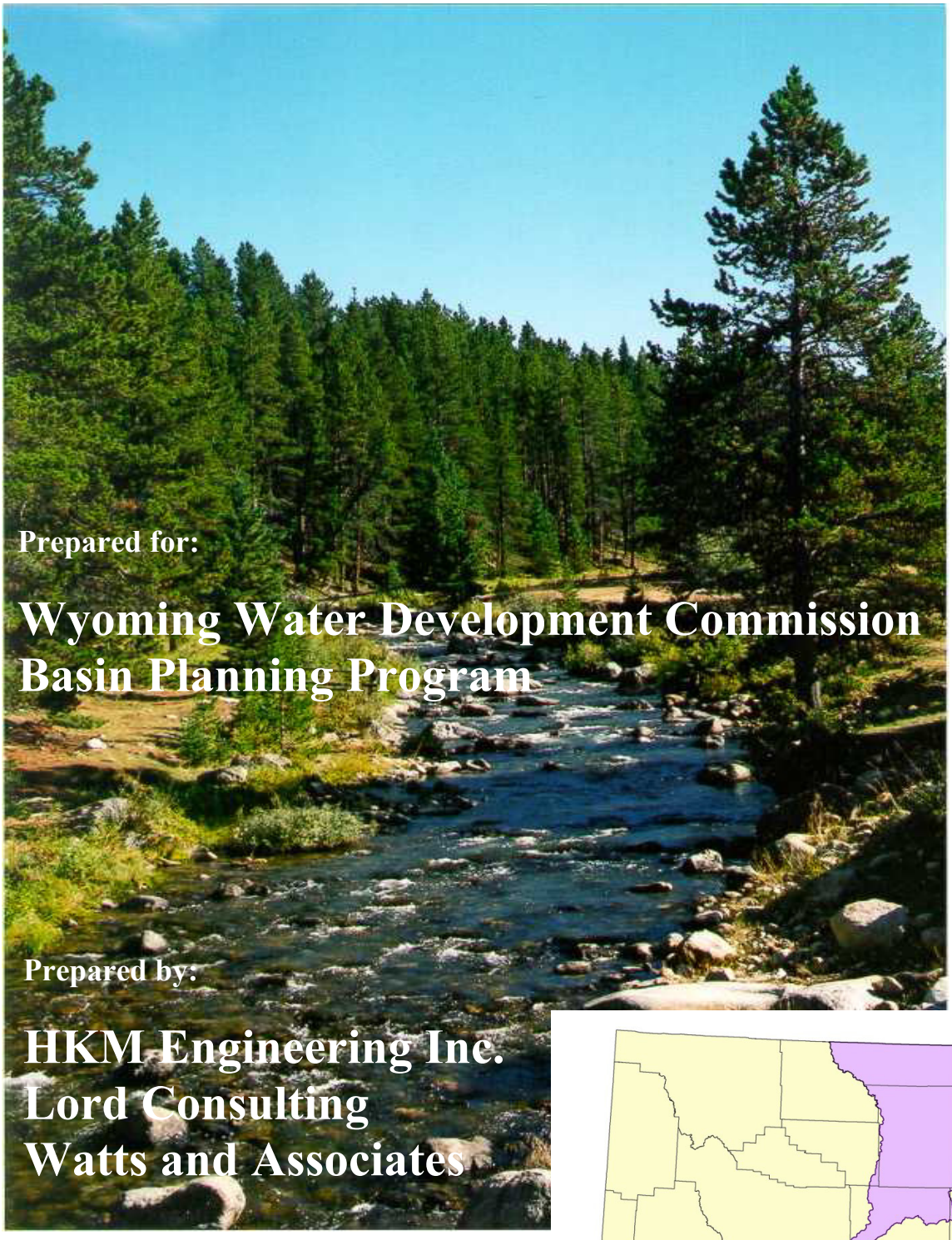
Powder/Tongue River Basin Plan
Executive Summary

