

Environmental and Recreational Water Use Analysis for the Green River Basin, Wyoming

Green River Basin Plan Update



Prepared for:

Wyoming Water Development Commission

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June 2018



EXECUTIVE SUMMARY

In 2010, the Wyoming Water Development Commission (WWDC) requested a study to develop more robust and consistent methods for defining environmental and recreational (E&R) water uses for the River Basin Planning program. The study outlined that recreational and environmental uses needed to be identified and mapped, in a way that would assess their interactions with traditional water uses throughout the state of Wyoming.

Harvey Economics completed the study in 2012 and produced a report and handbook (Handbook) to identify a consistent viewpoint and accounting process for E&R water demands and to help guide river basin planning efforts in moving forward. The methods developed in the Handbook were implemented on the Green River Basin (Basin), and the results of the Basin plan update are provided in this report. In addition to the Handbook guidelines, Western Ecosystems Technology, Inc. coordinated with the WWDC to further the analysis through the development of three models: 1) protection, 2) environmental, and 3) recreation.

The Basin is located in southwest and south-central Wyoming. It is bordered on the east by the continental divide including the Wind River Range in the north and northeast, the Great Divide Basin centrally, and the Sierra Madre Range in the southeast. It is bordered on the south by the Wyoming-Colorado and Wyoming-Utah state lines. The western border is defined by the Tump Range, which forms the division between the Green and Bear River Basins, and the Wyoming Range, which separates the Basin from the Greys River Basin. The far northwest of the Basin abuts the Gros Ventre Range. While the Basin includes the Great Divide Basin for the purposes of this plan, this region is a closed basin, and does not contribute any run-off to the Green River.

The Basin is comprised of 13,424,131 acres of land and 12 sub-basins. The majority of land in the Basin is managed by the Bureau of Land Management (BLM, 55.7%). Private land makes up nearly 4,000,000 acres and accounts for 27.6% of the Basin. Smaller land ownership and management includes the US Forest Service (USFS) at just under 10.0%; State Land Board makes up 460,987 acres (3.4%), Bureau of Reclamation (2.0%), Wyoming Game and Fish Commission (1.0%), and other miscellaneous landowners with less than 1% land ownership

Environmental uses are broken into state and federal environmental uses. Environmental water use in the Basin is demonstrated through permitted and protected resources and areas where environmental resources have been identified as important. State environmental uses include 43 instream flow filings, numerous Wyoming Game and Fish Department (WGFD) crucial habitat priority areas, and six designated crucial stream corridors. Other WGFD designated areas occurring across the Basin include key non-game areas, enhancement areas, and combined priority habitats. Federal environmental factors include the Seedskaadee National Wildlife Refuge (NWR), three designated wilderness areas, multiple BLM designated wilderness study areas, US Fish and Wildlife Service (USFWS) listed species (four birds, five mammals, five fish, and two plant species), critical habitat for the Canada lynx and yellow-billed cuckoo,

over 400,000 acres of National Wetlands Inventory polygons, and multiple BLM designated Areas of Critical Environmental Concern.

Recreation use in the Basin includes fishing, waterfowl hunting, boating, whitewater rafting, camping, hiking, general sightseeing (such as bird watching), and a variety of other passive and active recreation activities. Recreation activities associated with water use are fairly concentrated and often occur on land specifically identified for public access, such as USFS land, state parks, and federal refuges. Multiple reservoirs including Fontenelle, Big Sandy, Lake Viva Naughton, among others, provide recreation opportunities. The Flaming Gorge Reservoir and National Recreation Area is a major recreation destination in the Basin. Fisheries across the Basin are considered first class with miles of major river systems and mountain lakes providing access to the public.

All of the potential environmental and recreation uses identified in the report were evaluated and categorized as protected, complementary, or competing. These categories were defined based on the definition provided in the Handbook and additional discussion with the WWDC and Wyoming State Engineer's Office. A number of factors were considered to categorize the E&R uses including location in the Basin, land use and ownership and existing permits, among other factors. The location and magnitude of diversions were also evaluated to determine the use categories. Categorization of uses included specific individual E&R activities and categorizations were assigned to larger geographic areas where multiple uses may occur.

Protected E&R water uses in the Basin exist along the permitted instream flow sections. The instream flow starting at Fremont Lake provides protection for a stretch of blue ribbon fisheries classified along the downstream section of New Fork River. E&R uses are also protected in the sections of the Bridger and Gros Ventre Wilderness in the northern Basin and the small section of Huston Park Wilderness located along the eastern Little Snake sub-basin.

The E&R uses associated with Seedskaadee NWR are categorized as protected. Fontenelle Reservoir is located immediately upstream from the NWR and has permitted bypass flow requirements. The Green River segment and associated E&R uses from the NWR to Flaming Gorge can be considered complementary as no diversions currently existing along this stream section; however, no explicit protection is provided to this river segment. Other current E&R uses can be considered complementary due to their location in the Basins. All E&R uses above existing diversions can be considered complementary; however, these segments will be protected until future water diversions or management activities are permitted.

Competing recreational uses can be categorized around the large recreation reservoirs across the Basin. Due to the reliance of access (e.g., boat ramps, camp sites, etc.) to maintain specific recreation uses, these items are competing. It is not uncommon for heavy early season runoff entering the reservoirs and low-level early season release to flood the reservoirs, inhibiting recreation opportunities. This results in a competing situation. Similarly, depending on annual climate, late-season conditions may draw reservoirs down to a level where recreation becomes difficult. Major reservoirs including Fontenelle, Flaming Gorge, Big Sandy, Eden, Viva

Naughton, among other smaller reservoirs across the Basin, fall into the competing categorization.

All other E&R water uses across the Basin are assumed to be complementary. This is based on the assumption that current water conditions will continue in a similar regime to historic water use. A number of large permitted diversions with senior water rights exist throughout the Basin and require water to be maintained in the stream, thereby supporting E&R uses, specifically wetlands, potential USFWS listed species habitats, and WGFD priority and crucial areas. Similarly, while small in magnitude, the thousands of diversions that exist along the Basin's water resources cumulatively support E&R uses throughout the Basin, as water will remain in the system to complement the E&R activities. These small and large diversions have the ability to affect E&R uses at a localized scale if modifications were to occur.

The protection model demonstrates a range of protection scores across the Basin. In most cases, greater protection was assigned to areas higher in the watershed. These areas typically have institutional protection associated with USFS and wilderness areas and may include critical habitats. Less protection was evident along many of the larger-order streams. These areas typically have more private land ownership and less institutional regulations. These areas also support agriculture (and other divertible consumptive water uses); therefore, are more subject to impacts.

The environmental model followed a similar pattern to the protection model, with more environmental uses identified higher in the Basin's watershed. At a finer scale, more variability was demonstrated in the environmental model. This was often due to BLM and WGFD priority areas. These agency designated habitats are present throughout the Basin in upper and lower sections of the watershed. In general, higher environmental scores were apparent in the northern Basin, as many environmental uses were mapped in this region. Additionally, many of the major waterbodies, such as the Green River, New Fork River, and Black's Fork, received higher scores due to multiple environmental uses designated along the features.

High recreation scores were demonstrated in the upper watersheds, specifically on USFS managed land. In general, the Basin provides a range of recreation uses, with the northern sub-basins (e.g., New Fork, Upper Green) assigned higher scores relative to other areas across the Basin. These areas are known for the fisheries and general outdoor recreation opportunities. Many of the larger waterbodies in the Basin also scored high, including the Green River, Ham's Fork, New Fork, and Blacks Fork, among others. It is important to recognize fewer factors were used to inform the recreation model. The result is land ownership has a greater impact on the overall score and less individual recreation uses being captured. Additionally, the recreation model was not set up to capture the high recreation uses commonly associated with the Basin's reservoirs. The reservoirs are common destination locations for recreation.

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REPORT REFERENCE

Martinson, L. 2018. Environmental and Recreational Water Use Analysis for the Green River Basin, Wyoming - Green River Basin Plan Update. Wyoming Water Development Commission, Cheyenne, Wyoming. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. June 2018.

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1 INTRODUCTION

In 2016, the Wyoming Water Development Commission (WWDC) contracted Western EcoSystems Technology, Inc. (WEST) to identify, categorize, and evaluate environmental and recreational (E&R) water uses within the Green River Basin (Basin) in Wyoming. Environmental water demand is the amount of water required to support a given water-dependent ecosystem or ecosystem function, and recreational water demand is the amount of water needed to support water-based recreational activities. In most instances, these demands are non-consumptive and non-diverted, but do require that water be in place for the use to be sustained or for the activity to occur. To help identify areas with high environmental or recreation water use, WEST developed two use models; environmental and recreation. While these models do not quantify specific water demand requirements, they do provide a relative scale of E&R use throughout the Basin. WEST also developed a third model to identify levels of protection for water uses across the Basin. This report provides results of the E&R use analysis, including water use identification, mapping, categorization, and assimilation.

In the late 1990's the WWDC began implementing its current basin planning framework which seeks to identify and describe existing water demands and supplies within each river basin, as well as potential future water development opportunities. Under this framework a river basin plan has been developed for each of Wyoming's seven basins. The most recent *Green River Basin Plan Update* was the 2010 update (WWC Engineering et al. 2010). Early versions that included E&R information were prepared in 2009 (ERO Resources Corporation 2009a, 2009b). The goal of each basin plan is to estimate current water demand and project future water demands by type of use. The WWDC recognizes five unique categories of use:

1. Agricultural
2. Municipal and Rural Domestic
3. Industrial
4. Environmental
5. Recreational

Of the five water use categories, E&R water uses are the only categories that are almost exclusively non-consumptive in nature, so traditional methods for quantifying them do not apply. Thus, many of the E&R water uses identified in each basin plan are discussed solely in qualitative terms, which have resulted in inconsistencies in how E&R water uses are addressed across basin plans. Originally, E&R uses were mostly described without regard for how they interact with traditional uses; instead each use was summarized in terms of their overall impact on the water resources of the Basin.

To develop a more consistent approach that provides a more detailed assessment of the interaction between traditional and non-consumptive uses, the WWDC obtained funding from the 2010 Legislature for an Environmental and Recreation Water Use Study to develop a procedure that could be applied in all the basins. Harvey Economics (HE) was contracted to

complete the study, and in 2012, HE published a new set of procedures to address E&R water uses in *The Environmental and Recreational Use Handbook* (Handbook; Harvey Economics 2012). This analysis adheres to the procedures outlined in the Handbook, which are described in the methods sections, and furthers the evaluation through the development of use and protection models.

2 STUDY AREA - GREEN RIVER BASIN

The follow study area description is taken from the 2010 Green River Basin Plan Update.

The Basin covers nearly 25,000 square miles of land in southwest and south-central Wyoming (Figure 2-1). It is bordered on the east by the continental divide including the Wind River Range in the north and northeast, the Great Divide Basin centrally, and the Sierra Madre Range in the southeast. It is bordered on the south by the Wyoming-Colorado and Wyoming-Utah state lines. The western border is defined by the Tump Range, which forms the division between the Green and Bear River Basins, and the Wyoming Range, which separates the Basin from the Greys River Basin. The far northwest of the Basin abuts the Gros Ventre Range. While the Basin includes the Great Divide Basin for the purposes of this plan, this region is a closed basin, and does not contribute any run-off to the Green River.

The Basin generally slopes to the south, toward the Utah border, and elevations are mostly between 6,000 and 7,000 feet above sea level (asl); however, the mountain peaks that make up the Basin border commonly exceed 10,000 feet in the northern portion of the basin. At 13,804 feet asl, Gannet Peak, in the Wind River range, is the highest point in the Basin. The lowest point in the Basin in Wyoming is 6,040 feet asl, and it occurs along the Green River where it passes into Utah at Flaming Gorge Reservoir.

2.1 Unique Characteristics

The Green River in Wyoming is the largest tributary to the Colorado River, which is one of the most regulated and managed rivers in the world, as a result of a series of major dams that were constructed in the 20th century. A legal framework known as the “Law of the River” regulates dam operation and water distribution of Colorado River water in the seven states that make up the Colorado River drainage. The Colorado River and its tributaries are already over-appropriated, and the problem is compounded by growing water demands, as well as increasingly frequent and severe water shortages. In addition to consumptive demands for Colorado River water, federal regulations, like the Endangered Species Act, have created restraints and requirements that are equivalent to increased consumptive demands for environmental flows. As a result, Wyoming's ability to develop and consumptively use water in the Basin is constrained by two interstate compacts, the Colorado River Compact and the Upper Colorado River Basin Compact.

The most notable of the water features in the Basin is the Flaming Gorge Reservoir along the Green River as it passes into Utah, and which is formed by the Flaming Gorge dam in the state of Utah (Figure 2-1). Other major bodies of water in the central and eastern part of the Basin include the Green River Lakes, New Fork Lake, Willow Lake, Fremont Lake, Half Moon Lake,

Burnt Lake, Boulder Lake, Big Sandy Reservoir, Eden Valley Reservoir, and Fontenelle Reservoir, in addition to numerous high mountain lakes in the Wind River Range (Figure 2-2). In the western part of the Basin are Lake Viva Naughton and Kemmerer No. 1 Reservoirs. To the south, Meeks Cabin and Stateline Reservoirs serve various Wyoming users, although Stateline is located entirely in Utah (Figure 2-2).

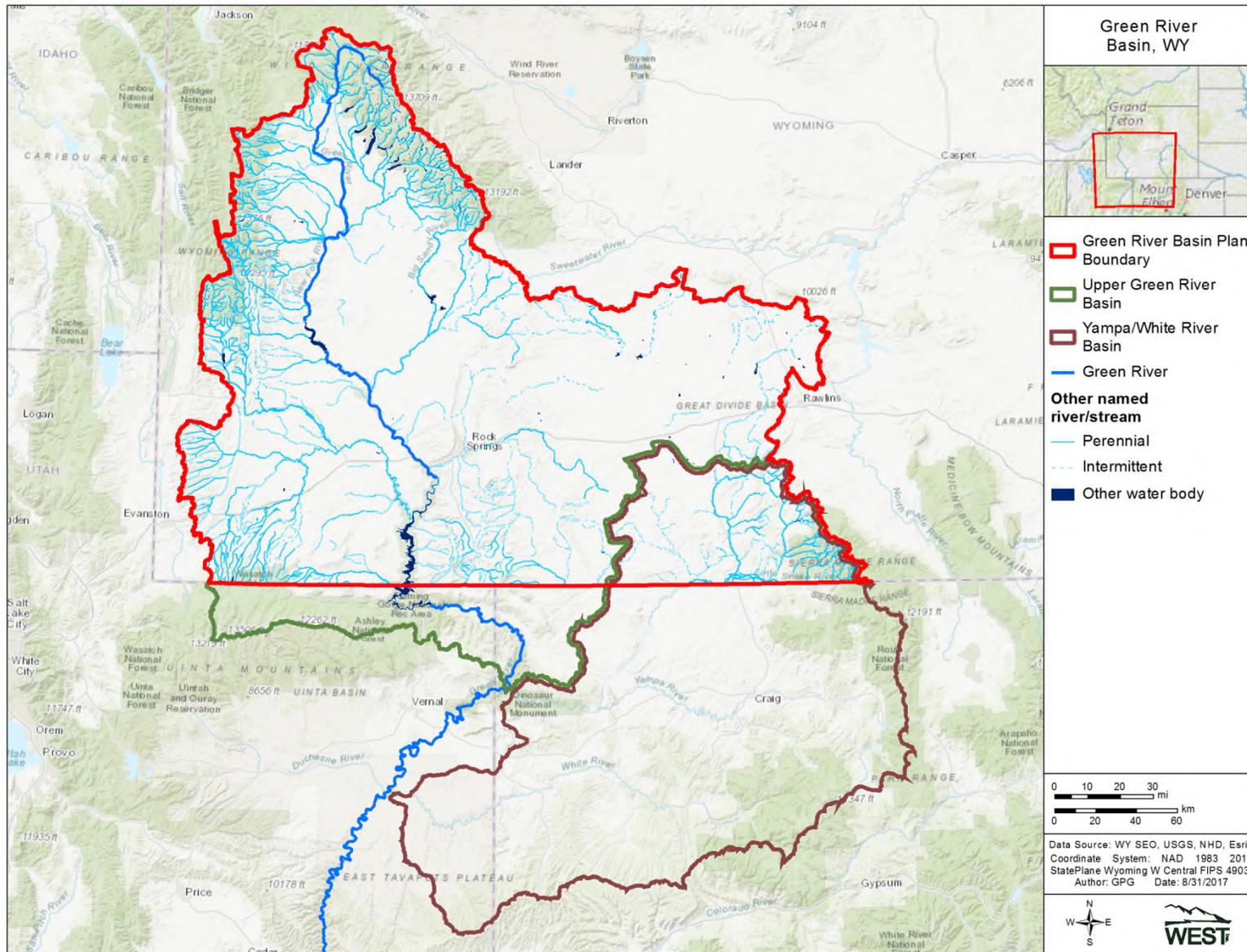


Figure 2-1. Overview of the entire Green River Basin in Wyoming, Utah, and Colorado.

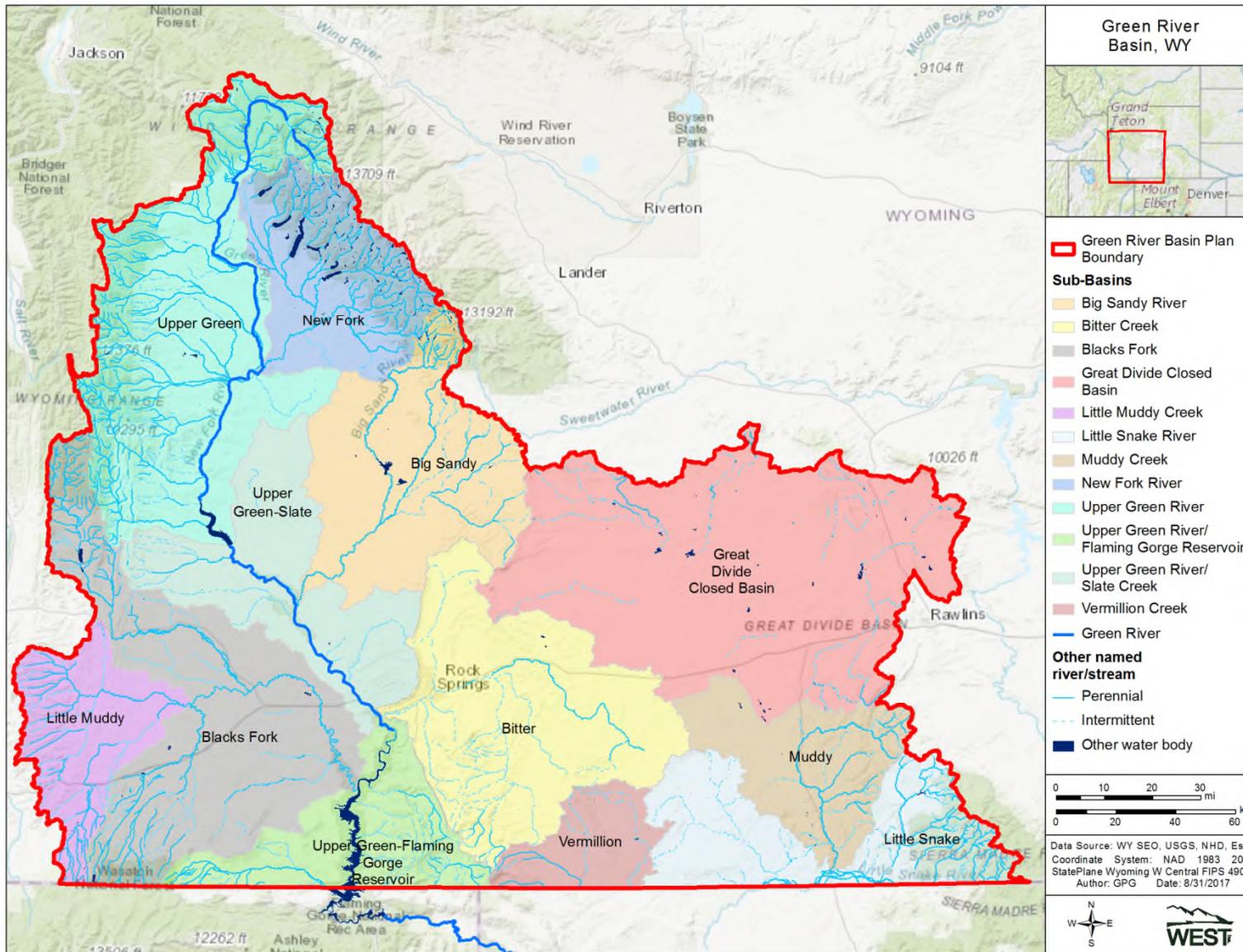


Figure 2-2. Overview of the Green River Basin and sub-basins in Wyoming.

3 METHODS

The Handbook describes the following five steps to address E&R water uses in the Basin:

- 1) **Identify E&R water uses in the Basin:** WEST gathered the Geographic information system (GIS) data recommended in the Handbook and additional data to support the E&R use descriptions, as well as data for other E&R water uses included in the original Basin Plan and the 2010 update (Table 3-1).
- 2) **Map E&R water uses in the Basin:** WEST used the GIS data identified in the previous step to create maps depicting the land ownership, environmental water uses, and recreational water uses across the Basin. These maps were used to identify where specific E&R uses were occurring within the Basin.
- 3) **Locate divertible non-E&R water uses in the Basin:** WEST mapped existing non-E&R consumptive water uses in the Basin by diversion location and magnitude using GIS data obtained from the WWDC and previous basin plans.
- 4) **Categorize non-consumptive E&R water uses in the Basin:** WEST used the land ownership, E&R water use, and non-E&R water diversion maps to categorize each E&R water use as “protected”, “complementary”, or “competing” based on their proximity downstream to non-E&R water diversions and their location in the watershed. These categories are defined in the Handbook and are described below.
- 5) **Assimilate the results of the E&R water use analysis into Basin Plan:** WEST evaluated all of the information collected and developed three models. This information was used to discuss and inform future water planning relative to the Basin’s E&R uses.

Table 3-1. Geographic information system data sources for environmental and recreational mapping in the Green River Basin.

Name	Source
Basin borders	WWDC
Hydrologic Unit Codes	USGS
Waters and reservoirs – National Hydrology Dataset	USGS
Land ownership	USGS
Instream Flows	WWDO, SEO, WGF
Crucial Habitat Priority Areas - Aquatic	WGFD
Crucial Habitat Priority Areas - Combined	WGFD
Enhancement Habitat Priority Areas	WGFD
Crucial Streams Corridors	WGFD
Wildlife Habitat Management Areas	WGFD
Key Nongame Wildlife Areas	WGFD
Wild and Scenic Rivers	WyGIS
Wilderness Areas	WyGIS

Table 3-1. Geographic information system data sources for environmental and recreational mapping in the Green River Basin.

Name	Source
Threatened, Endangered, Candidate, and Sensitive Species	USFWS – Information for Planning and Consultation (IPaC) database
USFWS Critical Habitat	USFWS
National Wetlands Inventory	USFWS
BLM Areas of Critical Environmental Concern	BLM
WGFD Stream Classifications	WGFD
National Parks	USGS
US Forest Service	USGS
State Parks ²	WYO Parks
National Recreation Areas	USGS
Fishing Spots	WyGISC
Model Demand Nodes	WWDO (2003 Basin Plan-GIS products)
National Wildlife Refuges	USFWS
Whitewater Rafting Stream Segments	American Whitewater
Golf course locations	WyGISC
Ski resort locations	WyGISC
Lakes	WSGS
Partners for Fish and Wildlife Program ¹	USFWS
Reservoir Storage	SEO

¹Partners for Fish & Wildlife 2017

²WYO Parks 2017

BLM=Bureau of Land Management; SEO=Wyoming State Engineer's Office; USFWS=US Fish and Wildlife Service; USGS=US Geological Survey; WDEQ=Wyoming Department of Environmental Quality; WGFD=Wyoming Game and Fish Department; WSGS=Wyoming State Geological Survey; WWDO=Wyoming Water Development Office; WyGISC=Wyoming Geographic Information Science Center.

3.1 Identification of E&R Water Uses

WEST searched a variety of publically available resources for data identifying specific recreational and environmental uses in the Basin. Initially, WEST used the Handbook and previous Basin plan to identify specific primary and secondary sources. Beyond previously identified and reported sources, WEST concentrated on publically available data sets from state and federal agencies (primarily web-based). Where possible, the data sets previously developed by the Wyoming Water Development Office (WWDO; <http://waterplan.state.wy.us/>) were used. An emphasis was put on state and federal resources, as these are typically referenced when evaluating potential project impacts. WEST contacted agency staff as appropriate to gather and interpret additional datasets.

3.2 Mapping of E&R Water Uses

WEST used ArcGIS to plot the identified E&R across the Basin and sub-basins. Prior to plotting information, the data were sorted between E&R uses and state and federal environmental uses.

Additionally, any dataset not linked to water resources was removed or specifically identified. Datasets that were difficult to represent or not visible at reasonable scales were not plotted. These data were stored in GIS and in some cases used in the model development. In addition to plotting data for visual representation, GIS data were sorted and stored in an ArcGIS geodatabase for ease of use and sharing on future projects.

3.3 Separating Consumptive Uses

The next step in estimating non-consumptive E&R water demands was to separate consumptive E&R water demands from non-consumptive uses. In other words, if a diversion exists for a golf course, those uses were identified in specific terms and aggregated as sub-elements of other uses. For example, golf course diversions may be classified as agricultural, municipal or recreational water by the Wyoming State Engineer's Office (SEO), and should be included in the divertible demands for the appropriate category. Divertible water uses with specific beneficial purposes that have received a water right in the state of Wyoming were treated in the same way as traditional water uses. Existing uses, as well as projected future uses for these diversions were identified and estimated in the Basin planning process. Due to the non-consumptive nature of E&R uses, this task was fairly brief.

3.4 Non-Consumptive E&R Water Use Categories

The Handbook recommended that non-consumptive E&R water uses be categorized so that they can be more easily compared to traditional uses. The majority of E&R water uses are non-consumptive, because they usually occur in the stream channel and therefore, benefit from water being left in the channel whereas traditional uses divert water from the channel for consumption. WEST used the existing Basin Plan update and supporting technical memorandums to identify diversion locations and magnitudes. The location and magnitude of diversions were used to support the categorization of E&R uses. The Handbook proposed that E&R water uses be classified as "protected" from traditional water uses that dewater the channel, "complementary" with consumptive water uses without explicit protection, or "competing" with consumptive water uses. The Handbook provides the following descriptions for each of these categories:

Protected – Protected E&R water uses are both recognized and protected in some way from incursions by traditional water uses. The obvious example is an instream flow water right. However, protected wetlands, protected bypass flows, or any environmental water uses protected by federal agencies through permit or water right fall into the protected category. In addition, protected water uses may have a senior traditional water use diverter in a location which ensures the continuation of that non-divertible use.

Example: If the most senior water right downstream is larger than or equal to the recreational or environmental water use immediately above that senior water diversion in the stream system, that recreational water use is protected and should be recognized as such in the Basin planning process.

Complementary – Complementary E&R water uses exist without explicit protection, but exist and will continue to exist typically by their location or linkage with a traditional water use. For instance, environmental water uses are often located at the highest reaches within a watershed, and intervening uses are very unlikely to occur. Environmental water uses which occur at high elevations or in a forest high in the watershed are unlikely to be disturbed by water users below. Without future intervening water uses, those complementary water uses are likely to continue and should be recognized as such in the river basin planning process.

Another example or sub-category of complementary water use stems from the incidental linkage of certain environmental or recreation water uses to traditional uses. For example, fisheries and spawning habitat may be supported by subsurface irrigation return flows, which would be lost if irrigation stops or the method is changed. These incidentally linked water uses are without explicit protection and will expand or contract with the linked traditional use.

Competing – Competing E&R water uses are located in areas where other traditional water use diversions may constrain or eliminate the environmental or recreational use at any point in time. These water uses are incidental and subject to elimination. These uses should also be recognized in the Basin planning process, but with the explicit understanding that such water uses can and will disappear when future appropriators step forward.

WEST concluded that the three non-consumptive E&R water use categories represent different points on a spectrum of stream protection. For example, blue ribbon stream segments that occur high up in a watershed in a designated wilderness area are afforded nearly the same level of protection as a stream segment with a permitted instream flow water right located on a higher order stream lower down in the watershed. However, using the E&R water use categories defined by the Handbook, the former stream segment would be classified as “complementary”, while the latter stream segment would be classified as “protected”. Furthermore, non-consumptive water uses in direct competition with traditional consumptive water uses could be considered to have little or no protection. Due to the potential difficulties categorizing individual E&R uses, WEST applied a general approach to categorize uses across large segments of the Basin, but looked to further the evaluation by assigning relative scales of protection. Building on this notion and work completed for the Snake and Salt River Plan (Wyoming Water Development Office 2013), WEST developed models to identify and categorize areas with varying degrees of environmental or recreational value within the Basin, as well as areas with varying degrees of protection for non-consumptive E&R water uses.

3.5 Model Development

The evaluation areas for the models followed the methods identified in the Snake and Salt River Plan where NHD data were used to identify stream corridors and these corridors were buffered by 0.25 miles. After the evaluation areas were identified, the E&R water use models were created by combining a series of GIS data layers into a single map, where objects in each of the data layers were assigned different values based on their environmental or recreational significance. For example, the WGFD stream classification GIS data layer includes different classes of spatial data for blue ribbon streams, red ribbon streams, yellow ribbon streams, and

so on. Because blue ribbon streams are the most productive streams, they are considered to have the highest recreational value and were accordingly assigned a higher numerical value than red ribbon streams, yellow ribbon streams, and so on. Similar values were assigned to other recreational features such as designated whitewater stream segments, state parks, public access areas, etc. All of these GIS data layers were then combined into a single raster map. Where two or more GIS data layers overlapped, the assigned numerical values for recreational features in each layer were added together for that raster point. The result was a raster map populated with a range of spatially distributed numerical values. These values were then classified as high, moderate-high, moderate-low, or low value using a defined range of values for each class, and then overlaid on a map of the Basin.

A third model was developed to identify areas that were afforded varying degrees of protection using the same method described above. The protection model evaluated the institutional protection afforded to waters throughout the Basin based on land management, land ownership, and other regulatory protections.

3.6 Assimilation of E&R Water Use Data into Basin Plans

The last step recommended by the Handbook is interpreting the E&R uses in an overall basin plan. To complete this task, the E&R models in combination with the E&R use maps were compared to the protection models to identify areas of high value that may not be afforded the appropriate level of protection. These results were summarized in this report to inform WWDC where these “at risk” areas occur, so they can be taken into account in future water development planning. Additionally, WEST reviewed the updated Basin Plan to identify if water shortages or excesses exist in the Basin or are assumed to occur in the future, and then evaluate how this situation may affect E&R uses.

4 SECTION ORGANIZATION AND MAPS

The Basin was divided into three regions (north, west, and east) and 12 sub-basins to help convey information in a more meaningful manner (see list below). Sub-basins were delineated according to the US Geological Survey Hydrologic Unit Code 4 classification (Figure 2-2). Descriptions and information presented in this report were broken down by region and/or sub-basin where appropriate. The main report body includes figures by region and is used to display E&R uses across larger areas of the Basin. Figures broken down by sub-basin are included in the Appendices and are used to demonstrate more detailed information for the model results.

1. Upper Green
2. New Fork
3. Upper Green-Slate
4. Big Sandy
5. Blacks Fork
6. Bitter
7. Great Divide Closed Basin
8. Muddy

9. Little Muddy
10. Upper Green-Flaming Gorge Reservoir
11. Vermillion
12. Little Snake

To maintain a consistent terminology throughout this report, the following terms will be used when referring to the areas or resources of study:

- Study Area or Basin: Refers to the all the sub-basins together, including the complete Basin within Wyoming.
- Sub-basin: Will be used to describe any of the smaller contributing drainages or partial basins that make up the Basin (Figure 2-2)
- Waters: Is used in reference to individual streams or reservoirs. In some instances, it may refer to all stream or reservoir features in the Basin or sub-basin.

A map was created for each of the regions that displays all gathered data for: 1) land ownership, 2) state – environmental uses, 3) federal – environmental uses, 4) recreational uses, and 5) diversions. These maps provide a landscape-level view of the specific use categories and demonstrate the wide-range of uses across the Basin. Additionally, more targeted sub-basin maps were created to depict the three model results and are included in the Appendices. These maps were determined to be important for depicting water uses related to E&R in the study area. Each of these maps is discussed in more detail in the model section 8.3. In most cases, the E&R information was available for the entire Basin (or state) and was therefore presented for the entire river basin. Exceptions are specifically noted.

5 RESULTS

5.1 Green River Basin Overview

These sections discuss the land ownership, environmental water use, and recreational water use identified throughout the Basin. Each of the sections is outlined in a manner generally consistent with the Handbook. The goal of this section is to identify the use factors that are supported by water across the Basin. This foundation supports subsequent categorization and model development.

5.2 Land Ownership

The Basin is comprised of 13,422,058 acres (ac) of land across 12 sub-basins (Table 5-1, Figures 5-1 through 5-3). The majority of land in the Basin is managed by Bureau of Land Management (BLM, 56.4%) and spread throughout the Basin as large blocks and checkerboard patterns. Private land makes up nearly 3,500,000 acres (ac) and accounts for 26.1% of the Basin. Private land is checkerboard in the west and east sections of the Basin with larger contiguous blocks in the northern Basin. Smaller land ownership and management includes the

US Forest Service (USFS) at 10.3%. USFS land is located in the far southeast Basin, along the north Basin limits, and around Flaming Gorge Reservoir. Scattered sections of Wyoming State Trust land exist throughout the Basin and make up 463,985 acres (3.5%). Other smaller land ownership includes Bureau of Reclamation (BOR; 2.0%), Wyoming Game and Fish Commission (1.0%), and other landowners with less than 1% land ownership.

While the USGS PAD-US dataset is considered the most accurate, comprehensive dataset of land protection designations within the United States, its methods of compilation (from a variety of data sources as well as its representation of jointly owned or managed areas) results in some land area that is overlapped by two or more different ownership polygons. To account for this double-counting, a sum of the overlap acres was calculated for each basin and was removed from the total acreages in Table 5.1.

Table 5-1. Land ownership acreage and percentage breakdown in the Green River Basin and sub-basins.

Basins & Sub-Basins	Bureau of Land Management		Private Landowner		US Forest Service		State Trust Land		Bureau of Reclamation	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Green River Basin	7,570,682	56.4	3,498,848	26.1	1,377,148	10.3	463,985	3.5	271,231	2.0
Big Sandy	903,798	78.7	57,516	5.0	62,811	5.5	52,956	4.6	70,421	6.1
Bitter	759,174	53.2	625,052	43.8	0	0	40,991	2.9	0	0
Blacks Fork	756,013	47.2	668,739	41.7	120,094	7.5	46,629	2.9	9,850	0.6
Great Divide Closed Basin	1,684,586	68.5	613,704	25.0	0	0	71,280	2.9	0	0
Little Muddy	237,456	38.8	350,159	57.2	1	0	24,639	4.0	0	0
Little Snake	473,176	54.9	164,879	19.1	165,593	19.2	49,726	5.8	0	0
Muddy	439,952	68.3	147,053	22.8	0	0	25,747	4.0	0	0
New Fork	222,694	27.8	164,145	20.5	360,916	45.0	30,259	3.8	0	0
Upper Green	781,281	41.5	385,064	20.5	579,534	30.8	64,211	3.4	16,114	0.9
Upper Green-Flaming Gorge Reservoir	436,285	64.3	82,015	12.1	88,200	13.0	32,654	4.8	38,145	5.6
Upper Green-Slate	589,716	60.9	207,316	21.4	0	0	8,969	0.9	136,699	14.1
Vermillion	286,550	85.4	33,198	9.9	0	0	15,924	4.7	0	0

Table 5-1 (continued). Land ownership acreage and percentage breakdown in the Green River Basin and sub-basins.

Basins & Sub-Basins	City Land		County Land		Easement		Other State Land		State DNR		The Nature Conservancy	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Green River Basin	1,667	0	1,558	0	76,094	0.6%	6	0	12	0%	2	0
Big Sandy	0	0	18	0	0	0	0	0	0	0%	0	0
Bitter	582	0	737	0.1	0	0	6	0	0	0%	0	0
Blacks Fork	52	0	109	0	920	0.1	0	0	0	0%	0	0
Great Divide												
Closed Basin	37	0	0	0	0	0	0	0	0	0%	0	0
Little Muddy	0	0	1	0	0	0	0	0	0	0%	0	0
Little Snake	16	0	0	0	2,598	0.3	0	0	0	0%	0	0
Muddy	40	0	0	0	0	0	0	0	0	0%	0	0
New Fork	110	0	70	0	15,894	2.0	0	0	0	0%	0	0
Upper Green	32	0	0	0	56,682	3.0	0	0	0	0%	2	0
Upper Green-Flaming Gorge Reservoir	730	0.1	517	0.1	0	0	0	0	12	0%	0	0
Upper Green-Slate	68	0	107	0	0	0	0	0	0	0%	0	0
Vermillion	0	0	0	0	0	0	0	0	0	0%	0	0

Table 5-1 (continued). Land ownership acreage and percentage breakdown in the Green River Basin and sub-basins.

Basins & Sub-Basins	American Indian Lands		Wyoming Game and Fish		US Fish and Wildlife Service		State Park & Recreation		Overlapping Claims	Total ^{ab}
			Acres	%	Acres	%	Acres	%	Acres	
Green River Basin	134	0	134,655	1.0	25,987	0.2	49	0	139,105	13,422,058
Big Sandy	0	0	0	0	222	0	2	0	610	1,147,745
Bitter	0	0	0	0	0	0	1	0	8,549	1,426,543
Blacks Fork	0	0	0	0	0	0	42	0	41,754	1,602,449
Great Divide Closed Basin	0	0	88,483	3.6	0	0	0	0	0	2,458,090
Little Muddy	0	0	0	0	0	0	1	0	4,377	612,258
Little Snake	0	0	6,359	0.7	0	0	0	0	23,088	862,347
Muddy	0	0	31,555	4.9	0	0	0	0	315	644,347
New Fork	134	0	8,259	1.0	0	0	0	0	3,114	802,480
Upper Green	0	0	0	0	0	0	4	0	41,490	1,882,926
Upper Green-Flaming Gorge Reservoir	0	0	0	0	0	0	0	0	6,791	678,558
Upper Green-Slate	0	0	0	0	25,764	2.7	0	0	90	968,641
Vermillion	0	0	0	0	0	0	0	0	8,927	335,672

^aDue to the size of the table and small percentage of land, some owners were omitted from the table. The total acreage value is inclusive of all landowners.

^bData compilation results in overlapping claims of landownership. The overlapping claims are not included in the total acreages.

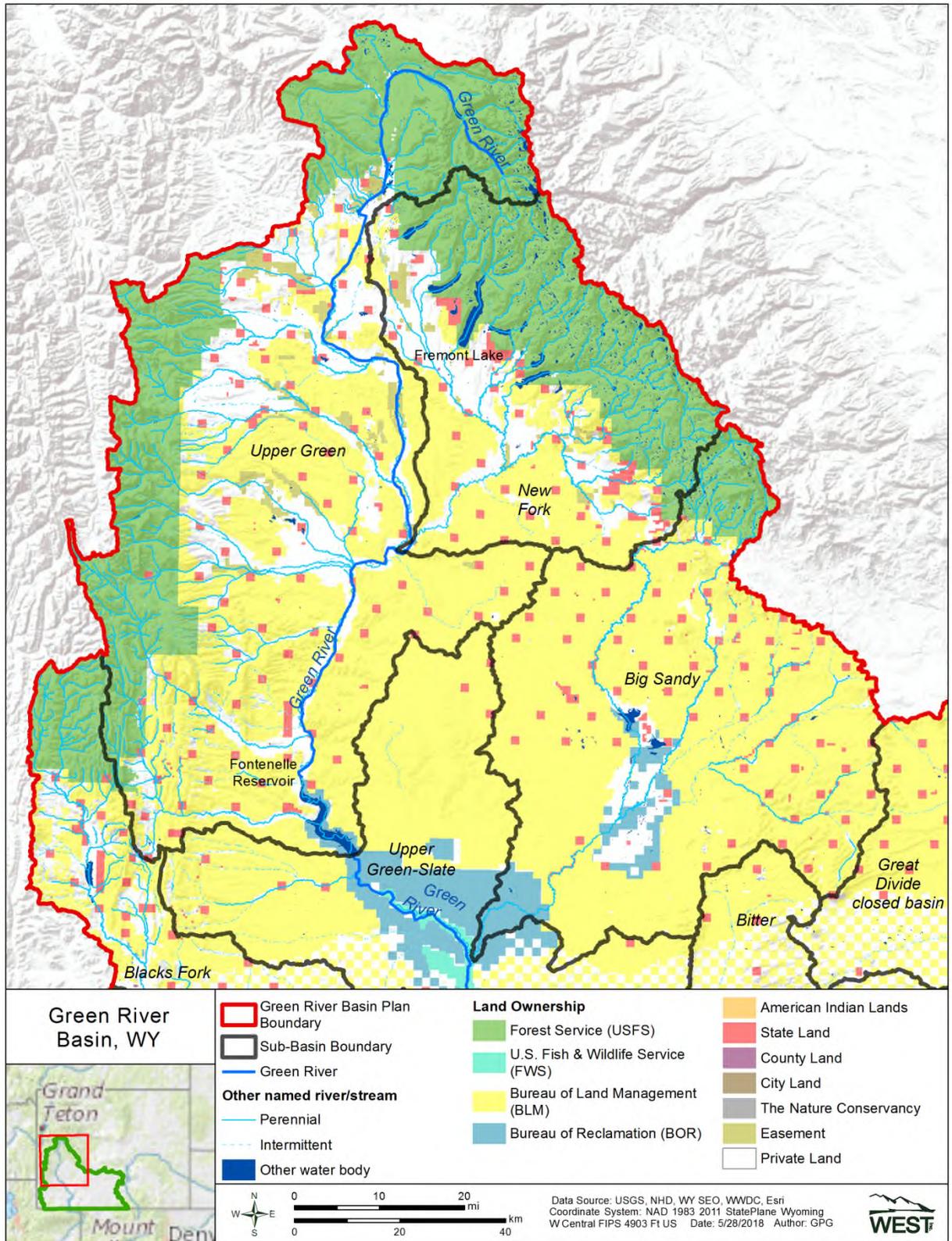


Figure 5-1. Land ownership in the Green River Basin – North Section.

