Executive Summary
Wind-Bighorn Basin Plan Update

Prepared For:

Wyoming Water Development Commission

Prepared By:

MWH

SEH

May 2010

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Prepared For:

Wyoming Water Development Commission
6920 Yellowtail Road
Cheyenne, WY 82002
(307) 777-7626

Prepared By:

MWH Americas, Inc.
3665 JFK Parkway, Suite 206
Fort Collins, Colorado 80525
(970) 377-9410

Short Elliott Hendrickson, Inc.
Colorado Center, Tower One
2000 S. Colorado Blvd., Suite 6000
Denver, Colorado 80222
(720) 540-6800

Harvey Economics
600 South Cherry Street, Suite 220
Denver, Colorado 80246
(720) 889-2755

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Preface

This document was prepared as part of the Wind-Bighorn Basin Plan Update by MWH Americas, Inc., under sub-contract with Short Elliot Hendrickson, Inc. (SEH) with assistance from SEH and Harvey Economics. This document fulfills reporting and documentation requirements of the SEH prime contract with the Wyoming Water Development Commission (WWDC) dated June 5, 2008 by WWDC.

This document is an update to the 2003 Wind-Bighorn Basin Plan, developed by BRS, Inc. and sub-consultants. Additionally, this document has been prepared to be consistent with the outline and reporting methods of the Wyoming Framework Water Plan. Each of these documents was prepared for and on behalf of WWDC. As such, certain text, language and materials from these documents were used in the Basin Plan Update without citation in many instances.

The study team for the project consisted of the consultants listed above, Jodie Pavlica, WWDO Project Manager, and Phil Ogle, WWDO Deputy Director - River Basin Planning. In addition, numerous individuals with the Wyoming State Engineer's Office, Water Resources Data System, other state and federal agencies, and the Basin Advisory Group assisted in providing information, guidance and technical review of the documents.

Professional Certification

I, Gerald A. Gibbens, a Wyoming registered Professional Engineer, certify that this executive summary, Wind-Bighorn Basin Plan Update, was prepared by me or under my direct supervision. (The original signature and stamp are available at the Wyoming Water Development Office).

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1 Introduction

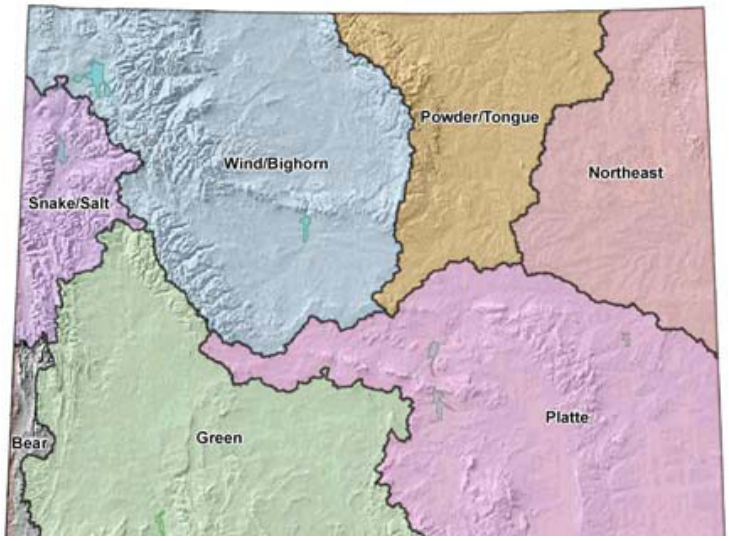

Figure 1. Wyoming River Basins

The Wind-Bighorn Basin Plan Update (Basin Plan Update) provides an update to the 2003 Wind-Bighorn Basin Plan (previous Basin Plan). The Basin Plan Update was prepared to be consistent with the information and presentation of the Wyoming Framework Water Plan (Framework Plan). The Framework Plan presents a statewide perspective on water resources compiled from the results of a seven-basin planning process performed by the Wyoming Water Development Commission (WWDC). Figure 1 shows the major river basins within the state. The Framework Plan is available on the World Wide Web. A PDF version and GIS products can be downloaded at http://waterplan.state.wy.us/frameworkplan.html. An interactive Presentation Tool is available at http://waterplan.wrds.uwyo.edu/fwp/.

The scope of the Wind-Bighorn Basin Plan update is to document current and future water uses within the Wind-Bighorn Basin (Basin), and adjust estimates of water availability based on recent hydrologic information, including the 2000's drought conditions within the basin. At the outset of the project, the basin planning team identified the following goals for the update:

- **Update Planning Tools** and associated analyses to include the most recent 5 years (2000's drought).
- **Develop Strategies** to help meet the needs of the Basin as they are identified by the planning process.
- **Promote and Enhance Stakeholder Dialog** through Basin Advisory Group meetings.

As part of the development of the Basin Plan Update, a Final Report and several technical memoranda were developed that document existing and future water use, hydrology, spreadsheet modeling, future water use opportunities and strategies. Additional information on many of the sections and sub-sections presented in this document are available in the technical memoranda, which are available on the Basin Plan website (http://waterplan.state.wy.us/basins/7basins.html).

The Wind-Bighorn Basin Advisory Group (BAG) met several times during the course of the Basin Plan Update. The primary purpose of the BAG meetings was to provide an update on current WWDC projects and planning activities within the Basin, to provide an update on consultant activities in the Basin Plan Update, and to promote and enhance stakeholder dialog. Meeting notes can be found at the following link (http://waterplan.state.wy.us/BAG/bighorn/meetingrecord.html).

It should be noted that this work documents surface and groundwater use and projections. However, groundwater resources and groundwater availability are discussed under separate cover by the Wyoming State Geological Survey.

2 Setting

The Wind-Bighorn Basin Plan study area encompasses the five river basins generally located in the northwest corner of Wyoming, including the Madison & Gallatin, Yellowstone headwaters, Clark's Fork, Wind and Bighorn River Basins. All of these river basins are on the eastern slope of the Continental Divide and are part of the Missouri River Basin. The Wind River and Bighorn River are actually the same river, changing names at the "Wedding of the Waters" located at the mouth of the Wind River Canyon south of Thermopolis. The study area encompasses most or all of five of Wyoming's 23 counties, including Big Horn, Fremont, Hot Springs, Park, and Washakie counties, as well as a small portion of Natrona County. The total basin area is nearly 22,900 square miles, or 23 percent of Wyoming's 98,210 square mile area. A map of the study area is presented in Figure 2.

Current basin population is approximately 89,500, which is approximately 17 percent of the state's total population of 533,000 people. Major population centers include Lander and Riverton in the Wind River Basin and Thermopolis, Worland, Cody and Powell in the Bighorn River Basin, all with populations between 3,000 and 10,000 people. There is a significant rural population throughout the study area, especially within major agricultural areas in the Wind and Bighorn River Basins. There are no population centers in the Madison/Gallatin, Yellowstone or Clark's Fork River Basins.

