MWH

Subject: **Wind/Bighorn River Basin Plan**

Task 3A/3B – Surface Water Hydrology

Date: **October 2002 (Revised March 2003)**

Prepared By: **MWH Americas, Inc.**

This Technical Memorandum reviews original data and methodologies used to develop surface water input data for the Wind/Bighorn River Basin Planning Model. The document fulfills the reporting requirements of Task 3A and a portion of Task 3B from the contract. The portion of the scope not included in this Technical Memorandum will be covered in later Technical Memoranda.

This technical memorandum contains the following sections. Within each section are tables and figures containing the data for each of the main study area basins.

SectionPage No.

Section 1 - Introduction

To be consistent with previous basin plans, the Wind-Bighorn Basin will be modeled using the same methodologies as used in the feasibility studies for the Bear River Basin and the Green River basin. The Guidelines for Development of Basin Plans (WWDC, 2001) recommended that for the purposes of the river basin plans, the hydrologic analysis be conducted for three 12-month periods using average dry-year conditions, average average-year conditions and average wet-year conditions. Therefore, each hydrologic region in the model will have three associated spreadsheet models representing those three hydrologic conditions. The gaged flows used in the spreadsheet model are developed by averaging recorded monthly streamflows for groups of years falling into those three hydrologic categories during a consistent period-of-record.

A map of the Wind/Bighorn River Basin Plan study area is shown in **Figure 1-1**. The study area includes those Missouri River basins located in northwestern Wyoming, including those portions of the Madison River Basin, Gallatin River Basin, Yellowstone River Basin and Wind/Bighorn River Basin located within the State of Wyoming. **Table 1-1** shows the USGS Hydrologic Unit classifications which are included in the planing area. All of the river basins are tributary to the Yellowstone River in southern Montana, which is subsequently tributary to the Missouri River in northeastern Montana.

Table 1-1. USGS Hydrologic Units and Associated Models Included in Study Area

Hydrologic Unit Code	Hydrologic Unit Name	Sub-Region Name[1]	Area (acres)	Study Basin	Study Sub-Basin
10020007	Madison	Missouri Headwaters	1,638,991	Madison/Gallatin	Madison/Gallatin
10020008	Gallatin	Missouri Headwaters	1,162,356	Madison/Gallatin	Madison/Gallatin
10070001	Yellowstone Headwaters	Upper Yellowstone	1,654,127	Yellowstone	Yellowstone
10070002	Upper Yellowstone	Upper Yellowstone	1,897,992	Yellowstone	Yellowstone
10070006	Clarks Fork Yellowstone	Upper Yellowstone	1,784,937	Clarks Fork	Clarks Fork
10080001	Upper Wind	Big Horn	1,628,472	Wind	Upper Wind
10080002	Little Wind	Big Horn	708,641	Wind	Little Wind
10080003	Popo Agie	Big Horn	511,611	Wind	Not Included[2]
10080004	Muskrat	Big Horn	466,187	Wind	Lower Wind
10080005	Lower Wind	Big Horn	1,084,233	Wind	Lower Wind
10080006	Badwater	Big Horn	538,167	Wind	Badwater
10080007	Upper Bighorn	Big Horn	2,217,263	Big Horn	Upper Big Horn
10080008	Nowood	Big Horn	1,282,397	Big Horn	Nowood
10080009	Greybull	Big Horn	733,218	Big Horn	Greybull
10080010	Big Horn Lake	Big Horn	1,150,802	Big Horn	Big Horn Lake
10080011	Dry	Big Horn	281,821	Big Horn	Big Horn Lake/Greybull
10080012	North Fork Shoshone	Big Horn	545,062	Big Horn	Shoshone
10080013	South Fork Shoshone	Big Horn	417,701	Big Horn	Shoshone
10080014	Shoshone	Big Horn	954,605	Big Horn	Shoshone

Notes:
[1]All Sub-Regions contained in the Missouri River Region.
[2]The Popo Agie River basin is modeled in the Popo Agie River Watershed study. This model contains an inflow node for the Popo Agie River that incorporates these results.

For purposes of the discussion herein, the Study Area has been divided into five basins: the Madison/Gallatin River Basin, the Yellowstone River Basin, the Wind River Basin and the Bighorn River Basin. The Madison River and Gallatin River are not hydrologically connected. However, they have been grouped together because the models will be very small. The Wind and Bighorn Rivers are actually the same river, changing names at the “Wedding of the Water” near Thermopolis. The river is called the Wind River south of the Owl Creek mountains while it is called the Bighorn River north of the Owl Creek mountains. The river has been separated because of the clear basin distinctions that occur through the Owl Creek mountains. There are no hydrologic connections, other than the river itself, across the mountain chain.

Section 2 - Historical Streamflow Records

The basin spreadsheet models utilize historical data to simulate river operations on a monthly basins during average dry, average and wet years. Therefore, data collection and reduction to useable formats within the model is the first task in the modeling effort.

Streamflow data is available for hundreds of locations throughout the study area for various periods-of-record. Streamflow gages are primarily operated and maintained by the USGS, while the SEO has historically operated miscellaneous gages in the basin for brief periods to assist in water delivery and accounting. USGS data is available from both the Wyoming Water Resources Data System (WRDS) and the USGS National Water Information System (NWIS) on the Internet (USGS, 2002). USGS data used in this model was researched using WRDS, then downloaded from the Internet to facilitate incorporation into existing data reduction spreadsheets.

Separate spreadsheets for each hydrologic unit were developed to store streamflow data. Typically, the base reporting level for the USGS is average daily streamflow in cubic feet per second (cfs). Therefore, in order to have available the most detailed records in the database, the average daily streamflow was downloaded from the Internet and stored in the spreadsheet. Then, the spreadsheet was used to reduce daily data into total monthly flow and total annual flow in acre-feet for each month and year that data was available.

Locations of river basins, major waterways, gages and approximate irrigated lands are shown in the figures within this section. It should be noted that the irrigated lands shown in these maps are from preliminary irrigated lands delineations and are intended only to show the locations of streamflow gages in relationship to irrigated lands. Final irrigated lands delineations within the study area are available in the GIS coverages developed as part of the Wind/Bighorn River Basin Plan.

2.1 Madison/Gallatin River Basins

The streamflow gages located within and immediately downstream of the study area for the Madison River and Gallatin River basins are shown in **Figure 2-1** and **Table 2-1**. There is a streamflow gage on both the Firehole River and Gibbon River within Wyoming upstream of their confluence. In addition, there is a gage on the Madison River just downstream of the Wyoming/Montana state line. The Firehole and Gibbon River gages ceased operations in 1996 while the Madison River gage is still operational. There are no streamflow gages on the Gallatin River within Wyoming. The closest gage to the state line is located approximately 10 miles downstream of the state line near the Gallatin Gateway. The gage is currently operational. However, there are small gaps in the record that required filling.

Table 2-1. Madison and Gallatin River Basin Streamflow Gages

Basin	Gage Number	Gage ID	Gage Name	Drainage Area (sq. mi.)	Period of Record
Madison/ Gallatin	06036905	Firehole	Firehole River near West Yellowstone, MT	282	Oct 1983 - Mar 1996
	06037000	Gibbon	Gibbon River near West Yellowstone, MT	118	Jun 1913 - Mar 1996[(1)]
	06037500	Mad_WstY	Madison River near West Yellowstone, MT	420	Jul 1913 - Sep 2001[(1)]
	06043500	Gal_GalGt2	Gallatin River near Gallatin Gateway, MT	825	Aug 1889 - Sep 2001[(1)]

Notes:
[(1)]Incomplete data within period-of-record.

2.2 Yellowstone River Basin

The streamflow gages located within the hydrologic unit are shown in **Figure 2-2** and **Table 2-2**. The Yellowstone River at Corwin Springs (06191500) is located in Montana, but was included in this analysis for two reasons: (1) it contains an uninterrupted long-term period-of-record which is extremely useful in data analysis and data extension, and (2) it is located just downstream of the confluence of the Gardner River confluence, which provides a convenient terminus for the model. Four of the gages are currently operational.

Table 2-2. Yellowstone River Basin Streamflow Gages

Basin	Gage Number	Gage ID	Gage Name	Drainage Area (sq. mi.)	Period of Record
Yellowstone	06186500	Yl_LkOut	Yellowstone River at Yellowstone Lake Outlet, YNP	1,006	Oct 1926 - Sep 2001[(1)]
	06187000	Yl_CnHot	Yellowstone River near Canyon Hotel, YNP	1,157	Jun 1913 - Sep 1951[(1)]
	06187500	Tow_TowF	Tower Creek at Tower Falls, YNP	50	Sep 1922 - Sep 1943[(1)]
	06187915	Sod_Slv	Soda Butte Creek at Park Boundary at Silver Gate	50	Oct 1999 - Sep 2001
	06187950	Sod_LRS	Soda Butte Creek near Lamar Ranger Station, YNP	99	Oct 1988 - Sep 2001
	06188000	Lam_TRS	Lamar River near Tower Falls Ranger Station, YNP	660	May 1923 – Sep 2001[(1)]
	06188500	EFBl_Mam	East Fork Blacktail Deer Creek near Mammoth, YNP	10	Nov 1937 - Sep 1941
	06189000	BlD_Mam	Blacktail Deer Creek near Mammoth, YNP	15	Nov 1937 - Sep 1993[(1)]
	06190000	Lup_Mam	Lupine Creek near Mammoth, YNP	5	Nov 1937 - Sep 1941
	06190500	Gard_Mam	Gardner River at Mammoth, YNP	200	Sep 1922 - Oct 1938[(1)]
	06190540	Gard_nrMam	Hot River at Mammoth, YNP	(2)	Oct 1988 - Sep 1995
	06191000	Hot_Mam	Gardner River near Mammoth, YNP	202	Oct 1938 - Sep 2001[(1)]
	06191500	Yl_CSp	Yellowstone River at Corwin Springs, MT	2,623	May 1897 - Sep 2001[(1)]

Notes:
[(1)]Incomplete data within period-of-record.

2.3 Clarks Fork River Basin

A list of streamflow gages in the Clarks Fork Hydrologic Unit is shown in **Figure 2-3** and **Table 2-3**. Gages are located on the Clarks Fork upstream of irrigation diversions within Wyoming and immediately downstream of the Wyoming/Montana State Line. In addition, Big Sand Coulee, which is the only major tributary that crosses the state line within the basin, also has gages upstream of the major diversions and downstream of the state line, just upstream of its confluence with the Clarks Fork. As shown, the Clarks Fork Yellowstone River near Belfry, Montana gage (06207500) has an extensive period-of-record. This gage is located just upstream of the confluence of the Clarks Fork and Big Sand Coulee. However, all other gages required extensive filling to be used in the model.

Table 2-3. Clarks Fork River Basin Streamflow Gages

Basin	Gage Number	Gage ID	Gage Name	Drainage Area (sq. mi.)	Period of Record
Clarks Fork	06205500	CFk_abSqC	Clarks Fork Yellowstone River above Squaw Crk near Painter, WY	194	Oct 1945 - Sep 1951
	06205950	Ldg_Pnt	Lodgepole Creek at Mouth, near Painter, WY	(2)	Apr 1989 - Sep 1989
	06206000	Cfk_blCrC	Clarks Fork Yellowstone River below Crandall Ck near Painter, WY	446	Oct 1929 - Sep 1957(1)
	06206500	Sun_Pnt	Sunlight Creek near Painter, WY	135	Aug 1929 - Sep 1971(1)
	06207000	CFk_nrClk	Clarks Fork Yellowstone River near Clark, WY	912	Oct 1918 - Dec 1924
	06207500	Cfk_BlfMT	Clarks Fork Yellowstone River near Belfry, MT	912	Aug 1921 - Sep 2001
	06207507	BigS_nrBdg	Big Sand Coulee above St Ditch near Badger Basin, WY	98	May 1973 - Sep 1977(1)
	06207510	BigS_Line	Big Sand Coulee at WY-MT State Line	98	May 1973 - Sep 1981(1)
	06207540	STip_BlfMT	Silver Tip Creek near Belfry t Mt	98	Oct 1967 - Sep 1975

Notes:
(1)Incomplete data within period-of-record.

2.4 Wind River Basin

Streamflow data for the Wind River Basin are shown in **Figure 2-4**, **Figure 2-5**, **Figure 2-6**, **Figure 2-7** and **Table 2-4**. Gages are located throughout the basin on the Wind River. In addition, there are several headwaters gages located on tributaries south of the Wind River, upstream of diversions and storage for the Wind River Irrigation Project and Riverton Unit. Streamflow gages are located on most major tributaries upstream of agricultural diversions. In addition, there are streamflow gages on the lower portions of the Little Wind River that improved model calibration. It should be noted that only streamflow gages are presented in this section – there are several return flow gages operated by the USGS that could be used in the model but are not shown in the following table and figures. Most of those gages shown are heavily influenced by agricultural diversions and return flows.

Table 2-4. Wind River Basin Streamflow Gages

Basin	Gage Number	Gage ID	Gage Name	Drainage Area (sq. mi.)	Period of Record
Upper Wind	06218500	wind_nrDub	Wind River near Dubois, WY	232	Oct 1945 - Sep 1992
	06220000	Wind_atDub	Wind River at Dubois, WY	486	Jan 1911 - Sep 1912
	06220500	EFWind_Dub	East Fork Wind River near Dubois, WY	427	May 1950 - Sep 1997(1)
	06220800	Wind_RedCk	Wind River above Red Creek near Dubois, WY	1,073	Oct 1990 - Sep 2001
	06221400	Din_abLks	Dinwoody Creek above Lakes near Burris, WY	88	Oct 1957 - Sep 2001(1)
	06221500	Din_Bur	Dinwoody Creek near Burris, WY	100	Jun 1918 - Sep 1958(1)
	06222000	Wind_Bur	Wind River near Burris, WY	1,236	Oct 1950 - Sep 1953
	06222500	DryCk_Bur	Dry Creek near Burris, WY	54	Jun 1921 - Sep 2001(1)
	06222700	CrowCk_Tip	Crow Creek near Tipperary, WY	30	Oct 1962 - Sep 1993
	06223000	MdCk_Len	Meadow Creek near Lenore, WY	42	Apr 1922 - Sep 1923(1)
	06223500	WlCk_Crow	Willow Creek near Crowheart, WY	55	Oct 1921 - Sep 2001(1)
	06224000	BlCk_abLk	Bull Lake Creek above Bull Lake, WY	187	Oct 1941 - Sep 2001(1)
	06225000	BlLk_Len	Bull Lake Creek near Lenore, WY	213	Jun 1918 - Sep 2001(1)
	06225500	Wind_Crow	Wind River near Crowheart, Wy	1,891	Oct 1945 - Sep 2001
	06227600	Wind_Kin	Wind River near Kinnear, Wy	2,194	Apr 1974 - Sep 2000(1)
	06228000	Wind_Riv	Wind River at Riverton, Wy	2,309	Apr 1912 - Sep 2001(1)
	06236100	wind_abBoy	Wind River above Boysen Reservoir near Shoshoni, WY	4,390	May 1990 - Sep 2001
Little Wind	06228350	SFLW_abWRes	Sf L Wind R Ab Washakie Re Nr Ft Washakie, WY	90	Oct 1976 - Sep 2001
	06228450	SFLW_blWRes	South Fork Little Wind Riv Bel Washakie Res, WY	94	Oct 1988 - Sep 2001
	06228500	LW_FtWa	Little Wind River near Fort Washakie, WY	117	May 1921 - Sep 1940
	06228800	NFLW_nrFW	North Fork Little Wind River Nr Fort Washakie, WY	(2)	Oct 1988 - Sep 2001
	06229000	NFLW_atFW	N Fk Little Wind R At Fort Washakie, WY	112	May 1921 - Sep 1940
	06229680	Sage_Nork	Sage Cr Ab Norkok Meadows Cr, Nr Ft Washakie, WY	118	Jul 1990 - Sep 1995
	06229900	Trout_FW	Trout Creek near Fort Washakie, WY	16	May 1990 - Sep 2001(1)
	06230190	Mill_abRL	Mill Cr Ab Ray Lake Outlet Canal, Nr Ft Washakie	16	May 1990 - Sep 1996
	06230500	LW_nrArap	Little Wind River near Arapahoe, WY	618	Oct 1950 - Sep 1953
	06231000	LW_abArap	Little Wind River above Arapahoe, WY	660	Oct 1979 - Sep 1995
	06234000	LW_blArap	Little Wind River below Arapahoe, WY	1,464	Jun 1906 - Oct 1918(1)
	06234500	Beav_nrLnd	Beaver Creek near Lander, WY	113	Jun 1938 - Sep 1941
	06235000	Beav_nrAr	Beaver Creek near Arapahoe, WY	354	May 1950 - Sep 1953
	06235500	LW_Riv	Little Wind River Near Riverton, WY	1,904	Jun 1941 - Sep 2001

Table 2-4 continued

Basin	Gage Number	Gage ID	Gage Name	Drainage Area (sq. mi.)	Period of Record
Lower Wind	06239000	Musc_Sho	Muscrat Creek near Shoshoni, WY	733	Jul 1950 - Sep 1973(1)
	06244500	5mi_aPav	Fivemile Creek above WY Ca near Pavillion, WY	118	Oct 1949 - Sep 2001(1)
	06245000	5mi_Pav	Fivemile Creek near Pavillion, WY	118	Sep 1948 - Sep 1949
	06250000	5mi_Riv	Fivemile Creek near Riverton, WY	356	Oct 1949 - Sep 1965(1)
	06251500	Sand_Sho	Sand Gulch near Shoshoni, WY	19	Sep 1948 - Sep 1953(1)
	06253000	5mi_Sho	Fivemile Creek near Shoshoni, WY	418	Jun 1941 - Sep 2001(1)
	06255500	Poi_Sho	Poison Creek near Shoshoni, WY	500	Oct 1952 - Dec 1953(1)
	06257500	Mud_Pav	Muddy Creek near Pavillion, WY	267	Apr 1949 - Sep 1973(1)
	06258000	Mud_Sho	Muddy Creek near Shoshoni, WY	332	Mar 1949 - Sep 1983(1)
	06258500	DCot_Bon	Dry Cottonwood Creek near Bonneville, WY	165	Oct 1949 - Sep 1953
	06259000	Wind_blBy	Wind River below Boysen Reservoir, WY	7,701	Jun 1951 - Sep 2001
Badwater	06256000	Bad_Lyb	Badwater Creek at Lybyer Ranch, near Lost Cabin, WY	131	Oct 1948 - Sep 1968
	06256500	Bad_LC	Badwater Creek at Lost Cabin, WY	166	Sep 1945 - Sep 1948
	06256650	Bad_Lys	Badwater Creek at Lysite, WY	415	Nov 1965 - Sep 1973
	06256800	Bri_Lys	Bridger Creek near Lysite, WY	182	Nov 1965 - Sep 1973
	06256900	Dry_Bon	Dry Creek near Bonneville, WY	53	Oct 1965 - Sep 1980
	06257000	Bad_Bon	Badwater Creek at Bonneville, WY	808	May 1947 - Sep 1973

Notes:
(1)Incomplete data within period-of-record.

2.5 Bighorn River Basin

Streamflow gaging stations for the Bighorn River Basin are shown in **Figure 2-8**, **Figure 2-9**, **Figure 2-10**, **Figure 2-11**, **Figure 2-12** and **Table 2-5**. Streamflow measurements have been taken on many of the mainstem river and tributaries at some point in recent history. However, many of those gages have been decommissioned and the number of currently active gages is considerable less than the total number of gages in the basin. The Shoshone River Basin, Greybull River Basin and portions of the Bighorn Lake basins have either a significant number of gages or adequate gages to develop and calibrate the model, including some headwaters gages. The Upper Bighorn tributary basins have periodic gage records that assisted in developing the model, however, model calibration was more difficult due to the large number of estimated flows that were required.

Table 2-5. Bighorn River Basin Streamflow Gages

Basin	Gage Number	Gage ID	Gage Name	Drainage Area (sq. mi.)	Period of Record
Upper Bighorn	06259500	Bh_Therm	Bighorn River at Thermopolis, WY	8,020	Oct 1911 - Sep 1953(1)
	06260000	SFOwl_nrAnc	South Fork Owl Creek near Anchor, WY	87	Oct 1940 - Sep 1995(1)
	06260200	MdOwl_abAnc	Middle Fork Owl Creek above Anchor Reservoir, WY	34	Mar 1959 - Sep 1965
	06260400	SFOwl_blAnc	South Fork Owl Creek below Anchor Reservoir, WY	131	May 1959 - Sep 2001(1)
	06260500	SFOwl_Crt	S F Owl Creek Ab Curtis Ranch, nr Thermopolis, WY	144	Oct 1943 - Sep 1959
	06261000	SFOwl_acrn	S F Owl C above C Rn near Thermopolis, WY	149	Oct 1938 - Sep 1943
	06261500	SFOwl_nrTh	South Fork Owl Creek Nr Thermopolis, WY	180	Aug 1921 - Apr 1932(1)
	06262000	NFOwl_nrAnc	North Fork Owl Creek Near Anchor, WY	55	May 1941 - Jul 1962(1)
	06262300	NFOwl_abBR	North Fork Owl Cr ab Basin Ranch nr Anchor, WY	61	Apr 1962 - Sep 1995(1)
	06262500	NFOwl_atCR	N.F. Owl Creek at Crann Ranch nr Thermopolis, WY	94	Jun 1938 - Sep 1939
	06263000	NFOwl_nrTh	North Fork Owl Creek nr Thermopolis, WY	102	May 1930 - Sep 1932
	06263500	Mud_Th	Mud Creek nr Thermopolis Wyo	101	May 1938 - Sep 1939
	06264000	Owl_Th	Owl Creek near Thermopolis, Wy	478	Mar 1911 - Sep 1969(1)
	06264500	Owl_Luc	Owl Creek near Lucerne, WY	509	Mar 1932 - Sep 1953(1)
	06265000	Kirb_Luc	Kirby Creek near Lucerne, WY	199	Jul 1941 - Sep 1945
	06265337	Cot_HamD	Cottonwood C at High Island Rnch nr Hamilton Dome	82	Apr 1993 - Sep 2001
	06265500	Cot_Win	Cottonwood Creek at Winchester, WY	416	Jun 1941 - Sep 1945
	06265800	Gos_atDk	Gooseberry Creek at Dickie, WY	95	Oct 1957 - Sep 1978
	06266000	Gos_Grs	Gooseberry Creek near Grass Creek, WY	142	Oct 1945 - Sep 1957
	06266500	Gos_nrDk	Gooseberry Creek near Dickie, WY	289	Jun 1938 - Sep 1941(1)
	06267000	Gos_Nei	Gooseberry Creek at Neiber, WY	361	Jun 1941 - Sep 1953(1)
	06267400	Now_Colt	East Fork Nowater Creek near Colter, WY	149	Oct 1971 - Sep 1991
	06268500	15mi_Wor	Fifteen Mile Creek near Worland, WY	518	Mar 1951 - Sep 1986(1)
	06268600	Bh_Wor	Bighorn River at Worland, WY	10,810	Jul 1965 - Oct 1969
	06269000	Bh_nrMand	Bighorn River near Manderson, WY	11,020	Apr 1949 - Sep 1956(1)
	06269500	Bh_atMand	Bighorn River at Manderson, WY	11,048	Oct 1941 - Sep 1949
	06271500	Pr_beLSol	Paintrock Creek below Lake Solitude, WY	16	Sep 1946 - Sep 1953(1)
	06274300	Bh_Bas	Bighorn River at Basin, WY	13,223	Oct 1983 - Sep 2001

Notes:
(1)Incomplete data within period-of-record.

Table 2-5 continued

Basin	Gage Number	Gage ID	Gage Name	Drainage Area (sq. mi.)	Period of Record
Nowood	06270000	Now_Ten	Nowood River near Tensleep, WY	803	Jun 1938 - Sep 1992(1)
	06270450	Can_beCk	Canyon Creek below Cooks Canyon, Near Tensleep, WY	72	Apr 1969 - Sep 1971
	06270500	Can_Ten	Canyon Creek near Tensleep, WY	86	Jun 1939 - Sep 1944
	06271000	Ten_Ten	Tensleep Creek near Tensleep, WY	247	Oct 1910 - Oct 1972(1)
	06272500	Pnt_Hyat	Paintrock Creek near Hyattville, WY	164	Aug 1920 - Sep 1953(1)
	06273000	Med_Hyat	Medicine Lodge Creek near Hyattville, WY	87	Oct 1943 - Sep 1973(1)
	06273500	Pnt_beHyat	Paintrock Creek near Mouth Below Hyattville, WY	376	Aug 1910 - Dec 1922(1)
	06274000	No_Bonz	Nowood River at Bonanza, WY	1,730	Aug 1910 - Sep 1928(1)
	06271500	Pnt_LkSol	Paintrock Creek below Lake Solitude, WY	16	Sep 1946 - Sep 1953(1)
Greybull	06274500	Gry_PtFk	Greybull River near Pitchfork, WY	282	May 1946 - Sep 1971(1)
	06274800	Wod_nrKir	Wood River near Kirwin, WY	8	Oct 1970 - Sep 1975
	06274810	Wod_atKir	Wood River at Kirwin, WY	11	Oct 1975 - Sep 1978
	06275000	Wod_Sun	Wood River at Sunshine, WY	194	Sep 1945 - Sep 1992
	06275500	Wod_Met	Wood River near Meeteetse, Wyo.	211	Oct 1936 - Sep 1949
	06276000	Gry_nrMet	Greybull River near Meeteetse, WY	659	Oct 1910 - Sep 1916(1)
	06276500	Gry_atMet	Greybull River at Meeteetse, WY	681	Oct 1920 - Sep 2000(1)
	06277500	Gry_Bas	Greybull River near Basin, WY	1,115	Oct 1930 - Sep 1973
	06277950	Dry_Grey	Dry Creek near Greybull, WY	432	Apr 1979 - Sep 1981
Bighorn Lake	06278000	Dry_Grey	Dry Creek at Greybull, WY	433	Apr 1951 - Sep 1959(1)
	06278300	Shl_abRes	Shell Creek above Shell Creek Reservoir, WY	23	Oct 1956 - Sep 2001
	06278500	Shl_nrShl	Shell Creek near Shell, WY	145	Oct 1940 - Sep 2001(1)
	06279000	Shl_atShl	Shell Creek at Shell, WY	256	Apr 1914 - Sep 1924(1)
	06279500	Bh_Kane	Bighorn River at Kane, WY	15,765	Oct 1928 - Sep 2001(1)
	06286250	Bh_Lov	Bighorn River near Lovell, WY	18,900	Dec 1964 - Sep 1966
	06286258	BiC_Lov	Big Coulee near Lovell, WY	30	Apr 1970 - Sep 1978
	06286260	Crk_Lov	Crooked Creek near Lovell, WY	119	Dec 1964 - Nov 1967
	06286270	Porc_Lov	Porcupine Creek near Lovell, WY	135	Nov 1964 - Nov 1967
Shoshone	06279790	Jones_Pah	Jones Creek at Mouth, near Pahaska, WY	25	Mar 1989 - Sep 1993(1)
	06279795	Crow_Pah	Crow Creek at Mouth, at Pahaska, WY	19	Mar 1989 - Sep 1993(1)
	06279800	NFSh_Pah	North Fork Shoshone River at Pahaska, WY	108	Apr 1989 - Sep 1990(1)
	06279850	Mdi_YNP	Middle Creek at East Entrance YNP, WY	33	Oct 1981 - Sep 1984
	06279940	NFSh_atWap	North Fork Shoshone River at Wapiti, WY	699	Oct 1989 - Sep 2000
	06280000	NFSh_nrWap	North Fork Shoshone River near Wapiti, WY	775	Jan 1921 - Sep 1989(1)
	06280300	SFSh_Val	South Fork Shoshone River near Valley, WY	297	Oct 1956 - Sep 2000(1)
	06280500	SFSh_Ish	South Fork Shoshone River near Ishawooa, WY	541	Jun 1915 - Oct 1923(1)
	06281000	SFSh_abBB	South Fork Shoshone R above Buffalo Bill Res, WY	585	May 1903 - Sep 2000(1)
	06281400	Dia_nrCdy	Diamond Creek near Mouth near Cody, WY	7	Dec 1980 - Sep 1992
	06282000	Sh_beBB	Shoshone River Below Buffalo Bill Reservoir, WY	1,538	Jan 1921 - Sep 2000
	06282500	Sh_Cody	Shoshone River at Cody, WY	1,603	May 1902 - Dec 1909
	06283000	Sho_Corb	Shoshone River at Corbett Dam, WY	1,793	May 1908 - Sep 1925(1)
	06283800	Sh_abWillD	Shoshone R ab Willwood Dam near Willwood, WY	(2)	Nov 1979 - Oct 1982
	06284000	Sh_atWillD	Shoshone River at Willwood Dam, WY	1,833	Aug 1925 - Sep 1926
	06284200	Sh_Will	Shoshone River at Willwood, WY	1,980	Apr 1974 - Sep 1979
	06284400	Sho_Garl	Shoshone River near Garland, WY	2,036	May 1958 - Sep 1979
	06284500	Bit_Garl	Bitter Creek near Garland, WY	81	Mar 1950 - Sep 1987(1)
	06284800	Whst_Garl	Whistle Creek near Garland, WY	101	Jun 1958 - Sep 1987(1)
	06285000	Sh_Byr	Shoshone River at Byron, WY	2,345	Jan 1929 - Sep 1966
	06285100	Sh_nrLov	Shoshone River near Lovell, WY	2,350	Oct 1966 - Sep 2000
	06285400	Sag_atSid	Sage Creek at Sidon Canal, near Deaver, WY	341	Jun 1958 - Sep 1987(1)
	06285500	Sag_Lov	Sage Creek near Lovell, WY	381	May 1951 - Sep 1960
	06286000	Sho_atLov	Shoshone River at Lovell, WY(1)	2,832	Jun 1897 - Sep 1898
	06286200	Sh_Kane	Shoshone River at Kane, WY	2,989	Oct 1957 - Sep 1968

Section 3 - Study Period Selection

Because historical data is not available for all gages since the inception of data collection, and to make the model less expansive and easier to use, a representative study period has been selected from the data set. The study period is intended to be representative of the overall long-term gage records and hydrologic conditions. To be consistent within the study period, overall patterns of basin inflows, diversions and storage must remain constant through the study period. Therefore, study periods were selected to minimize the impacts of major reservoirs or diversion projects within the period of record. This required examination of reservoir and diversion construction records. Streamflow statistics within each study period were checked against long-term statistics at gages with long-term records to ensure that the data was representative of the long-term period.

