Yellowstone County Multi-Hazard Mitigation Plan 2019 Update

APPENDIX A

Planning Process Documentation

APPENDIX A-1

PLANNING TEAM & PROJECT STAKEHOLDERS

APPENDIX A-1. PLANNING TEAM MEMBERS			
2019 YELLOWSTONE COUNTY MULTI-HAZARD MITIGATION PLAN			
TYPE	**FIRST NAME**	**LAST NAME**	**AFFILIATION**
Billings	Brian	Anderson	Billings Floodplain Administrator
Billings	Bill	Cole	Billings Mayor
Billings	Jon	Kristjanson	Billings Communications and Data Systems
Billings	Boris	Krizek	Billings Public Works, Environmental Affairs
Billings	David	Mumford	Billings Public Works Director
Billings	Mike	Pigg	Billings Parks Superintendent
Billings	Rick	Schauer	Billings Haz-Mat Team
Broadview	Travis	Jones	Broadview VFD Chief
Business	Tina	Beach	CHS Refinery - Pipelines and Terminals
Business	Jacob	Berry	Loveland Products
Business	Chuck	Bushey	Montana Prescribed Fire Service
Business	Mark	Nitz	CHS Refinery & Pipeline
Business	Perry	Rockvam	Diamond B Solutions
County	Paul	Christopher	Yellowstone Co. Information Technology
County	Don	Jones	Yellowstone Co. Commissioner
County	Ann	Kindness	Yellowstone Co. 911 Center
County	Janelle	Luppen	Yellowstone County GIS Manager
County	Bill	Michaelis	Yellowstone Co. Sheriff's Office
County	Lt. Kent	O'Donnell	Interim Yellowstone Co. DES
County	Linda	Oberg	Yellowstone Co. DES Admin
County	John	Ostlund	Yellowstone County Commissioner
County	Mike	Powell	Yellowstone County GIS
County	Kelly	Price	Yellowstone County Art Museum
County	Jeff	Slavick	Yellowstone County Information Technology Director
County	Darin	Swenson	Yellowstone County Floodplain Administrator
County	K.C.	Williams	Yellowstone County DES
Federal	Larry	Elders	BLM Billings Fire Prevention, Education, Mitigation
Federal	Tom	Frieders	National Weather Service
Federal	Randy	Middlebrook	Dept. Homeland Security
Fire	Matt	Hoppel	Billings Fire
Fire	Maury	Martin	Lockwood Fire
Fire	John	Staley	Lockwood Fire Dept. Chief
Laurel	Stanley	Langve	Laurel Police
Laurel	Matt	Lurker	Laurel Chief Administrator
Laurel	Kurt	Markegard	Laurel Public Works Director
Local Org	Dianne	Lehm	Big Sky Economic Development
Medical	Kim	Bailey	Riverstone Health
Medical	Gregory	Neill	Riverstone Health
Medical	Dave	Nordel	St. Vincent Health Care
Medical	Jennifer	Staton	Riverstone Health
Non-Profit	Abra	Farmen	American Red Cross
Non-Profit	Claudia	Stephens	Montana Migrant Workers Council
State	Charlie	Hanson	Montana DES District Representative
State	Ken	Hembry	MT Dept. Transportation
State	Walt	Houghton	MT Dept. Transportation
State	Tom	Tilzey	MT Dept. Transportation
Water	Gary	Davis	Billings Bench Water Assoc.
Water	Ed	Grube	Huntley Project Irrigation District
Water	Jim	Hinkle	Billings Bench Water Assoc.
Water	Allan	Workman	Billings Bench Water Assoc.

APPENDIX A-1. PROJECT STAKEHOLDER LIST

2019 YELLOWSTONE COUNTY MULTI-HAZARD MITIGATION PLAN

TYPE	FIRST NAME	LAST NAME	AFFILIATION
Adjoining County	Carol	Arkell	Stillwater County DES Coordinator
Adjoining County	Ed	Auker	Big Horn County DES Coordinator
Adjoining County	Marcus	Baue	Treasure County DES Coordinator
Adjoining County	Tom	Kohley	Carbon County DES Coordinator
Adjoining County	Robert	Pallas	Golden Valley County DES Coordinator
Adjoining County			Musselshell County DES Coordinator
Billings	Brian	Anderson	Billings Floodplain Administrator
Billings	Brenda	Beckett	Billings Community Development, Manager
Billings	Sean	Biggins	Billings Police Dept.
Billings	Denise	Bohlman	Billings City Clerk
Billings	Brent	Books	Billings City Attorney
Billings	Shaun	Brown	Billings Council - Ward 5
Billings	Richard	Clark	Billings Council - Ward 5
Billings	Bill	Cole	Billings Mayor
Billings	Brent	Cromley	Billings Council - Ward 1
Billings	Louis	Engles	Billings Water & Wastewater Dept.
Billings	Frank	Ewalt	Billings Council - Ward 2
Billings	Bryan	Francis	Billings Fire Dept.
Billings	Chris	Friedel	Billings Council - Ward 3
Billings	Reg	Gibbs	Billings Council - Ward 4
Billings	Kathy	Gibson	Billings Fire Dept.
Billings	Diane	Guy	911 Center
Billings	R. D.	Harper	Billings Police Dept.
Billings	Alan	Harper	Billings Fire Dept.
Billings	Matt	Hoppel	Billings Fire
Billings	Kevin	Iffland	Billings Assist. City Administrator
Billings	Denise	Joy	Billings Council - Ward 3
Billings	Bill	Kemp	Billings Public Works, Street-Traffic Superintendent
Billings	Anne	Kindness	911 Center
Billings	Jon	Kristjanson	Billings Communications & Data Systems
Billings	Boris	Krizek	Billings Public Works - Environmental Affairs.
Billings	Chris	Kukulski	Billings City Administrator
Billings	Jason	Lyon	Billings Fire Dept.
Billings	Wynnette	Maddox	Billings Admin. Assistant
Billings	David	Mumford	Billings Public Works Director
Billings	Roy	Neese	Billings Council - Ward 2
Billings	Cyndi	Pearce	Billings Public Schools
Billings	Mike	Pigg	Billings Parks Superintendent
Billings	Monica	Plecker	Billings Planning Division Manager
Billings	Kevin	Ploehn	Billings Logan Intnl Airport, Director Aviation & Transit
Billings	Bill	Rash	Billings Fire Chief
Billings	Penny	Ronning	Billings Council - Ward 4
Billings	Rick	Schauer	Billings Haz-Mat Team
Billings	Deb	Schmitt	Billings Network Administrator
Billings	Mike	Spini	Billings Fire Marshal
Billings	Rich	St. John	Billings Police Chief
Billings	Jon	Thompson	Billings Parks Dept. Supervisor
Billings	Paul	Tomton	Billings Logan Intnl Airport
Billings	Pepper	Valdez	Billings Asst. Fire Chief
Billings	Ronda	Vukasin	Billings Building Dept., Administrative Support
Billings	John	Walker	Billings Network Administrator
Billings	David	Watterson	Billings IT Director
Billings	Gary	Workman	Billings Public Works - Water
Billings	Mike	Yakawich	Billings Council - Ward 1
Billings	JoLynn	Yerger	Billings HR/ Safety
Broadview	Shelly	Ericson	Broadview Town Clerk

APPENDIX A-1. PROJECT STAKEHOLDER LIST

2019 YELLOWSTONE COUNTY MULTI-HAZARD MITIGATION PLAN

TYPE	FIRST NAME	LAST NAME	AFFILIATION
Broadview	Gary	Fisher	Broadview School Superintendent
Broadview	Kendra	Heiken	Broadview Asst. Fire Chief
Broadview	Travis	Jones	Broadview VFD Chief
Broadview	Roger	Swartz	Broadview Mayor
Business	Ben	Adelman	Phillips 66
Business	Dave	Armstrong	Alternatives, Inc.
Business	Tony	Bacino	Montana Rail Link
Business	Tina	Beach	CHS Refinery - Pipelines and Terminals
Business	Jacob	Berry	Loveland Products
Business	Maureen	Burns	Exxon Mobil
Business	Chuck	Bushey	Montana Prescribed Fire Service
Business	Howard	Butler	Jupiter Sulphur
Business	Amber	Collins	American Medical Response
Business	Rick	Deady	Alternatives, Inc.
Business	Kelly	Drain	Exxon Mobil Refinery
Business	Nick	Gold	Brenntag Pacific Inc.
Business	Diana	Grassel	Loveland Products
Business	Jacob	Haan	CHS Pipeslines and Terminals - Laurel
Business	Brian	Hansen	American Medical Response
Business	Erin	Harms	United Blood Services
Business	Desiree	Hawkins	United Blood Services
Business	Jim	Kelly	Diamond B Technology Solutions
Business	Chuck	Kelly	Sysco Food Services
Business	Shane	LaCasse	CHS Refinery
Business	Russ	Lowe	Cenex Refinery
Business	Jason	Mahoney	373 Consulting
Business	Jay	Martin	CHS Pipeslines and Terminals - Laurel
Business	Keith	Metzger	CHS Refinery
Business	Mark	Nitz	CHS Refinery & Pipeline
Business	Scott	Rainy	United Blood Services
Business	Perry	Rockvam	Diamond B Technology Solutions
Business	Ron	Rosh	DPC
Business	Jeniffer	Sutherland	SM Energy
Business	Jennifer	Ullman	Diamond B Technology Solutions
Business	Shawn T.	Wahlert	Phillips 66 Pipeline
Business	Patrick	Walker	Jupiter Sulphur
County	Roni	Baker	MSU Extension
County	Paul	Christopher	Yellowstone Co. Information Technology
County	Kevin	Cunningham	Yellowstone County Sheriff
County	Robyn	Driscoll	Yellowstone County Commissioner
County	Greg	Erpenbach	Yellowstone County Facilities Superintendent
County	Kevin	Evans	Yellowstone County Under Sheriff, Deputy DES
County	Wyeth	Friday	City/County Planning, Planning Division Manager
County	Don	Jones	Yellowstone Co. Commissioner
County	Lauri	Kimmerle	Central Services, Supervisor
County	Mike	Linder	Yellowstone County Sheriff
County	Sherry	Long	Yellowstone County Superintendent of Schools
County	Janelle	Luppen	Yellowstone County GIS Manager
County	Jeff	Martin	Yellowstone County Clerk and Recorder
County	Bill	Michaelis	Yellowstone Co. Sheriff's Office
County	Tim	Miller	Yellowstone County Public Works Director
County	Clay	Moore	Yellowstone County Road and Bridge, Asst. Director
County	Linda	Oberg	Yellowstone County DES Admin Asst.
County	Lt. Kent	O'Donnell	Yellowstone County Sheriff's Office
County	John	Ostlund	Yellowstone County Commissioner
County	Denis	Pitman	Yellowstone County Commissioner

APPENDIX A-1. PROJECT STAKEHOLDER LIST

2019 YELLOWSTONE COUNTY MULTI-HAZARD MITIGATION PLAN

TYPE	FIRST NAME	LAST NAME	AFFILIATION
County	Mike	Powell	Yellowstone County GIS
County	Kelly	Price	Yellowstone County Art Museum
County	Janet	Reynolds	Yellowstone County GIS
County	Daniel	Schwarz	Yellowstone County Deputy Attorney
County	Jeff	Slavick	Yellowstone County Information Technology Director
County	Darin	Swenson	Yellowstone County Floodplain Administrator
County	Scott	Twito	Yellowstone County Attorney
County	K.C.	Williams	Yellowstone County Emergency and General Services
Education	Scott	Carter	Shepherd School Superintendent
Education	Terry	Larson	MT Fire Service Training School
Education	Tobin	Novasio	Lockwood School Superintendent
Education	David	Perkins	Custer School Superintendent
Education	Mark	Wandell	Huntley/Worden School Superintendent
Federal	Chris	Barth	BLM
Federal	Nadine F.	Brown	FBI
Federal	Cathy	Caulfield	U.S. Postal Service
Federal	Chad	Cullum	BLM - Fire Mgmt Officer
Federal	Larry	Elder	BLM Billings Fire Prevention, Education, Mitigation
Federal	Tom	Frieders	National Weather Service
Federal	Matt	Henderson	Dept. Homeland Security
Federal	Randy	Middlebrook	Dept. Homeland Security
Federal	Craig	Myers	U.S. EPA
Federal	Lori	Reed	U.S. EPA
Federal	Nicolette G.	Rose	FBI
Federal	Kiffa	Shirley	FBI
Federal	Christi	Shortman	U.S. Postal Service
Federal	Michele	Stewart	FBI
Fire	Duane	Bjerke	Molt VFD Chief
Fire	Michael	Bowman	
Fire	William	Brenny	Billings Airport Fire
Fire	Larry	Carpenter	Fuego VFD, Shepherd VFD
Fire	Rick	Cortez	Blue Creek VFD Chief
Fire	Phil	Ehlers	Shepherd VFD Chief
Fire	Mike	Hammond	Haley Bench VFD
Fire	Allan	Hutton	Lockwood Fire Dept.
Fire	John	Hutzenbiler	Shepherd VFD Asst. Chief
Fire	Jason	Johnson	Billings Airport Fire
Fire	Keith	Kober	Lockwood Fire Dept.
Fire	Maury	Martin	Lockwood Fire
Fire	Milton	Motherhjead	Custer VFD Chief
Fire	Doug	O'Donnell	Huntley/Worden VFD Asst. Chief
Fire	Carl	Openshaw	Shepherd VFD Asst. Chief
Fire	Mark	Osborn	Fuego VFD Chief
Fire	John	Patterson	Waco VFD
Fire	Jim	Schubert	Haley Bench VFD
Fire	Colter	Smith	Billings Airport Fire
Fire	Mark	Solberg	Billings Fire / Regional Haz-Mat
Fire	John	Staley	Lockwood Fire Dept. Chief
Fire	Lance	Taylor	Huntley/Worden VFD Chief
Laurel	Linda	Filpula	Laurel School Superintendent
Laurel	Mark	Guy	Laurel Asst. Police Chief
Laurel	Keith	Kolstad	City of Laurel
Laurel	Kent	Kulsea	Laurel Asst. Fire Chief
Laurel	Bethany	Langve	Laurel City Clerk
Laurel	Stanley	Langve	Laurel Police
Laurel	Matt	Lurker	Laurel Chief Administrator

APPENDIX A-1. PROJECT STAKEHOLDER LIST			
2019 YELLOWSTONE COUNTY MULTI-HAZARD MITIGATION PLAN			
TYPE	**FIRST NAME**	**LAST NAME**	**AFFILIATION**
Laurel	Kurt	Markegard	Laurel Public Works Director
Laurel	Rick	Musson	Laurel Police Chief
Laurel	Tom	Nelson	Laurel Mayor
Laurel	Brent	Peters	Laurel Fire Chief
Laurel	Tim	Reiter	Laurel Public Works/Utilities
Laurel	Forrest	Sanderson	Laurel Floodplain Administrator
Laurel	Jason	Shovar	Laurel Fire Marshall
Laurel	Matt	Wheeler	Laurel Public Works
Local Org	Meridith	Cox	Business Watch Montana
Local Org	Dianne	Lehm	Big Sky Economic Development
Media	Vern	Drommond	
Medical	Kim	Bailey	Riverstone Health
Medical	Jason	Banfield	Billings Clinic
Medical	Chuck	Copeman	Advanced Care Hospital
Medical	Cynthia	DelPriove	Billings Clinic
Medical	Tony	Janskovitch	St. Vincent Health Care
Medical	Joe	Marcotte	Billings Clinic
Medical	Gregory	Neill	Riverstone Health
Medical	Dave	Nordel	St. Vincent Health Care
Medical	Claire	Oakley	Riverstone Health
Medical	Clark	Snyder	Riverstone Health
Medical	Jennifer	Staton	Riverstone Health
Medical	Marilyn	Tapia	Riverstone Health
Non-Profit	Jed	Barton	Living Independently Today/Tomorrow
Non-Profit	Chuck	Bikle	Yellowstone Amateur Radio Club
Non-Profit	Maj. Keith	Bottjen	Salvation Army
Non-Profit	Jim	Eckenroad	Rimrock Foundation
Non-Profit	Abbra	Farman	Red Cross
Non-Profit	Marcus	Gipson	Red Cross
Non-Profit	Ron	Glass	YARES Radio Club
Non-Profit	Darlene	Johnson	Salvation Army
Non-Profit	Bob	Lough	YARES Radio Club
Non-Profit	Chris	Mackey	United Way
Non-Profit	Pamela	Sanderson	United Way
Non-Profit	Harry	Schlitz	HOPE Animal Assisted Crisis Response Dogs
Non-Profit	Sterling	Silver	American Red Cross
Non-Profit	Claudia	Stephens	Montana Migrant Workers Council
Non-Profit	Rob	Wilkerson	St. John's Lutheran Ministries
Non-Profit	Steve	Woodard	Living Independently Today/Tomorrow
Public	Auzie	Blevins	County Resident
State	Adam	Davis	MSU Billings - Police
State	Keith	Edgell	Montana Highway Patrol
State	Jeff	Gates	Montana DES District Representative
State	Charlie	Hanson	Montana DES District Representative
State	Ken	Hembry	MT Dept. Transportation
State	Timothy	Hosa	Montana Woman's Prison
State	Walt	Houghton	MT Dept. Transportation
State	Michael	Moorman	Montana Woman's Prison
State	Shari	Pool	Montana DES
State	Tom	Tilzey	MT Dept. Transportation
State	Derek	Yeager	Montana DNRC
Student	Erin	Ellis	Student
Tribal	Ricardo	Murga	Indian Health Service
Tribal	Laura	Rides Horse	Crow Agency DES Coordinator
Utility	Joseph	Brent	NorthWestern Energy
Utility	Rick	Burt	NorthWestern Energy

APPENDIX A-1. PROJECT STAKEHOLDER LIST			
2019 YELLOWSTONE COUNTY MULTI-HAZARD MITIGATION PLAN			
TYPE	**FIRST NAME**	**LAST NAME**	**AFFILIATION**
Utility	Jerry	Ellis	Yellowstone Valley Electric-Huntley/Worden Engineering
Utility	Michelle	Tipton	Montana Dakota Utility
Utility	Brandon	Wittman	Yellowstone Valley Electric-Huntley/Worden Engineering
Water	Mike	Ariztia	Lockwood Water Manager
Water	Miles	Borges	City High Ditch Water Users Assoc.
Water	Peyton	Brookshire	County Water District of Billings Heights
Water	Russ	Cumin	Big Ditch / High Dith Company
Water	Gary	Davis	Billings Bench Water Assoc.
Water	Ed	Grube	Huntley Project Irrigation District
Water	Jim	Hinkle	Billings Bench Water Assoc.
Water	Mike	Kriztia	Lockwood Water & Sewer District
Water	Sandy	Kust	Worden Water District
Water	Duke	Nieskens	Billings Heights Water District
Water	Tony	Reed	Lockwood Asst. Water Manager
Water	Steve	Story	Cove Irrigation Co.
Water	Daniel	Walters	Grey Eagle Ditch
Water	Gary	Wichman	Burnstead Water Users Assoc.
Water	Allan	Workman	Billings Bench Water Assoc.

APPENDIX A-2

MEETING ANNOUNCEMENTS

tions and maintenance budget will decrease by about $205,000.

While budgeted officer overtime was planned at just under $300,000 for 2017-18, the actual amount spent by June 30 — the end of the current fiscal year — will be nearly $498,000. About $270,000 of that will be reimbursed.

The department lists four challenges during the coming fiscal year: sustainable funding, an increased demand for services, recruitment and retention, and constructing or repurposing an evidence facility.

The Fire Department budget is decreasing about by $406,000 during the coming fiscal year, from about $20.2 million during the current year to about $19.8 million during 2018-19. That's a 2-percent decrease.

The department generates about $1.95 in revenue annually. About 60 percent of that revenue comes from protecting residents and businesses within the Billings Urban Fire Service Area, nearly 48 square miles outside city limits.

The department lists a number of key issues, goals and challenges for the coming year and beyond, including:

Yellowstone County to begin update to hazard mitigation plan

SAM WILSON
swilson@billingsgazette.com

Local officials and community members will be talking wildfires, floods, rockfalls, cyberattacks and just about every other conceivable disaster in the coming months as Yellowstone County begins updating a sweeping plan that guides preparation, response and planning for both natural and man-made hazards.

Planning for the five-year update to the county's multi-hazard mitigation plan kicks off next week as Yellowstone County Disaster and Emergency Services and Tetra Tech, a planning services company hired to help with the effort, begin collecting input.

"These plans are really geared toward looking at where future development is happening and making sure homes and businesses aren't built in high-hazard areas," said Daphne Digrindakis, the senior project manager with Tetra Tech.

Those hazards range from natural events to the possibility of disease outbreaks, transportation incidents and hazardous material releases. Digrindakis said the final updated plan will include a lengthy list of possible projects, like establishing and upgrading tornado shelters, creating structures to mitigate flooding or upgrading the public alert systems.

"By having a project in this plan, then it positions the county and communities to get these FEMA grants," Digrindakis said, referring to funding available from the Federal Emergency Management Agency.

Those who participate in the planning meeting range from first responders and county planners to residents with homes and businesses in disaster-prone areas, or firsthand experience dealing with hazards identified in the plan, Digrindakis. Organizations that respond to disasters, such as the Red Cross and the Salvation Army, are also invited to attend.

The first meetings will focus on ranking hazards in Yellowstone County and putting together a planning team of 12-20 people to meet once per month to work on updating the mitigation strategy.

Subsequent meetings will take a closer look at critical facilities in the county, utilities that keep communities connected and hazard maps depicting which parts of the county are most susceptible to different hazards, Digrindakis said.

She expects the process of updating the plan, which began in April, to take about a year to complete.

"It's mainly a plan that's going to come up with a strategy that's going to make this community more resilient, or projects that can be done to minimize loss," she said.

The first pair of meetings will take place next week: Wednesday, May 9, at 6:30 p.m. in the Lincoln Center's School District Board Room, 415 N. 30th St.; and Thursday, May 10, at 1:30 p.m. in the basement of Billings Fire Station 1, 2305 8th Ave. N.

For more information, visit www.countypdm.com, select Yellowstone County and enter "Billings" as the password.

The Laurel Outlook

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Yellowstone County hazard mitigation planning to begin

Every five years Yellowstone County updates its hazard mitigation plan. Being prepared is important for both city and county government agencies, non profits, schools and other facilities, as well as the general public. The plan update is also necessary for entities in the county to be eligible for FEMA funding in the event of disaster.

To begin the process there will be two public meetings to get input from residents and those knowledgable on reducing the impacts of natural disasters and man-made hazards, like wildfire, flooding, severe weather, train derailments or industrial accidents.

The initial meetings of the Yellowstone County Multi-Hazard Mitigation Plan will be Wednesday, May 9 at 6:30 p.m. at the Lincoln Center in the School District Board Room and

Thursday, May 10, at 1:30 p.m.at the Emergency Operations Center in the basement of Billings Fire Station #1, 2305 8th Ave. N.

From an invitation to to public, Emergency Services Director Brad Shoemaker wrote, "By providing input and direction as a project stakeholder you can assist us by representing your interests in making our communities more resilient and resistant to the damages caused by natural and man-made hazards. The Federal Emergency Management Agency requires that a MHMP be in place for the County to receive disaster mitigation funds and apply for mitigation grants.

"The MHMP will re-examine the wide range of hazards that affect Yellowstone County, recent hazard events, the probability of future occurrences, and the vulnerabilities of our structures and population. From that assessment, a plan of action to mitigate these hazards can be updated. Your assistance with update of

Hazard, Page 8

Hazard from page 1

the MHMP will ensure it is meaningful and relevant throughout Yellowstone County."

Yellowstone County has contracted with Tetra Tech, Inc. to assist with the MHMP update. Although Tetra Tech will provide project management, technical assistance, and otherwise provide a majority of the administrative work on the Plan, participation is important to ensure vulnerabilities are identified and the appropriate mitigation projects are included in the Plan.

For more information contact Daphne Digrindakis with Tetra Tech at 406-475-2648.

APPENDIX A-4

MEETING SUMMARIES & PRESENTATIONS

YELLOWSTONE COUNTY MHMP UPDATE
PUBLIC MEETING NOTES
WEDNESDAY, MAY 9, 2018
6:30pm – 8:00pm

ATTENDANCE:

Brad Shoemaker	Yellowstone County DES
Charlie Hanson	Montana DES
Ben Adelman	Phillips 66
Jennifer Ullman	Diamond B Technology Solutions
Jim Kelly	Diamond B Technology Solutions
Joe Marcotte	Billings Clinic / Yellowstone County LEPC
Mark Solberg	Billings Fire / Regional Haz-Mat Team
Daphne Digrindakis	Tetra Tech

PRESENTATION & HANDOUTS:

- Calculated Priority Risk Index
- Types of Mitigation Projects
- 2012 Mitigation Strategy

Flooding

- Downtown Billings flooded due to lack of storm water infrastructure at 10th Ave. North. Larger diameter storm sewers are being installed but will still be problematic because they feed into smaller diameter main lines.
- Father's Day storm of 2010 caused $2.7 million in damages to Billings Clinic. Clinic has suffered total of $4.7 million in damages from surface water flooding.

Wildfire

- There has been significant subdivision development in high risk wildland urban interface, including Emerald (400 tiny homes), Sage, and Huntington Hill subdivisions.
- 12,000-acre fire on edge of subdivision area in 2017.
- Rehberg Ranch subdivision has done some fuel mitigation.
- Yellowstone County DES administers BLM funds for landowner fuel mitigation grants at 75/25 match. Landowners in Emerald Hill subdivision have participated in program.

Severe Weather

- Snowfall amounts in since 2012 have broken records twice.
- Three major hailstorms since 2012 with high losses (2013, 2015, 2016).

Dam Failure

- City is constructing storm water retention pond on west end of Billings that will be classified as a high hazard dam.

Expansive Soil

- Water main broke at Briarwood in 2016/17 due to soil shifting.

Landslide/Rock Fall

- Road damage on Zimmerman Way due to rockfalls.
- Phipps Park has also experienced rockfall damage.

YELLOWSTONE COUNTY MHMP UPDATE
PUBLIC MEETING NOTES
WEDNESDAY, MAY 9, 2018
6:30pm – 8:00pm

Hazardous Material Incidents

- Most of the significant transportation accidents have involved tractor-trailers.
- No major haz-mat incidents in past 3 years.
- Train derailed in Worden but no release.
- Technology available to protect first responders.
- Regional Haz-Mat Response Team responds to 3 to 4 narcotics transport incidents per year on the I-90/I-94 corridor. Not responding to as many meth labs.

YELLOWSTONE COUNTY MHMP UPDATE
PUBLIC MEETING NOTES
THURSDAY, MAY 10, 2018
1:30pm – 3:00pm

ATTENDANCE:

Brad Shoemaker	Yellowstone County DES
Charlie Hanson	Montana DES
David Nordel	St. Vincent Health Care
Terry Larson	MT Fire Service Training School
Chad Cullum	BLM Billings Field Office – Fire Management Officer
Joe Marcotte	Billings Clinic / Yellowstone County LEPC
Larry Elder	BLM Billings Field Office – Fire Prevention
Scott Rainey	United Blood Services
Brian Anderson	City of Billings – Floodplain Administrator
Auzie Blevins	County Resident
William Brenny	Billings Logan International Airport
Philip Ehlers	Shepherd Volunteer Fire Dept.
Kevin Cunningham	Yellowstone County Sheriff
Kurt Markegard	City of Laurel, Public Works Director
Keith Metzger	CHS Refinery
Shane LaCasse	CHS Refinery
Jon Kristjanson	City of Billings
Tom Frieders	National Weather Service Billings
Matt Hoppel	Billings Fire
Bill Cole	Billings Mayor
Kelly Price	Yellowstone Art Museum
Rob Wilkerson	St. John's Lutheran Ministries
Nadine Brown	FBI
Dianne Lehm	Big Sky Economic Development
Diana Grassel	Loveland Products, Inc.
Jacob Berry	Loveland Products, Inc.
Capt. RD Harper	Billings Fire Dept.
Greg Neill	Riverstone Health
Jennifer Staton	Riverstone Health
Colter Smith	Billings Airport Fire
Abbra Firman	American Red Cross
Mike Powell	Yellowstone County GIS
Tom Kohley	Carbon County DES
Erin Bail Ellis	Student
Rick Musson	Laurel Police Chief
Kathy Gibson	Billings Fire Dept.
Daphne Digrindakis	Tetra Tech

PRESENTATION & HANDOUTS:

- Calculated Priority Risk Index
- Types of Mitigation Projects
- 2012 Mitigation Strategy

YELLOWSTONE COUNTY MHMP UPDATE
PUBLIC MEETING NOTES
THURSDAY, MAY 10, 2018
1:30pm – 3:00pm

NOTES:

Flooding:

- Dry washes (Alkali Creek, Basin Creek) floods when after heavy thunderstorms or rapid snowmelt. USACE hydrographs can be used to model the 100-year flood. Basin Creek funnels into a narrow valley and there is a subdivision location there. Jim Kraft, former Yellowstone County DES, had identified a number of these dry washes as vulnerable areas.
- Urban area of Billings downtown has been impacted by 2-inch rains. Billings Clinic has suffered extensive damage from surface flooding.
- Banks of the irrigation ditch at Highland Golf Course collapsed flooding downtown before in heavy rain event prior to 1937.
- Cove Creek and East Reach below Country Club is currently being mapped by FEMA contractors. May be available for PDM flood analysis.
- Basement of Yellowstone Art Museum has flooded because of seepage through older foundation.
- Limited storm water collection system exists through downtown Billings to manage sheet-flow flooding through urban area.
- Pryor Creek drainage is problematic. During 2011 flood, Pryor to Huntley flooded to where it dumps into Yellowstone River inundating golf course, business, and several houses. One fatality resulted when saturated ground shifted and farmer got trapped under tractor.

Wildfire

- Need to identify method to dispose of fuel mitigated material so all of it doesn't have to travel long distances to come to landfill. Consolidation of material and local burn areas may be a solution. Possible mastication of material for composting.
- Large acreage in wildland urban interface with many new subdivisions. Subdivision regulations could be strengthened to require defensible space and construction with fire-proof materials.

Hazardous Material Incidents/Transportation Accidents

- Railroad accidents should be considered in PDM analysis.
- Regional Haz-Mat Response Team in Billings used to rely on State and Federal funding but this source has dried up. Keeping team together with local funding that may only last two more years. May need to limit response area due to funding limitations. Need legislation for increased funding.

Terrorism/Violence/Civil Unrest/Cyber Security

- Health Medical Group. Hospitals have seen response increase due to local violence.
- Cyber event in Lockwood recently when ransomware shut down the fire department's computer system.

YELLOWSTONE COUNTY MULTI-HAZARD MITIGATION PLAN UPDATE

Contractor: Tetra Tech, Inc.
Daphne Digrindakis
406-475-2648

WHAT IS MITIGATION?

Mitigation is a sustainable action that will reduce or eliminate injury to citizens, damages to structures and allow continuity of critical society function.

WHY HAVE A MULTI-HAZARD MITIGATION PLAN?

- Required by FEMA in order to receive mitigation funds after a declared disaster (Hazard Mitigation Grants Program), Public Assistance (PA) C-G.
- $100 million available annually through competitive grants for hazard mitigation projects through:
  - Pre-Disaster Mitigation (PDM) grants program
  - Grant funding this project – 75/25
    - Cost Share – Soft Match

BACKGROUND

- Yellowstone County first completed a Pre-Disaster Mitigation (PDM) Plan in 2004.
- The PDM Plan was updated in 2012.
- Hazard Mitigation Plans must be updated every 5 years to remain eligible for disaster funding.
- Must be adopted by resolution by County and incorporated communities.
- New FEMA guidance for completing PDM Plans in 2013.
- Multi-Hazard Mitigation Plan instead of PDM.

PLANNING PROCESS

- **Project Stakeholders**
  - County, City, Town staff, response personnel, school districts, medical, local organizations, state, federal, non-profits, businesses
- **Planning Team**
  - Jurisdictions wishing to adopt plan must participate
  - Community Partners
  - Conference calls/planning meetings
- **Public Meetings**
- **Project Website**
  - www.countypdm.com. Password: Billings

REVIEW OF PLANS & STUDIES

- **Plans with Mitigation Considerations**
  - Subdivision Regulations
  - Zoning Ordinances
  - Building Codes
  - Flood Insurance Study, West Billings Project
  - Community Wildfire Protection Plan
  - Emergency Action Plans for High Hazard Dams

2012 PLAN REVIEW

- **Hazards types included:**
  - Water – Flooding, Dam Failure
  - Wildfire
  - Weather – Wind, Hail, Tornado, Winter Storm, Drought
  - Geologic – Expansive Soil, Landslide, Volcanic Ash
  - Manmade – Urban Fire, Transportation Accident, Haz-Mat Incidents, Terrorism, Civil Unrest, Enemy Attack
- **Identified hazards that presented the greatest risk**
- **Identified areas that were cumulatively most vulnerable to hazards.**

2012 HAZARD RANKING

1. Flooding
2. Wildfire
3. Weather – Extreme Wind & Thunderstorms
4. Tornado
5. Severe Winter Storms
6. Drought
7. Dam Failure
8. Expansive Soils
9. Landslide
10. Earthquake
11. Volcano

2018 MITIGATION PLAN UPDATE HAZARD PROFILES

- **Identify Additional Hazards to Rank for Plan**
  - Consider New or Emerging Hazards
  - Communicable Disease, Terrorism, Cyber Security
  - Changes in frequency/magnitude due to climate change.
- **Use Calculated Priority Risk Index (CPRI) to Re-Prioritize Hazards (see handout).**
  - Probability - Highly likely to unlikely
  - Severity/Magnitude - catastrophic to negligible
  - Economic Impact – catastrophic to negligible
  - Warning Time - < 6 hours to > 24 hours
  - Duration - < 6 hours to > one week

2018 PLAN UPDATE RISK ASSESSMENT

- **Profile 8 Hazards in Plan**
  - Organized in Plan by priority
  - Some hazards can be combined into one profile
  - Lower priority hazards included in Plan appendix
- **Each Hazard Profile to Include**
  - Description and History
  - Vulnerability and Area of Impact
  - Probability and Magnitude
  - Future Development
  - Implications of Climate Change

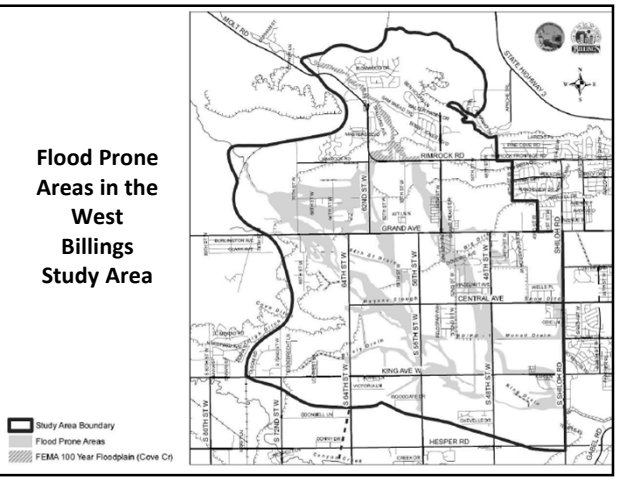
RISK ASSESSMENT METHODOLOGY

- **GIS layers of hazard areas**
  - Some hazards have uniform exposure across county
- **Analyze buildings at risk from various hazards**
  - Critical facility locations and insured values.
  - Dept. Revenue parcel data of locations and values of commercial & residential properties. Linked to NRIS Structures database with locations of building stock.
- **Using GIS – intersect building stock/critical facilities with hazard areas**
  - Determine number and value of buildings at risk
- **Population exposure – hazard area, > 65, < 18**
- **Future Development**

FLOODING

- **Regional Floods, Flash Floods, Ice Jam Floods**
- **$65.3 M in flood-related losses since 1937**
- **2011 Flood Insurance Study identified susceptible areas:**
  - Yellowstone River and Clarks Fork of Yellowstone related to development within the floodplain and uncertified levees.
  - Cove Creek and Little Cove Creek in West Billings due to undefined flood channels and intersections of irrigation and drainage ditches.
  - Italian Ditch and Main Street in Laurel due to intersection of ditches and undersized culverts and crossings of roadways.

Flood Prone Areas in the West Billings Study Area

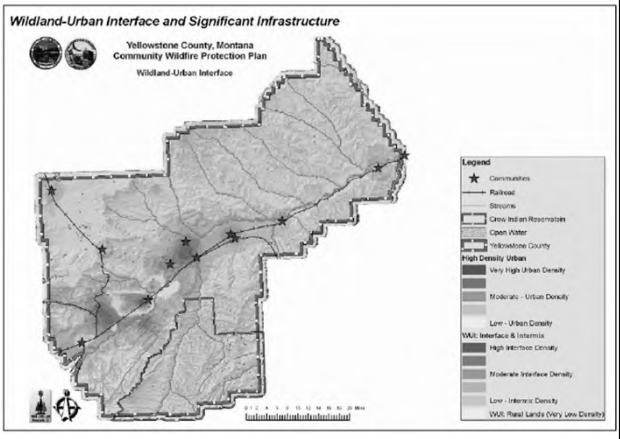


FLOODING

- **Critical Facilities in 100-year Floodplain**
  - Blue Creek School
  - Wilcox Airport
  - 48th Street Church of Christ
  - Billings Fire Dept. Station #7
- **National Flood Insurance Program**
  - 3 Repetitive Loss Properties
- **Future Losses estimated to average $1.1 M per year.**

WILDFIRE

- **2006 Community Wildfire Protection Plan identifies Yellowstone County Wildland Urban Interface.**
- **1,000 properties located in areas where fuel treatment is necessary to reduce risks.**
- **Estimated structure value is these areas $178 M.**
- **High potential for structural damage**
- **Moderate potential for injury /fatality**



THUNDERSTORM, SEVERE WIND, HAIL, TORNADO

- **$27 M in property damage; $6 M in crop damage in 30 years. Two recorded fatalities.**
- **2010 EF-2 Tornado in Billings estimated to have caused $50 M in damages.**
  - Significant damage at Rimrock Auto Arena and MetraPark.
- **High potential for structural damage and high potential for injury/fatality from extreme storms**

WINTER STORMS, COLD SPELLS

- **Prolonged event involving snow or ice and extreme cold.**
- **Disrupt public utilities, telecommunications, transportation routes.**
- **$1.85 M in losses over 50 years.**
- **Low potential for structural damage and high potential for injury/fatality from extreme storms**

DROUGHT & INSECT INFESTATION

- **Economic hardship is result of drought.**
- **Large impact on farming and ranching.**
- **During drought cycles there is increase in insect infestation, increase in wildfire occurrence, and decrease in water supplies.**

URBAN FIRE

- **Economic loss to individuals, damage to private and public structures, and utilities/**
- **All jurisdictions vulnerable to structural damage.**
- **High potential for injury/fatality.**

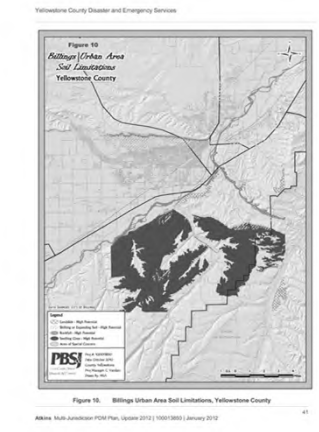
DAM FAILURE

- **High Hazard Dams that could impact Yellowstone County.**
  - Anita Dam
  - Cooney Dam in Carbon County
- **Potential for dam failure considered extremely low.**

EXPANSIVE SOILS

- **Fine-grained clay found in areas that historically were a floodplain or lake area and subject to swelling and shrinkage.**
- **Found in several areas on south side of Billings. Rest of county has not been mapped.**
  - Shifting foundations, cracks, ground movement.
  - Underground utilities may be affected with damage to pipes and lines.
  - Potential damage to roads, railways and bridges.
  - Little documented damages.

Expansive Soil Hazard Area



LANDSLIDE

- **Greatest area of rockfall damage is below the Rims in Billings.**

TRANSPORTATION ACCIDENT

- **County has high relative risk due to:**
  - Large population and industrial base.
  - I-90 and I-94 heavily used by commercial vehicles hauling chemicals, petroleum products and farm products.

HAZARDOUS MATERIALS INCIDENT

- **History of haz-mat incidents from refineries, railroad tank cars, highway tankers, and pipelines.**
- **County has high probability of haz-mat with two rail yards, large airport, three refineries and many chemical industries.**

TERRORISM, CIVIL UNREST, VIOLENCE

- **Hoaxes of anthrax, bomb threats to schools and government buildings.**
- **In past 23 years, two teachers strikes that had incidents of violence against those that crossed picket lines or were vocal about their opinions.**
- **Within last 10 years, two union-trucking strikes have had incidents of violence.**

2012 MITIGATION STRATEGY

- **See Handout**

2018 MITIGATION STRATEGY

- **Restructure Mitigation Strategy**
  - One goal for each hazard & all hazard goal
  - Objectives consistent with FEMA guidance
    - Prevention,
    - Property Protection,
    - Structural,
    - Public Education and Awareness,
    - Natural Resource Protection,
    - Emergency Services,
    - Planning/Mapping
- **Determine Status of Projects from 2012 Plan**
  - Complete, Retain/Reword, Delete, Ongoing

2018 MITIGATION STRATEGY

- **Identify New Projects**
  - Focus on mitigation – not response or preparedness
  - Consider Development Trends
- **Project Implementation Details**
  - Responsible Agencies and Partners
  - Potential Funding Sources
  - Timeframe
  - Progress Made
  - Planned Activities
- **Project Prioritization Factors**
  - Cost, Feasibility, Population Benefit, Property Benefit

CAPABILITY ASSESSMENT

- **Capabilities to Implement Mitigation Projects**
  - County & City Departments
    - DES, Planning, Public Works, GIS
  - LEPC
  - Local, State & Federal Partners
  - Programs – NFIP, FireSafe, Others
- **Funding Opportunities**
  - FEMA – HMPG, PDMC, FMA
  - BLM – National Fire Plan
  - HUD – CDBG Program
  - USDA, USDOT, Others

2018 MITIGATION PLAN UPDATE SCHEDULE

- Planning Team Conference Calls/Meetings – Jun, Jul, Aug, Sep, Oct, as needed
- Public Meeting to review draft risk assessment and mitigation strategy – Oct 2018
- Stakeholder review of Draft Plan (30 days) – Oct/Nov 2018
- Revision to address stakeholder comments – Nov 2018
- Submit to Montana DES (30 days) & FEMA (60 days) for approval – Dec/Jan/Feb
- Additional revision if necessary – Feb 2019
- Submit to County, Billings, Laurel, Broadview for adoption – Mar 2019

APPENDIX A-5

PLANNING TEAM MEETING NOTES

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #1
JUNE 13, 2018
10:30 am – 12:30 pm

Attendance:

Brad	Shoemaker	Yellowstone County Emergency and General Services
Chuck	Bushey	Montana Prescribed Fire Service
Dianne	Lehm	Big Sky Economic Development
Claudia	Stephens	Montana Migrant Workers Council
Tina	Beach	CHS Refinery - Pipelines and Terminals
Kelly	Price	Yellowstone County Art Museum
Kurt	Markegard	Laurel Public Works Director
Brian	Anderson	Billings Floodplain Administrator
Daphne	Digrindakis	Tetra Tech

Agenda:

1. Review and Discuss Calculated Priority Risk Index Matrix
    - Probability Description
    - Magnitude/Severity Description
    - Assigned Weighting Factor
2. Score Hazards
3. Review Scored Ranking
4. Determine Which Hazards to Group for MHMP Hazard Profiles. Consider the following:
    - Flooding, Dam Failure
    - Transportation Accident Profile - Highway, Railroad, Aviation Accidents
    - Severe Weather Profile - Winter Weather, Summer Weather and Drought
5. Identify 8 Hazard Profiles to include in MHMP
6. Prioritize Top 8 Hazards

Notes:

Wildfire

- Fire fighter injuries are most common.
- Two structures/year are destroyed, livestock fatalities annually, fence damage.
- 2015 citizen fatality, individual was entrapped when he didn't evacuate. Buffalo Trail Rd. north of Laurel. Clapper Flat Fire.
- 261 fires in 2017 in Yellowstone County.
- Some of most vulnerable areas include South Billings Blvd, Emerald Hills subdivision.
- 2 yrs ago Duck Creek Fire, 2 electric lines burned, another line threatened which was only line serving CHS Refinery. Could have been shut down refinery if damaged.
- Each year there are several fires which take 2-3 days to control.

Flooding

- Flash floods occur every third year that cause road closures.
- Hospitals have had damage, Zimmerman trail area.
- Flash flooding occurs from severe weather events.
- Riverine flooding is limited to three times a decade.

Severe Summer Weather

- Transient fatality from exposure.
- Eastern MT has high incidence of severe weather.

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #1
JUNE 13, 2018
10:30 am – 12:30 pm

Railroad Accidents

- 2 years ago, someone died at railroad crossing.
- 1 derailment every couple of years.
- Vehicles have been hit several times at Ballentine.
- BNFS says $275K of product per rail car.

Aircraft Accidents

- Billings has International Airport (in name only).
- Chinook helicopter business located in Billings.
- Lots of private flights
- In the 1990s, an Edwards Flying Service plane flew behind jet and lost control, crashed into school district warehouse.
- Aircraft fatalities occur about once every 25 years.
- Cessna crashed couple years ago but no one died.

Highway Accidents

- Multi-vehicle accidents, every couple of years.
- RV drove off Laurel bridge last year.

Cyber Security

- County IT is warding off attacks.
- Lockwood Fire almost lost entire system a couple months ago due to ransomware attack.
- Yellowstone Art Museum has had 4 ransomware attacks in past 18 months. Took down hospital system too. Art Museum system down for 3 weeks. Once effected computer is isolated can be back online in 48 hours. File recovery takes much longer.

HazMat Incidents

- Flaring from refineries are common events.
- Reports at least once a month from Tier II haz-mat reporters
- 2017 A1 propane explosion, Frontage Road in Billings

Terrorism

- DHS recently assessed Yellowstone Co. and ranked civil unrest as highest threat. Terrorism events in the county would be home grown.
- Since Billings is fairly large it is considered a likely target for pipeline protests.
- One documented event at Wells Fargo building – pipeline protest in 2017, 25-30 people attended.

Dam Failure

- 3 high hazard dams could affect Yellowstone Co. Cooney Dam would impact downtown Billings

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #1
JUNE 13, 2018
10:30 am – 12:30 pm

Irrigation Ditch Failure

- 2 documented events in residential areas with impacts, most recent was 2 years ago.
- Ditches are considered critical facilities for county agriculture economy.
- After recent failure it took 1½ weeks to get ditch back online.
- Big ditch study going on now. Results will be available for MHMP.
- During recent flooding, ditch was bulldozed in to prevent accidental rupture,
- Ditches built 100 yrs ago when there was little development. Now when they break they affect residential areas. Difficult problem to fix. Affected homes are not in mapped floodplains. Most residents don't know they're downstream of ditch and don't have flood insurance. Ditches can't be filled in because they support agriculture. Ditch water rights supersedes other water usage. Some fixes may involve lining ditch with concrete or rerouting ditch. Only way to eliminate ditches would be if landowners sue. Grants (public dollars) are available for ditch upgrades. Ditch companies have been very good to work with so far and may be available to participate in mitigation workshop.

Expansive Soils

- A few areas affected including one with residences built on top. Water main break, basement cracks, slow creeping issue
- Include hazard profile in Plan appendix and list soil affected soil types

Earthquake

- Low risk of impacting Yellowstone County; <1% of magnitude 5 earthquake in 50 years.
- Lots of small earthquakes that no one notices.

Rock Falls

- Rims area has been affected, parks closed, rocks through houses.
- Geotech assessments have been completed of parks and roads.

Volcanic Ash

- 3" ash from Mt. St. Helena, public health issue, crop damage.
- 3 feet of ash from Yellowstone, would kill everyone.

Calculated Priority Risk Index Score – See Next Page

County Hazard Priorities – See Next page

Next Planning Team Meeting

- Wednesday, July 11, 2018. 10:30am

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #1
JUNE 13, 2018
10:30 am – 12:30 pm

YELLOWSTONE COUNTY MULTI-HAZARD MITIGATION PLAN - 2018 UPDATE

CALCULATED PRIORITY RISK INDEX

	Probability				Magnitude/Severity				Warning Time				Duration				Economic Impact				
Hazard	Unlikely	Possibly	Likely	Highly Likely	Negligible	Limited	Critical	Catastrophic	< 6 hours	6 - 12 hours	12 - 24 hours	> 24 hours	< 6 hours	< 24 hours	< 1 week	> 1 week	Negligible	Limited	Critical	Catastrophic	CPRI Score
Hazardous Materials Incidents		x				x			x					x			x				2.10
Wildfire				x			x		x						x				x		3.45
Communicable Disease			x				x					x				x		x			2.60
Severe Weather				x				x	x						x				x		3.70
Railroad Accidents			x				x		x					x				x			2.85
Aircraft Accidents		x					x		x						x			x			2.65
Highway Accidents (Mass Casualty)				x			x		x					x			x				2.95
Cyber Security				x		x			x						x				x		3.20
Terrorism, Violence, Civil Unrest		x				x					x			x			x				1.80
Flooding			x			x						x				x			x		2.55
Irrigation Ditch Failure			x				x		x							x			x		3.25
Dam Failure	x							x	x					x						x	2.90
Expansive Soils		x				x						x			x			x			1.95
Drought			x			x						x				x			x		2.55
Landslide / Rock Fall			x			x			x				x				x				2.30
Volcanic Ash		x				x					x					x		x			2.20

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #1
JUNE 13, 2018
10:30 am – 12:30 pm

CPRI - CALCULATED PRIORITY RISK INDEX	
Severe Weather	3.7
Wildfire	3.45
Irrigation Ditch Failure	3.25
Cyber Security	3.2
Highway Accidents (Mass Casualty)	2.95
Dam Failure	2.9
Railroad Accidents	2.85
Aircraft Accidents	2.65
Communicable Disease	2.6
Flooding	2.55
Drought	2.55
Landslide / Rock Fall	2.3
Volcanic Ash	2.2
Hazardous Materials Incidents	2.1
Expansive Soils	1.95
Terrorism, Violence, Civil Unrest	1.8

HAZARD PRIORITIZATION	
1	severe weather / drought
2	wildfire
3	irrigation ditch failure
4	terrorism/cyber
5	haz-mat / transp
6	flooding / dam failure
7	communicable disease
8	landslide / rock fall

APPENDIX	
	expansive soils
	volcanic ash

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #2
JULY 11, 2018
10:30 am – 12:30 pm

Attendance:

Chuck	Bushey	Montana Prescribed Fire Service
Dianne	Lehm	Big Sky Economic Development
Tina	Beach	CHS Refinery - Pipelines and Terminals
Larry	Elders	BLM Billings Fire Prevention, Education, Mitigation
Travis	Jones	Broadview VFD Chief
Brian	Anderson	Billings Floodplain Administrator
Daphne	Digrindakis	Tetra Tech

Agenda:

- Review Critical Facility Maps
- Review Hazard Area Impact Maps

Presentation & Handouts:

- Yellowstone County Critical Facilities
- PowerPoint Presentation with Critical Facility and Hazard Maps

Critical Facility Review:

- Take off all communication sites not on Brad's prioritized list.
- Custer Fire is getting new building. Highlighted in red on Brad's list.
- Retain schools, shelters, and senior facilities not prioritized.
- For security purposes, do not identify CFs by name on maps in Plan.
- Remove Montana Rail Link in Laurel.
- Use different color dots for vulnerable populations (shelters, schools, senior facilities).

Wildfire Hazard Map Review:

- Consider separate map showing pasture and crop land as it interferes with depiction of WUI.
- Use 1,000-foot buffer into city limits for WUI depiction.
- Make WUI maps for Billings and Laurel showing city limits.

Irrigation Ditch Failure Hazard Map Review:

- Add names of ditches if available.
- Billings Bench Water Association (BBWA) is one of main ditches that has potential to threaten homes.
- Study being done/may be complete on water loss from irrigation ditches. May have pertinent info for PDM analysis.
- ¼ mile buffer not enough. Should be areas downslope for at least ½ mile.
- Public Works Dept. may have maps that show areas impacted by runoff.

Hazardous Material Hazard Map Review:

- Add Tier II facilities.
- Add names of highways/streets within buffer on aerial maps.
- Add pipelines available from National Pipeline Mapping Service.

Flood Hazard Map Review:

- Differentiate between DFIRM and channel migration zones.
- Add names of rivers/streams on aerial maps.

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #2
JULY 11, 2018
10:30 am – 12:30 pm

Dam Failure Hazard Map Review:

- Take off inundation area along top of county map that does not inundate into Yellowstone County.
- Get inundation maps for Anita and Lakeside high hazard dams near Billings. DES office may have these in EAPs.
- New stormwater retention ponds will be classified as high hazard dams. Check with location.
- New reservoir being constructed at 48th and Heber. Will serve as alternate water supply for City of Billings. Check with Dave Mumford. Diane can provide contact info.

Landslide/Rockfall Hazard Map Review:

- Take off landslide prone areas for areas outside Yellowstone County.
- Need to expand area in Billings to include more rim areas including Zimmerman Trail area.

General Notes:

- Tim Miller, Yellowstone County Public Works will be interim DES until replacement is hired.
- Travis Jones indicated that Lt. Kent O'Donnell will be filling in for Brad as DES.

Next Planning Team Meeting

- Tentative - Wednesday, August 8, 2018. 10:30 am
- Will check with Interim DES Coordinator on how to proceed.
- Daphne will come in person for next meeting for mitigation workshop.
- August/Sept. could be bad time several Planning Team members to meet due to fire season.

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #3
JANUARY 16, 2019
10 am – 12 pm

Attendance:

K. C.	Williams	Yellowstone Co. Emergency Manager
Tina	Beach	CHS Refinery - Pipelines and Terminals
John	Staley	Lockwood Fire Dept. Chief
Jacob	Berry	Loveland Products
Barry	Rockvam	Diamond B Solutions
Jon	Kristjanson	City of Billings
Ann	Kindness	Yellowstone Co. 911 Center
Matt	Hoppel	Billings Fire
Stanley	Langve	Laurel Police
Brian	Anderson	City of Billings
Matt	Lurker	Laurel Chief Administrator
Kurt	Markegard	Laurel Public Works Director
David	Mumford	Billings Public Works Director
John	Ostlund	Yellowstone County Commissioner
Janelle	Luppen	Yellowstone County GIS Manager
Linda	Oberg	Yellowstone Co. DES
Abra	Farmen	American Red Cross
Jennifer	Staton	Riverstone Health
Gregory	Neill	Riverstone Health
Daphne	Digrindakis	Tetra Tech

Agenda:

- Update 2012 Mitigation Strategy; Severe Weather and Drought, Wildfire
- See Presentation of Meeting Agenda

Handouts:

- 2012 Yellowstone County Mitigation Strategy
- Example Mitigation Projects
- Types of Mitigation

Notes:

- Development of water supplies – Not needed as a project except in less dense rural locations. Funding is big issue.
- Sirens in population dense areas including Custer and Worden. 911 Center activates sirens and tests twice weekly. Antiquated technology but no plan to discontinue use.
- City of Billings code for wind load up to 115 mph.
- Chief Ehlers at Shepperd VFD has mapped water supplies. Data has been collected but not yet shared with DES.
- See updated mitigation strategy on following pages.

Next Planning Team Meeting

- Wednesday, January 30th, 2019 @ 10:00. Update mitigation strategy for #3 hazard – Irrigation Ditch Failure and #4 hazard – Terrorism/Violence/Civil Unrest/Cyber Security, and #5 hazard – Hazardous Material Incidents/Transportation Accidents.

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #3
JANUARY 16, 2019
10 am – 12 pm

YELLOWSTONE COUNTY 2019 MITIGATION STRATEGY										
Goal	Objective	Mitigation Project	Status: Reword, Retain, Delete, New for 2019	Jurisdiction	Priority	Progress Made 2012-2018	Planned Activities 2019-2024	Responsible Agency	Schedule	Potential Funding Source(s)
Goal 1 - Reduce Impacts from Severe Weather and Drought										
	Objective 1.1 - Implement Structural Projects to Reduce Impacts from Severe Weather and Drought									
		1.1.1 - Encourage development of tornado safe rooms in schools.	Reword. Was specific to Broadview Elementary School. Broadened to include all schools.	County, Billings, Laurel, Broadview	Medium	No progress to report.	Determine specifications for safe room. Inventory schools and identify existing where safe rooms exist. Prioritize facilities and seek funding to create additional safe rooms.	DES, LEPC, School Districts	Mid-term	School District funding, Grants
		1.1.2 - Create and alternate water supply for the City of Billings water supply.	New Project	Billings	High	New project for 2019 Plan.	City to construct 290-acre reservoir which will provide Billings area 6 months of water. Land acquisition complete. Move forward with contracting and construction over next three years.	Billings Public Works	Mid-term	Billings resources
	Objective 1.2 - Provide Public Education and Awareness on Severe Weather and Drought									
		1.2.1 - Continue community outreach on preparation and safety during severe storms and tornadoes.	Reword. Added "tornadoes".	County, Billings, Laurel, Broadview	High	Tornado sirens exist throughout county and tested twice weekly. Drills announced publicly in conjunction with NWS Severe Weather Week. Code Red currently being implemented.	Participate in NWS weekly conference calls. Use social media to enroll citizens in Code Red.	DES, LEPC, 911 Dispatch	Ongoing	County resources
		1.2.2 - Continue to maintain NWS Storm Ready status for Yellowstone County and City of Billings and work towards City of Laurel becoming a Storm Ready community.	New Project	County, Billings, Laurel	High	New project for 2019 Plan.	Schedule weather spotter training classes. Establish backup for warning notification. Hold community seminars on public readiness.	DES, 911	Ongoing	County resources, Billings and Laurel resources
		1.2.3 - Encourage community partners to participate in NWS Weather Ready Nation Ambassador program.	New Project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Push info out on social media to get organizations involved.	DES, LEPC	Ongoing	County resources
		1.2.4 - Support drought programs implemented through the Conservation District, FSA, NRCS, DNRC, and MSU Extension.	New Project	County	High	New project for 2019 Plan.	Push info out on drought awareness via social media. Publicize workshops on drought mitigation offered by others.	DES, County Extension Service	Ongoing	County resources
	Objective 1.3 - Implement Property Protection Projects to Reduce Impacts from Severe Weather and Drought									
		1.3.1 - Encourage utility companies to ensure right-of-way around power lines are free of trees or limbs that could cause damage.	New Project	County	High	New project for 2019 Plan.	Identify problem areas and submit formal request to utility companies if needed.	Commissioners, LEPC	Ongoing	County resources
		1.3.2 - On older facilities as needed, install 3-mil window film on windows of schools and critical facilities to prevent shattering.	New Project	County, Billings, Laurel, Broadview	Medium	New project for 2019 Plan.	Identify facilities where window film is needed. Apply for grant to fund project. Implement as appropriate.	School Districts	Ongoing	School Districts, Grants

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #3
JANUARY 16, 2019
10 am – 12 pm

YELLOWSTONE COUNTY 2019 MITIGATION STRATEGY										
Goal	Objective	Mitigation Project	Status: Reword, Retain, Delete, New for 2019	Jurisdiction	Priority	Progress Made 2012-2018	Planned Activities 2019-2024	Responsible Agency	Schedule	Potential Funding Source(s)
	Objective 1.4 - Provide Prevention Projects to Reduce Impacts from Severe Weather and Drought									
		1.4.1 - Encourage utility companies to bury electric and communication lines in hazard areas.	New Project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Identify hazard areas where underground utilities are warranted. Invite utility companies to LEPC meeting and make formal request. Consider subdivision regulations that require underground utilities.	Commissioners, LEPC	Ongoing	County resources
		1.4.2 - Promote the use of hurricane clips for buildings vulnerable to high winds	New Project	County, Billings, Laurel, Broadview	Medium	New project for 2019 Plan.	Requirement in current Billings city code. Use social media to encourage citizens to upgrade during retrofits.	DES, Billings Planning Dept.	Ongoing	County and City resources.
		1.4.3 - Encourage water conservation by domestic, municipal, and industrial users.	New Project	County, Billings, Laurel	High	New project for 2019 Plan.	Cities can declare drought emergency. Continue to restrict water usage with tiered system when needed. Publicize city requirement for low flow toilets.	DES, Billings and Laurel Public Works	Ongoing	City resources.

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #3
JANUARY 16, 2019
10 am – 12 pm

YELLOWSTONE COUNTY 2019 MITIGATION STRATEGY										
Goal	Objective	Mitigation Project	Status: Reword, Retain, Delete, New for 2019	Jurisdiction	Priority	Progress Made 2012-2018	Planned Activities 2019-2024	Responsible Agency	Schedule	Potential Funding Source(s)
Goal 2 - Reduce Impacts from Wildfire										
	Objective 2.1 - Implement Planning, Mapping and/or Analysis Projects to Reduce Impacts from Wildfire									
		2.1.1 - Conduct wildland fire mapping to identify high-risk areas.	Reword	County	High	City of Billings has been aggressive with response zone mapping. Situation Analyst software provides maps to emergency managers.	Get input from BLM and DNRC on where mapping is needed. Integrate GIS technology to develop assessments using slope/fuels/land cover data.	DES, County GIS, BLM, DNRC	Short-term	County resources, DNRC, BLM
		2.1.2 - Develop database of hazardous fuel assessments and landowner fuel reductions projects to support future grants.	New Project	County, Billings	High	New project for 2019 Plan.	Review files from past projects and consolidate electronically in user-friendly format.	DES	Short-term	County resources
		2.1.3 - Update Yellowstone County Community Wildfire Protection Plan.	New Project	County, Billings, Laurel, Broadview	Medium	New project for 2019 Plan.	Seek funding for plan update. Complete fire mapping and capability assessment. Hire contractor to update CWPP.	DES, Fire Council	Mid-term	FEMA Grant, MT DES, DNRC
		2.1.4 - Conduct feasibility study to identify best method to dispose of fuel mitigated material so all of it doesn't have to travel long distances to come to landfill.	New Project	County	High	New project for 2019 Plan.	Evaluate alternatives and perform cost/benefit analysis of consolidation of material and local burn areas, mobile incinerator, mastication of material for composting, and others. Seek grant for funding	DES, Fire Council	Short-term	County resources
	Objective 2.2 - Provide Public Education and Awareness on Wildfire Mitigation									
		2.2.1 - Continue community outreach on FireWise building practices in the wildland urban interface.	Retain	County, Billings, Laurel, Broadview	High	DES and individual depts. have done outreach.	Continue same using social media, at county fair, building expos, etc.	DES, Fire Council	Ongoing	County resources
		2.2.2 - Promote and encourage individual fire departments to implement a FireWise program that will create fire adapted communities throughout the county.	New Project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Utilize FireWise website for available resources. Provide opportunities and incentives for citizens to participate.	DES, Fire Council, DNRC	Ongoing	County resources
		2.2.3 - Continue pushing out information on Red Flag Warnings for broadcast when conditions exist.	New Project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Coordinate with NWS. Utilize social media, broadcast media to publicize dangerous conditions.	DES, NWS	Ongoing	NWS, County resources
		2.2.4 - Provide timely messaging on wildfire smoke to protect vulnerable populations.	New Project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Coordinate with MT DEQ and NWS when poor air quality conditions exist. Inform public by broadcast and social media.	DES, County Health Dept., School Districts	Ongoing	County resources
	Objective 2.3 - Enhance Opportunities to Protect Property from Wildfire									
		2.3.1 - Continue grants programs to support hazardous fuel assessments and cost-share opportunities for landowners to create defensible space in the WUI.	New Project	County, Billings	High	New project for 2019 Plan.	Coordinate with federal and state partners on grant opportunities. Publicize program to garner support and participation.	DES, BLM, DNRC	Ongoing	Federal and state grants
	Objective 2.4 - Implement Prevention Projects to Reduce Impacts from Wildfire									
		2.4.1 - Explore whether subdivision regulations could be strengthened to require defensible space and construction with fire-proof materials.	New Project	County, Billings, Laurel	High	New project for 2019 Plan.	Cities to consider during update of subdivision regulations. County to encourage through growth policy since no ability to enforce.	County and City Planning Depts.	Ongoing	County and city resources.

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #3
JANUARY 16, 2019
10 am – 12 pm

YELLOWSTONE COUNTY 2019 MITIGATION STRATEGY										
Goal	Objective	Mitigation Project	Status: Reword, Retain, Delete, New for 2019	Jurisdiction	Priority	Progress Made 2012-2018	Planned Activities 2019-2024	Responsible Agency	Schedule	Potential Funding Source(s)
	Objective 2.5 - Enhance Emergency Service Capabilities to Reduce Impacts from Wildfire									
		2.5.1 - Continually improve fire agency training and infrastructure.	New Project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Identify needs. Update depts. of training and grant opportunities.	Fire Council	Ongoing	County and city resources
		2.5.2 - Develop database of water supplies, access points, and fire breaks, and other relevant criteria to enhance fire agency response.	New Project	County	High	New project for 2019 Plan.	Water supplies have been mapped. Create database and input information on access points, fire breaks, and other relevant data.	Fire Council	Ongoing	DNRC

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #4
JANUARY 30, 2019
10 am – 12 pm

Attendance:

Linda	Oberg	Yellowstone County DES Admin Asst.
Larry	Elders	BLM Billings Fire Prevention, Education, Mitigation
Jeff	Slavick	Yellowstone County Information Technology Director
Dave	Nordel	St. Vincent Health Care
Paul	Christopher	Yellowstone Co. IT System Admin.
Jacob	Berry	Loveland Products
Mike	Powell	Yellowstone County GIS
Stanley	Langve	Laurel Police
Randy	Middlebrook	Dept. Homeland Security
Mike	Pigg	Billings Parks Superintendent
Dianne	Lehm	Big Sky Economic Development
John	Staley	Lockwood Fire Dept. Chief
Allan	Workman	Billings Bench Water Assoc.
Gary	Davis	Billings Bench Water Assoc.
Ed	Grube	Huntley Project Irrigation District
Jim	Hinkle	Billings Bench Water Assoc.
Brian	Anderson	Billings Floodplain Administrator
Bill	Michaelis	Yellowstone Co. Sheriff's Office
Charlie	Hanson	Montana DES District Representative
Maurie	Martin	Lockwood Fire Dept.
Mark	Nitz	CHS Refinery & Pipeline
Matt	Lurker	Laurel Chief Administrator
Kurt	Markegard	Laurel Public Works Director
Barry	Rockvam	Diamond B Solutions
Boris	Krizek	Billings Environmental Affairs.
Claudia	Stephens	Montana Migrant Workers Council
Jennifer	Staton	Riverstone Health
Gregory	Neill	Riverstone Health
Daphne	Digrindakis	Tetra Tech

Agenda:

- Update 2012 Mitigation Strategy; Irrigation Ditch Failure, Terrorism/Violence/Civil Unrest/Cyber Security.
- See Presentation of Meeting Agenda

Handouts:

- 2012 Yellowstone County Mitigation Strategy
- Example Mitigation Projects
- Types of Mitigation

Notes:

- See mitigation strategy update on following pages.

Next Planning Team Meeting

- Wednesday, February 13, 2019 @ 10:00. Update mitigation strategy for #5 hazard – Hazardous Material Incidents/Transportation Accidents, #6 hazard: flooding and dam failure.

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #4
JANUARY 30, 2019
10 am – 12 pm

YELLOWSTONE COUNTY 2019 MITIGATION STRATEGY										
Goal	Objective	Mitigation Project	Status: Reword, Retain, Delete, New for 2019	Jurisdiction	Priority	Progress Made 2012-2018	Planned Activities 2019-2024	Responsible Agency	Schedule	Potential Funding Source(s)
Goal 3 - Reduce Impacts from Irrigation Ditch and Drain Failure										
	Objective 3.1 - Implement Structural Projects to Reduce Impacts from Irrigation Ditch and Drain Failure									
		3.1.1 - Remove unstable rocks above North 14th Street that could fall and block BBWA ditch at tunnel entrance.	New project	Billings	High	New project for 2019 Plan.	Continue coordination meetings. Develop design. Hire contractor. Implement project.	BBWA, Billings Public Works	Mid-term	City resources, BBWA, Grants
		3.1.2 - Move Washington Street drain half mile downriver to help move water out of drainage ditch faster.	New project	Billings	High	New project for 2019 Plan.	Continue design work. Hire contractor. Implement project.	Billings Public Works	Short-term	City resources
		3.1.3 - Re-establish blow out points to divert ditch flow in Billings.	New project	Billings	High	New project for 2019 Plan.	Identify other locations where water could be dicharged. Initiate conversation with Zoo MT on allowing water discharge. Improve structure on Canyon Creek if feasible.	Billings Public Works, BBWA	Long-term	BBWA, City resources, Grants
		3.1.4 - Maintain and improve rip-rap along Yellowstone River from Laurel to Bilings to prevent overflow into ditch and enhanced flood risk.	New project	County, Billings, Laurel	High	New project for 2019 Plan.	Work with DNRC on permitting to address risk of dith overtopping due to river migration at Laurel and into Billings. Identify and secure funding for project.	BBWA, DNRC	Mid-term	BBWA, Grants
		3.1.5 - Install rip-rap along Yellowstone River for approximatley 2,200 feet at Huntley Project to protect diversion dam and drainage ditch and maintain irrigation.	New project	County	High	New project for 2019 Plan.	Work with DNRC on permitting to address river migration that threatens irrigation capabilitis. Identify and secure funding for project.	HPID	Long-term	HPID, Grants
		3.1.6 - Improve conveyance at road / ditch crossings.	New project	Billings	High	New project for 2019 Plan.	Identify and priorize projects. Implement projects as funding allows.	Billings Public Works	Ongoing	City resources
	Objective 3.2 - Implement Planning, Analysis and Mapping Project to Reduce Impacts from Irrigation Ditch and Drain Failure									
		3.2.1 - Identifiy ownership of irrigation ditches and drains in order to determine operations and maintenace responsibilities.	New project	Billings	High	New project for 2019 Plan.	Identify and secure funding for title report. Hire firm.	Billings Public Works	Mid-term	City resources, grants
		3.2.2 - Conduct investigation of canals as they come through Billings for bank stability.	New project	Billings	High	New project for 2019 Plan.	Identify additional funding to be used to match grant funds . Hire firm to assess at least 3 miles of ditch to identify high steep banks. Prioritize ditch lining ;projects including Shiloh/King/W 32nd Street.	BBWA	Mid-term	BBWA, Grants
		3.2.3 - Conduct feasibility study to reduce risk of irrigation ditch failure that could impactf EOC, City-County dispatch and both hospitals.	New project	Billings	High	New project for 2019 Plan.	Identify and secure funding. Hire firm. Review report and select alternative. Prepare grant for funding.	Billings Public Works	Short-term	City resources, grants
		3.2.4 - Conduct study on how to improve drains and outlet structures to mitigate flood risk.	New project	Billings	High	New project for 2019 Plan.	Identify and secure funding. Hire firm. Review report and select alternative. Prepare grant for funding.	Billings Public Works	Short-term	City resources, grants

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #4
JANUARY 30, 2019
10 am – 12 pm

YELLOWSTONE COUNTY 2019 MITIGATION STRATEGY										
Goal	Objective	Mitigation Project	Status: Reword, Retain, Delete, New for 2019	Jurisdiction	Priority	Progress Made 2012-2018	Planned Activities 2019-2024	Responsible Agency	Schedule	Potential Funding Source(s)
	Objective 3.3 - Implement Property Protection Projects to Reduce Impacts from Irrigation Ditch and Drain Failure									
		3.3.1 - Obtain easements to access ditches and drains for maintenance purposes.	New project		High	New project for 2019 Plan.	Once ownership determined, negotiate to purchase easement. Prepare grant to fund project.	Billings Public Works	Mid-term	City resources, grants
	Objective 3.4 - Provide Public Education and Outreach to Reduce Impacts from Irrigation Ditch and Drain Failure									
		3.4.1 - Contineue to provide outreach to citizens that dumping of debris on ditch bank or within ditch can potentially block City's stormwater system and increase potential for flooding and cause ditch bank overflows.	New project		High	New project for 2019 Plan.	Signs, sent out letters, GIS segregates properties and cues out residents.	Billings Public Works	Ongoing	City resources

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #4
JANUARY 30, 2019
10 am – 12 pm

YELLOWSTONE COUNTY 2019 MITIGATION STRATEGY										
Goal	Objective	Mitigation Project	Status: Reword, Retain, Delete, New for 2019	Jurisdiction	Priority	Progress Made 2012-2018	Planned Activities 2019-2024	Responsible Agency	Schedule	Potential Funding Source(s)
Goal 4 - Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security										
	Objective 4.1 - Enhance Emergency Service Capabilities to Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security									
		4.1.1 - Continue active shooter preparedness training.	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Provide ongoing training to emergency response personnel and in schools (especially substitue teachers). Coordinate with Fire Depts. and Building officials to eliminate conflict in messaging.	DES, law enforcment, DHS	Ongoing	County & city resources, DHS
		4.1.2 - Continue to provide end-user training on email-related threats.	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Provide education to city and county personnel on phising campaigns and others issues as threat landscape changes. Provide refresher training annually.	City and County IT Depts., DHS, MATIC	Ongoing	County & city resources, DHS
		4.1.3 - Coordinate state/federal agencies and private industry on potential threats that may target critical facilities or large events.	New project	County, Billings	High	New project for 2019 Plan.	Utilize state and federal resources to broaden awareness of potential threats. Utilize private industry expertise to identify and prevent incidents.	LEPC, DHS, MT Dept. Justice MATIC, FBI, private industry	Ongoing	County & city resources, state and federal partners, private industry
	Objective 4.2 - Provide Public Education and Outreach to Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security									
		4.2.1 - Raise level of awareness on what public can do to prevent and /or mitigate threat of lone gunman/active shooter incident (report suspicious or unusual behavior, stop-the-bleed training, etc.)	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Utilize DHS curriculum and disseminate through Chamber of Commerce, print and social media. Translate message into multiple languages.	DES, DHS, Chamber of Commerce, MT Migrant Worker Council	Ongoing	County resources, DHS
	Objective 4.3 - Implement Planning, Analysis and Mapping Projects to Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security									
		4.3.1 - Conduct comprehensive vulnerability assessment of critical facilities with priorities for enhanced security.	New project	County, Billings, Laurel	High	New project for 2019 Plan.	Identify high risk areas and what needs to be fixed as per objectives. Provide information so officials can make decisions. Mitigate vulnerabilities.	DES, Law Enforcement, City and County Buidling Depts., DHS	Mid-term	County & city/town resources, DHS
		4.3.2 - Continue to conduct vulnerability assessment of critical cyber infrastructure with priorities for enhanced security.	New project	County, Billings, Laurel	High	New project for 2019 Plan.	Evaluate networks and firewalls as needed to ensure security. Update protective software.	County and City IT Depts. DHS	Ongoing	County & city/town resources, DHS
		4.3.3 - Develop cloud-based backup system for city-county network systems.	New project	County, Billings	High	New project for 2019 Plan.	Determine equipment needed to redirect traffic/keep flow going in event of cyber attack. Obtain funding. Establish protocols and test system.	County and City IT Depts, DHS	Short-term	County & city resources
		4.3.4 - Review Crisis Action Plans in all schools and hospitals to ensure adequate security measures are in place.	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	On annual basis, review and update plans. Schedule	School Resource Officers, DES, Hospitals	Ongoing	County & city/town resources, Hospitals

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #4
JANUARY 30, 2019
10 am – 12 pm

YELLOWSTONE COUNTY 2019 MITIGATION STRATEGY										
Goal	Objective	Mitigation Project	Status: Reword, Retain, Delete, New for 2019	Jurisdiction	Priority	Progress Made 2012-2018	Planned Activities 2019-2024	Responsible Agency	Schedule	Potential Funding Source(s)
	Objective 4.4 - Implement Structural Projects to Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security									
		4.4.1 - Continue physical hardening of critical facilities and schools (i.e. anti-vehicle barricades / interior barricades for locking doors [door kicks, door stops] / perimeter fencing / controlled access gates).	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Continue to explore grant opportunities for surveillance and key lock systems. As funding allows, physically harden all schools and critical facilities.	DES, Law Enforcement, Building Depts., Schools	Ongoing	County $ city/town resources, grants

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #5
FEBRUARY 13, 2019
10 am – 12 pm

Attendance:

Larry	Elders	BLM Billings Fire Prevention, Education, Mitigation
Jon	Kristjanson	City of Billings
Matt	Hoppel	Billings Fire
Rick	Schauer	Billings Haz-Mat
Stanley	Langve	Laurel Police
Perry	Rockvam	Diamond B Technology Solutions
Tom	Frieders	National Weather Service
Charlie	Hanson	Montana DES District Representative
Darin	Swenson	Yellowstone County Floodplain Administrator
Mike	Powell	Yellowstone County GIS
Dianne	Lehm	Big Sky Economic Development
Kurt	Markegard	Laurel Public Works Director
Boris	Krizek	Billings Environmental Affairs.
Jennifer	Staton	Riverstone Health
Gregory	Neill	Riverstone Health
John	Staley	Lockwood Fire Dept. Chief
Maury	Martin	Lockwood Fire
Walt	Houton	MDT
Tom	Tilzey	MDT
Ken	Hembree	MDT
KC	Williams	Yellowstone County DES
Linda	Oberg	Yellowstone County DES
Daphne	Digrindakis	Tetra Tech

Agenda:

- Update 2012 Mitigation Strategy - Hazardous Material Incidents/Transportation Accidents and Flooding & Dam Failure
- See Presentation of Meeting Agenda

Handouts:

- 2012 Yellowstone County Mitigation Strategy
- Example Mitigation Projects
- Types of Mitigation

Mitigation Strategy Update

- See mitigation strategy update on following pages.

Next Planning Team Meeting

- Wednesday, February 27, 2019 @ 10:00. Update mitigation strategy for #7 hazard – communicable disease, #8 hazard – landslide/rock fall, and All Hazard projects.

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #5
FEBRUARY 13, 2019
10 am – 12 pm

YELLOWSTONE COUNTY 2019 MITIGATION STRATEGY										
Goal	Objective	Mitigation Project	Status: Reword, Retain, Delete, New for 2019	Jurisdiction	Priority	Progress Made 2012-2018	Planned Activities 2019-2024	Responsible Agency	Schedule	Potential Funding Source(s)
Goal 5 - Reduce Impacts from Haz-Mat Incidents and Transportation Accidents										
	Objective 5.1 - Enhance Emergency Service Capabilities to Reduce Impacts from Haz-Mat Incidents and Transportation Accidents									
		5.1.1 - Encourage legislative support for funding of Billings Regional Haz-Mat response team.	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Encourage representatives to support funding for regional haz-mat response teams at 2019 legislature.	Commissioners, DES, Fire Depts.	Short-term	County and city resources.
		5.1.2 - Obtain personal protective kits for Laurel first responders and patrol cars so they can secure scene before haz-mat team arrive.	New project	Laurel	High	New project for 2019 Plan.	Identify and secure funding for skin protection, respirators, and other equipment as needed for first responders.	Laurel Fire Dept., Billings Haz-Mat Team, LEPC	Mid-term	City resources
		5.1.3 - Provide basic and refresher haz-mat response training with first responders and exercise regularly.	New project	County, Billings, Laurel	High	New project for 2019 Plan.	Provide first responders with basic knowledge on haz-mat capabilities, who to call to ensure quick activation of haz-mat team, securing sites, and maintaining equipment. Exercise and refresh training annually.	Fire Depts., Haz-Mat Team	Ongoing	County and city resources.
		5.1.4 - Update and maintain resource list of emergency response supplies and vendors.	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	List should include county equipment and private resources. Include expiration date on supplies.	DES, Fire Depts.	Ongoing	County resources
		5.1.5 - Identify railroad point of contact and establish protocol to shut down rail traffic when needed.	New project	County, Billings, Laurel	High	New project for 2019 Plan.	Coordinate with railroad to establish procedure. Ensure protocol includes official confirmation messaging.	Fire Depts., LEPC, Railroads	Short-term	County and city resources.
		5.1.6 - Increase participation of local, state and federal partners, industry, and utilities in Yellowstone County LEPC.	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Develop expanded email list of prospective LEPC members. Message frequently. Establish shared leadership to engage more members to participate.	DES, LEPC	Ongoing	County resources
	Objective 5.2 - Provide Public Education and Awareness to Reduce Impacts from Haz-Mat Incidents and Transportation Accidents									
		5.2.1 - Improve public messaging when episodes of refinery flaring occur.	New project	Billings, Laurel	High	New project for 2019 Plan.	Utilize social media and CodeRed to notify residents of flaring. Coordinate with MDT to utilize signs and road closures to protect populations at risk.	DES, MDT, Refineries	Ongoing	County resources
	Objective 5.3 - Implement Planning, Mapping and Analysis Projects to Reduce Impacts from Haz-Mat Incidents and Transportation Accidents									
		5.3.1 - Identify and prioritize intersections that could be improved to enhance safety.	New project	County, Billings, Laurel	High	New project for 2019 Plan.	Consider improvements around Metra, refineries, bridge and river crossings (Dick Johnston bridge, 1st Ave. No.). Utilize GIS to look for rerouting alternatives.	County and City Public Works, MDT	Short-term	County and city resources

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #5
FEBRUARY 13, 2019
10 am – 12 pm

YELLOWSTONE COUNTY 2019 MITIGATION STRATEGY										
Goal	Objective	Mitigation Project	Status: Reword, Retain, Delete, New for 2019	Jurisdiction	Priority	Progress Made 2012-2018	Planned Activities 2019-2024	Responsible Agency	Schedule	Potential Funding Source(s)
	Objective 5.4 - Implement Property Protection Projects to Reduce Impacts from Haz-Mat Incidents and Transportation Accidents									
		5.4.1 - Protect storm drains in industrial areas to ensure no hazardous materials are released to the river.	New project	Laurel	High	New project for 2019 Plan.	Determine best technology and install a fail-safe mechanism to prevent accidental release to river.	City Public Works	Short-term	City resources

YELLOWSTONE COUNTY 2019 MITIGATION STRATEGY										
Goal	Objective	Mitigation Project	Status: Reword, Retain, Delete, New for 2019	Jurisdiction	Priority	Progress Made 2012-2018	Planned Activities 2019-2024	Responsible Agency	Schedule	Potential Funding Source(s)
Goal 6 - Reduce Impacts from Flooding and Dam Failure										
	Objective 6.1 - Implement Property Protection Projects to Reduce Impacts from Flooding and Dam Failure									
		6.1.1 - Continue to implement Stormwater Master Plan to reduce impacts to private property from surface water runoff.	New project	Billings	High	New project for 2019 Plan.	City is addressing restrictions in stormwater system. Master Plan in place. Streets are designed to manage stormwater. Downstream are restrictions. City moving toward identifying and improve. Support.	City Public Works	Ongoing	City resources, grants
		6.1.2 - Upgrade and maintain culverts, bridges, and roads to improve conveyance of flood water.	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Identify and prioritize culverts for replacement. Identify funding and timeline.	County Road Dept., City Public Works	Ongoing	County and city resources, grants
	Objective 6.2 - Provide Public Education and Awareness to Reduce Impacts from Flooding and Dam Failure									
		6.2.1 - Continue community outreach on potential for flooding.	Reword. Removed " in flood-prone areas".	County, Billings, Laurel	High	Have participated in NWS conference calls and pushed messaging to public when threat exists.	Push out NWS messaging through broadcast and social media to alert citizens when flood potential appears threatening.	DES, NWS	Ongoing	County resources, NWS
		6.2.2 - Provide outreach to affected residents that new stormwater reservoir will be classified as high-hazard dam.	New project	Billings	Medium	New project for 2019 Plan.	When stormwater basin is complete, utilize print and social media to educate downstream residents of dam failure risk.	DES, City Public Works	Ongoing	City resources
		6.2.3 - Promote that homeowners in flood-prone areas purchase flood insurance through National Flood Insurance Program.	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Utilize print and social media to provide information on NFIP to property owners. Ensure FEMA brochures are available at Planning Office and county/city websites have information.	Floodplain administrators	Ongoing	County and city/town resources

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #5
FEBRUARY 13, 2019
10 am – 12 pm

YELLOWSTONE COUNTY 2019 MITIGATION STRATEGY										
Goal	Objective	Mitigation Project	Status: Reword, Retain, Delete, New for 2019	Jurisdiction	Priority	Progress Made 2012-2018	Planned Activities 2019-2024	Responsible Agency	Schedule	Potential Funding Source(s)
	Objective 6.3 - Implement Planning, Mapping and/or Analysis Projects to Reduce Impacts from Flooding and Dam Failure									
		6.3.1 - Study options for mitigating stormwater runoff from Highway 3 near Billings Airport.	Retain	Billings	High	MDT has project in planning phase. Issues with homes below rims and runoff.	City to coordinate with MDT on project implementation	Billings Public Works	Mid-term	MDT, City resources
		6.3.2 - Assess flood potential at Zoo Montana property and address options for managing zoo animals in the event of a flood.	Retain	Billings	Medium	No progress to report.	Develop evacuation protocol as annex to EOP. Coordinate with owners to include property as part of Flood Master Plan.	DES, Billings Public Works	Long-term	County and city resources
		6.3.3 - Update boundaries of approximate study areas for future floodplain mapping.	New project	Billings	High	New project for 2019 Plan.	Work with DNRC to extend study area boundaries and secure funding for future mapping effort.	DES, County Floodplain Administrator, DNRC	Mid-term	County resources
	Objective 6.4 - Implement Structural Projects to Reduce Impacts from Flooding and Dam Failure									
		6.4.1 - Construct two small storage features on Cove and Little Cove Creeks and improve flood conveyance through the West Billings area.	Retain	Billings	High	Master Flood Plan in place. Several small detention basins have been constructed (62nd/ Rimrock).	Expand boundaries. Create partnership and negotiate with Byerly drain district about more efficiently using drainage on west end.	City Public Works	Ongoing	City resources, grants
		6.4.2 - Reconstruct failed outfall drain with adjustable weir to prevent flooding.	New project. Talk to Boris.	Billings	High	New project for 2019 Plan.	Project will utilize same outfall area. Install adjustible weir on existing outfall to reduce flooding. Negotiate with property owners.	City Public Works	Mid-term	City resources, grants
		6.4.3 - Consider certifying dikes around water and wastewater treatment plants to ensure adequate protection.	New project	Billings, Laurel	Medium	New project for 2019 Plan.	Review structural integrity of existing dikes. Consider advantages of certification process. Determine course forward.	City Public Works, USACE	Long-term	City resources, grants
		6.4.4 - Update flood protection measures at Riverside Park in Laurel to prevent flooding.	Reword. Portion of original project complete (bury pipelines).	Laurel	Medium	No progress to report.	Identify and secure funding to strengthen levee and prevent erosion. Determine cultural significance of site prior to implementation.	City Public Works, USACE	Long-term	City resources, grants
		6.4.5 - Construct new stormwater reservoir on west end of Billings.	New project. Talk to Boris.	County, Billings	High	New project for 2019 Plan.	Land purchase complete. Develop design and construction plans. Hire and supervise contractor.	County and City Public Works	Mid-term	County and cty resources, grants
	Objective 6.5 - Implement Prevention Projects to Reduce Impacts from Flooding and Dam Failure									
		6.5.1 - Review NFIP Repetitive Loss properties in Yellowstone County and address means to eliminate or reduce impacts from flooding.	Retain	County	Medium	Letter sent to RL owners identifying mitigation grants. Cost share has been hang-up. One owner offered buyout and not interested. One house was moved and dropped off RL list.	Continue same.	Floodplain Administrator	Long-term	Private resources, FEMA grants
		6.5.2 - Strengthen subdivision regulations to ensure homes are not built where potentially impacted by flood flows from dry washes.	New project	County	Medium	New project for 2019 Plan	Develop language whereby dry washes are considered as source of flash flooding and disallowed unless engineered drainages are constructed.	Floodplain Administrator	Mid-term	County resources

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #5
FEBRUARY 13, 2019
10 am – 12 pm

YELLOWSTONE COUNTY 2019 MITIGATION STRATEGY										
Goal	Objective	Mitigation Project	Status: Reword, Retain, Delete, New for 2019	Jurisdiction	Priority	Progress Made 2012-2018	Planned Activities 2019-2024	Responsible Agency	Schedule	Potential Funding Source(s)
	Objective 6.6 - Enhance Emergency Service Capabilities to Reduce Impacts from Flooding and Dam Failure									
		6.6.1 - Participate in dam failure exercises on high hazard dams that could impact Yellowstone County.	New project	County, Billings, Laurel	Medium	New project for 2019 Plan.	Ensure that first responders are aware of scheduled exercises for Cooney Dam. Identify who should participate. Provide after action report to others. Encourage exercise at new stormwater reservoir in Billings.	DES	Ongoing	County resources
		COMPLETE - Study to assess options for controlling bank erosion and protection of buried pipelines near Riverside Park levee in Laurel.	Partially complete. Did $1million bank stabilization project with FEMA grant and USACE. Pipelines got moved below river bed.	Talk to Kurt						
		COMPLETE - Examine the option for creating stormwater retention basin in the Knife River Pit to mitigate potential flooding downstream of the West Billings area.	Complete. Purchase of Knife River Pit. Shilo Conservation Area (75 acre site) established.	Talk to Boris						
		DELETE - Construct Arrow Island weir project to stabilize stream banks north of Huntley.	Delete. No movement. Not feasible.							
		DELETE - Modify floodplain regulations to require property setbacks.	Delete. Floodplain regulations are consistent with state requirements.							

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #6
FEBRUARY 27, 2019
10 am – 12 pm

Attendance:

Dianne	Lehm	Big Sky Economic Development
Kim	Bailey	Riverstone Health
Chief	Langve	Laurel Police Dept.
Greg	Neill	Riverstone Health
Matt	Lurker	Laurel Chief Administrator
Boris	Krizek	Billings Public Works - Environmental Affairs.
Charlie	Hanson	Montana DES District Representative
Bill	Cole	Billings Mayor
Abra	Farmen	American Red Cross
Don	Jones	Yellowstone Co. Commissioner
Bill	Michaelis	Yellowstone Co. Sheriff's Office
Claudia	Stephens	Montana Migrant Workers Council
Tina	Beach	CHS Refinery - Pipelines and Terminals
Jen	Staton	Riverstone Health
KC	Williams	Yellowstone County DES
Linda	Oberg	Yellowstone County DES
Daphne	Digrindakis	Tetra Tech

Agenda:

- Update 2012 Mitigation Strategy - Communicable Disease, Landslide/Rock Fall, and All Hazard projects.
- See Presentation of Meeting Agenda

Handouts:

- 2012 Yellowstone County Mitigation Strategy
- Example Mitigation Projects
- Types of Mitigation

Notes:

- Landslide/Rock Fall
  - Road damage on Zimmerman Way due to rockfalls.
  - Phipps Park has also experienced rockfall damage.
  - Expansive Soil - Water main broke at Briarwood in 2016/17 due to soil shifting.
  - Pipeline companies required to monitor earth movement.

- All Hazard
  - Bill Michaelis: With this planning would putting in for mobile repeaters for patrol cars be part of the plan. These would come in helpful during a major event where deputies are on portable 5-watt radios and can't hit the stationary repeaters?

Mitigation Strategy Update:

- See mitigation strategy update on following pages.

Future Development:

- High school in Lockwood, next to existing school
- Fire station in Heights,
- Fuego Fire Station. Paul Getsmeier.
- Proposed water treatment plant in west Shilo/Monad equivalent. Knife River gravel pits. South of conservation area. North of ditch and zoo Montana.
- Subdivisions popping up everywhere.

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #6
FEBRUARY 27, 2019
10 am – 12 pm

- Lockwood TED industrial part north of Johnson Lane interchange, MDT building Billings bypass and connect to Mary Street in Heights.
- Major expansion of airport in next two years. Bumping out to north.
- Laurel Airport preparing to MTARNG helicopter base in 3-5 years.

Timeline for Finishing Plan:

- Draft to be submitted for 8-week review period March 29 – May 24, 2019
- Concurrent 45-day review by MT DES March 29 to May 10, 2019
- Public Meeting – potentially week of May 13th
- Plan Revision – May 25 to May 31, 2019
- Second Public Review for 2 weeks June 1-15, 2019
- FEMA 45-day review – May 13 to June 28, 2019
- Plan Revision (if needed) – July 1 to 5, 2019
- Adoption – During July 2019

Process for Plan Review:

- One hard copy and 12 CDs. Plan will be on project website to download by chapter.
- Submit all comments to K.C. who will review and forward to Tetra Tech.
- Plan will have page numbers and line numbers. Comments must be specific.
- Keep track of time spent reviewing Plan for cost-share match.

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #5
FEBRUARY 13, 2019
10 am – 12 pm

YELLOWSTONE COUNTY 2019 MITIGATION STRATEGY										
Goal	Objective	Mitigation Project	Status: Reword, Retain, Delete, New for 2019	Jurisdiction	Priority	Progress Made 2012-2018	Planned Activities 2019-2024	Responsible Agency	Schedule	Potential Funding Source(s)
Goal 7 - Reduce Impacts from Communicable Disease										
	Objective 7.1 - Implement Prevention Projects to Reduce Impacts from Communicable Disease									
		7.1.1 - Increase immunization rates for vaccine preventable communicable disease in all populations.	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Coordinate with DPHHS and local partners to continue community programs. Utilize RiverStone Health website and social media to advertise vaccination clinics.	RiverStone Health	Ongoing	State, County, and City resources
		7.1.2 - Continue to prevent and control communicable disease by surveillance.	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Continue to utilize DPHHS MT-IBIS database.	RiverStone Health, DPHHS	Ongoing	State, County, and City resources
		7.1.3 - Continue to conduct risk-based inspections of all food service establishments.	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Continue to inspect restaurants including mobile food venders during special events.	RiverStone Health, DPHHS	Ongoing	State, County, and City resources
	Objective 7.2 - Implement Public Education and Awareness Projects to Reduce Impacts from Communicable Disease									
		7.2.1 - Continue to promote public education on preventing communicable disease.	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Continue to utilize Health Alert Network to communicate internally. Send alerts to physicians. Utilize State's 406 Weekly public health messages.	RiverStone Health, DPHHS	Ongoing	State, County, and City resources
		7.2.2 - Continue to provide education and/or training for Health Dept. staff and key partners in medical community.	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Provide training on basic emergency response, surveillance and investigation, prevention of outbreaks, mass prophylaxis strategies, risk communication, isolation and quarantine protocols, and continuity of operations.	RiverStone Health, DPHHS	Ongoing	State, County, and City resources
	Objective 7.3 - Enhance Emergency Service Capabilities to Reduce Impacts from Communicable Disease									
		7.3.1 - Collaborate with community partners to train and exercise public health emergency response plans.	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Coordinate with LEPC to develop annual training and exercise schedules.	RiverStone Health, DPHHS	Ongoing	State, County, and City resources
		7.3.2 - Expand listserve for Health Alert Network.	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Identify additional entities to receive alerts including first responders.	RiverStone Health	Short-term	County, and City resources
	Objective 7.4 - Implement Planning, Mapping, and Analysis Projects to Reduce Impacts from Communicable Disease									
		7.4.1 - Collaborate and coordinate with community partners to review and update public health emergency response plans annually.	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Comply with DPHHS requirement for quarterly updates with focus on different plans each quarter. Revise plans as needed.	RiverStone Health, DPHHS	Ongoing	State, County, and City resources

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #5
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10 am – 12 pm

YELLOWSTONE COUNTY 2019 MITIGATION STRATEGY										
Goal	Objective	Mitigation Project	Status: Reword, Retain, Delete, New for 2019	Jurisdiction	Priority	Progress Made 2012-2018	Planned Activities 2019-2024	Responsible Agency	Schedule	Potential Funding Source(s)
Goal 8 - Reduce Impacts from Landslide and Rock Falls Hazards										
	Objective 8.1 - Implement Structural Projects to Reduce Impacts from Landslide and Rock Fall Hazards									
		8.1.1 - Identify, preserve, and stabilize rock fall-prone areas.	New project	County, Billings	High	New project for 2019 Plan.	Perform regular surveillance of Rims to identify loose rock. Implement preventative measures to reduce rock falls. Stabilize rock face after rock fall events.	City and County Public Works Depts.	Ongoing	County and City resources

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #5
FEBRUARY 13, 2019
10 am – 12 pm

YELLOWSTONE COUNTY 2019 MITIGATION STRATEGY										
Goal	Objective	Mitigation Project	Status: Reword, Retain, Delete, New for 2019	Jurisdiction	Priority	Progress Made 2012-2018	Planned Activities 2019-2024	Responsible Agency	Schedule	Potential Funding Source(s)
Goal 9 - Reduce Impacts Associated with All Hazards										
	Objective 9.1 - Enhance Emergency Service Capabilities to Mitigate Impacts from All Hazards									
		9.1.1 - Implement mass notification capabilities throughout county.	Reword. Was "Public Alert System".	County, Billings, Laurel, Broadview	High	In final stages of procuring Code Red for mass notification.	Implement Code Red system county-wide. Utilized broadcast, print, and social media on how to sign up. Begin first test alerts.	DES	Short-term	County resources
		9.1.2 -Implement enhanced rural communication by coordinating and cooperating on getting First Net in place in Yellowstone County to enhance first responder communications.	Reword. Removed "Montana Interoperability Project" and added "First Net".	County, Billings, Laurel, Broadview	High	Counties in former DES District 5 worked together as Big Sky 12 for Interoperability Project.	Assist, as needed, in mapping and identifying locations for First Net cell towers. Focus on rural locations.	DES, LEPC	Mid-term	County resources
		9.1.3 - Obtain mobile repeaters for patrol cars.	New project	County	High	New project for 2019 Plan.	Identify equipment needs and funding. Procure as feasible.	Sheriff's Office	Mid-term	County resources
		9.1.4 - Identify facilities that meet national standards to serve as emergency shelters and create Memorandums of Understanding.	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Work with Red Cross to identify shelter locations. Develop template for MOUs. Coordinate with facility owners to get agreements in place.	DES, American Red Cross	Mid-term	County and City resources
		9.1.5 - Obtain stationary and/or mobile generators for critical facilities and emergency shelters and install hookups.	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Create prioritized list of generator needs. Apply for funding. Determine hookup specifications for rental generators. Install transfer switches to accept mobile units.	DES, Critical Facility Owners	Mid-term	County and City resources, Grants
		9.1.6 - Recruit and train emergency response personnel	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Utilize print, broadcast, social media and word or mouth to recruit. Provide ICS and more specialized training as appropriate.	DES, LEPC	Ongoing	County and City resources
		9.1.7 - Continue to aggressively address rural properties.	New project	County	High	New project for 2019 Plan.	Utilized print, broadcast, and social media to ensure all rural homes are addressed. Promote placement of addresses at standard height and location.	Dispatch, County Planning Dept.	Ongoing	County resources
	Objective 9.2 - Implement Public Education and Awareness Projects to Reduce Impacts from All Hazards									
		9.2.1 - Interact with public safety officials and schools on planning for emergencies.	Retain	County, Billings, Laurel, Broadview	High	No progress to report.	Opportunity for new DES Coordinator to work with schools and first responders.	DES, LEPC, School Resource Officer	Ongoing	County, City, School District Resources
		9.2.2 - Provide special needs facilities with guidelines for disaster preparedness measures, including pet needs.	New project	County, Billings, Laurel, Broadview	High	New project for 2019 Plan.	Work with facilities to review and update emergency response plans.	DES, Special Needs Facilities, Migrant Worker Council	Ongoing	County, City, and private resources

YELLOWSTONE COUNTY MHMP PLANNING TEAM MEETING #5
FEBRUARY 13, 2019
10 am – 12 pm

YELLOWSTONE COUNTY 2019 MITIGATION STRATEGY										
Goal	Objective	Mitigation Project	Status: Reword, Retain, Delete, New for 2019	Jurisdiction	Priority	Progress Made 2012-2018	Planned Activities 2019-2024	Responsible Agency	Schedule	Potential Funding Source(s)
	Objective 9.3 - Implement Planning, Mapping, and/or Analysis Projects to Reduce Impacts from All Hazards									
		9.3.1 - Enhance GIS data to better to assist with mitigation.	New project	County, Billings	High	New project for 2019 Plan.	Update hazard layers, water sources, shelter locations, and others to assist with emergency management. Provide Fire Depts. continuously with updated road books, wall maps.	County and City GIS Depts.	Ongoing	County and City resources
		9.3.2 - Develop plan for short-term water supply in Billings.	New project	County, Billings	High	New project for 2019 Plan.	Identify resources that could supply bottled water. Develop agreements with distributors. Develop protocols for distribution. Look into gravel pit acquisition for temporary water storage. Consider new water treatment plant on west end of Billings.	County and City Public Works Depts.	Mid-term	County and City resources, grants
	Objective 9.4 - Implement Prevention Projects to Mitigate Impacts from All Hazards									
		9.4.1 - Update growth policies and subdivision regulations as needed to consider all hazards.	New project	County, Billings, Laurel	High	New project for 2019 Plan.	Promote that when policies and regulations are updated that mitigation strategies are implemented for risk reduction.	County and City Planning Depts.	Ongoing	County and City resources.

Yellowstone County Multi-Hazard Mitigation Plan 2019 Update

APPENDIX B

Risk Assessment Documentation

APPENDIX B-1

CPRI SUMMARY TABLE

YELLOWSTONE COUNTY MULTI-HAZARD MITIGATION PLAN - 2018 UPDATE

CALCULATED PRIORITY RISK INDEX

Hazard	Probability				Magnitude/Severity				Warning Time				Duration				Economic Impact				CPRI Score
	Unlikely	Possibly	Likely	Highly Likely	Negligible	Limited	Critical	Catastrophic	< 6 hours	6 - 12 hours	12 - 24 hours	> 24 hours	< 6 hours	< 24 hours	< 1 week	> 1 week	Negligible	Limited	Critical	Catastrophic	
Severe Weather				x				x	x						x				x		3.70
Wildfire				x			x		x						x				x		3.45
Irrigation Ditch Failure			x				x		x							x			x		3.25
Cyber Security				x		x			x						x				x		3.20
Highway Accidents (Mass Casualty)				x			x		x					x			x				2.95
Dam Failure	x							x	x					x						x	2.90
Railroad Accidents			x				x		x					x				x			2.85
Aircraft Accidents		x					x		x						x			x			2.65
Communicable Disease			x				x					x				x		x			2.60
Flooding			x			x						x				x			x		2.55
Drought			x			x						x				x			x		2.55
Landslide / Rock Fall			x			x			x				x				x				2.30
Volcanic Ash		x				x					x					x		x			2.20
Hazardous Materials Incidents		x				x			x					x			x				2.10
Expansive Soils		x				x						x			x			x			1.95
Terrorism, Violence, Civil Unrest		x				x					x			x			x				1.80

APPENDIX B-3

LOW PRIORITY HAZARD PROFILES

3.1.9. Expansive Soil

Expansive soil is defined as a fine-grained clay (composed of rocks and mineral particles mixed with organic matter) which occurs naturally and is generally found in areas that historically were a flood plain or lake area, but can occur in hillside areas also. Expansive soil is subject to swelling and shrinkage of the soil, varying in proportion to the amount of moisture present in the soil.

Mapped Expansive Soil Zones

The wetting and drying of expansive soils can impact the community by affecting the soundness of private and public structures built in these areas; the urban area around Billings has several areas that are affected by this condition, see **Figure 9** (the rest of the County has not been mapped). Buildings built in these areas have had numerous problems with shifting foundations, cracks, and ground movement problems. Utilities may be affected greatly as the ground continues to shift causing damage to underground pipes and lines. While the damage might not occur quickly, expansive soils have the potential to cause significant damage to roads, railways and bridges.

Summary of Vulnerability and Impact

Known areas of vulnerability are south of the City of Billings and in a small portion of Yellowstone County. Little documented damages is available, therefore the potential for structural damages is considered **low** and there is a **very low** potential for injuries/fatalities.

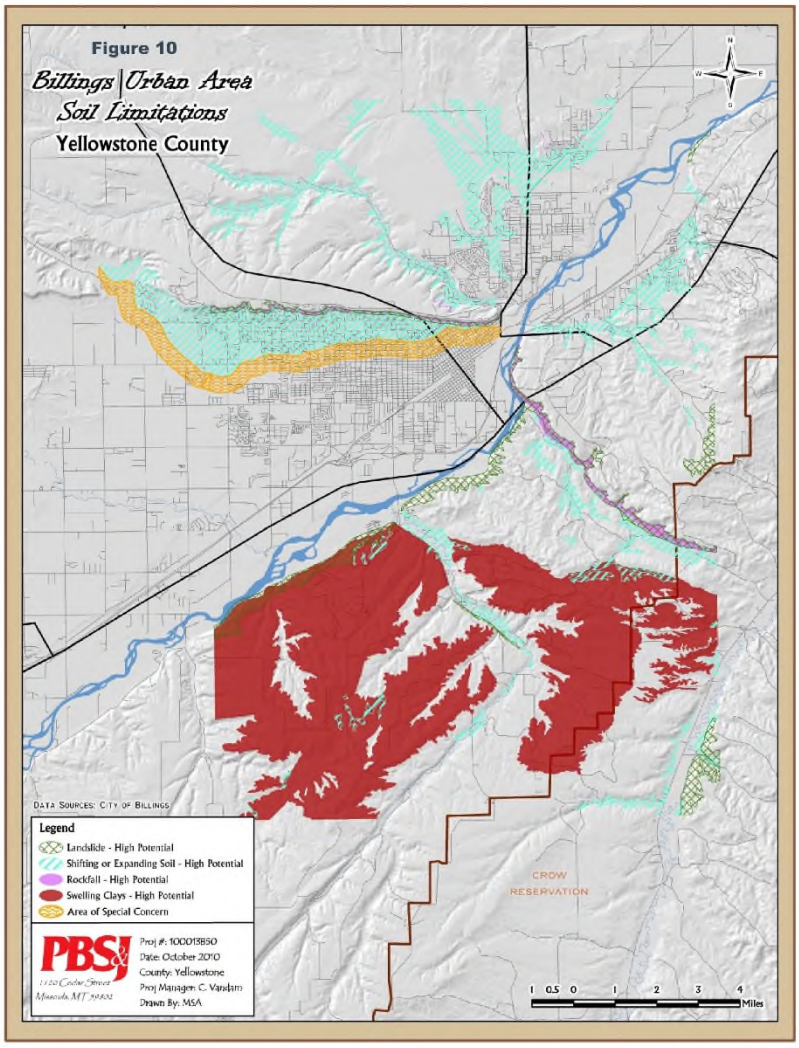


Figure 10. Billings Urban Area Soil Limitations, Yellowstone County

3.1.12. Volcanic Ash

When the violent energy of a volcano is released, the results can be catastrophic. Lava flows, debris avalanches, and explosive blasts have invaded communities, swept people to their deaths, choked major riverways, destroyed bridges, and devastated huge tracts of forest. Noxious volcanic gas emissions have caused widespread lung problems. Airborne ash clouds have disrupted the health, lives, and businesses of hundreds of thousands of people; caused millions of dollars of aircraft damage; and nearly brought down passenger flights. The risks to life, property, and infrastructure from volcanoes continue to increase as more and more people live, work, play, and travel in volcanic regions.

An explosive volcanic eruption blasts solid and molten rock fragments (tephra) and gases into the air with tremendous force. The largest rock fragments (bombs) usually fall back to the ground within 2 miles of the vent. Small fragments (less than about 0.1 inch across) of volcanic glass, minerals, and rock (ash) rise high into the air, forming a huge, billowing eruption column. Eruption columns can grow rapidly and reach more than 12 miles above a volcano in less than 30 minutes, forming an eruption cloud. The volcanic ash in the cloud can pose a serious hazard to aviation. Large eruption clouds can extend hundreds of miles downwind, resulting in ash fall over enormous areas; the wind carries the smallest ash particles the furthest. (Source: http://pubs.usgs.gov/fs/2006/3014/).

Volcanic ash, either from volcanic activity in Yellowstone National Park (approximately 90 miles to the west of Yellowstone County) or further to the west in Washington and Oregon, would impact the entire county causing health concerns for humans and livestock, and damaging equipment and utilities. Ash from the May 18, 1980, eruption of Mount St. Helens, Washington, fell over an area of 22,000 square miles in the Western United States. Heavy ash fall can collapse buildings, and even minor ash fall can damage crops, electronics, and machinery. Montana's Governor declared "State of Emergency" and closed all schools, businesses, and government offices. Western Montana was hardest hit with the ash, receiving 0.5-1 inch in places. Yellowstone County received a dusting of volcanic ash from the Mt. St. Helens eruption.

The Yellowstone Caldera is one of the largest and most active calderas in the world. The spectacular geysers, boiling hot springs, and mud pots that have made Yellowstone famous are surface manifestations of a magma chamber at depth. Cataclysmic eruptions 2.0, 1.3, and 0.6 million years ago ejected huge volumes of rhyolite magma; each eruption formed a caldera and extensive layers of thick pyroclastic-flow deposits. If another large caldera-forming eruption were to occur at Yellowstone, its effects would be worldwide. Thick ash deposits would bury vast areas of the United States, and injection of huge volumes of volcanic gases into the atmosphere could drastically affect global climate. The Yellowstone volcanic system shows no signs that it is headed toward such an eruption. The probability of a large caldera-forming eruption within the next few thousand years is exceedingly low (USGS, 2005).

The Cascade Range includes 27 volcanoes, many of which have been active in the last 10,000 years. The only threat these volcanoes pose to Montana is ash fall. The likely extent of such ash fall can be estimated on the basis of past eruptions. Volcanoes in Washington and Oregon that have erupted in the last 200 years include: Mount Hood, Mount St. Helens, Mount Rainier, and Mount Baker. Eruptions from any of these volcanoes are likely to occur in the next 100 years, the expected impacts to Yellowstone County will be similar to the Mount St. Helens event.

Summary of Vulnerability and Impact

All jurisdictions within Yellowstone County have a very low vulnerability to structure damage and injuries from a Cascade Range volcanic eruption. The vulnerability is significantly different from a Yellowstone eruption in which there would be major damage to structures, infrastructure, and high potential for fatalities. Since a significant eruption from Yellowstone is not predicted in the next several thousands of years, the vulnerability to both structure damage and injuries is very low.

Yellowstone County Multi-Hazard Mitigation Plan 2019 Update

APPENDIX C

Mitigation Documentation

APPENDIX C-1

EXAMPLE MITIGATION PROJECTS

ALL HAZARD - EXAMPLE MITIGATION PROJECTS		
	Prevention	
1		Update the countywide and town growth policies to require stricter consideration of high hazard areas during subdivision reviews.
2		Consider updating growth policies to encourage growth in low hazard areas.
3		Consider updating subdivision regulations to adopt higher minimum standards that improve disaster resistance.
	Emergency Services	
4		Obtain Reverse 911 (i.e. Code Red) for cell phones and broadband for the County
5		Work with National Weather Service to get a radio signals where needed
6		Provide NOAA weather radios to all schools and critical facilities
7		Look for corporate sponsorships to provide NOAA weather radios to the public
8		Negotiate with cell phone companies to get a tower in towns and rural areas, as needed
9		Identify and secure a back-up location for dispatch center
10		Ensure continuity of operations by providing operable generator in 9-1-1 center
11		Purchase and install generators at critical facilities and potential shelter locations.
12		Provide emergency back-up power to critical facilities; emergency generators, secondary feeds, portable generators with standard camlock connections
13		Recruit and train emergency response personnel
14		Develop templates for messaging system that could be used for transmission on radio stations (road reports, weather forecasts and conditions, emergency conditions and events, and public services).
15		Obtain a self-start generator for FM radio antennas.
16		Develop local hazard communication plan that establishes protocol for providing information to residents
17		Enhance GIS data to better to assist with mitigation.
18		Obtain additional repeaters or relocate existing repeaters to enhance radio communications.
19		Consider a mandatory signage program consisting of reflective, non-flammable address numbers at a standard height.
20		Improve and develop emergency preparedness and response plans.
21		Coordinate with Red Cross for mass care and sheltering plan.
22		Enhance general public alert, notification and warning capabilities.
	Public Outreach and Education	
23		Promote disaster-related educational programs through the school system.
24		Provide awareness on developing a family disaster plan and disaster supply kit.
25		Work with the local media and adjoining counties to continue broadcasting weather warnings over the Emergency Alert System.
26		Continue to broadcast warning information through dispatch.
27		Provide education on how to register cell phones to receive 9-1-1 notifications.
28		Educate local government officials in mitigation and readiness for all hazards.
29		Provide special needs facilities with guidelines for disaster preparedness measures, including pet needs.
30		Develop an ad campaign on readiness for evacuation or other emergencies.

COMMUNICABLE DISEASE - EXAMPLE MITIGATION PROJECTS		
	Prevention	
1		Control mosquito populations in wet areas.
2		Increase age-appropriate immunization rates for vaccine preventable communicable diseases.
3		Prevent and control communicable disease by surveillance.
4		Prevent and control communicable disease by activities to raise and sustain vaccine coverage in all populations.
5		Conduct risk-based inspections of all food service establishments.
6		Enforce sewage and solid waste disposal local and state regulations.
	Public Outreach and Education	
7		Promote mass vaccination clinics.
8		Promote public education on preventing communicable disease.
9		Promote active surveillance between Public Health and healthcare providers.
10		Provide education and/or training for Public Health Dept. staff.
	Emergency Services	
11		Conduct exercise on distribution of vacinations and/or antibiotics throughout county.
12		Complete exercise and update Chempack Plan on annual basis.
13		Keep pandemic plans up to date and complete exercises.
14		Procure, train, and supply all emergency responders for potential threats annually.
15		Expand listserve for Health Alert Network.

CYBER SECURITY - EXAMPLE MITIGATION PROJECTS		
	Emergency Services	
1		Conduct vulnerability assessment of city-county infrastructure (SCADA) systems
2		Conduct audit of city-county operations security.
3		Implement recommendations from vulnerability assessment.
	Property Protection	
4		Conduct vulnerability assessment of critical cyber infrastructure.
5		Conduct external security audit of fire walls on networks.
6		Expand access to controls that check computers to enhance security.
	Public Education and Awareness	
7		Require training for employees and local organizations on cyber security.
	Mapping/Analysis/Planning Projects	
8		Perform cyber mapping for planning and vulnerability mitigation.

DAM FAILURE - EXAMPLE MITIGATION PROJECTS		
	Prevention	
1		Develop planning and zoning guidelines for open space preservation within the floodway
2		Consider using dam inundation as criteria for future subdivision review and require disclosure by developers to prospective buyers.
3		Conduct dam safety inspections
4		Drain reservoir when conditions appear unsafe
5		Prepare Emergency Action Plans of High Hazard Dams
6		Implement zoning below and around dams.
	Structural Projects	
7		Install movement sensors on faces of dams to detect pending failure.
8		Construct dam improvements, spillway enlargements
9		Remove unsafe dams
10		Reconstruct rip rap on earthen dams
11		Decommission or modify non-essential dams that present unacceptablable risk of failure
	Emergency Services	
12		Develop evacuation plans, including means of transporting people and evacuation routes.
13		Promote installation of early warning systems on high hazard dams to interface with dispatch.
14		Participate in dam owner's table top exercises with emergency response partners.
15		Participate in dam exercises with emergency response partners.
16		Obtain and install real time monitoring and/or telemetry equipment on dams.
17		Investigate early warning systems for residents below dams.
18		Ensure owners of high hazard dams update EAPs and provide copies to DES.
	Public Outreach and Education	
19		Conduct public outreach / education with residents living in inundation areas.
20		Promote the benefit of residents downstream from high hazard dams having NOAA weather radios.
21		Target potentially affected citizens with information about the dam failure risk in their area and include information on exercises.
	Mapping/Analysis/Planning	
22		Revise breach flow projections for dams based on enhanced digital elevation models and improved flood modeling software.

DROUGHT - EXAMPLE MITIGATION PROJECTS		
	Structural Projects	
1		Consider feasible water storage where it will increase water supply security such as development of catchment basins and/or percolation ponds.
2		Develop funds and public impetus to improve water intake system
3		Create infiltration basins to capture early spring runoff.
	Public Outreach and Education	
4		Increase the educational emphasis given to forest and range management practices for the minimizing of drought impacts.
5		Develop and distribute range and agriculture management tools for local producers using weather and soil monitoring, planning, and education.
6		Support MSU Extension's efforts to develop and distribute range and agriculture management tools to mitigate affects from drought.
	Natural Resource Protection	
7		Promote and improve floodplain restoration and reconnection including restoration of hydrologic functions.
	Prevention	
8		Consider feasible water storage where it will increase water supply security.
9		Improve water conveyance efficiencies in agricultural, municipal, and industrial uses.
10		Encourage voluntary water conservation by domestic, municipal, and industrial users.
11		Establish stronger economic and other incentives for private investments in water conservation.
12		Support the State's efforts to establish a drought emergency fund for temporary water leases.
	Mapping/Analysis/Planning	
13		Pursue Drought Resiliency Planning Committee and Drought Coordinator position for County.
14		Support initiative of prescribed burning program to reduce conifer encroachment which impacts water availability.
15		Support water storage projects to enhance late summer flows.
16		Support drought programs implemented through the Conservation District, FSA, NRCS, DNRC, and MSU extension.

FLOODING - EXAMPLE MITIGATION PROJECTS		
	Prevention	
1		Create planning and zoning guidelines to preserve open space within the floodplain
2		Develop storm water management guidelines
3		Update floodplain ordinances with new DFIRM to protect future development
4		Implement a policy for residential and non-residential approach permits which includes installation standards and enforcement
5		Use conservation easements in high hazard areas such as flood prone areas to prevent future development.
6		Determine feasibility of regulating development within unmapped flood prone and channel migration zones.
7		Use State model floodplain ordinance to revise county flood ordinance.
	Property Protection	
8		Create structural openings in foundation walls allowing floodwaters in and out, thus avoiding collapse
9		Protect sewers from backing up by installing back-flow valves
10		Installing backflow valves or plugs in drains and toilets to prevent floodwaters from entering buildings
11		Purchase and instal sump pumps with back-up power
12		Obtain river gauges where needed for modeling and flood prediction.
13		Remove woody vegetation from the edge of levees and dikes
14		Relocate, elevate and/or floodproof structures which have been repeatedly flooded
15		Complete an engineering study of what needs to be done to mitigate flooding in flood-prone areas
16		Install security fencing and signage on levees and dikes
17		Consider forming a flood control district to address concerns with the dikes/levees.
18		Perform maintenance on drainage systems
19		Identify and secure use of emergency retention ponds
20		Relocate furnaces, hot water heaters, and electrical panels from flood-prone areas
	Natural Resource Protection	
21		Protect wetlands that can be used for flood control
22		Restore connectivity of floodplain and function around former facilities.
	Structural Projects	
23		Install culverts in areas where water runoff is problematic.
24		Construct levees/floodwalls/dikes
25		Repair impaired bridges
26		Replace culverts with bridges to mitigate impacts of runoff
27		Reduce flooding by installing drainage ditches
28		Resize and upgrade culverts in various locations throughout the county.
29		Identify locations throughout the county where culverts are needed
30		Increase stormwater systems in poor drainage areas.
31		Upgrade bridges, culverts, and roads to allow sufficient passage of floodwaters.
32		Continue to implement storm water plan.
33		Determine mitigation for waste-water lagoons which are in mapped flood hazard area.

FLOODING - EXAMPLE MITIGATION PROJECTS		
34		Encourage MDT to implement appropriate mitigation for highways that flood.
35		Replace rip-rap to preserve integrity of bridges where compromised.
36		Encourage responsible agency to remove debris in creeks to maintain integrity of culverts and bridge.
37		Consider ice jam mitigation for vulnerable segments of rivers.
38		Elevate community water supply wells where vulnerable to flooding.
39		Maintain the existing stormwater infrastructure to mitigate impacts from flash flooding.
40		Evaluate feasibility of creating a flood channel to redirect a portion of high water flow
41		Review use of detention ponds to mitigate flooding at problem areas within the county.
	Emergency Services	
42		Develop flood warning system
43		Establish flood response activities
44		Protect critical facilities
		Conduct exercises on levee failure/breach.
45		
	Public Outreach and Education	
46		Provide flood maps for real estate disclosure
47		Educate homeowners on the advantages of purchasing flood insurance through the National Flood Insurance Program.
48		Work towards achieving a lower rating through the National Flood Insurance Program Community Rating System.
49		Participate in the National Weather Service's Flood Awareness Week
50		Provide awareness training to repetitive loss property owners (and others) on mitigation programs to relocate, elevate, and floodproof structures in the floodplain
51		Provide bulletins as needed in agricultural areas that livestock grazing and farm equipment in floodplains should include a high spot where animals can evacuate to.
52		Educate county residents on what must be done to manage storm water in the community.
53		Distribute information about building in the floodplain.
54		Continue compliance with the National Flood Insurance Program and the County Flood Ordinance.
55		Consider joining the Community Rating System volunteer incentive program.
56		Educate development community (including surveyors, builders, realtors, and developers) on floodplain building requirements.
57		Provide awareness training to repetitive loss property owners (and others) on mitigation programs to relocate, elevate, and floodproof structures in the floodplain.
58		Promote personal responsibility to protect individual private property from flooding.
	Mapping/Analysis/Planning	
59		Assess vulnerability of wastewater treatment plant to flooding or levee damage.
60		Complete floodplain mapping
61		Complete elevation survey of structures in floodplain
		Develop a stormwater management plan

HAZARDOUS MATERIAL INCIDENTS - EXAMPLE MITIGATION PROJECTS		
	Prevention	
1		Pursue zoning regulations to ensure that perimeter security is provided at bulk chemical and petroleum facilities
2		Explore the possibility of an alternate route for truck traffic carrying hazardous material loads and/or a signed hazardous material route to avoid population center.
	Property Protection	
3		Encourage owners to install perimeter security fencing at bulk chemical and petroleum facilities.
	Emergency Services	
4		Ensure local emergency responders have adequate training to respond to hazardous material events consistent with local capabilities
5		Develop evacuation procedures for homes near transportation networks that commonly carry hazardous materials and near storage faculties and pipelines the house hazardous materials
6		Pursue funding for supplies and equipment trailer
7		Obtain decontamination trailers that can be placed around county.
8		Update resource list of emergency response supplies/vendors.
9		Obtain regional containment equipment trailers and supplies to strategically position for response in the county
10		Explore creating a safe haven for haz-mat loads that may be in trouble.
11		Continue to report hazardous material spills to MT DES.
12		Develop evacuation procedures for homes near highways that commonly carry hazardous materials and near haz-mat storage facilities and pipelines.
13		Determine whether a regional haz-mat team could be located in the County.
	Public Outreach and Education	
14		Increase public awareness of common hazardous materials either stored, used or transported through the area
15		Educate teachers and school staff in schools near hazardous materials facilities and transportation routes in how to limit exposure to hazardous materials to students during an incident.
16		Evaluate opportunities to inform private property owners who live along state highways on hazardous-material traffic.

IRRIGATION DITCH & DRAIN FAILURE - EXAMPLE MITIGATION PROJECTS		
	Prevention	
1		Continue to monitor and clean ditches and perform prevenative maintenance as needed.
2		Obtain easements to access ditches and drains for maintenance purposes.
	Structural Projects	
3		Complete overflow improvements
4		Line ditches with water-proof barrier.
5		Repair flood damage washouts and small erosions.
6		Move Washington Street drain half mile downriver to help move water out of drainage ditch faster.
7		Remove unstable rocks above North 14th Street that could fall and block BBWA ditch at tunnel entrance.
8		Improve conveyance at road / ditch crossings.
9		Construct a bypass channel to route flows to the Knife River gravel pit.
10		Divert excess flows.
11		Reroute ditches.
	Public Outreach and Education	
12		Provide outreach to citizens that dumping of debris on ditch bank or within ditch can potentially block City's stormwater system and increase potential for flooding and cause ditch bank overflows.
13		Provide outreach to citizens the permission from ditch owners is needed to divert or alter couse of ditches, contruct ditch crossings, discharge stormwater, and to use ditch water.
	Mapping/Analysis/Planning	
14		Encourage ditch companies to develop emergency plans.
	Emergency Services	
15		Develop E911 profile of ditch users and potentially impacted parties for emergency alerts of ditch failure.
	Property Protection	

SEVERE WEATHER - EXAMPLE MITIGATION PROJECTS		
	Prevention	
1		Encourage development and enforcement of wind resistant buildings and construction codes
2		Evaluate current building codes for efficiency in protecting structures from wind damage
3		Implement the tree maintenance ordinance and address problem trees.
	Property Protection	
4		Encourage utility companies to bury electric and communication lines in hazard areas.
5		Negotiate with utility companies for replacement of weak or rotten power poles.
8		Protect traffic lights from high winds
10		Install shutters on windows and doors or otherwise protect building openings from wind damage
11		Ensure that roof-mounted equipment is securely mounted
12		Develop and implement programs to keep trees from threatening lives, property, and public infrastructure during windstorm events
13		Develop partnerships between utility providers and county & local agencies to identify potentially hazardous trees
14		Thin trees to reduce wind damages and plant species of plants that are more resistant to wind damage
15		Make sure right-of-way around power lines is free of trees or limbs that may cause damage
16		Develop strategies for clearing roads of fallen trees, and clearing debris from public and private property
17		Install 3-mil window film on windows of existing and future schools and critical facilities to prevent shattering.
18		Promote the use of hurricane clips for buildings vulnerable to high winds
19		Maintain trees that could impact county or city property.
20		Install windows with shatterproof glass at new schools and critical facilities and upgrade windows at existing facilities during regular maintenance.
	Structural	
21		Structurally analyze all buildings or rooms identified as shelters and strengthen these as necessary
22		Perform retrofits on public buildings and shelters that could become compromised by snow loads.
	Public Outreach and Education	
23		Distribute educational materials to organizations and county residents regarding preparedness for no power situations
24		Promote the National Weather Service's Severe Weather Awareness Week.
25		Maintain a National Weather Service Storm Ready Community.
26		Provide awareness training on securing loose objects and pruning back large trees that could break during wind events and cause property damage.
27		Provide outreach on the risks of lightning and other severe summer weather hazards
28		Conduct workshops and educational programs focused on severe weather for public and school children.
29		Host National Weather spotter training sessions throughout the county.
30		Prepare a guide book for special needs populations on winter weather survival
31		Provide training or video on how to measure snow moisture to determine when shoveling of roofs is necessary.
32		Develop and distribute educational material on how to prepare for winter.
33		Perform public outreach/education of location of emergency shelters.

SEVERE WEATHER - EXAMPLE MITIGATION PROJECTS		
34		Conduct public outreach campaign where special needs residents would provide information on where they live and what they need. Develop a database with this information.
35		Promote the National Weather Service's Winter Weather Awareness Week
36		Continue participating in NWS storm ready community program
37		Distribute winter weather information in welcome packets to new residents.
38		Educate the public on techniques to construct homes that will better withstand severe winds
39		Conduct workshops and educational programs focused on severe weather for public and school children.
40		Partner with the National Weather Service on the Weather Ready Nation Ambassador Program and increase participation in program.
	Emergency Services	
41		Develop coordinated management strategies for de-icing roads, plowing snow, clearing roads of fallen trees, and clearing debris from public and private property
42		Develop a resource list of people who shovel snow from roofs.
43		Continue to aggressively address rural locations within the county so people's residences can be found for rescue purposes.
44		Obtain generators for emergency shelters.
45		Identify or update list of emergency shelters in each community.
46		Obtain generators for schools to maintain power supply during winter.
47		Consider enhanced snow removal services to support public safety and infrastructure protection
48		Encourage homeowners to install address plaques at proper height for rescue purposes.

TERRORISM - EXAMPLE MITIGATION PROJECTS		
	Emergency Services	
1		Continue to be notified when large events come through the County.
2		Continue awareness and training on active shooters
3		Continue armed intruder training.
4		Procure equipment and train to reduce impacts from terrorism.
5		Counter violent extremism (active shooter) training with schools and critical facilities
6		Continue to train with DPHHS on strategic national stockpile.
7		Integrate training with emergency services and real scenarios.
8		Review Crisis Action Plans in all schools and hospitals to ensure they include adequate security measures.
9		Conduct comprehensive vulnerability assessment that provides priorities.
10		Prioritize active shooter/armed intruder response training for employees of critical facilities.
11		Continue to train with DPHHS on strategic national stockpile.
	Public Outreach and Education	
12		Pursue funding for development and implementation of a campaign to educate the public on active shooter response.
13		Promote See Something-Say Something Campaign to report unusual behavior.
	Property Protection	
14		Consider installing video surveillance or alarms in critical facilities, especially in unattended locations (i.e. – water towers/communication sites/power or water sub-stations).
15		Consider physical hardening of critical facilities (i.e. anti-vehicle barricades / interior barricades for locking doors [door kicks, door stops] / perimeter fencing / controlled access gates).
16		Install security around municipal water tanks.

TRANSPORTATION ACCIDENT - EXAMPLE MITIGATION PROJECTS		
	Emergency Services	
1		Continue partnering with MDT to identify and rectify areas of concern on highway systems throughout County.
2		Acquire appropriate equipment to enhance aviation safety.
3		Implement training program for use of 2-way radio for all school bus drivers.
4		Examine unprotected railroad crossings and recommend if gates/signage are needed.
5		Invite railroad companies be part of LEPC and do exercises once every two or three years.
6		Encourage railroad to upgrade condition of railroad crossings throughout County and improve signage where needed.
7		Continue exercises to prepare for mass casualty incidents.
8		Recruit and train EMS volunteers to staff Quick Response Units.
9		Obtain equipment and provide training for responding agencies.
	Public Outreach and Education	
10		Support MDT's Transportation Safety Program.
	Structural	
11		Encourage railroads to enhance safety at crossings.
12		Work with railroad to reconstruct underpass to create a wider and straighter alignment.
	Prevention	
13		Encourage MDT to obtain electronic signs for dangerous sections of highway.
14		Encourage MDT to look at game fences or underpass to avoid vehicle/game collisions.
15		Encourage railroad to implement slower train speeds through towns and vulnerable areas to prevent derailments and protect water resources.
	Mapping/Analysis/Planning	
16		Develop population protection plans for residents along railroad or near chemical facilities.

WILDFIRE - EXAMPLE MITIGATION PROJECTS		
	Prevention	
1		Create zoning districts to reflect fire risk zones
2		Review subdivision regulations to ensure they address: on-site water storage, wide roads, multiple access, restrict builing on steep slopes, require defensible space and inspection of new development in the WUI
3		Adopt building code standards for roof materials
4		Review implementation process for rural impact fees for fire protection in the WUI.
5		Consider strategies for county regulations (subdivision and others) that would require maintenance of fuel reduction projects in the WUI and enforcement.
6		Consider implementing zoning in the county for requiring fuel reduction in the WUI.
7		Consider implementing zoning in the county requiring fire-resistant building materials in the WUI.
8		Investigate developing a regulatory mechanism to ensure that subdivisions are built as approved and fire protection systems are initially and periodically certified.
9		Develop WUI defensible space guidelines to update subdivision regulations.
10		Update subdivision regulations to include recommendations for wildfire resistant construction.
11		Encourage Planning Board to adopt subdivision regulations that require vegetation management plans to create and maintain survivable space, roof covering requirements, and fire protection covenants.
12		Encourage use of fire-resistant materials/design of non-combustible homes in future developments.
13		Expand county growth policy to address wildfire hazard in rural planning areas.
14		Adopt rural fire protection standards for low-density development.
15		Adopt an overlay zone for the WUI and other rural areas that applies to all development and includes enforceable measures to protect life and property.
	Property Protection	
16		Retrofit roofs with fire-resistant materials and add spark arrestors
17		Remove vegetation and combustible materials around structures
18		Perform fuel mitigation on evacuation routes, initial attack roads, power lines, and communication sites in the WUI.
19		Continue grants programs for landowners to create defensible space.
20		Study creation of fire breaks in appropriate locations in Conservation Reserve Program lands and areas of future development.
21		Perform fuel mitigation around historic sites
22		Upgrade the water supply in communities as needed to more effectively assist with wildfire suppression.
23		Encourage BLM and USFS to perform fuel mitigation on federal lands adjacent to the WUI
24		Encourage utility companies to perform fuel reduction along utility corridors
25		Encourage contiguity in fuel management projects so there will be no gaps in treatment.
26		Support inter-agency collaboration on fuel management projects.
27		Encourage state and federal agencies and landowners to conduct fuel reduction on their property in the WUI.
28		Continue to increase size of ingress/egress roads where possible to create fire breaks.
29		Encourage homeowner associations to review their covenants to incorporate fire resistant materials.
30		Use digital wildfire mapping for land management and project development.
31		Conduct individual home audits for residences in the wildland urban interface.
32		Encourage at risk landowners to participate in cost-share fuel reduction programs to reduce fuels round homes.
33		Encourage rural fire dept. and private landowners to install water storage tanks for fire protection.
34		Encourage evacuation route safety, including making roads wider, reducing fuels along them, and having secondary access.
35		Encourage land management agencies and private landowners to conduct stabilization and revegetation projects in burned areas.
36		Encourage creation of survivable space in current developments through coordinated landowner mitigation projects.
37		Identify, maintain, update and support high priority fuel treatment areas within the WUI for hazardous fuel treatment by private landowners.

WILDFIRE - EXAMPLE MITIGATION PROJECTS		
38		Implement FireWise principles and upgrade county facilities with non-combustible materials.
	Natural Resource Protection	
39		Prevent water pollution to the public water supply by stabilizing burned slopes after a wildfire
40		Encourage land management agencies and private landowners to conduct stabilization and revegetation projects in burned areas.
	Structural Projects	
41		Create fire breaks to prevent the spread of fire
42		Provide more than one means of access into and out of a community
43		Equip water storage facilities with fire-resistant electrical pump and other non-electrical source when not connected to a community water system
44		Develop alternative firefighting water sources
45		Widen initial attack roads and install culverts where needed.
	Emergency Services	
46		Recruit and train volunteer fire fighters
47		Enhance emergency services to increase the efficiency of wildfire response and recovery activities
48		Install more fire reporting stations for better access and coverage
49		Coordinate fire departments and other emergency services in prevention and response activities
50		Obtain more 4-WD tenders
51		Install booster antennas to enhance cell service in fire districts where it would be beneficial.
52		Improve training and qualifications of personnel to more effectively interface with incoming Incident Management Teams deployed in the county.
53		Coordinate activities of rural fire departments and partner agencies to provide for cooperation before, during, and after a fire incident.
54		Increase availability of water resources for wildland firefighting by strategic placement of water tanks and ponds.
55		Create a database of water sources for firefighting and make database available to rural fire districts.
56		Install dry hydrants through the county as determined necessary by local fire districts.
57		Obtain attachments to connect fire suppression equipment to rancher's sprinkler systems.
58		Obtain trailer-mounted 1,000-gallon pumps which can be used for fire fighting.
59		Integrate GIS technology for multi-jurisdictional response and mitigation planning.
60		Develop evacuation procedures for homes near highways that commonly carry hazardous materials and near haz-mat storage facilities and pipelines.
61		Perform fuel treatments along evacuation routes.
62		Formalize agreements for fire response in unprotected County lands.
63		Obtain mobile air quality monitors to determine unhealthy wildfire smoke conditions.
64		Develop and/or update water supplies (wells and tanks) in communities to enhance firefighting capabilities.
65		Develop and implement an enhanced communication/alert system for notification of impending wildland fire activity or evacuation for outlying areas.
66		Procure and designate a wildland supply cache to outfit fire departments to ensure wildland firefighter safety.
67		Develop public-private partnerships to fund regional water sources for fire protection.
	Public Outreach and Education	
68		Develop and disseminate updated maps relating to fire hazard to assist builders and homeowners in wildfire mitigation and guide emergency services during response.
69		Provide outreach to landowners on fuel mitigation funding opportunities for private land.
70		Develop partnerships to provide for fire mitigation activities and suppression preparedness.
71		Implement robust public outreach project on FireWise principles.

WILDFIRE - EXAMPLE MITIGATION PROJECTS		
72		Conduct community-based demonstration projects of fire prevention and mitigation in the urban interface
73		Establish neighborhood “drive-through” activities that pinpoint site-specific mitigation activities.
74		Support volunteer fire department fire prevention activities
75		Provide outreach to citizens on wildfire mitigation techniques.
76		Promote evacuation planning for landowners.
77		Provide education to landowners on fuel mitigation along evacuation routes.
78		Conduct workshops and distribute information on wildfire hazard reduction and seasonal fire danger to rural property owners.
79		Partner with surrounding counties and present workshops and presentations focused on defensible space and FireWise principles targeting county planning staff, county planning boards, architects, engineers, and realtors.
80		Continue pushing out information on Red Flag Warnings for broadcast over Emergency Alert Systems.
81		Educate the public on wildfire mitigation, especially those at high risk from wildland urban interface fires.
82		Support FireSafe Montana in their work educating realtors, building contractors, insurance industry, and landscaping companies to ensure they have knowledge on FIREWISE principals.
83		Support efforts of County Health Officer to provide public info and guidance when wildfire smoke conditions are unhealthy.
	Mapping/Analysis/Planning	
84		Study creation of fire breaks in appropriate locations in Conservation Reserve Program lands and areas of future development.
85		Conduct WUI mapping to support new Community Wildfire Protection Plan.
86		Update Community Wildfire Protection Plan.
87		Complete a study of impact fees for rural residents to fund more reliable water supplies and fire safety.
88		Continue to update and maintain fire hazard mapping project as well as compilation of completed fuel mitigation projects.
89		Assist fire jurisdictions/community groups with mapping.
90		Continue to work with cooperating agencies to develop population protection plans.
91		Continue to look for funding opportunities for fuel mitigation on private land.
92		Keep digital WUI map up to date.

APPENDIX C-2

RECONCILIATION BETWEEN 2012 & 2019 MITIGATION STRATEGY

APPENDIX C-2 - RECONCILIATION BETWEEN 2012 AND 2019 MITIGATION STRATEGY					
2019 YELLOWSTONE COUNTY MULTI-HAZARD MITIGATION PLAN					
Goal	Objective	Mitigation Project	Status: Reword, Retain, Delete, New for 2019	2019 Changes	Jurisdiction
Goal 1 - Reduce Impacts from Severe Weather and Drought					
	Objective 1.1 - Implement Structural Projects to Reduce Impacts from Severe Weather and Drought				
		1.1.1 - Encourage development of tornado safe rooms in schools.	Under Hazard Preparedness Goal. Reword.	Was specific to Broadview Elementary School. Broadened to include all schools.	County, Billings, Laurel, Broadview
		1.1.2 - Create an alternate water supply for the City of Billings with off stream storage and water treatment.	New Project		Billings
	Objective 1.2 - Provide Public Education and Awareness to Reduce Impacts from Severe Weather and Drought				
		1.2.1 - Continue community outreach on preparation and safety during severe storms and tornadoes.	Under Public Education Goal. Reword.	Added "tornadoes".	County, Billings, Laurel, Broadview
		1.2.2 - Continue to maintain NWS StormReady status for Yellowstone County and City of Billings and enhance communications and support with the City of Laurel.	New Project		County, Billings, Laurel
		1.2.3 - Encourage community partners to participate in NWS Weather Ready Nation Ambassador program.	New Project		County, Billings, Laurel, Broadview
		1.2.4 - Support drought programs implemented through the Conservation District, NWS, FSA, NRCS, DNRC, and MSU Extension.	New Project		County
	Objective 1.3 - Implement Property Protection Projects to Reduce Impacts from Severe Weather and Drought				
		1.3.1 - Encourage utility companies to ensure right-of-way around power lines are free of trees or limbs that could cause damage.	New Project		County, Billings, Laurel, Broadview
		1.3.2 - On older structures as needed, install 3-mil window film on windows of schools and critical facilities to prevent shattering.	New Project		County, Billings, Laurel, Broadview
	Objective 1.4 - Implement Prevention Projects to Reduce Impacts from Severe Weather and Drought				
		1.4.1 - Encourage utility companies to bury electric and communication lines in hazard prone areas.	New Project		County, Billings, Laurel, Broadview
		1.4.2 - Promote the use of hurricane clips for buildings vulnerable to high winds	New Project		County, Billings, Laurel, Broadview
		1.4.3 - Encourage water conservation by domestic, municipal, and industrial users.	New Project		County, Billings, Laurel
Goal 2 - Reduce Impacts from Wildfire					
	Objective 2.1 - Implement Planning, Mapping and/or Analysis Projects to Reduce Impacts from Wildfire				
		2.1.1 - Conduct wildland fire mapping to identify high-risk areas.	Under Hazard Preparedness Goal. Reword		County
		2.1.2 - Develop database of hazardous fuel assessments and landowner fuel reductions projects to support future grants.	New Project		County, Billings
		2.1.3 - Update Yellowstone County Community Wildfire Protection Plan.	New Project		County, Billings, Laurel, Broadview
		2.1.4 - Conduct feasibility study to identify best method to dispose of fuel mitigated material so all of it doesn't have to travel long distances to come to landfill.	New Project		County
	Objective 2.2 - Provide Public Education and Awareness to Reduce Impacts from Wildfire				
		2.2.1 - Continue community outreach on FireWise building practices in the wildland urban interface.	Under Public Education Goal. Retain		County, Billings, Laurel, Broadview
		2.2.2 - Promote and encourage individual fire departments to implement a FireWise program that will create fire adapted communities throughout the county.	New Project		County, Billings, Laurel, Broadview
		2.2.3 - Continue pushing out information on Red Flag Warnings for broadcast when conditions exist.	New Project		County, Billings, Laurel, Broadview
		2.2.4 - Provide timely messaging on wildfire smoke to protect vulnerable populations.	New Project		County, Billings, Laurel, Broadview
	Objective 2.3 - Implement Property Protection Projects to Reduce Impacts from Wildfire				
		2.3.1 - Continue grants programs to support hazardous fuel assessments and cost-share opportunities for landowners to create defensible space in the WUI.	New Project		County, Billings, Laurel, Broadview
	Objective 2.4 - Implement Prevention Projects to Reduce Impacts from Wildfire				
		2.4.1 - Explore whether subdivision regulations could be strengthened to require defensible space and construction with fire-proof materials.	New Project		County, Billings, Laurel
	Objective 2.5 - Enhance Emergency Service Capabilities to Reduce Impacts from Wildfire				
		2.5.1 - Continually improve fire agency training and infrastructure.	New Project		County, Billings, Laurel, Broadview
		2.5.2 - Develop database of water supplies, access points, and fire breaks, and other relevant criteria to enhance fire agency response.	New Project		County, Broadview
Goal 3 - Reduce Impacts from Ditch and Drain Failure					
	Objective 3.1 - Implement Structural Projects to Reduce Impacts from Ditch and Drain Failure				
		3.1.1 - Remove unstable rocks above North 14th Street that could fall and block BBWA ditch at tunnel entrance.	New project		Billings
		3.1.2 - Re-establish City-County Drain Outfall at Washington Street with an adjustable weir and 4,500 feet of 48 " diameter pipe washed out in the 2018 Spring runoff.	New project		Billings
		3.1.3 - Locate and re-establish unloader structures used to divert surge flow throughout the County and Billings and identify potential downstream impacts.	New project		County, Billings
		3.1.4 - Evaluate, maintain and improve rip-rap along Yellowstone River from Laurel to Huntley near ditch head gates to prevent failures that may cause uncontrolled flows into ditches increasing flood risk.	New project		County, Billings, Laurel
		3.1.5 - Install rip-rap along Yellowstone River for approximately 2,200 feet at Huntley Project to protect diversion dam and drainage ditch and maintain irrigation.	New project		County

APPENDIX C-2 - RECONCILIATION BETWEEN 2012 AND 2019 MITIGATION STRATEGY					
2019 YELLOWSTONE COUNTY MULTI-HAZARD MITIGATION PLAN					
Goal	**Objective**	**Mitigation Project**	**Status: Reword, Retain, Delete, New for 2019**	**2019 Changes**	**Jurisdiction**
	Objective 3.2 - Implement Planning, Analysis and Mapping Projects to Reduce Impacts from Ditch and Drain Failure				
		3.2.1 - Assess legal status of existing irrigation ditches and drains to determine Municipal legal authority for operations and maintenance responsibilities.	New project		Billings
		3.2.2 - Conduct bank stability assessment of BBWA canal and laterals within the Billings City limits.	New project		County, Billings
		3.2.3 - Conduct feasibility study to reduce risk of irrigation ditch failure that could impactf EOC, City-County dispatch and both hospitals.	New project		Billings
		3.2.4 - Conduct study on how to improve drains and outlet structures to mitigate flood risk.	New project		Billings
		3.2.5 – Encourage BBWA to implement recommendations of Main Canal Evaluation Study.	New project		Billings
	Objective 3.3 - Implement Property Protection Projects to Reduce Impacts from Ditch and Drain Failure				
		3.3.1 - Obtain easements to access ditches and drains for operational and maintenance purposes.	New project		Billings
	Objective 3.4 - Provide Public Education and Outreach to Reduce Impacts from Ditch and Drain Failure				
		3.4.1 - Continue to provide outreach to citizens that dumping of debris on ditch bank or within ditch can adversely impact the City's stormwater system and increase potential for flooding and cause ditch bank overflows.	New project		County, Billings, Laurel
Goal 4 - Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security					
	Objective 4.1 - Enhance Emergency Service Capabilities to Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security				
		4.1.1 - Continue active shooter preparedness training.	New project		County, Billings, Laurel, Broadview
		4.1.2 - Continue to provide end-user training on email-related threats.	New project		County, Billings, Laurel, Broadview
		4.1.3 - Coordinate state/federal agencies and private industry on potential threats that may target critical facilities or large events.	New project		County, Billings, Laurel
	Objective 4.2 - Provide Public Education and Outreach to Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security				
		4.2.1 - Raise level of awareness on what public can do to prevent and /or mitigate threat of lone gunman/active shooter incident (report suspicious or unusual behavior, stop-the-bleed training, etc.)	New project		County, Billings, Laurel, Broadview
	Objective 4.3 - Implement Planning, Analysis and Mapping Projects to Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security				
		4.3.1 - Conduct comprehensive vulnerability assessment of critical facilities with priorities for enhanced security.	New project		County, Billings, Laurel
		4.3.2 - Continue to conduct vulnerability assessment of critical cyber infrastructure with priorities for enhanced security.	New project		County, Billings, Laurel
		4.3.3 - Develop cloud-based backup system for city-county network systems.	New project		County, Billings
		4.3.4 - Review Crisis Action Plans in all schools and hospitals to ensure adequate security measures are in place.	New project		County, Billings, Laurel, Broadview
	Objective 4.4 - Implement Structural Projects to Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security				
		4.4.1 - Continue physical hardening of critical facilities and schools (i.e. anti-vehicle barricades / interior barricades for locking doors [door kicks, door stops] / perimeter fencing / controlled access gates).	New project		County, Billings, Laurel, Broadview
Goal 5 - Reduce Impacts from Haz-Mat Incidents and Transportation Accidents					
	Objective 5.1 - Enhance Emergency Service Capabilities to Reduce Impacts from Haz-Mat Incidents and Transportation Accidents				
		5.1.1 - Encourage legislative support for funding of Billings Regional Haz-Mat response team.	New project		County, Billings, Laurel, Broadview
		5.1.2 - Obtain personal protective kits for Laurel first responders and patrol cars so they can secure scene before haz-mat team arrive.	New project		Laurel
		5.1.3 - Provide basic and refresher haz-mat response training with first responders and exercise regularly.	New project		County, Billings, Laurel
		5.1.4 - Update and maintain resource list of emergency response supplies and vendors.	New project		County, Billings, Laurel, Broadview
		5.1.5 - Identify railroad point of contact and establish protocol to shut down rail traffic when needed.	New project		County, Billings, Laurel
		5.1.6 - Increase participation of local, state and federal partners, industry, and utilities in Yellowstone County LEPC.	New project		County, Billings, Laurel, Broadview
	Objective 5.2 - Provide Public Education and Awareness to Reduce Impacts from Haz-Mat Incidents and Transportation Accidents				
		5.2.1 - Improve public messaging when episodes of refinery flaring occur.	New project		Billings, Laurel

APPENDIX C-2 - RECONCILIATION BETWEEN 2012 AND 2019 MITIGATION STRATEGY					
2019 YELLOWSTONE COUNTY MULTI-HAZARD MITIGATION PLAN					
Goal	**Objective**	**Mitigation Project**	**Status: Reword, Retain, Delete, New for 2019**	**2019 Changes**	**Jurisdiction**
	Objective 5.3 - Implement Planning, Mapping and Analysis Projects to Reduce Impacts from Haz-Mat Incidents and Transportation Accidents				
		5.3.1 - Identify and prioritize intersections that could be improved to enhance safety.	New project		County, Billings, Laurel
	Objective 5.4 - Implement Prevention Projects to Reduce Impacts from Haz-Mat Incidents and Transportation Accidents				
		5.4.1 - Protect storm drains in industrial areas to ensure no hazardous materials are released to the river.	New project		Laurel
Goal 6 - Reduce Impacts from Flooding and Dam Failure					
	Objective 6.1 - Implement Property Protection Projects to Reduce Impacts from Flooding and Dam Failure				
		6.1.1 - Continue to implement Stormwater Master Plan to reduce impacts to private property from surface water runoff.	New project		Billings
		6.1.2 - Evaluate and replace culverts at street crossing in Billings. Upgrade and maintain culverts, bridges, and roads to improve conveyance of flood water elsewhere in the county.	New project		County, Billings, Laurel, Broadview
	Objective 6.2 - Provide Public Education and Awareness to Reduce Impacts from Flooding and Dam Failure				
		6.2.1 - Continue community outreach on potential for flooding.	Under Public Education Goal. Reword.	Removed " in flood-prone areas".	County, Billings, Laurel
		6.2.2 - Promote that homeowners in flood-prone areas purchase flood insurance through National Flood Insurance Program.	New project		County, Billings, Laurel, Broadview
	Objective 6.3 - Implement Planning, Mapping and/or Analysis Projects to Reduce Impacts from Flooding and Dam Failure				
		6.3.1 - Study options for mitigating stormwater runoff from Highway 3 near Billings Airport.	Under Feasibility Study Goal. Retain		Billings
		6.3.2 - Assess flood potential at Zoo Montana property and address options for managing zoo animals in the event of a flood.	Under Feasibility Study Goal. Retain		Billings
		6.3.3 - Update boundaries of approximate study areas for future floodplain mapping.	New project		Billings
	Objective 6.4 - Implement Structural Projects to Reduce Impacts from Flooding and Dam Failure				
		6.4.1 - Construct two small storage features on Cove and Little Cove Creeks and improve flood conveyance through the West Billings area.	Under Construction Project Goal. Retain		Billings
		6.4.2- Consider certifying dikes around water and wastewater treatment plants to ensure adequate protection.	New project		Billings, Laurel
		6.4.3 - Update flood protection measures at Riverside Park in Laurel to prevent flooding.	Reword.	Portion of original project complete (bury pipelines).	Laurel
	Objective 6.5 - Implement Prevention Projects to Reduce Impacts from Flooding and Dam Failure				
		6.5.1 - Review NFIP Repetitive Loss properties in Yellowstone County and address means to eliminate or reduce impacts from flooding.	Under Feasibility Study Goal. Retain		County
		6.5.2 - Strengthen subdivision regulations to ensure homes are not built where potentially impacted by flood flows from dry washes.	New project		County
	Objective 6.6 - Enhance Emergency Service Capabilities to Reduce Impacts from Flooding and Dam Failure				
		6.6.1 - Participate in dam failure exercises on high hazard dams that could impact Yellowstone County.	New project		County, Billings, Laurel
		COMPLETE - Study to assess options for controlling bank erosion and protection of buried pipelines near Riverside Park levee in Laurel.	Under Feasibility Study Goal. Partially complete.	Did $1million bank stabilization project with FEMA grant and USACE. Pipelines got moved below river bed.	Laurel
		COMPLETE - Examine the option for creating stormwater retention basin in the Knife River Pit to mitigate potential flooding downstream of the West Billings area.	Under Feasibility Study Goal. Complete.	Shilo Conservation Area (75 acre site) established.	
		DELETE - Construct Arrow Island weir project to stabilize stream banks north of Huntley.	Under Construction Project Goal. Delete.	No movement. Not feasible.	
		DELETE - Modify floodplain regulations to require property setbacks.	Under Hazard Preparedness Goal. Delete.	Floodplain regulations are consistent with state requirements.	
Goal 7 - Reduce Impacts from Communicable Disease					
	Objective 7.1 - Implement Prevention Projects to Reduce Impacts from Communicable Disease				
		7.1.1 - Increase immunization rates for vaccine preventable communicable disease in all populations.	New project		County, Billings, Laurel, Broadview
		7.1.2 - Continue to prevent and control communicable disease by surveillance.	New project		County, Billings, Laurel, Broadview
		7.1.3 - Contintue to conduct risk-based inspections of all food service establishments.	New project		County, Billings, Laurel, Broadview
	Objective 7.2 - Implement Public Education and Awareness Projects to Reduce Impacts from Communicable Disease				
		7.2.1 - Continue to promote public education on preventing communicable disease.	New project		County, Billings, Laurel, Broadview
		7.2.2 - Continue to provide education and/or training for Health Dept. staff and key partners in medical community.	New project		County, Billings, Laurel, Broadview

APPENDIX C-2 - RECONCILIATION BETWEEN 2012 AND 2019 MITIGATION STRATEGY					
2019 YELLOWSTONE COUNTY MULTI-HAZARD MITIGATION PLAN					
Goal	**Objective**	**Mitigation Project**	**Status: Reword, Retain, Delete, New for 2019**	**2019 Changes**	**Jurisdiction**
	Objective 7.3 - Enhance Emergency Service Capabilities to Reduce Impacts from Communicable Disease				
		7.3.1 - Collaborate with community partners to train and exercise public health emergency response plans.	New project		County, Billings, Laurel, Broadview
		7.3.2 - Expand listserve for Health Alert Network.	New project		County, Billings, Laurel, Broadview
	Objective 7.4 - Implement Planning, Mapping, and Analysis Projects to Reduce Impacts from Communicable Disease				
		7.4.1 - Collaborate and coordinate with community partners to review and update public health emergency response plans annually.	New project		County, Billings, Laurel, Broadview
Goal 8 - Reduce Impacts from Landslide and Rock Falls Hazards					
	Objective 8.1 - Implement Structural Projects to Reduce Impacts from Landslide and Rock Fall Hazards				
		8.1.1 - Identify, preserve, and stabilize rock fall-prone areas.	New project		County, Billings
Goal 9 - Reduce Impacts Associated with All Hazards					
	Objective 9.1 - Enhance Emergency Service Capabilities to Mitigate Impacts from All Hazards				
		9.1.1 - Implement mass notification capabilities throughout county.	Reword.	Was "Public Alert System".	County, Billings, Laurel, Broadview
		9.1.2 -Implement enhanced rural communication by coordinating and cooperating on getting First Net in place in Yellowstone County to enhance first responder communications.	Under Hazard Preparedness Goal. Reword.	Removed "Montana Interoperability Project" and added "First Net".	County, Billings, Laurel, Broadview
		9.1.3 - Obtain mobile repeaters for patrol cars.	New project		County
		9.1.4 - Identify facilities that meet national standards to serve as emergency shelters and create Memorandums of Understanding.	New project		County, Billings, Laurel, Broadview
		9.1.5 - Obtain stationary and/or mobile generators for critical facilities and emergency shelters and install hookups.	New project		County, Billings, Laurel, Broadview
		9.1.6 - Recruit and train emergency response personnel	New project		County, Billings, Laurel, Broadview
		9.1.8 - Continue to agressively address rural properties.	New project		County
	Objective 9.2 - Implement Public Education and Awareness Projects to Reduce Impacts from All Hazards				
		9.2.1 - Interact with public safety officials and schools on planning for emergencies.	Under Public Education Goal. Retain		County, Billings, Laurel, Broadview
		9.2.2 - Provide special needs facilities with guidelines for disaster preparedness measures, including pet needs.	New project		County, Billings, Laurel, Broadview
	Objective 9.3 - Implement Planning, Mapping, and/or Analysis Projects to Reduce Impacts from All Hazards				
		9.3.1 - Enhance GIS data to better to assist with mitigation.	New project		County, Billings
		9.3.2 - Develop plan for short-term water supply in Billings.	New project		County, Billings
	Objective 9.4 - Implement Prevention Projects to Mitigate Impacts from All Hazards				
		9.4.1 - Update growth policies and subdivision regulations as needed to considers all hazards.	New project		County, Billings, Laurel

APPENDIX C-3

MITIGATION ACTION PLANS

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 1 - Reduce Impacts from Severe Weather and Drought		
Objective	*Objective 1.1 - Implement Structural Projects to Reduce Impacts from Severe Weather and Drought*		
Project	**Project 1.1.1 - Encourage development of tornado safe rooms in schools.**		
Category	Structural		
Hazard(s) Addressed	Severe Weather		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)	x	1
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)		
	Medium = Technology may be available/implementation could be difficult (2 points)	x	2
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	6
	Low = 3 to 5 points		
County Priority	High, Medium, Low	Medium	
Responsible Agency	DES, LEPC, School Districts		
Potential Funding Source(s)	School District funding, Grants		
Implementation Schedule	Mid-term		
Progress Made	No progress to report.		
Planned Activities	Determine specifications for safe room. Inventory schools and identify existing where safe rooms exist. Prioritize facilities and seek funding to create additional safe rooms.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 1 - Reduce Impacts from Severe Weather and Drought		
Objective	*Objective 1.1 - Implement Structural Projects to Reduce Impacts from Severe Weather and Drought*		
Project	**Project 1.1.2 - Create an alternate water supply for the City of Billings with off stream storage and water treatment.**		
Category	Structural		
Hazard(s) Addressed	Drought		
Jurisdiction(s)	Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)	x	1
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	8
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	Billings Public Works		
Potential Funding Source(s)	Billings resources		
Implementation Schedule	Mid-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	City to construct 290-acre reservoir which will provide Billings area 6 months of water. Land acquisition complete. Move forward with contracting and construction over next three years.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 1 - Reduce Impacts from Severe Weather and Drought		
Objective	*Objective 1.2 - Provide Public Education and Awareness to Reduce Impacts from Severe Weather and Drought*		
Project	**Project 1.2.1 - Continue community outreach on preparation and safety during severe storms and tornadoes.**		
Category	Public Education and Awareness		
Hazard(s) Addressed	Severe Weather		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, LEPC, 911 Dispatch, NWS		
Potential Funding Source(s)	County resources, NWS		
Implementation Schedule	Ongoing		
Progress Made	Tornado sirens exist throughout county and tested twice monthly. Drills announced publicly in conjunction with NWS Severe Weather Week. CodeRed currently being implemented.		
Planned Activities	Participate in NWS monthly webinars/conference calls. Use social media to enroll citizens in CodeRed. NWS to educate alerting authorities on the advantages and limitations of CodeRed. Hold community seminars on public readiness including "Weather-Ready Wednesdays" geared toward current seasonal threats. NWS to identify larger outdoor events at risk for hazardous weather. Provide training and preparedness for organizers leading up to and support during event.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 1 - Reduce Impacts from Severe Weather and Drought		
Objective	*Objective 1.2 - Provide Public Education and Awareness to Reduce Impacts from Severe Weather and Drought*		
Project	**1.2.2 - Continue to maintain NWS StormReady status for Yellowstone County and City of Billings and enhance communications and support with the City of Laurel.**		
Category	Public Education and Awareness		
Hazard(s) Addressed	Severe Weather		
Jurisdiction(s)	County, Billings, Laurel		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	12
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, 911, NWS		
Potential Funding Source(s)	County resources, Billings and Laurel resources, NWS		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Continue to conduct spotter training sessions, at least 3 annually including Laurel. Schedule weather spotter training classes. Establish backup for warning notification.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 1 - Reduce Impacts from Severe Weather and Drought		
Objective	*Objective 1.2 - Provide Public Education and Awareness to Reduce Impacts from Severe Weather and Drought*		
Project	**Project 1.2.3 - Encourage community partners to participate in NWS Weather Ready Nation Ambassador program.**		
Category	Public Education and Awareness		
Hazard(s) Addressed	Severe Weather		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	12
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, LEPC		
Potential Funding Source(s)	County resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Push info out on social media to get organizations involved.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 1 - Reduce Impacts from Severe Weather and Drought		
Objective	*Objective 1.2 - Provide Public Education and Awareness to Reduce Impacts from Severe Weather and Drought*		
Project	**Project 1.2.4 - Support drought programs implemented through the Conservation District, NWS, FSA, NRCS, DNRC, and MSU Extension.**		
Category	Public Education and Awareness		
Hazard(s) Addressed	Drought		
Jurisdiction(s)	County		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, County Extension Service		
Potential Funding Source(s)	County resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Push info out on drought awareness via social media. Publicize workshops on drought mitigation offered by others.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 1 - Reduce Impacts from Severe Weather and Drought		
Objective	*Objective 1.3 - Implement Property Protection Projects to Reduce Impacts from Severe Weather and Drought*		
Project	**Project 1.3.1 - Encourage utility companies to ensure right-of-way around power lines are free of trees or limbs that could cause damage.**		
Category	Property Protection		
Hazard(s) Addressed	Severe Weather		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)		
	Medium = Technology may be available/implementation could be difficult (2 points)	x	2
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	11
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	Commissioners, LEPC		
Potential Funding Source(s)	County resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Identify problem areas and submit formal request to utility companies if needed.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 1 - Reduce Impacts from Severe Weather and Drought		
Objective	*Objective 1.3 - Implement Property Protection Projects to Reduce Impacts from Severe Weather and Drought*		
Project	**Project 1.3.2 - On older structures as needed, install 3-mil window film on windows of schools and critical facilities to prevent shattering.**		
Category	Property Protection		
Hazard(s) Addressed	Severe Weather		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	
	Medium = Technology may be available/implementation could be difficult (2 points)		3
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	11
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	Medium	
Responsible Agency	School Districts		
Potential Funding Source(s)	School Districts, Grants		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Identify facilities where window film is needed. Apply for grant to fund project. Implement as appropriate.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 1 - Reduce Impacts from Severe Weather and Drought		
Objective	*Objective 1.4 - Implement Prevention Projects to Reduce Impacts from Severe Weather and Drought*		
Project	**Project 1.4.1 - Encourage utility companies to bury electric and communication lines in hazard prone areas.**		
Category	Prevention		
Hazard(s) Addressed	Severe Weather		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)		
	Medium = Technology may be available/implementation could be difficult (2 points)	x	2
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	8
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	Commissioners, LEPC		
Potential Funding Source(s)	County resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Identify hazard areas where underground utilities are warranted. Invite utility companies to LEPC meeting and make formal request. Consider subdivision regulations that require underground utilities.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 1 - Reduce Impacts from Severe Weather and Drought		
Objective	*Objective 1.4 - Implement Prevention Projects to Reduce Impacts from Severe Weather and Drought*		
Project	**Project 1.4.2 - Promote the use of hurricane clips for buildings vulnerable to high winds.**		
Category	Prevention		
Hazard(s) Addressed	Severe Weather		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)		
	Medium = Technology may be available/implementation could be difficult (2 points)	x	2
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	Medium	
Responsible Agency	DES, Billings Planning Dept.		
Potential Funding Source(s)	County and City resources.		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Requirement in current Billings city code. Use social media to encourage citizens to upgrade during retrofits.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 1 - Reduce Impacts from Severe Weather and Drought		
Objective	*Objective 1.4 - Implement Prevention Projects to Reduce Impacts from Severe Weather and Drought*		
Project	**Project 1.4.3 - Encourage water conservation by domestic, municipal, and industrial users.**		
Category	Prevention		
Hazard(s) Addressed	Drought		
Jurisdiction(s)	County, Billings, Laurel		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, Billings and Laurel Public Works		
Potential Funding Source(s)	City resources.		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Cities can declare drought emergency. Continue to restrict water usage with tiered system when needed. Publicize city requirement for low flow toilets.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 2 - Reduce Impacts from Wildfire		
Objective	*Objective 2.1 - Implement Planning, Mapping and/or Analysis Projects to Reduce Impacts from Wildfire*		
Project	**Project 2.1.1 - Conduct wildland fire mapping to identify high-risk areas.**		
Category	Planning, Mapping and Analysis		
Hazard(s) Addressed	Wildfire		
Jurisdiction(s)	County		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, County GIS, BLM, DNRC		
Potential Funding Source(s)	County resources, DNRC, BLM		
Implementation Schedule	Short-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Get input from BLM and DNRC on where mapping is needed. Integrate GIS technology to develop assessments using slope/fuels/land cover data.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 2 - Reduce Impacts from Wildfire		
Objective	*Objective 2.1 - Implement Planning, Mapping and/or Analysis Projects to Reduce Impacts from Wildfire*		
Project	**Project 2.1.2 - Develop database of hazardous fuel assessments and landowner fuel reductions projects to support future grants.**		
Category	Planning, Mapping and Analysis		
Hazard(s) Addressed	Wildfire		
Jurisdiction(s)	County, Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	11
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES		
Potential Funding Source(s)	County resources		
Implementation Schedule	Short-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Review files from past projects and consolidate electronically in user-friendly format.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 2 - Reduce Impacts from Wildfire		
Objective	*Objective 2.1 - Implement Planning, Mapping and/or Analysis Projects to Reduce Impacts from Wildfire*		
Project	**Project 2.1.3 - Update Yellowstone County Community Wildfire Protection Plan.**		
Category	Planning, Mapping and Analysis		
Hazard(s) Addressed	Wildfire		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	11
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	Medium	
Responsible Agency	DES, Fire Council		
Potential Funding Source(s)	FEMA Grant, MT DES, DNRC		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Seek funding for plan update. Complete fire mapping and capability assessment. Hire contractor to update CWPP.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 2 - Reduce Impacts from Wildfire		
Objective	*Objective 2.1 - Implement Planning, Mapping and/or Analysis Projects to Reduce Impacts from Wildfire*		
Project	**Project 2.1.4 - Conduct feasibility study to identify best method to dispose of fuel mitigated material so all of it doesn't have to travel long distances to come to landfill.**		
Category	Planning, Mapping and Analysis		
Hazard(s) Addressed	Wildfire		
Jurisdiction(s)	County		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, Fire Council		
Potential Funding Source(s)	County resources		
Implementation Schedule	Short-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Evaluate alternatives and perform cost/benefit analysis of consolidation of material and local burn areas, mobile incinerator, mastication of material for composting, and others. Seek grant for funding.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 2 - Reduce Impacts from Wildfire		
Objective	*Objective 2.2 - Provide Public Education and Awareness to Reduce Impacts from Wildfire*		
Project	**Project 2.2.1 - Continue community outreach on FireWise building practices in the wildland urban interface.**		
Category	Public Education and Awareness		
Hazard(s) Addressed	Wildfire		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	11
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, Fire Council		
Potential Funding Source(s)	County resources		
Implementation Schedule	Ongoing		
Progress Made	DES and individual depts. have done outreach.		
Planned Activities	Continue same using social media, at county fair, building expos, etc.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 2 - Reduce Impacts from Wildfire		
Objective	*Objective 2.2 - Provide Public Education and Awareness to Reduce Impacts from Wildfire*		
Project	**Project 2.2.2 - Promote and encourage individual fire departments to implement a FireWise program that will create fire adapted communities throughout the county.**		
Category	Public Education and Awareness		
Hazard(s) Addressed	Wildfire		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	11
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, Fire Council, DNRC		
Potential Funding Source(s)	County resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Utilize FireWise website for available resources. Provide opportunities and incentives for citizens to participate.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 2 - Reduce Impacts from Wildfire		
Objective	*Objective 2.2 - Provide Public Education and Awareness to Reduce Impacts from Wildfire*		
Project	**Project 2.2.3 - Continue pushing out information on Red Flag Warnings for broadcast when conditions exist.**		
Category	Public Education and Awareness		
Hazard(s) Addressed	Wildfire		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	11
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, NWS		
Potential Funding Source(s)	NWS, County resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Coordinate with NWS. Utilize social media, broadcast media to publicize dangerous conditions.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 2 - Reduce Impacts from Wildfire		
Objective	*Objective 2.2 - Provide Public Education and Awareness to Reduce Impacts from Wildfire*		
Project	**Project 2.2.4 - Provide timely messaging on wildfire smoke to protect vulnerable populations.**		
Category	Public Education and Awareness		
Hazard(s) Addressed	Wildfire		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, County Health Dept., School Districts		
Potential Funding Source(s)	County resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Coordinate with MT DEQ and NWS when poor air quality conditions exist. Inform public by broadcast and social media.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 2 - Reduce Impacts from Wildfire		
Objective	*Objective 2.3 - Implement Property Protection Projects to Reduce Impacts from Wildfire*		
Project	**Project 2.3.1 - Continue grants programs to support hazardous fuel assessments and cost-share opportunities for landowners to create defensible space in the WUI.**		
Category	Property Protection		
Hazard(s) Addressed	Wildfire		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, BLM, DNRC		
Potential Funding Source(s)	Federal and state grants		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Coordinate with federal and state partners on grant opportunities. Publicize program to garner support and participation.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 2 - Reduce Impacts from Wildfire		
Objective	*Objective 2.4 - Implement Prevention Projects to Reduce Impacts from Wildfire*		
Project	**Project 2.4.1 - Explore whether subdivision regulations could be strengthened to require defensible space and construction with fire-proof materials.**		
Category	Prevention		
Hazard(s) Addressed	Wildfire		
Jurisdiction(s)	County, Billings, Laurel		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)	x	1
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)		
	Medium = Technology may be available/implementation could be difficult (2 points)	x	2
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	9
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	County and City Planning Depts.		
Potential Funding Source(s)	County and city resources.		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Cities to consider during update of subdivision regulations. County to encourage through growth policy since no ability to enforce.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 2 - Reduce Impacts from Wildfire		
Objective	*Objective 2.5 - Enhance Emergency Service Capabilities to Reduce Impacts from Wildfire*		
Project	**Project 2.5.1 - Continually improve fire agency training and infrastructure.**		
Category	Emergency Services		
Hazard(s) Addressed	Wildfire		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	12
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	Fire Council		
Potential Funding Source(s)	County and city resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Identify needs. Update depts. of training and grant opportunities.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 2 - Reduce Impacts from Wildfire		
Objective	*Objective 2.5 - Enhance Emergency Service Capabilities to Reduce Impacts from Wildfire*		
Project	**Project 2.5.2 - Develop database of water supplies, access points, and fire breaks, and other relevant criteria to enhance fire agency response.**		
Category	Emergency Services		
Hazard(s) Addressed	Wildfire		
Jurisdiction(s)	County, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	11
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	Fire Council		
Potential Funding Source(s)	DNRC, County resources		
Implementation Schedule	Short-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Water supplies have been mapped. Create database and input information on access points, fire breaks, and other relevant data. Integrate County GIS water source data.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 3 - Reduce Impacts from Ditch and Drain Failure		
Objective	*Objective 3.1 - Implement Structural Projects to Reduce Impacts from Ditch and Drain Failure*		
Project	**Project 3.1.1 - Remove unstable rocks above North 14th Street that could fall and block BBWA ditch at tunnel entrance.**		
Category	Structural		
Hazard(s) Addressed	Ditch and Drain Failure		
Jurisdiction(s)	Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)	x	1
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	9
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	BBWA, Billings Public Works		
Potential Funding Source(s)	City resources monies approved by City Council February 25, 2019, BBWA, Grants		
Implementation Schedule	Mid-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Continue coordination meetings. Develop design. Hire contractor. Implement project.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 3 - Reduce Impacts from Ditch and Drain Failure		
Objective	*Objective 3.1 - Implement Structural Projects to Reduce Impacts from Ditch and Drain Failure*		
Project	**Project 3.1.2 - Re-establish City-County Drain Outfall, at Washington Street with an adjustable weir and 4,500 feet of 48 " diameter pipe washed out in the 2018 Spring runoff.**		
Category	Structural		
Hazard(s) Addressed	Ditch and Drain Failure		
Jurisdiction(s)	Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)	x	1
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	9
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	Billings Public Works		
Potential Funding Source(s)	City resources		
Implementation Schedule	Short-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Continue design work. Hire contractor. Implement project.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 3 - Reduce Impacts from Ditch and Drain Failure		
Objective	*Objective 3.1 - Implement Structural Projects to Reduce Impacts from Ditch and Drain Failure*		
Project	**Project 3.1.3 - Locate and re-establish unloader structures used to divert surge flow throughout the County and Billings and identify potential downstream impacts.**		
Category	Structural		
Hazard(s) Addressed	Ditch and Drain Failure		
Jurisdiction(s)	County, Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)	x	1
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	9
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	County and Billings Public Works, BBWA		
Potential Funding Source(s)	BBWA, and other ditch associations County & City resources, Grants		
Implementation Schedule	Long-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Identify other locations where water could be discharged. Initiate conversation with Zoo MT on allowing water discharge. Improve structure on Canyon Creek if feasible.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 3 - Reduce Impacts from Ditch and Drain Failure		
Objective	*Objective 3.1 - Implement Structural Projects to Reduce Impacts from Ditch and Drain Failure*		
Project	**Project 3.1.4 - Evaluate, maintain and improve rip-rap along Yellowstone River from Laurel to Huntley near ditch head gates to prevent failures that may cause uncontrolled flows into ditches increasing flood risk.**		
Category	Structural		
Hazard(s) Addressed	Ditch and Drain Failure		
Jurisdiction(s)	County, Billings, Laurel		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)	x	1
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	9
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	BBWA, DNRC, USACE		
Potential Funding Source(s)	BBWA, Grants		
Implementation Schedule	Mid-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Work with DNRC and USACE on permitting to minimize risks associated with ditch flows overtopping due to river migration. Identify and secure funding for project.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 3 - Reduce Impacts from Ditch and Drain Failure		
Objective	*Objective 3.1 - Implement Structural Projects to Reduce Impacts from Ditch and Drain Failure*		
Project	**Project 3.1.5 - Install rip-rap along Yellowstone River for approximately 2,200 feet at Huntley Project to protect diversion dam and drainage ditch and maintain irrigation.**		
Category	Structural		
Hazard(s) Addressed	Ditch and Drain Failure		
Jurisdiction(s)	County		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)	x	1
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	8
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	HPID, Grants		
Potential Funding Source(s)	City resources		
Implementation Schedule	Long-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Work with DNRC on permitting to address river migration that threatens irrigation capabilities. Identify and secure funding for project.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 3 - Reduce Impacts from Ditch and Drain Failure		
Objective	*Objective 3.2 - Implement Planning, Analysis and Mapping Project to Reduce Impacts from Ditch and Drain Failure*		
Project	**Project 3.2.1 - Assess legal status of existing irrigation ditches and drains to determine Municipal legal authority for operations and maintenance responsibilities.**		
Category	Planning, Mapping and Analysis		
Hazard(s) Addressed	Ditch and Drain Failure		
Jurisdiction(s)	Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)		
	Medium = Technology may be available/implementation could be difficult (2 points)	x	2
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	Billings Public Works		
Potential Funding Source(s)	City resources, grants		
Implementation Schedule	Mid-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Identify and secure funding for title report. Hire firm.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 3 - Reduce Impacts from Ditch and Drain Failure		
Objective	*Objective 3.2 - Implement Planning, Analysis and Mapping Project to Reduce Impacts from Ditch and Drain Failure*		
Project	**Project 3.2.2 - Conduct bank stability assessment of BBWA canal and laterals within the Billings City limits.**		
Category	Planning, Mapping and Analysis		
Hazard(s) Addressed	Ditch and Drain Failure		
Jurisdiction(s)	County, Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	11
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	BBWA		
Potential Funding Source(s)	BBWA, Grants		
Implementation Schedule	Mid-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Identify additional funding to be used to match grant funds. Hire firm to assess at least 3 miles of ditch to identify high steep banks. Prioritize ditch lining projects including BBWA canal, Shiloh/King/W 32nd Street.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 3 - Reduce Impacts from Ditch and Drain Failure		
Objective	*Objective 3.2 - Implement Planning, Analysis and Mapping Project to Reduce Impacts from Ditch and Drain Failure*		
Project	**Project 3.2.3 - Conduct feasibility study to reduce risk of ditch failure that could impact EOC, City-County dispatch and both hospitals.**		
Category	Planning, Mapping and Analysis		
Hazard(s) Addressed	Ditch and Drain Failure		
Jurisdiction(s)	Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	11
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	Billings Public Works		
Potential Funding Source(s)	City resources, grants		
Implementation Schedule	Short-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Identify and secure funding. Hire firm. Review report and select alternative. Prepare grant for funding.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 3 - Reduce Impacts from Ditch and Drain Failure		
Objective	*Objective 3.2 - Implement Planning, Analysis and Mapping Project to Reduce Impacts from Ditch and Drain Failure*		
Project	**Project 3.2.4 - Conduct study on how to improve drains and outlet structures to mitigate flood risk.**		
Category	Planning, Mapping and Analysis		
Hazard(s) Addressed	Ditch and Drain Failure		
Jurisdiction(s)	Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	11
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	Billings Public Works		
Potential Funding Source(s)	City resources, grants		
Implementation Schedule	Short-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Identify and secure funding. Hire firm. Review report and select alternative. Prepare grant for funding.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 3 - Reduce Impacts from Ditch and Drain Failure		
Objective	*Objective 3.2 - Implement Planning, Analysis and Mapping Projects to Reduce Impacts from Ditch and Drain Failure*		
Project	**Project 3.2.5 – Encourage BBWA to implement recommendations of Main Canal Evaluation Study.**		
Category	Planning, Mapping and Analysis		
Hazard(s) Addressed	Ditch and Drain Failure		
Jurisdiction(s)	Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	12
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	Billings Public Works, Ditch and Drain Boards		
Potential Funding Source(s)	BBWA resources, grants		
Implementation Schedule	Long-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Encourage BBWA to secure funding, hire design consultant, develop designs, implement according to stated priorities.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 3 - Reduce Impacts from Ditch and Drain Failure		
Objective	*Objective 3.3 - Implement Property Protection Projects to Reduce Impacts from Ditch and Drain Failure*		
Project	**Project 3.3.1 - Obtain easements to access ditches and drains for operational and maintenance purposes.**		
Category	Property Protection		
Hazard(s) Addressed	Ditch and Drain Failure		
Jurisdiction(s)	Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)		
	Medium = Technology may be available/implementation could be difficult (2 points)	x	2
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	Billings Public Works, Ditch and Drain Boards		
Potential Funding Source(s)	City resources, grants		
Implementation Schedule	Mid-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Once ownership determined, negotiate to purchase easement. Prepare grant to fund project.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 3 - Reduce Impacts from Ditch and Drain Failure		
Objective	*Objective 3.4 - Provide Public Education and Outreach to Reduce Impacts from Ditch and Drain Failure*		
Project	**Project 3.4.1 - Continue to provide outreach to citizens that dumping of debris on ditch bank or within ditch can adversely impact the City's stormwater system and increase potential for flooding and cause ditch bank overflows.**		
Category	Public Education and Awareness		
Hazard(s) Addressed	Ditch and Drain Failure		
Jurisdiction(s)	Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)	x	1
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	1
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	Billings Public Works		
Potential Funding Source(s)	City resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Continue to put out signs and send letters to residents. Use GIS to segregate properties and cue out residents.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 4 - Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security		
Objective	*Objective 4.1 - Enhance Emergency Service Capabilities to Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security*		
Project	**Project 4.1.1 - Continue active shooter preparedness training.**		
Category	Emergency Services		
Hazard(s) Addressed	Terrorism, Violence, Civil Unrest		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, law enforcement, DHS		
Potential Funding Source(s)	County & city resources, DHS		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Provide ongoing training to emergency response personnel and in schools (especially substitute teachers). Coordinate with Fire Depts. and Building officials to eliminate conflict in messaging		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 4 - Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security		
Objective	*Objective 4.1 - Enhance Emergency Service Capabilities to Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security*		
Project	**Project 4.1.2 - Continue to provide end-user training on email-related threats.**		
Category	Emergency Services		
Hazard(s) Addressed	Terrorism, Violence, Civil Unrest		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	11
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	City and County IT Depts., DHS, MATIC		
Potential Funding Source(s)	County & city resources, DHS		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Provide education to city and county personnel on phising campaigns and others issues as threat landscape changes. Provide refresher training annually.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 4 - Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security		
Objective	*Objective 4.1 - Enhance Emergency Service Capabilities to Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security*		
Project	**Project 4.1.3 - Coordinate state/federal agencies and private industry on potential threats that may target critical facilities or large events.**		
Category	Emergency Services		
Hazard(s) Addressed	Cyber Security		
Jurisdiction(s)	County, Billings, Laurel		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	9
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	LEPC, DHS, MT Dept. Justice MATIC, FBI, private industry		
Potential Funding Source(s)	County & city resources, state and federal partners, private industry		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Utilize state and federal resources to broaden awareness of potential threats. Utilize private industry expertise to identify and prevent incidents.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 4 - Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security		
Objective	*Objective 4.2 - Provide Public Education and Outreach to Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security*		
Project	**Project 4.2.1 - Raise level of awareness on what public can do to prevent and /or mitigate threat of lone gunman/active shooter incident (report suspicious or unusual behavior, stop-the-bleed training, etc.)**		
Category	Emergency Services		
Hazard(s) Addressed	Terrorism, Violence, Civil Unrest		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, DHS, Chamber of Commerce, MT Migrant Worker Council		
Potential Funding Source(s)	County resources, DHS		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Utilize DHS curriculum and disseminate through Chamber of Commerce, print and social media. Translate message into multiple languages.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 4 - Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security		
Objective	*Objective 4.3 - Implement Planning, Analysis and Mapping Projects to Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security*		
Project	**Project 4.3.1 - Conduct comprehensive vulnerability assessment of critical facilities with priorities for enhanced security.**		
Category	Planning, Mapping, and Analysis		
Hazard(s) Addressed	Terrorism, Violence, Civil Unrest		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	12
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, Law Enforcement, City and County Building Depts., DHS		
Potential Funding Source(s)	County & city/town resources, DHS		
Implementation Schedule	Mid-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Identify high risk areas and what needs to be fixed as per objectives. Provide information so officials can make decisions. Mitigate vulnerabilities.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 4 - Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security		
Objective	*Objective 4.3 - Implement Planning, Analysis and Mapping Projects to Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security*		
Project	**Project 4.3.2 - Continue to conduct vulnerability assessment of critical cyber infrastructure with priorities for enhanced security.**		
Category	Planning, Mapping, and Analysis		
Hazard(s) Addressed	Cyber Security		
Jurisdiction(s)	County, Billings, Laurel		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	11
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	County and City IT Depts, DHS		
Potential Funding Source(s)	County & city/town resources, DHS		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Evaluate networks and firewalls as needed to ensure security. Update protective software.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 4 - Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security		
Objective	*Objective 4.3 - Implement Planning, Analysis and Mapping Projects to Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security*		
Project	**Project 4.3.3 - Develop cloud-based backup system for city-county network systems.**		
Category	Planning, Mapping, and Analysis		
Hazard(s) Addressed	Cyber Security		
Jurisdiction(s)	County, Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	11
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	County and City IT Depts, DHS		
Potential Funding Source(s)	County & city resources		
Implementation Schedule	Short-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Determine equipment needed to redirect traffic/keep flow going in event of cyber attack. Obtain funding. Establish protocols and test system.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 4 - Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security		
Objective	*Objective 4.3 - Implement Planning, Analysis and Mapping Projects to Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security*		
Project	**Project 4.3.4 - Review Crisis Action Plans in all schools and hospitals to ensure adequate security measures are in place.**		
Category	Planning, Mapping, and Analysis		
Hazard(s) Addressed	Terrorism, Violence, Civil Unrest		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	9
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	School Resource Officers, DES, Hospitals		
Potential Funding Source(s)	County & city/town resources, Hospitals		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	On annual basis, review and update plans. Schedule exercises.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 4 - Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security		
Objective	*Objective 4.4 - Implement Structural Projects to Reduce Impacts from Terrorism, Violence, Civil Unrest, and Cyber Security*		
Project	**Project 4.4.1 - Continue physical hardening of critical facilities and schools (i.e. anti-vehicle barricades / interior barricades for locking doors [door kicks, door stops] / perimeter fencing / controlled access gates).**		
Category	Structural		
Hazard(s) Addressed	Terrorism, Violence, Civil Unrest		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)	x	1
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	9
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, Law Enforcement, Building Depts., Schools		
Potential Funding Source(s)	County & city/town resources, grants		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Continue to explore grant opportunities for surveillance and key lock systems. As funding allows, physically harden all schools and critical facilities.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 5 - Reduce Impacts from Haz-Mat Incidents and Transportation Accidents		
Objective	*Objective 5.1 - Enhance Emergency Service Capabilities to Reduce Impacts from Haz-Mat Incidents and Transportation Accidents*		
Project	**Project 5.1.1 - Encourage legislative support for funding of Billings Regional Haz-Mat response team.**		
Category	Emergency Service		
Hazard(s) Addressed	Hazardous Materials and Transportation Accidents		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	12
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	Commissioners, DES, Fire Depts.		
Potential Funding Source(s)	County and city resources		
Implementation Schedule	Short-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Encourage representatives to support funding for regional haz-mat response teams at 2019 legislature.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 5 - Reduce Impacts from Haz-Mat Incidents and Transportation Accidents		
Objective	*Objective 5.1 - Enhance Emergency Service Capabilities to Reduce Impacts from Haz-Mat Incidents and Transportation Accidents*		
Project	**Project 5.1.2 - Obtain personal protective kits for Laurel first responders and patrol cars so they can secure scene before haz-mat team arrive.**		
Category	Emergency Service		
Hazard(s) Addressed	Hazardous Materials and Transportation Accidents		
Jurisdiction(s)	Laurel		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)	x	1
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	9
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	Laurel Fire Dept., Billings Haz-Mat Team, LEPC		
Potential Funding Source(s)	Mid-term		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Identify and secure funding for skin protection, respirators, and other equipment as needed for first responders.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 5 - Reduce Impacts from Haz-Mat Incidents and Transportation Accidents		
Objective	*Objective 5.1 - Enhance Emergency Service Capabilities to Reduce Impacts from Haz-Mat Incidents and Transportation Accidents*		
Project	**Project 5.1.3 - Provide basic and refresher haz-mat response training with first responders and exercise regularly.**		
Category	Emergency Service		
Hazard(s) Addressed	Hazardous Materials and Transportation Accidents		
Jurisdiction(s)	County, Billings, Laurel		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	11
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	Fire Depts., Haz-Mat Team		
Potential Funding Source(s)	County and city resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Provide first responders with basic knowledge on haz-mat capabilities, who to call to ensure quick activation of haz-mat team, securing sites, and maintaining equipment. Exercise and refresh training annually.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 5 - Reduce Impacts from Haz-Mat Incidents and Transportation Accidents		
Objective	*Objective 5.1 - Enhance Emergency Service Capabilities to Reduce Impacts from Haz-Mat Incidents and Transportation Accidents*		
Project	**Project 5.1.4 - Update and maintain resource list of emergency response supplies and vendors.**		
Category	Emergency Service		
Hazard(s) Addressed	Hazardous Materials and Transportation Accidents		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	12
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, Fire Depts.		
Potential Funding Source(s)	County resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	List should include county equipment and private resources. Include expiration date on supplies.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 5 - Reduce Impacts from Haz-Mat Incidents and Transportation Accidents		
Objective	*Objective 5.1 - Enhance Emergency Service Capabilities to Reduce Impacts from Haz-Mat Incidents and Transportation Accidents*		
Project	**Project 5.1.5 - Identify railroad point of contact and establish protocol to shut down rail traffic when needed.**		
Category	Emergency Service		
Hazard(s) Addressed	Hazardous Materials and Transportation Accidents		
Jurisdiction(s)	County, Billings, Laurel		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	Fire Depts., LEPC, Railroads		
Potential Funding Source(s)	County and city resources.		
Implementation Schedule	Short-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Coordinate with railroad to establish procedure. Ensure protocol includes official confirmation messaging.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 5 - Reduce Impacts from Haz-Mat Incidents and Transportation Accidents		
Objective	*Objective 5.1 - Enhance Emergency Service Capabilities to Reduce Impacts from Haz-Mat Incidents and Transportation Accidents*		
Project	**Project 5.1.6 - Increase participation of local, state and federal partners, industry, and utilities in Yellowstone County LEPC.**		
Category	Emergency Service		
Hazard(s) Addressed	Hazardous Materials and Transportation Accidents		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	12
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, LEPC		
Potential Funding Source(s)	County resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Develop expanded email list of prospective LEPC members. Message frequently. Establish shared leadership to engage more members to participate.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 5 - Reduce Impacts from Haz-Mat Incidents and Transportation Accidents		
Objective	*Objective 5.2 - Provide Public Education and Awareness to Reduce Impacts from Haz-Mat Incidents and Transportation Accidents*		
Project	**Project 5.2.1 - Improve public messaging when episodes of refinery flaring occur.**		
Category	Public Education and Outreach		
Hazard(s) Addressed	Hazardous Materials and Transportation Accidents		
Jurisdiction(s)	Billings, Laurel		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, MDT, Refineries		
Potential Funding Source(s)	County resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Utilize social media and CodeRed to notify residents of flaring. Coordinate with MDT to utilize signs and road closures to protect populations at risk.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 5 - Reduce Impacts from Haz-Mat Incidents and Transportation Accidents		
Objective	*Objective 5.3 - Implement Planning, Mapping and Analysis Projects to Reduce Impacts from Haz-Mat Incidents and Transportation Accidents*		
Project	**Project 5.3.1 - Identify and prioritize intersections that could be improved to enhance safety.**		
Category	Planning, Mapping and Analysis		
Hazard(s) Addressed	Hazardous Materials and Transportation Accidents		
Jurisdiction(s)	County, Billings, Laurel		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	11
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	County and City Public Works, MDT		
Potential Funding Source(s)	County and city resources		
Implementation Schedule	Short-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Consider improvements around Metra, refineries, bridge and river crossings (Dick Johnston bridge, 1st Ave. No.). Utilize GIS to look for rerouting alternatives.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 5 - Reduce Impacts from Haz-Mat Incidents and Transportation Accidents		
Objective	*Objective 5.4 - Implement Prevention Projects to Reduce Impacts from Haz-Mat Incidents and Transportation Accidents*		
Project	**Project 5.4.1 - Protect storm drains in industrial areas to ensure no hazardous materials are released to the river.**		
Category	Prevention		
Hazard(s) Addressed	Hazardous Materials		
Jurisdiction(s)	Laurel		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)	x	1
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	8
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	City Public Works		
Potential Funding Source(s)	City resources		
Implementation Schedule	Short-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Determine best technology and install a fail-safe mechanism to prevent accidental release to river.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 6 - Reduce Impacts from Flooding and Dam Failure		
Objective	*Objective 6.1 - Implement Property Protection Projects to Reduce Impacts from Flooding and Dam Failure*		
Project	**Project 6.1.1 - Continue to implement Stormwater Master Plan to reduce impacts to private property from surface water runoff.**		
Category	Property Protection		
Hazard(s) Addressed	Flooding		
Jurisdiction(s)	Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)	x	1
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)	x	1
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	8
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	City Public Works		
Potential Funding Source(s)	City resources, grants		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	City moving toward identifying restrictions in current system and improving stormwater infrastructure as per Master Stormwater Plan.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 6 - Reduce Impacts from Flooding and Dam Failure		
Objective	*Objective 6.1 - Implement Property Protection Projects to Reduce Impacts from Flooding and Dam Failure*		
Project	**Project 6.1.2 - Evaluate and replace culverts at street crossing in Billings. Upgrade and maintain culverts, bridges, and roads to improve conveyance of flood water elsewhere in the county.**		
Category	Property Protection		
Hazard(s) Addressed	Flooding		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	County Road Dept., City Public Works		
Potential Funding Source(s)	County and city resources, grants		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Identify and prioritize culverts for replacement. Identify funding and timeline.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 6 - Reduce Impacts from Flooding and Dam Failure		
Objective	*Objective 6.2 - Provide Public Education and Awareness to Reduce Impacts from Flooding and Dam Failure*		
Project	**Project 6.2.1 - Continue community outreach on potential for flooding.**		
Category	Public Education and Awareness		
Hazard(s) Addressed	Flooding		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	
	Medium = $100,000 to $500,000 (2 points)		3
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	11
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, NWS		
Potential Funding Source(s)	County resources, NWS		
Implementation Schedule	Ongoing		
Progress Made	Have participated in NWS conference calls and pushed messaging to public when threat exists.		
Planned Activities	Push out NWS messaging through broadcast and social media to alert citizens when flood potential appears threatening.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 6 - Reduce Impacts from Flooding and Dam Failure		
Objective	*Objective 6.2 - Provide Public Education and Awareness to Reduce Impacts from Flooding and Dam Failure*		
Project	**Project 6.2.2 - Promote that homeowners in flood-prone areas purchase flood insurance through National Flood Insurance Program.**		
Category	Public Education and Awareness		
Hazard(s) Addressed	Flooding		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)	x	1
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	Floodplain administrators		
Potential Funding Source(s)	County and city/town resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Utilize print and social media to provide information on NFIP to property owners. Ensure FEMA brochures are available at Planning Office and county/city websites have information.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 6 - Reduce Impacts from Flooding and Dam Failure		
Objective	*Objective 6.3 - Implement Planning, Mapping and/or Analysis Projects to Reduce Impacts from Flooding and Dam Failure*		
Project	**Project 6.3.1 - Study options for mitigating stormwater runoff from Highway 3 near Billings Airport.**		
Category	Planning, Mapping, and Analysis		
Hazard(s) Addressed	Flooding		
Jurisdiction(s)	Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)	x	1
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	Billings Public Works		
Potential Funding Source(s)	MDT, City resources		
Implementation Schedule	Mid-term		
Progress Made	MDT has project in planning phase. Issues with homes below rims and runoff.		
Planned Activities	City to coordinate with MDT on project implementation,		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 6 - Reduce Impacts from Flooding and Dam Failure		
Objective	*Objective 6.3 - Implement Planning, Mapping and/or Analysis Projects to Reduce Impacts from Flooding and Dam Failure*		
Project	**Project 6.3.2 - Assess flood potential at Zoo Montana property and address options for managing zoo animals in the event of a flood.**		
Category	Planning, Mapping, and Analysis		
Hazard(s) Addressed	Flooding		
Jurisdiction(s)	Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)	x	1
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	Medium	
Responsible Agency	DES, Billings Public Works		
Potential Funding Source(s)	County and city resources		
Implementation Schedule	Long-term		
Progress Made	No progress to report.		
Planned Activities	Develop evacuation protocol as annex to EOP. Coordinate with owners to include property as part of Flood Master Plan.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 6 - Reduce Impacts from Flooding and Dam Failure		
Objective	*Objective 6.3 - Implement Planning, Mapping and/or Analysis Projects to Reduce Impacts from Flooding and Dam Failure*		
Project	**Project 6.3.3 - Update boundaries of approximate study areas for future floodplain mapping.**		
Category	Planning, Mapping, and Analysis		
Hazard(s) Addressed	Flooding		
Jurisdiction(s)	Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)	x	1
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	9
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, County Floodplain Administrator, DNRC		
Potential Funding Source(s)	County resources		
Implementation Schedule	Mid-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Work with DNRC to extend study area boundaries and secure funding for future mapping effort.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 6 - Reduce Impacts from Flooding and Dam Failure		
Objective	*Objective 6.4 - Implement Structural Projects to Reduce Impacts from Flooding and Dam Failure*		
Project	**Project 6.4.1 - Construct two small storage features on Cove and Little Cove Creeks and improve flood conveyance through the West Billings area.**		
Category	Structural		
Hazard(s) Addressed	Flooding		
Jurisdiction(s)	Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)	x	1
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	9
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	City Public Works		
Potential Funding Source(s)	City resources, grants		
Implementation Schedule	Ongoing		
Progress Made	Master Flood Plan in place. Several small detention basins have been constructed (62nd/ Rimrock).		
Planned Activities	Expand boundaries. Create partnership and negotiate with Byerly drain district about more efficiently using drainage on west end.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 6 - Reduce Impacts from Flooding and Dam Failure		
Objective	*Objective 6.4 - Implement Structural Projects to Reduce Impacts from Flooding and Dam Failure*		
Project	**Project 6.4.2 - Consider certifying dikes around water and wastewater treatment plants to ensure adequate protection.**		
Category	Structural		
Hazard(s) Addressed	Flooding		
Jurisdiction(s)	Billings, Laurel		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)	x	1
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	9
	Low = 3 to 5 points		
County Priority	High, Medium, Low	Medium	
Responsible Agency	City Public Works, USACE		
Potential Funding Source(s)	City resources, grants		
Implementation Schedule	Long-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Review structural integrity of existing dikes. Consider advantages of certification process. Determine course forward.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 6 - Reduce Impacts from Flooding and Dam Failure		
Objective	*Objective 6.4 - Implement Structural Projects to Reduce Impacts from Flooding and Dam Failure*		
Project	**Project 6.4.3 - Update flood protection measures at Riverside Park in Laurel to prevent flooding.**		
Category	Structural		
Hazard(s) Addressed	Flooding		
Jurisdiction(s)	Laurel		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)	x	1
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	8
	Low = 3 to 5 points		
County Priority	High, Medium, Low	Medium	
Responsible Agency	City Public Works, USACE		
Potential Funding Source(s)	City resources, grants		
Implementation Schedule	Long-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Identify and secure funding to strengthen levee and prevent erosion. Determine cultural significance of site prior to implementation.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 6 - Reduce Impacts from Flooding and Dam Failure		
Objective	*Objective 6.5 - Implement Prevention Projects to Reduce Impacts from Flooding and Dam Failure*		
Project	**Project 6.5.1 - Review NFIP Repetitive Loss properties in Yellowstone County and address means to eliminate or reduce impacts from flooding.**		
Category	Prevention		
Hazard(s) Addressed	Flooding		
Jurisdiction(s)	County		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)	x	1
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)		
	Medium = Technology may be available/implementation could be difficult (2 points)	x	2
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	9
	Low = 3 to 5 points		
County Priority	High, Medium, Low	Medium	
Responsible Agency	Floodplain Administrator		
Potential Funding Source(s)	Private resources, FEMA grants		
Implementation Schedule	Long-term		
Progress Made	Letter sent to RL owners identifying mitigation grants. Cost share has been hang-up. One owner offered buyout and not interested. One house was moved and dropped off RL list.		
Planned Activities	Continue same.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 6 - Reduce Impacts from Flooding and Dam Failure		
Objective	*Objective 6.5 - Implement Prevention Projects to Reduce Impacts from Flooding and Dam Failure*		
Project	**Project 6.5.2 - Strengthen subdivision regulations to ensure homes are not built where potentially impacted by flood flows from dry washes.**		
Category	Prevention		
Hazard(s) Addressed	Flooding		
Jurisdiction(s)	County		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)	x	1
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	Medium	
Responsible Agency	Floodplain Administrator		
Potential Funding Source(s)	County resources		
Implementation Schedule	Mid-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Develop language whereby dry washes are considered as source of flash flooding and disallowed unless engineered drainages are constructed.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 6 - Reduce Impacts from Flooding and Dam Failure		
Objective	*Objective 6.6 - Enhance Emergency Service Capabilities to Reduce Impacts from Flooding and Dam Failure*		
Project	**Project 6.6.1 - Participate in dam failure exercises on high hazard dams that could impact Yellowstone County.**		
Category	Emergency Service		
Hazard(s) Addressed	Dam Failure		
Jurisdiction(s)	Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	11
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	Medium	
Responsible Agency	DES		
Potential Funding Source(s)	County resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Ensure that first responders are aware of scheduled exercises for Cooney Dam.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 7 - Reduce Impacts from Communicable Disease		
Objective	*Objective 7.1 - Implement Prevention Projects to Reduce Impacts from Communicable Disease*		
Project	**Project 7.1.1 - Increase immunization rates for vaccine preventable communicable disease in all populations.**		
Category	Prevention		
Hazard(s) Addressed	Communicable Disease		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	RiverStone Health		
Potential Funding Source(s)	State, County and City resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Coordinate with DPHHS and local partners to continue community programs. Utilize RiverStone Health website and social media to advertise vaccination clinics.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 7 - Reduce Impacts from Communicable Disease		
Objective	*Objective 7.1 - Implement Prevention Projects to Reduce Impacts from Communicable Disease*		
Project	**Project 7.1.2 - Continue to prevent and control communicable disease by surveillance.**		
Category	Prevention		
Hazard(s) Addressed	Communicable Disease		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	
	Medium = 20 to 50% of County residents (2 points)		3
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	RiverStone Health, DPHHS		
Potential Funding Source(s)	State, County and City resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Continue to utilize DPHHS MT-IBIS database.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 7 - Reduce Impacts from Communicable Disease		
Objective	*Objective 7.1 - Implement Prevention Projects to Reduce Impacts from Communicable Disease*		
Project	**Project 7.1.3 - Contintue to conduct risk-based inspections of all food service establishments.**		
Category	Prevention		
Hazard(s) Addressed	Communicable Disease		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	RiverStone Health, DPHHS		
Potential Funding Source(s)	State, County and City resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Continue to inspect restaurants including mobile food venders during special events.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 7 - Reduce Impacts from Communicable Disease		
Objective	*Objective 7.2 - Implement Public Education and Awareness Projects to Reduce Impacts from Communicable Disease*		
Project	**Project 7.2.1 - Continue to promote public education on preventing communicable disease.**		
Category	Public Education and Awareness		
Hazard(s) Addressed	Communicable Disease		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	RiverStone Health, DPHHS		
Potential Funding Source(s)	State, County and City resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Continue to utilize Health Alert Network to communicate internally. Send alerts to physicians. Utilize State's 406 Weekly public health messages.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 7 - Reduce Impacts from Communicable Disease		
Objective	*Objective 7.2 - Implement Public Education and Awareness Projects to Reduce Impacts from Communicable Disease*		
Project	**Project 7.2.2 - Continue to provide education and/or training for Health Dept. staff and key partners in medical community.**		
Category	Public Education and Awareness		
Hazard(s) Addressed	Communicable Disease		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	RiverStone Health, DPHHS		
Potential Funding Source(s)	State, County and City resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Provide training on basic emergency response, surveillance and investigation, prevention of outbreaks, mass prophylaxis strategies, risk communication, isolation and quarantine protocols, and continuity of operations.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 7 - Reduce Impacts from Communicable Disease		
Objective	*Objective 7.3 - Enhance Emergency Service Capabilities to Reduce Impacts from Communicable Disease*		
Project	**Project 7.3.1 - Collaborate with community partners to train and exercise public health emergency response plans.**		
Category	Emergency Services		
Hazard(s) Addressed	Communicable Disease		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	RiverStone Health, DPHHS		
Potential Funding Source(s)	State, County and City resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Coordinate with LEPC to develop annual training and exercise schedules.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 7 - Reduce Impacts from Communicable Disease		
Objective	*Objective 7.3 - Enhance Emergency Service Capabilities to Reduce Impacts from Communicable Disease*		
Project	**Project 7.3.2 - Expand listserve for Health Alert Network.**		
Category	Emergency Services		
Hazard(s) Addressed	Communicable Disease		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	RiverStone Health		
Potential Funding Source(s)	County and City resources		
Implementation Schedule	Short-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Identify additional entities to receive alerts including first responders.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 7 - Reduce Impacts from Communicable Disease		
Objective	*Objective 7.4 - Implement Planning, Mapping, and Analysis Projects to Reduce Impacts from Communicable Disease*		
Project	**Project 7.4.1 - Collaborate and coordinate with community partners to review and update public health emergency response plans annually.**		
Category	Planning, Mapping and Analysis		
Hazard(s) Addressed	Communicable Disease		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	RiverStone Health, DPHHS		
Potential Funding Source(s)	State, County and City resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Comply with DPHHS requirement for quarterly updates with focus on different plans each quarter. Revise plans as needed.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 8 - Reduce Impacts from Landslide and Rock Falls Hazards		
Objective	*Objective 8.1 - Implement Structural Projects to Reduce Impacts from Landslide and Rock Fall Hazards*		
Project	**Project 8.1.1 - Identify, preserve, and stabilize rock fall-prone areas.**		
Category	Structural		
Hazard(s) Addressed	Landslide / Rock Fall		
Jurisdiction(s)	County, Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)	x	1
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	9
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	City and County Public Works Depts.		
Potential Funding Source(s)	County and City resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Perform regular surveillance of Rims to identify loose rock. Implement preventative measures to reduce rock falls. Stablize rock face after rock fall events.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 9 - Reduce Impacts Associated with All Hazards		
Objective	*Objective 9.1 - Enhance Emergency Service Capabilities to Mitigate Impacts from All Hazards*		
Project	**Project 9.1.1 - Implement mass notification capabilities throughout Yellowstone County.**		
Category	Emergency Services		
Hazard(s) Addressed	All Hazards		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	11
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES		
Potential Funding Source(s)	County resources		
Implementation Schedule	Short-term		
Progress Made	In final stages of procuring Code Red for mass notification.		
Planned Activities	Implement Code Red system county-wide. Utilized broadcast, print, and social media on how to sign up. Begin first test alerts.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 9 - Reduce Impacts Associated with All Hazards		
Objective	*Objective 9.1 - Enhance Emergency Service Capabilities to Mitigate Impacts from All Hazards*		
Project	**Project 9.1.2 -Enhance rural communications by coordinating and cooperating on getting First Net in place in Yellowstone County to improve first responder communications.**		
Category	Emergency Services		
Hazard(s) Addressed	All Hazards		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	11
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, LEPC		
Potential Funding Source(s)	County resources		
Implementation Schedule	Mid-term		
Progress Made	Counties in former DES District 5 worked together as Big Sky 12 for Interoperability Project.		
Planned Activities	Assist, as needed, in mapping and identifying locations for First Net cell towers. Focus on rural locations.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 9 - Reduce Impacts Associated with All Hazards		
Objective	*Objective 9.1 - Enhance Emergency Service Capabilities to Mitigate Impacts from All Hazards*		
Project	**Project 9.1.3 - Obtain mobile repeaters for patrol cars.**		
Category	Emergency Services		
Hazard(s) Addressed	All Hazards		
Jurisdiction(s)	County		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	Sheriff's Office		
Potential Funding Source(s)	County resources		
Implementation Schedule	Mid-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Identify equipment needs and funding. Procure as feasible.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 9 - Reduce Impacts Associated with All Hazards		
Objective	*Objective 9.1 - Enhance Emergency Service Capabilities to Mitigate Impacts from All Hazards*		
Project	**Project 9.1.4 - Identify facilities that meet national standards to serve as emergency shelters and create Memorandums of Understanding.**		
Category	Emergency Services		
Hazard(s) Addressed	All Hazards		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)	x	2
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	9
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, American Red Cross		
Potential Funding Source(s)	County and City resources		
Implementation Schedule	Mid-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Work with Red Cross to identify shelter locations. Develop template for MOUs. Coordinate with facility owners to get agreements in place.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 9 - Reduce Impacts Associated with All Hazards		
Objective	*Objective 9.1 - Enhance Emergency Service Capabilities to Mitigate Impacts from All Hazards*		
Project	**Project 9.1.5 - Obtain stationary and/or mobile generators for critical facilities and emergency shelters and install hookups.**		
Category	Emergency Services		
Hazard(s) Addressed	All Hazards		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)	x	1
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	8
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, Critical Facility Owners		
Potential Funding Source(s)	County and City resources, Grants		
Implementation Schedule	Mid-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Create prioritized list of generator needs. Apply for funding. Determine hookup specifications for rental generators. Install transfer switches to accept mobile units.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 9 - Reduce Impacts Associated with All Hazards		
Objective	*Objective 9.1 - Enhance Emergency Service Capabilities to Mitigate Impacts from All Hazards*		
Project	**Project 9.1.6 - Recruit and train emergency response personnel.**		
Category	Emergency Services		
Hazard(s) Addressed	All Hazards		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, LEPC		
Potential Funding Source(s)	County and City resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Utilize print, broadcast, social media and word or mouth to recruit. Provide ICS and more specialized training as appropriate.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 9 - Reduce Impacts Associated with All Hazards		
Objective	*Objective 9.1 - Enhance Emergency Service Capabilities to Mitigate Impacts from All Hazards*		
Project	**Project 9.1.7 - Continue to agressively address rural properties.**		
Category	Emergency Services		
Hazard(s) Addressed	All Hazards		
Jurisdiction(s)	County		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)	x	1
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	8
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	Dispatch, County Planning Dept.		
Potential Funding Source(s)	County resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Utilized print, broadcast, and social media to ensure all rural homes are addressed. Promote placement of addresses at standard height and location.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 9 - Reduce Impacts Associated with All Hazards		
Objective	*Objective 9.2 - Implement Public Education and Awareness Projects to Reduce Impacts from All Hazards*		
Project	**Project 9.2.1 - Interact with public safety officials and schools on planning for emergencies.**		
Category	Public Education and Awareness		
Hazard(s) Addressed	All Hazards		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, LEPC, School Resource Officer		
Potential Funding Source(s)	County, City, School District Resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Opportunity for new DES Coordinator to work with schools and first responders.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 9 - Reduce Impacts Associated with All Hazards		
Objective	*Objective 9.2 - Implement Public Education and Awareness Projects to Reduce Impacts from All Hazards*		
Project	**Project 9.2.2 - Provide special needs facilities with guidelines for disaster preparedness, including pet needs.**		
Category	Public Education and Awareness		
Hazard(s) Addressed	All Hazards		
Jurisdiction(s)	County, Billings, Laurel, Broadview		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)	x	1
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	8
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	DES, Special Needs Facilities, Migrant Worker Council		
Potential Funding Source(s)	County, City, and private resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Work with facilities to review and update emergency response plans.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 9 - Reduce Impacts Associated with All Hazards		
Objective	*Objective 9.3 - Implement Planning, Mapping, and/or Analysis Projects to Reduce Impacts from All Hazards*		
Project	**Project 9.3.1 - Enhance GIS data to better to assist with hazard mitigation.**		
Category	Mapping, Planning, and Analysis		
Hazard(s) Addressed	All Hazards		
Jurisdiction(s)	County, Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	County and City GIS Depts.		
Potential Funding Source(s)	County and City resources		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Update hazard layers, water sources, shelter locations, and others to assist with emergency management. Provide Fire Depts. continuously with updated road books, wall maps.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 9 - Reduce Impacts Associated with All Hazards		
Objective	*Objective 9.3 - Implement Planning, Mapping, and/or Analysis Projects to Reduce Impacts from All Hazards*		
Project	**Project 9.3.2 - Develop plan for short-term water supply in Billings.**		
Category	Mapping, Planning, and Analysis		
Hazard(s) Addressed	All Hazards		
Jurisdiction(s)	Billings		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)	x	2
	Low = < $100,000 (3 points)		
Population Benefit	High = > 50% of County residents (3 points)	x	3
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)		
Property Benefit	High = > $500,000 (3 points)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)	x	1
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points		
	Medium = 6 to 9 points	x	9
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	County and City Public Works Depts.		
Potential Funding Source(s)	County and City resources, grants		
Implementation Schedule	Mid-term		
Progress Made	New project for 2019 Plan.		
Planned Activities	Identify resources that could supply bottled water. Develop agreements with distributors. Develop protocols for distribution. Look into gravel pit acquisition for temporary water storage. Consider new water treatment plant on west end of Billings.		