In general, the Basin has abundant water resources, especially on the mainstem of the Wind-Bighorn River. These water resources fuel a vibrant and active agricultural industry in the study area. Several large reservoirs within the study area, including Bull Lake Reservoir, Boysen Reservoir and Buffalo Bill Reservoir, provide supplemental late season water supplies to downstream irrigation districts. Some of the irrigated crops in the Basin are exported as cash crops, such as dry beans and sugar beets. However, a majority of the crops are grown to support the livestock industry within the Basin and throughout the state. The Basin also contains abundant mineral resources, including oil & gas reserves, and has a growing tourism and outdoor recreation industry that includes Yellowstone National Park.

Of the 14.6 million acres in the Basin, approximately 75 percent is owned by the federal government, 21 percent is privately held (including local and county governmental entities), and 4 percent is owned by the State of Wyoming. The Wind River Indian Reservation, which is settled and managed by the Eastern Shoshone and Northern Arapaho Tribes under the Bureau of Indian Affairs, encompasses approximately 1.5 million acres within the Basin, or slightly more than 11 percent of the total land area.

As with most other western states, the State of Wyoming adopted the prior appropriation doctrine, which establishes a "first-in-time, first-in-right" method for the allocation of surface and groundwater resources in times of limited water supply. Water rights are acquired by securing a permit from the Wyoming State Engineer and adjudicated through a state process. All unadjudicated permits within the Wind-Bighorn River Basin were verified and adjudicated in a general stream adjudication process which commenced in 1977 and is known as the Big Horn River Adjudication. The Big Horn River Adjudication included an award of federal reserved water rights to the Eastern Shoshone and Northern Arapaho Tribes. The administration and allocation of water resources in the Wind-Bighorn River Basin is also affected by the Yellowstone River Compact, which allocates water in the Yellowstone River Basin between the states of Wyoming, Montana and North Dakota.

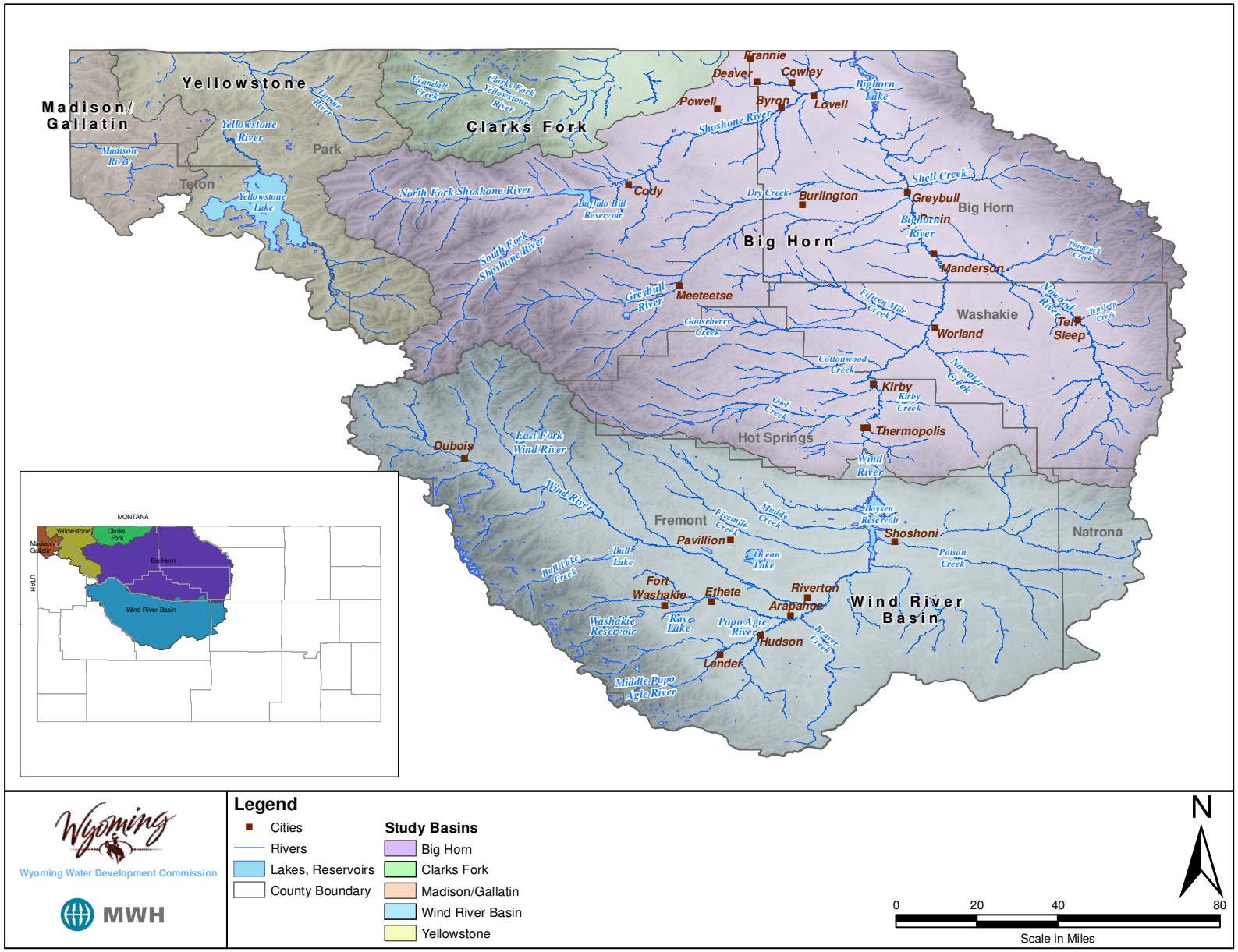

Figure 2. Wind-Bighorn Basin Study Area Map

3 Water Resources

Precipitation is the source of both groundwater and surface water in the Basin. Average annual precipitation produces approximately 18.5 million acre-feet (maf) per year. Total estimated annual outflow from the Wind-Bighorn Basin is nearly 6.8 maf. Approximately 2.4 maf of this water would be available to Wyoming in the Clarks Fork and Bighorn Rivers for future water use under the Yellowstone River Compact. Of the 11.6 million acre-feet that does not leave the state as streamflow, roughly 1.4 million acre-feet is consumed by crops, municipal/domestic, industrial or reservoir evaporative uses. Of the remaining volume, most is evaporated from the land surface prior to infiltration or transpired by native vegetation. A small portion serves to recharge alluvial and bedrock aquifers. A summary of the Basin water resources mass balance is presented in Figure 3.

