Subject: **Powder/Tongue River Basin Plan**
Irrigation Water Needs and Demand Projections
Task 4

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Prepared by: Watts and Associates, Inc.

INTRODUCTION

This memorandum presents projections of water requirements in the Powder/Tongue River Basin of Wyoming for the period from 2000 through 2030. 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 based upon a review and analysis of available literature and data, as well as input from irrigators and others associated with irrigated agriculture in the Powder/Tongue River Basin and other areas of Wyoming. The factors that will influence future irrigation water demands in the planning area are first described in qualitative terms in this memorandum, and are then used as the basis for formulating quantitative projections of future needs for the low, moderate, and high growth scenarios.

BACKGROUND

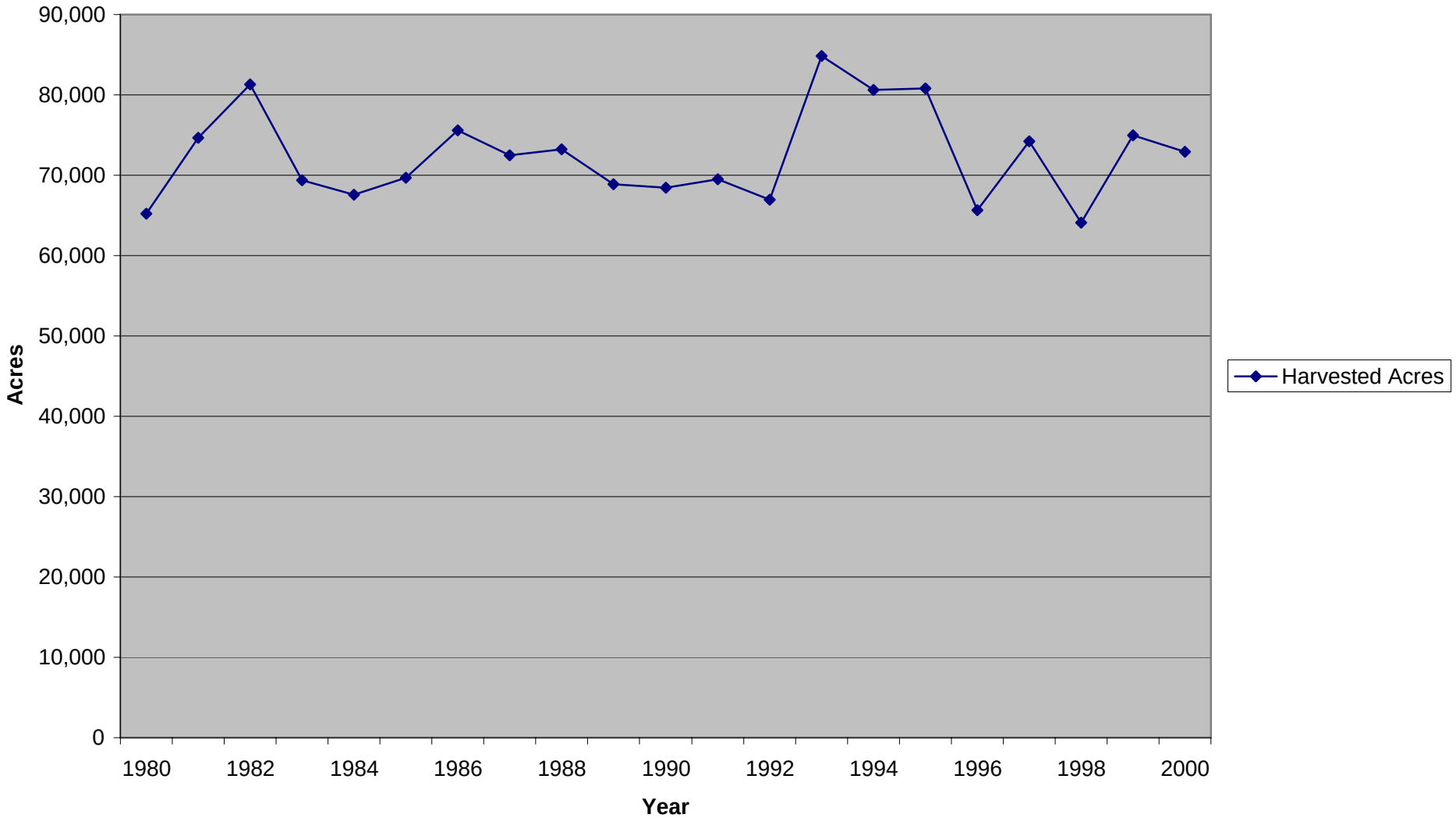
Irrigated agriculture is the largest user of water in the Powder/Tongue River Basin. The irrigated lands analysis conducted by HKM Engineering (2002a) indicates that there are about 169,600 acres of irrigated land in the planning area. Of this total, 8,300 are idle, primarily due to water delivery system problems, and another 4,300 acres have been converted or are in the process of conversion to residential use. Of the remaining 157,000 acres that are actively irrigated, about 15,000 are irrigated using spreader dikes or intermittent diversions. Only about 200 acres rely primarily on groundwater as an irrigation water supply. The remaining 156,800 actively irrigated acres are served primarily by surface water diversions. Total surface water depletions in the planning area are estimated to be about 183,800 acre-feet in a normal year (HKM, 2002b), or 1.17 acre-feet per acre for the actively irrigated lands with surface water diversions.

The majority of irrigated land is devoted to the production of forage crops such as alfalfa, grass hay, and irrigated pasture. According to the Wyoming Agricultural Statistics Service (WASS, 2000), alfalfa and grass hay have been harvested on an annual average of 72,500 acres of land in the planning area over the past 20 years. Other irrigated crops grown in significant amounts are small grains (about 6,500 acres annually), and corn (about 2,500 acres annually). The WASS does not keep records of irrigated pasture acreage or production, but the majority of the 75,500 actively irrigated acres not accounted for above are probably devoted to irrigated pasture.

