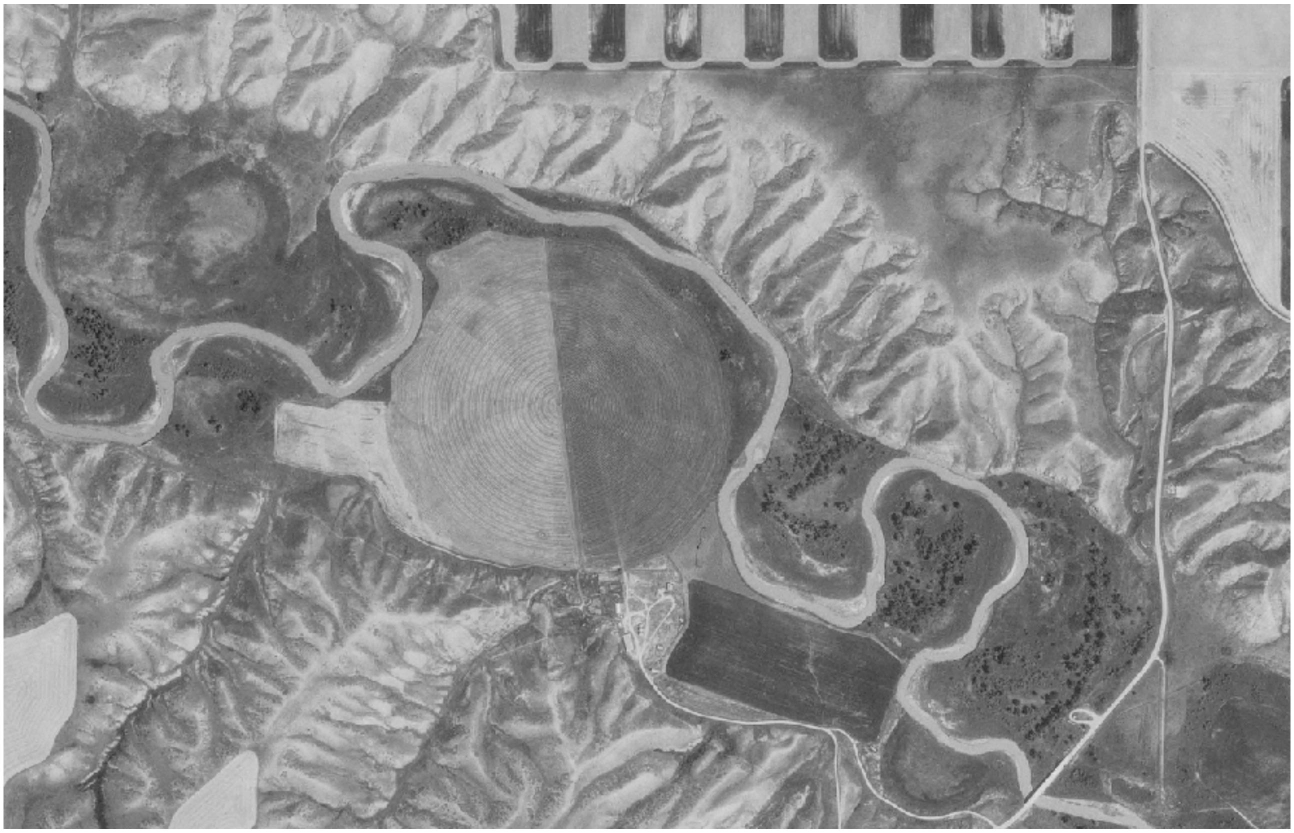
WATER QUALITY MANAGEMENT PLAN & TMDLS
FOR THE
TETON RIVER WATERSHED



FINAL
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Montana Department of
ENVIRONMENTAL QUALITY

ERRATA SHEET FOR THE "WATER QUALITY MANAGEMENT PLAN & TMDLS FOR THE TETON RIVER WATERSHED"

This TMDL was approved by EPA on November 26, 2003. Several copies were printed and spiral bound for distribution, or sent electronically on compact disks. The original version had minor changes that are explained and corrected on this errata sheet. If you have a bound copy, please note the corrections listed below or simply print out the errata sheet and insert it in your copy of the TMDL. If you have a compact disk please add this errata sheet to your disk or download the updated version from our website.

Appropriate corrections have already been made in the downloadable version of the TMDL located on our website at: http://deq.mt.gov/wqinfo/TMDL/finalReports.mcpx

The following table contains corrections to the TMDL. The first column cites the page and paragraph where there is a text error. The second column contains the original text that was in error. The third column contains the new text that has been corrected for the Water Quality Management Plan & TMDLS for the Teton River Watershed document. The text in error and the correct text are underlined.

Location in the TMDL	Original Text	Corrected Text
Page viii, Table E-4, third column, Priest Butte Lakes: (In-Lake) row	**< 6,200 µg/L**	**<6,200 µS/cm**
Page viii, Table E-4, third column, Priest Butte Lakes: (discharge at Hwy 221 Bridge) row	**< 1,000 µg/L** (Seasonal Ave.) **< 1,400 µg/L** (Instantaneous max)	**< 1,000 µS/cm** (Seasonal Ave.) **< 1,400 µS/cm** (Instantaneous max)
Page viii, Table E-4, third column, Teton River: (Dutton gage) row	**< 1,000 µg/L** (Seasonal Ave.) **< 1,400 µg/L** (Instantaneous max)	**< 1,000 µS/cm** (Seasonal Ave.) **< 1,400 µS/cm** (Instantaneous max)
Page viii, Table E-4, third column, Teton River: (Loma gage) row	**< 1,000 µg/L** (Seasonal Ave.) **< 1,400 µg/L** (Instantaneous max)	**< 1,000 µS/cm** (Seasonal Ave.) **< 1,400 µS/cm** (Instantaneous max)

EXECUTIVE SUMMARY: WATER QUALITY MANAGEMENT PLAN & TMDLS FOR THE TETON RIVER WATERSHED

Introduction

This document presents a water quality management plan (WQMP) and associated total daily maximum loads (TMDLs) for the Teton River watershed. The Teton River flows into the Marias River near Loma, in west central Montana and then into the Missouri River. Thirteen stream segment/water bodies in the Teton River watershed were listed with threatened or impaired beneficial use support on Montana's 1996 303(d) List while nine stream segment/water bodies have impaired status on the 2002 303(d) List (Table E-1). Five stream segment/water bodies have been determined as fully supporting all beneficial uses in 2002. All water bodies in the Teton River watershed are classified as B1, B2, or B3; therefore, they are to be maintained suitable for household use, aquatic life, cold or warm water fishery, agriculture, industry, and contact recreation beneficial uses per the Administrative Rules of Montana (17.30.620 – 629 ARM).

Montana's Water Quality Act provides specificity regarding surface water classification, water quality standards, and TMDL development and implementation. With the exception of point source discharges, which are permitted under the federal or state pollution discharge elimination system, the non-point source and TMDL programs are based on **voluntary** participation of stakeholders in implementing identified actions that can reduce non-point source pollutants. The Water Quality Act states: "*The department shall support a* ***voluntary program of reasonable land, soil, and water conservation practices*** *to achieve compliance with water quality standards for nonpoint source activities for water bodies that are subject to a TMDL developed and implemented pursuant to this section*." (***Emphasis added***) (75-5-703(8), MCA) and further provides protection to existing water rights: "*Nothing in this part may be construed to divest, impair, or diminish any water right recognized pursuant to Title 85.*" (75-5-705, MCA).

Within the context of the laws and rules governing water quality in the State of Montana, the MDEQ is directed to work towards the support of **all** beneficial uses associated with a water body as defined in the Surface Water Quality Standards and Procedures rules (17.30.6 et seq., ARM). It is important to note that the laws **do not** identify one beneficial use as more important than another, but that each water body should be maintained suitable so as to support all associated beneficial uses.

This document makes several recommendations for reducing pollutant loads and improving conditions in streams, lakes, and riparian areas in the Teton River watershed. However, given that in many cases the amount of real data, and subsequent knowledge of the actual "system" variability is limited, a phased approach is proposed.

Sections 2.0 through 4.0 of this document represent Phase I wherein the required elements of the TMDL (e.g., source assessment and characterization, numeric or surrogate targets, total maximum daily loads, etc.) are based upon the currently available information with the hypothesis that implementation of this plan will result in the restoring support for all beneficial uses. A monitoring and adaptive management strategy, as outlined in Section 6.0, will be implemented as Phase II to test this hypothesis and provide information necessary to adaptively manage the watershed as well as review water quality targets and TMDLs in the future.

Table E-1. Impaired beneficial uses identified on the 1996 & 2002 303(d) lists.

Stream Name & Reach Description	**1996 Use Support**						**2002 Use Support**					
	Aquatic Life	**Fishery**	**Drinking Water**	**Agriculture**	**Industry**	**Contact Rec.**	**Aquatic Life**	**Fishery**	**Drinking Water**	**Agriculture**	**Industry**	**Contact Rec.**
Teton River (N & S Fk to Deep Cr)	P	P				P	P	N				
Teton River (Deep Cr to Muddy Cr)	P	P	T	T		P	P	P		P		
Teton River (Muddy Cr to mouth)	P	P	P	P		P	P	P				
Willow Creek (Headwaters to mouth)	P	P					P	P				
Deep Creek (Headwaters to mouth)	P	P					P	P	P		P	P
McDonald Creek (Headwaters to mouth)		T					**F**	**F**	**F**	**F**	**F**	**F**
Upper Blackleaf Creek (Headwaters to Cow Cr.)	P	P	P				**F**	**F**	**F**	**F**	**F**	**F**
Lower Blackleaf Creek (Cow Cr. to mouth)							P	P				
Upper Teton Spring Cr. (Headwaters to Choteau)	P	P				P	P	P	P			P
Lower Teton Spring Cr. (Choteau to mouth)	P	P				P	P	P	P		P	P
Clark Fork Muddy Cr. (Headwaters to mouth)		T					**F**	**F**	**F**	**F**	**F**	**F**
Priest Butte Lakes	P	P	P			P	N	N				
Bynum Reservoir	P	P					**F**	**F**	**F**	**F**	**F**	**F**
Eureka Reservoir	P	P					**F**	**F**	**F**	**F**	**F**	**F**

Source: MDEQ (1996a, 2002a)
P = Partial support, N = Non-support, T = Threatened, F = Full support

Teton River – Sun River Connection

The Teton River watershed is connected to the Sun River watershed via man-made canals and irrigation works. However, in the interested of simplicity, the TMDLs and Water Quality Management Plans for the Teton and Sun Rivers have been developed in separate documents. The development of each of these plans was done in close coordination since water quality in the Teton River basin is intricately linked to actions in the Sun River basin. The pivot point for these watersheds is the Freezeout Lake discharge into Priest Butte Lakes. The setting of targets, especially those set for Priest Butte Lakes, were developed with an awareness as to their potential implication to Freezeout Lake, the Greenfields Irrigation District (GID), and the Sun River. This document does not attempt to describe the complex functioning of the Freezeout Lake Wildlife Management Area, the Sun River watershed, or its irrigation systems. This information and detail is contained in the Sun River Watershed Water Quality Restoration Plan and Total Maximum Daily Loads for the Sun River, Muddy Creek, Ford Creek, Gibson Reservoir, Willow Creek Reservoir, and Freezeout Lake (MDEQ, in development).

Watershed Description & Historical Context

The Teton watershed is located on the eastern side of the Rocky Mountain Front in west central Montana. Across the western third of the watershed Muddy Creek, the Teton River, and Deep Creek spill out onto the foothill prairie. The prairie landscape has much less relief than the mountain front but contains numerous buttes and low ridges. A dendritic, or branching, drainage pattern begins to form on the prairies once the streams leave the fault-controlled headwaters. The eastern two-thirds of the watershed is characterized by highly-dissected coulees and low river breaklands typical of the glaciated high plains in the western central Montana. The watershed's highest elevation is 9,400 feet along the continental divide and its lowest elevation is roughly 2,600 feet near the mouth at Loma.

Recorded conditions in the Teton basin begin with the Lewis & Clark expedition of 1804-1806. The expedition journals, as translated by Moulton (1999), documented several points of interest that can be used today to gain an understanding of the historical landscape and riparian vegetation. On June 3rd, 1805 the Fields brothers noted the Teton's riparian areas as "*containing much timber in it's bottom, consisting of the narrow and wide leafed cottonwood with some birch and box alder undrgrowth willows rosebushes currents &c*." Then on June 6th, 1805 while returning to the Marias River along the Teton, which he referred to as the "little river," Captain Clark noted "*the bottoms of this little river is in everry respect except in extent like the large bottoms of the Missouri below the forks containing a great perportion of a kind of cottonwood with a leaf resembling a wild Cherry* (narrow-leaf cottonwood). *I also observed wind* (wild) *Tanzey on this little river in great quantities…*" (non-italic interpretations provided by Wayne Phillips, retired Botanist, Lewis & Clark NF; author of Plants of the Lewis and Clark Expedition, 2003). Also noted by the journals were large herds of buffalo, elk, deer, and antelope as well as some goats. On the return trip in 1806, Capitan Lewis crossed the Teton River noting that the "*rose river at this place is fifty yards wide, the water which is only about 3 feet deep occupys about 35 yds. and is very terbid of a white colour*." Lewis also notes that between the Teton and Marias Rivers there was "*very probably no water*" and describes the riparian area and stream bed of the Teton as "*its bottoms are wide and well timbered with cottonwood both the broad and narrow leafed species. the bed of this stream is small gravel and mud*."

Trappers and hunters were the first to follow Lewis & Clark into this area, making their fortunes from the abundant game that covered the land. White settlers soon followed by the 1840s first using the expansive lands to raise large herds of cattle and horses. The limited upland trees were cleared for building and heating dwellings as well as for building fence lines. However, the settlers soon found that the stock animals could not survive the northern plain winters without supplemental feed, so grass was cut and stored for winter use. Where possible, rich river bottomlands were also cleared to increase forage production. Irrigation of the land soon followed to increase the amount of hay that could be stored. Some settlers began to farm, putting more land to use in order to survive the harsh landscape. As irrigation became more prevalent the increasing demand for water created the need for extensive canal systems and off-stream reservoirs. The demand for water has grown to exceed the annual flows of the river resulting in a basin closure to surface water appropriations and significant water shortages, even in “normal” years.

Natural disturbance events are part of the northern Rockies Mountains and Great Plains ecosystem and include wildfire and floods. Floods of 1948 and 1953 are reported as severe but having little documented effect to the river system, although one effect of the 1953 flood was that the US Army Corps of Engineers had contractors straightened out several river bends in the lower basin (personal communication with area landowners). However, the flood of 1964 was dramatically different. Leading up to this flood, land use along the river bottoms and floodplain had changed significantly: some reaches of the river were channelized (i.e. straightened), permanent bridges for transportation were installed, and riparian areas were being heavily used which reduced the cover of bank stabilizing vegetation. When the ’64 flood came, the ability of the river’s floodplain to accommodate and withstand extreme flows was reduced so the flood effects were severe. When the floodwaters receded, the Teton River had lost approximately 35 miles stream length as a result of flood flows and man’s reaction to it. Again, the US Army Corps of Engineers channelized a reach of river in an attempt to prevent future damage, this time near Choteau. The effects of the 1953 and 1964 floods continue to be manifested as the river works to regain its lost stream length. However, the river now has limited space within which to regain this length as people occupy much of the floodplain for agricultural purposes, homes, towns, and transportation infrastructures.

Society expects our waters to fully supporting many diverse beneficial uses, such as drinking water, irrigation, stock water, fisheries/aquatic life, and recreation, which results in significant conflicts among various user groups. Since the river is not able to fully meet the needs of all beneficial uses, some of the uses suffer greatly. Minimum needs of the upper and lower Teton basin irrigators are not met, let alone the full demands of water rights across the basin. Communities struggle to find enough water for the residents and community resources and the historical fisheries no longer exist in any significant quantities.

Problem Description

The type and magnitude of water quality impairments vary across the watershed and the listed impairments also differ between the 1996 and 2002 303(d) lists. Some of the listed causes and impairments changed due to the institution of a more structured and formalized 303(d) listing process. The new process requires a minimum level of data for beneficial use support determinations and greatly improves the documentation of the listing decisions. Primary causes of water quality impairments listed on the 1996 and 2002 303(d) lists include salinity/TDS/chlorides or sulfides, selenium, organic enrichment/dissolved oxygen, siltation/suspended solids, temperature, and nutrients. Other listed causes include stream flow alteration (dewatering), bank erosion, riparian degradation, fish habitat alteration, and other habitat alteration (Tables 3-1 and 3-2). Sources of impairments listed include agricultural related (irrigated and non-irrigated crop production, range land/grazing), stream flow modification, channelization, bank modification/destabilization, habitat modification, municipal point source, resource extraction, land disposal, highway/road/bridge construction, and natural or unknown sources.

Most impairment listings across the watershed result from salinity, riparian degradation, stream channel instability (bank erosion and sedimentation), and flow alteration. Sources are varied, but predominantly result from the effects of the 1964 flood or relate to agricultural land uses and associated practices. The 1964 flood altered the course of the river channel in many places ultimately reducing the overall stream length roughly 35 miles and, in some cases, formed new channels through existing agricultural lands where riparian vegetation did not exist. The natural reaction of any river after such an event is to seek to regain its stream length by growing meander bends, which will decrease its channel slope or overall “energy grade.” Additionally, the flood deposited large quantities of coarse sediment in the upper watershed that has led to channel instability and probably increased streambed conductivity. Agricultural activities dominate the watershed with 84% of the land cover/land use identified as cropland, rangeland, or pasture. Irrigated and dryland agriculture practices have a cumulative impact on the river system and resultant water quality either by altering stream flows or by raising groundwater levels and augmenting flows that contribute to saline seep. Riparian grazing activities also have an impact on the health of the riparian zones, stability of stream banks, and ultimately, water quality. Other sources exist in the watershed that, to some degree, also contribute to water quality impairments and include “urbanized” areas, transportation infrastructure (roads, bridges, etc.), and instream diversion structures.

Total Maximum Daily Loads and Restoration Targets

A “true” total daily maximum load (TMDL) for specific pollutants can be developed where sufficient data exists and it is logical to do so. This only proved to be the case for selenium loading into Priest Butte Lakes (Table E-2). EPA guidance also allows TMDLs to be expressed as either a reduction target or a surrogate target if applicable or warranted. This proved to be the best approach for salinity, sediment, temperature, and nutrients (Table E-2). Salinity and nutrient TMDLs are expressed as a reduction in the average and/or maximum measured concentrations of total dissolved solids (TDS), total nitrogen, total phosphorus, or Chlorophyll *a* biomass. Sediment and temperature TMDLs are expressed using a surrogate measure of channel stability as defined by a stabile channel geometry, riparian vegetation communities, and minimum stream flows on approximately 80% of a stream’s overall length (Table E-2).

Restoration targets describe the desired future conditions of the watershed or water column chemistry and have been developed for each listed water body. Targets are considered to reflect conditions necessary to meet Montana Water Quality Standards and thus support of the water bodies' beneficial uses. Physical habitat conditions developed for sediment and temperature targets are set to be protective of the water bodies' aquatic life and fisheries (Table E-3). Water column chemical conditions developed for salinity, selenium, and nutrients are set to be protective of agriculture, stock water, aquatic life/fisheries, waterfowl, and recreation beneficial uses, as appropriate (Table E-4).

Table E-2. TMDLs for Teton River Water bodies.

Pollutant: Water body	**Monitoring Location**	**Total Daily Maximum Load, Reduction Target, or Surrogate Measure**	**Conditions: Existing ↔ Target**
TDS / SC: Priest Butte Lakes	- In-lake - Discharge at Hwy 221	34% reduction in-lake SC concentrations No reduction in May to Sept. average SC 23% reduction in maximum SC	Table 4-6 Table 4-8
TDS / SC: Teton River	- USGS Loma gage	8% reduction in May to Sept. average SC 14% reduction in maximum SC	Table 4-3 Table 4-8
Selenium Priest Butte Lakes	- Yeager Seep	0.157 lbs/day to Priest Butte Lakes	Table 4-10
Sediment Teton River	- Deep Cr. to Muddy Cr. - Muddy Cr. to mouth	80% of total stream length exhibiting stabile channel geometry, riparian vegetative communities, and minimum stream flows. Refer to Section 4.3.2	Table 4-17
Sediment Willow Creek	- Headwaters to Deep Cr.	80% of total stream length exhibiting stabile channel geometry, riparian vegetative communities, and minimum stream flows. Refer to Section 4.3.2	Table 4-17
Sediment Deep Creek	- Willow Cr. to mouth	80% of total stream length exhibiting stabile channel geometry, riparian vegetative communities, and minimum stream flows. Refer to Section 4.3.2	Table 4-17
Sediment Teton Spring Cr.	- Headwaters to Choteau - Choteau to mouth	80% of total stream length exhibiting stabile channel geometry, riparian vegetative communities, and minimum stream flows. Refer to Section 4.3.2	Table 4-17
Thermal Modification Teton River	- Deep Cr. to Muddy Cr.	80% of total stream length exhibiting stabile channel geometry, riparian vegetative communities, and minimum stream flows. Refer to Section 4.4.2	Table 4-17
Thermal Modification Teton Spring Cr.	- Headwaters to Choteau	80% of total stream length exhibiting stabile channel geometry, riparian vegetative communities, and minimum stream flows. Refer to Section 4.4.2	Table 4-17
Nutrients Deep Creek	- Willow Cr. to mouth	**TP** 23% reduction **TN** 57% reduction **Chl *a*** 16% reduction	Table 4-20 Table 4-21
Nutrients Teton Spring Cr.	- In Choteau	**TP** No reduction required **TN** No reduction required **Chl *a*** 168% reduction (May – June)	Table 4-20 Table 4-21
	- Near mouth	**TP** No reduction required **TN** 25% reduction **Chl *a*** 4% reduction (May – June)	

Table E-3. Physical Surrogate Target values for sediment and temperature.

Water body (location)	**Stable Banks & Healthy Riparian**[1] (miles)	**Channel Geometry**			**Instream Flow**[3] (cfs)	**Riparian Vegetative Community**
		Rosgen Channel Type	Width / Depth Ratio	Average Meander Width Ratio[2]		
Teton River: (N-S Forks to Deep Creek)	147	C	> 12	11.4	35	Mix of cottonwood and willow species, which are determined by site-specific elevation and dominant soils. Refer to Tables 4-15, 4-16, and Figure A-14.
Teton River: (Deep Creek to Mouth)		C	> 12	11.4	To be determined[4]	
Deep Creek (Headwaters to Mouth)	7	C	> 12	11.4	18	
Teton Spring Creek (Headwaters to Mouth)	11.2	E	< 12	24.2	4.5	
Muddy Creek (Headwaters to Mouth)	65	C	> 12	11.4	Needs to be calculated	
Willow Creek (Headwaters to Deep Cr.)	15	C	> 12	11.4	Needs to be calculated	
McDonald Creek[5]	9.6	C	> 12	11.4	10	

[1] Refer to Table 4-17 for source of target values.

[2] Meander Width Ratio: Meander Belt Width / Bankfull Width (Rosgen, 1992).

[3] In-stream Flow Reservation requested by MFWP (refer to Table 2-6).

[4] To be determined by MFWP using wetted perimeter models and life history needs based on fish habitat requirements (Personal communication, Bill Gardner, MFWP).

[5] McDonald Creek is listed as fully supporting all beneficial uses in 2002; it is included in this table because minimum instream flows have been calculated.

Table E-4. Chemistry Targets Values.

Water body (location)	**TDS** (mg/L)	**SC** (µS/cm at 25ºC)	**Selenium** (µg/L)	**Total Phosphorus** (µg/L)	**Total Nitrogen** (µg/L)	**Chlorophyll *a*** (mg/m^2)
Priest Butte Lakes: (In-Lake)	**< 5,000 mg/L**	**< 6,200 µS/cm**	**< 5 µg/L**			
Priest Butte Lakes: (discharge at Hwy 221 Bridge)	**< 820 mg/L** (Seasonal Ave.) **< 1,145 mg/L** (Instantaneous max)	**< 1,000 µS/cm** (Seasonal Ave.) **< 1,400 µS/cm** (Instantaneous max)				
Teton River: (Dutton gage)	**< 820 mg/L** (Seasonal Ave.) **< 1,145 mg/L** (Instantaneous max)	**< 1,000 µS/cm** (Seasonal Ave.) **< 1,400 µS/cm** (Instantaneous max)				
Teton River: (Loma gage)	**< 820 mg/L** (Seasonal Ave.) **< 1,145 mg/L** (Instantaneous max)	**< 1,000 µS/cm** (Seasonal Ave.) **< 1,400 µS/cm** (Instantaneous max)				
Teton Spring Creek: (in Choteau)				**40 µg/L** (mid-June – Sept.)	**650 µg/L** (mid-June – Sept.)	**50 mg/m^2** (May – June max) **100 mg/m^2** (July – Sept. Ave.) **150 mg/m^2** (July – Sept. max)
Teton Spring Creek: (near mouth)				**40 µg/L** (mid-June – Sept.)	**650 µg/L** (mid-June – Sept.)	**50 mg/m^2** (May – June max) **100 mg/m^2** (July – Sept. Ave.) **150 mg/m^2** (July – Sept. max)
Deep Creek: (Hwy 287 Bridge)				**40 µg/L** (mid-June – Sept.)	**650 µg/L** (mid-June – Sept.)	**50 mg/m^2** (May – June max) **100 mg/m^2** (July – Sept. Ave.) **150 mg/m^2** (July – Sept. max)

Total Maximum Daily Load Allocations

Allocation of source loading is also a required part of the TMDL document. TMDL allocations describe the type/amount of improvement necessary from each identified source to reach the restoration target(s). Ideally, the allocations should be complete and justified as defined by the relative magnitude of all contributing sources. However, this may not always be possible given currently available data, resources, and schedules, and this certainly is the case in the Teton watershed. For salinity and selenium several potentially significant sources have been identified but have not yet been quantified. In these situations, full allocations have been assigned to the existing quantified sources with the intent of restructuring the loading allocation when the other sources have been quantified (Table E-5).

Table E-5. TMDL Allocations for Salinity and Selenium for Priest Butte Lakes.

Pollutant / Source	Existing Load (#/day)	Allocated Load (#/day)	Load Reduction (#/day)
Salinity			
Freezeout Lake	83,500	55,000	28,500
Yeager Seep	15,000	10,000	5,000
West Side drainages/seeps	Unknown	To be determined	To be determined
East Side drainages/seeps	Unknown	To be determined	To be determined
Shallow Groundwater	Unknown	To be determined	To be determined
Selenium			
Yeager Seep	0.471	0.157	0.314
Freezeout Lake	Unknown	To be determined	To be determined
West Side drainages/seeps	Unknown	To be determined	To be determined
East Side drainages/seeps	Unknown	To be determined	To be determined
Shallow Groundwater	Unknown	To be determined	To be determined

Reduction in TDS levels for the middle and lower Teton River is allocated to Priest Butte Lakes and agricultural lands employing practices that elevate soil water levels and/or increase shallow groundwater flows (i.e. dryland cropping and flood irrigation). However, the amount of acreage in these areas that would need to alter land management practices to insure instream SC values are reduced to below the 1,000 and 1,400 µS/cm targets is uncertain at present. It is recommended that an adaptive management approach be employed. Meaning that all opportunities for positive changes in land management, in terms of reducing salinity loading, be implemented wherever they can be identified beginning with the most economical alternatives. Additional measures may be needed as necessary if monitoring data suggests that targets are not yet being attained.

Sediment sources in the Teton River watershed are attributed to impacts from highway and road-related structures, instream diversion structures, irrigation practices, unmanaged riparian grazing, crop production in riparian areas, and natural stream channel adjustments. In addition, the Choteau Wastewater Treatment Plant delivers suspended sediments to the Teton River and is the only permitted municipal point source in the watershed that has an allocated sediment load. The wasteload allocation (WLA) component for the TMDL remains the amount allocated by permit, 100 mg/L. The remainder of the acceptable sediment load is allocated to other non-point source loads (i.e. load allocation or LA) and natural sources.

Thermal loading sources in the Teton River watershed are attributed to impacts from agricultural use of riparian areas for crop production or livestock grazing, water withdrawals, and highway and roads impinging on riparian areas. Source areas are not limited to only the middle Teton River and Teton Spring Creek, but also all major tributary systems, and specifically Muddy and Deep Creeks.

Both the sediment and temperature TMDLs rely on performance-based allocations as a way of describing land management practices that can be implemented to address specific sources of concern. The primary sectors identified - agriculture (crops), grazing, highways, water users (diversion structures), and stream flow (water withdrawals for agriculture, municipal, and domestic use).

Nutrient sources in the Deep Creek watershed are attributed to the impacts from agricultural use of riparian areas for crop production or livestock grazing and water withdrawals. Source areas are not only limited to Deep Creek, but includes Willow Creek given its influence as a major tributary stream to Deep Creek. However, no loading calculations have been conducted such that a true load allocation could be generated at this time, therefore land practices in both watersheds are equally allocated to for purposes of this document. Nutrient sources to Teton Spring Creek are attributed to the impacts from agricultural use of riparian areas for crop production or livestock grazing and water withdrawals and in addition, include stormwater runoff, septic systems, and municipal/residential lawn care.

The nutrient TMDLs also rely on a performance-based allocation as a way of describing land management practices that can be implemented to address specific sources of concern. The primary sectors identified will need to work together and participate in activities that contribute to reduced nutrient loading. These include active revegetation of the riparian area with natural vegetative communities, active management or elimination of riparian grazing, irrigation BMPs, improved efficiencies and controls of septic systems, revegetation of non-native turf grass with natives or reduction in lawn fertilizer use/application, and the equitable sharing of an over-allocated river system with all users and beneficial uses.

In the case of flow alteration and dewatering, water rights recognized under Title 85 (MCA) are afforded protection under 75-5-705, MCA. Where streams are being dewatered, minimum flows will only be attainable through the willing lease, sale, or donation of water rights or through the institution of a creative water salvage program whereby any salvaged water gained from increased irrigation efficiencies are dedicated to instream flows. Confounding the issue of stream flow is the fact that the basin is already over-allocated and presently closed to <u>surface</u> water appropriations, but not to groundwater.

Plan Implementation

TDS target implementation requires application of Best Management Practices for salinity and selenium to counter elevated shallow groundwater levels or that reduce the magnitude of groundwater flows (refer to Section 5.1). An adaptive management strategy is recommended for the Priest Butte Lakes watershed such that if water quality monitoring does not indicate sufficient reductions in salinity and selenium loadings, then additional management practice will need to be developed and implemented. Sediment and temperature-related problems result from altered riparian vegetation communities, additional stream sediment loads, changes to channel geometry, and/or diminished stream flow characteristics. These activities are identified in Section 4.3 and 4.4, respectively, however not all specific source locations have been identified or quantified. Land and water management practices outlined in Table 5-1 (General Best Management Practices for irrigation and agriculture activities applicable watershed-wide) will be used to improve the stream pattern, form, and function; and are easily applicable for streams with sediment- and temperature-related impairments. The sediment and temperature targets and load allocations will be developed/refined using an adaptive management strategy incorporating the results of ongoing monitoring, as outlined in Sections 6.1 and 6.2.

The nutrient allocations for Deep Creek (including Willow Creek) and Teton Spring Creek have been described in Section 4.5.5. Implementation measures that may be developed and applied are presented in Table 5-1 under the Riparian Management for Agricultural Lands and Municipal & Residential Area categories.

Effectiveness Monitoring

An *adaptive management* approach to monitoring will be used in the Teton River watershed. Adaptive management is a process that uses monitoring, research, and evaluation to determine results of land management changes and/or restoration activities. It monitors conditions and provides a "*basis for future review and revision of the TMDL*" (USEPA, 1999b). The effectiveness monitoring presented in Section 6.0 represents Phase II of the adaptive management plan that will measure the progress made toward target attainment. It will provide the critically needed data and information that will enable sound adaptive management in the watershed.

To determine the progress made through restoration projects or management changes, current (or baseline) conditions must first be reasonably estimated. MDEQ has an idea of the impairments facing the Teton River watershed; however, the extent of the impairments is not well understood. Monitoring is essential to establish current conditions as well as evaluate trends and use-support levels. A combination of GIS analysis, field sampling, and working with local stakeholders, as well as funding, will control the extent of monitoring.

In preparing this document, MDEQ found data gaps that will need to be in the monitoring plan. Data gaps identified are:

1) *Muddy Creek water quality and source assessment* – Eroding banks, stream channel incisement, riparian removal, and saline seep evidence have been described along Muddy Creek; however the MDEQ lacks sufficient and credible data to make beneficial use support determinations. Because of the stream length and large area it drains, Muddy Creek is a major tributary to the Teton River; therefore, its potential for adding pollutants needs to be characterized.

2) *Basin-wide sediment source assessment* – Although basic knowledge of sediment impairments to streams in the Teton River watershed is known (refer to Sections 3.3.4

and 4.3.1) a more detailed sediment source identification effort should be made. Data that is needed include sediment inputs that come from banks and tributaries. Baseline conditions, including riparian health, must be gathered and are the essence of Tier 1 monitoring (Table 6-1). Sediment inputs from the tributaries should include inputs from McDonald, Blackleaf, and Muddy Creeks; although these streams are not currently listed as impaired for sediment.

