MEMORANDUM

BBC RESEARCH & CONSULTING

TO: Wyoming Water Development Commission
FROM: Edward Harvey and Doug Jeavons
RE: **Task 4. Bear River Basin Water Demand Projections**
Memo 3: Future Water Demand Projections
DATE: October 6, 2000

Introduction

This memorandum describes future water demand projections for the Bear River Basin (Basin) under three alternative scenarios. It describes the study team's water use projections for the Basin in three separate sections:

- estimation of existing water use relationships (or water use factors) for each of the economic and demographic measures provided in the second memorandum;
- water use projections for each of the four key water use sectors – agricultural, municipal, rural domestic, and industrial – under three scenarios, presented on an annual basis; and
- water use projections for each of these key water use sectors presented on an monthly basis.

The bulk of this memo is based upon BBC estimates and projections. Other information was gathered from publicly available secondary sources and from personal and telephone interviews conducted by BBC Research and Consulting (BBC) from May through August 2000. References are listed at the end of this memorandum.

This memorandum is the third in a series of four technical memoranda related to water demands as authored by the study team for the Wyoming Water Development Commission. An overview of the current conditions in key economic and water use sectors was provided in Memo 1. The water demand projections presented here are based on the economic and demographic projections outlined in Memo 2. The last memo addresses recreational water requirements.

3773 CHERRY CREEK NORTH DRIVE, SUITE 850
DENVER, COLORADO 80209.3827
PHONE: 303.321.2547, FAX: 303.399.0448
e-mail: bbc@bbcresearch.com
internet: www.bbcresearch.com

Existing Water Use Relationships to Economic and Demographic Measures

This section of the memorandum describes the development of the estimated water use relationships for each of the four key water use sectors – agricultural, municipal, rural domestic and industrial – within the Basin. Wherever possible, separate water use factors were calculated for surface water and ground water. Separate estimates of total diversions and consumptive use were also calculated for each sector. After a detailed description of the methodology used to develop the water use factor in each sector, the section concludes by presenting a table of all the calculated water use factors.

Agricultural Sector

The agricultural sector consists of two primary areas of water use: irrigated hay production and livestock sustenance. The vast majority of irrigation water in the Basin comes from surface water diversions. It is assumed that all water used for livestock sustenance comes from surface water.

Irrigation water use factors, measured in acre-feet per acre, were calculated from historic water use data for the Upper and Central divisions of the Basin. Information on irrigation consumptive use for both surface water and ground water on a monthly basis from 1971 through 1998 was collected by the study team (Wilson). Because interviewees consistently indicated that 1) essentially all irrigable land is irrigated in a normal year, and 2) irrigated acreage within the Basin has not changed recently, the study team assumed a constant irrigated acreage level for each division within the Basin over the 30 year historical time period for which data was available (Burrough, Grandy, Grasmick). The mean and maximum consumptive use over this historical time period were calculated to represent irrigation water use in a “normal” and “high” year. As Table 1 shows below, irrigation consumptive use in a normal year is about 1.45 acre-feet per acre in the Basin. Of this, 1.42 acre-feet per acre or about 98 percent comes from surface water diversions with the remainder coming from ground water pumping.

Unfortunately, analogous records of total surface water diverted and total ground water pumped for irrigation were unavailable in aggregate form. Diversion estimates thus had to be constructed by inflating annual consumptive use totals using estimated application and conveyance efficiencies. Pumping estimates were calculated using only application efficiencies.

Estimated application efficiency depends on the relative share of acreage using a gravity or sprinkler irrigation system. Weighted average application efficiency estimates were calculated to be 55 percent in the Upper Division and 64 percent in the Central Division. Conveyance efficiency was estimated to be between 40 and 65 percent for the Upper Division and between 45 and 65 percent for the Central Division (Wilson). The midpoint of these ranges (52.5 and 55 percent respectively) was chosen as a point estimate of conveyance efficiency for each District. Resulting annual diversion estimates were converted to an acre-foot per acre basis using the estimated irrigated acreage totals. As with consumptive use, the mean and maximum water diverted over this historical time period were calculated to represent water use in a “normal” and "high demand" year. In a normal year, ranchers divert approximately 4.52 acre-feet per acre of irrigation water, of which 4.47 acre-feet per acre is surface water and the remainder is ground water.

Livestock water use factors in the Basin are estimated on a per animal unit basis. Previous estimates have placed daily water requirements at 12 gallons per head for cattle and 2 gallons per head for sheep. (EPA Manual of Individual and Non-Public Water Supply Systems, May 1991) The Kemmerer field office of the Bureau of Land Management estimates a daily requirement of 17.5 gallons for each cow-calf pair (Rawson). Since a cow-calf pair is the most common definition of an animal unit, it is appropriately converted to yield a livestock water use factor of .02 acre-feet per animal unit per year.

Municipal Sector

Municipal water use in the Basin is comprised of total water use in two municipalities: the City of Evanston and the town of Cokeville.   Water use in Evanston is divided into three distinct sectors – residential, commercial and institutional. All Evanston water supplies come from surface water diversions. Water use in Cokeville was analyzed in simplified form on a gallon per capita basis due to very limited information on end-user usage. The Cokeville system is non-metered. The total Cokeville water supply comes from three ground water wells just east of town (Kemp, August, 2000).