Figure 1 shows estimates of harvested forage acreage in the planning area for the period from 1980 through 2000 as developed by the WASS.[1] That figure shows that the number of acres of forage crops harvested each year varied from a low of about 65,000 acres to a high of about 85,000 acres. There appears to be no trend of increasing or decreasing production over time, meaning that the annual

[1]WASS county level acreage data were adjusted to Basin-wide estimates based upon the estimated proportion of irrigated acreage in each county that lies within the Powder/Tongue River Basin.

Figure 1
Powder/Tongue River Basin Harvested Forage Acreage
1980-2000



variations are likely attributable to variables such as weather, irrigation water availability, and cattle prices.

The distribution of harvested forage acreage by county is depicted in Figure 2. That figure shows that Sheridan County is the largest forage producer in the plannning area, producing an average of 53 percent of all forage harvested over the period from 1980 through 2000. Johnson County is the second largest producer with 39 percent of the total, followed by Campbell and Natrona Counties, each with four percent of the total.

A number of reservoirs store water for irrigation purposes in the Powder/Tongue River Basin, but the availability of storage water varies among drainages. Eleven significant storage facilities deliver irrigation to irrigators in some parts of the planning area, including the Big Goose Creek and Little Goose Creek drainages in the Tongue River sub-basin; Piney Creek and Clear Creek in the Clear Creek sub-basin; the North Fork of Crazy Woman Creek and Muddy Creek in the Crazy Woman Creek sub-basin: and the North Fork of the Powder River in the Powder River sub-basin. A complete description of these storage facilities is presented in a separate technical memorandum (HKM, 2002c).

TRENDS IN LIVESTOCK PRODUCTION

Trends in cattle and sheep inventories in the Powder/Tongue River Basin are depicted in Figure 3. These estimates were developed from WASS county estimates adjusted to the planning area totals based upon the amount of land area in each county that is in the Powder/Tongue River Basin. Figure 3 shows that the cattle inventory in the planning area has been increasing in recent years while the sheep inventory has been decreasing. Cattle numbers have increased from a low of about 150,000 head in 1990 to almost 250,000 head in 2000. Over that same period, sheep numbers decreased from about 220,000 to 125,000. These trends reflect the fact that sheep production has become relatively unprofitable in recent years and many ranchers are shifting from sheep to cattle production as a result.

Figure 3 also shows the trend in total animal units in the planning area based upon the conversion factor that five sheep are roughly equivalent to one cow in terms of forage requirements (Sedivec, 1996). The figure shows that the total number of animal units in the planning area was roughly the same in the year 2000 as it was in 1980, about 265,000 units. The total number of animal units varied considerably over that time period, however, from a low of 190,000 in 1991 to a high of about 290,000 units in 1995. These variations reflect changes in livestock prices, water availability for irrigation, and other factors that affect the profitability of livestock production over time. Figure 3 seems to indicate that the productive capacity of the livestock industry in the planning area is slightly less than 300,000 animal units.

The distribution of cattle and sheep by county is depicted in Figures 4 and 5. These figures reflect average annual livestock inventories over the period from 1980 through 2000. Figure 4 shows that Sheridan County has been the largest cattle producer, with 43 percent of basin-wide cattle inventories over the past 20 years. Johnson and Campbell Counties have averaged 28 and 20 percent of basin-wide production, respectively, followed by Natrona County with nine percent.

Average sheep inventories by county are depicted in Figure 5. That figure shows that Johnson and Natrona Counties have been the largest sheep producers in the planning area over the past 20 years, with 44 and 36 percent of basin-wide production respectively. Campbell County accounted for 14 percent of production during that period, while Sheridan County accounted for only six percent.

Several factors limit the capacity of the livestock industry in the planning area. One limiting factor with respect to herd size is the amount of summer range available on federal lands, which constitute a large proportion of rangeland in the planning area. Both the U.S. Forest Service (USFS) and the Bureau of Land Management (BLM) have become more conservative in recent years with respect to the management of grazing allotments in response to environmental concerns. Thus, there appears to be little opportunity for producers to increase future production by expanding grazing on federal lands.

Figure 2
Distribution of Powder/Tongue River Basin Harvested Forage Acreage by County
(1980-2000 Average)