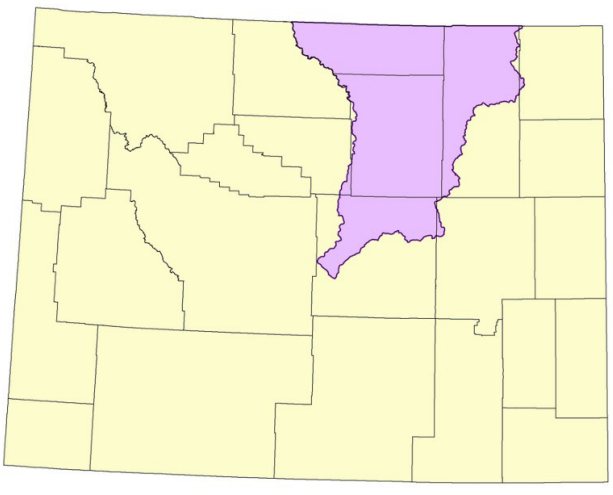


Prepared for:

Wyoming Water Development Commission
Basin Planning Program

Prepared by:

HKM Engineering Inc.
Lord Consulting
Watts and Associates



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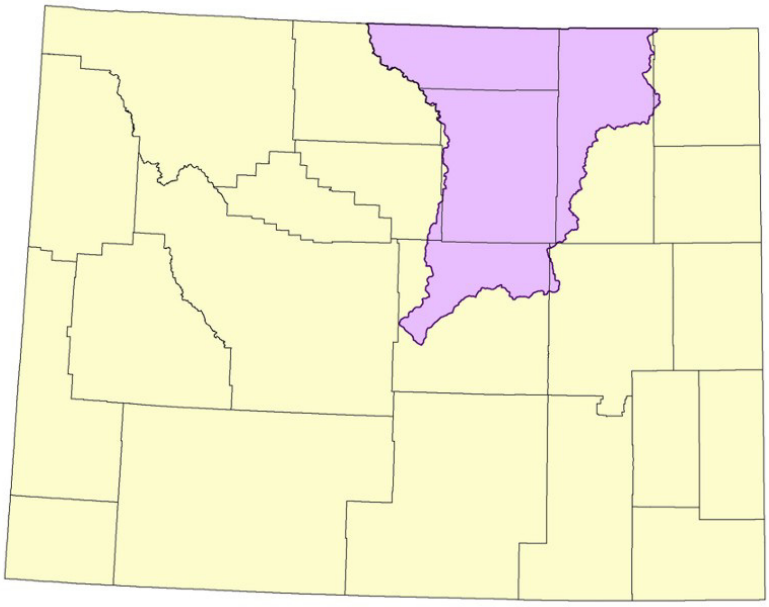

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Project Scope

The *Powder/Tongue River Basin Plan* document is one of four River Basin Plans thus far completed by the Wyoming Water Development Commission as authorized by the Wyoming Legislature in 1999. The plans for the Bear River Basin and Green River Basin were completed in 2001, and the plan for the Northeast Wyoming River Basins is being completed concurrently with the Powder/Tongue River Basin Plan. The Wind/Big Horn River Basin and the Snake/Salt River Basin plans were initiated in 2002 and the plan for the North Platte River will commence in the near future. It is the express desire of the program to revisit and update the basin planning documents every five years.