Information on metered water use in Evanston is available from 1960 to 1999. In order to estimate current diversion and consumptive use factors, the study team obtained water meter totals for all service categories for the recent 6-year period of 1993 through 1998 (Department of Public Works, City of Evanston). Meter totals are estimated to be 60 percent of total diversions equivalent to in-flows at the water treatment plant throughout the system (Sunrise report). Consumptive use for each sector may then be estimated by subtracting effluent totals from diversion totals in each sector. Diversions and effluents are assumed to have the same distribution among sectors.

Residential water use in Evanston consists of the sum of four distinct service categories: single unit residential, multi unit residential, senior residential and mobile homes. Total residential diversions and consumptive use were divided by corresponding population totals for the city in each of the six years in order to obtain two sets of daily residential water use factors (gallons per capita). The mean and maximum of these factors over this six-year period were calculated to represent current residential water use in a "normal" and "high demand" year. As Table 1 shows below, current diversions in the Evanston residential sector ranges from 158 gallons per capita in a normal year to 173 gallons per capita in a high demand year. Current consumptive use for residents of the city of Evanston is estimated to range from 95 gallons per capita in a normal year to 110 gallons per capita in a high year.

Current commercial diversion and consumptive use factors for Evanston during “normal” and “high” years were calculated in a similar fashion. The primary difference is that daily commercial water use factors are expressed in terms of gallons per employee. Employment totals for Evanston during the 1993-98 period were backcasted from 1999 totals assuming that employment levels during this period changed in direct proportion to population totals. As Table 1 shows below, current diversions in the Evanston commercial sector range from 70 gallons per employee in a normal year to 78 gallons per employee in a high year. Current commercial consumptive use for the city of Evanston is estimated to range from 43 gallons per employee in a normal year to 50 gallons per employee in a high year.

Current institutional diversion and consumptive use factors for Evanston were calculated in much the same way. Institutional water use in Evanston consists of the sum of three distinct service categories: government, churches and medical facilities. Daily institutional water use is also expressed in terms of gallons per capita. As Table 1 shows below, current diversions in the Evanston institutional sector range from 80 gallons per capita in a normal year to 105 gallons per capita in a high year. Current institutional consumptive use for the city of Evanston is estimated to range from 50 gallons per capita in a normal year to 75 gallons per capita in a high year.

The remaining municipal category is residential water use in the town of Cokeville. Water use in Cokeville is unmetered, and indeed little information on water use in the town exists. The study team has estimated that system wide diversions for the town of Cokeville total about 596 acre-feet per year (Forsgren Associates/Kemp), which translates to approximately 1,070 gallons per capita per day assuming Cokeville has approximately 500 residents (Kemp, August, 2000). This amount was assumed to remain constant from 1993 to 1998. Assuming that a meter system is in place, however, diversions are expected to drop to about 800 gallons per capita per day by the year 2030 (Kemp).

As with Evanston, consumptive use for the Cokeville system was calculated by subtracting total annual effluent from total annual diversions. The constant estimated diversion factors were converted to total annual diversions by multiplying the number of Cokeville residents. Population estimates were obtained by backcasting over the 6-year period assuming that Cokeville population varied proportionately with Lincoln County totals. Total annual effluent for the system, measured at about 145 acre-feet, or about 47.25 million gallons, was subtracted from annual diversion totals. Resulting consumptive use estimates were divided by annual population totals to obtain annual consumptive use factors (gallon per capita per day). The maximum and mean of the resulting annual consumptive use factor estimates were calculated to represent consumptive use in a “normal” and “high demand” year. Table 1 shows that daily consumptive use in Cokeville is estimated to range from 827 gallons per capita in a normal year to 830 gallons per capita in a high year.

Rural Domestic Sector

Outside of Evanston and Cokeville, the remaining residential water use in the Basin consists of domestic use on the individual ranches scattered throughout the Basin. The majority of these ranches pump their water from individual wells located on their property. Very little information exists on water use in this unmetered sector. The study team thus chose a general water use proxy of 180 gallons per capita per day for this sector, as this figure is slightly higher than the maximum purely residential water use in Evanston. In addition, 100 percent consumptive use is assumed for the rural domestic sector.

Industrial Sector

The primary source of industrial water use in the Basin is dedicated to natural gas processing. Both British Petroleum/Amoco and Chevron use significant amounts of water in natural gas processing at the Whitney Canyon natural gas field. All the water used by BP Amoco is pumped from a series of wells. Company representatives estimated average water use to be around 2.3 million gallons per month with a high of 4.1 million gallons per month, which translates to an average of 88 acre-feet per year and a high of 151 acre-feet per year (Robinson).

In contrast, all the water used by the Chevron processing plant is diverted surface water. Chevron representatives estimated their usage to range from an average 8.5 million gallons per month to a high of 12 million gallons per month, which translates to an average of 313 acre-feet per year and a high of 432 acre-feet per year (DeBerry).

These totals were then converted to industrial water use factors (measured in acre-feet per billion cubic feet of natural gas production) by dividing through by 1999 natural gas production totals for Lincoln and Uinta counties. The resulting annual water use factors of 1.39 and 2.06 acre-feet per billion cubic feet of production for average and high years respectively are also displayed in Exhibit 1 below. Note that 100 percent consumptive use is assumed for industrial water use (DeBerry, Robinson).