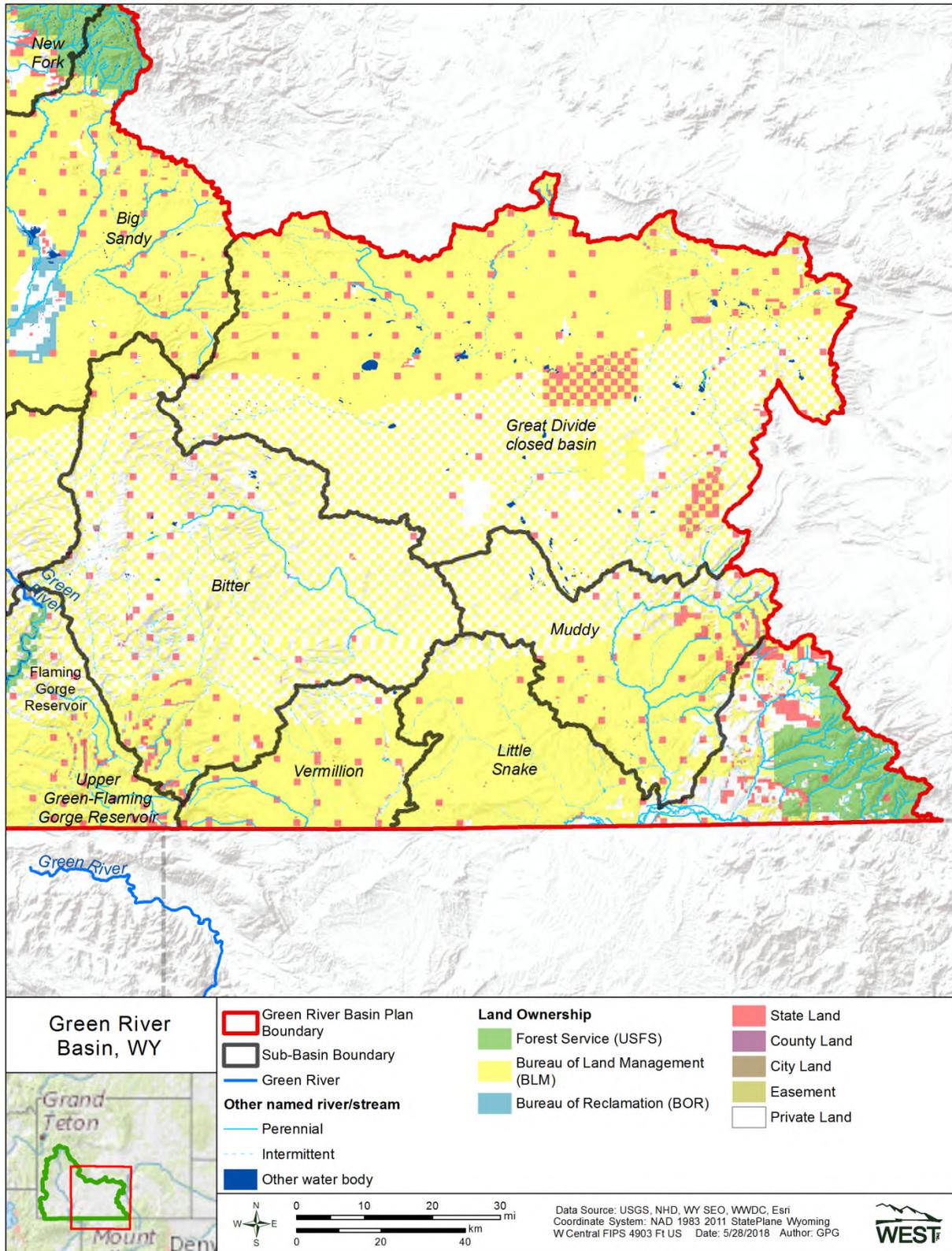


Figure 5-2. Land ownership in the Green River Basin – East Section.

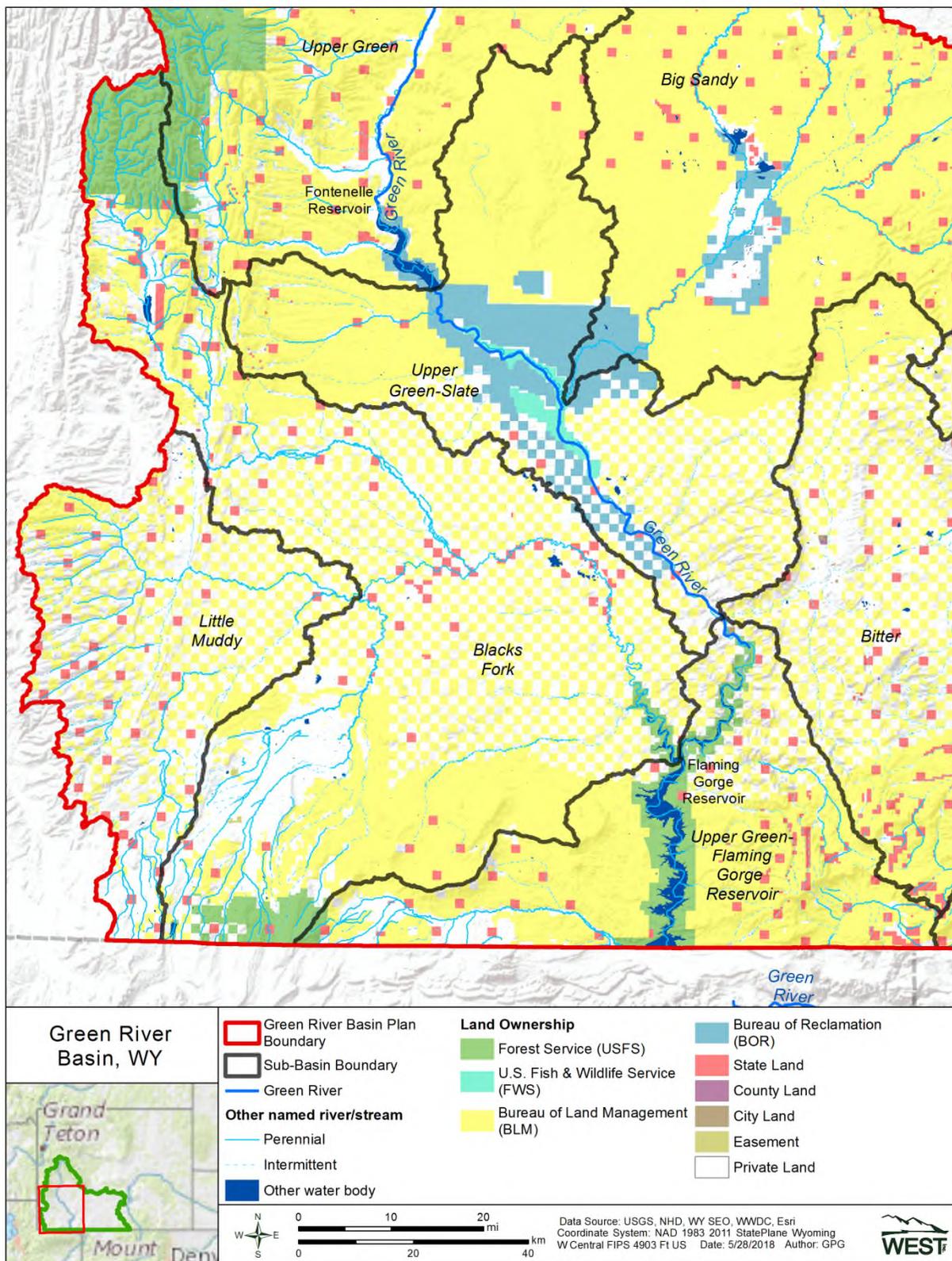


Figure 5-3. Land ownership in the Green River Basin – West Section.

Land ownership in the Basin is highly variable among sub-basins (Table 5-1, Figures 5-1 through 5-3). For example, over 80% (1,100,000 ac) of the USFS administered land in the Basin falls within the Upper Green, New Fork, and Little Snake sub-basins, while 66.8% (1,600,000 ac) of the land within the Great Divide Closed Basin sub-basin is administered by BLM.

Land ownership is often a driving factor for water use and distribution. As described in more detail below, E&R activities occur more frequently on public lands that provide a greater level of protection for environmental uses and allow more access to recreation opportunities. This is evident in the environmental and recreation models (see section 8.3). Additionally, traditional water uses such as agriculture, are more likely to be consolidated on private land. Potential water development projects may occur on either public or private land; however, the development and evaluation process is commonly more rigorous when public land is involved, which provides greater protection. The protection model demonstrates the difference between private and public land and is discussed in Section 8.3.

6 ENVIRONMENTAL

This section is broken into state and federal environmental uses. Environmental water use in the Basin is demonstrated through permitted and protected resources and areas where environmental resources have been identified as important. These include national wildlife refuge, state designed aquatic priority habitats and stream corridors, USFWS critical habitats, instream flows, and wetland complexes, among others. Further discussion on environmental water use is provided below.

Environmental water use is difficult to quantify as most environmental factors are non-consumptive or consumed at a level that makes quantifying difficult and potentially inaccurate. Where appropriate, the section does quantify water use associated with specific environmental uses. Environmental uses that cannot be specifically quantified are discussed using a qualitative approach relative to how a change in water availability may affect the environmental use. The relative scale or magnitude of environmental water uses across the Basin is discussed in the environmental model section 8.3.2.

6.1 State – Environmental

This section discusses the state-level management of environmental resources in the Basin that are associated with water use. State government bodies include the WWDC, Wyoming SEO, WGFD, and others.

6.1.1 Instream Flow Filings and Reservoir Minimum Pools

Instream flow filings are a legal means to protect and manage fish habitat. The instream flows designate a specific water flow that must be maintained in the permitted stream segment. Detailed information on instream flows was presented in the 2009 Technical Memorandum (ERO Resources Corporation 2009a) and updated in the 2010 Basin update (WWC Engineering

et al. 2010). This section provides a brief overview and identifies new filings that have been permitted since the most recent plan update (2010).

Forty-one instream flow filings provide environmental protection for over 194 miles (mi) of streams in the Basin (Figures 6-1 through 6-3; Table 6-1). Of these filings, 35 have permits issued totaling approximately 134 miles of permitted stream protection. The remaining filings are still in process. The Little Snake and Upper Green sub-basins have the largest number of instream flow filings and total stream length (Table 6-2), and the majority of instream flow water rights have a relatively junior status. The majority of instream flow rights protect low order streams at higher elevations in their respective watersheds on land administered by the USFS. In most case, instream flow water rights protect streams that occur on federal or state-owned lands in areas designated by the WGF D as Aquatic Habitat Crucial/Enhancement Areas or Key Nongame Wildlife Areas (Figures 6-1 through 6-3). One notable exception is a filing for a 33-mile section of Savery Creek, a tributary to the Little Snake River, that passes through a mixture of federal, state, and privately owned land, but this water right had not been issued at the time that this report was written (Table 6-1). Detailed information on the instream flow filings (e.g., monthly permitted cfs requirements) can be found in the 2009 Environmental Technical Memo (ERO 2009) and on the State of Wyoming Instream Flow Filings website (WWDC 2018). The Technical Memo also provides an estimated instream flow recommended to support aquatic resources in the Basin waterways. The flow recommendations range from 551 cfs along the Green River (below New Fork) to 10 cfs along a number of smaller creek segments (Twin Creek, Slide Creek, Lake Creek, Fall Creek, Elbow Creek, Duck Creek, and Devils Hole Creek). The full list is available in the Technical Memo. The information was developed based on conversations with the WGF D Water Management Coordinator – Tom Annear.

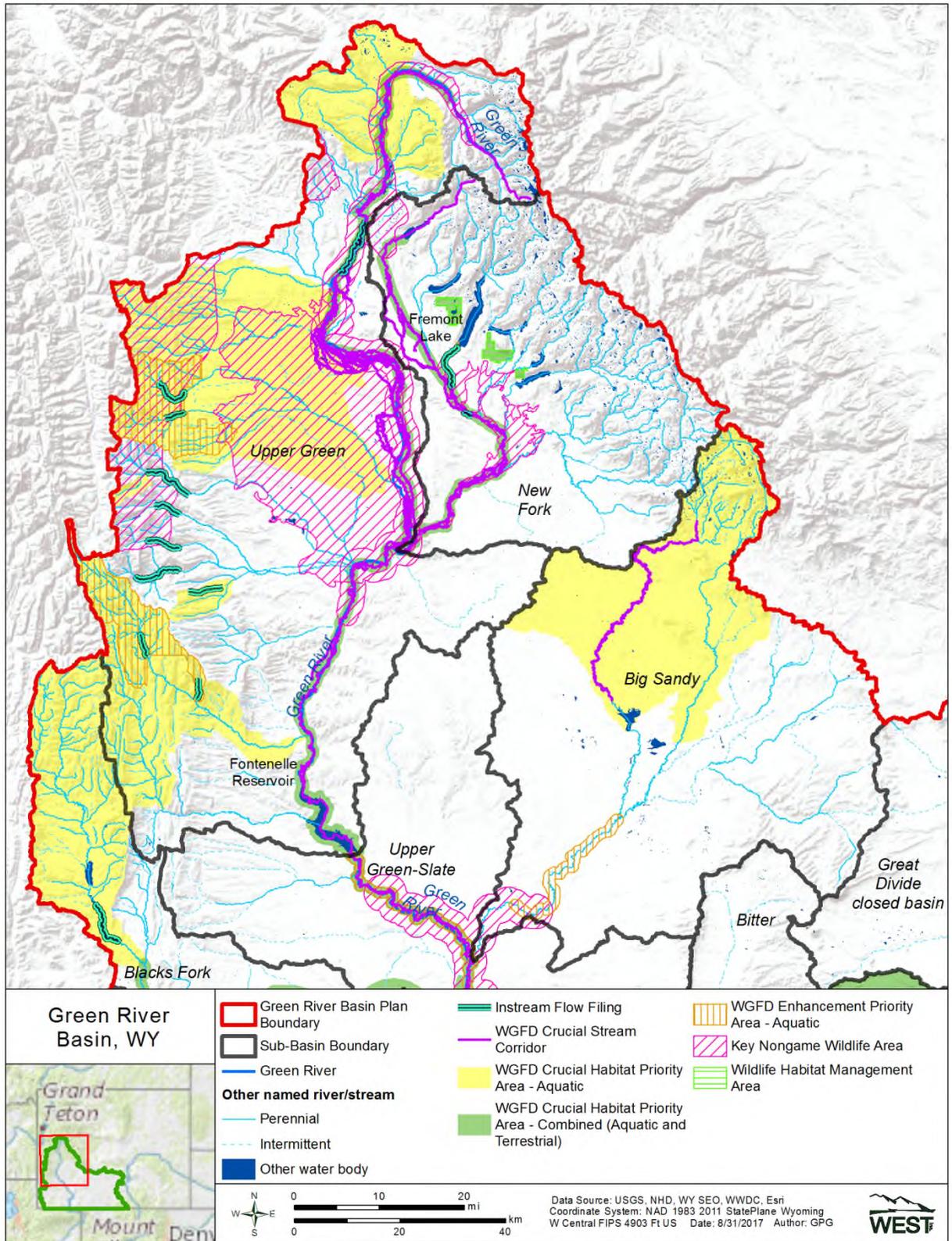


Figure 6-1. State - Environmental water uses in the Green River Basin – North Section.

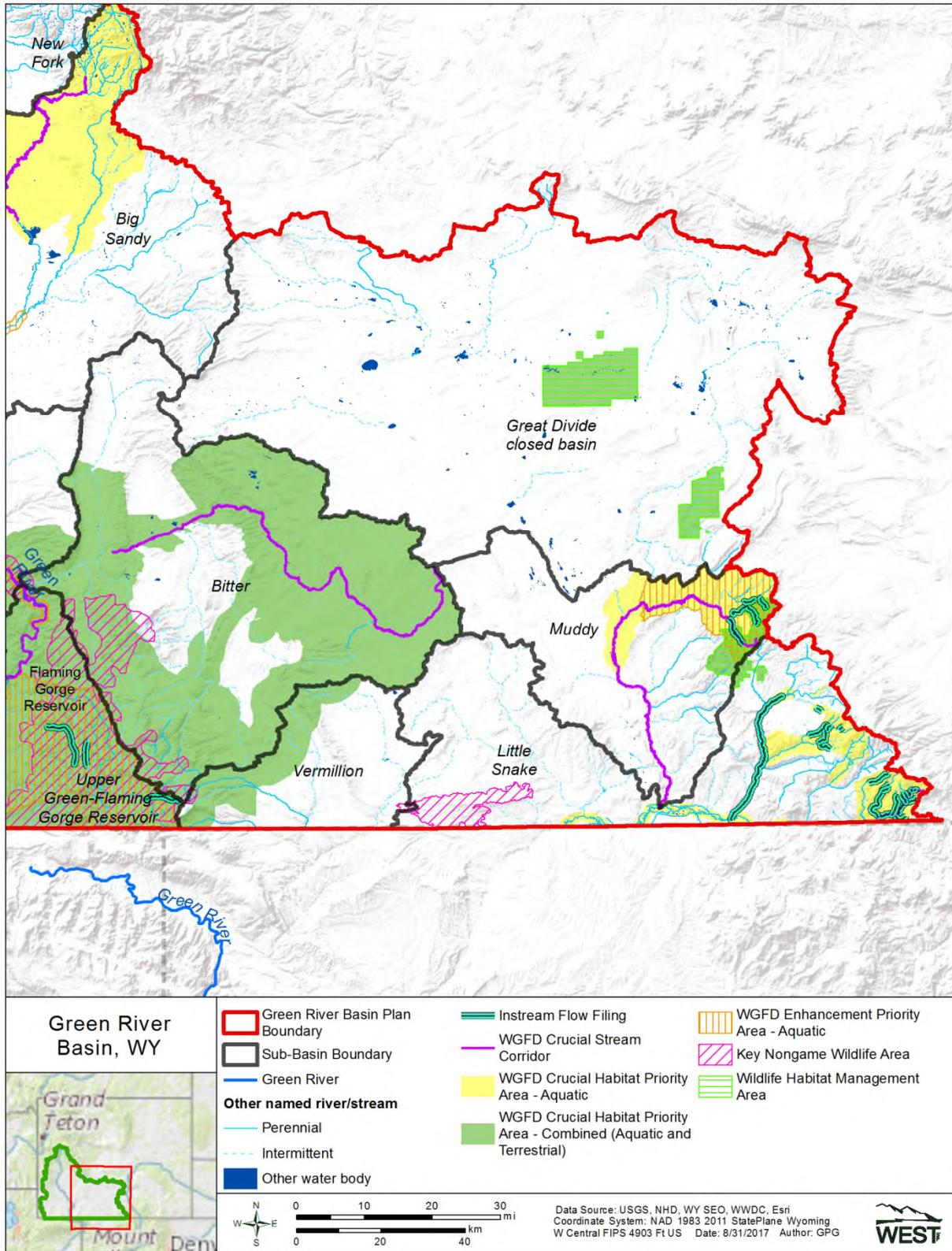


Figure 6-2. State - Environmental water uses in the Green River Basin – East Section.

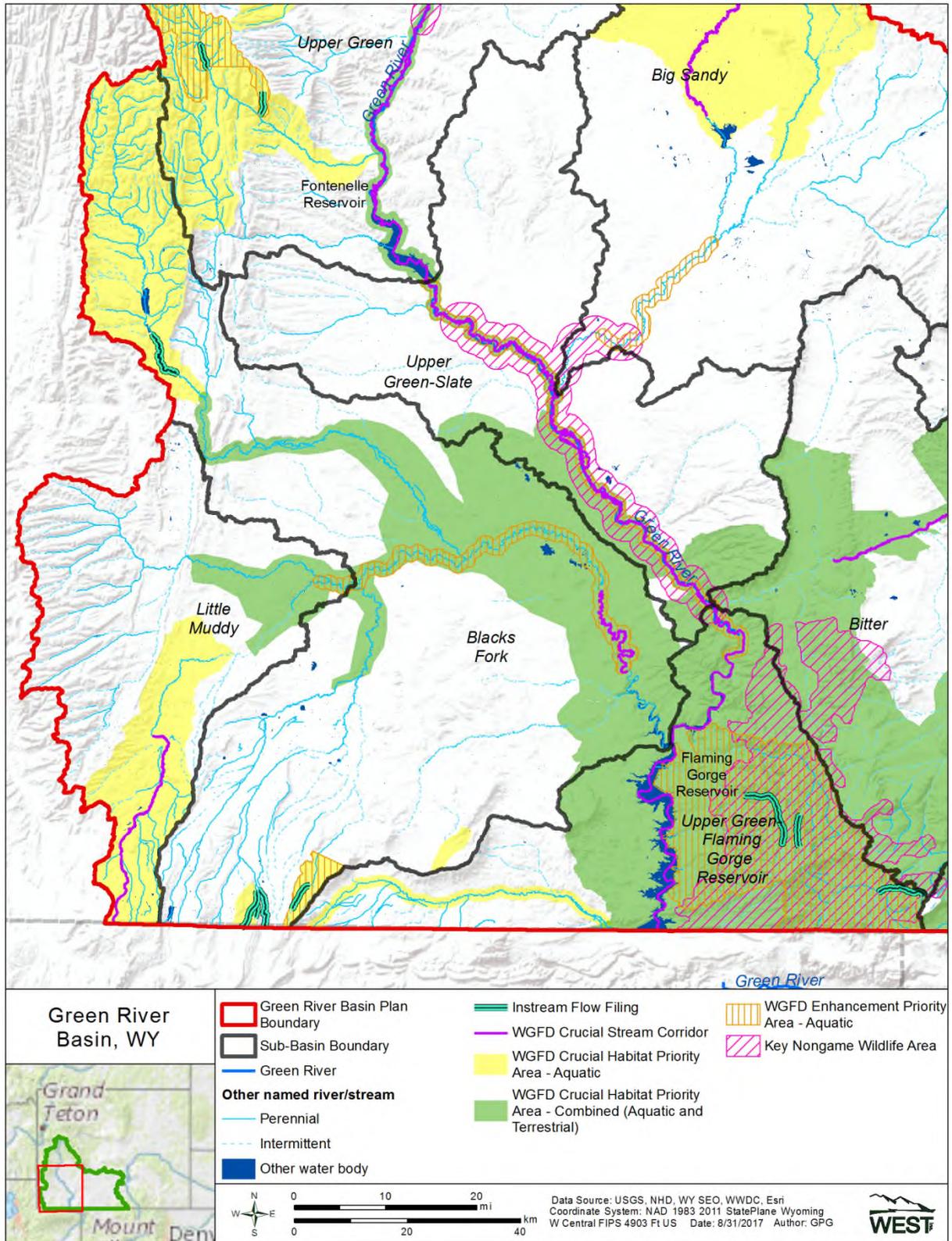


Figure 6-3. State - Environmental water uses in the Green River Basin – West Section.

Table 6-1. Green River Basin instream flow filings detailed breakdown.

Sub-Basin	Name	Priority Date	Issue Date	Length (miles)
Blacks Fork	Ham's Fork I.F. Segment No.1	2/2/1989		10.9
	East Fork Smith's Fork Creek I.F. Segment No.1	1/21/1993	6/25/2014	4.6
	Little Gilbert Creek I.F. Segment No.1	12/6/1999	1/9/2005	1.7
	Gilbert Creek I.F. Segment No.1	12/6/1999	1/9/2005	4.4
	Sage Creek I.F. Segment No.1	12/6/1999	1/9/2005	3.6
Little Snake	North Fork Little Snake River I.F. Segment No.1	6/21/1991	2/27/2006	9.1
	Savery Creek I.F. Segment No.1 Secondary Application	6/4/2002		27.7
	Granite Gulch / Green Timber Creek I.F. Segment No.1	6/21/1991	2/27/2006	1.7
	Deep Creek I.F. Segment No.1	12/19/1995	4/18/2006	3.5
	Mill Creek I.F. Segment No.1	6/27/1996	4/28/2006	3.1
	W. Fork N. Fork Little Snake River I.F. Segment No.1	6/21/1991	2/27/2006	6.6
	Roaring Fork Little Snake River I.F. Segment No.1	6/27/1996	4/18/2006	3.2
	Big Sandstone Creek I.F. Segment No.1	6/27/1996	4/28/2006	3.0
	Dirtyman Fork I.F. Segment No.1	12/19/1995	4/18/2006	0.9
	Solomon Creek I.F. Segment No.1	6/21/1991	2/27/2006	3.2
	North Fork Sandstone Creek I.F. Segment No.1	6/27/1996	4/28/2006	0.7
	Rose Creek I.F. Segment No.1	6/21/1991	2/27/2006	1.9
	Rabbit Creek I.F. Segment No.1	6/21/1991	2/27/2006	0.9
	Harrison Creek I.F. Segment No.1	6/21/1991	2/27/2006	1.3
	Douglas Creek I.F. Segment No.1	12/19/1995	4/18/2006	1.0
	Deadman Creek I.F. Segment No.1	6/21/1991	2/27/2006	0.8
	Third Creek I.F. Segment No.1	6/21/1991	2/27/2006	0.2
	Ted Creek I.F. Segment No.1	6/21/1991	2/27/2006	0.3
	Muddy	Little Muddy Creek	6/19/2012	
Littlefield Creek		6/19/2012		7.0
McKinney Creek		6/19/2012		1.9
Muddy Creek		6/19/2012		5.4
New Fork	West Fork New Fork River I.F. Segment No.1	2/10/1989	1/7/1992	1.5
	Pine Creek I.F. #1- from Fremont Lake	4/2/2002	12/10/2003	8.2
	Pine Creek I.F. Segment No.1	6/4/2002	12/10/2003	8.2
Upper Green	Fish Creek I.F. Segment No.1	3/11/1991	12/1/2003	4.2
	North Cottonwood Creek I.F. Segment No.1	7/12/1989	1/16/2008	8.9
	South Piney Creek I.F. Segment No. 1	3/11/1991	12/3/2003	7.0
	North Piney Creek I.F. Segment No.1	3/11/1991	2/10/2004	7.6
	Middle Piney Creek I.F. Segment No.1	3/11/1991	2/23/2004	3.6
	LaBarge Creek I.F. Segment No.1	12/17/1990	12/3/2003	3.3
	South Cottonwood Creek I.F. Segment No. 1	6/27/1989	1/16/2008	2.9
Green River I.F. Segment No.1	1/10/1989	1/7/1992	9.8	

Table 6-1. Green River Basin instream flow filings detailed breakdown.

Sub-Basin	Name	Priority Date	Issue Date	Length (miles)
Upper	Red Creek I.F. Segment No.1	12/6/1999	1/9/2005	5.7
Green-Flaming Gorge Reservoir	Currant Creek I.F. Segment No.1	6/8/2000	1/9/2005	9.0
	Trout Creek I.F. Segment No.1	12/6/1999	1/9/2005	3.8

Table 6-2. Green River Basin instream flow filings summary by sub-basin.

Sub-Basin	# Instream Flow Filings	Stream Length (mi)*
Blacks Fork	5	25.2
Little Snake	18	69.1
Muddy	4	16.3
New Fork	3	17.9
Upper Green	8	47.3
Upper Green-Flaming Gorge Reservoir	3	18.5
Green River Basin Totals	41	194.3

*The length provided includes instream flow filings that have been submitted but not approved. See Table 6-1 for a full list of approved and under review filings.

The previous Basin Plan Update identified several reservoirs in the Basin that have storage permitted for a variety of environmental uses. A summary of this information is presented here. No new reservoirs have been permitted since the most recent update; therefore, no new information is available to present.

The water rights associated with the reservoir include uses for fish or fish and wildlife. Recreational uses defined on permits can be considered to the extent that storage water is assigned allowing recreational uses. The storage may also be environmentally beneficial for fish habitat and wildlife consumption; those not specifically designated as such. Reservoirs with permitted capacity for stock water similarly serve a dual environmental function. Reservoirs with fish or fish and wildlife uses or pools listed in their permitting documents include:

- Boulder (1,621 acre-feet)
- High Savery (5,724 acre-feet)

Reservoirs that have an un-segregated portion of their total storage devoted to fish and wildlife (or similar use):

- Big Sandy
- Flaming Gorge
- Fontenelle

Additionally, three reservoirs have minimum flow bypasses included in their reservoir permit that support waters below the dams (Table 6-3). The Basin Plan Update Environmental Technical

Memo (ERO 2009) provides a full list of the recommended minimum water surface area required to support aquatic resources in reservoirs within the basin. The list assigns total acres and minimum acres to 43 reservoirs or lakes in the Basin. The full list is available in the Technical Memo. The information was developed based on conversations with the WGFD Water Management Coordinator – Tom Annear.

Table 6-3. Reservoirs in the Green River Basin with minimum flow bypass permit requirements.

Reservoir	Minimum flow bypass (cubic feet per second)
Fontenelle	50
Meeks Cabin	10
Stateline	7

6.1.2 Wyoming Game and Fish Department – Environmental

WGFD is a state agency that provides oversight and management for the natural resources in Wyoming, including both environmental and recreation management. The WGFD has prepared a number of documents that identify, categorize, and provide management recommendations for Wyoming environmental and recreation resources. These documents include the *State Wildlife Action Plan* (SWAP; 2010 and 2017) and *Strategic Habitat Plan* (SHP; WGFD 2001, 2009, and 2015). The SWAP identifies wildlife resources throughout the state by terrestrial habitats and aquatic regions (basins). The goal of the plan is to develop management strategies for wildlife based on current and future risks. The SHP identifies five goals including conservation and management, enhancement, increased recreation, increased public awareness, and promotions of collaborative efforts (WGFD 2015). Only data on aquatic resources were included in this report.

6.1.3 Wyoming Game and Fish Department – Aquatic Priority Habitat Areas

WGFD developed a SHP in 2001 with the most recent update in 2015. This plan recognized the important role habitat issues play in the future of Wyoming’s wildlife. Several habitats and vegetation communities were identified as important to maintain or enhance. The plan specifically acknowledged declines in water flows, water quality, loss of water flow to diversions, and loss of native fish to entrainment as risk factors affecting Wyoming resources. Through the plan, WGFD identified priority habitats that are “crucial” for wildlife and those habitats that have been degraded and have potential for “enhancement”.

This section identifies the priority habitat areas designated by WGFD as aquatic crucial habitat priority areas, combined crucial habitat priority areas, aquatic enhancement habitat priority areas, crucial stream corridors, wildlife habitat management areas, and key nongame wildlife areas.

6.1.3.1 Crucial Habitat Priority Areas - Aquatic

Crucial Habitat Priority Areas (CHPA) are areas that are considered to be crucial to conserving and maintaining populations of aquatic wildlife for the present and future. These areas are identified as having significant biological or ecological value that needs to be protected or

managed to maintain viable healthy populations of aquatic wildlife. These areas address Goal 1 in the SHP and are deemed valuable by WGFD. The WGFD provides examples of core crucial area values including: “*crucial winter range, sage grouse core areas, seasonal habitats, Species of Greatest Conservation Need (SGCN) diversity and uniqueness, quality of watershed hydrologic function, etc.* (WGFD 2015).” Management and habitat protection activities will be targeted in these areas.

CHPA occur in three distinct locations across the Basin including the northern sub-basins (Upper Green and New Fork), the southwest sub-basins (Little Muddy, Blacks Fork, and Upper Green – Flaming Gorge), and the southeast sub-basins (Little Snake and Muddy; Figures 6-1 through 6-3). Most of the CHPA in the Basin are dedicated to the preservation of the Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*), bluehead sucker (*Catostomus discobolus*), and flannelmouth sucker (*Catostomus latipinnis*), including part of the Bridger National Forest (NF), Muddy Creek in the southeastern portion of the Basin, part of the Medicine Bow NF, part of the Ashley NF along Gilbert Creek, along the Big Sandy River and Little Sandy Creek between the Wind River Mountains and Big Sandy Reservoir, and along the Henry’s Fork River Corridor (Figures 6-1 through 6-3). Genetically pure brood stock of Colorado River cutthroat trout and bluehead suckers exist in the Basin and are specifically targeted for conservation by WGFD and used to restore species populations. The Upper Green River Tributaries CHPA in the Upper Green sub-basin is designated for conservation of Kendall Warm Spring dace (*Rhinichthys osculus thermalis*). This species is listed by the USFWS (discussed in section 6.2.3) and is only known to exist in this region.

SWAP Tier 1 species targeted in the Basin’s CHPA include Colorado River cutthroat trout, flannelmouth suckers, bluehead sucker, roundtail chub (*Gila robusta*), Kendall Warm Springs dace, boreal toad (*Bufo boreas boreas*), great basin spadefoot (*Spea intermontana*), and midget faded rattlesnake (*Crotalus oreganus concolor*). Other fish species targeted for conservation by the CHPA include mountain whitefish (*Prosopium williamsoni*), mottled sculpin (*Cottus bairdii*), mountain sucker (*Catostomus platyrhynchus*), brook trout (*Salvelinus fontinalis*), rainbow trout (*Oncorhynchus mykiss*), speckled dace (*Rhinichthys osculus*), kokanee salmon (*Oncorhynchus nerka*), tiger trout (*Salmo trutta x Salvelinus fontinalis*), and brown trout (*Salmo trutta*). Amphibian species targeted for conservation by the CHPA in the Basin include smooth green snake (*Opheodrys vernalis*), boreal chorus frog (*Pseudacris maculata*), northern leopard frog (*Lithobates pipiens*), greater short-horned lizard (*Phrynosoma hernandesi*), rubber boa (*Charina bottae*), and Columbia spotted frog (*Rana luteiventris*).

A detailed description for each individual CHPA can be found on the WGFD website (<https://wgfd.wyo.gov/Habitat/Habitat-Priority-Areas/Statewide-Maps>). The CHPA are included in the environmental model and discussed in more detail below.

6.1.3.2 Combined Habitat Priority Areas

WGFD also identifies combined crucial areas in the SHP. The combined areas are designated where significant overlap between aquatic and terrestrial crucial habitat occurs. For the purpose of this report, combined crucial areas are presented and identified separately, but are assumed

to provide the same environmental use value as CHPA. In many cases, the combined areas cover more significant portions of the water resources and subsequent E&R uses across the Basin.

Four combined habitat priority areas exist in the Basin including the Green River, Black Hills and Hams Fork; Little Mountain and Flaming Gorge; Red Desert – Bitter Creek; and Green-New Fork River Corridor priority habitats (Figures 6-1 through 6-3). WGFD identifies these areas as key stream and riparian habitats that are critical to wildlife resources such as waterfowl, native and sport fisheries, unique reptile communities, deep-water habitats and shorelines, Colorado River cutthroat trout habitat, and playa wetlands. Major reservoirs are included in the combined areas and include Fontenelle Reservoir and Flaming Gorge National Recreational Area, as well as fisheries along the Ham’s Fork, Green River, New Fork River, Black’s Fork, Little Muddy Creek, Muddy Creek, and other small waters.

6.1.3.3 Enhancement Habitat Priority Areas - Aquatic

Enhancement Habitat Priority Areas (EHPA) have been identified by the WGFD as areas that have the potential to provide wildlife habitat, but are currently in a state that needs restoration or improvements. The areas may be targeted by WGFD to address Goal 2 in the SHP. If properly managed and addressed, the EHPA may provide a value similar to the CHPA. The WGFD provides examples of issues including: *“loss of aspen communities, habitat fragmentation, development, loss of connectivity, water quality effects, water quantity limitations, lack of fish passage, loss of fish to diversions, degraded habitat, etc. (WGFD 2015)”*

Most of the EHPA overlap CHPA located in the Bridger NF, Ashley NF, and Medicine Bow NF (Figures 6-1 through 6-3). There are a few notable exceptions along a large segment of the Big Sandy River below Big Sandy Reservoir, the Blacks Fork, and main stem of the Green River above Flaming Gorge Reservoir. All of these areas align with combined priority areas, except the Big Sandy River section. Because these areas do not currently provide high value habitat, they are not discussed in great detail or included in the environmental model section. These areas are important to note as changes in water regimes may have a greater effect on the recovery and enhancement goals targeted within these areas.

6.1.3.4 Crucial Stream Corridor

Crucial stream corridors are river segments that have been identified by WGFD to be unique, have high species richness, lack migration barriers, remain in relatively natural conditions, and provide connectivity between source and sink locations. The corridors include main stem, off shoot channels, and braided channel areas.

Eight primary crucial stream corridors segments have been identified in the Basin (Figures 6-1 through 6-3). This includes the main stem of the Green River from the headwaters to the Wyoming – Utah border, New Fork River from the headwaters to the confluence with the Green River, the Big Sandy River from the NF boundary to the Big Sandy Reservoir, the Ham’s Fork above Flaming Gorge, Muddy Creek (western) north of the state line, Muddy Creek (eastern) from the headwaters to Baggs, Bitter Creek from the headwaters to Rock Springs, and the North

Fork Little Snake River within the NF boundaries. The Green River corridor covers over 165 miles (straight line north to south) and includes multiple reservoir sites (Flaming Gorge, Fontenelle, and Green River Lake). These stream segments provide high quality fishery resources for both environmental and recreation opportunities. Most of these crucial stream corridors fall within WGFD designated priority habitats and have consistent management and conservation goals.

6.1.3.5 Wildlife Habitat Management Area

Wildlife Habitat Management Areas (WHMA) are Wyoming Game and Fish Commission owned lands that were purchased or donated to WGFD for the purpose of providing wildlife habitat needs on a seasonal or year round basis. These may include environmental and/or recreation goals. WGFD has drafted a brief document for each WHMA that describes location, access, habitat values/goals, and recreation opportunities. This information is available on the WGFD website (<https://wgfd.wyo.gov/Public-Access/WHMA>).

Seven WHMA covering approximately 134,700 acres occur in the Basin (Figures 6-1 through 6-3). Most of the WHMA occur in one of three distinct locations. The Soda Lake, Half Moon, Luke Lynch, and Fall Creek WHMA are located high in the watershed on USFS managed land along the western base of the Wind River Range. These WHMA occur among multiple natural lakes (e.g., Willow, New Fork, Fremont) and provide habitat for big game species as migratory pathways, and suitable habitat for sagebrush obligate species, specifically the greater sage-grouse. The Chain Lakes and Red Rim-Daley WHMA are located in the eastern Basin in the Red Desert which includes a large unique wetland complex that is surrounded by arid habitat and high alkaline conditions. The Red Rim-Grizzly WHMA is in the foothills of the Sierra Madre Mountains and includes several small stream segments (Muddy Creek, Little Savery Creek, among others).

6.1.3.6 Key Nongame Wildlife Areas

Key Nongame Wildlife Areas (KNWA) were identified by the WGFD as habitat that supports birds and mammals that are classified by WGFD as SGCN. These areas contain high densities of wildlife, high species richness, and unique habitat characteristics with low habitat fragmentation. Data provided by the WGFD for each KNWA includes a description of the area relative to uniqueness and a list of birds and mammals that occur in the area that are classified as SGCN.

There are approximately 1,241,290 acres of KNWA in the Basin, and most of the KNWA overlap with other state and federal priority areas (Figures 6-1 through 6-3). A large section of land east of the Green River is designated as a KNWA (Flaming Gorge) as well as a smaller KNWA (Powder Rim) along the south-central Basin limits; however, these areas are targeted for juniper obligate species. The KNWA (Green River) along a large section of the Green River corridor is specifically targeted for water-dependent species and habitat. This KNWA includes the New Fork Potholes (which supports diving ducks), Seedskaadee National Wildlife Refuge, and an area targeted by the trumpeter swan (*Cygnus buccinator*) expansion program. WGFD identifies 23 bird and 10 mammal species listed as SGCN associated with this KNWA. The riparian corridor

along New Fork River from Pinedale to the confluence with the Green River is a designated KNWA (Pinedale) as well as a large section of land west of the Green River corridor above Marbleton. WGFD associates 21 bird and 13 mammals listed as SGCN with this KNWA. This area has high species diversity and includes long-billed curlew (*Numenius americanus*) and sandhill crane (*Grus canadensis*) breeding and provides trumpeter swan habitat. The KNWA (Wyoming Range) along the northwestern Basin limits is identified for lynx habitat and other boreal species. Nine bird and 16 mammals listed as SGCN are identified for this KNWA. A section of land along Powder Rim is designated KNWA, but does not appear to support significant water resources.

6.1.4 Other Conservation Groups

A number of conservation programs and groups have been established in the Basin and include programs managed by Trout Unlimited (TU), Ducks Unlimited (DU), the Wyoming Wildlife and Natural Resource Trust (WNRT), Partners for Fish and Wildlife (PFW), and the Wyoming Landscape Conservation Initiative (WLCI). These groups often team with one another and other state and local agencies to support research and restoration/enhancement projects, commonly associated with water resources. Projects may include construction of fish passage structures, wetland restoration, riparian habitat enhancements, remove of diversion structures, updating culverts and underpasses, grazing management near water sources, and prescribed burns, among numerous other projects that have occurred over multiple decades. Locations of projects managed by these conservation groups were not plotted on the environmental use maps or included in the model; however, they are presented to recognize the grassroots efforts that are ongoing in the Basin. These groups have been working in the region for decades and will continue to target projects with the goal of restoring, enhancing, and conserving habitat. Additional information on the individual groups and specific projects can be found on the respective websites.