The following events were considered in selection of a model study period. Note that this list of events focuses primarily on significant events during the past 50 years that could have had significant impacts on streamflow.

- Construction of Boysen Reservoir was completed in 1952. Boysen Reservoir is located on the Wind River at the entrance to Wind River Canyon north of Shoshone. The reservoir has a capacity of approximately 760,000 acre-feet.

- Pumping plants for the Hanover-Bluff Unit were completed from 1956 through 1958. The pumping plants have a combined capacity of 240 cfs.

- Anchor Dam, located in the Owl Creek basin, was completed in 1960, and was used to temporarily store water in the mid-1960's. However, due to seepage problems in the floor of the reservoir, it typically does not provide any carryover storage, and is limited to only a portion of its original 17,000 acre-foot capacity.

- Construction of Yellowtail Dam, located on the Bighorn River at the Wyoming-Montana state line, was completed in 1967. Although the reservoir does not directly impact flows in Wyoming, the reservoir is used to administer the Yellowstone River Compact requirements, and its initial filling and use in administration does have impacts on river basin management.

- In 1972, construction was completed on Lower Sunshine Reservoir, which is an off-channel reservoir in the Greybull River Basin. The reservoir has a conservation capacity of approximately 66,000 acre-feet.

- In 1973, construction was completed on Lake Cameahwait Reservoir and Middle Cottonwood Creek Reservoir. These reservoirs are located in the Riverton Unit and primarily control return flows from Riverton Unit irrigation. These facilities likely have only small impacts on overall river flow.

- Modifications on Buffalo Bill Dam, which is located at the confluence of the North and South Forks of the Shoshone River, were completed in 1993. The modifications included an increase in conservation capacity of approximately 190,000 acre-feet of conservation storage. Total reservoir capacity is approximately 640,000 acre-feet.

- In 2000, construction was completed on Greybull Valley Dam, an off-channel facility tributary to the Greybull River. Total reservoir capacity is approximately 30,000 acre-feet.

- Several other minor enlargements (generally less than 5,000 acre-feet) were completed on a variety of small reservoirs throughout the study period. However, because the impact of these reservoirs has little affect on carryover storage, their overall impacts are minimal.

As shown, there is no time period that would completely eliminate impacts of new projects within the period-of-record. However, several events occurred between the 1950s and early 1970s, which would have had a substantial impact on river flows. In addition to the major projects shown above, use of more modern irrigation practices such as gated pipe and sprinklers also increased significantly during the early 1970's. Therefore, for purposes of this study, a study period of 1973-2001 was chosen. This period is especially beneficial in that for most of the basins, both the driest and wettest years on record are contained in the study period. A statistical analysis of the selected study period for each basin is detailed below.

3.1 Madison/Gallatin River Basin

In both the Madison and Gallatin River basins, because there are no major storage reservoirs or significant surface water diversions in the area, there have been few man-made changes in river regime. Although data is available for the Madison River since the 1910's and for the Gallatin River since the 1930's, only more recent data is available for the Firehole and Gibbon Rivers. To remain consistent with the other basins in this study, the 1973-2001 study period has been selected for the Madison River/Gallatin River basin model.

Table 3-1 presents a statistical summary of the period-of-record and the study period for the Madison River near West Yellowstone (06037500). As shown, the average flow during the study period is approximately 5.6 percent higher than the long-term average. In addition, for the hydrologic year classification, all of the hydrologic year classification averages are higher for the study period than for the long-term period-of-record (hydrologic year classification is further discussed in the following sub-section).

Table 3-1. Statistical Summary for Madison River near West Yellowstone (06037500)

Statistic	Period-of-Record 1914 – 2001	Study Period 1973-2001	Difference
Mean	363,725	384,160	5.6%
Standard Deviation	59,319	58,978	-0.6%
Avgerage – Dry Years	282,765	321,789	13.8%
Average – Average Years	356,965	373,437	4.6%
Average – Wet Years	446,142	476,914	6.9%
Maximum	571,071	571,071	0.0%
Minimum	243,949	319,163	30.8%

The cumulative departure from the mean analysis shown in **Figure 3-1** indicates that there was a more severe period of sustained low flows from 1922 - 1949 and except for a general period of lower flows from 1986 - 1994, a general trend of higher flows since that time. Two factors could be contributing to the variability in the statistical summary:

1) the basin is influenced by naturally unstable groundwater inflows,
2) runoff from the basin has a smaller variability from year to year, meaning small percentage changes in runoff have a more significant effect on summary statistics.

Because the general trend in the basin in river flows since 1950 is slightly higher flows than the long-term average, the period-of-record used is deemed adequate. However, if drought studies are conducted for downstream water users in the basin (downstream of Wyoming), a longer period-of-record that accounts for the lower flow conditions earlier in the 20th century should be used.

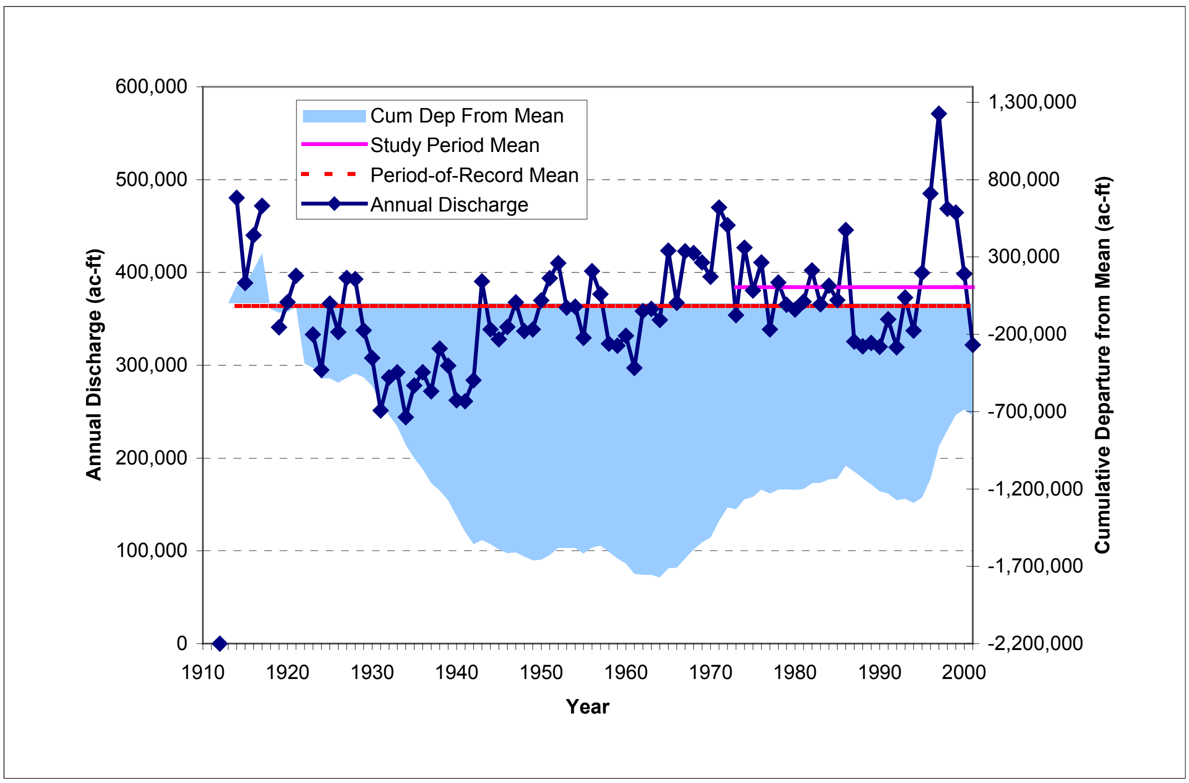

Figure 3-1. Comparison of Study Period Data to Long Term Data for Madison River near West Yellowstone (06037500)

3.2 Yellowstone River Basin

In the Yellowstone River basin, because there are no major storage reservoirs or significant surface water diversions in the area, there have been few man-made changes in river regime. In addition, data is available in part for several gages since the mid-1920s. Therefore, the study period for the Yellowstone River model could extend back through the years when data is available, or approximately 75 years. However, to remain consistent with the other basins in this study, the 1973-2001 study period has been selected for the Yellowstone River model.

Table 3-2 presents a statistical summary of the period-of-record and the study period for the Yellowstone River at Corwin Springs. As shown, the average flow during the study period is approximately 1.1 percent higher than the long-term average. For the hydrologic year classification, the drier years are slightly drier than the long-term average, while the wet years are slightly wetter than the long-term average. This will tend to make the model slightly conservative regarding water supply. However, if excess water were used to fill a reservoir used for carryover storage, the model may show that there is more water available during wet years to fill the reservoir than what has been available during the long-term average (hydrologic year classification is further discussed in the following sub-section).

Table 3-2. Statistical Summary for Yellowstone River at Corwin Springs

Statistic	Period-of-Record 1911 – 2001	Study Period 1973-2001	Difference
Mean	2,264,672	2,290,531	1.1%
Standard Deviation	496,186	553,594	11.6%
Avgerage – Dry Years	1,611,985	1,583,982	-1.7%
Average – Average Years	2,242,018	2,259,973	0.8%
Average – Wet Years	2,986,579	3,083,661	3.3%
Maximum	3,733,984	3,733,984	0.0%
Minimum	1,377,898	1,432,264	3.9%

The cumulative departure from the mean analysis shown in **Figure 3-2** indicates that there was a more severe period of sustained low flows (1928-1946) and a more significant period of sustained high flows (1961-1976) in the period-of-record than what is reflected in the study period. However, since the model includes on a single year analysis for each hydrologic condition, the hydrologic year classification is conservative, and because there is no long-term carryover water supply storage in the basin, this should not affect the results.

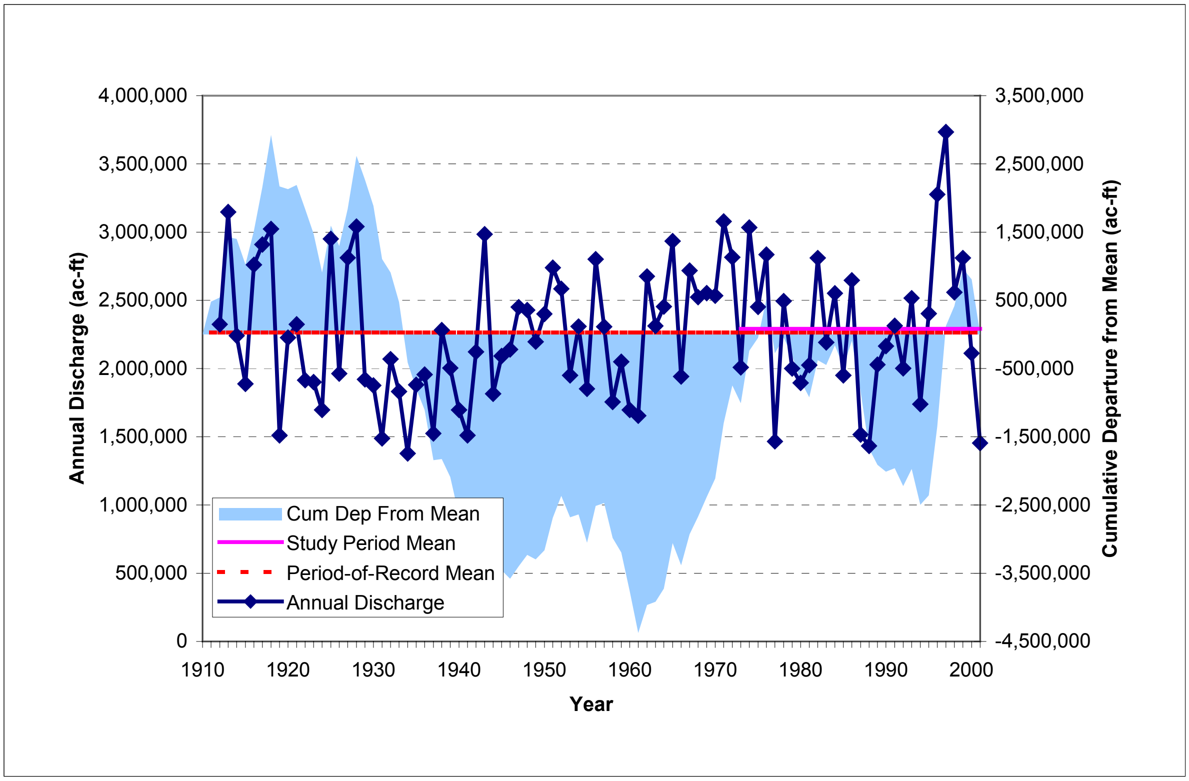

Figure 3-2. Comparison of Study Period Data to Long Term Data for Yellowstone River at Corwin Springs (06191500)

3.3 Clarks Fork River Basin

Although the Clarks Fork River basin does not have any major storage reservoirs within the study area, there are some minor diversions which affect river flows. However, in general, operations of those diversions have not changed for many years. In addition, the diversions are relatively minor in magnitude compared with the magnitude of river flows. Therefore, there likely has not been a significant change in river regime. Data is available in part for the Clarks Fork near Belfry gage since the early 1920s. However, all other gages will require significant filling for use in the model. Therefore, the study period for the Clarks Fork model could extend back through the years when data is available at the Belfry gage, or approximately 80 years. However, to remain consistent with the other basins in this study, the 1973-2001 study period has been selected for the Clarks Fork model.

Table 3-3 presents a statistical summary of the period-of-record and the study period for the Clarks Fork Yellowstone River near Belfry. As shown, the average flow during the study period is approximately 2.0 percent less than the long-term average. In addition, the hydrologic year averages for the study period are all slightly less than the long-term average, which results in the model being slightly conservative towards water supply in general (hydrologic year classification is further discussed in the following sub-section).

Table 3-3. Statistical Summary for Clarks Fork Yellowstone river near Belfry (06207500)

Statistic	Period-of-Record 1922 – 2001	Study Period 1973-2001	Difference
Mean	678,048	664,349	-2.0%
Standard Deviation	156,308	170,919	9.3%
Avgerage – Dry Years	482,266	430,150	-10.8%
Average – Average Years	659,734	658,300	-0.2%
Average – Wet Years	928,773	915,688	-1.4%
Maximum	1,075,109	1,075,109	0.0%
Minimum	395,919	395,919	0.0%

The cumulative departure from the mean analysis shown in **Figure 3-3** indicates that the study period will contain the most prolonged period of sustained high flows (1969-1976) as well as a prolonged period of sustained low flows (1982-1994). In addition, the study period contains the single highest and fifth highest high flows and six of the seven lowest flows in the period-of-record. These statistics all indicate that the period-of-record is conservatively representative of the long term data from a water supply perspective.

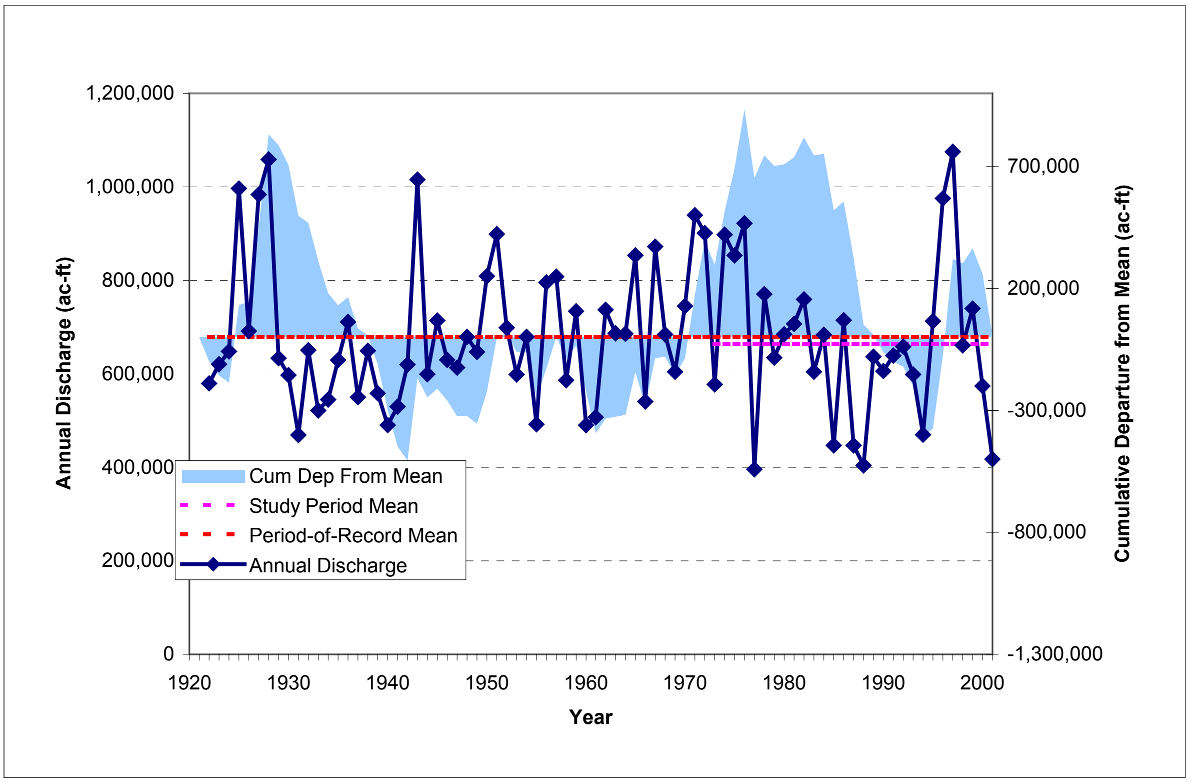

Figure 3-3. Comparison of Study Period Data to Long Term Data for Clarks Fork Yellowstone River near Belfry (06207500)

3.4 Wind River Basin

Although flows in the Wind River basin are significantly impacted by major storage reservoirs and irrigation diversions, the construction and operations of those facilities within the basin have remained fairly constant through the study period. The two return flow reservoirs previously mentioned, Lake Cameahwait Reservoir and Middle Cottonwood Creek Reservoir, have no impact on upstream river flows. Data is available for several gages within the basin for fairly long and significant time periods, especially gages located in the Upper Wind basin. Records in the Little Wind River basin are shorter in length, with several of the more important gages starting recording in the late 1970s and early 1980s or in the early 1990s. Therefore, record extensions were required for those gages.

Table 3-4 presents a statistical summary of the period-of-record and the study period for the Little Wind River near Riverton. As shown, the average flow during the study period is approximately 2.2 percent less than the long-term average. For the hydrologic year classification, the dry and average years are slightly drier than the long-term average, while the wet years are slightly wetter than the long-term average, which will generally make the model slightly conservative regarding water supply. However, if excess water were used to fill a reservoir for carryover storage, the model may show that there is slightly more water available to fill the reservoir during wet years than what has been available during the long-term average (hydrologic year classification is further discussed in the following sub-section).

Table 3-4. Statistical Summary for Little Wind near Riverton (06235500)

Statistic	Period-of-Record 1942 – 2001	Study Period 1973-2001	Difference
Mean	417,778	408,775	-2.2%
Standard Deviation	151,116	169,197	12.0%
Avgerage – Dry Years	212,305	199,337	-6.1%
Average – Average Years	415,338	396,907	-4.4%
Average – Wet Years	630,568	651,841	3.4%
Maximum	739,201	739,201	0.0%
Minimum	126,379	126,379	0.0%

The cumulative departure from the mean analysis shown in **Figure 3-4** indicates that the study period will contain a prolonged period of generally sustained low flows (1986-1994) as well as a prolonged period of generally sustained high flows (1994-1999). In addition, the study period contains the three highest high flows and three of the four lowest flows in the period-of-record. These statistics all indicate that the period-of-record is conservatively representative of the long term data from a water supply perspective. It should be remembered that this gage is heavily influenced by irrigation diversions and return flows. However, if it is assumed that these demands and return flows are relatively constant through the study period and long-term period-of-record, then the diversions and return flows do not influence the relative comparisons. In addition, it should be noted that the dry, average and wet years used in the comparison before the study period (prior to 1973) were developed using this gage (06235500) and not the index gage (06224000). Again, this should be negligible for this type of analysis.

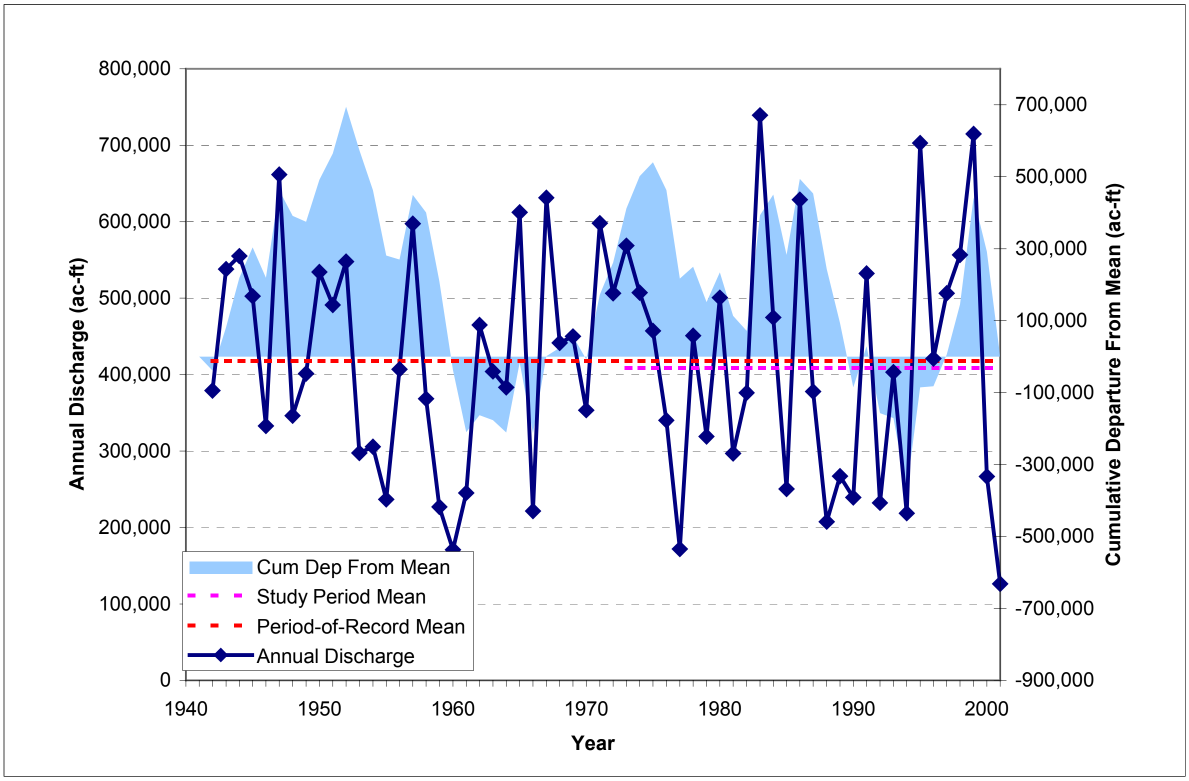

Figure 3-4. Comparison of Study Period with Long Term for Little Wind at Riverton (06235500)

3.5 Bighorn River Basin

As with the Wind River Basin, flows in the Bighorn River Basin are significantly impacted by major storage reservoirs and irrigation diversions. In the Upper Bighorn, Nowood and Bighorn Lake River basins, the operations of the diversions and reservoirs have remained fairly constant through the study period. However, storage improvements in the Greybull River (Greybull Valley Reservoir) and the Shoshone River (Buffalo Bill Reservoir) have had an impact on downstream flows in those basins. The impacts of these facilities are described below.

- Greybull Valley Reservoir was completed in 2000, and therefore only impacts streamflow and diversion records in the study period during 2000 and 2001. Both of these years were dry years and the reservoir could not be completely filled. For these reasons, no adjustments were made in either streamflow or diversion records downstream (although there would be some impacts on streamflow during periods when the reservoir was filled). For purposes of calibration, the reservoir node will be turned off. However, when the model is run, the full reservoir storage will be accounted for.

- The enlargement of Buffalo Bill Reservoir was completed in 1993. Analysis of historical storage contents data since the enlargement shows that although the enlargement space was filled during the wet year of 1995, the reservoir has not been drained to less than the volume of the enlargement, so its impacts to streamflow after the initial filling and its impacts on water deliveries during dry years have not been significant. Therefore, no adjustments to the Shoshone streamflow or diversion records have been made.

Table 3-5 presents a statistical summary of the period-of-record and the study period for the Shell Creek near Shell. As shown, the average flow during the study period is approximately 0.2 percent less than the long-term average. For the hydrologic year classification, the dry years are significantly drier than the long-term average, the wet years are slightly drier and the average years slightly wetter than the long-term averages. With the drier years, the dry years will generally make the model slightly conservative regarding water supply.

Table 3-5. Statistical Summary for Shell Creek Near Shell (06278500)

Statistic	Period-of-Record 1941 – 2001	Study Period 1973-2001	Difference
Mean	70,879	70,758	-0.2%
Standard Deviation	14,258	13,904	-2.5%
Average – Dry Years	64,545	50,416	-21.9%
Average – Average Years	71,812	72,046	0.3%
Average – Wet Years	89,192	87,452	-2.0%
Maximum	98,394	98,394	0.0%
Minimum	37,374	37,374	0.0%

The cumulative departure from the mean analysis shown in **Figure 3-5** indicates that the study period contains a consistent mix of dry and wet years. The study period does not contain a sustained period of either wet or dry years, as is shown in other locations within the period-of-record. However, because this analysis does not explicitly simulate carryover storage, this should not pose problems. The study period does contain both the wettest and driest years in the period-of-record. These statistics generally indicate that the period-of-record is conservatively representative of the long term data from a water supply perspective. It should be remembered that this gage is heavily influenced by irrigation diversions and return flows. However, if it is assumed that these demands and return flows are relatively constant through the study period and long-term period-of-record, then the diversions and return flows do not influence the relative comparisons.