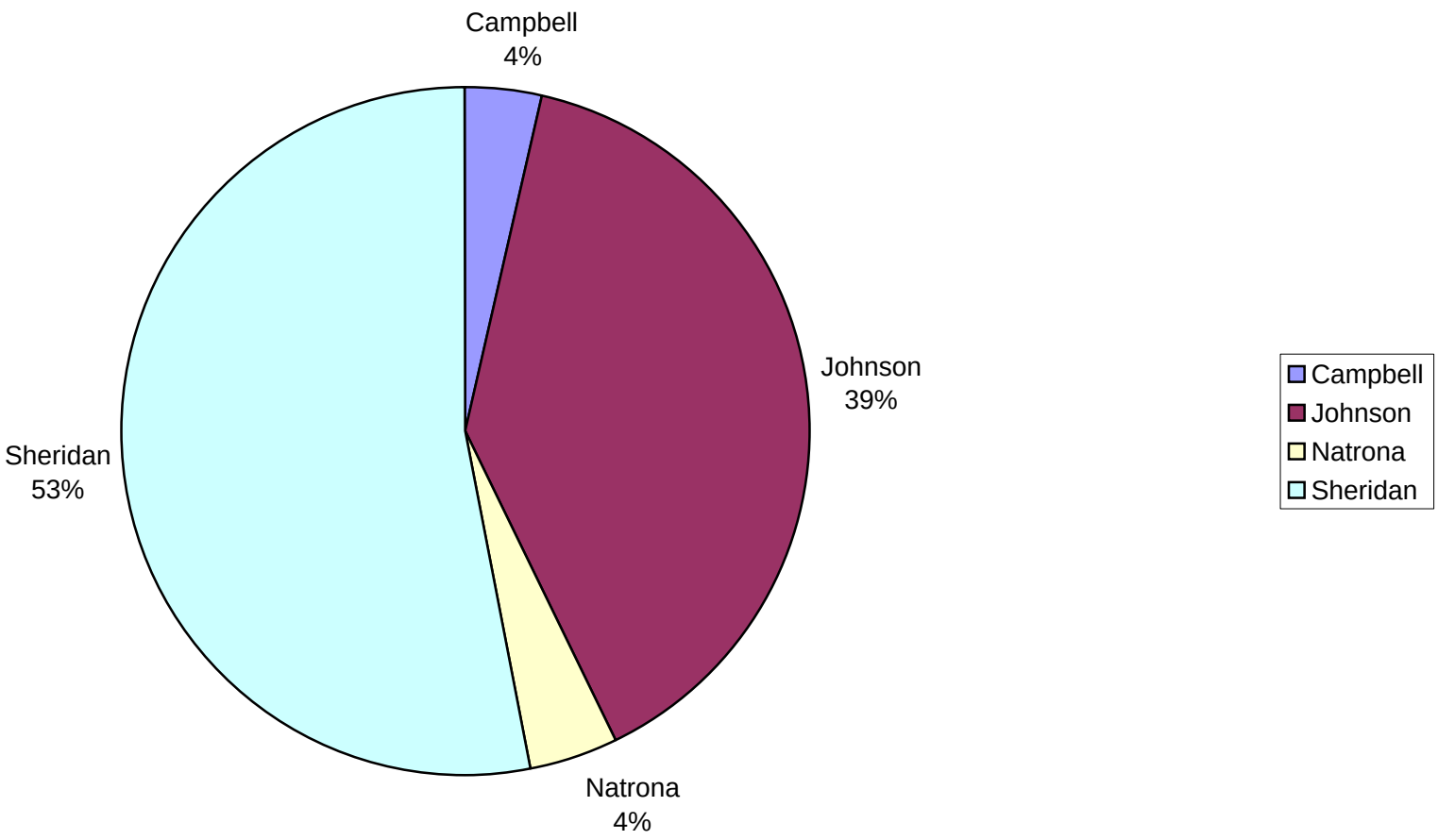


Figure 3
Powder/Tongue River Basin Cattle and Sheep Inventories
1980 - 2000

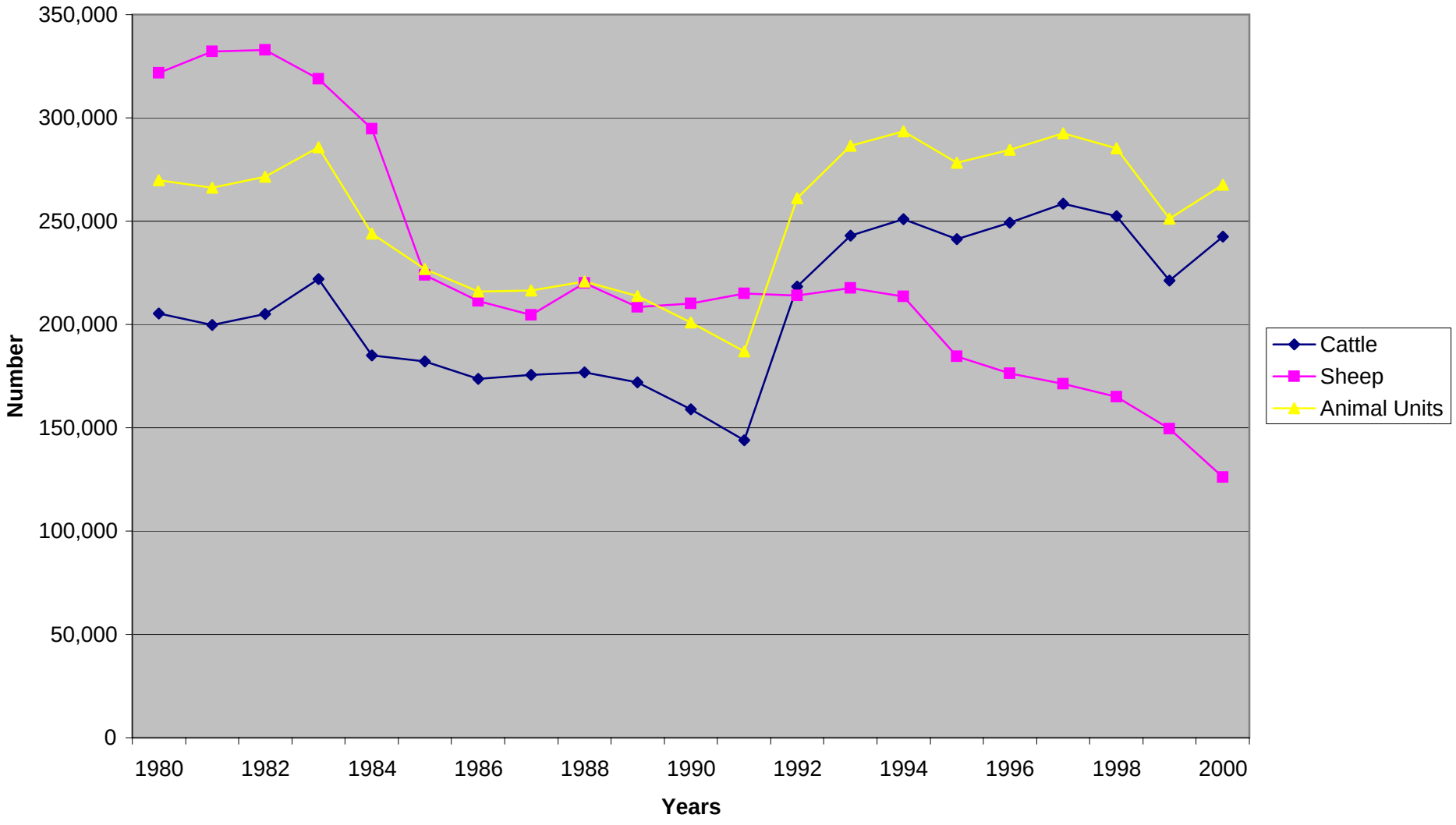