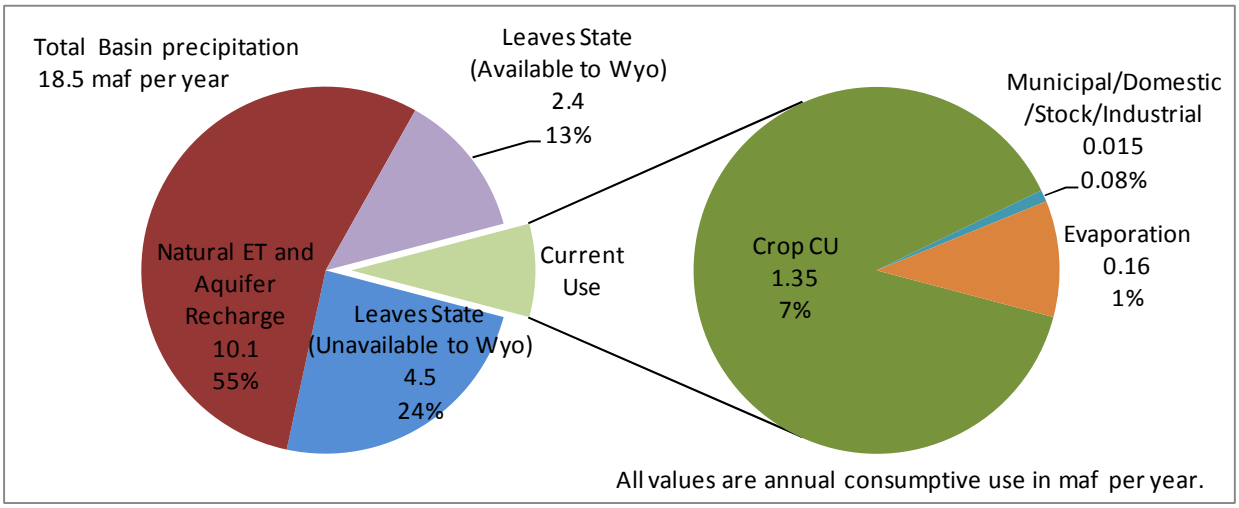

Figure 3. Current Basin Water Resources Mass Balance

There are currently 33 active streamflow gaging stations within the Wind-Bighorn Basin that are operated by the United States Geological Survey (USGS), Wyoming State Engineer's Office Division III, and the Bureau of Reclamation. Average annual flow at selected gaging stations is shown in Table 1. In addition, there are nearly 150 discontinued gaging stations that have been operated within the Basin over the years that are used in hydrologic analyses by estimating flows using regression analyses and other data extension techniques.

Table 1. Average Annual Streamflow at Selected Gaging Stations

Basin	Gage No.	Gage Name	Period-of-Record	Annual Flow (ac-ft)
Yellowstone	06191500	Yellowstone River At Corwin Springs MT	Sep 1910 - Present	2,239,249
Clarks Fork	06207500	Clarks Fork Yellowstone River Near Belfry MT	Aug 1921 - Present	652,258
Upper Wind	06220800	Wind River Above Red Creek, Near Dubois	Oct 1990 – Present	454,653
Little Wind	06235500	Little Wind River Near Riverton	Jun 1941 – Present	382,275
Lower Wind	06259000	Wind River Below Boysen Reservoir	Jun 1951 - Present	953,879
Upper Bighorn	06260000	South Fork Owl Creek Near Anchor	Oct 1940 - Present	23,948
Greybull	06276500	Greybull River At Meeteetse	Feb 1921 - Present	208,797
Bighorn Lake	06279500	Bighorn River At Kane	Oct 1928 - Present	1,431,787
Shoshone	06282000	Shoshone River Below Buffalo Bill Reservoir	Jan 1921 - Present	675,903

4 Current Water Use

Water use within the Basin includes both consumptive and non-consumptive uses. Consumptive uses are generally agricultural, stock water, municipal/domestic, industrial/mining water, and reservoir evaporation, while recreation and environmental uses are generally considered non-consumptive. These uses were all quantified as part of the Basin Plan Update. A summary of diversions and consumptive use for consumptive water uses is presented in Table 2.

Table 2. Summary of Current Consumptive Water Uses

Water Use	Diversion (ac-ft) [1] (ac-ft)	Diversion (ac-ft) [1] Percent of Total	Consumptive Use (ac-ft)	Consumptive Use Percent of Total
Agricultural	3,136,728	92%	1,079,971	85%
Stock Water	6,370	0.2%	6,370	0.50%
Municipal/Domestic [2]	19,252-23,396	1%	8,743	1%
Industrial/Mining	91,906	3%	19,163	2%
Reservoir Evaporation	156,157	5%	156,157	12%
Total	3,412,485	100%	1,270,404	100%

Notes:
[1] Includes both surface water and groundwater use.
[2] A range of municipal/domestic water use was determined. Calculations performed using an average of the range.
[3] Consumptive use not calculated for stock water use.

4.1 Agricultural Water Use

Agricultural water use includes water used for crop irrigation and water use by livestock. Currently, there are approximately 713,000 irrigated acres within the Basin, and approximately 560,000 animal units within the Basin. Stock water use is estimated to be 6,400 acre-feet per year, with nearly 88 percent of this water use by cattle.

Historical measured diversions within the Basin are approximately 2.6 million acre-feet per year. This is approximately 80 percent of the full supply irrigation requirements. Most of the diversions within the Basin experienced shortages during both 2002 and 2003. However, during early and later years within the 2000's drought, diversions through structures were near or slightly above normal, depending upon water supply availability within its particular system, the amount of storage available to the diversion and its priority within the water rights administration system.

Supply limited crop irrigation requirements (CIR) for existing irrigated lands within the Basin were estimated at 1.08 million acre-feet, while supply limited diversions for existing irrigated lands within the Basin were estimated at 3.14 million acre-feet. CIR and diversion requirements are slightly less than the previous Basin Plan due to changes in CIR estimation methodology and increases in estimated irrigation efficiencies for larger irrigation systems within the study area.

4.2 Municipal and Domestic Water Use

Municipal water use for the Basin is supplied by 60 active municipal water systems relying on both surface water resources (about 58 percent of total use) and groundwater resources (about 42 percent of total use). Total average municipal water use was 13,428 acre-feet per year, with a storage capacity of approximately 132 acre-feet per year (plus additional storage from Buffalo Bill Reservoir) to meet seasonal variations in municipal water use. The largest municipal surface water

diversion from the Basin was the Shoshone Municipal Pipeline, which delivered water to about 24,600 people from storage in Buffalo Bill Reservoir. The other regional municipal project in the Basin, the Big Horn Regional Water Supply System, provides primary, secondary or emergency potable water supplies to several municipal entities in Big Horn and Washakie counties, and receives its water from bedrock aquifers.

Non-community water use in the Basin, which includes public water systems at locations such gas stations, campgrounds, schools, factories, office building and hospitals that have their own water systems, was estimated at 1.4 million gallons per day (mgd) (1,568 acre-feet per year), based on an average daily population of 18,400 served by these systems. Domestic water use by rural domestic users for the Basin ranged from 3.8 to 7.5 mgd (4,256 to 8,400 acre-feet per year). Per capita water use was assumed to range from 150 to 300 gallons per capita per day (gpcd) for domestic water users in order to estimate total domestic demands.

4.3 Industrial/Mining Water Use

Industrial water uses in the Basin are water demands associated with industrial facilities, mining operations, coal bed natural gas (CBNG) and oil and gas production fields. Estimated total industrial and mining water use for the Basin is 91,908 acre-feet per year. Of this amount, 91,258 acre-feet is supplied from groundwater sources (USGS 2005). The estimated total consumptive groundwater use for industrial purposes for the Basin ranges from 19,030 to 20,074 acre-feet per year, or 20 to 22 percent of total industrial groundwater withdrawals.