2019 YELLOWSTONE COUNTY MONTANA MULTI-HAZARD MITIGATION PLAN			
Mitigation Action Plan			
Goal	Goal 9 - Reduce Impacts Associated with All Hazards		
Objective	*Objective 9.4 - Implement Prevention Projects to Mitigate Impacts from All Hazards*		
Project	**Project 9.4.1 - Update growth policies and subdivision regulations as needed to conside hazard mitigation.**		
Category	Prevention		
Hazard(s) Addressed	All Hazards		
Jurisdiction(s)	County, Billings, Laurel		
Benefit-Cost Ranking	**Options**	**Selection**	**Score**
Estimated Cost	High = > $500,000 (1 point)		
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (3 points)	x	3
Population Benefit	High = > 50% of County residents (3 points)		
	Medium = 20 to 50% of County residents (2 points)		
	Low = < 20% County residents (1 point)	x	1
Property Benefit	High = > $500,000 (3 points)	x	3
	Medium = $100,000 to $500,000 (2 points)		
	Low = < $100,000 (1 point)		
Feasibility	High = Technology available/implementation likely (3 points)	x	3
	Medium = Technology may be available/implementation could be difficult (2 points)		
	Low = No technology available/implementation unlikely (1 point)		
Total Score	High = 10 to 12 points	x	10
	Medium = 6 to 9 points		
	Low = 3 to 5 points		
County Priority	High, Medium, Low	High	
Responsible Agency	County and City Planning Depts.		
Potential Funding Source(s)	County and City resources.		
Implementation Schedule	Ongoing		
Progress Made	New project for 2019 Plan.		
Planned Activities	Promote that when policies and regulations are updated that mitigation strategies are implemented for risk reduction .		

Yellowstone County Multi-Hazard Mitigation Plan 2019 Update

APPENDIX D

Relevant Plans



Yellowstone County, Montana,

Community Wildfire Protection Plan

February 28, 2006

Vision: *Institutionalize and promote a countywide hazard mitigation ethic through leadership, professionalism, and excellence, leading the way to a safe, sustainable Yellowstone County.*

This plan was developed by the Yellowstone County Community Wildfire Protection Plan Committee in cooperation with Northwest Management, Inc., P.O. Box 565, Helena, MT 59624, Phone: (406) 442-7555, Fax: (406) 495-9605, www.Consulting-Foresters.com

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Acknowledgments

This Community Wildfire Protection Plan represents the efforts and cooperation of a number of organizations and agencies; through the commitment of people working together to improve the preparedness for wildfire events while reducing factors of risk.

Yellowstone County Commissioners and the employees of Yellowstone County

State of Montana

USDI Bureau of Land Management

USDI Bureau of Indian Affairs

USDA Forest Service

Federal Emergency Management Agency

Montana Disaster and Emergency Services

USDI Bureau of Reclamation

Beartooth Resource Conservation & Development Council

Montana Fish, Wildlife, & Parks

Montana Department of Natural Resources and Conservation

City of Billings
City of Laurel
Town of Broadview
Yellowstone County Sheriff's Office
Yellowstone County Fire Departments
Yellowstone County Fire Districts
Yellowstone County Fire Service Areas
Deaconess Hospital
&
Local Businesses and Citizens of Yellowstone County

To obtain original copies of this plan contact:

Yellowstone County Commissioner's Office
Yellowstone County Courthouse
217 North 27th Street
Billings, Montana 59101

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Chapter I: Overview of this Plan and its Development

1 Introduction

This Community Wildfire Protection Plan for Yellowstone County, Montana, is the result of analyses, professional cooperation and collaboration, assessments of wildfire risks and other factors considered with the intent to reduce the potential for wildfires to threaten people, structures, infrastructure, and unique ecosystems in Yellowstone County, Montana. This Community Wildfire Protection Plan is an amendment to the Yellowstone County Pre Disaster Mitigation Plan, which was approved by FEMA in January 2005. The Yellowstone County Commissioners led the planning team responsible for implementing this project. Agencies and organizations that participated in the planning process included:

- Yellowstone County Commissioners and County Departments
- Yellowstone County Fire Warden
- Yellowstone County Disaster and Emergency Services
- Montana Department of Natural Resources and Conservation
- USDI Bureau of Land Management (also providing funding through the National Fire Plan)
- USDA Forest Service
- USDI Bureau of Indian Affairs
- Yellowstone County Fire Departments
- Town of Broadview
- Big Sky Economic Development Authority
- Yellowstone County Fire Districts and Fire Service Areas
- City of Billings
- Deaconess Hospital
- USDI Bureau of Reclamation
- U.S. Department of Homeland Security
- Beartooth Resource Conservation and Development Council
- Montana Fish, Wildlife, & Parks
- City of Laurel
- USDA Natural Resources Conservation Service
- Montana Disaster and Emergency Services
- Northwest Management, Inc.

The Yellowstone County Commissioners solicited competitive bids from companies to provide the service of leading the assessment and the writing of the **Yellowstone County Community Wildfire Protection Plan**. The Commissioners selected Northwest Management, Inc., to provide this service. Northwest Management, Inc., is a professional natural resources consulting

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firm located in Helena, Montana. Established in 1984, NMI provides natural resource management services across the USA. The Project Manager from Northwest Management, Inc. was Dr. William E. Schlosser, a professional forester and regional planner.

1.1 Goals and Guiding Principles

1.1.1 Federal Emergency Management Agency Philosophy

Effective November 1, 2004, a Local Hazard Mitigation Plan approved by the Federal Emergency Management Agency (FEMA) is required for Hazard Mitigation Grant Program (HMGP) and Pre-Disaster Mitigation Program (PDM) eligibility. The HMGP and PDM program provide funding, through state emergency management agencies, to support local mitigation planning and projects to reduce potential disaster damages.

The new local hazard mitigation plan requirements for HMGP and PDM eligibility is based on the Disaster Mitigation Act of 2000, which amended the Stafford Disaster Relief Act to promote an integrated, cost effective approach to mitigation. Local hazard mitigation plans must meet the minimum requirements of the Stafford Act-Section 322, as outlined in the criteria contained in 44 CFR Part 201. The plan criteria cover the planning process, risk assessment, mitigation strategy, plan maintenance, and adoption requirements.

FEMA will only review a local hazard mitigation plan submitted through the appropriate State Hazard Mitigation Officer (SHMO). Draft versions of local hazard mitigation plans will not be reviewed by FEMA. FEMA will review the final version of a plan prior to local adoption to determine if the plan meets the criteria, but FEMA will be unable to approve it prior to adoption. In Montana the SHMO is:

Montana Disaster and Emergency Services
P.O. Box 4789 - 1900 Williams Street
Helena, Montana 59604-4789
Dan McGowen, 841-3911 - FAX: 841-3965

A FEMA designed plan will be evaluated on its adherence to a variety of criteria.

- Adoption by the Local Governing Body
- Multi-jurisdictional Plan Adoption
- Multi-jurisdictional Planning Participation
- Documentation of Planning Process
- Identifying Hazards
- Profiling Hazard Events
- Assessing Vulnerability: Identifying Assets
- Assessing Vulnerability: Estimating Potential Losses
- Assessing Vulnerability: Analyzing Development Trends
- Multi-Jurisdictional Risk Assessment
- Local Hazard Mitigation Goals
- Identification and Analysis of Mitigation Measures
- Implementation of Mitigation Measures
- Multi-Jurisdictional Mitigation Strategy
- Monitoring, Evaluating, and Updating the Plan
- Implementation Through Existing Programs
- Continued Public Involvement

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1.1.2 Additional State and Federal Guidelines Adopted

The Community Wildfire Protection Plan will include compatibility with FEMA requirements while also adhering to the guidelines proposed in the National Fire Plan and the Healthy Forests Restoration Act (2004). This Community Wildfire Protection Plan has been prepared in compliance with:

- The National Fire Plan; A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment 10-Year Comprehensive Strategy Implementation Plan–May 2002.
- Northern Rockies Coordinating Group
- Healthy Forests Restoration Act (2004)
- The Federal Emergency Management Agency's guidelines for a Local Hazard Mitigation Plan as defined in 44 CFR parts 201 and 206, and as related to a fire mitigation plan chapter of a Natural Hazards Mitigation Plan.

> ***"When implemented, the 10-Year Comprehensive Strategy will contribute to reducing the risks of wildfire to communities and the environment by building collaboration at all levels of government."***
> **- The NFP 10-Year Comprehensive Strategy August 2001**

The objective of combining these four complimentary guidelines is to facilitate an integrated wildland fire risk assessment, identify pre-hazard mitigation activities, and prioritize activities and efforts to achieve the protection of people, structures, the environment, and significant infrastructure in Yellowstone County while facilitating new opportunities for pre-disaster mitigation funding and cooperation.

1.1.2.1 National Fire Plan

The goals of this Community Wildfire Protection Plan include:

1. Improve Fire Prevention and Suppression
2. Reduce Hazardous Fuels
3. Restore Fire-Adapted Ecosystems
4. Promote Community Assistance

Its three guiding principles are:

1. Priority setting that emphasizes the protection of communities and other high-priority watersheds at-risk.
2. Collaboration among governments and broadly representative stakeholders
3. Accountability through performance measures and monitoring for results.

This Community Wildfire Protection Plan fulfills the National Fire Plan's 10-Year Comprehensive Strategy. The projects and activities recommended under this plan are in addition to other Federal, state, and private / corporate forest and rangeland management activities. The implementation plan does not alter, diminish, or expand the existing jurisdiction, statutory and regulatory responsibilities and authorities or budget processes of participating Federal, State, and tribal agencies.

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By endorsing this implementation plan, all signed parties agree that reducing the threat of wildland fire to people, communities, and ecosystems will require:

- Firefighter and public safety continuing as the highest priority.
- A sustained, long-term and cost-effective investment of resources by all public and private parties, recognizing overall budget parameters affecting Federal, State, Tribal, and local governments.
- A unified effort to implement the collaborative framework called for in the Strategy in a manner that ensures timely decisions at each level.
- Accountability for measuring and monitoring performance and outcomes, and a commitment to factoring findings into future decision making activities.
- The achievement of national goals through action at the local level with particular attention on the unique needs of cross-boundary efforts and the importance of funding on-the-ground activities.
- Communities and individuals in the wildland-urban interface to initiate personal stewardship and volunteer actions that will reduce wildland fire risks.
- Management activities, both in the wildland-urban interface and in at-risk areas across the broader landscape.
- Active forestland and rangeland management, including thinning that produces commercial or pre-commercial products, biomass removal and utilization, prescribed fire and other fuels reduction tools to simultaneously meet long-term ecological, economic, and community objectives.

The National Fire Plan identifies a three-tiered organization structure including 1) the local level, 2) state/regional and tribal level, and 3) the national level. This plan adheres to the collaboration and outcomes consistent with a local level plan. Local level collaboration involves participants with direct responsibility for management decisions affecting public and/or private land and resources, fire protection responsibilities, or good working knowledge and interest in local resources. Participants in this planning process include Tribal representatives, local representatives from Federal and State agencies, local governments, landowners and other stakeholders, and community-based groups with a demonstrated commitment to achieving the strategy's four goals. Existing resource advisory committees, watershed councils, or other collaborative entities may serve to achieve coordination at this level. Local involvement, expected to be broadly representative, is a primary source of planning, project prioritization, and resource allocation and coordination at the local level. The role of the private citizen is not to be underestimated, as their input and contribution to all phases of risk assessments, mitigation activities, and project implementation is greatly facilitated by their involvement.

1.1.2.1.1 Montana's Endorsement of the National Fire Plan

In May 2002, Montana Governor Martz, as a member of the Western Governors' Association, helped develop the *10-Year Comprehensive Strategy* and an implementation plan, titled *A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment*. With the Western Governors' Association endorsement of the Implementation plan, Montana adopted the national implementation plan as its own.

NFP funding to the states occurs under the community assistance point and is made available through the USFS, state, and private forestry programs. DNRC has responsibility for delivery of

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these programs on state-owned and private lands in Montana. NFP funding can also come directly from Department of Interior agencies.

The DNRC NFP Program is implemented primarily within the Forestry Division's Fire and Aviation Management Bureau (FAMB) and Service Forestry Bureau (SFB). The National Fire Plan is delivered, wherever appropriate, through existing state and private forestry programs. These programs are:

- County Cooperative Fire Program (FAMB)
- State Fire Assistance Program (FAMB)
- Private Forestry Assistance Program (SFB)
- Stewardship Program (SFB)

The Volunteer and Rural Fire Assistance (VFA/RFA) Program provides assistance to county fire agencies for equipment, training, and fire prevention materials. Adding National Fire Plan funding resulted in a grant program with more money than ever before. Again in 2003, the Department of the Interior agencies (FWS, BIA, & BLM) contributed their budgeted Rural Fire Assistance Program dollars to be combined with the Volunteer Fire Assistance funds granted by the USDA Forest Service. The total assistance available in Montana exceeded $1.1 million in 2003. DNRC and its partners were recognized with the Ben Franklin Award, given by the Forest Service annually to one state for excellence in delivering these programs.

1.1.2.2 Northern Rockies Coordinating Group

The Northern Rockies Coordination Group (NRCG) was established to provide an interagency approach to wildland fire management and all-risk support on all land ownerships within the States of Montana, North Dakota, northern Idaho, and a small portion of South Dakota and Wyoming. NRCG is made up of representatives from the Montana Fire Warden's Association, Montana Disaster and Emergency Services Division, Montana Department of Natural Resources and Conservation, Idaho Department of Lands, North Dakota Forest Service, Bureau of Land Management, National Park Service, Bureau of Indian Affairs, Fish and Wildlife Service, Forest Service, Montana Fire Chief's Association, and Montana Sheriff's and Peace Officer's Association. The purpose of NRCG is to further interagency cooperation, communications, coordination, and to provide interagency fire management direction and all-risk support for the Northern Rockies Geographic Area.

1.1.2.2.1 County Wildland Fire Interagency Group

Each County within the state has been requested to write a Community Wildfire Protection Plan. These plans should contain at least the following five elements:

1) Documentation of the process used to develop the mitigation plan. How the plan was developed, who was involved and how the public was involved.
2) A risk assessment to identify vulnerabilities to wildfire in the wildland-urban interface (WUI).
3) A prioritized mitigation strategy that addresses each of the risks. Examples of these strategies could be: training for fire departments, public education, hazardous fuel treatments, equipment, communications, additional planning, new facilities, infrastructure improvements, code and/or ordinance revision, volunteer efforts, evacuation plans, etc.

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4) A process for maintenance of the plan which will include monitoring and evaluation of mitigation activities
5) Documentation that the plan has been formally adopted by the involved agencies. Basically a signature page of all involved officials.

This five-element plan is an abbreviated version of the FEMA mitigation plan and will be an amendment to the Yellowstone County Pre Disaster Mitigation Plan. To develop these plans each county should bring together the following individuals, as appropriate for each county, to make up the County Wildland Fire Interagency Group. It is important that this group has representation from agencies with wildland fire suppression responsibilities:

- County Commissioners (Lead)
- Local Fire Chiefs
- Montana Department of Natural Resources and Conservation representative
- USDA Forest Service representative
- USDI Bureau of Land Management representative
- US Fish and Wildlife representative
- Bureau of Indian Affairs
- Local Tribal leaders
- Division of Disaster and Emergency Services
- LEPC Chairperson
- Resource Conservation and Development representative
- State Fish and Game representative
- Interested citizens and community leaders as appropriate
- Other officials as appropriate

If requested by the County Commissioners, the local Resource Conservation and Development Councils may be available to assist the County Commissioners in evaluating each County within their council area to determine if there is a community wildfire protection plan in place, or if a plan is currently in the development phase. If no plan is in place, the RC&D's, if requested, could be available to assist the Commissioners with the formation of the County Wildland Fire Interagency Group and/or to facilitate the development of a community wildfire protection plan.

If a plan has been previously completed, the Commissioners will determine if the recommended five elements have been addressed. The Counties will provide a copy of the completed mitigation plan to the Montana Department of Natural Resources and Conservation Fire Plan Coordinator, which will include a contact list of individuals that developed the plan.

1.1.2.3 National Association of State Foresters

1.1.2.3.1 Identifying and Prioritizing Communities at Risk

This plan is written with the intent to provide the information necessary for decision makers (elected officials) to make informed decisions in order to prioritize projects across the entire county. These decisions may be made from within the Board of Commissioners, or through the recommendations of ad hoc groups tasked with making prioritized lists of projects. It is not necessary to rank projects numerically, although that is one approach, rather it may be possible to rank them categorically (high priority set, medium priority set, and so forth) and still accomplish the goals and objectives set forth in this planning document.

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The following was prepared by the National Association of State Foresters (NASF), June 27, 2003, and is included here as a reference for the identification of prioritizing treatments between communities.

Purpose: To provide national, uniform guidance for implementing the provisions of the "Collaborative Fuels Treatment" MOU, and to satisfy the requirements of Task e, Goal 4 of the Implementation Plan for the 10-Year Comprehensive Strategy.

Intent: The intent is to establish broad, nationally compatible standards for identifying and prioritizing communities at risk, while allowing for maximum flexibility at the state and regional level. Three basic premises are:

- Include all lands and all ownerships.
- Use a collaborative process that is consistent with the complexity of land ownership patterns, resource management issues, and the number of interested stakeholders.
- Set priorities by evaluating projects, not by ranking communities.

The National Association of State Foresters (NASF) set forth the following guidelines in the Final Draft Concept Paper; Communities at Risk, December 2, 2002.

Task: Develop a definition for "communities at risk" and a process for prioritizing them, per the Implementation Plan for the 10-Year Comprehensive Strategy (Goal 4.e.). In addition, this definition will form the foundation for the NASF commitment to annually identify priority fuels reduction and ecosystem restoration projects in the proposed MOU with the federal agencies (section C.2 (b)).

1.1.2.3.2 Conceptual Approach

1. NASF fully supports the definition of the Wildland Urban Interface (WUI) previously published in the Federal Register. Further, proximity to federal lands should not be a consideration. The WUI is a set of conditions that exists on, or near, areas of wildland fuels nation-wide, regardless of land ownership.
2. Communities at risk (or, alternately, landscapes of similar risk) should be identified on a state-by-state basis with the involvement of all agencies with wildland fire protection responsibilities: state, local, tribal, and federal.
3. It is neither reasonable nor feasible to attempt to prioritize communities on a rank order basis. Rather, communities (or landscapes) should be sorted into three, broad categories or zones of risk: high, medium, and low. Each state, in collaboration with its local partners, will develop the specific criteria it will use to sort communities or landscapes into the three categories. NASF recommends using the publication "Wildland/Urban Interface Fire Hazard Assessment Methodology" developed by the National Wildland/Urban Interface Fire Protection Program (circa 1998) as a reference guide. (This program, which has since evolved into the Firewise Program, is under the oversight of the National Wildfire Coordinating Group (NWCG)). At minimum, states should consider the following factors when assessing the relative degree of exposure each community (landscape) faces.
    - **Risk:** Using historic fire occurrence records and other factors, assess the anticipated probability of a wildfire ignition.
    - **Hazard:** Assess the fuel conditions surrounding the community using a methodology such as fire condition class, or [other] process.

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- **Values Protected:** Evaluate the human values associated with the community or landscape, such as homes, businesses, and community infrastructure (e.g. water systems, utilities, transportation systems, critical care facilities, schools, manufacturing and industrial sites, and high value commercial timber lands).
- **Protection Capabilities:** Assess the wildland fire protection capabilities of the agencies and local fire departments with jurisdiction.

4. Prioritize by project not by community. Annually prioritize projects within each state using the collaborative process defined in the national, interagency MOU "For the Development of a Collaborative Fuels Treatment Program". Assign the highest priorities to projects that will provide the greatest benefits either on the landscape or to communities. Attempt to properly sequence treatments on the landscape by working first around and within communities, and then moving further out into the surrounding landscape. This will require:
   - First, focus on the zone of highest overall risk but consider projects in all zones. Identify a set of projects that will effectively reduce the level of risk to communities within the zone.
   - Second, determine the community's willingness and readiness to actively participate in an identified project.
   - Third, determine the willingness and ability of the owner of the surrounding land to undertake, and maintain, a complementary project.
   - Last, set priorities by looking for projects that best meet the three criteria above. It is important to note that projects with the greatest potential to reduce risk to communities and the landscape may not be those in the highest risk zone, particularly if either the community or the surrounding landowner is not willing or able to actively participate.
5. It is important, and necessary, that we be able to demonstrate a level of accomplishment that justifies to Congress the value of continuing the current level of appropriations for the National Fire Plan. Although appealing to appropriators and others, it is not likely that many communities (if any) will ever be removed from the list of communities at risk. Even after treatment, all communities will remain at some, albeit reduced, level of risk. However, by using a science-based system for measuring relative risk, we can likely show that, after treatment (or a series of treatments); communities are at "*reduced risk*".

Similarly, scattered, individual homes that complete projects to create defensible space could be "counted" as "households at reduced risk". This would be a way to report progress in reducing risk to scattered homes in areas of low priority for large-scale fuels treatment projects.

Using the concept described above, the NASF believes it is possible to accurately assess the relative risk that communities face from wildland fire. Recognizing that the condition of the vegetation (fuel) on the landscape is dynamic, assessments and re-assessments must be done on a state-by-state basis, using a process that allows for the integration of local knowledge, conditions, and circumstances, with science-based national guidelines. We must remember that it is not only important to lower the risk to communities, but once the risk has been reduced, to maintain those communities at a reduced risk.

Further, it is essential that both the assessment process and the prioritization of projects be done collaboratively, with all local agencies with fire protection jurisdiction – federal, state, local, and tribal – taking an active role.

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1.1.2.4 Healthy Forests Restoration Act

On December 3, 2003, President Bush signed into law the Healthy Forests Restoration Act of 2003 to reduce the threat of destructive wildfires while upholding environmental standards and encouraging early public input during review and planning processes. The legislation is based on sound science and helps further the President's Healthy Forests Initiative pledge to care for America's forests and rangelands, reduce the risk of catastrophic fire to communities, help save the lives of firefighters and citizens, and protect threatened and endangered species.

Among other things the Healthy Forests Restoration Act (HFRA):

- Strengthens public participation in developing high priority projects;
- Reduces the complexity of environmental analysis allowing federal land agencies to use the best science available to actively manage land under their protection;
- Creates a pre-decisional objections process encouraging early public participation in project planning; and
- Issues clear guidance for court action challenging HFRA projects.

The Yellowstone County Community Wildfire Protection Plan is developed to adhere to the principles of the HFRA while providing recommendations consistent with the policy document which should assist the federal land management agencies (US Forest Service and Bureau of Land Management) with implementing wildfire mitigation projects in Yellowstone County that incorporate public involvement and the input from a wide spectrum of fire and emergency services providers in the region.

1.1.3 Local Guidelines and Integration with Other Efforts

1.1.3.1 Yellowstone County Fire Mitigation Planning Effort and Philosophy

The goals of this planning process include the integration of the National Fire Plan, the Western Governors Association Implementation Strategy, the Healthy Forests Restoration Act, and the requirements of FEMA for a countywide Community Wildfire Protection Plan, a component of the County's All Hazards Pre-Disaster Mitigation Plan. This effort will utilize the best and most appropriate science from all partners, the integration of local and regional knowledge about wildfire risks and fire behavior, while meeting the needs of local citizens, the regional economy, the significance of this region to the rest of Montana and the Inland West.

1.1.3.1.1 Mission Statement

To make Yellowstone County residents, communities, state agencies, local governments, and businesses less vulnerable to the negative effects of wildland fires through the effective administration of wildfire hazard mitigation grant programs, hazard risk assessments, wise and efficient fuels treatments, and a coordinated approach to mitigation policy through federal, state, regional, and local planning efforts. Our combined prioritization will be the protection of people, structures, infrastructure, and unique ecosystems that contribute to our way of life and the sustainability of the local and regional economy.

1.1.3.1.2 Vision Statement

Institutionalize and promote a countywide wildfire hazard mitigation ethic through leadership, professionalism, and excellence, leading the way to a safe, sustainable Yellowstone County.

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1.1.3.1.3 Goals

- To reduce the area of WUI land burned and losses experienced because of wildfires where these fires threaten communities in the wildland-urban interface
- Prioritize the protection of people, structures, infrastructure, and unique ecosystems that contribute to our way of life and the sustainability of the local and regional economy
- Educate communities about the unique challenges of wildfire in the wildland-urban interface (WUI)
- Establish mitigation priorities and develop mitigation strategies in Yellowstone County
- Strategically locate and plan fuel reduction projects
- Provide recommendations for alternative treatment methods, such as modifying forest stand density, herbicide treatments, fuel reduction techniques, and disposal or removal of treated slash
- Meet or exceed the requirements of the National Fire Plan and FEMA for a County level Wildfire Protection Plan

1.1.3.2 Yellowstone County and City of Billings 2003 Growth Policy Plan

The Growth Policy Plan provides a vision for the County that indicates how it wants to develop and make public investments over the next 20 years. It analyzes land use, natural resources, public facilities, local services, population, economics, and housing to identify local issues and devise appropriate policies that will address those issues in a manner consistent with this vision. It provides the long-range focus to help decision-makers set priorities and evaluate whether development proposals are consistent with this vision. It is a tool to coordinate with other government agencies and to communicate to citizens and developers the vision of the community. The Plan provides the framework for regulatory updates, land use decisions, and public investments and will be an invaluable resource for the County as it enters the 21st Century.

The plan is a dynamic document that represents a continuous process of setting goals and establishing priorities on actions to achieve those goals. This plan provides for periodic updates and review of the plan. These updates will allow the County to reflect changing conditions and take advantage of new opportunities.

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Chapter 2: Planning Process

2 Documenting the Planning Process

Documentation of the planning process, including public involvement, is required to meet FEMA's DMA 2000 (44CFR§201.4(c)(1) and §201.6(c)(1)). This section includes a description of the planning process used to develop this plan, including how it was prepared, who was involved in the process, and how all of the involved agencies participated.

2.1 Description of the Planning Process

The Yellowstone County Community Wildfire Protection Plan was developed through a collaborative process involving all of the organizations and agencies detailed in Section 1.0 of this document. The County's local coordinator contacted these organizations directly to invite their participation and schedule meetings of the planning committee. The planning process included 5 distinct phases which were in some cases sequential (step 1 then step 2) and in some cases intermixed (step 4 completed though out the process):

1. **Collection of Data** about the extent and periodicity of wildfires in and around Yellowstone County. This included an area encompassing Big Horn, Treasure, Rosebud, Musselshell, Golden Valley, Stillwater, and Carbon Counties to insure a robust dataset for making inferences about fires in Yellowstone County specifically; this included a wildfire extent and ignition profile.
2. **Field Observations and Estimations** about wildfire risks including fuels assessments, juxtaposition of structures and infrastructure to wildland fuels, access, and potential treatments by trained wildfire specialists.
3. **Mapping** of data relevant to wildfire control and treatments, structures, resource values, infrastructure, fire prone landscapes, and related data.
4. **Facilitation of Public Involvement** from the formation of the planning committee, to a public mail survey, news releases, public meetings, public review of draft documents, and acceptance of the final plan by the signatory representatives.
5. **Analysis and Drafting of the Report** to integrate the results of the planning process, providing ample review and integration of committee and public input, followed by acceptance of the final document.

2.2 The Planning Team

Planning efforts were led by the Project Co-Directors, Dr. William E. Schlosser, Tera R. King, B.S., and Gary Ellingson, B.S., of Northwest Management, Inc. Dr. Schlosser's education includes 4 degrees in natural resource management (A.S. geology; B.S. forest and range management; M.S. natural resource economics & finance; Ph.D. environmental science and regional planning). Mrs. King and Mr. Ellingson both hold bachelor's degrees in Forest Resource Management.

They led a team of resource professionals, city and rural fire protection, law enforcement, State of Montana Disaster and Emergency Services, Montana Department of Natural Resources and Conservation, the Bureau of Land Management, and the Bureau of Indian Affairs; also included were fire mitigation specialists, resource management professionals, and hazard mitigation experts.

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The planning team met with many residents of the county during the inspections of communities, infrastructure, and hazard abatement assessments. This methodology, when coupled with the other approaches in this process, worked adequately to integrate a wide spectrum of observations and interpretations about the project.

The planning philosophy employed in this project included the open and free sharing of information with interested parties. Information from federal and state agencies was integrated into the database of knowledge used in this project. Meetings with the committee were held throughout the planning process to facilitate a sharing of information between cooperators.

When the public meetings were held, many of the committee members were in attendance and shared their support and experiences with the planning process and their interpretations of the results.

2.2.1 Multi-Jurisdictional Participation

CFR requirement §201.6(a)(3) calls for multi-jurisdictional planning in the development of community wildfire protection plans which impact multiple jurisdictions. This Community Wildfire Protection Plan is applicable to the following Jurisdictions:

- Yellowstone County, Montana
- City of Billings
- City of Laurel
- Town of Broadview

All of these jurisdictions were represented on the planning committee, in public meetings, and participated in the development of hazard profiles, risk assessments, and mitigation measures. The monthly planning committee meetings were the primary venue for authenticating the planning record. However, additional input was gathered from each jurisdiction in a combination of the following ways:

- Planning committee leadership visits to scheduled municipality public meeting (e.g., County Commission meetings, City Hall meetings) where planning updates were provided and information was exchanged.
- One-on-one visits between the planning committee leadership and the representatives of the municipality (e.g., meetings with County Commissioners, or City Councils in chambers).
- Special meetings at each jurisdiction by the planning committee leadership requested by the municipality involving elected officials (Mayor and County Commissioners, County Assessor, Sheriff), appointed officials (e.g. City Police, Disaster and Emergency Services Director), municipality employees, local volunteers (e.g., fire district volunteers), business community representatives, and local citizenry.
- Written correspondence was provided monthly between the planning committee leadership and each municipality updating the cooperators in the planning process, making requests for information, and facilitating feedback.

Planning committee leadership (referenced above) included: Jim Kraft, Yellowstone County Disaster and Emergency Services, Dr. William E. Schlosser and Tera King, of Northwest Management, Inc., Dianne Lehm from the Big Sky Economic Development Authority, and the Bureau of Land Management.

Like other rural areas of Montana and the USA, Yellowstone County's human resources have many demands put on them in terms of time and availability. Recognizing this, many of the

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jurisdictions decided to identify a representative from the jurisdiction to cooperate on the planning committee and then report back to the remainder of their organization on the process and serve as a conduit between the planning committee and the jurisdiction. This was the case with the Yellowstone County Commissioners where one of the Commissioners would attend the planning committee meetings as a regular attendee.

At the city level, the city mayors were represented in a variety of ways. The individual mayors commonly appointed a representative from the municipality to provide this representation on the committee meetings. For example, Jenny Johnson, Laurel City Councilperson represented the Mayor of the City of Laurel. The planning committee leadership provided communications and feedback with the municipality directly to insure the multi-jurisdictional planning necessitated by this process.

2.3 Public Involvement

Public involvement in this plan was made a priority from the inception of the project. There were a number of ways that public involvement was sought and facilitated. In some cases this led to members of the public providing information and seeking an active role in protecting their own homes and businesses, while in other cases it led to the public becoming more aware of the process without becoming directly involved in the planning process.

2.3.1 News Releases

Under the auspices of the Yellowstone County Community Wildfire Protection Plan Committee, news releases were submitted to the local area newspapers, television stations, and radio broadcast networks. The following is an example of one of the press releases submitted during the planning process.

Yellowstone County Plans to Mitigate Wildfire Risk In and Out of Cities of Billings, Laurel and Broadview

Yellowstone County Commissioners have created a Wildland Fire Mitigation Plan Committee to complete a Wildfire Mitigation Plan for Yellowstone County as part of the National Fire Plan and Healthy Forests Restoration Act as authorized by Congress and the White House. The Wildfire Mitigation Plan, funded through a grant from the Bureau of Land Management (BLM), will include risk analysis at the community level with predictive models for where fires are likely to ignite and where they are likely to spread rapidly once ignited. Northwest Management, Inc. (NWM) has been retained by Yellowstone County to provide wildfire risk assessments, mapping, field inspections, and interviews, and to collaborate with the committee to prepare the plan. The committee includes rural and wildland fire districts, land managers, elected officials, agency representatives, and others. NWM specialists are conducting analyses of fire prone landscapes and making recommendations for potential treatments. Specific activities for homes, structures, infrastructure, and resource capabilities will be proposed as part of the analysis.

One of the most important steps in gathering information about fire risk in Yellowstone County is to conduct a homeowner's survey. NWM, in cooperation with local fire officials, will mail a brief survey to randomly selected homeowners across the county seeking input about home construction materials, proximity to water sources, and other risk factors surrounding homes. This survey is very important to the success of the plan. Those homeowners that receive a survey are asked to please take the time to complete it, thereby benefiting the community overall.

The planning team, along with commissioner participation, will be conducting public meetings to

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discuss preliminary findings and to seek public involvement in the planning process in early October. A notice on the date and location of these meetings will be posted in local newspapers.

For more information on the Fire Mitigation Plan for Yellowstone County contact Jim Kraft, Yellowstone County Disaster and Emergency Services Director at 406-256-2775 or Marv Jochems, Billings City Fire Chief at 406-657-8420.

2.3.2 Newspaper Articles

Committee and public meeting announcements were published in the local newspaper ahead of each meeting. The following are examples of newspaper announcements that ran in the *Billings Gazette*, the *Yellowstone County News,* and the *Laurel Outlook*.

Figure 2.1. *Billings Gazette* announcement published on September 28th, September 30th, and October 2nd, 2005.

Yellowstone County values your input!

Please join us to learn about the **Community Wildfire Protection Plan** and how you can protect yourself and your property from wildfire.

Yellowstone County Commissioners and the Wildfire Mitigation Committee are seeking public input and comment on the development of a Community Wildfire Protection Plan. Take this opportunity to review the preliminary findings, draft plan, provide input on historical data, and participate in discussions of at risk areas.

Laurel
Monday, October 3, 7 pm
Laurel Fire Hall

Billings
Tuesday, October 4, 9:30 am
Yellowstone County Courthouse
Room 403

Wednesday, October 5, 12:00 pm
Yellowstone County Courthouse
Room 105

Worden/Huntley/Shepherd
Tuesday, October 4, 7:00 pm
Worden VFW

Broadview
Wednesday, October 5, 7:00 pm
Broadview Community Center

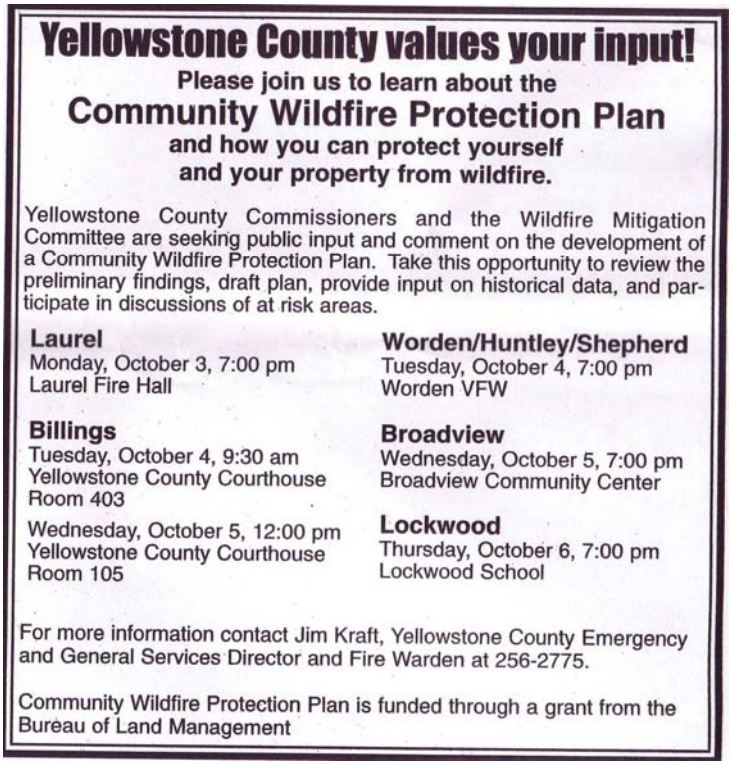
Lockwood
Thursday, October 6, 7:00 pm
Lockwood School

For more information contact Jim Kraft, Yellowstone County Emergency and General Services Director and Fire Warden at 256-2775.

Community Wildfire Protection Plan is funded through a grant from the Bureau of Land Management

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Figure 2.2. *Laurel Outlook* announcement published on September 28th, 2005.



Yellowstone County values your input!

Please join us to learn about the

Community Wildfire Protection Plan

and how you can protect yourself and your property from wildfire.

Yellowstone County Commissioners and the Wildfire Mitigation Committee are seeking public input and comment on the development of a Community Wildfire Protection Plan. Take this opportunity to review the preliminary findings, draft plan, provide input on historical data, and participate in discussions of at risk areas.

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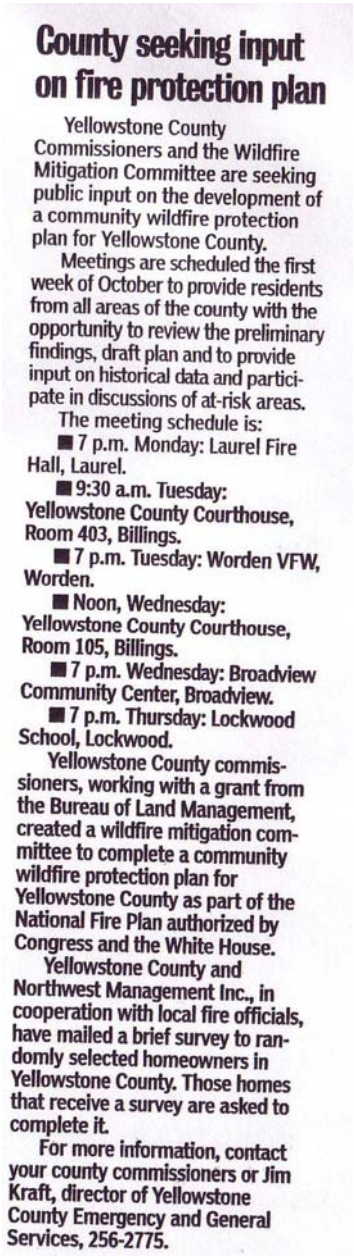
Lockwood
Thursday, October 6, 7:00 pm
Lockwood School

For more information contact Jim Kraft, Yellowstone County Emergency and General Services Director and Fire Warden at 256-2775.

Community Wildfire Protection Plan is funded through a grant from the Bureau of Land Management

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Figure 2.3. *Billings Gazette* article published on October 1st, 2005.



County seeking input on fire protection plan

Yellowstone County Commissioners and the Wildfire Mitigation Committee are seeking public input on the development of a community wildfire protection plan for Yellowstone County.

Meetings are scheduled the first week of October to provide residents from all areas of the county with the opportunity to review the preliminary findings, draft plan and to provide input on historical data and participate in discussions of at-risk areas.

The meeting schedule is:

- 7 p.m. Monday: Laurel Fire Hall, Laurel.
- 9:30 a.m. Tuesday: Yellowstone County Courthouse, Room 403, Billings.
- 7 p.m. Tuesday: Worden VFW, Worden.
- Noon, Wednesday: Yellowstone County Courthouse, Room 105, Billings.
- 7 p.m. Wednesday: Broadview Community Center, Broadview.
- 7 p.m. Thursday: Lockwood School, Lockwood.

Yellowstone County commissioners, working with a grant from the Bureau of Land Management, created a wildfire mitigation committee to complete a community wildfire protection plan for Yellowstone County as part of the National Fire Plan authorized by Congress and the White House.

Yellowstone County and Northwest Management Inc., in cooperation with local fire officials, have mailed a brief survey to randomly selected homeowners in Yellowstone County. Those homes that receive a survey are asked to complete it.

For more information, contact your county commissioners or Jim Kraft, director of Yellowstone County Emergency and General Services, 256-2775.

Figure 2.4. *Billings Gazette* article published on October 7th, 2005.

County drafting wildfire strategy

By BECKY SHAY
Of The Gazette Staff

Wildfire can be a formidable foe and the chance to fight it may be closer than you think.

To help residents and responders be prepared for the wildfires, Yellowstone County is working on a Community Wildfire Protection Plan.

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The document and projects will fit into the county's "all hazards plan" that was completed last year and covers potential problems as minor as hail and as devastating as terrorism, said to Tera King, who works for the county's consultant, Northwest Management Inc.

A committee of about 70 people has worked to develop the plan, which identifies areas that are at the most risk for fires that could damage private and public lands, buildings and infrastructure.

King said the committee hopes to hear from residents if they think there are areas that are not included or that should be made priorities.

Some of the projects areas identified so far include lands located in and around Buffalo Trail and Clapper Flats in the Laurel area, Echo Canyon toward Molt, Alkali Creek and Rehberg Ranch in the Billings area, areas in Blue Creek, Emerald Hills near Lockwood, High Trails in the Pryor Creek area, and Pleasant Hollow north of Shepherd.

King said work will include education and awareness efforts and thinning projects. The key to implementing the plan, she said, will be getting landowners to be proactive and take some responsibility to reduce risks, such as by thinning dying trees and removing brush around their buildings. Other objectives in the plan are to equip and train fire departments, she said.

"What we're trying to do is be prepared before we actually have a catastrophic fire," King said.

It is easier, and cheaper, to be prepared and mitigate fire hazards than to try to rehabilitate after a blaze, King said.

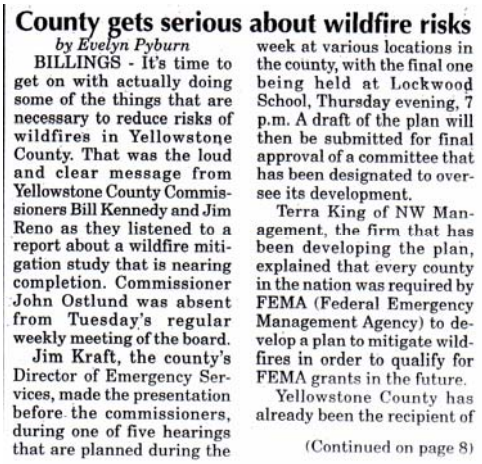
The plan is still being developed but should be reviewed by the committee at the end of this month. The draft plan will be made public in late November, and residents will have another chance to comment. King said she hopes the county commissioners and local city councils will be able to adopt the plan by early next year.

Several state and federal agencies that are partners in the plan will also sign off, she said. It will then become part of those agencies' fire planning documents.

Once local governments adopt the plan, the county will be eligible for more grant money, including funding from the Federal Emergency Management Agency, King said.

The county has already received $170,000 through the Bureau of Land Management. The grant is paying for the assessments and developing the draft plan. After paying the consultant, the county should have $100,000 to $110,000 to use for project work, said Jim Kraft, the county's director of emergency and general services, whose office is overseeing the plan.

Figure 2.5 *Yellowstone County News* article published on October 7th, 2005.



County gets serious about wildfire risks

by Evelyn Pyburn

BILLINGS - It's time to get on with actually doing some of the things that are necessary to reduce risks of wildfires in Yellowstone County. That was the loud and clear message from Yellowstone County Commissioners Bill Kennedy and Jim Reno as they listened to a report about a wildfire mitigation study that is nearing completion. Commissioner John Ostlund was absent from Tuesday's regular weekly meeting of the board.

Jim Kraft, the county's Director of Emergency Services, made the presentation before the commissioners, during one of five hearings that are planned during the week at various locations in the county, with the final one being held at Lockwood School, Thursday evening, 7 p.m. A draft of the plan will then be submitted for final approval of a committee that has been designated to oversee its development.

Terra King of NW Management, the firm that has been developing the plan, explained that every county in the nation was required by FEMA (Federal Emergency Management Agency) to develop a plan to mitigate wildfires in order to qualify for FEMA grants in the future.

Yellowstone County has already been the recipient of

(Continued on page 8)

Wildfire...

(Continued from page 1)

some pretty hefty grants that the commissioners want to direct to addressing the priorities that have been identified in the county as needed to reduce the potential of wildfire destruction.

In September 2003 the Bureau of Land Management awarded the county $43,000 for Hazardous Fuel Reduction projects and another $100,000 for planning efforts. Subsequently, $10,045 and another $17,170 in grants were awarded for a regional educational awareness campaign for total awards to the county of $170,215. Approximately $36,300 has been spent on the study.

"I would favor one less plan and have trees and brush gone," said Commissioner Reno.

"I would agree," said Commissioner Kennedy. "We need to prioritize."

Kennedy asked about the prospects of getting additional grants. Diane Lehm with the Big Sky Economic Development Authority, an agency which was contracted with to administer the grants, explained that there were more grants available. The size and terms of the grants are dependent upon the project for which they are applied, she said. A typical grant size might be $30,000 or $40,000, she suggested.

A top priority in the county which emerged from the study is the need for dry hydrants (dry hydrants are not the least bit dry, in that they are water storage units). Other needs included such things as tree removal, signage, equipment, training and education.

The county already has some dry hydrants, explained Kraft, some of which were built by the fire districts. Another 10 to 20 were identified as being needed in the study. Dry hydrants are often required, now, in the development of subdivisions.

Reno asked about the availability of grants to build the hydrants, and whether they required matching funds. Kraft said that grant money is available for that, and in some cases it's available with only a 10 percent required match, which could be beneficial to defray costs for subdivisions.

Lehm emphasized the importance of education and information "so the homeowners understand how to mitigate their risks." Areas in which property is particularly at risk to the threat of wildfires include Emerald Hills, Briarwood, Rehberg Estates, Buffalo Trail, Pleasant Hallow, Echo Canyon and Clapper Flats.

Meetings that have already been held regarding the wildfire plan have drawn strong interest from among homeowners in those areas, said commissioners.

Kraft said that they plan to make a lot of information available to the homeowners in such areas with "the idea to convince them to make their home defensible."

Kennedy noted that in several areas property owners indicated an interest in having the same kind of permanent fire ban that is imposed in Emerald Hills.

A citizen present at the meeting, Bob Fears, spoke in opposition to that idea, pointing out that controlled burning is one means of mitigating fire risks. He said that he is the Fire Committee Chairman for the Yellowstone Rifle Club on Molt Road. "We use fire as a mitigating tool," he said, noting that in 50 years they never had to worry much about the threat of fires. It's only been in the last three years, he said, that they have done controlled burns to reduce fuel levels. They also closed the club for 90 days, much to the consternation of their membership.

He said their biggest concern is neighbors who do not do anything to reduce the fire danger, and those neighbors include the City of Billings with Phipps Park and CRP land "where weeds are pocket high."

"We would like to see a requirement that CRP holders create fire breaks around their land," he said, adding, "We are ahead of the curve and would not like to get caught up in regulations that would not allow us to continue."

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Figure 2.6 *Yellowstone County News* article published on December 9th, 2005.

County seeks comments on proposed Community Wildfire Protection Plan

BILLINGS - The Yellowstone County Community Wildfire Protection Plan has been completed in draft and is available to the public for review and comment at locations throughout the county.

The plan includes risk analysis at the community level with predictive models for where fires are likely to ignite and where they are likely to spread once ignited. The coordination for this effort is being provided by Jim Kraft, Yellowstone County Disaster and Emergency Services (DES) Director with funding from a Bureau of Land Management grant. The committee includes rural and wildland fire districts, land managers, elected officials, agency representatives and others.

The draft plans will be available in the communities of Billings, Laurel, Broadview, Huntley, Shepherd, Lockwood, Molt, Custer and Worden, as well as on the Yellowstone County website at www.co.yellowstone.mt.us/.

For more information on the plan or if you have questions, contact Jim Kraft, Yellowstone County DES Director at 256-2775.

Draft Plans will be available at the following locations Dec. 2, 2005- Jan. 11, 2006:

Department of Disaster and Emergency Services
Yellowstone County Courthouse
217 North 27th, Room 312
Billings, MT 59101

Billings Library
City and County Planning Office
4th Floor
510 North Broadway
Billings, MT 59101

Huntley Post Office
155 Northern Avenue
Huntley, MT 59037

Shepherd Post Office
5450 Carey Avenue
Shepherd, MT 59079

Custer Post Office
413 2nd Avenue
Custer, MT 59024

Lockwood Fire District
3329 Driftwood Lane
Billings, MT 59101

Figure 2.7 *Billings Gazette* article published December 18th, 2005.

Yellowstone County wants your input!

The Yellowstone County Community Wildfire Protection Plan has been completed and is available for public review and comment at the listed locations:

Department of Disaster and Emergency Services
Yellowstone County Courthouse
217 N 27th St., Room 312
Billings, MT 59101

Custer Post Office
413 2nd Avenue
Custer, MT 59024-9759

Worden Post Office
2427 Main Street
Worden, MT 59088-2227

Broadview Community Center
Broadview, MT 59015

Prairie Wind Cafe
110 Wolfskill Avenue
Molt, MT 59057

Billings Library City and County Planning Office
4th Floor
510 N Broadway
Billings, MT 59101

Laurel City Hall
115 West 1st Street
Laurel, MT 59044

Shepherd Post Office
5450 Carey Avenue
Shepherd, MT 59079-9701

Lockwood Fire District
3329 Driftwood Lane
Billings, MT 59101

Huntley Post Office
155 Northern Avenue
Huntley, MT 59037-9701

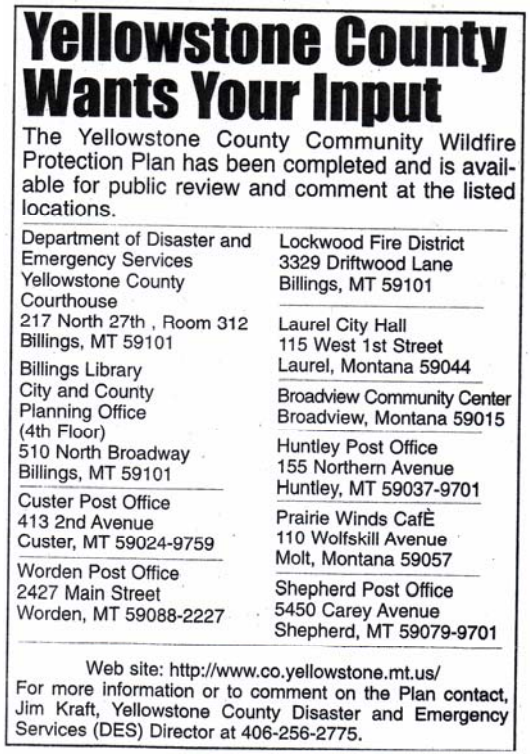
web site: http://www.co.yellowstone.mt.us

For more information or to comment on the plan, contact Jim Kraft, Yellowstone County Disaster (DES) Director at (406) 256-2775.

Community Wildfire Protection Plan is funded through a grant from the Bureau of Land Management

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Figure 2.8 *Laurel Outlook* article published December 21st, 2005.



Yellowstone County Wants Your Input

The Yellowstone County Community Wildfire Protection Plan has been completed and is available for public review and comment at the listed locations.

Department of Disaster and Emergency Services
Yellowstone County Courthouse
217 North 27th , Room 312
Billings, MT 59101

Billings Library
City and County Planning Office
(4th Floor)
510 North Broadway
Billings, MT 59101

Custer Post Office
413 2nd Avenue
Custer, MT 59024-9759

Worden Post Office
2427 Main Street
Worden, MT 59088-2227

Lockwood Fire District
3329 Driftwood Lane
Billings, MT 59101

Laurel City Hall
115 West 1st Street
Laurel, Montana 59044

Broadview Community Center
Broadview, Montana 59015

Huntley Post Office
155 Northern Avenue
Huntley, MT 59037-9701

Prairie Winds CafÈ
110 Wolfskill Avenue
Molt, Montana 59057

Shepherd Post Office
5450 Carey Avenue
Shepherd, MT 59079-9701

Web site: http://www.co.yellowstone.mt.us/
For more information or to comment on the Plan contact, Jim Kraft, Yellowstone County Disaster and Emergency Services (DES) Director at 406-256-2775.

Figure 2.9 *Yellowstone County News* article published December 23rd, 2005.



Yellowstone County Wants Your Input

The Yellowstone County Community Wildfire Protection Plan has been completed and is available for public review and comment at the listed locations.

Department of Disaster and Emergency Services
Yellowstone County Courthouse
217 North 27th, Room 312
Billings, MT 59101

Billings Library
City and County Planning Office (4th floor)
510 North Broadway
Billings, MT 59101

Custer Post Office
413 2nd Avenue
Custer, MT 59024-9759

Worden Post Office
2427 Main Street
Worden, MT 59088-2227

Lockwood Fire District
3329 Driftwood Lane
Billings, MT 59101

Laurel City Hall
115 West 1st Street
Laurel, MT 59044

Broadview Community Center
Broadview, MT 59015

Huntley Post Office
155 Northern Avenue
Huntley, MT 59037-9701

Prairie Winds Cafe
110 Wolfskill Avenue
Molt, MT 59057

Shepherd Post Office
5450 Carey Avenue
Shepherd, MT 59079-9701

Web Site: http://www.co.yellowstone.mt.us/

For more information or to comment on the plan, contact Jim Kraft, Yellowstone County Disaster and Emergency Services (DES) Director, at 406-256-2775.

2.3.3 Public Mail Survey

In order to collect a broad base of perceptions about wildland fire and individual risk factors of homeowners in Yellowstone County a mail survey was conducted. The survey was completed during 2005. Using the cadastral database of landowners in Yellowstone County, homeowners from the county were identified. Approximately 250 residents of Yellowstone County were randomly selected to receive mail surveys.

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The public mail survey developed for this project has been used in the past by Northwest Management, Inc., during the execution of other Hazard Mitigation Plans. The survey used The Dillman Total Design Method (Dillman 1978) as a model to schedule the timing and content of letters sent to the selected recipients. Copies of each cover letter, mail survey, and communication are included in the Appendices.

The first in the series of mailings was sent September 21st, 2005, and included a cover letter, a survey, and an offer of receiving a custom GIS map of the area of their selection in Yellowstone County if they would complete and return the survey. The free map incentive was tied into assisting their community and helping their interests by participating in this process. Each letter also informed residents about the planning process. A return self-addressed enveloped was included in each packet. A postcard reminder was sent to the non-respondents on October 4th, 2005, encouraging their response. A final mailing, with a revised cover letter urging with them to participate, was sent to non-respondents on October 11th, 2005.

Surveys were returned during the months of September, October, November, and December. A total of 125 residents responded to the survey as of January 10th, 2006. The effective response rate for this survey was 50%. Statistically, this response rate allows the interpretation of all of the response variables significantly at the 99% confidence level.

2.3.3.1 Survey Results

A summary of the survey's results will be presented here and then referred back to during the ensuing discussions on the need for various treatments, education, and other information.

Of the 125 respondents in the survey, approximately 25% were from the Billings area, 16% from Huntley, 15% were from Shepherd, 14% from Laurel, 8% from Ballantine, 8% from Worden, with the remaining respondents from other areas in the county.

The vast majority of the respondents (98%) correctly identified that they have emergency telephone 911 services in their area. When asked if their home was protected by a local fire department 13% *incorrectly* responded that they did not. Of the 87% that said they were protected, 26% said that the average response time by a fire department to their home was less than 10 minutes, 48% thought the average response time was between 10 and 20 minutes, and 20% of respondents thought that a fire department would be there within 20 to 30 minutes.

Respondents were asked to indicate the type of roofing material covering the main structure of their home. Approximately 67% of respondents indicated their homes were covered with a composite material (asphalt shingles). About 19% indicated their homes were covered with a metal (e.g., aluminum, tin) roofing material and 10% of the respondents indicated they have a wooden roofing material such as shakes or shingles.

When asked how many trees were within 250 feet of their homes 6% said none, 38% indicated less than 10, 40% said between 10 and 25, and 15% indicated more than 25. When asked how many were within 75 feet, 59% responded less than 10, 27% said between 10 and 25, and only 6% said more than 25. 89% of respondents replied that they had a lawn and 89% of those that had a lawn keep it green year round.

The average driveway length of respondents to the survey was 441.5 feet long (0.08 miles). The longest reported was 10,560 feet (2.0). Of those respondents (6%) with a driveway over ½ mile long, about half, 53%, do not have turnouts allowing two vehicles to pass. 7% of those respondents with a driveway indicated having a dirt surface, while 68% had gravel or rock and 25% had a paved driveway. Approximately 73% of the respondents indicated an alternate escape route was available in an emergency which cuts off their primary driveway access.

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100% of respondents indicated they have some type of tools to use against a wildfire that threatens their home. Table 2.1 summarizes these responses.

Table 2.1. Percent of homes with indicated fire fighting tools in Yellowstone County.

97% – Hand tools (shovel, Pulaski, etc.)

23% – Portable water tank

14% – Stationery water tank

27% – Pond, lake, or stream water supply close

13% – Water pump and fire hose

82% - Well or cistern

19% – Equipment suitable for creating fire breaks (bulldozer, cat, skidder, etc.)

Respondents were asked to complete a fuel hazard rating worksheet to assess their home's fire risk rating. The following is an example of the worksheet and a summarization of responses (Table 2.2).

Circle the ratings in each category that best describes your home.

Table 2.2. Fuel Hazard Rating Worksheet		**Rating**
Fuel Hazard	Small, light fuels (grasses, forbs, weeds, shrubs)	1
	Medium size fuels (brush, large shrubs, small trees)	2
	Heavy, large fuels (woodlands, timber, heavy brush)	3
Slope Hazard	Mild slopes (0-5%)	1
	Moderate slope (6-20%)	2
	Steep Slopes (21-40%)	3
	Extreme slopes (41% and greater)	4
Structure Hazard	Noncombustible roof and noncombustible siding materials	1
	Noncombustible roof and combustible siding material	3
	Combustible roof and noncombustible siding material	7
	Combustible roof and combustible siding materials	10
Additional Factors	Rough topography that contains several steep canyons or ridges	+2
	Areas having history of higher than average fire occurrence	+3
	Areas exposed to severe fire weather and strong winds	+4
	Areas with existing fuel modifications or usable fire breaks	-3
	Areas with local facilities (water systems, rural fire districts, dozers)	-3
Calculating your risk		

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Table 2.3. Percent of respondents in each risk category as determined by the survey responses.
00% – Extreme Risk = 26 + points
02% – High Risk = 16–25 points
42% – Moderate Risk = 7–15 points
56% – Low Risk = 6 or less points

Respondents were asked a series of questions regarding mitigation activities they had recently done or currently do on their property. The first question asked if they conducted a periodic fuels reduction program near their home; about half; 49% said that they did. Respondents were also asked if livestock was grazed around their home and 40% indicated that there was.

Finally, respondents were asked "If offered in your area, would members of your household attend a free or low cost, one-day training seminar designed to share with homeowners how to reduce the potential for casualty loss surrounding your home?" A strong majority, 59% of respondents, indicated a desire to participate in this type of training.

Homeowners were also asked, "How Hazard Mitigation projects should be funded in the areas surrounding homes, communities, and infrastructure such as power lines and major roads?" Responses are summarized in Table 2.4.

Table 2.4. Public Opinion of Hazard Mitigation Funding Preferences.

	100% Public Funding	Cost-Share (Public & Private)	Privately Funded (Owner or Company)
Home Defensibility Projects →	22%	40%	38%
Community Defensibility Projects →	51%	43%	6%
Infrastructure Projects Roads, Bridges, Power Lines, Etc. →	69%	22%	9%

We wish to thank all Yellowstone County residents completing and returning these surveys.

2.3.4 Committee Meetings

The following list of people who participated in the planning committee meetings, volunteered time, or responded to elements of the Yellowstone County Community Wildfire Protection Plan's preparation.

NAME **ORGANIZATION**

- Alan Riley.....Lockwood Fire District #8
- Annette Cabrera .....Yellowstone County GIS
- Aura Lindstrand .....Yellowstone County/City Planning
- Bill Kennedy.....Yellowstone County Commissioner
- Bob Meidinger.....Bureau of Land Management
- Bob Fears .....Yellowstone Rifle Club
- Bryan Juhas.....Broadview City Council
- Daniel Krum .....Worden Fire District #4
- Darrell Kurk.....Department of Natural Resources and Conservation
- Dena Lang .....Bureau of Land Management

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- Dianne Lehm ..... Big Sky Economic Development Authority
- E. J. Jensen ..... Huntley Project Fire Service Area
- Eric Chapman ..... Bureau of Land Management
- Eric Gilsrud ..... City of Billings Forester
- Gary Colley ..... Laurel Volunteer Fire Department
- George Richards..... Shepherd Fire Department
- Greg Smith..... Molt Volunteer Fire Department
- Irv Leach ..... Bureau of Land Management
- Jack Welsh ..... Billings Urban Fire Service Area
- Jan Wheeler..... Department of Natural Resources and Conservation
- Jenny Johnson..... City of Laurel
- Jim Kraft..... Yellowstone County Disaster and Emergency Services
- Jim Roessler ..... Bureau of Indian Affairs
- Jim Ziegler ..... Laurel Volunteer Fire Department
- John Ostlund..... Yellowstone County Commissioner
- John Raisler..... Department of Natural Resources and Conservation
- Jon Rutt ..... Laurel Fire District #5
- JT Smith..... Beartooth Resource Conservation and Development Council
- Keith Bauer ..... Blue Creek Fire Service Area
- Kenneth Kaufman ..... Shepherd Fire Service Area
- Larry Johnson ..... Broadview Fire District #3
- Lloyd Weber..... Laurel Fire District #7
- Marv Jochems ..... Billings Fire Department
- Michael Jansen..... Broadview Fire District #3
- Mike Dannenberg ..... Bureau of Land Management
- Mike Linder ..... Yellowstone County Sheriff's Office
- Mike Spini ..... Billings Fire Department
- Monte Dvorak ..... Worden Volunteer Fire Department
- Paul Aaby ..... Blue Creek Fire Service Area
- Rick Cortez III ..... Blue Creek Volunteer Fire Department
- Robby Badgett ..... Broadview Fire District #3
- Robert Guenther..... Lockwood Fire District
- Roger Boss ..... Yellowstone County Park Board
- Sandy Brooks ..... Bureau of Land Management
- William Cummins ..... Lockwood Fire District #8

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- William Jones.....Broadview Fire District #3
- David McKinney.....Lockwood Fire District #8

2.3.4.1 Committee Meeting Notes

Committee Meetings were scheduled and held on the dates indicated with each entry. This information is useful to observe what topics were discussed, who participated, and the source of recommendations made in this planning process.

2.3.4.1.1 August 18th, 2005 – Yellowstone County Courthouse

Jim Kraft, Yellowstone County Department of Emergency Services, opened the meeting and explained that funds had been obtained from the Bureau of Land Management (BLM) to assist Yellowstone County with the development of a Wildfire Mitigation Plan. The purpose of the plan is to identify were wildfire hazards exist and to identify ways that existing hazards can be mitigated. Hopefully the plan will assist with the goal to develop "firewise subdivisions" within the county. Tera King and Gary Ellingson, staff members of Northwest Management, Inc (NMI) were introduced. NMI is a natural resource consulting firm and was selected to assist Yellowstone County with the development of its Wildfire Mitigation Plan.

Tera King asked audience members to introduce themselves to begin the meeting. An Attendance Roster, Meeting Agenda, and Timeline for Completion were distributed to attendees.

Tera presented a power point presentation (see attached) that provided an overview of the process involved with the development of a Wildfire Mitigation plan. Tera then distributed the draft Community Assessments and encouraged committee members to provide comments as their input is vital if the planning process is to be successful.

Several committee members offered comment during the presentation.

Comments included:

- It's important that the committee define the wildland urban interface boundary. The boundary determination will not be strictly based on a mathematical equation.
- The community name of Shepherd (check spelling!) is spelled incorrectly.
- Lockwood should have a community assessment completed.
- Blue Creek and Duck Creek should be treated as separate communities.
- Documents associated with the mitigation plan should be made available on the county website (community assessments, public survey, etc.).

Tera distributed the draft Yellowstone County Fire Mitigation Plan Survey that will be mailed to approximately 235 households (probably more to account for the large population of Billings) in Yellowstone County. Committee members were asked to review the document and submit their comments to Jim Kraft Yellowstone County Disaster and Emergency Services (DES) Director by Friday, August 26th. The survey will be mailed out the following week.

Comments regarding the survey included:

- The survey seems to focus on homeowners and "backyard type" wildfire hazards. It's important to consider completing risk assessments for outlying areas on other ownerships.

Tera distributed a draft Press Release for comment by the committee. Additional written comments should be provided to Jim Kraft by August 26, 2005.

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Comments regarding the press release included:

- The survey could be mentioned in the press release and should be made available on the county website so that volunteers could complete it.
- Yellowstone County can make arrangements for distribution of the press release.
- The press release should mention that project funding was provided by the BLM.
- The City of Billings should be mentioned so that city residents know that they are included in the process.

Tera went on to review the timeline for completion of the mitigation plan and proposed meeting dates.

Comments regarding the proposed timeline included:

- The proposed public meeting dates are Oct 4-6 or the week prior.
- Evening meetings are preferred.
- Suggested locations for public meetings are: Huntley-Worden, Lockwood, Billings, Broadview, Custer, Blue Creek/Duck Creek, Laurel, and Shepherd.
- The press release for public meetings should include a map that indicates the meeting locations and shows residents that if they live within that area indicated on the map that the meeting pertains to them.
- The county commissioners meet on Tuesday mornings at 9:30 am and this would be a good time to present information that is to be presented at the public meetings.

Tera distributed a draft vision statement. Comments or changes to the vision statement should be submitted to Jim Kraft by August 26th.

The meeting ended with a general discussion regarding the planning process of the Wildfire Mitigation Plan. The next committee meeting was slated for September 15th, 2005.

2.3.4.1.2 September 15th, 2005 – Deaconess Billings Clinic

Tera King of Northwest Management, Inc. began the meeting by making introductions and passing around a sign in sheet. There were several housekeeping items on the agenda before the committee broke into working groups. The public survey has been modified and will be mailed by September 20th. There has also been several edits to the community assessments, which have been incorporated to date. Comments and edits on the assessments can still be sent to Tera at Northwest Management, Inc. There has been some response by the fire departments on the Resources and Capabilities surveys, but Tera will begin calling departments who have not sent there's in next week.

Public meeting dates were proposed for the week of October 3rd – 6th with the following schedule.

Date	Target Community	Tentative Location	Time
October 3	Laurel	Laurel Fire Hall	7 pm
October 4	Billings	Commissioner's Office (televised)	9 am
October 4	Huntley/Worden/ Shepherd/Custer	Worden Elementary Cafeteria	7 pm

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October 5	Broadview	Broadview Community Center	7 pm
October 6	Lockwood/Blue Creek/Emerald Hills	Lockwood School	7 pm

The final item on the agenda was a short presentation by Bill Schlosser of NMI explaining the features of the newly developed wall maps. Maps covered were: ownership, past fire history, historic fire regime, fire regime condition class, current fire severity, fire prone landscapes, wildland-urban interface, fire service areas, and topographic relief. During the discussion, it was pointed out that the past fire history for the county was limited. Jim Kraft mentioned that it would be beneficial to take the map to the Rural Fire Council meeting next Tuesday. Bill will send the information to Annette Cabrera, County GIS Department, who will make maps for this purpose.

After this discussion and question period, the committee broke into four groups focused on different areas of Yellowstone County. The goal of the groups was to identify hazardous areas, outline projects, and discuss the components of the significant infrastructure throughout the County. One topic that came up frequently was the role of the County's fire departments and their needs. The following notes were compiled from the each group's notes.

Broadview Group –

- Communications – need a repeater closer to the Broadview community
- There is a need to require new subdivisions to install water resources for fire suppression, i.e. dry hydrants, storage tanks, etc.
- Minimum road width standards are believed to be adequate across the County
- Buffalo Trail Area – Main County road is adequate. Most private roads are inaccessible to anything larger than a 1-ton truck. There are 100+ homes and structures located in this area, which is characterized by steep canyon walls and wildland vegetation. There are only two ways into this entire subdivision. Clappers Flat Subdivision is in the same situation, which contains 63 homes.
- Need a minimum countywide standard on private roads for emergency access. There are numerous areas across the county that are accessed via one-way in, one-way out.
- CRP lands – need to be able to treat to help reduce fire potential
- Broadview FD #3 does not respond to structural fires. They need to establish structural capabilities; however, there are several limitations; including lack of manpower and volunteers, lack of equipment, no personal protective equipment, and they lack a facility in which to house additional equipment.
- LUFSA needs new Type 3 WUI pumper truck, but their communication system is in good condition due to past grant. Communications with State DNRC is good, but an annual meeting would be helpful.
- Rural addressing is in progress and going well.
- Future issues – water availability and access in outlying subdivisions
- Lockwood/Emerald Hills has poor access and water availability

Laurel Group –

- There is a new substation on northern part of Laurel off Airport Road and a new subdivision northwest of Laurel.
- The intersection of Duck Creek Road and River Road has a history of past fire ignitions. There are a lot of new homes within this area.

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- Clappers Flat – one way in and generally poor roads (inaccessible for standard pumper trucks). People in this area may be resistant to defensible space or other mitigation projects. This area also needs more water resources within the subdivision. Clapper Flats is approximately 7-8 miles from Laurel.
- Laurel FD needs 4x4 WUI pumper and a 1500-2000 gallon water tender.
- Duck Creek Road – there are a lot of new homes in the coulees
- Laurel VFD #8 protects the northern tip of Carbon County. There are two tanks in this area.
- Buffalo Trail – lots of expensive homes in the area. It takes over 20 minutes to get there from Laurel VFD. There are also address and signage issues in this area.
- City of Laurel needs an ambulance.
- There is a need for roadside fuel mitigation along many of the high risk roads.
- Education/Awareness – need training of the public of wildfire issues through the Fire Marshall office.

Huntley/Shepherd/Worden/Custer –

- Pryor Creek Subdivision south of Huntley – needs funding for dry hydrants and a 10,000 gallon storage tank.
- Need river access for dry hydrant near new bridge west of Pompey's Pillar.
- Need to install a buried 10,000 gallon tank at spring on W. Arrow Creek south of Ballantine.
- White Buffalo and Shadow Canyon RFD did home-to-home assessments
- Shadow Canyon could use fuel reduction project in brushy areas.
- Need a truck in the north end of district (Worden). DNRC Type 6 engine could sit at Clair Tempero's farm house.

Greater Billings Area –

- Lockwood maintains a wildland fire public education program
- County/City of Billings has revised their subdivision regulations
- Railroads tend to ignite several fires. The interstates also get a lot of ignitions.
- Most of the transmission lines throughout the County are on wooden poles; however, the high tension lines are metal.
- The BLM recreational pieces along the river may be a source of ignitions; however, this is rare. They would recommend that these areas are kept clean with developed camp sites and fire or barbeque pits.
- Billings FD has a regular inspection program for new construction homes that checks for access and wildland fuel issues.
- Lockwood FD has made a proposal to build an 8-10 bay facility.
- Several areas throughout the County have developed Neighborhood Plans, which helps make plans for future development.
- The Shepherd FD would like to construct a satellite station in the Hidden Lake subdivision. This would consist of a warm shed with a truck. The Shepherd FD already maintains 7 dry hydrants in the area.
- County/City of Billings can govern all subdivisions in the County, but they cannot govern use of private property. The committee would like to recommend Countywide Zoning (Annette has current zoning layer).
- Rehberg Project Area – defensible space, thinning of neighboring coulees, and education

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- Emerald Hills Project Area – address access issues, defensible space, community defensible space, and education
- Alkali Creek Project Area – (developing area) address access issues, defensible space, and education
- Pine Hills Project Area – education
- Briarwood Project Area – some defensible space projects and education
- Pleasant Hollow Project Area – defensible space, address access on private drives, and some defensible space
- Indian Cliffs Project Area – thinning and defensible space
- Echo Canyon Project Area – education
- Secret Valley Project Area – address access issues (too steep) and education
- Hill Estates Project Area – (developing 40 lots and 1 dry hydrant) education and some defensible space
- High Trails Project Area – address access issues (too steep), some defensible space, and education
- Subdivisions on Jellison Road need annexed into the Blue Creek Fire Service Area

The next committee meeting will be on Wednesday October 19th. Reminder letters and emails with more information will be sent out prior to the meeting.

2.3.4.1.3 October 19th, 2005 – Billings Deaconess Hospital, Fortin Conference Center

William E. Schlosser, Northwest Management, Inc., opened the meeting (sign-in sheet was passed around). Pizza and beverages were available.

The purpose of the meeting was to go through the DRAFT Committee Review of the Yellowstone CWPP. Dr. Schlosser explained that the plan is not ready for distribution to the general public, and that this draft is the first time everyone on the committee has seen all of the components of the plan in one document. The dates of the committee review were set for October 20 through November 15. The committee will meet again on November 17 to review the public review draft, which will be available to the general public (and all committee members) until December 12th.

Each section of the document was talked about with discussions focusing on risk assessments, hazard profiles, community assessments and treatment priorities. The actual prioritization of the projects was discussed at length and it was agreed that the scoring criteria detailed in the recommendations section would be completed for all listed projects.

Edits were discussed and Dr. Schlosser asked everyone to reference the section of the document as opposed to the page number when sending in comments. Comments can be sent either to NMI or to Jim Kraft. Everyone was asked to have comments sent before November 15.

Requests for additional data were made of the committee. Dr. Schlosser said NMI would complete missing data concerning fire ignitions and extents. The supply of additional fire ignition data from the rural fire districts has been terrific as the fire districts have provided a lot of additional fire ignition data. NMI is working on digitizing this information and summarizing it for the plan. It will be available in the next draft version for public review.

The next meeting was set for November 17, 6:00 PM in Billings to review the Public Review Draft of the plan.

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2.3.4.1.4 November 17th, 2005 – Emergency Operations Center in Billings

The meeting was called to order by Tera King of Northwest Management, Inc. at 6pm. The purpose of this committee meeting was to discuss the logistics of putting the Draft CWPP out for public review for the month of December. In order to accomplish this Tera asked for possible locations in each town for the document to be available for viewing by local citizens. The list decided on by the committee was as follows:

- Billings County Courthouse
- Yellowstone County Website
- Billings City Hall
- Laurel City Hall
- Broadview Community Center
- Shepherd High School Office
- Yellowstone County News in Huntley
- Custer School Library
- Worden School Central Office
- Lockwood Fire House
- Prairie Winds Café in Molt

The second item on the agenda was to go over significant changes to the Draft document since the last meeting including all of the comments and edits received from committee members. A brief summary of these changes includes: additional Resources and Capabilities sections from fire departments, additional wildfire extent and profile information, public survey results, prioritization and ranking of projects in Chapter 5, BIA information, updated lists of cooperators and logos, and the addition of the Molt community assessment. All of the maps and prioritization tables were also added to the Appendices document.

In further discussions the committee requested that an Executive Summary be written for the Commissioners before they sign the final plan. The committee would also like to have fuel mitigation along roads separated from the home defensibility project areas in the recommendations and prioritization. It would also be helpful if we listed in the wildfire profile how many ignitions each fire department was experiencing each year.

At the conclusion of the meeting, it was decided that the public review period should be left open until after the first of the year in order to accommodate the holiday season; thus, the next meeting date was not identified at this time.

2.3.5 Public Meetings

Public meetings were scheduled in a variety of communities in Yellowstone County during the hazard assessment phase of the planning process. Public meetings were scheduled to share information on the planning process, inform details of the hazard assessments, and discuss potential mitigation treatments. Attendees at the public meetings were asked to give their impressions of the accuracy of the information generated, and provide their opinions of potential treatments.

Wall maps detailing risk assessments, hazard profiles, and a slide show were presented at each meeting. Public meetings were conducted by Tera King on the following dates and locations:

2.3.5.1 October 3rd, 2005 – Laurel Fire Hall

Attendance:

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Bill Kennedy	Yellowstone County Commissioner
Tera King	Northwest Management, Inc.
Jim Ziegler	Laurel Volunteer Fire Department
Gary Colley	Laurel Volunteer Fire Department
Bill Linger	Molt Volunteer Fire Department
Mat Kegling	Molt Volunteer Fire Department
Dennis Deppmeier	Rimrock Vista Estates
Gordon and Abby Brown	Residents
Sandra Miller	Residents
Ron and Linda Kesler	Rimrock Vista Estates
P. J. Smith	Molt Volunteer Fire Department
Stewart Brown	Residents
Nichole Brown	Residents
Duane Torby	Residents
David Charles	Residents
Patty Nordlund	Big Sky EDA
Dianne Lehm	Big Sky EDA
Darrell L. McGillen	Laurel Volunteer Fire Department
Kurt Markegard	Residents
Rob Harris	Laurel Volunteer Fire Department
Lori York	Residents
Silver Zubaith	Laurel Volunteer Fire Department
Irv Leach	Bureau of Land Management
Sandy Brooks	Bureau of Land Management

Jim Ziegler of the Laurel Volunteer Fire Department began by welcoming everyone to the meeting and making introductions.

Tera King from Northwest Management, Inc. gave an overview presentation of the Yellowstone County Community Wildfire Protection Plan. Included in the presentation was a discussion of the planning process, key elements of the plan, a discussion of the wildland urban interface, proposed project areas, and several Yellowstone County maps. After the formal presentation, Tera opened it up for discussion and questions. Some of the key issues that came up were:

- The Clapper Flats subdivision already has land available to install an additional dry hydrant. There were many questions on how they should go about finding funding to complete this project. Tera King explained the benefits of having this project included in the County plan.
- One resident had questions regarding whether or not new homes in rural subdivisions were being GPS'd by the County and if this information was available to the public. Dianne Lehm from the Big Sky EDA said that the County was keeping up to date and gave her some contact names for more information.
- A resident from the Rimrock Vista Estates noted that subdivision covenants and codes generally restricted fuels reduction projects and could affect other types of on-the-ground fire mitigation projects.
- The Clapper Flats subdivision has several wildfire issues that could be potential mitigation projects including: excessive grass and other vegetation surrounding homes, access issues, and a lack of water resources.
- The Emerald Hills subdivision currently has a year round burn ban that seems to be helping reduce ignitions. Clapper Flats and Buffalo Trails subdivisions would also benefit from this type of no burning restriction. The Laurel Volunteer Fire Department

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noted that although they already had some burning restrictions throughout the County, enforcement of these laws was difficult. Commissioner Kennedy said that he would bring this up at the next Rural Fire Committee meeting. It is important that all fire departments as well as law enforcement personnel were on the same page regarding burn bans.

- The Laurel Volunteer Fire Department said that the cities had a tendency to tell people to take their fireworks out into the County to light them off. This puts considerable pressure on the rural fire departments as well as increases the risk of a wildland fire.
- One problem with fuels reduction projects will be disposing of the waste. There will have to be some type of agreement with the refuge board as well as the cities to help dispose of slash and other waste from thinning and fuels reduction projects.

The County is working on new restrictions and codes for developing subdivisions that will help reduce the wildfire risk. Currently, fire departments do as many assessments of new subdivision as their manpower allows. The problem is generally with older subdivisions that already have established access routes, hydrants, etc.

2.3.5.2 October 4th, 2005 – Yellowstone County Courthouse, Commissioners Meeting

Jim Kraft, Yellowstone County Disaster and Emergency Services Director; Dianne Lehm, Big Sky EDA; and Tera King, Northwest Management, Inc. gave a short presentation at the regular meeting of the Yellowstone County Commissioners. Tera King gave a brief background and the current status of the Community Wildfire Protection Plan and then answered questions by the Commissioners. Commissioner Kennedy then opened the floor for public comment or questions. Bob Fears from the Yellowstone Rifle Club commented that the rifle club conducted an annual prescribed burn on their lands to reduce the fire risk. He thought it would also be beneficial if the neighboring property owners were to do some type of fuels reduction project due to the excess grass and sagebrush fuels in the area. Mr. Fears also commented that restrictions on burning or mowing on neighboring CRP lands increases the risk of wildfire.

2.3.5.3 October 4th, 2005 – Worden VFW Hall

Attendance:

Joe Feist	Ballantine
Tera King	Northwest Management, Inc.
Dan Krum	Worden Fire District #4
Monte Dvorak	Worden Fire Department
Joy Eshleman	Worden Fire Department
John Eshleman	Worden Fire Department
Stuart Andersen	Shepherd Volunteer Fire Dept.
Jim Kraft	Yellowstone County DES
Annie Rowe	Worden
William Jo Rowe	Worden

Tera King from Northwest Management, Inc. began the meeting by welcoming those who braved the storm to attend the meeting and making introductions. Tera then began the formal PowerPoint presentation and asked attendees to ask questions as she went through it. The group also spent considerable time discussing the wall maps.

Comments that came out of the meeting included:

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- We need to add the Cedar Ridge subdivision on Highway 87 to the project areas map. This area is need of fuels reduction and home defensible space projects. This area also has some access issues with dead end roads and private driveways. Education and awareness projects would also be beneficial to the homeowners.
- The local fire departments want to do assessments of all the new subdivisions; however, they don't generally have the time or the money to get people out on the ground. It would be helpful to set up some type of program to help pay the firefighters for time spent doing this type of work.
- The Worden Volunteer Fire Department is in need of two 1000 gallon pumper trucks. One would be stationed in Huntley and the other in Pompey's Pillar. They are also in need of a heated two-bay equipment storage facility at Huntley and Worden needs to construct an addition to the Worden Fire Station.

2.3.5.4 October 5th, 2005 – Yellowstone County Courthouse

Attendance:

Tera King	Northwest Management, Inc.
Jack Welsh	Billings Urban FSA
Keith Kolstad	Blue Creek VFD
Mike Spini	Billings Fire Department
Rebecca Helvik	Big Sky EDA
Patty Nordlund	Big Sky EDA
Dianne Lehm	Big Sky EDA
Beth Woodson	Landowner

The noon meeting at the County Courthouse was not well attended due to power outages throughout the County including the Courthouse building. Tera King from Northwest Management, Inc. went through the PowerPoint presentation showing the group slides on the laptop computer and then led a discussion regarding how the funding opportunities through FEMA worked and how the County would go about applying for additional funding to carry out project implementation. Specific project areas and potential educational opportunities were also discussed.

2.3.5.5 October 5th, 2005 – Broadview Community Center

Attendance:

Tera King	Northwest Management, Inc.
Jim Kraft	Yellowstone County DES
Robby Badgett	Broadview Rural Fire Dept
Mike Linder	Yellowstone County Sheriffs Office
Bill Jones	Broadview Rural Fire Dept
Tim Jones	Broadview Rural Fire Dept
Ben Heiken	Broadview Rural Fire Dept
Unreadable	Broadview Rural Fire Dept
Unreadable	Broadview Rural Fire Dept
Larry Johnson	Broadview Rural Fire Dept
Byron ?	Broadview Councilman
Ralph Brewington	Broadview Councilman
Jr. Conover	Resident of Broadview

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Sandy Brooks	Bureau of Land Management
Irv Leach	Bureau of Land Management

Tera King of Northwest Management, Inc. began the meeting by welcoming everyone and making introductions. Tera then gave an overview presentation of the Yellowstone County Community Wildfire Protection Plan. Included in the presentation was a discussion of the planning process, key elements of the plan, a discussion of the wildland urban interface, proposed project areas, and several Yellowstone County maps. After the formal presentation, Tera opened it up for discussion and questions. Some of the key issues that came up were:

- Broadview has a very limited water supply. Presently, they only have 18,000 gallons available in the storage tank for the town. The pump on this system can only pump approximately 25 gallons per hour (i.e. it would take about 30 days to refill if emptied). They need to install a 100,000 gallon tank. Broadview received a $100,000 grant to work with the School of Mines to locate new, more efficient well sites. They are also working on a long term project with the communities of Rygate, Lavina, Utica, and Roundup to install a well for the use by all communities. However, the water gained from this well project would be for household use only.
- The Broadview Rural Fire Department has fairly good equipment.
- They need some type of communications infrastructure. Brett Conover has donated land for a good tower site. They are also having trouble with the new narrow band frequencies not being able to reach over longer distances.
- Broadview Rural Fire Department would like to add on to their fire hall in order to house their 4,000 gallon tender.
- Outside of town the water supply is not bad due to stock tanks and farmers having their own mobile water tanks.

This group was very interested in the wall maps, so following the formal part of the meeting, there were several in depth discussions of the various maps.

2.3.5.6 October 6th, 2005 – Lockwood School

Attendance:

Tera King	Northwest Management, Inc.
Rebecca Helvik	Big Sky EDA
Dianne Lehm	Big Sky EDA
Becky Shay	Billings Gazette
Alan Riley	Lockwood Fire Department
Sandy Brooks	Bureau of Land Management
Eric Chapman	Bureau of Land Management

Tera King of Northwest Management, Inc. began the meeting by thanking everyone for coming and introducing those who came from the committee. Tera then gave an overview presentation of the Yellowstone County Community Wildfire Protection Plan. Included in the presentation was a discussion of the planning process, key elements of the plan, a discussion of the wildland urban interface, proposed project areas, and several Yellowstone County maps. After the formal presentation, Tera opened it up for discussion and questions. Ms. Shay from the *Billings Gazette* asked for clarification on a few points stemming from the presentation, but otherwise there were no additional comments.

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Figure 2.10. Public meeting slideshow overview.



The public meeting slide show (title slide above) is outlined below.

Table 2.5. Public meeting slide show.

Slide 1	Slide 2
	

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Table 2.5. Public meeting slide show.

Slide 3



Slide 4



Slide 5



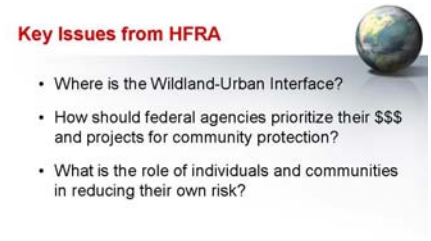
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Slide 7



Slide 8



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Table 2.5. Public meeting slide show.

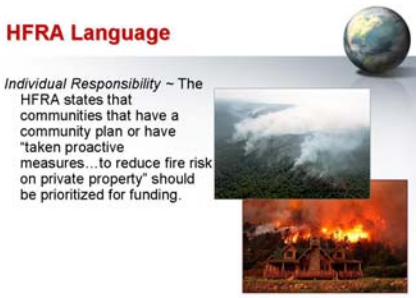
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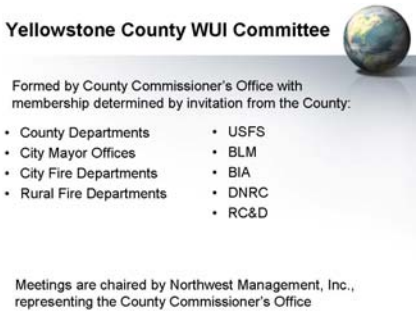
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Slide 13



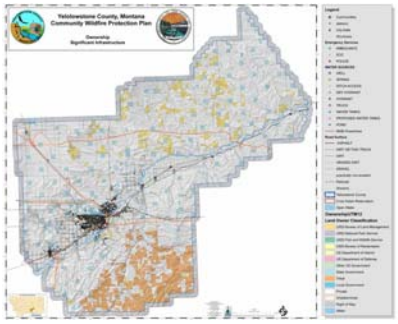
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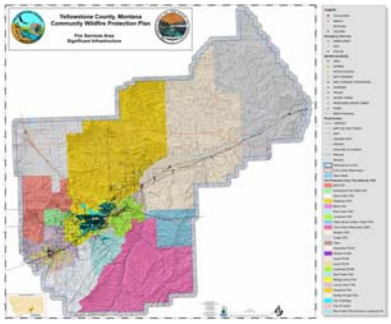
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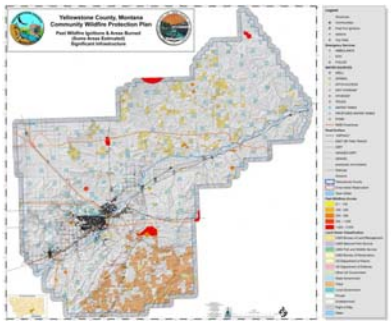
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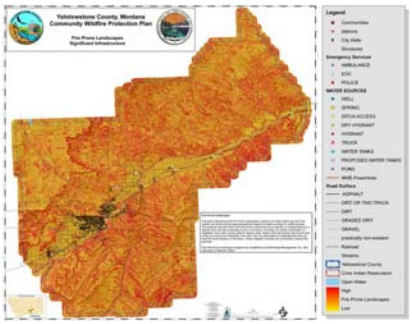
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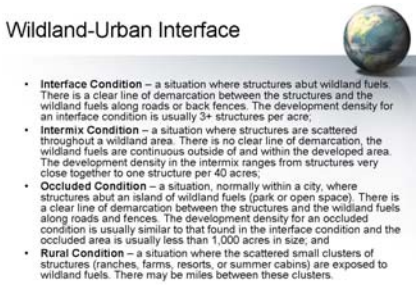
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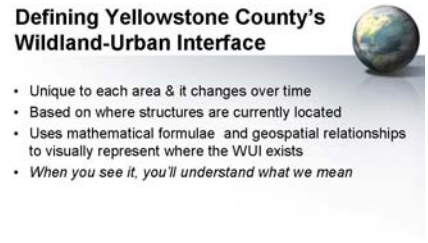
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Slide 20

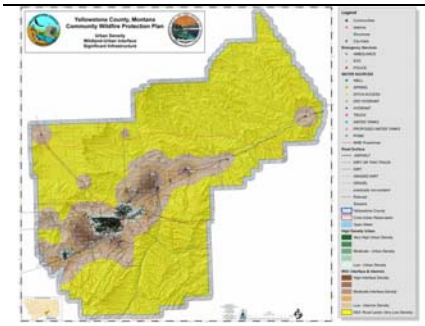


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Table 2.5. Public meeting slide show.



Slide 23



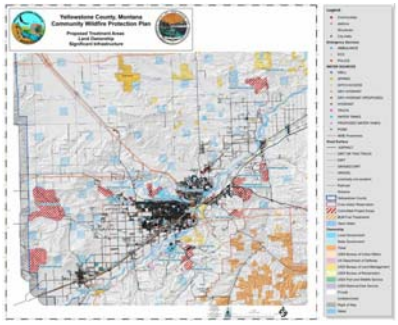
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Slide 26



Slide 27

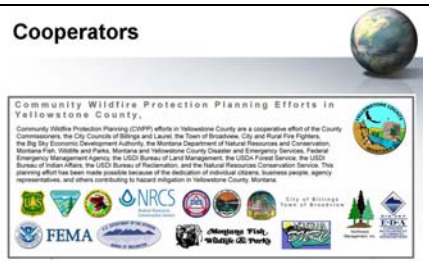


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Table 2.5. Public meeting slide show.





Slide 29



2.3.6 Documented Review Process

Reviews of sections of this document were conducted by the committee during the planning process as maps, summaries, and written assessments were completed. These individuals included fire mitigation specialists, firefighters, planners, elected officials, and others involved in the coordination process. Preliminary findings were discussed at the public meetings, where comments were collected and facilitated.

The results of these formal and informal reviews were integrated into a DRAFT Community Wildfire Protection Plan. This plan was given to members of the planning committee on October 19th, 2005 with comments provided by November 16th, 2005. Public review of the revised DRAFT document was made from November 29th until January 11th, 2006. All comments were integrated into the final version of the mitigation plan.

The final plans were prepared on February 28th, 2006. Adoption of the Community Wildfire Protection Plan was completed by the listed municipalities on the dates indicated in section 6.4 (Signature Pages) as being formally adopted on those dates by the municipalities. Other agencies and organizations indicated their cooperation and collaboration in the planning process.

2.3.7 Continued Public Involvement

Yellowstone County is dedicated to involving the public directly in review and updates of the Wildfire Protection Plan. The Yellowstone County Commissioners, through the Wildfire

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Protection Plan Committee are responsible for the annual review and update of the plan as recommended in Chapter 5 of this document.

The public will have the opportunity to provide feedback about the Plan annually on the anniversary of the adoption of this plan, at the meeting of the County Commissioners. Copies of the Plan will be catalogued and kept at all of the appropriate agencies in the county. The existence and location of these copies will be publicized. The Plan also includes the address and phone number of the County Commissioners Office, responsible for keeping track of public comments on the Plan.

A public meeting will be held as part of each annual evaluation or when deemed necessary by the Wildfire Protection Plan Committee. The meetings will provide the public a forum for which they can express its concerns, opinions, or ideas about the plans. The County Commissioners will be responsible for using county resources to publicize the annual public meetings and maintain public involvement through the public access channel, webpage, and newspapers.

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Chapter 3: County Characteristics & Risk Assessment

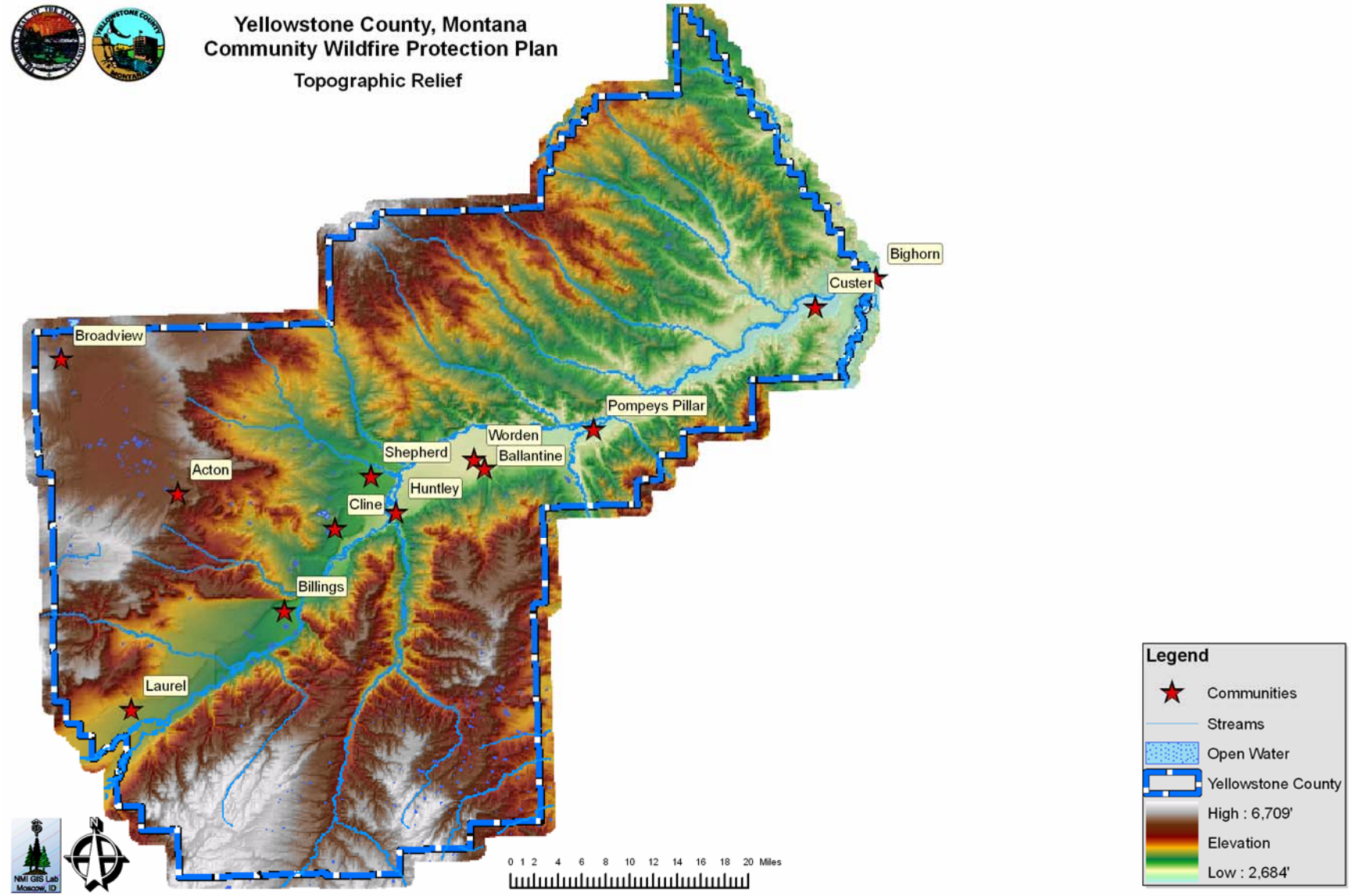
3 Background and Area Description

3.1 Location and Land Forms

Yellowstone County is located in south central Montana with the Yellowstone River cutting through its heartland. Elevations range from 4,700 feet above sea level south of Billings to approximately 3,000 feet in some areas in the northeastern corner of the County. Ownership is mixed between federal, tribal, state, and private owners.

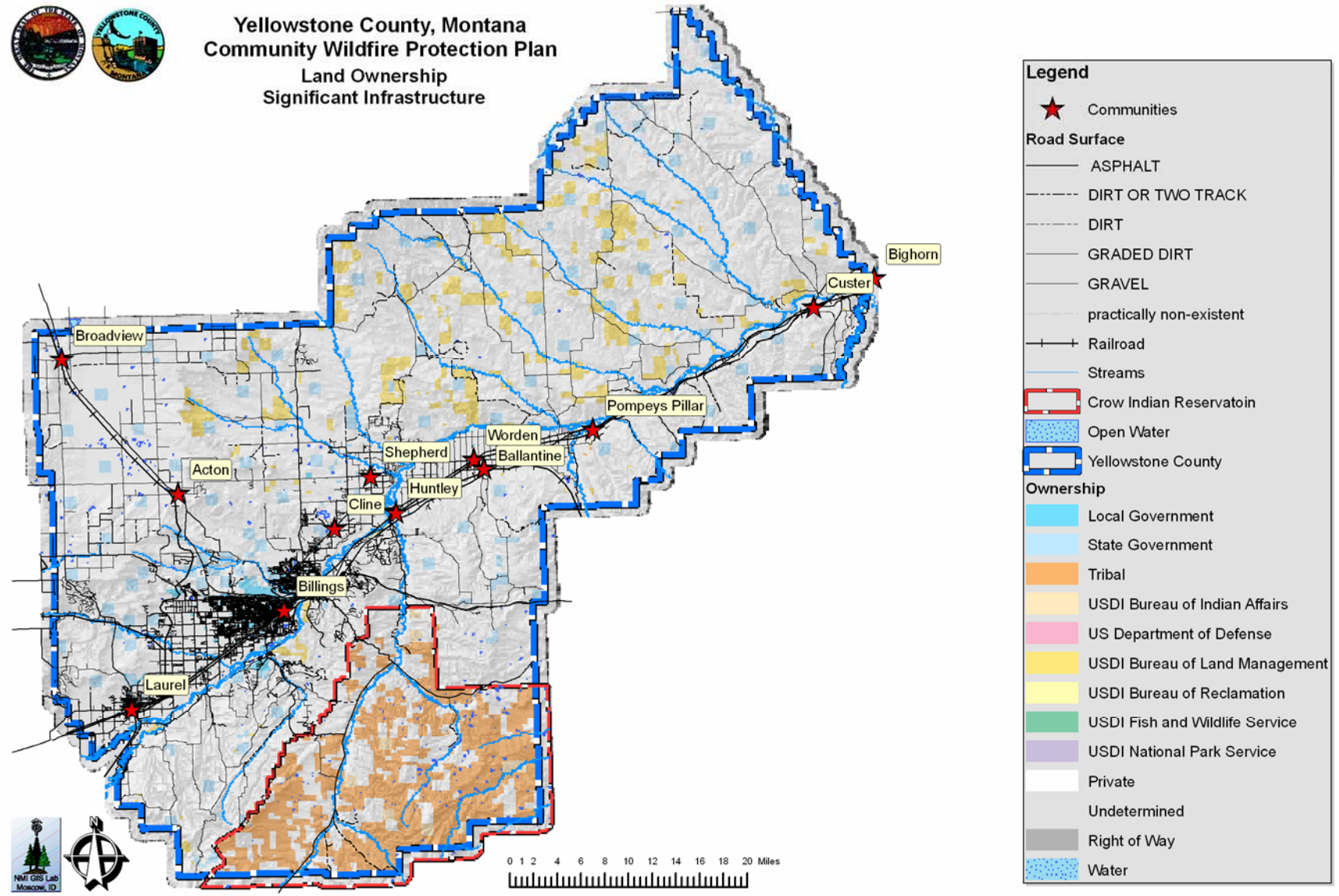
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Figure 3.1. Topographic relief of Yellowstone County, Montana.



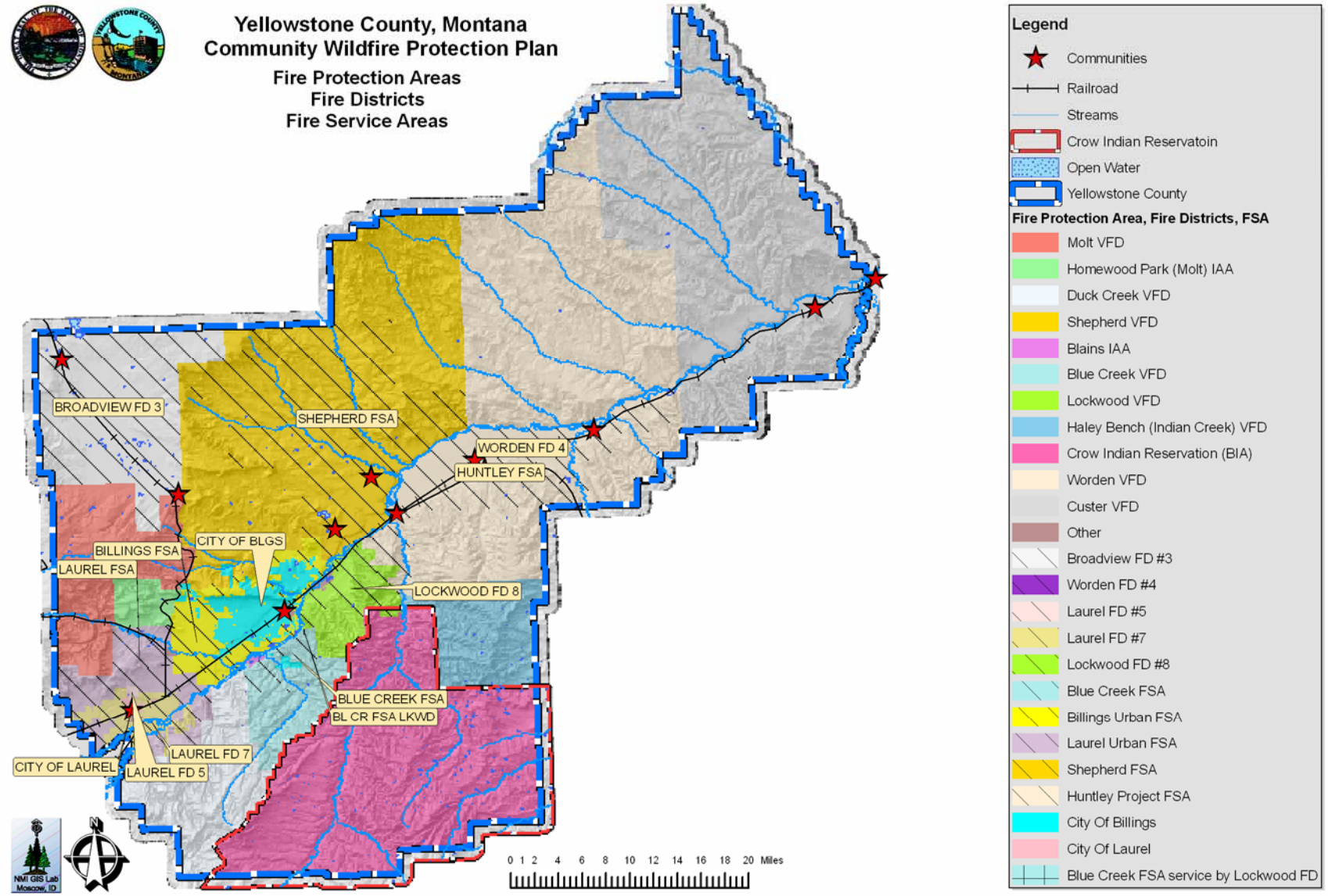
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Figure 3.2. Land Ownership in Yellowstone County.



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Figure 3.3. Rural and City Fire Protection in Yellowstone County.



3.2 Demographics

The number of persons residing in Yellowstone County has been growing steadily over the past few decades, rising by approximately 14 percent between 1990 and 2000. Yellowstone County remains the most populated county in Montana with a population of 129,352 in 2000. Yellowstone County has three incorporated communities, Billings (pop. 89,362), Laurel (pop. 6,142), and Broadview (pop. 184). Unincorporated communities recognized by the Census Bureau include Lockwood (pop. 4,282), Huntley (pop. 477), Worden (pop. 472), Shepherd (pop. 177), Ballantine (pop. 366), and Custer (pop. 145). The total land area of the county is roughly 2,649 square miles (1,695,392 acres).

Table 3.1 summarizes some relevant demographic statistics for Yellowstone County.

Table 3.1. Summary of selected demographic statistics for Yellowstone County, Montana (Census 2000).

Subject	Number	Percent
Total population	**129,352**	**100.0**
SEX AND AGE		
Male	63,045	48.7
Female	66,307	51.3
Under 5 years	8,440	6.5
5 to 9 years	9,463	7.3
10 to 14 years	9,517	7.4
15 to 19 years	9,180	7.1
20 to 24 years	8,519	6.6
25 to 34 years	16,087	12.4
35 to 44 years	21,172	16.4
45 to 54 years	18,426	14.2
55 to 59 years	6,249	4.8
60 to 64 years	5,076	3.9
65 to 74 years	8,636	6.7
75 to 84 years	6,475	5.0
85 years and over	2,112	1.6
Median age (years)	36.8	(X)
18 years and over	96,216	74.4
Male	45,785	35.4
Female	50,431	39.0
21 years and over	91,015	70.4
62 years and over	20,178	15.6
65 years and over	17,223	13.3
Male	7,121	5.5
Female	10,102	7.8
RELATIONSHIP		
Population	**129,352**	**100.0**
In households	126,413	97.7
Householder	52,113	40.3

Table 3.1. Summary of selected demographic statistics for Yellowstone County, Montana (Census 2000).

Subject	Number	Percent
Spouse	27,132	21.0
Child	37,421	28.9
Own child under 18 years	30,826	23.8
Other relatives	3,548	2.7
Under 18 years	1,450	1.1
Nonrelatives	6,199	4.8
Unmarried partner	2,941	2.3
In group quarters	2,939	2.3
Institutionalized population	1,652	1.3
Noninstitutionalized population	1,287	1.0
HOUSEHOLDS BY TYPE		
Households	**52,113**	**100.0**
Family households (families)	34,488	66.2
With own children under 18 years	16,668	32.0
Married-couple family	27,362	52.5
With own children under 18 years	11,901	22.8
Female householder, no husband present	5,050	9.7
With own children under 18 years	3,454	6.6
Nonfamily households	17,625	33.8
Householder living alone	14,548	27.9
Householder 65 years and over	5,632	10.8
Households with individuals under 18 years	17,700	34.0
Households with individuals 65 years and over	16,141	31.0
Average household size	2.43	(X)
Average family size	2.97	(X)
HOUSING TENURE		
Occupied housing units	**52,084**	**100.0**
Owner-occupied housing units	36,037	69.2
Renter-occupied housing units	16,047	30.8
Average household size of owner-occupied unit	2.59	(X)
Average household size of renter-occupied unit	2.06	(X)

(Census 2000)

Figure 3.4 Yellowstone County Population Trends from 1890 – 2000.

TABLE 1: Population Of Yellowstone County And Incorporated Areas
Percent Change By Decade 1890 – 2000

Decade	Yellowstone County	Percent Change	City of Billings	Percent Change	City of Laurel	Percent Change	Town of Broadview	Percent Change
1890	2065	*****	836	*****	No Data	*****	No Data	*****
1900	6212	66.76	3221	285.29	No Data	*****	No Data	*****
1910	22,944	22.49	10,031	50.53	806	*****	No Data	*****
1920	29,600	29.01	15,100	8.48	2239	177.80	191	*****
1930	30,785	4.00	16,380	42.00	2558	14.25	260	36.13
1940	41,182	33.77	23,261	36.85	2754	7.66	140	-120.00
1950	55,875	35.68	31,834	66.02	3663	33.00	164	17.14
1960	79,016	41.41	52,851	65.12	4601	.25.60	160	-2.44
1970	87,367	10.57	61,581	16.52	4454	-3.19	123	-23.13
1980	108,035	23.65	66,798	8.47	5481	23.06	120	-2.44
1990	113,419	4.98	81,151	21.49	5686	3.74	133	10.83
2000	129,352	14.04	89,847	10.72	6255	10.00	150	12.78

Yellowstone County and City of Billings 2003 Growth Policy Plan.

3.3 Socioeconomics

Yellowstone County had a total of 52,084 occupied housing units and a population density of 2.8 persons per square mile reported in the 2000 Census (Table 3.1). Ethnicity in Yellowstone County is distributed: white 92.8%, black or African American 0.4%, American Indian or Alaskan Native 3.1 %, other race 1.3%, and Hispanic or Latino 3.7%.

Specific economic data for individual communities is collected by the US Census; in Yellowstone County this includes Billings, Laurel, and Broadview. Billings's households earn a median income of $35,147 annually, Laurel households earn $32,679, and Broadview households earn $29,500, which are both below the Yellowstone County median income during the same period ($36,727). Table 3.2 shows the dispersal of households in various income categories in both communities.

Table 3.2. Income in 1999.	Billings		Laurel		Broadview		Yellowstone County	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Less than $10,000	3686	9.8	261	10.6	5	7.1	4773	9.2
$10,000 to $14,999	3642	9.9	252	10.3	7	10	4709	9.0
$15,000 to $24,999	5823	15.5	448	18.2	16	22.9	7928	15.2
$25,000 to $34,999	5512	14.7	338	13.8	14	20	7466	14.3
$35,000 to $49,999	6677	17.8	492	20	17	24.3	9508	18.2
$50,000 to $74,999	7029	18.8	390	15.9	7	10.0	9803	18.8
$75,000 to $99,999	2641	7	206	8.4	4	5.7	4128	7.9
$100,000 to $149,999	1518	4.1	40	1.6	0	0	2375	4.6
$150,000 to $199,999	437	1.2	7	0.3	0	0	667	1.3
$200,000 or more	505	1.3	21	0.9	0	0	756	1.5
Median household income (dollars)	35,147		32,679		29,500		36,727	

(Census 2000)

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations*, directs federal agencies to identify and address any disproportionately high adverse human health or environmental effects of its projects on minority or low-income populations. In Yellowstone County, a significant number of families are at or below the poverty level. Approximately 9.2% of Yellowstone County families are below poverty level (Table 3.3).

Table 3.3. Poverty Status in 1999 (below poverty level).	Yellowstone County	
	Number	Percent
Families	2,130	(X)
Percent below poverty level	(X)	9.2
With related children under 18 years	1,806	(X)
Percent below poverty level	(X)	15.6
With related children under 5 years	990	(X)
Percent below poverty level	(X)	21.7
Families with female householder, no husband present	1,220	(X)
Percent below poverty level	(X)	31.2
With related children under 18 years	1,125	(X)
Percent below poverty level	(X)	38.5
With related children under 5 years	683	(X)
Percent below poverty level	(X)	57.4

Table 3.3. Poverty Status in 1999 (below poverty level).	Yellowstone County	
	Number	Percent
Individuals	10,402	(X)
Percent below poverty level	(X)	12.0
18 years and over	6,851	(X)
Percent below poverty level	(X)	10.4
65 years and over	855	(X)
Percent below poverty level	(X)	7.0
Related children under 18 years	3,448	(X)
Percent below poverty level	(X)	16.5
Related children 5 to 17 years	2,168	(X)
Percent below poverty level	(X)	14.2
Unrelated individuals 15 years and over	3,860	(X)
Percent below poverty level	(X)	20.5

(Census 2000)

The unemployment rate was 2.1% in Yellowstone County in 1999, compared to 4.4% nationally during the same period. Approximately 20.6% of the Yellowstone County employed population worked in natural resources, with much of the indirect employment relying on the employment created through these natural resource occupations; Table 3.4 (Census 2000).

Table 3.4. Employment and Industry.	Yellowstone County	
	Number	Percent
OCCUPATION		
Management, professional, and related occupations	14,505	31.8
Service occupations	7,834	17.2
Sales and office occupations	14,540	31.9
Farming, fishing, and forestry occupations	113	0.2
Construction, extraction, and maintenance occupations	3,662	8.0
Production, transportation, and material moving occupations	4,906	10.8
INDUSTRY		
Agriculture, forestry, fishing and hunting, and mining	812	1.8
Construction	2,630	5.8
Manufacturing	2,221	4.9
Wholesale trade	2,824	6.2
Retail trade	6,893	15.1
Transportation and warehousing, and utilities	2,685	5.9
Information	1,100	2.4
Finance, insurance, real estate, and rental and leasing	3,310	7.3
Professional, scientific, management, administrative, and waste management services	3,771	8.3
Educational, health and social services	9,743	21.4
Arts, entertainment, recreation, accommodation and food services	5,071	11.1
Other services (except public administration)	2,708	5.9
Public administration	1,792	3.9

Figure 3.5 Labor Force and Unemployment Rates from 1980 to 2000.

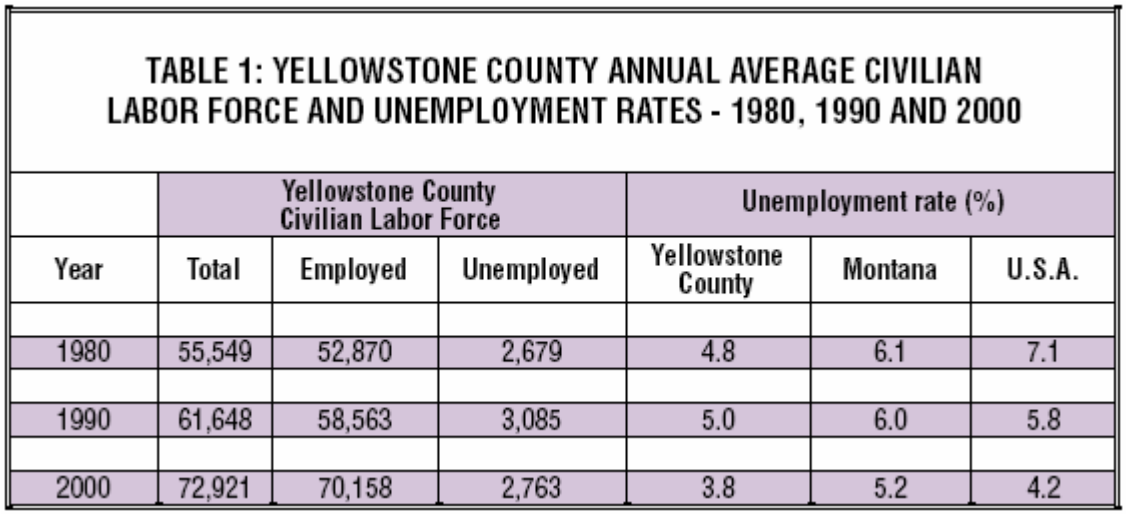


TABLE 1: YELLOWSTONE COUNTY ANNUAL AVERAGE CIVILIAN LABOR FORCE AND UNEMPLOYMENT RATES - 1980, 1990 AND 2000

	Yellowstone County Civilian Labor Force			Unemployment rate (%)		
Year	Total	Employed	Unemployed	Yellowstone County	Montana	U.S.A.
1980	55,549	52,870	2,679	4.8	6.1	7.1
1990	61,648	58,563	3,085	5.0	6.0	5.8
2000	72,921	70,158	2,763	3.8	5.2	4.2

Yellowstone County and City of Billings 2003 Growth Policy Plan

Approximately 80% of Yellowstone County's employed persons are private wage and salary workers, while around 12% are government workers (Table 3.5).

Table 3.5. Class of Worker	Yellowstone County	
	Number	Percent
Private wage and salary workers	36,439	80.0
Government workers	5,472	12.0
Self-employed workers in own not incorporated business	3,552	7.8
Unpaid family workers	97	0.2

(Census 2000)

3.4 Description of Yellowstone County

3.4.1 Recreation

This region is a favorite destination for a variety of recreational opportunities. Lake Elmo State Park is a favorite recreational opportunity for County residents offering swimming, hiking, fishing, and sail boating just outside of Billings. The Yellowstone River and the Clarks Fork of the Yellowstone River offer fishing, picnicking, and camping opportunities throughout the County as well. Pictograph Caves State Park and Pompeys Pillar draw tourists and residents alike for day use exploring, hiking, and picnicking. There are also several high-quality golf courses in the area.

Bird hunting and big game hunting for deer, elk, and antelope is especially intense every fall. During the winter, snowmobiling has become a very popular sport. Area residents can also travel to neighboring counties to take advantage of the skiing and snowshoeing opportunities.

The economic impacts of these activities to the local economy and the economy of Montana have not been enumerated. However, they are substantial given the many months of the year that activities take place and the staggering numbers of visitors that travel to this location. The large numbers of visitors to the region each year is noteworthy in light of wildfire mitigation efforts because of the combination of visitors traveling to rural and remote areas, visitors who are not necessarily familiar with rangeland and forestland fuel risk factors (e.g., campfire

protocols, use of fire, etc.), and their often unfamiliarity with access routes and other factors. Because of these reasons and others, the rural areas of Yellowstone County will receive increased attention during mitigation treatments.

3.4.1.1 BLM Public Lands

There are several scattered chunks of BLM administered lands in Yellowstone County. These areas are open to the public year round. Although there are no developed sites, residents of Yellowstone County use these lands to hunt, four-wheel, mountain bike, and drive off-road vehicles among many other things.

3.4.1.2 Camping

Camping is a popular activity enjoyed by residents and visitors of Yellowstone County. In addition to the developed RV parks along the freeway routes, there are also several undeveloped campsites along the Yellowstone River, most of which are easily accessed.

3.4.1.3 Fishing and Hunting

Fishing and hunting is very important to Yellowstone County both from a recreational standpoint and as an economic resource. A wide variety of fish can be caught in Yellowstone County including: trout, catfish, crappie, perch, and bass.

For those people who prefer a gun or bow to a fly rod, Yellowstone County offers a bounty of hunting experiences. Wild birds and game, like deer, elk, black bear, antelope, pheasant, partridge, grouse, wild duck, geese, and doves are found in abundance.

3.4.2 Resource Dependency

Economic conditions can affect county population, land use, population growth (or decline), and personal income and ability of communities to fund services and infrastructure. Yellowstone County completed the Yellowstone County and City of Billings 2003 Growth Policy Plan, which outlines an economic development strategy for the future. This document also provided descriptions and data on the county economy and other factors that can affect or be affected by the economy.

Resource industries and agriculture dominate the local economy. There are three oil refineries in the county, with two of those in Billings and the third in nearby Laurel. A Western Sugar refinery is located in Billings. About 350 Montana farmers supply sugar beets to the refinery, which has a direct impact of $50 million per year on the county's economy.

Billings is the medical and educational center for the region. The two hospitals employ over 3,200 people and have almost 600 beds. Several clinics also operate in Billings. Montana State University – Billings has 4,000 students while its College of Technology has approximately 500. Rocky Mountain College, a private, four-year university, has 800 students and is the oldest college in Montana.

The Billings and Yellowstone County economy can be summarized as follows:

- Employment grew by 1/3 between 1980 and 2000 and about 2/3 of those new workers were women.
- Employment growth in the mid to late 1990s was dominated by construction, retail sales and service jobs.

• Predicted Montana job growth through 2008 indicates that the most jobs will be produced in retail sales and services and the state growth rates for these jobs is predicted to be higher than for the U.S.

• The jobs that are predicted to grow most for the next few years have among the lowest job multipliers, thereby producing relatively low spin-off or secondary job opportunities.

• Supply of workers in Yellowstone County is predicted to equal or exceed the demand over the next several years.

• Per capita income has grown slowly over the past 30 years, but it has fallen when compared to the U.S., and has risen when compared to the state of Montana.

• When adjusted for inflation, average earnings per job have remained almost stagnant for the past 30 years and have fallen when compared to the U.S. average.

• The cost of living in Billings is slightly below the national average and is about the median among surveyed cities in Montana and the region.

• When the cost of living is compared to per capita income and earnings per job, Billings has a lower cost of living and higher income/earnings than most of the surveyed Montana cities. When compared to other surveyed cities in the region, Billings has about an equal cost of living and lower per capita income and job earnings.

• Yellowstone County and Billings aren't keeping pace with surrounding states and the nation in producing personal wealth, but appear to be doing better than the remainder of Montana.

3.4.3 Development Trends

Sixty-nine percent of the population in Yellowstone County lived in Billings in 2000. This is slightly less than the 71.5 percent of the population that lived in the City in 1990. These figures suggest a slight growth in population outside the City limits. This trend is supported by the increase in subdivision activity in the County. The growth trend has been to develop on the edges of Billings or in the County and not within the City. This trend is not because of the lack of developable parcels in the City. There are approximately 3,607 parcels classified by the Montana Department of Revenue as vacant residential land within the city limits. Of these, 3,529 parcels are two acres or less. The vacant parcels constitute 11 percent of all parcels in Billings. For the years of 2000 and 2001, there were more single family home building permits issued than there were lots created in the Billings Metro (building permit jurisdiction). There were 403 building permits issued for single family home construction in 2000, and 476 permits were issued in 2001. An estimated 298 lots were created in the Metro Area in 2000 and 312 in 2001. This trend indicates that, in addition to new construction occurring on newly created lots, lots created in previous years are being developed. Many of the older lots have remained vacant for a decade or more until being developed only recently. This is particularly true for subdivisions in the Heights, including several filings of the Lake Hills Subdivision.

According to the Billings Housing Needs Analysis, the need for low cost housing exceeds the supply. The study estimates a shortage of almost 2,200 low cost units that are affordable to households earning less than $15,000 per year. The estimates are based on the number of available units that would cost the homeowner no more than 30 percent of their income. There is also a shortage of housing for households earning more than $35,000 based on the same criteria. However, many people may choose to live in homes that are less expensive than they can afford and spend their money on other expenses.

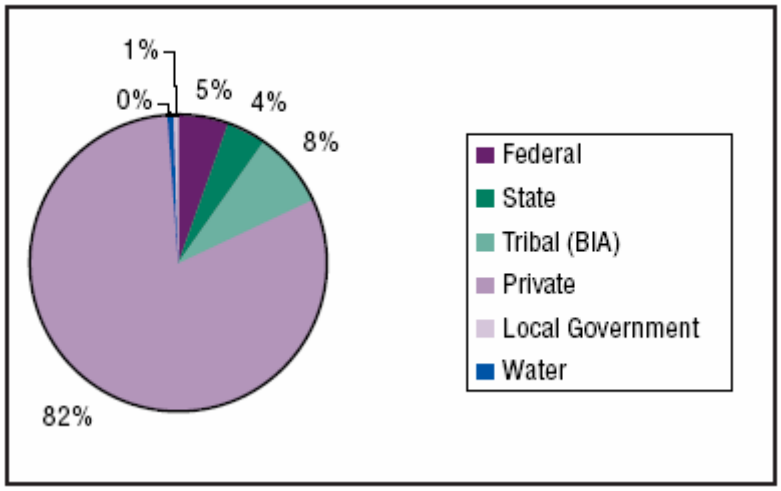
3.4.4 Land Use

Historically, Yellowstone County land use has been dominated by agriculture and related uses. Much of the early business in Billings developed to service the surrounding ranches and farms. Today, agriculture is still a dominant land use, but residential development and commercial uses have gained considerable ground.

The area of Yellowstone County is approximately 1,693,751 acres. Of the total, 1,374,730 acres, or 82 percent, is under private ownership. Tribal land administered by the U.S. Bureau of Indian Affairs comprises 139,983 acres (8 percent) and is located primarily in the southeast part of the County. Other Federal agencies, including the U.S. Bureau of Land Management, the U. S. Bureau of Reclamation, and U.S. Fish & Wildlife Service administer 88,581 acres (5 percent) and state agencies administer 73,414 acres (4 percent). State land management agencies include the Department of Natural Resources, responsible mainly for State Trust Land, and the Montana Department of Fish, Wildlife, and Parks, which oversees State Parks and fishing accesses.

Land owned by the City of Billings, City of Laurel and Yellowstone County comprise less than 1 percent of Yellowstone County. The ownership of land covered by water is also less than 1 percent where ownership is undetermined. In general terms, land use in Yellowstone County falls into five main categories: agricultural, residential, commercial, industrial and recreational. The majority of the County, over 1.3 million acres, is classified by the Montana Department of Revenue as agricultural. The primary residential and commercial centers are located in Billings, Laurel, and Lockwood and to a lesser extent, the communities of Custer, Shepherd, Huntley, Worden, Ballantine, Pompey's Pillar and Broadview. There is approximately 4,148 acres of commercially and industrially-classed property and 33,057 acres of residentially-classed property throughout the County. Industrial uses are mostly confined to Billings, Laurel and Lockwood. The remaining 350,000 acres includes land administered by the Bureau of Indian Affairs, or is not classified or is exempt.

Figure 3.6. Land ownership in Yellowstone County.



Yellowstone County and City of Billings 2003 Growth Policy Plan

3.4.4.1 Agricultural Land Use

The 1997 Census of Agriculture reported a 5 percent increase in the amount of land used for agricultural purposes between 1992 and 1997 in Yellowstone County. An estimated 1,526,007

acres or 90 percent of the total County land base is used for cropland and grazing. Most of the agricultural land, 1,144,617 acres, is used for livestock grazing while 381,390 acres are cultivated for crops. The amount of irrigated cropland increased from 73,261 acres in 1992 to 80,024 acres in 1997. This suggests that the loss of irrigated land to annexations and subdivisions was offset elsewhere in the County by an increase in irrigated land use. Within the County zoning jurisdiction, 69 percent or 100 square miles of land is zoned for agriculture.

Agricultural land is held in private, state and federal ownership. The Montana Department of Natural Resources manages 9,000 acres of land under agricultural production and 6,800 acres of grazing land. The Bureau of Land Management has approximately 76,900 acres allotted for grazing purposes.

3.5 Emergency Services

The City of Billings operates the 911 Dispatch Center for Yellowstone County and the City of Billings. In addition to handling law enforcement and emergency medical calls, the center also provides dispatch services to all of the fire departments in Yellowstone County except Laurel. The dispatch center, operational 24 hours a day, is located in Fire Station #1 in Billings.

With regard to wildfires, the 911 dispatch center is primarily responsible for receiving reports of fires and notifying the appropriate fire district and/or agency according to protocol sheets provided by the districts or agencies. The center will provide some support to incidents, but generally does not function as an expanded dispatch office. For large-scale incidents, the County Emergency Operations Center at Fire Station #1 is activated. The County Fire Warden will be involved in establishing and operating the EOC.

The City of Laurel also operates a 911 Dispatch Center for the City of Laurel, the Laurel Volunteer Fire Department, Laurel Police Department, and the Laurel Volunteer Ambulance. This dispatch center handles law enforcement, emergency medical calls, and dispatches fire departments with jurisdiction in the Laurel area. For large scale incidents, and EOC is set up in the Laurel Safety Complex.

3.6 Cultural Resources

The United States has a unique legal relationship with Indian tribal governments defined in history, the U.S. Constitution, treaties, statutes, Executive Orders, and court decisions. Since the formation of the union, the United States has recognized Indian tribes as domestic dependant nations under its protection. The Federal Government has enacted numerous regulations that establish and define a trust relationship with Indian tribes.

The relationship between Federal agencies and sovereign tribes is defined by several laws and regulations addressing the requirement of Federal agencies to notify or consult with Native American groups or otherwise consider their interests when planning and implementing Federal undertakings, among these are:

- **EO 13175, November 6, 2000**, Consultation and Coordination with Indian Tribal Governments.
- **Presidential Memorandum, April, 1994**. Government-Government Relations with Tribal Governments (Supplements EO 13175). Agencies must consult with federally recognized tribes in the development of Federal Policies that have tribal implications.
- **EO 13007, Sacred sites, May 24, 1996**. Requires that in managing Federal lands, agencies must accommodate access and ceremonial use of sacred sites and must avoid adversely affecting the physical integrity of these sites.

- **EO 12875, Enhancing Intergovernmental Partnerships, October 26, 1993**. Mainly concerned with unfunded mandates caused by agency regulations. Also states the intention of establishing "regular and meaningful consultation and collaboration with state, local and tribal governments on matters that significantly or uniquely affect their communities."
- **Native American Graves Protection and Repatriation Act (NAGPRA) of 1989**. Specifies that an agency must take reasonable steps to determine whether a planned activity may result in the excavation of human remains, funerary objects, sacred objects and items of cultural patrimony from Federal lands. NAGPRA also has specified requirements for notifying and consulting tribes.
- **Archaeological Resources Protection Act (ARPA), 1979**. Requires that Federal permits be obtained before cultural resource investigations begin on Federal land. It also requires that investigators consult with the appropriate Native American tribe prior to initiating archaeological studies on sites of Native American origin.
- **American Indian Religious Freedom Act (AIRFA), 1978**. Sets the policy of the US to protect and preserve for Native Americans their inherent rights of freedom to believe, express, and exercise the traditional religions of the American Indian . . . including, but not limited to access to sacred sites, use and possession of sacred objects, and the freedom to worship through ceremonies and traditional rites.
- **National Environmental Policy Act (NEPA), 1969**. Lead agency shall invite participation of affected Federal, State, and local agencies and any affected Indian Tribe(s).
- **National Historic Preservation Act (NHPA), 1966**. Requires agencies to consult with Native American tribes if a proposed Federal action may affect properties to which they attach religious and cultural significance. (Bulletin 38 of the act, identification of TCPs, this can only be done by tribes.)
- Treaties (supreme law of the land) in which tribes were reserved certain rights for hunting, fishing and gathering and other stipulations of the treaty.
- Unsettled aboriginal title to the land, un-extinguished rights of tribes.

3.6.1 Crow Indian Reservation

The Crow Reservation is in south central Montana, bordered by Wyoming to the south. The northwest boundary of the reservation is about ten miles from Billings in Yellowstone County. About 75 percent of the Crow tribe's, approximately 9,300, enrolled members live on or near the reservation. Many speak Crow as their first language.

For many years the vast coal deposits under the eastern portion of the reservation remained untapped. One mine is now in operation and is providing royalty income and employment to tribal members. The Crow use a portion of their land for irrigated and dryland farming and other portions for grazing land. They maintain a buffalo herd of 300 head. Crow Agency is home to Little Bighorn College. The college houses the Institute for MicroBusiness Development and offers degrees in eight fields.

Other points of interest on the reservation are:

- Bighorn Canyon National Recreation Area
- Little Bighorn National Monument/Reno-Benteen Battlefield
- Chief Plenty Coups State Park

- Yellowtail Dam and Reservoir

The Crow tribe call themselves "Apsaslooka", which means "children of the large-beaked bird." Other tribes called them "sharp people," meaning they were as crafty and alert as the raven. The Crow originally lived in the upper Midwest. The tribe began migrating west as early as the late 1300s. They migrated to North Dakota around 1600 and then continued their movement west. Finally, they settled along the Missouri and Yellowstone River bottoms in Montana.

Originally planters, as the Crow moved west, they came to rely on hunting, and they built a life around the buffalo. When the horse was first introduced in the 18th century, the Crow quickly became excellent horsemen and prospered.

William Clark met the Crow in 1806, and spent a month in Crow country. The expedition members, and later the fur traders, developed good relationships with the tribe. Nonetheless, the Crows, like so many other tribes, found themselves vulnerable to Euro-American diseases. Smallpox and other diseases reduced the tribe by over twenty percent.

At the same time, the buffalo were disappearing from the plains, and the tribe was forever changed. Despite their good relationship with the government, the tribe's lands dwindled and treaties were broken. Additionally, their traditional enemies, the Sioux and the Northern Cheyenne, invaded Crow land. The other tribes tried to get the Crow to work with them against the tide of white settlers, but the tribe did not have a hostile relationship with the government. George A. Custer had six Crow scouts at the Battle of The Little Bighorn. The reservation boundaries were finally fixed by 1904. The tribe has returned to an agricultural way of life, much like their ancestors 300 years before.

3.6.2 National Register of Historic Places

Section 106 of the National Historic Preservation Act requires federal agencies to consider the effects of their proposals on historic properties, and to provide state historic preservation officers, tribal historic preservation officers, and, as necessary, the Advisory Council on Historic Preservation a reasonable opportunity to review and comment on these actions.

Cultural resource impacts were qualitatively assessed through a presence/absence determination of significant cultural resources and mitigation measures to be employed during potential mitigation activities such as thinning, prescribed fire, road construction, flood abatement, and other activities.

Typical archeological sites include settlements, lithic scatters, village sites, rock art, and hunting blinds. The Crow had a network of trails throughout the area which included various trade routes, as well as gathering and hunting routes. Some of the same trails were later used by homesteaders and trappers. Traditional Cultural Properties (TCPs) are cultural resources defined as a significant place or setting, and does not necessarily have any associated material remains. For example, a TCP can be a mountain, river, or natural feature (i.e., rock formation, meadow, etc.). Some of these are present in Yellowstone County. The integrity of some cultural resources has been impacted in the past by logging activities, road building, mining, and grazing.

The National Park Service maintains the National Register of Historical Places as a repository of information on significant cultural locale. These may be buildings, roads or trails, places where historical events took place, or other noteworthy sites. The NPS has recorded sites in its database. These sites are summarized in Table 3.6.

Table 3.6. National Register of Historic Places in Payette County, Idaho.					
Item Number	**Resource Name**	**Address**	**City**	**Listed**	**Architect, Builder, or Engineer**
1	Antelope Stage Station	E of Broadview	Broadview	1983	
2	Billings Chamber of Commerce Building	303 N. 27th St.	Billings	1972	McAlister,G., Gagnon & Co.
3	Billings Historic District	Roughly bounded by N. 23rd and N. 25th Sts., 1st and Montana Aves.	Billings	1979	Crowe,J., Et al.
4	Billings West Side School	415 Broadwater Ave.	Billings	2002	Oehme, Curtis, et.al.
5	Boothill Cemetery	N of Billings	Billings	1979	
6	Electric Building	113-115 Broadway	Billings	2002	Link, John G.
7	Fire House No. 2	201 E. 30th St	Billings	1980	Ohme,Curtis E.
8	Hoskins Basin Archeological District		Billings	1974	
9	Masonic Temple	2806 Third Ave. N	Billings	1986	Link & Haire
10	Molt, Rudolph F. W., House	39 Yellowstone Ave	Billings	1987	Eames,V.W., Oehme,Curtis C.
11	Moss, Preston B., House		Billings	1982	Hardenbergh,R.J. , Gagnon,E.H.
12	North, Austin, House	622 N. 29th St.	Billings	1977	Link & Haire
13	O'Donnell, I. D., House	105 Clark Ave.	Billings	1977	Eams & Sawyer, Link & Haire
14	Parmly Billings Memorial Library	2822 Montana Ave	Billings	1972	Haire,Charles S.
15	Pictograph Cave	7 mi. SE of Billings in Indian Caves Park	Billings	1966	
16	Pompey's Pillar	W of Pompey	Pompey's Pillar	1966	
17	Prescott Commons	Rimrock Rd	Billings	1982	Comstock,Wallac e H.
18	US Post Office and Courthouse--Billings	2602 First Ave. N	Billings	1986	Wenderoth,Oscar , Et al
19	Yegen, Christian, House	208 S. 35th St	Billings	1979	
20	Yegen, Peter, House	209 S. 35th St	Billings	1980	Eames,Mr.

Hazard mitigation activities in and around these sites has the potential to affect historic places. In all cases, mitigation work will be intended to reduce the potential of damaging the site due to natural and man caused disasters. Areas where ground disturbance will occur will need to be inventoried depending on the location. Such actions may include, but are not be limited to, constructing firelines (handline, mechanical line, etc.), building new roads to creeks to fill water tankers, mechanical treatments, etc. Only those burn acres that may impact cultural resources that are sensitive to burning (i.e., buildings, peeled bark trees, etc.) would be examined. Burns

over lithic sites are not expected to have an impact, as long as the fire is of low intensity and short duration. Some areas with heavy vegetation may need to be examined after the burn to locate and record any cultural resources although this is expected to be minimal. Traditional Cultural Properties (TCPs) may also need to be identified. Potential impact to TCPs will depend on what values make the property important and will be assessed on an individual basis.

3.7 Transportation

The transportation system hierarchy in Yellowstone County begins with the Federal Highway System, which includes Interstates 90 and 94. U.S. Routes present in the County include U.S. Highway 87, 212 and 310. Numerous State highways and secondary roads traverse the County in addition to County roads and City streets. Maintaining the condition and efficiency of all these roadways is the responsibility of the Montana Department of Transportation, the County Public Works Department and the City Public Works Department. Much of the planning for these routes is accomplished through the Billings Metropolitan Planning Organization (MPO) under the jurisdiction of the County Planning Board.

Billings Logan International Airport is a growing regional air traffic hub with a market area encompassing central and eastern Montana and northern Wyoming. The airport is served by seven passenger airlines: Northwest, Delta/Skywest, Big Sky, United/Air Wisconsin, and Horizon, with 35 scheduled flights per day. Passenger emplanements have risen from 290,000 in 1989 to 354,722 emplanements in 2001.

The Billings Urban Area relies on two major rail companies and numerous trucking firms to move freight in, out, and through the region. The geographic location and the existing infrastructure generally restrict freight movement to east-west routes. Rail lines in particular are oriented toward transcontinental east-west flows, while freeway routes provide some, though less convenient, north-south flow. The two railroad operators in Billings are Burlington Northern Sante Fe and Montana Rail Link. Both move large volumes of coal and freight through the area and serve the downtown Billings intermodal facility. A total of 53 million tons of coal and freight was moved by rail through Billings in 1996. Freight originating in the region includes coal and coal products, petroleum, farm products, lumber and wood products, and stone, clay, glass and concrete products. Ninety percent of these commodities were shipped out of state. Existing rail facilities for Montana Rail Link and Burlington Northern Sante Fe are adequate and have sufficient capacity to accommodate current and anticipated freight movement demand.

3.8 Vegetation & Climate

Vegetation in Yellowstone County is a mix of grasslands, rangelands, and forested ecosystems. An evaluation of satellite imagery of the region provides some insight to the composition of the forest vegetation of the area. The full extent of the county was evaluated for cover type as determined from Landsat 7 ETM+ imagery in tabular format, Table 3.7.

The most represented vegetated cover types are Low Cover Grasslands at 28% and Xeric Shrubs and Dryland Agriculture at approximately 13% and 12%, respectively, of the County's total area. The next most common vegetation cover type represented is Low/Moderate Cover Grasslands at 6% of the total area. Big Sage Steppe represents 5% of Yellowstone County, while Very Low Cover Grasslands cover only 4%.

Table 3.7. Cover Types in Yellowstone County.	**Category**	**Acres**	**Percent of County's Total Area**
Low Cover Grasslands	Upland Grasslands	478,886	28%

Table 3.7. Cover Types in Yellowstone County.	Category	Acres	Percent of County's Total Area
Xeric Shrubs	Dry Shrubland	219,041	13%
Dryland Agriculture	Agricultural	211,025	12%
Low/Moderate Cover Grasslands	Upland Grasslands	102,049	6%
Big Sage Steppe	Dry Shrubland	83,050	5%
Very Low Cover Grasslands	Upland Grasslands	75,525	4%
Wyoming Big Sage Steppe	Dry Shrubland	72,703	4%
Irrigated Agriculture	Agricultural	66,999	4%
Xeric Shrub Grass	Dry Shrub/Grassland	52,629	3%
Ponderosa Pine	Conifer Forest	50,734	3%
Greasewood	Dry Shrubland	31,163	2%
Shrub Badlands	Badlands	27,719	2%
Urban	Urban	27,180	2%
Graminoid and Forb Riparian	Mixed Riparian	26,115	2%
Mixed Mesic Shrubs	Moist Shrubland	23,120	1%
Grass Badlands	Badlands	20,375	1%
Moderate/High Cover Grasslands	Upland Grasslands	19,078	1%
Water	Water	16,600	1%
Shrub Dominated Riparian	Mixed Riparian	15,326	1%
Mixed Broadleaf Forest	Mixed Deciduous	14,921	1%
Broadleaf Dominated Riparian	Mixed Riparian	10,590	1%
Xeric Mixed Shrub	Dry Shrubland	8,392	0%
Salt Desert Shrub	Dry Shrubland	7,703	0%
Mixed Forest Non-forest Riparian	Mixed Riparian	7,367	0%
Exposed Rock	Exposed Rock	6,994	0%
Badlands	Badlands	4,801	0%
Mountain Big Sagebrush	Dry Shrubland	3,532	0%
Mixed Barren Land	Barren Land	2,629	0%
Mixed Xeric Forest	Mixed Conifer Forest	2,295	0%
Tree Grassland Associations	Tree/Grassland	1,814	0%
Douglas Fir	Conifer Forest	1,210	0%
Mixed Tree Riparian	Mixed Riparian	1,164	0%
Silver Sage	Dry Shrubland	878	0%
Limber Pine	Tree/Grassland	572	0%
Mesic Shrub Grassland	Moist Shrub/Grassland	389	0%
Mixed Shrub Herbaceous Riparian	Mixed Riparian	358	0%
Mines Quarries Gravel Pits	Mines Quarries Gravel	261	0%
Forest Savannah	Tree/Grassland	250	0%
Mixed Broadleaf Conifer Forest	Mixed Deciduous-Conif	202	0%
Cattail Marshes	Mixed Riparian	125	0%
Very Low Cover Forest	Tree/Grassland	59	0%

Table 3.7. Cover Types in Yellowstone County.	Category	Acres	Percent of County's Total Area
Juniper Sage Grass	Dry Shrubland	5	0%
Total		**1,695,828**	

Vegetative communities within the county follow the strong moisture and temperature gradient related to the major river drainages. Scarce precipitation and soil conditions result in a relatively arid environment. As moisture availability increases, so does the abundance of shrub and forest vegetation.

3.8.1 Monthly Climate Summaries in Yellowstone County

3.8.1.1 Billings

Period of Record Monthly Climate Summary

Period of Record: 7/ 1/1948 to 3/31/2005

Table 3.8. Monthly Climate Summaries for Billings, Yellowstone County, Montana.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	32.4	39.0	45.8	56.8	67.1	76.7	86.4	85.1	72.6	60.4	44.9	36.0	58.6
Average Min. Temperature (F)	13.9	19.5	24.9	33.9	43.4	51.6	58.2	56.8	46.9	37.3	25.9	18.2	35.9
Average Total Precipitation (in.)	0.76	0.62	1.03	1.76	2.26	2.12	1.10	0.86	1.26	1.11	0.71	0.65	14.25
Average Total Snowfall (in.)	10.0	7.0	9.7	8.8	1.7	0.0	0.0	0.0	1.1	3.8	6.5	8.4	57.0
Average Snow Depth (in.)	2	2	1	0	0	0	0	0	0	0	1	2	1

Percent of possible observations for period of record. Max. Temp.: 100% Min. Temp.: 100% Precipitation: 100% Snowfall: 100% Snow Depth: 100%

3.8.1.2 Laurel

Period of Record Monthly Climate Summary

Period of Record: 8/28/1951 to 2/28/1994

Table 3.9. Monthly Climate Summaries for Laurel, Yellowstone County, Montana.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)					Insuff	icient	Data						
Average Min. Temperature (F)					Insuff	icient	Data						
Average Total Precipitation (in.)	0.67	0.51	0.94	1.76	2.58	2.10	1.03	1.06	1.51	1.09	0.69	0.66	14.61
Average Total Snowfall (in.)	8.3	5.5	6.4	4.1	0.7	0.0	0.0	0.0	0.5	1.6	4.9	7.6	39.4
Average Snow Depth (in.)	3	1	0	0	0	0	0	0	0	0	1	2	1

Percent of possible observations for period of record. Max. Temp.: 0% Min. Temp.: 0% Precipitation: 92% Snowfall: 81.5% Snow Depth: 77.9%

3.8.1.3 Huntley

Period of Record Monthly Climate Summary

Period of Record: 1/ 1/1911 to 3/31/2005

Table 3.10. Monthly Climate Summaries for Huntley, Yellowstone County, Montana.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	32.8	38.5	47.0	59.8	69.4	78.0	87.4	86.0	74.0	62.3	46.4	36.4	59.8
Average Min. Temperature (F)	7.9	12.7	20.8	31.1	40.5	48.6	53.7	51.3	41.6	31.5	20.4	11.5	31.0
Average Total Precipitation (in.)	0.56	0.45	0.79	1.33	2.07	2.39	1.12	0.94	1.31	1.03	0.63	0.60	13.22
Average Total Snowfall (in.)	8.1	5.7	6.9	3.3	0.5	0.0	0.0	0.0	0.4	1.1	5.4	7.5	39.0
Average Snow Depth (in.)	4	2	1	0	0	0	0	0	0	0	1	2	1

Percent of possible observations for period of record. Max. Temp.: 97.5% Min. Temp.: 97.5% Precipitation: 97.7% Snowfall: 47.5% Snow Depth: 46.9%

3.8.1.4 Custer

Period of Record Monthly Climate Summary

Period of Record: 7/ 1/1948 to 6/30/1975

Table 3.11. Monthly Climate Summaries for Custer, Yellowstone County, Montana.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	29.1	40.2	48.4	59.7	71.4	80.0	89.3	88.9	76.2	65.1	48.9	34.7	61.0
Average Min. Temperature (F)	4.1	13.2	20.8	31.2	41.4	50.0	55.5	53.8	43.4	32.6	22.6	10.1	31.6
Average Total Precipitation (in.)	0.76	0.42	0.61	1.84	1.84	2.81	0.97	1.14	0.88	0.97	0.43	0.55	13.21
Average Total Snowfall (in.)	10.7	5.5	7.2	6.4	0.6	0.0	0.0	0.0	0.3	1.5	2.8	8.6	43.7
Average Snow Depth (in.)	4	3	1	0	0	0	0	0	0	0	0	2	1

Percent of possible observations for period of record. Max. Temp.: 53.3% Min. Temp.: 53.3% Precipitation: 54.9% Snowfall: 52.4% Snow Depth: 53.2%

3.8.1.5 Broadview, Montana

Period of Record Monthly Climate Summary

Period of Record: 9/15/1951 to 3/31/1991

Table 3.12. Monthly climate summaries for Broadview, Yellowstone County, Montana.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	34.0	40.2	46.9	57.0	67.2	77.0	86.0	84.5	72.2	62.1	45.5	37.5	59.2
Average Min. Temperature (F)	11.1	15.8	21.2	30.4	39.8	47.7	53.1	51.2	41.4	33.1	21.6	13.9	31.7
Average Total Precipitation (in.)	0.52	0.45	0.76	1.38	2.74	2.20	1.13	1.26	1.22	0.95	0.59	0.41	13.60
Average Total Snowfall (in.)	7.2	6.0	5.6	6.3	0.1	0.0	0.0	0.0	0.4	1.5	5.1	4.1	36.3
Average Snow Depth (in.)	2	1	1	0	0	0	0	0	0	0	1	1	1

Percent of possible observations for period of record. Max. Temp.: 88.7% Min. Temp.: 86.9% Precipitation: 97.3% Snowfall: 77.1% Snow Depth: 72.3%

3.9 Wildfire Hazard Profiles

3.9.1 Wildfire Ignition Profile

Fire was once an integral function of the majority of ecosystems in Montana. The seasonal cycling of fire across the landscape was as regular as the seasonal lightning storms plying across the canyons and mountains. Depending on the plant community composition, structural configuration, and buildup of plant biomass, fire resulted from ignitions with varying intensities and extent across the landscape. Shorter return intervals between fire events often resulted in less dramatic changes in plant composition (Johnson 1998). The fires burned from 1 to 47 years apart, with most at 5- to 20-year intervals (Barrett 1979). With infrequent return intervals, plant communities tended to burn more severely and be replaced by vegetation different in composition, structure, and age (Johnson *et al.* 1994). Native plant communities in this region developed under the influence of fire, and adaptations to fire are evident at the species, community, and ecosystem levels. Fire history data (from fire scars and charcoal deposits) suggest fire has played an important role in shaping the vegetation in the region for thousands of years (Steele *et al.* 1986, Agee 1993).

Detailed records of fire ignition and extent have been compiled by the Forest Service, Bureau of Indian Affairs, and the Bureau of Land Management. Using this data on past fire extents and fire ignition data, the occurrence of wildland fires in the region of Yellowstone County has been evaluated. Since it was a major fire that burned several hundred thousand acres, it should be noted that the Hawk Creek Fire of 1984 is not included in this dataset.

Many fires have burned in the region of Yellowstone County (Table 3.13). There were approximately 285 fire ignitions during this 25 year period, with the highest number of total ignitions peaking in 1996. Although there were fewer ignitions, more acres burned in 2000 in Yellowstone County

Table 3.13. Summary of Wildfire Ignitions and Acres Burned by Cause from 1980 – 2005.

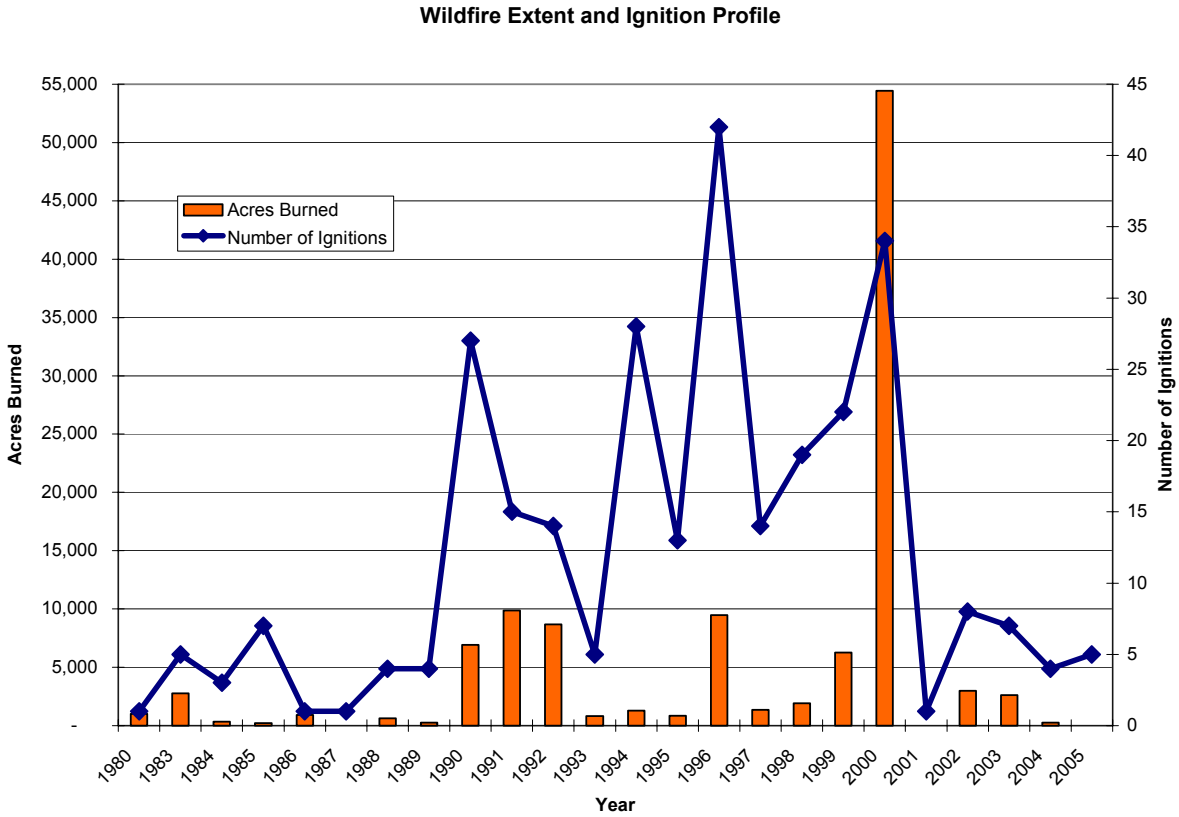
Cause	Acres Burned	Percent of Total	Number of Ignitions	Percent of Total
Campfire	1,000	1%	1	0%
Fireworks	-	0%	3	1%
Lightning	29,025	25%	81	28%
Machinery	2,000	2%	1	0%

Table 3.13. Summary of Wildfire Ignitions and Acres Burned by Cause from 1980 – 2005.

Cause	Acres Burned	Percent of Total	Number of Ignitions	Percent of Total
Mancaused	76,854	66%	120	42%
Unknown	739	1%	26	9%
Blank	6,290	5%	53	19%
Totals	**115908**		**285**	

Since 1980, it would appear that roughly 42% of all fires in Yellowstone County are human caused, while only 28% were naturally caused. There may be many factors contributing to this statistic, but the agrarian economy is likely mainly responsible. Mancaused fires have also contributed to the most acres burned throughout Yellowstone County. The large number of agriculture related wildfire ignitions has influenced this statistic greatly and it is important to note that the overwhelming majority of these fires have been contained at less than an acre.

Figure 3.7. Wildfire Extent and Ignition Profile for Yellowstone County.



During the course of the development of the Yellowstone County Community Wildfire Protection Plan all of the fire departments with jurisdiction in the County were asked to map fire ignitions by putting a dot or point on a map. This data was then merged and is summarized below in the "Past Fire Ignitions From All Departments" column of Table 3.14. In addition to the point data, the Billings Urban Fire Service Area also provided electronic data of their past fire ignitions including the cause and date of each fire. This information is summarized in Table 3.14 as well as in Section 3.9.1.2. The Shepherd Volunteer Fire Department also provided a written history of fires within their jurisdiction over the past 40 years. This information is included in the Table

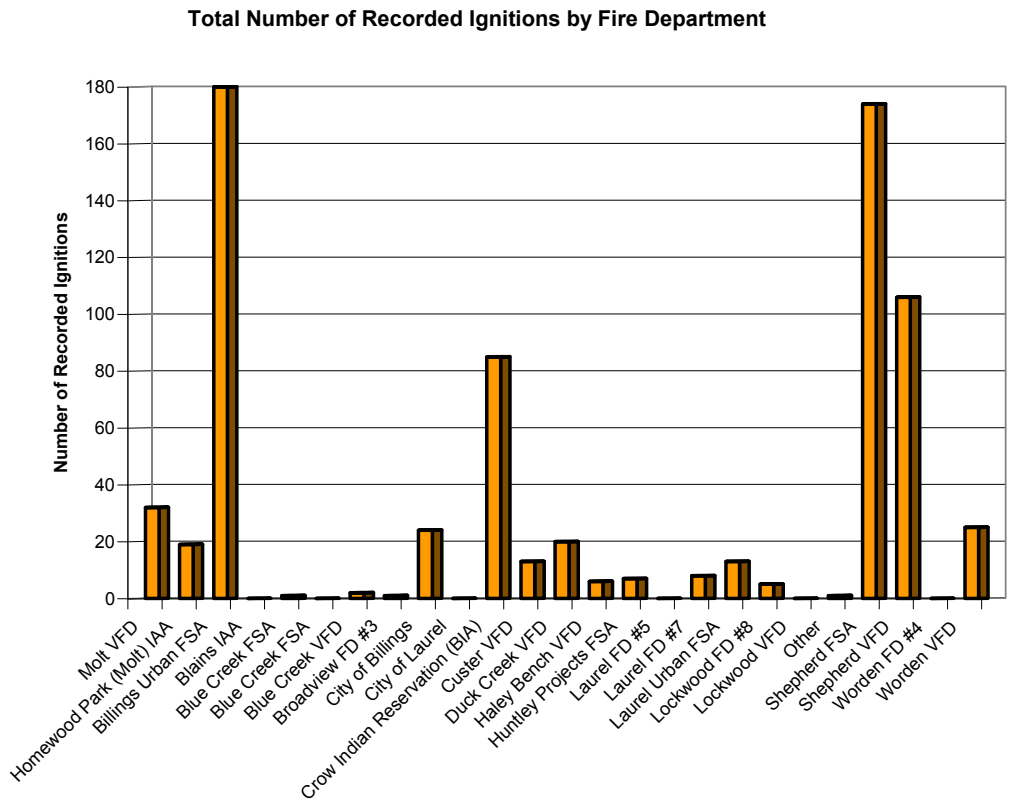
3.14 as well as in Section 3.9.1.1. This summarization allows local planners as well as fire departments to concentrate educational resources in areas with the highest frequency of recorded ignitions. This data does not; however, show dates of fires or the ultimate size of the fires. In many cases, ignitions were suppressed at less than an acre of burned area. Reference Appendix I for maps of wildfire ignition data throughout Yellowstone County.

Table 3.14. Summary of Yellowstone County Conditions by Fire Department From All Data Sources.

	Data Source			
District	**Past Fire Ignitions Data From All Departments**	**Billings Urban Fire Service Area Grass Fire Data**	**Shepherd Past Fires Data**	**Totals**
Billings Urban FSA	2	179	1	**182**
Blains IAA	0	0	0	**0**
Blue Creek FSA	0	1	0	**1**
Blue Creek FSA (provided by Lockwood FD)	0	0	0	**0**
Blue Creek VFD	2	0	0	**2**
Broadview FD #3	1	0	0	**1**
City of Billings	6	18	0	**24**
City of Laurel	0	0	0	**0**
Crow Indian Reservation	85	0	0	**85**
Custer VFD	9	0	4	**13**
Duck Creek VFD	14	0	6	**20**
Haley Bench VFD	6	0	0	**6**
Huntley Projects FSA	7	0	0	**7**
Laurel FD #5	0	0	0	**0**
Laurel FD #7	5	0	3	**8**
Laurel Urban FSA	5	2	6	**13**
Lockwood FD #8	3	2	0	**5**
Lockwood VFD	0	0	0	**0**
Other	0	1	0	**1**
Shepherd FSA	19	0	155	**174**
Shepherd VFD	14	0	92	**106**
Worden FD #4	0	0	0	**0**
Worden VFD	25	0	0	**25**
Totals	**254**	**203**	**267**	**724**

Figure 3.8 below shows the total number or recorded ignitions per fire department in Yellowstone County as summarized in Table 3.14. Some fire departments, such as the Billings Urban Fire Service Area, stand out as having a large number of ignitions. Part of the reason for this may be that they have a more complete record of ignitions or that they have been established for a longer period of time than many of the rural fire departments. It is important to remember that charting this information is a tool in order to better allocate resources to higher frequency areas; however, the data is not complete for every department and does not show the ultimate size of fires.

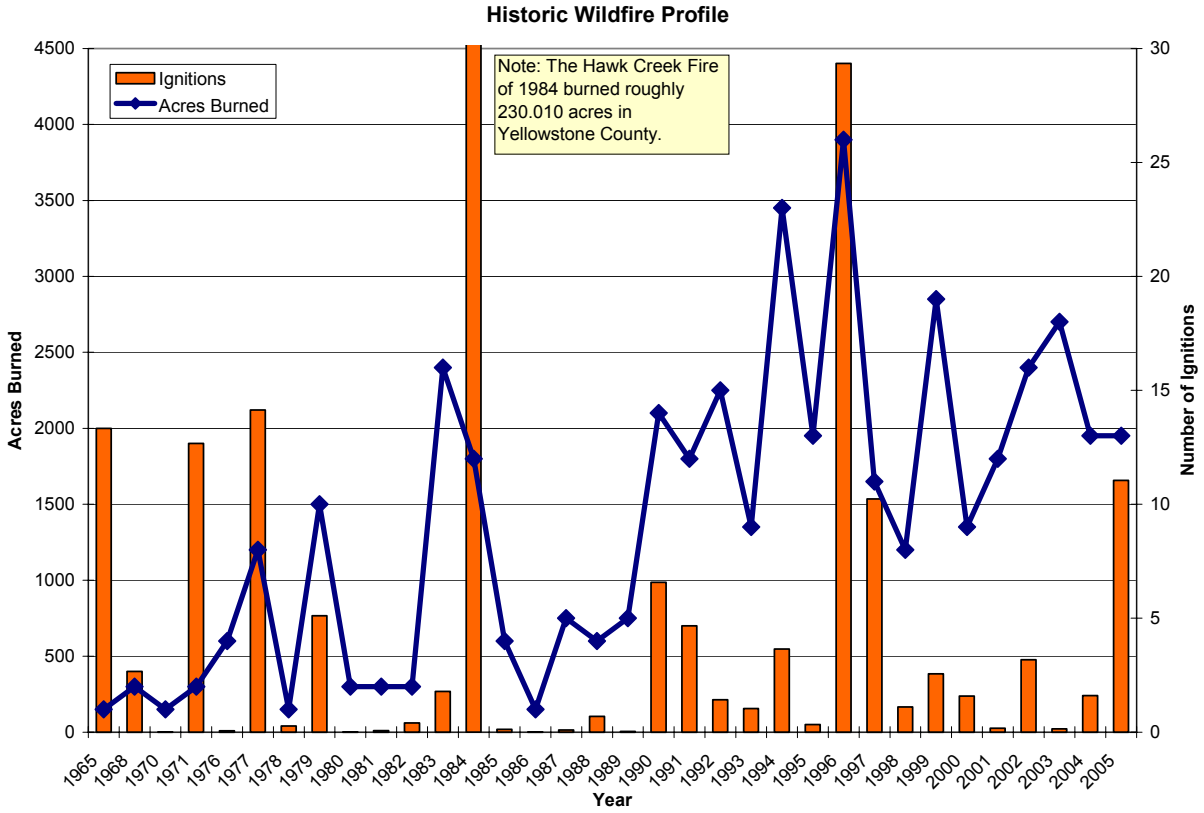
Figure 3.8. Total Number of Recorded Ignitions by Fire Department in Yellowstone County.



3.9.1.1 Shepherd Volunteer Fire Department Fire History

A long time member of the Shepherd Volunteer Fire Department has kept a personal journal of the fire history throughout the Shepherd Volunteer Fire Department's jurisdiction from 1965 through the present. While not complete, this data does provide some insight into the fire extent and frequency in the area. According to this record, there have been approximately 313 fire ignitions with 249,597 acres burned in the Shepherd area since 1965. Approximately 230,010 of those acres burned during the Hawk Creek Fire of 1984; however, the average annual acres burned is approximately 7,341. Consistent with the agency data presented in Table 3.13, the number of fire ignitions peaked in 1996 with 26 ignitions. The average annual number of fire starts in the Shepherd area is about 9.

Figure 3.9. Shepherd Volunteer Fire Department's Historic Wildfire Profile.

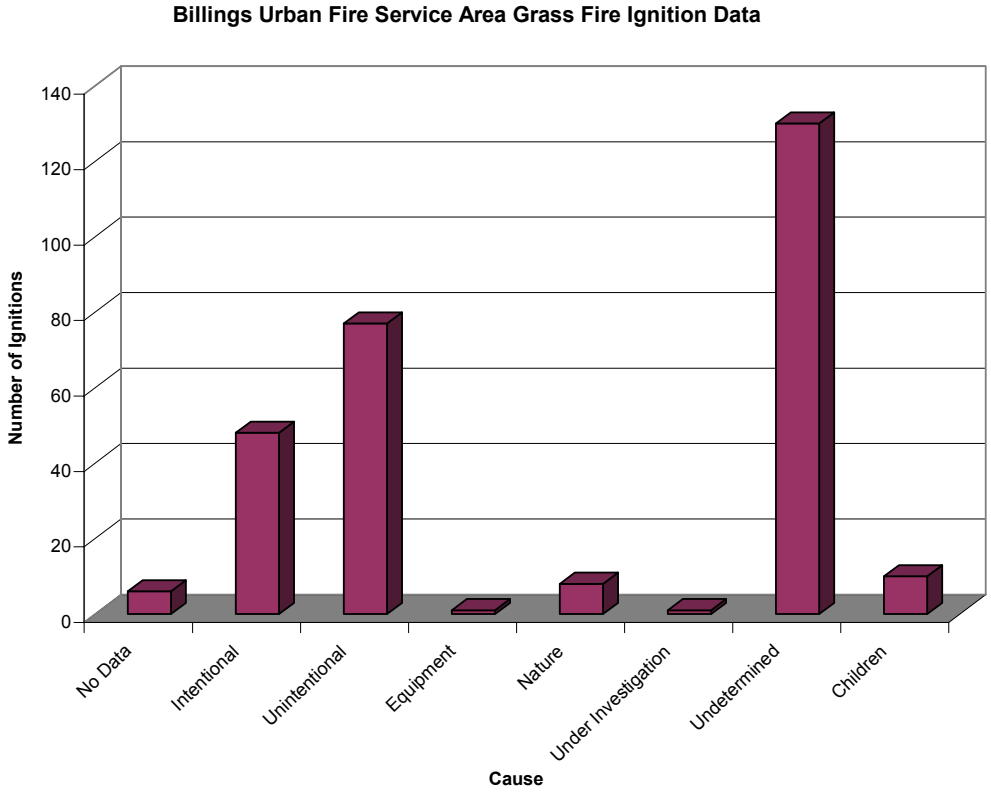


From Figure 3.8 it is clear that at least in the Shepherd area, the number of annual ignitions has been steadily increasing; however, the number of acres burned does not seem to support the same pattern.

3.9.1.2 Billings Urban Fire Service Area Statistics

The Billings Urban Fire Service Area has been recording the date and cause of grass fires within their jurisdiction since 1999. Figure 3.9 shows that only about 3% of grass fires are proven to be naturally caused.

Figure 3.10. Billings Urban Fire Service Area Grass Fire Ignition Data.



3.9.2 National Fire Statistics

Across the west, wildfires have been increasing in extent and cost of control. The National Interagency Fire Center (2005) reported over 77,500 wildfires in 2004 which burned a total of 6.7 million acres and cost $890 million in containment (Table 3.15). Data summaries for 2000 through 2004 are provided and demonstrate the variability of the frequency and extent of wildfires nationally (Table 3.15). It is important to note that the 10 year moving average number of acres burned reported each year has been increasing constantly since 2000.

Table 3.15. National Fire Season Summaries.

Statistical Highlights	2000	2001	2002	2003	2004
Number of Fires	122,827	84,079	88,458	85,943	77,534
10-year Average ending with indicated year	106,393	106,400	103,112	101,575	100,466
Acres Burned	**8,422,237**	**3,570,911**	**6,937,584**	**4,918,088**	**6,790,692**
10-year Average ending with indicated year	3,786,411	4,083,347	4,215,089	4,663,081	4,923,848
Structures Burned	861	731	2,381	5,781	1,095
Estimated Cost of Fire Suppression (Federal agencies only)	$1.3 billion	$542 million	$ 1.6 billion	$1.3 billion	$890 million

The National Interagency Fire Center, located in Boise, Idaho, maintains records of fire costs, extent, and related data for the entire nation. Tables 3.16 and 3.17 summarize some of the relevant wildland fire data for the nation, and some trends that are likely to continue into the future unless targeted fire mitigation efforts are implemented and maintained.

These statistics (Table 3.16) are based on end-of-year reports compiled by all wildland fire agencies after each fire season, and are updated by March of each year. The agencies include: Bureau of Land Management, Bureau of Indian Affairs, National Park Service, US Fish and Wildlife Service, USDA Forest Service and all State Lands.

Table 3.16. Total Fires and Acres 1960 - 2004 Nationally.

Year	Fires	Acres	Year	Fires	Acres
2004	77,534	* 6,790,692	1981	249,370	4,814,206
2003	85,943	4,918,088	1980	234,892	5,260,825
2002	88,458	6,937,584	1979	163,196	2,986,826
2001	84,079	3,555,138	1978	218,842	3,910,913
2000	122,827	8,422,237	1977	173,998	3,152,644
1999	93,702	5,661,976	1976	241,699	5,109,926
1998	81,043	2,329,709	1975	134,872	1,791,327
1997	89,517	3,672,616	1974	145,868	2,879,095
1996	115,025	6,701,390	1973	117,957	1,915,273
1995	130,019	2,315,730	1972	124,554	2,641,166
1994	114,049	4,724,014	1971	108,398	4,278,472
1993	97,031	2,310,420	1970	121,736	3,278,565
1992	103,830	2,457,665	1969	113,351	6,689,081
1991	116,953	2,237,714	1968	125,371	4,231,996
1990	122,763	5,452,874	1967	125,025	4,658,586
1989	121,714	3,261,732	1966	122,500	4,574,389
1988	154,573	7,398,889	1965	113,684	2,652,112
1987	143,877	4,152,575	1964	116,358	4,197,309
1986	139,980	3,308,133	1963	164,183	7,120,768
1985	133,840	4,434,748	1962	115,345	4,078,894
1984	118,636	2,266,134	1961	98,517	3,036,219
1983	161,649	5,080,553	1960	103,387	4,478,188
1982	174,755	2,382,036			

(National Interagency Fire Center 2004)

Table 3.17. Suppression Costs for Federal Agencies Nationally.

Year	Bureau of Land Management	Bureau of Indian Affairs	Fish and Wildlife Service	National Park Service	USDA Forest Service	Totals
2004	$ 147,165,000	$ 63,452,000	$ 7,979,000	$ 34,052,000	$ 637,585,000	**$890,233,000**
2003	$151,894,000	$ 96,633,000	$ 9,554,000	$ 44,557,000	$ 1,023,500,000	**$1,326,138,000**
2002	$ 204,666,000	$ 109,035,000	$ 15,245,000	$ 66,094,000	$ 1,266,274,000	**$1,661,314,000**
2001	$ 192,115,00	$ 63,200,000	$ 7,160,000	$ 48,092,000	$ 607,233,000	**$917,800,000**
2000	$180,567,000	$ 93,042,000	$ 9,417,000	$ 53,341,000	$ 1,026,000,000	**$1,362,367,000**
1999	$ 85,724,000	$ 42,183,000	$ 4,500,000	$ 30,061,000	$ 361,000,000	**$523,468,000**
1998	$ 63,177,000	$ 27,366,000	$ 3,800,000	$ 19,183,000	$ 215,000,000	**$328,526,000**
1997	$ 62,470,000	$ 30,916,000	$ 2,000	$ 6,844,000	$ 155,768,000	**$256,000,000**
1996	$ 96,854,000	$ 40,779,000	$ 2,600	$ 19,832,000	$ 521,700,000	**$679,167,600**
1995	$ 56,600,000	$ 36,219,000	$ 1,675,000	$ 21,256,000	$ 224,300,000	**$340,050,000**

Table 3.17. Suppression Costs for Federal Agencies Nationally.

Year	Bureau of Land Management	Bureau of Indian Affairs	Fish and Wildlife Service	National Park Service	USDA Forest Service	Totals
1994	$ 98,417,000	$ 49,202,000	$ 3,281,000	$ 16,362,000	$ 678,000,000	**$845,262,000**

(National Interagency Fire Center 2005)

Although many very large fires, growing to over 250,000 acres have burned in Montana, actual fires have usually been controlled at much smaller extents. This is not to imply that wildfires are not a concern in this county, but to point to the aggressive and professional manner to which the wildland and rural fire districts cooperate in controlling these blazes.

3.9.2.1 Prescribed Burning of Federal Acres

Prescribed fire has been effectively used as a mitigation tool, primarily on Federal and State lands across the US, and especially in the Western US. Federal Agencies report prescribed fire usage, with summaries provided by the National Interagency Fire Center, located in Boise, Idaho. National data is provided in Tables 3.18 and 3.19.

Table 3.18. Federal Wildland Fire Agency Prescribed Fire Acres Treated

Agency	1995 Acres	1996 Acres	1997 Acres	1998 Acres	1999 Acres	2000 Acres
USDA Forest Service	570,300	617,163	1,097,658	1,489,293	1,379,960	728,237
Bureau of Indian Affairs	21,000	16,000	37,000	48,287	83,875	3,353
Bureau of Land Management	56,000	50,000	72,500	200,223	308,000	125,600
National Park Service	62,000	52,000	70,000	86,126	135,441	19,072
U.S. Fish and Wildlife Service	209,000	180,000	324,000	285,758	300,508	201,052
Total	**918,300**	**915,163**	**1,601,158**	**1,889,564**	**2,240,105**	**1,077,314**

(National Interagency Fire Center 2005)

Table 3.19. Prescribed Fire Costs, Nationally.

Year	Bureau of Land Management	Bureau of Indian Affairs	Fish and Wildlife Service	National Park Service	USDA Forest Service	Totals
1995	$ 0	$ 840,000	$ 0	$ 3,200,000	$ 16,406,000	$ 20,446,000
1996	$ 1,200,000	$ 650,000	$ 0	$ 3,200,000	$ 24,500,000	$ 29,550,000
1997	$ 1,600,000	$ 800,000	$ 0	$ 4,600,000	$ 29,146,000	$ 36,146,000
1998	$ 6,700,000	$ 2,268,000	$ 4,825,000	$ 7,000,000	$ 50,000,000	$ 70,793,000
1999	$ 10,600,000	$ 6,300,000	$ 7,404,000	$ 9,800,000	$ 65,000,000	$ 99,104,000

3.9.2.2 Firefighter Accidents

The United States currently depends on approximately 1.2 million fire fighters (municipal and wildland) to protect its citizens and property from losses caused by fire. Of these fire fighters, approximately 210,000 are career/paid and approximately 1 million are volunteers. The National Fire Protection Association (NFPA) and the U.S. Fire Administration estimate that on average, 105 fire fighters die in the line of duty each year (NIFC 2005).

Due to the growing number of homes in the wildland/urban interface, it is almost inevitable that wildland and structural firefighters will find themselves in dangerous role reversals for which

they may not be adequately trained or equipped. For example, wildland fire fighters may be called on to protect threatened homes, and structural fire fighters may be called on to help battle the surrounding blazes in the wildlands.

In addition to the obvious difference of size, wildland fires and structure fires differ in that wildland fires require:

- more personnel, some of whom may have little or no fire fighting experience
- more resources spread out over a larger area.

Because of these factors, wildland fires present personal safety concerns to three areas:

- the firefighter
- the area immediately surrounding the firefighter
- the overall environment of the fire itself.

The most direct way to improve the safety of both structural and wildland fire fighters is cross-training of all fire fighters and improved equipment. While cross-training is being done in some regions throughout the country, it is still not standard practice everywhere. Until cross-training programs become universal, awareness may be the tool that saves lives.

Of the 1,046 firefighters who died while on duty from 1987 through 1996, 163 (15.6%) died while fighting wildland fires. The number of deaths was generally between 12 and 22 per year, with the exception of seven deaths in 1993 and 1996, and 33 deaths in 1994. Over the period, 23.6% of all fire ground deaths occurred at wildland fires (Firewise 2005).

This analysis includes members of municipal fire departments who responded to grass, brush and forest fires within their jurisdictions as well as career, seasonal and contract employees of state and federal wildland agencies who were involved in assigned firefighting activities at the time there were fatally injured (Firewise 2005). The federal wildland agencies include the U.S. Forest Service, the Bureau of Indian Affairs, the Bureau of Land Management, the Fish and Wildlife Service, the National Park Service and the military.

The 163 victims (1987-1996) ranged in age from 15 to 83, with a median age of 34. Fourteen of the victims were women. Approximately 70% of all wildland fire deaths (114) occurred during fire suppression activities. Another 49 deaths occurred when firefighters were responding to or returning from such fires.

3.9.2.2.1 Deaths on the Ground from Fire

The largest proportion of deaths during fire suppression activities resulted from being caught or trapped by fire progress. Twenty-five of these 38 firefighters died of smoke inhalation; the other 13 died as a result of burns. Fourteen of these 38 deaths occurred in a single incident in 1994.

Wildland fire deaths by nature of fatal injury, more commonly referred to as the medical cause of death, is important to understanding this issue. State and federal wildland officials believe that their rigorous fitness requirements lower the risk of heart attack death among firefighters under their jurisdiction. For this analysis, then, the fire ground deaths were broken down by type of department municipal (career or volunteer) or wildland agencies. A profile of the 114 fire ground victims shows that 50 were members of municipal fire departments (44 were volunteer firefighters and six were career firefighters). The other 64 firefighters were career, seasonal or contract employees of state and federal wildland agencies, or military personnel.

3.9.2.2.2 Municipal Fire Fighters

As shown in Table 3.20, heart attacks accounted for over half of the deaths of municipal firefighters during fire ground operations, while most of the deaths of state and federal employees were due to internal trauma, asphyxiation and burns.

Of the 17 municipal heart attack victims for whom medical documentation was available, nine had had prior heart attacks or bypass surgery, three had severe arteriosclerotic heart disease, three had hypertension and one was diabetic. The municipal volunteer firefighters who suffered fatal heart attacks ranged in age from 27 to 83, with a median age of 58. The one wildland agency firefighter who died of a heart attack was 38 years old and had severe arteriosclerotic heart disease.

The lower proportion of heart attacks among wildland agency firefighters may be a result of stricter fitness requirements, but it could also be a function of age. Older firefighters are more likely to suffer heart attacks and if the wildland agencies employ a significantly lower percentage of old firefighters, their experience would reflect this. Looking at all fire ground deaths, municipal vs. wildland agencies, the ages of wildland firefighters who died ranged from 18 to 64, with a median age of 32 years, while volunteer municipal firefighters ranged in age from 18 to 83, with a median age of 50. The six career municipal firefighters ranged in age from 20 to 49, with a median age of 29. Other factors besides age and fitness requirements that may impact the incidence of heart attack deaths at wildland fires include the equipment provided. In many of the incidents handled by municipal firefighters, those involved in fighting the fire did so in full protective clothing designed for structural firefighting, while wildland firefighters wear clothing, helmets and boots more appropriate to outdoor work (Firewise 2005).

Table 3.20. Wildland firefighter deaths on the fire ground by nature of Fatal Injury 1987-1996.

Fatality Cause	Federal and State Wildland Agencies	Municipal		Total
		Volunteer	Career	
Heart attack	1	27	0	28
Internal trauma	24	3	1	28
Asphyxiation	23	2	0	25
Burns	9	4	3	16
Crushing	4	4	0	8
Electric shock	1	2	0	3
Heat stroke	0	1	2	3
Stroke	2	0	0	2
Bleeding	0	1	0	1
Total	64	44	6	114

As far as the other types of injuries suffered on the fire ground are concerned, increased use of fire shelters could result in a reduction in fatal burns and smoke inhalation deaths and safer handling of aircraft could reduce the number of deaths due to aircraft crashes during suppression activities.

3.9.2.2.3 Deaths While Responding to or Return from Alarms

Of the 163 wildland-related deaths that occurred between 1987 and 1996, 49 occurred when firefighters were responding to or returning from such fires. Thirty four of the 49 deaths were the result of vehicle crashes, 12 were heart attacks, one firefighter was crushed when a tree fell on the crew area of a moving truck, one firefighter was crushed between two pieces of apparatus

while he attempted to start the rear-mounted pump in preparation for response to an incident and one firefighter drowned at a base camp after returning from the fire line.

The 34 deaths in crashes occurred in 25 separate incidents. Ten contractors and four federal employees were killed in six aircraft crashes. Eleven firefighters were killed in 10 crashes involving tankers, and five firefighters were killed when their personal vehicles crashed. The remaining four deaths resulted from crashes involving an engine, a brush unit, a supply vehicle and a military vehicle.

The 12 heart attack victims included eight municipal firefighters, three forestry employees and one contractor. Five of the 12 firefighters had had prior heart attacks or bypass surgery, one had severe arteriosclerotic heart disease and one was diabetic. No medical information was available for the other five heart attack victims.

3.9.2.2.4 Montana State Fatalities

Within Montana State, wildland fire injuries have been documented by the National Interagency Fire Center (2005) and are summarized in Table 3.21. From 1932-2003, there have been 38 fatalities during 16 incidents involving significant injuries. Burn over and entrapments are common themes in the listed fatalities. In order to reduce the risks to firefighters responding to wildland fire events, these issues must be addressed and eliminated.

Table 3.21. Wildfire accidents reported in Montana, 1910-2003.

Year	Place	Type of Accident	Organization	Fatalities
1933	Basin	Hypothermia	Federal	1
1934	Glacier NP	Snag	Federal	1
1934	Lincoln NF	Snag	Federal	1
1937	Missoula	Burnover	Federal	1
1949	Helena NF	Burnover	Federal	13
1967	Kootenai NF	Burnover	Federal	2
1984	Humansville	Burnover	Unknown	2
1988	Flathead NF	Snag	Federal	1
1988	Not Reported	Engine Rollover	Federal	1
1988	Not Reported	Snag	Other	1
1988	Not Reported	Vehicle	Federal	1
1991	Missoula	Fire Training	Federal	1
1991	Not Reported	Aircraft	Federal	2
1994	Missoula	Air tanker	Contractor/Federal	2
1996	Colstrip	Burnover	Private	2
1999	Pompeys Pillar	Dozer Burnover	Contractor	0
2001	Livingston	Helicopter	Contractor	3
2001	Not Reported	Snag	Federal	1
2002	Dillon	Work Capacity Test	State	1
2003	Missoula	Heart Attack	State	1

(National Interagency Fire Center 2005)

3.10 Analysis Tools and Techniques to Assess Fire Risk

Yellowstone County and the adjacent counties of Golden Valley, Musselshell, Rosebud, Treasure, Big Horn, Carbon, and Stillwater were analyzed using a variety of techniques, managed on a GIS system (ArcGIS 9). Physical features of the region were represented by data layers including roads, streams, soils, elevation, and remotely sensed images from the Landsat 7 ETM+ satellite. Field visits were conducted by specialists from Northwest Management, Inc., and others. Discussions with area residents and fire control specialists augmented field visits and provided insights to forest health issues and treatment options. This information was analyzed and combined to develop an assessment of wildfire risk in the region.

3.10.1 Fire Prone Landscapes

Schlosser *et al.* 2002, developed a methodology to assess the location of fire prone landscapes on forested and non-forested ecosystems in the western US. This analysis procedure has been completed on approximately 45 million acres across Montana, Wyoming, Idaho, Washington, and Nevada since 2002.

The goal of developing the Fire Prone Landscapes analysis is to make inferences about the relative risk factors across large geographical regions (multiple counties) for wildfire spread. This analysis uses the extent and occurrence of past fires as an indicator of characteristics for a specific area and their propensity to burn in the future. Concisely, if a certain combination of vegetation cover type, canopy closure, aspect, slope, stream and road density have burned with a high occurrence and frequency in the past, then it is reasonable to extrapolate that they will have the same tendency in the future, unless mitigation activities are conducted to reduce this potential.

The analysis for determining those landscapes prone to wildfire utilized a variety of sources.

Digital Elevation: Digital elevation models (DEM) for the project used USGS 30 meter DEM data provided at quarter-quadrangle extents. These were merged together to create a continuous elevation model of the analysis area.

The merged DEM file was used to create two derivative data layers: aspect and slope. Both were created using the spatial analyst extension in ArcGIS 9. Aspect data values retained one decimal point accuracy representing the cardinal direction of direct solar radiation, represented in degrees. Slope was recorded in percent and also retained one decimal point accuracy.

Remotely Sensed Images: Landsat 7 Enhanced Thematic Mapper (ETM+) images were used to assess plant cover information and percent of canopy cover. The Landsat ETM+ instrument is an eight-band multi-spectral scanning radiometer capable of providing high-resolution image information of the Earth's surface. It detects spectrally-filtered radiation at visible, near-infrared, short-wave, and thermal infrared frequency bands from the sun-lit Earth. Nominal ground sample distances or "pixel" sizes are 15 meters in the panchromatic band; 30 meters in the 6 visible, near and short-wave infrared bands; and 60 meters in the thermal infrared band.

The satellite orbits the Earth at an altitude of approximately 705 kilometers with a sun-synchronous 98-degree inclination and a descending equatorial crossing time of 10 a.m. daily.

Image spectrometry has great application for monitoring vegetation and biophysical characteristics. Vegetation reflectance often contains information on the vegetation chlorophyll absorption bands in the visible region and the near infrared region. Plant water absorption is easily identified in the middle infrared bands. In addition, exposed soil, rock, and non-vegetative surfaces are easily separated from vegetation through standard hyper-spectral analysis procedures.

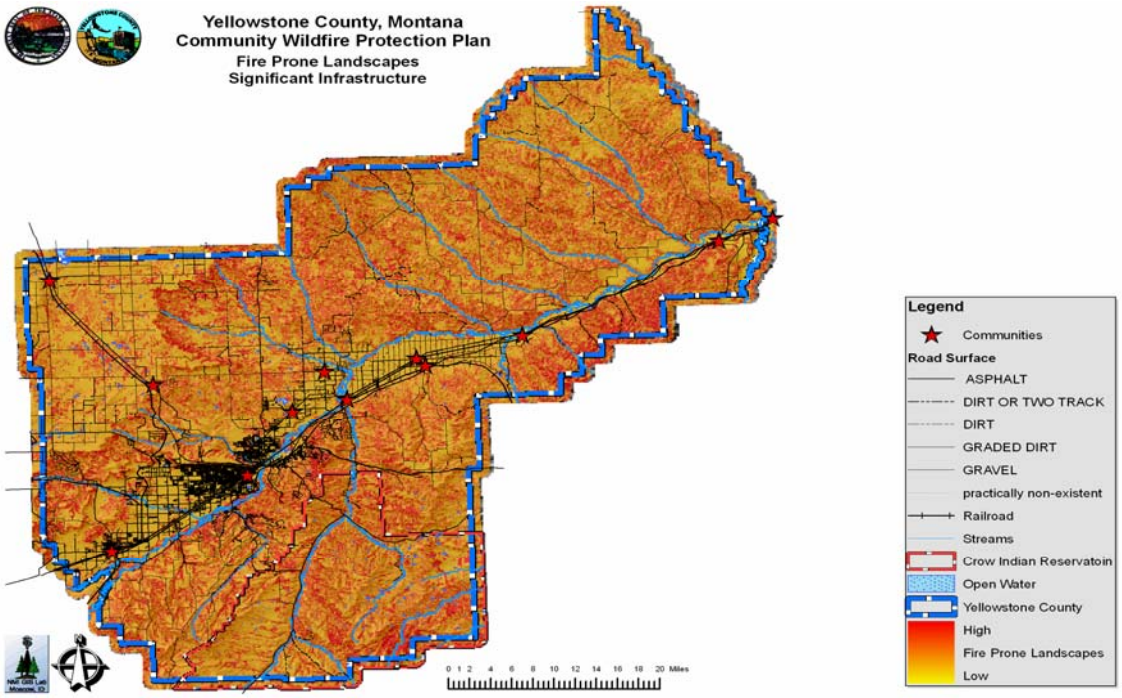
Landsat 7 ETM images were obtained to conduct hyper-spectral analysis for this project. The image was obtained in 1998. Hyper-spectral analysis procedures followed the conventions used by the Montana Vegetation and Land Cover Classification System, modified from Redmond (1997) and Homer (1998).

Riparian Zones: Riparian zones were derived from stream layers.

Past Fires: Past fire extents represent those locations on the landscape that have previously burned during a wildfire. Past fire extent maps were obtained from a variety of sources for the central Montana area including the U.S. Forest Service and the Montana Department of Natural Resources and Conservation. The Yellowstone County Fire Warden digitized fires reported by the Rural Fire Departments of Yellowstone County into a GIS system so that a full wildfire database was available to characterize wildfire occurrence in Yellowstone County. This data was used in the formation of the Fire Prone landscapes assessment.

Fire Prone Landscapes: Using the methodology developed by Schlosser *et al.* (2002), and refined for this project, the factors detailed above were used to assess the potential for the landscape to burn during the fire season in the case of fire ignition. Specifically, the entire region was evaluated at a resolution of 30 meters (meaning each pixel on the screen represented a 30 meter square on the ground) to determine the propensity for a particular area (pixel) to burn in the case of a wildfire. The analysis involved creating a linear regression analysis within the GIS program structure to assign a value to each significant variable, pixel-by-pixel. The analysis ranked factors from 0 (little to no risk) to 100 (extremely high risk) based on past fire occurrence.

Figure 3.11. Fire Prone Landscapes in Yellowstone County.



This map is presented for reference in this section of the plan. This map and additional maps are detailed in Appendix I.

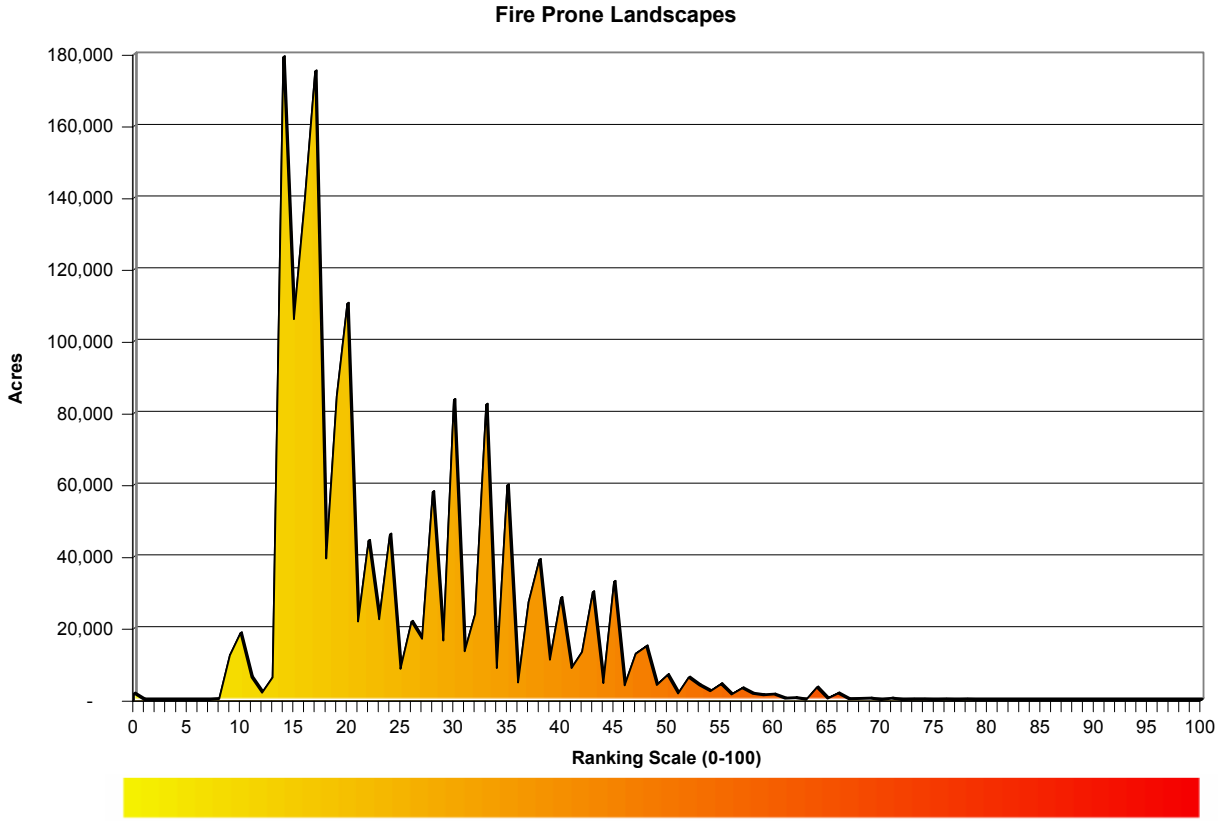
The maps depicting these risk categories display yellow as the lowest risk and red as the highest with values between a constant- gradient from yellow to orange to red (Table 3.22).

While large maps (16 square feet) have been provided as part of this analysis, smaller size maps are presented in the Appendices.

Table 3.22. Fire Prone Landscape rankings and associated acres in each category for Yellowstone County.

Color Code	Value	Total Acres	Percent of Total Area
	0	1,913	0%
	10	31,471	2%
	20	849,101	50%
	30	341,170	20%
	40	300,135	18%
	50	133,476	8%
	60	28,860	2%
	70	8,281	0%
	80	1,187	0%
	90	61	0%
	100	3	0%

Figure 3.12: Distribution of area by Fire Prone Landscape Class.



The risk category values developed in this analysis should be considered **ordinal data**, that is, while the values presented have a meaningful ranking, they neither have a true zero point nor

scale between numbers. Rating in the “40” range is not necessarily twice as “risky” as rating in the “20” range. These category values also do not correspond to a rate of fire spread, a fuel loading indicator, or measurable potential fire intensity. Each of those scales is greatly influenced by weather, seasonal and daily variations in moisture (relative humidity), solar radiation, and other factors. The risk rating presented here serves to identify where certain constant variables are present, aiding in identifying where fires typically spread into the largest fires across the landscape.

3.10.2 Historic Fire Regime

The US Forest Service has provided their assessment of Historic Fire Regimes for western Montana. These measures of forest conditions are the standard method of analysis for the USDA Forest Service. The Historic Fire Regime map is presented in Appendix I.

In the fire-adapted ecosystems of Montana, fire is undoubtedly the dominant process in terrestrial systems that constrain vegetation patterns, habitats, and ultimately, species composition. Land managers need to understand historical fire regimes (that is, fire frequency and fire severity prior to settlement by Euro-Americans) to be able to define ecologically appropriate goals and objectives for an area. Moreover, managers need spatially explicit knowledge of how historical fire regimes vary across the landscape.

Many ecological assessments are enhanced by the characterization of the historical range of variability which helps managers understand: (1) how the driving ecosystem processes vary from site to site; (2) how these processes affected ecosystems in the past; and (3) how these processes might affect the ecosystems of today and the future. Obviously, historical fire regimes are a critical component for characterizing the historical range of variability in the fire adapted ecosystems of Montana. Furthermore, understanding ecosystem departures provides the necessary context for managing sustainable ecosystems. Land managers need to understand how ecosystem processes and functions have changed prior to developing strategies to maintain or restore sustainable systems. In addition, the concept of departure is a key factor for assessing risks to ecosystem components. For example, the departure from historical fire regimes may serve as a useful proxy for the potential of severe fire effects from an ecological perspective.

We used a database of fire history studies in the region to develop modeling rules for predicting historical fire regimes (HFRs). Tabular fire-history data was stratified into spatial data ecoregions, potential natural vegetation types (PNVs), slope classes, and aspect classes to derive rule sets which were then modeled spatially. Expert opinion was substituted for a stratum when empirical data was not available.

Fire is the dominant disturbance process that manipulates vegetation patterns in Montana. The HFR data were prepared to supplement other data necessary to assess integrated risks and opportunities at regional and subregional scales.

3.10.2.1 General Limitations

These data were derived using fire history data from a variety of different sources. These data were designed to characterize broad scale patterns of historical fire regimes for use in regional and subregional assessments. Any decisions based on these data should be supported with field verification, especially at scales finer than 1:50,000. Although the resolution of the HFR theme is 30 meter cell size, the expected accuracy does not warrant their use for analyses of areas smaller than about 10,000 acres (for example, assessments that typically require 1:24,000 data).

Table 3.23. Historic Fire Regime by area in Yellowstone County.

Historic Fire Regime Description	Regime	Acres	Percent
Non-lethal Fires	I	46,259	3%
Mixed severity, short return interval	I	166	0%
Mixed severity, long return interval	III	43,783	3%
Mixed severity, high elevation	II	803,108	47%
Stand replacement, short return interval	III	26,854	2%
Stand replacement, long return interval	IV	329,623	19%
Stand replacement; grass/shrub type	V	109,676	6%
Agriculture	Agriculture	283,641	17%
Rock / barren	Urban	27,163	2%
Urban	Sparce Vegetation	9,543	1%
Water	Water	16,012	1%

3.10.3 Fire Regime Condition Class

The US Forest Service has provided their assessment of Fire Regime Condition Class for Yellowstone County to this Community Wildfire Protection Plan analysis. These measures of forest conditions are the standard method of analysis for the USDA Forest Service.

A natural fire regime is a general classification of the role fire would play across a landscape in the absence of modern human mechanical intervention, but including the influence of aboriginal burning (Agee 1993, Brown 1995). Coarse scale definitions for natural (historical) fire regimes have been developed by Hardy *et al.* (2001) and Schmidt *et al.* (2002) and interpreted for fire and fuels management by Hann and Bunnell (2001). The five natural (historical) fire regimes are classified based on average number of years between fires (fire frequency) combined with the severity (amount of replacement) of the fire on the dominant overstory vegetation. These five regimes include:

I – 0-35 year frequency and low (surface fires most common) to mixed severity (less than 75% of the dominant overstory vegetation replaced);

II – 0-35 year frequency and high (stand replacement) severity (greater than 75% of the dominant overstory vegetation replaced);

III – 35-100+ year frequency and mixed severity (less than 75% of the dominant overstory vegetation replaced);

IV – 35-100+ year frequency and high (stand replacement) severity (greater than 75% of the dominant overstory vegetation replaced);

V – 200+ year frequency and high (stand replacement) severity.

As scale of application becomes finer these five classes may be defined with more detail, or any one class may be split into finer classes, but the hierarchy to the coarse scale definitions should be retained.

A fire regime condition class (FRCC) is a classification of the amount of departure from the natural regime (Hann and Bunnell 2001). Coarse-scale FRCC classes have been defined and mapped by Hardy *et al.* (2001) and Schmidt *et al.* (2001) (FRCC). They include three condition classes for each fire regime. The classification is based on a relative measure describing the degree of departure from the historical natural fire regime. This departure results in changes to one (or more) of the following ecological components: vegetation characteristics (species composition, structural stages, stand age, canopy closure, and mosaic pattern); fuel

composition; fire frequency, severity, and pattern; and other associated disturbances (e.g. insect and diseased mortality, grazing, and drought). There are no wildland vegetation and fuel conditions or wildland fire situations that do not fit within one of the three classes.

The three classes are based on low (FRCC 1), moderate (FRCC 2), and high (FRCC 3) departure from the central tendency of the natural (historical) regime (Hann and Bunnell 2001, Hardy *et al.* 2001, Schmidt *et al.* 2002). The central tendency is a composite estimate of vegetation characteristics (species composition, structural stages, stand age, canopy closure, and mosaic pattern); fuel composition; fire frequency, severity, and pattern; and other associated natural disturbances. Low departure is considered to be within the natural (historical) range of variability, while moderate and high departures are outside.

Characteristic vegetation and fuel conditions are considered to be those that occurred within the natural (historical) fire regime. Uncharacteristic conditions are considered to be those that did not occur within the natural (historical) fire regime, such as invasive species (e.g. weeds, insects, and diseases), "high graded" forest composition and structure (e.g. large trees removed in a frequent surface fire regime), or repeated annual grazing that maintains grassy fuels across relatively large areas at levels that will not carry a surface fire. Determination of the amount of departure is based on comparison of a composite measure of fire regime attributes (vegetation characteristics; fuel composition; fire frequency, severity and pattern) to the central tendency of the natural (historical) fire regime. The amount of departure is then classified to determine the fire regime condition class. A simplified description of the fire regime condition classes and associated potential risks are presented in Table 3.24. Maps depicting Fire Regime and Condition Class are presented in Appendix I.

Table 3.24. Fire Regime Condition Class Definitions.

Condition Class	Description	Potential Risks
Condition Class 1	Within the natural (historical) range of variability of vegetation characteristics; fuel composition; fire frequency, severity and pattern; and other associated disturbances.	Fire behavior, effects, and other associated disturbances are similar to those that occurred prior to fire exclusion (suppression) and other types of management that do not mimic the natural fire regime and associated vegetation and fuel characteristics. Composition and structure of vegetation and fuels are similar to the natural (historical) regime. Risk of loss of key ecosystem components (e.g. native species, large trees, and soil) is low.
Condition Class 2	Moderate departure from the natural (historical) regime of vegetation characteristics; fuel composition; fire frequency, severity and pattern; and other associated disturbances.	Fire behavior, effects, and other associated disturbances are moderately departed (more or less severe). Composition and structure of vegetation and fuel are moderately altered. Uncharacteristic conditions range from low to moderate. Risk of loss of key ecosystem components is moderate.
Condition Class 3	High departure from the natural (historical) regime of vegetation characteristics; fuel composition; fire frequency, severity and pattern; and other associated disturbances.	Fire behavior, effects, and other associated disturbances are highly departed (more or less severe). Composition and structure of vegetation and fuel are highly altered. Uncharacteristic conditions range from moderate to high. Risk of loss of key ecosystem components is high.

The analyses of Fire Regime Condition Class in Yellowstone County shows that approximately 10% of the County is in Condition Class 1 (low departure), just about 1% is in Condition Class 2 (moderate departure), with the remaining 2% of the area is in Condition Class 3 (Table 3.25).

Table 3.25. Fire Regime Condition Class by Area in Yellowstone County.

Condition Class	Acres	Percent
Low	86,568	5%
Moderate	1,268,666	75%
High	701	0%
Agriculture	286,136	17%
Sparse Vegetation	9,773	1%
Urban	27,259	2%
Water	16,012	1%
Burned Areas	713	0%

See the Appendix I for map of Fire Regime Condition Class.

3.10.4 Predicted Fire Severity

Current fire severity (CFS) is an estimate of the relative fire severity if a fire were to burn a site under its current state of vegetation. In other words, how much of the overstory would be removed if a fire were to burn today. The US Forest Service (Flathead National Forest) did not attempt to model absolute values of fire severity, as there are too many variables that influence fire effects at any given time (for example, temperature, humidity, fuel moisture, slope, wind speed, wind direction). Current Fire Severity maps are depicted in Appendix I.

The characterization of likely fire severity was based upon historic fire regimes, potential natural vegetation, cover type, size class, and canopy cover with respect to slope and aspect. Each cover type was assigned a qualitative rating of fire tolerance based upon likely species composition and the relative resistance of each species to fire. The US Forest Service researchers defined 3 broad classes of fire tolerance: high tolerance (<20 percent post-fire mortality); moderate tolerance (20 to 80 percent mortality); and low tolerance (>80 percent mortality). We would expect that fires would be less severe within cover types comprised by species that have a high tolerance to fire (for example, western larch and ponderosa pine). Conversely, fires would likely burn more severely within cover types comprised by species having a low tolerance to fire (for example grand fir, subalpine fir). Data assignments were based upon our collective experience in the field, as well as stand structure characteristics reported in the fire-history literature. For example, if they estimated that a fire would remove less than 20 percent of the overstory, the current fire severity would be assigned to the non-lethal class (that is, NL). However, if they expected fire to remove more than 80 percent of the overstory, the current fire severity was assigned to a stand replacement class (that is, SR or SR3).

3.10.4.1 Purpose

Fire is a dominant disturbance process in Montana. The likely effect of fire upon vegetation (i.e., current fire severity) is critical information for understanding the subsequent fire effects upon wildlife habitats, water quality, and the timing of runoff. There have been many reports of how fire suppression and timber harvest has affected vegetation patterns, fuels, and fire behavior. The US Forest Service researchers from the Flathead National Forest, derived the current fire severity theme explicitly to compare with the historical fire regime theme to evaluate how fire severity has changed since Euro-American settlement (that is, to derive fire-regime condition class).

3.10.4.2 General Limitations

These data were designed to characterize broad scale patterns of estimated fire severity for use in regional and subregional assessments. Any decisions based on these data should be supported with field verification, especially at scales finer than 1:100,000. Although the resolution of the CFS theme is 90 meter cell size, the expected accuracy does not warrant their use for analyses of areas smaller than about 10,000 acres (for example, assessments that typically require 1:24,000 data).

Current fire severity rule-set was developed for an "average burn day" for the specific vegetation types in our area. Any user of these data should familiarize themselves with the rule sets to better understand our estimate of current fire severity.

Table 3.26. Predicted Fire Severity by area in Yellowstone County.

Predicted Fire Severity	Regime	Acres	Percent of Area
Mixed Severity-Short Interval	I	1,947	0%
Mixed Severity-Long Interval	III	43,645	3%
Non-Lethal Fires	I	43,521	3%
Non-forest-Mixed Severity-Moderate Interval	III	26,592	2%
Non-forest-Stand Replacement-Short Interval	II	799,375	47%
Agriculture	Agriculture	283,641	17%
Urban	Urban	27,163	2%
Sparse Vegetation	Sparce Vegetation	9,925	1%
Water	Water	16,012	1%
Recently Burned Area	Recently Burned Area	6,887	0%
Non-forest-Stand Replacement-Moderate Interval	IV	328,105	19%
Non-forest-Stand Replacement-Long Interval	V	109,013	6%

3.10.5 On-Site Evaluations

Fire control and evaluation specialists as well as hazard mitigation consultants evaluated the communities of Yellowstone County to determine, first-hand, the extent of risk and characteristics of hazardous fuels in the Wildland-Urban Interface. The on-site evaluations have been summarized in written narratives and are accompanied by photographs taken during the site visits. These evaluations included the estimation of fuel models as established by Anderson (1982). These fuel models are described in the following section of this document.

3.10.6 Fuel Model Descriptions

Anderson (1982) developed a categorical guide for determining fuel models to facilitate the linkage between fuels and fire behavior. These 13 fuel models, grouped into 4 basic groups: grass, chaparral and shrub, timber, and slash, provide the basis for communicating fuel conditions and evaluating fire risk. There are a number of ways to estimate fuel models in forest and rangeland conditions. The field personnel from Northwest Management, Inc., that evaluated communities and other areas of Yellowstone County have all been intricately involved in wildland fire fighting and the incident command system. They made ocular estimates of fuel models they observed. In an intense evaluation, actual sampling would have been employed to determine fuel models and fuel loading. The estimations presented in this document (Chapter 3) are estimates based on observations to better understand the conditions observed.

Fuel Model 0- This type consists of non-flammable sites, such as exposed mineral soil and rock outcrops. Other lands are also identified in this type.

3.10.6.1 Grass Group

3.10.6.1.1 Fire Behavior Fuel Model 1

Fire spread is governed by the fine, very porous, and continuous herbaceous fuels that have cured or are nearly cured. Fires are surface fires that move rapidly through the cured grass and associated material. Very little shrub or timber is present, generally less than one-third of the area.

Grasslands and savanna are represented along with stubble, grass-tundra, and grass-shrub combinations that met the above area constraint. Annual and perennial grasses are included in this fuel model.

This fuel model correlates to 1978 NFDRS fuel models A, L, and S.

Fuel model values for estimating fire behavior

Total fuel load, < 3-inch dead and alive, tons/acre 0.74
Dead fuel load, ¼-inch, tons/acre 0.74
Live fuel load, foliage, tons/acre 0
Fuel bed depth, feet 1.0

3.10.6.1.2 Fire Behavior Fuel Model 2

Fire is spread primarily through the fine herbaceous fuels, either curing or dead. These are surface fires where the herbaceous material, in addition to litter and dead-down stemwood from the open shrub or timber overstory, contribute to the fire intensity. Open shrub lands and pine stands or scrub oak stands that cover one-third to two-thirds of the area may generally fit this model; such stands may include clumps of fuels that generate higher intensities and that may produce firebrands. Some pinyon-juniper may be in this model.

This fuel model correlates to 1978 NFDRS fuel models C and T.

Fuel model values for estimating fire behavior

Total fuel load, < 3-inch dead and alive, tons/acre 4.0
Dead fuel load, ¼-inch, tons/acre 2.0
Live fuel load, foliage, tons/acre 0.5
Fuel bed depth, feet 1.0

3.10.6.1.3 Fire Behavior Fuel Model 3

Fires in this fuel are the most intense of the grass group and display high rates of spread under the influence of wind. Wind may drive fire into the upper heights of the grass and across standing water. Stands are tall, averaging about 3 feet (1 m), but considerable variation may occur. Approximately one-third or more of the stand is considered dead or cured and maintains the fire. Wild or cultivated grains that have not been harvested can be considered similar to tall prairie and marshland grasses.

This fuel correlates to 1978 NFDRS fuel model N.

Fuel model values for estimating fire behavior

Total fuel load, < 3-inch dead and live, tons/acre 3.0
Dead fuel load, ¼-inch, tons/acre 3.0
Live fuel load, foliage tons/acre 0
Fuel bed depth, feet 2.5

3.10.6.2 Shrub Group

3.10.6.2.1 Fire Behavior Fuel Model 4

Fire intensity and fast-spreading fires involve the foliage and live and dead fine woody material in the crowns of a nearly continuous secondary overstory. Stands of mature shrubs, 6 or more feet tall, such as California mixed chaparral, the high pocosin along the east coast, the pinebarrens of New Jersey, or the closed jack pine stands of the north-central States are typical candidates. Besides flammable foliage, dead woody material in the stands significantly contributes to the fire intensity. Height of stand qualifying for this model depends on local conditions. A deep litter layer may also hamper suppression efforts.

This fuel model represents 1978 NFDRS fuel models B and O; fire behavior estimates are more severe than obtained by Models B or O.

Fuel model values for estimating fire behavior

Total fuel load, <3-inch dead and live, tons/acre 13.0
Dead fuel load, ¼-inch, tons/acre 5.0
Live fuel load, foliage, tons/acre 5.0
Fuel bed depth, feet 6.0

3.10.6.2.2 Fire Behavior Fuel Model 5

Fire is generally carried in the surface fuels that are made up of litter cast by the shrubs and the grasses or forbs in the understory. The fires are generally not very intense because surface fuel loads are light, the shrubs are young with little dead material, and the foliage contains little volatile material. Usually shrubs are short and almost totally cover the area. Young, green stands with no dead wood would qualify: laurel, vine maple, alder, or even chaparral, manzanita, or chamise.

No 1978 NFDRS fuel model is represented, but model 5 can be considered as second choice for NFDRS model D or as third choice for NFDRS model T. Young green stands may be up to 6 feet (2m) high but have poor burning properties because of live vegetation.

Fuel model values for estimating fire behavior

Total fuel load, <3-inch dead and live, tons/acre 3.5
Dead fuel load, ¼-inch, tons/acre 1.0
Live fuel load, foliage, tons/acre 2.0
Fuel bed depth, feet 2.0

3.10.6.2.3 Fire Behavior Fuel Model 6

Fires carry through the shrub layer where the foliage is more flammable than fuel model 5, but this requires moderate winds, greater than 8 mi/h (13 km/h) at mid-flame height. Fire will drop to the ground at low wind speeds or at openings in the stand. The shrubs are older, but not as tall as shrub types of model 4, nor do they contain as much fuel as model 4. A broad range of shrub conditions is covered by this model. Fuel situations to be considered include intermediate

stands of chamise, chaparral, oak brush, low pocosin, Alaskan spruce taiga, and shrub tundra. Even hardwood slash that has cured can be considered. Pinyon-juniper shrublands may be represented but may over-predict rate of spread except at high winds, like 20 mi/h (32 km/h) at the 20-foot level.

The 1978 NFDRS fuel models F and Q are represented by this fuel model. It can be considered a second choice for models T and D and a third choice for model S.