Figure 4
Distribution of Powder/Tongue River Basin Cattle by County

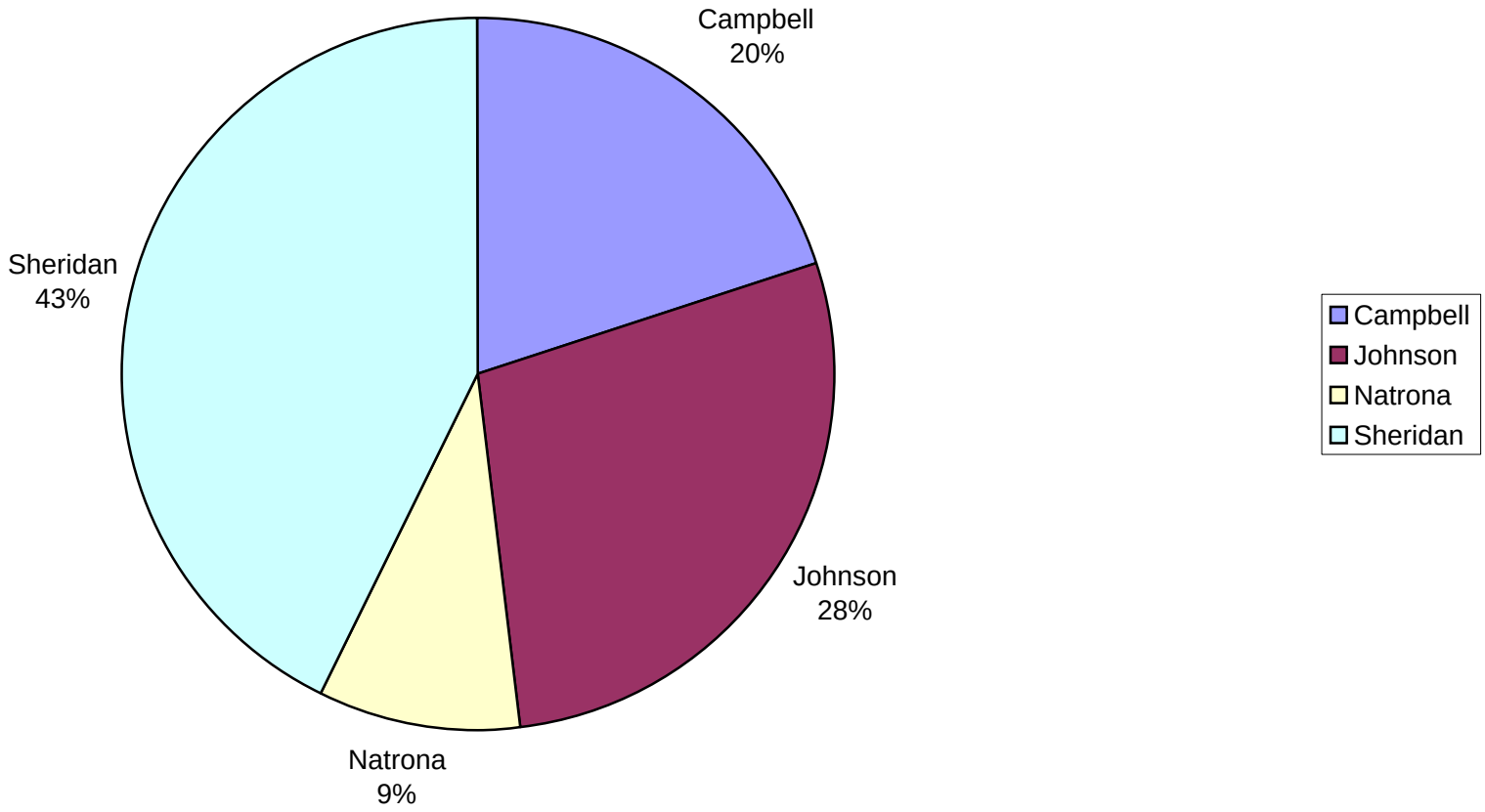
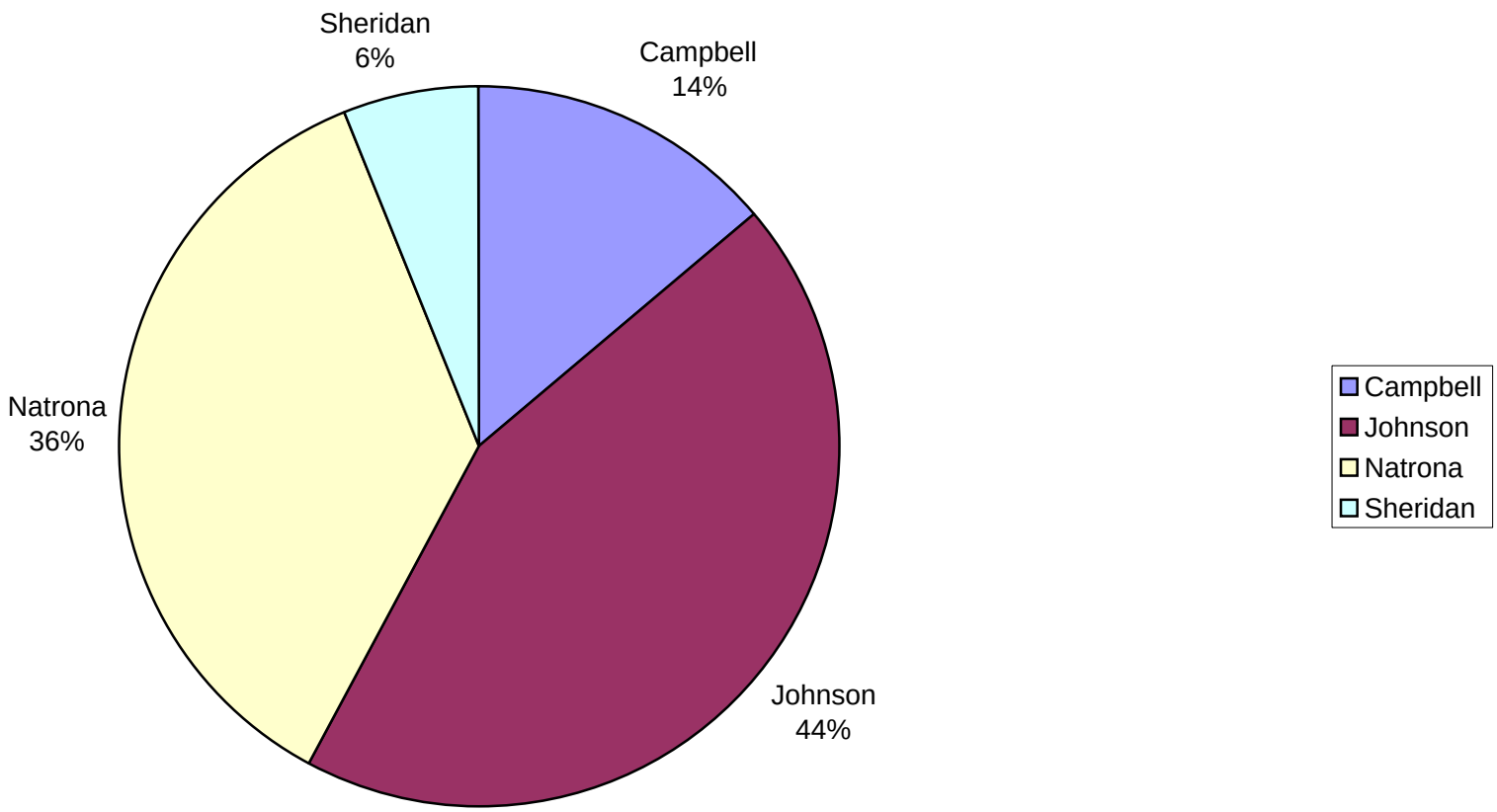