Exhibit 1.
Water Demand Factors by Economic Sector,
Annual Diversions and Annual Consumptive Use

Demand by Type of Use	Units	Diversions: Average Supply/ Demand	Diversions: High Supply/ Demand	Consumptive Use: Average Supply/ Demand	Consumptive Use: High Supply/ Demand
Agriculture					
Irrigation	*Acre feet per acre*	4.52	–	1.45	2.01
Surface Water		4.47	6.26	1.42	1.98
Ground Water		0.05	0.17	0.03	0.11
Livestock	*Acre feet per animal unit*	0.02	0.02	0.02	0.02
Municipal					
Evanston					
Residential	*Gallons/ capita per day*	157.68	172.72	95.38	110.89
Commercial	*Gallons/ employee per day*	70.59	77.97	42.80	50.35
Institutional	*Gallons/ capita per day*	80.63	104.71	49.47	73.74
Cokeville	*Gallons/ capita per day*	1070.00	1070.00	827.08	830.79
Rural Domestic	*Gallons/ capita per day*	180.00	180.00	180.00	180.00
Industrial					
Natural Gas	*Acre feet per Bcf of production*	1.39	2.06	1.39	2.06
Whitney(Chevron)		1.09	1.54	1.09	1.54
Whitney(BP-Amoco)		0.30	0.53	0.30	0.53

Projected Annual Water Demands by Scenario

This section presents current and projected annual water demands (both diversions and consumptive use) for the Basin under each of three separate scenarios: high, medium and low water use. The assumptions underlying each scenario have been previously described in Memo 2 of Task 4, Water Demand Projections. Water demands are derived by multiplying current or projected demographic or economic activity by the water use factors presented in the first section of this memo. Total water diversions and consumptive use are presented and discussed for each sector through three pairs of tables, one pair for each scenario. Patterns of change from current to projected future use by sector do not vary much from diversions to consumptive use within each scenario. At the bottom of each exhibit, these totals are aggregated into surface water and ground water totals for the Basin.

High Scenario

Total Basin water diversion requirements are projected to increase by about seven percent from year 2000 to year 2035 under the high case scenario. Under normal water year conditions, this amounts to about 21,400 acre-feet; under high demand year conditions, the increase would be about 29,000 acre-feet. The big difference is between "normal" and "high demand" or dry year conditions – about 40 percent more demand in the dry year.

Under the high scenario, total agricultural water demand grows slightly over the projection period, whether measured in terms of diversions or consumptive use. Despite a lack of growth in the sector, agriculture continues to comprise the vast majority of total water demand under the high scenario; agriculture is responsible for 97 percent of total water diverted and 94 percent of total consumptive use in the year 2030. Consumptive use is only 32 percent of total diversions for irrigated hay production within the Basin, reflecting low efficiencies and reuse of return flows. The vast majority of agricultural water demand remains in irrigated hay production, with only 0.19 percent going to direct livestock sustenance.

Exhibit 2.
Current and Projected Annual Bear River Water Demand
High Case Scenario,
Annual Diversions in Acre Feet per Year

	Current Demands		2030 High Scenario Demands	
	Normal Demand Year	High Demand Year	Normal Demand Year	High Demand Year
Demand by Type of Use				
Agriculture				
Irrigation	294,668	419,185	311,577	443,239
Livestock	528	528	611	611
Agriculture Subtotal	295,196	419,713	312,188	443,850
Municipal				
Evanston				
Residential	2,087	2,286	4,228	4,631
Commercial	638	705	1,310	1,447
Institutional	1,067	1,386	2,162	2,807
Subtotal	3,792	4,377	7,700	8,886
Cokeville	653	653	664	664
Municipal Subtotal	4,446	5,030	8,364	9,550
Rural Domestic	500	500	959	959
Industrial	459	680	494	731
Total Demand	300,601	425,923	322,005	455,091
Demand by Source of Supply				
Surface Water	293,454	416,212	314,042	444,416
Ground Water	7,147	9,710	7,963	10,675
Total Demand	300,601	425,923	322,005	455,091

Under the high scenario, while municipal water demand almost doubles over the 30-year projection period, it remains a relatively small sector, accounting for only 2.6 percent of total water diversions, and 4.8 percent of total consumptive use within the Basin. While water demand is projected to more than double in all municipal sectors in Evanston, water demand in Cokeville remains almost constant over the projection period. This is because the projected population growth of Cokeville is offset by the assumption that per capita water demand will decline sharply due to the implementation of a meter system in the town during the projection period.

Exhibit 3.
Current and Projected Annual Bear River Water Demand
High Case Scenario,
Annual Consumptive Use in Acre Feet per Year

	Current Demands		2030 High Scenario Demands	
	Normal Demand Year	High Demand Year	Normal Demand Year	High Demand Year
Demand by Type of Use				
Agriculture				
Irrigation	94,528	136,251	99,953	144,070
Livestock	528	528	611	611
Agriculture Subtotal	95,056	136,779	100,564	144,681
Municipal				
Evanston				
Residential	1,262	1,468	2,557	2,973
Commercial	387	455	794	935
Institutional	655	976	1,326	1,977
Subtotal	2,304	2,899	4,678	5,885
Cokeville	505	507	513	516
Municipal Subtotal	2,809	3,406	5,192	6,400
Rural Domestic	500	500	959	959
Industrial	459	680	494	731
Total Demand	98,825	141,365	107,209	152,772
Demand by Source of Supply				
Surface Water	95,829	137,460	103,629	148,229
Ground Water	2,996	3,906	3,580	4,543
Total Demand	98,825	141,365	107,209	152,772

Rural domestic water demand is projected to almost double over the next 30 years, due in large part to the projected population growth around the Evanston area. Although this sector is much more prevalent in Lincoln than in Uinta County (42 percent to 15 percent of total county population), the dramatic growth projected for the Evanston area drives the growth of the municipal sector within the Basin.

