TECHNICAL MEMORANDUM

SUBJECT: **Green River Basin Plan**
Industrial Water Needs Projections

PREPARED BY: Gary Watts, Watts and Associates, Inc.

Introduction

This memorandum presents projections of industrial water needs in the Green River Basin for the period from 2000 through 2030. These projections provide a basis for gaging the adequacy of current surface water and groundwater supplies in the Basin to meet potential future needs. Following guidelines established by the Wyoming Water Development Commission (WWDC), projections were developed for three planning scenarios:

1. Low Growth
2. Moderate Growth
3. High Growth

The projections for each scenario were developed judgmentally, industry by industry, based upon a review of available literature and a series of personal interviews with representatives of large industrial water users in the Basin. Although consideration was given to econometric methods of projecting future industrial growth, the factors that have and will continue to influence the rates of growth among water intensive industries in the Basin are not amenable to quantification in multivariate economic models.[1]

A number of industrial firms in Green River Basin use water as a part of their operations. Many of these firms are located in communities and make use of municipal water supplies. Generally, their usage rates are low and for that reason they have not needed to develop dedicated water supply facilities for their operations. Projections of water needs for these small industrial water users are included in projections of municipal demands for the communities in the Basin.

Industrial water users not dependent upon municipal water supplies include mining operations, the oil and gas industry, manufacturers of soda ash and related products, and electric power producers. This memorandum focuses on the future water needs of these industries.[2]

[1] Econometric models are statistical models that relate the variable to be forecast, in this case industrial water requirements, to other variables for which future values are more easily forecast, such as population.
[2] Current water usage for these industries is described in a separate technical memorandum (Purcell, 2000).

Currently, the largest industrial water uses in the Basin are those associated with electric power generation and soda ash production. Future water needs for electric power production will be largely determined by how electric utilities in the Basin and elsewhere in the west respond to various actions and proposals to deregulate the industry. Scenarios for possible industry responses to deregulation are not easily captured by multivariate statistical models. Similarly, future growth prospects for the soda ash industry are largely dictated by the ability of Wyoming producers to capture an increasing share of the international market in the face of volatile international economic conditions and the protective tariffs imposed by some foreign countries. The factors that influence the competitiveness of the Basin's soda ash producers in international markets are also difficult to incorporate into economic models.

The following sections of this memorandum discuss future growth prospects of the significant water using industries in the Basin and present low, medium, and high growth projections for future water use. The last section summarizes future industrial water needs.

Future Electric Power Production

Two coal-fired electric power plants are located in the Green River Basin; the Jim Bridger Power Plant near Point of Rocks in Sweetwater County and the Naughton Power Plant south of Kemmerer in Lincoln County. Both are owned and operated by Pacificorp, which is a subsidiary of Scottish Power. The Naughton Plant has a production capacity of 710 megawatts and consumptively uses approximately 13,500 acre-feet of water annually from the Ham's Fork River. The Jim Bridger Plant has a production capacity of 2,000 megawatts and consumptively uses approximately 34,300 acre-feet of water annually from the Green River. Much of the power from the Naughton Plant is exported via transmission lines to Utah, while much of the power from the Jim Bridger Plant is exported to Pacificorp customers in the Pacific Northwest (Hoopes, 2000; Meyer, 2000).

The future of electric power production in the Green River Basin is clouded by proposals and actions by some western states to open previously captive markets for electricity to competition. Historically, the electric utility industry in this country has been composed of vertically integrated monopolies under the regulation of state agencies who set the rates (prices) at which power can be sold to consumers. These power rates typically bundle charges for the three services that electric utilities provide -- power generation, transmission, and distribution.

Restructuring proposals for the industry vary in scope, but generally are typified by the following:

1. power generation would be deregulated to allow generation companies to compete and sell at market prices;

2. power transmission would be regulated by the Federal Energy Regulatory Commission (FERC) and would be made available to all parties; and

3. the local distribution function would remain state regulated, but local customers would be able to choose their generation company based upon price or other considerations.

Although the Wyoming Legislature has not yet acted on industry restructuring, the matter has been under study by the Wyoming Public Service Commission (PSC) and various Stakeholder Subcommittees (Black and Veatch, 1997; PSC, 2000). Furthermore, much of the power now generated in Wyoming's Green River Basin is exported to other western states (primarily Utah and the Pacific Northwest) where industry restructuring is in various stages of consideration or implementation.

Restructuring of the electric utility industry offers both potential for future development and roadblocks to the development of additional generating capacity in the Green River Basin. Currently, electric generating capacity in the western U.S. is being fully utilized during peak periods of summer demand, and the Department of Energy is forecasting the possibility of brown outs in some parts of the west during the year 2000 (Laramie Daily Boomerang, 2000). This fact, coupled with various proposals to reduce hydropower production in the Pacific Northwest to lessen environmental impacts on endangered species, means that additional generating capacity will be needed in the near future to meet growing needs in the region. The availability of water and low sulfur coal resources in the Green River Basin makes it a logical location for new generating capacity to meet some of the future power needs of the Rocky Mountain and West Coast regions.