These conservation programs and projects do not require a water demand. The programs' goal is to increase the health of habitats that often are associated with water, providing support for aquatic ecosystem. As such, the location of these projects can be used to identify areas where environmental practices have been implemented to increase the environmental function and values associated with water resources. Three PFW focus areas occur in the Basin and include the Upper Green River Focus Areas, Upper Sweetwater-Red Desert Focus Area, and Little Snake River-Upper North Platte Focus Area (Photograph 1). Tables 6-4 and 6-5 provide the accomplishments listed in the PFW FY2015 report in the Upper Green River and Little Snake River-Upper North Platte Focus Areas from 2012 to 2015. While all of the project locations are not specifically identified, it is clear that efforts are being made to enhance and restore environmental resources in the Basin. Future project development should be cognizant of the efforts made to support environmental resources in the Basin.



Wyoming Partners for Fish and Wildlife Program – Focus Areas (USFWS 2017d).

Table 6-4. Wyoming Partners for Fish and Wildlife Program – Upper Green River Focus Area 2015 Fiscal Year Report.

Habitat Type	FY 2012-15 Accomplishments	FY 2015 Accomplishments	FY 2012-2016 Goal	% Five-year Goal Completed
Stream Enhancement (feet)	6,336	6,336	10,000	63.0
Riparian Enhancement (miles)	2	2	10	24.0
Wetland Restoration (acres)	59	54	80	73.0
Upland Enhancement (acres)	227	0	2,000	11.0
Fish Passage/screens (units)	2	0	5	60.0

Table 6-5. Wyoming Partners for Fish and Wildlife Program – Little Snake/Upper North Platte River Focus Area 2015 Fiscal Year Report.

Habitat Type	FY 2012-15 Accomplishments	FY 2015 Accomplishments	FY 2012-2016 Goal	% 5-year Goal Completed
Stream Enhancement (feet)	34,584	22,968	20,000	172.0
Riparian Enhancement (miles)	5	4	35	15.0
Wetland Restoration (acres)	83	0	75	11.0
Upland Enhancement (acres)	3,857	2003	25,000	15.0
Fish Passage/screens (units)	3	0	5	60.0

6.2 Federal - Environmental

This section discusses the federal-level management of environmental resources in the Basin that are associated with water use. Federal government agencies include the USFWS, BOR, US Army Corps of Engineers (USACE), USFS, BLM, and others.

6.2.1 National Wildlife Refuges

The NWR system is “a national network of lands and waters for the conservation, management, and where appropriate, restoration of fish, wildlife, and plant resources and their habitats within the United States for the benefit of the present and future generations of Americans” (National Wildlife Refuge System Improvement Act 1997) that is managed by the USFWS. The USFWS publishes Comprehensive Conservation Plans that outline conservation and wildlife management goals for each NWR. NWR are typically managed to protect habitat, water quality, and endangered species, but they are also often open to recreational opportunities such as hunting, camping, and wildlife viewing.

The Seedskadee NWR is the only NWR in the Basin (Figures 6-4 through 6-6). The Seedskadee NWR was established in 1965 through the Colorado River Storage Project Act of 1956, and Section 8 of the Act provided for the establishment of wildlife habitat development areas to offset the loss of wildlife habitat resulting from reservoir development in the Colorado River Drainage. The Seedskadee Reclamation Act (Seedskadee Reclamation Act 1958) specifically authorized acquisition of lands for Seedskadee NWR. The principal purpose of Seedskadee NWR is to provide for the conservation, maintenance, and management of wildlife resources and its habitat including the development and improvement of such wildlife resources.

Additionally, the refuge is charged to protect the scenery, cultural resources, and other natural resources and provide for public use and enjoyment of compatible wildlife-dependent activities. The Seedskadee NWR provides dual purposes related to water use; supporting a variety of environmental benefits including wetlands and wildlife habitat, and the NWR provides recreation opportunities for hunting, hiking, wildlife viewing, among other passive recreation activities.

6.2.1 Wilderness Areas

The Wilderness Act of 1964 (The Wilderness Act 1964) allows Congress to designate wilderness areas within existing federal public land, which may in turn be managed by any of four federal land management agencies, including USFS, BLM, USFWS, and National Park Service. A wilderness designation is the highest level of conservation protection for federal lands, in that the Wilderness Act prohibits permanent roads and commercial enterprises, except commercial services that may provide for recreational or other purposes of the Wilderness Act. Wilderness areas generally do not allow motorized equipment, motor vehicles, mechanical transport, temporary roads, permanent structures or installations. In other words, wilderness areas are closed to water development.

The Bridger Wilderness Area and Gros Ventre Wilderness Area include most of the Bridger NF land in the Wind River Range in the Upper Green, New Fork, and Big Sandy sub-basins, and the Huston Park Wilderness Area includes some of the headwaters of the Little Snake River in the Medicine Bow NF (Figures 6-4 through 6-6). The wilderness areas are included in the protection model discussed in section 8.3.

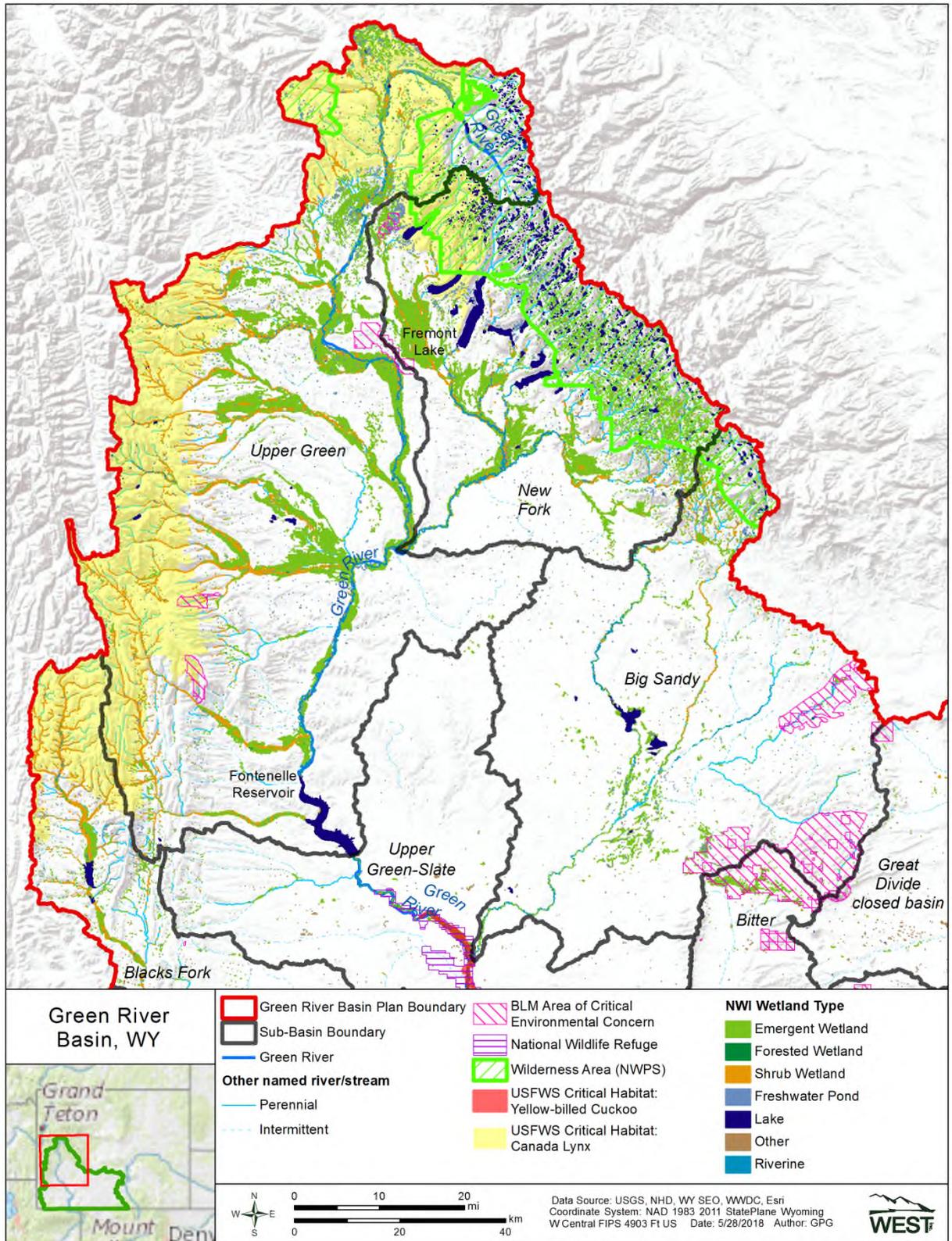


Figure 6-4. Federal - Environmental water uses in the Green River Basin – North Section.

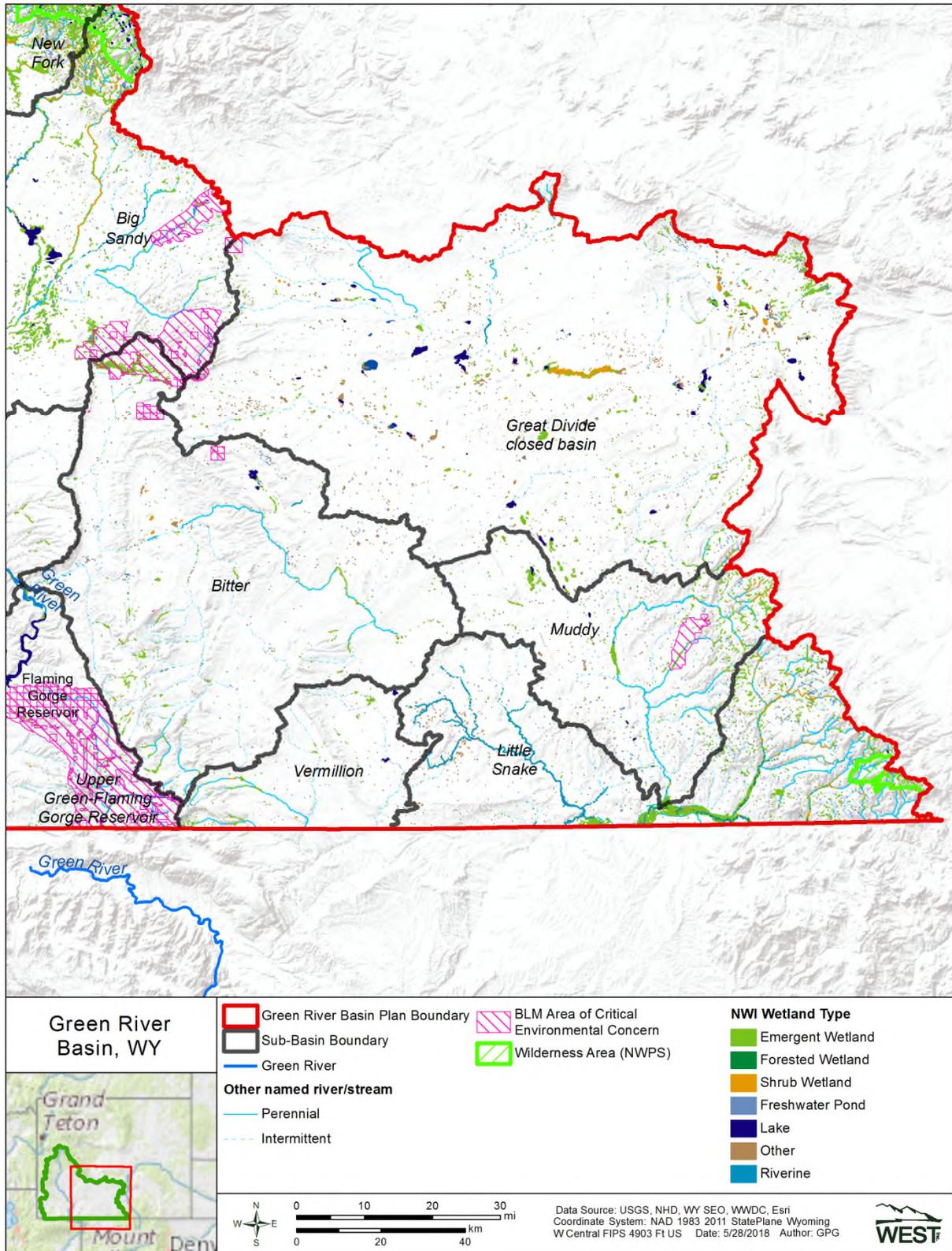


Figure 6-5. Federal - Environmental water uses in the Green River Basin – East Section.

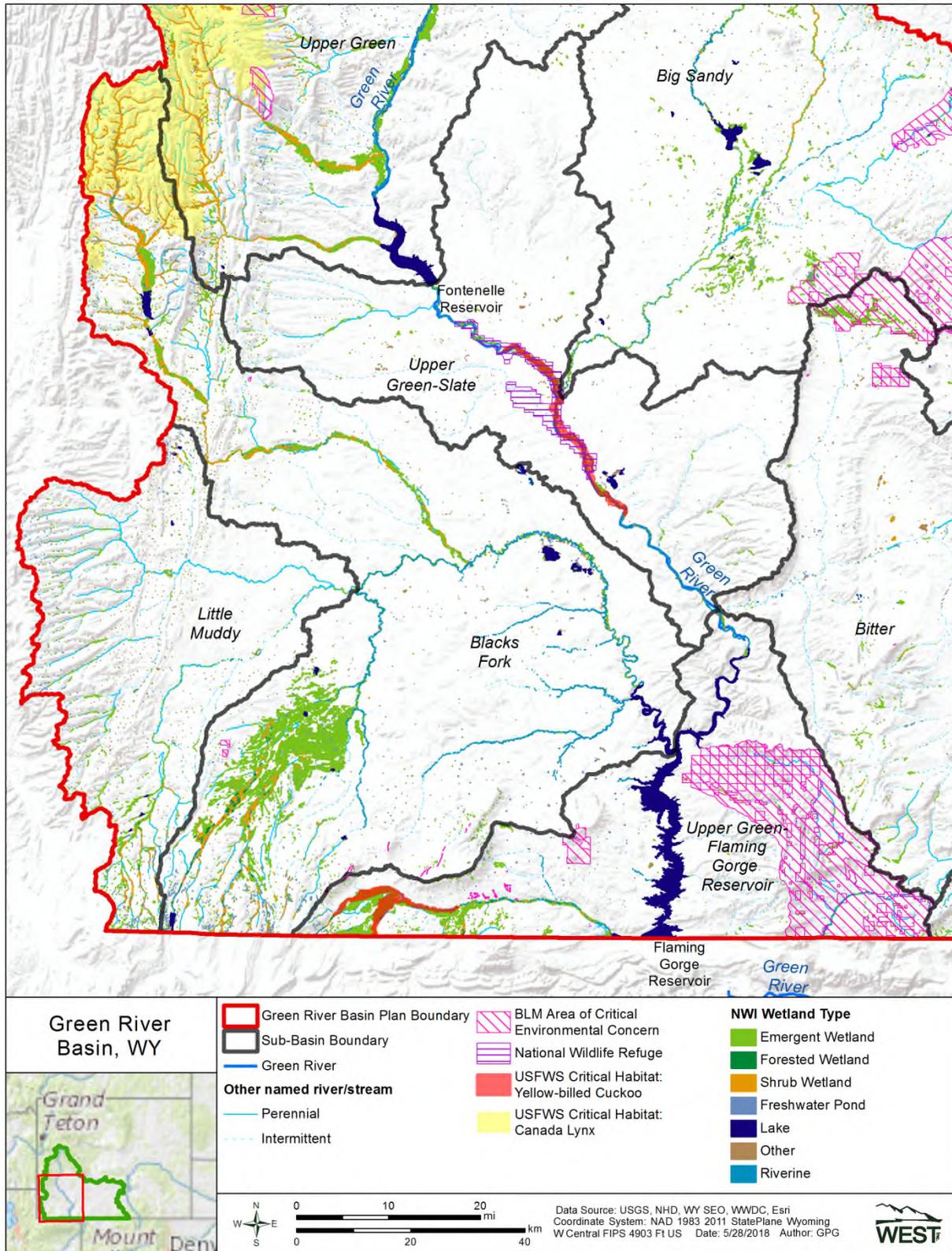


Figure 6-6. Federal - Environmental water uses in the Green River Basin – West Section.

6.2.2 USFWS Threatened and Endangered Species

The USFWS Information for Planning and Consultation (IPaC) report for the Basin identified four birds, five mammals, five fish, and three plants as threatened, endangered, or a candidate/proposed species under the Endangered Species Act (Table 6-6). While all species require some level of water to survive, certain species are more commonly associated with water as part of their suitable habitat or life cycles. The USFWS has designated potential suitable habitat for each listed species across the state. This information was not plotted on maps for this report, but was included in the environmental model section discussed below.

Table 6-6. Federally threatened and endangered species with potential to occur in the Green River Basin.

Common Name	Scientific Name	USFWS Status	Habitat Requirements	Potential Water Use in River Basin
<u>Birds</u>				
yellow-billed cuckoo	<i>Coccyzus americanus</i>	Threatened ¹	Mature riparian forest with multiple vegetative structures.	High - Habitat is typically associated with river/stream systems; critical habitat is identified in the river basin.
piping plover	<i>Charadrius melodus</i>	Threatened ¹	Sand bars along rivers.	Low - Stopover during migration, very edge of corridor.
whooping crane	<i>Grus americana</i>	Endangered ¹	Agricultural fields, marsh/pond areas.	Low - Stopover during migration, very edge of corridor.
least tern	<i>Sterna antillarum</i>	Endangered ¹	Sand bars along rivers.	Low - Stopover during migration, very edge of corridor.
<u>Mammals</u>				
black-footed ferret	<i>Mustela nigripes</i>	Experimental ² Population, Non-Essential	Prairie habitat associated with prairie dog colonies.	None – not associated with water.
Canada lynx	<i>Lynx canadensis</i>	Threatened ¹	Mature forest in areas where snow cover is abundant.	Low – not commonly associated with water; does have critical habitat in river basin.
gray wolf	<i>Canis lupus</i>	Experimental Population, Non-Essential ³	Habitat generalist.	Low – not associated with water.

Table 6-6. Federally threatened and endangered species with potential to occur in the Green River Basin.

Common Name	Scientific Name	USFWS Status	Habitat Requirements	Potential Water Use in River Basin
grizzly bear	<i>Ursus arctos horribilis</i>	Threatened ¹	Habitat generalist, but commonly associated with forested area around the greater Yellowstone area.	Moderate – may forage in rivers systems.
North American wolverine	<i>Gulo gulo luscus</i>	Proposed Threatened ⁴	Mature forest.	Low – not associated with water.
<u>Fish</u>				
Kendall Warm Springs dace	<i>Rhinichthys osculus thermalis</i>	Endangered ¹	Kendall Warm Springs and approximately 984 feet of stream that flows from the springs to the Green River.	High – only know populations exist in the Basin.
Colorado pikeminnow	<i>Ptychocheilus lucius</i>	Endangered ¹	Upper Colorado and Green Rivers. Adapted to warm rivers and requires uninterrupted passage with large spring peaks and stable base flows.	High – only known to occur in the Upper Colorado River Basin.
humpback chub	<i>Gila cypha</i>	Endangered ¹	Upper Colorado and Green Rivers. Requires swift, turbid waters.	High – only known to occur in the Upper Colorado River Basin.
razorback sucker	<i>Xyrauchen texanus</i>	Endangered ¹	Upper Colorado River. Requires high spring flows, cobble bars for spawning, and connected floodplains.	High – only known to occur in the Upper Colorado River Basin.
bonytail chub	<i>Gila elegans</i>	Endangered ¹	Upper and Lower Colorado River. Preferred habitat unknown.	High – only known to occur in the Upper Colorado River Basin.
<u>Plants</u>				
blowout penstemon	<i>Penstemon haydenii</i>	Endangered ¹	Early successional sand dunes.	None – not associated with water.
whitebark pine	<i>Pinus albicaulis</i>	Candidate ⁵	Alpine forests.	Low – not associated with water.
Ute ladies'-tresses	<i>Spiranthes diluvialis</i>	Threatened ¹	Mesic areas near streams or other water sources; wetlands.	Moderate – commonly associated with habitats where water is present.

¹USFWS 2017f²USFWS 2017c³USFWS 2017d⁴USFWS 2017e⁵USFWS 2017b

Two species have USFWS designated critical habitat in the Basin (Figures 6-4 through 6-6). The Canada lynx (*Lynx canadensis*) has designated habitat high in the forest region extending into the adjacent river basin. The Canada lynx is generally found in dense boreal forests,

especially where snowshoe hare (*Lepus americanus*) densities are high, but it may also venture into open forests and rocky areas. A number of water resources are present in the critical habitat area including crucial stream corridors, instream flow filings, wetlands, and various streams and lakes. However, the Canada lynx does not rely on water sources for life stages beyond hydration. Any proposed water projects or changes in use in designated critical habitat areas should evaluate how they may reduce the availability of water for the Canada lynx or alter the forest cover.

The yellow-billed cuckoo (*Coccyzus americanus*) has critical habitat designated along the portions of the Green River in the Upper Green-Slate sub-basin and along the Henry's Fork in the Green River-Flaming Gorge sub-basin (Figures 6-4 through 6-6). These areas provide suitable habitat for the species and should therefore, be identified and evaluated whenever a water project or change in water regime is proposed that may affect this potentially suitable habitat. Additionally, areas in the Basin where mature and complex riparian corridors exist may be considered suitable habitat. The potential effect on yellow-billed cuckoos of changes to water regimes should be considered during planning stages.

The Ute ladies'-tress (*Spiranthes diluvialis*) is the only listed plant species associated with riparian and wetland habitat. This species is believed to have the potential to occur in floodplains at lower elevations in the Basin (USFWS 2016, 2017), but has never been detected during surveys in the Basin in Wyoming (Fertig et al. 2005; Heidel 2007).

The Kendall Warm Springs dace is the only fish to inhabit the 85-degree Fahrenheit spring water of Kendall Warm Springs, located in the Bridger-Teton NF in the Basin (USFWS 2015, 2017a). The dace's entire known range includes the Kendall Warm Springs and approximately 984 feet of stream that flows from the springs to the Green River (USFWS 2017d). The Kendall Warm Springs dace occurs throughout the lower springs and stream, but are commonly found near plant growth. Plants within the stream provide both escape cover and current breaks (USFWS 2017d). Adult daces can also be found in small schools within the main channel or within relatively still eddies (USFWS 2017d). Fry commonly occupy backwaters and areas where dense mats of vegetation provide settled waters (USFWS 2017d). No Kendall Warm Springs dace occur at the spring sources; however, dace numbers increase as plant density and water flow increases downstream (USFWS 2015). Recreation activities that may influence the dace and its habitat include use of the dace as bait, which is prohibited; and using spring waters for bathing or cleaning with soaps, bleaches, or detergents, which degrade water quality directly and can lead to lowering of dissolved oxygen levels (USFWS 2015). USFWS considers recreational threats as low (USFWS 2015). Threats deliberated by the USFWS, including livestock in the dace's habitat, reservoir or water impoundment projects, wildfires, acid rain, global warming, and pesticide/herbicide use, are considered low likely threats or unlikely to immediately impact the Kendall Warm Springs dace (USFWS 2015).

The other fish species in the Basin are associated with the Upper Colorado River Endangered Fish Recovery Program. The humpback chub (*Gila cypha*) is a big-river minnow found only in canyon sections of the Colorado River Basin. The bonytail chub (*Gila elegans*) and Colorado

pikenminnow (*Ptychocheilus lucius*) are big-river minnows that are only in the Colorado River Basin. The razorback sucker (*Xyrauchen texanus*) is a big-river fish found only in the Colorado River Basin. Any modifications to waters in the Upper Colorado River Basin may require Section 7 consultation to address potential impact concerns.

All other species should be evaluated during planning for future projects; however, changes in water resources are less likely to directly affect these species and these species would be uncommon in areas supported by the Basin's water resources.

6.2.3 *National Wetlands Inventory*

Wetlands and riparian areas are important ecologically in that they can improve water quality, store sediment, provide habitat, and maintain stream flows. Wetlands are significant environmental features, specifically related to the state's water management planning. Addressing impacts to waters regulated by the USACE under the Clean Water Act are commonly associated with water management planning across the state and in the Basin. Additionally, wetlands provide a variety of recreation opportunities including hunting, fishing, and general passive and active recreation activities.

The USFWS National Wetlands Inventory (NWI) is publically available dataset that maps all potential wetland and waters resources. The dataset was updated in 2016. The NWI categorizes wetlands by type, following the Cowardin classification system (Cowardin et al. 1979). Table 6-7 lists all wetland types and acres by sub-basin in the Basin. Wetland type is important as higher functional value is commonly associated with woody wetlands (e.g., palustrine shrub-scrub or palustrine forested) and projects that impact these wetland types may require a greater level of mitigation.

Over 400,000 acres of NWI are mapped across the Basin (Figures 6-4 through 6-6). Wetlands in the Basin occur primarily along waterways such as rivers/streams and open waterbodies in the northern Basin. Large wetland complexes have developed along the river systems forming expansive riparian systems. Many of these riparian areas are mixed wetland classification (palustrine emergent and palustrine shrub-scrub/palustrine forested) with significant braided channel systems, typical of high functioning systems. The lake classification is also represented by the large reservoirs in the lower Basin and numerous alpine lakes in the Wind River Range. The western and eastern Basin regions have less wetlands when compared to the northern region. Wetlands in the eastern region are fairly small, scattered, isolated features. Wetlands in the western region are also limited to a small number of waterways. One large wetland complex exists near Lyman. This area supports significant agricultural activities which may increase and support wetland complexes through irrigation; however, the non-nature state and potential for seasonal and long-term hydrologic changes may affect the wetland's function and values.

A breakdown of wetland acreages by sub-basin confirms a higher wetland density in the upper watershed, with the New Fork and Upper Green sub-basins containing approximately half of all the wetlands in the entire Basin. The Blacks Fork sub-basin is the only lower basin region that supports a high wetland density.

Table 6-7. National Wetlands Inventory acreage in the Green River Basin by sub-basin.

Sub-basin	Palustrine Emergent	Palustrine Shrub-scrub	Palustrine Forested	Pond	Lake	Riverine	Other	Total
Big Sandy	8,560	1,396	1	705,706	4,344	882	147,148	16,037
Bitter	2,422	232	2	226	598,599	4,950	593	4,124
Blacks Fork	40,923	12,057	980	1,420	7,131	4,885	540,541	67,936
Great Divide								
Closed Basin	7,514	2,886	0	613	5,859	98	3,123	20,094
Little Muddy	3,467	972	39	472	254	23	288	5,517
Little Snake	9,578	1,240	904	627,628	1,920	4,504	299	17,173
Muddy	3,105	239	6	335	210,211	55	324	4,276
New Fork	47,421	6,957	15	3,102	22,678	1,475	2,627	81,674
Upper Green	95,762	29,603	102	2,522	11,186	4,190	7,475	143,440
Upper Green-Flaming Gorge Reservoir	10,653	1,486	260	232	26,185	1,104	109	40,029
Upper Green-Slate	2,143	515	20	127,128	639	2,559	362	6,365
Vermillion	514,515	45	0	2,223	280,281	0	5,556	919
Total	232,062	57,626	2,330	10,406	79,386	19,826	5,945	407,581

In addition to the classification as an NWI lake, the Flaming Gorge Reservoir in Wyoming is provided additional regulatory status as a jurisdictional waterway under Section 10 of the Rivers and Harbors Act. Section 10 of the Rivers and Harbors Act of 1899 (Section 10 of the Rivers and Harbors Appropriation Act 1899) requires that regulated activities conducted below the Ordinary High Water Mark elevation of navigable waters of the United States be approved and/or permitted by USACE. Regulated activities include the placement and/or removal of structures, work involving dredging, disposal of dredged material, filling, excavation, or any other disturbance of soils/sediments or modification of a navigable waterway. Any activity associated with the Flaming Gorge Reservoir will likely undergo additional scrutiny as a result of the navigable water's status.

6.2.4 BLM – Areas of Critical Environmental Concern

The BLM has identified sections of land in Wyoming as Areas of Critical Environmental Concern (ACEC). ACEC are areas within the public land where special management attention is required to protect and prevent irreparable damage to important historical, cultural, or scenic values, fish and wildlife resources, or other natural systems or processes, or to protect life and safety from natural hazards.

ACEC exist throughout the Basin and total approximately 342,800 acres (Figures 6-4 through 6-6); however, many of the polygons are located beyond major water resources. These areas do provide public access for recreational opportunities and in some cases have been sited to support wildlife habitats and sensitive plant species. ACEC in the Basin that were specifically identified as providing support to water resources are discussed in more detail below.

The Rock Creek and Beaver Creek ACECs are located on the southeast border of the Bridger NF and provide protection to the Rock Creek Drainage (tributary to LaBarge Creek) and Beaver Creek (tributary to Piney Creek), both which provide aquatic habitat for cutthroat trout species. The New Fork Potholes ACEC is located along northern section of the Wind River Range along the western slope. This ACEC houses unique pothole habitat which provide trumpeter swan and other migratory waterfowl habitat. Three ACEC all titled Greater Red Creek are located immediately east of the Flaming Gorge National Recreational Area and have been designated to support and enhance watershed values for the Red, Sage, and Currant Creek watersheds, including the protection of riparian areas and cutthroat trout aquatic habitat. The Steamboat ACEC is located in the center of the Basin and designated to enhance and maintain water quality along Jack Morrow Creek. A number of smaller ACEC occur near Henry's Fork Creek and have been designated as protecting rare plant species with the intent to stave off listing.

7 RECREATION

There are many water-based recreation destinations throughout the Basin that are located on public land, including over 1,500,000 acres of national forests, over 7,500,000 acres of BLM land, and almost 135,000 acres of state-managed land (Figures 5-1 through 5-3). The State Trust Land owns over 460,000 acres (one section in each township) of land in the Basin, but these lands are not typically used for water-based recreation.

Recreation use in the Basin includes fishing, boating, whitewater rafting, waterfowl hunting, boating, camping, hiking, general sightseeing (e.g., bird watching), and a variety of other passive recreation activities. Recreation activities associated with water use are fairly concentrated and often occur on land specifically identified for public access, such as USFS land, state parks, and national wildlife refuges. Further discussion on recreation water use is provided below.

Many of the environmental areas discussed above also provide recreation opportunities. Stream corridors and instream flow filings provide opportunities for fishing and boating. The Seedskaadee NWR is an example of a defined area that provides many environmental benefits and recreation opportunities.

7.1 US National Forests

The Bridger-Teton NF covers most of the headwaters in the Wind River Range and Wyoming Range in the northern part of the Basin. There are several lakes and streams in the Bridger-Teton NF that provide water-based recreation opportunities, including fishing, boating, whitewater rafting, and other activities. The Bridger Wilderness and Gros Ventre Wilderness protect higher elevations of the Bridger-Teton NF and restrict use to passive recreation. There are several alpine lakes and small streams that provide recreation opportunities for the public; however, this region does not receive substantial use due to the rugged landscape and limited access. Fremont Lake, Willow Lake, and New Fork Lake are all in the foothills of the Wind River Range near Pinedale in the Bridger-Teton NF. All three waterbodies are popular water-based recreation destinations for boating, camping, fishing, swimming, and other activities. Waters in the Bridger-Teton NF also support native cutthroat populations, which is a popular species with anglers.

The Medicine Bow NF covers some of the headwaters in the Sierra Madre Mountains in the southeastern part of the Basin. Only a small section of this forest occurs in the basin, with a much larger section of forest extending east beyond the Basin boundaries. The Huston Park Wilderness straddles the Continental Divide and protects the forested headwaters for the Little Snake River and the North Platte River. This area provides a variety of recreation opportunities, but human use is low except during elk hunting season. A number of stream segments adjacent to the Huston Park Wilderness in the Medicine Bow NF have instream flow filings to protect high value fisheries that are continuous upstream into the wilderness. No major reservoirs are located in the NF sections, so boating activities are unlikely to occur.

7.2 Reservoirs, Lakes, and Parks

There are over 30 reservoirs and lakes in the Basin, and several of these waterbodies are recognized as major recreation sites, including Flaming Gorge, Fontenelle, Big Sandy, Eden, High Savery, Boulder, and Lake Viva Naughton. Large reservoirs and lakes provide the public with water-based recreation opportunities in the form of boating, fishing, swimming, rafting, jet skiing, wake boarding/waterskiing/tubing, camping, and other passive and active recreation opportunities.

Flaming Gorge and Fontenelle Reservoirs are the two largest reservoirs in the Basin, and the land around Flaming Gorge is designated as a National Recreation Area and managed by the National Park Service. These destination locations are discussed in more detail below.

7.2.1 Fontenelle Reservoir

Fontenelle Reservoir was created by the construction of the Fontenelle Dam that was completed in 1964. The reservoir is located 24 miles southeast of La Barge, Wyoming, almost entirely within Lincoln County, with the east end of the Fontenelle Dam and a tiny portion of the reservoir in northwestern Sweetwater County. The reservoir has recreational facilities that are managed by the BOR for boating, fishing, and camping. Recreation at the reservoir is considered “low” and “seasonal” (Recreation.gov 2014).

Fontenelle Reservoir has a maximum conservation pool elevation of 6,506 feet asl, and at 100% of conservation storage there are approximately 8,000 acres of water surface in the reservoir that is open for fishing and boating, with approximately 56 miles of shorelines. The reservoir is also part of an ongoing WWDC project. The project seeks to increase the usable reservoir capacity by placing rip-rap on the dam.

7.2.2 Flaming Gorge Reservoir and National Recreation Area

The Flaming Gorge National Recreation Area encompasses 96,223 acres in southwestern Wyoming surrounding Flaming Gorge Reservoir from Green River, Wyoming 91 miles south to the Wyoming-Utah border. The reservoir was created by the construction of the Flaming Gorge Dam that was completed in 1964, and with a storage capacity of more than 3,700,000 acre-feet, it is the largest reservoir in Wyoming. Flaming Gorge National Recreation area is administered by the Ashley NF, and recreational activities in the area include camping, hiking, boating, and fishing on the Flaming Gorge Reservoir; however, fishing is by far the most popular activity.

Flaming Gorge Reservoir has a maximum conservation pool elevation of 6,040 feet asl, and at 100% of conservation storage there are approximately 42,000 acres of water surface in the reservoir that is open for fishing and boating. There are at least five boat ramps in the portion of the reservoir that is in Wyoming: Firehole, Buckboard Marina, Holmes Crossing, Upper Marsh Creek, and Anvil Draw.

7.2.3 Big Sandy Reservoir

Big Sandy Reservoir was created by the construction of Big Sandy Dam that was built from 1941 to 1952, and it is located approximately 10 miles north of Farson, Wyoming. Big Sandy Dam is an earthen dam with an unregulated open side-channel spillway with a capacity of 7,350 cubic feet per second. The reservoir is administered by the BOR and has a total storage capacity of approximately 56,750 acre-feet.

Big Sandy Reservoir has a maximum conservation pool elevation of 6757.5 feet asl, and at 100% of conservation storage there are approximately 17,000 acres of water surface in the reservoir that is open for fishing and boating. There is one boat ramp that provides access for

boats to the reservoir. This reservoir is part of an ongoing WWDC project to evaluate expansion potential for storage.

7.2.4 Lake Viva Naughton

Lake Viva Naughton Reservoir is located approximately 10 miles northwest of Kemmerer, Wyoming. The reservoir is owned and operated by the Naughton Power Plant in Kemmerer, and the plant uses water from the reservoir for cooling and steam generation. Occasionally water is released for irrigation in times of abundance, but there are no irrigation uses listed in the permit. The reservoir has a total storage capacity of 45,465 acre-feet, and WGFD has secured public access for fishing, boating, and camping around the reservoir. This reservoir is part of an ongoing WWDC project to evaluate expansion potential for storage.

7.2.5 Seedskafee National Wildlife Refuge

The USFWS manages the Seedskafee NWR to allow for recreation activities while protecting the wildlife and habitats found on the unique landscape in the high desert plains along the Green River. In addition, the NWR is managed to protect the scenery, cultural resources, and other natural resources and provide for public use and enjoyment of compatible wildlife-dependent activities. Recreation opportunities in the NWR include hunting, hiking, wildlife viewing, and other passive recreation activities. However, the NWR is only open from one half hour before sunrise to one half hour after sunset, except for waterfowl hunters with a valid hunting permit, which extends this timeframe to an hour before sunset to an hour after sunset.

7.3 Fishing

Fishing is a major water-based recreation activity in the Basin, and in 2011, over 300,000 anglers took 2,900,000 fishing trips in Wyoming over 3,100,000 fishing days (USFWS 2011). According to the 2015 overnight visitor use census for Wyoming, fishing was the primary motivation for 7% of all trips to Wyoming, and 16% of tourists participated in fishing during their stay (Strategic Marketing and Research 2016). By 2030, fishing in Wyoming is projected to grow as follows:

2030 Low Growth Scenario

- Residential approximately 322,000 angler-days
- Non-residential approximately 166,000 angler-days

2030 Moderate Growth Scenario

- Residential approximately 354,000 angler-days
- Non-residential approximately 223,000 angler-days

2030 High Growth Scenario

- Residential approximately 423,000 angler-days
- Non-residential approximately 299,000 angler-days

WGFD has identified over 60 publicly accessible fishing locations in the Basin along rivers, streams, lakes, reservoirs, and other waterbodies (Figures 7-1 through 7-3). Many of these fishing spots are readily accessible via public lands, or through the WGFD Walk-in Fishing Area program that secures seasonal access to private land or inaccessible public lands that is restricted to foot traffic only. There are four walk-in locations in the Basin that occur along the Green River, New Fork River, and Little Snake River. The remaining fishing spots are accessible through public land.

WGFD has a system for classifying stream fisheries (WGFD 2006) that ranks Wyoming streams and rivers according to the number of pounds of trout per mile measured in each segment (Table 7-1). Blue ribbon streams are classified as having over 600 pounds of trout per linear stream mile, and red ribbon streams are classified as having between 300 pounds and 600 pounds of trout per linear stream mile. Blue ribbon and red ribbon streams are recognized as “special resources” under the Wyoming Stream Mitigation Procedure, which was promulgated by the USACE (USACE 2013).

Table 7-1. Wyoming Game and Fish Department stream fisheries classifications.

Category	Percent of Stream Miles	Pounds of Sport Fish Per Mile
Blue Ribbon	3	≥600
Red Ribbon	6	≥300 and <600
Yellow Ribbon	28	≥50 and <300
Green Ribbon	63	≥1 and <50
Orange Ribbon	Unknown	Any cool/warm water game fish present

A portion of the New Fork River (East Fork – Pine) is classified as a blue ribbon fishery (Figures 7-1 through 7-3). This river section is located in the New Fork sub-basin and is the only blue ribbon fishery in the Basin. Multiple red ribbon fisheries occur throughout the Basin including segments of the Green River above and below Fontenelle Reservoir, Boulder Creek below Boulder Lake, Pine Creek below Fremont Lake, Fremont Creek above Fremont Lake in the northern Basin around the chain lakes, and Fish Creek. A variety of other green and yellow ribbon fisheries occur throughout the Basin, mostly near the Basin’s outer limits. Nearly all of the chain lakes and reservoirs discussed above provide opportunity for sport fishing.

Updated angler data from the past 10 years was not available to support this report. A 2011 *National Survey of Fishing, Hunting, and Wildlife-Associated Recreation* report was reviewed; however, based on the limited sample size and presented standard error this report was not deemed appropriate for the use in this report. Additional efforts were also made to obtain fishing licenses purchase information and associate these data with fishing practices. These data were ultimately determined to be incomplete and potentially biased. Please reference the 2001 and 2010 plans for the most recent available data.

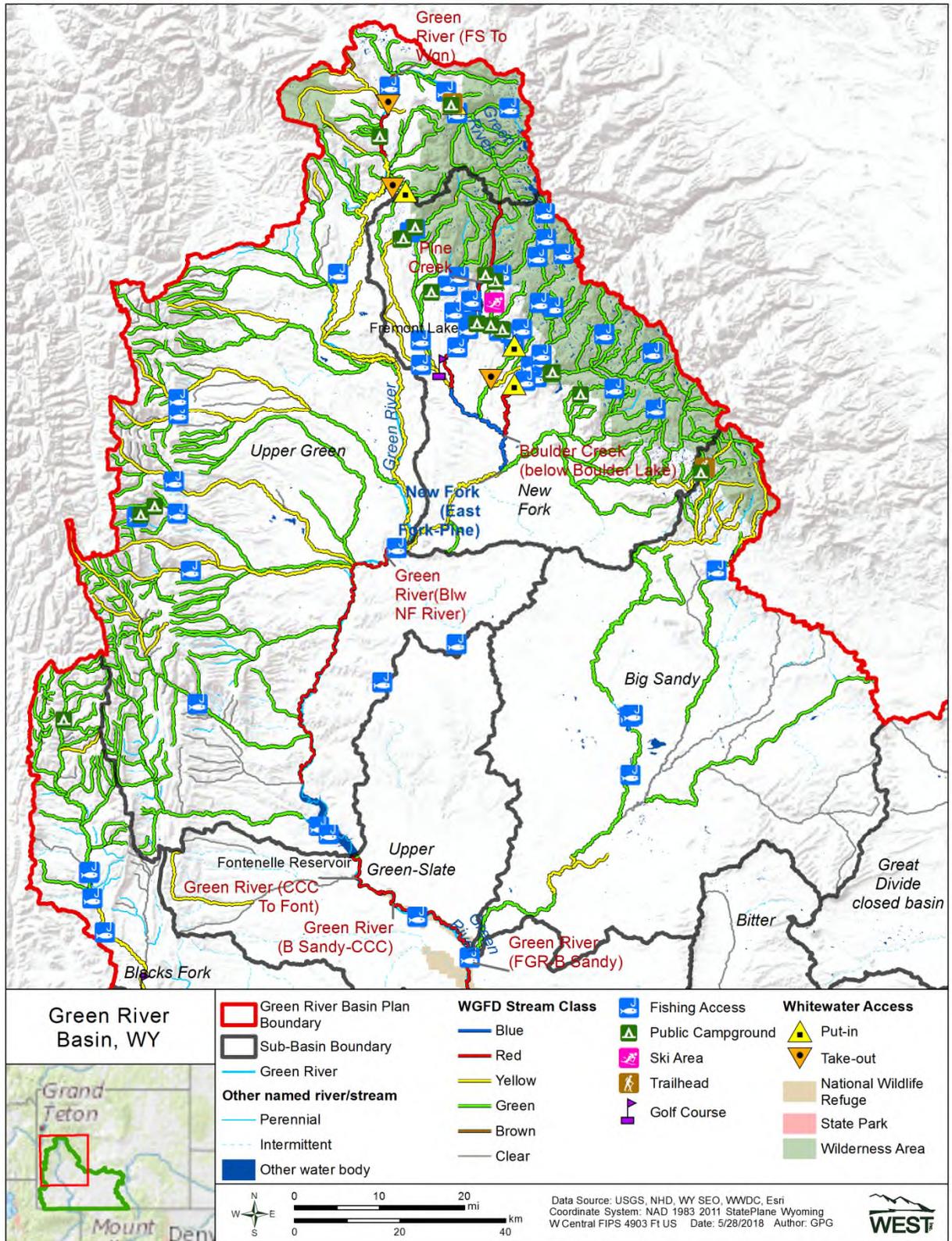


Figure 7-1. Recreational water uses in the Green River Basin – North Section.