Water demand within the industrial sector is not likely to change substantially over the projection period under the high scenario. This reflects the 15 percent projected increase in natural gas production over the projection period. Industrial diversions and industrial consumptive use are likely to continue to be minor considerations within the Basin.

Low Scenario

Total water diversion requirements under the low economic forecasting scenario are projected to about the same in 2030 as they were in 2000. However, in any given year from 2000 to 2030, there might be the need for 125,000 more acre-feet in a high demand, dry year compared with a normal year.

Under the low scenario, total water demand in the agricultural sector declines over the projection period due to the anticipated agricultural policy changes described in the second memorandum of Task 4, Water Demand Projections. Since both irrigation diversions and consumptive use are projected to decline by 6 percent over the projection period, overall agricultural demand declines correspondingly. The decline in livestock water demand directly reflects the impacts of a change in BLM grazing policy and the implementation of the Cokeville Meadows Wildlife Refuge.

Exhibit 4.
Current and Projected Annual Bear River Water Demand
Low Case Scenario,
Annual Diversions in Acre Feet per Year

	Current Demands		2030 Low Scenario Demands	
	Normal Demand Year	High Demand Year	Normal Demand Year	High Demand Year
Demand by Type of Use				
Agriculture				
Irrigation	294,668	419,185	277,139	394,249
Livestock	528	528	487	487
Agriculture Subtotal	295,196	419,713	277,627	394,736
Environmental				
Wetland Impoundments	0	0	15,305	21,434
Municipal				
Evanston				
Residential	2,087	2,286	2,126	2,329
Commercial	638	705	659	728
Institutional	1,067	1,386	1,087	1,412
Subtotal	3,792	4,377	3,872	4,468
Cokeville	653	653	471	471
Municipal Subtotal	4,446	5,030	4,342	4,938
Rural Domestic	500	500	504	504
Industrial	459	680	0	0
Total Demand	300,601	425,923	297,779	421,614
Demand by Source of Supply				
Surface Water	293,454	416,212	291,261	412,753
Ground Water	7,147	9,710	6,518	8,860
Total Demand	300,601	425,923	297,779	421,614

The environmental sector line item included in the low scenario specifically refers to the wetland water requirements within the Cokeville Meadows Wildlife Refuge. If the refuge is fully implemented, water impoundments will likely be made in order to augment existing waterfowl habitat area. Both diversion and consumptive use totals were estimated by taking the projected acreage devoted to refuge impoundments, and multiplying this total by the corresponding water use factors calculated for surface water irrigation. The diversion factor was chosen, as it represents the lost opportunity for usage of the water – the amount of water that would have been used had the impoundments not been created. Estimates of actual consumptive use for wetlands in the region were not readily available. The water use factor for irrigated hay in the Basin was chosen to derive this estimate because irrigated meadow is a close approximation of waterfowl impoundments in this region.

In the municipal sector, the modest decline in both diversions and consumptive use is the direct result of two factors: constant population levels and the anticipated implementation of a residential water metering system in Cokeville (Kemp). Essentially zero population growth is projected for the Basin under the low scenario. Water demand in the rural domestic sector, completely a function of projected population, also remains unchanged.

Exhibit 5.
Current and Projected Annual Bear River Water Demand
Low Case Scenario,
Annual Consumptive Use in Acre Feet per Year

	Current Demands		2030 Low Scenario Demands	
	Normal Demand Year	High Demand Year	Normal Demand Year	High Demand Year
Demand by Type of Use				
Agriculture				
Irrigation	94,528	136,251	88,905	128,146
Livestock	528	528	487	487
Agriculture Subtotal	95,056	136,779	89,393	128,634
Environmental				
Wetland Impoundments	0	0	4,862	6,780
Municipal				
Evanston				
Residential	1,262	1,468	1,286	1,495
Commercial	387	455	399	470
Institutional	655	976	667	994
Subtotal	2,304	2,899	2,352	2,959
Cokeville	505	507	364	365
Municipal Subtotal	2,809	3,406	2,716	3,324
Rural Domestic	500	500	504	504
Industrial	459	680	0	0
Total Demand	98,825	141,365	97,475	139,242
Demand by Source of Supply				
Surface Water	95,829	137,460	94,829	135,809
Ground Water	2,996	3,906	2,646	3,433
Total Demand	98,825	141,365	97,475	139,242

The most significant change under the low scenario was the complete elimination of any industrial water demand within the Basin. This result is reflective of the assumed extraction of all remaining recoverable natural gas reserves within the Basin during the 30-year projection period. Although the overall effect on water demand within the Basin is slightly due to the comparatively small amount of industrial water use, this represents the largest projected change in any one sector under the low scenario.