Fuel model values for estimating fire behavior

Total fuel load, <3-inch dead and live, tons/acres..... 6.0
Dead fuel load, 1/4 –inch, tons/acre 1.5
Live fuel load, foliage, tons/acre 0
Fuel bed depth, feet 2.5

3.10.6.2.4 Fire Behavior Fuel Model 7

Fires burn through the surface and shrub strata with equal ease and can occur at higher dead fuel moisture contents because of the flammability of live foliage and other live material. Stands of shrubs are generally between 2 and 6 feet (0.6 and 1.8 m high). Palmetto-gallberry understory-pine overstory sites are typical and low pocosins may be represented. Black spruce-shrub combinations in Alaska may also be represented.

This fuel model correlates with 1978 NFDRS model D and can be a second choice for model Q.

Fuel model values for estimating fire behavior

Total fuel load, <3-inch dead and live, tons/acre 4.9
Dead fuel load, ¼-inch, tons/acre 1.1
Live fuel load, foliage, tons/acre 0.4
Fuel bed depth, feet 2.5

3.10.6.3 Timber Group

3.10.6.3.1 Fire Behavior Fuel Model 8

Slow-burning ground fires with low flame lengths are generally the case, although the fire may encounter an occasional “jackpot” or heavy fuel concentration that can flare up. Only under severe weather conditions involving high temperatures, low humilities, and high winds do the fuels pose fire hazards. Closed canopy stands of short-needle conifers or hardwoods that have leafed out support fire in the compact litter layer. This layer is mainly needles, leaves, and occasionally twigs because little undergrowth is present in the stand. Representative conifer types are white pine, and lodgepole pine, spruce, fire and larch

This model can be used for 1978 NFDRS fuel models H and R.

Fuel model values for estimating fire behavior

Total fuel load, <3-inch, dead and live, tons/acre 5.0
Dead fuel load, ¼-inch, tons/acre 1.5
Live fuel load, foliage, tons/acre 0
Fuel bed depth, feet 0.2

3.10.6.3.2 Fire Behavior Fuel Model 9

Fires run through the surface litter faster than model 8 and have longer flame height. Both long-needle conifer stands and hardwood stands, especially the oak-hickory types, are typical. Fall fires in hardwoods are predictable, but high winds will actually cause higher rates of spread than predicted because of spotting caused by rolling and blowing leaves. Closed stands of long-needled pine like ponderosa, Jeffrey, and red pines, or southern pine plantations are grouped in this model. Concentrations of dead-down woody material will contribute to possible torching out of trees, spotting, and crowning.

NFDRS fuel models E, P, and U are represented by this model. It is also a second choice for models C and S.

Fuel model values for estimating fire behavior

Total fuel load, <3-inch dead and live, tons/acre 3.5
Dead fuel load, ¼-inch, tons/acre 2.9
Live fuel load, foliage, tons/acre 0
Fuel bed depth, feet 0.2

3.10.6.3.3 Fire Behavior Fuel Model 10

The fires burn in the surface and ground fuels with greater fire intensity than the other timber models. Dead-down fuels include greater quantities of 3-inch (7.6 cm) or larger limbwood, resulting from overmaturity or natural events that create a large load of dead material on the forest floor. Crowning out, spotting, and torching of individual trees are more frequent in this fuel situation, leading to potential fire control difficulties. Any forest type may be considered if heavy down material is present; examples are insect- or disease-ridden stands, wind-thrown stands, overmature situations with dead fall, and aged light thinning or partial-cut slash.

The 1978 NFDRS fuel model G is represented.

Fuel model values for estimating fire behavior

Total fuel load, < 3-inch dead and live, tons/acre 12.0
Dead fuel load, ¼-inch, tons/acre 3.0
Live fuel load, foliage, tons/acre 2.0
Fuel bed depth, feet 1.0

The fire intensities and spread rates of these timber litter fuel models are indicated by the following values when the dead fuel moisture content is 8 percent, live fuel moisture is 100 percent, and the effective wind speed at mid-flame height is 5 mi/h (8 km/h):

Table 3.27. Comparative Fire Intensities and Rates of Spread in Timber Fuel Models.

Fuel Model	Rate of Spread (Chains/hour)	Flame length (Feet)
8	1.6	1.0
9	7.5	2.6
10	7.9	4.8

Fires such as above in model 10 are at the upper limit of control by direct attack. More wind or drier conditions could lead to an escaped fire.

3.10.6.4 Logging Slash Group

3.10.6.4.1 Fire Behavior Fuel Model 11

Fires are fairly active in the slash and herbaceous material intermixed with the slash. The spacing of the rather light fuel load, shading from overstory, or the aging of the fine fuels can contribute to limiting the fire potential. Light partial cuts or thinning operations in mixed conifer stands, hardwood stands, and southern pine harvests are considered. Clearcut operations generally produce more slash than represented here. The less-than-3-inch (7.6-cm) material load is less than 12 tons per acre (5.4 t/ha). The greater-than-3-inch (7.6-cm) is represented by not more than 10 pieces, 4 inches (10.2 cm) in diameter, along a 50-foot (15 m) transect.

The 1978 NFDRS fuel model K is represented by this model.

Fuel model values for estimating fire behavior

Total fuel load, < 3-inch, dead and live, tons/acre 11.5
Dead fuel load, ¼-inch, tons/acre 1.5
Live fuel load, foliage, tons/acre 0
Fuel bed depth, feet 1.0

3.10.6.4.2 Fire Behavior Fuel Model 12

Rapidly spreading fires with high intensities capable of generating firebrands can occur. When fire starts, it is generally sustained until a fuel break or change in fuels is encountered. The visual impression is dominated by slash and much of it is less than 3 inches (7.6 cm) in diameter. The fuels total less than 35 tons per acres (15.6 t/ha) and seem well distributed. Heavily thinned conifer stands, clearcuts, and medium or heavy partial cuts are represented. The material larger than 3 inches (7.6 cm) is represented by encountering 11 pieces, 6 inches (15.3 cm) in diameter, along a 50-foot (15-m) transect.

This model depicts 1978 NFDRS model J and may overrate slash areas when the needles have dropped and the limbwood has settled. However, in areas where limbwood breakup and general weathering have started, the fire potential can increase.

Fuel model values fore estimating fire behavior

Total fuel load, < 3-inch, dead and live, tons/acre 34.6
Dead fuel load, ¼-inch, tons/acre 4.0
Live fuel load, foliage, tons/acre 0
Fuel bed depth, feet 2.3

3.10.6.4.3 Fire Behavior Fuel Model 13

Fire is generally carried across the area by a continuous layer of slash. Large quantities of material larger than 3 inches (7.6 cm) are present. Fires spread quickly through the fine fuels and intensity builds up more slowly as the large fuels start burning. Active flaming is sustained for long periods and a wide variety of firebrands can be generated. These contribute to spotting problems as the weather conditions become more severe. Clearcuts and heavy partial-cuts in mature and overmature stands are depicted where the slash load is dominated by the greater-tayhn-3-inch (7.6-cm) diameter material. The total load may exceed 200 tons per acre (89.2 t/ha) but fuel less than 3 inches (7.6 cm_ is generally only 10 percent of the total load. Situations where the slash still has “red’ needles attached but the total load is lighter, more like model 12, can be represented because of the earlier high intensity and quicker area involvement.

The 1978 NFDRS fuel model I is represented. Areas most commonly fitting his model are old-growth stands west of the Cascade and Sierra Nevada Mountains. More efficient utilization standards are decreasing the amount of large material left in the field.

Fuel model values for estimating fire behavior

Total fuel load, < 3-inch dead and live, tons/acre 58.1
Dead fuel load, ¼-inch, tons/acre 7.0
Live fuel load, foliage, tons/acre 0
Fuel bed depth, feet 3.0

For other slash situations:

Hardwood slash .....Model 6
Heavy "red" slash.....Model 4
Overgrown slash .....Model 10
Southern pine clearcut slash.....Model 12

The comparative rates of spread and flame lengths for the slash models at 8 percent dead fuel moisture content and a 5 mi/h (8 km/h) mid-flame wind are presented in Table 3.28.

Table 3.28. Comparative Fire Intensities and Rates of Spread in Slash Fuel Models.

Fuel Model	Rate of Spread (Chains/hour)	Flame length (Feet)
11	6.0	3.5
12	13.0	8.0
13	13.5	10.5

3.11 Wildland-Urban Interface

3.11.1 People and Structures

A key component in meeting the underlying need is the protection and treatment of fire hazard in the wildland-urban interface. The wildland-urban interface refers to areas where wildland vegetation meets urban developments, or where forest fuels meet urban fuels (such as houses). These areas encompass not only the interface (areas immediately adjacent to urban development), but also the continuous slopes and fuels that lead directly to a risk to urban developments. Reducing the fire hazard in the wildland urban interface requires the efforts of federal, state, local agencies, and private individuals (Norton 2002). "The role of [most] federal agencies in the wildland urban interface includes wildland fire fighting, hazard fuels reduction, cooperative prevention and education and technical experience. Structural fire protection [during a wildfire] in the wildland urban interface is [largely] the responsibility of Tribal, state, and local governments" (USFS 2001). Property owners share a responsibility to protect their residences and businesses and minimize fire danger by creating defensible areas around them and taking other measures to minimize the fire risks to their structures (USFS 2001). With treatment, a wildland-urban interface can provide firefighters a defensible area from which to suppress wildland fires or defend communities. In addition, a wildland urban interface that is properly thinned will be less likely to sustain a crown fire that enters or originates within it (Norton 2002).

By reducing hazardous fuel loads, ladder fuels, and tree densities, and creating new and reinforcing defensible space, landowners would protect the wildland-urban interface, the biological resources of the management area, and adjacent property owners by:

- minimizing the potential of high-severity ground or crown fires entering or leaving the area;

- reducing the potential for firebrands (embers carried by the wind in front of the wildfire) impacting the WUI. Research indicates that flying sparks and embers (firebrands) from a crown fire can ignite additional wildfires as far as 1¼ miles away during periods of extreme fire weather and fire behavior (McCoy *et al.* 2001 as cited in Norton 2002);
- improving defensible space in the immediate areas for suppression efforts in the event of wildland fire.

Four wildland/urban conditions have been identified for use in the wildland urban interface (Norton 2002). These include the Interface Condition, Intermix Condition, Occluded Condition, and Rural Condition. Descriptions of each are as follows:

- **Interface Condition** – a situation where structures abut wildland fuels. There is a clear line of demarcation between the structures and the wildland fuels along roads or back fences. The development density for an interface condition is usually 3+ structures per acre;
- **Intermix Condition** – a situation where structures are scattered throughout a wildland area. There is no clear line of demarcation, the wildland fuels are continuous outside of and within the developed area. The development density in the intermix ranges from structures very close together to one structure per 40 acres;
- **Occluded Condition** – a situation, normally within a city, where structures abut an island of wildland fuels (park or open space). There is a clear line of demarcation between the structures and the wildland fuels along roads and fences. The development density for an occluded condition is usually similar to that found in the interface condition and the occluded area is usually less than 1,000 acres in size; and
- **Rural Condition** – a situation where the scattered small clusters of structures (ranches, farms, resorts, or summer cabins) are exposed to wildland fuels. There may be miles between these clusters.

Structure locations in Yellowstone County were first mapped by the Yellowstone County GIS Department for use in the 911 database. However, this dataset was missing a number of structures in the city of Billings, as well as in the rural regions of the county. To determine the location of these structures, aerial photography from 1998 and 2004 was used to manually locate missing structures and add them to the dataset. The result was a GIS data layer including most, if not all, of the structures in Yellowstone County.

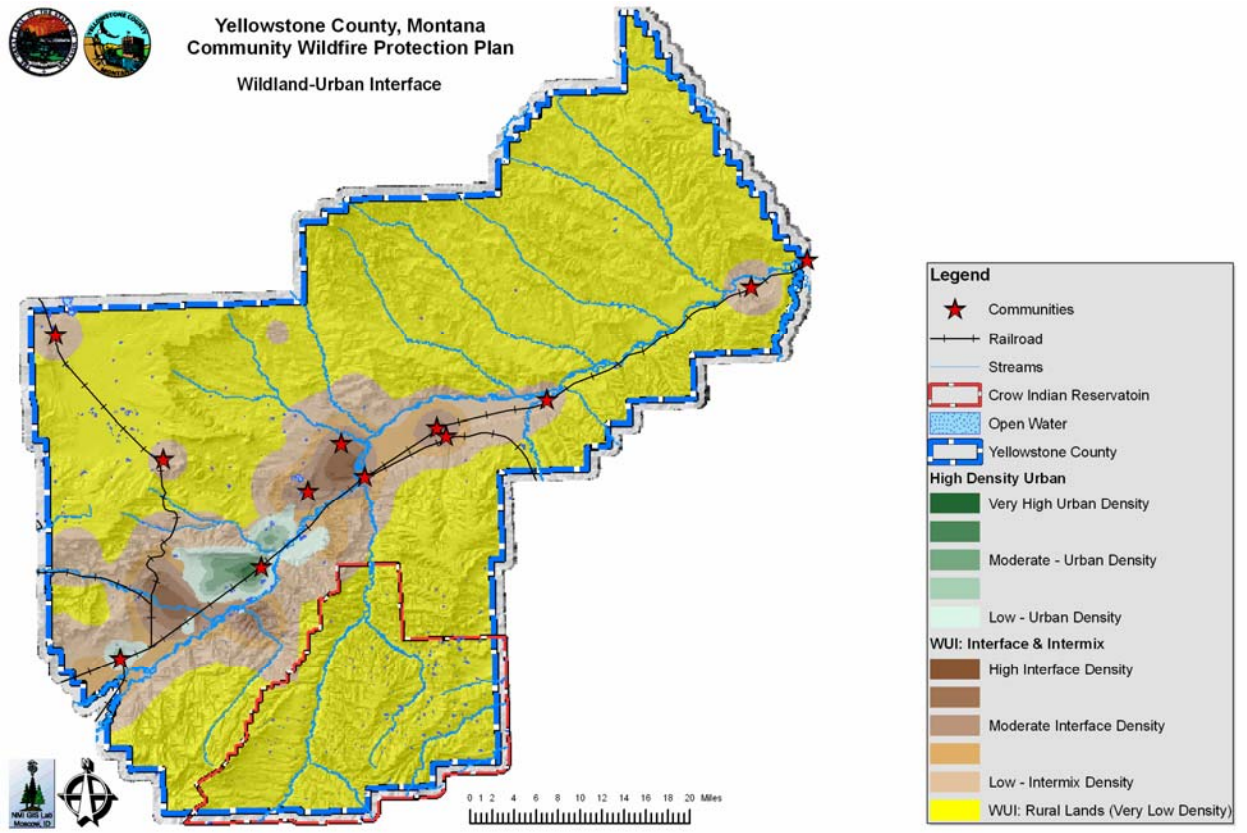
All structures are represented by a “dot” on the map. No differentiation is made between a garage and a home, or a business and a storage building. The density of structures and their specific locations in this management area are critical in defining where the potential exists for casualty loss in the event of a wildfire in the region.

By evaluating this structure density, we can define WUI areas on maps by using mathematical formulae and population density indexes to define the WUI based on where structures are located. The resulting population density indexes create concentric circles showing high density areas of Interface and Intermix WUI, as well as Rural WUI (as defined by Secretary Norton of the Department of Interior). This portion of the analysis allows us to “see” where the highest concentrations of structures are located in reference to high risk landscapes, limiting infrastructure, and other points of concern.

It is critical to understand that in the protection of people, structures, infrastructure, and unique ecosystems, this portion of the analysis only serves to identify structures and by some extension the people that inhabit them. It does not define the location of infrastructure and unique ecosystems. Other analysis tools will be used for those items.

The WUI interface areas as defined here are presented in map form in the Appendices.

Figure 3.13. Wildland-Urban Interface of Yellowstone County.



This map is presented for reference in this section of the plan. This map and additional maps are detailed in Appendix I.

3.11.2 Infrastructure

Yellowstone County has both significant infrastructure and unique ecosystems within its boundaries. Of note for this Wildfire Protection Plan is the existence of highway routes (e.g., Interstates 90 and 94 and U.S. Routes 87, 212, and 312 and State Route 3), oil fields and refineries, and the presence of power lines supplying surrounding counties. These resources will be considered in the protection of infrastructural resources for Yellowstone County and to the larger extent of this region, and the rest of Montana.

High Tension Power Lines have been mapped and are presented in the Appendices. Protection of these lines from loss during a wildfire is paramount in as much as the electrical power they provide serves not only the communities of Yellowstone County but of surrounding counties. The protection of these lines allows for community sustainability, support of the economic viability of Yellowstone County, and the protection of people who rely on that power. Fuels mitigation under power lines has received considerable attention in forested ecosystems as timber is thinned and heavy accumulations of brush are managed. This practice should be mandated into the future. However, the importance of management of rangeland ecosystems under high tension power lines should not be overlooked. Brush intermixed with grasses and other species, during extreme fire weather events, coupled with steep slopes can produce considerable heat and particulate matter. When this occurs under power lines, the result can be

arcing between lines and even failure of the electrical media itself. Fuel mitigation treatments in high risk areas, especially where multiple lines are co-located, will be recommended for treatments.

3.11.3 Ecosystems

Yellowstone County is a diverse ecosystem with a complex array of vegetation, wildlife, and fisheries that have developed with, and adapted to fire as a natural disturbance process. A century of wildland fire suppression coupled with past land-use practices (primarily livestock grazing and farming) has altered plant community succession and has resulted in dramatic shifts in the fire regimes and species composition. As a result, woodlands and rangelands in Yellowstone County have become more susceptible to large-scale, high intensity fires posing a threat to life, property, and natural resources including wildlife and special status plant populations and habitats. High-intensity, stand-replacing fires have the potential to seriously damage soils and native vegetation. In addition, an increase in the number of large high intensity fires throughout the nation's forest and rangelands, has resulted in significant safety risks to firefighters and higher costs for fire suppression (House of Representatives, Committee on Agriculture, Washington, DC, 1997).

3.12 Soils

Our soil resource is an extremely important component for maintaining a healthy ecosystem and economy. Fire can play an intricate role in this process, if it occurs under normal conditions of light fuels associated with low intensity underburns. However, the buildup of fuels and consequent high severity fires can cause soils to become water repellent (hydrophobic), and thus greatly increases the potential for overland flow during intense rains. Soil in degraded conditions does not function normally, and will not be able to sustain water quality, water yield, or plant communities that have normal structure, composition, and function. Fire is also strongly correlated with the carbon-nutrient cycles and the hydrologic cycle. Fire frequency, extent, and severity are controlled to a large degree by the availability of carbon, as well as the moisture regime (Quigley & Arbelbide 1997).

Soils were evaluated for their propensity to become hydrophobic during and after a fire as evidenced by the presence of clay and clay derivatives (e.g., clay loam, cobbly clay) in the upper soil layers. In addition, their permeability and tendency to allow runoff to infiltrate the soil was evaluated. Soils formed in place tend to contain high amounts of clay, silt and sand and low amounts of organic material in the surface horizons. These soils are located on the higher terraces and hills north and south of the Yellowstone River valley. The transported soils found in the Yellowstone River valley are more loam rich. On average, soils in Yellowstone County are well drained with moderate permeability.

Low to moderate intensity fires would be not be expected to damage soil characteristics in the region, especially if the hotter fires in this range were limited to small extents associated with jackpots of cured fuels. Hot fires providing intense heat to the C horizon substrate depth have the potential to create hydrophobic characteristics in that layer. This can result in increased overland flow during heavy rains, following wildfire events, potentially leading to mass wasting. Rocky and gravelly characteristics in the A horizon layer would be expected to be displaced, while the silty and loamy fines in these soils may experience an erosion and displacement potential. These soils will experience the greatest potential impacts resulting from hot fires that burn for prolonged periods (especially on steep slopes).

3.12.1 Fire Mitigation Practices to Maintain Soil Processes

Firelines constructed by hand or with the use of machinery will have varying impacts, depending upon construction techniques. If only the surface litter is removed in the fireline construction, minor increases to soil erosion may occur. If trenches are dug which channelize runoff down steep slopes, heavy rilling or gullying could occur depending upon rock content of surface layers exposed. Jackpot burning and, to a greater extent, large scale pile burning would result in greater soil heating, but with localized impacts. Loss of soil carbon, nitrogen, sulphur, phosphorus, potassium, and soil organisms would be high in the soil surface layer. Soil physical structure could be altered thereby creating hydrophobic soils, especially where clay content is moderate or high. Loosely stacked hand piles resulting from typical defensible space projects in Yellowstone County would not be expected to have lasting affects on soil properties.

Indirect effects of prescribed burning to slope stability are highly variable in the soil types found in Yellowstone County. Vegetation structure, including root strength after over-burning, is maintained from three to fifteen years following low to moderate intensity burns and therefore soil saturation potential is not greatly altered. Re-vegetation of burned areas within this time frame will be a critical component to maintaining soil resources and pre-empting noxious weeds and invasive species from occupying the site. Locale experiencing high intensity burns will need to be evaluated immediately for mechanical erosion control followed by re-vegetation efforts. Holding soils in place will be a difficult challenge in many locations, especially on moderate to steep slopes.

Where heavy grazing has occurred in the past, there is also a possibility that soil productivity has been reduced. This is especially true in riparian areas where animal concentrations have historically been the greatest. These areas generally have easily compacted soils, and are where cattle tend to linger if not managed well. Mining also has significant effects on soil quality through soil compaction and mass displacement. Grazing across Yellowstone County was observed to be maintained in a sustainable manner without the overgrazing found in other areas of the region.

Severe fires in the past have consumed surface organics and volatilized nitrogen into the air. On some sites, however, these severe burns are a natural process, and therefore the inherent soil productivity may not be reduced. On other sites, however, where low intensity underburns typically occurred, high intensity wildland fires have consumed amounts of soil organics in excess of the historic patterns. Furthermore, excessive soil heating in these intense fires likely resulted in creation of water repellent soils, and therefore increased overland flow and soil erosion. In these cases, it can be assumed that wildland fires have reduced long-term soil productivity. Soil compaction damage typically is persistent in the area; several decades of rest from further compactive forces are needed until adequate soil recovery occurs. Loss of organics due to displacement and severe fire also requires decades to recuperate. This slow recovery from soil damage makes cumulative effects to soil productivity and soil hydrologic function a major concern.

To avoid potential impacts, wherever possible, firelines should be located outside of highly erosive areas, steep slopes, intermittent streams, and riparian and other sensitive areas. Following prescribed fire or fire suppression activities, firelines should be rehabilitated.

3.13 Hydrology

The Montana Department of Natural Resources and Conservation Water Resources Division is charged with the development of the Montana State Ground Water Plan. Included in the Plan is the statewide water policy plan along with detailed subsections regarding the protection,

education, and remediation of Montana's ground water resources. The Montana DNRC Water Resources Division has prepared Surface Water Supply Index Maps for all of the surface water systems in Montana. This agency also addresses statewide floodplain management, streamflow conditions, and dams and canals, and water rights issues.

The geology and soils of this region lead to slow to moderate moisture infiltration. Soils that have a clay pan or clay layer near the surface inhibit downward water transmission; thus, have a high potential for overland flow. Clayey soils also have a high shrink swell potential. Disrupted vegetation patterns from logging or agriculture (soil compaction) and wildland fire (especially hot fires that increase soil hydrophobic characteristics), can lead to increased surface runoff and debris flow to stream channels.

A correlation to mass wasting due to the removal of vegetation caused by high intensity wildland fire has been documented for the central Montana region. Burned vegetation can result in changes in soil moisture and loss of rooting strength that can result in slope instability, especially on slopes greater than 30%. The greatest watershed impacts from increased sediment will be in the lower gradient, depositional stream reaches.

3.13.1 Fire Mitigation Practices to Maintain Hydrologic Processes

The effects of wildland fire and prescribed burning on water quality are variable. The removal of the vegetative canopy will tend to reduce transpiration and increase water yield, especially during the growing season and immediately afterwards (MacDonald *et al.* 1991). Prescribed burning is used to maintain a healthy, dynamic ecosystem while meeting land management objectives. Prescribed burning objectives include reduction of natural fuels, assuring current and future habitat conditions for native plants and animals, improvement of forest health, and enhancement, protection, and maintenance of old growth and riparian areas. The majority of the burned areas are expected to receive low intensity ground fires with some areas of moderate intensity. This may include occasional torching of single trees or larger clumps of trees and consumption of some patches of regeneration. Impacts to soil and large woody debris are expected to be minimal, given project targets. In rangeland ecosystems, prescribed fire will have variable impacts dependant on burn intensity and proximity to streams. Stream buffering (low intensity to no burn around streams) has been shown to preserve most if not all normal sediment filtering functions.

A large, stand-replacing fire could have negative effects on watershed conditions, thus affecting both fish and habitat in streams. Treatment with low to moderate intensity fire would result in a mosaic pattern of burned and unburned areas of ground level vegetation species and ground level natural fuels. Some patches of shade-tolerant, fire intolerant species may also be consumed. Prescribed burning is not designed to consume all vegetation within project areas. Each treatment will leave a mosaic of burned and unburned areas. Once the target fuels and the risk of fire carrying from one tributary to another have been reduced, hand ignition may be considered on a site-specific basis.

The effects on sediment yield vary according to the intensity of fire; degree of soil disturbance; steepness of the slope and drainage network; the size of the area burned; and the extent to which the vegetation controls the movement and storage of sediment. Fire also increases surface erosion and sediment delivery rates by removing the litter layer and organic debris that traps sediment both on slopes and in the stream channel (MacDonald *et al.* 1991). The magnitude of these effects will depend on the geomorphic sensitivity of the landscape, which is largely a function of slope steepness and parent material (Swanson 1978).

Fire can greatly increase surface erosion by temporarily creating a hydrophobic soil layer. Soils within the project area are generally at moderate risk for hydrophobic conditions due to their

fine-grained textures and clay content. In addition, the relatively low burn intensity of the prescribed fires will also help prevent the formation of hydrophobic soils.

The effects of wildland fire or prescribed fire are generally considered in terms of potential short-term, negative effects and long-term benefits of fuels reduction, which will result in a decreased risk of high intensity, stand-replacing fire. Potential short-term effects to streams and fish include increased risk of landslides, mass movement and debris torrents, increases in surface sediment erosion, possible reduction in streamside vegetation resulting in changes within management areas, and possible increases in water yield depending on the amount and severity of the vegetation burned. Long-term effects include increases in nutrient delivery, possible increases in woody debris in streams, and possible increases in stream temperature if shading is significantly reduced. The design criteria described above minimizes the risk that landslides, mass movement, significant increases in surface sediment yield, and significant changes in water yield will occur.

Reduction of vegetation will mostly be limited to creeping ground fires, which will reduce understory vegetation, but will not affect mature trees or result in significant mortality to the overstory. Spring burning often results in minimal riparian vegetation burned because streamside areas have higher humidity and live plant moisture. Fall burning will more likely result in understory vegetation removal, with a possibility of some tree and large shrub mortality, especially outside of riparian zones where live plant moisture is less.

Riparian buffer strips will be maintained, thereby preserving canopy cover for shading, sediment filtering, and streambank and floodplain stability (PACFISH guidelines). Areas not burned will provide significant protection from adverse water quality impacts associated with wildland fire and prescribed burning. Therefore, effects to fish and habitat in these streams from increased water yield are unlikely. The area has been roaded from past management activities. Therefore, increased road densities from road construction are not expected to be of a magnitude to increase sedimentation to affected drainages provided adequate planning for new road construction is implemented. Forest practices in the area will be conducted to meet the standards of the Montana Streamside Management Law. These rules are designed to use best management practices that are adapted to and take account of the specific factors influencing water quality, water quality objectives, on-site conditions, and other factors applicable to the site where a forest practice occurs.

3.14 Air Quality

The primary means by which the protection and enhancement of air quality is accomplished is through implementation of National Ambient Air Quality Standards (NAAQS). These standards address six pollutants known to harm human health including ozone, carbon monoxide, particulate matter, sulfur dioxide, lead, and nitrogen oxides (USDA Forest Service 2000). There are nine monitoring stations in Yellowstone County that are monitored for EPA emission standards. All locations are in compliance and well below allowable emission thresholds. These stations are positioned at Billings Logan International Airport, Pine Hills, Beartooth, Brickyard Lane, St. Lukes, Coburn Road, Lockwood Park, Johnson Lane, and Bernhardt Road in Laurel (Yellowstone City-County Health Department 2005).

Smoke emissions from fires potentially affect an area and the airsheds that surround it. Climatic conditions affecting air quality in central Montana are governed by a combination of factors. Large-scale influences include latitude, altitude, prevailing hemispheric wind patterns, and mountain barriers. At a smaller scale, topography and vegetation cover also affect air movement patterns. Air quality in the area and surrounding airshed is generally good to excellent. However, locally adverse conditions can result from occasional wildland fires in the summer and

fall, and prescribed fire and agricultural burning in the spring and fall. All major river drainages are subject to temperature inversions which trap smoke and affect dispersion, causing local air quality problems. Air quality is also affected by winter inversions trapping emissions form internal combustion engines and wood burning stoves.

Yellowstone County is in the Montana Airshed Unit 10: Idaho/Montana Airshed Group Operating Guide (Levinson 2002). An airshed is a geographical area which is characterized by similar topography and weather patterns (or in which atmospheric characteristics are similar, e.g., mixing height and transport winds). The USDA Forest Service, Bureau of Land Management, and the Montana Department of Natural Resources and Conservation are all members of the Idaho/Montana State Airshed Group, which is responsible for coordinating burning activities to minimize or prevent impacts from smoke emissions. Prescribed burning must be coordinated through the Missoula Monitoring Unit, which coordinates burn information, provides smoke forecasting, and establishes air quality restrictions for the Idaho/Montana Airshed Group. The Monitoring Unit issues daily decisions which may restrict burning when atmospheric conditions are not conducive to good smoke dispersion. Burning restrictions are issued for airsheds, impact zones, and specific projects. The monitoring unit is active March through November. Each Airshed Group member is also responsible for smoke management all year.

The Clean Air Act, passed in 1963 and amended in 1977, is the primary legal authority governing air resource management. The act established a process for designation of Class I and Class II areas for air quality management. Class I areas receive the highest level of protection and numerical thresholds for pollutants are most restrictive for this Class. The Gates of the Mountains Wilderness and the Anaconda-Pintler Wilderness Class 1 areas lie distantly to the northwest and west, respectively, of Yellowstone County.

All of the communities within Yellowstone County could be affected by smoke or regional haze from burning activities in the region. Montana Department of Environmental Quality maintains Air Pollution Monitoring Sites throughout Montana. The Air Pollution Monitoring program monitors all of the six criteria pollutants. Measurements are taken to assess areas where there may be a problem, and to monitor areas that already have problems. The goal of this program is to control areas where problems exist and to try to keep other areas from becoming problem air pollution areas (Louks 2001).

The Clean Air Act provides the principal framework for national, state, and local efforts to protect air quality. Under the Clean Air Act, OAQPS (Organization for Air Quality Protection Standards) is responsible for setting standards, also known as national ambient air quality standards (NAAQS), for pollutants which are considered harmful to people and the environment. OAQPS is also responsible for ensuring these air quality standards are met, or attained (in cooperation with state, Tribal, and local governments) through national standards and strategies to control pollutant emissions from automobiles, factories, and other sources (Louks 2001).

3.14.1 Fire Mitigation Practices to Maintain Air Quality

Smoke consists of dispersed airborne solids and liquid particles, called particulates, which can remain suspended in the atmosphere for a few days to several months. Particulates can reduce visibility and contribute to respiratory problems. Very small particulates can travel great distances and add to regional haze problems. Regional haze can sometimes result from multiple burn days and/or multiple owners burning within an airshed over too short a period of time to allow for dispersion.

For prescribed fires, there are three principle strategies to manage smoke and reduce air quality effects. They include:

1. **Avoidance -** This strategy relies on monitoring meteorological conditions when scheduling prescribed fires to prevent smoke from drifting into sensitive receptors, or suspending burning until favorable weather (wind) conditions exist. Sensitive receptors can be human-related (e.g. campgrounds, schools, churches, and retirement homes) or wildlife-related (threatened and endangered species and their critical habitats);
2. **Dilution –** This strategy ensures proper smoke dispersion in smoke sensitive areas by controlling the rate of smoke emissions or scheduling prescribed fires when weather systems are unstable, not under conditions when a stable high-pressure area is forming with an associated subsidence inversion. An inversion would trap smoke near the ground; and
3. **Emission Reduction –** This strategy utilizes techniques to minimize the smoke output per unit area treated. Smoke emission is affected by the number of acres burned at one time, pre-burn fuel loadings, fuel consumption, and the emission factor. Reducing the number of acres burned at one time would reduce the amount of emissions generated by that burn. Reducing the fuel beforehand reduces the amount of fuel available. Prescribed burning when fuel moistures are high can reduce fuel consumption. Emission factors can be reduced by pile burning or by using certain firing techniques such as mass ignition.

If weather conditions changed unexpectedly during a prescribed burn, and there was a potential for violating air quality standards or for adverse smoke impacts on sensitive receptors (schools, churches, hospitals, retirement homes, campgrounds, wilderness areas, and species of threatened or endangered wildlife), the management organization may implement a contingency plan, including the option for immediate suppression. Considering 1) the proposed action would result in prescribed fire on a relatively small number of acres, 2) burning as part of this mitigation plan's implementation in the County will most likely occur over a 5-year or 10-year period at a minimum, and 3) the County will adhere to Montana/Idaho Airshed Group advisories and management strategies to minimize smoke emissions, prescribed fire activities would not violate national or state emission standards and would cause very minor and temporary air quality impacts. The greatest threat to air quality would be smoke impacts on sensitive receptors; however, the relative scarcity of sensitive receptors within the County minimizes this potential air quality impact.

In studies conducted through the Interior Columbia Basin Management Project, smoke emissions were simulated across the Basin to assess relative differences among historical, current, and future management scenarios. In assessing the whole Upper Columbia Basin, there was a 43 percent reduction in smoke emissions between the historical and current periods (Quigley and Arbelbide 1997). The projected smoke emissions varied substantially with the vastly different management scenarios. The consumptive demand and passive management scenarios were projected to substantially increase smoke emissions above current levels. The active management scenarios were projected to result in a decrease of current levels.

Although prescribed fire smoke would occur more frequently than wildland fire smoke, since prescribed fires are scheduled during the year, the effects of wildland fire smoke on visibility are more acute. Prescribed fires produce less smoke than wildland fires for comparatively shorter periods, because they are conducted under weather conditions that provide for better smoke dispersion. In a study conducted by Holsapple and Snell (1996), wildland fire and prescribed fire scenarios for the Columbia Basin were modeled. In conclusion, the prescribed fire scenarios did not exceed the EPA particulate matter (PM 10) standard in a 24-hour period. Similar projections were observed for a PM 2.5 threshold. Conversely, all wildland fire scenarios exceeded air quality standards. Similar responses were reported by Huff *et al.* (1995) and Ottmar *et al.* (1996)

when they compared the effects of wildland fire to prescribed fire on air quality. The impacts of wildland fire and management ignited prescribed fire on air quality vary because of the differences in distribution of acres burned, the amount of fuel consumed per acre (due to fuel moisture differences), and the weather conditions in which typical spring and fall prescribed burns occur. This analysis reveals wildland fire impacts on air quality may be significantly greater in magnitude than emissions from prescribed burns. This may be attributable, in part, to the fact that several states within the project area have smoke management plans requiring favorable weather conditions for smoke dispersion prior to igniting wildland fires (Quigley and Arbelbide 1997).

Chapter 4: Summaries of Risk and Preparedness

4 Overview

4.1 Wildland Fire Characteristics

An informed discussion of fire mitigation is not complete until basic concepts that govern fire behavior are understood. In the broadest sense, wildland fire behavior describes how fires burn, the manner in which fuels ignite, how flames develop and how fire spreads across the landscape. The three major physical components that determine fire behavior are the fuels supporting the fire, the topography in which the fire is burning, and the weather and atmospheric conditions during a fire event. At the landscape level, both topography and weather are beyond our control. We are powerless to control winds, temperature, relative humidity, atmospheric instability, slope, aspect, elevation, and landforms. It is beyond our control to alter these conditions, and thus impossible to alter fire behavior through their manipulation. When we attempt to alter how fires burn, we are left with manipulating the third component of the fire environment, the fuels which support the fire. By altering fuel loading and fuel continuity across the landscape, we have the best opportunity to determine how fires burn.

A brief description of each of the fire environment elements follows in order to illustrate their effect on fire behavior.

4.1.1 Weather

Weather conditions are ultimately responsible for determining fire behavior. Moisture, temperature, and relative humidity determine the rates at which fuels dry and vegetation cures, and whether fuel conditions become dry enough to sustain an ignition. Once conditions are capable of sustaining a fire, atmospheric stability and wind speed and direction can have a significant affect on fire behavior. Winds fan fires with oxygen, increasing the rate at which fire spreads across the landscape. Weather is the most unpredictable component governing fire behavior, constantly changing in time and across the landscape.

4.1.2 Topography

Fires burning in similar fuel conditions burn dramatically different under different topographic conditions. Topography alters heat transfer and localized weather conditions, which in turn influence vegetative growth and resulting fuels. Changes in slope and aspect can have significant influences on how fires burn. Generally speaking, north slopes tend to be cooler, wetter, more productive sites. This can lead to heavy fuel accumulations, with high fuel moistures, later curing of fuels, and lower rates of spread. The combination of light fuels and dry sites lead to fires that typically display the highest rates of spread. In contrast, south and west slopes tend to receive more direct sun, and thus have the highest temperatures, lowest soil and fuel moistures, and lightest fuels. These slopes also tend to be on the windward side of mountains. Thus these slopes tend to be “available to burn” a greater portion of the year.

Slope also plays a significant roll in fire spread, by allowing preheating of fuels upslope of the burning fire. As slope increases, rate of spread and flame lengths tend to increase. Therefore, we can expect the fastest rates of spread on steep, warm south and west slopes with fuels that are exposed to the wind.

4.1.3 Fuels

Fuel is any material that can ignite and burn. Fuels describe any organic material, dead or alive, found in the fire environment. Grasses, brush, branches, logs, logging slash, forest floor litter, conifer needles, and home sites (the structures) are all examples. The physical properties and characteristics of fuels govern how fires burn. Fuel loading, size and shape, moisture content and continuity and arrangement all have an affect on fire behavior. Generally speaking, the smaller and finer the fuels, the faster the potential rate of fire spread. Small fuels such as grass, needle litter and other fuels less than a quarter inch in diameter are most responsible for fire spread. In fact, "fine" fuels, with high surface to volume ratios, are considered the primary carriers of surface fire. This is apparent to anyone who has ever witnessed the speed at which grass fires burn. As fuel size increases, the rate of spread tends to decrease, as surface to volume ratio decreases. Fires in large fuels generally burn at a slower rate, but release much more energy, and burn with much greater intensity. This increased energy release, or intensity, makes these fires more difficult to control. Thus, it is much easier to control a fire burning in grass than to control a fire burning in timber.

When burning under a forest canopy, the increased intensities can lead to torching (single trees becoming completely involved) and potentially development of crown fire. That is, they release much more energy. Fuels are found in combinations of types, amounts, sizes, shapes, and arrangements. It is the unique combination of these factors, along with the topography and weather, which determine how fires will burn.

The study of fire behavior recognizes the dramatic and often-unexpected affect small changes in any single component has on how fires burn. It is impossible to speak in specific terms when predicting how a fire will burn under any given set of conditions. However, through countless observations and repeated research, some of the principles that govern fire behavior have been identified and are recognized.

4.1.3.1 Conservation Reserve Program Lands

The Conservation Reserve Program is administered by the USDA Farm Services Agency. The Conservation Reserve Program (CRP) is a voluntary program for agricultural landowners. Through CRP, farmers can receive annual rental payments and cost-share assistance to establish long-term, resource conserving covers on eligible farmland. The Commodity Credit Corporation (CCC) makes annual rental payments based on the agriculture rental value of the land, and it provides cost-share assistance for up to 50 percent of the participant's costs in establishing approved conservation practices. Participants enroll in CRP contracts for 10 to 15 years.

The program is administered by the CCC through the Farm Service Agency (FSA), and program support is provided by Natural Resources Conservation Service, Cooperative State Research and Education Extension Service, state forestry agencies, and local Soil and Water Conservation Districts. Approximately 3.4 million acres of farm land in Montana have been enrolled in the CRP program through February 2005.

USDA Farm Service Agency's (FSA) Conservation Reserve Program (CRP) is a voluntary program available to agricultural producers to help them safeguard environmentally sensitive land. Producers enrolled in CRP plant long-term, resource-conserving covers to improve the quality of water, control soil erosion, and enhance wildlife habitat. In return, FSA provides participants with rental payments and cost-share assistance. Contract duration is between 10 and 15 years.

The Food Security Act of 1985, as amended, authorized CRP. The program is also governed by regulations published in 7 CFR, part 1410. The program is implemented by FSA on behalf of USDA's Commodity Credit Corporation.

CRP protects millions of acres of American topsoil from erosion and is designed to safeguard the Nation's natural resources. By reducing water runoff and sedimentation, CRP protects groundwater and helps improve the condition of lakes, rivers, ponds, and streams. Acreage enrolled in the CRP is planted to resource-conserving vegetative covers, making the program a major contributor to increased wildlife populations in many parts of the country.

Although there are many benefits to the County stemming from CRP land enrollment, the impact on wildfire control is problematic. When these lands, often near communities and homes, build up heavy fuel loading consistent with natural grasses and shrubs, the fuel loading increases dramatically above that found on farmlands. Fires in these fuels can move very rapidly when fanned by winds (common during the fire season). The FSA allows periodic fuels mitigation treatments on CRP lands. These fuel treatments are critical to the development of a successful wildfire mitigation program in Yellowstone County and are fully endorsed and encouraged by the Wildfire Protection Plan Committee.

4.2 Yellowstone County Conditions

Yellowstone County is characterized by cold winters and dry summers. The cities of Billings and Laurel make up a densely populated metropolitan center; however, much of the remaining area in the county is quite rural. Farms and ranches tend to be widely spread. Grazing activity on both public and private lands by livestock and wildlife tends to decrease the build up of fine fuel loads; however, this does not drastically reduce the fire potential.

The majority of the county is covered by native rangelands, while most of the Yellowstone River valley has been developed or converted to irrigated farm or pasture. Undeveloped rangelands are characterized by low growing grasses with scattered stands of sagebrush or juniper and occasionally ponderosa pine. Rangelands are typically either grazed, thereby keeping the fine fuel buildup to a minimum, or are in various stages of crop production. Agricultural fields are generally not considered to be at high risk of uncontrolled wildland fires; however, fires in this type of vegetation could burn very intensely with large flame lengths depending on the crop type. Annual burning of stubble after harvest occasionally leads to escaped grass fires. Usually, these fires are relatively easily controlled at road crossings or by using available farm implements to modify the vegetation in its path.

Since the induction of the Conservation Reserve Program by the federal government, many former crop producing fields have been allowed to return to native grasses. CRP fields are creating a new fire concern all over the West. As thick grasses are allowed to grow naturally year after year, dense mats of dead plant material begin to buildup. Due to the availability of a continuous fuel bed, fires in CRP fields tend to burn very intensely with large flame lengths that often times jump roads or other barriers, particularly under the influence of wind. Many landowners and fire personnel are researching allowable management techniques to deal with this increasing problem. Currently, according to the CRP Handbook, all management must be part of the landowner's Conservation Plan of Operations, which includes burning to reduce the fuel loading, and must be in the best interest of the CRP. Under certain circumstances, burning may be used as a process to enhance or renovate the existing vegetative cover for wildlife, especially if it is overgrown and stagnant. As noted in Montana CRP-542, burning can only be conducted under an approved burn plan by qualified personnel. The County must also issue a burn permit for any controlled burning on CRP fields.

Human activity is strongly correlated with fire frequency, with increasing numbers of fires as use increases. Discarded cigarettes, tire fires, and hot catalytic converters have increased the number of fires experienced along roadways. Careless and unsupervised use of fireworks also contributes to unwanted and unexpected wildland fires. Further contributing to ignition sources are the debris burners and the practice of ditch burning where fire is used to rid ditches of weeds and other burnable materials.

4.2.1 County Wide Potential Mitigation Activities

There are four basic opportunities for reducing the loss of homes and lives to fires. There are many single actions that can be taken, but in general they can be lumped into one of the following categories:

- Prevention
- Education/ Mitigation
- Readiness
- Building Codes

4.2.1.1 Prevention

The safest, easiest, and most economical way to mitigate unwanted fires is to stop them before they start. Generally, prevention actions attempt to prevent human-caused fires. Campaigns designed to reduce the number and sources of ignitions can be quite effective. Prevention campaigns can take many forms. Traditional “Smokey Bear” type campaigns that spread the message passively through signage can be quite effective. Signs that remind folks of the dangers of careless use of fireworks, burning when windy, and leaving unattended campfires can be quite effective. It’s impossible to say just how effective such efforts actually are, however the low costs associated with the posting of a few signs is inconsequential compared to the potential cost of fighting a fire.

Slightly more active prevention techniques may involve mass media, such as radio or the local newspaper. Fire districts in other counties have contributed to the reduction in human-caused ignitions by running a weekly “run blotter,” similar to a police blotter, each week in the paper. The blotter briefly describes the runs of the week and is followed by a weekly “tip of the week” to reduce the threat from wildland and structure fires. The federal government has been a champion of prevention, and could provide ideas for such tips. When fire conditions become high, brief public service messages could warn of the hazards of misuse of fire or any other incendiary devise. Such a campaign would require coordination and cooperation with local media outlets. However, the attempt is likely to be worth the efforts, costs and risks associated with fighting unwanted fires.

Fire Reporting: Fires cannot be suppressed until they are detected and reported. As the number and popularity of cellular phones has increased, expansion of the #FIRE program throughout Montana may provide an effective means for turning the passing motorist into a detection resource.

Burn Permits: The issues associated with debris burning during certain times of the year are difficult to negotiate and enforce. However, there are significant risks associated with the use of fire adjacent to expanses of flammable vegetation under certain scenarios. Burning permits are required by State law on all forested lands within the State during the official fire season of May 1 to September 30. The wildland fire agencies (DNRC, USFS, BLM, and US Fish and Wildlife Service) each have their own guidelines for issuing burn permits in their jurisdictions. Since local government fire agencies are also involved with burn permit regulation, close coordination

between the two types of agencies is needed to ensure safe burning and to exchange information. Enforcement of burning permit requirements is the responsibility of the County Sheriff's Department. Although this is a statewide regulation, compliance and enforcement has been variable between fire departments. There is also considerable confusion on the part of the public as to when a permit is necessary and the procedure for which to obtain the permit. The best-intentioned citizen may unknowingly break this law for a lack of understanding. Clearly, there is a need to coordinate this process and educate the public.

Fire Resistant Oil Rig Sites: The occurrence of oil rig sites throughout central Montana is high. Although the fire risk associated with this machinery is low, the potential for an ignition due to mechanical failure or other reason exists. Maintaining fire resistant vegetation in the immediate vicinity of the rigs will decrease the likelihood of a stray spark igniting nearby fuels. A method for maintaining these sites with an awareness of the associated fire danger should be a priority of every county.

4.2.1.2 Education

Once a fire has started and is moving toward homes or other valued resources, the probability of that structure surviving is largely dependent on the structural and landscaping characteristics of the home. Also of vital importance is the accessibility of the home to emergency apparatus. If the home cannot be protected safely, firefighting resources will not jeopardize lives to protect a structure. Thus, the fate of the home will largely be determined by homeowner actions prior to the event.

The majority of the uncultivated vegetation in Yellowstone County is comprised of rangelands. These fuels tend to be very flammable and can support very fast moving and intense fires. In many cases, homes can easily be protected by following a few simple guidelines that reduce the ignitability of the home. There are multiple programs such as FIREWISE that detail precautions that should be taken in order to reduce the threat to homes, such as clearing timber or cured grass and weeds away from structures and establishing a green zone around the home.

However, knowledge is no good unless acted upon. Education needs to be followed up by action. Any education programs should include an implementation plan. Ideally, funds would be made available to financially assist the landowner making the necessary changes to the home. The survey of the public conducted during the preparation of this Community Wildfire Protection Plan indicated that approximately 61% of the respondents are interested in participating in this type of an activity.

4.2.1.3 Readiness

Once a fire has started, how much and how large it burns is often dependent on the availability of suppression resources. In most cases, rural fire departments are the first to respond and have the best opportunity to halt the spread of a wildland fire. For many departments, the ability to reach these suppression objectives is largely dependent on the availability of functional resources and trained individuals. Increasing the capacity of departments through funding and equipment acquisition can improve response times and subsequently reduce the potential for resource loss.

In order to assure a quick and efficient response to an event, emergency responders need to know specifically where emergency services are needed. Continued improvement and updating of the rural addressing system is necessary to maximize the effectiveness of a response.

4.2.1.4 Building Codes

The most effective, albeit contentious, solution to some fire problems is the adoption of building codes in order to assure emergency vehicle access and home construction that does not "invite" a fast and intense house fire. Codes that establish minimum road construction standards and access standards for emergency vehicles are an effective means of assuring public and firefighter safety, as well as increasing the potential for home survivability. County building inspectors should look to the fire departments in order to assure adequate minimum standards. Fire departments may want to consider apparatus that may be available during mutual aid events in order that the adopted standards meet the access requirements of the majority of suppression resources.

Coupled with this need is the potential to implement a set of requirements or recommendations to specify construction materials allowed for use in high risk areas of the County. The Yellowstone County Commissioners may want to consider a policy for dealing with this situation into the future as more and more homes are located in the wildland-urban interface.

4.3 Yellowstone County's Wildland-Urban Interface

Individual community assessments have been completed for all of the populated places in the county. The following summaries include these descriptions and observations. Local place names identified during this plan's development include:

Table 4.1. Yellowstone County Communities

Community Name	Planning Description	Vegetative Community	National Register Community At Risk?[1]
Billings	City	Rangeland	Yes
Laurel	City	Rangeland	Yes
Broadview	Town	Rangeland	No
Huntley Project	Community	Rangeland	No
Worden	Community	Rangeland	Yes
Lockwood	Community	Rangeland	No
Shepherd	Community	Rangeland	No
Custer	Community	Rangeland	No
Acton	Community	Rangeland	No
Ballantine	Community	Rangeland	No
Pompeys Pillar	Community	Rangeland	No

[1]Those communities with a "Yes" in the National Register Community at Risk column are included in the Federal Register, Vol. 66, Number 160, Friday, August 17, 2001, as "Urban Wildland Interface Communities within the vicinity of Federal Lands that are at high risk from wildfires". All of these communities have been evaluated as part of this plan's assessment.

Site evaluations on these communities are included in subsequent sections.

4.3.1 Mitigation Activities Applicable to all Communities

4.3.1.1 Homesite Evaluations and Creation of Defensible Space

Individual home site evaluations can increase homeowners' awareness and improve the survivability of structures in the event of a wildfire. Maintaining a lean, clean, green zone around structures to reduce the potential loss of life and property is highly recommended. Assessing

individual homes in the outlying areas can address the issue of escape routes and home defensibility characteristics. Educating the homeowners in techniques for protecting their homes is critical in these environments.

4.3.1.2 Travel Corridor Fire Breaks

Ignition points are likely to continue to be concentrated along the roads and railway lines that run through the county. These travel routes have historically served as the primary source of human-caused ignitions. In areas with high concentrations of resource values along these corridors, fire lines may be considered in order to provide a fire break in the event of a roadside ignition. Access route mitigation can provide an adequate control line under normal fire conditions. Alternatively, permanent fuel breaks can be established in order to reduce the potential for ignitions originating from the main travel roads to spread into the surrounding lands.

4.3.1.3 Power Line Corridor Fire Breaks

The treatment opportunities specified for travel corridor fire breaks apply equally for power line corridors. The obvious difference between the two is that the focus area is not an area parallel to and adjacent to the road, but instead focuses on the area immediately below the infrastructure element. Protection under the high tension power lines is strongly recommended. This may be an opportunity for intensive livestock grazing practices as a tool for reducing fine fuels around significant infrastructure.

4.4 Communities in Yellowstone County

4.4.1 Vegetative Associations and Overall Fuels Assessment

The land ownership pattern in Yellowstone County is a mixture of state, federal, and private. Additionally, a portion of the Crow Indian Reservation lies in the southeast corner of the county. Most of the Yellowstone River valley and the flatter rangeland regions are privately owned. Tillable or grazable ground is generally utilized for the production of agricultural products. The northeastern corner of the county is a mixture of rangeland and scattered forestlands. Ownership in this area is by and large private with scattered inholdings of Bureau of Land Management and State, much of which is leased for grazing rights.

The native mixed grass and sage rangelands present throughout the majority of the county are fairly inconsistent. Farming, ranching, and housing development has broken the continuity of native fuels. Where native rangelands do exist, they are dominated by bluebunch wheatgrass, blue gramagrass, crested wheatgrass, needle and thread, western wheatgrass, Indian ricegrass, little bluestem, juniper, prairie sandreed, and several species of sage. Harsh winters, low precipitation, short growing season, and periodic droughts limit the establishment of trees in low elevation areas.

Much of the rangeland is actively grazed by livestock, mule deer, pronghorn antelope, and other ungulates. Grazing helps keep fine fuel loads low, reducing available fuel for rangeland fire. Fires in areas dominated by grasses and scattered sage tend to spread rapidly, but burn at relatively low intensities. The grass and sage fuels in many areas tend to be relatively sparse and short, with little continuity, limiting fire spread in the absence of wind. Agricultural fields can also serve to fuel a fire after curing, burning in much the same manner as consistent grass fuel. Fires in grass and rangeland fuels tend to burn at relatively low intensities, with moderate flame lengths and only short-range spotting. Suppression resources are generally quite effective in

such fuels. Homes and other improvements can be easily protected from direct flame contact and radiant heat through adoption of precautionary measures around the structure.

Although fires in these fuels may not present the same control problems as those associated with large, high intensity fires in timber fuel types, they can cause significant damage if precautionary measures have not taken place prior to a fire event. Wind driven fires in these short, grass fuel types spread very rapidly. During extreme drought and pushed by high winds, fires in these fuel types can exhibit extreme rates of spread, thwarting suppression efforts. The fires within the Missouri Breaks Complex of 2003 demonstrate the potential for fires in these fuels to grow to enormous size and demonstrate fire behavior atypical of these fuel complexes.

Where moisture becomes more available, ponderosa pine and juniper grow on ridges or in protected draws. Fires tend to be quite common in these habitat types, as open forest structure allows for the accumulation of light grass and surface fuels which dry quite rapidly. In the absence of heavy regeneration or downed wood fuels, these swift moving fires tend to burn at relatively low intensities. Historically, grassland understories were maintained in this type of open pine stand by periodic surface fires. Historic fire frequencies ranged from 5 to 25 years. These fires helped to reduce juniper encroachment and limit survival of pine regeneration, thus maintaining a relatively open understory. Only under extreme weather conditions would crowning and torching occur. The current drought conditions in Yellowstone and surrounding counties is causing large scale mortality of many stands pockets of ponderosa pine. The needles left on these standing dead trees provide excellent fuel for an ignition and increase the probability of a crown fire.

4.4.2 Individual Community Assessments

4.4.2.1 Billings

(This assessment includes Hillcrest Subdivision, Blue Creek Area, Rehberg Ranch Estates, and Lone Eagle Subdivision).

Billings is the commercial center and population hub of Yellowstone County. The city spans the Yellowstone River valley just northeast of where the Clarks Fork of the Yellowstone River joins the main channel. Outside of the urban developments, the city is surrounded, for the most part, by agricultural development in the form of various crops and livestock grazing. North of the city, past the Rimrock, there are some agricultural crop fields; however, relatively flat rangelands extend for many miles broken only by a few shallow and usually sparsely forested coulees. On the south side of the Yellowstone River, there are several developing subdivisions. Wheat, hay, and other crop fields abut many of these housing projects; however, a few are intermingled with somewhat sparse stands of ponderosa pine and juniper.

Extensive development of subdivisions and rural communities has occurred throughout the foothills in almost every direction from the city. Included in this assessment are *Hillcrest, Blue Creek Area, Rehberg Ranch Estates, and Lone Eagle*.

The Hillcrest Subdivision is a newer development going in on the hilltop just south of the Yellowstone River and west of State Route 416 (Blue Creek Road). This has been subdivided out of former agricultural land; thus, there is little native fuels remaining.

The Blue Creek community is a compilation of several small clusters of homes and the Briarwood Estates Subdivision located along State Route 416, otherwise known as Blue Creek Road. The west side of the road is characterized by a gentle, grassy slope leading up to agricultural development along the top. Homes on the west side of the Blue Creek Road are generally at low risk due to lack of dense fuels. There are a few homes in the Basin Creek

drainage that may be at slightly higher risk due to accumulation sage and juniper in the creek bed. Many of the graveled roads accessing homes on the west side of road, namely Basin Creek Road and Vandaveer Road, are very rough due to potholes and washboards. During certain times of the year, emergency vehicles may need to travel very slowly to negotiate the bumpiness. Some of the homes along the east side of the road abut rangeland fuels with an increased sagebrush and juniper component. Homes in the Briarwood Estates Subdivision are generally well protected from fire by the well-manicured lawns that surround their homes. Nevertheless, structures along the perimeter of the development, particularly to the east and south, abut rangeland fuels consisting of medium length grasses, sagebrush, and juniper clumps. Additionally, there are a few occluded sections of wildland fuels within the subdivision that would be much more susceptible to an ignition.

The Rehberg Ranch Estates development sits north of Billings about one mile north of the Rimrock. Upon completion, this subdivision will contain 1,200 homes. Most of this area has previously been employed as a working ranch. This subdivision straddles a small coulee with several smaller drainages throughout. Although the coulee area is lightly timbered with ponderosa pine and juniper with a moderate grass understory, much of the trees are dead or dying. Insect infestation is evident by a significant number of trees with spiked tops and thinning foliage. This overstocked area contains high fuel densities, increasing ladder fuels, and dead and down fuels; which sets the stage for potential crown fires. The risk of a wildland fire occurring in this area is great. Fire history in the general area includes 6-9 fires in the past 15 years. The most recent fire occurred in 2002 on state land immediately to the west of the subdivision. Fire behavior has been characterized by high intensity crown fires and complete consumption of the timber overstory.

The Lone Eagle Subdivision lies a few miles northwest of Billings off of State Highway 3. Most of the homes in the Lone Eagle Subdivision sit on large lots (approximately 5-10 acre parcels) with horse pasture or rangeland surrounding manicured lawns. Many of the homes in this area are accessed via gated private driveways. There is a small rock ledge cutting through the middle of development that supports a few ponderosa pine and juniper; however, the surrounding area is predominantly rangeland.

4.4.2.1.1 Fire Potential

Fuels Assessment

The native rangeland ecosystem around the outskirts of the city and abutting several of the rural subdivisions consist of short to medium length grasses with scattered clumps of sagebrush and juniper. This type of fuel is typically very flashy. Fires spread quickly, particularly upslope, but tend to burn at lower intensities. In some areas, the lack of a consistent fuel bed may slow the spread of fire. The rangelands of eastern Montana, including Yellowstone County, historically burned at frequent intervals. 5 to 25 year return intervals helped maintain the grassland ecosystem by limiting the establishment of slower growing species.

Along the face of the Rimrock and in several coulees north of State Route 3 a mixed rangeland/forestland vegetation type abuts many homes and intermixes with the Rehberg Ranch Estates. The overstory consists of ponderosa pine and juniper with a light grass understory. Under normal conditions, a fire in these fuels would burn quickly along the surface with occasional flare ups, particularly in areas with juniper concentrations. Torching of individual trees, increased flame lengths, and high rates of spread would be expected under the influence of drought and/or wind.

The agricultural fields currently dominating the river bottom and regions of the surrounding foothills become very dry during the summer months. These cured grasses can be very flammable, especially under extreme weather conditions, such as drought or wind. In the event of an uncontrolled wildfire, these light fuels would tend to support very fast moving, yet lower intensity fires. Modification of the vegetation around structures can be done quickly with available farm equipment and is usually effective in controlling wildfire.

Ignition Profile

Both natural and human caused ignitions occur around the City of Billings. The community center is more prone to human caused ignitions than lightning strikes due to the flat topography and agricultural development; however, lightning strikes occur fairly frequently in the rangeland and forestlands throughout the county. Annual field burning, trains, debris fires, and vehicle use are common potential ignition sources. Stubble fires seldom escape landowner's boundaries; however, there are occasional incidents. These fires are generally easily suppressed by modifying the vegetation and homes are rarely threatened.

Vehicle use on- and off-road is also a significant source of ignitions. Not only do sparks from vehicles ignite fuels along roadways, but fires are also commonly started by vehicles driving through dry fields or on unimproved trails. Grain trucks, ATV's, and pick ups are used regularly in farming operations.

4.4.2.1.2 Ingress-Egress

There are several arterials traveling to and from Billings including Interstate 90, Interstate 94, U.S. Route 87, U.S. Route 212, U.S. Route 312, and State Route 3. All of these highways are bordered by rangeland fuels. Many of the rural subdivisions are accessed off secondary routes or gravel roads; however, most of these are also well maintained, two-way routes.

The Hillcrest community is accessed via the Hillcrest Road off of State Route 416 (Blue Creek Road). This is a gravel road with enough room for two vehicles to pass easily. State Route 416, known as the Blue Creek Road, accesses several subdivisions in the Blue Creek area including Briarwood Estates. Both the Hillcrest Road and Blue Creek Road are bordered by manicured yards, rangeland fuels, or agricultural fields.

The Rehberg Ranch Estates is accessed from the Rod and Gun Club Road off of State Route 3. Both routes are paved with agricultural fields abutting both sides. There is only one designated access point to the entire subdivision; however, an emergency only access road has been identified on the far northwest end. Currently, it is not maintained, but would likely serve its purpose in an emergency situation.

The Lone Eagle Subdivision is also located directly off of State Route 3 on Lone Eagle Road. Lone Eagle Road is a well maintained paved road that winds through the subdivision with several short spurs accessing homes. Neither Lone Eagle Road nor any of the spurs provide a thru access back to the highway, which not only decreases the safety of residents, but also inhibits the ability of emergency personnel to safely respond. Furthermore, a significant number of personal driveways are gated making access to structures by fire suppression equipment much more difficult and time consuming.

4.4.2.1.3 Infrastructure

The City of Billings is on a municipal water system; however, many of the outlying subdivisions rely on personal or multiple home well systems and water storage tanks.

There is a multitude of high tension transmission lines in the Billings area. Many of these power line corridors extend to other Yellowstone County communities traveling over expansive rangeland fuels. Sparks caused by downed lines, transformer malfunctions, or arcing could easily ignite the receptive rangeland fuel bed below.

There are two active refineries in Billings. The ConocoPhillips and the ExxonMobil, both of which maintain their own security and fire suppression capabilities specific to the needs of the company.

4.4.2.1.4 Fire Protection

The Billings Fire Department is responsible for structural and wildland protection in the City of Billings, the Billings Urban Fire Service Area (BUFSA), Briarwood Subdivision, and Rehberg Ranch Estates. The Blue Creek Volunteer Fire Department provides structural and wildland fire protection to the residents of the Blue Creek Area and the Hillcrest Subdivision. The Montana Department of Natural Resources and Conservation and the Bureau of Land Management will respond to wildland fires in Yellowstone County upon request.

4.4.2.1.5 Community Assessment

Residents within the urban community of Billings have a low risk of being directly affected by wildland fire. Homes located in the more rural subdivisions scattered around the outskirts of the city have an increased risk of fire, particularly those surrounded by or abutting timber type fuels. Developments such as Hillcrest and the west side of Blue Creek Road abut lower risk agricultural fields or rangeland. Nevertheless, landowners should still take precautions to safeguard their homes and families from fire. Creating a green defensible space around structures will help insure that a rapidly spreading grass fire will not threaten their property or lives.

Those subdivisions built near or within higher risk rangeland fuels or wooded areas have an increased risk of wildland fire. Homes located in the Lone Eagle, Rehberg Ranch Estates, and on the east side of Blue Creek Road are surrounded by fuels that have a moderate wildland fire risk due to the higher density of sagebrush, juniper, or timber. The Lone Eagle Subdivision has additional risk due to the lack of a thru access road and restricted driveways.

It is imperative that homeowners, particularly in higher risk areas, implement fire mitigation measures to protect their structures and families prior to a wildland fire event. As the city grows, more and more homes will be built in the wildland urban interface. It will become increasingly important to educate landowners of the potential fire risk. The receptive nature of the rangeland fuels in Yellowstone County and their natural tendency towards frequent burn intervals increases the likelihood of a fire start. Most homeowners maintain an adequate defensible space around structures by watering their yards or mowing grass and weeds; however, there is still a need to inform others of the potential danger.

4.4.2.1.6 Mitigation Activities

Effective mitigation strategies begin with public awareness campaigns designed to educate homeowners of the risks associated with living in a flammable environment. Residents of Yellowstone County must be made aware that home defensibility starts with the home. Once a fire has started and is moving toward a structure or other valued resources, the probability of that structure surviving is largely dependent on the structural and landscaping characteristics of the home. “Living with Fire, A Guide for the Homeowner” is an excellent tool for educating homeowners as to the steps to take in order to create an effective defensible space. Residents

of Billings and the surrounding area should be encouraged to work with local fire departments and fire management agencies within the county to complete individual home site evaluations. Home defensibility steps should be enacted based on the results of these evaluations.

Community defensible space projects can also help improve the safety of groups of homes. Rural subdivisions adjacent to wildland fuels can create fuel breaks along their perimeter that also increase the value of the homes in the community. Greenbelts or xeriscaped strips with a walking path not only provide a community defensible space, but they can potentially increase property values.

Also of vital importance is the accessibility of the home to emergency apparatus. If the home cannot be protected safely, firefighting resources will not jeopardize lives to protect a structure. Thus, the fate of the home will largely be determined by homeowner actions prior to the event. In many cases, homes' survivability can be greatly enhanced by following a few simple guidelines to increase accessibility such as widening or mowing driveways and creating a turnaround area for large vehicles. Roads and driveways accessing homes should be regularly maintained with the edges mowed to prevent an accidental ignition. Homeowners with structures located on dead end roads or driveways with no alternative escape route should construct loop roads where possible or establish gates in fencing to allow for an emergency evacuation if the primary escape route becomes impassable.

New developments in the wildland urban interface should be regulated by building codes that protect residents from the effects of wildfire. Insuring that there are adequate water resources available for emergency use and that new roads and driveways are accessible to emergency apparatus will become increasingly important as the community expands.

4.4.2.2 Laurel

The community of Laurel lies in the Yellowstone River valley southwest of Billings west of the junction of the Clarks Fork of the Yellowstone River and north of the main Yellowstone River channel. The community itself is surrounded primarily by agricultural development and is nearly connected to Billings by residential growth. Across the Yellowstone River to the south, much of the native rangelands have been converted to agricultural land, but to the north the agricultural development gives way to rangelands just a few miles past the city limits.

Several rural housing developments have become established in the rangelands north of Laurel. Included in this assessment is the *Buffalo Trail Subdivision, Clappers Flat, Canyon Creek Road area, and Duck Creek area.*

The Buffalo Trail area consists of several housing projects along State Route 401 (Buffalo Trail Road) near the Yellowstone-Stillwater County line. Buffalo Trail Road travels through a relatively wide coulee that is made up of rangeland grass with patches of sagebrush and juniper. Stunted ponderosa pine exists sporadically, but is somewhat denser near the upper slopes. The south side of highway is predominantly newer homes extending from the roadside up a gentle slope to a large plateau where 50 to 60 large lots have been established for construction. The north side of Buffalo Trail Road is a mixture of old and new homes. Structures near the road generally sit on fairly large, open lots, but as the steepness of the coulee wall increases, homes are more closely intermixed with the rangeland/forestland fuels.

The Canyon Creek Road area, which branches off the Buffalo Trail Road just south of the Buffalo Trail Subdivision. The Canyon Creek Road area follows the Canyon Creek drainage west towards the county line. There are several homes in the bottom of this little valley, most of which graze livestock and are relatively spread out.

The Clappers Flat area is a large plateau lying northwest of Laurel and is characterized by rangeland fuels with clumps of juniper and stunted ponderosa pine along the edges. Homes are typically built on large lots intermingled with the semi-wooded areas.

The Duck Creek Area refers to the scattered homes along Duck Creek Road south of the Yellowstone River about half way between Billings and Laurel. These are predominately large lots surrounded by agricultural fields, pasture, or rangeland. Many of the homes on the north end of this community are bordered by the riparian fuels associated with either the Yellowstone River or Duck Creek. The more remote homes towards the south end of Duck Creek Road are typically larger landowners surrounded by farm fields.

4.4.2.2.1 Fire Potential

Fuels Assessment

The native rangeland ecosystem around the outskirts of the community and abutting several of the rural subdivisions consist of short to medium length grasses with scattered clumps of sagebrush and juniper. This type of fuel is typically very flashy. Fires spread quickly, particularly upslope, but tend to burn at lower intensities. In some areas, the lack of a consistent fuel bed may slow the spread of fire. The rangelands of eastern Montana, including Yellowstone County, historically burned at frequent intervals. 5 to 25 year return intervals helped maintain the grassland ecosystem by limiting the establishment of slower growing species.

The partially timbered areas near Laurel are almost exclusively made up of ponderosa pine. Stringers and patches of trees typically exist in the coulees and canyons where moisture is more readily available. In most cases, fires in this type of timber will stay on the surface with only occasional torching of individual trees or clumps of trees, particularly where juniper offers a ladder fuel. Under extreme conditions, such as drought or high winds, fires will spread very rapidly with larger flame lengths.

The agricultural fields currently dominating the river bottom and regions of the surrounding foothills become very dry during the summer months. These cured grasses can be very flammable, especially under extreme weather conditions, such as drought or wind. In the event of an uncontrolled wildfire, these light fuels would tend to support very fast moving, yet lower intensity fires. Modification of the vegetation around structures can be done quickly with available farm equipment and is usually effective in controlling wildfire.

Ignition Profile

Both natural and human caused ignitions occur around the vicinity of Laurel. The community center is more prone to human caused ignitions than lightning strikes due to the flat topography and agricultural development; however, lightning strikes occur fairly frequently in the rangeland and forestlands throughout the county. Annual field burning, debris fires, and vehicle use are common potential ignition sources. Stubble fires seldom escape landowner's boundaries; however, there are a few incidences each year. These fires are generally easily suppressed by modifying the vegetation and homes are rarely threatened.

Vehicle use on- and off-road is also a significant source of ignitions. Not only do sparks from vehicles ignite fuels along roadways, but fires are also commonly started by vehicles driving through dry fields or on unimproved trails. Grain trucks, ATV's, and pick ups are used regularly in farming operations.

4.4.2.2.2 Ingress-Egress

The primary access into Laurel is via Interstate 90 from the east or west; however, there are several other main transportation routes coming into the area including U.S. Highway 310/212 and State Route 532. Most of the rural housing is accessed from gravel roads branching off of these primary routes.

Buffalo Trail Road provides the main access into the Buffalo Trail Subdivision. This two lane highway abuts rangeland fuels and provides an escape route out of both ends of the coulee. The Mountain View Road off of Buffalo Trail Road is primary access route for homes on the north side of the road. Mountain View is a graveled loop road; however, it becomes very narrow near the top and it is not well maintained. Potholes and severe washboards may hinder the speed of emergency response. There are several entrances to groups of homes on the south side of the road. These are typically graveled roads that loop through the subdivision. Roads in the Valley Canyon area start out as two-lane routes, but turn to one-lane further south. There are also numerous unmarked spur roads and long driveways extending off of these access routes making navigation through the area somewhat difficult. Better signing of the roads and house numbers at the end of driveways would help reduce confusion for emergency response personnel and for residents during an evacuation. The Medicine Man Road provides access to a large group of homes; however, this route dead ends at the last house. The lack of an alternate escape route significantly decreases the safety of residents in an emergency situation.

Homes in the Canyon Creek area are accessed via the Canyon Creek Road off of the Buffalo Trail Road. This is a two lane, graveled road that extends past the county line to the west. For the most part, this route is well maintained; however, there are a few rough spots that may slow emergency response.

Clapper Flats is reached by following Clapper Flats Road off of the Buffalo Trail/Laurel Road. This is also a two lane, graveled road that is kept in good condition. Most of the homes in this area are accessed by Red and King Gulch Road, which dead ends on the south side of the development. This road starts out as rough, but graveled two lane route; however, it tapers into a one lane dirt road towards the end. There are several dead end spur roads and driveways branching from the Red and King Gulch Road, none of which seem to have alternate escape routes. The safety of residents in the Clappers Flat area would be drastically improved with the development of a thru road.

The Duck Creek Area can be accessed from both Laurel and Billings. From Laurel, Theil Road, which turns into River Road along the south bank of the Yellowstone River provides the most direct access. From Billings, Duck Creek is reached by following Hillcrest Road out of the Blue Creek area. Thiel Road and River Road are both two-way paved routes while Hillcrest Road is mostly a well maintained gravel road. Duck Creek Road is also a well maintained graveled route that abuts mostly agricultural land with some isolated sections of rangeland. Near where Duck Creek Road connects to River Road, the actual Duck Creek parallels the roadway. The denser riparian fuels in the creek bed could potentially cause access problems from this end in the event of a fire in the area.

4.4.2.2.3 Infrastructure

The City of Laurel has a municipal water system for residents within the city limits. Rural subdivisions and individual homes rely on personal or multiple home well systems and storage tanks.

There are several high tension power lines crisscrossing the Laurel area, most of which travel over surrounding rangeland fuels. These fuels are highly receptive to sparks originating from the downed lines, arcing, or malfunctioning transformers.

A Cenex Harvest States oil refinery is located within the City of Laurel. This is a large facility that maintains its own security and fire suppression programs.

4.4.2.2.4 Fire Protection

The Laurel Volunteer Fire Department is responsible for structural protection for the community of Laurel, Fire District #5, Fire District #7, and the Laurel Urban Fire Service Area. Many of the more rural subdivisions north of Laurel including Buffalo Trails, Clappers Flat, and the Canyon Creek Road area receive structural protection from the Molt Volunteer Fire Department. The Montana Department of Natural Resources and Conservation and the Bureau of Land Management respond to wildland fires in the area as necessary.

4.4.2.2.5 Community Assessment

Commercial and residential development is expanding along U.S. Highway 310/212 to the south and along Thiel Road and River Road, which parallels the Yellowstone River. There are a few remaining patches of native rangelands; however, this area is primarily used for the production of agricultural products. The banks of both the Yellowstone River and the Clarks Fork of the Yellowstone River are lined with dense riparian vegetation that could support an intense fire. Homes directly adjacent to these fuels could be at high risk; however, the development of irrigated lawns and crop fields next to the channels will help keep the fire contained.

Residents within the urban community of Laurel have a low risk of being directly affected by wildland fire. Subdivisions built near or within higher risk rangeland fuels or wooded areas have an increased risk of wildland fire. Homes located in the Buffalo Trail area, Canyon Creek drainage, Duck Creek, and near Clappers Flat are surrounded by fuels that have a moderate to high wildland fire risk due to the higher density of sagebrush, juniper, and timber.

The Buffalo Trails Subdivision has moderate risk of wildfire. Many homes have created an adequate defensible space; however, there are several homes that have juniper and ponderosa pine directly abutting or overhanging structures. Furthermore, many of these homes are built along the upper slopes of the coulee. Fires originating near the road could spread upslope very rapidly giving residents little time to escape. Road and house number signage, as well as road widening and maintenance would significantly improve the safety of residents in the Buffalo Trails Subdivision.

Canyon Creek is a relatively large drainage with thick grasses in the valley bottom and ponderosa pine and juniper lining the rocky slopes. Dense riparian vegetation, including large black cottonwood trees, marks the path of the creek. Homes in this area have primarily been built in the valley bottom with small agricultural crops or livestock pasture surrounding home sites. For the most part, landowners have created defensible space around structures. Homes built closer to the timber may benefit from clearing brush and other ladder fuels from the understory and pruning trees within at least 50 to 100 feet.

Homes in the Clappers Flats area have a moderate to high risk of experiencing a wildfire. Not only are many of the houses intermixed with timber and rangeland fuels, but access into the area is very poor. Ponderosa pine, juniper, and sagebrush commonly abut homes with small or non-existent green yard space creating a continuous fuel bed with the surrounding rangelands. Additionally, not only does the main access route dead end, there are several unmarked spur roads that dead end at home sites. Homeowner education regarding the value of a defensible

space, especially in areas with hazardous fuels would help increase community awareness of the wildfire risk. The safety of residents and emergency response personnel would be improved by road and house number signing as well as construction of a thru road to provide an alternate escape route.

Most of the fuels in the Duck Creek area consist of developed croplands except for the denser riparian vegetation associated with the Yellowstone River and the Duck Creek drainage. Homes along these waterways should be especially aware of the potential for a wildland fire to be carried within the continuous fuel bed of the drainages. Insuring that fuels between the riparian fuels and structures are kept green and free of debris will help decrease the fire risk. Homes surrounded by agricultural fields have lower fire risk; however, the potential for an escaped stubble fire to threaten their structures exists.

It is imperative that homeowners, particularly in higher risk areas, implement fire mitigation measures to protect their structures and families prior to a wildland fire event. As the community grows, more and more homes will be built in the wildland urban interface. It will become increasingly important to educate landowners of the potential fire risk. The receptive nature of the rangeland fuels in Yellowstone County and their natural tendency towards frequent burn intervals increases the likelihood of a fire start. Most homeowners maintain an adequate defensible space around structures by watering their yards or mowing grass and weeds; however, there is still a need to inform others of the potential danger.

4.4.2.2.6 Mitigation Activities

Effective mitigation strategies begin with public awareness campaigns designed to educate homeowners of the risks associated with living in a flammable environment. Residents of Yellowstone County must be made aware that home defensibility starts with the home. Once a fire has started and is moving toward a structure or other valued resources, the probability of that structure surviving is largely dependent on the structural and landscaping characteristics of the home. “Living with Fire, A Guide for the Homeowner” is an excellent tool for educating homeowners as to the steps to take in order to create an effective defensible space. Residents of Laurel and the surrounding area should be encouraged to work with local fire departments and fire management agencies within the county to complete individual home site evaluations. Home defensibility steps should be enacted based on the results of these evaluations.

Community defensible space projects can also help improve the safety of groups of homes. Rural subdivisions adjacent to wildland fuels can create fuel breaks along their perimeter that also increase the value of the homes in the community. Greenbelts or xeriscaped strips with a walking path not only provide a community defensible space, but they can potentially increase property values.

Also of vital importance is the accessibility of the home to emergency apparatus. If the home cannot be protected safely, firefighting resources will not jeopardize lives to protect a structure. Thus, the fate of the home will largely be determined by homeowner actions prior to the event. In many cases, homes' survivability can be greatly enhanced by following a few simple guidelines to increase accessibility such as widening or mowing driveways and creating a turnaround area for large vehicles. Roads and driveways accessing homes should be regularly maintained with the edges mowed to prevent an accidental ignition. Homeowners with structures located on dead end roads or driveways with no alternative escape route should construct loop roads where possible or establish gates in fencing to allow for an emergency evacuation if the primary escape route becomes impassable.

New developments in the wildland urban interface should be regulated by building codes that protect residents from the effects of wildfire. Insuring that there are adequate water resources available for emergency use and that new roads and driveways are accessible to emergency apparatus will become increasingly important as the community expands.

4.4.2.3 Broadview and Acton

Broadview and Acton are small rural communities located along State Route 3. Broadview lies in the northwestern most corner of the county and Acton sits about 15 miles southeast of Broadview. Development in these communities has mostly occurred in tight clusters around the city centers. This part of Yellowstone County is almost entirely grass and sagebrush rangelands with the exception of a couple small coulees and a few sparse stringers of ponderosa pine on a low lying ridge east of Acton. Patches of farm and pasture ground intermittently break up the landscape, but due to the lack of water available, these fields are not extensive.

4.4.2.3.1 Fire Potential

Fuels Assessment

The native rangeland ecosystem surrounding these communities consists of short to medium length grasses with scattered clumps of sagebrush and juniper. This type of fuel is typically very flashy. Fires spread quickly, but tend to burn at lower intensities. In some areas, the lack of a consistent fuel bed may slow the spread of fire. The rangelands of eastern Montana, including Yellowstone County, historically burned at frequent intervals. 5 to 25 year return intervals helped maintain the grassland ecosystem by limiting the establishment of slower growing species.

There is a small sparse stand of ponderosa pine near some homes east of Acton. Under normal conditions, a fire in these fuels would tend to spread quickly along the surface with only occasional torching of individual trees or clumps of trees. Larger flame lengths and small crown fires could be expected under the influence of wind and severe drought.

The agricultural fields and pasture ground near Broadview and Acton become very dry during the summer months. These cured grasses can be very flammable, especially under extreme weather conditions, such as drought or wind. In the event of an uncontrolled wildfire, these light fuels would tend to support very fast moving, yet lower intensity fires. Modification of the vegetation around structures can be done quickly with available farm equipment and is usually effective in controlling wildfire.

Ignition Profile

Both natural and human caused ignitions occur around both Broadview and Acton. The community center is more prone to human caused ignitions than lightning strikes due to the flat topography and more abundant ignition sources; however, lightning strikes occur fairly frequently in the rangeland and forestlands throughout the county. Annual field burning, debris fires, and vehicle use are common potential ignition sources. Stubble fires seldom escape landowner's boundaries; however, there are a few incidences each year. These fires are generally easily suppressed by modifying the vegetation and homes are rarely threatened.

Vehicle use on- and off-road is also a significant source of ignitions. Not only do sparks from vehicles ignite fuels along roadways, but fires are also commonly started by vehicles driving through dry fields or on unimproved trails. Grain trucks, ATV's, and pick ups are used regularly in farming operations.

4.4.2.3.2 Ingress-Egress

Both Broadview and Acton are accessed by State Route 3. This is the only paved roadway in the area. The main secondary roads such as Buffalo Trail Road heading south along the county line and the Acton-Shepherd Road are typically two-lane graveled routes.

4.4.2.3.3 Infrastructure

There are several high tension power lines crisscrossing heading to and from a substation near Broadview. Sparks or downed lines could easily start a fire in dry, flashy rangeland fuels.

The town of Broadview has a municipal water system with a storage tank on the west side of the community. The surrounding area as well as the community of Acton relies on personal or multiple home well systems and storage tanks.

4.4.2.3.4 Fire Protection

The Broadview Volunteer Fire Department is responsible for wildland fire protection within Broadview Fire District #3. The Montana Department of Natural Resources and Conservation and the Bureau of Land Management respond to wildland fires in this area as necessary.

4.4.2.3.5 Community Assessment

The communities of Broadview and Acton are at low to moderate risk of experiencing a wildland fire. Fires in the rangeland fuels surrounding these areas are relatively common; however, under normal conditions they can be controlled by modifying the vegetation and creating a fuel break with the available farm implements. East of Acton there is a scattered group of homes along the Shepherd-Acton Road. Some of these structures abut a lightly timbered slope. This stand of timber is relatively isolated; however, homes with trees adjacent to or overhanging roofs may have an increased risk. Pruning nearby trees and removing any potential ladder fuels will help reduce the risk to the structure. Drought and/or high winds can lead to a very fast spreading fire with large flame lengths that can be much more difficult to control; therefore, it is imperative that homeowners implement fire mitigation measures to protect their structures and families prior to a wildland fire event.

The receptive nature of the rangeland fuels in Yellowstone County and their natural tendency towards frequent burn intervals increases the likelihood of a fire start. Most homeowners maintain an adequate defensible space around structures by watering their yards or mowing grass and weeds; however, there is still a need to inform others of the potential danger.

4.4.2.3.6 Mitigation Activities

Effective mitigation strategies begin with public awareness campaigns designed to educate homeowners of the risks associated with living in a flammable environment. Residents of Yellowstone County must be made aware that home defensibility starts with the home. Once a fire has started and is moving toward a structure or other valued resources, the probability of that structure surviving is largely dependent on the structural and landscaping characteristics of the home. “Living with Fire, A Guide for the Homeowner” is an excellent tool for educating homeowners as to the steps to take in order to create an effective defensible space. Residents of Broadview, Acton, and the surrounding area should be encouraged to work with local fire departments and fire management agencies within the county to complete individual home site

evaluations. Home defensibility steps should be enacted based on the results of these evaluations.

Also of vital importance is the accessibility of the home to emergency apparatus. If the home cannot be protected safely, firefighting resources will not jeopardize lives to protect a structure. Thus, the fate of the home will largely be determined by homeowner actions prior to the event. In many cases, homes' survivability can be greatly enhanced by following a few simple guidelines to increase accessibility such as widening or mowing driveways and creating a turnaround area for large vehicles.

4.4.2.4 Custer

The small rural community of Custer is located along Interstate 94 near the Yellowstone-Treasure County line. Most of the structures associated with the community lie on the south side of the highway; however, there is several farming and ranching enterprises scattered around the area. There is a low-lying ridge south of town that is partially timbered, but the agricultural development on both the bottom and top side keep the fire danger relatively low. Grass and sagebrush rangelands extend past the crop fields to the north.

4.4.2.4.1 Fire Potential

Fuels Assessment

The native rangeland ecosystem surrounding Custer consists of short to medium length grasses with scattered clumps of sagebrush and juniper. This type of fuel is typically very flashy. Fires spread quickly, but tend to burn at lower intensities. In some areas, the lack of a consistent fuel bed may slow the spread of fire. The rangelands of eastern Montana, including Yellowstone County, historically burned at frequent intervals. 5 to 25 year return intervals helped maintain the grassland ecosystem by limiting the establishment of slower growing species.

There is a small stand of ponderosa pine on a ridge bordering the south side of the community. This stand is completely surrounded by agricultural crops; thus, the fire danger associated with the increased fuels is minimal. Under normal conditions, a fire in this type of open timber would tend to spread quickly along the surface with only occasional torching of individual trees or clumps of trees. Larger flame lengths and small crown fires could be expected under the influence of wind and severe drought.

The agricultural fields and pasture ground near Custer becomes very dry during the summer months. These cured grasses can be very flammable, especially under extreme weather conditions, such as drought or wind. In the event of an uncontrolled wildfire, these light fuels would tend to support very fast moving, yet lower intensity fires. Modification of the vegetation around structures can be done quickly with available farm equipment and is usually effective in controlling wildfire.

Ignition Profile

Both natural and human caused ignitions occur in the Custer area. The community center is more prone to human caused ignitions than lightning strikes due to the flat topography and abundant ignition sources; however, lightning strikes occur fairly frequently in the rangeland and forestlands throughout the county. Annual field burning, debris fires, and vehicle use are common potential ignition sources. Stubble fires seldom escape landowner's boundaries; however, there are a few incidences each year. These fires are generally easily suppressed by modifying the vegetation and homes are rarely threatened.

Vehicle use on- and off-road is also a significant source of ignitions. Not only do sparks from vehicles ignite fuels along roadways, but fires are also commonly started by vehicles driving through dry fields or on unimproved trails. Grain trucks, ATV's, and pick ups are used regularly in farming operations.

4.4.2.4.2 Ingress-Egress

The primary access into Custer is from Interstate 94 from either the east or the west. State Route 47 is also a paved access route coming from Hardin to the south. Both of these major travel corridors are bordered by rangeland or agricultural type fuels. State Route 310 and the Custer-Pine View Road are graveled routes that could provide additional escape routes. Both of these roadways travel north through the vastly unpopulated rangelands of the northeastern region of Yellowstone County.

4.4.2.4.3 Infrastructure

The community of Custer relies on personal or multiple home well systems.

4.4.2.4.4 Fire Protection

The Custer Volunteer Fire Department is responsible for structural and wildland fire protection in Custer and the surrounding area. The Montana Department of Natural Resources and Conservation provide wildland fire protection throughout the County as necessary.

4.4.2.4.5 Community Assessment

The community of Custer is at low to moderate risk of experiencing a wildland fire. Fires in the rangeland fuels surrounding these areas are relatively common; however, under normal conditions they can be controlled by modifying the vegetation and creating a fuel break with the available farm implements. Drought and/or high winds can lead to a very fast spreading fire with large flame lengths that can be much more difficult to control; therefore, it is imperative that homeowners implement fire mitigation measures to protect their structures and families prior to a wildland fire event.

The receptive nature of the rangeland fuels in Yellowstone County and their natural tendency towards frequent burn intervals increases the likelihood of a fire start. Most homeowners maintain an adequate defensible space around structures by watering their yards or mowing grass and weeds; however, there is still a need to inform others of the potential danger.

4.4.2.4.6 Mitigation Activities

Effective mitigation strategies begin with public awareness campaigns designed to educate homeowners of the risks associated with living in a flammable environment. Residents of Yellowstone County must be made aware that home defensibility starts with the home. Once a fire has started and is moving toward a structure or other valued resources, the probability of that structure surviving is largely dependent on the structural and landscaping characteristics of the home. “Living with Fire, A Guide for the Homeowner” is an excellent tool for educating homeowners as to the steps to take in order to create an effective defensible space. Residents of Custer and the surrounding area should be encouraged to work with local fire departments and fire management agencies within the county to complete individual home site evaluations. Home defensibility steps should be enacted based on the results of these evaluations.

Also of vital importance is the accessibility of the home to emergency apparatus. If the home cannot be protected safely, firefighting resources will not jeopardize lives to protect a structure. Thus, the fate of the home will largely be determined by homeowner actions prior to the event. In many cases, homes' survivability can be greatly enhanced by following a few simple guidelines to increase accessibility such as widening or mowing driveways and creating a turnaround area for large vehicles.

4.4.2.5 Huntley

Huntley is a small agricultural community that sits just off of Interstate 94 approximately 7 miles east of Billings. The city center and most of the residential housing is located within the Yellowstone River valley. The valley bottom has been developed for agricultural use, which is fairly continuous to the north towards Shepherd and east towards Worden.

There are also numerous homes and ranches in the Pryor Creek area, which is directly south of the Huntley city center. Pryor Creek is a small drainage that runs through a relatively wide valley with steep slopes rising on both sides. The Pryor Creek area consists of agricultural and residential development along the valley floor with native rangeland fuels dominating the steeper slopes.

4.4.2.5.1 Fire Potential

Fuels Assessment

The native rangeland ecosystem around the outskirts of the community and in the Pryor Creek area consist of short to medium length grasses with scattered clumps of sagebrush and juniper. This type of fuel is typically very flashy. Fires spread quickly, particularly upslope, but tend to burn at lower intensities. In some areas, the lack of a consistent fuel bed may slow the spread of fire. The rangelands of eastern Montana, including Yellowstone County, historically burned at frequent intervals. 5 to 25 year return intervals helped maintain the grassland ecosystem by limiting the establishment of slower growing species.

Riparian vegetation along the Yellowstone River and in some of the other major drainages, such as Pryor Creek, is relatively dense. Due to the availability of moisture, thick grasses as well as brush, weeds, and other forbs grow very well. Black cottonwoods and other trees are also common along the river and creek beds. During, the summer, these fuels become dry and very receptive to an ignition. The consistent fuel bed afforded by the thicker fuels in the riparian zone could easily carry an uncontrolled fire from an ignition point in the rangelands to populated areas. This type of fire is somewhat difficult to suppress due to the lack of access points and the density of the vegetation.

The agricultural fields and pasture ground currently dominating the river bottom and much of the valley floor in the Pryor Creek drainage become very dry during the summer months. These cured grasses can be very flammable, especially under extreme weather conditions, such as drought or wind. In the event of an uncontrolled wildfire, these light fuels would tend to support very fast moving, yet lower intensity fires. Modification of the vegetation around structures can be done quickly with available farm equipment and is usually effective in controlling wildfire.

Ignition Profile

Both natural and human caused ignitions occur around the community of Huntley. The community center is more prone to human caused ignitions than lightning strikes due to the flat topography and agricultural development; however, lightning strikes occur fairly frequently in the rangeland throughout the county. Annual field burning, debris fires, and vehicle use are

common potential ignition sources. Stubble fires seldom escape landowner's boundaries; however, there are a few incidences each year. These fires are generally easily suppressed by modifying the vegetation and homes are rarely threatened.

Vehicle use on- and off-road is also a significant source of ignitions. Not only do sparks from vehicles ignite fuels along roadways, but fires are also commonly started by vehicles driving through dry fields or on unimproved trails. Grain trucks, ATV's, and pick ups are used regularly in farming operations.

4.4.2.5.2 Ingress-Egress

The primary access into Huntley is provided by Interstate 94; however, State Routes 568 and 312 are also paved highways that offer good ingress and egress to the city center. These roads are predominantly bordered by agricultural development.

4.4.2.5.3 Infrastructure

The community of Huntley and the surrounding area relies on a municipal water system as well as personal or multiple home wells.

4.4.2.5.4 Fire Protection

The Worden Volunteer Fire Department responds to structural and wildland fires in the Huntley area and Huntley Project Fire Service Area. Wildland fire protection is provided by the Montana Department of Natural Resources and Conservation and the Bureau of Land Management as necessary.

4.4.2.5.5 Community Assessment

Homes located in the agriculturally-based community of Huntley have low to moderate risk of wildfire. Fires originating in the crop fields are usually suppressed quickly by creating fuel breaks with the available farming equipment. Fires in the rangeland fuels in the surrounding areas and particularly on the slopes of the Pryor Creek drainage are relatively common. Under normal conditions this type of fire can be controlled by relatively quickly. Drought and/or high winds can lead to very fast spreading fires with large flame lengths that can be much more difficult to control; therefore, it is imperative that homeowners implement fire mitigation measures to protect their structures and families prior to a wildland fire event. Homeowners adjacent to the riparian zones of the Yellowstone River, Pryor Creek, or other drainages should be aware of the possibility of a fire within the watershed. Keeping structures an adequate distance from these fuels and maintaining a clean and green yard will help insure the safety of their property.

It is imperative that homeowners, particularly in higher risk areas, implement fire mitigation measures to protect their structures and families prior to a wildland fire event. As the community grows, more and more homes will be built in the wildland urban interface. It will become increasingly important to educate landowners of the potential fire risk. The receptive nature of the rangeland fuels in Yellowstone County and their natural tendency towards frequent burn intervals increases the likelihood of a fire start. Most homeowners maintain an adequate defensible space around structures by watering their yards or mowing grass and weeds; however, there is still a need to inform others of the potential danger.

4.4.2.5.6 Mitigation Activities

Effective mitigation strategies begin with public awareness campaigns designed to educate homeowners of the risks associated with living in a flammable environment. Residents of Yellowstone County must be made aware that home defensibility starts with the home. Once a fire has started and is moving toward a structure or other valued resources, the probability of that structure surviving is largely dependent on the structural and landscaping characteristics of the home. “Living with Fire, A Guide for the Homeowner” is an excellent tool for educating homeowners as to the steps to take in order to create an effective defensible space. Residents of Huntley and the surrounding area should be encouraged to work with local fire departments and fire management agencies within the county to complete individual home site evaluations. Home defensibility steps should be enacted based on the results of these evaluations.

Also of vital importance is the accessibility of the home to emergency apparatus. If the home cannot be protected safely, firefighting resources will not jeopardize lives to protect a structure. Thus, the fate of the home will largely be determined by homeowner actions prior to the event. In many cases, homes' survivability can be greatly enhanced by following a few simple guidelines to increase accessibility such as widening or mowing driveways and creating a turnaround area for large vehicles.

New developments in the wildland urban interface should be regulated by building codes that protect residents from the effects of wildfire. Insuring that there are adequate water resources available for emergency use and that new roads and driveways are accessible to emergency apparatus will become increasingly important as the community expands.

4.4.2.6 Lockwood

Lockwood is a large unincorporated area on the southeast side of the city of Billings. The lower northern part of the area, near the Interstate, is comprised of residential subdivisions, commercial businesses, and large industry. This area has a municipal water system.

The upper area of the community has five notable wildland urban interface developments. These are *Yellowstone Trail, Pine Hills, Emerald Hills, High Trail, and Coburn Hills*. Each of these areas is characterized by a ponderosa pine overstory with juniper, sagebrush, and grasses in the understory. These urban interface areas have homes irregularly distributed on steep, narrow, winding roads. Many of the roads are unpaved. Driveways tend to be long and narrow without adequate turnarounds for large fire trucks. Water is extremely limited in these areas as well.

4.4.2.6.1 Fire Potential

Fuels Assessment

The native rangeland ecosystem around the outskirts of the city and abutting several of the rural subdivisions consist of short to medium length grasses with scattered clumps of sagebrush and juniper. This type of fuel is typically very flashy. Fires spread quickly, particularly upslope and tend to burn at higher intensities. In some areas, the lack of a consistent fuel bed may slow the spread of fire. The rangelands of eastern Montana, including Yellowstone County, historically burned at frequent intervals. 5 to 25 year return intervals helped maintain the grassland ecosystem by limiting the establishment of slower growing species.

Fires in the urban interface areas of Lockwood tend to spread quickly thru the light flashy fuels, which are generally continuous. Flame lengths can reach 15 feet or more in areas of high grass. Fires move rapidly, especially when pushed by upslope winds or in steep terrain. Fuels

have built up over the years as fires in these areas have been aggressively suppressed. Several years of drought have stressed the ponderosa pine stands and bark beetles have added to the mortality. Fires move easily from the ground to the trees due to the abundance of ladder fuels. Individual tree torching is common, which increases the potential for crown fires. There is also an increased likelihood of short and medium range spotting as a result of the excessive build up of flammable fuels.

Between Highway 87 East and Interstate 90 a mixed rangeland/forestland vegetation type abuts and intermixes with the Emerald Hills Subdivision. The overstory consists of ponderosa pine and juniper with a light grass understory. Under normal conditions, a fire in these fuels would burn quickly along the surface with occasional flare ups, particularly in areas with juniper concentrations. Torching of individual trees, increased flame lengths, and high rates of spread would be expected under the influence of drought and/or wind.

Ignition Profile

Both natural and human caused ignitions occur around the community of Lockwood. The community center and surrounding subdivisions are more prone to human caused ignitions than lightning strikes due to the flat topography and agricultural development; however, lightning strikes occur fairly frequently in the rangeland and forestlands throughout the county. Annual field burning, debris fires, and vehicle use are common potential ignition sources. Stubble fires seldom escape landowner's boundaries; however, there are a few incidences each year. These fires are generally easily suppressed by modifying the vegetation and homes are rarely threatened.

Vehicle use on- and off-road is also a significant source of ignitions. Not only do sparks from vehicles ignite fuels along roadways, but fires are also commonly started by vehicles driving through dry fields or on unimproved trails. Grain trucks, ATV's, and pick ups are used regularly in farming operations.

4.4.2.6.2 Ingress-Egress

Access to Yellowstone Trail and Pine Hills is from Old Hardin Road. The access route to High Trail Road and Coburn Hill Road is U.S. Highway 87 East. Roads in these areas are mainly gravel with the exception of Emerald Hills Drive and Coburn Road, which are paved. All roads are narrow two lane routes with steep, winding grades.

The most straight forward access into the Emerald Hills Subdivision is via the Old Hardin Road through the Lockwood area to Emerald Hills Road on the northeast side of the development. The main roadways through the subdivision are two-lane graveled routes; however, many of the secondary roads are one-lane dead ends. Dead end roads are typically signed; however, it would be helpful for emergency purposes if the thru roads were marked as potential escape routes. Additionally, there is no organized grid pattern to the road system; therefore, there are several winding corners, short grades, and Y-intersections. The road system makes for a hazardous situation under normal conditions, but would become particularly unsafe for emergency response vehicles and evacuees during a wildfire event. On the primary roads, escape routes are marked with (evacuation signs) provide by the Lockwood Fire District and Yellowstone County DES.

4.4.2.6.3 Infrastructure

High risk infrastructure in the wildland-urban interface area includes numerous cellular, radio, and television towers in all areas except Pine Hills. A large microwave tower is located off U.S.

Highway 87 East adjacent to the High Trail area. Overhead power lines are predominant in most of Yellowstone County.

The community of Lockwood and the surrounding rural subdivisions rely on a municipal water system as well as personal or multiple home wells and storage tanks.

Low risk infrastructure includes the ExxonMobil Refinery, several chemical plants, and other large industry on the north end of the community.

4.4.2.6.4 Fire Protection

Both structural fire protection and wildland fire protection is provided by the Lockwood Fire District. The Lockwood Fire District is manned 24/7 with career firefighters supplemented with volunteer firefighters.

4.4.2.6.5 Community Assessment

The Emerald Hills area of Lockwood has the highest risk of the five areas in the urban interface due to the higher density of homes. Many homes have trees and juniper shrubs next to or overhanging structures. A number of homeowners have built next to steep slopes with continuous fuels directly abutting their homes. So far, only a few homeowners in the Emerald Hills Subdivision have taken proactive steps, such as clearing a defensible space, to protect their homes from wildfire.

There is no fuel break around the perimeter of these higher risk communities; therefore, a fire could easily spread north out of the partially forested rangelands into the residential areas. Further exacerbating this situation is the poor road systems and narrow driveways that make access to homes by emergency response equipment much more difficult and potentially unsafe. Additionally, many homes were constructed with flammable siding or decking and have propane tanks sitting next to or very near structures. Other potential hazards for firefighters include narrow roads, long driveways, lack of available water, and overhead power lines.

It is imperative that homeowners implement fire mitigation measures to protect their structures and families prior to a wildland fire event. Lockwood is seeing continued growth in homes built in these interface areas. Education of homeowners to the potential fire risk will increase the likelihood that additional properties will have the defensible space needed to make their homes safe and provide for a safer environment for firefighters responding to these subdivisions.

4.4.2.6.6 Mitigation Activities

Effective mitigation strategies begin with public awareness campaigns designed to educate homeowners of the risks associated with living in a flammable environment. Residents of Yellowstone County must be made aware that home defensibility starts with the home. Once a fire has started and is moving toward a structure or other valued resources, the probability of that structure surviving is largely dependent on the structural and landscaping characteristics of the home. “Living with Fire, A Guide for the Homeowner” is an excellent tool for educating homeowners as to the steps to take in order to create an effective defensible space. Residents of Lockwood and the surrounding area should be encouraged to work with local fire departments and fire management agencies within the county to complete individual home site evaluations. Home defensibility steps should be enacted based on the results of these evaluations.

Community defensible space projects can also help improve the safety of groups of homes. Rural subdivisions adjacent to wildland fuels can create fuel breaks along their perimeter that

also increase the value of the homes in the community. Greenbelts or xeriscaped strips with a walking path not only provide a community defensible space, but they can potentially increase property values.

Also of vital importance is the accessibility of the home to emergency apparatus. If the home cannot be protected safely, firefighting resources will not jeopardize lives to protect a structure. Thus, the fate of the home will largely be determined by homeowner actions prior to the event. In many cases, homes' survivability can be greatly enhanced by following a few simple guidelines to increase accessibility such as widening or mowing driveways and creating a turnaround area for large vehicles. Roads and driveways accessing homes should be regularly maintained with the edges mowed to prevent an accidental ignition. Homeowners with structures located on dead end roads or driveways with no alternative escape route should construct loop roads where possible or establish gates in fencing to allow for an emergency evacuation if the primary escape route becomes impassable.

New developments in the wildland urban interface should be regulated by building codes that protect residents from the effects of wildfire. Insuring that there are adequate water resources available for emergency use and that new roads and driveways are accessible to emergency apparatus will become increasingly important as the community expands.

4.4.2.7 Shepherd

Shepherd is a small agricultural community located approximately four miles northwest of Huntley and about two miles west of the Yellowstone River. There is a small city center; however, most of the homes in the area are scattered throughout the area. There is also a relatively large subdivision, Pleasant Hollow, which sits on a plateau north of town. Homes in this area are spread out on large lots usually with horses or other livestock grazing in adjacent pastures. Undeveloped lots and the surrounding area are typically native rangeland fuels consisting of medium length grasses and scattered clumps of sagebrush and juniper. Stringers and small stands of ponderosa pine are also common on the plateau and extending in a northeasterly direction.

The Cedar Ridge subdivision is located about 11 miles northwest of Shepherd on U.S. Highway 87. Homes in this area are typically situated on big lots with private driveways. This area is very rural with native rangeland fuels and stringers of ponderosa pine between lots and completely surrounding the development.

4.4.2.7.1 Fire Potential

Fuels Assessment

The native rangeland ecosystem around the outskirts of the community and surrounding both subdivisions consist of short to medium length grasses with scattered clumps of sagebrush and juniper. This type of fuel is typically very flashy. Fires spread quickly, particularly upslope, but tend to burn at lower intensities. In some areas, the lack of a consistent fuel bed may slow the spread of fire. The rangelands of eastern Montana, including Yellowstone County, historically burned at frequent intervals. 5 to 25 year return intervals helped maintain the grassland ecosystem by limiting the establishment of slower growing species.

The scattered stands of ponderosa pine in the both the Pleasant Hollow and Cedar Ridge subdivisions present an increased risk of wildland fire. Under normal conditions; however, a fire in this type of open timber would tend to spread quickly along the surface with only occasional torching of individual trees or clumps of trees. Larger flame lengths and small crown fires could be expected under the influence of wind and severe drought.

The agricultural fields and pasture ground currently surrounding the community of Shepherd and dominating the river bottom to the east become very dry during the summer months. These cured grasses can be very flammable, especially under extreme weather conditions, such as drought or wind. In the event of an uncontrolled wildfire, these light fuels would tend to support very fast moving, yet lower intensity fires. Modification of the vegetation around structures can be done quickly with available farm equipment and is usually effective in controlling wildfire.

Riparian vegetation along the Yellowstone River is relatively dense. Due to the availability of moisture, thick grasses as well as brush, weeds, and other forbs grow very well. Black cottonwoods and other trees are also common along the river bed. During, the summer, these fuels become dry and very receptive to an ignition. The consistent fuel bed afforded by the thicker fuels in the riparian zone could easily carry an uncontrolled fire from an ignition point in the rangelands to populated areas. This type of fire is somewhat difficult to suppress due to the lack of access points and the density of the vegetation.

Ignition Profile

Both natural and human caused ignitions occur around the community of Shepherd. The community center is more prone to human caused ignitions than lightning strikes due to the flat topography and agricultural development; however, lightning strikes occur fairly frequently in the rangeland throughout the county. Both of the subdivisions near Shepherd may be at increased risk of lightning caused fires due to the slightly increased elevation and surrounding rangelands.

Annual field burning, debris fires, and vehicle use are common potential ignition sources. Stubble fires seldom escape landowner's boundaries; however, there are a few incidences each year. These fires are generally easily suppressed by modifying the vegetation and homes are rarely threatened. Vehicle use on- and off-road is also a significant source of ignitions. Not only do sparks from vehicles ignite fuels along roadways, but fires are also commonly started by vehicles driving through dry fields or on unimproved trails. Grain trucks, ATV's, and pick ups are used regularly in farming operations.

4.4.2.7.2 Ingress-Egress

Shepherd can be reached by taking the Shepherd-Acton Road east from U.S. Route 87 or via the Shepherd Road from Huntley. Shepherd Road is a paved two lane route with agricultural development adjacent to both sides. The Shepherd-Acton Road is a two lane gravel road abutting rangeland and agricultural fuels. There also numerous other secondary routes crisscrossing the area, most of which are well maintained graveled roads.

The Pleasant Hollow area can be reached by following West Tenny Road off of Shepherd Road. Roads through the housing development are two lane graveled routes abutted by pasture or rangeland fuels.

The Cedar Ridge subdivision is reached via Highway 87. P K Road is a loop road through the development; however, a section of it is not maintained as a drivable route. Stonehouse Road is another access point off of Highway 87, but this is also a dead end route with several dead end spurs leading to clusters of homes.

4.4.2.7.3 Infrastructure

The community of Shepherd and the surrounding area rely on personal or multiple home well systems.

4.4.2.7.4 Fire Protection

The Shepherd Volunteer Fire Department is responsible for structural and wildland fire protection in the town site of Shepherd and the Shepherd Fire Service Area. The Montana Department of Natural Resources and Conservation and the Bureau of Land Management provide wildland fire protection as necessary.

4.4.2.7.5 Community Assessment

Homes located in the agriculturally-based community of Shepherd have low to moderate risk of wildfire. Fires originating in the crop fields are usually suppressed quickly by creating fuel breaks with the available farming equipment. Fires in the rangeland fuels in the surrounding areas are relatively common. Under normal conditions this type of fire can be controlled relatively quickly. Drought and/or high winds can lead to very fast spreading fires with large flame lengths that can be much more difficult to control; therefore, it is imperative that homeowners implement fire mitigation measures to protect their structures and families prior to a wildland fire event. Homeowners adjacent to the riparian zone of the Yellowstone River or other drainages should be aware of the possibility of a fire within the watershed. Keeping structures an adequate distance from these fuels and maintaining a clean and green yard will help insure the safety of their property.

Structures in both the Pleasant Hollow and Cedar Ridge subdivisions have an increased risk of experiencing a wildfire. Homes in these areas usually have a maintained lawn or pasture ground that may serve as a defensible space in the event of a fire, but many do not. Fires in the surrounding rangeland and partially timber fuels could easily move through these communities. Additionally, many homes in these areas were built using wood siding and decking, which make them more susceptible to ignition. Roads and driveways accessing homes should be regularly maintained with the edges mowed to prevent an accidental ignition. Homeowners with structures located on dead end roads or driveways with no alternative escape route should construct loop roads where possible or establish gates in fencing to allow for an emergency evacuation if the primary escape route becomes impassable.

In Shepherd, as well as several other communities in Yellowstone County, availability of water is an issue for rural fire departments, particularly in drought years. Other than the river corridor and a few other minor drainages, there are very few easily accessed water resources available for drafting or pumping to refill fire suppression engines. The lack of water puts many of the more remote subdivisions and communities at greater risk. Some of this risk can be alleviated by establishing water storage tanks, developed drafting sites, or dry hydrants in closer proximity to developments.

It is imperative that homeowners, particularly in higher risk areas, implement fire mitigation measures to protect their structures and families prior to a wildland fire event. As the community grows, more and more homes will be built in the wildland urban interface. It will become increasingly important to educate landowners of the potential fire risk. The receptive nature of the rangeland fuels in Yellowstone County and their natural tendency towards frequent burn intervals increases the likelihood of a fire start. Most homeowners maintain an adequate defensible space around structures by watering their yards or mowing grass and weeds; however, there is still a need to inform others of the potential danger.

4.4.2.7.6 Mitigation Activities

Effective mitigation strategies begin with public awareness campaigns designed to educate homeowners of the risks associated with living in a flammable environment. Residents of Yellowstone County must be made aware that home defensibility starts with the home. Once a fire has started and is moving toward a structure or other valued resources, the probability of that structure surviving is largely dependent on the structural and landscaping characteristics of the home. “Living with Fire, A Guide for the Homeowner” is an excellent tool for educating homeowners as to the steps to take in order to create an effective defensible space. Residents of Shepherd and the surrounding area should be encouraged to work with local fire departments and fire management agencies within the county to complete individual home site evaluations. Home defensibility steps should be enacted based on the results of these evaluations.

Also of vital importance is the accessibility of the home to emergency apparatus. If the home cannot be protected safely, firefighting resources will not jeopardize lives to protect a structure. Thus, the fate of the home will largely be determined by homeowner actions prior to the event. In many cases, homes' survivability can be greatly enhanced by following a few simple guidelines to increase accessibility such as widening or mowing driveways and creating a turnaround area for large vehicles.

New developments in the wildland urban interface should be regulated by building codes that protect residents from the effects of wildfire. Insuring that there are adequate water resources available for emergency use and that new roads and driveways are accessible to emergency apparatus will become increasingly important as the community expands.

4.4.2.8 Worden, Ballantine, and Pompeys Pillar

Worden, Ballantine, and Pompeys Pillar are small agricultural communities lying in the Yellowstone River valley along Interstate 94. The Pompeys Pillar community lies along Interstate 94 just south of the Pompeys Pillar National Historical Landmark. The Worden and Ballantine community centers are only about one mile apart; however, the residential and agricultural development extends from the Interstate north to the river, west to Huntley, and east to Pompey’s Pillar. There are patches of native rangeland fuels remaining; however, this part of the valley has been almost entirely converted to agriculture.

4.4.2.8.1 Fire Potential

Fuels Assessment

The agricultural fields and pasture ground surrounding Worden, Ballantine, and Pompeys Pillar become very dry during the summer months. These cured grasses can be very flammable, especially under extreme weather conditions, such as drought or wind. In the event of an uncontrolled wildfire, these light fuels would tend to support very fast moving, yet lower intensity fires. Modification of the vegetation around structures can be done quickly with available farm equipment and is usually effective in controlling wildfire.

Riparian vegetation along the Yellowstone River is relatively dense. Due to the availability of moisture, thick grasses as well as brush, weeds, and other forbs grow very well. Black cottonwoods and other trees are also common along the river and creek beds. During, the summer, these fuels become dry and very receptive to an ignition. The consistent fuel bed afforded by the thicker fuels in the riparian zone could easily carry an uncontrolled fire from an ignition point in the rangelands to populated areas. This type of fire is somewhat difficult to suppress due to the lack of access points and the density of the vegetation.

The native rangeland ecosystem on the north side of the Yellowstone River and south of the Interstate consist of short to medium length grasses with scattered clumps of sagebrush and juniper. This type of fuel is typically very flashy. Fires spread quickly, but tend to burn at lower intensities. In some areas, the lack of a consistent fuel bed may slow the spread of fire. The rangelands of eastern Montana, including Yellowstone County, historically burned at frequent intervals. 5 to 25 year return intervals helped maintain the grassland ecosystem by limiting the establishment of slower growing species.

Ignition Profile

Both natural and human caused ignitions occur near Worden, Ballantine, and Pompeys Pillar. The community center is more prone to human caused ignitions than lightning strikes due to the flat topography and abundant ignition sources; however, lightning strikes occur fairly frequently in the rangeland and forestlands throughout the county.

Annual field burning, debris fires, and vehicle use are common potential ignition sources. Stubble fires seldom escape landowner's boundaries; however, there are a few incidences each year. These fires are generally easily suppressed by modifying the vegetation and homes are rarely threatened. Vehicle use on- and off-road is also a significant source of ignitions. Not only do sparks from vehicles ignite fuels along roadways, but fires are also commonly started by vehicles driving through dry fields or on unimproved trails. Grain trucks, ATV's, and pick ups are used regularly in farming operations.

4.4.2.8.2 Ingress-Egress

Interstate 94, U.S. Highway 212, and State 568 provide access to these communities. All are paved routes adjacent to agricultural development or rangeland fuels. There are also numerous secondary routes crisscrossing the area to provide access to farms and ranches.

4.4.2.8.3 Infrastructure

The communities of Worden and Ballantine rely on a municipal water system as well as personal or multiple home wells. The scattered homes near Pompeys Pillar typically rely on personal well systems. There are also a few springs providing surface water collection points at remote locations in the rangelands south of the Interstate.

There is a dry hydrant located at Fly Creek near Pompeys Pillar for use by the local fire protection departments and agencies.

4.4.2.8.4 Fire Protection

The Worden Volunteer Fire Department provides structural protection to the Worden, Worden Fire District, Huntley Project Fire Service Area, Ballantine, Pompeys Pillar, and Huntley and wildland protection to the surrounding area. Wildland fire protection is provided by the Montana Department of Natural Resources and Conservation and the Bureau of Land Management as necessary.

4.4.2.8.5 Community Assessment

The communities of Worden, Ballantine, and Pompeys Pillar are at low risk of experiencing a wildland fire. The Yellowstone River and Interstate 94 would, under normal circumstances, serve as effective fuel breaks from fires in the rangeland areas beyond. Fires ignited within the valley bottom could, however, move very quickly through curing agricultural fields; therefore, it is

imperative that homeowners implement fire mitigation measures to protect their structures and families prior to a wildland fire event.

4.4.2.8.6 Mitigation Activities

Effective mitigation strategies begin with public awareness campaigns designed to educate homeowners of the risks associated with living in a flammable environment. Residents of Yellowstone County must be made aware that home defensibility starts with the home. Once a fire has started and is moving toward a structure or other valued resources, the probability of that structure surviving is largely dependent on the structural and landscaping characteristics of the home. “Living with Fire, A Guide for the Homeowner” is an excellent tool for educating homeowners as to the steps to take in order to create an effective defensible space. Residents of Worden, Ballantine, Pompeys Pillar, and the surrounding area should be encouraged to work with local fire departments and fire management agencies within the county to complete individual home site evaluations. Home defensibility steps should be enacted based on the results of these evaluations.

Also of vital importance is the accessibility of the home to emergency apparatus. If the home cannot be protected safely, firefighting resources will not jeopardize lives to protect a structure. Thus, the fate of the home will largely be determined by homeowner actions prior to the event. In many cases, homes' survivability can be greatly enhanced by following a few simple guidelines to increase accessibility such as widening or mowing driveways and creating a turnaround area for large vehicles.

4.4.2.9 Molt

Molt is a farming community located in eastern Stillwater County, at the end of Molt Road, which originates in Yellowstone County as Rimrock Road. The majority of the Molt area consists of dryland grain farming and cattle ranching. Areas that are unusable for agricultural are coulees filled with sagebrush, juniper, and ponderosa pine.

Ten miles east of Molt are the McFarland and Echo Canyon subdivisions. Echo Canyon straddles Molt Road, which offers good access. Homes in Echo Canyon abut light rangeland fuels; however, many landowners graze horses or other livestock near their homes. The steep, rocky slope of a plateau rises behind the development to the east. Rangeland fuels tend to be somewhat inconsistent with patches of sagebrush and bare ground throughout.

Hidden Valley and Chief Joseph subdivisions are five miles southeast of Molt along Buffalo Trail Road. Some homes area accessible from Buffalo Trail, but many more are located off both sides of the highway on gravel loop roads that are not maintained. Vegetation consists of grasses, juniper, and ponderosa pine.

Canyon Creek and Clappers Flat Road are in the southern part of the Molt Fire District. Both roads are well maintained. Some homes are set in among trees and rimrocks.

4.4.2.9.1 Fire Potential

Fuels Assessment

The agricultural land in Molt consists of open grassland and strip farming for grain. Sagebrush is present in some of the pastures. The canyons south and east of Molt consist of grassland, juniper, and ponderosa pine. Most of these canyons consist of rimrocks with grassy areas on top and between them.

Ignition Profile

The vast majority of fires surrounding Molt are lightning caused. Field burning and slash fires are normally done with the consent of the fire department under favorable conditions. Occasionally, fires start from farming operations due to equipment malfunction.

4.4.2.9.2 Ingress-Egress

There are only two paved roads in the Molt Fire District, Molt Road and Buffalo Trail Road (from Laurel to Molt Road). Molt Road is the main highway leading to Molt from Billings. The pavement ends there and the graveled Molt-Rapelje Road begins. The Echo Canyon development has several entrances off of Molt Road. These roads are two-lane graveled routes traveling adjacent to developed lots, pasture ground, or low risk rangeland fuels.

Buffalo Trail crosses Molt Road two miles east of Molt. This is the main highway between Laurel and Broadview. North of Molt Road, it is gravel.

4.4.2.9.3 Infrastructure

Water sources in the Molt area consist of wells and cisterns. The fire department uses water from a storage tank and wells. Several gas and oil pipelines cross the Molt area. A natural gas compressor station is west of Molt. A power substation with high-voltage power lines is the eastern boundary of the Molt fire area.

4.4.2.9.4 Fire Protection

Molt Volunteer Fire Department is responsible for wildland and structural fire protection in the area. Mutual aid agreements in each county help with this protection.

4.4.2.9.5 Community Assessment

Homes and businesses in the community of Molt all have grassland or cropland adjoining their property. The risk of fire is relatively low.

The subdivisions along Molt Road and Buffalo Trail Road all include steep slopes with grassland, juniper, and ponderosa pine. Because of recent drought these areas are extremely dry. All homes in these areas need to have clean and clear areas around their homes.

4.4.2.9.6 Mitigation Activities

Education is the key to protecting rural subdivisions in the Molt area. Homeowners need to be shown techniques that can be used to make protection of their homes from fire much easier.

Roads in these rural subdivisions are privately owned, which is why upkeep on them is minimal. Homeowners need to keep these roads in the best shape possible so that emergency vehicles can enter and leave quickly and safely. Driveways should be built with enough room for emergency vehicles to turn around.

City and County planning boards should require developers to install water resources, such as cisterns and wells, in new subdivisions. Adequate water resources would make protection of these areas much easier.

4.4.2.10 Blue Creek

The community of Blue Creek lies south of the Yellowstone River between Billings and the Crow Indian Reservation. The community itself is surrounded by agricultural development. Several rural housing developments have become established in the rangelands south and southwest of the Yellowstone River. Included in this assessment is the Vista View Subdivision, Hillcrest Views, and the Hill Subdivision.

The Vista View area consists of several housing projects off of Basin Creek Road. Vista View Road travels to the top of the hill that is made up of rangeland grass with patches of sagebrush and juniper. The entire area is predominantly newer homes extending from the roadside up a gentle slope to a large plateau where 24 large lots have been established for construction. Structures near the road generally sit on fairly large open lots. These homes are more closely intermixed with the rangeland fuels.

The Hill Subdivision is just southwest of the Vista View Subdivision. There are several homes at the top of this hill that overlook most of the Blue Creek area.

The Hillcrest Views area is a large plateau lying southwest of Billings and is characterized by rangeland fuels with clumps of juniper and stunted ponderosa pine along the edges. Homes are typically built on large lots intermingled with the semi-wooded areas.

4.4.2.10.1 Fire Potential

Fuels Assessment

The native rangeland ecosystem around the outskirts of the community and abutting several of the rural subdivisions consists of short to medium length grasses with scattered clumps of sagebrush and juniper. This type of fuel is typically very flashy. Fires spread quickly, particularly upslope, but tend to burn at lower intensities. In some areas, the lack of a consistent fuel bed may slow the spread of fire. The rangelands of eastern Montana, including Yellowstone County, historically burned at frequent intervals. 5 to 25 year return intervals helped maintain the grassland ecosystem by limiting the establishment of slower growing species.

The partially timbered areas in Blue Creek are almost exclusively made up of ponderosa pine. Stringers and patches of trees typically exist in the coulees and canyons where moisture is more readily available. In most cases, fires in this type of timber will stay on the surface with only occasional torching of individual trees or clumps of trees, particularly where juniper offers a ladder fuel. Under extreme conditions, such as drought or high winds, fires will spread very rapidly with larger flame lengths.

The agricultural fields that currently dominate the surrounding foothills become very dry during the summer months. These cured grasses can be very flammable, especially under extreme weather conditions, such as drought or wind. In the event of an uncontrolled wildfire, these light fuels would tend to support very fast moving, yet lower intensity fires. Modification of the vegetation with available farm equipment is usually effective in controlling wildfire.

Ignition Profile

Both natural and human caused ignitions occur in Blue Creek. The community center is more prone to human caused ignitions than lightning strikes due to the flat topography and agricultural development; however, lightning strikes occur fairly frequently in the rangeland and forestlands throughout the county. Annual field burning, debris fires, and vehicle use are common potential ignition sources. Stubble fires seldom escape landowner's boundaries;

however, there are a few incidences each year. These fires are generally easily suppressed by modifying the vegetation and homes are rarely threatened.

Vehicle use on and off road is also a significant source of ignitions. Not only do sparks from vehicles ignite fuels along roadways, but fires are also commonly started by vehicles driving through dry fields or on unimproved trails. Grain trucks, ATV's, and pickups are used regularly in farming operations.

4.4.2.10.2 Ingress-Egress

The primary access into Blue Creek is via Blue Creek Road from the north or south; however, there is another transportation route coming into the area. This is Duck Creek Road to Keller Road. Most of the rural housing is accessed from gravel roads branching off of these primary routes.

Blue Creek Road provides the main access into the Vista View Subdivision. This two lane highway abuts rangeland fuels and provides an escape route out of this subdivision. Vista View Road is the primary access route for homes in this subdivision. Vista View is a loop road; however, it branches off near the top and it is fairly well maintained. Potholes and severe washboards may hinder the speed of emergency response. Better signing of the roads and house numbers at the end of driveways would help reduce confusion for emergency response personnel and for residents during an evacuation. The Vista Blue Road provides access to a couple of homes; however, this route dead ends at the last house. The lack of an alternate escape route significantly decreased the safety of residents in an emergency situation.

Homes in the Hill Subdivision area are accessed via the Vandeveer Road off of Blue Creek Road. This is a two lane, graveled road that extends past the fire service area to the west. For the most part, this route is well maintained; however, the further west you travel, it is for the most part, impassible.

Hillcrest Views is reached by following Hillcrest Road off of Blue Creek Road. This is also a two land paved road that is kept in good condition. Most of the homes in this area are accessed off of Hillcrest Road, which continues south to the Crow Indian Reservation. This road starts out as a paved two lane route; however, it tapers into a two lane gravel road towards the end. There are several dead end spur roads and driveways branching from the Hillcrest Road, none of which seem to have alternate escape routes. The safety of residents in the Hillcrest area would be drastically improved with the development of some thru roads.

4.4.2.10.3 Infrastructure

Blue Creek has a municipal water system for residents within the city limits. Rural subdivisionsx and individual homes rely on personal or multiple home well systems and storage tanks.

There are several high tension power lines crisscrossing the Blue Creek area, most of which travel over surrounding rangeland fuels. These fuels are highly receptive to sparks originating from the downed lines, arcing, or malfunctioning transformers.

4.4.2.10.4 Fire Protection

The Blue Creek Volunteer Fire Department is responsible for EMS, structural, and wildland protection for the community of Blue Creek and the immediately surrounding areas.

4.4.2.10.5 Community Assessment

Residential development is expanding along Blue Creek Road to the south. There are few remaining patches of native rangelands; however, this area is primarily used for the production of agricultural products. The banks of the Yellowstone River are lined with dense riparian vegetation that could support an intense fire. Homes directly adjacent to these fuels could be at high risk; however, the development of irrigated lawns and crop fields next to the channels will help keep the fire contained.

Subdivisions built near or within higher risk rangeland fuels or wooded areas have an increased risk of wildland fire. Homes located in the Vista View area, Hill subdivision, and near Hillcrest Views are surrounded by fuels that have a moderate to high wildland fire risk due to the higher density of sagebrush, juniper, and timber.

The Vista View Subdivision has a moderate risk of wildfire. Many homes have created an adequate defensible space; however, there are several homes that have juniper and ponderosa pine directly abutting structures. Furthermore, many of these homes are built along the upper slopes of that area. Fires originating near the road could spread upslope very rapidly giving residents little time to escape. Road and house number signage, as well as road widening and maintenance would significantly improve the safety of residents in the Vista View area.

Hillcrest View is a relatively large drainage with thick grasses in the valley bottom and ponderosa pine and juniper lining the upraising slopes. Homes in this area have been built in the valley bottom with small agricultural crops or livestock pasture surrounding home sites. For the most part, landowners have created defensible space around structures. Homes built closer to the timber may benefit from clearing brush and other ladder fuels from the understory and pruning trees within at least 50 to 100 feet.

Homes in the Hill Subdivision area have a moderate to high risk of experiencing a wildfire. Not only are many of the houses intermixed with heavy rangeland fuels, but access into the area is very poor. Ponderosa pine, juniper, and sagebrush commonly abut these homes. Additionally, not only does the main access route dead end, there are several unmarked spur roads that dead end at home sites. Homeowner education regarding the value of a defensible space, especially in areas with hazardous fuels would help increase community awareness of the wildfire risk. The safety of residents and emergency response personnel would be improved by road and house number signing as well as construction of a thru road to provide an alternate escape route.

It is imperative that homeowners, particularly in higher risk areas, implement fire mitigation measures to protect their structures and families prior to a wildland fire event. As the community grows, more and more homes will be built in the wildland urban interface. It will become increasingly important to educate landowners of the potential risk of fire. The receptive nature of the rangeland fuels in Yellowstone County and their natural tendency towards frequent burn intervals increases the likelihood of a fire start. Most homeowners maintain an adequate defensible space around structures by watering their yards or mowing grass and weeds; however, there is still a need to inform others of the potential danger.

4.4.2.10.6 Mitigation Activities

Effective mitigation strategies begin with public awareness campaigns designed to educate homeowners of the risks associated with living in a flammable environment. Residents of Yellowstone County must be made aware that home defensibility starts with the home. Once a fire has started and is moving toward a structure or other valued resources, the probability of

that structure surviving is largely dependent on the structural and landscaping characteristics of the home. "Living with Fire, A Guide for the Homeowner" is an excellent tool for educating the homeowners as to the steps to take in order to create an effective defensible space. Residents of Blue Creek and the surrounding area should be encouraged to work with the local fire departments and fire management agencies within the county to complete individual home site evaluations. Home defensibility steps should be enacted based on the results of these evaluations.

Community defensible space projects can also help improve the safety of groups of homes. Rural subdivisions adjacent to wildland fuels can create fuel breaks along their perimeter that also increase the value of the homes in the community.

Also of vital importance is the accessibility of the home to emergency apparatus. If the home cannot be protected safely, firefighting resources will not jeopardize lives to protect a structure. Thus, the fate of the home will largely be determined by homeowner actions prior to the event. In many cases, homes' survivability can be greatly enhanced by following a few simple guidelines to increase accessibility such as widening or mowing driveways and creating a turnaround area for large vehicles. Roads and driveways accessing homes should be regularly maintained with the edges mowed to prevent an accidental ignition. Homeowners with structures located on dead end roads or driveways with no alternate escape route should construct loop roads where possible or establish gates in fencing to allow for an emergency evacuation if the primary escape route becomes impassible.

New developments in the wildland urban interface should be regulated by building codes that protect residents from the effects of wildfire. Insuring that there are adequate water resources in the case of an emergency.

4.5 Firefighting Resources and Capabilities

The Fire Fighting Resources and Capabilities information provided in this section is a summary of information provided by Yellowstone County Fire Organizations and Representatives of the Wildland Fire Fighting Agencies listed. Their answers to a variety of questions are summarized here. These summaries indicate their perceptions and information summaries.

4.5.1 Rural and City Fire Protection

4.5.1.1 Billings Fire Department

Marv Jochems, Chief
(406) 657-8420 or (406) 657-8423
JochemsM@ci.billings.mt.us
2305 8th Avenue North, Billings, MT 59101

District Summary:

The Billings Fire Department provides services to the City of Billings and surrounding contracted areas in Yellowstone County commonly referred to as the Billings Urban Fire Service Area (BUFSA). The total response area is approximately eighty-four square miles. The fire department provides emergency services such as fire suppression, emergency medical response, hazardous materials response, high angle rescue, confined space rescue, vehicle accident extrication, and fire investigations. There are currently six fire stations within the city limits with plans for an additional station on the west end of Billings.

Personnel include a Fire Chief, an Assistant Fire Chief, A Sr. Administrative Coordinator, an Administrative Secretary, a Fire Marshal, an Assistant Fire Marshal, 3 Deputy Fire Marshals, a Training Officer, a Maintenance Officer, 4 Battalion Chiefs, 27 Captains, 27 Engineers, and 39 Firefighters.

Under the direction of the Billings Fire Department, the City/County 9-1-1 Center provides the critical link between the community and public safety resources. Twenty-seven (27) full-time employees and three (3) 9-1-1 supervisors receive, coordinate, and process emergency and non-emergency radio and telephone traffic twenty-four (24) hours a day. Additionally, the 9-1-1 Center oversees the maintenance and usage of the citywide 800 MHz radio system.

Priority Areas:

Residential Growth:

The Billings area is growing at a steady rate. Growth is not expected to slow, in part, due to the population exceeding 100,000 people. At this population level, planners anticipate the community to become 'self generating' and continue to grow at a steady and significant rate.

Communications:

Communications within the Billings City Fire, Police and EMS systems are relatively effective and efficient, all using an 800 MHz radio system with a central dispatch center. However, communications with organizations outside of the City, such as other fire departments, is challenging, as many of these organizations are still using VHF or other systems not compatible with the 800 MHz system.

Fire Fighting Vehicles:

With the steady expansion of City limit boundaries, the amount of wildland urban interface area in the jurisdiction is increasing. The City's wildfire fighting apparatus, such as brush trucks, may be inadequate to handle potentially large wildfire events which include interface with urban development, such as in Rehberg Ranch Subdivision. Additional wildland firefighting resources are needed.

Burn Permit Regulations:

The current burn permit regulations appear to be adequate. The Billings Fire Department administers and regulates burn permits within the city limits. The Yellowstone City-County Health Department administers and regulates burn permits in the county.

Effective Mitigation Strategies:

The Department is making great efforts to expand the number of stations, equipment and personnel to meet the increasing demands resulting from population growth. The Department actually employees fewer firefighting personnel in 2005 than it did 30 years ago. From 1974 to 2004, the fire service area has expanded from 18 to 84 square miles. During the same period, staffing has decreased from 112 to 104 personnel. While the demand for firefighting and prevention efforts has dramatically increased, staffing has decreased, resulting in longer response times on calls and an inability to maintain relative levels of service to the public. Staffing and equipment resources are at a critical level.

Education and Training:

The Billings Fire Department provides annual wildland firefighting training. This includes a pre-fire season firefighter safety and survival course of instruction. Also provided is training for pumper drafting, tender and water shuttle operations, collapsible tank deployment, and a

sawyer class. This takes place in the context of 12 hours minimum of training. Additional training takes place at individual stations at the discretion of station Captains. Many of the firefighters certify on their own to carry wildland firefighting certifications such as red cards, engine boss, and various other positions.

Cooperative Agreements:

Billings has formal and signed mutual aid agreements with ConocoPhillips, ExxonMobil, and Cenex refineries, the communities of Laurel and Lockwood, and the Billings Logan International Airport ARFF. Billings generally offers mutual aid to all requesting fire departments surrounding the Billings area, pursuant to MCA 1-3-209, the State Mutual Aid Law.

Current Resources:

Station #1 – 2305 8th Avenue North:

Table 4.2. Billings Fire Department Station #1 Equipment List.

Year	Make	Model	Tank Capacity	Pump Capacity
2003	HME	Pumper	750 Gallons	1500 GPM
1997	Sutphen	Aerial Ladder	750 Gallons	1500 GPM
1997	Freightliner	Water Tender	2500 Gallons	300 GPM
2004	Ford	4x4 Brush Truck	450 Gallons	100 GPM
1991	E-1	Reserve Pumper	750 Gallons	1500 GPM
1992	Dodge	Utility Pickup	N/a	N/a
2002	Chevrolet	Suburban (Battalion Chief)	N/a	N/a
1996	Chevrolet	Suburban (Training Officer)	N/a	N/a

Station #2 – 501 South 28th Street:

Table 4.3. Billings Fire Department Station #2 Equipment List.

Year	Make	Model	Tank Capacity	Pump Capacity
2001	Sutphen	Pumper	750 Gallons	1500 GPM
1998	Chevrolet	Rescue	N/a	N/a

Station #3 – 1928 17th Street West:

Table 4.4. Billings Fire Department Station #3 Equipment List.

Year	Make	Model	Tank Capacity	Pump Capacity
1993	3D MFG.	Pumper	750 Gallons	1500 GPM
1991	E-1	Reserve Pumper	750 Gallons	1500 GPM

Station #4 – 475 6th Street West:

Table 4.5. Billings Fire Department Station #4 Equipment List.

Year	Make	Model	Tank Capacity	Pump Capacity
2003	HME	Pumper	750 Gallons	1500 GPM
2004	Freightliner	Haz-Mat Van	N/a	N/a

Station #5 – 605 South 24th Street West:

Table 4.6. Billings Fire Department Station #5 Equipment List.

Year	Make	Model	Tank Capacity	Pump Capacity
2001	Sutphen	Pumper	750 Gallons	1500 GPM
2004	Freightliner	Water Tender	2600 Gallons	300 GPM
2002	Ford	4x4 Brush truck	450 Gallons	100 GPM
2005	Sutphen	Quint	500 Gallons	1500 GPM

Station #6 – 1601 St. Andrews Drive:

Table 4.7. Billings Fire Department Station #6 Equipment List.

Year	Make	Model	Tank Capacity	Pump Capacity
1993	3D MFG	Pumper	750 Gallons	1500 GPM
1992	Ford	4x4 Brush Truck	300 Gallons	100 GPM
1986	Chevrolet	Air (SCBA) Van	N/a	N/a

Future Considerations:

A 7th Fire Station is currently being planned and is tentatively scheduled to begin construction in early 2006.

There is a need for City and County regulations to require minimum levels of wildland fuel mitigation in urban interface areas to protect lives and property. Virtually no regulations currently exist in City and County Code. Some individuals may view these new regulations as unnecessarily restrictive, but these changes could reduce insurance rates and the loss of life and property within the community.

4.5.1.2 Broadview Rural Fire District #3

District Summary:

Broadview Rural Fire District #3 is based in Broadview, Montana. The Broadview Rural Fire District covers four counties, northwestern Yellowstone County, northeastern Stillwater County, southeastern Golden Valley County, and southwestern Musselshell County. The fire hall is located in Broadview, Montana. They have mutual aid agreements with the surrounding fire departments. At the present time, the Broadview Rural Fire District does not respond to structural fires within their district; they are solely a wildland fire response organization. As a recommendation for this plan, they believe it would be in the best interests of the community for the department to assume structural suppression responsibilities.

Broadview Rural Fire District #3 has a few interface areas in Yellowstone County. More are located in the surrounding counties where they have people moving into timbered areas.

Their needs at the present time are a repeater/pager tower in the Broadview area to help with communications, a Type 6 Wildland Fire Truck, a Pro-PAC foam kit, a floater pump, and any kind of PPE that they can get. They also need basic wildland fire training. For the future needs of the BRFD, they would like to get a Type 3 truck and the training necessary to use this truck.

Current Resources:

Table 4.8. Broadview Rural Fire District #3 Equipment List.

Year	Make	Model	Tank Capacity (gal)	Pump	Comments
1973	Ford	F-250	200 gal w/ Vanguard 9 hp motor	Davy pump	Midland radio, 100' of 1" hose with hand reel, 5 gal gas can and 5 gal foam can, 4 bladder packs, 20' log chain, First Aid kit, 1 flapper, 2 axes, 1 shovel, and 1 rake
1989	Chevrolet	1-ton	215 gal w/ 18 hp	Briggs & Stratton pump	Kenwood radio, 100' of 1" hose w/ electric reel, 8' suction hose, 2 ½ gal gas can, 2 ½ foam can, First Aid kit, 2 flappers, 2 Pulaski's, 1 brush rake, and 1 shovel
1976	GMC	25	200 gal slide in		100' hose and reel, 3 bladder packs, 4 Pulaski's, 1 brush rake, 2 shovels, 2 flappers, and 1 axe
		6x6 Military Truck	1000 gal w/ 5 hp engine	Centrifugal pump	100' of ¾" hose w/ hand reel and 50' of 1 ½" hose
1974	Peterbuilt	Tender	5000 gal	300 gpm (50 psi)	20' of 2" hose, 40' of 3" hose, and 1500 gallon drop tank
1967	International	1300	300 gal w/ Vanguard 9 hp motor	Davy pump	Regency radio, 100' of 1 ¼ " hose w/ hand reel, 2 Indian backpacks, 1 fire shelter, 2 ½ gal gas can, 5 gal foam can, 3 shovels, 1 brush rake, 1 Pulaski, 20' 3/8" log chain
1979	Ford	F-350	215 gal w/ 18 hp Twin Briggs engine	Davy pump	Midland radio, 12' suction hose, 150' of 1" hose w/ electric reel, 25' of 1 ½" hose, 5 gal gas can, 5 gal foam can, 3 bladder packs, 3 fire shelters, 4 tire chains, 1 oxygen kit, 1flare kit, 20' of 3/8" log chain, burn First Aid kit, 2 shovels, 3 flappers, 1 Pulaski, 1 brush rake, and 1 axe

Other items: 8 SCBA's, 3 sections of 50' of 1 ½" water hose, 6 cots, 11 hp Wisconsin engine with 2" pump, 50 gallons of foam, aluminum extension ladder, one bladder pack, 1000 gallon water tank, 1000 gallon propane tank, 500 gallon propane tank, 2 slide in 200 gallon tanks with engine, pump, hose, and reel, 1 state lands slide in tank, engine, pump, hose, and reel, 1 ½" socket set, various sizes and amounts of structural and brush turnouts, helmets, pants, and fire shirts (all are hand-me-downs), 2 Bendix King radios, 2 Kenwood Radios, 2 Johnson Radios, 3 Kenwood Radios, and 9 handheld radios.

4.5.1.3 Lockwood Fire Department

Alan Riley, Chief
(406) 855-0400
Officer1198@yahoo.com
3329 Driftwood Lane
Billings, MT 59101

District Summary:

Lockwood Fire District is responsible for structural and wildland fire protection, hazmat, rescue, and emergency medical service in the unincorporated area east of the city of Billings. Lockwood Fire District covers 80 square miles and has both Interstate 90 and Interstate 94 within its district boundaries.

Lockwood Fire District is a combination department with 14 career firefighters, 1 administrative aid, and 8 volunteer firefighters. All aspects of the district response are major concerns due to the limited manpower and equipment. Lockwood Fire District has mutual aid agreements with the city of Billings and surrounding volunteer fire departments. Additional resources are available from the Department of Natural Resources and Conservation and the Bureau of Land Management for larger wildland incidents.

Priority Areas:

Residential Growth:

The residential growth in the district has far exceeded the expected growth for the area. New subdivisions are being developed from the flat farm lands to the steep wooded Hills on the eastern edge of the district. The wildland urban interface area is a major "red flag" for the district with the placement of houses with high risk indefensible landscapes.

Communications:

The communications in the district are barely adequate to meet the needs. Topographical features within the district make radio communications difficult to impossible in some areas. Frequently, "dead spots" are found where communications are nonexistent. Furthermore, inadequate common frequencies make for dangerous situations during interface fires.

Fire Fighting Vehicles:

Due to limited funding, the age and capabilities of the firefighting vehicles in our District has been an on-going concern.

Effective Mitigation Strategies:

The Fire District has strived to keep pace with the growth in the district, but due to a drop in the district's taxable value, this has not been possible. Over the last ten years the Fire District has added one aerial truck and one front line pumper with the aid of state grants and low interest loans. The District has been unsuccessful in attempts to fund a quick response wildland urban interface truck to replace the 1985 truck currently in operation.

Future plans to build a new fire station are now being explored. The current location does not have adequate space to house the number of vehicles or firefighters the District has at this time and there is no room for further expansion.

Education and Training:

Our department provides continued training for all firefighters in the Fire District. Several of our members teach classes for the County through the Department of Resources and Conservation. The department has planned and participated in a number of countywide mutual aid drills. At this time our training room has been converted into an additional bay to house another vehicle.

The Fire District has provided public education through the schools as well as providing public informational meetings. The firefighters have gone door to door talking to the homeowners about defensible space and making their homes more defensible in the event of wildfire. A video was produced and distributed statewide on how the home owner can protect their homes. Firefighters in this district have made themselves available to do on-site evaluations of property

in this district. Efforts have been made to assist the homeowner in clearing brush from the property.

Cooperative Agreements:

The Lockwood Fire District has a mutual aid agreement with Yellowstone County, which covers all fire departments within the county including the City of Billings. In addition, the fire District has a mutual aid agreement with the Bureau of Indian Affairs through Yellowstone County. The County Fire Warden can provide additional help from the Department of Natural Resources and Conservation and from the Bureau of Land Management.

Current Resources:

Station #1 – 2305 8th Avenue North:

Table 4.9. Lockwood Fire District Equipment List

Name	Year	Make/Model	Tank Capacity	Pump Capacity
Engine 1	1997	Pierce Saber	750 gal	1250 gpm
Engine 2	1992	Pierce Arrow 65' Telesquirt	500 gal	1500 gpm
Engine 3	1985	GMC 1-ton	300 gal	200 gpm
Engine 4	1979	International 4x4	1400 gal	1000 gpm
Tender 1	1979	GMC General	3700 gal	PTO
Squad 1	1995	E-350 Type 3 Ambulance		
Squad 2	1993	Ford 4x4 Type 1 Ambulance		
Squad 3	1997	Suburban Multi-Use Vehicle		
Unit 20	2001	Dodge Intrepid (Chief's Car)		

Proposal for New Fire Station:

The Lockwood Fire District operates out of one station. Over the years, we have steadily been running out of room. When the Fire District was first formed in 1988, we had two trucks and operated out of a garage and a Boise Cascade house. Today, the department has multiple vehicles consisting of four trucks, one tender, and four utility vehicles. The department also operates an Advanced Life Support (ALS) service with two ambulances and three paramedics. The Lockwood Fire District has recently purchased five acres of land on Johnson Lane. This piece of property has direct access onto Johnson Lane both north and south. It was decided that no tax dollars would be used for the construction of a facility except for the purchase of the land. After several conceptual meetings, it was decided to consider a building that encompasses a fire station, clinic, pharmacy, and community hall. The firehouse would be approximately 11,728 square feet and the apparatus bay would be 14,760 square feet. The clinic/community hall would be 5,112 square feet. The total square footage of the whole area would be approximately 110,000 square feet. The construction of this facility would create at least sixteen new jobs.

Future Considerations:

Lockwood Fire District will continue to be proactive in protecting the community and the firefighters. New information and projects will be provided to the residents in the District to reduce fire hazards and make the community safe. Building the new fire station and training facility will allow the Fire District to keep pace with the needs of the District, the community, and

the firefighters. Additional and upgraded equipment will be necessary to protect the citizens in the District. The new fire station and equipment should reduce insurance costs to the homeowners and reduce the loss of life and property within the District.

4.5.1.4 Worden Volunteer Fire Department

Monte Dvorak, Chief
(406) 967-4946
P.O. Box 369
Worden, MT 59088

District Summary:

The Worden Fire Department is all volunteer. They have 32 members in all and provide structure, wildland, and EMS. The district covers over 550 square miles. Both Worden Fire District #4 and the Huntley Project Fire Service Area contract with the Worden Volunteer Fire Department to provide structural and wildland fire protection to their constituents. Worden VFD borders two other counties, which are Musselshell and Big Horn. This department has mutual aid agreements with all other surrounding departments, specifically the Billings, Blue Creek, Broadview, Custer, Duck Creek, Haley Bench, Homewood Park, Laurel, Lockwood, Molt, and Shepherd. Also, BLM helps whenever requested. They have three fire stations located in Worden (our main station), Huntley, and Pompeys Pillar. In all they have 6 small communities that make up the Huntley Project.

Priority Areas:

Residential Growth:

The greatest concern lies in the Huntley - Pryor Creek area. There are numerous subdivisions that have been built in that area without any water storage tanks with dry hydrants. Most of the subdivisions are built in dryland areas where water is not readily available. They are also getting a lot more subdivisions in the valley, but most are on irrigated ground.

The Worden VFD is asking that any subdivisions proposed to have five or more residential dwellings be required to put in a 10,000 gallon dry hydrant.

Communications:

Communications is always a concern. At this time all of their fire vehicles have radios and all personnel have handheld radios. Their concern is that when they go to narrow band some of their radios won't be compatible.

Fire Fighting Vehicles:

The Worden VFD has upgraded substantially in the last 10 years, but they still have two Type 6's that are very hard to order parts for. One is owned by the DNRC and definitely needs to be replaced. It would be in the DNRC's best interest if they could replace theirs with a newer model.

Burning Permit Regulations:

Burning permits have been an issue for years. The County now has stricter laws in effect, but they are not always enforced by law enforcement when they are called on. The Worden VFD gets hundreds of calls during the spring to fall period when people are wanting to burn ditches, limbs, and old grass. It keeps more than one person busy just taking these calls. The department would like these calls to be recorded and used for

future references if a fire gets away. This way the calls would not tie up our lines in case there is a real emergency.

Effective Mitigation Strategies:

The department has been upgrading their vehicles and buildings as is affordable. They have updated the Huntley Station from a cold storage station to a heated station after they got a fire service area formed in 1994-95. They also built a fire station at Pompeys Pillar and supplied it with structural and wildland vehicles. The department is also in the process of buying two more lots in Worden, so they can expand the station there. The department has upgraded much of their equipment from FEMA grants and VFA/RFA grants. They are in the process of getting a new tender through a FEMA grant. All of their wildland firefighting vehicles have been fitted for foaming capabilities and our main structure vehicles have foam as well. The department has tried to keep up with the times and changes, but it takes a lot of money. Even the department's Humvees that were bought almost new are now 10 years old.

Education and Training:

The Worden VFD has had an open house the last two years at which they explain to the people where they are at and where they are going. The department hands out information on how to make their dwellings safer. In 2004, the firefighters went from door to door in the Huntley-Pryor Creek area handing out information and explaining how to make their homes more firewise.

The department was unable to go back to that area this year, but plan to go there again in 2006. They also have the kindergarten and first graders come to the Worden Fire Station and the firefighters explain and demonstrate what they do. They also give the teachers and pupils some helpful hints on how to be firewise.

Training for the department is always an important factor. They train twice a month on fire and once on EMS. Every department is always looking for new training skills and classes that will make the department better and their personnel safer. They have been struggling with DNRC to get the classes they want. For the last several years, many classes have been held out of county so it makes it hard to attend and also very expensive. Some of these classes are 2-4 days long and it gets awful expensive and time consuming for the volunteers. Some people just can't afford to take off work and the added expense. There also seems to be many people that like to join the departments, but don't like to train regularly.

Cooperative Agreements:

The department has a good mutual aid agreement with all surrounding fire departments. BLM is also very helpful if resources are needed. It is not always easy to get help from the DNRC when there is more than one fire in the area.

Current Resources:

Station #1 –Worden:

Table 4.10. Worden Volunteer Fire Department Worden Station Equipment List.

Year	Make	Model	Tank Capacity	Pump Capacity
1975	Ford	F-750	750	750
1995	Freightliner	EEI	1000	1250
1995	HummVee	AmGeneral	250	350
1995	HummVee	AmGeneral	250	350
1968	Kaiser 6x6		1000	350
1969	White	9000	4200	350

Station #2 – Pompeys Pillar:

Table 4.11. Worden Volunteer Fire Department Pompeys Pillar Station Equipment List.

Year	Make	Model	Tank Capacity	Pump Capacity
1996	HummVee	AmGeneral	250	350
1969	Kaiser 6x6		1000	350
1969	Chevy	C70	750	750
1965	Jeep		250	350

Station #3 – Huntley:

Table 4.12. Worden Volunteer Fire Department Huntley Station Equipment List.

Year	Make	Model	Tank Capacity	Pump Capacity
1965	International		1000	1000
1968	Jeep		250	250

Future Considerations:

- All new subdivisions will have 10,000 gallon dry hydrants when 5 or more houses are to be built.
- Putting more dry hydrants and storage tanks in existing subdivisions like White Buffalo and Shadow Canyon.
- A storage tank and dry hydrant at Scouthern and Bundy and one on Arrow Creek Road.
- We have 3 250 gallon slide-in tanks with pumps that we lent out to ranches north and east of Pompeys Pillar.
- We would like to put a Type 6 out at Clair Tempro's.

4.5.1.5 Worden Fire District #4

Daniel Krum, President
406-967-3281
P.O. Box 213
Worden, MT 59088
danielk@be-quik.com

District Summary:

We have no assets. We have a taxing district, but contract fire suppression services from the Worden Volunteer Fire Department.

4.5.1.6 Custer Volunteer Fire Department

Milton Mothershed, Chief
(406) 856-4261
Milton@midrivers.com
P.O. Box 47
Custer, MT 59024

Current Resources:

Station #1

Table 4.13. Custer Volunteer Fire Department Station #1 Equipment List.

Year	Make	Model	Tank Capacity	Pump Capacity
1967	AMG	2 ½ ton 6x6 Tender	1800	150
1982	AMG	2 ½ ton 6x6 Tender	2100	150
1993	Ford	350 4x4 Type 6	400	150
1983	Ford (DNRC)	350 4x4 Type 6	250	150
1967	Ford 850	Structural	1000	750

Station #2

Table 4.14. Custer Volunteer Fire Department Station #2 Equipment List.

Year	Make	Model	Tank Capacity	Pump Capacity
1965	Jeep	Type 6	250	150

4.5.1.7 Molt Volunteer Fire Department

Greg Smith, Chief
(406) 669-3139
1438 Buffalo Trail
Molt, MT 59057-2101
buffalo@ttc-cmc.net

District Summary:

The Molt Volunteer Fire Department is responsible for wildland and structural fire protection in western Yellowstone County and eastern Stillwater County. The fire station is located in the town of Molt, which is in Stillwater County. One truck is kept at a member's home in the southern part of our area. Our main emphasis is wildland protection. We are not structure rated, but will do what we can at a structure fire. We have mutual aid agreements with each county.

Priority Areas:

Residential Growth:

The Buffalo Trail area has experienced a large increase in home building in recent years. Some homes have been built in areas where it will be hard to defend them from wildfires.

Communications:

We are constantly upgrading our radio and pager systems. All our members have pagers. We are working towards all members having radios.

Fire Fighting Vehicles:

With the exception of a new vehicle provided by the State of Montana, our vehicles are old and probably not capable of adequately protecting our wildland/urban interface.

Burning Permit Regulations:

The county government needs to come up with an enforceable burn permit system. Most of our residents do call and ask permission if they want to burn and have worked with us very well.

Effective Mitigation Strategies:

The county planning departments need to develop a process that will make sure homeowners and developers build homes that are well protected from fire. This could include sprinkler systems in homes, fire resistant construction materials, and landscaping designed to minimize exposure to a wildfire. Dry hydrants in developments would be assets. Roads and driveways need to be wide enough for safe access by fire trucks.

Our department needs to replace several old firefighting vehicles. Structure rated engines are much needed. Our low income has kept us from replacing vehicles as needed.

Education and Training:

Our volunteers attend training sessions sponsored by the State and sometimes attend training at neighboring departments. Our department also holds monthly training sessions.

Cooperative Agreements:

Molt Volunteer Fire Department has mutual aid agreements with Stillwater and Yellowstone Counties. The State of Montana and Bureau of Land Management are available for fires that exceed the resources of the local fire department.

Current Resources:

Station #1

Table 4.15. Molt Volunteer Fire Department Station #1 Equipment List.

Year	Make	Model	Tank Capacity	Pump Capacity
1992	Ford	Tender	2500 gal	350 gpm pto, 300 gpm portable
1987	Dodge 4x4	Type 6 engine	300 gal	120 gpm
1975	International 4x4	Mini-pumper	300 gal	350 gpm pto, 120 gpm portable
1976	Military 6x6	Type 6 engine	1000 gal	120 gpm
2005	Ford 4x4	Type 6 engine	300 gal	120 gpm
1968	Jeep 4x4	Type 6 engine	200 gal	120 gpm

Station #2

Table 4.16. Molt Volunteer Fire Department Station #2 Equipment List.

Year	Make	Model	Tank Capacity	Pump Capacity
1978	Military 6x6	Type 6 engine	1000 gal	120 gpm

4.5.1.8 Shepherd Volunteer Fire Department

Stuart Andersen, Chief
406-373-5802
Cell: 406-698-6339
P.O. Box 1
Shepherd, MT. 59079
Wildfire_engines@hotmail.com

District Summary:

Shepherd Volunteer Fire Department (SVFD) covers approximately 520 square miles. The District runs north to the Musselshell County line, south to the city of Billings north boundary, west to the railroad tracks to Acton and east to the Yellowstone River to Worden. There are two SVFD fire stations in the district and two satellite stations. There are 30 members, all volunteer. In most cases, out of the 30 members, 10 to 15 are active, depending on what time of day it is. The reason for this is that most of the members work in Billings, so at times during the work week, they have only two to five people available. The Bureau of Land Management (BLM), Billings Field Office has been a lifesaver the last couple of years in responding to some of their wildland fires near or adjacent to BLM lands. The department also uses Worden, Blue Creek, City of Billings, Custer, Haley Bench, Molt, Lockwood, Homewood Park, Laurel, Duck Creek and Broadview for mutual aid.

Shepherd VFD covers a wide variety of topography. There are more “leap frog” residential areas into urban interface type zones. Yellowstone County has done little in the way of regulations for road access, rural addressing, road design and water supply, etc. Individual fire departments have had to go it alone.

Priority Areas:

Residential Growth:

The entire Shepherd area has almost doubled in population in the last 8 to 10 years and the way it looks, it will double again in the next ten years.

We are getting people that don’t keep their yards or property up resulting in higher wildland fuel loadings in these areas. Some of the rural public burn any time they so desire. We need strict regulations. Possibly Yellowstone County needs to make better laws for people that are burning and letting weeds, grass and combustible fuels build up around their property. And when these laws are approved, enforce them.

Effective Mitigation Strategies:

1. Upgrade to newer equipment
2. We have had five dry hydrants installed and two more are on the way
3. We upgraded the Communication System with a new paging system
4. We built a new five bay fire station
5. Purchased a new 1250 gpm structure engine

Future Plans:

1. To replace station 2 with a fire department owned one in a better location.
2. Upgrade the 6 x 6's to newer Type 3 engines.
3. Purchase a new 3000 gal water tender.
4. Plan to develop more dry hydrants in the north half of the protection area.
5. Rural addressing system needs to be reviewed.
6. Fuels reduction around home sites and increase public awareness.

Education and Training:

The Shepherd VFD has experienced a lack of interest from our members for training and education. How can we resolve this issue? We have had a problem with getting training from DNRC in a timely manner.

Communications:

Due to topography, sometimes it is impossible without going through dispatch. It would be nice Shepherd had their own repeater system.

Fire Fighting Vehicles:

The Shepherd VFD needs one new structure engine, for station 2. All three 6 x 6's need to be replaced with Type 3 engines. They also need one new Type 2 water tender.

Current Resources:

Station #1 – Shepherd

Table 4.17. Shepherd Volunteer Fire Department Station #1 Equipment List.

Year	Make/Model	Type	Tank Capacity (gal)	Pump Capacity (gpm)
1970	American General 6x6 Brush Tender		1000	
1986	GMC Water Tender	Type 2	3000	
1995	Ford Engine	Type 6	220	
1983	Dodge Engine	Type 6	210	
2003	Almonte Structural Engine	Type 1	1000	1250
1975	Hendrickson Ladder Truck	Type 1	1000	1500
1996	Chevy Suburban (EMS only)			

Station #2

Table 4.18. Shepherd Volunteer Fire Department Station #2 Equipment List.

Year	Make/Model	Type	Tank Capacity (gal)	Pump Capacity (gpm)
1972	American General 6x6 Brush Tender		1500	
1975	Ford Darley Structural Engine	Type 2	1000	500

Station #3

Table 4.19. Shepherd Volunteer Fire Department Station #3 Equipment List.

Year	Make/Model	Type	Tank Capacity (gal)	Pump Capacity (gpm)
	Brush Truck, 1 ton (DNRC owned – assigned to Bar Diamond Initial Attack)			

Station #4

Table 4.20. Shepherd Volunteer Fire Department Station #4 Equipment List.

Year	Make/Model	Type	Tank Capacity (gal)	Pump Capacity (gpm)
1975	American General 6x6 Brush Tender		800	

4.5.1.9 Blue Creek Volunteer Fire Department

Rick Cortez III, Chief
406-208-0524

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2144 Santiago Blvd
Billings, MT 59101

District Summary:

Blue Creek VFD is responsible for EMS, structure, and wildland fire protection for 54 square miles south of the Yellowstone River. The department is flanked on the west by Duck Creek IAA, on the east by Lockwood Fire District, and bordered to the south by the Crow Indian Reservation/BIA. There is one fire station in the service area. The station is located at the north end of our coverage area. We are an all-volunteer department with a total of 24 firefighters. Our primary areas of concern are structural fire protection and EMS, but due to the nature of our service area, the majority of our responses are wildland fires in wither grassland or timber environments. We are cabable of handling most Type 4 wildland incidents. Because of overlapping areas of responsibility, we have a mutual aid agreement with the Bureau of Indian Affairs.

Priority Areas:

Residential Growth:

The south and west ends of the fire service area have been experiencing significant residential growth over the last several years and indications are that this trend will continue into the foreseeable future.

The use of improper building materials, and/or construction practices for new construction in "high risk" wildland-urban interface areas and indefensible ground surrounding existing structures is a problem in some areas.

Communications:

Communications capabilities in our area are barely adequate. Topographical features within the area make radio communications with county dispatch and other agencies, difficult to impossible in some areas.

Firefighting Vehicles:

Due to limited funding, the age and capabilities of the firefighting vehicles in our department has been a concern.

Burn Permit Regulations:

The careless and unregulated use of fire to remove trash, weeds, and other burnable materials in addition to burning during stat burn ban periods needs to be addressed.

Effective Mitigation Strategies*:*

The department continues to keep pace with expansion in the area and has been successful in the upgrading of equipment and resources through the use of state and federal grants. The intent of the department is to continue to replace our aging equipment. Over the past six years, the fire service area has replaced two vehicles and is currently in the process of replacing two more.

Future plans include building a new fire station on the land the department owns in the area. Our current station is now located in a newly annexed area to the City of Billings. We are also looking to replace present vehicle and portable radio communications equipment.

County development of stricter building codes for designated "high risk" wildland-urban interface areas is needed. These codes should focus on the use of fire proof or fire retardant roofing,

siding materials, and roof ventilation systems that inhibit entry of airborne burning materials into roof and attic areas. Recommendations to persons building new homes to consider earthen terraces and patios constructed of non-flammable materials instead of highly flammable wooden decks should be developed. Additional considerations should also be made for the possible regulation of non-"Fire Wise" landscaping treatments and the mandatory inclusion of defensible space with green zones in these "high risk" areas.

Education and Training:

The department continues to emphasize the importance of continued training to our firefighters, and this issue could have just as easily been included in the "Priorities" section of the discussion. The department's members participate in training activities provided to us through our mutual aid agreement with surrounding departments and agencies in addition to local training activities conducted at our fire department drills. However, the department feels a countywide training program, if one were to be developed, would benefit us and the other departments by creating a more standardized level of training and familiarizing each agency to the other's equipment, personnel, and operating procedures.

The Blue Creek VFD participates in community education by hosting child fire safety education promotions in local schools. They familiarize the children to the appearance of firefighters in full turnout gear with SCBA and instruct them in safe evacuation techniques. Also, we do on-site evaluations of property to assist owners in making their homes more defensible in the event of a wildland fire.

Cooperative Agreements:

Blue Creek VFD has mutual aid agreements with Yellowstone County and the Bureau of Indian Affairs. The department believes they have very good working relationships with these agencies and enjoy the cooperative nature of this mutually beneficial association.

Current Resources:

Table 4.21. Blue Creek Volunteer Fire Department Equipment List.

Year	Make/Model	Tank Capacity (gal)	Pump Capacity (gpm)
1976	Ford Boardman	750	1000
1989	Ford Marion Mini-pumper	200	250
1986	Ford Type 6 ¾ ton 4x4	200	105
1991	Chevy Type 6 ¾ ton 4x4	200	100
1990	Chevy Type 6 1ton 4x4	200	105
1972	International Tender	3000	150 pto
1979	Ford F600 Heavy Type 6	300	100

The 1979 Ford F600 is on loan to Blue Creek VFD from the Department of Natural Resources through the Montana Department of State Lands. Though this truck is owned by the state government, the fire service area is responsible for the equipping and operating costs.

Future Considerations:

Blue Creek VFD will continue to be actively engaged in upgrading and modernizing existing vehicles and equipment assets. Protecting our community and our firefighters is our paramount objective. The building of a new fire station in the Blue Creek area is in the initial stages at this time (November 2005), with anticipated completion within the next three to five years. This station will provide the fire department with much needed space and training facilities to allow the department to keep pace with the needs of the firefighters and the community.

As previously stated, there is a need in the County for new regulations concerning new construction in "high risk" wildland-urban interface areas and stricter burn permit regulations. Some individuals may view these new regulations as unnecessarily restrictive, but these changes could reduce insurance rates and the loss of life and property within our communities.

4.5.1.10 Laurel Volunteer Fire Department

Current Resources:

Table 4.22. Laurel Volunteer Fire Department Equipment List.

Year	Make/Model	Name	Tank Capacity (gal)	Pump Capacity (gpm)
1996	Freightliner	Engine #1	750	1250
1990	Becker	Engine #4	750	1000
1976		Engine #3	750	1000
2002	Freightliner	Tender #1	4000	
1976	Kenworth	Tender #2	4000	
1978	Ford F-350	Brush #1	250	
1958	2 ½ ton Truck	Brush #2	750	
1992	Oheo 1 ton	Brush #3	250	
1960	Engine (converted)	Brush #4	750	
1974	Ford Truck (converted)	Support #1		
1993	Suburban	Support #2		

4.5.2 Wildland Fire Protection

4.5.2.1 Bureau of Land Management

Irv Leach, Fire Management Officer
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1299 Rimtop Dr.
Billings, MT 59105

District Summary:

The Following information was excerpted from the Billings Field Office Fire Management Plan. For more detailed information please visit the web at: http://www.mt.blm.gov/fire/fireplans/index.html.

There are approximately 78,500 acres of BLM administered lands within Yellowstone County. An Interagency Fire Dispatch center is located within the City of Billings to assist wildland suppression forces under the direction of the Billings BLM Field Office (BIFO). This dispatch center directs the wildland fire response of two Type-6 engines and two 800 gallon Single Engine Air Tankers (SEATs), as well as numerous operational and administrative wildland fire support personnel. The Billings BLM Fire Program conducts all wildland fire management actions in compliance with the 1995 Federal Wildland Fire Policy and the 2001 Federal Wildland Fire Policy Update guiding principles. These principles are:

- Firefighter and public safety are the highest priority in every fire management activity.
- Provide an appropriate management response (AMR) on all wildland fires, with emphasis based on risks to firefighter and public safety, consistent with resource objectives weather and fuels conditions, threats and values to be protected, cost

efficiencies and standards and guidelines . AMR allows land managers to tailor preplanned wildland fire responses to meet objectives established in resource management plans and their associated implementation plans.

- Work with communities at risk to assess risk in terms of direct wildland fire impacts and implement programs to mitigate that risk through collaborative planning and projects.

- Establish partnerships with all interagency cooperators to facilitate coordinated fire management activities.

- Encourage close coordination and collaboration among specialists within the BIFO and among the BIFO and federal, interested organizations, private landowners, state, and local partners.

- Develop and use the best scientific information available to deliver technical and community assistance to support ecological, economic, biological, physical and sociological factors.

- Wildland fire use is not approved in the current land use plan so fire use objectives and goals will not be addressed in this plan.

Priority Areas:

The BLM has on-going hazard mitigation projects in WUI areas including the Shepherd Ah-Nei Recreation Area, the Pompeys Pillar National Monument, Acton area, South Hills area, Four Dances Natural area, and Sundance Lodge SRMA (maps of these areas are included in Appendix I). They are also dedicated to identifying other higher risk WUI areas within their ownership with the intention of implementing fuels mitigation projects for the safety of public users.

Education and Training:

All training and education is done in accordance with NWCG and Northern Rockies Coordination Group/ Northern Rockies Geographic Area Interagency Wildland Fire Training program standards. Any information pertaining to this process can be accessed through: http://nationalfiretraining.net/nr/

BLM is an active participant throughout the Billings protection zone working with county and local government, as well as private entities in education, prevention and mitigation activities. Community education presentations are frequent throughout the county to interested persons upon request, as well as local school presentations with a “prevention” theme covering various younger age groups.

One of the most facilitative projects within the county is the cooperative fire restrictions coordination between the various agencies. The BLM works extremely well with local governments when evaluating the need for fire restrictions and when processing requests for and implementing fire restrictions. This allows for uniform restrictions across the county.

Cooperative Agreements:

All cooperative agreements with county and state entities within the Billings Field Office fire protection boundary are currently under revision.

Current Resources:

Table 4.23. Bureau of Land Management Available Equipment List for Yellowstone County

ENGINES

Year	Make	Model	Tank Capacity	Pump Capacity
2001	Ford F-550	BLM Brush Model Type-6	300 gal	90 gpm
2005	GMC 5500	BLM Brush Model Type-6 (CAFs Unit)	400 gal	125 gpm

AIRCRAFT

Make/Model	Capacity	Availability
Air Tractor 802 Single Engine Air Tanker	800 gal	Available July 4th through Sept 1st
Air Tractor 802 Single Engine Air Tanker	800 gal	Available July 4th through Sept 1st

Bureau of Land Management Project Area Maps are included in Appendix I.

4.5.2.2 Bureau of Indian Affairs, Crow Agency Wildland Fire and Aviation Management Program

Ed Morgan, Forest Manager
Steve Collins, Fire Management Officer
BIA Crow Agency, Forestry
P.O. Box 69
Crow Agency, MT. 59022

District Summary:

There are approximately 139,983 acres of Tribal lands administered by the U.S. Bureau of Indian Affairs within the southeast part of Yellowstone County. These lands are within the exterior boundaries of the Crow Indian Reservation. Additionally, north of the reservation boundary lays an area known as the Crow Ceded area, in which approximately 41 tribal tracts exist, totaling roughly 2,000 acres and about 108 allotted tracts, totaling roughly 12,000 similar acres. Some of these lands are within Yellowstone County.

Wildland fire activities, including suppression within the Crow Reservation, are coordinated from the Crow Agency Forestry complex. This station has eight garage bays that house wildland fire suppression vehicles. A 100 person fire cache for equipping Type II MIF crews is available at the Crow Forestry Station. This cache is used for both agency and off-reservation fire dispatches.

The B.I.A. Crow Agency Wildland Fire and Aviation Management Program only fights wildland fires. Structure fires, vehicle fires, and dump fires are the responsibility of the local city, county, or tribal fire departments. Wildland fire management engines will not be used for structural firefighting.

Helicopter operations are housed at a separate helibase just down the street from the main forestry complex. There is one helipad with room for one additional helicopter on an emergency or temporary basis. In 2005, a new helibase operations building was built at Crow Agency to support the BIA Helitack Crew and contract helicopter. There is also a temporary helipad behind the Pryor Forestry Station, just south of the Yellowstone County line.

All personnel hired by or through B.I.A Crow Agency will meet minimum wildland fire qualification requirements which are equal to or exceed those recommended by the NWCG.

The BIA Crow Agency Wildland Fire and Aviation Management Program objectives include the following:

* Take aggressive and continued suppression action on wildland grass, brush, and timber fires that threaten human life, structures, or high value resources without compromising firefighter safety.

* Strive to prevent disastrous conflagrations that impact management objectives, have adverse environmental consequences, and affect the socioeconomic conditions of the area by conducting a fire prevention program that will reduce human caused wildfires.

* Provide guidelines for the implementation of an Appropriate Management Response (AMR) type fire management strategy, based on protection of human life, identified private property, high value resources, and fuel types, and burning conditions.

* Encourage good interagency relationships with adjacent federal, tribal, state, county and local fire fighting agencies in the spirit of mutual support and interagency cooperation.

Wildland Fire Organization - Initial Attack (IA) Resources/Equipment

Crow Agency:

3 - Type 6 Wildland Fire Engines, 4x4, 200 gallon, Model 52
1 - Type 4 Wildland Fire Engine, 4x2, 750 gallon, Model 52
1 - Type 3 Helicopter with bucket and helitack personnel (7/1 to 9/30)
1 - Helitack Crew Carrier with equipment
1 - Type 7 Slip-on Unit, 4x4 crew cab, 100 gallon
1 - Type 2 Water Tender, 6x4, 4000 gallon, 200 gpm (Branch of Roads)
1 - Road Grader (Branch of Roads)
1 - Type 2 Bulldozer, Cat D-6H & Transport (Branch of Roads)

Pryor:

2 - Type 6 Wildland Fire Engines, 4x4, 200 gallon, Model 52
1 - Road Grader (Branch of Roads)

4.6 Current Wildfire Mitigation Activities in Yellowstone County

4.6.1 Yellowstone County Coop Program

The County Coop Program is a formal written agreement between the Montana DNRC and all of the counties in eastern Montana. The plan is based on the following elements:

- The county is responsible for the suppression of all wildland fires on private and State land.
- If the suppression effort exceeds the counties capabilities, the county fire warden or commissioners call for assistance.
- The county must put the request in writing and submit to the DNRC Land Office (Southern-Billings, Eastern-Miles City, or Northeastern-Lewistown) within 48 hours of the request. Yellowstone County falls into the Southern Land Office area of responsibility.

- The DNRC/State of Montana pays the full cost for everything that is ordered on the fire.
- The county resources on the fire are in a non-pay status as far as the DNRC financial end of the incident is concerned. (The county road equipment costs are paid for by that particular county). The fire district(s) of the particular fire within the county maintain the Incident Command and use their own equipment to help with the extended attack. Once the fire is controlled and contained, the DNRC turns the incident back to the county, department, or district.

The other layer to the County Coop Program is that the DNRC also offers NWGG fire course training and fire equipment (Fed Excess Property or DNRC developed equipment) to the counties. Usually the county fire council and DNRC Rural Fire Coordinator decide which departments within the county get this particular equipment and what courses are needed.

4.6.2 Lockwood Fire District Education and Awareness Campaign

The Lockwood Fire District currently maintains a public education program for citizens within their district. This includes having firefighters go door-to-door with brochures and advice regarding home defensible space in the wildland-urban interface. Firefighters also explain to homeowners how maintaining a clean defensible space can help save their property and families during a wildfire event. As part of this program, other home defensibility issues are recognized and identified to interested homeowners such as access and water availability concerns.

4.7 Issues Facing Yellowstone County Fire Protection

4.7.1 Augmentation of Emergency Water Supplies

Residential growth will likely accelerate in the coming years in all areas of Yellowstone County. Growth will continue to stress rural and wildland fire suppression abilities into the future. It is prudent to address development practices before they become significant issues. Of primary concern to fire departments will be water availability and access. County zoning and planning officials need to address this issue in order to assure that new development is built following specifications that will result in a safe and prosperous community.

In many rural areas of Yellowstone County, there are no readily accessible, year-round water resources available for use by local fire departments. Thus, it is necessary for firefighters to keep large amounts of water loaded on trucks at all times. In the event of a large fire situation, additional water supplies must be transported to the site. The Yellowstone County fire departments feel that establishing permanent augmentations to emergency water supplies is necessary throughout the County. This includes establishment of pressurized water delivery systems in subdivisions as well as establishment of dry hydrants and drafting sites where immediate access to water is limited. Retrofitting dependable, year-round irrigation water sources with necessary fittings for use by emergency response equipment would also be highly beneficial. Once developed, these water sources need to be mapped and use agreements need to be made between landowners, local fire departments, the Crow Indian Reservation, the Montana Department of Natural Resources and Conservation, and the Bureau of Land Management.

4.7.2 Recruitment and Retention, Funding, Equipment Needs, Etc.

There are a number of pervasive issues that challenge volunteer districts within Yellowstone County. A short list of such issues include recruitment and retention of volunteers, lack of funding for equipment needs, keeping pace increases in training requirements, as well as numerous other factors that test district's abilities. The members of all fire protection districts should be recognized for the dedication they have shown and the excellent level of protection they provide for residents throughout the county. Volunteers take time out of their lives every day in order to assure the safety of the community.

The demands on volunteer departments are considerable. Keeping pace with ever-increasing training requirements can lead to burn-out of volunteers who are scantly compensated for their time and efforts. Keeping pace with the growing needs of the communities the districts serve is a constant challenge as well. Although there are many potential funding sources available for local districts to acquire equipment and other needs, grant writing and chasing of funding sources takes considerable time and effort. Recommendations that can help to reduce these challenges will be presented in Chapter 5.

4.7.3 Persistent Rapid Growth

Growth will continue to present the greatest challenge to fire management in the urban interface over the long term. The dramatic increase in demand for homes throughout Yellowstone County has resulted in significant changes in land use patterns. Many agricultural lands and private non-industrial rangelands have been sold and subdivided over the last few decades, pushing residential development further into the wildlands. This trend will continue into the future, as forestland and rangelands are sold for real estate development. This will have a dramatic effect on the ability of emergency resources to maintain current levels of fire protection without considerable increases in funding for equipment, personnel, and training. Indeed, many emergency response resources in Yellowstone County are already at a critical threshold. Further increases in protection responsibility will come at the expense of preparedness, as emergency resources are increasingly spread over an expanding protection area.

4.7.4 Accessibility

Fire chiefs throughout the County have identified home accessibility issues as a primary concern in some parts of Yellowstone County. It appears as though many homes and driveways have been constructed without regard to access requirements of large emergency vehicles. Lack of accessibility precludes engagement by suppression resources. Many homes within fire protection districts in Yellowstone County effectively have no fire protection simply because access is not possible or is potentially dangerous. Enforcement of the International Fire Code, regarding road and driveway construction standards for fire apparatus would prevent accessibility issues in new developments.

4.8 Proposed Home Defensible Space and Education Projects

The following are areas specifically identified by the committee as needing fuels treatments around homes. These projects would consist of individual home site assessments conducted by professionals to identify needed actions to help homeowners prepare for wildland fires. The assessments generally benefit the homeowner by providing specific wildfire information and preventative measures that they can do to improve the safety of their homes and families. If the homeowner agrees to these recommendations, the defensible space project would then be completed by a professional contractor. Individual home projects vary, but usually consist of

brush clearing, very selective tree removal, pruning, weed eradication, and slash removal. These projects along with estimated costs are included in Table 5.2.

Billings Area/Blue Creek Area

- Rehberg Ranch Estates
- Briarwood Subdivision
- Indian Cliffs
- Alkali Creek
- Hills Estates
- Secret Valley

Molt Area

- Echo Canyon

Laurel Area

- Clapper Flats
- Buffalo Trails

Shepherd/Huntley/Worden Area

- Pleasant Hollow
- Shadow Canyon
- Cedar Ridge
- White Buffalo

Lockwood Area

- Emerald Hills
- Pine Hills
- High Trails

Chapter 5: Treatment Recommendations

5 Administration & Implementation Strategy

Critical to the implementation of this Community Wildfire Protection Plan will be the identification of, and implementation of, an integrated schedule of treatments targeted at achieving an elimination of the lives lost, and reduction in structures destroyed, infrastructure compromised, and unique ecosystems damaged that serve to sustain the way-of-life and economy of Yellowstone County and the region. Since there are many land management agencies and thousands of private landowners in Yellowstone County, it is reasonable to expect that differing schedules of adoption will be made and varying degrees of compliance will be observed across all ownerships.

Yellowstone County encourages the philosophy of instilling disaster resistance in normal day-to-day operations. By implementing plan activities through existing programs and resources, the cost of mitigation is often a small portion of the overall cost of a project's design or program.

The federal land management agencies in Yellowstone County, specifically Bureau of Land Management, are participants in this planning process and have contributed to its development. Where available, their schedule of land treatments have been considered in this planning process to better facilitate a correlation between their identified planning efforts and the efforts of Yellowstone County.

All risk assessments were made based on the conditions existing during 2005, thus, the recommendations in this section have been made in light of those conditions. However, the components of risk and the preparedness of the county's resources are not static. It will be necessary to fine-tune this plan's recommendations annually to adjust for changes in the components of risk, population density changes, infrastructure modifications, and other factors.

As part of the Policy of Yellowstone County in relation to this planning document, the Community Wildfire Protection Plan should be reviewed annually at a special meeting of the Yellowstone County Commissioners, open to the public and involving all municipalities/jurisdictions, where action items, priorities, budgets, and modifications can be made or confirmed. A written review of the plan should be prepared (or arranged) by the Chairman of the County Commissioners, detailing plans for the year's activities, and made available to the general public ahead of the meeting (in accord with the Montana Open Public Meeting Laws). Amendments to the plan should be detailed at this meeting, documented, and attached to the formal plan as an amendment to the Community Wildfire Protection Plan. Total re-evaluation of this plan should be made on the 5th anniversary of its acceptance, and every 5-year period following.

5.1 Prioritization of Mitigation Activities

Prioritization of projects will occur at the County, City, agency, and private levels. Differing prioritization processes will occur, however, the county and cities will adopt the following prioritization process, as indicated through the adoption of this plan by each municipality.

The prioritization process will include a special emphasis on cost-benefit analysis review. The process will reflect that a key component in funding decision is a determination that the project will provide an equivalent or more in benefits over the life of the project when compared with the

costs. Projects will be administered by county and local jurisdictions with overall coordination provided by the County Disaster and Emergency Services Director.

County Commissioners and the elected officials of all jurisdictions will evaluate opportunities and establish their own unique priorities to accomplish mitigation activities where existing funds and resources are available and there is community interest in implementing mitigation measures. If no federal funding is used in these situations, the prioritization process may be less formal. Often the types of projects that the County can afford to do on their own are in relation to improved codes and standards, department planning and preparedness, and education. These types of projects may not meet the traditional project model, selection criteria, and benefit-cost model. The County will consider all pre-disaster mitigation proposals brought before the County Commissioners by department heads, city officials, fire districts and local civic groups.

When federal or state funding is available for hazard mitigation, there are usually requirements that establish a rigorous benefit-cost analysis as a guiding criterion in establishing project priorities. The county will understand the basic federal grant program criteria which will drive the identification, selection, and funding of the most competitive and worthy mitigation projects. FEMA's three grant programs (the post-disaster Hazard Mitigation Grant Program, the pre-disaster Flood Mitigation Assistance and Pre-Disaster Mitigation grant programs) that offer federal mitigation funding to state and local governments all include the benefit-cost and repetitive loss selection criteria.

The prioritization of projects will occur annually and be facilitated by the County Disaster and Emergency Services Director to include the County Commissioner's Office, City Mayors and Councils, Fire District Chiefs and Commissioners, agency representatives (USFS, BLM, WA DNR, BIA, etc.). The prioritization of projects will be based on the selection of projects which create a balanced approach to pre-disaster mitigation which recognizes the hierarchy of treating in order (highest first):

- People and Structures
- Infrastructure
- Local and Regional Economy
- Traditional Way of Life
- Ecosystems

5.1.1 Prioritization Scheme

A numerical scoring system is used to prioritize projects. This prioritization serves as a guide for the county when developing mitigation activities. This project prioritization scheme has been designed to rank projects on a case by case basis. In many cases, a very good project in a lower priority category could outrank a mediocre project in a higher priority. The county mitigation program does not want to restrict funding to only those projects that meet the high priorities because what may be a high priority for a specific community may not be a high priority at the county level. Regardless, the project may be just what the community needs to mitigate disaster. The flexibility to fund a variety of diverse projects based on varying reasons and criteria is a necessity for a functional mitigation program at the county and community level.

To implement this case by case concept, a more detailed process for evaluating and prioritizing projects has been developed. Any type of project, whether county or site specific, will be prioritized in this more formal manner.

To prioritize projects, a general scoring system has been developed. This prioritization scheme has been used in statewide all hazard mitigations plans. These factors range from cost-benefit ratios, to details on the hazard being mitigated, to environmental impacts.

Since planning projects are somewhat different than non-planning projects when it comes to reviewing them, different criteria will be considered, depending on the type of project.

The factors for the non-planning projects include:

- Benefit / Cost
- Population Benefit
- Property Benefit
- Economic Benefit
- Project Feasibility (environmentally, politically, socially)
- Hazard Magnitude/Frequency
- Potential for repetitive loss reduction
- Potential to mitigate hazards to future development
- Potential project effectiveness and sustainability

The factors for the planning projects include:

- Benefit / Cost
- Vulnerability of the community or communities
- Potential for repetitive loss reduction
- Potential to mitigate hazards to future development

Since some factors are considered more critical than others, two ranking scales have been developed. A scale of 1-10, 10 being the best, has been used for cost, population benefit, property benefit, economic benefit, and vulnerability of the community. Project feasibility, hazard magnitude/frequency, potential for repetitive loss reduction, potential to mitigate hazards to future development, and potential project effectiveness and sustainability are all rated on a 1-5 scale, with 5 being the best. The highest possible score for a non-planning project is 65 and for a planning project is 30.

The guidelines for each category are as follows:

5.1.1.1 Benefit / Cost

The analysis process will include summaries as appropriate for each project, but will include benefit / cost analysis results. Projects with a negative benefit / cost analysis result will be ranked as a 0. Projects with a positive Benefit / Cost analysis will receive a score equal to the projects Benefit / Cost Analysis results divided by 25. Therefore a project with a BC ratio of 125:1 would receive 5 points, a project with a BC ratio of 250:1 (or higher) would receive the maximum points of 10.

5.1.1.2 Population Benefit

Population Benefit relates to the ability of the project to prevent the loss of life or injuries. A ranking of 10 has the potential to impact 90% or more of the people in the municipality (county, city, or district). A ranking of 5 has the potential to impact 50% of the people, and a ranking of 1 will not impact the population. The calculated score will be the percent of the population impacted positively multiplied by 10. In some cases, a project may not directly provide population benefits, but may lead to actions that do, such as in the case of a study. Those

projects will not receive as high of a rating as one that directly effects the population, but should not be considered to have no population benefit.

5.1.1.3 Property Benefit

Property Benefit relates to the prevention of physical losses to structures, infrastructure, and personal property. These losses can be attributed to potential dollar losses. Similar to cost, a ranking of 10 has the potential to save $20,000,000 or more in losses. Property benefit of less than $20,000,000 will receive a score of the benefit divided by $20,000,000 (a ratio below $20 million). The calculated score will be the percent of the population impacted positively multiplied by 10. Therefore, a property benefit of $6,000,000 would receive a score of 3. In some cases, a project may not directly provide property benefits, but may lead to actions that do, such as in the case of a study. Those projects will not receive as high of a rating as one that directly effects property, but should not be considered to have no property benefit.

5.1.1.4 Economic Benefit

Economic Benefit is related to the savings from mitigation to the economy. This benefit includes reduction of losses in revenues, jobs, and facility shut downs. Since this benefit can be difficult to evaluate, a ranking of 10 would prevent a total economic collapse, a ranking of 5 could prevent losses to about half the economy, and a ranking of 1 would not prevent any economic losses. In some cases, a project may not directly provide economic benefits, but may lead to actions that do, such as in the case of a study. Those projects will not receive as high of a rating as one that directly affects the economy, but should not be considered to have no economic benefit.

5.1.1.5 Vulnerability of the Community

For planning projects, the vulnerability of the community is considered. A community that has a high vulnerability with respect to other jurisdictions to the hazard or hazards being studied or planned for will receive a higher score. To promote planning participation by the smaller or less vulnerable communities in the state, the score will be based on the other communities being considered for planning grants. A community that is the most vulnerable will receive a score of 10, and one that is the least, a score of 1.

5.1.1.6 Project Feasibility (Environmentally, Politically & Socially)

Project Feasibility relates to the likelihood that such a project could be completed. Projects with low feasibility would include projects with significant environmental concerns or public opposition. A project with high feasibility has public and political support without environmental concerns. Those projects with very high feasibility would receive a ranking of 5 and those with very low would receive a ranking of 1.

5.1.1.7 Hazard Magnitude/Frequency

The Hazard Magnitude/Frequency rating is a combination of the recurrence period and magnitude of a hazard. The severity of the hazard being mitigated and the frequency of that event must both be considered. For example, a project mitigating a 10-year event that causes significant damage would receive a higher rating than one that mitigates a 500-year event that causes minimal damage. For a ranking of 5, the project mitigates a high frequency, high

magnitude event. A 1 ranking is for a low frequency, low magnitude event. Note that only the damages being mitigated should be considered here, not the entire losses from that event.

5.1.1.8 Potential for repetitive loss reduction

Those projects that mitigate repetitive losses receive priority consideration here. Common sense dictates that losses that occur frequently will continue to do so until the hazard is mitigated. Projects that will reduce losses that have occurred more than three times receive a rating of 5. Those that do not address repetitive losses receive a rating of 1.

5.1.1.9 Potential to mitigate hazards to future development

Proposed actions that can have a direct impact on the vulnerability of future development are given additional consideration. If hazards can be mitigated on the onset of the development, the county will be less vulnerable in the future. Projects that will have a significant effect on all future development receive a rating of 5. Those that do not affect development should receive a rating of 1.

5.1.1.10 Potential project effectiveness and sustainability

Two important aspects of all projects are effectiveness and sustainability. For a project to be worthwhile, it needs to be effective and actually mitigate the hazard. A project that is questionable in its effectiveness will score lower in this category. Sustainability is the ability for the project to be maintained. Can the project sustain itself after grant funding is spent? Is maintenance required? If so, are or will the resources be in place to maintain the project. An action that is highly effective and sustainable will receive a ranking of 5. A project with effectiveness that is highly questionable and not easily sustained should receive a ranking of 1.

5.1.1.11 Final ranking

Upon ranking a project in each of these categories, a total score can be derived by adding together each of the scores. The project can then be ranking high, medium, or low based on the project thresholds of:

Project Ranking Priority Score Non-Planning Projects

- High 40-65
- Medium 25-39
- Low 9-24

Project Ranking Priority Score Planning Projects

- High 18-30
- Medium 12-17
- Low 1-11

5.2 Possible Fire Mitigation Activities

As part of the implementation of fire mitigation activities in Yellowstone County, a variety of management tools may be used. Management tools include but are not limited to the following:

- Homeowner and landowner education
- Building code changes for structures and infrastructure in the WUI

- Home site defensible zone through fuels modification
- Community defensible zone fuels alteration
- Access improvements
- Access creation
- Emergency response enhancements (training, equipment, locating new fire stations, new fire departments, merging existing departments)
- Regional land management recommendations for private, state, and federal landowners

Maintaining private property rights will continue to be one of the guiding principles of this plan's implementation. Sound risk management is a foundation for all fire management activities. Risks and uncertainties relating to fire management activities must be understood, analyzed, communicated, and managed as they relate to the cost of either doing or not doing an activity. Net gains to the public benefit will be an important component of decisions.

5.2.1 Existing Practices That Should Continue

Yellowstone County currently is implementing many projects and activities that, in their absence, could lead to increased wildland fire loss potential. By enumerating some of them here, it is the desire of the authors to point out successful activities.

- Existing rural addressing efforts have aided emergency responses well.
- The City of Billings currently operates the 911 Dispatch Center, which not only handles law enforcement and emergency medical calls, but also provides dispatch service to all of the County's fire companies. For large-scale incidents, the County Emergency Operations Center is activated.
- Automatic mutual aid is dispatched in extreme dry wildland conditions and stage 2 restrictions.
- Land management agencies within the county are conducting fuel reduction projects in response to increasing concerns of fire hazard in WUI areas.
- Several of the rural fire departments have begun implementing educational and awareness programs within their jurisdictions as their budgets allow. Many of these programs are geared towards schools; however, some have gone as far as door-to-door campaigns in high risk areas.

5.3 WUI Safety & Policy

Wildfire mitigation efforts must be supported by a set of policies and regulations at the county level that maintain a solid foundation for safety and consistency. The recommendations enumerated here serve that purpose. Because these items are regulatory in nature, they will not necessarily be accompanied by cost estimates. These recommendations are policy related and therefore are recommendations to the appropriate elected officials; debate and formulation of alternatives will serve to make these recommendations suitable and appropriate.

5.3.1 Overall Goals

Reduce Yellowstone County's wildfire risk by mitigating hazards affecting communities through improvement of County policies and enhancement of individual and public safety. Specific goals outlined by the County include:

- Educate the public regarding the existence of eminent hazards and how to respond during a wildfire event.
- Improve emergency response capabilities.
- Develop policies and standards concerning new building and housing projects that will reduce their exposure to fire risk factors.

5.3.2 Proposed Activities

Table 5.1. WUI Action Items in Safety and Policy.

Action Item	Goals and Objectives	Responsible Organization	Action Items & Planning Horizon
5.1.a: Adoption and enforcement of International Building Codes and/or more stringent hazard--related building code provisions.	**Protection of people and structures** by improving the ability of emergency response personnel to respond to threatened homes in high-risk areas. Project Ranking Priority Score: **High** (24/30)	**Yellowstone County Commissioners**, Yellowstone County Building Department, City of Billings, City of Laurel, Town of Broadview, and the County Fire Warden.	**2006**: Annual review of IBC updates and relevance to hazards in the County.
5.1.b: Develop County policy concerning building materials used in high-risk WUI areas on existing structures and new construction.	**Protection of people and structures** by improving the ability of emergency response personnel to respond to threatened homes in high-risk areas. Project Ranking Priority Score: **High** (30/30)	**County Commissioners Office** in cooperation with Billings Fire Department, Billings Urban FSA, Molt VFD, Homewood Park IAA, Duck Creek VFD, Shepherd VFD, Blains IAA, Blue Creek VFD, Lockwood VFD, Hailey Bench VFD, Crow Indian Reservation, Worden VFD, Custer VFD, Broadview FD #3, Worden FD #4, Laurel FD #5, Laurel FD #7, Lockwood FD #8, Blue Creek FSA, Laurel Urban FSA, Shepherd FSA, and Huntley Project FSA.	**2006**: Consider and develop policy to address construction materials for homes and businesses located in high wildfire risk areas. Specifically, a County policy concerning wooden roofing materials and flammable siding, especially where adjacent to heavy wildland fuels.
5.1.c: Develop County policy requiring the installation of dry hydrants in subdivisions with 5 or more dwellings.	**Protection of people and structures** by improving the ability of emergency response personnel to respond to threatened homes in high-risk areas. Project Ranking Priority Score: **High** (24/30)	**County Commissioners Office and City and County Planning Department** in cooperation with Billings Fire Department, Billings Urban FSA, Molt VFD, Homewood Park IAA, Duck Creek VFD, Shepherd VFD, Blains IAA, Blue Creek VFD, Lockwood VFD, Hailey Bench VFD, Crow Indian Reservation, Worden VFD, Custer VFD, Broadview FD #3, Worden FD #4, Laurel FD #5, Laurel FD #7, Lockwood FD #8, Blue Creek FSA, Laurel Urban FSA, Shepherd FSA, and Huntley Project FSA.	**2006**: Consider and develop policy to address the need for additional water resources for homes and businesses located in high wildfire risk areas. Specifically, a County policy requiring the installation of dry hydrants in subdivisions with 5 or more dwellings, especially where adjacent to heavy wildland fuels.

Table 5.1. WUI Action Items in Safety and Policy.

Action Item	Goals and Objectives	Responsible Organization	Action Items & Planning Horizon
5.1.d: Begin distributing "New Code of the West" pamphlets with sub-division permit requests.	**Protection of people and structures** by improving the ability of emergency response personnel to respond to threatened homes in high-risk areas. Project Ranking Priority Score: **High** (40/65)	**County Commissioners, City and County Planning Departments**, City of Billings, City of Laurel, and Town of Broadview.	• **2006**: Obtain copyrights to "New Code of the West" pamphlet. • **2006**: Distribute pamphlets.
5.1.e: Develop a policy to enforce "No Burning" restrictions in specified high risk subdivisions.	**Protection of people and structures** by reducing the fire ignition risk in high-risk areas. Project Ranking Priority Score: **High** (26/30)	**County Commissioners, City and County Planning Departments**, City of Billings, City of Laurel, Town of Broadview, and rural subdivision associations.	• **2006**: Consider and develop policy to address burning regulations for subdivisions and population clusters located in high wildfire risk areas. Specifically, a County policy concerning a "No Burning" restriction where subdivisions are juxtaposed near heavy wildland fuels
5.1.f: Review need to inspect and enforce access and water issues in new subdivisions and individual homes.	**Protection of people and structures** by improving the ability of emergency response personnel to respond to threatened homes in high-risk areas. Project Ranking Priority Score: **High** (27/30)	**County Commissioners**, City and County Planning Departments, County Fire Warden, City of Billings, City of Laurel, and Town of Broadview.	• **2006-07**: Study need for inspections and enforcement of access and water issues and other programmatic responses. • **2007**: Review need for inspector and potential duties.
5.1.g: Develop county policy concerning access in moderate to high-risk WUI areas where subdivisions are built to insure adequate ingress and egress during wildfire emergencies.	**Protection of people and structures** by improving the ability of emergency response personnel to respond to threatened homes in high-risk areas. Project Ranking Priority Score: **High** (30/30)	**County Commissioners Office and Planning Board** in cooperation with Billings Fire Department, Billings Urban FSA, Molt VFD, Homewood Park IAA, Duck Creek VFD, Shepherd VFD, Blains IAA, Blue Creek VFD, Lockwood VFD, Hailey Bench VFD, Crow Indian Reservation, Worden VFD, Custer VFD, Broadview FD #3, Worden FD #4, Laurel FD #5, Laurel FD #7, Lockwood FD #8, Blue Creek FSA, Laurel Urban FSA, Shepherd FSA, and Huntley Project FSA.	**2006**: Consider and develop policy to address access language for homes and businesses located in moderate to high wildfire risk areas. Specifically, a County policy concerning road widths, turning radii, and number of access points.

Table 5.1. WUI Action Items in Safety and Policy.

Action Item	Goals and Objectives	Responsible Organization	Action Items & Planning Horizon
5.1.h: Develop a county policy to support grant applications for projects resulting from this plan.	**Protection of people and structures** by improving the ability of residents and organizations to implement sometimes costly projects. Project Ranking Priority Score: **High** (30/30)	**County Commissioners Office**	**Ongoing activity:** Support grant applications as requested in a manner consistent with applications from residents and organizations in Yellowstone County.

5.4 People and Structures

The protection of people and structures will be tied together closely as the loss of life in the event of a wildland fire is generally linked to a person who could not, or did not, flee a structure threatened by a wildfire. The other incident is a firefighter who suffers the loss of life during the combating of a fire. Many of the recommendations in this section will define a set of criteria for implementation while others will be rather specific in extent and application.

Many of the recommendations in this section involve education to increase awareness and teach mitigation strategies to the residents of Yellowstone County. These recommendations stem from a variety of factors including items that became obvious during the analysis of the public surveys, discussions during public meetings, and observations about choices made by residents living in the Wildland-Urban Interface. Unlike many other counties across the west, Yellowstone County residents demonstrated a higher awareness of wildfire risk factors such as the responses to the homeowner survey questions concerning home risk factors. The results of that survey pointed to a recognition of risk very similar to what “fire professionals” estimated in the county. However, while the risk was recognized, it was still documented, giving specialists the opportunity to concentrate efforts on conveying methods of reducing risk instead of just learning how to identify it.

- Homeowners in the public mail survey ranked their home site wildfire risk factors very similar to the results of a random sample of home rankings completed by fire mitigation specialists.
- Discussions with the general public indicated an awareness of wildland fire risk, but they could not specifically identify risk factors.
- More than half (61%) of the respondents to the public mail survey indicated that they want to participate in educational opportunities focused on the WUI and what they can do to increase their home’s chances of surviving a wildfire.

In addition to those items enumerated in Table 5.1, residents and policy makers of Yellowstone County should recognize certain factors that exist today, that in their absence would lead to an increase in the risk factors associated with wildland fires in the WUI of Yellowstone County. These items listed below should be encouraged, acknowledged, and recognized for their contributions to the reduction of wildland fire risks:

- **Livestock Grazing** in and around the communities of Yellowstone County has led to a reduction of many of the fine fuels that would have been found in and around the

communities and in the wildlands of Yellowstone County. Domestic livestock not only eat these grasses, forbs, and shrubs, but also trample certain fuels to the ground where decomposition rates may increase. Livestock ranchers tend their stock, placing resource professionals into the forests and rangelands of the area where they may observe ignitions, or potentially risky activities. There are ample opportunities throughout the County to increase grazing. This could contribute to the economic output of the county as well as reduce the fuel loading. Livestock grazing in this region should be encouraged into the future as a low cost, positive tool of wildfire mitigation in the wildland-urban interface and in the wildlands.

- **Forest Health** in Yellowstone County has been greatly impacted by the continuation of drought conditions over the last decade. Drought related stress on many of the forest stands has also let to a widespread beetle infestation, which is further increasing the rate of mortality, particularly in the ponderosa pine. Thinning operations focused on removing dead and dying trees would help reduce the wildfire hazard; however, there is little forest resource professionals or others can do to help prevent further mortality caused by the lack of water.
- **Agriculture** is a significant component of Yellowstone County's economy. The original conversion of these lands to agriculture from rangeland, was targeted at the most productive soils and juxtaposition to infrastructure. Many of these productive ecosystems were consequently also at some of the highest risk to wildland fires because biomass accumulations increased in these productive landscapes. The result today, is that much of the rangeland historically prone to frequent fires, has been converted to agriculture, which is at a much lower risk than prior to its conversion. The preservation of a viable agricultural economy in Yellowstone County is integral to the continued management of wildfire risk in this region.

5.4.1 Overall Goals

Reduce Yellowstone County's wildfire risk by mitigating hazards affecting communities through direct improvement of personal and structure safety. Specific goals outlined by the County include:

- Improve the ability of communities to carry out necessary operations during emergency events.
- Educate the public regarding the existence of fire risk and how to respond during a wildfire event.
- Reduce the fire risk around homes and communities by maintaining a defensible space.
- Improve access and reduce the fire risk on major roads throughout the County.

5.4.2 Proposed Activities

Table 5.2. WUI Action Items for People and Structures.

Action Item	Goals and Objectives	Responsible Organization	Action Items, Planning Horizon and Estimated Costs
5.2.a: Youth and Adult Wildfire Educational Programs and Professional Development Training.	**Protect people and structures** by increasing awareness of WUI risks, how to recognize risk factors, and how to modify those factors to reduce risk. Project Ranking Priority Score: **High** (30/30)	Cooperative effort including: • Montana State University Extension Service • Montana Department of Natural Resources and Conservation • Bureau of Land Management • Local School Districts • U.S. Forest Service • Bureau of Indian Affairs, Crow Agency • Yellowstone County Fire Departments, Fire Districts, and Fire Service Areas	Evaluate effectiveness of currently funded County education programs. If possible, use existing educational program materials and staffing. These programs may need reformatted using Firewise materials. Formal needs assessments should be responsibility of Extension Service faculty and include the development of an integrated WUI educational series by year 3 (2008). Costs initially to be funded through existing budgets for these activities to be followed with grant monies to continue the programs as identified in the formal needs assessment. Detailed information on home defensible space requirements is contained on the Firewise CD, which can be purchased and personalized by the County. The CD costs $2,500.

Public Education Project Areas	Project Cost
Pine Hills Public Education Project Area Briarwood Public Education Project Area Secret Valley Public Education Project Area Echo Canyon Public Education Project Area	Public education targeted at specific communities or subdivisions is usually hosted and/or sponsored by the fire department, fire service area, or other related organization with jurisdiction in that area. Overall cost of educational classes is highly dependent on attendance and types of materials used; however, we can estimate that on average a class would cost $2,500. If other more time intensive or more individual citizen oriented methods are used the cost would likely increase due to the increase in manpower.

Table 5.2. WUI Action Items for People and Structures.

Action Item	Goals and Objectives	Responsible Organization	Action Items, Planning Horizon and Estimated Costs
5.2.b: Wildfire risk assessments of homes in identified communities.	**Protect people and structures** by increasing awareness of specific risk factors of individual home sites in the at-risk landscapes. Only after these are completed can home site treatments follow. Project Ranking Priority Score: **Prioritized with 5.2.c.**	To be implemented by **County Commissioners Office** in cooperation with **Billings Fire Department, Billings Urban FSA, Molt VFD, Homewood Park IAA, Duck Creek VFD, Shepherd VFD, Blains IAA, Blue Creek VFD, Lockwood VFD, Hailey Bench VFD, Crow Indian Reservation, Worden VFD, Custer VFD, Broadview FD #3, Worden FD #4, Laurel FD #5, Laurel FD #7, Lockwood FD #8, Blue Creek FSA, Laurel Urban FSA, Shepherd FSA, Huntley Project FSA, City of Billings, City of Laurel, and Town of Broadview**. Actual work may be completed by Wildfire Mitigation Consultants or trained volunteers.	• **Cost:** Approximately $100 per home site for inspection, written report, and discussions with the homeowners. • There are approximately 7,740 housing units outside of the High Density Urban WUI designation in Yellowstone County, roughly 5,031 (65%) of these structures would benefit from a home site inspection and budget determination for a total cost estimate of $503,100. • **Action Item:** Secure funding and contract to complete the inspections during years 1 & 2 (2006-07) • Home site inspection reports and estimated budget for each home site's treatments will be a requirement to receive funding for treatments through grants.

Table 5.2. WUI Action Items for People and Structures.

Action Item	Goals and Objectives	Responsible Organization	Action Items, Planning Horizon and Estimated Costs
5.2.c: Home Site WUI Treatments	**Protect people, structures, and increase firefighter safety** by reducing the risk factors surrounding homes in the WUI of Yellowstone County. Project Ranking Priority Score: **High** (42/65)	**County Commissioners** in cooperation with a Fire Mitigation Consulting company , Farm Service Agency, Billings Fire Department, Billings Urban FSA, Molt VFD, Homewood Park IAA, Duck Creek VFD, Shepherd VFD, Blains IAA, Blue Creek VFD, Lockwood VFD, Hailey Bench VFD, Crow Indian Reservation, Worden VFD, Custer VFD, Broadview FD #3, Worden FD #4, Laurel FD #5, Laurel FD #7, Lockwood FD #8, Blue Creek FSA, Laurel Urban FSA, Shepherd FSA, Huntley Project FSA, City of Billings, City of Laurel, Town of Broadview, and local subdivision and community associations. *Complete concurrently with 5.2.b.*	• Actual funding level will be based on the outcomes of the home site assessments and cost estimates • **Estimate** that treatments will cost approximately $900 per home site for a defensible space of roughly 150'. Approximately 3,483 (45%) home site treatments throughout the County would add up to an estimated cost of $3,134,700. • Home site treatments can begin after the securing of funding for the treatments and immediate implementation in 2006 and will continue from year 1 through 5 (2010). • Plan and implement an ongoing fuels reduction plan on Conservation Reserve Program lands surrounding home sites.

Table 5.2. WUI Action Items for People and Structures.

Action Item	Goals and Objectives	Responsible Organization	Action Items, Planning Horizon and Estimated Costs
5.2.d: Community Defensible Zone WUI Treatments, specifically in the Clapper Flats, Buffalo Trails, Rehberg Ranch Estates, Alkali Creek, Hills Estates, Indian Cliffs, Pleasant Hollow, Shadow Canyon, Cedar Ridge, White Buffalo, High Trails, and Emerald Hills subdivisions.	**Protect people, structures, and increase firefighter safety** by reducing the risk factors surrounding high risk communities in the WUI of Yellowstone County. Project Ranking Priority Score: **High** (50/65)	**County Commissioners** in cooperation with a Fire Mitigation Consultant, Farm Service Agency, Billings Fire Department, Billings Urban FSA, Molt VFD, Homewood Park IAA, Duck Creek VFD, Shepherd VFD, Blains IAA, Blue Creek VFD, Lockwood VFD, Hailey Bench VFD, Crow Indian Reservation, Worden VFD, Custer VFD, Broadview FD #3, Worden FD #4, Laurel FD #5, Laurel FD #7, Lockwood FD #8, Blue Creek FSA, Laurel Urban FSA, Shepherd FSA, Huntley Project FSA, City of Billings, City of Laurel, Town of Broadview, and local subdivision and community associations.	• Actual funding level will be based on the outcomes of the home site assessments and cost estimates. • **Years 2-5 (2007-10):** Treat high risk wildland fuels from home site defensible space treatments (5.4.c) to an area extending 400 feet to 750 feet beyond home defensible spaces, where steep slopes and high accumulations of risky fuels exist. Should link together home treatment areas. Treatments should focus on high risk concentrations of fuels and not 100% of the area identified. To be completed only after or during the creation of home defensible spaces have been implemented. • Approximate average cost on a per structure basis is $500 depending on extent of home defensibility site treatments, estimate 1077 (total number of structures in project areas) homes in need of this type of treatment for a cost estimate of $538,500. • Plan and implement an ongoing fuels reduction plan on Conservation Reserve Program lands surrounding communities.
5.2.e: Maintenance of Home Site WUI Treatments	**Protect people, structures, and increase firefighter safety** by reducing the risk factors surrounding homes in the WUI of Yellowstone County. Project Ranking Priority Score: **Prioritized with 5.2.f.**	**County Commissioners Office** in cooperation with Billings Fire Department, Billings Urban FSA, Molt VFD, Homewood Park IAA, Duck Creek VFD, Shepherd VFD, Blains IAA, Blue Creek VFD, Lockwood VFD, Hailey Bench VFD, Crow Indian Reservation, Worden VFD, Custer VFD, Broadview FD #3, Worden FD #4, Laurel FD #5, Laurel FD #7, Lockwood FD #8, Blue Creek FSA, Laurel Urban FSA, Shepherd FSA, Huntley Project FSA, and local home owners.	• Home site defensibility treatments must be maintained periodically to sustain benefits of the initial treatments. • Each site should be assessed 5 years following initial treatment • Estimated re-inspection cost will be $50 per home site on all sites initially treated or recommended for future inspections ($174,150) • Follow-up inspection reports with treatments as recommended years 5 through 10.

Table 5.2. WUI Action Items for People and Structures.

Action Item	Goals and Objectives	Responsible Organization	Action Items, Planning Horizon and Estimated Costs
5.2.f: Re-entry of Home Site WUI Treatments	**Protect people, structures, and increase firefighter safety** by reducing risk factors around homes in the WUI of Yellowstone County. Project Ranking Priority Score: **High** (47/65)	**County Commissioners Office** in cooperation with Billings Fire Department, Billings Urban FSA, Molt VFD, Homewood Park IAA, Duck Creek VFD, Shepherd VFD, Blains IAA, Blue Creek VFD, Lockwood VFD, Hailey Bench VFD, Crow Indian Reservation, Worden VFD, Custer VFD, Broadview FD #3, Worden FD #4, Laurel FD #5, Laurel FD #7, Lockwood FD #8, Blue Creek FSA, Laurel Urban FSA, Shepherd FSA, Huntley Project FSA, and local home owners.	• Re-entry treatments will be needed periodically to maintain the benefits of the initial WUI home treatments. Each re-entry schedule should be based on the initial inspection report recommendations, observations, and changes in local conditions. Generally occurs every 5-10 years.
5.2.g: Implement proposed home defensible space projects.	**Protect people, structures, and firefighter safety** by decreasing the fire risk around homes and communities.	**Rural Fire Departments, County Commissioners, area residents, and private contractor.**	• **Year 1 (2005):** Locate funding source and conduct home site evaluations for structures in mapped project areas. Write project plans for individual landowners. • **Year 2 (2006):** Continue to work with landowners to implement agreed upon project plans.

Defensible Space Project Areas	Acres	Project Cost	Priority Ranking
Rehberg Ranch Estates Defensible Space Treatment Area	1110.1	Approximately 92 structures at $900/per structure constitutes an estimated cost of $82,800.	**High** (40/65)
Clapper Flats Defensible Space Treatment Area	3463.0	Approximately 55 structures at $900/per structure constitutes an estimated cost of $49,500.	**Medium** (35/65)
Alkali Creek Defensible Space Treatment Area	448.6	Approximately 245 structures at $700/per structure constitutes an estimated cost of $171,500.	**High** (51/65)
Hills Estates Defensible Space Treatment Area	552.6	Approximately 13 structures at $500/per structure constitutes an estimated cost of $6,500.	**Medium** (38/65)
Buffalo Trails Defensible Space Treatment Area	7715.0	Approximately 138 structures at $900/per structure constitutes an estimated cost of $124,200.	**Medium** (38/65)
Indian Cliffs Defensible Space Treatment Area	228.0	Approximately 100 structures at $700/per structure constitutes an estimated cost of $70,000.	**High** (43/65)
Pleasant Hollow Defensible Space Treatment Area	2071.7	Approximately 86 structures at $900/per structure constitutes an estimated cost of $77,400.	**Medium** (36/65)

Table 5.2. WUI Action Items for People and Structures.