3) *Watershed surface water temperature characterization* – The middle section of the Teton River is listed for temperature exceedences; however, the station that provides the data is located at the end of the reach where the river changes from B-2 to B-3, or becomes a warm-water fishery. Temperature data collected with data loggers stationed between the headwater and the mouth are needed to show the characteristics of the watershed's temperature regime, the contributions from tributaries, wastewater discharge(s), Priest Butte Lakes, and potential groundwater inputs. Supplemental fishery information is also needed to confirm what temperature tolerances resident fish have. Teton Spring Creek is also listed for temperature impairment, and although limited, the data shows a large temperature increase from the source and downstream at least eight miles. More information regarding flows and riparian cover need to be gained along with temperature data.

4) *Groundwater characteristics* - Priest Butte Lakes has been briefly studied in the past, but the characteristics of the shallow groundwater that drain into the lake have not. An extensive groundwater study was completed around Freezeout Lake, Benton Lake, and the surrounding areas. For a better understanding of the load contributed to Priest Butte Lakes from the geology and groundwater, a groundwater-monitoring plan needs to be implemented. As for the remainder of the watershed, groundwater studies should take place in irrigated areas between Choteau and Bynum (Figure A-9b) and along the Teton River to determine losing/gaining reaches of a stream. Identification of land practices that contribute to increased salts and salinity should be used to supplement or support groundwater data.

5) *Nutrient contributions* – A statistically significant upward trend was seen in total phosphate values for the middle reach of the Teton River. Also, the tributary streams of Deep, Willow, and Teton Spring Creeks have shown increased algae growth and higher than the recommended total phosphate levels. The city of Choteau releases wastewater from its lagoons into the Teton River. Effects from all of these sources, plus any other non-regulated, un-permitted, or non-point source of nutrients need to be studied. The available data also leaves the status of Willow Creek in question. Water quality samples for Willow Creek showed higher nutrient values, yet Chl *a* results were well below impairment criteria. Additional plant and nutrient analyses should be completed for all the Teton River mainstem and its tributaries.

6) *Dissolved oxygen (DO)* – Low, one time measurements of DO have been collected during the summer and winter in Priest Butte Lakes. However, the extent and effects of stratification are not known. Also, data known to MDEQ has not been collected recently, or within the past ten years. To fully understand the impacts of DO,

comprehensive study of daily DO levels, as well as the extent of aquatic plant life in Priest Butte Lakes, must be determined.

A “tiered approach” for monitoring has been developed (Table 6-1) and is designed to outline data that can be gathered based on time, funding, personnel, and stakeholder(s) interest/willingness to participate. Each tier is progressively more involved then the previous one. Tier 1 outlines the basic data needed to establish baseline conditions, identify sources, and better define loads. It is intentionally basic and geared towards being the most economical and fundamental. Although the term “basic” is used, the data collected through Tier 1 is *essential* and needed for improving water quality in the Teton River watershed. Tiers 2 and 3 have progressively more detailed monitoring. Tier 2 builds on the basic data needs from Tier 1, while Tier 3 is almost geared towards specific, specialized projects and would rely on more funding and greater technical staff and oversight.

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List of Acronyms & Abbreviations

General

Ave.	Average
ARM	Administrative Rules of Montana
BLM	Bureau of Land Management
BMP	Best Management Practices
BP	Before Present
CRP	Conservation Reserve Program

DNRC	(Montana) Department of Natural Resources and Conservation
GID	Greenfields Irrigation District
GIS	Geographic Information System
GPS	Geographic Positioning System
MCA	Montana Code Annotated
MDEQ	Montana Department of Environmental Quality
MDOT	Montana Department of Transportation
MFWP	Montana Department of Fish, Wildlife, and Parks
MSEO	Montana State Engineer's Office
NRCS	Natural Resources Conservation Service
ODEQ	Oregon Department of Environmental Quality
PCS	Permit Compliance System
SI	Systemé International
TRWG	Teton River Watershed Group
USDA	United State Department of Agriculture
USDI	United States Department of Interior
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USGS	United States Geological Survey
WQB-7	MDEQ Water Quality Bureau Circular – (Numerical) Water Quality Standards
WWTP	Waste Water Treatment Plant

Monitoring Constituents

Chl *a*	Chlorophyll *a*
Cl	chloride
DO	dissolved oxygen
EC	Electrical Conductivity
Mg	magnesium
Na	sodium
NO_3+NO_2	Nitrate + Nitrite as Nitrogen
SC	Specific Conductance
Se	selenium
SO_4	sulfate
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids

Units of Measure & Reference

cfs	cubic feet per second
mg/L	milligram per liter (parts per million)
mg/m^2	milligram per meter squared
lbs/d	pounds per day
µg/L	microgram per liter (parts per billion) - **note:** "u" maybe substituted for "µ"
µS/cm	microsiemens per centimeter at 25° C

μg/g	microgram per gram
d/s	downstream
u/s	upstream
nr	near

SECTION 1.0
INTRODUCTION

1.1 Purpose

The water quality plan presented herein describes known water quality impairments, existing water quality data, and proposes various land management practices that may be beneficial to improving water quality and quantity. It also defines, to the extend possible, all necessary Total Maximum Daily Loads (TMDLs) for pollutants specified in Montana's 1996 303(d) List in the Teton River watershed. The 1996 list was recently amended by Montana Department of Environmental Quality's (MDEQ) 2002 303(d) List submission to the U.S. Environmental Protection Agency (USEPA), and in some cases impairments listed in 1996 have been changed or refined using new and additional information.

Section 303 of the Clean Water Act requires states to submit a list (i.e., the 303(d) List) of impaired and threatened water bodies to the EPA every two years. Impaired or threatened water bodies are those that do not at present fully support all beneficial uses or meet water quality standards, or are likely to be impaired in the near future. The 303(d) List identifies which beneficial uses are impaired and indicates the probable causes (i.e., the pollutant) and probable sources of impairment.

While the 2002 303(d) List is now Montana's most current approved list, and is based on greater scientific analysis than the 1996 list, a ruling by the U.S. District Court (CV97-35-M-DWM) on September 21, 2000 stipulated that the state of Montana must complete all necessary TMDLs for waters listed as impaired or threatened on the 1996 303(d) List. The purpose of this document is thus two-fold: 1) to fulfill the requirements of the Federal Clean Water Act, § 303(d) and the Montana Water Quality Act (75-5-7 et seq.) regarding Total Maximum Daily Loads (TMDLs); and 2) to provide a prioritized water quality management plan based on an adaptive management strategy for impaired water bodies in the Teton River watershed.

1.2 The TMDL Context

Montana's Water Quality Act provides specificity regarding surface water classification, water quality standards, and TMDL development and implementation. With the exception of point source discharges, which are permitted under the federal or state pollution discharge elimination system, the non-point source and TMDL programs are based on **voluntary** participation of stakeholders in implementing identified actions that can reduce non-point source pollutants. The Water Quality Act states: "*The department shall support a **voluntary program of reasonable land, soil, and water conservation practices** to achieve compliance with water quality standards for nonpoint source activities for water bodies that are subject to a TMDL developed and implemented pursuant to this section.*" (***Emphasis added***) (75-5-703(8), MCA) and further provides protection to existing water rights: "*Nothing in this part may be construed to divest, impair, or diminish any water right recognized pursuant to Title 85.*" (75-5-705, MCA).

The Administrative Rules of Montana (Rule 17, Chapter 30, Subchapter 6) provide further guidance and definitions pertaining to surface water quality standards and procedures. Two specific and relevant definitions that should be highlighted are for a "dewatered stream" and "reasonable land, soil, and water conservation practices" found in 17.30.602(8) and 17.30.602(23), respectively. These definitions are as follows:

> "**Dewatered stream**" *means a perennial or intermittent stream from which water has been removed for one or more beneficial uses.*
>
> "**Reasonable land, soil, and water conservation practices**" *means methods, measures, or practices that protect present and reasonably anticipated beneficial uses. These practices include, but are not limited to, structural and nonstructural controls and operation and maintenance procedures. Appropriate practices may be applied before, during, or after pollution-producing activities.*

More inclusive text of the Montana Water Quality Act - Title 75, Chapter 5, MCA, the Montana Water Use Act - Title 85, Chapter 2, MCA, and the Surface Water Quality Standards and Procedures – ARM 17.30.6 are provided in Appendix D of this document. Full text of these laws and rules, as well as the federal Clean Water Act, may be accessed via the Internet at:

Federal and state TMDL laws:	http://www.deq.state.mt.us/ppa/mdm/tmdl/lawsRules.asp
Water Quality Act and ARMs:	http://www.deq.state.mt.us/wqinfo/Standards/Index.asp
Water Use Act:	http://data.opi.state.mt.us/bills/mca_toc/85_2.htm

Within the context of the laws and rules governing water quality in the State of Montana, the MDEQ is directed to work towards the support of **all** beneficial uses associated with a water body as defined in the Surface Water Quality Standards and Procedures rules (17.30.6 et seq., ARM). It is important to note that the laws **do not** identify one beneficial use as more important than another, but that each water body should be maintained suitable so as to support all associated beneficial uses.

1.2.1 Background

Pollutants addressed in this plan include total dissolved solids (salinity), selenium, sediment, thermal modifications, nutrients, and organic enrichment/dissolved oxygen. Flow alterations and riparian habitat degradation also have an effect on water quality and are addressed in this document where they are associated with listed pollutants. Probable sources of water quality impairments have been identified as unstable banks, stream channalization, irrigation (both withdrawal and return flow), farming and grazing practices, riparian habitat modification, municipal and stockwater withdrawals, municipal wastewater discharge, petroleum production, and naturally occurring sources.

Ten water bodies have been listed as impaired on Montana's 303(d) List and will be addressed in the plan (Table 1-1). All water bodies in the Teton River watershed are classified as B1, B2, or B3. These classifications are part of the Montana water quality standards and define the character of the water. B1 is cold water with a mineral content that is safe for irrigation and supports a trout fishery. B2 is cool water with a mineral content that is safe for irrigation and may support a trout fishery. B3 is warm water with a mineral content that is safe for irrigation and supports a warm water fishery. All “B” waters are also to be maintained suitable for household use after conventional treatment, stockwater, recreation, industry, waterfowl, and furbearers.

Table 1-1. Water bodies in the Teton River Watershed Addressed In This Plan.

Segment	Size (2002 List)	Reach Description	Water body #	Class
Upper Teton River	29.5 mi	N & S Forks to Deep Creek	MT41O001-030	B1
Middle Teton River	42.0 mi	Deep Creek to Muddy Creek	MT41O001-020	B2
Lower Teton River	110.6 mi	Muddy Creek to Marias	MT41O001-010	B3
Willow Creek	18.9 mi	Headwaters to Deep Creek	MT41O002-010	B1
Deep Creek	9.0 mi	Willow Creek to Teton	MT41O002-020	B1
McDonald Creek	9.1 mi	Headwaters to Teton	MT41O002-030	B1
Teton Spring Creek	4.5 mi 8.5 mi	Choteau to Teton Headwaters to Choteau	MT41O002-060 MT41O002-070	B1
Clark Fork of Muddy Creek	7.7 mi	Headwaters to Muddy Creek	MT41O002-080	B2
Blackleaf Creek (also NF Muddy Creek)	19.8 mi	Headwaters to Muddy Creek	MT41O002-040	B2
Bynum Reservoir	4,120 ac	Reservoir	MT41O003-010	B2
Eureka Reservoir	400 ac	Reservoir	MT41O003-020	B1
Priest Butte Lakes	300 ac	Lake	MT41O004-020	B1

The Teton River watershed is a 1,960 square mile basin located in west central Montana with its headwaters rising out of the Rocky Mountain Front (Figure A-1). The Teton River joins the Marias River near Loma, Montana and the watershed covers parts of Chouteau, Pondera, and Teton counties.

1.3 Adaptive Management Approach

This report makes several recommendations for reducing pollutant loads and improving conditions in streams, lakes, and riparian areas in the Teton River watershed. Stakeholders would like assurance that these actions will restore and protect water quality. Land managers and water users would like to know the whole extent and precise cost of restoration measures. However, these are complex problems and issues influenced by climate, stream flows, land use practices, and other variables outside of our control. In addition, state laws pertaining to water rights and use also play an integral role in how water quality may or can be managed. Given that in many cases the amount of real data, and subsequent knowledge of the actual “system” variability is limited, a phased approach is proposed for the Water Quality Management Plan and TMDLs for the Teton River Watershed.

This document represents Phase I wherein the required elements of the TMDL (e.g., source characterization, numeric or surrogate targets, total maximum daily loads, etc.) are based upon the currently available information with the hypothesis that implementing this plan will result in restoring all beneficial uses. A monitoring and adaptive management strategy, as outlined in Section 6.0, will be implemented as Phase II to test this hypothesis and provide information necessary to adaptively manage the watershed as well as review water quality targets and TMDLs in the future.

1.4 Teton River – Sun River Connection

The Teton River watershed is connected to the Sun River watershed via man-made canals and irrigation works. The Greenfields Irrigation District (GID) receives irrigation water from the Sun River and some of the irrigation "waste water" and return flows then drain into Freezeout Lake. Freezeout Lake was connected to Priest Butte Lakes to assist in the management of lake levels and to relieve local flooding in Freezeout Lake. A drainage canal connecting Priest Butte Lakes to the Teton River was constructed during the 1950s thus creating the hydrologic connection of the Sun River to the Teton River via these two previously internally closed drainage basins.

In the interested of simplicity, the TMDLs and Water Quality Management Plans for the Teton and Sun Rivers have been developed in separate documents. However, the development of each of these plans was done in close coordination since water quality in the Teton River basin is intricately linked to actions in the Sun River basin. The pivot point for these watersheds is the Freezeout Lake discharge into Priest Butte Lakes. The setting of targets, especially those set for Priest Butte Lakes, was done with awareness as to their potential implication to Freezeout Lake, the Greenfields Irrigation District (GID), and the Sun River. This document does not however attempt to describe the complex functioning of the Freezeout Lake Wildlife Management Area, the Sun River watershed, or its irrigation systems. This information and detail is contained in the Sun River Watershed Water Quality Restoration Plan and Total Maximum Daily Loads for the Sun River, Muddy Creek, Ford Creek, Gibson Reservoir, Willow Creek Reservoir, and Freezeout Lake (MDEQ, in development).

1.5 Document Layout

This water quality management plan begins with this introduction and background section and then introduces the Teton River watershed's geographic context and physical and biologic characteristics in Section 2.0. Water quality impairments are presented in Section 3.0, which is followed by a presentation of existing conditions, source assessment, water quality targets, and TMDLs in Section 4.0. A broad-brushed outline of implementation strategies roughly based on the level of necessity, expense, and practicality is presented in Section 5.0. Finally, a tiered water quality-monitoring plan designed to evaluate both the progress toward achieving defined water quality targets and the level of beneficial use support is provided in Section 6.0.

SECTION 2.0
WATERSHED DESCRIPTION

2.1 State of the Watershed: A Historical Context & Overview

Conditions of the land and water, and its uses in any area of the earth change over time and the Teton basin is no exception. The type and degree of these changes will determine the sustainability of those uses over time.

Recorded conditions in the Teton basin begin with the Lewis & Clark expedition of 1804-1806. The expedition journals, as translated by Moulton (1999), documented several points of interest that can be used today to gain an understanding of the historical landscape and riparian vegetation. Native Americans are said to have referred to the Teton as the Rose River for the rose bushes located along the river and Lewis and Clark also refer to the river variously as the Rose or Tanzey River. On June 3rd, 1805 the Fields brothers noted the Teton's riparian areas as "*containing much timber in it's bottom, consisting of the narrow and wide leafed cottonwood with some birch and box alder undrgrowth willows rosebushes currents &c.*" Then on June 6th, 1805 while returning to the Marias River along the Teton, which he referred to as the "little river," Captain Clark noted "*the bottoms of this little river is in everry respect except in extent like the large bottoms of the Missouri below the forks containing a great perportion of a kind of cottonwood with a leaf resembling a wild Cherry* (narrow-leaf cottonwood). *I also observed wind* (wild) *Tanzey on this little river in great quantities*…" (non-italic interpretations provided by Wayne Phillips, retired Botanist, Lewis & Clark NF; author of Plants of the Lewis and Clark Expedition, 2003). Moulton's footnote for the Tanzey states "*The identity if the plant is problematic. The possibilities include Dyssodia papposa, (fetid marigold) or more likely Matricaria matircarioides, (pineapple weed)*… Also noted by the journals were large herds of buffalo, elk, deer, and antelope as well as some goats. On the return trip in 1806, Captain Lewis crossed the Teton River noting that the "*rose river at this place is fifty yards wide, the water which is only about 3 feet deep occupys about 35 yds. and is very terbid of a white colour*." Lewis also notes that between the Teton and Marias Rivers there was "*very probably no water*" and describes the riparian area and stream bed of the Teton as "*its bottoms are wide and well timbered with cottonwood both the broad and narrow leafed species. the bed of this stream is small gravel and mud*."

Trappers and hunters were the first to follow Lewis & Clark into this area, making their fortunes from the abundant game that covered the land. White settlers soon followed, first settling around Fort Benton in the 1840s, a location called Montana's first commercial hub. The settlers continued to move into new areas and by 1859 had settled near present day Choteau. The town grew as the center of sheep and cattle country (Spritzer, 1999).

The early settlers first used the expansive lands to raise large herds of cattle and horses. The limited upland trees were cleared for building and heating dwellings as well as for building fence lines. However, the settlers soon found that the stock animals could not survive the northern plain winters without supplemental feed, so grass was cut and stored for winter use. Where possible, rich river bottomlands were also cleared to increase forage production. Irrigation of the land soon followed to increase the amount of hay that could be stored. Some settlers began to farm, putting more land to use in order to survive the harsh landscape. As irrigation became more prevalent the increasing demand for water created the need for extensive canal systems and off-stream reservoirs. The demand for water has grown to exceed the annual flows of the river resulting in a basin closure to surface water appropriations and significant water shortages, even in “normal” years.

Natural disturbance events in the northern Rockies Mountains and plains ecosystem include wildfire and floods, which are reoccurring events across the scale of time. As far back as man can remember this area has seen a range of “minor,” inconvenient flooding to floods of extreme magnitude. Floods of 1948 and 1953 are reported as severe but having little documented effect to the river system, although one effect of the 1953 flood was that the US Army Corps of Engineers had contractors straightened out several river bends in the lower basin (personal communication with area landowners). However, the flood of 1964 was dramatically different. Leading up to this flood, land use along the river bottoms and floodplain had changed significantly: some reaches of the river were channelized (i.e. straightened) to try and slow erosion; permanent bridges for transportation were installed, constricting the river channel; and riparian areas were being heavily used thus reducing vegetation that stabilizes and holds the soils. When the ’64 flood came, the ability of the river’s floodplain to accommodate and withstand extreme flows was reduced so the flood effects were severe. When the floodwaters receded, the Teton River had lost a substantial amount of stream length as a result of flood flows and man’s reaction to it. Again, the US Army Corps of Engineers channelized a reach of river in an attempt to prevent future damage, this time near Choteau. The resulting destabilization of the stream is considered a significant reason for the continued instability of the upper reaches (personal communication with area landowners). Local NRCS staff and volunteers using aerial photo analysis have calculated that the river has lost approximately 35 miles of length from these events. The effects of the 1953 and 1964 floods continue to be manifested as the river works to regain its lost stream length. However, the river now has limited space within which to regain this length as people occupy much of the floodplain for agricultural purposes, homes, towns, and transportation infrastructures.

The 1975 flood was not as severe as the flood of 1964, however the stream banks and overall river system had not yet recovered from the 1964 flood. Thus, additional bank erosion and soil loss occurred across the watershed.

The river continues to work at regaining stream length and is eroding its banks into rich farmland that once had functioning vegetative buffers. Efforts are being made to try and find methods that will slow erosion and protect fields while letting the river have some room to move. An additional problem with the present instability of the river is to keep diversion structures intact and functioning as desired (personal communication with area landowners). Frequent maintenance of these structures result in the disturbance of the channel bed and contributes additional gravel to the system, which decreases the overall stability of the reach (Watershed Consulting, 1999). This activity prevents the stream channel from stabilizing and thus requires continual channel management.

With societies’ expectation for fully supporting many diverse beneficial uses, such as drinking water, irrigation, stock water, fisheries/aquatic life, and recreation, there are significant conflicts among various user groups. Since the river is not able to fully meet the needs of all beneficial uses, some of the uses suffer greatly. Minimum needs of the upper and lower Teton basin irrigators are not met, let alone the full demands of water rights across the basin. Communities struggle to find enough water for the residents and community resources and the historical fisheries no longer exist in any significant quantities.

The remainder of this document gets into more detailed and scientific description of the watershed and its processes – to the extent possible given the current resources available to MDEQ. There are limitations and shortcomings in both available data and understanding of all the issues. Regardless, this water quality management plan is a first step in an adaptive management strategy where by an initial direction and critical data needs are identified. Traveling this path and filling these data needs is the task at hand. Where the level of support between conflicting beneficial uses should be balanced is for the current and future generations to decide. How we work together today, and what we do to the river, will determine what the river will be able to do tomorrow.

2.2 Physical Characteristics

2.2.1 Topography

The Teton River watershed is located on the eastern side of the Rocky Mountain Front in west central Montana (Figure A-1). The Rocky Mountain Front was formed by tectonic fault thrusting creating distinct north-south trending ridgelines that rise to roughly 9,400 feet along the continental divide on the watershed's western edge. A trellis drainage pattern has formed in these fault-controlled headwaters. The Teton River and its major headwater tributaries, the North, Middle, and South Forks bisect these north-south trending ridgelines in the northern half while the North and South Forks of Deep Creek bisect the southwest corner.

Across the western third of the watershed Muddy Creek, the Teton River, and Deep Creek spill out onto the foothill prairie. The prairie landscape has much less relief than the mountain front but contains numerous buttes and low ridges. A dendritic drainage pattern begins to form on the prairies once the streams leave the fault-controlled headwaters. The eastern two-thirds of the watershed is characterized by highly-dissected coulees and low river breaklands typical of the glaciated high plains in the western central Montana. The watershed's lowest elevation is roughly 2,600 feet near the mouth at Loma.

2.2.2 Climate

General climatic characteristics of the Teton River watershed are typical of a continental climate with local variation controlled by its location on the eastern Rocky Mountain Front. Typical annual weather patterns consist of dominant winter high-pressure with periodic low-pressure storm systems moving across from the west resulting in an accumulation of snows in the high elevation headwaters. During the spring months, April through June, the Rocky Mountain Front experiences its wettest period as the northern jet stream moves southward from southern Canada. During this period, low pressure storm systems track from the south and southwest bringing moisture-laden warm air masses from the Gulf coast. As the high-elevation plains and Rocky

Mountains lift these air masses they release their moisture in the form of prairie rains and heavy mountain snowstorms. Low-pressure systems generally set up during the summer months, which are dominated with isolated, but intense, convective storms driven by land heating.

Dramatic differences in atmospheric pressure and temperature between the east and west sides of the Rocky Mountain Front can set up conditions that generate katabatic, or Chinooks winds. These down slope winds occur periodically from November through April and can have a significant desiccating effect on vegetation and soil moisture east of the mountain front (Barry, 1992).

Weather data collected at the Choteau airport includes temperature and precipitation (Figure 2.1) from 1971 through 2000 and is used as a general characterization of the watershed's recent climate. Temperature extremes reported range from an average minimum temperature of 13.2 °F (for January) to an average maximum temperature of 81 °F. Recorded temperature extremes range from -50 °F (February 15, 1936) to 106 °F (August 26, 1894). In any given month, daily temperature fluctuations could range by as much as 50 °F (Western Regional Climate Center, 2003).

Annual precipitation varies across the watershed from an average of 12 inches in the east near Fort Benton to 60 inches or more in the western headwaters where approximately 30% of annual precipitation is in the form of snow. At Choteau, reported monthly averages for the year range from 0.19 inches in February to 2.15 inches in June (Figure 2.1). Several months (December through February) have monthly averages less than 0.25 inches. May and June receive the highest amount of monthly average precipitation of 2.00 and 2.15 inches, respectively. These two months also have the highest maximum precipitation of 5.06 and 6.82 inches, respectively.

2.2.3 Geology and Soils

Basic geology of the Teton River watershed varies from folded sedimentary units of Devonian, Mississippian, and Cretaceous age in the Rocky Mountain Front to younger Cretaceous sedimentary units in the eastern prairies (Figure A-2). Limestone and dolomite, both calcium-carbonate rich rocks, are common in the folded units of the Front Range. Quaternary gravel benches cover much of the western third of the watershed, while the eastern two thirds are mostly sandstone, siltstone, and/or shale.

Two major tectonic, or mountain building, episodes followed by a period of glaciation, has shaped the foundation for the modern day Teton River watershed. First, in the late Cretaceous period (approximately 65-140 million years BP) erosion carved away the ancestral Rocky Mountains. Remainders of the erosion include gravel beds near Choteau and sand and gravel covered bedrock near Fort Benton. Also during the Cretaceous period, shallow inland seas deposited layers of silt and clay that would become known today as the Colorado Shale. This geological unit covers much of the eastern reach of the Teton River and is associated with water that has relatively increased total dissolved solids, particularly elements such as sodium, chloride, sulfate, and selenium. Following the Cretaceous period, the Tertiary (approximately 3-65 million years BP) experienced a second period of mountain building, where the present day Rocky Mountains were uplifted. Barren rock cliffs and poorly developed soils still persist in the higher elevations in the western portion of the Teton River watershed. In Montana, the most recent continental glacial event was the Wisconsin glaciations, from about 10,000 to 80,000 years BP. During this time, glacial tills were deposited on the eastern portion of the watershed; these tills have been shown to contain nitrogen, arsenic, and selenium (Kendy et al., 1999).

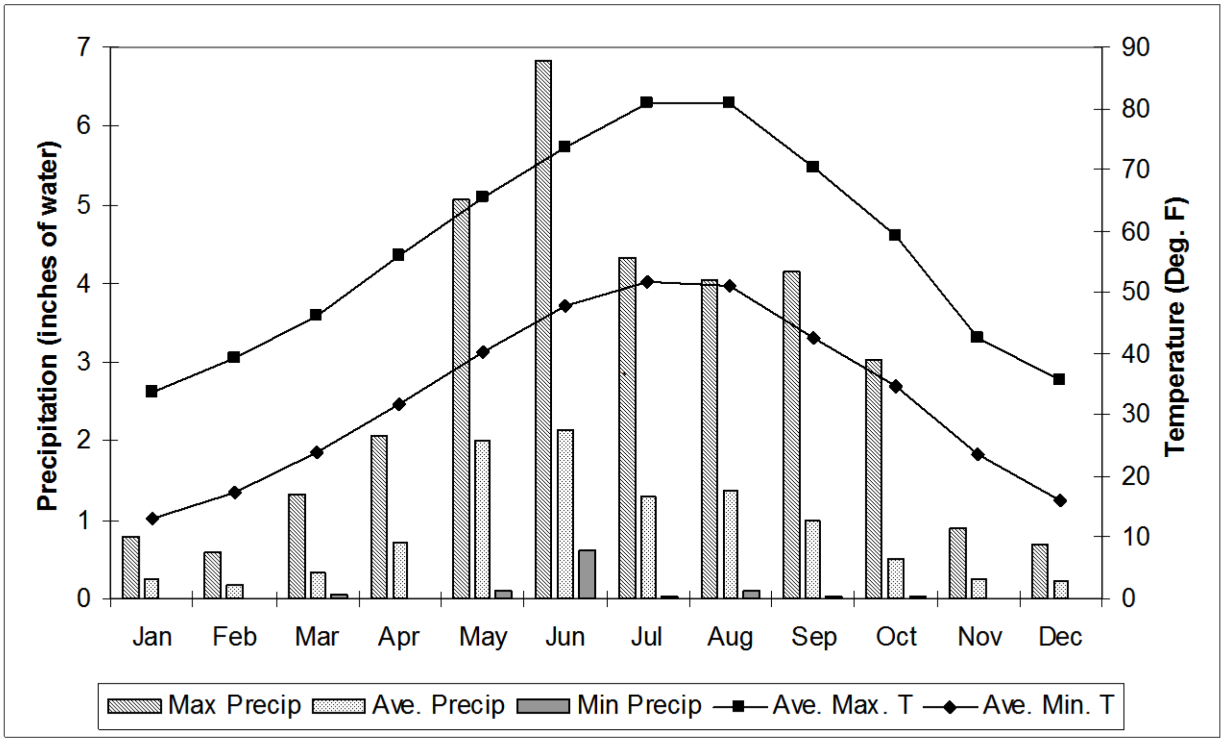

Figure 2-1. Average monthly precipitation and temperature data for Choteau Airport during the period 1971 to 2000 (data from the Western Regional Climate Center).

Soil series found in the Teton River watershed range from gravelly loams to clay loams and soil series have a characteristic influence on the quality of surface and shallow groundwater (Table 2-1). In the western portion of the watershed, the soils are dominated by gravel, transitioning to gravelly loam in the middle watershed, to silt loams and finally sandy loams in the lower watershed.

2.2.4 Hydrology

The Teton River watershed begins in the Rocky Mountains and water flows east into the Marias River, draining an area of 1,960 square miles (Seaber et al., 1987). The North Fork Teton River begins at the continental divide and flows southeast through a forested basin. The South Fork Teton River begins at a local divide east of the Sun River. The two forks converge and the mainstem of the Teton River then flows through a wide “outwash gravelly flat” (Gieseker, 1937). The river flows through this gravelly flat, around a terminal glacial moraine (Burton Bench), and out onto the prairie. Gieseker (1937) described the Teton River at low flow as “a swiftly flowing stream 30 to 40 feet wide and 1 to 3 feet deep” with a flood plain consisting of “stony river wash.”

Table 2-1. Soil Series of the Teton River Watershed (Gieseker, 1937).

Soil Series	Area Found	Description
Joplin	Over glacial drift in north central part of basin	Loams and silt loams; fair water holding capacity; crop/fallow or rangeland with gramma grass as chief cover; June grass, needle grass and mountain sage indicate grazing pressure.
Scobey	Over glacial drift in central and eastern part of basin	Silt and silty clay loams, good tilth and water holding capacity. Good agricultural soil. Dominant species gramma grass.
Bainville	Over calcareous sandstone and shales in south central and western part of basin	Immature silty clay loams used as rangeland, poorly drained and impregnated with alkali, dominant species gramma grass. Where mature loams develop and are irrigated, alfalfa and spring wheat can be grown.
Marias	North of Teton River central part of basin	Clay loam used for crop/fallow farming and grazing, dominated by western wheat grass, contains alkali and is plastic when moist, very productive soils due to water holding capacity
Ashuelot	Burton Bench, benches between Willow and Deep creeks	Gravelly loam, droughty, rangeland, dominated by gramma grass in lower areas and bunchgrass in higher elevations
Morton	Over sandstone bordering glacial lake deposits in western part of basin	Loams used for crop/fallow farming and grazing, dominant species gramma grass
Teton	Over calcareous sandstone and shales in higher elevations	Immature loams used for hay production and rangeland
Laurel	Covering stream valleys along Teton River	Loams of alkali phase, naturally sub-irrigated or irrigated to grow alfalfa hay. Sedges dominate in sloughs along with cottonwood and willow. Greasewood indicates alkaline conditions. Rose indicates grazing pressure.

Flow in the Teton River is typical of a perennial snowmelt dominated stream. The river experiences extremes of both high and low flow conditions from a combination of climatic influences and water diversions for agricultural activities (Figure 2-2). Major tributaries to the Teton River include two perennial streams, Deep and Muddy Creeks, and two spring fed streams, McDonald and Teton Spring Creek. Two other perennial streams, Willow Creek and Blackleaf Creek (also know as North Fork Muddy Creek), are tributaries to Deep and Muddy Creeks, respectively. Several water storage reservoirs in the watershed, including Bynum and Eureka Reservoirs, were created for the development of irrigated agriculture.

Hydrographs for most streams in the Teton River watershed follow climatic events. High flows occur during the spring when a combination of spring rains and snowmelt from the mountains contribute to the flows. Stream flow decreases as summer progresses and base flow theoretically maintains stream flow through the fall and winter. At present, three active USGS gaging stations are located along the Teton River mainstem (Figure A-3). While there are currently no active gaging stations on any of the tributaries, the USGS reports data from several historical stations for the Teton River and its tributaries (Table 2-2).