Figure 5
Distribution of Powder/Tongue River Basin Sheep by County



Another factor limiting the capacity of livestock production is the amount of forage that can be produced on private land holdings. The potential for increasing production on private lands is a function of irrigation water availability and the cost of developing that water. Developing new sources of irrigation water is a capital-intensive effort that has not been financially feasible for most producers over the past two decades. Thus, the productive capacity of the planning area's livestock industry has remained relatively constant over that period.

Future Water Needs and Demands

In discussing the future of irrigation in the Powder/Tongue River Basin, it is necessary to distinguish between needs and demands for irrigation water. A need for additional irrigation water is an identifiable current or future use that would enhance the economic well being of irrigator and/or the economy of the planning area as a whole. Demands are distinguished from needs by the fact that they are measured in relationship to price. To give a simple example, an irrigator may need additional irrigation water in a dry year to grow enough hay to provide winter feed for his cattle. If additional water costs $500 per acre-foot, however, the irrigator's demand for additional water would probably be zero because it would be more cost-effective to either buy additional forage from other producers or reduce the size of his herd.

In analyzing municipal and industrial water uses, needs and demands are often viewed interchangeably. The cost of water is usually a relatively minor part of the costs involved in developing water intensive manufacturing facilities such as electric power plants and soda ash production facilities. As a result, it can be assumed that manufacturers will demand the water that they need to expand production over a reasonable range of prices. Similarly, municipal needs are usually assumed to be essential and thus will be translated into demands over a reasonable price range. That convention was used for projecting municipal and industrial demands in this planning study.

Irrigated agriculture, however, is an industry in which producers are very sensitive to the price of water, and their demands for water can change dramatically as a function of price.[2] For that reason, this section of the memorandum discusses both irrigation water needs in the planning area and the circumstances under which those needs may be translated into future demands.

The hydrologic modeling effort undertaken for this planning study (HKM, 2002d), as well as conversations with irrigators and water professionals, indicate that there are areas of the planning area that could benefit from additional irrigation water, especially in dry years. Areas of particular need appear to be the Little Tongue drainage, some of the irrigated acreage along Clear Creek and its tributaries, the Middle and North Forks of Crazy Woman Creek, and the Powder River and some of its tributaries, especially Buffalo Creek. Additional irrigation water in these areas would stabilize forage production and allow ranchers to operate more profitably. Additional storage would also allow some operators to adjust more readily to potential future changes in the management of federal grazing allotments. If access to forage on federal lands were restricted in the future, the only alternative available to ranchers for keeping their operations at current production levels would be to increase forage production on private lands. This increase in production would require more intensive management of private land resources and more irrigation water. Additional irrigation water could allow producers to expand their cattle herds on private holdings or grow additional hay for sale outside of the planning area.

The biggest practical problem associated with fulfilling these needs for additional irrigation water is that the returns to forage production in recent decades have not been sufficient to offset the costs of new water storage projects. Studies of returns to irrigation water in the Little Snake Drainage and in other parts of Wyoming indicate that one acre-foot of irrigation water used for forage production in relatively high altitude areas of the state can be expected to generate a $15 to $25 increase in net farm income (Western Research Corporation, 1989). The cost of developing new storage can be significantly higher than that figure even under very favorable circumstances. For example, the recently completed Greybull Dam and Reservoir in the Bighorn River Basin of Wyoming is considered a very cost-effective project from a cost per acre-foot of yield perspective. The project's total cost was approximately $25 million for 25,000

[2] In economic jargon, irrigators tend to have highly elastic demand curves with respect to irrigation water.

acre-feet of storage, or about $1,000 per acre-foot of storage (Tyrrell, 2000). On an annual basis, the project's cost is equivalent to $63.44 for each acre-foot of reservoir storage, excluding O&M charges.[3] Current WWDC guidelines for new water project developments in Wyoming allow for up to a 50 percent state grant for project construction. If new irrigation water projects were developed in the planning area with WWDC assistance, the total cost of water would probably be at least $63.44 per acre-foot annually. Under current WWDC guidelines, irrigators would be responsible for annual payments of at least $31.72 per acre-foot of water plus O&M charges. Irrigators in the Bighorn River Basin can repay costs of this magnitude because they predominantly grow higher valued cash crops such as dry beans and sugar beets. However, these costs exceed the magnitude of returns that most producers in the planning area would realize from additional forage production under current market conditions.