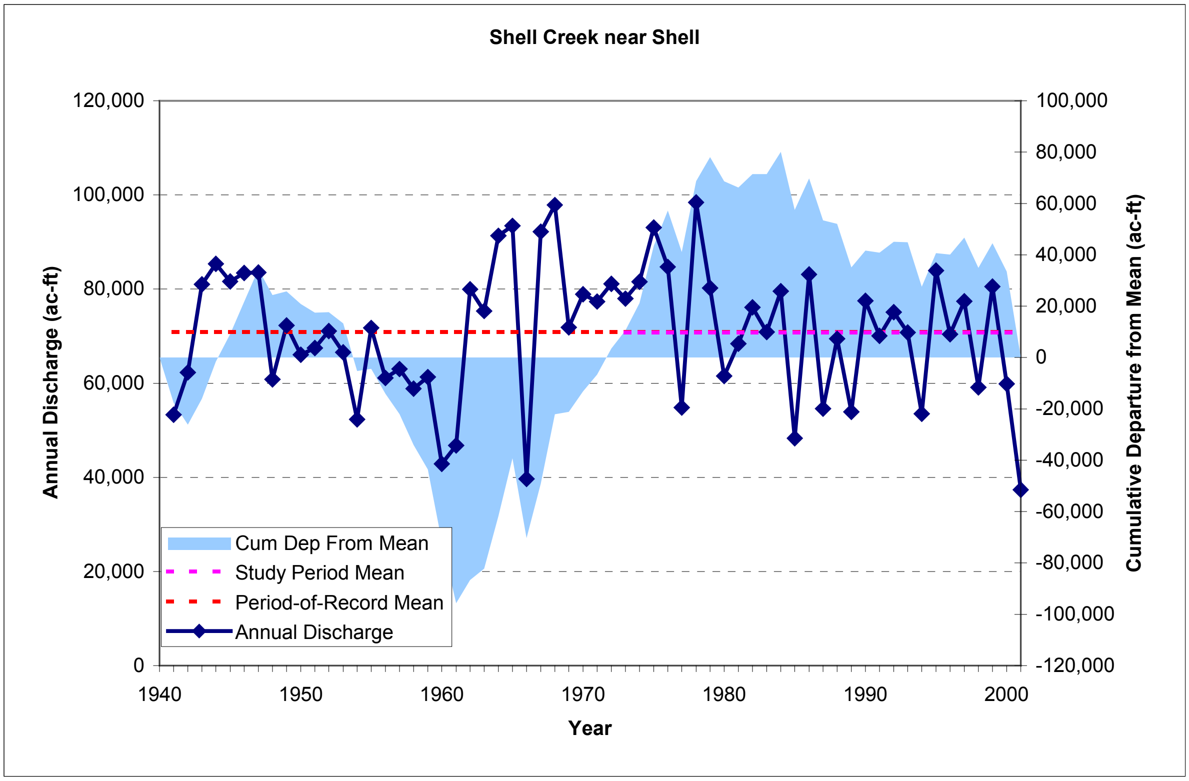

Figure 3-5. Comparison of Study Period Data to Long Term Data for Shell Creek Near Shell (06278500)

Section 4 - Data Filling and Extension

Many of the gages used in the model have an incomplete record or have periods within the record where data is missing. Therefore, in order for the gage data to be used in the model, the period-of-record for the gage requires either extension or filling. For purposes of this analysis, the same methodologies were used for both filling of gage records and extension of gage records. In addition, the gage records were only filled or extended for those periods in the selected study period (1973-2001). Methodologies for determining the study period are discussed in previous sections.

Many methods can be used for filling gage records. The most common and easiest to use method is regression of measured streamflow at the dependent gage (the gage where data filling is required) to measured streamflow at the independent gage (the gage where data exists for the missing period). Once this mathematical relationship is established, measured data from the independent gage can be used to estimate the streamflow for the dependent gage. Typical regression relationships can be based on linear, polynomial, power or logarithmic relationships. For this study most of the strongest relationships were found to be either linear or polynomial in nature. The measure of the degree to which the two gages correlate is typically called the correlation coefficient (or r^2 value). A correlation coefficient of 1.0 indicates perfect correlation. Therefore, those relationships with correlation coefficients closer to 1.0 have good correlation. Typically, in streamflow data filling and extension, correlation coefficients greater than approximately 0.7 are desired. When correlation coefficients are less than this value, then relationships are considered weak, and attempts to find gages with better relationships should be made. Correlations were developed between monthly streamflows.

For a majority of the gages, monthly regressions with nearby streamflow gages yielded acceptable correlations to fill the records. However, for the gages where correlations were weak, attempts were made to find other relationships to fill the streamflow values. First, regressions with precipitation data were attempted. This regression is typically more valid where snowmelt is not a significant component of streamflow, which limits its use in the study area. Another methodology that can be used is correlation between annual streamflows, then distribution of annual streamflow to monthly streamflow using historical distributions. If the annual streamflow regression correlation was weaker than the original monthly streamflow correlation, then the monthly regression was used. Finally, the streamflow record can be filled using regional equations based upon basin characteristics. However, this methodology is only used in rare occasions when the correlation coefficient is extremely weak. This methodology was not used for any of the streamflow gaging stations.

4.1 Madison/Gallatin River Basin

All three stations in the Madison River Basin required data filling. Missing data for the Madison River gage was filled using a regression relationship with the Gardner River near Mammoth (06191000) which also required filling. Correlation coefficients were 0.81 for the Madison River regression with the Gardner River while correlation coefficients were 0.89 and 0.95 for the Gibbon and Firehole River regressions, respectively. There were small gaps in Gallatin River at Gallatin Gateway data that also required filling. Again, missing data for the gage was filled using a regression relationship with the Gardner River near Mammoth gage. A summary of the regression analysis is shown in **Table 4-1**.

Table 4-1. Correlation Results for Madison/Gallatin River Basin

Basin	Gage Number	Gage ID	Percent of Record Filled	Dependent Gage	Corr. Coeff. r^2	Correlation Equation
Madison/Gallatin	06036905	Firehole	57%	06037500	0.95	$y = -2.0E\text{-}6x^2 + 0.6751x + 699$
	06037000	Gibbon	57%	06037500	0.89	$y = 2.0E\text{-}6x^2 + 0.2573x - 2293$
	06037500	Mad_WstY	41%	06191000	0.81	$y = 0.8636x + 19478$
	06043500	Gal_GalGt2	14%	06191000	0.93	$y = -2.0E\text{-}5x^2 + 4.9378x - 8616$

4.2 Yellowstone River Basin

All of the gages in the Yellowstone Headwaters Hydrologic Unit required data filling except for the Yellowstone River at Corwin Springs (06191500) gage. The Gardner River at Mammoth Gage (06191000) was filled using the Yellowstone River at Corwin Springs gage using separate regressions for January through June and July through December to account for the lagging effect caused on the Yellowstone River by Yellowstone Lake. The Yellowstone River at Yellowstone Lake outlet (06186500) and the Lamer River gages (06188000) were filled using the same methodology. These gages were then used as independent gages for the remaining regressions. Correlation coefficients ranged from 0.87 to 0.98, except for the Yellowstone River at Yellowstone Lake outlet, where the correlation coefficients were 0.87 for the January through May regression, 0.68 for the June regression and 0.98 for the July through December regression. Regressions were not performed at various other gages due to regulation of flows or lack of data. A summary of the regression analysis is shown in **Table 4-2**.

Table 4-2. Correlation Results for Yellowstone River Basin

Basin	Gage Number	Gage ID	Percent of Record Filled	Dependent Gage	Corr. Coeff. r^2	Correlation Equation
Yellowstone	06186500	Yl_LkOut	10%	06191500	0.87	$y = 2.0E\text{-}8x^2 + 0.1324x + 18099$ (Jan-May)
					0.68	$y = 2.0E\text{-}7x^2 + 0.0042x + 121403$ (Jun)
					0.95	$y = -4.0E\text{-}7x^2 + 0.8036x - 15813$ (Jul-Dec)
	06187000	Yl_CnHot	100%	06186500	0.94	$y = 0.9884x + 13052$
	06187500	Tow_TowF	100%	06191500	0.96	$y = 2.0E\text{-}8x^2 + 0.0054x + 768$
	06187915	Sod_Slv	---	(1)	---	
	06187950	Sod_LRS	55%	06191500	0.94	$y = 0.0549x - 1874$
	06188000	Lam_TRS	52%	06191500	0.98	$y = -4.0E\text{-}8x^2 + 0.4509x - 15332$ (Jan-Jun)
					0.94	$y = 2.0E\text{-}7x^2 + 0.0986x - 660$ (Jul-Dec)
	06188500	EFBl_Mam	100%	06191000	0.88	$y = 2.0E\text{-}7x^2 + 0.0181x - 84$
	06189000	BlD_Mam	83%	06191000	0.85	$y = 0.0661x - 249$
	06190000	Lup_Mam	100%	06191000	0.98	$y = 0.0302x - 97$
	06190500	Gard_Mam	---	(5)	---	
	06190540	Hot_Mam	---	(2)	---	
	06191000	Gard_nrMam	---	06191500	0.94	$y = -1.0E\text{-}8x^2 + 0.0715x + 1918$ (Jan-Jun)
					0.94	$y = 4.0E\text{-}8x^2 + 0.0143x + 5677$ (Jul-Dec)
	06191500	Yl_CSp	0%	(---)	---	

Notes:
- (---) No regression needed.
- (1) Not enough data for regression.
- (2) Too regulated for regression.
- (3) Too little inflow to compute.
- (4) Canal, drain, etc.
- (5) Gage not needed for analysis.

4.3 Clarks Fork River Basin

The Clarks Fork Yellowstone River near Belfry, Montana gage (06207500) has an extensive period-of-record. This gage is located just upstream of the confluence of the Clarks Fork and Big Sand Coulee. However, all other gages will require extensive filling to be used in the model. The two remaining Clarks Fork gages as well as the Sunshine Creek gage (06206500) were filled using the Belfry gage. However, not enough data was available or flows were too small for a regression of the remaining gages. Other methods of streamflow estimation were required for these gage locations. The correlation coefficients were fairly strong for all three gages, ranging from 0.97 to 0.99. A summary of the regression analysis is shown in **Table 4-3**.

Table 4-3. Correlation Results for Clarks Fork River Basin

Basin	Gage Number	Gage ID	Percent of Record Filled	Dependent Gage	Corr. Coeff. r^2	Correlation Equation
	06205500	CFk_abSqC	100%	06207500	0.97	$y = 0.4640x - 2201$
	06205950	Ldg_Pnt	---	(1)	---	
	06206000	Cfk_blCrC	100%	06207500	0.99	$y = 0.8234x - 4569$
	06206500	Sun_Pnt	100%	06207500	0.97	$y = 0.1322x + 74$
	06207000	CFk_nrClk	---	(5)	---	

	06207500	Cfk_BlfMT	0%	(---)	---	
	06207507	BigS_nrBdg	---	(3)	---	
	06207510	BigS_Line	---	(2)	---	
	06207540	STip_BlfMT	---	(3)	---	

Notes:
(---) No regression needed.
(1) Not enough data for regression.
(2) Too regulated for regression.
(3) Too little inflow to compute.
(4) Canal, drain, etc.
(5) Gage not needed for analysis.

4.4 Wind River Basin

Because of its geographic expanse, flows in the Wind River basin are derived from a variety of sources with unique influences on streamflow, such as the Wind River range, the Owl Creek range, Beaver Rim and the high plains divide between the Wind Basin and the Platte Basin. Therefore, estimation of streamflows is unique to each sub-basin and/or flow source. Correlation results for each of the gages in the Wind River Basin are shown in **Table 4-4**.

There are several currently operating gages on the Wind River and its tributaries. In addition, most gages used in the analysis have at least a portion of their data contained within the study period. The key headwaters gage within the Upper Wind hydrologic unit is Bull Lake Creek above Bull Lake (06224000). This gage was used to fill several of the headwaters gages in the upper portion of the hydrologic unit originating from the Wind River Range or Absaroka Range. The Wind River near Crowheart (06225500) gage was used to fill the Wind River above Red Creek gage (06220800), while the Wind River at Riverton gage (06228000) was used to fill Wind River gages located lower in the basin. Correlation coefficients for these regressions ranged from 0.86 to 0.95. One gage was not filled because it is too regulated for a regression analysis, while two gages were not filled because there is not enough data for a regression analysis.

Analysis of available data shows that runoff from the Owl Creek mountains occurs at different times of the year and at different magnitudes than runoff from the Wind River range or the Absoraka range. The only gage measuring runoff from the Owl Creek mountains in the Upper Wind hydrologic unit is the Crow Creek gage (06222700), which has data from the mid 1960's to the mid 1990's. There are gages on other tributaries from the Owl Creeks in the Lower Wind hydrologic unit, but these gages are more heavily influenced by irrigation return flows and have shorter periods-of-record. Although the hydrologic characteristics are different, a regression analysis remains the preferred option for extending data if a correlation can be found. The Bull Lake Creek above Bull Lake gage was used to extend the Crow Creek gage data with a resulting correlation coefficient was 0.75.

The South Fork above Washakie Reservoir gage, which is located above all storage and diversion influences, has data from the late 1970's to present. In addition, the Little Wind near Riverton gage, which is downstream of all major diversions within the basin, has data from the early 1940's to present. There are several other gages which have data for a portion of the study period (described in later sections), but will require filling for the remainder of the study period. The South Fork Little Wind above Washakie Rservoir gage (06228350) was filled using the Bull Lake Creek above Bull Lake gage (06224000). Then, the gage was used to fill the South Fork

Little Wind below Washakie Reservoir gage (06228450). The Little Wind above Arapahoe gage (06231000) was filled using the Little Wind near Arapahoe gage. Although these gages are influenced by diversions, there are no major diversions between the gages, making the correlation between the two gages relative strong. Correlation coefficients ranged from 0.59 at the Trout Creek gage (06229900) to 0.97 at the Little Wind above Arapahoe gage. The Trout Creek gage correlation coeffecient is low, but because the tributary is relatively small, it was deemed adequate for modeling purposes. Several gages were too regulated for data filling using headwaters gages and the Little Wind near Arapahoe (06230500) gage did not have enough data for a regression analysis. These gages will be located in the model as flow accumulation nodes but will not be used for calibration purposes.

There are several gages within the hydrologic unit that contain a significant amount of data. However, because many of the gages flow only intermittantly and are heavily influenced by agricultural activities, filling the missing data becomes more difficult. The Fivemile Creek near Shoshoni gage (06253000) requires filling for only six years. However, regressions with other gages did not yield acceptable correlation coefficients. In addition, regressions with both monthly and annual precipitation also did not yield acceptable results. Therefore, the data was filled using a regression with annual inflows into Boysen Reservoir that are not attributable to the Wind River. This data was calculated by subtracting Wind River at Riverton flows from total Boysen Reservoir inflows. The resulting correlation coefficient was 0.45, which is significantly below a normal acceptable level. However, because the data period filled is relatively short, because the amount of inflows to the model represented by Fivemile Creek are relatively small and because it is the best available flow estimation technique, the results were deemed acceptable for this analysis.

The Fivemile Creek near Shoshoni gage data was used to fill several other gages in the basin. Correlation coefficients for these gages were 0.98, 0.91 and 0.53, respectively. Again, the 0.53 is significantly lower than the desired correlation for streamflow regressions. However, because the stream is intermittant, and because its contribution to flow is relatively small, the correlation was deemed acceptable for this analysis. The Fivemile Creek near Pavillion (06245000) and Poison Creek near Shoshoni (06255500) gages did not have enough data in the period-of-record to perform a regression analysis with another gage. Several other gages had too little and unseasonably variable flow to perform the regression analysis.

None of the gages in the Badwater Creek sub-basin are currently operating, with the most recent data in 1980. Therefore, all of the gages required filling before they could be used in the model. Since these gages exhibit flow patterns which are unique to this basin orientation, existing streamflow records from other sites in the Wind River basin could not be used as dependent gages for the regression. Therefore, the Badwater Creek at Bonneville gage was filled using annual precipitation at Black Mountain. The annual flow was then distributed on a monthly basis using the average monthly distribution from the period-of-record flows. The Badwater Creek at Lysite (06256500) and Bridger Creek near Lysite (06256800) gages were then filled using the Bonneville gage. Finally, the Dry Creek gage (06256900) was filled using the Lost Cabin gage. The Badwater Creek at Lost Cabin gage (06256500) was not filled because the period-of-record was too short to regress. A summary of the regression analysis is shown in **Table 4-4**.

Table 4-4. Correlation Results for Wind River Basin

Basin	Gage Number	Gage ID	Percent of Record Filled	Dependent Gage	Corr. Coeff. r^2	Correlation Equation
Upper Wind	06218500	wind_nrDub	31%	06224000	0.82	y = 0.4634x + 2361
	06220000	Wind_atDub	---	(1)	---	
	06220500	EFWind_Dub	24%	06224000	0.85	y = 0.7749x + 1060
	06220800	Wind_RedCk	62%	06225500	0.90	y = 0.6110x -3105
	06221400	Din_abLks	34%	06224000	0.90	y = 0.4349x + 863
	06221500	Din_Bur	---	(2)	---	
	06222000	Wind_Bur	---	(1)	---	
	06222500	DryCk_Bur	64%	06224000	0.95	$y = 7.0E\text{-}7x^2 + 0.1255x + 50$
	06222700	CrowCk_Tip	28%	06224000	0.75	y = 0.0714x + 17
	06223000	MdCk_Len	---	(1)	---	
	06223500	WlCk_Crow	67%	06224000	0.86	$y = 1.0E\text{-}6x^2 -0.0021x + 350$
	06224000	BlCk_abLk	0%	(---)	---	
	06225000	BlLk_Len	0%	(---)	---	
	06225500	Wind_Crow	0%	(---)	---	
	06227600	Wind_Kin	53%	06228000	0.95	y = 1.2547x + 564
	06228000	Wind_Riv	0%	(---)	---	
	06236100	wind_abBoy	61%	06228000	0.96	y = 1.9702x + 8009
Little Wind	06228350	SFLW_abWRes	14%	06224000	0.96	$y = 2.0E\text{-}6x^2 + 0.3301x + 485$
	06228450	SFLW_blWRes	55%	06228350	0.95	y = 0.8885x + 605
	06228500	LW_FtWa	---	(2)	---	
	06228800	NFLW_nrFW	55%	06224000	0.93	$y = 2.0E\text{-}6x^2 + 0.3302x + 815$
	06229000	NFLW_atFW	---	(2)	---	
	06229680	Sage_Nork	82%	06224000	0.83	$y = 6.0E\text{-}7x^2 -0.0074x + 289$
	06229900	Trout_FW	71%	06224000	0.60	$y = 3.0E\text{-}7x^2 + 0.0030x + 289$
	06230190	Mill_abRL	78%	06224000	0.72	$y = 2.0E\text{-}7x^2 + 0.0025x + 108$
	06230500	LW_nrArap	---	(1)	---	
	06231000	LW_abArap	45%	06235500	0.97	$y = 2.0E\text{-}7x^2 + 0.3287x -182$
	06234000	LW_blArap	---	(1)(2)	---	
	06234500	Beav_nrLnd	---	(2)	---	
	06235000	Beav_nrAr	---	(2)	---	
	06235500	LW_Riv	0%	(---)	---	
Lower Wind	06239000	Musc_Sho	---	(2)	---	
	06244500	5mi_aPav	---	(3)	---	
	06245000	5mi_Pav	---	(1)	---	
	06250000	5mi_Riv	100%	06233000	0.98	y = 1.8852x -197
	06251500	Sand_Sho	100%	06233000	0.91	y = 0.1985x -18
	06253000	5mi_Sho	21%	(6)	0.45	y = 502.4x
	06255500	Poi_Sho	---	(1)	---	
	06257500	Mud_Pav	---	(3)	---	
	06258000	Mud_Sho	62%	06253000	0.53	$y = 2.0E\text{-}6x^2 + 0.0718x + 314$
	06258500	Dcot_Bon	---	(3)	---	
	06259000	Wind_blBy	---	(1)	---	

Table 4-4 continued

Basin	Gage Number	Gage ID	Percent of Record Filled	Dependent Gage	Corr. Coeff. r^2	Correlation Equation
Badwater	06256000	Bad_Lyb	100%	06257000	0.72	$y = 9.0E\text{-}6x^2 + 0.4853x + 109$
	06256500	Bad_LC	---	(1)	---	
	06256650	Bad_Lys	97%	06256000	0.84	$y = 8.0E\text{-}5x^2 + 0.5778x + 195$
	06256800	Bri_Lys	97%	06256000	0.89	$y = 5.0E\text{-}5x^2 + 0.2819x + 307$
	06256900	Dry_Bon	72%	06256650	0.81	$y = 4.0E\text{-}6x^2 + 0.0150x$
	06257000	Bad_Bon	97%	(7)	0.46	$y = 3790x – 15152$

Notes:
(---) No regression needed.
(1) Not enough data for regression.
(2) Too regulated for regression.
(3) Too little inflow to compute.
(4) Canal, drain, etc.
(5) Gage not needed for analysis.
(6) Annual Non-Wind River Computed Inflows to Boysen Reservoir
(7) Annual Black-Mountain Precipitation

4.5 Bighorn River Basin

As with the Wind River Basin, because of its geographic expanse, flows in the Bighorn River basin are derived from a variety of sources with unique influences on streamflow, such as the Absoroka Range, the Owl Creek range, the Bighorn Mountains and the interior high plains of the Bighorn Basin. Therefore, estimation of streamflows is unique to each sub-basin and/or flow source. Correlation results for each of the gages in the Wind River Basin are shown in **Table 4-5**.

The Upper Bighorn Basin does not contain any gages that have data for the entire study period, and there are only three gages that are currently operational. The Wind River below Boysen gage (06259000) was used to fill Bighorn River gages, including the gages at Thermopolis, Worland and Basin. Correlation coefficients ranged from 0.85 to 1.00. As expected, as the Bighorn River gages further downstream are more influenced by irrigation diversions and return flows, the data is less well correlated. Key gages in the basins west of the Bighorn River included the USBR’s record of Anchor Reservoir computed inflow, Anchor Reservoir releases, and the South Fork of Owl Creek near Anchor Reservoir gage (0626000). Correlation coefficients for these gages ranged from 0.57 to 0.98, with only the Gooseberry Creek at Dickie (06265800) having a correlation coefficient less than 0.7 This correlation was determined to be acceptable because a better correlation using other gages could not be calculated.

There are currently no active gages in the Nowood River basin, and only the Nowood River at Tensleep gage (06270000) has significant data within the period-of-record Several correlation attempts were made with nearby gages from different basins to extend the record of this gage. However, none of those attempts yielded acceptable results. Therefore, the annual gage record was extended using the annual precipitation at Black Rock Mountain. The annual value was distributed monthly using the average monthly distribution of the actual gage data. This gage was then used to extend the record at the Canyon Creek at Tensleep gage (06270500). The correlation coefficient was 0.65, slightly less than the desired value of 0.70. However, no other methods or gages yielded better correlations. The remaining gages in the basin were extended using Shell Creek gages, all of which had correlation coefficients greater than 0.90.

The Greybull River at Meeteetsee gage (06276500) is the only currently active gage in the Greybull River basin. However, the data for this gage is only collected in the late spring, summer and early fall months when the river is not frozen. Therefore, the South Fork Shoshone at Valley gage (06280300) was used to fill the winter month flows. Although the correlation coefficient of 0.67 is below the desired value of 0.70, the only flows filled are during the winter, which are less important in the overall annual hydrograph. Therefore, it was deemed acceptable for this study. The remainder of the gages in the basin were filled using the Greybull River at Meeteetsee gage, with correlation coefficients ranging from 0.74 to 0.94.

The Bighorn Lake basin contains gages along the mainstem of the Bighorn River and in several tributary sub-basins, including the Shell Creek sub-basin. Gages in the Shell Creek, Porcupine Creek and Crooked Creek sub-basins were filled using the Shell Creek above Shell Reservoir gage, with correlation coefficients ranging from 0.79 to 0.94. The Dry Creek gage (06278000) was filled using the Greybull River at Meeteetsee gage. The correlation coefficient for this regression was below the target of 0.7. However, because the flows in the creek are small and there are no major diversions, the correlation was deemed acceptable.

Two gages were used to fill missing data in the Shoshone River basin. For the upper portions of the basin (above Buffalo Bill Reservoir), the South Fork Shoshone near Valley gage (0628300) was used, while for the lower portions of the basin, the Shoshone River near Lovell gage (06285100) was used. Both of these gages have data for the entire study period and are active gages. Correlation coefficients for the upper gages ranged from 0.66 to 0.98, with a majority greater than 0.90. Correlation coefficients for the lower basin were all greater than 0.90. Several of the gages could not be filled because their period-of-record was not long enough, the flow was too regulated for a regression analysis.

Table 4-5. Correlation Results for Bighorn River Basin

Basin	Gage Number	Gage ID	Percent of Record Filled	Dependent Gage	Corr. Coeff. r^2	Correlation Equation
Upper Bighorn	06259500	Bh_Therm	100%	06259000	1.00	y = 1.0072x + 2830
	06260000	SFOwl_nrAnc	40%	09999001 (6)	0.81	$y = 3.0E\text{-}5x^2 + 1.0239x + 378$
	06260200	MdOwl_abAnc	---	(3)	---	
	06260400	SFOwl_blAnc	24%	09999002 (7)	0.98	y = 0.9511x + 12
	06260500	SFOwl_Crt	---	(2)	---	
	06261000	SFOwl_acrn	---	(1)(2)	---	
	06261500	SFOwl_nrTh	---	(1)(2)	---	
	06262000	NFOwl_nrAnc	100%	06260000	0.81	y = 0.3515x + 44
	06262300	NFOwl_abBR	81%	06260000	0.75	y = 0.3378x + 89
	06262500	NFOwl_atCR	---	(1)	---	
	06263000	NFOwl_nrTh	---	(1)	---	
	06263500	Mud_Th	---	(1)	---	
	06264000	Owl_Th	---	(2)	---	
	06264500	Owl_Luc	---	(2)	---	
	06265000	Kirb_Luc	---	(1)	---	
	06265337	Cot_HamD	71%	09999001 (6)	0.73	y = 0.4244x + 98
	06265500	Cot_Win	---	(1)	---	
	06265800	Gos_atDk	79%	09999001 (6)	0.57	y = 0.4687x + 244
	06266000	Gos_Grs	---	(1)(2)	---	
	06266500	Gos_nrDk	---	(1)	---	
	06267000	Gos_Nei	---	(2)	---	
	06267400	Now_Colt	---	(3)	---	
	06268500	15mi_Wor	---	(3)	---	
	06268600	Bh_Wor	100%	06259000	0.91	y = 1.0101x -16486
	06269000	Bh_nrMand	---	(1)	---	
	06269500	Bh_atMand	---	(1)	---	
	06271500	Pr_beLSol	---	(1)	---	
	06274300	Bh_Bas	38%	06259000	0.85	y = 1.2616x + 3749
Nowood	06270000	Now_Ten	31%	Prc-BlRk	0.00	
	06270450	Can_beCk	---	(1)	---	
	06270500	Can_Ten	100%	06270000	0.65	y = 0.1047x + 1065
	06271000	Ten_Ten	100%	06278300	0.91	y = 2.3956x + 2752
	06272500	Pnt_Hyat	100%	06278500	0.96	y = 1.3242x -1755
	06273000	Med_Hyat	97%	06278300	0.90	y = 0.6754x + 571
	06273500	Pnt_beHyat	---	(1)(2)	---	
	06274000	No_Bonz	---	(1)(2)	---	
	06271500	Pnt_LkSol	---	(1)	---	
Greybull	06274500	Gry_PtFk	100%	06276500	0.89	y = 0.6108x -1196
	06274800	Wod_nrKir	90%	06276500	0.92	$y = 9.0E\text{-}8x^2 + 0.0348x + 105$
	06274810	Wod_atKir	90%	06276500	0.94	$y = 9.0E\text{-}7x^2 + 0.0063x + 51$
	06275000	Wod_Sun	31%	06276500	0.87	y = 0.3230x + 627
	06275500	Wod_Met	100%	06276500	0.80	y = 0.3337x + 1121
	06276000	Gry_nrMet	---	(1)	---	
	06276500	Gry_atMet	51%	06280300	0.67	y = 0.7542x + 402
	06277000	BeCan_Brl	---	(4)	---	
	06277500	Gry_Bas	97%	06276500	0.74	$y = 3.0E\text{-}6x^2 + 0.2472x + 4141$
	06277950	Dry_Grey	---	(1)	---	

Table 4-5 continued

Basin	Gage Number	Gage ID	Percent of Record Filled	Dependent Gage	Corr. Coeff. r^2	Correlation Equation
Bighorn Lake	06278000	Dry_Grey	100%	06276500	0.51	y = 0.0403x + 685
	06278300	Shl_abRes	3%	(---)	---	
	06278500	Shl_nrShl	51%	06278300	0.92	y = 2.1704x + 2357
	06279000	Shl_atShl	---	(1)	---	
	06279500	Bh_Kane	0%	(1)	---	
	06286250	Bh_Lov	---	(1)	---	
	06286258	BiC_Lov	---	(3)	---	
	06286260	Crk_Lov	100%	06278300	0.79	$y = 3.0E\text{-}6x^2 + 0.0529x + 461$
	06286270	Porc_Lov	100%	06278300	0.94	y = 1.1576x + 800
Shoshone	06279790	Jones_Pah	90%	06280300	0.66	y = 0.0957x + 1080
	06279795	Crow_Pah	90%	06280300	0.89	$y = -1.0E\text{-}7x^2 + 0.0843x -176$
	06279800	NFSh_Pah	97%	06280300	0.66	$y = 3.0E\text{-}6x^2 + 0.1795x + 7410$
	06279850	Mdi_YNP	90%	06280300	0.98	$y = 7.0E\text{-}7x^2 + 0.0904x + 355$
	06279940	NFSh_atWap	59%	06280300	0.96	$y = -8.0E\text{-}7x^2 + 2.2210x -1089$
	06280000	NFSh_nrWap	64%	06280300	0.95	$y = 5.0E\text{-}7x^2 + 1.9994x + 1509$
	06280300	SFSh_Val	0%	(---)	---	
	06280500	SFSh_Ish	---	(1)	---	
	06281000	SFSh_abBB	3%	06280300	0.96	$y = 4.0E\text{-}6x^2 + 0.5169x + 1949$
	06281400	Dia_nrCdy	---	(3)	---	
	06282000	Sh_beBB	0%	(---)	---	
	06282500	Sh_Cody	---	(1)	---	
	06283000	Sho_Corb	---	(1)	---	
	06283800	Sh_abWillD	90%	06285100	0.98	$y = 1.0E\text{-}6x^2 + 0.4491x + 10798$
	06284000	Sh_atWillD	---	(1)	---	
	06284200	Sh_Will	81%	06285100	0.98	$y = 7.0E\text{-}7x^2 + 0.7665x + 4854$
	06284400	Sho_Garl	76%	06285100	0.93	$y = 8.0E\text{-}7x^2 + 0.6562x -1201$
	06284500	Bit_Garl	---	(2)	---	
	06284800	Whst_Garl	---	(2)	---	
	06285000	Sh_Byr	---	(5)	---	
	06285100	Sh_nrLov	0%	(---)	---	
	06285400	Sag_atSid	---	(2)	---	
	06285500	Sag_Lov	---	(2)	---	
	06286000	Sho_atLov	---	(1)	---	
	06286200	Sh_Kane	100%	06285100	0.97	$y = -3.0E\text{-}7x^2 + 1.1130x + 7405$

Notes:
- (---) No regression needed.
- (1) Not enough data for regression.
- (2) Too regulated for regression.
- (3) Too little inflow to compute.
- (4) Canal, drain, etc.
- (5) Gage not need for analysis.
- (6) Anchor Reservoir computed inflows
- (7) Anchor Reservoir releases

Section 5 - Ungaged Headwaters Site Data Estimation

In order for the model to accurately simulate streamflow and diversions for the entire basin, an estimation of streamflow above all diversions is required. However, in many parts of the basin, there are no streamflow gaging stations above the most upstream diversion on the stream. Therefore, streamflow upstream of the diversion must be estimated. Two methods are available to make these estimations:

(1) estimate streamflow based on regional equations which are a funtion of basin characteristics such as location, elevation and orientation;
(2) estimate streamflow by adding diversions and subtracting inflows from the closes downstream gage.