Estimated industrial/mining surface water use for the Basin is 650 acre-feet per year, with 100 percent supplied from fresh water sources. Industrial withdrawals account for 448 acre-feet per year of surface water use and mining accounts for 201 acre-feet per year. Based on calculated averages from the National Water Use Information Program reports, the estimated total consumptive industrial surface water use for the Basin is 133 acre-feet per year, or 20% of the total fresh water withdrawals. Consumptive surface water use for industrial facilities is 67 acre-feet per year and 66 acre-feet per year for mining activities in the Basin. No surface water withdrawals or consumptive use for industrial purposes for the Basin occurred from saline water sources.

4.4 Recreational Water Use

Non-consumptive recreational water uses in the Basin, such as those associated with fishing, boating, hunting, and swimming, account for a majority of the activities tourists participate in when visiting the State of Wyoming. Recreational fishing is the most important water-based recreational activity in the Basin, comprising over 55 percent of the total water-based activities. Fishing includes fishing in streams, rivers, and flatwater (or lake) fishing.

Whitewater and scenic rafting segments are located on several of the Basin's rivers, with 18 designated whitewater rafting segments totaling over 197 miles of stream and over 32 miles of stream designated as Wild and Scenic. River rafting and kayaking comprise approximately 7.4 percent of tourist activities in the State of Wyoming.

In addition to the extensive network of streams and rivers in the Basin, there are 38 major reservoirs and lakes. Of these, 11 are recognized as major recreation sites in Wyoming and include: Bighorn

Lake, Boysen Reservoir, Bull Lake, Lake Cameahwait, Deaver Reservoir, Greybull Valley Reservoir, Newton Reservoir, Pilot Butte Reservoir, Ten Sleep Reservoir, and Yellowstone Lake.

4.5 Environmental Water Use

Environmental water uses within the Basin are non-consumptive water demands associated with the rivers, streams, lakes and terrestrial habitats that represent an integral part of the Basin's ecosystems. An abundance of wildlife reside in the aquatic and terrestrial habitats located throughout the Basin and utilize a wide range of migratory routes that traverse the vast expanses of public and private lands. The environmental uses within the Basin include the maintenance flows required to protect warm and cold water fisheries, wetlands and riparian ecosystems, wildlife and big game habitat.

Instream flow water rights for the protection of fisheries within the Wind-Bighorn Basin are an important environmental resource. Federal Reserve instream flow rights in the Basin for the Bighorn National Forest total about 43,500 acre-feet per year, and Federal Reserve instream flow rights in the Shoshone National Forest total about 605,600 acre-feet per year. In addition, there are currently 25 state instream flow filings (21 of which are permitted) within the Basin, most of which occur in the Bighorn Basin.

Wetlands and riparian ecosystems are ecologically important to the Basin and play a key role in sustaining the livelihoods of plant communities and the survival of wildlife and biodiversity both in the catchment and downstream. There are over 395,000 acres of wetlands within the Basin comprised of freshwater emergent wetlands, freshwater forested shrub wetlands, freshwater ponds, lakes, other freshwater wetlands and riverine.

4.6 Evaporation

Water is stored within the Basin for irrigation, municipal, industrial, recreation, fisheries, and flood control purposes. Evaporation from reservoirs is a consumptive use and is charged against Wyoming's allocation under the Yellowstone River Compact. Evaporation was calculated based on spatially variable precipitation, evaporation data maps, and area-elevation-capacity curves for each reservoir. Evaporation was calculated using the surface area at maximum capacity for each reservoir. Thus, the calculations for net evaporative loss can be considered conservative as the average surface area will be less than the maximum surface area. Total net evaporation for reservoirs 500 acre-feet or greater is approximately 156,000 acre-feet per year. This is about 5% of the total storage capacity.

5 Water Use Projections

Water use projections were developed for agriculture, industry, municipal use, recreation and environmental water use in the Basin. Projections for years 2020, 2040 and 2060 are provided. The original Basin Plan looked at existing conditions within key water use sectors and made specific supply-driven assumptions about future potential development opportunities in each sector. For the Basin Plan Update, a demand-driven approach utilizing a modified economic base analysis for water use sectors was used. Economic base analysis focuses on activities and sectors that drive economic and demographic change. Economic base analysis is well suited to the Basin as the study team was able to focus on the three key economic sectors; agriculture, industry and tourism. Agriculture and industry, particularly mining, are also the largest water using sectors in the Basin. Research and interviews were performed on each key sector to identify trends in the Basin since the original Basin Plan. The projections for these economic sectors led to development of population projections.

The Basin Plan Update provides three planning scenarios for 2020, 2040 and 2060 projections:

Low scenario – This scenario represents the minimal likely development, or possible contraction, in the Basin. Although this scenario will not result in any new water demand pressures in the Basin due to socioeconomic activity, it provides a supportable lower limit for water planning purposes.

Medium scenario – This scenario represents the most likely set of factors that will occur in each of the Basins over the planning horizon. This scenario represents the most probable future conditions in the Basin in the opinion of the study team.

High scenario – This scenario represents the highest growth that could potentially occur in the Basin over the planning horizon. These conditions will provide an upper boundary for water planning in the Basin.

For each water use sector within the Basin, a set of assumptions was developed that would inform the low, medium and high projections. These assumptions were based upon Basin and state specific data as well as national and international prospects for economic sectors related to Basin activities. Primary drivers for future water use under the low future water use scenario are decreased irrigated acreage due to prolonged economic downturn and slight increases in groundwater use by oil and gas producers. Primary drivers under the medium future water use scenario are maintenance of existing irrigated acreage, development of the Riverton East Tribal Futures Project, and increased production by oil and gas producers. Primary drivers under the high future water use scenario are full recovery of irrigated acreage to pre-drought conditions, development of all Tribal Futures Projects, development of the Westside Irrigation Project, and increased mining and industrial operations including oil and gas development. Municipal use is projected to increase slightly under all conditions.

The medium and high water use projects include development of Tribal Futures Projects. Through the Big Horn Adjudication, the courts determined that the Tribes were entitled to divert 499,862 acre-feet per year with a July 3, 1868 priority date. Approximately 290,500 acre feet of these water rights have been historically used for irrigation on the Wind River Indian Reservation (WRIR). The remaining 209,400 acre-feet is for potential development of future irrigation projects (or Futures

Projects), including the North Crowheart, South Crowheart, Arapahoe, Riverton East, and Big Horn Flats Projects, which would irrigate an additional 53,760 acres on the WRIR. Separately, the Tribes compiled their own set of non-agricultural water development prospects as described in the draft Wind River Water Plan of 2007. This plan identified such activities as a bottled water plant, a rangeland water system, small-scale hydrogeneration, off-stream storage for recreation and other purposes, light industrial uses, cultural water uses, and community parks and gardens.