Future demands for additional irrigation water in the planning area are thus largely dependent upon factors that might either increase the returns that Powder/Tongue River Basin irrigators receive from irrigation or reduce the cost to them of developing new storage. Possibilities for increasing economic returns to irrigated agriculture in the planning area include diversifying cropping patterns into higher valued crops, the possibility that hay prices may rise to the point that it would be profitable to export hay from the planning area to other domestic markets, and the possibility that cattle prices may rise significantly over the next 30 years.

Although there are some opportunities for diversifying cropping patterns in the planning area, it is doubtful that diversification out of forage production will occur on a wide enough scale over the next 30 years to warrant significant new water development projects. Specialty crops, such as alfalfa seed or seed potatoes, could possibly be grown in some of the lower elevation areas of the planning area. Seed alfalfa production is moving into Wyoming's Bighorn River Basin, where acreage has grown from 2,000 to 15,000 acres in recent years (Gray, 2000). Nevertheless, such crops still require relatively small acreages and tend to be produced in areas that have a competitive advantage with respect to climate and/or soils, which does not appear to be the case in the planning area.

Some trends in the agricultural industry in the western U.S. suggest that certain types of forage production will become more valuable in the future as cash crops. Population pressures in Arizona, California, and parts of Idaho, Oregon, and Washington are increasingly displacing agricultural production in those states; especially forage production. As more agricultural land is taken from production in the future, there will be less hay production because it is among the lower valued crops that can be grown in lower elevation areas. This trend has already resulted in a large exodus of dairy producers from California to states such as Idaho, Nebraska, and western Kansas because of the lack of alfalfa in California. Dairy producers in the Boise, Idaho area and along the Colorado Front Range are now having difficulty securing enough alfalfa locally and are relying upon imports from other states or are relocating to hay producing areas. One dairy recently moved into the Riverton area in Wyoming and another is considering relocation to Torrington (Gray, 2000).

Wyoming is currently a net exporter of alfalfa and Timothy grass hay. No official statistics are available on the magnitude of hay exports from Wyoming, but some experts put the figure at about 25 percent, and expect that percentage to increase in the future. The largest market for Wyoming hay is now Colorado, but some producers in the Bighorn River Basin are shipping hay by rail to dairies as far away as Florida and other east coast states (Gray, 2000). The types of hay expected to be in high demand in the future are alfalfa for dairies and Timothy hay for horses. Although alfalfa prices have been somewhat depressed in recent years, that trend is now reversing. Timothy hay is already bringing prices as high as $180 per ton in some parts of Wyoming and alfalfa prices in many parts of the state now exceed $100 per ton. If future market prices for these crops stabilize at high levels, it may become practical for some producers to develop additional storage and expand production of these crops for export markets. Timothy hay producers would have to build storage sheds to house the crop until it is sold because it is subject to moisture degradation, but few other changes to current production practices would be needed to expand production of these crops.

[3] Annual costs were computed by amortizing the $25 million construction cost over 50 years at six percent interest and dividing by 25,000 acre-feet.

Two other events could translate into more demand for irrigation water in the planning area over the next 30 years, a significant and long-term increase in cattle prices and/or an increase in the amount of financial assistance available to producers for reservoir construction from state and federal agencies.

Cattle prices have increased somewhat in recent years as per capita beef consumption in the U.S. has stabilized at around 67 pounds after many years of decline. But according to the Cattleman's Beef Production and Research Board, per-capita consumption is not expected to increase in the future and will most likely decrease from today's levels (Lambert, 2000). The USDA, however, is forecasting a significant increase in exports of U.S. beef over the next 10 years (USDA, 2000). The basis of this projection is the fact that demand for high quality beef in Pacific Rim nations is expected to increase significantly in the future as the economies of these countries recover from the 1998 financial crisis that affected the region. The U. S. has been and will continue to be the primary source of high quality beef for export, including exports for the hotel-restaurant market, primarily because of the availability of grain and feedlots for fattening. Although Argentina, Australia, and Brazil are also expected to increase their beef exports in the future, these exports will be composed primarily of lower quality grass fed beef, some of which will be imported by the U.S. for use in processed foods and hamburger.

Although the U.S. is now a net importer of beef, the USDA projects that the U.S. will become a net exporter of beef by the year 2010. The net effect of expanded overseas markets for quality beef is expected to be an increase in cattle prices over the next 10 years that could well extend further into the future. According to USDA projections, cash returns above expenses to cow-calf enterprises are expected to increase from an annual average of $32.02 per cow in 1999 and 2000 to $47.14 per cow during 2008 and 2009. This 47 percent increase in net returns, if extended over a significant time frame, could make additional storage affordable to some Powder/Tongue River Basin livestock producers.

The other factor that will influence future irrigation water demands is the cost of developing new water supplies. The prospects for increased federal assistance for reservoir construction seem more remote than the projected increase in cattle prices. Federal assistance for agriculture and new reservoir construction has been declining in recent years, and there are no indications that this situation will change over the planning horizon. The WWDC also has tightened its funding criteria for new water project construction in recent years. This tightening has been primarily motivated by budget constraints, however, and the possibility exists that more state funds may be allocated to water development over the next 30 years than are available under current economic conditions.