Action Item	Goals and Objectives	Responsible Organization	Action Items, Planning Horizon and Estimated Costs	
Cedar Ridge Defensible Space Treatment Area	2931.6	Approximately 47 structures at $700/per structure constitutes an estimated cost of $32,900.	**Medium** (35/65)	
White Buffalo Defensible Space Treatment Area	319.3	Approximately 22 structures at $500/per structure constitutes an estimated cost of $11,000.	**Medium** (33/65)	
High Trails Defensible Space Treatment Area	765.0	Approximately 25 structures at $500/per structure constitutes an estimated cost of $12,500.	**Medium** (39/65)	
Emerald Hills Defensible Space Treatment Area	1710.0	Approximately 234 structures at $900/per structure constitutes an estimated cost of $210,600.	**High** (49/65)	
Shadow Canyon Defensible Space Treatment Area	680.8	Approximately 20 structures at $500/per structure constitutes an estimated cost of $10,000.	**Medium** (33/65)	

5.5 Infrastructure

Significant infrastructure refers to the communications, transportation (road and rail networks), energy transport supply systems (gas and power lines), and water supply that service a region or a surrounding area. All of these components are important to Yellowstone County. These networks are by definition a part of the Wildland-Urban Interface in the protection of people, structures, **infrastructure**, and unique ecosystems. Without supporting infrastructure a community's structures may be protected, but the economy and way of life lost. As such, a variety of components will be considered here in terms of management philosophy, potential policy recommendations, and on-the-ground activities.

Communication Infrastructure: This component of the WUI seems to be diversified across the county with multiple source and destination points, and a spread-out support network. Although site specific treatments will impact local networks directly, little needs to be done to insure the system's viability. To ensure good communications with the DNRC and the BLM resources a narrow band capability is needed and the radio's need to be able to be placed in "scan mode" to monitor cooperators frequencies.

Transportation Infrastructure (road and rail networks): This component of the WUI has some potential limitations in Yellowstone County. Specific infrastructure components have been discussed in this plan.

Ignitions along highways are significant and should be addressed as part of the implementation of this plan. Various alternatives from herbicides to intensive livestock grazing coupled with mechanical treatments have been suggested. These corridors should be further evaluated with alternatives implemented. A variety of approaches will be appropriate depending on the landowner, fuels present, and other factors. These ignitions are substantial and the potential risk of lives to residents in the area is significant.

Many roads in the county have limiting characteristics, such as narrow travel surfaces, sharp turning radii, low load limit bridges and cattle guards, and heavy accumulations of fuels adjacent to some roads. Some of these road surfaces access remote forestland and rangeland areas. While their improvements will facilitate access in the case of a wildfire, they are not necessarily the priority for treatments in the County.

Roads that have these inferior characteristics and access homes and businesses are the priority for improvements in the county. Specific recommendations for these roads are enumerated in Table 5.2.

Energy Transport Supply Systems (gas and power lines): A number of power lines crisscross Yellowstone County. Nearly all of these power lines cross over rangeland ecosystems. When fires ignite in these vegetation types, the fires tend to be fast moving and burn at relatively low intensities. However, there is a potential for high temperatures and low humidity with high winds to produce enough heat and smoke to threaten power line stability. Most power line corridors have been cleared of vegetation both near the wires and from the ground below. It is the recommendation of this Community Wildfire Protection Plan that this situation be evaluated annually and monitored but that treatments not be specifically targeted at this time. The use of these areas as "fuel breaks" should be evaluated further, especially in light of the treatments enumerated in this plan (e.g., intensive livestock grazing, mechanical treatments, and herbicide treatments).

Water Supply: In some of Montana's communities, water is derived from surface flow that is treated and piped to homes and businesses. When wildfires burn a region, they threaten these watersheds by the removal of vegetation, creation of ash and sediment. As such, watersheds

should be afforded the highest level of protection from catastrophic wildfire impacts. In Yellowstone County, water is supplied to many homes by municipal wells or single home and multiple home wells.

5.5.1 Overall Goals

Reduce Yellowstone County's fire risk by mitigating hazards affecting communities through enhancements of key infrastructure components. Specific goals outlined by the County include:

- Improve all components of the primary and secondary access routes.
- Educate the public regarding use of designated evacuation routes.
- Improve countywide communication systems.

5.5.2 Proposed Activities

Table 5.3. Infrastructure Enhancements.

Action Item	Goals and Objectives	Responsible Organization	Action Items & Planning Horizon
5.3.a: Post "Emergency Evacuation Route" signs along the identified Primary and Secondary access routes in the County.	**Protection of people and structures** by informing residents and visitors of **significant infrastructure** in the County that will be maintained in the case of an emergency. Project Ranking Priority Score: **High** (51/65)	**County Commissioners** in cooperation with County Fire Warden, Billings Fire Department, Billings Urban FSA, Molt VFD, Homewood Park IAA, Duck Creek VFD, Shepherd VFD, Blains IAA, Blue Creek VFD, Lockwood VFD, Hailey Bench VFD, Crow Indian Reservation, Worden VFD, Custer VFD, Broadview FD #3, Worden FD #4, Laurel FD #5, Laurel FD #7, Lockwood FD #8, Blue Creek FSA, Laurel Urban FSA, Shepherd FSA, Huntley Project FSA, City of Billings, City of Laurel, and Town of Broadview.	• Purchase of signs (2006). • Posting roads and make information available to residents of the importance of Emergency Routes

Table 5.3. Infrastructure Enhancements.

Action Item	Goals and Objectives	Responsible Organization	Action Items & Planning Horizon
5.3.b: Access improvements of bridges, cattle guards, and limiting road surfaces.	**Protection of people, structures, infrastructure, and economy** by improving access for residents and fire fighting personnel in the event of a wildfire. Reduces the risk of a road failure that leads to the isolation of people or the limitation of emergency vehicle and personnel access during an emergency. Project Ranking Priority Score: **High** (48/65)	**County Road and Bridge Department** in cooperation with BLM, State of Montana (Dept of Transportation), BIA, and forestland or rangeland owners.	• **Year 1 (2006):** Update existing assessment of travel surfaces, bridges, and cattle guards in Yellowstone County as to location. Secure funding for implementation of this project (grants). • **Year 2 (2007):** Conduct engineering assessment of limiting weight restrictions for all surfaces (e.g., bridge weight load maximums). Estimate cost of $35,000 which might be shared between County, BLM, BIA, State, and private based on landownership associated with road locations. • **Year 2 (2007):** Post weight restriction signs on all crossings, copy information to rural fire departments and wildland fire protection agencies in affected areas. Estimate cost at roughly $10-$12,000 for signs and posting. • **Year 3 (2008):** Identify limiting road surfaces in need of improvements to support wildland fire fighting vehicles and other emergency equipment. Develop plan for improving limiting surfaces including budgets, timing, and resources to be protected for prioritization of projects (benefit/cost ratio analysis). Create budget based on full assessment.
5.3.c: Improve communications throughout the County by installing additional repeater towers and obtaining portable repeaters for emergency response personnel.	**Protection of people and structures** by providing improved communication resources. Project Ranking Priority Score: **High** (52/65)	**County Commissioners,** Billings Fire Department, Billings Urban FSA, Molt VFD, Homewood Park IAA, Duck Creek VFD, Shepherd VFD, Blains IAA, Blue Creek VFD, Lockwood VFD, Hailey Bench VFD, Crow Indian Reservation, Worden VFD, Custer VFD, Broadview FD #3, Worden FD #4, Laurel FD #5, Laurel FD #7, Lockwood FD #8, Blue Creek FSA, Laurel Urban FSA, Shepherd FSA, Huntley Project FSA, Montana DNRC, and BLM.	• **Year 1 (2006):** Summarize existing communication capabilities and limitations. Identify costs to add towers and obtain equipment and locate funding opportunities. • **Year 2 (2007):** Acquire and install equipment as needed.
5.3.d: Erect a repeater tower on the site donated by the Conover Ranch	**Protection of people and structures** by providing improved communication	**Broadview FD #3**, Montana DNRC, and BLM.	• **Year 1 (2006):** Summarize existing communication capabilities and limitations. Identify cost to install tower and obtain equipment and locate funding opportunities.

Table 5.3. Infrastructure Enhancements.

Action Item	Goals and Objectives	Responsible Organization	Action Items & Planning Horizon
near Broadview.	resources. Project Ranking Priority Score: **Medium** (36/65)		• **Year 2 (2007):** Acquire and install equipment as needed.
5.3.e: Fuel mitigation of the "Emergency Evacuation Routes" in the County to insure these routes can be maintained in the case of an emergency.	**Protection of people and structures** by providing residents and visitors with ingress and egress that can be maintained during an emergency. Project Ranking Priority Score: **High** (42/65)	**County Commissioners** in cooperation with County and State Road Departments, Billings Urban FSA, Molt VFD, Homewood Park IAA, Duck Creek VFD, Shepherd VFD, Blains IAA, Blue Creek VFD, Lockwood VFD, Hailey Bench VFD, Crow Indian Reservation, Worden VFD, Custer VFD, Broadview FD #3, Worden FD #4, Laurel FD #5, Laurel FD #7, Lockwood FD #8, Blue Creek FSA, Laurel Urban FSA, Shepherd FSA, and Huntley Project FSA. .	• Full assessment of road defensibility and ownership participation (2005). • Implementation of projects (linked to item 5.3.b and 5.3.c).
5.3.f: Erect a repeater tower system to support the Shepherd Volunteer Fire Department and Shepherd community.	**Protection of people and structures** by providing improved communication resources. Project Ranking Priority Score: **High** (41/65)	**Shepherd Volunteer Fire Department** and community of Shepherd.	• **Year 1 (2006):** Summarize existing communication capabilities and limitations. Identify cost to install towers and obtain equipment and locate funding opportunities. • **Year 2 (2007):** Acquire and install equipment as needed.

Table 5.3. Infrastructure Enhancements.

Action Item	Goals and Objectives	Responsible Organization	Action Items & Planning Horizon
5.3.g: Access improvements through roadside fuels management.	**Protection of people, structures, infrastructure, and economy** by improving access for residents and fire fighting personnel in the event of a wildfire. Allows for a road based defensible area that can be linked to a terrain based defensible areas.	**County Road and Bridge Department** in cooperation with US Forest Service, BLM, BIA Crow Agency, State of Montana (Dept. of Transportation), and forestland or rangeland owners.	• **Year 1 (2006):** Update existing assessment of roads in Yellowstone County as to location. Secure funding for implementation of this project (grants). • **Year 2 (2007):** Specifically address access issues listed below, plus recreation areas, and others identified in assessment. Target 100' extending from each side of the roadway. Total estimated cost for mowing in mostly grass vegetation is $126,244 based on estimate of $95 per treated acre. (Mileage and acreage estimates are for all main thoroughfares within the project area plus the main ingress/egress routes accessing the project area from a main road (usually a paved County road). • **Year 3 (2008):** Secure funding and implement projects to treat road-side fuels.

Roadside Fuels Treatments for Project Areas	Miles	Acres	Project Cost	Priority Ranking
Rehberg Ranch Estates Project Area	3.44	83.4	Mowing mostly grass within 100 feet from each side of the roadway cost approximately $95 per acre totaling $7,923 for this project area.	**High** (44/65)
Clapper Flats Project Area	3.14	76.0	Mowing mostly grass within 100 feet from each side of the roadway cost approximately $95 per acre totaling $7,720 for this project area.	**High** (42/65)
Alkali Creek Project Area	3.84	93.2	Mowing mostly grass within 100 feet from each side of the roadway cost approximately $95 per acre totaling $8,854 for this project area.	**High** (52/65)
Hills Estates Project Area	1.66	40.2	Mowing mostly grass within 100 feet from each side of the roadway cost approximately $95 per acre totaling $3,819 for this project area.	**Medium** (37/65)
Buffalo Trails Project Area	11.55	280.0	Mowing mostly grass within 100 feet from each side of the roadway cost approximately $95 per acre totaling $26,600 for this project area.	**High** (42/65)
Indian Cliffs Project Area	2.46	59.8	Mowing mostly grass within 100 feet from each side of the roadway cost approximately $95 per acre totaling $5,681 for this project area.	**High** (42/65)
Pleasant Hollow Project Area	8.71	211.1	Mowing mostly grass within 100 feet from each side of the roadway cost approximately $95 per acre totaling $20,054 for this project area.	**High** (40/65)
Cedar Ridge Project Area	2.97	72.0	Mowing mostly grass within 100 feet from each side of the roadway cost approximately $95 per acre totaling $6,840 for this project area.	**Medium** (39/65)
White Buffalo Project Area	2.46	59.6	Mowing mostly grass within 100 feet from each side of the roadway cost approximately $95 per acre totaling $5,662 for this project area.	**Medium** (36/65)
High Trails Project Area	2.42	58.7	Mowing mostly grass within 100 feet from each side of the roadway cost approximately $95 per acre totaling $5,577 for this project area.	**Medium** (38/65)
Emerald Hills Project Area	7.3	176.9	Mowing mostly grass within 100 feet from each side of the roadway cost approximately $95 per acre totaling $16,806 for this project area.	**High** (52/65)
Shadow Canyon Project Area	4.86	117.8	Mowing mostly grass within 100 feet from each side of the roadway cost	**Medium** (32/65)

Table 5.3. Infrastructure Enhancements.

Action Item	Goals and Objectives	Responsible Organization	Action Items & Planning Horizon
		approximately $95 per acre totaling $11,191 for this project area.	

5.6 Resource and Capability Enhancements

There are a number of resource and capability enhancements identified by the rural and wildland firefighting departments in Yellowstone County. All of the needs identified by the departments are in line with increasing the ability to respond to emergencies in the WUI and are fully supported by the planning committee.

Specific reoccurring themes of needed resources and capabilities include:

- Development of dry hydrants in rural locations
- Improved radio capabilities within each district and for mutual aid operations
- Retention and recruitment of volunteers
- Training and development of rural firefighters in structure and wildland fire
- Enhancement of equipment available for rural and city departments

Although additional, and specific, needs were enumerated by the departments in Yellowstone County, these items were identified by multiple departments and/or in the public meetings. The implementation of each issue will rely on either the isolated efforts of the rural fire departments or a concerted effort by the county to achieve equitable enhancements across all of the departments.

5.6.1 Overall Goals

Reduce Yellowstone County's fire risk by mitigating hazards affecting communities through direct enhancements of emergency response capabilities. Specific goals outlined by the County include:

- Obtain necessary equipment to effectively and safely prevent and respond to emergency situations.
- Enhance communications system throughout the County.
- Improve training of firefighters and all emergency personnel and provide incentives for trained firefighters and new recruits to stay with the force.

5.6.2 Proposed Activities

Table 5.4. WUI Action Items in Firefighting Resources and Capabilities.

Action Item	Goals and Objectives	Responsible Organization	Action Items & Planning Horizon
5.4.a: Enhance radio availability in each department, link into existing dispatch, improve range within the region, and conversion to consistent standard of radio types.	**Protection of people and structures** by direct capability enhancements. Project Ranking Priority Score: **High** (59/65)	**Montana Department of Natural Resources and Conservation** in cooperation with County Commissioners, Billings Urban FSA, Molt VFD, Homewood Park IAA, Duck Creek VFD, Shepherd VFD, Blains IAA, Blue Creek VFD, Lockwood VFD, Hailey Bench VFD, Crow Indian Reservation, Worden VFD, Custer VFD, Broadview FD #3, Worden FD #4, Laurel FD #5, Laurel FD #7, Lockwood FD #8, Blue Creek FSA, Laurel Urban FSA, Shepherd FSA, Huntley Project FSA, and BLM,.	• **Year 1 (2006):** Summarize existing two-way radio capabilities and limitations. Identify costs to upgrade existing equipment and locate funding opportunities. • **Year 2 (20076):** Acquire and install upgrades as needed. • **Year 2-3 (2007-08):** Identify opportunities for radio repeater towers located in the region for multi-county benefits.
5.4.b: Retention of Volunteer Fire Fighters.	**Protection of people and structures** by direct firefighting capability enhancements. Project Ranking Priority Score: **High** (30/30)	**Rural and Wildland Fire Departments, Districts, and Fire Service Areas** working with broad base of county citizenry to identify options, determine plan of action, and implement it.	• 5 Year Planning Horizon, extended planning time frame • Target an increased recruitment (+10%) and retention (+20% longevity) of volunteers. • **Year 1 (2006):** Apply for S.A.F.E.R. grants. • **Year 1 (2006):** Develop incentives program and implement it.
5.4.c: Increased training and capabilities of firefighters.	**Protection of people and structures** by direct firefighting capability enhancements. Project Ranking Priority Score: **High** (30/30)	**Rural and Wildland Fire Departments, Districts, and Fire Service Areas** working with the **BLM and DNRC** for wildland training opportunities and with the **Fire Services Training School** for structural firefighting training.	• **Year 1 (2006):** Develop a multi-county training schedule that extends 2 or 3 years in advance (continuously). • Identify funding and resources needed to carry out training opportunities and sources to acquire. • **Year 2 (2007)**: Begin implementing training opportunities for volunteers.

Table 5.4. WUI Action Items in Firefighting Resources and Capabilities.

Action Item	Goals and Objectives	Responsible Organization	Action Items & Planning Horizon

5.4.d: Obtain a Type 6 wildland fire truck, a ProPAC foam kit, a floater pump, and additional personal protective equipment for the Broadview Fire District #3.	**Protection of people and structures** by direct firefighting capability enhancements.
	
	Project Ranking Priority Score: **Medium** (27/65)
		Broadview Fire District #3.	• **Year 1 (2006):** Verify stated need still exists, develop budget, and locate funding or equipment (surplus and grant) sources.
			• **Year 1 or 2 (2006-07):** Acquire and deliver needed equipment based on prioritization by need and funding awards.
			  • **Estimated cost**
			  • **$80,000**

5.4.e: Support the construction of the new Fire Station/Clinic/Pharmacy/Community Center proposed in Lockwood.	**Protection of people and structures** by direct firefighting capability enhancements.
	
	Project Ranking Priority Score: **High** (30/30)
		Lockwood Fire District and community of Lockwood.	• **Year 1 (2006):** Verify stated need still exists, develop budget, locate funding and equipment (surplus) sources, and acquire required building plans and permits.
			• **Year 2 - 5 (2007-10):** Complete construction of new multiple-use facility.
			  • Estimated cost
			  • $5,200,000

5.4.f: Obtain a Type 6 engine, two 1,000 gallon pumper trucks, and a heated truck storage facility for the Worden Volunteer Fire Department.	**Protection of people and structures** by direct firefighting capability enhancements.
	
	Project Ranking Priority Score: **Medium** (39/65)
		Worden Volunteer Fire Department, Worden Fire District #4, and the Huntley Project FSA.	• **Year 1 (2006):** Verify stated need still exists, develop budget, and locate funding or equipment (surplus) sources.
			• **Year 1 or 2 (2006-07):** Acquire and deliver needed equipment based on prioritization by need and funding awards.
			  • Estimated cost
			  • $430,000

5.4.g: Obtain a 4x4 pumper truck and a 1,500-2,000 gallon water tender for the Laurel Fire Department.	**Protection of people and structures** by direct firefighting capability enhancements.
	
	Project Ranking Priority Score: **Low** (22/65)
		Laurel Fire Department.	• **Year 1 (2006):** Verify stated need still exists, develop budget, and locate funding or equipment (surplus) sources.
			• **Year 1 or 2 (2006-07):** Acquire and deliver needed equipment based on prioritization by need and funding awards.
			  • Estimated cost
			  • $280,000

Table 5.4. WUI Action Items in Firefighting Resources and Capabilities.

Action Item	Goals and Objectives	Responsible Organization	Action Items & Planning Horizon
5.4.h: Construction of a Shepherd Volunteer Fire Department satellite station in the Hidden Lake area.	**Protection of people and structures** by direct firefighting capability enhancements. Project Ranking Priority Score: **High** (41/65)	**Shepherd Volunteer Fire Department and Shepherd Fire Service Area**	• **Year 1 (2006):** Verify stated need still exists, develop budget, acquire land and equipment, and locate funding sources. • Estimated cost • $100,000
5.4.i: Additional heated equipment storage facility for the Broadview Fire Department #3.	**Protection of people and structures** by direct firefighting capability enhancements. Project Ranking Priority Score: **Medium** (26/65)	**Town of Broadview and Broadview Fire District #3.**	• **Year 1 (2006):** Verify stated need still exists, develop budget, acquire site, and locate funding sources. • Estimated cost • $80,000
5.4.j: Establish onsite water sources such as dry hydrants or underground storage tanks for rural housing developments.	**Protection of people and structures** by direct firefighting capability enhancements. Project Ranking Priority Score: **High** (46/65)	**County Commissioners, County Fire Warden,** Billings Urban FSA, Molt VFD, Homewood Park IAA, Duck Creek VFD, Shepherd VFD, Blains IAA, Blue Creek VFD, Lockwood VFD, Hailey Bench VFD, Crow Indian Reservation, Worden VFD, Custer VFD, Broadview FD #3, Worden FD #4, Laurel FD #5, Laurel FD #7, Lockwood FD #8, Blue Creek FSA, Laurel Urban FSA, Shepherd FSA, and Huntley Project FSA.	• **Year 2 -4 (2006-08):** Identify populated areas lacking sufficient water supplies and develop project plans to develop fill or helicopter dipping sites. • **Year 2 – 6 (2007-11):** Implement project plans.
5.4.k: Establish a site and install a higher capacity municipal well and pump and a 100,000 gallon storage tank for the town of Broadview.	**Protection of people and structures** by direct firefighting capability enhancements. Project Ranking Priority Score: **Medium** (28/65)	**Town of Broadview, Broadview Fire District #3, and the School of Mines.**	• **Year 1 – 3 (2006-08):** Identify populated areas lacking sufficient water supplies and develop project plans to develop fill or helicopter dipping sites. • **Year 2 – 6 (2007-11):** Implement project plans.

Table 5.4. WUI Action Items in Firefighting Resources and Capabilities.

Action Item	Goals and Objectives	Responsible Organization	Action Items & Planning Horizon
5.4.l: Establish a non-potable water well and storage system to supply fire hydrants, dry hydrants, and fire suppression systems in public buildings in the town of Broadview.	**Protection of people and structures** by direct firefighting capability enhancements. Project Ranking Priority Score: **Medium** (28/65)	**Town of Broadview, Broadview Fire District #3, and the School of Mines.**	• **Year 2 – 4 (2006-08):** Conduct feasibility study and identify non-potable water source. • **Year 3 – 4 (2007-08):** Establish well and storage system and install water lines throughout the community to handle non-potable water. • On-going: Update public facilities with fire suppression systems using the non-potable water source.
5.4.m: Obtain a Type 3 WUI pumper truck for the Laurel Urban Fire Service Area.	**Protection of people and structures** by direct fire fighting and emergency response capability enhancements. Project Ranking Priority Score: **High** (40/65)	**Laurel Urban Fire Service Area.**	• **Year 1 (2006):** Verify stated need still exists, develop budget, and locate funding or equipment (surplus) sources. • Estimate cost $150,000 • **Year 1 or 2 (2006-07):** Acquire and deliver needed equipment to district based on prioritization by need and funding awards.
5.4.n: Obtain funding to add structural fire responsibilities to Broadview Fire District #3, which would include personnel incentives, additional rolling stock equipped with structural firefighting capabilities, structural turnout gear, and a larger equipment storage facility.	**Protection of people and structures** by direct fire fighting and emergency response capability enhancements. Project Ranking Priority Score: Low (23/65)	**Town of Broadview and Broadview Fire District #3.**	• **Year 1 (2006):** Design plans for extension, identify grant funding opportunities, other funding as available. • **Year 2 (2007):** Begin and complete acquisition of funding and equipment, construction of a storage facility, and development of a mission statement and department policies. ○ Estimate cost $362,500
5.4.o: Obtain a Type 6 wildland engine and a wood chipper for Lockwood Fire District #8.	**Protection of people and structures** by direct fire fighting and emergency response capability enhancements. Project Ranking Priority Score: **Medium** (38/65)	**Community of Lockwood and Lockwood Fire District #8.**	• **Year 2 (2006):** Verify stated need still exists, develop budget, and locate funding or equipment (surplus) sources. • Estimate cost $72,000 • **Year 2 - 3 (2007-08):** Acquire and deliver needed equipment to district based on prioritization by need and funding awards.

Table 5.4. WUI Action Items in Firefighting Resources and Capabilities.

Action Item	Goals and Objectives	Responsible Organization	Action Items & Planning Horizon
5.4.p: Acquire sites and install dry hydrants on Pine Hills Road, High Trails Road, Coburn Hill Road, Yellowstone Trail Road, and Box Canyon Spring Road.	**Protection of people and structures** by direct fire fighting and emergency response capability enhancements. Project Ranking Priority Score: **High** (43/65)	**Community of Lockwood, Yellowstone County Fire Warden, and Lockwood Fire District #8.**	• **Year 2 -4 (2006-08):** Acquire land and develop project plans to develop dry hydrant sites. • **Year 2 – 10 (2007-17):** Implement project plans. o Estimate $17,000 per site.
5.4.q: Obtain one structural engine, 3 Type 3 engines (to replace old 6x6's), and one Type 2 water tender for the Shepherd Volunteer Fire Department.	**Protection of people and structures** by direct fire fighting and emergency response capability enhancements. Project Ranking Priority Score: **Medium** (37/65)	**Shepherd Volunteer Fire Department**	• **Year 1 (2006):** Verify stated need still exists, develop budget, and locate funding or equipment (surplus) sources. • Estimate cost $790,000 • **Year 1 or 2 (2006-07):** Acquire and deliver needed equipment to district based on prioritization by need and funding awards.
5.4.r: Secure funding for a full time Laurel Volunteer Fire Department Chief.	**Protection of people and structures** by direct fire fighting and emergency response capability enhancements. Project Ranking Priority Score: **Medium** (39/65)	**Laurel Volunteer Fire Department and City of Laurel.**	• **Year 1 (2006):** Research and locate funding resources and work into yearly budget. Estimate cost $65,000 • Advertise position and select qualified candidate.
5.4.s: Equip Laurel Emergency Operations Center with radios and phone lines.	**Protection of people and structures** by direct fire fighting and emergency response capability enhancements. Project Ranking Priority Score: **High** (49/65)	**Laurel Volunteer Fire Department and City of Laurel.**	• **Year 1 (2006):** Verify stated need still exists, develop budget, and locate funding. • Estimate cost $75,000 • **Year 1 or 2 (2006-07):** Acquire and deliver needed equipment to department based on prioritization by need and funding awards.

5.7 Regional Land Management Recommendations

In section 5.3 of this plan, reference was given to the role that forestry, grazing and agriculture have in promoting wildfire mitigation services through active management. Yellowstone County is dominated by wide expanses of rangelands intermixed with communities and rural houses.

Wildfires will continue to ignite and burn fuels and homes depending on the weather conditions and other factors enumerated earlier. However, active land management that modifies fuels,

promotes healthy range and forestland conditions, and promotes the use of these natural resources (consumptive and non-consumptive) will insure that these lands have value to society and the local region. We encourage the Bureau of Land Management, the Montana Department of Natural Resources and Conservation, the Bureau of Indian Affairs, industrial land owners, private land owners, and all other landowners in the region to actively administer their Wildland-Urban Interface lands in a manner consistent with the management of reducing fuels and risks in this zone.

5.7.1 Federal and State Agency Projects

The guiding documents used to determine land use are the National Fire Plan (NFP), Healthy Forest Restoration Act (HFRA), and the goal statements of the individual agency to implement ecosystem restoration, protect communities from wildland fires, and to utilize prescribed fire as a tool in the restoration of the forest and to reduce the effects of wildfire leading to catastrophic loss. During the development of this project, acres managed by the USDA Forest Service, Bureau of Land Management, and the State of Montana that are in Fire Regime Condition Class II and III, as defined by the Forest Service and within the Wildland Urban Interface (WUI), were identified by the County as high priority areas to be treated under the NFP and HFRA. Federal or State managed lands adjacent to homes are particularly high priorities for these treatments. These projects may include, but are not limited to, mechanical treatments, prescribed fire, and creation of buffer zones and greenbelts.

5.7.1.1 Bureau of Land Management On-going Projects

5.7.1.1.1 Sundance Lodge Special Recreation Management Area

The Sundance Lodge Special Recreation Management Area (SRMA) is a small tract of land (379.9 acres) at the confluence of the Yellowstone and Clarks Fork of the Yellowstone River, south of the city of Laurel. This area includes habitat for whitetail deer, pheasants, waterfowl, and songbirds. (See Appendix I for map).

The Sundance Lodge is farm land intermixed with mature cottonwood and shrubs along the Clarks Fork River. It is characterized by Fuel models are 1, 2, 5 and 6. Fuel loads range from .74 to 6.0 ton/acre.

5.7.1.1.2 Four Dances Natural Area

The Four Dances Natural Area SRMA Area of Critical Concern (ACEC) (765 acres) is a tract of land with potential for heavy recreation use due to its location immediately east of downtown Billings. (See Appendix I for map).

The Four Dances area is native grasses including wheat and needle grasses, sagebrush, and pine along the rims above the Yellowstone River and cottonwood and brush along the river bottom. Fuel models are 1 and 5. Fuel loads range from .74 ton/acre to 3.0 ton/acre. Cultural values at the Four Dances Natural Area are, for the most part, not sensitive to damage from wildfire. The Native American religious values and similar values as a Traditional Cultural Properties are not at risk from wildfire. Suppression techniques should be modified to consider the fragile nature of the traditional and religious values.

5.7.1.1.3 South Hills Area

The South Hills area is directly south of Billings along the Yellowstone River. This tract of land lies between the river and a developed subdivision. (See Appendix I for map).

The South Hills area is native wheat grass and needle grasses, sagebrush, and a small amount of pine. This area fits fuel model 1. Fuel loads average .50 ton/acre.

5.7.1.1.4 Acton Area

The Acton area consists of six sections of public land north of Billings. Grazing and recreation are the primary uses of this area. (See Appendix I for map).

The Acton area is native wheat grass and needle grasses with mixed pine and big sagebrush, which fits fuel models 1 and 2. Fuel loads range from .74 tons/acre to 4.0 tons/acre.

5.7.1.1.5 Pompey's Pillar National Monument

Pompey's Pillar National Monument is located 30 miles east of Billings on the south side of the Yellowstone River. Within the Pompeys Pillar boundaries are the Pompeys Pillar National Landmark (approximately 8.23 acres) and a National Monument (approximately 51 acres). The combined acreage of the Landmark, the Monument, and the surrounding public lands, including the island in the Yellowstone River, is approximately 431 acres. The entire area is part of the Pompeys Pillar ACEC. This area includes a visitor center, associated outbuildings, and irrigated cropland. There is a 14 acre private inholding, owned by Robert Taylor, located within the eastern Pillar boundary along the south channel of the Yellowstone River. (See Appendix I for map).

Most of the land south and east of the pillar has been cultivated for the past 50-100 years. Some of this area near the pillar will be planted with native vegetation. The land north and east of the pillar has not been cultivated and is presently covered with dense cottonwood riparian woodland. The area is characterized by fuel loads that range from .74 to 6.0 ton/acre. Fuel models 1 and 5 fit the majority of this area with some fuel type 6.

South Pompey's Pillar represents an area of special consideration. The unit contains a National Landmark and National Monument. The entire unit is part of the Pompey's Pillar ACEC based on cultural values. Pictographs and petroglyphs, both historic and prehistoric, are the outstanding features of the monument, with the 1806 signature of William Clark as the centerpiece. Away from the pillar, visitor facilities, interpretive exhibits and historic structures and features require protection. Suppression objectives include:

- Protect native vegetative cover on all sites in and around the monument from catastrophic wildfire to prevent accelerated erosion and invasive species establishment on sites completely denuded of vegetative cover due to catastrophic wildfire.
- Protect riparian habitat, bald eagles and habitat, hairy woodpecker, spiny soft-shell turtles, Wood house's toad, hognose snake, and pale milk snake.
- Protect the presence of a national landmark, a national monument, an ACEC, and other archeological and historic resources.
- Protect structures that need fire protection including an interpretative center and farm structures.
- Protect the public with an estimated 130,000 visitors per year.

5.7.1.1.6 Shepherd Ah-Nei Recreation Area

The Shepherd Ah-Nei Recreation area is located north of the town of Shepherd. Heavy recreational use and urban interface combine to create safety concerns for firefighters and the general public on a 4,800 acre parcel of public land within this area.

The Shepherd Ah-Nei area is similar to the Acton area characterized by needle grasses with

mixed pine and big sagebrush which fits fuel models 1 and 2. Fuel loads range from .74 tons/acre to 4.0 tons/acre.

5.7.1.1.7 Other Projects

In general, almost all BLM lands within the Yellowstone County area contain a wide diversity of habitats and cultural sites. In general, identifiable site types are predominated by late prehistoric and protohistoric aboriginal sites and by historic period Euro-American homesteads. Typical prehistoric sites include tepee rings, brush and log habitation structures, open campsites, and resource procurement sites such as buffalo jumps.

5.7.2 Conservation Reserve Program

The fire hazard associated with the abundant Conservation Reserve Program (CRP) lands has become a prominent issue for all fire departments and emergency personnel in Yellowstone County. Due to the lack of management on CRP, a dense mat of highly flammable fuels build up as they sit in fallow year after year. Fires in these fuels burn at very high intensities with large flame lengths, particularly under the influence of the strong winds common in Yellowstone County. Once ignited, CRP fires can burn very rapidly, jumping roads and other barriers that would normally inhibit a natural range or grass fire. In the recent past, uncontrolled CRP fires have burned hundreds of acres and threatened countless homes and critical infrastructure such as main highways and power poles in Montana.

It is the recommendation of this plan that Yellowstone County enacts a policy defining an active management plan for fire hazard fuel reduction on Conservation Reserve Program lands. This plan should be based on a three year rotation where a certain number of acres are treated each year. Potential treatment options may include, but are not limited to, grazing, haying, prescribed fire, and/or tilling. Yellowstone County believes active management will reduce the fire risk associated with these fuels and cut down on the number of CRP fires responded to each year. This is especially critical on those acres adjacent to homes, businesses, and critical infrastructure.

Chapter 6: Supporting Information

6

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6.3 List of Preparers

The following personnel participated in the formulation, compilation, editing, and analysis of alternatives for this assessment.

Table 6.1. List of Preparers

Name	Affiliation	Role
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Dennis S. Thomas	Northwest Management, Inc.	Fire & Fuels Specialist, Prescribed Burning Manager
Vaiden E. Bloch, M.S.	Northwest Management, Inc.	GIS Analyst
Greg Bassler, M.S.	Northwest Management, Inc.	Roads Engineer, Timber Sale Layout & Harvest Manager
Jim Kraft	Yellowstone County	Yellowstone County Fire Warden
Entire Planning Committee		

6.4 Signature Pages

This **Yellowstone County Community Wildfire Protection Plan** has been developed in cooperation and collaboration with the representatives of the following organizations, agencies, and individuals.

6.4.1 Yellowstone County Resolution

RESOLUTION NUMBER 06-22

Community Wildfire Protection Plan (CWPP)

This resolution declares County support and adoption of the Yellowstone County Community Wildfire Protection Plan as an amendment to the existing Yellowstone County Pre-Disaster Mitigation Plan.

Whereas, The Board of Yellowstone County Commissioners supports the Yellowstone County Community Wildfire Protection Plan, and

Whereas, The Yellowstone County Community Wildfire Protection Plan will be utilized as a guide for planning as related to FEMA Pre-Disaster Mitigation, The National Fire Plan, The Healthy Forest Restoration Act, and other purposes as deemed appropriate by the Yellowstone County Commissioners,

Therefore be it resolved, that the Yellowstone County Commissioners do hereby adopt, support, and will facilitate the Yellowstone County Community Wildfire Protection Plan implementation.

Passed and approved this 28th day of February, 2006

Board of County Commissioners
Yellowstone County, Montana

John Ostlund, Chairperson

Bill Kennedy, Member

James E. Reno, Member

(SEAL)

ATTEST:

Tony Nave, Clerk / Recorder

6.4.2 City of Billings Resolution

RESOLUTION NO. **06-18395**

A RESOLUTION OF THE CITY COUNCIL OF BILLINGS LOCATED IN YELLOWSTONE COUNTY, MONTANA DECLARING CITY SUPPORT AND ADOPTION OF THE YELLOWSTONE COUNTY COMMUNITY WILDFIRE PROTECTION PLAN AS AN AMENDMENT TO THE YELLOWSTONE COUNTY PRE-DISASTER MITIGATION PLAN.

WHEREAS, the City Council of Billings supports the Yellowstone County Community Wildfire Protection Plan; and

WHEREAS, The City Council of Billings has participated in the development of the Yellowstone County Community Wildfire Protection Plan, and

WHEREAS, The Yellowstone County Community Wildfire Protection Plan will be utilized as a guide for planning as related to FEMA Pre-Disaster Mitigation, The National Fire Plan, The Healthy Forest Restoration Act, and other purposes as deemed appropriate by the City Council of Billings,

NOW, THEREFORE, BE IT RESOLVED THAT THE CITY COUNCIL OF THE CITY OF BILLINGS, MONTANA, DOES HEREBY ADOPT, SUPPORT, AND WILL FACILITATE THE YELLOWSTONE COUNTY COMMUNITY WILDFIRE PROTECTION PLAN'S IMPLEMENTATION.

PASSED by the City Council and APPROVED this 27th day of February, 2006.

THE CITY OF BILLINGS:

BY: _____
Ron Tussing, MAYOR

CITY OF BILLINGS SEAL YELLOWSTONE COUNTY, MONTANA

ATTEST:

BY: Marita Herold
Marita Herold, CMC/AAE CITY CLERK

6.4.3 City of Laurel Resolution

RESOLUTION NO. R06-15

A RESOLUTION OF THE CITY COUNCIL OF LAUREL DECLARING ITS SUPPORT AND ADOPTION OF THE YELLOWSTONE COUNTY COMMUNITY WILDFIRE PROTECTION PLAN AS AN AMENDMENT TO THE YELLOWSTONE COUNTY PRE-DISASTER MITIGATION PLAN.

WHEREAS, the City Council of Laurel supports the Yellowstone County Community Wildfire Protection Plan; and

WHEREAS, the City Council of Laurel has participated in the development of the Yellowstone County Community Wildfire Protection Plan; and

WHEREAS, the Yellowstone County Community Wildfire Protection Plan will be utilized as a guide for planning as related to FEMA Pre-Disaster Mitigation, The National Fire Plan, The Healthy Forest Restoration Act, and other purposes as deemed appropriate by the City Council of Laurel.

NOW, THEREFORE, BE IT RESOLVED by the City Council of the City of Laurel, Montana,

That the City Council of Laurel does hereby adopt, support and shall facilitate the Yellowstone County Wildfire Protection Plan's implementation.

Introduced at a regular meeting of the City Council on March 7, 2006, by Alderperson Poehls.

PASSED and APPROVED by the City Council of the City of Laurel, located in Yellowstone County, Montana, this 7th day of March, 2006.

APPROVED by the Mayor this 7th day of March, 2006.

CITY OF LAUREL

Kenneth E. Olson, Jr., Mayor

ATTEST:

Mary K. Embleton, Clerk-Treasurer

Approved as to form:

Sam Painter, Legal Counsel
Elk River Law Office, P.L.L.P.

R06-15 Community Wildfire Protection Plan

6.4.4 Town of Broadview Resolution

Resolution of the Town Council of Broadview
located in Yellowstone County, Montana
281

A resolution of the Town Council of Broadview declaring Town support and adoption of the Yellowstone County Community Wildfire Protection Plan as an amendment to the Yellowstone County Pre-Disaster Mitigation Plan.

Whereas, The Town Council of Broadview supports the Yellowstone County Community Wildfire Protection Plan, and

Whereas, The Town Council of Broadview has participated in the development of the Yellowstone County Community Wildfire Protection Plan, and

Whereas, The Yellowstone County Community Wildfire Protection Plan will be utilized as a guide for planning as related to FEMA Pre-Disaster Mitigation, The National Fire Plan, The Healthy Forest Restoration Act, and other purposes as deemed appropriate by the Town Council of Broadview,

Therefore be it resolved, that the Town Council of Broadview does hereby adopt, support, and will facilitate the Yellowstone County Wildfire Protection Plan's implementation.

Passed and approved this 21 Day of March 2006

Town Council of Broadview located in Yellowstone County, Montana

John Hougardy

Mayor, Town of Broadview

Carol Terpstra

Attested by:

, Town Clerk

6.4.5 Representatives of Fire Departments

Marvin L. Jochems — 2/22/06
By: Marv Jochems, Chief — Date
Billings Fire Department

2/28/06
By: Shadd Fritz, Chief — Date
Duck Creek Volunteer Fire Department

2-22-2006
By: Terry Ruff, Chief — Date
Laurel Fire Department

2-22-2006
By: Greg Smith, Chief — Date
Molt Volunteer Fire Department

2/22/06
By: Stuart Andersen, Chief — Date
Shepherd Volunteer Fire Deparment

2-22-06
By: Rick Cortez, Chief — Date
Blue Creek Volunteer Fire Department

2.22.06
By: Alan Riley, Chief — Date
Lockwood Fire District #8

By: Bill Glaser, Chief — Date
Haley Bench Volunteer Fire Department

2/22/06
By: Milton Mothershead, Chief — Date
Custer Volunteer Fire Department

2/22/06
By: Robby Badgett, Chief — Date
Broadview Volunteer Fire Department

2/24/06

Monte Dvorak 2-22-06

By: Monte Dvorak, Chief
Worden Volunteer Fire Department

Date

Eugene Metzger 2/24/06

By: Gene Metzger, Chief
Homewood Park Fire Department

Date

6.4.6 Representatives of Community Organizations, Federal, and State Agencies

These agencies and organizations collaborated and cooperated in the development of this plan.

Sharon Moore — February 14, 2006
By: Sharon Moore
Montana Department of Natural Resources and Conservation

Dianne B. Lehm — 2.17.2006
By: Dianne Lehm
Big Sky Economic Development Authority

Sandy Brooks — 2/23/06
By: Sandy Brooks
Bureau of Land Management

Jim Roessler — 2/27/2006
By: Jim Roessler
Bureau of Indian Affairs

6.4.7 Yellowstone County Community Wildfire Protection Plan Coordinators

James T. Kraft — February 14, 2006
By: Jim Kraft
Yellowstone County Fire Warden
& Yellowstone County DES Director

William E. Schlosser — February 28, 2006
By: William E. Schlosser, Ph.D.
Project Manager-Yellowstone County Wildfire Protection Plan, Lead Author, Northwest Management, Inc.

6.5 Glossary of Terms

Anadromous - Fish species that hatch in fresh water, migrate to the ocean, mature there, and return to fresh water to reproduce (Salmon & Steelhead).

Appropriate Management Response - Specific actions taken in response to a wildland fire to implement protection and fire use objectives.

Biological Assessment - Information document prepared by or under the direction of the Federal agency in compliance with U.S. Fish and Wildlife standards. The document analyzes potential effects of the proposed action on listed and proposed threatened and endangered species and proposed critical habitat that may be present in the action area.

Backfiring - When attack is indirect, intentionally setting fire to fuels inside the control line to contain a rapidly spreading fire. Backfiring provides a wide defense perimeter, and may be further employed to change the force of the convection column.

Blackline - Denotes a condition where the fireline has been established by removal of vegetation by burning.

Burning Out - When attack is direct, intentionally setting fire to fuels inside the control line to strengthen the line. Burning out is almost always done by the crew boss as a part of line construction; the control line is considered incomplete unless there is no fuel between the fire and the line.

Canyon Grassland - Ecological community in which the prevailing or characteristic plants are grasses and similar plants extending from the canyon rim to the rivers edge.

Confine - Confinement is the strategy employed in appropriate management responses where a fire perimeter is managed by a combination of direct and indirect actions and use of natural topographic features, fuel, and weather factors.

Contingency Plans: Provides for the timely recognition of approaching critical fire situations and for timely decisions establishing priorities to resolve those situations.

Control Line - An inclusive term for all constructed or natural fire barriers and treated fire edge used to control a fire.

Crew - An organized group of firefighters under the leadership of a crew boss or other designated official.

Crown Fire - A fire that advances from top to top of trees or shrubs more or less independently of the surface fire. Sometimes crown fires are classed as either running or dependent, to distinguish the degree of independence from the surface fire.

Disturbance - An event which affects the successional development of a plant community (examples: fire, insects, windthrow, timber harvest).

Disturbed Grassland - Grassland dominated by noxious weeds and other exotic species. Greater than 30% exotic cover.

Diversity - The relative distribution and abundance of different plant and animal communities and species within an area.

Drainage Order - Systematic ordering of the net work of stream branches, (e.g., each non-branching channel segment is designated a first order stream, streams which only receive first order segments are termed second order streams).

Duff - The partially decomposed organic material of the forest floor beneath the litter of freshly fallen twigs, needles, and leaves.

Ecosystem - An interacting system of interdependent organisms and the physical set of conditions upon which they are dependent and by which they are influenced.

Ecosystem Stability - The ability of the ecosystem to maintain or return to its steady state after an external interference.

Ecotone - The area influenced by the transition between plant communities or between successional stages or vegetative conditions within a plant community.

Energy Release Component - The Energy Release Component is defined as the potential available energy per square foot of flaming fire at the head of the fire and is expressed in units of BTUs per square foot.

Equivalent Clearcut Area (ECA) - An indicator of watershed condition, which is calculated from the total amount of crown removal that has occurred from harvesting, road building, and other activities based on the current state of vegetative recovery.

Exotic Plant Species - Plant species that are introduced and not native to the area.

Fire Adapted Ecosystem - An arrangement of populations that have made long-term genetic changes in response to the presence of fire in the environment.

Fire Behavior - The manner in which a fire reacts to the influences of fuel, weather, and topography.

Fire Behavior Forecast - Fire behavior predictions prepared for each shift by a fire behavior analysis to meet planning needs of fire overhead organization. The forecast interprets fire calculations made, describes expected fire behavior by areas of the fire, with special emphasis on personnel safety, and identifies hazards due to fire for ground and aircraft activities.

Fire Behavior Prediction Model - A set of mathematical equations that can be used to predict certain aspects of fire behavior when provided with an assessment of fuel and environmental conditions.

Fire Danger - A general term used to express an assessment of fixed and variable factors such as fire risk, fuels, weather, and topography which influence whether fires will start, spread, and do damage; also the degree of control difficulty to be expected.

Fire Ecology - The scientific study of fire's effects on the environment, the interrelationships of plants, and the animals that live in such habitats.

Fire Exclusion - The disruption of a characteristic pattern of fire intensity and occurrence (primarily through fire suppression).

Fire Intensity Level - The rate of heat release (BTU/second) per unit of fire front. Four foot flame lengths or less are generally associated with low intensity burns and four to six foot flame lengths generally correspond to "moderate" intensity fire effects. High intensity flame lengths are usually greater than eight feet and pose multiple control problems.

Fire Prone Landscapes – The expression of an area's propensity to burn in a wildfire based on common denominators such as plant cover type, canopy closure, aspect, slope, road density, stream density, wind patterns, position on the hillside, and other factors.

Fireline - A loose term for any cleared strip used in control of a fire. That portion of a control line from which flammable materials have been removed by scraping or digging down to the mineral soil.

Fire Management - The integration of fire protection, prescribed fire and fire ecology into land use planning, administration, decision making, and other land management activities.

Community Wildfire Protection Plan (CWPP) - A strategic plan that defines a program to manage wildland and prescribed fires and documents the fire management program in the

approved land use plan. This plan is supplemented by operational procedures such as preparedness, preplanned dispatch, burn plans, and prevention. The fire implementation schedule that documents the fire management program in the approved forest plan alternative.

Fire Management Unit (FMU) - Any land management area definable by objectives, topographic features, access, values-to-be-protected, political boundaries, fuel types, or major fire regimes, etc., that set it apart from management characteristics of an adjacent unit. FMU's are delineated in FMP's. These units may have dominant management objectives and preselected strategies assigned to accomplish these objectives.

Fire Occurrence - The number of wildland fires started in a given area over a given period of time. (Usually expressed as number per million acres.)

Fire Prevention - An active program in conjunction with other agencies to protect human life, prevent modification, of the ecosystem by human-caused wildfires, and prevent damage to cultural resources or physical facilities. Activities directed at reducing fire occurrence, including public education, law enforcement, personal contact, and reduction of fire risks and hazards.

Fire Regime - The fire pattern across the landscape, characterized by occurrence interval and relative intensity. Fire regimes result from a unique combination of climate and vegetation. Fire regimes exist on a continuum from short-interval, low-intensity (stand maintenance) fires to long-interval, high-intensity (stand replacement) fires.

Fire Retardant - Any substance that by chemical or physical action reduces flareability of combustibles.

Fire Return Interval - The number of years between two successive fires documented in a designated area.

Fire Risk - The potential that a wildfire will start and spread rapidly as determined by the presence and activities of causative agents.

Fire Severity - The effects of fire on resources displayed in terms of benefit or loss.

Foothills Grassland - Grass and forb co-dominated dry meadows and ridges. Principle habitat type series: bluebunch wheatgrass and Idaho fescue.

Fuel - The materials which are burned in a fire; duff, litter, grass, dead branchwood, snags, logs, etc.

Fuel Break - A natural or manmade change in fuel characteristics which affects fire behavior so that fires burning into them can be more readily controlled.

Fuel Loading - Amount of dead fuel present on a particular site at a given time; the percentage of it available for combustion changes with the season.

Fuel Model - Characterization of the different types of wildland fuels (trees, brush, grass, etc.) and their arrangement, used to predict fire behavior.

Fuel Type - An identifiable association of fuel elements of distinctive species; form, size, arrangement, or other characteristics, that will cause a predictable rate of fire spread or difficulty of control, under specified weather conditions.

Fuels Management - Manipulation or reduction of fuels to meet protection and management objectives, while preserving and enhancing environmental quality.

Gap Analysis Program (GAP) - Regional assessments of the conservation status of native vertebrate species and natural land cover types and to facilitate the application of this information to land management activities. This is accomplished through the following five objectives:

1. Map the land cover of the United States

2. Map predicted distributions of vertebrate species for the U.S.
3. Document the representation of vertebrate species and land cover types in areas managed for the long-term maintenance of biodiversity
4. Provide this information to the public and those entities charged with land use research, policy, planning, and management
5. Build institutional cooperation in the application of this information to state and regional management activities

Habitat - A place that provides seasonal or year-round food, water, shelter, and other environmental conditions for an organism, community, or population of plants or animals.

Heavy Fuels - Fuels of a large diameter, such as snags, logs, and large limbwood, which ignite and are consumed more slowly than flash fuels.

Hydrologic Unit Code - A coding system developed by the U. S. Geological Service to identify geographic boundaries of watersheds of various sizes.

Hydrophobic - Resistance to wetting exhibited by some soils, also called water repellency. The phenomena may occur naturally or may be fire-induced. It may be determined by water drop penetration time, equilibrium liquid-contact angles, solid-air surface tension indices, or the characterization of dynamic wetting angles during infiltration.

Human-Caused Fires - Refers to fires ignited accidentally (from campfires or smoking) and by arsonists; does not include fires ignited intentionally by fire management personnel to fulfill approved, documented management objectives (prescribed fires).

Intensity - The rate of heat energy released during combustion per unit length of fire edge.

Inversion - Atmospheric condition in which temperature increases with altitude.

Ladder Fuels - Fuels which provide vertical continuity between strata, thereby allowing fire to carry from surface fuels into the crowns of trees or shrubs with relative ease. They help initiate and assure the continuation of crowning.

Landsat Imagery - Land remote sensing, the collection of data which can be processed into imagery of surface features of the Earth from an unclassified satellite or satellites.

Landscape - All the natural features such as grasslands, hills, forest, and water, which distinguish one part of the earth's surface from another part; usually that portion of land which the eye can comprehend in a single view, including all its natural characteristics.

Lethal - Relating to or causing death; extremely harmful.

Lethal Fires - A descriptor of fire response and effect in forested ecosystems of high-severity or severe fire that burns through the overstory and understory. These fires typically consume large woody surface fuels and may consume the entire duff layer, essentially destroying the stand.

Litter - The top layer of the forest floor composed of loose debris, including dead sticks, branches, twigs, and recently fallen leaves or needles, little altered in structure by decomposition.

Maximum Manageable Area - The boundary beyond which fire spread is completely unacceptable.

Metavolcanic - Volcanic rock that has undergone changes due to pressure and temperature.

Minimum Impact Suppression Tactic (MIST) - "Light on the Land." Use of minimum amount of forces necessary to effectively achieve the fire management protection objectives consistent with land and resource management objectives. It implies a greater sensitivity to the impacts of

suppression tactics and their long-term effects when determining how to implement an appropriate suppression response.

Mitigation - Actions to avoid, minimize, reduce, eliminate, replace, or rectify the impact of a management practice.

Monitoring Team - Two or more individuals sent to a fire to observe, measure, and report its behavior, its effect on resources, and its adherence to or deviation from its prescription.

National Environmental Policy Act (NEPA) - This act declared a national policy to encourage productive and enjoyable harmony between humans and their environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and will stimulate the health and welfare of humankind; to enrich the understanding of important ecological systems and natural resources; and to establish a Council on Environmental Quality.

National Fire Management Analysis System (NFMAS) - The fire management analysis process, which provides input to forest planning and forest and regional fire program development and budgeting.

Native - Indigenous; living naturally within a given area.

Natural Ignition - A wildland fire ignited by a natural event such as lightning or volcanoes.

Noncommercial Thinning - Thinning by fire or mechanical methods of precommercial or commercial size timber, without recovering value, to meet MFP standards relating to the protection/enhancement of adjacent forest or other resource values.

Notice of Availability - A notice of Availability published in the Federal Register stating that an EIS has been prepared and is available for review and comment (for draft) and identifying where copies are available.

Notice of Intent - A notice of Intent published in the Federal Register stating that an EIS will be prepared and considered. This notice will describe the proposed action and possible alternatives, the proposed scoping process, and the name and address of whom to contact concerning questions about the proposed action and EIS.

Noxious Weeds - Rapidly spreading plants that have been designated “noxious” by law which can cause a variety of major ecological impacts to both agricultural and wild lands.

Planned Ignition - A wildland fire ignited by management actions to meet specific objectives.

Prescribed Fire - Any fire ignited by management actions to meet specific objectives. A written, approved prescribed fire plan must exist, and NEPA requirements must be met, prior to ignition.

Prescription - A set of measurable criteria that guides the selection of appropriate management strategies and actions. Prescription criteria may include safety, economic, public health, environmental, geographic, administrative, social, or legal considerations.

Programmatic Biological Assessment - Assesses the effects of the fire management programs on federally listed species, not the individual projects that are implemented under these programs. A determination of effect on listed species is made for the programs, which is a valid assessment of the potential effects of the projects completed under these programs, if the projects are consistent with the design criteria and monitoring and reporting requirement contained in the project description and summaries.

Reburn - Subsequent burning of an area in which fire has previously burned but has left flareable light that ignites when burning conditions are more favorable.

Riparian Habitat Conservation Areas (RHCA) - Portions of watersheds where riparian-dependent resources receive primary emphasis, and management activities are subject to specific standards and guidelines. RHCAs include traditional riparian corridors, wetlands,

intermittent headwater streams, and other areas where proper ecological functioning is crucial to maintenance of the stream's water, sediment, woody debris, and nutrient delivery systems.

Riparian Management Objectives (RMO) - Quantifiable measures of stream and streamside conditions that define good fish habitat and serve as indicators against which attainment or progress toward attainment of goals will be measured.

Road Density - The volume of roads in a given area (mile/square mile).

Scoping - Identifying at an early stage the significant environmental issues deserving of study and de-emphasizing insignificant issues, narrowing the scope of the environmental analysis accordingly.

Seral - Refers to the stages that plant communities go through during succession. Developmental stages have characteristic structure and plant species composition.

Serotinous - Storage of coniferous seeds in closed cones in the canopy of the tree. Serotinous cones of lodgepole pine do not open until subjected to temperatures of 113 to 122 degrees Fahrenheit causing the melting of the resin bond that seals the cone scales.

Stand Replacing Fire - A fire that kills most or all of a stand.

Sub-basin - A drainage area of approximately 800,000 to 1,000,000 acres, equivalent to a 4th - field Hydrologic Unit Code.

Surface Fire - Fire which moves through duff, litter, woody dead and down, and standing shrubs, as opposed to a crown fire.

Watershed - The region draining into a river, river system, or body of water.

Wetline - Denotes a condition where the fireline has been established by wetting down the vegetation.

Wildland Fire - Any nonstructure fire, other than prescribed fire, that occurs in the wildland.

Wildland Fire Implementation Plan (WFIP) - A progressively developed assessment and operational management plan that documents the analysis and selection of strategies and describes the appropriate management response for a wildland fire being managed for resource benefits. A full WFIP consists of three stages. Different levels of completion may occur for differing management strategies (i.e., fires managed for resource benefits will have two-three stages of the WFIP completed while some fires that receive a suppression response may only have a portion of Stage I completed).

Wildland Fire Situation Analysis (WFSA) - A decision making process that evaluates alternative management strategies against selected safety, environmental, social, economic, political, and resource management objectives.

Wildland Fire Use - The management of naturally ignited wildland fires to accomplish specific prestated resource management objectives in predefined geographic areas outlined in FMP's. Operational management is described in the WFIP. Wildland fire use is not to be confused with "fire use", which is a broader term encompassing more than just wildland fires.

Wildland Fire Use for Resource Benefit (WFURB) - A wildland fire ignited by a natural process (lightning), under specific conditions, relating to an acceptable range of fire behavior and managed to achieve specific resource objectives.

Xeriscape - a trademark for a method of landscaping that emphasizes water conservation in its use of drought-resistant plants

6.6 List of Acronyms

ACEC: Area of Critical Environmental Concern

AIRFA: American Indian Religious Freedom Act

ARPA: Archaeological Resources Protection Act

ATV: All Terrain Vehicle

B/C: Benefit/Cost

BIA: Bureau of Indian Affairs

BLM: Bureau of Land Management

BUFSA: Billings Urban Fire Service Area

CFS: Current Fire Severity

CRP: Conservation Reserve Program

CWPP: Community Wildfire Protection Plan

DES: Disaster and Emergency Services

DNRC: Department of Natural Resources and Conservation

ECA: Equivalent Clearcut Area

EDA: Economic Development Authority

EMS: Emergency Medical Services

EPA: Environmental Protection Agency

ETM: Enhanced Thematic Mapper

FAMB: Fire and Aviation Management Bureau

FD: Fire District

FEMA: Federal Emergency Management Agency

FMU: Fire Management Unit

FPL: Fire Prone Landscapes

FRCC: Fire Regime Condition Class

FSA: Fire Service Area

FWS: Fish and Wildlife Service

GAP: Gap Analysis Program

GIS: Geographic Information System

GPS: Global Positioning System

HFR: Historic Fire Regime

HFRA: Healthy Forests Restoration Act

HMGP: Hazard Mitigation Grant Program

ID: Idaho

LUFSA: Laurel Urban Fire Service Area

MIST: Minimum Impact Suppression Tactic

MOU: Memorandum of Understanding

MPO: Metropolitan Planning Organization

MT: Montana

NAAQS: National Ambient Air Quality Standards

NAGPRA: Native American Graves Protection and Repatriation Act

NASF: National Association of State Foresters

NEPA: National Environmental Policy Act

NFMAS: National Fire Management Analysis System

NFP: National Fire Plan

NFPA: National Fire Protection Association

NHPA: National Environmental Policy Act

NIFC: National Interagency Fire Center

NMI: Northwest Management, Inc.

NPS: National Park Service

NRCG: Northern Rockies Coordinating Group

NRCS: Natural Resources Conservation Service

NWCG: National Wildfire Coordinating Group

OAQPS: Organization for Air Quality Protection Standards

PDM: Pre Disaster Mitigation

RC&D: Resource Conservation and Development

RHCA: Riparian Habitat Conservation Area

RFA: Rural Fire Assistance

RFD: Rural Fire District

RMO: Riparian Management Objective

SFB: Service Forestry Bureau

SHMO: State Hazard Mitigation Officer

SRMA: Special Recreation Management Area

TCP: Traditional Cultural Property

USA: United States of America

USDA: United States Department of Agriculture

USDI: United States Department of Interior

USFS: United States Forest Service

VFA: Volunteer Fire Assistance

VFD: Volunteer Fire Department

WFIP: Wildland Fire Implementation Plan

WFSA: Wildland Fire Situation Analysis

WUFRB: Wildfire Use for Resource Benefit

WUI: Wildland Urban Interface

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Appendix I: Maps

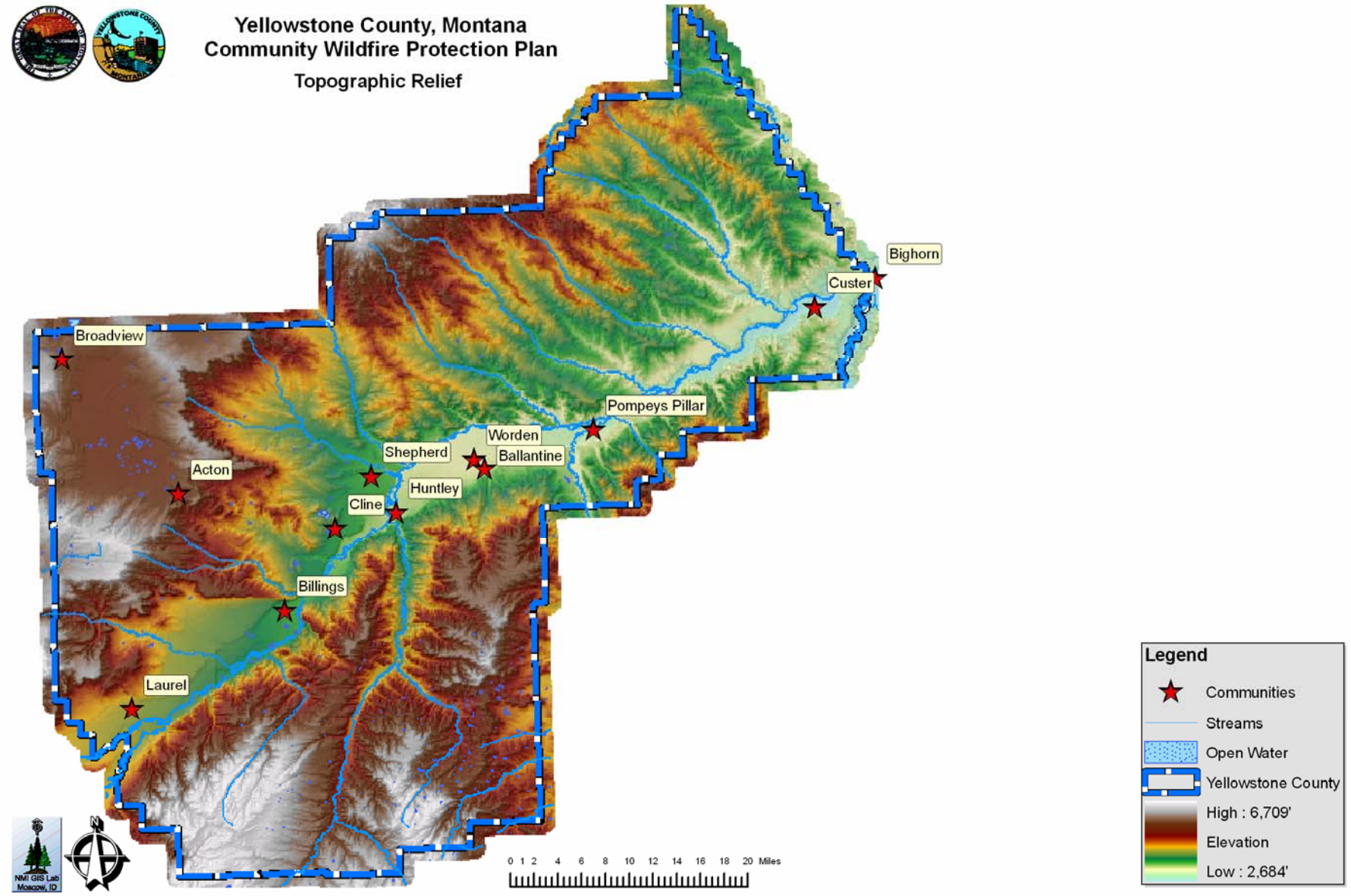
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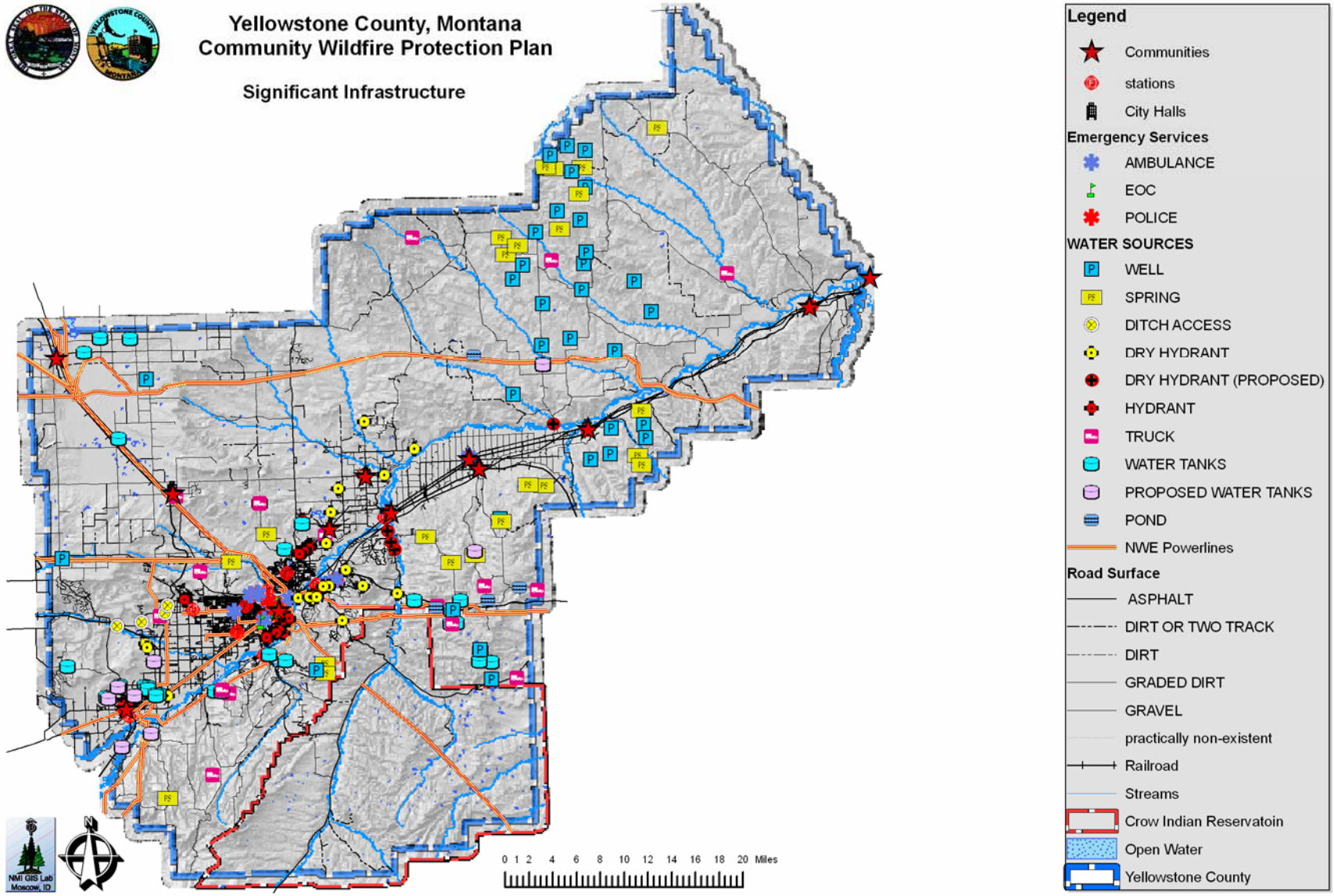
Northwest Management, Inc.
Geographical Information Systems Laboratory
233 East Palouse River Dr., P.O. Box 9748, Moscow, ID 83843 www.Consulting-Foresters.com

The information on the attached maps was derived from digital databases from NMI's GIS lab. Care was taken in the creation of these maps, but all maps are provided "as is" with no warranty or guarantees. Northwest Management, Inc., cannot accept any responsibility for any errors, omissions, or positional accuracy, and therefore, there are no warranties which accompany this product. Although information from Land Surveys may have been used in the creation of this product, in no way does this product represent or constitute a Land Survey. Users are cautioned to field verify information on this product before making any decisions.

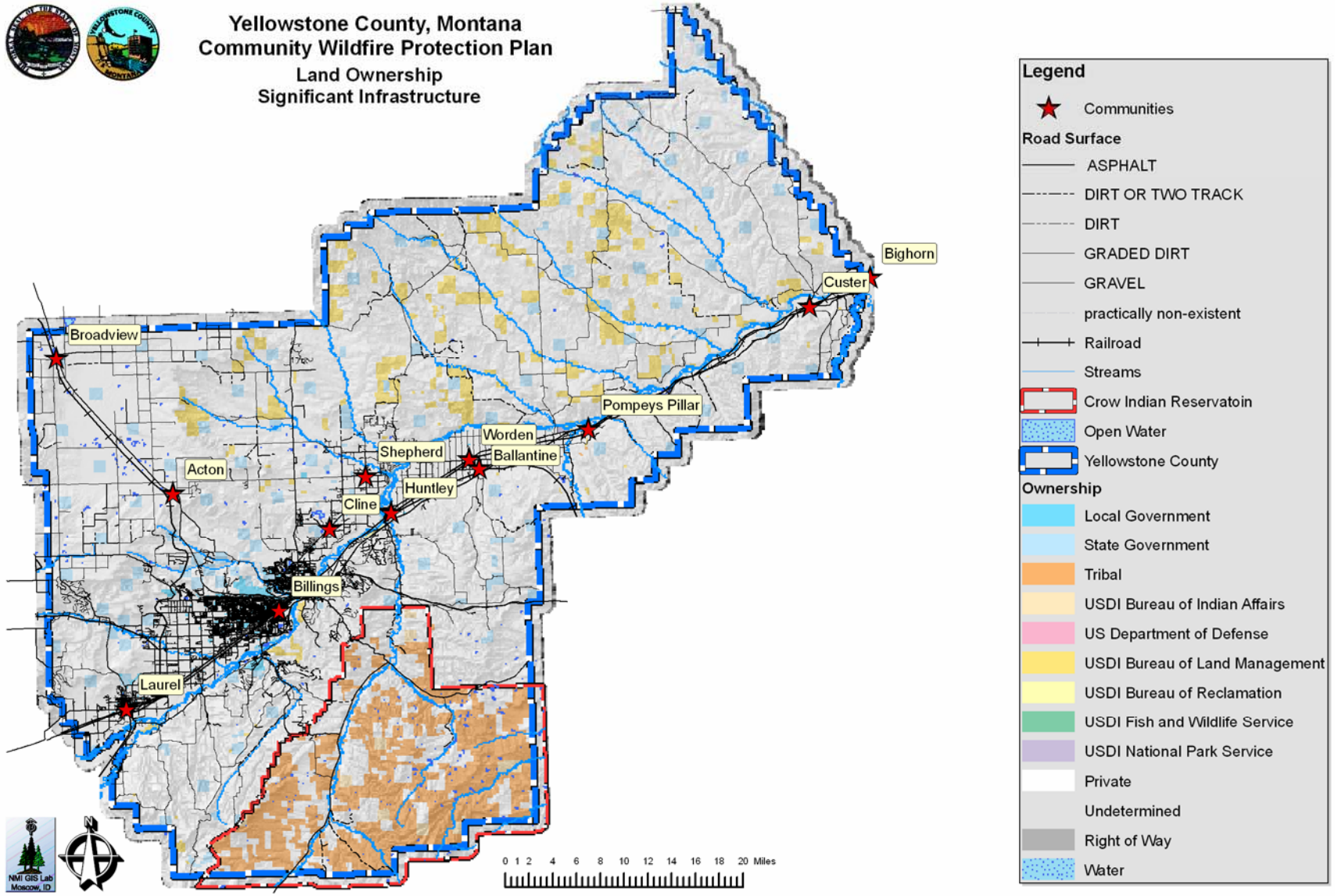
Shaded Elevation Relief of Yellowstone County



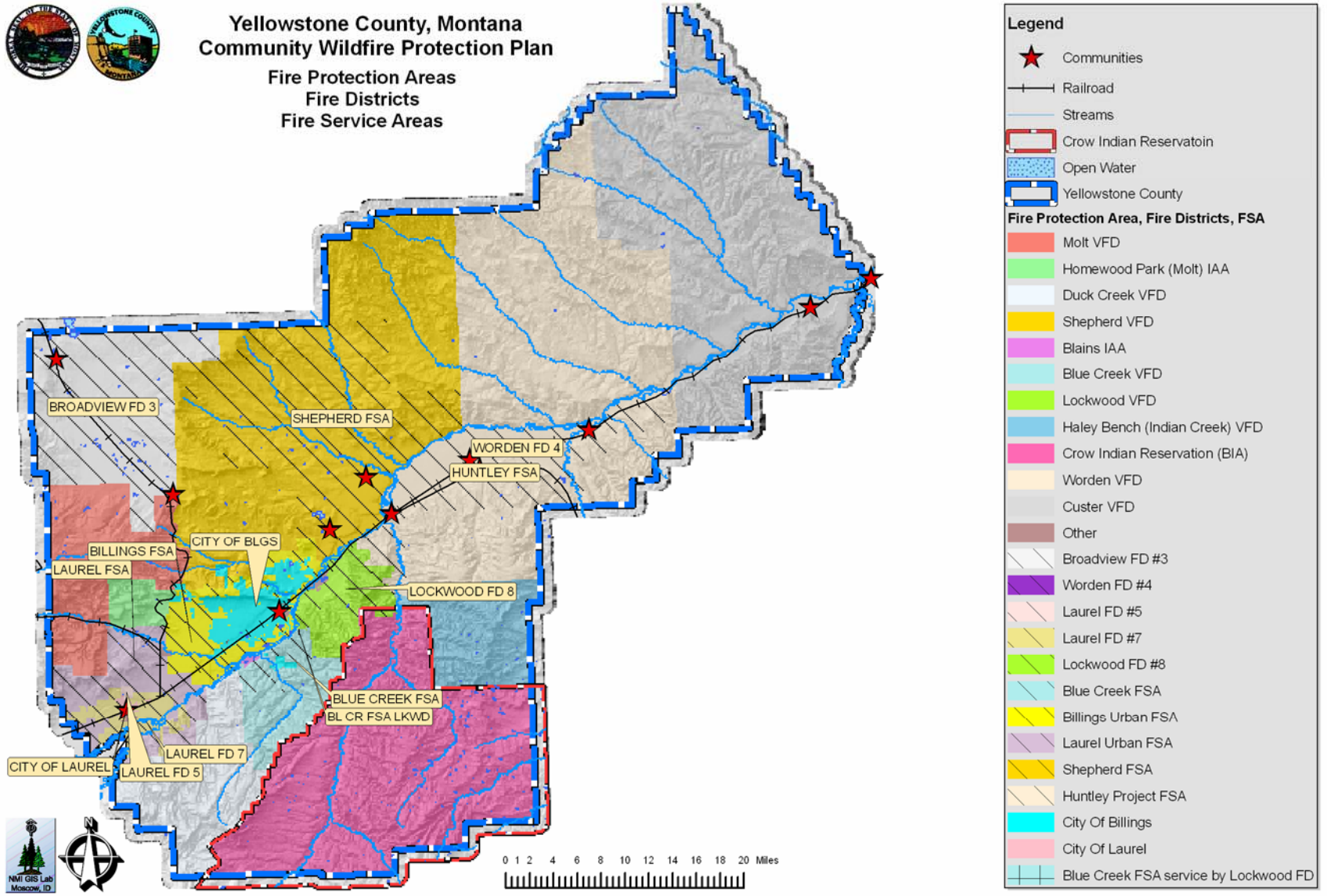
Significant Infrastructure in Yellowstone County



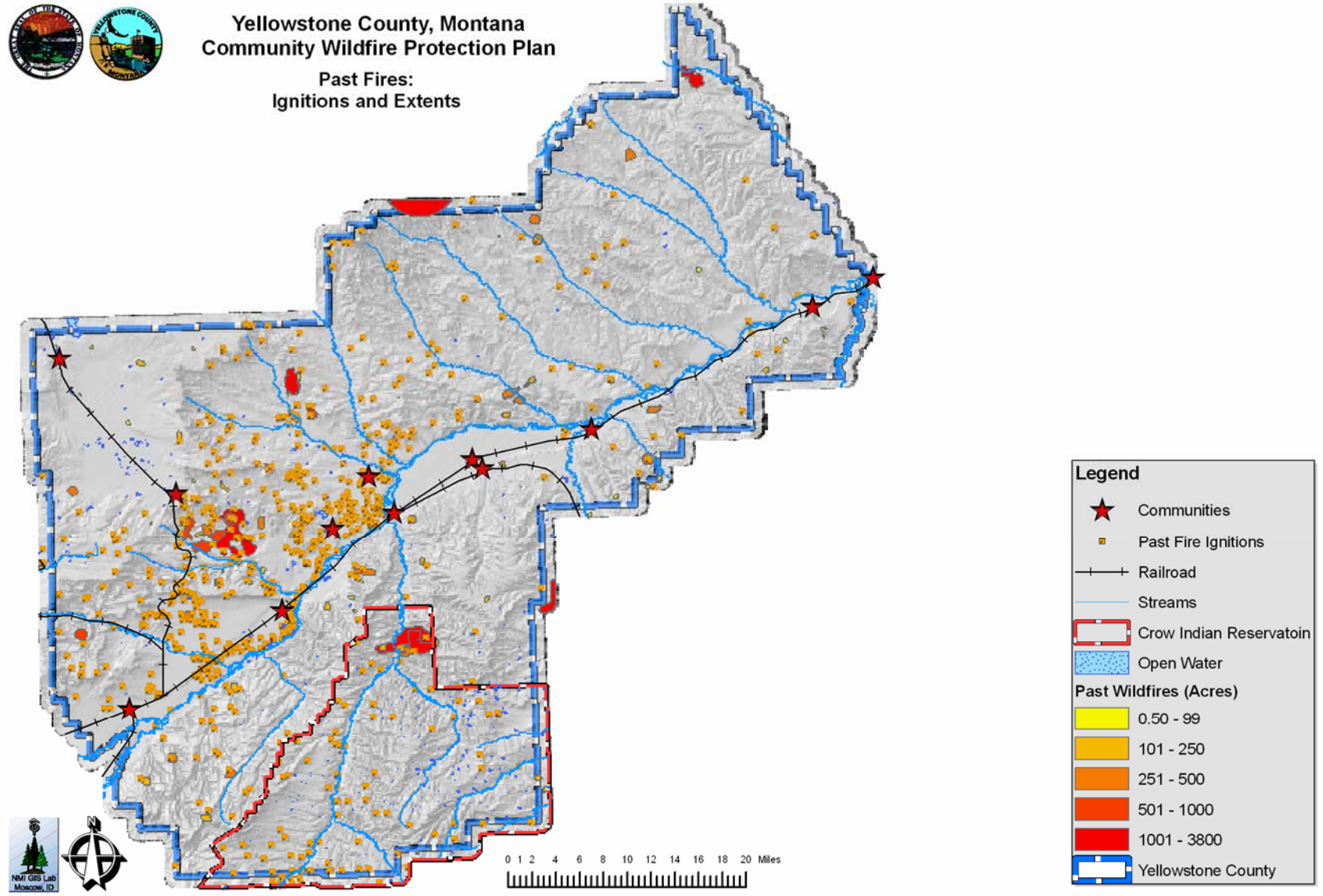
Yellowstone County Ownership Map



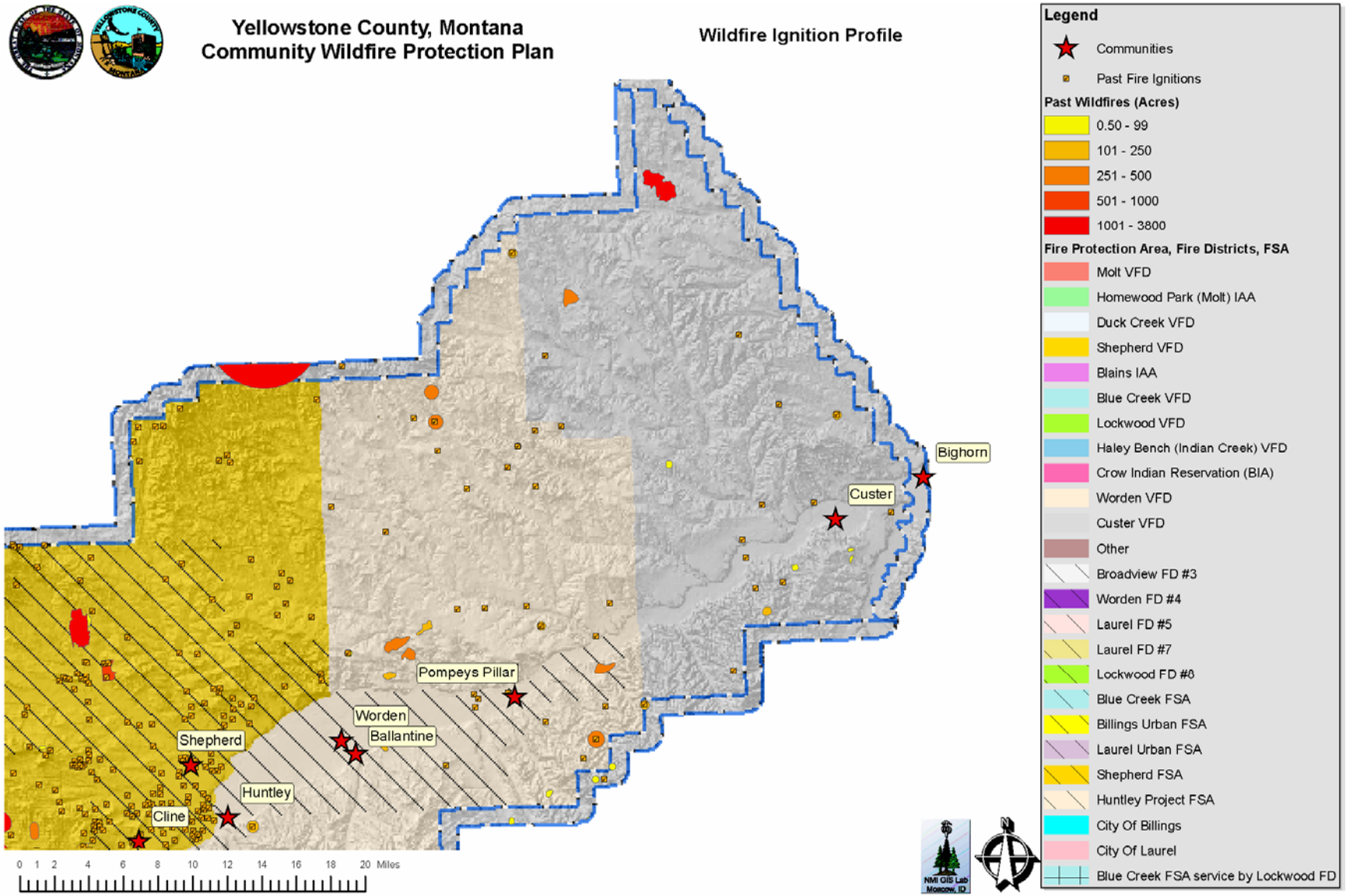
Fire Protection Districts



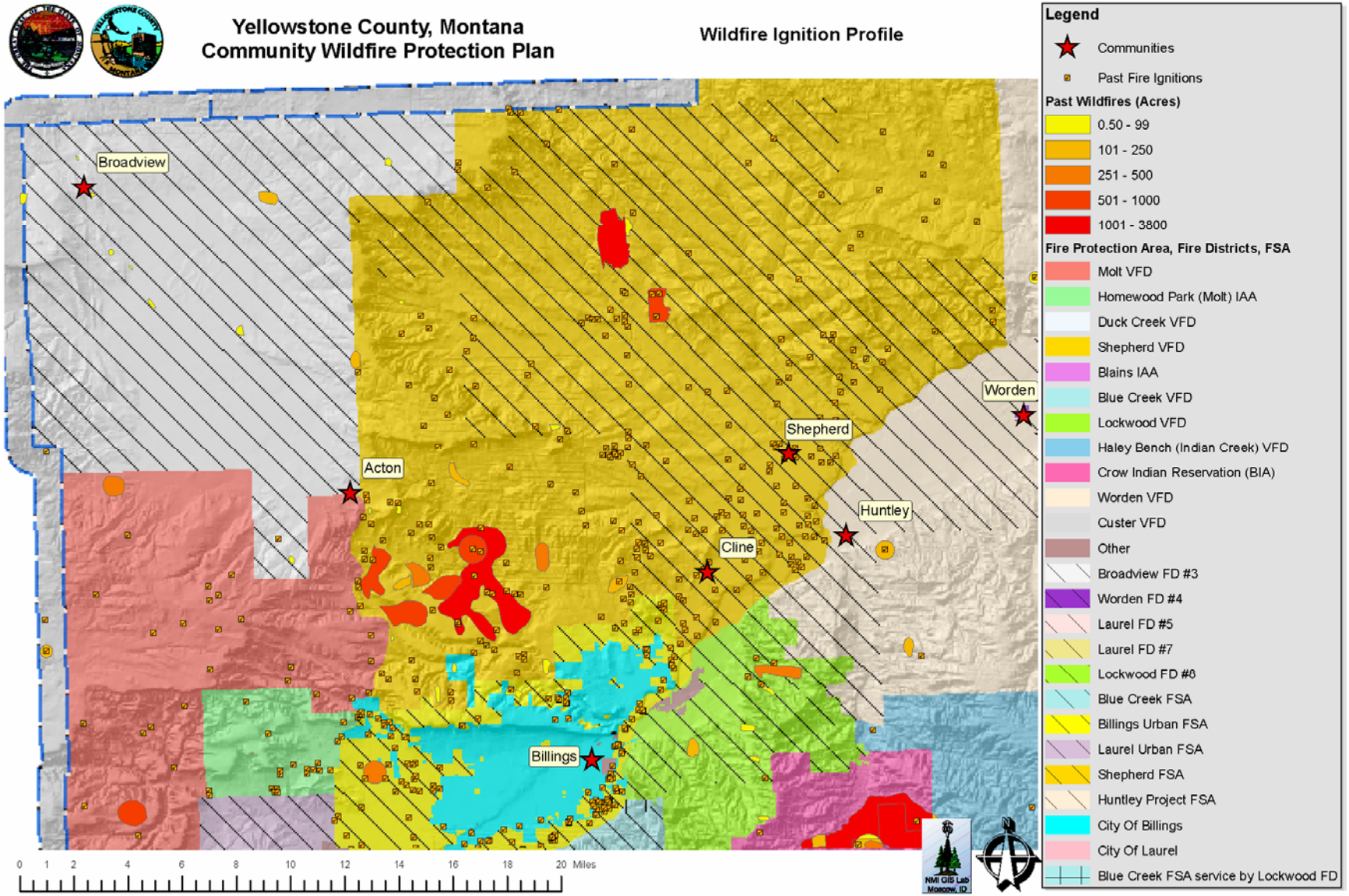
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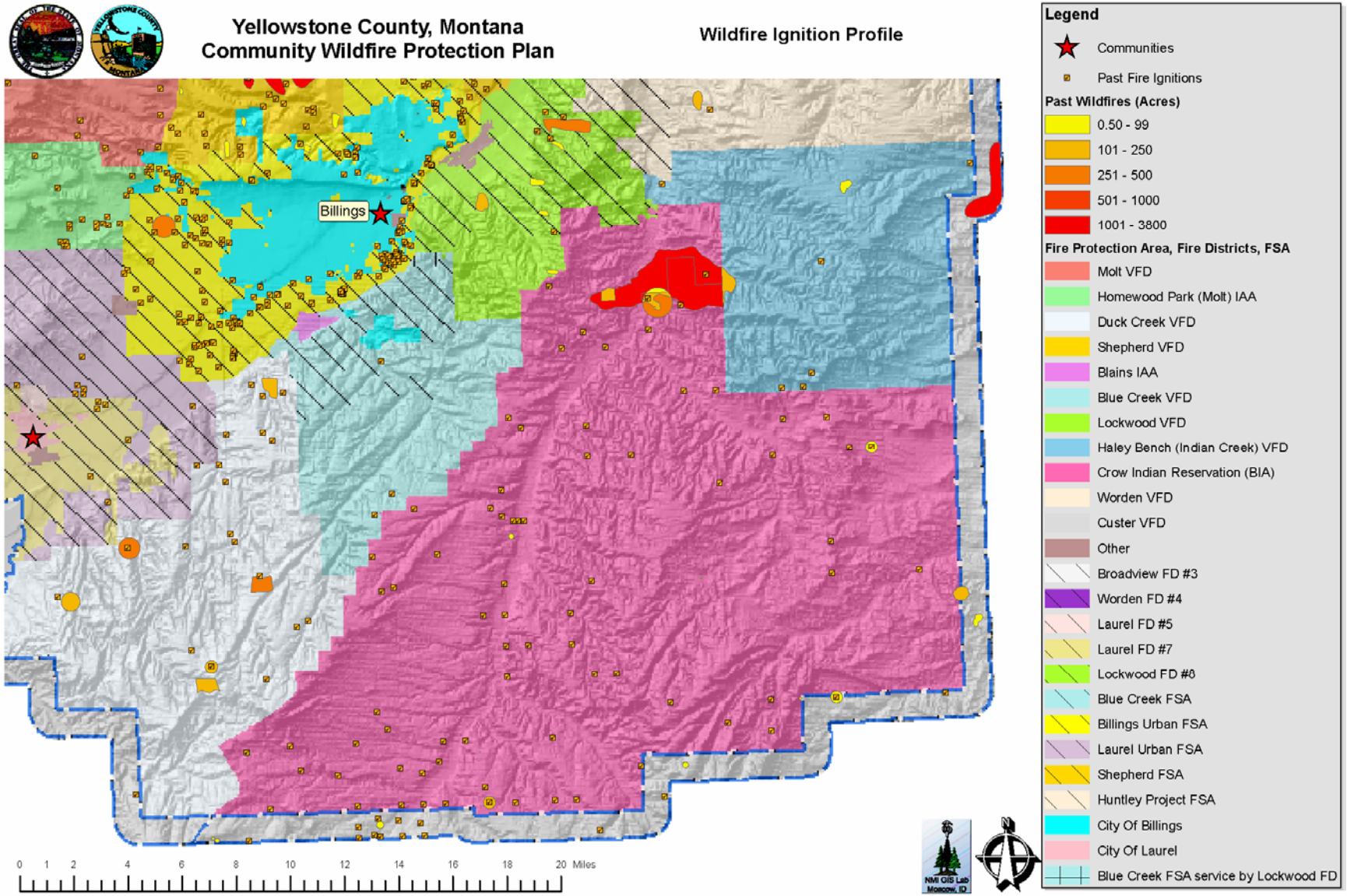
Wildfire Ignition Profile for Northeast Yellowstone County



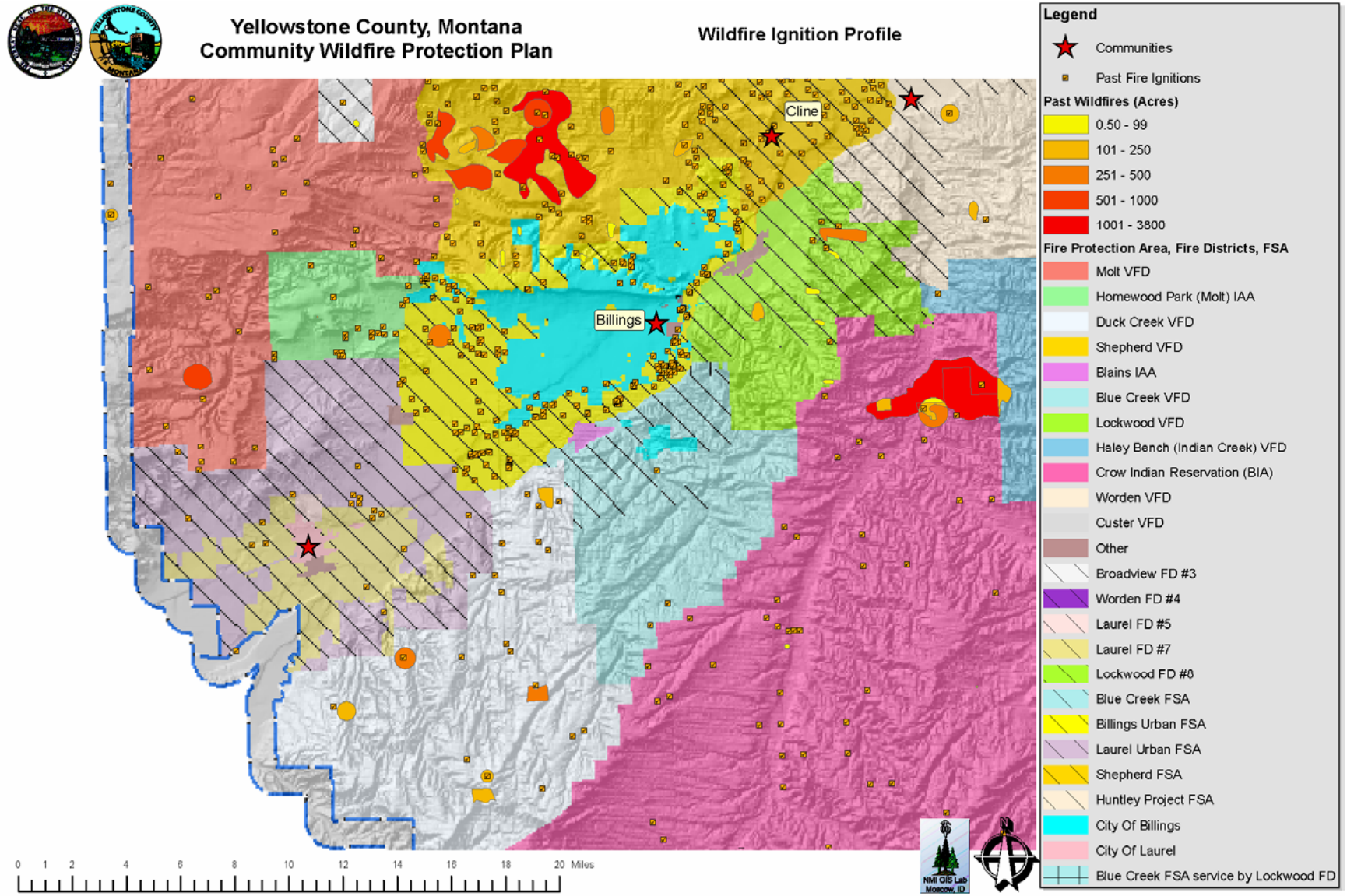
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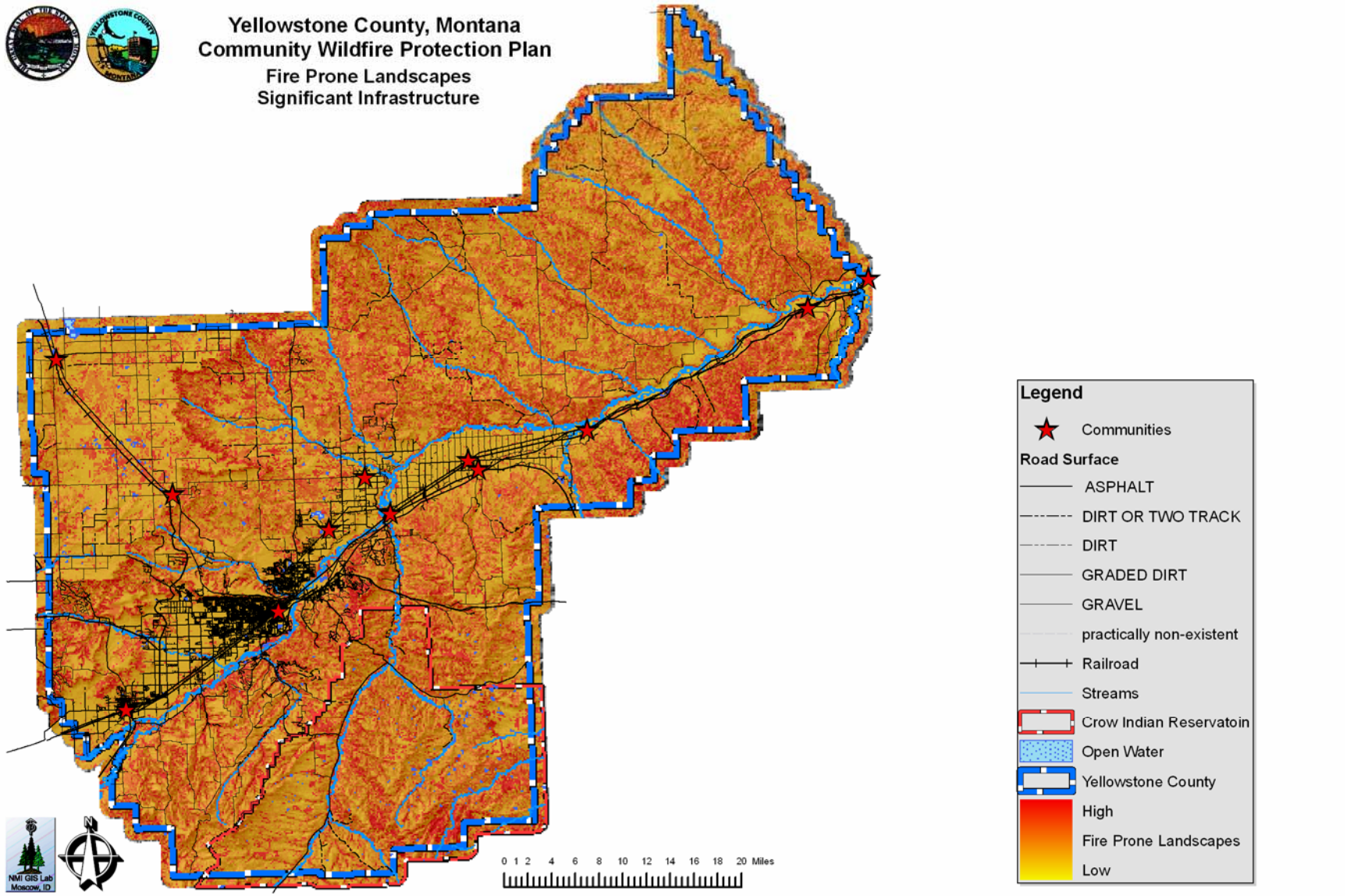
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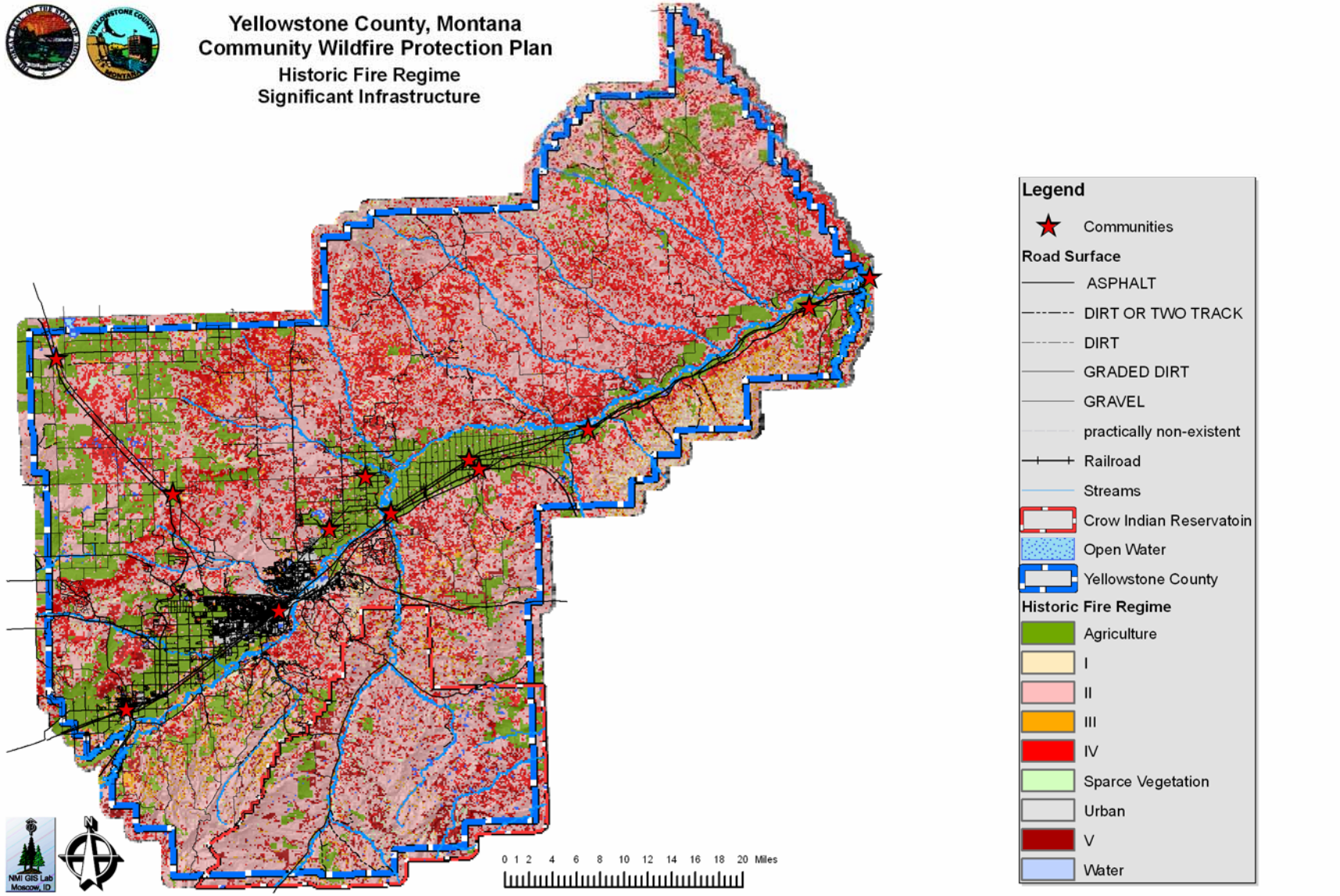
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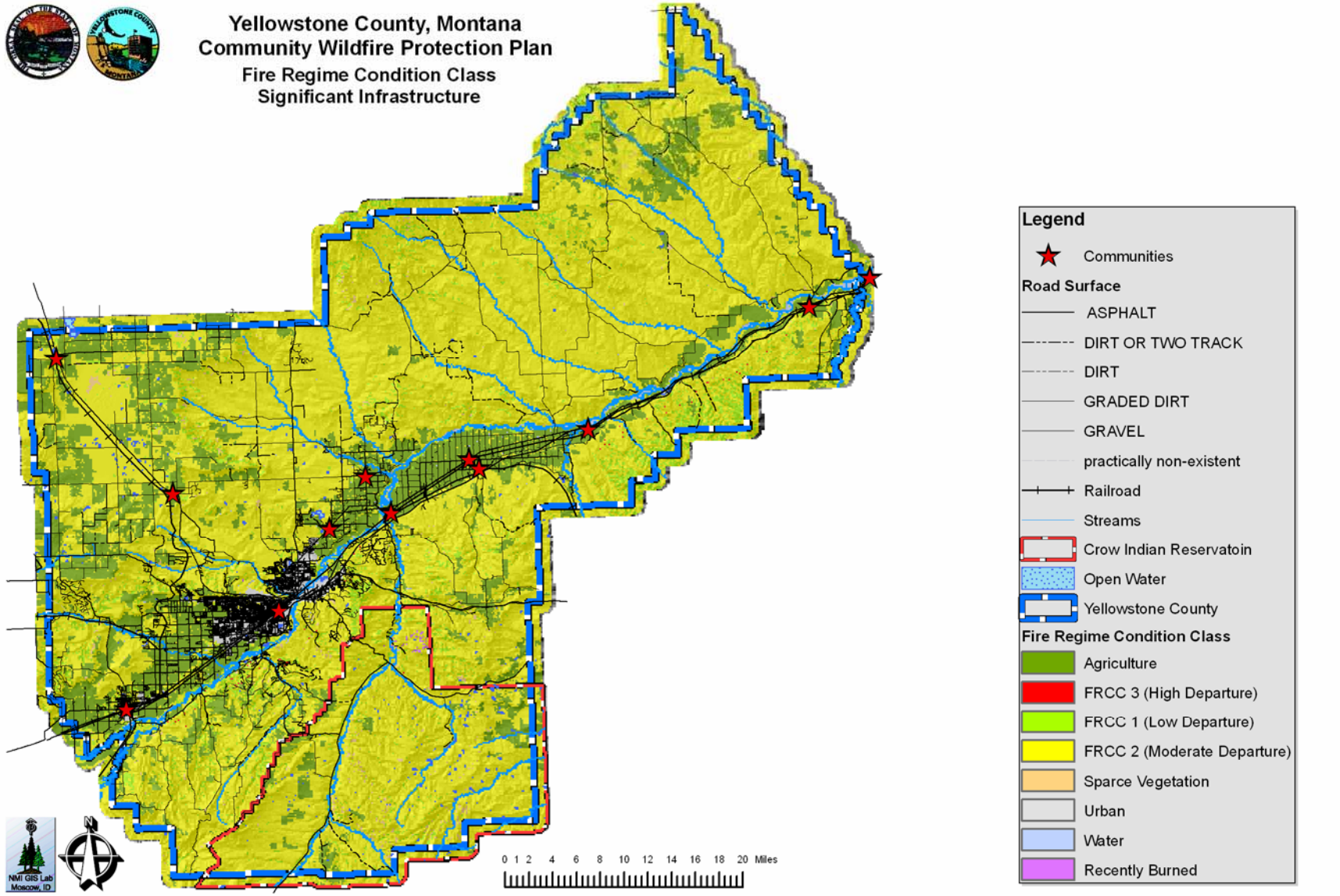
Fire Prone Landscapes in Yellowstone County



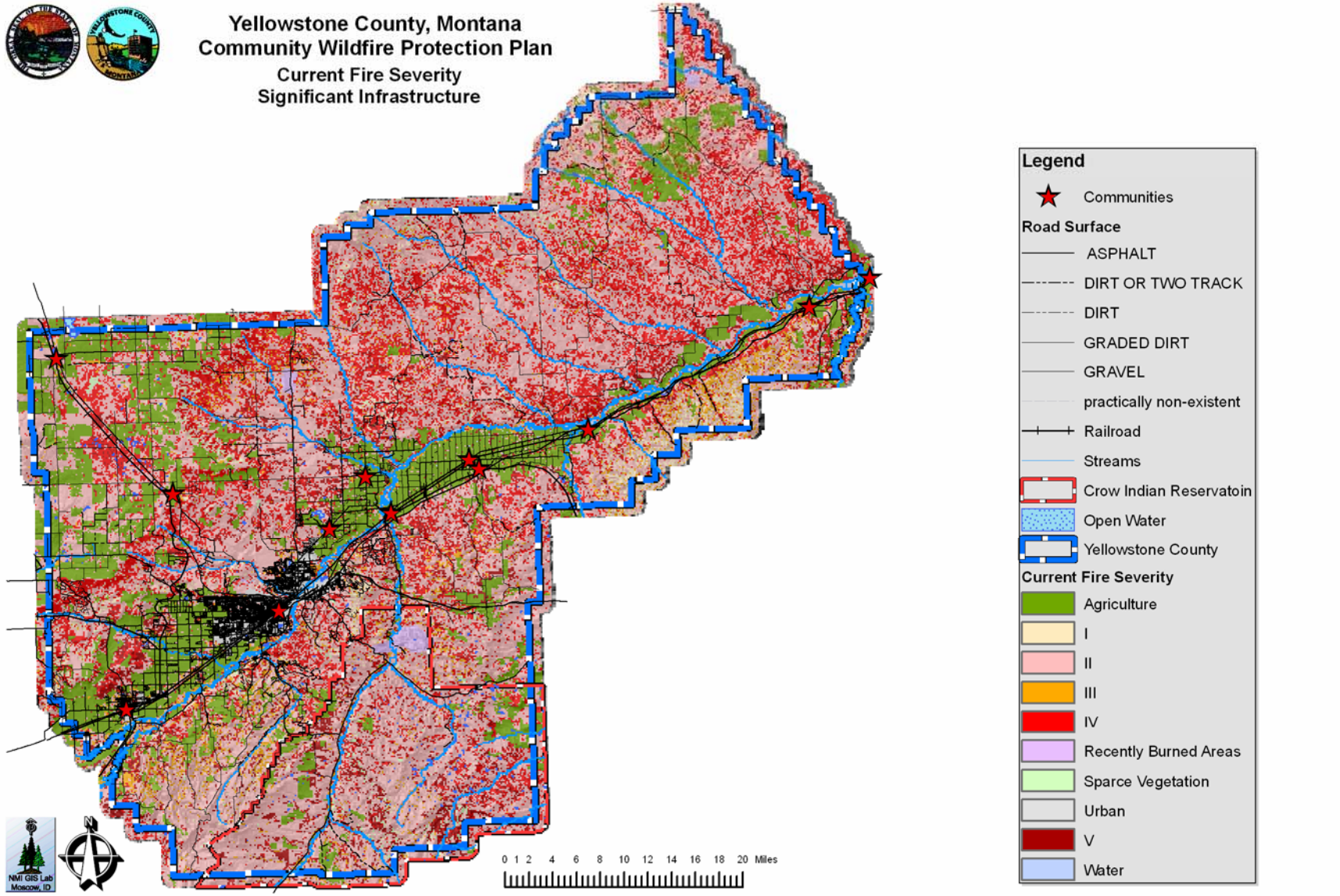
Historic Fire Regime in Yellowstone County



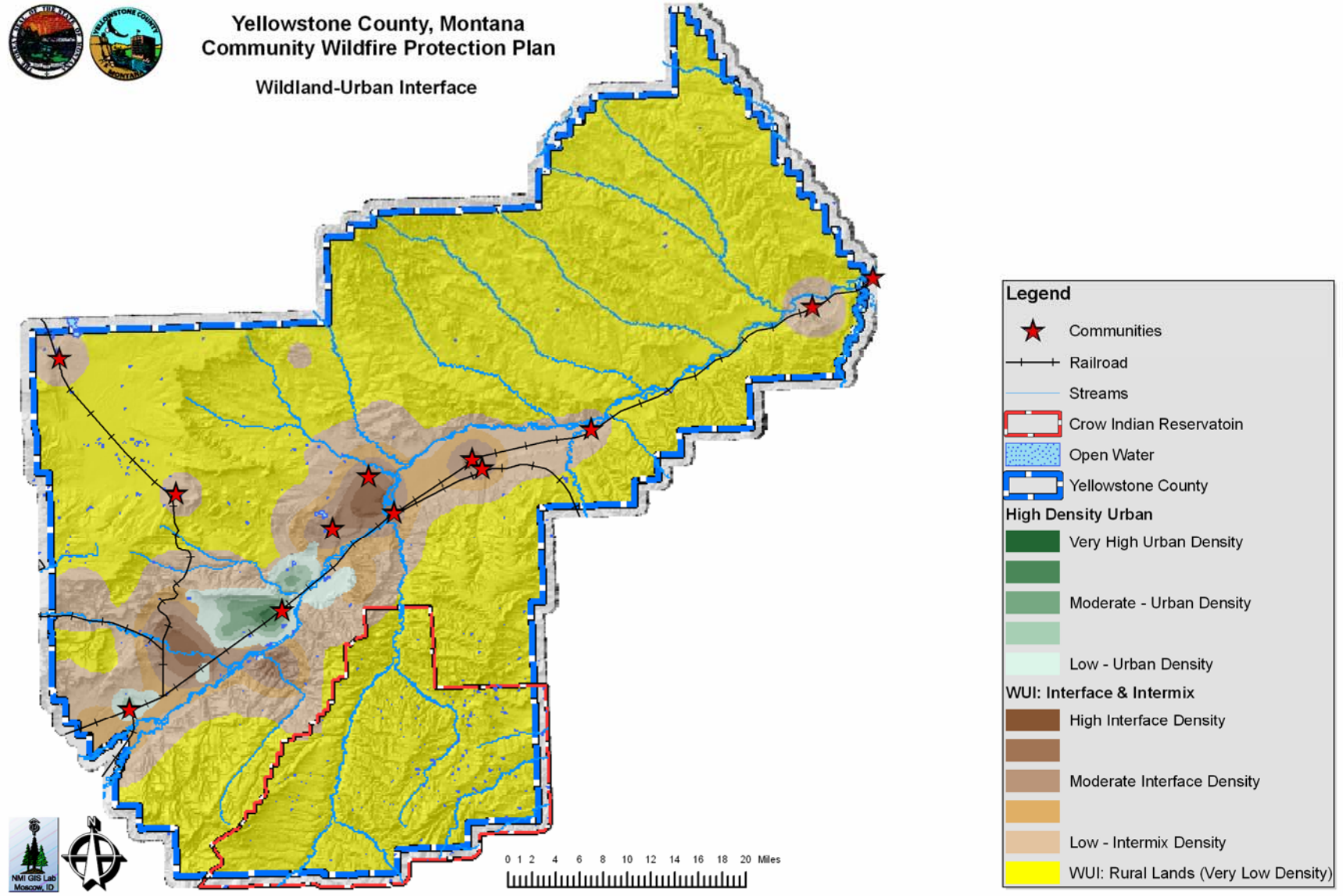
Fire Regime Condition Class in Yellowstone County



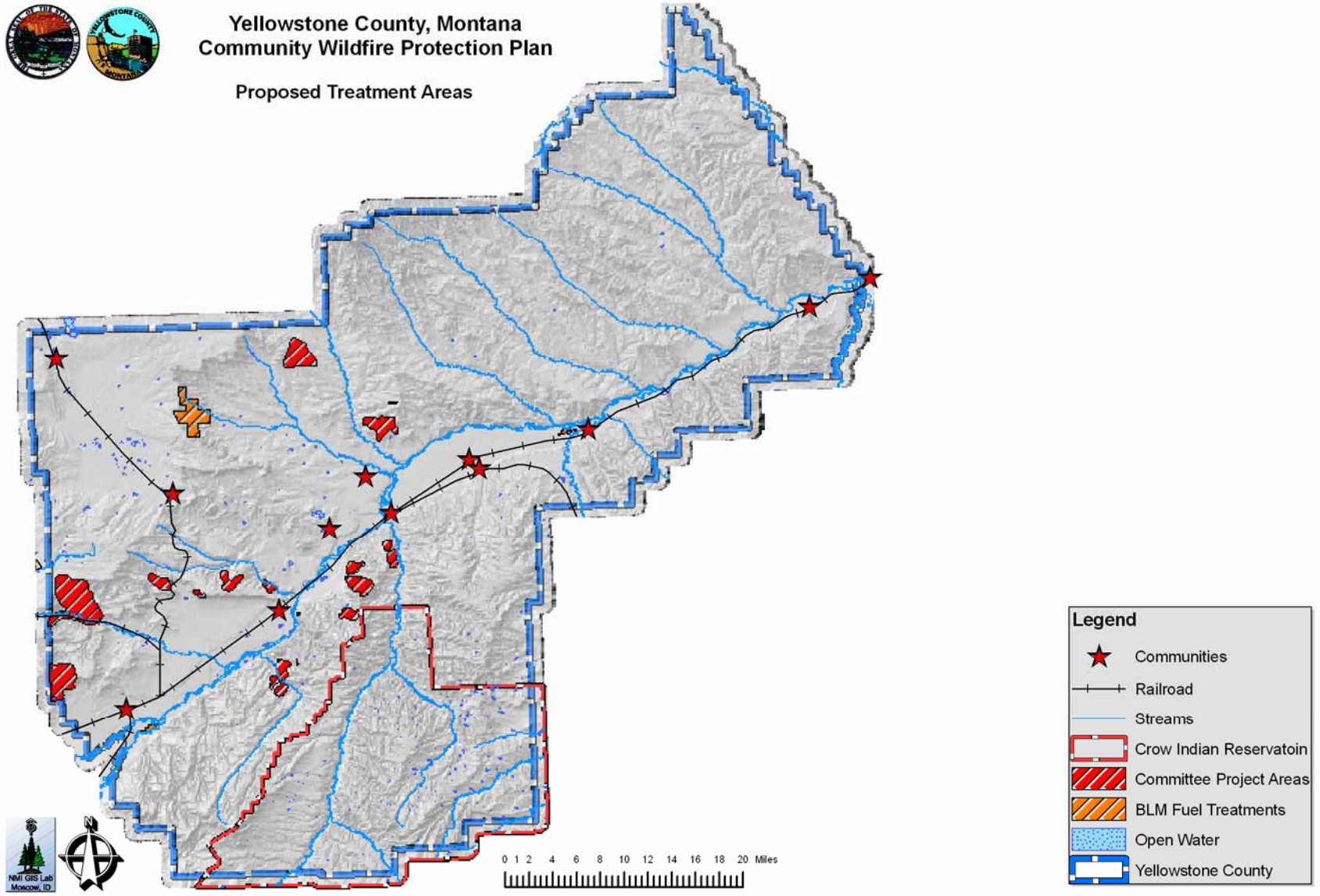
Current Fire Severity in Yellowstone County



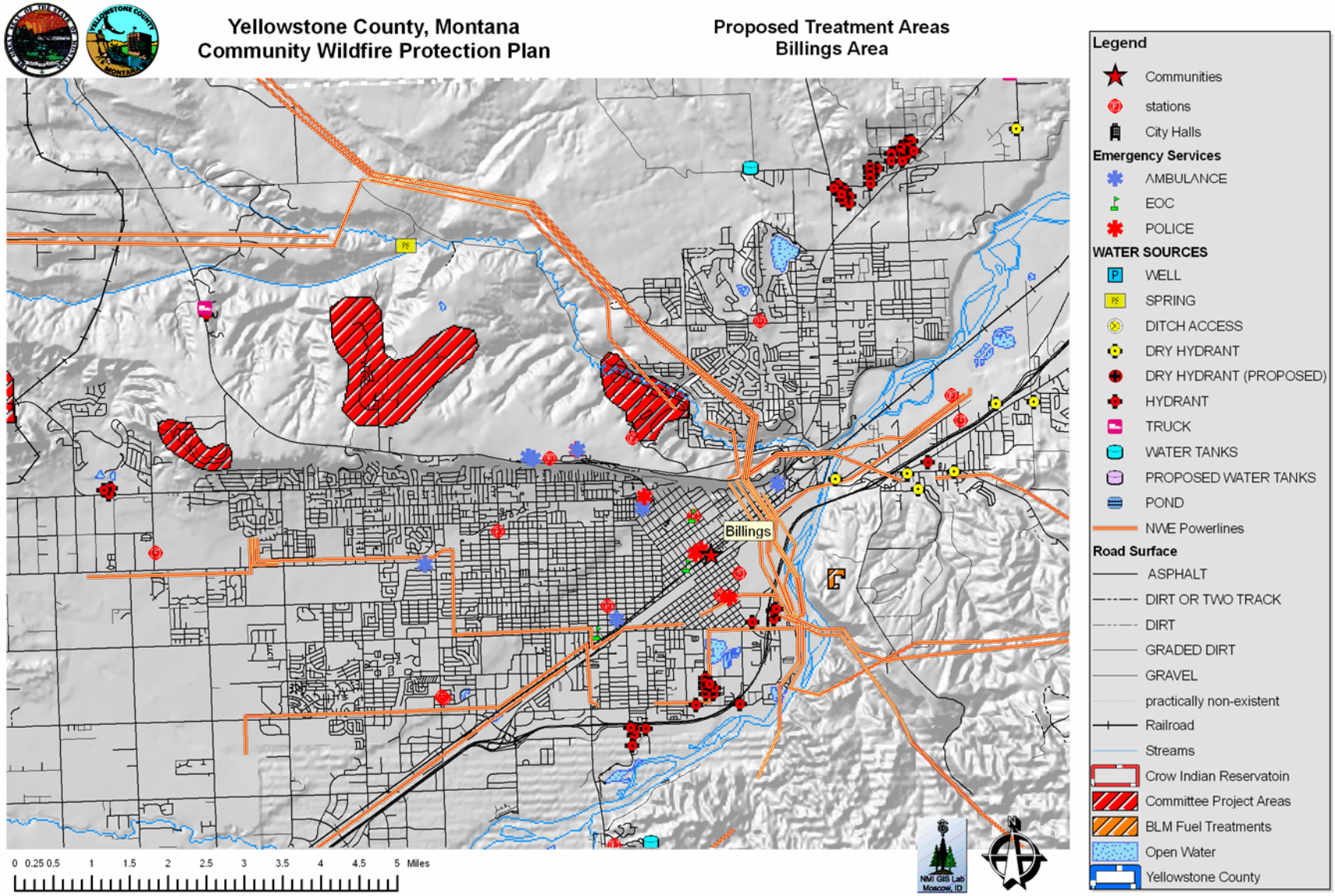
Wildland-Urban Interface and Significant Infrastructure



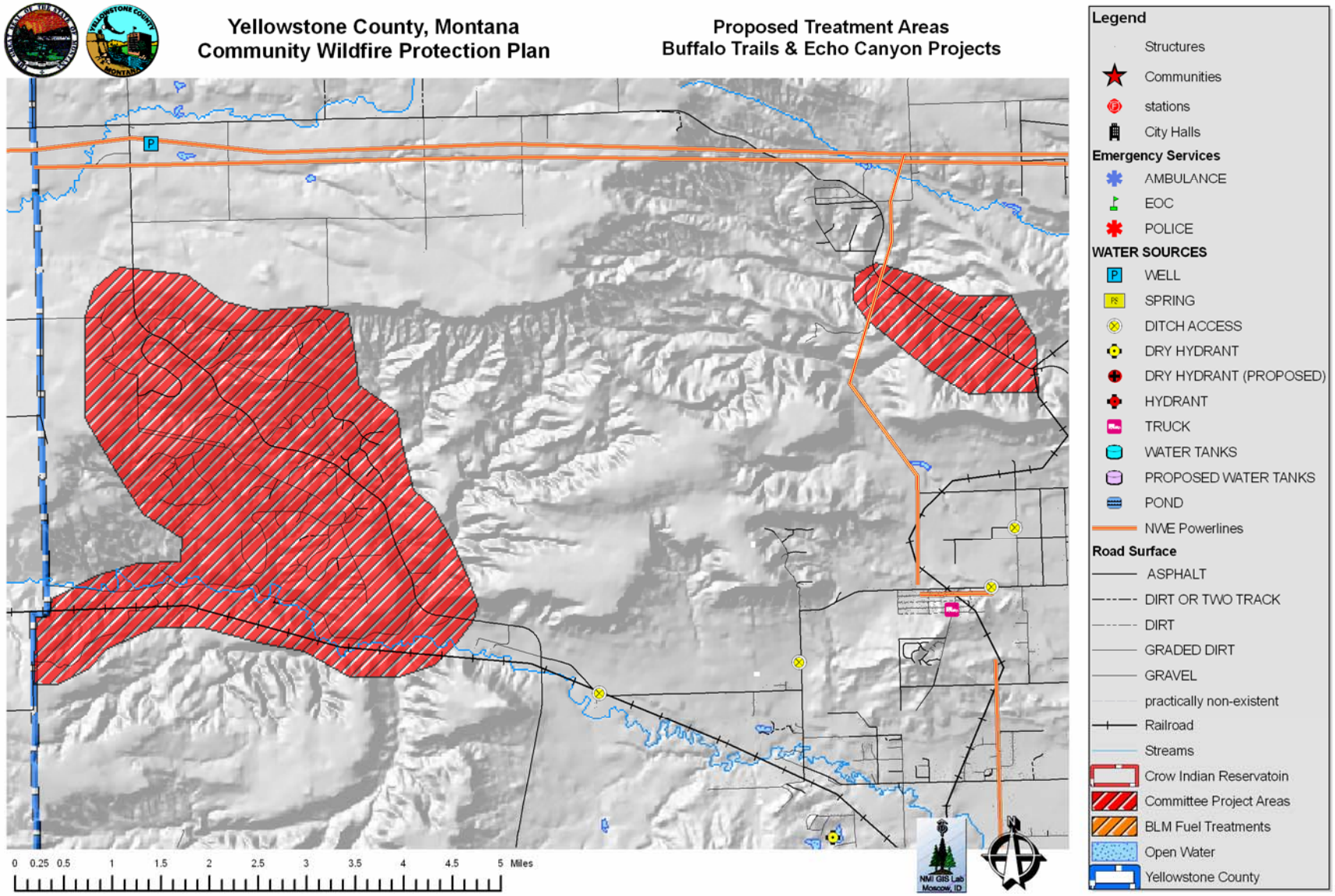
Proposed Treatment Areas: Overview



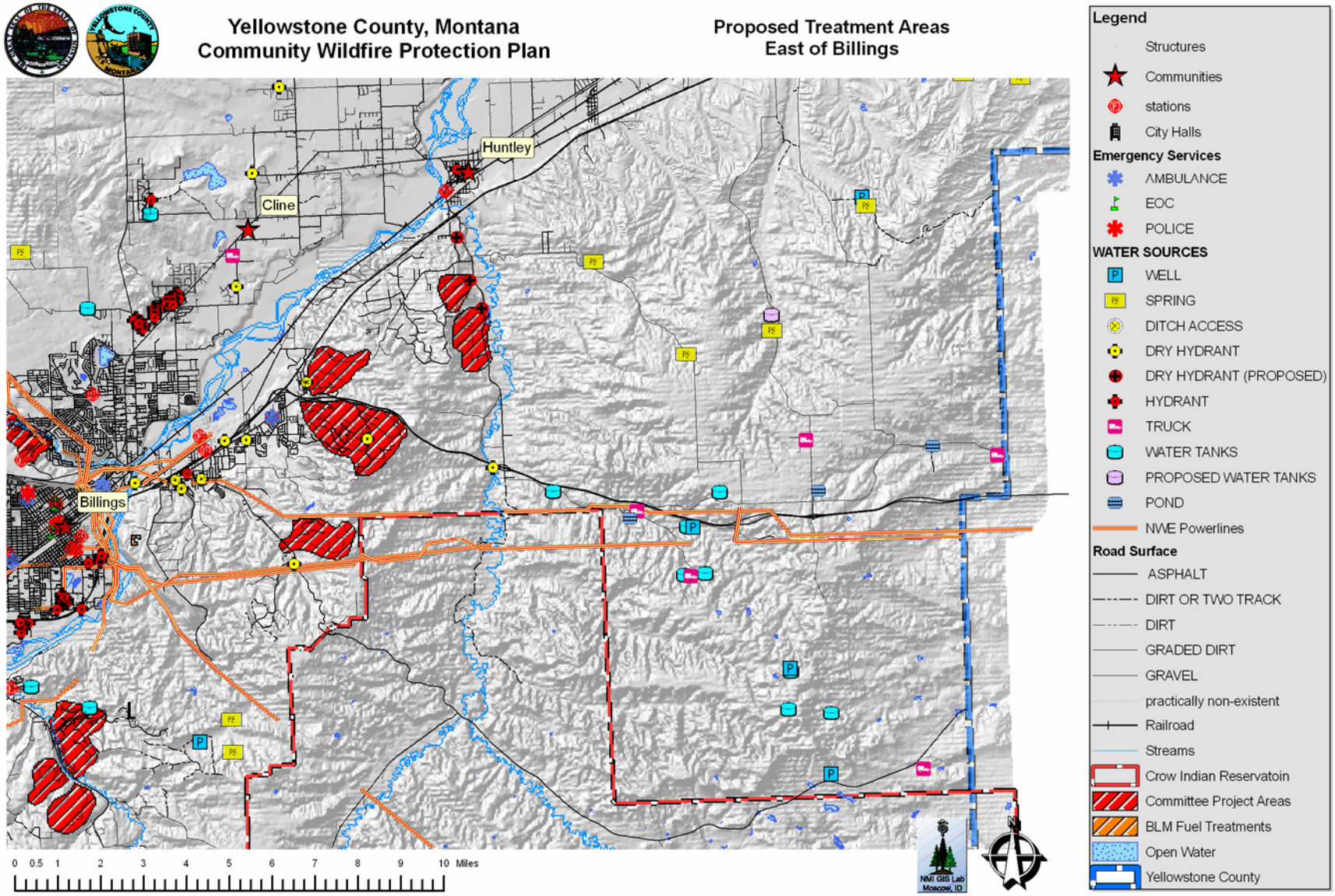
Proposed Treatment Areas in Billings Area, Yellowstone County.



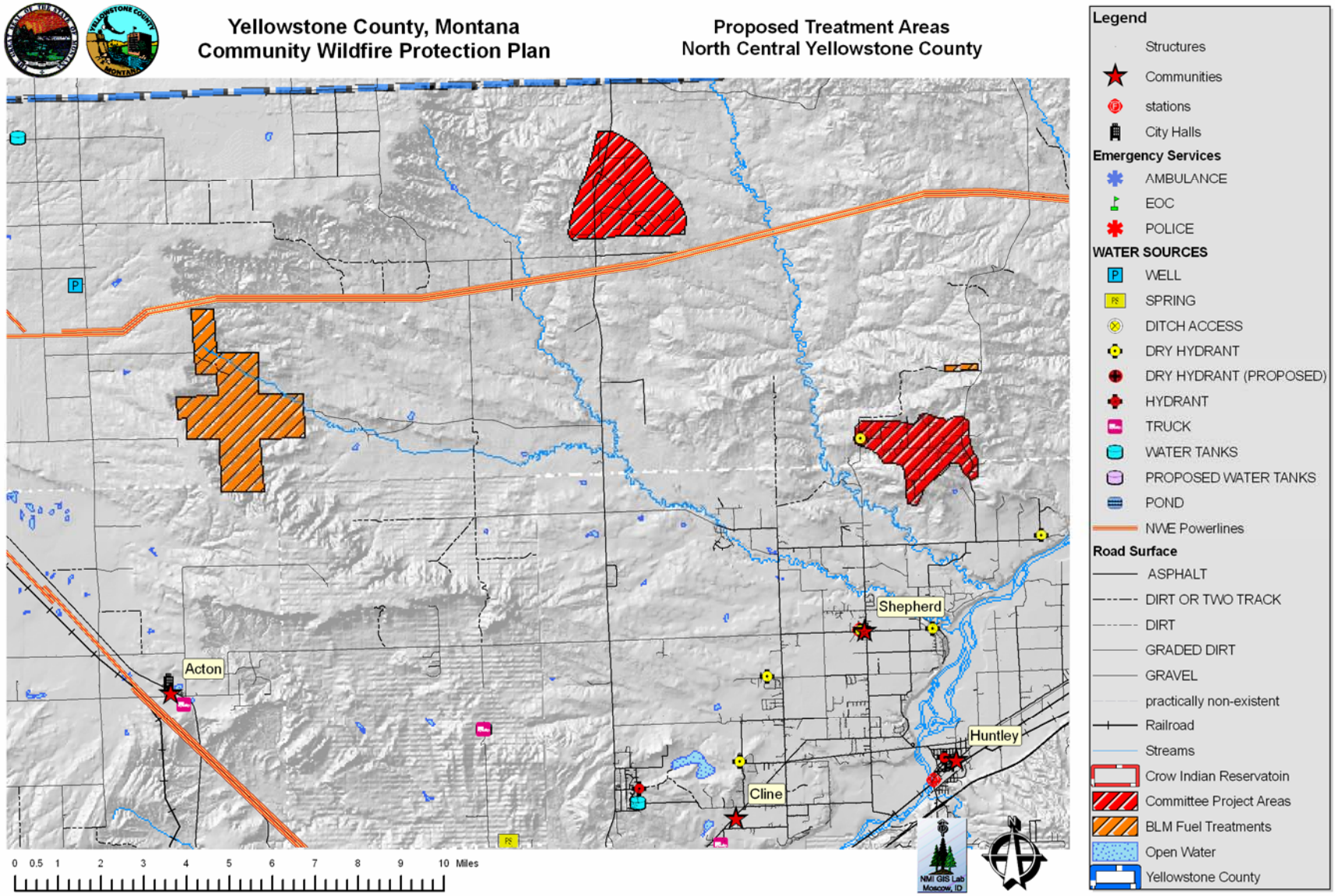
Buffalo Trails and Echo Canyon Proposed Treatment Areas



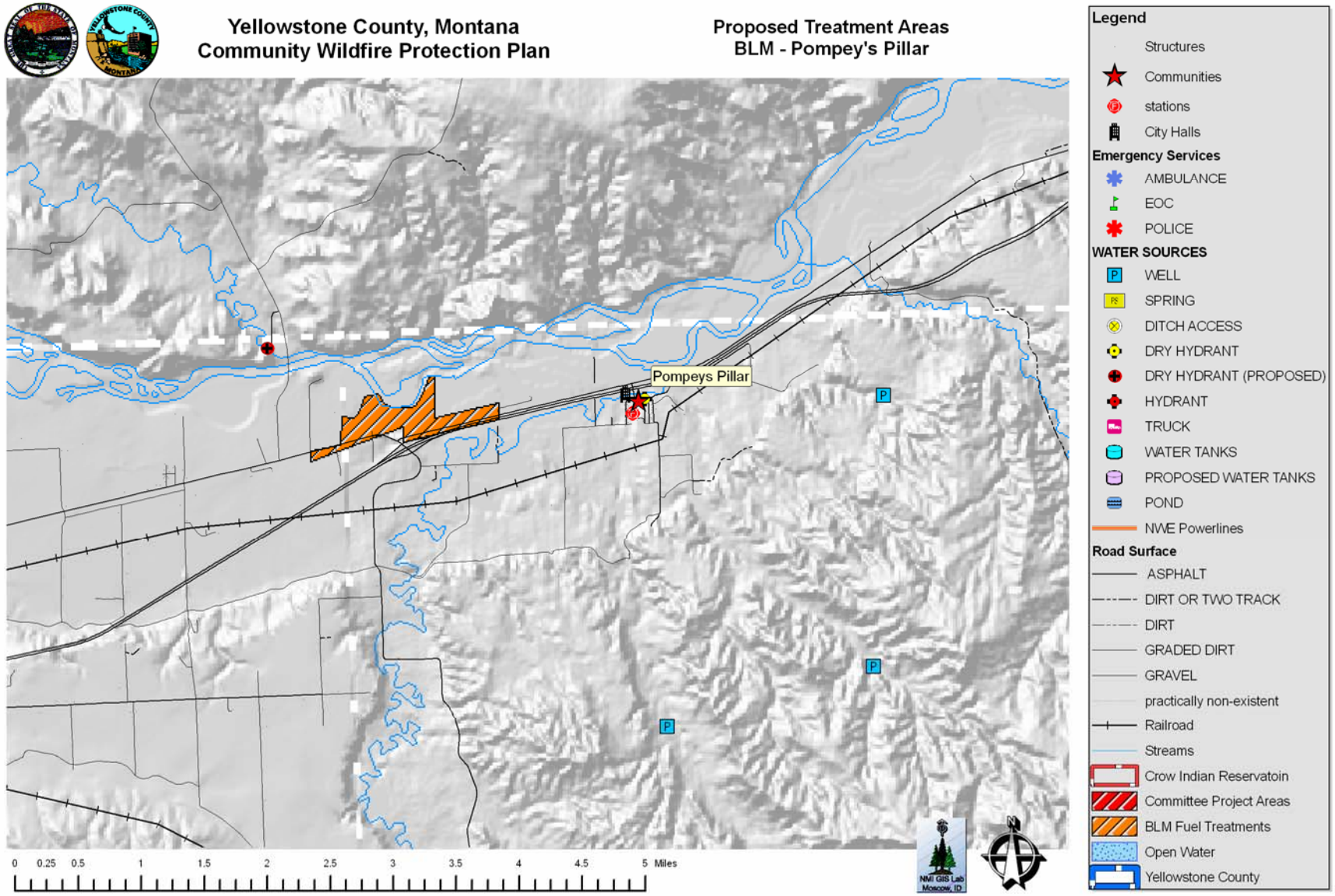
Proposed Treatment Areas East of Billings, Yellowstone County



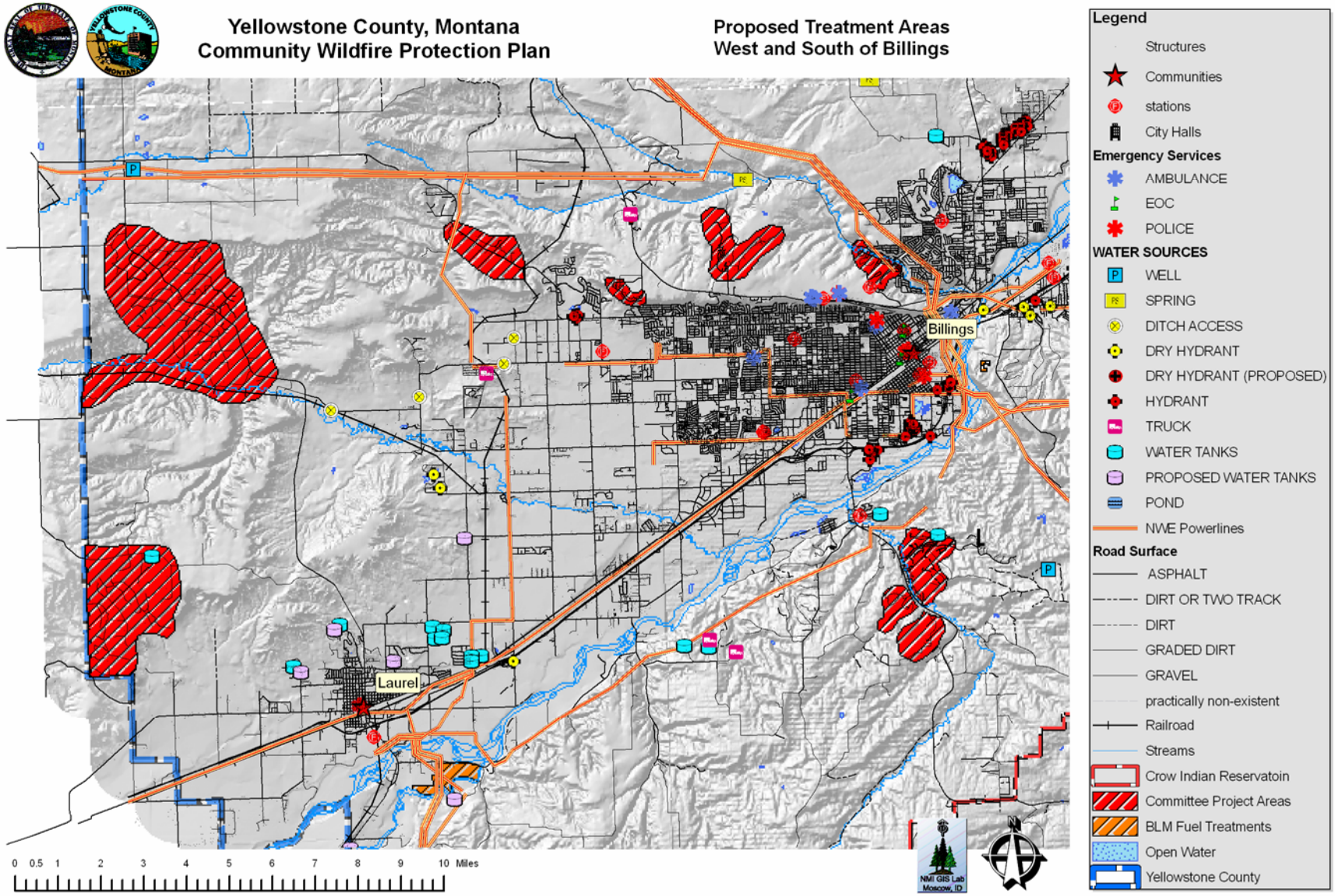
Proposed Treatment Areas in North Central Yellowstone County



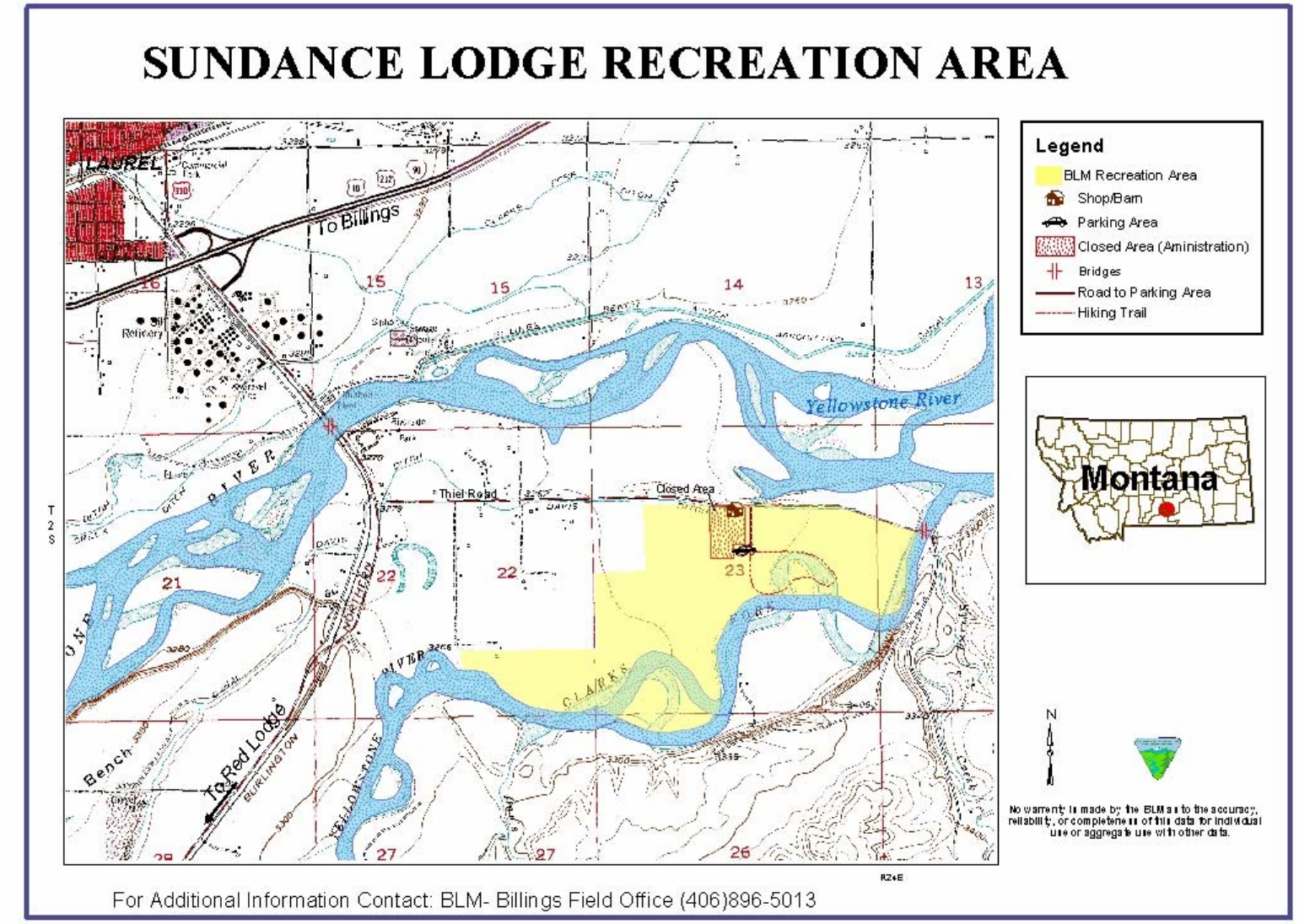
Proposed Treatment Areas near Pompeys Pillar, Yellowstone County



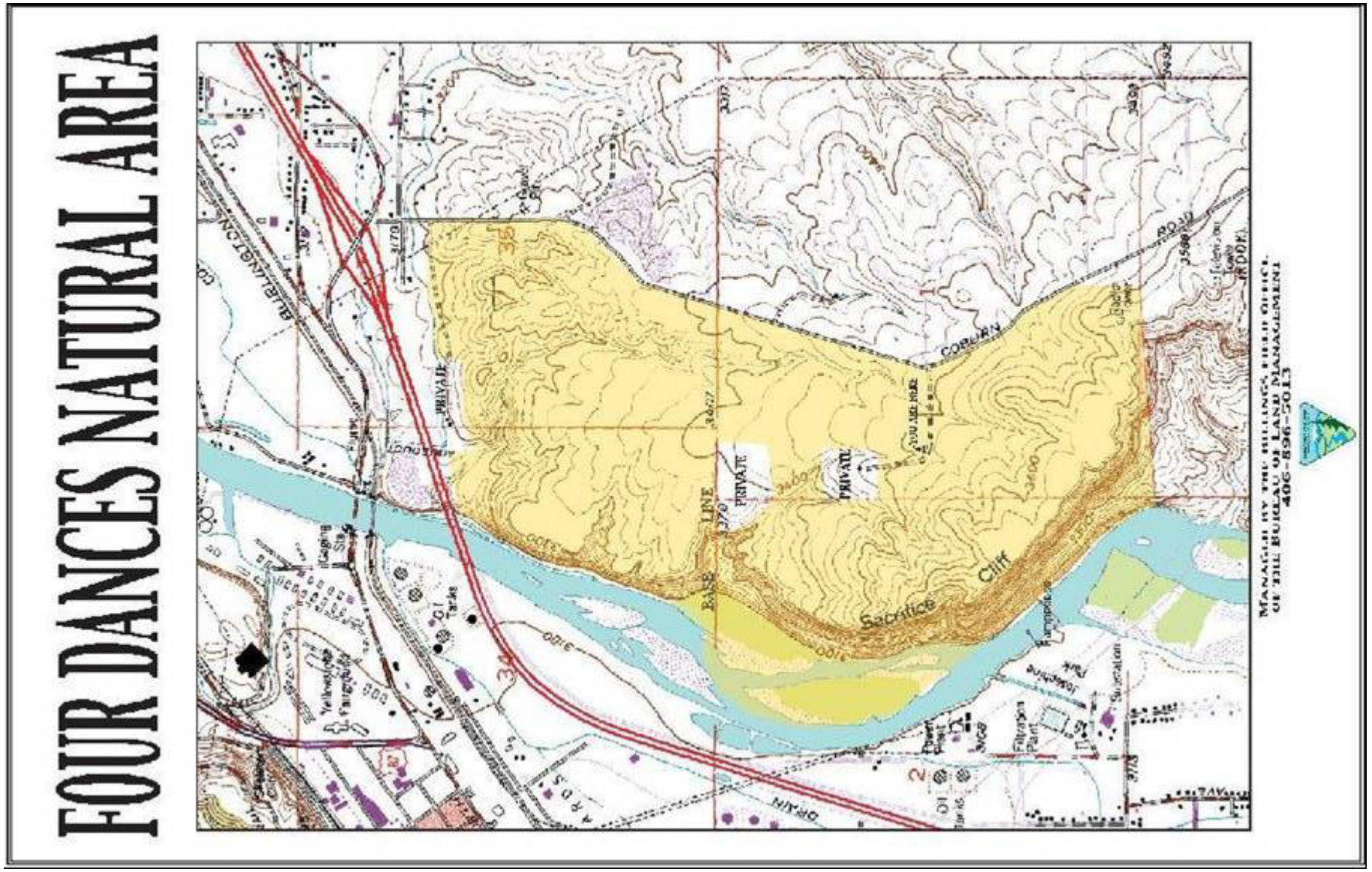
Proposed Treatment Areas West and South of Billings, Yellowstone County



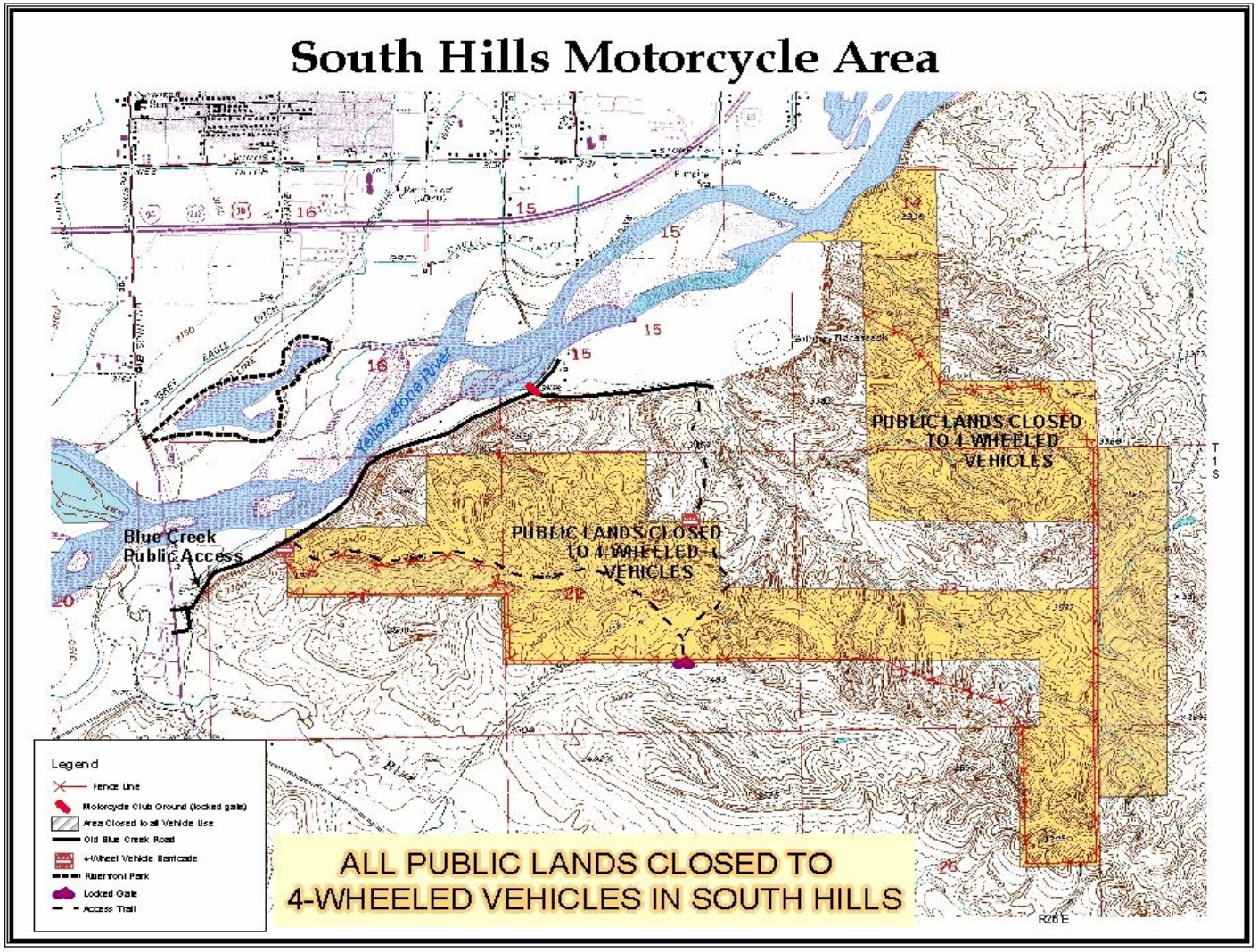
Bureau of Land Management Sundance Lodge Recreation Area Map



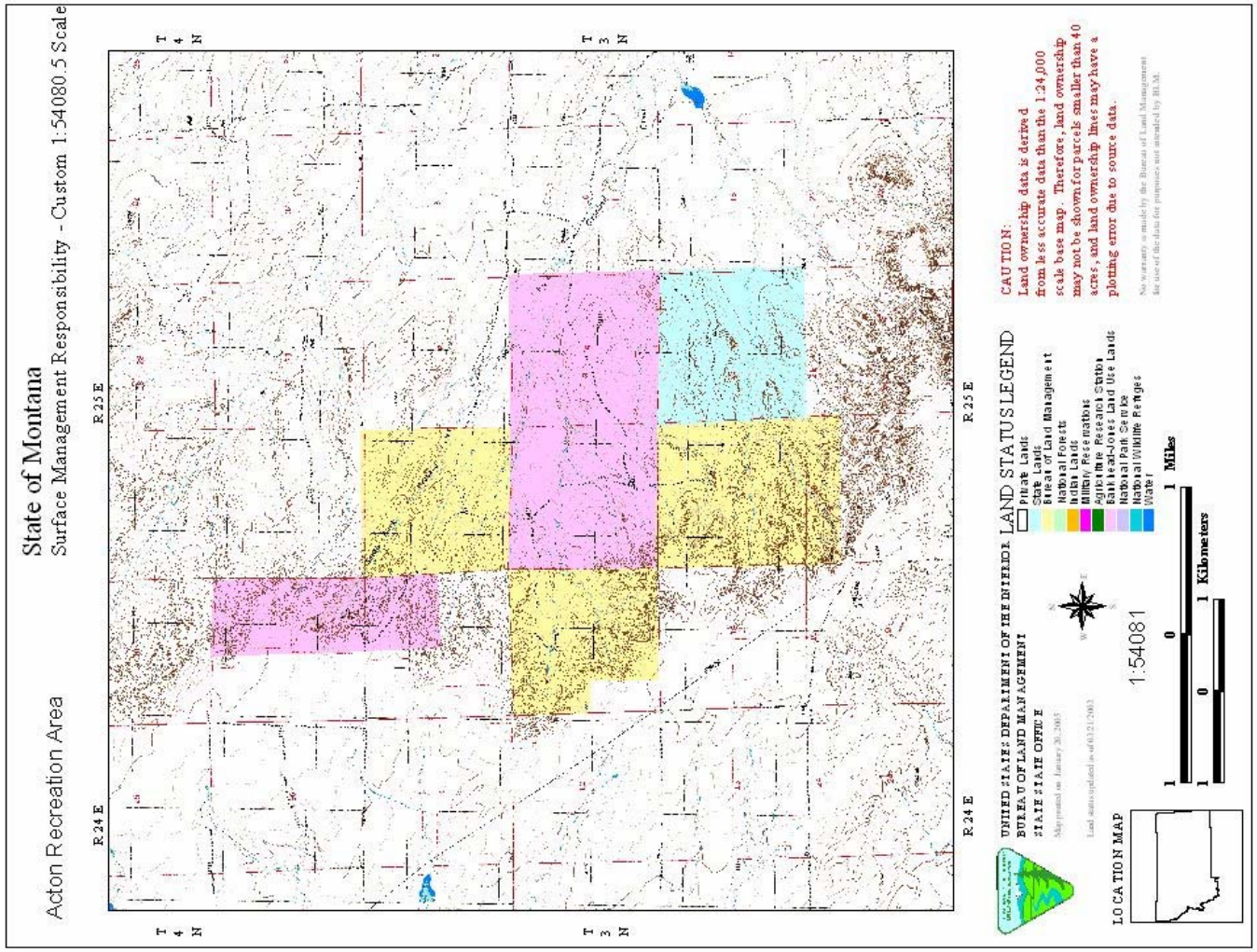
Bureau of Land Management Four Dances Natural Area Map



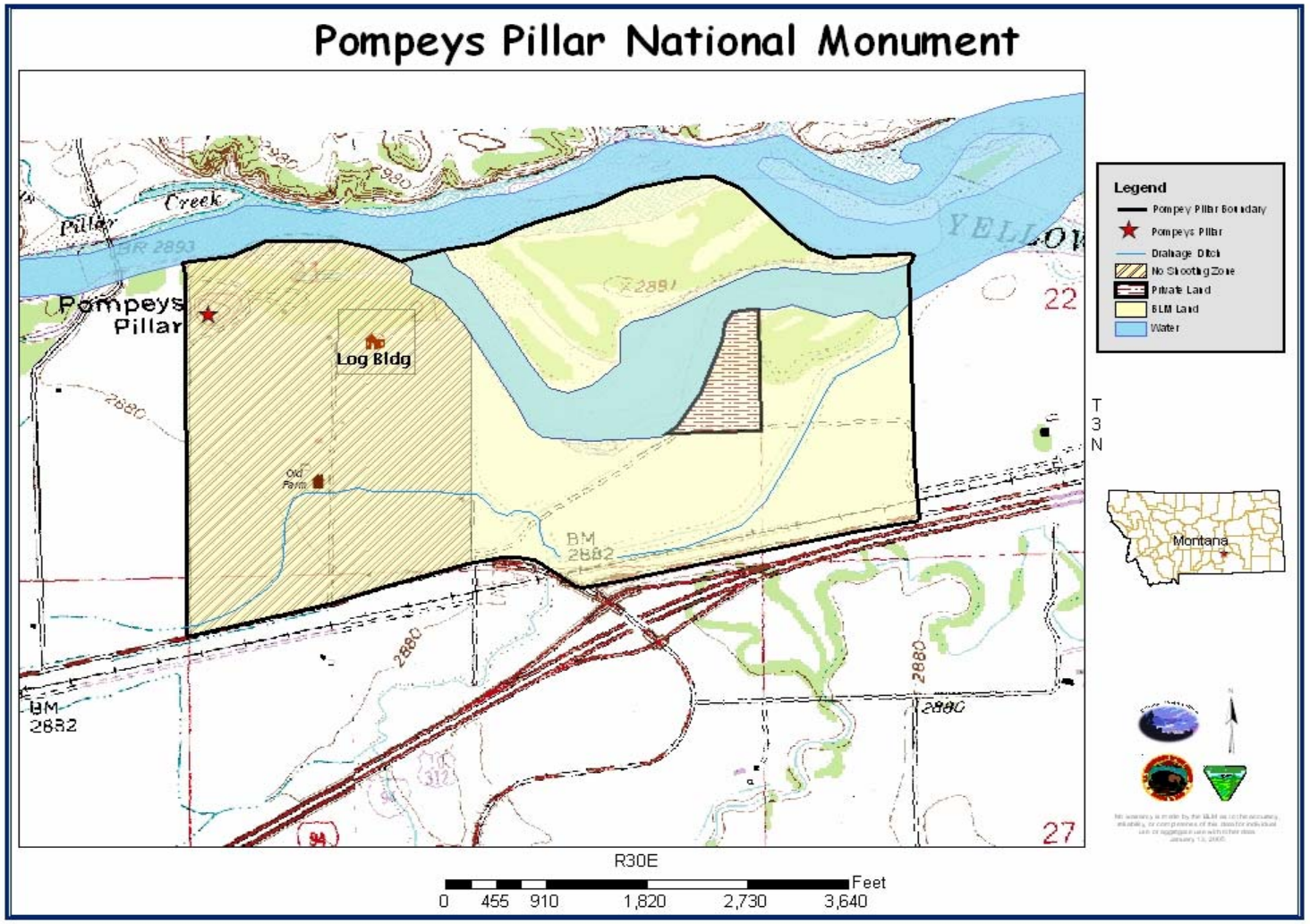
Bureau of Land Management South Hills Motorcycle Area Map



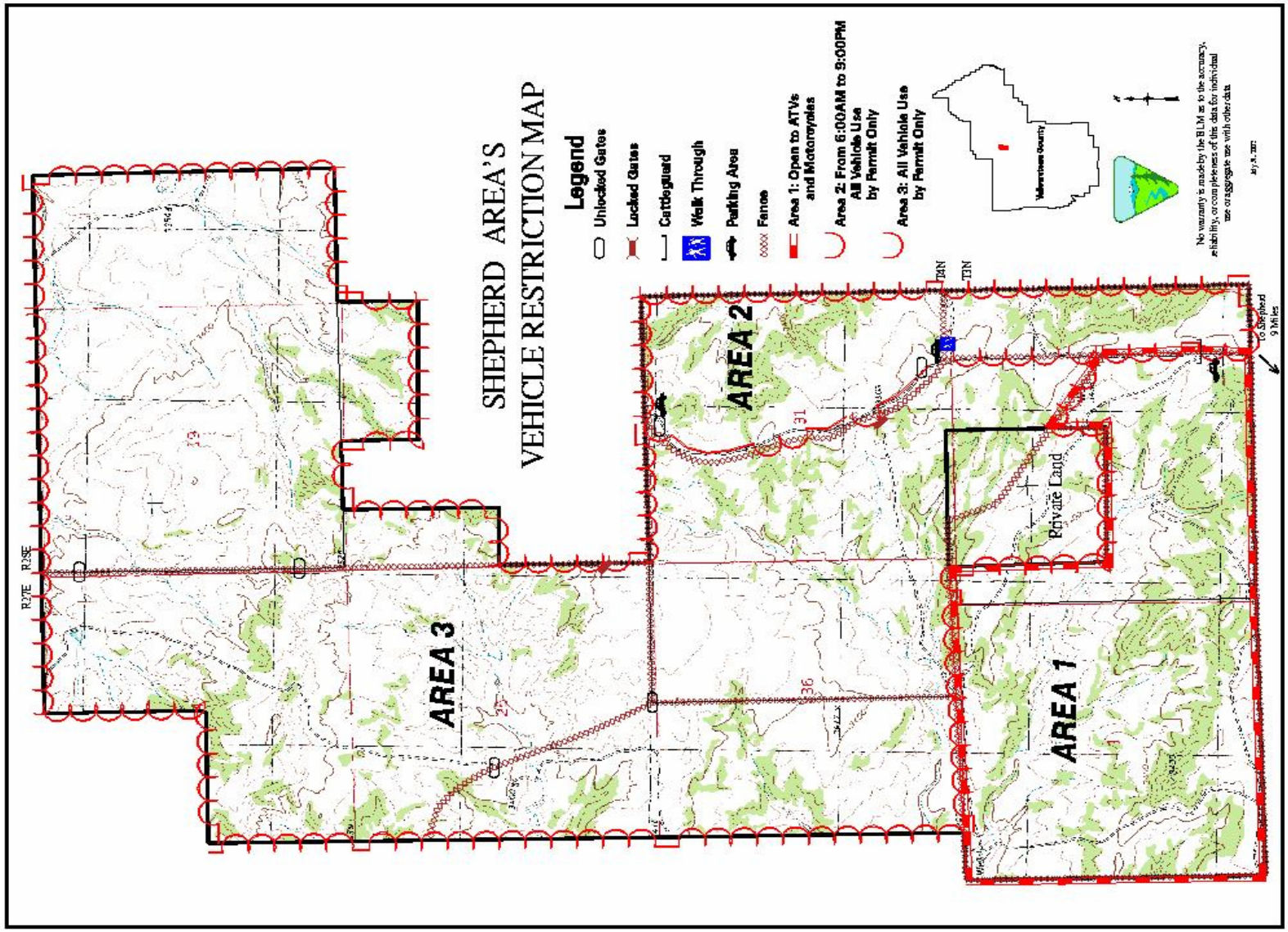
Bureau of Land Management Acton Recreation Area Map



Bureau of Land Management Pompeys Pillar National Monument Map



Bureau of Land Management Shepherd Area Vehicle Restriction Map



Appendix II

Project Prioritization

Planning Projects

Action Items for Safety and Policy

5.1.a. Adoption and enforcement of International Building Codes and/or more stringent hazard-related building code provisions.

	Project Type: Planning Project	
Item	**Criteria**	**Score**
1	Benefit/Cost	8
2	Vulnerability of the community or communities	6
3	Potential for repetitive loss reduction	5
4	Potential to mitigate hazards to future development	5
	Total	**24**
	Project Ranking Priority Score	**High**

5.1.b: Develop county policy concerning building materials used in high-risk WUI areas on existing structures and new construction.

	Project Type: Planning Project	
Item	**Criteria**	**Score**
1	Benefit/Cost	10
2	Vulnerability of the community or communities	10
3	Potential for repetitive loss reduction	5
4	Potential to mitigate hazards to future development	5
	Total	**30**
	Project Ranking Priority Score	**High**

5.1.c: Develop county policy requiring the installation of dry hydrants in subdivisions with 5 or more dwellings.

	Project Type: Planning Project	
Item	**Criteria**	**Score**
1	Benefit/Cost	4
2	Vulnerability of the community or communities	10
3	Potential for repetitive loss reduction	5
4	Potential to mitigate hazards to future development	5
	Total	**24**
	Project Ranking Priority Score	**High**

5.1.e: Develop a policy to enforce "No Burning" restrictions in specified high-risk subdivisions.

Item	Project Type: Planning Project Criteria	Score
1	Benefit/Cost	6
2	Vulnerability of the community or communities	10
3	Potential for repetitive loss reduction	5
4	Potential to mitigate hazards to future development	5
	Total	**26**
	Project Ranking Priority Score	**High**

5.1.f: Review need to inspect and enforce access and water issues in subdivisions and individual homes.

Item	Project Type: Planning Project Criteria	Score
1	Benefit/Cost	10
2	Vulnerability of the community or communities	7
3	Potential for repetitive loss reduction	5
4	Potential to mitigate hazards to future development	5
	Total	**27**
	Project Ranking Priority Score	**High**

5.1.g: Develop county policy concerning access in moderate to high-risk WUI areas where subdivisions are built to insure adequate ingress and egress during wildfire emergencies.

Item	Project Type: Planning Project Criteria	Score
1	Benefit/Cost	10
2	Vulnerability of the community or communities	10
3	Potential for repetitive loss reduction	5
4	Potential to mitigate hazards to future development	5
	Total	**30**
	Project Ranking Priority Score	**High**

5.1.h: Develop a county policy to support grant applications for projects resulting from this plan.

Item	Project Type: Planning Project Criteria	Score
1	Benefit/Cost	10
2	Vulnerability of the community or communities	10
3	Potential for repetitive loss reduction	5
4	Potential to mitigate hazards to future development	5
	Total	**30**
	Project Ranking Priority Score	**High**

Action Items for People and Structures

5.2.a: Youth and Adult Wildfire Educational Programs and Professional Development Training.

	Project Type: Planning Project	
Item	Criteria	Score
1	Benefit/Cost	10
2	Vulnerability of the community or communities	10
3	Potential for repetitive loss reduction	5
4	Potential to mitigate hazards to future development	5
	Total	30
	Project Ranking Priority Score	High

Action Items for Resources and Capabilities

5.4.b: Retention of Volunteer Firefighters.

	Project Type: Planning Project	
Item	Criteria	Score
1	Benefit/Cost	10
2	Vulnerability of the community or communities	10
3	Potential for repetitive loss reduction	5
4	Potential to mitigate hazards to future development	5
	Total	30
	Project Ranking Priority Score	High

5.4.c: Increased training and capabilities of firefighters.

	Project Type: Planning Project	
Item	Criteria	Score
1	Benefit/Cost	10
2	Vulnerability of the community or communities	10
3	Potential for repetitive loss reduction	5
4	Potential to mitigate hazards to future development	5
	Total	30
	Project Ranking Priority Score	High

5.4.e: Support the construction of the new Fire Station/Clinic/Pharmacy/Community Center in Lockwood.

	Project Type: Planning Project	
Item	Criteria	Score
1	Benefit/Cost	10
2	Vulnerability of the community or communities	10
3	Potential for repetitive loss reduction	5
4	Potential to mitigate hazards to future development	5
	Total	30
	Project Ranking Priority Score	High

Non-Planning Projects

Action Items for Safety and Policy

5.1.d: Begin distributing "New Code of the West" pamphlets with subdivision permit requests.

Project Type: Implementation Project (Non-Planning)

Item	Criteria	Score
1	Benefit / Cost	1077:1
2	Population Benefit	3
3	Property Benefit	$ 140,874,831
4	Economic Benefit	2
5	Project Feasibility (environmentally, politically, socially)	5
6	Hazard Magnitude/Frequency	2
7	Potential for repetitive loss reduction	1
8	Potential to mitigate hazards to future development	4
9	Potential project effectiveness and sustainability	3
	Total	**40**
	Project Ranking Priority Score	**High**

Action Items for People and Structures

5.2.b: Wildfire risk assessments of homes in identified communities.

5.2.c: Home site WUI Treatments.

Project Type: Implementation Project (Non-Planning)

Item	Criteria	Score
1	Benefit / Cost	133:1
2	Population Benefit	5
3	Property Benefit	$ 416,051,316
4	Economic Benefit	4
5	Project Feasibility (environmentally, politically, socially)	5
6	Hazard Magnitude/Frequency	3
7	Potential for repetitive loss reduction	3
8	Potential to mitigate hazards to future development	2
9	Potential project effectiveness and sustainability	5
	Total	**42**
	Project Ranking Priority Score	**High**

5.2.d: Community Defensible Zone WUI Treatments (specifically, Clapper Flats, Buffalo Trails, Rehberg Ranch, Alkali Creek, Hills Estates, Cedar Ridge, Pleasant Hollow, Shadow Canyon, White Buffalo, High Trails, Indian Cliffs, and Emerald Hills).

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	262:1
2	Population Benefit	10
3	Property Benefit	$ 140,874,831
4	Economic Benefit	3
5	Project Feasibility (environmentally, politically, socially)	5
6	Hazard Magnitude/Frequency	3
7	Potential for repetitive loss reduction	3
8	Potential to mitigate hazards to future development	1
9	Potential project effectiveness and sustainability	5
	Total	**50**
	Project Ranking Priority Score	**High**

5.2.e: Maintenance of Home site WUI Treatments.

5.2.f: Re-entry of Home site WUI Treatments.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	239:1
2	Population Benefit	5
3	Property Benefit	$ 416,051,316
4	Economic Benefit	4
5	Project Feasibility (environmentally, politically, socially)	5
6	Hazard Magnitude/Frequency	3
7	Potential for repetitive loss reduction	3
8	Potential to mitigate hazards to future development	2
9	Potential project effectiveness and sustainability	5
	Total	**47**
	Project Ranking Priority Score	**High**

5.2.g: Implement proposed home defensible space projects.

	Project Type: Implementation Project (Non-Planning	Scores		
Item	**Criteria**	**Rehberg Ranch**	**Clapper Flats**	**Alkali Creek**
1	Benefit / Cost	197:1	114:1	191:1
2	Population Benefit	10	10	10
3	Property Benefit	$ 16,347,652	$ 5,658,240	$ 32,807,504
4	Economic Benefit	5	4	7
5	Project Feasibility (environmentally, politically, socially)	5	5	5
6	Hazard Magnitude/Frequency	3	3	3
7	Potential for repetitive loss reduction	3	3	3
8	Potential to mitigate hazards to future development	0	0	0
9	Potential project effectiveness and sustainability	5	5	5
	Total	**40**	**35**	**51**
	Project Ranking Priority Scores	**High**	**Medium**	**High**

5.2.g: Implement proposed home defensible space projects.

	Project Type: Implementation Project (Non-Planning	Scores		
Item	Criteria	Hills Estates	Buffalo Trails	Indian Cliffs
1	Benefit / Cost	268:1	138:1	274:1
2	Population Benefit	10	10	10
3	Property Benefit	$ 1,742,546	$ 17,105,638	$ 19,202,149
4	Economic Benefit	2	6	6
5	Project Feasibility (environmentally, politically, socially)	5	5	5
6	Hazard Magnitude/Frequency	3	3	3
7	Potential for repetitive loss reduction	3	3	3
8	Potential to mitigate hazards to future development	0	0	0
9	Potential project effectiveness and sustainability	5	5	5
	Total	**38**	**38**	**43**
	Project Ranking Priority Scores	**Medium**	**Medium**	**High**

5.2.g: Implement proposed home defensible space projects.

	Project Type: Implementation Project (Non-Planning	Scores		
Item	Criteria	Pleasant Hollow	Cedar Ridge	White Buffalo
1	Benefit / Cost	122:1	119:1	96:1
2	Population Benefit	10	10	10
3	Property Benefit	$ 9,416,085	$ 3,921,391	$ 1,056,852
4	Economic Benefit	5	4	3
5	Project Feasibility (environmentally, politically, socially)	5	5	5
6	Hazard Magnitude/Frequency	3	3	3
7	Potential for repetitive loss reduction	3	3	3
8	Potential to mitigate hazards to future development	0	0	0
9	Potential project effectiveness and sustainability	5	5	5
	Total	**36**	**35**	**33**
	Project Ranking Priority Scores	**Medium**	**Medium**	**Medium**

5.2.g: Implement proposed home defensible space projects.

	Project Type: Implementation Project (Non-Planning	Scores		
Item	Criteria	Shadow Canyon	High Trails	Emerald Hills
1	Benefit / Cost	100:1	262:1	139:1
2	Population Benefit	10	10	10
3	Property Benefit	$ 996,257	$ 3,277,614	$ 29,342,713
4	Economic Benefit	3	3	7
5	Project Feasibility (environmentally, politically, socially)	5	5	5
6	Hazard Magnitude/Frequency	3	3	3
7	Potential for repetitive loss reduction	3	3	3
8	Potential to mitigate hazards to future development	0	0	0
9	Potential project effectiveness and sustainability	5	5	5
	Total	**33**	**39**	**49**
	Project Ranking Priority Scores	**Medium**	**Medium**	**High**

Action Items for Infrastructure Enhancement Projects

5.3.a: Post "Emergency Evacuation Route" signs along the identified primary and secondary access routes in the county.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	123274:1
2	Population Benefit	10
3	Property Benefit	$ 9,245,585
4	Economic Benefit	6
5	Project Feasibility (environmentally, politically, socially)	5
6	Hazard Magnitude/Frequency	5
7	Potential for repetitive loss reduction	5
8	Potential to mitigate hazards to future development	5
9	Potential project effectiveness and sustainability	5
	Total	**51**
	Project Ranking Priority Score	**High**

5.3.b: Access improvements of bridges, cattle guards, and limiting road surfaces.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	180:1
2	Population Benefit	2
3	Property Benefit	$ 184,911,696
4	Economic Benefit	8
5	Project Feasibility (environmentally, politically, socially)	5
6	Hazard Magnitude/Frequency	2
7	Potential for repetitive loss reduction	4
8	Potential to mitigate hazards to future development	5
9	Potential project effectiveness and sustainability	5
	Total	**48**
	Project Ranking Priority Score	**High**

5.3.c: Improve communications throughout the County by installing additional repeater towers and obtaining portable repeaters for emergency response personnel.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	2845:1
2	Population Benefit	8
3	Property Benefit	$ 739,646,784
4	Economic Benefit	6
5	Project Feasibility (environmentally, politically, socially)	4
6	Hazard Magnitude/Frequency	3
7	Potential for repetitive loss reduction	3
8	Potential to mitigate hazards to future development	3
9	Potential project effectiveness and sustainability	5
	Total	**52**
	Project Ranking Priority Score	**High**

5.3.d: Erect a repeater tower on the site donated by the Conover Ranch near Broadview.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	716:1
2	Population Benefit	3
3	Property Benefit	$ 14,327,461
4	Economic Benefit	3
5	Project Feasibility (environmentally, politically, socially)	5
6	Hazard Magnitude/Frequency	3
7	Potential for repetitive loss reduction	3
8	Potential to mitigate hazards to future development	3
9	Potential project effectiveness and sustainability	5
	Total	**36**
	Project Ranking Priority Score	**Medium**

5.3.e: Fuels mitigation of the "Emergency Evacuation Routes" in the County to insure these routes can be maintained in the case of an emergency.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	92:1
2	Population Benefit	8
3	Property Benefit	$ 277,367,544
4	Economic Benefit	7
5	Project Feasibility (environmentally, politically, socially)	2
6	Hazard Magnitude/Frequency	3
7	Potential for repetitive loss reduction	3
8	Potential to mitigate hazards to future development	3
9	Potential project effectiveness and sustainability	2
	Total	**42**
	Project Ranking Priority Score	**High**

5.3.f: Erect a repeater tower system to support the Shepherd Volunteer Fire Department and Shepherd community.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	2659:1
2	Population Benefit	2
3	Property Benefit	$ 159,554,607
4	Economic Benefit	2
5	Project Feasibility (environmentally, politically, socially)	3
6	Hazard Magnitude/Frequency	3
7	Potential for repetitive loss reduction	3
8	Potential to mitigate hazards to future development	4
9	Potential project effectiveness and sustainability	4
	Total	**41**
	Project Ranking Priority Score	**High**

5.3.g: Access improvements through roadside fuels management.

	Project Type: Implementation Project (Non-Planning	Scores		
Item	Criteria	Rehberg Ranch	Clapper Flats	Alkali Creek
1	Benefit / Cost	2063:1	783:1	3705:1
2	Population Benefit	10	10	10
3	Property Benefit	$ 16,347,652	$ 5,658,240	$ 32,807,504
4	Economic Benefit	5	4	7
5	Project Feasibility (environmentally, politically, socially)	4	4	4
6	Hazard Magnitude/Frequency	3	3	3
7	Potential for repetitive loss reduction	3	3	3
8	Potential to mitigate hazards to future development	3	3	0
9	Potential project effectiveness and sustainability	5	5	5
	Total	**44**	**42**	**52**
	Project Ranking Priority Scores	**High**	**High**	**High**

5.3.g: Access improvements through roadside fuels management.

	Project Type: Implementation Project (Non-Planning	Scores		
Item	Criteria	Hills Estates	Buffalo Trails	Indian Cliffs
1	Benefit / Cost	456:1	643:1	3383:1
2	Population Benefit	10	10	10
3	Property Benefit	$ 1,742,546	$ 17,105,638	$ 19,202,149
4	Economic Benefit	2	6	6
5	Project Feasibility (environmentally, politically, socially)	4	4	4
6	Hazard Magnitude/Frequency	3	3	3
7	Potential for repetitive loss reduction	3	3	3
8	Potential to mitigate hazards to future development	0	0	0
9	Potential project effectiveness and sustainability	5	5	5
	Total	**37**	**42**	**42**
	Project Ranking Priority Scores	**Medium**	**High**	**High**

5.3.g: Access improvements through roadside fuels management.

	Project Type: Implementation Project (Non-Planning	Scores		
Item	Criteria	Pleasant Hollow	Cedar Ridge	White Buffalo
1	Benefit / Cost	469:1	573:1	187:1
2	Population Benefit	10	10	10
3	Property Benefit	$ 9,416,085	$ 3,921,391	$ 1,056,852
4	Economic Benefit	5	4	3
5	Project Feasibility (environmentally, politically, socially)	4	4	4
6	Hazard Magnitude/Frequency	3	3	3
7	Potential for repetitive loss reduction	3	3	3
8	Potential to mitigate hazards to future development	0	0	0
9	Potential project effectiveness and sustainability	5	5	5
	Total	**40**	**39**	**36**
	Project Ranking Priority Scores	**High**	**Medium**	**Medium**

5.3.g: Access improvements through roadside fuels management.

	Project Type: Implementation Project (Non-Planning	Scores		
Item	Criteria	Shadow Canyon	High Trails	Emerald Hills
1	Benefit / Cost	89:1	588:1	1746:1
2	Population Benefit	10	10	10
3	Property Benefit	$ 996,257	$ 3,277,614	$ 29,342,713
4	Economic Benefit	3	3	7
5	Project Feasibility (environmentally, politically, socially)	4	4	4
6	Hazard Magnitude/Frequency	3	3	3
7	Potential for repetitive loss reduction	3	3	3
8	Potential to mitigate hazards to future development	0	0	0
9	Potential project effectiveness and sustainability	5	5	5
	Total	**32**	**38**	**52**
	Project Ranking Priority Scores	**Medium**	**Medium**	**High**

Action Items for Resources and Capabilities

5.4.a: Enhance radio availability in each department, link into existing dispatch, improve range within the region, and conversion to consistent standard of radio types.

	Project Type: Implementation Project (Non-Planning)	
Item	Criteria	Score
1	Benefit / Cost	370:1
2	Population Benefit	10
3	Property Benefit	$ 92,455,848
4	Economic Benefit	6
5	Project Feasibility (environmentally, politically, socially)	5
6	Hazard Magnitude/Frequency	3
7	Potential for repetitive loss reduction	5
8	Potential to mitigate hazards to future development	5
9	Potential project effectiveness and sustainability	5
	Total	**59**
	Project Ranking Priority Score	**High**

5.4.d: Obtain a Type 6 wildland fire truck, a ProPAC foam kit, a floater pump, and additional personal protective equipment for the Broadview Fire District #3.

	Project Type: Implementation Project (Non-Planning)	
Item	Criteria	Score
1	Benefit / Cost	179:1
2	Population Benefit	2
3	Property Benefit	$ 14,327,461
4	Economic Benefit	2
5	Project Feasibility (environmentally, politically, socially)	4
6	Hazard Magnitude/Frequency	3
7	Potential for repetitive loss reduction	3
8	Potential to mitigate hazards to future development	2
9	Potential project effectiveness and sustainability	3
	Total	**27**
	Project Ranking Priority Score	**Medium**

5.4.f: Obtain a Type 6 engine, two 1,000 gallon pumper trucks, and a heated truck storage facility for the Worden Volunteer Fire Department.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	346:1
2	Population Benefit	2
3	Property Benefit	$ 148,815,924
4	Economic Benefit	2
5	Project Feasibility (environmentally, politically, socially)	4
6	Hazard Magnitude/Frequency	3
7	Potential for repetitive loss reduction	3
8	Potential to mitigate hazards to future development	2
9	Potential project effectiveness and sustainability	3
	Total	**39**
	Project Ranking Priority Score	**Medium**

5.4.g: Obtain a 4x4 pumper truck and a 1,500-2,000 gallon water tender for the Laurel Fire Department.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	52:1
2	Population Benefit	2
3	Property Benefit	$ 14,500,006
4	Economic Benefit	2
5	Project Feasibility (environmentally, politically, socially)	4
6	Hazard Magnitude/Frequency	2
7	Potential for repetitive loss reduction	3
8	Potential to mitigate hazards to future development	3
9	Potential project effectiveness and sustainability	3
	Total	**22**
	Project Ranking Priority Score	**Low**

5.4.h: Construction of a Shepherd Volunteer Fire Department satellite station in the Hidden Lake area.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	1596:1
2	Population Benefit	2
3	Property Benefit	$ 159,554,607
4	Economic Benefit	2
5	Project Feasibility (environmentally, politically, socially)	4
6	Hazard Magnitude/Frequency	3
7	Potential for repetitive loss reduction	3
8	Potential to mitigate hazards to future development	3
9	Potential project effectiveness and sustainability	4
	Total	**41**
	Project Ranking Priority Score	**High**

5.4.i: Additional heated equipment storage facility for the Broadview Fire Department #3.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	179:1
2	Population Benefit	2
3	Property Benefit	$ 14,327,461
4	Economic Benefit	2
5	Project Feasibility (environmentally, politically, socially)	4
6	Hazard Magnitude/Frequency	3
7	Potential for repetitive loss reduction	2
8	Potential to mitigate hazards to future development	3
9	Potential project effectiveness and sustainability	2
	Total	**26**
	Project Ranking Priority Score	**Medium**

5.4.j: Establish onsite water sources such as dry hydrants or underground storage tanks for rural housing developments.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	4623:1
2	Population Benefit	4
3	Property Benefit	$ 924,558,480
4	Economic Benefit	3
5	Project Feasibility (environmentally, politically, socially)	4
6	Hazard Magnitude/Frequency	2
7	Potential for repetitive loss reduction	3
8	Potential to mitigate hazards to future development	5
9	Potential project effectiveness and sustainability	5
	Total	**46**
	Project Ranking Priority Score	**High**

5.4.k: Establish a site and install a higher capacity municipal well and pump and a 100,000 gallon storage tank for the town of Broadview.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	57:1
2	Population Benefit	3
3	Property Benefit	$ 14,327,461
4	Economic Benefit	3
5	Project Feasibility (environmentally, politically, socially)	3
6	Hazard Magnitude/Frequency	3
7	Potential for repetitive loss reduction	3
8	Potential to mitigate hazards to future development	5
9	Potential project effectiveness and sustainability	5
	Total	**28**
	Project Ranking Priority Score	**Medium**

5.4.l: Establish a non-potable water well and storage system to supply fire hydrants, dry hydrants, and fire suppression systems in public buildings in the town of Broadview.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	72:1
2	Population Benefit	3
3	Property Benefit	$ 14,327,461
4	Economic Benefit	3
5	Project Feasibility (environmentally, politically, socially)	3
6	Hazard Magnitude/Frequency	3
7	Potential for repetitive loss reduction	3
8	Potential to mitigate hazards to future development	4
9	Potential project effectiveness and sustainability	5
	Total	**28**
	Project Ranking Priority Score	**Medium**

5.4.m: Obtain a Type 3 WUI pumper truck for the Laurel Urban Fire Service Area.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	418:1
2	Population Benefit	2
3	Property Benefit	$ 62,739,255
4	Economic Benefit	2
5	Project Feasibility (environmentally, politically, socially)	5
6	Hazard Magnitude/Frequency	2
7	Potential for repetitive loss reduction	3
8	Potential to mitigate hazards to future development	3
9	Potential project effectiveness and sustainability	3
	Total	**40**
	Project Ranking Priority Score	**High**

5.4.n: Obtain funding to add structural fire responsibilities to Broadview Fire District #3, which would include personnel incentives, additional rolling stock equipped with structural firefighting capabilities, structural turnout gear, and a larger equipment storage facility.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	40:1
2	Population Benefit	2
3	Property Benefit	$ 14,327,461
4	Economic Benefit	2
5	Project Feasibility (environmentally, politically, socially)	4
6	Hazard Magnitude/Frequency	3
7	Potential for repetitive loss reduction	3
8	Potential to mitigate hazards to future development	3
9	Potential project effectiveness and sustainability	4
	Total	**23**
	Project Ranking Priority Score	**Low**

5.4.o: Obtain a Type 6 structural engine and a wood chipper for Lockwood Fire District #8.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	2839:1
2	Population Benefit	2
3	Property Benefit	$ 204,422,546
4	Economic Benefit	2
5	Project Feasibility (environmentally, politically, socially)	3
6	Hazard Magnitude/Frequency	2
7	Potential for repetitive loss reduction	3
8	Potential to mitigate hazards to future development	3
9	Potential project effectiveness and sustainability	3
	Total	**38**
	Project Ranking Priority Score	**Medium**

5.4.p: Acquire sites and install dry hydrants on Pine Hills Road, High Trails Road, Coburn Hill Road, Yellowstone Trail Road, and Box Canyon Spring Road.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	2405:1
2	Population Benefit	2
3	Property Benefit	$ 204,422,546
4	Economic Benefit	2
5	Project Feasibility (environmentally, politically, socially)	4
6	Hazard Magnitude/Frequency	3
7	Potential for repetitive loss reduction	4
8	Potential to mitigate hazards to future development	4
9	Potential project effectiveness and sustainability	4
	Total	**43**
	Project Ranking Priority Score	**High**

5.4. q: Obtain one structural engine, 3 Type 3 engines (to replace old 6x6's), and one Type 2 water tender for the Shepherd Volunteer Fire Department.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	202:1
2	Population Benefit	2
3	Property Benefit	$ 159,554,607
4	Economic Benefit	2
5	Project Feasibility (environmentally, politically, socially)	4
6	Hazard Magnitude/Frequency	2
7	Potential for repetitive loss reduction	3
8	Potential to mitigate hazards to future development	3
9	Potential project effectiveness and sustainability	3
	Total	**37**
	Project Ranking Priority Score	**Medium**

5.4.r: Secure funding for a full time Laurel Volunteer Fire Department Chief.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	5327:1
2	Population Benefit	4
3	Property Benefit	$ 346,236,721
4	Economic Benefit	2
5	Project Feasibility (environmentally, politically, socially)	4
6	Hazard Magnitude/Frequency	2
7	Potential for repetitive loss reduction	2
8	Potential to mitigate hazards to future development	2
9	Potential project effectiveness and sustainability	3
	Total	**39**
	Project Ranking Priority Score	**Medium**

5.4.s: Equip Laurel Emergency Operations Center with radios and phone lines.

	Project Type: Implementation Project (Non-Planning)	
Item	**Criteria**	**Score**
1	Benefit / Cost	4616:1
2	Population Benefit	4
3	Property Benefit	$ 346,236,721
4	Economic Benefit	2
5	Project Feasibility (environmentally, politically, socially)	5
6	Hazard Magnitude/Frequency	5
7	Potential for repetitive loss reduction	3
8	Potential to mitigate hazards to future development	5
9	Potential project effectiveness and sustainability	5
	Total	**49**
	Project Ranking Priority Score	**High**

Data Tables Used to Calculate Prioritization

Average Structure Value and Cost To Inspect and Treat per Project Area

Treatment Area	Acres	Parcels with Structures	Total Structure Value	Average Structure Value	Cost To Inspect and Treat
Clapper Flats Project Area	3463	55	$5,658,240	$102,877	$49,500
Buffalo Trails Project Area	7715	138	$17,105,638	$123,954	$124,200
Indian Cliffs Project Area	228	100	$19,202,149	$192,021	$70,000
Rehberg Ranch Project Area	1110	92	$16,347,652	$177,692	$82,800
Alkali Creek Project Area	449	245	$32,807,504	$133,908	$171,500
Emerald Hills Project Area	1710	234	$29,342,713	$125,396	$210,600
High Trail Project Area	765	25	$3,277,614	$131,105	$12,500
Hill Estates Project Area	553	13	$1,742,546	$134,042	$6,500
Pleasant Hollow Project Area	2072	86	$9,416,085	$109,489	$77,400
Shadow Canyon Project Area	681	20	$996,257	$49,813	$10,000
White Buffalo Project Area	319	22	$1,056,852	$48,039	$11,000
Cedar Ridge Project Area	2932	47	$3,921,391	$83,434	$32,900
Treatment Area Summary	21996	1077	$140,874,641	$130,803	$969,300
Structures Outside High Density Urban Area	***	7740	$924,559,341	$119,452	$6,966,000

Average Value of Structures per Fire Department

Name	Number of Structures	Total Value	Average Value
Billings FSA	3189	$ 423,860,078	$ 132,913
Blue Ck FSA Lakewood	274	$ 33,021,122	$ 120,515
Broadview FD 3	194	$ 14,327,461	$ 73,853
City of Billings	32517	$4,501,259,310	$ 138,428
City of Laurel	2158	$ 169,621,596	$ 78,601
Huntley FSA	1364	$ 135,498,014	$ 99,339
Laurel FD 5	133	$ 14,511,116	$ 109,106
Laurel FD 7	848	$ 99,364,754	$ 117,175
Laurel FSA	528	$ 62,739,255	$ 118,824
Lockwood FD 8	2118	$ 204,422,546	$ 96,517
Shepherd FSA	1685	$ 159,554,607	$ 94,691
Worden FD 4	145	$ 13,317,910	$ 91,848
Wildland Protection	1306	$ 131,785,180	$ 100,907

Roadside Fuels Treatments Within or Near Project Areas

Roadside Fuels Treatment Area	Total Miles	Total Acres	Cost
Clapper Flats Project Area	3.14	76.0	$ 7,221.83
Buffalo Trails Project Area	11.55	280.0	$ 26,603.49
Indian Cliffs Project Area	2.46	59.8	$ 5,676.45
Rehberg Ranch Project Area	3.44	83.4	$ 7,923.21
Alkali Creek Project Area	3.84	93.2	$ 8,854.89
Emerald Hills Project Area	7.30	176.9	$ 16,808.20
High Trail Project Area	2.42	58.7	$ 5,577.87
Hill Estates Project Area	1.66	40.2	$ 3,823.12
Pleasant Hollow Project Area	8.71	211.1	$ 20,058.61
Shadow Canyon Project Area	4.86	117.8	$ 11,192.81
White Buffalo Project Area	2.46	59.6	$ 5,665.11
Cedar Ridge Project Area	2.97	72.0	$ 6,837.99
Total	**54.82**	**1328.9**	**$126,243.57**

Appendix III

Public Mail Survey

Public Letter #1

Sent on September 21, 2005 and included a survey and a return envelope.

Yellowstone County

COMMISSIONERS
(406) 256-2701
(406) 256-2777 (FAX)

P.O. Box 35000
Billings, MT 59107-5000
commission@co.yellowstone.mt.us

Yellowstone County Community Wildfire Protection Plan Survey

September 21, 2005

«Name»

«Address»

«City», ID «Zip»

Dear Yellowstone County Resident:

Thank you for taking fifteen minutes of your time to read and respond to this short inquiry. Yellowstone County has contracted with Northwest Management, Inc., through a Bureau of Land Management grant, to work with a host of fire protection and emergency service organizations in Yellowstone County to develop a **community wildfire protection plan** in your area. As an individual who lives in Yellowstone County, you know that the urban-rural interface is at very high risk to casualty loss due to wildland fires.

This year we are taking a proactive role in mitigating wildland fire-caused casualty losses in the County. We are inviting you to take a proactive role as well.

Northwest Management, Inc. is developing improved predictive models of where fires are likely to ignite, locating and identifying high risk landscape characteristics, advancing improved land management practices to reduce fire rate-of-spread on forestlands and rangelands, and working with rural landowners to create wildland fire

defensible zones around homes and buildings. It is with the last of these goals that your help is needed.

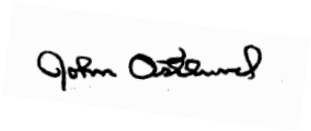
We would like you to complete the attached survey about your home's defensible space in the case of wildland fire. Your responses will be kept completely confidential and released only in aggregated form. This questionnaire will allow us to identify key criteria that may place your home and the homes of your neighbors at the greatest risk. We will use this information to develop mitigation activities that may lead to saving your home and the community you live in.

We have sent this letter and survey to only a select number of people living in Yellowstone County. Because of this, your response is very important to our efforts and the application of our findings to your home and to your community. Please take a few minutes to complete the enclosed survey and return it in the self addressed envelope.

We would like to thank you for your assistance on this project with a small token of appreciation. During the development of this project, Northwest Management, Inc. is completing some very advanced mapping of Yellowstone County. They have created detailed maps showing roads, rivers, elevation, fire prone landscapes, potential fire ignition locations, plant cover characteristics, and even orthophoto coverage (black and white images taken from high elevation) with features over them. These maps are printed at 8.5” x 11” sizes. If you give us a legal land description, they will make a high resolution map of this property and send it to you. The map might be the locale of your home, your property, or even your favorite recreation spot. When you complete your survey, please mark which map coverage you would like, and they will custom color print this map for you and send it at no charge. It is our way of thanking you for your input to this very important project.

Thank you for your assistance. If you have any questions about this project or this survey please contact Jim Kraft, Yellowstone County Fire Warden at 406-256-2775 or at jkraft@co.yellowstone.mt.us or Bill Schlosser at Northwest Management, Inc. in Moscow, Idaho, at 208-883-4488 or at schlosser@consulting-foresters.com.

Sincerely,



John Ostlund, Chairman

Board of County Commissioners

Yellowstone County, Montana

Yellowstone County Community Wildfire Protection Plan

Public Survey

1. Do you have a home in Yellowstone County?

   - O Yes
   - O No

2. Is this your primary residence?

   - O Yes
   - O No

3. Which community do you live closest to?

   _____

4. Does your area have 911 emergency telephone service?

   - O Yes
   - O No

5. Is your home protected by a rural fire department?

   - O No
   - O Yes, if yes what is the fire response time to your home?
     - O under 10 minutes
     - O 10 – 20 minutes
     - O 20 – 30 minutes
     - O 30 – 45 minutes
     - O more than 45 minutes

6. What type of roof does your home have (please mark one):

   - O Composite
   - O Wooden shake (shingles)
   - O Ceramic tiles
   - O Aluminum, tin, or other metal
   - O Other (please indicate: _____)

7. How many trees are within 250 feet of your home?

   - O None
   - O less than 10

- O Between 10 and 25
- O More than 25

8. How many trees are within 75 feet of your home?

   - O None
   - O less than 10
   - O Between 10 and 25
   - O More than 25

9. Do you have a lawn surrounding your home?

   - O No
   - O Yes, if yes is it kept green and trimmed all summer?
     - O No
     - O Yes

10. How long is your driveway, from the main road to your home parking area? Please indicate distance units in feet or miles.

    _____

    - O Feet
    - O Miles

11. If your driveway is over ½ mile long, does it have turnouts that would allow two trucks to pass each other?

    - O No
    - O Yes

12. What type of surfacing does your driveway have?

    - O Dirt
    - O Gravel/rock
    - O Paved

13. If the primary access to your home were cut off because of a wildfire, would you have an alternative route to escape through?

    - O No
    - O Yes

14. Please indicate which of the following items you have available at or near your home that could be used in fighting a wildland fire that threatens your home (mark all that apply)

    - O Hand tools (shovel, pulaski, etc.)
    - O Portable water tank

- Stationery water tank
- Pond, lake, or stream water supply close
- Water pump and fire hose
- Well or cistern
- Equipment suitable for creating fire breaks (bulldozer, cat, skidder, etc.)

15. Use this exercise below to assess your home's fire risk rating:
    Circle the ratings in each category that best describes your home.

16.

Fuel Hazard Rating Worksheet		Rating
Fuel Hazard (within 200 feet of structures)	Small, light fuels (grasses, forbs, weeds, shrubs)	1
	Medium size fuels (brush, large shrubs, small trees)	2
	Heavy, large fuels (woodlands, timber, heavy brush)	3
Slope Hazard (within 200 feet of structures)	Mild slopes (0-5%)	1
	Moderate slope (6-20%)	2
	Steep Slopes (21-40%)	3
	Extreme slopes (41% and greater)	4
Structure Hazard	Noncombustible roof and noncombustible siding materials	1
	Noncombustible roof and combustible siding material	3
	Combustible roof and noncombustible siding material	7
	Combustible roof and combustible siding materials	10
Additional Factors	Rough topography that contains several steep canyons or ridges	+2
	Areas having history of higher than average fire occurrence	+3
	Areas exposed to severe fire weather and strong winds	+4
	Areas with existing fuel modifications or usable fire breaks	-3
	Areas with local facilities (water systems, rural fire districts, dozers)	-3

Calculating your risk

Fuel hazard _____ x Slope Hazard _____ = _____

Structural hazard + _____

Additional factors (+ or -) _____

Total Hazard Points = _____

Extreme Risk = 26 + points
High Risk = 16–25 points
Moderate Risk = 6–15 points
Low Risk = 6 or less points

17. Do you conduct a periodic fuels reduction program near your home site such as grass or brush burning?

    O No

    O Yes

18. Do livestock (cattle, horses, sheep) graze the grasses and forbs around your home?

    O No

    O Yes

19. If offered in your area, would members of your household attend a free, or low cost, half-day training seminar designed to teach homeowners in the rural–urban interface how to improve the defensible space surrounding your home and adjacent outbuildings?

    O No

    O Yes

20. How do you feel Fire Mitigation projects should be **<u>funded</u>** in the areas surrounding homes, communities, and infrastructure such as power lines and major roads?

	Mark the box that best applies to your preference		
	100% Public Funding	**Cost-Share (Public & Private)**	**Privately Funded (Owner or Company)**
Home Defensibility Projects	O	O	O
Community Defensibility Projects	O	O	O
Infrastructure Projects **Roads, Bridges, Power Lines, Etc.**	O	O	O

Thank you very much for completing this survey and sending it back to us. This information will be combined with other data to assess the greatest threats to defending homes and adjacent buildings in the rural–urban interface where Wildland fires are common.

Please place the completed survey and the Map Request Form in the self-addressed envelope and place it in the mail for return to us. Thank you!

Your name and address are printed here so we can remove you from our mailing list once we have received your completed survey.

Order Your Yellowstone County Area Map

FREE

As a token of appreciation for completing and returning this survey, we would like to send you a detailed map of your favorite area. Complete this form and return it to us with your survey and we will custom print a color map of your property and send it to you. Maps are produced by NMI during the winter months of December, January and February. Expect your maps to arrive in the mail during this time.

What is the legal land description of the property you want mapped (must be in Yellowstone County).

_____ T _____N, R _____ E.

or describe the area _____

_____

About how many acres is the parcel you want mapped? _____ acres

What would you like printed as the title of the map? (Five or less words, please print)

_____

Please select which coverage (only one per map) you would like as the primary theme:

- O Land Ownership Categories (over shaded relief map)
- O Ortho photo (limited availability)

All maps include:

- Roads
- Streams & rivers
- Community locations
- Building locations (where available)
- Township, Range, and Sections (property lines are not included)
- Hillshade relief placed in the background to provide representation of slope and elevation.

Please verify your name and full address here so we can send your map to you:

Our records indicate that your address is:	If this is incorrect please correct it here: _____ _____ _____

Public Letter #2

sent as a postcard on October 4, 2005

October 4, 2005

Dear Yellowstone County Resident:

About a week ago, we mailed you a letter and a brief survey concerning the wildfire situation in your community. That survey is instrumental to the success of the Community Wildfire Protection Plan we are developing in conjunction with Northwest Management, Inc. through a grant from the Bureau of Land Management. We have received responses from many families in the area and we wish to extend our thanks and appreciation to everyone who has participated. However, we still have not received completed surveys from many homes in the region. If you have not returned the completed survey to us yet, please take a few minutes to complete the survey and return it in the self-addressed envelope provided with the letter.

Your responses are very important to this effort which will recommend the location and type of fire mitigation projects to be implemented in the area of your home. If you have any questions about the survey, please contact Jim Kraft, the Yellowstone County Fire Warden, at 406-256-2775 or Bill Schlosser at the Northwest Management, Inc. office in Moscow, ID at 208-883-4488. If you did not receive my original letter, or if you misplaced your survey, you can request a new one at one of the numbers above.

Thank you for your time and your assistance with this project!

John Ostlund, Chairman

Yellowstone County Board of Commissioners

Public letter #3

Sent on October 11, 2005 and included a replacement survey and return envelope (not included here).

Yellowstone County

COMMISSIONERS
(406) 256-2701
(406) 256-2777 (FAX)

P.O. Box 35000
Billings, MT 59107-5000
commission@co.yellowstone.mt.us

Yellowstone County Community Wildfire Protection Plan

{{Date}}

«Name»
«Address»
«City», ID «Zip»

Dear Yellowstone County Landowner:

Thank you for taking some of your time to read and respond to this short inquiry. About two weeks ago, we sent you a letter and package of materials much like this one. In it, we asked if you would please assist our efforts by reading, filling out, and returning a survey concerning a **Community Wildfire Protection Plan** Yellowstone County is preparing through a grant from the Bureau of Land Management. We are working in cooperation with the natural resource consulting firm, Northwest Management, Inc., and a host of fire protection and emergency service organizations in Yellowstone County. While we have received excellent responses from many residents of the area, we have not received them from everyone**. If you have completed and returned your survey, please accept our sincere thanks!** If you have not returned the completed survey, please do so as soon as possible.

As an individual who owns property in Yellowstone County, you know that this area is at very high risk to casualty loss due to wildfires. We have all witnessed the images of fires over the past few years that ravaged the western states. However, today we are doing more than watching for wildland fires; we are taking a proactive role in reducing fire-caused casualty losses in Yellowstone County. We are inviting you to take a proactive role as well.

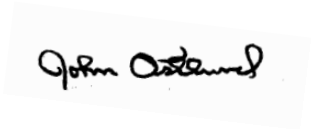
We would like you to complete the attached survey about your home's defensibility in the case of a wildland fire. Your responses will be kept completely confidential and released only in aggregated form. This questionnaire will allow us to identify key criteria that may place your home and the homes of your neighbors at the greatest risk. We will use this information to develop mitigation activities that may lead to saving your home and the community you live in.

We have sent this letter and survey to only a select number of people in Yellowstone County. Because of this, your response is very important to our efforts and the application of our findings to your home and to your community. Please take a few minutes to complete the enclosed survey and return it in the self-addressed envelope.

We would like to thank you for your assistance on this project with a small token of appreciation. During the development of this project, Northwest Management, Inc. is completing some very advanced mapping of Yellowstone County. They have created detailed maps showing roads, rivers, elevation, fire prone landscapes, potential fire ignition locations, plant cover characteristics, and even orthophoto coverage (black and white images taken from high elevation) with features over them. These maps are printed at 8.5" x 11" sizes. If you give us a legal land description, they will make a high resolution map of this property and send it to you. The map might be the locale of your home, your property, or even your favorite recreation spot. When you complete your survey, please mark which map coverage you would like, and they will custom color print this map for you and send it at no charge. It is our way of thanking you for your input to this very important project.

Thank you for your assistance. If you have any questions about this project or this survey please contact Jim Kraft, Yellowstone County Fire Warden at 406-256-2775 or at jkraft@co.yellowstone.mt.us or Bill Schlosser at Northwest Management, Inc. in Moscow, Idaho, at 208-883-4488 or at schlosser@consulting-foresters.com.

Sincerely,



John Ostlund, Chairman

Board of County Commissioners

Yellowstone County, Montana

Appendix IV

Potential Funding Sources

Program: **Rural Fire Assistance**

Source: Montana Department of Natural Resources and Conservation

Description: The Rural Fire Assistance Program is a Department of the Interior program to enhance firefighter safety and strengthen fire protection capabilities. Safe and effective fire suppression in the wildland urban interface demands close coordination among local, state, tribal, and federal firefighting resources. Funding will be used to provide technical assistance, training, supplies, equipment and public education support to rural fire departments.

More info: VFA/RFA Grant Program Coordinator Montana DNRC Forestry Division / Fire and Aviation Management Bureau 2705 Spurgin Road Missoula, Montana 59804-3199

Program: **Communities at Risk**

Source: USDA Forest Service

Description: Assistance to communities for hazardous fuels reduction projects in the wildland urban interface; includes funding for assessments and mitigation planning.

More info: Regional Forester Rick Cables 303-275-5350

Program: **State Fire Assistance**

Source: US Forest Service

Description: USFS grants to state foresters through state and private grants, under authority of Cooperative Forestry Assistance Act. Grant objectives are to maintain and improve protection efficiency and effectiveness on non-federal lands, training, equipment, preparedness, prevention and education.

More info: www.fireplan.gov

Program: **State Fire Assistance Hazard Mitigation Program**

Source: National Fire Plan

Description: These special state Fire Assistance funds are targeted at hazard fuels treatment in the wildland-urban interface. Recipients include state forestry organizations, local fire services, county emergency planning committees and private landowners.

More info: www.fireplan.gov and www.fs.fed.us/r4

Program: **Volunteer Fire Assistance**

Source: Montana Department of Natural Resources and Conservation

Description: VFA, Title IV, is a federal matching funds program with dollars provided through the USDA Forest Service. The program is administered by the Montana State Forester (State Department of Natural Resources and Conservation - DNRC). Title II/IV authorizes the Secretary of Agriculture to provide funds and technical assistance to the Montana DNRC to organize, train and equip local forces for preventing and suppressing wildfires.

More info: VFA/RFA Grant Program Coordinator Montana DNRC
Forestry Division / Fire and Aviation Management Bureau 2705 Spurgin Road Missoula, Montana 59804-3199

Program: **Forest Land Enhancement Program**

Source: US Forest Service

Description: The 2002 Farm Bill repealed the Forestry Incentives Program (authorized in 1978) and Stewardship Incentive Program (1990) cost share programs and replaced it with a new Forest Land Enhancement Program (FLEP). FLEP purposes include 1) Enhance the productivity of timber, fish and wildlife habitat, soil and water quality, wetland, recreational resources, and aesthetic values of forest land through landowner cost share assistance, and 2) Establish a coordinated, cooperative federal, state and local sustainable forestry program to establish, manage, maintain, enhance and restore forests on non-industrial private forest land.

More info: www.usda.gov/farmbill

Program: **National Association of State Agencies for Surplus Property**

Source: Montana State Agency for Surplus Property

Description: Provides assistance to other state, county, and local governments by providing excess state property (equipment, supplies, tools) for wildland and rural community fire response.

More info: Mark Athearn, Program Manager Phone: 406-495-6016, Fax: 406-495-6001, Email: mathearn@state.mt.us

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Program: **Federal Excess Property**

Source: US Forest Service

Description: Provides assistance to state, county and local governments by providing excess federal property (equipment, supplies, tools) for wildland and rural community fire response.

More info: Mark Athearn, Program Manager Phone: 406-495-6016, Fax: 406-495-6001, Email: mathearn@state.mt.us

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Program: **Economic Action Program**

Source: US Forest Service

Description: A USFS, state and private program with involvement from local Forest Service offices to help identify projects. Addresses long-term economic and social health of rural areas; assists the development of enterprises through diversified uses of forest products, marketing assistance, and utilization of hazardous fuel byproducts.

More info: http://www.fs.fed.us/spf/coop/programs/eap/; Dave Atkins Phone: 406-329-3132 Fax:406-329-3132, email: datkins@fs.fes.us

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Program: **Forest Stewardship Program**

Source: US Forest Service

Description: Funding helps enable preparation of management plans on state, private and tribal lands to ensure effective and efficient hazardous fuel treatment.

More info: http://www.fs.fed.us/r1-r4/spf/stewardship.html, Dee Sessions (801) 625-5189, (801) 625-5127 FAX, dsessions@fs.fed.us

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Program: **Community Planning**

Source: US Forest Service

Description: USFS provides funds to recipients with involvement of local Forest Service offices for the development of community strategic action and fire risk management plans to increase community resiliency and capacity.

More info:

Program: **Firefighters Assistance**

Source: Federal Emergency Management Agency and US Fire Administration Program

Description: Financial assistance to help improve fire-fighting operations, services and provide equipment.

More info: www.usfa.fema.gov

Program: **Pre-Disaster Mitigation Program**

Source: Federal Emergency Management Agency

Description: Emergency management assistance to local governments to develop hazard mitigation plans.

More info: www.usfa.fema.gov; Larry Akers, Montana Disaster and Emergency Services, (406) 841-3960 e-mail: lakers@mt.gov

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Program: **Community Protection Fuels Mitigation Grants**

Source: USDA Forest Service

Description: The purpose of this grant program is to protect communities and subdivisions from fires that cross onto private property from adjacent federal property. By providing assistance to private landowners to reduce their fuel hazard, the threat to communities is reduced.

More info: Montana DNRC @ http://dnrc.mt.gov/forestry/Fire/Grants/cwpp.asp

---

Program: **Community Facilities Loans and Grants**

Source: Rural Housing Service (RHS) U. S. Dept. of Agriculture

Description: Provides grants (and loans) to cities, counties, states and other public entities to improve community facilities for essential services to rural residents. Projects can include fire and rescue services; funds have been provided to purchase fire-fighting equipment for rural areas. No match is required.

More info: http://www.rurdev.usda.gov;/or local county Rural Development office.