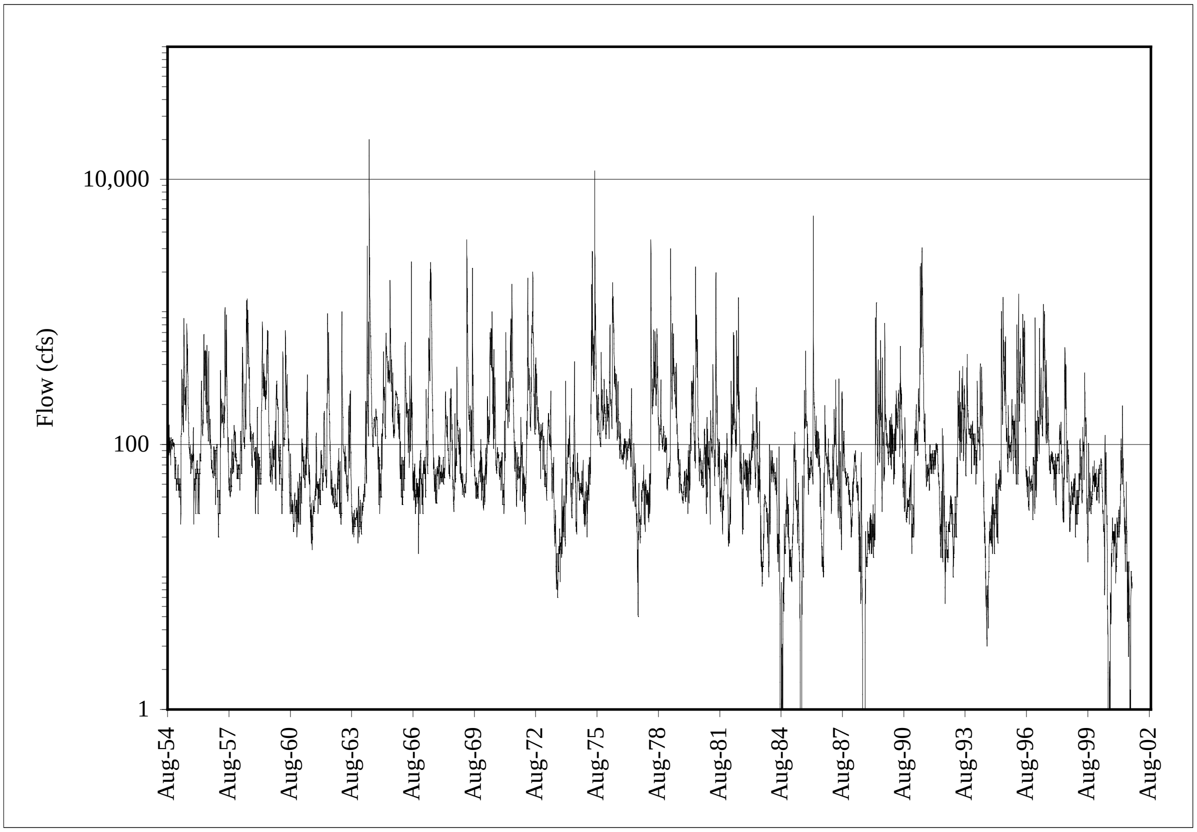

Figure 2-2. Mean daily stream flow at the USGS gage near Dutton from 1954 to 2001.

2.2.4.1 Historical Stream Flows

The nature, or consistency of stream flow in the Teton River is a point of debate between local residents and the historical data. Local residents indicate that the Teton River typically goes dry near Choteau during late summer and winter periods. Field notes from MDEQ monitoring staff has documented zero-flow conditions, and additionally, MFWP has identified the lower 188 miles of the Teton River (Bynum diversion to the mouth) as chronically dewatered (MFWP, 1997b). Evaluation of the earliest stream flow data collected in the watershed may be informative as to the historical nature of the river. However, water resources in the basin were being developed during the latter half of the 19th century (MSOE, 1962) while the USGS did not begin systematic stream flow gaging until first decade of the 20th century. Regardless, the historical data may offer a glimpse as to the character of the river prior to the development of large water withdrawal infrastructures that were first completed in 1928 (e.g. Bynum Reservoir).

Table 2-2. USGS gaging stations, both historical and active, for the Teton River Watershed (USGS, 2002).

Stream	Site Description	Period of Record	Station Number
Teton River	Below South Fork near Choteau [1]	Jun 1947 – present	06102500
	Near Dutton [2]	Aug 1954 – present	06108000
	At Loma [2]	Jun 1998 – present	06108800
	At Strabane	Jun 1908 – Sept 1925	06103000
	Near Choteau	Apr 1906 – Jun 1919	06104500
	Near Fort Benton	Mar 1929 – Sept 1932	06108500
Teton Spring Creek	Near Strabane	Jun 1913 – Sept 1920	06103500
	Near Choteau	Apr 1917 – Sept 1920	06104000
Deep Creek	At Frazier's Ranch, near Choteau	May 1912 – Nov 1912	06105000
	Near Choteau	Apr 1911 – Dec 1924	06106000
Willow Creek	Near Choteau	Apr 1912 – Sept 1917	06105500
Muddy Creek	Near Bynum	Mar 1912 - Dec 1924	06106500
	Near Agawam	Jun 1917 – Sept 1917	06107500
North Fork Muddy Creek	Near Bynum	May 1912 – Dec 1924	06107000

[1] Active gaging station.
[2] Active gaging stations with real time data transfer via Internet.

Historical flow data implies that the present trend of going dry is not likely the “natural” character of the river. There were two USGS gaging stations on the upper Teton River that pre-date the Bynum Reservoir, “at Strabane” and “near Choteau” (Table 2-2). The station at Strabane was located 14 miles northwest of Choteau or eight miles downstream of the South Fork of the Teton River and was published as “near Belleview” prior to 1910. The near Choteau site was located 1½ miles south of Choteau. The earliest gaging station on the lower Teton River was the “near Ft. Benton” site, but this was not in operation until 1929 or just after the completion of the Bynum Reservoir. Hydrographs of these stations show flows typical for a snowmelt-dominated system with spring/early summer peak flows and low flows during the remainder of the year (Figure 2-3).

Flows at the two upper stations, at Strabane and near Choteau, did not record zero-flow conditions between 1906 and 1925, with one exception. The Strabane station recorded zero-flow from December 20, 1920 to January 9, 1921. However, flows from early November 1920 through mid-January 1921 were consistently low (i.e. less than 2 cubic feet per second (cfs)) and there is a good likelihood that the zero-flow recorded is due to cold temperatures and freeze-up.

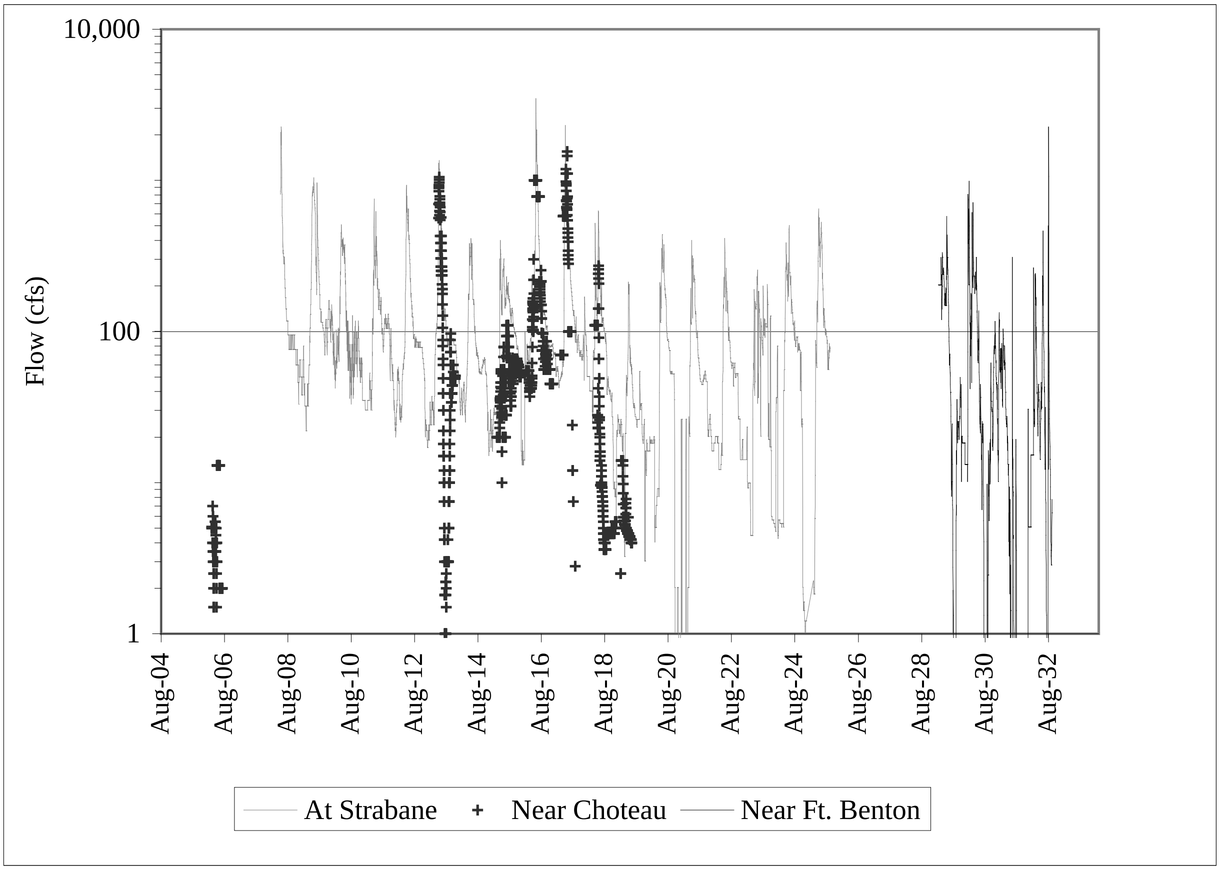

Figure 2-3. Historical mean daily stream flows on the Teton River recorded at USGS gaging stations. Flows of less than one cfs represent zero-flow conditions.

Unfortunately, the station near Choteau was not in operation at this time nor is the daily climatic record for this period readily available to confirm this assumption. The lowest monthly average stream flow at Strabane during its 17-year period of record is 30.5 cfs. Flows recorded near Choteau were often low, with 347 days measured with flows of five cfs or less, yet zero-flow conditions were never recorded.

In contrast, the lower Teton River did go dry near the mouth (Ft. Benton) on 195 days between March 1929 and November 1931. Zero-flow conditions were reported during the summers of 1929, 1931, and 1932, with 1931 having the longest continuous period - 184 days from June 27 through December 28. It is uncertain whether the zero-flow conditions at Ft. Benton gage were solely a result of climatic conditions (i.e. drought) or the result of operation of the newly completed Bynum Reservoir and other water withdrawals in the basin alone, or in conjunction with, a dry climatic pattern.

Unfortunately, there were no gaging stations on both the upper and lower Teton in concurrent operation to evaluate flow consistency across the entire river prior to the completion of large-scale water resource infrastructures in 1928.

Eight stream gaging stations were in operation on tributary streams between 1911 and 1924 (Table 2-2). Mean monthly flows were calculated for six of the eight stations that were operating for more than one year (Table 2.3). Two stations, Deep Creek near Frazier's Ranch and Muddy Creek near Agawam were in operation for less than one year and are thus not presented. Flows in these streams follow a typical pattern of increasing flows in April and tapering off in July. Teton Spring Creek (near Choteau) also has an increased springtime flow pattern although the difference between maximum and minimum flows is not as great given it is a spring-fed stream.

Minimum and maximum flows for the periods of record indicate flow regimes that, at times, reached zero-flow on all but Deep and Teton Spring Creeks (Table 2.3). Maximum flows occurred during May and June on all streams except Deep Creek. Minimum flows generally occurred during September except for Willow and Muddy Creeks with January minimum flows and Deep Creek with minimum flows in February. Consecutive periods of zero-flow ranged from over two months in Willow Creek to seven months in North Fork Muddy Creek (Blackleaf Creek).

Table 2-3. Monthly mean stream flows (in cfs) at historical USGS gaging stations on Teton River tributary streams (USGS, 2002).

	Deep Creek nr Choteau	**Teton Spring Creek nr Strabane**	**Teton Spring Creek nr Choteau**	**Willow Creek nr Choteau**	**Muddy Creek nr Bynum**	**NF Muddy Creek nr Bynum**
January	23	4	20	5	3	7
February	22	4	17	7	0	3
March	39	7	16	19	1	6
April	71	10	22	40	15	21
May	190	11	31	98	16	21
June	225	8	26	83	34	28
July	100	2	16	29	9	9
August	43	1	13	10	2	4
September	33	1	11	9	1	2
October	36	4	13	15	3	4
November	35	5	15	15	1	3
December	31	5	16	9	3	5
Minimum	3	0.4	5	0	0	0
Maximum (Date of Max)	3,050 (9/1916)	64 (5/1917)	138 (5/1917)	880 (6/1916)	976 (6/1916)	600 (6/1916)
Period of Record	1911-1924	1913-1920	1917-1920	1912-1917	1912-1924	1912-1924

2.2.4.2 Current Stream Flows

The current gaging stations in operations in the Teton River watershed include the station below the South Fork (06102500), near Dutton (06108000), and at Loma (06108800) (Figure A-3). These stations have been active since 1947, 1954, and 1998, respectively. The record high flow for the Teton River was recorded at Dutton on June 9, 1964 at 20,000 cfs[1]. Other high flow events recorded at the Dutton station are 11,600 cfs on June 21, 1975, 3,510 cfs on March 10, 1977, and 5,280 cfs on February 26, 1986.

Data from current Teton River gaging stations show high flows occur in June. Mean monthly flows for June range from 499 cfs near the South Fork, to 393 cfs near Dutton, to 98.5 cfs near Loma. Mean monthly low flows are 45.1 cfs below South Fork near Choteau, 56.5 cfs near Dutton, and 10.6 cfs at Loma during March, January, and September, respectively.

The old gaging station at Strabane was replaced with the station located downstream of the South Fork confluence near Choteau (Table 2-2). Originally this station operated year-round, but since 1954 it has operated annually from April 1 to October 31. This station is upstream of the major irrigation diversion structures, and thus the annual hydrograph reflects that of a snowmelt-dominated stream (Figure 2-4) with peak flows in May – July and fairly consistent base flows occurring during October – March. **Note**: in Figure 2-4 monthly mean flows for November through March were calculated from 1947 – 1954 data and April through October flows were calculated from 1998 – 2001 data.

Stream flow in the upper Teton has been gaged by the USGS during 71 years since 1908 and the flow regime appears to be fairly consistent over this period. Mean monthly stream flows at the current South Fork station (Figure 2-4) are similar, although systematically higher, than those calculated for the old Strabane gage that operated from 1908 to 1925 (Figure 2-5). The reason for this shift is unclear, but may result from improved gaging systems or other changes in the headwaters that alter the timing or magnitude of annual runoff. The 14% shift in mean peak flow during June however is likely due to the significant influence of the two major floods during 1964 and 1975.

The USGS installed a gaging station on the middle Teton River at Dutton in August of 1954. This station is the longest running site that collects both daily stream flows as well as water quality data at various intervals. Stream flow below five cfs was not reported at this station until 1984, after which date, several years have seen flows less than one cfs (1984, 1985, 1988, 2000, 2001).

The seasonal nature of stream flow in the middle Teton River, as well as climatic variability can be seen with five-year monthly mean stream flows (Figure 2-6). The affect irrigation withdrawals have on stream flow can be seen in hydrograph by the decreased flows in April and May. This is likely a result of upstream water users diverting spring runoff to fill storage reservoirs. In addition, the influence of the 1964 flood can also be seen in the highest average flow data for 1964-1968 period. Likewise, the current drought is reflected in the data for 1999-

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[1] The flow of 20,000 cfs was the officially reported peak during the 1964 flood. However, the post-flood estimated peak flow was 71,300 cfs using slope-area measurements of high water marks (Boner and Stermitz, 1967).

2002 and is the lowest averages on the graph. Seasonality appears basically consistent through all the data, showing constant lower flows (base flow) from August through February. From March through July, monthly values typically increase, showing effects of snow melt and spring rains.

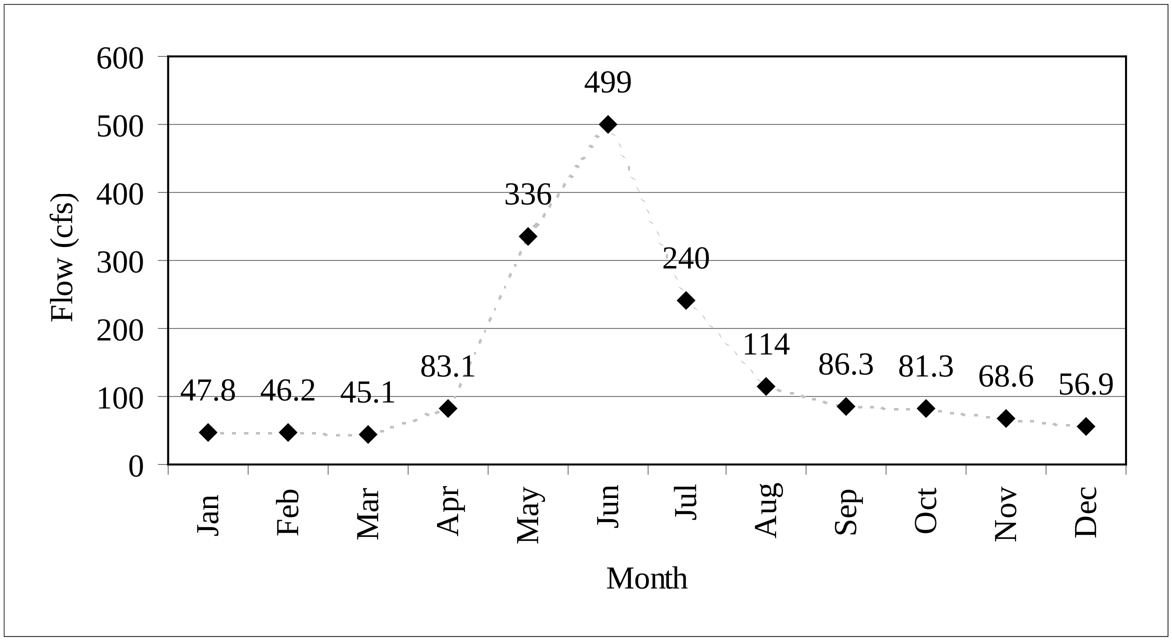


Figure 2-4. Mean monthly stream flows for the Teton River downstream of South Fork Teton confluence from 1947 to present (station # 06102500). November to March values from 1947 to 1954 data and April to October values from 1998 to 2001 data.

In 1998 the USGS re-established a gaging station near the mouth of the watershed with the installation of the station near Loma. Stream flow is collected daily and other water quality data is collected at various intervals. Based on this five-year dataset, the highest flow recorded at Loma was 1,739 cfs and the lowest flow was zero. During this period 278 days of zero-flow have been recorded from 1999 to 2001. In 1999, the “dry” period was from July 30 through August 12, or 14 days. The period of zero-flow increased substantially in 2000, with zero-flow in the river for 107 days from July 14 through October 28, or 29% of the year. Finally, the summer of 2001 measured the longest dry spell for the three-year period with zero-flow in the river for 157 days from June 30 through December 8, or 43% of the year. Flows that are probably closer to typical were achieved in 2002, with no zero-flow conditions recorded. Mean monthly flows at Loma (Figure 2-7) mimic those of the Dutton gage where upper basin water diversions show a marked decrease in mean stream flows during April and May.

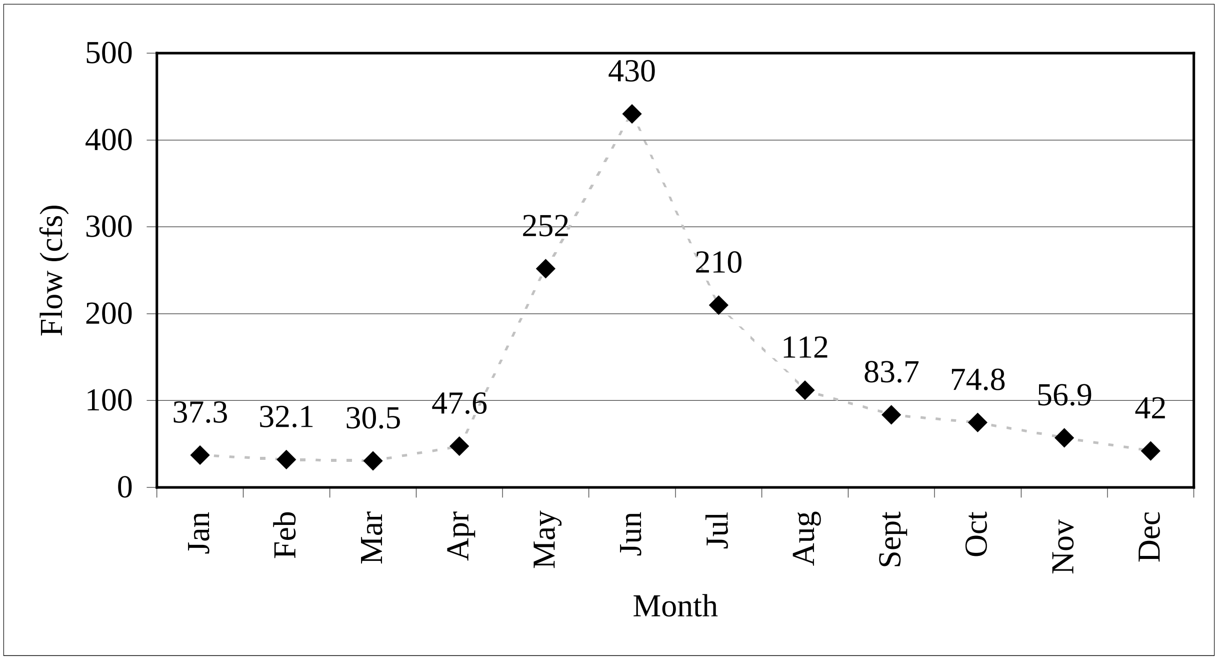


Figure 2-5. Mean monthly stream flows for the Teton River at Strabane (upstream of Choteau) from 1908 to 1925.

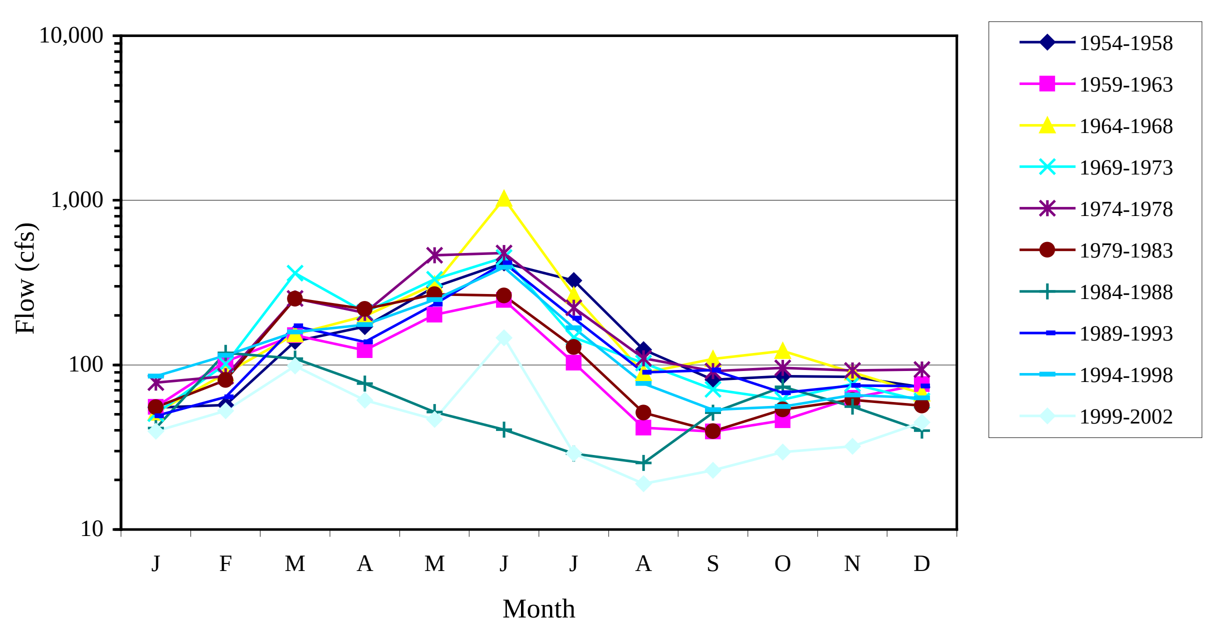


Figure 2-6. Five-year monthly mean stream flows at the USGS gage near Dutton from 1954 to present (station # 06108000).

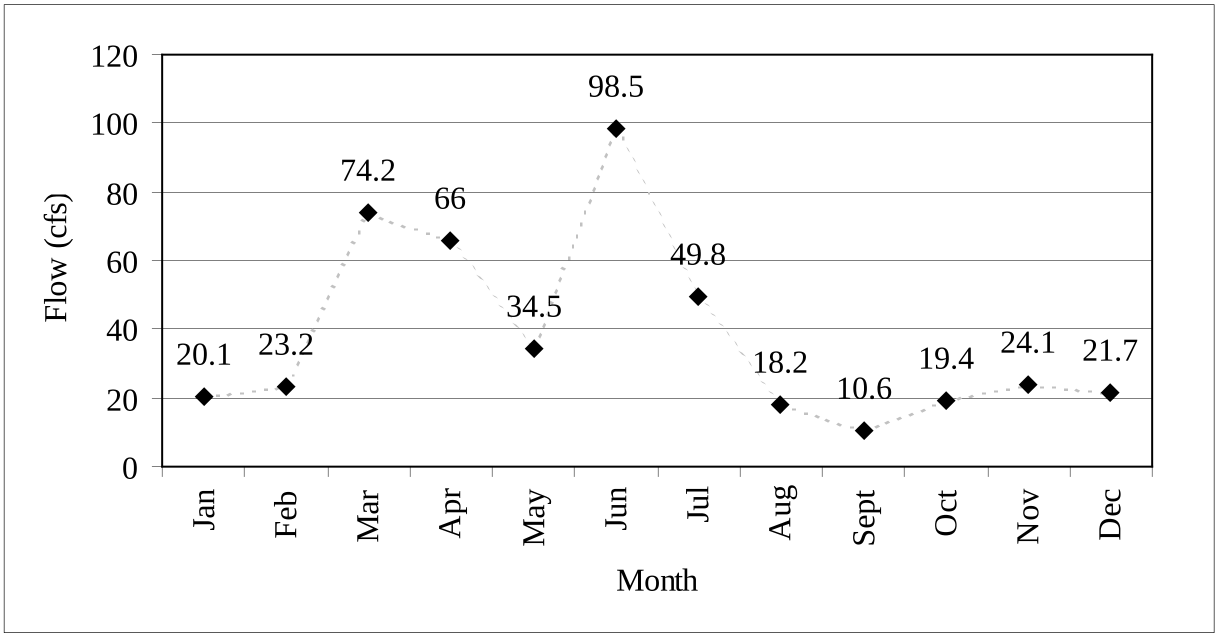


Figure 2-7. Mean monthly stream flows for the Teton River near Loma from 1998 to present (station # 06108800).

2.2.4.3 The 1964 Flood

In June of 1964 climatic and weather events conspired in the Northern Rocky Mountains resulting in a significant flood event that affected the Dearborn, Sun, Teton, and Marias Rivers in the Missouri River Basin, as well as the Flathead, St. Mary, Belly, and Waterton Rivers on the west side of the Rocky Mountains. A low-pressure system that brought a warm moist air mass from the Gulf of Mexico dropped up to 14” of rain on the Rocky Mountains over a 36-hour period. The rain fell on top of a heavy winter snow pack that had experienced minimal melting prior to the rain event. Resultant flood flows on the Teton River at an old gaging station near Farmington was estimated to have peaked at 54,600 cfs, or 11.5 times the probable 50-year flood (Boner and Stermitz, 1967). This report provides station information that describes this gage location as “*300 feet downstream of the highway bridge, 1 1/8 miles downstream of the South Fork confluence, and about 20 miles west of Farmington*” and was discontinued in 1954. The reported flow of 54,600 cfs was estimated using slope-area measurements at the old gage site, which was destroyed during the flood. At the USGS Dutton gage, the flood flow had increased with the additional flows from tributary streams to a peak discharge of 71,300 cfs on June 9th estimated with slope-area measurements (Boner and Stermitz, 1967). The current USGS web site does not include the gage near Farmington in its list of discontinued stations and also has the officially recorded flow at Dutton as 20,000 cfs on June 9,1964.

The impact of this flood event on the Teton River was significant. The city of Choteau was evacuated when floodwaters up to six feet deep inundated the town of 2,000 residents damaging 640 homes and businesses (Figures 2-8 and 2-9). Boner and Stermitz (1967) report that the damage across the Teton watershed included five of eight bridges were destroyed while the remaining three requiring repairs to their approaches. Additionally, the flood destroyed many irrigation works and washed out several irrigation canals leading to off-stream reservoirs. Amazingly, no lives were lost in the Teton River watershed during the flood event.

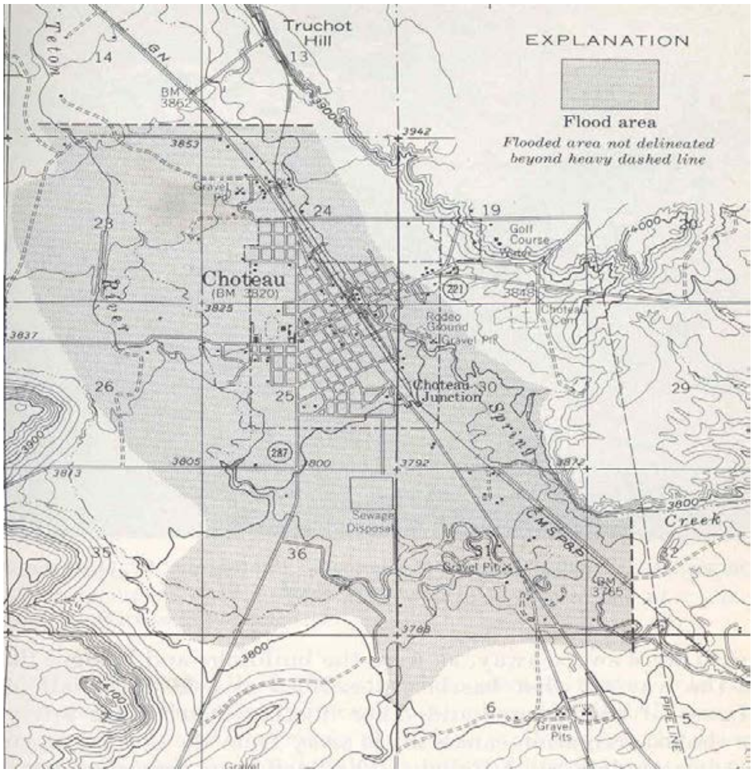


Figure 2-8. Inundated area around Choteau on June 8, 1964. From Boner and Stermitz (1967)

Figure 2-9. City of Choteau on June 8, 1964. From Boner and Stermitz (1967)

2.2.4.4 Priest Butte Lakes

Priest Butte Lakes, part of the Freezout Lake Wildlife Management Area (WMA), was a closed basin between the Sun and Teton River watersheds. Prior to the building of the Greenfields Irrigation District, the Freezout Lake WMA was a mud flat during dry years and a large, shallow pool in wet years, although Priest Butte Lakes was deep enough that it usually contained water. After the implementation of large-scale irrigation on Fairfield Bench east of Freezeout Lake, the basin became a natural sump for irrigation wastewater and return flows from the Greenfields Irrigation District. In 1954, a canal was excavated connecting Freezeout Lake and Priest Butte Lakes to alleviate the flooding of the railroad grade and Montana State Highway 89 next to Freezeout Lake. An aqueduct was then built to connect Priest Butte Lakes with the Teton River (Figure A-4) so that water levels within the WMA could be managed (MFWP 1997a). MFWP moves water through the Freezeout Lake pond system and then into Priest Butte Lakes, and finally releases water from Priest Butte Lakes into the Teton River when river flows are greater than 20 cfs.

2.3 Biological Characteristics

2.3.1 Vegetation and Land Cover

The Teton River watershed consists of arid grassland plains and sparsely timbered foothills along the Rocky Mountain Front. Rivers and streams are lined with riparian vegetation consisting of cottonwoods, willows, and rushes. Land use and land cover in the basin (Figure A-5) is dominated by agricultural lands with 40% classified as range land, 33% as crop land, and 11% as pastures. The remaining 16% of the basin is classified as forested, grass or shrub land, open water, and other “land covers” of minimal areal extent relative to the entire watershed.

2.3.2 Ecoregions

Ecoregions are a broad-scale classification system that combines climatic regimes with soil and vegetative properties to classify regions of similar ecological conditions (Woods et al., 1999). Represented in the Teton River watershed are the Northwestern Glaciated Plains in the eastern portion, Mountain Valley and Foothill Prairie in the middle portion, and Canadian Rockies in the western portion (Figure A-6).

2.3.3 Fish and Wildlife

Montana FWP has observed and recorded numerous species of fish in the streams of the Teton River watershed (Table 2-4). Although numerous fish species have been observed, several are of special management concern as a result of threatened habitats. Westslope cutthroat trout (*Oncorhynchus clarki lewisi*) are present in the headwaters of the Teton River watershed (Figure A-7). It has been identified as 100% pure with distributions in Cow Creek, East Fork of the Teton River, Waldron Creek, Green Gulch, Rierdon Gulch, and the North Fork of Willow Creek. None of these streams are listed as impaired on the Montana 303(d) List. However, it is on Montana's list of Animal Species of Special Concern, classified by the USFS as ‘sensitive’, and by the BLM as a ‘special status’ species (Carlson, 2001). The blue sucker, sauger, and sturgeon chub are warm water species that are also species of special concern. The lower Teton River is considered by MFWP as historically important spawning and rearing habitat for the Missouri River sauger. Unfortunately, spatial representation of their occurrences and distribution is not readily available from MFWP in GIS format and thus is not shown on Figure A-7.

The Teton River watershed is also home to several terrestrial species of special concern as well as those identified as threatened or endangered. Harlequin ducks use portions of the North Fork and South Fork of the Teton River for breeding grounds (Figure A-7). Grizzly bears are also prevalent in the watershed and feed in riparian areas but primarily during the spring and fall. Forested and riparian habitats of the Teton River watershed are considered part of the Northern Continental Divide Ecosystem that is also host to other species such as gray wolf, bald eagles, and peregrine falcons.

