Utah Department of Environmental Quality
Division of Water Quality
TMDL Section

Lower Bear River & Tributaries TMDL

Waterbody ID	**Lower Bear River & Tributaries**
Location	**Box Elder County, Utah (HUC # 16010204)**
TMDL Pollutants of Concern	**Total Phosphorus**
Impaired Beneficial Uses	**Class 3B: Protected for warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain.**
Loading Assessment **- At Cutler** **- At Corinne**	 **703 kg/day annual average load TP** **980 kg/day annual average load TP**
Water Quality Targets/Endpoints **- Below Cutler Reservoir** **- At Corinne** **- Basin wide endpoints**	 **365.5 kg/day annual average TP load** ***(Based on 0.075-mg/l instream concentration of TP)*** **380.6 kg/day annual average TP load** ***(Based on 0.075-mg/l instream concentration of TP)*** · **load reduction of 458.8 kg/day** · **not to exceed 0.075 mg/l TP concentration in river** · **35 comprehensive nutrient mgt systems** · **25% reduction of cropland runoff** · **10 miles of streambank restoration** · **install BMPs on acres designated as critical** · **point sources meet UPDES requirements**
Load Reduction **- Below Cutler Reservoir** **- At Corinne**	 **410 kg/day annual average load TP** **458.8 kg/day annual average load TP** **(includes 41.7 kg/day MOS 10% of initial target)**
Implementation Strategy	**BMPs - Animal waste mgt., irrigation water mgt., riparian rehabilitation, nutrient mgt., streambank stabilization, power ramping mgt., range/pasture mgt., wetland construction, point source control.**

This document is identified as a TMDL for Lower Bear & tributaries from Great Salt Lake to Cutler Reservoir and is officially submitted to the U.S. EPA to act upon and approve as a TMDL. It has been developed utilizing information submitted by Ecosystems Research Institute through a locally administered contract with Bear River Water Conservancy District.

LOWER BEAR RIVER
WATERSHED RESTORATION
ACTION STRATEGY

A Sub-basin Assessment
for the Lower Bear River and Tributaries
from GSL to Cutler Reservoir
in Box Elder County, Utah

***Prepared by*:**

Utah Department of Environmental Quality
Division of Water Quality

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Ecosystems Research Institute, Inc.
Bear River Water Conservancy District

April 2002

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1.0 INTRODUCTION

1.1 Historic Perspective

Utah is required through the Clean Water Act, Section 303(d) to develop total maximum daily loads (TMDL) for waters identified as not meeting or not expected to meet water quality standards. Two waterbody segments located in Lower Bear/Malad River (Sub-basin# 16010204) have been declared impaired in Utah's year 2000, 303(d) list of water bodies needing TMDL analyses. These segments are the Bear River from Cutler Dam to its confluence with the Malad River and from the Malad River confluence to the Great Salt Lake (Bear River Migratory Bird Refuge). Beneficial use standards for class 3B-warm water species of game fish including necessary aquatic organisms in the food chain are not met. Total phosphorus is identified as the pollutant of concern. The entire HUC area was surveyed in the process of preparing the TMDL.

A plan entitled the "Lower Bear River Water Quality Management Plan" was completed in November 1995. It focused on Cache County water quality concerns above Cutler Dam and reservoir, but included data for three sites below the dam. The major value of this earlier study has been to identify and quantify the pollutants entering the lower Bear River in Box Elder County at Cutler Dam.

Water quality demonstration projects dealing with animal waste have been completed or are in process under the EQIP (Environmental Quality Incentives Program) program of the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS).

The United States Geological Survey (USGS) is currently preparing a water quality assessment for the Great Salt Lake Basin as part of its National Water-Quality Assessment (NAWQA) program. The Bear River, the Great Salt Lake's largest tributary, is included in the study and additional information has come from this effort.

Utah's Division of Drinking Water has required Source Water Protection Zone delineation for all culinary water systems in the study area. Most are completed and are identified in this document.

1.2 Utah's Watershed Approach

This comprehensive project has resulted in a Watershed Management Plan assuring that TMDL requirements will be met. The watershed approach has been presented in detail in the Utah Division of Water Quality report "Utah's Watershed Approach" printed in 1997. There are seven elements in the plan and are presented below:

Element 1 - Local Involvement
Element 2 - Watershed Management Units
Element 3 - Watershed Planning Cycle
Element 4 - Water Quality Data
Element 5 - Watershed Assessment and TMDL Development
Element 6 - Management and Implementation Strategies
Element 7 - Implementation

These seven elements are synonymous with the TMDL process. This document sets forth a TMDL that is flexible, quantitative, and model-based while focusing on the attainment of water quality standards. The approach recognizes the seasonality of the observed loadings and includes a margin of safety.

The overall philosophy of this project has been to provide a sustainable Bear River ecosystem while protecting and enhancing the socioeconomic values of northern Utah.

1.3 Role of Stakeholder Input

The contracting entity, Bear River Water Conservancy District (BRWCD), was created in 1988 under the Utah Water Conservancy Act and consists of an eleven-member board, appointed by the Box Elder County Commission, and a small staff. In addition to board direction, the Eastern Box Elder County Committee, a citizen and technical agency group organized to identify and find means to solve natural resource issues, has worked closely with BRWCD to broaden local input and provide technical assistance. Water quality was identified as a high priority concern by the group. The groups has also received the benefit of invaluable coordination with Northern Utah Soil Conservation District and the Utah Division of Water Quality.

Agency and public review of these findings and reports in the watershed and TMDL process has been critical. Technical review and public involvement have been necessary to insure a defendable product and ongoing landowner cooperation in solving the problems within water quality limited stream segments.

This study was under the direction of BRWCD's General Manager, James G. Christensen. Ecosystems Research Institute (ERI) prepared the technical and scientific tasks for the TMDL plan. Primary technical staff were Vincent Lamarra, Ph.D., Elisabeth Evans, R. Hart Evans and Justin Barker.

2.0 PROJECT AREA

2.1 Watershed Boundaries

The Bear River is the Western Hemisphere's largest stream that does not reach an ocean. Beginning in the Uinta Mountains of Utah, it flows through parts of Wyoming and Idaho before returning to Utah to discharge into the Great Salt Lake. In its circuitous course, the river travels about 500 miles and drops almost 8,800 feet in elevation. The straight line distance from its headwaters to its mouth is only 90 miles. Six sub-basins have been delineated by the USGS within the total Bear River basin as shown on Figure 2-1.

About 7,118 square miles of mountain and valley lands make up the whole watershed of the Bear River. Approximately 2,695 (35%) square miles are in Idaho; 3,381 (45%) in Utah; and 1,507 (20%) in Wyoming. The lower Bear River/ Malad area is 1,244 square miles, of which about 409 (33%) are in Idaho and 835 (67%) in Utah. This plan covers the Utah portion only. Figure 2-2 depicts the study area.

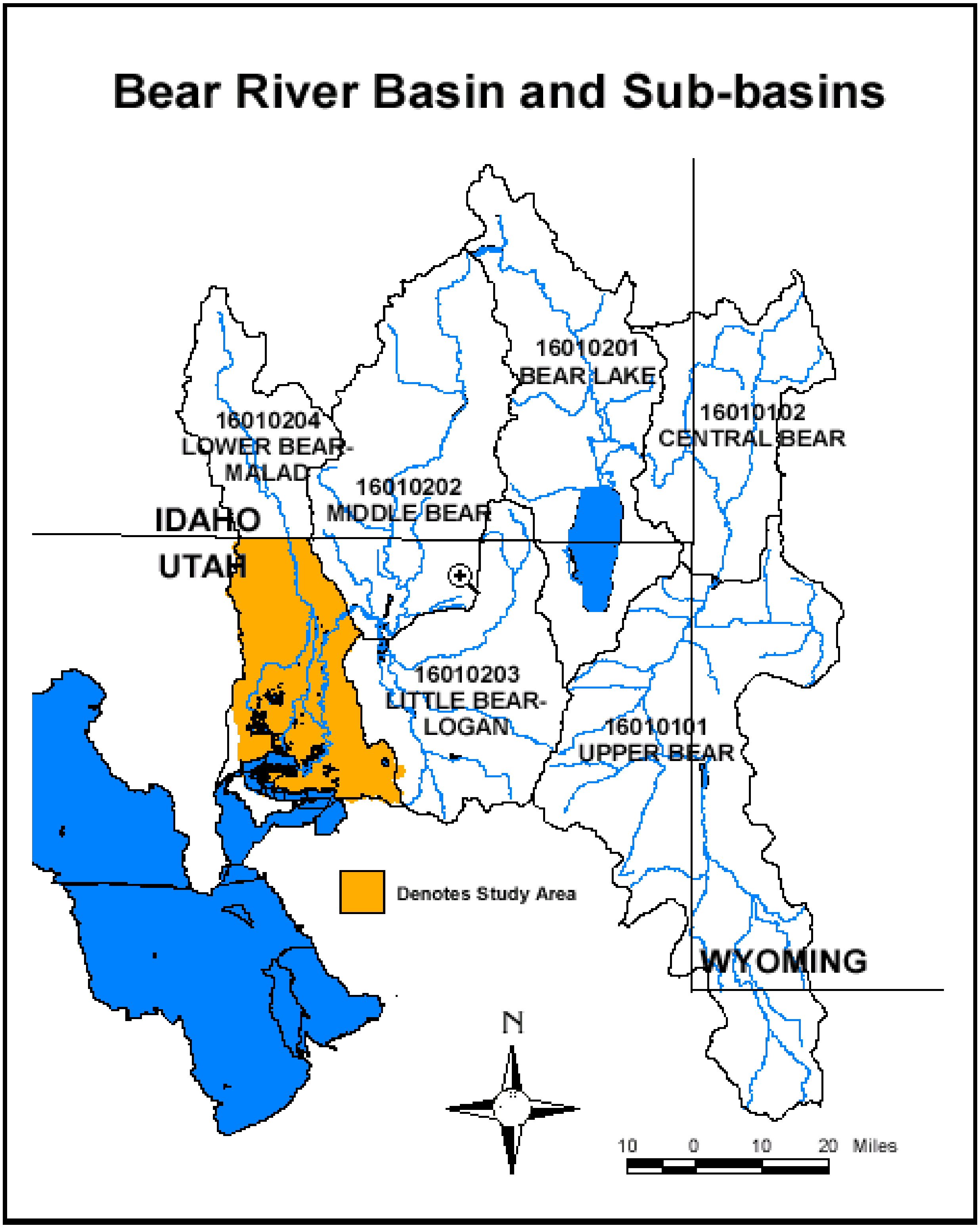


Figure 2-1. A map illustrating the project area in relation to the entire Bear River basin

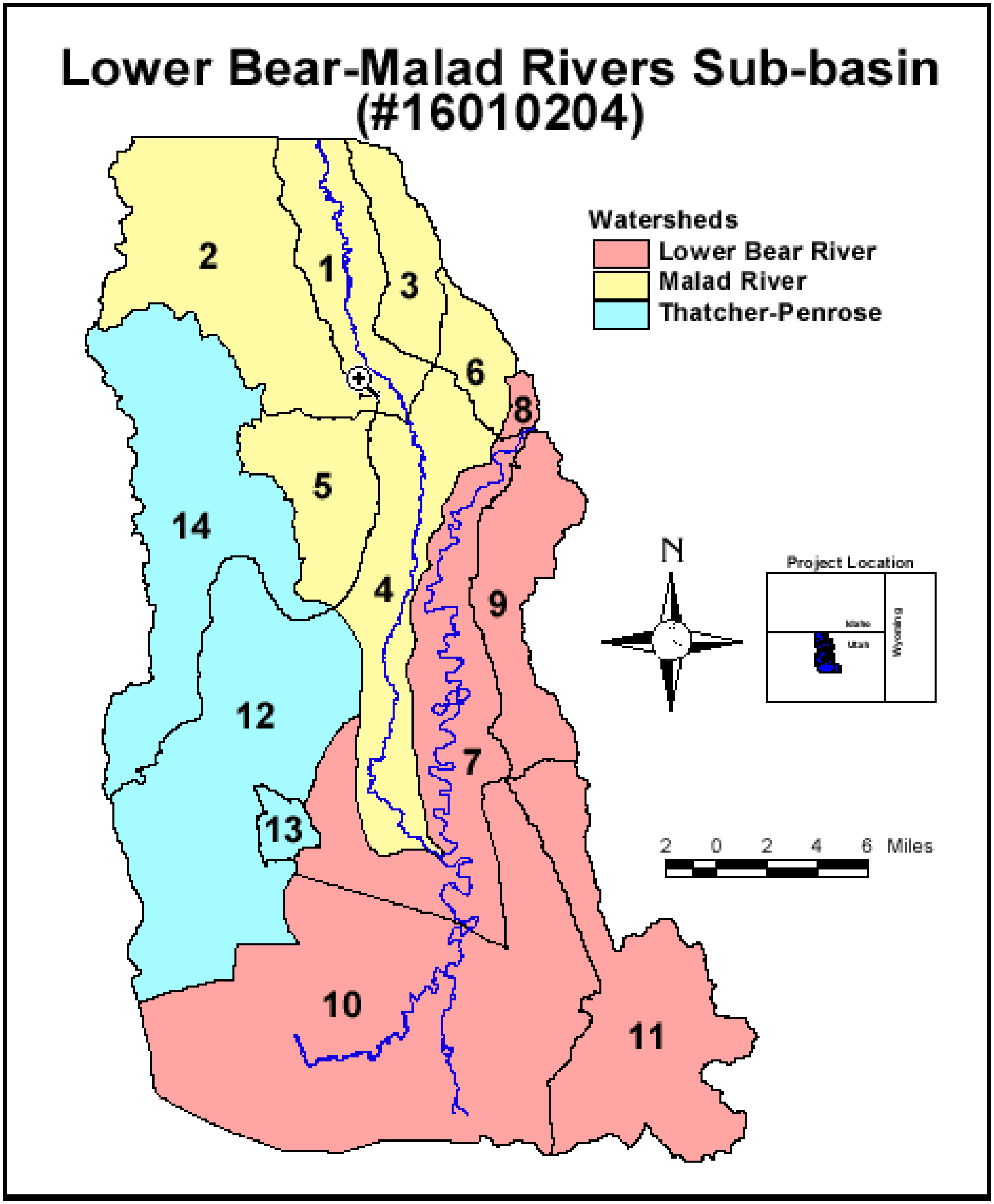


Figure 2-2 A map illustrating the lower Bear/Malad River subwatershed delineation.

Three watersheds, the Malad River, lower Bear River and Thatcher/Penrose Area have been recognized for this study. Only the Malad River and lower Bear River watersheds have been analyzed for the TMDL. Fourteen sub-watersheds have been delineated as follows:

Malad River:

1. Idaho border to flume crossing (Highway 191) -Valley below 4,500 feet
2. West Hills - 4,500 feet to ridge
3. Clarkston Mountains - 4,500 feet to ridge
4. Flume crossing (H-191) to confluence Bear River -Valley below 4,500 feet
5. West Hills - 4,500 feet to ridge
6. Clarkston Mountains - 4,500 feet to ridge

Lower Bear River:

7. Cutler Dam to State Road 83 (Corinne Gage)-Valley below 4,500 feet
8. Clarkston Mountains - 4,500 feet to ridge
9. Wellsville Mountains - 4,500 feet to ridge
10. SR 83 to discharge into Great Salt Lake including Bear River Bird Refuge, Valley, and Lake Plain below 4,500 feet
11. Wellsville and Wasatch Mountains including Box Elder Creek - 4,500 feet to ridge

Thatcher/Penrose Area (No TMDL required and not analyzed in this plan):

12. Thatcher/Penrose - Valley/Lake Plain Area - below 4,500 feet
13. Little Mountain - 4,500 feet to summit
14. Blue Spring Hills - 4,500 feet to ridge (including White Valley)

2.2 Economy and Demographics

Located in the northwest corner of the state of Utah, Box Elder County covers an area of about 6,594 square miles which includes approximately 1,000 square miles occupied by the waters of the Great Salt Lake. The county is the fourth largest in Utah.

2.2.1 Population

Approximately 94 percent of Box Elder's estimated 2000 population of 43,083 is located in the cities and towns of the valley of the lower Bear River. Brigham City and Tremonton City contain 55 percent of the total population. Table 2-1illustrates the current and projected population to the year 2020. Table 2-2 lists population estimates by watershed based on data from drinking water systems and the Governor's Office of Planning and Budget (OPB). Figure 2-3 maps out the 2000 population in the study area.

Table 2-1. Current and projected population for cities within Box Elder county.

PLACE	YEAR 2000	YEAR 2010	YEAR 2020	YEAR 2030
Bear River City	832	971	1,068	1,165
Brigham City	17,215	19,987	22,387	24,509
Corinne	691	1,086	1,266	1,338
Deweyville	351	431	513	595
Elwood	684	728	768	808
Fielding	472	509	529	549
Garland	1,938	2,811	3,798	4,552
Honeyville	1,326	1,646	1,987	2,328
Howell	270	381	443	505
Mantua	724	930	1,150	1,370
Perry	2,239	3,665	5,085	6,006
Plymouth	291	313	333	353
Portage	218	290	330	370
Snowville	277	317	407	497
Tremonton	5,309	7,604	9,329	10,852
Willard	1,563	1,793	2,321	2,741
Outside of towns	8,683	10,255	11,495	12,217
COUNTY TOTAL:	**43,083**	**53,855**	**63,209**	**70,755**

Source: Utah Office of Budget and Planning and Bear River Association of Governments - June 2000

Table 2-2. Current and projected population by sub-watershed (see Figure 2-2 for placement in the watershed).

Watershed and Sub-watershed	YEAR		
	2000	**2010**	**2020**
Malad River:			
1. Idaho border to flume crossing	510	600	660
2. West Hills	none		
3. Clarkston Mountains	none		
Subtotal	***510***	***600***	***660***
4. Flume crossing (H-191) to confluence Bear River	9060	12540	15620
5. West Hills	none		
6. Clarkston Mountains	none		
Subtotal	***9060***	***12540***	***15620***
MALAD RIVER TOTAL	**9570**	**13140**	**16280**
Lower Bear River:			
7. Cutler Dam to State Road 83	3290	3970	4530
8. Clarkston Mountains	none		
9. Wellsville Mountains	110	230	250
Subtotal	***3400***	***4200***	***4780***
10. SR 83 to discharge into Great Salt Lake	19460	26710	31180
11. Wellsville and Wasatch Mountains	724	930	1150
Subtotal	***20184***	***27640***	***32330***
LOWER BEAR RIVER TOTAL	**23584**	**31840**	**37110**
Thatcher/Penrose Area			
12. Thatcher/Penrose	910	1080	1240
13. Little Mountain	none		
14. Blue Spring Hills	130	440	630
THATCHER/PENROSE TOTAL	**1040**	**1520**	**1870**

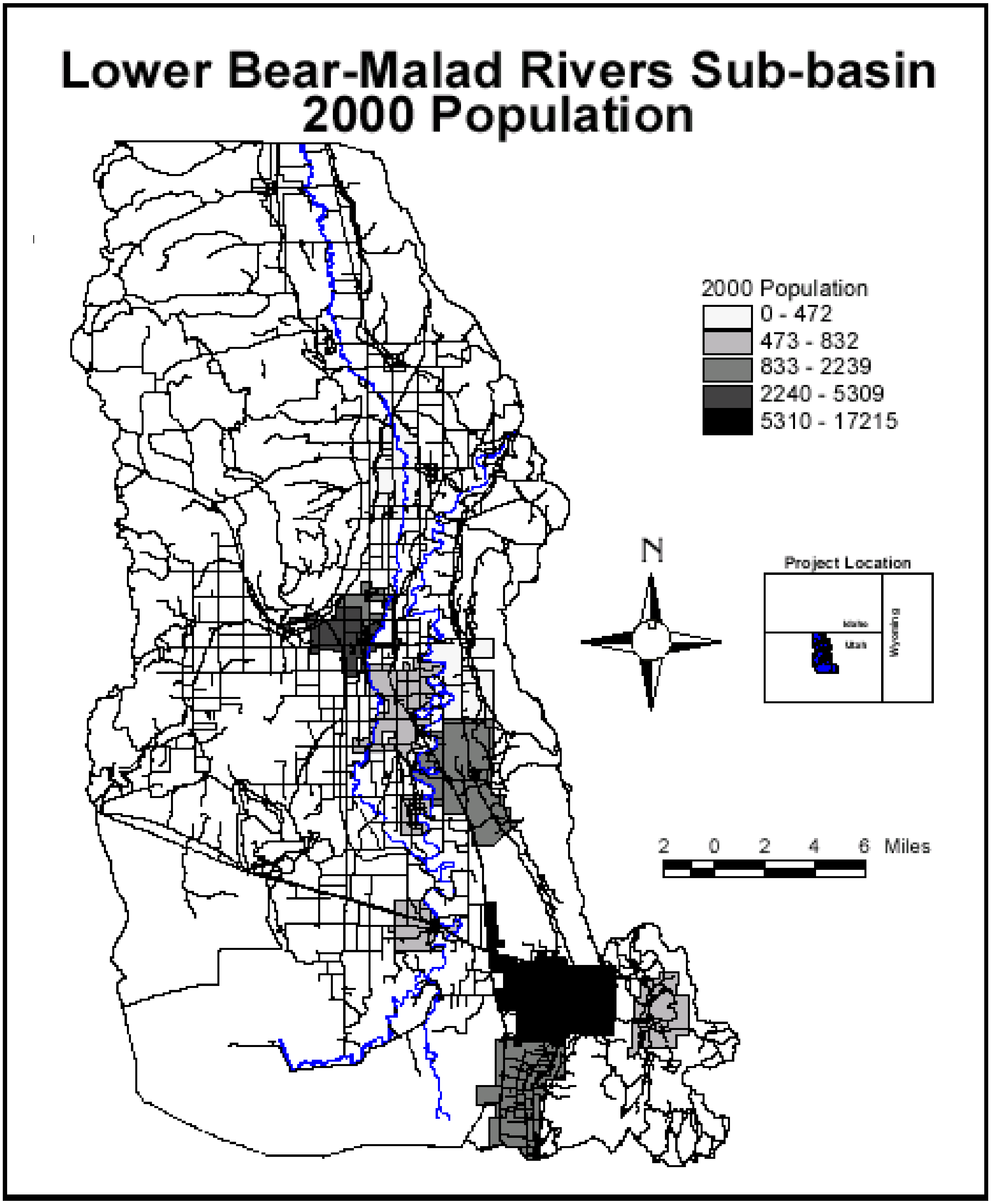


Figure 2-3. A map illustrating lower Bear/Malad River 2000 population.

2.2.2 Land Ownership

Table 2-3 contains land ownership by study sub-watershed. Figure 2-4 is a map of land ownership.

2.2.3 Land Use and Economy

Land use is dominated by rangeland, irrigated crop lands and dry-farmed crop lands. The agriculture industry is still the basic industry of the county. Figure 2-5 is a map of land use in the study area. Production statistics, compiled by the Utah Agricultural Statistics Service, rank Box Elder County as number one in the state for total winter and spring wheat production, oats, barley, corn for grain, and cattle and calves inventory. Box Elder County was also ranked number one in the state for cash receipts in 1997, totaling $103.8 million (UASS 1999). Employment is diversified with about 11 percent in agriculture, 37 percent in manufacturing, 19 percent in all service industries, 15 percent in finance, insurance and real estate activities, and 18 percent in construction, transportation, retail trade, public administration and other economic activity.

2.3 Physical Setting

2.3.1 Geology

Geologists have divided the United States into many physiographic provinces based on their characteristics. The lower Bear/Malad River watershed is primarily located in the Basin and Range Province with three physiographic sections: Wasatch Front Valley; Great Salt Lake; and the Hansel Mountains-Blue Springs-West Hills. A small portion of the study area containing the Clarkston and Wellsville mountains and the northern portion of the Wasatch range is considered to be part of the Middle Rocky Mountain Province. Figure 2-6 identifies the provinces and sections. Figures 2-7, 2-8 and 2-9 show topography, geology and lithology of the study area. Table 2-4 illustrates the section occurrence within each watershed and sub-watershed.

Basin and Range Province

Wasatch Front Valley Section

This valley, a fault block basin, is part of the large closed drainage basin of the Great Salt Lake. The quaternary alluvial materials of the plains area were actually the lake bottom and much sorting of material occurred as they were deposited. This resulted in sand and gravel near the mountain slopes with finer clay and silt particles toward the center of the valley. In addition, wave and current action created "benches" now discernible as terraces, spits and bars.

The land forms are lake plain, alluvial fans and incised river flood plains of the Malad and Bear Rivers. Elevations range from the 4,220 foot boundary of the Great Salt Lake section up to about 4,500 feet - the approximate level at the break from plain to mountain.

Table 2-3. A summary of land ownership in the lower Bear River basin. All values are in acres. See Figure 2-2 for locations of sub-watersheds.

	Malad River						Bear River					Thatcher/Penrose			TOTAL
Sub-watershed#:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	
BLM		40	162				101			175	76	857		176	**1,587**
BLM/BOR								18	71						**89**
BLM/Power Withdrawal		587													**587**
BLM/Protective Withdrawal												622			**622**
Forest Service			4,871			498					5,419				**10,788**
FS/Acquired Land											1,146				**1,146**
FS/Protective Withdrawal							12		249		53				**314**
Military Reservations												68		178	**246**
Private	19,873	41,883	6,347	32,859	16,871	6,546	42,472	1,674	10,300	60,673	2,450	34,327	3,305	46,134	**325,714**
Private/FS			513			113	663		5,379	1,261	20,117				**28,046**
Private/USFWS Wildlife Refuge												813			**813**
Sovereign Lands										92					**92**
State		704	1		376	40				167		2,447		2,986	**6,721**
State Wildlife Reserves				3			7			9	4,371	11,207	2		**15,599**
USFWS Nat'l Wildlife Refuge										9,156		7,179			**16,335**
Water							251			25,442	458	2,651			**28,802**
Wilderness Area/ Prot. Withdw/FS							1		2,425		2,334				**4,760**
Wilderness Area/FS									2,384	5	4,400				**6,789**
TOTAL:	**19,873**	**43,214**	**11,894**	**32,862**	**17,247**	**7,197**	**43,507**	**1,692**	**20,808**	**96,980**	**40,824**	**60,171**	**3,307**	**49,474**	**449,050**

Table 2-4. Physiographic provinces occurrence within the project sub-watersheds. All values are in acres. See Figure 2-2 for sub-watershed location.

Watershed and Sub-watershed	SECTION					TOTALS
	Wasatch Front Valley	Great Salt Lake	Blue Springs/ West Hills	Wasatch Range	Clarkston Mountain	
Malad River:						
1. Idaho border to flume crossing	19873					19,873
2. West Hills			43,247			43,247
3. Clarkston Mountains					11,895	11,895
Subtotal	***19,873***		***43,247***		***11,895***	***75,015***
4. Flume crossing to confl.	32,857					32,857
5. West Hills			17,248			17,248
6. Clarkston Mountains					7,197	7,197
Subtotal	***32,857***		***17,248***		***7,197***	***57,302***
MALAD RIVER TOTAL	**52,730**	**0**	**60,494**	**0**	**19,092**	**132,316**
Lower Bear River:						
7. Cutler Dam to State Road 83	41,385	2,122				43,507
8. Clarkston Mountains					1,692	1,692
9. Wellsville Mountains				20,808		20,808
Subtotal	***41,385***	***2,122***		***20,808***	***1,692***	***66,007***
10. SR 83 to discharge into GSL	31,447	65,532				96,979
11. Wellsville and Wasatch Mtns				40,822		40,822
Subtotal	***31,447***	***65,532***		***40,822***		***137,801***
LOWER BEAR RIVER TOTAL	**72,832**	**67,655**	**0**	**61,631**	**1,692**	**203,810**
Thatcher/Penrose Area						
12. Thatcher/Penrose	42,228	17,942				60,170
13. Little Mountain	3,306					3,306
14. Blue Spring Hills			49,474			49,474
THATCHER/PENROSE TOTAL	**45,534**	**17,942**	**49,474**	**0**	**0**	**112,950**
TOTALS:	**171,096**	**85,597**	**109,968**	**61,631**	**20,784**	**449,076**

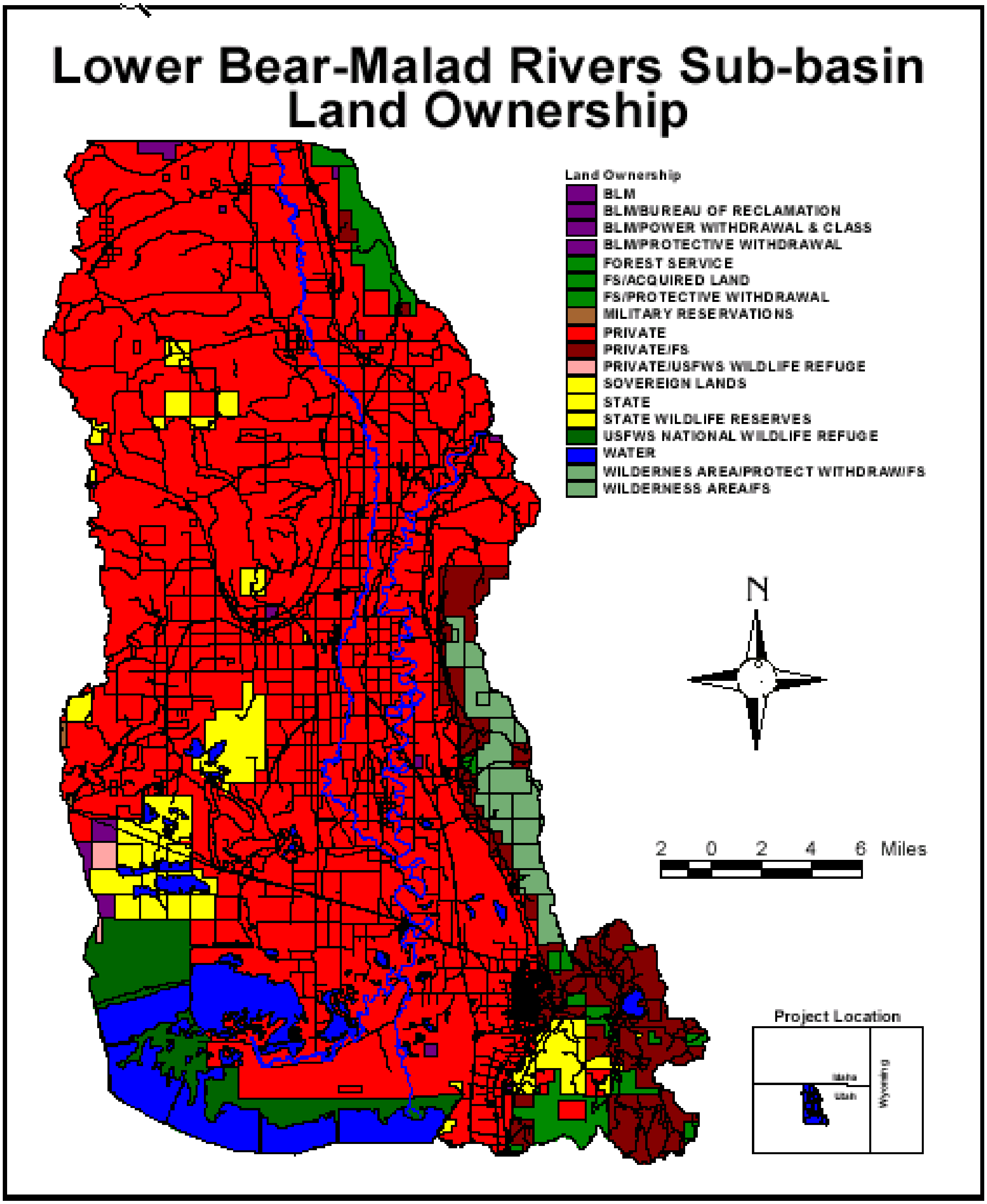


Figure 2-4. A map illustrating lower Bear/Malad River land ownership.

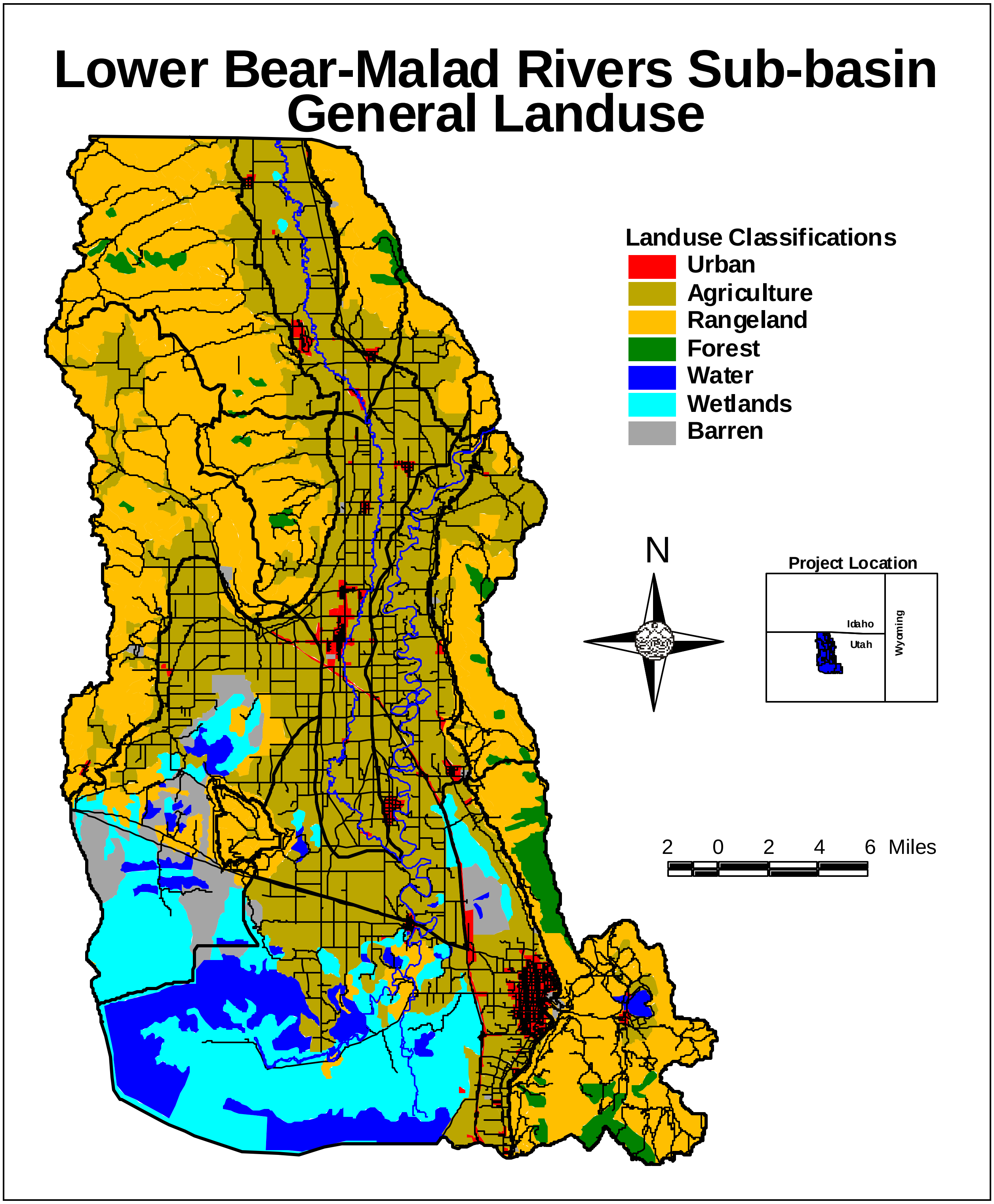


Figure 2-5. A map illustrating lower Bear/Malad River land use.

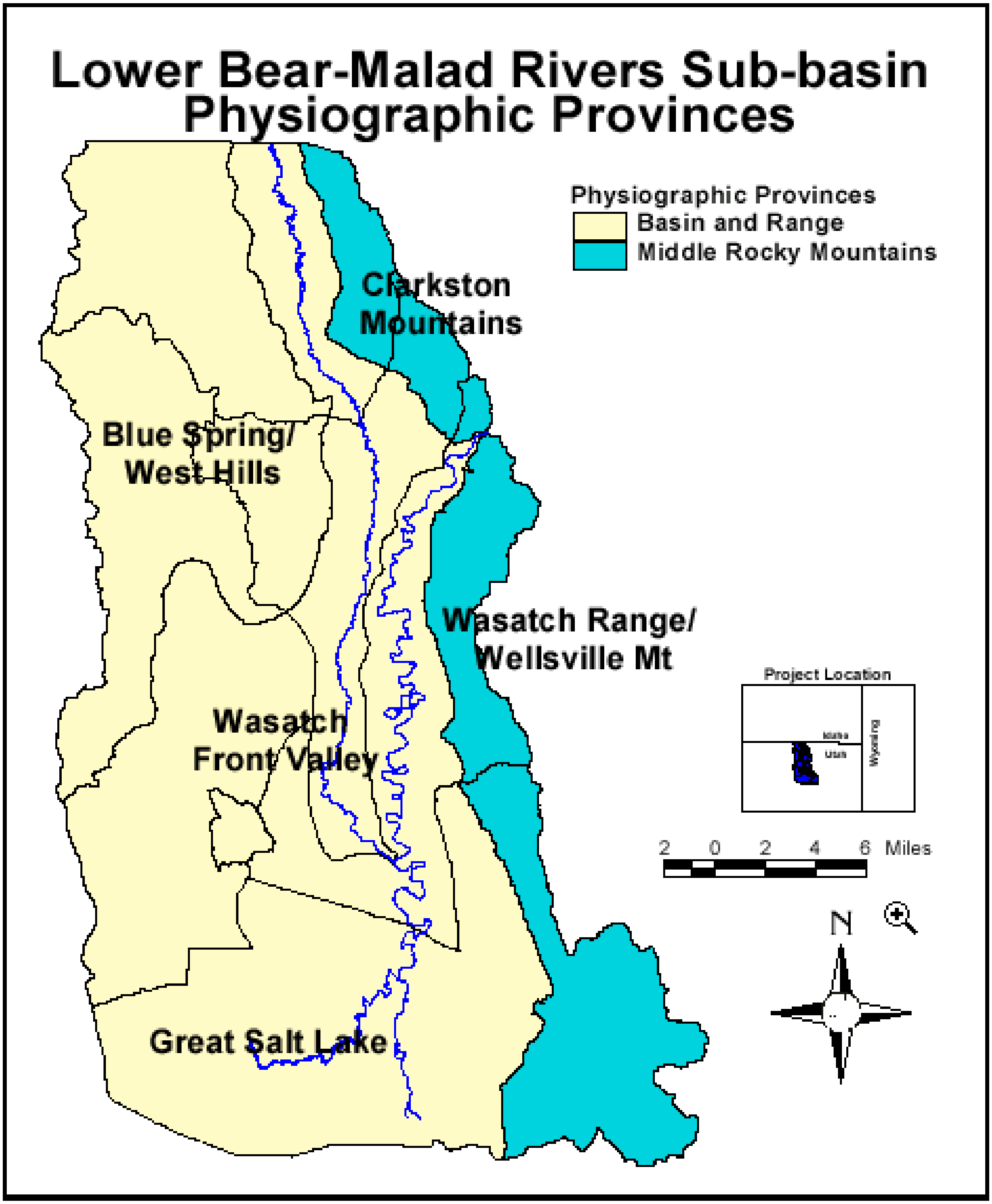


Figure 2-6. A map illustrating lower Bear/Malad River physiographic provinces.

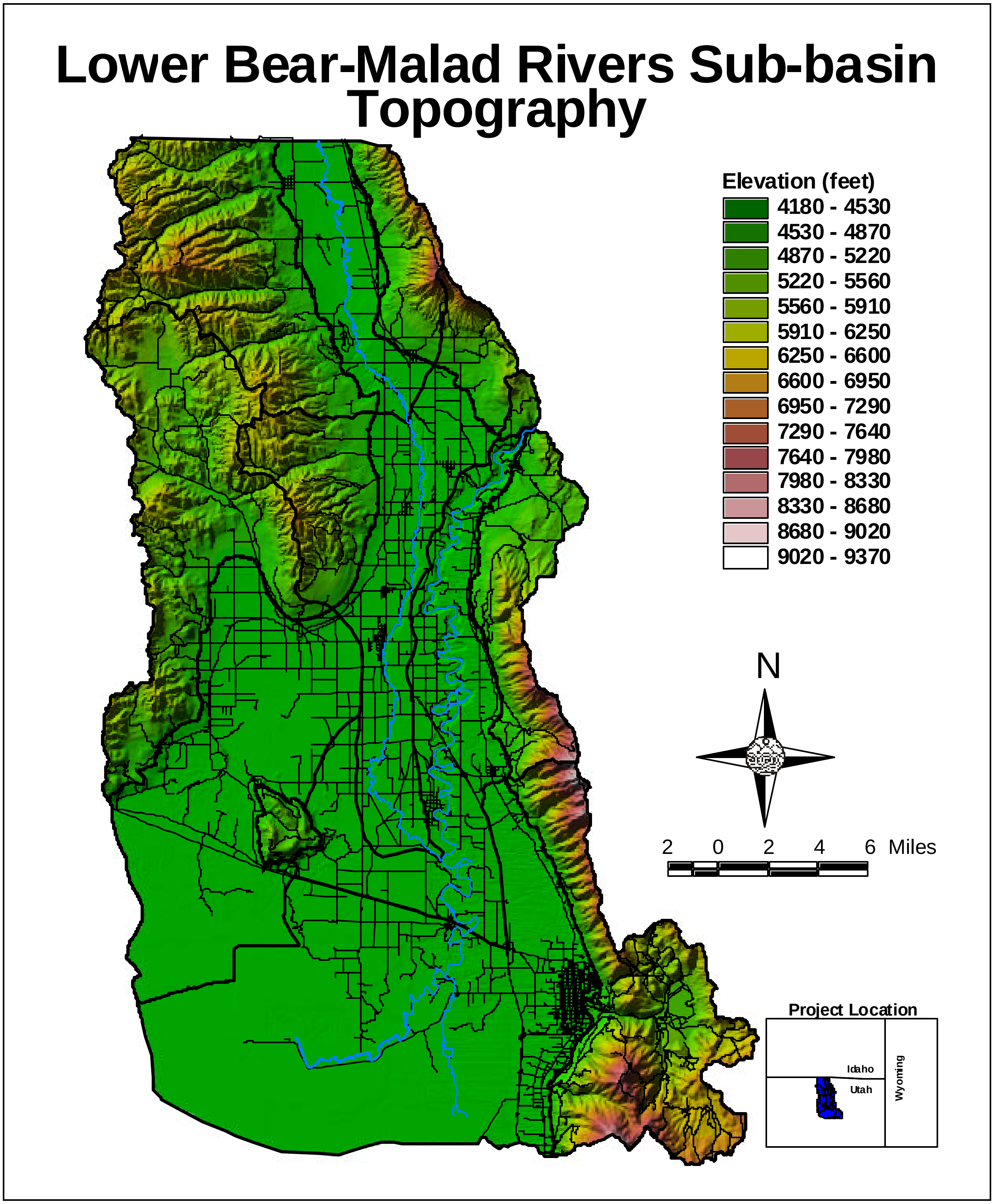


Figure 2-7. A map illustrating lower Bear/Malad River elevations.

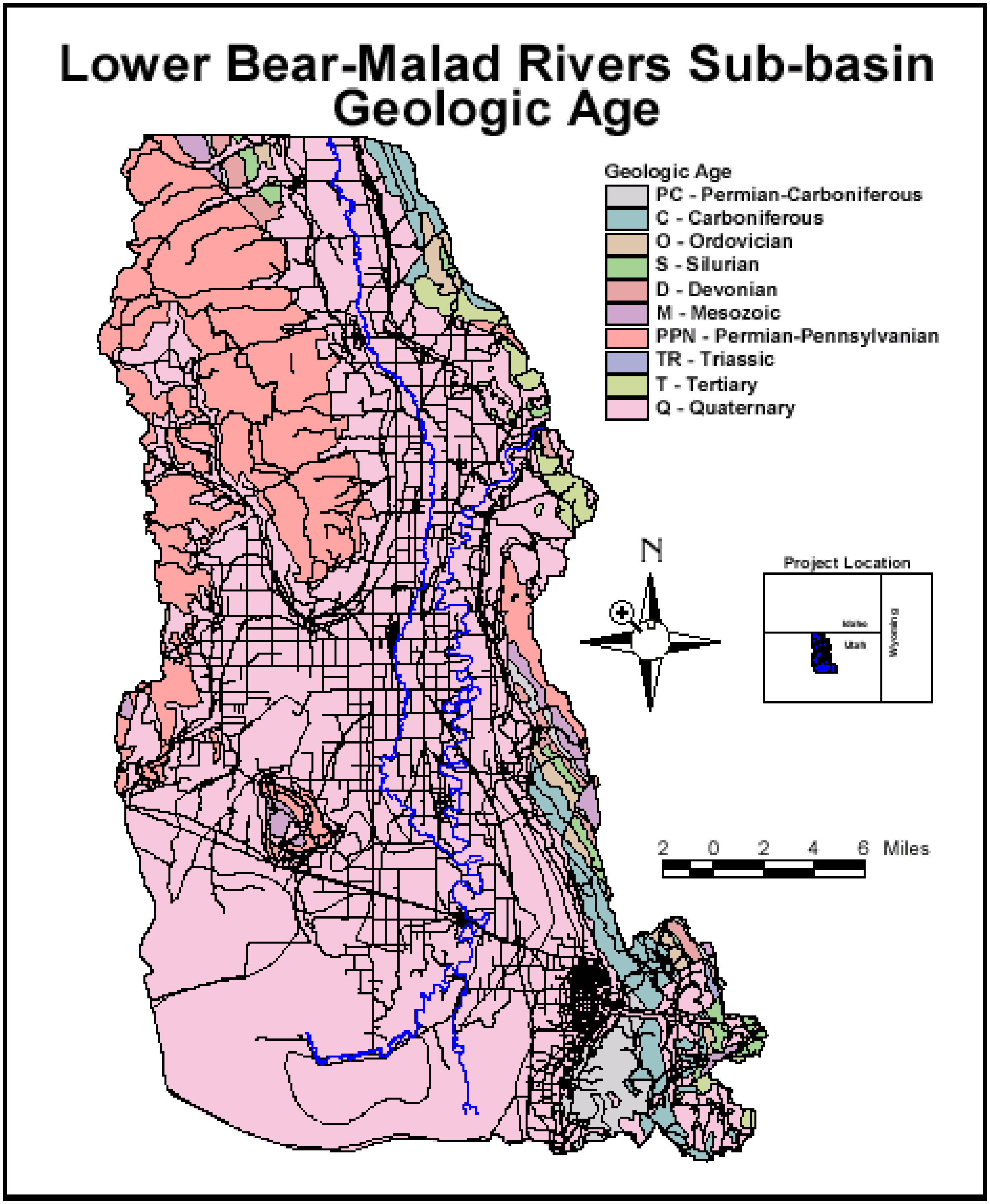


Figure 2-8. A map illustrating lower Bear/Malad River geologic age.

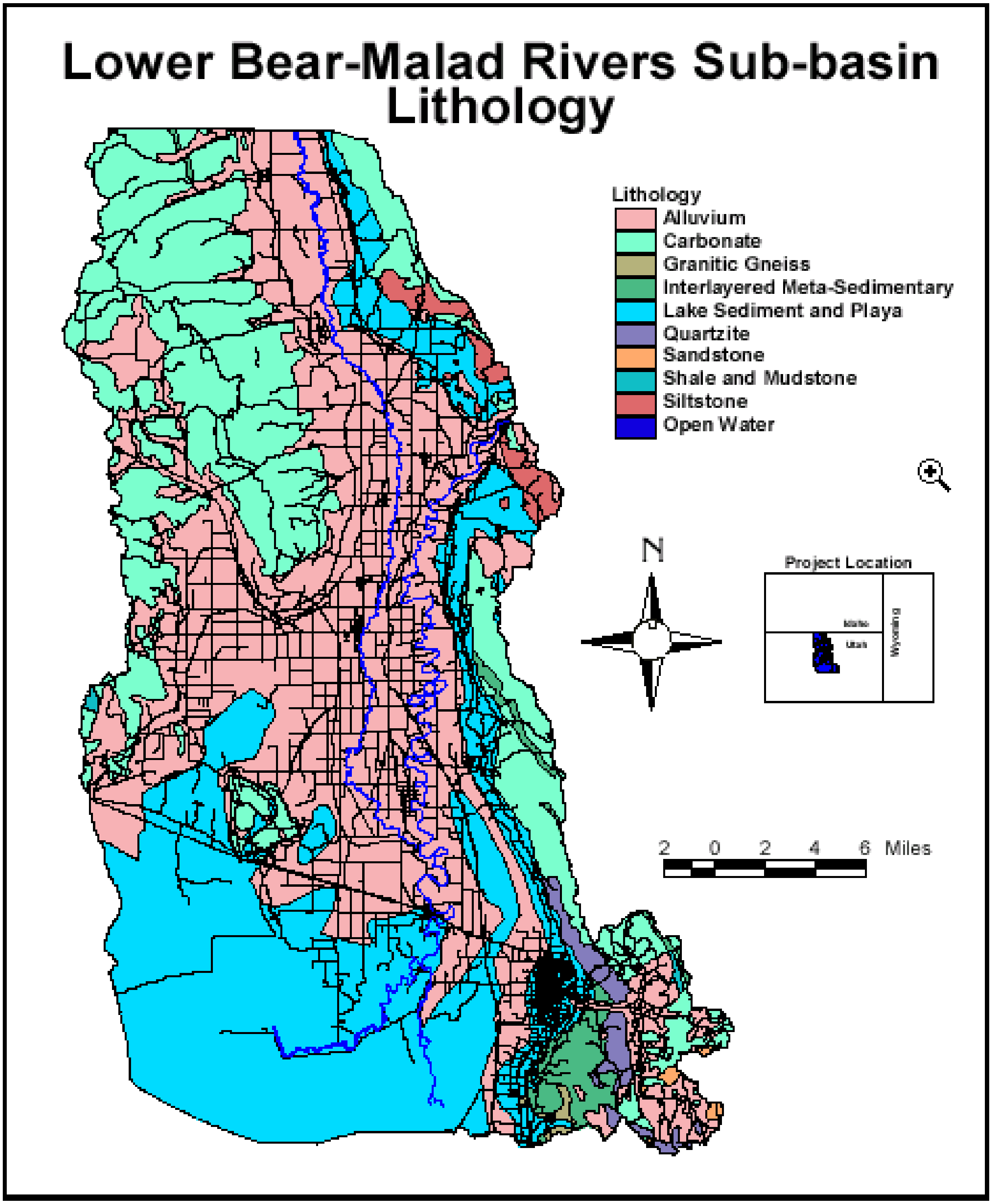


Figure 2-9. A map illustrating lower Bear/Malad River lithology.

Great Salt Lake Section

The landlocked Great Salt Lake, including its islands and a belt of surrounding playa land that is subject to flooding, constitutes a unique physiographic division. The lake is a remnant of the larger ancient Pleistocene Epoch Lake Bonneville which covered a large portion of western Utah and parts of Idaho and Nevada. The lake is highly saline (up to 27%) with salt content varying dependent on lake water level. The lake is about eight times as salty as sea water.

Mean elevation of the lake is about 4,200 feet but has historically ranged from 4,190 feet to about 4,212 feet with great areal variation depending on the balance between inflow and evaporation. Average depth is 13 feet with a maximum of 335 feet. This section has been delineated at 4,420 feet for this report as shown on Figure 2-2.

Blue Springs-West Hills Section

Only the eastern slopes of the Blue Springs and West Hills mountains of a whole section, which includes mountains and valleys westward to Snowville, are located in the study area. The topography is best described as rolling or rounded with few outcrops of bare rock and V-shaped fluvial canyons and ravines. The section includes a mountain valley. This section also has great accumulations of gravel and sand along the ancient Lake Bonneville shoreline. Bedrock exposed in this uplifted fault block is principally sedimentary (limestone, sandstone, siltstone, marl). There are, however, some metamorphic (quartzite) rocks present. All of the indurated rocks have been tilted due to faulting or folding and are generally highly fractured. Elevations range from about 4,500 feet at the valley floor to about 6,770 feet at the high point along the ridge line of West Hills, a vertical distance of 2,270 feet. White's valley floor is at about 5,200 feet elevation.

Middle Rocky Mountain Province

Wasatch Range Section

This section includes the northernmost extension of the Wasatch Mountains, south of Box Elder Creek Canyon, and the Wellsville Mountains. These are very steep, craggy mountains with V-shaped fluvial canyons and ravines. A mountain valley is located in the Wasatch mountain portion. They consist of a complex folded and thrust-faulted Paleozoic formation intruded by granitic stocks and later elevated and rotated in a series of fault blocks, overlooking the Great Salt Lake. Elevations range from 4,500 feet at the valley floor to Box Elder Peak at 9,372 feet in the Wellsville mountains and to Willard Peak in the main Wasatch mountains at elevation 9,820 feet, a respective vertical rise of 4,872 feet to 5,320 feet. The floor of Mantua mountain valley lies at about 5,200 feet.

Clarkston Mountain Section

The Clarkston Mountains in Utah are the southernmost end of the Malad Range, which is part of the Bannock Range, both of which are in Idaho. Some geologists consider it to be within the Basin and Range Province but Stokes places it in the Middle Rocky Mountain Province. It is a narrow and sharp-crested mountain range consisting mainly of faulted early Paleozoic marine sedimentary Cambrian and Ordovician formations with V-shaped fluvial canyons and ravines. Elevation from the valley floor range from about 4,500 feet to 8,244 feet on Gunsight Peak, a vertical distance of about 4,744 feet.

2.3.2 Soils

The soil characteristics and, to some extent, the geology of the lower Bear River watershed were strongly influenced by ancient Lake Bonneville which, aside form the mountainous regions, once inundated the area. Land features of the watershed consists of a series of gently sloping terraces, alluvial fans, and rolling uplands punctuated by steep mountains. Elevations of the region range from 4,200 feet along the marshy shores of the Great Salt Lake to 8,900 feet mountain peaks. The watershed eventually drains south-southwesterly into the Great Salt Lake - after being temporarily impounded in the Bear River Migratory Bird Refuge - through the mainstems of the Malad and Bear rivers as well as numerous small drainageways.

There are nine soil associations in the lower Bear River watershed within the study area. For ease of interpretation, they have been grouped into four landscape types, as per the "Soil Survey of Box Elder County, Utah, Eastern Part" prepared by the USDA Soil Conservation Service. Soil associations are categorized as landscapes with distinctive proportional patterns of soils. Associations normally consists of one or more major soils and at least one minor soil. Soils in one association may occur in another, but in a different pattern. A brief discussion of each broad group and its respective soil associations is included below (USDA 1975).

Well-Drained and Somewhat Excessively Drained Soils of the Mountains

Silt loams, gravelly loams and very stony loams formed in residuum, colluvium, and alluvium on mountain slopes and alluvial fans. They are derived from quartzite, sandstone, and limestone. These soils are used for range, wildlife habitat, and water supply.

1) Foxol-Elzinga-Agassiz association: Well-drained and somewhat excessively drained, very steep silt loams, gravelly loams, and very stony loams; on mountains and alluvial fans. This association is mainly in scattered locations along the eastern mountains of the watershed. Elevations are 4,800 to 8,000 feet.

Well-Drained Soils of the Mountain Foot Slopes, High Fans, and Terraces

These soils are mainly located on mountain foot slopes and associated alluvial fans and high lake terraces. They are comprised of silt loams and loams that are cobbly in some areas. They are formed in residuum and colluvium derived from sandstone, limestone, basalt, and quartzite and in alluvium derived from sandstone, limestone, and quartzite. These soils are used for non-irrigated crops, range, wildlife habitat, and water supply.

2) Middle-Broad association: Well-drained, gently sloping to very steep cobbly loams and cobbly silt loams; on mountain foot slopes. Formed in residuum and colluvium derived from sandstone, limestone, basalt, and quartzite. Found in areas of the Malad River. Elevations are 4,800 to 6,600 feet.

3) Hendricks-Forsgren-Manila association: Well-drained, gently to very steep silt loams and loams; on foothills, fans, and high lake terraces. Formed in residuum, colluvium, and alluvium derived from sandstone, quartzite, and limestone. Found near Mantua, Utah. Elevations are 4,900 to 6,800 feet.

Moderately Well-Drained to Somewhat Excessively Drained Soils of the High, Medium, and Low Lake Terraces

These soils are mainly on lake terraces, alluvial fans, and associated mountains and foot slopes. They are silt loams, loams, and sandy loams that are cobbly or gravely in some areas. They are formed mostly in alluvium and colluvium derived from sandstone, quartzite, limestone, and some gneiss, schist, and lake sediment. A few soils are formed in residuum derived from sandstone, quartzite, and limestone. These soils are used for non-irrigated crops, range, wildlife habitat, and water supply with small areas used for irrigated crops and urban developments.