Program: **Sale of Federal Surplus Personal Property**

Source: General Services Administration

Description: This program sells property no longer needed by the federal government. The program provides individuals, businesses and organizations the opportunity to enter competitive bids for purchase of a wide variety of personal property and equipment. Normally, there is no use restrictions on the property purchased.

More info: www.gsa.gov

Program: **Reimbursement for Firefighting on Federal Property**

Source: U. S. Fire Administration, Federal Emergency Management Agency

Description: Program provides reimbursement to fire service organizations that have engaged in firefighting operations on federal land. Payments can be for direct expenses and direct losses.

More info: www.fema.gov

Program: **Fire Management Assistance Grant Program**

Source: Readiness, Response and Recovery Directorate, FEMA

Description: Program provides grants to states, tribal governments and local governments for the mitigation, management and control of any fire burning on publicly (nonfederal) or privately owned forest or grassland that threatens such destruction as would constitute a major disaster. The grants are made in the form of cost sharing with the federal share being 75 percent of total eligible costs. Grant approvals are made within 1 to 72 hours from time of request.

More info: www.fema.gov

Program: **Hazard Mitigation Grant Program**

Source: Federal Insurance and Mitigation Administration, FEMA

Description: Provides states and local governments with financial assistant to implement measures to reduce of eliminate damage and losses from natural hazards. Funded projects have included vegetation management projects. It is each State's responsibility to identify and select hazard mitigation projects.

More info: www.fema.gov

Program: **Catalog of Selected Federal Grants and Assistance**

Source: National Association of Conservation Districts

Description: Provides several lists of potential federal funding sources supporting the National Fire Plan.

More info: http://www.forestry.nacdnet.org/biomass/Funding/SpecificSources.htm

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Program: **Building Better Rural Places**

Source: U.S. Department of Agriculture in collaboration with the Michael Fields Agricultural Institute

Description: This guide is written for anyone seeking help from federal programs to foster innovative enterprises in agriculture and forestry in the United States. Specifically, the guide addresses program resources in community development; sustainable land management; and value-added and diversified agriculture and forestry. Thus, it can help farmers, entrepreneurs, community developers, conservationists, and many other individuals, as well as private and public organizations, both for-profit and not-for-profit.

More info: http://attra.ncat.org/guide/index.html

Program: **Fuels for Schools and Beyond**

Source: Fuels for Schools Partnership

Description: To promote and encourage the use of wood as a renewable, natural resource to provide a clean, readily available energy source suitable for use in heating systems in public and private buildings. To facilitate the removal of hazardous fuels from our forests by assisting in the development of viable commercial uses of removed material.

More info: http://www.fuelsforschools.org/

Appendix V

Training Programs

Program: **National Fire Academy Educational Program**

Source: National Fire Academy, U. S. Fire Administration, FEMA

Description: Provides training to people responsible for fire prevention and control. Training is provided at the resident facility in Emmetsburg, Maryland, and travel stipends are available for attendees. The course is available to any individual who is a member of a fire department; attendees are selected based on need and benefit to be derived by their community.

More info: www.fema.gov

Program: **Emergency Management Institute (EMI), Independent Study Program**

Source: EMI Readiness, Response and Recovery Directorate, FEMA

Description: The program currently provides 32 courses in emergency management practices to assist fire department managers with response to emergencies and disasters. Several courses could apply to fires in rural interface areas.

More info: www.fema.gov

Program: **Northern Rockies Training Center**

Source: Various state and federal agencies

Description: This site enables access to the Northern Rockies Geographic Area Interagency Wildland Fire Training program. The Northern Rockies Training Center (NRTC) and the Northern Rockies Local Zones together, serve the Wildland Fire training needs of the Northern Rockies Area..

More info: http://www.nationalfiretraining.net/nr/schedule.htm

Program: **Fire Services Training School**

Source: Montana State University Extension Service

Description: This program offers a wide variety of fire rescue courses and hands-on training in various locations throughout Montana.

More info: http://www.montana.edu/~wwwfire/index.html or phone: 1-800-294-5272

Program: **National Interagency Fire Center**

Source: Various federal agencies

Description: The National Interagency Fire Center (NIFC) in Boise, Idaho is the nation's support center for wildland fire fighting offering various wildland fire training courses.

More info: www.nifc.gov or phone: 208-387-5512

Research Programs

Program: **Forestry Research** (Forest and Rangeland Renewable Resources Research Act)

Source: U S Forest Service

Description: Awards grants for research in a wide array of forest-related fields, including forest management and forest fire protection.

Contact: www.fs.fed.uslinksresearch.html

Private Foundations

Source: **The Allstate Foundation**

Description: Provides grants for community development, government/public administration, safety/disasters. Grants average $1,000 to $10,000.

Deadline: None

More info: Guidelines available by mail request only: 2775 Sanders Rd., Suite F3, Northbrook, IL 60062-6127; www.allstate.com/foundation/

Source: **Plum Creek Foundation**

Description: Provides grants for community projects in areas of company operations. In 2000, grants were awarded to a volunteer fire department and a county search & rescue unit. An application form is required. Grants average around $5,000.

Deadline: None

More info: Contact foundation at 999-3rd Ave, Suite 2300, Seattle, WA 98104; 206-467-3600; www.plumcreek.com/company/foundation.cfm; foundation@plumcreek.com

Source: **The Steele-Reese Foundation**

Description: Provides grants for rural development and projects that benefit rural areas; Montana is one of several areas in which the foundation funds projects. Have funded projects for emergency volunteers and fire protection districts in the past. Grant amounts fall within a wide range. The foundation requires three copies of the request letter; no application form is required.

Deadline: April 1

More info: 32 Washington Square West, New York, NY 10011. Info on programs:

406-722-4564

Appendix VI

Forming a Not For Profit Fire Service Organization

A non-profit organization is a group organized for purposes other than generating profit and in which no part of the organizations income is distributed to its members, directors, or officers. Some volunteer fire departments are organized as non-profit organizations.

Many -- but not all -- non-profit corporations, depending upon their purposes, can qualify for exemption from federal corporate income taxes. The U.S. Internal Revenue Code contains more than 25 different classifications of tax-exempt groups, including professional associations, charitable organizations, civic leagues, labor unions, fraternal organizations, and social clubs, to name just a few. Depending on the category of the exemption, such groups are entitled to certain privileges and subject to certain reporting and disclosure requirements and limitations on their activities. There are also a number of reporting requirements that must be adhered to after your organization is up and running.

Incorporation as a non-profit organization:

- Incorporation is a good idea if the group plans on being in existence for several years and has the need to raise money through grants and donations that require tax-exempt status.
- Incorporation and the process of seeking tax-exempt status can be costly and time-consuming.
- Liability of leaders and members of the corporation is limited (in other words, the individuals who control the corporation are not responsible, except in unusual situations, for the legal and financial obligations of the organization).
- There is a tax advantage for the financial donor if money is given to a tax-exempt corporation. (Tax-exempt status is defined in section 501 (c) (3) of the IRS Tax Code.) Money can, however, be legally given to any group or individual without tax-exempt status.
- Some foundations will simply not fund groups that do not have final approval from IRS of its tax-exempt application.
- Incorporation requires careful minutes of official organizational meetings and good financial record keeping.
- If the group's budget is more than $25,000 per year, a tax return needs to be filed.
- Incorporation takes between 6 and 18 months to complete.

Incorporation Process:

- Develop clear and detailed By-laws and Articles of Incorporation
- Incorporation as a not-for-profit corporation within the state (filing with the state includes names and addresses of the first board of directors, etc.)
- File for recognition as tax-exempt with IRS

Estimated Costs for Incorporation . $2,600

Attorney fees	$1,000
Accountant fees	$1,000
Incorporation fees (state)	$ 50
Nonprofit application (IRS)	$ 550

Appendix VII

Federal Fire Related Codes

The Bureau of Land Management, the National Park Service, the Bureau of Indian Affairs, Fish and Wildlife Service, and the US Forest Service are all members of the National Wildfire Coordinating Group (NWCG). This group provides a formalized system of agreement on substantive issues. Any agreed-on policies, standards or procedures are then implemented directly by each agency. In effect, the NWCG is a large umbrella that coordinates wildland fire matters between all members of the group.

The 2001 Federal Wildland Fire Management Policy is in Chapter 3 in a report entitled "Review and Update of the 1995 Federal Wildland Fire Management Policy." The 2001 Wildland Fire Management Policy and the recommended changes in policy were accepted by the US Secretaries of Interior and Agriculture in 2001, bringing policy changes to the local agency level.

The National Fire Policy sets the policy for support among federal agencies for fire management, and encourages coordination with the individual states, tribes, and municipalities. The National Fire Policy places high priority on several other important topics. This interagency policy highlights and reiterates firefighter and public safety as the number one priority; the policy calls for an assessment of the consequences on safety, property, and cultural resources in choosing the appropriate response to wildland fire.

The National Fire Policy explains the role of federal wildland firefighters (including equipment) as that of only wildland firefighting, and in the special case of the wildland-urban interface use of federal personnel will be limited to exterior structural fire suppression only. The national policy forbids use of wildland firefighters to enter a house (or other structure).

Key Features of the 2001 Wildland Fire Policy:

The 2001 Wildland Fire Policy is the guiding source for how the federal government deals with wildland fire. The document covers a wide variety of issues: safety, protection priorities, planning for possible ignitions, and the use of fire for land management purposes; and communication and education of public and agency personnel.

The 2001 Wildland Fire Policy provides a loose framework that allows agencies at all levels of government (federal to local) to work together. Below are some listed points from the 2001 Wildland Fire Policy that briefly summarize what the document is about, and summarize what applies to the homeowner.

Point 1 - Safety

"Firefighter and public safety is the first priority. All Fire Management Plans and activities must reflect this commitment."

Point 3 - Response to Wildland Fire

"Fire, as a critical natural process, will be integrated into land and resource management plans and activities on a landscape scale, and across agency boundaries. Response to wildland fire is based on ecological, social, and legal consequences of the fire. The circumstances, under which a fire occurs, and the likely consequences on firefighter and public safety and welfare, natural and cultural resources, and values to be protected, dictate the appropriate management response to the fire."

Point 6 - Protection Priorities

“The protection of human life is the single, overriding priority. Setting priorities among protecting human communities and community infrastructure, other property and improvements, and natural and cultural resources will be based on the values to be protected, human health and safety, and the costs of protection. Once people have been committed to an incident, these human resources become the highest value to be protected.”

Point 7 – Wildland-Urban Interface

“The operational roles of federal agencies as partners in the Wildland-Urban Interface are wildland firefighting, hazardous fuels reduction, cooperative prevention and education, and technical assistance. Structural fire suppression is the responsibility of tribal, State, or local governments. Federal agencies may assist with exterior structural protection activities under formal Fire Protection Agreements that specify the mutual responsibilities of the partners, including funding.”

Point 14 - Interagency Cooperation

“Fire management planning, preparedness, prevention, suppression, fire use, restoration, and rehabilitation, monitoring, research, and education will be conducted on an interagency basis with the involvement of cooperators and partners.”

Organization

In terms of a firefighting organization, the federal government has come to terms with the challenges of multiple agencies, multiple land ownerships, and multiple objectives. Although each agency views wildland fire differently, through the interagency approach, the federal agencies have managed to establish a strong fire management organization.

The interagency effort has come about because it is difficult for any one agency to fund enough resources to protect all of its lands. By pooling their resources and carefully coordinating their efforts, the agencies can deal with the many fires that burn every year.

On the operational end of the National Wildfire Coordinating Group (NWCG) is the National Interagency Fire Center (NIFC) in Boise, Idaho. NIFC is a complex that houses all of the agencies in one place. NIFC provides safe, effective, and efficient policies and guidance, as well as technical and logistical support to the wildland fire management community.

All of the resources available on the national level are available for fire wildland fire suppression. Through a system of allocation and prioritizing, crews and resources are frequently moved around the United States to provide fire suppression services on federal lands.

The fire teams and crews ultimately carry out the wildland fire policy. These teams have the responsibility of ordering resources, asking for assistance, and for providing the fire suppression. They also determine whose land a fire is on and if it is a threat to people, to homes, or to other property.

The personnel within that fire management organization are wildland fire trained. The rules, regulations, and legal authority of the federal government are for the preservation of federally administered lands. With the exception of government compounds that have firefighters trained to deal with fires inside of buildings and other structures, federal wildland firefighters are not trained to deal with structural fires.

This plan was developed by Northwest Management, Inc., under contract with the Yellowstone County Commissioners with funding provided by the Montana Department of Natural Resources and Yellowstone County.

Citation of this work:

Schlosser, W. E. and T. R. King. *Lead Authors.* 2006. Yellowstone County, Montana, Community Wildfire Protection Plan. Northwest Management, Inc., Helena, Montana. February 28, 2006. Pp. 216.

Schlosser, W. E. and T. R. King. *Lead Authors.* 2006. Yellowstone County, Montana, Community Wildfire Protection Plan – Executive Summary. Northwest Management, Inc., Helena, Montana. February 28, 2006. Pp. 10.

Schlosser, W. E. and T. R. King. *Lead Authors.* 2006. Yellowstone County, Montana, Community Wildfire Protection Plan Appendices. Northwest Management, Inc., Helena, Montana. February 28, 2006. Pp. 66.

Last Page of Document



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Final Project Summary
BBWA Main Canal Evaluation
Yellowstone County Conservation District – Irrigation Development Grant Program
Completed: March 2018
Prepared by: WWC Engineering

1.1 Introduction

The Billings Bench Water Association (BBWA) main canal is a gravity fed canal that is diverted from the Yellowstone River near Laurel, Montana. The canal consists of 63 miles of main canal and over 200 laterals, distribution canals, and two storage reservoirs. In 2016, the BBWA experienced a breach within the City Limits of Billings that prompted a proactive approach to determining how to best limit seepage from the canal to protect against future breaching. This study is a result of this proactive approach. The grantee for this project is:

Billings Bench Water Association
PO Box 50150
Billings, MT 59105
Phone: (406) 259-6241

1.2 Project Costs and Partners

This project was initiated by pursuit of grants from the Montana Department of Natural Resources and Conservation through two separate programs, the Conservation and Development Division Conservation District 223 Grant Program (CD 223 Program) and the Irrigation Development Grant Program (IDG Program). This report and attached appendices were prepared for a total cost of $42,000, with $22,000 being provided through the CD 223 Program (223-17-3528), $15,000 being provided through the IDG Program (IDG-18 0249), and $5,000 being provided by the BBWA. No cost overruns or savings were found on this project.

1.3 Project Timeframe

The project was started after award of the CD 223 Program grant in February of 2017 and was completed in February of 2018. Due to the award date of the IDG Program grant, significant work was not started on the project until November of 2017.

1.4 Project Purpose

The BBWA contracted with WWC Engineering (WWC) to prepare an analysis of approximately 11.5 miles of the main canal that runs through the city of Billings, Montana. The stretch of the main canal that is covered in this study extends from the crossing at Shiloh Road to the crossing at Shamrock Lane. In this study, the canal was evaluated to determine flow changes, seepage points, breach concerns, and to develop a hydrology and hydraulics model (H&H Model). In completing the above items, the significant seepage from the canal could be identified such that future lining projects could be conducted in the most beneficial locations. A complete summary of this information is included in the Final Project Summary Billings Bench Water Association, provided to the BBWA, which has a copy available upon request at their office.

1.5 Project Accomplishments

This report provided the BBWA with the information necessary to develop a prioritized list for improvements to the main canal in effort to reduce the risk of breaching inside of the City limits of Billings. As such, the people served by completion of this project include not only the BBWA, but all residents and businesses located beneath the canal inside the study area, which includes a large percentage of the City of Billings. In addition to providing a prioritized list, this report identified the areas resulting in the highest seepage within the study area, which will allow the BBWA to line these sections and further develop irrigated acreage with the conserved water.

1.6 Project Conclusions

The data collected throughout the study is presented in a summary in the final report provided to the BBWA and in greater detail in the appendices attached to the report. In general, the data indicates that breaching of the main canal due to a storm event is of minimal concern and that breaching due to natural occurrences (e.g., decaying tree roots) is a high concern. This is based on hydrology data that shows two 100-year+ storm events that occurred in the previous 10 years in the Billings area and the canal did not overtop during either storm event. In addition, data collected related to embankment seepage, flow loss, embankment height, soil type, and tree density was utilized to prioritize the highest risk sections of the canal for breaching.

1.7 Project Continuation

The information developed in the study was utilized to prepare a prioritization of improvements to the canal. Based on the prioritization, the BBWA received a grant from the RRGL to prepare a Preliminary Engineering Report such that pursuit of state and federal funds for lining of the most critical section of the canal can be completed.

1.8 Project Recommendations

Information developed through this report provides a tool to the BBWA in future projects, however due to limited funds and time, the study was limited in scope. The main canal of the BBWA is approximately 63 miles, of which only 11.5 miles was developed into an H&H Model. A model of the BBWA's entire main canal would be helpful in evaluation of future upgrades to the canal. In addition to the limited length of the developed H&H Model, evaluations related to seepage from the canal banks would have benefited from measurements taken at three times, low canal flow, peak canal flow, and off season. As the scope of the project was limited, only one time was investigated. However, the BBWA has proactively requested WWC to conduct an additional two investigations, which will allow determination of whether a seep is related to groundwater discharge or irrigation seepage and whether the seepage increases with increased flows in the canal.

Although the study could have been on a broader scope and provided more detail to the BBWA, it accomplished the precise goal of the BBWA in determining a prioritization of projects to protect against breaching of the main canal within the City of Billings.

CERTIFICATE OF COMPLIANCE

Project Sponsor: **Billings Bench Water Association**

Name of Project: **Billings Bench Water Association Hydrology & Hydraulics Study of Main Canal**

I, the undersigned, being duly qualified, respectfully, of the Billings Bench Water Assoc.. (Name of Sponsor), in the County of Yellowstone, State of Montana, do hereby certify that the above-named project is in full compliance with all of the covenants and conditions set forth in Grant Agreement Number IDG-18-0249 & 223-17-3528 between the Billings Bench Water Assoc.. (Name of Sponsor) and the State of Montana, Department of Natural Resources and Conservation.

Authorized Signature

3-29-18
Date

BBWA President
Title

FINAL REPORT

STATEMENT OF COMPLETION

Project Sponsor: **Billings Bench Water Association**

Name of Project: **Billings Bench Water Association Hydrology and Hydraulics Study of Main Canal**

I, Greg Reid, P.E., (enter name of Project Engineer) a Registered Professional Engineer in the State of Montana, license number 40921, do hereby state that the above-named project was completed according to the approved plans and specifications. I further state that the information prepared and presented in this report is true and accurate, to the best of my knowledge.

Greg T. Reid
(Name)


(Signature)

40921
P.E. Number

3-29-2018
Date

WWC Engineering
(Name of firm)

51 N 15th St., Ste. 1 Billings, MT 59101
(Address of firm)

FINAL PROJECT SUMMARY

BILLINGS BENCH WATER ASSOCIATION

PREPARED FOR:

YELLOWSTONE CONSERVATION DISTRICT

1371 RIMTOP DRIVE
BILLINGS, MT 59105

AND

BILLINGS BENCH WATER ASSOCIATION

PO BOX 50150
BILLINGS, MT 59105

PREPARED BY:

WWC ENGINEERING

51 NORTH 15TH STREET, SUITE 1
BILLINGS, MT 59101
(406) 894-2210
www.WWCengineering.com

Innovation
Quality
Value

MARCH 2018

BILLINGS BENCH WATER ASSOCIATION FINAL PROJECT SUMMARY

Prepared for:

Yellowstone Conservation District
ATTN: LaVerne Ivie
1371 Rimtop Drive
Billings, MT 59105
(406) 247-4420

Billings Bench Water Association
ATTN: Board
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Principal Authors: Shawn Thorson, P.E.

Reviewed by: Greg Reid, P.E., Billings Branch Manager

Date: March 8, 2018

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Appendix D. Soils, Vegetation and Embankment Height

1.0 INTRODUCTION

The Billings Bench Water Association (BBWA) main canal is a gravity-fed irrigation canal that is diverted from the Yellowstone River near Laurel, Montana. The canal consists of 63 miles of main canal with over 200 laterals, distribution canals, and two storage reservoirs. The main canal is platted as private property of the BBWA. The area of focus for this study is approximately 11.5 miles of canal that runs through the city of Billings, MT, spanning from the crossing at Shiloh Road to the crossing at Shamrock Lane.

The BBWA contracted with WWC Engineering (WWC) to prepare an analysis of this section of canal. The purpose of this analysis was to evaluate the hydrology and hydraulics of the main canal, identify flow gains and losses through the canal, identify points of seepage from the lower embankment, and provide a desktop analysis of soils, vegetation, and embankment height that would contribute to areas of high risk. The following report summarizes the results of each of these analyses, and individual reports or memorandums detailing the results further are attached.

1.1 LOCATION

Please refer to the attached reports and memorandums for location maps, site maps, and topographic maps included in this report. The BBWA main canal is diverted from the Yellowstone River near the town of Laurel, Montana, just east of where U.S. Highway 212 crosses the Yellowstone River. The canal then delivers water to various customers along its 63-mile span, until its point of termination where it feeds into Cabin Creek approximately 1.75 miles from the Yellowstone River. Exhibit 1 shows the overall BBWA Canal in addition to the approximate irrigated acreage of the BBWA. This study is focused on an 11.5-mile stretch of the main canal in Billings, MT from where Shiloh Road crosses the canal to where Shamrock Lane crosses the canal. The study section of the canal is highlighted on Figure 1.

2.0 HYDROLOGY

The hydrology model shows that during two separate storms in excess of the 100-year event that occurred within the past 10 years, the BBWA canal did not overtop. Based on this information, no revisions relative to stormwater inflows are recommended to the BBWA canal. A summary of the hydrology model is included in the Hydrology and Hydraulics Report (H&H Report) provided in Appendix A.

3.0 HYDRAULICS

Data from preparation of the hydraulics model is included in the H&H Report in Appendix A. Per the hydraulics model, the canal capacity within the study area boundary is limited

(decreased) at two separate minimum points. The first minimum flow point that would cause canal overtopping is located near 16th Street West and Colton Boulevard (canal Segment 6-7), which passes 450 cfs. The second minimum flow point is the Rim Tunnel, which passes 372 cfs. Figure 1 shows the gradual decrease of flows for the canal. Please note, these minimum flow sections are due to degradation of sections of the canal as discussed in Appendix A. Maintenance projects for increasing the capacity of the canal in the degraded areas is included in Section 8.3. It is recommended that the maintenance projects should increase the canal capacity to 600 cfs; however, it is noted that this capacity would not reach these minimum points if diverted at the Yellowstone River unless the entire canal were to be lined such that no seepage occurs. As such, although the capacities of the minimum points are degraded from the original canal capacity, they do not indicate the required diversion rate due to unaccounted seepage occurring outside of the study. Additionally, it is anticipated that the entire water right capacity would be required during peak usage times to overcome canal seepage. It is also worth noting that during times of peak usage (early July) water is unavailable at the far reaches of the canal, such that users are out of water for significant stretches of time. Maintenance of the areas that have degraded that would increase the overall canal capacity, is anticipated to provide water availability such that these users would not be without water for significant amounts of time.

Figure 1. Reach Flow Capacity

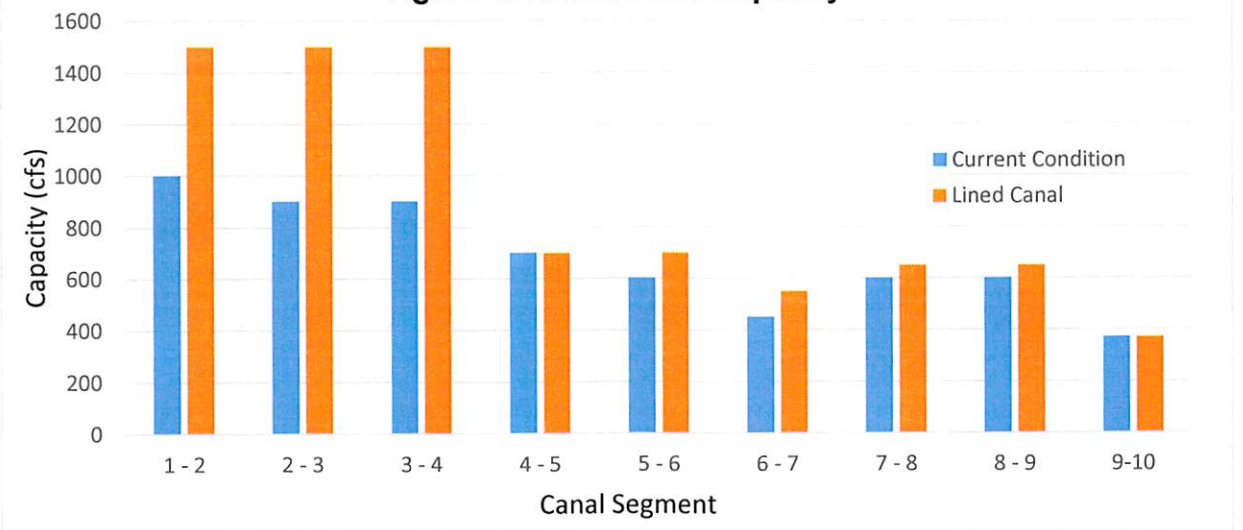


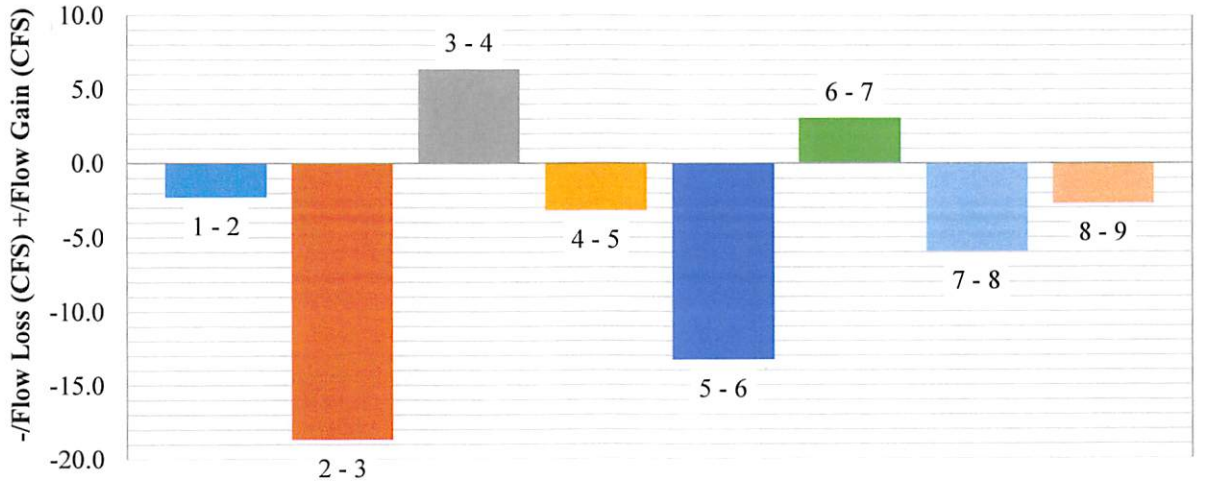
Figure 1 also shows the capacity of the canal should it be lined. This shows that the capacities would increase due to lining (assuming that the lining product is not covered by soil). By lining the canal segment from gauges 6-7, a flow of 550 cfs would be able to reach the Rim Tunnel as opposed to the previous minimum of 450 cfs resulting in approximately 175 cfs over capacity at this location. As breaching at the Rim Tunnel would be catastrophic, it is recommended to not increase the capacity of the canal at the 16th Street West and Colton Boulevard area until after increasing the capacity at the Rim Tunnel.

4.0 FLOW MEASUREMENTS

Flow measurements were performed based on 10 staff gauges installed through the study area during the 2017 irrigation season. A discussion of the flow measurements and results is included in Appendix B. A table of the results is shown below.

As shown in the table, the majority of the study area experienced flow losses on average throughout the irrigation season. In addition, two sections experienced flow losses in excess of 10 cubic feet per second (cfs) each. Priority ranking relative to flow losses in the canal is ordered from largest flow loss to largest flow gain with scoring of 1 through 9. Please note, the final section of the study is not included in Figure 2 as only one flow measurement point was available for development of a flow rating curve. However, this section experienced a flow gain of 6 cfs on the initial flow measurement and is ranked as the second lowest priority section for flow losses.

Figure 2. Average Reach Flow Change - May to October 2017



5.0 SEEPAGE

In October 2017, prior to canal shut down, WWC staff investigated the lower portion of the canal to identify areas of concern regarding bank seepage. A memorandum outlining this investigation is included as Appendix C. The results of this investigation are shown in Table 1.

As shown in the table, 14 separate seepage sections (identified as different canal bank seepage type areas) were identified as portions of the original 9 study sections (identified from staff gauge to staff gauge). In addition, Canal Sections 4, 6, and 8 had no seepage points identified, which is primarily due to the canal being incised in these locations. For purposes of compiling a scoring matrix by reach, the seepage sections were revised to match the original 9 sections as shown in Table 2. If several seepage sections were identified within a study section, the highest rating seepage criteria was used. For example, Seepage Sections 1 through 3 are all in Study Section 1. As Seepage Section 3 was the highest concern, it was therefore selected as the score for this overall section.

Table 1. Seepage Investigation Results

Seepage Area Section Number	Gauge Reach Identifiers	Ranking Total	Ranking Priority
1	1A	10	6
2	1B	11	7
3	1C	9	5
4	2A	9	5
5	2B	10	6
6	3A	10	6
7	3B	5	1
8	5	9	5
9	7	11	7
10	7A	9	5
11	9	11	7
12	9A	7	3
13	9B	8	4
14	9C	6	2

Table 2. Seepage Investigation Results

Seepage Section	Study Section	Seepage Score	Lowest Score	Ranking Priority
1	1A	10	9	3
2	1B	11		
3	1C	9		
4	2A	9	9	3
5	2B	10		
6	3A	10	5	1
7	3B	5		
	4	15	15	7
8	5	9	9	3
	6	15	15	7
9	7	11	9	3
10	7A	9		
	8	15	15	7
11	9	11	6	2
12	9A	7		
13	9B	8		
14	9C	6		

6.0 SOILS, VEGETATION, EMBANKMENT HEIGHT

To provide a complete prioritization of potential canal breaching locations, it was necessary to also include consideration of embankment soil materials, vegetation along the embankment, and embankment height. A memorandum discussing these items is included in Appendix D. Table 3 shows the prioritization scoring from this memorandum.

Table 3. Soils, Vegetation, and Embankment Height Analysis

Canal Segment	Flow Gauge Reach	Soil Analysis Rating	Vegetation Analysis Rating	Embankment Height Analysis Rating	Cumulative Segment Rating	Segment Priority Ranking
1	1-2	1	2	2	5	3rd
2	2-3	1	1	3	5	3rd
3	3-4	1	3	2	6	4th
4	4-5	2	2	4	8	5th
5	5-6	3	4	4	11	8th
6	6-7	3	3	4	10	7th
7	7-8	3	2	4	9	6th
8	8-9	1	2	1	4	2nd
9	9-10	1	1	1	3	1st

7.0 COMPOSITE RANKING

A compilation of the ranking criteria from the aforementioned studies is included in Table 4. Table 4 includes composite ranking criteria related to normal canal lining operations only as breaching due to a stormwater event is considered less likely to occur.

8.0 CANAL IMPROVEMENT OPTIONS

A compilation of the ranking criteria from the aforementioned studies is included in Table 4. The following sections outline options with American Association of Cost Engineers (AACE) Class 5 Cost Estimates (order of magnitude) for the purposes of allowing BBWA to plan for future operations.

Table 4. Compiled Ranking Criteria

Canal Segment	Flow Gauge Reach	Priority Ranking				
		Soils, Veg, Emb Hgt	Seepage	Flow Loss	Composite	Ranking
1	1-2	3	3	6	12	3
2	2-3	3	3	1	7	1
3	3-4	4	1	8	13	5
4	4-5	5	7	4	16	8
5	5-6	8	3	2	13	5
6	6-7	7	7	7	21	9
7	7-8	6	3	3	12	3
8	8-9	2	7	4	13	5
9	9-10	1	2	8	11	2

8.1 Stormwater Breach Protection Options

As discussed previously, breaching of the BBWA canal from a stormwater event is anticipated to be an unlikely scenario comparatively to breaching from normal canal operations. However, for the BBWA's consideration, several options could be completed that would increase the protection of the BBWA Canal within the study area from breaching during a major storm event. In addition, the below options would provide greater operational flexibility to the BBWA should immediate draining of the canal be required.

8.1.1 Option 1 – Increase Discharge Capacity at Canyon Creek Flume

As discussed in the H&H Report, the Canyon Creek Flume is operated as an emergency discharge location in the event that flows must be reduced prior to the City of Billings. Discharge at this location is limited by four 36-inch headgates on the sides of the flume. As discussed in the H&H Report, approximately 368 total cfs may be discharge through these headgates, while 670 cfs continues along the canal. As nearly half of the canal cannot be discharged at this location, increased capacity of the discharge at this flume would provide the BBWA with greater protection of the downstream structures. Increasing the capacity of the discharge at the flume would not be entirely accomplished by only adding headgates on the sides of the flume as decreased discharge to Canyon Creek would occur as the water elevation drops past each headgate. Therefore, it would be essential to construct a headgate structure in the canal near the Canyon Creek Flume that could be closed to back up canal waters in the flume and allow complete discharge of incoming flows. Construction of a headgate structure immediately downstream of the Canyon Creek Flume would also allow the BBWA a point to close flows off should a

blockage occur at either the Rim Tunnel or Alkali Creek Siphon. The estimated cost for completion of this item is $295,000.

8.1.2 Option 2 – Overflow at Alkali Creek Siphon

The Alkali Creek Siphon is located in an area that is central to the City of Billings in addition to being adjacent to Alkali Creek, which is one of the only drainage areas not limited by storm water piping of the City of Billings. At this location, an emergency discharge capable of transferring 100 to 150 cfs could be installed to discharge directly to Alkali Creek. To accomplish this, a turnout structure would be required to be installed immediately above the Alkali Creek Siphon that would include a locking mechanism requiring both the BBWA and the City of Billings to unlock. By requiring both BBWA and the City to have locks on the turnout, discharges would not be allowed by the City when downstream capacity is unavailable (i.e., from this manhole, an approximate 48-inch storm drain that is 400 feet in length would be required). This option could also be constructed to provide a drain point for the canal, should emergency draining be necessary, as no emergency spill locations exist between the Canyon Creek Flume and beyond the northern extents of the City of Billings. The estimated cost for completion of this item is $167,000.

8.1.3 Option 3 – Overflow to Alkali Creek after Siphon

Several sections of the BBWA canal cross natural drainage swales flowing to Alkali Creek, such as the location that breached in 2016. The location that breached in 2016 crosses two separate individual lots, which may be difficult to obtain easements for the purpose of construction of a discharge line from the canal to the creek. However, on the west side of the intersection of the canal and Aronson Avenue, the parcel of land located between the canal and Alkali Creek is owned by the City of Billings, which could be utilized to construct piping across for discharging directly to Alkali Creek. The canal is approximately 600 feet from Alkali Creek at this point. This discharge point would be constructed similar to Option 2, with a turnout structure, locked gate, and piping capable of 100 to 150 cfs. The estimated cost for completion of this item is $150,000.

8.1.4 Option 4 – Overflow to Drain at Lillis Park

A City drain ditch is located immediately to the east (less than 100') of the canal in the Lillis Park area. This drain ditch could not accept storm water overflows as it has no additional capacity for controlling any storm events; however, in the event of a blockage in the canal, a turnout and drain point to this ditch would be centrally located between the Rim Tunnel and the Canyon Creek Flume. As with the Alkali Creek Siphon option, a turnout structure would be required to be installed that discharges to the drain. From the turnout structure an approximate 36-inch storm drain that is 100 feet in length would be required to discharge 100 to 150 cfs to this drain. Final discharge amounts would be

dependent on City storm drain capacity. The estimated cost for completion of this item is $80,000.

8.1.5 Option 5 – Overflow to Hogans Slough

This option would require the upsizing of the Hogans Slough from the point nearest the canal at Millennium Circle to its outfall on the Yellowstone River, which is approximately 2 miles away. It is possible that discharge to Hogans Slough could be conducted at numerous points from where it crosses beneath the canal immediately south of the Shiloh Road and Shiloh Crossing Boulevard intersection. However, this section of Hogans Slough traverses through developed properties in the Transtech Center and it is likely that large flows (>100 cfs) would result in flooding of this development. As such, a turnout structure could be installed near Millennium Circle similar to Option 3 discussed previously at an estimated cost of $80,000.

8.1.6 Option 6 – Multiple Discharge Locations

In discussions with the City of Billings regarding storm water overflow locations, it was determined that, with the exception of Hogans Slough that would require modifications, no locations exist that a large discharge would be feasible throughout the study area. The City did note that multiple smaller discharge locations would be acceptable to the City, such as 10 to 20 cfs discharge points. The focus of these discharge points would be to either existing major drains or to greenspace locations. After crossing Shiloh Road, the canal has 6 locations that could serve as potential discharge locations. If overflow structures were constructed in all 6 locations, the total cost estimate for this option would be $220,000. Please note, additional unknown costs such as property or easement acquisition are not included in this cost, which may be substantially larger than the estimated construction cost.

8.2 Normal Operation Breach Protection Options

The BBWA Canal within the study area is at risk of breaching due to normal canal operations as outlined previously (e.g., tree roots creating piping failures). The following outline provides several options for mitigating these breaching concerns.

8.2.1 Option 1 – Tree Management Plan

As discussed in the soils, vegetation, and embankment height memorandum, numerous trees have been planted along the lower embankment of the canal that may lead to canal failure. In order to mitigate the risks from these trees, a tree management plan such as that outlined in the *Technical Manual for Dam Owners: Impacts of Plants on Earthen Dams* (FEMA, 2005) may be implemented by the BBWA staff to reduce the quantity of these trees and mitigate the potential failure locations. This outline requires that trees in the upper 1/3 of the embankment include removal of the root ball and compaction of low

permeability soils in the excavation. Trees found in the lower 2/3 of the embankment are required to be removed and toe drains installed either in their place or a french drain installed above a row of trees along the embankment. Trees that are removed beyond the toe of the canal, but within a distance of ½ the height of the embankment require a filter cloth to be installed in the root ball excavation and the excavation to be backfilled with permeable soils. Cost estimates for each of the types of tree removal are included below. Costs for tree removal and toe drain installation are based upon completion by BBWA staff. Costs for construction of a french drain are based upon contractor estimates.

- Root ball removal and compaction with low permeability soils
    - $400 per tree
- Root ball removal and installation of a toe drain in excavation (similar cost for trees located below canal toe)
    - $800 per tree
- French drain installation approximately 10-foot depth (cost assumes that a bench may be constructed on the embankment for construction of the french drain)
    - $90 per linear foot

8.2.2 Option 2 – Canal Lining

WWC has identified 5 potential lining options that may be utilized for the BBWA canal. Renewable resource benefits, environmental impacts, capital costs, and annual O&M Costs are factors that were considered for each alternative analyzed for the project. The alternatives that were analyzed are listed below. In all alternatives, initial construction would involve stripping all organic material from inside the canal and reshaping it to the desired dimensions. The canal geometry would be reshaped to include a bottom width to match pre-construction and a minimum of 2H:1V side slopes to provide canal bank stability.

- Alternative 1 – Rehabilitation with Canal Seal™
- Alternative 2 - Rehabilitation with Shotcrete Liner
- Alternative 3 - Rehabilitation with Firestone PondGard™ Liner
- Alternative 4 - Rehabilitation with Huesker Canal^3 Liner
- Alternative 5 - Rehabilitation with Aquamaster Armorliner

8.2.3 Lining Alternative 1 – Canal Seal™

After completing physical restorations to the canal as discussed previously, Canal Seal™ would be applied to the canal reach on an annual basis prior to each irrigation season. Each annual application of Canal Seal™ requires the need for annual cleaning. BBWA staff would have the ability to perform the annual maintenance, preparation, and chemical application of Canal Seal™.

Canal Seal™ would not optimize seepage reduction within the canal. The annual application of Canal Seal™ is only expected to be approximately 60% effective at reducing seepage. This reduced effectiveness is due to unfavorable conditions caused by existing soils within the Project Area. Additionally, a concern that arises with this alternative is that the Bureau of Reclamation (BOR) has raised several concerns about the environmental effects of the annual application of Canal Seal™.

Seepage would be slightly reduced under this alternative, resulting in several project goals being achieved. The volume of water conserved under this alternative would provide a small improvement in the irrigation efficiency of the canal. However, costs associated with the annual maintenance of the actual canal would not be realized under this alternative.

8.2.4 Lining Alternative 2 – Shotcrete Liner

After completing physical restorations to the canal as discussed previously, a 3-inch thick shotcrete liner would be installed. The wet sand/cement mixture that the shotcrete liner is comprised of will be applied directly to the canal floor and extended up the canal banks to a height that would provide approximately one foot of freeboard within the canal. Requirements for this mixture include a 3,000 psi minimum compressive strength and a 3-inch maximum slump.

Due to a study performed by the Bureau of Reclamation's (BOR) Canal Lining Program, it is estimated that seepage would be reduced by approximately 70% with the application of a shotcrete liner. The effectiveness of the shotcrete liner in reducing seepage, as documented in the BOR's *Canal Lining Demonstration Project Year 10 Final Report*, was determined in a cost and performance analysis done on several liner systems installed in various canals in the Pacific Northwest Region. In particular, the seepage reduction ability of shotcrete was determined from studying a 500-foot section of canal in Idaho. The liner was located in similar environmental conditions as the BBWA canal, including climate and soil types, and performed adequately ten years after construction. During the study period, minor patching was necessary to repair cracks and holes, but the structural integrity of the liner was considered in good condition. The reason this liner did not completely eliminate seepage however was that cracking and scouring occurred during the liner's design life.

The canal section rehabilitation paired with a shotcrete liner would provide short-term seepage reduction. This would allow for a short-term increase in irrigation efficiency, increasing the canal's ability to augment flows for a short duration. In addition, O&M costs associated with the actual canal would be reduced during this time. Once cracks and scour holes appear within the liner, these benefits would be rapidly reduced. Therefore, the project goals would be achieved for a short period of time.

8.2.5 Lining Alternative 3 – Firestone Pondgard™ Liner

After completing physical restorations to the canal as discussed previously, a Firestone 45-mil EPDM (Ethylene Propylene Diene Monomer) PondGard™ geomembrane liner system would be installed. The liner system specified includes an 8-oz geotextile fabric underlay and a 45-mil PondGard™ geomembrane liner. An 8-oz geotextile fabric overlay would then be placed over the liner followed by a 6-inch ballast layer to protect the liner system from being damaged due to wildlife traffic and/or vandalism. The ballast layer would provide additional benefits to the system by securing the liner in place and preventing the liner from floating as a result of air being trapped underneath. The liner system will need to be installed accounting for approximately one-foot of freeboard within the canal.

The rehabilitation of the canal with a PondGard™ geomembrane liner would provide maximized seepage reduction or elimination within the Project Area, providing substantial water conservation. The irrigation efficiency would be significantly increased, optimizing the canal's ability to deliver water to users. Additionally, O&M costs associated with the canal would be reduced.

8.2.6 Lining Alternative 4 – Huesker Canal³ Liner

After completing physical restorations to the canal as discussed previously, a Huesker Canal³ liner would be installed. The Huesker Canal³ liner that would be used includes a 20-mil EVA geomembrane with 8 oz polyester nonwoven geotextile fabrics bonded to the top and bottom. This combined system allows for decreased installation efforts required by other liner systems in which multiple layers are installed on top of one another. The Canal³ liner would be installed directly on the canal bottom and canal banks. The liner would be extended to a height above the canal floor to provide approximately one-foot of freeboard within the canal. Similar to the previous alternative, a 6-inch ballast layer would be placed on top of the liner on the canal bottom to secure the liner in place and prevent floating caused by air becoming trapped under the liner. Also, please note, if the Canal³ were to be buried, the warranty would be extended from approximately a 25-year length (exposed) to a 35-year length, which would be proportionate over the life of the project and dependent on several factors such as installation oversight by Huesker staff and the type of project. The study mentioned previously in the shotcrete lining section also evaluated the life of canal lining options over a 10-year period. In this study it was

identified that an exposed liner would have an expected service life of 10-25 years and that a liner with shotcrete cover would have a lifespan of 40-60 years. This lifespan is based upon the estimated lifespan of the concrete cover.

Similar to the previous alternative, rehabilitation of the canal with Canal^3 liner would minimize or eliminate seepage within the Project Area and provide maximum water conservation. Irrigation efficiency would be substantially improved, optimizing the canal's ability to provide water to downstream users. As with the previous alternatives, this alternative would significantly reduce the O&M costs associated with the canal. In addition, Huesker Canal^3 has an advantage over other liner systems in that Canal^3's composition of recycled materials provides an additional environmental benefit, which is favorably looked on when applying for grant funding. Based on these expected results, all project goals and objectives would be achieved by the implementation of Alternative 5.

8.2.7 Lining Alternative 5 – Aquamaster Armorliner 45L

After completing physical restorations to the canal as discussed previously, the Aquamaster Armorliner would be installed. The Aquamaster Armorliner that would be used is a double scrim, heavyweight geomembrane fabric that incorporates a special weave pattern to enhance thickness, flatness, and tear properties. In addition, a LDPE 5.0 mil coating is applied to both sides for improved toughness and abrasion resistance. This combined system allows for superior strength and leak protection. The total thickness of the Aquamaster Armorliner is nominal 45 mil, including the two woven black HDPE scrims and the 5 mil coating on either side. The Armorliner would be installed directly on the canal bottom and canal banks. Similar to the previous alternatives, a 6-inch ballast layer would be placed on top of the liner on the canal bottom to secure the liner in place and prevent floating caused by air becoming trapped under the liner. The liner would be extended to a height that would provide approximately one foot of freeboard within the canal.

Similar to the previous alternative, rehabilitation of the canal with Aquamaster Armorliner would minimize or eliminate seepage and provide maximum water conservation. Irrigation efficiency would be substantially improved, maximizing the canal's ability to deliver irrigation water. This alternative would significantly reduce the O&M costs associated with the canal. Based on these expected results, all project goals and objectives would be achieved by this alternative. It is noted in the Aquamaster Armorliner product literature, that this product has approximately triple the puncture resistance and tear strength of a HDPE 60 mil liner.

8.2.8 Lining Alternative 6 – HDPE 60 mil Liner

After completing physical restorations to the canal as discussed previously, the HDPE liner would be installed. The HDPE liner has historically been the liner selected for large

projects that require UV and Ozone resistance due to the availability and relatively inexpensive material cost. However, liner products that degrade at a slower rate than HDPE have been introduced in the past 15 years. In typical Montana installation scenarios, an exposed HDPE liner will become brittle between 10 and 15 years, after which point wildlife traffic across or potentially storm events on the liner may result in punctures in the liner, potentially resulting in an ineffective liner.

In addition to the HDPE liner, typically a geotextile cushioning layer is installed beneath the liner to prevent puncture from soils and gravels beneath the liner. Similar to the previous alternatives, a 6-inch ballast layer would be placed on top of the liner on the canal bottom to secure the liner in place and prevent floating caused by air becoming trapped under the liner. The liner would be extended to a height that would provide approximately one foot of freeboard within the canal.

Similar to the previous alternative, rehabilitation of the canal with HDPE liner would minimize or eliminate seepage and provide maximum water conservation. Irrigation efficiency would be substantially improved, maximizing the canal's ability to deliver irrigation water. This alternative would significantly reduce the O&M costs associated with the canal. Based on these expected results, all project goals and objectives would be achieved by this alternative.

8.2.9 Lining Alternative Cost Comparison

Included in Table 5 is a cost comparison of the six lining alternatives that includes installation costs and operation and maintenance costs. The estimated O&M cost was conducted for a 20-year time cycle and includes a present worth analysis to compare long term cost savings. Each alternative's capital costs are included in this analysis. Please note, the Firestone Pondgard™ Liner and the HDPE 60 mil liner include an additional $0.75 per square foot for installation due to the second cushioning liner required.

Table 5. Long Term Cost Savings Analysis

ALTERNATIVE	CAPITAL COST PER LF CANAL*	O&M COST PER LF CANAL*	ESTIMATED SERVICE LIFE**	TOTAL COST
CANAL SEAL™	$45.40	$28.51	N/A	$73.91
SHOTCRETE LINER	$274.11	$14.62	40-60 years	$288.73
FIRESTONE PONDGARD™ LINER	$97.73	$9.36	15-20 years	$107.09
HUESKER CANAL³ LINER	$94.73	$2.92	25-35 years	$97.65
AQUAMASTER ARMORLINER	$89.72	$9.36	20-25 years	$99.08
HDPE 60 MIL LINER	$87.33	$9.36	20-25 years	$96.09

*Assumes a canal lining width of 42 feet

**Per BOR Canal-Lining Demonstration Project Year 10 Final Report and Product Warranties

8.2.10 Lining Alternative Recommendation

The project alternatives were compared in the cost/benefit analysis to determine the most desirable project alternative. From this analysis, it was determined that Alterative 4, rehabilitation with Huesker Canal^3 liner or Alternative 6 rehabilitation with an HDPE 60 mil liner, provided the most benefit, dependent on the installation technique and service life expectations. However, as stated previously, the HDPE 60 mil liner is anticipated to have a significantly shorter life expectancy than the Huesker Canal^3 liner, which is not accounted for in the total costs presented previously. As stated previously, the HDPE liner is anticipated to have a life expectancy between 10 and 20 years, dependent on outside conditions puncturing the liner, and the Huesker liner is anticipated to have a life expectancy between 25 and 35 years. Therefore, the HDPE liner may necessitate installation twice in the lifespan of a Huesker liner in its place. It is noted that Alternatives 3 and 5 each provided significant renewable resource benefits and met the stated project objectives as with Alternatives 4 and 6, but Alternative 4 provided the largest economic benefit during initial installation and over the life of the project. Therefore, Alternative 4 is recommended as the preferred alternative.

8.2.11 Option 3 – Toe Drain

In order to eliminate uncontrolled seepage from the BBWA embankment, a toe drain could be installed at the base of the embankment in problematic areas to capture and divert flows. This option by itself would provide difficulty in controlling seepage through the embankment as it would require to be both 1) constructed to a significant enough height to provide a drawdown relative to overall embankment height (e.g., 1/3 of embankment height) and 2) include removal of all trees and shrubs in the immediate area to limit clogging of the drain piping. As such, this cost would significantly exceed the cost of lining of the canal and was not considered feasible.

8.3 Canal Capacity Increase Maintenance

As discussed previously, several sections of the main canal have degraded over time resulting in decreased capacity, which the first two sections limit the flows able to reach the third section. These three sections are identified as maintenance projects for the BBWA and are detailed below. It is recommended that prior to increasing the capacities of any of the following three sections, a seepage loss study be conducted to identify the maximum seepage that may occur in the canal in addition to evaluation of the amount of lining the BBWA would be able to economically maintain such that a true required capacity of each section could be determined relative to the maximum canal flows (i.e., a significant seepage is occurring prior to the Rim Tunnel in unlined canal sections that the Rim Tunnel capacity does not need to be oversized to account for).

8.3.1 Rim Tunnel Maintenance

The Rim Tunnel inlet has several feet that are unsubmerged during normal canal flows, which would allow additional capacity to flow through this section if canal banks were of a height sufficient to prohibit overtopping. In addition, the estimated flow capacity of the Rim Tunnel based on the HEC-RAS model and dimensions of the tunnel is 500 cfs, which flow measurements indicate actual flow capacity has been reduced to 372 cfs (at the same elevation). This information indicates that the interior of the Rim Tunnel may be degenerated due to boulders caving in or roughening of the section (e.g., staff indicated debris must be cleaned out of the tunnel every year that may be scraping and roughening the walls). Also, the downstream slope of the embankment on the upstream side of the Rim Tunnel has had slope failures occur, necessitating stabilization by BBWA staff, which likely resulted in decreases in the embankment height.

To reestablish the capacity of the Rim Tunnel to the original design capacity, the allowable depth on the upstream side and the Rim Tunnel roughness would need to be addressed. To raise the water level on the upstream side of the Rim Tunnel, the existing concrete liner upstream of the inlet would be required to be removed and a new taller section of concrete would be required to be installed in its place. The slope of the channel in this location is approximately 0.0002 foot/foot, which would require an approximately 5,000-foot section to raise the water level 1 foot. Correction of the roughness in the Rim Tunnel would require grinding of the walls to remove any scratches and also removal of all debris through the Rim Tunnel. In addition to this, it appears as though the Rim Tunnel was originally constructed as an open tunnel through the sandstone. Subsequently, a concrete support structure has been poured inside of this, reducing the carrying capacity. It is estimated that the concrete structure (removal of the existing structure, over excavation to increase the channel section, and installation of the new structure) would have an approximate cost of $1.8 million, and no cost is included for the Rim Tunnel wall maintenance as that would be performed by the BBWA staff when time is available.

8.3.2 Alkali Creek Siphon Maintenance

The Soil Conservation Service (SCS) assisted with replacement of the Alkali Creek Siphon (wooden pipe installed after the 1937 floods) in the 1970s and evaluated several options for pipe sizes. In this document, a 96" diameter steel pipe was determined to be the recommended option, which would increase capacity of the siphon to 286 cfs. Flow measurements indicate that the siphon can pass a minimum of the flow going through the Rim Tunnel (372 cfs) and additional head is available on the upstream side of the siphon. The design completed by the SCS in the 1970s indicates that the BBWA was likely experiencing significant seepage losses above the Rim Tunnel at that time, as well as the siphon was not required to pass the full water right diversion capacity. It is recommended to increase the capacity of the siphon by raising the embankments on the inlet side of the

siphon between the Rim Tunnel and siphon. This section is approximately 800 feet long and increasing the upstream elevation head by 1 foot is anticipated to allow a flow of 475 cfs through the siphon and an increase of 2 feet would allow a flow of 540 cfs through the siphon. It is recommended that as sections of canal are lined and the capacity of the Rim Tunnel is increased, the embankment sections between the Rim Tunnel and Alkali Creek Siphon also be increased. This section is anticipated to be able to be increased without widening of the toe of the embankment to the north. This is because the north side of the embankment (downhill side) has an access road on the top in addition to the south side. By raising the embankment on the north side, the top width would be decreased and the access road would be lost, however the access road on the south side would still allow BBWA access for maintenance of this section. The estimated cost of this project is $35,000.

8.3.3 Segment 6-7 Maintenance

This segment of the canal accounts for an approximate 1,000 foot long section that has a degraded capacity of 450 cfs, currently. Lining of this section would increase the capacity to 550 cfs. This increased capacity is in excess of what could reach this section with 600 cfs diverted at the headgates, given lining of other segments of the canal is not completed. However, should all of the canal above this location be lined, an additional capacity of 50 cfs would be necessary. To accomplish this the canal section would require widening the bottom width of the canal. It is apparent that several locations in this segment have had a decreased section width, such as immediately upstream of the 17th Street bridge (likely during construction of the bridge or Solomon Avenue immediately north) and south of the residences off Shadow Place (likely during construction of the residences). Sufficient vacant space exists in the majority of this section (on either side of the canal) to widen the canal from the minimum 35-foot top width back to the 42-foot top width that is common for the rest of the canal. The estimated cost of this project is $75,000.

9.0 RECOMMENDATIONS

As stated previously, it is considered unlikely that breaching will occur of the BBWA canal due to a storm event based on recent history. As such, the recommendations for improvements to the canal as a result of this study are for protection of breaching from normal conditions first, projects to increase degraded capacity of canal sections second, and protection from uncontrolled flow conditions third (i.e., blockages in the canal or storm events in excess of 100-year event).

As shown above, costs were prepared for three options related to protection of the canal from breaching under normal conditions, which are a tree management plan (including construction of a french drain), lining of the canal, and construction of a toe drain. As the

size of the required toe drain would be infeasible to construct due to costs, it was removed from the potential options. As shown previously, the capital costs for canal lining are anticipated to be nearly $100 per linear foot and the costs for french drain installation in relation to a tree management plan are estimated to be $90 per linear foot (not including tree removal costs). As completion of a tree removal plan in conjunction with a french drain would have a higher total cost and would also not reduce canal leakage or increase canal capacity, it is recommended to complete the canal lining option for mitigation of concerning areas for breaching due to normal operating conditions. A prioritization of these areas was completed and includes canal segments 1, 2 (plus the initial section of segment 3 to Millennium Court), 7, and 9 (in unlined areas past the Alkali Creek Siphon). Due to the significant canal losses experienced in these sections, funding through resource conservation-focused grants such as WaterSMART or RRGL are anticipated to be available.

Previous information shows that three sections of the canal have degraded in capacity over the years due to factors inside and outside of the BBWA's control. Capacity increases of these sections are recommended to be completed by priority of where a catastrophic failure would occur, should the improvements not be made. Therefore, the Rim Tunnel is the first recommended improvement, the Alkali Creek Siphon the second, and Segment 6-7 the third.

As hydrologic data does not indicate a high potential for breaching of the canal, canal improvement options related to breaching from a storm event or blockage in the canal would be difficult to obtain grant funding for assistance with construction. As such, it is not recommended to prioritize construction of these improvements over the canal lining options, unless a funding source specific to these options can be found (e.g., the City of Billings). If emergency spill options were to be considered, prioritization would be based upon the highest cfs per dollar and the most beneficial location to operations (i.e., prior to the Rim Tunnel, but as near as possible). As such, it is recommended that an emergency drain to Lillis Park is the highest ranked option, an emergency drain to Hogans Slough is the second ranked option, and the improvements to the Canyon Creek Flume is the third ranked option. However, if significant work were to be conducted to the canal in the area of Hogans Slough, it would be recommended to consider the improvements to the Canyon Creek Flume at that time.

LEGEND

BBWA CANAL

IRRIGATED AREA

NOTE: ACREAGE SHOWN IS FROM AVAILABLEBBWA MAPPING FROM 1981. ACREAGE HAS DECLINED WITHIN THE CITY LIMITS OF BILLINGS SINCE 1981; HOWEVER, IRRIGATED ACREAGE HAS INCREASED BY APPROX. 8% OVERALL SINCE 1981.

0 10,000 20,000

SCALE: 1" = 10,000'

ALKALI CREEK SIPHON

LILLIS PARK

CANYON CREEK FLUME

RIM TUNNEL

PROJECT STUDY AREA

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BBWA IRRIGATION AREAS

FIGURE NO.
1
OF 1

BILLINGS BENCH WATER ASSOCIATION

MAIN CANAL

HYDRAULICS REPORT

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MARCH 2018

BILLINGS BENCH WATER ASSOCIATION MAIN CANAL HYDRAULICS REPORT

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1.0 INTRODUCTION

The Billings Bench Water Association (BBWA) main canal is a gravity-fed irrigation canal that is diverted from the Yellowstone River near Laurel, Montana. The canal consists of 63 miles of main canal with over 200 laterals, distribution canals, and two storage reservoirs. The main canal is platted as private property of the BBWA. The focus of this study is approximately 11.5 miles of the main canal that runs through the city of Billings, MT. This stretch of the main canal extends from the crossing at Shiloh Road to the crossing at Shamrock Lane. The intent of this study is to 1) determine if stormwater inflows to the canal during current conditions would cause overtopping or breaching and 2) to determine areas of the canal that, due to degeneration, have decreased in capacity from the original canal capacity.

1.1 Location and Physical Characteristics of the Crossings

Please refer to the Exhibit 1 and 2 for location maps detailing the canal extents and features analyzed during this study. The BBWA main canal is diverted from the Yellowstone River near the town of Laurel, MT, just east of where US HWY 212 crosses the Yellowstone River. The 63-mile long canal then delivers water to various customers before terminating where it feeds into Cabin Creek, approximately 1.75 miles from the Yellowstone River. This study focuses on an 11.5-mile stretch of the main canal in Billings, MT from where Shiloh Road crosses the canal to where Shamrock Lane crosses the canal.

2.0 HYDROLOGY

The hydrology for the drainage area upstream of the BBWA main canal through the modeled reach was developed using the Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS) software V4.2.1 developed by the U.S. Army Corps of Engineers. The HEC-HMS model was built using current conditions of the drainage areas and adjusted to produce peak flow rates close to those estimated by the United States Geological Survey (USGS) StreamStats website. The HEC-HMS program was selected due to the size of the drainage area, the ability to break the watershed up into several smaller sub-watersheds, and the universal acceptance of HEC-HMS within the hydrologic sciences community.

2.1 Watershed Description

The watersheds for the HEC-HMS model were delineated using the Hydrologic Unit Code (HUC) boundaries. The HEC-HMS model contains seven watersheds that are upstream from the modeled BBWA canal sections. Two watersheds were further split into smaller sub-watersheds (SWS) because the watersheds contain multiple locations where surface

water runoff flows into or bypasses the canal system. A map showing the delineated watersheds is provided Exhibit 1. The total area of the watersheds is 89,879 acres (140.44 square miles). Although the focus of this study is a section of canal within the City Limits of Billings, drainage basins were included from headgates on the Yellowstone River to the end of the study to provide peak hydrologic inflows that may be discharged to the canal.

2.2 StreamStats Peak Flow Predictions

The USGS gage stations in the vicinity of the project were checked to see if any of the watersheds modeled have USGS flow rate data. None of the drainages upstream from the BBWA canal within the modeled section have USGS gage stations. Therefore, peak flow rate estimates were obtained from the USGS StreamStats website. This widely-used website generates peak-flow statistics for Montana based on 2011 regression equations developed by Sando et. al., (2016). Two watersheds from the model were selected that are believed to be the most representative of the StreamStats results. These two watersheds are Alkali Creek and Hogans Slough. These watersheds were selected because the landcover is predominately native vegetation with relatively low amounts of urban development. The watersheds for the HEC-HMS model are located within both the Upper Yellowstone-Central Mountain and East-Central Plains regions for which regression equations were developed. The regression equations for these two regions utilize characteristic parameters for the watershed including:

- Drainage area (square miles);
- Percentage of drainage basin above 6,000 feet elevation (%);
- Percentage of area with slopes greater than 30 percent (%); and
- Mean spring (March-June) evapotranspiration (inches/month)

It is important to note that the USGS regressions from StreamStats do not account for soil types, land cover, natural depressions or manmade detention/retention ponds, or developments such as roadways, ditches and culverts that can provide detention storage capabilities that attenuate peak flow rates.

Peak-Flow statistics were calculated by the StreamStats website for Alkali Creek and Hogans Slough. A summary of peak flow rates from the StreamStats reports are provided in Table 1. The two drainages are both located within two separate StreamStats regression regions, the East Central Plains and Yellowstone-Central Mountain. The StreamStats website computes the peak flow rate for the drainages using both regressions and then computes a final peak flow rate that is weighted by percentage of the basin within each region. The complete StreamStats results are provided in Appendix A. The StreamStats regression peak flow rates provide a comparison point for the peak flow rate computed from the HEC-HMS model that was developed for this evaluation,

which is discussed later in the report. While StreamStats provides a peak flow rate, it does not provide a hydrograph of a storm event, nor does it provide a volume of runoff from the event.

Table 1. StreamStats Peak Flow Rate Summary

Statistic	Flow Rate (cfs)					
	East-Central Plains (ECP) Regression		Yellowstone-Central Mountain (YCM) Regression		Area-Averaged StreamStats Prediction	
	Alkali Creek	Hogans Slough	Alkali Creek	Hogans Slough	Alkali Creek[1]	Hogans Slough[2]
2 Year Peak Flood	176	124	90	77	155	78
5 Year Peak Flood	610	471	323	278	540	281
10 Year Peak Flood	1,130	929	625	538	1,010	546
25 Year Peak Flood	2,080	1,830	1,200	1,040	1,860	1,050
50 Year Peak Flood	3,000	2,760	1,770	1,530	2,700	1,550
100 Year Peak Flood	4,100	3,910	2,430	2,110	3,690	2,150

Notes:

1) Alkali Creek is 75% in the ECP Region and 25% in the YCM Region.

2) Hogans Slough is 2% in the ECP Region and 98% in the YCM Region.

2.3 HEC-HMS Model Development

2.3.1 Software Description

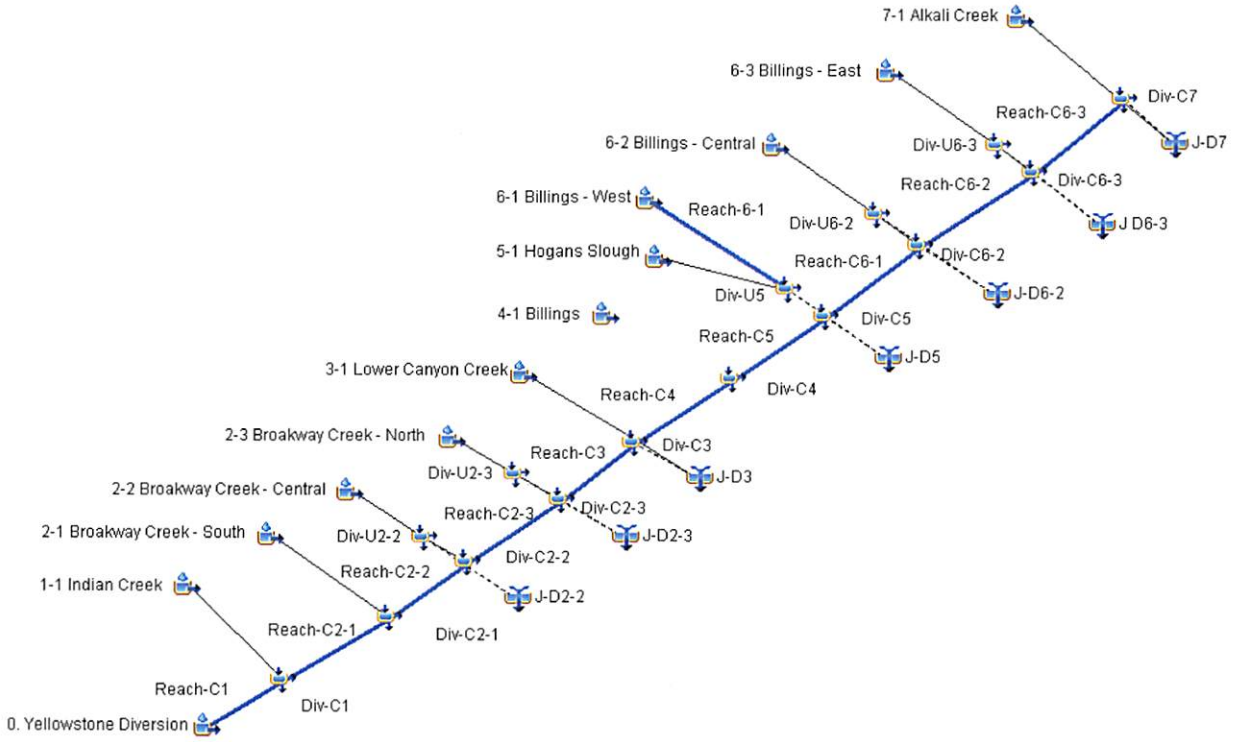
Runoff calculations were performed using the U.S. Army Corps of Engineers Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) software. HEC-HMS uses deterministic mathematical modeling algorithms to simulate the precipitation-runoff processes of dendritic watershed systems. It is designed to be applicable in a wide range of geographic areas for solving the widest possible range of hydrologic problems. These may include large river basin water supply, flood hydrology, and small urban or natural watershed runoff. Hydrographs produced by HEC-HMS can be used directly or in conjunction with other software for studies of water availability, urban drainage, flow forecasting, future urbanization impact, reservoir spillway design, flood damage reduction, floodplain regulation, and systems operation.

HEC-HMS is a generalized modeling system capable of representing many different types of watersheds. A model of the watershed is constructed by separating the various segments of the hydrologic cycle into pieces and constructing boundaries around the watershed and/or portions of the watershed of interest. There are at least six different

choices available for representing infiltration, transforming excess precipitation into runoff, and routing methods for simulating flow in open channels. Each component listed above is suitable in different environments and under different conditions.

There are multiple ways of creating a watershed stream network and specifying its properties in HEC-HMS. The model can be developed manually, in GIS, or using a combination of the two in which the watershed network is created manually while its properties are derived in GIS. In this case the model network was developed manually and the properties were primarily derived in GIS. For the purposes of modeling, the HEC-HMS model of the drainages above the BBWA was broken into seven watersheds, with two of the watersheds further broken into a total of 6 sub-watersheds. The model also includes ten canal reaches as shown in Figure 1.

Figure 1. HEC-HMS Model Elements



2.3.2 Reason for Model Selection

This program was selected due to the size of the drainage area, the ability to break the watershed up into multiple smaller sub-watersheds, the universal acceptance of HEC-HMS within the hydrologic sciences community, and the unrestricted (free) use of the software due to its development by the Hydrologic Engineering Center.

2.3.3 Inputs

The main inputs used in the model include:

- Watershed stream network and size;
- Infiltration loss method;
- Transform method for transforming excess precipitation into runoff;
- Routing methods;
- Meteorological data; and
- The time span of the simulation.

2.3.4 Outputs

The outputs from the model include:

- Hydrographs; and
- Flow volume.

2.3.5 Datasets Utilized for Model Development

Multiple datasets were used to develop the hydrologic model. These include the hydrologic unit delineation, elevation, precipitation, soil classification, and land use data. The datasets and their sources are as follows:

- Hydrologic Unit Code (HUC) – Drainage basin delineations
- Elevation – USGS National Elevation Dataset (NED) 1/3 arc-second Digital Elevation Model (DEM).
- Precipitation – NOAA Atlas 2. Precipitation Atlas of the Western United States (1973).
- Soil Classification – Soil Survey Geographic Database (SSURGO)
- Land Use – USGS National Land Cover Database (NCLD).

2.3.6 Selecting HMS Parameters

A HEC-HMS model requires four main input process parameters. These include the meteorological model, precipitation loss method, transform method and the streamflow routing method. Procedures followed in applying these methods may be found in the HEC-HMS User's Manual (USACE 2013), HEC-HMS Technical Reference Manual (USACE 2013) and the U.S. Bureau of Reclamation Design of Small Dams (USBR 1977).

Meteorological Model

A meteorological model file was created in HEC-HMS from the Meteorological Model Manager in the Components tab. A rainfall depth was input for the 2-yr, 5-yr, 10-yr, 25-yr,

50-yr, and 100-yr storms. The rainfall depths were calculated using the Precipitation-Frequency Atlas of the Western United States, NOAA Atlas No. 2 for Montana (Miller et al. 1973) and are the same values used in the HEC-HMS model. The NOAA Atlas 2 rainfall depths are presented in Table 2 for various return periods and frequencies.

Table 2. Precipitation-Frequency Values for Billings Region

Storm Event	NOAA Precip. (in)
2-yr	1.57
5-yr	2.05
10-yr	2.37
25-yr	2.78
50-yr	3.08
100-yr	3.38

The SCS Type II hypothetical storm was utilized for the HEC-HMS meteorological model, which implements a synthetic rainfall distribution developed by the Natural Resources Conservation Service (NRCS) from observed precipitation events. The unit hydrograph distribution contains rainfall intensities arranged to maximize the peak runoff for a given total storm depth.

Precipitation Loss

The precipitation loss methods available in HEC-HMS include Initial and Constant, Deficit and Constant, Exponential, SCS Curve Number, Green-Ampt, Smith Parlange and Soil Moisture Accounting. The SCS Curve Number method was selected for this project. The curve numbers were derived using a combination of each soil's Hydrologic Soil Group (HSG), Range Production Ratings (RPR) for a Normal Year (where applicable) and the land use. The Hydrologic Soil Classification, Range Production Ratings, and Land Use characteristics for the watersheds are provided in Appendix B. Overlaying these three parameters with the sub-watersheds in GIS results in approximately 25,000 discrete areas within the entire watershed. Each discrete area has properties associated with it for the HSG, RPR, and Land Use that are used to assign a curve number. The curve number for each discrete area is area-weighted to assign a curve number to each sub-watershed.

The soil conditions and range production values were taken from the NRCS soil survey of Yellowstone County. A map of the hydrologic soil groups is provided in Appendix B. The range production values were taken from the NRCS soil surveys for Normal Years and had values within the watershed ranging from 123 to 4,492 pounds per acre per year. The range production values were used to assign agricultural lands a hydrologic condition rating of good, fair or poor. Based on the NRCS soil survey results, areas with range production ratings between 1271 and 4,492 were assigned a good condition, ratings

between 791 and 1,271 were assigned a fair condition, and ratings of less than 790 were assigned a poor condition for the HEC-HMS model. A report with a map of the range production ratings for normal years is provided in Appendix B.

The land cover was determined by using data from the USGS National Land Cover Database (NLCD) that is modified from the Anderson Land Cover Classification System. The NLCD is updated on a five-year cycle, with 2011 being the most recent dataset. A map of the NLCD land cover for the watershed is provided in Appendix B. The land cover designations from the NLCD within the watershed analyzed are shown in Table 3.

The land cover descriptions from the USGS NLCD do not align exactly with typical land cover descriptions for curve number selections that are presented in the National Engineering Handbook – Part 630 – Hydrology (NEH 630) manual. Therefore, the NLCD land cover description has been used to select a land cover description from NEH 630 for the purpose of determining curve numbers. Table 3 shows the NLCD and the selected NEH 630 land cover descriptions side-by-side.

Table 3. Land Cover Conversion (National Land Cover Database to NEH 630)

NLCD Land Cover Description	NEH 630 Land Cover Description
Barren Land	Bare Soil
Cultivated Crops	Row Crops - SR +CR
Deciduous Forest	Oak-Aspen
Developed, High Intensity	Urban District
Developed, Low Intensity	Residential, 1/4 Acre
Developed, Medium Intensity	Residential, 1/8 Acre
Developed, Open Space	Open Space
Emergent Herbaceous Wetland	Water
Evergreen Forest	Woods
Hay/Pasture	Pasture, Grassland or Range
Herbaceous	Herbaceous
Open Water	Water
Shrub/Scrub	Brush-Forbs-Grass Mixture
Woody Wetlands	Water

Table 4 shows the NEH 630 land cover description in combination with the ratings of good, fair and poor (where applicable) and the curve number from NEH 630 based on the hydrologic soil group. Note that the usage of Range Production Ratings for determination of good, fair, or poor hydrologic conditions results in some areas being mapped as Row Crops:Fair which NEH 630 does not provide curve numbers for. Therefore, this model uses the average of curve numbers for good and poor hydrologic conditions to assign a curve number for Row Crops:Fair. Additionally, NEH 630 does not provide curve numbers for Herbaceous or Oak-Aspen land covers with HSG A soils, for which estimates have

been made for this model. Areas with a HSG rating of C/D have been estimated as the average of the curve numbers for C and D.

The properties of the discrete areas within the sub-watersheds and the curve numbers from Table 4 are used to calculate a weighted curve number based on area for each sub-watershed. The resulting curve number values for each sub-watershed are shown in Table 5.

Table 4. Curve Numbers by Land Cover and Hydrologic Soil Group

Land Cover	Curve Number for HSG				
	A	B	C	C/D	D
Bare Soil	77	86	91	92.5	94
Row Crops - SR+CR:Fair	67.5	77.5	84.5	86	87.5
Row Crops - SR+CR:Good	64	75	82	83.5	85
Row Crops - SR+CR:Poor	71	80	87	88.5	90
Oak-Aspen:Fair	31	48	57	60	63
Oak-Aspen:Good	30	30	41	44.5	48
Oak-Aspen:Poor	49	66	74	76.5	79
Urban District: Industrial	81	88	91	92	93
Residential, 1/4 Acre	61	75	83	85	87
Residential, 1/8 Acre	77	85	90	91	92
Open Space:Fair	49	69	79	81.5	84
Open Space:Good	39	61	74	77	80
Open Space:Poor	68	79	86	87.5	89
Woods:Fair	36	60	73	76	79
Woods:Good	30	55	70	73.5	77
Woods:Poor	45	66	77	80	83
Pasture, Grassland or Range:Fair	49	69	79	81.5	84
Pasture, Grassland or Range:Good	39	61	74	77	80
Pasture, Grassland or Range:Poor	68	79	86	87.5	89
Herbaceous:Fair	52	71	81	85	89
Herbaceous:Good	43	62	74	79.5	85
Herbaceous:Poor	61	80	87	90	93
Brush-Forbs-Grass:Fair	35	56	70	73.5	77
Brush-Forbs-Grass:Good	30	48	65	69	73
Brush-Forbs-Grass:Poor	48	67	77	80	83
Water	100	100	100	100	100

Transform Method

After the precipitation losses are taken into account, a transform method must be specified for transforming overland flow into surface runoff. The methods available for the transform method in HEC-HMS include the SCS, Clark or Snyder unit hydrographs, Kinematic wave, ModClark and a User specified unit hydrograph. The SCS unit hydrograph method was selected for this project. The SCS method requires only one parameter, as it assumes the shape of the unit hydrograph. In the SCS method, 37.5% of the runoff volume occurs before the peak flow, and the lag time can be approximated by taking 60% of the time of concentration.

The lag time for the watersheds was calculated using the velocity method from NEH 630 to determine the travel time for segments along the hydraulically most distant flow path. The time of concentration for overland flow limits the maximum distance to 300 feet. The lag time is calculated to be 60% of the total time of concentration for a watershed. The lag time for each watershed is shown in Table 5 and the time of concentration calculations are provided in Appendix C.

Table 5. Weighted Curve Numbers and Lag Time

Basin Name	Basin SWS	Area (sq. mi.)	Weighted Curve Number	Lag Time (minutes)
INDIAN CREEK	1-1	3.777	80.62	53.6
BROAKWAY CREEK	2-1	12.209	73.43	75
BROAKWAY CREEK	2-2	5.568	76.09	86.3
BROAKWAY CREEK	2-3	6.442	77.64	102.8
CANYON CREEK	3-1	25.805	76.12	260.7
BILLINGS	4-1	0.576	71.71	69.9
HOGANS SLOUGH	5-1	32.529	77.78	147.50
BILLINGS	6-1	4.927	75.98	55.7
BILLINGS	6-2	4.685	82.27	38.7
BILLINGS	6-3	4.398	78.91	36.5
ALKALI CREEK	7-1	39.521	78.75	177.30

Model Calibration

The model was calibrated to Alkali Creek because this drainage does not have significant levels of development and is considered to be more representative of the drainages used in the USGS regressions. The land cover within Alkali Creek is approximately 6% developed (residential housing and the Billings airport), 13% cultivated crops and 81% native vegetation (predominately herbaceous and shrub/scrub). The HEC-HMS model with the initial inputs from Table 5 significantly over-predicted the peak flow rates when

comparing the HEC-HMS results to the USGS StreamStats regression flow rates for the Alkali Creek sub-watershed. The magnitude of the over-prediction ranged from approximately 400% for the 2-year, 24-hour event to 50% for the 100-year, 24-hour event.

The model was calibrated by adjusting the initial abstraction until the HEC-HMS peak flow rates approximated the StreamStats predicted peak flow rates. The initial abstraction accounts for the reduction in runoff that occurs as a result of evaporation, absorption, transpiration and surface storage. The calibration was done by calculating the Potential Maximum Retention (S) for each sub-watershed, which is a function of the curve number for the SWS, and then calculating the Initial Abstraction (Ia) which is a percentage of S. The default relationship typically used for the SCS method is that Ia equals 0.2S. The HEC-HMS model aligns significantly closer to the StreamStats values by setting Ia equal to 0.42S, therefore this value was selected for the model. Table 6 provides a comparison of the peak flow rates predicted by StreamStats versus the HEC-HMS model along with the percentage difference from the HEC-HMS model. As shown in the table, the HEC-HMS over predicts the peak flow rate (compared with the StreamStats regression results) by 2% for the 100-year, 24-hour event. The HEC-HMS model over predicts the peak flow rate by a range from 7% to 18% for the 2-year though the 50-year events.

Table 6. Calibration Comparison of StreamStats to HEC-HMS Model

Event	Peak Flow Rate (cfs) SWS 7-1 Alkali Creek		Δ HEC-HMS - StreamStats	
	StreamStats	HEC-HMS	(cfs)	(%)
2-YR, 24-HR	155	177	22	14%
5-YR, 24-HR	540	637	97	18%
10-YR, 24-HR	1,010	1,193	183	18%
25-YR, 24-HR	1,860	2,107	247	13%
50-YR, 24-HR	2,700	2,894	194	7%
100-YR, 24-HR	3,690	3,764	74	2%

Table 7 provides a summary for each sub-watershed of the weighted curve number, the calculated value for the potential maximum retention (S), the percentage used for Ia calculations and the value of Ia in inches of initial abstraction. Basin 6 is predominately the City of Billings and Ia for these drainages uses the default value of 0.2S due to the high level of development that limits infiltration. The remainder of the drainages use a value of 0.42S except for SWS 2-1 and 4-1. The initial abstraction for these drainages was limited to a maximum value of 1.30 inches, which results in a lower percentage for the initial abstraction as shown in Table 7. The limit of 1.30 inches for initial abstraction was selected such that the initial abstraction would be less than the 2-year, 24-hour precipitation of 1.57 inches.

Table 7. Initial Abstraction Values

Basin Name	Basin SWS	Weighted Curve Number	S (in)	I_a %	I_a (in)
INDIAN CREEK	1-1	80.62	2.40	0.42	1.01
BROAKWAY CREEK	2-1	73.43	3.62	0.36	1.30
BROAKWAY CREEK	2-2	76.09	3.14	0.42	1.30
BROAKWAY CREEK	2-3	77.64	2.88	0.42	1.21
CANYON CREEK	3-1	76.12	3.14	0.42	1.30
BILLINGS	4-1	71.71	3.95	0.33	1.30
HOGANS SLOUGH	5-1	77.78	2.86	0.42	1.20
BILLINGS	6-1	75.98	3.16	0.20	0.63
BILLINGS	6-2	82.27	2.16	0.20	0.43
BILLINGS	6-3	78.91	2.67	0.20	0.53
ALKALI CREEK	7-1	78.75	2.70	0.42	1.13

Canal Crossing Structures

Estimation of inflows to the canal must include consideration of flows crossing beneath or over the canal due to the numerous constructed crossings. The following outlines these crossings and identifies how the capacity of each crossing was determined.

The model incorporates a junction for the diversion at the Yellowstone River that can be set to use a constant baseflow for the diversion capacity. The diversion has an assumed hydraulic capacity up to 600 cfs or equivalent to the original water right (No. 208219) flow rate. During a large precipitation event, BBWA will close the diversion so the model uses a flowrate of zero for the diversion. Once the excess precipitation from the sub-watersheds has been transformed into overland runoff and routed to the outlet of the SWS, it is either diverted underneath the canal (if a canal crossing structure exists) or flows into the canal at that point. For locations that have upstream diversion structures (culverts or siphons), a rating curve for the diversion is added to the HEC-HMS model. Flow rates less than the maximum hydraulic capacity of the diversion bypass the BBWA canal and continue downstream while excess flow goes into the canal. For locations without upstream diversion structures, all of the flow from the drainage goes directly into the BBWA canal.

The hydraulic capacity of the upstream diversion structures with head water at the elevation of the upstream canal berm is provided in Table 8 and the calculations are provided in Appendix D for structures where data was available. Stormwater structures within the City of Billings have a design criteria of passing the 10-year, 24-hour event.

While data is not available for all of the City's stormwater structures, this model assumes that these structures are able to pass the peak flow rate from the 10-year event as shown in Table 9. In addition to these canals crossing structures, the BBWA canal passes over Canyon Creek using an elevated wooden flume and passes underneath Alkali Creek using a siphon. The HEC-HMS model is structured such that all flow from Canyon Creek (SWS 3-1) and Alkali Creek (SWS 7-1) bypasses the BBWA canal. Due to flows from Canyon Creek passing underneath the BBWA flume, the upper portion of the drainage basin is not included in the HEC-HMS model.

Table 8. Canal Crossing Flow Capacities - Calculated

Crossing	SWS	HEC-HMS Element Name	Flow Capacity (cfs)
Broakway Central Siphon (24" Schreibis Pipe)	2-2	Div-U2-2	88.9
Broakway North Culvert (30" CMP)	2-3	Div-U2-3	64.8
Hogans Slough Culvert (60" CMP)	5-1	Div-U5	285.6

Table 9. Canal Crossing Flow Capacities – Assumed

Crossing	SWS	HEC-HMS Element Name	Flow Capacity (cfs)
Billings - Central	6-2	Div-U6-2	1,377.2
Billings - East	6-3	Div-U6-3	1,040.6

Streamflow Routing

The available methods in HEC-HMS for streamflow routing are Kinematic Wave, Lag, Modified Puls, Muskingum, Muskingum-Cunge, and Straddle Stagger. The Muskingum-Cunge method was selected for this project. The Muskingum-Cunge method is an adaptation of the Muskingum method for routing, utilizing physical channel characteristics in the routing model and relating the Muskingum K (travel time through the reach) and X (weighting factor between inflow and outflow influence) values to the hydraulic properties of a simplified, prismatic channel. The canal is modeled as a trapezoidal channel with a bottom width between 11 and 16 feet and side slopes ranging from 1.99 to 2.30 H:1V.

The canal is modeled as a series of reaches with diversion structures at each of the drainages. While physical diversion structures are not present in the canal at these locations, the canal has a maximum flow capacity that it can convey before excess water would overtop the downstream canal berm. Modelling the junctions between canal reaches as diversion structures allows the model to incorporate the conveyance capacity of the canal for each reach. Flow rates in excess of the canal capacity will overtop the downstream canal berm and are modeled as being diverted out of the canal. Water that overtops the canal will continue to flow downstream towards the Yellowstone River. An evaluation of canal capacity is included in the HEC-RAS section of this report.

An additional reach is included in the model for the drainage ditch along the west side of Shiloh Road that intercepts stormwater from SWS 6-1 and conveys the water to the Hogans Slough drainage (SWS 5-1) and the 60" CMP crossing structure.

2.3.7 HEC-HMS Model Results

The peak flow rates are listed by HEC-HMS hydrologic element in Table 10 below for the 2-year through the 100-year storms. The results are listed for each sub-watershed. It is important to note that the evaluation of any natural or man-made pond structures within the watershed was outside the scope of this project and not included in the HEC-HMS model. The presence of ponds with larger storage capacities will dampen the peak flow rate from any watersheds containing such ponds and can dramatically reduce the peak flow rates.

Table 10. HEC-HMS Model Peak Flow Rates

Hydrologic Element	Peak Drainage Discharge without Detention (cfs)					
	2-YR, 24-HR	5-YR, 24-HR	10-YR, 24-HR	25-YR, 24-HR	50-YR, 24-HR	100-YR, 24-HR
1-1 Indian Creek	32	170	325	579	797	1,033
2-1 Broakway Creek - South	17	117	295	658	1,005	1,411
2-2 Broakway Creek - Central	9	59	144	313	471	653
2-3 Broakway Creek - North	17	96	208	409	589	792
3-1 Lower Canyon Creek	37	200	406	766	1,087	1,447
4-1 Billings	1	5	13	30	46	65
5-1 Hogans Slough	86	443	901	1,691	2,388	3,170
6-1 Billings - West	180	447	674	1,005	1,269	1,545
6-2 Billings - Central	523	1,012	1,377	1,875	2,255	2,645
6-3 Billings - East	330	728	1,041	1,486	1,833	2,194
7-1 Alkali Creek	142	637	1,193	2,107	2,894	3,764

The results from the HEC-HMS model have been compared with historical modeling results and historical precipitation events. The West Billings Stormwater Management Plan prepared by DOWL in May of 2017 for the City of Billings summarizes previous modeling peak flow rate predictions for Hogan's Slough and significant historical precipitation events. The month and year of the study and the peak flow rate predicted by the study are summarized below for Hogan's Slough at Shiloh Road:

- March 1970 = 2,550 cfs
- May 1991 = 5,100 cfs
- May 2007 = 680 cfs

Additionally, the May 2007 report found that "roadways act as dams with culverts limiting flows which results in ponding and flood flows spreading over larger areas" and "the current spreading of floodwaters provides temporary storage which reduces flood peaks."

An August 2008 study, conducted by the City of Billings, utilized the May 1991 design flows and updated it to incorporate the drainage improvements constructed to date. The 2008 study also evaluated the reduction in peak flow that would occur as the result of constructing the proposed 34 acres-feet of detention storage proposed for the Shiloh Conservation Area. This study determined that the peak inflow rate of 350 cfs into the Shiloh Conservation Area would result in peak outflow rate of 186 cfs.

The DOWL report also evaluated the impacts from large precipitation events to the BBWA canal at Hogan's Slough:

> *During the two years preceding the design of Shiloh Conservation Area, several severe storms occurred in Billings, some exceeding the 100-year storm as compared to the 2011 City of Billings SWMM design storm precipitation depths. The "Father's Day Storm" of June 20th, 2010 (2.24 inches in under 2 hours) was much in excess of the 100-year for storm durations up to 6-hours. The May 24th, 2011 storm (2.74 inches in 6 hours and 3.12 inches in 24 hours) exceeded the 100-year for storm durations up to 6-hours and approached the 100-year storm even at the 24-hour duration. There were no known observations of overtopping into the BBWA Canal at the Hogan's Slough culvert crossing during these storms and based on hydraulic analysis of high water marks in the Shiloh Road and BBWA Canal crossing culverts, the maximum flow was on the order of 100 cfs through these storms.*

The peak flow rates predicted by the WWC HEC-HMS model are more in line with the 1970 and 1991 studies. This is an expected result because the HEC-HMS model does not include detention structures that attenuate the peak flow rate from the drainage basins, which have been constructed after the 1970 and 1991 studies.

Table 10 presented the maximum potential inflows to the BBWA canal during major storm events based upon previous assumptions. However, per data provided by the City of Billings and the BBWA, two 100-year storm events occurred over the previous 10 years (2010 and 2011). During these storm events the canal did not overtop, which indicates the maximum stormwater inflows to the canal must be less than the degenerated capacity of the Rim Tunnel of 372 cfs (please refer to the hydraulics section for an explanation of this) with the assumptions that the diversion headgates are closed and the Alkali Creek Siphon is flowing at the maximum possible flowrate. This 372 cfs must also account for the Canyon Creek Flume discharging approximately ½ of the canal flow at this location,

which would account for SWSs 1-1, 2-1, 2-2 and 2-3. In addition, the SWSs inside City Limits (6-1, 6-2, and 6-3) bypass at a minimum the 10-year storm event beneath the canal per the City of Billings storm water design standards. Information that is not accounted for in the development of the hydrology model, that is being accounted for in Table 11, is purposeful or incidental detention of stormwater flows above the BBWA canal. This detention is created by nearly all development that either includes stormwater ponding structures or roads with culverts that only pass the 10-year event and back up water creating an incidental pond during large storm events. Therefore, Table 11 presents estimated maximum inflow rates accounting for assumptions as stated below.

- SWS 3-1 flows through Canyon Creek underneath the BBWA elevated canal flume
- SWS 4-1 discharges to the Knife River pits which have capacity to store the flow from the 100-year event
- SWSs 5-1 and 6-1 are routed through the Shiloh Conservation Area that reduces peak flow rates to be within the capacity of the canal bypass structure. These SWSs do not discharge to the BBWA canal during events up to at least the 100-year event
- SWSs 6-2 and 6-3 peak discharges were decreased by each SWSs' 10-year storm events
- SWS 7-1 flows through Alkali Creek and over the BBWA siphon without entering the canal
- The remaining 100-year peak discharges were totaled and proportionately adjusted to total 372 cfs at the Rim Tunnel by the following formula
    - 372 cfs / [(SWS 1-1, 2-1, 2-2, and 2-3)*0.5 + (SWSs 6-1, 6-2, and 6-3)]
    - Inflows for all other storm events were multiplied by the proportioning determined for the 100-year event

In addition to the data provided by the City, the BBWA provided staff gauge elevations and data for the two 100-year+ storm events for both the Canyon Creek Flume and the headgates on the Yellowstone. During the June 2010 storm event, one headgate was open approximately 27" and the Canyon Creek Flume was discharging through all 4 headgates to Canyon Creek. During the May 2011 storm event, one headgate was open 24" and the Canyon Creek Flume was again discharging through all 4 headgates to Canyon Creek. The model assumed that all headgates were closed at the diversion from the Yellowstone and that the Canyon Creek Flume was discharging through the 4 headgates. As such, the single open headgate at the diversion indicates that the results of the model are conservative when being used for planning purposes for potential breaching of the canal during a stormwater event.

Table 11. BBWA Canal Stormwater Estimated Inflows

Hydrologic Element	Estimated Peak Drainage Discharge into BBWA Canal (cfs)					
	2-YR, 24-HR	5-YR, 24-HR	10-YR, 24-HR	25-YR, 24-HR	50-YR, 24-HR	100-YR, 24-HR
1-1 Indian Creek	1	8	15	27	37	47
2-1 Broakway Creek - South	1	5	14	30	46	65
2-2 Broakway Creek - Central	0	3	7	14	22	30
2-3 Broakway Creek - North	1	4	10	19	27	36
3-1 Lower Canyon Creek	0	0	0	0	0	0
4-1 Billings	0	0	0	0	0	0
5-1 Hogans Slough	0	0	0	0	0	0
6-1 Billings - West	0	0	0	0	0	0
6-2 Billings - Central	0	0	0	46	80	116
6-3 Billings - East	0	0	0	41	73	106
7-1 Alkali Creek	0	0	0	0	0	0

3.0 HYDRAULICS

The hydraulics for the BBWA canal through the modeled length was developed using the Hydrologic Engineering Center's (CEIWR-HEC) River Analysis System (HEC-RAS) software V5.0.3 developed by the U.S. Army Corps of Engineers. The HEC-RAS model was developed for the canal's current conditions to calculate the capacity of the canal through the study area and locate possible diversion locations in the event of a major storm event. The HEC-RAS program was selected due to the length of study area of the canal and the universal acceptance of HEC-RAS within the hydrologic sciences community.

3.1 HEC-RAS Model Development

3.1.1 Software Description

HEC-RAS system is able to perform multi-dimensional hydraulic calculations for a full network of natural and constructed channels. The HEC-RAS system contains several components for multiple flow situations: Steady Flow Water Surface Profiles, One- and Two-Dimensional Unsteady Flow, Sediment Transport/Moveable Boundary Computations, and Water Quality Analysis. For the purpose of this study, the Steady Flow Water Surface Profiles component was used.

This component of the modeling system is intended for calculating water surface profiles for steady gradually varied flow. The system can handle a full network of channels, a dendritic system, or a single river reach. The steady flow component is capable of modeling subcritical, supercritical, and mixed flow regimes water surface profiles.

3.1.2 Reason for Model Selection

HEC-RAS was selected due to the length of the canal study area, the ability to model the structures along the canal through the study area, the need for modeling a system that has a fairly constant water surface profile, and gradually varying flow throughout the system. The system consists of a single long canal which was broken into multiple reaches.

3.1.3 Survey of the Main Canal

WWC Engineering (WWC) surveyed the Main Canal using a Global Positioning System (GPS) to obtain data approximately every 500 feet along the canal and at the flow gauges located at key points in the canal. A distance of 500 feet was determined to be reasonable as the canal has a flat grade that allows an accurate model to be created from minimal section data (i.e., channel elevations changed less than 0.1 feet per 500 feet of canal). Survey points collected include the tops of banks, high water marks, and bottoms of each side of the trapezoidal canal. WWC collected invert elevations on culverts that crossed under the canal throughout the study area in support of the hydrologic study. Survey elevations were collected adjacent to each flow gauge such that canal flow depths could be correlated to staff gauge readings for calibration purposes.

3.1.4 AutoCAD Civil 3D

Once the survey was complete for the entire study area of the canal, WWC imported the data into AutoCAD Civil 3D to create a 3D surface of the canal. WWC assumed while creating the canal's surface that the topography from cross section to cross section was a constant grade. An alignment was created following the center of the bottom of the canal surface. From this surface, canal cross sections were inserted at 500-foot intervals to model the flow of the canal. Sample lines were also added at key points along the canal including: flow gauge locations and transition points where water in the canal enters structures, in order to model the system correctly.

3.1.5 Selecting HEC-RAS Parameters

Geometric Data

The prepared data was exported from AutoCAD into HEC-RAS. Each section identified in AutoCAD created a cross section in HEC-RAS. An initial Manning's N-value of 0.018 for the canal's bottom and 0.030 for the canal's banks was used as initial inputs prior to calibrating the model. The N-values 0.018 and 0.030 relate to clean weathered ditch bottom and some grass and seeds, respectively. As calibration would later be completed for each section based upon staff gauge and channel flow data, varied Manning's N values were not deemed necessary in the preliminary modeling stage. The high-water marks were utilized as the elevation on the cross section where the Manning's N-value changed from canal bottom to banks. This is an accurate estimation as, due to the

consistent flows in the canal, no vegetation exists below the high-water mark providing a generally uniform channel roughness. As the canal banks are above the max water surface elevation from staff gauge readings, this Manning's N-value could not be calibrated based on measured data.

Creation of the Rim Tunnel and Alkali Creek Siphon in the model was completed by insertion of culverts. The tunnel is a 13-foot wide flume with concrete bottom and sides. The siphon is a 96-inch diameter circular steel pipe. Both modeled culverts were given a Manning's N value of n = 0.013, which is representative of and is the accepted value of finished concrete.

Steady Flow Data

The observed water surface (W.S.) gauge readings provided by BBWA were used to calculate the modeled W.S. elevation. The elevation of the existing W.S. was calculated by using the collected elevation of the GPS reading at the flow gauge and measuring to a height reading on the gauge. The W.S. elevation at the flow gauges were entered in the steady flow data section to calibrate the model of the Main Canal.

The observed W.S. elevations while the ditch was half-full, measured May 7, 2017, and full, measured July 11, 2017, were both used for this calibration. Both elevations were used in order get a better calibration of the HEC-RAS model in obtaining the Manning's N value. When two different modeled elevations matched the observed elevations, the Manning's N value is representative of the canal.

3.1.6 HEC-RAS Model Results

Operating Conditions

The W.S. data from the calibrated model can be seen in Table 12. The values in Table 12 also include the velocity results from the HEC-RAS model. A Manning's N value of n = 0.02 calibrated the HEC-RAS model correctly in order to match the observed W.S. elevations as close as possible. The HEC-RAS results of the calibrated model can be seen in Appendix E.

Table 12. Existing Hydraulic Data

Flow Gauge	Operating Flow under Main Canal Full Flow Condition* (cfs)	Gauge Reading	W.S. Elevation (ft.)	Velocity (ft./sec)
1	411	6.00	3237.41	2.96
2	409	4.50	3234.59	3.73
3	386	5.05	3232.74	3.13
4	393	4.65	3230.74	3.17
5	384	4.66	3228.32	3.11
6	377	5.55	3227.41	2.01
7	374	5.5	3226.91	2.09
8	367	4.62	3225.98	2.06
9	362	5.12	3224.11	2.53
10	362	5.66	3216.43	3.18

*Identified as typical full flow canal volume, leaving canal capacity for small storm events or disruptions to flow (i.e., blockages).

BBWA Main Canal Capacity

The hydraulic study indicates the capacity of the canal at this time for different segments of the canal, which identifies areas requiring maintenance due to degeneration of the canal banks or section. Table 13 displays the capacity of canal study segments and Exhibit 2 shows the segments and capacities in plain view. These results indicate the capacity at which the pertaining flow would spill over the canal's banks in order from Gauge 1 downstream to Gauge 10.

Flow estimates developed by the model were verified with BBWA operating staff and it was noted that all flows matched their understanding of the canal, with the exception of the Rim Tunnel. This location shows a potential capacity of 500 cfs, which is not the complete capacity of the Rim Tunnel as the inlet is not entirely submerged. However, during flow measurements at full canal flow, approximately 2 inches (0.15 feet) of freeboard was available at this location and a flow of 352 cfs was measured. Based on the rating curve for this location and a height of 0.15 feet above the recorded maximum elevation, the calculated capacity for the Rim Tunnel is 372 cfs. A revised capacity table for the canal is shown in Table 14.

Table 13. BBWA Preliminary Main Canal Capacities

Canal Segment	Canal Reach Locations	Flow Capacity (cfs)	Lined Flow Capacity (cfs)
1	Gauge 1 – Gauge 2	1,000	1500
2	Gauge 2 – Stewart Park	900	1500
3	Stewart Park – Gauge 5	700	700
4	Gauge 5 – King Ave	650	700
5	King Ave – Gauge 6	600	700
6	Gauge 6 – 17th St. West	550	500
7	17th St. West – 16th St. West	450	550
8	Gauge 7 – Gauge 8	600	650
9	Gauge 8 – Gauge 9	600	650
10	Tunnel	500	500
11	Tunnel – Siphon	550	650
12	Siphon	400	400
13	Siphon – Gauge 10	750	1000

The Rim Tunnel's degraded capacity from the original 600 cfs designed capacity is due to several reasons. The first reason is that a small section of the canal embankment has been lowered, which is the section that is nearly overtopping at a flow of 352 cfs as discussed previously. If this section were to be raised back to original height, the capacity would be increased to the modeled 500 cfs. A second reason for the decreased capacity is that several lining projects have been completed on the upstream side of the Rim Tunnel, due to concerns by the BBWA over breaching in this section and the catastrophic results of that breach occurring. These lining projects involved an original concrete liner, that was subsequently covered with an asphalt tar liner to patch the cracks in the concrete. The concrete liner was constructed above the original channel grade and included steep side slopes, which reduced the overall channel section and capacity. In addition, the asphalt tar further reduced the section. This section is identified as a section requiring maintenance to increase the canal capacity back to the original flow capacity.

The canal, not considering the Rim Tunnel and Alkali Creek Siphon, has a minimum capacity of 450 cfs found near the corner of 16th St. West and Colton Boulevard. Canal capacity at this section appears to have been reduced due to development encroachment on the canal resulting in individuals altering, in the form of steeping, the canal banks to increase their yard space. This segment is also identified as an area to have maintenance done to restore the canal to the original flow capacity; however, this maintenance should be done after the Rim Tunnel and Alkali Creek Siphon are improved as a breach at this location is considerably less likely to result in catastrophic consequences.

Table 14. BBWA Main Canal Capacities

Canal Segment	Canal Reach Locations	Flow Capacity (cfs)	Lined Flow Capacity (cfs)
1	Gauge 1 – Gauge 2	1,000	1500
2	Gauge 2 – Stewart Park	900	1500
3	Stewart Park – Gauge 5	700	700
4	Gauge 5 – King Ave	650	700
5	King Ave – Gauge 6	600	700
6	Gauge 6 – 17th St. West	550	500
7	17th St. West – 16th St. West	450	550
8	Gauge 7 – Gauge 8	600	650
9	Gauge 8 – Gauge 9	600	650
10	Tunnel	372	372
11	Tunnel – Siphon	550	650
12	Siphon	400	400
13	Siphon – Gauge 10	750	1000

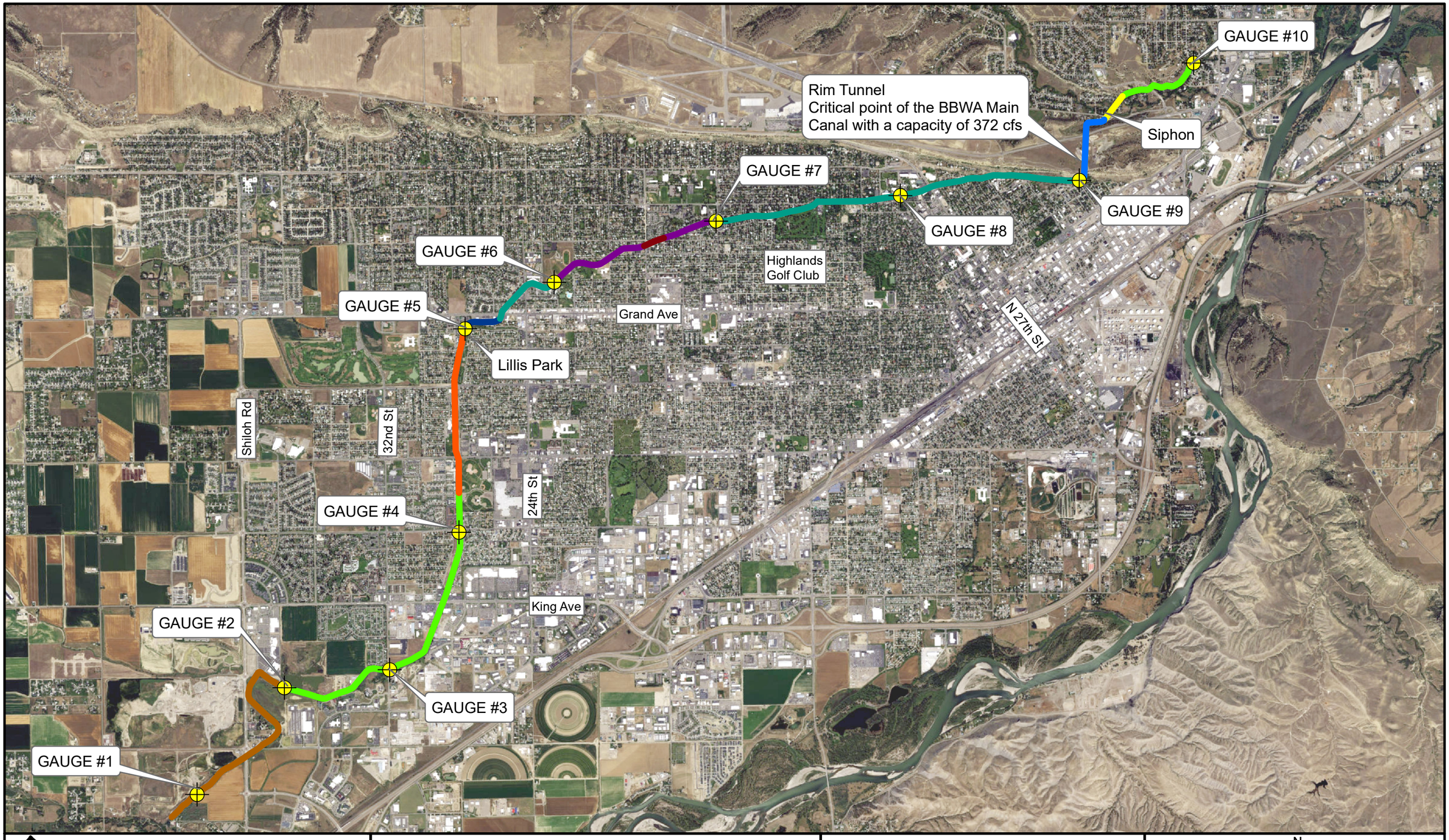
It is of note that canal segment 1 has a capacity of 1,000 cfs. At this flowrate, water in the canal would spill over the north bank into Knife River's reclaimed pits southwest of the corner of Shiloh Road and Hesper Road. As the Knife River pits are a large undeveloped area available for ponding, overtopping of the canal, if necessary, would be favorable here. However, this location is immediately downstream of the Canyon Creek Flume, which restricts flows, and it would not allow any meaningful overtopping of flows to occur (i.e., with the headgates open on the flume, less than 1,000 cfs would be passing this location).

A scenario was run through HEC-RAS to model if the BBWA were to line the entirety of the Main Canal. To accomplish this analysis, a Manning's N-value of 0.01 was used. The results of this scenario show that if the entire canal were to be lined, the capacity of the canal would be increased to 500 cfs and that the point the canal overtops would now be located between Gauge 9 and the Rim Tunnel. The increase in flow in the canal is caused by an increase in velocity due to the decreased friction on the sides and bottom of the canal, post lining. Appendix F shows the comparison when the canal is running at 500 cfs with current conditions and if the canal were to be lined. All sections with projected capacities less than 600 cfs post lining should be identified to require maintenance to increase the canal section prior to lining.

4.0 CONCLUSION

The BBWA Main Canal currently has a capacity of 450 cfs before topping the banks within the City Limits of Billings prior to the Rim Tunnel, which would overtop at 372 cfs. It is identified that maintenance of the canal due to degradation of components in the study

area is required to return it to the capacity of 600 cfs in the order of 1) Rim Tunnel section, 2) Alkali Creek Section, and 3) Segment 6-7. Through review of data provided by the City of Billings and BBWA and through completion of this study, overtopping of the canal due to storm events is highly unlikely as it did not occur during two separate 100-year+ storm events in which water was still being diverted into the canal from the Yellowstone. However, breaching of the canal could occur due to an act outside of the BBWA's control, such as a blockage in the canal (i.e., vehicle entering the canal at night, large vegetation, etc). As no emergency spillways exist on the canal between Canyon Creek Flume and the Five-Mile Creek Flume, it is recommended to consider options for emergency discharge of water should a blockage occur in the canal.



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EXHIBIT 2
BILLINGS BENCH WATER ASSOCIATION
MAIN CANAL FLOW CAPACITY
PO BOX 50150
BILLINGS, MT 59105

Legend

- BBWA Canal Gauge
- BBWA Capacity 372 CFS
- BBWA Capacity 400 CFS
- BBWA Capacity 450 CFS
- BBWA Capacity 550 CFS
- BBWA Capacity 600 CFS
- BBWA Capacity 650 CFS
- BBWA Capacity 700 CFS
- BBWA Capacity 900 CFS
- BBWA Capacity 1000 CFS

N
W E
S

LEGEND

- YELLOWSTONE RIVER–INDIAN CREEK DRAINAGE BASIN
- YELLOWSTONE RIVER–BROAKWAY CREEK DRAINAGE BASIN
- LOWER CANYON CREEK DRAINAGE BASIN
- HOGANS SLOUGH DRAINAGE BASIN
- YELLOWSTONE RIVER–BILLINGS DRAINAGE BASIN
- ALKALI CREEK DRAINAGE BASIN
- BILLINGS BENCH WATER ASSOCIATION CANAL

NOTES:
- 50' AND 250' FOOT DEM CONTOURS
- YELLOWSTONE RIVER–INDIAN CREEK DRAINAGE BASIN ONLY DELINIATED TO BEGINNING OF CANAL

0 10000 20000

SCALE: 1" = 10000'

SWS 7–1
SWS 6–1
SWS 6–3
SWS 6–2
SWS 5–1
SWS 3–1
SWS 2–3
SWS 4–1
SWS 1–1
SWS 2–1
SWS 2–2
LAUREL
BEGINNING OF CANAL AT RIVER
BILLINGS CITY LIMITS
INTERSTATE 90
YELLOWSTONE RIVER

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BILLINGS, MT 59105

DSGN	CKD	STH	
DCT	12/18/17	DATE	CKD
REV	DATE		

JOB # 2017-153

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PLOT DATE: 2/9/2018
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BILLINGS BENCH WATER PROJECT

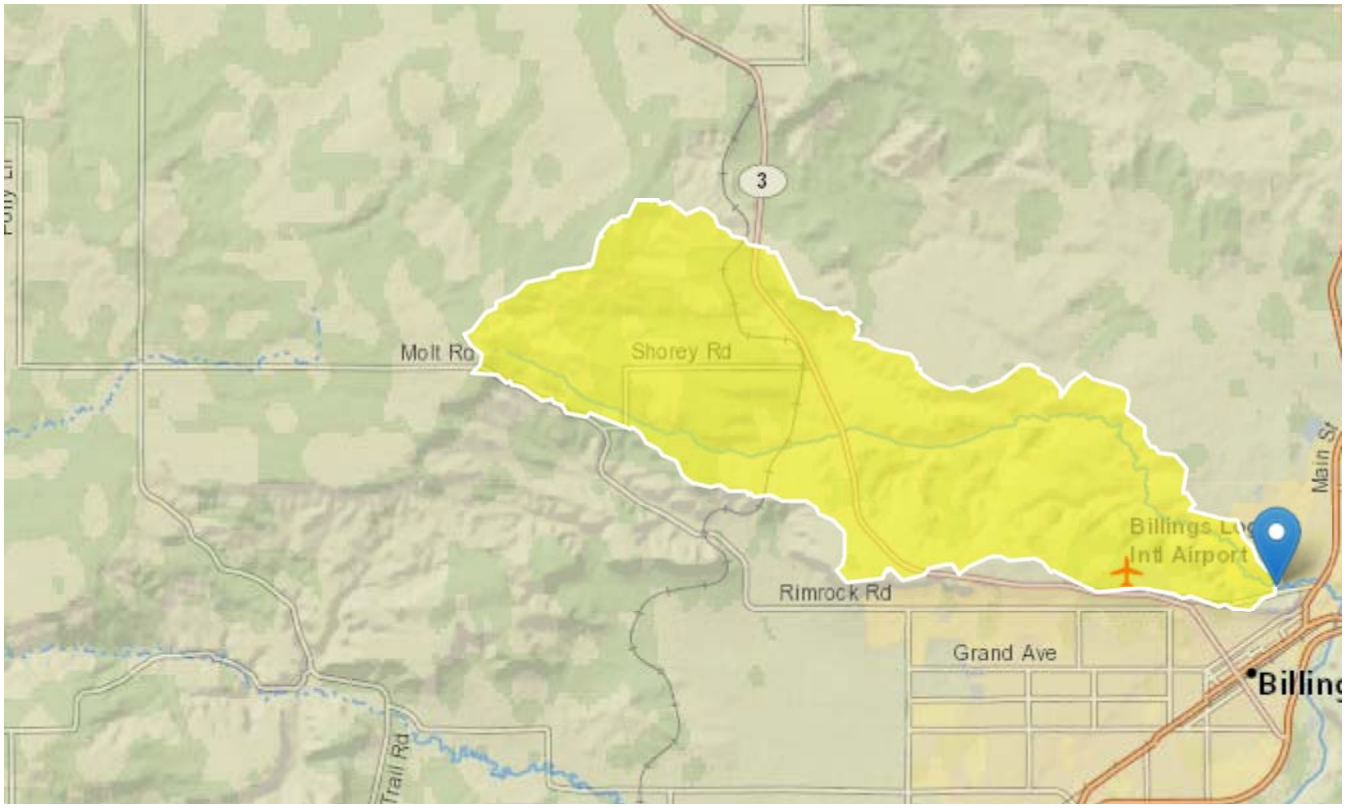
BBWA CANAL WATERSHEDS

E

EXHIBIT 1

Alkali Creek StreamStats Report

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Workspace ID: MT20180110222503607000
Clicked Point (Latitude, Longitude): 45.80358, -108.49186
Time: 2018-01-10 15:25:19 -0700



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
CONTDA	Area that contributes flow to a point on a stream	39.4	square miles
ET0306MOD	Spring (March-June) mean monthly evapotranspiration (2001-2011), MODIS	1.04	inches
SLOP30_30M	Percent area with slopes greater than 30 percent from 30-meter DEM.	1.6	percent
EL6000	Percent of area above 6000 ft	0	percent

General Disclaimers

Upstream regulation was checked for this watershed.

Peak-Flow Statistics Parameters [75 Percent (29.7 square miles) EC Plains Region BasinC 2015 5019F]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
CONTDA	Contributing Drainage Area	39.4	square miles	0.11	2560
ET0306MOD	Mean_Monthly_EvapTrans_Mar_to_Jun_MODIS	1.04	inches	0.9	1.57
SLOP30_30M	Slopes gt 30pct from 30m DEM	1.6	percent	0	31.9

Peak-Flow Statistics Parameters [25 Percent (9.72 square miles) UpYellow CentMount Region BasinC 2015 5019F]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
CONTDA	Contributing Drainage Area	39.4	square miles	0.39	2040
EL6000	Percent above 6000 ft	0	percent	0	100

Peak-Flow Statistics Flow Report [75 Percent (29.7 square miles) EC Plains Region BasinC 2015 5019F]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SEp
1.5 Year Peak Flood	103	ft^3/s	26.9	396	98.2
2 Year Peak Flood	176	ft^3/s	47.8	647	93.8
2 33 Year Peak Flood	230	ft^3/s	68	779	86.2
5 Year Peak Flood	610	ft^3/s	227	1640	66.2
10 Year Peak Flood	1130	ft^3/s	454	2810	60.9
25 Year Peak Flood	2080	ft^3/s	812	5310	62.7
50 Year Peak Flood	3000	ft^3/s	1120	8070	67.2
100 Year Peak Flood	4100	ft^3/s	1410	11900	73.5
200 Year Peak Flood	5390	ft^3/s	1700	17100	81.3
500 Year Peak Flood	7360	ft^3/s	2040	26500	93.1

Peak-Flow Statistics Flow Report [25 Percent (9.72 square miles) UpYellow CentMount Region BasinC 2015 5019F]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SEp
1.5 Year Peak Flood	57	ft^3/s	11.8	276	119
2 Year Peak Flood	90	ft^3/s	20.3	399	111
2 33 Year Peak Flood	117	ft^3/s	28.7	480	103
5 Year Peak Flood	323	ft^3/s	98.6	1060	82.4
10 Year Peak Flood	625	ft^3/s	213	1830	73
25 Year Peak Flood	1200	ft^3/s	432	3330	68.4
50 Year Peak Flood	1770	ft^3/s	646	4830	67.7
100 Year Peak Flood	2430	ft^3/s	874	6750	69
200 Year Peak Flood	3220	ft^3/s	1130	9220	71.6

Statistic	Value	Unit	PII	Plu	SEp
500 Year Peak Flood	4470	ft^3/s	1480	13500	77

Peak-Flow Statistics Flow Report [Area-Averaged]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

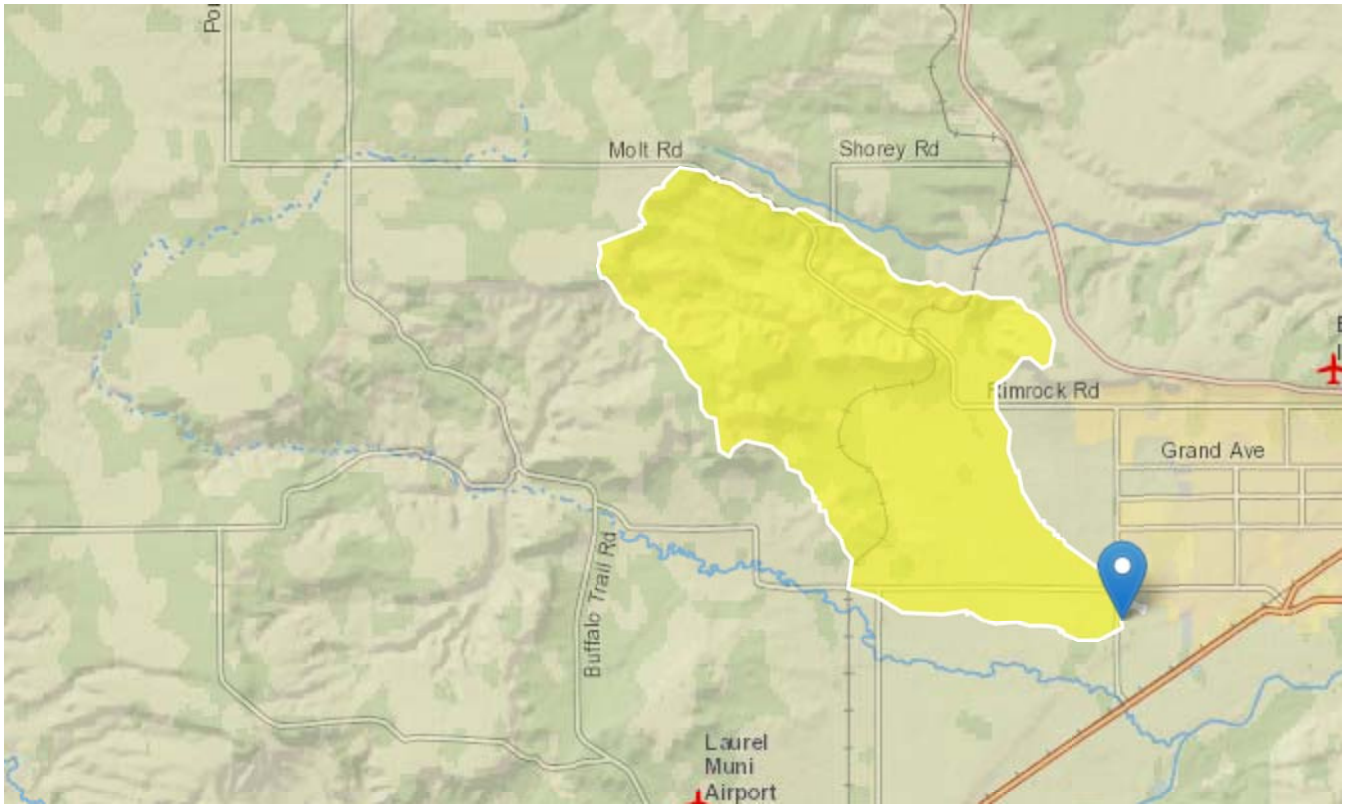
Statistic	Value	Unit	PII	Plu
1.5 Year Peak Flood	91.8	ft^3/s	23.2	367
2 Year Peak Flood	155	ft^3/s	41	586
2 33 Year Peak Flood	202	ft^3/s	58.3	705
5 Year Peak Flood	540	ft^3/s	195	1500
10 Year Peak Flood	1010	ft^3/s	395	2570
25 Year Peak Flood	1860	ft^3/s	719	4820
50 Year Peak Flood	2700	ft^3/s	1000	7270
100 Year Peak Flood	3690	ft^3/s	1280	10600
200 Year Peak Flood	4850	ft^3/s	1550	15200
500 Year Peak Flood	6640	ft^3/s	1900	23300

Peak-Flow Statistics Citations

Sando, Roy, Sando, S.K., McCarthy, P.M., and Dutton, D.M.,2016, Methods for estimating peak-flow frequencies at ungaged sites in Montana based on data through water year 2011: U.S. Geological Survey Scientific Investigations Report 2015–5019–F, 30 p. (http://dx.doi.org/10.3133/sir20155019F)

Hogans Slough StreamStats Report

Region ID: MT
Workspace ID: MT20180110223353587000
Clicked Point (Latitude, Longitude): 45.74698, -108.61629
Time: 2018-01-10 15:34:09 -0700



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
CONTDA	Area that contributes flow to a point on a stream	32.2	square miles
ET0306MOD	Spring (March-June) mean monthly evapotranspiration (2001-2011), MODIS	1.13	inches
SLOP30_30M	Percent area with slopes greater than 30 percent from 30-meter DEM.	6.5	percent
EL6000	Percent of area above 6000 ft	0	percent

General Disclaimers

Upstream regulation was checked for this watershed.

Peak-Flow Statistics Parameters [2 Percent (0.622 square miles) EC Plains Region BasinC 2015 5019F]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
CONTDA	Contributing Drainage Area	32.2	square miles	0.11	2560
ET0306MOD	Mean_Monthly_EvapTrans_Mar_to_Jun_MODIS	1.13	inches	0.9	1.57
SLOP30_30M	Slopes gt 30pct from 30m DEM	6.5	percent	0	31.9

Peak-Flow Statistics Parameters [98 Percent (31.6 square miles) UpYellow CentMount Region BasinC 2015 5019F]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
CONTDA	Contributing Drainage Area	32.2	square miles	0.39	2040
EL6000	Percent above 6000 ft	0	percent	0	100

Peak-Flow Statistics Flow Report [2 Percent (0.622 square miles) EC Plains Region BasinC 2015 5019F]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SEp
1.5 Year Peak Flood	70.7	ft^3/s	18	278	98.2
2 Year Peak Flood	124	ft^3/s	33	469	93.8
2 33 Year Peak Flood	165	ft^3/s	47.7	573	86.2
5 Year Peak Flood	471	ft^3/s	171	1300	66.2
10 Year Peak Flood	929	ft^3/s	363	2380	60.9
25 Year Peak Flood	1830	ft^3/s	690	4840	62.7
50 Year Peak Flood	2760	ft^3/s	985	7710	67.2
100 Year Peak Flood	3910	ft^3/s	1290	11800	73.5
200 Year Peak Flood	5310	ft^3/s	1590	17700	81.3
500 Year Peak Flood	7540	ft^3/s	1990	28700	93.1

Peak-Flow Statistics Flow Report [98 Percent (31.6 square miles) UpYellow CentMount Region BasinC 2015 5019F]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SEp
1.5 Year Peak Flood	48.2	ft^3/s	9.97	233	119
2 Year Peak Flood	76.6	ft^3/s	17.3	339	111
2 33 Year Peak Flood	100	ft^3/s	24.5	409	103
5 Year Peak Flood	278	ft^3/s	84.6	910	82.4
10 Year Peak Flood	538	ft^3/s	184	1580	73
25 Year Peak Flood	1040	ft^3/s	374	2870	68.4
50 Year Peak Flood	1530	ft^3/s	560	4190	67.7
100 Year Peak Flood	2110	ft^3/s	760	5860	69
200 Year Peak Flood	2810	ft^3/s	981	8030	71.6

Statistic	Value	Unit	PII	Plu	SEp
500 Year Peak Flood	3900	ft^3/s	1290	11800	77

Peak-Flow Statistics Flow Report [Area-Averaged]

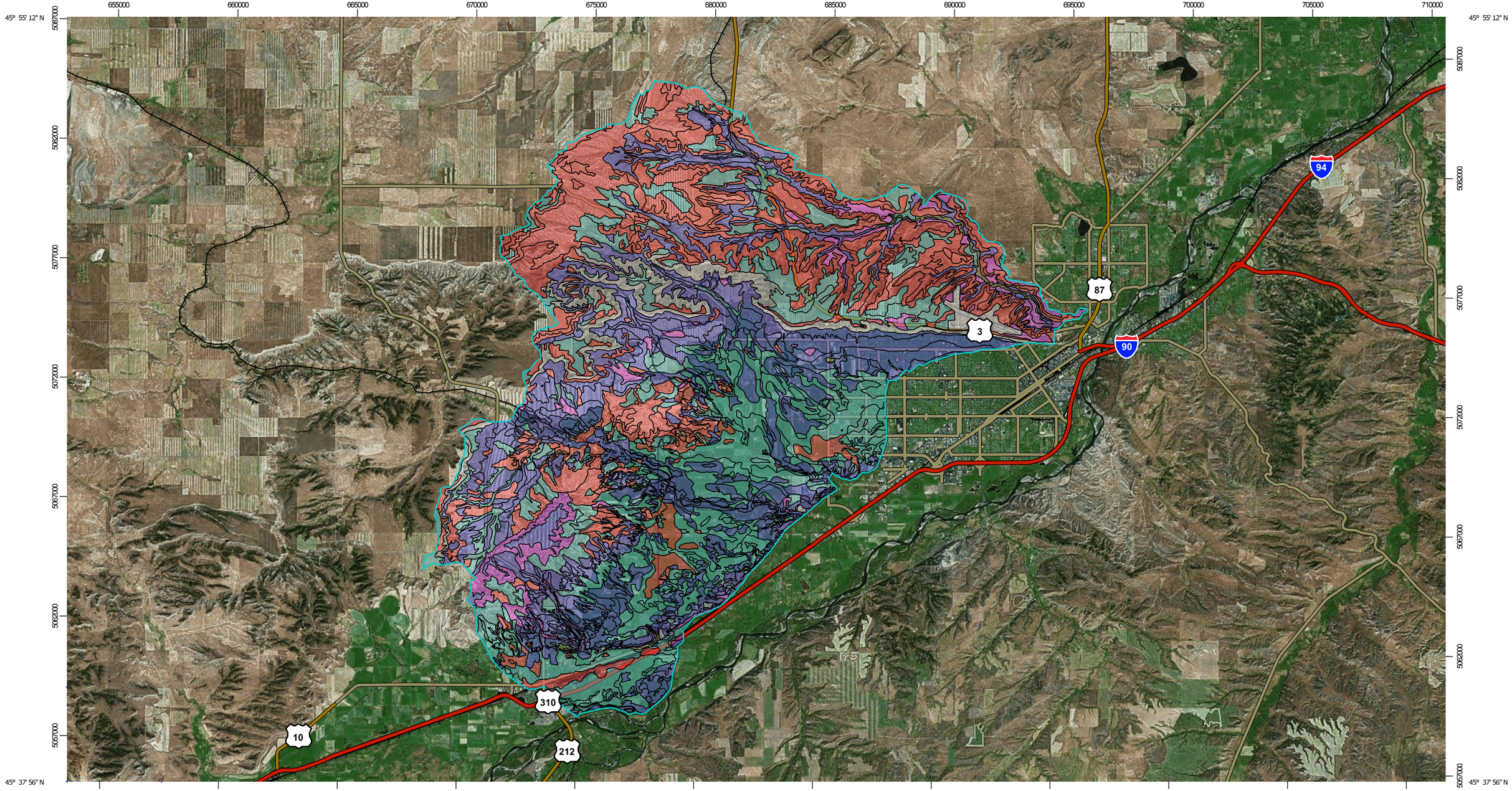
PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu
1.5 Year Peak Flood	48.7	ft^3/s	10.1	234
2 Year Peak Flood	77.5	ft^3/s	17.6	341
2 33 Year Peak Flood	101	ft^3/s	24.9	412
5 Year Peak Flood	281	ft^3/s	86.3	917
10 Year Peak Flood	546	ft^3/s	187	1590
25 Year Peak Flood	1050	ft^3/s	380	2910
50 Year Peak Flood	1550	ft^3/s	568	4250
100 Year Peak Flood	2150	ft^3/s	770	5980
200 Year Peak Flood	2850	ft^3/s	993	8220
500 Year Peak Flood	3970	ft^3/s	1300	12200

Peak-Flow Statistics Citations

Sando, Roy, Sando, S.K., McCarthy, P.M., and Dutton, D.M.,2016, Methods for estimating peak-flow frequencies at ungaged sites in Montana based on data through water year 2011: U.S. Geological Survey Scientific Investigations Report 2015–5019–F, 30 p. (http://dx.doi.org/10.3133/sir20155019F)

Hydrologic Soil Group—Yellowstone County, Montana
(BBWA WATERSHED HSG)



Map Scale: 1:156,000 if printed on B landscape (17" x 11") sheet.

N

Meters
0 2000 4000 8000 12000

Feet
0 5000 10000 20000 30000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Lines

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Points

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Yellowstone County, Montana
Survey Area Data: Version 15, Sep 21, 2017

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jan 1, 1999—Dec 31, 2003

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
80D	Blacksheep sandy loam, 4 to 15 percent slopes	D	1,496.3	1.7%
81B	Delpoint-Cabbart loams, 2 to 8 percent slopes	C	877.1	1.0%
83E	Blacksheep-Twilight complex, 4 to 25 percent slopes	D	3,072.6	3.4%
182D	Cabbart-Delpoint loams, 4 to 15 percent slopes	D	1,120.8	1.2%
189B	Rentsac-Beenom complex, 1 to 4 percent slopes	D	133.9	0.1%
282D	Cabbart-Blacksheep complex, 4 to 15 percent slopes	D	1,189.0	1.3%
285F	Blacksheep, dry-Cabbart, dry-Rock outcrop, complex, 8 to 60 percent slopes	D	4,120.2	4.6%
354B	Bonfri-Cabbart loams, 0 to 4 percent slopes	D	828.8	0.9%
381D	Blacksheep-Tusler complex, 4 to 15 percent slopes	D	50.5	0.1%
383E	Cabbart-Blacksheep complex, 8 to 25 percent slopes	D	275.1	0.3%
453C	Cabbart-Bonfri loams, 2 to 8 percent slopes	D	646.3	0.7%
Al	Alluvial land, mixed	B/D	8.3	0.0%
Am	Alluvial land, seeped	C/D	460.7	0.5%
An	Alluvial land, wet	C	239.6	0.3%
As	Apron fine sandy loam, 4 to 7 percent slopes	A	856.2	1.0%
Av	Arvada clay loam, 1 to 4 percent slopes	D	276.0	0.3%
Aw	Arvada clay loam, 4 to 7 percent slopes	D	1.2	0.0%
Ax	Arvada-Bone silty clay loams, 0 to 1 percent slopes	D	418.1	0.5%
Bf	Bainville-Elso-Shale outcrop complex, 7 to 25 percent slopes	C	134.3	0.1%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
Bl	Bainville-Worland complex, 4 to 7 percent slopes	C	199.9	0.2%
Bm	Bew silty clay loam, 0 to 1 percent slopes	C	1,603.4	1.8%
Bn	Bew clay, 0 to 1 percent slopes	C	1,007.5	1.1%
Br	Bew-Allentine clays, 0 to 1 percent slopes	C	45.8	0.1%
Bs	Big Horn clay loam, 0 to 2 percent slopes	C	13.5	0.0%
Bt	Bone silty clay, 0 to 1 percent slopes	D	47.0	0.1%
Bu	Bone silty clay, 1 to 6 percent slopes	D	263.6	0.3%
Cg	Clapper gravelly loam, 7 to 15 percent slopes	B	877.1	1.0%
Ec	Elso clay loam, 4 to 7 percent slopes	D	285.6	0.3%
El	Elso clay loam, 7 to 15 percent slopes	D	1,155.5	1.3%
Es	Elso-Lohmiller complex, 15 to 35 percent slopes	C	1,661.4	1.8%
Fl	Fort Collins-Arvada clay loams, 0 to 1 percent slopes	B	137.5	0.2%
Fo	Fort Collins-Arvada clay loams, 1 to 4 percent slopes	B	38.8	0.0%
Fr	Fort Collins and Thurlow clay loams, 0 to 1 percent slopes	B	74.8	0.1%
Ft	Fort Collins and Thurlow clay loams, 1 to 4 percent slopes	B	675.9	0.8%
Gh	Glenberg fine sandy loam, 1 to 4 percent slopes	A	394.5	0.4%
Gl	Glenberg loam, 0 to 1 percent slopes	B	228.0	0.3%
GP	Gravel pit		82.5	0.1%
Ha	Haverson loam, 0 to 1 percent slopes	B	533.2	0.6%
Hb	Haverson loam, clay substratum, 0 to 1 percent slopes	B	151.7	0.2%
Hc	Haverson clay loam, 0 to 1 percent slopes	C	486.7	0.5%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
Hd	Haverson silty clay loam, 0 to 1 percent slopes	C	1,271.0	1.4%
He	Haverson silty clay loam, 1 to 3 percent slopes	C	788.3	0.9%
Hl	Haverson and Lohmiller soils, 0 to 4 percent slopes	B	307.5	0.3%
Hm	Haverson and Lohmiller soils, channeled, 0 to 35 percent slopes	B	444.4	0.5%
Hn	Haverson loam, gravelly variant, 0 to 1 percent slopes	B	5.1	0.0%
Ho	Heldt silty clay loam, 4 to 7 percent slopes	C	44.0	0.0%
Hp	Hesper silty clay loam, 0 to 1 percent slopes	C	7.0	0.0%
Hr	Hesper silty clay loam, 1 to 4 percent slopes	C	55.3	0.1%
Hs	Hilly, gravelly land	A	1,566.8	1.7%
Hv	Hydro-Allentine complex, 2 to 7 percent slopes	C	201.9	0.2%
Hx	Hysham-Laurel loams, 0 to 2 percent slopes	B	93.5	0.1%
Hy	Hysham-Laurel silty clay loams, 0 to 2 percent slopes	B	598.4	0.7%
Hz	Hysham and Haverson soils, 0 to 4 percent slopes	B	419.6	0.5%
Kc	Keiser silty clay loam, 0 to 1 percent slopes	C	719.8	0.8%
Ke	Keiser silty clay loam, 1 to 4 percent slopes	C	1,347.4	1.5%
Kg	Keiser silty clay loam, 4 to 7 percent slopes	C	398.8	0.4%
Kh	Keiser and Hesper silty clay loams, 0 to 1 percent slopes	C	1,698.5	1.9%
Kl	Kyle silty clay, 0 to 1 percent slopes	D	1,048.4	1.2%
Kn	Kyle silty clay, 4 to 7 percent slopes	D	34.4	0.0%
La	Lonna-Vanstel complex, 0 to 4 percent slopes	B	1,073.6	1.2%
Lb	Lonna silt loam, 4 to 8 percent slopes	B	394.5	0.4%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
Lc	Lonna silt loams, 8 to 15 percent slopes	B	6.4	0.0%
Ld	Lambert soils, 7 to 35 percent slopes	C	598.4	0.7%
Le	Larim loam, 0 to 4 percent slopes	B	65.9	0.1%
Lg	Larim gravelly loam, 0 to 4 percent slopes	B	258.2	0.3%
Lh	Larim gravelly loam, 4 to 7 percent slopes	B	85.3	0.1%
Ll	Larim gravelly loam, 15 to 35 percent slopes	A	315.0	0.4%
Lm	Lavina loam, 2 to 4 percent slopes	D	951.1	1.1%
Ln	Lismas clay, 15 to 35 percent slopes	D	774.4	0.9%
Lo	Lohmiller silty clay, 3 to 7 percent slopes	C	628.8	0.7%
Lr	Lohmiller silty clay, 0 to 1 percent slopes	C	4,402.4	4.9%
Ls	Lohmiller soils, seeped, 0 to 2 percent slopes	C	1,325.0	1.5%
Lt	Lohmiller-Elso complex, 4 to 15 percent slopes	C	706.2	0.8%
Lu	Lohmiller-Hysham silty clay loams, 0 to 1 percent slopes	C	6.5	0.0%
Lv	Lohmiller silty clay, gravelly variant, 0 to 1 percent slopes	C	270.7	0.3%
Ma	Maginnis channery clay loam, 7 to 15 percent slopes	D	2.5	0.0%
Mk	McKenzie clay, 0 to 1 percent slopes	D	5.9	0.0%
Mm	McRae loam, 0 to 1 percent slopes	B	3,049.5	3.4%
Mn	McRae loam, 1 to 4 percent slopes	B	3,362.5	3.7%
Mo	McRae loam, 4 to 7 percent slopes	B	3,115.2	3.5%
Mr	McRae loam, 7 to 15 percent slopes	B	374.8	0.4%
Ms	McRae-Bainville loams, 7 to 15 percent slopes	B	5,629.9	6.3%
Mt	McRae-Hysham loams, 0 to 1 percent slopes	B	269.8	0.3%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
Mu	McRae-Hysham loams, 1 to 3 percent slopes	B	161.9	0.2%
Mv	McRae-Hysham loams, 3 to 6 percent slopes	B	9.9	0.0%
Mw	Midway-Razor clay loams, 4 to 7 percent slopes	D	641.8	0.7%
My	Midway-Shale outcrop complex	D	4,658.6	5.2%
Pc	Pierre clay, 4 to 7 percent slopes	D	45.3	0.1%
Pl	Pierre-Lismas clays, 7 to 15 percent slopes	D	436.9	0.5%
Ra	Razor clay loam, 2 to 7 percent slopes	D	523.1	0.6%
Rk	Rock land		3,864.9	4.3%
Rn	Ryegate fine sandy loam, 2 to 4 percent slopes	C	837.0	0.9%
Sa	Sage clay, 0 to 1 percent slopes	C/D	16.2	0.0%
Sm	Shale outcrop-Midway complex, 15 to 35 percent slopes	D	219.3	0.2%
So	Shorey gravelly loam, 1 to 4 percent slopes	B	128.7	0.1%
Sr	Shorey gravelly loam, 4 to 7 percent slopes	B	1,041.6	1.2%
Ta	Thurlow clay loam, 0 to 1 percent slopes	C	22.0	0.0%
Te	Toluca clay loam, 0 to 1 percent slopes	B	1,003.4	1.1%
Th	Toluca clay loam, 1 to 4 percent slopes	B	1,445.9	1.6%
Tm	Toluca clay loam, 4 to 7 percent slopes	B	189.2	0.2%
Tn	Toluca and Wanetta clay loams, 0 to 2 percent slopes	B	424.0	0.5%
To	Toluca and Wanetta clay loams, 2 to 4 percent slopes	B	203.5	0.2%
Tu	Treasure fine sandy loam, 1 to 4 percent slopes	B	1,202.1	1.3%
Tw	Treasure fine sandy loam, 4 to 10 percent slopes	B	639.1	0.7%
UL	Urban land		557.6	0.6%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
Va	Vananda silty clay, 0 to 1 percent slopes	D	835.7	0.9%
Vd	Vananda silty clay, 1 to 7 percent slopes	D	257.3	0.3%
Ve	Vananda-Bone clays, 4 to 7 percent slopes	D	5.2	0.0%
W	Water		44.0	0.0%
Wc	Wanetta loam, 1 to 4 percent slopes	B	74.7	0.1%
We	Wanetta gravelly loam, 0 to 2 percent slopes	B	76.5	0.1%
Wf	Wanetta clay loam, 0 to 1 percent slopes	B	660.2	0.7%
Wg	Wanetta clay loam, 1 to 4 percent slopes	B	113.7	0.1%
Wh	Wanetta-Larim clay loams, 0 to 1 percent slopes	B	11.1	0.0%
Wk	Wanetta-Larim clay loams, 1 to 4 percent slopes	B	21.7	0.0%
Wl	Wanetta-Larim clay loams, 4 to 7 percent slopes	B	32.2	0.0%
Wo	Worland fine sandy loam, 2 to 7 percent slopes	A	660.2	0.7%
Ws	Wormser clay loam, 1 to 4 percent slopes	C	512.7	0.6%
Wt	Wormser clay loam, 4 to 7 percent slopes	C	404.5	0.4%
Wv	Wormser-Lavina clay loams, 2 to 4 percent slopes	C	2,052.2	2.3%
Ww	Wormser-Worland sandy loams, 4 to 7 percent slopes	C	851.1	0.9%
Ya	Yegen sandy loam, 0 to 1 percent slopes	B	8.9	0.0%
Yd	Yegen sandy loam, 1 to 4 percent slopes	B	120.5	0.1%
Yt	Yegen and Toluca soils, 7 to 15 percent slopes	B	41.0	0.0%
Totals for Area of Interest			**89,947.2**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

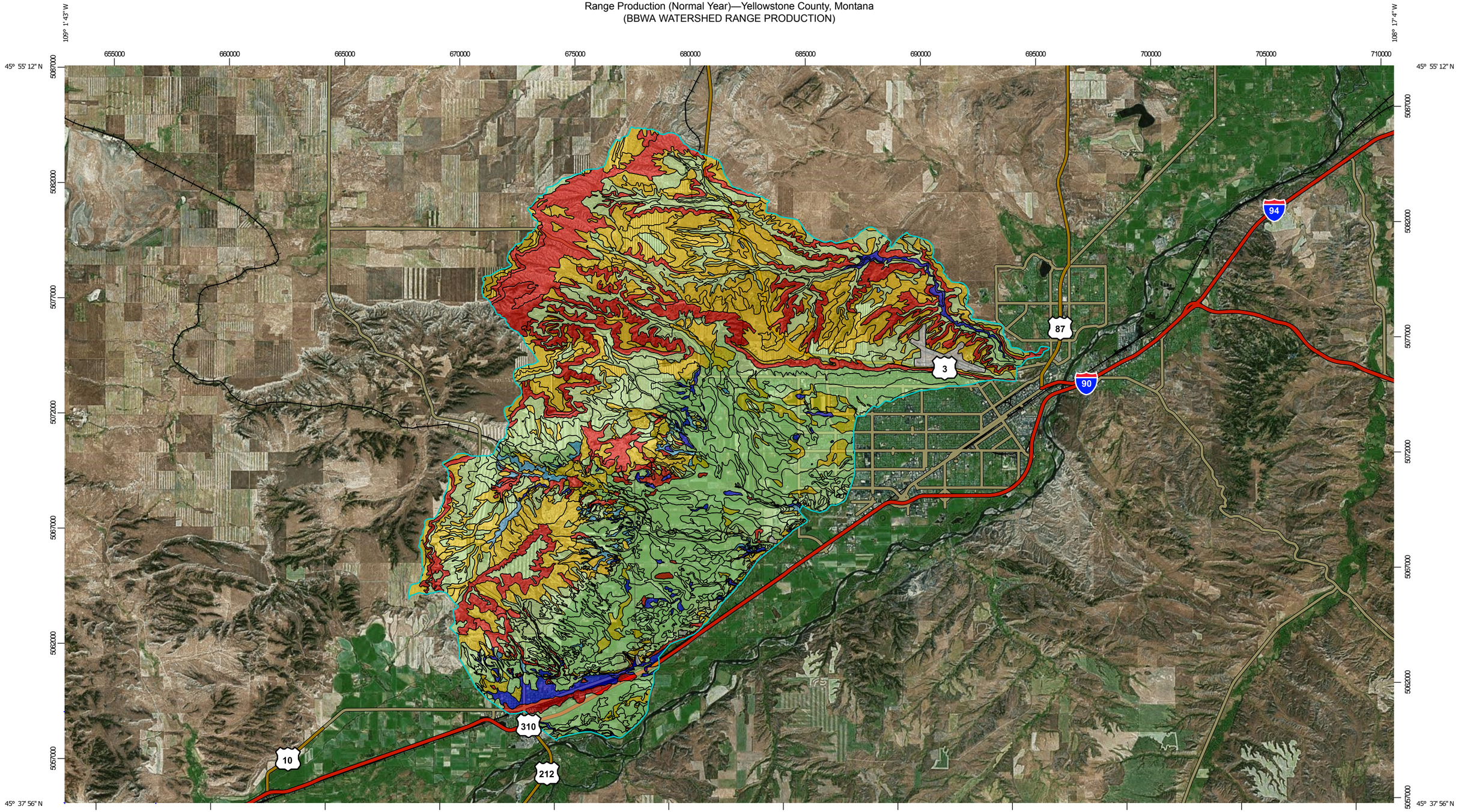
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Range Production (Normal Year)—Yellowstone County, Montana
(BBWA WATERSHED RANGE PRODUCTION)



Map Scale: 1:156,000 if printed on B landscape (17" x 11") sheet.

N

Meters
0 2000 4000 8000 12000

Feet
0 5000 10000 20000 30000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- <= 790
- > 790 and <= 1270
- > 1270 and <= 1741
- > 1741 and <= 2555
- > 2555 and <= 4492
- Not rated or not available

Soil Rating Lines

- <= 790
- > 790 and <= 1270
- > 1270 and <= 1741
- > 1741 and <= 2555
- > 2555 and <= 4492
- Not rated or not available

Soil Rating Points

- <= 790
- > 790 and <= 1270
- > 1270 and <= 1741
- > 1741 and <= 2555
- > 2555 and <= 4492
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Yellowstone County, Montana
Survey Area Data: Version 15, Sep 21, 2017

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jan 1, 1999—Dec 31, 2003

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Range Production (Normal Year)

Map unit symbol	Map unit name	Rating (pounds per acre per year)	Acres in AOI	Percent of AOI
80D	Blacksheep sandy loam, 4 to 15 percent slopes	881	1,496.3	1.7%
81B	Delpoint-Cabbart loams, 2 to 8 percent slopes	1255	877.1	1.0%
83E	Blacksheep-Twilight complex, 4 to 25 percent slopes	981	3,072.6	3.4%
182D	Cabbart-Delpoint loams, 4 to 15 percent slopes	996	1,120.8	1.2%
189B	Rentsac-Beenom complex, 1 to 4 percent slopes	890	133.9	0.1%
282D	Cabbart-Blacksheep complex, 4 to 15 percent slopes	892	1,189.0	1.3%
285F	Blacksheep, dry-Cabbart, dry-Rock outcrop, complex, 8 to 60 percent slopes	600	4,120.2	4.6%
354B	Bonfri-Cabbart loams, 0 to 4 percent slopes	1065	828.8	0.9%
381D	Blacksheep-Tusler complex, 4 to 15 percent slopes	1138	50.5	0.1%
383E	Cabbart-Blacksheep complex, 8 to 25 percent slopes	826	275.1	0.3%
453C	Cabbart-Bonfri loams, 2 to 8 percent slopes	1008	646.3	0.7%
Al	Alluvial land, mixed	834	8.3	0.0%
Am	Alluvial land, seeped	4492	460.7	0.5%
An	Alluvial land, wet	3850	239.6	0.3%
As	Apron fine sandy loam, 4 to 7 percent slopes	1359	856.2	1.0%
Av	Arvada clay loam, 1 to 4 percent slopes	1199	276.0	0.3%
Aw	Arvada clay loam, 4 to 7 percent slopes	1228	1.2	0.0%
Ax	Arvada-Bone silty clay loams, 0 to 1 percent slopes	965	418.1	0.5%
Bf	Bainville-Elso-Shale outcrop complex, 7 to 25 percent slopes	939	134.3	0.1%

Map unit symbol	Map unit name	Rating (pounds per acre per year)	Acres in AOI	Percent of AOI
Bl	Bainville-Worland complex, 4 to 7 percent slopes	1375	199.9	0.2%
Bm	Bew silty clay loam, 0 to 1 percent slopes	1314	1,603.4	1.8%
Bn	Bew clay, 0 to 1 percent slopes	1246	1,007.5	1.1%
Br	Bew-Allentine clays, 0 to 1 percent slopes	1100	45.8	0.1%
Bs	Big Horn clay loam, 0 to 2 percent slopes	1979	13.5	0.0%
Bt	Bone silty clay, 0 to 1 percent slopes	287	47.0	0.1%
Bu	Bone silty clay, 1 to 6 percent slopes	287	263.6	0.3%
Cg	Clapper gravelly loam, 7 to 15 percent slopes	1035	877.1	1.0%
Ec	Elso clay loam, 4 to 7 percent slopes	908	285.6	0.3%
El	Elso clay loam, 7 to 15 percent slopes	905	1,155.5	1.3%
Es	Elso-Lohmiller complex, 15 to 35 percent slopes	866	1,661.4	1.8%
Fl	Fort Collins-Arvada clay loams, 0 to 1 percent slopes	1450	137.5	0.2%
Fo	Fort Collins-Arvada clay loams, 1 to 4 percent slopes	1450	38.8	0.0%
Fr	Fort Collins and Thurlow clay loams, 0 to 1 percent slopes	1410	74.8	0.1%
Ft	Fort Collins and Thurlow clay loams, 1 to 4 percent slopes	1410	675.9	0.8%
Gh	Glenberg fine sandy loam, 1 to 4 percent slopes	1540	394.5	0.4%
Gl	Glenberg loam, 0 to 1 percent slopes	1380	228.0	0.3%
GP	Gravel pit		82.5	0.1%
Ha	Haverson loam, 0 to 1 percent slopes	1660	533.2	0.6%
Hb	Haverson loam, clay substratum, 0 to 1 percent slopes	1692	151.7	0.2%
Hc	Haverson clay loam, 0 to 1 percent slopes	1733	486.7	0.5%

Map unit symbol	Map unit name	Rating (pounds per acre per year)	Acres in AOI	Percent of AOI
Hd	Haverson silty clay loam, 0 to 1 percent slopes	1740	1,271.0	1.4%
He	Haverson silty clay loam, 1 to 3 percent slopes	1704	788.3	0.9%
Hl	Haverson and Lohmiller soils, 0 to 4 percent slopes	1741	307.5	0.3%
Hm	Haverson and Lohmiller soils, channeled, 0 to 35 percent slopes	1556	444.4	0.5%
Hn	Haverson loam, gravelly variant, 0 to 1 percent slopes	1181	5.1	0.0%
Ho	Heldt silty clay loam, 4 to 7 percent slopes	1243	44.0	0.0%
Hp	Hesper silty clay loam, 0 to 1 percent slopes	1366	7.0	0.0%
Hr	Hesper silty clay loam, 1 to 4 percent slopes	1364	55.3	0.1%
Hs	Hilly, gravelly land	668	1,566.8	1.7%
Hv	Hydro-Allentine complex, 2 to 7 percent slopes	1150	201.9	0.2%
Hx	Hysham-Laurel loams, 0 to 2 percent slopes	2552	93.5	0.1%
Hy	Hysham-Laurel silty clay loams, 0 to 2 percent slopes	2555	598.4	0.7%
Hz	Hysham and Haverson soils, 0 to 4 percent slopes	2075	419.6	0.5%
Kc	Keiser silty clay loam, 0 to 1 percent slopes	1445	719.8	0.8%
Ke	Keiser silty clay loam, 1 to 4 percent slopes	1424	1,347.4	1.5%
Kg	Keiser silty clay loam, 4 to 7 percent slopes	1389	398.8	0.4%
Kh	Keiser and Hesper silty clay loams, 0 to 1 percent slopes	1315	1,698.5	1.9%
Kl	Kyle silty clay, 0 to 1 percent slopes	1331	1,048.4	1.2%
Kn	Kyle silty clay, 4 to 7 percent slopes	1215	34.4	0.0%
La	Lonna-Vanstel complex, 0 to 4 percent slopes	1400	1,073.6	1.2%

Map unit symbol	Map unit name	Rating (pounds per acre per year)	Acres in AOI	Percent of AOI
Lb	Lonna silt loam, 4 to 8 percent slopes	1400	394.5	0.4%
Lc	Lonna silt loams, 8 to 15 percent slopes	1389	6.4	0.0%
Ld	Lambert soils, 7 to 35 percent slopes	1262	598.4	0.7%
Le	Larim loam, 0 to 4 percent slopes	1089	65.9	0.1%
Lg	Larim gravelly loam, 0 to 4 percent slopes	1020	258.2	0.3%
Lh	Larim gravelly loam, 4 to 7 percent slopes	1020	85.3	0.1%
Ll	Larim gravelly loam, 15 to 35 percent slopes	680	315.0	0.4%
Lm	Lavina loam, 2 to 4 percent slopes	974	951.1	1.1%
Ln	Lismas clay, 15 to 35 percent slopes	1055	774.4	0.9%
Lo	Lohmiller silty clay, 3 to 7 percent slopes	1318	628.8	0.7%
Lr	Lohmiller silty clay, 0 to 1 percent slopes	1649	4,402.4	4.9%
Ls	Lohmiller soils, seeped, 0 to 2 percent slopes	3592	1,325.0	1.5%
Lt	Lohmiller-Elso complex, 4 to 15 percent slopes	980	706.2	0.8%
Lu	Lohmiller-Hysham silty clay loams, 0 to 1 percent slopes	1615	6.5	0.0%
Lv	Lohmiller silty clay, gravelly variant, 0 to 1 percent slopes	1444	270.7	0.3%
Ma	Maginnis channery clay loam, 7 to 15 percent slopes	1470	2.5	0.0%
Mk	McKenzie clay, 0 to 1 percent slopes	2021	5.9	0.0%
Mm	McRae loam, 0 to 1 percent slopes	1560	3,049.5	3.4%
Mn	McRae loam, 1 to 4 percent slopes	1527	3,362.5	3.7%
Mo	McRae loam, 4 to 7 percent slopes	1493	3,115.2	3.5%
Mr	McRae loam, 7 to 15 percent slopes	1491	374.8	0.4%
Ms	McRae-Bainville loams, 7 to 15 percent slopes	1465	5,629.9	6.3%

Map unit symbol	Map unit name	Rating (pounds per acre per year)	Acres in AOI	Percent of AOI
Mt	McRae-Hysham loams, 0 to 1 percent slopes	975	269.8	0.3%
Mu	McRae-Hysham loams, 1 to 3 percent slopes	1125	161.9	0.2%
Mv	McRae-Hysham loams, 3 to 6 percent slopes	1070	9.9	0.0%
Mw	Midway-Razor clay loams, 4 to 7 percent slopes	1083	641.8	0.7%
My	Midway-Shale outcrop complex	790	4,658.6	5.2%
Pc	Pierre clay, 4 to 7 percent slopes	1184	45.3	0.1%
Pl	Pierre-Lismas clays, 7 to 15 percent slopes	1149	436.9	0.5%
Ra	Razor clay loam, 2 to 7 percent slopes	1280	523.1	0.6%
Rk	Rock land	123	3,864.9	4.3%
Rn	Ryegate fine sandy loam, 2 to 4 percent slopes	1531	837.0	0.9%
Sa	Sage clay, 0 to 1 percent slopes	1687	16.2	0.0%
Sm	Shale outcrop-Midway complex, 15 to 35 percent slopes	470	219.3	0.2%
So	Shorey gravelly loam, 1 to 4 percent slopes	1455	128.7	0.1%
Sr	Shorey gravelly loam, 4 to 7 percent slopes	1453	1,041.6	1.2%
Ta	Thurlow clay loam, 0 to 1 percent slopes	1342	22.0	0.0%
Te	Toluca clay loam, 0 to 1 percent slopes	1330	1,003.4	1.1%
Th	Toluca clay loam, 1 to 4 percent slopes	1318	1,445.9	1.6%
Tm	Toluca clay loam, 4 to 7 percent slopes	1318	189.2	0.2%
Tn	Toluca and Wanetta clay loams, 0 to 2 percent slopes	1485	424.0	0.5%
To	Toluca and Wanetta clay loams, 2 to 4 percent slopes	1315	203.5	0.2%
Tu	Treasure fine sandy loam, 1 to 4 percent slopes	1233	1,202.1	1.3%

Map unit symbol	Map unit name	Rating (pounds per acre per year)	Acres in AOI	Percent of AOI
Tw	Treasure fine sandy loam, 4 to 10 percent slopes	1245	639.1	0.7%
UL	Urban land		557.6	0.6%
Va	Vananda silty clay, 0 to 1 percent slopes	748	835.7	0.9%
Vd	Vananda silty clay, 1 to 7 percent slopes	645	257.3	0.3%
Ve	Vananda-Bone clays, 4 to 7 percent slopes	598	5.2	0.0%
W	Water		44.0	0.0%
Wc	Wanetta loam, 1 to 4 percent slopes	1452	74.7	0.1%
We	Wanetta gravelly loam, 0 to 2 percent slopes	1210	76.5	0.1%
Wf	Wanetta clay loam, 0 to 1 percent slopes	1279	660.2	0.7%
Wg	Wanetta clay loam, 1 to 4 percent slopes	1282	113.7	0.1%
Wh	Wanetta-Larim clay loams, 0 to 1 percent slopes	1204	11.1	0.0%
Wk	Wanetta-Larim clay loams, 1 to 4 percent slopes	1210	21.7	0.0%
Wl	Wanetta-Larim clay loams, 4 to 7 percent slopes	1180	32.2	0.0%
Wo	Worland fine sandy loam, 2 to 7 percent slopes	1455	660.2	0.7%
Ws	Wormser clay loam, 1 to 4 percent slopes	1255	512.7	0.6%
Wt	Wormser clay loam, 4 to 7 percent slopes	1270	404.5	0.4%
Wv	Wormser-Lavina clay loams, 2 to 4 percent slopes	1135	2,052.2	2.3%
Ww	Wormser-Worland sandy loams, 4 to 7 percent slopes	1458	851.1	0.9%
Ya	Yegen sandy loam, 0 to 1 percent slopes	1648	8.9	0.0%
Yd	Yegen sandy loam, 1 to 4 percent slopes	1648	120.5	0.1%
Yt	Yegen and Toluca soils, 7 to 15 percent slopes	1395	41.0	0.0%
Totals for Area of Interest			**89,947.2**	**100.0%**

Description

Total range production is the amount of vegetation that can be expected to grow annually in a well managed area that is supporting the potential natural plant community. It includes all vegetation, whether or not it is palatable to grazing animals. It includes the current year's growth of leaves, twigs, and fruits of woody plants. It does not include the increase in stem diameter of trees and shrubs. It is expressed in pounds per acre of air-dry vegetation. In a normal year, growing conditions are about average. Yields are adjusted to a common percent of air-dry moisture content.

In areas that have similar climate and topography, differences in the kind and amount of vegetation produced on rangeland are closely related to the kind of soil. Effective management is based on the relationship between the soils and vegetation and water.

Rating Options

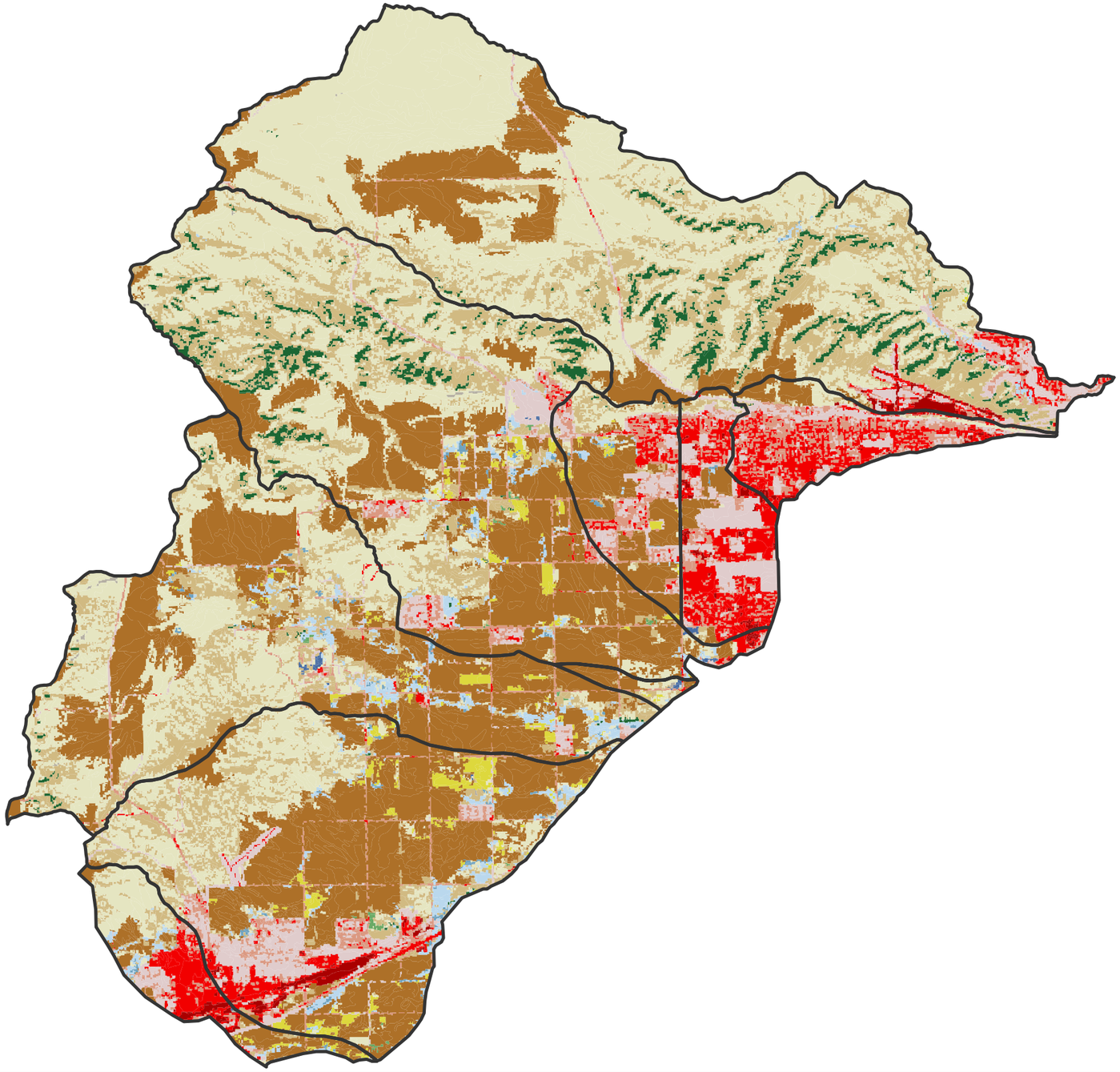
Units of Measure: pounds per acre per year

Aggregation Method: Weighted Average

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: Yes



Legend

- BASINS
- <all other values>

LANDCOVER_

- Barren Land
- Cultivated Crops
- Deciduous Forest
- Developed, High Intensity
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, Open Space
- Emergent Herbaceuous Wetlands
- Evergreen Forest
- Hay/Pasture
- Herbaceuous
- Open Water
- Shrub/Scrub
- Woody Wetlands

WWC ENGINEERING
51 N 15th Street, Suite 1
Billings, MT 59101
(406) 894 - 2210

BILLINGS BENCH WATER ASSOCIATION
PO BOX 50150
BILLINGS, MT 59105

NATIONAL LAND COVER DATABASE (NLCD)

N
W E
S

SWS 1-1	Drainage Area:	3.77648	sq mi	2,417	acres	Avg. Elev =	3518.91			
	Overland Flow --	Length:	300	Elevation 1:	3773.40	Elevation 2:	3768.82	Difference:	4.58	
	Stream 1 --	Length:	5295	Elevation 1:	3768.82	Elevation 2:	3500.00	Difference:	268.82	
	Stream 2 --	Length:	19413	Elevation 1:	3500.00	Elevation 2:	3264.41	Difference:	235.59	
SWS 2-1	Drainage Area:	12.2094	sq mi	7,814	acres	Avg. Elev =	3513.37			
	Overland Flow --	Length:	300	Elevation 1:	3772.97	Elevation 2:	3721.76	Difference:	51.21	
	Stream 1 --	Length:	14637	Elevation 1:	3721.76	Elevation 2:	3360.90	Difference:	360.86	
	Stream 2 --	Length:	21652	Elevation 1:	3360.90	Elevation 2:	3253.76	Difference:	107.14	
SWS 2-2	Drainage Area:	5.56779	sq mi	3,563	acres	Avg. Elev =	3497.49			
	Overland Flow --	Length:	300	Elevation 1:	3750	Elevation 2:	3747.09	Difference:	2.91	
	Stream 1 --	Length:	14197	Elevation 1:	3747.09	Elevation 2:	3330.55	Difference:	416.54	
	Stream 2 --	Length:	19192	Elevation 1:	3330.55	Elevation 2:	3244.97	Difference:	85.58	
SWS 2-3	Drainage Area:	6.44186	sq mi	4,123	acres	Avg. Elev =	3500.66			
	Overland Flow --	Length:	300	Elevation 1:	3756	Elevation 2:	3755	Difference:	1	
	Stream 1 --	Length:	18173	Elevation 1:	3755	Elevation 2:	3334.21	Difference:	420.79	
	Stream 2 --	Length:	18772	Elevation 1:	3334.21	Elevation 2:	3245.31	Difference:	88.9	
SWS 3-1	Drainage Area:	25.8049	sq mi	16,515	acres	Avg. Elev =	3646.12			
	Overland Flow --	Length:	300	Elevation 1:	4067.23	Elevation 2:	4061.84	Difference:	5.39	
	Stream 1 --	Length:	4756	Elevation 1:	4061.84	Elevation 2:	3743.64	Difference:	318.2	
	Stream 2 --	Length:	27071	Elevation 1:	3743.64	Elevation 2:	3352.48	Difference:	391.16	
	Stream 3 --	Length:	56723	Elevation 1:	3352.48	Elevation 2:	3225.00	Difference:	127.48	
SWS 4-1	Drainage Area:	0.57644	sq mi	369	acres	Avg. Elev =	3257.02			
	Overland Flow --	Length:	300	Elevation 1:	3273.08	Elevation 2:	3272.23	Difference:	0.85	
	Stream 1 --	Length:	10112	Elevation 1:	3272.23	Elevation 2:	3240.95	Difference:	31.28	
	Stream 2 --	Length:	---	Elevation 1:	---	Elevation 2:	---	Difference:	---	
SWS 5-1	Drainage Area:	32.5286	sq mi	20,818	acres	Avg. Elev =	3712.50			
	Overland Flow --	Length:	300	Elevation 1:	4185.00	Elevation 2:	4181.47	Difference:	3.53	
	Stream 1 --	Length:	40310	Elevation 1:	4181.47	Elevation 2:	3397.77	Difference:	783.7	
	Stream 2 --	Length:	15671	Elevation 1:	3397.77	Elevation 2:	3276.71	Difference:	121.06	
	Stream 3 --	Length:	14149	Elevation 1:	3276.71	Elevation 2:	3240.00	Difference:	36.71	
SWS 6-1	Drainage Area:	4.92665	sq mi	3,153	acres	Avg. Elev =	3537.65			
	Overland Flow --	Length:	300	Elevation 1:	3830.12	Elevation 2:	3821.44	Difference:	8.68	
	Stream 1 --	Length:	753	Elevation 1:	3821.44	Elevation 2:	3500.00	Difference:	321.44	
	Stream 2 --	Length:	14928	Elevation 1:	3500.00	Elevation 2:	3254.10	Difference:	245.9	
	Stream 3 --	Length:	5083	Elevation 1:	3254.10	Elevation 2:	3245.18	Difference:	8.92	
SWS 6-2	Drainage Area:	4.68469	sq mi	2,998	acres	Avg. Elev =	3507.81			
	Overland Flow --	Length:	300	Elevation 1:	3787.08	Elevation 2:	3782.76	Difference:	4.32	
	Stream 1 --	Length:	1653	Elevation 1:	3782.76	Elevation 2:	3450.00	Difference:	332.76	
	Stream 2 --	Length:	13404	Elevation 1:	3450.00	Elevation 2:	3228.54	Difference:	221.46	
SWS 6-3	Drainage Area:	4.39814	sq mi	2,815	acres	Avg. Elev =	3498.28			
	Overland Flow --	Length:	300	Elevation 1:	3765.00	Elevation 2:	3763.00	Difference:	2	
	Stream 1 --	Length:	1782	Elevation 1:	3763.00	Elevation 2:	3450.00	Difference:	313	
	Stream 2 --	Length:	7812	Elevation 1:	3450.00	Elevation 2:	3231.55	Difference:	218.45	
SWS 7-1	Drainage Area:	39.5213	sq mi	25,294	acres	Avg. Elev =	3695.00			
	Overland Flow --	Length:	300	Elevation 1:	4225.00	Elevation 2:	4200.00	Difference:	25	
	Stream 1 --	Length:	42447	Elevation 1:	4200.00	Elevation 2:	3450.00	Difference:	750	
	Stream 2 --	Length:	50651	Elevation 1:	3450.00	Elevation 2:	3165.00	Difference:	285	

Total Area = 89,879 Avg. Elev. = 3,633

Drainage ID	Overland Flow Routing Parameters						First Channel Routing Parameters						Second Channel Routing Parameters						Third Channel Routing Parameters							
SWS Name	Overland Length (ft)	Length Adjustment Factor	Overland Length (ft)	Overland Elevation Difference (ft)	Overland Slope (ft/ft)	Time of Conc.[1] (hrs)	Channel Length (ft)	Length Adjustment Factor	Channel Length (ft)	Channel Elevation Difference (ft)	Channel Slope (ft/ft)	Time of Conc.[2] (hrs)	Channel Length (ft)	Length Adjustment Factor	Channel Length (ft)	Channel Elevation Difference (ft)	Channel Slope (ft/ft)	Time of Conc.[2] (hrs)	Channel Length (ft)	Length Adjustment Factor	Channel Length (ft)	Channel Elevation Difference (ft)	Channel Slope (ft/ft)	Time of Conc.[2] (hrs)	Watershed Lag Time[3] (hrs)	Watershed Lag Time[3] (min)
SWS 1-1	300	1.0	300	4.58	0.0153	0.56	5,295	1.0	5,295	268.82	0.0508	0.11	19,413	1.0	19,413	235.59	0.0121	0.82	---	1.0	---	---	---		0.89	53.6
SWS 2-1	300	1.0	300	51.21	0.1707	0.21	14,637	1.0	14,637	360.86	0.0247	0.43	21,652	1.0	21,652	107.14	0.0049	1.44	---	1.0	---	---	---		1.25	75.0
SWS 2-2	300	1.0	300	2.91	0.0097	0.67	14,197	1.0	14,197	416.54	0.0293	0.39	19,192	1.0	19,192	85.58	0.0045	1.34	---	1.0	---	---	---		1.44	86.3
SWS 2-3	300	1.0	300	1	0.0033	1.03	18,173	1.0	18,173	420.79	0.0232	0.56	18,772	1.0	18,772	88.9	0.0047	1.27	---	1.0	---	---	---		1.71	102.8
SWS 3-1	300	1.0	300	5.39	0.0180	0.52	4,756	1.0	4,756	318.2	0.0669	0.09	27,071	1.0	27,071	391.16	0.0144	1.05	56,723	1.0	56,723	127.48	0.0022	5.58	4.35	260.7
SWS 4-1	300	1.0	300	0.85	0.0028	1.09	10,112	1.0	10,112	31.28	0.0031	0.85	---	1.0	---	---	---		---	1.0	---	---	---		1.17	69.9
SWS 5-1	300	1.0	300	3.53	0.0118	0.62	40,310	1.0	40,310	783.7	0.0194	1.35	15,671	1.0	15,671	121.06	0.0077	0.83	14,149	1.0	14,149	36.71	0.0026	1.30	2.46	147.5
SWS 6-1	300	1.0	300	8.68	0.0289	0.43	753	1.0	753	321.44	0.4269	0.01	14,928	1.0	14,928	245.9	0.0165	0.54	5,083	1.0	5,083	8.92	0.0018	0.57	0.93	55.7
SWS 6-2	300	1.0	300	4.32	0.0144	0.57	1,653	1.0	1,653	332.76	0.2013	0.02	13,404	1.0	13,404	221.46	0.0165	0.49	---	1.0	---	---	---		0.64	38.7
SWS 6-3	300	1.0	300	2	0.0067	0.78	1,782	1.0	1,782	313	0.1756	0.02	7,812	1.0	7,812	218.45	0.0280	0.22	---	1.0	---	---	---		0.61	36.5
SWS 7-1	300	1.0	300	25	0.0833	0.28	42,447	1.0	42,447	750	0.0177	1.49	50,651	1.0	50,651	285	0.0056	3.15	---	1.0	---	---	---		2.95	177.3

Worksheet for Broakway Central Crossing

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Pressure 1	4.57	psi
Pressure 2	0.91	psi
Elevation 1	3232.68	ft
Elevation 2	3231.71	ft
Length	103.00	ft
Roughness Coefficient	0.010	
Diameter	2.00	ft

Results

Discharge	88.90	ft^3/s
Headloss	9.41	ft
Energy Grade 1	3255.66	ft
Energy Grade 2	3246.25	ft
Hydraulic Grade 1	3243.22	ft
Hydraulic Grade 2	3233.81	ft
Flow Area	3.14	ft^2
Wetted Perimeter	6.28	ft
Velocity	28.30	ft/s
Velocity Head	12.44	ft
Friction Slope	0.09138	ft/ft

Messages

Notes

Assuming similar profile as the 30" crossing to the east that is close to this location.

Max Upstream Head = 10.54 feet = 4.57 psi
Downstream head assumed to be 20% of upstream head
Pipe Length = 103 feet
Inlet Manhole Elevation = 3232.68 ft
Outlet Manhole Elevation = 3231.21 +0.5 = 3231.71 ft

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0 cfs

Design Flow: 62 cfs

Maximum Flow: 1000 cfs

Table 1 - Summary of Culvert Flows at Crossing: Broakway North - S 56th Ave - 30

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
3232.68	0.00	0.00	0.00	1
3243.08	62.00	62.00	0.00	1
3243.48	200.00	63.32	136.11	8
3243.59	300.00	63.69	235.62	5
3243.68	400.00	64.00	334.96	4
3243.76	500.00	64.18	435.35	4
3243.84	600.00	64.28	535.33	4
3243.91	700.00	64.43	634.62	3
3243.98	800.00	64.43	735.10	3
3244.05	900.00	64.46	835.45	3
3244.11	1000.00	64.48	934.73	2
3243.22	62.47	62.47	0.00	Overtopping

Rating Curve Plot for Crossing: Broakway North - S 56th Ave - 30

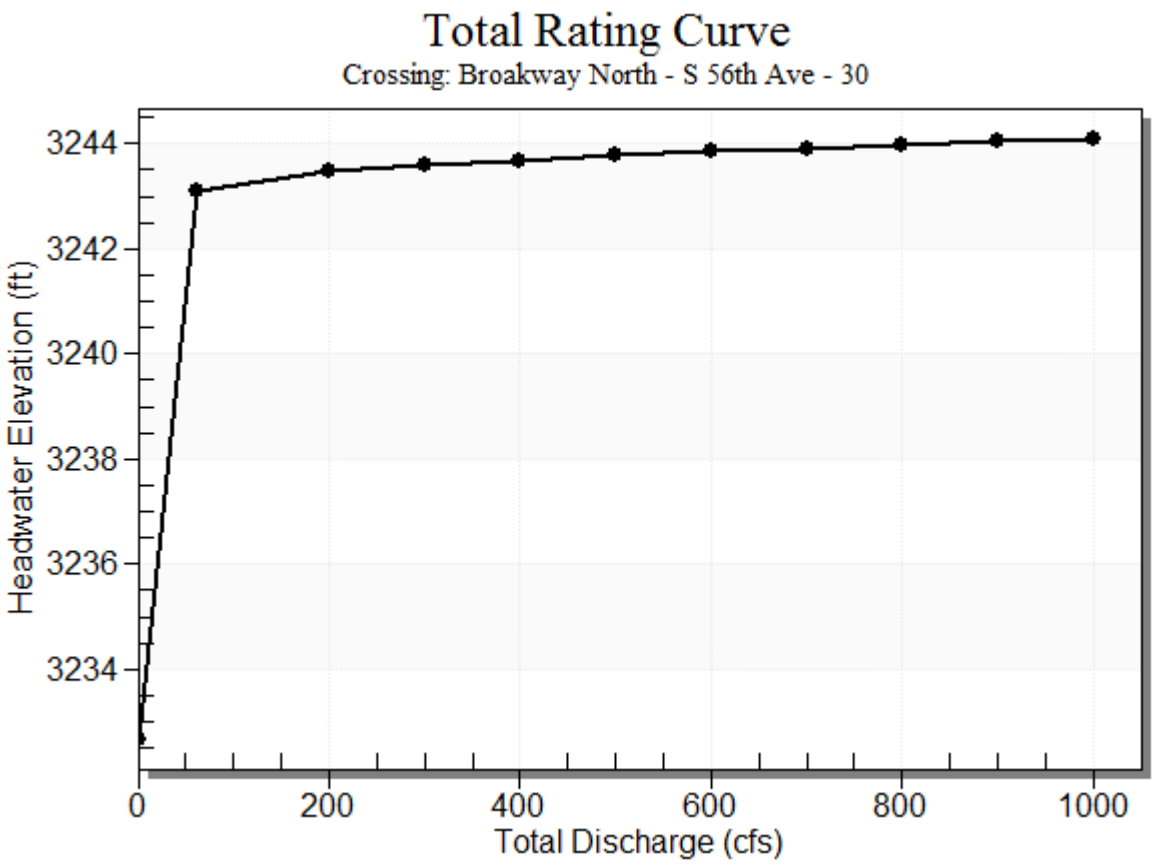


Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	3232.68	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
62.00	62.00	3243.08	10.401	0.000	7-M2c	2.500	2.280	2.280	1.160	13.200	3.964
200.00	63.32	3243.48	10.796	0.000	7-M2c	2.500	2.214	2.214	2.169	13.775	5.587
300.00	63.69	3243.59	10.906	14.580	4-FFf	2.500	2.188	2.500	2.666	12.974	6.251
400.00	64.00	3243.68	11.000	15.120	4-FFf	2.500	2.319	2.500	3.077	13.037	6.759
500.00	64.18	3243.76	11.055	15.552	4-FFf	2.500	2.167	2.500	3.433	13.074	7.176
600.00	64.28	3243.84	11.087	15.913	4-FFf	2.500	2.133	2.500	3.749	13.095	7.532
700.00	64.43	3243.91	11.133	16.265	4-FFf	2.500	2.194	2.500	4.036	13.126	7.845
800.00	64.43	3243.98	11.133	16.528	4-FFf	2.500	2.366	2.500	4.300	13.126	8.125
900.00	64.46	3244.05	11.142	16.785	4-FFf	2.500	2.340	2.500	4.545	13.132	8.379
1000.00	64.48	3244.11	11.149	17.024	4-FFf	2.500	2.355	2.500	4.774	13.136	8.612

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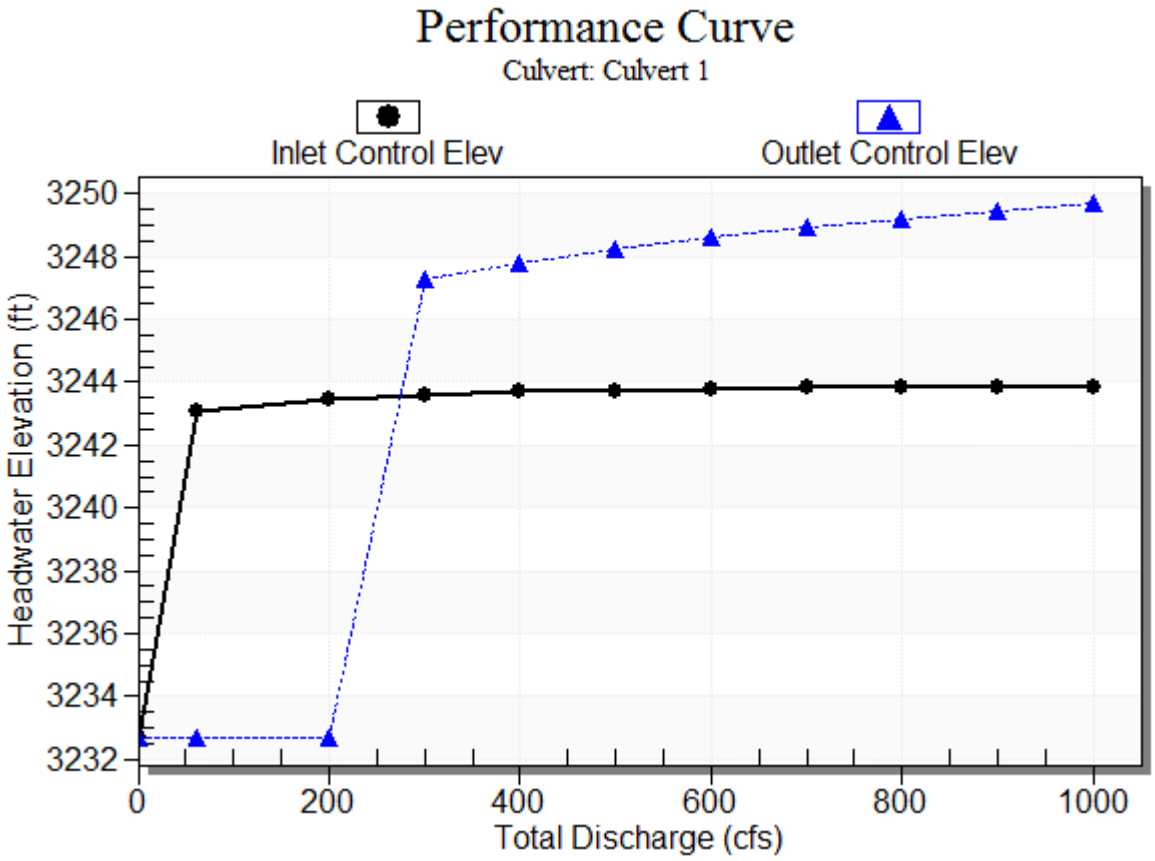
Straight Culvert

Inlet Elevation (invert): 3232.68 ft, Outlet Elevation (invert): 3231.21 ft

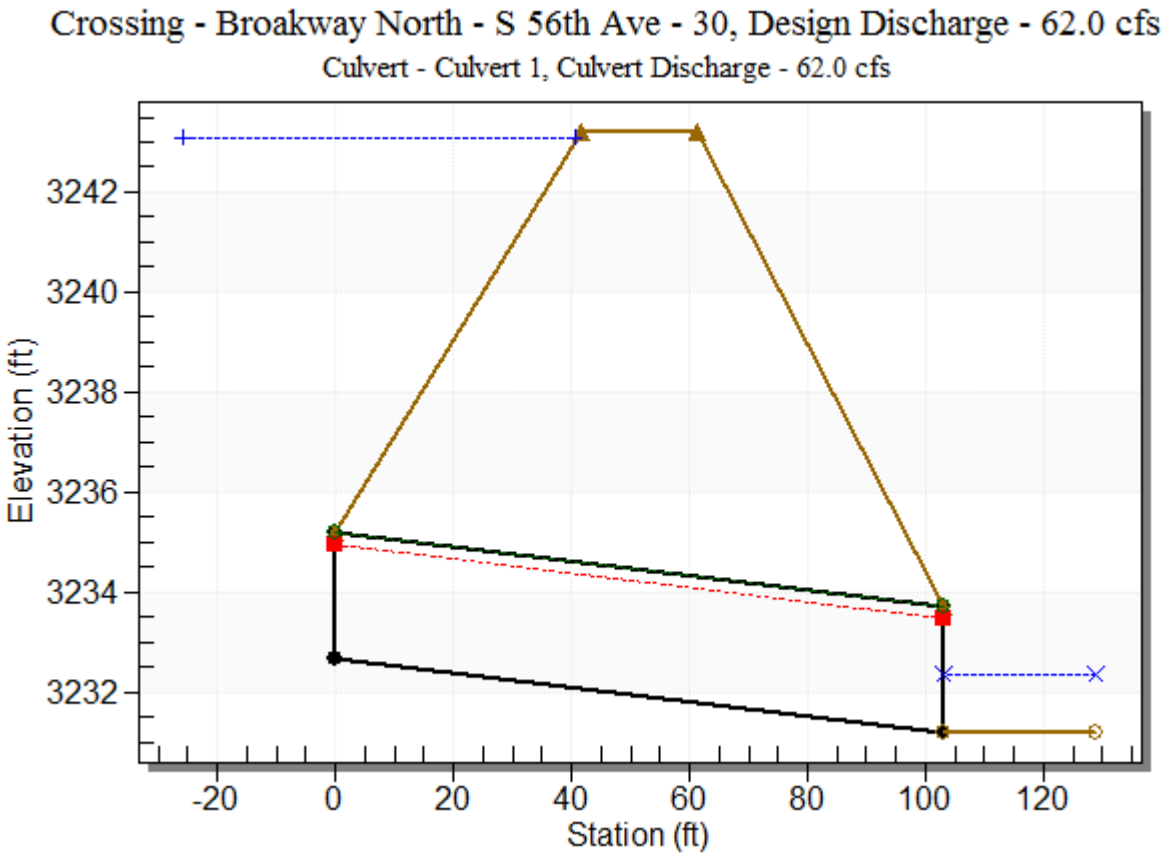
Culvert Length: 103.01 ft, Culvert Slope: 0.0143

****

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 3232.68 ft

Outlet Station: 103.00 ft

Outlet Elevation: 3231.21 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 2.50 ft

Barrel Material: Corrugated Steel

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Thin Edge Projecting

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Broakway North - S 56th Ave

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	3231.21	0.00	0.00	0.00	0.00
62.00	3232.37	1.16	3.96	0.72	0.73
200.00	3233.38	2.17	5.59	1.35	0.79
300.00	3233.88	2.67	6.25	1.66	0.81
400.00	3234.29	3.08	6.76	1.92	0.83
500.00	3234.64	3.43	7.18	2.14	0.84
600.00	3234.96	3.75	7.53	2.34	0.85
700.00	3235.25	4.04	7.84	2.52	0.86
800.00	3235.51	4.30	8.12	2.68	0.86
900.00	3235.75	4.54	8.38	2.84	0.87
1000.00	3235.98	4.77	8.61	2.98	0.88

Tailwater Channel Data - Broakway North - S 56th Ave - 30

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 10.00 ft

Side Slope (H:V): 3.00 (_:1)

Channel Slope: 0.0100

Channel Manning's n: 0.0350

Channel Invert Elevation: 3231.21 ft

Roadway Data for Crossing: Broakway North - S 56th Ave - 30

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 400.00 ft

Crest Elevation: 3243.22 ft

Roadway Surface: Gravel

Roadway Top Width: 20.00 ft

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0 cfs

Design Flow: 256 cfs

Maximum Flow: 3000 cfs

Table 1 - Summary of Culvert Flows at Crossing: Hogan's Slough - Shiloh Ave 60"

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
3224.06	0.00	0.00	0.00	1
3238.22	256.00	256.00	0.00	1
3238.70	600.00	261.86	337.61	6
3238.93	900.00	264.72	634.34	5
3239.13	1200.00	267.02	932.55	5
3239.30	1500.00	268.85	1229.44	4
3239.45	1800.00	270.84	1528.46	4
3239.60	2100.00	272.63	1827.14	4
3239.73	2400.00	274.22	2124.44	3
3239.87	2700.00	275.74	2423.66	3
3239.99	3000.00	277.18	2722.70	3
3238.24	256.28	256.28	0.00	Overtopping

Rating Curve Plot for Crossing: Hogan's Slough - Shiloh Ave 60"

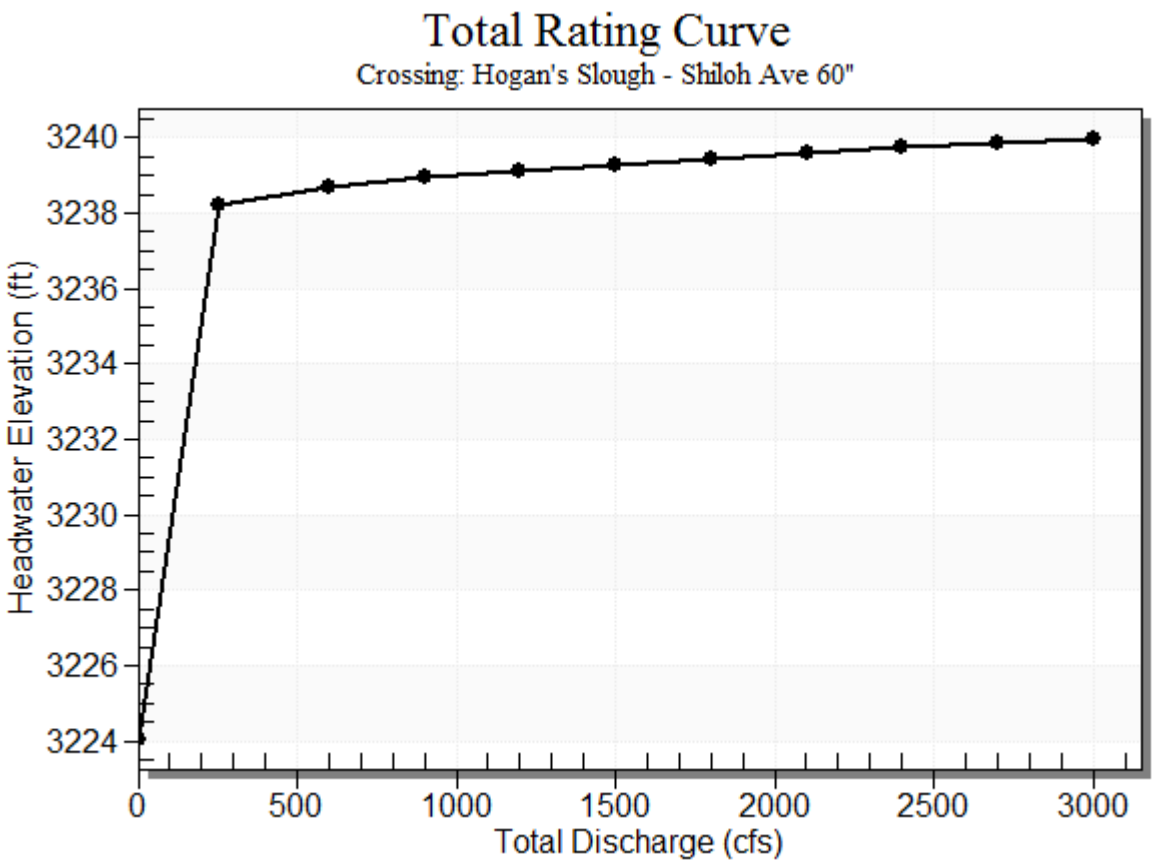


Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	3224.06	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
256.00	256.00	3238.22	12.325	14.157	7-M2c	5.000	4.459	4.459	2.461	13.846	5.984
600.00	261.86	3238.70	12.763	14.642	7-M2c	5.000	4.493	4.493	3.749	14.084	7.532
900.00	264.72	3238.93	12.981	14.879	7-M2t	5.000	4.509	4.545	4.545	14.122	8.379
1200.00	267.02	3239.13	13.159	15.458	4-FFf	5.000	4.521	5.000	5.195	13.599	9.029
1500.00	268.85	3239.30	13.302	16.165	4-FFf	5.000	4.531	5.000	5.753	13.693	9.564
1800.00	270.84	3239.45	13.458	16.823	4-FFf	5.000	4.541	5.000	6.248	13.794	10.023
2100.00	272.63	3239.60	13.600	17.418	4-FFf	5.000	4.550	5.000	6.695	13.885	10.426
2400.00	274.22	3239.73	13.727	17.960	4-FFf	5.000	4.558	5.000	7.105	13.966	10.788
2700.00	275.74	3239.87	13.849	18.467	4-FFf	5.000	4.567	5.000	7.484	14.043	11.116
3000.00	277.18	3239.99	13.966	18.943	4-FFf	5.000	4.574	5.000	7.839	14.117	11.418

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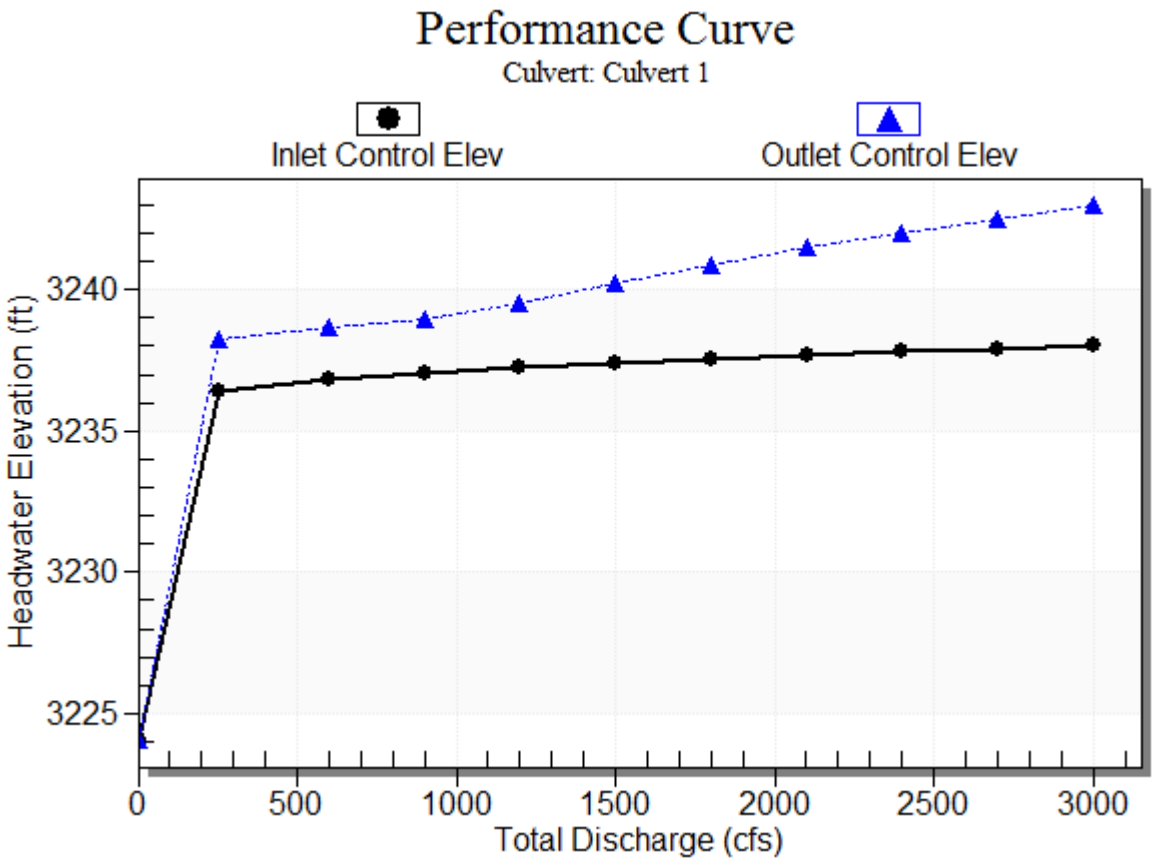
Straight Culvert

Inlet Elevation (invert): 3224.06 ft, Outlet Elevation (invert): 3223.48 ft

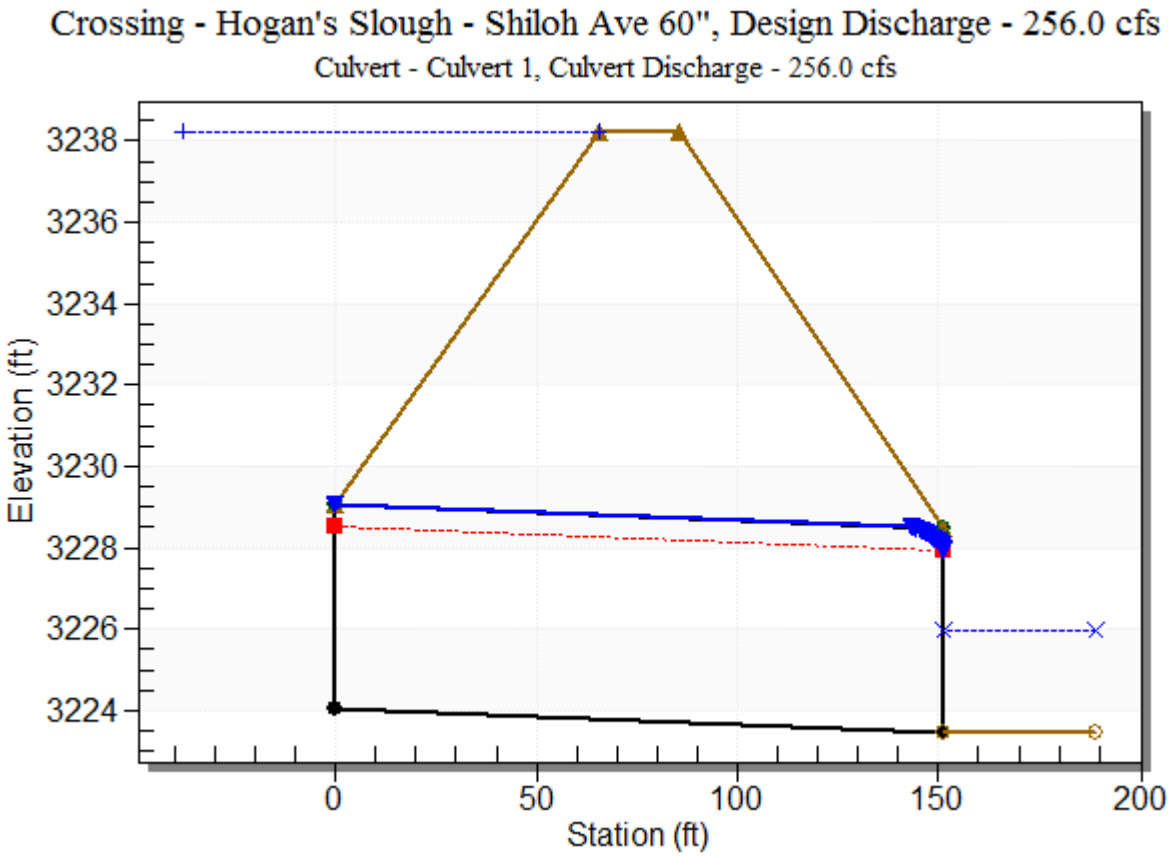
Culvert Length: 151.20 ft, Culvert Slope: 0.0038

****

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 3224.06 ft

Outlet Station: 151.20 ft

Outlet Elevation: 3223.48 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 5.00 ft

Barrel Material: Corrugated Steel

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Thin Edge Projecting

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Hogan's Slough - Shiloh Ave

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	3223.48	0.00	0.00	0.00	0.00
256.00	3225.94	2.46	5.98	1.54	0.80
600.00	3227.23	3.75	7.53	2.34	0.85
900.00	3228.02	4.54	8.38	2.84	0.87
1200.00	3228.67	5.19	9.03	3.24	0.89
1500.00	3229.23	5.75	9.56	3.59	0.90
1800.00	3229.73	6.25	10.02	3.90	0.91
2100.00	3230.18	6.70	10.43	4.18	0.92
2400.00	3230.58	7.10	10.79	4.43	0.92
2700.00	3230.96	7.48	11.12	4.67	0.93
3000.00	3231.32	7.84	11.42	4.89	0.94

Tailwater Channel Data - Hogan's Slough - Shiloh Ave 60"

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 10.00 ft

Side Slope (H:V): 3.00 (_:1)

Channel Slope: 0.0100

Channel Manning's n: 0.0350

Channel Invert Elevation: 3223.48 ft

Roadway Data for Crossing: Hogan's Slough - Shiloh Ave 60"

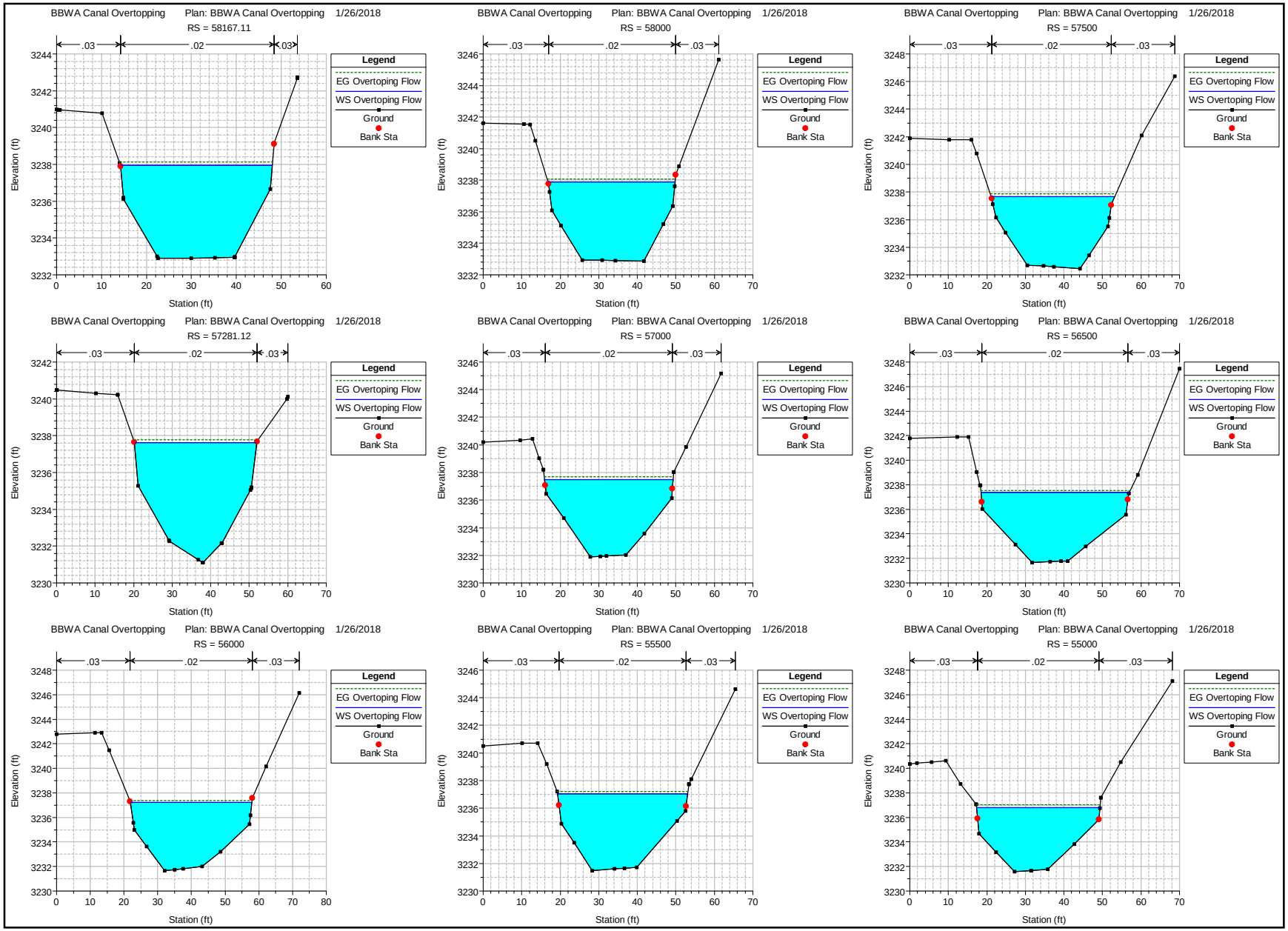
Roadway Profile Shape: Constant Roadway Elevation