One roadblock to developing additional generating capacity in the Basin is the possibility that industry restructuring will encourage large industrial power users in other states to develop co-generation facilities to meet their own needs and sell excess power to retail consumers. If such developments take place on a large scale, electric utilities might be reluctant to make large investments in new generating facilities in the Green River Basin (Dahl, 1999).

Another roadblock to developing new generating capacity in the Basin is the fact that the transmission lines that carry power out of the Basin to western markets are now at capacity, and Wyoming markets, where transmission capacity is adequate, are growing slowly (Meyer, 2000). Thus, any substantial increase in generating capacity in the Basin would have to be accompanied by new transmission facilities to carry the power out of state. Traditionally, new transmission facilities have been financed by utilities that were assured of recovering their investment through tariffs imposed upon a captive set of retail customers. Prospects for industry restructuring, however, have made utilities leery of significant large capital investments in new transmission facilities because of uncertainty concerning their customer base and their ability to recover capital costs in a competitive market (Parrish, 2000). The FERC and the Wyoming PSC both recognize this problem, and various proposals have been put forth to encourage the construction of new electrical transmission facilities.

The issue of how electrical utility industry restructuring evolves in the western U.S. will play an important role in determining the magnitude of future water requirements for electrical power generation in the Green River Basin. Three scenarios for future growth are described below.

Low Growth Scenario

The low growth scenario for future power generation projects current levels of water consumption for power generation to remain constant over the next thirty years. Both the existing Jim Bridger and Naughton Power Plants have been running at nearly full capacity in recent years, and expanding power production at either facility would require significant capital investments in both generation and transmission facilities. The low growth scenario is based upon the assumption that additional power needs in the western U.S. over the next 30 years will be met by the construction of new generating facilities outside of the Basin, possibly co-generation facilities developed in conjunction with industrial plants in other states. As a result, water requirements for power generation in the Basin will remain at current levels over the planning horizon. That level is approximately 47,800 acre-feet annually.

Moderate Growth Scenario

The moderate growth scenario is based upon the reasonably foreseeable possibility that co-generation facilities will not be developed at a rate sufficient to meet regional power needs over the next 30 years, and that the State of Wyoming and/or the Federal Energy Commission will take steps to solve the transmission bottleneck out of Wyoming and thus encourage the construction of additional electrical generating capacity in the Basin. The Wyoming Legislature recently considered legislation to guarantee revenue bonds to repay the construction of new transmission facilities in the state. Although the legislation did not pass, it is expected to be re-introduced in the future with greater likelihood of passage as regional power needs grow. Furthermore, the FERC is expected to play a much more active role in future efforts to encourage states and the private sector to expand transmission facilities in the region to avoid future power shortages (Parrish, 2000). These actions, combined with the potential resolution of other industry restructuring issues over the next 30 years, provide a reasonable basis for expecting at least a moderate expansion of electrical generating capacity in the Basin over the planning horizon.

The logical location for a moderate expansion of generating capacity is the Jim Bridger Power Plant near Point of Rocks, east of Rock Springs. The facility was originally designed for up to six 500 MW coal-fired generating units, although only four such units have been installed. The existing units are among the most cost-efficient in the Pacific Power generating system, and an expansion to six coal-fired units at Jim Bridger would be a logical step to increase regional power production in a cost effective manner. According to plant engineers, the water requirements for coal-fired generating units have not changed significantly since the plant was constructed (Meyer, 2000). Thus, the moderate growth scenario for electric power production projects a 50 percent increase in water requirements for the Jim Bridger Power Plant over the next 30 years, with water requirements at the Naughton facility remaining constant at current levels. Total water use for the moderate growth scenario is projected to grow from a current rate of 47,800 acre-feet annually to approximately 65,000 acre-feet by the year 2030.

High Growth Scenario

The rapid economic growth that occurred in the Green River Basin during the 1970s and early 1980s was partially a result of political events that occurred beyond the Basin's boundaries. The threat of curtailed oil imports led the U.S. to mount a campaign for energy independence that emphasized developing and utilizing the nation's own energy resources, including oil and gas, uranium, and coal. The Green River Basin has abundant reserves of all of these natural resources, and high-energy prices and government programs to stimulate development of those resources led to a period of rapid growth in the Basin.

There are no immediate prospects for another disruption in international energy markets, and there is no evidence that the federal government is currently poised to reinstate programs to encourage domestic energy production. However, there is a possibility that over the next three decades international events will transpire in a manner that would place increasing emphasis on domestic energy production because of shortages of imported oil and/or surging energy prices. Such developments could lead the U.S. to institute incentives for developing new coal-fired electrical generating facilities to reduce the nation's dependence on foreign oil. The Green River Basin's water and coal reserves make it a natural place for such developments. In fact, at least two electric utilities have studied the possibility of locating new generating facilities at a site in the Basin near Creston Junction (Wyoming Water Development Commission [WWDC], 1981).