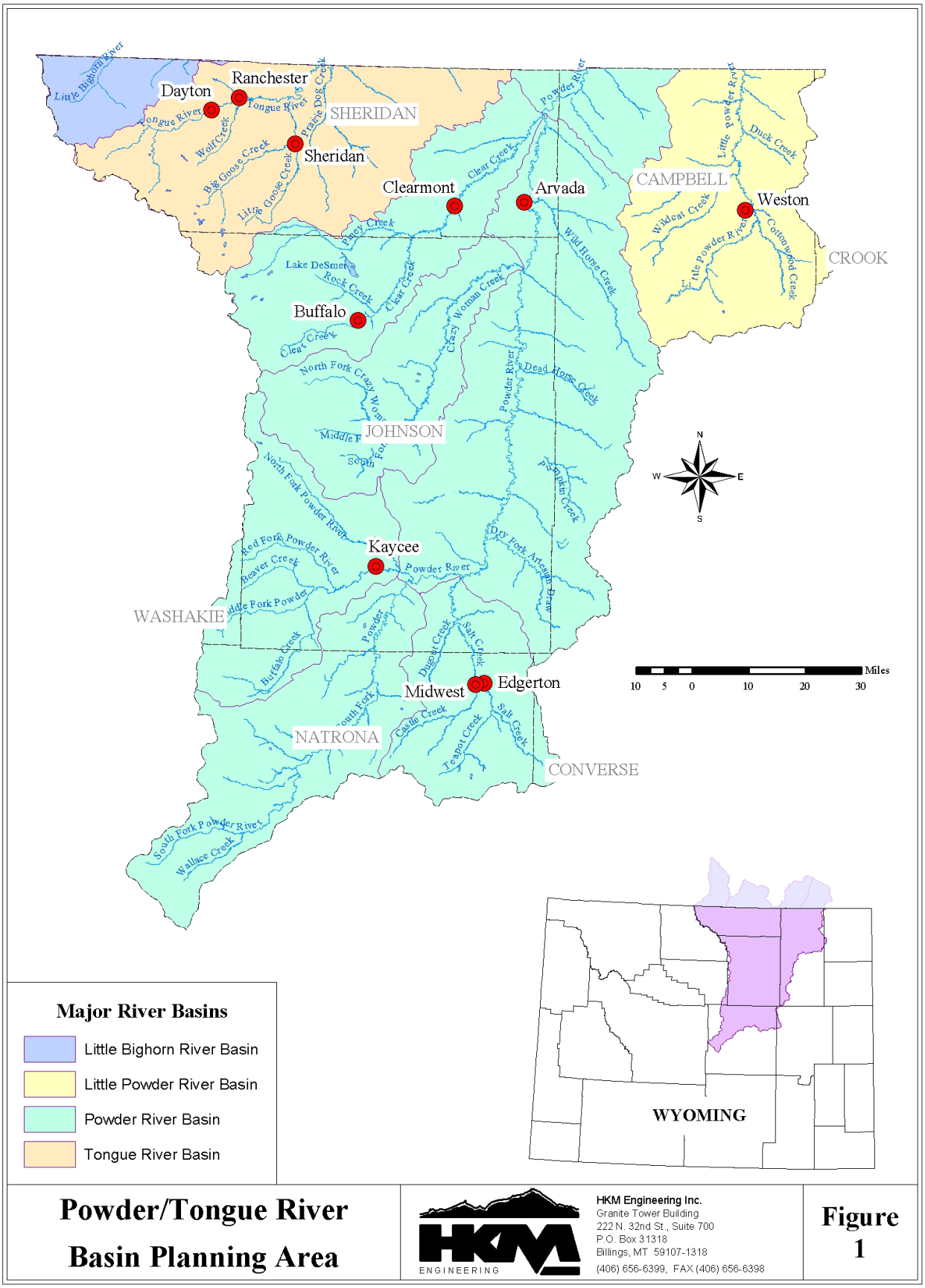
This planning document presents current and projected future uses of water in Wyoming's Powder/Tongue River Basin. Uses inventoried and analyzed in this plan include agricultural, municipal, industrial, environmental, and recreational. Surface and ground water uses are both described as is overall water quality. Given current uses, the availability of surface water and ground water to meet estimated future requirements is analyzed. The current institutional and legal framework of water development and management is presented.