4) Hupp-Sterling-Abela association: Well-drained and somewhat excessively drained, gently sloping to very steep gravelly silt loams and gravelly loams; on alluvial fans, lake terraces, escarpments, and mountain foot slopes. Formed in alluvium and colluvium derived from limestone, dolomite, sandstone, and quartzite and in mixed lake sediments. Elevations are 4,300 to 5,400 feet.

5) Kearns-Parleys association: Well-drained and moderately well-drained, nearly level to steep silt loams; on alluvial fans and lake terraces. Formed in alluvium derived from mixed lake sediments. Elevations are 4,220 to 5,575 feet.

6) Fielding-Kilburn-Kidman association: Well-drained and somewhat excessively drained, nearly level to very steep silt loams, gravelly sandy loams, and fine sand loams; on lake terraces, benches, alluvial fans, and broad valley plains. Formed in mixed lake sediments and alluvium derived from limestone, quartzite, sandstone, gneiss, and schist. Elevations are 4,250 to 5,150 feet.

Moderately Well-Drained and Poorly Drained Soils of the Low Lake Terraces and Lake Plains

These soils are on broad low lake terraces, broad lake plains, associated alluvial fans, and playas. They are silt loams and silty clay loams that formed in mixed lake sediments derived from many rock types. These soils are used for irrigated crops, native pasture, non-irrigated crops, range, and wildlife habitat.

7) Honeyville-Greenson-Collett association: Moderately well-drained and somewhat poorly drained, nearly level silty clay loams and silt loams; on broad low lake terraces and lake plains. Formed in fine textured and moderately fine texture, mixed lake sediments derived dominantly from sandstone and limestone. Elevations are 4,250 to 4,355 feet.

8) Lasil-Fridlo association: Somewhat poorly drained and moderately drained, nearly level and gently sloping silt loams; on broad low lake terraces and lake plains. Formed in mixed lake sediments. Elevations are 4,220 to 4,600 feet.

9) Playas-Saltair association: Playas and poorly drained, nearly level silty clay loams; on lake beds and broad plains. Formed in strongly calcareous, mixed lake sediments. Elevations are 4,205 to 4,225 feet.

2.3.3 Climate

Climate is the sum of weather conditions over an extended period of time. It has direct influences on agriculture, transportation, recreation, and almost all aspects of human life. Moreover, climate has enormous influence on the development of soils, vegetation, animal life and hydrology. Weather conditions - the aggregate of temperature, humidity, cloudiness, precipitation, pressure and winds - are short term and in a constant state of change. The five climate types occurring in the project area are listed in Table 2-5.

Table 2-5. Climate types found in the study area.

Type	Approximate Elevation	Precipitation Inches	Mean Temp. (°F)	Frost Free Days
Desert	4,200 - 4,220 feet	< 8"	45 to 50	100 to 120
Semiarid	4,220 - 4,500 feet	8 to 12"	45 to 50	110 to 130
Upland	4,500 - 5,600 feet	12 to 16"	45 to 50	120 to 140
Mountain	5,600 - 8,000 feet	16 to 22"	36 to 45	100 to 120
High Mountain	over 8,000 feet	22 to 35"	35 to 42	

There is a marked variation in the seasonal precipitation, most of which falls in winter and spring. The wettest month is usually April, and midsummer is the driest part of the year. Most of the summer precipitation comes from local thunderstorms that build up along the mountains. Hail in summer and spring occasionally causes damage to crops and property. The average seasonal snowfall ranges between 8 and 12 inches in the areas below 5,000 feet; up to 22 inches along the higher benches; and more than 30 inches in the higher mountains. Figure 2-10 shows the aerial extent of precipitation amounts to be expected within the area.

2.3.4 Ecotypes

The lower Bear/Malad study area is composed of northerly trending, fault-block ranges bordering a fault block basin. In the higher mountains, woodland, mountain brush, and scattered open forest are found. Lower elevation basins, slopes and alluvial fans are either shrub and grass covered, shrub covered, or barren. The potential natural vegetation is, in order of decreasing elevation and ruggedness, scattered western spruce-fir forest, juniper woodland, Great Basin sagebrush, and saltbush-greasewood and tule marshes which occur locally especially along the Great Salt Lake shoreline. The valley bottom supports the bulk of the Box Elder County population and commercial activity and is fed by perennial streams and aqueducts that originate in the adjacent mountains ranges. Alfalfa, vegetables, small grains, and orchard crops are grown. Land cover has been mapped by satellite images and GIS technology in a program known by the acronym GAP. Figure 2-10 and Table 2-6 summarize this data for 15 categories.

Wetlands are an important component of the plant cover and are presented in more detail in Figure 2-11 and Table 2-7.

Table 2-6. A summary of land use in the lower Bear River based on GAP classifications. All values are in acres. See Figure 2-2 for locations of subwatersheds.

	Malad River						Bear River					Thatcher/Penrose		
Subwatershed #:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Agricultural	17300	4771	1737	28803	2983	2844	35450	606	5785	21771	1326	20439		8345
Alpine Fir/Spruce									108		210			
Aspen		14	41			51			365		2874			
Barren									115	810	353	266		
Bitterbrush		19												
Doug Fir-White Fir			79			3			381		652			
Dry Meadow											542			
Grassland	556	3190	959	419	1858	448	1118	225	1558	1026	2783	3466	905	6492
Greasewood	23	81	15	93	89	25	261		16	642		897	10	
Juniper		2955	4467		396	1324	82	194	4304	1170	9164	65		1692
Lowland Riparian	407			1485	63	12	1604		69	643	207	322		
Maple		5532	229		2680	570		42	2221	152	5226			328
Montane Shrub		1412	101		99	168	22		735		1227			170
Mountain Mahogany			101						18					
Mountain Sage		4318	242		587	76			11		2575			1318
Mt Riparian		887		22	252	160	34				659			80
Oak										22	7343			
Pickleweed										46		3316		
Pinyon			103			44			147		533			
Pinyon-Juniper		72	191			89			643		1901			
Sagebrush	80	6362	1821		2624	350	183	255	2400	68	868	271	1228	13793
Sagebrush Steppe	81	13339	1202		4920	610	13	241	395		1435	44	366	15438
Salt Desert Scrub	593	267	510	218	664	411	1660	123	1399	8094	24	10640	796	1814
Urban	635	16	80	1821	34		970		100	4094	437	255		
Water							126			46911	415	5912		
Wetland	194						1984			11529		14277		

Table 2-7. A summary of wetlands in the lower Bear River based on NWI "palustrine" classifications. All values are in acres. See Figure 2-2 for locations of subwatersheds.

Watershed and Sub-watershed	Wetland Acreage
Malad River:	
1. Idaho border to flume crossing	527
2. West Hills	6
3. Clarkston Mountains	1
Subtotal	***534***
4. Flume crossing (H-191) to confluence Bear River	491
5. West Hills	1
6. Clarkston Mountains	0.4
Subtotal	***493***
MALAD RIVER TOTAL	**1,026**
Lower Bear River:	
7. Cutler Dam to State Road 83	2,988
8. Clarkston Mountains	0
9. Wellsville Mountains	49
Subtotal	***3,036***
10. SR 83 to discharge into Great Salt Lake	25,657
11. Wellsville and Wasatch Mountains	6
Subtotal	***25,663***
LOWER BEAR RIVER TOTAL	**28,699**
Thatcher/Penrose Area	
12. Thatcher/Penrose	12,861
13. Little Mountain	0
14. Blue Spring Hills	7
THATCHER/PENROSE TOTAL	**12,868**

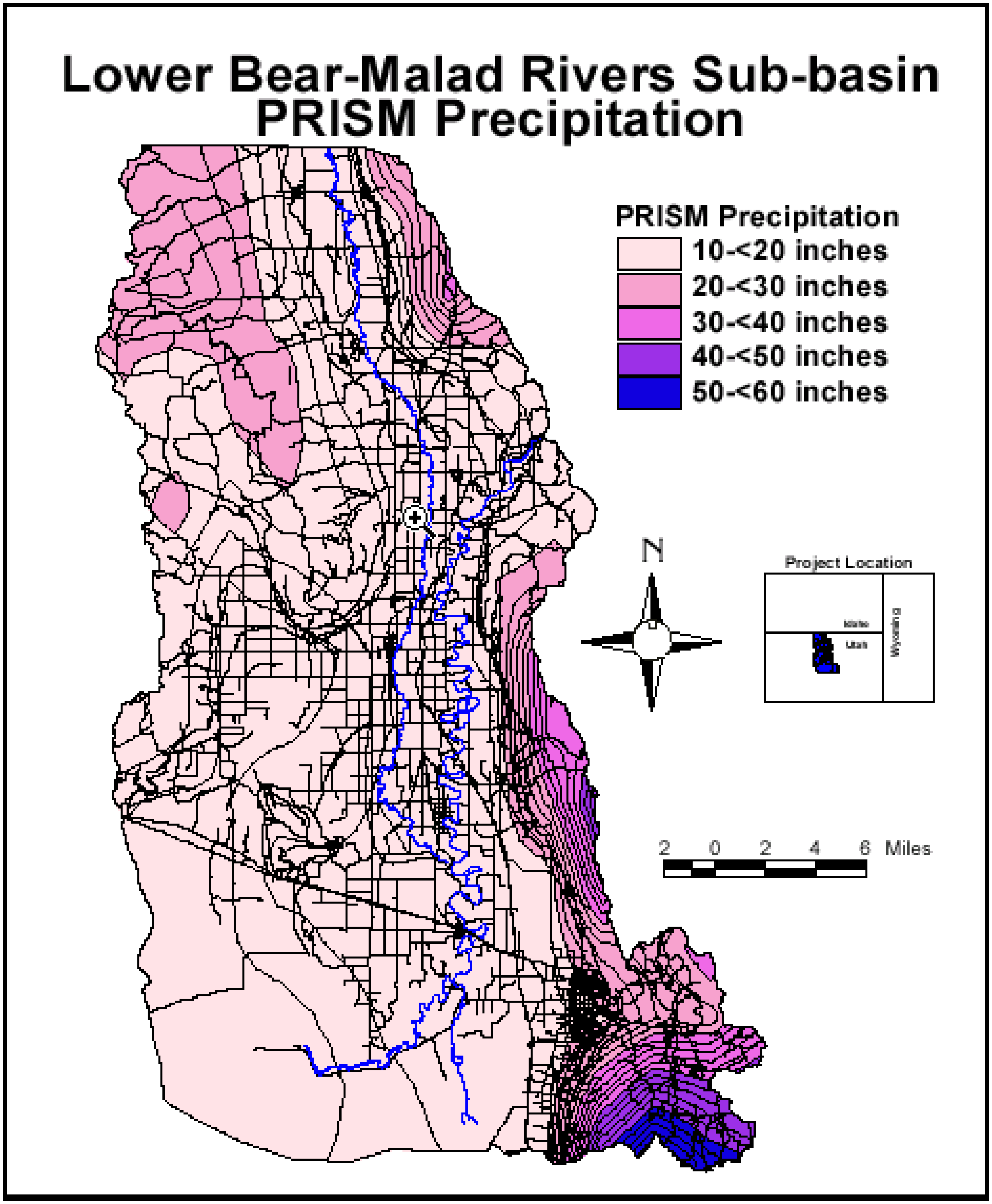


Figure 2-10. A map illustrating lower Bear/Malad River average precipitation.

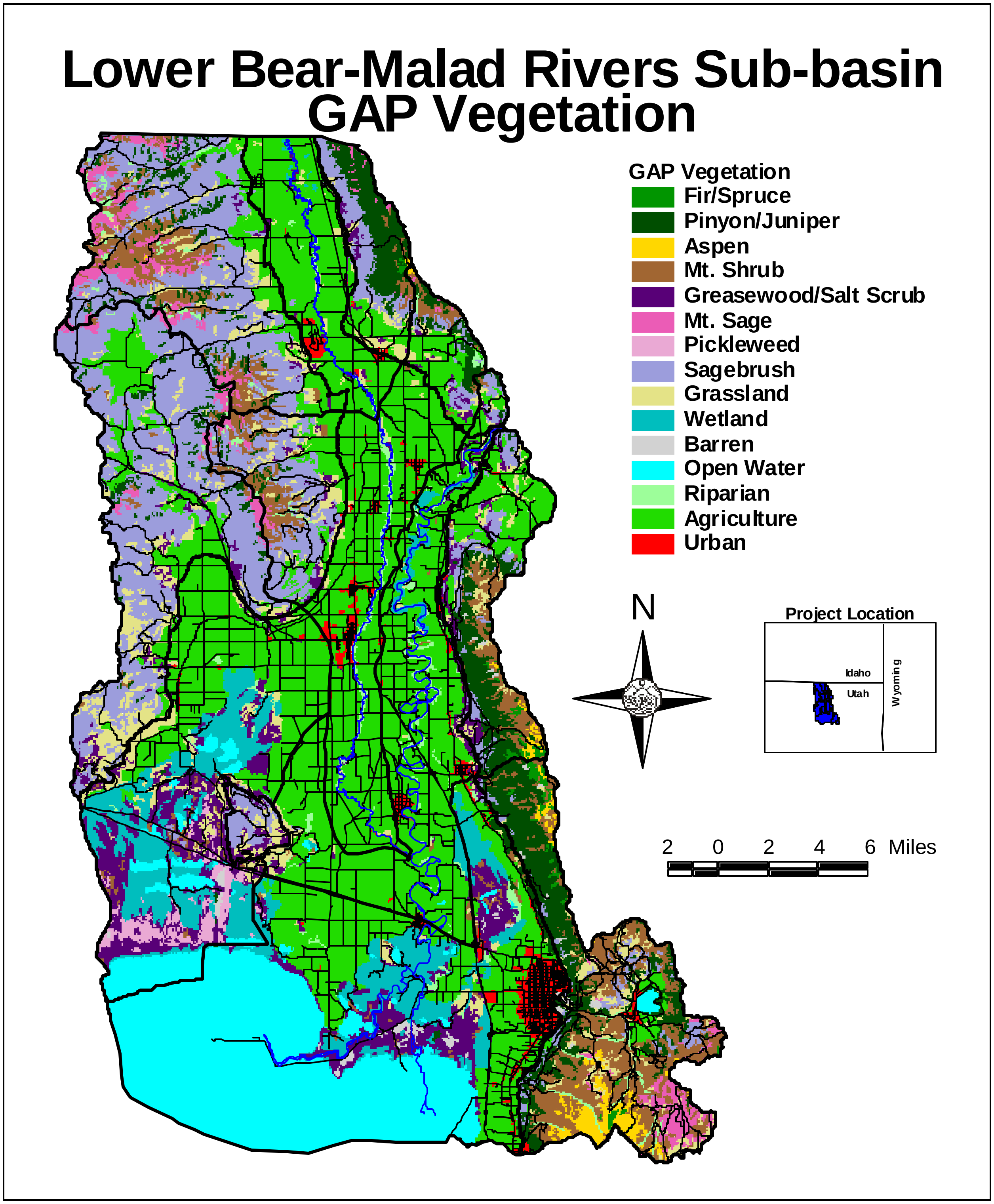


Figure 2-11. A map illustrating lower Bear/Malad River GAP vegetation coverage.

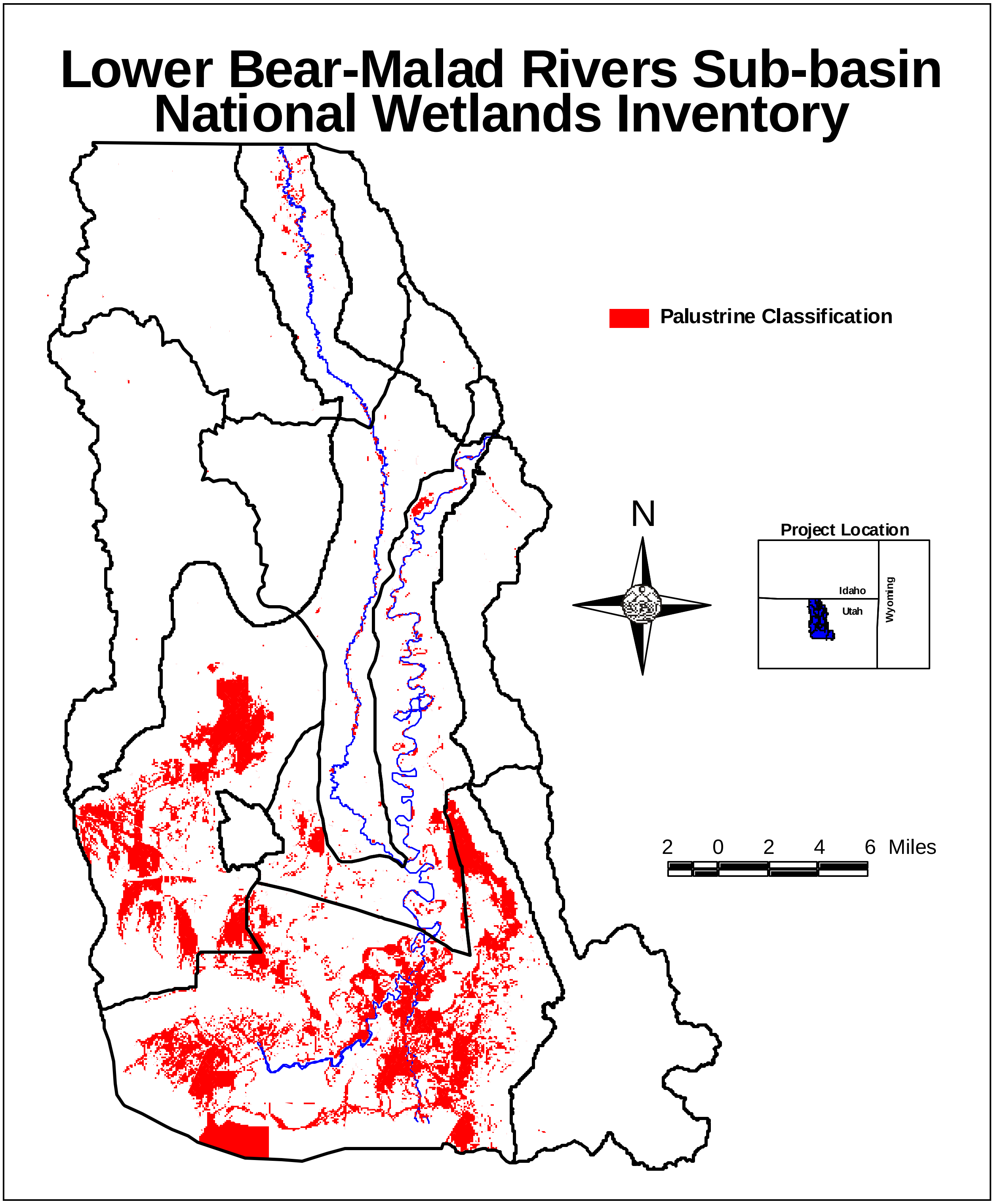


Figure 2-12. A map illustrating lower Bear/Malad River wetlands.

The Utah Division of Wildlife Resources has conducted surveys in Box Elder County of the Malad and Bear River basins, as well as Box Elder Creek. The purpose of these surveys was to classify these waters from a fishery standpoint. The ratings are from one through four with one being the highest. The Bear River is a class three fishery, primarily because it is a warm water fishery. The Malad River is a class four, because of warm, poor quality water, associated with sediment problems. Box Elder Creek is rated a class three stream because of the small flows. It is a cold, clear water creek with a population of trout. Mantua Reservoir is listed as class two water. Fish species identified in these waters are shown in Table 2-8.

Table 2-8. Fish of the lower Bear/Malad River Sub-basins.

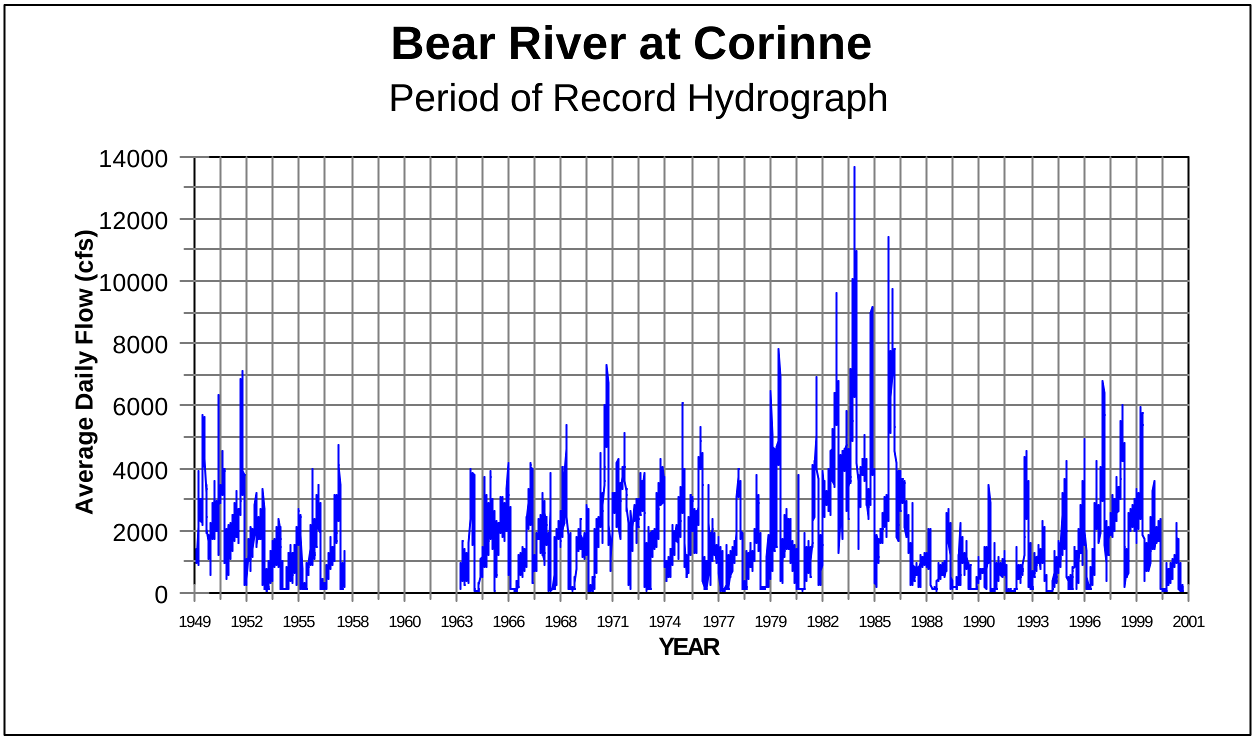
Type	Malad River	Bear River	Box Elder Creek	Mantua Reservoir
rainbow trout			X	X
cutthroat trout			X	
brown trout		X *limited*		
channel catfish	X	X		
black bullhead		X		
carp	X	X		
Utah chub	X	X		
red sided shiner	X	X	X	
longnose dace	X	X		
speckled dace				X
Utah sucker	X	X		
large mouth bass		X		X
small mouth bass				X
green sunfish		X		
black crappie		X		
yellow perch		X		
walleye		X		
sculpin	X			

2.4 Hydrology

2.4.1 Surface Water

The Bear River entering the study area at Cutler Dam is indicative of intermountain west streams with high water yields associated with spring melting of winter snow packs. There is only one major tributary, the Malad River entering the Bear River within the study area. The entire water yield within the confines of the Lower Bear River Valley, including the inflow of the Malad River, adds less than 10 percent of the Bear River flow. Figure 2-13 depicts the annual pattern by month for both the Bear River and the Malad River. In addition to illustrating a large difference in flow, it is interesting to note that the Malad River peaks in March, while the Bear River peaks in May. The Malad river is influenced by its lower elevation watershed compared to the higher elevation of the Bear River. Snow melts earlier on the lower elevation watersheds of the Malad system, while the high elevation watershed's snow pack melt is delayed.

Figure 2-14 shows the average total yearly flow of the Bear River for the period 1950 to 2000. It is easy to see both the seasonal and annual variability in yield. The cycle of drought to floods seen in this figure has prompted the development of reservoirs to help even out such flows. The spacious Bear Lake on the Utah-Idaho border is the storage reservoir utilized by the Bear River Canal Company. This reservoir stores high spring flows from the north slope of the Uinta mountains. This storage water is delivered to the diversion points at Cutler Dam for irrigation within the lower Bear River watershed. This storage water only enters the lower river via irrigation return flow. The natural flows seen in Figure 2-14 are the result of watershed inflows below Bear Lake, primarily from the watershed draining Cache Valley.



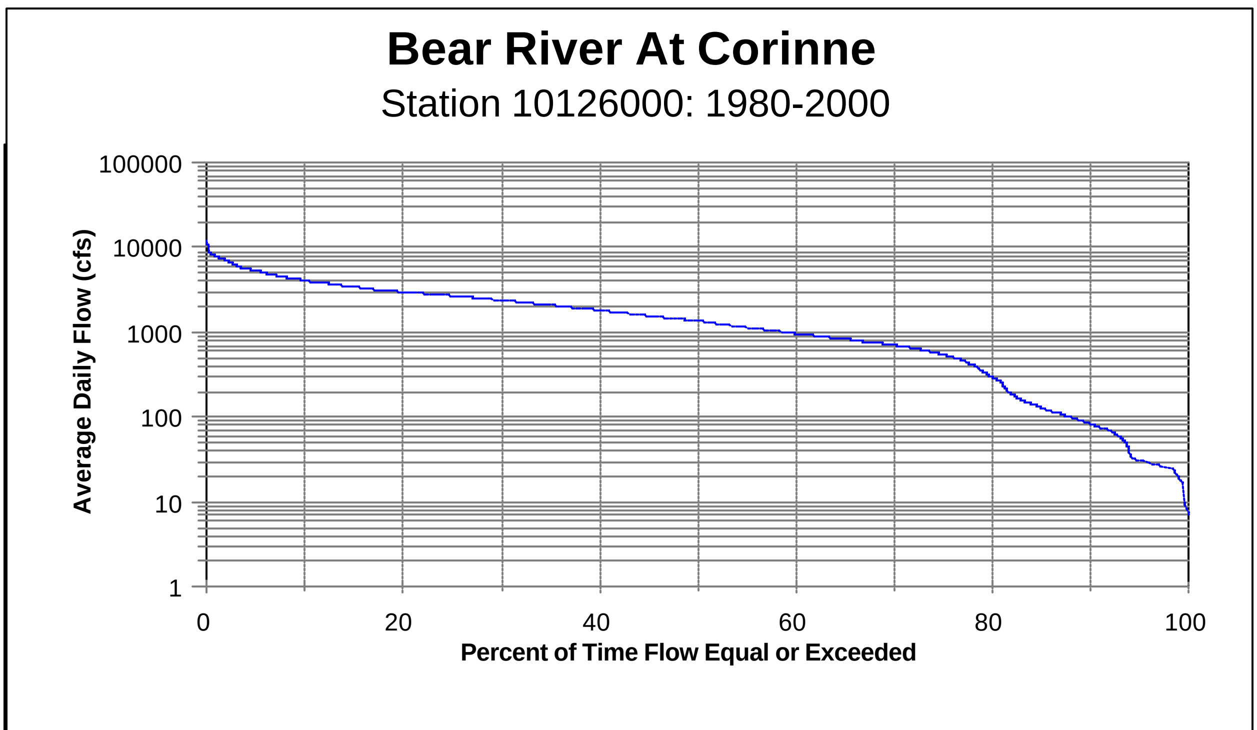


Figure 2-14. The daily flows of the Bear River at Corinne from 1949 to 2000 (above) and the flow exceedence curve for the same time period (below).

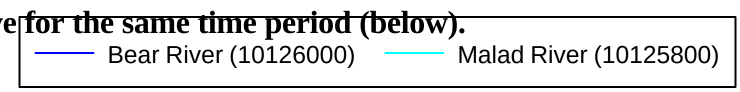


Figure 2-13. The average daily flows for the Bear River (1949-2000) and the Malad River (1964-1974).

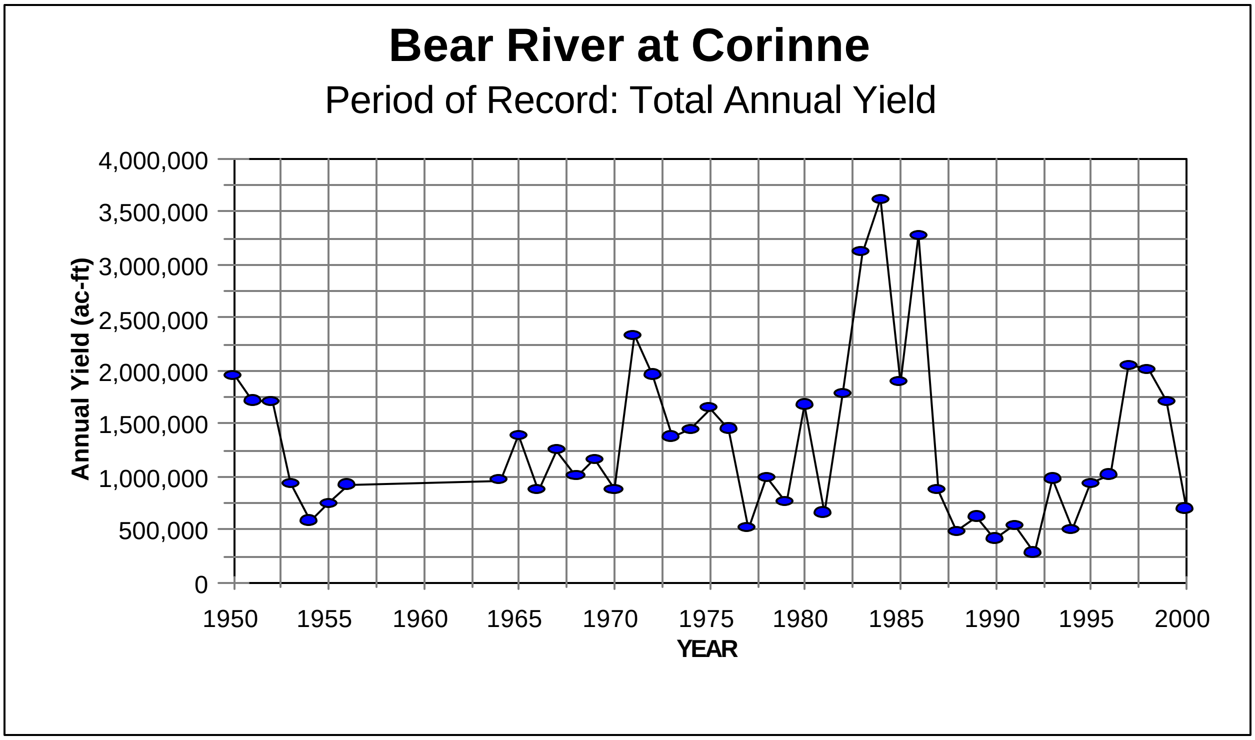


Figure 2-15. The annual water yield from the Bear River at Corinne from 1950 to 2000.

The record flows of 1983 through 1986 (Figure 2-15) were part of greatly increased precipitation in the entire Great Salt Lake system. These flows resulted in raising Great Salt Lake, a closed basin lake, by 11 feet from its low point in the late 1960s. Following this wet period was six years of below normal precipitation. The flow exceedence curve for the Bear River at Corinne is also shown in Figure 2-14. The data indicated that the 50 percent exceedence flow is 1,350 cfs. Flows greater than 100 cfs occur 90 percent of the time while daily flows exceeding 4,500 occur only 10 percent of the time.

Streams that originate as springs in and near the mountains bordering the lower Bear River valley discharge a total of more than 50,000 acre-feet of water annually. These streams include Box Elder Creek, which drains Mantua Valley, Salt Creek (west) which heads at Salt Creek Spring at the south end of West Hills, Salt Creek (east) which heads at Crystal Springs near Honeyville, and several smaller streams.

Streams that develop on the valley floor from small springs, sloughs, and drains include Black Slough, Sulphur Creek, and several smaller streams. The flow of several streams is increased greatly at times by direct spilling from the irrigation canal system with much of the water in all the streams on the valley floor representing irrigation return flows. Flow in Sulphur Creek is also augmented by diversion from the Malad River via the Bear River Duck Club Canal. Both Bear River and Malad River gain in discharge within the project area.

2.4.2 Irrigation Systems

Table 2-9 lists irrigation companies in the project area and the acreage covered. Figure 2-16 is a map of all areas listed within Table 2-9.

2.4.3 Drainage Systems

Twenty-six known drainages are listed in Table 2-10 which drain about 25,000 acres of irrigated farm land. Figure 2-17 illustrates the drainage locations. Other drains may exist though not listed in this report.

2.4.4 Water Budget

Utah's Division of Water Resources has prepared several water budgets over the years. The most recent Water Budget Report of the Bear River Basin prepared in September 1994, has been used in this report and is the basis of our hydrologic and phosphorous mass balances. Tables 2-11, 2-12 and 2-13 are summaries of the total Lower Bear River in Box Elder County adapted from that report. These tables are a summary of average daily flows expressed as cfs for each month. The data are based upon a period of record from 1961 to 1990. Where necessary, data were correlated between hydrologic gaging stations to fill in missing data. Three sub-areas are summarized in the report and are included in tables 2-11, 2-12 and 2-13.

Table 2-9. Distribution systems (canals and ditches) for irrigation companies in the lower Bear River valley.

NAME	AREA (acres)	SOURCE
Box Elder Cr. Irrig. Co.	1,200	Box Elder Cr,. & Pine View
Cold Water Spr. Dam Irrig Company	335	Cold Springs
Cook-Porter Group	525	Weber Basin
Grover, Olsen, Ridd & Peterson-Valentine	83	Box Elder Cr,. & Pine View
Mantua Irrig. Co.	711	Springs
North Field Irrig.	750	Box Elder Crk., & Pine View
North String Irrig. Co.	196	Rees Spring
North Willard Irrig. Co.	200	Three Mile Crk. & Pine View
Pack & Barnard Spring	110	Spring
Perry Irrigation Co.	423	Three Mile Crk., & Pine View
Pine View Water System	2,305	Ogden River
Reeder-Marble-Kotter Gr.	167	Springs
South Perry Irrig. Co.	165	Three Mile Crk. & Pine View
Three Mile Crk. & Water Co.	189	Three Mile Crk. & Pine View
West Field Stream	200	Box Elder Crk., & Pine View
Willard Water Company	1,170	Willard Crk., & Pine View
Samaria Lake Irrig. Co.	1,100	Samaria Lake
Bear River Canal Company	64,001	Bear River

Table 2-10. Known drainages in lower Bear River valley.

Name	Acres	Land Use	Receiving Stream
Two Private Systems	785	Agriculture	Malad River
Bear River Drainage Inc.	240		Malad River
Belmont District	540		Malad River
Fielding	640		Malad River
Tremonton/Garland Drainage Dist.	2,000		Malad River
Four Private Systems	324		Bear River
Elwood Drainage District	2,740		Bear River & Canal
Private System	150		Corinne Canal
Private System	320		Bear River Canal
Private System	160		Mill Ditch
Private System	250		Mill Ditch
Private System	2225		Irrigation Ditch
Five Private Systems	1,303		Eastern Salt Creek
Iowa String Drainage District	3,600		Western Salt Creek
Private System	15		Box Elder Creek
Corrine Drainage District	11,300		Slough
Private System	125		Swamps
Private System	40		Open Drain
TOTAL	**25,107**		

Table 2-11. The water budget for the Malad subarea.

	MALAD SUBAREA WATER BUDGET (cfs)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	AVG
Precipitation	2.2	1.9	2.1	2.4	2.5	1.4	0.6	0.7	1.1	1.6	2.0	2.3	1.7
Effective Cropland Precipitation	11.3	9.8	11.1	12.4	12.8	7.5	3.2	3.4	5.7	8.2	10.5	11.9	6.9
Domestic Water Supply Pumped	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subsurface Inflow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Importation	0.0	0.0	0.0	0.3	9.0	14.2	14.2	13.6	6.2	1.5	0.0	0.0	3.9
River Inflow	90.5	122.0	158.0	125.0	84.5	48.1	27.6	27.2	27.5	49.2	75.4	77.0	76.0
Gaged Tributary Inflow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gaged Tributary Inflow 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ungaged Inflow	9.8	15.1	26.4	26.0	30.1	43.9	54.9	53.0	27.7	13.9	3.9	2.4	25.6
Agricultural Return Flow	11.2	9.4	10.8	0.0	1.0	2.8	0.9	0.5	0.2	1.7	10.1	11.6	5.0
Domestic Return Flow	0.4	0.4	0.4	0.4	1.8	3.6	4.4	3.6	1.4	0.9	0.4	0.4	1.5
Wetland/Open Water Return Flow	1.5	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.5	0.4
River Outflow	107.0	139.6	193.2	144.2	97.4	57.0	32.9	34.2	33.3	54.1	85.0	85.5	88.6
Tributary Outflow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subsurface Outflow	6.1	8.2	1.8	4.3	0.7	0.3	0.4	0.0	0.3	0.9	2.6	5.6	2.6
Wetland/Open Water Diversions	0.0	0.0	0.0	2.3	5.5	9.6	13.6	12.0	6.5	2.6	0.0	0.0	4.3
Crop Diversions	0	0	0	0.3	20.1	41.0	49.1	46.9	20.6	8.2	1.1	1.0	15.7
Domestic Diversions Pumped	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Domestic Diversions Stream	0.4	0.4	0.4	0.4	1.9	4.0	4.9	4.0	1.6	1.1	0.4	0.4	1.7
Export Out	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture Crop Consumption	0.1	0.1	0.3	13.0	31.9	49.0	58.2	46.4	26.6	11.8	0.3	0.1	19.8
Domestic Consumption	0.0	0.0	0.0	0.0	0.2	0.4	0.5	0.4	0.2	0.1	0.0	0.0	0.2

Wetland/Open Water Consumption	0.7	0.7	2.2	4.6	7.9	11.0	14.2	12.6	7.6	4.1	1.6	0.7	5.7

Table 2-12. The water budget for the Tremonton subarea.

	TREMONTON SUBAREA WATER BUDGET (cfs)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**AVG**
Precipitation	43.3	37.5	42.5	47.4	49.1	28.7	12.1	13.0	21.8	31.4	40.3	45.5	34.4
Effective Cropland Precipitation	120.1	104.0	117.8	131.6	136.2	79.5	33.7	35.9	60.4	87.2	111.7	125.9	95.3
Domestic Water Supply Pumped	0.5	0.5	0.5	0.5	1.1	1.3	1.9	1.3	1.1	0.8	0.5	0.5	0.9
Subsurface Inflow	6.1	8.2	1.8	4.3	0.7	0.3	0.4	0.0	0.3	0.9	2.6	5.6	2.6
Importation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
River Inflow	1672.6	1715.7	2312.2	2746.3	3336.9	2691.7	1504.4	1465.0	1436.9	1658.3	1646.3	1711.4	1991.5
Gaged Tributary Inflow	107.0	139.6	193.2	144.2	97.4	57.0	32.9	34.2	33.3	54.1	85.0	85.5	88.6
Gaged Tributary Inflow 2	2.1	2.1	2.1	2.1	20.5	45.5	69.4	68.1	42.8	3.8	2.1	2.1	21.9
Ungaged Inflow	126.5	78.5	248.5	164.0	206.1	203.4	93.0	117.0	138.6	232.5	161.3	145.1	159.5
Agricultural Return Flow	92.2	85.6	109.8	45.9	253.9	422.5	503.3	531.0	350.2	140.5	55.0	92.1	223.5
Domestic Return Flow	2.6	2.6	2.6	2.6	5.5	6.4	6.3	7.0	5.3	4.4	2.6	2.7	4.2
Wetland/Open Water Return Flow	30.9	25.9	16.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.1	33.4	10.2
River Outflow	1987.8	1990.9	2872.3	3041.9	3282.7	2539.3	1115.4	1077.2	1291.5	1777.4	1876.8	2034.5	2074.0
Tributary Outflow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subsurface Outflow	13.6	46.1	5.0	29.9	62.9	35.6	6.2	7.2	0.0	0.0	0.7	2.0	17.4
Wetland/Open Water Diversions	0.0	0.0	0.0	12.7	37.3	101.3	182.9	192.5	101.1	34.1	0.0	0.0	55.2
Crop Diversions	0.0	0.0	0.0	1.8	420.2	717.5	869.5	909.4	588.9	235.2	26.2	0.0	314.1
Domestic Diversions Pumped	0.5	0.5	0.5	0.5	1.1	1.2	1.8	1.4	1.0	0.8	0.5	0.5	0.9
Domestic Diversions Stream	1.8	1.8	1.8	1.8	3.6	4.2	6.3	4.7	3.5	2.9	1.8	1.8	3.0
Export Out	32.8	19.2	7.1	32.4	116.1	24.9	31.0	30.9	20.4	49.6	56.7	40.9	38.5

Agriculture Crop Consumption	0.3	0.3	1.0	82.6	331.2	541.6	605.3	395.4	197.4	50.5	1.0	0.3	183.9
Domestic Consumption	0.1	0.1	0.1	0.1	0.3	0.3	0.5	0.4	0.3	0.2	0.1	0.1	0.2
Wetland/Open Water Consumption	11.0	10.4	25.3	48.8	86.4	129.1	194.6	206.4	122.2	66.1	22.9	11.7	77.9

Table 2-13. The water budget for the Brigham subarea.

	BRIGHAM SUBAREA WATER BUDGET (cfs)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**AVG**
Precipitation	241.2	232.0	236.8	274.2	274.0	165.3	68.2	72.5	125.0	174.9	231.9	253.6	195.8
Effective Cropland Precipitation	37.2	35.7	36.5	42.2	42.2	25.5	10.4	11.1	19.3	27.0	35.8	39.1	30.2
Domestic Water Supply Pumped	6.3	7.0	6.3	6.5	12.6	15.6	22.7	15.1	13.0	10.1	6.5	6.3	10.7
Subsurface Inflow	13.6	51.0	4.8	30.9	60.8	36.8	6.2	6.5	0.0	0.0	0.7	2.0	17.8
Importation	32.9	21.3	12.5	71.9	210.5	208.7	301.6	270.0	165.5	100.6	58.6	40.9	0.0
River Inflow	1987.3	2205.3	2776.5	3152.7	3146.9	2596.5	1103.3	976.5	1354.6	1752.2	1952.0	1963.7	2080.6
Gaged Tributary Inflow	23.8	30.2	30.8	49.4	73.5	36.8	26.6	21.8	20.0	21.4	41.6	25.9	33.5
Gaged Tributary Inflow 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ungaged Inflow	0.3	0.3	0.3	0.3	2.1	49.2	93.5	55.9	22.1	1.7	0.3	0.3	18.8
Agricultural Return Flow	2304.2	2539.7	2962.0	3280.6	3242.8	2301.5	792.0	606.6	954.6	1631.0	2185.1	2290.5	2090.9
Domestic Return Flow	14.8	16.4	14.8	15.3	29.7	36.8	53.4	35.6	30.6	23.7	15.3	14.8	25.1
Wetland/Open Water Return Flow	182.4	168.9	68.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63.9	191.7	56.2
River Outflow	2281.9	2518.2	2931.3	3236.9	3091.6	2000.3	371.7	235.3	721.2	1549.2	2158.7	2267.0	1946.9
Tributary Outflow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subsurface Outflow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland/Open Water Diversions	0.0	0.0	0.0	76.1	333.3	797.3	983.8	972.0	788.4	338.9	0.0	0.0	357.5
Crop Diversions	2267.4	2504.5	2927.1	3277.4	3307.8	2428.3	969.2	749.5	1035.1	1641.6	2151.4	2251.9	2125.9

Domestic Diversions Pumped	6.3	7.0	6.3	6.5	12.6	15.6	22.7	15.1	13.0	10
Domestic Diversions Stream	10.2	11.2	10.2	10.5	20.3	25.2	36.6	24.4	21.0	16
Export Out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Agriculture Crop Consumption	0.5	0.5	1.6	40.2	106.0	152.2	187.7	156.3	97.6	37
Domestic Consumption	1.6	1.8	1.6	1.7	3.3	4.0	5.9	3.9	3.4	2
Wetland/Open Water Consumption	58.8	63.1	168.7	350.2	607.3	962.6	1051.9	1044.5	913.3	513

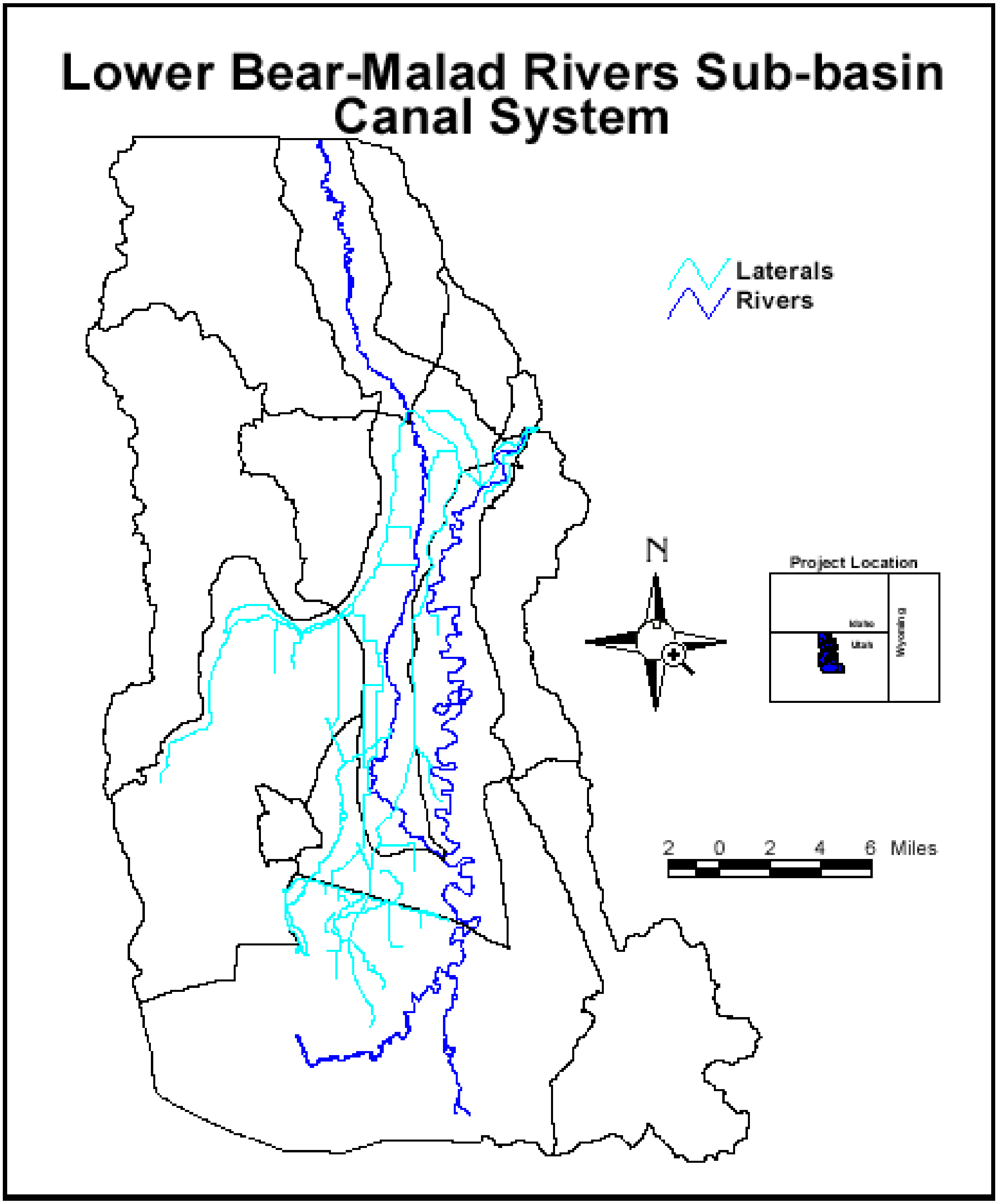


Figure 2-16. A map illustrating the lower Bear/Malad River canal system.

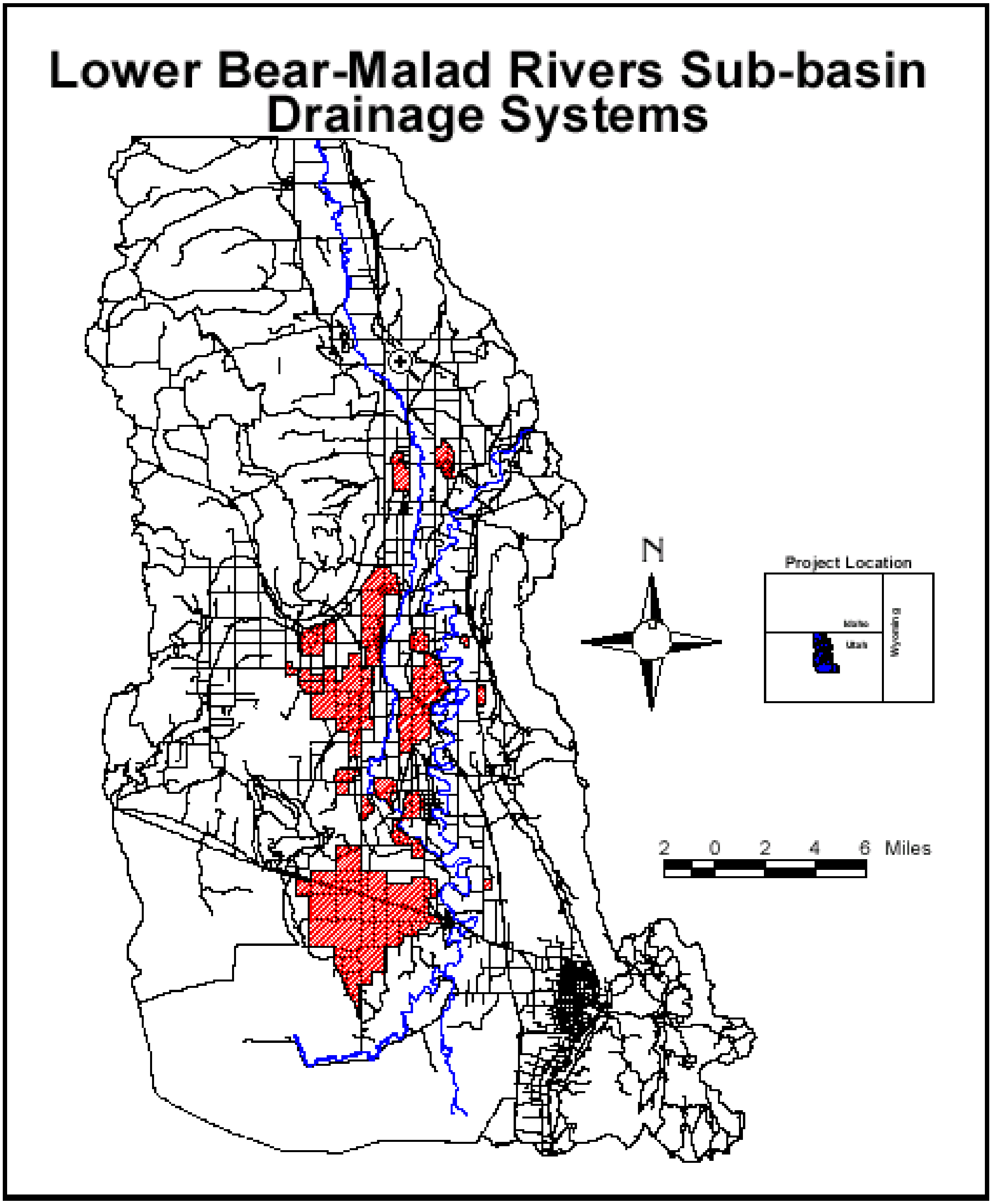


Figure 2-17. A map illustrating the lower Bear/Malad River drainage areas.

2.5 Groundwater

2.5.1 Groundwater Systems

Groundwater in the lower Bear River drainage basin occurs 1) in a principal groundwater system; 2) in a shallow unconfined system in the central-plain area; and 3) in perched systems. The system is considered to be complex. It is an area of transition from cold, fresh groundwater at the upstream end of the valley and in the mountains, to generally warm, very saline groundwater at the downstream end near the Great Salt Lake. There are a wide variety of hydrologic conditions throughout the transition zone. Surface water sources supply most of the water used for irrigation. Groundwater supplies almost all of the irrigation needs in the Bothwell Pocket and supplements the surface-water supply in the Brigham City and Perry area. Groundwater sources supply all of the culinary water used in the valley.

<u>Principal Groundwater System</u>

The principal groundwater system includes most of the groundwater in all geologic units in the project area. This system is complex and includes both confined and unconfined groundwater. The most productive aquifer materials are the well-sorted sand and gravel of the Quaternary (Lake Bonneville) deposits along the edges of the valley. The Oquirrh formation rocks, whose permeability has been increased by fracturing, is also a productive aquifer. All the public-water supplies are from wells and springs drawing from this aquifer.

<u>Shallow Unconfined System in the Central-Plain Area</u>

The clay and silt deposits located in the middle of the valley have low permeability and yield smaller quantities of water, but are important because they are the only water-bearing unit over a large part of the area. The shallow unconfined groundwater system exists in the central-plain area in materials near the land surface that are part of the interior deposits of Lake Bonneville Basin. Unconfined groundwater occurs in similar materials elsewhere in the valley, but the separation from the principal system is generally less distinct. Shallow wells in the central-plain area supply water for many lawns and gardens.

<u>Perched Systems</u>

Perched groundwater systems occur mostly in the marginal deposits of Lake Bonneville basin; in colluvium, alluvium, and undifferentiated deposits in the mountains; and in the Oquirrh Formation along the west side of the Wellsville Mountains. They occur along most of the east side of the West Hills and west of Garland at the south end of the West Hills.

2.5.2 Recharge

The primary recharge areas are along the mountain fronts which is also an area of many springs and wells. Secondary recharge zones occur in the broad alluvial fans and benches in the northern portion of the valley along the Malad and Bear Rivers and also in the northern portion of the Bothwell Pocket.

Recharge directly from precipitation occurs mostly in and near the mountains at locations where rain or snowmelt enters permeable materials. Infiltration from streams where they flow from canyons onto permeable materials is an important source of recharge in the project area. Much of this recharge is from perennial streams but considerable recharge also comes from many smaller intermittent and ephemeral streams that commonly lose all their flow in the alluvial slopes at the base of the mountains.

The principal streams on the valley floor flow to a lower groundwater discharge area. They do not contribute directly to the groundwater reservoir and are consequently gaining streams. The Bear River does contribute water indirectly, however, through infiltration irrigation water.

Recharge to the groundwater reservoir in the area has been increased substantially by diverting water from streams for irrigation. Because the land surface materials are quite permeable, between one-fourth and one-half of this water probably infiltrates to groundwater reservoir.

2.5.3 Direction of groundwater flow and potentiometric surface

The direction of groundwater movement is generally from the mountains toward the valley and then south and southwest toward the lowest parts of the basin. An exception is in the southern part of the West Hills, where water moves from the valley toward the West Hills and then generally toward Salt Creek Springs, about two miles southeast of Bothwell.

The potentiometric surface of the principal groundwater system includes the water table in areas where the principal system is unconfined and the imaginary surface defined by the head of the water in areas where it is confined.

Water-level data shows an approximate range of 28 feet to 745 feet below land surface. However, water levels at most wells are between 10 feet above and 200 feet below land surface. Water levels rise during the summer in areas irrigated with surface water and decline between irrigation seasons.

3.0 MONITORING PROGRAM

Investigation of the available data for selected water quality parameters indicates that the most complete coverage occurred during the 1990s. In order to expedite the data analysis without having to qualify data (accepted or rejected) for analysis, only data collected in the 1990s was used in this TMDL.

3.1 Analysis of Current Monitoring

3.1.1 Locations

In the 1990s, the state of Utah established a series of long-term water quality stations within the study area of the lower Bear River. Stations included mainstem and tributary sites and their locations can be seen in Figure 3-1. Additional stations were established for synoptic studies carried out in 1999-2000 to develop a more comprehensive representation of the watershed. They included tributaries, point sources, agricultural drains, and mainstem sites. The locations of these stations can be seen in Figure 3-2.

3.1.2 Frequency and Parameters

A summary of the number of samples (count) during the 10 year period (1990-2000) for each location in the database can be seen in Table 3-1. For both the mainstem and tributaries, the number of data points available varied by both site and parameter. Typically, the field parameters (dissolved oxygen, pH, and temperature) were the most frequent, followed by total suspended solids and the nutrient total phosphorous. The concentrations of the soluble forms of nitrogen (ammonia, nitrate and nitrite) and phosphorous (ortho phosphate) were also determined at some sites.