One potential low cost source of irrigation water for future use is CBM production water. Projections made for this planning study indicate that water production associated with CBM development in the planning area may exceed 150,000 acre-feet annually at some point during the next 10 years (Watts, 2002). There are several practical problems with utilizing that water for irrigation, however, one of which is the fact that high levels of production are not expected to last more than about 10 years. Given this relatively short duration, it is doubtful that many irrigators would be willing to make the significant changes in their operations that would be required to put this water to beneficial use. Making use of CBM water is also complicated by questions of water quality and the proximity of water production to areas of need in the planning area. Unless these issues can be resolved, there appears to be no significant long-term potential for enhancing agricultural production in the planning area through the use of CBM production water for irrigation.

For the reasons discussed above, the low, moderate, and high growth scenarios for future irrigation water demand in the planning area are based upon varying assumptions concerning the financial returns to beef and forage production and the availability of WWDC assistance for new project construction. Those scenarios are described in the following sections of this memorandum.

Low Growth Scenario

The low growth scenario is based upon the assumptions that irrigation in the planning area will continue to be dominated by forage production for winter livestock feed and that cattle and forage prices will not

make sustained increases over the next 30 years relative to reservoir construction costs. This scenario also projects no increase in state funding available for new project construction and no change in WWDC criteria for financial assistance to project sponsors. As a result, irrigators will probably be unwilling to make long-term financial commitments to develop new storage following WWDC funding guidelines.

Under this scenario, there will probably be a small reduction in total irrigated acreage in the planning area as some lands are taken out of production for home sites in the more scenic parts of the planning area. Overall forage production will probably increase somewhat, however, as irrigators adopt better water management techniques and take advantage of new production practices. This increase in forage production may allow cattle numbers to increase modestly over the planning horizon, but total consumptive use of surface irrigation water is expected to remain relatively constant at 183,800 acre-feet in a normal year.

Moderate Growth Scenario

The moderate growth scenario is based upon the reasonably foreseeable possibility that cattle prices will increase significantly over the next 10 years as forecast by the USDA in response to increased demand for high quality beef in Pacific Rim markets (USDA, 2000). Cattle prices are projected to stabilize at these higher prices over the planning horizon and thus provide a financial incentive for ranchers to maximize forage production and irrigation water use. This scenario also assumes that the State of Wyoming will solve its long-term revenue problems over the 30-year planning horizon, thus allowing water development funds to be used exclusively for that purpose. As a result, the WWDC will increase its financial commitment to new storage projects from a current level of 50 percent to 75 percent.

The combination of higher cattle prices and increased WWDC assistance will allow irrigators to maximize use of existing storage and perhaps fund some new storage projects in those parts of the planning area where developable sites are available. For example, the Lower Clear Creek Irrigation District has 11,800 acre-feet of storage in Lake DeSmet that is seldom fully utilized under current economic conditions, and additional water could be made available from Lake DeSmet through agreements with the Joint Powers Board that now owns and operates the reservoir. Furthermore, previous studies have identified several small storage sites on the tributaries of Crazy Woman Creek that are off the Bighorn National Forest and which could potentially be developed if economic conditions improve for ranchers and the WWDC provides financial assistance for 75 percent of project costs.

Both the Crazy Woman Creek and Clear Creek Drainages have been identified in this study as areas that could benefit from additional storage, especially in dry years (HKM, 2001d). The moderate growth scenario assumes that a combination of increased usage of Lake DeSmet storage plus one or two small storage projects in the Crazy Woman Creek Drainage would increase stored irrigation water use by an average of 15,000 acre-feet in a normal year. The equivalent increase in consumptive irrigation water use would be approximately 6,000 ace-feet annually.[4] In addition, there would be financial incentives for most irrigators in the planning area to manage their existing water supplies more carefully, thus further increasing consumptive use. This scenario assumes that basin-wide irrigation efficiency would increase by one percent as a result of these incentives, adding another 4,600 acre-feet to consumptive irrigation water use in a normal year. As a result, total surface irrigation water use would increase from 183,800 acre-feet under current conditions to 194,400 acre-feet in a normal year.

High Growth Scenario

The high growth scenario is based not only upon the reasonably foreseeable possibility that cattle prices will increase over the planning horizon, but that reductions in forage production in high growth areas of the west will drive forage prices high enough to encourage planning area irrigators to produce alfalfa and Timothy hay as cash crops. Alfalfa production could be expanded in lower elevation areas of the planning area and the hay shipped out of the planning area to dairies in other states. In higher elevation

[4] This estimate is based upon the assumption that 40 percent of reservoir storage would be consumptively used in a normal year.

areas of the planning area, irrigators could diversify into Timothy hay as a cash crop in addition to producing mixed grass hay for winter-feed. Some of the Timothy hay would be exported out of the planning area to surrounding states.

If forage prices stabilize at higher levels and WWDC funding is increased in the future, additional storage could be developed in the planning area to support increased forage production as a cash crop. The amount of additional storage that would be developed and the amount of additional water that would be consumptively used under this scenario are difficult to estimate because the outcome depends not only upon future financial returns to forage and beef production, but also upon the cost of developing additional storage in those areas where unappropriated water is available. A survey of members of the Greybull Valley Irrigation District in Wyoming's Bighorn River Basin suggests that irrigators are very sensitive to the cost of irrigation water (GEI Consultants, 1994). As a result, they tend to demand relatively large amounts of water at relatively low prices and very little water at relatively high prices. Irrigators in the planning area are likely to be equally sensitive to irrigation water costs, which are a controlling factor in the level of future development under the high growth scenario.

Unfortunately, there is relatively little current information concerning water development costs in the planning area. Previous studies have developed cost estimates for certain projects, such as the Sheridan Canal Project (Harza, 1983) and the Middle Fork Dam and Reservoir Project (Harza, 1986), but these estimates are now out of date and do not consider the fact that permitting costs (among other factors) are now significantly higher that when those costs studies were undertaken. As a result, it is possible to make only very general approximations of how much additional water would be developed and used for irrigation under the High Growth Scenario.