The primary products of this planning study are technical memoranda prepared for the large number of topics addressed in the plan. These memoranda provide detailed descriptions of the data collected, source references, analyses performed, tools developed, and the results of each investigation required to fully explore the water resources within the planning area. The intent of this Executive Summary, and the associated Final Report, is to describe the planning study in sufficient detail for the reader to gain a general understanding of the investigations that were performed and the results of those investigations. For detailed information on a specific topic the reader is directed to the technical memorandum prepared for that topic.

Basin Description

The study area of the Powder/Tongue River Basin Plan includes the drainages of the Little Bighorn River, Tongue River, Powder River, and Little Powder River. These river basins encompass all or part of Sheridan, Johnson, Campbell, Natrona, and Converse counties as well as a small part of Washakie county in north central Wyoming. The planning area is shown on Figure 1.

Climate throughout the Basin varies, but generally follows the pattern of a high desert region. Annual precipitation in the range of 13 to 15 inches is the norm for the majority of the planning area.



Powder/Tongue River Basin Planning Area

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Figure 1

The major rivers and streams in the study area include the following:

- Little Bighorn River Basin – Little Bighorn River, Elkhorn Creek, Red Canyon Creek, and East Pass Creek
- Tongue River Basin – Goose Creek, Big Goose Creek, Little Goose Creek, Prairie Dog Creek, and Tongue River.
- Powder River Basin – Powder River, Little Powder River, Clear Creek, Piney Creek, and Crazy Woman Creek

There have been a number of reservoirs developed in the Powder/Tongue River Basin to enhance the water supply in the study area. The major storage facilities include:

- Tongue River Basin – Twin Lakes, Big Goose Park Reservoir, Cross Creek Reservoir, Big Horn Reservoir, Dome Lake, and Sawmill Reservoir
- Powder River Basin – Lake DeSmet, Healy Reservoir, Kearney Lake, Willow Park Reservoir, Cloud Peak Reservoir, and Tie Hack Reservoir, in the Clear Creek watershed, Muddy Guard No. 2 Reservoir in the Crazy Woman Creek drainage, and Dull Knife Reservoir on the North Fork of the Powder River.

Water Law and the Yellowstone River Compact

The Wyoming constitution establishes water in the state to be the property of the state. Consequently, all development and management of water resources in Wyoming is governed by the water laws embodied in the Constitution and Statutes. These water laws are recognized as inviolate in the river basin planning program.

The Yellowstone River Compact of 1950 controls the development and use of water from the Tongue River, Powder River, and Little Powder River. This compact divides the unappropriated flow of the Tongue River, Powder River, and Little Powder River, after needs for supplemental supply for existing rights are met, as follows:

- Tongue River: 40% to Wyoming, 60% to Montana
- Powder River and Little Powder River: 42% to Wyoming, 58% to Montana

Article X of the Compact stipulates that no water shall be diverted from the Yellowstone River Basin without the unanimous consent of the three signatory states, Wyoming, Montana, and North Dakota.

Agricultural Water Use

Irrigated agriculture in the planning area is primarily associated with forage production for the livestock industry. Ranchers depend on irrigated cropland to provide winter feed and summer grazing for their stock. Alfalfa, grass hay, and pasture grass are the dominant crops grown in the planning area. Lesser amounts of small grains and corn are also produced. In total, 161,360

acres of land are actively irrigated in the planning area and the vast majority of these lands are irrigated with surface water.

The depletion of water by irrigation is primarily dependent on the number of acres irrigated, the crop water demands, and the amount of water available to meet these demands. Depletions for wet, normal, and dry years total 194,000 acre-feet, 184,000 acre-feet, and 178,000 acre-feet respectively.

Municipal and Domestic Water Use

There are twenty public water supply entities in the planning area, consisting of incorporated municipalities, districts, and privately owned water systems. Two of the communities obtain water from sources outside the study area. Four of the entities obtain their primary water supply from surface water and consume approximately 2,700 acre-feet per year. The remaining sixteen entities use approximately 500 acre-feet per year of ground water. Domestic use is satisfied by ground water and is on the order of 2,400 to 4,400 acre-feet per year.