Future new water requirements in the Basin under the medium, most likely, scenario will reach 306,600 acre-feet in 2060. This demand includes agricultural, industrial, municipal and tribal water demand. New surface water demand in 2060 under the medium scenario will be about 24,000 acre-feet. Under the same scenario, new environmental water use would be about 12,000 acre-feet. Total new water requirements for agriculture, municipal, and industrial use are provided in Table 3. New surface water requirements for agriculture, municipal and industrial use are provided in Table 4.

Table 3. Total New Water Requirements for Agriculture, Municipal and Industrial Use

Year	Sector	Change in Diversions (ac-ft) Low	Medium	High
2020	Agriculture	-75,000	100	55,000
	Municipal and Domestic	300	500	1,600
	Industry	22,800	35,300	40,800
	WRIR	0	0	0
	2020 Total	**-51,900**	**35,900**	**97,400**
2040	Agriculture	-200,000	200	153,000
	Municipal and Domestic	1,000	2,000	4,800
	Industry	74,200	126,600	152,700
	WRIR	0	19,000	75,000
	2040 Total	**-124,800**	**147,800**	**385,500**
2060	Agriculture	-320,000	500	254,000
	Municipal and Domestic	1,700	3,500	8,600
	Industry	148,800	283,600	359,200
	WRIR	0	19,000	209,000
	2060 Total	**-169,500**	**306,600**	**830,800**

Table 4. Total New Surface Water Requirements for Agriculture, Municipal and Industrial Use

Year	Sector	Change in Diversions (ac-ft) Low	Medium	High
2020	Agriculture	-75,000	100	55,000
	Municipal and Domestic	170	290	920
	Industry	50	280	340
	WRIR	0	0	0
	2020 Total	**-74,800**	**700**	**56,300**
2040	Agriculture	-200,000	200	153,000
	Municipal and Domestic	570	1,150	2,760
	Industry	160	1,060	1,370
	WRIR	0	19,000	75,000
	2040 Total	**-199,300**	**21,400**	**232,100**
2060	Agriculture	-320,000	500	254,000
	Municipal and Domestic	980	2,010	4,940
	Industry	330	2,500	3,450
	WRIR	0	19,000	209,000
	2060 Total	**-318,700**	**24,000**	**471,400**

6 Water Availability

Water availability is the amount of water that is physically and legally available for new water uses in the Basin. Water availability was determined for surface water uses using a spreadsheet model. The Wind-Bighorn sub-basin models can simulate four different scenarios as described below. The three full supply scenarios roughly correspond to the low, mid and high future water use scenarios developed in the economic analysis. The model scenarios do not match the future water use scenarios exactly because the spreadsheet models were not designed to simulate several of the water use changes that are documented in the economic analysis.

- Calibration (Historical) – Simulates actual historical diversions. This mode is primarily used for model calibration.
- Full Supply for Existing Irrigated Lands – Simulates full supply, based on computed diversion requirements, for irrigated lands with water rights mapped as part of the planning process. This roughly corresponds to the Low Demand Scenario.
- Full Supply for Existing Irrigated Lands and Riverton East Futures Project –Simulates Full Supply for Existing Irrigated Lands plus the Riverton East Tribal Futures project. This roughly corresponds to the Mid Demand Scenario.
- Full Supply for Existing Irrigated Lands and All Futures Projects - Simulates Full Supply for Existing Irrigated Lands plus all Tribal Futures project. This roughly corresponds to the High Demand Scenario.

Simulated basin-wide shortages for each scenario are shown in Table 5 for dry, normal, and wet year hydrologic conditions. A map-based summary of available flow, shortages, industrial wells and permitted industrial discharge points is presented in Figure 4, Figure 5, Figure 6, and Figure 7. Shortages shown in the maps are for dry-year hydrologic conditions, or a worst case scenario for shortages, for the Full Supply with Riverton East Futures Project scenario, which is the "most likely" future scenario. It should be noted that most available flows are shown on mainstem streams. In many basins, most shortages are on tributaries, meaning some of the available flow may be inaccessible to the diversion structures that need it without significant additional infrastructure (such as new canals, pump stations and/or pipelines).

Table 5. Summary of Modeled Diversions and Reach Shortages

Basin	Diversion (ac-ft) [1]	Reach Shortages (ac-ft)			Reach Shortages (percent)		
		Dry	Normal	Wet	Dry	Normal	Wet
Clarks Fork [2]	76,404	19,658	11,883	7,647	26%	16%	10%
Bighorn [2]	1,908,232	222,203	117,942	67,520	12%	6%	4%
Wind - Full Supply	1,363,341	161,649	81,425	61,938	12%	6%	5%
Wind - Full Supply, Riverton East	1,380,890	161,649	81,425	61,938	12%	6%	4%
Wind - Full Supply, All Futures	1,563,210	359,266	109,887	79,159	23%	7%	5%
Total - Full Supply	3,347,977	403,510	211,250	137,105	12%	6%	4%
Total - Full Supply, Riverton East	3,365,526	403,510	211,250	137,105	12%	6%	4%
Total - Full Supply, All Futures	3,547,846	601,127	239,711	154,325	17%	7%	4%

Notes:

[1] Includes Full Supply Diversion plus diversions by "carrier ditches" that divert water to reservoirs or other ditches.

[2] Diversions and Reach Shortages are the same in all scenarios for the Clarks Fork and Bighorn Basins.