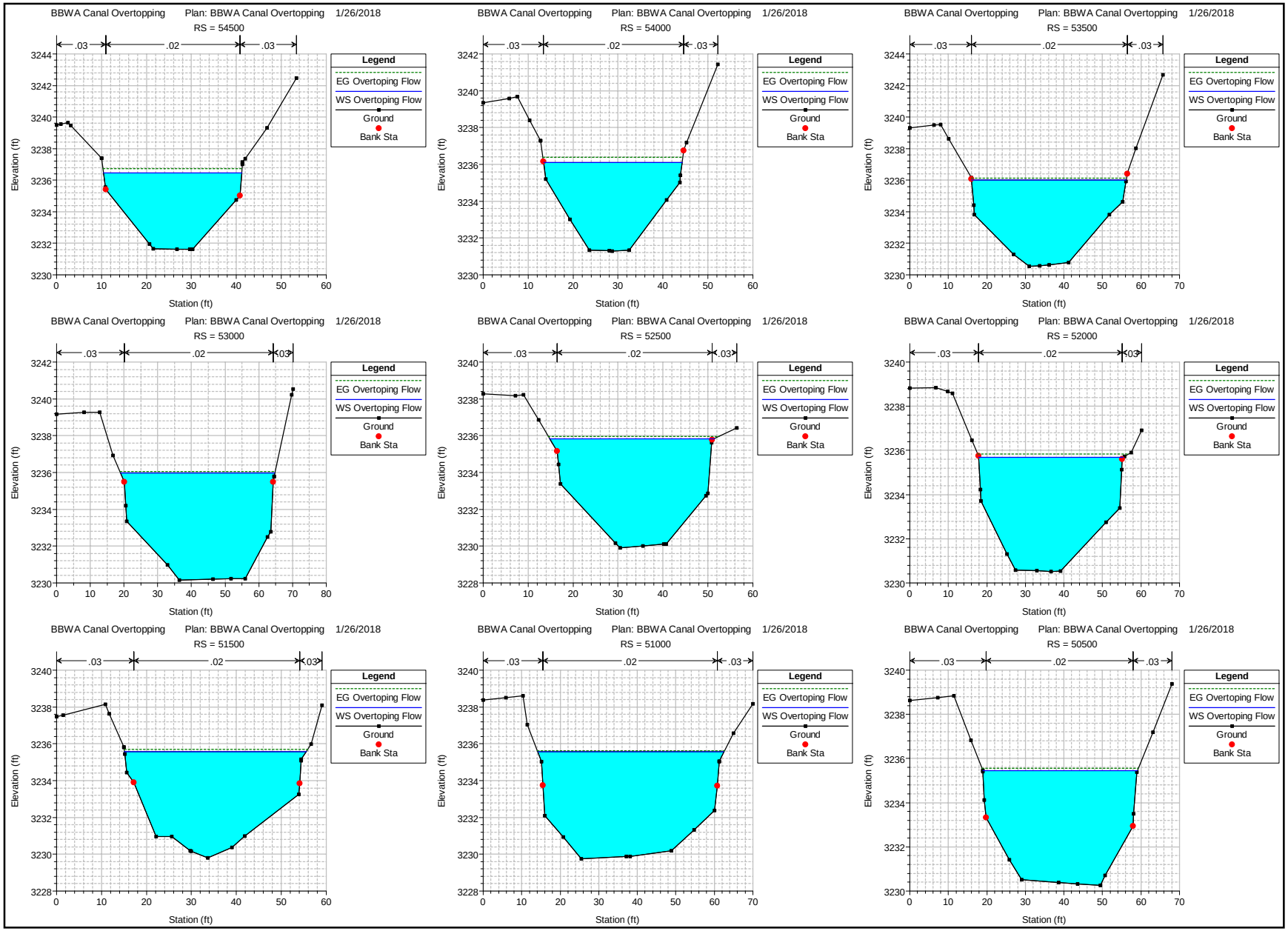
Crest Length: 400.00 ft

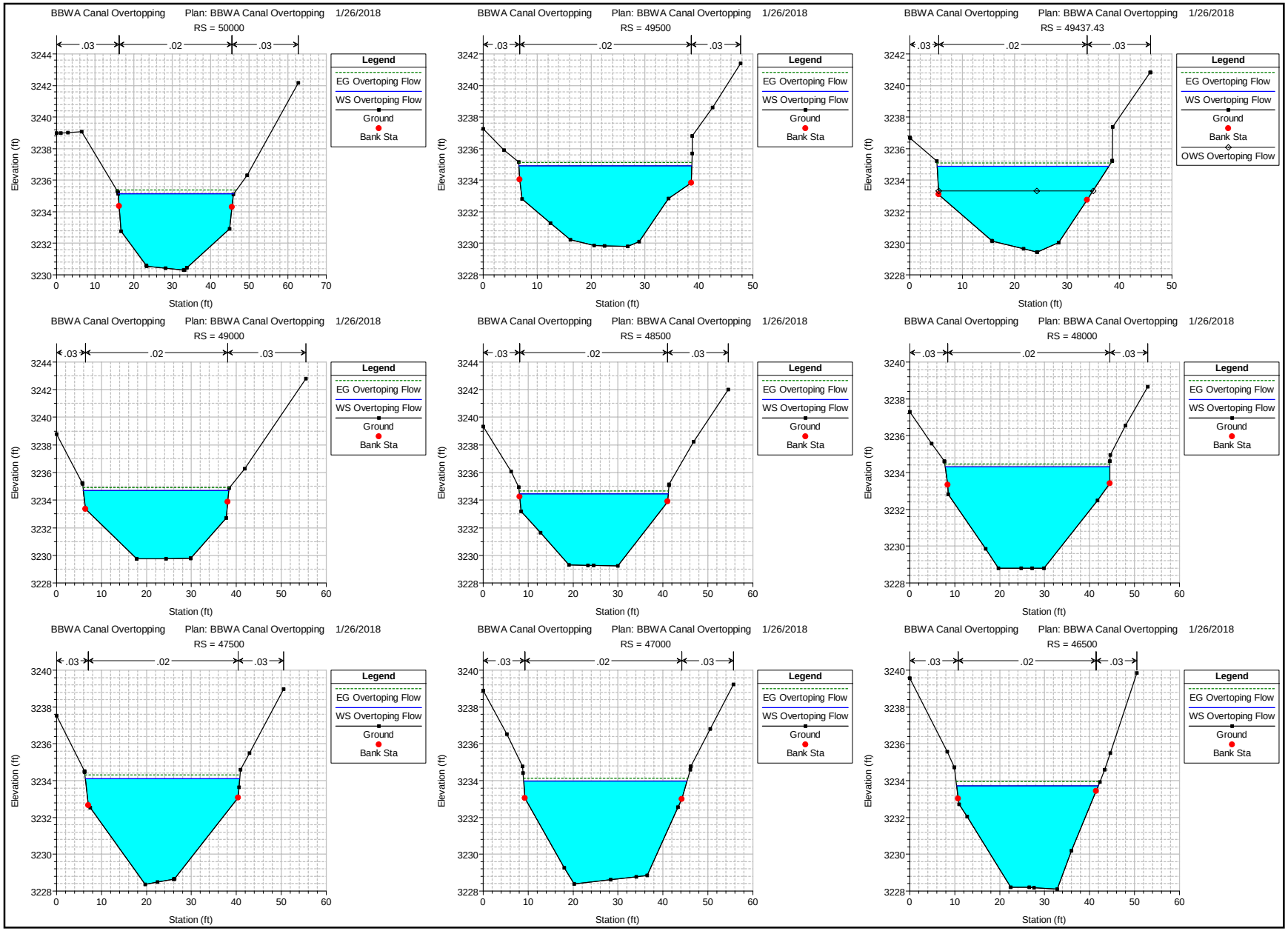
Crest Elevation: 3238.24 ft

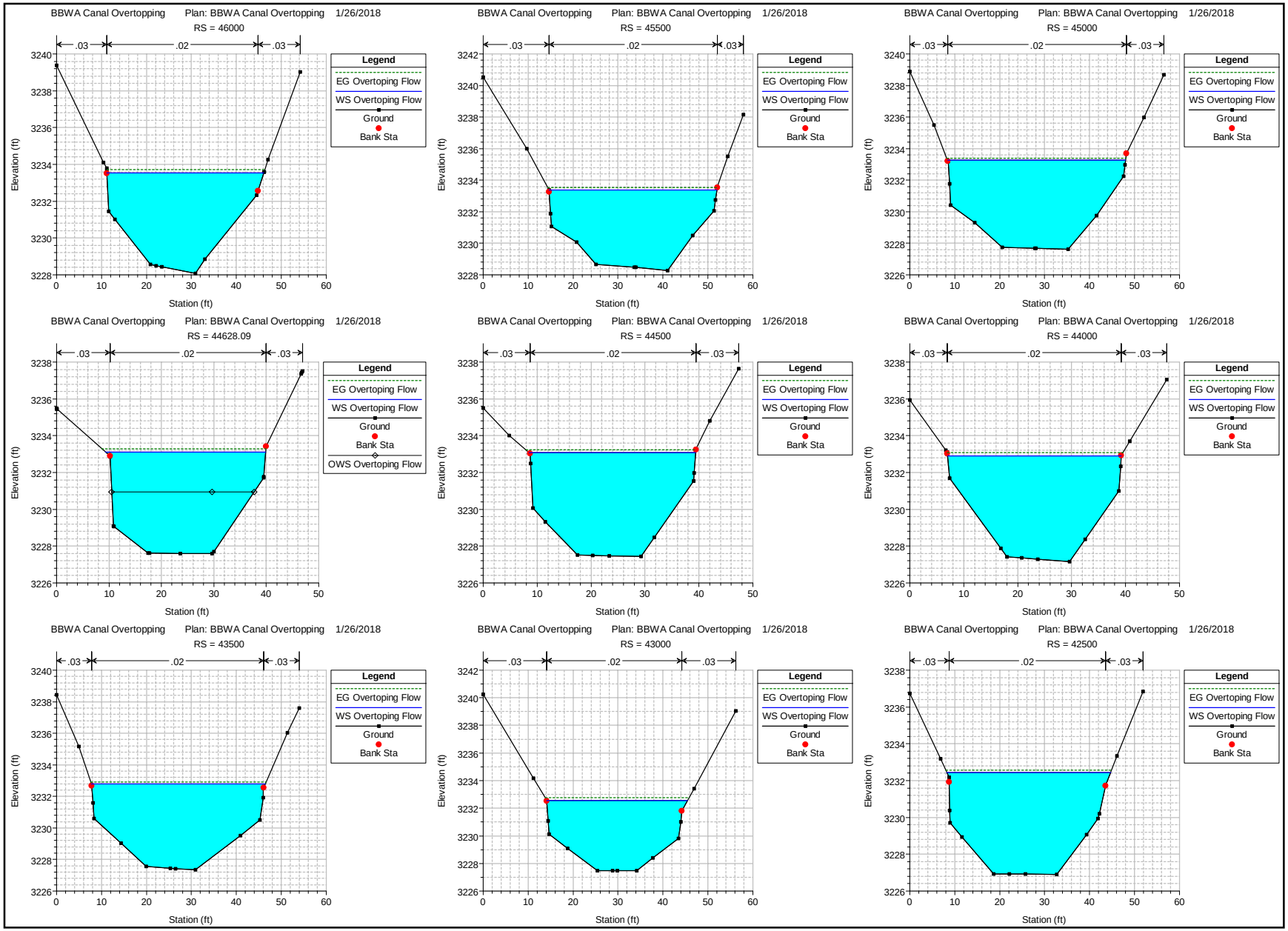
Roadway Surface: Gravel

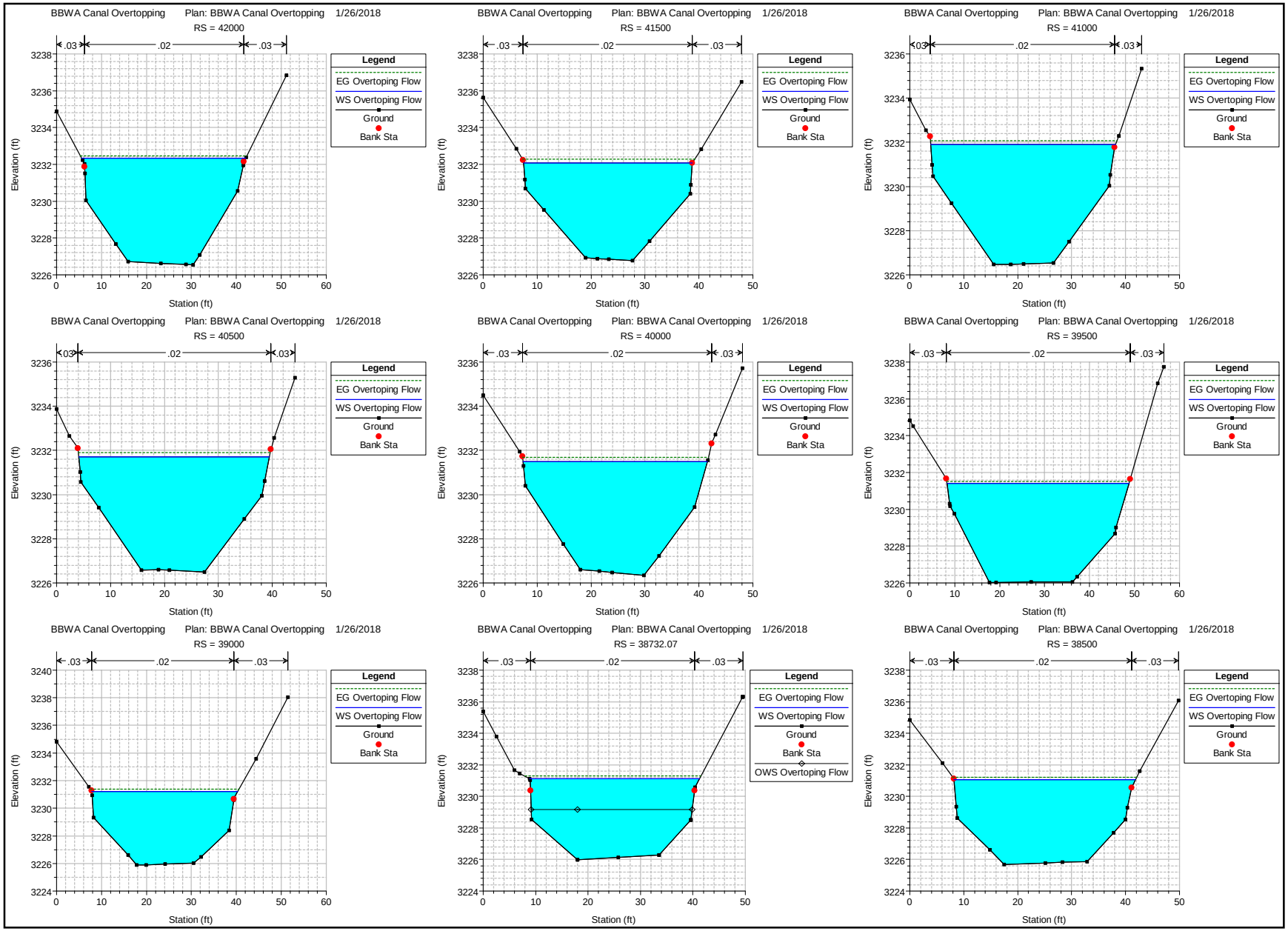
Roadway Top Width: 20.00 ft

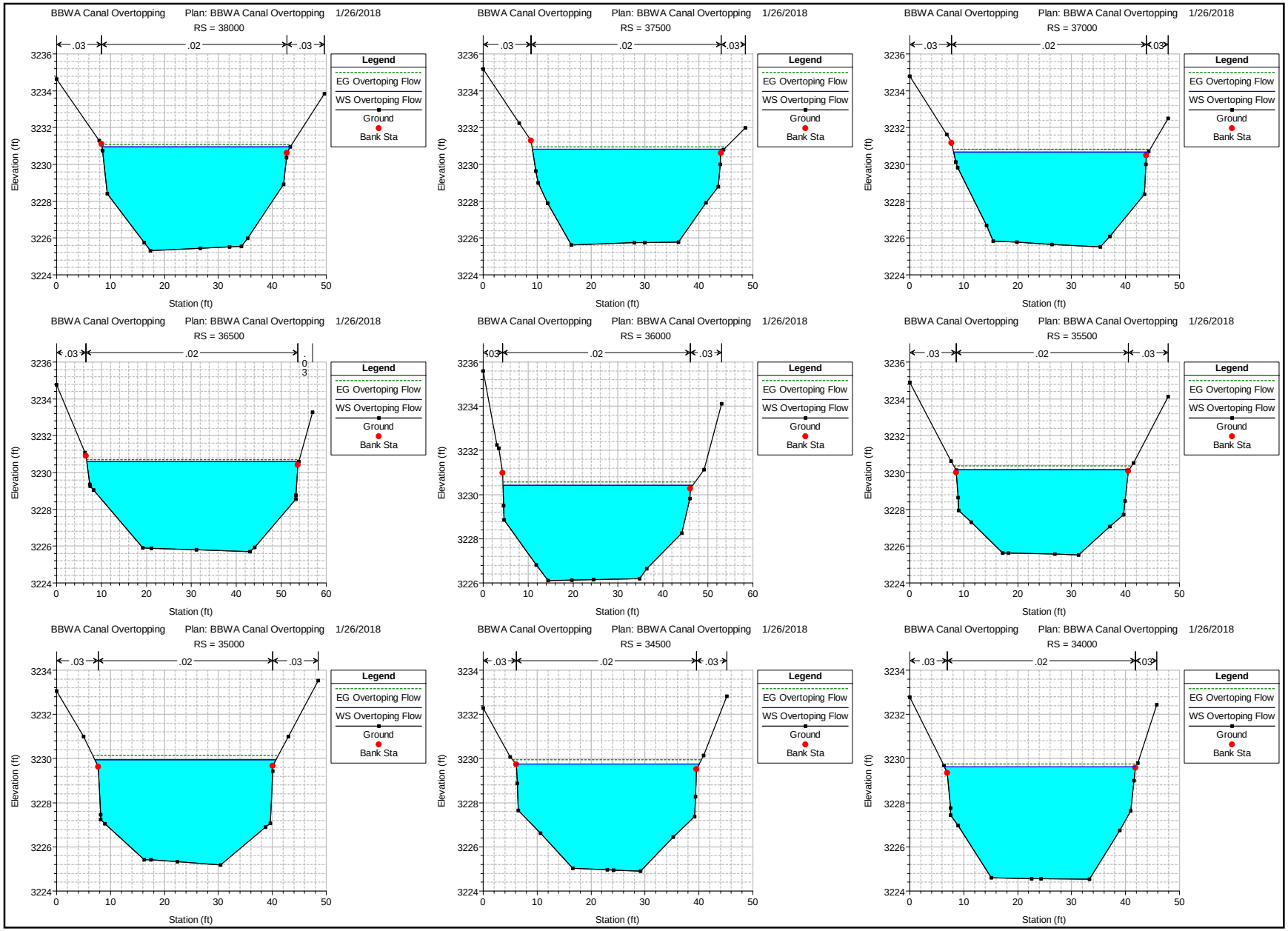

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 58167.11
RS = 58000
RS = 57500
RS = 57281.12
RS = 57000
RS = 56500
RS = 56000
RS = 55500
RS = 55000
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

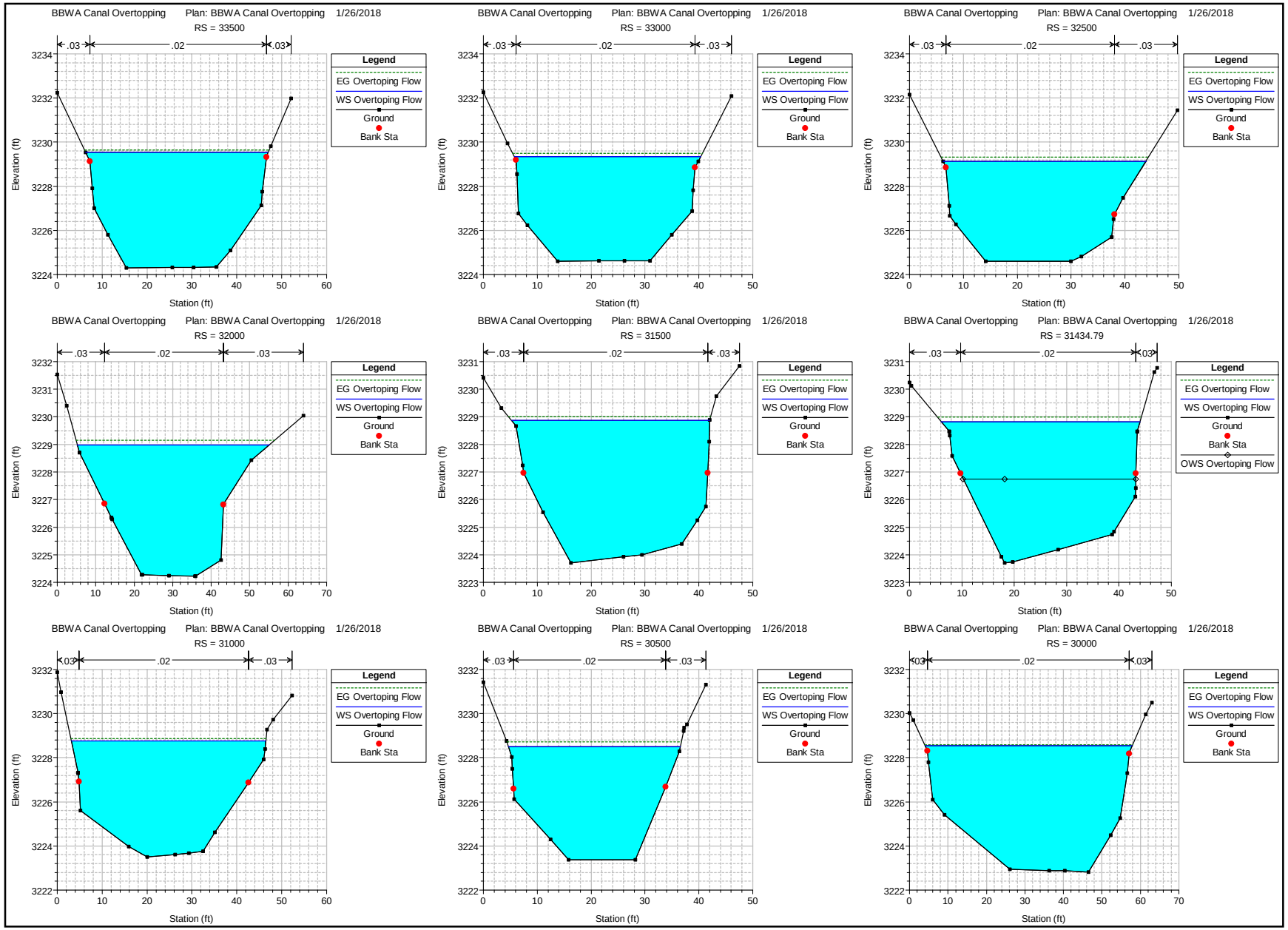

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 54500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 54000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 53500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 53000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 52500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 52000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 51500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 51000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 50500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

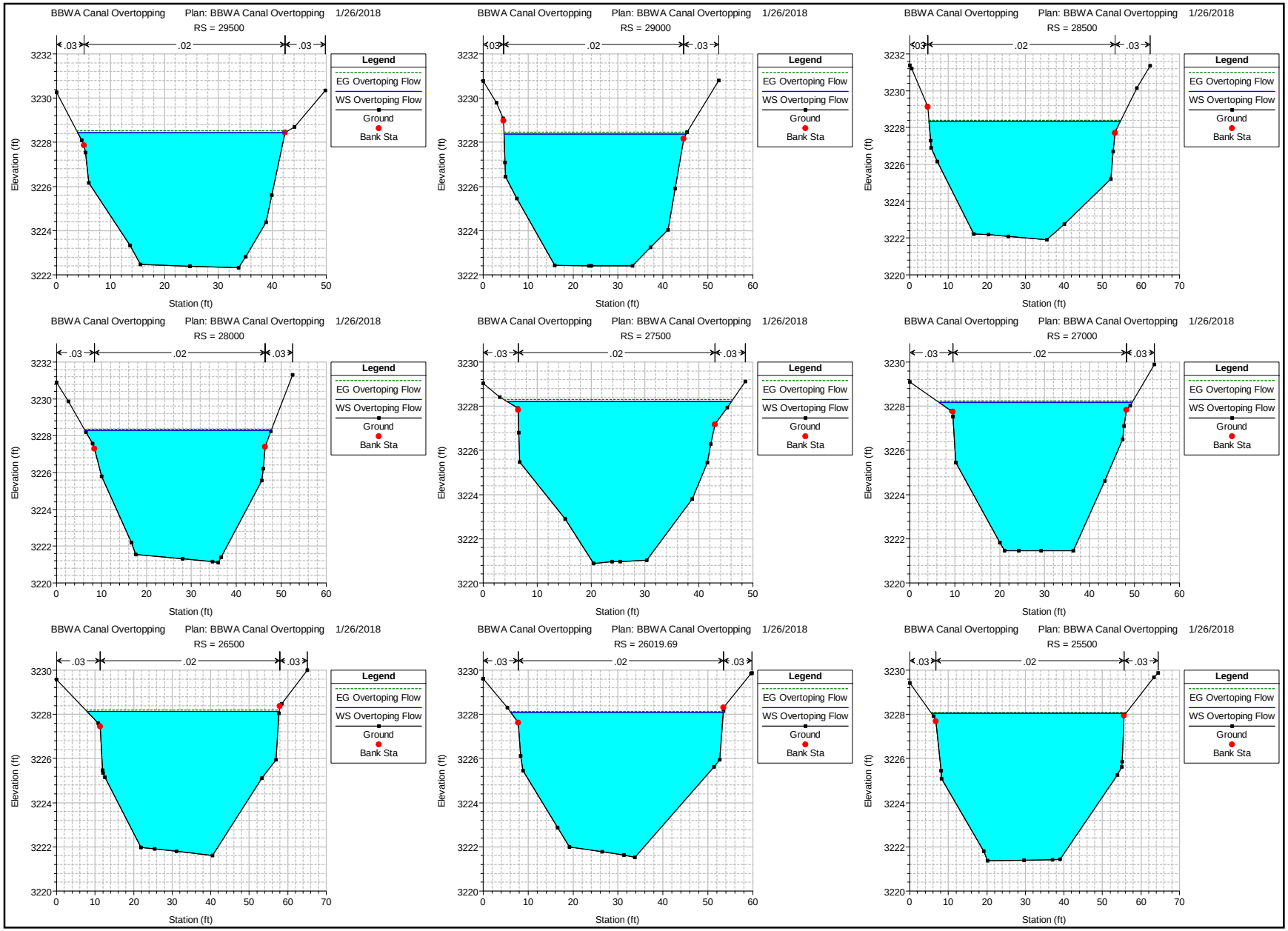

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 50000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 49500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 49437.43
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
OWS Overtoping Flow
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 49000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 48500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 48000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 47500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 47000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 46500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

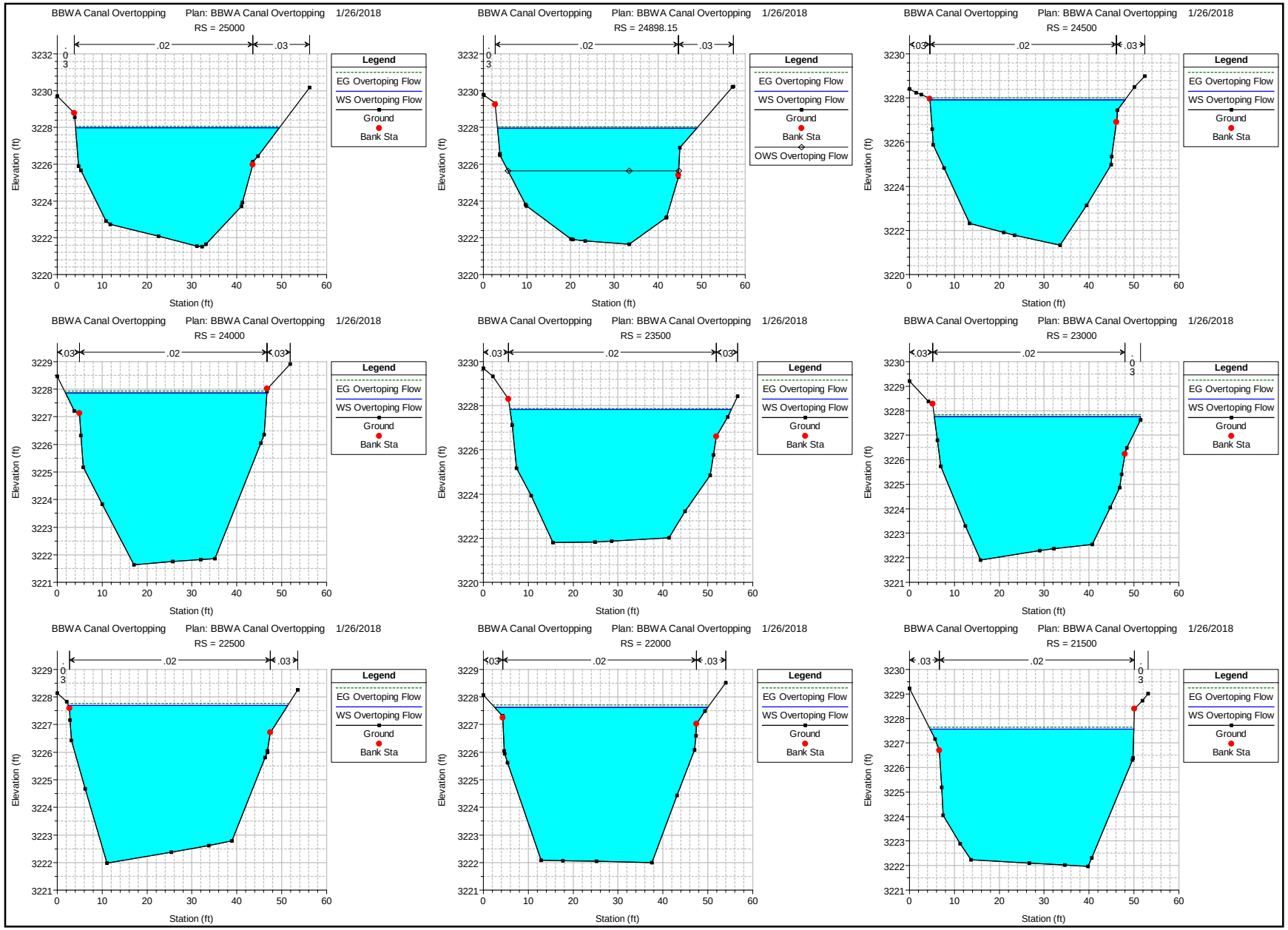

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RS = 45500
RS = 45000
RS = 44628.09
RS = 44500
RS = 44000
RS = 43500
RS = 43000
RS = 42500
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
OWS Overtoping Flow
Elevation (ft)
Station (ft)

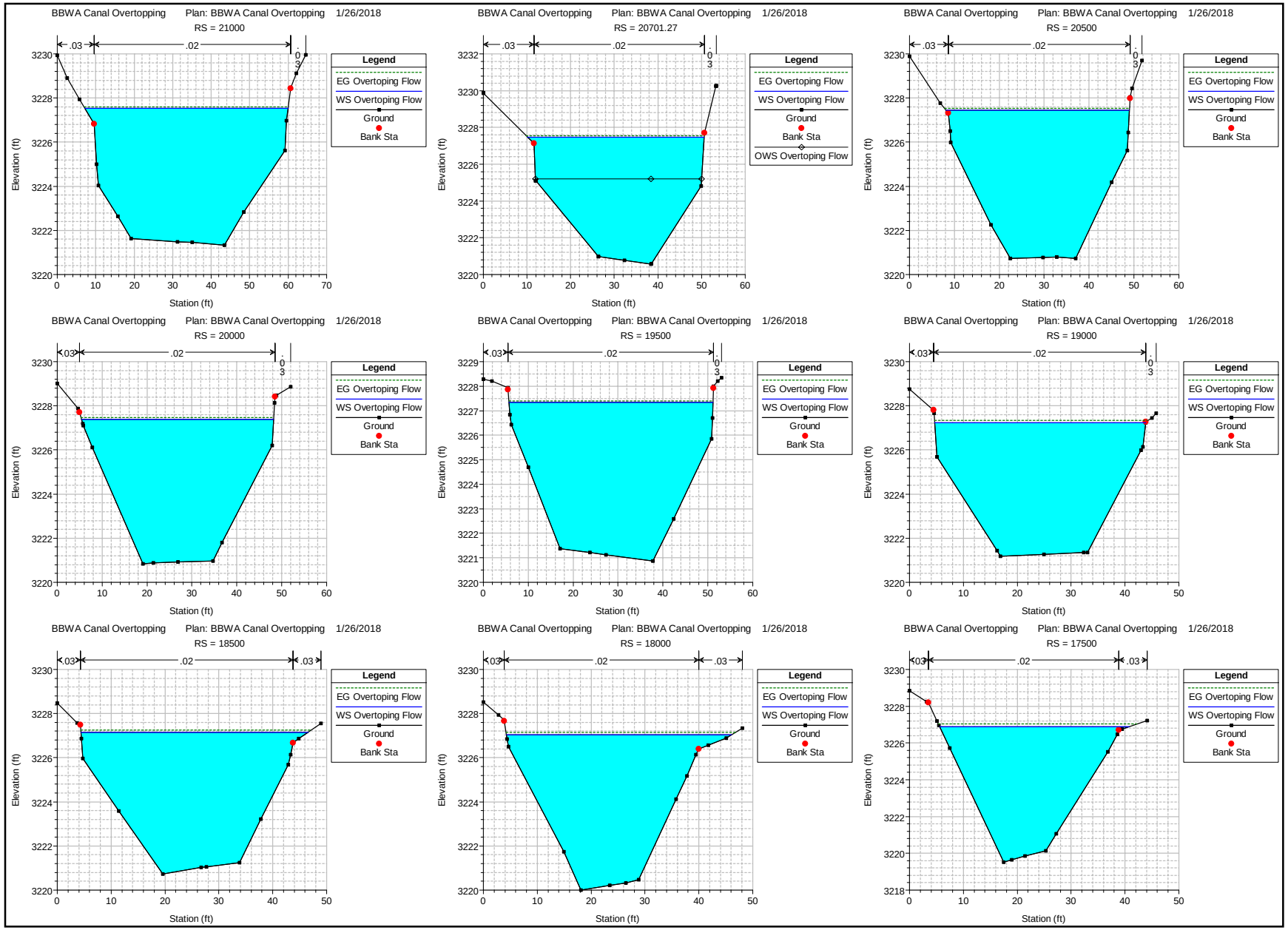

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 42000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 41500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 41000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 40500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 40000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 39500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 39000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 38732.07
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
OWS Overtoping Flow
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 38500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

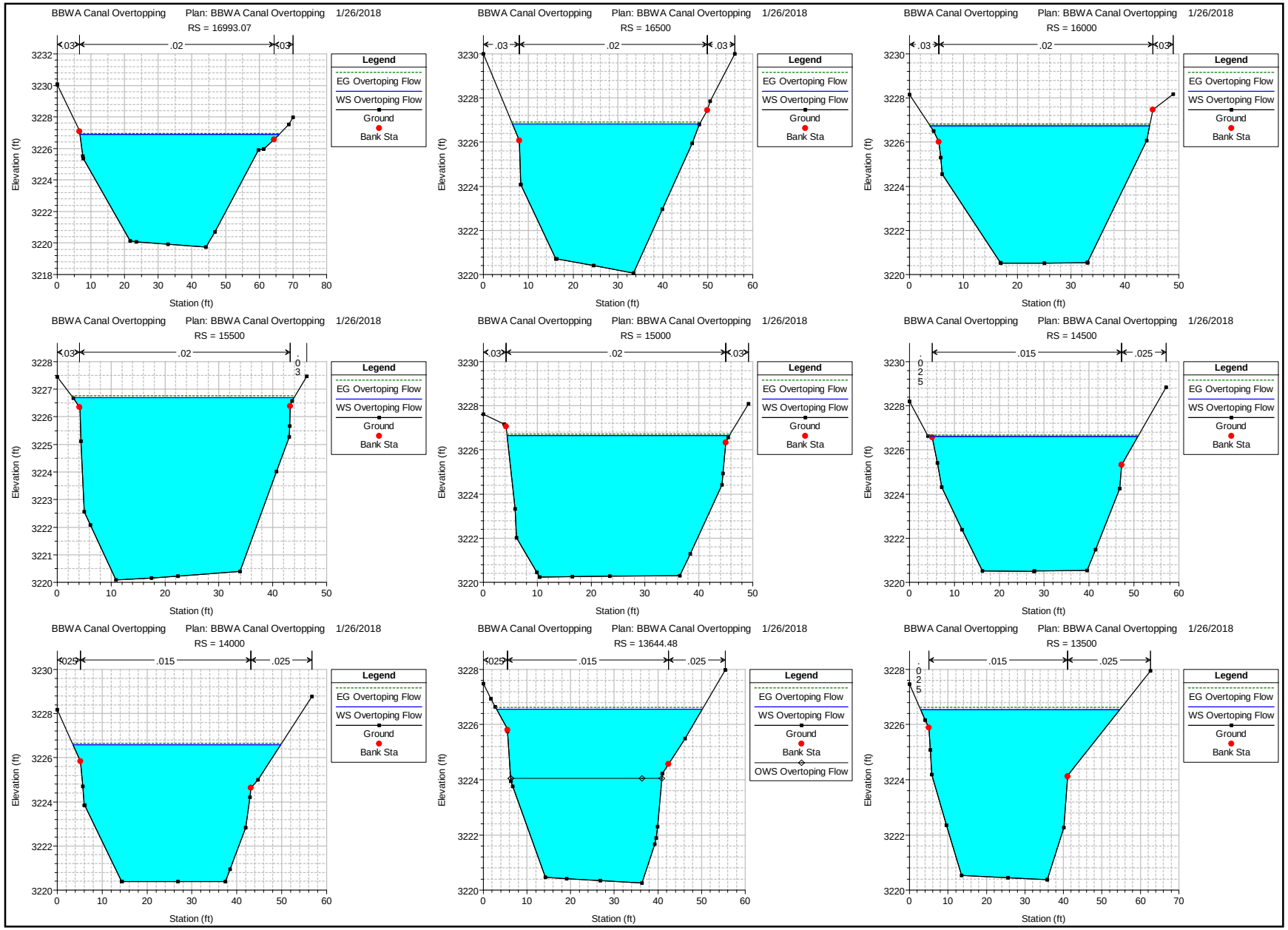

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RS = 38000
RS = 37500
RS = 37000
RS = 36500
RS = 36000
RS = 35500
RS = 35000
RS = 34500
RS = 34000
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

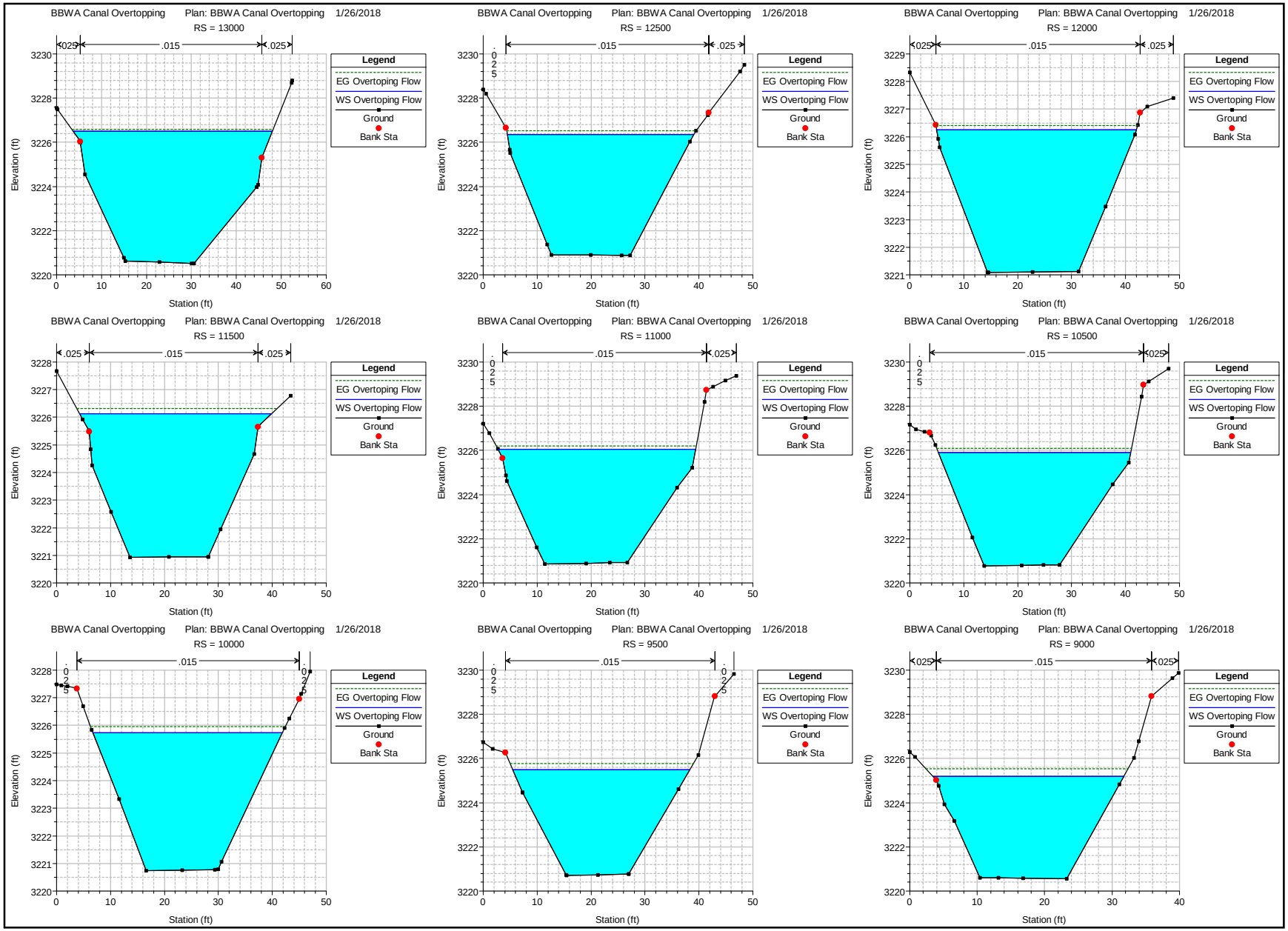

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 33500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 33000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 32500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 32000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 31500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 31434.79
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
OWS Overtoping Flow
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 31000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 30500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 30000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

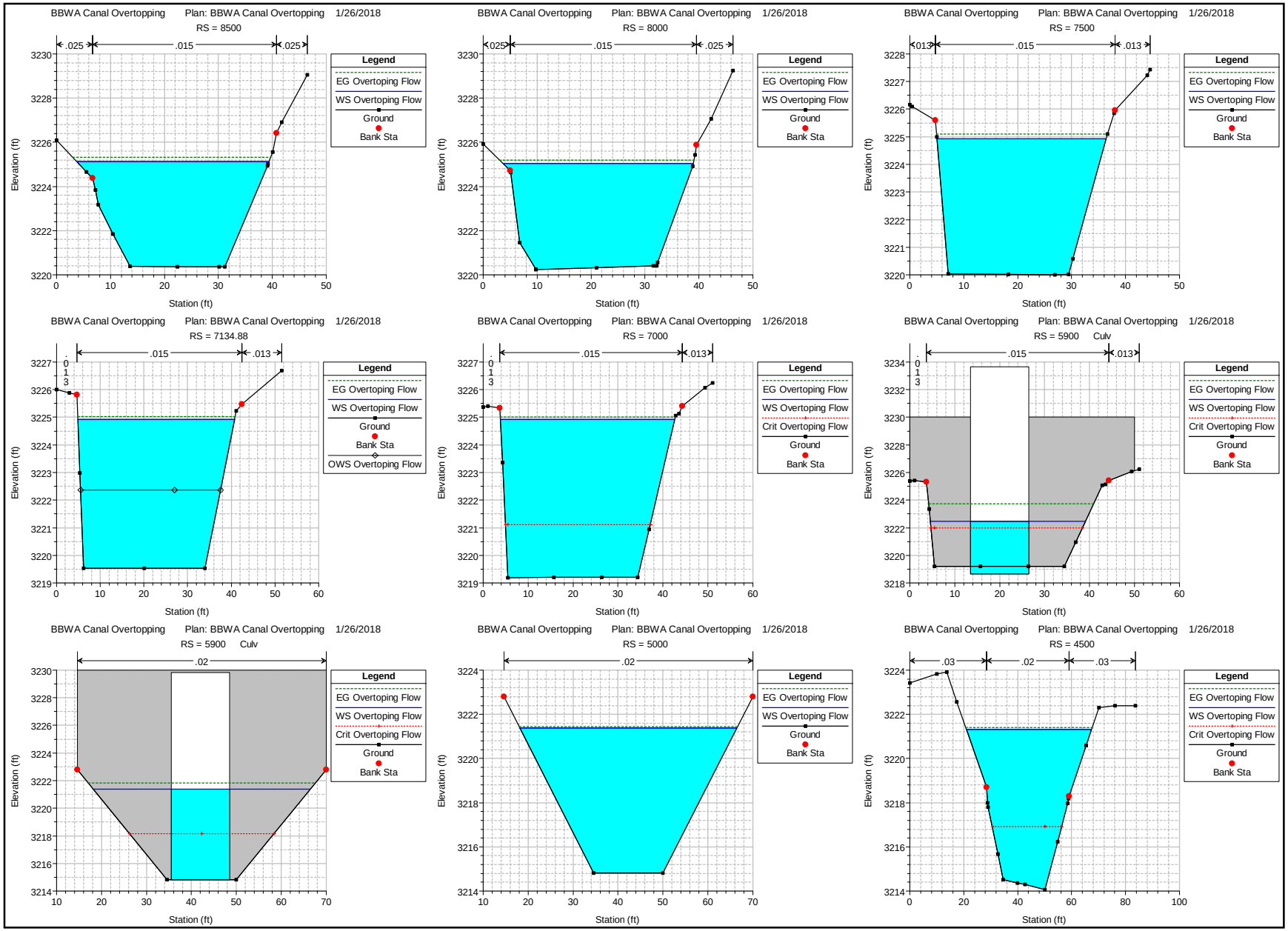

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RS = 29500
RS = 29000
RS = 28500
RS = 28000
RS = 27500
RS = 27000
RS = 26500
RS = 26019.69
RS = 25500
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

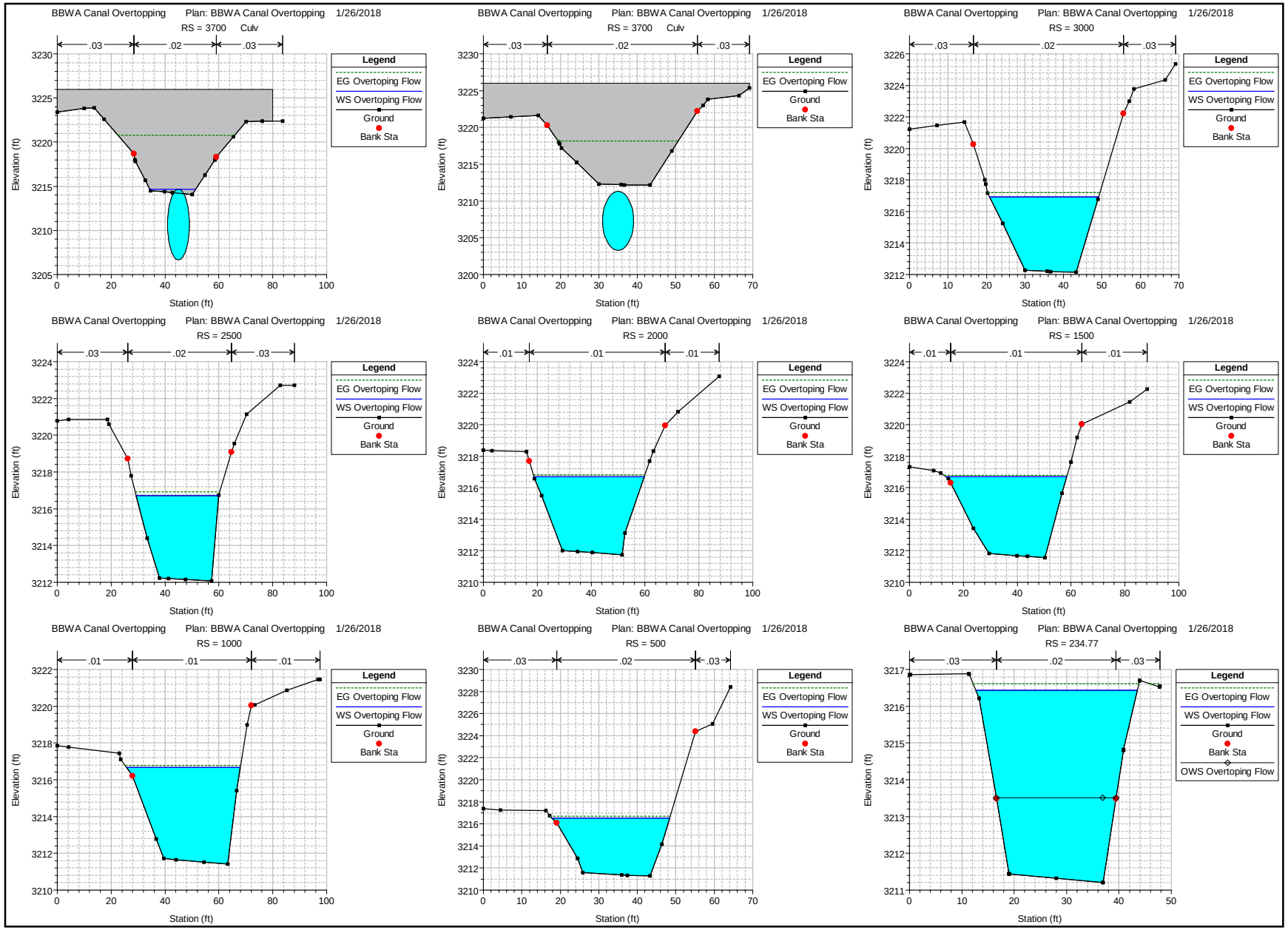

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 25000
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 24898.15
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
OWS Overtoping Flow
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 24500
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 24000
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 23500
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 23000
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 22500
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 22000
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 21500
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)


BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 21000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 20701.27
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
OWS Overtoping Flow
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 20500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 20000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 19500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 19000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 18500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 18000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 17500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

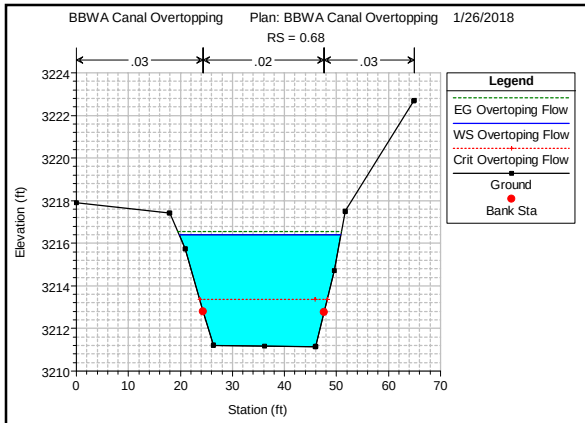

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 16993.07
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 16500
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 16000
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 15500
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 15000
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 14500
.015
.025
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 14000
.025
.015
.025
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 13644.48
.025
.015
.025
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
OWS Overtoping Flow
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 13500
.015
.025
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)


BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 13000
RS = 12500
RS = 12000
RS = 11500
RS = 11000
RS = 10500
RS = 10000
RS = 9500
RS = 9000
.025
.015
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)


BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 8500
.025 .015 .025
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 8000
.025 .015 .025
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 7500
.013 .015 .013
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 7134.88
.013 .015 .013
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
OWS Overtoping Flow
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 7000
.013 .015 .013
Legend
EG Overtoping Flow
WS Overtoping Flow
Crit Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 5900 Culv
.013 .015 .013
Legend
EG Overtoping Flow
WS Overtoping Flow
Crit Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 5900 Culv
.02
Legend
EG Overtoping Flow
WS Overtoping Flow
Crit Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 5000
.02
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 4500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Crit Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)


BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 3700 Culv
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 3700 Culv
.03 .02 .03
Legend
EG Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 3000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 2500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 2000
.01 .01 .01
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 1500
.01 .01 .01
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 1000
.01 .01 .01
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 234.77
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
OWS Overtoping Flow
Elevation (ft)
Station (ft)

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018

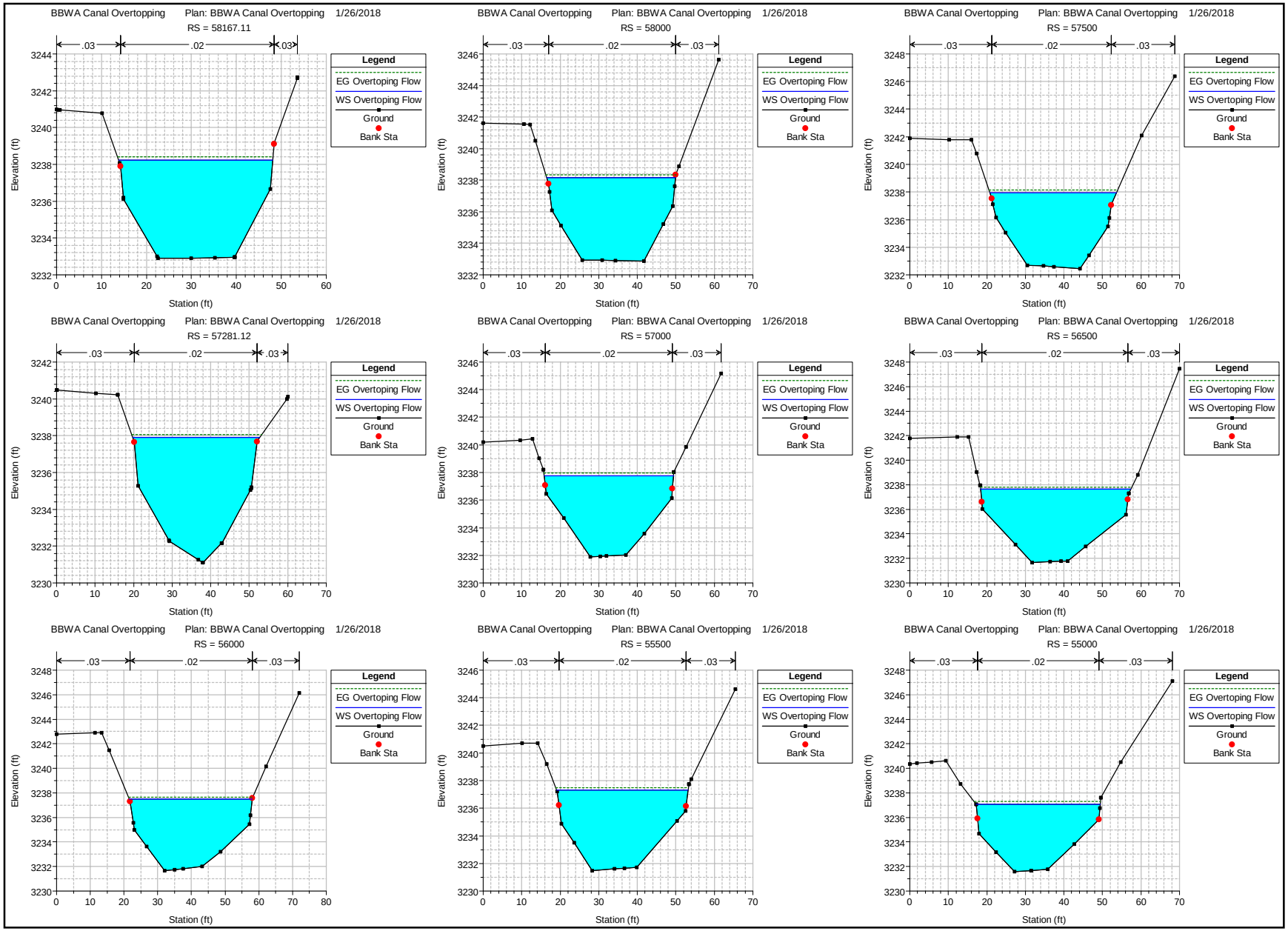


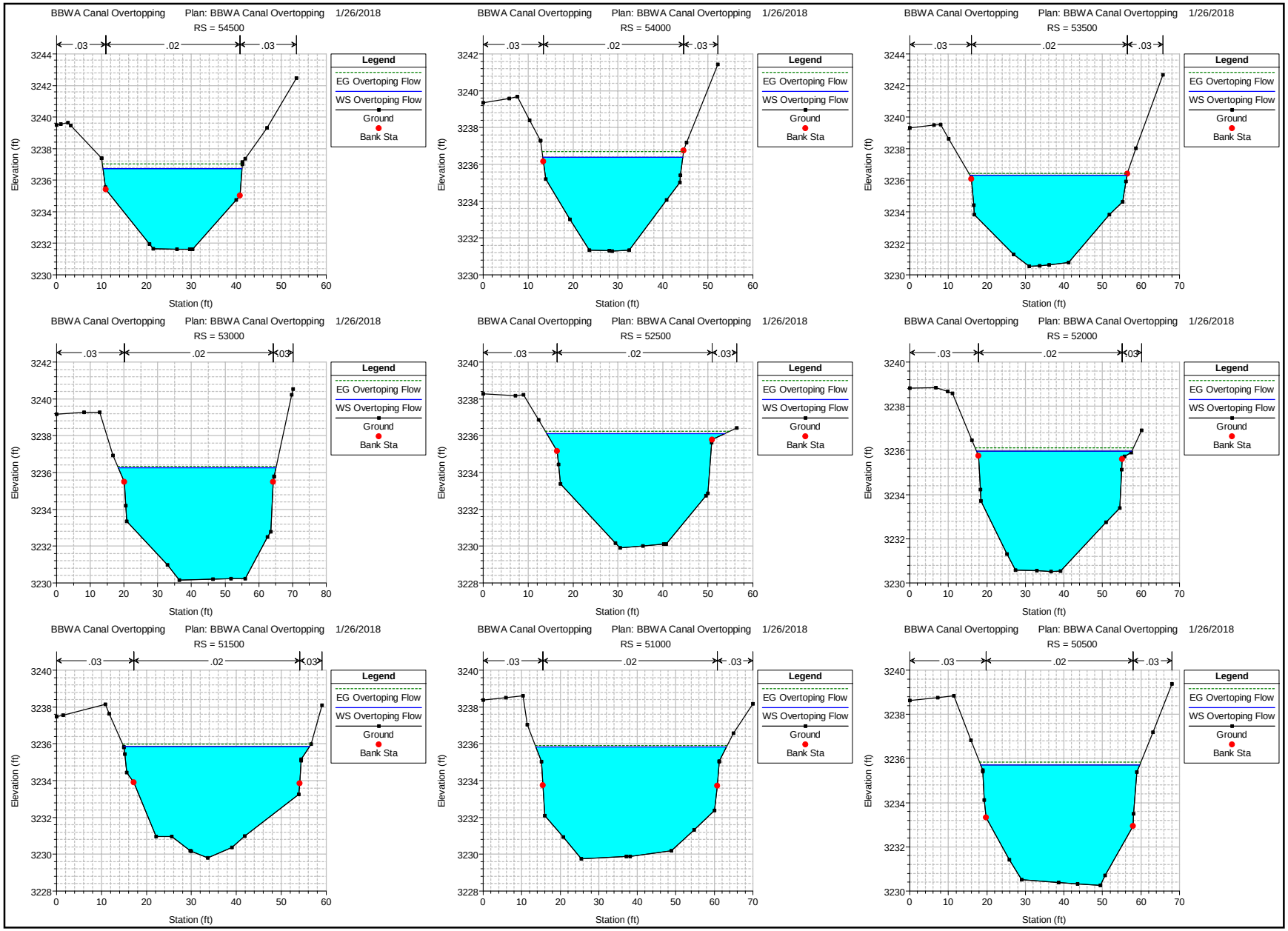
HEC-RAS Plan: 450 CFS River: BBWA_Canal Reach: BBWA_CANAL Profile: Overtoping Flow

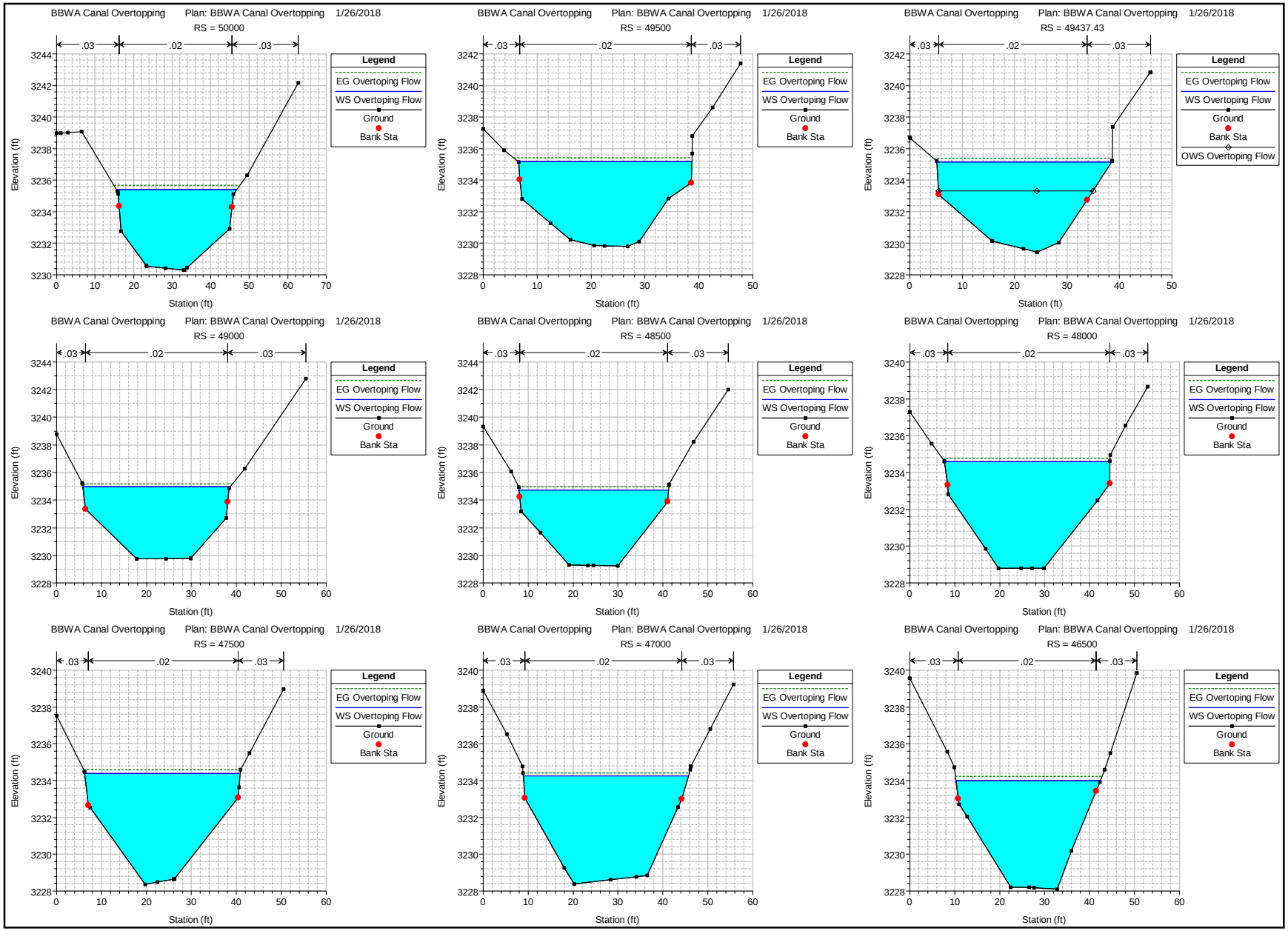
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
BBWA_CANAL	58167.11	Overtoping Flow	450.00	3232.89	3237.96		3238.13	0.000333	3.25	138.60	33.76	0.28
BBWA_CANAL	58000	Overtoping Flow	450.00	3232.86	3237.88		3238.06	0.000375	3.40	132.26	33.01	0.30
BBWA_CANAL	57500	Overtoping Flow	450.00	3232.46	3237.66		3237.87	0.000414	3.60	125.16	32.08	0.32
BBWA_CANAL	57281.12	Overtoping Flow	450.00	3231.12	3237.63		3237.78	0.000267	3.08	146.06	31.75	0.25
BBWA_CANAL	57000	Overtoping Flow	450.00	3231.88	3237.50		3237.69	0.000376	3.44	131.03	33.40	0.30
BBWA_CANAL	56500	Overtoping Flow	450.00	3231.66	3237.38		3237.52	0.000257	2.91	154.58	38.46	0.25
BBWA_CANAL	56000	Overtoping Flow	450.00	3231.67	3237.23		3237.38	0.000293	3.05	147.51	36.08	0.27
BBWA_CANAL	55500	Overtoping Flow	450.00	3231.49	3237.05		3237.22	0.000326	3.30	136.68	33.72	0.29
BBWA_CANAL	55000	Overtoping Flow	450.00	3231.58	3236.80		3237.02	0.000481	3.79	119.02	32.00	0.34
BBWA_CANAL	54500	Overtoping Flow	450.00	3231.61	3236.47		3236.74	0.000620	4.22	107.24	30.72	0.39
BBWA_CANAL	54000	Overtoping Flow	450.00	3231.30	3236.11		3236.40	0.000757	4.35	103.51	30.80	0.42
BBWA_CANAL	53500	Overtoping Flow	450.00	3230.54	3236.01		3236.14	0.000263	2.85	157.83	40.13	0.25
BBWA_CANAL	53000	Overtoping Flow	450.00	3230.15	3235.97		3236.04	0.000111	2.10	214.55	45.71	0.17
BBWA_CANAL	52500	Overtoping Flow	450.00	3229.90	3235.83		3235.96	0.000224	2.85	158.64	36.63	0.23
BBWA_CANAL	52000	Overtoping Flow	450.00	3230.52	3235.69		3235.83	0.000286	2.98	150.87	37.55	0.26
BBWA_CANAL	51500	Overtoping Flow	450.00	3229.81	3235.58		3235.70	0.000214	2.80	162.84	40.41	0.24
BBWA_CANAL	51000	Overtoping Flow	450.00	3229.74	3235.56		3235.62	0.000089	1.98	228.22	48.32	0.16
BBWA_CANAL	50500	Overtoping Flow	450.00	3230.26	3235.44		3235.55	0.000182	2.66	170.85	40.07	0.22
BBWA_CANAL	50000	Overtoping Flow	450.00	3230.30	3235.14		3235.39	0.000540	4.00	112.88	29.98	0.36
BBWA_CANAL	49500	Overtoping Flow	450.00	3229.79	3234.91		3235.13	0.000469	3.74	120.34	32.09	0.34
BBWA_CANAL	49437.43	Overtoping Flow	450.00	3229.44	3234.88		3235.10	0.000418	3.81	121.70	32.77	0.33
BBWA_CANAL	49000	Overtoping Flow	450.00	3229.74	3234.69		3234.90	0.000433	3.67	123.15	32.35	0.33
BBWA_CANAL	48500	Overtoping Flow	450.00	3229.25	3234.47		3234.68	0.000461	3.66	122.97	33.10	0.33
BBWA_CANAL	48000	Overtoping Flow	450.00	3228.79	3234.32		3234.48	0.000306	3.15	143.17	36.64	0.28
BBWA_CANAL	47500	Overtoping Flow	450.00	3228.37	3234.11		3234.30	0.000397	3.52	128.25	34.34	0.32
BBWA_CANAL	47000	Overtoping Flow	450.00	3228.39	3233.97		3234.12	0.000273	3.07	147.03	36.32	0.26
BBWA_CANAL	46500	Overtoping Flow	450.00	3228.11	3233.72		3233.94	0.000465	3.76	119.75	31.51	0.34
BBWA_CANAL	46000	Overtoping Flow	450.00	3228.09	3233.53		3233.71	0.000401	3.47	130.40	34.92	0.31
BBWA_CANAL	45500	Overtoping Flow	450.00	3228.26	3233.37		3233.52	0.000327	3.12	144.38	37.36	0.28
BBWA_CANAL	45000	Overtoping Flow	450.00	3227.63	3233.28		3233.38	0.000195	2.60	173.01	39.64	0.22
BBWA_CANAL	44628.09	Overtoping Flow	450.00	3227.59	3233.11		3233.28	0.000336	3.35	134.62	30.59	0.28
BBWA_CANAL	44500	Overtoping Flow	450.00	3227.44	3233.07		3233.24	0.000320	3.27	137.43	30.83	0.27
BBWA_CANAL	44000	Overtoping Flow	450.00	3227.15	3232.91		3233.08	0.000336	3.30	136.42	32.20	0.28
BBWA_CANAL	43500	Overtoping Flow	450.00	3227.34	3232.80		3232.92	0.000244	2.82	159.47	38.72	0.24
BBWA_CANAL	43000	Overtoping Flow	450.00	3227.46	3232.54		3232.75	0.000436	3.66	123.45	31.31	0.32
BBWA_CANAL	42500	Overtoping Flow	450.00	3226.90	3232.45		3232.57	0.000223	2.85	158.60	36.47	0.24
BBWA_CANAL	42000	Overtoping Flow	450.00	3226.53	3232.34		3232.46	0.000223	2.83	159.27	36.53	0.24
BBWA_CANAL	41500	Overtoping Flow	450.00	3226.78	3232.08		3232.29	0.000491	3.75	119.99	31.28	0.34
BBWA_CANAL	41000	Overtoping Flow	450.00	3226.47	3231.91		3232.08	0.000342	3.27	137.65	34.24	0.29
BBWA_CANAL	40500	Overtoping Flow	450.00	3226.50	3231.72		3231.89	0.000384	3.36	134.04	35.37	0.30
BBWA_CANAL	40000	Overtoping Flow	450.00	3226.34	3231.49		3231.69	0.000447	3.57	126.16	34.22	0.33
BBWA_CANAL	39500	Overtoping Flow	450.00	3226.02	3231.41		3231.51	0.000203	2.63	170.78	40.47	0.23
BBWA_CANAL	39000	Overtoping Flow	450.00	3225.89	3231.20		3231.38	0.000341	3.33	135.17	32.51	0.28
BBWA_CANAL	38732.07	Overtoping Flow	450.00	3225.97	3231.12		3231.29	0.000327	3.32	135.94	32.37	0.28
BBWA_CANAL	38500	Overtoping Flow	450.00	3225.68	3231.06		3231.21	0.000282	3.10	145.24	33.67	0.26
BBWA_CANAL	38000	Overtoping Flow	450.00	3225.31	3230.95		3231.08	0.000229	2.87	157.01	34.85	0.24
BBWA_CANAL	37500	Overtoping Flow	450.00	3225.61	3230.81		3230.95	0.000265	2.99	150.80	35.45	0.25
BBWA_CANAL	37000	Overtoping Flow	450.00	3225.52	3230.68		3230.82	0.000280	3.02	149.24	36.11	0.26
BBWA_CANAL	36500	Overtoping Flow	450.00	3225.69	3230.60		3230.69	0.000183	2.41	186.40	47.12	0.21
BBWA_CANAL	36000	Overtoping Flow	450.00	3226.10	3230.42		3230.56	0.000337	3.04	148.22	42.24	0.28
BBWA_CANAL	35500	Overtoping Flow	450.00	3225.52	3230.15		3230.36	0.000476	3.68	122.45	32.12	0.33
BBWA_CANAL	35000	Overtoping Flow	450.00	3225.19	3229.95		3230.14	0.000389	3.42	131.77	33.62	0.30
BBWA_CANAL	34500	Overtoping Flow	450.00	3224.90	3229.76		3229.94	0.000400	3.42	131.62	34.04	0.30
BBWA_CANAL	34000	Overtoping Flow	450.00	3224.53	3229.62		3229.76	0.000281	3.05	147.81	35.44	0.26
BBWA_CANAL	33500	Overtoping Flow	450.00	3224.30	3229.53		3229.63	0.000188	2.59	173.96	40.61	0.22
BBWA_CANAL	33000	Overtoping Flow	450.00	3224.60	3229.33		3229.50	0.000348	3.29	137.04	34.54	0.29
BBWA_CANAL	32500	Overtoping Flow	450.00	3224.60	3229.14		3229.32	0.000368	3.46	135.10	37.60	0.30
BBWA_CANAL	32000	Overtoping Flow	450.00	3224.22	3228.98		3229.15	0.000311	3.30	150.02	48.71	0.28
BBWA_CANAL	31500	Overtoping Flow	450.00	3223.70	3228.86		3229.00	0.000243	3.00	151.59	36.75	0.25
BBWA_CANAL	31434.79	Overtoping Flow	450.00	3223.71	3228.83		3228.98	0.000292	3.20	143.59	37.96	0.28
BBWA_CANAL	31000	Overtoping Flow	450.00	3223.50	3228.75		3228.87	0.000207	2.75	168.45	43.25	0.23
BBWA_CANAL	30500	Overtoping Flow	450.00	3223.38	3228.51		3228.72	0.000381	3.69	124.47	31.90	0.31
BBWA_CANAL	30000	Overtoping Flow	450.00	3222.81	3228.54		3228.59	0.000089	1.86	241.93	53.81	0.15
BBWA_CANAL	29500	Overtoping Flow	450.00	3222.32	3228.44		3228.53	0.000150	2.46	183.33	38.43	0.20
BBWA_CANAL	29000	Overtoping Flow	450.00	3222.40	3228.37		3228.46	0.000133	2.30	195.67	40.55	0.18
BBWA_CANAL	28500	Overtoping Flow	450.00	3221.90	3228.34		3228.40	0.000079	1.85	243.88	49.71	0.15
BBWA_CANAL	28000	Overtoping Flow	450.00	3221.11	3228.28		3228.35	0.000091	2.10	215.83	41.41	0.16
BBWA_CANAL	27500	Overtoping Flow	450.00	3220.88	3228.22		3228.30	0.000109	2.23	203.09	41.71	0.17
BBWA_CANAL	27000	Overtoping Flow	450.00	3221.45	3228.17		3228.24	0.000114	2.23	202.98	42.90	0.17
BBWA_CANAL	26500	Overtoping Flow	450.00	3221.60	3228.13		3228.19	0.000086	1.91	235.94	49.89	0.15
BBWA_CANAL	26019.69	Overtoping Flow	450.00	3221.53	3228.08		3228.14	0.000101	2.03	222.06	47.23	0.16
BBWA_CANAL	25500	Overtoping Flow	450.00	3221.37	3228.05		3228.10	0.000067	1.74	258.67	50.46	0.13
BBWA_CANAL	25000	Overtoping Flow	450.00	3221.53	3227.98		3228.05	0.000112	2.21	207.96	45.34	0.17
BBWA_CANAL	24898.15	Overtoping Flow	450.00	3221.64	3227.97		3228.04	0.000102	2.13	213.56	45.71	0.17
BBWA_CANAL	24500	Overtoping Flow	450.00	3221.34	3227.93		3228.00	0.000104	2.12	212.91	43.54	0.17
BBWA_CANAL	24000	Overtoping Flow	450.00	3221.64	3227.87		3227.94	0.000119	2.20	205.32	44.84	0.18
BBWA_CANAL	23500	Overtoping Flow	450.00	3221.80	3227.83		3227.89	0.000086	1.93	234.93	49.30	0.15
BBWA_CANAL	23000	Overtoping Flow	450.00	3221.90	3227.76		3227.83	0.000124	2.23	203.70	45.91	0.18
BBWA_CANAL	22500	Overtoping Flow	450.00	3221.98	3227.69		3227.77	0.000129	2.21	204.82	48.86	0.18
BBWA_CANAL	22000	Overtoping Flow	450.00	3221.99	3227.63		3227.71	0.000125	2.22	203.64	47.49	0.18
BBWA_CANAL	21500	Overtoping Flow	450.00	3221.97	3227.57		3227.64	0.000122	2.18	207.00	45.34	0.18

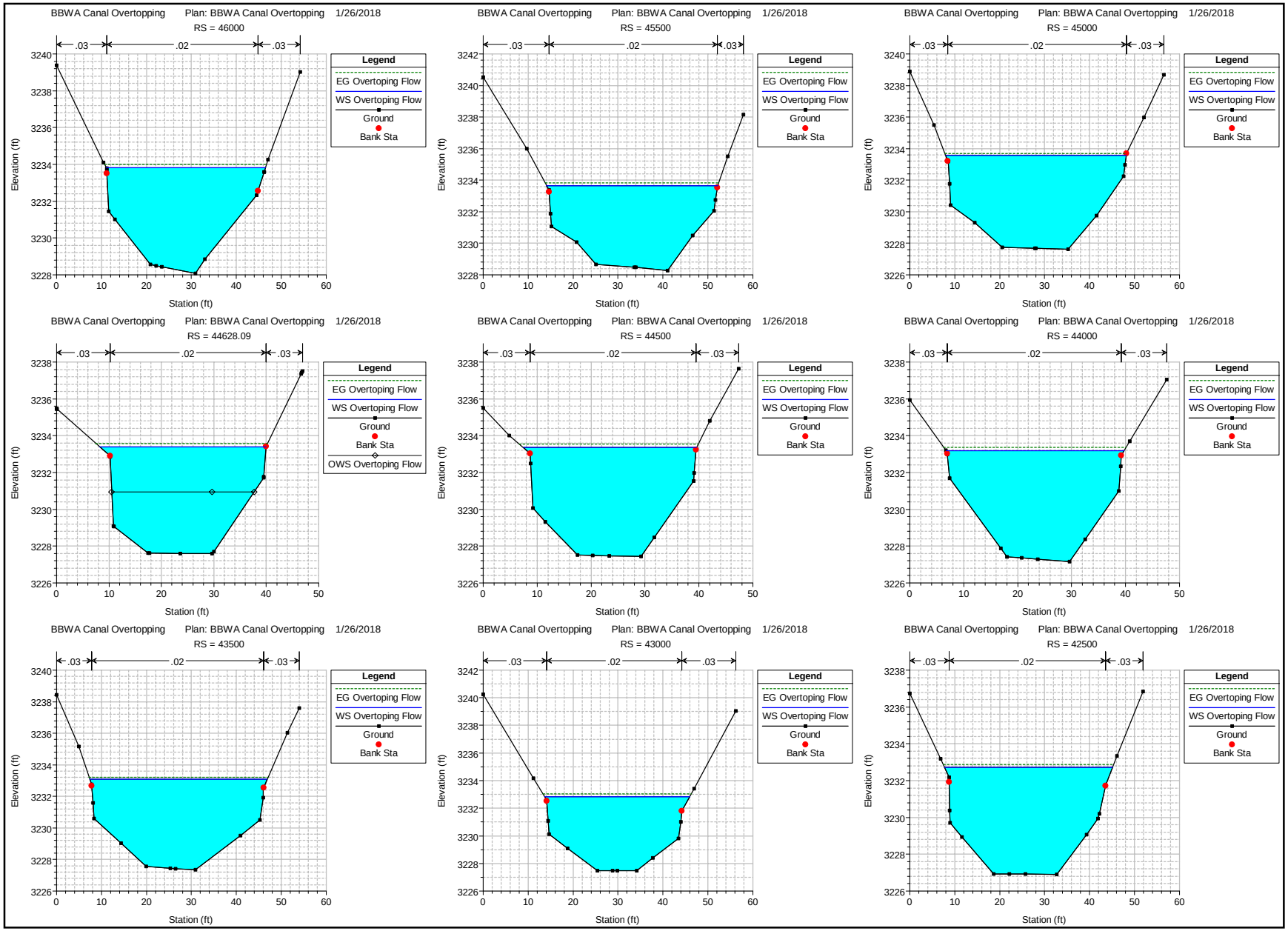
HEC-RAS Plan: 450 CFS River: BBWA_Canal Reach: BBWA_CANAL Profile: Overtoping Flow (Continued)

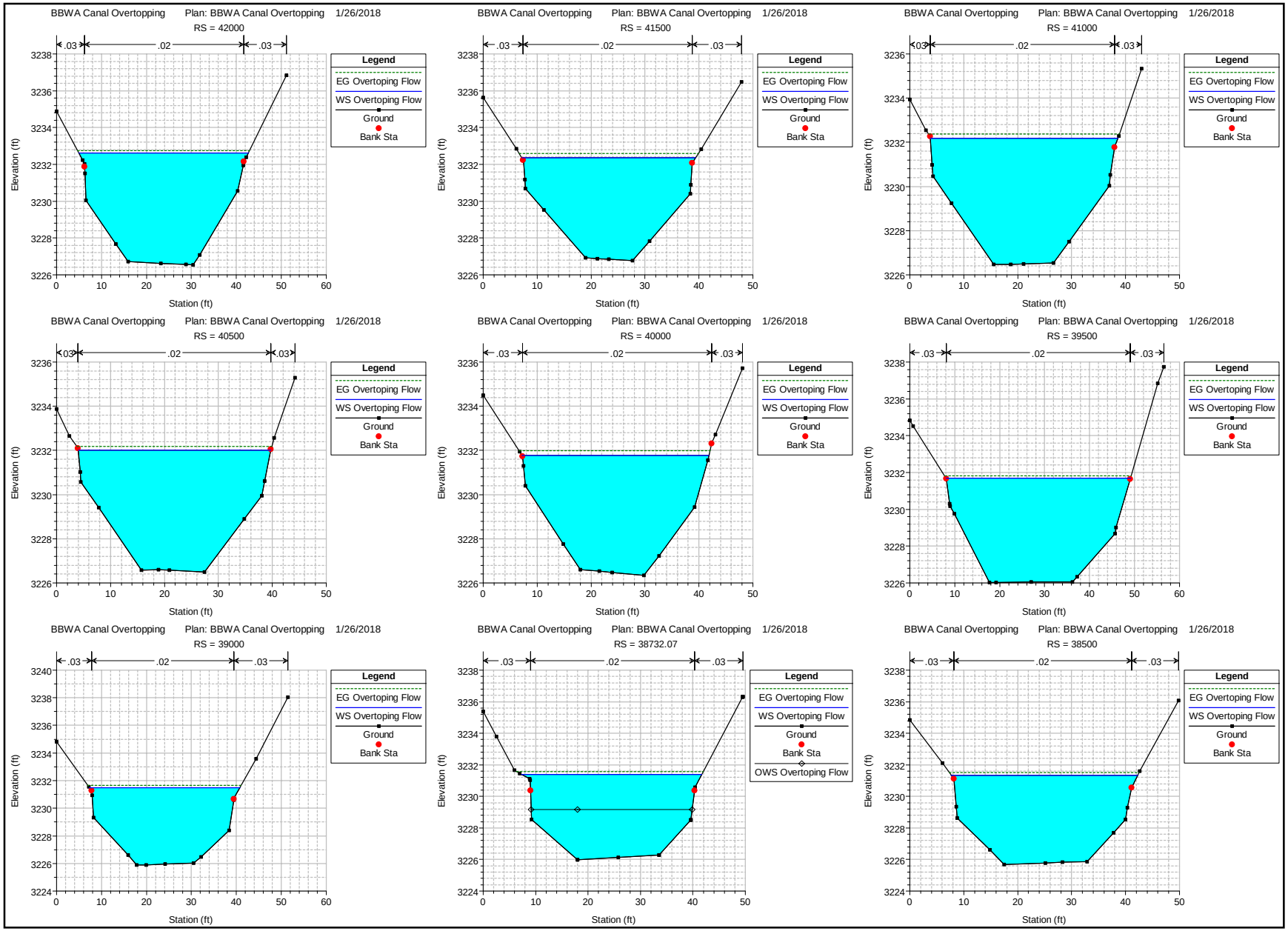
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
BBWA_CANAL	21000	Overtoping Flow	450.00	3221.34	3227.54		3227.59	0.000075	1.78	253.24	52.82	0.14
BBWA_CANAL	20701.27	Overtoping Flow	450.00	3220.56	3227.48		3227.56	0.000120	2.24	201.47	40.44	0.17
BBWA_CANAL	20500	Overtoping Flow	450.00	3220.73	3227.46		3227.53	0.000119	2.22	202.89	40.85	0.17
BBWA_CANAL	20000	Overtoping Flow	450.00	3220.84	3227.39		3227.47	0.000138	2.29	196.23	42.75	0.19
BBWA_CANAL	19500	Overtoping Flow	450.00	3220.87	3227.34		3227.40	0.000106	2.06	218.40	45.43	0.17
BBWA_CANAL	19000	Overtoping Flow	450.00	3221.19	3227.23		3227.33	0.000176	2.54	177.33	39.19	0.21
BBWA_CANAL	18500	Overtoping Flow	450.00	3220.73	3227.15		3227.25	0.000172	2.52	178.86	42.14	0.21
BBWA_CANAL	18000	Overtoping Flow	450.00	3220.01	3227.03		3227.15	0.000204	2.76	165.00	41.78	0.23
BBWA_CANAL	17500	Overtoping Flow	450.00	3219.53	3226.89		3227.03	0.000268	3.06	147.40	35.15	0.26
BBWA_CANAL	16993.07	Overtoping Flow	450.00	3219.74	3226.91		3226.95	0.000058	1.58	284.31	59.27	0.13
BBWA_CANAL	16500	Overtoping Flow	450.00	3220.07	3226.82		3226.90	0.000129	2.29	197.30	41.62	0.18
BBWA_CANAL	16000	Overtoping Flow	450.00	3220.51	3226.74		3226.83	0.000152	2.44	184.97	40.75	0.20
BBWA_CANAL	15500	Overtoping Flow	450.00	3220.09	3226.70		3226.76	0.000094	2.07	218.16	41.11	0.15
BBWA_CANAL	15000	Overtoping Flow	450.00	3220.23	3226.66		3226.72	0.000085	1.97	228.28	41.28	0.15
BBWA_CANAL	14500	Overtoping Flow	450.00	3220.50	3226.61		3226.68	0.000057	2.10	216.55	46.27	0.16
BBWA_CANAL	14000	Overtoping Flow	450.00	3220.38	3226.58		3226.65	0.000055	2.15	214.94	46.19	0.16
BBWA_CANAL	13644.48	Overtoping Flow	450.00	3220.25	3226.55		3226.63	0.000062	2.25	207.51	47.07	0.17
BBWA_CANAL	13500	Overtoping Flow	450.00	3220.38	3226.54		3226.62	0.000062	2.26	211.95	51.76	0.17
BBWA_CANAL	13000	Overtoping Flow	450.00	3220.51	3226.50		3226.59	0.000081	2.39	190.09	44.25	0.19
BBWA_CANAL	12500	Overtoping Flow	450.00	3220.88	3226.35		3226.52	0.000201	3.31	135.77	34.57	0.29
BBWA_CANAL	12000	Overtoping Flow	450.00	3221.08	3226.26		3226.42	0.000191	3.19	141.03	37.08	0.29
BBWA_CANAL	11500	Overtoping Flow	450.00	3220.93	3226.13		3226.31	0.000206	3.46	130.93	35.53	0.30
BBWA_CANAL	11000	Overtoping Flow	450.00	3220.85	3226.04		3226.21	0.000196	3.26	138.34	36.61	0.29
BBWA_CANAL	10500	Overtoping Flow	450.00	3220.77	3225.90		3226.09	0.000249	3.51	128.28	35.70	0.33
BBWA_CANAL	10000	Overtoping Flow	450.00	3220.74	3225.74		3225.96	0.000300	3.74	120.24	35.14	0.36
BBWA_CANAL	9500	Overtoping Flow	450.00	3220.71	3225.50		3225.77	0.000412	4.23	106.41	32.84	0.41
BBWA_CANAL	9000	Overtoping Flow	450.00	3220.55	3225.19		3225.54	0.000504	4.75	94.82	28.32	0.45
BBWA_CANAL	8500	Overtoping Flow	450.00	3220.36	3225.12		3225.32	0.000248	3.62	125.28	35.62	0.33
BBWA_CANAL	8000	Overtoping Flow	450.00	3220.23	3225.04		3225.20	0.000194	3.28	137.59	35.24	0.29
BBWA_CANAL	7500	Overtoping Flow	450.00	3220.00	3224.92		3225.10	0.000213	3.42	131.51	31.31	0.29
BBWA_CANAL	7134.88	Overtoping Flow	450.00	3219.53	3224.92		3225.03	0.000108	2.63	171.27	35.90	0.21
BBWA_CANAL	7000	Overtoping Flow	450.00	3219.19	3224.92	3221.12	3225.01	0.000078	2.32	193.69	38.79	0.18
BBWA_CANAL	5900		Culvert									
BBWA_CANAL	5000	Overtoping Flow	450.00	3214.82	3221.38		3221.46	0.000127	2.15	209.00	48.29	0.18
BBWA_CANAL	4500	Overtoping Flow	450.00	3214.06	3221.31	3216.91	3221.40	0.000100	2.35	207.80	46.29	0.17
BBWA_CANAL	3700		Culvert									
BBWA_CANAL	3000	Overtoping Flow	400.00	3212.15	3216.94		3217.20	0.000647	4.07	98.39	28.35	0.38
BBWA_CANAL	2500	Overtoping Flow	400.00	3212.07	3216.72		3216.91	0.000442	3.48	114.85	30.58	0.32
BBWA_CANAL	2000	Overtoping Flow	400.00	3211.74	3216.71		3216.82	0.000064	2.69	148.64	40.97	0.25
BBWA_CANAL	1500	Overtoping Flow	400.00	3211.55	3216.70		3216.79	0.000049	2.45	163.60	44.75	0.22
BBWA_CANAL	1000	Overtoping Flow	400.00	3211.41	3216.67		3216.76	0.000045	2.43	165.11	42.17	0.21
BBWA_CANAL	500	Overtoping Flow	400.00	3211.27	3216.54		3216.71	0.000355	3.32	120.74	30.65	0.29
BBWA_CANAL	234.77	Overtoping Flow	400.00	3211.20	3216.43		3216.62	0.000294	3.50	122.16	30.85	0.28
BBWA_CANAL	0.68	Overtoping Flow	400.00	3211.13	3216.39	3213.38	3216.55	0.000236	3.27	132.59	31.06	0.25

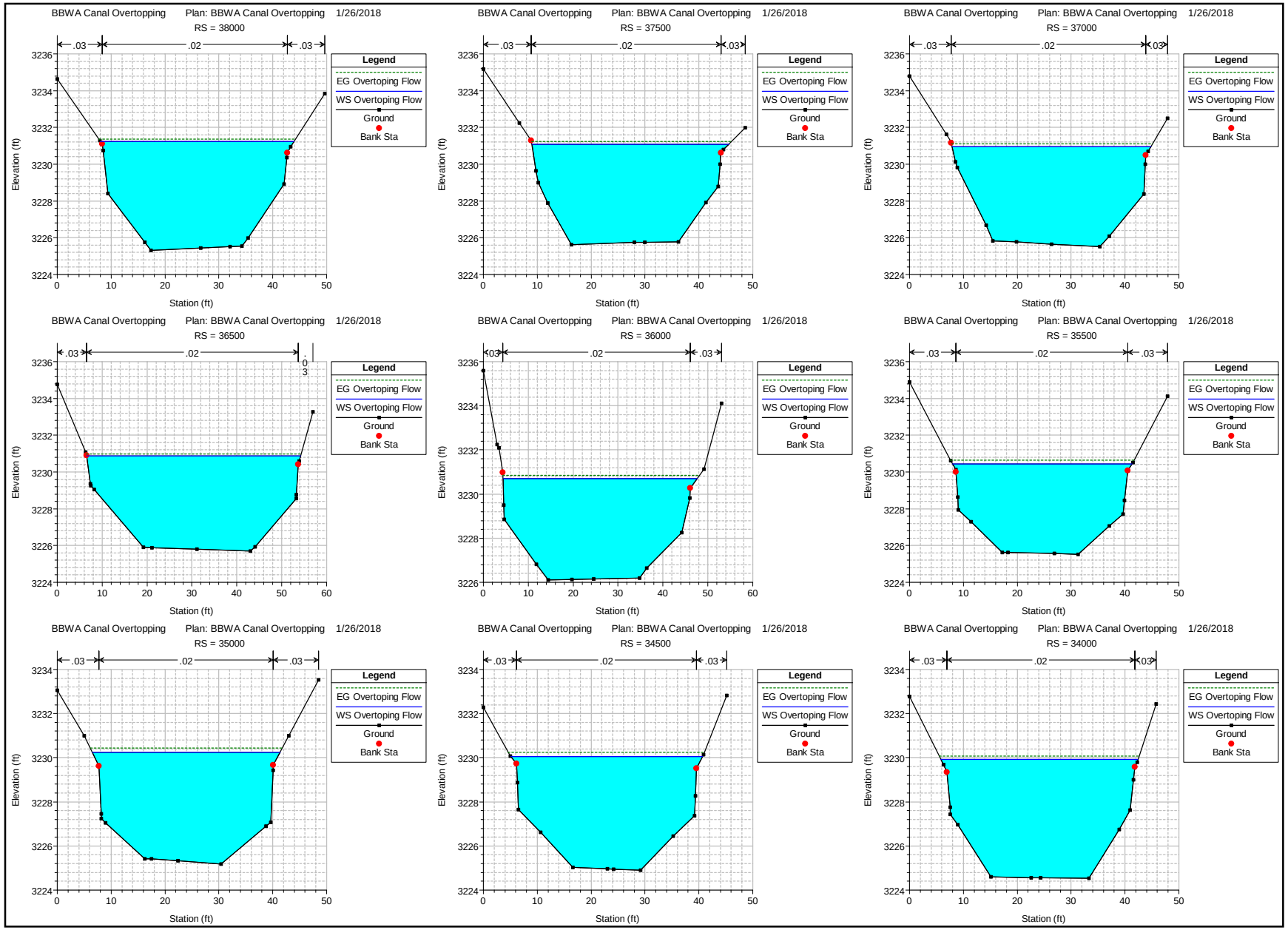

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 58167.11
RS = 58000
RS = 57500
RS = 57281.12
RS = 57000
RS = 56500
RS = 56000
RS = 55500
RS = 55000
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

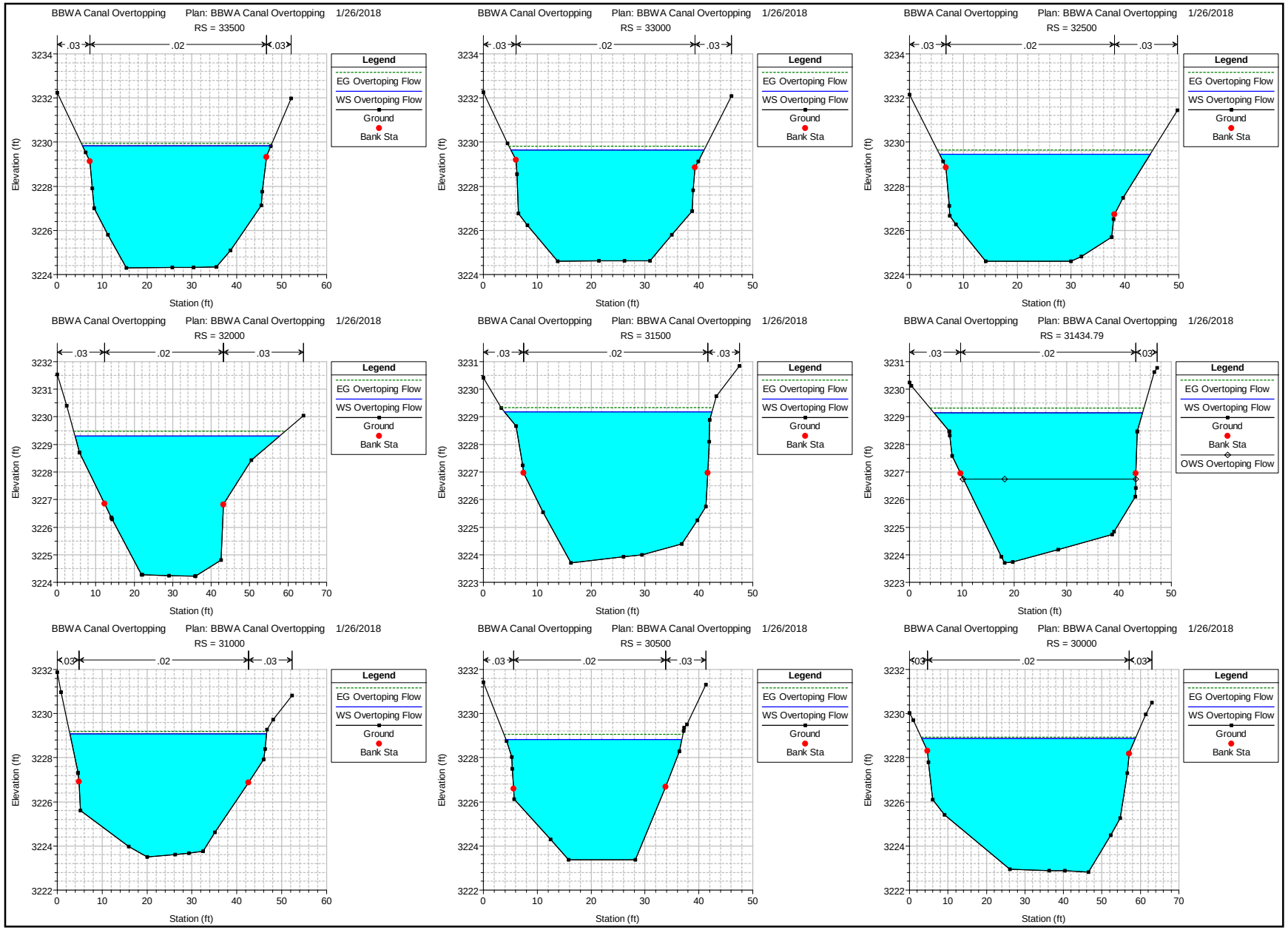

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 54500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 54000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 53500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 53000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 52500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 52000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 51500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 51000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 50500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

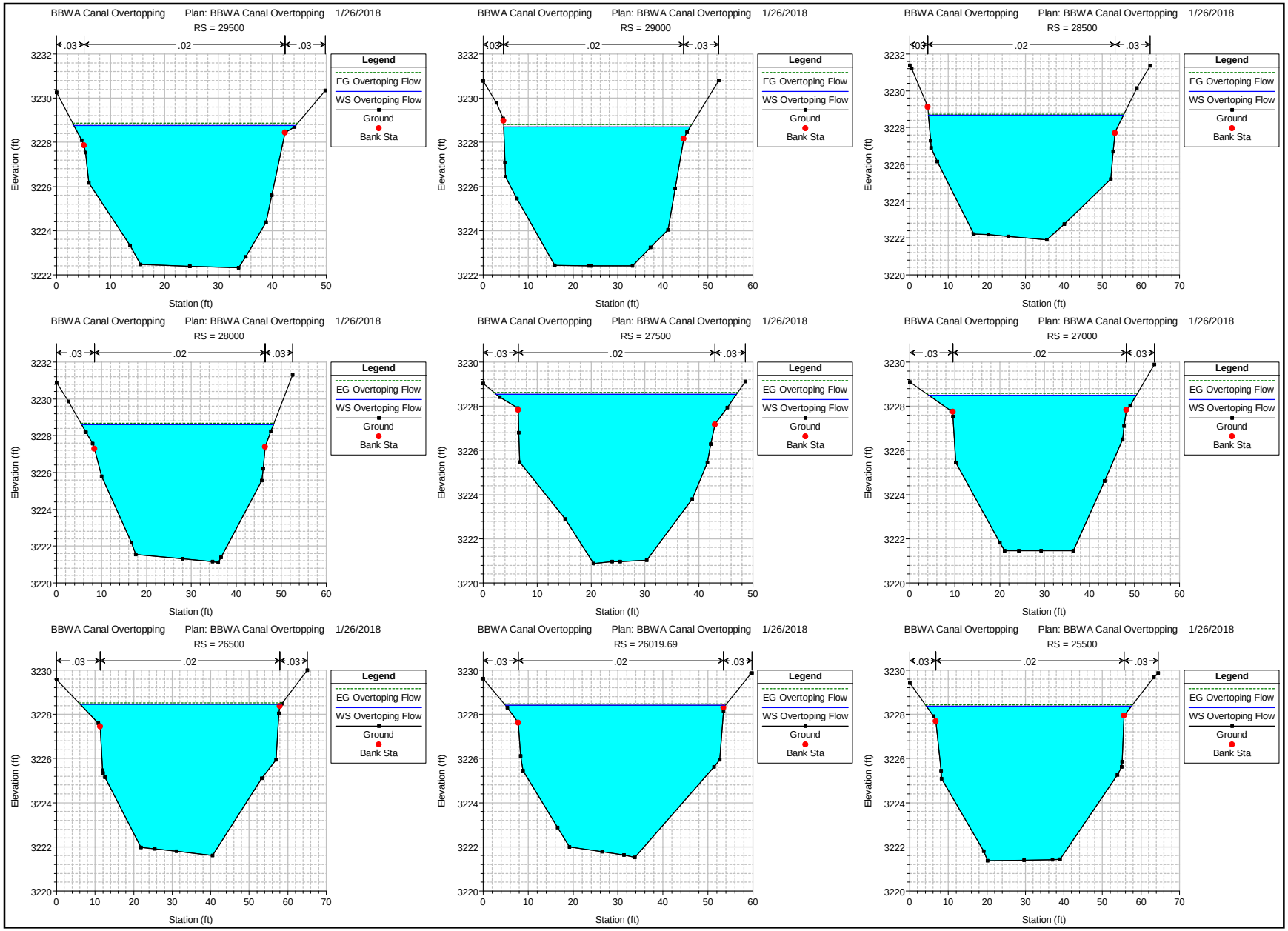

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 50000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 49500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 49437.43
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
OWS Overtoping Flow
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 49000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 48500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 48000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 47500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 47000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 46500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

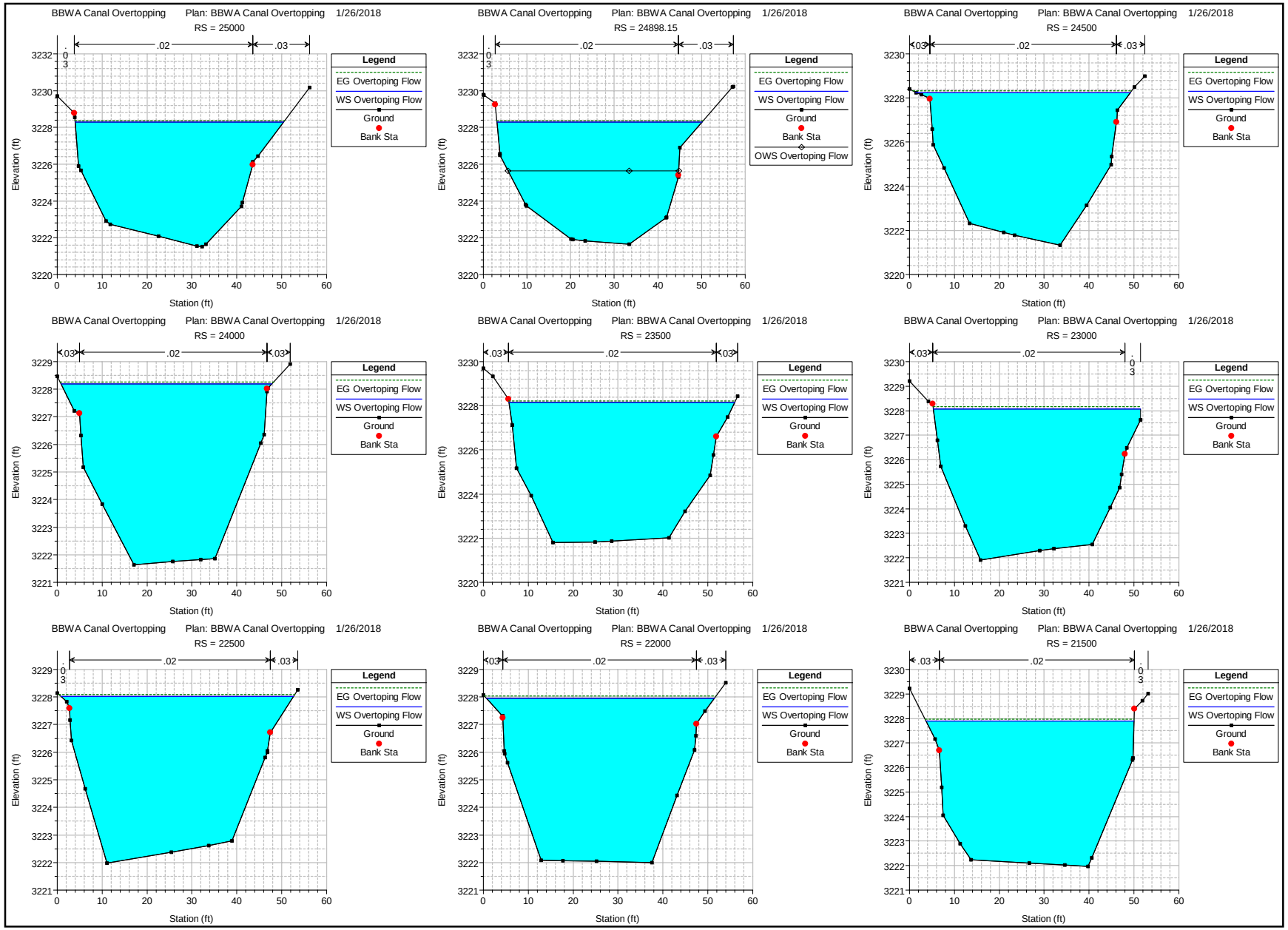

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 46000
RS = 45500
RS = 45000
RS = 44628.09
RS = 44500
RS = 44000
RS = 43500
RS = 43000
RS = 42500
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
OWS Overtoping Flow
Elevation (ft)
Station (ft)

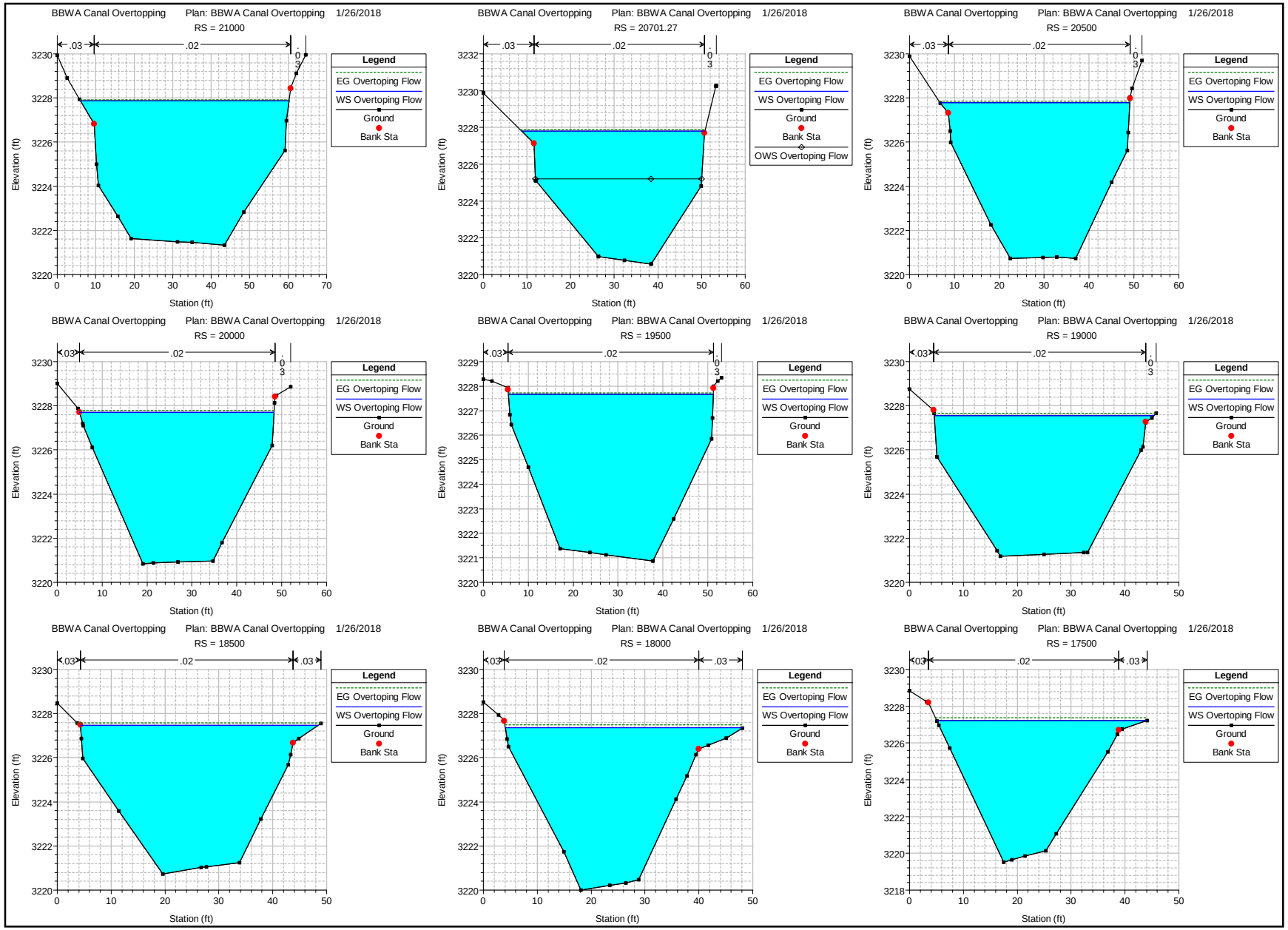

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 42000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 41500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 41000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 40500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 40000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 39500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 39000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 38732.07
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
OWS Overtoping Flow
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 38500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

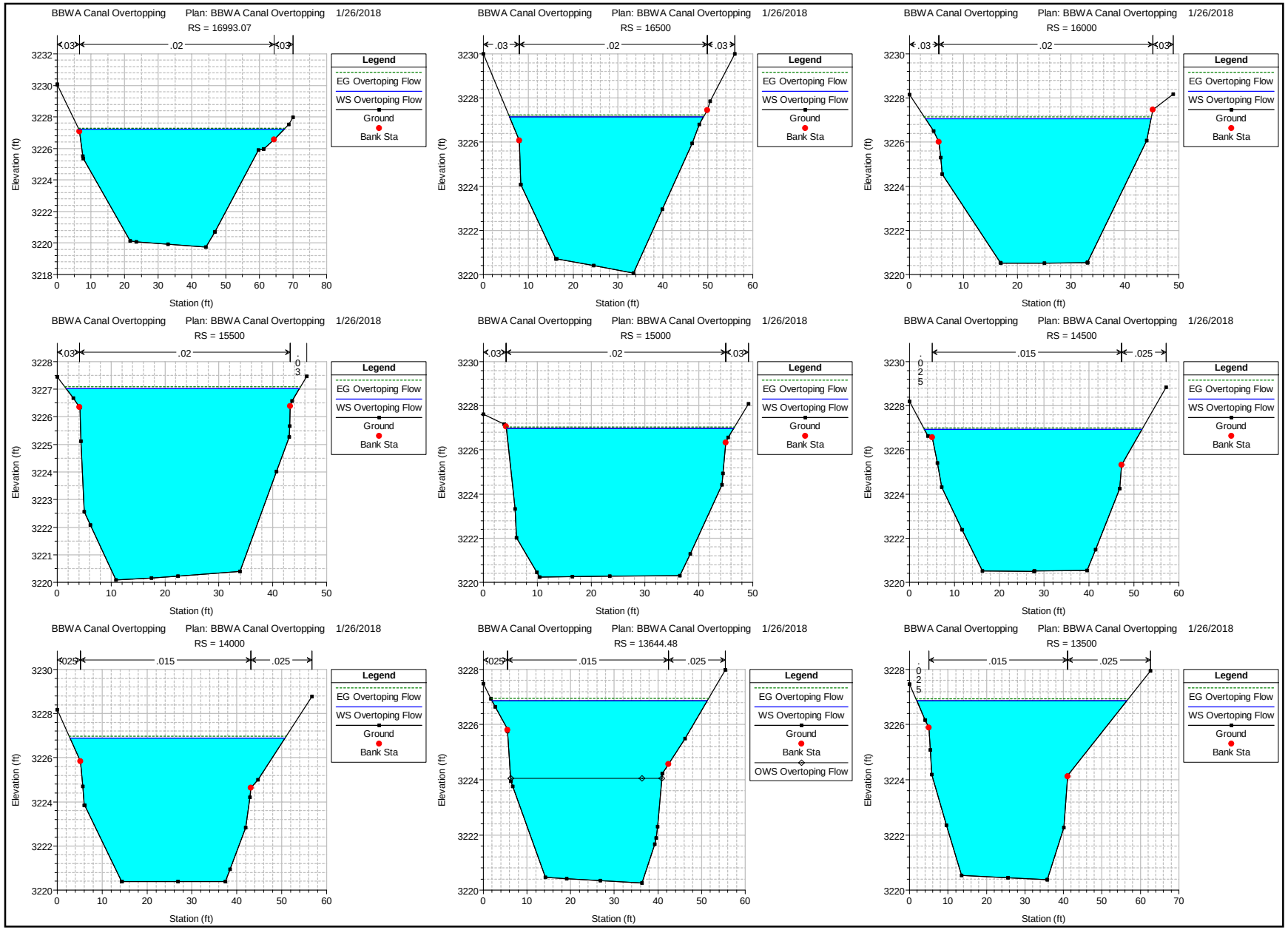

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 38000
RS = 37500
RS = 37000
RS = 36500
RS = 36000
RS = 35500
RS = 35000
RS = 34500
RS = 34000
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

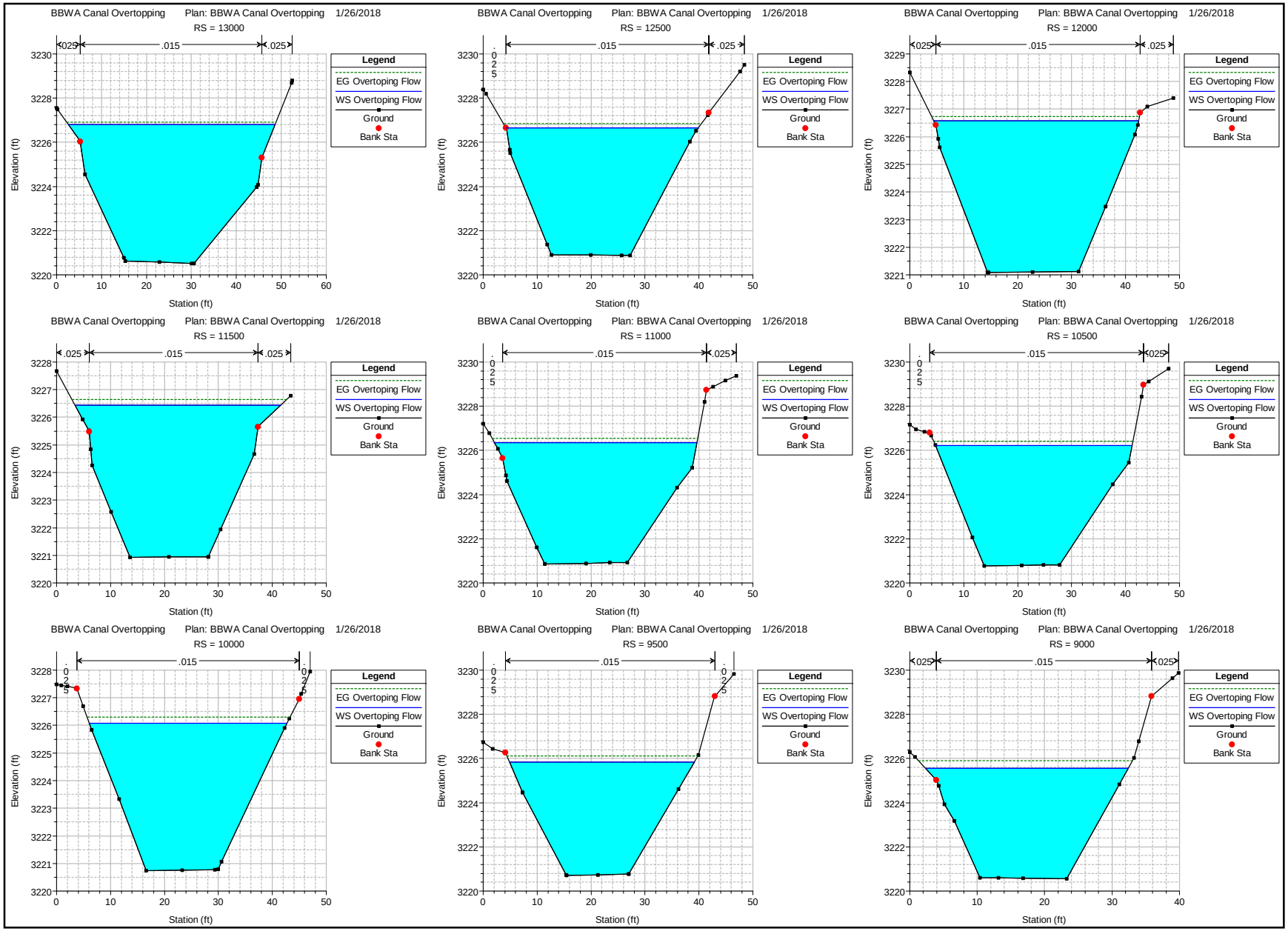

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 33500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 33000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 32500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 32000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 31500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 31434.79
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
OWS Overtoping Flow
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 31000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 30500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 30000
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

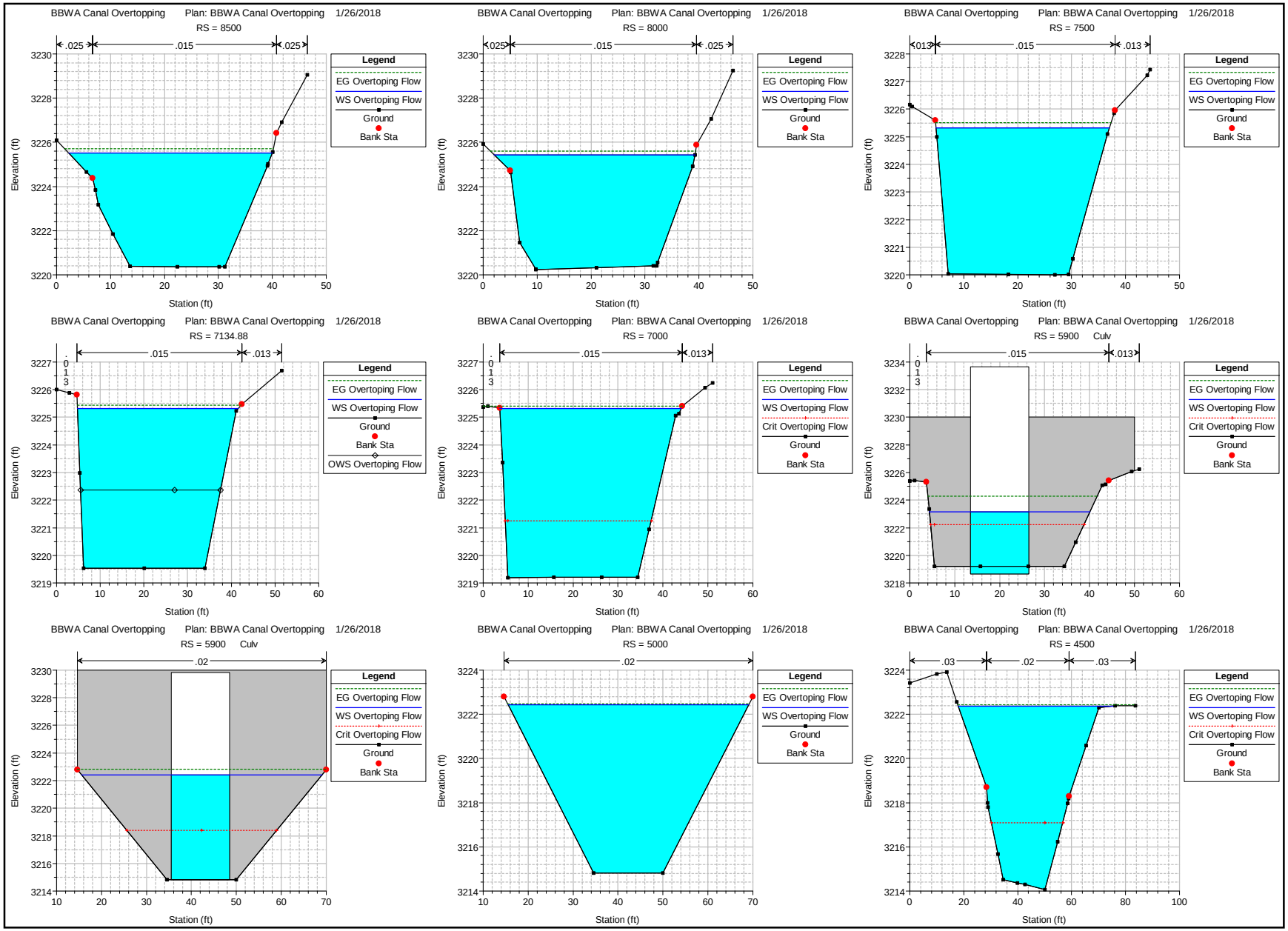

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 29500
RS = 29000
RS = 28500
RS = 28000
RS = 27500
RS = 27000
RS = 26500
RS = 26019.69
RS = 25500
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

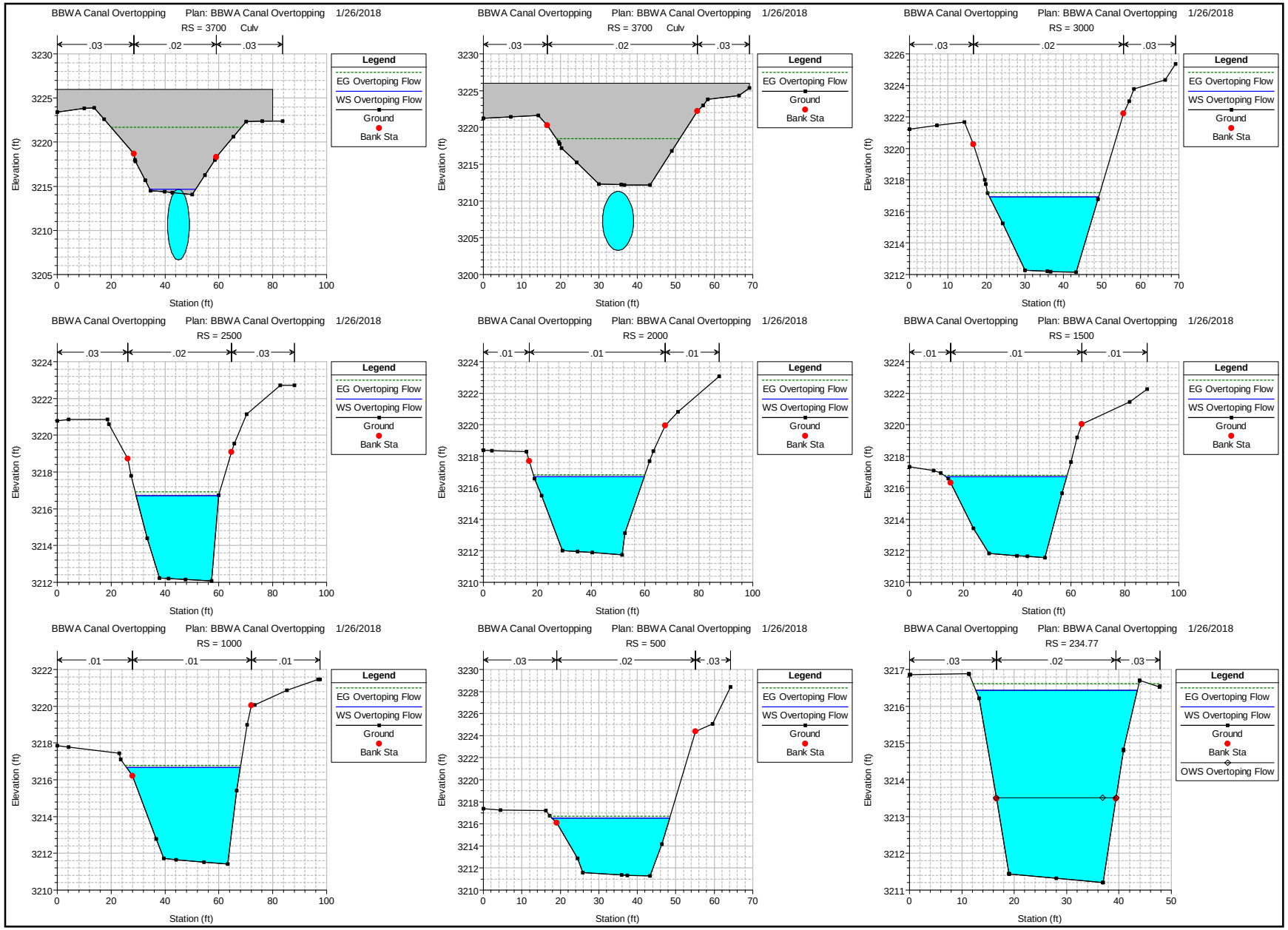

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 25000
RS = 24898.15
RS = 24500
RS = 24000
RS = 23500
RS = 23000
RS = 22500
RS = 22000
RS = 21500
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
OWS Overtoping Flow
Elevation (ft)
Station (ft)


BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 21000
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 20701.27
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
OWS Overtoping Flow
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 20500
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 20000
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 19500
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 19000
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 18500
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 18000
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 17500
.03
.02
.03
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

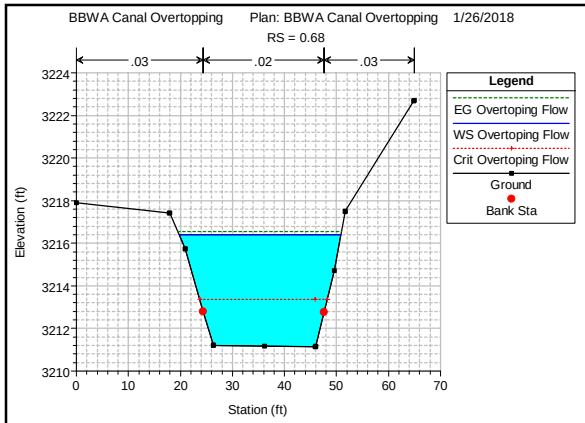

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 16993.07
RS = 16500
RS = 16000
RS = 15500
RS = 15000
RS = 14500
RS = 14000
RS = 13644.48
RS = 13500
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
OWS Overtoping Flow
Elevation (ft)
Station (ft)

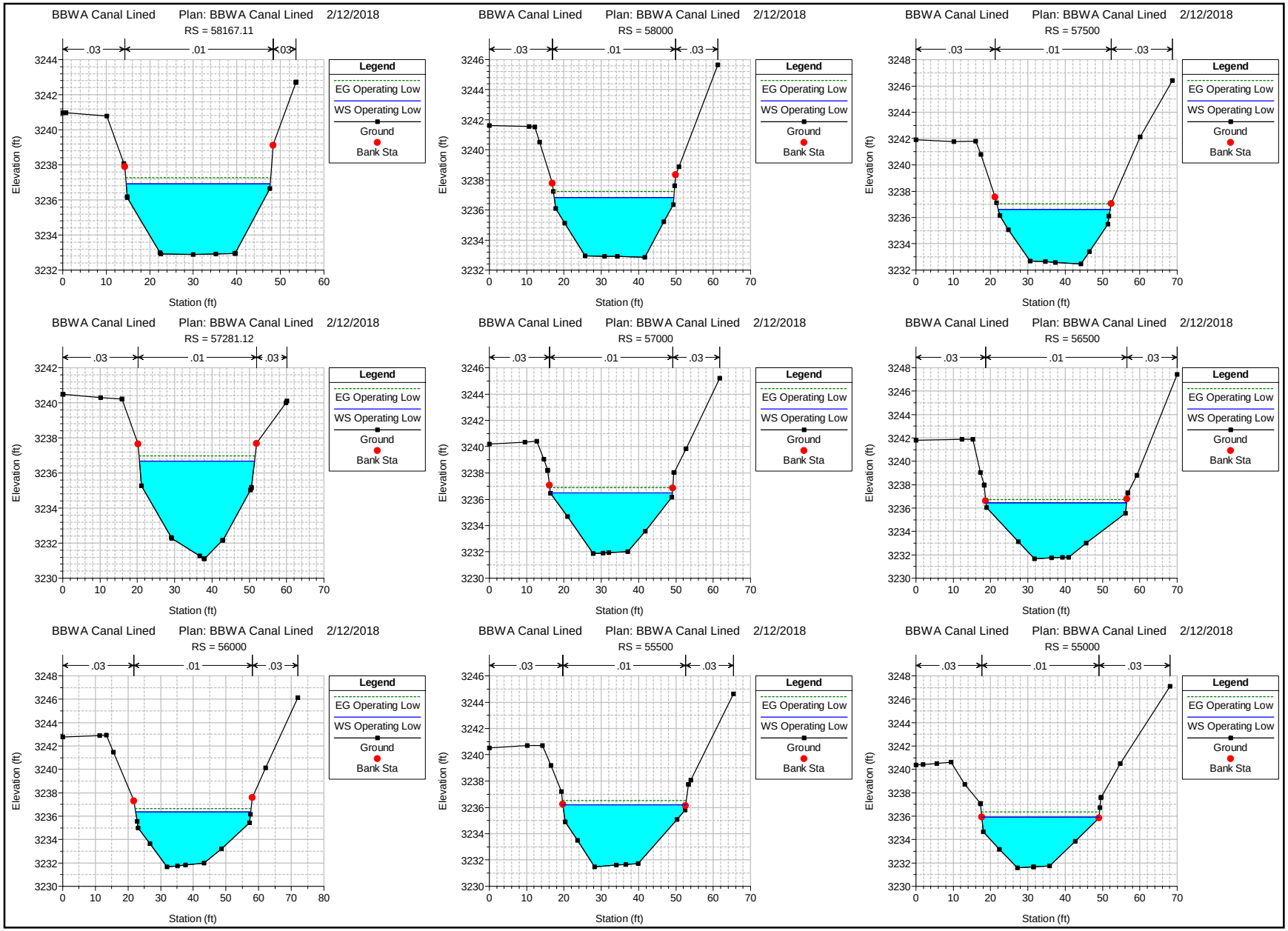

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 13000
.025
.015
.025
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 12500
.025
.015
.025
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 12000
.025
.015
.025
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 11500
.025
.015
.025
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 11000
.025
.015
.025
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 10500
.025
.015
.025
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 10000
.025
.015
.025
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 9500
.025
.015
.025
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 9000
.025
.015
.025
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

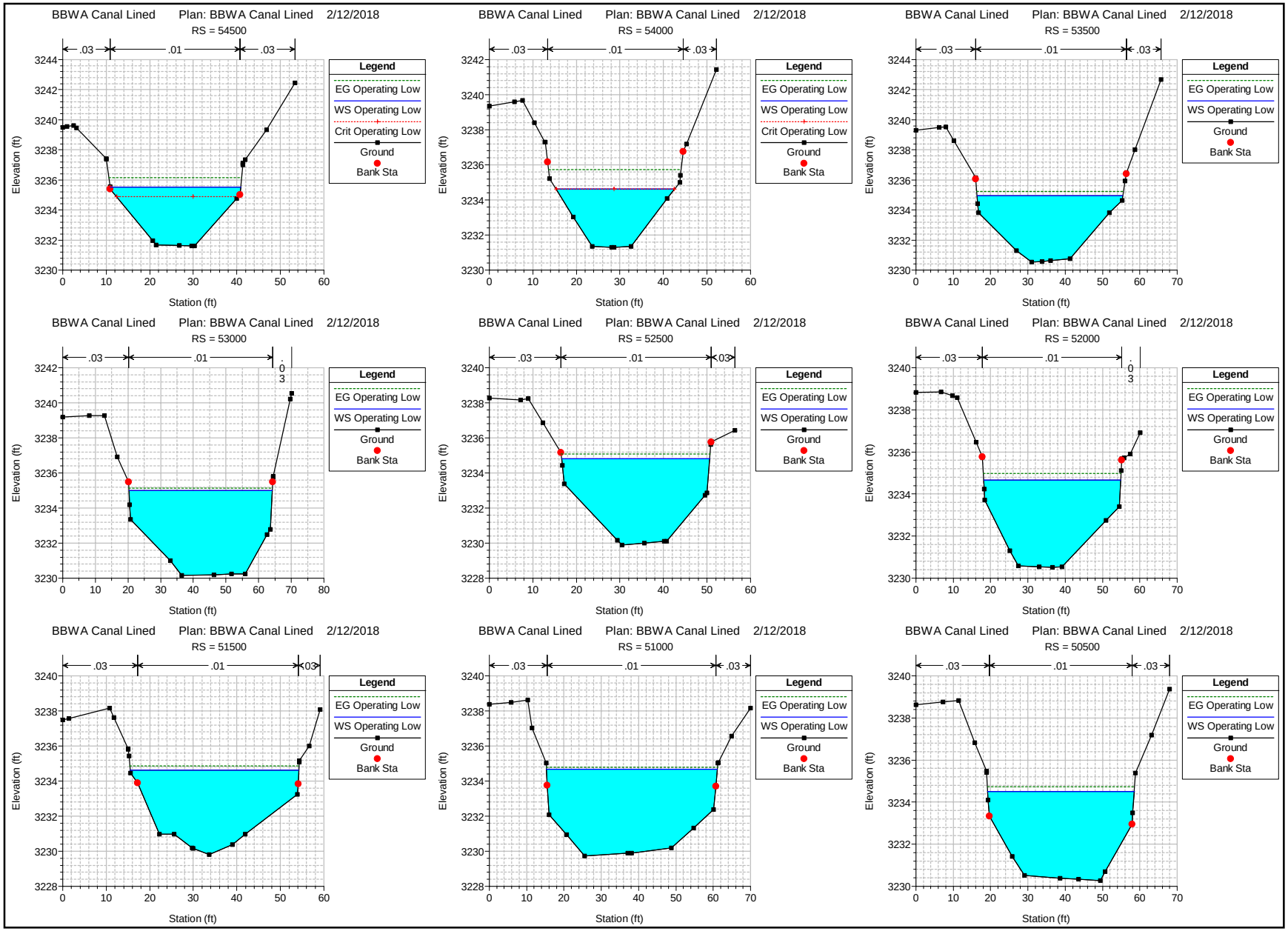

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 8500
.025 .015 .025
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 8000
.025 .015 .025
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 7500
.013 .015 .013
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 7134.88
.015 .013
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
OWS Overtoping Flow
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 7000
.015 .013
Legend
EG Overtoping Flow
WS Overtoping Flow
Crit Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 5900 Culv
.015 .013
Legend
EG Overtoping Flow
WS Overtoping Flow
Crit Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 5900 Culv
.02
Legend
EG Overtoping Flow
WS Overtoping Flow
Crit Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 5000
.02
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 4500
.03 .02 .03
Legend
EG Overtoping Flow
WS Overtoping Flow
Crit Overtoping Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

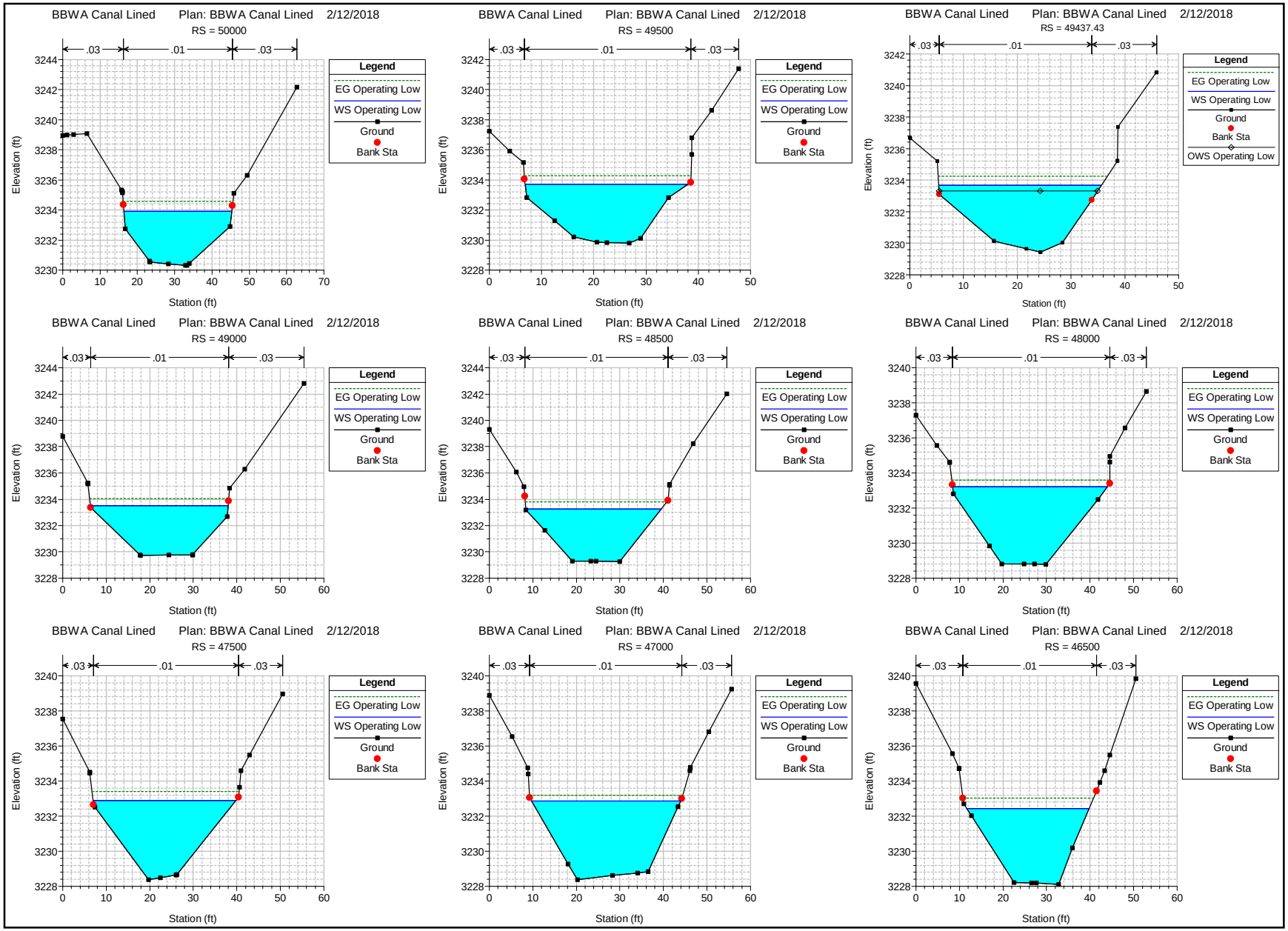

BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 3700 Culv
.03 .02 .03
Elevation (ft)
Station (ft)
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 3700 Culv
.03 .02 .03
Elevation (ft)
Station (ft)
Legend
EG Overtoping Flow
Ground
Bank Sta
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 3000
.03 .02 .03
Elevation (ft)
Station (ft)
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 2500
.03 .02 .03
Elevation (ft)
Station (ft)
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 2000
.01 .01 .01
Elevation (ft)
Station (ft)
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 1500
.01 .01 .01
Elevation (ft)
Station (ft)
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 1000
.01 .01 .01
Elevation (ft)
Station (ft)
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 500
.03 .02 .03
Elevation (ft)
Station (ft)
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018
RS = 234.77
.03 .02 .03
Elevation (ft)
Station (ft)
Legend
EG Overtoping Flow
WS Overtoping Flow
Ground
Bank Sta
OWS Overtoping Flow

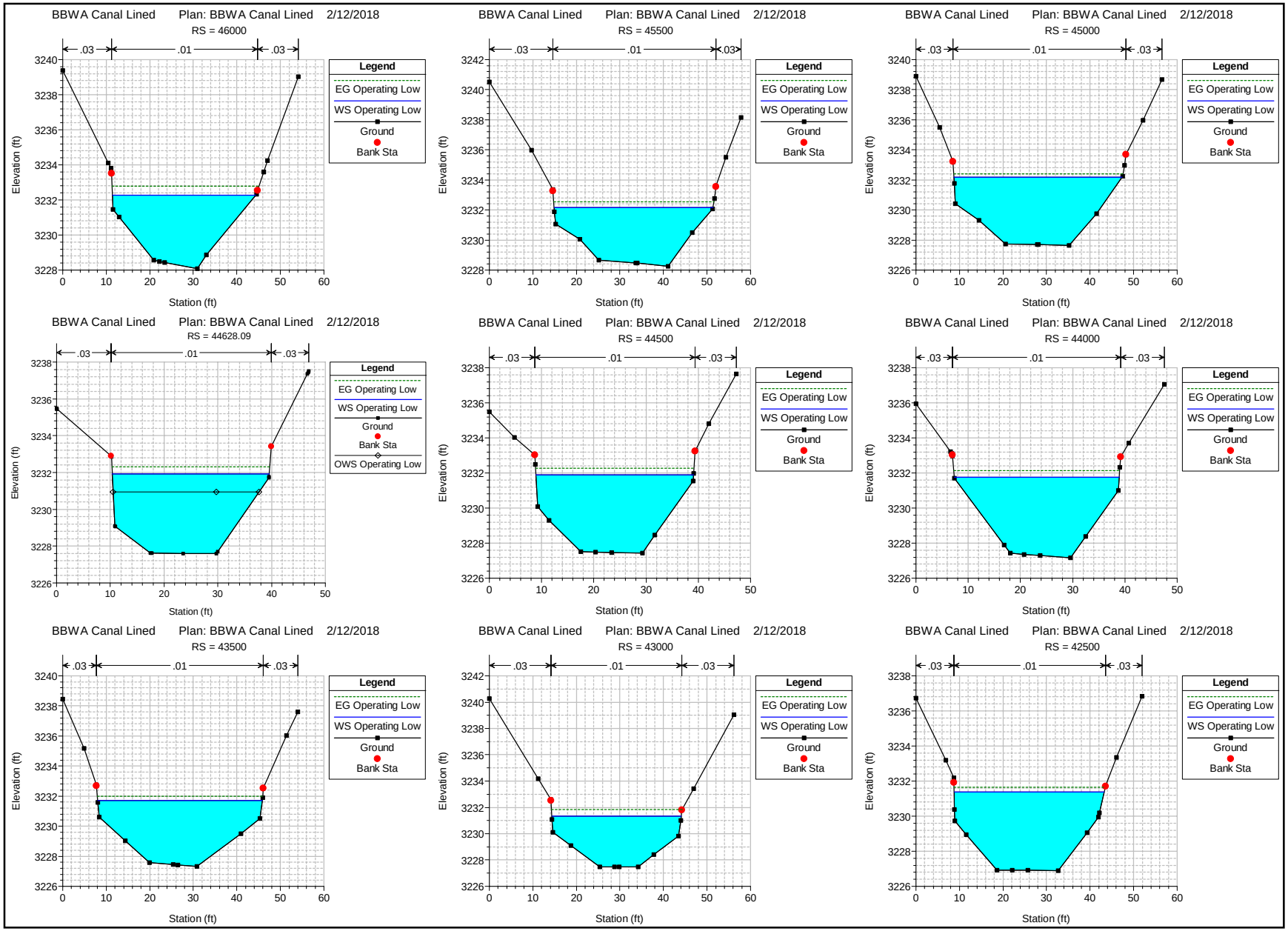
BBWA Canal Overtopping Plan: BBWA Canal Overtopping 1/26/2018

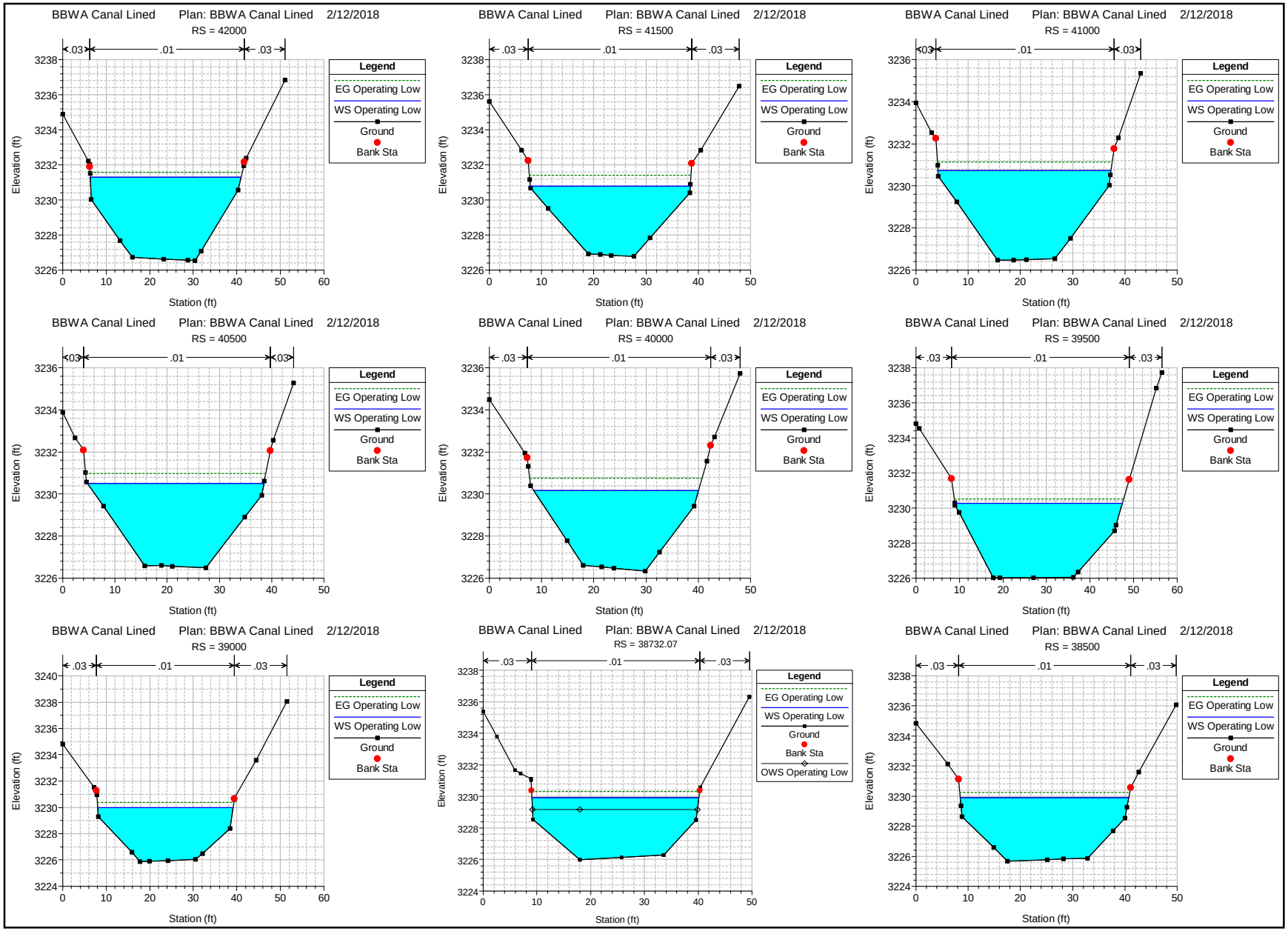


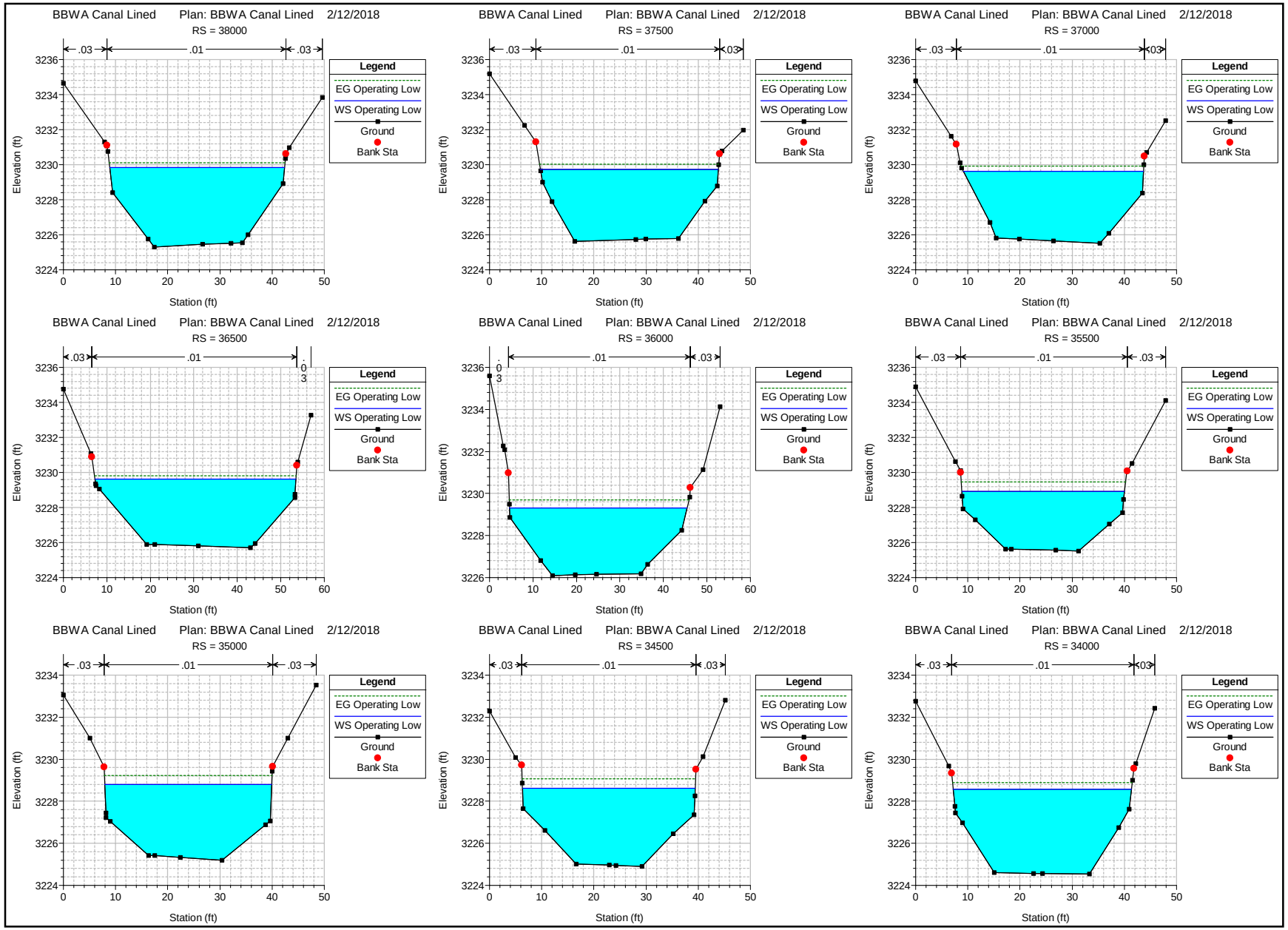

BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 58167.11
.03 .01 .03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 58000
.03 .01 .03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 57500
.03 .01 .03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 57281.12
.03 .01 .03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 57000
.03 .01 .03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 56500
.03 .01 .03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 56000
.03 .01 .03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 55500
.03 .01 .03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 55000
.03 .01 .03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)

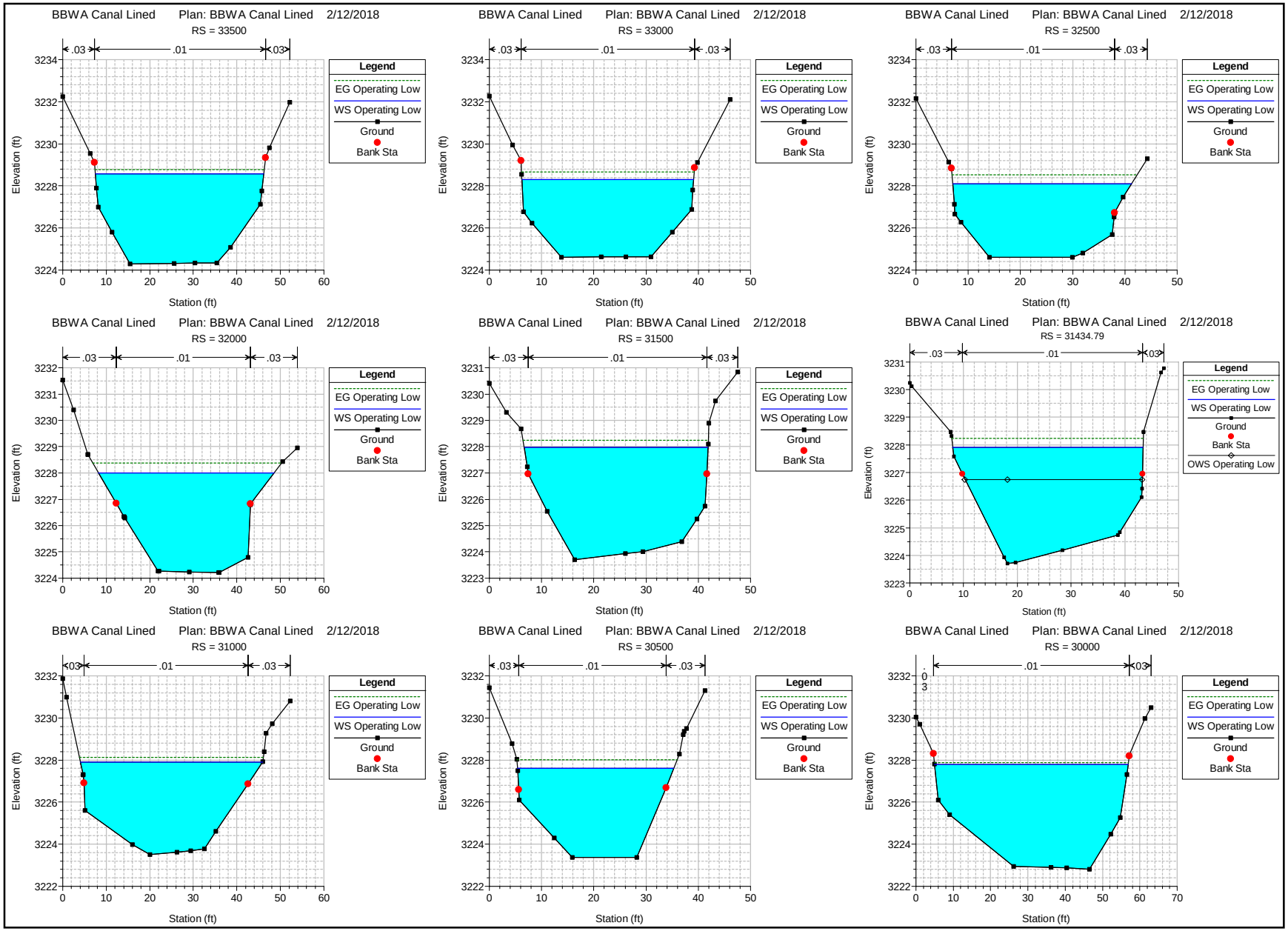

BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 54500
RS = 54000
RS = 53500
RS = 53000
RS = 52500
RS = 52000
RS = 51500
RS = 51000
RS = 50500
.03
.01
.03
Legend
EG Operating Low
WS Operating Low
Crit Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)

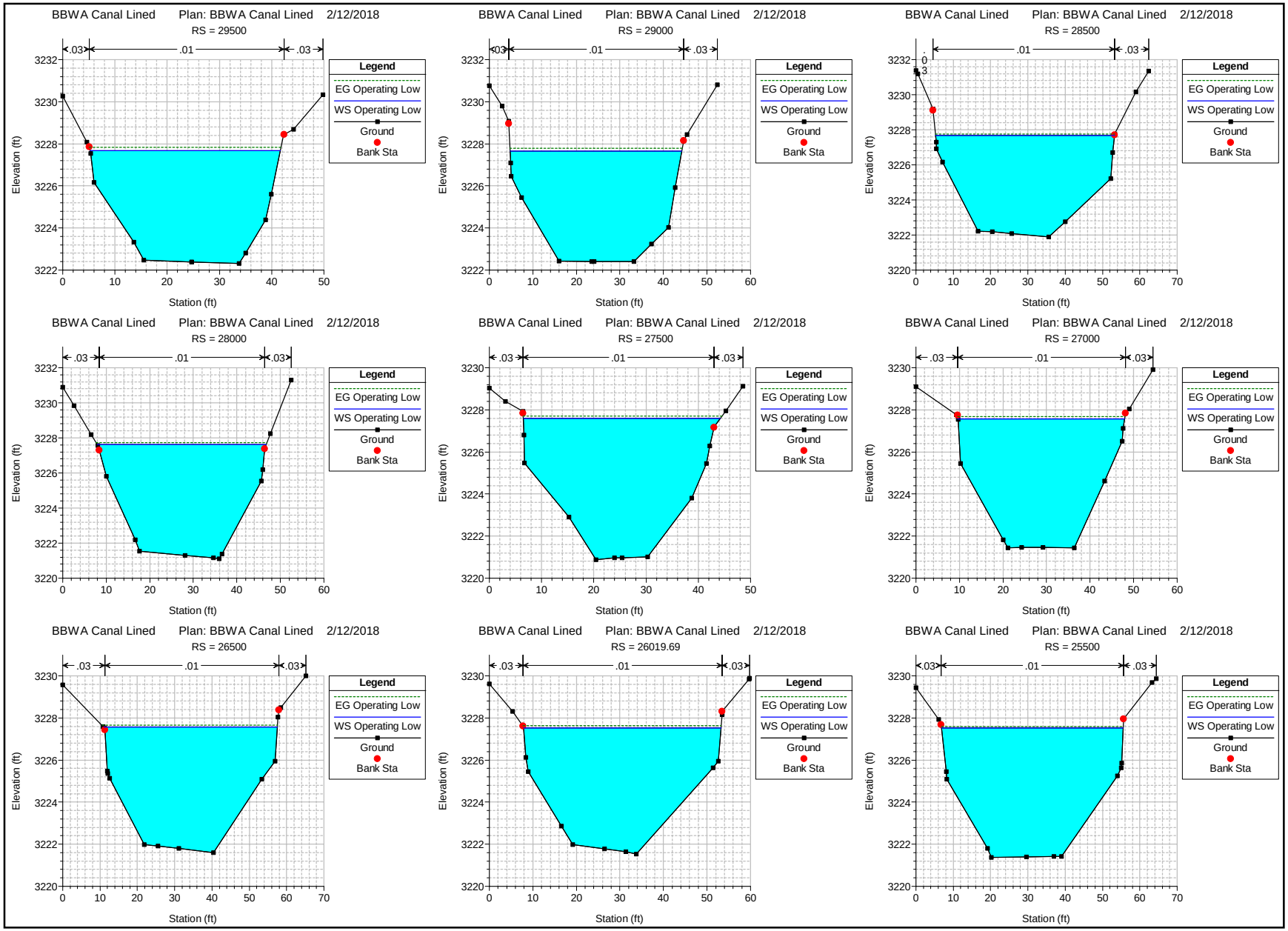

BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 50000
.03 .01 .03
Elevation (ft)
Station (ft)
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 49500
.03 .01 .03
Elevation (ft)
Station (ft)
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 49437.43
.03 .01 .03
Elevation (ft)
Station (ft)
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
OWS Operating Low
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 49000
.03 .01 .03
Elevation (ft)
Station (ft)
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 48500
.03 .01 .03
Elevation (ft)
Station (ft)
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 48000
.03 .01 .03
Elevation (ft)
Station (ft)
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 47500
.03 .01 .03
Elevation (ft)
Station (ft)
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 47000
.03 .01 .03
Elevation (ft)
Station (ft)
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 46500
.03 .01 .03
Elevation (ft)
Station (ft)
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta

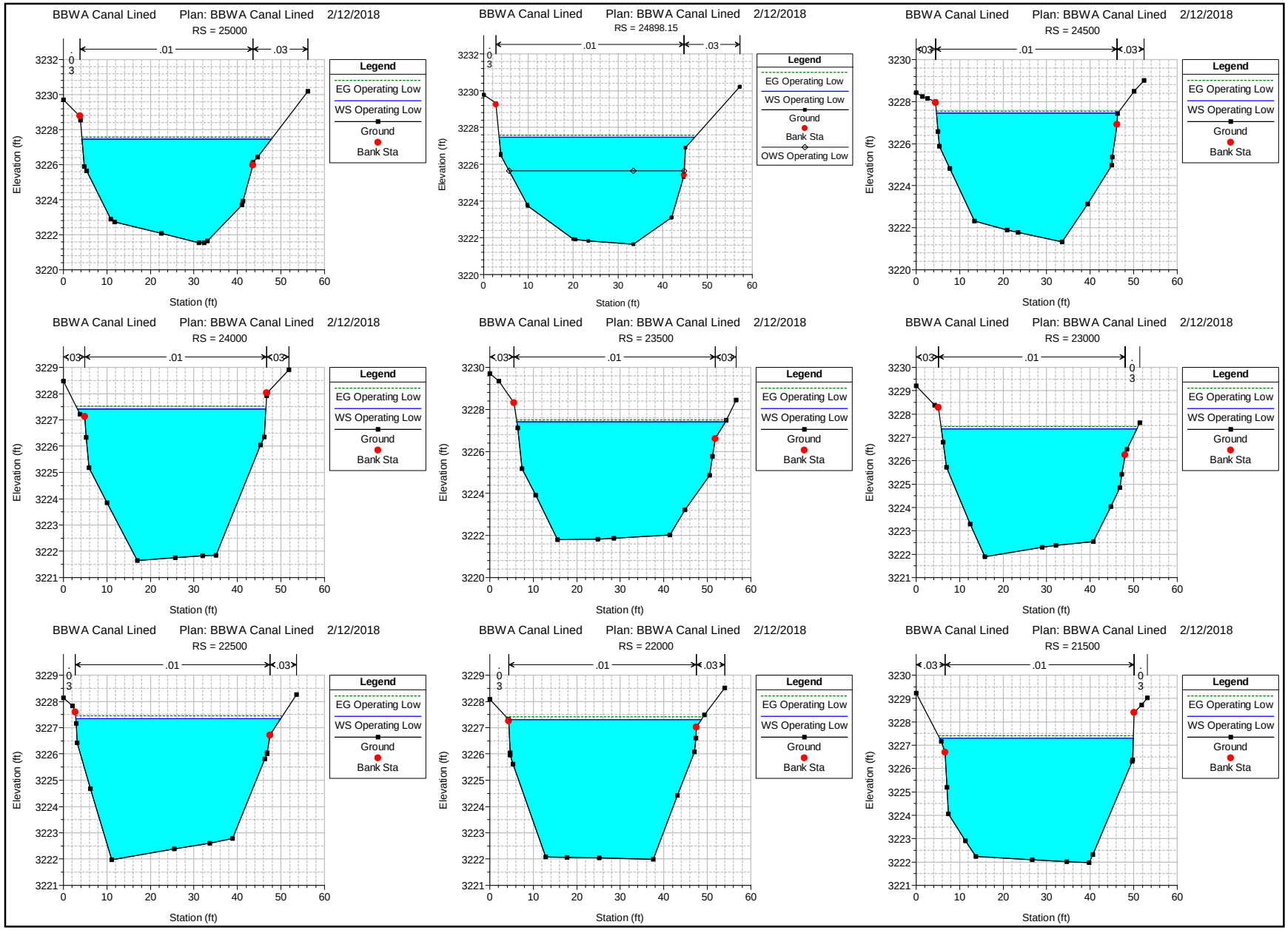

BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 46000
RS = 45500
RS = 45000
RS = 44628.09
RS = 44500
RS = 44000
RS = 43500
RS = 43000
RS = 42500
.03
.01
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
OWS Operating Low
Elevation (ft)
Station (ft)

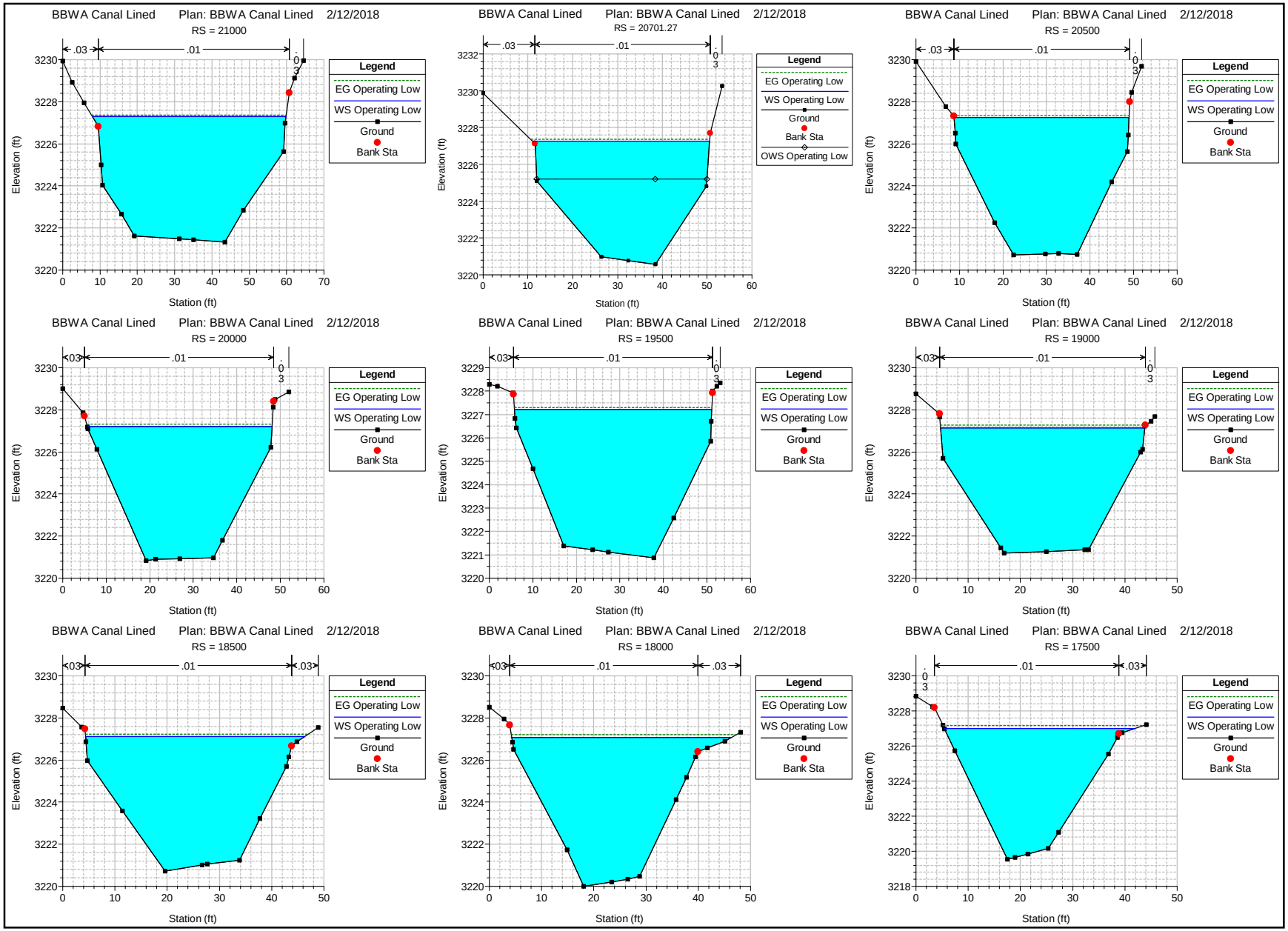

BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 42000
RS = 41500
RS = 41000
RS = 40500
RS = 40000
RS = 39500
RS = 39000
RS = 38732.07
RS = 38500
.03
.01
.03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
OWS Operating Low
Elevation (ft)
Station (ft)

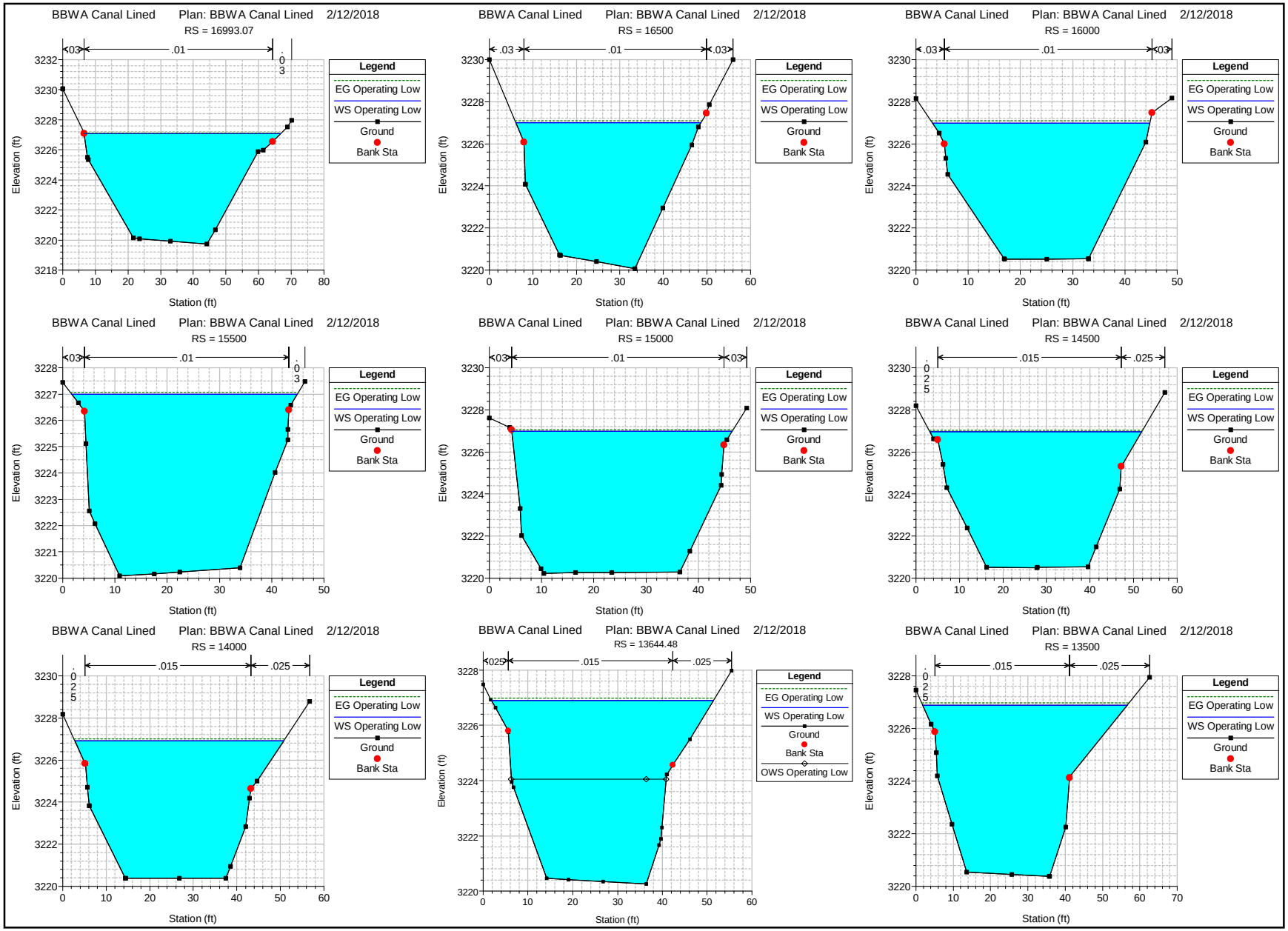

BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 38000
RS = 37500
RS = 37000
RS = 36500
RS = 36000
RS = 35500
RS = 35000
RS = 34500
RS = 34000
.03
.01
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)

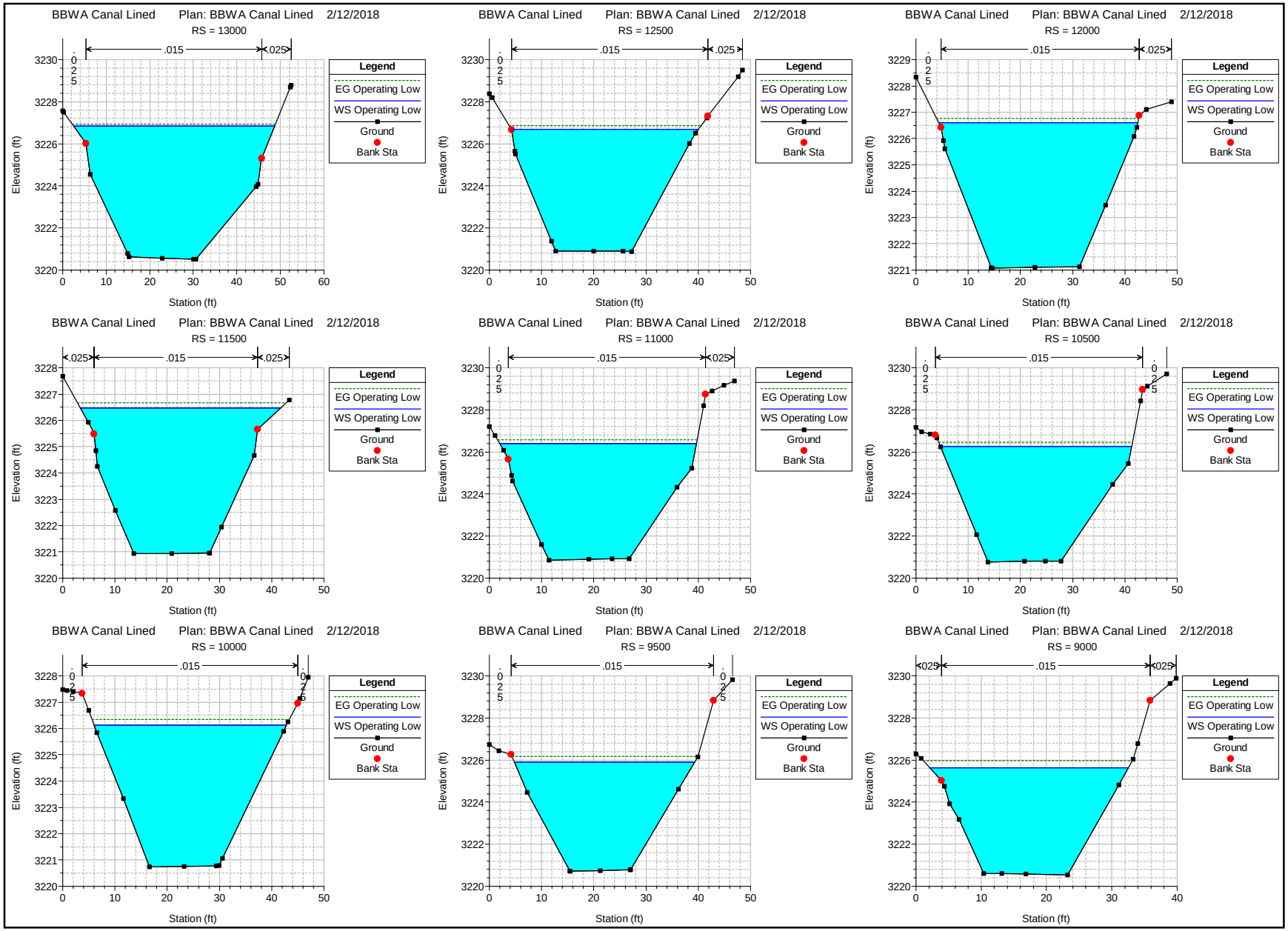

BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 33500
.03 .01 .03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 33000
.03 .01 .03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 32500
.03 .01 .03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 32000
.03 .01 .03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 31500
.03 .01 .03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 31434.79
.03 .01 .03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
OWS Operating Low
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 31000
.03 .01 .03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 30500
.03 .01 .03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 30000
.01 .03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)

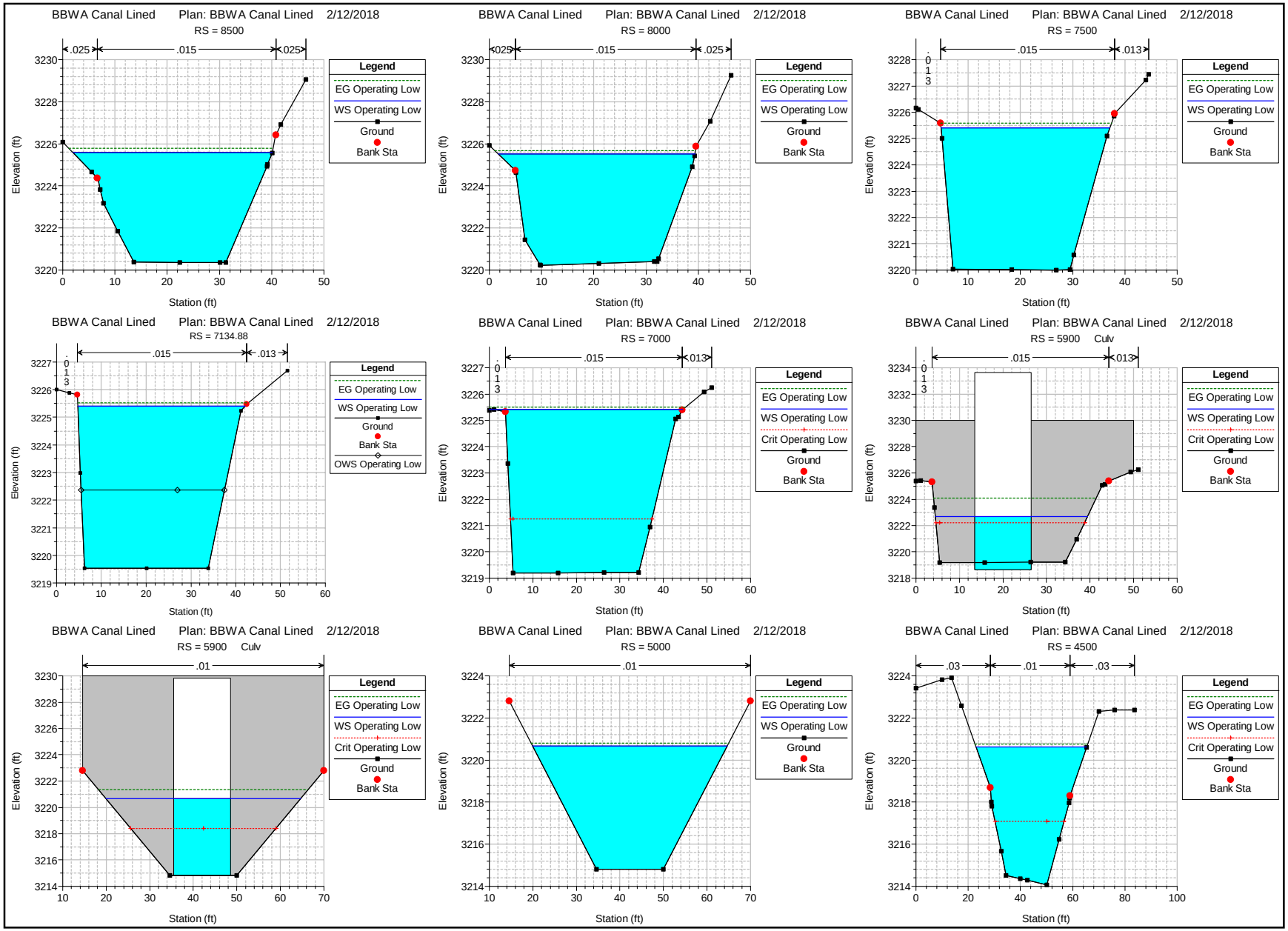

BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 29500
RS = 29000
RS = 28500
RS = 28000
RS = 27500
RS = 27000
RS = 26500
RS = 26019.69
RS = 25500
.03
.01
.03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)

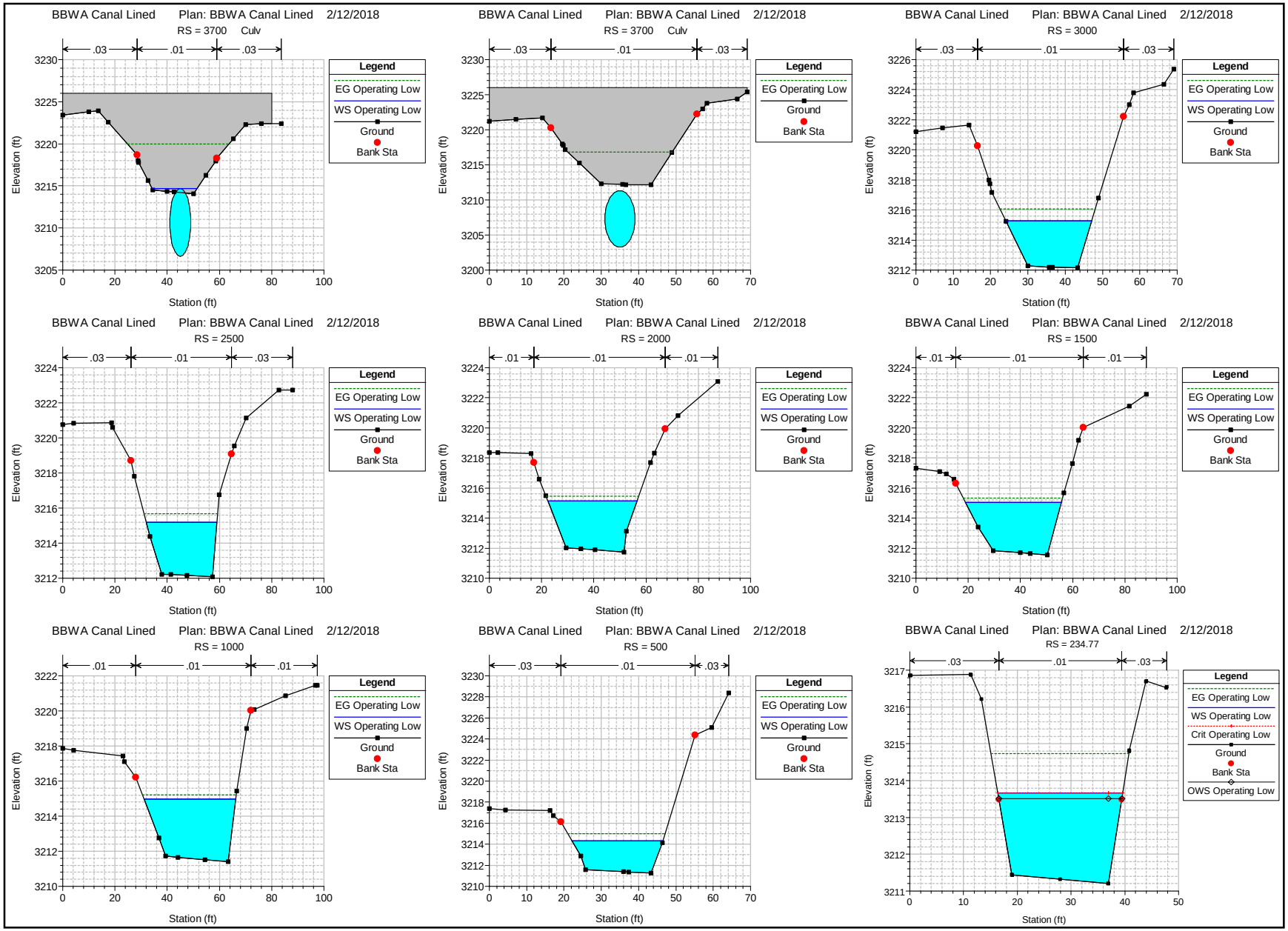

BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 25000
RS = 24898.15
RS = 24500
RS = 24000
RS = 23500
RS = 23000
RS = 22500
RS = 22000
RS = 21500
.01
.03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
OWS Operating Low
Elevation (ft)
Station (ft)

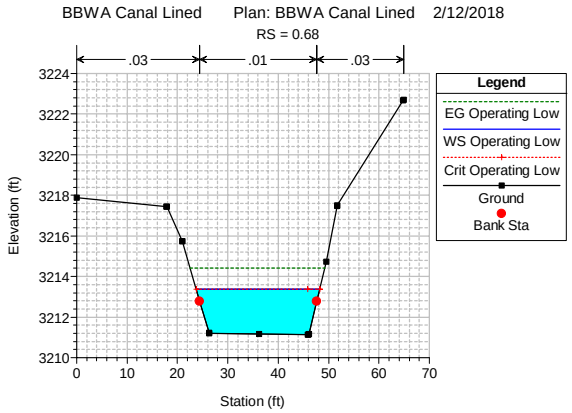

BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 21000
.03
.01
.03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 20701.27
.03
.01
.03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
OWS Operating Low
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 20500
.03
.01
.03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 20000
.03
.01
.03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 19500
.03
.01
.03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 19000
.03
.01
.03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 18500
.03
.01
.03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 18000
.03
.01
.03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 17500
.03
.01
.03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)


BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 16993.07
.03
.01
.03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 16500
.03
.01
.03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 16000
.03
.01
.03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 15500
.03
.01
.03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 15000
.03
.01
.03
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 14500
.025
.015
.025
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 14000
.025
.015
.025
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 13644.48
.025
.015
.025
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
OWS Operating Low
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 13500
.025
.015
.025
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)


BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 13000
.015
.025
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 12500
.015
.025
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 12000
.015
.025
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 11500
.025
.015
.025
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 11000
.015
.025
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 10500
.015
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 10000
.015
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 9500
.015
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 9000
.025
.015
.025
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)


BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 8500
.025
.015
.025
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 8000
.025
.015
.025
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 7500
.015
.013
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 7134.88
.015
.013
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
OWS Operating Low
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 7000
.015
.013
Legend
EG Operating Low
WS Operating Low
Crit Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 5900 Culv
.015
.013
Legend
EG Operating Low
WS Operating Low
Crit Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 5900 Culv
.01
Legend
EG Operating Low
WS Operating Low
Crit Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 5000
.01
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 4500
.03
.01
.03
Legend
EG Operating Low
WS Operating Low
Crit Operating Low
Ground
Bank Sta
Elevation (ft)
Station (ft)


BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 3700 Culv
.03 .01 .03
Elevation (ft)
Station (ft)
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 3700 Culv
.03 .01 .03
Elevation (ft)
Station (ft)
Legend
EG Operating Low
Ground
Bank Sta
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 3000
.03 .01 .03
Elevation (ft)
Station (ft)
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 2500
.03 .01 .03
Elevation (ft)
Station (ft)
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 2000
.01 .01 .01
Elevation (ft)
Station (ft)
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 1500
.01 .01 .01
Elevation (ft)
Station (ft)
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 1000
.01 .01 .01
Elevation (ft)
Station (ft)
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 500
.03 .01 .03
Elevation (ft)
Station (ft)
Legend
EG Operating Low
WS Operating Low
Ground
Bank Sta
BBWA Canal Lined Plan: BBWA Canal Lined 2/12/2018
RS = 234.77
.03 .01 .03
Elevation (ft)
Station (ft)
Legend
EG Operating Low
WS Operating Low
Crit Operating Low
Ground
Bank Sta
OWS Operating Low


BBWA Canal Lined
Plan: BBWA Canal Lined
2/12/2018
RS = 0.68
.03
.01
.03
Elevation (ft)
Station (ft)
Legend
EG Operating Low
WS Operating Low
Crit Operating Low
Ground
Bank Sta

MEMORANDUM

WWC ENGINEERING

51 North 15th Street, Suite 1 Billings, MT 59101
PHONE: (406) 894-2210 E-MAIL infobil@wwcengineering.com

TO: **Billings Bench Water Association**

FROM: **Greg Reid, P.E., Project Manager, WWC Engineering**

DATE: **December 19, 2017**

SUBJECT: **Staff Gage Rating Curves**

SUMMARY
In order to characterize losses in the Billings Bench Water Association (BBWA) Main Canal, a monitoring program was implemented from May to October 2017. The monitoring plan included collecting staff gage height data at ten locations that each represented a different reach of the BBWA Main Canal. A total of 16 measurements were taken at each staff gage location during this study. Doppler radar was used to measure flow in the ditch at each staff gage location for three of the 16 total measurements. The tenth gage location (north of the tunnel) only included a single flow measurement. This gage location was therefore not able to have a flow curve derived and is not included in the following flow loss discussions. The three measured gage heights with associated flow rates were plotted and fit with a trend line using power regression. The derived regression equations were then used to calculate flow rates for the remaining gage height data. Change in flow, from reach to reach, was calculated and averaged for each reach and presented in Figure 1. (labeled as station to station).

METHOD

Gage Locations

Staff gage sites were determined based on the following considerations:

1. Create equal length reaches by spacing approximately one mile between gages.
2. Where possible, similar channel characteristics, i.e. friction factor, shape, slope, etc., were attempted to be found upstream and downstream of the gage to create consistency in the flow measurement.
3. Geographic and topographic accessibility.

Please refer to Attachment 2 for gage locations.

Gage Data

The gage height data were collected by BBWA personnel and provided to WWC Engineering (WWC). The BBWA collected gage data every other Sunday from May to October of 2017. At the beginning of the year, a letter was sent to the users along the BBWA Main Canal asking them not to divert water on Sundays. Tabulated gage data are included in Attachment 3.

Flow Data
Flow rates were determined at each staff gage site using a vessel mounted acoustic profiler that utilizes the principles of the Doppler effect to determine flow rate. Multiple measurements were taken at each site and an average was calculated. As outlined by Bureau of Reclamation staff, the measurement device has an accuracy of 2-5%, which is as accurate a measurement that may be made for this scenario. Tabulated flow data can be found in Attachment 3.

Rating Curves
Power regression lines were derived from the measured flow data and corresponding gage measurements. The graphs with associated regression lines are included in Attachment 4 of this memorandum. Regression equations corresponding to the respective regression lines were then used to calculate flow rates for the gage readings that did not have measured flow rates.

Observations
Reach 1 – 2 fluctuated from a gain of 12 CFS in July to a loss of 27 CFS in October and reach 7 – 8 varied from seven CFS in August to -24 CFS in October. The large variance in flow of reach 1 – 2 and 7 – 8 may be attributed to the locations of the gages. There may be channel characteristics (such as slope, friction factor, shape, etc.) that do not correlate well using power regression with only three points for calibration. Additional data points would help develop a more accurate rating curve for these reaches.

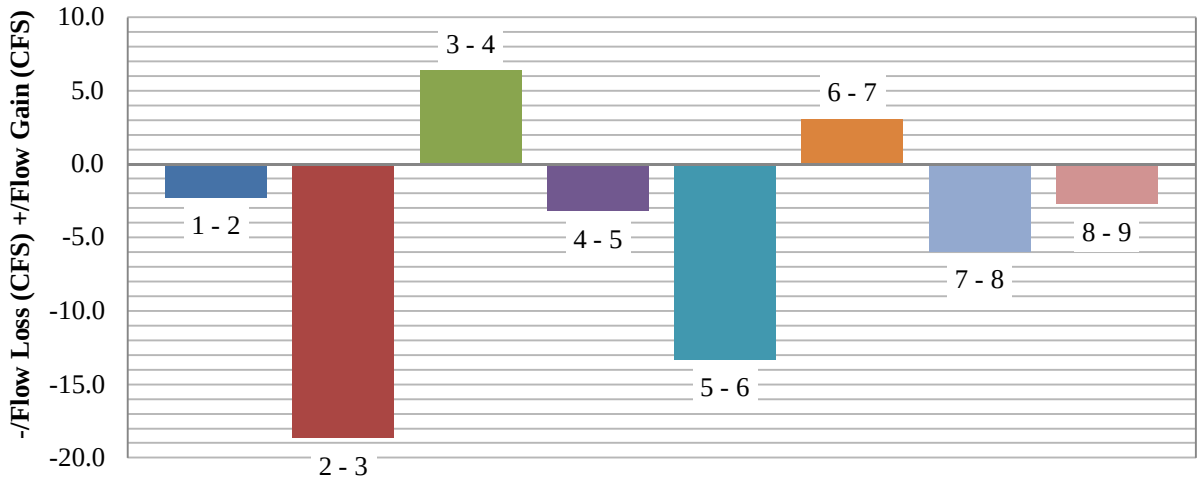
Reaches 2 – 3, 3 – 4, and 8 - 9 were the most consistent, varying by 5 CFS, 8 CFS, and 14 CFS, respectfully, over the six months. The steady loss in reach 2 – 3 and steady gain in reach 3 – 4 can be attributed to selecting reaches with consistent characteristics that are modelled well with power regression. Reach 8 – 9 appears to have fluctuated with groundwater elevations, i.e. gains in the spring and losses in summer and fall.

Reach 5 – 6 had consistent loss from May to August and jumped sharply from a loss of nine CFS to 35 CFS in September bringing the average loss to 13 CFS. The high loss in September is suspect and may have to do with ditch use during data collection. Disregarding the September spike in loss, the average loss for reach 5 – 6 is still 10 CFS keeping its rank of second to reach 2 – 3 for losses.

The final staff gage location (station 10) did not include the necessary measurements to develop a rating curve for that section. However, the individual flow measurement that was collected indicated that the reach from gages 9 to 10 gained 6 cfs. This information does correlate with expectations as in this reach the canal passes through a tunnel, through a siphon, and over a lined section of canal. As such, seepage found in this section would be minimal comparatively with other sections.

RESULTS

Figure 1. Average Reach Flow Change - May to October 2017



A net gain in flow of six CFS was observed in reach 3 - 4. Reach 6 - 7 also had a net gain of three CFS in average flow over the six-month observation period. Loss of flow in reaches 1 - 2, 4 - 5, 7 - 8, and 8 - 9 was less than seven CFS for each reach. Reach 2 - 3 had the highest change in average flow with a loss of 19 CFS and reach 5 - 6 had the second highest loss of 13 CFS. The average change in flow in reach 9 - 10 was not calculated due to insufficient data. Tabulated average change in flow can be found in Attachment 1.

DISCUSSION

The net gain in flow in reach 3 - 4 is likely attributed to recharge from groundwater and surface runoff along this reach. The high net loss in reaches 2 - 3 and 5 - 6 may be from seepage through the ditch banks and infiltration into the ground where groundwater is relatively lower than the ditch flow elevation. Further discussion of the results is contained herein.

The BBWA provided a letter to the irrigation users throughout the study area stating that water was not to be pumped from the canal on Sundays (when staff gage readings were recorded). Although this was requested of the users, absolute compliance could not be ensured. As a result, some channel losses may include irrigation usage. However, staff gage readings were performed by the BBWA staff as they traveled along the study area and as such, if any irrigation usage occurred during the readings it is anticipated to be minimal (i.e., gallons per minute of irrigation usage versus cubic feet per second of channel losses).

RECOMMENDATION

The sum of the flow changes through the study area, excluding reaches 2 - 3 and 5 - 6, is negative five CFS. Given this trend in the data, funds used to reduce losses in the BBWA Main Canal would be most beneficially used to address reaches 2 – 3 (Scheels to 32nd St.) and 5 – 6 (Lillis Park to 19th St.). These two reaches account for most of the loss observed in the BBWA Main Canal during this analysis. This recommendation is made solely on channel losses and does not include other factors such as soil conditions or bank height, which are considered in other reports.

ATTACHMENTS

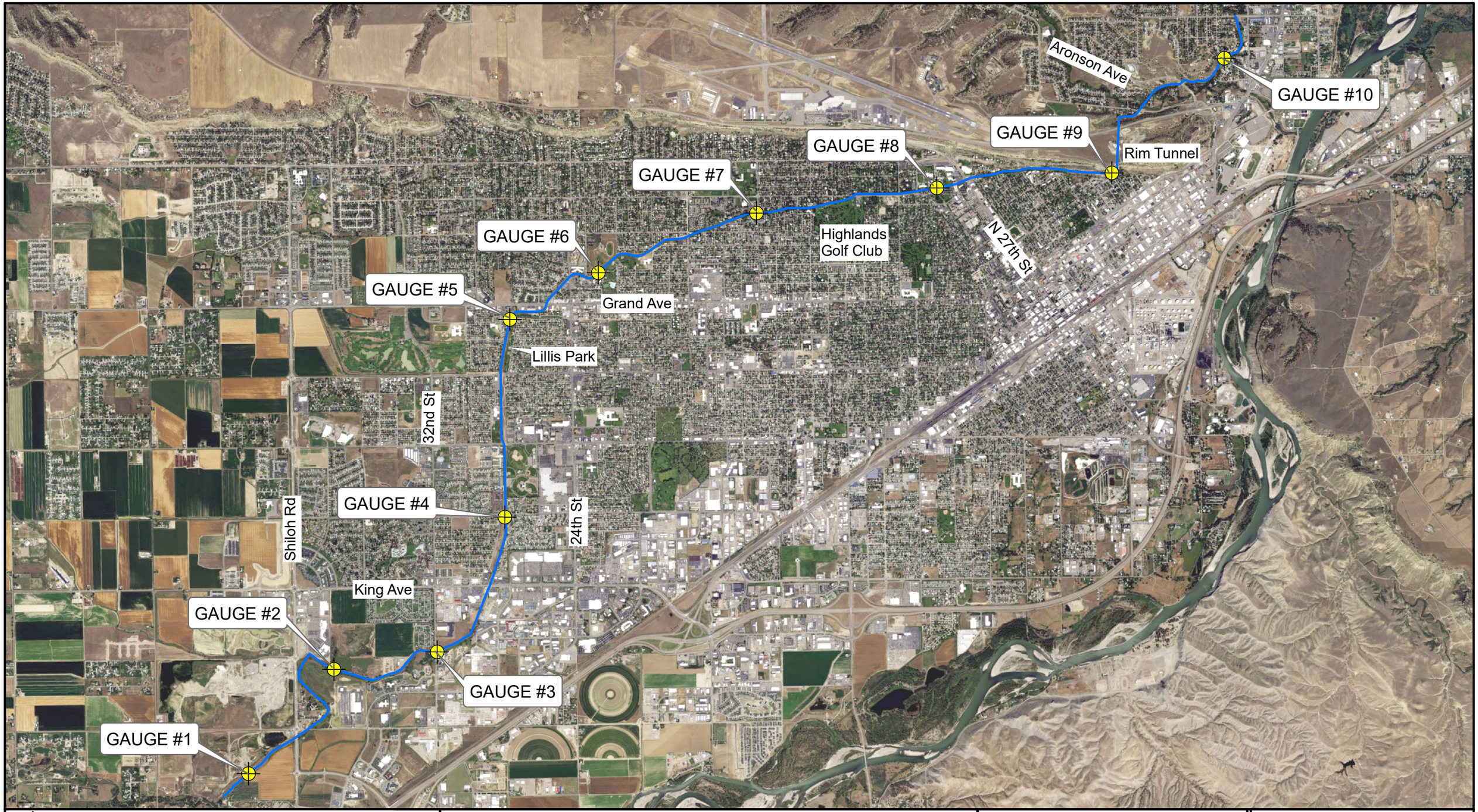
1) Tabulated Average Change in Flow and Monthly Average Change in Flow
2) Gage Location Map
3) Tabulated Gage Heights & Flow Data
4) Gage Height vs. Flow Rate Graphs

Attachment 1

Reach	AVG Flow Change[1] CFS	Average Monthy Change in Flow[2]					
		May CFS	**June** CFS	**July** CFS	**Aug** CFS	**Sept** CFS	**Oct** CFS
1 - 2	-2	-16	-3	12	2	-10	-27
2 - 3	-19	-16	-18	-20	-19	-21	-17
3 - 4	6	2	4	7	9	10	9
4 - 5	-3	-2	-3	-9	-7	12	-1
5 - 6	-13	-5	-14	-10	-9	-35	ND
6 - 7	3	-2	16	-4	-6	10	ND
7 - 8	-6	-5	-21	0	7	2	-24
8 - 9	-3	1	3	-4	-6	-10	-6
Total	-37	-44	-36	-27	-29	-42	-67

[1]The average flow change was calcuated using all of the flow data for each reach.

[2]The average monthly data was calculated on a per month basis. Flow data was not calculated for the reach from Station 9 to Station 10 due to a lack of data.



WWC ENGINEERING
51 N 15th Street, Suite 1
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(406) 894 - 2210

BILLINGS BENCH WATER ASSOCIATION
MAIN CANAL FLOW GUAGE LOCATIONS
PO BOX 50150
BILLINGS, MT 59105

Legend

- BBWA Canal Gauge
- BBWA Main Canal

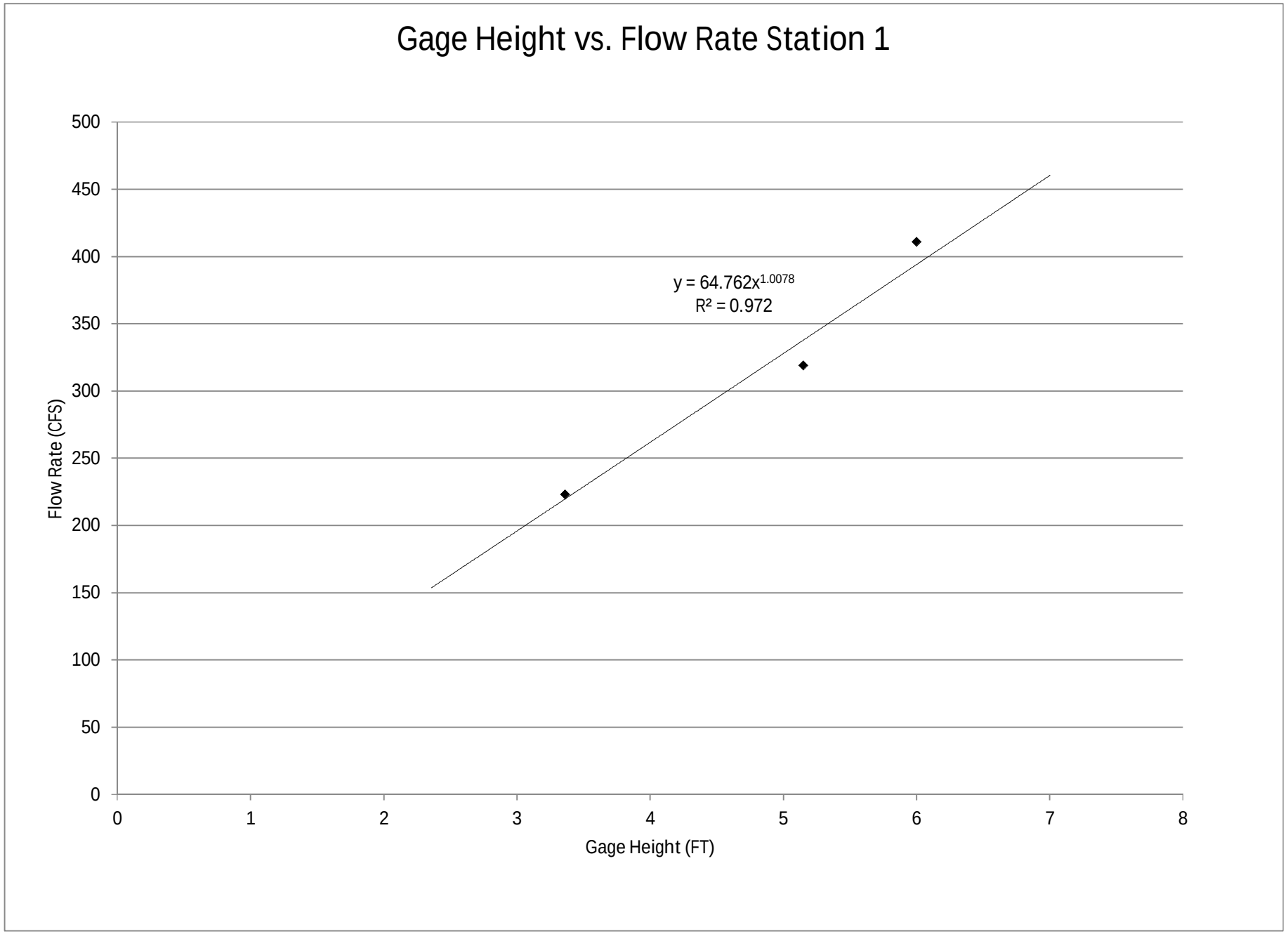
N
W
E
S

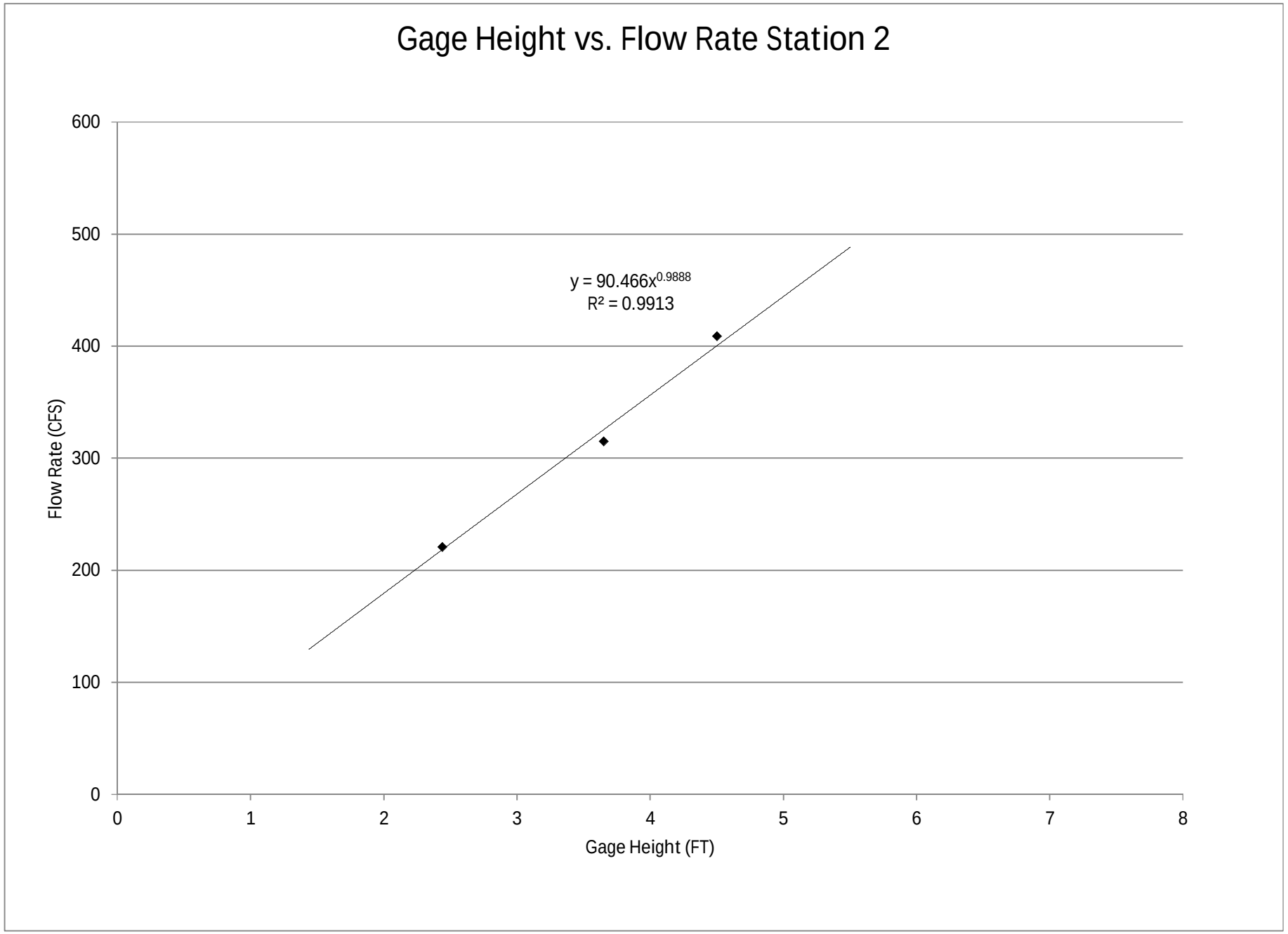
Attachment 3

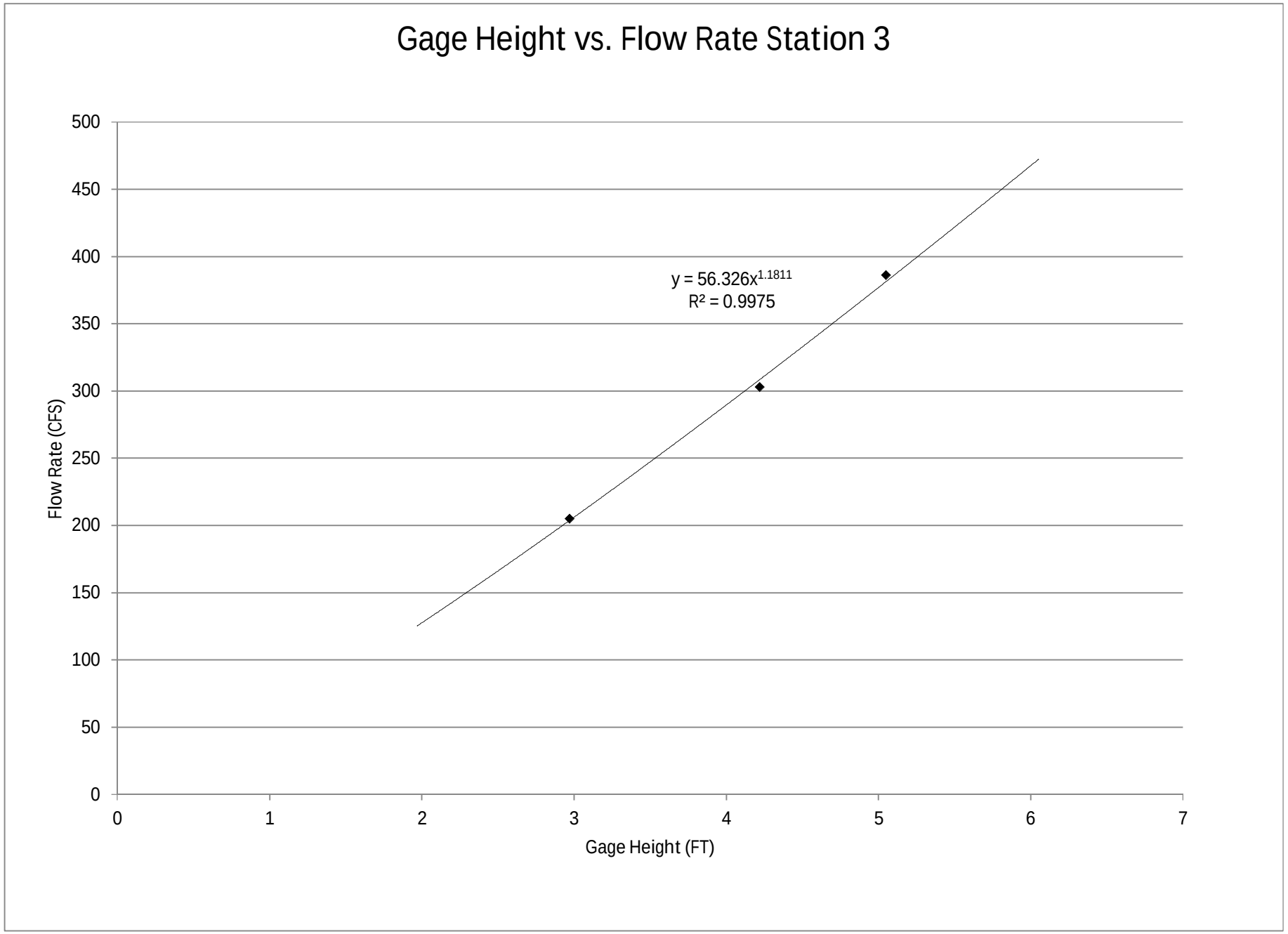
Date	Sta. 1 - Shiloh		Sta. 2 - Scheels		Sta. 3 - 32nd St.		Sta. 4 - Monad		Sta. 5 - Lillis Park		Sta. 6 - 19th		Sta. 7 - 13th		Sta. 8 - MSUB		Sta. 9 - Tunnel	
	Gage ht. (FT)	**Flow (CFS)**	**Gage ht. (FT)**	**Flow (CFS)**	**Gage ht. (FT)**	**Flow (CFS)**	**Gage ht. (FT)**	**Flow (CFS)**	**Gage ht. (FT)**	**Flow (CFS)**	**Gage ht. (FT)**	**Flow (CFS)**	**Gage ht. (FT)**	**Flow (CFS)**	**Gage ht. (FT)**	**Flow (CFS)**	**Gage ht. (FT)**	**Flow (CFS)**
5/7/17	3.36	223	2.44	221	2.97	205	2.6	205	2.22	199	3.3	198	3.25	196	2.73	192	2.69	194
5/21/17	4.55	298	3	268	3.55	252	3.2	255	2.98	256	4.01	248	3.97	246	3.28	240	3.34	239
6/2/17	5.15	319	3.65	315	4.22	303	3.85	302	3.71	305	4.7	289	4.62	285	3.83	288	4.16	295
6/4/17	5.2	341	3.68	328	4.22	309	3.86	313	3.75	313	4.7	300	5.65	377	3.86	293	4.16	296
6/5/17	5.15	338	3.65	325	4.22	309	3.85	312	3.71	311	4.7	300	4.62	296	3.83	290	4.16	296
6/18/17	5.9	387	4.55	405	5.07	383	4.74	392	4.63	377	5.49	363	5.4	357	4.54	357	5.04	356
7/2/17	5.9	387	4.43	394	4.96	373	4.6	380	4.58	374	5.5	363	5.4	357	4.55	358	5.05	357
7/11/17	6	411	4.5	409	5.05	386	4.65	393	4.66	384	5.55	377	5.5	374	4.62	367	5.12	362
7/16/17	5.5	361	4.47	398	5	377	4.66	385	4.62	376	5.5	363	5.47	362	4.6	363	5.11	361
7/30/17	6	394	4.51	401	5.08	384	4.7	389	4.65	379	5.58	370	5.5	365	4.66	369	5.16	364
8/13/17	5.84	383	4.32	384	4.88	366	4.55	375	4.48	366	5.4	355	5.35	353	4.55	358	5	353
8/15/17	5.95	391	4.45	396	5.04	380	4.65	384	4.63	377	5.53	366	5.43	359	4.62	365	5.1	360
8/20/17	5.63	370	4.15	369	4.66	347	4.4	362	4.33	356	5.34	351	5.2	341	4.47	351	4.86	344
9/3/17	5.45	358	3.98	355	4.48	331	4.15	339	4.45	364	5.05	328	5	325	4.22	327	4.48	318
9/17/17	5.02	329	3.5	312	4.05	294	3.77	305	3.63	305	4.33	272	4.6	294	3.9	297	4.01	285
10/1/17	4.57	299	3.05	272	3.6	256	3.31	264	3.07	263	ND	-	4.4	279	3.45	255	3.48	249

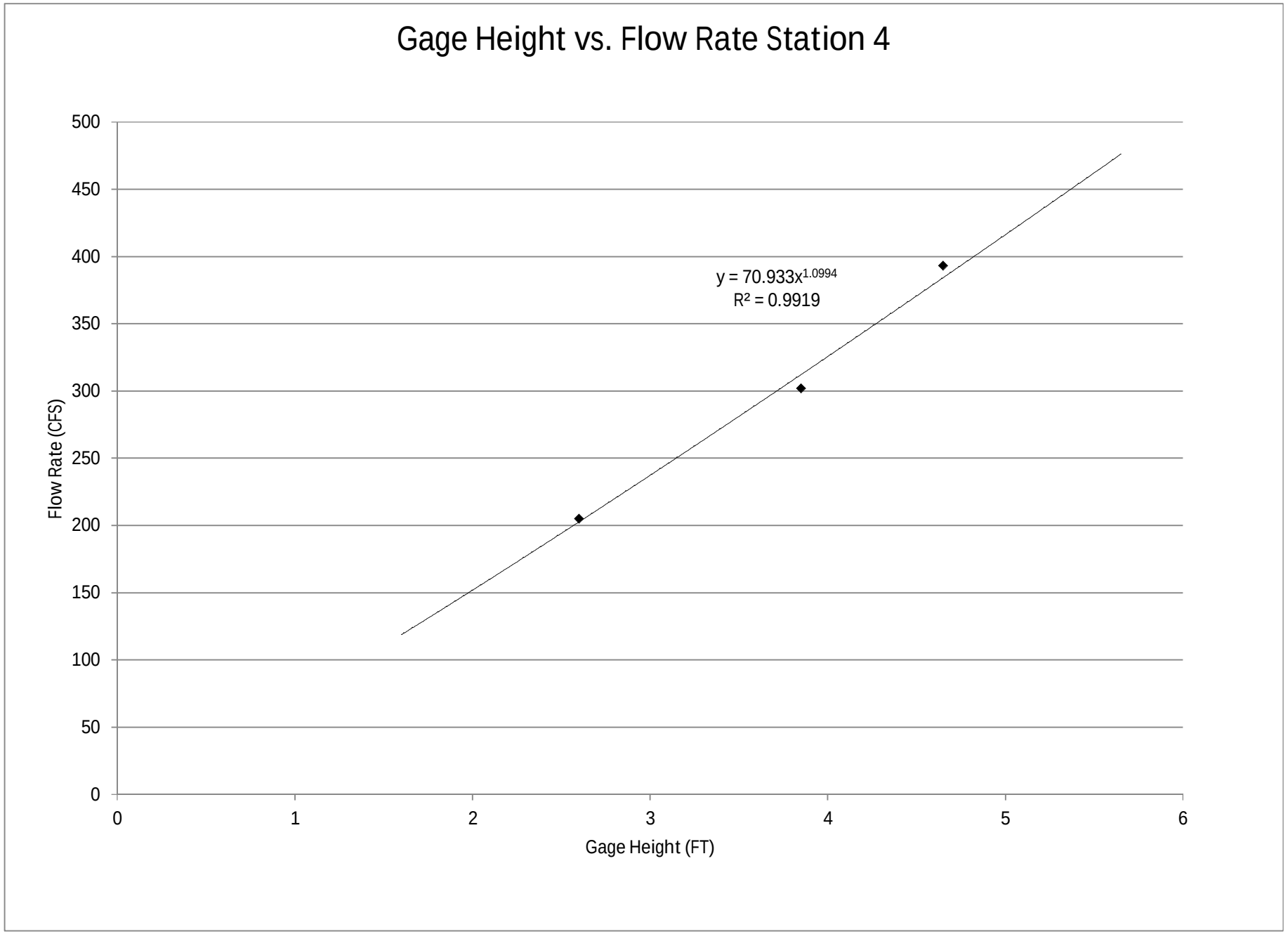
Gray highlight denotes measured value.