For most locations, the regional equation methodology was used to estimate streamflow for ungaged headwaters sites. However, in areas where this methodology yielded implausible results, such as the streamflow being less than the actual measured diversion, or the streamflow being greater than the next downstream gage adjusted for inflows and diversions, then the estimated headwaters flows were adjusted based on the available data. More detailed explanations are found in the detailed model description chapters.

For the study area, two sources of regional regression equations are available for estimating natural flows. The USGS (Rankl, 1994) has published monthly regression equations for the Wind River basin based upon several physical basin characteristics, including drainage area, mean basin elevation, basin slope, maximum basin relief and mean annual precipitation. Discharges are given for the 10, 50, 70 and 90 percent exceedance levels (Q_{10}, Q_{50}, Q_{70} and Q_{90}). For purposes of this report, Q_{10} was used for wet years, Q_{50} was used for average years and Q_{90} was used for dry years. Monthly regional regression equations for the entire state of Wyoming were developed by Miselis (1999). Equations were developed for the Wind, Bighorn and Absoraka ranges within the study area, are a function of drainage area and precipitation. **Table 5-1** presents the regression equations from these sources. As shown, the USGS study was used for the Wind River basin (because the study was more specific to this basin) while the Miselis data was used for the other two areas. The specific set of equations used for each site is shown in the tables for each river basin.

Physical basin data was developed through GIS using tiled 30 meter Digital Elevation Models (DEMs) from the USGS. Drainage basins were delineated using the BASIN1 extension (Petras, 2000), with the lowest point in the drainage generally taken as the most downstream point on the stream immediately upstream of the first diversion on the stream. In some cases, this was modified as needed to include or exclude portions of the drainage area. From the drainage area, the extension calculates several basin parameters that are used directly in the equations or used to calculate parameters for the equations, including average slope, and minimum and maximum elevation. For most area, average annual basin precipitation was developed from the 2000 meter PRISM coverage available for the State of Wyoming (Daly and Taylor, 1997). However, it was found that for some of the higher elevations in the Wind River range, the coverage produced much higher precipitation values that those used to develop the USGS equations, thereby producing unrealistic flow values. For these areas, the precipitation was taken directly from the USGS report for those sub-basins where data was available in the report, or from the USGS source of information which was Plate 1b in the 1988 USGS report (Lowham, 1988).

Table 5-1. Regression Equations Used for Estimation of Natural Flow

Month	Q_{10} (cfs)	Q_{50} (cfs)	Q_{90} (cfs)
Runoff From Absaroka Range (Miselis, 1999)			
Jan	$Q = 0.05927\ A^{1.31}$	$Q = 0.03402\ A^{1.37}$	$Q = 0.04791\ A^{1.26}$
Feb	$Q = 0.07135\ A^{1.26}$	$Q = 0.03247\ A^{1.37}$	$Q = 0.03247\ A^{1.37}$
Mar	$Q = 0.14064\ A^{1.17}$	$Q = 0.05100\ A^{1.31}$	$Q = 0.01385\ A^{1.47}$
Apr	$Q = 1.08668\ A^{1.02}$	$Q = 0.17865\ A^{1.18}$	$Q = 0.05363\ A^{1.30}$
May	$Q = 1.80260\ A^{1.17}$	$Q = 0.84333\ A^{1.16}$	$Q = 0.39274\ A^{1.10}$
Jun	$Q = 1.79473\ A^{1.21}$	$Q = 0.94254\ A^{1.21}$	$Q = 0.37077\ A^{1.25}$
Jul	$Q = 0.96739\ A^{1.19}$	$Q = 0.50816\ A^{1.18}$	$Q = 0.23550\ A^{1.19}$
Aug	$Q = 0.68077\ A^{1.09}$	$Q = 0.38753\ A^{1.09}$	$Q = 0.17235\ A^{1.14}$
Sep	$Q = 0.62791\ A^{1.02}$	$Q = 0.31930\ A^{1.06}$	$Q = 0.16719\ A^{1.10}$
Oct	$Q = 0.58304\ A^{1.01}$	$Q = 0.24406\ A^{1.09}$	$Q = 0.07011\ A^{1.25}$
Nov	$Q = 0.26835\ A^{1.11}$	$Q = 0.06778\ A^{1.30}$	$Q = 0.03518\ A^{1.35}$
Dec	$Q = 0.08177\ A^{1.28}$	$Q = 0.04419\ A^{1.34}$	$Q = 0.00935\ A^{1.56}$
Runoff From Bighorn Range (Miselis, 1999)			
Jan	$Q = 0.17438\ A^{1.03}$	$Q = 0.17390\ A^{0.97}$	$Q = 0.14588\ A^{0.96}$
Feb	$Q = 0.13397\ A^{1.07}$	$Q = 0.14371\ A^{1.01}$	$Q = 0.12379\ A^{0.99}$
Mar	$Q = 0.23036\ A^{0.99}$	$Q = 0.15718\ A^{1.00}$	$Q = 0.09543\ A^{1.04}$
Apr	$Q = 0.81846\ A^{0.95}$	$Q = 0.49751\ A^{0.84}$	$Q = 0.17848\ A^{0.95}$
May	$Q = 4.76650\ A^{0.92}$	$Q = 2.95597\ A^{0.80}$	$Q = 0.78253\ A^{0.83}$
Jun	$Q = 0.00003\ A^{1.07}\ P^{4.03}$	$Q = 0.00087\ A^{0.93}\ P^{2.70}$	$Q = 0.00020\ A^{0.98}\ P^{2.82}$
Jul	$Q = 0.00230\ A^{0.91}\ P^{2.30}$	$Q = 0.00045\ A^{0.93}\ P^{2.50}$	$Q = 0.00170\ A^{0.83}\ P^{2.03}$
Aug	$Q = 0.00778\ A^{0.93}\ P^{1.52}$	$Q = 0.00030\ A^{0.94}\ P^{2.44}$	$Q = 0.00355\ A^{0.85}\ P^{1.59}$
Sep	$Q = 0.47599\ A^{0.94}$	$Q = 0.37094\ A^{0.91}$	$Q = 0.51357\ A^{0.74}$
Oct	$Q = 0.41879\ A^{0.95}$	$Q = 0.25281\ A^{0.96}$	$Q = 0.26110\ A^{0.91}$
Nov	$Q = 0.30917\ A^{0.97}$	$Q = 0.17159\ A^{1.01}$	$Q = 0.19235\ A^{0.96}$
Dec	$Q = 0.22141\ A^{1.01}$	$Q = 0.17080\ A^{0.99}$	$Q = 0.15389\ A^{0.97}$
Runoff in Wind River Basin above Owl Creek Confluence (including Owl Creek) (USGS, 1994)			
Jan	$Q = 0.20100\ A^{1.05}\ P^{1.57}\ S^{-0.70}$	$Q = 0.16000\ A^{1.07}\ P^{1.65}\ S^{-0.77}$	$Q = 0.49300\ A^{1.15}\ P^{1.70}\ S^{-1.07}$
Feb	$Q = 0.31800\ A^{1.07}\ P^{1.55}\ S^{-0.78}$	$Q = 0.58500\ A^{1.23}\ P^{1.26}\ R^{-0.74}$	$Q = 0.31600\ A^{1.31}\ P^{1.36}\ R^{-0.80}$
Mar	$Q = 1.52000\ A^{1.18}\ P^{1.13}\ R^{-0.73}$	$Q = 1.02000\ A^{1.26}\ P^{1.17}\ R^{-0.78}$	$Q = 1.24000\ A^{1.34}\ P^{1.07}\ R^{-0.85}$
Apr	$Q = 15.5000\ A^{1.15}\ P^{1.25}\ R^{-0.89}$	$Q = 19.7000\ A^{1.26}\ P^{0.93}\ R^{-0.95}$	$Q = 8.62000\ A^{1.30}\ P^{0.80}\ R^{-0.89}$
May	$Q = 0.92500\ A^{0.86}\ P^{2.54}\ R^{-0.69}$	$Q = 0.29100\ A^{0.88}\ P^{2.72}\ R^{-0.69}$	$Q = 0.02380\ A^{0.85}\ P^{3.03}\ R^{-0.57}$
Jun	$Q = 0.00451\ A^{0.66}\ P^{2.87}$	$Q = 0.00042\ A^{0.71}\ P^{3.41}$	$Q = 0.00010\ A^{0.85}\ P^{3.54}\ E^{3.11}$
Jul	$Q = 0.00314\ A^{0.94}\ P^{2.46}\ E^{3.79}$	$Q = 0.00042\ A^{0.95}\ P^{2.90}\ E^{4.65}$	$Q = 0.00027\ A^{1.03}\ P^{2.66}\ E^{6.08}$
Aug	$Q = 0.00126\ A^{0.99}\ P^{2.34}\ E^{5.49}$	$Q = 0.00044\ A^{1.02}\ P^{2.45}\ E^{5.29}$	$Q = 0.00003\ A^{1.19}\ P^{2.88}\ E^{6.06}$
Sep	$Q = 0.00138\ A^{1.00}\ P^{2.09}\ E^{3.62}$	$Q = 0.00045\ A^{1.04}\ P^{2.21}\ E^{3.04}$	$Q = 0.00008\ A^{1.09}\ P^{2.53}\ E^{3.16}$
Oct	$Q = 0.00081\ A^{0.97}\ P^{2.14}$	$Q = 0.00073\ A^{0.96}\ P^{2.02}$	$Q = 0.00033\ A^{1.01}\ P^{2.04}$
Nov	$Q = 0.00223\ A^{0.97}\ P^{1.68}$	$Q = 0.00201\ A^{0.96}\ P^{1.60}$	$Q = 0.00139\ A^{1.01}\ P^{1.48}$
Dec	$Q = 0.00258\ A^{0.95}\ P^{1.56}$	$Q = 0.00124\ A^{0.96}\ P^{1.67}$	$Q = 0.00068\ A^{1.06}\ P^{1.56}$

Notes:

(1) Q - Mean Monthly Discharge (cfs)
A - Drainage Basin Area (sq. mi.)
P - Mean Annual Precipitation (in)
S - Basin Slope (feet/mile)
R - Maximum Basin Relief (feet/10000 feet)
E – Mean Basin Elevation

5.1 Madison/Gallatin River Basin

No natural flow nodes were needed for the Madison/Gallatin River Basin.

5.2 Yellowstone River Basin

No natural flow nodes were needed for the Yellowstone River Basin.

5.3 Clarks Fork River Basin

Several natural flow nodes were required in the Clarks Fork River Basin. Because all basins originate in the Absaroka Range, the Absaroka equation set was used for the calculations. Basin data is shown in **Table 5-2**.

Table 5-2. Natural Flow Data for the Clarks Fork River Basin

Sub-Basin	Site Name	Location	Area (sq.mi.)	Precip-itation (in)	Slope (ft/mile)	Relief (ft)	Mean Elev. (feet)
Clarks Fork Yellowstone	Bars Creek - Natural Flow	Absaroka	2.2	25.8	1,596	3,717	9,266
	Bennett Creek – Natural Flow	Absaroka	14.1	30.6	1,801	5,348	9,022
	Camp Creek – Natural Flow	Absaroka	2.5	26.7	1,425	2,510	7,743
	Deadman Creek - Natural Flow	Absaroka	1.6	25.5	1,165	1,791	7,643
	Dutch Charlie Creek - Natural Flow	Absaroka	1.3	27.2	1,502	3,330	9,313
	Elk Creek – Natural Flow	Absaroka	12.1	27.0	2,017	3,734	8,113
	Gravel Bar Creek – Natural Flow	Absaroka	12.1	35.4	2,779	4,898	9,130
	Huff Creek – Native Flow	Absaroka	4.6	32.8	2,100	3,583	8,247
	Line Creek – Natural Flow	Absaroka	2.5	26.0	1,730	4,278	7,174
	Little Rocky Creek - Natural Flow	Absaroka	43.5	32.4	1,725	5,987	9,163
	Luce Reservoir - Natural Flow	Absaroka	1.5	10.3	1,040	902	5,069
	Natural Springs - Natural Flow	Absaroka	0.4	29.9	2,465	2,910	8,009
	New Meyer Creek - Natural Flow	Absaroka	7.2	12.9	1,709	3,881	6,444
	Paint Creek – Natural Flow	Absaroka	8.8	18.6	1,189	3,169	7,247
	Pat O'Hare Creek - Natural Flow	Absaroka	34.6	18.3	1,844	4,800	7,205
	Sunlight Creek - Natural Flow	Absaroka	47.1	41.3	2,938	4,524	9,158

5.4 Wind River Basin

The USGS equation set was used for all drainages in the Wind River basin. As previously stated, mean annual basin precipitation calculated from the PRISM coverage produced monthly discharges that were significantly higher than those estimated in the original USGS study, especially in the more mountainous regions and in the high runoff months. Therefore, mean annual basin precipitation was taken directly from the USGS report for those drainages that were studied in the report. For those that were not shown in the report and were contained in the more mountainous areas, precipitation was taken from either nearby, similar basins or estimated from Plate 1b of the Lowham report. For those not within the more mountainous areas of the Wind River range, the PRISM coverage values were used (in the non-mountainous area, values seemed to be more in agreement). Basin characteristics are shown in **Table 5-3**.

Table 5-3. Natural Flow Data for the Wind River Basin

Sub-Basin	Site Name	Location	Area (sq.mi.)	Precip-itation (in)	Slope (ft/mile)	Relief (ft)	Mean Elev. (feet)
Upper Wind	Alkali Creek – Natural Flow	Wind	8.3	20.0	1,082	2,126	8,476
	Bear Creek – Natural Flow	Wind	61.9	23.0	1,665	5,089	9,222
	Bob Creek – Natural Flow	Wind	23.4	17.0	1,355	5,541	9,947
	Dry Creek – Natural Flow	Wind	52.3	22.0	1,562	6,627	10,284
	East DuNoir Creek - Natural Flow	Wind	26.9	22.0	1,882	4,035	9,596
	East Fork Wind River - Natural Flow	Wind	52.0	20.0	1,881	4,196	9,893
	Fivemile Creek – Natural Flow	Wind	4.1	17.0	1,089	2,733	9,037
	Geyser Creek - Natural Flow	Wind	5.3	22.0	1,192	2,897	9,054
	Horse Creek – Natural Flow	Wind	70.5	15.0	1,804	4,472	9,389
	Jakeys Fork – Natural Flow	Wind	47.9	23.0	1,379	5,259	9,984
	Little Dry Creek Natural Flow	Wind	15.8	22.0	1,421	5,098	8,688
	Little Horse Creek - Natural Flow	Wind	12.4	15.0	1,003	2,326	8,274
	Little Warms Springs Ck - Natural Flow	Wind	12.8	19.0	1,135	3,720	9,096
	Meadow Creek – Natural Flow	Wind	8.8	17.0	1,581	3,645	8,068
	Meadow Creek - Natural Flow	Wind	8.1	20.0	1,421	3,484	8,902
	Red Creek – Natural Flow	Wind	14.5	16.0	1,666	5,223	8,855
	Red Creek - Natural Flow	Wind	0.1	12.4	1,140	374	7,465
	Sixmile Creek - Natural Flow	Wind	13.6	18.0	1,682	4,203	9,545
	Torrey Creek - Natural Flow	Wind	52.7	21.0	2,065	5,909	10,257
	Warm Springs Creek - Natural Flow	Wind	74.4	22.0	902	3,320	9,091
	West DuNoir Creek - Natural Flow	Wind	28.1	22.0	1,328	3,845	9,260
	West Fork Dry Pasup Ck - Natural Flow	Wind	20.5	19.5	1,665	4,423	8,999
	Wiggins Fork - Natural Flow	Wind	204.0	20.0	2,223	5,646	9,548
	Willow Branch Creek - Natural Flow	Wind	4.8	17.0	1,068	2,972	9,001
	Wind River - Natural Flow	Wind	102.6	20.0	928	3,960	8,624
Little Wind	Beaver Creek - Natural Flow	Wind	78.1	18.1	777	3,091	7,329
	Crooked Creek - Natural Flow	Wind	12.1	15.0	1,587	3,934	7,914
	Mill Creek - Natural Flow	Wind	10.1	14.0	1,002	2,890	6,469
	Norkok Creek - Natural Flow	Wind	7.4	13.0	544	932	6,093
	North Fork Sage Creek - Natural Flow	Wind	25.2	13.0	1,506	5,049	8,559
	Pevah Creek - Natural Flow	Wind	6.2	13.0	1,281	3,232	7,561
	South Fork Sage Creek - Natural Flow	Wind	14.5	13.0	1,538	4,406	8,284
	Spring Creek - Natural Flow	Wind	2.0	15.0	760	1,565	6,157
Lower Wind	Bargee Creek - Natural Flow	Wind	8.8	14.6	1,209	3,195	7,633
	Dry Cottonwood Creek - Natural Flow	Wind	2.4	13.1	1,282	1,867	7,257
	Dry Muddy Creek - Natural Flow	Wind	27.8	17.2	1,339	4,797	8,450
	East Fork Sheep Creek - Natural Flow	Wind	2.9	16.5	1,421	1,775	8,404
	Five Mile Creek - Natural Flow	Wind	4.6	10.6	405	820	6,313
	Gill Meadows - Natural Flow	Wind	0.3	9.2	2,159	1,594	6,037
	Holland Creek – Natural Flow	Wind	2.1	13.6	1,632	3,205	7,960
	Ingalls Creek - Natural Flow (Spring)	Wind	0.2	11.8	1,441	1,175	6,086
	McKee Grave Creek - Natural Flow	Wind	5.4	15.3	1,437	3,035	7,852
	Mexican Draw - Natural Flow	Wind	2.1	11.6	1,211	1,818	6,176
	Morrison Canyon - Natural Flow	Wind	3.7	12.1	1,738	1,916	6,655
	Morrison Meadows – Nat Flow (Spring)	Wind	0.0	9.2	1,595	184	5,214
	Sagwup Creek - Natural Flow	Wind	22.7	14.1	1,047	2,244	7,302
	Shotgun Creek – Natural Flow	Wind	5.4	15.8	1,366	3,048	8,032
	Stagner Creek - Natural Flow	Wind	2.3	11.3	1,586	1,962	6,452
	Warm Springs Creek - Natural Flow	Wind	1.4	12.6	1,554	2,379	7,450
	West Fork Sheep Creek - Natural Flow	Wind	6.3	15.6	1,523	2,769	8,042
	Wood Road Canyon - Natural Flow	Wind	1.2	11.6	1,698	2,005	6,536

Table 5-3 continued

Sub-Basin	Site Name	Location	Area (sq.mi.)	Precip-itation (in)	Slope (ft/mile)	Relief (ft)	Mean Elev. (feet)
Badwater	Alkali Creek - Natural Flow	Wind	9.9	9.9	167	335	6,085
	Badwater Creek - Natural Flow	Wind	19.4	19.4	982	3,320	7,242
	East Bridger Creek - Natural Flow	Wind	15.9	15.9	776	1,027	6,260
	E-K Creek - Natural Flow	Wind	10.9	10.9	465	299	6,373
	Lysite Creek - Natural Flow	Wind	16.9	16.9	747	1,312	6,660
	Meadow Creek - Natural Flow	Wind	19.4	19.4	645	617	6,829
	West Bridger Creek - Natural Flow	Wind	16.6	16.6	1,092	2,595	6,532
	West Fork Dry Creek - Natural Flow	Wind	15.7	15.7	1,530	2,572	7,178

5.5 Bighorn River Basin

Natural flow drainages in the Bighorn River Basin originate in the Owl Creek range, the Absaroka Range, the Bighorn Range and on the high plains within the basin. For those that originate in the Owl Creek range and the high plains, the USGS equation set was used. This was done for two reasons:

(1) When the USGS equations were developed, flow stations from the Owl Creek range were used in their development. Therefore, they can be considered valid for those areas that were used in their development;

(2) Of the three equation sets, the USGS equations for the Wind River basin most closely estimate runoff in the high plains.

Because the PRISM data and the Plate 1b data are more closely correlated in the Owl Creek range, the mean annual basin precipitation calculated from the PRISM data was used in the entire basin. Drainage basin characteristics for the Owl Creek basin are shown in **Table 5-4**.

Table 5-4. Natural Flow Data for the Bighorn River Basin

Sub-Basin	Site Name	Location	Area (sq.mi.)	Precip-itation (in)	Slope (ft/mile)	Relief (ft)	Mean Elev. (feet)
	Adobe Creek - Natural Flow	Wind	6.4	6.9	165	489	4,081
	Carney Creek Natural Flow	Wind	1.8	15.2	1,512	3,543	7,926
	Cottonwood Creek - Natural Flow	Wind	34.8	17.0	1,488	4,285	8,121
	Dry Cottonwood Creek - Natural Flow	Wind	5.3	16.7	1,245	2,372	8,435
	Enos Creek - Natural Flow	Wind	23.8	14.4	1,378	2,904	6,920
	Goat Creek Natural Flow	Wind	3.3	14.4	1,326	3,517	7,462
	Gooseberry Creek - Natural Flow	Wind	57.6	16.9	1,426	4,255	7,539
	Grass Creek - Natural Flow	Wind	11.6	14.5	1,195	1,972	7,028
	Hamilton Dome Well - Natural Flow	Wind	2.7	11.0	600	751	5,668
	Kirby Creek Natural Flow	Wind	194.4	13.2	741	3,540	5,143
	Lake Creek Natural Flow	Wind	4.5	15.7	1,350	1,348	7,854
	Little Grass Creek Natural Flow	Wind	32.2	16.2	1,396	2,792	7,469
	Mayfield Wells - Natural Flow	Wind	24.3	11.5	1,172	1,916	6,164
	McCumber Spring Natural Flow	Wind	0.5	12.2	404	377	4,771
	Middle Fork Mud Creek - Natural Flow	Wind	10.4	13.9	1,231	3,150	6,854
	Mud Creek - Natural Flow	Wind	26.6	14.4	1,263	3,907	6,917
	Natural Flow Node	Wind	0.1	11.9	83	62	5,554
	Natural Flow Node	Wind	5.1	10.8	201	525	4,806

Sub-Basin	Site Name	Location	Area (sq.mi.)	Precip-itation (in)	Slope (ft/mile)	Relief (ft)	Mean Elev. (feet)
	North Fork Owl Creek - Natural Flow	Wind	17.9	18.1	1,796	4,475	9,106
	Red Canyon Creek - Natural Flow	Wind	87.6	11.7	877	3,310	6,005
	Red Creek Natural Flow	Wind	14.5	15.8	1,302	3,845	7,717
	Sixmile Creek Natural Flow	Wind	6.7	7.3	251	394	4,275
	South Fork Mud Creek Natural Flow	Wind	12.9	13.5	1,148	3,304	6,718
	Spring Draw Natural Flow	Wind	15.5	11.5	717	1,594	5,473
	Unnamed Creek Natural Flow	Wind	2.6	7.3	241	344	4,274
	Un-named River - Natural Flow	Wind	6.6	11.1	451	1,122	5,193
	Whitney Spring Natural Flow	Wind	3.3	11.7	1,181	1,214	5,896
Nowood	Bear Creek - Natural Flow	Wind	11.9	18.3	1,048	3,104	7,053
	Beth Wells - Natural Flow	Wind	0.1	10.9	425	190	4,565
	Box Elder Creek - Natural Flow	Wind	24.8	15.9	1,177	3,468	6,422
	Brokenback Creek - Natural Flow	Wind	17.2	20.4	1,263	3,937	6,862
	Buffalo Flat Creek - Natural Flow	Wind	21.3	14.4	852	1,939	5,268
	Crooked Creek - Natural Flow	Wind	7.5	16.7	963	1,919	6,142
	Deep Creek - Natural Flow	Wind	66.4	20.9	1,063	3,966	7,473
	Gomer Well #1- Natural F.ow	Wind	0.3	9.4	472	272	4,547
	Gomer Well #2- Natural F.ow	Wind	0.8	10.1	669	538	4,696
	Green Beret Wells - Natural Flow	Wind	24.0	20.5	1,160	4,728	7,089
	Hamilton and Walters Wells - Natural Flow	Wind	25.2	15.2	986	2,516	5,568
	Little Canyon Creek - Natural Flow	Wind	16.0	18.6	1,271	2,638	6,769
	Lone Tree Creek - Natural Flow	Wind	9.5	15.9	829	2,051	6,711
	Medicine Lodge Creek - Natural Flow	Wind	45.5	22.1	1,260	5,968	7,727
	North Fork Spring Creek - Natural Flow	Wind	6.1	17.4	1,059	2,290	6,016
	Nowood River - Natural Flow	Wind	36.4	16.6	755	1,857	6,539
	Otter Creek - Natural Flow	Wind	46.4	20.0	1,199	3,720	7,098
	Red Bank Creek - Natural Flow	Wind	23.9	15.8	1,032	3,048	6,543
	South Fork Little Canyon Creek - Natural Flow	Wind	0.4	13.5	520	262	5,371
	South Fork Otter Creek - Natural Flow	Wind	36.5	19.4	916	3,487	6,695
	Spring Creek - Natural Flow	Wind	26.3	19.0	1,043	3,501	6,916
	Taylor #2 Well - Natural Flow	Wind	0.1	13.9	560	430	5,131
	Ten Sleep Creek - Natural Flow	Wind	35.6	27.2	1,045	3,812	9,800
	Unnamed Creek Natural Flow	Wind	0.1	10.9	698	285	4,561
	West Fork Tensleep Creek Natural Flow	Wind	50.5	29.6	1,261	4,423	9,950