As with the other scenarios, changes in overall water demand over the 30-year time horizon are relatively small because of the continued domination of the agricultural sector. Total surface water diversions and consumptive use are projected to decline by roughly six percent while corresponding ground water measures are expected to decline by 13 percent. The larger percentage decline in ground water demand is the result of the complete elimination of the industrial water use sector under the low scenario.

Medium Scenario

The medium economic projection scenario is structurally different from the high and low scenarios. Instead of the economic base, “bottom-up” forecasting approach used in the other scenarios, the medium scenario employs a population base “top-down” forecasting methodology. This approach ultimately resulted in a projected level of population growth between the two economic base scenarios. Accordingly, projected water demands for each sector presented in Exhibits 6 and 7 were interpolated between the corresponding totals under the high and low scenarios. The results illustrate a scenario where water diversions and consumptive use remain almost constant over the course of the 30-year projections period.

Exhibit 6.
Current and Projected Annual Bear River Water Demand
Mid Case Scenario,
Annual Diversions in Acre Feet per Year

	Current Demands		2030 Middle Scenario Demands	
	Normal Demand Year	High Demand Year	Normal Demand Year	High Demand Year
Demand by Type of Use				
Agriculture				
Irrigation	294,668	419,185	292,636	416,295
Livestock	528	528	543	543
Agriculture Subtotal	295,196	419,713	293,179	416,838
Municipal				
Evanston				
Residential	2,087	2,286	3,072	3,365
Commercial	638	705	952	1,051
Institutional	1,067	1,386	1,571	2,040
Subtotal	3,792	4,377	5,594	6,456
Cokeville	653	653	558	558
Municipal Subtotal	4,446	5,030	6,152	7,014
Rural Domestic	500	500	709	709
Industrial	459	680	222	329
Total Demand	300,601	425,923	300,263	424,889
Demand by Source of Supply				
Surface Water	293,454	416,212	293,095	415,213
Ground Water	7,147	9,710	7,168	9,677
Total Demand	300,601	425,923	300,263	424,889

Exhibit 7.
Current and Projected Annual Bear River Water Demand
Mid Case Scenario,
Annual Consumptive Use in Acre Feet per Year

	Current Demands		2030 Middle Scenario Demands	
	Normal Demand Year	High Demand Year	Normal Demand Year	High Demand Year
Demand by Type of Use				
Agriculture				
Irrigation	94,528	136,251	93,877	135,312
Livestock	528	528	543	543
Agriculture Subtotal	95,056	136,779	94,420	135,855
Municipal				
Evanston				
Residential	1,262	1,468	1,858	2,160
Commercial	387	455	577	679
Institutional	655	976	964	1,436
Subtotal	2,304	2,899	3,399	4,276
Cokeville	505	507	431	433
Municipal Subtotal	2,809	3,406	3,830	4,709
Rural Domestic	500	500	709	709
Industrial	459	680	222	329
Total Demand	98,825	141,365	99,181	141,602
Demand by Source of Supply				
Surface Water	95,829	137,460	96,115	137,670
Ground Water	2,996	3,906	3,066	3,932
Total Demand	98,825	141,365	99,181	141,602

Projected Monthly Demands by Scenario

Current and projected monthly water demands (both diversions and consumptive use) have been prepared for the Basin under each of three separate scenarios: high, medium and low water use. Monthly water demands are derived by multiplying the current and projected annual water demands for each sector by observed monthly shares of annual water over the historical period. Total water diversions and consumptive use are presented and discussed for each sector through three tables, one for each scenario.

An analysis of the temporal distribution of water demands throughout the year illustrates the seasonal nature of water demand within the Basin. Almost all sectors exhibit a significant difference in demand between the peak summer months and the off-peak winter months. Such distinct seasonal patterns in water demand are characteristic of economies for areas with colder climates similar to the Basin. One simplifying assumption made is that the temporal distribution of diversions and consumptive use throughout the year are identical.

The distribution of irrigation water demand was calculated for both surface water and ground water by division within the Basin by taking an average of historical data obtained by the study team. As expected, positive demand for both surface and ground water used in irrigation occurs only from April through October. Of interest is the fact that while the pulse in irrigation surface water demand occurs in the summer months (87 percent of total demand occurs in June-August), the pulse in ground water demand occurs earlier (75percent of total demand occurs in May and June). Livestock water demand is assumed to be twice as high during the months of April through September to reflect the presence of the spring calf crop during those months.

Residential and commercial water demand in Evanston was based on the average water use observed by sector in 1995-96 (Evanston Master Plan Study, Sunrise Engineering Inc.). Both sectoral distributions exhibit a baseline demand of about 5 percent per month for the months of October through May, and 60 percent of total water demand in these sectors occurs during the months of June through September. Institutional water demand in Evanston was based on the average water use observed by sector in 1995-96 (Large Users Summary, Evanston Master Plan Study, Sunrise Engineering Inc.). Water demand in this sector is even more seasonal, with a baseline demand of 3 percent during the months of October through May. The remaining 76 percent of annual demand occurs from June through September.