Table 2-4. Fish species in the Teton River watershed that have been observed and reported by MFWP**.**

Stream	Fish present (MFWP, 2002)	
Willow Creek	Brook trout Longnose dace Mottled sculpin	Mountain whitefish Rainbow trout White sucker
Deep Creek	Brook trout Brown trout Fathead chub Goldeye Lake chub Longnose dace	Longnose sucker Mottled sculpin Mountain sucker Mountain whitefish Rainbow trout White sucker
Teton Spring Creek	Brook trout Longnose dace Longnose sucker Mottled sculpin	Mountain sucker Rainbow trout White sucker
McDonald Creek	Brook trout	
Priest Butte Lakes	Brassy minnow Brook stickleback Common carp	Fathead minnow Lake chub White sucker
Eureka Reservoir * Stocked annually w/ Rainbow trout	Brook trout Brown trout Longnose sucker	Rainbow trout Northern Redbelly dace N. Redbelly x finescale dace hybrid [1] White sucker
Bynum Reservoir * Walleye stocked from 1985 to 1992; Supplemental stocking began again in 2002	Brown trout Mountain whitefish Rainbow trout Spottail shiner	Walleye Westslope Cutthroat trout [1] White sucker Yellow perch

Table 2-4. Fish species in the Teton River watershed that have been observed and reported by MFWP**.**

Stream	Fish present (MFWP, 2002)
Teton River	Blue sucker [1] Brassy minnow Brook trout Brown trout Burbot Channel catfish Common carp Emerald shiner Fathead minnow Flathead chub Freshwater drum Goldeye Lake chub Longnose dace Longnose sucker Mottled sculpin Mountain sucker Mountain whitefish Northern pike Northern Redbelly dace Rainbow trout River carpsucker Sand shiner Sauger [1] Shorthead redhorse Shovelnose sturgeon Stonecat Sturgeon chub [1] Western silvery/plains minnow White sucker

[1] Aquatic species of concern (Carlson, 2001)

2.4 Cultural Characteristics

The Teton River watershed is a rural landscape located along the southern tier of Montana's "Golden Triangle." The watershed has an average population density of less than two people per square mile with about 2,500 residents in Ft. Benton, 1,781 in Choteau, 389 in Dutton, 60 in Rockport, 50 in Bynum, and 20 in Blackleaf. The economy relies on tourism, farming, and agricultural service businesses. The primary agricultural products are alfalfa, wheat, barley, cattle, and hogs.

2.4.1 Ownership and Land Use

The majority of the watershed is either privately owned (54%) or is managed by the Lewis and Clark National Forest (34%) (Figure A-8). Of the remaining twelve percent of the watershed, MFWP and DNRC combined manage approximately 8% and the BLM and USFWS combined manage approximately 4% of the land area. Of the private lands, open range/prairie and both irrigated and dryland agriculture are the dominant land uses (Figures A-9a and A-9b). These land uses/covers transition into deciduous and evergreen forests along the western edge of the prairie and into the Rocky Mountain Front (Figure A-5).

In addition to agriculture, other managed land uses in the watershed include wildlife habitat on the Freezout Lake Wildlife Management Area, Teton Spring Creek Bird Preserve, Ear Mountain Wildlife Management Area, and Blackleaf Wildlife Management Area. Land management activities on the Lewis and Clark National Forest include livestock grazing and recreation (e.g. hunting, fishing, camping, and bird watching).

2.4.2 Water Resources

2.4.2.1 Water Use and Infrastructure Development

Water resource infrastructure and facilities have been developed to facilitate agricultural activities in the watershed for at least the past 120 years (MSEO, 1962; 1964a; 1964b). Numerous canals have been constructed to deliver stream water to irrigate fields, water stock, or supply storage reservoirs (Figure A-9a, A-9b). Three primary reservoirs were constructed in the upper watershed during the early part of the 1900's - Bynum, Eureka, and Brady Lake.

Bynum Reservoir was completed in 1928 and stores 72,000 acre-feet of water for use by the Teton Co-operative Reservoir Company (MSEO, 1962). The reservoir was built to encourage settlement of the area by homesteaders. It was designed to serve a dual function of storing spring runoff, and thereby moderating the affects of flooding, and to provide irrigation water in the dry summer months. The Bynum Reservoir diversion canal traverses five miles from the Teton River to the reservoir and the stored water irrigates about 20,500 acres. This amounts to about one-third of the total irrigated acres (61,000 acres) in the Teton River watershed.

Eureka Reservoir was built in 1936 and stores 5,500 acre-feet of water for use by the Teton Cooperative Canal Company. The reservoir was built in response to the drought of the early 1930s (MSEO, 1962) and also uses the Teton River as its source.

Brady Lake Reservoir was constructed in 1936 and stores 3,300 acre-feet for use on 6,000 acres (14,800 potential acres) by the Brady Irrigation Company (MSEO, 1962; personal communication via TRWG & Brady Irrigation Company). The reservoir system actually uses two other lakes as storage or “transfer pools” to deliver water from Muddy Creek. Diverted water is transferred in 2½ miles of supply canal from Muddy Creek to Round Lake, then via ¼ mile supply canal to Eyraud Lake, and finally to Brady Lake via another ¼ mile length of supply canal. The Brady Lake Reservoir is also capable of receiving water from the Teton River.

Harvey and Farmers Lake Reservoirs were constructed in 1912 and 1941, respectively, by the Farmers' Co-Operative Canal Company. Each reservoir receives water from the Teton River with priority dates of 1897 and 1898. Harvey Lake has a capacity of 2,000 acre-feet while Farmers Lake Reservoir holds 2,560 acre-feet. Both reservoirs were constructed solely for irrigation purposes and are not meant support a fishery or recreational uses (personal communication via TRWG & Farmers' Co-Operative Canal Company).

Various private and incorporated water companies use the Teton River and its tributaries (MSEO, 1962). Three ditch companies, Eldorado, Farmers, and the Teton Co-operative Canal Company use Teton River water on the “Burton” or “Farmington” Bench, which is located north of Choteau. The Teton Co-operative Reservoir Company supplies Teton River water to the Brady Irrigation Company, Bynum Irrigation District, and several private ditch systems. The Bynum Irrigation District also uses water from Muddy Creek, as does a private irrigation system. Waters from Deep, Willow, Teton Spring, and McDonald Creeks are all used by private irrigation systems.

2.4.2.2 Water Rights and Adjudication

Water right claims in the Teton River watershed prior to 1973 numbered 1,405 for a total of 75,902.8 cfs. From 1973 to 1985 an additional 27 water right permits were issued for 40.5 cfs (DNRC, 1991). The Teton River main stem has water right claims for 1,638 cfs, which can be grouped by location in the watershed (Table 2-5). Most of the issued water rights concentrate in the western third of the watershed, with the oldest priority date in the watershed being 1858. The oldest, most downstream water right on the Teton River has an 1874 priority date for 6.9 cfs. This right is located downstream of the Dent Bridge area and is for irrigating 182 acres. In addition, there is also an associated stock watering right with the same priority date and owner.

Table 2-5. Location and volume of issued water rights.

Location	Water Rights Issued
Upper Teton: above Choteau	828 cfs
Middle Teton: Choteau to I-15	289 cfs
Lower Teton: I-15 to Loma	521 cfs

In 1985, in response to directive from the Montana Legislature, the Montana DNRC conducted a water reservation proceeding for the Missouri River Basin. Public entities were allow to make reservations which could be for consumptive use or maintaining instream flows for the protection of aquatic life, recreation, or water quality (DNRC, 1992). The Montana FWP submitted six requests for instream flows in the watershed to protect aquatic life totaling 81.4 cfs (Table 2-6). The amount of flow necessary to support aquatic life was determined using either a habitat retention approach (wetted perimeter) or a fixed percentage analysis, which also includes base flow calculation (DNRC, 1992).

Table 2-6. Instream flow reservation requests from MFWP (DNRC, 1992).

Stream	Reach Description	Dates Requested	Flow (cfs)	Method of determination [1]
Deep Creek	Headwaters to mouth	Jan. 1 – Dec. 31	18	WETP
McDonald Creek	Headwaters to mouth	Jan. 1 – Dec. 31	10	BF
NF Deep Creek	Headwaters to mouth	Jan. 1 – Dec. 31	7.2	FP
SF Deep Creek	Headwaters to mouth	Jan. 1 – Dec. 31	6.9	FP
(Teton) Spring Cr.	Headwaters to mouth	Jan. 1 – Dec. 31	4.5	BF
Teton River	Headwaters to Priest Butte Lakes Discharge	Jan. 1 – Dec. 31	35	WETP

[1] WETP = wetted perimeter
BF = base flow
FP = fixed percentage

Three streams had been adjudicated prior to 1962, the Teton River (including McDonald Creek), (Teton) Spring Creek, and Spring Coulee (MSEO, 1962). However, these adjudications have been deemed to be not all-inclusive. Presently, the Teton River watershed is a closed basin, meaning no new claims or permits are being accepted and a new adjudication process in underway. The current adjudication will incorporate the “old” decrees and a new temporary preliminary decree will be issued at its completion. The scheduled completion date for this adjudication, and subsequent release of the temporary preliminary decree, is the end of 2003 (Personal Communication, Bob Larsen, DNRC).

SECTION 3.0
EXISTING WATER QUALITY CONCERNS AND SOURCES

3.1 303(d) Listing Status

Water bodies listed in both the 1996 and the 2002 303(d) List include three reaches of the Teton River mainstem, six tributary streams, two reservoirs, and one lake (Figure A-10a, A-10b). Water bodies included on the 1996 list (Table 3-1) showed impairments, but listing decisions were typically based on professional judgment, lacked supporting scientific data, and/or often lacked adequate documentation. Impairments for water bodies listed on the 2002 list (Table 3-2) were based on sufficient and credible data, as legally stipulated in the Montana Water Quality Act (MCA 75-5-702).

Table 3-1. 1996 Listing Information for the Teton River Watershed.

Segment Name, MT Water body ID	Est. Size (mi)	Probable Cause	Probable Source
Teton River (N. & S. Fork to Deep Creek), MT41O001_080	29	Flow alteration (dewatering) Other habitat alterations	Agriculture Irrigated Crop Production Natural Sources
Teton River (Deep Creek to Muddy Creek), MT41O001_070	28	Flow alterations (dewatering) Other habitat alterations Siltation Suspended sediment	Agriculture Irrigated crop production Non-irrigated Crop Production Natural Sources Range Land Streambank Modification/Destabilization
Teton River (Muddy Creek to mouth), MT41O001_060	93	Flow alteration (dewatering) Other habitat alterations Other inorganics Salinity/TDS/chlorides Siltation Suspended solids Thermal modifications	Agriculture Irrigated Crop Production Natural Sources Non-irrigated Crop Production Range Land Streambank Modification/Destabilization
Willow Creek, MT41O001_010	29	Flow alteration (dewatering) Other habitat alteration Siltation	Agriculture Irrigated Crop Production

Table 3-1. 1996 Listing Information for the Teton River Watershed.

Segment Name, MT Water body ID	Est. Size (mi)	Probable Cause	Probable Source
Deep Creek, MT41O001_020	7	Flow alteration Other Habitat alterations Siltation Suspended solids	Agriculture Irrigated Crop Production Natural Sources Range Land
McDonald Creek, MT41O001_030	10	Flow alteration (threatened)	Agriculture Irrigated Crop Production
North Fork Muddy Creek[1] (Blackleaf Creek), MT41O001_040	15	Salinity/TDS/chloride Siltation	Agriculture Petroleum activities Resource extraction
Teton Spring Creek, MT41O001_090	3	Flow alteration (dewatering) Other habitat alterations	Agriculture Channelization Irrigated crop production Land Disposal Removal of riparian vegetation
Teton Spring Creek, MT41O001_100	6	Flow alteration (dewatering)	Agriculture Irrigated Crop Production
Clark Fork Muddy Creek, MT41O001_011	11	Siltation (threatened)	Petroleum Activities Resource Extraction
Priest Butte Lakes, MT41O002_020	300 ac	Metals Organic enrichment/DO Salinity/TDS/chloride	Agriculture Irrigated crop production Nonirrigated crop production
Bynum Reservoir, MT41O003_010	4,120 ac	Flow alteration Siltation	Agriculture Highway/Road/Bridge Construction Irrigated crop production
Eureka Reservoir, MT41O003_020	400 ac	Flow alteration Siltation	Agriculture Highway/Road/Bridge Construction Irrigated crop production

Source: MDEQ (1996a)

[1] Name changed to Blackleaf Creek for subsequent 303(d) Lists.

Table 3-2. 2002 Listing Information for the Teton River Watershed.

Segment Name, MT Water body ID	Est. Size (mi)	Probable Cause	Probable Source
Teton River (N. & S. Fork to Deep Creek), MT41O001_030	29.5	Flow alteration (dewatering) Other habitat alteration Riparian degradation	Hydromodification Channelization Flow regulation &/or modification Bank modification &/or destabilization Habitat modification
Teton River (Deep Creek to Muddy Creek), MT41O001_020	42	Salinity/TDS/sulfate Thermal modifications Flow alteration (dewatering) Other habitat alteration Riparian degradation Suspended solids	Agriculture Crop-related sources Grazing-related sources Hydromodification Channelization Flow regulation &/or modification Bank modification &/or destabilization Municipal point sources Habitat modification
Teton River (Muddy Creek to mouth), MT41O001_010	110.6	Siltation Flow alteration (dewatering) Salinity/TDS/sulfate	Hydromodification Channelization Flow regulation &/or modification Bank modification &/or destabilization Habitat modification
Willow Creek, MT41O002_010	18.9	Riparian degradation Siltation Fish habitat degradation Other habitat alteration	Removal of riparian vegetation Agriculture Bank modification &/or destabilization

Table 3-2. 2002 Listing Information for the Teton River Watershed.

Segment Name, MT Water body ID	Est. Size (mi)	Probable Cause	Probable Source
Deep Creek (Willow Cr to mouth), MT41O002_020	9	Dewatering Flow alteration Nutrients Siltation Riparian degradation Bank erosion Fish habitat degradation Other habitat alteration	Flow regulation &/or modification Removal of riparian vegetation Agriculture
McDonald Creek[1] MT41O002_030	9.1	Fully supporting all BU	
Upper Blackleaf Creek [2] (headwaters to Cow Creek), MT41O002_041	7.3	Fully supporting all BU	
Lower Blackleaf Creek [2] (Cow Creek to mouth), MT41O002_042	19.8	Riparian Degradation Bank Erosion	Removal of Riparian Vegetation Range Grazing – Riparian Bridge Construction
Teton Spring Creek (Choteau to mouth), MT41O002_060	4.5	Nutrients Flow alteration Siltation Riparian degradation Other habitat alterations Fish habitat alterations	Flow regulation &/or modification Channelization Removal of riparian Habitat modification Source unknown
Teton Spring Creek (headwaters to Choteau), MT41O002_070	8.5	Dewatering Flow alteration Riparian degradation Thermal modification Siltation	Flow regulation &/or modification Removal of riparian vegetation Pasture grazing – riparian Grazing related Natural sources

Table 3-2. 2002 Listing Information for the Teton River Watershed.

Segment Name, MT Water body ID	Est. Size (mi)	Probable Cause	Probable Source
Clark Fork Muddy Creek, MT41O002_080	7.7	Fully supporting all BU [1]	
Priest Butte Lakes, MT41O004_020	300 ac	Selenium	Nonirrigated crop production
Bynum Reservoir, MT41O003_010	4,120 ac	Fully supporting all BU	
Eureka Reservoir, MT41O003_020	400.3 ac	Fully supporting all BU	

Source: MDEQ (2002a)

[1] Listed as "threatened" in 1996; further examination of data and existing conditions for 2002 list have shown that all beneficial uses (BU) are supported.

[2] Stream was split into 2 reaches for 2002 list, based on changes in geography. Also called North Fork Muddy on 1996 303(d) List.

Listing decisions for the 303(d) lists are based on the direction that all Montana water bodies are to be maintained suitable (e.g. support) the beneficial uses specified by surface water classifications. All of the streams, reservoirs, and the one lake listed in the Teton River watershed are classified as "B" water bodies (see Section 3.2 Applicable Water Quality Standards). Beneficial uses associated with "B-class" waters have been established and designated within Montana's Surface Water Quality Standards and Procedures (ARM 17.30.601 et seq.) and include aquatic life, fisheries, (human) drinking water, agriculture, industry, and contact recreation. **NOTE:** the listing order is not meant to infer any priority for, or preference of, any particular use.

The water body classification system is also stratified to reflect the type of fishery and associated aquatic life that is present. Class "1" refers to a cold-water salmonid fishery, class "2" is an intermediate cold-water/warm-water fishery, and class "3" is a warm-water non-salmonid fishery. Class "2" waters are to be "maintained suitable… for the growth and marginal propagation of salmonids" (ARM 17.30.624 and 17.30.627). Water quality standards that relate to temperature, turbidity, pH, and dissolved oxygen may change between these classes.

Water bodies on Montana's 1996 and 2002 303(d) lists (Tables 3-1 and 3-2) did not fully support all designated beneficial uses or a beneficial use may be have been determined to be "threatened." The level of beneficial use support for the listed waters can be as threatened, partially supported, or not supported (Table 3-3).

Water bodies on the 303(d) lists that are classified as B-1 include the upper Teton River, Willow Creek, Deep Creek, McDonald Creek, Teton Spring Creek, Priest Butte Lakes, and Eureka

Reservoir. Water bodies classified as B-2 include the middle Teton River, Clark Fork of Muddy Creek, Blackleaf Creek (called North Fork Muddy Creek in 1996), and Bynum Reservoir. The only water body classified as B-3 is the lower Teton River (Figure A-11).

Table 3-3. Impaired beneficial uses identified on the 1996 & 2002 303(d) lists.

Stream Reach, Description, & MT Water body ID	**1996 Use Support**						**2002 Use Support**					
	Aquatic Life	**Fishery**	**Drinking water**	**Agriculture**	**Industry**	**Contact Recreation**	**Aquatic Life**	**Fishery**	**Drinking water**	**Agriculture**	**Industry**	**Contact Recreation**
Teton River (N. & S. Fork to Deep Cr), MT41O001_030	P	P				P	P	N				
Teton River (Deep Cr to Muddy Cr), MT41O001_020	P	P	T	T		P	P	P		P		
Teton River (Muddy Cr to mouth), MT41O001_010	P	P	P	P		P	P	P				
Willow Creek, MT41O001_010	P	P					P	P				
Deep Creek, MT41O002_020	P	P					P	P	P		P	P
McDonald Creek, MT41O001_030		T					F	F	F	F	F	F
Upper Blackleaf Creek, MT41O001_041	P	P	P				F	F	F	F	F	F
Lower Blackleaf Creek, MT41O001_042							P	P				
Upper Teton Spring Creek (Headwaters to Choteau), MT41O001_070	P	P				P	P	P	P			P

Table 3-3. Impaired beneficial uses identified on the 1996 & 2002 303(d) lists.

Stream Reach, Description, & MT Water body ID	1996 Use Support						2002 Use Support					
	Aquatic Life	Fishery	Drinking water	Agriculture	Industry	Contact Recreation	Aquatic Life	Fishery	Drinking water	Agriculture	Industry	Contact Recreation
Lower Teton Spring Creek (Choteau to mouth), MT41O001_060	P	P				P	P	P	P		P	P
Clark Fork Muddy Creek, MT41O001_011		T					F	F	F	F	F	F
Priest Butte Lakes, MT41O002_020	P	P	P			P	N	N				
Bynum Reservoir, MT41O003_010	P	P					F	F	F	F	F	F
Eureka Reservoir, MT41O003_020	P	P					F	F	F	F	F	F

Source: MDEQ (1996a, 2002a)
P = Partial support, N = Non-support, T = Threatened, F = Full support

3.2 Applicable Water Quality Standards

Water quality standards that are not being met in the Teton River watershed include:

- Salinity/TDS/chlorides or sulfides,
- Selenium,
- Dissolved oxygen / nutrient enrichment
- Siltation / suspended solids,
- Temperature, and
- Nutrients

Montana State law provides numerical water quality standards for selenium (Se) and temperature. Given in the *Circular WQB-7: Montana Water Quality Standards* (MDEQ, 2002b) are acute (20 µg/L) and chronic (5 µg/L) aquatic life standards for Se in surface water, based on total recoverable samples. The drinking water standard for Se in surface water is based on a maximum contamination level (MCL) of 50 μg/L and no samples are allowed to exceed this without violating the standard. Temperature standards for aquatic life are based upon Water-use classifications as defined in the Administrative Rules of Montana (ARM). Along with quasi-numeric standards for temperature, narrative standards for sediment, suspended solids, and nutrients are based on Water-use classifications, in ARM 17.30.620-629.

Narrative standards for turbidity, temperature, siltation/sediment, and nutrients coincide with the classification of the stream. Water quality standards for all classes of B waters state the following:

(1) *"Waters…are to be maintained suitable for drinking, culinary, and food processing purposes, after conventional treatment; bathing, swimming and recreation; growth and propagation of [salmonid or non-salmonid] fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply."*
(2) *"No person may violate the following specific water quality standards for waters classified [B-1, B-2, or B-3]."*

B-1 standards read as follows:

Turbidity: *"the maximum allowable increase above naturally occurring turbidity is five nephelometric units except as permitted in 75-5-318 MCA."*

Temperature: *"A 1°F maximum increase above naturally occurring water temperature is allowed within the range of 32°F to 66°F; within the naturally occurring range of 66°F to 66.5°F, no discharge is allowed which will cause the water temperature to exceed 67°F; and where the naturally occurring water temperature is 66.5°F or greater, the maximum allowable increase in water temperature is 0.5°F. A 2°F per-hour maximum decrease below naturally occurring water temperature is allowed when the water temperature is above 55°F, and a 2°F maximum decrease below naturally occurring water temperature is allowed within the range of 55°F to 32°F."*

Sediment: *"no increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except as permitted in 75-5-318, MCA*), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife"*
* 75-5-318, MCA: <u>Short-term water quality standards for turbidity</u>. (Refer to Appendix D)

Nutrient: *"state surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will:*
- Create conditions which produce undesirable aquatic life" (ARM 17.30.637 (1)(e)).

B-2 standards read as follows:

Turbidity: *"the maximum allowable increase above naturally occurring turbidity is 10 nephelometric turbidity units except as permitted in 75-5-318 MCA."*

> **Temperature**: "*a 1°F maximum increase above naturally occurring water temperature is allowed within the range of 32°F to 66°F; within the naturally occurring range of 66°F to 66.5°F, no discharge is allowed which will cause the water temperature to exceed 67°F; and where the naturally occurring water temperature is 66.5°F or greater, the maximum allowable increase in water temperature is 0.5°F.*"
>
> **Sediment**: "*no increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except as permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife*"
>
> **Nutrient**: "*state surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will:*
> *- Create conditions which produce undesirable aquatic life*" (ARM 17.30.637 (1)(e)).

B-3 standards read as follows:

> **Turbidity:** "*the maximum allowable increase above naturally occurring turbidity is 10 nephelometric turbidity units except as permitted in 75-5-318 MCA.*"
>
> **Temperature**: "*a maximum increase above naturally occurring water temperature is allowed within the range of 32°F to 77°F; within the naturally occurring range of 77°F to 79.5°F, no thermal discharge is allowed which will cause the water temperature to exceed 80°F; wands where the naturally occurring water temperature is 79.5°F or greater, the maximum allowable increase in water temperature is 0.5°F.*"
>
> **Sediment**: "*no increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except as permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife*"
>
> **Nutrient**: "*state surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will:*
> *- Create conditions which produce undesirable aquatic life*" (ARM 17.30.637 (1)(e)).

Currently, the state the Montana does not have specific standards for salinity or total dissolved solids (TDS) outside of the Tongue, Powder, and Rosebud basins. All B-class waters are to support agricultural and industrial uses. Studies conducted by farm extension agencies have determined crop and animal salt tolerance levels and have developed guidelines for water users. In general, water with less than 1,000 mg/L TDS (SC < 1,500 μS/cm) is suitable for most crops but could have "detrimental effects on sensitive crops" (Ayers and Westcott, 1985). As TDS increase, e.g. 1,000-2,000 mg/L TDS (750-1,500 μS/cm SC), adverse effects on many crops may occur and careful water management is recommended. For animal consumption, water with TDS less than 1,000 mg/L (<1,500 μS/cm SC) is considered excellent for all classes of livestock and poultry. TDS values up to 3,000 mg/L (5,000 μS/cm) are suitable for most animals, but may cause slight digestive disruption in unaccustomed animals (NAS, 1974). For industrial purposes, increased TDS may cause scale (precipitation of Ca-Mg salts) that can clog pumps, fittings, etc.

3.2.1 B-1 Classification for Priest Butte Lakes

Currently, Priest Butte Lakes is classified as a B-1 water and thus is supposed to be "*maintained suitable for drinking, culinary, and food processing purposes, after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply*." MDEQ recognizes that this may be an inappropriate use classification given the saline condition of the lake. Based on local interest and if requested the department may pursue an evaluation of the classification, and if necessary begin a formal Use Attainability Analysis for Priest Butte Lakes and initiate rule making for reclassification. Subsequent to this analysis Priest Butte Lakes may be reclassified into an existing use classification that is more appropriate or a new classification for saline lakes may be developed. All previous beneficial use support determinations would need to be re-evaluated, and updated, if the use classification is changed as a result of the review process.

3.3 Existing Conditions and Review of Supporting Water Quality Data

Impairment listings per the 1996 and 2002 303(d) lists for water bodies in the Teton River watershed were presented earlier in the document (Tables 3.1 through 3.3). This section provides greater detail to impairment status, including brief comparisons between the 1996 and 2002 listing decisions and how/why they may differ. Specific impairments are provided in the following sections along with listed reaches. Based on a watershed approach for TMDL development, data supporting specific impairments will be presented on an impairment-by-impairment basis. Impairments for the Teton River watershed include sediment, salinity, temperature, nutrients, flow alteration or dewatering, riparian degradation, and habitat alteration, including channelization.

TMDLs or Total Daily Maximum Loads are developed for pollutants. These are water quality impairments that can be quantified and thus calculating a load makes sense. Riparian degradation, habitat alteration, and channelization are not *pollutants* but are considered *pollution*. Additionally, flow alteration and dewatering are impairment issues related to quantity and when viewed alone are not subject to a TMDL. However, since pollutant "loads" are calculated as the product of the *pollutant concentration* and *flow*, the quantity of water becomes inextricably related to a TMDL and may often prove to be the most limiting factor.

Water rights <u>will not</u> be affected by this plan unless willing parties lease, donate, bank, etc. water rights to help other beneficial uses, or users, in the watershed. However, the over-appropriation of surface waters in the basin, in and of itself, does not allow the full support of agriculture across the watershed, let alone all other beneficial uses. Certainly, the 1964 flood and the connection of Priest Butte Lakes to the Teton River have both adversely impacted water quality, and all beneficial uses, in the Teton River watershed. However, in addition to the flood and Priest Butte Lakes connection, the cumulative effects of man's activities in the watershed have also added to existing water quality impacts. Moreover, groundwater remains open for future appropriations, which may further adversely impact surface water supplies (Glennon, 2003; Uthman, 2002). Thus, this plan will incorporate solutions and ideas that directly deal with improvement to riparian areas, aquatic habitats, and stream flow. Stable and properly functioning riparian areas and channel dimension, pattern, and profile, which implicitly include adequate flows, are important features that river systems require to adequately carry its load of sediment, nutrients, and/or dissolved solids. Management efforts that include sources of pollution will inevitably assist in the reduction of pollutant loads.

3.3.1 Salinity/TDS/Sulfate and Specific Conductivity (SC)

Streams listed for salinity/TDS/sulfate on the 2002 303(d) list included the middle and lower reaches of the Teton River. On the 1996 303(d) list, "other inorganics" was listed as a probable impairment cause and will be addressed in this section. Other inorganics was used at that time to refer generally to sulfate-related issues. Blackleaf Creek (called North Fork Muddy Creek on 1996 list) was listed for having salinity/TDS/chlorides impairment on the 1996 303(d) list.

Salinity is a measure of dissolved minerals (salts) in water and is typically reported as total dissolved solids (TDS). Increased dissolved salts, such as sodium, chloride, and/or sulfate, can reduce the usefulness of water for agricultural and/or industrial processes. Salinity and TDS can also be determined through the use of specific conductance (SC) or electrical conductivity (EC) if enough data is available to establish a relationship between the parameters. SC and EC imply the same measurement and are used interchangeably in this document. The Systemé International (SI) unit used for salinity is microsiemen per centimeter (μS/cm) and is equivalent to the standard unit μmhos/cm.

SC and EC are dependent on the TDS in the water; therefore, the higher the conductivity, the higher the salt concentration. This allows for correlation between TDS and SC values. This correlation is beneficial for water quality monitoring because SC can be easily and inexpensively measured through the use of a probe in the field; however, TDS requires a more difficult and expensive laboratory analysis.

The relationship of TDS and SC in the Teton River is highly correlated, with a coefficient of determination (r^2) of 0.98 and was calculated by graphing related samples and fitting a trend line with the y-intercept forced through zero (Figure 3-1). The closer an r^2 is to 1.0 the stronger the correlation. The equation that describes the correlation between TDS and SC is TDS = 0.80(SC), which can be used to estimate TDS based on SC measurements.

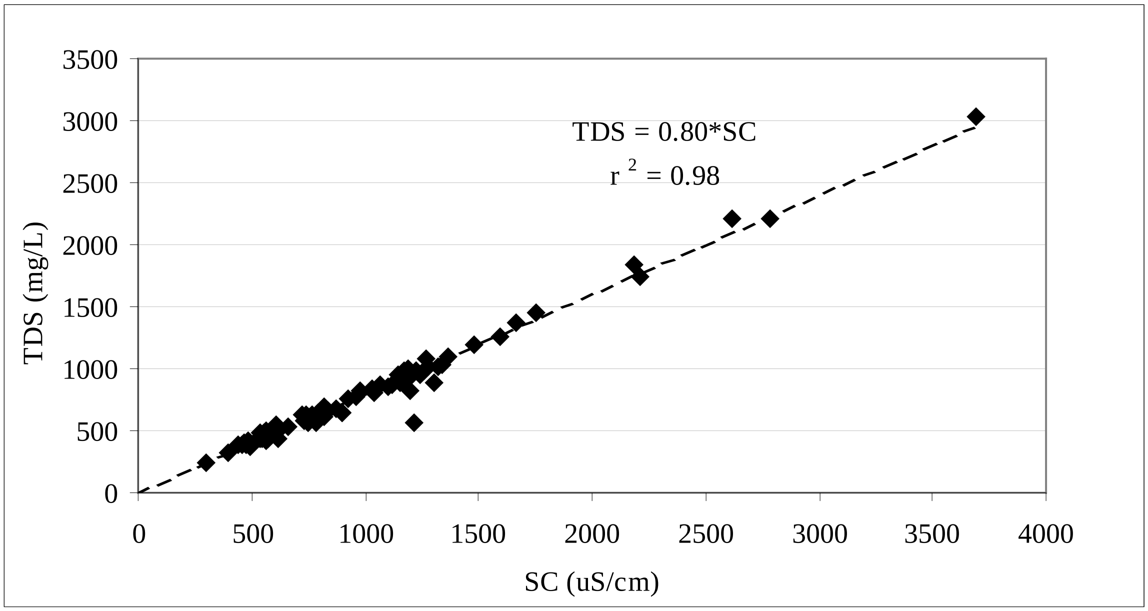


Figure 3-1. Relationship of total dissolved solids (TDS) and specific conductance (SC) in the Teton River, Montana. Samples were collected in the Teton and N. Fork Teton Rivers from 1974 to 1998 (n=86).

Three active USGS gaging stations (Figure 3-2 and Table 3-4) provide a consistent long-range collection of SC data for the Teton River mainstem (Figure A-3). Data shown for the gages near the South Fork confluence and Loma were collected between 1998 and 2001. The data from the Dutton site range from 1982 through August 2001.

SC data collected from 1998 to 2001 at the USGS Teton River gaging stations are compared using box and whisker plots (Figure 3-2). These plots show the 5th, 25th, 50th (median), 75th, and 95th percentiles and “outlying” values for a data set. The line in the middle of each box represents the median value, while the lower and upper edges of the box show the 25th and 75th percentile, respectively. Horizontal lines at the end of the vertical lines indicate the 5th and 95th percentile limits. Points outside of the 5th and 95th percentiles show the extremes for the data set and may be considered outliers.

Measured median SC levels and overall SC variability in the Teton River increased from the upper to lower reaches of the river during 1998 to 2001 (Figure 3-2). Between the “South Fork” and “Dutton” stations, median SC values increased by 276% and the minimum and maximum recorded values increased by 198% and 336%, respectively. Between the “South Fork” and “Loma” stations median and maximum values increased 307% and 383%, respectively while the minimum recorded SC value decreased by 58%. The reason for the decrease in this minimal value is unclear. However, the majority of the SC samples, or those defined as between the 5th and 95th percentiles, are greater than the equivalent percentile values at the Dutton station.