Table 5-4 continued

Sub-Basin	Site Name	Location	Area (sq.mi.)	Precip-itation (in)	Slope (ft/mile)	Relief (ft)	Mean Elev. (feet)
Greybull	Dick Creek Natural Flow	Absaroka	12.1	20.4	2,074	3,714	8,532
	Dorsey Creek Natural Flow	Absaroka	23.9	7.8	445	1,243	4,397
	Dry Creek Natural Flow	Absaroka	381.1	10.0	383	2,815	5,121
	Four Bear Creek - Natural Flow	Absaroka	8.6	22.9	978	4,318	8,564
	Francs Fork - Natural Flow	Absaroka	40.5	24.3	2,134	6,109	9,606
	Greybull River - Natural Flow	Absaroka	191.9	24.5	2,136	5,974	9,909
	Iron Creek - Natural Flow	Absaroka	12.9	14.1	1,191	1,339	6,556
	Little Rawhide Creek - Natural Flow	Absaroka	2.1	28.6	1,290	2,152	10,069
	Long Hollow Creek Natural Flow	Absaroka	3.6	14.8	555	869	6,694
	Meeteetse Creek - Natural Flow	Absaroka	13.6	28.9	1,715	3,248	10,057
	North Fork Dick Creek Natural Flow	Absaroka	3.0	18.4	1,338	1,854	7,892
	Pappapau Creek - Natural Flow	Absaroka	19.8	16.4	887	2,717	7,007
	Pickett Creek - Natural Flow	Absaroka	2.8	20.0	1,034	3,110	8,077
	Rawhide Creek - Natural Flow	Absaroka	4.7	27.5	1,406	3,245	9,937
	Roach Gulch Natural Flow	Absaroka	1.2	9.7	697	417	5,055
	Rock Creek - Natural Flow	Absaroka	28.1	25.6	1,756	5,138	9,567
	South Fork Meeteetse Creek - Natural Flow	Absaroka	6.4	20.8	905	2,297	7,586
	Spring Creek - Natural Flow	Absaroka	9.1	19.2	823	4,160	7,497
	Sunshine Creek Natural Flow	Absaroka	10.0	15.8	668	1,348	6,828
	Timber Creek - Natural Flow	Absaroka	7.2	23.9	2,287	3,402	8,794
	Wardell Reservoir Natural Flow	Absaroka	0.4	7.8	116	102	4,309
	Wilcox Draw - Natural Flow	Absaroka	1.6	14.3	539	538	6,415
	Willow Creek Natural Flow	Absaroka	29.2	9.7	779	1,775	5,009
Big Horn Lake	Adelaide Creek Natural Flow	Bighorn	2.8	30.9	878	1,325	9,679
	Bear Creek - Natural Flow	Bighorn	6.9	24.4	1,688	4,767	7,439
	Beaver Creek - Natural Flow	Bighorn	13.9	29.6	1,775	4,114	8,356
	Cedar Creek - Natural Flow	Bighorn	2.8	29.6	2,037	3,278	8,479
	Crooked Creek Natural Flow	Bighorn	0.3	7.1	810	440	4,273
	Crystal Creek - Natural Flow	Bighorn	20.0	12.3	809	3,471	4,722
	Fire Spring Creek - Natural Flow	Bighorn	20.5	21.1	1,416	6,060	6,513
	Gypsum Creek Natural Flow	Bighorn	0.1	7.5	879	239	4,552
	Horse Creek - Natural Flow	Bighorn	13.1	27.7	1,851	4,928	8,445
	Red Canyon Natural Flow	Bighorn	15.0	24.3	1,657	5,230	7,537
	Roundup/Harmon Spring Natural Flow	Bighorn	0.1	10.0	719	279	4,142
	South Fork Beaver Creek - Natural Flow	Bighorn	5.0	31.6	1,915	3,366	8,856
	Sykes Spring Natural Flow	Bighorn	0.3	7.6	857	479	4,036
	Trapper Creek - Natural Flow	Bighorn	57.1	22.1	1,448	6,073	7,564
	White Creek - Natural Flow	Bighorn	26.8	22.7	1,371	4,380	7,914

Table 5-4 continued

Sub-Basin	Site Name	Location	Area (sq.mi.)	Precip-itation (in)	Slope (ft/mile)	Relief (ft)	Mean Elev. (feet)
Shoshone	Aldrich Creek - Natural Flow	Absaroka	10.3	27.4	2,720	5,915	9,002
	Alkali Creek - Natural Flow	Absaroka	10.8	9.3	104	617	4,857
	Ashworth Creek - Natural Flow	Absaroka	1.3	18.4	848	1,273	6,753
	Belknap Creek - Natural Flow	Absaroka	9.7	25.2	1,656	5,131	8,328
	Big Creek - Natural Flow	Absaroka	16.4	33.1	2,895	5,449	9,609
	Bitter Creek Natural Flow	Absaroka	76.9	7.7	191	1,056	4,524
	Black Draw Natural Flow	Absaroka	0.6	7.1	267	164	3,956
	Bob Cat Creek - Natural Flow	Absaroka	13.6	29.3	2,613	5,633	9,298
	Boulder Creek - Natural Flow	Absaroka	41.7	26.5	2,471	5,823	9,616
	Breteche Creek Natural Flow	Absaroka	5.3	21.5	1,738	3,054	7,547
	Bull Creek - Natural Flow	Absaroka	6.8	23.2	1,339	4,616	8,036
	Canyon Creek - Natural Flow	Absaroka	6.5	30.3	2,898	5,577	8,688
	Carter Creek - Natural Flow	Absaroka	9.3	21.9	1,467	4,675	7,752
	Cottonwood Creek - Natural Flow	Absaroka	5.0	12.6	923	981	6,358
	Crane Creek - Natural Flow	Absaroka	2.2	22.6	2,933	4,632	8,734
	Deer Creek - Natural Flow	Absaroka	18.8	33.0	3,061	5,062	9,572
	Derry Drain Natural Flow	Absaroka	16.3	7.6	563	1,565	4,519
	Elk Fork Creek Natural Flow	Absaroka	107.5	29.5	2,623	6,161	8,859
	Green Creek - Natural Flow	Absaroka	6.5	26.8	2,288	5,315	8,099
	Hard Pan Creek - Natural Flow	Absaroka	19.2	28.3	2,375	5,758	9,192
	Hunter Creek - Natural Flow	Absaroka	0.6	15.0	3,220	3,104	8,471
	Ishawooa Creek - Natural Flow	Absaroka	65.7	31.9	2,767	5,659	9,166
	Jim Creek - Natural Flow	Absaroka	5.6	16.5	1,602	4,501	8,068
	Jordan Creek - Natural Flow	Absaroka	5.1	20.6	1,686	3,107	7,577
	Legg Creek - Natural Flow	Absaroka	3.1	27.3	1,884	3,839	9,632
	Little Sand Draw - Natural Flow	Absaroka	4.2	7.5	362	1,381	3,957
	Marquette Creek Natural Flow	Absaroka	10.0	19.2	1,195	5,095	7,330
	North Branch Alkali Creek Natural Flow	Absaroka	0.7	9.0	146	171	4,821
	North Fork Shoshone River -Natural Flow	Absaroka	56.0	41.6	2,328	5,049	9,096
	Rand Creek - Natural Flow	Absaroka	3.3	21.8	1,601	3,136	7,580
	Rattlesnake Creek - Natural Flow	Absaroka	3.1	27.2	1,766	2,241	8,431
	Rock Creek - Natural Flow	Absaroka	24.8	26.5	2,067	5,823	8,733
	Sage Creek - Natural Flow	Absaroka	6.5	21.4	1,189	4,682	7,474
	Sand Creek Natural Flow	Absaroka	26.8	7.2	315	715	4,335
	SF Shoshone Tributary Natural Flow	Absaroka	1.0	20.3	2,550	2,799	8,042
	South Fork Sage Creek Natural Flow	Absaroka	0.0	28.4	2,934	883	9,883
	South Fork Shoshone River - Natural Flow	Absaroka	213.9	30.4	2,854	3,625	10,492
	Spring Creek - Natural Flow	Absaroka	0.9	21.1	3,458	3,711	8,280
	Trail Creek - Natural Flow	Absaroka	4.8	15.8	1,577	2,195	7,399
	Trout Creek - Natural Flow	Absaroka	47.1	22.8	1,907	6,539	8,258
	Unnamed Creek Natural Flow	Absaroka	1.0	16.8	2,250	1,594	7,018
	Whit Creek - Natural Flow	Absaroka	10.6	24.5	1,230	3,829	8,015

Section 6 - Hydrologic Year Classification

Once the study period is selected, the monthly data is further reduced into average data for dry, average and wet hydrologic year classifications. To determine which years within the period-of-record fall into which hydrologic year classifications, index gages were selected within each of the hydrologic units. These gages were selected based upon their period-of-record and their lack of influence by diversion and return flows. Then, the hydrologic classification for the index gage was applied to the remaining gages within its influence area. The hydrologic classifications for the Wind/Bighorn River Basin plan are consistent with the hydrologic classifications for the

other river basin plans and with the guidelines. A summary of the classification methodology is shown in **Table 6-1**, while a summary of the hydrologic year classification for each index gage are shown in
Table 6-2.

Table 6-1. Hydrologic Classification Methodology

	Dry	Average	Wet
Percent of Years	Driest 20 percent	Middle 60 percent	Wettest 20 percent
Number of Years in 29-year Study Period	6	17	6

Table 6-2. Summary of Hydrologic Classifications for Study Area

Basin	USGS Gage No	Gage ID	1970								1980									1990										2000	
			3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1
Mad. /Gal.	06037500	Madison Near West Yellowstone	A	W	A	A	A	A	A	A	A	A	A	A	A	W	D	D	D	D	A	D	A	A	A	W	W	W	W	A	D
	06191500	Yellowstone At Corwin Springs	A	W	A	W	D	A	A	D	A	W	A	A	A	A	D	D	A	A	A	A	A	D	A	W	W	A	W	A	D
	06205500	Clarks Fk Ab Squaw Ck	A	W	W	W	D	W	A	A	A	A	A	A	D	A	D	D	A	A	A	A	A	D	A	W	W	A	A	A	D
Wind	06222700	Crow C Nr Tipperary Wyo	A	A	A	A	D	A	A	A	D	W	A	A	D	W	A	D	A	A	W	A	A	D	W	A	W	A	W	A	D
	06224000	Bull Lake Creek Above Bull Lake	A	A	A	A	D	A	A	A	A	A	W	A	D	W	A	D	A	A	W	D	A	D	W	A	W	A	W	A	D
	06228350	SF Little Wind Ab Washakie Res	A	A	A	A	D	A	A	A	A	A	W	A	D	W	A	D	A	A	A	D	A	D	W	A	W	W	W	A	D
Bighorn	06260000	South Fork Owl Ck Near Anchor	A	A	A	A	D	A	D	A	A	A	A	A	D	W	A	D	A	A	W	A	A	D	W	W	W	A	W	A	D
	06270000	Nowood River Near Tensleep	W	A	W	A	A	W	A	D	D	D	W	W	A	A	A	A	D	A	A	A	A	A	D	W	A	A	A	A	D
	06275000	Wood River At Sunshine	W	W	A	A	D	A	A	A	A	D	W	A	D	A	A	D	D	D	A	A	A	A	A	A	W	W	W	A	A
	06278500	Shell Creek Near Shell	A	A	W	W	D	W	A	A	A	A	A	A	D	W	A	A	D	A	A	A	A	D	W	A	A	A	W	D	D
	06280300	SF Shoshone River Near Valley	A	W	A	W	D	A	A	A	A	W	A	A	A	W	D	D	A	A	A	D	A	D	A	W	W	A	A	A	D

Notes:
(1) Hydrologic Year Classification
- Wet Year (Wettest 20 percent of years)
- Average (Middle 60 percent of years)
- Dry Year (Driest 20 percent of years)

6.1 Madison/Gallatin River Basins

Both the Madison River near West Yellowstone gage and the Gallatin River gage contain adequate data to classify hydrologic years. However, since the primary gages that need to be classified in the model are Madison River tributaries, the Madison River near West Yellowstone gage (06037500) has been selected for the analysis. A summary of the annual classifications is shown in **Table 6-3**.

Table 6-3. Annual Summary of Hydrologic Classification for Madison/Gallatin River Basin

Hyd. Class.	Rank	Exceedance Probability	Mad_WstY 6037500	
			Year	ac-ft
Dry	1	97%	1992	319,163
	2	93%	1990	319,857
	3	90%	1988	320,343
	4	87%	1989	323,876
	5	83%	1987	325,576
	6	80%	2001	325,718
Average	7	77%	1977	334,959
	8	73%	1994	337,320
	9	70%	1991	349,560
	10	67%	1980	353,507
	11	63%	1973	353,846
	12	60%	1979	357,054
	13	57%	1983	359,521
	14	53%	1981	359,964
	15	50%	1985	370,089
	16	47%	2000	372,904
	17	43%	1993	372,938
	18	40%	1975	375,209
	19	37%	1978	378,618
	20	33%	1984	385,759
	21	30%	1982	394,155
	22	27%	1976	394,727
	23	23%	1995	399,487
Wet	24	20%	1974	403,342
	25	17%	1986	445,688
	26	13%	1999	464,538
	27	10%	1998	468,532
	28	7%	1996	485,023
	29	3%	1997	571,071

6.2 Yellowstone River Basin

There are three gages within the Yellowstone model that would be adequate for hydrological classification: the Yellowstone River at the Yellowstone Lake Outlet (06186500), Gardner River near Mammoth (06190500) and the Yellowstone River at Corwin Springs (06191500). The first two gages, respectively, have short periods where data would need to be filled. In addition, the annual flow variation at the Yellowstone Lake Outlet gage is small and may not provide a good measure of hydrologic variability throughout the entire basin. Therefore, the Corwin Springs gage was selected as the index gage for the entire basin. A summary of the annual classification is shown in **Table 6-4**.

Table 6-4. Annual Summary of Hydrologic Classification for Yellowstone River Basin

Hyd. Class.	Rank	Exceedance Probability	Yl_CSp 6191500 Year	ac-ft
Dry	1	97%	1988	1,432,264
	2	93%	1977	1,465,559
	3	90%	2001	1,469,775
	4	87%	1987	1,515,455
	5	83%	1994	1,739,690
	6	80%	1980	1,896,240
Average	7	77%	1985	1,950,495
	8	73%	1979	1,999,467
	9	70%	1992	2,002,359
	10	67%	1973	2,008,748
	11	63%	1981	2,025,027
	12	60%	1989	2,027,794
	13	57%	2000	2,033,189
	14	53%	1990	2,165,736
	15	50%	1983	2,192,144
	16	47%	1991	2,313,669
	17	43%	1995	2,402,856
	18	40%	1975	2,452,548
	19	37%	1978	2,494,101
	20	33%	1993	2,516,278
	21	30%	1984	2,551,455
	22	27%	1998	2,558,338
	23	23%	1986	2,646,850
Wet	24	20%	1982	2,810,473
	25	17%	1999	2,810,917
	26	13%	1976	2,835,864
	27	10%	1974	3,033,936
	28	7%	1996	3,276,792
	29	3%	1997	3,733,984

6.3 Clarks Fork River Basin

Although the Clarks Fork near Belfry gage contains continuous data through the period-of-record, the gage is located downstream of agricultural diversions. These diversions have an influence on the relative flow at the gage making it unsuitable for use as an index gage in the hydrologic year classification. Two other gages within the basin are located upstream of diversions making them more suitable for use as the index gage: the Clarks Fork Yellowstone River above Squaw Creek and Sunlight Creek near Painter. Neither of these gages has any data in the study period. However, since the correlation coefficients used to fill the data were very strong, the filled data should be representative of actual flows at the gage, allowing either to be used as an index gage. Because the Clarks Fork above Squaw Creek gage is on the mainstem and contains a larger portion of flow in the basin, it was selected as an index gage. A summary of the annual classification is shown in **Table 6-5**.

Table 6-5. Annual Summary of Hydrologic Classification for Clarks Fork River Basin

Hyd. Class.	Rank	Exceedance Probability	CFk_abSqC 06205500 Year	ac-ft
	1	97%	1977	157,292
	2	93%	1988	162,139
	3	90%	2001	168,504

Hyd. Class.	Rank	Exceedance Probability	CFk_abSqC 06205500	
			Year	ac-ft
	4	87%	1985	180,960
	5	83%	1987	181,061
	6	80%	1994	191,993
Average	7	77%	2000	239,216
	8	73%	1973	241,625
	9	70%	1993	251,384
	10	67%	1983	254,106
	11	63%	1990	254,764
	12	60%	1979	267,893
	13	57%	1989	269,858
	14	53%	1991	270,145
	15	50%	1992	278,943
	16	47%	1998	280,137
	17	43%	1984	290,709
	18	40%	1980	291,356
	19	37%	1981	301,619
	20	33%	1995	304,153
	21	30%	1986	305,178
	22	27%	1999	316,801
	23	23%	1982	325,962
Wet	24	20%	1978	331,186
	25	17%	1975	369,678
	26	13%	1974	389,981
	27	10%	1976	401,423
	28	7%	1996	426,084
	29	3%	1997	472,436

6.4 Wind River Basin

Several gages within the Wind River basin contain adequate data to serve as index gages for development of hydrologic year classifications. As with previous index gage selection, gages that are not significantly influence by diversions, storage or return flows are the most desireable gages. For the Wind River basin, to account for differences in hydrology between sub-basins and location of gages, separate gages were selected for sites along the Wind River range in the Wind River sub-basin and Little Wind River sub-basin, and those located along the Owl Creek range. For purposes of this analysis, the following gages were selected as index gages: Bull Lake Creek above Bull Lake (06224000), South Fork Little Wind River above Washakie Reservoir (06228350) and Crow Creek near Tipperary (06222700). A summary of the annual hydrologic classification for each of these gage is shown in **Table 6-6**.

Table 6-6. Annual Summary of Hydrologic Classification for Wind River Basin

Hyd. Class.	Rank	Exceedance Probability	CrowCk_Tip 06222700		BlCk_abLk 06224000		SFLW_abWRes 06228350	
			Year	ac-ft	Year	ac-ft	Year	ac-ft
Dry	1	97%	1977	4,058	1977	126,271	2001	43,797
	2	93%	1985	6,297	2001	128,295	1977	51,583
	3	90%	1988	8,787	1992	132,032	1994	55,627
	4	87%	2001	9,365	1994	132,676	1988	55,774
	5	83%	1981	9,429	1988	138,843	1992	63,176
	6	80%	1994	9,678	1985	146,821	1985	73,728
A	7	77%	1973	10,560	2000	167,042	1981	74,239

Hyd. Class.	Rank	Exceedance Probability	CrowCk_Tip 06222700		BICk_abLk 06224000		SFLW_abWRes 06228350	
			Year	ac-ft	Year	ac-ft	Year	ac-ft
	8	73%	2000	12,132	1979	172,414	2000	74,611
	9	70%	1990	12,263	1990	172,975	1979	76,579
	10	67%	1984	12,840	1981	182,436	1990	78,551
	11	63%	1989	12,898	1989	189,216	1989	79,098
	12	60%	1979	12,917	1987	193,715	1987	87,230
	13	57%	1987	13,783	1993	197,805	1976	89,320
	14	53%	1992	14,328	1976	200,758	1973	90,941
	15	50%	1974	16,310	1975	204,060	1984	90,941
	16	47%	1980	16,585	1973	209,154	1993	94,879
	17	43%	1996	16,657	1984	217,294	1975	98,999
	18	40%	1993	16,992	1978	224,227	1982	99,475
	19	37%	1976	17,177	1980	229,388	1974	107,407
	20	33%	1975	17,441	1996	230,413	1996	108,325
	21	30%	1998	17,468	1974	232,504	1980	110,291
	22	27%	1978	17,950	1998	241,775	1991	113,234
	23	23%	1983	18,519	1982	245,651	1978	114,021
Wet	24	20%	1997	18,991	1991	246,210	1998	115,485
	25	17%	1982	19,139	1997	263,103	1997	122,894
	26	13%	1995	19,264	1995	266,931	1983	126,601
	27	10%	1986	19,414	1999	275,244	1999	133,361
	28	7%	1999	19,858	1983	286,164	1995	135,304
	29	3%	1991	20,251	1986	300,455	1986	136,312

6.5 Bighorn River Basin

Only a few gages within the Bighorn basin contain adequate data to serve as index gages for development of hydrologic year classifications. As with previous index gage selection, gages that are not significantly influence by diversions, storage or return flows are the most desirable gages. In the Bighorn basin, separate gages were selected for sites along the Owl Creek Range in the Upper Bighorn Basin and Nowood River basins, the Bighorn range in the Nowood River basin, and Bighorn Lake River basin, and the Absaroka range in the Greybull and Shoshone River basins. For purposes of this analysis, the following gages were selected as index gages: the South Fork of Owl Creek near Anchor (0626000), Nowood River near Tensleep (0627000), Wood River at Sunshine (06275000), Shell Creek near Shell (06278500) and the South Fork Shoshone River near Valley (06280300). A summary of the annual hydrologic classification for each of these gages is shown in **Table 6-7** and **Table 6-8**.

Table 6-7. Annual Summary of Hydrologic Classification for Upper Bighorn and Greybull River Basins

Hyd. Class.	Rank	Exceedance Probability	SFOwl_nrAnc 06260000		Now_Ten 06270000		Wod_Sun 06275000	
			Year	ac-ft	Year	ac-ft	Year	ac-ft
Dry	1	97%	2001	9,057	1995	48,437	1977	28,027
	2	93%	1994	9,868	1989	49,105	1985	32,102
	3	90%	1985	10,269	1980	52,662	1982	33,013
	4	87%	1977	10,813	2001	54,585	1988	35,164
	5	83%	1988	17,060	1981	54,772	1989	39,662
	6	80%	1979	18,270	1982	58,017	1990	43,147
A	7	77%	2000	19,366	1992	59,894	2001	44,959
	8	73%	1982	21,021	2000	62,873	1986	46,732
	9	70%	1981	21,961	1985	63,347	1987	53,210
	10	67%	1984	22,709	1993	64,093	1979	54,717
	11	63%	1990	24,177	1997	67,117	1980	60,833

Hyd. Class.	Rank	Exceedance Probability	SFOwl_nrAnc 06260000		Now_Ten 06270000		Wod_Sun 06275000	
			Year	ac-ft	Year	ac-ft	Year	ac-ft
	12	60%	1973	24,702	1987	67,897	1992	61,179
	13	57%	1989	24,713	1979	68,090	1994	62,936
	14	53%	1993	25,955	1990	71,158	2000	65,234
	15	50%	1980	27,103	1988	71,298	1976	66,657
	16	47%	1976	28,021	1974	72,017	1981	67,117
	17	43%	1987	28,305	1976	72,481	1978	68,321
	18	40%	1974	28,519	1991	72,820	1984	77,764
	19	37%	1978	30,736	1998	73,166	1993	83,381
	20	33%	1983	30,938	1994	77,481	1991	87,968
	21	30%	1975	31,129	1986	78,295	1975	88,650
	22	27%	1992	32,065	1999	84,286	1995	92,835
	23	23%	1998	32,710	1977	104,788	1996	93,989
Wet	24	20%	1996	33,690	1996	106,347	1983	97,824
	25	17%	1997	35,567	1983	114,541	1973	99,332
	26	13%	1999	37,169	1975	125,252	1998	100,575
	27	10%	1995	38,295	1973	129,050	1974	108,587
	28	7%	1986	40,395	1984	136,752	1997	109,054
	29	3%	1991	40,665	1978	183,819	1999	112,350

Table 6-8. Annual Summary of Hydrologic Classification for Bighorn Lake and Shoshone River Basins

Hyd. Class.	Rank	Exceedance Probability	Shl_nrShl 06278500		SFSh_Val 06280300	
			Year	ac-ft	Year	ac-ft
Dry	1	97%	2001	55,848	1977	159,664
	2	93%	1985	66,267	2001	181,470
	3	90%	1989	70,131	1994	185,366
	4	87%	1994	70,758	1988	196,253
	5	83%	2000	71,947	1992	206,754
	6	80%	1977	72,003	1987	218,431
Average	7	77%	1987	72,859	1979	236,390
	8	73%	1998	76,645	2000	237,314
	9	70%	1980	77,928	1973	241,555
	10	67%	1981	86,610	1993	245,516
	11	63%	1988	87,047	1985	249,330
	12	60%	1991	87,251	1990	259,033
	13	57%	1993	88,214	1981	264,964
	14	53%	1996	88,266	1989	275,921
	15	50%	1983	89,527	1980	298,057
	16	47%	1982	91,926	1998	301,155
	17	43%	1992	92,432	1983	309,712
	18	40%	1990	94,362	1975	318,943
	19	37%	1997	94,746	1984	323,529
	20	33%	1973	96,041	1995	326,448
	21	30%	1984	97,881	1991	337,143
	22	27%	1974	99,042	1999	350,738
	23	23%	1979	99,095	1978	352,728
Wet	24	20%	1999	99,685	1976	369,709
	25	17%	1986	100,445	1982	376,575
	26	13%	1976	100,563	1996	378,708
	27	10%	1995	103,062	1986	386,116
	28	7%	1975	109,673	1974	400,141
	29	3%	1978	116,732	1997	440,652

Section 7 - Summary Flow Data

This section presents an annual summary of the overall study period average and hydrologic period averages. As previously discussed, gage records were reduced from monthly data throughout the study period to the hydrologic classifications shown by averaging the data for the years within each hydrologic classification, based upon the classification at the index gage. The natural flow node flows were estimated based on regional regression equations for the Q_{10}, Q_{50} and Q_{90} for the wet, dry and average years, respectively. Monthly average flows are presented in Appendix A.

7.1 Madison/Gallatin River Basin

A summary of annual flows for the Madison/Gallatin River Basin are presented in **Table 7-1**. As shown, because of its heavy influence by groundwater inflows, flows in the Madison river basin do not vary significantly between dry and wet years.

Table 7-1. Summary of Average Annual Flows for the Madison/Gallatin River Basins

Sub-Basin	USGS Gage No.	Site Name	Gaged/Estimated Annual Flow (ac-ft)		
			Dry	Average	Wet
Madison/Gallatin	06037000	Gibbon River Near West Yellowstone Mt	76,829	97,101	120,010
	06036905	Firehole River Near West Yellowstone Mt	216,029	234,984	266,559
	06037500	Madison River Near West Yellowstone Mt	340,745	375,009	437,417
	06043500	Gallatin River Near Gallatin Gateway Mt	501,921	634,324	716,471

7.2 Yellowstone River Basin

A summary of streamflow data for the Yellowstone River Basin is shown in **Table 7-2**. As with the Madison and Gallatin basins, there is not a significant variation between dry, average and wet year flows in the basin. The Lamar River gage, the average annual flow during average years is less than for dry years. This is because the dry, average and wet years were determined at the Yellowstone gage, which is influence more by flows from the Yellowstone River upstream of its confluence with the Lamar River. Because of its different physical setting (originating on the west slope of the Absarokas rather than the north slope of the Absarokas) the distribution of dry, average and wet years are different.

Table 7-2. Summary of Average Annual Flows for the Yellowstone River Basin

Sub-Basin	USGS Gage No.	Site Name	Gaged/Estimated Annual Flow (ac-ft)		
			Dry	Average	Wet
Yellowstone Headwaters	06186500	Yellowstone River At Yellowstone Lk Outlet Ynp	664,734	1,001,588	1,185,711
	06187000	Yellowstone River Near Canyon Hotel Ynp	813,647	1,146,594	1,328,581
	06187500	Tower Creek At Tower Falls Ynp	27,200	43,145	51,977
	06187915	Soda Butte Cr At Park Bndry At Silver Gate	27,892	41,211	--- (1)
	06187950	Soda Butte Cr Nr Lamar Ranger Station Ynp	74,928	108,886	115,585
	06188000	Lamar River Nr Tower Falls Ranger Station Ynp	373,084	353,678	687,920
	06190000	Lupine Creek Near Mammoth Ynp	2,362	3,694	4,247
	06190500	Gardner River At Mammoth Ynp	--- (1)	--- (1)	--- (1)
	06190540	Hot River At Mammoth Ynp	18,961	19,417	19,776
	06191000	Gardner River Near Mammoth Ynp	116,866	160,968	179,296
	06189000	Blacktail Deer Creek Nr Mammoth Ynp	4,895	7,795	9,115
	06188500	E F Blacktail Deer Cr Nr Mammoth Ynp	1,444	2,732	3,322

Notes:
(1) No data available for hydrologic period. Gage record was not extended for reasons discussed in previous sections. Gage not included in model.