The mainstem Bear River stations at Cutler, Honeyville above and below the Malad, above Salt Creek and at Corinne had sufficient data to look at temporal trends in total phosphorous, and total suspended solids. The largest tributary data set was found in Box Elder Creek above the Brigham City wastewater treatment plant. Sufficient data was available to evaluate temporal trends in total phosphorous, and total suspended solids at Black Slough, Box Elder Creek above and below the Brigham City wastewater treatment plant, Salt Creek and the Malad River.

The synoptic sampling undertaken during this investigation collected water quality data at four mainstem sites as well as stations in the Malad River, the major tributary to the lower Bear River. Sampling occurred four times corresponding to the four major hydrologic periods (lower basin runoff, upper basin runoff, summer baseflow, and fall baseflow). The tabular data is provided in Appendix A.

3.1.3 Monitoring Results

The results of the water quality monitoring program for mainstem Bear River sites can be seen in figures 3-3 through 3-7 and for tributary sites, figures 3-8 and 3-9. Because total phosphorous and total suspended solids are key water quality parameters in the lower Bear River, they were used to illustrate the temporal distribution of the data.

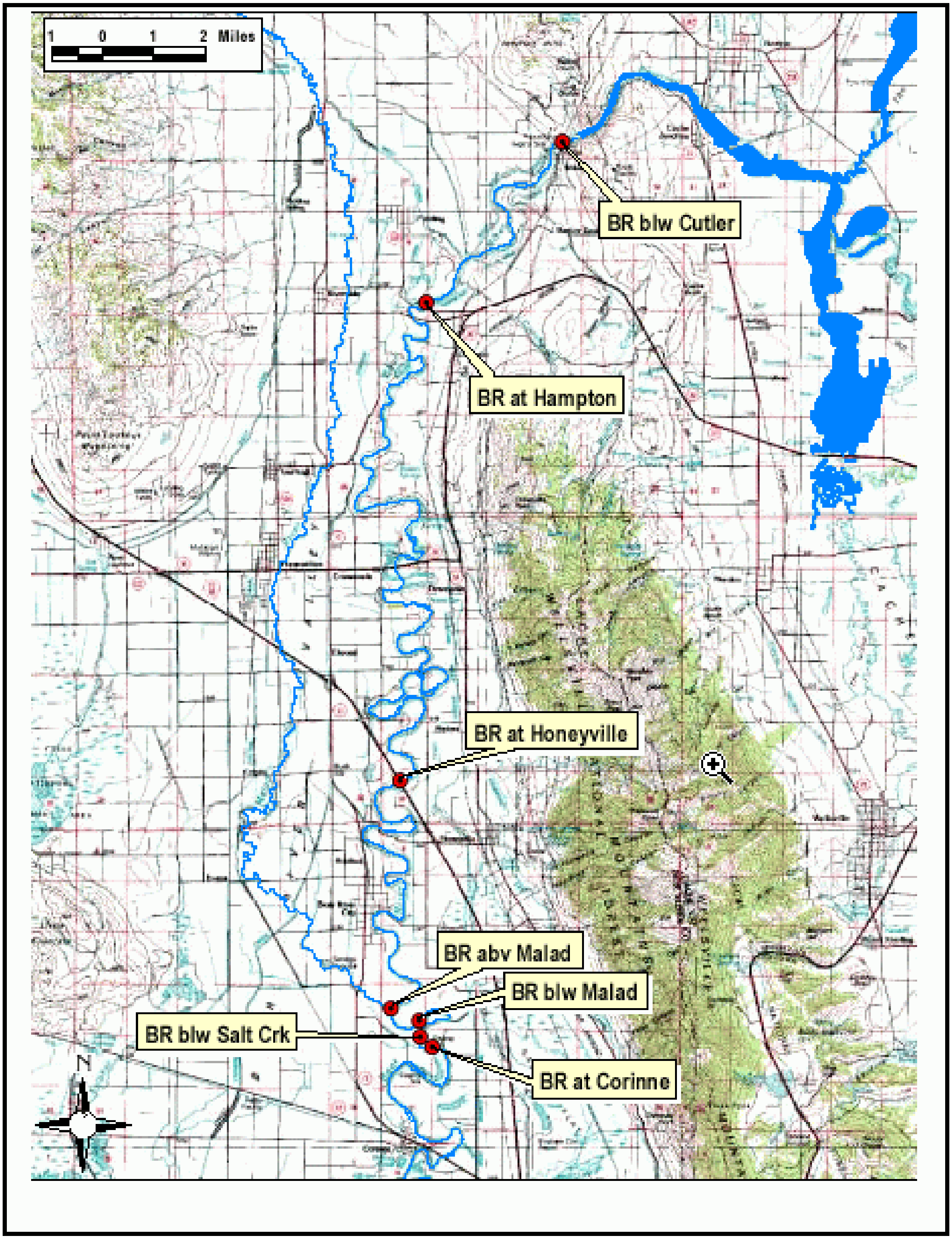


Figure 3-1. The location of monitoring stations used in the water quality analysis of the lower Bear River.

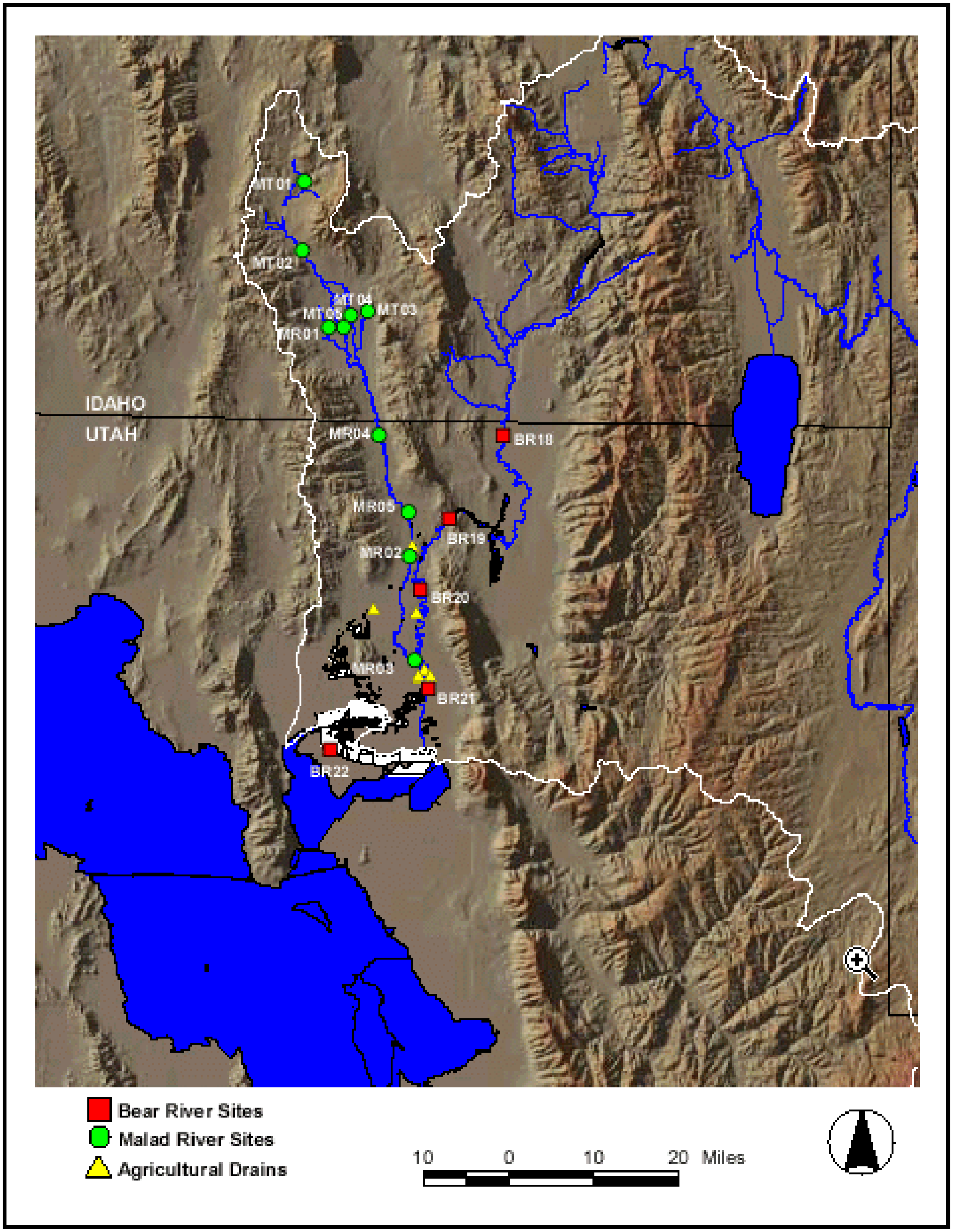
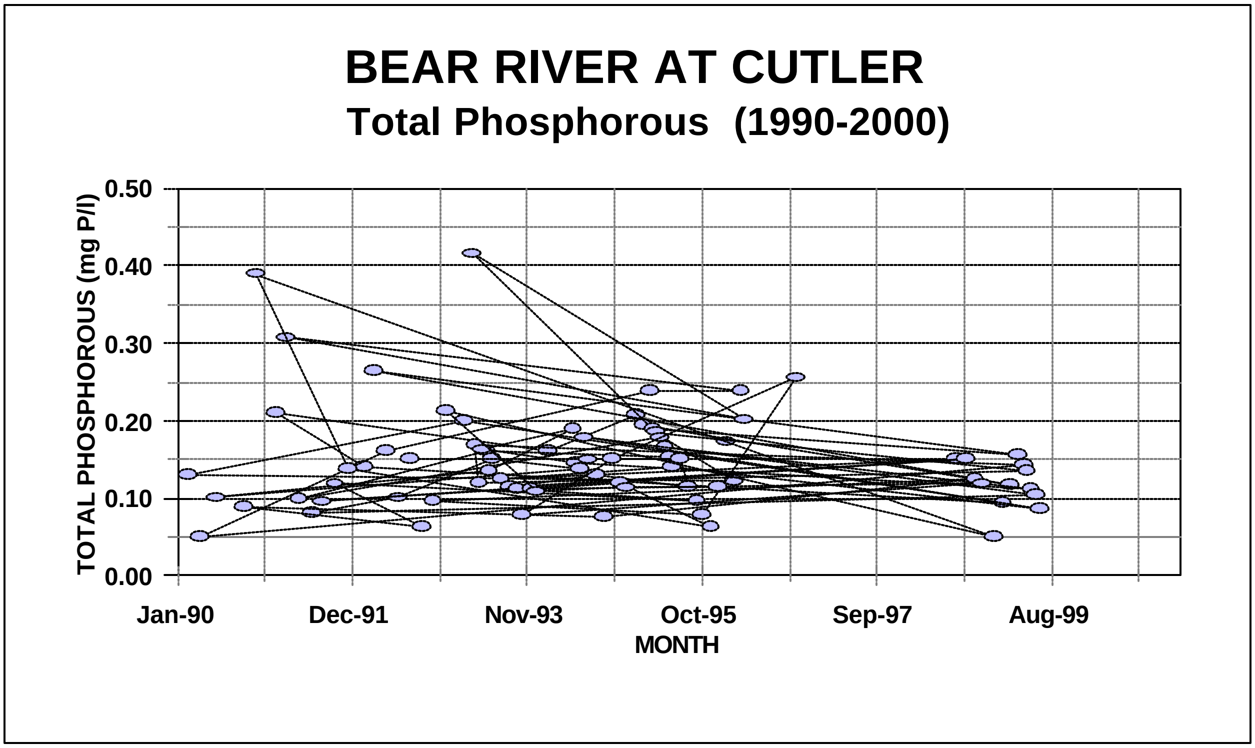


Figure 3-2. The location of the synoptic sample sites sampled in 1999-2000 in the lower Bear River.



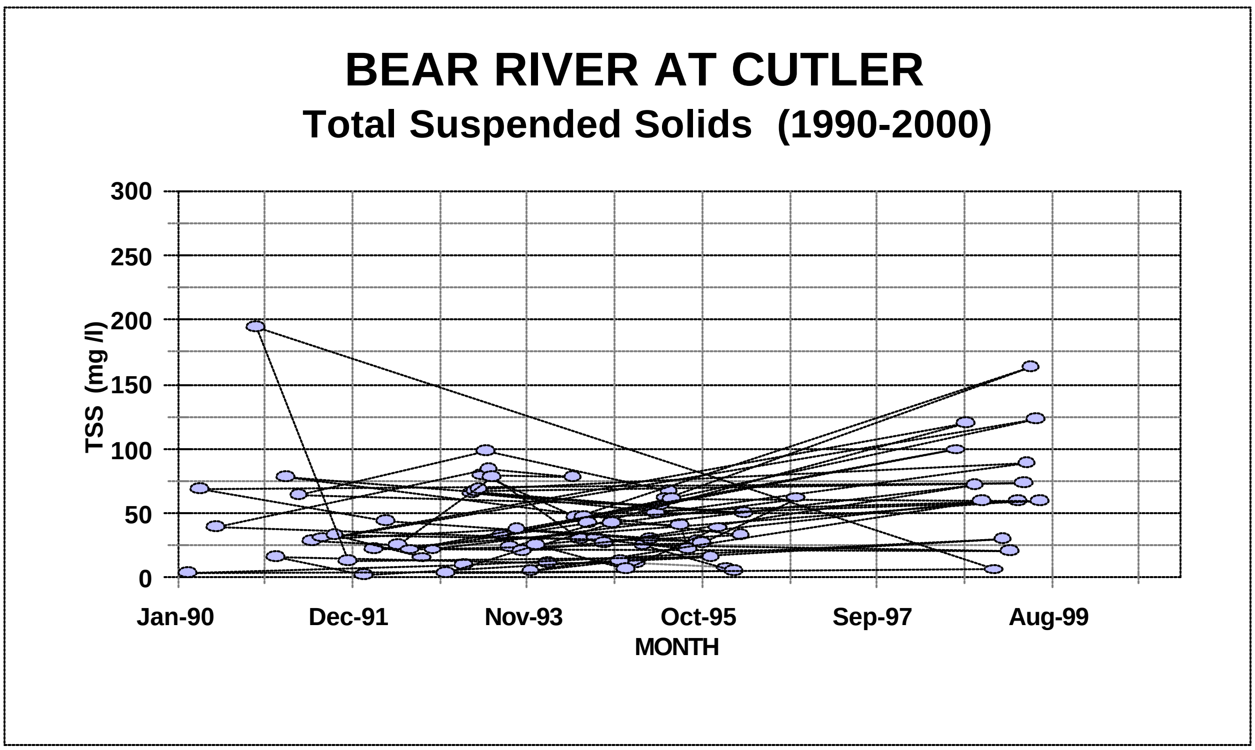
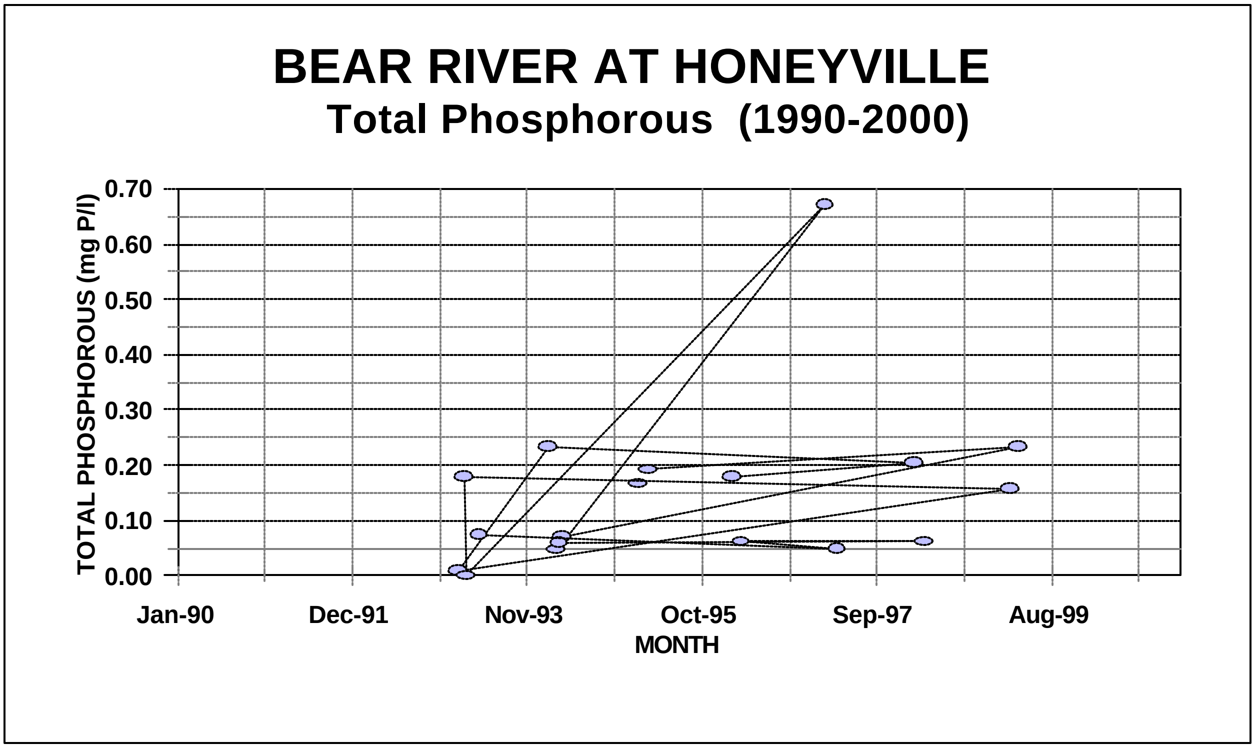


Figure 3-3. The concentration of total phosphorous (above) and total suspended solids (below) in the Bear River below Cutler Dam (Storet# 490198).



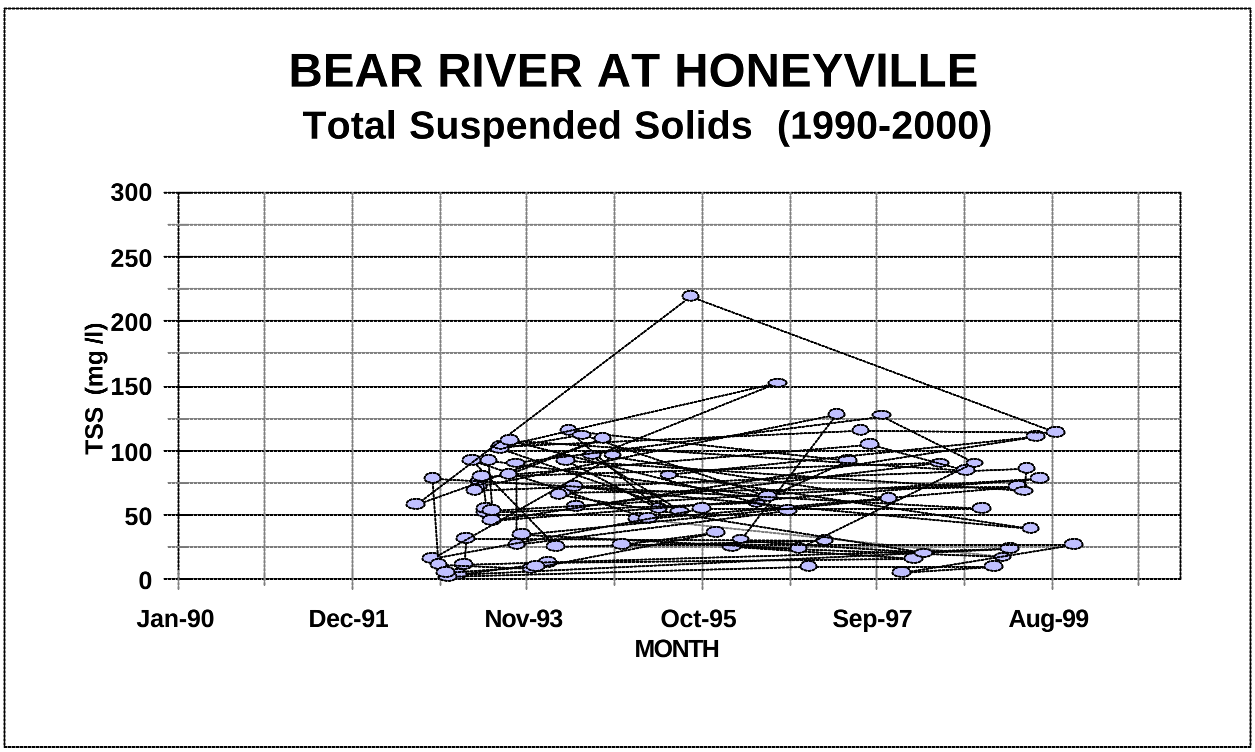
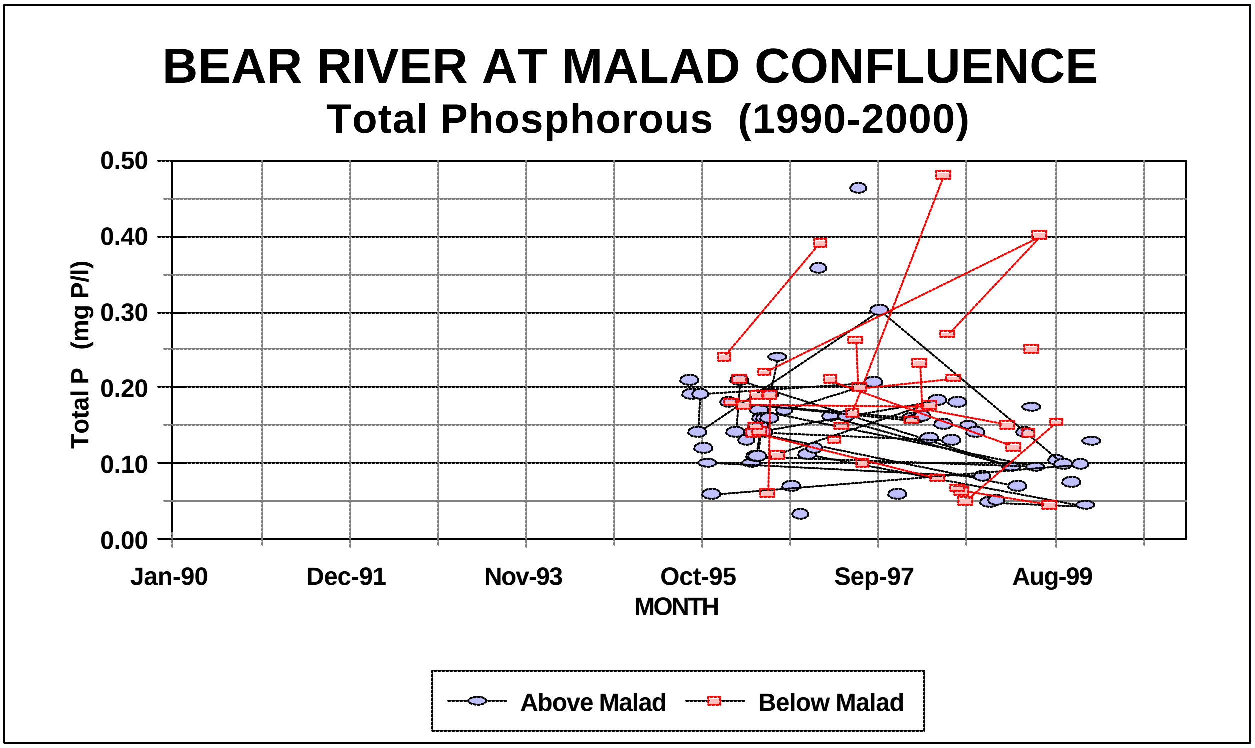


Figure 3-4. The concentration of total phosphorous (above) and total suspended solids (below) in the Bear River at Honeyville (Storet# 490170).



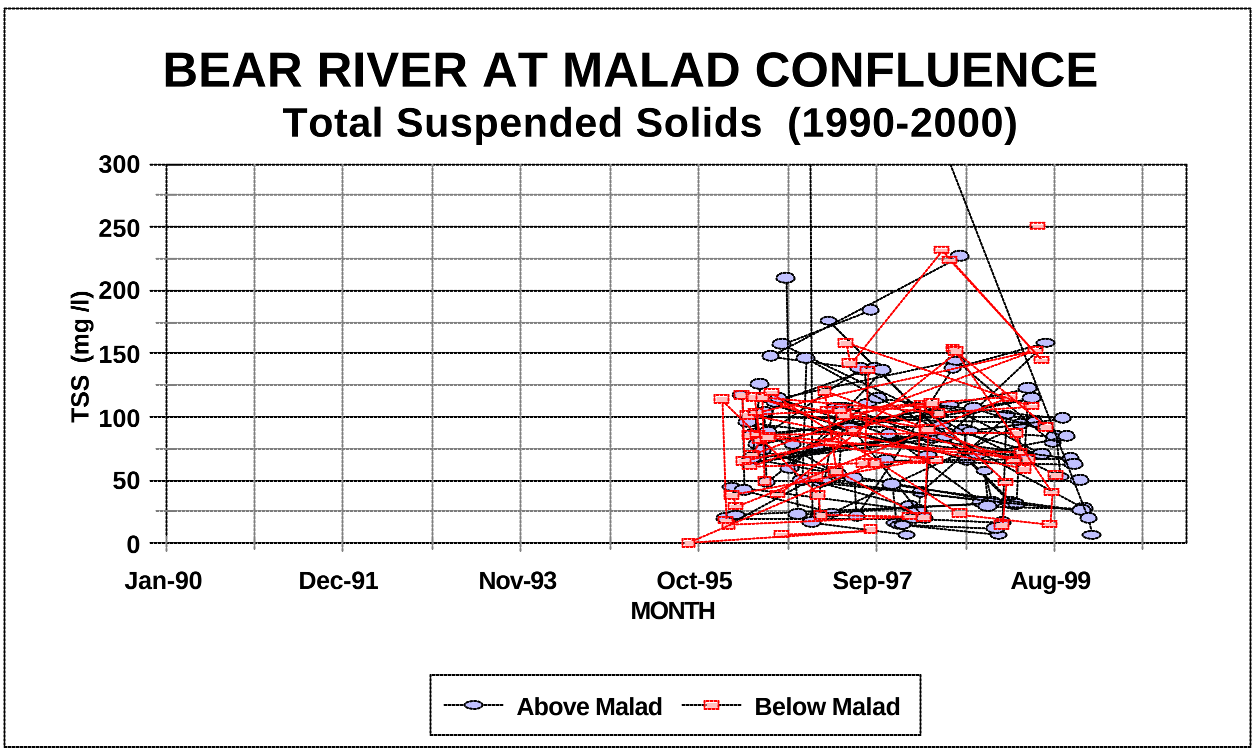
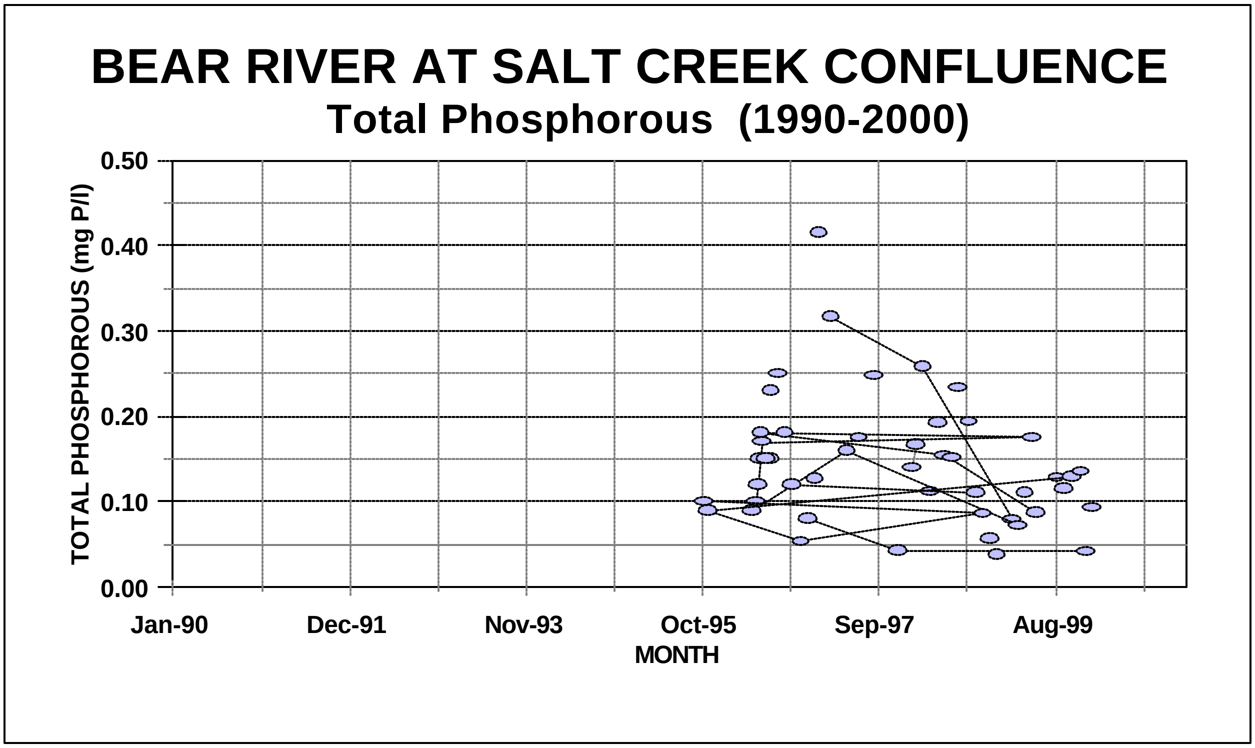


Figure 3-5. The concentration of total phosphorous (above) and total suspended solids (below) in the Bear River at the Malad River confluence (Storet# 490145 and 490144).



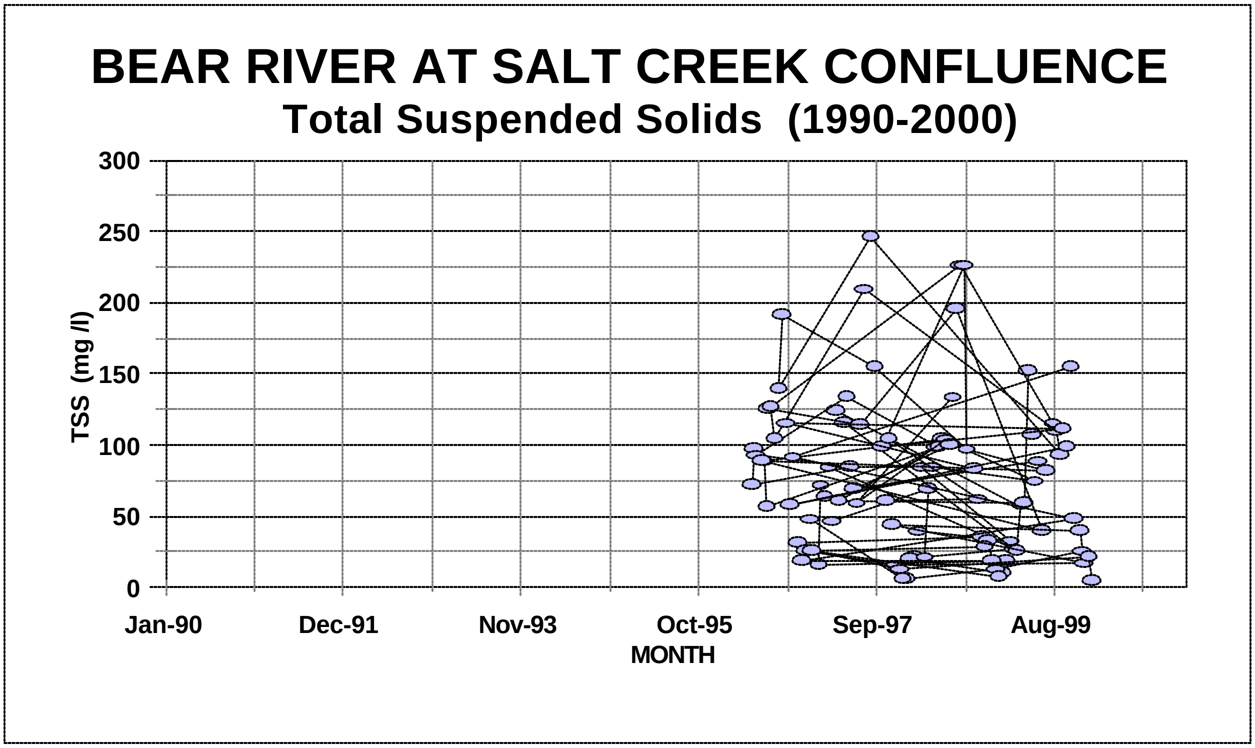
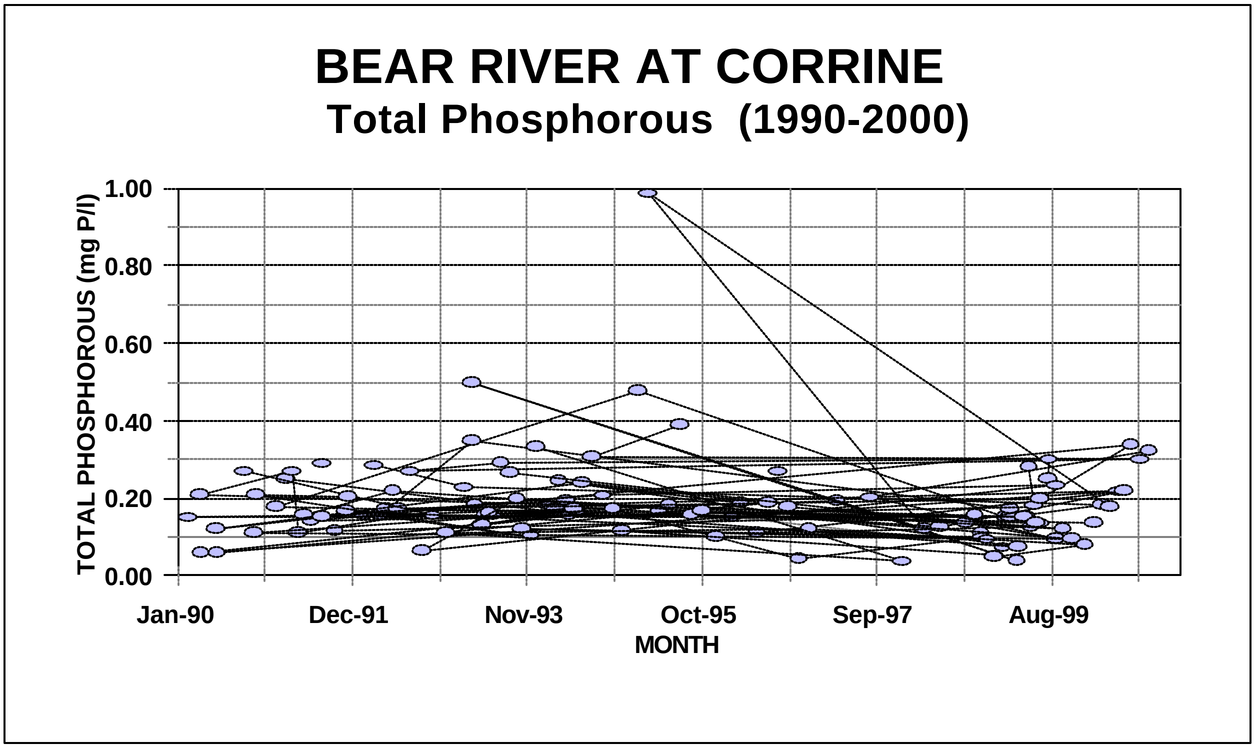


Figure 3-6. The concentration of total phosphorous (above) and total suspended solids (below) in the Bear River at the Salt Creek confluence (Storet# 490142).



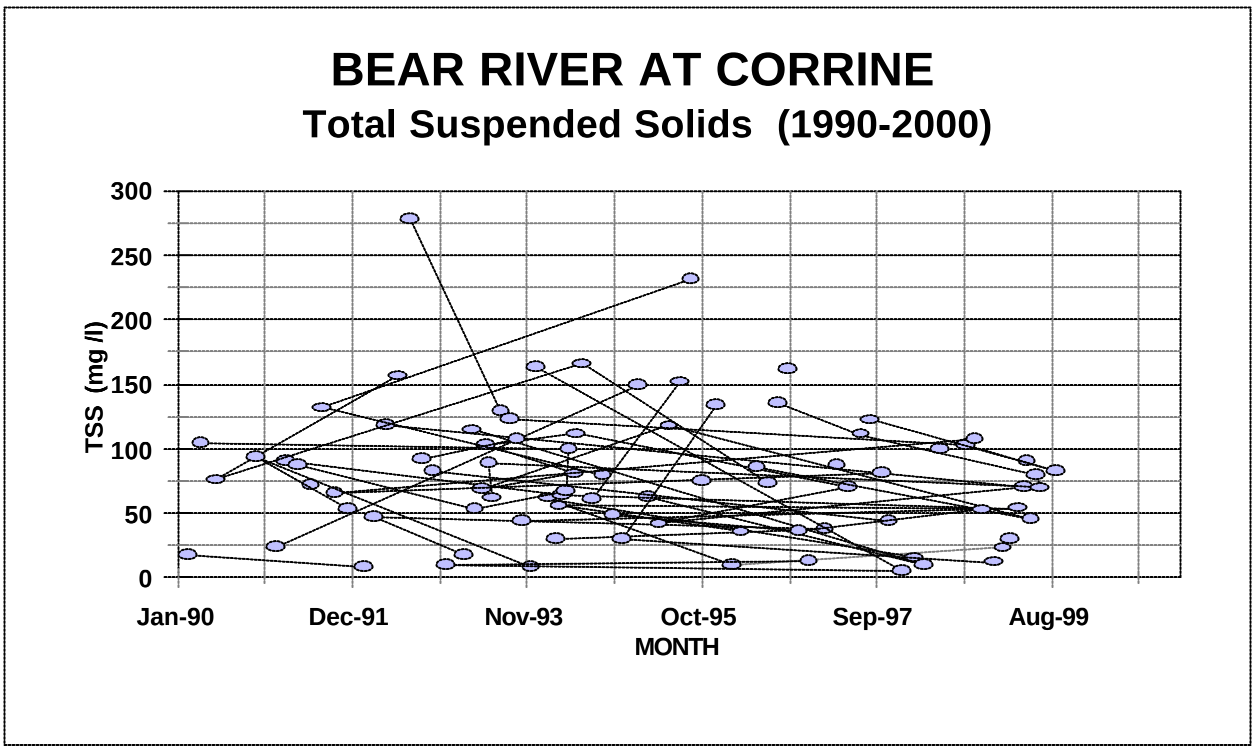
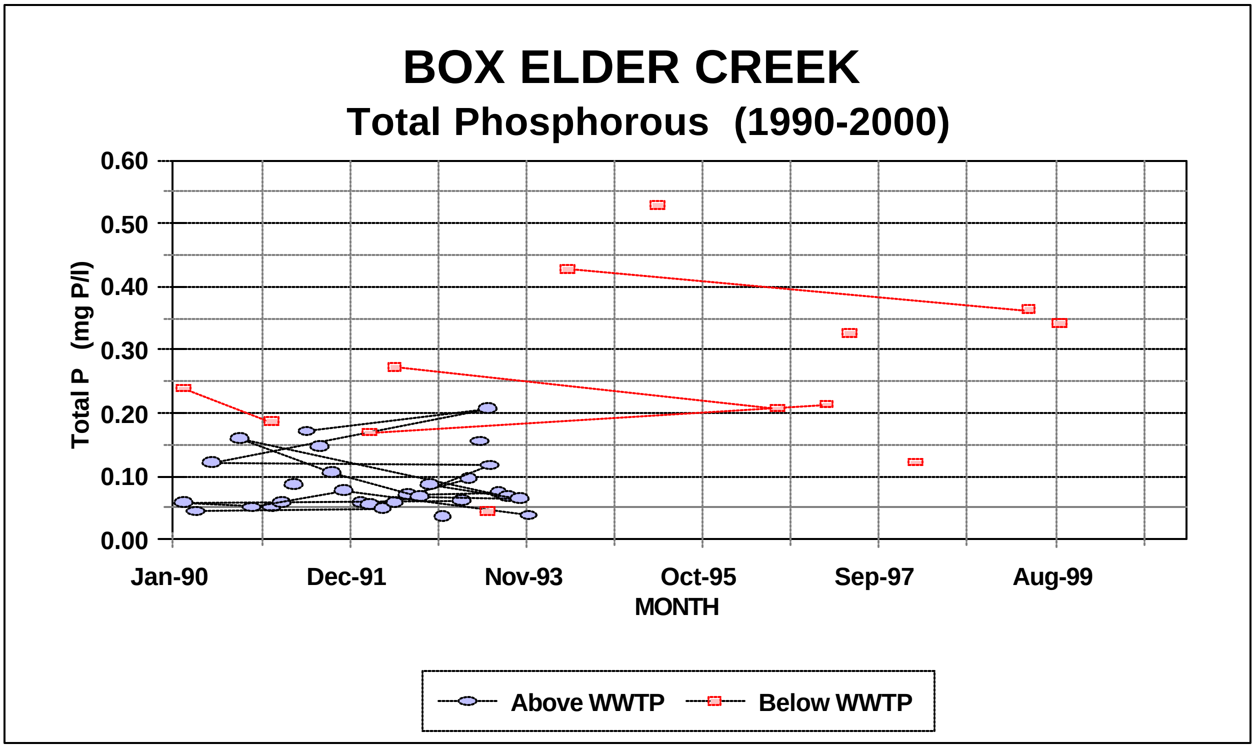


Figure 3-7. The concentration of total phosphorous (above) and total suspended solids (below) in the Bear River at Corinne (Storet# 490110 and USGS# 10126000).



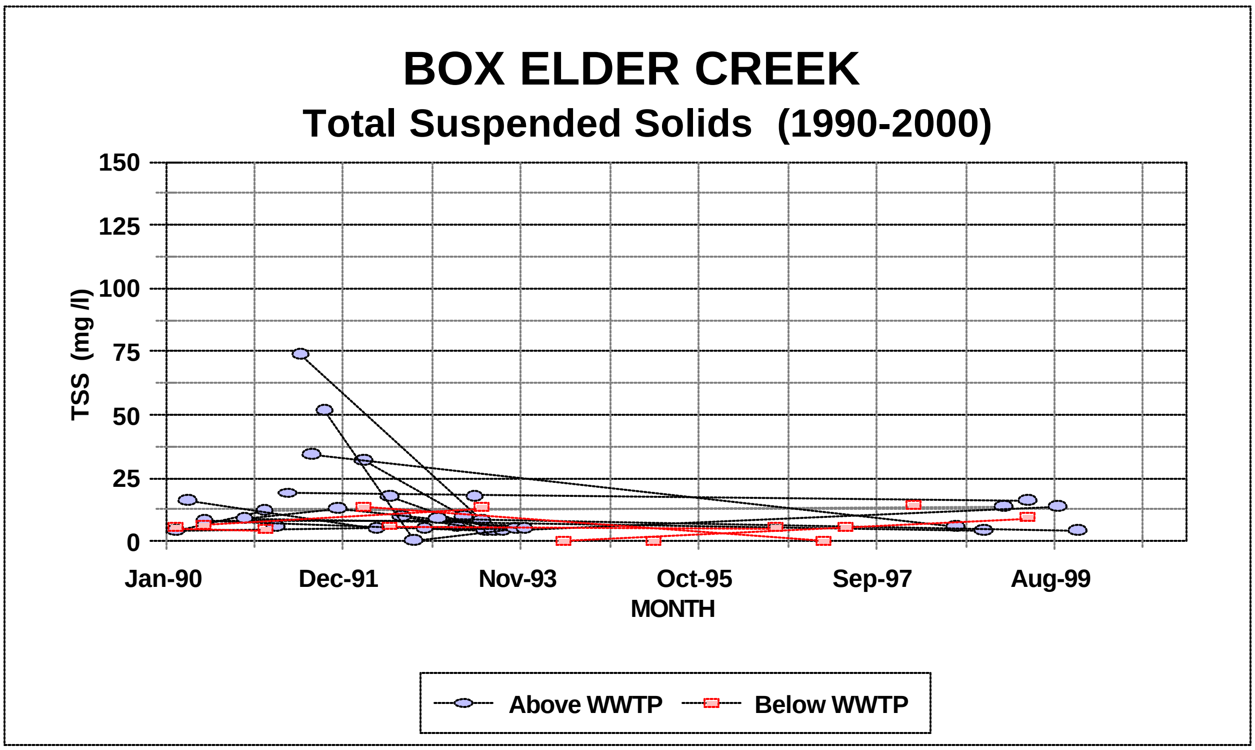
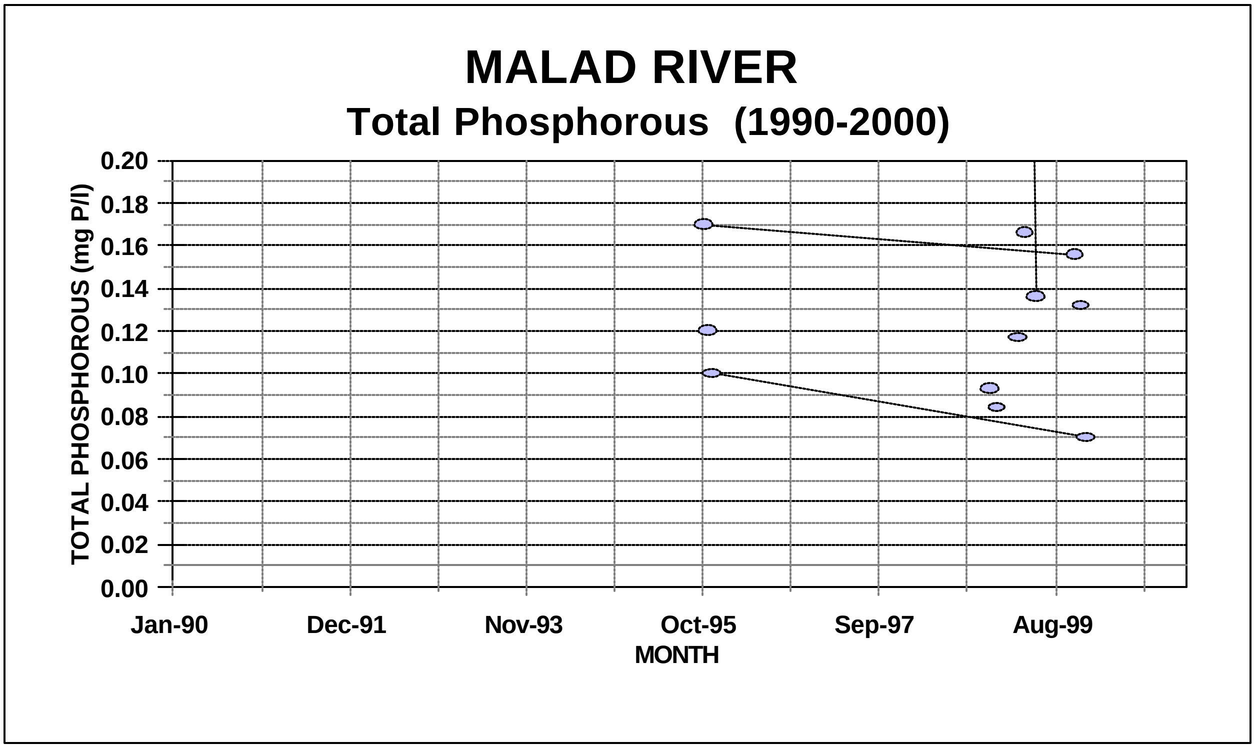


Figure 3-8. The concentration of total phosphorous (above) and total suspended solids (below) in Box Elder Creek, a tributary to the Bear River (Storet# 490118 and 490119).



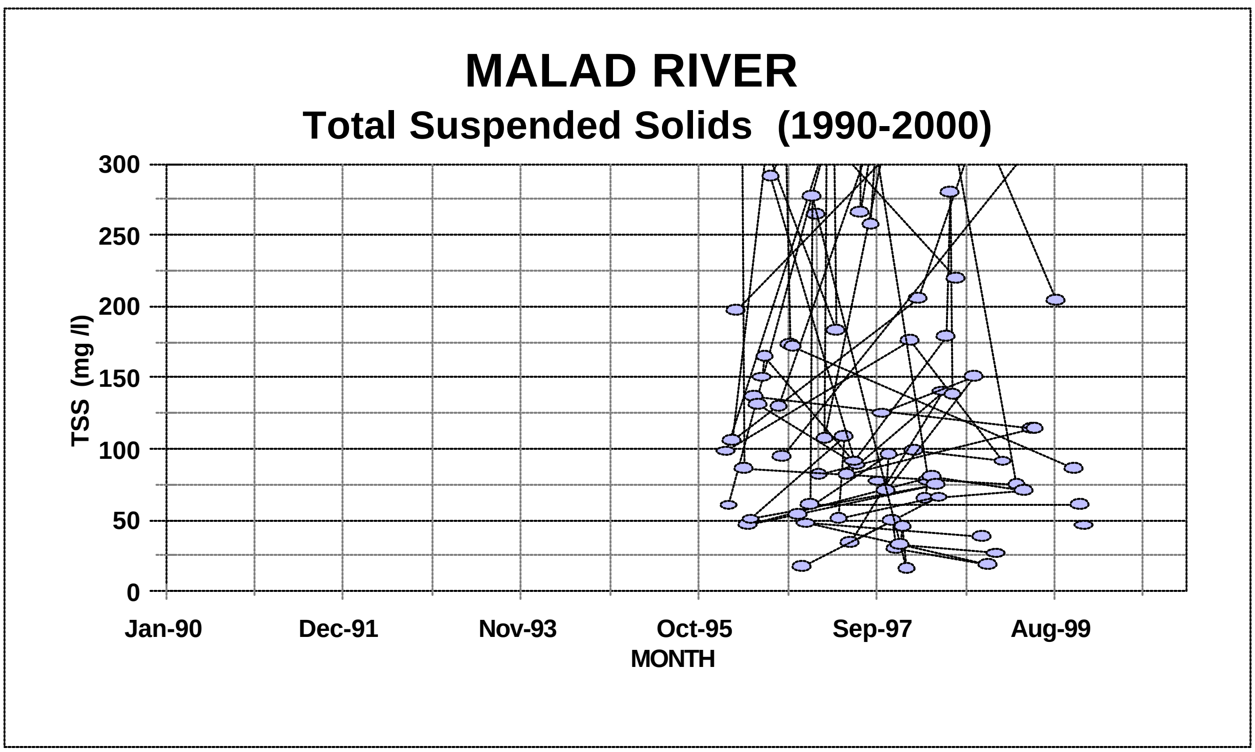


Figure 3-9. The concentration of total phosphorous (above) and total suspended solids (below) in the Malad River, a tributary to the Bear River (Storet# 490146).

Table 3-1. The count of water quality samples for the mainstem Bear River and tributaries between Cutler Reservoir and the Great Salt Lake. Data are from 1990 to 2000.

STATION # and DESCRIPTION		Dissolved Oxygen	pH	Temperature	TSS	NH3	NO3+NO2	DTP	TP
MAINSTEM SITES									
490198	Bear R Bl Cutler Res at UPL Bridge	134	231	135	144	145	41	43	144
490179	Bear R. at Hampton's Ford Xing	18	20	17	20	19			19
490170	Bear R at I-15 2 Mi Ne of Honeyville	84	181	93	98	87	65	58	92
10118000	Bear R Nr Collinston			50					
490145	Bear R Ab Cnfl/ Malad	3	196	92	105	5			57
490144	Bear River Bl Cnfl/ Malad		127	52	67				39
490142	Bear R Bl Salt Creek	4	177	92	93	5			46
490115	Bear R Ab Corinne Lagoons		8	4	4	4			
490110	Bear R near Corinne at U83 Xing	197	362	198	208	200	77	73	196
10126000	Bear R Nr Corinne	126	122	153		102	82	98	109
490160	Bear R S of Bear R City	1	3	1	2	2	2	2	2
	TOTAL:	**567**	**1427**	**887**	**741**	**569**	**267**	**274**	**704**
TRIBUTARY SITES									
490056	Pump Station Ab Mantua Res	14	14	14	14	14	14	14	14
490117	Blacks Slough Ab Cnfl/ Box Elder ck	13	26	13	13	12	11	11	13
490141	Reeder Overflow Canal @ Rd Xing		134	57	73				42
490118	Box Elder Ck Bl Brigham WWTP	37	50	37	14	37	11	11	13
490055	Bunderson Spring	9	9	9	8	8	9	9	9
490119	Box Elder Ck Ab Brigham City WWTP	128	229	147	123	140	23	24	114
490053	West Flow from Maple Springs	6	6	6	6	5	6	6	6

Table 3-1 (continued). The count of water quality samples for the mainstem Bear River and tributaries between Cutler Reservoir and the Great Salt Lake. Data are from 1990 to 2000.

STATION # and DESCRIPTION		Dissolved Oxygen	pH	Temperature	TSS	NH3	NO3+NO2	DTP	TP
490146	Malad R Ab Cnfl/ Bear r	2	157	72	83	5			18
490047	Dam Ck Ab Mantua Res	10	10	10	10	8	10	9	10

Table 3-1 (continued). The count of water quality samples for the mainstem Bear River and tributaries between Cutler Reservoir and the Great Salt Lake. Data are from 1990 to 2000.

STATION # and DESCRIPTION		Dissolved Oxygen	pH	Temperature	TSS	NH3	NO3+NO2	DTP	TP
TRIBUTARY SITES (continued)									
490051	Maple Ck Ab Res	16	15	16	15	12	15	16	16
490121	Box Elder Ck Bl Brigham City Wwtp	4	29	20	20	11			10
490193	Hammond Main Canal at Bridge	9	10	10	10	9			10
490194	Corrine Canal @ U30 Xing		3	1	3	3			3
490195	West Side Cnl Bl Cutler Res	7	12	7	8	8			8
490140	Reeder Canal Ab Bear R Bird Refuge	1	54	27	29	5			13
490200	Malad R S of Bear R City	36	36	36	17	35	13	13	15
490204	Malad R Ab Bear R City Lagoons	25	25	25	5	24			
490272	Malad R Ab Tremonton Wwtp	52	51	52	32	52	24	25	28
490290	Malad R S of Plymouth at U191 Xing	12	11	12	12	11	10	10	12
490294	Malad River East of Portage	13	12	13	12	13	11	11	13
490042	Big Ck Bl Mantua Res	18	19	18	14	16	15	15	18
490143	Salt Creek Ab Cnfl/ Bear River		123	54	67				6
	TOTALS	**412**	**1035**	**656**	**588**	**428**	**172**	**174**	**391**

4.0 WATER QUALITY

4.1 Water Quality Standards

The water quality standards applicable to the lower Bear River and its tributaries can be seen in Table 4-1. The Bear River is classified as 2B, which is protected for secondary contact recreation such as boating and wading. In addition, the mainstem is also designated 3B and 3D. This classification is for the protection of warm water species of game fish and other aquatic life (waterfowl) including aquatic organisms in their food chain. The final beneficial use is Class 4, which is protected for crop irrigation and watering stock. The tributaries have the same classification as the mainstem except the Malad River and Box Elder Creek which are protected for non-game species (Classification 3C). In addition, the Malad River is not protected for Class 4. Numeric standards can be found in Table 4-1.

Several water quality parameters do not have numeric standards but do have water quality indicators or criteria. Total phosphorous has a criteria of 0.05 mg P/l for streams and 0.025 mg P/l for receiving waters such as lakes or reservoirs. The criteria for the state of Utah for total suspended solids is 90 mg/l.

4.2 Water Quality Assessment

In order to assess the water quality trends in the Bear River and its tributaries, an analysis was undertaken which summarized the spatial and temporal data (primarily phosphorous and total suspended solids) as monthly mean values. Data from 1990 to 2000 were used in this analysis. In addition, flows at the time of sampling were also averaged. This facilitated the calculations of daily loading for these parameters.

The hydrology data for the reach of the Bear River between Cutler Reservoir and the great Salt Lake is limited to one active aging station at Corinne. The average daily flows between 1990 and 2000 can be seen in Figure 4-1. Peak flows occur in May with the spring period (March to June) being the wettest months. Summer flow periods are low with agricultural diversions removing most of the rivers water. Following irrigation season (ending in September), base flows increase to approximately 1000 cfs. In Figure 4-2, a comparison of the 10 year period used in the water quality analysis is made to the annual yield percent exceedence data. It is evident that this 10 year period includes a wide range of flows.