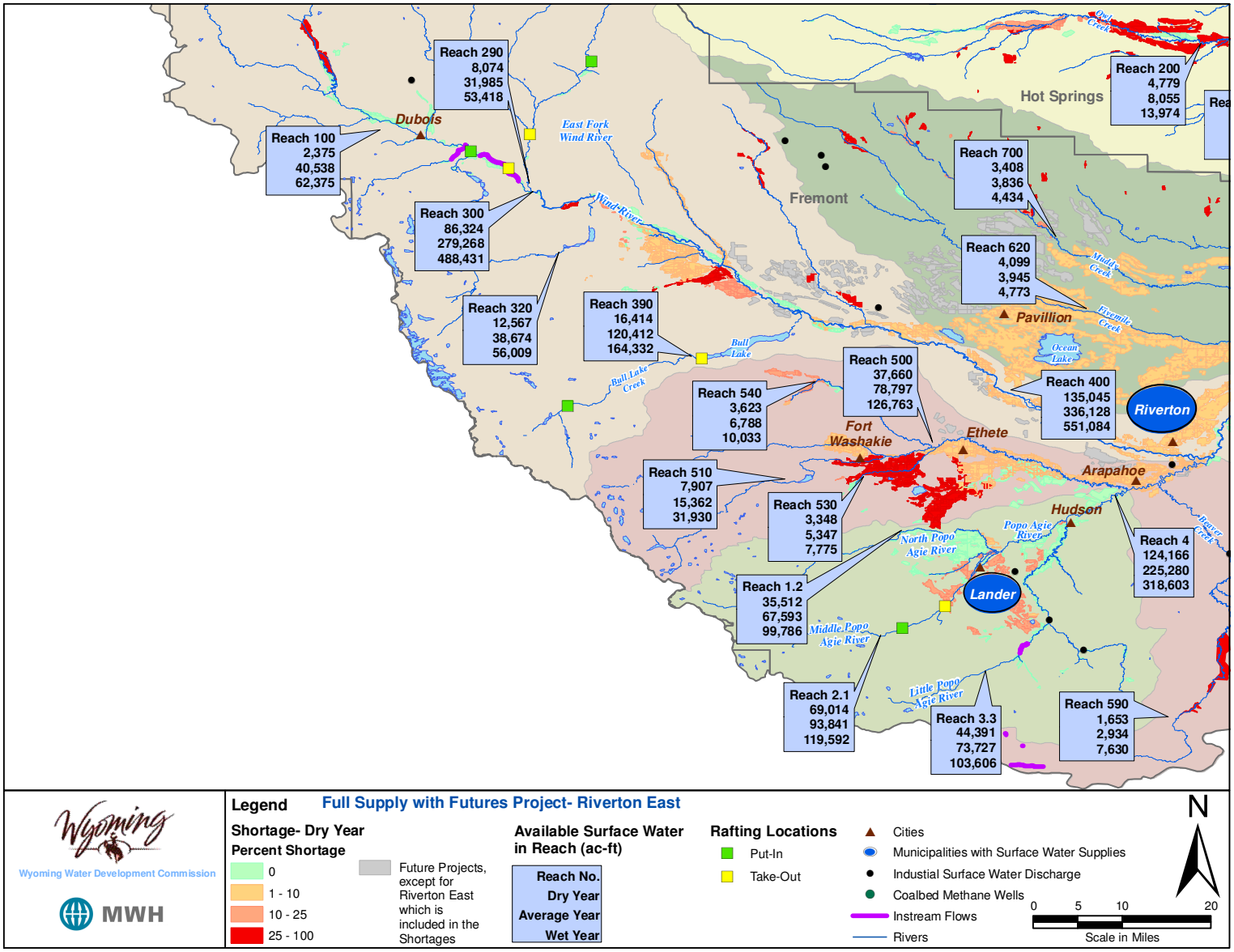

Figure 4. Wind River Basin West - Shortage and Available Flow Map

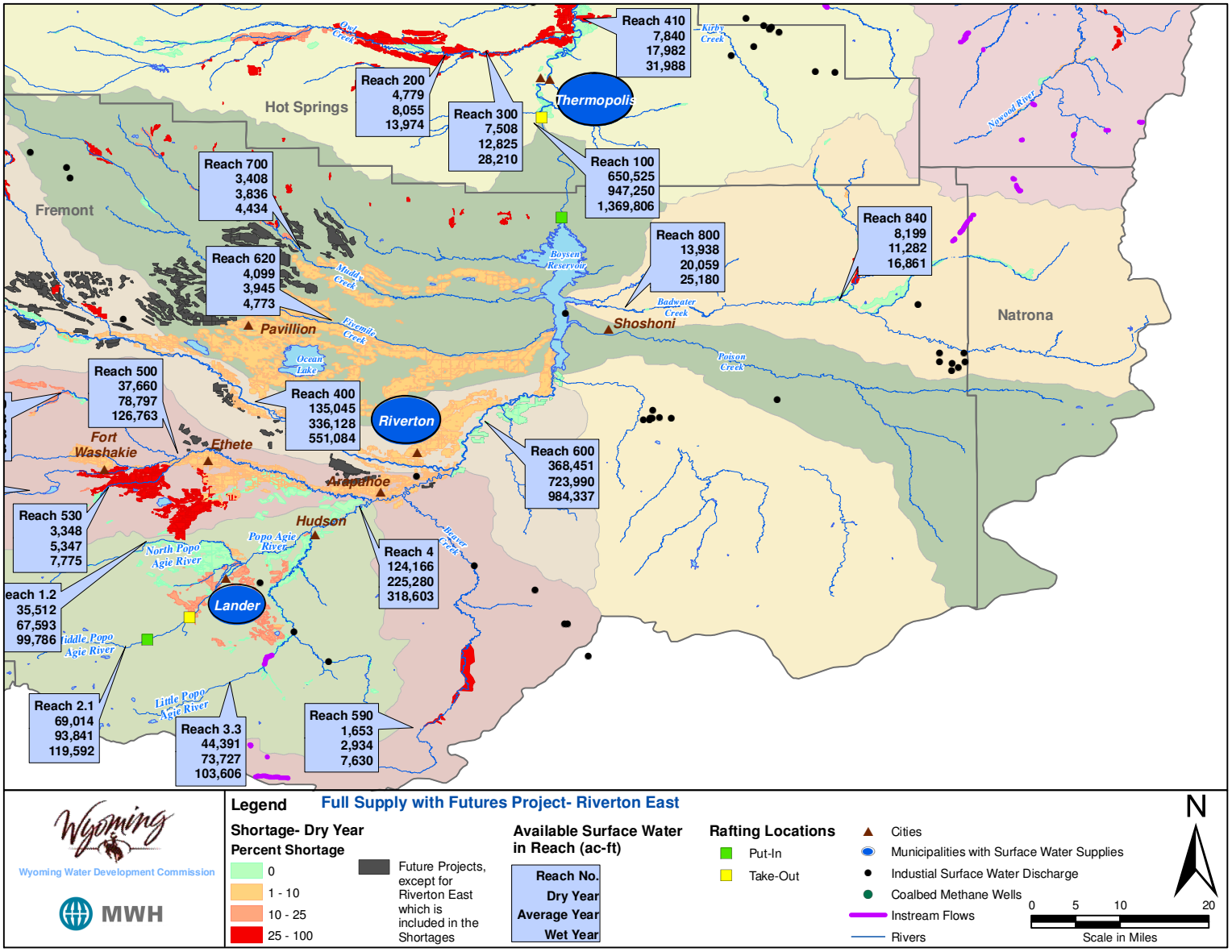

Figure 5. Wind River Basin East - Shortage and Available Flow Map

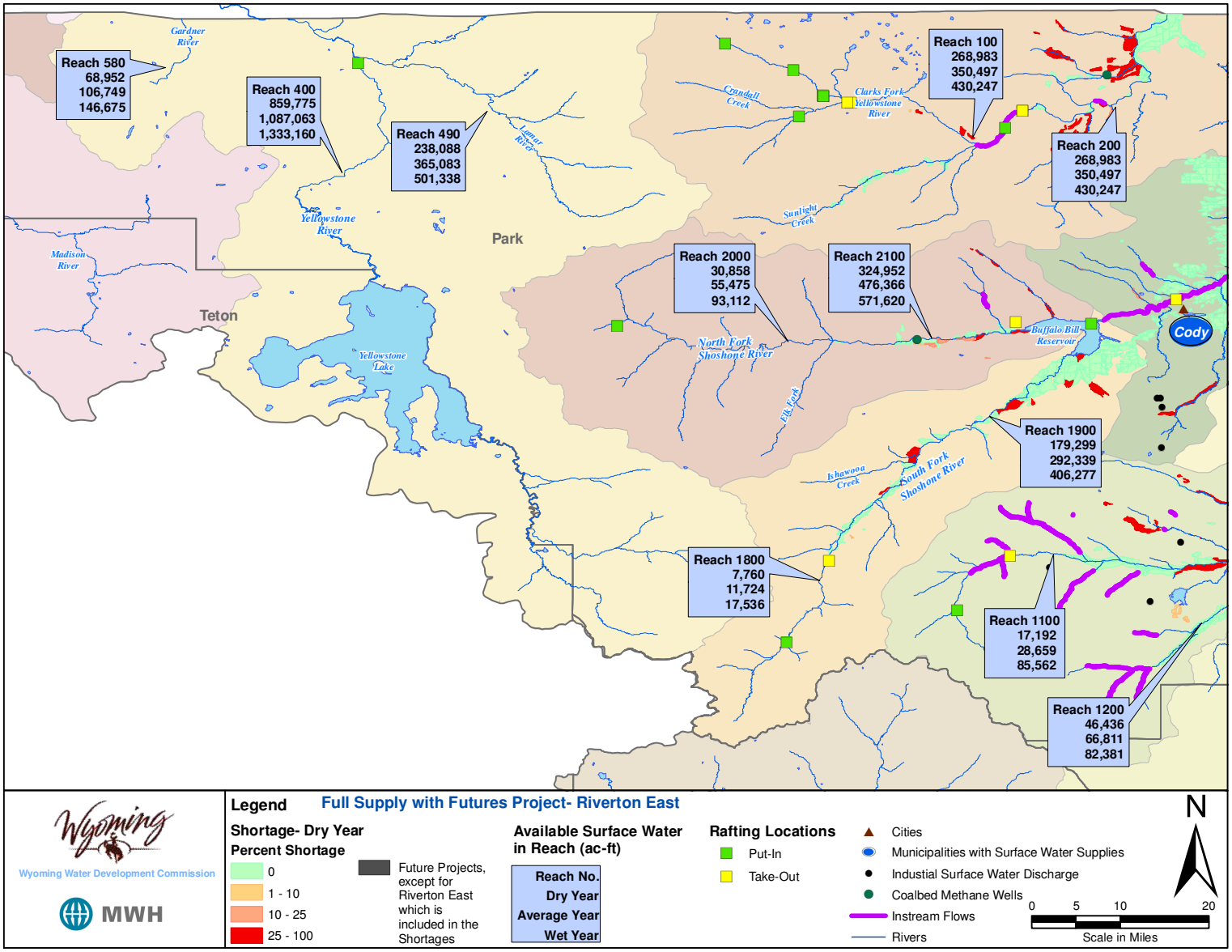

Figure 6. Clark's Fork and Bighorn Basin West - Shortage and Available Flow Map

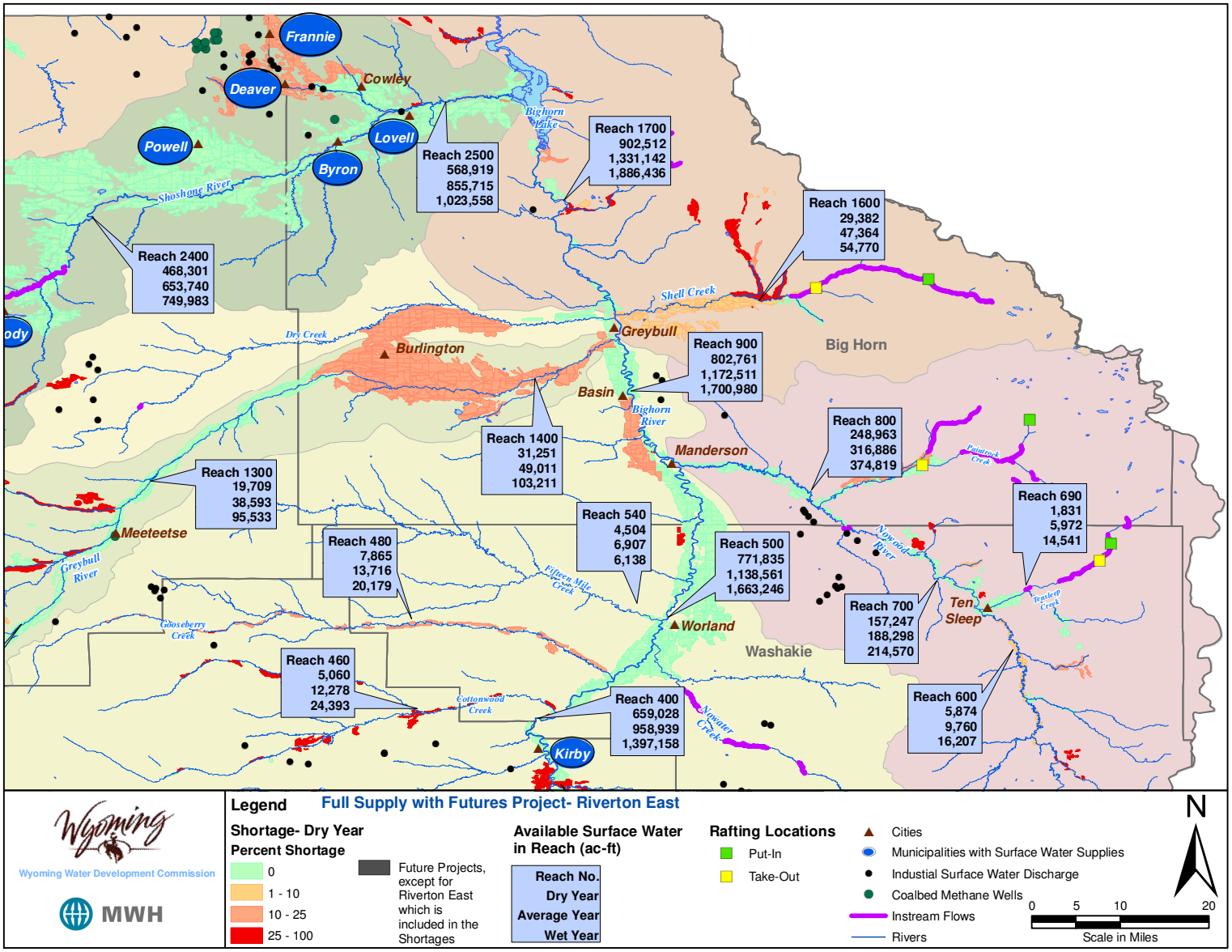

Figure 7. Bighorn Basin East - Shortage and Available Flow Map

7 Project Opportunities and Program Strategies

Project opportunities and program strategies were developed as part of the Basin Plan Update in an attempt to address existing and future water use issues in the Wind-Bighorn Basin (Basin) as developed by the Basin Advisory Group (BAG) and the basin planning team. These terms are defined as follows:

Project Opportunities – Specific projects generally tied to specific areas or locations and identifiable on-the-ground activities. Examples include reservoirs, irrigation system improvements, water distribution system improvements, groundwater development, water transfers, and conjunctive use.

Program Strategies – Generally state-level or regional-level approaches not tied to specific projects or locations; activities performed by WWDC or other state/federal agencies; management approaches rather than project approaches. Examples include water planning, water administration, data collection, data management, water conservation, and future studies.