The high growth scenario for electrical energy production is based upon the reasonable possibility that high international energy prices and/or a disruption of oil imports into the U.S. will stimulate the construction of a significant addition to current electric generating capacity in the Basin. This scenario assumes that in addition to a 1,000-megawatt expansion of the Jim Bridger Power Plant, a new 3,000-megawatt coal-fired generating facility will be built in the vicinity of coal deposits near Creston Junction, utilizing water piped from the Green River. (Although the Little Snake River also would be a potential source of water for such a plant, the lack of storage facilities for industrial water in the Little Snake Basin makes the Green River a more likely source of water for future power production.)

The two existing coal-fired generating facilities in the Basin use approximately 47,800 acre-feet of water annually. The addition of 4,000 megawatts of generating capacity over the next 30 years would raise total water use for power production to 116,500 acre-feet annually.[3] This figure represents a 144 percent increase over current utilization levels.

Future Soda Ash Production

The trona patch in the vicinity of Green River, Wyoming is the site of five industrial facilities that convert trona to soda ash, an industrial product that is used in manufacturing glass, detergents, baking soda, and several other industrial and consumer products. General Chemical, OCI Wyoming, and Solvay each operate one facility in the Basin. FMC, the largest soda ash producer, operates two facilities; FMC Westvaco and FMC Granger (formerly Texas-Gulf). As a group, these five facilities produced approximately 11.7 million tons of soda ash in 1999, and consumptively used about 17,900 acre-feet of

[3] This projection assumes the same wet-cooling technology and water requirements as the existing Jim Bridger facility.

water from the Green River. Not all of this water is used in soda ash production, however; some soda ash facilities use cooling water for on-site electric power generation and sell their excess power. Furthermore, the FMC Westvaco facility uses water for manufacturing processes associated with their bicarbonate, sodium cyanide, sodium hydroxide, and sodium phosphate plants. In addition, Church and Dwight, the manufacturer of Arm and Hammer products, used slightly over 200 acre-feet of water in 1999 for post-processing soda ash, bringing total industry usage for all purposes to about 18,100 acre-feet annually.[4]

World soda ash consumption is estimated to be approximately 32 million tons annually, meaning that the Green River patch supplies about 37 percent of world's needs. The two other domestic producers of natural soda ash are located in Colorado and California, and have a combined capacity of 2.4 million tons annually. Roughly 60 percent of current production in the Basin is used domestically, and the remainder is exported. The major foreign markets for Wyoming soda ash are in Asia and South America, although Europe, Mexico, the Middle East, and Africa also import significant quantities (Kostick, 1999).

Future growth in soda ash production in the Basin will be largely dependent upon export markets. Domestic consumption has been relatively flat in recent years and is expected to grow by only 1.0 to 1.5 percent annually for the foreseeable future (Kostick, 1999). This relatively low growth rate

is attributable to the fact the U.S. market is relatively mature in terms of per capita consumption of soda ash products. Furthermore, glass container production, the largest domestic use of soda ash, faces increasing competition from plastics in the domestic bottled beverages market.
Foreign demand for soda ash, especially in developing countries, is expected to increase at a more rapid rate than in the U.S. over the next 30 years. As disposable income rises in developing countries, consumption of beverages in glass containers -- now considered a luxury in many parts of the world -- is expected to become commonplace. The increased use of glass containers in foreign markets is expected to translate into increased demand for U.S. soda ash because the U.S. has the world's largest deposits of trona and is the lowest cost producer of soda ash.

Other factors that affect future U.S. soda ash production include trade barriers that many countries have established to protect their domestic soda ash industries, which, in some cases, utilize synthetic processes that are not cost competitive with natural soda ash imports. China, India, and certain Eastern European countries are examples of markets with large populations, high potential for growth in terms of glass container usage, and high soda ash tariffs that discourage imports. Over the next 30 years, efforts by the World Trade Organization and the U.S. government have the potential to lower these tariff barriers and open up new markets for U.S. soda ash.

---

[4] The technical memorandum on current Green River Basin industrial water uses (Purcell, 2000) lists Church and Dwight under "other surface water users". In this memorandum Church and Dwight is included in the soda ash industry because it is a value-added producer of soda ash products.

Soda ash exports from the Basin may also receive a boost from future cost savings in the production and transportation of soda ash. On the production side, solution mining processes have the potential to lower production costs and thus make Wyoming soda ash more cost competitive in international markets. One producer in the Basin has used this process, and most of the other producers have indicated that it is in their future plans. Solution mining involves injecting a sodium hydroxide solution into a trona bed, converting the trona into water and soda ash, which is then pumped out of recovery wells. This process has the potential to be more cost effective than conventional processes, which involve first mining the trona and then extracting the soda ash in a surface plant.