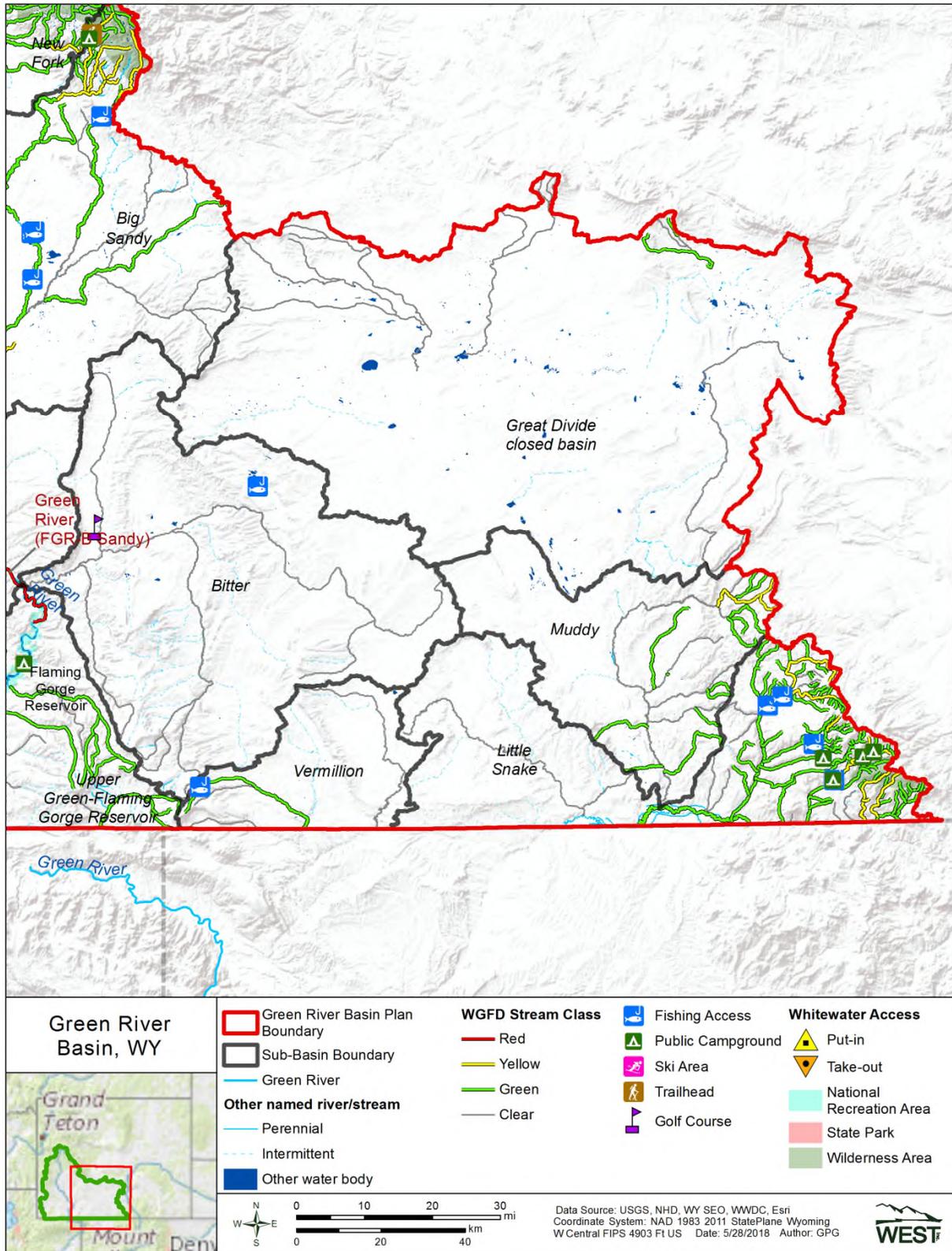


Figure 7-2. Recreational water uses in the Green River Basin – East Section.

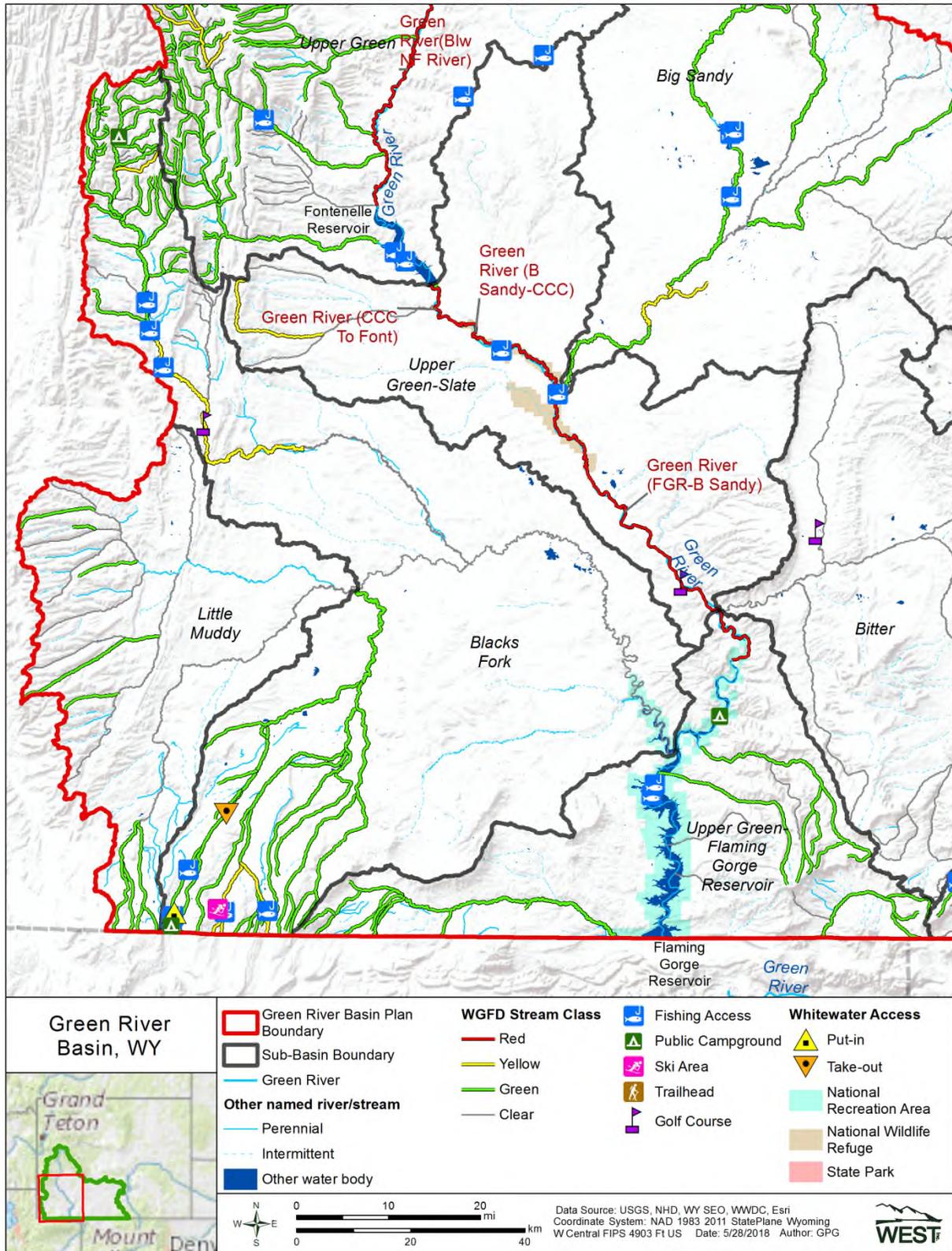


Figure 7-3. Recreational water uses in the Green River Basin – West Section.

7.4 Waterfowl Hunting

The Basin occurs in the Pacific Flyway on the western side of the Continental Divide, and provides several areas for hunting ducks and geese. Between 2011 and 2015, waterfowl hunting in the Basin accounted for 13.0% of the total statewide duck harvest (Table 7-2) and 4.2% of the total statewide goose harvest (Table 7-3). Seedskafee NWR provides the largest contiguous hunting area in the Basin, but there are other hunting areas located along rivers and wetlands. Maintenance and improvement of existing wetlands and riparian areas, and establishment of new areas will help maintain and improve habitat for waterfowl. By 2030, waterfowl hunting in Wyoming is projected to grow as follows:

2030 Low Scenario

- Duck hunting approximately 18,050 hunting-days
- Goose hunting approximately 10,420 hunting-days

2030 Moderate Scenario

- Duck hunting approximately 39,010 hunting-days
- Goose hunting approximately 22,510 hunting-days

2030 High Scenario

- Duck hunting approximately 50,090 hunting-days
- Goose hunting approximately 28,910 hunting-days

The WGFD has divided the Basin into five waterfowl management areas: Upper Green River Basin, Great Divide Basin, Lower Green River Basin, Ham's Fork/Black Fork, and Little Snake. Most waterfowl hunting occurs in the Lower Green River Basin, Ham's Fork/Black Fork, and Upper Green River Basin management areas, with only a handful of hunters in the Great Divide and Little Snake management areas each year. In the Lower Green River Basin management area, between 2011 and 2015, there were an average of 357 duck hunters harvesting 2,173 ducks over 1,508 hunting days (Table 7-2), and an average of 332 goose hunters harvesting 600 geese over 1,181 hunting days (Table 7-3). The Upper Green River Basin and Ham's Fork/Black Fork management areas combined provide comparable waterfowl statistics to the Lower Green River Basin management area, and by comparison, there were less than 25 hunters each year on average in the Great Divide and Little Snake management areas.

Table 7-2. Duck hunter and harvest data for the Green River Basin from 2011-2015.

Management Area	Statistic	5-year Average (2011-15)	2011	2012	2013	2014	2015	WGDF Objective
Upper Green River Basin	# of Hunters	184	147	97	162	242	271	184
	# of Recreation							
	Days	720	439	248	537	1,012	1,362	720
	Harvest	1,261	550	402	1,375	1,681	2,297	1,261
Great Divide Basin	# of Hunters	17	13	15	34	4	21	17
	# of Recreation							
	Days	86	41	34	180	18	156	86
	Harvest	99	25	87	266	18	101	99

Table 7-2. Duck hunter and harvest data for the Green River Basin from 2011-2015.

Management Area	Statistic	5-year Average (2011-15)	2011	2012	2013	2014	2015	WGDF Objective
Lower Green River Basin	# of Hunters	357	365	306	446	325	344	357
	# of Recreation							
	Days	1,508	1,826	1,112	2,337	1,114	1,150	1,508
	Harvest	2,713	2,771	1,769	4,494	2,203	2,326	2,713
	# of Hunters	216	276	140	250	181	235	216
Ham's Fork/Black Fork	# of Recreation							
	Days	890	1,042	400	1,041	999	968	890
	Harvest	1,538	1,656	919	2,176	1,413	1,524	1,538
	# of Hunters	23	24	9	31	26	24	23
	# of Recreation							
Little Snake	Days	52	55	18	61	54	72	52
	Harvest	312	102	1,182	66	102	110	312
Total		2011-15	2011	2012	2013	2014	2015	
Total Basin Harvest		29,615	5,104	4,359	8,377	5,417	6,358	
Total Statewide Harvest		228,116	47,387	50,233	53,296	30,456	46,744	
% of Statewide Harvest in Basin		13.0%	10.8%	8.7%	15.7%	17.8%	13.6%	

Source: Wyoming Game and Fish Department (WGFD) 2017

Objectives source: Huck 2015

Table 7-3. Goose hunter and harvest data for the Green River Basin from 2011-2015.

Management Area	Statistic	5-year Average (2011-15)	2011	2012	2013	2014	2015	WGDF Objective
Upper Green River Basin	# of Hunters	109	85	57	119	134	148	109
	# of Recreation							
	Days	331	191	128	262	477	597	331
	Harvest	167	54	100	94	427	160	167
	# of Hunters	7	7	no data	no data	2	13	7
Great Divide Basin	# of Recreation							
	Days	53	15	no data	no data	4	139	53
	Harvest	2	0	no data	no data	0	7	2
	# of Hunters	332	395	242	450	274	301	332
	# of Recreation							
Lower Green River Basin	Days	1,181	1,190	784	1,961	814	1,156	1,181
	Harvest	600	554	156	882	585	824	600
	# of Hunters	171	213	93	193	172	184	171
	# of Recreation							
	Ham's Fork/Black Fork	Days	694	616	332	624	1,099	797
Harvest		321	364	243	237	387	375	321
# of Hunters		13	9	no data	25	16	2	13
# of Recreation								
Little Snake		Days	18	9	no data	36	23	4
	Harvest	54	9	no data	36	172	0	54

Table 7-3. Goose hunter and harvest data for the Green River Basin from 2011-2015.

Management Area	Statistic	5-year Average (2011-15)					WGDF Objective
		Total 2011-15	2011	2012	2013	2014	2015
Total Basin Harvest		5,666	981	499	1,249	1,571	1,366
Total Statewide Harvest		134,555	21,732	31,993	30,861	29,147	20,822
% of Statewide Harvest in Basin		4.2%	4.5%	1.6%	4.0%	5.4%	6.6%

Source: Wyoming Game and Fish Department (WGFD) 2017

Objectives source: Huck 2015

7.5 Whitewater Rafting and Kayaking

Whitewater rafting is not a major recreation activity in the Basin; however, there are a few established river rafting stream segments between designated “put-in” and “take-out” locations (Figures 7-1 through 7-3) that cover approximately 34 river miles in the Basin (Table 7-4). This information was taken from the American Whitewater website (American Whitewater 2009). These river segments occur in the upper watershed in the northern Basin and in the southwest Basin (Figures 6-4 through 6-6). Other rafting locations exist but are not specifically identified by the website.

Whitewater rapids in the Basin range from beginner (Class I) to expert (Class V+) based on the International Scale of River Difficulty (American Whitewater 2009). Rapid classifications and recommended flows for whitewater segments located in the Basin vary considerably (Table 7-4).

Table 7-4. River rafting stream segment locations, difficulty, flow ranges, and length in the Green River Basin.

Stream Segment	Stream Class	Recommended Flow Range (cfs)	Length (mi)
Pole Creek (Half Moon Lake to Fayette Pole Creek Rd)	I	NA	5
Blacks Fork (Meek’s Cabin to WY 410)	I - III	NA	15
Boulder Creek (Boulder Basin RD to WY 352)	I		2
Green (Green River Lakes to Tepee Creek)	II - III	400 - 5000	12
Total			34

Source: American Whitewater 2009

cfs=cubic feet per second; mi=miles

7.6 Golf Courses

There are four golf courses in the Green River Basin (Figures 7-1 through 7-3, Table 7-5). Two of the courses are linked to municipal water use; one receives water through a ditch diversion, and one has on-site wells. It is estimated that the White Mountain course uses between 185-225 million gallons per year. Water use estimates were not available for the remaining courses.

Table 7-5. Golf courses in the Green River Basin.

Golf Course	Sub-Basin	Water Supply	Estimated Water Use	Estimated Rounds per Year
Rendezvous Meadows Golf Course	New Fork	Pine Creek via Colorado Ditch	NA	16,000-20,000
Fossil Island Golf Club	Blacks Fork	Municipal	NA	NA
White Mountain Rolling Green Country Club	Bitter Upper Green	Two on-site wells Municipal	185-225 million gallons/year NA	40,000 NA

Source: ERO Resources Corporation 2009b

7.7 Ski Resorts

The only commercial ski resort in the Basin is located approximately 10 miles northeast of Pinedale in the New Fork sub-basin (Figures 7-1 through 7-3). The White Pine Ski resort is located within the Bridger-Teton NF boundary in the Wind River Range. The resort has two lifts which provide access to 25 downhill runs. When natural snowfall does not provide sufficient snowpack for skiing, the resort makes snow using water from a small reservoir in the Surveyor Park drainage. The quantity of water used for this purpose is variable and not quantified.

There are several designated cross-country ski areas in the Basin that offer miles of trails, and some of these areas have high use. Popular groomed cross-country ski trails include the White Pine Resort, Skyline Drive, Kelly Park, and CCC Ponds areas near Pinedale (ERO Resources Corporation 2009b). In addition, many ungroomed cross-country and backcountry ski routes are available on NF lands.

8 CATEGORIZATION OF USES

All of the potential E&R use identified above were evaluated and categorized as protected, complementary, or competing. These categories were categorized based on the definition provided in the Handbook and additional discussion with the WWDC and Wyoming SEO. A number of factors were considered to categorize the E&R uses including location in the Basin, land use and ownership, and existing permits, among other factors. The location and magnitude of diversions were specifically evaluated to determine the use categories. Categorization of uses included specific individual E&R activities and categorizations were assigned to larger geographic areas where multiple uses may occur.

Additional information is presented in the Model Development – Protection section that can be used to support discussions on these categories. The protection model demonstrates a relative scale of protection based on a number of identified factors.

8.1 Diversions in the Basin

Prior to evaluating and categorizing E&R uses, water diversions within the Basin were identified and plotted to support the categorization discussions. Diversion data was obtained from the

WWDC River Basin library GIS Products. Figures 8-1 through 8-3 depict the numerous permitted diversions located throughout the Basin. Over 2,000 permitted diversions were identified in the dataset throughout the Basin. This illustrates the large volume of water that is diverted for typical consumptive use and the locations in the Basin where diversions are more common. To help focus the categorization discuss, diversions were filtered to highlight the largest and often most senior water rights. To identify the significant diversions, the spreadsheet model produced for the 2009 update was obtained and the *Technical Memorandum – Green River Basin Plan II Surface Water Data Synthesis & Spreadsheet Model Development* (Frantz 2009) was reviewed. Based on the information provided in the model and Technical Memorandum, the significant diversions were filtered out. This was completed by identifying which model data were associated with permitted diversion, then filtering out diversions that were less than 10 cubic feet per second. The result was a list of 111 significant diversions that exist across the Basin (Figures 8-1 through 8-3). It should be noted that the model and discussion in the Green River Basin Plan Update (2010) aggregated the diversion information which may differ from the information presented here. However, the demonstration of all diversion locations and significant diversion locations will support the categorization exercise provided below.

A large number of diversions are permitted throughout the Basin; however, most individual diversions are small enough to have little significant effects on E&R water use. The more significant diversions may have a greater effect on E&R uses due to the volume of water diverted for consumption. In general, the significant diversions are more commonly located in the northern Basin region in the Upper Green and New Fork sub-basins. A relatively high number of significant diversions also exist in the Blacks Fork and Little Snake sub-basins. The largest diversion exists in the Big Sandy sub-basin. The Eden No. 1 Canal diversion is permitted for 243.6 cubic feet per second. No diversions exist along the Green River from Fontenelle Reservoir to Flaming Gorge and the Wyoming – Colorado State line. Similarly, no diversions exist in the Great Basin Divide Closed sub-basin and there are limited diversions in the Bitter, Big Sandy, Vermillion, and Upper Green-Slate sub-basins. Detailed information on the water use and diversions within the Basin can be found in the Green River Basin Plan Update (2010).

8.2 Categorization of E&R Uses

E&R uses were categorized based on the relationship between current and future water conditions and their ability to significantly alter E&R uses. The categorization process did assume that current conditions support existing E&R uses and that a change in water regimes is unlikely to be significant and wide spread. While individual E&R uses may be impacted or enhanced by individual diversion or other water projects, this exercise did not try to identify every potential situation for each individual body of water and associated use. Instead, a broad-scale approach was taken to categorize E&R uses based on common traits (e.g., all wilderness areas are protected or all reservoir recreation is competing). The model section of this report (see Section 8.3) can be used to support the categorization of uses, by identifying a sliding-scale of protection and associating it to areas where high levels of E&R uses exist. Ultimately, the model approach may be more useful when evaluating E&R uses relative to potential future project planning and the effect on E&R uses.

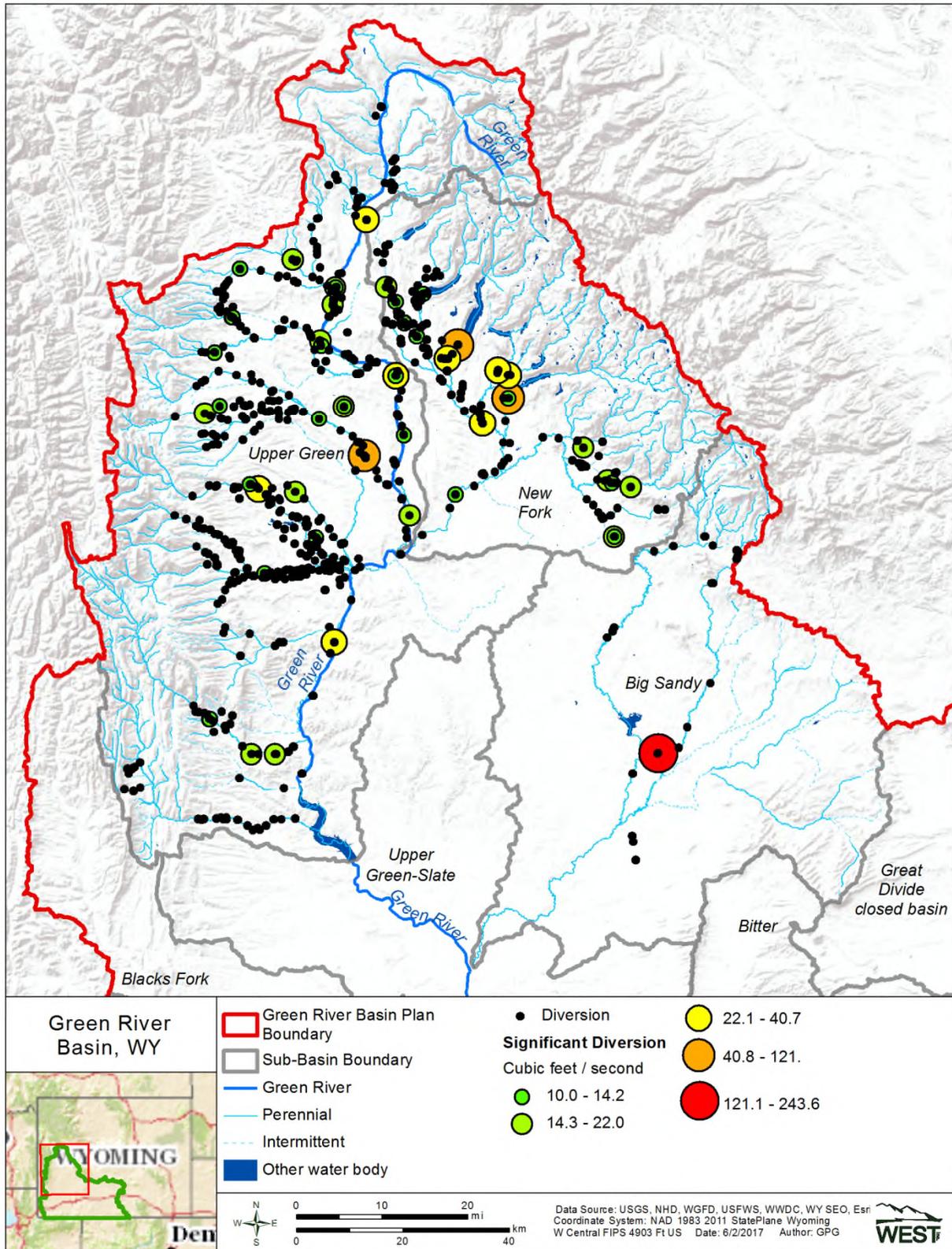


Figure 8-1. Diversion locations and magnitude in the Green River Basin – North Section.

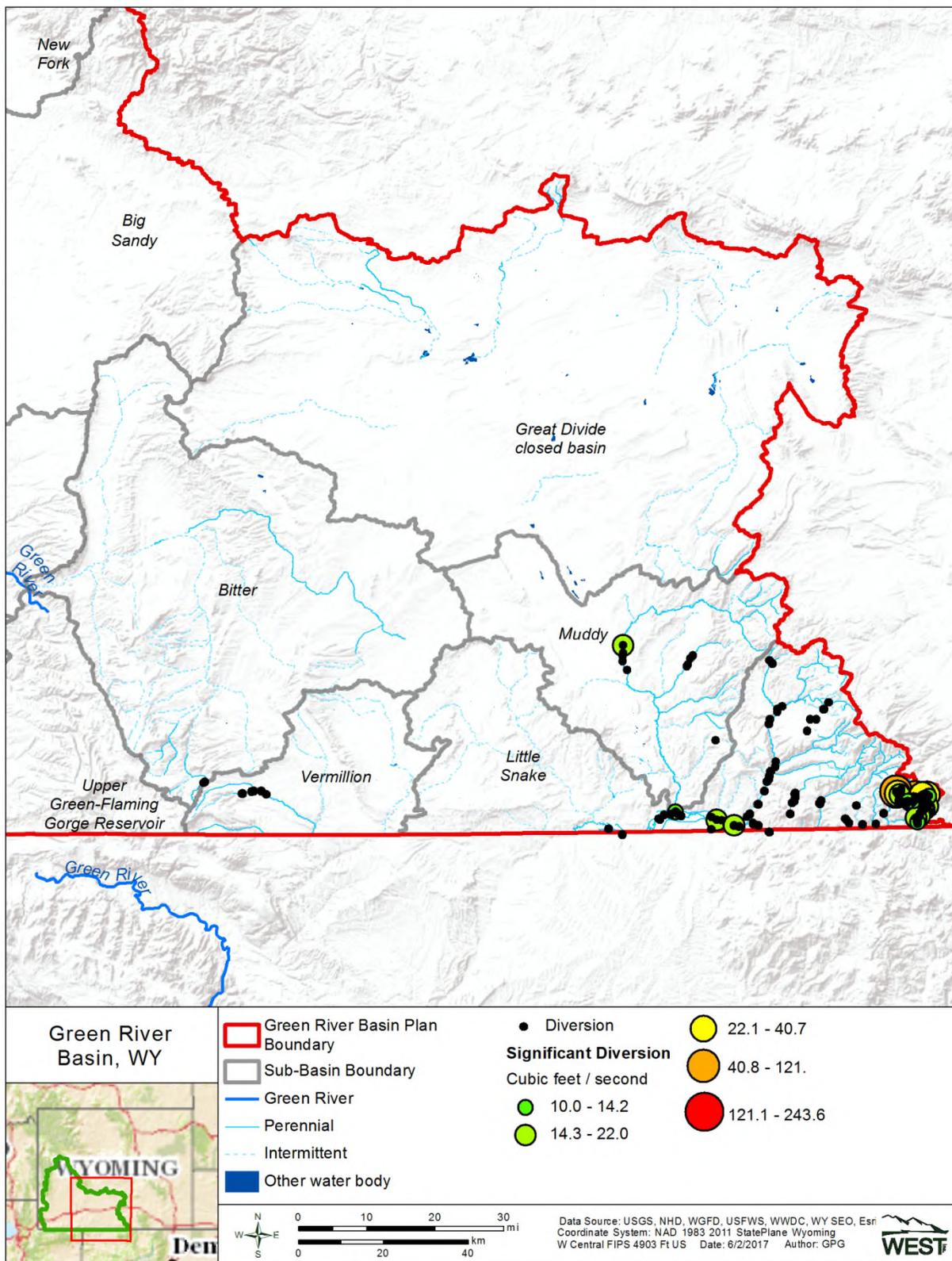


Figure 8-2. Diversion locations and magnitude in the Green River Basin – East Section.

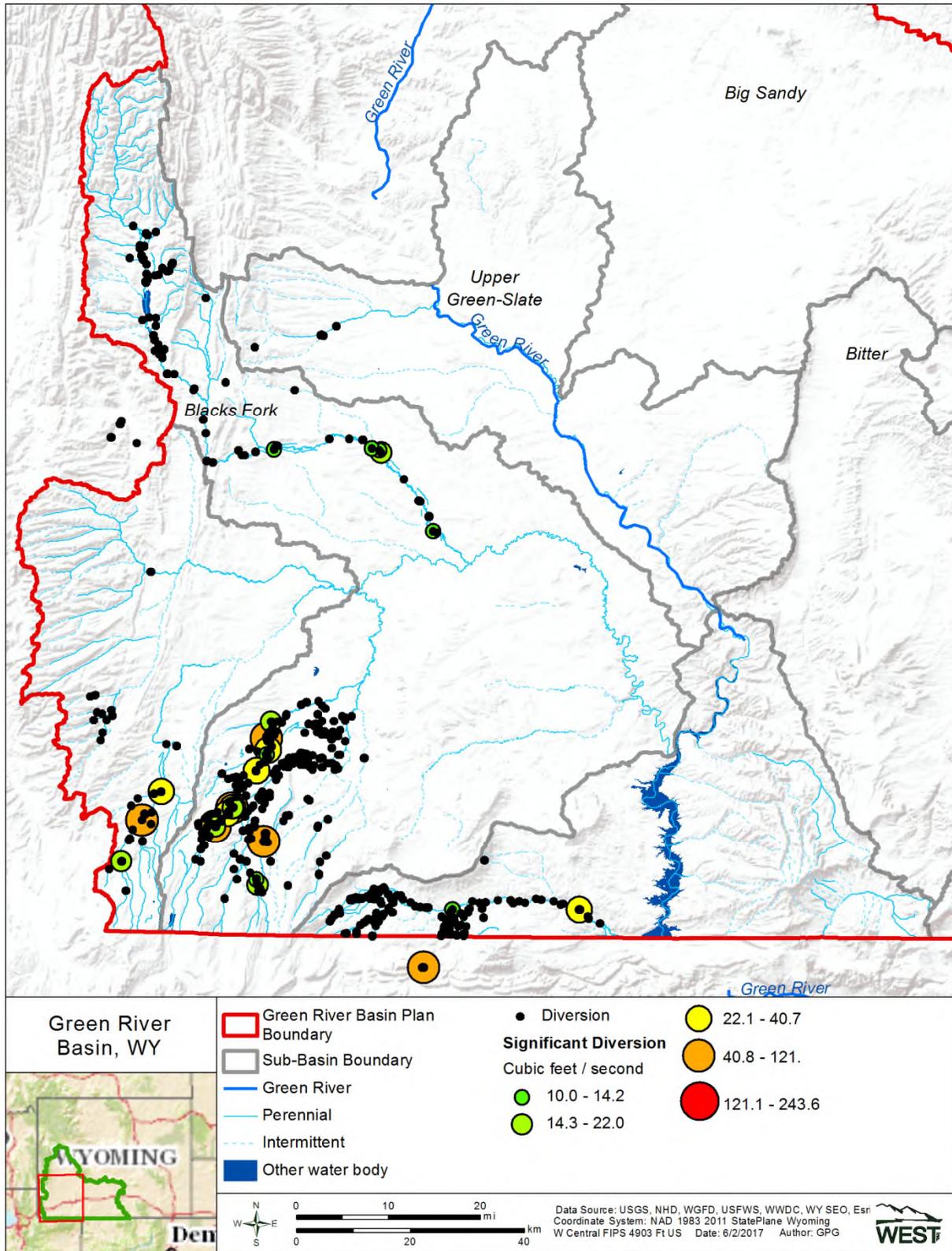


Figure 8-3. Diversion locations and magnitude in the Green River Basin – West Section.

Protected E&R water uses in the Basin exist along the permitted instream flow sections. The stream segment stretches and associated E&R uses occur on USFS land in the Upper Green, Black's Fork, and Little Snake sub-basins and provide a high level of recreation use that include fishing, hiking, camping, boating, and other passive recreation opportunities; and environmental uses including wetlands/waters, USFWS critical habitat, and WGFD priority areas. The other instream flows are scattered around the Basin, typically high in the watershed. The instream flow starting at Fremont Lake provides protection for a stretch of blue ribbon fisheries classified along the downstream section of New Fork River. Additional information on the instream flows are provided in Section 6.1.1 and in previous Basin Plans. E&R uses are also protected in the sections of Bridger and Gros Ventre Wilderness in the northern Basin and the small section of Huston Park Wilderness located along the eastern Little Snake sub-basin. Development is precluded in these areas; therefore, all associated E&R uses cannot be affected. E&R uses in the wilderness areas are similar to those discussed for instream flow filings, but due to the remote nature, likely are used less by the public.

The E&R uses associated with Seedskafee NWR are categorized as protected. Fontenelle Reservoir is located immediately upstream from the NWR and has permitted bypass flow requirements. This ensures that the all E&R uses provided by the NWR are protected. The Green River segment and associated E&R uses from the NWR to Flaming Gorge can be considered complementary as no diversions were identified along this stream section; however, no explicit protection is provided to this river segment. Similar situations occur along the Blacks Fork below Meeks Cabin Reservoir and Cottonwood Creek below the Stateline Reservoir. These reservoirs have permits that stipulate a minimum bypass that protects E&R uses along stretches of river below the dams. Other current E&R uses can be considered protected at the present time due to their location in the Basin; however, are complementary as no finite protection is assigned. All E&R uses above existing diversions can be considered complementary, but are technically protected until future water diversion or management activities are permitted. Waters and E&R uses above the diversion cover a large portion of the Basin, specifically in the New Fork, Upper Green, Black's Fork, and Big Sandy sub-basins where a significant amount of water and subsequent E&R uses exist. This includes major E&R uses from the Green River headwaters downstream to the confluence with Beaver Creek and all associated tributaries along this stretch; all of the chain lakes and upstream waters; North and South Horse Creeks upstream of the Bridger USFS line; a number of stream sections associated with the Cottonwood Creek, Piney Creek, and Muddy Creek complexes along the western Basin limits; and the Savery and Sandstone Creeks complexes along the southeastern Basin limits. These areas include a large section of USFS managed lands, which provide an additional layer of protection. Fishing access is common along these waterbodies. Most, if not all of the E&R uses in the Great Divide Closed Basin, Bitter, and Vermillion sub-basins can be considered complementary (though currently protected) due to the lack of diversions. These areas have not been targeted for water development due to a lack of industry or agriculture that requires water for operation.

Competing recreational uses can be categorized around the large recreation reservoirs across the Basin. Due to the reliance of access (e.g., boat ramps, camp sites, etc.) to maintain specific

recreation uses, these sites are competing. It is not uncommon for heavy early season runoff entering the reservoirs and low-level early season water releases to flood the reservoirs, inhibiting recreation opportunities. This results in a competing situation. Similarly, depending on annual climate, late season conditions may draw reservoirs down to a level where recreation becomes difficult. Major reservoirs including Fontenelle, Flaming Gorge, Big Sandy, Eden, Viva Naughton, among other smaller reservoirs across the Basin, fall into the competing categorization. E&R use along the Smiths Fork and Blacks Fork can be considered competing as the water moves downstream. These areas have a significant number of diversions, including high volume and senior water rights. Potential impacts to E&R uses may be observed depending on the season and annual climate, resulting in a competing situation.

All other E&R water uses across the Basin are assumed to be complementary. This is based on the assumption that current water conditions will continue in a similar regime to historic water use. A number of large permitted diversions with senior water rights exist throughout the Basin and require water to be maintained in the stream, thereby complementing E&R uses, specifically wetlands, potential USFWS listed species habitats, and WGFD priority and crucial areas. Similarly, while small in magnitude, the thousands of other diversions that exist along the waterways cumulatively support E&R uses throughout the Basin, as water will remain in the system to complement the E&R activities. These small and large diversions have the ability to affect E&R uses at a localized scale if modifications were to occur.

Divertible recreation uses include golf courses and ski resorts. All of the golf courses are protected uses as they receive water through either municipal entities or other permitted diversions or wells. Information on the amount of water used and the permit status by the ski resort was not available for this report; therefore, no categorization is assigned.

8.3 Model Development

The development of protection and use models was first investigated by the WWDC and implemented in the Snake and Salt River Basin Plan Update (Pavlica 2013). The model development was prompted as a way to reevaluate the methods presented in the Handbook (Harvey Economics 2012). The Handbook outlined a consistent method to identify E&R uses, as detailed above. However, implementation of the method on full basins has identified two key factors that require further and potentially new evaluation methods:

- 1) The large volume of data demonstrating E&R uses across the individual basins can be overwhelming to the evaluators and readers. Many of the data are focused in localized areas making interpretation and demonstration of uses difficult.
- 2) The categorization of uses can be complicated by potential future changes in water regimes, as well as separating out the current relationships among E&R uses, land ownership requirements, climate effects, divertible/non-divertible, and water demands/diversions.

These factors are often so intermingled a person may make a reasonable argument to categorize a use under more than one category; this can become a slippery slope that does not answer the key questions or meet the goals and objectives of basin planning.

To that end, the model approach has been developed and implemented to address the key questions and goals as listed below:

- 1) Where do the E&R uses exist and at what magnitude are they present across the Basin?
- 2) What protection is in place for the E&R uses and at what scale are the protections present across the Basin?
- 3) What E&R uses and locations may be most affected by changes in future water management and planning?

Ultimately, these models will be used in conjunction with the E&R use information presented above and water uses detailed in the individual basin plans. These models will demonstrate the relative scales, but it is still important to recognize the individual E&R uses and how they may affect or be affected by a change in water management.

8.3.1 Protection Model

The protection model was developed to demonstrate the institutional protection provided to stream segments in the basin and subsequent support of E&R uses. This model may be used to identify the level of effort required to obtain a permit or make changes to the surrounding landscape. The results of the model for each sub-basin are displayed in Appendix A.

Two primary factors were considered to inform the protection model: 1) Land ownership and 2) Individual factors. Land ownership is often a driving component related to the inherent protection of waters. Scores for land ownership protection were informed based on the answers to five questions listed below and a general understanding as to the process each landowner/manager undergoes to evaluate projects and manage resources (Table 8-1).

- Is water development allowed?
- Do proposed actions trigger National Environmental Protection Act compliance?
- Is water development a land manager objective?
- Are lands managed for environmental uses?
- Are lands managed for recreational uses?

Table 8-1. Land ownership – management scores used to inform the protection model.

Land Ownership	Score	Justification
State Park	4	Protected: State application process.
National Forest Service	5	Protected: Each national forest has its own land and resource management plan with defined goals and objectives; NEPA required.
National Park Service	5	Protected: All parks "tier" to the system plan; however, there are individual Park Management Plans that have specific goals and objectives for each park; NEPA required.
Bureau of Land Management	4	Each field office has its own Resource Management Plan that identifies goals and objectives for a specific management unit; NEPA required.
Bureau of Indian Affairs	3	Bureau of Indian Affairs has its own environmental management system and review process (Environmental Management Assessment and Performance Program), but they also must comply with the National Environmental Policy Act by showing alternatives and impacts were considered in water development projects.
Bureau of Reclamation	3	Bureau of Reclamation either develops a Resource Management Plan for a specific management unit or they partner and relinquish management to state land management agencies. Water management clear BOR goal.
US Fish and Wildlife Service	5	Protected land; National Wildlife Refuges are required to have a Comprehensive Conservation Plan that outlines management objectives to protect the environmental and recreational integrity of the National Wildlife Refuge. Development not typically allowed.
Wyoming Game and Fish	5	Protected land; Wildlife Habitat Management Areas are managed for wildlife and hunting/fishing. Development not typically allowed.
The Nature Conservancy	5	Protected land; The Nature Conservancy drafts different management plans tailored to specific environmental/land use objectives. Development not typically allowed.
Department of Defense	5	If a federal action, requires NEPA compliance. Specific management goals/objectives.
Other	2	Level of protection based on specific owner.
State Department of Natural Resources	5	Assigned consistent with the Wyoming Game and Fish.
County	2	Varies, most have conditional use permit requirement; no NEPA.
State land	2	No NEPA evaluation is required. Limited management planning.
Private	0	No evaluation required.

Other factors used to inform the protection model were the presence of wilderness areas, instream flows, critical habitat, Wild and Scenic Rivers, and NWI wetlands. These factors were selected for inclusion in the model due to the existing permits that regulate a change in water use (e.g., instream flows) or because they are protected by laws or acts and/or require additional analysis or permitting to allow a change in water use (e.g., jurisdictional wetlands are protected and require permits to impact under the CWA). In most cases, these factors were scored as present or absent, either receiving the full score or no score at all. Wild and Scenic Rivers and NWI wetlands were treated slightly different, as a different value is associated with the sub-categories of these datasets. The presence of Wild and Scenic Rivers was provided as an example of a protected area in the Snake and Salt River Plan. Presence of NWI wetlands is also an example as wetlands are categorized by the habitat value and general rarity, which

results in a different evaluation when considering impacts and required mitigation. Palustrine forested wetlands are less common and provide structural diversity that benefits wildlife. Conversely, palustrine emergent wetlands are more common and provide less functional value. Mitigation required to offset palustrine forested wetland impacts may range from 3:1 to 5:1, while impacts to palustrine emergent wetlands typically require mitigation ratios of 1:1 to 1.5:1. As such, NWI wetland categories were scored relative to their assumed functional value. The full list of factors, scores, and justification are provided in Table 8-2.