Industrial Water Use

Conventional oil and gas production and coalbed methane development constitute the industrial water use in the Powder/Tongue River Basin. The estimated depletion of ground water for these uses is approximately 68,000 acre-feet per year. No water is currently being used in the study area for electric power generation or coal mining. Lake DeSmet has been developed as a surface water supply for future electric power generation, but this source has yet to be utilized.

Recreational Water Use

Recreational uses associated with the water resources of the Powder/Tongue River Basin include boating, fishing, and waterfowl hunting. Although these uses are generally non-consumptive, water-based recreation is enhanced through minimum flow releases from reservoirs, minimum pool levels maintained in reservoirs, and instream flow water rights established on streams. Lake DeSmet, the largest standing water recreation attraction in the Powder/Tongue River Basin, supports skiing, fishing, swimming, boating, and camping.

Environmental Water Use

Environmental uses of water in the Powder/Tongue River Basin are largely non-consumptive. Environmental use topics addressed in this planning study include water administration (minimum flow releases, minimum pool maintenance, and instream flow water rights), environmental concerns associated with water produced by coal bed methane development, and wetland mapping. Concerns expressed by environmental organizations are also presented in the basin plan.

Reservoir Evaporation

The majority of water use from storage reservoirs within the Powder/Tongue River Basin is for irrigation. Evaporation from these storage reservoirs constitutes another consumptive use of water within the planning area. Evaporation from the 14 key storage facilities (generally larger than 1,000 acre-feet) totals 11,300 acre-feet annually.

Current Water Use Summary

The current water uses in the planning area are summarized as follows:

Water Use	Dry Year		Normal Year		Wet Year	
	(AF/Year)					
	Surface Water	Ground Water	Surface Water	Ground Water	Surface Water	Ground Water
Agricultural	178,000	200	184,000	200	194,000	300
Municipal	2,700	500	2,700	500	2,700	500
Domestic	---	4,400	---	4,400	---	4,400
Industrial[1]	---	68,000	---	68,000	---	68,000
Recreation	Non-consumptive					
Environmental	Non-consumptive					
Evaporation	11,300		11,300		11,300	
TOTAL	192,000	73,100	198,000	73,100	208,000	73,200

Note 1:Includes conventional oil and gas production water and CBM production water.

Available Surface Water

The determination of available surface water was broken down into the following seven tasks for this study:

1. Compilation of Historic Streamflow Records
2. Selection of an appropriate Study Period
3. Extension of Records to represent the entire study period
4. Estimating Natural Flow at Ungaged Model Nodes
5. Determining Streamflows during Wet, Normal, and Dry years
6. Development and Calibration of Spreadsheet Models
7. Determination of Available Surface Water

Records from 114 USGS and SEO streamflow gages were compiled and then extended where records were missing, to provide estimates of streamflow for each month, of each year during the 1970 to 1999 study period. These recorded and estimated streamflows were used together with

regression equations developed by the USGS to determine the amount of streamflow at additional ungaged locations needed for the water availability models. The annual streamflows were ranked and the years were divided into three hydrologic conditions (dry years, normal years, and wet years). The average flows for each of these three conditions are primary inputs to the models.

Water availability spreadsheet models were developed for the following six sub-basins within the Powder/Tongue River Basin planning area:

- Little Bighorn River sub-basin
- Tongue River sub-basin
- Clear Creek sub-basin
- Crazy Woman Creek sub-basin
- Powder River sub-basin
- Little Powder River sub-basin

Three models were developed for each sub-basin to represent each of the three hydrologic conditions. The models each represent one calendar year of flows, on a monthly time step. Streamflow, estimated actual diversions, full supply diversions, irrigation returns, and reservoir storage conditions are the basic input data to the models. For all of these data, average values drawn from the dry, normal, or wet years of the study period were computed for use in the spreadsheets.