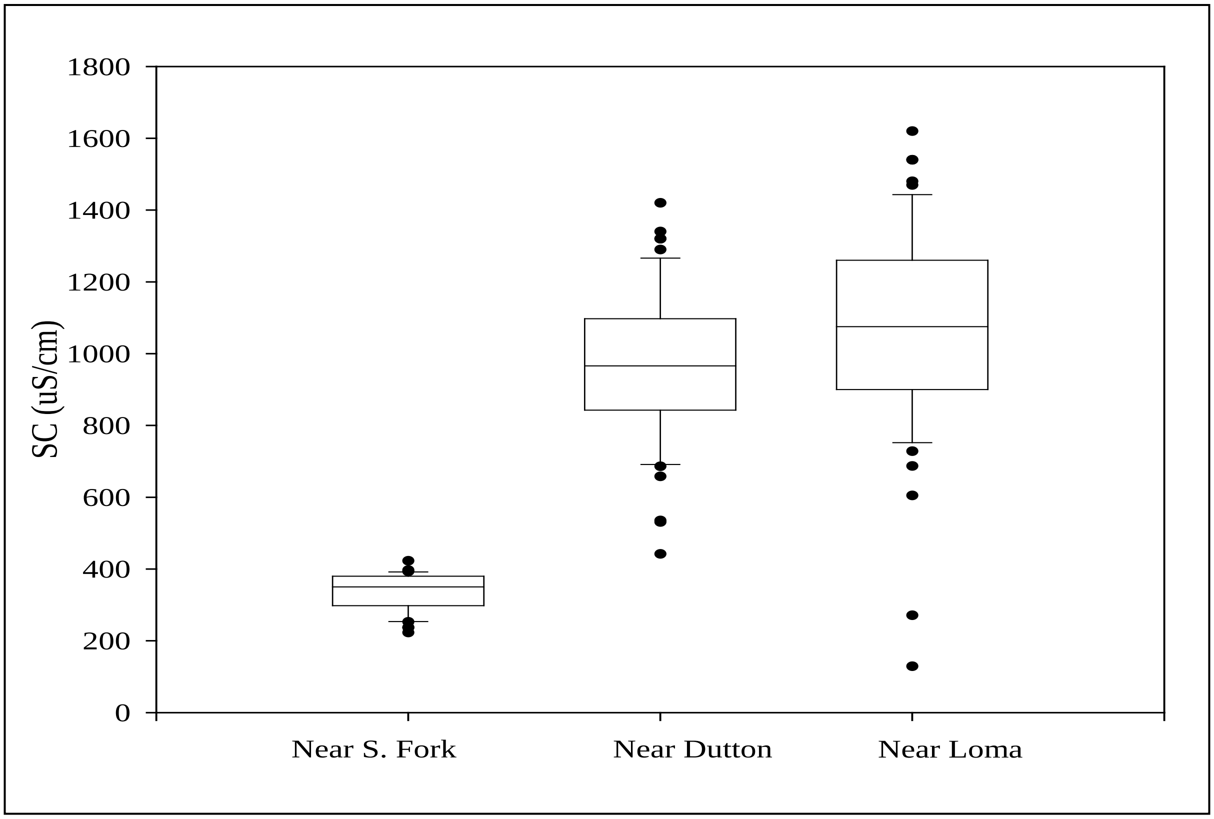


Figure 3-2. Specific conductance data collected at USGS gaging stations along the Teton River. The South Fork station is the most upstream station and Loma is the most downstream. Data presented are from 1998 to 2001 (Table 3-4).

Table 3-4. Summary of SC values from USGS gaging sites along the Teton River.

	Near S. Fork (06102500)	**Near Dutton (06108000)**	**Near Loma (06108800)**
Dates reported	**May ’98 – Sept ‘01**	**May ’98 – Aug ‘01**	**May ’98 – Jun ‘01**
# Data points reported	47	52	52
Median SC (µS/cm)	350	966	1,075
Maximum SC (µS/cm)	423	1,420	1,620
Minimum SC (µS/cm)	223	442	129

Geology and local soils control SC values for surface water through groundwater contributions. Near the South Fork gaging station on the upper Teton River, Cretaceous-age limestone and dolomite are common rock types found in the folds and alluvium of the Rocky Mountain Front. Limestone and dolomite are calcium- to calcium-magnesium carbonates that are fairly soluble when in contact with groundwater relative to igneous or metamorphic rock solubility. Therefore, the Teton River and tributaries that have their headwaters in the Rocky Mountain Front all begin with elevated SC/TDS values.

MDEQ collected SC and TDS values for tributary streams near the Rocky Mountain Front (Figure B-1a) and found SC values comparable to the upper Teton River gaging site (Table 3-5). Blackleaf Creek had the lowest headwater SC (312 μS/cm) and TDS (167 mg/L), while the other streams range 486 to 769 μS/cm for SC and 292-446 mg/L for TDS. All tributary sites, and the USGS site near the South Fork confluence, are within 20 miles of the Rocky Mountain front.

A spring flowing into Blackleaf Creek near its mouth was sampled by MDEQ in July 2002 (Figure B-1a). Data collected at the spring shows local groundwater SC and TDS values of 634 μS/cm and 358 mg/L, respectively (Table 3-5). This site is in a transitional area of the watershed where the landscape is more prairie-like and several irrigation projects are located nearby (Figure A-9b). Shallow groundwater levels can be artificially elevated by irrigation, irrigation supply ditches, or dry land farming practices and provides a mechanism for dissolving and transporting salts to surface water. These land uses practices contribute to the higher SC/TDS in the surface waters and occur around the Teton River main stem and tributary streams of the upper watershed. Although these practices are not limited to the upper watershed, irrigated agriculture is more concentrated in that area of the basin (Figure A-9a).

Table 3-5. Teton River Tributary SC values collected near the headwaters along the Rocky Mountain Front.

Tributary	Field SC (μS/cm)	TDS (mg/L)	Date sampled
Willow Creek, near headwaters	769	446	May, 2001
Blackleaf Creek, near headwaters	312	167	May, 2001
Blackleaf Creek, near county road crossing	486	292	July, 2002
Spring flowing into Blackleaf, near mouth	634	358	July, 2002
Clark Fork Muddy Creek, near headwaters	630	371	July, 2002
“Unnamed” Tributary to Muddy Creek, near headwaters	556	NA	July, 2002
Muddy Creek, downstream of Clark Fork Muddy Creek confluence	620	NA	July, 2002

Several likely contributors to increased SC/TDS and their relative contributions need to be explored in more detail using an adaptive management approach is outlined in Section 6. Many of these inputs and changes in the geology and soils occur upstream of Dutton. Geological and soil changes occur between the mountain front and the town of Choteau, which create one mechanism for increased dissolved solids. Downstream of Choteau, a canal connects Priest Butte Lakes to the Teton River main stem and discharges water with higher SC/TDS than the ambient Teton River water. Tributary streams and coulees are another source of SC/TDS to the Teton River main stem. Most perennial tributaries in the watershed are upstream of the Dutton gage site while downstream of Dutton the tributaries are primarily intermittent coulees and washes.

Specific conductance data was collected by the USGS at the Dutton gaging site from June 1982 through August 2001. When the SC data are plotted versus flow, a weak correlation of decreasing SC with increasing flow is observed (Figure 3.3). When flows are low, dissolved solids concentrate and are reflected with higher SC values. Likewise, as flows increase, a dilution effect is seen with lower SC values. Therefore an assumption is made that this trend in the SC-flow relationship would continue, and strengthen, if there were a greater number of samples collected at flows of 300 cfs or greater.

Flow-dependence is evident in the SC data; therefore, the data had to be *flow adjusted* before completing a statistical trend analysis. Properly performed flow adjustment eliminates or minimizes the effects of flow. Flow adjusting can be applied to data that show a correlation of one variable to stream flow and where the probability distribution of stream flow has not changed during the analysis period (Hirsch et. al., 1991). SYSTAT was used to flow adjust the SC data using a smoothing methods called *loess* (Wilkinson, 1996).

A Mann Kendall trend test indicates that SC in the Teton River at Dutton decreased between 1982 and 2001 with a 95% confidence level (Figure 3.4). The Mann Kendall trend test assumes the lack of serial correlation and a constant data spread or distribution within the data set. Rank Von Neumann test results indicate some serial correlation within the data set. Although a Seasonal Kendall trend test could be applied if seasonality were the cause of the correlation, seasonality test results indicate some other cause. Since visual inspection of the time series graph suggests that the level of serial correlation is moderate, the significance level of the trend test is relatively high, the number of data points used is relatively large, and the period of record is reasonably long, it is probable that a decreasing SC trend is present. Data sets from the gage near the South Fork (e.g., upper watershed) and gage near Loma lacked sufficient periods to record to support meaningful statistical analyses.

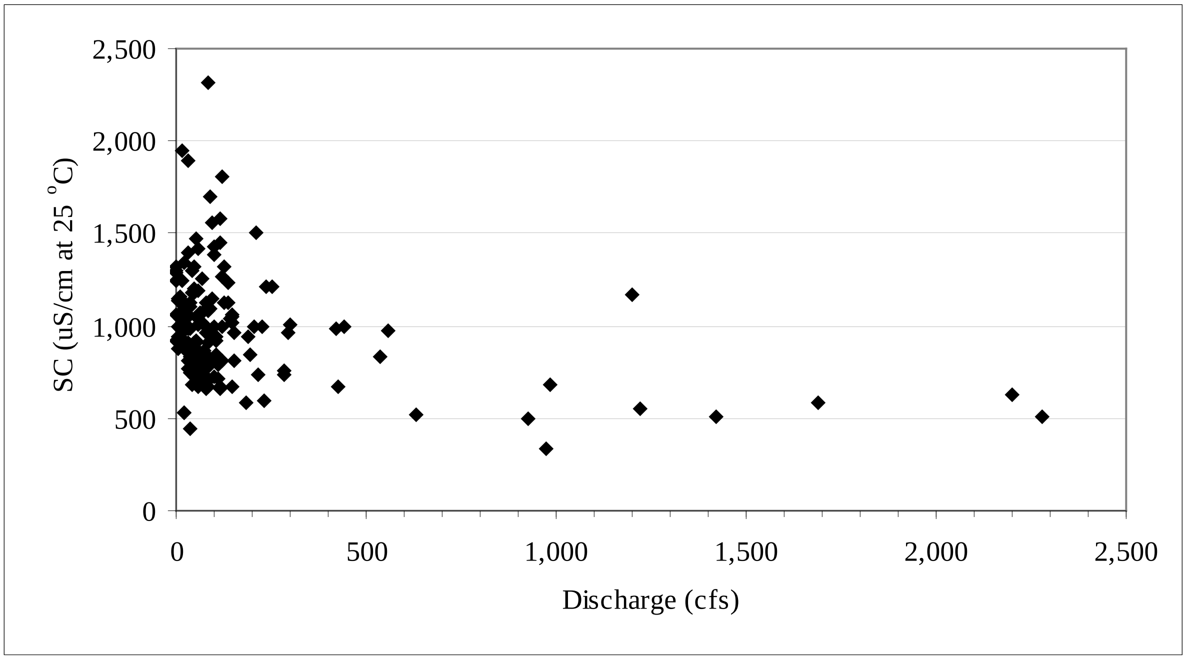
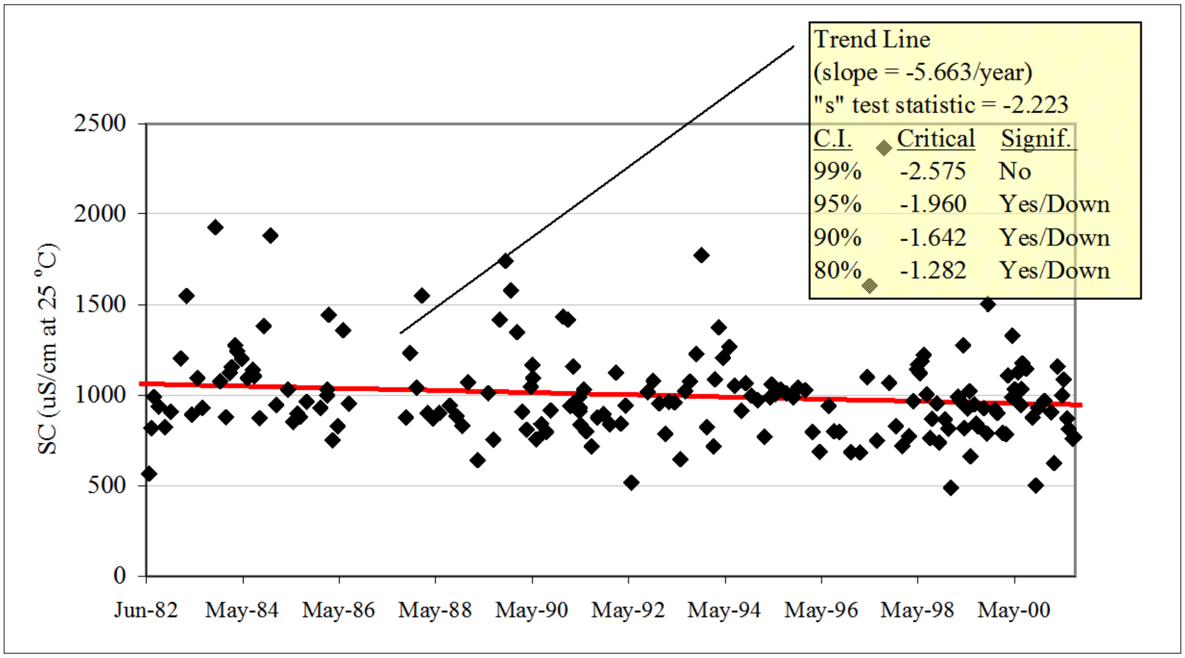


Figure 3-3. USGS Dutton gage data from June 1982 through August 2001.



Trend Line
(slope = -5.663/year)
"s" test statistic = -2.223

C.I.	Critical	Signif.
99%	-2.575	No
95%	-1.960	Yes/Down
90%	-1.642	Yes/Down
80%	-1.282	Yes/Down

Figure 3-4. Time series of flow-adjusted SC data at the Dutton gage and associated Mann Kendall trend test results.

The Priest Butte Lakes outlet structure was built in 1954 to drain water from the naturally closed Freezeout Lake basin. The drain, located downstream of Choteau, connected the lake system to the Teton River and is allowed to discharge when flows in the river are greater than 20 cfs. An investigation conducted by the USGS from August 1954 to September 1957 studied the initial impacts of the Priest Butte Lakes discharge on the Teton River's water quality. Provided in a report to the State Engineer's office, the USGS (1958) states, "*large erratic increases in the mineralization of the water occurred although the rate of flow remained constant*." Data provided showed an example of a nearly 10-fold increase in SC over a two-day time span from 650 to 6,000 µS/cm with a relatively constant mean daily discharge of 110 cfs.

Water quality samples collected from 1954 through 1957 showed two, distinctly different chemical compositions of the main stem water. During times when Priest Butte Lakes was not discharging, the water downstream was calcium bicarbonate dominated. However, when discharge occurred in the spring and fall, the chemical composition changed to sodium-magnesium sulfate dominated (USGS, 1958). Conclusions based on data collected in winter months, when Priest Butte Lakes was not discharging, showed tributary inputs between Choteau and Dutton increased dissolved salts and SC by two times.

Montana Department of Fish, Wildlife, and Parks (MFWP) has collected SC data from 1997 through 2000 in the Priest Butte Lakes discharge and in the Teton River both upstream and downstream of the outlet (Figures A-4 and Table 3-6). Values upstream of the outlet range from 345-788 µS/cm, while downstream of the lakes' outfall, at the Highway 221 Bridge crossing, SC ranged from 412-1,820 µS/cm. By comparison, SC at the USGS Dutton gage range from 442-1,420 µS/cm (Figure 3-5).

Statistical analysis of mean SC values at MFWP sites above and below the Priest Butte Lakes discharge and the USGS Dutton gage indicated that the SC samples are from different populations. Mann-Whiney analysis of means was used and showed that each data set is independent of the other and none of the data sets are "subsets" of the other(s). Priest Butte Lakes discharge increases the SC and TDS of the Teton River; and river water at the Dutton site differs yet from the two upstream sites. However, other sources of TDS loading to the Teton River between the Priest Butte Lakes discharge and the Dutton gaging station have yet to be quantified.

A broader spatial SC coverage has been gained through MDEQ and volunteer monitoring efforts. However, most data (Figures B-1a through B-1c) are limited either by single sample points (MDEQ) or short time intervals (volunteer data sporadically collected between 1998 and 2001). MDEQ data collected around Priest Butte Lakes outlet in July/August of 1998 show the only values greater than 1,000 µS/cm collected during that period or any other sampling attempt. Volunteer data were collected more frequently than the single events by the MDEQ and provided more detail for SC ranges. Several locations from Choteau to the mouth of the Teton River have median values greater than 1,000 µS/cm although only one site in this section had more than three samples in the dataset. Of those sites downstream of Choteau, maximum reported values exceeded 1,000 µS/cm (ranging from 1,000-1,660 µS/cm).

Table 3-6. Summary of SC values collected by MFWP near Priest Butte Lakes discharge along the Teton River. Dates for data collection are from March 1997 through July 2000.

Station	**# of samples**	**Min. (μS/cm)**	**Max. (μS/cm)**	**Median (μS/cm)**	**Mode (μS/cm)**	**Ave. (μS/cm)**	**Std D. (μS/cm)**
Teton R. upstream	249	345	788	523	580	520	59.5
Lake Discharge	250	5,050	14,890	8,970	8,600	9,127	1,130
Teton R. at Hwy 221 [1]	250	412	1,820	988	869	983	193.6

[1] Teton River Salinity TMDL compliance point (MDEQ, 1999)

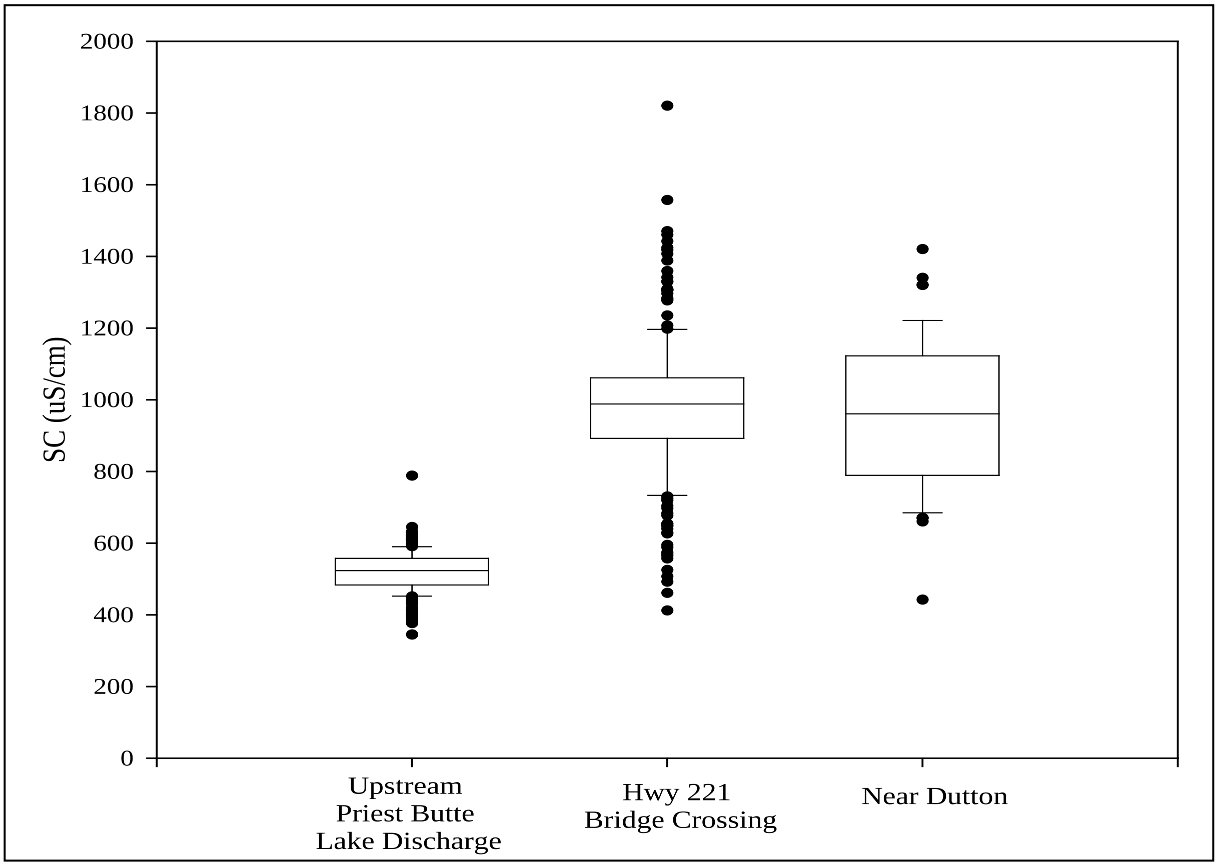


Figure 3-5. SC data near the Priest Butte Lakes discharge. Hwy 221 Bridge crossing is below the mixing zone of Priest Butte Lakes' outfall in the Teton River.

Changes from the 1996 to 2002 list, concerning SC impairments, include the change of chloride and other inorganics (1996) to sulfates for the lower Teton River. For the 2002 list, sulfate replaced chloride. The impairment listing of "other inorganics" in 1996 most likely referred to the elevated sulfate values in the river. Teton River chloride values are less than 80 mg/L (1974 through 1998). Sulfate values, on the other hand, range from 9 to 1,810 mg/L with a median of 170 mg/L (n=115, collected between September 1973 and July 1998). Comparison of anions for the lower reach of the Teton River show that of the two, sulfate to chloride, sulfate is the dominate anion (SO_4:Cl = 17:1).

On the 1996 303(d) List, the lower 15-miles of Blackleaf Creek (called North Fork Muddy) was listed as partially supporting cold-water fishery, associated aquatic life, and drinking water caused by increased SC/TDS/Chlorides impairments. In looking at the SC data found in both Blackleaf Creek and streams in the surrounding area, SC values were considered normal (Table 3-5). Near the headwaters, Blackleaf Creek begins high in TDS, as a result of flowing through carbonaceous rocks (312 μS/cm). Down in the foothills of the Rocky Mountain Front, values increase slightly in Blackleaf, Clark Fork of Muddy, Muddy, and Willow Creeks (486-769 μS/cm). Water quality sample results from Blackleaf Creek show calcium bicarbonate water, with low sodium, chloride, and sulfate values (Table 3-7).

Table 3-7. Blackleaf Creek water quality sample results for selected major ions (as collected by MDEQ, July 2000 and July 2002).

	Calcium (mg/L)	Bicarbonate (mg/L)	Sodium (mg/L)	Sulfate (mg/L)	Chloride (mg/L)
Upstream of FS boundary	48	149	4	7	<1
Downstream of Blackleaf Wildlife Management Area	79.2	272	9.2	11.5	1.37
Near Mouth	62.3	290	27.4	34.2	3.17

3.3.2 Selenium

Based on the EPA-approved MDEQ sufficient and credible data review, it was concluded during the 2002 303(d) list development that Priest Butte Lakes was not supportive of its aquatic life and fisheries beneficial uses (MDEQ, 2002a). Priest Butte Lakes was the only water body in the Teton River watershed with an impairment listing as a result of exceeding Montana’s numerical water quality criteria for selenium (Se). The state has two numeric criteria values for aquatic life, acute and chronic. The acute aquatic life criterion is 20 μg/L and is not to be exceeded in any sample collected from surface water. The chronic aquatic life criterion is 5 μg/L based on a four-day (96-hour) averaging period (MDEQ, 2002b). However, where only one credible data point exists in any 96-hour period, this data point may be assumed to be representative and used to evaluate a chronic criteria (MDEQ, 2002a, Appendix A, Table 9).

Water quality data has been collected in Priest Butte Lakes by both MDEQ and USGS from 1986 through 1992 (Figure A-4 shows sample locations). Between 1990 and 1992 four samples were taken from the south end of Priest Butte Lake with total recoverable Se values ranging from 8 to 15 μg/L (average of 11 μg/L). The reported value of 15 μg/L is 300% of the chronic criterion, which is considered “overwhelming evidence” of a non-support beneficial use listing decision for aquatic life (MDEQ, 2002a, Appendix A). Additionally, subsequent biological samples taken during the mid-1990s have shown bioaccumulation of Se with concentrations of up to 48 μg/g dry weight in yellow perch tissue. Increased Se concentrations in fish, amphibians, and/or waterfowl have also shown increased rates of reproductive failure and/or teratogenesis (deformities and abnormalities) of developing embryos (Lemley, 1999). Although Se was specified as being the limiting element, the total dissolved solids of the lake may also be hindering its beneficial uses.

Since the most recent water quality data has been collected (1990-1992) some changes have occurred in the immediate watershed that could influence selenium loading to Priest Butte Lakes. According to the Freezout Lake WMA manager, the farming operation in the Yeager seep drainage has changed from summer fallow to chemical fallow. This practice is believed to have a reducing impact on storm runoff and flow from the seep thus potentially reducing the volume of water discharging from the seep. However, range land/pastures on the west side of the lake that had been in enrolled in the Conservation Reserve Program (CRP) has since been withdrawn and is currently being grazed. Water for stock is spilled from the Cascade Canal and runs down the three draws near the Priest Butte. The increased flow to the lake, via these draws, would likely result in an increased loading from this area that was not present, or active, during the early 1990s sampling period. Despite these changes in land use practices, it is the determination of the MDEQ that Priest Butte Lakes’ use support of aquatic life and fisheries is still impaired. This conclusion is also supported with biological data from the mid-1990s that indicated bioaccumulation of Se is occurring in macroinvertebrates, fish, and waterfowl.

However, even with the mid-1990’s data substantiating an impairment listing, a newly revised monitoring plan is called for in Section 6.2.2 and Table 6-1 that is aimed at collecting new and additional data to better understand Se loading to the lake and its water column concentration in several key locations. Even though Se levels in Priest Butte Lakes have been recorded at high levels, water quality samples taken from the Teton River and its tributaries are not elevated and have not exceeded the state’s Se chronic or acute criteria (Figure B-2).

Rainbow trout were stocked in Priest Butte Lakes in the late 60’s to early 70’s, in hopes of starting a “new” sportsman’s fishery. Although some large rainbows were caught, reports of poor tasting flesh was the cause for decreased interest in maintaining a trout fishery in the lake. In the early 1980’s, MFWP attempted to stock Priest Butte Lakes with several warm-water species, including walleye, crappy, yellow perch, and small mouth bass (Knapton et al., 1988). Fish populations dwindled, partially due to the lack of reproduction of the fish. Presently, a few tolerant non-game species (including whitefish, carp, and minnows) sustain populations.

In the late 1980’s, the USGS collected biological samples to be analyzed for bioaccumulation of Se. Fish, macroinvertebrate, and aquatic plants were collected and analyzed for several sites in the Freezout Lake WMA. White suckers and yellow perch captured from Priest Butte Lakes had Se values of 10 μg/g wet (35 μg/g dry) and 13 μg/g wet weight (48 μg/g dry weight), respectively. Macroinvertebrates were collected and included orders of odonata (dragon and/or damsel flies) and hemiptera (water bugs). Selenium values found in odonata were 0.51 μg/g wet (32 μg/g dry), while values found in hemiptera were 1.3 μg/g wet (15 μg/g dry). Aquatic plants were collected and analyzed, and although Se was detected (0.31 μg/L wet weight in sago pondweed), concentrations were considered low for plants (Knapton et al., 1988).

Another USGS sampling in 1991 yielded similar Se results for several species of fish and amphibians (black crappie, brassy minnow, brook stickleback, carp, fathead minnow, tiger salamander, which sucker, and yellow perch), macroinvertebrates, aquatic plants, and bird eggs. Average Se-concentrations for fish and amphibians, based on species, ranged from 25-67 μg/g dry weight. Six macroinvertebrate species were represented in a sample, with a Se-concentration range of 13-36 μg/g dry weight (median = 15 ug/g dry weight). Sago pondweed was collected both in the lake and in the seep near the southeastern end of the lake. The Se concentration in the lake plants was 5.5 μg/g, while the plants from the seep were 10 μg/g. Se concentrations in bird eggs ranged from 4.0-7.3 μg/g dry weight in duck eggs to 16-39 μg/g dry weight in American avocet eggs. To consider Se concentrations in adult birds, livers were taken from a Canadian goose and an American avocet. Se-concentrations in the goose liver were14 μg/g dry weight and the avocet was 43 μg/g dry weight (Lambing et al., 1994).

Selenium concentrations found in fish are considered to have toxic effects at 2 μg/g wet weight (Knapton et al., 1988). Toxic concentrations, believed responsible for decrease in blue gill populations in a lake in southwestern US, have been reported to be between 6.7 μg/g and 9.7 μg/g wet weight. Selenium effects on macroinvertebrates are unclear; however, bioaccumulation in both aquatic life and waterfowl that rely on macroinvertebrates in their diets is evident. Bioaccumulation of Se up the food chain has been shown to decrease duckling survival and to have teratogenic effects in mallards (Knapton et al., 1988). Bird eggs from a non-selenium enriched area usually have selenium concentrations less than 3-4 μg/g, and livers from adult birds are less than 12-16 μg/g dry weight (Knapton et al., 1988).

The USGS has completed several studies for the Freezout Lake WMA and attempted to correlate the surface water quality to the groundwater quality and current land management practices. Sources of Se are most likely associated with the underlying geology of the Freezout Lake WMA. To the east, Quaternary glacial lake deposits can be found, while older Cretaceous rocks underlie the area to the west-south west. Several intensive USGS studies have shown the Quaternary glacial lake sediments to have higher concentrations of Se associated with them (Kendy et al., 1999; Nimick ed al., 1996, Lambing et al., 1994). Evaporate minerals, especially magnesium (Mg), sodium (Na), and sulfate (SO_4) rich salts, can also be associated with elevated Se levels. Shallow groundwater (irrigation controlled) can readily dissolve evaporate minerals and increase dissolved solids concentrations (including Se) in groundwater that directly flows into the Freezeout-Priest Butte Lakes system. A seep draining near the southeastern edge of Priest Butte Lakes has extraordinary values reported for Se, as well as Mg, Na, and SO_4. Data ranges reported by the USGS, collected in 1991, for Se are 720-1,000 μg/L, Mg are 7,700-8,400 mg/L, Na are 2,300 to 2,700 mg/L, and SO_4 are 38,000 to 43,000 mg/L (Lambing et al., 1994). While Mg and Na do not have standards, the USEPA recommends SO_4 values remain below 250 mg/L.

On the 1996 303(d) list, Priest Butte Lakes was listed as not supporting aquatic life caused by increased metals, salinity/TDS/chlorides, and organic enrichment or DO depletion. Metals, specifically Se for the 2002 list, are still considered as impairing aquatic life, as is the salinity/TDS impairment. However, SO_4, rather than chloride (Cl), is the anion of concern. No value known to MDEQ exceeds the USEPA suggested secondary Cl standard of 250 mg/L. Also, when considering a SO_4:Cl ratio, approximately 18:1, one can see SO_4 is the dominant anion.

3.3.3 Organic Enrichment/Dissolved Oxygen (DO)

Priest Butte Lakes was listed on the 1996 303(d) list for having organic enrichment and/or low dissolved oxygen (DO). On the 2002 303(d) list, the lake was not listed for organic enrichment/dissolved oxygen due to of the lack of recently collected, credible, and relevant data. The proposed effectiveness-monitoring plan in Section 6 includes the collection of dissolved oxygen data with sufficient QA/QC for Priest Butte Lakes. This data will provide a better understanding of the lakes’ condition and allow the determination of whether water quality standard exceedences, or beneficial use impairments, exist.

Data collection should include both diurnal DO data and a comprehensive study of the lakes’ aquatic plant life. Diurnal implies continuous 24-hour data collection and should be collected on a seasonal basis. Seasonality will affect dissolved oxygen levels, specifically during the summer when plant life and photosynthesis effect oxygen levels, or in the winter when ice-over effects are suspected. For completeness, spring and fall seasons should be included. A "comprehensive" aquatic plant life survey is essential in determining sources of impairment and aims to qualify and quantify plant species present in the lake.

Priest Butte Lakes is a shallow lake open to prevailing winds. Its maximum depth is about nine feet, and while stratification may occur in shallow lakes, a constant wind can keep it well mixed, as well as maintaining a nearly continual aeration component. The most likely time for DO depletion in lakes is during the summer and/or winter. During the summer, aquatic vegetation will affect oxygen levels both on a daily cycle due to plant respiration or through microbial activity on dead and decaying plant material. Winter ice-over conditions reduce oxygen inputs and thus DO levels slowly decrease through fish respiration.

Increased nutrients to a water body can lead to excessive plant life that can adversely affect dissolved oxygen levels. USGS studies of the Freezeout-Priest Butte Lakes system, geology, and groundwater have shown that human activities related to irrigation and fertilizer application are contributing nutrient components to the lakes. However, local MFWP biologists that manage the Freezout Lake WMA do not believe that the lake has an excessive plant community. Sago pondweed (*Potamogeton pectinatus*) has been observed and collected in the lake. This filamentous macrophyte is common around the edges and decreases towards the center.

Dissolved oxygen standards set for the State of Montana are based on flowing conditions. To date, standards specific to lakes have not been set in Montana. For B-1 water bodies, the Montana WQB7 standard for DO is listed as 8.0 mg/L for the 1-day minimum for early life stages; for “other life stages,” the one-day minimum is 4.0 mg/L. Because reproduction is limited, somewhat to entirely by TDS and/or Se concentrations, the 1-day minimum for early life stages may not be a suitable minimum DO. Also, although Priest Butte Lakes is classified as being supportive of a cold water fishery (B-1 classification, ARM 17.30.610), the populations of fish are principally warm-water species. Warm-water fish are tolerant of lower DO levels, and standards given in the WQB-7 for B-3 waters reflect that with 5 mg/L and 3 mg/L for early-life stages and other life stages, respectively.