Table 8-2. Protection model factors, scores, and justification used to inform the protection model.

Factors	Presence/Category	Score	Justification for inclusion
Wilderness Areas	Yes	5	No construction allowed.
	No	0	
Instream Flow	Yes	5	Flow protected by permit
	No	0	
Critical Habitat	Yes	3	Protected under the Endangered Species Act
	No	0	
Wild and Scenic	Wild	5	Protection under the Wild and Scenic Rivers Act
	Scenic	4	
	Recreation	3	
National Wetlands Inventory	Forested	3	Protected under the Clean Water Act
	Shrub	2	
	Emergent	1	
	Waters of US	1	

8.3.1.1 Upper Green – Protection

Protection scores ranged from low to high across the Upper Green sub-basin. High scores exist in the upper watershed along the north and west sub-basin limits. These areas include the headwaters to the Green River, Cottonwood Creek, Piney Creek, South Creek and other smaller tributaries where instream flows exist. Protection in these areas includes critical habitat, NWI mapping, and USFS managed lands. Water resources below the USFS boundaries received lower protection scores.

8.3.1.2 New Fork – Protection

Protection scores ranged low to high across the New Fork sub-basin. High protection scores are more common in the upper reaches of the sub-basin's watershed. These areas are typically USFS managed land and include wilderness areas, instream flows filings, critical habitat, or other high scoring protection factors. The highest scores were assigned to waters above Willow and New Fork Lakes. Moderate-high scores exist throughout the remainder of the upper watershed above the chain lakes. Moderate to moderate-low scores were assigned to waters below the chain lakes, including New Fork River, Pole Creek, Boulder Creek, East Fork River and tributaries throughout the sub-basin. The main stem of the New Fork River had sections with scores ranging from 3 to 8, which is important considering the high E&R scores demonstrated below.

8.3.1.3 Upper Green-Slate – Protection

Protection scores ranged from low to moderate-high in the Upper Green-Slate sub-basin. Moderate-high scores exist along the Green River, below Fontenelle Reservoir where critical habitat is designated for the yellow-billed cuckoo and Seedskafee NWR exists. Low protection scores exist along most other water resources including Alkali Creek, Shute Creek, Slate Creek, and large sections along the lower Green River.

8.3.1.4 Big Sandy – Protection

Protection scores ranged from low to moderate-high across the Big Sandy sub-basin. Moderate-high scores occur in the very northern reaches of the sub-basin. Scores in this area were driven by USFS managed land. Scores along nearly all other waters were on the lower end of the protection range. Based on the protection model scores, this sub-basin is provided less protection relative to the other sub-basins.

8.3.1.5 Blacks Fork – Protection

Protection scores ranged from low to moderate-high across the Blacks Fork sub-basin. Moderate-high scores were more common in the upper watershed near the northwestern sub-basin limits in and around the Ham's Fork River complex. Individual river segments are protected by instream flow filings, critical habitat, and USFS land management. The majority of the other water resources in the sub-basin scored low to low-moderate due to the lack of institutional protections, including the main stem of the Blacks Fork and Hams Fork.

8.3.1.6 Bitter – Protection

Scores across the Bitter sub-basin ranged from low to low-moderate. Individual stream segments displayed high score variability along the stream lengths due to checkerboard ownership patterns. Outside of generally low protection scores, no trend was apparent in the sub-basin.

8.3.1.7 Great Divide Closed Basin – Protection

Limited water resources exist across the large sub-basin. Scores range from low to moderate, with most stream reaches in the low scoring range. Moderate scores exist in short segments along Separation Creek. Based on the scoring model results, generally low protection is afforded to the water resources in the Great Divide Closed Basin.

8.3.1.8 Muddy – Protection

Water resources only exist in the eastern portion of the Muddy sub-basin. Protection scores range from low to moderate-high. Moderate and moderate-high scores exist along segments of the Muddy Creek, Littlefield Creek, and McKinney Creek where instream flow filings provide additional protection scores. All other water resources scored low or moderate-low, including the Muddy Creek and associated tributary complex.

8.3.1.9 Little Muddy – Protection

Protection scores ranged from low to moderate across the Little Muddy sub-basin. Only small segments of the Muddy Creek complex in the southern sub-basin scored moderate. Outside of small low-moderate scoring segments in the upper watershed, most of the water resources scored low for protection.

8.3.1.10 Upper Green-Flaming Gorge – Protection

Protections scores ranged from low to moderate–high across the Upper Green-Flaming Gorge sub-basin. Moderate and moderate–high protection scores exist along the Current Creek, Trout Creek, and Red Creek within the instream flow filing segments. Other smaller stream segments scored moderate along the Henry’s Fork and Green River. All other water resources scored low or low–moderate due to a lack of institutional protection.

8.3.1.11 Vermillion – Protection

Protection scores ranged from low to moderate across the Vermillion sub-basin. One small segment of the North Fork Vermillion Creek and Canyon Creek scored moderate due to the presence of NWI mapping. In general, limited protection is evident for water resources in the sub-basin.

8.3.1.12 Little Snake – Protection

Protection scores ranged from low to high across the Little Snake sub-basin. High and moderate-high scores were more common in the upper watershed near the eastern sub-basin limits in and around Battle Creek. These water resources are protected by instream flow filings and USFS land management. The Little Snake River main stem and tributaries scored low to low-moderate.

8.3.2 *Environmental Model*

The goal of the environmental model is to identify the range of environmental factors present for specific water resources in the Basin. This model can be used in conjunction with the protection model to identify areas where high levels of environmental resources exist and associated levels of protection are provided. This can be used to focus on areas where a change in water management may have a greater effect on the environmental resources present. The results of the model for each sub-basin are displayed in Appendix B.

Three categories were considered to inform the environmental model: 1) Land ownership; 2) state resources; and 3) federal resources (Table 8-3 and 8-4). These factors are consistent with the E&R use data presented in the results section. Land ownership is often a driving component related to the inherent environmental value present near Basin waters. Land ownership may affect environmental components in a number of ways. Many of the major land owners have formalized resource management plans to specifically address and manage environmental resources. For example, the USFS and BLM have formalized plans identifying natural resource locations and a plan to manage these resources in line with other agency objectives. Other state agencies have developed strategic action plans to support management

of environmental resources. The WGFD is an example where the state agency does not own the land, but has identified areas to focus and strategize management activities. Scoring for land ownership was assigned in this manner. Scores for land ownership environmental resources were informed based on the answers to three questions listed below and a general understanding as to the process each landowner/manager undergoes to evaluate projects and manage environmental resources (Table 8-3). These scores may be different from the protection model land ownership scores due to the methods used to evaluate the landowner relative to environmental resources.

- Does the landowner have a formalized resource management plan (RMP)?
- If yes, where do environmental resources fit in the overall objectives of the RMP?
- Is NEPA compliance (or another evaluation that includes environmental resources) required to authorize projects that may impact environmental resources?

Table 8-3. Land ownership – management scores used to inform the environmental model.

Landowner-Manager	Scores	Justification for Score
State Park	3	Has a comprehensive recreation plan that includes environmental resources, but more focus on recreation resources.
National Forest	5	Detailed Resource Management Plan (RMP) with Environmental Impact Statement (EIS) requirements for changes; heavy focus on environmental resources.
National Park	5	Detailed RMP with EIS requirements for changes; heavy focus on environmental resources.
Bureau of Land Management	4	Detailed RMP with EIS requirements for changes; primary objectives focused on promoting mixed land use of which environment is considered.
Bureau of Indian Affairs	3	Has an Irrigation RMP which includes small environmental sections.
State land	3	No clear environmental RMP. Focus on agriculture and commercial uses.
Private	0	Highly dependent on individual owner, no requirements.
Bureau of Reclamation	2	Follows standard laws/acts/regulations but does not have a clear RMP; either develops a RMP for a specific management units or they partner and relinquish management to state land management agencies.
State Fish and Wildlife	5	Has clear SHP/SWAP, but in many cases does not own the land it is targeting (in this case it does own the land).
US Fish and Wildlife Service	5	Primary objective is to conserve, enhance, restore environment.
The Nature Conservancy	5	Primary objective is to conserve, enhance, restore environment.
Department of Defense	3	Has a natural resource program, but primary goal is to support military actions (natural habitat for training).
Other	0	Unknown; therefore no score provided.
State Department of Natural Resources	5	Assume these fall under Wyoming Game and Fish Department action plans.
County	2	Varies by county; most have a conditional use permit (or similar). Environment not a major focus.

State and federal environmental resources were also included to inform the environmental model. These include a variety of designated areas including WGFD priority habitats, USFWS NWRs, USFWS threatened and endangered species habitat, and NWI wetlands, among others. The report relies on the state and federal agencies and other publically available data to identify the environmental factors. It is assumed that the state and federal agencies are familiar with the important environmental resources and have targeted areas in the Basin that should be recognized. Similar to the protection model scheme, most of these resources were scored as present or absent, either receiving the full score or no score at all. Exceptions were made to resources that included multiple categories (e.g., NWI wetlands and WGFD priority habitats). The full list of factors, scores, and justification are provided in Table 8-4.

Table 8-4. State and federal resources used to inform the environmental model.

Resource	Presence/Category	Score	Justification for Score
State			
Wyoming Game and Fish Department (WGFD) Priority Areas	Crucial Stream	2	WGFD identifies these as specific environmental features, but they are not formally recognized in the State Wildlife Action Plan or Strategic Habitat Plan or tied to clear management objectives. Additionally, WGFD does not own the land where these features exist.
	Crucial Aquatic	4	WGFD identified features with specific management strategies as Goal 1; however, WGFD does not own the land where these features exist.
	Crucial Combined	4	WGFD identified features with specific management strategies; however, WGFD does not own the land where these features exist.
	Nongame	3	WGFD identified features with specific management strategies, does not necessarily target water resources; WGFD does not own the land where these features exist.
Instream Flow Filing	Yes	5	State permitted features with the goal of maintaining/conserving environmental factors (i.e., fisheries).
	No	0	
Federal			
National Wildlife Refuge	Yes	5	US Fish and Wildlife Service (USFWS) owned and managed lands specifically for the environment.
	No	0	
Wild and Scenic	Wild	5	Rare features identified specifically for the environmental properties; highest level of Wild and Scenic.
	Scenic	4	Rare features identified specifically for the environmental properties; second tier Wild and Scenic.
Wilderness Areas	Yes	5	Areas provided the highest level of conservation protection.
	No	0	
USFWS Threatened and Endangered	Species habitat (individual)	1	Areas identified by the USFWS as having the potential for individual listed species.
	No species habitat	0	
Critical habitat	Yes	5	USFWS designated areas that are essential to the conservation of individual species.
	No	0	

Table 8-4. State and federal resources used to inform the environmental model.

Resource	Presence/Category	Score	Justification for Score
National Wetlands Inventory	Forested	5	Features identified specially for the regular presence of hydrology. These features provide demonstrable value to the environment. Forest wetlands are the least common and often require a greater level of mitigation due to the values they provide.
	Shrub	3	Same wetland definition...second tier value associated (relative to other wetland types).
	Emergent	1	Same wetland definition...third tier value associated (relative to other wetland types), most common wetland type.
	Waters of the US	2	Regulated under the Clean Water Act due to value provided to the environment.
Bureau of Land Management	Yes	2	Areas identified as needing additional management actions...not all are environmental related (e.g.; historic sites).
Critical Environmental Concern	No	0	

8.3.2.1 Upper Green – Environmental

Environmental scores ranged from low to high across the Upper Green sub-basin. High and moderate-high scores exist throughout the upper watershed near the headwaters for the Green River, Horse Creek, Cottonwood Creek, and Piney Creek complexes. These areas contain a variety of environmental uses including instream flow filings, critical habitat, and WGFD designated priority areas. Most of the lower Green River main stem scored moderate, from the confluence with Horse Creek to Fontenelle Reservoir. Smaller stream segments lower in the watershed (below USFS boundaries) score low or low–moderate. Based on the environmental scores, the Upper Green sub-basin demonstrates a wide range of environmental uses.

8.3.2.2 New Fork – Environmental

Environmental scores across the New Fork sub-basin ranged from low to high. High and moderate-high environmental scores exist along small sections of the New Fork River and the streams above the chain lakes. This area includes wilderness area, critical habitat, and is located on USFS managed land. Moderate–high scores exist throughout the sub-basin’s upper watershed in areas that include wilderness areas and USFS managed lands. Extensive NWI features also occur throughout this region. A long segment of the New Fork River from the confluence with Pine Creek to the sub-basin limits scored moderate. This segment is designed at a priority habitat and crucial stream corridor by WGFD. The remaining water resources scored low-moderate or low, including the waters from the East Fork River – Silver Creek confluence to the USFS boundary, Pole Creek, small segments below the chain lakes, and a scattering of other New Fork River tributaries. A handful of small stream segments along the East Fork River, Cottonwood Creek, Muddy Creek, and Silver Creek scored low.

8.3.2.3 Upper Green-Slate – Environmental

Environmental scores ranged from low to high in the Upper Green-Slate sub-basin. High scores exist along the Green River where Seedskafee NWR and critical habitat for the cuckoo are

mapped. Moderate scores exist along the Green River above and below the NWR limits. Low protection scores exist along most other water resources including Alkali Creek, Shute Creek, and Slate Creek.

8.3.2.4 Big Sandy – Environmental

Environmental scores ranged from low to moderate–high across the Big Sandy sub-basin. Moderate–high scores exist in the northern sub-basin region, where WGFD crucial habitat, wilderness area, and USFS managed lands are mapped. Moderate scoring segments were mapped along segments of the Big Sandy River and Little Sandy River. The remaining water resources across the sub-basin were scored as low or low–moderate due to a lack of mapped environmental uses.

8.3.2.5 Blacks Fork – Environmental

Environmental scores ranged from low to moderate-high across the Black's Fork sub-basin. Moderate-high scores exist in the northwest section of the sub-basin along the Ham's Fork headwaters. This area is mapped as critical habitat and WGFD priority habitat. Other small sections of moderate–high scores exist along instream flow filings near the southern sub-basin border. Moderate scores are scattered throughout the sub-basin along the Black's Fork and Ham's Fork River complexes. Low and low–moderate scores make up the bulk of the water resources across the sub-basin, typically along higher order stream segments.

8.3.2.6 Bitter – Environmental

Environmental scores ranged from low to moderate across the Bitter sub-basin. Moderate scoring segments exist along the Bitter Creek, Black Butte Creek, and Salt Creek complexes, where WGFD crucial stream segments and KNWA are mapped. The moderate and moderate-low scores are highly variable along the stream segments, based on land ownership changes.

8.3.2.7 Great Divide Close Basin – Environmental

Environmental scores ranged from low to moderate across the Great Divide Closed Basin sub-basin, with most water resources scored for low environmental uses. Moderate environmental scores exist along small segments of Separation Creek. These areas scored higher due to WGFD WHMA and BLM ACEC designations. All other stream segments scored low for environmental uses.

8.3.2.8 Muddy – Environmental

Environmental scores ranged from low to moderate-high across the Muddy sub-basin. Moderate-high scores exist in the northeast sub-basin segments. These areas scored higher due to instream flow filings and WGFD priority designations. Other small segments along Muddy Creek and Middle Fork Wild Cow Creek scored moderate due to WGFD crucial stream and WHMA designation. Most of the water resources in the sub-basin scored low or low–moderate due to a lack of environmental factors.

8.3.2.9 Little Muddy – Environmental

Environmental scores ranged from low to moderate across the Little Muddy sub-basin. Moderate scores are scattered along Muddy Creek and Little Muddy Creek alignments. These areas include WGFD designated priority habitats and NWI features. Low and low–moderate scores were common throughout the remainder of the sub-basin including most of the upper watershed.

8.3.2.10 Upper Green-Flaming Gorge – Environmental

Environmental scores ranged from low to moderate–high across the Upper Green-Flaming Gorge sub-basin. Moderate and moderate–high environmental scores exist along Current Creek, Trout Creek, and Red Creek within the instream flow filing segments. The Green River scored moderate and moderate–high within the sub-basin. Moderate scores were also common along the Henry’s Fork system and along the tributary system east of Flaming Gorge Reservoir. These areas were designed by WGFD as priority habitats. All other water resources scored low or low–moderate.

8.3.2.11 Vermillion – Environmental

Environmental scores ranged from low to moderate across the Vermillion sub-basin. However, only small segments along the North Fork Vermillion Creek and Canyon Creek scored moderate due to the presence of NWI mapping and a small WGFD designated priority area. In general, limited environmental uses are evident in the sub-basin.

8.3.2.12 Little Snake – Environmental

Environmental scores ranged from low to moderate–high across the Little Snake sub-basin. Moderate–high scores occur in the eastern sub-basin limits where instream flow filings, WGFD priority habitat, and USFS managed lands are mapped. Moderate scores are scattered throughout the sub-basin along the Little Snake River, sections of Savery Creek, and a variety of other small tributaries. Low and low–moderate scores are also scattered throughout the sub-basin, in areas where limited environmental factors were mapped and private land ownership was common.

8.3.3 *Recreation Model*

The goal of the recreational model is to identify the range of recreational factors present for specific water resources in the basin. This model can be used in conjunction with the protection model to identify areas where high levels of recreational resources exist and associated levels of protection are provided. This can be used to focus on areas where a change in water management may have a greater effect on the recreational resources present. The results of the model for each sub-basin are displayed in Appendix C.

Two categories were considered to inform the recreation model: 1) Land ownership; and 2) other factors. These categories are consistent with the results data presented in the results section. Land ownership is often a driving component related to the inherent recreational value present near Basin waters. Land ownership may affect recreational opportunities in a number of

ways. Many of the major land owners have formalized RMPs to specifically address, manage, and promote recreational opportunities. An example would be the State Parks Department and National Park Service. These entities have formalized plans identifying recreational resource locations and a plan to manage these resources in line with other agency objectives. Scores for land ownership recreational resources were informed based on the answers to three questions listed below and a general understanding as to the process each landowner/manager undergoes to evaluate projects and manage recreational resources. These scores may be different from the protection model land ownership scores due to the methods used to evaluate the landowner relative to recreational resources (Table 8-5).

- Is public access provided to the land and recreational resource?
- Is access to the land and recreational resource fee or permit based?
- Does the landowner have a formalized RMP?
- If yes, where do recreational resources fit in the overall objectives of the RMP?
- Is NEPA compliance (or another evaluation that includes recreation resources) required to authorize projects that may impact recreation resources?

Table 8-5. Land ownership – management scores used to inform the recreational model.

Landowner-Manager	Score	Justification for Score
State Park	5	Has a comprehensive recreation plan that includes environmental resources, but more focus on recreation resources. Provides both open access and fee-based.
National Forest	5	Detailed Resource Management Plan (RMP) with Environmental Impact Statement (EIS) requirements for changes; heavy focus on E&R resources; may be open access or fee-based.
National Park	5	Detailed RMP with EIS requirements for changes; heavy focus on E&R resources; typically fee-based access.
Bureau of Land Management	4	Detailed RMP with EIS requirements for changes; primary objectives focused on promoting mixed land use of which recreation is considered, but typically not the focus. Open access to public.
Bureau of Indian Affairs	2	Has an Irrigation RMP, but limited recreation based requirements. Does provide fee-based access to recreation uses.
State land	2	No clear environmental RMP. Focus on agriculture and commercial uses. Access varies based on location.
Private	0	Highly dependent on individual owner, no requirements. Follows standard laws/acts/regulations but does not have a clear RMP; either develops a RMP for a specific management units or they partner and relinquish management to state land management agencies. Application process for recreation activities.
Bureau of Reclamation	2	Has clear Strategic Habitat Plan/State Wildlife Action Plan, but in many cases does not own the land it is targeting (in this case it does own the land). Access varies based on location.
State Fish and Wildlife	4	Primary objective is to conserve, enhance, restore environment; recreation may not be primary object for land.
US Fish and Wildlife Service	4	Primary objective is to conserve, enhance, restore environment.
The Nature Conservancy	2	Public access for recreation is often not provided.

Department of Defense	1	Has a natural resource program, but primary goal is to support military actions (natural habitat for training); limited to no public access.
Other	2	Unknown; dependent on specific owner.
State Department of Natural Resources	4	Assume these fall under Wyoming Game and Fish Department action plans
County	2	Varies by county; most have a conditional use permit (or similar). Recreation not a major focus.

Other factors used to inform the recreation model were stream classification, whitewater rafting, and WGFD wildlife habitat management areas (Table 8-6). Stream classifications were scored on a sliding scale based on the value provided by the individual stream categories. This is consistent with the other models where factors included multiple categories.

Table 8-6. Factors used to inform the recreational model.

Resources	Presence/Category	Score	Justification for Score
Stream Classification	Blue	5	Wyoming Game and Fish Department (WGFD) Fisheries scoring specifically for sport fishing; highest level
	Red	4	Second level
	Yellow	3	Third level
	Green	2	Fourth level
	Orange	1	Fifth level
Whitewater Rafting Segment	Clear	0	No fisheries identified
	Yes	5	Provides opportunity for recreation activity
WGFD	No	0	
	Wildlife Habitat Management Area	5	Managed to provide recreational opportunities

Many other factors were presented in the results section of this report and may affect recreational value, but were not included in the model. This is primarily based on the type of data available. For example, waterfowl hunting is a major water-associated recreational activity across the Basin; however, a dataset was not readily available to support this evaluation. Similarly, many of the recreation resources in the Basin are associated with land ownership. These individual factors were not investigated, but their presence and value were included in the model through the land ownership scoring.

8.3.3.1 Upper Green – Recreation

Recreation scores ranged from low to high across the Upper Green sub-basin. High scores exist along the very upper reaches of the Green River. Moderate–high scores were common throughout the sub-basin, specifically in the upper watershed. Recreation in these areas is supported by USFS managed land and sport fishing opportunities. Scores along the Green River main stem were highly variable with large sections of moderate and low-moderate scores. Only small segments of low scores exist along water resources in the sub-basin.

8.3.3.2 New Fork – Recreation

Recreation scores ranged from low–moderate to high across the New Fork sub-basin. High scores exist along Pole Creek below Half Moon Lake and on Boulder Creek below Boulder Lake. Moderate–high scores exist along water resources on USFS managed land limits above and around the chain lakes area and along segments of the New Fork. New Fork provides high recreation value through the fisheries, but is routed through private land, restricting access. Low–moderate and moderate scores are less common and scattered along the East Fork River, Pole Creek, and New Fork River segments. Overall, the New Fork sub-basin demonstrates a high recreational value across the entire sub-basin. The large lakes that occur in the sub-basin also provide high levels of recreation uses, but were not specifically scored.

8.3.3.3 Upper Green-Slate – Recreation

Recreation scores ranged from low to moderate–high across the Upper Green-Slate sub-basin. Moderate–high scores occur along the Green River where Seedskadee NWR and red ribbon fisheries designations exist. Slate Creek also scored moderate-high. Most other water resources scored moderate, with smaller sections of low and low-moderate.

8.3.3.4 Big Sandy – Recreation

Recreation scores ranged from low to moderate–high across the Big Sandy sub-basin. Moderate–high scores exist in the northern sub-basin region, where USFS managed lands are mapped. Moderate-high and moderate scores exist along Big Sandy River below the reservoir and along Pacific Creek. The remainder of water resources across the sub-basin are scored as low or low–moderate due to a lack of mapped recreation resources. This sub-basin does provide additional recreation opportunities associated with Big Sandy and Eden Reservoirs.

8.3.3.5 Blacks Fork – Recreation

Recreation scores ranged from low to moderate–high across the Black’s Fork sub-basin. Moderate-high scores exist in the northwest section of the sub-basin along the upper Ham’s Fork River headwaters. This area is on NF land and provides fishing opportunities. Other small sections of moderate–high scores exist along instream flow filings near the southern sub-basin border, including the Black’s Fork River where rafting is common. Moderate, low-moderate, and low scores make up the bulk of the water resources across the sub-basin, typically along higher order stream segments on private land where access is limited. Recreation scores are highly variable across the sub-basin.

8.3.3.6 Bitter – Recreation

Recreation scores ranged from low to moderate across the Bitter sub-basin. Recreation scores are highly variable along all of the sub-basin’s waters. No clear trend was apparent outside of land ownership driving recreation scores.

8.3.3.7 Great Divide Closed Basin – Recreation

Recreation scores ranged from low to moderate-high across the Great Divide Closed Basin sub-basin, with most water resources scored for moderate recreation uses. Moderate-high

recreation scores exist along a segment of the Separation Creek. Moderate scoring water resources exist along Black Rock Creek, Separation Creek, Bear Creek, Bush Creek, and a number of other waters in the sub-basin. While recreation scores are respectable for the sub-basin, this area is not known for high recreation value.

8.3.3.8 Muddy – Recreation

Recreation scores ranged from low to high across the Muddy sub-basin. High scores exist in the northeast sub-basin segments along Littlefield Creek, Muddy Creek, and McKinney Creek. These waters occur within a WHMA and provide sport fishing opportunities. Moderate and moderate-high scores are scattered throughout the sub-basin, typically on BLM land and along streams where green ribbon fisheries designations occur. Smaller sections of low and low-moderate recreation scores are displayed throughout the sub-basin, including most of Muddy Creek.

8.3.3.9 Little Muddy – Recreation

Recreation scores ranged from low to moderate-high across the Little Muddy sub-basin. Moderate-high scores occur along small segments of Little Muddy Creek, East Muddy Creek, and other scattered sections of waters in the sub-basin. The remainder of the waters in the sub-basin depicts high variability of recreation with moderate and low scores intermixed along many of the streams.

8.3.3.10 Upper Green-Flaming Gorge – Recreation

Recreation scores ranged from low to moderate-high across the Upper Green – Flaming Gorge sub-basin. Moderate-high scores exist along the Green River, far west sections of the Henry's Fork, Current Creek, Trout Creek, Red Creek, and Sage Creek. Other waters east of Flaming Gorge scored moderate. Most of the Henry's Fork system and tributaries to Flaming Gorge were scored low or low-moderate. The Flaming Gorge area is known to provide high recreation value.

8.3.3.11 Vermillion – Recreation

Recreation scores ranged from low to moderate-high across the Vermillion sub-basin. Moderate-high scores exist along segments of the Vermillion Creek. These segments have been mapped for green ribbon fisheries. Moderate scores are scattered along the majority of other waters in the sub-basin, with low or low-moderate scores intermixed.

8.3.3.12 Little Snake – Recreation

Recreation scores ranged from low to moderate-high across the Little Snake sub-basin. Moderate-high scores exist in the eastern sub-basin limits where NF and wilderness area are mapped along Battle Creek, the headwaters of Savery Creek, and other small tributaries to the Little Snake River. Moderate scores exist in the western sub-basin along Sand and West Branch Willow Creek. Scores throughout the remainder of the sub-basin are low or low-moderate, including the main stem of the Little Snake River. This area does provide fishing opportunities (green ribbon fisheries), but is primarily private land without public access.

9 MODEL SUMMARY

The protection model demonstrated a range of assumed protections across the Basin. In most cases, greater protection was assigned to areas higher in the watershed. These areas typically provide institutional protection associated with NF and wilderness areas and may include critical habitats. High levels of protect were also demonstrated along areas where instream flow filings currently exist. Most of the upper reaches of the watershed are above existing diversions; therefore, changes in water use are less likely to result from diversion changes and more likely to be affected by water storage projects. Less protection was evident along many of the larger-order streams. These areas typically have more private land ownership and less institutional regulations. These areas more typically support agriculture (and other water uses); therefore, are more subject to impacts.

The environmental model followed a similar pattern to the protection model, with more environmental uses identified higher in the Basin's watershed. This is not surprising, given many environmental factors provide some level of institutional protection. At a finer scale, more variability was demonstrated in the environmental model. This was often due to BLM and WGFD priority areas. These agency designated habitats are present throughout the Basin in upper and lower sections of the watershed. In general, higher environmental scores were apparent in the northern Basin. Many environmental uses were mapped in this region and subsequently resulted in higher environmental model scores. Additionally, many of the major waterbodies, such as the Green River, New Fork River, and Black's Fork, received higher scores due to multiple environmental uses designated along the features.

Higher recreation scores were demonstrated in the upper watersheds, specifically on USFS managed land. This makes sense, given the recreation opportunities and purposeful management of USFS to provide the public with open space. In general, the Basin provides a range of recreation uses, with the northern sub-basins (e.g., New Fork, Upper Green) assigned higher scores relative to other areas across the Basin. These areas are known for the fisheries and general outdoor recreation. Many of the larger waterbodies in the Basin also scored high including the Green River, Ham's Fork, New Fork, Blacks Fork, among others. It is important to recognize fewer factors were used to inform the recreation model. This results in land ownership having a greater impact on the overall score and less recreation uses being captured. Additionally, the recreation model was not set up to capture the higher recreation use commonly associated with the Basin's reservoirs. The reservoirs are common destination locations for recreation.

10 DISCUSSION

The WWDC developed a river basin planning framework as a consistent method to evaluate existing water resources and support existing and future water use planning. Environmental and recreation water uses were included in the initial basin planning framework, but were not fully addressed due to the non-consumptive nature of the uses. To that end, the Handbook (Harvey Economics 2012) was developed and laid out a process to identify, map, categorize, and

assimilate E&R use data. WEST followed the Handbook guidance and developed new methods to further evaluate the E&R use data for the Basin.

The Green River Basin is located in southwest and south-central Wyoming, with 12 sub-basins. Wyoming's ability to develop and consumptively use water in the Green River Basin is constrained by two interstate compacts, the Colorado River Compact and the Upper Colorado River Basin Compact. Surface and ground water are detailed in the 2001 and 2010 Green River Basin Plans. Agriculture is by far the highest consumptive water source in the Basin. The 2010 Plan projects limited (if any) increase in consumptive water use demands into the future. Additionally, the plan demonstrates a large quantity of water not currently allocated under the compact. This suggests that the water quantity required to support non-consumptive E&R uses in the Basin will remain intact.

To assist planning with future projects, WEST gathered E&R use data and prepared models to highlight E&R use across the Basin. Multiple areas demonstrated higher E&R uses when compared with the remainder of the Basin. The northern Basin (Upper Green and New Fork sub-basins) demonstrated the most E&R uses. These areas support a variety of environmental uses including instream flow filings, wetlands, USFWS T&E habitat, and number of WGFD designated priority habitats and are headwaters for a number of waters in the Basin, including the Green River. The presence of USFS land and blue and red ribbon fisheries also makes this area a destination location for recreation uses. Sections along the Green River main stem also support high E&R uses, specifically around Flaming Gorge Reservoir and National Recreation Area and Seedskadee NWR. Other areas identified for high environmental uses occur in the southern Blacks Fork and western Upper Green River – Flaming Gorge Reservoir sub-basins. This area includes critical habitat for the yellow-billed cuckoo, instream flow filings, wetlands, and WGFD designated priority habitats.

In addition to the E&R use models, WEST prepared a protection model to identify areas where E&R uses may be at more risk to impacts from future project planning. The protection scores were fairly consistent with the E&R use scores, with waters high in the watershed scoring higher for all models. Evaluation of the E&R models and protection model highlights the Green River as a water that may be at risk to future impacts. The Green River is primary water resource in the Basin and provided significant E&R uses. The levels of protection along this river vary due to the length and inputs from tributaries. Additionally, the areas below USFS, across the Basin, often scored higher for E&R uses than for protection. This can be seen below the chain lakes, around Big Sandy Reservoir, along the Ham's Fork, and in the Little Snake sub-basin. This suggests that future planning may impact uses along these waters. The large number of diversions (Figures 8-1 through 8-3) and agriculture operations in these areas support the need to monitor and evaluate future project planning.

Water in the Basin appears stable at this time, and in fact, the 2010 Basin Plan suggests that excess water is available. This has resulted in planning for a number of water storage projects, including New Fork Lake, Big Sandy, Meeks Cabin, Fontenelle, Viva Naughton, and Middle

Piney. Most of these projects are located in areas where high E&R uses exist. Future project planning should be cognizant of E&R uses across the Basin.

While not specifically discussed in the report, economics is a factor that can be used to further evaluate environmental and recreational water uses in Wyoming and the Green River Basin. A brief literature review was conducted on economics and is presented below. This information was limited to Wyoming, with basin specific information presented as available. The information can be used to highlight benefits a community may receive from environmental and recreational water use opportunities.

Based on the most recent USFWS survey data for Wyoming (USFWS 2011), 775,000 people fished, hunted or watched wildlife in Wyoming. This includes 303,000 people who fished, 140,000 who hunted, and 518,000 who watched wildlife. In 2011, \$1.1 billion was spent on wildlife recreation in Wyoming, including \$874 million on trip-related expenditures and \$181 million on equipment expenditures. An additional \$82 million was spent on licenses, contributions, land ownership and leasing and other items.

Another more recent analysis from the University of Wyoming showed that hunting, fishing and wildlife viewing activities had a significant impact on the state's economy in 2016. This analysis estimated that hunters, anglers and wildlife watchers spent an estimated \$788 million in Wyoming, with the total economic importance up to \$1 billion in business activity. The 2016 data showed that wildlife-related activities accounted for an estimated 9,600 jobs in Wyoming, with a total labor income of \$262 million. This included jobs directly connected to wildlife as well as those in the service and hospitality industries. Based on the analysis it was estimated that hunters spent \$206 million, anglers spent \$186 million, and wildlife watchers spent \$365 million in Wyoming, for a total of \$788 million in wildlife related spending in 2016 (WGFD 2018).

In another recent survey, the Outdoor Industry Association (OIA 2016) estimated that 73% of Wyoming residents participated in some form of outdoor recreation, although this includes other outdoor activities in addition to hunting, fishing or wildlife-watching. The OIA estimated that outdoor recreation in Wyoming creates more jobs (50,000) than oil and gas and mining combined (27,000). It was further estimated that outdoor recreation in Wyoming generates \$5.6 billion in consumer spending, \$1.6 billion in wages and salaries, and \$514 million in state and local tax revenue.

According to the USFWS (2013a), the 518,000 people who watched wildlife in Wyoming in 2011 spent over \$350 million dollars in their pursuits, creating 8,232 jobs, nearly \$200 million in salaries and wages, \$47 million in state and local tax revenues, and \$43 million in federal tax revenues. Of all 50 states, Wyoming had the fifth highest percentage of people who birdwatched in 2011 (USFWS 2013b). It was estimated that 417,000 people watched birds in Wyoming in 2011, of which 31% were residents and 69% were non-residents. Of specific relevance to river basin planning is that 75% of people reported observing waterfowl, making this group the most watched type of bird.

In Wyoming, the 281,000 people that fished for trout in 2011 spent a total of 2,439,000 angler days fishing for trout in the state (USFWS 2013c). Each angler fished an average of 8.7 days. When combined with people who fished for species other than trout, there were 303,000 anglers in Wyoming in 2011, who each fished an average of 10 days per year. Each angler spent \$1,530 in 2011, or \$126 per day. Anglers in Wyoming had \$394 million in trip-related expenses and nearly \$70 million in equipment-related expenses, for a total of nearly \$464 million (USFWS 2013c).

The number of people who fish in the Green River Basin cannot accurately be determined. However, the WGFD does keep records on the number of fishing licenses sold by location. In 2016, 39,066 fishing licenses were sold at outlets located within the Green River Basin. Major locations where licenses were sold included Pinedale (11,148), Rock Springs (9,649), Kemmerer (7,701), and Green River (4,919). This does not include fishing licenses purchased on-line, which accounted for about 25% of all licenses sold in 2016.

All hunting expenditures in Wyoming totaled \$289 million in 2011. Trip related expenses such as food, lodging and transportation totaled \$159 million. Equipment expenditures totaled another \$81 million. The average expenditure per hunter was \$1,136 (USFWS 2011). Of particular relevance to river basin planning is the economic impact of waterfowl hunting; however, information on waterfowl hunting and expenditures in Wyoming were not provided. In the U.S., however, waterfowl hunters comprised 11% of all hunters, 6% of all hunting trip-related expenditures, and 7% of all hunting equipment expenditures in 2011 (USFWS 2013d). It is assumed that waterfowl hunting in Wyoming makes up a similar percentage of the hunting population.

The only National Wildlife Refuge within the Green River Basin is the Seedskafee National Wildlife Refuge. The economic impact of visitors to Seedskafee and Cokeville Meadows National Wildlife Refuges has been analyzed by the USFWS (Carver and Caudill 2013). Both refuges are managed out of the same office and unfortunately visitor and economic impact data are combined for the two refuges. Most of the visitation and economic impact is likely associated with Seedskafee, however, as most of the Cokeville Meadows NWR is closed to the public except for a wildlife viewing station and limited hunting on the refuge. The two refuges combined had 13,410 visits in 2011, the latest data available. Approximately 29% of the visits were by Wyoming residents and the remaining 71% was by non-residents. The economic area for the refuges included Lincoln, Sweetwater and Uinta Counties. It was estimated that total expenditures of refuge visitors in this area was \$498,100, and that the refuges accounted for employment of 6 jobs, \$177,900 in employment income and \$81,800 in total tax revenue (Carver and Caudill 2013). No state parks are located within the Green River Basin.

The value and economic benefits received from environmental and recreational uses in Wyoming and the Green River Basin is clear. Jobs, revenue, and indirect expenses support the local communities as a result of these opportunities. As travel and recreation associated with outdoor activities grows, the need to manage water to support environmental and recreation uses may need to become a bigger focus at the state and basin level.

This report and supporting data can be used to evaluate potential impact to E&R uses. The resources provided in this report include direct E&R uses across the Basin; general categorization of E&R uses; and the environmental, recreation, and protection models. Each of the resources should be evaluated, as no one dataset is all encompassing.

11 REFERENCES

- 82 Federal Register (FR) 20284d. 2017d. Endangered and Threatened Wildlife and Plants; Reinstatement of Removal of Federal Protections for Gray Wolves in Wyoming; Final Rule. 50 CFR Part 17. Department of the Interior, Fish and Wildlife Service. Docket No. FWS–R6–ES–2017–0025. 82 FR 20284. May 1, 2017. Available online: <https://www.gpo.gov/fdsys/pkg/FR-2017-05-01/pdf/2017-08720.pdf>
- American Whitewater. 2009. Whitewater Stream Segments and Stream Flow Data. <https://www.americanwhitewater.org/content/River/state-summary/state/WY/>
- Carver, E. and J. Caudill. 2013. Banking on Nature. The economic benefits to local communities of National Wildlife Refuge visitation. Division of Economics, US Fish & Wildlife Service, Arlington, VA.
- Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. US Department of the Interior (USDOI) Fish and Wildlife Service, Office of Biological Services, Washington, D.C.
- ERO Resources Corporation. 2009a. Green River Basin Plan Basin Water Use Profile - Environmental Technical Memorandum. June 2009. 20 pp.
- ERO Resources Corporation. 2009b. Green River Basin Plan II Basin Water Use Profile - Recreation Technical Memorandum. April 2009. 12 pp.
- ESRI. 2015. Geographic Information System (Gis) Online Topographic Base Map. ESRI, producers of ArcGIS software. Redlands, California.
- Fertig, W., R. Black, and P. Wolken. 2005. Rangewide Status Review of Ute Ladies'-Tresses (*Spiranthes Diluvialis*). Prepared for the US Fish and Wildlife Service (USFWS) and Central Utah Water Conservancy District.
- Frantz, M. 2009. Green Rier Basin Plan II Surface Water Daa Synthesis and Spreadsheet Model Development Technical Memorandum. June 5, 2009. 66 pp.
- Harvey Economics. 2012. Environmental and Recreational Water Use Study. April 18, 2012. Denver, Colorado. 43 pp.
- Heidel, B. 2007. Survey of *Spiranthes Diluvialis* (Ute Ladies'-Tresses Orchid) in Eastern Wyoming (Campbell, Converse, Goshen, Laramie, Niobrara and Platte Counties) 2005-2006. Prepared for the Bureau of Land Management (BLM) and Medicine Bow/Routt National Forest/Thunder Basin National Grassland.
- Huck, N. 2015. 2015 Migratory Game Bird Job Completion. 54 pp. https://wgfd.wyo.gov/WGFD/media/content/PDF/Hunting/JCRS/JCR_MIGRATORYGAMEBIRD_2015.pdf

- National Wildlife Refuge System Improvement Act. 1997. 111 Statute 1252-1260
<https://www.congress.gov/105/plaws/publ57/PLAW-105publ57.pdf>
- North American Datum (NAD). 1983. NAD83 Geodetic Datum.
- Outdoor Industry Association. 2016. Wyoming. Available online at <https://outdoorindustry.org/state/wyoming/>
- Pavlica, J. 2013. Snake/Salt River Basin Plan Update, 2012, Environmental and Recreational Water Use - Tab IV (2012). 76 pp.
- Recreation.gov. 2014. Fontenelle Reservoir, Utah.
<https://www.recreation.gov/recreationalAreaDetails.do?contractCode=NRSO&recAreaId=701>
- Section 10 of the Rivers and Harbors Appropriation Act. 1899. <https://www.epa.gov/cwa-404/section-10-rivers-and-harbors-appropriation-act-1899>
- Seedskaadee Reclamation Act. 1958. 72 Stat 963 <https://www.gpo.gov/fdsys/pkg/STATUTE-72/pdf/STATUTE-72-Pg963.pdf>
- Spatial Reference. 2017. Esri Projection 102757 - NAD 1983 Stateplane Wyoming West Central Fips 4903 Feet. <http://www.spatialreference.org/ref/esri/nad-1983-stateplane-wyoming-west-central-fips-4903-feet/>
- Strategic Marketing and Research. 2016. 2015 Overnight Visitor Profile Research. February 2016. 26 pp. <https://www.travelwyoming.com/sites/default/master/files/uploads/industry/SMARI-Overnight-Visitor-Profile-2015.pdf>
- Stynes, D.J. and S.D. Stynes. 2010. Contributions of Wyoming State Parks and Historic Sites to State and Local Economies, 2009. Available online at <http://wyoparks.state.wy.us/pdf/Planning/2010EIR.pdf>
- US Army Corps of Engineers (USACE). 2013. Wyoming Stream Mitigation Procedure (WSMP). February 2013. 15 pp. https://wgfd.wyo.gov/WGFD/media/content/PDF/Fishing/Stream%20Class/WYSTREAM_WSMP_FEB2013.pdf
- US Fish and Wildlife Service (USFWS). 2011. 2011 National Survey of Fishing, Hunting and Wildlife-Associated Recreation, Wyoming. Revised January 2014.
- U.S. Fish and Wildlife Service. 2013a. Wildlife watching in the United States: The economic impacts on national and state economies in 2011. Addendum to the 2011 National Survey of Fishing, Hunting and Wildlife-Associated Recreation. Report 2011-2. U.S. Fish and Wildlife Service, Arlington, VA.
- U.S. Fish and Wildlife Service. 2013b. Birding in the United States: A demographic and economic analysis. Addendum to the 2011 National Survey of Fishing, Hunting and Wildlife-Associated Recreation. Report 2011-1. U.S. Fish and Wildlife Service, Arlington, VA.
- U.S. Fish and Wildlife Service. 2013c. Trout fishing in 2011: A demographic description and economic analysis. Addendum to the 2011 National Survey of Fishing, Hunting and Wildlife-Associated Recreation. Report 2011-4. U.S. Fish and Wildlife Service, Arlington, VA.
- U.S. Fish and Wildlife Service. 2013d. Economic impact of waterfowl hunting in the United States. Addendum to the 2011 National Survey of Fishing, Hunting and Wildlife-Associated Recreation. Report 2011-6. U.S. Fish and Wildlife Service, Arlington, VA.