Inspection of the water quality data relative to the numeric standards based upon established beneficial uses as well as the state of Utah’s criteria for total phosphorous and total suspended solids, indicates that several parameters commonly exceed the water quality targets established for the lower Bear River and its tributaries. A summary is provided in Table 4-2. Although dissolved oxygen and temperature exceed standards six to ten percent of the time in mainstem and tributary sites, total suspended solids (37%), and total phosphorous (93%) exceed criteria most often.

Utilizing the entire historical database, average monthly flows at the time of sampling, as well as the average monthly concentrations of TSS and TP, were determined and plotted against the established criteria (Figure 4-3). As with Table 4-2, it is evident that phosphorous concentrations are exceeded at every Bear River site in every month. In general, TSS exceeds criteria during spring runoff and summer base flows.

Table 4-1. A summary of established beneficial uses and applicable standards or criteria for stream segments in the lower Bear River.

	BENEFICIAL USE [(1)]		
	Class 2	**Class 3**	**Class 4**
Bear River and tributaries, from Great Salt Lake to Utah-Idaho border	2B	3B and 3D	4
Malad River and tributaries, from confluence with Bear River to state line	2B	3C	
Box Elder Creek from confluence with Black Slough to Brigham City Reservoir (the Mayor's Pond)	2B	3C	4
Box Elder Creek, from Brigham City Reservoir (the Mayor's Pond) to headwaters	2B	3A	4

STANDARDS OR CRITERIA

TSS, mg/L	Phosphorus, mg/L	Temperature, °C	pH, SU	Dissolved Oxygen, mg/L
Class 3B: <90	into stream: <0.05	Class 3B: <27	6.5 - 9.5	>6.50
Class 3A: <35	into reservoir: <0.025	Class 3A: <20		

[(1)] ***Class 2 -- Protected for recreational use and aesthetics.***

b. Class 2B -- Protected for secondary contact recreation such as boating, wading, or similar uses.

Class 3 -- Protected for use by aquatic wildlife.

a. Class 3A -- Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.

b. Class 3B -- Protected for warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain.

c. Class 3C -- Protected for nongame fish and other aquatic life, including the necessary aquatic organisms in their food chain.

d. Class 3D -- Protected for waterfowl, shore birds and other water-oriented wildlife not included in Classes 3A, 3B, or 3C, including the necessary aquatic organisms in their food chain.

Class 4 -- Protected for agricultural uses including irrigation of crops and stock watering.

Table 4-2. The percent exceedence of water quality standards or criteria for the mainstem Bear River and watershed tributaries between Cutler Reservoir and the Great Salt Lake.

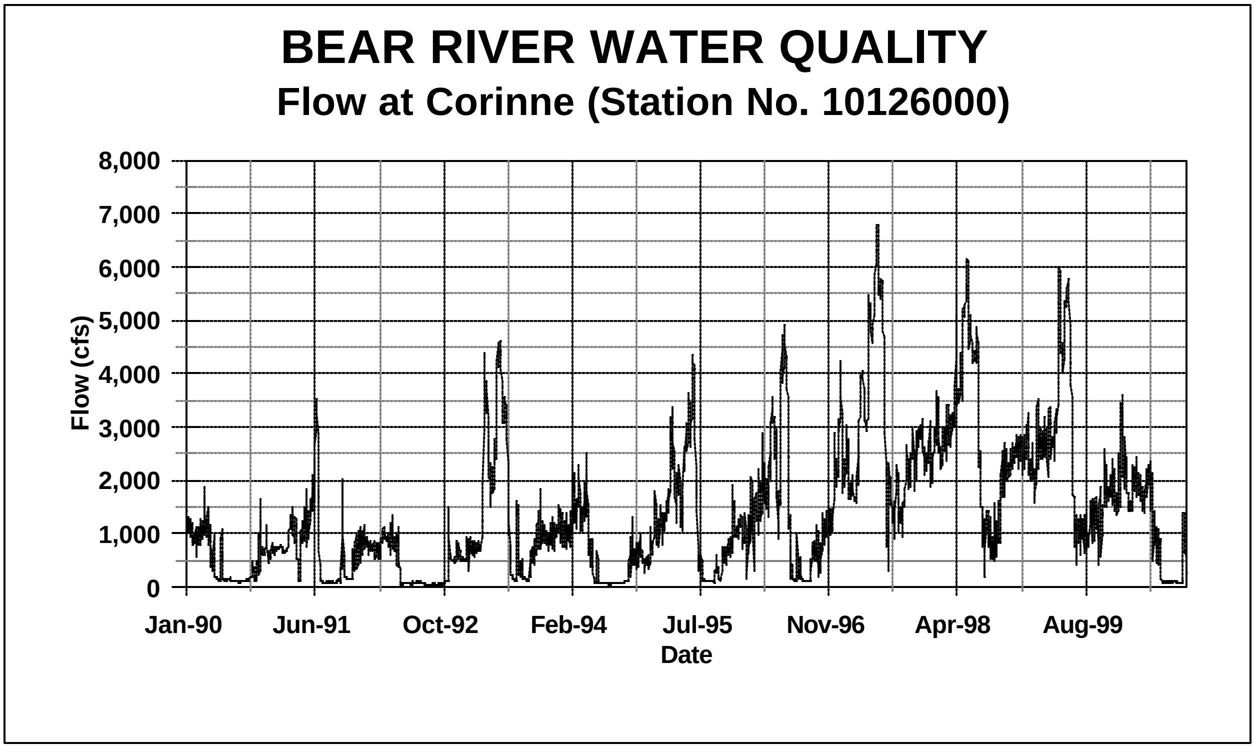
STATION # and DESCRIPTION		Dissolved Oxygen	pH	Temperature	TSS	NH3	NO3+NO2	OP	TP
	Criteria or Standard:	***<6.5 mg/L***	***<6.5 or >9.5***	*>27°C*	***>90 mg/L***	***>4** mg/L*	***>4** mg/L*	***>0.05** mg/L*	***>0.05 mg/L***
MAINSTEM SITES									
490198	Bear R Bl Cutler Res at UPL Bridge	6.7%	0.9%	0.0%	20.8%	0.0%	0.0%	53.5%	93.8%
490179	Bear R. at Hampton's Ford Xing	11.1%	0.0%	0.0%	15.0%	0.0%			78.9%
490170	Bear R at I-15 2 Mi Ne of Honeyville	4.8%	0.0%	0.0%	23.5%	0.0%	0.0%	50.0%	94.6%
10118000	Bear R Nr Collinston			2.0%					
490145	Bear R Ab Cnfl/ Malad	0.0%	1.5%	0.0%	35.2%	0.0%			94.7%
490144	Bear River Bl Cnfl/ Malad		0.8%	0.0%	40.3%				94.9%
490142	Bear R Bl Salt Creek	25.0%	0.6%	0.0%	38.7%	0.0%			93.5%
490115	Bear R Ab Corinne Lagoons		0.0%	0.0%	75.0%	0.0%			
490110	Bear R near Corinne at U83 Xing	7.1%	0.0%	0.5%	39.9%	0.0%	0.0%	56.2%	98.5%
10126000	Bear R Nr Corinne	3.2%	0.8%	0.0%		0.0%	0.0%	41.8%	92.7%
490160	Bear R S of Bear R City	0.0%	0.0%	0.0%	50.0%	0.0%	0.0%	50.0%	100.0%
	AVERAGE:	**7.2%**	**0.5%**	**0.2%**	**37.6%**	**0.0%**	**0.0%**	**50.3%**	**93.5%**
TRIBUTARY SITES									
490056	Pump Station Ab Mantua Res	42.9%	0.0%	0.0%	0.0%	7.1%	0.0%	92.9%	100.0%
490117	Blacks Slough Ab Cnfl/ Box Elder ck	38.5%	0.0%	0.0%	0.0%	0.0%	0.0%	9.1%	53.8%
490141	Reeder Overflow Canal @ Rd Xing		0.0%	0.0%	47.9%				97.6%
490118	Box Elder Ck Bl Brigham WWTP	10.8%	0.0%	0.0%	7.1%	0.0%	0.0%	100.0%	92.3%
490055	Bunderson Spring	33.3%	0.0%	0.0%	0.0%	0.0%	0.0%	11.1%	22.2%
490119	Box Elder Ck Ab Brigham City WWTP	1.6%	0.9%	0.0%	2.4%	0.0%	0.0%	50.0%	63.2%

Table 4-2 (continued). The percent exceedence of water quality standards or criteria for the mainstem Bear River and watershed tributaries between Cutler Reservoir and the Great Salt Lake.

STATION # and DESCRIPTION		Dissolved Oxygen	pH	Temperature	TSS	NH3	NO3+NO2	OP	TP
	Criteria or Standard:	*<6.5 mg/L*	*<6.5 or >9.5*	*>27°C*	*>90 mg/L*	*>4 mg/L*	*>4 mg/L*	*>0.05 mg/L*	*>0.05 mg/L*
TRIBUTARY SITES (continued)									
490053	West Flow from Maple Springs	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	16.7%
490146	Malad R Ab Cnfl/ Bear r	0.0%	0.0%	0.0%	60.2%	0.0%			100.0%
490047	Dam Ck Ab Mantua Res	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.1%	10.0%
490051	Maple Ck Ab Res	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	25.0%	75.0%
490121	Box Elder Ck Bl Brigham City Wwtp	50.0%	3.4%	0.0%	0.0%	9.1%			100.0%
490193	Hammond Main Canal at Bridge	11.1%	0.0%	0.0%	20.0%	0.0%			100.0%
490194	Corrine Canal @ U30 Xing		0.0%	0.0%	0.0%	0.0%			100.0%
490195	West Side Cnl Bl Cutler Res	28.6%	0.0%	0.0%	25.0%	0.0%			100.0%
490140	Reeder Canal Ab Bear R Bird Refuge	0.0%	0.0%	7.4%	41.4%	0.0%			92.3%
490200	Malad R S of Bear R City	11.1%	11.1%	5.6%	58.8%	0.0%	0.0%	76.9%	100.0%
490204	Malad R Ab Bear R City Lagoons	12.0%	20.0%	8.0%	60.0%	0.0%			
490272	Malad R Ab Tremonton Wwtp	23.1%	17.6%	5.8%	56.3%	0.0%	16.7%	68.0%	89.3%
490290	Malad R S of Plymouth at U191 Xing	0.0%	0.0%	0.0%	41.7%	0.0%	0.0%	10.0%	91.7%
490294	Malad River East of Portage	7.7%	0.0%	0.0%	41.7%	0.0%	0.0%	9.1%	92.3%
490042	Big Ck Bl Mantua Res	38.9%	0.0%	0.0%	0.0%	0.0%	0.0%	26.7%	72.2%
490143	Salt Creek Ab Cnfl/ Bear River		0.0%	0.0%	26.9%				66.7%
490125 *	Box Elder Ck Ab Diversion	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	AVERAGE:	**15.5%**	**2.3%**	**1.2%**	**21.3%**	**0.8%**	**1.2%**	**35.0%**	**74.3%**

**Class 3A, protected for coldwater species (temperature must remain greater than 20°C)*

Table 4-2 (continued). The percent exceedence of water quality standards or criteria for the mainstem Bear River and watershed tributaries between Cutler Reservoir and the Great Salt Lake.



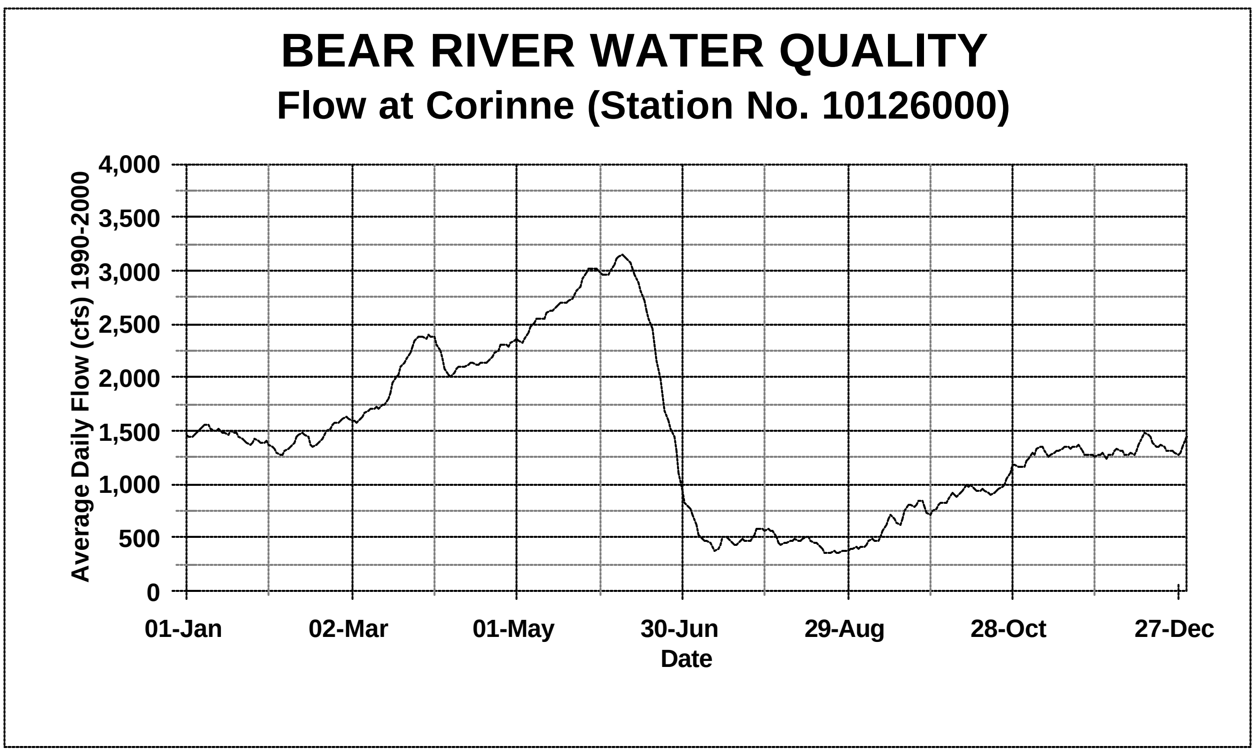


Figure 4-1. The flows in the Bear River at Corinne (Station No. 10126000) for the period of record (above) and the daily average for the 10 year period (below).

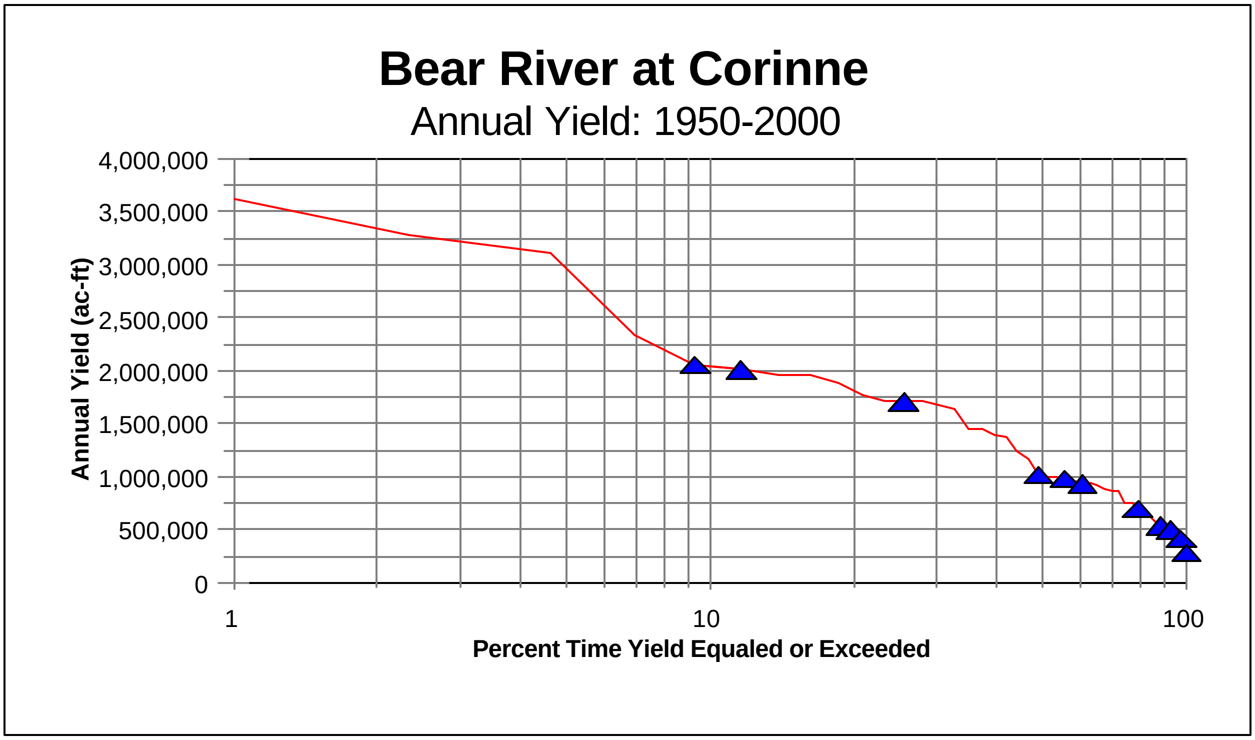


Figure 4-2. The annual flow yield exceedence curve with the ten years (1990-2000) of water quality data plotted as a comparison.

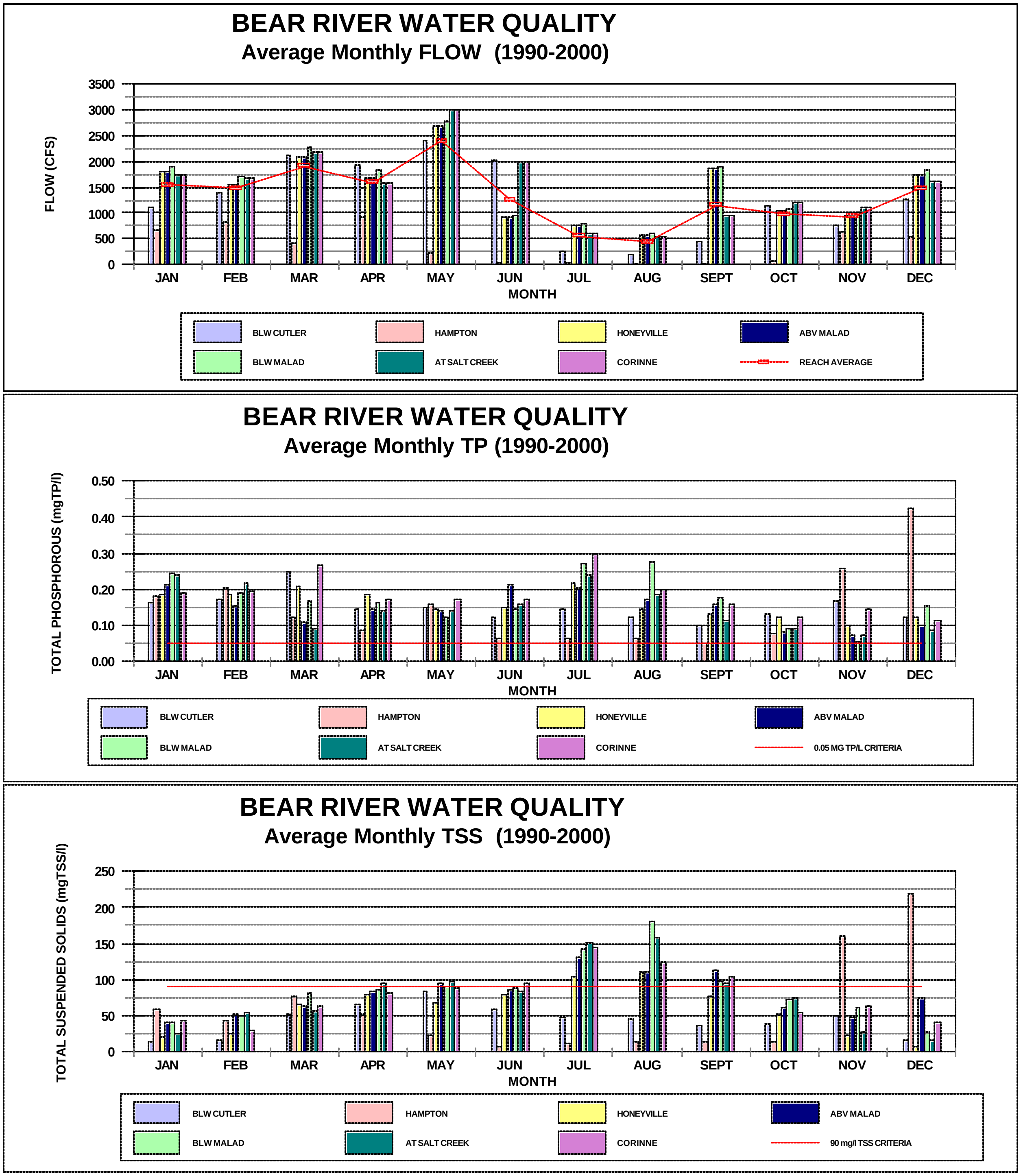
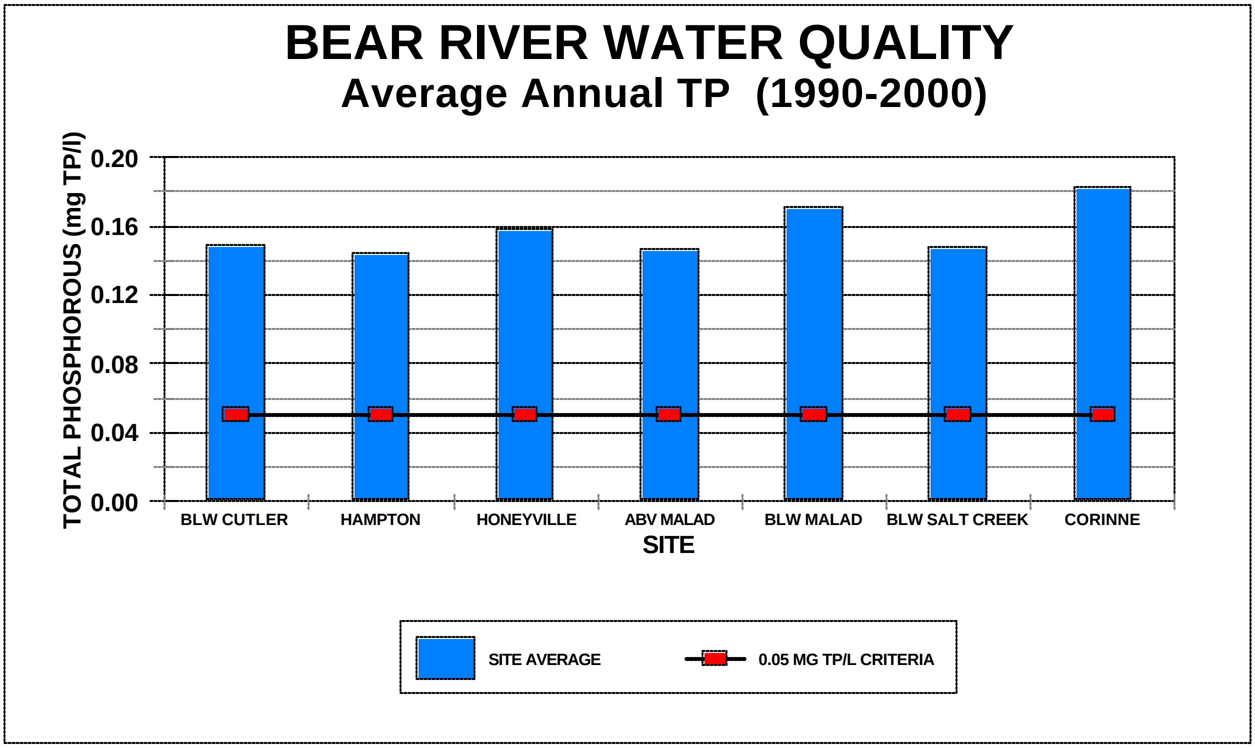


Figure 4-3. The average monthly flows (upper), total phosphorous concentrations (middle) and total suspended solids concentrations (lower) for six mainstem Bear River sites based upon the available historical data from 1990-2000.



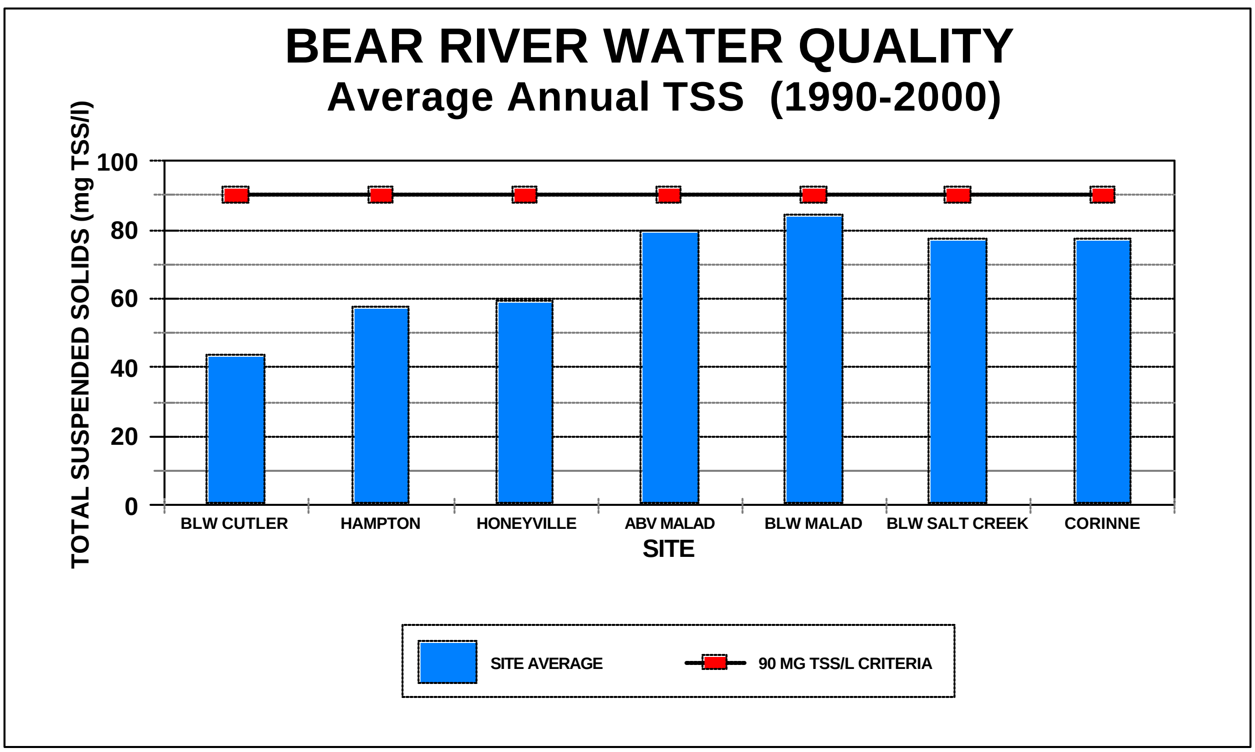


Figure 4-4. The overall 10 year average for total phosphorous (above) and total suspended solids (below) for six mainstem sites in the Bear River. Data are compared to state of Utah water quality criteria.

For each of the six mainstem Bear River sites, an overall average of the entire period was calculated and compared between sites. The results can be seen in Figure 4-4. It is evident that the concentration of total phosphorus in the Bear River is never, on average, less than 0.14 mg P/liter compared to the criteria of 0.05 mg P/l. No spatial trend is evident. A comparison of the same sites for total suspended solids indicated an increasing trend in solids in the river. The first site on the Bear River to approach the 90 mg/l criteria for TSS was the station immediately above the Malad River confluence (Figure 4-4). On average, no station exceeded the TSS criteria.

In addition to the historical data, the synoptic data collected during the four hydrologic time periods was also analyzed in the same manner. The results, shown in Figure 4-5, have the same pattern as noted previously, with total phosphorous exceeding criteria at all stations and suspended solids exceeding criteria at lower stations.

Data from four tributaries were also summarized for the period 1990-2000. The results of this summary is shown in Figures 4-6 through 4-9. Black Slough and Salt Creek had only limited amounts of data and did not appear to exceed criteria for TP or TSS with any regularity. However, Box Elder Creek and the Malad River did exceed the total phosphorous pollution indicator in a majority of the months. In Box Elder Creek, the impact of the discharge of the Brigham City wastewater treatment facility is clearly evident. The Malad River was the only tributary to exceed the 90 mg/l TSS criteria. This could contribute to the increase in TSS concentrations with distance downstream.

The Malad River was also sampled intensively as part of the synoptic surveys previously described. The results of those surveys can be seen in Figure 4-10.The data indicates that in three out of four sample periods large increases in both suspended solids and phosphorous occurred in the lower portion of the stream course.

4.3 Nonpoint Source

4.3.1 Overview

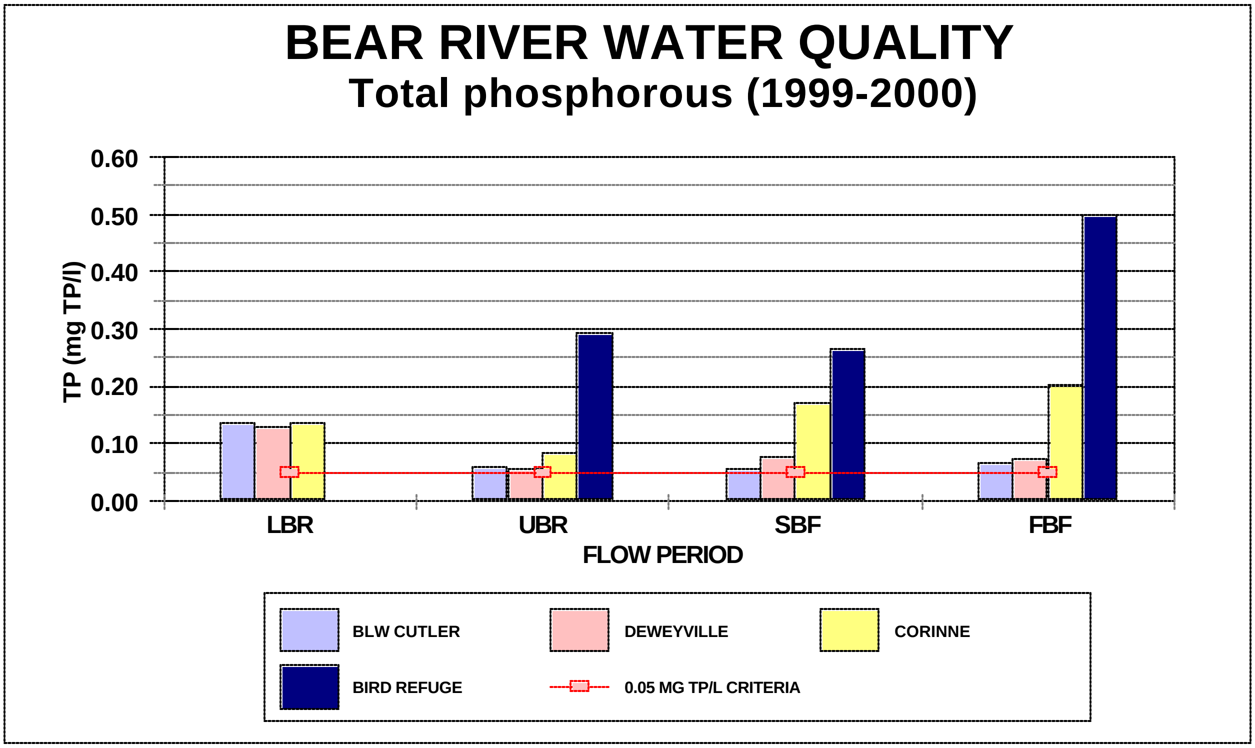
Nonpoint source pollution is usually associated with large, watershed scale impacts caused by land use activities. In some cases, specific alterations of the riparian zone adjacent to the stream has resulted in increased erosion to the stream bank. Nonpoint source pollution is difficult to quantify and is usually defined using a mass balance approach. In this analysis, nonpoint source is the amount calculated to balance the equations. By necessity, this approach must define and quantify all other sources (upstream, point sources and tributary inputs). It should be noted that the nonpoint source term also is the cumulative error in the equation.

4.3.2 Pollutants

In the lower Bear River, the most dominant nonpoint source pollutant is phosphorous and total suspended solids.

4.3.3 Agricultural Return Flows

As part of this project, the amount of agricultural land use was quantified using mapping data provided by the GAP analysis merged with state of Utah data. The results of this mapping can be seen in Figure 4-11 and represent the best available data. In addition, the data are provided in tabular form in Table 4-3.



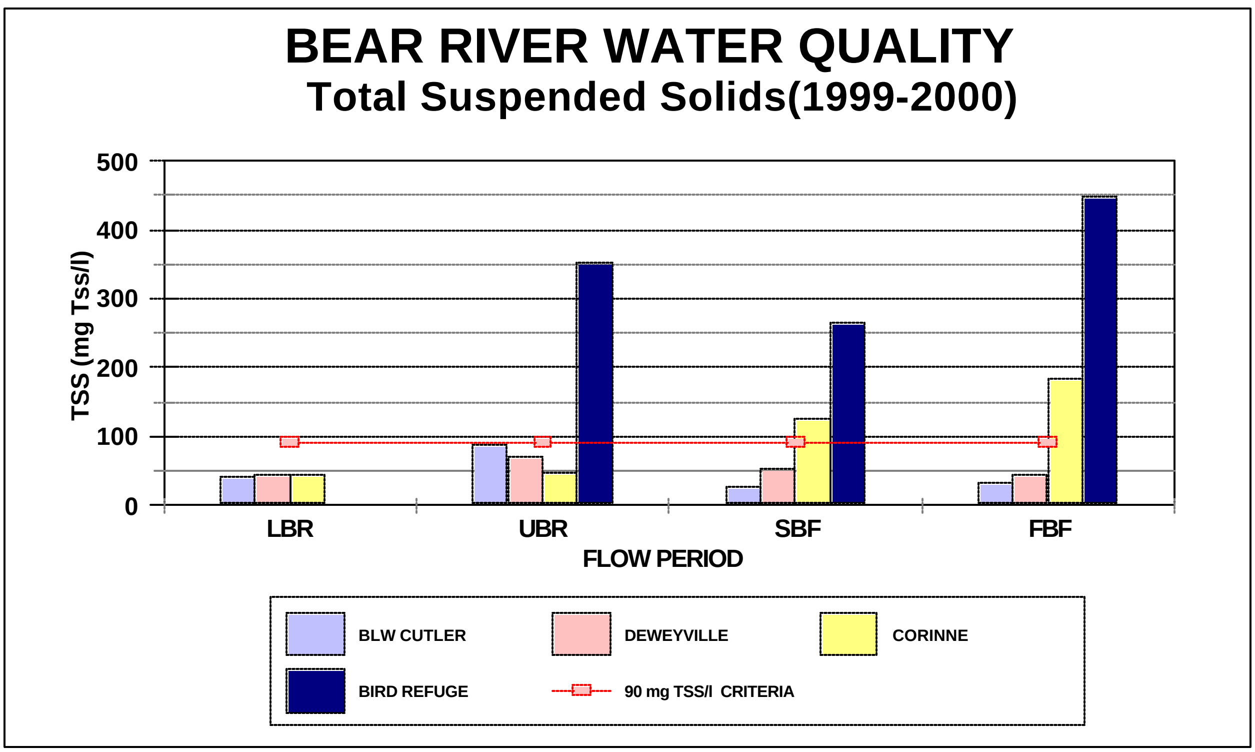
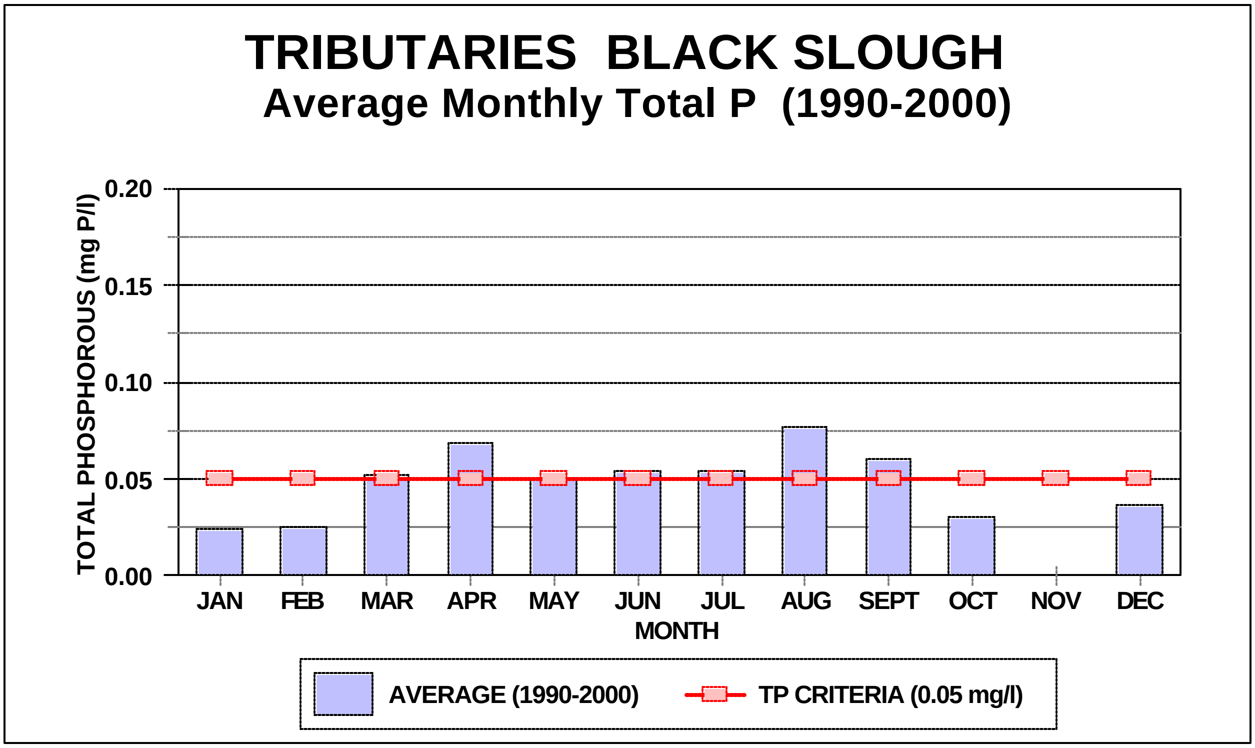


Figure 4-5. The results of the synoptic survey conducted in 1999-2000. LBR= Lower basin runoff; UBR= Upper basin runoff; SBF= Summer baseflow; FBF= Fall baseflow. Criteria is an indicator not a standard.



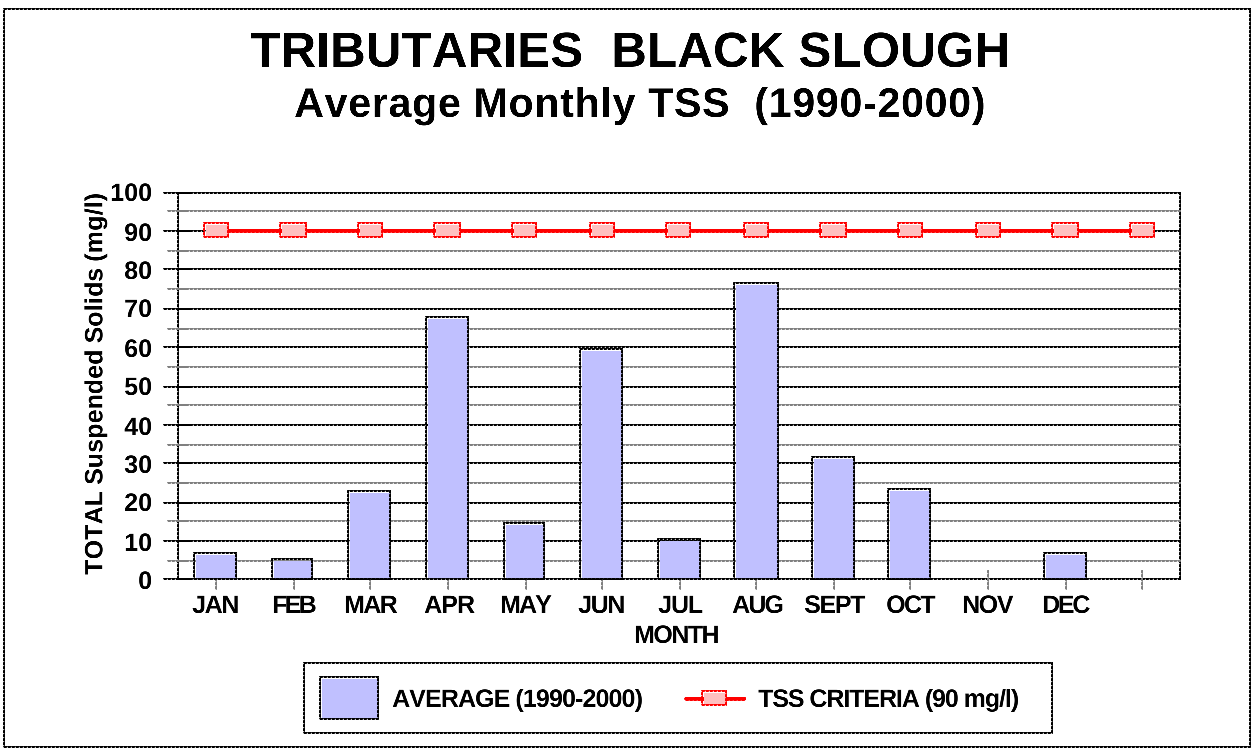
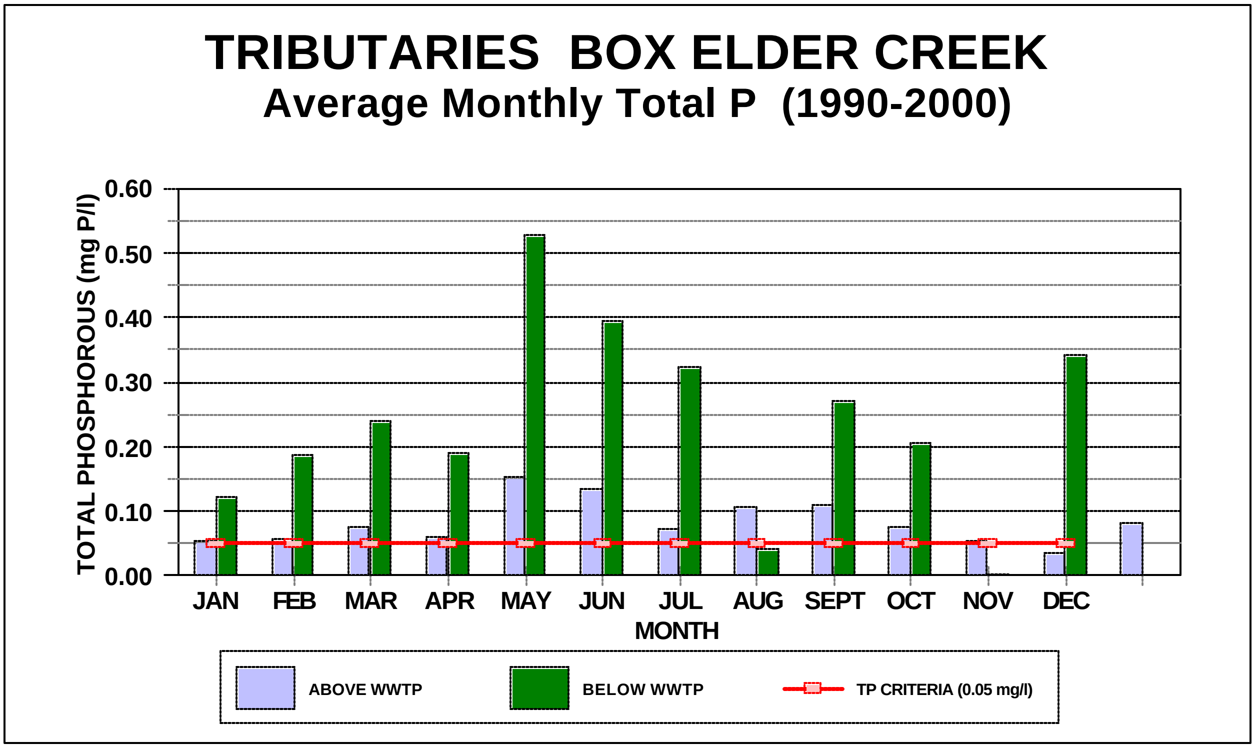


Figure 4-6. The average monthly concentrations of total phosphorous (above) and total suspended solids (below) in Black Slough. Criteria is an indicator not a standard.



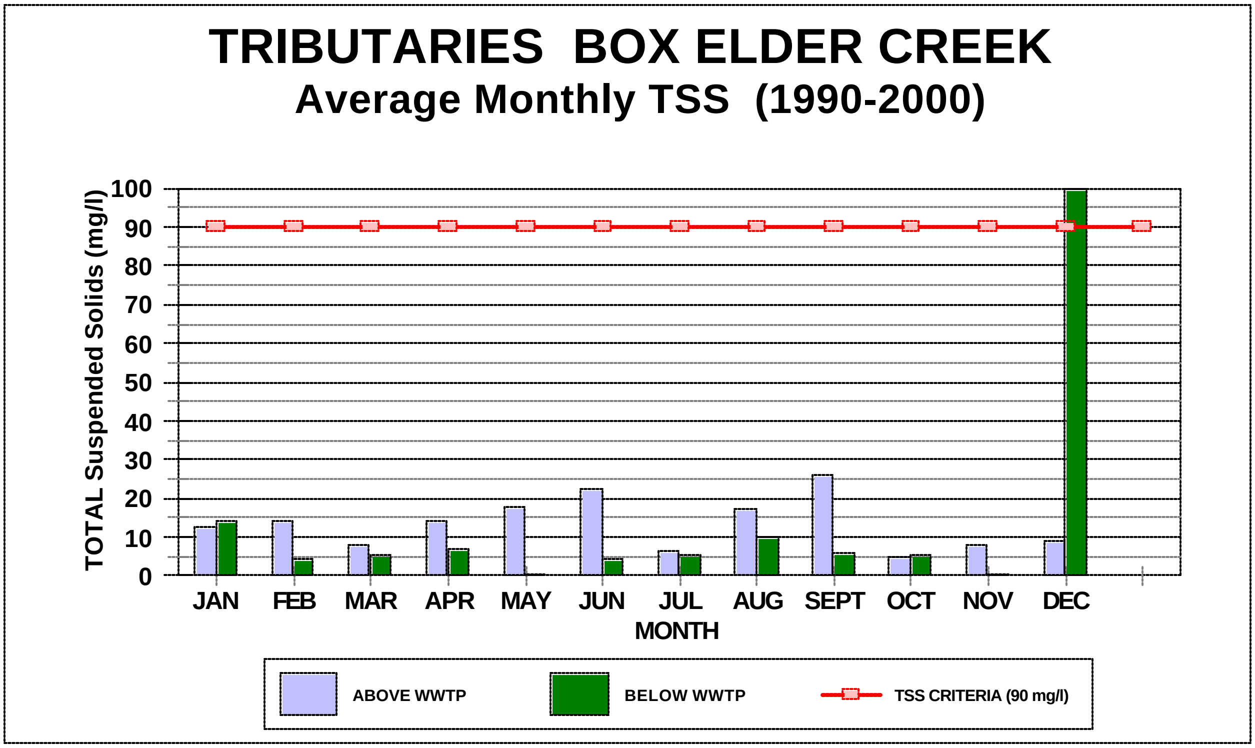
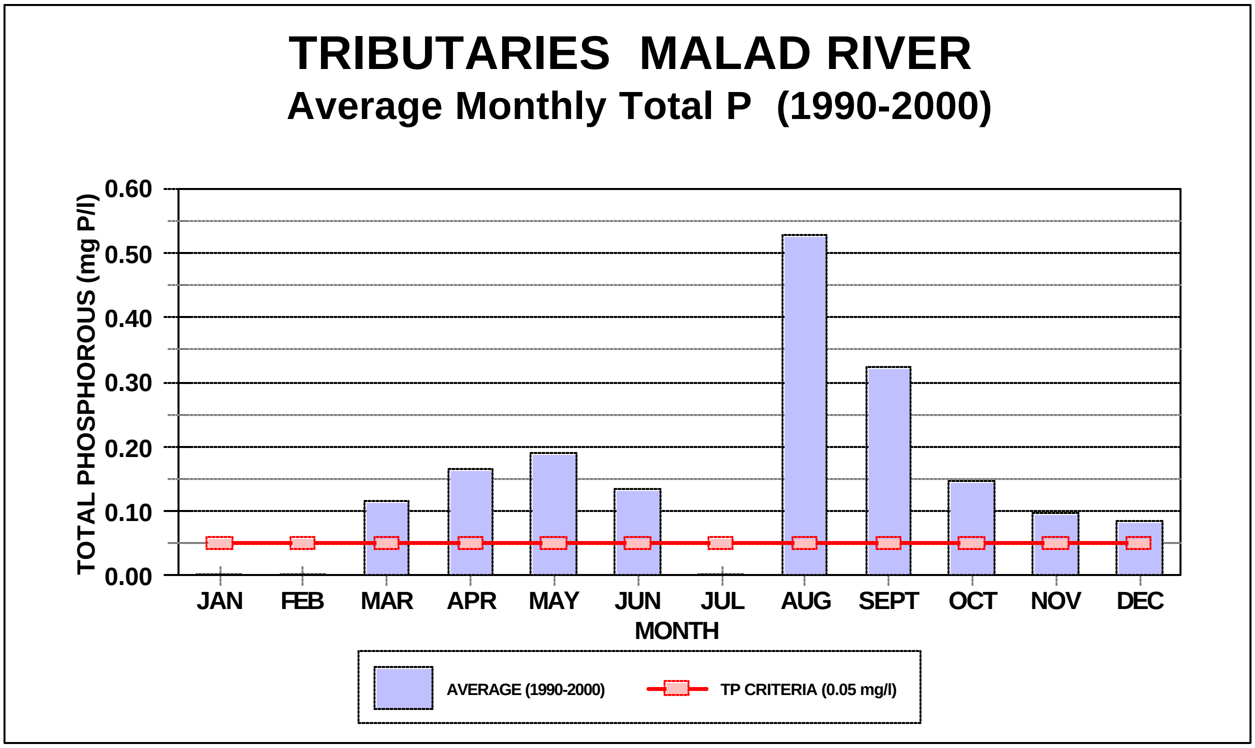


Figure 4-7. The average monthly concentrations of total phosphorous (above) and total suspended solids (below) in Box Elder Creek. Criteria is an indicator not a standard.



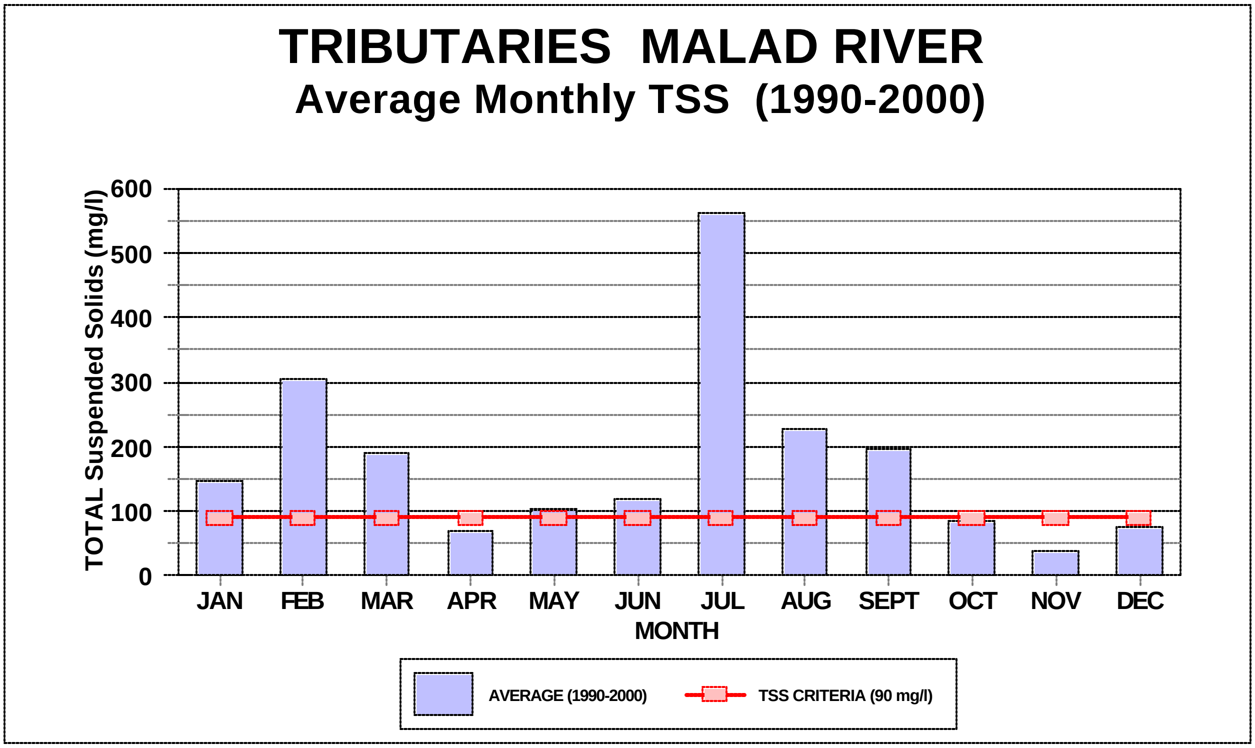
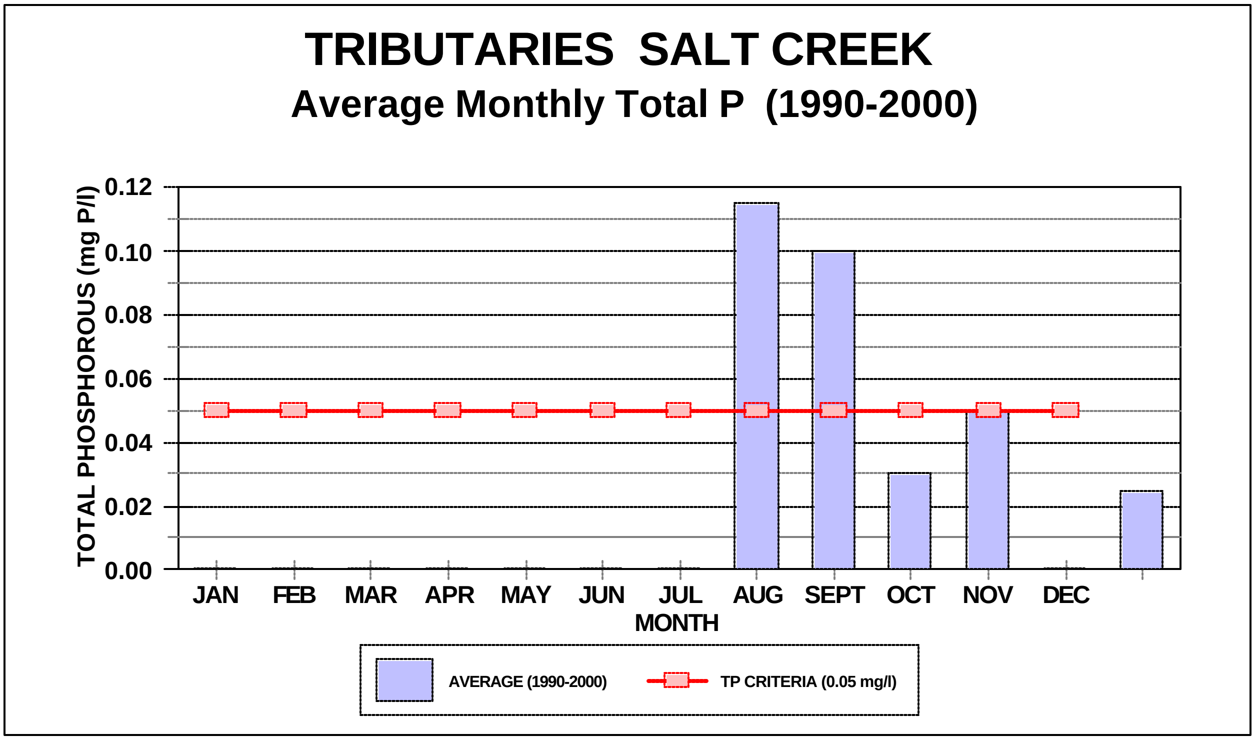


Figure 4-8. The average monthly concentrations of total phosphorous (above) and total suspended solids (below) in the Malad River. Criteria is an indicator not a standard.