The distribution of the remaining sectors was based on anecdotal evidence, as no summary information was available. Water demand in Cokeville is assumed to follow the same temporal distribution as the Evanston residential sector. Rural domestic water use is assumed to be flat throughout the year since rural residential demand is less likely to have seasonal influences such as summer irrigation of lawn acreage. Industrial water demand is assumed to be constant throughout the year (DeBerry, Robinson).

High Scenario

The aggregate temporal distribution of water demand in the Basin under the high scenario is presented in Exhibit 8 below. It is possible to divide the months into three categories of water use: the baseline or off-peak months of October through April; the peak months of June and July; and the shoulder months of May and August and September.

Exhibit 8.
Current and Projected Monthly Bear River Basin Water Demand
High Case Scenario,
Estimated Diversions and Consumptive Use in Acre Feet

	Current Demands				2030 High Scenario Demands			
	Normal Year		High Demand Year		Normal Year		High Demand Year	
	Diversions	Cons. Use	Diversions	Cons. Use	Diversions	Cons. Use	Diversions	Cons. Use
Total Demand by Month								
January	292	225	331	265	495	367	557	429
February	282	219	319	257	477	355	535	415
March	290	224	329	263	491	364	552	426
April	1,071	539	1,769	934	1,312	695	2,069	1,133
May	25,596	8,783	39,090	14,466	27,327	9,463	41,629	15,506
June	94,995	30,690	134,509	43,825	100,957	32,777	142,807	46,735
July	109,125	35,082	153,148	49,183	116,076	37,530	162,733	52,550
August	53,761	17,497	75,311	24,465	57,639	18,999	80,549	26,493
September	13,251	4,527	18,630	6,394	14,554	5,133	20,325	7,192
October	1,377	605	1,851	804	1,737	825	2,278	1,076
November	282	218	321	255	472	351	531	409
December	277	216	315	254	468	350	526	408
Total Annual Demand	300,601	98,825	425,923	141,365	322,005	107,209	455,091	152,772

The distribution of percentage increases over the 2000-2030 projection period is exactly inverted, with the largest percentage increases coming the baseline months (roughly 67 percent) and the smallest percentage increases coming during the peak months (roughly 6 percent). This result stems from the fact that water demand in the baseline months is based on municipal demand (the fastest growing sector) while water demand in the peak months is based on agricultural demand (the slowest growing sector).

Low Scenario

The aggregate temporal distribution of water demand in the Basin under the low scenario is presented in Exhibit 9 below.

Exhibit 9.
Current and Projected Monthly Bear River Basin Water Demand
Low Case Scenario,
Estimated Diversions and Consumptive Use in Acre Feet

	Current Demands				2030 Low Scenario Demands			
	Normal Year		High Demand Year		Normal Year		High Demand Year	
	Diversions	Cons. Use	Diversions	Cons. Use	Diversions	Cons. Use	Diversions	Cons. Use
Total Demand by Month								
January	292	225	331	265	1,522	586	2,054	767
February	282	219	319	257	1,512	579	2,043	759
March	290	224	329	263	1,520	584	2,051	765
April	1,071	539	1,769	934	2,254	880	3,405	1,396
May	25,596	8,783	39,090	14,466	25,324	8,636	38,512	14,126
June	94,995	30,690	134,509	43,825	90,604	29,244	128,267	41,745
July	109,125	35,082	153,148	49,183	103,906	33,381	145,812	46,795
August	53,761	17,497	75,311	24,465	51,839	16,844	72,611	23,550
September	13,251	4,527	18,630	6,394	13,728	4,641	19,287	6,546
October	1,377	605	1,851	804	2,549	946	3,491	1,279
November	282	218	321	255	1,512	578	2,044	758
December	277	216	315	254	1,508	577	2,038	756
Total Annual Demand	300,601	98,825	425,923	141,365	297,779	97,475	421,614	139,242

Under the low scenario, water demand for the Basin declines during all months of the year. Similar to the high scenario, the baseline months exhibit the largest percentage changes (roughly 17 percent) and the peak months exhibit the smallest percentage changes (roughly 6 percent). The absolute magnitude of these changes is, however, much smaller under the low scenario than under the high scenario. Clearly, both the relative stability and the overall dominance of the agricultural sector in terms of water demand controls the patterns of change under the two economic base scenarios.

Medium Scenario

The aggregate temporal distribution of water demand in the Basin under the medium scenario is presented in Exhibit 10 below. As with the annual demands, monthly totals for each sector were interpolated between the two economic base scenarios based on the relative relationship of the population projections under the three scenarios.

Exhibit 10.
Current and Projected Monthly Bear River Basin Water Demand
Mid Case Scenario,
Estimated Diversions and Consumptive Use in Acre Feet

	Current Demands				2030 High Scenario Demands			
	Normal Year		High Demand Year		Normal Year		High Demand Year	
	Diversions	Cons. Use	Diversions	Cons. Use	Diversions	Cons. Use	Diversions	Cons. Use
Total Demand by Month								
January	292	225	331	265	359	264	398	304
February	282	219	319	257	345	256	382	293
March	290	224	329	263	356	262	394	302
April	1,071	539	1,769	934	1,129	574	1,821	967
May	25,596	8,783	39,090	14,466	25,524	8,785	38,932	14,436
June	94,995	30,690	134,509	43,825	94,561	30,611	133,827	43,680
July	109,125	35,082	153,148	49,183	108,681	35,025	152,444	49,074
August	53,761	17,497	75,311	24,465	53,748	17,591	75,201	24,564
September	13,251	4,527	18,630	6,394	13,398	4,639	18,772	6,526
October	1,377	605	1,851	804	1,482	669	1,963	877
November	282	218	321	255	343	253	381	290
December	277	216	315	254	338	252	375	289
Total Annual Demand	300,601	98,825	425,923	141,365	300,263	99,181	424,889	141,602

The temporal distribution of water demand under the medium scenario is almost identical to current use. This is not surprising since overall diversions are projected to decline by less than 400 acre-feet over the 30-year time horizon. As can be seen in Exhibit 10, slight increases are projected for the baseline months (driven by municipal demand) while slight decreases are projected for the peak months (driven by agricultural demand).