- US Fish and Wildlife Service (USFWS). 2015. Kendall Warm Springs Dace (*Rhinichthys Osculus Thermalis*) Revised Recovery Plan. October 2015. 75 pp.
https://ecos.fws.gov/docs/recovery_plan/First%20Revised%20Kendall%20Warm%20Springs%20Dace%20Recovery%20plan_10.14.2015.pdf
- US Fish and Wildlife Service (USFWS). 2016. Federally Listed, Proposed and Candidate Species - Ute Ladies'-Tresses. April 26, 2016. <https://www.fws.gov/wyominges/Species/ULT.php>
- US Fish and Wildlife Service (USFWS). 2017a. Kendall Warm Springs Dace (*Rhinichthys Osculus Thermalis*). <https://www.fws.gov/mountain-prairie/es/kendallDace.php>
- US Fish and Wildlife Service (USFWS). 2017b. Partners for Fish and Wildlife Program Mountain-Prairie Region Strategic Plan. 42 pp. <https://www.fws.gov/mountain-prairie/refuges/partnersPDFs/WYPFW%20SP2017-2021.pdf>
- US Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI). 2016. NWI Data Mapper. Updated October 13, 2016. Fort Snelling, Minnesota. Wetlands Mapper:
<http://www.fws.gov/wetlands/Data/Mapper.html>
- US Fish and Wildlife Service. 2017a. 2016 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. National Overview. Issued August 2017. Preliminary Findings. USFWS, Washington, D.C.
- US Fish and Wildlife Service (USFWS). 2017b. Candidate Species Believed to or Known to Occur in Wyoming. Environmental Conservation Online System (ECOS), USFWS, Washington, D. C. Accessed August 29, 2017. Available online: <https://ecos.fws.gov/ecp0/reports/species-listed-by-state-report?state=WY&status=candidate>
- US Fish and Wildlife Service (USFWS). 2017c. Experimental Populations. Environmental Conservation Online System (ECOS), USFWS, Washington, D. C. Accessed August 29, 2017. Available online: <https://ecos.fws.gov/ecp0/pub/experimentalPopulations.jsp>
- US Fish and Wildlife Service (USFWS). 2017d. Listed Species Believed to or Known to Occur in Wyoming. Environmental Conservation Online System (ECOS), USFWS, Washington, D. C. Accessed August 29, 2017. Available online: <https://ecos.fws.gov/ecp0/reports/species-listed-by-state-report?state=WY&status=listed>
- US Fish and Wildlife Service (USFWS). 2017e. Species Proposed for Listing. Environmental Conservation Online System (ECOS), USFWS, Washington, D. C. Accessed August 29, 2017. Available online: <https://ecos.fws.gov/ecp0/reports/ad-hoc-species-report?status=P&header=Species+Proposed+for+Listing&fleadreg=on&fstatus=on&finvpop=on>
- US Fish and Wildlife Service. (USFWS). 2017f. Ute Ladies'-Tresses (*Spiranthes Diluvialis*). 2017. <https://ecos.fws.gov/ecp0/profile/speciesProfile?sId=2159>
- US Geological Survey (USGS). 2016. National Hydrography Dataset (NHD). USGS NHD Extracts: North Dakota. Last accessed February 2016. Information available online at: <http://nhd.usgs.gov/>; State data available online at: <ftp://nhdftp.usgs.gov/DataSets/Staged/States/FileGDB/HighResolution/>
- The Wilderness Act. 1964. <https://wilderness.nps.gov/document/wildernessAct.pdf>
- WWC Engineering, AECOM, and ERO Resources Corporation. 2010. Green River Basin Plan. December 2010. 189 pp.
- WYO Parks. 2017. Wyoming State Parks Arcgis. <http://wysphst.maps.arcgis.com/apps/webappviewer/index.html?id=bc28bacc97904286943d272cff9a5bce>

Wyoming Department of State Parks & Cultural Resources. 2015. State Parks & Historic Sites Visitor Use Program. Wyoming Department of State Parks & Cultural Resources Division of State Parks, Historic Sites and Trails, Cheyenne, WY.

Wyoming Game and Fish Department. 2017. Wyoming State Wildlife Action Plan. 1,692 pp.
<https://wgfd.wyo.gov/Habitat/Habitat-Plans/Wyoming-State-Wildlife-Action-Plan>

Wyoming Game and Fish Department (WGFD). 2006. Modification of the Wyoming Game and Fish Department's System for Classifying Stream Fisheries. WGFD, Fish Division Administration Report. March 2006.

Wyoming Game and Fish Department (WGFD). 2015. Strategic Habitat Plan. August 2015.
https://wgfd.wyo.gov/WGFD/media/content/PDF/Habitat/Strategic%20Habitat%20Plan/SHP2015_Final.pdf

Wyoming Game and Fish Department (WGFD). 2017. Annual Reports of Big and Trophy Game Harvest and Annual Reports of Small and Upland Game Harvest. <https://wgfd.wyo.gov/Hunting/Harvest-Reports/>

Wyoming State Engineer's Office (WSEO). 2016. Maps and Spatial Data Seo Wells Shapefile.
<https://sites.google.com/a/wyo.gov/seo/documents-data/maps-and-spatial-data>

Wyoming Water Development Office (WWDO). 2013. Environmental and Recreational Water Use - Tab IV (2012). October 4, 2013. 76 pp.

Wyoming Water Development Commission (WWDC). 2018. State of Wyoming Instream Flow Filings. Available online: http://wwdc.state.wy.us/instream_flows/instream_flows.html

Wyoming Wildlife & Natural Resource Trust. 2017. Wyoming Wildlife & Natural Resource Trust Projects.
<https://sites.google.com/a/wyo.gov/wwnrt/home>

Wyoming Game and Fish Department. 2018. Hunting, fishing and wildlife viewing are economic drivers for Wyoming. Wyoming Game and Fish Department News Release. March 5, 2018. Available online at <https://wgfd.wyo.gov/News/Hunting,-fishing-and-wildlife-viewing-are-economic>.

Appendix A. Protection Model for the Green River Basin

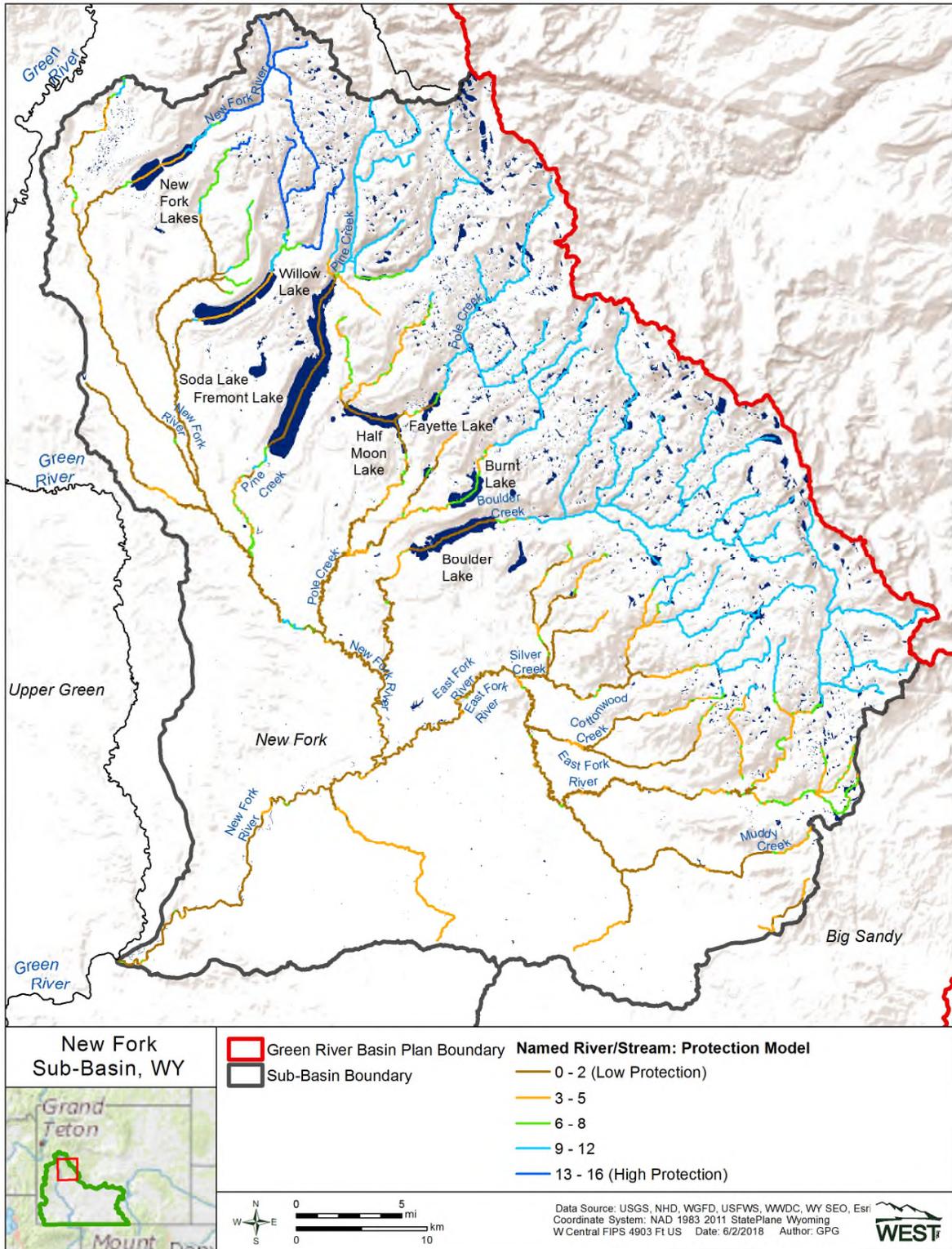


Figure A-2. Protection model results for the New Fork sub-basin in Wyoming.

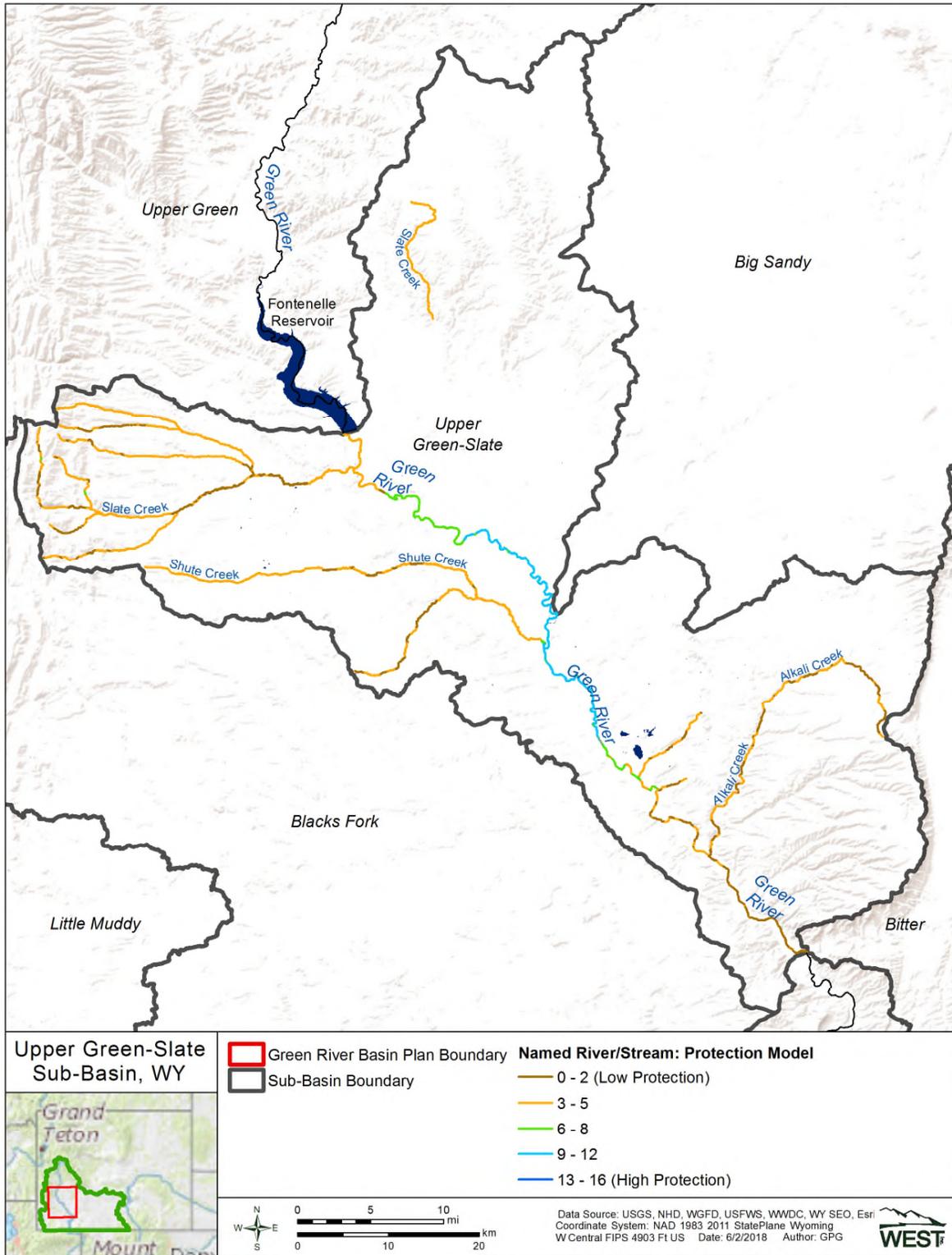


Figure A-3. Protection model results for the Upper Green-Slate sub-basin in Wyoming.

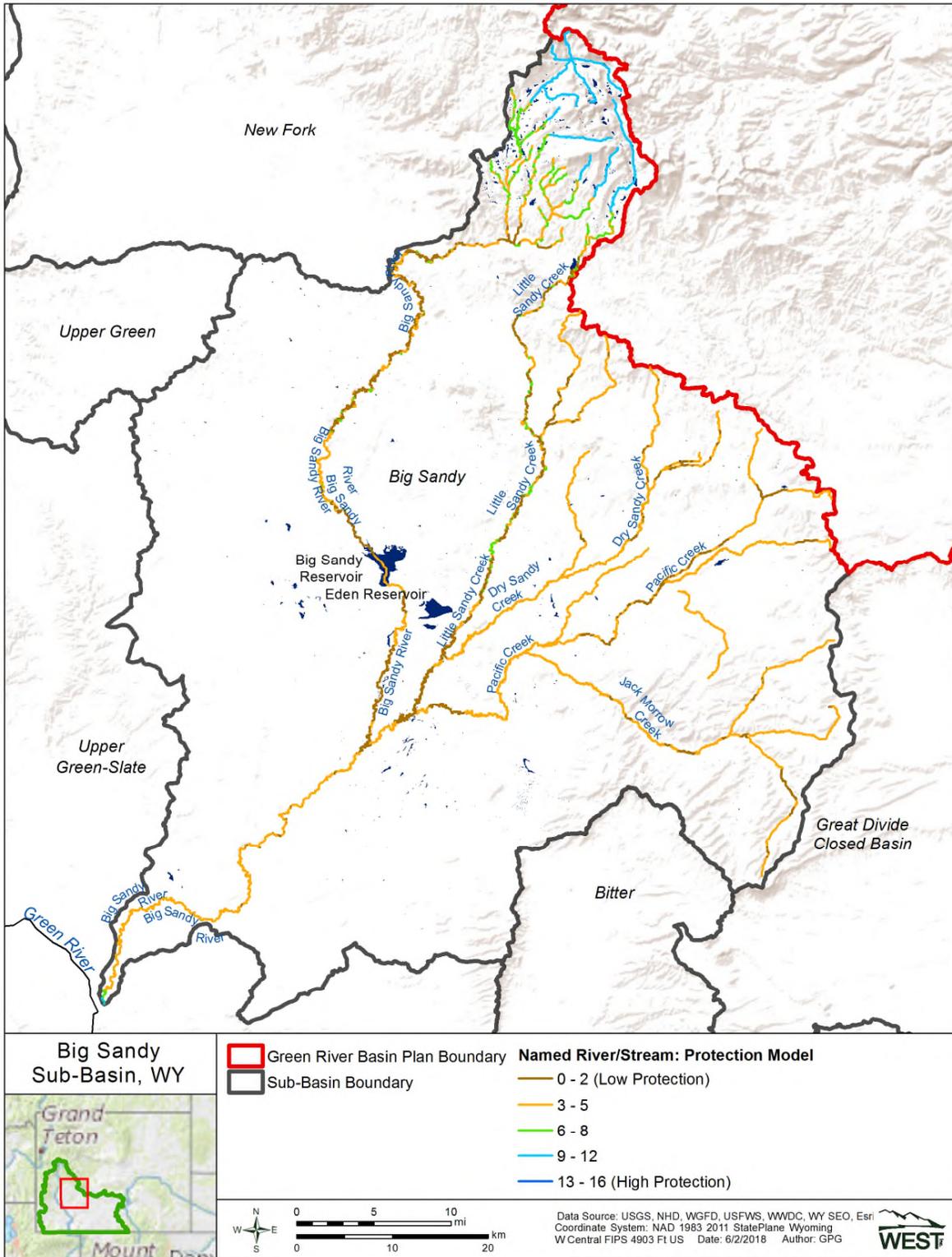


Figure A-4. Protection model results for the Big Sandy sub-basin in Wyoming.

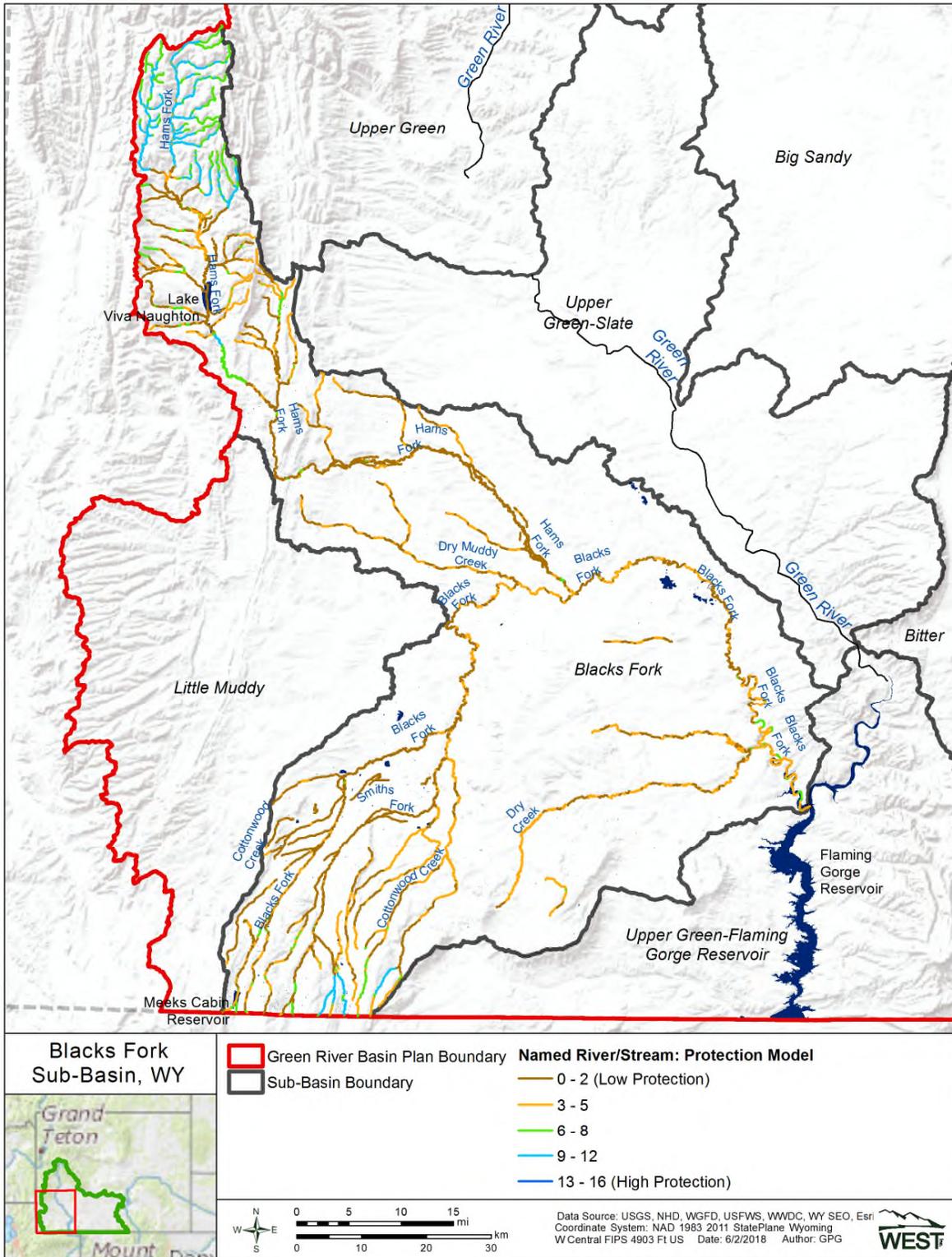


Figure A-5. Protection model results for the Black's Fork sub-basin in Wyoming.

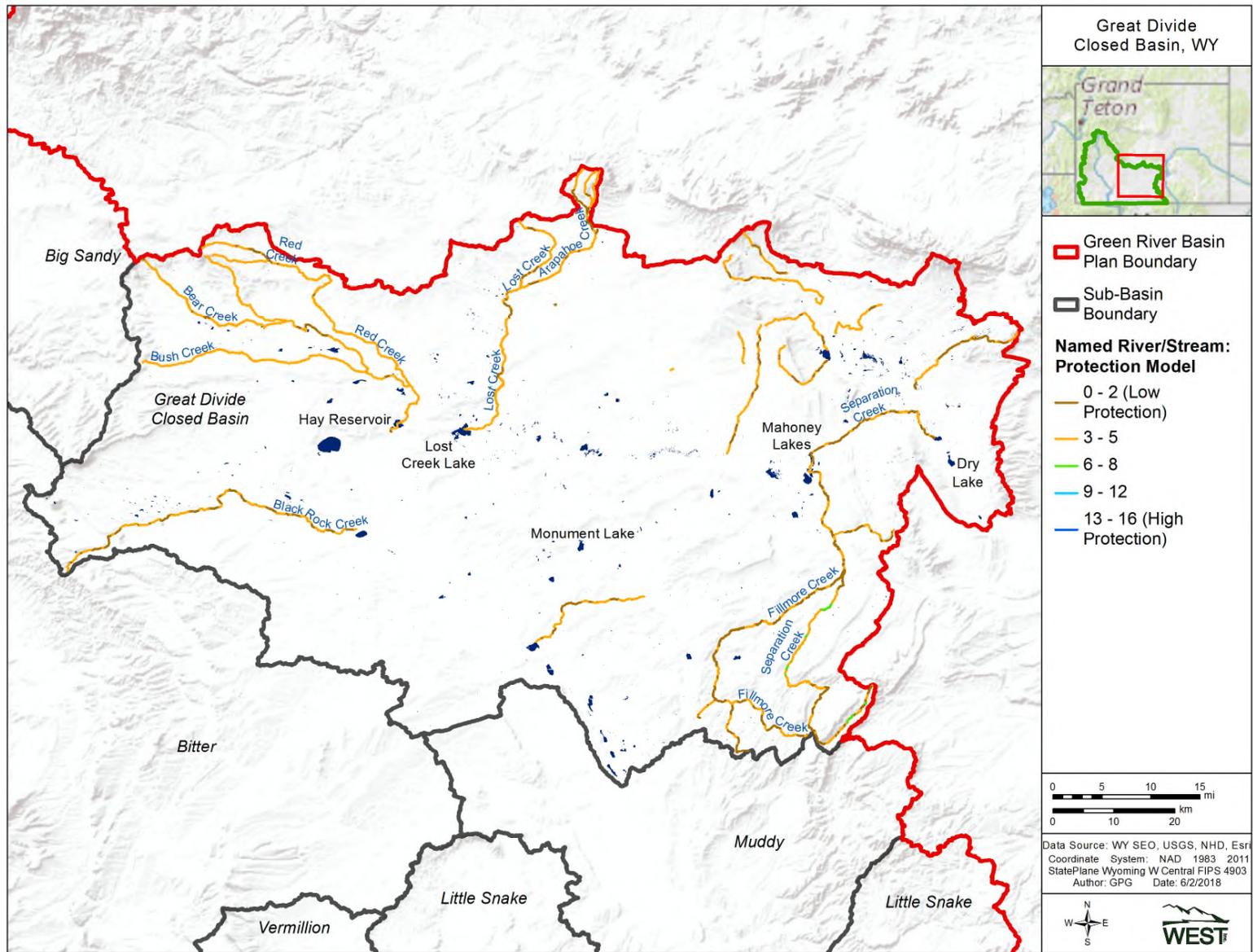


Figure A-7. Protection model results for the Great Divide Closed Basin sub-basin in Wyoming.

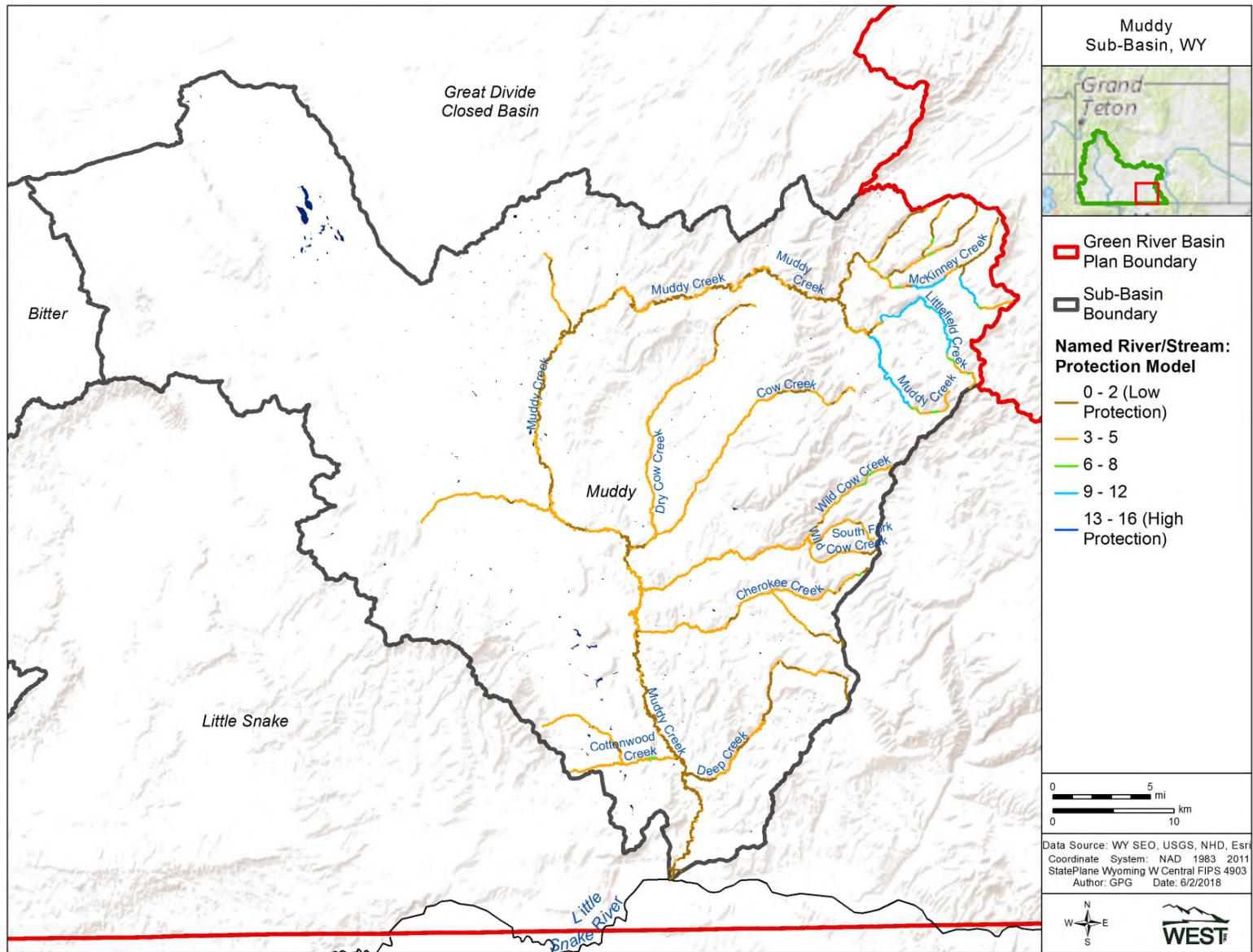


Figure A-8. Protection model results for the Muddy sub-basin in Wyoming.

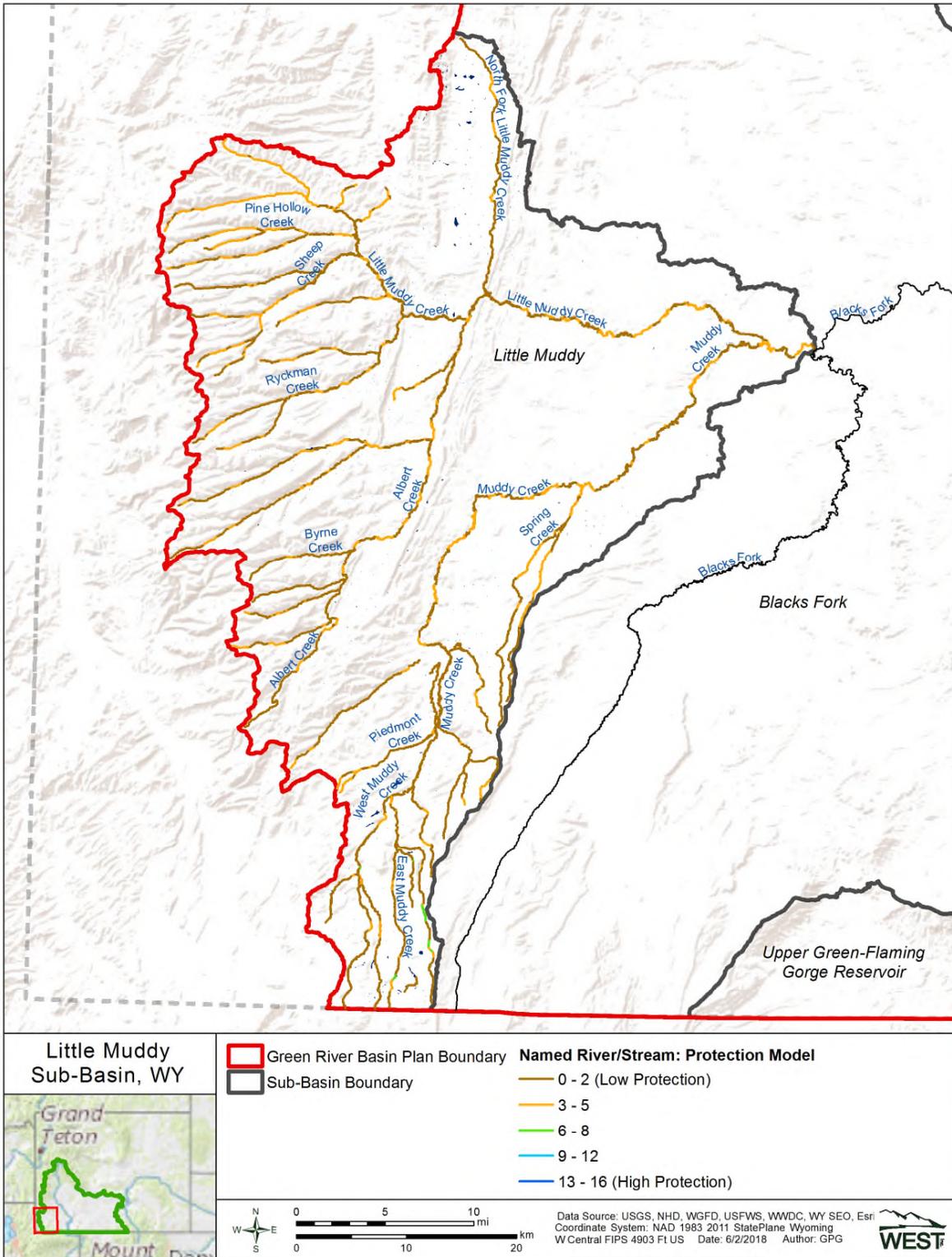


Figure A-9. Protection model results for the Little Muddy sub-basin in Wyoming.

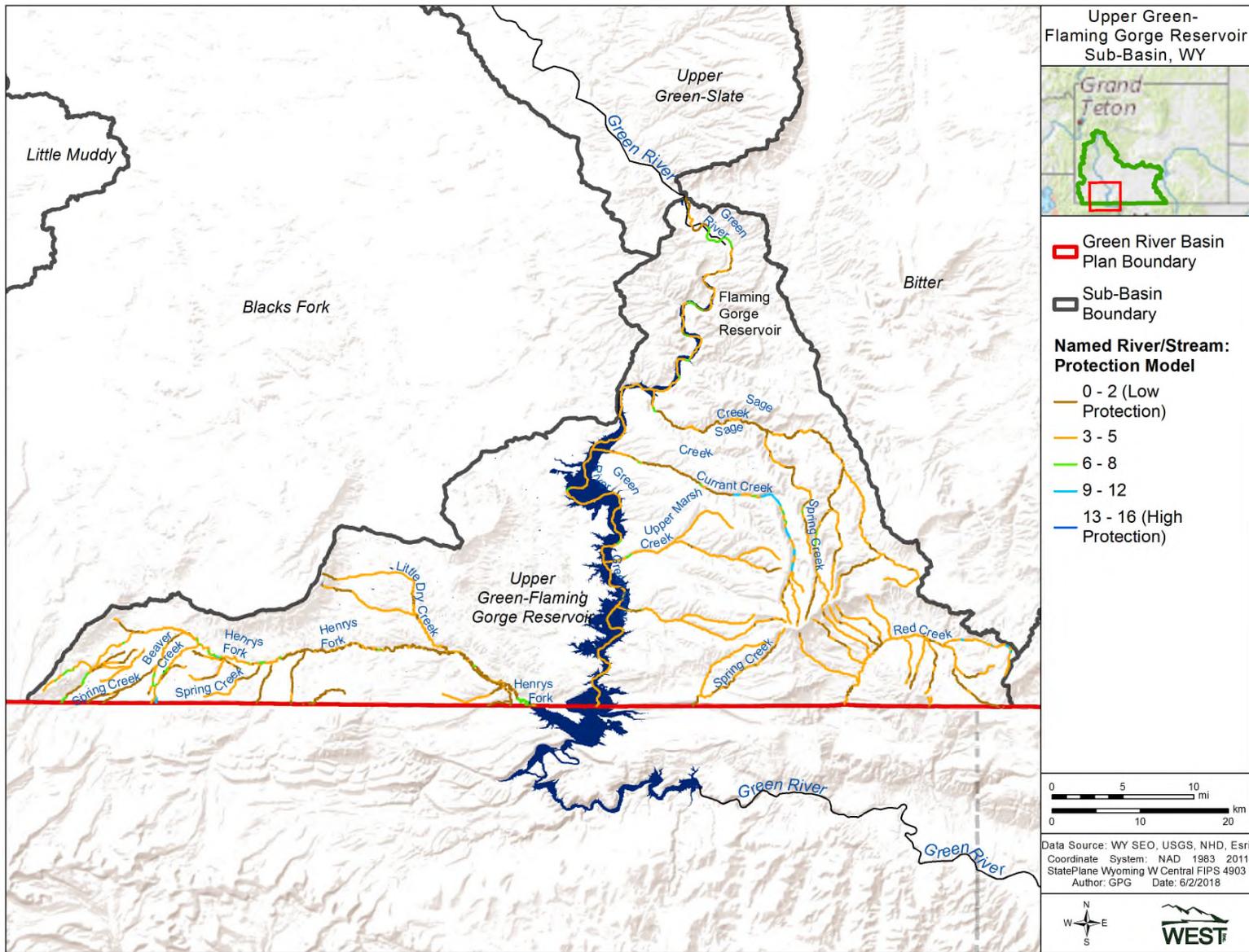


Figure A-10. Protection model results for the Upper Green-Flaming Gorge sub-basin in Wyoming.

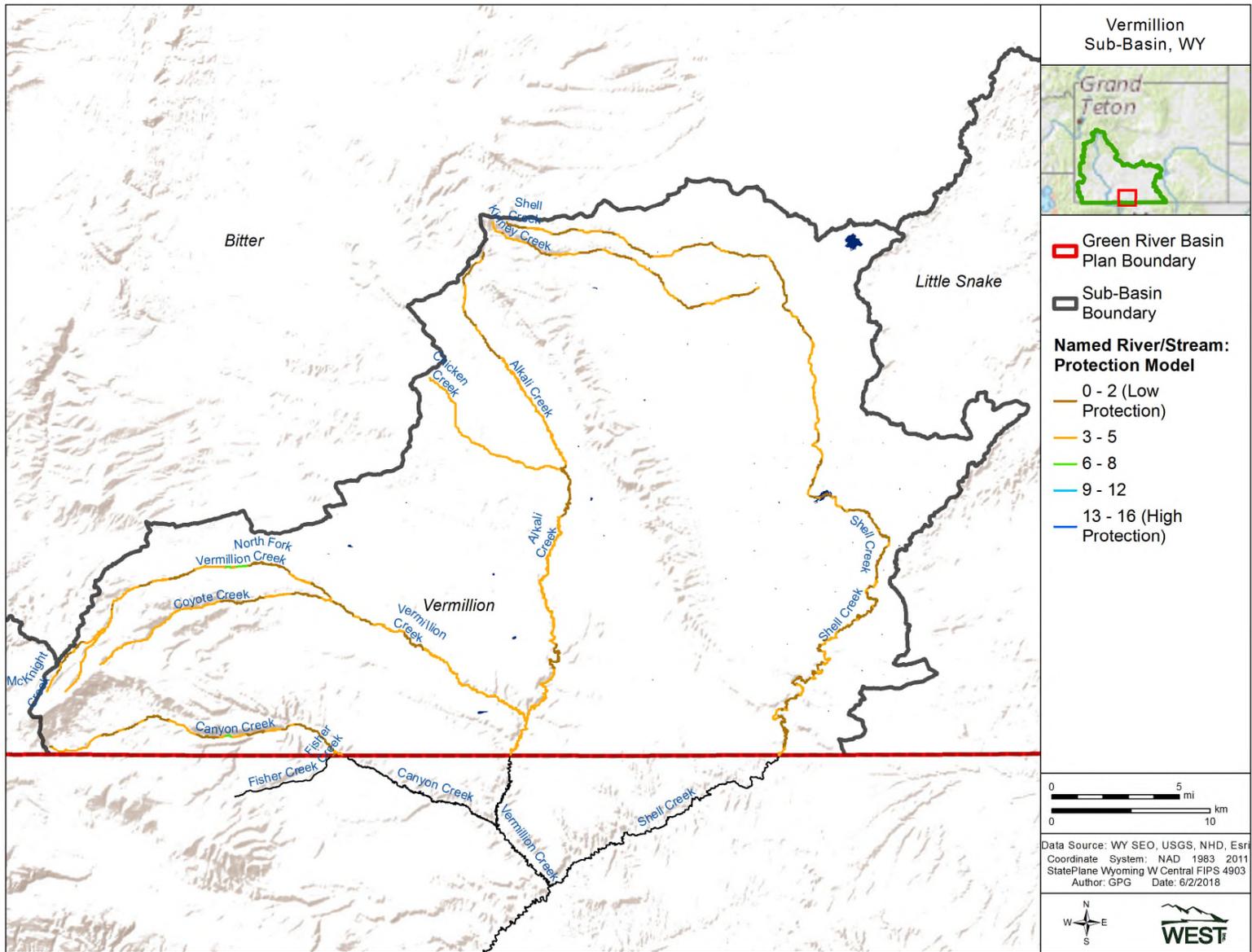


Figure A-11. Protection model results for the Vermillion sub-basin in Wyoming.