Dissolved oxygen data has been historically collected in Priest Butte Lakes during both the summer and winter. Dissolved oxygen levels less than 4.0 mg/L have been reported, but these values were nearly limited to ice-over conditions of the lake. MFWP collected 51 DO samples between 1969 and 1971 with the lowest reported value at 7.5 mg/L. Samples collected between 1971 and 1973 recorded lower DO levels, ranging from 2.4 to 8.0 mg/L. The lowest DO values (2.0-3.4 mg/L) were recorded during the winter when 20-inches of ice was reported to be covering the lake. Only one sample between 1971-1973 was collected during a summer month (June), and that value was 6.2 mg/L. In 1982, two samples were collected below 18 inches of ice with the DO level at 2.5 and 3.5 mg/L.

3.3.4 Sediment

Reaches in the Teton River watershed that have sediment-related impairments include:

- Teton River (middle and lower reaches),
- Deep Creek,
- Willow Creek,
- Spring Creek (both reaches),
- Blackleaf Creek,
- Clark Fork of Muddy (threatened),
- Bynum Reservoir, and
- Eureka Reservoir

In 2002, a change in the cause of impairment occurred for the middle reach of the Teton River (from Deep to Muddy Creek) with suspended solids replacing siltation. No change in the sediment-related impairment was made for the lower Teton (Muddy Creek to mouth). Spring Creek, not listed in 1996 for having a sedimentation-related impairment, was listed in 2002 for siltation. Blackleaf Creek (called North Fork Muddy Creek on 1996 303(d) List) and Bynum and Eureka Reservoirs had impairment changes from the 1996 to 2002 303(d). All three were listed as partially supporting cold-water fisheries and associated aquatic life due to sediment impairments. However, consideration of new data suggests sediment is not impairing beneficial uses. More detail will be provided later in this section.

Data used to support siltation impairments include notes and photos from fieldwork, an aerial flight, suspended sediment concentrations, fishery studies, and biological assemblages. Fieldwork has been completed by agencies such as MDEQ, NRCS, USGS, MFWP, and a fluvial geomorphic survey of the upper Teton River (upstream of Choteau) by Dave Rosgen (1992). Information from the collective agencies and professionals shows that the Teton River and some of its tributary streams are “out of balance,” meaning that the streams have lost their ability to transport sediment and/or maintain channel dimension, pattern, and profile. As flows are decreased (i.e. through dewatering), sediment transport efficiency decreases and fine sediment deposition increases.

Based on MDEQ field investigations, the Teton River main stem shows vertical banks and downcutting (i.e. lowering of the streambed elevation), and is affected by increased sediment from eroding stream banks, loss of stream energy from dewatering, and riparian degradation. Data shows areas that are actively adding sediment to the streams through erosion intensified by removal of riparian vegetation and/or occupation of the active floodplain by farmland (Deep Creek, Figure 3-6). Field notes and photos show a channel that is downcut and incised (unable to access the flood prone area) along most of the Teton River, and in Deep and Willow Creeks (Figures 3-6 through 3-9). The upper portion of the Teton River has evidence of aggradation, or the deposition of larger particles from past floods and from a reduction in stream energy. In the middle and lower reaches, the dominant channel type was characterized "F" (Rosgen classification, explained in Section 3.3.4.1), with localized "C" channels. In several locations, stream access to the floodplain is very limited to non-existent (Figure 3-7, left bank). Bank erosion was common at all sites visited with substrate sedimentation limiting fish and other aquatic habitats. Regionally, local areas did have positive indicators for fish habitat, including deep pools and good regeneration of woody riparian species.

The NRCS completed an aerial assessment of portions of the Teton River watershed (Hawn et al. 1998) but incorporated very limited follow-up ground truthing. Many of the same observations were made as those from MDEQ in 1998: the upper Teton River has a short channelized reach with poor riparian conditions and aggradation and braiding are common in the area above the Bynum irrigation diversion; the middle to lower Teton River is characterized as having an entrenched channel with vertical, actively eroding banks on almost all meander bends. Low flow is attributed to the weak transport mechanism of the supplied sediment load. Riparian conditions were reported to be unhealthy on much of the ranchland and pasture areas. In some areas, cropland now extends up to the stream bank (Figures 3-6, 3-8, and 3-9). The close proximity of agricultural fields to the stream channel with out a riparian vegetative buffer zone may have resulted from either channel movement during the 1964 flood or due to land management decisions.

Figure 3-6. Riparian zone devoid of stabilizing or shading vegetation on Deep Creek (outside bank).

Figure 3-7. High banks along the Teton River are indicative of downcutting and restricted access to the flood plain (far bank in photo).

Figure 3-8. Farmland and vegetation removal along the Teton River has restricted flood plain and riparian function.

Figure 3-9. Riparian removal and apparent downcutting on Willow Creek.

A reconnaissance level stream morphology survey was conducted in the reach of the Teton upstream of Choteau (Rosgen, 1992). The purpose behind the study was to “seek alternative solutions” to the river’s imbalance. Rosgen identified “stable” areas of the stream, but also identified sections that have lost the natural ability to transport sediment effectively. The Bynum Reservoir diversion was a specific area identified as contributing to the instability of the stream by trapping of bedload behind the structure (Rosgen, 1992).

Qualitative data from fieldwork and the aerial assessment also described the current conditions of the tributary streams. Data includes field observations, photo documentation, and percentages of eroding banks determined during an aerial flight. Pebble counts and/or percent fine estimations are typical data collected for stream substrate characterization. Comments regarding increased fine deposition in gravels were made in field notes and forms. However, pebble count data were not collected for the streams listed as impaired by sediment.

Photos from Deep Creek show a channel that has potentially downcut and has minimal to no riparian vegetation (Figure 3-6). Willow Creek shows similar characteristics, along with vertical, actively eroding banks (Figure 3-9). MDEQ notes from 2002 field visits on Teton Spring Creek state that some reaches of the stream are over-widened and lack proper riparian communities (i.e. a suite of plants with good root binding characteristics that can slow high stream flows and trap sediment), while other reaches show evidence of channelization. As a result, many locations were noted to have “excessive sediment deposition” or high embeddedness of gravels. Channelization of Spring Creek and the conversion of woody riparian species to turf grasses (Figure 3-10) are common through the town of Choteau (Decker-Hess, 1986). A site located downstream of Choteau was found to have sufficient riparian species and no active widening or downcutting was noted (Figure 3-11).

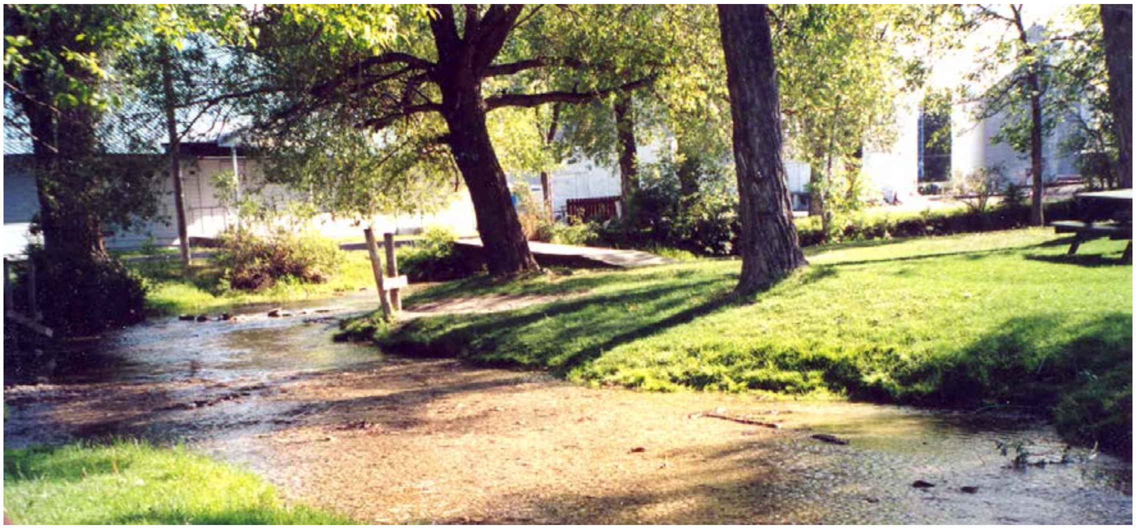


Figure 3-10. Teton Spring Creek shows a tendency to be over-widened through Choteau.

Figure 3-11. Teton Spring Creek downstream of Choteau; channel has narrowed.

Suspended sediment data has been collected, nearly on a monthly basis, by the USGS at the three active stations on the Teton River from 1998 to the present. Measured values range from one to 32 mg/L at the upper station near the South Fork, 20 to 578 mg/L near Dutton, and 12 to 2,540 mg/L near Loma. Although stream flows were collected concurrently with suspended sediment, data across the complete range of flow conditions is lacking, thus making valid flow-TSS trends or load calculation unrealistic. Additionally, landforms and sediment sources change from the headwaters to the mouth, making comparisons of upper to lower stations unworkable as well. Regardless, suspended sediment data from the USGS station does provide information as to when increased sediment transport occurs and with a reasonable indication of the amount.

MDEQ collected water quality samples that included total suspended sediment (TSS) during sampling events in 1998, 2000, and 2001 (Figure B-3). TSS data on the Teton River during July 1998 showed an increase of TSS concentrations in the downstream direction. The highest TSS concentration of 628 mg/L was recorded near Loma. Associated comments in field notes state the water is brown and opaque, however, again no turbidity values were collected in association with the TSS measurements.

Newcombe et al (1996) published data calculated from models that related suspended sediment to effects on fish (both salmonid and nonsalmonids). The model used for both salmonid and nonsalmonid larvae showed "*reduced growth rate, delayed hatching, and reduced density*" when suspended sediment concentrations were 148 mg/L for a one-day period. For adult nonsalmonids, suspended sediment concentrations were shown to produce reduced growth rates after two days at a concentration of 403 mg/L; after two weeks at 403 mg/L, mortality (estimated up to 20%), increased predation, and/or habitat degradation could affect fish. Models for salmonids indicated that they were slightly more tolerant to increased suspended sediment. Juvenile salmonids could tolerate suspended sediment values near 403 mg/L for six days before experienced reduced growth rate and reduced fish density and could last two weeks at 148 mg/L. Adults might be able to tolerate values around 403 mg/L for up to seven weeks. Warm water or nonsalmonids are believed to be more sensitive partially due to their higher metabolisms and subsequent faster oxygen intake.

3.3.4.1 Channel Morphological Indicators

MDEQ measured channel geometries to determined Rosgen stream channel classifications at nearly all of the sampling locations visited from 1998 through 2002. Channel types at each sample site were assigned based measurements that included bankfull width and depth, sinuosity (meandering of stream), and gradient of both stream and valley (Tables 3-8, 3-9, and Figure A-12). “Stable” channel types are those that transport sediment and water through the basin such that the stream can maintain its dimension, pattern, and profile (including slope). Channel types “B”, “C”, and “E” are considered stable channels, whereas “D”, “F”, and “G” denote unstable to transitioning stream channels.

Table 3-8. Teton River main stem Rosgen classifications, as determined by MDEQ (Also see Figure A-12).

Teton River		
	Station	**Rosgen channel type**
↓ **Downstream to Upstream** ↓	Near South Fork Gage	D-3 w/ C-3
	Upstream of Choteau	D-3
	General u/s of Choteau	D-3 w/ localized, short C-3
	Near Hwy 89 x-ing	C-4
	d/s of Priest Butte Lakes	C-4
	At Hwy 221 bridge	F-4
	d/s of I-15 bridge	F-4
	At Kerr Bridge	F-4
	At Dent Bridge	F-4
	Near mouth at Loma	Mix of F-4 & C-4

Table 3-9. Tributary Rosgen classifications, as determined by MDEQ.

Tributaries		
Stream	**Site**	**Rosgen channel type**
NF Teton	Overall stream reach	C-3 to D-3
McDonald Creek	Near headwaters	E-5
	Near mouth	D
Teton Spring Creek	Below Choteau	E
Deep Creek	Near Hwy 287 bridge	C-3 locally, going to a B-4
	Below Willow Confluence	F-3
Willow Creek	Headwaters	F-4
	Near mouth	F-3
Clark Fork of Muddy	Upstream of dam	E-5
	Near mouth	E-5
Blackleaf	USFS land (upper reach)	B-3
	Upper site (lower reach)	C-3
	County road crossing	C-3 w/ localized E-3
	Ranch house, near ford	Area of braiding u/s of ford: D-4; otherwise F moving to C-4
	Near mouth	C-4

3.3.4.2 Biological Indicators

Biological assemblages (fish, macroinvertebrates, and/or algae) can be used to evaluate the biological response to excessive sedimentation. MFWP conducts fish studies, counts and estimates, and plantings (MFWP, 2002). According the MFWP, the Teton River watershed supports a wide variety of fish species, including many sport fish (Table 2-4). For the mainstem of the Teton alone, MFWP reports 31 different fish species, including three “species of special concern” (blue sucker, sauger, and sturgeon chub). Species of special concern are fish native to Montana that have been identified as having limited habitats and/or numbers in Montana (American Fisheries Society, 2002). In 1997, shovelnose sturgeon larvae were found in the Teton River, which was the first documented record of sturgeon spawning in the Teton (Gardner, 1998a).

Increased sediment, silt, and suspended solids can be detrimental to all aquatic life, and are specifically harmful to fish as habitat is degraded or removed by sediment filling in spawning gravels or pools. For example, the blue sucker feeds on insects found amongst cobbles in the substrate (Gardner, 1998b). Rainbow, brook, and brown trout are examples of fish that need gravels free of fine sediments for spawning. During the summer as temperatures increase, many fish depend on deep pools as refugia from warmer water temperatures; fine sediment deposition will fill in such pools reducing available habitat or refugia. Increased suspended sediment can also abrade gills or hinder the line of sight of a fish. Warm water species appear to be more sensitive to gill abrasion, due to faster metabolism and respiration (Newcombe et al., 1996).

Macroinvertebrate assemblages were collected in 1998 along the Teton River, and in 2000 and 2001 along tributary streams. Data summary from the biologist (Tables C-1, C-2, C-3a, C-3b Appendix C) are organized based on a "multimetric index" for Montana (Bolman, 2001). Biological metrics are designed to test for macroinvertebrate population sensitivity or response to varying degrees of human-induced impacts. A numeric score is assigned to each metric per site and a total score allows comparison between sample sites. Correlations have been shown between metrics and scores to human-caused changes in water quality parameters and/or instream habitats. Samples collected from the Teton River downstream of Choteau generally showed communities that were "*adapted to the plains ecoregions*" (Bollman, 1999). However, based on metrix analysis, the two sites in the lower reach of the Teton River were deemed as partially supporting aquatic life.

A sample of macroinvertebrates collected from the lower Teton River near the Dent Bridge (Figure A-3, fourth DEQ monitoring site upstream of mouth) had only 31 specimens collected from 11 taxonomic groups. To calculate macroinvertebrate biometrics with any degree of statistical certainity a minimum sample size of 300 indiviuduals is recommended (Bollman, 2001). However, two major functional groups, scrapers and clingers, were not identified in the sample and the absence of these two groups alone is suggestive of aquatic habitat degradation and increased sedimentation. Additionally, the limited number of individuals and low taxa diversity at this location also suggested some level of aquatic habitat degradation.

In contrast, 26 and 24 different taxa were collected at sites near Dutton and Highway 221 crossing, respectively. Species diversity at the other Teton sites included several species in each of the EPT (e.g. may-, caddis-, and stoneflies), as well as long lived species and species of all functional groups.

For the tributary streams, reduced biotic integrity due to fine sediment deposition and loss of instream habitat complexity appeared to limit macroinvertebrate health (Bollman, 2001). In Willow and Spring Creeks the lack of stonefly species suggest a reach-scale loss of habitat. Worms and midges, common to sediment rich substrates, were common in both streams.

Algae samples from the Teton River indicate moderate impairment and lack of habitat diversity due to sedimentation (Bahls, 1999). Tributary samples collected from both Deep and Willow Creeks suggested siltation issues, coupled with organic loading, and the presence of teratological (e.g., mutated or deformed) cells (Bahls, 2002). Through identification of diatom and non-diatom species, algae can show decreased biological integrity from stressors in several ways. Certain diatom species indicate increased sediment by being mobile or free living and are able to migrate above deposited sediment. The presence of “opportunistic” species can be used to suggest recent disturbance to the stream. Certain species may indicate organic enrichment, which may be attributed to soil inputs via erosion. Finally, abnormal cells can be used as indicators of the water quality for the stream from which the samples are collected.

Two streams, McDonald Creek and Clark Fork of Muddy Creek, were listed in 1996 as “threatened” for aquatic life and fishery. “Threatened,” suggests that there is evidence or reason to believe that a fully supporting beneficial use may soon be impaired. Both streams are characterized as being fully supporting (2002 303(d) List), based on current conditions, land use practices, and management.

Blackleaf Creek (also referred to as North Fork Muddy Creek) was listed on the 1996 list as being impaired for aquatic life, cold-water fishery, and drinking water caused by siltation. Fieldwork completed in 2002 show that sediment is not impairing Blackleaf Creek at this time. Cobbles and gravel-sized particles were the dominant substrate and did not show evidence of excessive deposition or embeddedness. Wolman pebble count data from the three sites show close resemblance in size distribution (Figure 3-12). A shift to the left, or to smaller particles, is expected as a stream moves down gradient, as shown by Lower Site data. Energy decreases as a stream moves into gentler gradients and will deposit its sediment load. Cumulative percentages of fine particles <6 mm are low for all three sites. Approximately three percent of the particles measured at the lowest site were <1 mm, or diameters representative of clay and fine sediment. Some increase in the range of sand is shown at all three sites (1-2 mm); however total cumulative percent for particle sizes less than two mm is 6.4 %. The red circle is around the “D_{50}”, or the diameter of the 50% percentile or median grain size. Basically, this shows that 50% of the sampled particles are 12-16 mm (medium gravel) or smaller.

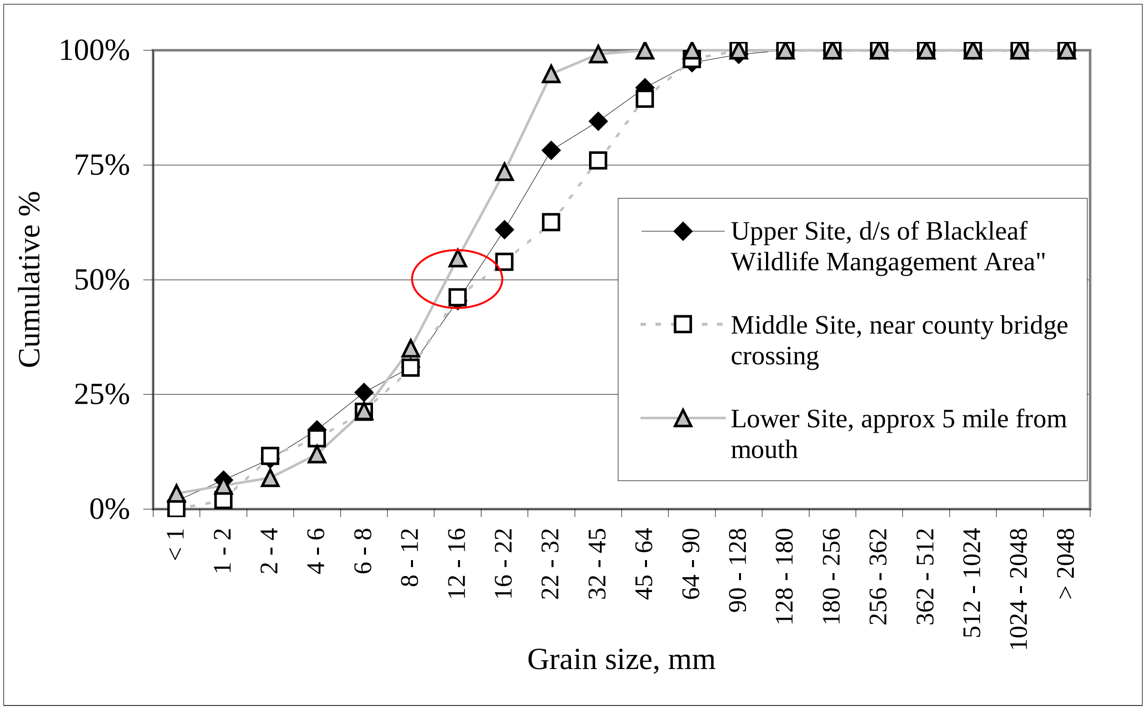


Figure 3-12. Wolman pebble count data collected along Blackleaf Creek by MDEQ, July 2002. The red circle indicates the D_{50} value, or the median particle size.

For the 2002 303(d) listing, “riparian degradation” and “bank erosion” are more accurate impairments for Blackleaf Creek. In the past, Blackleaf Creek has suffered from riparian degradation but appears to currently have a positive trend. Most areas showed good stream bank coverage by diverse riparian species including young willows, birch, bushes, and several species of perennials, grasses, forbs, and sedges.

Two irrigation reservoirs, Bynum and Eureka, were listed on the 1996 list as being impaired for sediment and flow fluctuations. Both reservoirs are listed on the 2002 303(d) list as fully supporting all beneficial uses due to recent data collection and assessment of the data using the EPA-approved MDEQ sufficient and credible data process (MDEQ, 2002a, Appendix A). Field site visits, fishery reports, and observations from MFWP staff allowed MDEQ monitoring staff to score the existing data for both reservoirs high enough (>6) for aquatic life and fisheries to demonstrate sufficient and credible data. Natural sources of sediment in the reservoirs come from the underlying erodible bedrock. Underlying the reservoirs is late Mesozoic to Cretaceous-age siltstone and shale (Montana Group), both of which are fairly erodible when compared with other rock types. Coupled with the geology, both reservoirs are shallow, surrounded by open land, and exposed to a prevailing westerly winds. Wind action provides a natural mechanism of bank erosion. On both reservoirs, the eastern banks show more evidence of wave action, while the western banks are covered with more vegetation. Due to the openness of the reservoirs, the relatively shallow depths, and the prevalent wind, natural mechanisms for turbidity and sedimentation were always present. At present, no turbidity measurements, such as Secchi disk measurements are known to MDEQ.

Field investigations of sediment sources were conducted during both fall low-water elevations and spring high-water elevations. Inlet channel observations were made to determine if sediment sources to the reservoir from channel erosion were present. Channels into both reservoirs were well vegetated, appeared stable, and did not show evidence of fine sediment sources. Additionally, Bynum Reservoir drains into a natural channel downstream so impacts to this channel were also considered to assure proper management and operation of the reservoir. The channel downstream of Bynum Reservoir does not show evidence of excessive flows (i.e. downcutting or channel widening).

Although classified as a cold-water fishery, Bynum has been historically stocked with walleye and yellow perch (MFWP, 2002). Walleye Unlimited, along with MFWP, have made several improvements to the lake to improve walleye habitat. Eureka Reservoir has been historically stocked with cold-water species (predominately rainbow trout). Both reservoirs support healthy fish populations and no fish kills have been reported.

Flow regimes for both reservoirs include filling by natural precipitation and through diversion channels during spring run-off. Water level elevations decrease as water is withdrawn through ditches during the irrigation season. The nature of irrigation reservoirs is to store water to be used as the summer progresses; therefore, water level fluctuations are expected. Both reservoirs are owned and operated by private irrigation companies.

3.3.5 Temperature

Two stream reaches, the upper reach of Teton Spring Creek and the middle Teton River, are listed for thermal modifications. Thermal modification for Teton Spring Creek relies on a combination of two data points collected in August 2000 by MDEQ and supporting information for increased temperatures. Teton Spring Creek is a B-1 stream, meaning that it shall support growth and propagation of salmonids, or cold-water fish species, and associated aquatic life. A water temperature was recorded as 25^{o} C (77^{o} F) at 12 PM in August 2000 by MDEQ staff following standard operating procedures for sample collection (i.e. reading parameter measurements in flowing water, representative of the stream). Two hours earlier (10 AM), a water temperature of 13.4^{o} C (56^{o} F) was measured eight miles upstream near the stream's source. Comparing the two data points shows a nearly two-fold increase over eight miles and only spanning a two-hour period.

Other factors that contribute to increased temperatures include channel geometry, lack of riparian cover, and low flow. Field observations and photos show a channel that is wide and shallow and lacking shading vegetation. An "E-type" channel, which is narrow and deep, is the expected classification for Teton Spring Creek, given the gentle gradient of the valley. Photos collected in the field show how the stream has been over-widened (Figures 3-10 and 3-13) in comparison to a more typical "E" channel (Figure 3-14). Teton Spring Creek is considered chronically dewatered (by MFWP), which during August would suggest that flows are extremely low, if existent at all. Because it is a spring creek, groundwater influences should aid in maintaining a constant water temperature, close to that of groundwater. However, 25^{o} C (77^{o} F) is much higher than reported groundwater temperatures and this area is not known for thermal springs.

Figure 3-13. Teton Spring Creek upstream of Choteau. Channel is wide and shallow.

Figure 3-14. Teton Spring Creek, upstream of Choteau. E-Type channel: narrow and deep, with well-vegetated banks.

The middle reach of the Teton River mainstem, classified as a B-2, was also listed as being temperature impaired. B-2 streams are considered intermediate cold-warm water streams that should "*be maintained suitable for…growth and marginal propagation of salmonid fishes and associated aquatic life*" (ARM 17.30.624(1)). Human influences that alter instream water temperatures include sedimentation, loss of riparian or shading vegetation, and dewatering. MFWP states that rainbow and brown trout are present in the middle reach of the Teton River. However, the effects of temperature upon their use and residence during the summer are not clear. But because fish are migratory and will travel miles to reach preferred areas for different life stages, the temperature effects on the middle Teton River fishery are not known. Applying the State of Montana temperature standards requires a good understanding of naturally occurring or reference conditions. An increase in temperature of 0.5^{o} C (1.0^{o} F) is allowed when naturally occurring temperatures area between 0.0^{o} C (32^{o} F) and 0.25^{o} C (66.5^{o} F) and a maximum increase of only 0.25^{o} C (0.5^{o} F) is allowed if naturally occurring is 19.2^{o} C (66.5^{o} F) or greater (ARM 17.30.624). Reference temperature conditions are not known for this reach of the Teton. Collection of these data is included in the monitoring plan (Section 6).

To justify the current temperature listing, consideration of literature values regarding temperature tolerances of fish was used. Preferred temperatures for rainbow trout range from 12.8^{o} C (55 ^{o} F) to 18.8^{o} C (66^{o} F) for juvenile/adult to fry/fingerling, respectively. Preferred temperature conditions for brown trout are very similar. For spawning (maximum weekly temperature) and embryo survival, however, temperature tolerance decreases dramatically to 7.8^{o} C (46^{o} F) and 15^{o} C (59^{o} F), respectively (USEPA, 1976).

Temperature values are collected in this reach by the USGS at the Dutton gaging station (Table 3-10 and Figure 3-15), by the MFWP at Hwy 221 crossing, and sporadically by MDEQ and volunteer monitoring (Figures B-4a and B-4b). Temperature measurements show extremes that exceed many of the literature recommended salmonid preferences in March and May through September. March, May, and September only show one record for each month that exceeds 19.4° C, while June, July, and August values exceed 19.4° C eight, eleven, and ten times respectively. Median values for March, May, and September are fairly low (2.8, 13.9, 15.9 ° C, respectively), while median values for June, July, and August indicate a stream that has warmed considerably (19.5, 22.0, 20.5 ° C, respectively).

MDEQ collected "grab samples" of temperature at 28 sites between 1998 and 2002 (Figure B-4a) while volunteer monitors collected grab samples at 13 sites over the past few years (Figure B-4b). Values collected along the temperature impaired reach of the Teton River (e.g., Choteau to the I-15 bridge) ranged from 23° C (73° F) to 28° C (82° F) on August 3-5, 1998 when flows were reported between 60-80 cfs. Volunteer data shows values greater than the 67° F standard on July 26, 2001; near Priest Butte Lakes, 19.6 ° C (67° F) was measured at 1:30 PM and a temperature of 24.6 ° C (76° F) was measured upstream of Muddy Creek's confluence at 2:15 PM.

Table 3-10. Water Temperature Data Summary from USGS Station near Dutton. Temperatures in degrees Fahrenheit are in parenthesis.

	# Records	**Records > 19.4° C (67)**	**Mean**	**Median**	**Maximum**	**Minimum**
Jan	14	0	0.0 (32)	0.0 (32)	0.5 (33)	0 (32)
Feb	11	0	0.5 (33)	0.0 (32)	3 (37)	0 (32)
Mar	14	1	4.1 (39)	2.8 (37)	21.7 (71)	0 (32)
Apr	11	0	10.8 (51)	10.5 (51)	15.5 (60)	6.5 (44)
May	28	1	13.9 (57)	13.3 (56)	28.5 (84)	0 (32)
Jun	19	8	18.2 (65)	19.5 (67)	24.5 (76)	12.5 (55)
Jul	13	11	22.9 (73)	22.0 (72)	28.5 (84)	19 (66)
Aug	15	10	20.9 (70)	20.5 (69)	26 (79)	11 (52)
Sept	9	1	15.9 (61)	15.5 (60)	22.5 (73)	10 (50)
Oct	12	0	7.1 (45)	6.8 (44)	14 (57)	3 (37)
Nov	10	0	3.0 (37)	3.0 (37)	9.5 (49)	0 (32)
Dec	11	0	0.0 (32)	0.0 (32)	0 (32)	0 (32)

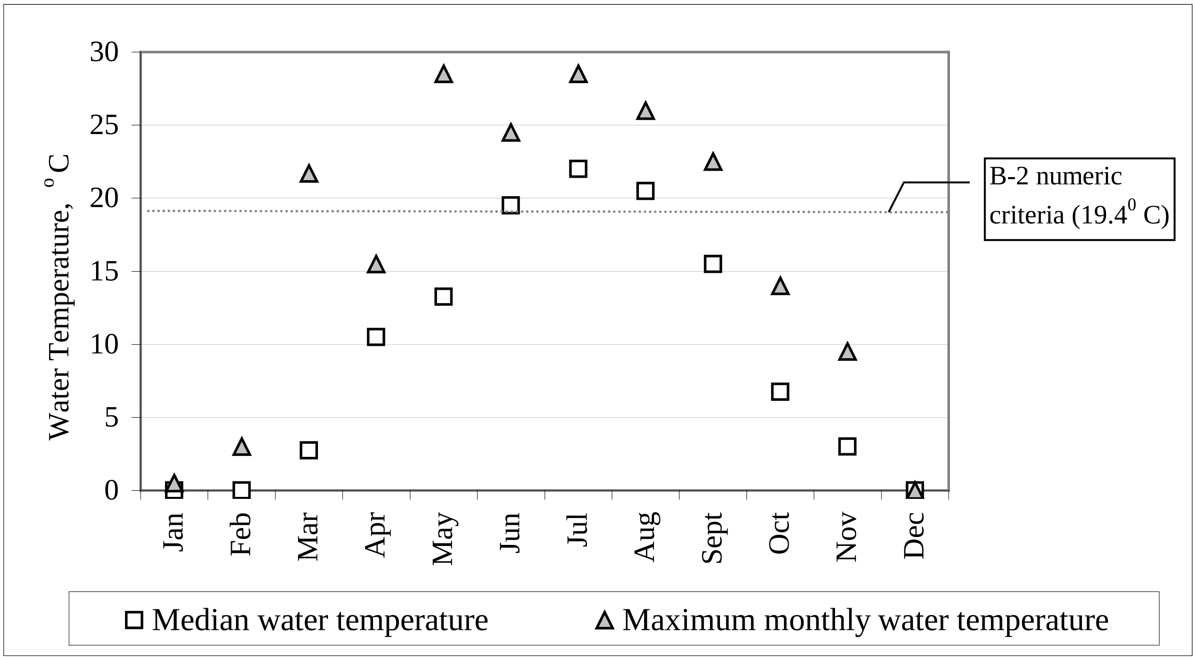


Figure 3-15. Monthly maximum and median water temperature data for the Teton River near Dutton (USGS).

3.3.6 Nutrients

Deep Creek and Teton Spring Creek (from Choteau to the mouth) are listed as nutrient impaired. Impairment decisions for the 2002 303(d) list for Deep and Teton Spring Creeks were made based on a combination of data including:

- Water column chemistry,
- Algae and chlorophyll *a* (Chl *a*), and
- Field observations of algae growth.

A nutrient impairment is based on both water column chemical analysis and on the current status of aquatic flora. Plants use bioavailable nutrients during the summer growing season, so "excessive" values may not be observed in water chemistry data. For this reason, aquatic plant life data were used to support nutrient impairment decisions. Water column nutrient values that exceed 650 µg/L for total N and 40 µg/L for total P are considered high. Chl *a* values above 50 mg/m^2 exceed MDEQ recommendations for contact recreation and aesthetics, while values greater than 100 mg/m^2 exceed values for aquatic life (MDEQ, 2002c).

MDEQ staff sampled Deep Creek, the lower reach of Teton Spring Creek, and Willow Creek in late May 2001 and the upper reach of Teton Spring Creek in August 2000 (Figures B-5 through B-7). Samples for water quality, Chl *a*, and algae were collected following methods outlined in MDEQ's SOP manual (2002). Water samples were analyzed for nitrate, total Kjeldahl nitrogen (TKN), and total phosphate.