Comparison of Projected Demand Growth with Available Supplies by Division

One of the purposes of developing water demand forecasts in a Basin planning study is to compare maximum projected demand, the High Scenario during a dry or high demand year with potential available water supplies to help determine the need for new water storage projects. To facilitate these comparisons, the study team estimated the level of monthly water demand growth (measured as the difference between 2030 conditions and current conditions) that would occur in both the Upper and Central Divisions of the Basin. For purposes of this comparison, only surface supplied demands were included as relevant when considering potential future storage projects.

Monthly projections of the growth in future demands, for both the Upper and Central Division, were developed for two sets of water demand conditions. “Normal” year projections are projections of growth by the year 2030 under the average water demand conditions described previously for each sector in this memorandum. “Dry” year projections are projections by the year 2030 assuming high water demand conditions, also described previously for each water use sector. Available monthly surface supplies were calculated by the study team, and are presented in the Task 3.D technical memorandum for “normal”, “dry” and “wet” year climate conditions. These totals represent the amount of available surface water that is currently uncommitted to specific uses.

The geographic allocation of future monthly water demands reflects the following assumptions:

- Agriculture (irrigation and livestock use) demands were allocated based on the current geographic distribution of this type of water demand throughout the Bear River Basin.
- The "Other" category includes two types of demand -- surface supplied municipal demands and industrial demands. City of Evanston demands were included in the Upper Division. City of Cokeville demands were excluded from this analysis, since Cokeville is supplied with groundwater. For purposes of this analysis, Upper Division industrial demands include the surface water supplied to the Chevron gas processing facility. No additional surface supplied industrial demands were projected for the Central Division, since new industrial operations in that region are likely to be supplied with groundwater.

Exhibit 11 depicts the projected monthly growth in surface water supplied, monthly water demands, by division, under normal year conditions. It also shows the monthly, uncommitted surface water supply as well as the estimated surplus/shortage that is the difference of these two totals.

Exhibit 11.
Projected Acre-Foot Increases in Bear River Basin Surface Water Diversions
Needed Versus Available Supply
Under Normal Year Conditions

Upper Division

	Projected Demand Growth by Month			Available	Surplus/
	Agriculture	Other	Total	Surface Supply	(Shortage)
Jan	2	156	158	4,745	4,587
Feb	2	150	152	4,836	4,684
Mar	2	152	155	11,520	11,365
Apr	38	145	183	18,627	18,444
May	813	237	1,050	19,049	17,999
Jun	2,725	491	3,217	66,197	62,980
Jul	3,210	698	3,908	97	(3,811)
Aug	1,457	803	2,260	0	(2,260)
Sep	405	551	956	0	(956)
Oct	42	269	311	6,162	5,851
Nov	2	141	143	5,932	5,789
Dec	2	143	145	5,260	5,115
Total	8,702	3,936	12,637	142,425	129,788

Central Division

	Projected Demand Growth by Month			Available	Surplus/
	Agriculture	Other	Total	Surface Supply	(Shortage)
Jan	2	0	2	0	(2)
Feb	2	0	2	0	(2)
Mar	2	0	2	6,939	6,937
Apr	10	0	10	34,769	34,759
May	610	0	610	53,300	52,690
Jun	2,804	0	2,804	69,232	66,428
Jul	3,008	0	3,008	23,551	20,543
Aug	1,575	0	1,575	0	(1,575)
Sep	319	0	319	0	(319)
Oct	22	0	22	0	(22)
Nov	3	0	3	0	(3)
Dec	2	0	2	0	(2)
Total	8,359	0	8,359	187,791	179,432

During a normal year, while the growth in demands are dominated by the agricultural sector in both the Upper and Central Divisions, growth in demand for non-agricultural purposes will be an important factor only in the Upper Division. During the summer growing season agricultural demands constitute between 64 and 84 percent of total demand growth in the Upper Division. In the Central Division, agricultural demand growth constitutes 100 percent of the total increase in monthly demands through 2030. This difference is due mainly to the growth in municipal water demand projected for the Evanston area over the next 30 years. Thus, while agricultural demands follow roughly the same monthly distribution in both divisions, the monthly distribution of total demand growth between the divisions varies due to the influence of the non-agricultural sector.

The monthly distribution of available, uncommitted surface water supplies for a normal year is similar for both the Upper and Central Division. Available supplies begin building with the spring runoff and peak in the month of June. In each division, available supplies stabilize throughout the fall and winter seasons. The main difference is that, while in the Upper Division, some surface water supplies remain available in all months of the year with the exception of the three-month peak irrigation period (July-September), in the Central Division, supplies are available only during the spring runoff period.