The models do not explicitly account for water rights nor are the models operated based on these legal constraints. Further, the models do not associate supplemental reservoir releases to the specific water users. However, by calibrating the models to historical streamflows at gaged locations, the models can be used to generally represent existing operations. Model inputs can then be modified to estimate the impacts associated with potential future water projects.

The total annual flow, physically available in excess of current Wyoming water demands, is summarized as follows:

Subbasin	Hydrologic Condition		
	Wet Years	Normal Years	Dry Years
Little Bighorn River	152,000	113,000	81,000
Tongue River	473,000	326,000	218,000
Clear Creek	213,000	124,000	80,000
Crazy Woman Creek	69,000	32,000	16,000
Powder River	547,000	324,000	194,000
Little Powder River	48,000	12,000	3,000

The Yellowstone River Compact of 1950 governs the allocation of the waters in the Powder River and Tongue River between the States of Montana and Wyoming.

The methodology used in the current study to evaluate water availability under the Yellowstone River Compact was coordinated through the Wyoming State Engineer's Office and relies heavily

on previous work performed by each of the two States. Wyoming's estimated compact allocation under each of the three hydrologic conditions is summarized as follows.

Hydrologic Condition	Tongue River Basin		Powder River Basin
	Conservative Estimate	Liberal Estimate	
Wet Years	163,000	189,000	211,500
Normal Years	90,000	117,000	131,100
Dry Years	40,000	67,000	74,300

Available Ground Water

The objectives of this element of the study were as follows:

1. Inventory and catalog the Wyoming State Engineer's Office (SEO) ground water permit database for various categories of ground water uses in the planning area, and incorporate the information into GIS data themes.
2. Inventory and document existing published data on ground water studies and ground water planning documents for the planning area.
3. Summarize existing information on aquifers with regards to location, storage, yield and development potential within the planning area.
4. Summarize the potential effects that ground water development might have on the ground water and surface water systems in the basins within the planning area.
5. Characterize coalbed methane development and its short and long-term effects on ground water and surface water supplies within the river basins of the planning area.

The information developed through this study provides a starting point for site specific ground water investigations.

The significance of ground water in the planning area is demonstrated by the 16,432 active ground water permits (as of December 31, 2000) within the planning area. Because of the dynamic nature of coalbed methane (CBM) development, the inventory of permitted CBM wells was updated to reflect data as of December 31, 2001. The number of permits for each use category are summarized below:

- 111 Permitted active agricultural wells with production rates greater than 49 gpm
- 8 Permitted active municipal wells with production rates greater than 49 gpm
- 301 Permitted active industrial and miscellaneous wells with production rates greater than 49 gpm
- 4,646 Active permitted domestic wells
- 4,546 Active permitted stock wells
- 6,820 Permitted coalbed methane wells (9393 by December 31,2001)

The five major aquifer systems within the planning area are (oldest to youngest): 1) Madison Aquifer System; 2) Dakota Aquifer System; 3) Fox Hills/Lance Aquifer System; 4) Fort Union/Wasatch Aquifer System; and 5) Quaternary Alluvial Aquifer System.

General conclusions regarding ground water development potential of four of these five major aquifer systems are summarized below:

- The Madison Aquifer System may have the most development potential for high yield wells on a sustained basis. Drilling depths and water quality may constrain development at specific locations within the planning area.
- The Fox Hills/Lance Aquifer System may have local potential for development of wells with low to moderate yields. The possible high fluoride content in water from this system might influence the desirability of use for a municipal/public supply without provision for treatment or special management.
- The Fort Union/Wasatch Aquifer System is utilized for most uses in the planning area. The Wyodak-Anderson coal and hydraulically interconnected aquifers of the Aquifer System will be heavily impacted by ground water withdrawals in and near coalbed methane development. The water co-produced with coalbed methane may provide an opportunity for utilization, depending on location, quality and nature of potential use.
- Aquifers in the Quaternary Alluvial Aquifer System may have local development potential if induced infiltration of surface water can be tolerated.