One downside of solution mining is that production rates are harder to forecast and control than with conventional techniques, so it is doubtful that solution mining will completely replace conventional processing in the foreseeable future (Demshar, 2000). A more likely scenario is that producers will implement solution mining for some portion of their future expansion plans, while keeping existing facilities operating for an assured level of baseline production. Solution mining may also open the door for more competition among U.S. soda ash producers. American Soda Ash recently opened a 1.1 million-ton soda ash facility near Rifle, Colorado that uses solution mining exclusively and will compete with Wyoming producers for shares of domestic and international markets.

There is also a possibility of future competition in the rail transport of soda ash to loading ports on the West Coast for shipment overseas. Currently, most soda ash exports are shipped via

Union Pacific to an export terminal in Portland, Oregon. Some soda ash, however, is trucked to a Burlington Northern loading point near Shoshoni for rail shipment. If Burlington Northern or some other carrier were to extend a rail line into the trona patch near Green River, the competition would tend to lower transportation costs and thus make Wyoming soda ash even more cost competitive in overseas markets.

How all of these influences come together over time will largely determine the future growth rate of soda ash production in the Basin and the corresponding need for additional process water. Three scenarios for future water needs for the Basin's soda ash industry are described below.

Low Growth Scenario

The low growth scenario for future soda ash production projects no significant changes in the structure of domestic or international markets for soda ash over the 30-year planning horizon, and no significant changes in production and transportation costs for Wyoming producers. Under these conditions, Green River Basin producers would be expected to maintain their current shares of both domestic and international markets, and their production would be expected to grow roughly proportional to growth in consumption.

According to Kostick (1999), future domestic consumption is expected to grow by 1.0 to 1.5 percent annually, and world consumption is expected to grow by 2.0 to 3.0 percent annually for the foreseeable future. Using the mid-point of these estimates gives a projected domestic growth rate of 1.25 percent annually and projected export growth rate of 2.50 percent annually. Based on current production estimates, approximately 60 percent of soda ash from the Green River patch is consumed domestically and 40 percent is exported. Using these percentages as weighting factors, the overall future growth rate for soda ash production in the Basin is projected to be 1.75 percent annually for the low growth scenario.

The amount of water used for soda ash production varies widely among producers for numerous reasons, including the type of production technology used, whether power is generated on site and how it is generated, how much water is used to inject process insolubles back into the mining void, how much water is lost to evaporation in holding and settling ponds, how much water is used for dust control, and how much water is recycled for various process purposes. Based upon industry interviews, the overall average consumptive use rate for current production in the Green River patch is on the order of 450 gallons per ton of soda ash production. This figure was used to project future water requirements for the industry for the low growth scenario.

At a 1.75-percent annual growth rate, soda ash production in the Basin will grow from 11.7 million tons in 1999 to 20.0 million tons by the year 2030. The production increase of 8.3 million tons annually will require an estimated 3.735 billion gallons of additional water annually, the

equivalent of approximately 11,500 acre-feet. That increase would bring total consumptive use in the patch up to 29,600 acre-feet by the year 2030, an increase of 64 percent over current levels.

Moderate Growth Scenario

The moderate growth scenario, like the low growth scenario, projects no significant changes in the structure of domestic or international markets for soda ash over the next 30 years. Unlike the low growth scenario, however, this scenario projects the reasonably foreseeable possibility that producers will be able to achieve an additional competitive advantage in the export marketplace through reductions in rail transportation costs and the implementation of solution mining for a portion of their future production. The construction of a new rail line into the patch would introduce competition into the transportation arena for the first time, and could be expected to reduce the delivered cost of Wyoming soda ash in overseas markets. The implementation of solution mining on a limited scale should also have some cost reduction implications that would give Wyoming soda ash an additional competitive advantage in overseas markets.

Foreign soda ash consumption is estimated to be roughly 25.0 million tons annually (Kostick, 1999), of which approximately 20 percent is supplied by Wyoming producers. If foreign consumption increases at the projected rate of 2.5 percent annually, it will reach 53.8 million tons by the year 2030. Wyoming producers could reasonably expect to increase their share of foreign market penetration from 20 to 25 percent as a result of efficiencies described above, meaning that total foreign sales would approach 13.5 million tons annually by the year 2030. Assuming that domestic sales continue to grow at the project rate of 1.25 percent, total soda ash production from the patch would be 23.8 million tons by the year 2030, an increase of 12.1 million tons over current output levels.

The water requirements associated with this scenario are more difficult to estimate than for the low growth scenario because of the assumption that solution mining would be employed for a portion of future production. Only one of the Basin's current soda ash producers has production experience with solution mining, and good estimates of historical water utilization are not available. Even if they were, potential improvements in the process, such as the use of directional drilling techniques, may make future production more water efficient than past efforts. For purposes of estimating water requirements for this scenario, it was assumed that 50 percent of future production increases would come from solution mining, and that solution-mining techniques would require 750 gallons of water per ton of soda ash production. Based upon these assumptions, the consumptive use of water by soda ash industry in the Basin would grow by 22,300 acre-feet annually by the year 2030 to a total of 40,400 acre-feet. This figure represents a 123 percent increase over current water consumption levels.