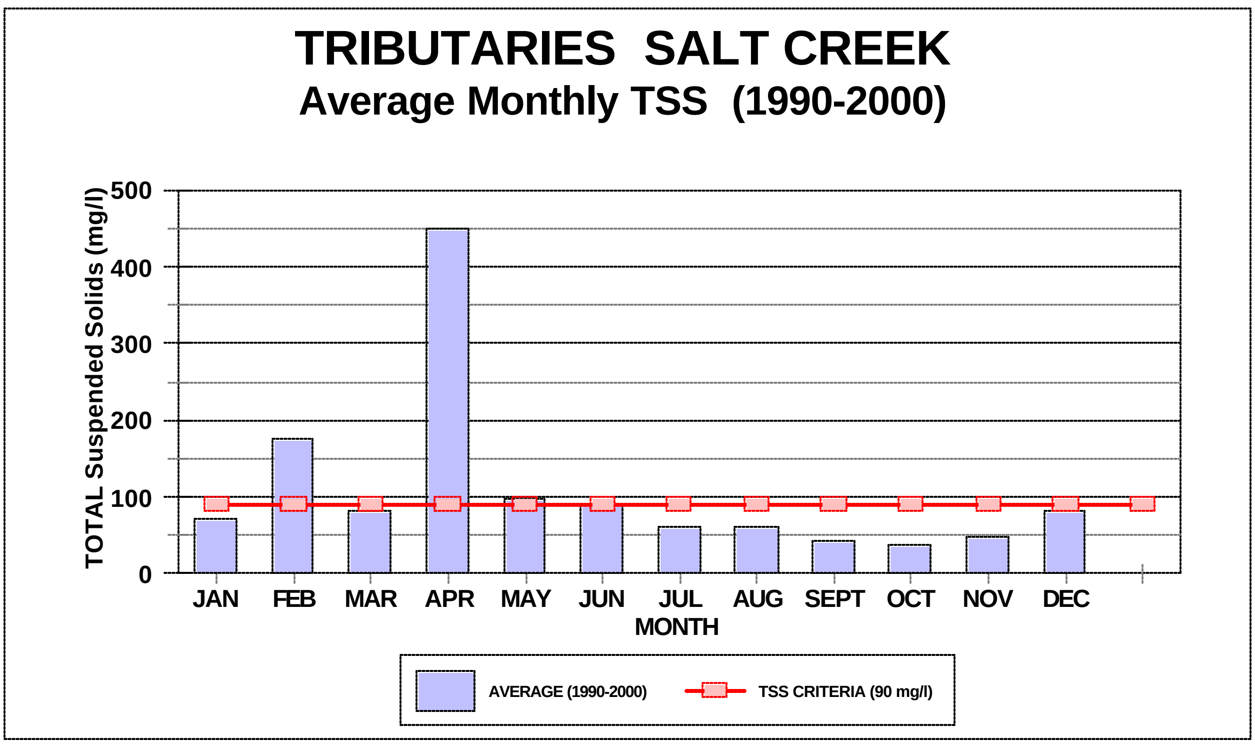
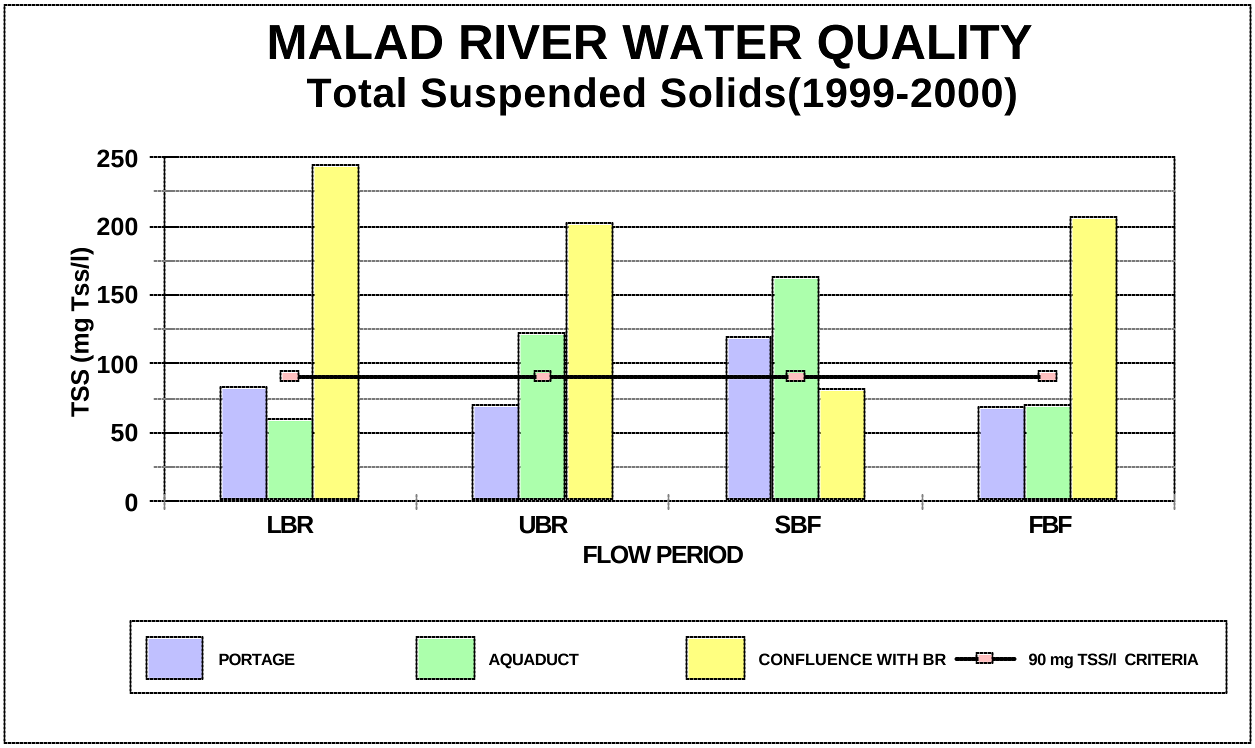


Figure 4-9. The average monthly concentrations of total phosphorous (above) and total suspended solids (below) in Salt Creek. Criteria is an indicator not a standard.



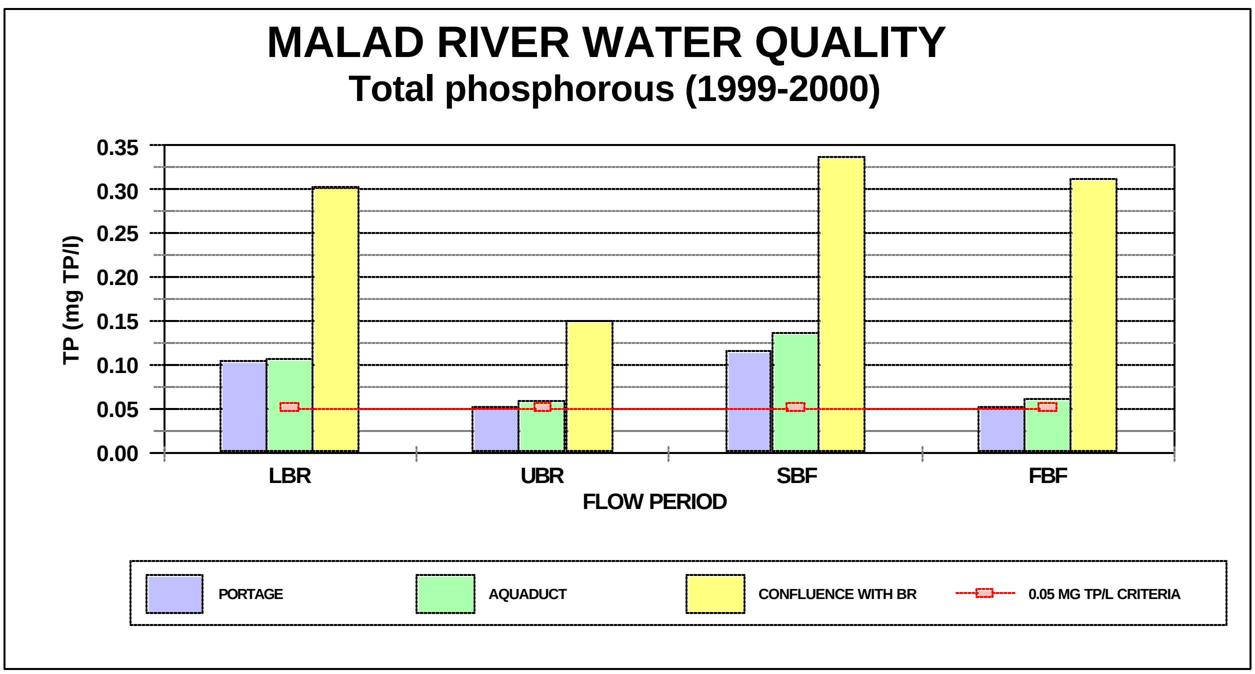


Figure 4-10. The results of the synoptic survey conducted in 1999-2000. LBR= Lower basin runoff; UBR= Upper basin runoff; SBF= Summer baseflow; FBF= Fall baseflow. Criteria is an indicator not a standard.

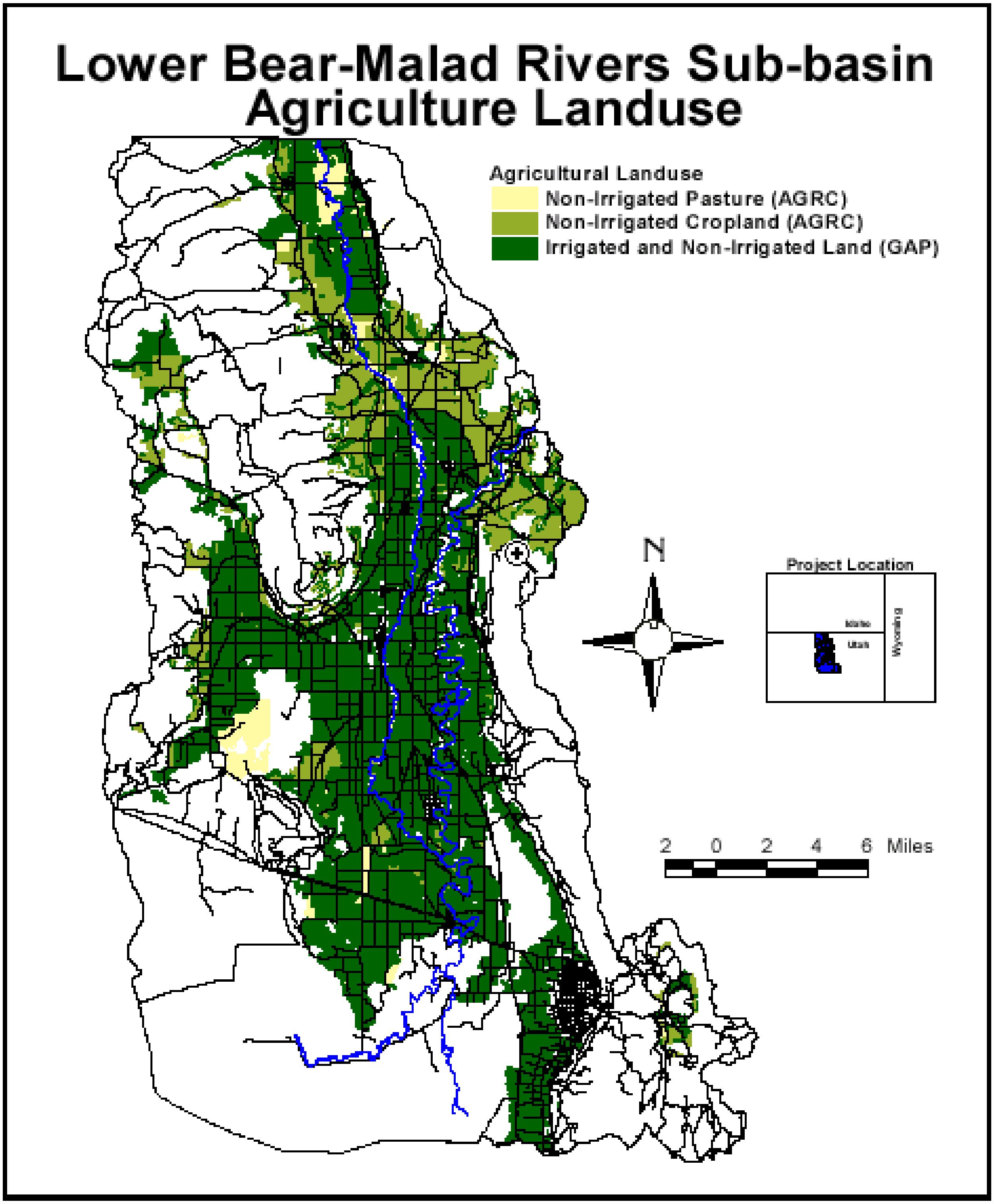


Figure 4-11. A map illustrating lower Bear/Malad River agricultural lands.

Table 4-3. A summary of agricultural lands in the lower Bear River project area. All values are in acres. See Figure 2-2 for locations of sub-watersheds.

Sub-basin and Sub-watershed	Agricultural Land Use
Malad River:	
1. Idaho border to flume crossing	18,572
2. West Hills	5,459
3. Clarkston Mountains	1,978
Subtotal	***26,009***
4. Flume crossing (H-191) to confluence Bear River	29,348
5. West Hills	3,291
6. Clarkston Mountains	3,298
Subtotal	***35,936***
MALAD RIVER TOTAL	**61,945**
Lower Bear River:	
7. Cutler Dam to State Road 83	35,665
8. Clarkston Mountains	688
9. Wellsville Mountains	6,426
Subtotal	***42,778***
10. SR 83 to discharge into Great Salt Lake	21,968
11. Wellsville and Wasatch Mountains	1,623
Subtotal	***23,591***
LOWER BEAR RIVER TOTAL	**66,369**
Thatcher/Penrose Area	
12. Thatcher/Penrose	22,936
13. Little Mountain	0
14. Blue Spring Hills	8,989
THATCHER/PENROSE TOTAL	**31,925**

Associated with agricultural activities in the lower Bear River, are irrigation return flows. These flows represent three types of sources: 1) water applied to crops which is considered excess and is returned to the river via overland flow; 2) water which remains in the canal system and never used for irrigation; and 3) water which percolates through the soil, is collected in drains and returned to the river. Because it was felt that this region of the Bear River would be influenced by irrigation return flows, an attempt was made to characterize these return flow types. The water quality results which characterize these return flow types can be seen in Table 4-4. In addition, the magnitude of return flows were quantified using the state of Utah's hydrologic mass balance (section 5.0).

4.3.4 Rangeland/Urban

The surface areas covered by rangeland and urban developments can be seen in Figure 2-4. Urban sites tend to be located in the valley bottoms while rangelands are in upland areas.

4.3.5 Feedlots

Feedlots or confined cattle feeding operations may be considered point or nonpoint sources. The location of these facilities within the Bear River basin can be seen in Figure 4-12. In total, there are approximately 350 animal feeding operations within the study area. There are approximately 9,100 cattle in the floodplain of the lower Malad and 6,800 cattle in the floodplain of the Bear River. A total of 18 CAFO/AFOs are within 500 feet of these streams.

According to1997 Census of Agriculture the following number of livestock were reported in Box Elder county. In addition to the numbers in the following chart, it should be noted that in the report a total of 69,608 cattle and calves, and 9,075 hogs and pigs were sold in the county.

Animal reporting category	Number of animals
Cattle and calves inventory	101,522
Beef Cows	37,332
Milk Cows	8,941
Hogs and pigs inventory	3,764
Sheep and lambs inventory	70,004
Total Animals	221,563

4.3.6 Unstable Streambanks/Natural Sources

A detailed investigation was undertaken by the U.S. Bureau of Reclamation (Baxter, pers. comm.) in which the amount of unstable streambanks from below Cutler Reservoir to Corinne were documented. Between these two sites, 308,000 linear feet of streambank was inventoried. Thirty-five percent were found to be unstable with 65% (201,000 feet) being stable (Figure 4-13). During periods of high flows, unstable banks can lead to increased suspended solids and total phosphorus loading.

4.4 Point Source

Point sources are defined as the location of a pollutant discharge that can be directly measured. By definition, point sources are typically a permitted discharge. Within the lower Bear River basin, there are five permitted point source discharges. Four are waste water treatment facilities and one is an industrial source. Brigham City wastewater treatment plant discharges into Box Elder Creek which is not a tributary of the lower Bear River. It discharges into Black Slough. Although water quality data associated with this facility and Box Creek they are not included in the analysis of the TMDL for the lower Bear River information has been gatheered and analyzed as part of an overall basin plan.

4.4.1 Wastewater Treatment Plant

A summary of the wastewater treatment facilities data four the four point sources can be seen in Table 4-5. The data have been averaged by month. The averages are for the ten year period 1990-2000. Inspection of Table 4-5 indicates that the total phosphorous data for these facilities is indicative of discharge concentrations at similar types of facilities.

4.4.2 Other Point Sources

There was only one additional permitted point source in the lower Bear River basin. The summary of available water quality data can be seen in Table 4-5.

4.5 Macroinvertebrates/Fisheries

A description of the aquatic life in the Bear River between Cutler Dam and the Great Salt Lake is limited. The most current macroinvertebrate data (USGS 1999) was collected in August, 1999. Thirty-four individual species of benthic invertebrates were collected, however 90 percent were Hydropsyches. Chironomids, or Naidides. These families are indicators of poor water quality conditions.

A historical description of the fisheries community was developed for the relicense of the Cutler Hydroelectric project (PacifiCorp 1991). This review indicated that the most comprehensive fisheries survey of the Bear River basin from the Utah-Idaho stateline to the Bear River Bird Refuge was conducted by the Utah Division of Natural Resources (Bangerter 1965). From 1962 through 1965, stations were sampled on the Bear River and the lower reaches of tributaries entering Cutler Reservoir. The sites below Cutler Dam were documented as not having a silt or nutrient problem. Although algal blooms were noted to be a problem, water level fluctuations from power generation and irrigation were defined as the factor limiting the fishery. Walleye and largemouth bass were the most abundant species below the dam with a transition downstream to channel catfish, common carp and suckers. PacifiCorp also conducted a survey on the fish community as part of their relicense. The surveys below Cutler Dam were completed in the spring and summer of 1990. These surveys indicated that for both seasons fathead minnows made up over 90 percent of the total catch, followed by carp (8%) and channel catfish (1%). A comparison of species richness in 1962-1965 and 1990 can be seen in Table 4-6. Twelve species were present in 1962-65 with nine species found in 1990. In 1999, the USGS sampled the fisheries in the Bear River near Corinne. They found only four species in the Bear River. Gizzard shad made up 57 percent of the catch, followed by carp (40%) channel catfish (1.5%) and walleye (1.5%). It is interesting to note that gizzard shad had not been described in either 1962-1965 or 1990 (Table 4-6) but now represents over 50 percent of the total number of fish. The species richness has also been decreasing since 1965.

Table 4-4. A summary of the water quality characterization of irrigation return flows in the lower Bear River.

SITE ID	DATE	FLOW (cfs)	TEMP (°C)	pH	COND µmho/cm	DO (mg/L)	NH3 (mg/L)	NO3+NO2 (mg/L)	NO2 (mg/L)	TIN (mg/L)	TP (mg/L)	TSS (mg/L)	OP (mg/L)
OVERLAND FLOW													
DR01A	08/07/00	1.6	20.2	8.2	1051	6.7	0.05	0.81	0.02	0.86	0.15	12	0.11
DR01B	08/07/00	0.6	23.1	8.4	993	6.5	0.09	2.38	0.05	2.47	0.90	754	0.23
DR02	08/07/00	0.1	19.7	8.0	3650	3.7	0.71	3.13	0.30	3.85	0.28	36	0.20
CANAL RETURN													
DR03A	08/07/00	4.9	24.0	8.6	941	10.9	0.06	0.41	0.01	0.48	0.12	40	0.07
DR03B	08/07/00	7.7	23.5	8.6	1030	8.1	0.06	0.56	0.02	0.62	0.16	51	0.10
PT02	10/02/00	9.2	16.4	8.4	895	10.6	0.08	0.28	0.03	0.36	0.09	17	0.07
FIELD DRAIN													
PT01	10/02/00	2.2	13.3	7.8	173.8	6.2	0.09	2.21	0.05	2.30	0.10	25	0.01
PT03	10/02/00	0.2	24.9	8.3	575	6.7	1.25	1.28	0.25	2.52	0.87	197	0.56
T29	03/21/00	0.1	8.3	7.8	1889	9.4	0.03	22.86	0.01	22.89	0.19	14	0.18
T29	04/27/00	0.0	10.2	8.3	1915	10.3	0.04	22.55	0.01	22.59	0.08	1	0.17
T29	06/21/00	0.2	21.2	7.7	1207	5.3	0.44	9.25	0.22	9.69	0.09	30	0.38
T29	08/07/00	0.0	17.5	7.9	1373	6.2	0.07	11.29	0.01	11.36	0.18	8	0.15
T29	10/02/00	0.2	18.8	8.7	873	8.1	0.04	0.10	0.01	0.14	0.06	10	0.04

Table 4-5. A summary of point sources in the lower Bear River watershed. Data are for the period of record.

		Concentrations (mg/L)		Loading (kg/day)	
	FLOW (cfs)	**TP**	**TSS**	**TP**	**TSS**
CORINNE WWTP					
January	0.01	0.22	9.5	0.01	0.31
February	0.10	1.10	36.3	0.28	9.27
March	0.12	0.84	26.5	0.24	7.50
April	0.07	0.49	19.1	0.08	3.09
May	0.01	1.20	23.0	0.03	0.58
June	0.25	1.71	11.4	1.03	6.83
July	0.08	2.28	7.0	0.43	1.31
August	0.06	0.99	21.7	0.14	3.11
September	0.04	1.16	25.9	0.11	2.43
October	0.02	0.92	9.6	0.04	0.43
November	0.02	1.50	12.8	0.08	0.71
December	0.06	0.87	8.2	0.13	1.27
AVERAGE	**0.07**	**1.11**	**17.6**	**0.22**	**3.07**
BRIGHAM CITY WWTP					
January	2.72	5.19	9.1	34.51	60.50
February	2.93	4.98	10.9	35.66	77.96
March	3.26	5.80	9.1	46.20	72.36
April	3.59	5.36	10.3	46.97	90.46
May	3.31	6.26	9.1	50.67	73.51
June	3.40	4.39	14.3	36.53	119.23
July	3.36	3.96	10.0	32.54	82.23
August	4.03	4.19	8.5	41.37	83.83
September	7.85	3.73	11.8	71.59	225.99
October	3.89	4.64	8.3	44.09	78.93
November	3.08	4.93	10.3	37.13	77.60
December	3.09	4.38	6.9	33.18	52.49
AVERAGE	**3.71**	**4.82**	**9.9**	**42.54**	**91.26**

Table 4-5 (continued). A summary of point sources in the lower Bear River basin. Data are for the period of record.

		Concentrations (mg/L)		Loading (kg/day)	
	FLOW (cfs)	**TP**	**TSS**	**TP**	**TSS**
BEAR RIVER CITY WWTP					
January					
February	0.55		13.5		18.31
March		2.63	28.5		
April	0.33		20.0		16.38
May					
June	0.93	7.85	15.3	17.8	34.8
July					
August	0.69	4.49	23.7	7.56	39.86
September	0.12		6.0		1.82
October	0.46		22.0		24.88
November	0.38		18.7		17.40
December			3.0		
AVERAGE	**0.50**	**4.99**	**16.7**	**12.69**	**21.92**
TREMONTON WWTP					
January	1.39		8.3		28.39
February	0.83	6.00	2.0	12.11	4.04
March	6.34		3.0		46.55
April	1.69	3.76	2.0	15.54	8.27
May	0.77	8.65		16.37	
June	3.75	9.66	4.0	88.66	36.71
July	1.70		3.5		14.57
August	1.39	0.86	184.8	2.93	629.33
September	1.65		17.7		71.32
October	3.78	8.90	3.3	82.36	30.08
November	1.24	2.85	10.3	8.63	31.04
December	0.70	7.01	1.5	11.94	2.55
AVERAGE	**2.10**	**5.96**	**21.8**	**29.82**	**82.08**

Table 4-5 (continued). A summary of point sources in the lower Bear River basin. Data are for the period of record.

		Concentrations (mg/L)		Loading (kg/day)	
	FLOW (cfs)	**TP**	**TSS**	**TP**	**TSS**
NUCOR STEEL					
January	0.11		3.0		0.80
February	0.11		4.0		1.08
March	0.15		3.0		1.09
April	0.09		4.0		0.88
May	0.00		0.0		0.00
June	0.14		4.3		1.48
July	0.07		13.0		2.16
August	0.22		2.0		1.10
September	0.06		5.0		0.70
October	0.19		3.0		1.39
November	0.18		4.0		1.80
December	0.14		23.0		8.15
AVERAGE	**0.12**		**5.7**		**1.72**

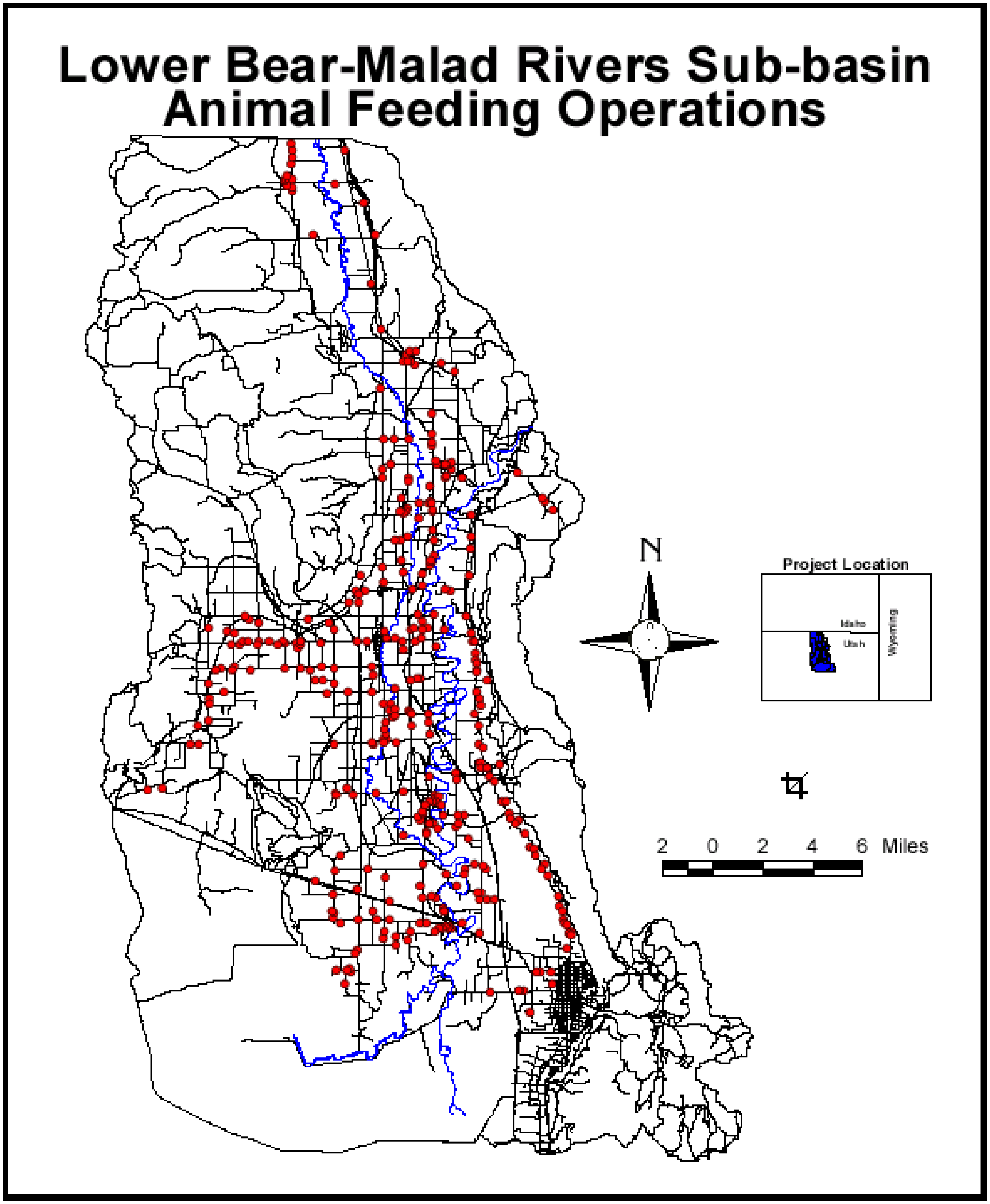


Figure 4-12. A map illustrating animal feeding operations in the lower Bear/Malad River project area.

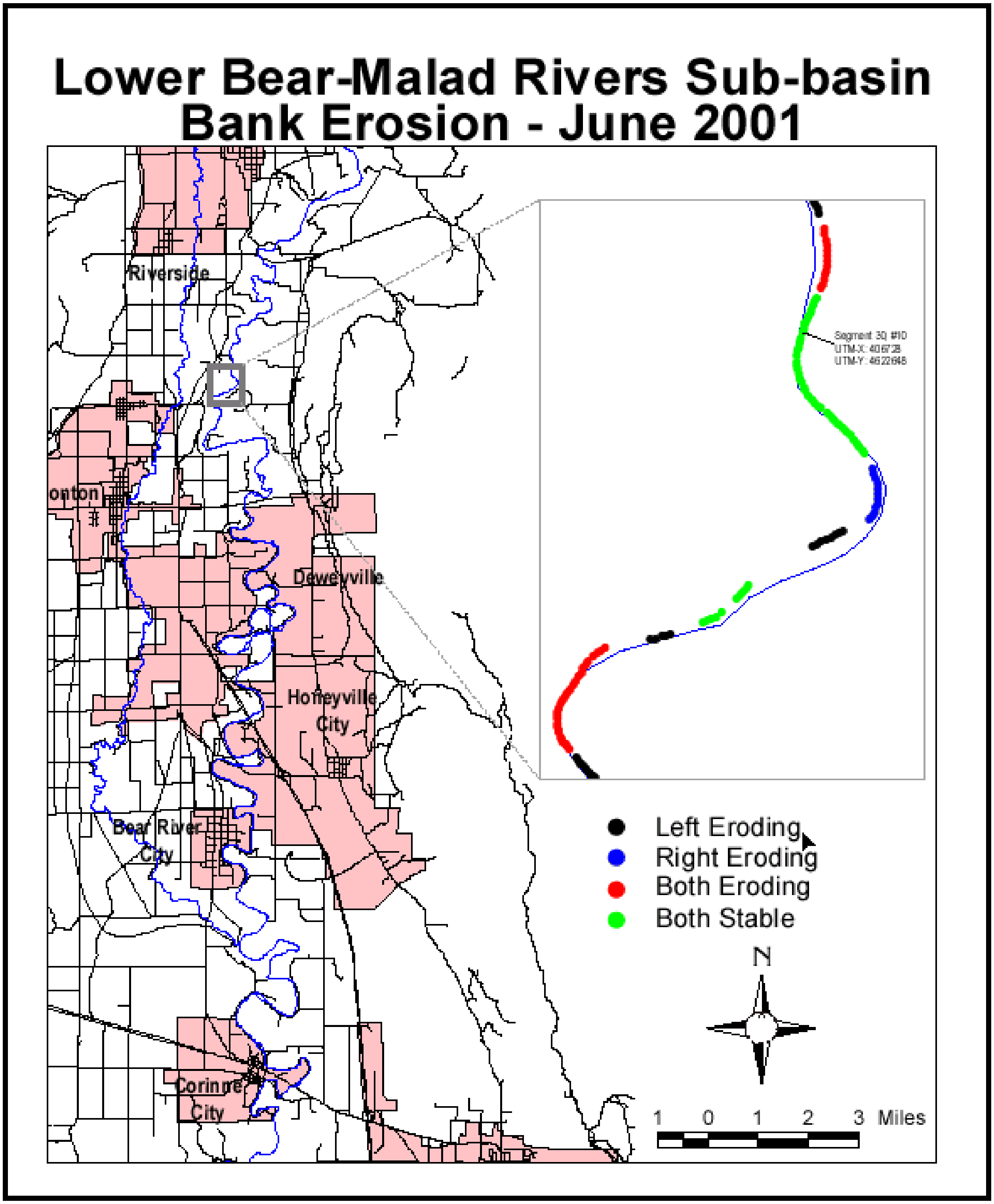


Figure 4-13. The physical state of the banks along Bear River below Cutler Reservoir. Data was gathered during June 2001.

4.6 Loading Calculations

A loading analysis was conducted on the two data sets available. These data included the historical water quality data and the synoptic sampling events conducted as part of this project. The results of this analysis can be seen in figures 4-14 through 4-18 for mainstem Bear River sites using historical data, and Figure 4-19 for the current monitoring data. Tributary loadings are shown in figures 4-20 and 4-21. The acceptable loading levels are provided based upon a 0.075 mg P/l and 90 mg/l TSS concentration.

4.7 Reach Gains/Losses

A reach/gain loss analysis is a valuable tool in the investigation of nonpoint source loadings. The reach analysis utilized the average daily loading values at the six sites previously described in Section 4.6 of this report. The data indicates that positive reach gains for total phosphorus were found between Cutler and Honeyville, above and below the Malad River, and the reach between Salt Creek and Corinne. Reach losses were found at Honeyville to above the Malad River and below the Malad River to below Salt Creek.

Total suspended solids demonstrated a different pattern with the upper three reaches exhibiting positive gains (Cutler to Honeyville, Honeyville to above Malad River, and above to below Malad River), while the two lower reaches exhibited losses (below Malad to below Salt Creek and below Salt Creek to Corinne). These results can be seen in Figure 4-22.

4.8 Water Quality Goals and Targets

The water quality targets or endpoints for the mainstem Bear River is 0.075 mg /l total phosphorus for streams. The criteria for total suspended solids has been established at 90 mg/l. This is based on the pollution indicator values or 0.05 mg/l and 90 mg/l for total phosphorus and suspended solids respectively. Target loads are determined utilizing these concentrations and the average flows for the month as defined by the hydrologic analysis.

The total phosphorus concentration of 0.075 mg/l was selected based on the following information:

- It is typically a high volume, slow moving river.
- It is the last segment of a river system that has its headwaters in Utah, but traverses north and west through Wyoming and Idaho before returning to Utah providing the opportunity for large inputs of total phosphorus as is exhibited by upstream concentrations.
- It has a significant upstream loading as is evident by the load for total phosphorus below Cutler Reservoir. Therefore before selecting a lower more stringent endpoint concentration, substantial reductions will need to occur to major sources upstream in Utah, Idaho and Wyoming.
- There is an uncertainty on establishing the threshold value for total phosphorus in this lower drainage.
- To establish a lower value would require significantly nigher costs to treat point sources. With an inadequate justification established for a lower concentration relative to point source contributions, it seems impractical to require treatment to a level that would require chemical phosphorus reduction at this time.
- An uncertainty exists relative to the control of nonpoint sources of total phosphorus. Therefore, until significant implementation of BMP's can be implemented coupled with additional loading

analysis and a more accurate determination of the threshold value of total phosphorus in this system the current endpoint of 0.075 mg/l provides an adequate target to be achieved.

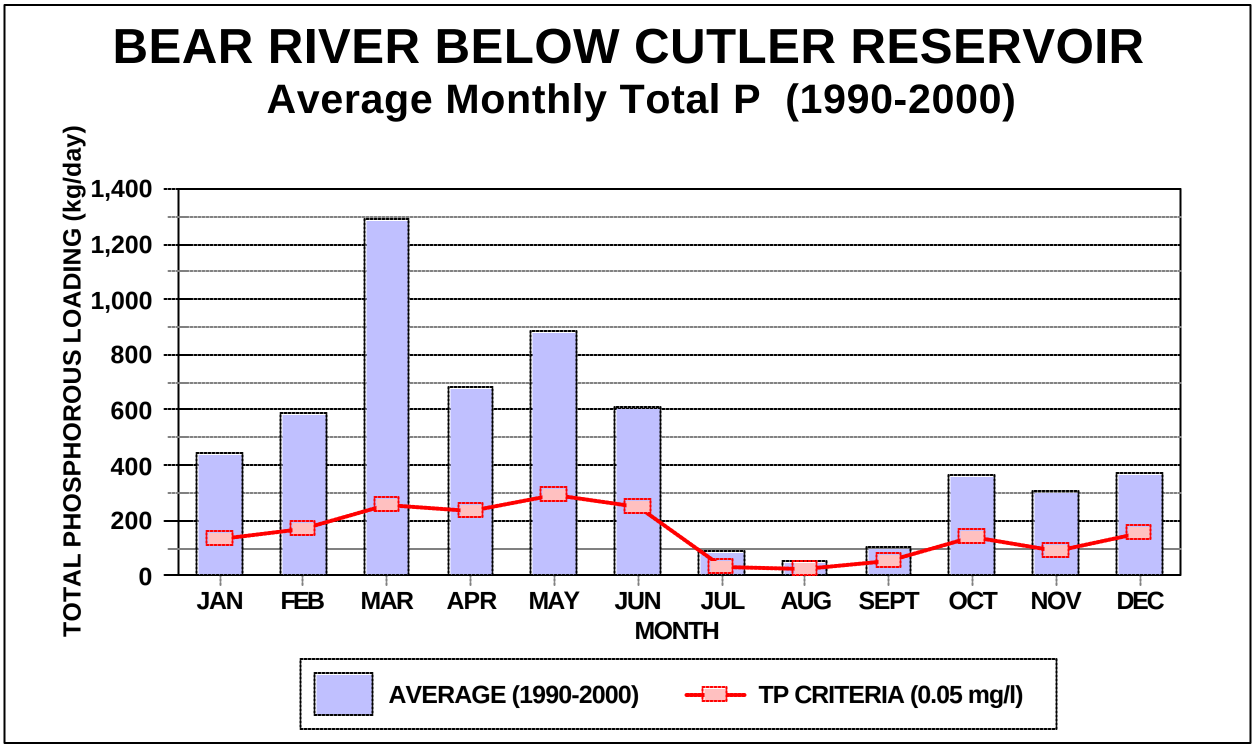
Table 4-6. The comparison of species richness between three different fish surveys below Cutler Reservoir.

	Bear River Below Cutler Dam Study Year		
Fish Species	**1965** [(1)]	**1990** [(2)]	**1999** [(3)]
carp	X	X	X
Utah chub	X		
green sunfish	X	X	
black crappie	X		
black bullhead	X		
largemouth bass	X		
channel catfish	X	X	X
walleye	X		X
whitefish	X	X	
Utah sucker	X		
Colorado sucker		X	
brown trout		X	
longnose dace	X	X	
fathead minnow		X	
redside shiner	X		
logperch		X	
gizzard shad			X
TOTAL	**12**	**9**	**4**

[(1)] Bangerter, 1965

[(2)] PacifiCorp, 1990 (Exhibit E, FERC Relicense)

[(3)] USGS 1999 (unpublished)



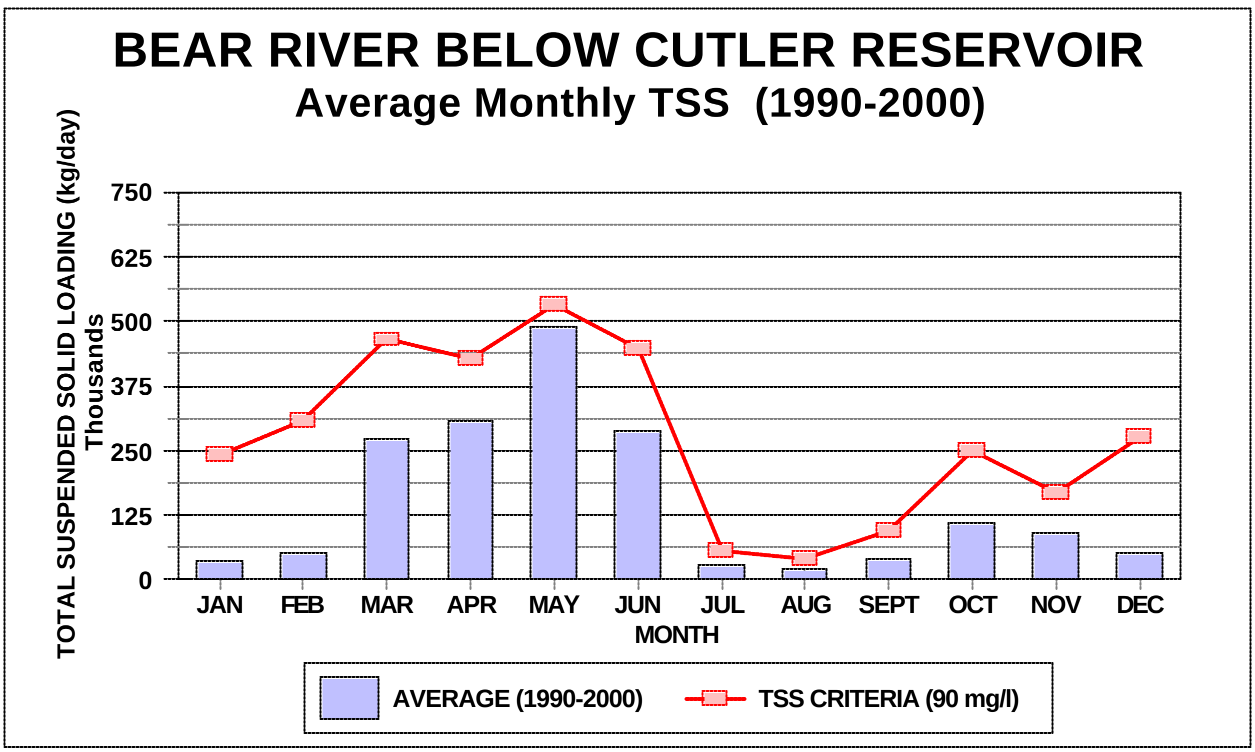
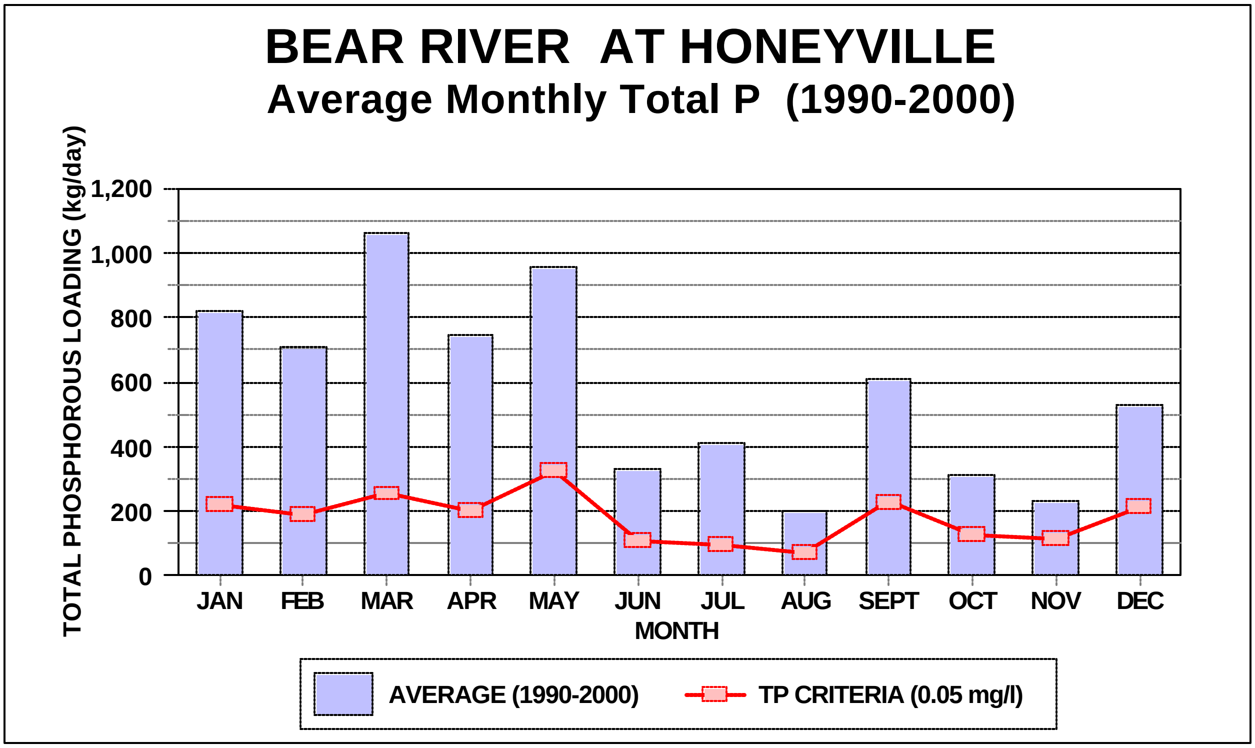


Figure 4-14. The average monthly total phosphorus (above) and total suspended solids (below) loading compared to the state of Utah criteria for the Bear River below Cutler Reservoir (Storet# 490198). Data are from 1990-2000. Criteria are indicator values and not a standard.



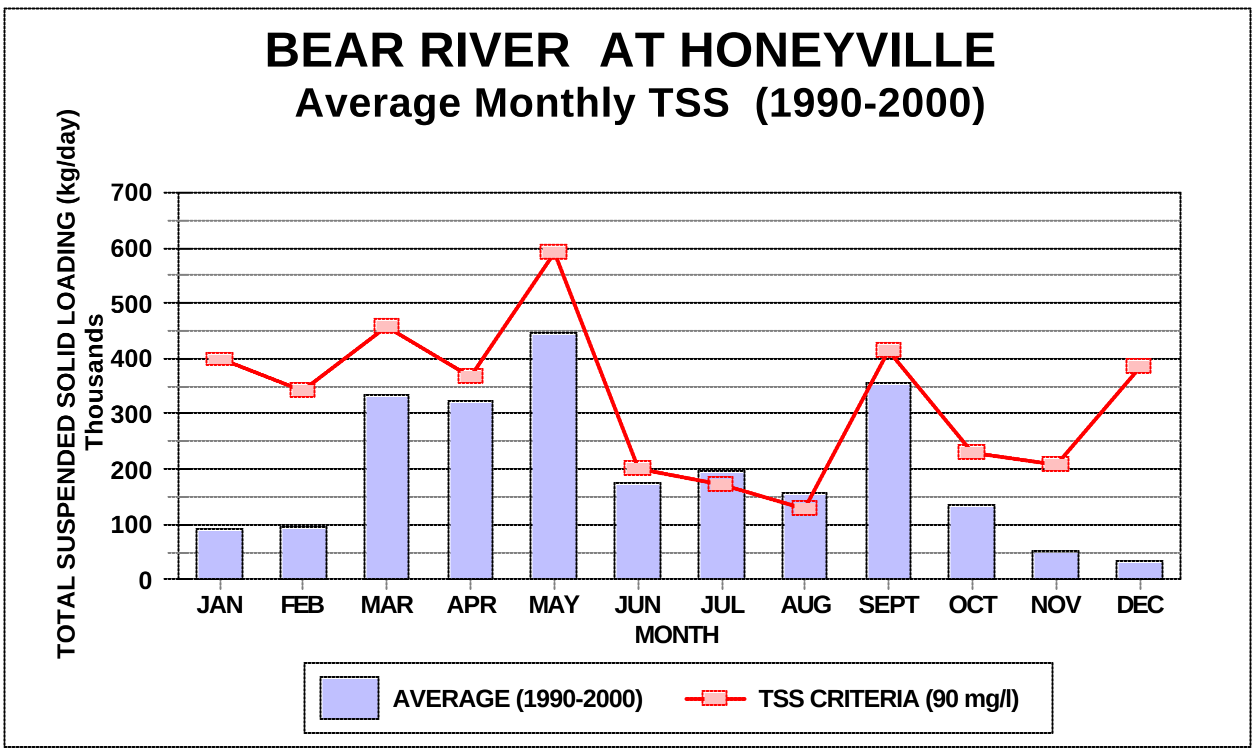
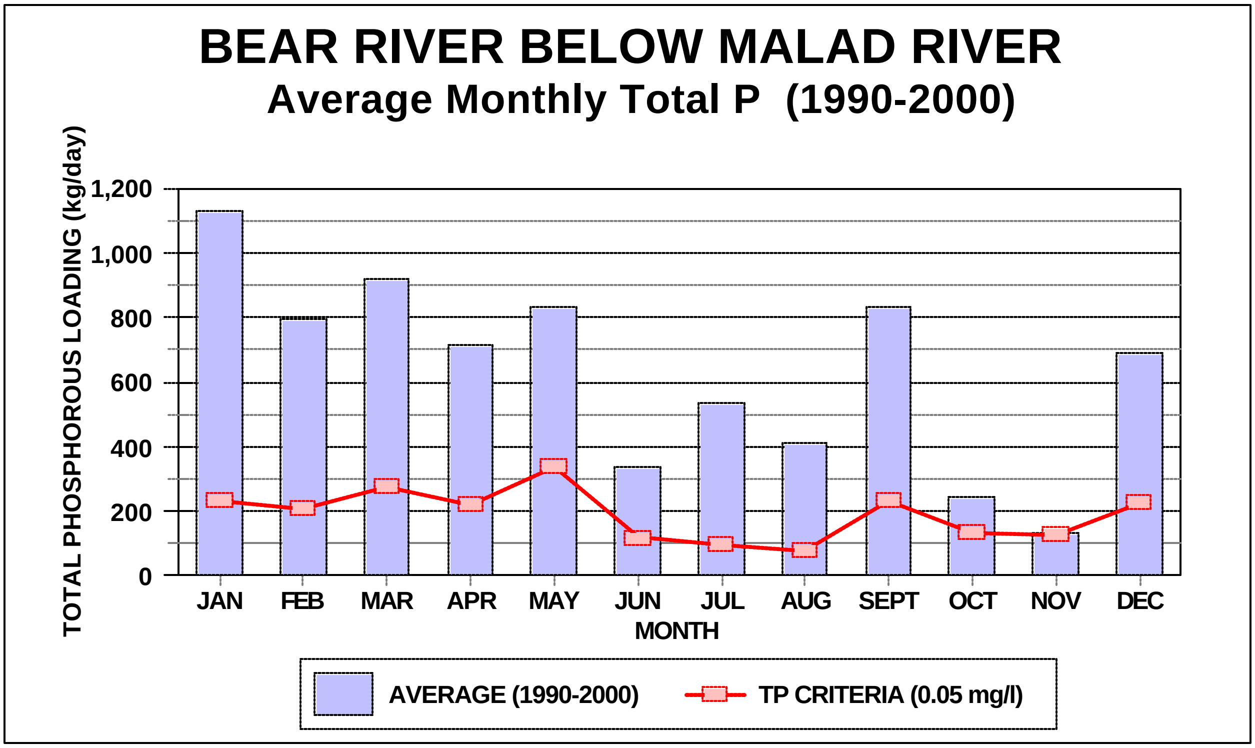


Figure 4-15. The average monthly total phosphorus (above) and total suspended solids (below) loading compared to the state of Utah criteria for the Bear River at Honeyville (Storet# 490170). Data are from 1990-2000. Criteria are indicator values and not a standard.



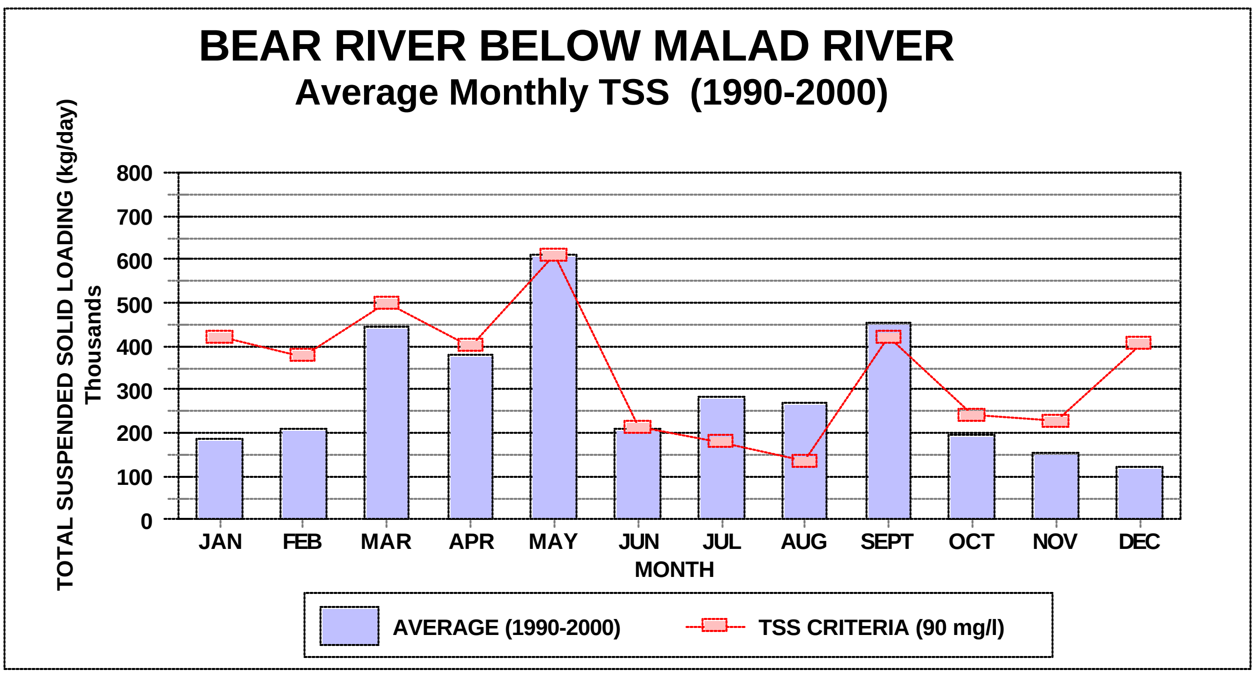
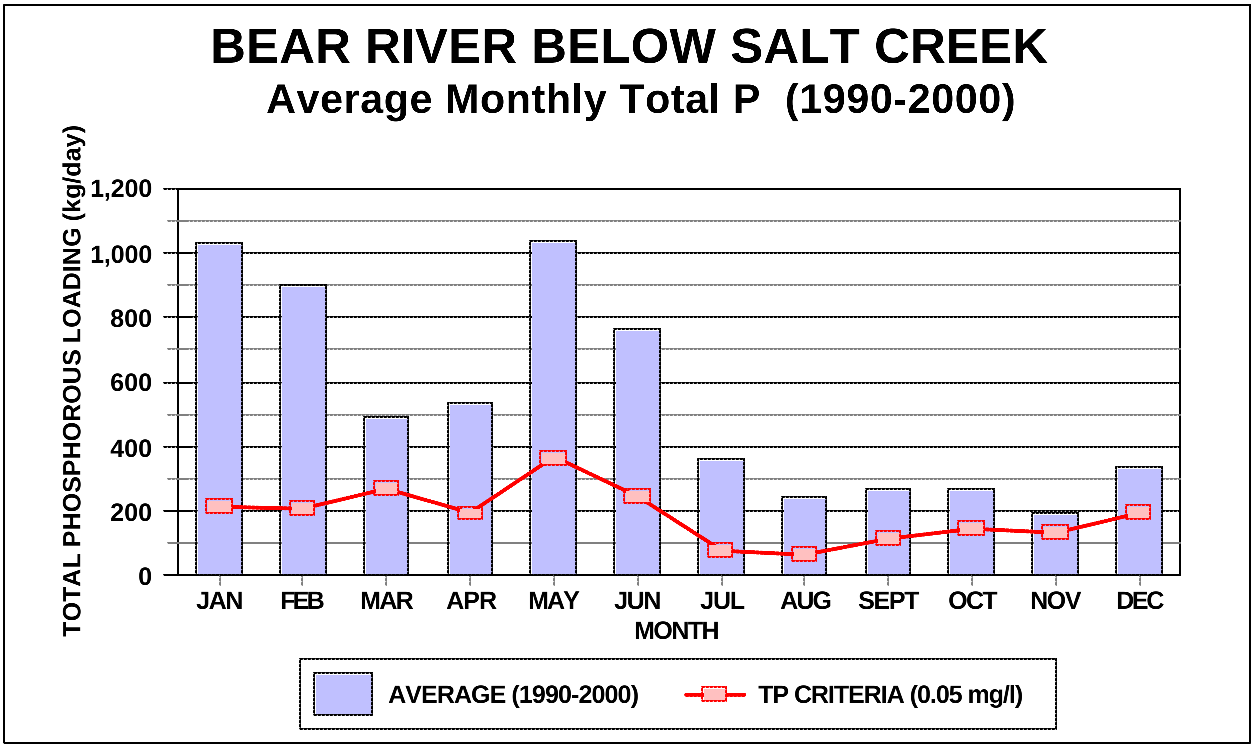


Figure 4-16. The average monthly total phosphorus (above) and total suspended solids (below) loading compared to the state of Utah criteria for the Bear River below the Malad River confluence (Storet# 490144). Data are from 1990-2000. Criteria are indicator values and not a standard.