Appendix B. Environmental Model for the Green River Basin

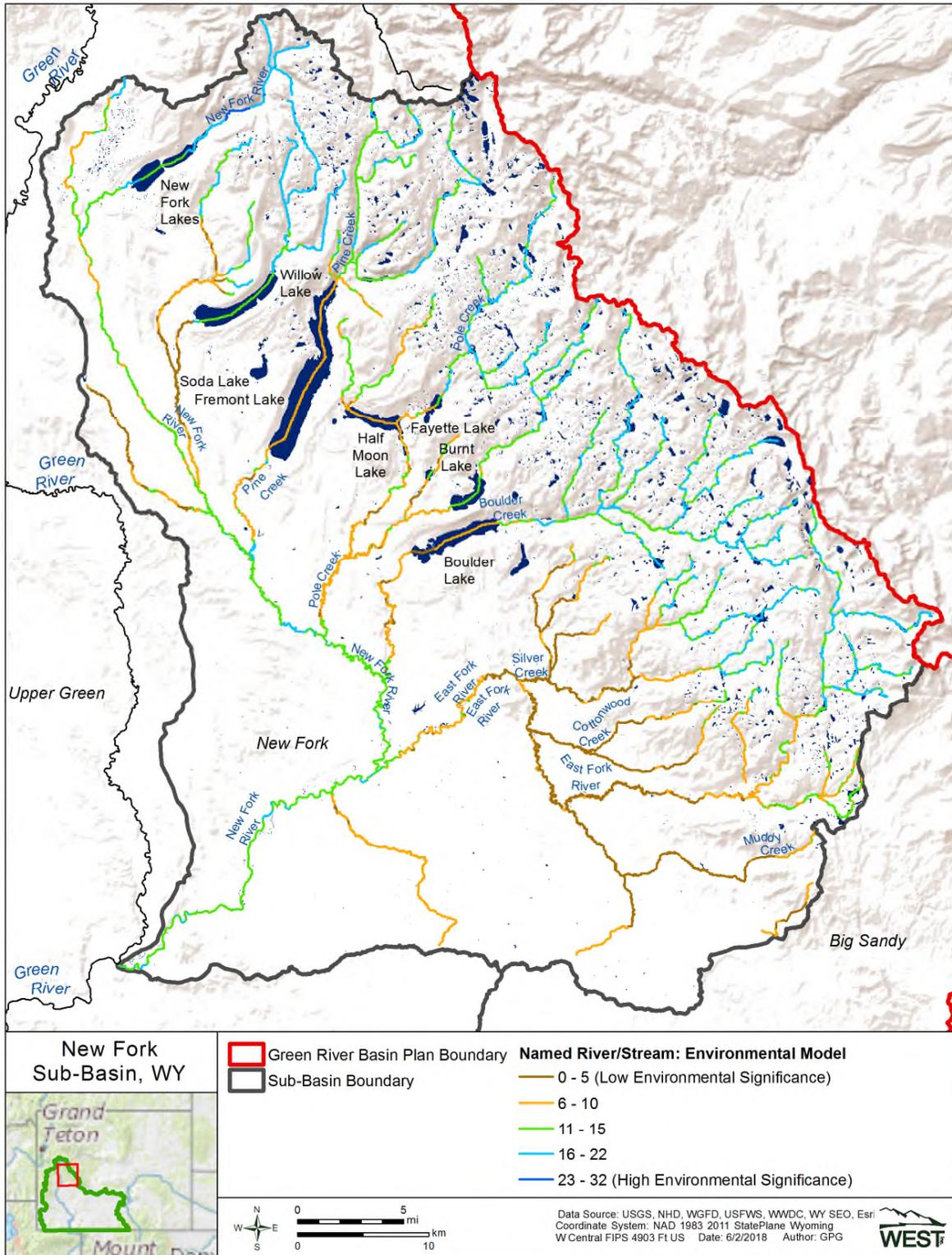


Figure B-2. Environmental model results for the New Fork sub-basin in Wyoming.

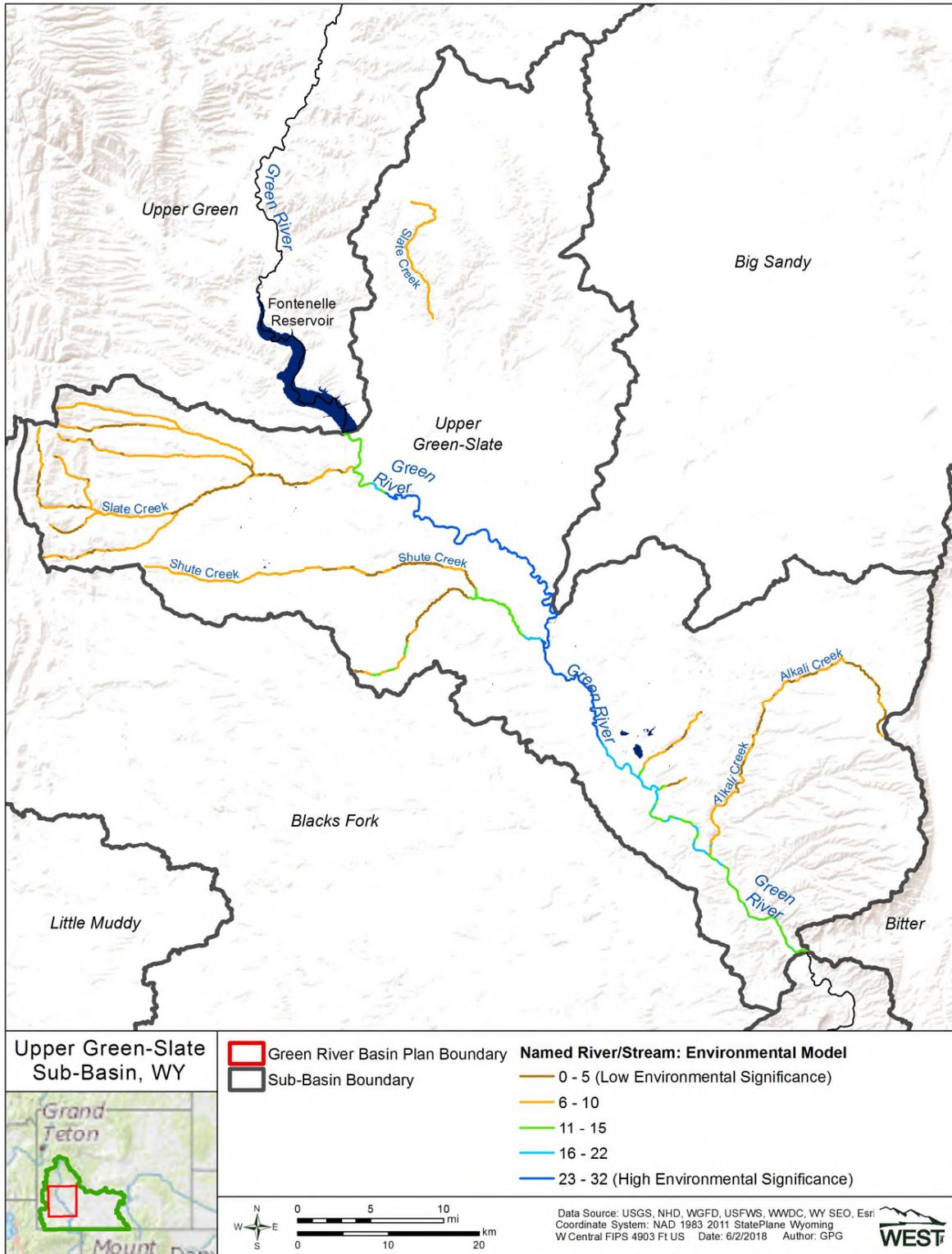


Figure B-3. Environmental model results for the Upper Green-Slate sub-basin in Wyoming.

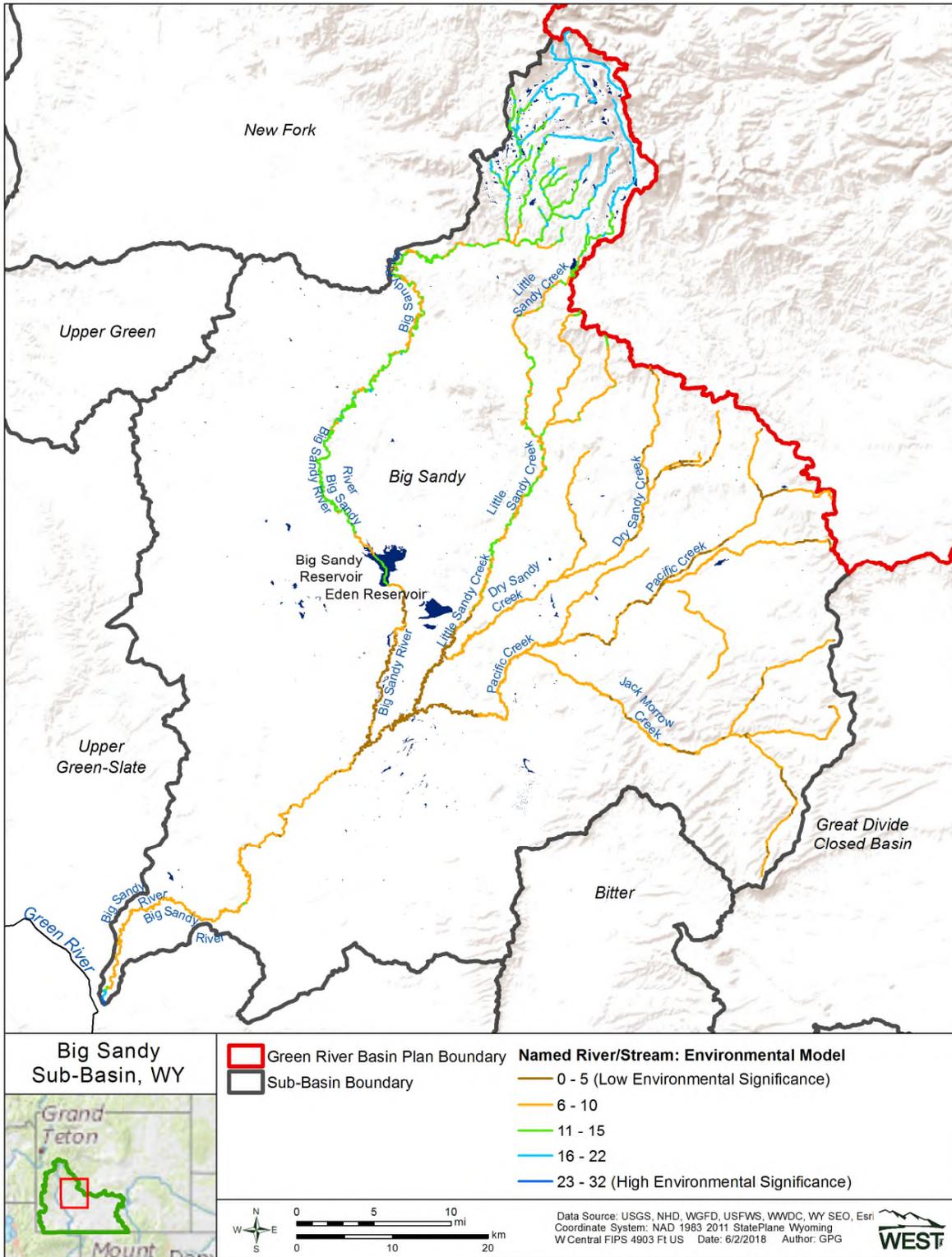


Figure B-4. Environmental model results for the Big Sandy sub-basin in Wyoming.

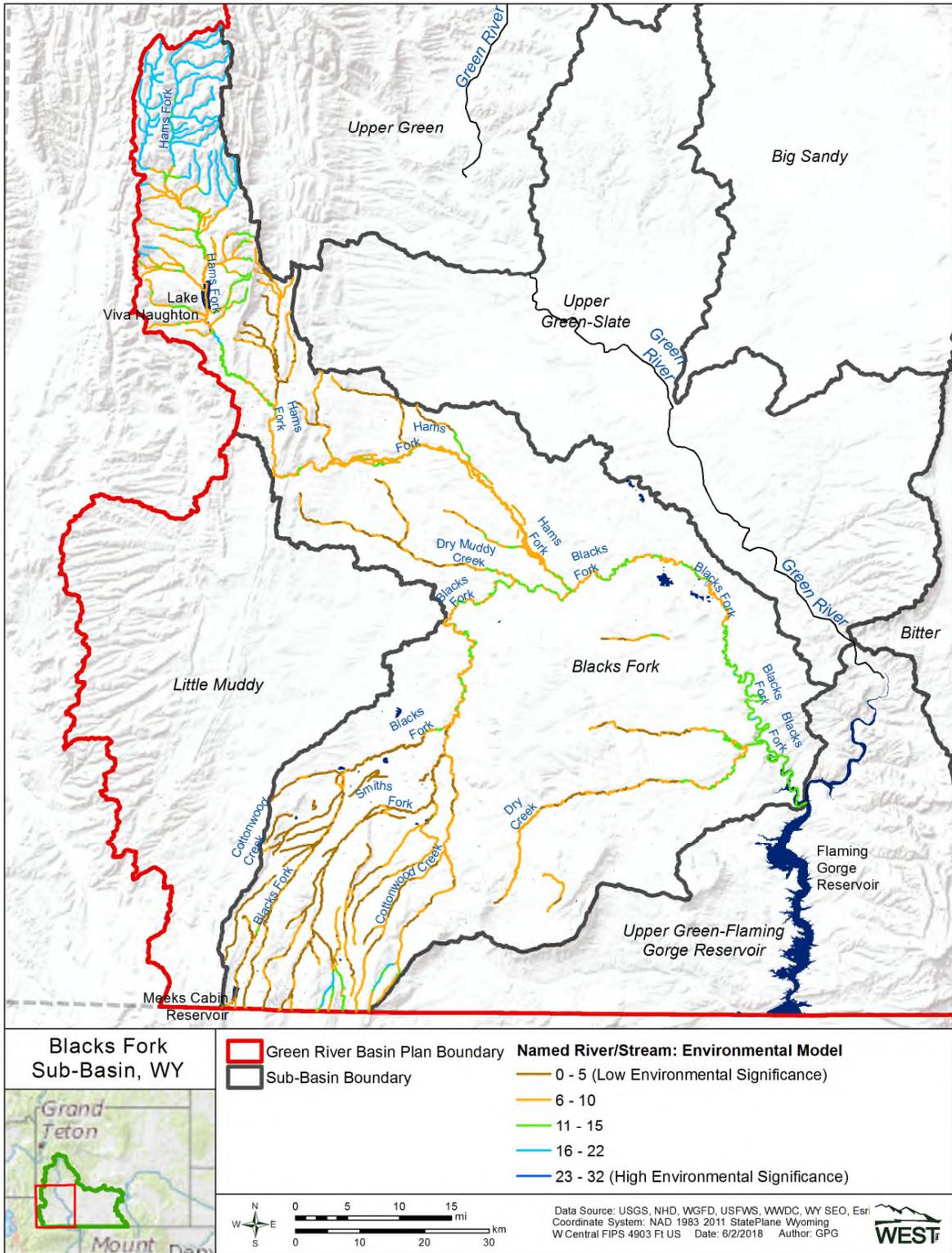


Figure B-5. Environmental model results for the Black's Fork sub-basin in Wyoming.

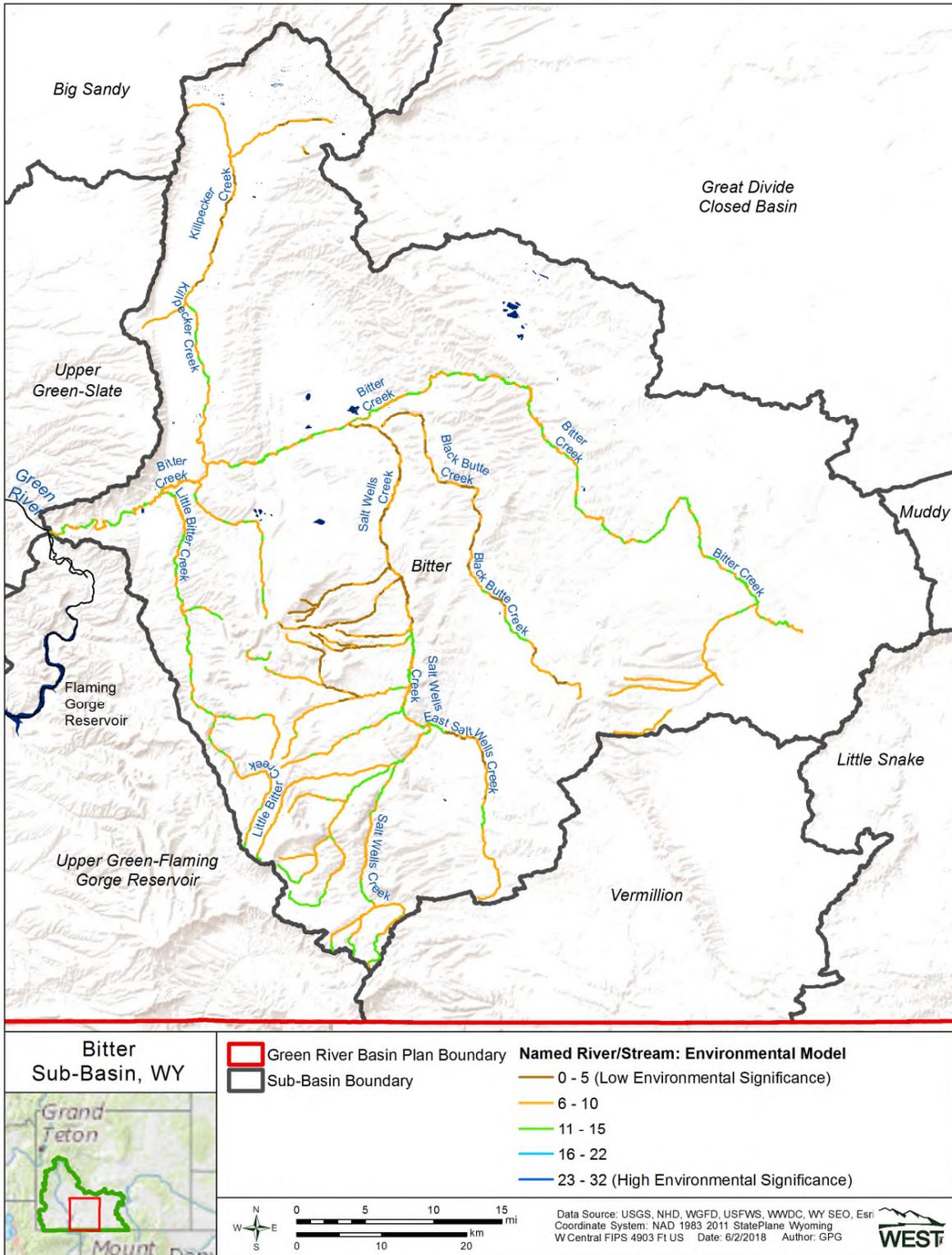


Figure B-6. Environmental model results for the Bitter sub-basin in Wyoming.

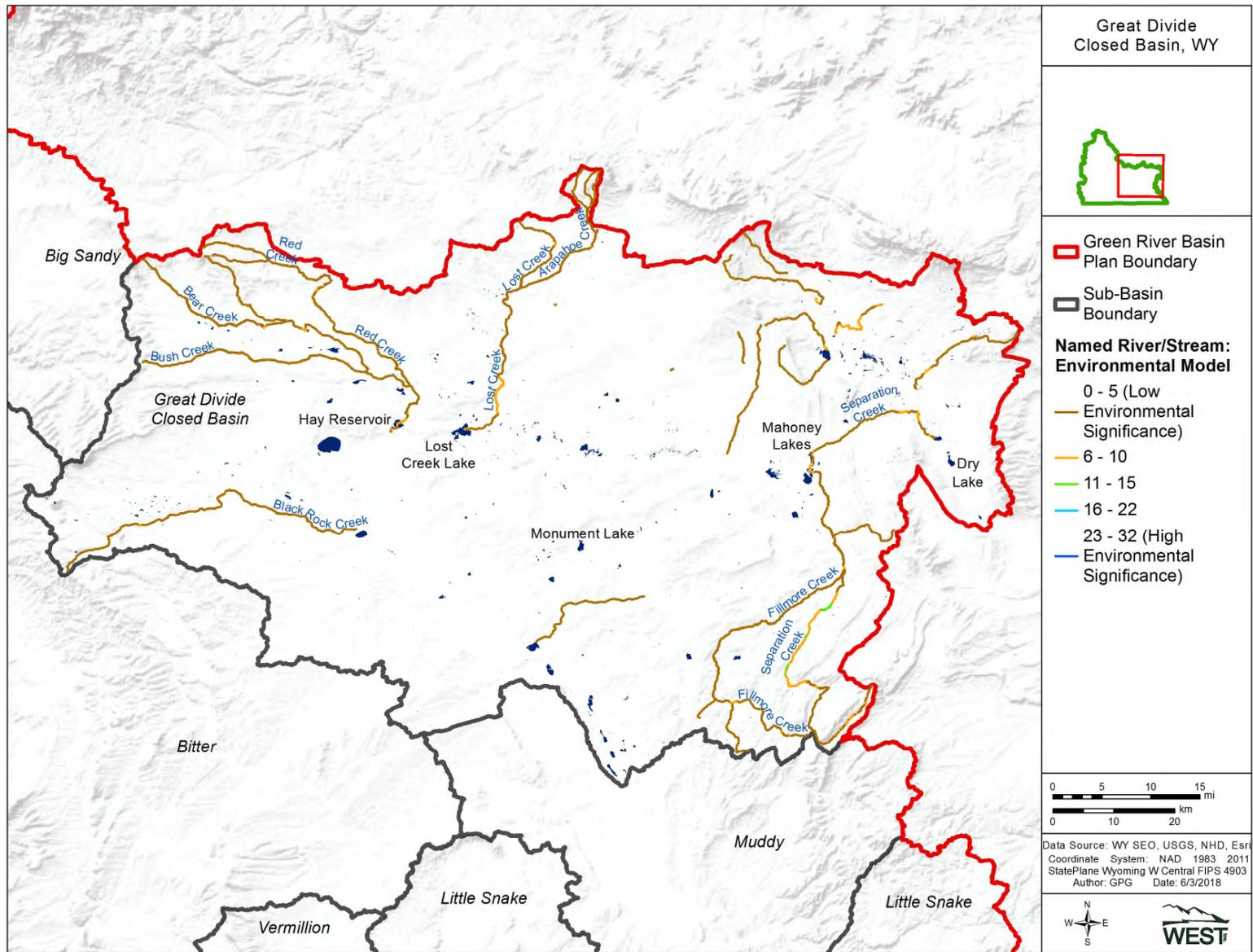


Figure B-7. Environmental model results for the Great Divide Closed Basin sub-basin in Wyoming.

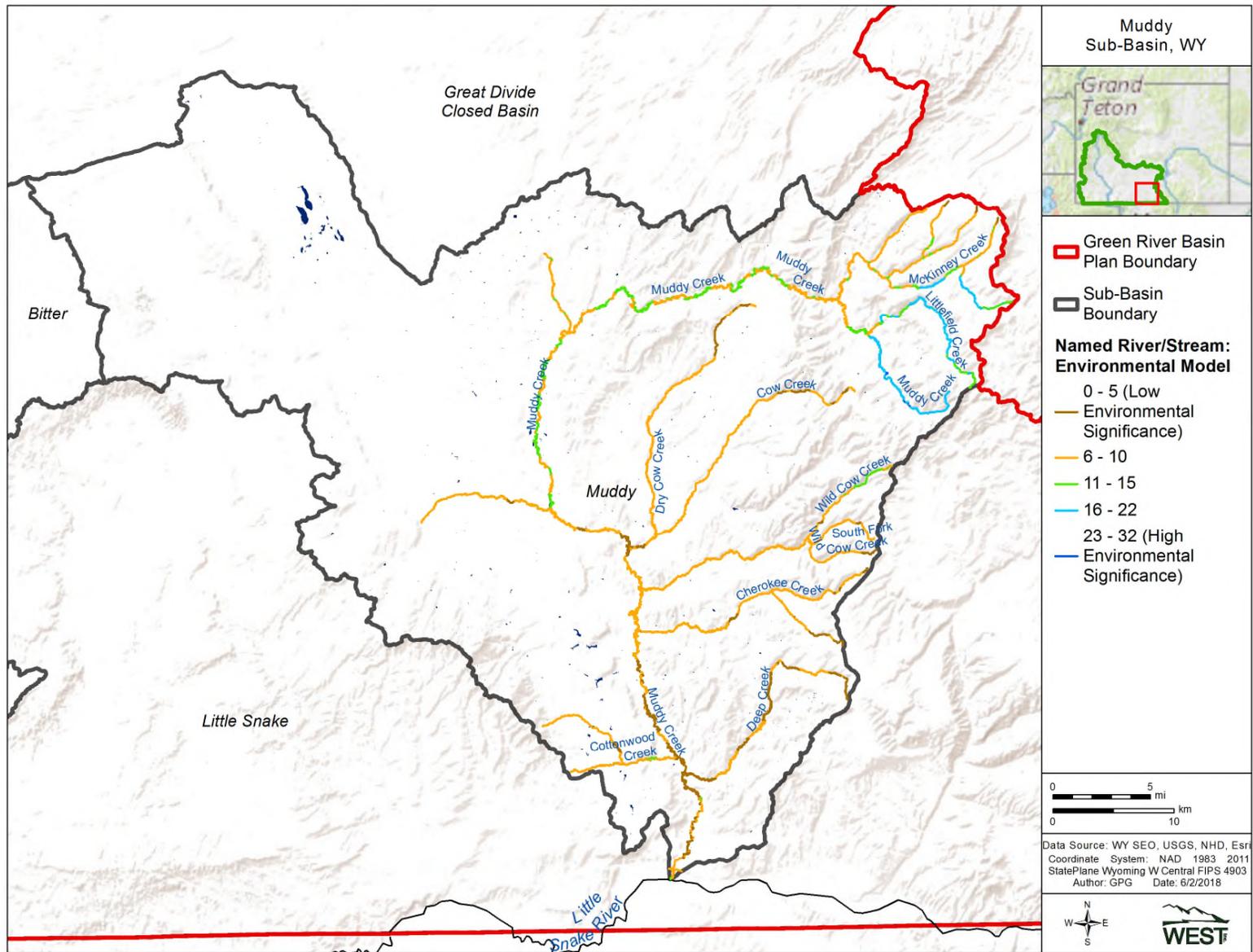


Figure B-8. Environmental model results for the Muddy sub-basin in Wyoming.

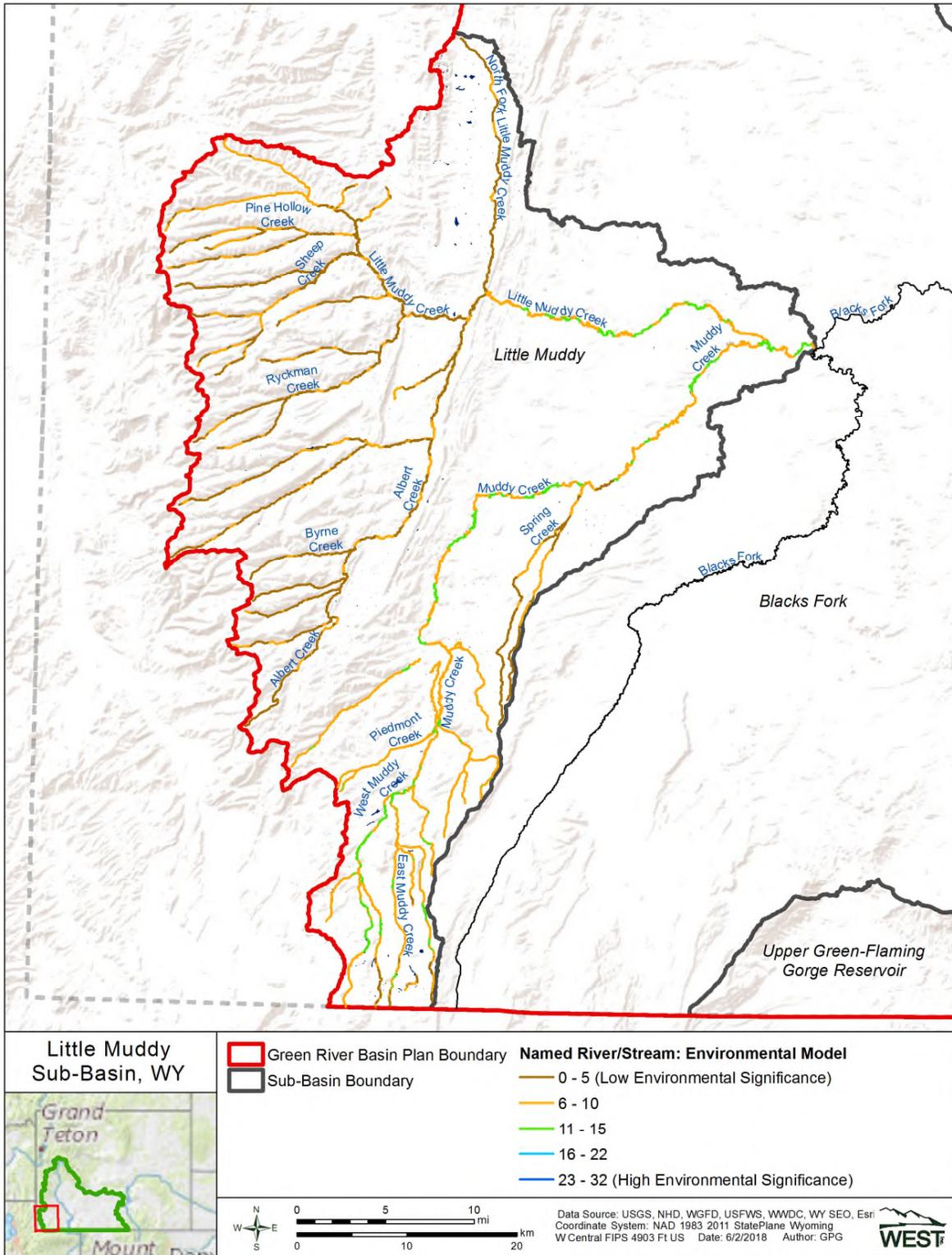


Figure B-9. Environmental model results for the Little Muddy sub-basin in Wyoming.

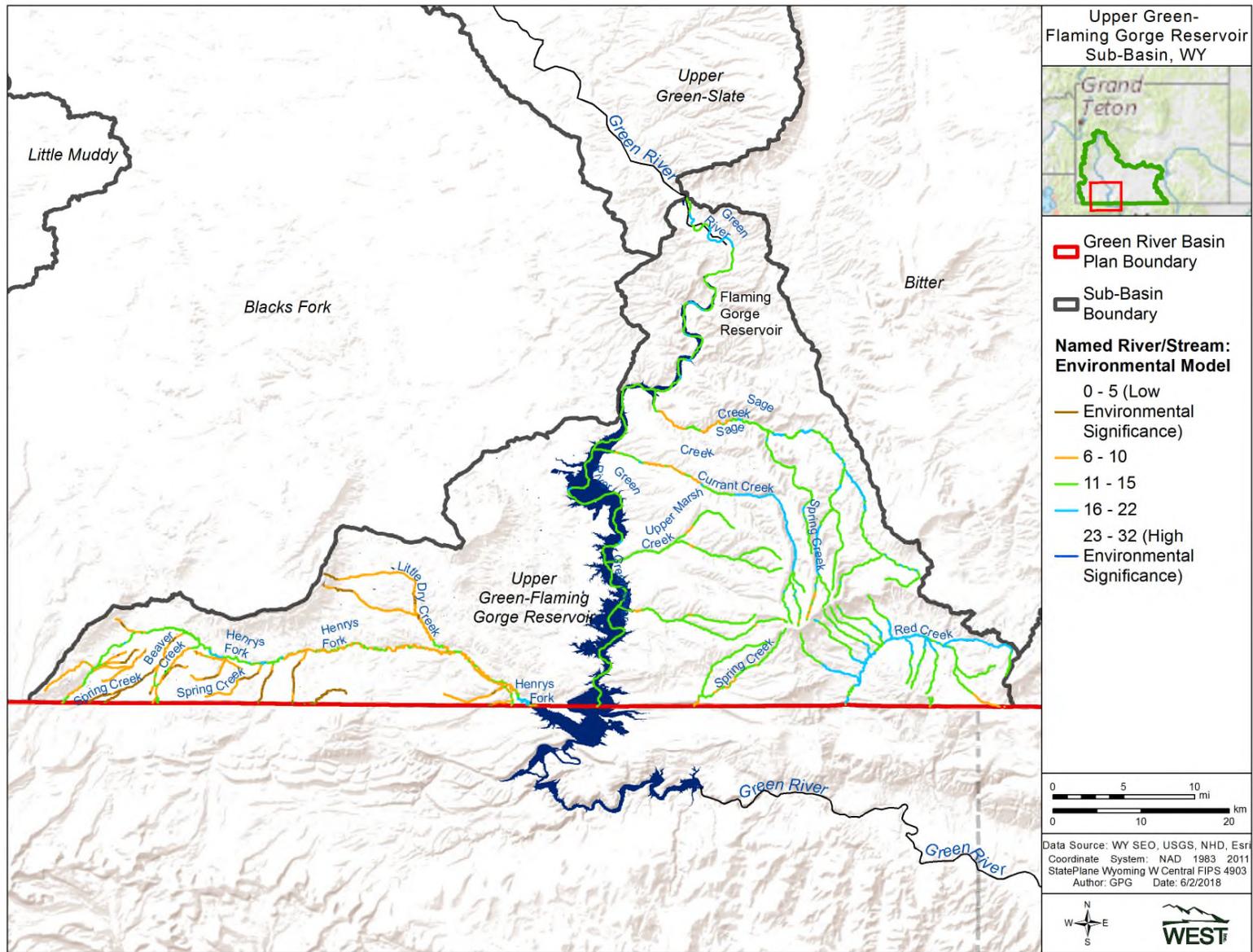


Figure B-10. Environmental model results for the Upper Green-Flaming Gorge sub-basin in Wyoming.

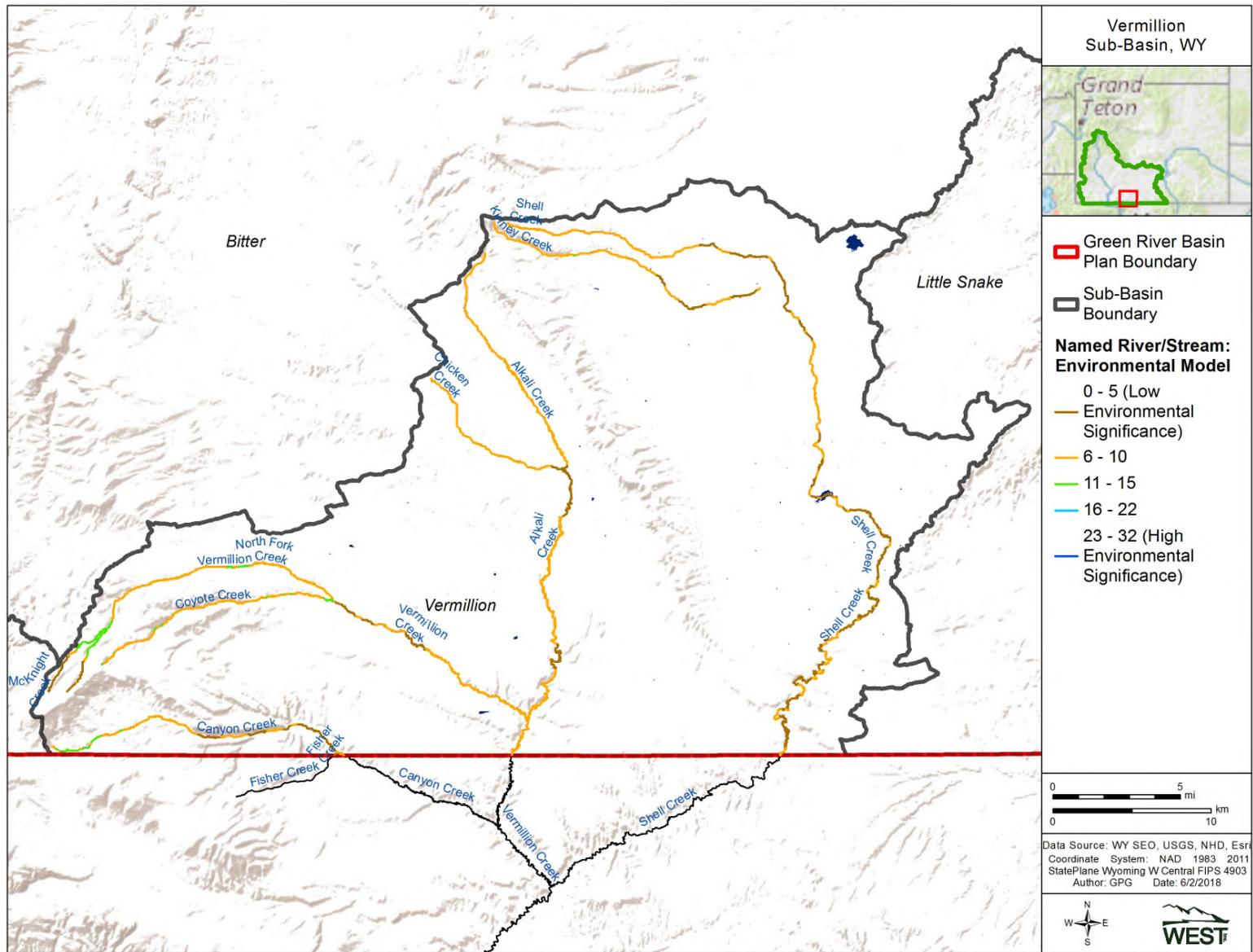


Figure B-11. Environmental model results for the Vermillion sub-basin in Wyoming.

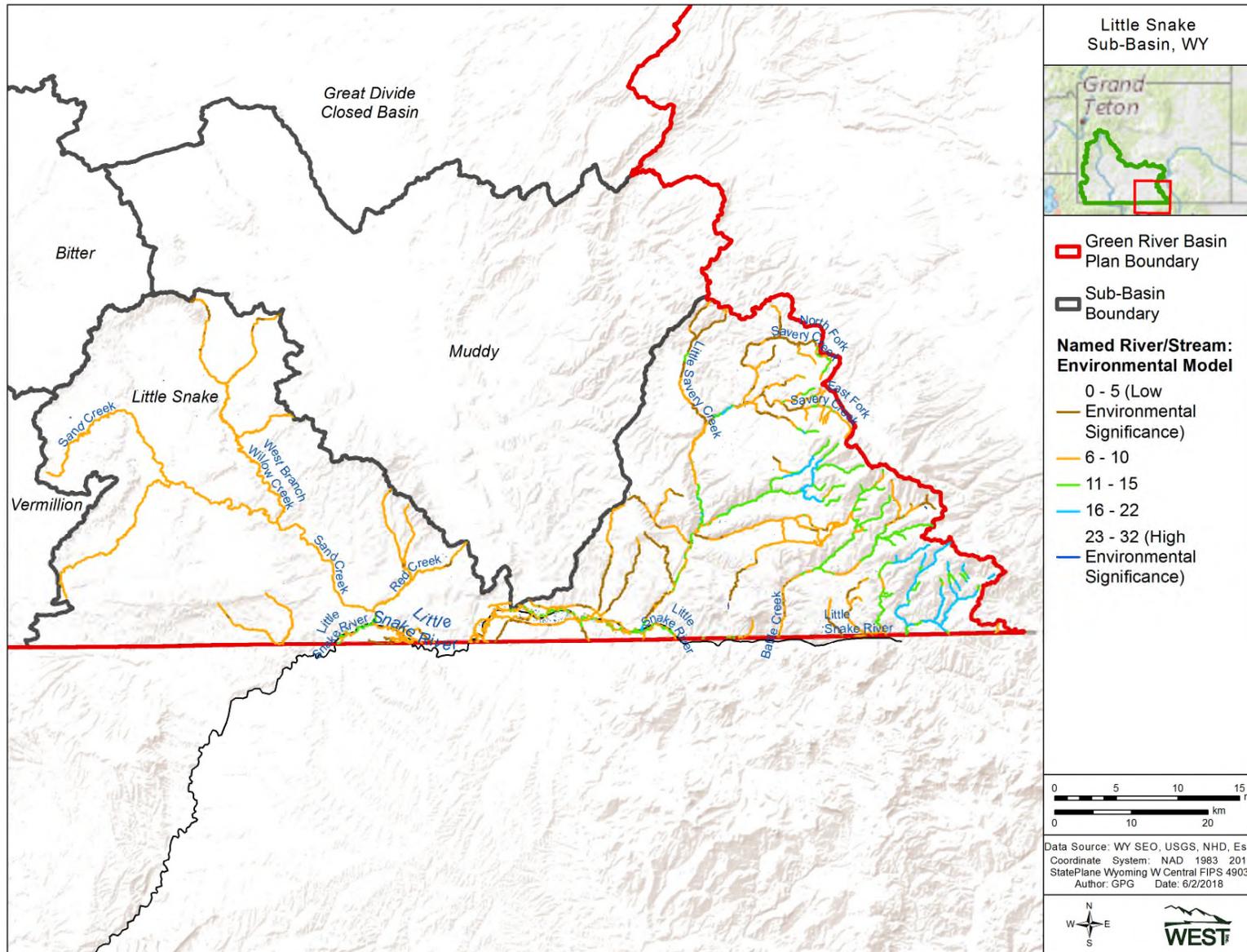


Figure B-12. Environmental model results for the Little Snake sub-basin in Wyoming.