High Growth Scenario

The high growth scenario for soda ash production in the Basin, like the moderate growth scenario, projects increasing efficiencies in production and transportation through solution mining and competition in rail transportation of the finished product. In addition, this scenario projects the possibility of structural changes in some overseas markets that will result from falling tariffs and the elimination of certain other trade barriers. These changes could come about through pressure form the World Trade Organization and the U.S. Government to eliminate punitive tariffs on imported soda ash in countries such as China and India. They could also come about if other countries, particularly in Eastern Europe, become convinced that their antiquated synthetic soda ash plants are not efficient and worthy of further investment or tariff protection. If trade barriers to U.S. exports of soda ash are gradually lowered or eliminated over the next 30 years,
Wyoming producers could be expected to benefit enormously because they have a competitive advantage with respect to production costs that few other suppliers can equal.

With a projected gradual elimination of trade barriers, it is not unreasonable to assume that U.S. producers could eventually capture 50 percent of the foreign market for soda ash. Wyoming producers may face increasing competition from other domestic suppliers under this scenario however, especially if solution-mining techniques make it more cost effective to develop less accessible deposits of trona in other states. For this reason, the high growth scenario for Wyoming producers is based upon the assumption that they could reasonably capture one-third of the total world market of 53.8 million tons by the year 2030.

Assuming that domestic production in the patch will grow at 1.25 percent annually, and that exports will grow to one-third of foreign consumption by the year 2030, total estimated soda ash production in the Basin would be 28.1 million tons in 30 years. That figure represents an increase of 16.4 million tons annually over current production levels. Assuming that 50 percent of the increased production comes from solution mining (750 gallons per ton) and 50 percent from conventional processes (450 gallons per ton), the increase in annual water requirements for the industry by the year 2030 will be 30,200 acre-feet. Total water requirements for the industry would be 48,300 acre-feet annually, an increase of 167 percent over current levels.

Other Surface Water Uses

Electrical power generation and soda ash production constitute the current major uses of surface water for industrial purposes in the Green River Basin. The only other surface water user of significance is FS Industries, which manufactures phosphate fertilizer in a plant near Rock Springs. This plant current consumptively uses about 560 acre-feet of water annually, which is purchased from the Rock Springs-Green River Water Supply System. Phosphate is delivered to the facility via a slurry pipeline from a mine near Vernal, Utah. An expansion of production at this facility is probable over the next 30 years, although the timing of the expansion is uncertain.

According to plant officials, the facility would triple its current water use if it processed all of the phosphate that could be delivered via its slurry line (Iring, 2000). For purposes of projecting future water needs, the low growth scenario for this facility assumes no future growth in water needs over the 30 year planning horizon. For the moderate growth scenario, consumptive use is projected to increase to 1,000 acre-feet annually by the year 2030. For the high growth scenario, consumptive use is projected to increase to 1,500 acre-feet annually by the year 2030.

Groundwater Uses

The oil and gas industry is an important user of groundwater in the Basin, although water requirements are generally small and spread over a large geographic area. Water is used to create mud during drilling and can be used for waterflooding operations. The Bureau of Land Management (BLM) has projected that the number of producing oil and gas wells in the Green River Resource Area (GRRA) through the year 2010 (BLM, 1996). That projection shows that the total number of producing wells is expected to decline slightly from a total of 1,725 in the year 2000 to about 1,570 in the year 2010. Although the number of new wells drilled each year is expected to increase during this period, the number of wells abandoned each year is projected to more than offset the increase in drilling. The GRRA contains about one-half of the oil and gas activity in the Basin, and production conditions are considered by the BLM to be representative of the Basin as a whole. Thus, there are no indications of a significant change in future water requirements for oil and gas drilling in the Basin.

There is a potential for coal-bed methane development to impact groundwater resources in the Basin over the next 30 years. Coal-bed methane development is not a consumptive user of groundwater resources, but produces groundwater as a by-product of gas production. Water is pumped to relieve pressure on gas in coal seams so that the gas can be captured at the surface. Generally speaking, areas of the Basin with coal seams in the range of from 200 to 500 feet of the surface have the potential for coal-bed methane production, although the availability of gas in commercial quantities can only be determined by drilling (Peacock, 2000).

The *Green River Resource Area Resource Management Plan* (GRRARMP) issued by the BLM in 1996 identifies an area north of Rock Springs and extending east and west of the Eden-Farson area as being likely for future development (BLM, 1996). Up to 300 commercial wells were forecast for this area during the following decade. Since the GRRARMP was issued, the BLM has begun environmental assessments for proposed coal-bed methane developments in the Jack Marrow Hills area near Farson and the Muddy Creek area between Baggs and Rawlins, and other proposals are expected (Doncaster, 2000; Peacock, 2000). The extent of future coal-bed methane development is difficult to project because the commercial viability of large-scale production has not been established. Given the extensive coal resources located in some parts of the Basin, however, it is possible that extensive production could develop in some areas.