The preliminary water use projections for this scenario are that the increase in surface irrigation water under high growth conditions will be double the amount of the increase projected for the moderate growth scenario. That means that the amount of irrigation water consumptively used in a normal year will increase by 21,200 acre-feet annually relative to the low growth scenario. That increase would bring average annual consumptive use by planning area irrigators to 205,000 acre-feet annually. Part of this growth could occur because of increased incentives for efficient use of existing water supplies. Part of the growth could also be associated with developing one of the larger projects that have been identified in the past, such the Sheridan Canal Project or the Middle Fork Dam and Reservoir Project.

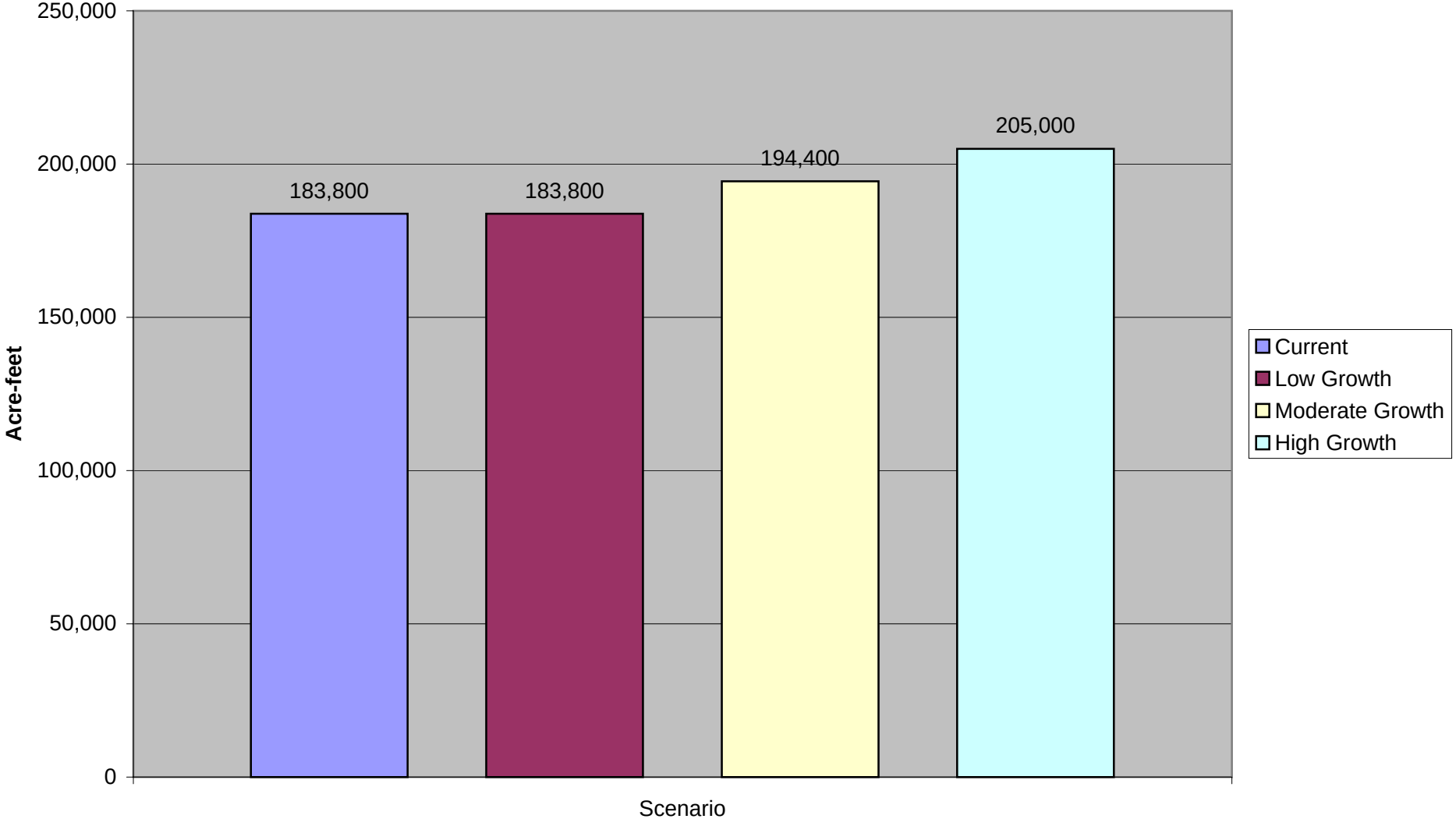
The high growth consumptive use estimate should be considered a first approximation that will be refined as more water development cost information becomes available.

Summary of Findings

Estimates of consumptive irrigation water use in the planning area are summarized in Figure 6 for current conditions and three future scenarios. The use estimates for the three future scenarios are for the year 2030. The first bar in Figure 6 shows that current consumptive use averages about 183,800 acre-feet annually, although consumption can be higher in a wet year and lower in a dry year. The second bar shows that for the low growth scenario, irrigation water use will remain constant at 183,800 acre-feet annually through the year 2030. No increases are projected for the low growth scenario because, under current economic conditions and WWDC funding criteria, irrigators are unable to finance the construction of new storage facilities.

The third bar in Figure 6 shows that for the moderate growth scenario, consumptive irrigation water use is expected to rise to 194,400 acre-feet annually by the year 2030. This scenario assumes that cattle prices rise significantly in the future as projected by the U.S. Department of Agriculture in response to export demand for high quality U.S. beef for the overseas restaurant and resort market. Furthermore, the WWDC is expected to adopt more favorable criteria for project assistance. As a consequence, irrigators will become more efficient in their water management practices and utilize more storage in Lake DeSmet, and develop some small storage projects on some tributaries such as Crazy Women Creek.

Figure 6
Summary of Consumptive Irrigtion Water Use Projections
2000-2030



The fourth bar in Figure 6 shows that for the high growth scenario, consumptive irrigation water use is expected to rise to 205,000 acre-feet annually by the year 2030. This scenario assumes that, in addition to rising cattle prices and more favorable WWDC financing terms, forage prices will increase to the point where forage production for markets outside of the planning area will become profitable. As a consequence, the increase in consumptive use projected for the moderate growth scenario will double to 21,200 acre-feet in a normal year.

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