Appendix C. Recreation Model for the Green River Basin

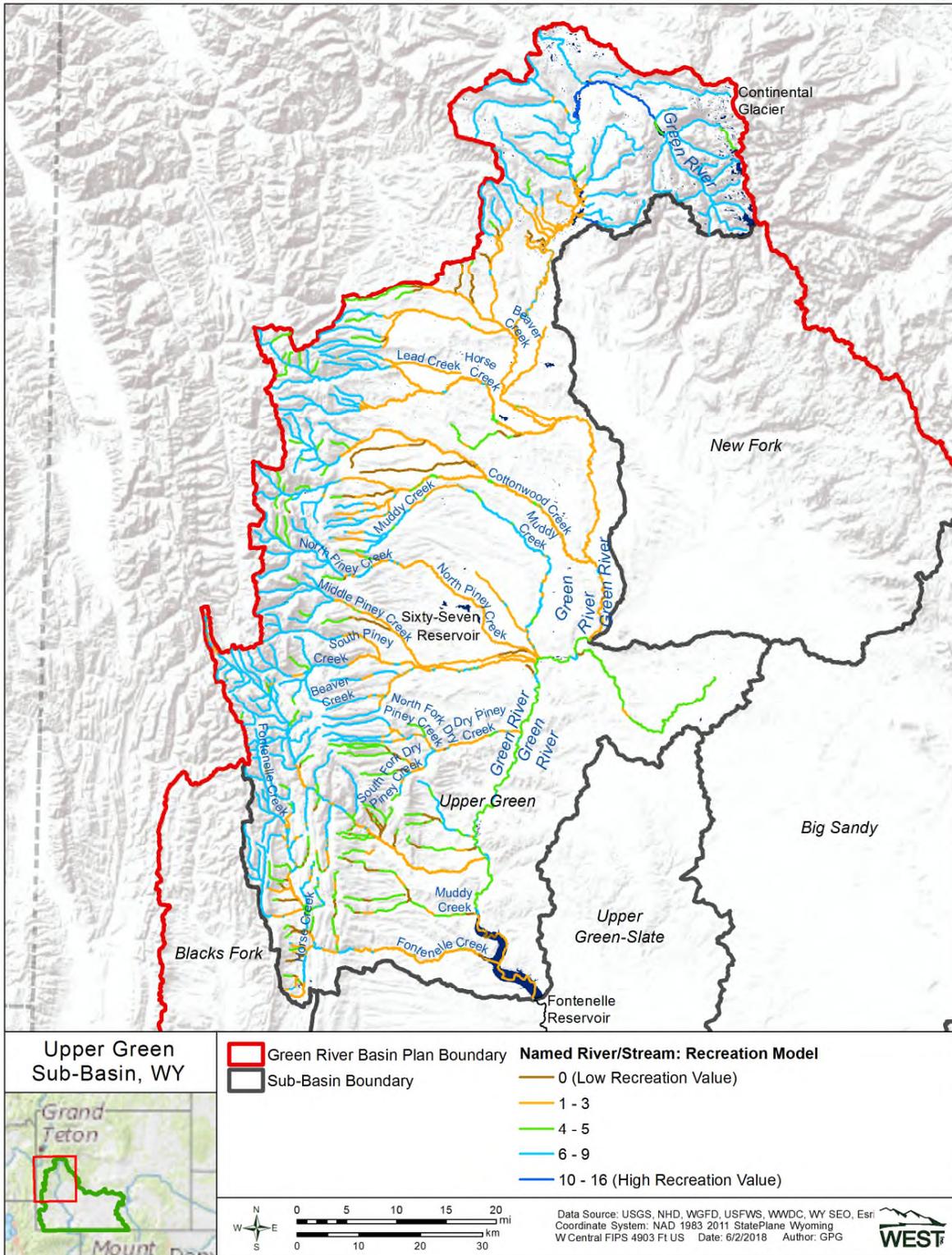


Figure C-1. Recreation model results for the Upper Green sub-basin in Wyoming.

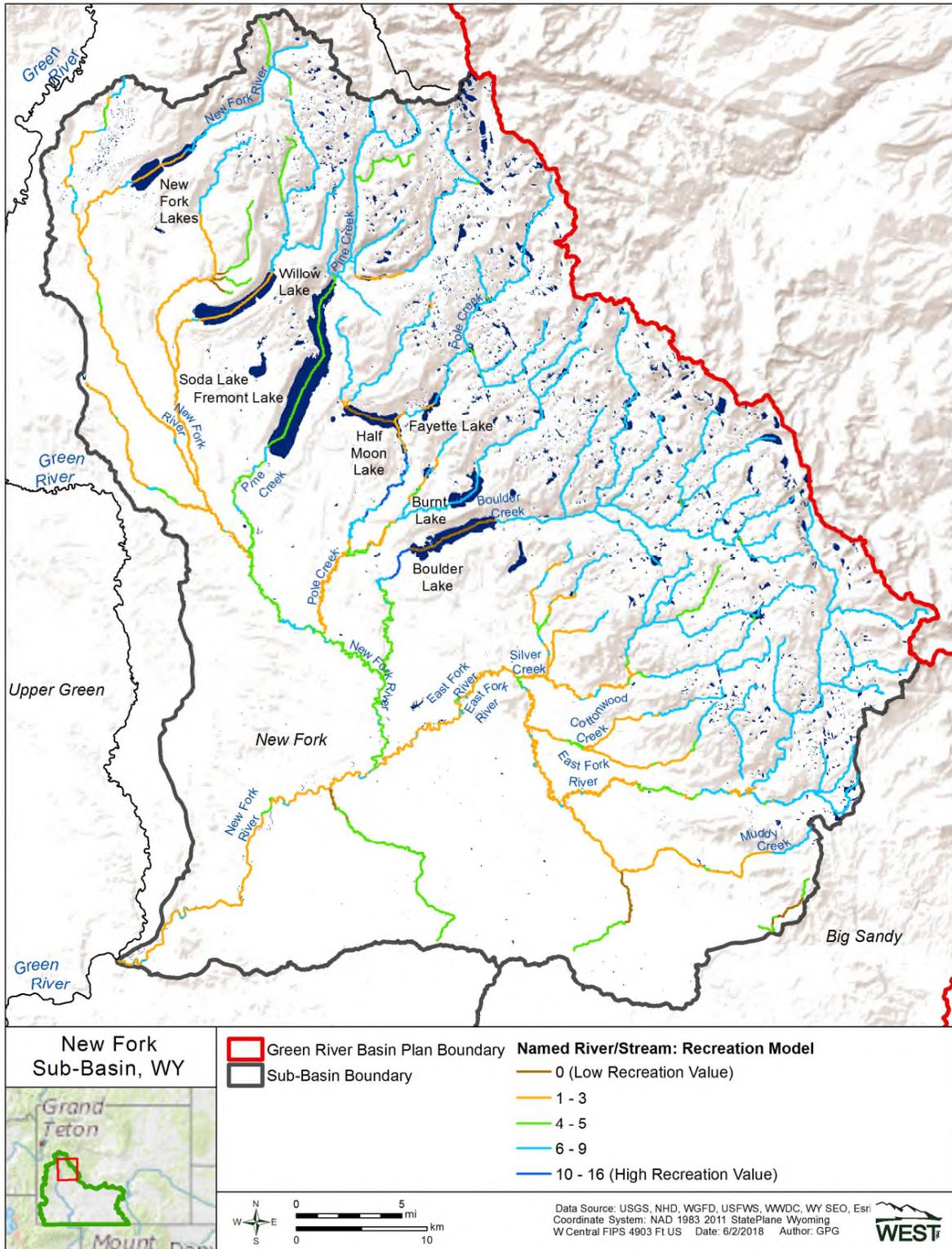


Figure C-2. Recreation model results for the New Fork sub-basin in Wyoming.

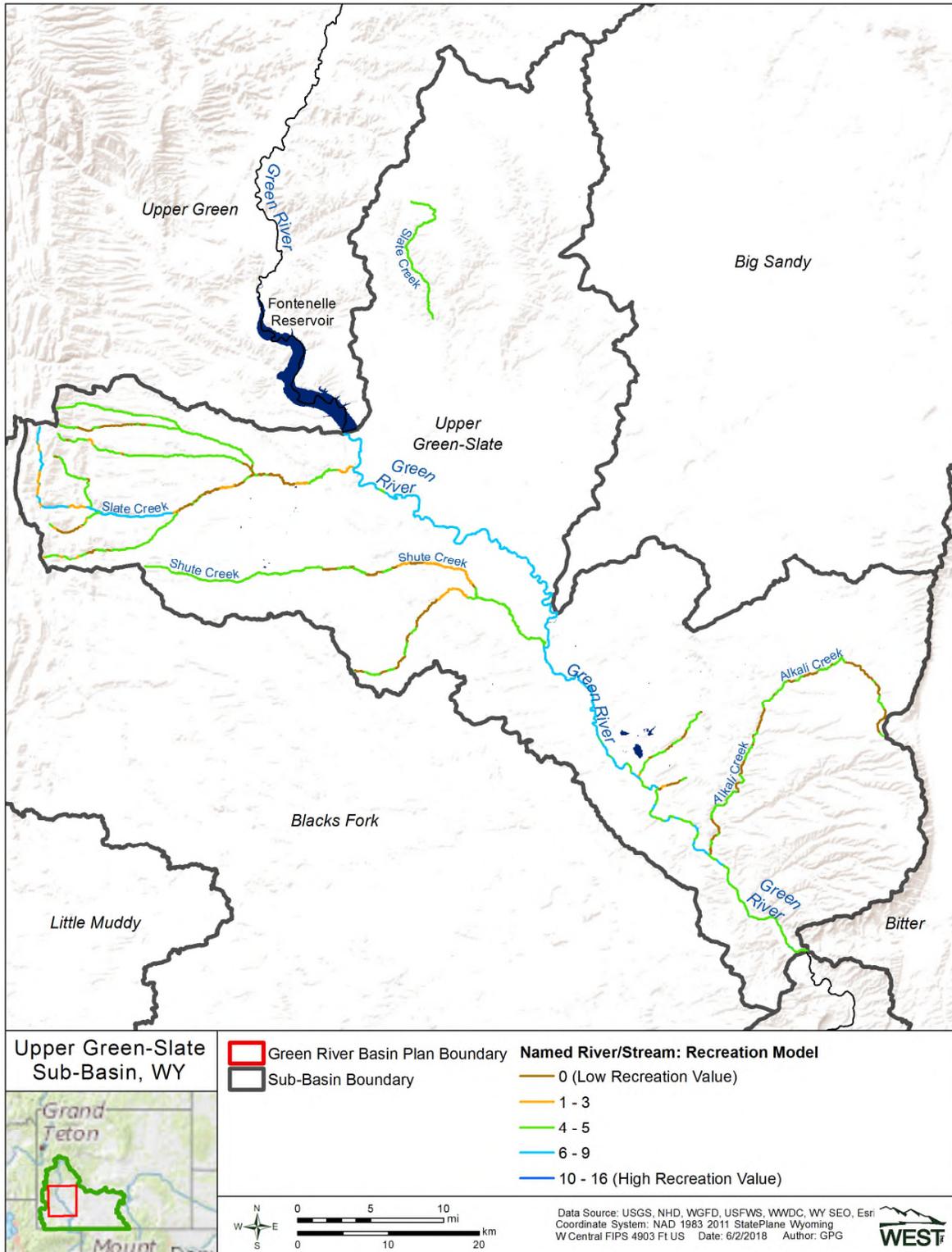


Figure C-3. Recreation model results for the Upper Green-Slate sub-basin in Wyoming.

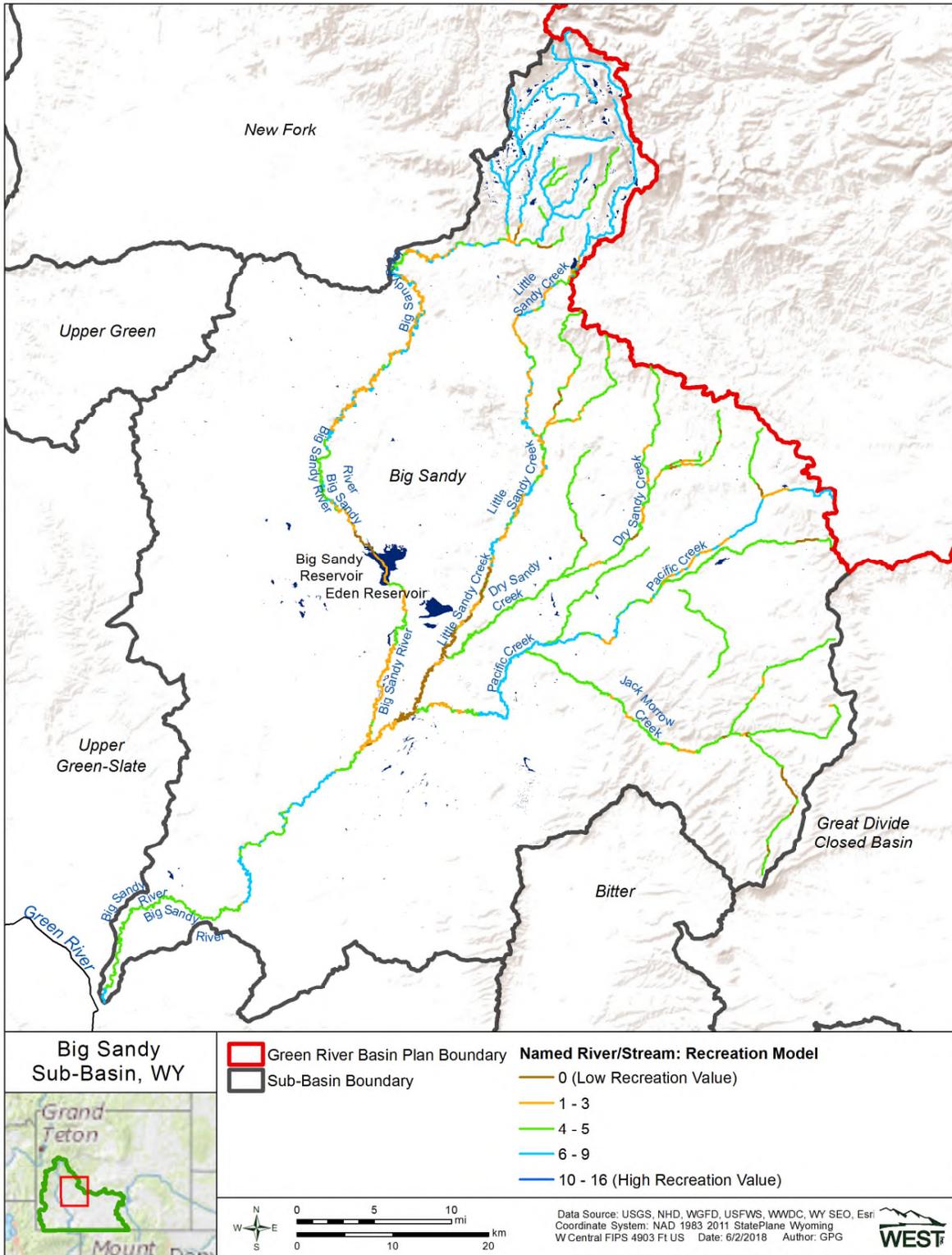


Figure C-4. Recreation model results for the Big Sandy sub-basin in Wyoming.

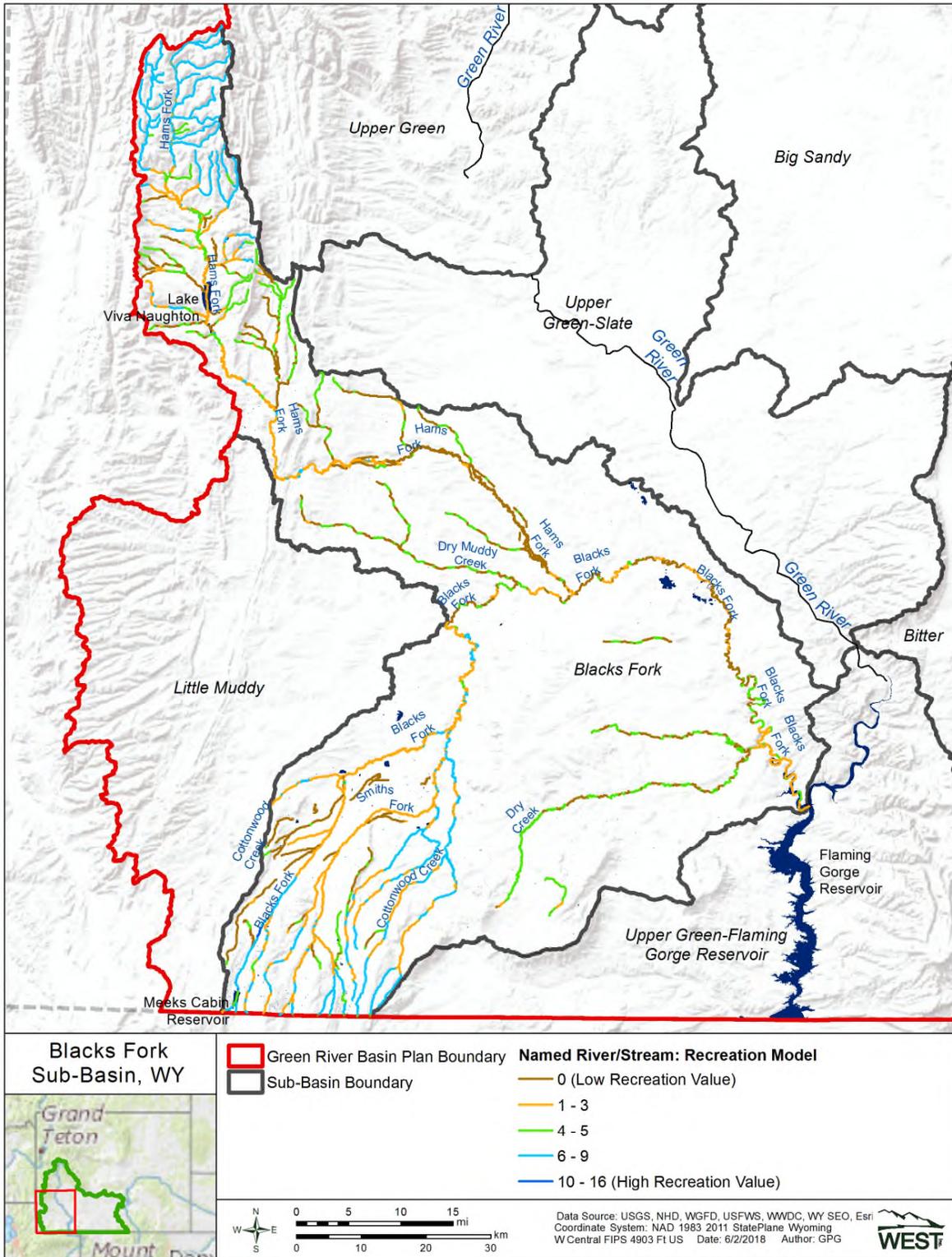


Figure C-5. Recreation model results for the Black's Fork sub-basin in Wyoming.

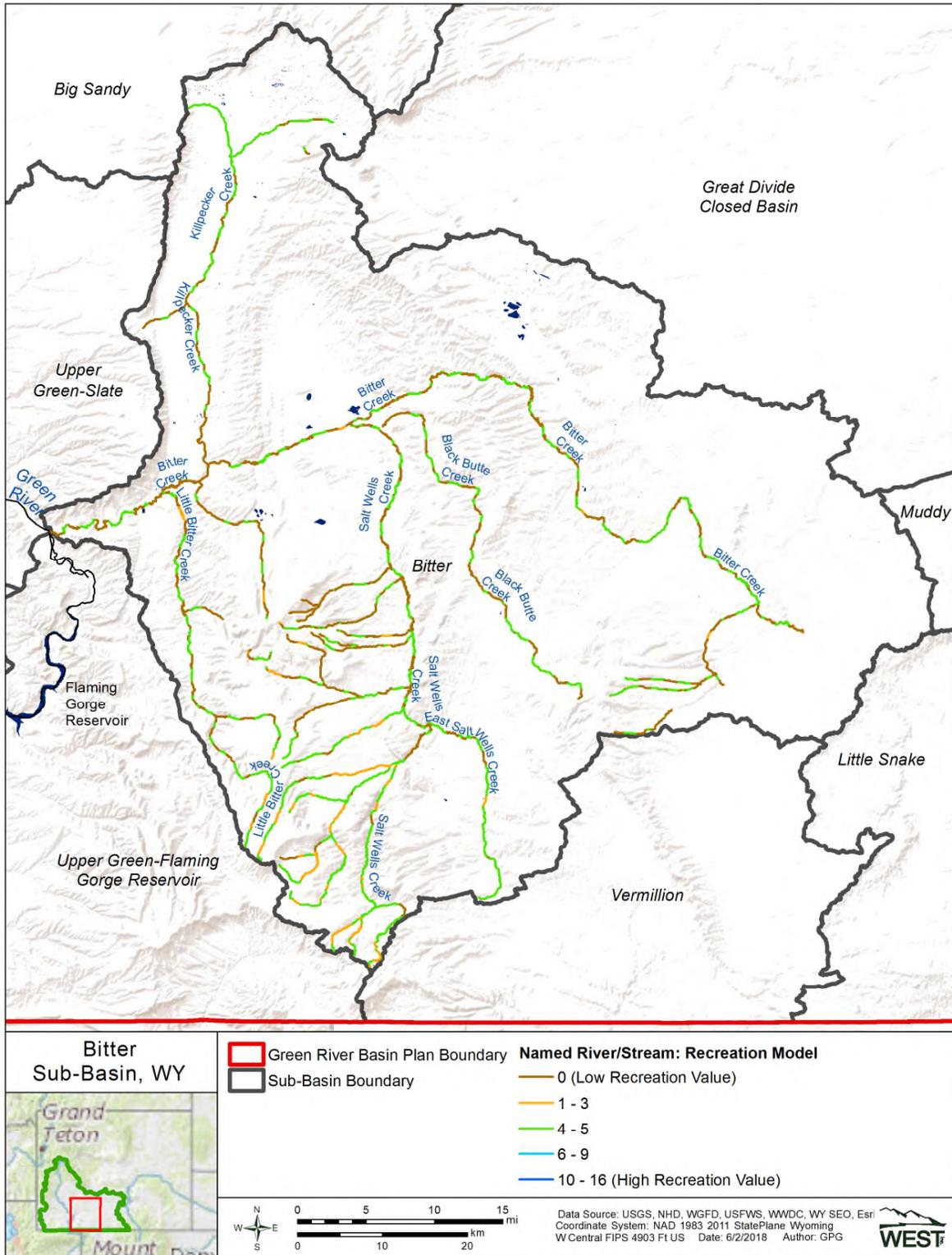


Figure C-6. Recreation model results for the Bitter sub-basin in Wyoming.

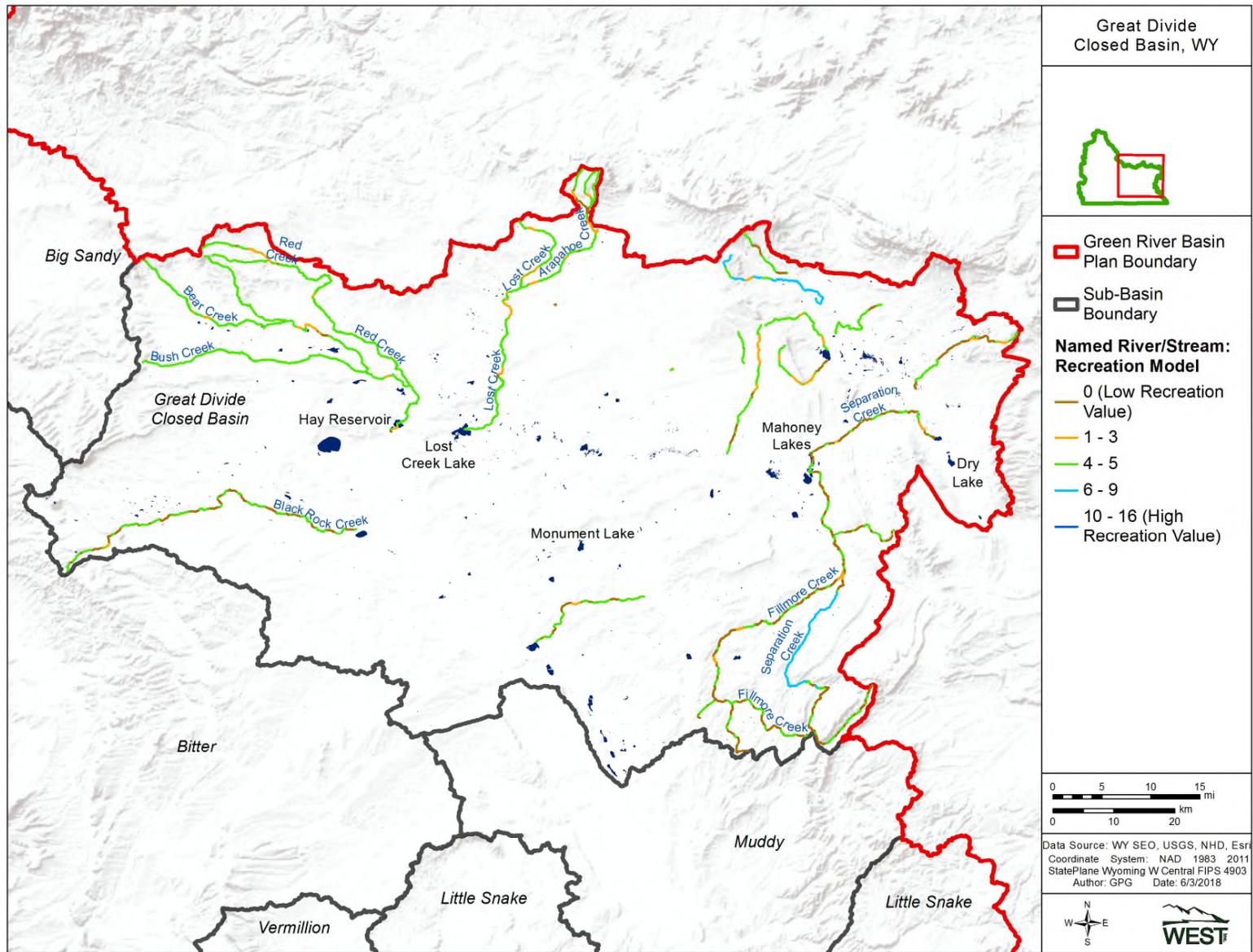


Figure C-7. Recreation model results for the Great Divide Closed Basin sub-basin in Wyoming.

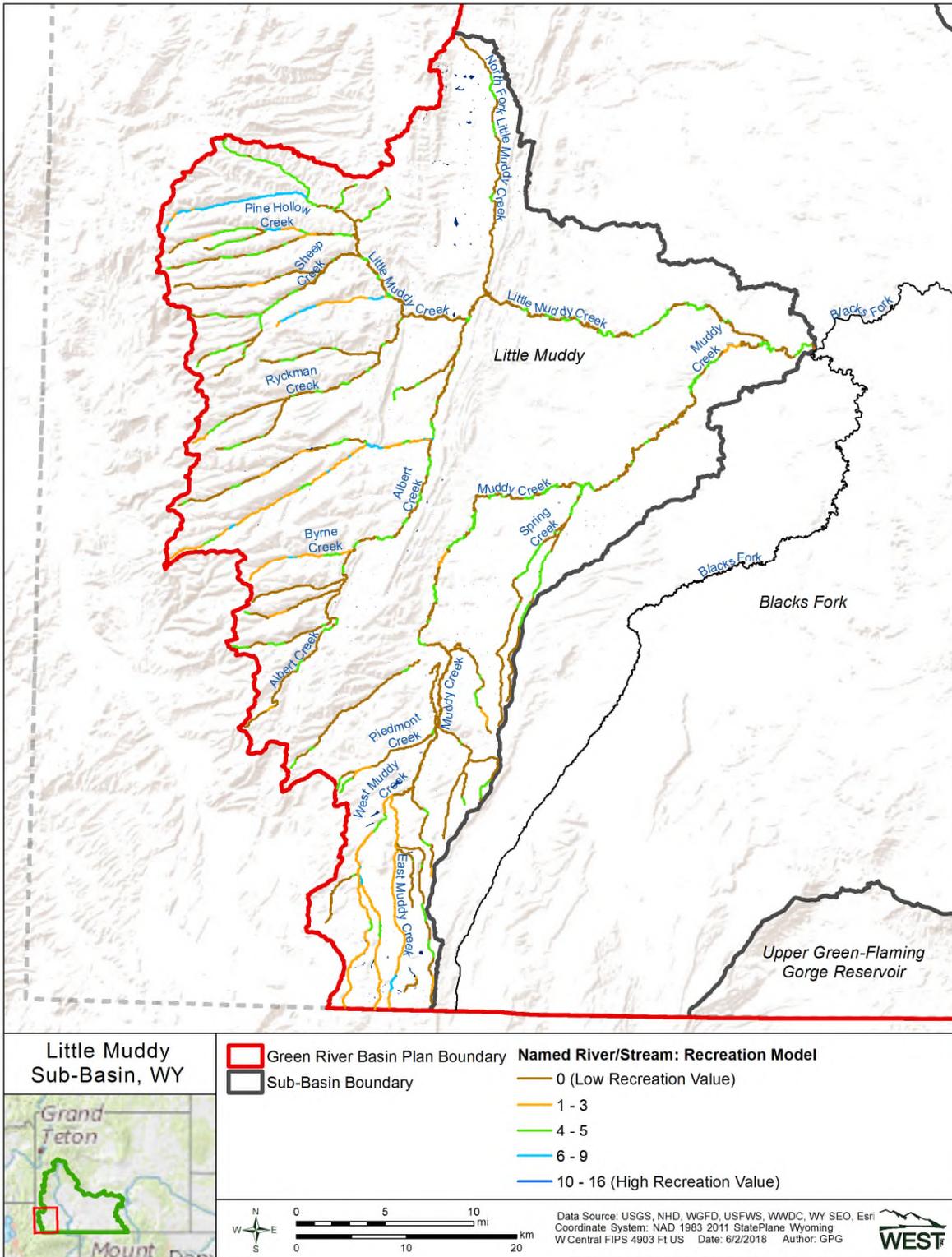


Figure C-9. Recreation model results for the Little Muddy sub-basin in Wyoming.

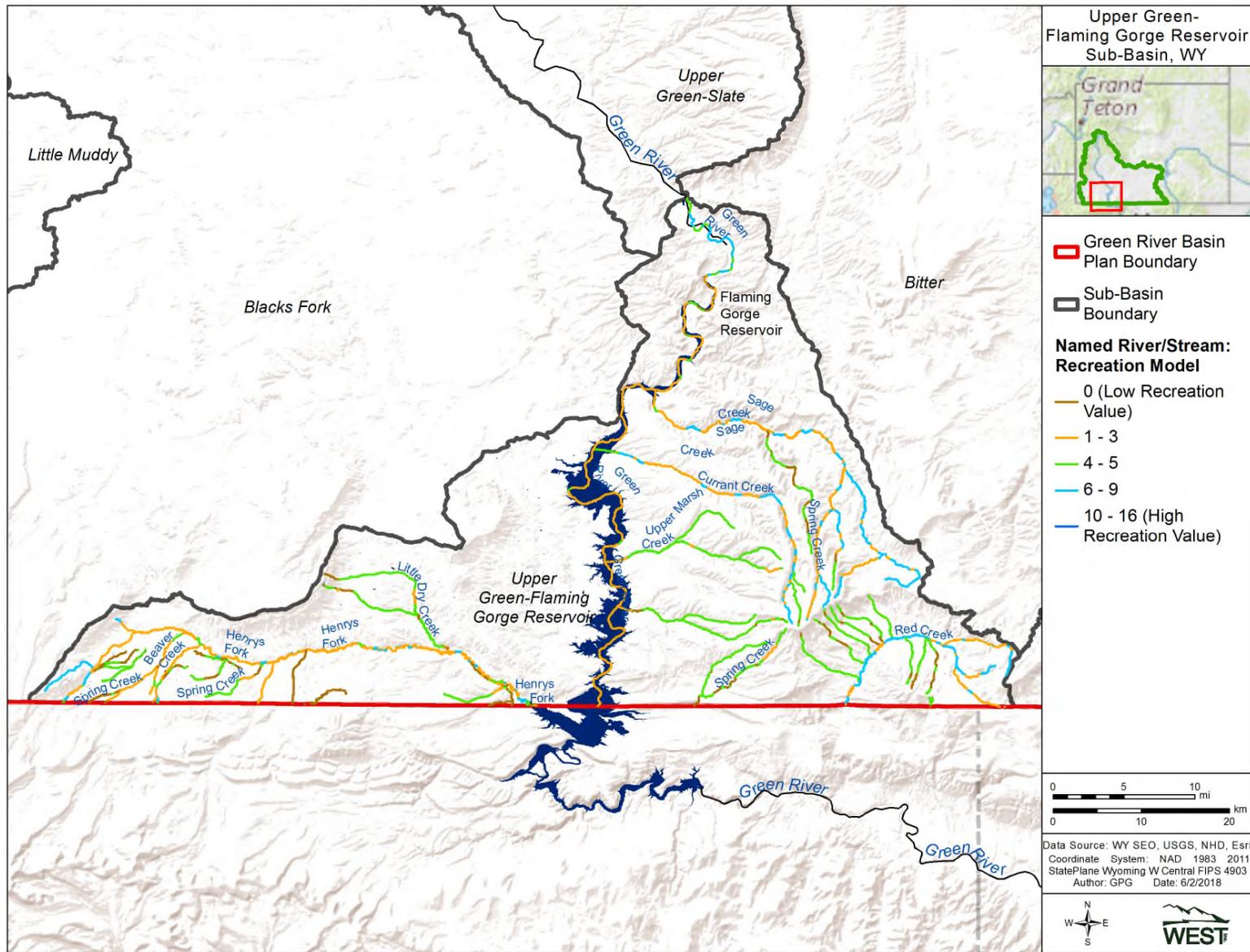


Figure C-10. Recreation model results for the Upper Green-Flaming Gorge Reservoir sub-basin in Wyoming.

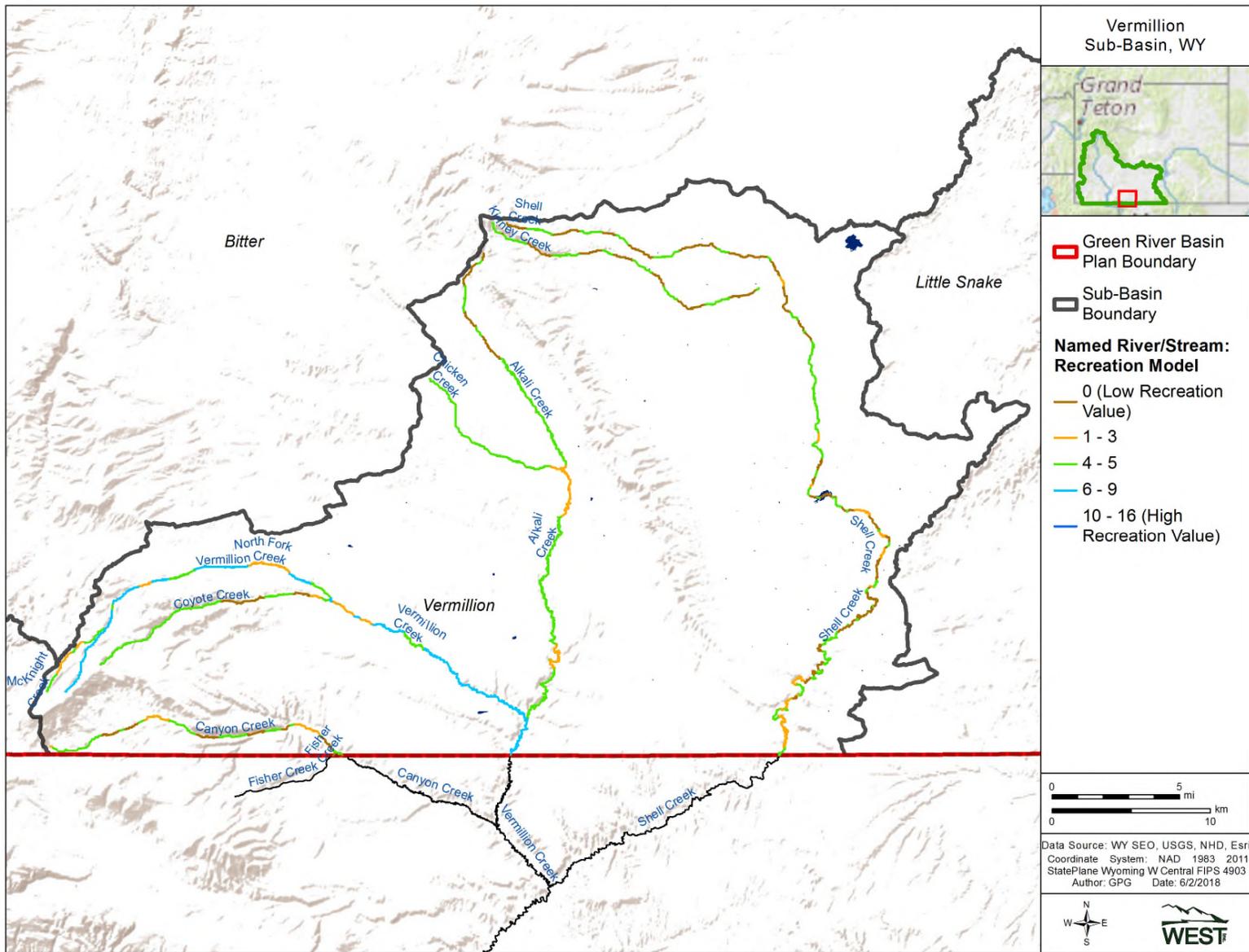


Figure C-11. Recreation model results for the Vermillion sub-basin in Wyoming.

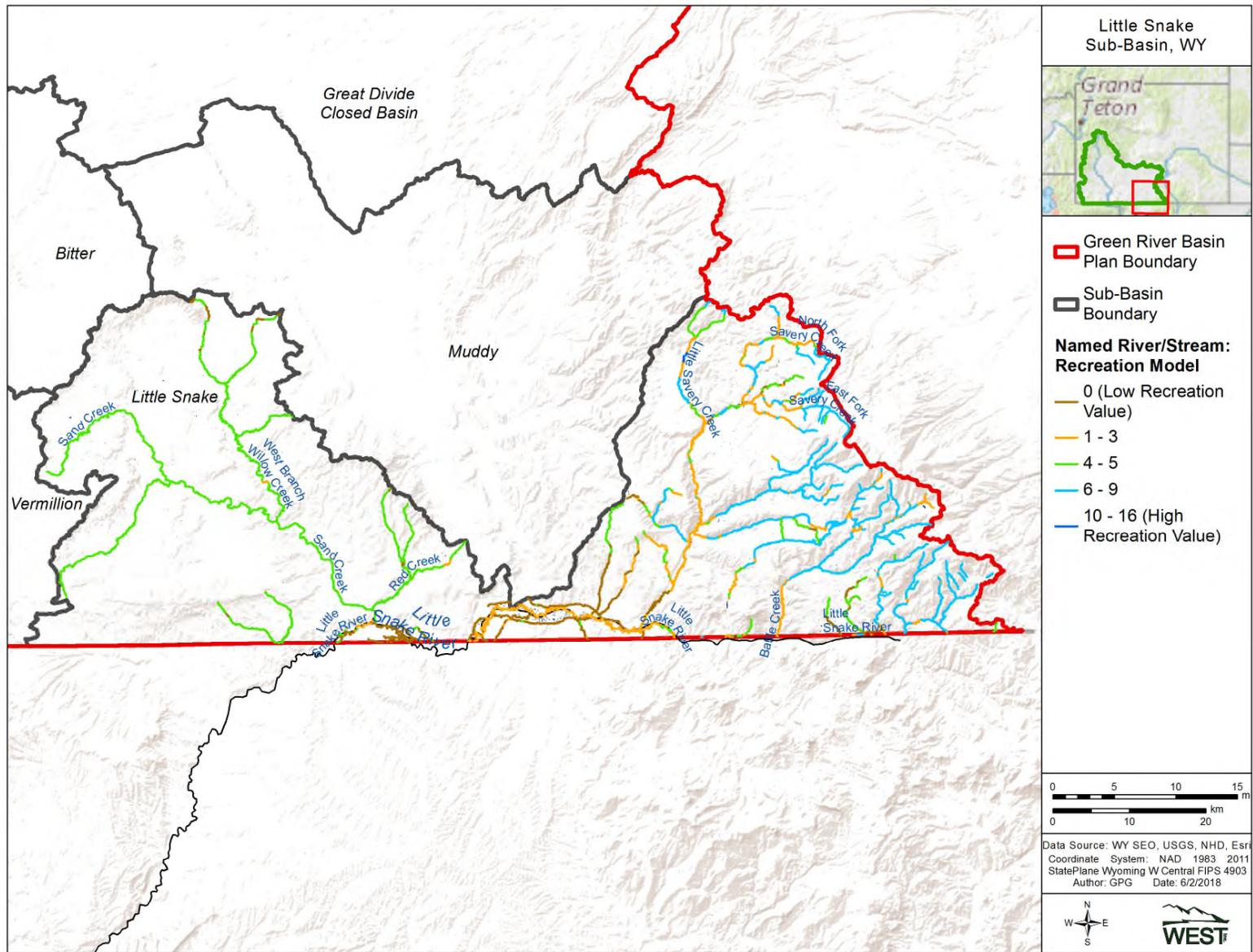


Figure C-12. Recreation model results for the Little Snake sub-basin in Wyoming.