One limiting factor with respect to future coal-bed methane development are federal laws and programs, collectively known as the Colorado River Basin Salinity Control Program (CRBSCP), which regulate the amount of salt that can be discharged into surface water systems of the Green River Basin. [5] The CRBSCP strictly limits and in some cases prohibits saline discharges from new industrial sources in the Basin. If coal-bed methane developments produce saline groundwater as a by-product of gas production, in all likelihood that water would have to be either reinjected into low quality aquifers, if available, or held and evaporated in disposal ponds that have no hydrologic connection to surface water systems. This requirement may limit the commercial development of coal-bed methane resources in some parts of the Basin.

Natural gas processing facilities in the Basin also use groundwater, but typically in relatively small amounts. For example, the Exxon Shute Creek Plant has two wells permitted for 100 gpm each and a small surface water permit (0.134 cfs). In the larger picture of industrial water uses in the Basin, groundwater uses for natural gas processing are relatively small and future needs have not been projected.

Several coal mines in the Basin have groundwater permits and use water primarily for drinking water, sanitation, dust control, and mine reclamation activities. The three largest mines are the Black Butte and Bridger Mines that supply coal to the Jim Bridger Power Plant and the Pittsburgh-Midway Mine that supplies the Naughton Power Plant. The groundwater used by these mines does not directly impact surface water flows, and needs have not been projected into the future.

The Kennecott Uranium Company also has a number of groundwater permits for its inactive mine and processing facility in the Great Basin northeast of Rawlins. When it was operational, the mine used well water in a process solution for extracting uranium from ore. Given current conditions in the world market for uranium and prospects for future growth, however, the prospects for the mine and processing facility reopening during the planning horizon of this study are remote (Lummis, 2000).

Potential New Industrial Uses

[5] A history and description of the CRBSCP is contained in another technical memorandum (Tyrrell, 2000).

The industrial water use projections for the Green River Basin described above focus on existing industries and their future water needs. The potential for new industries to locate in the Basin to take advantage of available water resources also merits discussion. According to the U.S. Department of Commerce (1992), four industry groups account for over 95 percent of all of the industrial water used in this country each year. These industries are (1) electric power producers, (2) chemical and allied products manufacturers, (3) primary metals producers, and (4) paper and

allied products manufacturers. Electric power producers alone consume over 80 percent of all industrial water used in this country each year. The other three industry groups account for roughly 14 percent of all industrial water use.

The Green River Basin is already well represented with respect to electric power production and chemical manufacturers (the soda ash and phosphate producers fall into this group). The other two intensive water use industries, primary metals and paper producers, tend to locate near the source of their largest process inputs -- metals and wood respectively. Although the Basin does have a large timber inventory on National Forest lands, water requirements for timber harvesting and lumber production are minimal.[6] If a pulp and paper mill were to locate in the Basin, water requirements could be substantial. This possibility seems remote at the present time, however, given recent trends of reduced timber harvests on federal lands in the west. It thus appears likely that any new water intensive industrial developments in the Basin over the next 30 years will fall into the electric power generation and/or chemical products categories.

Expansion of electric power production in the Basin is considered in an earlier section of this memorandum, as is the potential for expansion by the soda ash and phosphate fertilizer industries. The possibility remains that new industrial water uses not discussed in this report will develop over the next 30 years, but the nature and extent of such developments is not foreseeable at this time and water requirements for such developments are not included in the projections described in this memorandum.

Summary of Findings

Projected industrial water requirements for the Green River Basin are presented graphically in Figures 1 through 3, and the numerical results are summarized in Table 1. These projections are for surface water requirements for large industrial water users. Industrial uses of groundwater are discussed qualitatively in a previous section of this memorandum. Requirements for small industrial users dependent upon municipal water supplies are included in projected municipal water requirements.

Figure 1 depicts current water use for electric power generation in the Basin, along with low, moderate, and high growth projections of water needs for the year 2030. The results show a wide range of potential future water needs for this industry. This range reflects the uncertainty surrounding how future power generation requirements in the western United States will be met by an industry that is

[6] The total estimated consumptive use of water by the timber industry in Wyoming in 1970 was less than 200 acre-feet annually (Wyoming Water Planning Program, 1970).

restructuring itself to operate in a more competitive marketplace. It also reflects uncertainty concerning international events that may affect the price and availability of foreign oil that is used to satisfy much of the energy demand in this country.