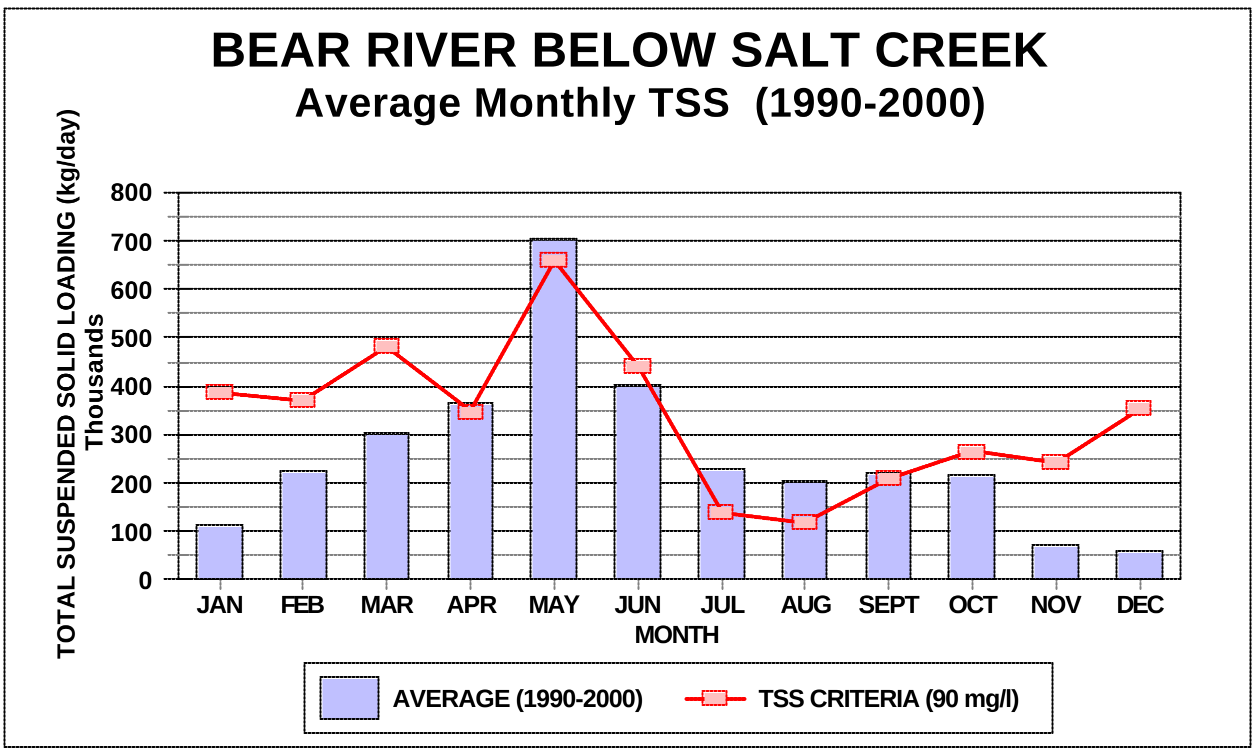
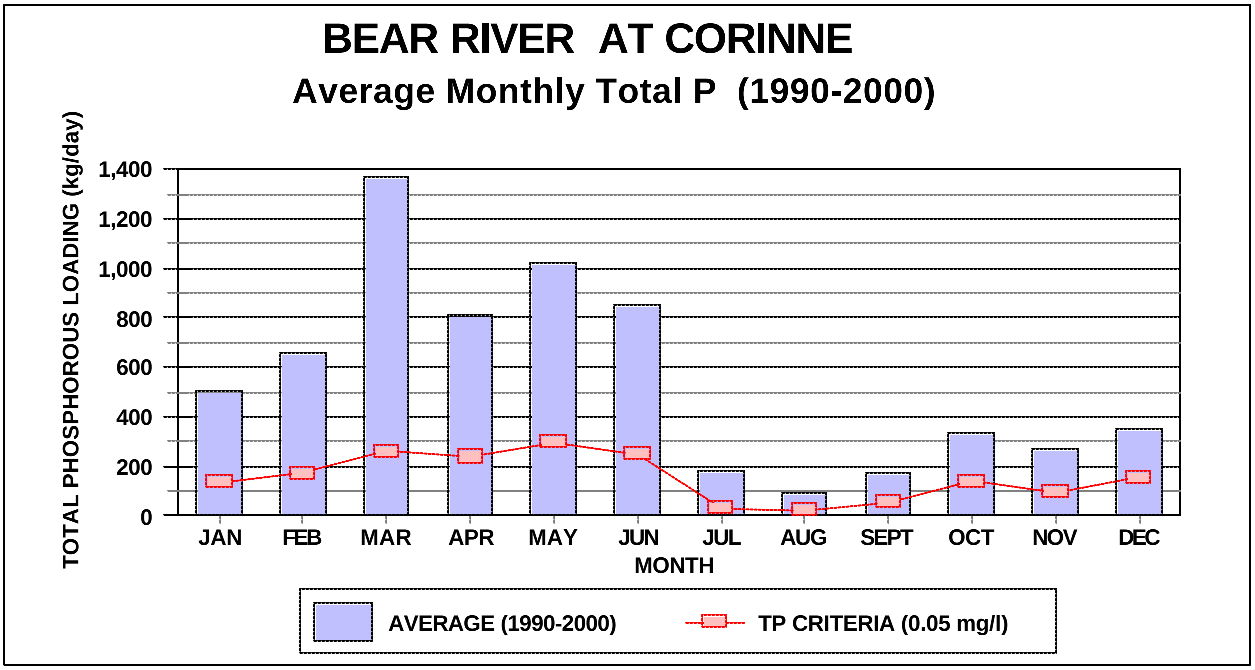


Figure 4-17. The average monthly total phosphorus (above) and total suspended solids (below) loading compared to the state of Utah criteria for the Bear River below the Salt Creek confluence (Storet# 490142). Data are from 1990-2000. Criteria are indicator values and not a standard.



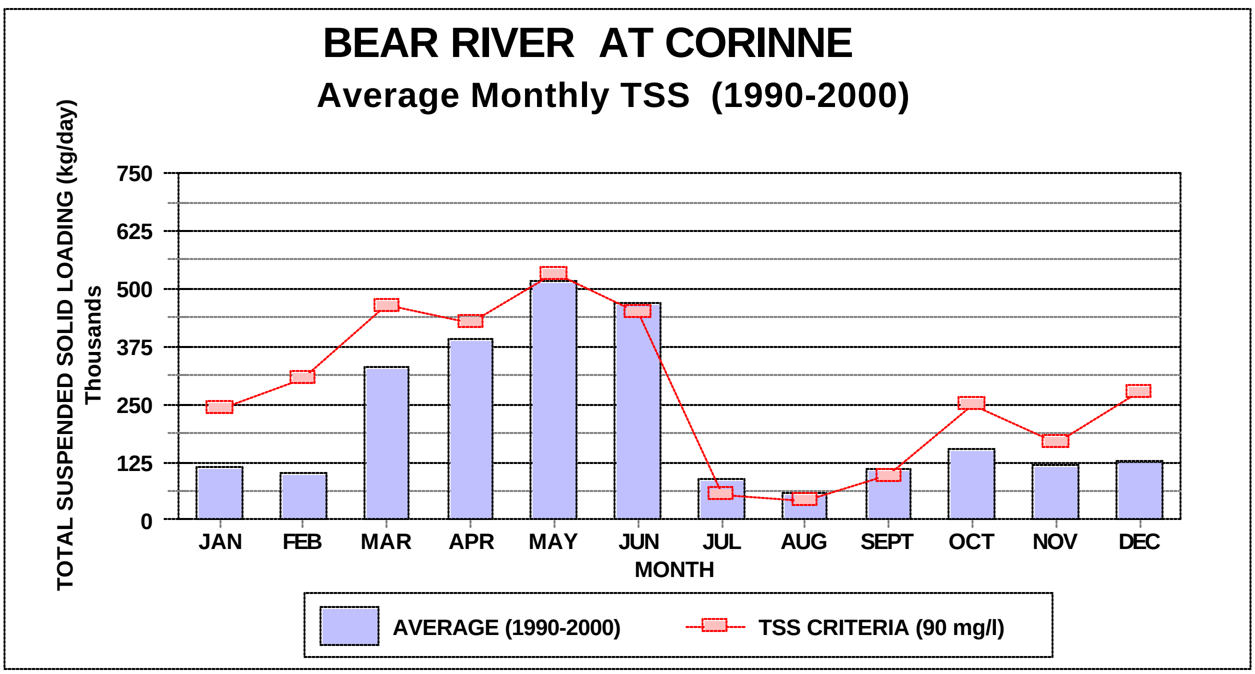
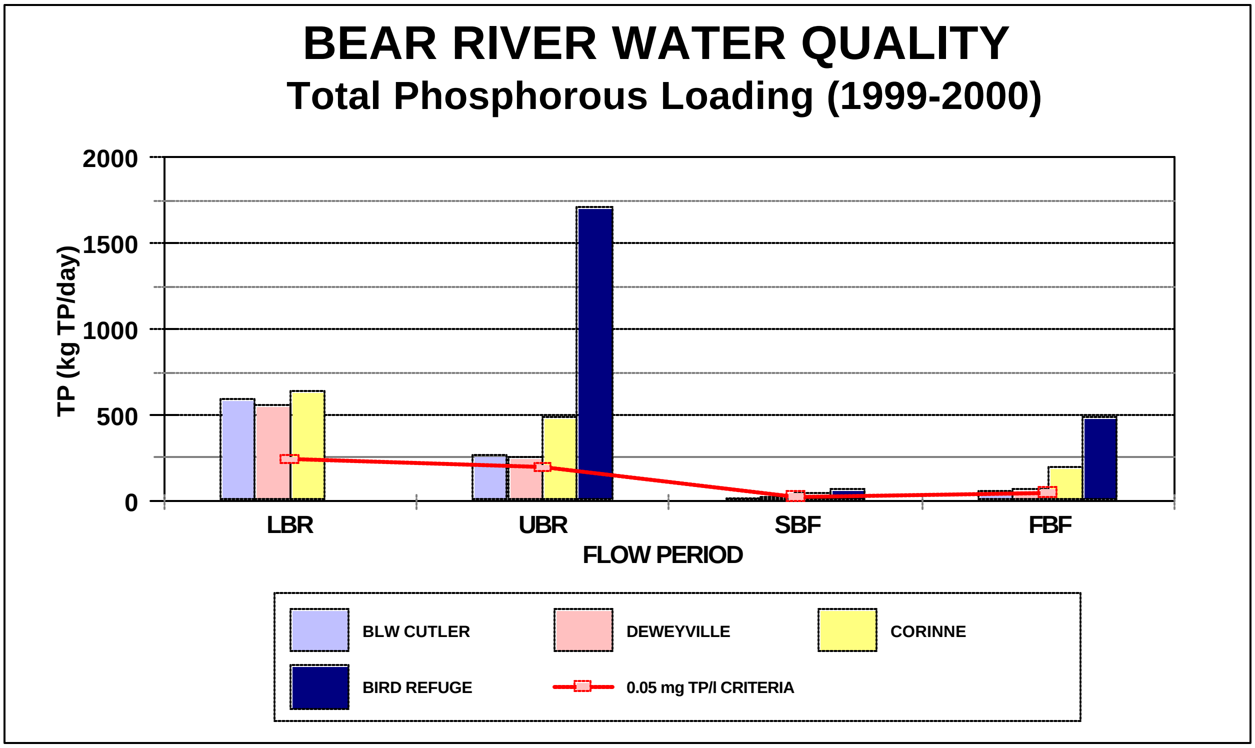


Figure 4-18. The average monthly total phosphorus (above) and total suspended solids (below) loading compared to the state of Utah criteria for the Bear River at Corinne (Storet# 490110 and USGS# 10126000). Data are from 1990-2000. Criteria are indicator values and not a standard.



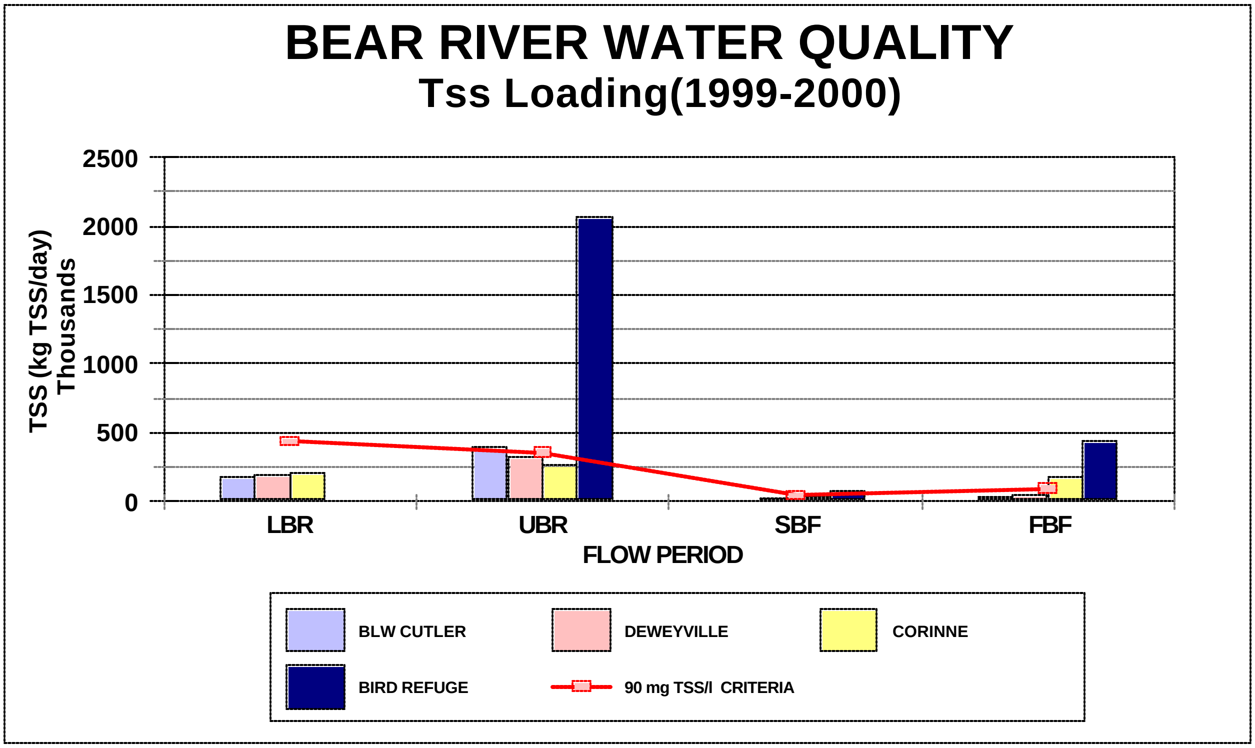
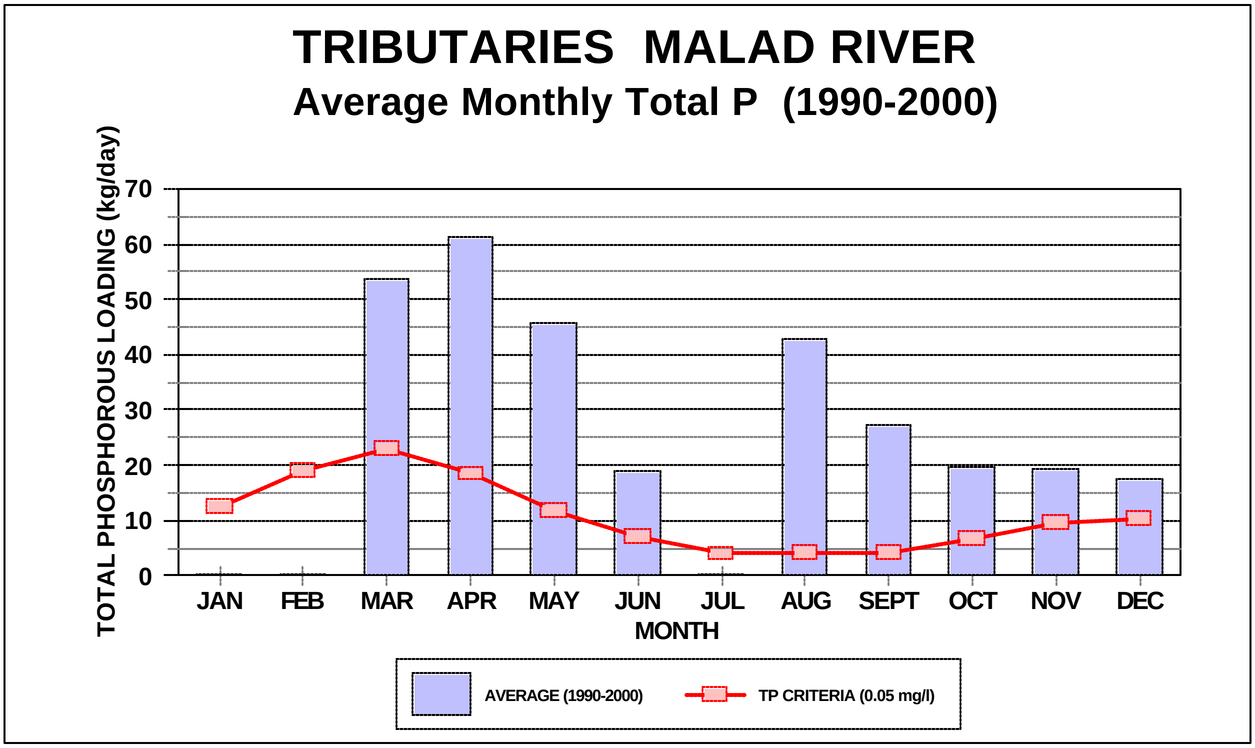


Figure 4-19. The daily loading in the Bear River for total phosphorus (above) and total suspended solids (below) during four hydrologic time periods (LBR=lower basin runoff; UBR=upper basin runoff; SBF=summer baseflow; and FBF=fall baseflow). Criteria are indicator values and not a standard.



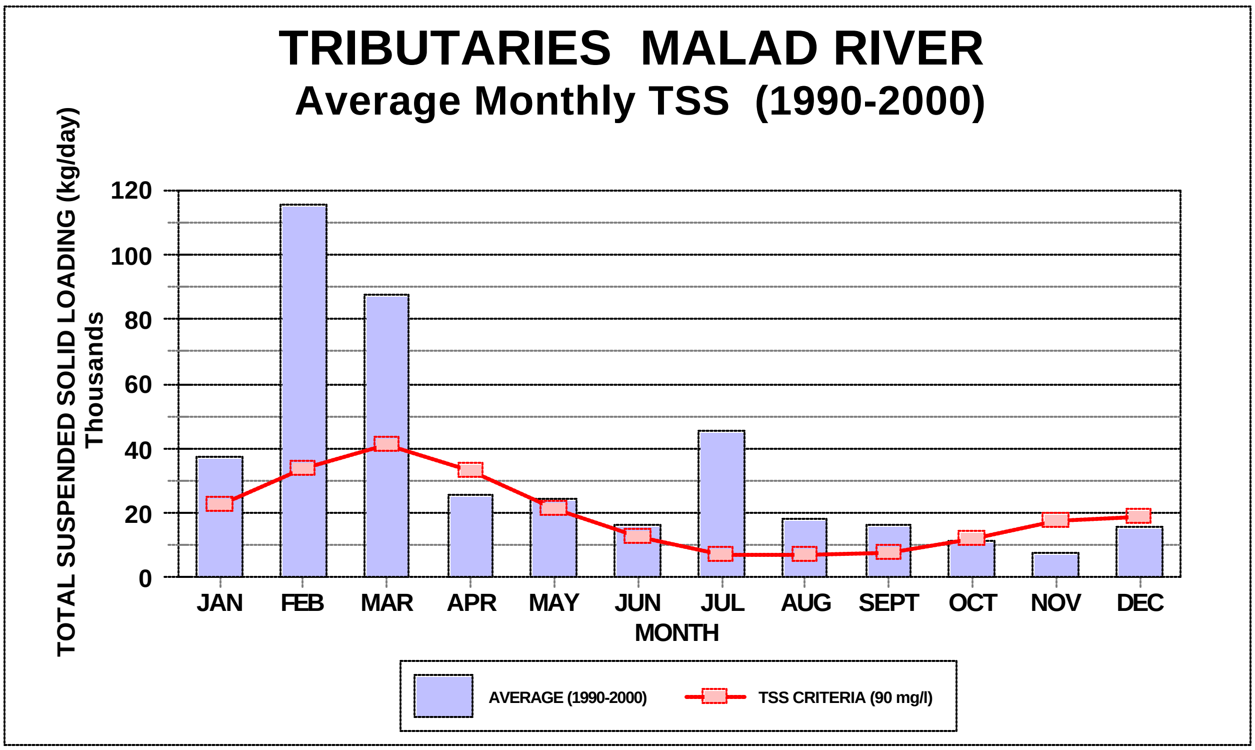
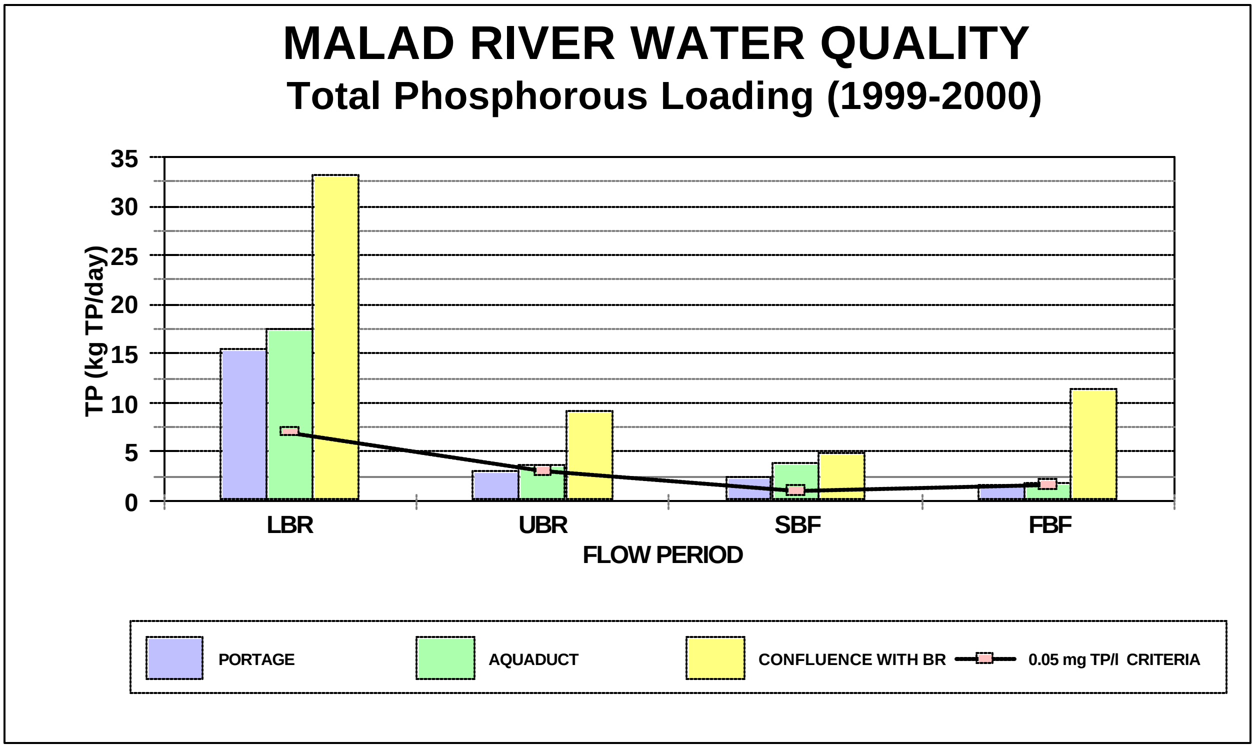


Figure 4-20. The average monthly total phosphorus (above) and total suspended solids (below) loading compared to the state of Utah criteria for the Malad River. Data are from 1990-2000. Criteria are indicator values and not a standard.



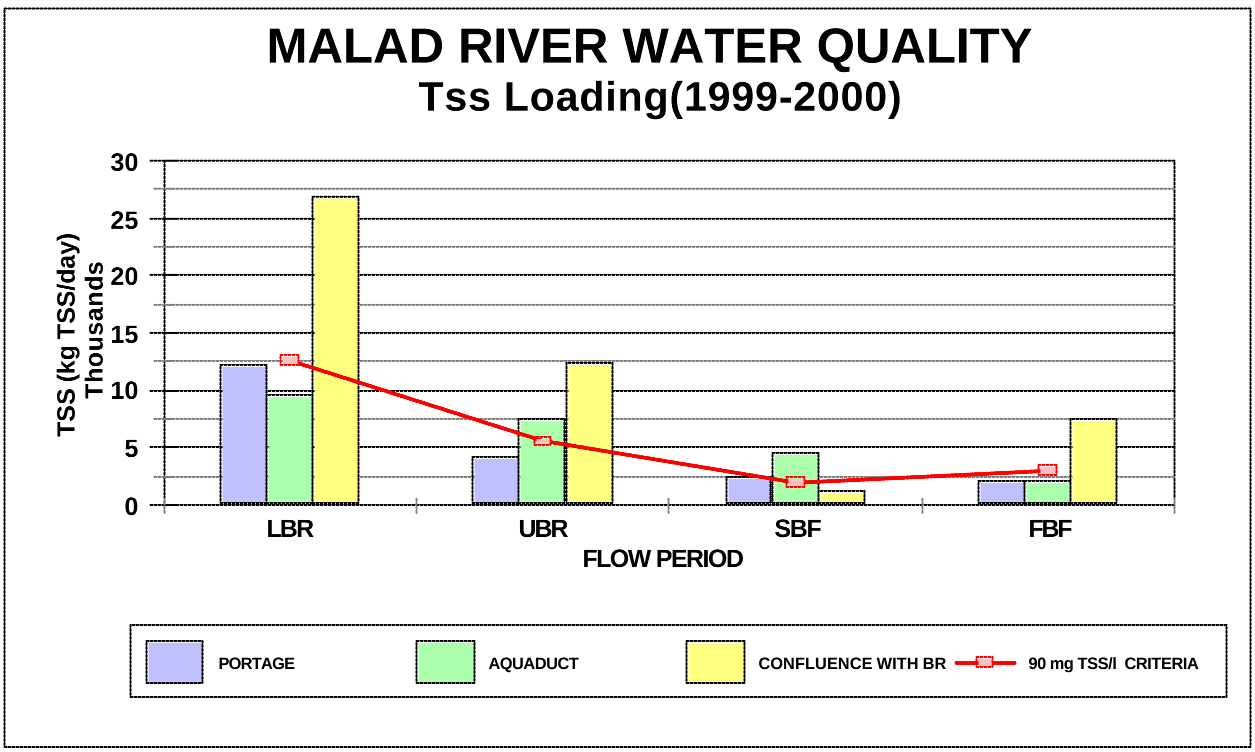
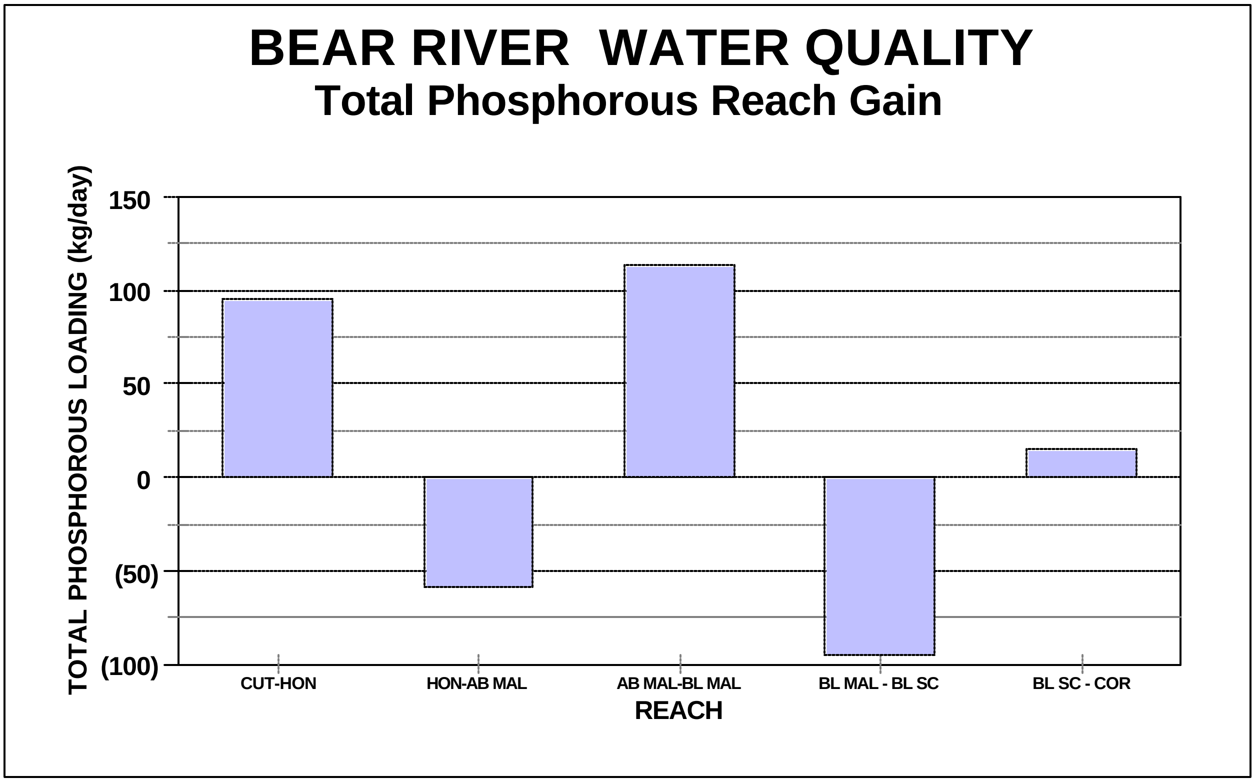


Figure 4-21. The daily loading in the Malad River for total phosphorus (above) and total suspended solids (below) during four hydrologic time periods (LBR=lower basin runoff; UBR=upper basin runoff; SBF=summer baseflow; and FBF=fall baseflow). Criteria are indicator values and not a standard.



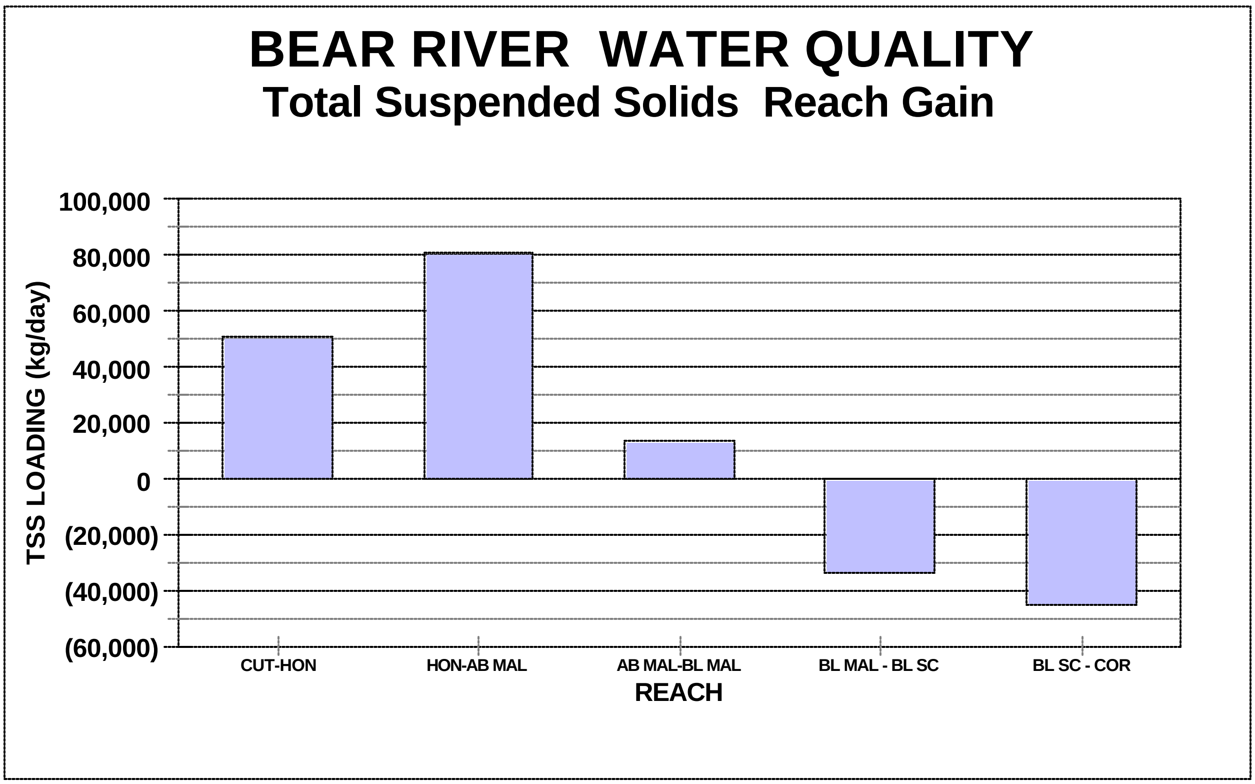


Figure 4-22. A reach gain/loss analysis for total phosphorus (above) and total suspended solids (below) for the Bear River from below Cutler to Corinne. Data are for annual averages expressed as kg/day gain (positive) or loss (negative).

5.0 TMDL ANALYSIS

The following analysis is based upon the historical data summarized in the previous section of this report as well as the new data collected as part of this investigation. The TMDL uses a mass balance approach for the basis of analysis.

5.1 Technical Analysis

The data used in the following analysis was based on the period of record encompassing 1990-2000. The data were summarized by month and expressed as daily loads (i.e. kg TP/day). Seven stations along the mainstem Bear River between Cutler Reservoir and the Great Salt Lake were found to have sufficient data to determine the seasonal patterns of loadings.

The previous water quality analysis indicated that total phosphorous was the pollutant of concern (POC). Total suspended solids (TSS) has also been addressed but no endpoints have been defined or submitted for review as endpoints of this TMDL. In addition to evaluating the reach gains and losses and excess loads at each Bear River station, a second approach was also utilized. In 1994, the state of Utah developed a detailed water budget for the Malad subarea in Utah, as well as the Bear River Basin from Cutler Reservoir to Corinne. This hydrologic model used an average hydrologic year (based upon a 30-year record, 1961 to 1990), with the inflows and outflows being accounted for in the balance. The computation of the water budget for this period was based upon an accounting procedure to balance the inflow and outflow of the sub-basins with the tributary inflows and consumptive uses that occurred in the area. The methodology utilized a computer program BUDEDIT, developed by the Division of Water Resources. The program is based on the SCS modified Blaney-Criddle formula. By applying the historically available water quality concentrations supplemented by the additional data collected in this investigation (i.e. agricultural drains), a mass balance for total phosphorous was determined for each of the two sub-basins. Input data are provided as tables in Appendix B. It should be noted that the water quality dataset below Cutler Reservoir is based on the USGS flow station near Collinston for the period beginning in 1999.

5.2 Water Targets/Endpoints

The water quality targets or endpoints for the mainstem Bear River is 0.075 mg /l total phosphorus. The criteria for total suspended solids has been established at 90 mg/l. This is based on the pollution indicator values or 0.05 mg/l and 90 mg/l for total phosphorus and suspended solids respectively. Target loads are determined utilizing these concentrations and the average flows for the month as defined by the hydrologic analysis.

5.3 Total Maximum Daily Loads

In section 4.0 of this report**,** data was presented on the instantaneous total suspended solids and total phosphorus loading with a comparison to the state of Utah pollution indicator values outlined in section 5.2. Tables 5-1 reflects the amount of instantaneous loadings of total suspended solids and total phosphorus in excess of those values. Data are provided for each river site by month.

In Table 5-1, it is evident that the only months where excess solids were found in the river was April to September. This time period corresponds to the irrigation season during summer baseflow.

A review of Figure 4.22, reach gain analysis, indicates that there is a significant sediment loading in the upper reaches and a loss in the lower reaches of the study area. Insufficient information exists on the transport of sediments in this system. It is evident that the morphology of the stream changes to a depositional type in the lower reaches, but there could also be an extensive movement of sediments via bedload transport. The lower reaches do have a high collodial bedload substrate.

The reach-gain analysis for total phosphorus as indicated in Figure 4.22 depicts alternating reaches of gains and losses. There doesn't appear to be a correlations to sediments, but that analysis hasn't been developed. It is obvious that there are significant gains at various points in the river supporting the analysis indicating high potential background levels of total phosphorus sources, primarily nonpoint source in nature.

It is interesting to note that the Bear River entering the lower basin has excess TP loading ranging from 18.3 kg TP/day to 477.2 kg TP/day, with an annual average of 292.7 kg TP/day (Table 5.6).

The second approach also utilized a mass balance approach. The results can be seen in tables 5-2 and 5-3 for total phosphorous for the Malad and Bear River watersheds. The nonpoint gains or losses were determined by balancing the hydrologic and nutrient budgets. As depicted in Figure 5-1, in the Bear River sub-basin animal wastes from AFO/CAFO's are accounted for in this analysis and represent the second largest source, which is exceeded only by inflow from Cutler Reservoir. Streambank/misc sources are the third largest source followed by irrigation return flows.

In order to meet the state's criteria at Corinne with no upstream (above Cutler) remediation, it will

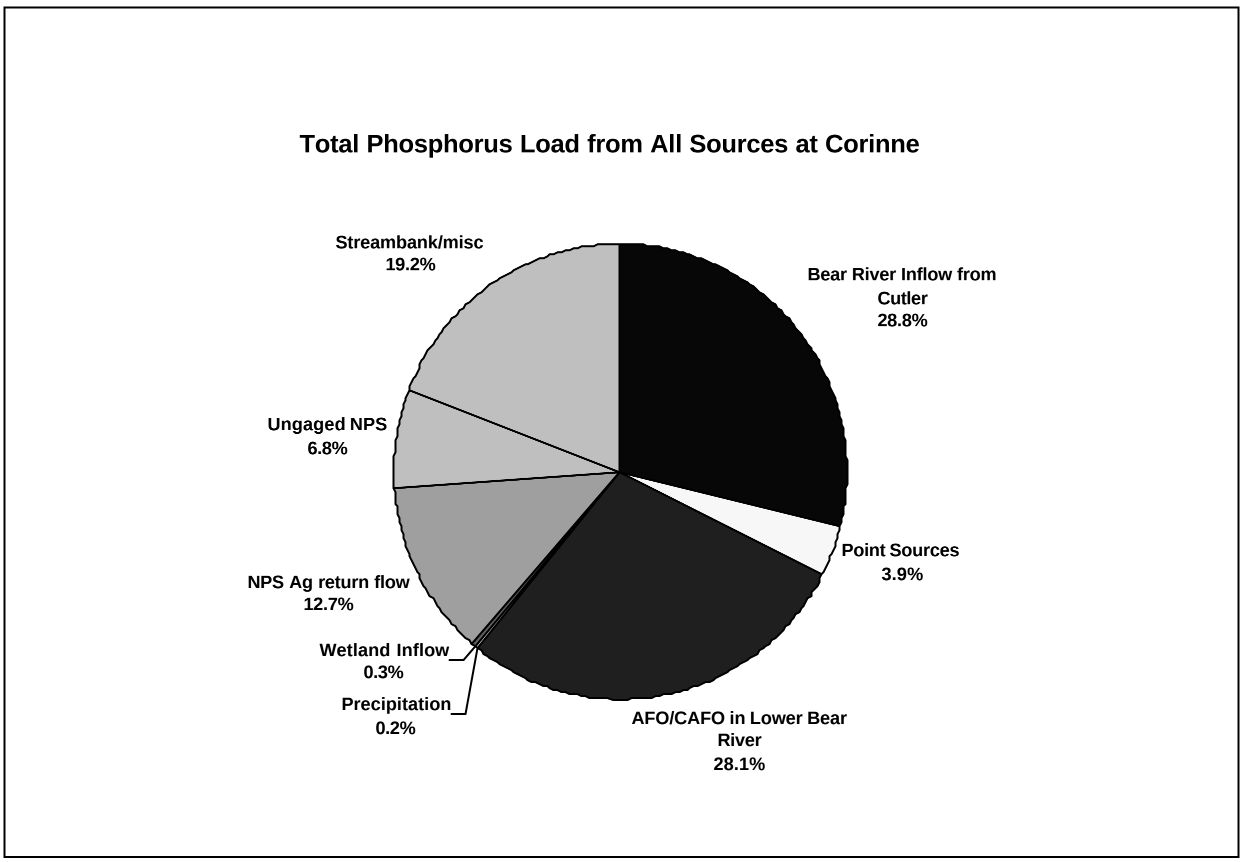


Figure 5.1 Total Phosphorus Source loading percentates at Corinne.

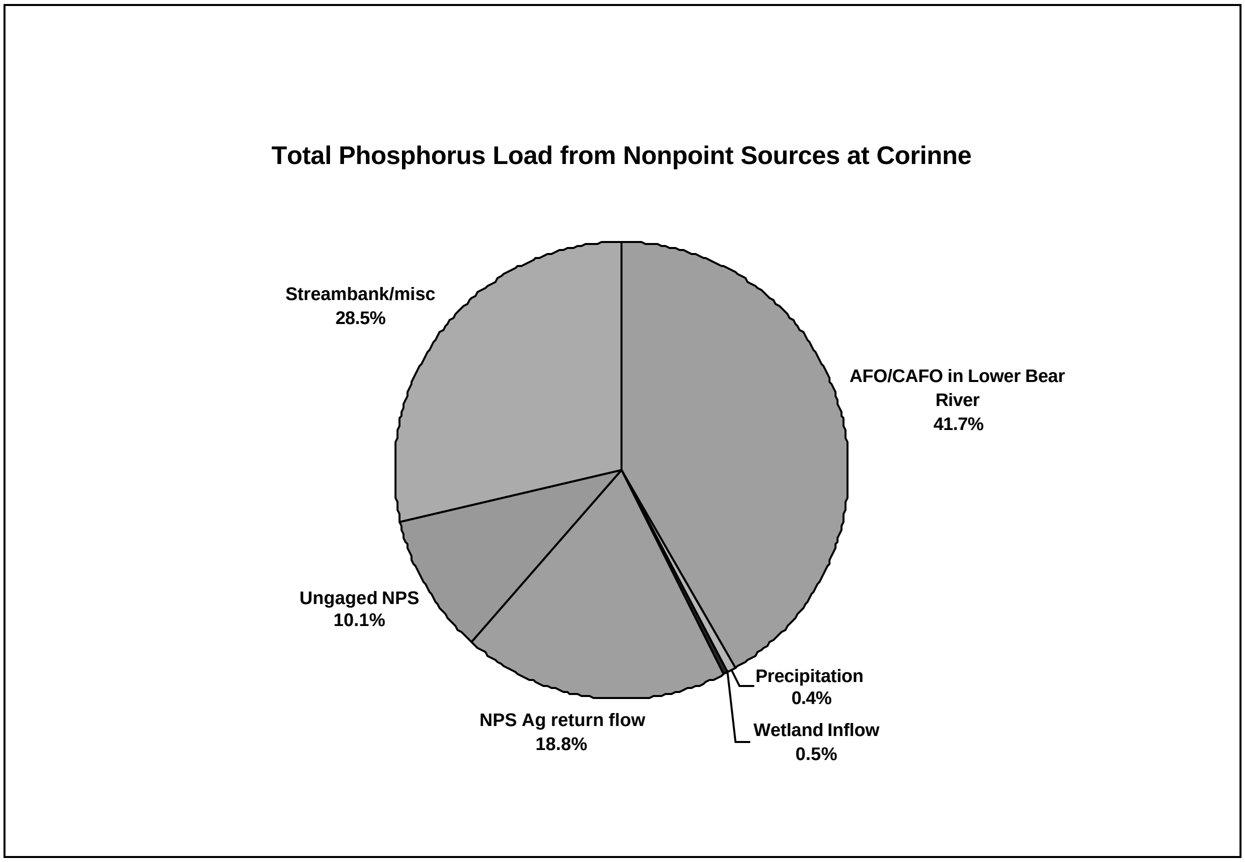


Figure 5.2 NPS loading percentages at Corinne.

be necessary to remove between 120 and 1654 kg TP/day (see Table 5.6). The annual average would be 599 kg TP/day. If, however, the Bear River meets the 0.075 mg/l criteria at Cutler, this excess mass would be reduced to 0 to 1374 kg TP/day with an annual average of 417 kg TP/day.

An analysis of the sources of phosphorus into the lower Bear River at Corinne on an annual basis (average daily load) can be seen in Figure 5-1. Because nonpoint source loads represent such a large source (67% of the total sources minus point sources and load from Bear River below Cutler), breakddown was necessary. The results of this refinement indicated that nonpoint source agricultural return flows were 18.8 percent of the nonpoint source total, while unstable streambanks/misc sources accounted for 28.5 percent of the nonpoint source total. Ungaged inflows were 10.1 percent and CAFO/AFOs were the highest with 41.7 percent of the total nonpoint source load (Figure 5-2). The agricultural return flows and ungaged inflows were determined from the basin mass balance (section 5.0) while CAFO/AFO loadings were based upon the number and location of cattle in the lower Bear River basin, as well as the delivery rates of total phosphorus from cattle feedlots. The unstable streambanks/misc total phosphorus loads were determined by difference from the known or calculated sources and the total nonpoint source load.

5.4 Margin of Safety and Loads

Incorporating a margin of safety in the removal of excess total phosphorous loads in the Bear River has been mandated by the USEPA as part of the TMDL process. In this case there are two built in margins of safety relative to the proposed removal levels. The first is the use of the 0.075 mg

Table 5-1. The amount of excess daily total suspended solids loading (kg/day) at selected mainstem sites on the lower Bear River for each month and station.

	Below Cutler	At Hampton Ford	At Honeyville	Above Malad River	Below Malad River	Below Salt Creek	At Corinne
January	(204,701)	(52,690)	(306,903)	(215,086)	(234,576)	(273,171)	(128,644)
February	(255,298)	(98,764)	(247,747)	(142,287)	(164,929)	(144,895)	(203,716)
March	(191,387)	(13,104)	(123,435)	(138,244)	(51,635)	(175,579)	(133,019)
April	(118,912)	(84,882)	(43,514)	(27,511)	(22,347)	19,976	(38,455)
May	(41,670)	(34,092)	(145,124)	32,774	1,068	44,555	(15,959)
June	(160,065)	(5,652)	(23,197)	(10,103)	(3,536)	(36,114)	19,940
July	(25,821)	(7,633)	25,952	78,655	105,205	94,136	33,605
August	(20,553)	(3,161)	28,447	29,478	135,328	87,698	16,434
September	(57,500)	(3,579)	(57,444)	101,858	35,160	9,686	13,789
October	(141,262)	(13,564)	(94,336)	(75,062)	(47,045)	(48,714)	(97,580)
November	(77,072)	111,521	(155,862)	(97,692)	(72,135)	(172,061)	(48,263)
December	(227,349)	173,180	(352,657)	(62,606)	(283,448)	(289,940)	(151,154)
AVERAGE	**(126,799)**	**(2,702)**	**(124,652)**	**(43,819)**	**(50,241)**	**(73,702)**	**(61,085)**

TP/liter criteria concentration. As noted in this document, the total phosphorous concentrations in the Bear River are in excess of this concentration approximately 94 percent of the time (Table 4-2). Although much of this excess load is anthropogenic, some fraction is undoubtedly natural background. Setting the criteria level at 0.075 mg TP/l provides some margin of safety. Secondly, the water quality and hydrologic analysis conducted in this investigation utilized two separate approaches. The results of the loading calculations for both approaches was similar, but did differ in amounts. This investigation has chosen to use the higher of the two loading estimate methodologies to insure an added level of safety (a higher level of remediation needed to reach the criteria load). As depicted in Table 5.6, the required average daily load reduction needed to meet the TMDL endpoint of 380.6 Kg/day based on an endpoint concentration of 0.075 mg/l is 417.1 Kg/day. The TMDL has defined an additional 10% reduction of 41.7 Kg/day to provide for an addition MOS and allow for future growth and development associated with a variety of sources. Therefore the implementation plan will be based on an overall reduction of 458. Kg/day (417.1 + MOS (41.7 Kg/day))

Table 5-2. The mass balance of the Malad River based upon existing water quality data and the hydrologic balance defined by the state of Utah (1994).

	MALAD RIVER TOTAL PHOSPHORUS MASS (kg/day)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**AVG**
Malad River Outflow (cfs)	107.0	139.6	193.2	144.2	97.4	57.0	32.9	34.2	33.3	54.1	85.0	85.5	88.6
Precipitation													0.0
Effective Cropland Precipitation	0.8	0.7	0.8	0.9	0.9	0.5	0.2	0.2	0.4	0.6	0.8	0.9	0.0
Domestic Water Supply Pumped	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subsurface Inflow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
Importation	0.0	0.0	0.0	0.0	1.8	4.0	2.9	1.8	1.0	0.3	0.0	0.0	16.8
River Inflow (existing)	22.8	31.0	40.6	15.6	17.1	13.5	5.7	3.5	4.5	9.8	18.6	19.2	0.0
Gaged Tributary Inflow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gaged Tributary Inflow 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.3
Ungaged Inflow	2.5	4.6	8.0	12.5	14.6	21.9	22.1	16.3	5.9	1.7	0.7	0.5	2.4
Agricultural Return Flow	5.2	3.7	4.9	0.0	0.2	0.6	0.4	0.3	0.1	1.1	6.2	6.3	14.1
Domestic Return Flow	2.4	3.5	2.7	2.8	23.1	52.5	33.6	23.4	8.4	10.4	2.9	3.5	0.2
Wetland/Open Water Return Flow	0.7	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	0.0
River Outflow (measured)	27.5	35.9	55.3	58.6	45.8	19.0	60.4	44.2	26.4	19.7	20.5	17.6	35.9
Tributary Outflow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subsurface Outflow	0.4	0.6	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.2
Wetland/Open Water Diversions	0.0	0.0	0.0	0.9	2.6	3.2	24.9	15.5	5.2	0.9	0.0	0.0	4.4
Crop Diversions	0.0	0.0	0.0	0.0	4.1	11.5	10.1	6.1	3.4	1.6	0.3	0.3	3.1
Domestic Diversions Pumped	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Domestic Diversions Stream	0.1	0.1	0.1	0.0	0.4	1.1	1.0	0.5	0.3	0.2	0.1	0.1	0.3
Export Out	0.1	0.1	0.1	0.0	0.4	1.1	1.0	0.5	0.3	0.2	0.1	0.1	0.3
River Outflow (TP Endpoint 0.075 mg/l)	13.1	17.1	23.6	17.6	11.9	7.0	4.0	4.2	4.1	6.6	10.4	10.5	10.8
River Outflow (calculated)	30.5	38.1	48.0	17.0	35.2	54.8	6.5	7.0	5.2	18.8	27.3	28.7	26.4
Agriculture Crop Consumption	0.0	0.0	0.1	1.6	6.5	13.8	11.9	6.0	4.4	2.4	0.1	0.0	3.9
Domestic Consumption	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Wetland/Open Water Consumption	0.2	0.2	0.6	1.9	3.7	3.7	26.0	16.3	6.0	1.5	0.4	0.2	5.1
Unknown Gain/Loss Existing Data	3.0	2.2	-7.3	-41.5	-10.6	35.8	-53.9	-37.2	-21.1	-0.9	6.8	11.2	-9.5

Table 5-3 The mass balance of the Bear River based upon existing water quality data and the hydrologic balance defined by the state of Utah (1994).

	BEAR RIVER TOTAL PHOSPHORUS MASS (kg/day)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**AVG**
Bear River flow below Cutler (cfs)	1672.6	1715.7	2312.2	2746.3	3336.9	2691.7	1504.4	1465.0	1436.9	1658.3	1646.3	1711.4	1991.5
Bear River flow at Corinne (cfs)	1988.0	1990.9	2872.3	3041.9	3282.7	2539.3	1115.4	1077.2	1291.5	1777.4	1876.8	2034.5	2074.0
Precipitation	3.2	2.8	3.1	3.5	3.6	2.1	0.9	1.0	1.6	2.3	3.0	3.3	2.5
Effective Cropland Precipitation	8.8	7.6	8.6	9.7	10.0	5.8	2.5	2.6	4.4	6.4	8.2	9.2	7.0
Domestic Water Supply Pumped	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1
Subsurface Inflow	0.4	0.6	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.2
Importation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
River Inflow (existing)	587.2	627.6	692.4	982.3	994.4	643.5	479.7	592.1	424.0	668.8	694.1	1048.0	702.8
Gaged Tributary Inflow	27.5	35.9	55.3	58.6	45.8	19.0	60.4	44.2	26.4	19.7	20.5	17.6	35.9
Gaged Tributary Inflow 2	0.2	0.5	0.7	0.7	7.3	13.0	15.3	15.7	10.3	0.9	0.5	0.6	5.5
Ungaged Inflow	67.6	60.2	182.4	44.1	55.7	90.6	57.7	43.8	48.5	79.6	53.3	46.6	69.2
Agricultural Return Flow	18.0	17.6	23.6	21.5	184.8	298.2	344.0	324.0	188.0	65.1	21.4	42.3	129.0
Domestic Return Flow	17.5	26.0	19.9	20.7	71.9	91.8	47.9	45.3	31.7	51.6	20.0	27.3	39.3
Wetland/Open Water Return Flow	6.0	5.3	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	15.4	3.3
River Outflow (measured)	832.4	839.7	1204.6	2212.0	1592.4	987.8	329.6	376.1	356.4	821.5	884.4	1322.7	980.0
Tributary Outflow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subsurface Outflow	1.0	3.4	0.4	2.2	4.6	2.6	0.5	0.5	0.0	0.0	0.1	0.1	1.3
Wetland/Open Water Diversions	0.0	0.0	0.0	4.1	16.1	29.7	28.5	48.8	35.6	15.3	0.0	0.0	14.8
Crop Diversions	0.0	0.0	0.0	0.6	125.2	171.5	277.3	367.5	173.8	94.8	11.0	0.0	101.8
Domestic Diversions Pumped	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1
Domestic Diversions Stream	0.6	0.6	0.5	0.6	1.1	1.0	2.0	1.9	1.0	1.2	0.7	1.1	1.0
Export Out	0.6	0.6	0.5	0.6	1.1	1.0	2.0	1.9	1.0	1.2	0.7	1.1	1.0
River Inflow (TP Endpoint 0.075 mg/l)	306.9	314.9	424.3	504.0	612.4	494.0	276.1	268.8	263.7	304.3	302.1	314.1	365.5
River Outflow (TP Endpoint 0.075 mg/l)	364.8	365.4	527.1	558.2	602.4	466.0	204.7	197.7	237.0	326.2	344.4	373.4	380.6
River Outflow (calculated)	722.2	768.9	976.5	1120.1	1211.7	950.0	694.7	644.4	517.4	773.2	806.3	1195.8	865.1
Agriculture Crop Consumption	0.1	0.1	0.3	29.5	98.7	129.5	193.0	159.8	58.2	20.4	0.4	0.2	57.5
Domestic Consumption	0.0	0.1	0.0	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Wetland/Open Water Consumption	2.1	2.1	5.4	15.8	37.2	37.8	30.3	52.4	43.0	29.7	12.5	5.4	22.8
Unknown Gain/Loss Existing Data	110.2	70.8	228.1	1092.0	380.6	37.8	-365.1	-268.3	-161.0	48.2	78.1	127.0	114.9

5.5 Allocation of Load Reductions

As noted in the previous section, various sources of total phosphorous loadings have been described using two approaches. The first, which focused on the mainstem Bear River, utilized data collected at set locations. Daily mass loadings were calculated for each month as well as an annual basis. Differences between stations (after removing known sources) were attributed to nonpoint source (NPS) loads. The NPS sources are believed to be: 1) agricultural return flows; 2) ungaged inflows; 3) wetland/riparian area inflows; 4) cattle feeding operations (CAFO/AFO); and 5) unstable streambanks or miscellaneous. Utilizing the above data set alone, it is not possible to segregate the magnitude of the various NPS total phosphorus loadings. In order to partially overcome this limitation, a second dataset was used. This approach used the available water quality data and applied it to the sub-basin hydrologic model built for the lower Bear River. In this way, several of the nonpoint sources (agricultural return flow, wetland/riparian inflows, and ungaged inflow) could be better quantified. These results have been provided in Table 5-4. Further refinement of the nonpoint source category was undertaken in the following manner.