7.3 Clarks Fork River Basin

Average annual flows for the Clarks Fork River Basin are shown in **Table 7-3**. The Clarks Fork basin shows significant differences between dry and wet years. This is because basin runoff is primarily dependent upon snowpack and because there is no upstream storage in the basin. Several natural flow nodes were required to model the basin; these outnumber gage flows by over three to one. The Clarks Fork above Squaw Creek (06205500) gage represents natural flows for the Clarks Fork River.

Table 7-3. Summary of Average Annual Flows for the Clarks Fork River Basin

Sub-Basin	USGS Gage No.	Site Name	Gaged/Estimated Annual Flow (ac-ft) Dry	Average	Wet
Clarks Fork Yellowstone	6205500	Clarks Fk Yellowstone R Ab Squaw C Nr Painter,Wy	204,675	289,994	336,440
	6206000	Clarks Fk Yellowstone R Bl Crandal C Nr Painter	355,882	506,663	589,085
	Natural Flow	Deadman Creek Natural Flow	173	390	856
	Natural Flow	Camp Creek Natural Flow	290	649	1,406
	Natural Flow	Dutch Charlie Creek Natural Flow	133	302	669
	Natural Flow	Bars Creek Natural Flow	253	568	1,234
	Natural Flow	Sunlight Creek Natural Flow	9,971	20,470	40,655
	Natural Flow	Gravel Bar Creek Natural Flow	1,920	4,122	8,509
	Natural Flow	Huff Creek Natural Flow	603	1,329	2,823
	6206500	Sunlight Creek Near Painter, Wyo.	66,582	91,038	104,272
	Natural Flow	Elk Creek Natural Flow	1,923	4,128	8,522
	Natural Flow	New Meyer Creek Natural Flow	1,027	2,236	4,688
	Natural Flow	Paint Creek Natural Flow	1,306	2,829	5,896
	Natural Flow	Luce Reservoir Natural Flow	160	363	798
	Natural Flow	Pat O'Hare Creek Natural Flow	6,838	14,193	28,436
	Natural Flow	Bennett Creek Natural Flow	2,310	4,937	10,147
	Natural Flow	Natural Springs Natural Flow	33	76	176
	Natural Flow	Little Rocky Creek Natural Flow	9,038	18,608	37,042
	Natural Flow	Line Creek Natural Flow	294	659	1,426
	6207500	Clarks Fork Yellowstone River Nr Belfry Mt	496,917	681,915	782,014
	6207510	Big Sand Cl At Wy-Mont State Line	32,320	29,058	25,148

Notes:
(1) No data available for hydrologic period. Gage record was not extended for reasons discussed in previous sections. Gage not included in model.

7.4 Wind River Basin

Table 7-4 presents a summary of average annual flows for the Wind River Basin. The basin contains a mixture of gage sites and natural flow nodes. In addition, four creeks within the basin contain gages that represent natural flows for the creek: Crow Creek (6222700), Bull Lake Creek (6224000), South Fork Little Wind (06228350) and North Fork Little Wind (06228350). The Popo Agie gage has been included in the Wind River basin gages. However, the Popo Agie river basin has been modeled under a separate study (Anderson, 2002). As shown and as previously discussed, there are several streamflow gages that were not used in the modeling analysis.

Table 7-4. Summary of Average Annual Flows for the Wind River Basin

Sub-Basin	USGS Gage No.	Site Name	Gaged/Estimated Annual Flow (ac-ft) Dry	Average	Wet
Upper Wind	Natural Flow	Wind River Natural Flow	23,780	49,726	86,258
	Natural Flow	East Dunoir Creek Natural Flow	11,014	22,584	39,529
	Natural Flow	West Dunoir Creek Natural Flow	10,624	22,802	39,927
	Natural Flow	Willow Branch Creek Natural Flow	949	2,492	5,065
	Natural Flow	Sixmile Creek Natural Flow	3,151	7,007	13,445
	Natural Flow	Fivemile Creek Natural Flow	844	2,233	4,560
	6218500	Wind River Near Dubois, Wyo.	83,224	128,144	147,394
	Natural Flow	Warm Springs Creek Natural Flow	26,516	53,558	91,147
	Natural Flow	Geyser Creek Natural Flow	897	2,319	4,778
	Natural Flow	Little Warms Springs Creek Natural Flow	3,196	7,589	14,352
	Natural Flow	Horse Creek - Natural Flow	8,720	17,327	32,811
	Natural Flow	Little Horse Creek - Natural Flow	1,528	3,984	8,009
	6220000	Wind River At Dubois Wyo	--- (1)	--- (1)	--- (1)
	Natural Flow	Jakeys Fork - Natural Flow	23,280	42,544	72,137
	Natural Flow	Torrey Creek Natural Flow	20,673	36,409	63,381
	Natural Flow	East Fork Wind River Natural Flow	16,726	31,433	55,589
	Natural Flow	Meadow Creek Natural Flow	2,366	6,011	11,339
	Natural Flow	Alkali Creek Natural Flow	2,491	6,605	12,396
	Natural Flow	Bear Creek Natural Flow	23,901	47,966	80,871
	Natural Flow	Wiggins Fork Natural Flow	54,177	94,640	160,960
	6220500	East Fork Wind River Nr Dubois Wyo	106,052	177,501	221,433
	6220800	Wind River Above Red Creek, Near Dubois, Wy	314,982	489,170	611,810
	Natural Flow	Red Creeknatural Flow	1,912	4,696	9,383
	6221400	Dinwoody Creek Above Lakes, Near Burris, Wyo.	75,115	99,612	126,925
	6221500	Dinwoody Creek Near Burris, Wyo.	--- (1)	--- (1)	--- (1)
	6222000	Wind River Near Burris, Wy	--- (1)	--- (1)	--- (1)
	Natural Flow	Little Dry Creek Natural Flow	5,095	12,666	22,620
	Natural Flow	Dry Creek Natural Flow	23,533	40,941	70,245
	6222500	Dry Creek Near Burris, Wyo.	18,822	33,114	48,754
	6222700	Crow C Nr Tipperary Wyo	7,936	15,107	19,486
	Natural Flow	Meadow Creek Natural Flow	1,303	3,709	7,372
	Natural Flow	Bob Creek Natural Flow	4,741	9,531	18,304
	6223000	Meadow Creek Nr Lenore Wyo	--- (1)	--- (1)	--- (1)
	6223500	Willow Creek Near Crowheart, Wyo.	7,216	13,290	22,927
	6224000	Bull Lake Creek Above Bull Lake, Wy	134,156	206,519	273,018
	6225000	Bull Lake Creek Near Lenore, Wy	161,646	194,507	232,087
	6225500	Wind River Near Crowheart, Wy	573,394	861,074	1,066,800
	Natural Flow	West Fork Dry Pasup Creek Natural Flow	646	1,453	3,190
	Natural Flow	Red Creek Natural Flow	9	31	82
	6227600	Wind River Near Kinnear, Wy	242,380	527,696	780,446
	6228000	Wind River At Riverton, Wy	169,632	406,669	619,260
	6236100	Wind River Ab Boysen Reservoir, Nr Shoshoni, Wy	423,079	899,138	1,318,331

Table 7-4 continued

Sub-Basin	USGS Gage No.	Site Name	Gaged/Estimated Annual Flow (ac-ft)		
			Dry	Average	Wet
Little Wind	6228350	Sf L Wind R Ab Washakie Re Nr Ft Washakie Wy	57,281	93,420	128,326
	6228450	South Fork Little Wind Riv Bel Washakie Res, Wy	57,385	89,827	123,268
	6228500	Little Wind R Nr Fort Washakie, Wyo.	--- (1)	--- (1)	--- (1)
	Natural Flow	Crooked Creek Natural Flow	1,181	3,300	6,722
	Natural Flow	Spring Creek Natural Flow	248	898	1,935
	6229900	Trout Creek Near Fort Washakie, Wy	4,737	6,901	10,415
	Natural Flow	Mill Creek Natural Flow	751	2,377	4,905
	6230190	Mill Cr Ab Ray Lake Outlet Canal, Nr Ft Washakie	2,370	3,663	5,471
	6228800	North Fork Little Wind River Nr Fort Washakie, Wy	57,571	99,885	140,330
	6229000	N Fk Little Wind R At Fort Washakie, Wyo.	--- (1)	--- (1)	--- (1)
	Natural Flow	North Fork Sage Creek Natural Flow	1,746	4,175	8,590
	Natural Flow	South Fork Sage Creek Natural Flow	999	2,597	5,464
	Natural Flow	Pevah Creek Natural Flow	429	1,295	2,814
	6229680	Sage Cr Ab Norkok Meadows Cr, Nr Ft Washakie, Wy	4,343	7,835	11,732
	Natural Flow	Norkok Creek Natural Flow	772	2,268	4,624
	6230500	Little Wind River Nr Arapahoe Wyo	--- (1)	--- (1)	--- (1)
	6231000	Little Wind R Above Arapahoe, Wyo.	61,917	137,892	219,921
	6234000	Little Wind River Below Arapahoe Wyo	--- (1)	--- (1)	--- (1)
	Natural Flow	Beaver Creek Natural Flow	4,571	10,276	19,485
	6235500	Little Wind River Near Riverton, Wy	201,224	399,911	641,442
	6233900	Popo Agie River Nr Arapahoe Wy	141,836	227,330	356,443
Lower Wind	Natural Flow	Five Mile Creek Natural Flow	232	636	1,379
	6244500	Fivemile C Ab Wyo Ca Nr Pav Wyo	3,787	3,608	5,797
	6245000	Fivemile Creek Nr Pavillion Wyo	--- (1)	--- (1)	--- (1)
	6250000	Fivemile Creek Near Riverton, Wy	168,760	231,478	256,404
	6253000	Fivemile Creek Near Shoshoni, Wy	90,773	124,041	137,263
	6239000	Muscrat Creek Near Shoshoni, Wy	--- (1)	15,681	--- (1)
	Natural Flow	Dry Cottonwood Creek Natural Flow	167	539	1,229
	Natural Flow	Ingalls Creek Natural Flow (Spring)	20	84	213
	Natural Flow	Mexican Draw Natural Flow	134	472	1,081
	Natural Flow	Stagner Creek Natural Flow	140	489	1,118
	Natural Flow	Wood Road Canyon Natural Flow	77	287	681
	Natural Flow	Gill Meadows Natural Flow	25	106	269
	Natural Flow	Morrison Meadows Natural Flow (Spring)	4	15	40
	Natural Flow	Morrison Canyon Natural Flow	230	748	1,662
	6258500	Dry Cottonwood Creek Near Bonneville, Wy	--- (1)	--- (1)	--- (1)
	Natural Flow	Holland Creek Natural Flow	200	652	1,467
	Natural Flow	Warm Springs Creek Natural Flow	138	486	1,108
	Natural Flow	Bargee Creek Natural Flow	740	2,158	4,519
	Natural Flow	Sagwup Creek Natural Flow	2,033	5,403	10,626
	Natural Flow	Dry Muddy Creek Natural Flow	1,004	2,320	4,949
	Natural Flow	Shotgun Creek Natural Flow	209	585	1,352
	Natural Flow	Mckee Grave Creek Natural Flow	204	579	1,337
	Natural Flow	West Fork Sheep Creek Natural Flow	254	695	1,580
	Natural Flow	East Fork Sheep Creek Natural Flow	142	403	943
	6257500	Muddy Creek Near Pavillion, Wyo.	--- (1)	4,172	--- (1)
	6258000	Muddy Creek Near Shoshoni, Wyo.	13,152	18,361	18,907
	6259000	Wind R Bl Boysen Res Wyo	766,870	1,047,812	1,329,777

Table 7-4 continued

Sub-Basin	USGS Gage No.	Site Name	Gaged/Estimated Annual Flow (ac-ft) Dry	Average	Wet
Badwater	Natural Flow	Badwater Creek Natural Flow	3,451	6,596	11,885
	6256000	Badwater Creek At Lybyer Ranch, Nr Lost Cabin, Wy	23,422	24,206	21,224
	6256500	Badwater Creek At Lost Cabin Wyo	--- (1)	--- (1)	--- (1)
	Natural Flow	E-K Creek Natural Flow	52	159	368
	Natural Flow	Alkali Creek Natural Flow	561	1,341	2,620
	6256650	Badwater C At Lysite, Wy	24,442	24,209	21,529
	Natural Flow	East Bridger Creek Natural Flow	51	157	378
	Natural Flow	Bridger Creek Natural Flow	1,289	2,769	5,279
	Natural Flow	Meadow Creek Natural Flow	239	622	1,308
	Natural Flow	Lysite Creek Natural Flow	654	1,512	2,991
	6256800	Bridger Creek Near Lysite, Wyo.	15,646	16,489	14,000
	Natural Flow	West Fork Dry Creek Natural Flow	138	378	873
	6256900	Dry Creek Near Bonneville, Wyo.	1,031	1,547	742
	6257000	Badwater Creek At Bonneville, Wyo.	39,904	40,510	36,361

Notes:
(1) No data available for hydrologic period. Gage record was not extended for reasons discussed in previous sections. Gage not included in model.

7.5 Bighorn River Basin

Average annual flows for the Bighorn River Basin are shown in **Table 7-5**. The basin does have a mixture of gaged sites and natural flow nodes. However, especially in the Nowood and Greybull basins, there are a significant number of ungaged sites. Streams that contain gage sites representing natural flow include: South Fork Owl Creek (06260000), Middle Fork Owl Creek (06260200) Paint Rock Creek (06271500), Wood River (06274800) and Shell Creek (06278300). As shown and as previously discussed, there are several streamflow gages that were not used in the modeling analysis.

Table 7-5. Summary of Average Annual Flows for the Bighorn River Basin

Sub-Basin	USGS Gage No.	Site Name	Gaged/Estimated Annual Flow (ac-ft)		
			Dry	Average	Wet
Upper Bighorn	Natural Flow	Red Canyon Creek Natural Flow	4,242	9,988	18,602
	6259500	Bighorn River At Thermopolis, Wyo.	843,625	1,069,496	1,392,167
	Natural Flow	North Fork Owl Creek Natural Flow	3,639	8,419	16,001
	6262000	North Fork Owl Creek Near Anchor, Wy	4,950	9,930	13,756
	6262300	North Fork Owl Cr Ab Basin Ranch Nr Anchor Wyo	5,082	10,092	13,827
	6262500	N.F. Owl Creek At Crann Ranch Nr Thermopolis, Wy	--- [1]	--- [1]	--- [1]
	6263000	North Fork Owl Creek Nr Thermopolis Wyo	--- [1]	--- [1]	--- [1]
	6260000	South Fork Owl Creek Near Anchor, Wy	12,578	26,747	37,630
	6260400	South Fork Owl Creek Below Anchor Reservoir, Wy	9,019	17,498	22,880
	Natural Flow	Goat Creek Natural Flow	302	1,009	2,203
	Natural Flow	Carney Creek Natural Flow	214	724	1,603
	6260500	S F Owl Creek Ab Curtis Ranch, Nr Thermopolis, Wy	--- [1]	--- [1]	--- [1]
	6261000	Sf Owl C A C Rn N Thermopolis Wyo	--- [1]	--- [1]	--- [1]
	6261500	South Fork Owl Creek Nr Thermopolis Wyo	--- [1]	--- [1]	--- [1]
	Natural Flow	Arapaho Ranch Pumps Natural Flow	59	202	460
	Natural Flow	Dry Cottonwood Creek Natural Flow	942	2,621	5,312
	Natural Flow	Red Creek Natural Flow	1,567	4,409	8,779
	Natural Flow	Unnamed Creek Natural Flow	418	1,234	2,607
	Natural Flow	Thompson Reservoir #1 Natural Flow Node	482	1,346	2,792
	Natural Flow	Middle Fork Mud Creek Natural Flow	766	2,360	4,890
	Natural Flow	Mud Creek Natural Flow	1,956	5,513	10,867
	Natural Flow	South Fork Mud Creek Natural Flow	846	2,562	5,293
	Natural Flow	Whitney Spring Natural Flow	226	734	1,612
	Natural Flow	Spring Draw Natural Flow	905	2,529	5,107
	6263500	Mud Creek Nr Thermopolis Wyo	--- [1]	--- [1]	--- [1]
	Natural Flow	Mccumber Spring Natural Flow	71	253	581
	6264000	Owl Creek Near Thermopolis, Wy	--- [1]	--- [1]	--- [1]
	6264500	Owl Creek Near Lucerne, Wyo.	--- [1]	--- [1]	--- [1]
	Natural Flow	Kirby Creek Natural Flow	11,807	26,786	46,764
	6265000	Kirby Creek Nr Lucerne Wyo	--- [1]	--- [1]	--- [1]
	Natural Flow	Cottonwood Creek Natural Flow	4,626	11,462	21,605
	Natural Flow	Lake Creek Natural Flow	748	2,186	4,473
	6265337	Cottonwood C At High Island Rnch Nr Hamilton Dome	4,803	9,188	12,155
	Natural Flow	Hamilton Dome Well Natural Flow	205	642	1,409
	Natural Flow	Little Grass Creek Natural Flow	3,871	10,166	19,180
	Natural Flow	Grass Creek Natural Flow	1,166	3,399	6,829
	Natural Flow	Mayfield Wells Natural Flow	1,363	3,612	7,140
	6265500	Cottonwood Creek At Winchester Wyo	--- [1]	--- [1]	--- [1]
	Natural Flow	Gooseberry Creek Natural Flow	6,660	16,753	30,848
	6265800	Gooseberry Creek At Dickie, Wyo.	7,199	12,662	14,795
	Natural Flow	Enos Creek Natural Flow	1,944	5,435	10,666
	6266000	Gooseberry Creek Near Grass Creek, Wyo.	--- [1]	--- [1]	--- [1]
	6266500	Gooseberry Creek Nr Dickie Wyo	--- [1]	--- [1]	--- [1]
	6267000	Gooseberry Creek At Neiber, Wyo.	--- [1]	--- [1]	--- [1]
	6267400	East Fork Nowater Creek Near Colter, Wyo.	1,710	3,153	2,155
	6268500	Fifteen Mile Creek Near Worland, Wyo.	3,508	5,834	4,708
	Natural Flow	Unnamed Creek Natural Flow	144	385	814
	6268600	Bighorn R At Worland Wyo	614,170	840,692	1,164,292
	Natural Flow	Sixmile Creek Natural Flow	375	907	1,778
	6269000	Bighorn River Near Manderson, Wy	--- [1]	--- [1]	--- [1]
	6269500	Bighorn R At Manderson Wyo	--- [1]	--- [1]	--- [1]

Table 7-5 continued

Sub-Basin	USGS Gage No.	Site Name	Gaged/Estimated Annual Flow (ac-ft) Dry	Average	Wet
	Natural Flow	Adobe Creek Natural Flow	290	679	1,358
	6274300	Bighorn R At Basin Wy	963,340	1,327,128	1,757,979
Nowood	Natural Flow	Nowood River Natural Flow	4,971	13,482	24,793
	Natural Flow	Lone Tree Creek Natural Flow	1,170	3,621	7,196
	Natural Flow	Bear Creek Natural Flow	1,866	5,810	11,088
	Natural Flow	Deep Creek Natural Flow	13,613	34,619	59,756
	Natural Flow	Box Elder Creek Natural Flow	2,292	6,902	13,245
	Natural Flow	Red Bank Creek Natural Flow	2,342	6,900	13,255
	Natural Flow	Little Canyon Creek Natural Flow	2,615	8,062	15,042
	Natural Flow	South Fork Little Canyon Creek Natural Flow	96	333	747
	Natural Flow	Crooked Creek Natural Flow	1,012	3,380	6,673
	Natural Flow	Otter Creek Natural Flow	8,211	22,580	39,807
	Natural Flow	South Fork Otter Creek Natural Flow	5,801	16,906	30,299
	Natural Flow	Spring Creek Natural Flow	4,143	12,214	22,322
	Natural Flow	Taylor #2 Well Natural Flow	20	80	197
	Natural Flow	North Fork Spring Creek Natural Flow	847	3,016	5,959
	6270000	Nowood River Near Tensleep, Wy	52,476	72,981	132,627
	Natural Flow	Ten Sleep Creek Natural Flow	29,211	55,336	89,030
	Natural Flow	West Fork Tensleep Creek Natural Flow	53,243	94,509	145,753
	6270450	Canyon Creek Below Cooks Canyon, Near Tensleep,	9,754	9,901	10,876
	6270500	Canyon Creek Nr Ten Sleep Wyo	18,271	20,418	26,662
	6271000	Tensleep Creek Near Tensleep, Wyo.	85,668	87,522	99,890
	Natural Flow	Beth Wells Natural Flow	22	81	198
	Natural Flow	Unnamed Creek Natural Flow	12	45	115
	Natural Flow	Brokenback Creek Natural Flow	3,163	10,087	18,330
	Natural Flow	Green Beret Wells Natural Flow	4,334	13,112	23,576
	Natural Flow	Buffalo Flat Creek Natural Flow	1,839	5,503	10,626
	Natural Flow	Gomer Well #1 Natural F.Ow	28	98	238
	Natural Flow	Gomer Well #2 Natural F.Ow	58	198	465
	Natural Flow	Medicine Lodge Creek Natural Flow	10,578	27,740	47,733
	6273000	Medicine Lodge Creek Near Hyattville, Wyo.	21,698	22,221	25,826
	6271500	Paintrock Creek Below Lake Solitude, Wy	--- (1)	--- (1)	--- (1)
	6272500	Paintrock Creek Near Hyattville, Wyo.	85,641	94,079	110,948
	Natural Flow	Hamilton And Walters Wells Natural Flow	2,213	6,720	12,844
	6273500	Paintrock Creek Near Mouth Below Hyattville Wy	--- (1)	--- (1)	--- (1)
	6274000	Nowood River At Bonanza Wyo	--- (1)	--- (1)	--- (1)
Big Horn Lake	6278300	Shell Creek Above Shell Creek Reservoir, Wyo.	18,102	23,915	28,518
	Natural Flow	Adelaide Creek Natural Flow	1,266	2,730	7,809
	6278500	Shell Creek Near Shell, Wy	68,277	89,404	105,027
	Natural Flow	White Creek Natural Flow	6,141	12,427	32,556
	Natural Flow	Trapper Creek Natural Flow	11,837	23,755	65,450
	Natural Flow	Horse Creek Natural Flow	4,291	9,061	27,136
	6279000	Shell Creek At Shell Wyo	--- (1)	--- (1)	--- (1)
	Natural Flow	Beaver Creek Natural Flow	5,060	10,829	35,295
	Natural Flow	South Fork Beaver Creek Natural Flow	2,247	4,875	15,324
	Natural Flow	Cedar Creek Natural Flow	1,183	2,527	6,880
	Natural Flow	Red Canyon Natural Flow	3,971	8,157	21,497
	Natural Flow	Bear Creek Natural Flow	1,966	4,045	9,894
	Natural Flow	Crystal Creek Natural Flow	2,708	5,045	9,776
	6279500	Bighorn River At Kane, Wy	982,568	1,650,463	1,982,999
	Natural Flow	Fire Spring Creek Natural Flow	4,383	8,753	20,999
	Natural Flow	Crooked Creek Natural Flow	59	116	163
	Natural Flow	Gypsum Creek Natural Flow	19	39	49
	6286258	Big Coulee Near Lovell, Wyo.	38	82	89
	6286260	Crooked C Nr Lovell Wyo	6,813	7,417	7,981

Table 7-5 continued

Sub-Basin	USGS Gage No.	Site Name	Gaged/Estimated Annual Flow (ac-ft) Dry	Average	Wet
	Natural Flow	Sykes Spring Natural Flow	50	98	135
	Natural Flow	Roundup/Harmon Spring Natural Flow	32	63	83
Shoshone	Natural Flow	South Fork Shoshone River Natural Flow	63,887	123,306	234,780
	Natural Flow	Deer Creek Natural Flow	3,272	6,930	14,126
	Natural Flow	Hunter Creek Natural Flow	50	115	261
	Natural Flow	Sf Shoshone Tributary Natural Flow	92	211	471
	Natural Flow	Legg Creek Natural Flow	367	818	1,761
	Natural Flow	Boulder Creek Natural Flow	8,586	17,704	35,283
	6280300	South Fork Shoshone River Near Valley, Wy	190,964	290,432	391,984
	Natural Flow	Spring Creek Natural Flow	85	195	437
	Natural Flow	Crane Creek Natural Flow	244	548	1,191
	Natural Flow	Aldrich Creek Natural Flow	1,575	3,397	7,047
	Natural Flow	Ishawooa Creek Natural Flow	14,962	30,340	59,701
	Natural Flow	Bob Cat Creek Natural Flow	2,196	4,698	9,668
	Natural Flow	Hard Pan Creek Natural Flow	3,342	7,074	14,411
	Natural Flow	Rock Creek Natural Flow	4,574	9,601	19,416
	Natural Flow	Jordan Creek Natural Flow	673	1,481	3,137
	Natural Flow	Belknap Creek Natural Flow	1,464	3,163	6,574
	6280500	South Fork Shoshone River Nr Ishawooa Wyo	--- (1)	--- (1)	--- (1)
	Natural Flow	Bull Creek Natural Flow	963	2,102	4,413
	6281000	South Fork Shoshone R Ab Buffalo Bill Res, Wy	135,796	254,070	387,997
	Natural Flow	Marquette Creek Natural Flow	1,520	3,282	6,815
	Natural Flow	Carter Creek Natural Flow	1,401	3,031	6,305
	6281400	Diamond Creek Nr Mouth Nr Cody Wy	4,065	4,446	4,932
	Natural Flow	North Fork Shoshone River Natural Flow	12,298	25,088	49,588
	6279790	Jones Creek At Mouth, Near Pahaska, Wy	31,830	40,550	50,475
	6279795	Crow Creek At Mouth, At Pahaska, Wy	13,932	20,425	27,331
	6279800	North Fork Shoshone River At Pahaska, Wy	143,475	197,216	267,152
	6279850	Middle Cr At E Entrance Ynp Wy	26,256	43,666	64,907
	Natural Flow	Elk Fork Creek Natural Flow	27,348	54,385	105,556
	Natural Flow	Canyon Creek Natural Flow	905	1,977	4,158
	Natural Flow	Big Creek Natural Flow	2,766	5,883	12,039
	Natural Flow	Green Creek Natural Flow	912	1,993	4,190
	Natural Flow	Rand Creek Natural Flow	399	886	1,904
	Natural Flow	Whit Creek Natural Flow	1,641	3,537	7,330
	6279940	North Fork Shoshone River At Wapiti, Wy	414,717	606,805	849,719
	Natural Flow	Jim Creek Natural Flow	751	1,648	3,482
	Natural Flow	Breteche Creek Natural Flow	709	1,557	3,294
	Natural Flow	Unnamed Creek Natural Flow	94	214	478
	Natural Flow	Trout Creek Natural Flow	9,950	20,429	40,577
	6280000	North Fork Shoshone River Nr Wapiti Wyo	389,849	610,251	826,179
	Natural Flow	Rattlesnake Creek Natural Flow	376	836	1,798
	Natural Flow	Trail Creek Natural Flow	626	1,378	2,926
	6282000	Shoshone River Below Buffalo Bill Reservoir, Wy	486,134	681,752	1,020,454
	Natural Flow	Cottonwood Creek Natural Flow	659	1,450	3,074
	Natural Flow	Ashworth Creek Natural Flow	128	291	645
	Natural Flow	Sage Creek Natural Flow	899	1,964	4,131
	Natural Flow	South Fork Sage Creek Natural Flow	3	6	16
	6283000	Shoshone River At Corbett Dam Wyo	--- (1)	--- (1)	--- (1)
	6283800	Shoshone R Ab Willwood Dam Nr Willwood Wy	311,587	461,383	727,848
	6284000	Shoshone River At Willwood Dam Wyo	--- (1)	--- (1)	--- (1)
	Natural Flow	Alkali Creek Natural Flow	1,678	3,613	7,483