Out of a total of 16,432 active ground water permits inventoried as of December 31, 2000, 9,612 of the permits were for WWDC categories other than coalbed methane development (agricultural, municipal, industrial, domestic and stock). Possible impacts of further development for these uses could include:

- Depletion of surface water that is interconnected with aquifer systems. The principal aquifer systems of concern with respect to this impact include the Madison and the Quaternary Alluvial Aquifer Systems.
- Interference problems between wells and / or aquifer depletion problems related to domestic and stock well densities.
- Aquifer depletion where aquifers are used for secondary oil and gas recovery operations.
- Water quality impacts due to oil and gas drilling and recovery operations and leakage through inadequate or failed plugging of production wells.

A total of 9,393 permitted coalbed methane wells (December 31, 2001) were identified. Possible impacts of coalbed methane development include:

- The dewatering of aquifers and the lowering of water levels and yields in production wells located in the vicinity of coalbed methane development.
- Methane seepage into wells and structures in the proximity of coalbed methane development that could pose a health and safety hazard to residents.

- Increased infiltration of water from coalbed methane production into shallow alluvial ground water systems that could aggravate subsurface structure problems.
- Increased infiltration of water from coalbed methane production into shallow ground water systems that could impact the quality and use of ground water from shallow systems.
- Impacts to surface coal mining operations.

Possible surface water related impacts that have been identified could include:

- Change in drainage characteristics from ephemeral to perennial. This could result in an increase in the erosion potential and sedimentation problems in receiving drainages.
- Increased flooding potential in receiving drainages. Higher flows could also impede landowner access associated with their operations.
- Alteration of the chemical characteristics of receiving surface waters due to coalbed methane generated water. This could include a change due to increased salinity and sodium content that could impact irrigation practices and the utilization of surface water for irrigation.

Irrigation Use Projections

To assess future water needs in the Powder/Tongue River Basin, projections of water demands were developed for major water use categories through the year 2030. Surface water uses were projected for low, moderate, and high growth scenarios.

Future demands for irrigation water are largely dependent upon factors such as crop and livestock prices and the cost of developing new water storage and delivery systems. The low growth scenario projects no changes in those factors relative to current conditions, and thus no increase in irrigation water use. The moderate and high growth scenarios project moderate increases in irrigation water use based upon projected increases in crop and livestock prices and the possibility of increased state assistance in developing new irrigation water supplies. For the moderate growth scenario, consumptive irrigation water use rises from a current level of 184,000 acre-feet annually to 194,000 acre-feet annually by the year 2030, an increase of six percent. For the high growth scenario, consumptive use rises to 205,000 acre-feet annually by 2030.

Municipal and Domestic Use Projections

The larger municipalities in the Powder/Tongue River Basin rely upon surface water sources to meet their needs. Their future municipal water demands are closely tied to future population levels in the planning area. Three population-forecasting methods were used to develop low, moderate, and high growth population projections for communities in the Powder/Tongue River Basin through the year 2030. Based upon these projections, municipal surface water use is expected to grow from a current level of 2,700 acre-feet annually to 3,200 acre-feet annually by

2030 for the low growth scenario. For the moderate and high growth scenarios, the increases are to 3,500 and 3,800 acre-feet respectively. Domestic water needs in the Powder/Tongue River Basin are typically satisfied by groundwater. Projections developed for this plan Indicate that domestic water use is expected to increase from a current level of about 4,800 acre-feet annually to between 5,500 and 6,400 acre-feet by the year 2030.

Industrial Use Projections

There are no large industrial users of surface water in the planning area. Industries such as oil and gas development and mining all make use of relatively small amounts of groundwater. That situation could change in the future with the construction of coal-fired electric generating facilities and coal-conversion facilities designed to increase the heat content of coal. For the low growth scenario, no such developments are projected to take place. For the moderate and high growth scenarios, however, industrial surface water demand is expected to grow to between 17,000 and 35,000 acre-feet annually by 2030.