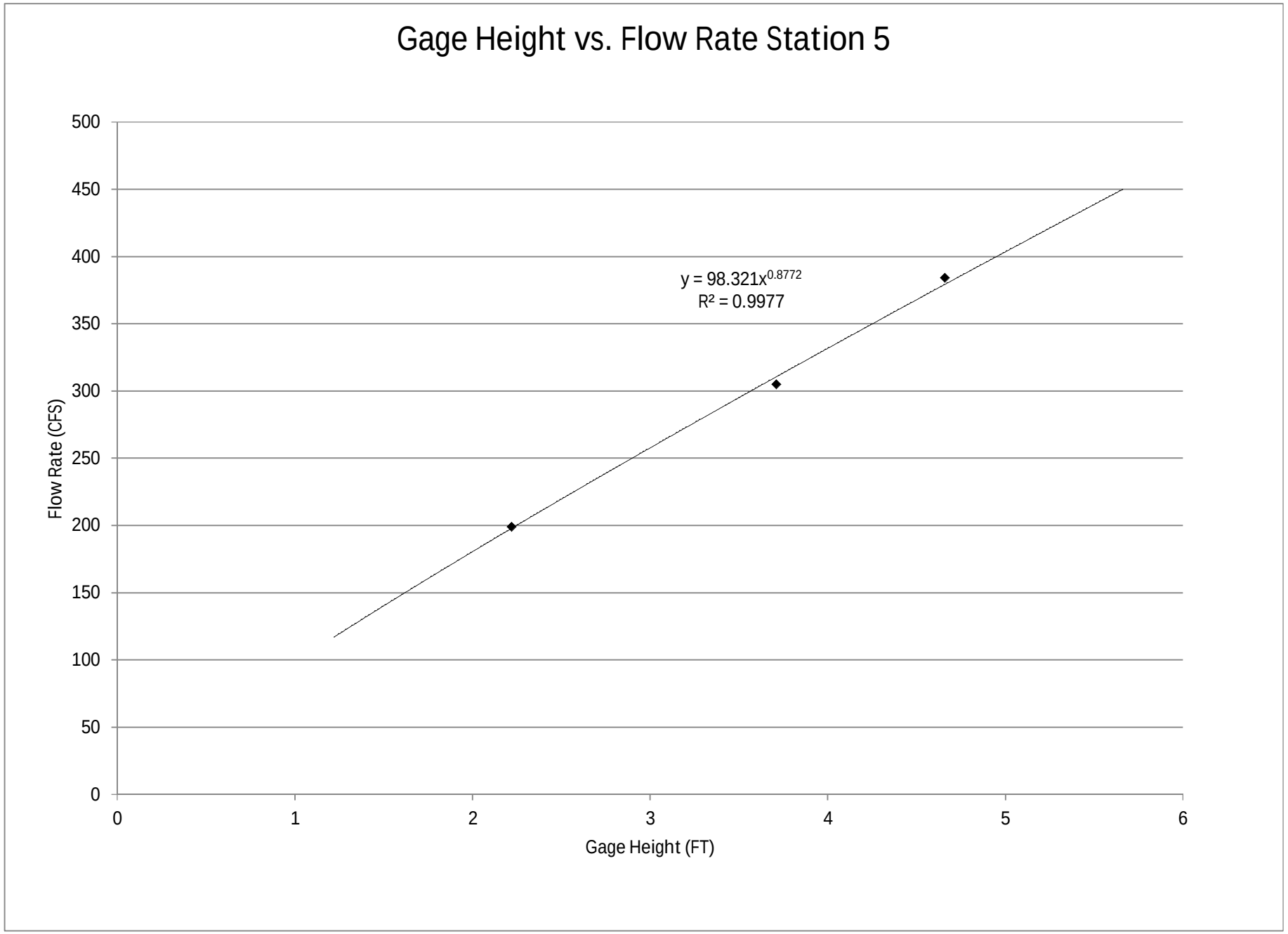
ND - No Data

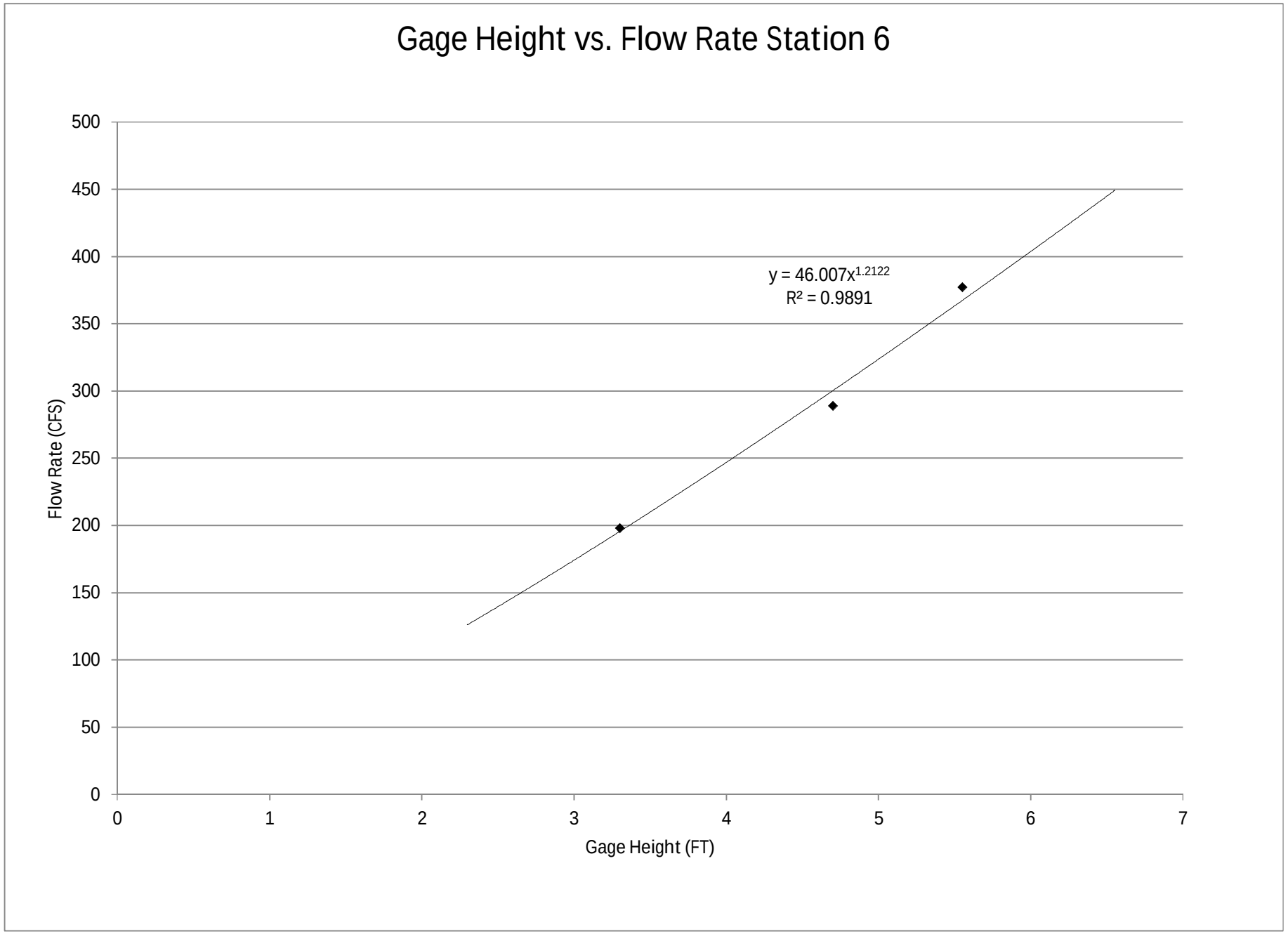

Gage Height vs. Flow Rate Station 1
y = 64.762x^1.0078
R² = 0.972
Flow Rate (CFS)
Gage Height (FT)
0
50
100
150
200
250
300
350
400
450
500
0
1
2
3
4
5
6
7
8

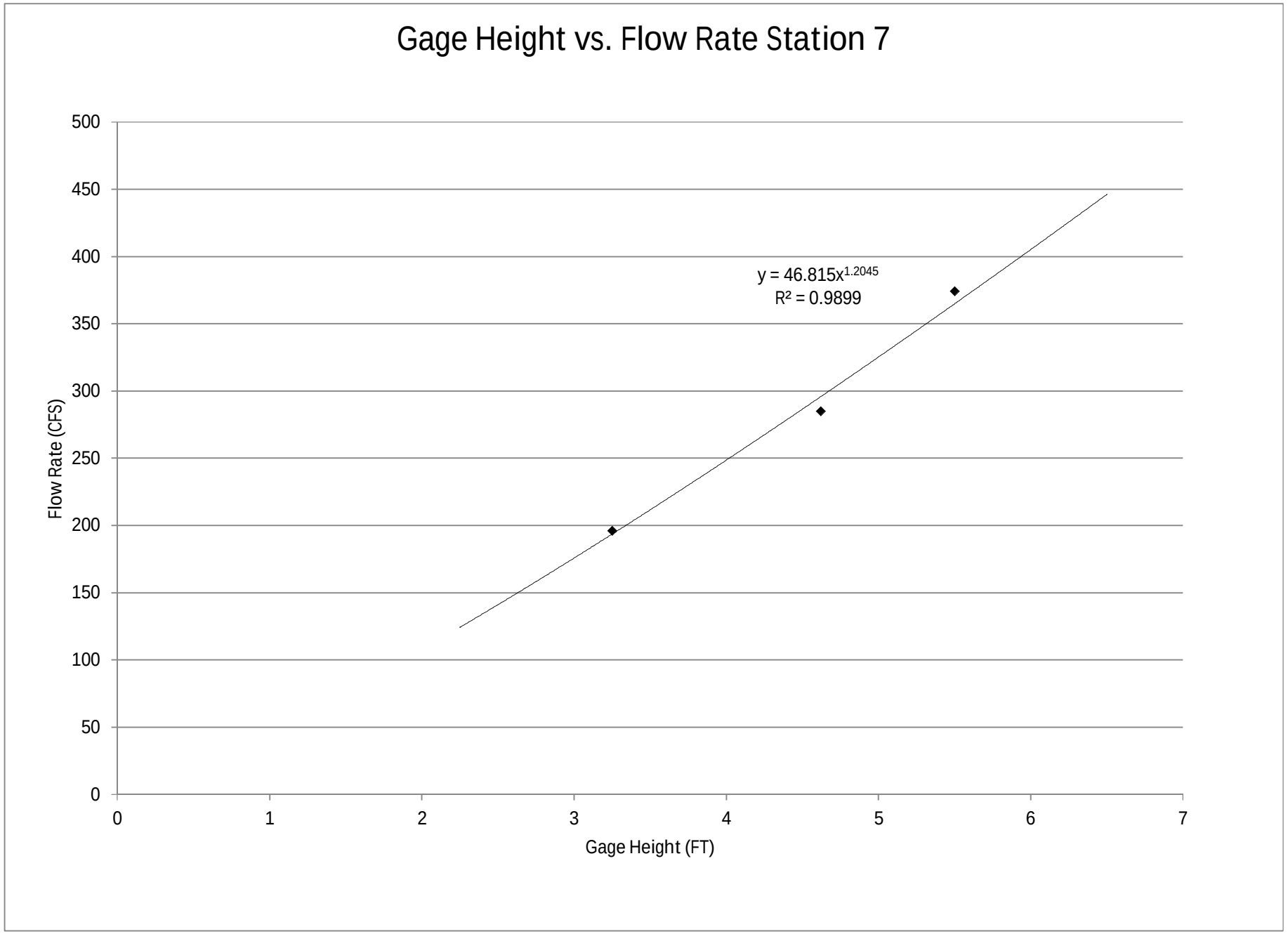

Gage Height vs. Flow Rate Station 2
600
500
400
300
200
100
0
Flow Rate (CFS)
y = 90.466x^0.9888
R² = 0.9913
0
1
2
3
4
5
6
7
8
Gage Height (FT)

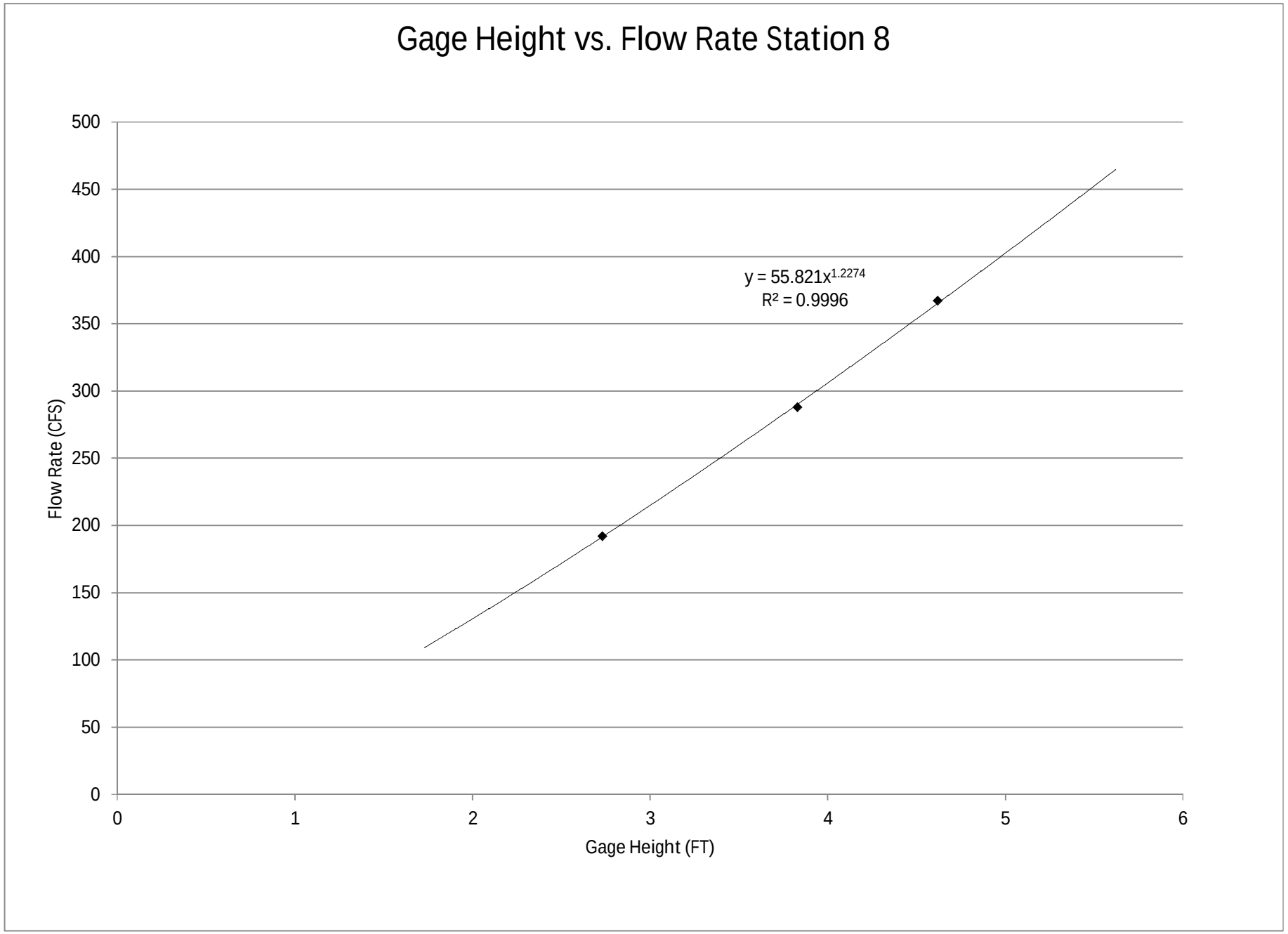

Gage Height vs. Flow Rate Station 3
y = 56.326x^1.1811
R² = 0.9975
Flow Rate (CFS)
Gage Height (FT)
0
50
100
150
200
250
300
350
400
450
500
0
1
2
3
4
5
6
7

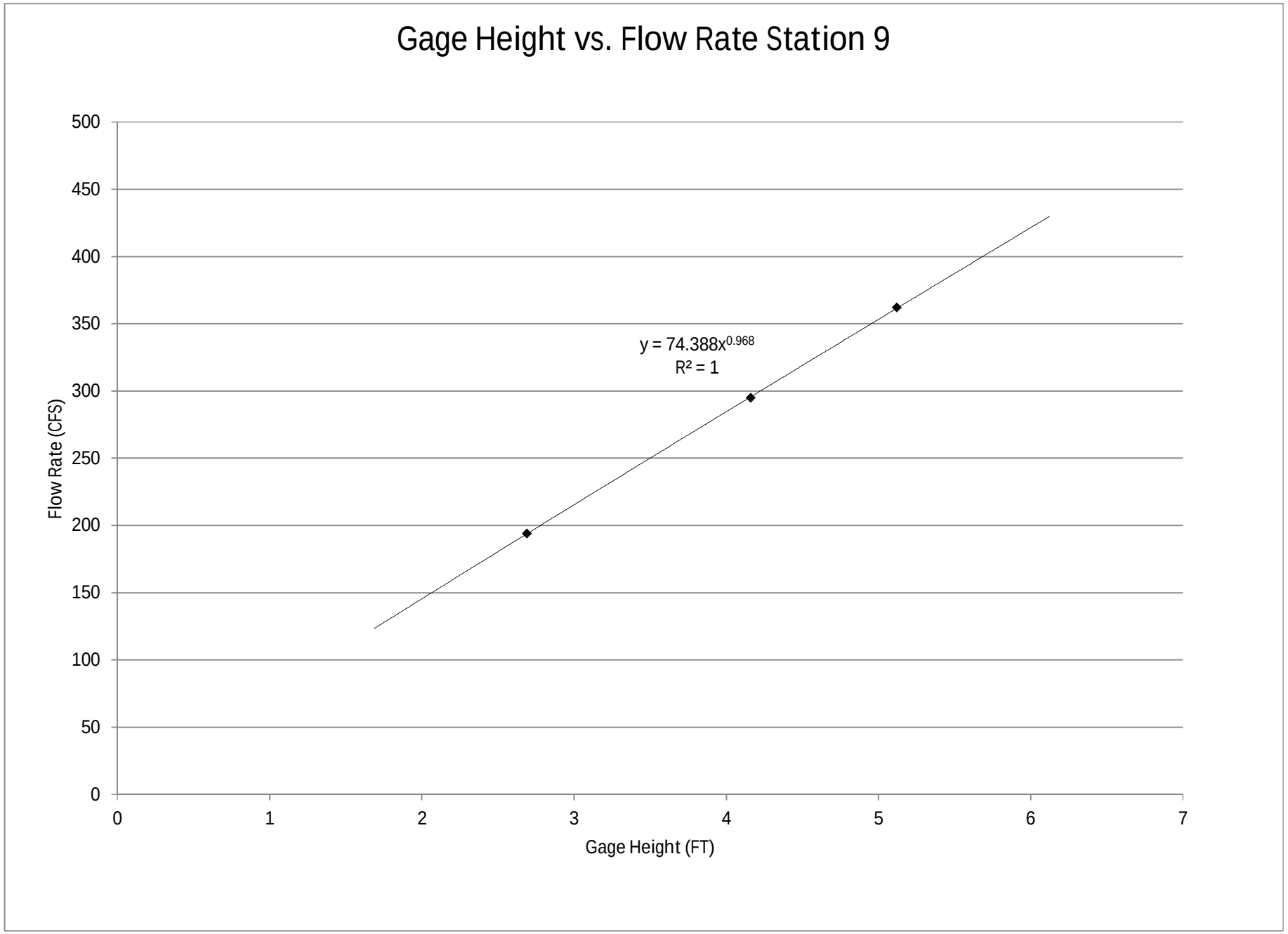

Gage Height vs. Flow Rate Station 4
y = 70.933x^1.0994
R² = 0.9919
Flow Rate (CFS)
Gage Height (FT)
500
450
400
350
300
250
200
150
100
50
0
0
1
2
3
4
5
6


Gage Height vs. Flow Rate Station 5
y = 98.321x^0.8772
R² = 0.9977
Flow Rate (CFS)
Gage Height (FT)
500
450
400
350
300
250
200
150
100
50
0
0
1
2
3
4
5
6


Gage Height vs. Flow Rate Station 6
y = 46.007x^1.2122
R² = 0.9891
Flow Rate (CFS)
Gage Height (FT)
0
50
100
150
200
250
300
350
400
450
500
0
1
2
3
4
5
6
7


Gage Height vs. Flow Rate Station 7
y = 46.815x^1.2045
R² = 0.9899
Flow Rate (CFS)
Gage Height (FT)
0
50
100
150
200
250
300
350
400
450
500
0
1
2
3
4
5
6
7


Gage Height vs. Flow Rate Station 8
y = 55.821x^1.2274
R² = 0.9996
Flow Rate (CFS)
Gage Height (FT)
0
50
100
150
200
250
300
350
400
450
500
0
1
2
3
4
5
6


Gage Height vs. Flow Rate Station 9
Flow Rate (CFS)
500
450
400
350
300
250
200
150
100
50
0
0
1
2
3
4
5
6
7
Gage Height (FT)
y = 74.388x^0.968
R² = 1

MEMORANDUM

WWC ENGINEERING

51 North 15th Street, Suite 1 Billings, MT 59101
PHONE: (406) 894-2210 E-MAIL infobil@wwcengineering.com

TO: **Billings Bench Water Association**

FROM: **Greg Reid, P.E., Project Manager, WWC Engineering**

DATE: **January 4, 2018**

SUBJECT: **Bank Seepage Investigation Findings and Recommendations**

SUMMARY
In order to determine areas of concern regarding bank seepage in the Billings Bench Water Association (BBWA) Main Canal, a seepage investigation was conducted by WWC Engineering (WWC) in October 2017. This investigation reflects information similar to the flow losses investigation that was performed in that reaches with large flow losses generally exhibit numerous points of seepage also. However, this investigation in conjunction with the flow losses investigation provides a holistic comparison of channel losses, groundwater infiltration, and embankment points of concern due to seepage.

The seepage investigation included manual survey of the BBWA canal from its intersection with Hesper Road near the Shiloh Road roundabout to the canal's intersection with Shamrock Lane. The manual survey consisted of walking the toe slope of the canal embankment to inspect for visible seepage of water, soft spots, abnormal vegetation, or other surface variations indicating loss of water from the canal. This seepage investigation was done while the canal was in use to ensure seeping water would be accounted for if present. Criteria used to determine if seepage or other water losses from the BBWA canal were present included:

- Visual streams or flowing water from the canal embankment
- Soft soil areas caused by apparent saturation
- Wetland vegetation
- Standing water

Using the above detailed criteria, it was determined by WWC there were 49 distinct locations where apparent seepage is occurring, or has historically occurred, in the stretch of the BBWA canal inspected by WWC. Although there were 49 locations identified, WWC worked to group these locations into areas or stretches of the canal that have similar characteristics, and/or would be mitigated at the same time, so they could be examined as a section rather than individual points. After analyzing each identified seepage location, it was determined there were 12 sections of the canal that would be analyzed in more detail (shown on Figure 1). These 12 locations, overlapped the gauge reaches previously identified in the flow measurements investigation. Therefore further

separation of sections was required. Two of the sections identified cross the flow gauge reaches, which were divided at the gauge location to create a total of 14 seepage sections.

The 14 seepage sections were examined to determine the potential for contributing to canal embankment failure, quantity of water lost, and critical nature of the seep in relation to existing infrastructure surrounding the location. A rating (from 1 to 5, with 1 being the most critical) for each consideration was applied to the seepage locations in an effort to determine which locations are of the highest concern. Detailed observations at each of the 49 identified locations are included as an attachment. The detailed observations may be used following canal lining to determine if further improvements are necessary (e.g. embankment toe drains).

The seepage investigation also provides a baseline of potential groundwater seepage locations along the toe of the canal. It is recommended that should a section of canal be lined, this baseline should be utilized to reevaluate each point to ensure that seepage is not continuing. If seepage persists, it is a result of groundwater and may still lead to a failure of the embankment. If this scenario occurs, further remedial actions will be necessary such as construction of a toe drain along the canal at the point of seepage.

METHOD

In order to remain consistent with gauge flow measurement locations, the 14 identified seepage areas were assigned identifiers that correlate to the gauge locations used for taking flow measurements. Where areas of identified seepage crossed over gauge reaches, a new section was made after the gauge (e.g., Sections 3 and 4, Sections 5 and 6); as such, ratings for those split sections are the same. Table 1 details the seepage section number, seepage points included in each section, main canal station ranges, and gauge identifiers for each area analyzed.

Table 1. Seepage Area Identification

Seepage Area Section Number	Seepage Point Numbers Included	Section Station Range	Gauge Reach Identifiers
1	1-5	36+58 to 39+38	1A
2	6-10	42+62 to 68+33	1B
3	11-17	71+83 to 88+21	1C
4	18-23	88+21 to 115+83	2A
5	24-28	122+53 to 132+80	2B
6	28-32	132+80 to 142+60	3A
7	33-39	145+96 to 163+11	3B
8	40	267+62	5
9	41 & 42	383+64 to 385+38	7
10	43 & 44	432+99 to 437+19.	7A
11	45 & 46	513+00	9
12	47	552+34	9A
13	48	555+93	9B
14	49	578+62	9C

Upon determining the sections to be analyzed, WWC applied the following rating criteria to determine which sections are most critical when considering seepage amount, threat posed to canal

embankment failure, and surrounding critical infrastructure. A priority rating of 1 indicates the most critical, while a rating of 5 indicates the least concern.

- Seepage Amount
    1. Visible water flowing from embankment
    2. Visible water, but no discernable flow
    3. Wet surface surrounding embankment
    4. Cattails or soil soft spots
    5. Indiscernible if seepage or water from other cause
- Threat Posed to Canal Embankment Failure
    1. Muddy water seeping, altered embankment, history of failure
    2. Clear water seeping
    3. Chronic seepage or history of continued seepage
    4. Minimal evidence of seepage
    5. Indiscernible if seepage or water from other cause
- Surrounding Critical Infrastructure
    1. High density development, no barriers from potential failure
    2. High density development, barriers from potential failure
    3. Developed land, no barriers from failure
    4. Developed land, barriers from failure
    5. Range or other undeveloped land

This detailed priority ranking was then applied to each section determining which areas should be considered for mitigation first.

RESULTS

Preliminary results from the priority ranking of the identified seepage areas indicated Sections 7 and 11 as being the most critical areas in regards to seepage. However, per discussions with the BBWA, seepage points 45 and 46 are in relation to toe drains and french drains constructed along the edge of the embankment near the Rim Tunnel as a result of historic seepage at these locations. Therefore, the points that were identified in this study are not anticipated to pose a threat to embankment failure. As such, Section 11 is no longer a priority section based on identified seepage. Results of the analyses for each section are presented in Table 2.

DISCUSSION

Seepage in the BBWA canal embankment can have a major negative impact on the structural integrity of the embankment as well as pose risks to the water users served by BBWA and those property owners who would be greatly impacted should a failure occur on the canal embankments. Seepage poses these concerns for multiple reasons, including water loss, soil fines transport from the embankment which decreases its structural integrity, as well as negative impacts that a seep may have on foundation walls, basement, and other structures over time. It is imperative that, as BBWA is able to do so, seepage from the canal be mitigated to eliminate the potential for these negative impacts.

RECOMMENDATION

WWC recommends utilizing the priority ranking matrix provided in Table 2, in addition to other considerations, to guide mitigation projects to reduce the amount of seepage occurrences in the BBWA canal. Potential mitigation options for each section include canal lining with concrete or plastic, piping of the canal, toe french drains to collect seeping water and prevent from impacting other entities, and canal reconstruction with suitable material. As canal reconstruction is the most expensive and intrusive option, it should be considered as a last resort recommendation. In addition to identifying where seepage is occurring in the BBWA canal, it is recommended to perform a soil analysis of the BBWA canal to assist in determining the preferred mitigation measures at each location.

Table 2. Seepage Analysis Results

Seepage Area Section Number	Seepage Amount	Threat to Canal Embankment	Surrounding Critical Infrastructure	Ranking Total	Ranking Priority
1	2	3	5	10	6th
2	4	3	4	11	7th
3	4	3	2	9	5th
4	4	3	2	9	5th
5	4	3	3	10	6th
6	4	3	3	10	6th
7	1	3	1	5	1st
8	4	3	2	9	5th
9	5	5	1	11	7th
10	4	4	1	9	5th
11	5	5	1	11	7th
12	2	2	3	7	3rd
13	2	3	3	8	4th
14	1	2	3	6	2nd

ATTACHMENTS

1) Figure 1 showing identified seepage areas
2) Field notes from seepage investigation

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BILLINGS BENCH WATER ASSOCIATION

P.O. BOX 50150
BILLINGS, MT 59105

DSGN	DATE	REV	DATE
XXX	XX/XX		
CKD	XXX	CKD	

JOB # XXXX-XXX

PLOT STYLE: WWC COLOR.ctb
PLOT DATE: 2/9/2017
FILE PATH: K:\Billings\BBWA\17-161\DWG\BBWA SeepageAnalysisPoints.dwg

BILLINGS BENCH WATER ASSOCIATION SEEPAGE INVESTIGATION

FIGURE 1

© 2017 DigitalGlobe ©CNES (2017) Distribution Airbus DS © 2017 Microsoft Corporation

WWC ENGINEERING – BBWA CANAL SEEPAGE INVESTIGATION FIELD NOTES

1 - Concentrated stream of seepage leading in to cannel adjacent to ditch embankment. Begins at toe of embankment.

2 - 5’ wide seepage with mud and water visible at toe of embankment. Cattails present.

3 - Cattails present on edge of toe. Evidence of shallow gw because tails are on, elevated bench above surface water adjacent to ditch. 200’ x 30’ seepage noted in cattails as well. Mud and water noted between toe and adjacent ditch.

4 - Seepage noted coming from embankment 20’ up from toe to adjacent ditch below. Approx. 20’ wide.

5 - Seepage 6’ x 20’, characterized by mud and visible trickle 20’ up from ditch below toe.

6 - Seepage noted midway up embankment beginning at road ditch and north 30’ x 200’. Heavily vegetated. Could hear trickle under veg. drainage below embankment flowing water.

7 - Seepage noted at toe of embankment in a 15’ X 100’ area characterized by mud holes.

8 - Mud puddle and cattails noted at toe of embankment 20’ x 20’ below concrete armoring.

9 - North of 8 it was difficult discerning seepage from the adjacent parallel ditch at toe of embankment. Adjacent ditch prevalent with water and banks heavily saturated and vegetated.

10 - Surface water in toe ditch not visible at this point. Seepage assumed to be minimal. 8 to 10 seepage prevalent evidenced by cattails and visible surface water.

11 - Seepage ditch 18” wide - 12” deep.

12 - Seepage ditch 12’ across.

13 - Large wetland below toe

14 - Large wetland below toe

15 - Large wetland at toe

16 - End of cattails, transition to grass banks on toe ditch

17 - Cattails begin at toe

18 - Cattails continue at toe

19 - Cattails continue at toe

20 - Seepage ditch picks up flow, weir structure

21 - Cattails, seepage along edge of toe

22 - Cattails, seepage along edge of toe

23 - Cattails, seepage along edge of toe

24 - Cattails, seepage along edge of toe

25 - End of Cattails/Embankment

26 - Begin embankment

27 - Minor seepage, cattails present at toe, no water, and north to road

28 - 6' x 6' open water seepage at toe in bottom of adjacent drainage

29 - Cattails present at toe

30 - Continued cattails at toe

31 - Continued cattails, adjacent seepage ditch picking up flow

32 - Adjacent ditch becoming more prevalent

33 – Cattails at toe entire length; No major changes to seepage amounts

34 – Below sidewalk an embankment water is ponded in a 1' depression; Similar instances to waypoint 426 on both sides of sidewalk; No observable flowing water so no estimate, significant standing water; At waypoint 426 a fair amount (2-4 gpm) is draining in the landscaping behind the building

35 –Toe drain connected to City Storm Drain; 10 gpm flowing through drain

36 – Approximately 10' long section of sidewalk with seepage crossing it; Seepage across sidewalk minimal with gpm; This is near the toe drain constructed at the end of Millenium Ct.

37 – Pond behind HDR likely receives seepage from Ditch above; Overflow into storm drain at north end running – 10 gpm; Lower portion of ditch embankment has wetland type plants from end to end of pond

38 – Lot has noticeable standing water problems and soft soil; Appears as though a french drain may be installed under sidewalk paralleling the ditch on the east side. A storm manhole was observed with 20-30 gpm flowing through it.

39 – Building drops N 20' to bac and seepage points are visible in the sod as muddy lawn moves trades; No visible seepage but extremely soft soil

40 - Not a concern for breach failure, but loss of water occurs here

41 –Photo has ~1' sluff at top of bank; 50' wide sluff of bank from seepage; Likely caused by poorly compacted materials settling once saturated; No observable seepage or soft spots

42 – 20’ wide soft section in berm, noticeable sluffing of bank; No noticeable seepage; Soft soils not noticeable walking, but cuts from vehicle at location

43 – Area along Poly from Pine to Highlands Golf Course; Entire ditch bank seeps minor amounts; No water surfacing, but wetland type vegetation along entire bank; In past years, prairie dog holes have led to seepage in Poly; Several locations have had sediment carried away and cave in of bank

44 - 50’ x 25’ area of soft soil and distressed vegetation; Visible seepage is not at this location; Can tell area seeps based on vegetation and heel test with boot goes ~1” into soil; Near Poly & Pine intersection

45 –Standing water and seepage onto street was present near where the canal turns into the tunnel at the toe of the berm; It appears this is a constant seep, with water flowing onto the street (can be seen in aerial images as well).

46 – Cattails were present at the base of toe in the vicinity where the canal enters the tunnel; The cattails seem to be connected with the standing water at point 411.

47 – Seepage appears to be originating from a single point at the toe of the berm; May be from a pipe adjacent to the seep approx. 20’ west; Flow estimate would be 5 GPM.

48 – Seepage appears to be happening on the east side of the PVC stormwater pipe, contributing to the flow in the drainage; There are two evident sources of flow in the drainage; Flow estimate would be 10-15 GPM.

49 - Seepage appears to be occurring for 35 to 40’ at the toe of the berm; Extends approx. 5’ from toe; May be in relation to irrigation system; Flow estimate is 5 GPM.

MEMORANDUM

WWC ENGINEERING

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TO: **Billings Bench Water Association**

FROM: **Greg Reid, P.E., Project Manager, WWC Engineering**

DATE: **January 16, 2018**

SUBJECT: **BBWA Main Canal Soils, Vegetation, and Embankment Investigation Findings and Recommendations**

SUMMARY
In order to determine areas of concern regarding embankment failure in the Billings Bench Water Association (BBWA) Main Canal (Main Canal), an investigation was conducted by WWC Engineering (WWC) looking at the soil types, vegetative cover, and embankment height of the Main Canal. The embankment investigation included manual survey of the BBWA canal from its intersection with Hesper Road near the Shiloh Road roundabout to the canal's intersection with Shamrock Lane, review of United States Department of Agriculture (USDA) Natural Resource Conservation Resource (NRCS) soil maps, and review of aerial photogrammetry. The manual survey and review of aerial photogrammetry was performed to determine embankment characteristics including height, proximity to other notable features (parallel ditches, canals, etc.), and vegetative cover. The review of USGS soil maps was performed to determine the surficial soils present near the Main Canal and potential materials used to construct the embankment.

Evaluation of the Main Canal in relation to soil types, vegetative cover, and embankment height was broken into nine segments correlating with the ten flow gauge stations used to measure flows. This was done to provide a means of correlating results from this investigation with those determined during the seepage, inflow, hydrologic, and hydraulic investigations conducted on the same stretch of the Main Canal.

METHOD
Soil, vegetation, and embankment evaluation of the Main Canal was conducted using a rating criteria for the 9 distinct segments. The rating criteria used in this evaluation was developed by WWC based on the observed conditions of the embankment, as well as soils data collected from the USDA soil maps. The rating criteria for each indicator is depicted below, with lower numbers indicating more concern for potential embankment failure than larger numbers.

- Soils: Each individual segment was inputted into the USDA web soil maps as the Area of Interest, and analyzed for limitations or suitability for use in surface water management systems (i.e., graded ditches, grassed waterways, terraces, and diversions). The ratings for surface water management system are based on the soil properties that affect the capacity

of the soil to convey surface water across the landscape. Factors affecting the system installation and performance are considered, including depth to bedrock, saturated hydraulic conductivity, depth to cemented pan, slope, flooding, ponding, large stone content, sodicity, surface water erosion, and gypsum content are all considered in the ratings. Results from the USDA NRCS soil map database are included with this memorandum as attachments. Based on the results for each segment, the following rating criteria was developed for canal soils:

1. Very Limited, Soil has one or more features that are unfavorable for surface water management
2. Somewhat limited, Soil has features that are moderately favorable for surface water management; fair performance and moderate maintenance can be expected.
3. Not limited, indicates soil has features that are favorable for surface water management, good performance and low maintenance can be expected.

- Vegetation: In order to rate the level of vegetative cover (trees, shrubs, bushes, etc.) that could lead to potential piping failures and/or cause concern regarding the embankment structural integrity, WWC estimated the percentage of embankment that is covered by vegetation for each segment, with specific focus on tree-type vegetation. This was done by tabulating continuous vegetation in excess of 100' along the embankment, and dividing by the total length of the analyzed segment. Based on these percentages, a rating was developed as described below:
    1. High density of vegetation along downstream side of embankment. (>80%)
    2. Moderately high density of vegetation along downstream side of embankment. (60-80%)
    3. Moderate density of vegetation along downstream side of embankment. (30-60%)
    4. Low density of vegetation along downstream side of embankment (0-30%)
- Embankment Height: Embankment height would directly increase the rate of water infiltration at the base of the canal and surfacing on the side of the embankment. As this flow increases, potential for sediments being removed by bank seepage increases. In addition, as the main canal is expected to maintain a limited width right-of-way, larger embankments would likely include a steeper slope on the downstream toe, which increases the potential for canal failure. Therefore, it is imperative to consider embankment height when assessing the potential for failure. Field investigations and surface elevation comparison in Google Earth was used to estimate average embankment heights for the 9 segments, with heights being taken every 500'. Based on the observed average embankment heights for each segment, the following rating criteria was developed.
    1. Embankment height 17'-30'
    2. Embankment height 11'-17'
    3. Embankment height of 5'-11'
    4. Embankment height from 0'-4', meaning embankment height is negligible

Following rating each segment of the canal based on the results of analyses for soils, vegetation, and embankment height, the cumulative rating for each segment was summed to determine which segment of the canal is of most concern in relation to the rating criteria. As with each individual rating based on soils, vegetation, and embankment height, a lower summed rating indicates the segment of the canal is of more concern for potential failure, and therefore has a higher priority ranking for mitigations.

RESULTS

Results from the soils, vegetation, and embankment height evaluation can be seen in Table 1. Soil analysis results include the majority ranking assigned to the segment per the USDA soil maps and the percentage encompassed by that ranking. For example, Segment 3, had a fairly evenly distributed rating for the soils with very limited (40%), somewhat limited (34%), and not limited (26%) soils all being present; however, as very limited was the largest component, it was selected as the segment rating. Vegetation analysis results include the percentage of embankment length in each segment that was determined to have trees, shrubs, or bushes growing. Embankment height analysis results indicate the average embankment height for the given segment.

Table 1. Soil, Vegetation, and Embankment Height Analysis Results

Canal Segment	Flow Gauge Reach	Soil Analysis Results	Vegetation Analysis Results	Embankment Height Analysis Results
1	1-2	Very Limited (68%)	70%	13’
2	2-3	Very Limited (72%)	81%	10’
3	3-4	Very Limited (40%)	40%	16’
4	4-5	Somewhat Limited (65%)	62%	4’
5	5-6	Not Limited (60%)	28%	3’
6	6-7	Not Limited (100%)	57%	4’
7	7-8	Not Limited (100%)	62%	5’
8	8-9	Very Limited (70%)	79%	28’
9	9-10	Very Limited (88%)	84%	19’

Table 2 displays the priority ranking of each segment based on the analysis results listed in Table 1 and the rating criteria discussed in the Method section of this memorandum. Again, lower numbers indicate a higher concern for canal embankment failure, versus higher numbers indicating less concern. Segment priority rankings have been included in Table 2 indicating which segment is the highest priority for mitigation implementation based on soils, vegetation, and embankment height.

Table 2. Soil, Vegetation, and Embankment Height Ratings

Canal Segment	Flow Gauge Reach	Soil Analysis Rating	Vegetation Analysis Rating	Embankment Height Analysis Rating	Cumulative Segment Rating	Segment Priority Ranking
1	1-2	1	2	2	5	3rd
2	2-3	1	1	3	5	3rd
3	3-4	1	3	2	6	4th
4	4-5	2	2	4	8	5th
5	5-6	3	4	4	11	8th
6	6-7	3	3	4	10	7th
7	7-8	3	2	4	9	6th
8	8-9	1	2	1	4	2nd
9	9-10	1	1	1	3	1st

DISCUSSION

Based on WWC's evaluation of the soils, vegetation, and embankment height of the BBWA canal, it was determine the canal segment (9) between flow gauge stations 9 and 10 is most pressing for further consideration of mitigations. Segment 9 is ranked immediately ahead of Segment 8, followed by Segments 1 and 2 which are ranked 3rd.

RECOMMENDATION

WWC's recommendation is to consider potential mitigation efforts (canal lining, clearing and grubbing of dense vegetation along embankment, toe drains, etc.) in those canal segments identified as being highest priority first, followed by those segments with a lower priority ranking. Mitigations including canal lining would be best used to address issues related to poor soil conditions and embankment height, ensuring decreased water losses through the embankment and limiting canal erosion that could potentially lead to failure. Toe drains would also benefit segments where embankment height is of concern, providing a preferential pathway for water in the embankment to escape with minimal fines being transported from the existing soils.

Clearing and grubbing to the embankment is recommended to be done only in instances were vegetation is clearly causing problems (i.e., roots providing a preferential pathway for water losses, vegetation encroaching on water movement in canal, etc.) and/or the vegetation is dead. Removing living vegetation when no other problems are noted may lead to roots shrinking in place and causing piping of the embankment soils. If a segment of the canal is to be cleared, it is recommended to follow a documented procedure, such as that outlined in the *Technical Manual for Dam Owners: Impacts of Plants on Earthen Dams* (FEMA, 2005).

Mitigation strategies resulting from the analysis of soils, vegetation, and embankment height should also incorporate the findings of investigations related to seepage, inflow, hydraulics, and hydrology performed by WWC as part of this project. An overall rating matrix incorporating all the mentioned aspects of the canal will be provided at a later date in association with this project.

ATTACHMENTS

//as noted

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

Very limited

Somewhat limited

Not limited

Not rated or not available

Soil Rating Lines

Very limited

Somewhat limited

Not limited

Not rated or not available

Soil Rating Points

Very limited

Somewhat limited

Not limited

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Yellowstone County, Montana
Survey Area Data: Version 15, Sep 21, 2017

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 3, 2013—Mar 6, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Description

The ratings for Surface Water Management, System are based on the soil properties that affect the capacity of the soil to convey surface water across the landscape. Factors affecting the system installation and performance are considered. Water conveyances include graded ditches, grassed waterways, terraces, and diversions. The ratings are for soils in their natural condition and do not consider present land use. The properties that affect the surface system performance include depth to bedrock, saturated hydraulic conductivity, depth to cemented pan, slope, flooding, ponding, large stone content, sodicity, surface water erosion, and gypsum content.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the specified use. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as that listed for the map unit. The percent composition of each component in a particular map unit is given so that the user will realize the percentage of each map unit that has the specified rating.

A map unit may have other components with different ratings. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

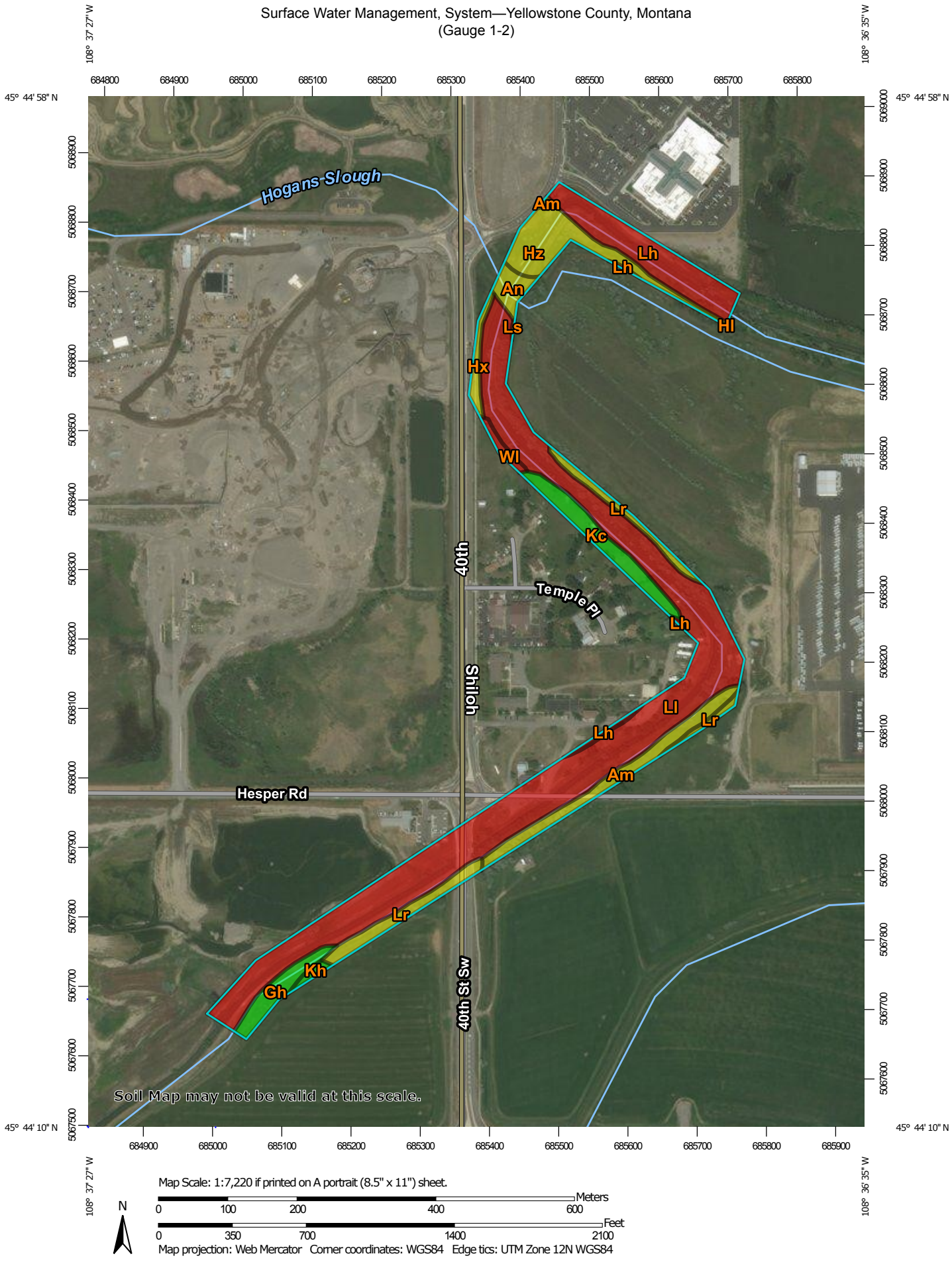
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Surface Water Management, System—Yellowstone County, Montana
(Gauge 1-2)



Map Scale: 1:7,220 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 100 200 400 600

Feet: 0 350 700 1400 2100

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

Surface Water Management, System

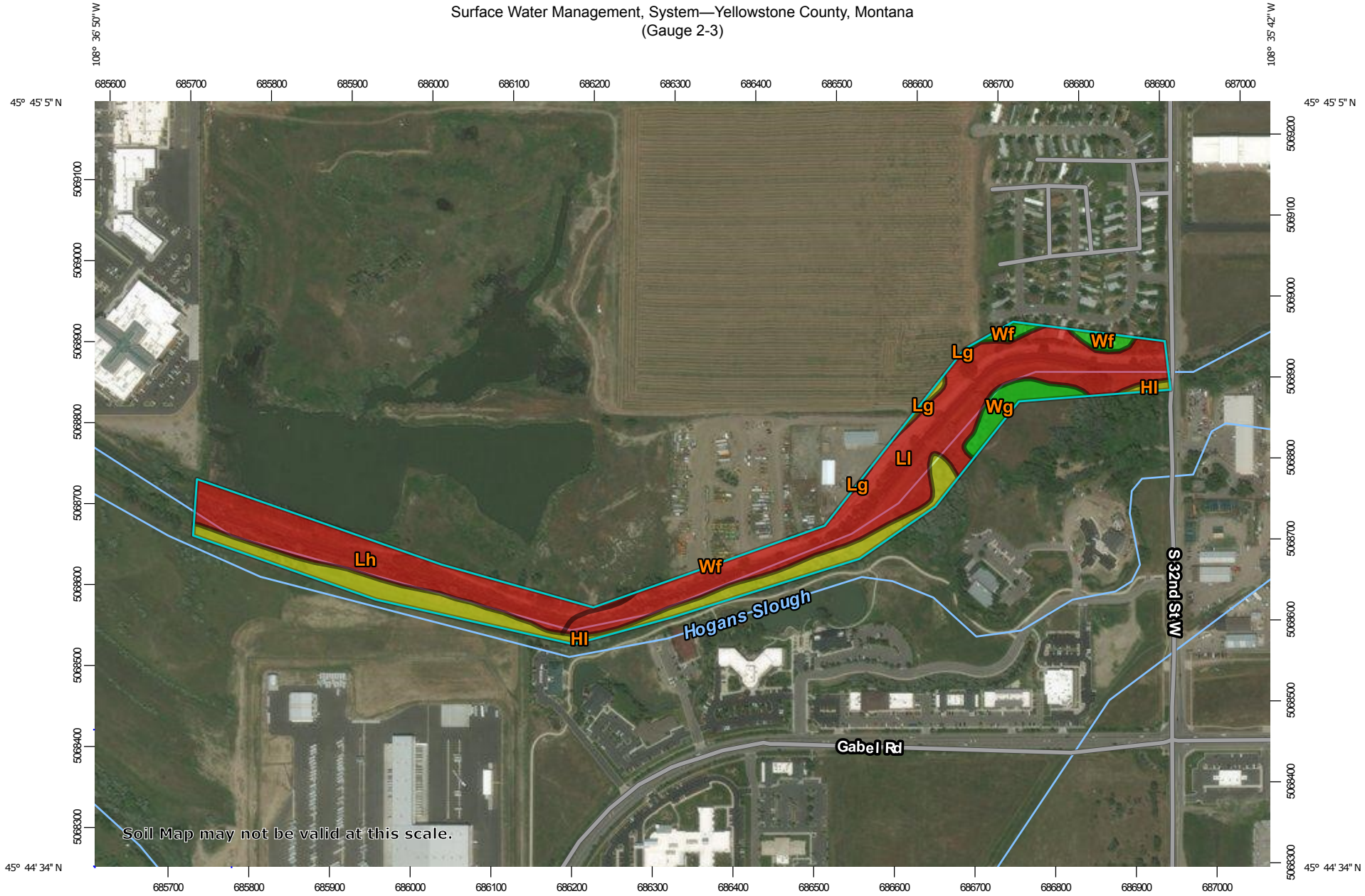
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
Am	Alluvial land, seeped	Somewhat limited	Alluvial land (85%)	Slope (0.22)	1.9	6.0%
			Glenberg (7%)	Excess Salt (0.01)		
An	Alluvial land, wet	Somewhat limited	Alluvial land (90%)	Large rock fragments (0.06)	0.6	1.9%
			Glenberg (5%)	Excess Salt (0.01)		
Gh	Glenberg fine sandy loam, 1 to 4 percent slopes	Not limited	Glenberg (80%)		1.0	3.3%
			Haverson (10%)			
Hl	Haverson and Lohmiller soils, 0 to 4 percent slopes	Somewhat limited	Lohmiller (40%)	Slow water movement (0.20)	0.0	0.0%
				Excess Sodium (0.01)		
			Grail (8%)	Slow water movement (0.20)		
			Hysham (7%)	Excess Salt (0.78)		
				Excess Sodium (0.01)		
			Glenberg (5%)	Excess Salt (0.01)		
Hx	Hysham-Laurel loams, 0 to 2 percent slopes	Somewhat limited	Hysham (60%)	Excess Salt (0.78)	0.5	1.4%
				Excess Sodium (0.01)		
			Lohmiller (5%)	Excess Sodium (0.26)		
				Slow water movement (0.20)		
				Excess Salt (0.06)		
			Lallie (1%)	Flooding (0.40)		
				Slow water movement (0.20)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
Hz	Hysham and Haverson soils, 0 to 4 percent slopes	Somewhat limited	Hysham (45%)	Excess Salt (0.78)	2.4	7.4%
				Excess Sodium (0.01)		
			Glenberg (10%)	Excess Salt (0.01)		
Kc	Keiser silty clay loam, 0 to 1 percent slopes	Not limited	Keiser (85%)		1.6	5.1%
			Hesper (4%)			
Kh	Keiser and Hesper silty clay loams, 0 to 1 percent slopes	Not limited	Hesper (45%)		0.2	0.6%
			Keiser (45%)			
			Wanetta (2%)			
Lh	Larim gravelly loam, 4 to 7 percent slopes	Very limited	Larim (80%)	Slope (1.00)	3.5	10.9%
				Large rock fragments (0.81)		
Ll	Larim gravelly loam, 15 to 35 percent slopes	Very limited	Larim (80%)	Slope (1.00)	17.8	56.1%
				Water Erosion (1.00)		
				Large rock fragments (1.00)		
			Bainville (8%)	Slope (1.00)		
				Water Erosion (1.00)		
			Clapper (8%)	Slope (1.00)		
				Water Erosion (1.00)		
				Large rock fragments (0.72)		
			Elso (4%)	Depth to bedrock (1.00)		
				Slope (1.00)		
				Water Erosion (1.00)		
				Slow water movement (0.61)		
				Excess Salt (0.01)		
Lr	Lohmiller silty clay, 0 to 1 percent slopes	Somewhat limited	Lohmiller (85%)	Slow water movement (0.20)	2.0	6.4%

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Excess Sodium (0.01)		
			Hysham (5%)	Excess Salt (0.78)		
				Excess Sodium (0.01)		
			Glenberg (4%)	Excess Salt (0.01)		
Ls	Lohmiller soils, seeped, 0 to 2 percent slopes	Somewhat limited	Lohmiller (80%)	Slow water movement (0.20)	0.0	0.0%
			Lallie (2%)	Flooding (0.40)		
				Slow water movement (0.20)		
Wl	Wanetta-Larim clay loams, 4 to 7 percent slopes	Very limited	Wanetta (55%)	Slope (1.00)	0.3	0.8%
				Water Erosion (0.02)		
			Larim (35%)	Slope (1.00)		
				Large rock fragments (0.75)		
				Water Erosion (0.42)		
			Toluca (5%)	Slope (1.00)		
				Water Erosion (0.23)		
			Larim (5%)	Slope (1.00)		
				Large rock fragments (0.81)		
Totals for Area of Interest					**31.7**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Very limited	21.5	67.8%
Somewhat limited	7.4	23.2%
Not limited	2.8	9.0%
Totals for Area of Interest	**31.7**	**100.0%**

Surface Water Management, System—Yellowstone County, Montana
(Gauge 2-3)



Map Scale: 1:6,660 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 50 100 200 300

Feet
0 300 600 1200 1800

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

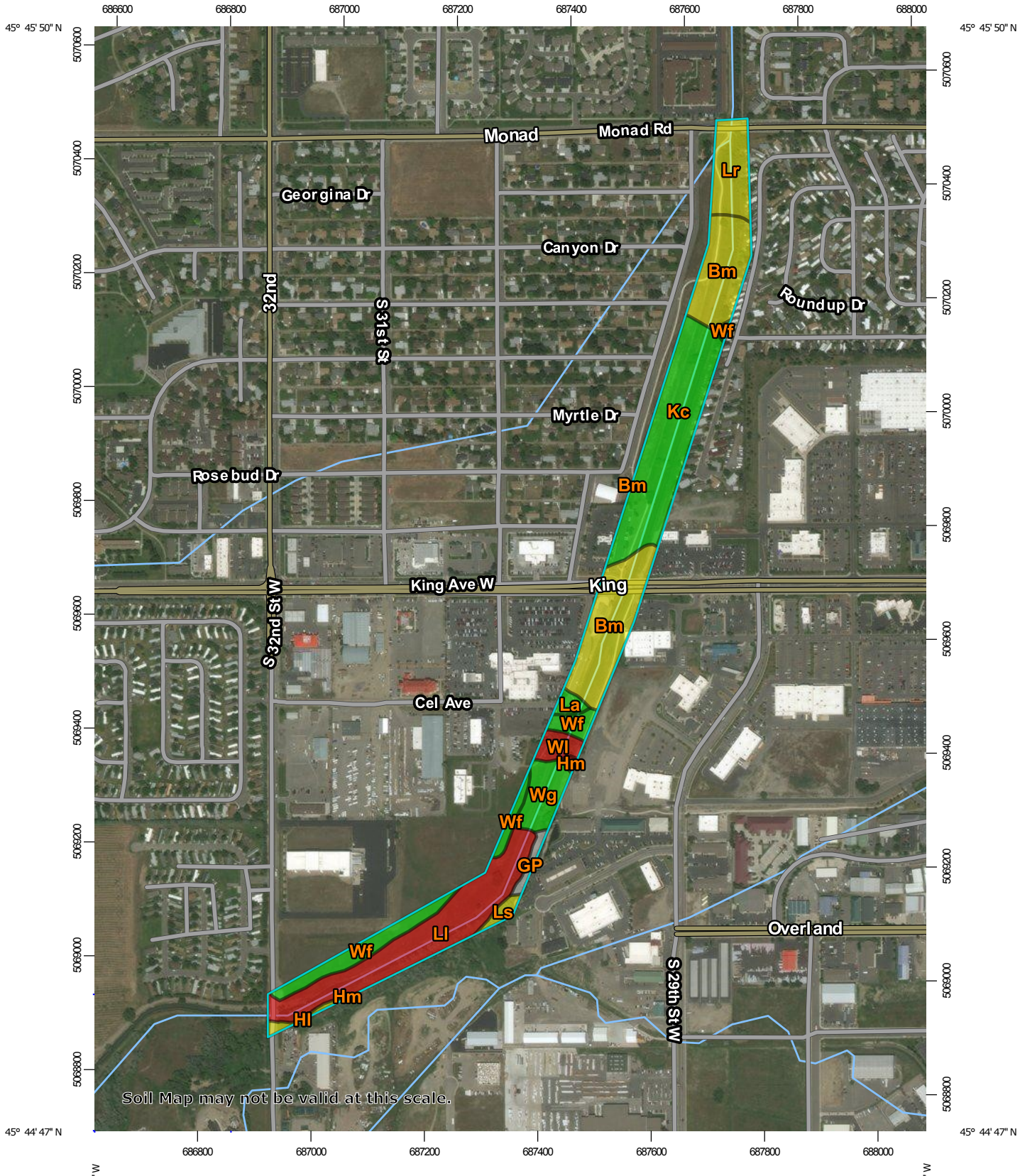
Surface Water Management, System

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
Hl	Haverson and Lohmiller soils, 0 to 4 percent slopes	Somewhat limited	Lohmiller (40%)	Slow water movement (0.20)	4.4	20.0%
				Excess Sodium (0.01)		
			Grail (8%)	Slow water movement (0.20)		
			Hysham (7%)	Excess Salt (0.78)		
				Excess Sodium (0.01)		
			Glenberg (5%)	Excess Salt (0.01)		
Lg	Larim gravelly loam, 0 to 4 percent slopes	Somewhat limited	Larim (80%)	Large rock fragments (0.81)	0.1	0.6%
			Larim (10%)	Large rock fragments (0.75)		
Lh	Larim gravelly loam, 4 to 7 percent slopes	Very limited	Larim (80%)	Slope (1.00)	5.5	24.8%
				Large rock fragments (0.81)		
Ll	Larim gravelly loam, 15 to 35 percent slopes	Very limited	Larim (80%)	Slope (1.00)	10.4	47.2%
				Water Erosion (1.00)		
				Large rock fragments (1.00)		
			Bainville (8%)	Slope (1.00)		
				Water Erosion (1.00)		
			Clapper (8%)	Slope (1.00)		
				Water Erosion (1.00)		
				Large rock fragments (0.72)		
			Elso (4%)	Depth to bedrock (1.00)		
				Slope (1.00)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Water Erosion (1.00)		
				Slow water movement (0.61)		
				Excess Salt (0.01)		
Wf	Wanetta clay loam, 0 to 1 percent slopes	Not limited	Wanetta (80%)		0.6	2.7%
			Toluca (6%)			
Wg	Wanetta clay loam, 1 to 4 percent slopes	Not limited	Wanetta (85%)		1.0	4.7%
Totals for Area of Interest					**22.0**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Very limited	15.9	72.0%
Somewhat limited	4.5	20.6%
Not limited	1.6	7.4%
Totals for Area of Interest	**22.0**	**100.0%**

Surface Water Management, System—Yellowstone County, Montana
(Gauge 3-4)



Map Scale: 1:9,450 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 100 200 400 600

Feet: 0 450 900 1800 2700

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

Surface Water Management, System

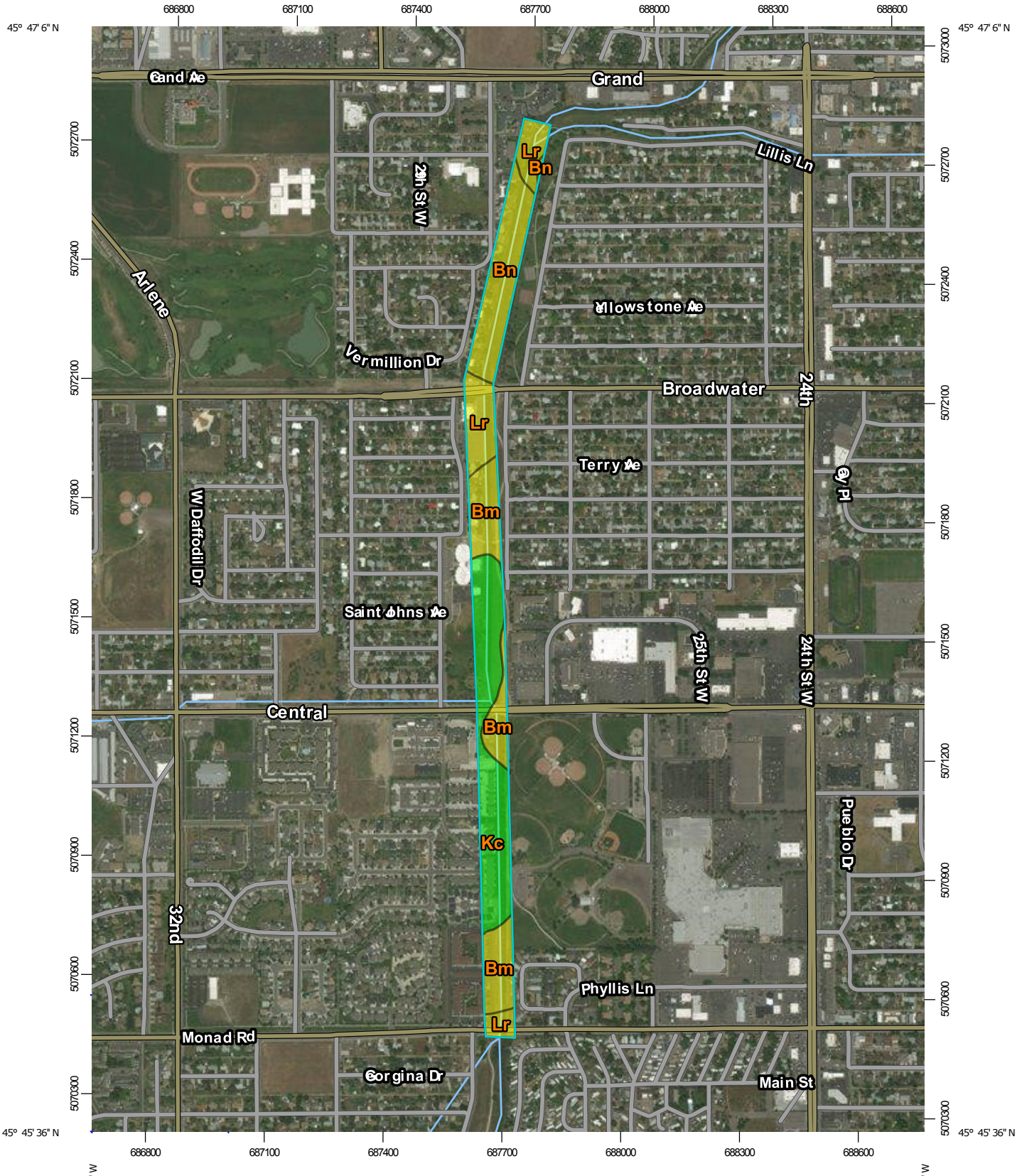
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
Bm	Bew silty clay loam, 0 to 1 percent slopes	Somewhat limited	Bew (85%)	Slow water movement (0.20)	8.7	24.7%
GP	Gravel pit	Not rated	Pits, gravel (100%)		0.4	1.2%
Hl	Haverson and Lohmiller soils, 0 to 4 percent slopes	Somewhat limited	Lohmiller (40%)	Slow water movement (0.20)	0.3	0.9%
				Excess Sodium (0.01)		
			Grail (8%)	Slow water movement (0.20)		
			Hysham (7%)	Excess Salt (0.78)		
				Excess Sodium (0.01)		
			Glenberg (5%)	Excess Salt (0.01)		
Hm	Haverson and Lohmiller soils, channeled, 0 to 35 percent slopes	Very limited	Lohmiller (40%)	Slope (1.00)	0.1	0.4%
				Water Erosion (1.00)		
				Slow water movement (0.20)		
Kc	Keiser silty clay loam, 0 to 1 percent slopes	Not limited	Keiser (85%)		8.2	23.2%
			Hesper (4%)			
La	Lonna-Vanstel complex, 0 to 4 percent slopes	Not limited	Lonna (70%)		0.4	1.2%
			Vanstel (20%)			
			Floweree (10%)			
Ll	Larim gravelly loam, 15 to 35 percent slopes	Very limited	Larim (80%)	Slope (1.00)	7.7	21.7%
				Water Erosion (1.00)		
				Large rock fragments (1.00)		
			Bainville (8%)	Slope (1.00)		
				Water Erosion (1.00)		
			Clapper (8%)	Slope (1.00)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Water Erosion (1.00)		
				Large rock fragments (0.72)		
			Elso (4%)	Depth to bedrock (1.00)		
				Slope (1.00)		
				Water Erosion (1.00)		
				Slow water movement (0.61)		
				Excess Salt (0.01)		
Lr	Lohmiller silty clay, 0 to 1 percent slopes	Somewhat limited	Lohmiller (85%)	Slow water movement (0.20)	2.7	7.6%
				Excess Sodium (0.01)		
			Hysham (5%)	Excess Salt (0.78)		
				Excess Sodium (0.01)		
			Glenberg (4%)	Excess Salt (0.01)		
Ls	Lohmiller soils, seeped, 0 to 2 percent slopes	Somewhat limited	Lohmiller (80%)	Slow water movement (0.20)	0.4	1.2%
			Lallie (2%)	Flooding (0.40)		
				Slow water movement (0.20)		
Wf	Wanetta clay loam, 0 to 1 percent slopes	Not limited	Wanetta (80%)		3.5	9.9%
			Toluca (6%)			
Wg	Wanetta clay loam, 1 to 4 percent slopes	Not limited	Wanetta (85%)		2.0	5.6%
Wl	Wanetta-Larim clay loams, 4 to 7 percent slopes	Very limited	Wanetta (55%)	Slope (1.00)	0.8	2.4%
				Water Erosion (0.02)		
			Larim (35%)	Slope (1.00)		
				Large rock fragments (0.75)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Water Erosion (0.42)		
			Toluca (5%)	Slope (1.00)		
				Water Erosion (0.23)		
			Larim (5%)	Slope (1.00)		
				Large rock fragments (0.81)		
Totals for Area of Interest					**35.2**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Not limited	14.0	39.9%
Somewhat limited	12.1	34.4%
Very limited	8.6	24.5%
Null or Not Rated	0.4	1.2%
Totals for Area of Interest	**35.2**	**100.0%**

Surface Water Management, System—Yellowstone County, Montana
(Gauge 4-5)



Map Scale: 1:13,500 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 200 400 800 1200

Feet: 0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

Surface Water Management, System

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
Bm	Bew silty clay loam, 0 to 1 percent slopes	Somewhat limited	Bew (85%)	Slow water movement (0.20)	11.0	25.6%
Bn	Bew clay, 0 to 1 percent slopes	Somewhat limited	Bew (85%)	Slow water movement (0.20)	9.3	21.6%
			Vananda (4%)	Slow water movement (0.99)		
				Excess Salt (0.78)		
				Excess Sodium (0.75)		
Kc	Keiser silty clay loam, 0 to 1 percent slopes	Not limited	Keiser (85%)		15.0	34.8%
			Hesper (4%)			
Lr	Lohmiller silty clay, 0 to 1 percent slopes	Somewhat limited	Lohmiller (85%)	Slow water movement (0.20)	7.8	18.0%
				Excess Sodium (0.01)		
			Hysham (5%)	Excess Salt (0.78)		
				Excess Sodium (0.01)		
			Glenberg (4%)	Excess Salt (0.01)		
Totals for Area of Interest					**43.2**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Somewhat limited	28.2	65.2%
Not limited	15.0	34.8%
Totals for Area of Interest	**43.2**	**100.0%**

Surface Water Management, System—Yellowstone County, Montana
(Gauge 5-6)



Map Scale: 1:5,480 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 50 100 200 300

Feet
0 250 500 1000 1500

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

Surface Water Management, System

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
Bn	Bew clay, 0 to 1 percent slopes	Somewhat limited	Bew (85%)	Slow water movement (0.20)	3.8	28.2%
			Vananda (4%)	Slow water movement (0.99)		
				Excess Salt (0.78)		
				Excess Sodium (0.75)		
Lr	Lohmiller silty clay, 0 to 1 percent slopes	Somewhat limited	Lohmiller (85%)	Slow water movement (0.20)	1.5	11.4%
				Excess Sodium (0.01)		
			Hysham (5%)	Excess Salt (0.78)		
				Excess Sodium (0.01)		
			Glenberg (4%)	Excess Salt (0.01)		
Mm	McRae loam, 0 to 1 percent slopes	Not limited	McRae (85%)		4.3	32.2%
			Fort Collins (9%)			
Mn	McRae loam, 1 to 4 percent slopes	Not limited	McRae (85%)		3.8	28.1%
			Haverson (9%)			
			Fort Collins (6%)			
Totals for Area of Interest					**13.4**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Not limited	8.1	60.3%
Somewhat limited	5.3	39.7%
Totals for Area of Interest	**13.4**	**100.0%**

Surface Water Management, System—Yellowstone County, Montana
(Gauge 6-7)



Map Scale: 1:10,500 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 150 300 600 900

Feet: 0 500 1000 2000 3000

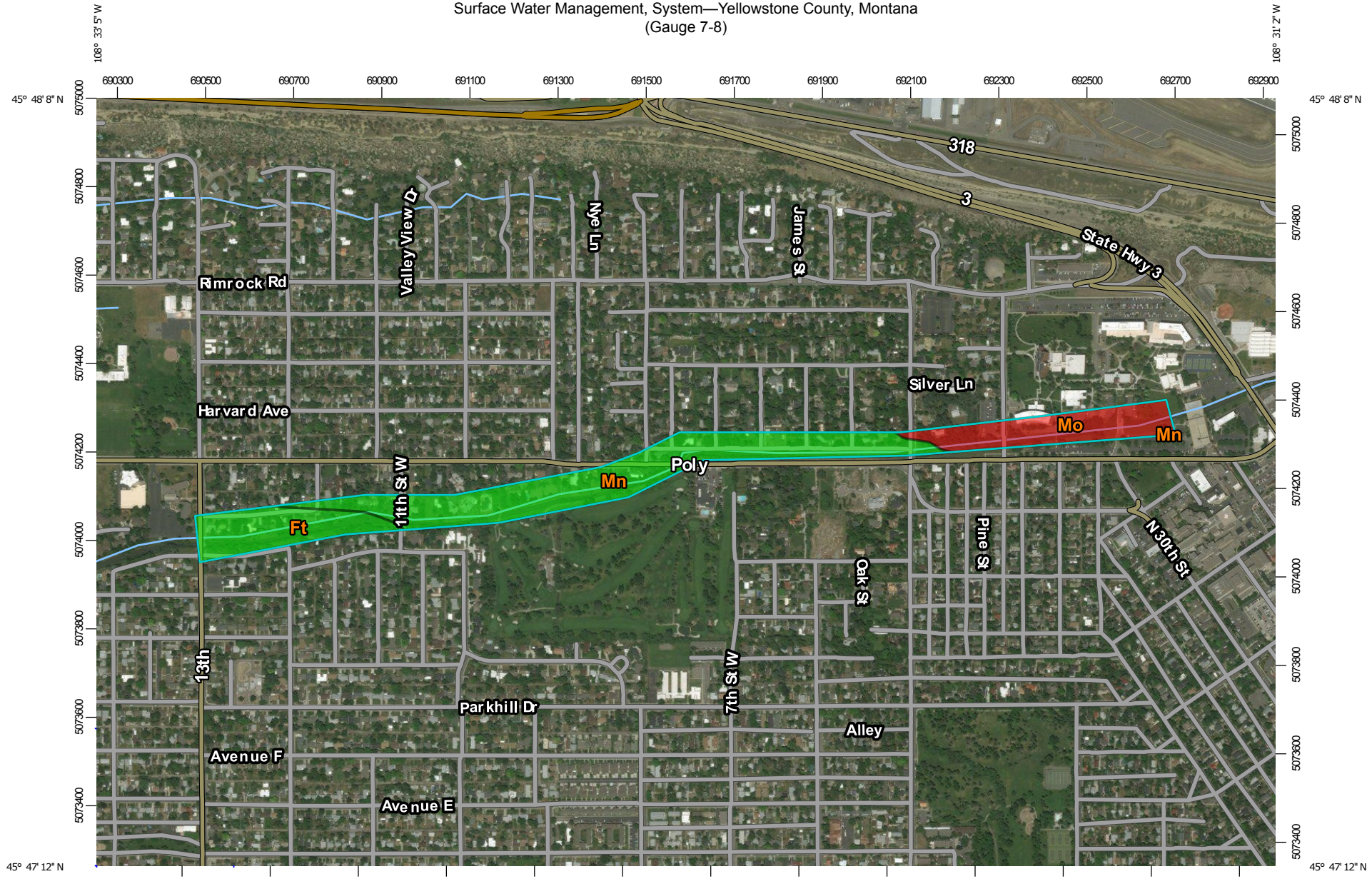
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

Surface Water Management, System

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
Ft	Fort Collins and Thurlow clay loams, 1 to 4 percent slopes	Not limited	Thurlow (45%)		15.9	51.5%
			Fort Collins (45%)			
			McRae (10%)			
Ls	Lohmiller soils, seeped, 0 to 2 percent slopes	Somewhat limited	Lohmiller (80%)	Slow water movement (0.20)	0.0	0.0%
			Lallie (2%)	Flooding (0.40)		
				Slow water movement (0.20)		
Mm	McRae loam, 0 to 1 percent slopes	Not limited	McRae (85%)		8.8	28.6%
			Fort Collins (9%)			
Mn	McRae loam, 1 to 4 percent slopes	Not limited	McRae (85%)		0.2	0.6%
			Haverson (9%)			
			Fort Collins (6%)			
Ta	Thurlow clay loam, 0 to 1 percent slopes	Not limited	Thurlow (85%)		5.9	19.3%
			Fort Collins (6%)			
			McRae (5%)			
			Haverson (4%)			
Totals for Area of Interest					**30.9**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Not limited	30.9	100.0%
Somewhat limited	0.0	0.0%
Totals for Area of Interest	**30.9**	**100.0%**

Surface Water Management, System—Yellowstone County, Montana
(Gauge 7-8)

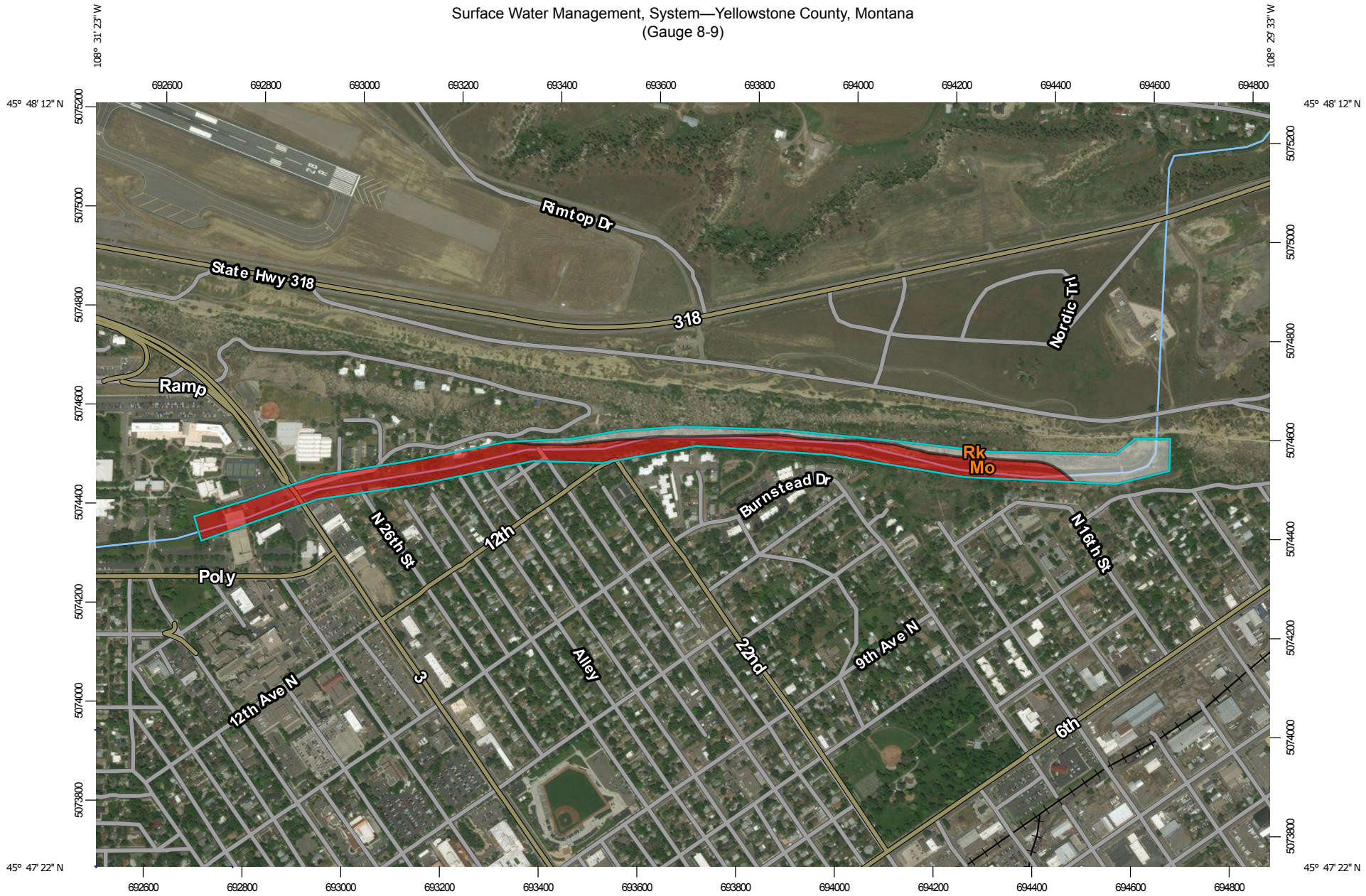


Surface Water Management, System

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
Ft	Fort Collins and Thurlow clay loams, 1 to 4 percent slopes	Not limited	Thurlow (45%)		8.5	20.8%
			Fort Collins (45%)			
			McRae (10%)			
Mn	McRae loam, 1 to 4 percent slopes	Not limited	McRae (85%)		23.0	56.3%
			Haverson (9%)			
			Fort Collins (6%)			
Mo	McRae loam, 4 to 7 percent slopes	Very limited	McRae (85%)	Slope (1.00)	9.4	22.9%
				Water Erosion (0.23)		
Totals for Area of Interest					**40.8**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Not limited	31.5	77.1%
Very limited	9.4	22.9%
Totals for Area of Interest	**40.8**	**100.0%**

Surface Water Management, System—Yellowstone County, Montana
(Gauge 8-9)



Map Scale: 1:10,900 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 150 300 600 900

Feet: 0 500 1000 2000 3000

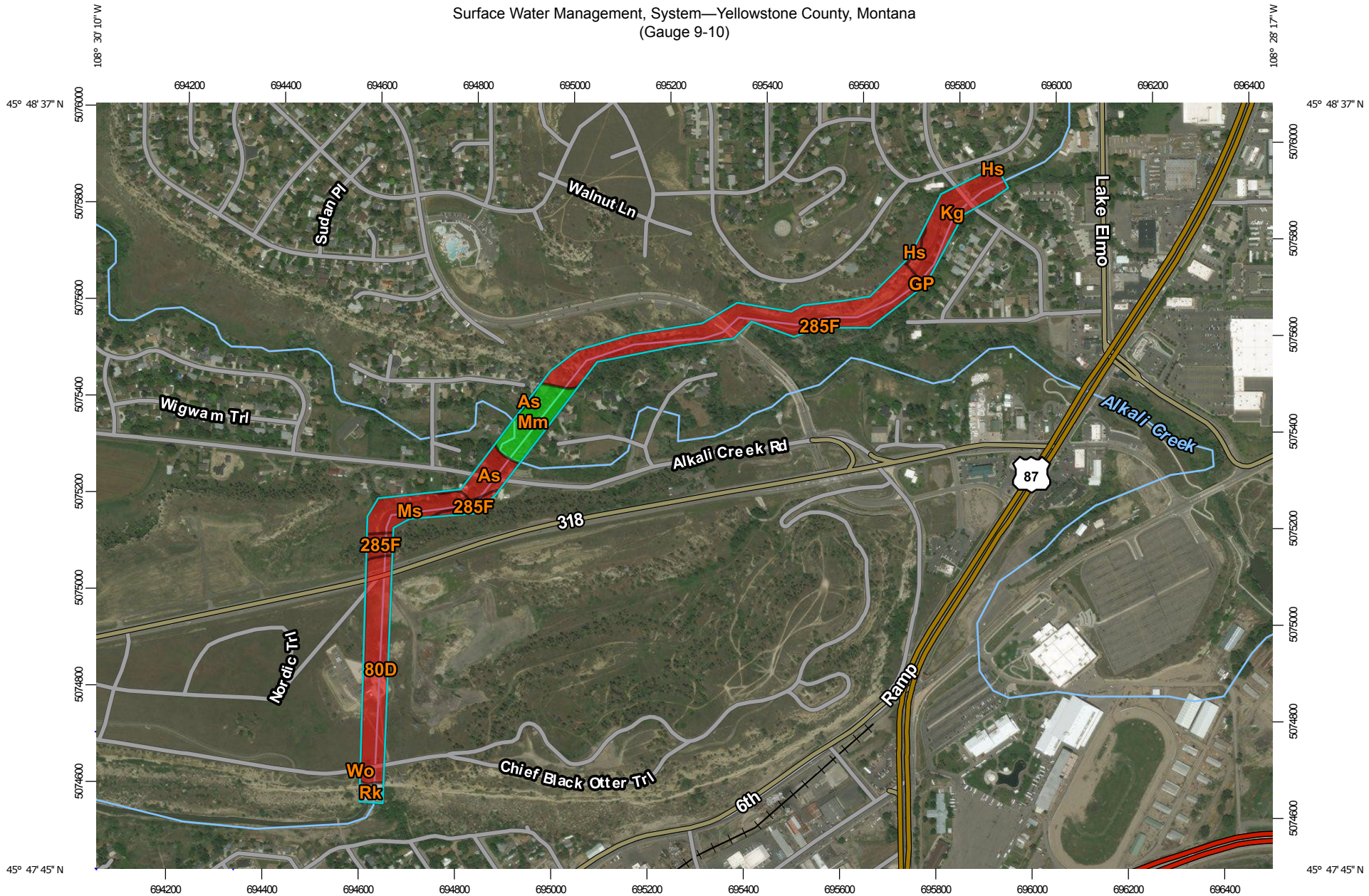
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

Surface Water Management, System

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
Mo	McRae loam, 4 to 7 percent slopes	Very limited	McRae (85%)	Slope (1.00) Water Erosion (0.23)	17.5	70.5%
Rk	Rock land	Not rated	Rock outcrop (90%)		7.3	29.5%
Totals for Area of Interest					**24.8**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Very limited	17.5	70.5%
Null or Not Rated	7.3	29.5%
Totals for Area of Interest	**24.8**	**100.0%**

Surface Water Management, System—Yellowstone County, Montana
(Gauge 9-10)



Map Scale: 1:11,200 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 150 300 600 900

Feet: 0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

Surface Water Management, System

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
80D	Blacksheep sandy loam, 4 to 15 percent slopes	Very limited	Blacksheep (70%)	Depth to bedrock (1.00)	6.0	20.8%
				Slope (1.00)		
				Water Erosion (0.50)		
			Twilight (12%)	Slope (1.00)		
				Water Erosion (0.82)		
			Cabbart (8%)	Depth to bedrock (1.00)		
				Slope (1.00)		
				Water Erosion (0.98)		
				Excess Salt (0.01)		
				Gypsum content (0.01)		
			Rentsac (5%)	Depth to bedrock (1.00)		
				Slope (1.00)		
				Water Erosion (0.65)		
			Blacksheep (2%)	Depth to bedrock (1.00)		
				Slope (1.00)		
				Water Erosion (0.50)		
285F	Blacksheep, dry-Cabbart, dry-Rock outcrop, complex, 8 to 60 percent slopes	Very limited	Blacksheep, dry (35%)	Depth to bedrock (1.00)	11.0	38.1%
				Slope (1.00)		
				Water Erosion (1.00)		
			Cabbart, dry (30%)	Depth to bedrock (1.00)		
				Slope (1.00)		
				Water Erosion (1.00)		
				Excess Salt (0.01)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Gypsum content (0.01)		
			Busby (7%)	Slope (1.00)		
				Water Erosion (0.82)		
			Twilight (5%)	Slope (1.00)		
				Water Erosion (0.99)		
			Yawdim (3%)	Depth to bedrock (1.00)		
				Slope (1.00)		
				Water Erosion (1.00)		
				Slow water movement (0.20)		
As	Apron fine sandy loam, 4 to 7 percent slopes	Very limited	Apron (80%)	Slope (1.00)	1.7	6.0%
				Water Erosion (0.10)		
			Travessilla (6%)	Depth to bedrock (1.00)		
				Slope (1.00)		
				Water Erosion (0.70)		
				Slow water movement (0.61)		
GP	Gravel pit	Not rated	Pits, gravel (100%)		0.1	0.4%
Hs	Hilly, gravelly land	Very limited	Hilly (85%)	Slope (1.00)	0.2	0.6%
				Large rock fragments (1.00)		
				Water Erosion (0.03)		
			Bainville (3%)	Slope (1.00)		
				Water Erosion (1.00)		
			Larim (3%)	Slope (1.00)		
				Large rock fragments (0.81)		
			Elso (3%)	Depth to bedrock (1.00)		
				Slope (1.00)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Water Erosion (1.00)		
				Slow water movement (0.61)		
				Excess Salt (0.01)		
			Midway (2%)	Depth to bedrock (1.00)		
				Water Erosion (1.00)		
				Slope (1.00)		
				Slow water movement (0.61)		
Kg	Keiser silty clay loam, 4 to 7 percent slopes	Very limited	Keiser (85%)	Slope (1.00)	3.9	13.4%
				Water Erosion (1.00)		
			Lambert (4%)	Slope (1.00)		
				Water Erosion (1.00)		
			Clapper (4%)	Slope (1.00)		
				Large rock fragments (0.72)		
				Water Erosion (0.21)		
Mm	McRae loam, 0 to 1 percent slopes	Not limited	McRae (85%)		2.9	10.0%
			Fort Collins (9%)			
Ms	McRae-Bainville loams, 7 to 15 percent slopes	Very limited	McRae (45%)	Slope (1.00)	2.6	9.1%
				Water Erosion (0.89)		
			Bainville (35%)	Slope (1.00)		
				Water Erosion (1.00)		
			Worland (15%)	Slope (1.00)		
				Water Erosion (1.00)		
				Slow water movement (0.61)		
Rk	Rock land	Not rated	Rock outcrop (90%)		0.5	1.7%
Wo	Worland fine sandy loam, 2	Somewhat limited	Worland (85%)	Slope (0.78)	0.0	0.0%

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
	to 7 percent slopes			Slow water movement (0.61)		
				Water Erosion (0.08)		
			Bainville (9%)	Slope (0.78)		
				Water Erosion (0.36)		
Totals for Area of Interest					**28.8**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Very limited	25.3	88.0%
Not limited	2.9	10.0%
Somewhat limited	0.0	0.0%
Null or Not Rated	0.6	2.0%
Totals for Area of Interest	**28.8**	**100.0%**

GROUNDWATER MODEL AND BACKGROUND DATA WEST BILLINGS FLOOD MITIGATION AND GROUNDWATER RECHARGE STUDY

Yellowstone County, Montana

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1.0 INTRODUCTION

This document presents data and analyses designed to facilitate groundwater modeling efforts, along with a preliminary groundwater flow model for the West Billings Flood Mitigation and Groundwater Recharge Study. The project is intended to identify and evaluate the feasibility of alternatives to mitigate flooding impacts in the project Study Area, shown on **Figure 1-1**, and to assess the potential of using those mitigation measures to provide recharge to groundwater in the West Billings area. This document includes modeling results of potential benefits from groundwater recharge of flood water.

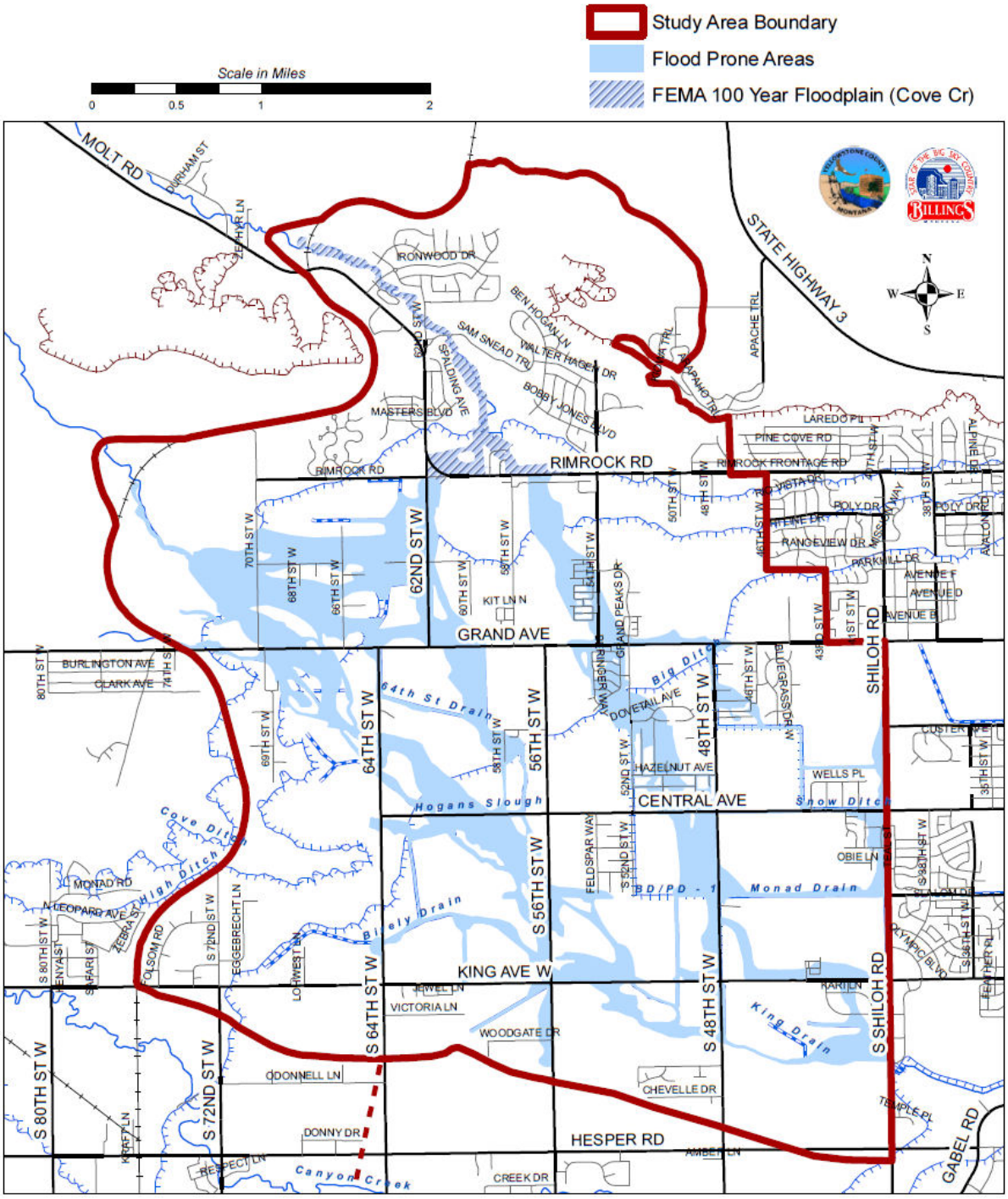


Figure 1-1. West Billings Study Area

The focus of efforts described in this document has been the northern portion of the Study Area because ongoing efforts by the Montana Bureau of Mines and Geology (MBMG) have already addressed the southern portion (see **Appendix B**). The MBMG has agreed to cooperate on this study by providing data and information from their model areas, and allow the use of their models to simulate potential groundwater recharge impacts from flood mitigation alternatives. In exchange, the detailed analyses developed north of the MBMG model areas and described in this document will be provided to the MBMG to facilitate possible expansion of their modeling efforts to the north.

To date, a series of documents and meetings have been completed for the West Billings Flood Mitigation and Groundwater Recharge Study that include the following:

- *Steering Committee Meeting*. Initial Steering Committee meeting to discuss goals and objectives of the study;
- *Problem Statement Report* (PBS&J, 2010a). Report outlining project goals and objectives;
- *Public Meeting*. Public meeting held on April 22, 2010 in Billings to present the Study and solicit input;
- *Existing Data Review Report* (PBS&J, 2010b). Report summarizing known data and analyses, along with data gaps identified as important for this study;
- *Additional Data Gathering Work Plan* (PBS&J, 2010c). Document outlining additional data gathering tasks;
- *Additional Data Gathering Report* (PBS&J, 2010d). Report summarizing additional data gathered, ongoing analyses, and site visits; and
- *Feasibility Study Draft Methodology and Preliminary Alternatives List* (PBS&J, 2010e). Technical Memorandum outlining proposed methodology for this feasibility study and including a list of potential alternatives. The memo was discussed in a subsequent meeting with the Steering Committee and modified into what is presented in this report.

This report has been organized into the following sections:

- 1.0 Introduction. This section listing document purpose and study milestones completed to date;
- 2.0 Data and Analyses. Results of detailed analyses of stratigraphy, changes in land use, and groundwater levels and well information;
- 3.0 Preliminary Model. Presentation of a preliminary groundwater flow model incorporating information from the data and analysis section. Also included are some example simulations of potential flood mitigation-groundwater recharge scenarios;
- 4.0 Conclusions. Summary of the results;
- 5.0 References. List of references cited in the report;
- Appendix A. A detailed summary of the methodology used and results from the stratigraphic analysis; and
- Appendix B. A summary of the MBMG ongoing modeling efforts in the area along with results from groundwater recharge simulations completed for this flood mitigation study.

2.0 DATA AND ANALYSES

This section presents a summary of data and analyses focused on the West Billings area lying to the north of the MBMG model areas. The focus on the northern area is because MBMG has already developed an adequate understanding of the areas covered by their models and the analyses presented below will better facilitate the expansion of modeling to the north.

2.1 Stratigraphy

Well logs obtained from MBMG's GWIC database for the West Billings area were reviewed to identify the subsurface stratigraphy of the area. A detailed summary of the methodology is provided in **Appendix A**. The list of well logs presented in previous documents for this study was reduced to include only those logs located north of the MBMG model areas, which includes a total of 824 borings at the locations as shown on **Figure 2-1**.

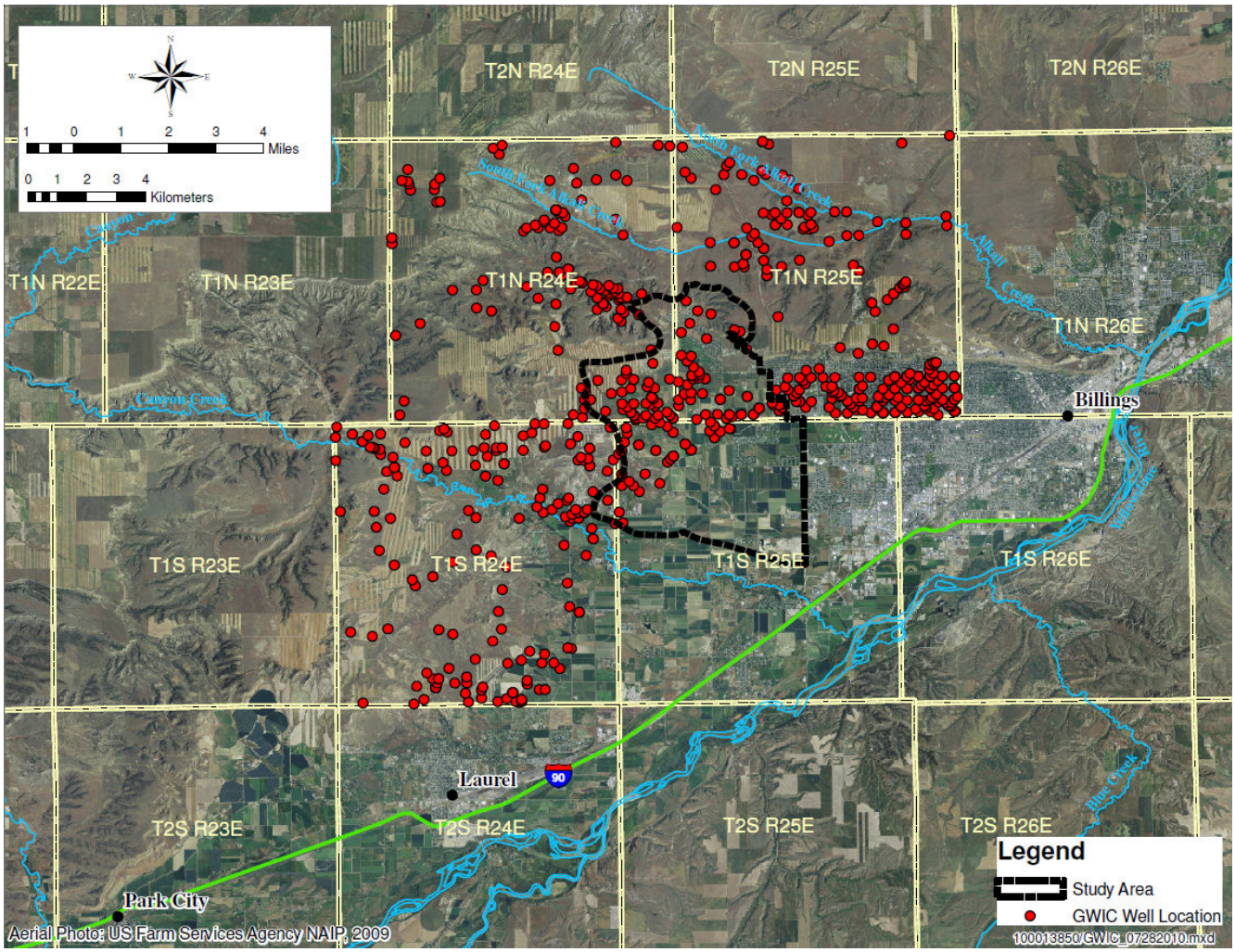


Figure 2-1. Location of MBMG GWIC Well Logs Reviewed

The information from the well log interpretation was compiled into a spreadsheet and was incorporated into GIS coverages shown on maps in this document. Each GWIC entry in the MBMG database was evaluated, and if a well log existed it was reviewed for the information noted below. Of the 824 GWIC en-

tries a total of 136 did not have well logs, leaving 688 to review for stratigraphic information. Information noted in the spreadsheet during review of the well logs included:

- Ground Elevation
- Fine-Grained Cap (FGC) bottom depth, bottom elevation, and thickness
- Aquifer (unconsolidated) thickness, type, and hydraulic conductivity values
- Bedrock/Bottom Clay depth and elevation
- Data Qualifiers and Comments

Data for the stratigraphy in the area were contoured and imported into GIS to develop maps of the fine-grained cap thickness, aquifer thickness, aquifer hydraulic conductivity, and depth to bedrock. The fine-grained cap thickness map is shown on **Figure 2-2**, and maps of the other properties are included in **Appendix A**. Well logs with information on the particular property were filtered to only include logs of good quality and reasonable accuracy for location, although some poorer quality points were added back in to have adequate spatial coverage. Data points clearly outside of the spatial extent of the unconsolidated aquifer were not included.

A series of wells were used to develop cross-sections along the lines shown on **Figure 2-2**. A north-south section (A-A' on **Figure 2-2**) is shown on **Figure 2-3**. A west-east cross-section (B-B' on **Figure 2-2**) is shown on **Figure 2-4**.

The stratigraphy in the area reviewed appears more complex than and not as uniform as it is to the south. In general the fine-grained cap thickens to the north and to the east, while the unconsolidated aquifer thins toward the north but maintains a consistent thickness east to west (**Figure 2-3 and 2-4**). ,

Hydraulic conductivity was estimated based on well log descriptions of the material. These should only be considered estimates because many of the descriptions do not clearly identify the relative amounts of coarse material. Water level and pumping information on the logs were used to get a more accurate estimates at select locations. The northern termination of the unconsolidated aquifer is not clear because as the aquifer thins the wells are commonly drilled into deeper units and as a result the shallower units are not described with much accuracy.

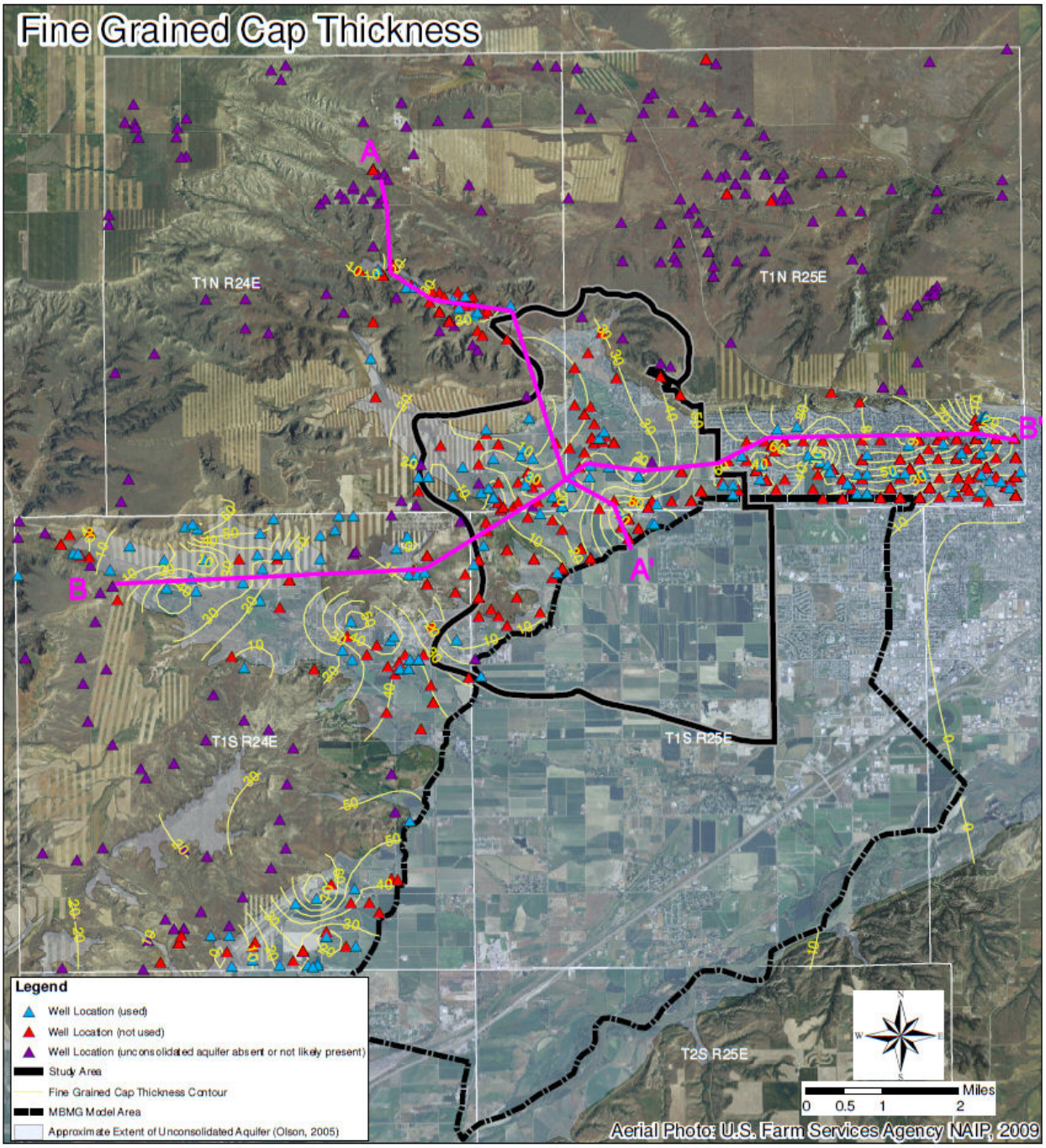
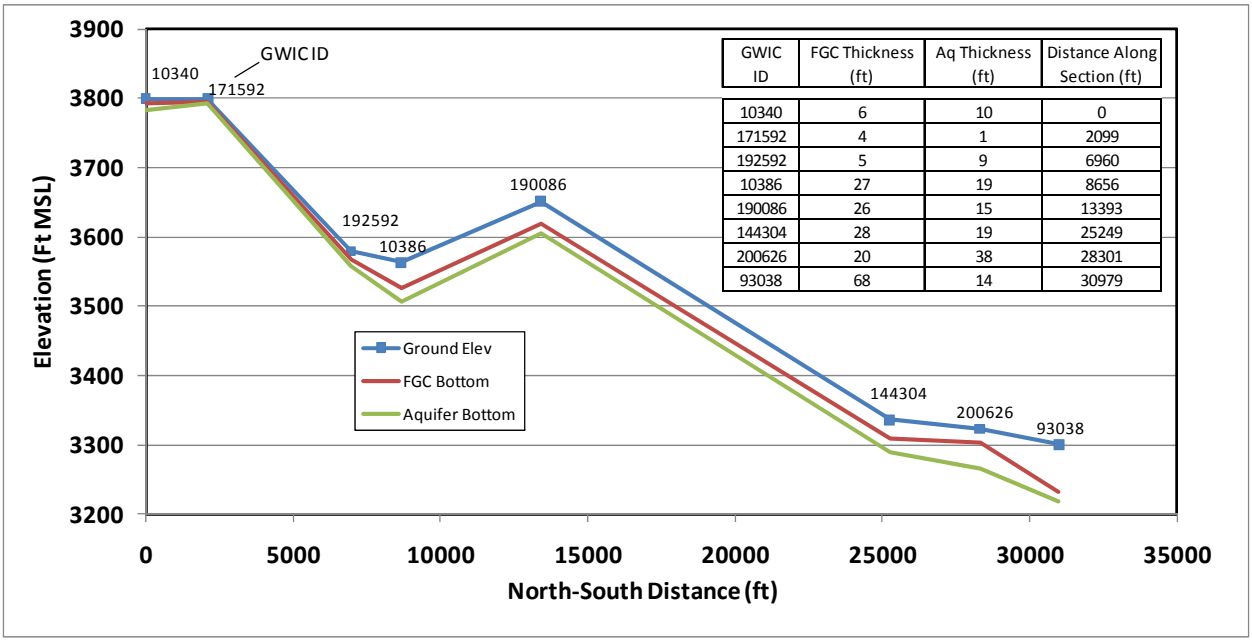
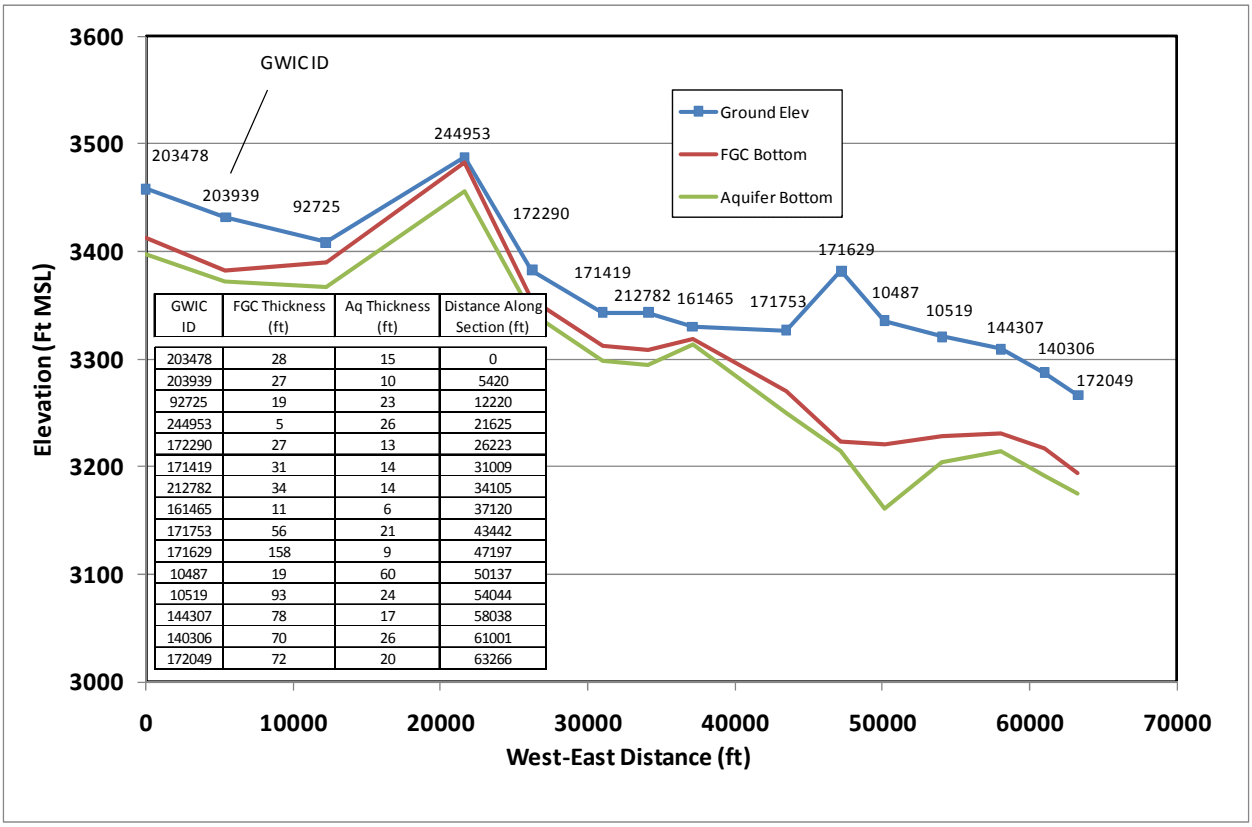


Figure 2-2. Map of Fine-Grained Cap Thickness and Cross-Section Lines



GWIC ID	FGC Thickness (ft)	Aq Thickness (ft)	Distance Along Section (ft)
10340	6	10	0
171592	4	1	2099
192592	5	9	6960
10386	27	19	8656
190086	26	15	13393
144304	28	19	25249
200626	20	38	28301
93038	68	14	30979

Figure 2-3. North-South Cross-Section



GWIC ID	FGC Thickness (ft)	Aq Thickness (ft)	Distance Along Section (ft)
203478	28	15	0
203939	27	10	5420
92725	19	23	12220
244953	5	26	21625
172290	27	13	26223
171419	31	14	31009
212782	34	14	34105
161465	11	6	37120
171753	56	21	43442
171629	158	9	47197
10487	19	60	50137
10519	93	24	54044
144307	78	17	58038
140306	70	26	61001
172049	72	20	63266

Figure 2-4. West-East Cross Section

2.2 Land Use and Recharge

Land use designations were developed for the West Billings area. The designations were specified for years 2000 and 2009 to match the dates being used in the MBMG modeling efforts. Current land use designations were previously presented in the *Existing Data Review* report (PBS&J, 2010b), but those designations were based on tax terminology, so for this evaluation an approach used by the MBMG was adopted which incorporates aerial photo interpretation.

Previously specified land use designations for 2000, shown below on **Figure 2-5**, were provided by MBMG and used as a starting point. The MBMG designations extend into a portion of the flood mitigation Study Area but do not cover the entire area. The MBMG designations were extended to the north by reviewing a 1996 aerial photograph of the area and specifying land use categories consistent with the MBMG designations. An aerial photograph for 2000 could not be found so it is assumed the 1996 conditions are close enough to those in 2000. Resulting land use designations are shown on **Figure 2-6**.

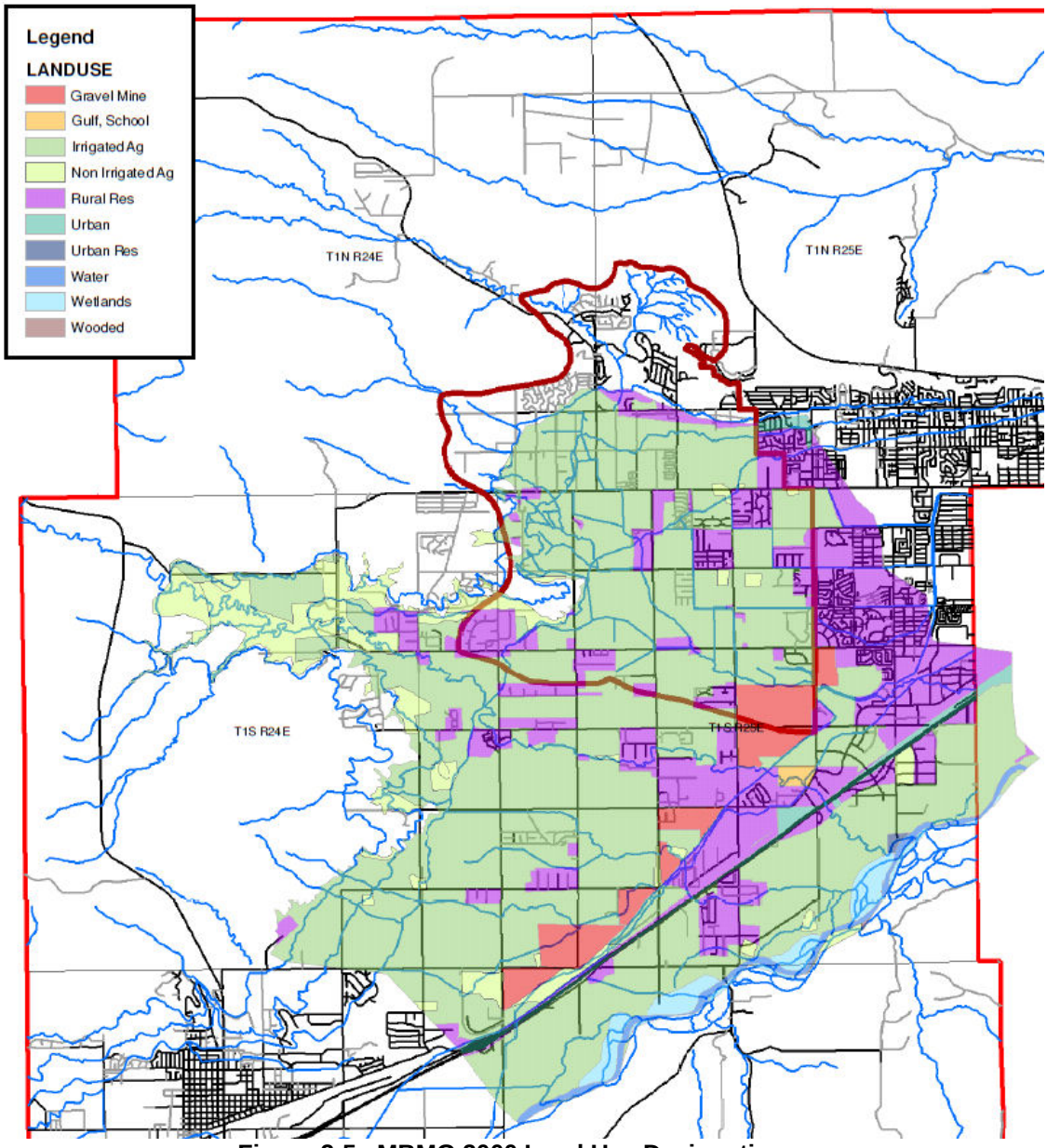


Figure 2-5. MBMG 2000 Land Use Designations

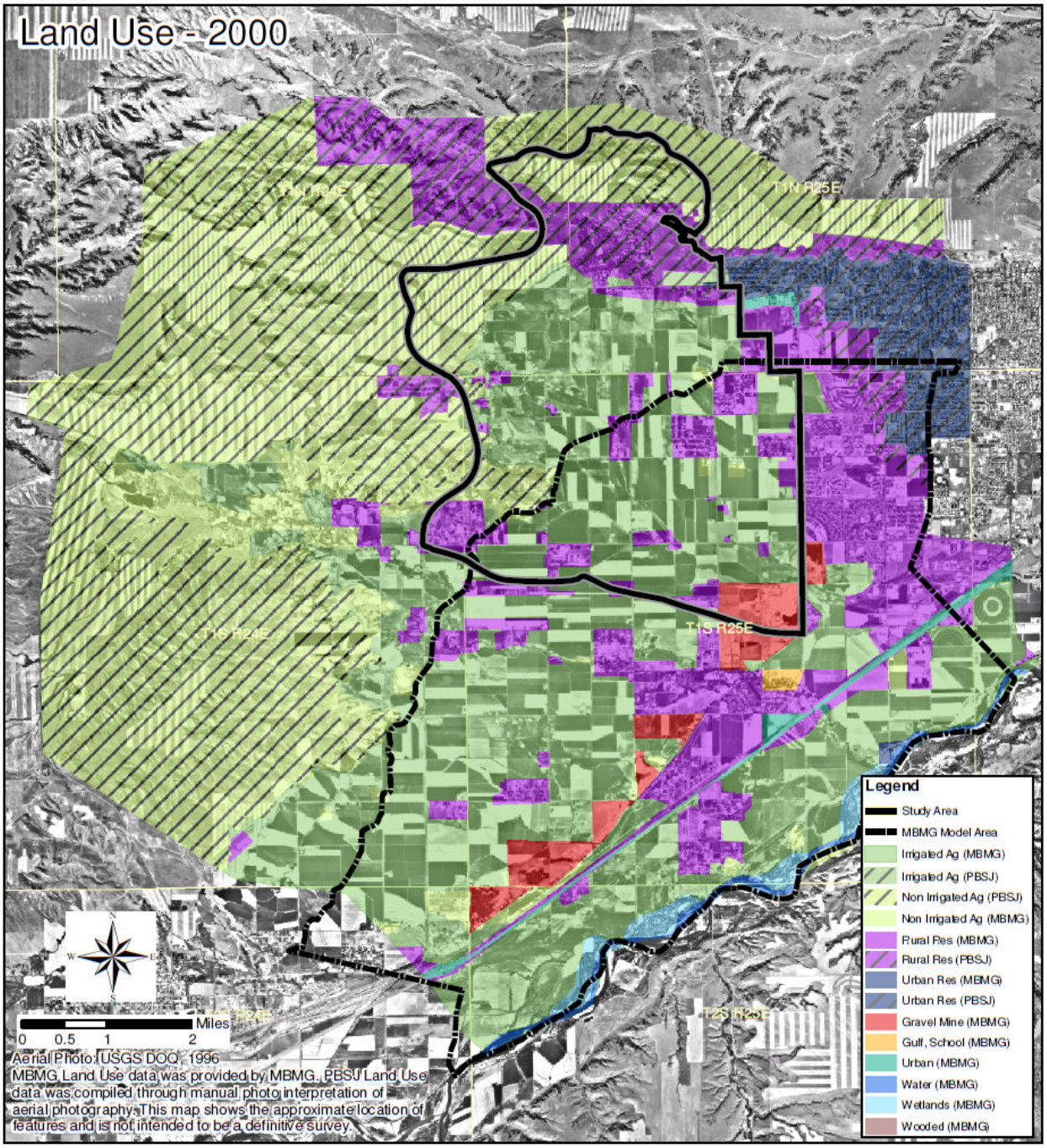


Figure 2-6. Land Use Designations for 2000

For 2009, the designated land uses identified for 2000 were overlain on an aerial photograph from 2009. The 2000 land uses were then reassessed and modified where changes in land use were evident. The results of the 2009 land use evaluation are shown on **Figure 2-7**.

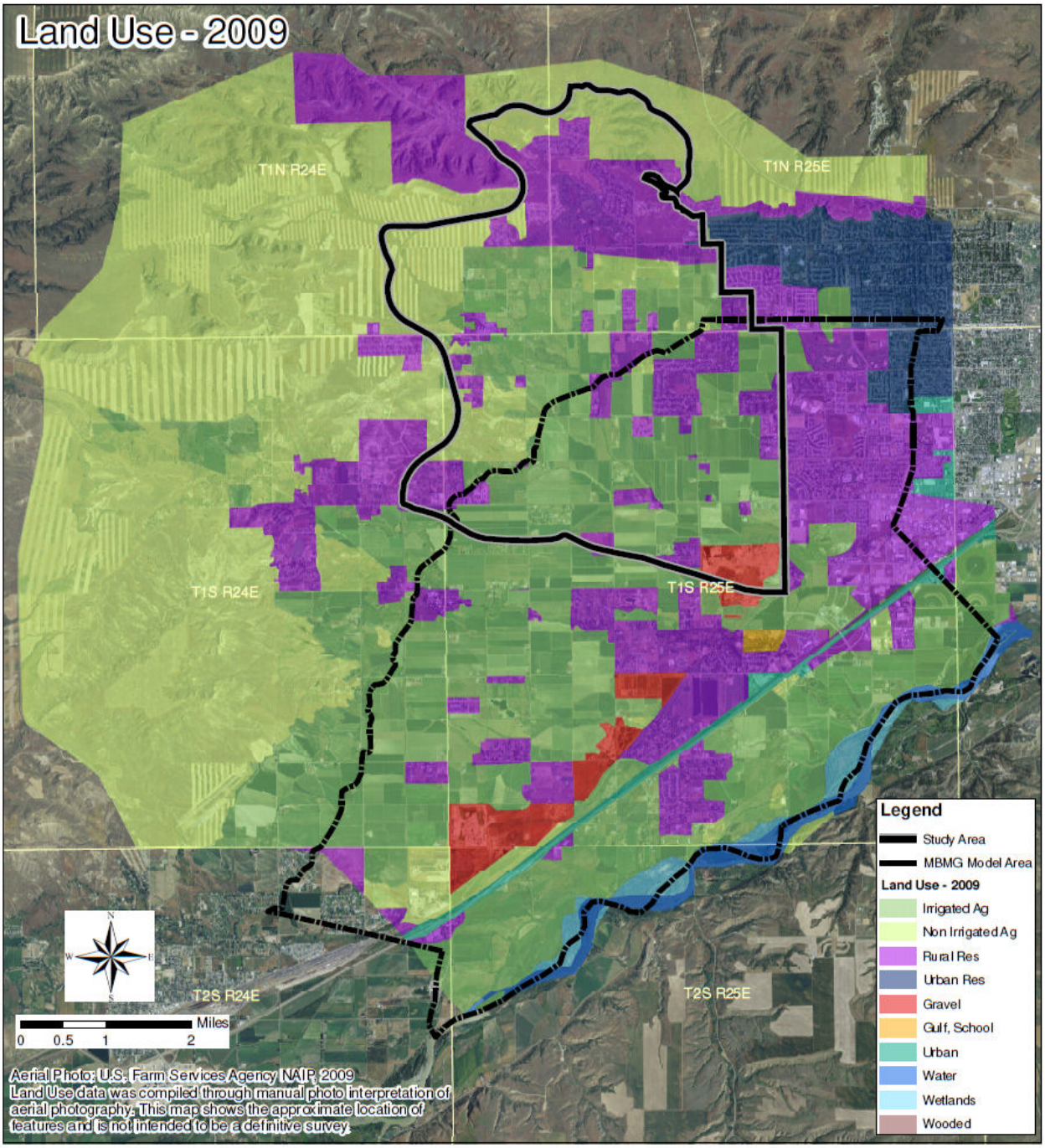


Figure 2-7. Land Use Designations for 2009

Land use changes in the West Billings area have a significant impact upon groundwater and surface-water conditions. Land use changes affect volume of water the land surface is capable of transmitting to the subsurface and the volume of runoff. Spatially quantifying these changes is critical for calibration of modeling efforts, and allows prediction of additional impacts under various future land use scenarios.

The *Existing Data Review* report presented a map showing land use change from irrigation to development for the period 1966-1999 from an MBMG study (Olson & Reiten, 2002), and is reproduced below on **Figure 2-8**.

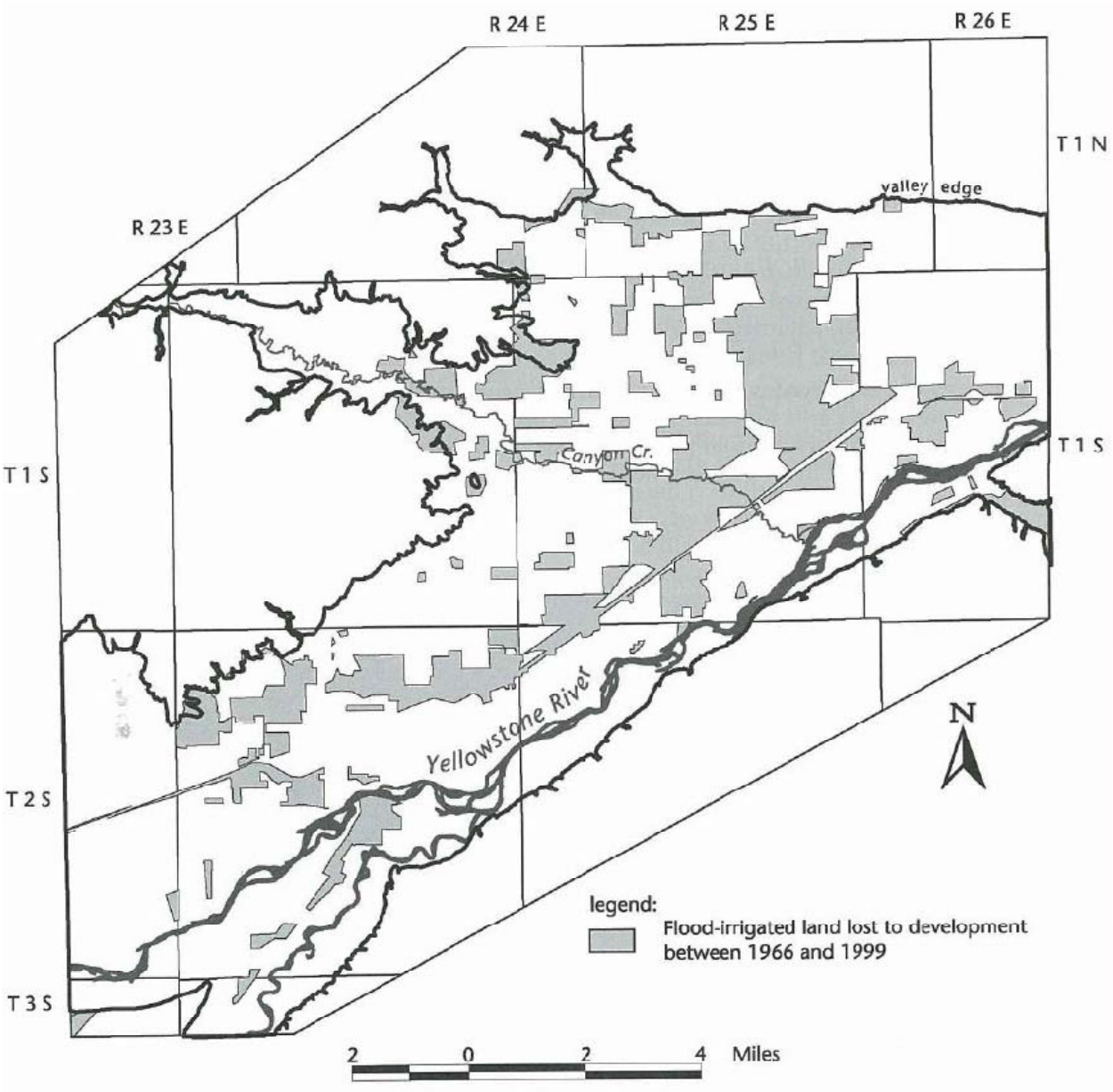


Figure 2-8. Loss of Agricultural Land 1966-1999 (from Olson & Reiten, 2002)

Land use changes for the period 2000-2009 were identified by comparing the land use coverages presented above and identifying areas where agricultural land has been lost to other uses. The results of this comparison are shown on the land use change map presented as **Figure 2-9**.

The comparison reveals that a total of 1,787.6 acres of agricultural land was lost to rural residential use between 2000 and 2009. About a quarter of the lost agricultural land falls within the Study Area for the flood mitigation and groundwater recharge study. A small amount (167.75 acres) of agricultural land was gained during that same period, most coming from former gravel mining areas.

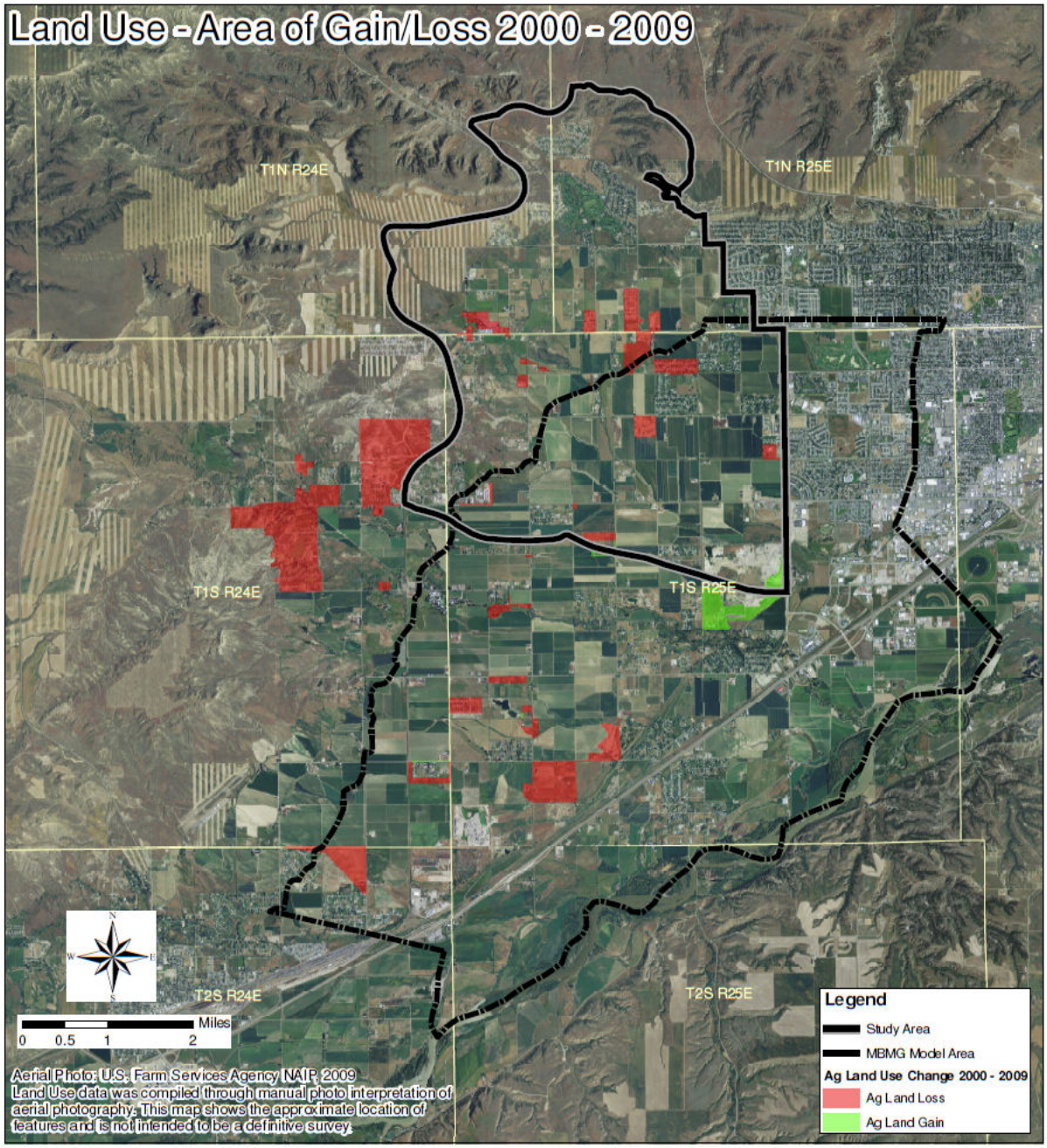


Figure 2-9. Loss of Agricultural Land 2000-2009

2.3 Groundwater Levels and Wells

A search was completed to identify wells with water level data for 2000 and 2009 in the West Billings area north of the MBMG models. In addition, pumping wells were identified from available water rights information. Results are presented below.

2.3.1 Wells and Available Data

Wells in the area north of the MBMG models with water level data were identified and are summarized in **Table 2-1**. The wells listed are those from the GWIC database that are shown above on **Figure 2-1**, and also from the USGS database. The USGS database included a number of additional wells that only had a single water level measurement from long before 2000 so those were not included in the list.

Table 2-1. Wells With Water Level Data: Northern Portion of West Billings Area

GWIC No.	Data Source	Name	Location				Coordinates NAD83		Well Depth (ft)	Ground Elev. (ft MSL)		Water Levels			Aq Code	Target Water Level Period	
			T	R	S	QS	X	Y		Log	Map	Start Date	End Date	No. Rdgs		2000	2009
10615	GWIC	EVERGREEN PARK (BILLINGS)	01N	25E	36	DDBB	2209983.2	561989.4	21	3205	3209	04/08/97	07/27/10	59	111ALVM	x	x
92757	GWIC	Walter Virgil	01S	24E	25	BABA	2169393.9	539130.6	50	3325		03/23/97	07/27/10	46	111TRRC	x	x
10457	GWIC	CARAWAY HERB	01N	25E	31	BABA	2181048.0	565450.8	19	3370	3366	11/08/99	10/09/00	12	111ALVM	x	
10471	GWIC	HANSON CLARENCE	01N	25E	33	ABDD	2193450.2	564893.1	138	3342	3345	11/08/99	10/09/00	12	111ALVM	x	
158556	GWIC	NORTHERN SKIES AVIATION	01S	24E	34	CBCB	2157588.9	530291.6	90	3475	3469	03/25/97	10/16/00	20	112TRRC	x	
158590	GWIC	CDP CONSTRUCTION	01S	25E	7	ADAC	2177504.6	553383.3	38	3320	3327	03/06/97	10/10/00	18	111ALVM	x	
158591	GWIC	DALTON JESSIE	01N	24E	35	CCCB	2168855.8	560765.6	28	3435	3435	03/06/97	10/09/00	21	111CLVM	x	
158941	GWIC	YELLOWSTONE COUNTRY CLUB	01N	25E	30	BBCA	2179876.7	570250.9	18	3415	3409	05/06/97	04/04/03	44	111ALVM	x	
171256	GWIC	WEBER-1	01S	26E	18	DDCC	2208575.6	562481.5	19	3169	3216	08/18/99	04/04/01	361	112YRT2	x	
705285	GWIC	SCHLAEPPI NEIL	01S	25E	6	AABB	2176592.4	559935.5	16	3355	3350	03/06/97	11/21/00	38	111ALVM	x	
92730	GWIC	OLSEN PETER	01S	24E	6	DABA	2145495.1	557412.4	50	3440	3438	03/21/97	03/21/97	1	111CLVM		
92738	GWIC	GRICE PAUL	01S	24E	12	CCCC	2167687.8	549928.4	50	3325	3323	03/24/97	07/11/97	2	111ALVM		
158552	GWIC	Ownwer Unknown From GWCP03	01N	25E	31	BAAD	2181766.6	565168.7	8	3360	3363	03/23/97	03/23/97	1	111ALVM		
158555	GWIC	OLSEN PETE	01S	24E	6	DAAB	2145701.8	557304.1	18	3440	3428	03/21/97	03/21/97	1	111CLVM		
158940	GWIC	YELLOWSTONE COUNTRY CLUB	01N	25E	30	CACB	2180975.8	567599.9	19	3390	3392	05/06/97	05/06/97	1	111ALVM		
705256	GWIC	USGS	01N	25E	25	CD	2207535.5	566153.0	119	3310	3309	10/01/68	08/01/69	14	???		
	USGS	454721108335001	01N	25E	36	CBDA	2207213.8	562628.0	12.5	3222		12/05/66	04/13/92	57	110ALVM		
	USGS	454611108400901	01S	25E	5	CD	2180438.1	555235.6	62	3294		10/22/68	04/06/88	21	110ALVM		
	USGS	454705108333101	01N	25E	36	CDDD	2208584.8	561022.3	17.2	3215		08/04/78	03/27/85	18	110ALVM		
	USGS	454721108335001	01N	25E	36	CBDA	2207213.8	562628.0	12.5	3222		12/05/66	04/13/92	62	110ALVM		

In order to be consistent with the MBMG modeling approach, the wells with water level data for 2000 or 2009 were identified and the location of these wells is shown on **Figure 2-10**. Only two wells could be found in the area searched that have water level data for both 2000 and 2009. There are eight additional wells that have water level data for 2000. The eight wells with only 2000 data could be visited to measure water levels in the future and the data used as an approximation of 2009 conditions.

A list of additional wells with water level data was received from MBMG and is included as **Table 2-2**. The list was received after completion of the search for wells with water level data and development of the groundwater model presented below and the data available were not pursued.

Table 2-2. MBMG List of Additional Wells With Water Level Data

92777	DAUGHERTY THOMAS	01S	24E	36	AABA	111TRRC
147423	SCOTT	01S	25E	3	BAD	111TRRC
151382	CHURCH OF CHRIST	01S	25E	4	DDDC	111TRRC
171246	BELL-1 HOFMAN	01S	25E	10	AABC	112TRRC
93073	EMMANUEL BAPTIST CHURCH	01S	25E	10	ADDC	111TRRC
156654	MACDONALD GREGORY	01S	25E	14	ABCA	111TRRC
171243	SLOUGH-1	01S	25E	15	ACCC	112TRRC
705291	USGS	01S	25E	17	AAAA	111TRRC
93305	ELDERGROVE SCHOOL	01S	25E	18	DDDC	111TRRC
93316	Yellowstone Treatment Ctr - Yellowstone Boys Ranch Well 2	01S	25E	19	BBAB	111TRRC
93329	BERGER, DON	01S	25E	20	A	111TRRC
93351	A-1 LANDSCAPING	01S	25E	21	AADD	111TRRC
171251	SAUNDERS-1	01S	25E	21	DAAA	112YRT2
171252	SAUNDERS-2	01S	25E	21	DAAA	112YRT2
171250	JONES-2	01S	25E	21	DDAD	112YRT3
171249	JONES-1	01S	25E	21	DDDB	211CLRD
93417	ZOO MONTANA INC	01S	25E	22	DADA	111TRRC
144832	ZOO MONTANA	01S	25E	22	DBAB	111TRRC
93432	ELYSIAN ELEMENTARY SCHOOL	01S	25E	24	AAAA	112TRRC
166073	ZEILER HAROLD	01S	25E	25	AABA	
171258	GOODMAN-1	01S	25E	25	BCBC	112YRT2
154210	GABEL EVERETT	01S	25E	26	AADD	111TRRC
162752	JONES ELLEN	01S	25E	28	CDCD	111TRRC
171248	THOMAS-1	01S	25E	29	BCCC	112YRT3
93528	SWANSON CLARENCE L.	01S	25E	30	DDDC	111TRRC
158589	CRYSTAL SPRINGS	01S	25E	33	ACDA	111ALVM
162779	LIMPP RICK AND MARCIE	01S	25E	34	ADDD	111TRRC
158946	REITEN PALMER	01S	25E	34	BBBB	111TRRC
158606	HICKS AL	02S	24E	2	DCAA	111TRRC

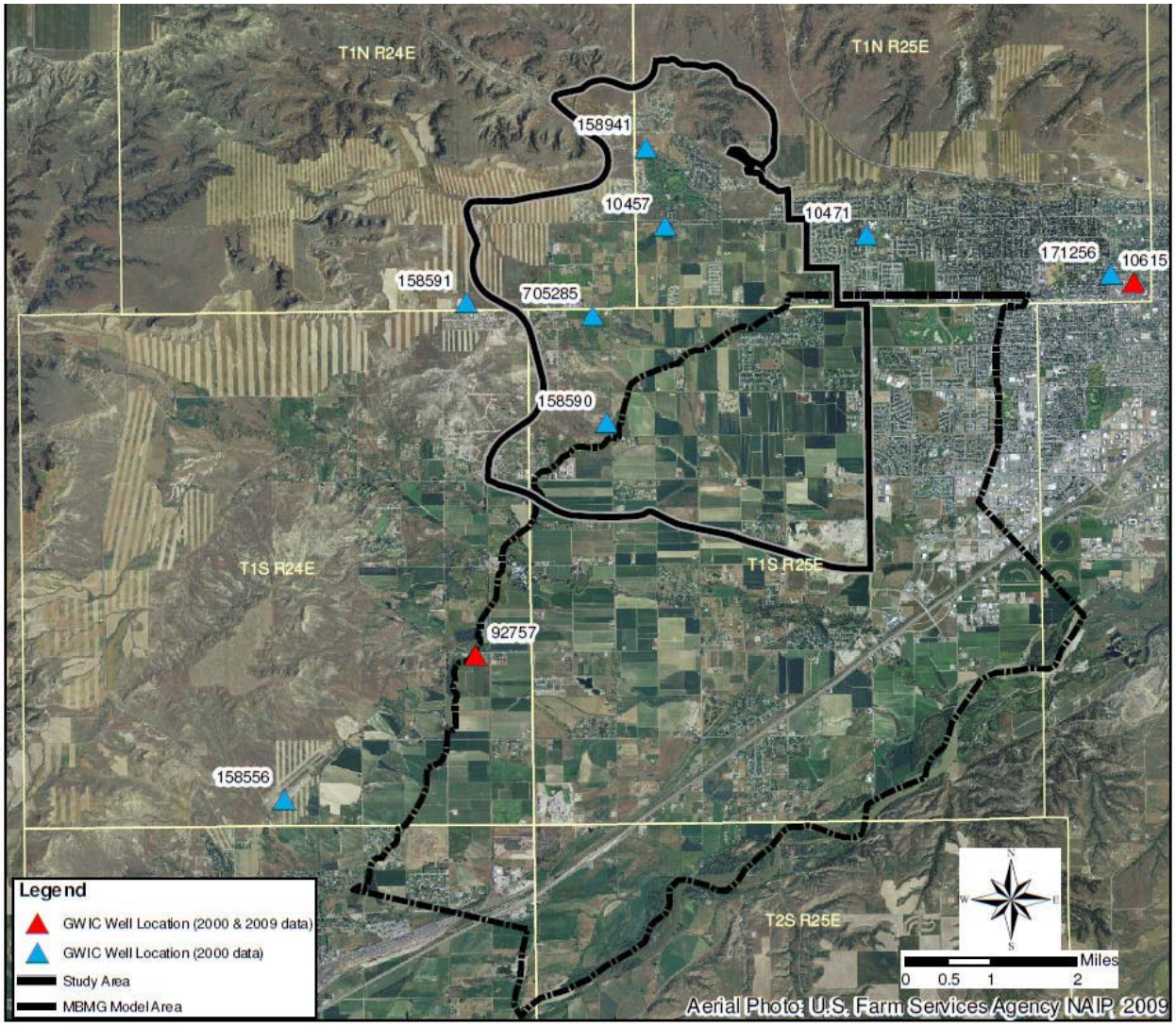


Figure 2-10. Wells With Water Level Data for 2000 and 2009

2.3.2 Pumping Wells

The Montana Department of Natural Resources and Conservation (DNRC) database was queried for wells with water rights that are located in the area north of the MBMG models. The resulting list of wells was further reduced to wells with pumping rates of 50 gpm or greater, with the results shown in **Table 2-3**. The location of these wells is shown on **Figure 2-11**.

The 50 gpm is an arbitrary cut-off and is used to identify wells that have what is considered a "significant" pumping rate and therefore should potentially be included in a groundwater model. The rates and volumes listed are what have been appropriated and may not reflect actual pumping rates. It is also important to point out that the DNRC listings only include wells that have acquired a water right. There are an unknown number of wells in the project area that are low yield wells and thus exempt from the water rights process. In many cases these wells aren't important to model, but in some cases such as developments that use a number of exempt wells instead of a single public water supply well it may be appropriate to include in a model.

Table 2-3. Select DNRC Water Right Listings-Area Not Modeled By MBMG

Map Key	WR Number	Name	TR	Sec	Q Sec	Well Dpth	Coordinates X	Coordinates Y	Purpose	Max Flow Rate	Max Flow Unit	Max Vol
203213-1	43Q 115422 00	REHBERG RANCH LLC	1N25E	15	SWNENE	120	580769.36	2200051.84	Commercial	500	GPM	333
						100	580077.10	2198083.33				
335061-1	43Q 107106 00	YELLOWSTONE VALLEY MEMORIAL PARK	1N25E	34	SESWSW	51	560902.23	2196171.26	Irrigation	150	GPM	50
320867-1	43Q 10441 00	PARKER DORIS E	1N24E	11	SWSW		582040.68	2169169.95	Stock Irrigation Domestic	90	GPM	27
188954-1	43Q 107159 00	ROCKY MOUNTAIN COLLEGE	1N25E	36	SWNENE	75	565065.62	2210022.97	Irrigation	110	GPM	25
137911-1	43Q 74729 00	YELLOWSTONE COUNTY SCHOOL DIST #2	1N25E	33	NENE	125	565200.13	2194452.10	Lawn & Garden	85	GPM	25
179119-1	43Q 101478 00	ROCKY MOUNTAIN COLLEGE	1N25E	36	SENWNE	77	565052.49	2209363.52	Irrigation	85	GPM	22.5
331358-1	43Q 80822 00	ASPEN MEADOWS PARTNERSHIP	1N25E	34	NWSESE		561614.17	2199458.66	Lawn & Garden	80	GPM	22.16
8038-1	43Q 2968 00	HALLBERG FAMILY TRUST	1N25E	11	SESESW		582158.79	2202673.88	Irrigation	102	GPM	21.4
285294-1	43Q 208170 00	WOODS EDITH J	1S25E	6	NWSENE		558704.07	2176847.11	Irrigation	100	GPM	21.4
157319-1	43Q 88845 00	YELLOWSTONE COUNTY SCHOOL DIST #2	1N25E	33	NESENE	188	564215.88	2194799.87	Irrigation	90	GPM	17.5
146679-1	43Q 79837 00	GREYSTONE CONDOMINIUM ASSN	1N25E	34	SENWSE	65	562263.78	2198789.37	Lawn & Garden	80	GPM	10
188951-1	43Q 107157 00	ROCKY MOUNTAIN COLLEGE	1N25E	36	NENWNE	92	565711.94	2209353.67	Irrigation	70	GPM	10
131213-1	43Q 70861 00	ROCKY MOUNTAIN COLLEGE	1N25E	36	SWNWNE	76	565042.65	2208704.07	Lawn & Garden	60	GPM	10
330075-1	43Q 72289 00	SHILOH UNITED METHODIST CHURCH	1N25E	33	NWSE	58	562539.37	2193175.85	Lawn & Garden	55	GPM	10
188953-1	43Q 107158 00	ROCKY MOUNTAIN COLLEGE	1N25E	36	SWNENE	85	565065.62	2210022.97	Irrigation	50	GPM	10

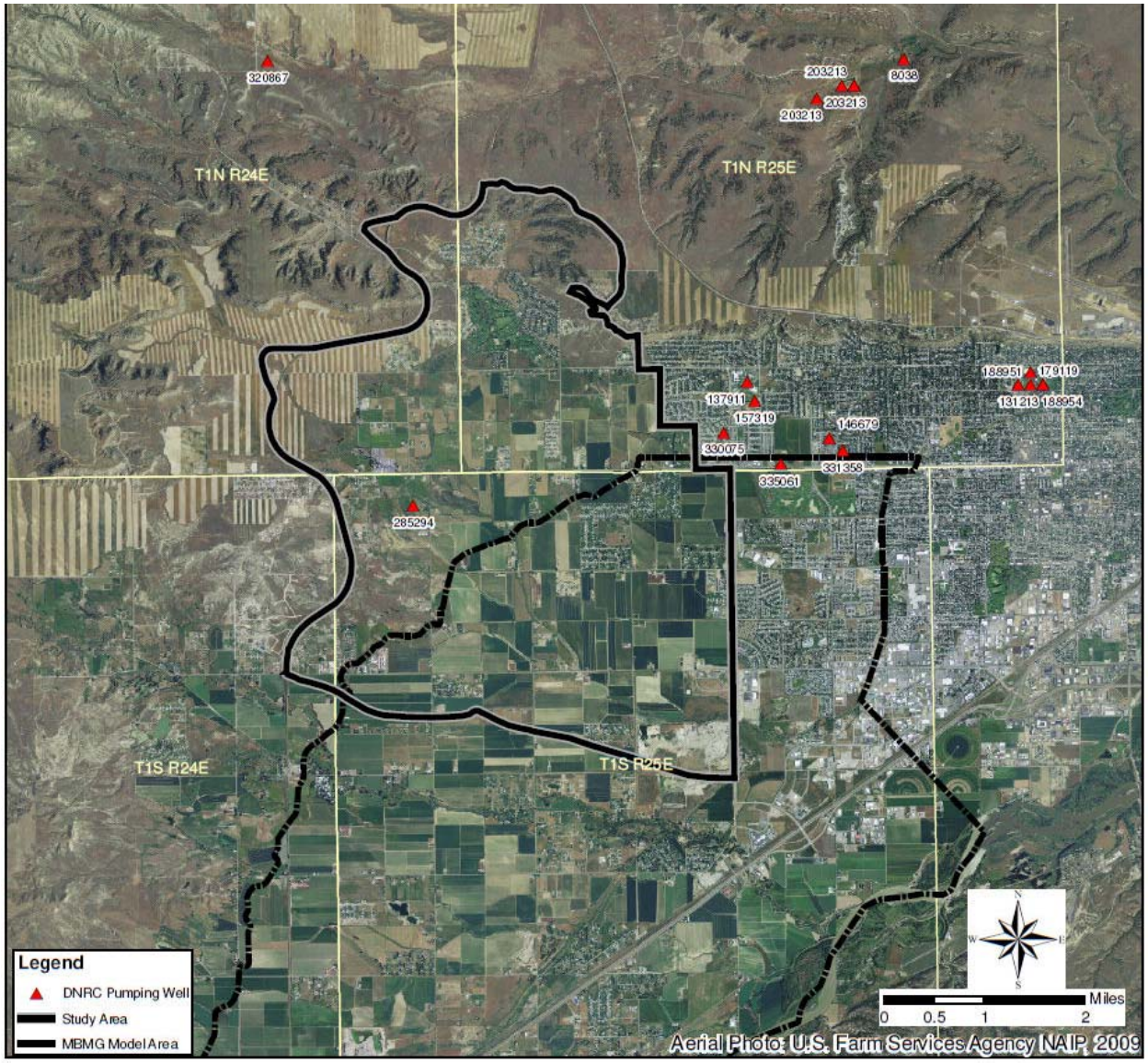


Figure 2-11. Wells in DNRC Database: 50 gpm or Greater

3.0 PRELIMINARY GROUNDWATER FLOW MODEL

The MBMG modeling areas extend northward as far as Big Ditch. The unconsolidated aquifer extends beyond Big Ditch to the northwest, and also to the north of the eastern portion of the MBMG models. A map showing the MBMG model areas and the previously mapped extent of the unconsolidated aquifer is shown on **Figure 3-1**. The boring log review presented in **Section 2.1** above suggests that the aquifer may extend beyond the area mapped.

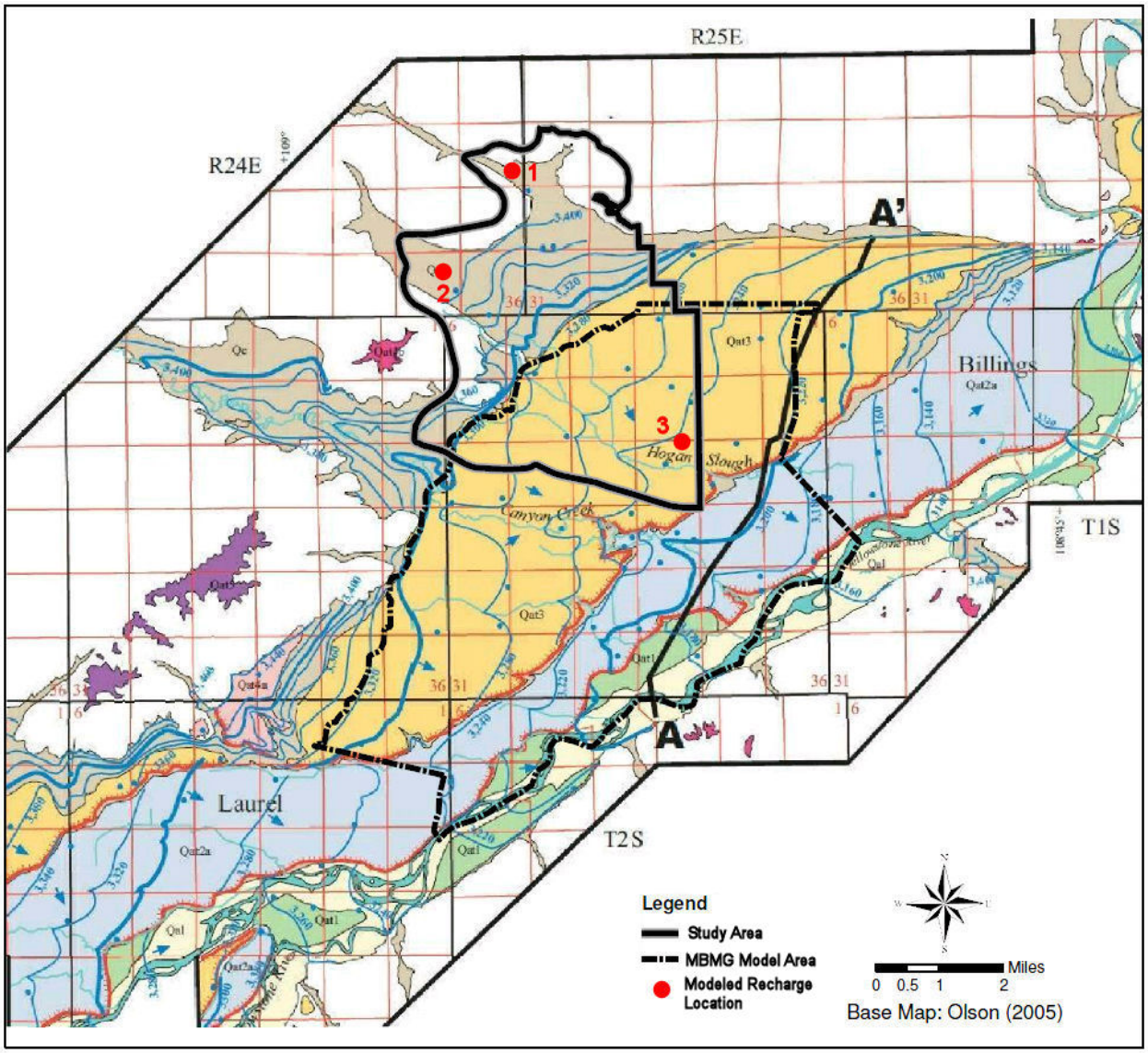


Figure 3-1. MBMG Model Area and Mapped Extent of Unconsolidated Aquifer

A preliminary groundwater flow model was created for this study that covers the area occupied by the unconsolidated aquifer to the north of the MBMG modeled areas. The model is considered preliminary because it has not been aggressively calibrated, is currently steady-state (pre-irrigation conditions), and will require some additional modifications to represent additional spatial features (see **Section 4**).

The model is presented below and was developed primarily to allow simulation of potential groundwater recharge effects from flood mitigation alternatives. Model construction was developed in a manner similar to the MBMG models and is designed to facilitate the potential extension of their modeling to the north.

3.1 Preliminary Model Construction

The preliminary model was constructed using the stratigraphic and land use information presented in **Section 2**, along with groundwater level and stratigraphic information from the MBMG models. Layer elevations and recharge information is detailed but some other aspects of the model have been simplified to facilitate development of a functional model for the purpose of simulating potential groundwater recharge from flood mitigation alternatives. Specifics of model construction are included below.

The model uses the code MODFLOW (McDonald and Harbaugh, 1988) and is housed in the user interface Groundwater Vistas, version 5.32 (ESI, 2007). Groundwater Vistas houses the properties and boundary condition information detailed below and uses that information to generate model files for MODFLOW simulations. Separate spreadsheets have also been developed that include all of this information to facilitate easier import into other user interfaces.

3.1.1 Grid and Domain

The model domain is shown on **Figure 3-2**. The southern extent of the model ends where the MBMG model areas begin. To the northwest the model domain includes the unconsolidated aquifer where it is believed to be present along Canyon Creek, Little Cove Creek, and Cove Creek. The eastern portion of the model extends to the bluffs north of Billings.

The model grid cells are not presented on **Figure 3-2** for clarity, but consists of 180 rows and 280 columns with each cell 200 ft by 200 ft. The model is made up of three layers, similar to the MBMG models, and includes a total of 41,433 active cells. Boundary conditions are also shown on **Figure 3-2** and are discussed further below.

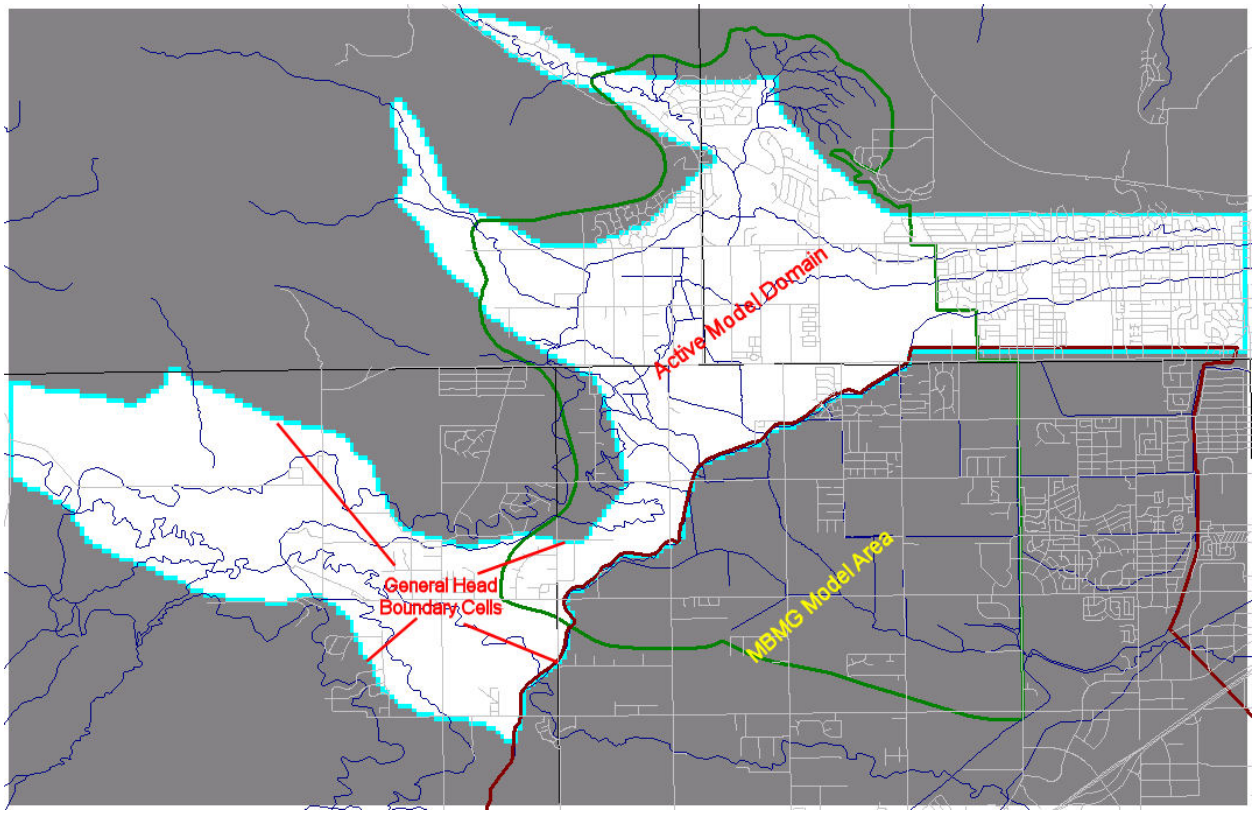


Figure 3-2. Preliminary Model Domain and Boundary Conditions

3.1.2 Properties

Model properties include layer elevations, hydraulic conductivity, and recharge. Layer elevations were specified by importing Surfer grids. The grids were developed to cover the area of the model domain and contoured using 200 ft centers to eliminate interpolation upon import into Groundwater Vistas. Imported fields include ground surface elevation, developed from DEM coverage, plus bottom elevations for the fine-grained cap, unconsolidated aquifer, and bedrock base. Bottom elevations for the fine-grained cap and unconsolidated aquifer were developed from the stratigraphic maps included in **Appendix A**, with a minimum thickness set at 5 ft. The bedrock thickness was set at 20 ft, consistent with the MBMG approach. In some cases, elevations were manually modified to address anomalies. A map of the top elevation assigned to layer 2 is presented on **Figure 3-3**.

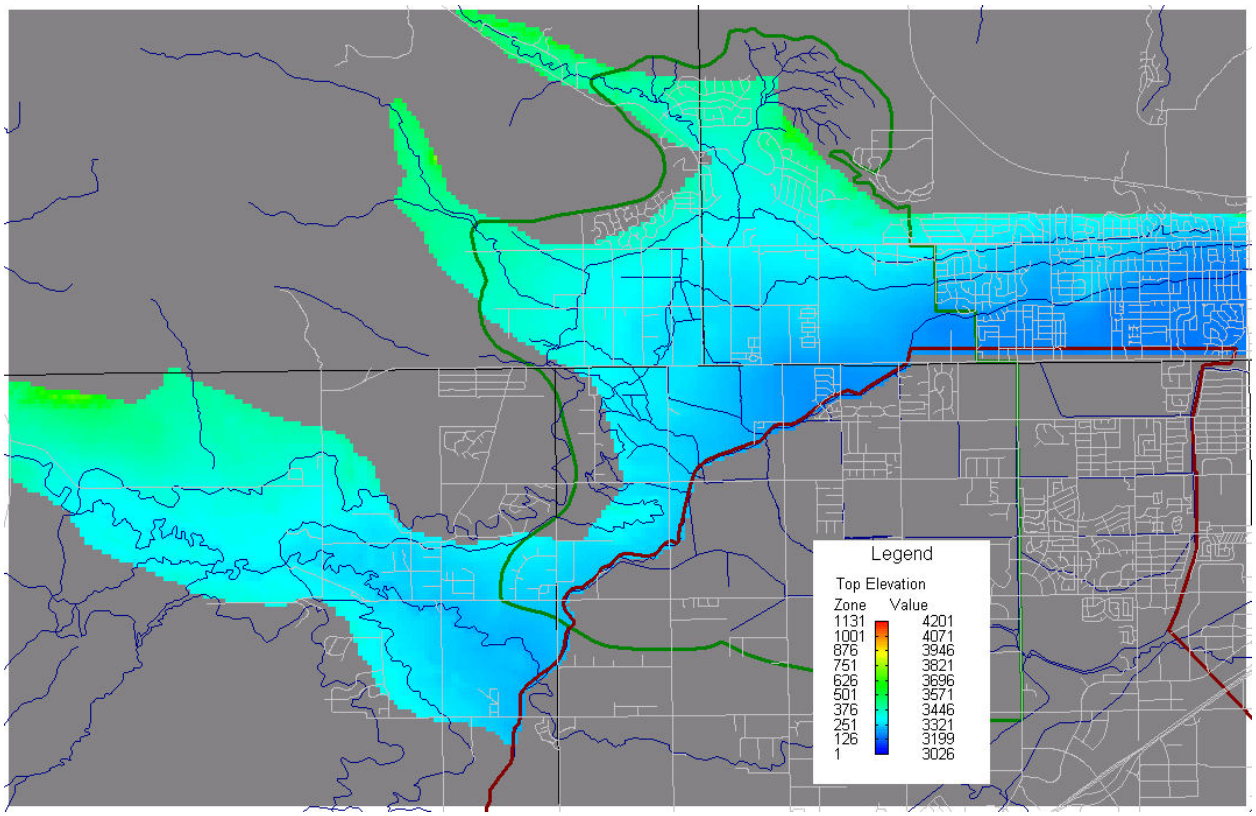


Figure 3-3. Model Layer 2 Top Elevation

Hydraulic conductivity values were assigned by importing a Surfer grid contoured in a similar fashion to those for layer elevations (see **Appendix A** for initial field of values). Prior to import, a total of 11 specific values were set such that the imported cells were assigned one of the specific values. Two of the set values were for model layer 1 and layer 3 consistent with the values in the MBMG model (see **Appendix B**). The other values are for the unconsolidated aquifer and range from 5-140 ft/d. The resulting hydraulic conductivity field for layer 2 is shown on **Figure 3-4**.

Model recharge values (**Figure 3-5**) were assigned to one of three values representing irrigated agriculture, non-irrigated agriculture, and housing. Land use designations shown on **Figure 2-7** were used to assign cell values. The model values specified are as follows:

- Housing, Zone 2, 0.00097 ft/d (MBMG value for April);
- Non-Irrigated Agriculture, Zone 3, 0.002 (estimated value)
- Gravel Pit, Zone 43 (not currently used)
- Irrigated Agriculture, Zone 5, 0.003 ft/d (modified from MBMG value for April of 0.0046 ft/d.

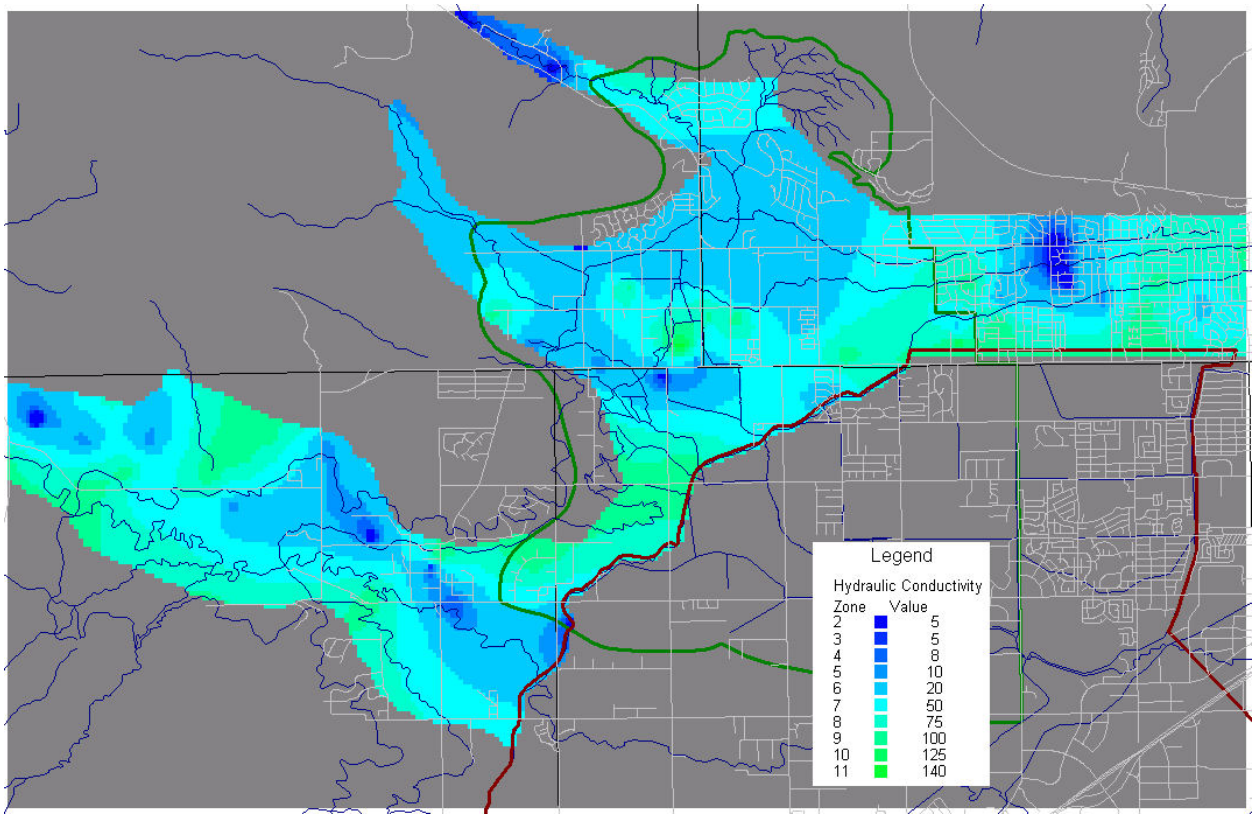


Figure 3-4. Model Layer 2 Hydraulic Conductivity Values

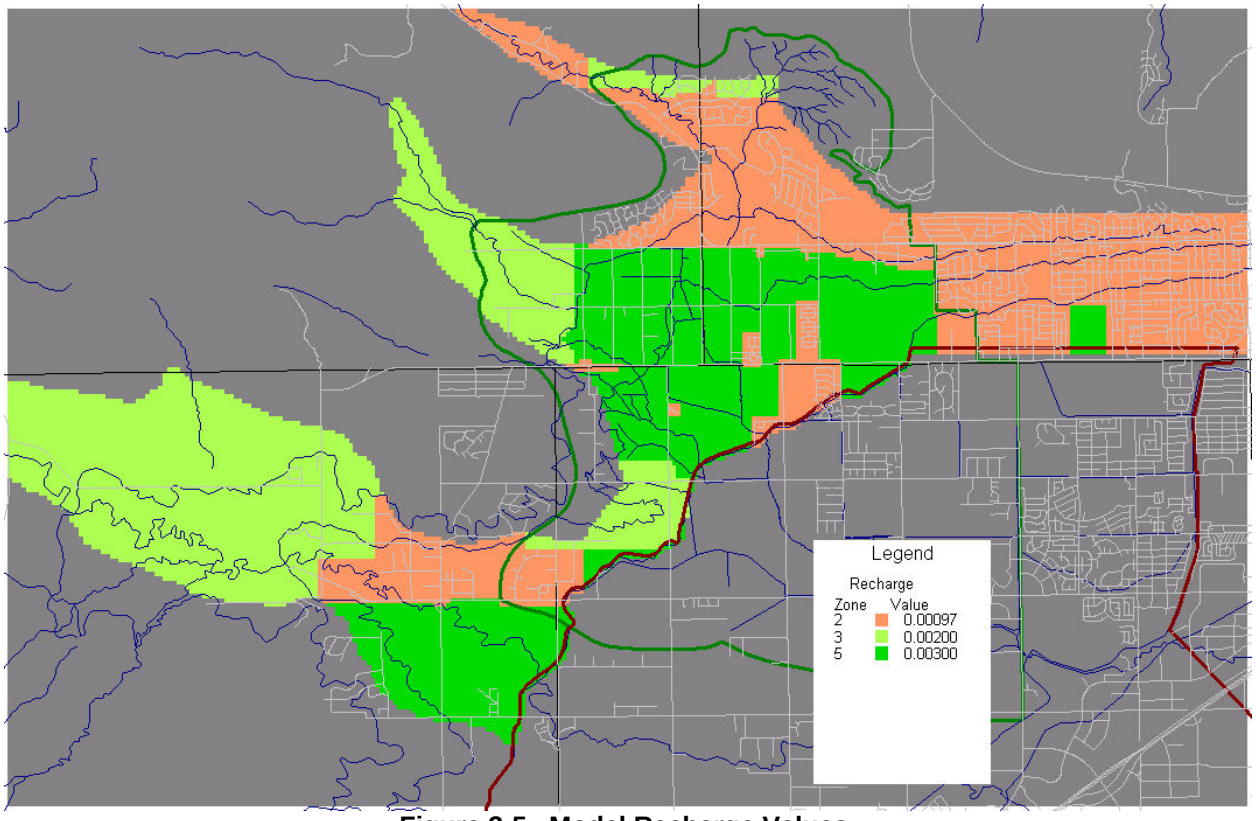


Figure 3-5. Model Recharge Values

3.1.3 Boundary Conditions

Other than no-flow cells (gray area on the model figures) the only boundary condition currently specified in the model are general head boundary cells (GHB's). The GHB cells are located along the perimeter of the active model area in layer 2, as shown on **Figure 3-3** above. GHB cells use an assigned value of water level, or head, and a calculated conductance term to let water in or take it out of the model.

The head values assigned to the GHB cells along the perimeter of the MBMG model area and the easternmost boundary were calibrated values for April from the MBMG model. Heads for the other GHB cells were initially set to the top elevation for layer 1 and subsequently lowered in places.

The conductance term for all GHB cells is based on assigned values of hydraulic conductivity (10 ft/d), saturated thickness (10 ft) and cell width (200 ft). This is a simplified approach and future versions of the model may incorporate the actual hydraulic conductivity and saturated thickness in each cell rather than common values.

3.2 Base Simulation

Model calibration consisted of a qualitative review of the simulated groundwater contours rather than the typical aggressive approach using observed heads at specific points. This simplified assessment of the model was done in part due to time constraints and also because a thoroughly calibrated model was not necessary to meet the modeling goals for this study. The review included using two points with measured water levels and also a visual comparison to previously developed groundwater contour maps (**Figure 3-1**). Resulting groundwater elevation contours for model layer 2 for the "base case" simulation are shown on **Figure 3-6**. The contours match the general pattern of those on **Figure 3-1**, but because the model represents more current conditions an exact match to the older contours was not attempted. Simulated groundwater levels were within 2 ft of measured values at two points within the model domain. Additional observed water level points will be needed for future calibration efforts.

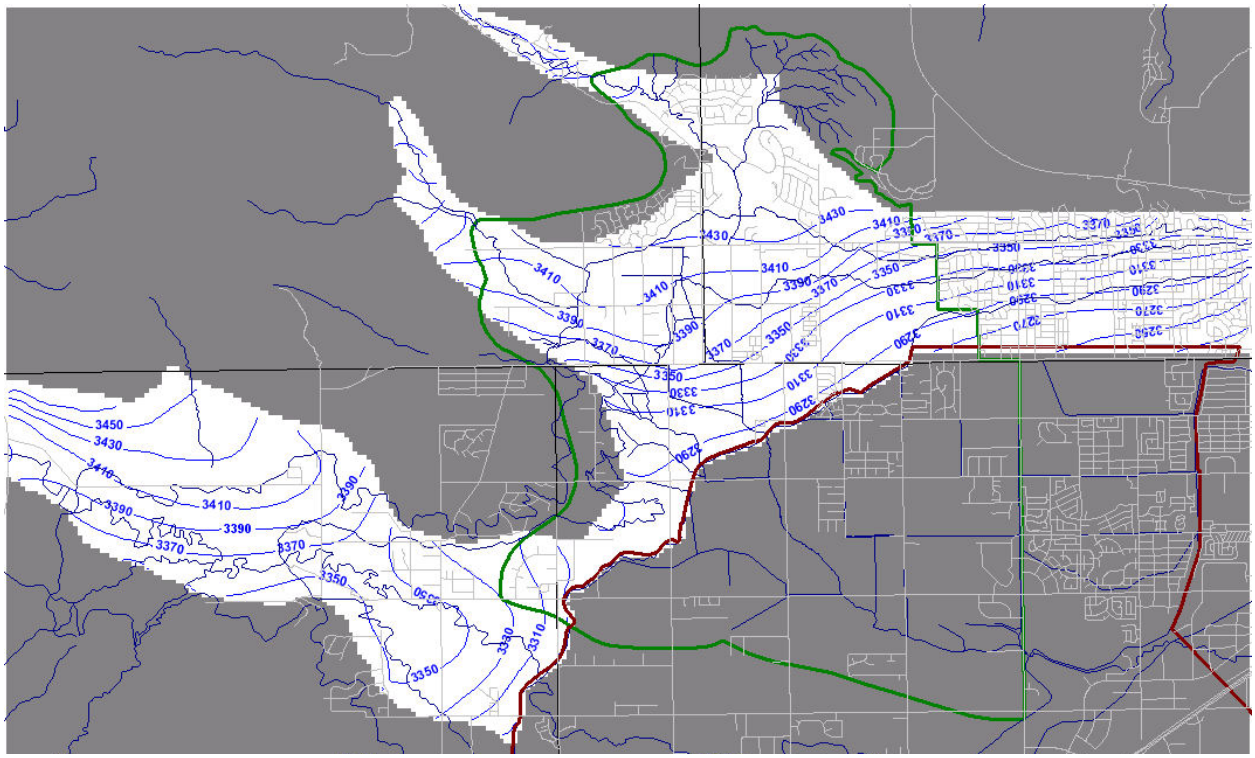


Figure 3-6. Base Case Groundwater Elevation Contours: Model Layer 2

3.3 Groundwater Recharge Simulations

Potential groundwater recharge simulations were completed for three locations, as shown on **Figure 3-1**. Two locations, Cove Creek and Little Cove Creek, are in the domain of the preliminary model presented in this section. The third location, Sharptail Pond, is located in the northern MBMG model domain. The MBMG model and recharge simulation results are included as **Appendix B**.

Two simulations were completed for each location. The simulations consisted of applying additional water for a month at the rates shown in **Table 3-1** for a 10-year and 100-year flood event. Surface water modeling provided the total volume of water expected for each of these events, and the total volume was subsequently reduced based on assumed losses due to evaporation and drainage through surface water.

Points were identified in the models at various distances downstream from the potential reservoirs to evaluate changes in water levels on a monthly basis resulting from the additional recharge. The preliminary model was converted to transient with monthly time steps, although the conditions were held at those of the steady-state model for each month with the exception of the additional groundwater recharge.

Table 3-1. Groundwater Recharge Rates and Volume for Modeling Scenarios

100-year

Site	Location	Area			Available Water				Rate (ft^3/d)	
		acres	ft^2	# cells	Ttl (af)	Lost (af)[1]	Rech (af)	Rech (ft^3)	Total	Per Cell
1	Cove Creek	55	2,395,800	59	550	275	275	11,979,000	386,419	6,549
2	Little Cove Crk	48	2,090,880	52	484	242	242	10,541,520	340,049	6,539
3	Sharptail Pond	30	1,306,800	32.67	120	19.5	100.5	4,375,166	141,134	4,320

10-year

Site	Location	Area			Available Water				Rate (ft^3/d)	
		acres	ft^2	# cells	Ttl (af)	Lost (af)[1]	Rech (af)	Rech (ft^3)	Total	Per Cell
1	Cove Creek	55	2,395,800	59	350	175	175	7,623,000	245,903	4,168
2	Little Cove Crk	48	2,090,880	52	300	150	150	6,534,000	210,774	4,053
3	Sharptail Pond	30	1,306,800	32.67	75	19.5	55.5	2,418,495	78,016	2,388

1 Water lost to evaporation & downstream surface flow (Site 1 and 2) or just evaporation (Site 3)

3.3.1 Cove Creek Simulations

The potential reservoir site for groundwater recharge of flood water at Cove Creek is shown as Site 1 on **Figure 3-1**. The site would cover an area of approximately 55 acres, but the exact location has not yet been specified. An approximation of the Cove Creek reservoir area was developed in the preliminary model and is shown on **Figure 3-7**. Also shown on the figure are the location of four model/monitoring points located at distances of 100, 1000, 2000, and 5000 ft from the downgradient end of the potential reservoir.

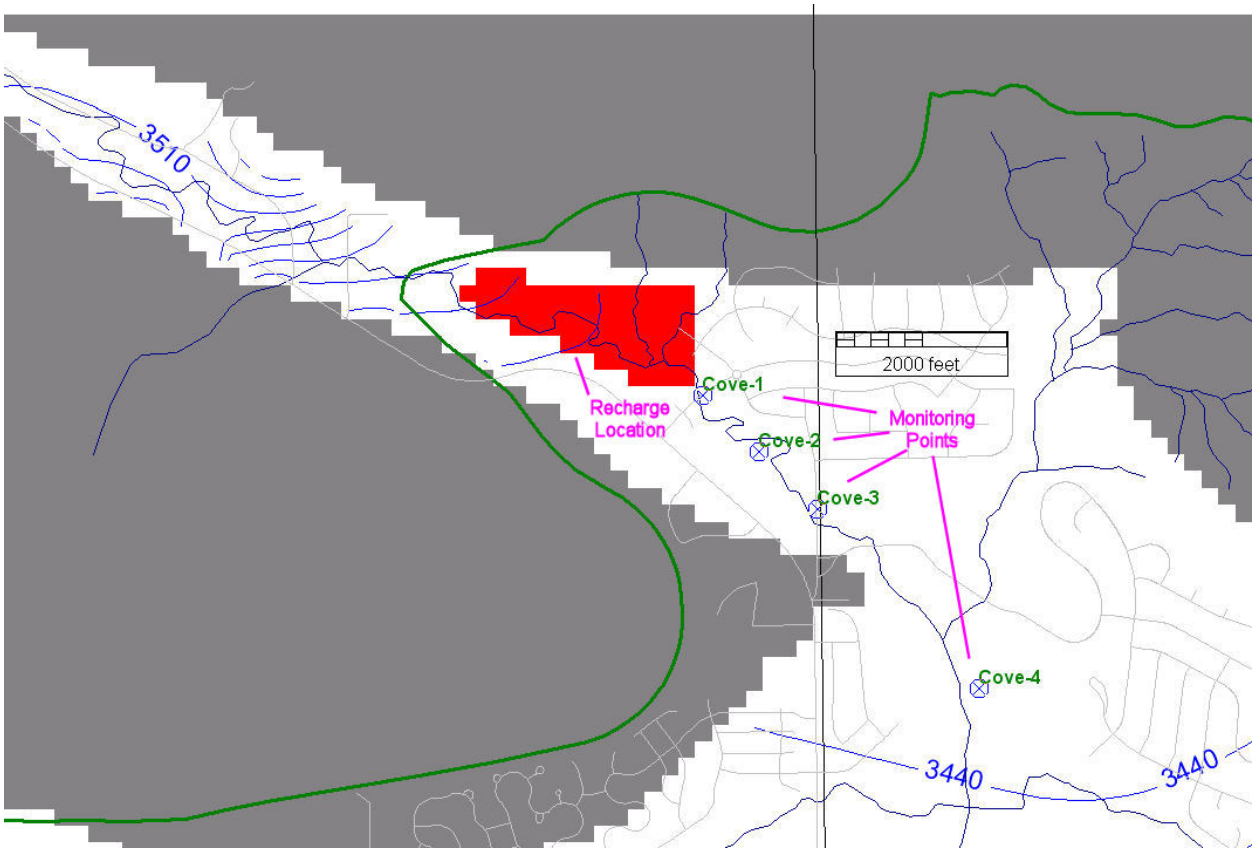


Figure 3-7. Model Setup for Cove Creek Groundwater Recharge Simulation

The reservoir was represented in the model as injection wells in layer 2. Rates used are shown in **Table 3-1** and are 6,549 ft^3/d for the 100-year event and 4,168 ft^3/d for the 10-year event for each cell. A total of 59 wells were used to represent the reservoir.

Results of the 100-year and 10-year recharge events are shown on **Figure 3-8** and **Figure 3-9**, respectively. The results show that, given the model limitations and the assumptions of a 55-acre reservoir that can route 50% of the water from a 100-year or 10-year flood event into the groundwater, that water levels might be expected to rise 1-2 ft immediately downgradient of the reservoir, with the effect decreasing to almost nothing a distance of 5,000 ft away. The water level rise will be realized for some period of time after the recharge event though, with a rise of less than 0.5 ft still present near the reservoir after 4 years. At a distance of 1,000 ft from the reservoir the maximum water level rise of 0.3-0.5 ft isn't realized until about two years after the recharge event.

These results suggest that routing flood water into the shallow aquifer may not have a significant effect and the effect will be localized to within a mile or so of the point of recharge. However, the effect appears to be longer lasting and if more frequent flood events can be utilized and even with some regular input of water, a greater impact could result.

To evaluate the effect of multiple recharge events a third simulation was performed combining flood events along with an annual input of water. The simulation assumes the 100-year flood event in the first year, the 10-year flood event in the third year, and an annual input of water of roughly 10% of the 10-year event volume (17.5 af) used as recharge during June, July, and August of each year. The resulting hydrographs are shown on **Figure 3-10**.

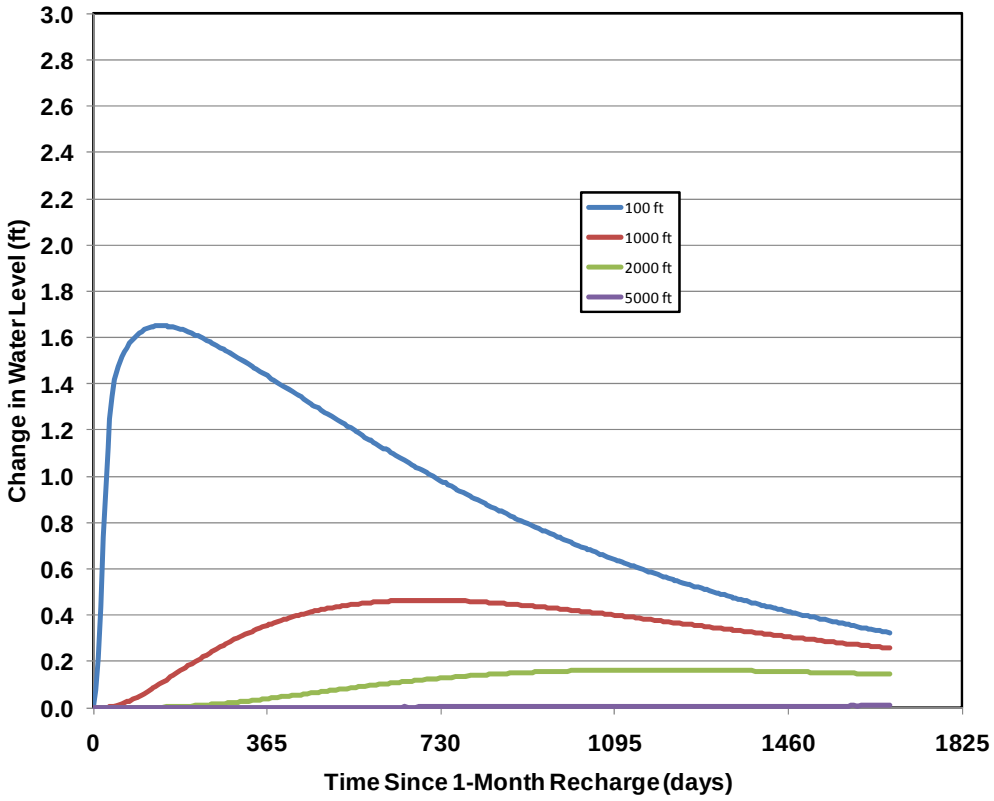


Figure 3-8. Monitoring Point Hydrographs: Cove Creek Reservoir 100-year Flood Event

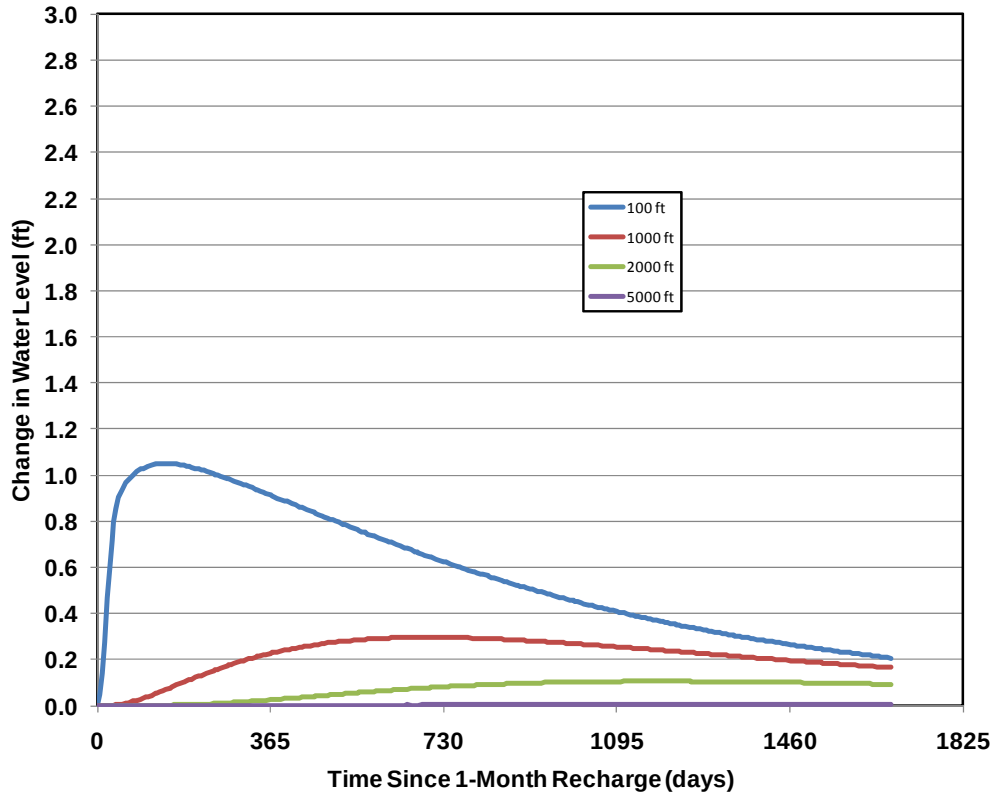


Figure 3-9. Monitoring Point Hydrographs: Cove Creek Reservoir 10-year Flood Event

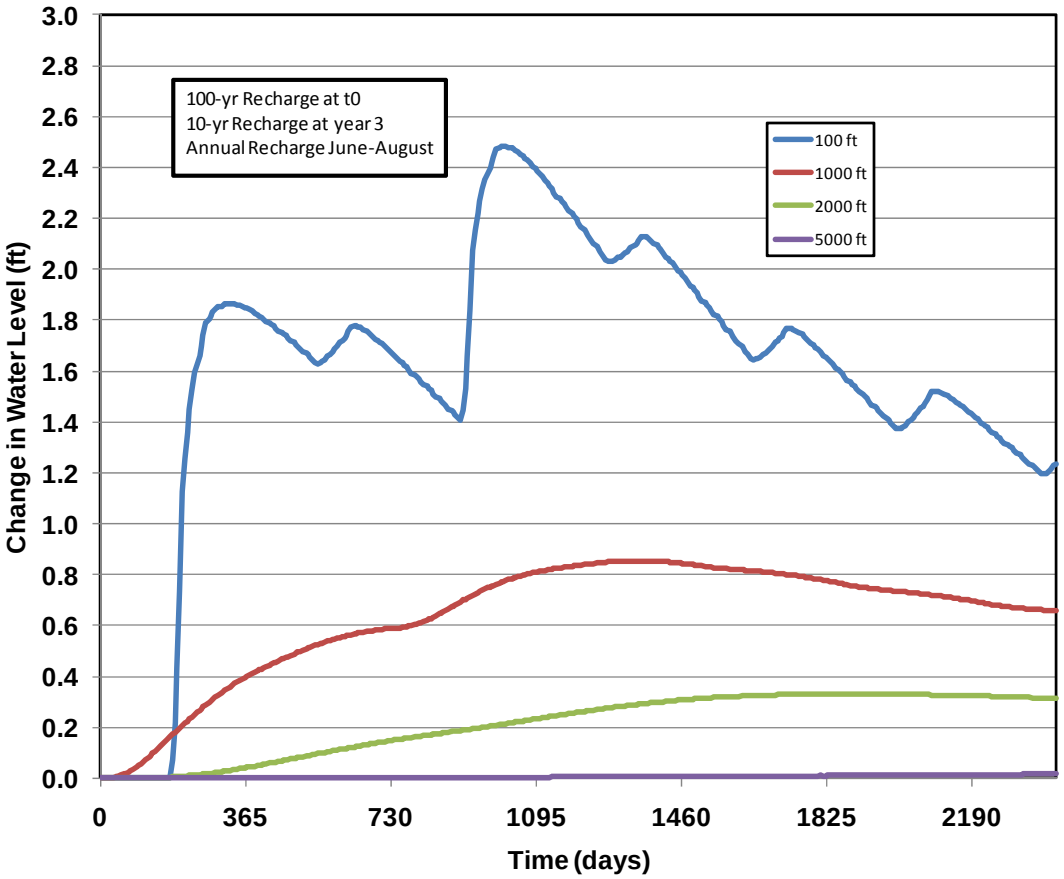


Figure 3-10. Monitoring Point Hydrographs: Cove Creek Reservoir Combined Recharge Events

The combined recharge events have a greater impact than either of the single events in the first two simulations, although the distance away that the impact is realized is still less than a mile. Six years after the 100-year event water levels remain over a foot higher at a distance of 100 ft from the reservoir. At a distance of 2,000 ft from the reservoir groundwater levels exhibit a small increase of about 0.3 ft but the rise is delayed several years after the 100-year flood event. Like in the previous simulations, there is essentially no change at a distance of 5,000 ft but water levels were rising slightly at the end of the time modeled.

The regular annual input is evident as small rises on the curve for the 100 ft monitoring point. These inputs could represent recharge from smaller and more frequent flood events or they could be other regular inputs such as purchased water rights from land use changes. The regular inputs were included to illustrate how they might benefit groundwater conditions and could be considered as a means to keep water in the reservoir rather than have long periods where it is dry.

Clearly there are an infinite number of ways to combine flood events and arranging the sequence of events, or even adding in other potential flood events. Rearranging the sequence of events would likely change the appearance of the hydrographs, and some additional patterns of recharge may need to be evaluated in the event groundwater recharge from flood events is considered further.

3.3.2 Little Cove Creek Simulations

The potential reservoir site for groundwater recharge of flood water at Little Cove Creek is shown as Site 2 on **Figure 3-1**. The site would cover an area of approximately 48 acres, but the exact location has not

yet been specified. An approximation of the Little Cove Creek reservoir area was developed in the preliminary model and is shown on **Figure 3-11**. Also shown on the figure are the location of four model/monitoring points located at distances of 100, 1000, 2000, and 5000 ft from the downgradient end of the potential reservoir.

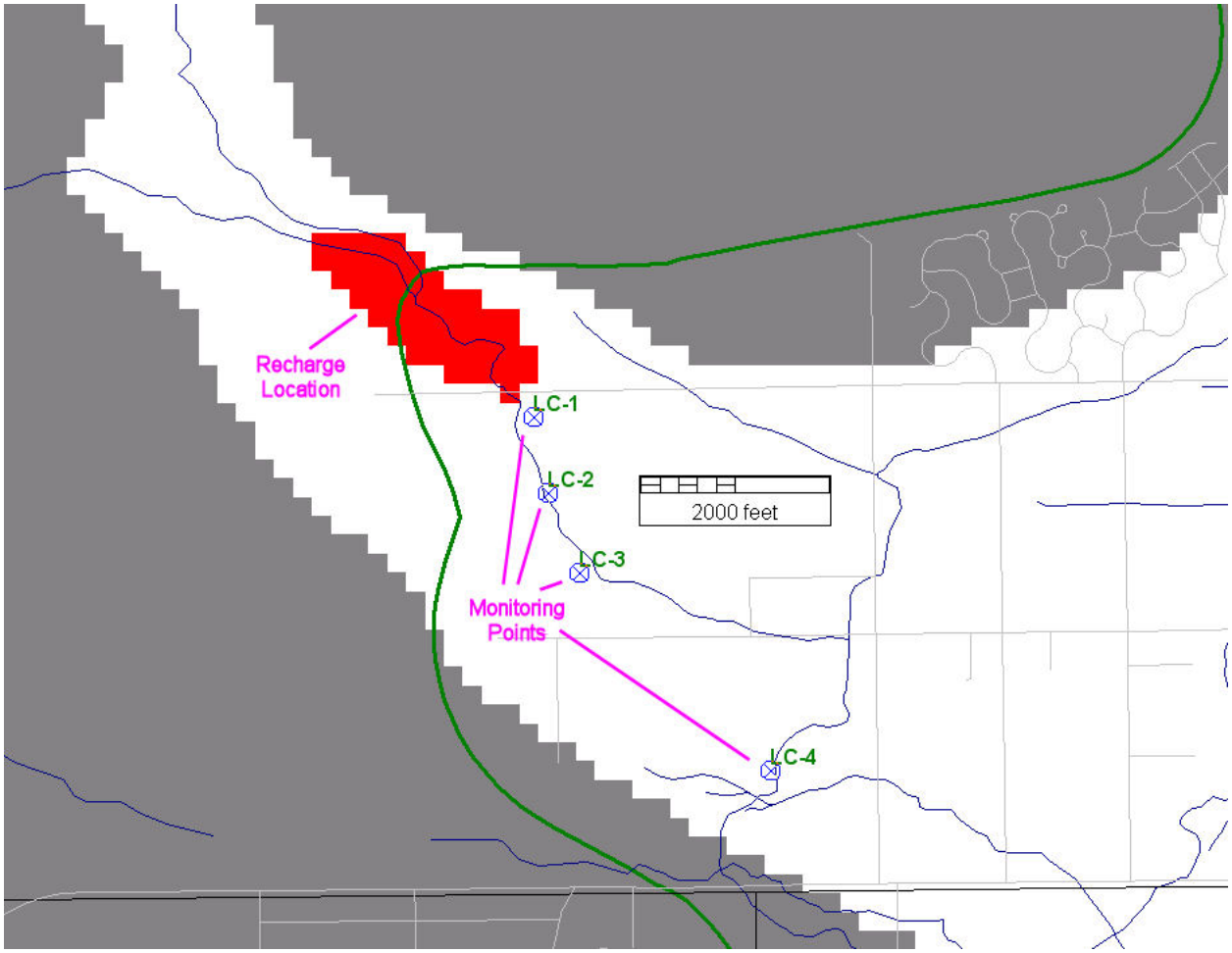


Figure 3-11. Model Setup for Little Cove Creek Groundwater Recharge Simulation

The reservoir was represented in the model as injection wells in layer 2. Rates used are shown in **Table 3-1** and are 6,539 ft^3/d for the 100-year event and 4,053 ft^3/d for the 10-year event for each cell. A total of 52 wells were used to represent the reservoir.

Results of the 100-year and 10-year recharge events are shown on **Figure 3-12** and **Figure 3-13**, respectively. The results show that, given the model limitations and the assumptions of a 48-acre reservoir that can route 50% of the water from a 100-year or 10-year flood event into the groundwater, that water levels might be expected to rise 1-1.5 ft immediately downgradient of the reservoir, with the effect decreasing to almost nothing a distance of 5,000 ft away. The water level rise will be realized for some period of time after the recharge event though, with a rise of less than 0.4-0.6 ft still present near the reservoir after 4 years. At a distance of 1,000 ft from the reservoir the maximum water level rise of 0.3-0.4 ft isn't realized until about two years after the recharge event.

Like the results from the Cove Creek simulations, these results suggest that routing flood water into the shallow aquifer may not have a significant effect and the effect will be localized to within a mile or so of the point of recharge.

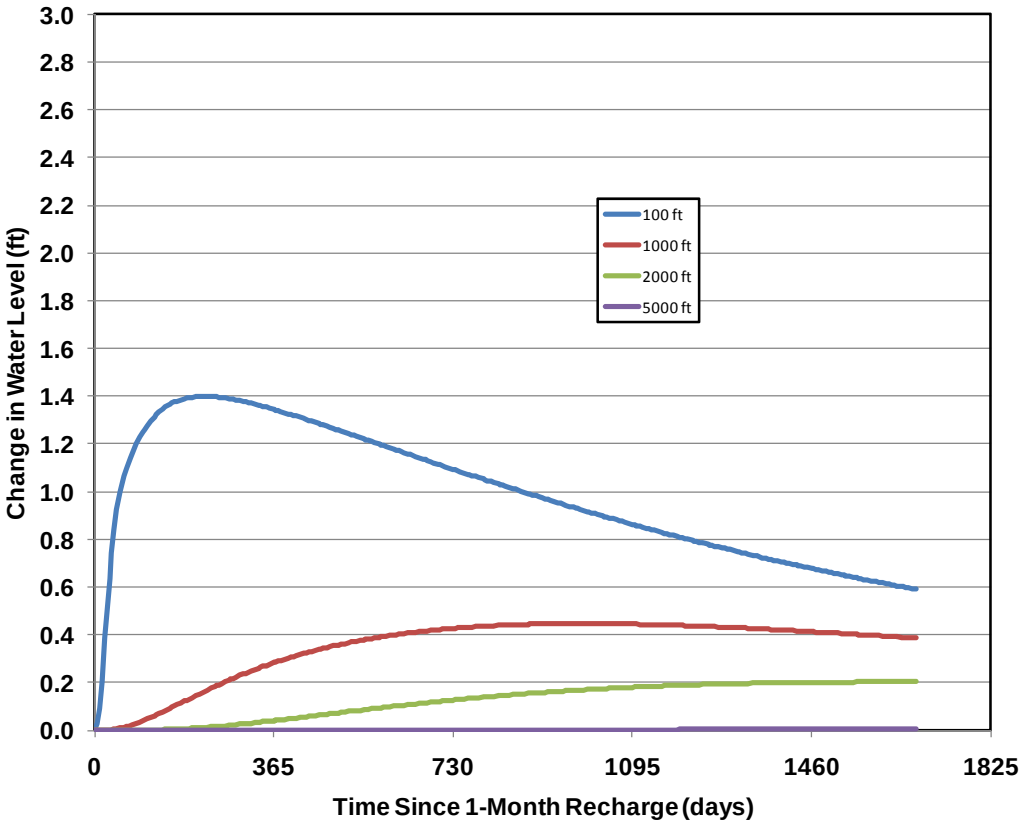


Figure 3-12. Monitoring Point Hydrographs: Little Cove Creek Reservoir 100-year Flood Event

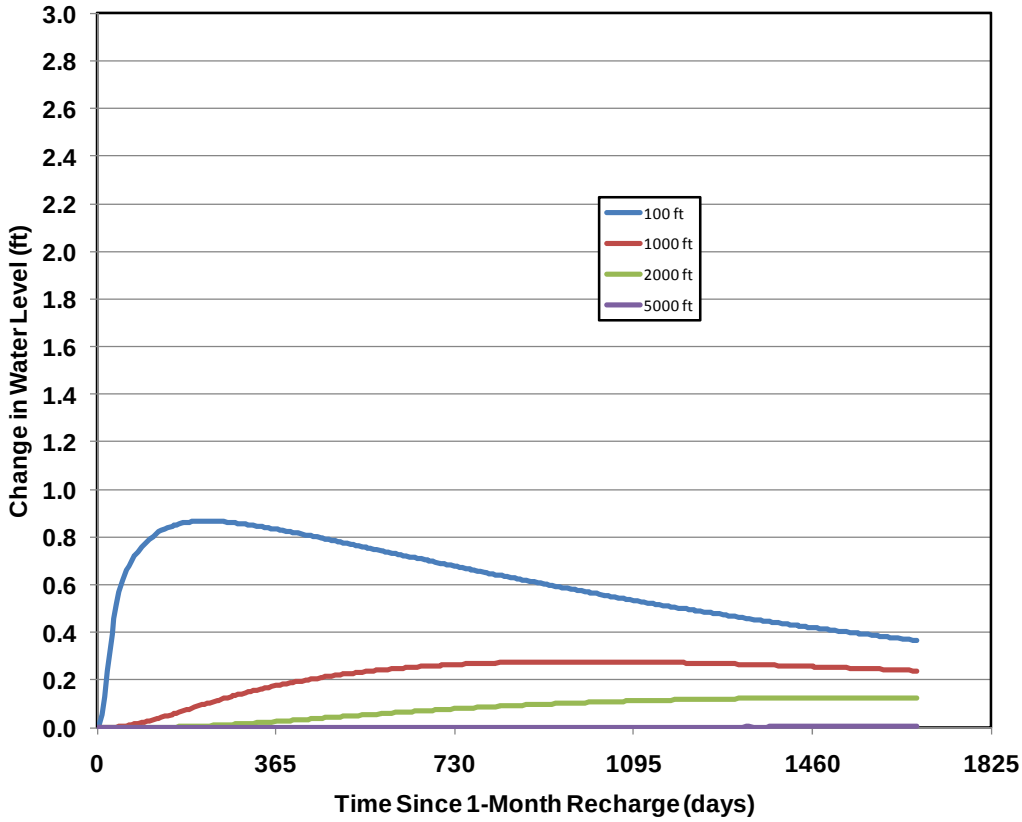


Figure 3-13. Monitoring Point Hydrographs: Little Cove Creek Reservoir 10-year Flood Event

A third simulation was performed combining flood events along with an annual input of water. The simulation assumes the 100-year flood event in the first year, the 10-year flood event in the fourth year, and an annual input of water of roughly 10% of the 10-year event volume (15.0 af) used as recharge during June, July, and August of each year. Note that the timing for the 10-year flood event is a year later than was simulated for Cove Creek to illustrate the effect of a difference in timing. The resulting hydrographs are shown on **Figure 3-14**.

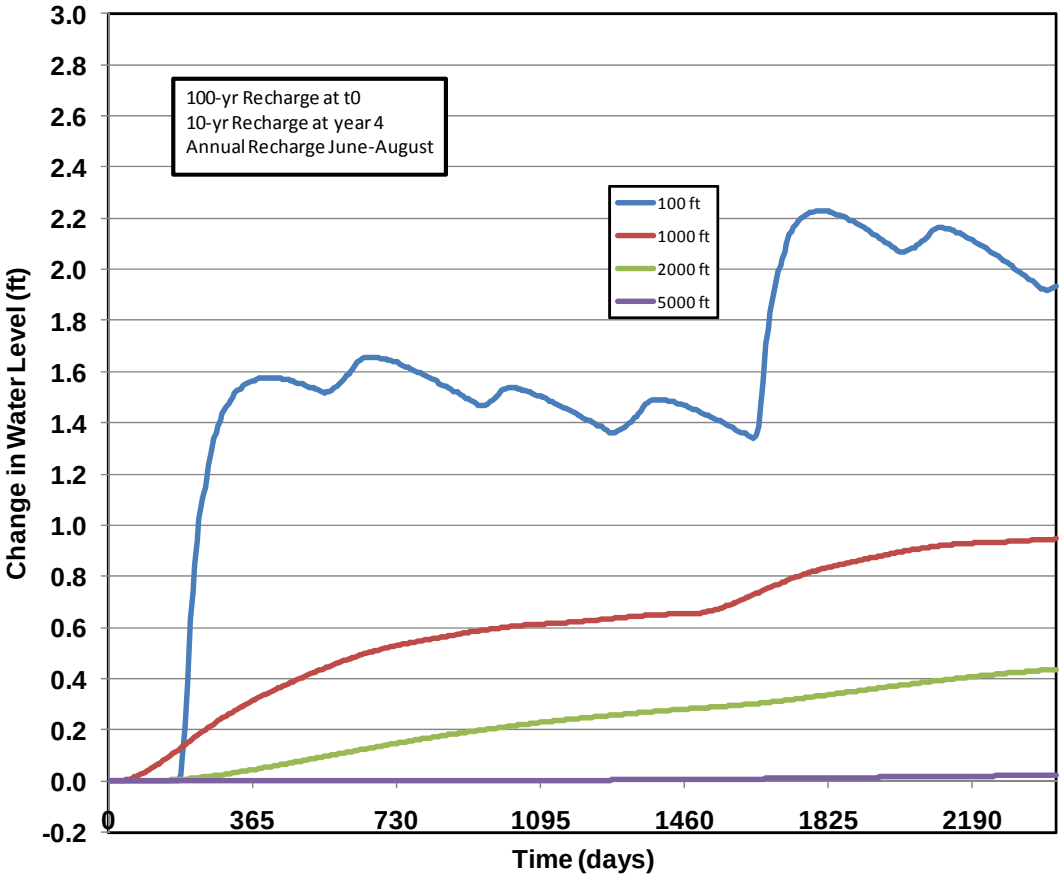


Figure 3-14. Monitoring Point Hydrographs: Little Cove Creek Reservoir Combined Recharge Events

Like for the Cove Creek simulations, the combined recharge events have a greater impact than either of the single events in the first two simulations, although the distance away that the impact is realized is still less than a mile. This combined simulation differs from that for Cove Creek however in that with the regular annual input the decline in water levels 100 ft from the reservoir is slower and when the 10-year event happens the water level rise jumps to over 2 ft. At a distance of 1,000 ft the water level rise is just starting to peak four years into the simulation when the effects of the 10-year event increase the water level change to nearly 1.0 ft. There still is essentially no change at a distance of 5,000 ft but water levels were rising slightly at the end of the time modeled. These results suggest that groundwater recharge in the Little Cove Creek drainage may have a greater impact than along Cove Creek, but the effects would still be limited to less than a mile.