The last column of Exhibit 11 shows the difference in the growth of demands and the uncommitted surface water supplies on a monthly basis under normal conditions. In the Upper Division, shortages are projected to only occur during the peak irrigation periods. During the remaining months, uncommitted surface supplies are more than adequate to meet the projected growth in demand. In the Central Division, while monthly shortages are projected to occur from August through February, with the exception of August, none are really significant. From March through July, the study team projects that more than enough surface water will be available to meet the projected growth in demand.

Exhibit 12 depicts projected increases in surface supplied monthly water demands, by division, under dry year conditions. These demands were calculated assuming high water demand conditions. Although it could be considered the "worst case," this scenario is reasonable to explore, as historical data indicate a high correlation between high water demand and dry year climate conditions. Dry conditions were evident as often as three years out of a decade historically (Wilson and Kemp, 2000).

Exhibit 12.
Projected Acre Foot Increases in Bear River Basin Surface Water Diversions Needed Versus Available Supply Under Dry Year Conditions

Upper Division

	Projected Demand Growth by Month			Available	Surplus/
	Agriculture	Other	Total	Surface Supply	(Shortage)
Jan	2	180	183	1,972	1,789
Feb	2	173	176	1,665	1,489
Mar	2	176	178	3,744	3,566
Apr	51	168	219	3,934	3,715
May	1,128	274	1,403	0	(1,403)
Jun	3,789	568	4,356	9,524	5,168
Jul	4,463	806	5,269	0	(5,269)
Aug	2,025	927	2,952	0	(2,952)
Sep	561	636	1,197	0	(1,197)
Oct	58	311	369	1,735	1,366
Nov	2	163	165	2,255	2,090
Dec	2	165	168	1,959	1,791
Total	12,088	4,547	16,635	26,788	10,153

Central Division

	Projected Demand Growth by Month			Available	Surplus/
	Agriculture	Other	Total	Surface Supply	(Shortage)
Jan	2	0	2	0	(2)
Feb	2	0	2	0	(2)
Mar	2	0	2	0	(2)
Apr	12	0	12	0	(12)
May	847	0	847	0	(847)
Jun	3,899	0	3,899	0	(3,899)
Jul	4,183	0	4,183	0	(4,183)
Aug	2,189	0	2,189	0	(2,189)
Sep	441	0	441	0	(441)
Oct	30	0	30	0	(30)
Nov	3	0	3	0	(3)
Dec	2	0	2	0	(2)
Total	11,612	0	11,612	0	(11,612)

The distribution of demand growth depicted in Exhibit 12 has many of the same characteristics as that shown in Exhibit 11. The main difference is that in a dry year, the growth in demand for the agricultural sector increases to a much greater extent than in the non-agricultural sector. Demand growth in a dry year for the agricultural sector in both the Upper and Central Divisions increased by 40 percent over what they were in a normal year. In contrast, the Upper Division non-agricultural growth in demand increased by only 16 percent. Overall demand growth in dry years is approximately 35 percent greater than under normal year climate and hydrologic conditions.

Annual uncommitted surface supplies declined dramatically in both divisions for dry year conditions versus normal year conditions. For the Upper Division, annual available supplies shrank to 19 percent of what they were under normal conditions. The largest monthly percentage declines comes during the months of May through September, when agricultural usage is at its highest. During this period, available supplies go to zero for all months except June, which declines to 14 percent of what was available in a normal year. For the Central Division, available supplies during dry year conditions go to zero during all months of the year. This result is expected, given that the months of August through February were already at zero during a normal year, and the remaining months reflect the spring runoff accumulation.

The significant decline in available surface water supplies has important consequences for the monthly surplus/shortage totals projected for each division. Whereas under normal year conditions both the Upper and Central Divisions experienced very few months with significant projected shortages, under dry year conditions, both divisions experience significant projected shortages during the summer irrigation season. It should be noted that sequential dry years would aggravate these shortages considerably.

Summary

This memorandum has presented the water demand projections developed for the Bear River Basin under three alternative scenarios. The methodology used to derive the quantitative relationships (water use factors) for each water use sector is outlined and discussed. These water use factors, together with projected demographic and economic information, are applied to develop annual water use projections by sector under three alternative scenarios. Historically, observed temporal distributions of annual totals for each sector allowed the study team to derive monthly aggregate water use projections for each scenario.

The largest projected changes in water demand occur in the municipal sector. Total water demand in this sector remains small relative to water demand in the agricultural sector. While the agricultural sector experiences the smallest percentage change over the projection period, the sector's relative magnitude allows it to drive the water use patterns exhibited in both the annual and monthly water demand projections. Although industrial water demand is completely eliminated under the low scenario, the sector's diminutive size implies minimal overall impact on water demand in the Basin.

High Scenario projected growth in water demand under both normal and dry year conditions are compared to potential uncommitted surface water supplies under both sets of conditions. The comparison of the growth in water demand to uncommitted supplies for both the Upper and Central Divisions, demonstrates that under both normal and dry year conditions, agricultural demands during the irrigation season are the most at risk of exceeding available supplies. Indeed, under dry year conditions, both divisions are projected to experience substantial shortages during the summer season.

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