Wieneke et al (1980) conducted a comprehensive investigation of the impact of livestock feeding operations on water quality. Utilizing his data from over 200 feeding operations in Cache Valley, it was possible to calculate total phosphorous loading levels on a per capita basis. The loadings were for each month and can be seen in Table 5-5. Using an estimate of 6,800 animal units (AU) within the floodplain of the lower Bear River, 9,100 AUs in the Malad River (based upon observations at sites noted in Figure 4-12), and an estimate of 125,000 animals in the entire basin a daily loading for each month and each river was calculated. Daily loadings for the Bear River ranged from 50.4 kg/day in March to 0.7 kg/day in August. The daily average for the entire year was 13.9 kg/day. A similar pattern was evident for the Malad River with a range of 67.5 to 0.9 kg/day and an average of 18.6 kg/day. However, an analysis on total animals, projects a significantly higher loading rate (255.9 Kg/day).

Whereas point sources can be measured directly. The relative importance of pollutant loads from nonpoint sources can only be estimated by applying nutrient export coefficients to the areas of different landuse. Literature values for animal waste export coefficients were obtained from an EPA publication authored by Reckhow et. al. (Table 5-4). A range of coefficients are available, arising from different studies in different geographic areas and under different conditions. Due to the uncertainty associated with estimating nutrient loading from animal wastes an attempt was made to compare loadings from Reckhow's coefficients versus Wieneke's coefficient developed for the basin just upstream from the lower Bear River basin. Table 5-4 provides an estimate of the animal waste loading in the basin using both sets of coefficients. As noted earlier in section 4.3.5 there were inventoried 221,563 animals in Box Elder county. The number of animals used in the Wieneke calculation was 125,000. All of Box Elder county is not in the lower Bear River basin, therefore this value is an estimation for use in calculating overall animal waste loading. It does yield a value of 250 kg/day which substantiates the loading using the medium coefficient based on Reckhow's studies. The uncertainty associated with this loading noted, but it provides the best estimate of the animal waste loading recognizing the limitations of existing data. Therefore, to estimate animal waste loadings for this report, a medium loading coefficient was chosen and only those animals identified in the floodplain, 15,900, were used in the calculation.

TABLE 5.4 A range of phosphorus loading coefficients for animal feeding operations. Rates used in loading calculations compiled from Reckhow et al. 1980.

	Reckhow's coefficients			Wieneke's coefficient
	Low	Medium	High	Based on data for Cache County
Loading Kg/acre/day	0.177	0.277	0.477	
Loading Kg/cow/day	0.0008	0.018	0.032	0.002
Comparative total phosphorus loadings				
Source	Coefficient	Animal numbers	Kg/day	
Reckhow low value	.0008	15,900	12.72	
Reckhow medium value	.018	15,900	286.2	
Reckhow high value	.032	15,900	508.8	
Wieneke	.002	125,000	250	

Reckhow, K.H., M.N. Beauloac, J.T. Simpson. 1980. Modeling phosphorus loading and lake response under uncertainty: A manual and compilation of export coefficients. USEPA 440/5-80-011.

The final nonpoint source category (streambanks/natural sources) was determined by difference using the defined quantities noted above and the total empirically determined nonpoint source.

5.5.1 Nonpoint Sources

This section of the report describes the specific loading conditions in the lower Bear River sub-basin and addresses the potential loading reductions that can be obtained using various remedial activities. As has been discussed in various sections of this document, the relative importance of nonpoint source loads were quantified (estimated) by various methods. In addition to specific categories of nonpoint sources (agricultural returns, CAFO/AFO runoff, ungaged inflows), point source contributions were also estimated. Data were provided on a monthly time step utilizing average daily values. Using the data outputs from the Utah Division of Water quality hydrologic model for the lower Bear River and the empirical water quality data summarized from 1990-2000, the total phosphorous sources are described in Table 5-6. The largest single source of total phosphorous into the Bear River below Cutler Dam is the Bear River (average 703 kg TP/day), followed by the nonpoint sources of streambank erosion and agricultural return flows. After the sources of phosphorous to the lower Bear River have been defined, the potential reduction of the excess phosphorous loading (average daily

724.6 kg TP/day) through various remediations was evaluated. These nutrient reduction activities range from changes in treatment processes in the wastewater treatment facilities (point sources) to additional best management practices (BMPs) on agricultural lands and feedlots (nonpoint sources). Table 5-7 lists a wide range of remediation activities and BMPs, the effectiveness of each of these actions in reducing nutrient and solids input into waterways and, when available, typical costs associated with each practice. The ability to reduce pollutant inputs is largely a function of the amount of effort and money available for the task. Because of this, a range of nutrient reduction were calculated using categorical reduction percentages from the chart below. This general analysis indicates that in order to attain the desired TMDL for total phosphorous in the Bear River at Corinne, a slightly higher than medium effort will be required to achieve the loading endpoint as depicted in figure 5.3.

	Estimated Level of Effort		
Source	**Low**	**Medium**	**High**
Corinne WWTP	**40%**	**50%**	**90%**
Bear River City WWTP	**50%**	**75%**	**90%**
Tremonton WWTP	**50%**	**75%**	**90%**

5.5.2 Point Sources

The point sources were defined in section 4.4 and quantified in Table 4-5. Relative to the other sources of phosphorus within the Lower Bear River, the point sources (as quantified by the mass balance) account for 3.36 percent of the total sources. The amount of potential reductions which could be attained by remedial activities are described in Table 5-7. Depending upon the level of effort, between 30 to 97 percent reduction in total phosphorus loading could be realized. We have chosen to define the level of effort (and its concurrent level of reduction) in the above chart.

Potential reductions for point sources					
Facility	**Average concentration**	**Average load**	**Low 50%**	**Medium 75%**	**High 90%**
Corinne WWTP	**1.11**	**0.2**	**NC**	**NC**	**NC**
Bear River City WWTP	**4.99**	**12.7**	**2.5/6.4**	**1.25/3.2**	**0.05/1.3**
Tremonton WWTP	**5.96**	**29.8**	**3.0/14.9**	**1.5/7.5**	**0.06/3.0**

		Level of Effort		
	Current Load	Low	Medium	High
Point Sources	39.3	19.7	9.8	3.9
Nonpoint Sources				
AFO/CAFO in Lower Bear River	286.0	143.0	71.5	28.6
Precipitation	2.5	2.5	2.5	2.5
Wetland Inflow	3.3	3.3	3.3	3.3
NPS Ag return flow	129.0	77.4	64.5	12.9
Ungaged NPS	69.2	41.5	34.6	6.9
Streambank/misc	195.3	117.2	97.7	19.5
Total load remaining	724.6	404.6	283.9	77.7
Total load reduction		320.1	440.7	647.0

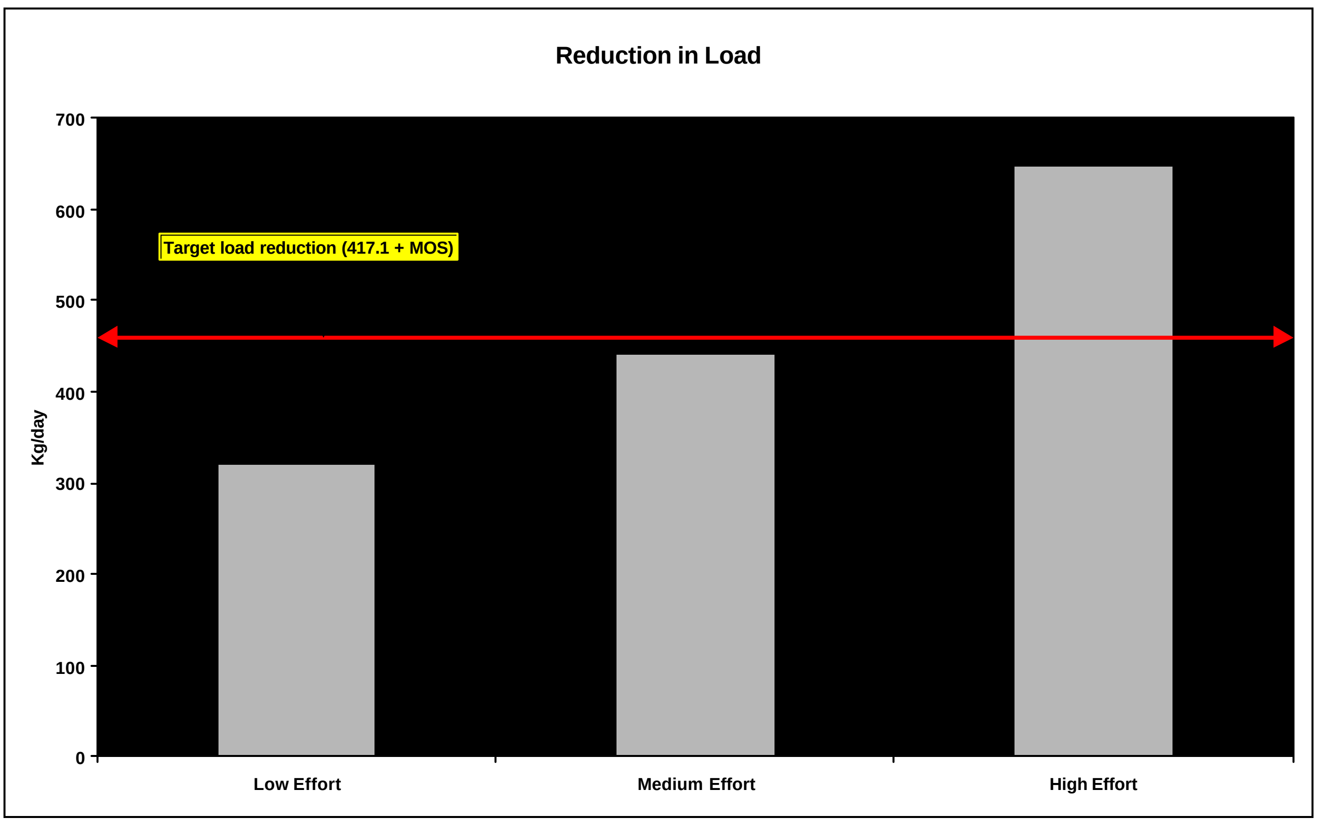


Figure 5.3 Load reduction based on level of effort

Table 5-5. The per capita loadings for cattle feeding operations in Cache Valley (after Wieneke et al. 1980).

SITE	# of AFOs	KILOGRAMS TOTAL PHOSPHORUS/DAY/ANIMAL UNIT												
		JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	AVE
1	4	0.0012	0.0044	0.0041	0	0	0	0	0	0	0	0	0.001	0.001
2	15	0.0042	0.0059	0.0091	0.0014	0.001	0.001	0.001	0	0.001	0.001	0.001	0.001	0.002
3	16	0.0042	0.013	0.0111	0.0013	0	0.001	0.0014	0	0.001	0.001	0	0.0015	0.003
4	22	0.0022	0.0027	0.0026	0	0	0	0	0	0	0	0	0	0.001
5	13	0.0321	0.0323	0.0273	0.0027	0.0016	0.0018	0.0015	0.001	0.0018	0.0028	0.0017	0.0035	0.009
12	10	0.0022	0.0066	0.0102	0.0016	0.001	0.001	0.001	0	0.001	0.0009	0.0012	0.001	0.002
14	20	0.0017	0.0019	0.0026	0	0	0	0	0	0	0	0	0	0.001
15	7	0.0054	0.0055	0.0061	0.001	0.001	0.001	0.001	0	0	0.001	0.001	0.001	0.002
6	9	0.0048	0.0072	0.0084	0.001	0.001	0.001	0.001	0	0.001	0.001	0.001	0.001	0.002
8	20	0.0051	0.0054	0.0074	0.001	0	0.001	0.001	0	0.001	0.0011	0.001	0.0011	0.002
9	24	0.0012	0.0019	0.0027	0	0	0	0	0	0	0	0	0	0.001
10	20	0.0052	0.0053	0.0078	0.0011	0.001	0.001	0.001	0	0.001	0.001	0.001	0.0011	0.002
11	8	0.0039	0.005	0.0048	0	0	0	0	0	0	0.001	0	0.001	0.001
7	11	0.0007	0.0014	0.0024	0	0	0	0	0	0	0	0	0	0.001
13	7	0.0025	0.0034	0.0047	0	0	0	0	0	0	0.001	0	0.001	0.001
Average		0.0051	0.0068	0.0074	0.0008	0.0004	0.0006	0.0006	0.0001	0.0005	0.0008	0.0006	0.0009	0.002
Bear River Total Load (kg/day) in floodplain		34.7	46.2	50.5	5.8	2.9	3.9	3.8	0.7	3.2	5.3	3.8	6.3	13.9
Malad River Total Load (kg/day) in floodplain		46.5	61.8	67.5	7.7	3.9	5.2	5.1	1.0	4.2	7.1	5.0	8.5	18.6
Total floodplain load		81.2	108.0	118.0	13.5	6.9	9.0	8.9	1.7	7.4	12.4	8.8	14.8	32.6
Total Basin Load (based on 125,000 animals)		638.3	849.2	927.5	105.8	54.2	70.8	70.0	13.3	58.3	97.5	69.2	116.7	255.9

Table 5.6 The summary by month of the daily loading of the sources of total phosphorus into the Lower Bear River between Cutler Dam and Corinne

Bear River Loads Kg/day													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Ave**
Load from Cutler	293.1	359.8	448.7	545.5	456.3	302.1	38.0	18.3	51.7	165.7	331.0	477.2	292.7
Target inflow at 0.075 mg/l	153.2	180.6	274.9	279.9	281.0	231.9	21.8	8.3	32.1	75.4	144.0	143.0	152.2
Above Cutler load reduction	139.9	179.3	173.8	265.7	175.3	70.2	16.1	10.0	19.5	90.3	186.9	334.2	138.4
AFO/CAFO basin wide	274.1	274.5	396.1	419.5	452.7	350.2	153.8	148.5	178.1	245.1	258.8	280.6	286.0
Precipitation	3.2	2.8	3.1	3.5	3.6	2.1	0.9	1.0	1.6	2.3	3.0	3.3	2.5
Wetland Inflow	6.0	5.3	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	15.4	3.3
Point Sources	17.5	26.0	19.9	20.7	71.9	91.8	47.9	45.3	31.7	51.6	20.0	27.3	39.3
NPS Ag return flow	18.0	17.6	23.6	21.5	184.8	298.2	344.0	324.0	188.0	65.1	21.4	42.3	129.0
Ungaged NPS	67.6	60.2	182.4	44.1	55.7	90.6	57.7	43.8	48.5	79.6	53.3	46.6	69.2
Streambank/misc	81.2	87.9	48.9	1144.5	221.3	0.0	0.0	0.0	0.0	51.6	174.7	533.8	195.3
Total	467.6	474.3	677.5	1653.8	990.0	832.9	604.3	562.6	447.9	495.3	540.0	949.3	724.6
Bear River at Corinne	832.4	839.7	1204.6	2212.0	1592.4	987.8	329.6	376.1	356.8	821.5	884.4	1322.7	980.0
Target load at 0.075 mg/l	364.8	365.4	527.1	558.2	602.4	466.0	204.7	197.7	237.0	326.2	344.4	373.4	380.6
Excess load at Corinne	467.6	474.3	677.5	1653.8	990.0	521.8	124.9	178.4	119.8	495.3	540.0	949.3	599.4
Target Load from Cutler	153.2	180.6	274.9	279.9	281.0	231.9	21.8	8.3	32.1	75.4	144.0	143.0	152.2
Required load reduction	314.4	293.7	402.6	1373.9	709.0	289.9	0.0	0.0	0.0	419.9	396.0	806.3	417.1
MOS 10% allocation	31.44	29.37	40.26	137.39	70.9	28.99	0	0	0	41.99	39.6	80.63	41.71

Table 5-7. A literature review of remediations and their effectiveness.

POTENTIAL SOURCES OF POLLUTION	REMEDIATION	PERCENT REDUCTION	COST	IMPACT
Feedlots (manure management)				
	Structural			Reduce runoff of nutrients, fecal coliform and total suspended solids from animal waste into adjacent waterways
	Holding Ponds	50-70%	$25,000	
	Lagoons	75-100%	$25,000-$85,000	
	Bunkers	*	$10,000-$50,000	
	Tanks	*		
	Composting			
	Operational			
	Total animal waste management			
	Hook into MWWTF	*		
Agriculture	Structural			These practices reduce soil erosion and therefore, decrease the transport of sediments and associated nutrients (soluble and insoluble) into adjacent waterways
	Sprinkler systems			
	Operational (BMPs)			
	Conservation tillage	full strip 40-90% (1)		
		wide strip 40-60% (1)		
		narrow strip 50-95% (1)		
	Contour farming	50% max (1)		
	Strip cropping	75% max (1)		
	Cover crops	40-60% (1)		
	Terrace	95-98% (1)		
	Grade stabilization	75-90% (1)		
	Water sediment control	40-60% (1)		
		60-80% (1)		

POTENTIAL SOURCES OF POLLUTION	REMEDIATION	PERCENT REDUCTION	COST	IMPACT
	Filter strips	35-40% (general) [2]	0.18-1.92/m² [2]	
	(10-25 m width)	70% (nutrients) [1]		
		80-90% (feedlots) [1]		
Agriculture (cont.)	Nutrient Management			
	Livestock Management			Reduce streambank erosion, reduce the transport of animal waste and associated pollutants (nutrients, fecal coliform and total suspended solids) into adjacent waterways
	Exclusion	*		
	Rest-rotation	*		
	Mgmt + reveg	groundcover >30% [1]		
	Mgmt w/o reveg	groundcover >10% [1]		
	Fencing	*	$2-$2.50/ft [1]	
	Constructed wetlands	?	$5,000 and up	
Streambank	Non-structural			These practices stabilize streambanks and reduce soil and streambank erosion.
	Revegetation			
	Trees	15-50%	$1-$2/ft for willows [1]	
	Brush	50-60%	0.18-1.92/m² [2]	
	Grass	up to 90% [2]	$55 and up/acre [1]; $1.50-$3.50/ft [1]	
	Snag removal and clearing	*	$1/ft [1]	
	Structural			
	Flow regulation		Up to $5,000 depend. on size, length	
	Drop structures	*		
	Rock Pools	*	up to $20-placed rock	
	Wire structures		$500/ea	
	Revetments			
	Conifer	** [1]	$12/ft [3]	

POTENTIAL SOURCES OF POLLUTION	REMEDIATION	PERCENT REDUCTION	COST		IMPACT
	Rock	** [1]	$200-$400/ft		
	Deflectors				
	Single	75% [1]	$500/ea		
	Irrigation management (offsite watering, pipelines)	25-75% [1]	$400/trough + $?/pump + $2/ft for pipe [1]		
Open Channel	Meander Reconstruction	** [1]	$50/ft [2]		Reduce streambank erosion
			COST PER MGD		
			CONSTRUCTION [4]	**MAINTENANCE [4]**	
Wastewater	Hook into MWWTF				Reduce total phosphorus
	Land treatment option	80-90% [3]	$980,000-1,200,000	$44,000-64,000	
	Rapid infiltration (underdrained or not)	80-90% [3]	$34,000-44,000	$25,000-47,000	
	Overland flow	30-60% [3]			
	Activated sludge	>90% [3]	$160,000-820,000	$10,000-64,000	
	Alum	94% [3]	$18,000-48,000	$40,000-55,000	
	Ferric chloride	56-97% [3]	$16,000-46,000	$28,000-40,000	
	Lime clarification of raw wastewater	75% [3]	$21,000-47,000	$20,000	
	Primary treatment				Reduce total suspended solids
	With mineral addition	60-75% [3]			
	Without mineral addition	40-70%			
	Secondary treatment				
	Trickling filter				
	With mineral addition	85-95% [3]			
	Without mineral addition	70-92%			
	Activated sludge				
	With mineral addition	85-95% [3]			
	Without mineral addition	85-95%			

[1] Utah Little Bear River Hydrologic Unit Plan 1992 [2] Water Quality Investigations - Lower Bear River and Hyrum Reservoir; ERI 1991 [3] Process Design Manual for Phosphorus Removal; USEPA 625/1-76-0019 [4] Barker et al. 1989

6.0 PROJECT RANKING AND IMPLEMENTATION

6.1 Project Ranking & Phasing

As required by 26-11-6 of the Utah Code Annotated 1953, the waters of the State of Utah are grouped into classes so as to protect against controllable pollution. The Lower Bear River from Cutler Reservoir to the confluence with Great Salt Lake has been identified as a High Priority watershed, 303(d) list Unified Assessment Category IB. The Eastern Box Elder County Committee, a citizen and technical agency group organized to identify and find means to solve natural resource issues, has worked closely with BRWCD to broaden local input and provide technical assistance. Water quality was identified as a high priority concern by the group.

6.2 Project Implementation Plans (PIPs)

The Project Implementation Plan for this project has been prepared and is included within this document as Appendix E.

7.0 FUTURE LAND AND WATER USE

7.1 Zoning Ordinances

Box Elder County General Plan contains policy for water quality protection stated as 1) Maintain the current level of water quality, 2) protection measures for springs and watersheds and 3) protection of groundwater recharge areas and wellhead protection. The county has adopted Ordinance # 216 entitled "An ordinance of Box Elder County Amending Ordinance No. 121 and Establishing Drinking Water Source Protection." It requires all source protection zones to be registered with the county in form of maps and water quality protection criteria as defined by the Utah Division of Drinking Water. The purpose of the ordinance is "... to ensure the provision of a safe and sanitary drinking water supply...from public water systems... by the establishment of drinking water source protection zones surrounding ...wellheads and springs...and by designation and regulation of property uses and conditions that may be maintained within such zones."

7.2 Potential Water Quality Impacts

Population growth from year 2000 level of 33,150 is expected to reach about 52,700 in the year 2020. These low population levels are not now a serious threat to water quality and will not be significant in the future.

The Utah State Water Plan proposes that by the year 2015 an export of 100,000 acre-feet of Bear River water to the highly urbanized areas along the Wasatch Front will be required for projected municipal and industrial needs. This plan calls for a new large reservoir in the sub-basin with diversion and delivery systems. A diversion point located near the town of Elwood has been identified. This would require adding the beneficial use category of class 1C defined as "Protected for domestic purposes with prior treatment by treatment processes as required by the Utah Division of Drinking Water." A drinking water source protection zone would need to be established along the Bear River corridor extending for about 25 miles.

7.3 Recommended Monitoring Program

The main objective of a water quality investigations will be to document the water quality conditions above, at and below the current project location.

It is recommended that grab samples be obtained from the Bear River above and below Cutler Reservoir and at Corinne. Samples should also be collected in the Malad River, just upstream of the confluence with the Bear River. It is recommended that samples be collected quarterly, and follow the major hydrologic conditions including upper and lower basin runoff as well as summer and winter baseflow. Parameters will include nutrients (nitrogen and phosphorous), total suspended solids, dissolved oxygen and temperature. All sampling procedures should follow Standard Methods (APHA 1999).

8.0 CONCLUSIONS

A detailed investigation of water quality conditions within the Bear River from Cutler Reservoir to the Bear River Bird Refuge was undertaken by the Utah Department of Environmental Quality and the Bear River Water Conservancy District through a contract with Ecosystems Research Institute. The investigation included a summary of historical conditions at several mainstem sites as well as the larger tributaries entering the Bear River. In addition to the review of historical water quality conditions, additional data was collected on the mainstem Bear River and the Malad River. Data were collected during four hydrologic time periods corresponding to upper and lower basin runoff and summer and winter baseflow.

The historical as well as the current water quality data was analyzed for spatial and temporal trends. The analysis indicated that the historical data (primarily from 1990 to 2000) was similar to data collected in this study.

The complete data set (1990-2000) was also analyzed for the number and locations of water quality exceedences based upon the current water quality standards. This analysis indicated that for the mainstem sites, the total phosphorous criteria of 0.05 mg/l was violated 93.5 per cent of the observations. Total suspended solids exceeded the 90 mg/l criteria 37.6 per cent of the observations, followed by dissolved oxygen (7.2%), pH (0.5%) and temperature (0.2%). The major tributaries to the river showed the same pattern.

Based upon the exceeded criteria, a Total Maximum Daily Load (TMDL) for the Lower Bear River was calculated for total phosphorous. Several approaches were used to calculate the non point source category. Using water quality data combined with flows at several mainstem locations, a mass loading reach gain/loss analysis was done for total phosphorous as well as total suspended solids. In addition, a basin wide hydrologic mass balance was modified to include water quality conditions. This modifications allowed for a watershed mass balance of phosphorous which also included unknown sources (nonpoint). Both approaches were used in the determination of load allocations and load reductions necessary to reach the TMDL level for total phosphorous.

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APPENDIX A

Water Quality Data

SITE	DESCRIPTION	DATE	FLOW (cfs)	TEMP (°C)	pH	COND (µmho/cm)	DO (mg/L)	TURB (NTU)	NH_3 (mg/L)	NO_3+NO_2 (mg/L)	NO_2 (mg/L)	TP (mg/L)	TSS (mg/L)	OP (mg/L)
BR18	BR at UT-ID stateline	05/20/99		13.47	8.1	651	9.49	19	0.04	0.35	0.005	0.112	44	<0.005
BR18	BR at UT-ID stateline	10/06/99		12	8.04	815	9.57	4.1	0.005	0.35	0.01	0.033	7	<0.005
BR18	BR at UT-ID stateline	03/13/00		6.01	7.81	818	10.61	22	0.147	0.765	0.01	0.067	33	0.024
BR18	BR at UT-ID stateline	04/25/00		13.74	8.39	878	8.84		0.078	0.415	0.01	0.064	30	0.015
BR18	BR at UT-ID stateline	06/20/00		17.32	8.38	880	7.45		0.057	0.154	0.007	0.063	37	0.007
BR19	BR blw Cutler	03/13/00		6.77	8.28	832	11.1	36	0.106	0.873	0.017	0.138	40	0.069
BR19	BR blw Cutler	04/25/00		13.01	8.28	606	8.7		0.052	0.472	0.017	0.058	86	0.029
BR19	BR blw Cutler	06/21/00		20.58	8.06	1710	6.48		<0.030	0.104	0.002	0.054	26	0.009
BR19	BR blw Cutler	10/02/00		15.83	8.11	1439	6.45		0.070	0.097	0.004	0.065	32	0.011
BR20	BR at Deweyville (old SR30)	03/13/00		6.25	8.32	760	11.2	28	0.081	0.851	0.017	0.13	44	0.063
BR20	BR at Deweyville (old SR30)	04/25/00		13.22	8.39	615	8.77		<0.030	0.509	0.016	0.055	69	0.028
BR20	BR at Deweyville (old SR30)	06/21/00		23.75	8.49	1323	10.87		<0.030	0.005	0.001	0.076	52	0.007
BR20	BR at Deweyville (old SR30)	10/02/00		16.65	8.5	1043	9.02		0.085	0.021	0.002	0.072	43	0.017
BR21	BR at Corinne	03/13/00		7.67	8.35	1147	11.78	33	0.047	0.999	0.02	0.138	43	0.065
BR21	BR at Corinne	04/25/00		16.01	8.49	858	9.9		<0.030	0.547	0.018	0.083	46	0.024
BR21	BR at Corinne	06/21/00		22.82	8.63	4730	18.77		0.064	0.424	0.112	0.171	126	0.014
BR21	BR at Corinne	10/02/00		17.62	8.32	2580	9.71		0.099	0.639	0.059	0.201	184	0.027
BR22	BR at Bird Refuge	04/28/00		20.02	8.31	1173	6.8		<0.030	0.021	<0.001	0.293	353	0.020
BR22	BR at Bird Refuge	06/21/00		26.4	8.71	2240	11.3		0.048	0.007	0.002	0.265	266	0.011
BR22	BR at Bird Refuge	10/02/00		19.19	8.92	4040	9.79		0.046	0.018	0.003	0.501	449	0.042
BR23	BR at Bird Refuge Building	10/02/00		17.3	8.5	3300	10.35		0.052	0.098	0.043	0.105	75	0.022
BSLOUGH	Black Slough	10/02/00		18.62	8.27	1126	9.75		0.043	0.507	0.005	0.229	25	0.179
DR01A	Drain	08/07/00	1.62	20.24	8.15	1051	6.71		0.046	0.811	0.023	0.146	12	0.112
DR01B	Drain - Field RO	08/07/00	0.638	23.1	8.42	993	6.46		0.091	2.378	0.047	0.904	754	0.228
DR02	Drain	08/07/00	0.101	19.72	8	3650	3.7		0.714	3.133	0.300	0.280	36	0.200
DR03A	Drain - Above	08/07/00	4.87	24.01	8.58	941	10.94		0.062	0.415	0.014	0.118	40	0.072
DR03B	Drain - Below	08/07/00	7.68	23.5	8.55	1030	8.05		0.060	0.559	0.019	0.160	51	0.098
MR01	Malad at 3700 South	10/06/99	21.29	10.89	8.48	277	8.95	21	0.016	0.46	0.005	0.154	54	0.042
MR01	Malad at 3700 South	03/13/00	1.82	7.42	7.92	1785	10.12		0.05	1.867	0.008	0.146	122	0.045
MR01	Malad at 3700 South	04/27/00	2.22	8.3	8.15	1735	11.22		0.032	1.742	0.012	0.026	10	0.034
MR01	Malad at 3700 South	06/21/00	1.75	19.93	8.2	2000	11.03		0.047	0.420	0.008	0.055	25	0.012

SITE	DESCRIPTION	DATE	FLOW (cfs)	TEMP (°C)	pH	COND (µmho/cm)	DO (mg/L)	TURB (NTU)	NH_3 (mg/L)	NO_3+NO_2 (mg/L)	NO_2 (mg/L)	TP (mg/L)	TSS (mg/L)	OP (mg/L)
MR01	Malad at 3700 South	10/02/00	0.74	11.44	7.77	2300	8.56		<0.030	0.777	0.004	0.032	8	0.024
MR02	Malad River blw Riverside	03/13/00		7.68	7.99	3240	9.71		0.076	0.659	0.012	0.172	174	0.045
MR03	Malad abv Confluence	03/13/00		7.93	8.11	2970	9.92	93	0.134	1.758	0.021	0.302	244	0.088
MR03	Malad abv Confluence	04/27/00		14.01	8.3	4260	8.35		0.402	0.964	0.039	0.151	203	0.144
MR03	Malad abv Confluence	06/21/00	5.83	24.94	8.64	3180	18.14		0.182	4.731	0.136	0.338	81	0.110
MR03	Malad abv Confluence	10/02/00		16.59	8.19	2370	8.22		0.259	1.280	0.032	0.311	206	0.205
MR04	Malad at Portage	03/13/00		8.7	7.74	3120	9.21		0.09	0.345	0.004	0.105	83	0.028
MR04	Malad at Portage	04/27/00		13.12	8	3710	7.63		0.082	0.221	0.005	0.051	70	0.021
MR04	Malad at Portage	06/21/00	8.55	20.92	7.96	6920	7.47		<0.030	<0.004	0.001	0.115	119	0.007
MR04	Malad at Portage	10/02/00		15.09	7.82	7480	7.24		0.044	0.008	0.001	0.053	68	0.016
MR05	Malad River at Aquaduct	03/21/00		6.17	8.05	3950	10.23		0.145	0.482	0.011	0.107	59	0.03
MR05	Malad River at Aquaduct	04/27/00		13.44	8.19	4450	7.92		0.068	0.276	0.009	0.059	122	0.020
MR05	Malad River at Aquaduct	06/21/00	11.44	22.06	8	8710	8.13		0.039	0.010	0.003	0.137	163	0.008
MR05	Malad River at Aquaduct	10/02/00	12.71	16.96	7.79	8710	6.94		0.084	0.169	0.009	0.061	70	0.012
MT01	Wrights Creek	10/06/99	3.7	11.77	8.18	1128	9.53	19	0.011	0.351	0.017	0.219	62	0.091
MT01	Wrights Creek	03/13/00	3.42	-0.11	7.22	548	9.91		0.056	0.22	0.002	0.131	38	0.089
MT01	Wrights Creek	04/27/00	4.57	6.39	8.19	512	10.63		<0.030	0.119	0.003	0.075	99	0.086
MT01	Wrights Creek	06/21/00	0.79	17.74	8.3	508	8.32		<0.030	0.172	0.006	0.173	41	0.123
MT01	Wrights Creek	10/02/00	0.59	10.14		612	7.99		<0.030	0.601	0.004	0.175	75	0.084
MT02	Elkhorn Creek	10/06/99	1.57	12.1	7.97	885	9.77	1.2	0.005	0.255	0.009	0.014	7	0.006
MT02	Elkhorn Creek	03/13/00	0.85	2.18	8.23	368	11.58		0.039	0.329	<0.001	0.102	169	<0.006
MT02	Elkhorn Creek	04/27/00	0.89	8.14	8.4	360	10.04		<0.030	0.332	0.002	0.025	8	0.005
MT03	Deep Creek	10/06/99	2.3	10.56	8.35	515	9.44	0.7	0.01	2.01	0.014	0.019	2	0.01
MT03	Deep Creek	03/13/00	0.53	6.5	7.93	2770	11.38		0.058	1.904	0.008	0.033	5	0.02
MT03	Deep Creek	04/27/00	0.62	7.36	8.08	2910	11.01		0.058	1.254	0.007	0.013	8	0.011
MT03	Deep Creek	06/21/00	1.22	19.42	8	3360	9.23		0.047	0.030	0.002	0.048	3	0.031
MT03	Deep Creek	10/02/00	0.57	11.7	7.83	3220	8.69		<0.030	0.553	0.005	0.011	5	0.013
MT04	Devil Creek	10/06/99	1.74	6.66	8.26	353	10.56	4.3	0.012	3	0.018	0.136	17	0.091
MT04	Devil Creek	03/13/00	0.35	2.53	8.17	753	13.52		0.054	3.842	0.025	0.122	10	0.088
MT04	Devil Creek	04/27/00	0.93	7.67	8.57	472	12.38		<0.030	0.844	0.016	0.047	13	0.070
MT05	Little Malad River	10/06/99	4.47	14.01	8.2	1424	8.63	8.4	0.041	0.281	0.005	0.126	34	0.057

SITE	DESCRIPTION	DATE	FLOW (cfs)	TEMP (°C)	pH	COND (µmho/cm)	DO (mg/L)	TURB (NTU)	NH_3 (mg/L)	NO_3+NO_2 (mg/L)	NO_2 (mg/L)	TP (mg/L)	TSS (mg/L)	OP (mg/L)
MT05	Little Malad River	03/13/00	4.83	4.03	8	835	12.47		0.043	0.46	0.004	0.092	40	0.039
MT05	Little Malad River	04/27/00	5.07	10.06	8.09	1040	10.26		0.036	0.155	0.003	0.084	16	0.154
MT05	Little Malad River	06/21/00	0.62	22.92	8.37	1433	12.22		0.036	0.009	0.003	0.118	16	0.083
MT05	Little Malad River	10/02/00	0.963	11.77	7.85	1445	8.26		0.048	0.205	0.011	0.117	48	0.072
MT06	Trib. to Malad at Riverside	03/21/00	0.8	7.3	8.14	1376	11.98		<0.030	2.948	0.041	0.176	58	0.009
MT06	Trib. to Malad at Riverside	04/27/00	0.36	9.53	8.18	1417	7.64		0.082	2.175	0.078	0.036	8	0.029
MT06	Trib. to Malad at Riverside	06/21/00	1.22	20.69	8.27	1152	10.74		0.084	2.252	0.059	0.181	54	0.103
MT06	Trib. to Malad at Riverside	08/07/00	2.63	16.65	8.09	1281	8.53		0.161	2.478	0.115	0.279	196	0.012
MT06	Trib. to Malad at Riverside	10/02/00	2.23	13.52	7.97	1310	8.54		0.050	2.606	0.056	0.147	80	0.006
PT01	Point	10/02/00	2.2	13.34	7.82	173.8	6.17		0.088	2.212	0.053	0.102	25	0.006
PT02	Point	10/02/00	9.16	16.37	8.35	895	10.57		0.079	0.278	0.027	0.085	17	0.066
PT03	Point	10/02/00	0.16	24.93	8.26	575	6.72		1.246	1.279	0.252	0.867	197	0.555
T29	Tributary to Bear at Elwood	03/21/00	0.1	8.32	7.8	1889	9.38		<0.030	22.863	0.011	0.188	14	0.179
T29	Tributary to Bear at Elwood	04/27/00	0.01	10.19	8.29	1915	10.27		0.041	22.548	0.013	0.080	1	0.169
T29	Tributary to Bear at Elwood	06/21/00	0.15	21.22	7.69	1207	5.25		0.442	9.248	0.218	0.088	30	0.375
T29	Tributary to Bear at Elwood	08/07/00	0.045	17.51	7.94	1373	6.24		0.067	11.292	0.007	0.176	8	0.155
T29	Tributary to Bear at Elwood	10/02/00	0.21	18.82	8.66	873	8.06		0.043	0.102	0.015	0.064	10	0.035
TREWWTP	Tremonton WWTP	10/02/00	1.7	17.6	7.6	1466	7.13		0.151	11.080	0.005	2.526	6	2.387

APPENDIX B

Hydrologic Modeling Data

Model Input Data: Malad River Flows

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	AVG
INFLOWS													
Precipitation	2.2	1.9	2.1	2.4	2.5	1.4	0.6	0.7	1.1	1.6	2.0	2.3	1.7
Effective Cropland Precipitation	11.3	9.8	11.1	12.4	12.8	7.5	3.2	3.4	5.7	8.2	10.5	11.9	6.9
Domestic Water Supply Pumped	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subsurface Inflow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Importation	0.0	0.0	0.0	0.3	9.0	14.2	14.2	13.6	6.2	1.5	0.0	0.0	3.9
River Inflow (Existing)	90.5	122.0	158.0	125.0	84.5	48.1	27.6	27.2	27.5	49.2	75.4	77.0	76.0
Gaged Tributary Inflow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gaged Tributary Inflow Number 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ungaged Inflow	9.8	15.1	26.4	26.0	30.1	43.9	54.9	53.0	27.7	13.9	3.9	2.4	25.6
Agricultural Return Flow	11.2	9.4	10.8	0.0	1.0	2.8	0.9	0.5	0.2	1.7	10.1	11.6	5.0
Domestic Return Flow	0.4	0.4	0.4	0.4	1.8	3.6	4.4	3.6	1.4	0.9	0.4	0.4	1.5
Wetland Open Water Return Flows	1.5	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.5	0.4
OUTFLOWS													
River Outflow (Existing)	107.0	139.6	193.2	144.2	97.4	57.0	32.9	34.2	33.3	54.1	85.0	85.5	88.6
Tributary Outflow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subsurface Outflow	6.1	8.2	1.8	4.3	0.7	0.3	0.4	0.0	0.3	0.9	2.6	5.6	2.6
Wetland Open Water Diversions	0.0	0.0	0.0	2.3	5.5	9.6	13.6	12.0	6.5	2.6	0.0	0.0	4.3
Crop Diversions	0	0	0	0.3	20.1	41.0	49.1	46.9	20.6	8.2	1.1	1.0	15.7
Domestic Diversions Pumped	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Domestic Diversions Stream	0.4	0.4	0.4	0.4	1.9	4.0	4.9	4.0	1.6	1.1	0.4	0.4	1.7
Export out	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSUMPTIONS													
Agricultural Crop Consumption	0.1	0.1	0.3	13.0	31.9	49.0	58.2	46.4	26.6	11.8	0.3	0.1	19.8
Domestic Consumption	0.0	0.0	0.0	0.0	0.2	0.4	0.5	0.4	0.2	0.1	0.0	0.0	0.2
Wetland Openwater Consumption	0.7	0.7	2.2	4.6	7.9	11.0	14.2	12.6	7.6	4.1	1.6	0.7	5.7

Model Input Data: Bear River Flows (Cutler to Corinne)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	AVG
INFLOWS													
Precipitation	43.3	37.5	42.5	47.4	49.1	28.7	12.1	13.0	21.8	31.4	40.3	45.5	34.4
Effective Cropland Precipitation	120.1	104.0	117.8	131.6	136.2	79.5	33.7	35.9	60.4	87.2	111.7	125.9	95.3
Domestic Water Supply Pumped	0.5	0.5	0.5	0.5	1.1	1.3	1.9	1.3	1.1	0.8	0.5	0.5	0.9
Subsurface Inflow	6.1	8.2	1.8	4.3	0.7	0.3	0.4	0.0	0.3	0.9	2.6	5.6	2.6
Importation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
River Inflow (Existing)	1672.6	1715.7	2312.2	2746.3	3336.9	2691.7	1504.4	1465.0	1436.9	1658.3	1646.3	1711.4	1991.5
Gaged Tributary Inflow	107.0	139.6	193.2	144.2	97.4	57.0	32.9	34.2	33.3	54.1	85.0	85.5	88.6
Gaged Tributary Inflow Number 2	2.1	2.1	2.1	2.1	20.5	45.5	69.4	68.1	42.8	3.8	2.1	2.1	21.9
Ungaged Inflow	126.5	78.5	248.5	164.0	206.1	203.4	93.0	117.0	138.6	232.5	161.3	145.1	159.5
Agricultural Return Flow	92.2	85.6	109.8	45.9	253.9	422.5	503.3	531.0	350.2	140.5	55.0	92.1	223.5
Domestic Return Flow	2.6	2.6	2.6	2.6	5.5	6.4	6.3	7.0	5.3	4.4	2.6	2.7	4.2
Wetland Open Water Return Flows	30.9	25.9	16.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.1	33.4	10.2
OUTFLOWS													
River Outflow (Existing)	1987.8	1990.9	2872.3	3041.9	3282.7	2539.3	1115.4	1077.2	1291.5	1777.4	1876.8	2034.5	2074.0
Tributary Outflow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subsurface Outflow	13.6	46.1	5.0	29.9	62.9	35.6	6.2	7.2	0.0	0.0	0.7	2.0	17.4
Wetland Open Water Diversions	0.0	0.0	0.0	12.7	37.3	101.3	182.9	192.5	101.1	34.1	0.0	0.0	55.2
Crop Diversions	0.0	0.0	0.0	1.8	420.2	717.5	869.5	909.4	588.9	235.2	26.2	0.0	314.1
Domestic Diversions Pumped	0.5	0.5	0.5	0.5	1.1	1.2	1.8	1.4	1.0	0.8	0.5	0.5	0.9
Domestic Diversions Stream	1.8	1.8	1.8	1.8	3.6	4.2	6.3	4.7	3.5	2.9	1.8	1.8	3.0
Export out	32.8	19.2	7.1	32.4	116.1	24.9	31.0	30.9	20.4	49.6	56.7	40.9	38.5
CONSUMPTIONS													
Agricultural Crop Consumption	0.3	0.3	1.0	82.6	331.2	541.6	605.3	395.4	197.4	50.5	1.0	0.3	183.9
Domestic Consumption	0.1	0.1	0.1	0.1	0.3	0.3	0.5	0.4	0.3	0.2	0.1	0.1	0.2
Wetland Openwater Consumption	11.0	10.4	25.3	48.8	86.4	129.1	194.6	206.4	122.2	66.1	22.9	11.7	77.9

Model Input Data: Malad River Phosphorus Concentrations

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	AVG
INFLOWS													
River Inflow	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
Precipitation	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.030
Effective Cropland Precipitation	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.030
Domestic Water Supply Pumped	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.030
Subsurface Inflow	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.030
Importation	0.103	0.104	0.105	0.051	0.083	0.115	0.084	0.053	0.067	0.082	0.101	0.102	0.087
River Inflow	0.103	0.104	0.105	0.051	0.083	0.115	0.084	0.053	0.067	0.082	0.101	0.102	0.087
Gaged Tributary Inflow	0.102	0.106	0.107	0.047	0.093	0.130	0.140	0.145	0.117	0.090	0.094	0.098	0.106
Gaged Tributary Inflow Number 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ungaged Inflow	0.105	0.124	0.124	0.197	0.198	0.203	0.165	0.126	0.088	0.049	0.068	0.087	0.128
Agricultural Return Flow	0.189	0.159	0.188	0.080	0.084	0.088	0.192	0.297	0.288	0.279	0.249	0.219	0.193
Domestic Return Flow	2.7	4.0	3.1	3.2	5.4	5.9	3.1	2.6	2.4	4.8	3.1	4.1	3.708
Wetland Open Water Return Flows	0.184	0.224	0.188	0.080	0.084	0.088	0.132	0.176	0.120	0.064	0.104	0.144	0.132
OUTFLOWS													
River Outflow	0.105	0.105	0.117	0.166	0.192	0.136	0.750	0.529	0.324	0.149	0.099	0.084	0.230
Tributary Outflow	0	0	0	0	0	0	0	0	0	0	0	0	0.000
Subsurface Outflow	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Wetland Open Water Diversions	0.105	0.105	0.117	0.166	0.192	0.136	0.750	0.529	0.324	0.149	0.099	0.084	0.230
Crop Diversions	0.103	0.104	0.105	0.051	0.083	0.115	0.084	0.053	0.067	0.082	0.101	0.102	0.087
Domestic Diversions Pumped	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Domestic Diversions Stream	0.103	0.104	0.105	0.051	0.083	0.115	0.084	0.053	0.067	0.082	0.101	0.102	0.087
Export out	0.103	0.104	0.105	0.051	0.083	0.115	0.084	0.053	0.067	0.082	0.101	0.102	0.087
CONSUMPTIONS													
Agricultural Crop Consumption	0.103	0.104	0.105	0.051	0.083	0.115	0.084	0.053	0.067	0.082	0.101	0.102	0.087
Domestic Consumption	0.103	0.104	0.105	0.051	0.083	0.115	0.084	0.053	0.067	0.082	0.101	0.102	0.087
Wetland Openwater Consumption	0.105	0.105	0.117	0.166	0.192	0.136	0.750	0.529	0.324	0.149	0.099	0.084	0.230

shaded (red) text indicates data from ERI study

Model Input Data: Bear River Phosphorus Concentrations (Cutler to Corinne)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	AVG
INFLOWS													
River Inflow	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.050
Precipitation	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.030
Effective Cropland Precipitation	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.030
Domestic Water Supply Pumped	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.030
Subsurface Inflow	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.030
Importation	0	0	0	0	0	0	0	0	0	0	0	0	0.000
River Inflow	0.144	0.150	0.122	0.146	0.122	0.098	0.130	0.165	0.121	0.165	0.172	0.250	0.149
Gaged Tributary Inflow	0.105	0.105	0.117	0.166	0.192	0.136	0.750	0.529	0.324	0.149	0.099	0.084	0.106
Gaged Tributary Inflow Number 2	0.047	0.093	0.130	0.140	0.145	0.117	0.090	0.094	0.098	0.102	0.106	0.107	0.183
Ungaged Inflow	0.219	0.313	0.300	0.110	0.110	0.182	0.254	0.153	0.143	0.140	0.135	0.131	0.183
Agricultural Return Flow	0.080	0.084	0.088	0.192	0.297	0.288	0.279	0.249	0.219	0.189	0.159	0.188	0.193
Domestic Return Flow	2.7	4.0	3.1	3.2	5.4	5.9	3.1	2.6	2.4	4.8	3.1	4.1	3.708
Wetland Open Water Return Flows	0.080	0.084	0.088	0.132	0.176	0.120	0.064	0.104	0.144	0.184	0.224	0.188	0.132
OUTFLOWS													
River Outflow	0.171	0.172	0.171	0.297	0.198	0.159	0.121	0.143	0.113	0.189	0.193	0.266	0.183
Tributary Outflow	0	0	0	0	0	0	0	0	0	0	0	0	0.000
Subsurface Outflow	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Wetland Open Water Diversions	0.080	0.084	0.088	0.132	0.176	0.120	0.064	0.104	0.144	0.184	0.224	0.188	0.132
Crop Diversions	0.144	0.150	0.122	0.146	0.122	0.098	0.130	0.165	0.121	0.165	0.172	0.250	0.149
Domestic Diversions Pumped	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Domestic Diversions Stream	0.144	0.150	0.122	0.146	0.122	0.098	0.130	0.165	0.121	0.165	0.172	0.250	0.149
Export out	0.144	0.150	0.122	0.146	0.122	0.098	0.130	0.165	0.121	0.165	0.172	0.250	0.149
CONSUMPTIONS													
Agricultural Crop Consumption	0.144	0.150	0.122	0.146	0.122	0.098	0.130	0.165	0.121	0.165	0.172	0.250	0.149
Domestic Consumption	0.144	0.150	0.122	0.146	0.122	0.098	0.130	0.165	0.121	0.165	0.172	0.250	0.149
Wetland Openwater Consumption	0.080	0.084	0.088	0.132	0.176	0.120	0.064	0.104	0.144	0.184	0.224	0.188	0.132

shaded (red) text indicates data from ERI study

APPENDIX C

BMP and BAT Research Data

The following is a list of proposed BMPs that may be used along with the information and education efforts to improve water quality in the Lower Bear-Malad Rivers Sub-basin.

Cropland Practices include: irrigation water management, crop sequencing, field borders, conservation tillage and filter strips.

Riparian practices include: streambank protection, fencing, filter strips, livestock exclusion, channel stabilization, off-site stock watering, and forest riparian buffers.

Grazing land practices include: off-site stock watering, range seeding, fencing, prescribed grazing and pasture plantings.

Manure management practices include: manure management and utilization systems, nutrient management, and runoff management systems.

All projects will include BMPs and will be planned to the level of a total resource management system in accordance with NRCS standards and specifications.

The following procedures will be used to achieve Project Goals:

1. Isolate water quality problem sources.

2. Select and implement projects for watershed non-point source problems.

3. Promote fair and cost effective nonpoint source pollution control.

4 Monitor progress and evaluate economic benefits of implementing water quality improvements.

5. Create a public awareness of water quality concerns and educate the public on how they can protect water quality for themselves and the community. Promote community involvement in project implementation activities by use of volunteer groups.

APPENDIX D

Project Implementation Plan

Draft

1.0 PROJECT PROPOSAL SUMMARY SHEET

PROJECT TITLE: Lower Bear-Malad Sub-basin (#16010204) TMDL Implementation

NAME, ADDRESS, PHONE AND E-MAIL OF LEAD PROJECT SPONSOR/SUBGRANTEE:

Eastern Box Elder Local Work Group

Attn: Penny Trinca - UACD Resource Coordinator

1860 N. 100 E.

Logan, Utah 84341-1780 Phone: 435-753-6029 #30

E-Mail: penny-trinca@ut.nacdnet.org

STATE CONTACT PERSON:

Mike Allred

Utah Division Water Quality

288 N. 1460 W.

Salt Lake City, UT 84114-4870 Phone: (801) 538-6316

E-Mail: mallred@deq.state.ut.us

STATE: Utah **BASIN:** Bear River **SUB-BASIN:** Lower Bear-Malad 16010204

HIGH PRIORITY WATERSHED: Yes, 303(d) list, Assessment Category IB

PROJECT TYPES	WATERBODY TYPES	NPS CATEGORY
[ ] Staffing & Support	[ ] Groundwater	[X] Agriculture
[X] Watershed	[ ] Lakes/Reservoirs	[ ] Urban Runoff
[ ] Groundwater	[X] Rivers	[ ] Silviculture
[X] I&E	[X] Streams	[ ] Construction
	[ ] Wetlands	[ ] Resource
		[X] Hydro-Mod

PROJECT LOCATION: Utah portion of Lower Bear-Malad Sub-basin. A point at the confluence of the Malad and Bear Rivers is located at Latitude: 41 deg 35 min 3 sec; Longitude: -112 deg 6 min 59 sec.

SUMMARIZATION OF MAJOR GOALS:

Goal #1: Implement five CAFOs and about 30 AFOs Comprehensive Nutrient Management Systems.

Goal #2: Improve stability of 10 miles of river channel and enhance the riparian corridor to reduce sediment nutrient loading to the river and its tributaries.

Goal #3: Improve irrigation, cropland and pasture management practices on about 60,000 acres to reduce sediment and nutrient runoff to the river and its tributaries.

Goal #4: Work with Utah Division of Water Quality to bring all point source pollution in to conformance with UPDES program.

Goal #5: Establish a post-project water quality monitoring program

Goal #6: Inform and educate the community concerning non-point source pollution and the importance of maintaining and improving water quality within the watershed.

Goal #7: Provide administrative services to project sponsors including match tracking, coordination, and reporting.

PROJECT DESCRIPTION: The intent of this project is to implement management practices, over a twelve year period, that will bring pollution loads identified in the Utah portion of the Lower Bear River/Malad River Sub-basin into compliance with state standards. Utah has coordinated with Idaho in the preparation of this plan.

Specific pollution concerns have been identified in the watershed and goals and endpoints defined. Potential remedial methods have also been described to accomplish this task.

BUDGET:

319 Funds (FY 2002-2014)	$	4,458,300
Match Funds	$	2,611,100
Other Federal Funds	$	0
319 Funded Full Time Personnel	$	0
Total Project Cost	**$**	**7,069,400**

319 Funds First Year (FY 2002)	$	337,000
Match Funds First Year (FY 2002)	$	218,000

2.0 STATEMENT OF NEED

Completion of a TMDL plan for the Utah portion of the Lower Bear - Malad Sub-basin has defined water quality issues. Earlier 319 demonstration projects have been completed or are now underway addressing known problem areas and that can be viewed as initial efforts to implement corrective action to remedy identified problems.

2.1 Project Water Quality Priority

As required by 26-11-6 of the Utah Code Annotated 1953, the waters of the State of Utah are grouped into classes so as to protect against controllable pollution (Table 1). The Lower Bear River from Cutler Reservoir to the confluence with Great Salt Lake has been identified as a High Priority watershed, 303(d) list Unified Assessment Category IB.

Total phosphorus was found to be exceeding State standards. Nutrient contamination causes additional excessive algal growth and turbidity in the deeper, slower flowing water of the Lower Bear. Warmer water with higher biological productivity may result in lower oxygen concentrations and stress to the aquatic community. It is possible that oxygen declines to harmful concentrations during the night time, particularly during the summer when flows are low and temperatures are highest. Nutrients associated with poor land management are most likely to enter during spring runoff or storm events.

High sediment loads in the river also impair fisheries and the ability of the river to support macroinvertebrates and other aquatic life. High turbidity also impacts the waters value for recreational uses. Sediments are delivered to the river during spring runoff, during summer storm events, and in canal return flows. Total suspended solids did not exceed state standards

Bacterial contamination in the river and its tributaries is a health concern for any recreational users of the stream. These bacterial contaminants are found in the same reaches with high nutrients. Coliforms and nutrients from animal feeding operations are often concentrated during spring runoff, although these may enter at a lower level continuously throughout the year. The river was not assessed for class 2 standards for protecting recreational use.

2.2 Boundaries and River Characteristic

The Lower Bear-Malad River Sub-basin has been divided into three watersheds. These are the Malad River, Lower Bear River and Thatcher-Penrose area. Fourteen sub-watersheds were also delineated. Sub-watersheds 1, 4, 7, and 10 required a full TMDL analysis (Figures 1 and 2).

The average flow of the Bear River measured at Corrine, Utah is 1,605 cfs over the period of record (1921-1998) (Division of Water Resources, Bear River Development report, August 5, 1999). Discharge in the Lower Bear below Cutler is affected by spring runoff, irrigation diversion, irrigation returns, outlet regulation and power ramping rates. Daily flows from July through October can be very low, averaging 25 cfs. Typical baseline flows range from 100-800 cfs.

The lower Bear River reach can be described as a meandering river flowing through broad valley silt-clay-sand old lake bed alluvium. It is laterally unstable with high bank erosion potential. A river bank analysis shows 35% of actively eroding bank areas. The river discharges into the Great Salt Lake through an elongated constructive delta with a distributary channel system highly altered by manmade dikes and canal systems.

Table 1. A summary of established beneficial uses and applicable standards or criteria for stream segments in the lower Bear River.

	BENEFICIAL USE [(1)]		
	Class 2	**Class 3**	**Class 4**
Bear River and tributaries, from Great Salt Lake to Utah-Idaho border	2B	3B and 3D	4
Malad River and tributaries, from confluence with Bear River to state line	2B	3C	
Box Elder Creek from confluence with Black Slough to Brigham City Reservoir (the Mayor's Pond)	2B	3C	4
Box Elder Creek, from Brigham City Reservoir (the Mayor's Pond) to headwaters	2B	3A	4

STANDARDS OR CRITERIA

TSS, mg/L	Phosphorus, mg/L	Temperature, °C	pH, SU	Dissolved Oxygen, mg/L
Class 3B: <90	into stream: <0.05	Class 3B: <27	6.5 - 9.5	>6.50
Class 3A: <35	into reservoir: <0.025	Class 3A: <20		

[(1)] ***Class 2 -- Protected for recreational use and aesthetics.***

b. Class 2B -- Protected for secondary contact recreation such as boating, wading, or similar uses.