Nitrate (NO_3) is a common soluble form of nitrogen and is readily available for plant uptake. TKN is the sum of organically bound nitrogen and ammonia. Chemically, organic molecules tightly bind nitrogen; however, microbial reduction releases nitrogen from organic molecules for plant use. Through sunlight reduction, ammonia is broken down into gaseous nitrogen that is released to the atmosphere. Total nitrogen (N) was calculated by summing nitrate and TKN (Table 3-11). Phosphate (PO_4) is a readably available form of phosphorus used by plants. Due to its chemical nature, the negatively charged phosphate ion adsorbs to clays, organic molecules, or colloids present in surface water. Therefore, "total" phosphate values are reported as phosphorus, to represent all species of phosphate. Nitrogen levels, from $NO_3 + NO_2$, are below stated ecoregion values, but total phosphate values exceed them. This suggests the stream is nitrogen limited, meaning that plant-life is limited by nitrogen as phosphate is available in excess.

Values that would define "excessive" nutrients vary across Montana and "acceptable" values for Total N or P may differ between drainages. One approach to determining excessive nutrient levels and/or acceptable aquatic plant life has been suggested based on Ecoregions (USEPA, 2001; Richards et al, 2000). Two ecoregions are dominant in the Teton River watershed (Figure A-6). Approximately, the western quarter of the watershed is in Ecoregion 16 – Montana Valley and Foothill Prairies, while the remaining watershed area is in Ecoregion 42 – Northwestern Glaciated Plains. Based on an Ecoregion approach, the USEPA (2001) has suggested nitrogen and phosphate limits, using the 25th percentile method or *reference* conditions (Table 3-12). The 25th percentile method considers pooled data collected in a specific ecoregion at or below 25% of all data to be reference, or approximately what natural conditions should be. Data found above the 25% are considered above natural. The USEPA looked at all nutrient values collected in the Ecoregions 16 and 42 and suggested limits. In a similar, but independent study, Richards et al (2000) pooled historical data for Ecoregions 16 and 42 and determined limits, also using the 25th percentile approach (Table 3-12). Both suggested TNK and Total P limits are relatively close in value, while Richards et al. (2000) suggests much lower NO_3+NO_2 as N values. All of the streams listed as nutrient impaired (Table 3-2) are found in Ecoregion 16 (Figure A-6); however, they are also very close to Ecoregion 42, as is the middle reach of the Teton River.

Table 3-11. Nutrient concentrations and algal biomass measured in 2000 and 2001 by MDEQ.

Sample location	**NO_3 as N (µg/L)**	**TKN as N (µg/L)**	**Total N (µg/L)**	**Total PO_4 as P (µg/L)**	**Chl *a* (mg/m^2)**
Deep Creek, below Willow Creek confluence	<10	700	701	49	54
Deep Creek, below Hwy 287 bridge	20	1,000	1,020	107	58
Willow Creek, near headwaters	<10	700	701	41	18.6
Willow Creek, near mouth	<10	1,000	1,010	53	16.8

Table 3-11. Nutrient concentrations and algal biomass measured in 2000 and 2001 by MDEQ.

Sample location	NO_3 as N (µg/L)	TKN as N (µg/L)	Total N (µg/L)	Total PO_4 as P (µg/L)	Chl *a* (mg/m^2)
Spring Creek, near Source	220	500	720	11	N/A
Spirng Creek, upstream of Choteau	<10	500	510	19	N/A
Spring Creek, in Choteau	<10	400	410	19	134
Spring Creek, near Mouth	<10	800	810	22	52

Chl *a* is present in all plants and is necessary for photosynthesis. Chl *a* biomass is one method used to measure aquatic plant growth. Increased amounts of Chl *a* have been associated with increased algae growth that, for example, could degrade water quality aesthetics, harm fisheries, or clog pumps. Filamentous algae species are often associated with both nutrient enrichment and increased Chl *a* biomass. Increased biomass associated with higher Chl *a* values can affect aquatic life by depleting dissolved oxygen levels, altering pH, or clogging gravels. Increased water column cloudiness, or turbidity, is another side effect to high biomass and/or algae (Peterson et al., 2002). Attempts to quantify protective Chl *a* values for aquatic life and contact recreation consistently show a maximum value of 150 mg/m^2 (USEPA, 2000). In New Zealand, a provisional guideline of 100 mg/m^2 Chl *a* and 40% filamentous algae coverage of the substrate were proposed to protect contact recreation. Montana DEQ SOP manual suggest Chl *a* values greater than 50 mg/m^2 hinder contact recreation and greater than 100 mg/m^2 could be harmful to aquatic life.

Table 3-12. Recommended nutrient levels by ecoregion (USEPA, 2001; Richards et al., 2000).

	Reported by:	TKN (µg/L)	NO_3+NO_2, as N (µg/L)	Total N, calc'd (µg/L)	Total P (µg/L)
Subregion 16	USEPA	190	60	250	10
	Richards et al.	200	20	100	20
Subregion 42	USEPA	550	60	610	41
	Richards et al.	400	10		40

Deep Creek is considered impaired for nutrients based on a combination of field observations, photos, high phosphate levels, and elevated Chl *a* biomass (Table 3-11). Field observations note the presence of algae, stating roughly 40% of substrate is covered and filamentous algae can be seen in the photo of the stream substrate (Figure 3-16). Increased turbidity can also be seen in the photo, some of which is related to increased plant life. However, no numeric turbidity values were collected. Chl *a* samples collected in late May were above MDEQ SOP recommended levels for contact recreation (50 mg/m^2). Because the Chl *a* samples were collected early in the growing season, it is reasonable to expect that Chl *a* values would only increase as the summer progressed and algae matures.

Teton Spring Creek, specifically the reach from Choteau to the mouth, is listed for nutrients due to the increase in Chl *a* collected in town (Choteau). By their nature, spring creeks tend have higher nutrients and dissolved solids due to increased residence time of groundwater and microbial processes (Stumm et al., 1981). Background levels of NO_3+NO_2 as N in Teton Spring Creek near its source support this with much greater values than in other streams or lower in Teton Spring Creek itself. Increased aquatic plant life, near Choteau’s city park, is documented in field observations stating approximately 10% of the substrate was covered by algae. A Chl *a* sample, collected from the stream in the park, reported a Chl *a* value of 134 mg/m^2. This sample was collected in May and Chl *a* values can be expected to increase as the summer continues. The Chl *a* sample collected downstream of Choteau was lower (52 mg/m^2), but field notes indicate substrate coverage by algae increased to approximately 20%. A photo taken downstream of town (Figure 3-17) shows young filamentous algae covering most of the stream’s cobbles. Chl *a* samples were not collected for the upper reach of Teton Spring Creek (upstream of Choteau). Photos taken in August show a robust aquatic plant community (Figure 3-18) and algae samples collected showed a diverse community of soft-celled and diatom algae, typical of a spring creek (Bahls, 2002). Potential increased nutrients, impairments, and sources in the upper reach of Teton Spring Creek should be considered and incorporated into future nutrient studies in the Teton River watershed.

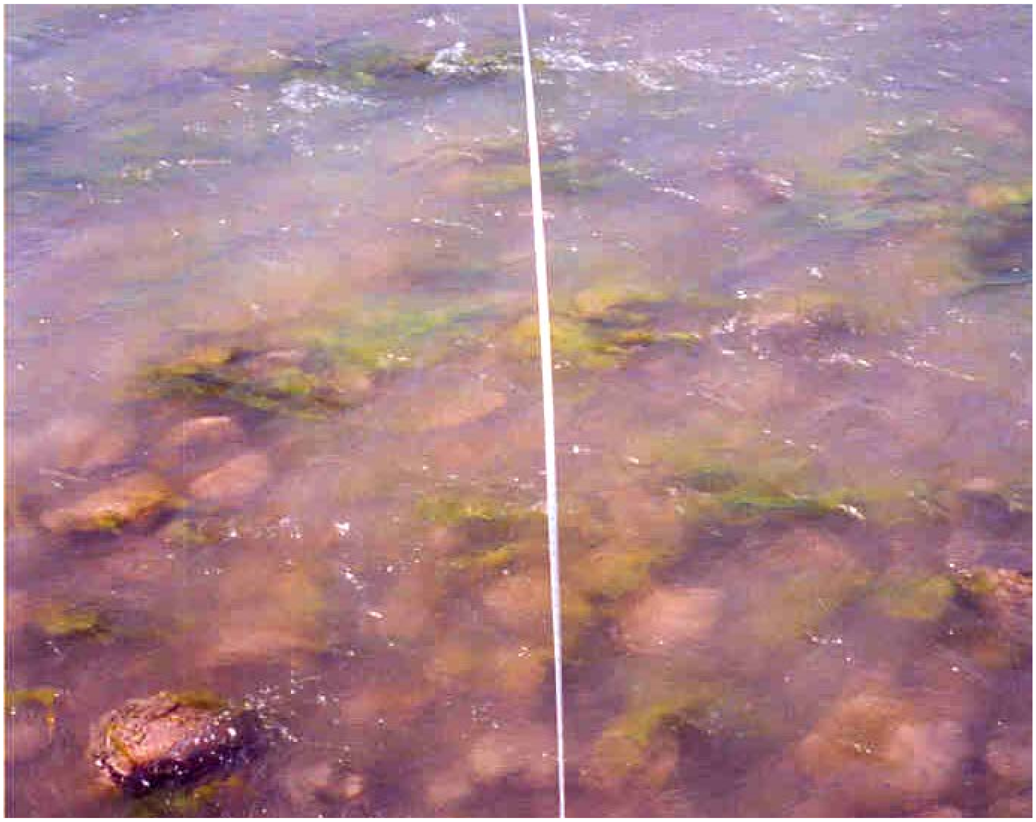


Figure 3-16. Filamentous algae in Deep Creek, May 2001.

Figure 3-17. Algae in Teton Spring Creek, downstream of Choteau, May 2001.

Figure 3-18. Aquatic vegetation in Teton Spring Creek, upstream of Choteau, August 2000.

Willow Creek was not listed on the 2002 303(d) list for nutrients and is included in Table 3-11 to show contrast in both water column nutrients and Chl *a* values. TKN and total P values are greater than suggested nutrient limits (Table 3-12) and floristically, algae samples showed "*exceptional species diversity and evenness*" (Bahls, 2002). Measured Chl *a* values were much lower than other tributaries and were below the recommended upper limits. Because Willow Creek is a tributary stream to Deep Creek, its high water column nutrient values should be considered a potential source for excessive nutrients and algae growth in Deep Creek. Also, because the data for all tributary streams are limited to one field season, further collection and field observations should be conducted. These data gaps are addressed in the monitoring plan provided in Section 6.

Although the middle portion of the Teton is not currently listed, data collected at the USGS gage near Dutton suggests an increasing trend in total phosphate concentrations. Statistical analysis of 41 samples for total phosphorus, collected from 1998 to 2002, showed a significant increasing trend with time with a 90% confidence using median values for each water year. Summer data points (June through September) ranged from below detection (<10 μg/L) to 177 μg/L (July 1998). Twelve data points make up the five-year summer data set, and of those, five are greater than 40 μg/L. In considering potential sources for the middle Teton, inputs from Deep, Willow, and Spring Creeks should be addressed. Increased phosphate could be a result of erosional processes and/or sediment inputs. Also, the role of the wastewater discharge from the town of Choteau should continue to be monitored and the effects on the Teton further considered.

3.3.7 Flow

Montana FWP has listed the Teton River, Deep Creek, and Teton Spring Creek as being chronically dewatered, meaning dewatering is a significant problem virtually every year. Dewatered streams do not support all beneficial uses that have been assigned to them. Therefore, as provided in the beneficial use support determination guidance (MDEQ, 2002a), dewatering is considered overwhelming evidence that these streams are not supporting fisheries, aquatic life, or recreational uses (i.e. swimming, fishing, or other water contact recreation).

Biological affects seen in the Teton River include absence of historical fish species and decreased habitat for macroinvertebrates. The sturgeon chub (a species of special concern) once used the Teton River but may not be represented any longer due to low flow conditions (Gould, 1998). Macroinvertebrates assemblages collected near the Dent Bridge (lower portion of the Teton River, upstream of Loma) reflected impacts from diminished flows. Low EPT richness and a high proportion of tubificid worms were attributed to low flows and habitat degradation (Bollman, 1999).

Historical data provided in Section 2 indicates that the upper Teton River and these tributary streams had perennial flow. Dewatering of the listed streams occurs from water withdrawals for human use.

SECTION 4.0
SOURCE ASSESSMENTS, WATER QUALITY TARGETS, AND TMDLS

4.1 Salinity

A total daily maximum load (TMDL) for salinity, i.e. total dissolved solids (TDS) as measured by specific conductance (SC), for the Teton River was established in 1999 (MDEQ, 1999). However, the focus of the 1999 TMDL was solely on TDS loading to the river from Priest Butte Lakes. The document presented herein looks to address salinity from a watershed perspective and includes data collected since the completion of the previous TMDL. Water bodies with total dissolved solids/salinity TMDLs developed or refined in this document include Priest Butte Lakes (MT41O004_020), the middle Teton River (MT41O001_020), and the lower Teton River (MT41O001_010). Blackleaf Creek (North Fork of Muddy Creek), listed as impaired in 1996, was evaluated in 2002 as having natural levels TDS and will not have a specific TMDL developed herein.

4.1.1 Existing Conditions and Source Assessment

Priest Butte Lakes and Freezout Lake WMA

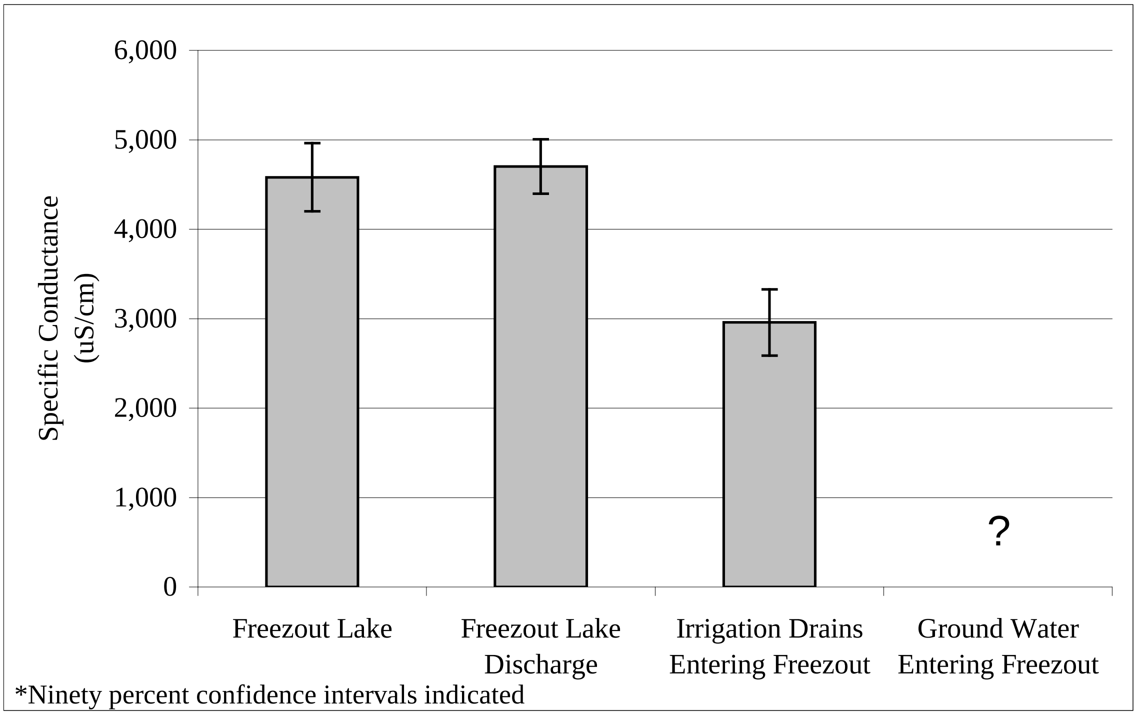
The most significant source of salinity (TDS) to the Teton River is attributed to discharge from Priest Butte Lakes that enters the river downstream of Choteau (Figure A-4). Priest Butte Lakes is part of a larger wetland-lake system, Freezout Lake Wildlife Management Area (WMA), which encompasses roughly 11,350 acres of shallow lakes, ponds, marsh, and grasslands. Priest Butte Lakes itself is roughly 300 acres in size. The Freezout Lake WMA has become important bird habitat, especially as a stop over for migratory and/or endangered species with over 200 species of birds having been identified. However, the Freezout Lake WMA was historically a natural closed basin that periodically went dry (Knapton et al., 1988). After the initiation of irrigated agriculture on the Greenfields Bench water levels in the WMA began to rise as a result of irrigation return flow via shallow groundwater flow paths, irrigation drain ditches, and irrigation “waste” water at the end of supply ditches. The additional inflow of water resulted in periodic flooding of U.S. Highway 89 and agricultural lands surrounding Freezeout Lake. To mitigate problems caused by the flooding the U.S Bureau of Reclamation constructed a system of drainage canals in the 1950s connecting Freezeout Lake with Priest Butte Lakes and then to the Teton River just downstream of Teton Spring Creek (MFWP, 1997a).

Freezeout Lake is a naturally saline lake system, however its salinity levels are now greatly influenced by the inflow of water from the Greenfield Irrigation District. Irrigation return flow from the Greenfields Bench has measured SC values of approximately 3,000 μS/cm. In-lake salinity, as measured by SC, is in the 4,500 μS/cm range and the resultant Freezeout Lake discharge (i.e. flow to Priest Butte Lakes) has SC values in the 4,750 μS/cm range (Figure 4-1).

Water quality data in or near Priest Butte Lakes was monitored by MDEQ, MFWP, and USGS at seven monitoring sites between 1974 and 1996 (Table 4-1; Figure A-4). Measured levels of TDS, and consequently specific conductance (SC), indicate elevated concentrations with reported (in-lake) values ranging from 775 μS/cm to 11,670 μS/cm (Table 4-2). Yeager seep

(USGS site 7021; MFWP unnamed site) is located near the southeastern portion of the lake and is a critical source of TDS/salinity loading to Priest Butte Lakes. Measurements of SC in the Yeager seep discharge are extremely high, ranging from 30,000 to 40,640 µS/cm (Table 4-2).

Because Priest Butte Lakes discharges through a canal/ditch to the Teton River, efforts to monitor SC/TDS have been made by MDEQ (formerly MDHES), MFWP, USGS, and volunteer landowners/stakeholders. From 1980 through 1987, MDEQ monitored upstream and downstream of the discharge. Sixty-four SC samples were collected upstream of the discharge with a range of 348 to 1,751 µS/cm (median value: 568 µS/cm). Fifty-two samples were collected downstream of the discharge with a range of 543 to 3,689 µS/cm (median: 1,057 µS/cm).



*Ninety percent confidence intervals indicated

Figure 4-1. Specific conductance levels in Freezeout Lake, Freezeout Lake Discharge, and irrigation drains entering Freezeout Lake. (Data collected from 1980 – 1995.)

Table 4-1. Monitoring stations for Priest Butte Lakes area from 1974 to 1996.

Site ID	Site Description	Agency	Dates collected
2454	At weir	DEQ	April 1980 - April 1996
2456	"Feeder" stream	DEQ	October 1974
2520	Flow out of PBL	DEQ	April 1980 - May 1984
7020	"Site 20", near western shore	USGS	August 1986
7021	Seep, southeast area of lake [1] (Yeager seep)	USGS	August 1991 - May 1992
--	Yeager seep [2]	MFWP	July 1995 – June 1996
7023	South end of lake [1]	USGS	April 1991 - June 1992

[1] data from Lambing et al., 1994

[2] data from MFWP, 1997a

Table 4-2. SC values for Priest Butte Lakes and vicinity.

Site ID	Minimum Value (µS/cm)	Maximum Value (µS/cm)	Average Value (µS/cm)	Number of samples
2454	2,333	11,670	7,044	17
2456	--	4,840	--	1
2520	775	8,230	3,878	32
7020	--	7,900	--	1
7021	30,000	39,900	33,583	6
--- [1]	30,300	40,640	35,679	5
7023	7,200	9,350	8,360	4

[1] data collected by MFWP and are lab calculated SC values

- *(Shade rows depict stations in source areas to the lake; non-shaded rows are either in-lake or lake-discharge sites.)*

In the late 1990s a salinity TMDL was approved for the Teton River that specifically addressed discharge from Priest Butte Lakes (MDEQ, 1999). The TMDL for the Priest Butte Lakes discharge was defined in this document as "*<u>not to exceed</u> 1,000 µS/cm (or 700 mg/L TDS) measured in the Teton River at State Highway 221 Bridge*," about two miles downstream. Consequently, MFWP has continued to monitor water quality in the Priest Butte Lakes discharge, and in the Teton River upstream and downstream of the discharge while releases are occurring. Monitoring is done on average three times per week and lake discharge is adjusted based on SC levels measured upstream in the Teton River and in the lake's effluent (Personal Communication, Mark Schlepp, MFWP). Data collected at these monitoring locations (Figure A-4) from 1997 to 2000 indicate that, on average, the current TMDL is being met only 56% of the time (141 of 250 samples). Teton River SC measured at State Highway 221 Bridge (the TMDL compliance point) ranged from 412 µS/cm to 1,820 µS/cm with a median value of 988 µS/cm (Table 3-6, Figure 4-2).

Salinity (i.e. salt) loading to Priest Butte Lakes comes from sources internal to the surface watershed or groundwater source area, as well as sources “external” to the lake’s natural watershed. Internal sources include drainage from the Yeager seep, other seeps east of the lake, and intermittent drainages west side of the lake (Figure 4-3). The Yeager seep drainage has the most extreme measurements of SC recorded in the Teton River watershed, with a maximum-recorded value of nearly 40,640 µS/cm (Table 4-2, MFWP unnamed site). Along the stream bottom of Yeager seep several saline seeps are evident as whitish areas as are three other saline seep areas to the north (Figure 4-4). In addition, the canal from Freezeout Lake discharges into Priest Butte Lakes at the Yeager seep mouth (Figure A-4). The west side of the lake also has seep areas along intermittent drainages (Figure 4-5) which carry water that is spilled or leaked out of the Cascade Canal (as noted on the USGS 7½’ quadrangle) (Personal Communication, Alan Rollo, TRWG Coordinator). Again, as can be noted in Figure 4-5, the whitish areas along the bottom of these draws indicate accumulation of salts.

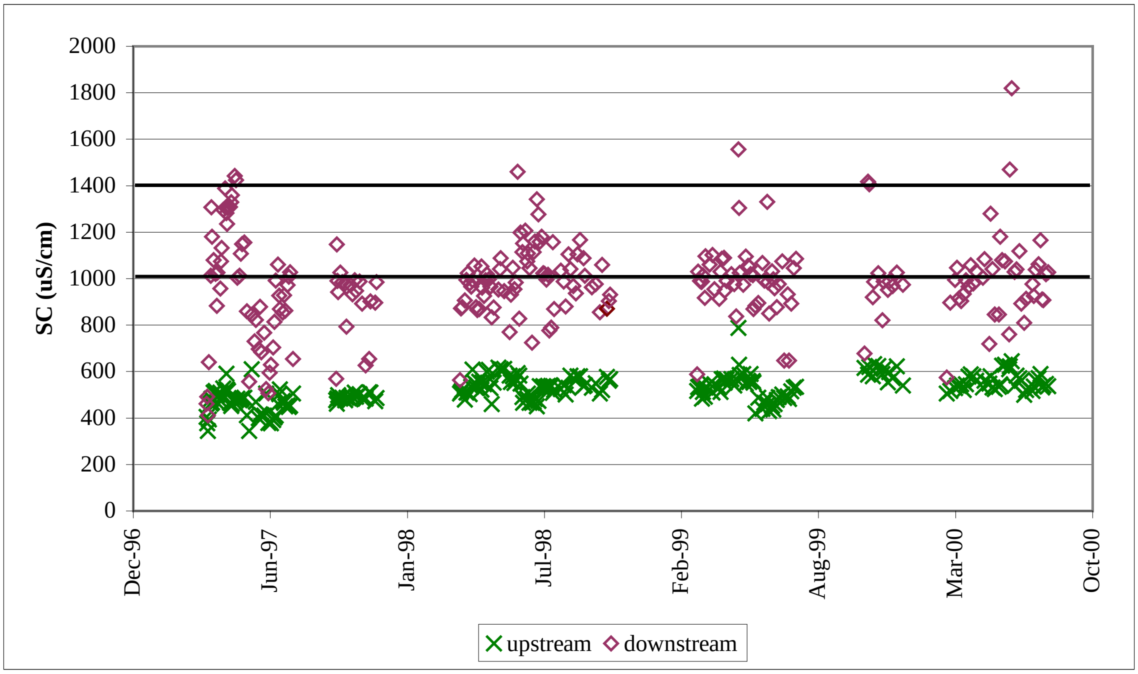


Figure 4-2. Specific Conductance (SC) measurements from 1997 to 2000 in the Teton River near the Priest Butte Lakes discharge. Darkened lines are placed at 1,000 µS/cm and 1,400 µS/cm levels and represent SC target values for the Teton River.

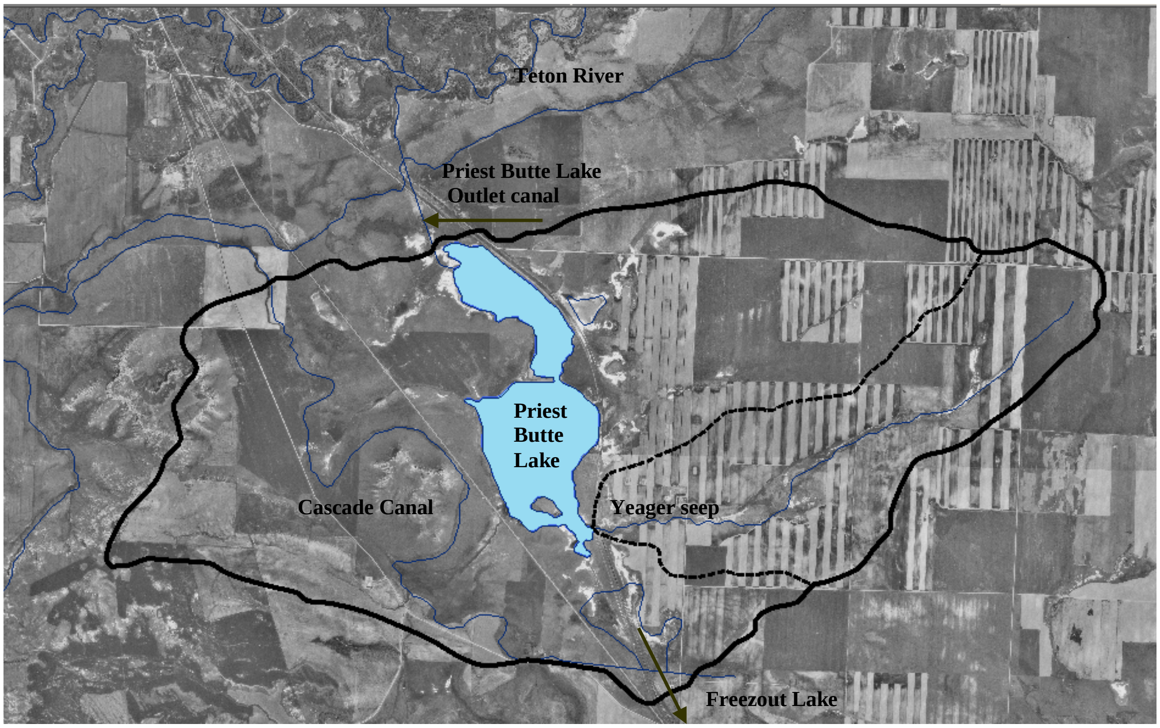


Figure 4-3. Approximate boundary of the Priest Butte Lakes watershed excluding its hydrologic connection to the Freezeout Lake. The Yeager seep sub-watershed is delineated with a dashed line. Blue lines are streams, irrigation ditches, or artificial canals. (Photo source is USGS; north is to the top of the photo; scale is approximately 1:45,000.)

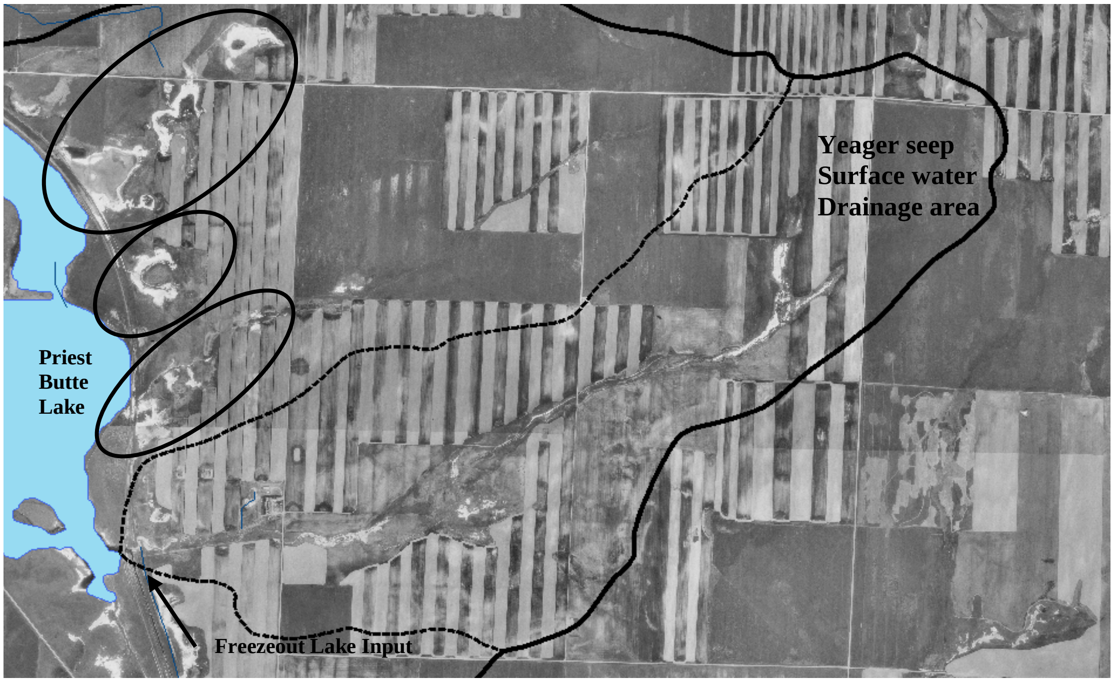


Figure 4-4. Yeager seep surface water drainage area (dashed line) and other Priest Butte Lakes east-side saline seep areas (solid ovals). The light blue lines are man-made ditches or canals. (Photo source is USGS; north is to the top of the photo; scale is approximately 1:25,000.)

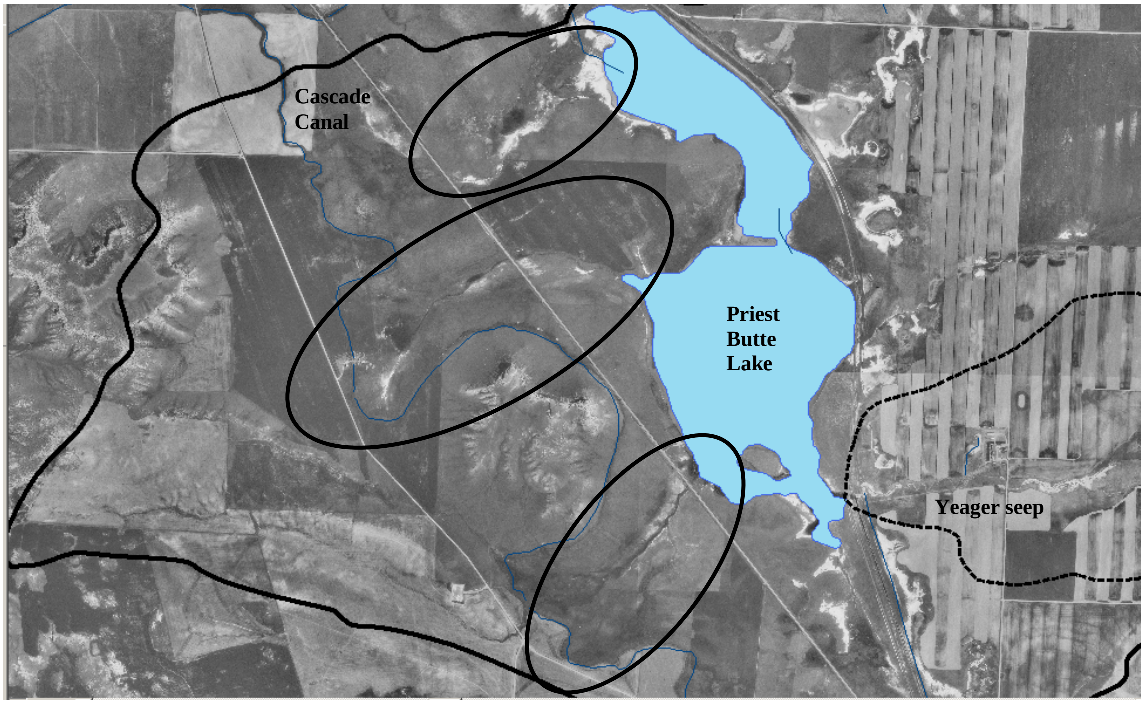


Figure 4-5. West side of Priest Butte Lakes watershed showing intermittent draws (ovals) that are influenced by flows and/or leakage from the Cascade Canal that traverses the western side of the watershed (light blue line). (Photo source is USGS; north is to the top of the photo; scale is approximately 1:25,000.)