Recreation Use Projections

Fishing is the predominant water-based recreational activity in the planning area, and angers currently engage in approximately 272,000 activity days of fishing each year. Projections developed for this plan indicate fishing demand is expected to increase to between about 330,000 and 430,000 activity days annually by the year 2030. The Powder/Tongue River Basin is well endowed with both stream and stillwater fisheries, which are generally adequate to meet current demands. These resources will come under increasing pressure as recreational demand increases as a result of population growth and increases in tourism.

Environmental Use Projections

Environmental water requirements are not directly related to changes in population or tourism, but instead reflect human desires concerning the type of environment in which people want to live. These desires are reflected in environmental programs and regulations promulgated by elected representatives at the local, state and federal levels. Examples include Wyoming's instream flow statues and minimum reservoir pools dedicated to fish and wildlife enhancement. While generally non-consumptive, environmental needs can conflict with consumptive water uses in some situations. No significant conflicts between environmental and consumptive water uses are projected for the Powder/Tongue River Basin.

Compact Considerations

Wyoming's use of surface waters from the Powder and Tongue Rivers is subject to limitation by interstate compact. Projected surface water demands were contrasted with estimates of Wyoming's remaining allocations of water in the Powder and Tongue River sub-basins. No potential conflicts were identified.

Demand Projections Summary

The projected surface water uses are summarized in the following table for the low, moderate, and high growth scenarios.

Summary of Current and Projected Surface Water Uses

Use	Current	Projected Use by Growth Scenario (Acre-feet/Yr.)		
		Low	Moderate	High
Municipal	2,700	3,200	3,500	3,800
Industrial	(included in municipal)	(included in municipal)	17,000	35,000
Irrigation	184,000	184,000	194,000	205,000
Evaporation	11,300	11,300	11,300	11,300
Recreational	(non-consumptive)			
Environmental	(not estimated)			
Total	**198,000**	**198,500**	**225,800**	**255,100**

Future Water Use Opportunities

This river basin plan quantifies water resources available for development and use and identifies current and projected future water needs in the Powder/Tongue River Basin. The concluding task of this study is to identify future water use opportunities that can be implemented to satisfy the water demands in the Little Big Horn River, Tongue River, and Powder River Basins in Wyoming. The list of potential water use opportunities provided is intended to assist individuals and organizations in finding ways to meet their specific needs.

To further assist the users of this list in identifying potential opportunities to satisfy their demands, a methodology is presented that can be employed to evaluate a specific opportunity on the list relative to similar and related opportunities. The suggested methodology evaluates opportunities according to the likelihood they are desirable, functional, and capable of receiving the support required for development. By using the list of future water use opportunities and employing the evaluation methodology, individuals and organizations will have "a place to start" in their investigation.

The procedure used to complete this task consisted of four steps:

1. Develop screening criteria to evaluate future water use opportunities – the six screening criteria are: 1) water availability; 2) financial feasibility; 3) number of sponsors, beneficiaries, and participants; 4) public acceptance; 5) legal and institutional concerns; and, 6) environmental and recreational benefits.

2. Develop a long-list of future water use opportunities – this list was compiled from published reports and information provided by the members of the Basin Advisory Group (BAG).
3. Develop a short-list of opportunities – projects and opportunities on the long-list were screened to eliminate projects considered to have little likelihood of development.
4. Evaluate the opportunities on the short-list – the projects advancing to the short-list were categorized by location and type, then evaluated using the criteria developed in Step 1 of the process.

Legal and institutional constraints that need to be addressed in water management and development were identified and described in the planning study.

The success of a water development project is also dependent on the ability of the source to meet the water quality needs of the proposed uses. In addition, the project itself must protect existing and potential uses of waters of the State. As a part of this river basin planning process a description of the water quality character of the Powder/Tongue River Basin was developed. The plan also describes contemporary water quality programs initiated to protect and enhance the quality of surface water in the planning area. Finally, the primary issues related to the quality of water in the planning area are detailed in industrial, agricultural, and municipal categories.