Table 7-5 continued

Sub-Basin	USGS Gage No.	Site Name	Gaged/Estimated Annual Flow (ac-ft)		
			Dry	Average	Wet
Shoshone (continued)	Natural Flow	North Branch Alkali Creek Natural Flow	64	148	334
	6284200	Shoshone River At Willwood, Wy	357,226	555,936	910,934
	Natural Flow	Derry Drain Natural Flow	2,744	5,838	11,950
	6284400	Shoshone River Near Garland, Wy	248,171	422,417	751,324
	Natural Flow	Bitter Creek Natural Flow	18,132	36,545	71,596
	6284500	Bitter Creek Near Garland, Wy	94,667	100,136	109,307
	6284800	Whistle Creek Near Garland, Wy	13,831	18,469	18,659
	6285000	Shoshone River At Byron, Wyo.	--- (1)	--- (1)	--- (1)
	Natural Flow	Sand Creek Natural Flow	5,020	10,511	21,210
	6285100	Shoshone River Near Lovell, Wy	374,488	608,010	981,613
	6286000	Shoshone River At Lovell Wyo	--- (1)	--- (1)	--- (1)
	6285400	Sage Creek At Sidon Canal, Near Deaver, Wy	40,520	47,255	47,112
	6285500	Sage Creek Near Lovell, Wy	--- (1)	--- (1)	--- (1)
	Natural Flow	Black Draw Natural Flow	56	128	291
	6286200	Shoshone River At Kane, Wy	501,521	751,110	1,139,733
	Natural Flow	Little Sand Draw - Natural Flow	534	1,181	2,517
Greybull	Natural Flow	Greybull River Natural Flow	55,880	108,384	206,993
	Natural Flow	Four Bear Creek Natural Flow	327	729	1,574
	Natural Flow	Francs Fork Natural Flow	8,287	17,106	34,119
	6274500	Greybull River Near Pitchfork, Wyo.	87,088	121,314	161,480
	Natural Flow	Four Bear Creek Natural Flow	1,276	2,765	5,766
	Natural Flow	Timber Creek Natural Flow	1,024	2,231	4,677
	Natural Flow	Pappapau Creek Natural Flow	3,470	7,338	14,937
	Natural Flow	Wilcox Draw Natural Flow	173	392	860
	Natural Flow	Sunshine Creek Natural Flow	1,529	3,300	6,850
	6274800	Wood River Near Kirwin, Wyo.	7,429	9,612	11,776
	6274810	Wood R At Kirwin Wyo	5,659	10,088	16,058
	Natural Flow	Dick Creek Natural Flow	1,917	4,116	8,497
	Natural Flow	North Fork Dick Creek Natural Flow	356	792	1,706
	6275000	Wood River At Sunshine, Wyo.	35,186	69,353	104,620
	6275500	Wood River Near Meeteetse, Wyo.	68,865	87,564	109,508
	Natural Flow	Rawhide Creek Natural Flow	619	1,363	2,895
	Natural Flow	Little Rawhide Creek Natural Flow	235	527	1,148
	6276000	Greybull River Nr Meeteetse Wyo	--- (1)	--- (1)	--- (1)
	Natural Flow	Iron Creek Natural Flow	2,070	4,434	9,138
	6276500	Greybull River At Meeteetse, Wyo.	166,072	222,106	287,865
	Natural Flow	Spring Creek Natural Flow	1,362	2,947	6,136
	Natural Flow	Meeteetse Creek Natural Flow	2,208	4,723	9,717
	Natural Flow	South Fork Meeteetse Creek Natural Flow	891	1,948	4,099
	Natural Flow	Long Hollow Creek Natural Flow	449	996	2,132
	Natural Flow	Roach Gulch Natural Flow	123	279	617
	Natural Flow	Willow Creek Natural Flow	5,572	11,633	23,418
	Natural Flow	Wardell Reservoir Natural Flow	31	72	166
	6277500	Greybull River Near Basin, Wyo.	103,866	131,342	165,141
	Natural Flow	Dorsey Creek Natural Flow	4,372	9,188	18,600
	Natural Flow	Dry Creek Natural Flow	130,830	245,629	460,155
	6277950	Dry Creek Near Greybull Wy	--- (1)	21,437	--- (1)
	6278000	Dry Creek At Greybull, Wy	14,638	17,649	18,735

Notes:
(1) No data available for hydrologic period. Gage record was not extended for reasons discussed in previous sections. Gage not included in model.

Section 8 - References

Daly, Chris and George Taylor. 1997. "Wyoming Average Annual Precipitation, 1961-1990." PRISM Services/Oregon State University. GIS Coverage.

Lowham, H.W. 1988. *Streamflows in Wyoming*. USGS Water-Resources Investigations Report 88-4045.

Miselis, Daiva V. 1999. *Development of Improved Hyrologic Models for Estimating Streamflow Characteristics of the Mountainous Basins in Wyoming*. Thesis submitted to the Department of Renewable Resources and The Graduate School of the University of Wyoming. Laramie, Wyoming. May.

Petras, Ivan. 2000. "Arcview 2.1 Basin Extension." Downloaded from www.esri.com. April 11.

Rankl, James G., Ellen Montague and Bernard N. Lenz. *Estimates of Monthly Streamflow Characteristics at Selected Sites, Wind River and Part of Bighorn River Drainage Basins, Wyoming*. USGS Water-Resources Investigations Report 94-4014. Cheyenne.

States West Water Resources Corporation. 2001. *Guidelines for Development of Basin Plans*. Prepared for the Wyoming Water Development Commission, State of Wyoming Water Basin Planning Process. February.

United States Geological Survey (USGS). 2002.