Class 3 -- Protected for use by aquatic wildlife.

a. Class 3A -- Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.

b. Class 3B -- Protected for warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain.

c. Class 3C -- Protected for nongame fish and other aquatic life, including the necessary aquatic organisms in their food chain.

d. Class 3D -- Protected for waterfowl, shore birds and other water-oriented wildlife not included in Classes 3A, 3B, or 3C, including the necessary aquatic organisms in their food chain.

Class 4 -- Protected for agricultural uses including irrigation of crops and stock watering.

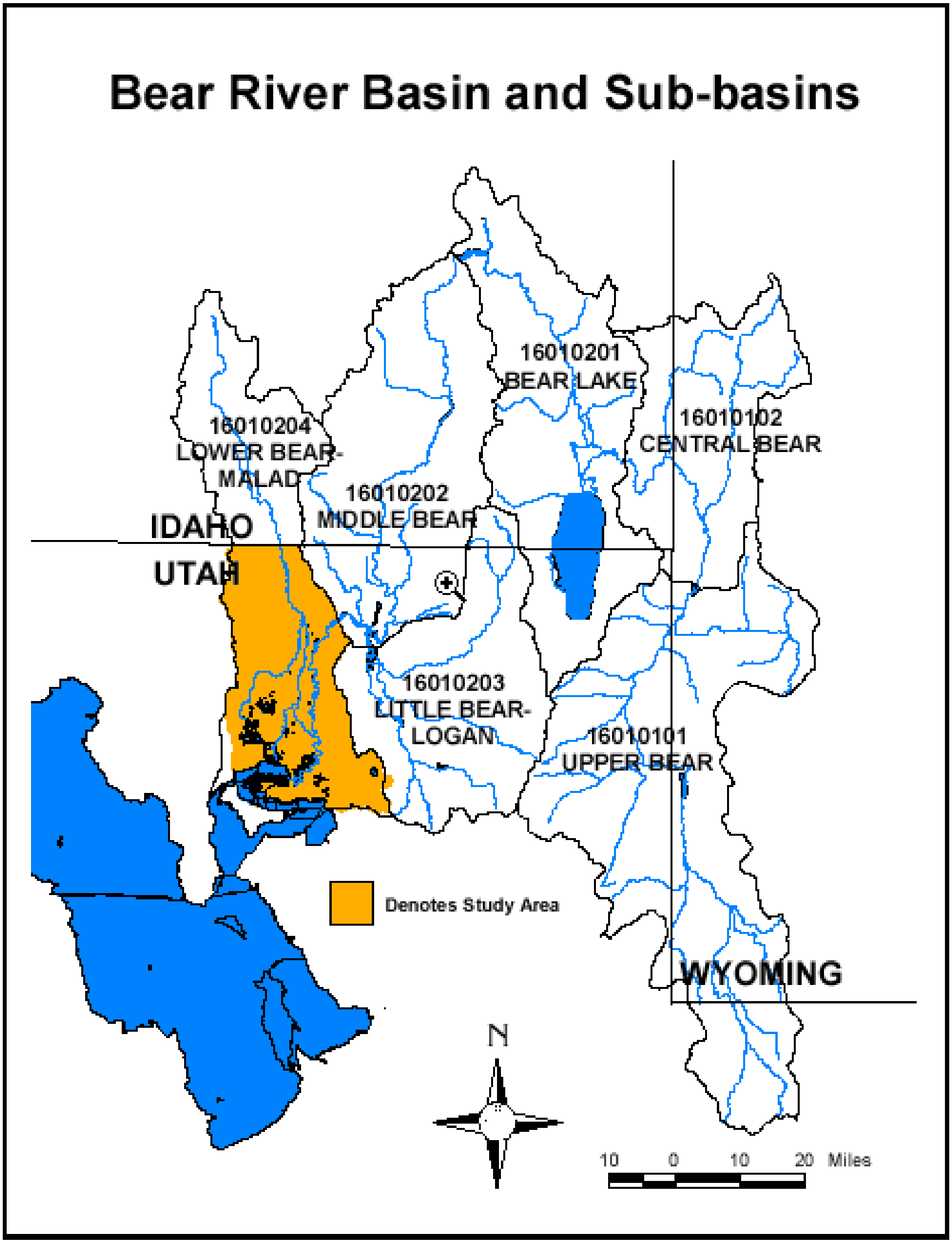


Figure 1. A map illustrating the project area in relation to the entire Bear River basin.

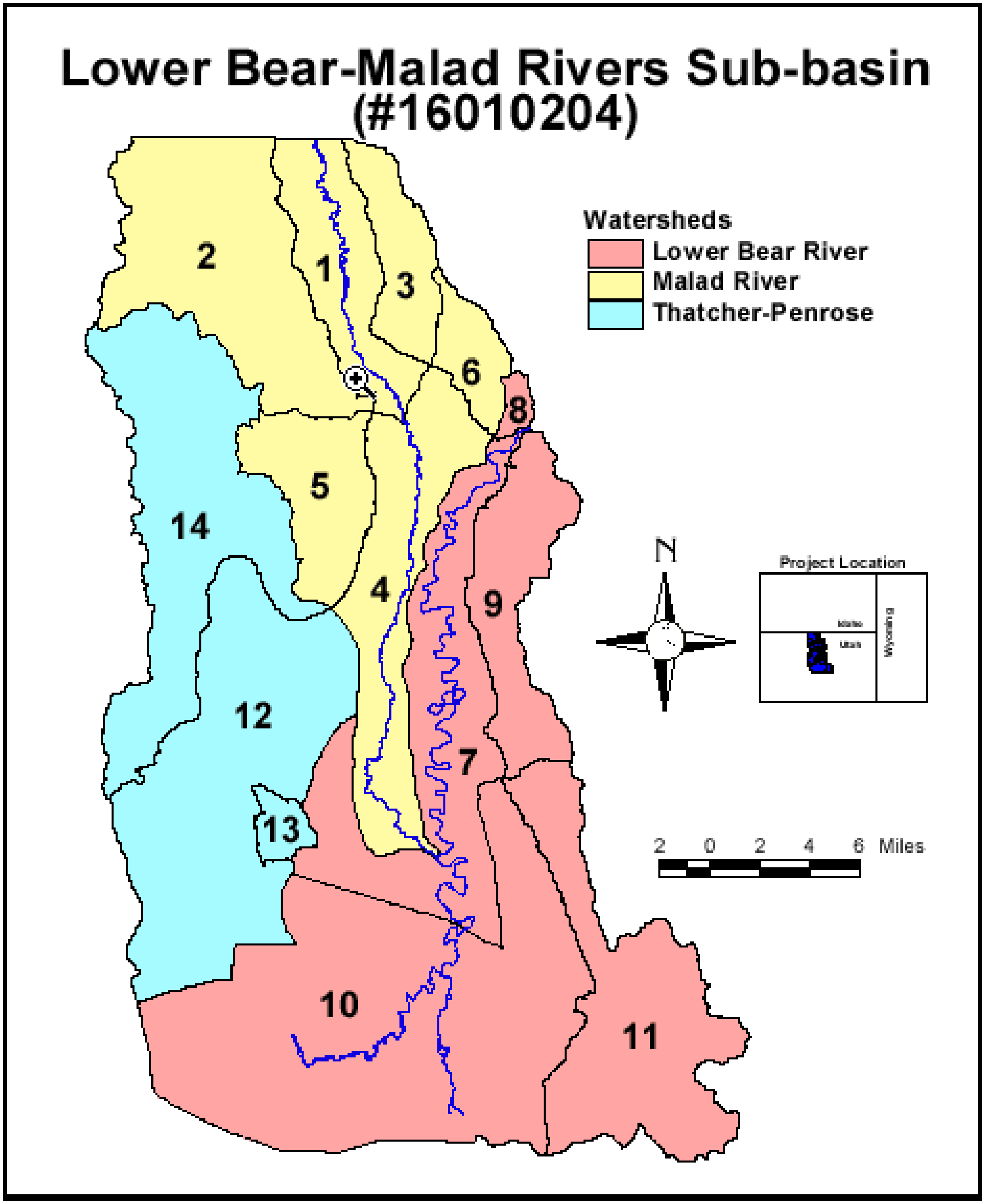


Figure 2. A map illustrating the lower Bear/Malad River watershed delineation. Numbers refer to sub-watersheds.

2.3 General Watershed Information

The Lower Bear-Malad River sub-basin is located in Box Elder County, Utah. The watershed encompasses approximately 429,000 acres. Land within the watershed is used primarily for small grains production, truck crops, livestock feed production, grazing and wildlife. Land use is about 2% urban, 34% cropland, 42% rangeland, 1% forest land, and 21% wetland, open water and barren.

Figure 3 displays cropland and pasture area and Figure 4 gives general location of animal feeding operations.

Land ownership, shown on Figure 5, is private 66 percent, state, 10 percent and federal 24 percent. Approximately 94 percent of the county's year 2000 population of 43,000 resides in the plan area. Employment is diversified with about 11 percent in agriculture, 37 percent manufacturing, 19 percent service industries, 18 percent construction and the remaining 15 percent in other activities.

Average annual precipitation in the valley ranges from 8-12 inches and in the uplands and mountains 12-35 inches, with most of that falling as snow during the winter months. Mean annual air temperature is 46-51 degrees Fahrenheit with a frost-free season of 100-150 days.

Mapped soils below the 4,500-foot elevation level are formed in mixed lake sediments derived from many kinds of rocks. They are nearly level to gently sloping. The soils are mostly silt loam, silty clay loams, and are moderately well drained to poorly drained. Permeability range is from 0.06 to 2 inches per hour.

The Lower Bear/Malad study area is composed of northerly trending, fault-block ranges bordering a fault block basin. In the higher mountains, woodland, mountain brush, and scattered open forest are found. Lower elevation basins, slopes and alluvial fans are either shrub and grass covered, shrub covered, or barren. The potential natural vegetation is, in order of decreasing elevation and ruggedness, scattered western spruce-fir forest, juniper woodland, Great Basin sagebrush, and saltbush-greasewood and tule marshes which occur locally especially along the Great Salt Lake shoreline. The valley bottom supports the bulk of Box Elder County's population and commercial activity. It is fed by perennial streams and aqueducts that originate in the adjacent mountains ranges. Alfalfa, vegetables, small grains, and orchard crops are grown. Land cover has been mapped by satellite images and GIS technology in a program known by the acronym GAP.

Principle native vegetation is big sagebrush, western wheat grass, Great Basin wildrye, and other associated grasses, forbs and shrubs. Riparian species within the drainage include cottonwood, booth willow, golden willow, river birch, red osier dogwood, coyote willow, saltgrass, sedges, foxtail, and wood rose. Non native russian olive and siberian elm trees have invaded the system.

Current uses of the river and its tributaries include irrigation and managed wetland diversions. Fishing and recreation are important. The river flood plain is used intensively for agricultural purposes; for animal watering and as pasture, cropland and several community parks.

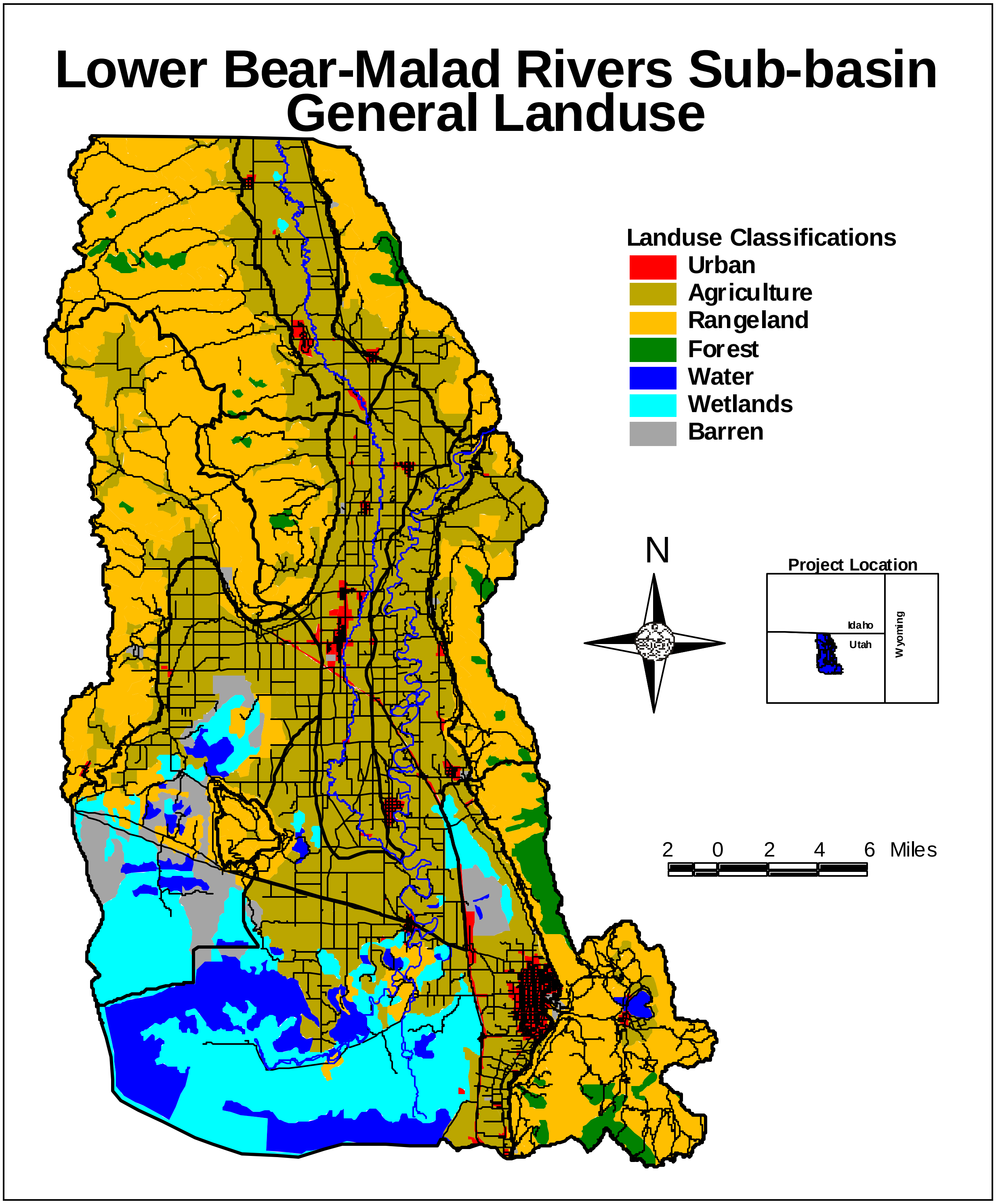


Figure 3. A map illustrating Lower Bear-Malad Rivers Sub-basin land use.

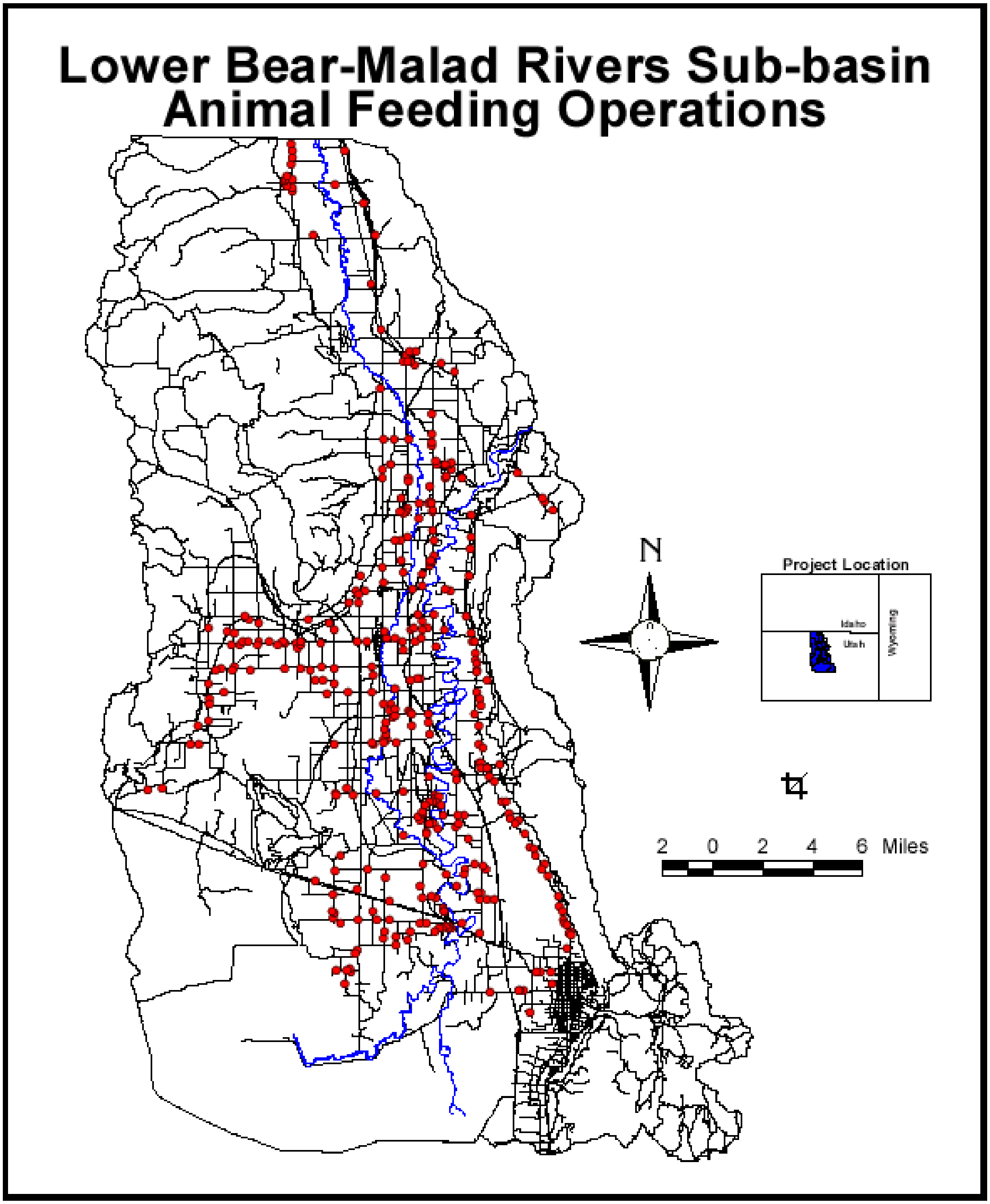


Figure 4. A map illustrating animal feeding operations in the Lower Bear-Malad Rivers Sub-basin project area.

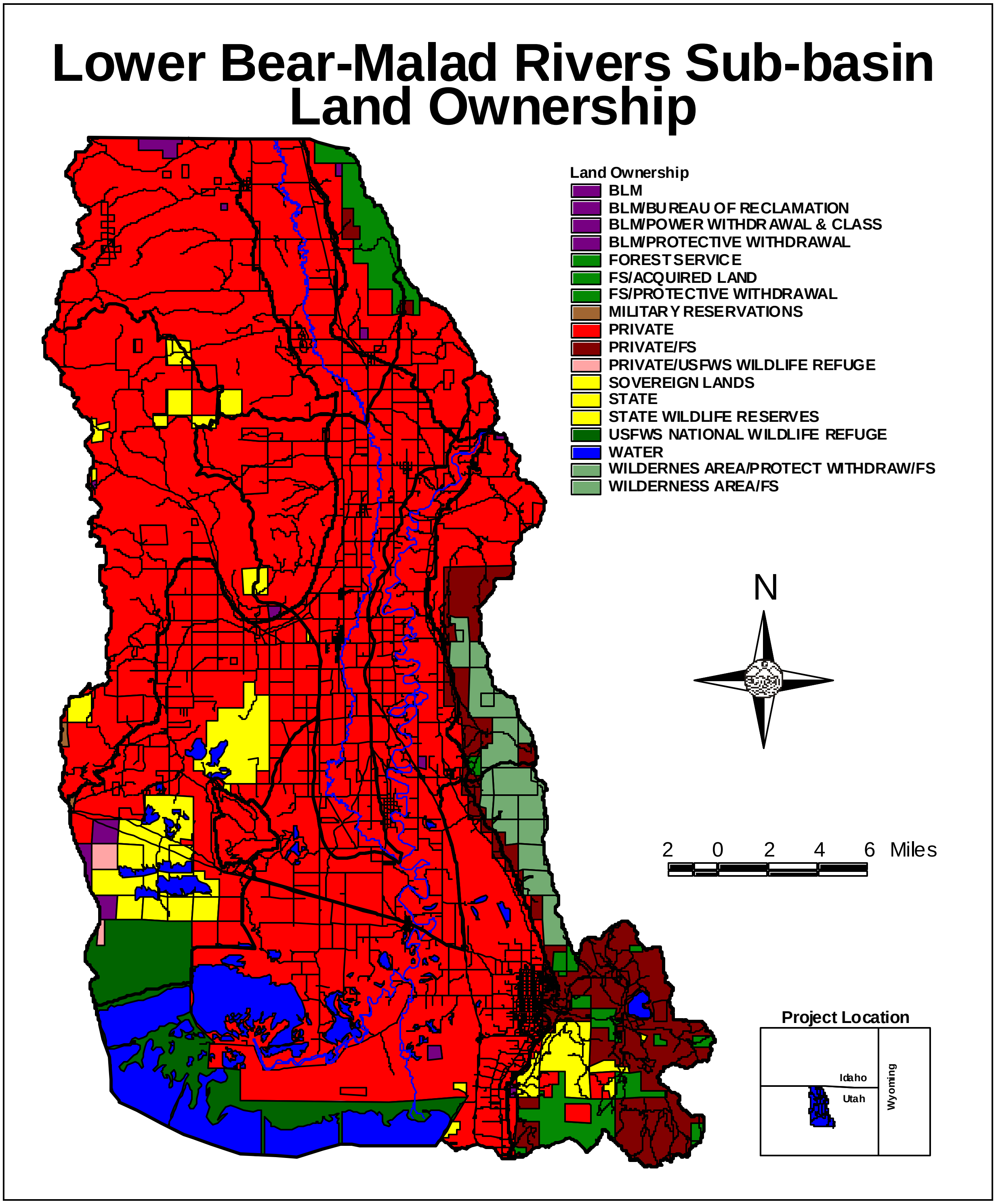


Figure 5. A map illustrating Lower Bear-Malad Rivers Sub-basin land ownership.

2.5 Water Quality Problems

In the 1990s, the state of Utah established a series of long-term water quality stations within the study area. Stations included mainstem and tributary sites. Additional stations were established during the TMDL study for synoptic studies carried out in 1999-2000 to develop a more comprehensive representation of the watershed. They included tributaries, point sources, agricultural drains and mainstem sites. Locations are shown on Figures 6 and 7.

Inspection of the water quality data relative to the numeric standards by the state of Utah, indicates that several parameters commonly exceed the water quality targets. Dissolved oxygen exceeded standards 6 percent, temperature 10 percent and total suspended solids 37 percent of the time which did not qualify the pollutant to be listed as significantly impairing beneficial use were not included in 303(d) status. However, total phosphorous exceeded indicator standards 97 percent of the time and are listed.

Sources of total phosphorus were identified as entering the watershed from upstream sources, in watershed nonpoint sources, tributary, point sources and others. Nonpoint sources sources were further defined as stream banks/natural (see Figure 8), agriculture return flows, CAFO/AFOs and ungaged inflow. Figure 9 displays this information in graphic form and percentages.

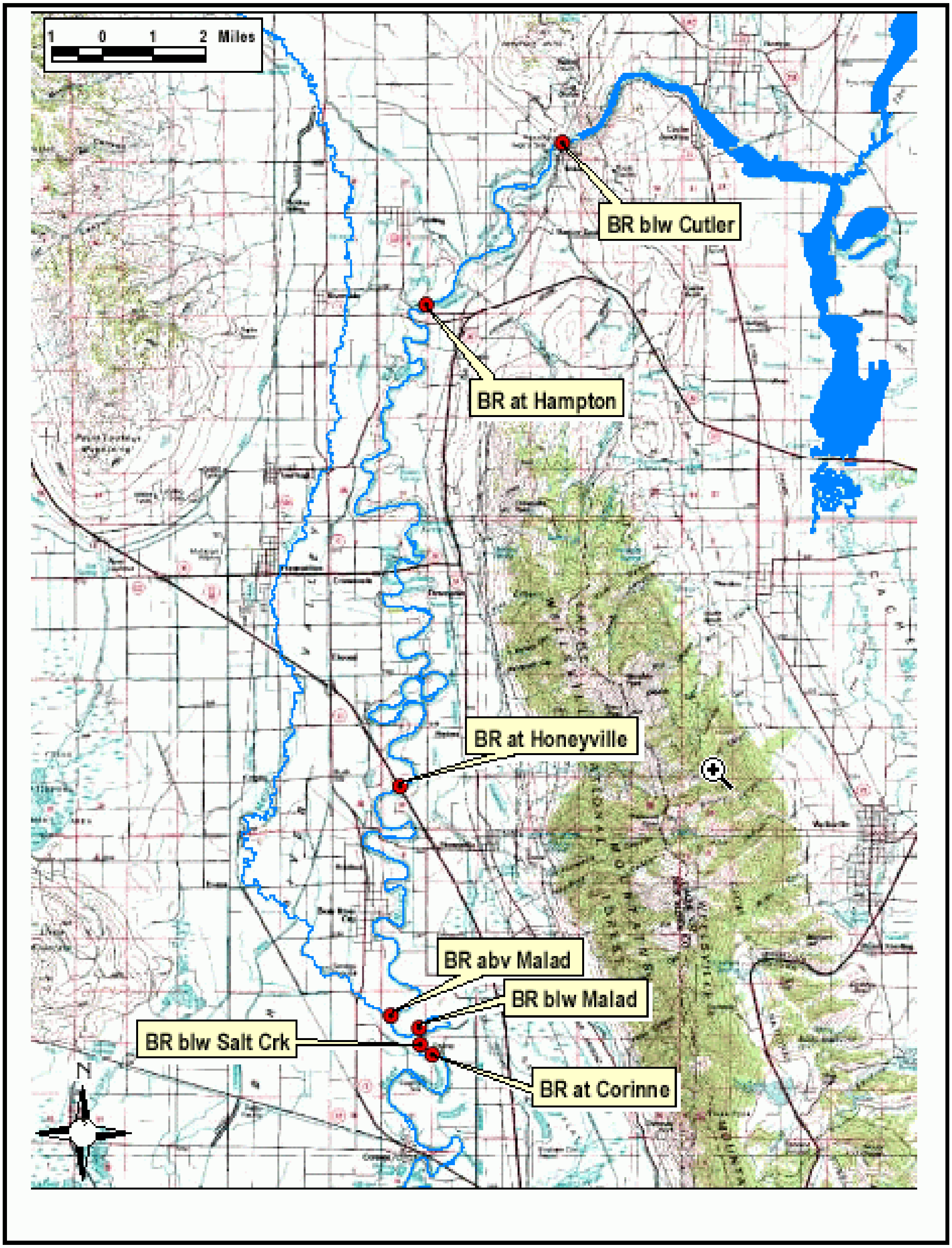


Figure 6. The location of monitoring stations used in the water quality analysis of the Lower Bear-Malad Rivers Sub-basin.

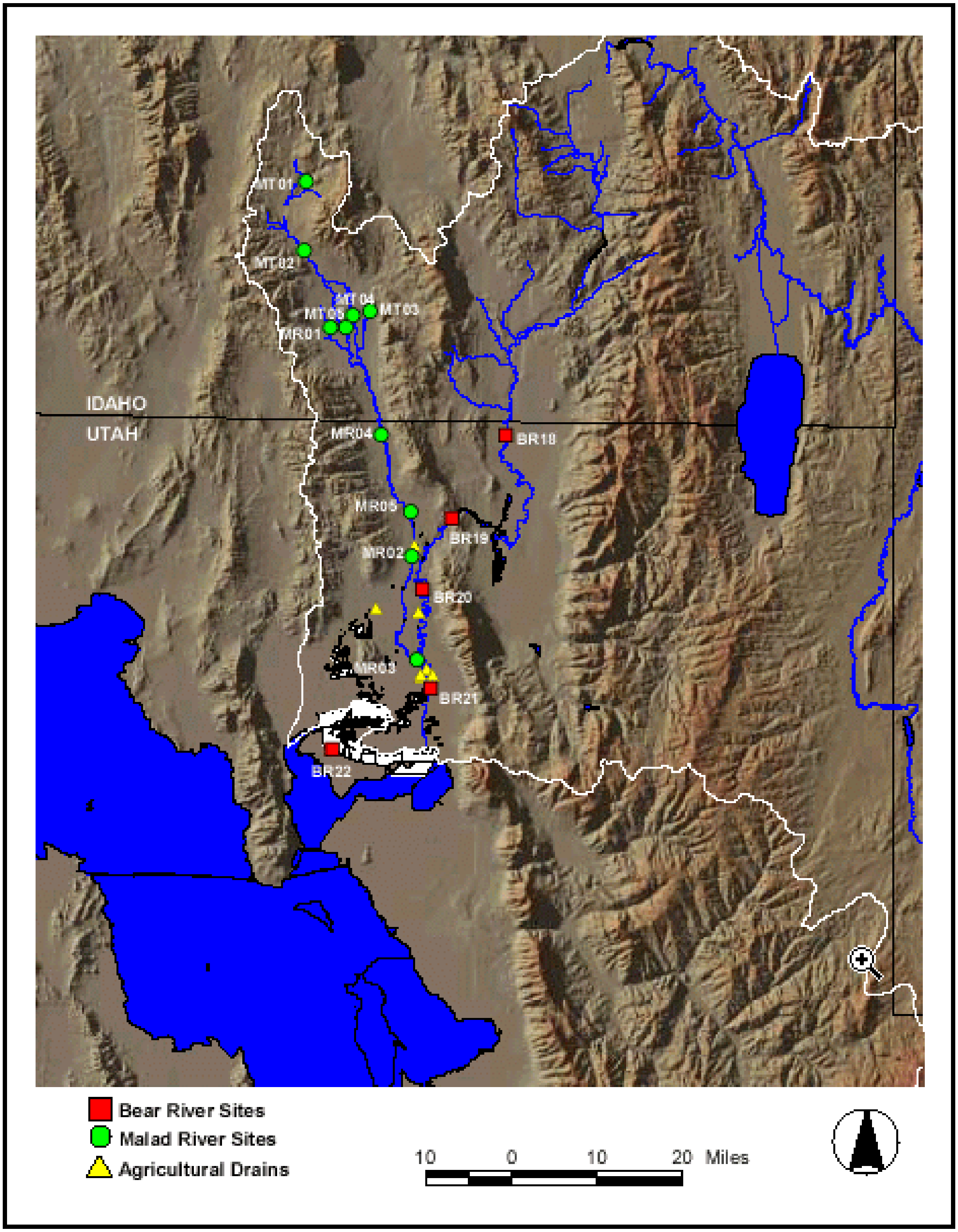


Figure 7. The location of the synoptic sample sites sampled in 1999-2000 in the Lower Bear-Malad Rivers Sub-basin.

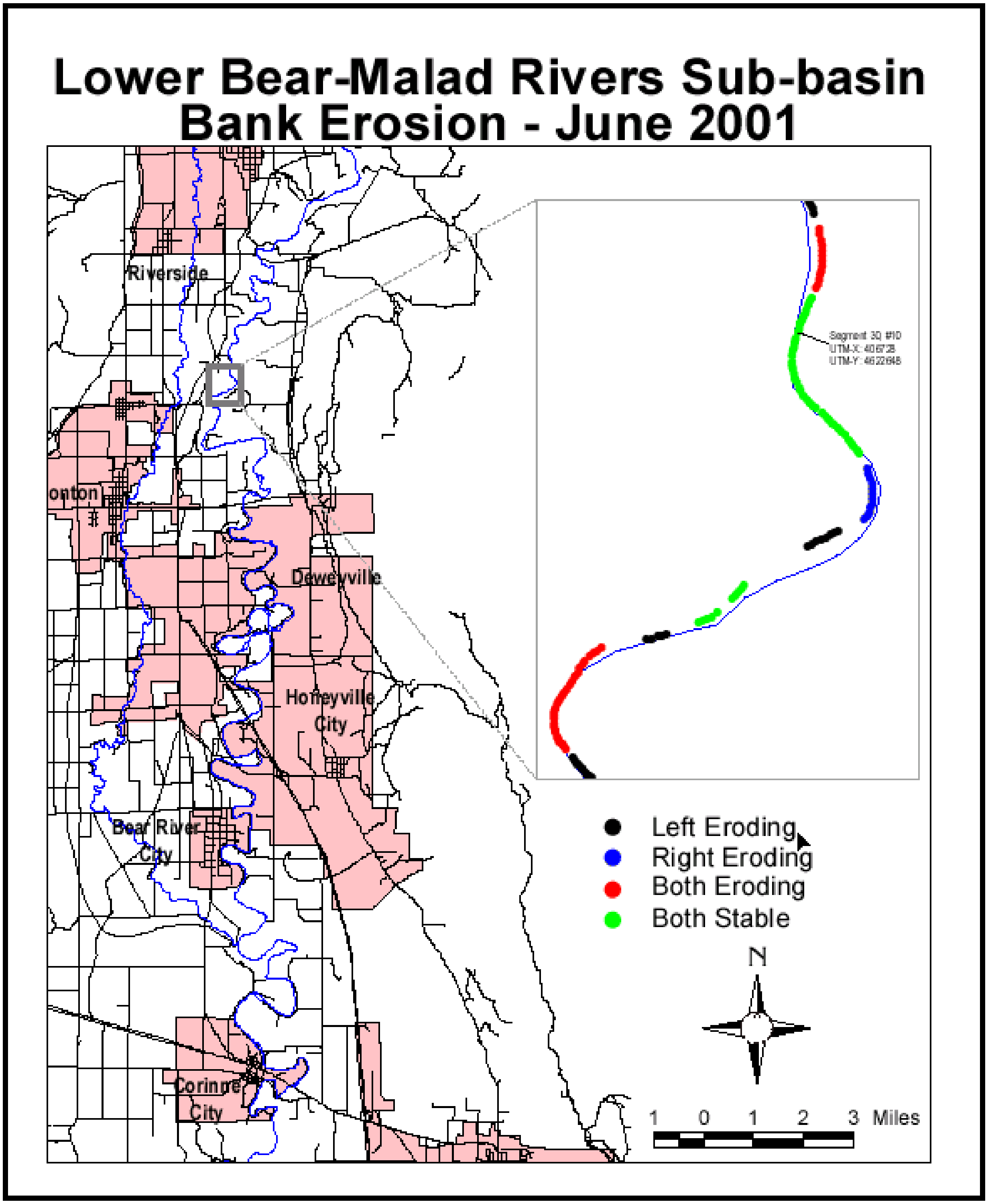
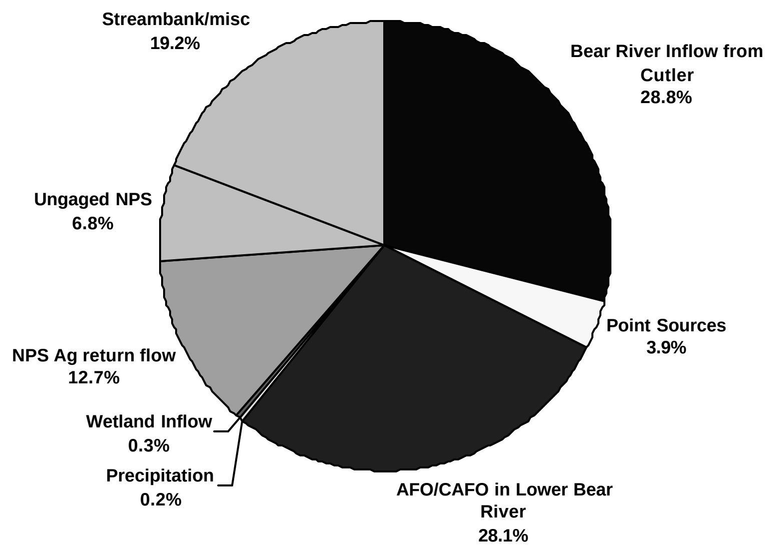
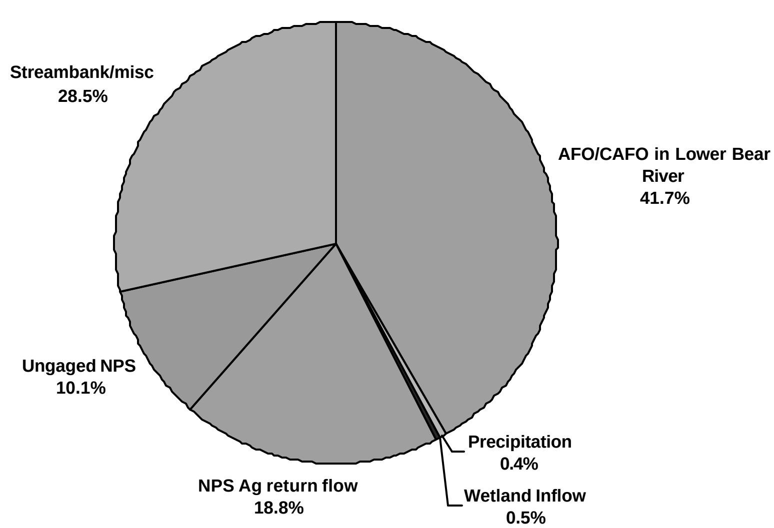


Figure 8. Bank erosion on the Bear River in Box Elder County, Utah.

Total Phosphorus Load from All Sources at Corinne



Total Phosphorus Load from Nonpoint Sources at Corinne



3.0 PROJECT DESCRIPTION

3.1 Project Goals, Objectives and Tasks

The overall project goal is to implement practices to reduce non-point source pollution in the Lower Bear-Malad sub-basin of the Bear River to meet State indicator standard of 0.5 mg/l for total phosphorous by: reducing the amount of pollutants entering the watershed from animal feeding operations; improving the stability of the stream channels and enhancing the riparian corridor to reduce sediment and nutrient loading; improving upland and pastureland management practices to reduce sediment and nutrient runoff; and informing and educating the community concerning non-point source pollution and the importance of managing natural resources within the watershed.

GOAL #1: Implement comprehensive nutrient management plans for five identified CAFOs and about 30 AFOs. Tasks include containment, proper application and utilization of animal manures using Best Management Practices.

Objective: Develop animal waste systems to ensure total containment of animal manure and reduce pollutants entering the Lower Bear River drainage.

Task 1 - Identify CAFO and qualifying AFO project cooperators

Output - Problem identification and prioritize, cooperator selection (35 total). This will be lead by the local soil conservation district cooperatively with the local work group.

Task 2 - Develop Comprehensive Nutrient Management using BMPs and CNMPs.

Output - Project plans and cost estimates. Design work will be performed by NRCS and District staff.

Task 3 - Implement projects

Output - Completed projects.

GOAL #2: Improve stability of the stream channel and enhance the riparian corridor to reduce sediment nutrient loading to the river and its tributaries.

Objective: Develop projects that stabilizes approximately 10 miles of currently eroding river bank to reduce sediment and nutrient loading to the river through improved function of the stream bank and riparian area.

Task 4 - Identify critical and repairable bank reaches and select project cooperators

Output - Problem identification, cooperator selection. This will be lead by the local soil conservation district cooperatively with the local work group and will be conducted in the early spring of the first contract year.

Task 5 - Develop streambank and riparian improvement plan using BMPs and bioengineering principles (like willow revetment, grassed waterways, etc.)

Output - One or two streambank improvement project plans. This will be conducted in spring of the first contract year. Design work will be performed by NRCS and District staff.

Task 6 - Develop power ramping management program.

Output - Problem identification and cooperator secured. Management plan prepared. Design work will be done by Utah Power Cutler Power Plant officials

Task 7 - Implement projects

Output - Project implemented. Decreased bank erosion caused by sudden cessation of power water surge. Implementation will occur in the first contract year. Project will be implemented by Utah Power.

GOAL#3: Improve upland, cropland and pastureland management practices on critical sites within area to reduce sediment and nutrient runoff to the river and its tributaries.

Objective: Reduce nonpoint pollution, sediment and nutrients, from improved upland/pastureland management.

Task 8 - Select, identify demonstration project cooperators

Output - Problem identification, cooperator selection. This will be lead by the local soil conservation district cooperatively with the local work group and will be conducted in the early spring of the first contract year.

Task 9 - Develop upland/pastureland management plan using BMPs.

Output - 1 or 2 upland/pastureland management plans. This will be conducted in spring of the first contract year. Design work will be performed by NRCS and District staff.

Task 10 - Construct wetland buffers and discharge point of field drain systems

Output - Identify workable sites and obtain cooperators. Design wetland plans. Design work will be performed by NRCS and District staff.

Task 11 - Implement projects.

Output - Projects implemented. Implementation will occur between fall of the first contract year through spring of the second contract year. Projects will be implemented by landowners, NRCS and District staff will advise, review and certify project implementation.

GOAL #4: Work with Utah Division of Water Quality to bring all point source pollution in to conformance with UPDES program.

Objective: All point source pollution sites remain in compliance with UPDES.

Task 12 - Identify each point source and review conformance with UPDES.

Output - Documented history of compliance. Work to be carried out by Utah Division of Water Quality and point source owners.

Task 13 - Implement program.

Output - Ongoing program of Utah DWQ.

GOAL #5: Establish a post TMDL Water Quality Monitoring Program

Objective: Improvements in water quality from project benefits are measured and recorded.

Task 14 - Monitor water quality at sites sufficent to ascertain improvements in water quality within the Lower Bear-Malad Rivers Sub-basin.

Output - water quality data for project use and long term monitoring. Data will be collected four times each year before, during and after This data will be collected by a team of agency professionals made up of the landowner, NRCS, UACD, UDWR, UT-DEQ, USU extension, USFWS, etc.

Task 15 - Continue ongoing program augmented with occasional synoptic sampling as deemed necessary.

GOAL #6: Inform and educate the community concerning non-point source pollution and the importance of maintaining and improving water quality within the watershed.

Objective 1: At least one tour annually will be conducted to existing projects focusing on: 1) animal waste system designs and proper manure application; 2) functioning riparian areas, stable streambanks, and properly managed uplands/pasture lands.

Task 16 - Conduct animal waste system design and proper manure application tour.

Output - Tour. The tour will be conducted either near project completion or shortly after. USU Extension, UACD, District staff and the landowner will jointly plan this tour.

Task 17 - Conduct riparian area/streambank and pasture/upland tour.

Output - Tour. The tour will be conducted either near project completion or shortly after. USU Extension, UACD, District staff and the landowner will jointly plan this tour.

Objective 2: Share general and technical information with producers and area stakeholders.

Task 18 - Develop Fact Sheets and Newspaper Articles

Output - Fact Sheet series, Newspaper articles. These products will be completed during implementation of the project and will be disseminated during tours after project completion and other times of the year. USU Extension, UACD, and NRCS will colaborate on the content of these products. USU Extension and UACD will jointly produce and disseminate them.

GOAL #7: Provide administrative services to project sponsors documenting matching contributions, tracking individual project progress, coordinating team efforts, and generating reports and data in a timely manner.

Objective: Provide administrative services.

Task 19 - Track Match and Prepare Reports

Output - Documented match records. Ongoing for duration of project. UACD staff will coordinate this effort.

Output - Semiannual, Annual and Final reports. Completed semiannually, at the end of the first contract year and again at the completion of the project. UACD staff will prepare these products.

3.2 Proposed Project BMPs

The following is a list of proposed BMPs that may be used along with the information and education efforts to improve water quality in the Lower Bear-Malad Rivers Sub-basin.

Cropland Practices include: irrigation water management, crop sequencing, field borders, conservation tillage and filter strips.

Riparian practices include: streambank protection, fencing, filter strips, livestock exclusion, channel stabilization, off-site stock watering, and forest riparian buffers.

Grazing land practices include: off-site stock watering, range seeding, fencing, prescribed grazing and pasture plantings.

Manure management practices include: manure management and utilization systems, nutrient management, and runoff management systems.

All projects will include BMPs and will be planned to the level of a total resource management system in accordance with NRCS standards and specifications.

The following procedures will be used to achieve Project Goals:

1. Isolate water quality problem sources.
2. Select and implement projects for watershed non-point source problems.
3. Promote fair and cost effective nonpoint source pollution control.

4 Monitor progress and evaluate economic benefits of implementing water quality improvements.

5. Create a public awareness of water quality concerns and educate the public on how they can protect water quality for themselves and the community. Promote community involvement in project implementation activities by use of volunteer groups.

3.3 Milestone Table

GOAL and TASK	Output	YEAR											
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
GOAL 1: Nutrient management													
Task 1. Select projects	35 projects	35											
Task 2. Develop plans	35 projects	3	3	3	3	3	3	3	3	3	3	3	2
Task 3. Implement	35 projects	3	3	3	3	3	3	3	3	3	3	3	2
GOAL 2: Bank stability													
Task 4. Identify reaches	10 miles	10											
Task 5. Develop plans	10 miles	1	1	1	1	1	1	1	1	1	1		
Task 6. Ramping program	1 program	1											
Task 7. Implement	10 miles	1	1	1	1	1	1	1	1	1	1		
GOAL 3. Upland management													
Task 8. Identify projects	150 projects	25	25	25	25	25	25						
Task 9. Develop plans	150 plans	12	12	12	12	12	12	12	12	14	14	13	13
Task 10. Wetland plans	15 plans	1	2	2	2	2	2	2	2				
Task 11. Implement	165 projects	13	14	14	14	14	14	14	14	14	14	13	13
GOAL 4. Point Sources													
Task 12. Identify and review	1 program	1											
Task 13. Implement	continuous												

GOAL and TASK	Output	YEAR											
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
GOAL 5. Monitoring													
Task 14. Define sites	1 program	1											
Task 15. Implement	continuous												
GOAL 6. Outreach													
Task 16. Nutrient Tours	1 program	1											
Task 17. River Tours	1 program	1											
Task 18. Share Information	1 program	1											
GOAL 7. Administration													
Task 19. Tracking	1 program	1											

3.4 Permits

All project BMPs will adhere fully to all federal, state, and local regulations and permitting requirements regarding cultural resources, wetlands, endangered species, and sensitive aquatic habitats. Any required permits will be obtained in a timely manner.

3.5 Lead Sponsor

The Northern Utah Soil Conservation District (District) is the sponsor of the East Box Elder Local Work Group and will be the lead project sponsor. The District is empowered by the State of Utah to devise and implement measures for the prevention of nonpoint water pollution. Additionally the District is able to enter into contracts, receive and administer funds from agencies, and contract with other agencies and corporate entities to promote conservation and appropriate development of natural resources. Memoranda of Understanding with state, federal and local agencies along with individual cooperator agreements empower the District and individual cooperators to accomplish this work.

3.6 Assurance of Project Operation and Maintenance

No long-term funding is planned for operation or maintenance of these demonstration projects. Maintenance of these projects will be the responsibility of the private landowner. Projects will be inspected by the project lead sponsor, UACD and NRCS staff. The operation and maintenance of the designed systems will be thoroughly explained to the land owner and they will sign a document indicating their comprehension. If the landowner does not operate or maintain the system according to NRCS protocols, they will be in violation of their 319 contract and no longer eligible for NRCS assistance. Additionally they may risk having to pay back the federally contributed portion of their project funding.

4.0 COORDINATION PLAN AND PUBLIC INVOLVEMENT

4.1 Lead Project Sponsor

The Northern Utah Soil Conservation District (District) is the sponsor of the East Box Elder Local Work Group and will be the lead project sponsor. The District is empowered by the State of Utah to devise and implement measures for the prevention of nonpoint water pollution. Additionally the District is able to enter into contracts, receive and administer funds from agencies, and contract with other agencies and corporate entities to promote conservation and appropriate development of natural resources. Memoranda of Understanding with state, federal and local agencies along with individual cooperator agreements empower the District and individual cooperators to accomplish this work.

The East Box Elder Local Work Group (Local Work Group) has brought together citizens who are concerned about the future condition of the Lower Bear River and its tributaries. They are the primary stakeholders in the future value and future problems that affect this watershed. Utah Association of Conservation Districts is a non-profit corporation that provides staffing for project coordination and financial administration to the Districts of the State of Utah, and specifically to the Northern Utah Soil Conservation District.

The East Box Elder Local Work Group or an empowered subcommittee, will provide oversight of project conceptualization, cooperator selection, volunteer efforts during implementation, and sharing of information generated by this project with others.

The Local Work Group directs the Northern Utah Soil Conservation District to oversee detailed project development, planning, implementation, approval, creation of fact sheets and educational materials, administration and reporting. Some of these duties will be transferred to UACD, NRCS, DEQ, USU Extension Service and others as per Memoranda of Understanding.

UACD will oversee project administration, match documentation, and contracting with agencies and individuals. They will also provide staffing assistance at the direction of the District.

4.2 Local Support

The East Box Elder Local Work Group is coordinating with the Bear River Water Conservancy District to develop a watershed plan to further define water quality problems in the Lower Bear-Malad Rivers Sub-basin and to proceed with a coordinated resource management approach to improve water quality within the watershed. A steering committee, working with a Technical Advisory Committee will establish criteria and select cooperators for implementation of demonstration projects. This demonstration project will be used to show landowners and cooperators Best Management Practices (BMPs) for minimizing land use impacts on water quality in the Lower Bear River and its tributaries.

4.3 Coordination and Linkages

The District and Local Work Group anticipate coordinating efforts with the following other entities, agencies, and organizations:

Cooperators - provide match for cost share, implementation of water quality plans
Utah State University Extension - I&E, Technical assistance
NRCS - Technical planning design and oversight
Utah Department of Agriculture & Food - Technical assistance, I&E assistance
Utah Division of Water Quality - Standard program monitoring, Technical assistance
EPA - Financial assistance
Utah Association of Conservation Districts - Administration, contracting, staff and technical assistance
Utah Division of Wildlife Resources - Advisory and monitoring assistance
Utah Division of Water Rights- Permits advisory, and monitoring assistance
Utah Division of Water Resources - Advisory
U.S. Fish and Wildlife Service - Advisory and monitoring assistance
Bear River Water Conservancy District - Advisory and TAC coordination
Bear River RC&D- Additional funding and volunteer coordination

4.4 Similar Activities

Funding of one or two Animal Waste System demonstration projects was granted by the 319 program in fiscal year 2000 ($36,400). A cooperator was selected by the Steering Committee and the project should begin this fall. An application for EQIP funding to assist with animal manure containment systems was submitted this year. If this funding is granted, it will be combined with 319 monies to help more operators.

5.0 EVALUATION AND MONITORING PLAN

5.1 Sampling and Analysis Plan

The monitoring goals of this project are: To document progress in achieving improved water quality conditions as non-point source control programs are implemented, and to document and review effectiveness of BMPs.

Work activities associated with these goals include the following:

1. Changes to water quality will be documented by an ongoing effort of the State of Utah Division of Water Quality intensive rotational monitoring program. The Bear River Basin was sampled intensively in FY98-99 and will be sampled again in FY 03-04. These results will be summarized in the final report for this project. Lead agency for this work task is Utah Division of Water Quality.

2. Establish photo points to document BMP effectiveness at individual project sites. Pre-project condition, construction phase, and post project condition photos will be taken to document visual impact of pollution reduction. These photos will be compiled into the final report. Lead agency for this work task is UACD and Local Districts and staff. EPA photo point protocol will be followed.

3. Utilize a standardized method for estimating load reduction (PSIAC, Universal Soil Loss Equation, other approved estimating equations or models provided by EPA) that is appropriate to the type of project (e.g. greenline transects for riparian projects, rangeland health index for upland erosion reduction, reduction in animal waste load from animal feeding operations). Lead agency for this work task will be NRCS. UACD will coordinate closely and be responsible for reporting.

4. Annual and semi-annual reporting of progress including quantitative estimates of load reduction, (e.g. tons of manure removed, tons of soil stabilized, feet of streambank revegetated). These data will be summarized into a format compatible with EPA's national nonpoint source database. Lead agency for this work task will be UACD staff.

5.2 General Design and Parameters

Sampling of individual project locations is designed to identify and determine the successful use of implemented BMPs for the reduction of nutrients and sediments, and to document riparian corridor improvement. The individual project monitoring will supplement the State's ongoing overall water quality monitoring program. Utah Division of Water Quality will continue to monitor several sites on the Upper Bear River and its tributaries as part of its long-term water quality monitoring efforts.

Photo points will be established for each site, and for each of the stream channel monitoring sites. Photos will be taken prior to BMP implementation, during construction, and after implementation. Additional monitoring will include parameters appropriate for the specific project. Such parameters may include acreage (of plantings, seeding or weed control), linear feet of stream bank stabilization, or estimated volume of manure converted from inappropriate disposal to appropriate utilization measures.

5.3 Data Management, Storage, and Reporting

The data from this project will be maintained in an accessible common database. In addition, water quality and other relevant data will be transferred electronically to the Utah Division of Water Quality database. Data will be compiled, analyzed and used in completing progress reports to the State NPS coordinator, NPS Task Force, DEQ, EPA and others. All water quality monitoring data will be transferred electronically to the Utah Division of Water Quality who regularly enter data into EPA's national nonpoint source data tracking system. These data will be available to all interested parties and organizations. Quality Assurance and Quality Control will by conducted according to the guidelines established in the Utah Water Quality Manual. Only those data which meet QA/QC standards will be entered into the project database.

5.4 Models Used

It is not anticipated that mechanistic models will be used in developing or evaluating the projects. Mass loadings will be calculated, however, for each of the sites for pollutants of concern. This will allow us to evaluate changes at specific sites and to also evaluate the total impact on the Bear River loads. Finally, it will provide useful information to predict changes from similar implementations at other locations in the basin.

5.5 Long-term Funding Plans for Operation and Maintenance

No long-term funding is planned for operation or maintenance of these projects. Maintenance of these projects will be the responsibility of the private land owner. We do anticipate increased interest in participation of BMP application and anticipate moving to a watershed-wide "implementation" phase in the future.

6.0 BUDGET

6.1 Funding Sources

FUNDING SOURCES	TOTAL	YEARLY AVERAGE (12 YEARS TOTAL)
EPA Section 319 Funds	4,043,530	336,961
NRCS (TA)	279,940	23,328
USFW (TA)	42,410	3,534
Landowner Match (FA)	2,433,200	202,767
Soil Cons. District Match (TA)	43,830	3,653
UACD Match (TA)	56,550	4,713
USU Extension Match (TA)	42,410	3,534
Ut. Div. Water Qlt. Match (TA)	42,410	3,534
Ut. Div. Wildlife Res. Match (TA)	42,410	3,534
Ut. Div Water Res. (TA)	42, 410	3,534
Jordan Valley Water Conservancy District	?	?
Weber Basin Water Conservancy District	?	?
TOTAL	**$7,026,732**	**$589,092**

6.2 Task Budgets

ELEMENT	CASH MATCH	IN-KIND MATCH	319 FUNDS	TOTAL COSTS
Goal 1 - Nutrient management				
Task 1. Select projects		$ 1,800		$ 1,800
Task 2. Develop plans		$ 136,500	$ 38,500	$ 175,000
Task 3. Implement	$ 875,000		$ 1,312,500	$ 2,187,500
Goal 2 - Bank stability				
Task 4. Identify reaches		$ 800		$ 800
Task 5. Develop plans		$ 28,100	$ 16,500	$ 44,600
Task 6. Ramping program		$ 5,000		$ 5,000
Task 7. Implement	$ 640,000		$ 960,000	$ 1,600,000
Goal 3 - Uplands management				
Task 8. Identify projects		$ 7,500		$ 7,500
Task 9. Develop plans		$ 130,500	$ 94,500	$ 225,000
Task 10. Wetland plans		$ 11,200	$ 11,300	$ 22,500
Task 11. Implement	$ 660,000		$ 1,980,000	$ 2,640,000
Goal 4 - Point Source				
Task 12. Identify and review		$ 1,000		$ 1,000
Task 13. Implement		$ 5,000		$ 5,000
Goal 5 - Monitoring				
Task 14. Define sites		$ 500		$ 500
Task 15. Implement		$ 27,200		$ 27,200
Goal 6 - Outreach				
Task 16. Nutrient Tours		$ 12,000		$ 12,000
Task 17. River Tours		$ 12,000		$ 12,000
Task 18. Share Information		$ 12,000		$ 12,000
Goal 7 - Administration				
Task 19. Tracking & Reports		$ 45,000	$ 45,000	$ 90,000
TOTAL COSTS	**$ 2,175,000**	**$ 436,100**	**$ 4,458,300**	**$ 7,069,400**

7.0 PUBLIC INVOLVEMENT

There has been public involvement from the inception of earlier demonstration projects on through the development of the TMDL plan. The Eastern Box Elder Local Work Group will select project participants and give oversight to planning and implementation. We anticipate volunteer help to be provided at many phases of the project.