Table 1
Green River Basin Industrial
Water Use Projections

Scenario/ Industry	Consumptive Use (af/yr) 2000	2030	Percentage Change
Low Growth			
Electric power	47,800	47,800	0%
Soda ash[1]	18,100	29,600	64%
Other[2]	600	600	0%
Total	66,500	78,000	17%
Moderate Growth			
Electric power	47,800	65,000	36%
Soda ash[1]	18,100	40,400	123%
Other[2]	600	1,000	67%
Total	66,500	106,400	60%
High Growth			
Electric power	47,800	116,500	144%
Soda ash[1]	18,100	48,300	167%
Other[2]	600	1,500	150%
Total	66,500	166,300	150%

[1]Includes related production activities.

[2]Excludes groundwater and small municipal water users.

The results in Figure 1 show that water requirements for power generation in the Basin could remain roughly static at about 48,000 acre-feet annually under the low growth scenario. For the high growth scenario, water requirements could more than double to over 116,000 acre-feet annually. The moderate growth scenario presents a reasonably foreseeable projection of 65,000 acre-feet annually, an increase of 36 percent over current usage levels.

Figure 2 shows that there is somewhat less uncertainty associated with future water requirements for soda ash production in the Basin. Future water requirements are projected to grow under all scenarios as the industry responds to projected increases in worldwide demand over the next 30 years. The low growth scenario projects no structural changes in production techniques, transportation costs, or trade barriers over the 30-year planning horizon, meaning that the industry should maintain its current share of domestic and international markets. The moderate growth and high growth scenarios project various reasonably foreseeable changes that would give producers in the Basin greater access to international markets.

Figure 1
Electric Power Water Use Projections
Green River Basin

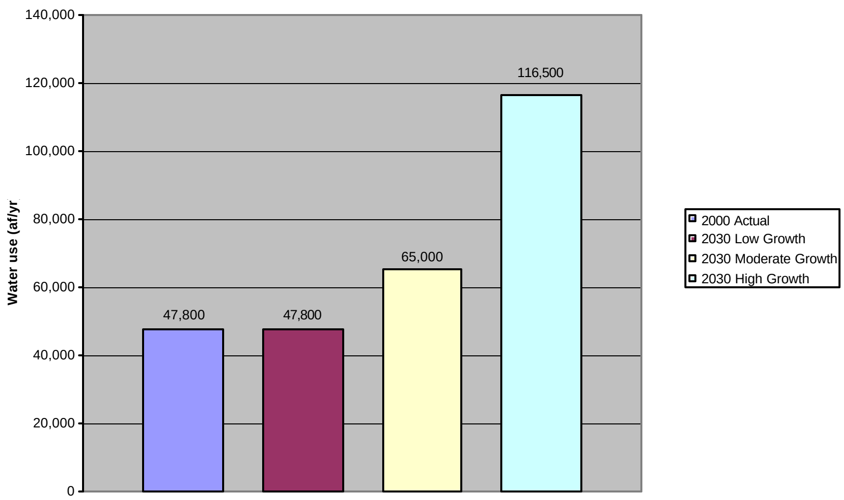
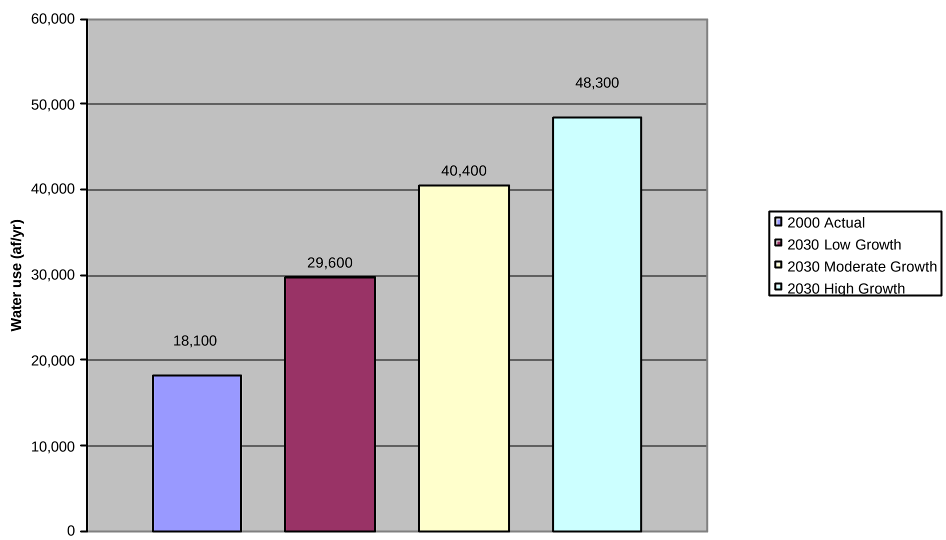