3.3.3 Sharptail Pond Simulations

The potential groundwater impacts from recharging water at a reservoir site located at Sharptail Pond was simulated by the MBMG using their model covering the southern portion of the Study Area. Their modeling efforts and results are covered in **Appendix B**.

The magnitude of the water level rise in the Sharptail Pond simulations is similar to the results from the simulations in the northern portion of the Study Area near the point of recharge. However, the Sharptail Pond simulations indicate much less of a rise downgradient, with a maximum rise of 0.003 ft predicted at a distance of roughly 1,000 ft. Water level rise for the Sharptail Pond simulations are also much briefer, lasting only about three months after the recharge event.

The differences from the Sharptail Pond simulations may be due to the fact that recharge was simulating by increasing recharge rates at the model surface instead of using injection wells, or it may be because hydraulic conductivity values or other model specifications are different in that area. Regardless, the results from all the simulations show a very localized and short-lived groundwater impact from flood water recharge.

4.0 CONCLUSIONS

Detailed analyses have been completed of the shallow stratigraphy and land use changes in the West Billings area. These analyses have been used to develop a preliminary groundwater flow model for the northern portion of the Flood Mitigation and Groundwater Recharge Study Area. The model represents an extension of areas already being modeled by MBMG, and, in combination, are means to simulate potential groundwater recharge alternatives in the entire West Billings area.

Simulations of potential groundwater recharge events have been completed for locations on Cove Creek and Little Cove Creek using the preliminary model. Modeling included simulating recharge from a 100-year flood event, a 10-year flood event, and a combination of the two flood events with regular annual recharge. A third location at Sharptail Pond was simulated by MBMG using their model. The Sharptail Pond modeling included simulating recharge from a 100-year flood event and a 10-year flood event.

The modeling results suggest that recharging groundwater from flood events will cause a modest rise in groundwater levels near the point of recharge but the effect may not be noticeable more than one mile away. Water level rises of roughly 1-2 feet are evident 100 ft away from the recharge and could be even greater depending upon the timing of flood events. Further away the degree of rise is less but for simulations in the northern part of the drainage it is delayed by a year or more, with a rise of up to one foot occurring 1,000 ft from the point of recharge for one of the combined flood recharge simulations.

Modeling simulates a 10 year flood, which represents a 10% annual occurrence per year, and a 100 year flood, which represents a 1% occurrence. Relying on these infrequent events suggest recharging groundwater through flood flows alone is insignificant. The only way to have appreciable impact is by supplementing the flood water with a diversion of water on a regular basis.

These modeling results should be viewed as general indicators of the potential impact upon groundwater from routing flood water into the subsurface because there are a number of limitations that affect the results. The volume of water from flood events that recharges the groundwater is only an estimate at this point and may be greater or less than modeled, and which events can be used for groundwater recharge is uncertain at this level of the feasibility evaluation. In addition, the sequence of various flood events cannot be predicted and the model results show that varying the timing of flood events changes the downgradient groundwater response over time. Additional modeling may be necessary if groundwater recharge alternatives are considered further in the flood mitigation study.

The preliminary model developed for the northern portion of the Study Area is considered adequate for simulating general impacts from groundwater recharge events. It is considered to be preliminary because it has not been aggressively calibrated and some modifications will likely be necessary if greater accuracy of simulations is needed and if it is to become part of the MBMG model network in the area. Modifications might include representing creeks, ditches, and drains in the model domain with boundary conditions, including pumping wells, and varying boundary conditions seasonally.

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PBS&J, 2010d. Additional Data Report, West Billings Flood Mitigation and Groundwater Recharge Study. Prepared by PBS&J for the City of Billings and Yellowstone County. August.

PBS&J, 2010e. Feasibility Study Draft Methodology and Preliminary Alternatives List, West Billings Flood Mitigation and Groundwater Recharge Study. Technical Memorandum prepared by PBS&J for the City of Billings and Yellowstone County. August.

Appendix A

Stratigraphic Analysis Methodology and Results

This Appendix provides a detailed summary of the methodology used to review and interpret well logs for the West Billings area to the north of the current MBMG model areas. The information from the well log interpretation was compiled into a spreadsheet and was incorporated into GIS coverages shown on maps in this document.

The list of well logs obtained from MBMG's GWIC database and presented in previous documents for this study was reduced to include only those logs located north of the MBMG model areas. The reduced list includes a total of 824 borings at the locations shown on **Figure A-1**.

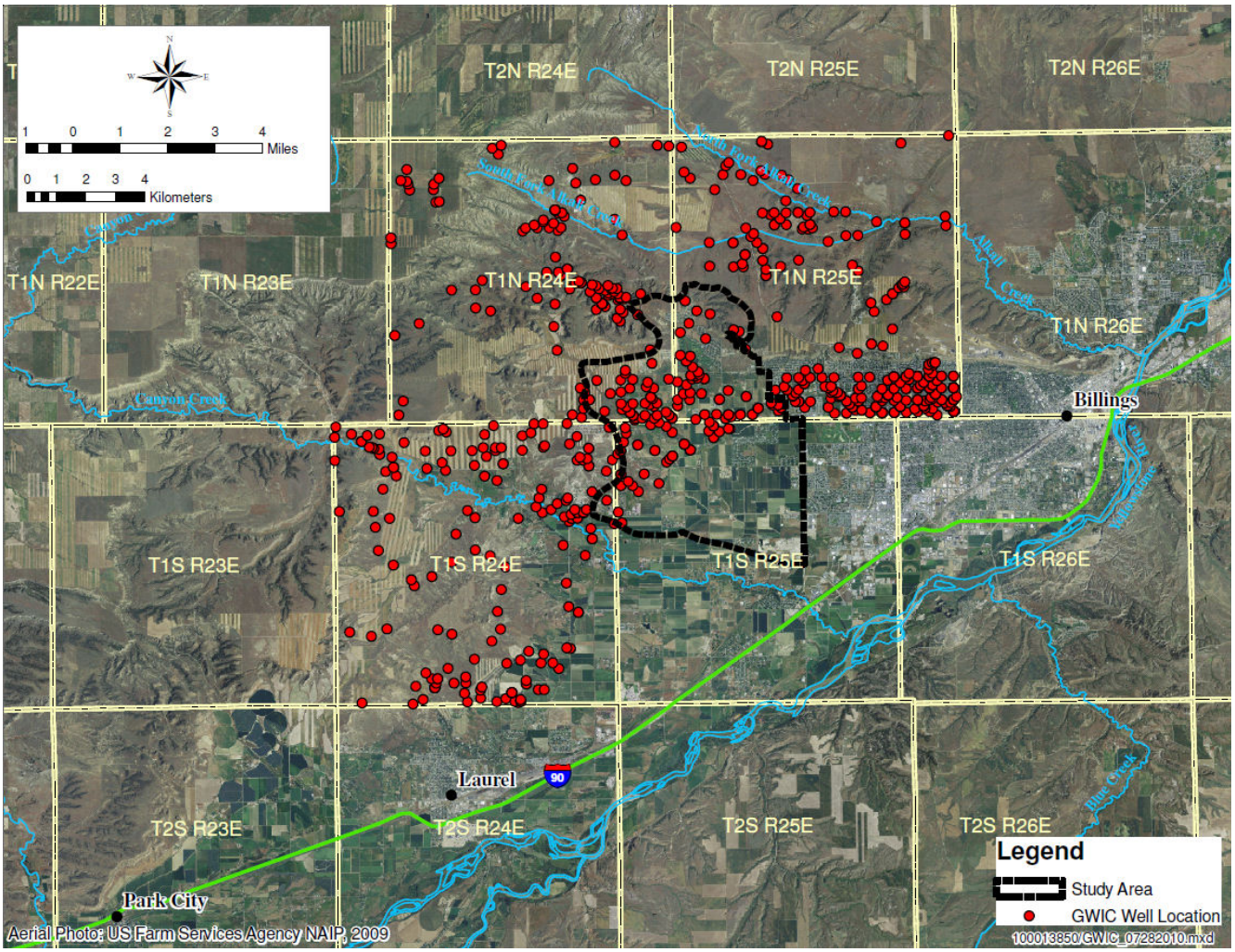


Figure A-1. Location of MBMG GWIC Well Logs Reviewed

The GIS coverage for the wells initially consisted of information provided in the GWIC database including features such as GWIC number, owner name, location information, and others. This information was then imported into an Excel spreadsheet and reduced to relevant information. Additional information columns were added as noted below. Each GWIC entry was visited in the MBMG database, and if a well log existed it was reviewed for the information noted below. Of the 824 GWIC entries a total of 136 did not have well logs, leaving 688 to review for stratigraphic information. Information that was missing or could not be determined was noted with a "---".

Information added to the spreadsheet during review of the well logs included:

- Ground Elevation
- Fine-Grained Cap bottom depth, bottom elevation, and thickness
- Aquifer (unconsolidated) thickness, type, and hydraulic conductivity values
- Bedrock/Bottom Clay depth and elevation
- Data Qualifiers and Comments

Ground Elevation

Ground elevation was specified in two manners. First, the well location was compared to topographic coverage and the elevation at the location specified was noted in the spreadsheet. The topographic coverage used was USGS 24K DEM with a 10 meter resolution. Second, during review of the well logs some of the logs included the ground elevation. These were noted in a separate column. In general, elevation noted on the logs matched closely to elevations obtained from GIS topographic information, but in some cases there was a significant difference.

The ground elevations were used to specify other elevations in the spreadsheet as noted below. Ground elevations from well logs were assumed to be more accurate and were given preference when available. Subsequent elevations deriving from this information were color coded to indicate which of the two ground surface elevations were used.

Fine-Grained Cap Information

Information on the fine-grained material, overlying the unconsolidated aquifer was added at each location. If this cap material was not present in the log a thickness of 0 was assigned. In some cases the material was noted by a single entry such as “clay” or “silt”. In other cases there were interbedded fine and coarse-grained units, and in those cases some of the coarse grained material that was considered to be above the main unconsolidated aquifer was included in the fine-grained cap and the thickness adjusted as noted below.

Bottom Depth

Depth on the log where the fine-grained material transitions to the unconsolidated aquifer, if present, or to bedrock. For logs where drilling did not get through the fine-grained material, the total drilling depth was used with a “greater than” sign.

Bottom Elevation

Bottom elevation where the fine-grained material transitions to the unconsolidated aquifer, if present, or to bedrock. Elevation related to ground elevation and color coded as to whether the reference elevation was a log value of the USGS DEM.

Thickness

Thickness of the fine-grained material. If minor layers of coarse-grained material were included in the interpretation of the cap material their total thickness was subtracted out to allow for future assignment of variable hydraulic conductivity values.

Aquifer Information

Aquifer information was specified for locations where the shallow unconsolidated aquifer was present. For locations where it was absent in the log a thickness of 0 was assigned.

Thickness

Thickness of the aquifer was assigned at the difference between the fine-grained cap bottom depth and the depth to bedrock or bottom clay. For logs where drilling did not get through the aquifer material a “greater than” sign was added.

Type

An aquifer type qualifier was assigned based on the log description. The types used in the spreadsheet are noted below and were used to assign hydraulic conductivity values.

Aquifer Types Assigned

Aq Types:		K (ft/d)
1	mostly gravel	200
2	gvl & sand	100
3	med-crs sand	50
4	fine sand	10
5	sand & fines	1

Hydraulic Conductivity

Hydraulic conductivity (K) values were assigned in two manners. The first approach was to assign K values based on the aquifer types as described above. The second approach was to assign K values based on water level and yield information in the logs. For the second approach, the list of wells was reduced to those with information on static water level, pumping water level, and yield (a total of 301 wells). This information was then used to estimate K in a separate spreadsheet tab using the following empirical formula:

T (gpd/ft) = [Q (gpm) * 2000] / s (ft)

K = T/b

Where:

T = transmissivity
Q = yield
s = drawdown
K = hydraulic conductivity
b = saturated thickness

Bedrock/Bottom Clay Information

The depth to and elevation of bedrock or fine-grained material on top of bedrock was noted in additional columns in the spreadsheet. These columns were filled in with "---" for logs where drilling did not clearly go through the unconsolidated material. Elevation was related to ground elevation and color coded as to whether the reference elevation was a log value of the USGS DEM.

Data Qualifiers

Two types of data qualifiers were assigned to allow for filtering of the data points when developing spatial GIS coverages. The qualifiers ranked log quality, and location quality.

Log Quality

Log quality consisted of two separate components and columns consisting of "contacts" and "description". For each GWIC well these columns were assigned numbers from 1 to 4 based on the table below.

Contacts and Description Quality Assignments

Log Qual:		
	1	V Good (high detail level)
	2	Good (contacts/desc reliable)
	3	Poor (contact/desc questionable)
	4	Unconsol. aquifer absent/outside of probable area

The contact qualifier is a measure of how reasonable the depth information noted on the log appears to be. The description qualifier is a measure of the reliability of the description. For example a log describing 40 feet of "sand & gravel" was not considered reliable for determining aquifer types, but is reliable for the contact depth information.

Location Quality

A location qualifier was added to allow for filtering of data points as needed based on the accuracy of the location. Each GWIC well was assigned a location qualifier from 1 to 3 based on the table below.

Location Quality Assignments

Loc Qual:	1	V Good (GPS or survey)
	2	Good (at least qtr-qtr-qtr)
	3	Poor (less than qtr-qtr-qtr)

Comments

A comment column was added to the spreadsheet and notes were added where appropriate as an aide for future use of the data. The notes vary from ones indicating that there is no log or the log was too poor to use, to more specific notes such as how much coarse material was included or that the description of aquifer material type is limited.

Results

Datasets were created from the final log review spreadsheet, contoured in Surfer and imported into GIS. The datasets included data points with information for a given property from the stratigraphy spreadsheet. In addition, datapoints from the northern extent of the MBMG model area were included so the data would transition smoothly from the modeled areas.

The data points used for contouring were filtered to remove locations where the unconsolidated aquifer is clearly not present, using the previously mapped extent shown on the figures below as a guide. The data were also filtered to only include points with a log and location quality of 1 or 2. After initial contouring some poorer quality data points were added back in for areas where there would otherwise be no coverage, and some points were removed if they appeared anomalous based on other nearby points. Finally, contours were truncated just beyond the perimeter of the unconsolidated area previously mapped by Olson (2005).

Results are shown below for thickness of the fine-grained cap (**Figure A-2**), thickness of the unconsolidated aquifer (**Figure A-3**), hydraulic conductivity of the unconsolidated aquifer (**Figure A-4**), and depth to bedrock (**Figure A-5**). The location of well logs evaluated are shown on the figures with those that were used for the contouring shown as blue, those not used as red, and those that indicate the unit is absent or is in a location that the unconsolidated aquifer is clearly not present as purple. Note that for the "used" well postings the data points from the MBMG model were not included. A printout of the final spreadsheet is included at the end of this Appendix as **Table A-1**.

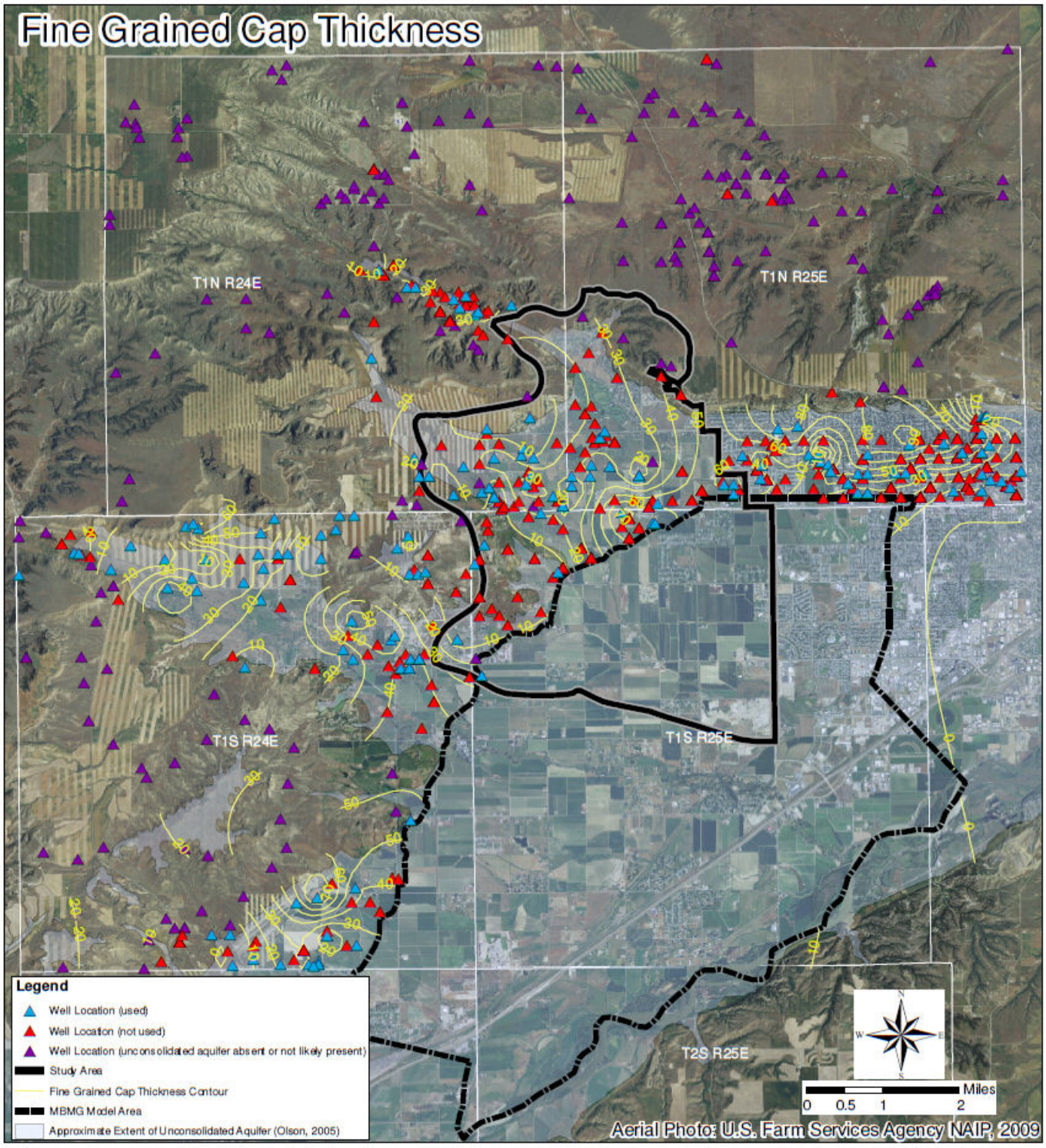


Figure A-2. Thickness of Fine-Grained Cap

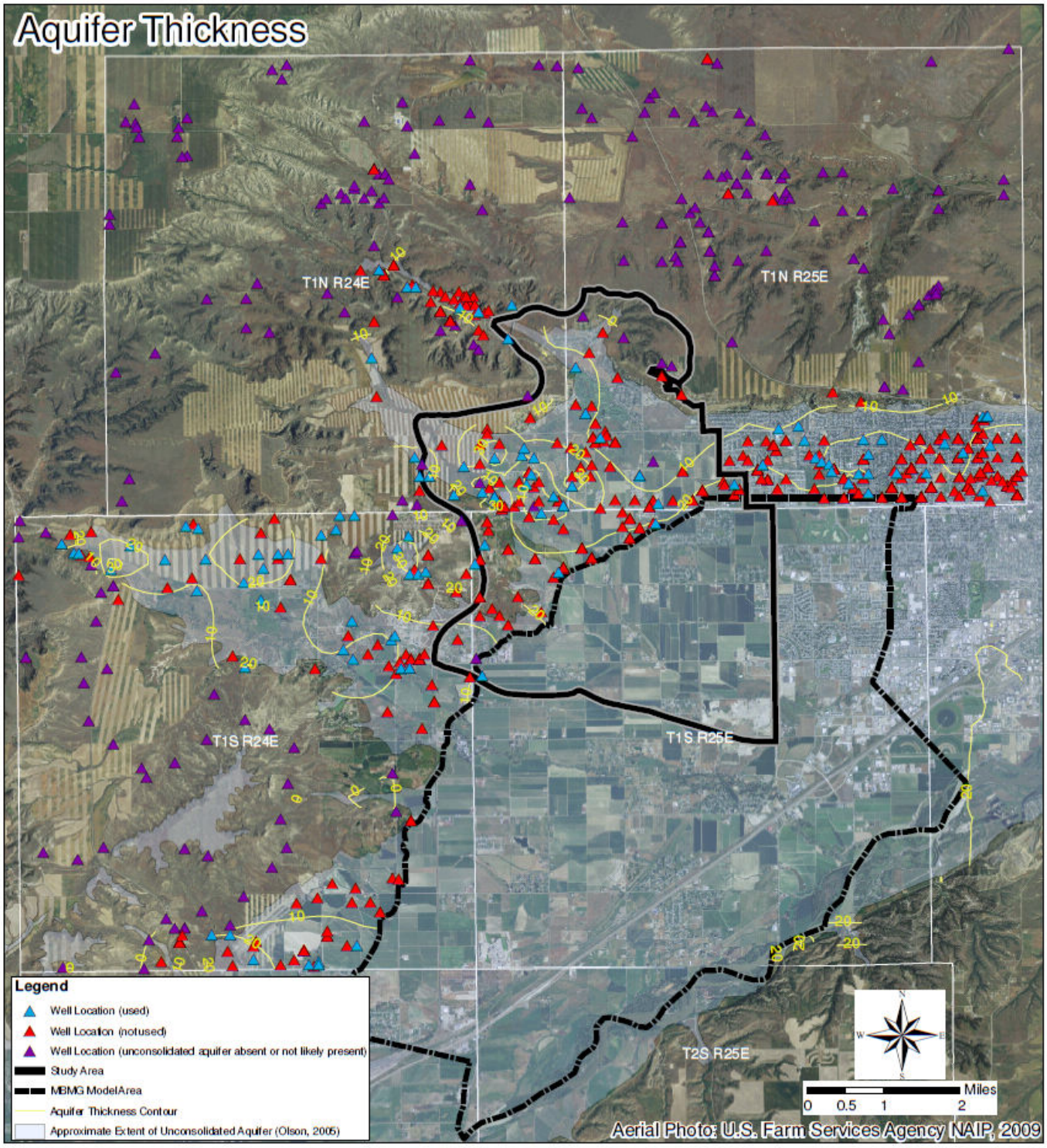


Figure A-3. Thickness of Unconsolidated Aquifer

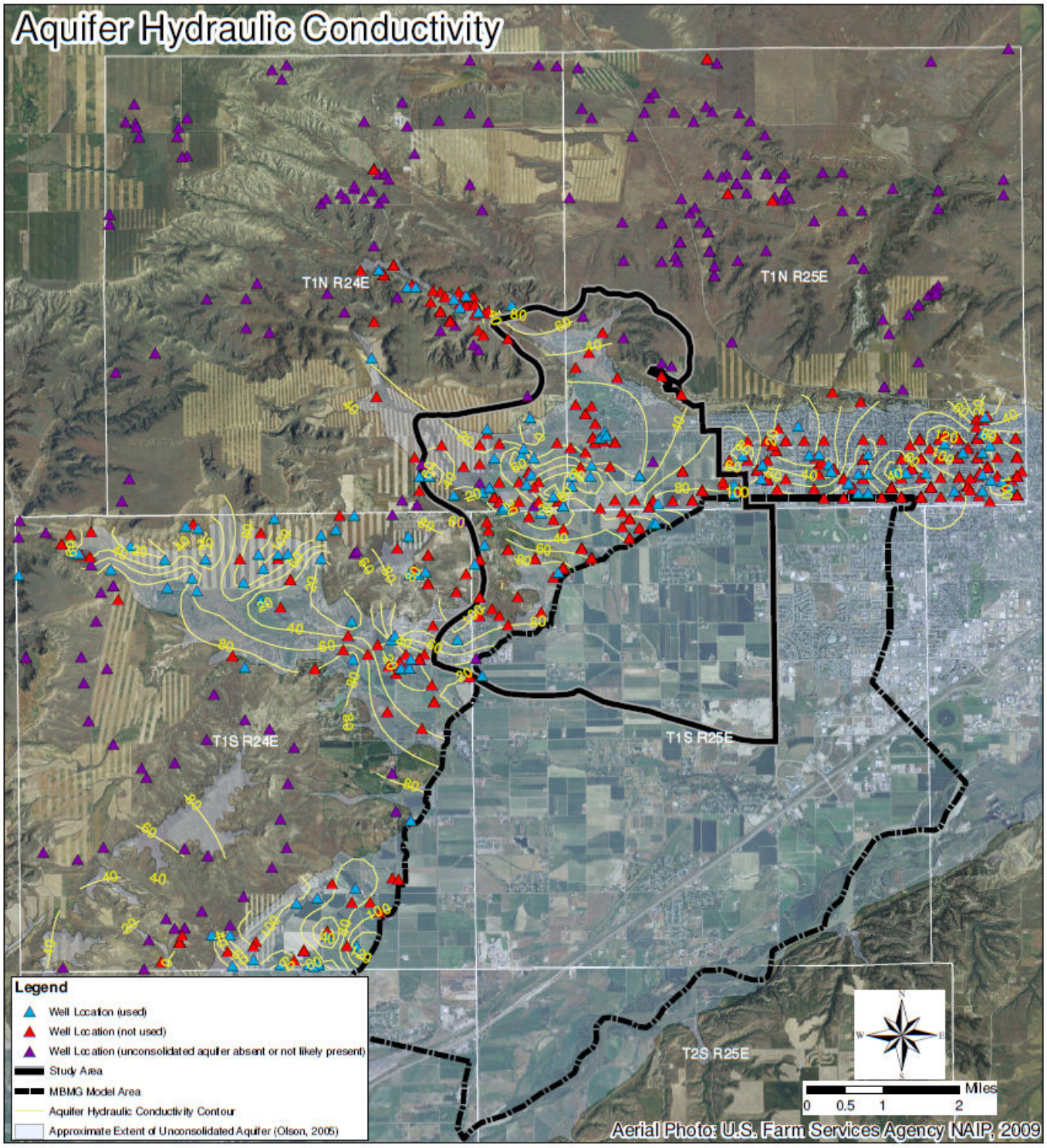


Figure A-4. Hydraulic Conductivity of Unconsolidated Aquifer

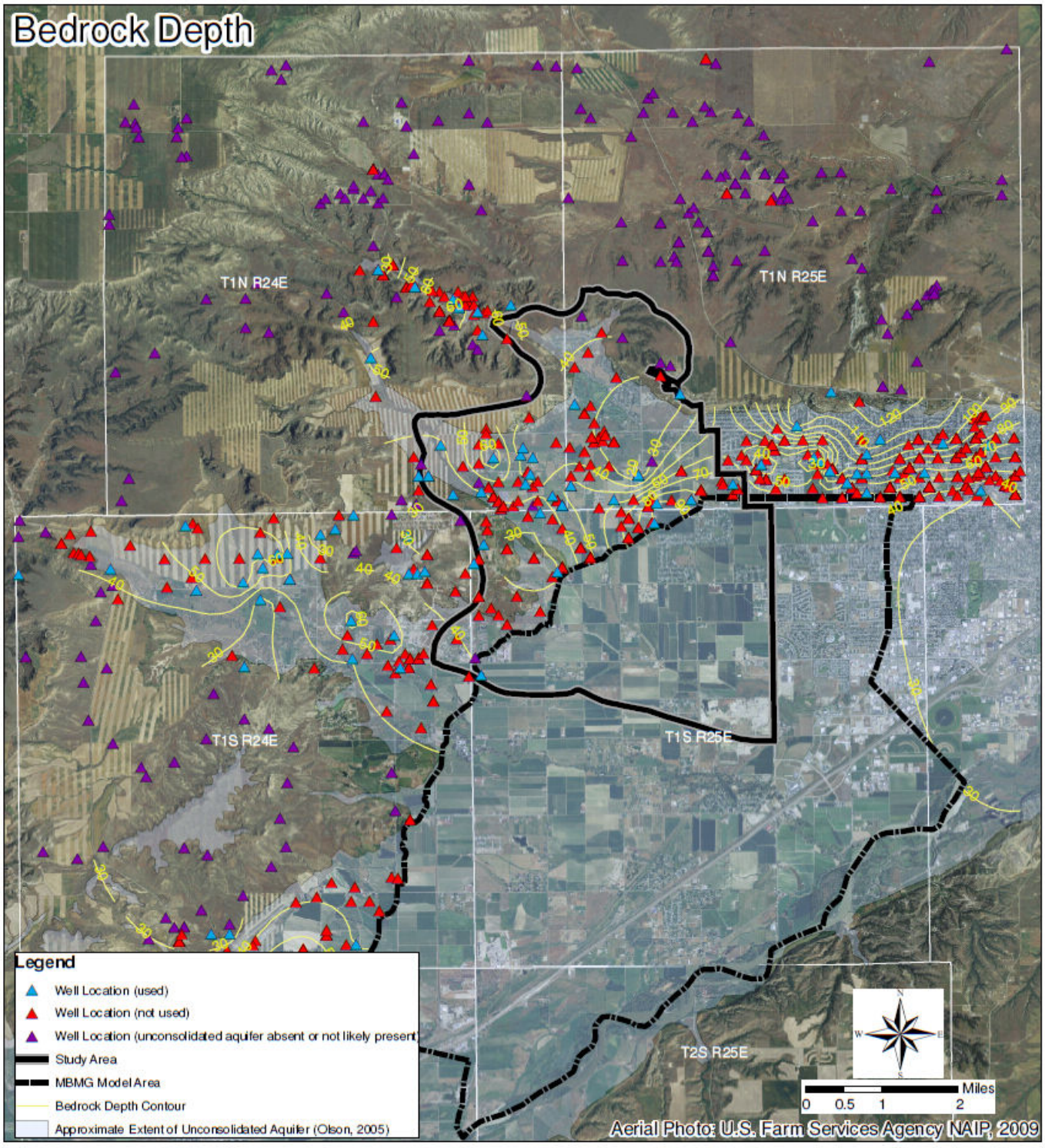


Figure A-5. Depth to Bedrock

Table A-1. West Billings Study Well Log Review Summary

Identification				Location				Ground Elev. (ft MSL)		Fine-Grained Cap			Aquifer Material				Bedrock/Clay		Data Qualifiers			
															K (ft/d)				Log Quality		Loc	
Map	GWIC	Name	Geo Method	T	R	S	QS	Log	Map	Btm Dpth (ft)	Btm Elev (ft MSL)	Thkns (ft)	Thkns (ft)	Type	Type	WL/Yld	Depth (ft)	Elev (ft MSL)	Contacts	Descr	Qual	Comment
422	142014	BILLINGS WATER SUPPLY * CALAMITY JANE	TRS-SEC	01S	24E	6	BCBB		3451	0	---	0	>20	5	1	---	---	---	4	4	2	no apparent clay cap
423	142015	BILLINGS WATER * CALAMITY JANE DAMSITE	TRS-SEC	01S	24E	6	CCBB	3708.9	3730	0	---	0	39	5	1	---	39	3670	1	1	2	no clay cap. Landslide debris
425	179873	HUGHES DOUG	TRS-SEC	01S	24E	6	BBB		3484	---	---	---	---	---	---	---	---	---	4	4	3	no log
436	222251	SCARIANO RON *WELL 2	TRS-SEC	01S	24E	7	CC	---	3665	37	3628	37	0	---	---	---	37	3628	4	4	3	no sand?
461	92765	KUKES JAKE	TRS-SEC	01S	24E	30	BDC	---	3788	---	---	---	---	---	---	---	---	---	4	4	3	no log
478	142013	BILLINGS WATER SUPPLY * CALAMITY JANE	TRS-SEC	01S	24E	6	BADC	3474	3481	>25	---	---	---	---	---	---	---	---	4	4	2	19' clayey sand on top of silty shale
518	92767	FRANK ALEX P.	TRS-SEC	01S	24E	31	DCC	---	3740	---	---	---	---	---	---	---	---	---	4	4	2	no log
530	92728	KASEMAN CLAUDE	TRS-SEC	01S	24E	6	AC		3448	---	---	---	---	---	---	7.6	---	---	3	3	3	poor log
531	92729	KASEMAN E.C.	TRS-SEC	01S	24E	6	AC		3448	15	3433	15	33	2	100	---	48	3400	2	2	3	
558	92727	OLSEN PETER	TRS-SEC	01S	24E	6	A		3465	30	3435	30	15	1	200	17.4	45	3420	2	2	3	
573	92766	KUKES JAKE W.	TRS-SEC	01S	24E	30	DABB	---	3645	---	---	---	---	---	---	---	---	---	4	4	3	no log
578	222252	SCARIANO RON *WELL 1	TRS-SEC	01S	24E	7	DD	---	3543	74	3469	73	>10	1	200	---	---	---	4	4	3	general clay description
581	142064	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	18	AADC	3517	3524	>25	---	---	---	---	---	---	---	---	4	4	2	didn't go through clay
597	142065	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	18	DADD	3518	3512	>25	---	---	---	---	---	---	---	---	4	4	2	didn't go through clay
607	141949	BILLINGS WATER SUPPLY * CALAMITY JANE	TRS-SEC	01S	24E	5	CBBBC	3426	3425	>25	---	---	---	---	---	---	---	---	1	1	2	11 ft clayey sand on clay
610	141948	BILLINGS WATER SUPPLY * CALAMITY JANE	TRS-SEC	01S	24E	5	BBCC	3483	3478	>25	---	---	---	---	---	---	---	---	1	1	2	19' clayey sand on top of silty shale
611	141950	BILLINGS WATER SUPPLY * CALAMITY JANE	TRS-SEC	01S	24E	5	CBCB		3425	0	---	0	>25	4	10	---	---	---	4	4	2	no clay cap
624	142017	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	8	BCCA	3520	3524	>25	---	---	---	---	---	---	---	---	4	4	2	didn't go through clay
636	92764	KUKES JAKE W.	TRS-SEC	01S	24E	29	BC	---	3602	---	---	---	---	---	---	---	---	---	4	4	3	no log
642	142016	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	8	BBAB	3519	3530	>25	---	---	---	---	---	---	---	---	4	4	2	didn't go through clay
651	248381	MERCHANT LOUIE	TRS-SEC	01S	24E	17	BBAA	---	3465	11	3454	11	28	2	100	---	40	3425	4	4	2	general aquifer description
658	92726	MT DEPT OF HWYS * CANYON CRK BRIDGE	TRS-SEC	01S	24E	5	CACC	3415	3412	0	---	0	41	2	100	---	41	3374	1	1	2	no clay cap
659	142068	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	20	BABB	3520	3502	>25	---	---	---	---	---	---	---	---	4	4	2	didn't go through clay
660	10354	DOWNER HAROLD F.	TRS-SEC	01N	24E	18	BBB		4177	---	---	---	---	---	---	---	---	---	4	4	2	no log
661	10355	DOWNER HAROLD F.	TRS-SEC	01N	24E	18	BBC		4190	---	---	---	---	---	---	---	---	---	4	4	2	no log
662	203474	BRENNAN MATT	TRS-SEC	01S	24E	5	CDC		3458	46	3412	18	>14	2	100	---	---	---	4	4	2	28' sand interbedded with clay
663	203478	KLEIN BUTCH	TRS-SEC	01S	24E	5	CDC		3458	45	3413	28	>15	2	100	---	---	---	4	4	2	17' sand interbedded with clay
668	200619	RYAN BILL	TRS-SEC	01N	24E	30	BB		3780	---	---	---	---	---	---	---	---	---	4	4	3	interbedded "sand rock" & shale
669	206373	"WIDUP, HAROLD J & EUNICE E"	TRS-SEC	01S	24E	8	BA		3458	24	3434	24	16	2	100	---	40	3418	2	2	3	
699	10398	KINNEY LAVINA	TRS-SEC	01N	24E	31	CCA		3901	---	---	---	---	---	---	---	---	---	4	4	2	no log
723	192601	HEGER JIRI	TRS-SEC	01N	24E	31	CABB		3885	6	3879	6	34	4	10	26.1	40	3845	4	4	2	
728	141947	BILLINGS WATER SUPPLY * PIPELINE	TRS-SEC	01S	24E	5	ACCB	3465	3465	0	---	0	>20	5	1	---	---	---	1	1	2	no apparent clay cap
748	219895	MCFARLAND CLINT	TRS-SEC	01N	24E	6	CA		4203	---	---	---	---	---	---	---	---	---	4	4	3	callouts unclear
749	183602	MCFARLAND CLINT	TRS-SEC	01N	24E	6	CD		4160	---	---	---	---	---	---	0.2	---	---	4	4	3	Eagle Sandstone
757	142066	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	20	ACAC	3525	3516	>25	---	---	---	---	---	---	---	---	4	4	2	didn't go through clay
758	142117	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	32	DCDC	3563	3574	0	---	0	>22	5	1	---	---	---	4	4	2	no apparent cap
760	10337	BERMES ROBERT JR	TRS-SEC	01N	24E	7	BAA		4157	---	---	---	---	---	---	6.5	---	---	4	4	2	sandstone
772	142067	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	20	ACDD	3531	3499	>25	---	---	---	---	---	---	---	---	4	4	2	didn't go through clay
773	142116	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	32	DBAD	---	3540	>25	---	---	---	---	---	---	---	---	4	4	2	didn't go through clay
803	232021	WEBER ROSEMARIE	TRS-SEC	01N	24E	19	DC		3973	18	3955	18	>22	4	10	---	---	---	4	4	3	
804	92768	FRANK ALEX P.	TRS-SEC	01S	24E	32	DD	---	3499	---	---	---	---	---	---	---	---	---	3	3	3	no log
833	133213	LAUREL LANDFILL * MW-4	TRS-SEC	01S	24E	32	ADA	---	3589	12	3577	12	0	---	---	---	12	3577	4	4	2	no sand, shale unclear
848	141951	BILLINGS WATER SUPPLY * PIPELINE	TRS-SEC	01S	24E	5	DAAD	3465	3458	0	---	0	>20	4	10	---	---	---	1	1	2	no clay cap
852	220060	FONERY LISA & KEN	TRS-SEC	01S	24E	4	CCCC		3409	57	3352	50	>12	2	100	---	---	---	2	2	2	7' sand interbedded with clay
874	133212	LAUREL LANDFILL * MW-3	TRS-SEC	01S	24E	33	BCC	---	3560	35	3525	35	0	---	---	---	35	3525	4	4	2	no sand, shale unclear
882	142069	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	21	BCBA	3540	3538	>25	---	---	---	---	---	---	---	---	4	4	2	didn't go through clay
908	166026	CITY OF LAUREL CONTAINER SITE	TRS-SEC	01S	24E	33	CB	---	3537	---	---	---	---	---	---	---	---	---	3	3	3	no log
909	166027	CITY OF LAUREL CONTAINER SITE	TRS-SEC	01S	24E	33	CB	---	3537	---	---	---	---	---	---	---	---	---	3	3	3	no log
910	166028	CITY OF LAUREL CONTAINER SITE	TRS-SEC	01S	24E	33	CB	---	3537	---	---	---	---	---	---	---	---	---	3	3	3	no log
911	166029	CITY OF LAUREL CONTAINER SITE	TRS-SEC	01S	24E	33	CB	---	3537	---	---	---	---	---	---	---	---	---	3	3	3	no log
912	166030	CITY OF LAUREL CONTAINER SITE * MW-2D	TRS-SEC	01S	24E	33	CB	---	3537	---	---	---	---	---	---	---	---	---	3	3	3	no log
913	166031	CITY OF LAUREL CONTAINER SITE * MW-2	TRS-SEC	01S	24E	33	CB	---	3537	---	---	---	---	---	---	---	---	---	3	3	3	no log
927	142121	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	33	CBAB	3534	3537	>25	---	---	---	---	---	---	---	---	1	1	2	didn't go through clay
943	133210	LAUREL LANDFILL * MW-1	TRS-SEC	01S	24E	33	BCD	---	3538	6	3532	6	0	---	---	---	6	3532	4	4	2	no sand, shale unclear
944	133211	LAUREL LANDFILL * MW-2	TRS-SEC	01S	24E	33	BCD	---	3538	10	3528	10	0	---	---	---	10	3528	4	4	2	no sand, shale unclear
951	10335	JOHNSON DAROLD	TRS-SEC	01N	24E	7	AAA		4196	---	---	---	---	---	---	---	---	---	4	4	2	sandstone

Table A-1. West Billings Study Well Log Review Summary

Identification				Location				Ground Elev. (ft MSL)		Fine-Grained Cap			Aquifer Material				Bedrock/Clay		Data Qualifiers			
															K (ft/d)				Log Quality		Loc	
Map	GWIC	Name	Geo Method	T	R	S	QS	Log	Map	Btm Dpth (ft)	Btm Elev (ft MSL)	Thkns (ft)	Thkns (ft)	Type	Type	WL/Yld	Depth (ft)	Elev (ft MSL)	Contacts	Descr	Qual	Comment
952	10334	MCFARLAND CLINTON B.	TRS-SEC	01N	24E	6	DDD		4170	---	---	---	---	---	---	---	---	---	4	4	2	no log
1000	235997	"MEYER, DON"	TRS-SEC	01S	24E	4	BACB		3606	48	3558	33	7	2	100	---	55	3551	2	2	2	
1012	10338	DOWNER HAROLD F.	TRS-SEC	01N	24E	8	BCB		4177	---	---	---	---	---	---	---	---	---	4	4	2	no log
1013	219505	JONES STEPHON AND STEPHANIE	TRS-SEC	01N	24E	5	CCB		4183	0	---	0	16	3	50	---	16	4167	4	4	2	
1023	203939	EKLE TIGE AND TERESA	TRS-SEC	01S	24E	4	CDBD		3432	50	3382	27	>10	2	100	---	---	---	2	2	2	23' sand interbedded with clay
1024	204411	BENTSUN ERIC	TRS-SEC	01S	24E	4	BA		3560	62	3498	54	>18	2	100	---	---	---	2	2	3	
1045	142120	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	33	BADC	3537	3540	>25	---	---	---	---	---	---	---	---	4	4	2	didn't go through clay
1050	176228	KRASKE WILLIAM	TRS-SEC	01S	24E	4	BAD		3540	78	3462	78	14	3	50	12.1	92	3448	2	2	2	
1075	92763	MCLEOD R.C.	TRS-SEC	01S	24E	28		3900	3742	0	---	---	>24	1	200	174.4	---	---	4	4	3	poor log
1115	142063	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	16	DCCC	3526	3523	>15	---	---	---	---	---	---	---	---	4	4	2	didn't go through clay
1116	141946	BILLINGS WATER SUPPLY * PIPELINE	TRS-SEC	01S	24E	4	DBBC	3465	3465	0	---	0	>20	4	10	---	---	---	1	1	2	no clay cap
1117	228846	PELCHER JAY	TRS-SEC	01S	24E	33	DBBB	---	3505	3	3502	3	21	5	1	---	25	3480	2	2	2	
1124	144294	CELLMER STEVEN	TRS-SEC	01N	24E	20	BAC		3852	11	3841	11	19	5	1	0.5	30	3822	4	4	2	shale on top of Eagle Sandstone
1147	158346	MT DEPT OF HWYS * INT SIGN CL 4-50-96	TRS-SEC	01S	24E	16	AC	---	3463	5	3458	5	>16	5	1	---	---	---	4	4	3	very thin cap?
1185	92769	FELKE FRANK	TRS-SEC	01S	24E	33	D	---	3458	30	3428	30	>60	2	100	17.8	---	---	3	3	3	poor log
1196	142119	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	33	ADCB	3539	3519	>25	---	---	---	---	---	---	---	---	4	4	2	didn't go through clay
1197	225298	HIMMELSLACH RON L.	TRS-SEC	01S	24E	33	DABB	---	3506	0	---	0	25	2	100	---	25	3481	2	2	2	no apparent clay
1198	171429	WEBER & SONS	TRS-SEC	01S	24E	33	DDC	---	3449	0	---	0	93	4	10	21.2	93	3356	1	1	2	interbedded, variable
1222	243005	INTERCOUNTY LAND BANK	TRS-SEC	01S	24E	9	DD	---	3379	---	---	---	---	---	---	---	---	---	3	3	3	poor log
1258	141945	BILLINGS WATER SUPPLY * PIPELINE	TRS-SEC	01S	24E	4	DAAD	3455	3451	>20	---	---	---	---	---	---	---	---	1	1	2	10 ft clayey sand on clay
1259	142118	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	33	AAAA	3534	3541	>25	---	---	---	---	---	---	---	---	4	4	2	didn't go through clay
1261	228841	HANN KAREN AND KEITH	TRS-SEC	01S	24E	3	CCCB		3425	48	3377	41	22	2	100	---	70	3355	2	2	2	7' gravel interbedded with clay
1262	217748	WAGNER PAUL & CINDY	TRS-SEC	01S	24E	15	BBBB	---	3425	4	3421	4	22	2	100	---	27	3398	2	2	2	
1263	142061	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	15	CBCC	3528	3541	>25	---	---	---	---	---	---	---	---	4	4	2	didn't go through clay
1277	10356	ZIMMERMAN CHARLES	TRS-SEC	01N	24E	20	AAC		3730	---	---	---	---	---	---	1.6	---	---	4	4	2	8' clay on top of Eagle Sandstone
1278	185981	PAULSON RANDY	TRS-SEC	01N	24E	20	DAB		3737	0	---	0	24	2	100	---	24	3713	4	4	2	
1298	92770	VISSER MIKE	TRS-SEC	01S	24E	34	CB	---	3468	70	3398	70	>40	5	1	23.4	---	---	3	3	3	poor log
1336	221280	OLSEN JEFF	TRS-SEC	01S	24E	3	CBAA		3458	34	3424	34	27	2	100	---	61	3397	2	2	2	
1337	247497	HAYES MIKE	SUR-GPS	01S	25E	27	BBB		3740	0	---	0	>30	2	100	---	---	---	4	4	1	limited aq description
1339	160913	GILMAN GARY	TRS-SEC	01S	24E	3	B		3507	50	3457	50	9	2	100	74.9	59	3448	2	2	3	
1347	217731	NORTH HILL DEVELOPMENT	TRS-SEC	01S	24E	3	CACC		3445	22	3423	22	30	2	100	---	52	3393	2	2	2	
1366	142062	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	15	CDBD	3536	3537	>25	---	---	---	---	---	---	---	---	4	4	2	didn't go through clay
1367	142113	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	27	CACA	3543	3552	>25	---	---	---	---	---	---	---	---	4	4	2	didn't go through clay
1390	10357	ZIMMERMAN CHARLES	TRS-SEC	01N	24E	21	CB		3737	---	---	---	---	---	---	---	1	3736	4	4	3	shale at surface?
1394	127682	KENNEDY MARK	TRS-SEC	01S	24E	3	BAA		3609	55	3554	55	>18	2	100	---	---	---	2	2	2	
1395	92771	FOX HARVEY & MELODYE	TRS-SEC	01S	24E	34	CDD	---	3425	67	3358	22	>15	3	50	---	---	---	2	2	2	40' sand on top of clay
1408	10329	MCFARLAND CLINT	TRS-SEC	01N	24E	4	BBD		3983	---	---	---	---	---	---	0.9	---	---	4	4	2	limited descriptions
1409	237560	CAUDILL CONSTRUCTION CO.	TRS-SEC	01S	24E	3	CAAA		3458	48	3410	41	27	2	100	---	75	3383	2	2	2	7' gravel in with clay
1410	141944	BILLINGS WATER SUPPLY * PIPELINE	TRS-SEC	01S	24E	3	CAAD	3455	3461	>20	---	---	---	---	---	---	---	---	1	1	2	10 ft clayey sand on clay
1411	142115	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	27	BAAA	3526	3531	>25	---	---	---	---	---	---	---	---	4	4	2	didn't go through clay
1463	142114	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	27	ACCB	3563	3567	>25	---	---	---	---	---	---	---	---	4	4	2	didn't go through clay
1465	142112	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	22	DBB	3530	3534	>25	---	---	---	---	---	---	---	---	4	4	2	didn't go through clay
1477	10330	MCFARLAND CLINTON B.	TRS-SEC	01N	24E	4	BDB		4003	---	---	---	---	---	---	---	---	---	4	4	2	no log
1478	208699	MARKEGAND CURT	TRS-SEC	01S	24E	3	DBBA		3451	28	3423	14	22	2	100	92.6	50	3401	2	2	2	14' gravel on top of clay
1480	92725	KLOTOVICH M JOSEPH	TRS-SEC	01S	24E	3	DC		3409	19	3390	19	>23	2	100	118.0	---	---	2	2	3	
1481	143867	ENGEL CONSTRUCTION	TRS-SEC	01S	24E	3	DC		3409	25	3384	25	>16	2	100	34.8	---	---	2	3	3	
1486	160912	FOSSUM SHAWN	TRS-SEC	01S	24E	34	DC	---	3404	55	3349	52	>14	1	200	10.5	---	---	3	3	3	3' gravel on top of clay
1499	10328	MCFARLAND CLINTON	TRS-SEC	01N	24E	4	BA		3937	---	---	---	---	---	---	0.1	---	---	4	4	3	Very limited shallow detail
1500	142111	BILLINGS WATER * CALAMITY JANE CANAL	TRS-SEC	01S	24E	22	ABAC	3537	3513	>25	---	---	---	---	---	---	---	---	4	4	2	didn't go through clay
1513	92772	FRANK JAKE H.	TRS-SEC	01S	24E	34	D	---	3398	50	3348	40	>5	3	50	---	---	---	3	3	3	10' gravel on top of clay
1514	160914	GOODMAN PAUL	TRS-SEC	01S	24E	34	D	---	3398	72	3326	56	8	2	100	35.3	90	3308	2	2	3	16' gravel on top of clay
1515	160916	R & J BUILDERS INC	TRS-SEC	01S	24E	34	D	---	3398	36	3362	28	20	2	100	60.9	56	3342	2	2	3	6' gravel on top of clay
1516	217749	ERLENBUSH GENE & LINDA	TRS-SEC	01S	24E	34	D	---	3398	---	---	---	---	---	---	---	---	---	3	3	3	no log
1551	224605	"CRITELLI, ROD"	TRS-SEC	01S	24E	34	DDC	---	3383	51	3332	37	14	2	100	---	64	3319	2	2	2	14' gravel on top of clay
1576	240089	KLASNA JOHN	NAV-GPS	01S	24E	34	DDDD	---	3377	34	3343	26	21	2	100	---	55	3322	2	2	1	8' gravel on top of clay
1577	224960	REITER RANDY	TRS-SEC	01S	24E	34	AAA	---	3420	88	3332	88	>13	2	100	---	---	---	2	2	2	

Table A-1. West Billings Study Well Log Review Summary

Identification				Location				Ground Elev. (ft MSL)		Fine-Grained Cap			Aquifer Material				Bedrock/Clay		Data Qualifiers			
										Btm Dpth	Btm Elev	Thkns	Thkns		K (ft/d)		Depth	Elev	Log Quality		Loc	
Map	GWIC	Name	Geo Method	T	R	S	QS	Log	Map	(ft)	(ft MSL)	(ft)	(ft)	Type	Type	WL/Yld	(ft)	(ft MSL)	Contacts	Descr	Qual	Comment
1578	167982	R AND J BUILDERS INC	TRS-SEC	01S	24E	34	DDD	---	3374	36	3338	31	20	1	200	4.7	56	3318	2	2	2	5' gravel on top of clay
1579	198658	MYRUP RANDY	TRS-SEC	01S	24E	34	DDD	---	3374	31	3343	27	>15	1	200	---	---	---	2	2	2	4' gravel on top of clay
1590	232107	BEARTOOTH HOLDING & CONST*WELL #1	TRS-SEC	01S	24E	2	BCBB		3494	4	3490	4	15	2	100	---	19	3475	2	2	2	
1591	141943	BILLINGS WATER SUPPLY * PIPELINE	TRS-SEC	01S	24E	2	CBBC	3420	3419	0	---	0	>20	4	10	---	---	---	1	1	2	no clay cap
1595	139083	KRAFT BOB	TRS-SEC	01S	24E	35	CBB	---	3384	51	3333	45	>10	2	100	---	---	---	3	3	2	
1596	160917	RUFF DAVID	TRS-SEC	01S	24E	35	CBB	---	3384	8	3376	8	>30	2	100	11.9	---	---	2	2	2	
1600	191011	SPANJIAN KRIS	TRS-SEC	01N	24E	9	DDC		3783	16	3767	16	16	4	10	---	32	3751	4	4	2	limited aq description
1601	176230	RUFF DAN	TRS-SEC	01S	24E	26	CC	---	3414	82	3332	75	>14	1	200	---	---	---	2	2	3	at least 7' sand on/in clay
1642	170121	COVE CANYON RANCHLAND LLC	TRS-SEC	01N	24E	21	AA		3855	---	---	---	---	---	---	2.5	---	---	4	4	3	Eagle Sandstone
1643	212659	GILBERTSON RAY	TRS-SEC	01N	24E	9	DD		3812	16	3796	16	8	4	10	---	24	3788	4	4	3	limited aq description
1647	232104	BEARTOOTH HOLDING & CONST*WELL #2	TRS-SEC	01S	24E	2	BBDD		3471	10	3461	10	10	2	100	---	20	3451	2	2	2	
1655	232105	BEARTOOTH HOLDING & CONST*WELL #3	TRS-SEC	01S	24E	2	BABB		3497	9	3488	8	9	2	100	---	18	3479	2	3	2	general aquifer description
1657	92733	SCHWEHR LEO	TRS-SEC	01S	24E	11	CDB	3180	3337	21	3159	21	9	2	100	---	30	3150	2	3	2	general aquifer description
1658	100347	BAIRD DORIS	TRS-SEC	01S	24E	35	CAC	---	3359	---	---	---	---	---	---	---	---	---	3	3	3	no log
1660	165438	WHITFIELD BRUCE	TRS-SEC	01N	24E	10	CCB		3839	---	---	---	---	---	---	0.2	---	---	4	4	2	sandstone
1661	92732	SCHILD GARY C.	TRS-SEC	01S	24E	11	CA		3360	55	3305	55	13	3	50	0.6	68	3292	2	3	3	general aquifer description
1662	212663	MCEVOY LARRY	TRS-SEC	01N	24E	22	BC		3806	---	---	---	---	---	---	---	---	---	4	4	3	interbedded sand and shale?
1663	216693	PICARD DEVELOPMENT	TRS-SEC	01S	24E	35	BA	---	3382	10	3372	10	>20	2	100	---	---	---	2	2	3	
1671	154999	GRIFFIN BILL	TRS-SEC	01N	24E	10	CC		3786	---	---	---	---	---	---	0.3	---	---	4	4	3	sandstone
1675	143870	DECKER JIM	TRS-SEC	01S	24E	26	CDD	---	3384	41	3343	41	>18	2	100	60.3	---	---	2	2	2	clay mixed with some coarse
1676	92734	SCHWEHR LEO	TRS-SEC	01S	24E	11	CDD	---	3340	23	3317	23	17	2	100	---	40	3300	2	2	2	
1677	171195	FRANK VICTOR	TRS-SEC	01S	24E	35	CAD	---	3349	27	3322	27	12	2	100	145.9	39	3310	2	2	2	
1678	208036	RONAN DEAN	TRS-SEC	01S	24E	2	BAAA		3497	17	3480	17	22	2	100	---	39	3458	2	2	2	
1679	141942	BILLINGS WATER SUPPLY * PIPELINE	TRS-SEC	01S	24E	2	CAAA	3465	3438	>25	---	---	---	---	---	---	---	---	4	4	2	11 ft clayey sand on clay
1681	92724	KINNEY LAVINA	TRS-SEC	01S	24E	2			3442	---	---	---	---	---	---	---	---	---	4	4	3	no log
1719	10343	FORD DAVID	TRS-SEC	01N	24E	10	C		3852	---	---	---	---	---	---	14.3	---	---	4	4	3	sandstone
1732	231869	BROWN BEN	TRS-SEC	01N	24E	15	CDB		3606	---	---	---	---	---	---	---	---	---	3	3	2	interbedded shale and sandstone
1735	92735	MEYER JAMES	TRS-SEC	01S	24E	11	DC	---	3340	37	3303	37	>11	2	100	29.7	---	---	2	2	3	
1736	92774	FRANK HENRY H.	TRS-SEC	01S	24E	35	AB	---	3362	53	3309	53	22	2	100	41.1	65	3297	2	2	3	
1755	171591	SHAWHAN TIM	TRS-SEC	01N	24E	10	CD		3812	---	---	---	---	---	---	---	---	---	4	4	3	sandstone
1756	10327	SCHAAK DAN	TRS-SEC	01N	24E	3	CD		3957	0	---	0	33	2	100	0.02	33	3924	4	4	3	limited aq description
1773	194001	GRAYSON LYLE	TRS-SEC	01N	24E	22	CDDD		3517	30	3487	30	21	3	50	18.2	51	3466	2	2	2	
1774	10344	MCFARLAND CLINTON B.	TRS-SEC	01N	24E	10	CDAA		3802	---	---	---	---	---	---	---	---	---	4	4	2	no log
1775	10358	RICHARDSON A W	TRS-SEC	01N	24E	22			3812	0	---	0	32	2	100	---	32	3780	2	3	3	limited aq description, no clay?
1776	92773	FRANK HENRY H.	TRS-SEC	01S	24E	35	A	---	3342	63	3279	63	6	2	100	---	69	3273	3	3	3	good shale contact
1777	127684	YAGER JIM	TRS-SEC	01S	24E	11	D		3340	39	3301	39	10	4	10	---	41	3299	2	3	3	general aquifer description
1820	10348	LECHTENBERGER ADOLPH	TRS-SEC	01N	24E	15			3694	---	---	---	---	---	---	15.3	---	---	4	4	3	Eagle Sandstone
1821	10339	BRADSHAW GARY	TRS-SEC	01N	24E	10			3799	---	---	---	---	---	---	0.1	---	---	3	3	3	limited descriptions
1822	10340	MURRAY TOM	TRS-SEC	01N	24E	10			3799	6	3793	6	10	5	1	1.9	16	3783	4	4	3	
1823	10341	WARNER ROBERT	TRS-SEC	01N	24E	10			3799	6	3793	6	55	---	---	0.4	---	---	4	4	3	sand/bedrock descriptions unclear
1824	10342	WILLIAMS BERT & LINDA	TRS-SEC	01N	24E	10			3799	---	---	---	---	---	---	2.2	38	3761	4	4	3	poor shallow detail
1825	161458	MEHRER RICHARD	TRS-SEC	01N	24E	10			3799	10	3789	10	0	---	---	3.2	---	---	4	4	3	well in Eagle Sandstone
1826	10396	SALEY WILLIAM	TRS-SEC	01N	24E	27	ACCC		3504	---	---	---	---	---	---	---	---	---	3	3	3	Eagle Sandstone and drift
1841	192592	BROWN BEN	TRS-SEC	01N	24E	15	DCB		3579	12	3567	5	9	4	10	---	21	3558	2	2	2	
1842	192597	BROWN BEN	TRS-SEC	01N	24E	15	DCB		3579	---	---	---	---	---	---	---	---	---	2	2	2	Eagle Sandstone
1843	10346	MCFARLAND CLINTON B.	TRS-SEC	01N	24E	10	DBB		3780	---	---	---	---	---	---	---	---	---	4	4	2	no log
1844	10347	IMLAY JEFF	TRS-SEC	01N	24E	10	DCC		3796	---	---	---	---	---	---	0.2	5	3791	4	4	2	no clay or sand described
1847	176229	HEINS BILL	TRS-SEC	01S	24E	14	DA	---	3365	---	---	---	---	---	---	---	---	---	3	3	3	poor log
1883	10352	LEE ROGER	TRS-SEC	01N	24E	15	DC		3599	---	---	---	---	---	---	---	---	---	1	1	3	thin sand on Eagle Sandstone
1884	10353	LEE ROGER	TRS-SEC	01N	24E	15	DC		3599	---	---	---	---	---	---	0.4	---	---	2	2	3	14' sand on Eagle Sandstone
1885	150051	BROWN BEN	TRS-SEC	01N	24E	15	DC		3599	---	---	---	---	---	---	---	---	---	2	2	3	Eagle Sandstone
1886	171592	THOMPSON KEN	TRS-SEC	01N	24E	10	DC		3799	4	3795	4	1	5	1	0.5	7	3792	4	4	3	
1887	92747	ZEILER W. E.	TRS-SEC	01S	24E	14	AAAB	---	3320	---	---	---	---	---	---	---	---	---	3	3	2	no log
1889	92762	RONAN PAUL & RALPH	TRS-SEC	01S	24E	26	DDA	---	3354	---	---	---	---	---	---	---	---	---	3	3	3	no log
1891	92748	KRAFT EDWARD	TRS-SEC	01S	24E	23	ADD	---	3389	---	---	---	---	---	---	---	---	---	4	4	2	no log
1892	144771	YAGER JIM	TRS-SEC	01S	24E	11	DAD		3350	46	3304	46	13	2	100	4.5	59	3291	2	3	2	general aquifer description

Table A-1. West Billings Study Well Log Review Summary

Identification				Location				Ground Elev. (ft MSL)		Fine-Grained Cap			Aquifer Material				Bedrock/Clay		Data Qualifiers			
										Btm Dpth	Btm Elev	Thkns	Thkns		K (ft/d)		Depth	Elev	Log Quality		Loc	
Map	GWIC	Name	Geo Method	T	R	S	QS	Log	Map	(ft)	(ft MSL)	(ft)	(ft)	Type	Type	WL/Yld	(ft)	(ft MSL)	Contacts	Descr	Qual	Comment
1904	141941	BILLINGS WATER SUPPLY * PIPELINE	TRS-SEC	01S	24E	2	AAAA	3460	3458	0	---	0	>20	5	1	---	---	---	4	4	2	no apparent clay cap
1907	10349	REHBERG MARY A.	TRS-SEC	01N	24E	15	D		3583	---	---	---	---	---	---	---	---	---	3	3	3	no log
1908	10350	REBERG JACK	TRS-SEC	01N	24E	15	D		3583	16	3567	16	---	---	---	16.5	---	---	2	3	3	16' clay on top of Eagle Sandstone
1909	10351	ARCHER JAMES	TRS-SEC	01N	24E	15	D		3583	0	---	0	42	3	50	44.6	42	3541	2	2	3	
1910	228838	ENCORE CONSTRUCTION	TRS-SEC	01S	24E	1	BCCC		3501	0	---	0	34	2	100	---	34	3467	2	3	2	
1912	92742	HOLDEN HAROLD	TRS-SEC	01S	24E	13	BBB	---	3317	40	3277	40	10	3	50	7.3	50	3267	2	3	2	general aquifer description
1913	171347	LOVE BRUCE AND BARB	TRS-SEC	01S	24E	13	BBB	---	3317	37	3280	37	12	4	10	4.7	49	3268	2	2	2	"quick sand"
1917	170726	SCHENNAM DEAN	TRS-SEC	01N	24E	22	AAC		3760	---	---	---	---	---	---	---	---	---	4	4	2	difficult to interpret log
1918	190959	GRICE HERB	TRS-SEC	01S	24E	12	CC	---	3333	46	3287	46	>7	2	100	---	---	---	2	3	3	general aquifer description
1941	161457	BEARTOOTH HOLDING	TRS-SEC	01N	24E	3	DA		3862	17	3845	17	17	2	100	102.8	34	3828	4	4	3	
1943	92760	WALTER VIRGIL	TRS-SEC	01S	24E	25	BBA	---	3345	---	---	---	---	---	---	---	---	---	3	3	2	no log
1944	92761	WALTERS VIRGIL	TRS-SEC	01S	24E	25	BBA	---	3345	57	3288	53	>13	2	100	---	---	---	2	2	2	4' gravel on top of clay
1945	197697	LOVE BRUCE AND BARB	TRS-SEC	01S	24E	13	BBA	---	3320	46	3274	46	4	4	10	7.8	50	3270	2	3	2	
1946	209803	SORENSON GORDON	TRS-SEC	01S	24E	13	BBA	---	3320	45	3275	45	>3	4	10	---	---	---	2	3	2	general aquifer description
1947	225283	BAKER ROB	TRS-SEC	01S	24E	1	BCA		3478	0	---	0	29	2	100	---	29	3449	2	2	2	
1948	218248	FRONTIER BUILDERS	TRS-SEC	01S	24E	1	CCA		3537	4	3533	4	31	2	100	---	35	3502	2	2	2	
1949	190943	HARRELL LEO	TRS-SEC	01S	24E	12	CCD	---	3330	30	3300	30	>18	4	10	---	---	---	2	2	2	
1950	209800	BRITTON LEVI * WELL 4	TRS-SEC	01S	24E	12	CCD	---	3330	40	3290	40	>8	2	100	---	---	---	2	3	2	general aquifer description
1951	224207	LEVI BRITTON WELL 4	TRS-SEC	01S	24E	12	CCD	---	3330	---	---	---	---	---	---	---	---	---	3	3	2	no log
1952	10359	REICHERT DAVE	TRS-SEC	01N	24E	22	AAA		3622	40	3582	40	>8	2	100	---	---	---	3	3	2	upper 40" "sand & clay"
1953	165962	CLADIS NICK	TRS-SEC	01N	24E	22	AAA		3622	38	3584	38	19	5	1	0.1	57	3565	2	3	2	limited aq description
1956	236624	"KIRKSEY PROPERTIES, LLC "	TRS-SEC	01N	24E	3	DDD		3871	---	---	---	---	---	---	---	---	---	4	4	2	Poor log
1958	10415	JOVANOVICH GARY L.	TRS-SEC	01S	24E	1	C		3533	---	---	---	---	---	---	---	---	---	3	3	3	no log
1966	218058	BYORTH PAUL	TRS-SEC	01N	24E	35	BCBB		3435	31	3404	13	9	3	50	---	40	3395	2	3	2	18' quick sand in clay layer
1967	10386	JONES JIM	TRS-SEC	01N	24E	23	BBB		3563	37	3526	27	19	4	10	5.5	56	3507	2	2	2	10' coarse material in with clay
1968	144295	JONES JIM	TRS-SEC	01N	24E	23	BBB		3563	---	---	---	---	---	---	0.1	---	---	3	3	2	sandstone and shale, well in Eagle SS
1969	227199	KELLY JAMES AND MARIC	TRS-SEC	01N	24E	23	BBB		3563	---	---	---	---	---	---	---	---	---	2	2	2	sandstone and siltstone
1970	191829	LLEWELLYN ASSOC TRUST	TRS-SEC	01S	24E	1	CDB		3514	3	3511	3	29	3	50	---	32	3482	2	2	2	
1971	209797	BRITTON LEVI * WELL 1	TRS-SEC	01S	24E	12	CDC	---	3330	40	3290	40	>8	2	100	---	---	---	2	3	2	general aquifer description
1972	209798	BRITTON LEVI * WELL 2	TRS-SEC	01S	24E	12	CDC	---	3330	40	3290	40	>8	2	100	---	---	---	2	3	2	general aquifer description
1973	209799	BRITTON LEVI * WELL 3	TRS-SEC	01S	24E	12	CDC	---	3330	40	3290	40	>8	2	100	---	---	---	2	3	2	general aquifer description
1974	224204	LEVI BRITTON WELL 1	TRS-SEC	01S	24E	12	CDC	---	3330	---	---	---	---	---	---	---	---	---	3	3	2	no log
1975	224205	LEVI BRITTON WELL 2	TRS-SEC	01S	24E	12	CDC	---	3330	---	---	---	---	---	---	---	---	---	3	3	2	no log
1976	224206	LEVI BRITTON WELL 3	TRS-SEC	01S	24E	12	CDC	---	3330	---	---	---	---	---	---	---	---	---	3	3	2	no log
1979	195540	CELLMER STEVE	TRS-SEC	01N	24E	11	BCB		3845	0	---	0	42	4	10	---	42	3803	4	4	2	
1981	197900	FETTING DENNIS	TRS-SEC	01N	24E	35	CBBA		3419	30	3389	30	4	2	100	13.4	34	3385	2	2	2	
1982	140466	BILLINGS WATER * BILLINGS PIPELINE	TRS-SEC	01N	24E	35	CBCD	3415	3415	>20	---	---	---	---	---	---	---	---	1	1	2	did not go through clay
1983	92744	LENHARDT ADOLPH	TRS-SEC	01S	24E	13	CDBD	---	3340	---	---	---	---	---	---	---	---	---	3	3	2	no log
1985	221793	EGGART PE QUENTIN *DRY HOLE 2	TRS-SEC	01N	24E	35	BC		3425	47	3378	47	0	---	---	---	47	3378	4	4	3	no sand described
1994	205761	KNAUP ROGER	TRS-SEC	01S	24E	12	CD	---	3333	42	3291	42	>8	3	50	---	---	---	2	3	3	general aquifer description
2000	244953	O'REAN DAVID	TRS-SEC	01S	24E	1	CDAB		3488	5	3483	5	26	2	100	---	31	3457	2	2	2	
2001	191826	LLEWELLYN ASSOC TRUST	TRS-SEC	01S	24E	1	CAA		3468	0	---	0	31	2	100	---	31	3437	3	3	2	no clay cap described
2002	191828	LLEWELLYN ASSOC TRUST	TRS-SEC	01S	24E	1	CAA		3468	0	---	0	32	2	100	---	32	3436	3	3	2	no clay cap described
2003	218102	FRONTIER BUILDERS	TRS-SEC	01S	24E	1	CDD		3445	0	---	0	32	2	100	---	32	3413	3	3	2	may have missed clay cap
2004	218105	RIEDLINGER BRAD	TRS-SEC	01S	24E	1	CDD		3445	0	---	0	35	2	100	---	35	3410	3	3	2	may have missed clay cap
2006	92743	WILLEMS MARTIN	TRS-SEC	01S	24E	13	BDAA	---	3317	---	---	---	---	---	---	---	---	---	3	3	2	no log
2007	227098	OTT STEVE	TRS-SEC	01N	24E	35	CBAA		3415	24	3391	6	7	2	100	---	32	3383	2	2	2	17' quick sand in with clay
2008	227286	OTT STEVE	TRS-SEC	01N	24E	35	CBAA		3415	24	3391	6	7	2	100	---	32	3383	2	2	2	17' quick sand in with clay
2009	92739	ZAHM ROY	TRS-SEC	01S	24E	13		---	3320	40	3280	40	1	4	10	0.5	41	3279	3	3	3	
2010	92740	LENHARDT ADOLPH	TRS-SEC	01S	24E	13		---	3320	---	---	---	---	---	---	---	---	---	3	3	3	no log
2012	92736	HAPPMAN JOAN	TRS-SEC	01S	24E	12			3369	---	---	---	---	---	---	1.7	---	---	3	3	3	very poor log
2015	10383	HERTZ JAMES	TRS-SEC	01N	24E	23	B		3553	---	---	---	---	---	---	---	---	---	3	3	3	interbedded "sand rock" & shale
2024	171349	ANDERSON HERBERT LAURALEE	TRS-SEC	01N	24E	35	BA		3435	16	3419	16	22	5	1	7.0	38	3397	2	2	3	
2029	10385	KNUTSON GEORGE	TRS-SEC	01N	24E	23	BA		3560	30	3530	30	45	4	10	---	75	3485	2	3	3	shale is "sandy"
2030	10387	STRAW PAUL	TRS-SEC	01N	24E	23	BD		3599	0	---	0	40	4	10	---	40	3559	2	3	3	deep well, poor shallow detail
2031	145007	HENDERSON ED	TRS-SEC	01N	24E	23	BD		3599	---	---	---	---	---	---	14.3	---	---	2	2	3	Eagle Sandstone

Table A-1. West Billings Study Well Log Review Summary

Identification				Location				Ground Elev. (ft MSL)		Fine-Grained Cap			Aquifer Material				Bedrock/Clay		Data Qualifiers			
															K (ft/d)				Log Quality		Loc	
Map	GWIC	Name	Geo Method	T	R	S	QS	Log	Map	Btm Dpth (ft)	Btm Elev (ft MSL)	Thkns (ft)	Thkns (ft)	Type	Type	WL/Yld	Depth (ft)	Elev (ft MSL)	Contacts	Descr	Qual	Comment
2032	200618	FLOYD JOE	TRS-SEC	01N	24E	23	BD		3599	0	---	0	31	4	10	---	31	3568	2	2	3	
2033	10388	CHAUNCEY JIM	TRS-SEC	01N	24E	23	CA		3652	36	3616	36	---	---	---	---	---	---	4	4	3	sandstone below silt
2039	170993	BERMIS ERVIN	TRS-SEC	01N	24E	2	CD		3848	18	3830	18	102	5	1	0.5	120	3728	4	4	3	limited aq description
2043	217029	FINNICUM CURT	TRS-SEC	01N	24E	23	BAD		3524	---	---	---	---	---	---	---	12	3512	2	3	2	poor shallow detail
2057	10360	KASSAHN JACK	TRS-SEC	01N	24E	23			3694	80	3614	80	>15	4	10	7.6	---	---	2	3	3	sand rock in with clay
2058	10361	KASSAHN JACK	TRS-SEC	01N	24E	23			3694	45	3649	45	>53	4	10	28.7	---	---	2	3	3	limited aq description
2059	10363	THEISEN WILFRED	TRS-SEC	01N	24E	23			3694	---	---	---	---	---	---	3.6	---	---	3	3	3	Eagle Sandstone
2060	10365	KNUTSON GEORGE & LINDA	TRS-SEC	01N	24E	23			3694	0	---	0	60	4	10	9.4	60	3634	2	2	3	
2061	10366	KASSHAW JACK	TRS-SEC	01N	24E	23			3694	45	3649	45	>11	3	50	51.4	---	---	2	2	3	
2062	10367	BLACK JIM	TRS-SEC	01N	24E	23			3694	0	---	0	70	4	10	8.9	70	3624	2	2	3	
2063	10369	RANDASH EDWARD	TRS-SEC	01N	24E	23			3694	0	---	0	55	4	10	2.7	55	3639	2	2	3	
2064	10370	CHAUNCEY JIM	TRS-SEC	01N	24E	23			3694	10	3684	10	35	4	10	0.03	45	3649	2	2	3	well below shale
2065	10371	CHAUNCEY JIM	TRS-SEC	01N	24E	23			3694	---	---	---	---	---	---	5.5	120	3574	2	2	3	Eagle Sandstone on top of shale
2066	10372	CHAUNCEY JIM	TRS-SEC	01N	24E	23			3694	---	---	---	---	---	---	5.3	100	3594	2	2	3	Eagle Sandstone on top of shale
2067	10373	MONGER KEN	TRS-SEC	01N	24E	23			3694	---	---	---	---	---	---	5.9	60	3634	2	2	3	Eagle Sandstone on top of shale
2068	144699	GATZEMEIER PAUL	TRS-SEC	01N	24E	23			3694	---	---	---	---	---	---	1.1	50	3644	2	2	3	sandstone on top of shale
2069	161456	GOLDEN ACRES PARTNERSHIP	TRS-SEC	01N	24E	23			3694	---	---	---	---	---	---	---	---	---	3	3	3	poor shallow detail
2075	218242	MCLELLY ROBERT	TRS-SEC	01N	24E	35	DCBB		3399	0	---	0	25	4	10	---	31	3368	2	2	2	
2079	92737	PELICAN FRANK	TRS-SEC	01S	24E	12	AAB		3409	---	---	---	---	---	---	46.5	---	---	3	3	2	poor log
2080	28367	CHEX-91-076 * BORING MW-3	TRS-SEC	01S	24E	12	DAC		3327	3	3324	3	>17	2	100	---	---	---	1	1	2	
2084	10391	ZIMMERMAN CHAS INC	TRS-SEC	01N	24E	23	DBB		3566	43	3523	43	0	---	---	---	43	3523	4	4	2	shallow detail unclear
2088	160911	TIMBERMAN BOB	TRS-SEC	01S	24E	1	AA		3419	24	3395	24	0	---	---	---	24	3395	4	4	3	
2094	131684	BEIERS G D	TRS-SEC	01N	24E	23	AB		3681	---	---	---	---	---	---	---	---	---	2	2	3	all sandstone
2105	201566	AMES CATHERINE L	TRS-SEC	01N	24E	35	ACDB		3402	18	3384	18	21	3	50	---	39	3363	2	3	2	limited aq description
2106	92723	ORSER E.D.	TRS-SEC	01S	24E	1	DDA	3600	3402	---	---	---	---	---	---	---	---	---	3	3	2	no log
2109	10378	ZIMMERMAN CHARLES	TRS-SEC	01N	24E	23	ABD		3540	---	---	---	---	---	---	---	---	---	3	3	2	limestone?
2118	10375	MARTIN EVERETT	TRS-SEC	01N	24E	23	A		3589	---	---	---	36	4	10	5.8	72	3517	3	3	3	sandstone on top of shale
2121	226681	BRUCKHUNST WILLIAM	TRS-SEC	01N	24E	2	DDBB		3829	0	---	0	36	2	100	---	36	3793	4	4	2	No clay described
2122	219528	DOT *BIG DITCH *3-102-04	TRS-SEC	01S	25E	7	CCC	---	3310	20	3290	20	0	---	---	---	20	3290	4	4	2	no sand?
2123	160921	WOLFF MAGDALENA	TRS-SEC	01S	25E	6	CBC		3415	7	3408	7	25	2	100	111.3	32	3383	2	2	2	
2125	10377	ZIMMERMAN CHARLES	TRS-SEC	01N	24E	23	AAC		3701	---	---	---	---	---	---	---	---	---	3	3	2	Eagle Sandstone
2126	10392	WEEDEN WILLIAM W.	TRS-SEC	01N	24E	23	DDB		3570	---	---	---	---	---	---	---	---	---	4	4	2	no log
2133	221869	CITY OF BILLINGS PUD *MW-05-B	TRS-SEC	01S	25E	7	BB		3376	5	3371	5	17	2	100	---	22	3354	2	2	3	
2134	221870	CITY OF BILLINGS PUD *MW-05-C	TRS-SEC	01S	25E	7	BB		3376	8	3368	8	9	2	100	---	17	3359	2	2	3	
2135	93056	TUCKER F.W. JR.	TRS-SEC	01S	25E	7	BC	3250	3350	---	---	---	---	---	---	---	---	---	3	3	3	poor log
2136	93054	BASTIAN MILTON	TRS-SEC	01S	25E	6	CB		3379	---	---	---	---	---	---	---	---	---	3	3	3	no log
2137	160939	ENGBERG MARLON	TRS-SEC	01S	25E	6	CB		3379	8	3371	8	28	2	100	---	36	3343	2	2	3	
2145	10379	CHAUNCEY JIM	TRS-SEC	01N	24E	23	AD		3510	0	---	0	45	5	1	0.2	45	3465	3	3	3	poor shallow detail, well in bedrock
2146	10380	CHAUNCEY JIM	TRS-SEC	01N	24E	23	AD		3510	---	---	---	---	---	---	1.5	---	---	3	3	3	all sandstone
2147	10381	CHAUNCEY JAMES	TRS-SEC	01N	24E	23	AD		3510	---	---	---	---	---	---	---	---	---	3	3	3	sandstone and shale at about 33'
2148	10389	FLEER ELMER	TRS-SEC	01N	24E	23	DA		3533	15	3518	15	15	4	10	1.6	30	3503	2	2	3	well below shale
2149	237199	OHMAN GARY	TRS-SEC	01N	24E	23	DD		3576	---	---	---	>40	4	10	---	---	---	4	4	3	shale contact unclear
2150	222157	EGGART QUENTIN PE	TRS-SEC	01N	24E	35	AA		3399	---	---	---	---	---	---	---	---	---	3	3	3	difficult to interpret log
2151	221792	EGGART PE QUENTIN *WELL 1	TRS-SEC	01N	24E	35	AD		3396	55	3341	55	>4	1	200	---	---	---	2	2	3	
2152	221794	EGGART PE QUENTIN *DRY HOLE 3	TRS-SEC	01N	24E	35	DA		3399	44	3355	44	0	---	---	---	44	3355	4	4	3	no sand
2155	185980	BRAUN STEVEN	TRS-SEC	01S	25E	6	BCD		3369	4	3365	4	25	2	100	244.1	29	3340	2	2	2	
2157	142497	REHBERG DENNIS	TRS-SEC	01N	24E	14	AAA		3675	---	---	---	---	---	---	0.1	---	---	4	4	2	60' soft sand on top Eagle SS
2158	10390	PENDERGRAFT LARRY & DOROTHY	TRS-SEC	01N	24E	23	DAD		3533	---	---	---	---	---	---	3.7	65	3468	2	2	2	"sand rock" on top of shale
2161	140465	BILLINGS WATER * BILLINGS PIPELINE	TRS-SEC	01N	24E	26	DDDA	3420	3422	0	---	0	>20	5	1	---	---	---	2	1	2	no clay apparent
2162	10395	US GEOLOGICAL SURVEY	TRS-SEC	01N	24E	26	DDDD	3406	3412	>48	---	---	---	---	---	---	---	---	2	2	2	did not get through clay
2168	172290	TOAVS WARREN	TRS-SEC	01S	25E	6	B		3383	27	3356	27	13	5	1	2.9	40	3343	2	2	3	
2176	197015	MURPHY MARJORIE	TRS-SEC	01S	25E	7	BDBB		3383	---	---	---	---	---	---	---	---	---	3	3	2	poor log
2179	227926	RUTH CHARLES	TRS-SEC	01N	24E	1	CCCB		3793	7	3786	7	34	2	100	---	41	3752	4	4	2	9' of quick sand
2186	10403	LUDINGTON EDWIN M	TRS-SEC	01N	24E	36	BCB		3392	28	3364	28	42	3	50	25.5	70	3322	2	2	2	
2187	219187	MCKENZIE CRAIG	TRS-SEC	01N	24E	36	CCB		3369	0	---	0	38	4	10	---	38	3331	2	3	2	no clay. "quick sand"
2188	219188	MCKENZIE CRAIG	TRS-SEC	01N	24E	36	CCB		3369	26	3343	12	17	4	10	---	43	3326	2	3	2	14' quick sand on top of clay

Table A-1. West Billings Study Well Log Review Summary

Identification				Location				Ground Elev. (ft MSL)		Fine-Grained Cap			Aquifer Material				Bedrock/Clay		Data Qualifiers			
															K (ft/d)				Log Quality		Loc	
Map	GWIC	Name	Geo Method	T	R	S	QS	Log	Map	Btm Dpth (ft)	Btm Elev (ft MSL)	Thkns (ft)	Thkns (ft)	Type	Type	WL/Yld	Depth (ft)	Elev (ft MSL)	Contacts	Descr	Qual	Comment
2189	219190	MCKENZIE CRAIG	TRS-SEC	01N	24E	36	CCB		3369	0	---	0	41	4	10	---	41	3328	2	3	2	no clay. "quick sand"
2190	219191	MCKENZIE CRAIG	TRS-SEC	01N	24E	36	CCB		3369	48	3321	11	30	4	10	---	78	3291	2	3	2	37' quick sand on top of clay
2193	235588	SCARIANO RON	TRS-SEC	01S	25E	7	BD		3360	75	3285	75	6	2	100	---	81	3279	2	2	3	"quick sand" & gravel
2198	235586	PICARD SHAY	TRS-SEC	01N	24E	36	BB		3396	7	3389	7	>23	2	100	---	---	---	2	3	3	limited aq description
2199	171350	SCHIE DUDLEY	TRS-SEC	01N	24E	36	CB		3383	20	3363	20	>40	3	50	57.3	---	---	2	2	3	34' of quick sand
2200	10404	GRAND AVE TRADING POST	TRS-SEC	01N	24E	36	CC		3360	---	---	---	---	---	---	---	---	---	3	3	3	no log
2201	10405	PESTAL ROSE	TRS-SEC	01N	24E	36	CC		3360	---	---	---	---	---	---	37.1	---	---	3	3	3	no log
2202	235463	COPELAND MIKE AND JOAN	TRS-SEC	01N	24E	36	CC		3360	12	3348	12	>23	2	100	---	---	---	2	3	3	
2206	10408	KINNEY LAVINA	TRS-SEC	01N	24E	36	CCDC		3360	40	3320	40	>12	2	100	7.0	---	---	3	3	2	
2207	10409	KINNEY LAVINA	TRS-SEC	01N	24E	36	CCDC		3360	---	---	---	---	---	---	2.8	---	---	3	3	2	poor log
2210	10406	PESTEL ROSE	TRS-SEC	01N	24E	36	CCD		3356	35	3321	35	>5	2	100	17.8	---	---	3	3	2	very general descriptions
2211	10407	PESTAL ROSE	TRS-SEC	01N	24E	36	CCD	3369	3356	---	---	---	---	---	---	---	---	---	3	3	2	no log
2214	93051	HARDESTY JAN E.	TRS-SEC	01S	25E	6			3350	25	3325	25	2	4	10	82.5	27	3323	3	3	3	poor log
2215	93052	SELWYN JEFF	TRS-SEC	01S	25E	6			3350	25	3325	25	>5	2	100	66.9	---	---	2	2	3	gravel in with silt
2217	93884	YELLOWSTONE INVESTORS	TRS-SEC	01S	25E	7			3340	---	---	0	33	2	100	49.8	37	3303	3	3	3	no cap?
2227	10393	REHBERG MARY A.	TRS-SEC	01N	24E	24	C		3501	---	---	---	---	---	---	---	---	---	3	3	3	no log
2231	190086	WEBER JOHN	TRS-SEC	01N	24E	24	BDB		3652	32	3620	26	15	2	100	---	47	3605	2	2	2	
2232	10411	PESTAL ROSE	TRS-SEC	01N	24E	36	CDC	3362	3356	---	---	---	---	---	---	---	---	---	3	3	2	no log
2239	221868	CITY OF BILLINGS PUD *MW-05-A	TRS-SEC	01S	25E	7	AB		3327	3	3324	3	22	2	100	---	---	---	2	2	3	
2252	248918	HILL DIANE	TRS-SEC	01N	24E	36	CA		3369	31	3338	30	3	2	100	---	36	3333	2	2	3	0.5' wet gravel in with clay
2253	10410	KINNEY LAVINA	TRS-SEC	01N	24E	36	CD		3356	---	---	---	---	---	---	---	---	---	3	3	3	no log
2254	200177	SCHERMERHORN SCOT	TRS-SEC	01N	24E	36	BDAB		3366	18	3348	18	20	2	100	---	38	3328	2	2	2	3' of quick sand
2259	150052	ANDERSON LAURA	TRS-SEC	01N	24E	36	BAD		3366	8	3358	8	20	4	10	1.9	28	3338	2	2	2	
2269	194002	SLOAN DAN	TRS-SEC	01N	24E	36	CADA		3363	39	3324	39	10	2	100	50.0	49	3314	2	2	2	
2276	10394	GOLDEN ACRES PARTNER	TRS-SEC	01N	24E	25			3468	---	---	---	---	---	---	---	46	3422	4	4	3	difficult to interpret log above shale
2277	10402	WEGNER ALBERT	TRS-SEC	01N	24E	36			3363	---	---	---	---	---	---	---	---	---	3	3	3	no log
2278	192072	LAMM FRANK AND JENNIFER	TRS-SEC	01N	24E	36			3363	17	3346	17	22	2	100	---	39	3324	2	2	3	9' of quick sand
2286	140464	BILLINGS WATER * BILLINGS PIPELINE	TRS-SEC	01N	24E	25	DCBB	3430	3422	0	---	0	>20	5	1	---	---	---	1	1	2	no distinct clay layer
2289	237607	COLD STONE ESTATES	TRS-SEC	01N	24E	36	DBBB		3360	26	3334	26	2	3	50	---	28	3332	2	2	2	
2292	190088	KNUTSON ROBERT E.	TRS-SEC	01N	24E	36	ACB		3360	8	3352	8	26	4	10	---	33	3327	2	2	2	quick sand and clay above water
2293	10412	BLANKENBAKER RALPH	TRS-SEC	01N	24E	36	DBC		3356	---	---	---	---	---	---	---	---	---	3	3	2	no log
2294	222905	SHENIDAN PAUL	TRS-SEC	01N	24E	36	DCC		3350	71	3279	49	0	---	---	---	71	3279	4	4	2	22' quick sand on top of clay
2295	93055	JONES THEODORE W AND MURIEL	TRS-SEC	01S	25E	6	DA		3317	---	---	---	---	---	---	---	---	---	3	3	3	no log
2296	176236	KUEHN DIANA & STEVE	TRS-SEC	01S	25E	6	DA		3317	13	3304	13	19	2	100	21.7	32	3285	2	2	3	
2315	235573	HANEY NATE	TRS-SEC	01N	24E	36	DB		3350	30	3320	30	>7	1	200	---	---	---	2	3	3	limited descriptions
2316	222158	ANDERSON JON	TRS-SEC	01N	24E	36	DC		3346	18	3328	18	3	3	50	---	21	3325	2	2	3	
2330	93053	US GEOLOGICAL SURVEY	TRS-SEC	01S	25E	6	AAAA	3343	3346	21	3322	21	9	5	1	---	30	3313	2	2	2	
2331	247491	GOODMAN JERRY	SUR-GPS	01N	25E	35	CAA		3625	53	3572	53	>7	1	200	---	---	---	4	4	1	limited aq description
2341	171419	BERNHARDT ROGER	TRS-SEC	01N	24E	36	DDB		3343	31	3312	31	14	3	50	143.2	45	3298	2	2	2	
2342	190089	COLBY SHAWN	TRS-SEC	01S	25E	5	BB		3340	---	---	---	---	---	---	---	---	---	3	3	3	poor log
2343	10419	BAILEY SHARON C.	TRS-SEC	01S	25E	5	CC		3307	---	---	---	---	---	---	---	---	---	3	3	3	no log
2371	232026	NIEHABER FRANK AND NICHOLE	TRS-SEC	01N	24E	36	AA		3360	0	---	0	>40	4	10	---	---	---	2	3	3	limited description. no clay?
2372	208704	NELSON SHELDON	TRS-SEC	01N	24E	36	DD		3340	28	3312	28	4	2	100	---	32	3308	2	2	3	
2373	216609	JONES & OLSON JIM & JOHN L.	TRS-SEC	01N	24E	36	DD		3340	20	3320	8	7	5	1	---	27	3313	2	3	3	12' quick sand mixed in with clay
2374	190090	WILCOX DAVID E.	TRS-SEC	01S	25E	5	CCA		3301	3	3298	3	25	2	100	---	28	3273	2	2	2	
2379	150469	TIMBERMEN BOB	TRS-SEC	01N	24E	1	AAD		3615	20	3595	20	0	---	---	---	20	3595	4	4	2	No sand described
2380	192605	CONNAGHAN ROBERT L.	TRS-SEC	01N	24E	36	DDD		3337	18	3319	18	>22	5	1	---	---	---	2	2	2	thin gravel on top of type 5
2381	192609	CONNAGHAN ROBERT	TRS-SEC	01N	24E	36	DDD		3337	41	3296	40	6	4	10	---	47	3290	2	2	2	"quick sand"
2382	195555	CONNRGHOR ROBERT	TRS-SEC	01N	24E	36	DDD		3337	48	3289	48	0	---	---	---	48	3289	4	4	2	no aq material described
2383	197012	CONNAGHAN ROBERT	TRS-SEC	01N	24E	36	DDD		3337	31	3306	31	9	2	100	11.1	40	3297	2	2	2	
2384	93042	AMEN DANIEL & GEORGE	TRS-SEC	01S	25E	5	B		3327	---	---	---	---	---	---	---	---	---	3	3	3	no log
2385	93043	AMEN DANIEL & GEORGE	TRS-SEC	01S	25E	5	C		3297	---	---	---	---	---	---	---	---	---	3	3	3	no log
2386	93045	AMEN HENRY JR.	TRS-SEC	01S	25E	5	C		3297	---	---	---	---	---	---	---	---	---	3	3	3	no log
2387	243013	ANDERSON HENRY	TRS-SEC	01S	25E	5	C		3297	58	3239	58	>1	1	200	---	---	---	3	3	3	some sand in with clay
2425	170113	MOMAHEN BRIAN	TRS-SEC	01N	25E	31	BBC		3353	---	---	---	---	---	---	16.8	---	---	3	3	2	difficult to interpret log
2426	144304	KAY LARRY	TRS-SEC	01N	25E	31	CBB		3337	28	3309	28	>19	2	100	92.8	---	---	2	2	2	

Table A-1. West Billings Study Well Log Review Summary

Identification			Geo	Location				Ground Elev. (ft MSL)		Fine-Grained Cap			Aquifer Material				Bedrock/Clay		Data Qualifiers			Comment
										Btm Dpth	Btm Elev	Thkns	Thkns		K (ft/d)		Depth	Elev	Log Quality		Loc	
Map	GWIC	Name	Method	T	R	S	QS	Log	Map	(ft)	(ft MSL)	(ft)	(ft)	Type	Type	WL/Yld	(ft)	(ft MSL)	Contacts	Descr	Qual	
2427	204418	LOHRENZ DONALD R.	TRS-SEC	01N	25E	31	CBC		3327	49	3278	??	39	4	10	---	88	3239	2	3	2	upper 49' clay and sand
2428	220045	LOHRENZ DONALD	TRS-SEC	01N	25E	31	CBC		3327	0	---	0	53	3	50	---	53	3274	2	2	2	37' quick sand. No clay described
2446	183606	BUSCHER DEVELOPMENT	TRS-SEC	01N	25E	30	CB		3402	---	---	---	---	---	---	8.6	36	3366	3	3	3	difficult to interpret log above shale
2450	220044	STANICK JOHN	TRS-SEC	01N	25E	31	BCD		3340	0	---	0	38	4	10	---	38	3302	3	3	2	27' of quick sand, no clay?
2451	93041	GLENN JAME	TRS-SEC	01S	25E	5			3310	23	3287	23	>20	2	100	115.3	---	---	2	2	3	
2452	144454	FRANKS DOUG	TRS-SEC	01S	25E	5			3310	70	3240	65	>10	2	100	8.2	---	---	2	3	3	5' gravel in with clay
2453	150207	AMEN RALPH	TRS-SEC	01S	25E	5			3310	55	3255	55	20	2	100	23.5	75	3235	2	3	3	
2464	10421	BROWN CURTIS T.	TRS-SEC	01N	25E	6	C		3717	8	3709	8	21	4	10	0.4	29	3688	4	4	3	well in Eagle Sandstone
2465	238682	MURDOCK J.J.	TRS-SEC	01N	25E	31	B		3350	---	---	---	---	---	---	---	---	---	3	3	3	difficult to interpret log
2466	10453	ZIMMERMAN CHARLES	TRS-SEC	01N	25E	30	C		3389	72	3317	72	>8	4	10	---	---	---	2	3	3	limited aq description
2467	10454	ZIMMERMAN CHARLES	TRS-SEC	01N	25E	30	C		3389	58	3331	58	>14	4	10	---	---	---	2	3	3	limited aq description
2473	185707	SUNNYCOVE FRUIT FARM	TRS-SEC	01N	25E	31	CAB		3337	30	3307	30	>2	2	100	---	---	---	2	2	2	
2474	10441	ZIMMERMAN FAMILY LTD PARTNERSHIP	TRS-SEC	01N	25E	19	CDC		3445	---	---	---	---	---	---	---	---	---	3	3	3	no log
2475	93050	SCHILLINGER CLYDE	TRS-SEC	01S	25E	5	DB		3301	18	3283	10	>42	5	1	---	---	---	2	3	3	8' gravel on top of clay
2476	176235	HAWKINS TIM	TRS-SEC	01S	25E	5	DB		3301	63	3238	53	>15	1	200	4.1	---	---	2	3	3	10' sand interbedded in clay
2477	200582	AMEN MIKE AND CHERYL	TRS-SEC	01S	25E	5	DB		3301	67	3234	64	>13	1	200	---	---	---	2	3	3	
2495	185982	NELSON ED & LINDA	TRS-SEC	01N	25E	6	CD		3727	14	3713	14	6	4	10	---	22	3705	4	4	3	well in Eagle Sandstone
2496	144303	BORNE KEN COLLEN	TRS-SEC	01N	25E	31	BA		3360	---	---	---	---	---	---	---	---	---	3	3	3	difficult to interpret log
2497	171757	COSGROVE TAMMY & SHAWN	TRS-SEC	01N	25E	31	BA		3360	42	3318	40	>8	4	10	38.2	---	---	2	2	3	quick sand
2499	10455	STEWART L.J.	TRS-SEC	01N	25E	30	CD		3373	---	---	---	---	---	---	---	---	---	3	3	3	no log
2507	255176	"TERRACON CONSULTANTS, INC."	MAP	01N	25E	31	CDD		3320	>25	---	---	---	---	---	---	---	---	2	2	2	did not go through clay
2508	146356	BATTAGLIA JOHN AND CHRISTIE VICKIE	TRS-SEC	01N	25E	31	BAA		3366	25	3341	25	>6	5	1	1.1	---	---	2	2	2	
2509	204419	CATEN DAVE	TRS-SEC	01N	25E	31	BAA		3366	36	3330	20	2	3	50	23.1	37	3329	2	3	2	assume bottom is shale
2541	239993	TERRACON CONSULTANTS	NAV-GPS	01N	25E	30	CDD		3369	25	3344	25	>6	5	1	---	---	---	2	2	1	
2555	200178	STERNAD JAY	TRS-SEC	01N	25E	31	ACC		3340	34	3306	34	>3	3	50	---	---	---	2	3	2	limited aq description
2578	208688	HARRINGTON CORBIT	TRS-SEC	01N	25E	31	AB		3363	0	---	0	56	2	100	---	57	3306	2	3	3	2' clay laer 16-18'
2579	212686	PETERSON BOB	TRS-SEC	01N	25E	31	AB		3363	---	---	---	---	---	---	---	---	---	3	3	3	difficult to interpret log
2580	232011	COSGROVE SHAWN	TRS-SEC	01N	25E	31	AB		3363	46	3317	46	>4	3	50	---	---	---	2	2	3	
2581	200626	PLUHAR LARON	TRS-SEC	01N	25E	31	DC		3323	20	3303	20	38	4	10	---	58	3265	2	2	3	
2591	10452	YELLOWSTONE COUNTRY CLUB	TRS-SEC	01N	25E	30	ACAB		3448	---	---	---	---	---	---	---	---	---	3	3	2	Very limited shallow detail
2595	150199	GOODMAN RANDY	MAP	01S	25E	4	BB		3310	75	3235	75	17	2	100	13.7	92	3218	2	2	3	
2603	10442	ZIMMERMAN DOME OIL CO	TRS-SEC	01N	25E	19	D		3504	---	---	---	---	---	---	---	---	---	4	4	3	no log
2604	10439	REHBERG MARY A.	TRS-SEC	01N	25E	18	A		3550	---	---	---	---	---	---	---	---	---	4	4	3	no log
2605	10440	REHBERG MARY A.	TRS-SEC	01N	25E	18	D		3645	---	---	---	---	---	---	---	---	---	4	4	3	no log
2628	93035	WARD DURAND	TRS-SEC	01S	25E	4	BB		3310	85	3225	85	>13	2	100	2.3	---	---	2	3	3	details for clay not described
2629	93036	BELL RODGER	TRS-SEC	01S	25E	4	BB		3310	---	---	---	---	---	---	19.1	---	---	3	3	3	poor log
2630	221806	WARD DURAND	TRS-SEC	01S	25E	4	BB		3310	81	3229	81	>13	2	100	---	---	---	2	2	3	
2631	93037	LARSEN GARY	TRS-SEC	01S	25E	4	BC		3301	72	3229	72	>16	2	100	5.9	---	---	2	3	3	details for clay not described
2632	93038	OLSEN ROBERT	TRS-SEC	01S	25E	4	BC		3301	68	3233	68	14	2	100	24.2	82	3219	2	3	3	details for clay not described
2662	190094	MAHAN JOHN	TRS-SEC	01N	25E	31	DD		3317	38	3279	38	>2	1	200	---	---	---	2	3	3	limited aquifer description
2664	208669	RAMIREZ JACK	TRS-SEC	01N	25E	7	AA		3593	0	---	0	44	4	10	---	44	3549	4	4	3	well in Eagle Sandstone
2681	165980	SULLIVAN JIM	TRS-SEC	01S	25E	4	B		3301	70	3231	70	>22	2	100	28.7	---	---	2	2	3	
2682	238381	CARDWELL SARA	TRS-SEC	01S	25E	4	B		3301	84	3217	56	>4	2	100	---	---	---	2	3	3	28' sand and "soil" in with clay
2686	161465	MICHELS FRED	TRS-SEC	01N	25E	31	DAA		3330	11	3319	11	6	4	10	12.4	17	3313	2	2	2	
2687	171755	MACDONALD DONNA	TRS-SEC	01N	25E	31	DAA		3330	9	3321	9	1	4	10	---	10	3320	2	2	2	
2688	171756	MACDONALD DONNA	TRS-SEC	01N	25E	31	DAA		3330	10	3320	10	1	2	100	---	11	3319	2	2	2	
2726	128181	STURTAUNT SMOKEY TERRY	TRS-SEC	01N	25E	5	CCB		3609	>13	---	---	---	---	---	3.5	---	---	4	4	2	Eagle SS. Interbed sand rock & shale
2768	133284	JOHNSON CLIFF	TRS-SEC	01S	25E	4	BAD		3297	61	3236	61	>27	2	100	23.5	---	---	2	2	2	
2771	126397	RAY JERRY	TRS-SEC	01N	25E	32	BC		3340	60	3280	60	0	---	---	---	60	3280	4	4	3	no sand described
2772	10460	DEINES ROY	TRS-SEC	01N	25E	32	CC		3310	87	3223	72	10	2	100	11.8	97	3213	2	3	3	15' "sand rock" in with clay
2773	252514	JEFF JUNKENT CONSTRUCTION	TRS-SEC	01N	25E	32	CC		3310	92	3218	92	6	1	200	---	98	3212	2	2	3	general aquifer description
2774	10417	BAR DIAMOND RANCH	TRS-SEC	01N	25E	5	CB		3563	17	3546	17	---	---	---	---	---	---	4	4	3	well in Eagle Sandstone
2783	160954	KRESKE BILL	MAP	01S	25E	4	BAD		3297	70	3227	70	21	2	100	34.3	91	3206	2	2	2	
2793	247349	GRANITE PEAKS TOWN HOME ASSOC	NAV-GPS	01N	25E	32	C		3307	82	3225	59	13	2	100	---	95	3212	2	2	1	23' sand/soft sand on top of clay
2797	10418	BAR DIAMOND RANCH	TRS-SEC	01N	25E	5	CBA		3543	25	3518	25	---	---	---	---	75	3468	4	4	2	well in Eagle Sandstone
2819	10451	MILLS BOB	TRS-SEC	01N	25E	29	B		3793	---	---	---	---	---	---	0.4	---	---	1	1	3	sandstone & shale. well in Eagle SS

Table A-1. West Billings Study Well Log Review Summary

Identification			Geo	Location				Ground Elev. (ft MSL)		Fine-Grained Cap			Aquifer Material				Bedrock/Clay		Data Qualifiers			Comment
										Btm Dpth	Btm Elev	Thkns	Thkns		K (ft/d)		Depth	Elev	Log Quality		Loc	
Map	GWIC	Name	Method	T	R	S	QS	Log	Map	(ft)	(ft MSL)	(ft)	(ft)	Type	Type	WL/Yld	(ft)	(ft MSL)	Contacts	Descr	Qual	
2823	10431	OSGOOD LINDA DIANNE	TRS-SEC	01N	25E	17	B		3550	---	---	---	---	---	---	---	---	---	4	4	3	29' topsoil above Eagle SS
2824	127237	OSGOOD KIT	TRS-SEC	01N	25E	17	B		3550	---	---	---	---	---	---	2.2	---	---	4	4	3	well in Eagle Sandstone
2825	10433	REHBERG JACK	TRS-SEC	01N	25E	17	C		3648	---	---	---	---	---	---	0.4	---	---	4	4	3	sand & shale. well in Eagle SS
2867	201572	MILLS BOB	TRS-SEC	01N	25E	29	BA		3806	---	---	---	---	---	---	---	---	---	4	4	3	sandstone & shale. well in Eagle SS
2868	232013	DEINES JUDY	TRS-SEC	01N	25E	32	CD		3310	78	3232	48	>12	2	100	---	---	---	2	2	3	30' sand/gravel in with clay
2883	127734	HAYNES JOHNATHON	TRS-SEC	01N	25E	5	CDA		3573	>13	---	---	---	---	---	---	---	---	4	4	2	Eagle SS. Interbed sand rock & shale
2897	10434	RUBLE ROBERT T	TRS-SEC	01N	25E	17	CAD	3580	3576	---	---	---	---	---	---	0.03	---	---	4	4	2	sand & shale. well in Eagle SS
2930	254569	CHURCH OF JESUS CHRIST OF LATTER DAY SAIN	TRS-SEC	01N	25E	29			3796	---	---	---	---	---	---	---	26	3770	3	3	3	limited detail above shale
2933	10458	DEINES WILLIAM	TRS-SEC	01N	25E	32			3327	---	---	---	---	---	---	---	---	---	3	3	3	poor log
2934	126723	DEINES WILLIAM	TRS-SEC	01N	25E	32			3327	---	---	---	---	---	---	---	---	---	3	3	3	poor log
2937	10427	DANIELS WHEELER	TRS-SEC	01N	25E	17			3579	---	---	---	---	---	---	0.6	---	---	4	4	3	well in Eagle SS at top
2938	10428	REHBERG MARY A	TRS-SEC	01N	25E	17			3579	---	---	---	---	---	---	---	---	---	4	4	3	no log
2939	10429	REHBERG MARY A	TRS-SEC	01N	25E	17			3579	---	---	---	---	---	---	---	---	---	4	4	3	no log
3031	200627	DEINES BILL	TRS-SEC	01N	25E	32	DC		3304	72	3232	48	>17	2	100	---	---	---	2	3	3	24' sand/gravel in with clay
3032	200628	DEINES BILL	TRS-SEC	01N	25E	32	DC		3304	74	3230	66	14	2	100	---	88	3216	2	2	3	8' gravel in with clay
3042	156814	MUNSELL NEIL & CAROLYN	TRS-SEC	01N	25E	17	AB		3520	34	3486	34	0	---	---	0.4	34	3486	4	4	3	well below shale in Eagle SS
3066	209929	BLOTT HAROLD	TRS-SEC	01N	25E	5	DCD		3517	12	3505	12	14	2	100	---	26	3491	4	4	2	
3067	145013	ROMIREZ JACK	TRS-SEC	01N	25E	17	ABA		3501	51	3450	51	---	---	---	0.6	---	---	4	4	2	well in Eagle SS below clay
3083	10461	BROMENSHENK FLORENCE	TRS-SEC	01N	25E	32	D		3301	0	---	0	>58	2	100	---	---	---	2	3	3	limited descrip, no clay noted
3084	10462	BROMENSHENK FLORENCE	TRS-SEC	01N	25E	32	D		3301	---	---	---	---	---	---	---	---	---	3	3	3	no log
3085	10463	BROMENSHENK FLORENCE	TRS-SEC	01N	25E	32	D		3301	---	---	---	---	---	---	---	---	---	3	3	3	no log
3089	10430	REHBERG MARY A.	TRS-SEC	01N	25E	17	A		3560	---	---	---	---	---	---	---	---	---	4	4	3	no log
3157	238114	MACKEY SHEEP COMPANY	TRS-SEC	01N	25E	5	AA		3596	---	---	---	---	---	---	---	---	---	2	2	3	Eagle Sandstone
3158	212679	GRYGIEL ANDY	TRS-SEC	01N	25E	8	DA		3625	6	3619	6	79	4	10	---	85	3540	4	4	3	well in Eagle Sandstone
3159	157221	FENSKE BRIAN	TRS-SEC	01N	25E	17	AD		3635	6	3629	6	14	4	10	20.4	20	3615	4	4	3	well in Eagle Sandstone
3160	212685	SCHERER LEE	TRS-SEC	01N	25E	17	AD		3635	7	3628	7	22	4	10	---	29	3606	4	4	3	well in Eagle Sandstone
3161	10437	NANCE BOB	TRS-SEC	01N	25E	17	DA		3619	0	---	0	70	4	10	6.4	70	3549	4	4	3	well in Eagle SS below shale
3162	10438	SCOTT TOM	TRS-SEC	01N	25E	17	DA		3619	18	3601	18	---	---	---	---	---	---	4	4	3	well in Eagle Sandstone
3163	247440	CEDAR GROVE CONDO ASSOCIATION	NAV-GPS	01S	25E	11	DB		3596	6	3590	6	20	2	100	---	26	3570	4	4	1	limited aq description
3188	134371	TAYLOR PHILL	TRS-SEC	01N	25E	17	DDA		3602	11	3591	11	8	4	10	0.1	19	3583	4	4	2	well in Eagle SS below shale
3189	150471	STONE KEITH	TRS-SEC	01N	25E	17	DDD		3681	---	---	---	---	---	---	---	---	---	4	4	2	sandstone & shale. well in Eagle SS
3190	219960	ANDERSON DAVE	TRS-SEC	01N	25E	17	DDD		3681	---	---	---	---	---	---	---	---	---	4	4	2	sandstone & shale. well in Eagle SS
3191	147426	CANTON MARK	TRS-SEC	01N	25E	5	DDA		3586	0	---	0	22	4	10	26.7	22	3564	4	4	2	well in Eagle Sandstone
3219	10474	LENHARDT MARK	MAP	01N	25E	33	CD		3291	63	3228	63	20	2	100	---	83	3208	2	2	3	
3223	10473	LENHARDT JOHN & CAROLINE	TRS-SEC	01N	25E	33	CBC		3287	65	3222	65	>14	2	100	---	---	---	2	3	2	limited descriptions
3242	171753	BILLINGS URBAN FIRE SERVICE AREA	TRS-SEC	01N	25E	33	BC		3327	56	3271	56	>21	2	100	35.8	---	---	2	2	3	
3254	212681	BAKER JIM AND LINDA	TRS-SEC	01N	25E	9	CB		3635	---	---	---	---	---	---	---	---	---	4	4	3	hard to interpret log. well in Eagle SS
3255	177311	MARKEGARD ROD AND JANE	TRS-SEC	01N	25E	9	CC		3625	---	---	---	---	---	---	---	---	---	2	2	3	well in Eagle Sandstone
3256	216655	SWAIN JIM	TRS-SEC	01N	25E	9	CC		3625	---	---	---	---	---	---	---	---	---	4	4	3	interbedded "sand rock" & shale
3259	10443	REHBERG DENNIS	TRS-SEC	01N	25E	21	CCA		3737	---	---	---	---	---	---	0.03	---	---	4	4	2	poor log. well in Eagle SS
3260	131687	SWAIN DAVE	TRS-SEC	01N	25E	33	CBD		3287	62	3225	62	22	2	100	19.4	84	3203	2	2	2	
3261	140303	VULETICK MARK	TRS-SEC	01N	25E	33	CCA		3281	58	3223	58	>23	2	100	145.3	---	---	2	2	2	
3302	161466	NEUHOFF DOUG & KATHY	TRS-SEC	01N	25E	33	C		3281	55	3226	55	23	2	100	64.5	78	3203	2	2	3	
3303	171752	POPPLER MARILIAN	TRS-SEC	01N	25E	33	C		3281	50	3231	50	16	2	100	40.5	66	3215	2	2	3	
3309	171353	HOLLEY PAUL	TRS-SEC	01N	25E	9	C		3645	13	3632	13	97	4	10	4.1	110	3535	4	4	3	sand rock on shale. well in Eagle SS
3310	177312	ALAMAN PAUL AND JONI	TRS-SEC	01N	25E	9	C		3645	13	3632	13	15	4	10	---	28	3617	4	4	3	sand rock on shale. well in Eagle SS
3311	10426	MILLER SAUNDER	TRS-SEC	01N	25E	16	C		3609	---	---	---	---	---	---	---	---	---	4	4	3	no log
3314	203953	RLK HYDRO	TRS-SEC	01N	25E	33	BDB		3338	56	3282	56	>24	2	100	---	---	---	2	2	2	
3339	165959	RIETZ DAVE	TRS-SEC	01N	25E	33	BA		3361	125	3236	125	15	4	10	3.4	140	3221	2	2	3	
3340	232015	WALKER ENOCH	TRS-SEC	01N	25E	33	BD		3326	6	3320	6	20	2	100	---	26	3300	2	2	3	
3344	181036	GRYGIEL ANDY AND LAURIE	TRS-SEC	01N	25E	9	BD		3553	---	---	---	---	---	---	---	---	---	4	4	3	no log. Eagle SS
3345	226439	SCHREIBER CHRIS	TRS-SEC	01N	25E	9	CA		3645	17	3628	17	13	4	10	0.1	30	3615	4	4	3	sand rock on shale. well in Eagle SS
3346	185986	MORGANTHALER FRED	TRS-SEC	01N	25E	9	CD		3654	16	3638	16	8	4	10	---	24	3630	4	4	3	well in Eagle Sandstone
3382	142499	HIARING BOB	TRS-SEC	01N	25E	4	CDD		3585	---	---	---	---	---	---	0.3	---	---	4	4	3	interbedded "sand rock" & shale
3394	10464	RATCLIFF DWIGHT	TRS-SEC	01N	25E	33			3303	55	3248	35	>29	4	10	6.9	---	---	2	2	3	20' sand in with clay
3395	10465	STEVENS IRA	TRS-SEC	01N	25E	33			3303	75	3228	32	>17	4	10	9.6	---	---	2	2	3	43' sand in with clay

Table A-1. West Billings Study Well Log Review Summary

Identification				Location				Ground Elev. (ft MSL)		Fine-Grained Cap			Aquifer Material				Bedrock/Clay		Data Qualifiers			
										Btm Dpth	Btm Elev	Thkns	Thkns		K (ft/d)		Depth	Elev	Log Quality		Loc	
Map	GWIC	Name	Geo Method	T	R	S	QS	Log	Map	(ft)	(ft MSL)	(ft)	(ft)	Type	Type	WL/Yld	(ft)	(ft MSL)	Contacts	Descr	Qual	Comment
3396	10466	RUSHTON RONALD A.	TRS-SEC	01N	25E	33			3303	75	3228	35	>19	4	10	9.1	---	---	2	2	3	40' sand in with clay
3397	10467	MOBELY GERALD E.	TRS-SEC	01N	25E	33			3303	---	---	---	---	---	---	---	---	---	3	3	3	poor log
3398	10468	KLEIN LYNN	TRS-SEC	01N	25E	33			3303	100	3203	100	>20	3	50	5.6	---	---	2	3	3	limited aq description
3399	10469	HALL JAMES	TRS-SEC	01N	25E	33			3303	123	3180	123	20	3	50	8.6	143	3160	2	3	3	limited aq description
3416	11856	WEISGERBER DONALD A.	TRS-SEC	01N	25E	33	ACC		3307	80	3227	32	>10	2	100	13.4	---	---	2	2	2	48' sand in with clay
3417	166250	LELEND / HAN WELLS	TRS-SEC	01N	25E	33	ACC		3307	6	3301	6	20	2	100	---	26	3281	2	2	2	
3440	239883	ELITE HOMES	TRS-SEC	01N	25E	33	AB		3355	5	3350	5	>20	2	100	---	---	---	2	3	3	limited aq description
3441	120315	SCHMIDT DELMER	TRS-SEC	01N	25E	33	AC		3315	94	3221	94	3	2	100	33.4	97	3218	2	2	3	
3442	10476	SHILOH UNITED METHODIST CHURCH	TRS-SEC	01N	25E	33	DB		3282	38	3244	38	20	1	200	---	58	3224	2	3	3	limited aq description
3443	171348	SYLVAN NORBERT AND RAMONA	TRS-SEC	01N	25E	33	DB		3282	36	3246	36	>15	2	100	216.8	---	---	2	1	3	
3444	190106	LIPP BRENT	TRS-SEC	01N	25E	33	DB		3282	55	3227	55	>21	1	200	---	---	---	2	3	3	limited aq description
3445	239921	DR NELSON	TRS-SEC	01N	25E	33	DB		3282	5	3277	5	>15	4	10	---	---	---	2	3	3	limited aq description
3451	195535	CEBULL RICK	TRS-SEC	01N	25E	9	AB		3574	6	3568	6	8	4	10	---	14	3560	4	4	3	well in Eagle Sandstone
3452	231998	MIKE NINICHUCK%ALL DESIGN LANDSCAPING	TRS-SEC	01N	25E	9	DB		3561	0	---	0	40	4	10	---	40	3521	4	4	3	well in Eagle Sandstone
3453	239886	"JOHNSON KIRK, AND KATHERINE HATCH"	TRS-SEC	01N	25E	9	DB		3561	6	3555	6	72	4	10	---	78	3483	4	4	3	well in Eagle Sandstone
3454	208685	REHBERG DENNIE AND JAN	TRS-SEC	01N	25E	16	DB		3505	---	---	---	---	---	---	---	---	---	4	4	3	all sand. well in Eagle Sandstone
3462	253483	FINN BRADLEY	NAV-GPS	01N	25E	9	ADA		3642	---	---	---	---	---	---	---	27	3615	2	2	1	sandstone above shale
3464	120314	SCHOOL DISTRICT # 2	TRS-SEC	01N	25E	33	A		3331	102	3229	102	23	2	100	23.8	125	3206	2	2	3	
3465	239920	HI TECH CONSTRUCTION	TRS-SEC	01N	25E	33	A		3331	29	3302	29	>115	2	100	---	---	---	2	3	3	limited descriptions
3466	10475	GOODMAN GERALD R.	TRS-SEC	01N	25E	33	D		3269	0	---	0	>50	2	100	24.1	---	---	2	3	3	limited descrip, no clay noted
3471	252194	FINN BRAD	NAV-GPS	01N	25E	9	ADA		3644	---	---	---	---	---	---	---	35	3609	4	4	1	sandstone above shale
3472	171629	MCKNIRE DENNIS	TRS-SEC	01N	25E	28	DDCC		3382	158	3224	158	9	1	200	---	167	3215	2	3	2	limited aq description
3499	190093	BARTA ALLAN	TRS-SEC	01N	25E	9	DAC		3522	4	3518	4	28	4	10	0.1	32	3490	4	4	2	well in Eagle Sandstone
3501	252508	CUMMINGS CHRISI	NAV-GPS	01N	25E	9	DA		3633	18	3615	18	0	---	---	---	18	3615	4	4	1	no sand above shale
3503	10470	BLACKFORD ALLEN DDS	TRS-SEC	01N	25E	33	AA		3348	106	3242	106	>5	4	10	5.5	---	---	2	2	3	
3504	171754	MISSIONS UNITED INC	TRS-SEC	01N	25E	33	AA		3348	120	3228	120	>16	2	100	47.8	---	---	2	2	3	
3505	171751	EGGEH ALLEN	TRS-SEC	01N	25E	33	DA		3275	64	3211	64	>16	2	100	---	---	---	2	3	3	24-64 described as "clay sand"
3511	185983	TALLMAN PHILLIP & LAURA	TRS-SEC	01N	25E	9	DA		3479	0	---	0	22	4	10	---	22	3457	4	4	3	well in Eagle Sandstone
3512	185984	BARNETT MARTIN K.	TRS-SEC	01N	25E	9	DD		3648	12	3636	12	14	4	10	0.2	26	3622	4	4	3	well in Eagle Sandstone
3513	200620	FISHER MIKE	TRS-SEC	01N	25E	9	DD		3648	0	---	0	30	4	10	---	30	3618	4	4	3	well in Eagle Sandstone
3550	252526	CUMMINGS CHRIS	NAV-GPS	01N	25E	9	DA		3650	10	3640	10	36	4	10	---	46	3604	4	4	1	
3560	161464	ALLEN WEBSTER & PRICILLA	TRS-SEC	01N	25E	27	CCC		3376	157	3219	157	11	4	10	1.7	168	3208	2	2	2	
3574	200630	BUSCHER DEVELOPMENT	TRS-SEC	01N	25E	34	BB		3344	57	3287	42	19	2	100	---	76	3268	2	2	3	15' of sand in with clay
3582	10488	KOBELT DARREL	TRS-SEC	01N	25E	34	BCA		3317	60	3257	60	>65	2	100	1.0	---	---	2	3	2	limited aq description
3639	10492	FOX WILLIAM	TRS-SEC	01N	25E	34	C		3262	---	---	---	---	---	---	---	---	---	3	3	3	poor log
3648	247357	BATERSLUB ROB	NAV-GPS	01N	26E	33	CB		3308	15	3293	15	11	2	100	---	27	3281	2	2	1	
3650	10424	REHBERG JACK	TRS-SEC	01N	25E	15	B		3442	---	---	---	---	---	---	1.6	---	---	4	4	3	limited description. well in Eagle SS
3651	10489	HOWARD CLYDE	TRS-SEC	01N	25E	34	BDB		3313	0	---	0	123	2	100	32.4	123	3190	2	1	2	clay layer 32-34'
3652	10490	STORY WILLARD F	TRS-SEC	01N	25E	34	BDC		3294	---	---	---	---	---	---	---	---	---	3	3	2	no log
3653	10493	STORY WILLARD F.	TRS-SEC	01N	25E	34	CAB		3276	---	---	---	---	---	---	---	---	---	3	3	2	no log
3669	98378	BOISE CASCADE - FLOBERG SALES	TRS-SEC	01N	25E	34	BDCA		3297	0	---	0	22	2	100	178.3	22	3275	2	2	2	
3673	10487	CHILDS PEGGY	TRS-SEC	01N	25E	34	BA	3330	3336	109	3221	19	>60	2	100	---	---	---	3	1	3	hard to discern upper zone
3674	10494	ZIMMERMAN RODNEY	TRS-SEC	01N	25E	34	CD		3250	---	---	---	---	---	---	---	---	---	3	3	3	no log
3679	212682	CELLMER LAWRENCE	TRS-SEC	01N	25E	10	CA		3447	---	---	---	---	---	---	---	---	---	4	4	3	well in Eagle Sandstone. no shale
3681	10491	IRVINE CALVIN & LEON	TRS-SEC	01N	25E	34	BDD		3283	62	3221	37	29	2	100	8.5	91	3192	2	3	2	25' sand in clay, limited aq desc
3697	211542	SULLINS MONTY	TRS-SEC	01N	25E	34	CAAA		3271	80	3191	59	15	2	100	22.1	95	3176	2	2	2	21' sand & quick sand in clay
3699	10450	MAXWELL CHARLES	TRS-SEC	01N	25E	27			3748	140	3608	140	22	1	200	---	162	3586	2	3	3	limited aq description
3700	10477	HAVIG DONALD R	TRS-SEC	01N	25E	34			3273	50	3223	50	23	2	100	24.9	73	3200	2	2	3	
3701	10478	REICHENBACH ERNEST	TRS-SEC	01N	25E	34			3273	48	3225	48	>18	2	100	51.8	---	---	2	2	3	
3702	10479	STEDMAN DENNIS	TRS-SEC	01N	25E	34			3273	7	3266	7	>122	4	10	0.6	---	---	2	2	3	
3703	10480	HALLAND DAVE	TRS-SEC	01N	25E	34			3273	---	---	---	---	---	---	5.3	120	3153	2	3	3	poor shallow description
3704	10481	BENDER LYLE	TRS-SEC	01N	25E	34			3273	---	---	---	---	---	---	0.1	---	---	3	3	3	poor log
3705	10482	BOGGESS VIOLA	TRS-SEC	01N	25E	34			3273	125	3148	125	15	2	100	50.9	140	3133	2	2	3	
3706	10483	BURGESS ARNOLD	TRS-SEC	01N	25E	34			3273	---	---	---	---	---	---	297.1	---	---	3	3	3	poor log
3738	170114	WYNDHAM PARK ASSOC.	TRS-SEC	01N	25E	34	DB		3258	41	3217	41	>21	2	100	121.2	---	---	2	2	3	
3739	239888	BILLSTEIN RON	TRS-SEC	01N	25E	34	DB		3258	126	3132	126	>14	2	100	---	---	---	2	3	3	limited aq description

Table A-1. West Billings Study Well Log Review Summary

Identification				Location				Ground Elev. (ft MSL)		Fine-Grained Cap			Aquifer Material				Bedrock/Clay		Data Qualifiers			
										Btm Dpth	Btm Elev	Thkns	Thkns		K (ft/d)		Depth	Elev	Log Quality		Loc	
Map	GWIC	Name	Geo Method	T	R	S	QS	Log	Map	(ft)	(ft MSL)	(ft)	(ft)	Type	Type	WL/Yld	(ft)	(ft MSL)	Contacts	Descr	Qual	Comment
3740	10497	ZIMMERMAN E.M.	TRS-SEC	01N	25E	34	DC		3240	---	---	---	---	---	---	---	---	---	3	3	3	no log
3741	170131	YELLOWSTONE MEMORIAL PARK	TRS-SEC	01N	25E	34	DC		3240	30	3210	30	20	2	100	---	50	3190	2	2	3	
3750	212683	KOWALSKI PAUL	TRS-SEC	01N	25E	10	DB		3425	6	3419	6	30	4	10	---	36	3389	4	4	3	well in Eagle Sandstone
3751	190092	MPC	TRS-SEC	01N	25E	15	AB		3428	7	3421	7	18	2	100	---	25	3403	4	4	3	missing interval 7-18'
3754	131688	GREYSTONE CONDOMINIUM ASSOC	TRS-SEC	01N	25E	34	DBD		3250	33	3217	33	22	2	100	242.1	57	3193	2	2	2	
3755	145017	JOHNSON FLOYD	TRS-SEC	01N	25E	34	DBD		3250	38	3212	38	>22	2	100	105.6	---	---	2	2	2	
3766	10495	KOBER CONST.	TRS-SEC	01N	25E	34	D		3244	16	3228	16	20	2	100	160.4	36	3208	2	2	3	
3767	154979	PREMIER DEVELOPMENT LTD	TRS-SEC	01N	25E	34	D		3244	31	3213	31	20	2	100	69.3	51	3193	2	2	3	
3768	154980	PREMIER DEVELOPMENT LTD	TRS-SEC	01N	25E	34	D		3244	27	3217	27	22	2	100	48.3	49	3195	2	2	3	
3769	161468	PREMIER DEVELOPMENT LTD	TRS-SEC	01N	25E	34	D		3244	20	3224	15	24	2	100	99.0	44	3200	2	2	3	5' gravel in with clay
3777	10425	WALKER EUGENE	TRS-SEC	01N	25E	15	D		3560	0	---	0	>21	4	10	---	---	---	4	4	3	
3798	144306	MANKIN JIM	TRS-SEC	01N	25E	34	DAB		3266	54	3212	54	18	2	100	---	72	3194	2	2	2	
3799	131690	ASPEN MEADOWS	TRS-SEC	01N	25E	34	DDB		3238	24	3214	24	>24	2	100	560.7	---	---	2	2	2	
3815	145016	HOLLAR KENNETH	TRS-SEC	01N	25E	27	DA		3539	---	---	---	---	---	---	---	---	---	3	3	3	poor log
3820	10484	HICKEY J.R.	TRS-SEC	01N	25E	34	AA		3323	0	---	0	>20	2	100	---	---	---	3	3	3	limited description
3821	10485	HILL WALT S.	TRS-SEC	01N	25E	34	AD	3290	3288	0	---	0	24	1	200	14.3	24	3266	2	3	3	no clay. limited aquifer description
3822	10486	BELL DAVID W.	TRS-SEC	01N	25E	34	AD	3117	3288	10	3107	10	96	1	200	83.6	106	3011	2	2	3	assumed 10' clay
3823	192664	MAY FLOWER CHURCH	TRS-SEC	01N	25E	34	AD		3288	78	3210	78	>7	2	100	51.4	---	---	2	2	3	
3824	125035	MICHAEL CALVIN D AND DEBRA L	TRS-SEC	01N	25E	34	DA		3260	38	3222	38	>22	2	100	35.8	---	---	2	2	3	
3825	177314	WYNDHAM PARK ASSOCIATION	TRS-SEC	01N	25E	34	DA		3260	36	3224	36	>19	1	200	108.2	---	---	2	2	3	
3828	208680	SCHRENDER DAVE	TRS-SEC	01N	25E	15	AA		3402	6	3396	6	12	3	50	---	18	3384	4	4	3	
3829	200622	SPARBOE ARON	TRS-SEC	01N	25E	15	DD		3524	8	3516	8	22	3	50	---	30	3494	4	4	3	
3881	230094	APPLEWOOD PATIO HOMES	TRS-SEC	01N	25E	34	ADA		3295	80	3215	80	28	2	100	---	108	3187	2	2	2	
3882	10496	STRIBLEY JOE	TRS-SEC	01N	25E	34	DAA		3268	55	3213	55	20	2	100	64.2	75	3193	2	2	2	
3883	131689	ELIOT STEVE	TRS-SEC	01N	25E	34	DDA		3237	22	3215	22	>23	2	100	229.2	---	---	2	2	2	
3884	134373	WAYLANDER GARY	TRS-SEC	01N	25E	34	DDA		3237	25	3212	25	24	2	100	20.9	49	3188	2	2	2	
3945	10519	DONOVAN GARY W.	TRS-SEC	01N	25E	35	BB		3321	93	3228	93	24	2	100	16.7	117	3204	2	3	3	limited description
3946	10530	DAVIES J.M.	TRS-SEC	01N	25E	35	CC		3229	---	---	---	---	---	---	---	---	---	3	3	3	no log
3947	208480	FARMER DAN	TRS-SEC	01N	25E	35	CC		3229	25	3204	25	>23	2	100	---	---	---	2	3	3	
3954	145015	HAMILTON RICHARD D.	TRS-SEC	01N	25E	26	BCD		3717	---	---	---	---	---	---	---	---	---	4	4	2	Eagle Sandstone
3955	145038	HAMILTON RICHARD	TRS-SEC	01N	25E	26	BCD		3717	---	---	---	---	---	---	---	---	---	4	4	2	Eagle Sandstone
3956	161529	POOL STEVE	TRS-SEC	01N	25E	23	CBA		3690	23	3667	23	---	---	---	---	---	---	4	4	2	"sand rock" below clay
4059	10449	LILLEBERG PHILLIP A.	TRS-SEC	01N	25E	23	C		3696	6	3690	6	---	---	---	0.1	---	---	4	4	3	well in Eagle SS below clay
4062	10522	FRITZ GERALD L.	TRS-SEC	01N	25E	35	C		3240	---	---	---	---	---	---	---	---	---	3	3	3	no log
4063	10523	WALTER RONALD A. MR. & MRS.	TRS-SEC	01N	25E	35	C		3240	30	3210	30	>23	2	100	---	---	---	2	2	3	
4064	10524	SNETTING OMER H.	TRS-SEC	01N	25E	35	C		3240	27	3213	27	>8	2	100	---	---	---	2	2	3	
4065	10525	BROMENSHENK JIM	TRS-SEC	01N	25E	35	C		3240	---	---	---	---	---	---	---	---	---	3	3	3	poor log
4066	10526	RASMUSSEN EDGAR	TRS-SEC	01N	25E	35	C		3240	36	3204	36	36	4	10	40.5	71	3169	2	2	3	
4067	10527	VADNAIS DWIGHT	TRS-SEC	01N	25E	35	C		3240	40	3200	40	>22	2	100	48.6	---	---	2	3	3	10' of quick sand
4068	10528	SPATH RICHARD	TRS-SEC	01N	25E	35	C		3240	45	3195	45	>15	2	100	30.7	---	---	2	2	3	
4071	194004	ASKINS JOHN	TRS-SEC	01N	25E	35	CABB		3263	86	3177	55	>7	2	100	12.0	---	---	2	2	2	31' quick sand in with clay
4072	248992	HALLBERG DONALD AND SHARON	TRS-SEC	01N	25E	11	CDBC		3398	5	3393	5	---	---	---	---	---	---	4	4	2	sandstone below clay
4084	10529	DEMING RONALD L	TRS-SEC	01N	25E	35	CAB		3260	40	3220	40	26	2	100	25.9	66	3194	2	2	2	
4107	10520	LEISCHNER NORM	TRS-SEC	01N	25E	35	BD	3280	3283	26	3254	26	>38	2	100	9.2	---	---	2	2	3	
4108	10521	HIRT JIM	TRS-SEC	01N	25E	35	BD		3283	---	---	---	---	---	---	---	---	---	3	3	3	difficult to interpret log
4109	185988	FOREST PARK HOA *WELL #3	TRS-SEC	01N	25E	35	CA		3252	14	3238	14	21	1	200	---	35	3217	2	3	3	limited aq description
4110	10531	FOX LAND & CATTLE CO	TRS-SEC	01N	25E	35	CD		3232	---	---	---	---	---	---	---	---	---	3	3	3	no log
4111	185989	FOREST PARK HOA *WELL #4	TRS-SEC	01N	25E	35	CD		3232	14	3218	14	21	1	200	---	35	3197	2	3	3	general aquifer description
4112	185991	FOREST PARK HOME OWNERS	TRS-SEC	01N	25E	35	CD		3232	16	3216	16	>24	1	200	---	---	---	2	3	3	general aquifer description
4113	185992	J & E CONSTRUCTION *WELL #2	TRS-SEC	01N	25E	35	CD		3232	15	3217	15	20	2	100	---	35	3197	2	2	3	
4114	185993	J & E CONSTRUCTION *WELL#1	TRS-SEC	01N	25E	35	CD		3232	14	3218	14	20	2	100	---	34	3198	2	2	3	
4115	192667	FOREST PARK HOME OWNERS	TRS-SEC	01N	25E	35	CD		3232	14	3218	14	21	2	100	---	35	3197	2	2	3	
4139	127735	VADNAIS DWIGHT	TRS-SEC	01N	25E	35	CAA		3258	52	3206	51	>13	2	100	55.7	---	---	2	2	2	
4153	10444	NELSEN JOHN	TRS-SEC	01N	25E	23			3595	---	---	---	---	---	---	---	---	---	4	4	3	45' shale then sandstone
4154	252512	JENSEN BRUCE	NAV-GPS	01N	25E	35	BA		3301	95	3206	93	>13	2	100	---	---	---	2	3	1	limited aq description
4158	10499	ROGERS KALE	TRS-SEC	01N	25E	35			3263	65	3198	65	25	2	100	6.7	90	3173	2	2	3	

Table A-1. West Billings Study Well Log Review Summary

Identification				Location				Ground Elev. (ft MSL)		Fine-Grained Cap			Aquifer Material				Bedrock/Clay		Data Qualifiers			
										Btm Dpth	Btm Elev	Thkns	Thkns		K (ft/d)		Depth	Elev	Log Quality		Loc	
Map	GWIC	Name	Geo Method	T	R	S	QS	Log	Map	(ft)	(ft MSL)	(ft)	(ft)	Type	Type	WL/Yld	(ft)	(ft MSL)	Contacts	Descr	Qual	Comment
4159	10500	CHRESTINASEN DEE	TRS-SEC	01N	25E	35			3263	66	3197	66	>19	2	100	8.4	---	---	2	3	3	limited aq description
4160	10501	GRANLIE HAROLD N.	TRS-SEC	01N	25E	35			3263	69	3194	39	19	2	100	14.3	88	3175	2	3	3	limited aq description
4161	10502	RITTER RAY	TRS-SEC	01N	25E	35			3263	35	3228	35	20	1	200	30.9	55	3208	2	3	3	limited aq description
4162	10503	LAMBRECHT JACK	TRS-SEC	01N	25E	35		3160	3263	38	3122	38	25	2	100	---	63	3097	2	3	3	limited descriptions
4163	10504	MCCORMICK RICHARD/ROWLING TIM	TRS-SEC	01N	25E	35			3263	25	3238	25	31	1	200	---	56	3207	2	3	3	limited aq description
4164	10505	YEGON PETER III	TRS-SEC	01N	25E	35			3263	---	---	---	---	---	---	---	---	---	3	3	3	no log
4165	10506	ERICKSON LARRY	TRS-SEC	01N	25E	35			3263	55	3208	55	>40	4	10	5.3	---	---	2	3	3	limited aq description
4166	10507	REINKE HAROLD W.	TRS-SEC	01N	25E	35			3263	40	3223	40	25	2	100	12.7	65	3198	2	2	3	
4167	10508	FERRIS MORTY	TRS-SEC	01N	25E	35			3263	30	3233	30	20	2	100	13.3	50	3213	2	3	3	limited aq description
4168	10509	JOHNSON BOYD W.	TRS-SEC	01N	25E	35			3263	50	3213	50	>7	2	100	14.9	---	---	2	2	3	
4169	10510	PECKHAM JOHN	TRS-SEC	01N	25E	35			3263	70	3193	70	>12	2	100	---	---	---	2	2	3	
4204	177313	PALMER MITCH	TRS-SEC	01N	25E	26	AB		3721	24	3697	24	---	---	---	---	---	---	4	4	3	sandy clay & claystone on sandstone
4211	10448	LECLAIRE ROBERT & FRANCIS	TRS-SEC	01N	25E	23	AC		3592	---	---	---	---	---	---	---	---	---	4	4	3	all sandstone. well in Eagle SS
4212	145014	LECLAIRE ROBERT & FRANCIS B.	TRS-SEC	01N	25E	23	AC		3592	---	---	---	---	---	---	---	---	---	4	4	3	all sandstone. well in Eagle SS
4220	10515	KREJCI ERVIN	TRS-SEC	01N	25E	35	AB		3319	20	3299	20	99	3	50	13.3	119	3200	2	2	3	48' of quick sand
4221	170116	RICE LAUUNNE	TRS-SEC	01N	25E	35	AB		3319	90	3229	90	>12	2	100	48.6	---	---	2	2	3	
4222	177315	KOVASH BRYAN	TRS-SEC	01N	25E	35	AB		3319	91	3228	76	>19	2	100	---	---	---	2	3	3	limited aq description
4223	10516	FERRO ANGELO	TRS-SEC	01N	25E	35	AC		3268	55	3213	55	23	2	100	54.0	78	3190	2	2	3	
4224	10517	MACK GUS	TRS-SEC	01N	25E	35	AC		3268	55	3213	55	20	2	100	57.5	75	3193	2	2	3	
4225	136426	DAVIS JOHN (RESIDENCE) * MW-1	TRS-SEC	01N	25E	35	AC		3268	60	3208	60	>5	4	10	---	---	---	2	2	3	
4226	171758	COLTON HEIGHTS APARTMENT	TRS-SEC	01N	25E	35	DB		3237	33	3204	33	>19	2	100	---	---	---	2	2	3	
4227	10539	ROLANDSON HAZEL	TRS-SEC	01N	25E	35	DC		3227	12	3215	12	>16	2	100	62.7	---	---	3	3	3	12' "topsoil" assumed as clay
4228	195526	STEVENSON ROB	TRS-SEC	01N	25E	35	DC		3227	0	---	0	40	2	100	---	40	3187	2	3	3	no apparent clay cap
4229	208701	STICHMAN BOB	TRS-SEC	01N	25E	35	DC		3227	0	---	0	40	2	100	---	40	3187	2	3	3	no apparent clay cap
4230	208702	EGAN MYLES	TRS-SEC	01N	25E	35	DC		3227	17	3210	17	>23	2	100	---	---	---	2	2	3	
4231	239923	REGER STEVE	TRS-SEC	01N	25E	35	DC		3227	27	3200	27	>22	2	100	---	---	---	2	2	3	
4235	170982	BUILDERS MANAGEMENT INVESTMENT CO.	TRS-SEC	01N	25E	35	DBA		3244	30	3214	30	22	2	100	57.3	52	3192	2	2	2	
4250	10445	WEBER KEN	TRS-SEC	01N	25E	23	A		3596	7	3589	7	---	---	---	0.1	---	---	4	4	3	well in Eagle SS below clay
4251	10511	GAUDET ART	TRS-SEC	01N	25E	35	A		3285	82	3203	82	20	4	10	8.7	102	3183	2	3	3	45' "sand rock" in with clay
4252	10532	KOLPIN N V	TRS-SEC	01N	25E	35	D		3228	0	---	0	59	2	100	25.7	59	3169	2	2	3	no clay described
4253	10533	VALLEY NURSING HOME	TRS-SEC	01N	25E	35	D		3228	0	---	0	>40	2	100	---	---	---	2	2	3	no clay described
4254	10534	FARNHAM FRANK	TRS-SEC	01N	25E	35	D		3228	25	3203	25	31	1	200	51.4	56	3172	2	3	3	limited aq description
4255	10535	ROSE PARK PLAZA PARTNERSHIP	TRS-SEC	01N	25E	35	D		3228	12	3216	12	>19	2	100	84.9	---	---	2	3	3	limited aq description
4256	10536	ROSE PARK PLAZA PARTNERSHIP	TRS-SEC	01N	25E	35	D		3228	7	3221	7	>20	2	100	59.4	---	---	2	3	3	limited aq description
4257	10537	ROSE PARK PLAZA PARTNERSHIP	TRS-SEC	01N	25E	35	D		3228	9	3219	9	>19	2	100	74.3	---	---	2	3	3	limited aq description
4258	10538	ST.THOMAS CATHOLIC CHURCH	TRS-SEC	01N	25E	35	D		3228	30	3198	30	25	1	200	7.0	55	3173	2	3	3	
4281	161462	HERBERT LARRY & DAWN	TRS-SEC	01N	25E	23	AAC		3615	---	---	---	---	---	---	---	---	---	4	4	2	all sandstone
4283	204415	WEBER SHANON	TRS-SEC	01N	25E	2	AAC		3515	18	3497	18	>22	2	100	---	---	---	4	4	2	
4293	10512	HANSEN VICTOR W.	TRS-SEC	01N	25E	35	AA		3309	---	---	---	---	---	---	21.4	---	---	3	3	3	poor log
4294	10513	SARDENSON R. LORIN	TRS-SEC	01N	25E	35	AA		3309	---	---	---	---	---	---	38.2	---	---	3	3	3	poor log
4295	144307	GILMOR CHARLES	TRS-SEC	01N	25E	35	AA		3309	78	3231	78	>17	2	100	---	---	---	2	3	3	limited aq description
4296	10518	KENNEDY DANIEL	TRS-SEC	01N	25E	35	AD		3260	---	---	---	---	---	---	122.9	---	---	3	3	3	poor log
4297	221795	RICHARDSON BLAKE	TRS-SEC	01N	25E	35	AD		3260	33	3227	33	>19	2	100	---	---	---	2	2	3	
4298	253845	DIOCESE OF GREAT FALLS AND BILLINGS	TRS-SEC	01N	25E	35	DA		3230	13	3217	13	26	2	100	---	39	3191	2	2	3	
4299	10540	LEISCHNER HAROLD	TRS-SEC	01N	25E	35	DD		3225	11	3214	11	>17	1	200	125.8	---	---	2	2	3	
4300	10447	KENNEDY KEN	TRS-SEC	01N	25E	23	AA		3629	---	---	---	---	---	---	0.1	---	---	4	4	3	well in Eagle Sandstone
4304	192614	PIHLASA LARRY	TRS-SEC	01N	25E	11	DD		3361	0	---	0	30	4	10	---	30	3331	4	4	3	well in Eagle Sandstone
4305	192650	WISLER JOHN	TRS-SEC	01N	25E	11	DD		3361	0	---	0	25	4	10	---	25	3336	4	4	3	well in Eagle Sandstone
4306	10423	WISLER JOHN	TRS-SEC	01N	25E	14	AA		3418	---	---	---	---	---	---	0.5	---	---	4	4	3	all sandstone. well in Eagle SS
4319	10514	PELLAT JAMES & JONES JAMES	TRS-SEC	01N	25E	35	AAA		3320	---	---	---	---	---	---	9.9	---	---	3	3	2	poor log
4320	170115	NIEBUHN DARIN	TRS-SEC	01N	25E	35	AAD		3288	85	3203	85	19	2	100	139.3	104	3184	2	2	2	
4347	131691	ABBOTT BRUCE	TRS-SEC	01N	25E	36	CCB		3223	7	3216	7	>25	2	100	63.7	---	---	2	2	2	
4355	10572	GUSTAFSON F W	TRS-SEC	01N	25E	36	BB		3295	70	3225	70	24	1	200	8.4	94	3201	2	3	3	limited aq description
4356	10573	COLBERG MAURICE R.	TRS-SEC	01N	25E	36	BB		3295	73	3222	73	30	1	200	1.1	103	3192	2	3	3	limited aq description
4357	10574	ELLIOT MRS H. W.	TRS-SEC	01N	25E	36	BB		3295	---	---	---	---	---	---	4.3	95	3200	2	3	3	only shale contact clear
4358	10575	VOCHEM ROBERT H.	TRS-SEC	01N	25E	36	BB		3295	95	3200	95	20	1	200	---	115	3180	2	3	3	limited aq description

Table A-1. West Billings Study Well Log Review Summary

Identification				Location				Ground Elev. (ft MSL)		Fine-Grained Cap			Aquifer Material				Bedrock/Clay		Data Qualifiers			
										Btm Dpth	Btm Elev	Thkns	Thkns		K (ft/d)		Depth	Elev	Log Quality		Loc	
Map	GWIC	Name	Geo Method	T	R	S	QS	Log	Map	(ft)	(ft MSL)	(ft)	(ft)	Type	Type	WL/Yld	(ft)	(ft MSL)	Contacts	Descr	Qual	Comment
4359	10576	STEEDMAN JOHN	TRS-SEC	01N	25E	36	BC		3254	25	3229	25	>15	1	200	171.9	---	---	2	2	3	
4360	121698	FORSYTHE ANDY (WM A. & PATRICIA S.)	TRS-SEC	01N	25E	36	BC		3254	50	3204	50	>21	2	100	28.8	---	---	2	2	3	
4361	203476	ROCKY MOUNTAIN COLLEGE *MW4-MV4	TRS-SEC	01N	25E	36	BC		3254	---	---	---	---	---	---	---	---	---	3	3	3	poor log
4362	203480	ROCKY MOUNTAIN COLLEGE *MW5-MV5	TRS-SEC	01N	25E	36	BC		3254	---	---	---	---	---	---	---	---	---	3	3	3	poor log
4363	10594	ESTEN ROBERT F.	TRS-SEC	01N	25E	36	CB		3228	---	---	---	---	---	---	---	---	---	3	3	3	no log
4364	10595	SCHREIBER DEAN & DONNA	TRS-SEC	01N	25E	36	CB		3228	---	---	---	---	---	---	---	---	---	3	3	3	no log
4365	10596	BAKER LEO B.	TRS-SEC	01N	25E	36	CB		3228	---	---	---	---	---	---	---	---	---	3	3	3	no log
4366	10597	PARKS EDWARD	TRS-SEC	01N	25E	36	CC	3250	3221	---	---	---	---	---	---	59.4	---	---	3	3	3	poor log
4436	10577	LLOYD HAROLD	TRS-SEC	01N	25E	36	BCA	3440	3261	62	3378	62	17	2	100	8.1	79	3361	2	3	2	limited aq description
4437	122629	TESKY THEUPHIL	TRS-SEC	01N	25E	36	BCA		3261	40	3221	40	>26	2	100	34.3	---	---	2	2	2	
4453	10569	REICHERT ED	TRS-SEC	01N	25E	36	B		3266	---	---	---	---	---	---	7.1	---	---	3	3	3	poor log
4454	145298	SASICH MIKE	TRS-SEC	01N	25E	36	B		3266	72	3194	72	19	2	100	---	91	3175	2	3	3	limited aq description
4455	10581	STRATTON JAMES	TRS-SEC	01N	25E	36	C		3222	---	---	---	---	---	---	---	---	---	3	3	3	no log
4456	10582	STALEY GEORGE H. & MARY A.	TRS-SEC	01N	25E	36	C		3222	---	---	---	---	---	---	---	---	---	3	3	3	no log
4457	10583	MARCUS CHARLES E. & CARROLL E.	TRS-SEC	01N	25E	36	C	3117	3222	---	---	---	---	---	---	45.7	---	---	3	3	3	no log
4458	10584	JOVANOVICH GEORGE	TRS-SEC	01N	25E	36	C		3222	---	---	---	---	---	---	---	---	---	3	3	3	no log
4459	10585	GRENG CARL C.	TRS-SEC	01N	25E	36	C		3222	0	---	0	>21	2	100	---	---	---	3	3	3	limited descrip, no clay noted
4460	10586	SCHLEINGER EDWARD J. SR.	TRS-SEC	01N	25E	36	C	3220	3222	0	---	0	>21	2	100	---	---	---	3	3	3	limited descrip, no clay noted
4461	10587	MCPANN DOROTHY G.	TRS-SEC	01N	25E	36	C		3222	---	---	---	---	---	---	133.7	---	---	3	3	3	no log
4462	10588	WRIGHT HERBERT J. & SHIRLEY N.	TRS-SEC	01N	25E	36	C		3222	---	---	---	---	---	---	---	---	---	3	3	3	no log
4463	10589	MCBRIDE JACK	TRS-SEC	01N	25E	36	C		3222	---	---	---	---	---	---	---	---	---	3	3	3	no log
4464	10590	HAHM ED	TRS-SEC	01N	25E	36	C		3222	4	3218	4	>21	1	200	935.9	---	---	2	3	3	limited descrip, no clay noted
4465	10591	JAMISON BURL	TRS-SEC	01N	25E	36	C		3222	---	---	---	---	---	---	84.9	---	---	3	3	3	poor log
4466	10592	RINEHART GARTH W.	TRS-SEC	01N	25E	36	C		3222	5	3217	5	>21	4	10	---	---	---	2	3	3	limited aq description
4507	124852	LOGAN MARJORIE P	TRS-SEC	01N	25E	25	CD		3339	---	---	---	---	---	---	---	---	---	3	3	3	no log
4508	254250	CITY OF BILLINGS	TRS-SEC	01N	25E	25	CD		3339	30	3309	30	5	4	10	---	---	---	2	3	3	limited aq description
4510	10570	SCARIANO RONALD & SUE	TRS-SEC	01N	25E	36	BA		3281	76	3205	24	22	2	100	167.1	98	3183	2	1	3	sand/clay on top of clay
4511	10571	LDS MISSION CENTER	TRS-SEC	01N	25E	36	BA		3281	104	3177	104	16	2	100	---	120	3161	2	3	3	limited aq description
4512	145018	STANFORD COURT CONDO ASSO.	TRS-SEC	01N	25E	36	BA		3281	80	3201	80	23	3	50	15.8	103	3178	2	2	3	
4513	145019	STANFORD COUNT CONDO ASSC.	TRS-SEC	01N	25E	36	BA		3281	81	3200	76	18	2	100	60.4	99	3182	2	2	3	
4514	162981	BILLING CONOCO POLLY DR & 17TH W	TRS-SEC	01N	25E	36	BA		3281	52	3229	52	>3	2	100	---	---	---	2	2	3	
4515	162990	BILLINGS CONOCO POLY DR & 17TH WEST	TRS-SEC	01N	25E	36	BA		3281	51	3230	51	>6	2	100	---	---	---	2	2	3	
4516	162992	BILLINGS CONOCO POLY DR & 17TH WEST	TRS-SEC	01N	25E	36	BA		3281	51	3230	51	>5	2	100	---	---	---	2	2	3	
4517	162994	BILLINGS CONOCO POLY DR & 17TH WEST	TRS-SEC	01N	25E	36	BA		3281	51	3230	51	>6	2	100	---	---	---	2	2	3	
4518	162997	BILLINGS CONOCO POLY DR & 17TH WEST	TRS-SEC	01N	25E	36	BA		3281	48	3233	48	>7	2	100	---	---	---	2	2	3	
4519	163000	BILLINGS CONOCO POLY DR & 17TH WEST	TRS-SEC	01N	25E	36	BA		3281	47	3234	47	>10	2	100	---	---	---	2	2	3	
4520	163002	BILLINGS CONOCO POLY DR & 17TH WEST	TRS-SEC	01N	25E	36	BA		3281	47	3234	47	>9	2	100	---	---	---	2	2	3	
4521	216658	THE GRANARY	TRS-SEC	01N	25E	36	BA		3281	38	3243	38	>20	2	100	---	---	---	2	2	3	
4522	10578	LA FEVER NEAL	TRS-SEC	01N	25E	36	BD		3243	54	3189	54	>12	2	100	---	---	---	3	2	3	unclear clay-sand contact
4523	10579	PAMAN RALPH F.	TRS-SEC	01N	25E	36	BD	3135	3243	19	3116	19	>19	1	200	24.8	---	---	3	3	3	interbedded, limited description
4524	216665	JOHNSON NANCY	TRS-SEC	01N	25E	36	BD		3243	8	3235	8	>22	2	100	---	---	---	2	3	3	limited aq description
4525	10593	REESE GUY	TRS-SEC	01N	25E	36	CA		3223	4	3219	4	>21	1	200	---	---	---	2	3	3	limited descriptions
4526	192669	KURKOWSKI JOE	TRS-SEC	01N	25E	36	CD		3218	5	3213	5	22	2	100	22.5	27	3191	2	2	3	
4540	247370	ROLFSON ERLING	NAV-GPS	01N	25E	36	AC		3222	14	3208	14	>22	2	100	---	---	---	2	2	1	
4541	140306	MILLS BILL	TRS-SEC	01N	25E	36	BAA		3287	70	3217	70	>26	2	100	76.4	---	---	2	2	2	
4542	10580	PETERSON D.E.	TRS-SEC	01N	25E	36	BDA		3248	44	3204	44	>21	2	100	---	---	---	2	2	2	
4543	170611	AYRE DAVE & CHARLOTTE	TRS-SEC	01N	25E	36	BDA		3248	---	---	---	---	---	---	---	---	---	3	3	2	no log
4544	211530	GULBRANDSON DAVID AND DANIELLE	TRS-SEC	01N	25E	36	CDA		3216	10	3206	10	20	2	100	247.3	30	3186	2	2	2	
4545	239838	MONTANA MUNICIPAL INSURANCE	NAV-GPS	01N	25E	25	CDA		3349	0	---	0	16	5	1	---	16	3333	2	3	1	bedrock interp not certain
4549	239894	MONTANA MUNICIPAL INSURANCE	NAV-GPS	01N	25E	25	CDA		3332	10	3322	10	>7	5	1	---	---	---	3	3	1	clay/sand descriptions not clear
4556	239900	MONTANA MUNICIPAL INSURANCE	NAV-GPS	01N	25E	25	CDA		3342	0	---	0	>15	4	10	---	---	---	2	2	1	no distinct clay layer
4558	239898	MONTANA MUNICIPAL INSURANCE	NAV-GPS	01N	25E	25	CDA		3341	0	---	0	10	5	1	---	10	3331	2	3	1	bedrock interp not certain
4559	10541	HOPKINS LARRY	TRS-SEC	01N	25E	36			3227	65	3162	65	25	2	100	10.1	90	3137	2	2	3	
4560	10542	WRENCH J A	TRS-SEC	01N	25E	36			3227	---	---	---	---	---	---	---	---	---	3	3	3	poor log
4561	10543	BROWN KEITH	TRS-SEC	01N	25E	36			3227	50	3177	50	26	2	100	108.4	76	3151	2	2	3	
4562	10544	OFFT HENRY S.	TRS-SEC	01N	25E	36			3227	6	3221	6	>22	2	100	62.7	---	---	2	2	3	

Table A-1. West Billings Study Well Log Review Summary

Identification				Location				Ground Elev. (ft MSL)		Fine-Grained Cap			Aquifer Material				Bedrock/Clay		Data Qualifiers			
															K (ft/d)				Log Quality		Loc	
Map	GWIC	Name	Geo Method	T	R	S	QS	Log	Map	Btm Dpth (ft)	Btm Elev (ft MSL)	Thkns (ft)	Thkns (ft)	Type	Type	WL/Yld	Depth (ft)	Elev (ft MSL)	Contacts	Descr	Qual	Comment
4563	10545	CERNOHLAVEK LEWIS	TRS-SEC	01N	25E	36		3115	3227	11	3104	11	>10	2	100	---	---	---	3	3	3	assumed clay thkns, lim aq desc
4564	10546	BAILEY EARL C.	TRS-SEC	01N	25E	36			3227	---	---	---	---	---	---	---	---	---	3	3	3	no log
4565	10547	GOOD LLOYD R.	TRS-SEC	01N	25E	36			3227	---	---	---	---	---	---	297.1	---	---	3	3	3	poor log
4566	10548	MASSICK JOHN L.	TRS-SEC	01N	25E	36			3227	---	---	---	---	---	---	222.8	---	---	3	3	3	poor log
4567	10549	LUNNEY JOHN	TRS-SEC	01N	25E	36			3227	17	3210	17	>8	1	200	---	---	---	2	3	3	limited descriptions
4568	10550	SCHMIDT JERRY	TRS-SEC	01N	25E	36			3227	5	3222	5	>20	1	200	---	---	---	2	3	3	limited descriptions
4569	10551	LARSEN R.L.	TRS-SEC	01N	25E	36			3227	---	---	---	---	---	---	148.6	---	---	3	3	3	poor log
4570	10552	MAJERUS GERALD F.	TRS-SEC	01N	25E	36			3227	20	3207	20	50	2	100	---	70	3157	2	3	3	limited aq description
4571	10553	COREY HOWARD	TRS-SEC	01N	25E	36			3227	10	3217	10	>13	1	200	1050.5	---	---	2	3	3	limited descriptions
4572	10554	CORCORAN EDWARD	TRS-SEC	01N	25E	36			3227	10	3217	10	>14	1	200	1050.5	---	---	2	3	3	limited descriptions
4573	10555	HELGER EDWIN	TRS-SEC	01N	25E	36			3227	---	---	---	---	---	---	9.0	---	---	3	3	3	poor log
4574	10556	JOHNSON RODGER	TRS-SEC	01N	25E	36			3227	0	---	0	>20	2	100	222.8	---	---	2	2	3	no clay described
4575	10557	KOBER JOHN	TRS-SEC	01N	25E	36			3227	---	---	---	---	---	---	---	---	---	3	3	3	no log
4576	10558	MITCHELL BERNE	TRS-SEC	01N	25E	36			3227	---	---	---	---	---	---	---	---	---	3	3	3	no log
4577	10559	MERCHEN GEORGE M.	TRS-SEC	01N	25E	36			3227	25	3202	25	21	2	100	133.7	---	---	2	2	3	
4578	10560	SIMONS LOIS	TRS-SEC	01N	25E	36			3227	---	---	---	---	---	---	---	---	---	3	3	3	no log
4579	10561	HENSLEY CHARLES	TRS-SEC	01N	25E	36			3227	---	---	---	---	---	---	---	---	---	3	3	3	no log
4580	10562	WHITMYER CARL	TRS-SEC	01N	25E	36			3227	0	---	0	>28	2	100	123.8	---	---	2	3	3	no clay described
4581	10563	BOLAND FLOYD J	TRS-SEC	01N	25E	36			3227	---	---	---	---	---	---	107.0	---	---	3	3	3	no log
4582	10564	RICKETT GLEN E.	TRS-SEC	01N	25E	36			3227	52	3175	52	23	1	200	6.4	---	---	2	3	3	limited aq description
4583	103055	CITY OF BILLINGS	TRS-SEC	01N	25E	36			3227	0	---	0	>28	2	100	---	---	---	2	3	3	no clay, limited aq desc
4584	103066	BILLINGS CITY OF	TRS-SEC	01N	25E	36			3227	0	---	0	>29	2	100	---	---	---	2	3	3	no clay, limited aq desc
4585	239899	MONTANA MUNICIPAL INSURANCE	NAV-GPS	01N	25E	25	CDA		3340	0	---	0	14	5	1	---	14	3326	2	3	1	bedrock interp not certain
4615	144308	ROCKY MOUNTAIN COLLEGE	TRS-SEC	01N	25E	36	ABCC		3257	46	3211	46	29	2	100	---	75	3182	2	2	2	
4624	180468	ROCKY MOUNTAIN COLLEGE	TRS-SEC	01N	25E	36	AB		3273	---	---	---	---	---	---	---	---	---	3	3	3	no log
4625	180469	ROCKY MOUNTAIN COLLEGE	TRS-SEC	01N	25E	36	AB		3273	---	---	---	---	---	---	---	---	---	3	3	3	no log
4626	177316	LEGACY HOMES	TRS-SEC	01N	25E	36	AC		3237	44	3193	44	>23	2	100	197.2	---	---	2	2	3	
4627	10619	KENNEDY DAVID W.	TRS-SEC	01N	25E	36	DB		3215	10	3205	10	>15	2	100	---	---	---	2	3	3	assumed top 10 ft is clay
4628	10620	JOHANNES JOHN F.	TRS-SEC	01N	25E	36	DB		3215	---	---	---	---	---	---	---	---	---	3	3	3	no log
4647	10422	WESTON KENNETH S	TRS-SEC	01N	25E	12	D		3348	---	---	---	---	---	---	3.6	---	---	4	4	3	well in Eagle Sandstone
4648	10598	MORSE SIDNEY & FRAN	TRS-SEC	01N	25E	36	D		3209	15	3194	15	>10	1	200	---	---	---	2	3	3	limited aq description
4649	10599	LAWRENZ MARTIN E.	TRS-SEC	01N	25E	36	D		3209	0	---	0	>27	2	100	81.9	---	---	2	2	3	no clay described
4650	10600	MCCANN THOMAS	TRS-SEC	01N	25E	36	D		3209	---	---	---	---	---	---	27.9	---	---	3	3	3	poor log
4651	10601	KOBER AMELIA	TRS-SEC	01N	25E	36	D		3209	---	---	---	---	---	---	---	---	---	3	3	3	no log
4652	10602	RAMSETT WILLARD H.	TRS-SEC	01N	25E	36	D		3209	0	---	0	>25	2	100	---	---	---	2	3	3	no clay described, lim aq descrip.
4653	10603	BEVEN THOMAS D.	TRS-SEC	01N	25E	36	D		3209	---	---	---	---	---	---	---	---	---	3	3	3	no log
4654	10604	ISAACSON BRUCE D.	TRS-SEC	01N	25E	36	D	3200	3209	16	3184	16	>9	4	10	107.7	---	---	2	3	3	limited aq description
4655	10605	BAILEY WILLIAM	TRS-SEC	01N	25E	36	D		3209	4	3205	4	>21	1	200	719.9	---	---	2	2	3	
4656	10606	COOK KENNARD K	TRS-SEC	01N	25E	36	D	3200	3209	15	3185	15	>8	4	10	101.9	---	---	2	3	3	limited aq description
4657	10607	CLAXTON ROY C.	TRS-SEC	01N	25E	36	D		3209	---	---	---	---	---	---	37.1	---	---	3	3	3	poor log
4675	10618	MCKINNEY CHARLES G.	TRS-SEC	01N	25E	36	DAC		3210	---	---	---	---	---	---	---	---	---	3	3	2	no log
4684	209840	MANDIN DALE	TRS-SEC	01N	25E	1	AABA		3351	5	3346	5	24	2	100	---	29	3322	4	4	2	
4691	171759	ROCKY MOUNTAIN COLLEGE	TRS-SEC	01N	25E	36	AA		3267	53	3214	53	22	2	100	135.5	75	3192	2	2	3	
4692	172049	ROCKY MOUNTAIN COLLEGE	TRS-SEC	01N	25E	36	AA		3267	72	3195	72	20	3	50	35.9	92	3175	2	2	3	
4693	10565	CAIN GLENN M.	TRS-SEC	01N	25E	36	AD		3226	---	---	---	---	---	---	---	---	---	3	3	3	no log
4694	10566	LANG JACK C.	TRS-SEC	01N	25E	36	AD		3226	---	---	---	---	---	---	---	---	---	3	3	3	no log
4695	10567	HARLOW FRANK	TRS-SEC	01N	25E	36	AD		3226	4	3222	4	>18	1	200	649.4	---	---	2	2	3	
4696	10568	DOMAN LLOYD E.	TRS-SEC	01N	25E	36	AD		3226	---	---	---	---	---	---	48.6	---	---	3	3	3	no log
4697	195524	ROCKY PLAZA	TRS-SEC	01N	25E	36	AD		3226	32	3194	32	18	2	100	---	50	3176	2	2	3	
4698	10609	PURSELL DAVID	TRS-SEC	01N	25E	36	DA		3212	---	---	---	---	---	---	---	---	---	3	3	3	no log
4699	10610	DROSTE LEONARD H & MARJORIE A	TRS-SEC	01N	25E	36	DA	3600	3212	0	---	0	>45	2	100	---	---	---	2	3	3	no clay described
4700	10611	DEWEY KIRK M.	TRS-SEC	01N	25E	36	DA		3212	---	---	---	---	---	---	---	---	---	3	3	3	no log
4701	10612	BARNES LETA	TRS-SEC	01N	25E	36	DA		3212	8	3204	8	>13	1	200	---	---	---	2	3	3	limited descriptions
4702	10613	KUHL SYDNEY M & VALBERG S	TRS-SEC	01N	25E	36	DA		3212	---	---	---	---	---	---	148.6	---	---	3	3	3	no log
4703	10614	CITY OF BILLINGS	TRS-SEC	01N	25E	36	DA		3212	10	3202	10	>17	2	100	178.3	---	---	2	2	3	
4704	10616	STEELE BILL	TRS-SEC	01N	25E	36	DA		3212	3	3209	3	>21	1	200	649.4	---	---	2	2	3	

Table A-1. West Billings Study Well Log Review Summary

Identification				Location				Ground Elev. (ft MSL)		Fine-Grained Cap			Aquifer Material				Bedrock/Clay		Data Qualifiers			
															K (ft/d)				Log Quality		Loc	
Map	GWIC	Name	Geo Method	T	R	S	QS	Log	Map	Btm Dpth (ft)	Btm Elev (ft MSL)	Thkns (ft)	Thkns (ft)	Type	Type	WL/Yld	Depth (ft)	Elev (ft MSL)	Contacts	Descr	Qual	Comment
4705	10621	SAUNDERS MRS EARLICE	TRS-SEC	01N	25E	36	DD		3208	---	---	---	---	---	---	---	---	---	3	3	3	no log
4706	10622	HOLT NORMA	TRS-SEC	01N	25E	36	DD		3208	4	3204	4	>20	1	200	1470.7	---	---	2	2	3	
4707	10623	EVERGREEN SHOPPING CENTER	TRS-SEC	01N	25E	36	DD		3208	---	---	---	---	---	---	---	---	---	3	3	3	no log
4708	208703	KETTERLING BONNIE	TRS-SEC	01N	25E	36	DD		3208	8	3200	8	>20	2	100	---	---	---	2	2	3	
4709	234852	HENRICKSON BOB*LS-1	TRS-SEC	01N	25E	36	DD		3208	6	3202	6	>14	2	100	---	---	---	2	2	3	
4710	234853	HENRICKSON BOB*LS-2	TRS-SEC	01N	25E	36	DD		3208	5	3203	5	>15	2	100	---	---	---	2	2	3	
4711	234854	HENRICKSON BOB*LS-5	TRS-SEC	01N	25E	36	DD		3208	5	3203	5	>15	2	100	---	---	---	2	2	3	
4712	234855	HENRICKSON BOB*LS-4	TRS-SEC	01N	25E	36	DD		3208	5	3203	5	>15	2	100	---	---	---	2	2	3	
4713	234856	HENRICKSON BOB*LS-3	TRS-SEC	01N	25E	36	DD		3208	5	3203	5	>15	2	100	---	---	---	2	2	3	
4731	10617	JOHNSTON JOHN F. & SHIRLEY	TRS-SEC	01N	25E	36	DAA		3214	12	3202	12	>16	2	100	---	---	---	2	3	2	assumed upper 12' is clay
8056	207217	OLSEN PETE AND LINDA	NAV-GPS	01S	24E	6	ADC		3442	35	3407	27	7	2	100	135.5	42	3400	2	3	1	8' "rubble" in clay
8059	92730	OLSEN PETER	MAP	01S	24E	6	DABA	3440	3438	30	3410	30	20	2	100	11.0	50	3390	2	3	2	
8060	158555	OLSEN PETE	MAP	01S	24E	6	DAAB	3440	3428	---	---	---	---	---	---	---	---	---	3	3	2	no log
8080	10332	MCFARLAND CLINTON	MAP	01N	24E	6	CCAD		4154	---	---	---	---	---	---	1.5	---	---	4	4	2	sandstone?
8085	10333	MCFARLAND CLINTON B.	MAP	01N	24E	6	CDC	4155	4150	---	---	---	---	---	---	---	---	---	4	4	2	no log
8115	202562	PELICAN FRANK	NAV-GPS	01S	24E	28	BCA	---	3744	---	---	---	---	---	---	---	---	---	4	4	3	very poor log
8116	10336	MCFARLAND CLINT AND TED	MAP	01N	24E	7	ADAD	4175	4177	---	---	---	---	---	---	---	---	---	4	4	2	no log
8125	124880	PETERSON RICHARD	MAP	01S	24E	9	BAAB	3420	3422	38	3382	38	7	2	100	40.1	45	3375	2	2	2	
8165	158556	NORTHERN SKIES AVIATION	MAP	01S	24E	34	CBCB	3475	3469	---	---	---	---	---	---	---	---	---	3	3	3	no log
8166	224969	TEEGARDON TOM	NAV-GPS	02S	24E	3	CDB	---	3459	24	3435	11	24	2	100	---	48	3411	2	2	1	13' gravel on top of clay
8173	187143	HATTON JAY/SANDRA	NAV-GPS	02S	24E	3	CD		3396	15	3381	15	9	2	100	11.6	24	3372	2	2	1	
8180	705275	KRAFT B	UNKNOWN	01S	24E	10	BDAA	3380	3379	---	---	---	---	---	---	---	---	---	3	3	2	no log
8182	218658	COONEY TODD	NAV-GPS	01S	24E	34	ADA	---	3448	53	3395	53	>8	2	100	---	---	---	2	2	1	
8185	145415	MELBY ED	MAP	01S	24E	34	DDCD	3380	3376	10	3370	10	>45	1	200	22.7	---	---	2	2	2	16' clay in the gravel
8186	705277	RATLIFF R	UNKNOWN	01S	24E	15	AAAB	3440	3399	---	---	---	---	---	---	---	---	---	3	3	2	no log
8190	705281	KRAFT R	UNKNOWN	01S	24E	35	BCCC	3390	3386	---	---	---	---	---	---	---	---	---	3	3	3	no log
8192	92731	PAULSEN WELDON	MAP	01S	24E	11	BDDC	3370	3376	60	3310	60	5	2	100	0.05	65	3305	2	2	2	wekk in shale
8193	91	WORMSER JOSEPH * 3 MI NW RIMROCK MT	UNKNOWN	01N	24E	10	C		3829	---	---	---	---	---	---	---	---	---	4	4	3	no log
8205	126396	MCFARLAND TED	MAP	01N	24E	10	DBBD	3780	3783	---	---	---	---	---	---	0.1	---	---	4	4	2	no shallow detail
8207	10345	MCFARLAND TED	MAP	01N	24E	10	DBDB		3763	---	---	---	---	---	---	0.3	---	---	4	4	2	Eagle Sandstone
8208	126414	YAGER JIM	MAP	01S	24E	11	DAAD	3355	3353	48	3307	48	4	2	100	---	52	3303	2	2	2	
8209	6961	KRAFT J * 13 MI SW BILLINGS	MAP	01S	24E	23	DDDD	3370	3357	---	---	---	---	---	---	---	---	---	4	4	2	poor log
8210	705276	BEARTOOTH FARM	MAP	01S	24E	14	AAAD	3340	3333	---	---	---	---	---	---	---	---	---	3	3	2	no log
8211	705280	FOX L	UNKNOWN	01S	24E	26	DDAA	3350	3342	---	---	---	---	---	---	---	---	---	3	3	3	no log
8213	92738	GRICE PAUL	MAP	01S	24E	12	CCCC	3325	3323	---	---	---	---	---	---	---	---	---	3	3	2	no log
8214	218576	LOVE JEFF	NAV-GPS	02S	24E	2	DCA		3465	0	---	0	>35	1	200	495.9	---	---	4	4	1	no apparent clay
8219	145000	LINDA	MAP	01N	24E	22	AAAA	3580	3560	---	---	---	---	---	---	---	---	---	3	3	2	difficult to interpret log
8220	158591	DALTON JESSIE	MAP	01N	24E	35	CCCB	3435	3435	---	---	---	---	---	---	---	---	---	4	4	2	no log
8223	204922	STRAW MARIE	NAV-GPS	01N	24E	23	BDA		3547	---	---	---	---	---	---	---	---	---	2	3	1	sandstone and shale
8228	138308	HENDERSON ED	UNKNOWN	01N	24E	23	ABCC	3530	3537	35	3495	35	37	4	10	---	72	3458	2	2	2	sandstone on top of shale
8232	10364	AMAN MELVIN	UNKNOWN	01N	24E	23	ACBA		3520	---	---	---	---	---	---	10.8	---	---	3	3	2	all sandstone
8233	138310	CAMPEN EDWARD AND ELIZABETH	UNKNOWN	01N	24E	23	ACBD		3507	37	3470	37	14	4	10	9.1	51	3456	2	2	2	sandstone on top of shale
8236	10362	BIRLZ ALLEN G	UNKNOWN	01N	24E	23	ACA		3527	---	---	---	---	---	---	---	55	3472	3	3	2	poor shallow detail
8237	138309	BIRLZ ALLEN G	UNKNOWN	01N	24E	23	ACA	3620	3527	---	---	---	---	---	---	---	---	---	3	3	2	no log
8238	6959	LENHARDT E * 11.5 MI WSW BILLINGS P.O.	MAP	01S	24E	13	AADD	---	3307	---	---	---	---	---	---	---	---	---	3	3	2	poor log, indicates "quick sand"
8239	10384	KAERCHER JAMES	UNKNOWN	01N	24E	23	ABD		3560	40	3520	40	50	4	10	---	90	3470	2	2	2	sandstone on top of shale
8241	92	HUSBAND R.W. * 11.5 MI SE MOLT MT	UNKNOWN	01N	24E	11	D		3793	---	---	---	---	---	---	---	---	---	4	4	3	no log
8245	10326	CELLMER LAWRENCE	MAP	01N	24E	2	AABC		3698	---	---	---	---	---	---	---	13	3685	4	4	2	difficult to interpret log above shale
8247	10374	BARKER JAMES	UNKNOWN	01N	24E	23	ADB		3570	---	---	---	---	---	---	2.2	40	3530	3	3	2	40' sand and clay on top of shale
8248	10376	TOAVS WARREN OR BONNY	UNKNOWN	01N	24E	23	ADC	3500	3501	30	3470	30	---	---	---	1.1	---	---	2	3	2	poor detail below clay
8254	10368	BARNHART BILL	UNKNOWN	01N	24E	23	ADCB	3500	3501	39	3461	39	21	4	10	5.0	72	3428	2	2	2	
8255	143880	LENHARDT FREDERICK	MAP	01S	25E	18	BBCA	3310	3307	26	3284	26	14	4	10	1.4	40	3270	2	2	2	
8257	10400	WILSON BARB	MAP	01N	24E	35	DDAB	3390	3386	28	3362	28	12	3	50	20.3	40	3350	2	2	2	
8263	155351	HERMES CYNTHIA	NAV-GPS	01N	24E	23	ADDB	3500	3501	---	---	---	---	---	---	---	---	---	3	3	1	no log
8264	6964	FISHER H	MAP	01S	25E	6	BBDA	3396	3392	---	---	---	---	---	---	---	---	---	3	3	3	no log
8265	10399	WILSON BARB	MAP	01N	24E	35	DADD		3389	53	3336	53	0	---	---	---	53	3336	4	4	2	well in shale

Table A-1. West Billings Study Well Log Review Summary

Identification				Location				Ground Elev. (ft MSL)		Fine-Grained Cap			Aquifer Material				Bedrock/Clay		Data Qualifiers			
															K (ft/d)				Log Quality		Loc	
Map	GWIC	Name	Geo Method	T	R	S	QS	Log	Map	Btm Dpth (ft)	Btm Elev (ft MSL)	Thkns (ft)	Thkns (ft)	Type	Type	WL/Yld	Depth (ft)	Elev (ft MSL)	Contacts	Descr	Qual	Comment
8266	10401	WILSON BARBARA	MAP	01N	24E	35	DADD	3390	3389	0	---	0	>36	2	100	22.1	---	---	2	3	2	limited descrip, no clay noted
8267	10382	COE MRS	MAP	01N	24E	23	ADDA	3540	3527	---	---	---	---	---	---	---	---	---	2	2	2	17' clay and sand on top of sandstone
8283	705285	SCHLAEPPI NEIL	MAP	01S	25E	6	AABB	3355	3350	---	---	---	---	---	---	---	---	---	3	3	2	no log
8287	158590	CDP CONSTRUCTION	MAP	01S	25E	7	ADAC	3320	3327	---	---	---	---	---	---	---	---	---	3	3	2	no log
8295	192661	GUNDLACH SHANE *WELL NO.3	NAV-GPS	01N	25E	19	DBD		3638	---	---	---	---	---	---	---	---	---	4	4	1	poor log
8297	158941	YELLOWSTONE COUNTRY CLUB	NAV-GPS	01N	25E	30	BBCA	3415	3409	---	---	---	---	---	---	---	---	---	3	3	1	no log
8298	131686	CELLMER LAWRENCE	MAP	01N	25E	6	BBDC	3600	3586	44	3556	44	3	4	10	3.3	47	3553	4	4	2	well in Eagle Sandstone
8301	192654	GUNDLACH SHANE *WELL NO.2	NAV-GPS	01N	25E	19	DBB		3596	49	3547	49	0	---	---	---	49	3547	4	4	1	no sand
8305	212782	CAFTE TAMMY	NAV-GPS	01N	25E	31	BDC		3343	34	3309	34	>14	3	50	13.2	---	---	2	3	1	limited aq description
8306	158940	YELLOWSTONE COUNTRY CLUB	MAP	01N	25E	30	CACB	3390	3392	---	---	---	---	---	---	---	---	---	3	3	2	no log
8307	10457	CARAWAY HERB	UNKNOWN	01N	25E	31	BABA	3370	3366	---	---	---	---	---	---	607.7	---	---	3	3	2	no log
8308	705257	CARAWAY H	UNKNOWN	01N	25E	31	BABA	3370	3366	---	---	---	---	---	---	---	---	---	3	3	2	no log
8310	192658	GUNDLACH SHANE *WELL NO.1	NAV-GPS	01N	25E	19	DBD		3481	12	3469	12	---	---	---	---	---	---	3	3	1	sandstone below clay
8311	158552	OWNER UNKNOWN FROM GWCP03	MAP	01N	25E	31	BAAD	3360	3363	---	---	---	---	---	---	---	---	---	3	3	2	no log
8313	10456	MESSER JOHN	MAP	01N	25E	31	BAAA	3370	3369	0	---	0	39	5	1	0.2	39	3331	3	3	2	error in depths
8316	145012	HOPE EVANGELICAL CHURCH	MAP	01S	25E	4	BBBB		3317	81	3236	79	>15	2	100	---	---	---	2	3	2	
8330	95	DEINES S * 6 MI BILLINGS MT	MAP	01N	25E	32	CCCC	3313	3310	---	---	---	---	---	---	---	---	---	3	3	2	log starts at 130'
8331	10459	DEINES SOLOMAN	UNKNOWN	01N	25E	32	CCCC	3313	3310	---	---	---	---	---	---	---	---	---	3	3	2	no log
8342	149794	PIERCE CHARLES D.	MAP	01N	25E	29	BBAD	3800	3799	---	---	---	---	---	---	---	---	---	4	4	2	sandstone & shale. well in Eagle SS
8350	10435	RUBLE ROBERT T	MAP	01N	25E	17	CDAB	3580	3573	0	---	0	60	4	10	0.1	60	3520	4	4	2	well in Eagle SS below shale
8353	144298	CELLMER LAWRENCE	MAP	01N	25E	8	CDDD	3515	3507	---	---	---	---	---	---	---	35	3480	4	4	2	Eagle ss. 5' clay above shale
8379	142500	HOLZHEIMER DON	MAP	01N	25E	5	DACD	3530	3533	0	---	0	18	5	1	2.5	18	3512	4	4	2	well in Eagle Sandstone
8383	13293	CELLMER LAWRENCE	MAP	01N	25E	5	AB	3600	3589	30	3570	30	10	4	10	---	40	3560	4	4	3	well in Eagle Sandstone
8386	248803	ALEFTERAS KENNY AND ECHO	SUR-GPS	01N	25E	9	CB		3635	0	---	0	48	4	10	---	48	3587	4	4	1	sandstone on shale. long well screen
8393	93	MALIN YATES CO * 10 MI NW BILLINGS MT	UNKNOWN	01N	25E	4	C		3586	---	---	---	---	---	---	---	---	---	4	4	3	no log
8396	186845	CULVER GENE/ KINCADE LAND LLC	NAV-GPS	01N	25E	33			3288	63	3225	63	>12	2	100	---	---	---	2	2	1	
8399	10471	HANSON CLARENCE	MAP	01N	25E	33	ABDD	3342	3345	---	---	---	---	---	---	4.2	---	---	3	3	3	difficult to interpret log
8400	705258	HANSON	UNKNOWN	01N	25E	33	ABDC	3341	3344	---	---	---	---	---	---	---	---	---	3	3	2	no log
8439	890470	DEELEEUW	UNKNOWN	01N	25E	26	CAAB	3705	3704	---	---	---	---	---	---	---	---	---	4	4	2	no log
8448	150171	JOHNSON DAVID F. & DENISE D.	MAP	01N	25E	23	AACB		3594	---	---	---	---	---	---	---	---	---	4	4	2	all sandstone. well in Eagle SS
8449	10446	JOHNSON DAVE	MAP	01N	25E	23	AACD	3560	3555	---	---	---	---	---	---	0.04	---	---	4	4	2	160' of sandstone. well in Eagle SS
8460	705262	CITY OF BILLINGS	UNKNOWN	01N	25E	36	CBDA	3222	3225	---	---	---	---	---	---	---	---	---	3	3	2	no log
8461	705263	CITY WATER DEPT	UNKNOWN	01N	25E	36	CCAA	3222	3220	---	---	---	---	---	---	---	---	---	3	3	2	no log
8464	705256	USGS	UNKNOWN	01N	25E	25	CD	3310	3309	---	---	---	---	---	---	---	---	---	3	3	3	no log
8465	705261	CITY WATER DEPT	UNKNOWN	01N	25E	36	CABD	3220	3225	---	---	---	---	---	---	---	---	---	3	3	2	no log
8467	705264	CITY OF BILLINGS	UNKNOWN	01N	25E	36	CDDD	3215	3212	---	---	---	---	---	---	---	---	---	3	3	2	no log
8468	171256	WEBER-1	MAP	01S	26E	18	DDCC	3169	3216	10	3159	10	>10	2	100	---	---	---	1	1	2	bottom may be shale?
8471	240219	SMITH GREG	NAV-GPS	01N	25E	36	DB		3211	4	3207	4	>23	2	100	---	---	---	2	2	1	
8474	135879	ALGRA JERRY	MAP	01N	25E	12	DCDD	3360	3369	0	---	0	27	4	10	---	27	3333	4	4	2	well in Eagle Sandstone
8475	10615	EVERGREEN PARK (BILLINGS)	NAV-GPS	01N	25E	36	DDBB	3205	3209	8	3197	8	>13	2	100	297.1	---	---	2	2	1	

Appendix B

MBMG Model and Recharge Simulations

This Appendix provides a general summary of the models being developed by MBMG for the West Billings area. Also included are some modeling results of potential groundwater recharge events MBMG completed for this Flood Mitigation and Groundwater Recharge Study.

Two groundwater models are currently being developed by MBMG for portions of the West Billings area. These models were briefly discussed in the *Additional Data Report* (PBSJ, 2010). Additional information on the models is presented in this section courtesy of the MBMG. Because the models have not been finalized the information presented below should be considered preliminary and subject to change.

The MBMG model development was begun prior to and is independent of the Flood Mitigation and Groundwater Recharge Study. MBMG model information is provided below to illustrate the similarity with the preliminary model presented in **Section 3**, and because the MBMG has provided simulation results of potential effects of groundwater recharge from flood mitigation alternatives. In addition, much of the analyses presented elsewhere in this document were performed to facilitate the extension of their modeling efforts further north. Although a preliminary model for the area north of the MBMG has been developed, it is expected that at some point in the future the MBMG will refine that modeling effort.

B.1 Current Groundwater Modeling Coverage and Status

The areas covered by the two MBMG models are shown on **Figure B-1**. The two models were successfully calibrated to steady-state conditions representing spring time prior to irrigation. The models are currently being modified to simulate transient conditions to better evaluate groundwater changes due to seasonal variations in recharge and longer-term changes in land use.

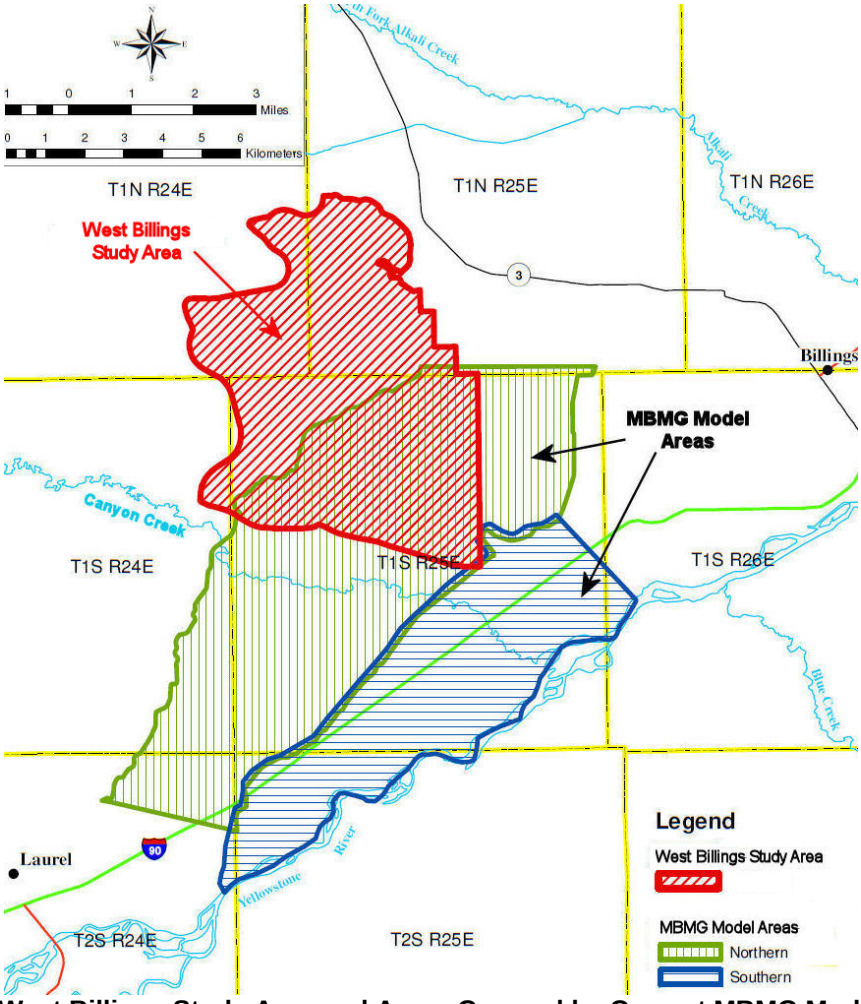


Figure B-1. West Billings Study Area and Areas Covered by Current MBMG Modeling Efforts

B.2 Preliminary Model Information

The models were constructed to simulate conditions for 2000 and for 2009. The 2000 conditions are simulated because there is a significant amount of data available from a previous MBMG study for that time (Olson and Reiten, 2002). The 2009 conditions represent the current time period.

Based on preliminary model information provided by MBMG, the models consist of three layers representing the fine-grained cap material, the unconsolidated aquifer, and the underlying shale. Three north-south cross-sections through their northern model, shown on **Figure B-2**, illustrate the thicknesses of the three layers as represented in the model. The cross-section shows how the aquifer generally thins toward the northern extent of the model while the fine-grained cap thickens.

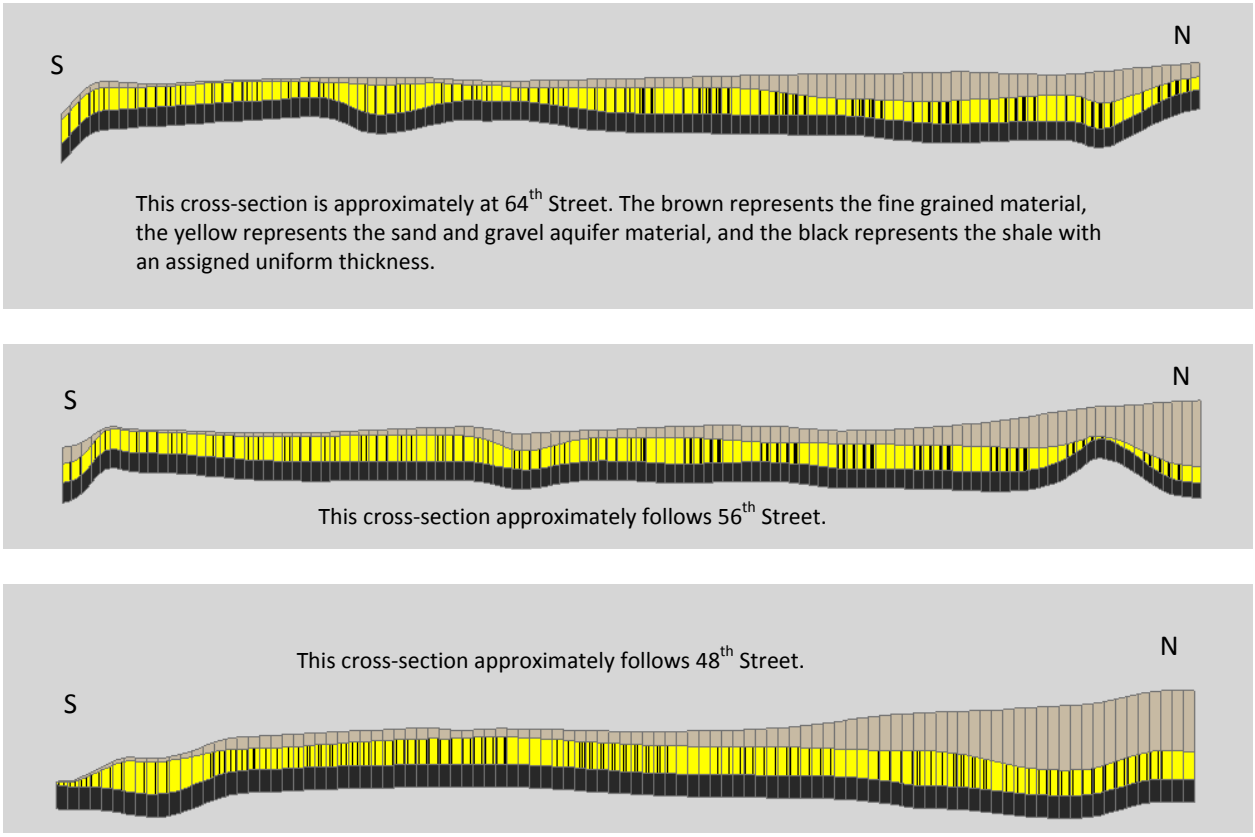


Figure B-2. North-South Cross Sections from the MBMG Northern Model

Boundary conditions consist of General Head cells representing flow into or out of the model. Ditches, and creeks and sloughs are represented with drains and river cells.

Model properties include hydraulic conductivity estimated from pumping test data and recharge (infiltration from precipitation and irrigation) estimated from Land Use designations. Horizontal (Kh) and vertical (Kv) hydraulic conductivity designations for the steady-state calibrated models are as follows (in ft/d):

- Fine-grained cap: Kh = 5, Kz = 1.5;
- Unconsolidated Aquifer: Kh = 90, Kz = 30; and
- Bedrock: Kh = 0.5, Kz = 0.1.

Model layer elevations, illustrated on **Figure B-2** above, were established by interpolating borehole contacts elevations. The contact elevations were assigned using well logs from GWIC wells in the model area.

Recharge values vary seasonally in the transient models, with recharge set at 0 for the months of December through February. For the other months, at the time this document was produced the values range as follows (in ft/d):

- Irrigated Agriculture: 0.0005-0.0075;
- Gravel Pit: 0.00042-0.00444;
- Big Ditch: 0.006-0.1;
- Housing: 0.00042-0.0014; and
- Small Ditch: 0.075-0.08.

B.3 Model Results

As previously noted, the MBMG models are being developed for purposes other than this study, and are in the process of being calibrated and modified. As a result, detailed model results have not yet been documented and presenting them here is premature and beyond the scope of this document. However, MBMG has provided the preliminary modeled groundwater contours shown on **Figure B-3**. These results from their steady-state model, illustrate the general pattern of modeled heads which are used to help develop the model results for the preliminary model discussed in **Section 3**.

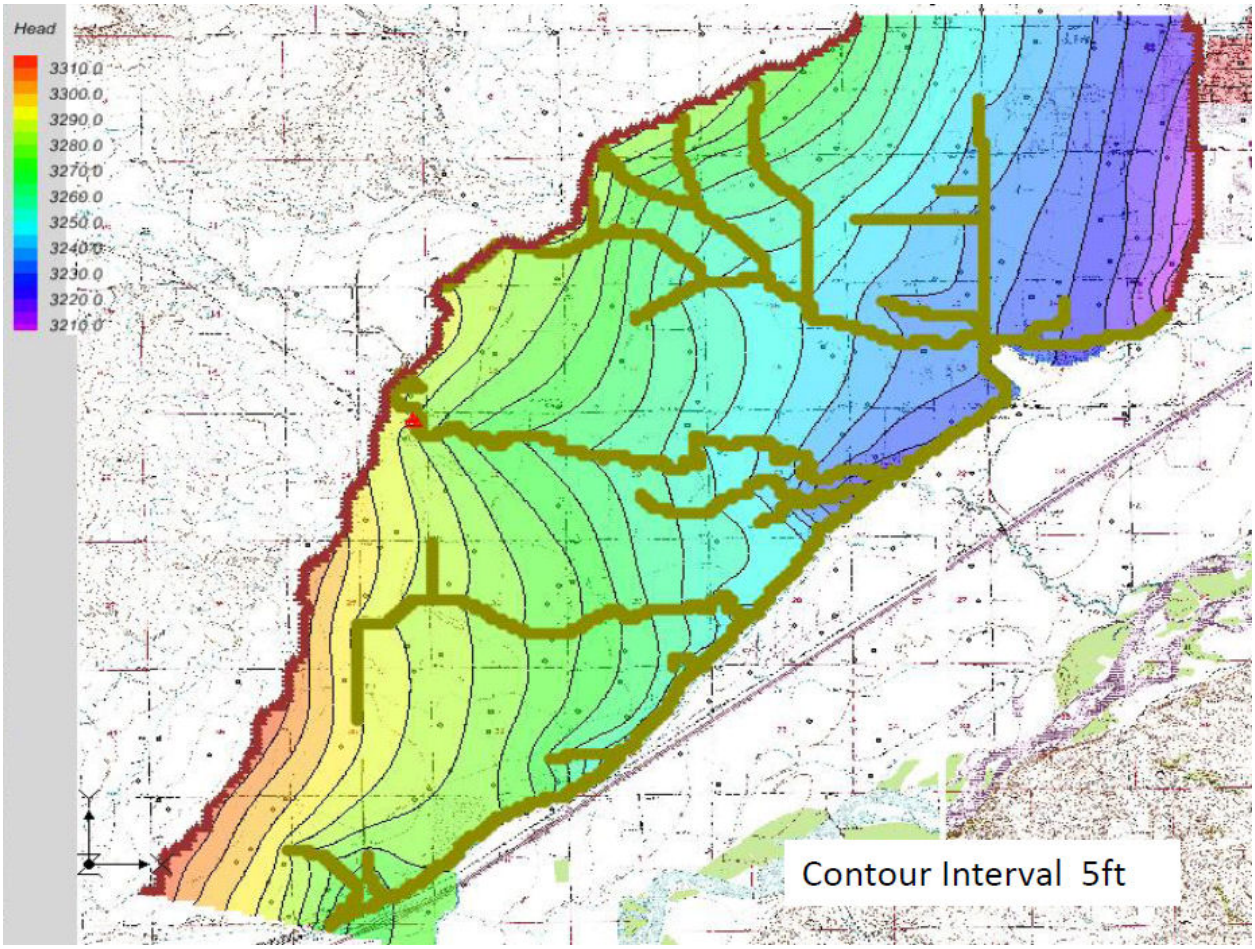


Figure B-3. MBMG North Steady-State Model Groundwater Elevation Contours

Sharptail Pond Recharge Simulation

MBMG has completed model simulations of potential groundwater recharge from flood mitigation at Sharptail Pond (shown as Site 3 on **Figure 3-1**). The site would cover an area of approximately 30 acres, but the exact location has not yet been specified. An approximation of the Sharptail Pond reservoir area was developed in the MBMG-north model using a polygon that is shown on **Figure B-4**. The polygon was sized to include

approximately 32.67 grid cells or 30 acres. Also shown on the figure are the location of three monitoring points. One monitoring point is located at the pond, and the two others are located at distances of roughly 400 and 1,000 ft from the downgradient end of the potential reservoir.

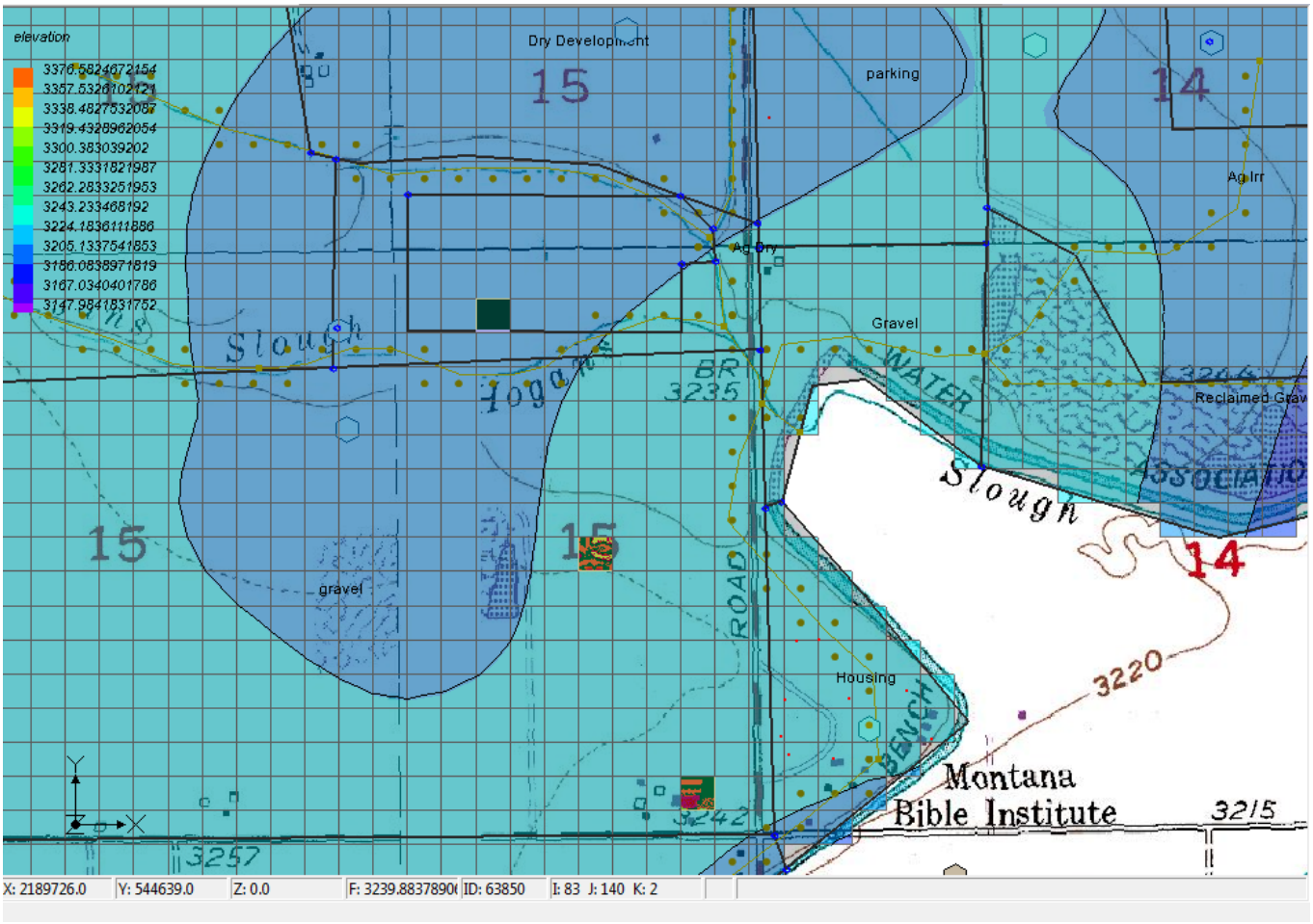


Figure B-4. Model Setup for Sharptail Pond Groundwater Recharge Simulations

The reservoir was represented in the model by modifying the recharge rates in the area of the pond. The rates were modified for the month of July. Rates used are shown in **Table B-1** and are 4,320 ft^3/d per cell for the 100-year event and 2,388 ft^3/d per cell for the 10-year event for each cell.

Table B-1. Recharge Values for Sharptail Pond Groundwater Recharge Simulations

Simulation	Recharge Rate (ft/day)	Recharge (ft^3)	Recharge (af)
Base Conditions	0.00366	148,270	3.4
10-year Flood	0.0597	2,418,495	55.5
100-year Flood	0.108	4,375,166	100.4

Results of the 100-year and 10-year recharge events are shown on **Figure B-5** and **Figure B-6**, respectively. The results show that, given the model limitations and the assumptions of a 32-acre reservoir that can route 83% of the water from a 100-year or 10-year flood event into the groundwater, that water levels might be expected to rise 2.6-4.7 ft beneath the reservoir. Downgradient of the reservoir the effect decreases significantly, with a rise of only 0.02 ft at a distance of roughly 400 ft from the reservoir, and virtually no change 1,000 ft away. The maximum water level rise will occur within one month of the recharge event, however at 1,000 ft away the maximum rise is delayed for 2-3 months.

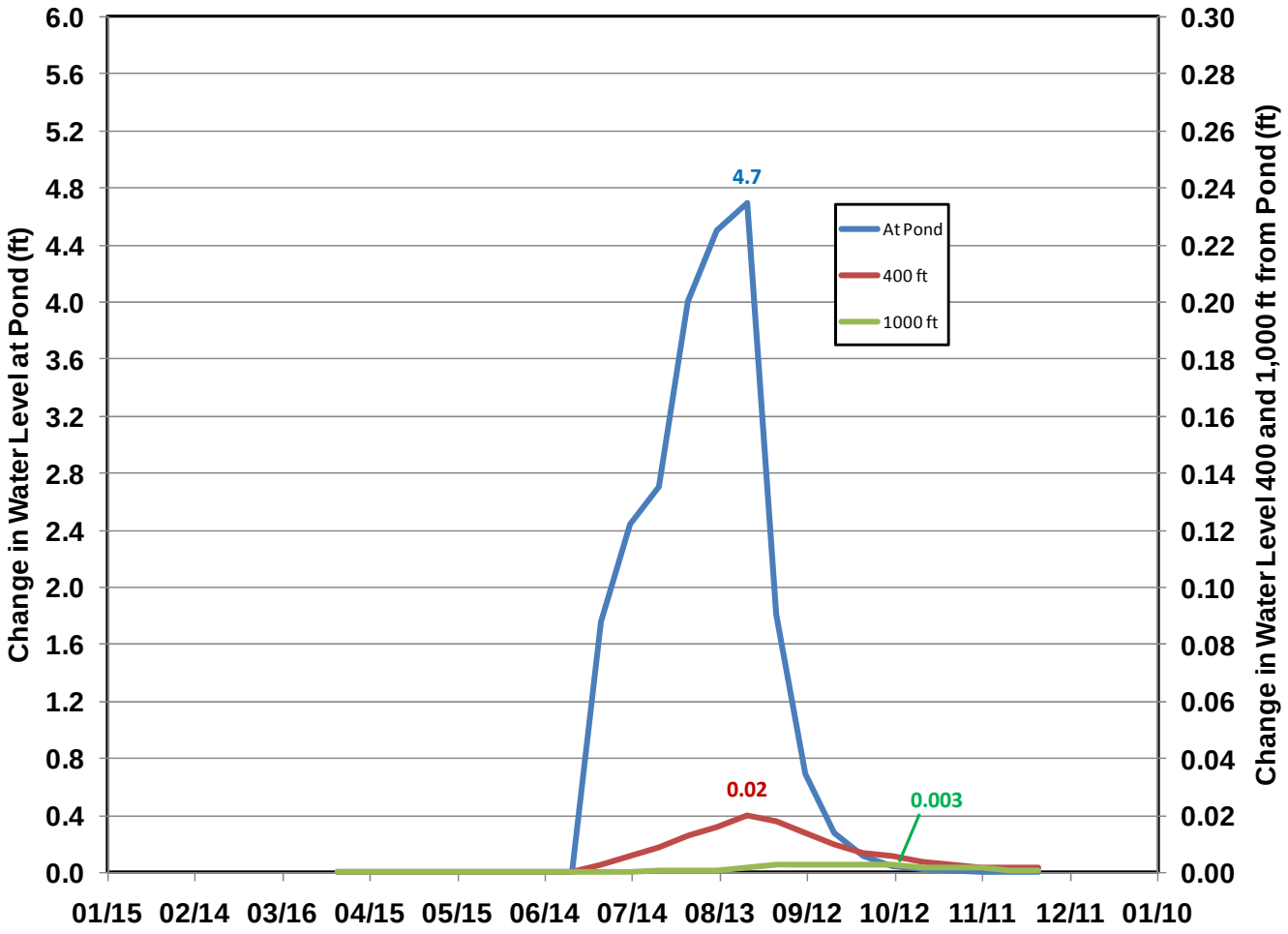


Figure B-5. Monitoring Point Hydrographs: Sharptail Pond Reservoir 100-year Flood Event

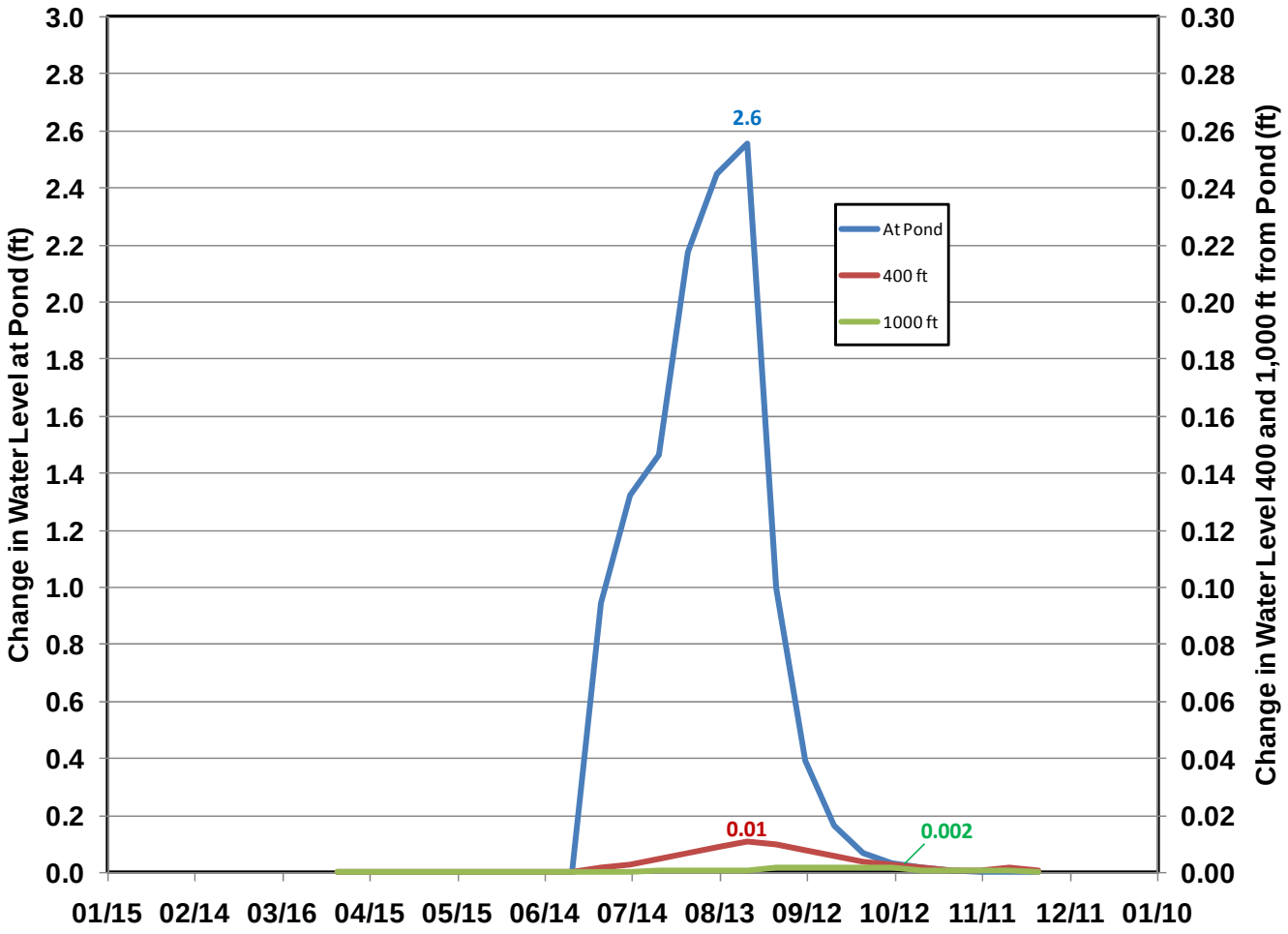


Figure B-6. Monitoring Point Hydrographs: Sharptail Pond Reservoir 100-year Flood Event