Project opportunities were developed based on the opportunities identified in the previous Basin Plan and those identified as part of the Framework Water Plan. This list was supplemented by recommendations from watershed and Level I and II planning studies performed within the Basin since the previous Basin Plan. The list was presented to the BAG and modifications were made to reflect the current status of recently completed and on-going projects, and to reflect the BAGs current recommendation on future projects. A summary of project opportunities is presented in Table 6. An analysis of hydropower development opportunities was also performed. In general, it was found at current energy prices, which are lower than prices prior to 2009, conclusions regarding hydropower opportunities would mostly remain unchanged from previous studies. However, if higher pre-2009 energy prices of around $0.05 per kilowatt hour were to return, some projects that are currently marginally feasible could become more feasible.

A comprehensive list of program strategies was developed to help meet the needs of the Basin as they have been identified throughout the current Wind-Bighorn planning process and the statewide Framework Water Plan process. These strategies are a merging of specific strategies identified by the BAG, WWDC staff and the consultant team. Many of the strategies have a time frame that help define and guide the Basin Plan Update process. Other strategies have short-term or long-term implementation schedules, and will rely on several state agencies and local stakeholders to implement. A summary of program strategies is presented in Table 7.

Table 6. Summary of Project Opportunities

Category	Project Type	Project Examples
Municipal/ Industrial	New Source	New groundwater supplies; municipal wastewater reuse
	New Use	Fossil fuels power generation, hydropower, industrial uses, and retail bottling
	Regionalization	Municipal water system regionalization in Dubois, WRIR, Lander-Hudson-Riverton, Tensleep
	Water Conservation	Municipal and industrial conservation measures
Agricultural	Basin Transfer	Transfers from Wood River to Cottonwood/Grass Creek Basin or Gooseberry Creek Basin and Clarks Fork to Greybull Basin
	Conjunctive Use	Recharge of alluvial system along Upper Wind and Bighorn River
	Irrigation Non-Structural	Change in crop types, soil tensiometers and irrigation scheduling
	Irrigation Rehabilitation	Irrigation rehabilitation, including consolidation, lining, pipes
	New Use	Tribal Futures Projects, Westside Project
	Reservoir Rehabilitation	Repair existing dams, Anchor Reservoir improvements
	Storage	New reservoir sites throughout Basin up to 375,000 acre-feet
	Watershed Improvements	Improved stockwater distribution, cross-fence riparian corridors
Environmental/ Recreation	Environmental	Instream or minimum flows, minimum reservoir supplies, invasive species control and quantification
	Recreation and Tourism	Golf courses, public access, whitewater parks
	Watershed Improvements	Watershed/ habitat improvement
Water Planning and Management	Administrative: USBR	Revised Boysen Reservoir operations schedule - winter releases
	Administrative: WSEO	Groundwater control district, stream gaging stations, augmentation plans, beneficial uses
	New Source	Cloud Seeding / Weather Modification - Bighorn Mountains
	Watershed Improvements	Implement watershed plans
Cultural	Cultural	Coordinated releases

Table 7. Summary of Program Strategies

Category	Strategy	Time Frame
Admin-istrative	Continue to hold BAG meetings and adopt new ideas for maintaining the BAG's diversity, viability and effectiveness	On-Going
	Describe and continue maintenance of existing irrigation and municipal water supply infrastructure	On-Going
	Establish and use master plans to assess growth potential and establish water and infrastructure needs for municipalities	On-Going
	Work to maintain and protect water rights within the Basin	On-Going
	Promote better understanding of and address issues regarding federal project issues	Long-Term
	Improve communication and understanding of issues at local, Tribal and state level	On-Going
Basin Planning	Evaluate and consider environmental, recreation, aesthetic and other non-consumptive and aesthetic water uses and needs in planning	On-Going
	Project future agricultural and municipal water system needs and compare to current and future water availability	On-Going
	Incorporate basin plan products into existing WRDS data storage system, including the development of GIS layers where necessary	On-Going
Technical Analysis	Plan for potential future industrial water use within the Basin	On-Going
	Perform a comprehensive groundwater study within the Basin and determine safe yields from aquifers	On-Going
	Evaluate potential for aquifer storage and retrieval throughout the basin	Short-Term
	Implement new modeling tool	Long-Term
	Extend water supply study period in new model platform using historical and stochastic hydrology	Long-Term
	Analyze hydrologic effects of 2000's drought	Short-Term
	Analyze effects of Tribal Futures Projects	Short-Term
WWDC Projects	Encourage water resource development to meet the current and future needs and demands in the Basin	On-Going
	Conduct watershed studies to assess water resources and opportunities	On-Going
	Evaluate potential for and effects of additional municipal and agricultural conservation	Short-Term

8 Summary

The Basin Plan Update provides an update to the previous 2003 Wind-Bighorn Basin Plan. The Basin Plan Update was prepared to be consistent with the information and presentation of the Wyoming Framework Water Plan. The Framework Plan presents a statewide perspective on water resources compiled from the results of a seven-basin planning process performed by the Wyoming Water Development Commission.

Total annual diversions in the Wind-Bighorn Basin are approximately 3.3 million acre-feet, while consumptive use is approximately 1.2 million acre-feet. Three projections of overall water use through 2060 were prepared. The low water use projection shows a decline of 169,500 acre-feet, the medium water use projection shows an increase of 306.600 acre-feet, and the high water use projection shows an increase of 830,800 acre-feet. Surface water use is expected to decline 318,700 acre-feet in 2060 for the low water use projection, and increase by 24,000 acre-feet and 512,400 acre-feet for medium and high water use projections, respectively. Most additional new surface water use will be for agriculture. Estimated 2060 water use was approximately the same as the estimated 2030 water use in the previous Basin Plan. However, new water use in the previous Basin Plan was primarily comprised of increased surface water use for irrigation, while new water use in the Basin Plan update is primarily comprised of increased groundwater use for industry and mining, as well as increased surface water use for irrigation.

In general, it was found that there is substantial water available in most mainstem rivers, especially in downstream reaches, if storage were available. Water use availability on most tributary streams and upstream reaches of mainstem rivers is more limited, and much more dependent upon storage availability. Water availability in the Bighorn River at Yellowtail Dam exceeds 1.3 million acre-feet in average hydrologic years. In general, surface water availability increased or stayed the same as that estimated in the previous Basin Plan during dry years, and decreased during average and wet years. It should be noted that the spreadsheet models used for this analysis are for broad-based planning purposes only. The spreadsheet models do not include the ability to simulate water rights or carryover storage. More advanced hydrologic modeling is required prior to the development of any major water supply or storage project.

Project opportunities and program strategies were developed as part of the Basin Plan Update to address existing and future water use issues as developed by the BAG and the basin planning team. Project opportunities were developed based on the opportunities identified in the previous Basin Plan, those identified as part of the Framework Water Plan, and updates since the previous Basin Plan. A comprehensive list of program strategies was developed to help meet the needs of the Basin as they have been identified throughout the current Wind-Bighorn planning process and the statewide Framework Water Plan process.