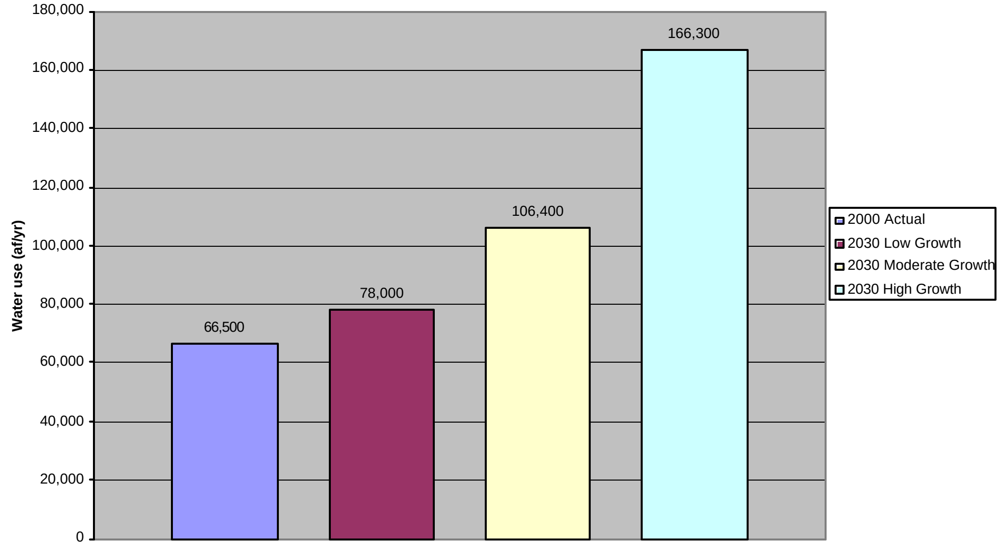
Figure 2
Soda Ash Use Projections
Green River Basin



The results in Figure 2 show that industry water requirements for the low growth scenario are expected to increase from about 18,000 acre-feet currently to over almost 30,000 acre-feet by the year 2030. Under the high growth scenario, water requirements could reach 48,300 acre-feet by 2030. The moderate growth scenario projects a reasonably foreseeable estimate of 40,400 acre-feet annually, an increase of 123 percent over current usage levels.

Projections of total industrial water requirements in the Basin are depicted in Figure 3. The results show that for the low growth scenario, water requirements are expected to increase from a current level of 66,500 acre-feet to 78,000 acre-feet by 2030, an increase of 17 percent. For the high growth scenario, requirements are projected to grow to 166,300 acre-feet, an increase of 150 percent. The moderate growth scenario projects a reasonably foreseeable requirement of 106,400 acre-feet by 2030, an increase of 68 percent.

Figure 3
Total Industrial Water Use Projections
Green River Basin



References

Black and Veatch. 1997. *Study of the Potential Economic Impacts of Electric Restructuring on the State of Wyoming*. Prepared for the Wyoming Public Service Commission. September 15.

Bureau of Land Management. 1996. *Green River Resource Area Resource Management Plan and Final Environmental Impact Statement*. U.S. Department of the Interior. Rock Springs District Office. March.

Dahl, Bob. 1999. Personal communication. Customer Business Manager, Pacificorp. November 10.

Demshar, Carl R. 2000 Personal communication. Environmental Superintendent, FMC Corporation. June 7.

Doncaster, Dennis. 2000. Personal communication. Bureau of Land Management, Rock Springs District Office. August 21.

Hoopes, Neil L. 2000. Personal communication. Project Engineer, Naughton Plant, Pacificorp. June 13.

Iring, Edward. 2000. Personal Communication. FS Phosphates. August 8.

Kostick, Dennis. 1999. *The Outlook for US Soda Ash*. Glass Industry Magazine. October.

Laramie Daily Boomerang. 2000. *Energy Department Warns of Power Outages*. Associated Press Story by Josef Hebert. June 29.

Lummis, Marion. 2000. Personal communication. Executive Director, Wyoming Mining Association. July 31.

Meyer, Michael W. 2000. Personal communication. Engineer, Jim Bridger Power Plant, Pacificorp. June 12.

Parrish, Denise K. 2000. Personal communication. Supervisor, Rates and Pricing, Wyoming Public Service Commission. May 24.

Peacock, Kenneth. 2000. Personal communication. Bureau of Land Management, Rawlins District Office. August 21.

Purcell, Mike. 2000. *Green River Basin Plan: Basin Water Use Profile – Industrial*. Technical

Memorandum. August.

Tyrrell, Pat. 2000. *Green River Basin Plan: Colorado River Basin Salinity Control Program.* Technical Memorandum. States West Water Resources Corporation. August 21.

U.S. Department of Commerce. 1996. *1992 Census of Manufacturers: Water Use in Manufacturing*. Bureau of the Census. March.

Wyoming Public Service Commission. 2000. *White Paper on Electric Utility Industry Restructuring Issues*. Cheyenne. May 18.

Wyoming Water Development Commission. 1981. *Current and Potential Water Demands, Green River Basin, Southwest Wyoming.* Second Draft.

Wyoming Water Planning Program. 1970. *Wyoming Water Planning Program Report No. 3: Water and Related Land Resources of the Green River Basin, Wyoming.* State Engineer's Office. September.