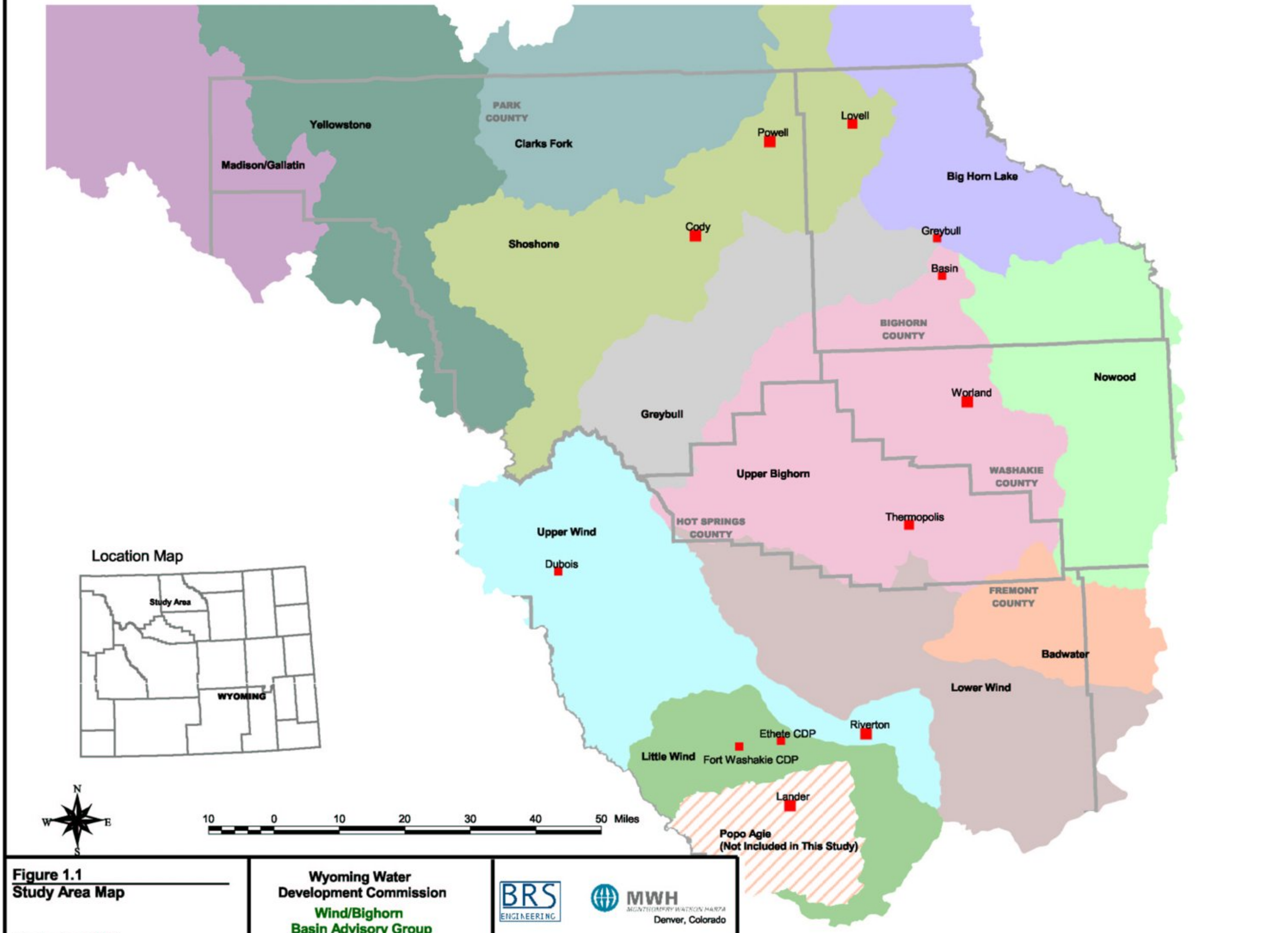

Figure 1.1
Study Area Map

September 2002

Wyoming Water Development Commission

Wind/Bighorn Basin Advisory Group

BRS ENGINEERING

MWH MONTGOMERY WATSON HARZA
Denver, Colorado

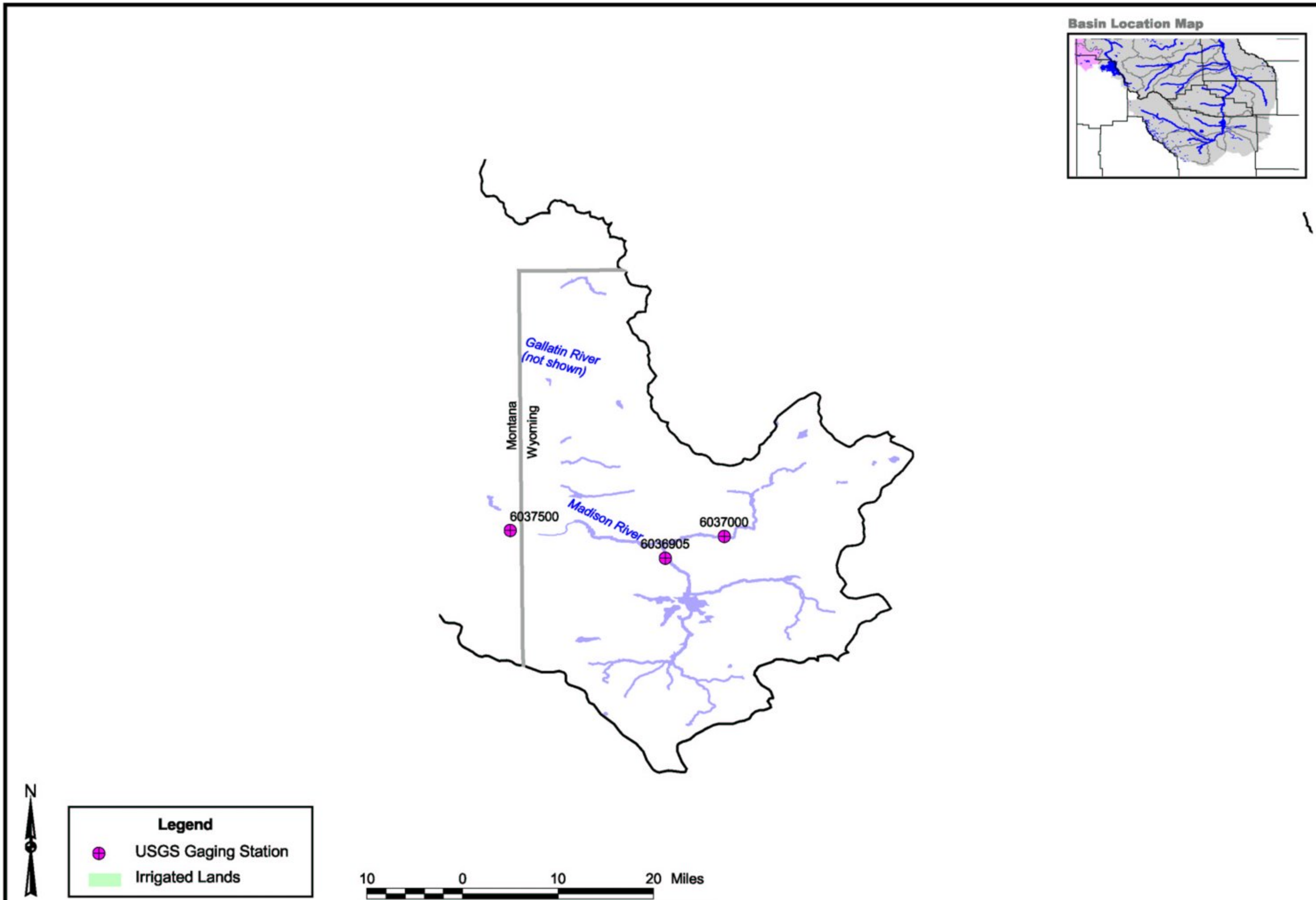

Figure 2.1
Madison/Gallatin River Basins

October, 2002

Wyoming Water Development Commission

Wind/Bighorn Basin Advisory Group

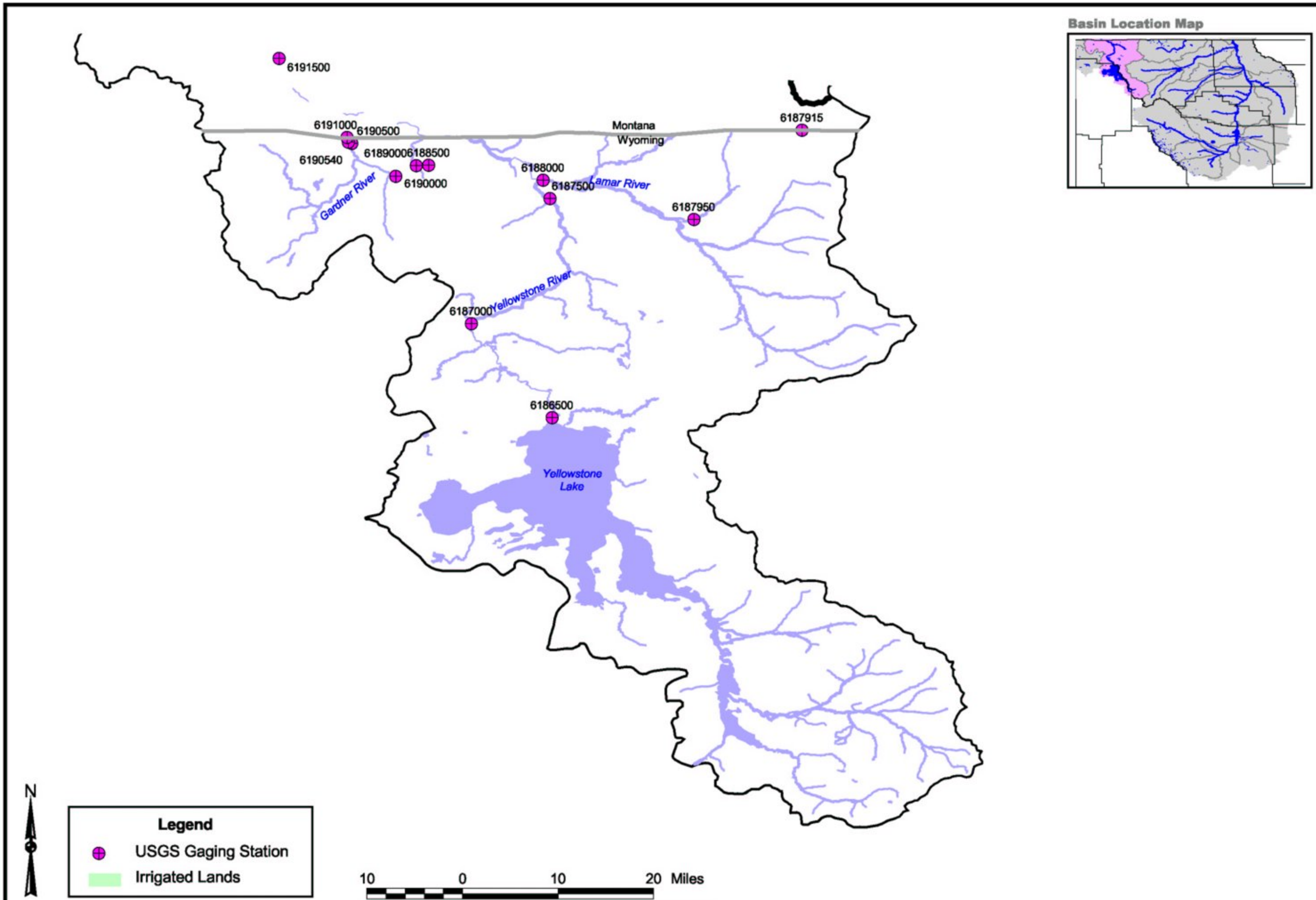

Figure 2.2
Yellowstone River Basin

October, 2002

Wyoming Water Development Commission

Wind/Bighorn Basin Advisory Group

BRS ENGINEERING

MWH

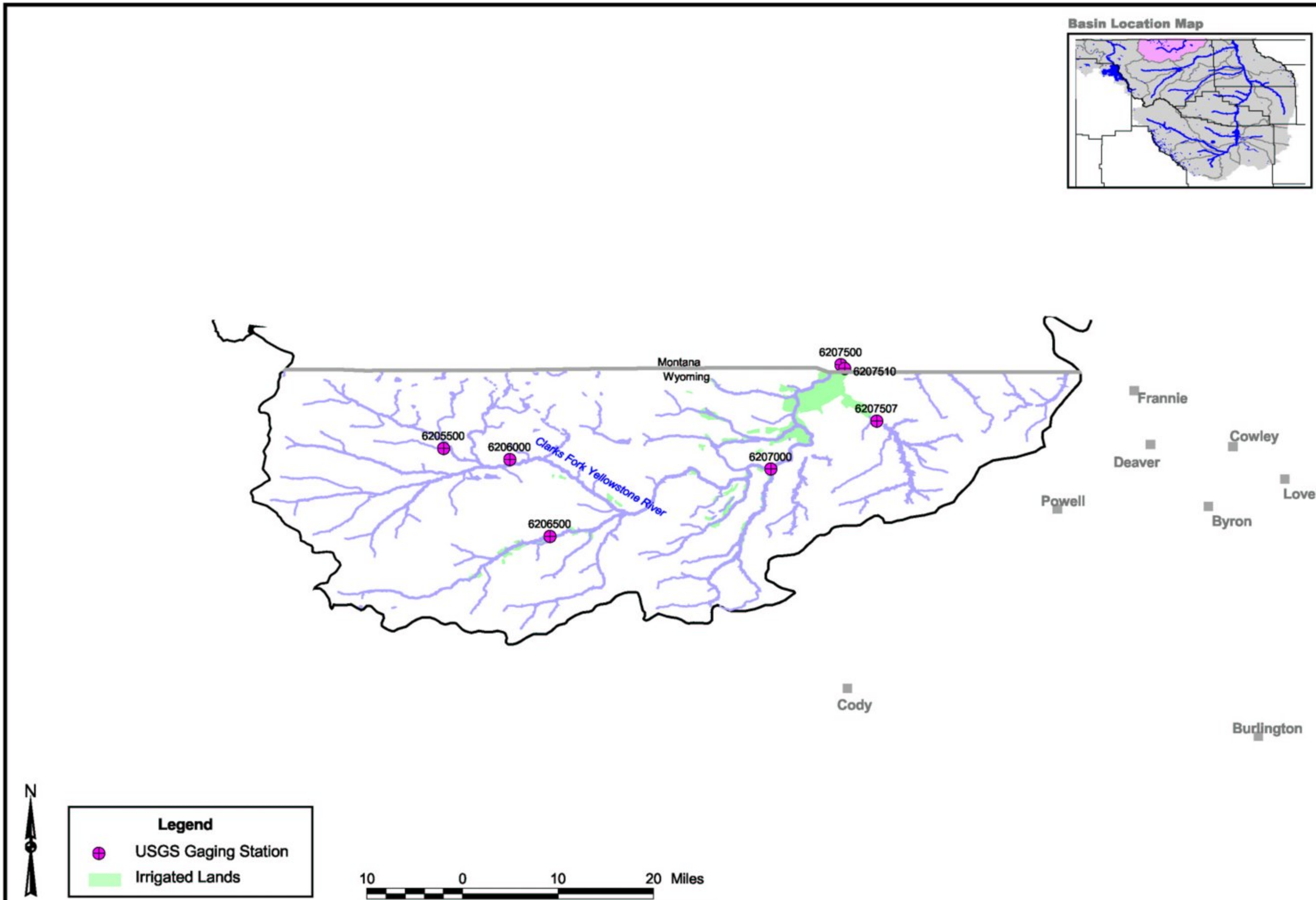

Figure 2.3
Clarks Fork River Basin

October, 2002

Wyoming Water Development Commission

Wind/Bighorn Basin Advisory Group

BRS ENGINEERING

MWH

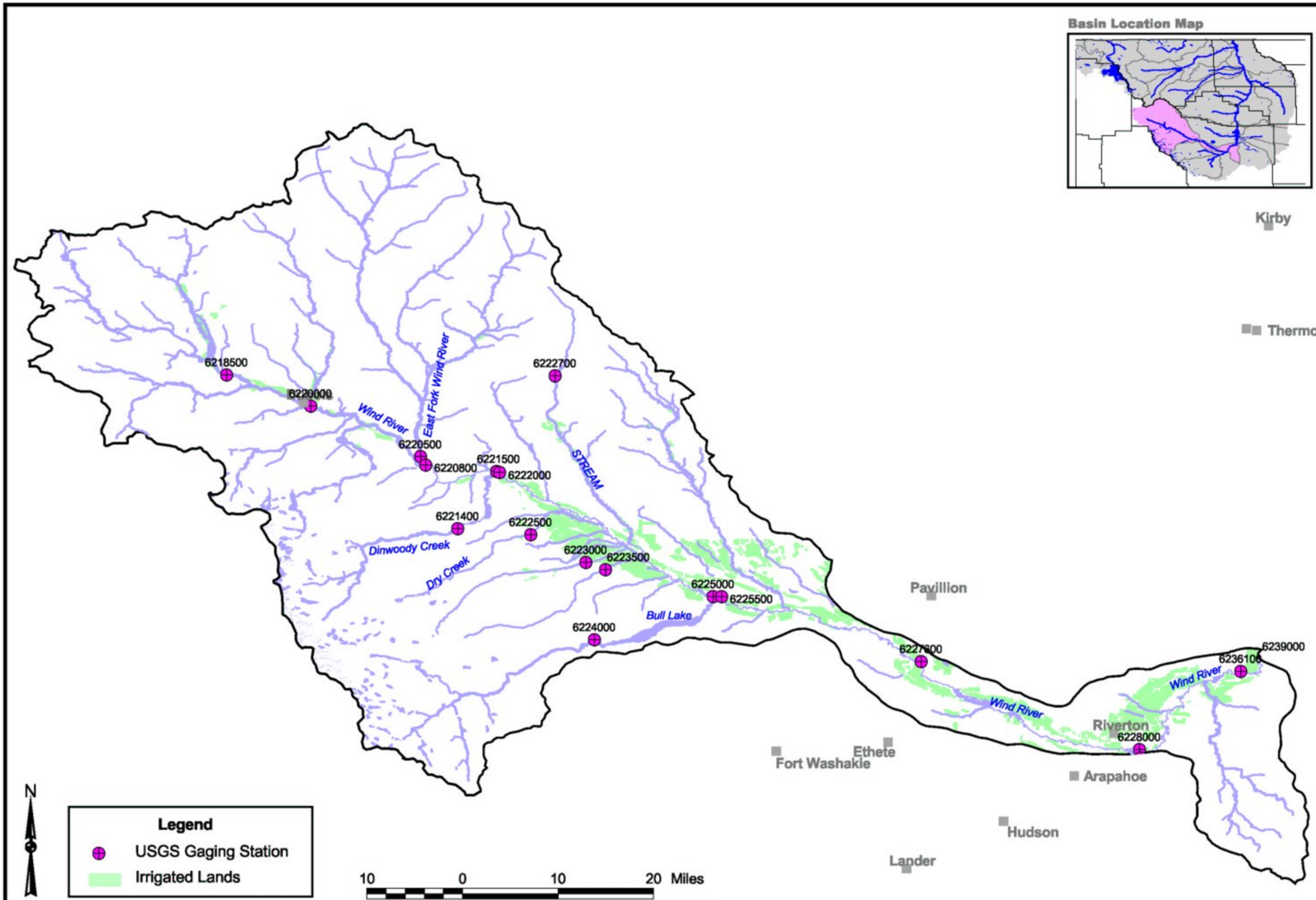

Figure 2.4
Upper Wind Sub-Basin

October, 2002

Wyoming Water Development Commission

Wind/Bighorn Basin Advisory Group

BRS ENGINEERING MWH

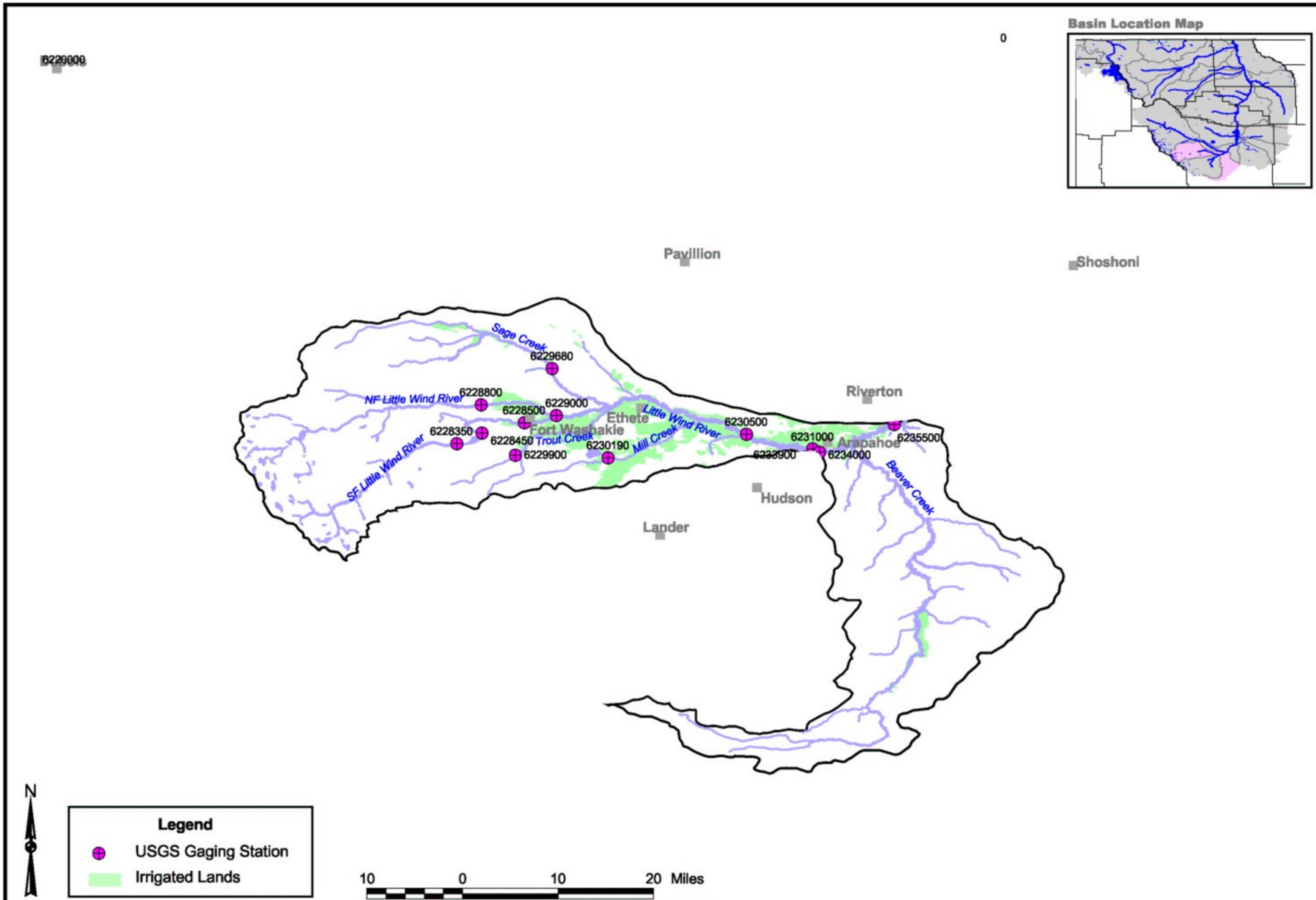

Figure 2.5
Little Wind Sub-Basin

October, 2002

Wyoming Water Development Commission

Wind/Bighorn Basin Advisory Group

BRS ENGINEERING

MWH

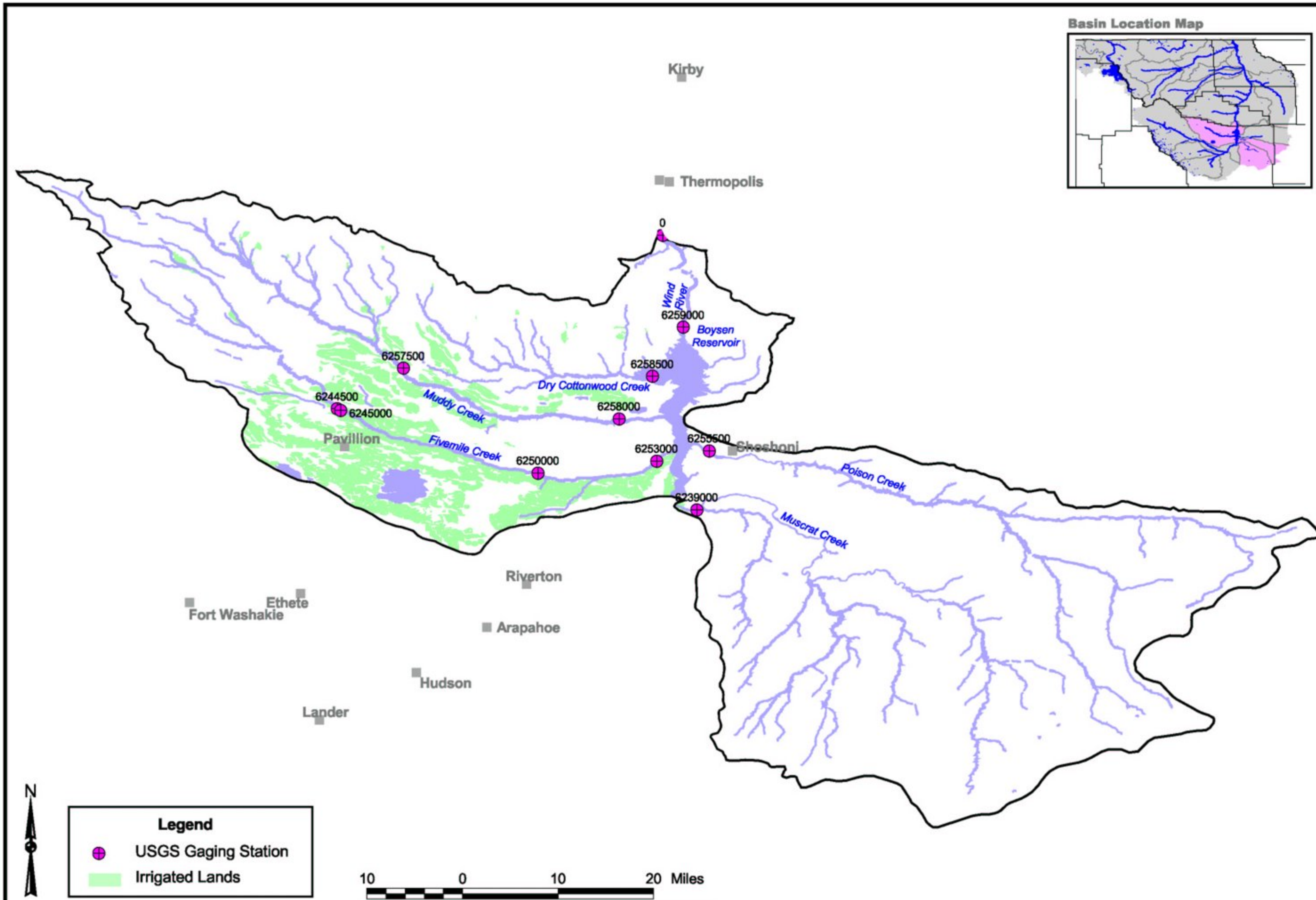

Figure 2.6
Lower Wind Sub-Basin

October, 2002

Wyoming Water Development Commission

Wind/Bighorn Basin Advisory Group

BRS ENGINEERING
MWH

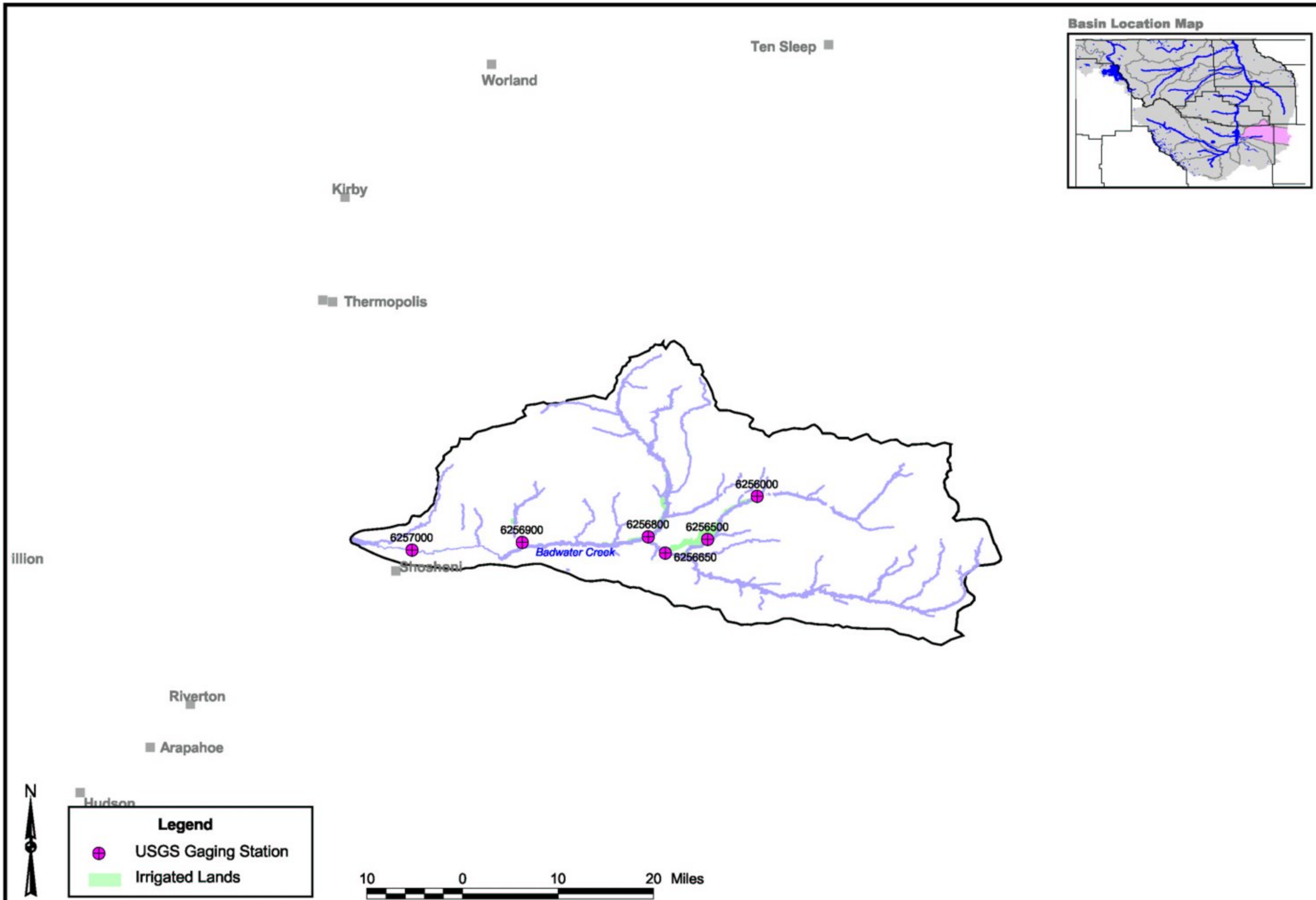

Figure 2.7
Badwater Sub-Basin

October, 2002

Wyoming Water Development Commission

Wind/Bighorn Basin Advisory Group

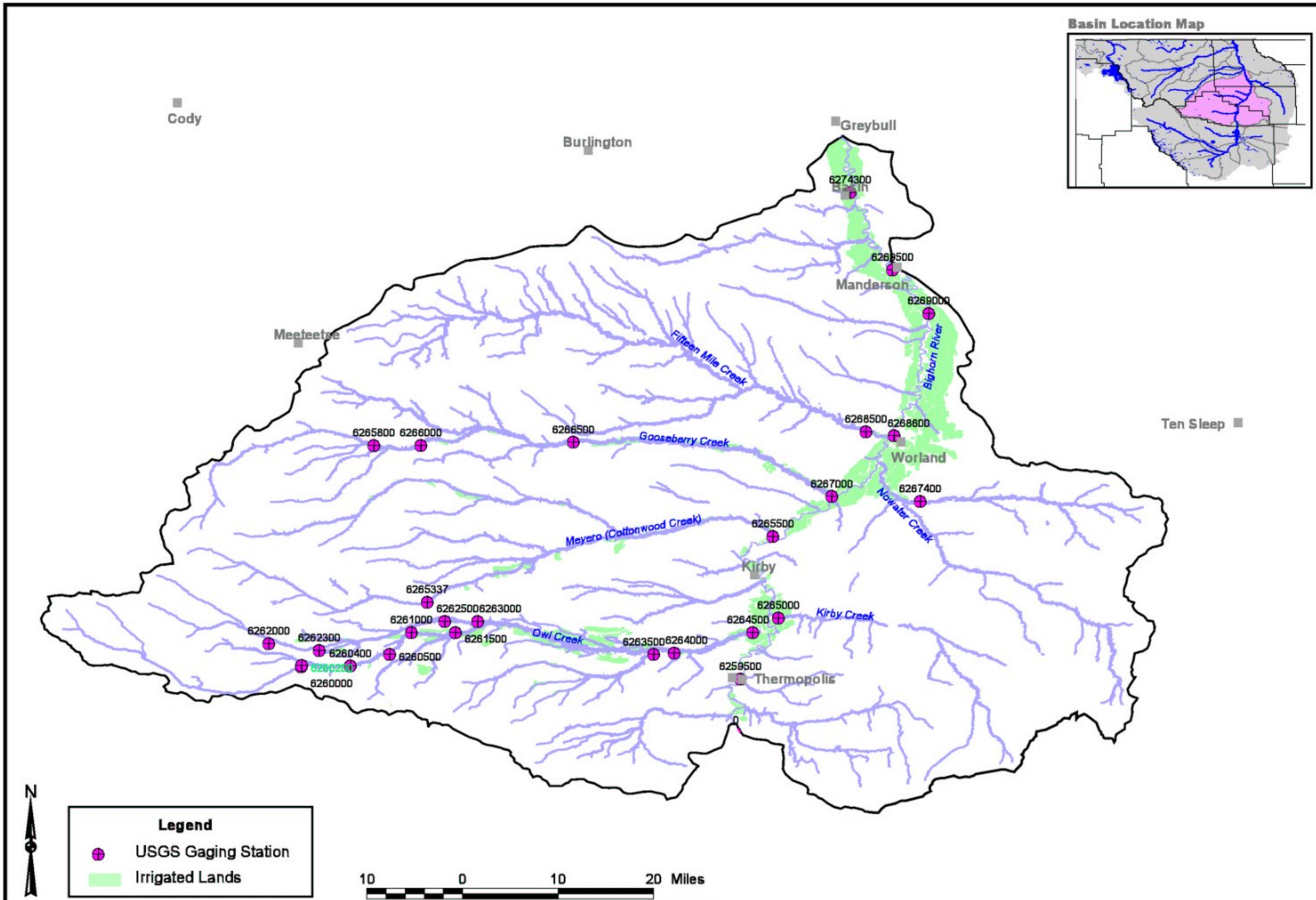

Figure 2.8
Upper Bighorn Sub-Basin

October, 2002

Wyoming Water Development Commission

Wind/Bighorn Basin Advisory Group

BRS ENGINEERING

MWH

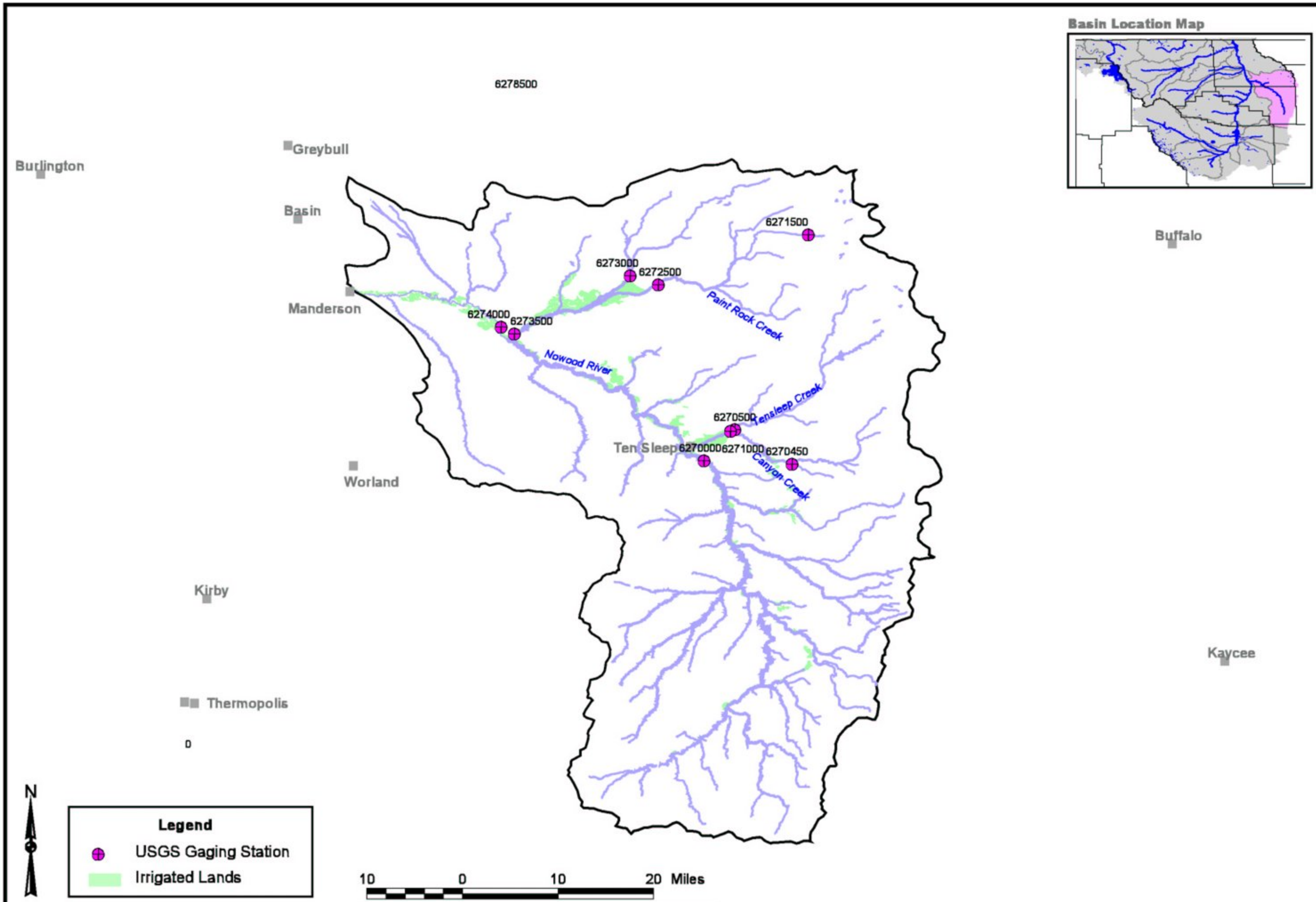

Figure 2.9 **Nowood Sub-Basin** *October, 2002*	**Wyoming Water Development Commission** **Wind/Bighorn Basin Advisory Group**	BRS ENGINEERING MWH

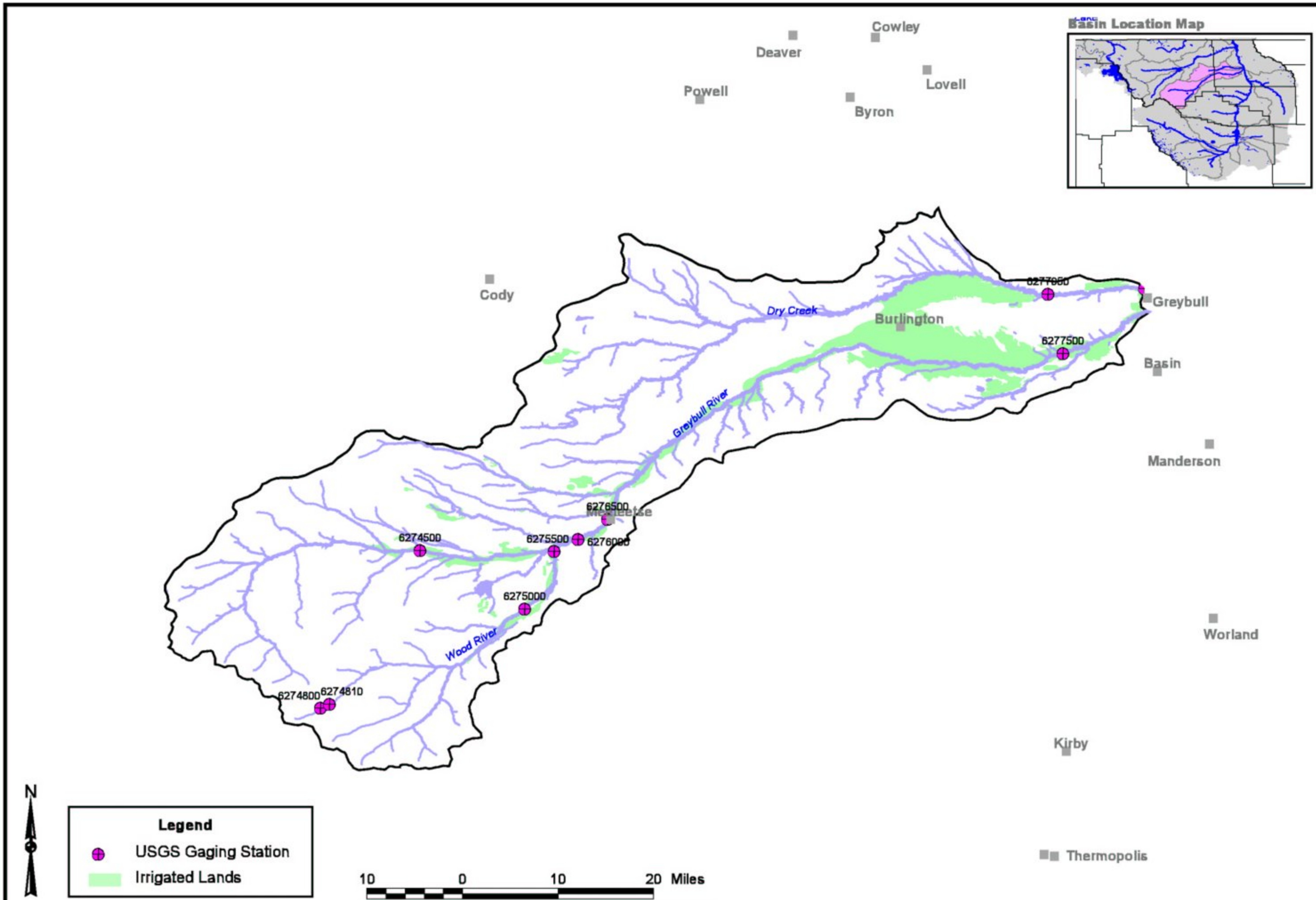

Figure 2.10
Greybull Sub-Basin

October, 2002

Wyoming Water Development Commission

Wind/Bighorn Basin Advisory Group

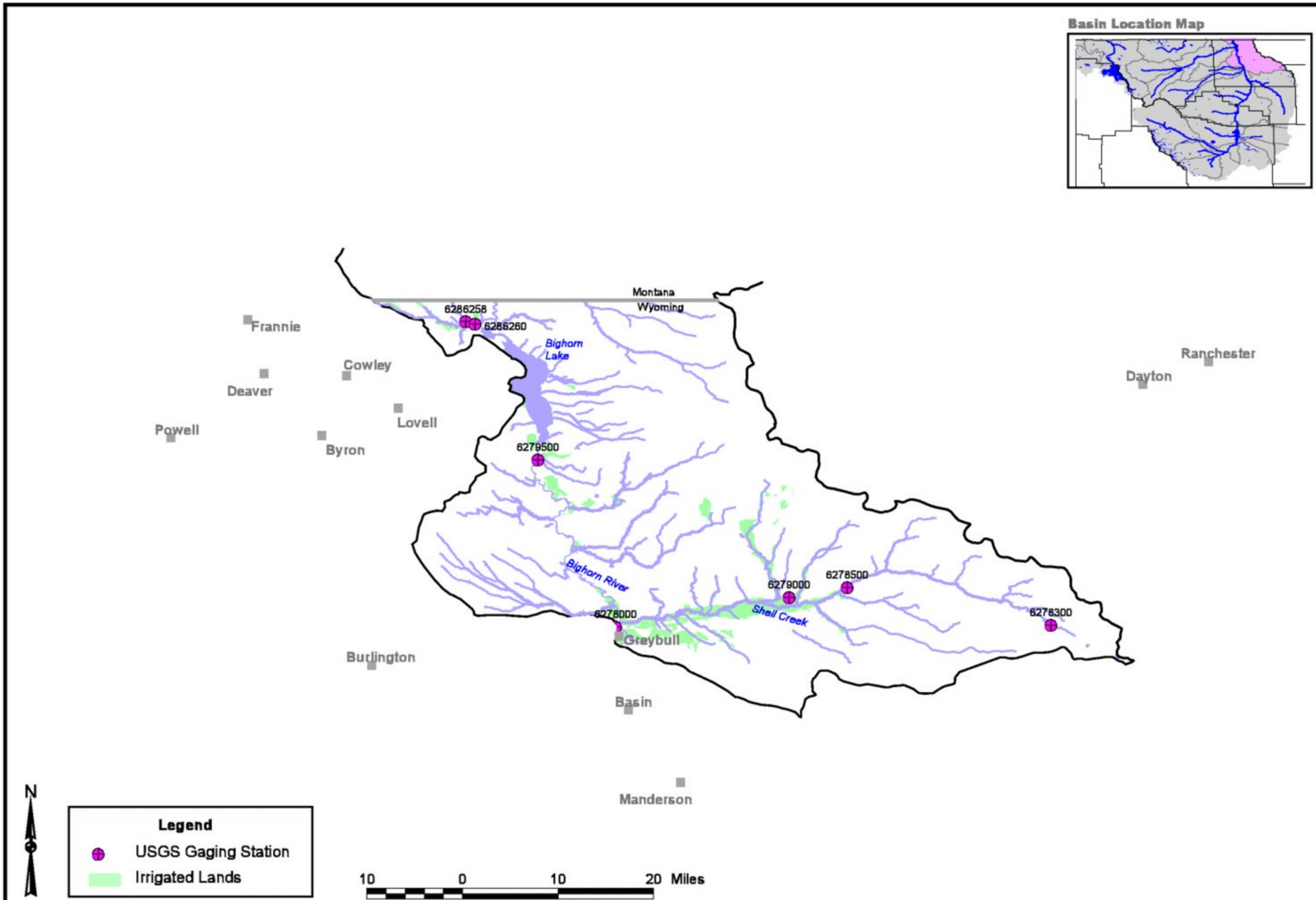

Figure 2.11
Bighorn Lake Sub-Basin

October, 2002

Wyoming Water Development Commission

Wind/Bighorn Basin Advisory Group

BRS ENGINEERING MWH

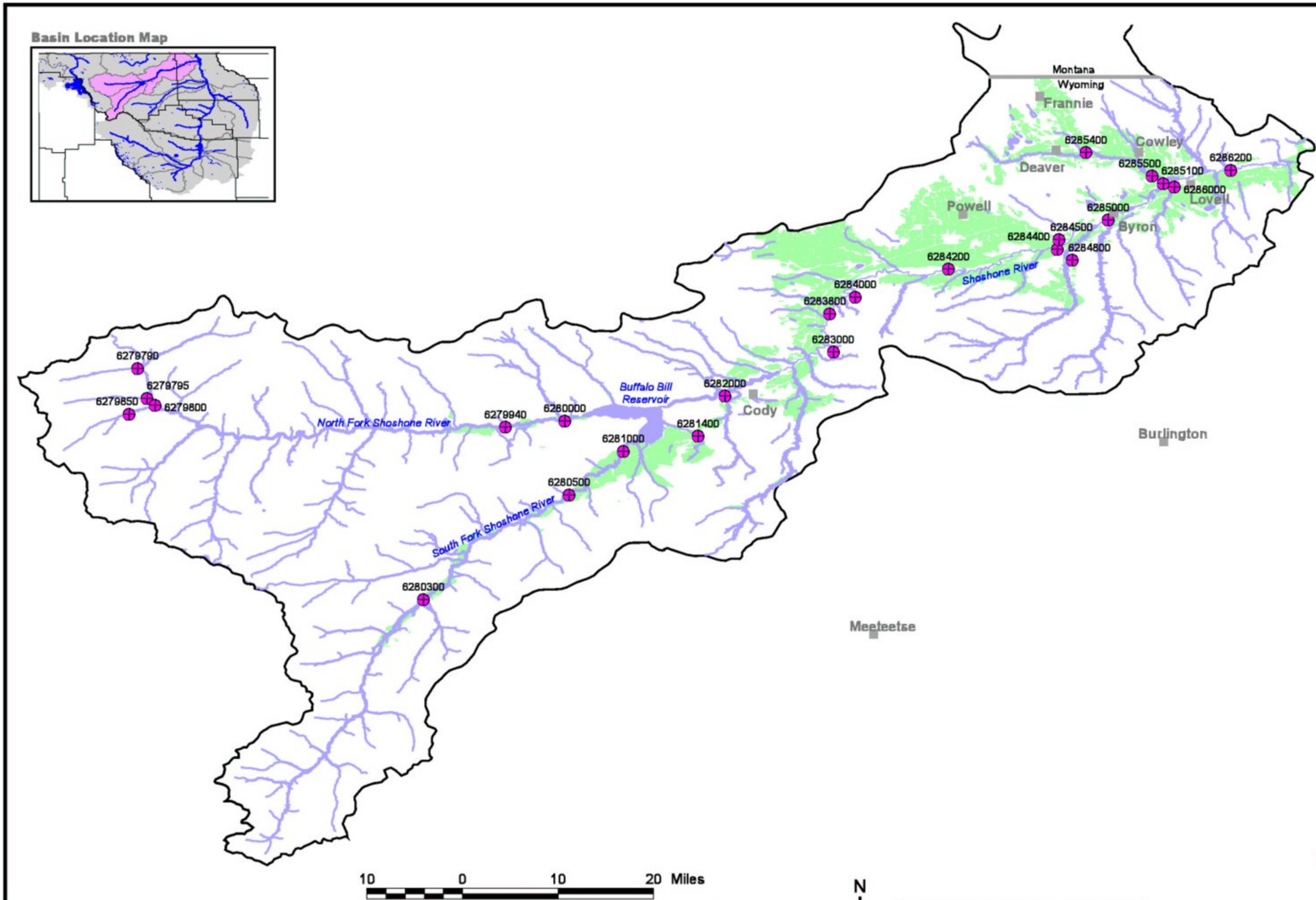

Figure 2.12
Shoshone Sub-Basin

October, 2002

Wyoming Water Development Commission

Wind/Bighorn Basin Advisory Group

BRS ENGINEERING

MWH