Estimating the TDS loading from these sources is only possible for the Yeager seep and Freezeout Lake. The TDS load from Yeager seep is estimated using Equation 4-1 with the following assumptions: 1) the average SC value measured by the USGS and MFWP in Table 4-2 is reasonable, 2) the relationship of SC to TDS calculated in Figure 3-1 is valid for Priest Butte Lakes, and 3) using an average annual discharge from the seep measured from 1990-1992 by the USGS (Nimick et al., 1996) is a valid estimate for daily loading calculations. With these assumptions in mind, the following is the estimated daily loading from Yeager seep.

$$Load(lbs/day) = Q_{af/yr} * CF_Q * C * 5.39 \qquad \textbf{Eq. 4-1}$$

Where:
$Q_{af/yr}$ = average annual discharge in acre-feet/year
CF_Q = 0.00138 (conversion factor for discharge from af/yr to cfs)
C = mean concentration of TDS in mg/L
5.39 = conversion factor from mg/L to lbs/day

Inserting values from Yeager seep into equation 4-1, where $Q_{af/yr}$ = 72 ac-ft and C = 27,970 mg/L TDS, results in an estimated annual load of 14,979, or roughly 15,000 lbs/day.

Using the same equation for loading from Freezeout Lake discharge, but replacing values for $Q_{af/yr}$ and C with 2,790 ac-ft and 4,028 mg/L respectively (MFWP, 1997a), estimates annual TDS loading at 83,591 or roughly 83,500 lbs/day. Combined, these two sources total an estimated annual load of TDS to Priest Butte Lakes of 98,500 lbs/day, of which, 15% is from the Yeager seep, and 85% is from Freezeout Lake.

However, loading from Freezeout Lake and the Yeager seep are not the sole sources of salinity to Priest Butte Lakes. Additional loading can be reasonably assumed to also come from the intermittent draws to west of the lake, small drainages to the north of Yeager seep on the east side of the lake, and from shallow groundwater flow enhanced from agricultural practices. Unfortunately, at this time there is no field data to evaluate the absolute load or relative magnitude of the loads in context with the other known sources. Moreover, the groundwater source area for the lake is unknown. There is a strong potential for groundwater connectivity from sources east of the Yeager seep topographic divide (Figures 4-3 and A-4) based on local soils, geology, and agricultural practices (Personal Communication, Mark Schlepp, MFWP). Knowledge and understanding of the local groundwater flow paths for Priest Butte Lakes area is considered a critical data gap that needs to be quantified.

What is known is that the soils and geology of the Priest Butte Lakes area (Figures 4-6, 4-7, and 4-8) have been identified as having elevated levels of salts and selenium (Nimick et al., 1996). Soil electrical conductivity (EC) in the upper 150 cm (~ 60 inches) of the soil profile range from one to 33 mS/cm (Figure 4-6). The highest soil EC levels in the Priest Butte Lakes watershed are around the shore of the lake and specifically along the Yeager seep drainage and the small drainage in the northeast of the watershed. (**Note:** these values are reported in mS/cm and are numerically larger than µS/cm by a factor of 100. The data source for Figure 4-6 is the NRCS Soil Survey Geographic (SSURGO) database (NRCS, 1995).) In addition, the geology of the Priest Butte Lakes watershed is predominantly comprised of Colorado Shale (Figure 4-7), which is cretaceous sedimentary rock derived from a shallow inland sea. These rock types typically are easily erodible and have high levels of salts, nutrients, and clay material. The Colorado Shale formation is overlain by quaternary glacial drift and glacial lake deposits east of the lake (Figure 4-8), which have also been identified as significant sources of salinity to Priest Butte Lakes (Nimick et al., 1996).

The existing load from sources other than Freezeout Lake and the Yeager seep cannot be estimated at present. However, an evaluation of the local soils and parent material strongly suggests that the eastern boundary of the lake, the small drainages to the west, and shallow groundwater flows generated by precipitation, field irrigation, or augmented by crop-fallow practices are also likely significant sources of salinity loading.

General Teton River Watershed

Between 1998 and 2001 the Montana DEQ collected TDS/SC samples at 27 locations through out the watershed (one sample each), including a “synoptic” run of eight locations from the headwaters to the mouth spanning four days in August of 1998 (Figure B-1a). In this data set the only stations with values greater the 1,000 µS/cm were the two sites below the Priest Butte Lakes discharge, where reported values were 1,200 and 1,300 µS/cm. In addition, volunteer monitors from the local watershed group collected SC data along the entire reach of the Teton River in 2000 and 2001 (Figures B-1b and B-1c, median and maximum values, respectively). These data also indicate an increase in salinity levels below the Priest Butte Lakes discharge downstream to the confluence of Muddy Creek, where the Teton River SC levels moderate to below 1,000 µS/cm. SC increased to values above the 1,000 µS/cm 1999 TMDL threshold along the lower reaches of the watershed below the confluence of Muddy Creek. This volunteer monitoring data set includes 56 samples with 18 samples greater than 1,000 µS/cm and only one sample greater than 1,400 µS/cm.

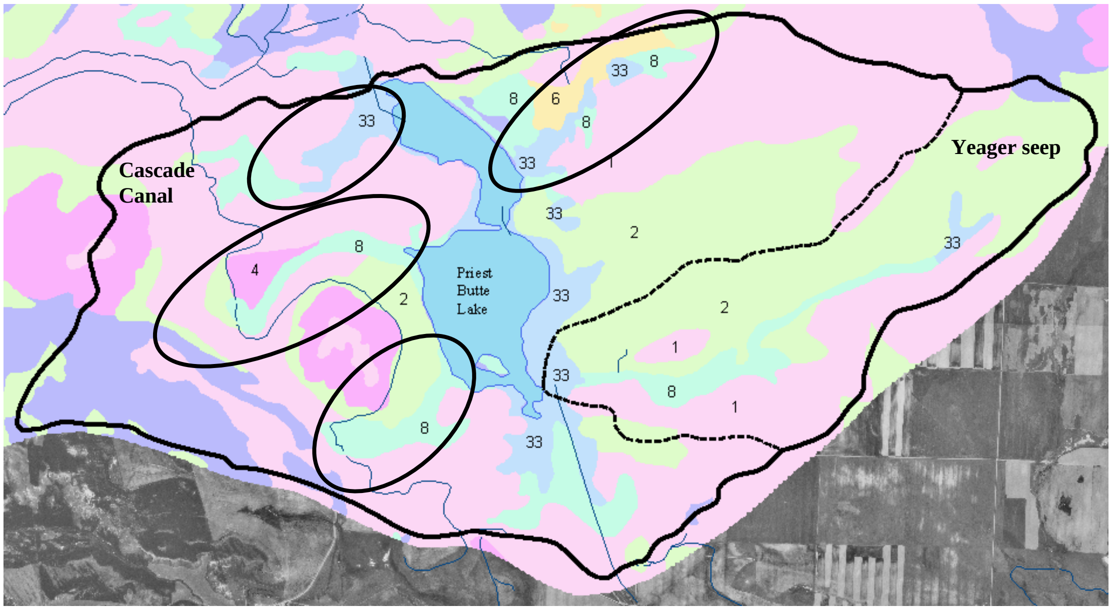


Figure 4-6. Soil electrical conductivity (EC reported in mS/cm) for Priest Butte Lakes topographic watershed. Values represent the mean value for EC within the upper 150 cm (~60 inches) of the soil profile. Yeager seep (dashed line) and intermittent drainages (solid ovals) are highlighted. North is to the top of the figure; the scale is approximately 1:40,000.

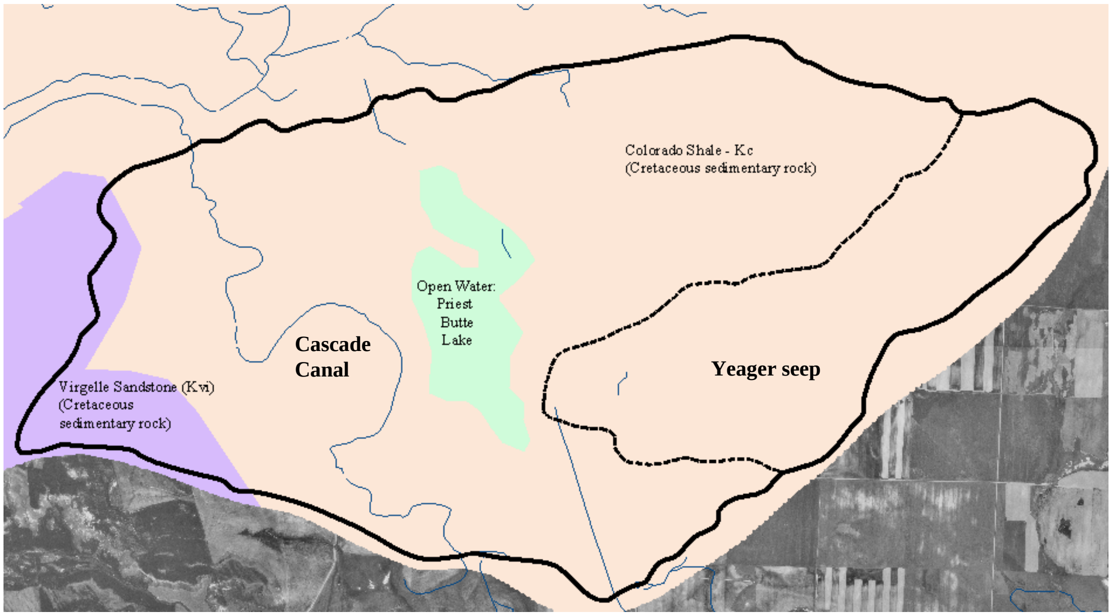


Figure 4-7. Generalized geology of the Priest Butte Lakes topographic watershed with the Yeager seep drainage demarcated with the dashed line. North is to the top of the figure; scale is approximately 1:40,000.

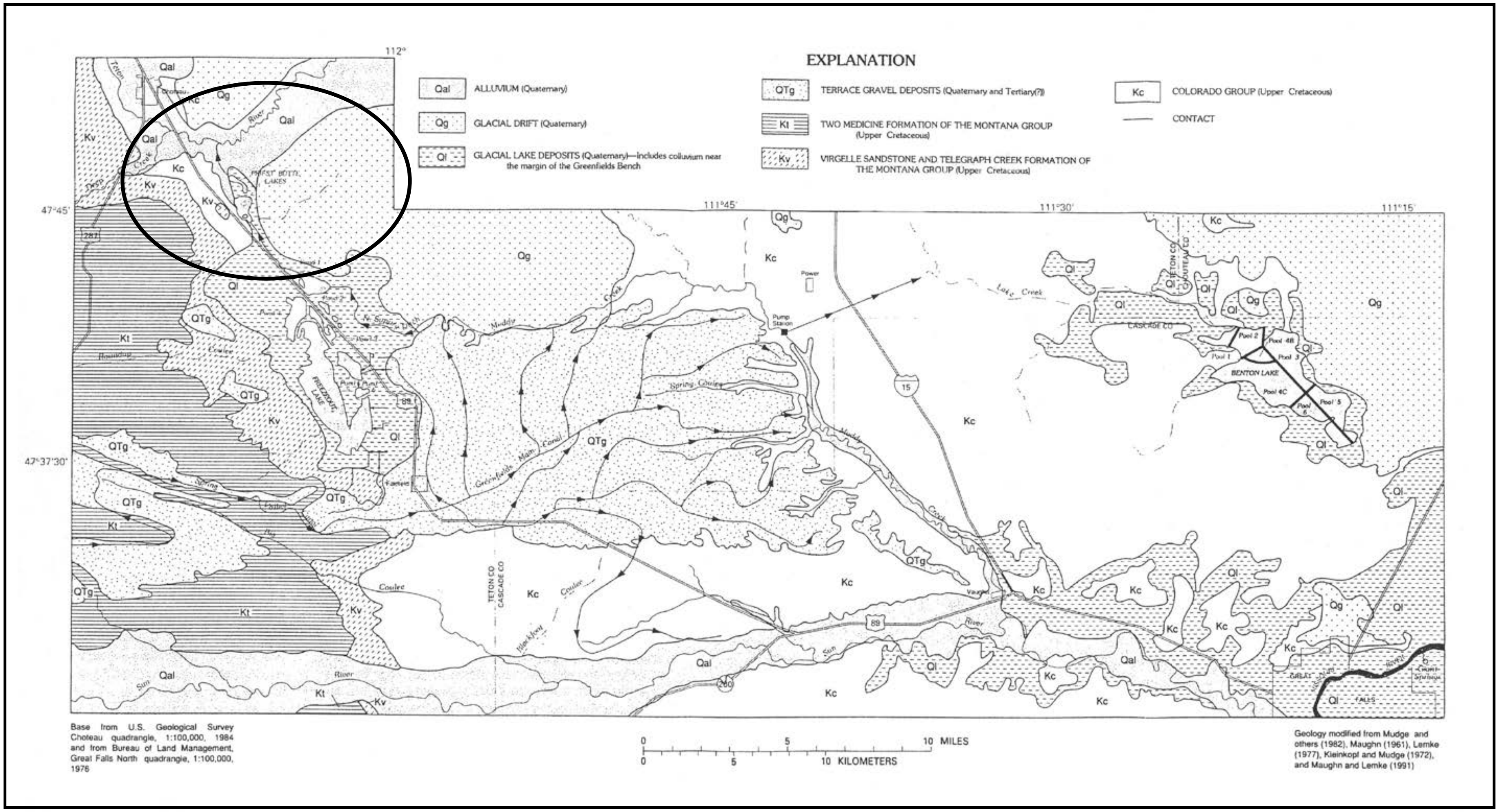


Figure 4-8. Detailed geology of the Freezeout Lake/Priest Butte Lakes area of the Sun and Teton River watersheds. Priest Butte Lakes area is isolated in the circled area in the upper left corner. East of the lake quaternary Glacial Drift (Qg) and Glacial Lake deposits (Ql) overlay the Colorado Group (Kc) deposit that is noted in the broader-scaled geology maps (Figures 4-7 and A-2) (Nimick et al., 1996).

The USGS has collected SC measurements at the Dutton site from 1982 to present and from 1998 to present at two other gaging stations, near Choteau and near Loma (Table 4-3, Figure A-3). Again, the influence of the Priest Butte Lakes discharge is evident where the ambient SC of the Teton River above the lake discharge ranges from 200 to 423 µS/cm at the USGS Choteau gage and then increasing to where the average SC at the USGS Dutton gage over the past 19 years is 973 µS/cm with a median of 961 µS/cm. Near the mouth of the watershed, at the USGS Loma gage, SC values remain elevated with an average of 1,080 µS/cm, which is greater on average than at Dutton, but the maximum values are not as high. The increase in Teton River SC along the lower section of the river is attributed to agricultural practices along the floodplain of the river as well as loading of salts from tributary coulees that wash into the Teton River during spring and summer rain storms.

Table 4-3. Specific conductance measurements from USGS gaging stations (Figure A-3).

Station	**# of samples**	**Sample Dates**	**Min. (µS/cm)**	**Max. (µS/cm)**	**Ave. (µS/cm)**	**Median (µS/cm)**
Choteau (6104500)	43	1998 – 2001	200	423	338	350
Dutton (6108000)	176	1982 –2001	336	2,320	973	961
Loma (6108500)	45	1998 – 2001	271	1620	1085	1080

Average soil EC levels in the upper 60 inches (150 cm) of the soil profile through out much of the watershed tends to be in the 1 – 4 mS/cm (1,000 – 4,000 µS/cm) range with pockets reaching as high as 33 mS/cm (33,000 µS/cm) (Figure A-13a). Soil EC tends to be elevated in regions down gradient of areas dominated by dryland crop agricultural practices (Figure A-9a) and in the Bynum area of Muddy Creek where there is a concentration of irrigated acreage as well as dryland cropping (Figure A-9b). Dryland cropping is usually done via crop-fallow practices where the soils are left barren of vegetative cover for a season or two in order to increase soil moisture before seeding a crop. This practice tends to raise the water table by reducing moisture loss from evaporation and transpiration (ET) during the growing season. Salts that accumulate at or near the soil surface during periods of vegetative cover are subsequently flushed from the soil profile into the groundwater by precipitation falling on the fallow ground. Salts leached into the elevated water table often manifest as saline seeps down gradient in areas that may not have intercepted the water table when up-gradient fields had perennial vegetation.

4.1.2 Salinity Targets

Priest Butte Lakes (Freezout Lake WMA)

Beneficial uses associated with Priest Butte Lakes are primarily waterfowl production/management and agricultural uses. MFWP manages the Freezout Lake WMA and has made several unsuccessful attempts to develop a fishery in Priest Butte Lakes and currently has no plans to do so in the future (Personal Communication, Mark Schlepp, MFWP). Therefore, salinity targets for Priest Butte Lakes will be based on waterfowl management and agricultural support (i.e. livestock watering).

Tolerance of ducklings to salt water is age dependent and ducklings are more sensitive at young life stages (Barnes and Nudds, 1991). A recent study found that when mallard ducklings were exposed to water with approximately the same specific conductance as found in Priest Butte Lakes (i.e. 7,200 – 9,650 µS/cm) for 14 days, growth rates were reduced (Table 4-4). In addition, Swanson et al. (1984) found that drinking water in the range of 11,000 mg/L TDS was fatal to young Mallard ducklings (Table 4-5). Ducklings on saline lakes are associated with fresh water areas and may use avoidance of saline conditions for survival (Swanson et al., 1984).

Based on these toxicity studies, and others outlined in the National Irrigation Water Quality Program Information Report No. 3 (USDI, 1998), the in-lake salinity target for Priest Butte Lakes is proposed at, on average, less than 5,000 mg/L TDS (Table 4-6). Applying the relationship in Figure 3-1 to this TDS value a corresponding specific conductance of approximately 6,200 µS/cm is calculated. The associated reduction in average SC values amounts to an approximate 34% decrease for in-lake conditions as measured in the early 1990s (Table 4-2). The Priest Butte Lakes in-lake salinity target should afford protection of reproduction and food sources for most resident waterfowl. This range is also satisfactory for growth in all classes of livestock although it may cause temporary and mild diarrhea in livestock or be refused at first by animals not accustomed to these salinity levels (NAS, 1974).

Table 4-4. Effects of naturally saline drinking water on one-day old mallard ducklings (Mitcham and Wobeser, 1998).

Water Conductivity (µS/cm)	Salt Concentrations (mg/L TDS)		Length of Exposure	Effects
	Sodium	Magnesium		
3,750-7,490	512-911	195-639	14d	No apparent effect
4000	821	560	28d	Poor growth in last 2 weeks
7,720	1980	62	14d	Poor growth
20,000	2550	1310	14d	6 of 10 died, poor growth
21,500	3860	1300	14d	7 of 9 died
35,000	87900	1310	60h	100% mortality
67,000	12300	5260	30h	100% mortality

Table 4-5. Summary of comprehensive biotic effects of salinity (modified from USDI, 1998, Table 30).

Species	Salinity Concentration (mg/L TDS)	Effects
Mallard duck	~11,000	Reduced growth; fatal to young ducklings
	8,800-12,000	100 percent mortality
	9,000-12,000	No effect
	10,000-15,000	Level of concern
	15,000	100 percent mortality (7-day-old ducklings)
Mottled duck	9,000	Threshold level for adverse effects
	12,000	Reduced growth, 10% mortality
	15,000	90% mortality
	18,000	100% mortality
Peking duck	20,000	Level of concern

Table 4-6. Priest Butte Lakes Salinity Targets.

Location	Parameter	Existing Condition - Range	Existing Condition - Average	Desired Future Condition
In-lake	TDS (mg/L)			< 5,000
	SC (µS/cm)	7,200 – 9,350	8,360	< 6,200 [1]
Lake Discharge (Teton River at state Hwy 221 bridge)	TDS [1] (mg/L)	345 – 1,483	914	< 820 [2] < 1,145 [3]
	SC (µS/cm)	412 – 1,820	983	< 1,000 [2] < 1,400 [3]

[1] Calculated using desired future TDS level (5,000) and the regression equation in Figure 3-1.
[2] Average value measured from May 1 – September 30.
[3] Any instantaneous measured value.

Teton River

Salinity targets for the Teton River have been developed with the same approach as used in the Powder/Tongue River area of Montana (MDEQ, 2002d) but have been tailored to the Teton River watershed. Irrigation activities are the most sensitive use of water regarding salinity, however targets are also established with an upper threshold limit such that aquatic life beneficial uses will be protected throughout the year. Targets are established both for the general Teton River watershed irrigation season (May 1 to September 30), which is based on field irrigation and for the remainder of the year such that an upper threshold SC value is defined (Table 4-7).

Table 4-7. Salinity targets (TDS & SC) for the Middle and Lower Teton River.

Parameter	Value	Time of Year/Season	Value Description	Locations
Total Dissolved Solids (TDS) [1]	820 mg/L	May1 – Sept. 30 (irrigation season)	Seasonal Average	Hwy 221 Bridge Dutton Gage Loma Gage
Specific Conductance (SC)	1,000 µS/cm	May1 – Sept. 30 (irrigation season)	Seasonal Average	Hwy 221 Bridge Dutton Gage Loma Gage
Total Dissolved Solids (TDS) [1]	1,145 mg/L	All Year	Instantaneous maximum	Hwy 221 Bridge Dutton Gage Loma Gage
Specific Conductance (SC)	1,400 µS/cm	All Year	Instantaneous maximum	Hwy 221 Bridge Dutton Gage Loma Gage

[1] Calculated using regression equation in Figure 3-1.

The technical basis for the Teton River SC targets is contained in the draft water quality standards for specific conductance (SC) and sodium adsorption ratio (SAR) developed for the Tongue and Power River watersheds (MDEQ, 2002d) and is present in summary here. These standards are intended to protect riparian plants as well as plants and crops that are irrigated with water from the rivers and streams. Targets proposed here are intended to protect the riparian plants and crops growing in the watershed now and those that are likely to be grown in the future.

Specific conductance is a measure of the amount of dissolved solids ("salts") in water, which directly affect a plant's ability to take up water. The SC of the irrigation water directly affects the SC in the soil water and thus it is important to distinguish between the SC of the irrigation water and the SC of the soil water. The SC of the soil water may be higher than the SC of the irrigation water because the process of evaporation and plant transpiration (i.e. ET or evapotranspiration) removes water from the soil but does not remove salts. Unless salts are removed or leached from the soil by excess water, the concentration of salts in the soil will build up as irrigation water is added over time. As the SC in the soil water increases, a threshold is reached where further increases in SC cause decreases in plant growth.

Water applied to a given area of soil in excess of plant use and evaporation is termed the leaching fraction. This excess water may be supplied by irrigation and by precipitation. The portion of the water that is used by plants, or which evaporates, does not directly add to the leaching fraction. Irrigation or precipitation that occurs when soils are already at saturation, or that is stored in the soil when excess water is applied, does directly add to the leaching fraction.

A leaching fraction of 15% is considered a typical average for conventional sprinkler and flood irrigation and assumes that leaching is uniform throughout a field. In practice however, the leaching fraction is not uniform throughout a field and local impacts due to salinity can occur. Although these impacts cannot be quantified, they should be relatively minor. Soil EC increases as a result of the concentrating effect of evaporation and plant transpiration (ET) of irrigation water that leaves dissolved salts behind in the soil (Figure 4-9).

In the Teton River watershed most of the irrigation is done with conventional or modified flooding with some operators using sprinkler systems. Crops that are grown on a commercial basis include alfalfa, barley, wheat, and grass with alfalfa being the most prevalent crop (Personal Communication, Alan Rollo, TRWG Coordinator). Garden crops were also considered since the Teton River is used for irrigating small, local gardens plots. However, since gardens are more closely managed and plant symptoms of high soil EC and dehydration are similar, more irrigation water is easily applied to counter high soil EC. Given this management situation a greater leaching fraction (i.e. 30%) should be assumed for garden crops. Following the analytical process conducted by MDEQ (2002d) a leaching fraction of 30% would result in irrigation water threshold values similar to, or greater than, values calculated for alfalfa using a 15% leaching fraction. Garden crop values range from 1,216 to 1,316 μS/cm depending on the crop, but all fall below the 1,400 μS/cm upper level target established (Table 4-7). Thus, for purpose of establishing the Teton River salinity target alfalfa was the crop used.

Precipitation must also be considered to correctly calculate SC values for irrigation water that is protective of irrigated crops because of its diluting effect. In the Middle and Lower Teton River the average annual total precipitation is about 12 inches (USDA-SCS, 1977; Daly et al., 1997). According to DeMooy and Franklin (1977), the effective infiltration of precipitation in the region is about 80%. That is, some precipitation runs overland to the nearest drainage without soaking into the soil. This is especially true during thunderstorms, which are common in the region. An effective precipitation of 9.6 inches (0.8 X 12 = 9.6) is thus used for calculating the infiltrating rainfall correction factor in Equation 4-2.

The diluting effect of this precipitation is also dependent on the amount of irrigation water that is applied. Alfalfa requires approximately 24 inches of water for proper growth with a net irrigation need for of about 15 inches (Personal Communication, Stacey Eneboe, District Conservationist, USDA NRCS). The actual amount of water applied via irrigation is dependent on the irrigation system employed – sprinkler or flood. Flood irrigation is the prevalent method used in the watershed and more water is typically applied to fields than needed by the crop to account for inherent inefficiencies and the lack of application control relative to sprinkler systems. The amount applied to a field typically ranges from 25 to 30 inches, which is either enough to push water to the end of the field or is limited by ditch capacity (Personal Communication, Stacey Eneboe, District Conservationist, USDA NRCS). For purposes of calculations, 30 inches will be considered the depth of irrigation water in Equation 4-2. Thus, a rainfall correction factor of <u>1.32</u> is calculated for the area using Equation 4-2.

$$RCF = \frac{(Depth_{effectiveprecipitation} + Depth_{irrigationwater})}{Depth_{irrigationwater}} \qquad \textbf{Eq. 4-2}$$

Where:

$\mathrm{Depth}_{\mathrm{effectivepreciptation}}$ = 9.6

$\mathrm{Depth}_{\mathrm{irrigationwater}}$ = 30

RCF (Rainfall Correction Factor) = 1.32

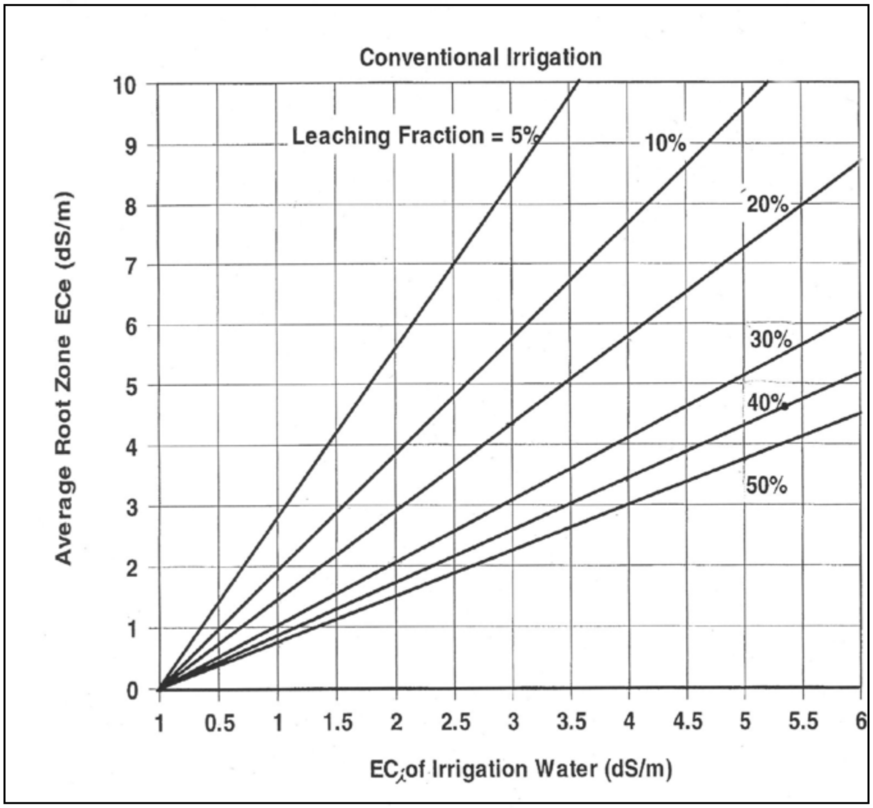


Figure 4-9. Relationship between leaching fractions, irrigation water, and soil water SC (adopted from Hansen et al., 1999).

When deriving the SC target for the irrigation season consideration was given to the type of crops being irrigated in the watershed, the sensitivity of the plants to SC, the amount or magnitude of leaching fraction, and the precipitation correction factor that should be applied. Plant or crop yields begin to decrease when thresholds are exceeded. Alfalfa is the most prevalent and sensitive field crop grown in the middle and lower Teton River. The soil water SC threshold of alfalfa is 2,000 μS/cm (MDEQ, 2002d). On Figure 4-9, a line is drawn horizontally at the 2 dS/m level of root zone ECe (i.e. soil water) to where is would intersect the 15% Leaching Fraction line at approximately 1.3 dS/m EC of Irrigation Water. The value of 1,320 μS/cm (or 1.3 dS/m) is also referenced in Technical Basis for Draft EC and SAR Standards (MDEQ, 2002d). The maximum SC value for river water without affecting alfalfa yields is calculated at 1,716 μS/cm (1,399 mg/L TDS) by multiplying the 1,320 μS/cm irrigation water value from Figure 4-9 by the precipitation correction factor of 1.32 calculated using Equation 4-2.

However, irrigated agriculture is only one of the beneficial uses of rivers and streams in the Teton River watershed. Benthic aquatic life is also sensitive to elevated salinity levels in streams Klarich and Regele (1980). Although research is limited concerning the affect of salinity on aquatic life, one relevant study conducted in SE Montana (Klarich and Regele, 1980) indicates that as SC levels increase, sensitive species are eliminated while more SC-tolerant species increase in abundance. Thus, while the overall abundance of macroinvertebrates may not change, the diversity, or taxa richness, of the aquatic biota does change.

Klarich and Regele (1980) compared macroinvertebrate population diversities using Shannon-Weaver and Margalef Indexes (Shannon and Weaver, 1964; Margalef, 1952) on A-, B-, and C-class stratified waters. A-class waters were noted as unstressed with an excellent biological health, B-class had mild environmental stress with good biological health, and C-class had moderate environmental stress with fair biological health. Mean SC values for A-, B-, and C-class waters were reported as 1,135, 2,580, and 3,215 µS/cm, respectively. The authors found the difference in mean SC values between A- and C-class waters were statistically significant using a least significant difference multiple comparison at less than 5% ($t_{31} = 3.06$).

Klarich and Regele (1980) also grouped macroinvertebrate data based on stream salinity values as opposed to a diversity index. Streams were segregated based on instream biotic reference criteria suggested by McKee and Wolfe (1963) at 2,400 µS/cm and by the NTAC (1968) at 1,800 µS/cm. This analysis suggested that the 1,800 µS/cm criteria would be better at determining mild salinity stress in streams since the mean Mergalef Index values differentiated between A- and B-class waters. The authors also developed a regression equation based on the relationship of mean Mergalef Index diversity values and SC. This equation suggests a range of SC values of 1,325 to 4,750 µS/cm for B-class waters (e.g. mild environmental stress with good biologic health) with a correlation coefficient of $r = -0.46$ ($n=35$).

Finally, another study (Mount et al., 1997) suggests that chronic toxicity to fresh water crustaceans and minnows can begin to occur with in the range of 1,200 to 1,800 µS/cm. The point at which toxicity manifests, however, is dependent on individual ionic concentrations of the water.

Evaluating the needs of both irrigated agriculture and aquatic biota, a maximum in-stream SC <u>not to exceed</u> target of 1,400 µS/cm is proposed that would be applied to all monitoring stations at anytime of year (Table 4-7). The target was determined by taking 1,500 µS/cm and subtracting a 100 µS/cm as a margin of safety to arrive at the 1,400 µS/cm value. The 1,500 µS/cm value was derived using the <u>general</u> mid-point of the available research (Klarich and Regele, 1980; Mount et al., 1997) for aquatic biota and the irrigation target for alfalfa of 1,716 µS/cm calculated above. In addition, the instream salinity target of 1,000 µS/cm, established in the 1999 Teton River TMDL (MDEQ, 1999), is maintained as the <u>seasonal average</u> measured from May 1 to September 30 (Table 4-7).

Specific conductance targets for the Teton River are based on information derived from data sets that are limited in their geographic scope (Klarich and Regele, 1980; Mount et al., 1997). An adaptive management approach that includes further monitoring and analysis of the relationship between salinity affects on aquatic biota is strongly suggested. In addition, analysis of the salinity tolerance of important riparian vegetation species would be beneficial in evaluating SC target levels. As new and additional data is collected and analyzed, salinity targets for the Teton River relative to fisheries, aquatic life, and riparian vegetation should be reviewed.

4.1.3 TMDLs

The focus of the 1999 Salinity TMDL for the Teton River (MDEQ, 1999) was on TDS loading from Priest Butte Lakes and stipulated a specific target of not to exceed 1,000 µS/cm as measured at Montana State Highway 221 bridge (Figure A-4). This document looks to address salinity from a watershed perspective and incorporates data collected since the completion of the 1999 TMDL.

During the development of salinity targets and TMDL for waters in the Teton River watershed all relevant and valid data were evaluated. These data were collected by MFWP during the operational management of Priest Butte Lakes, USGS, MDEQ, and volunteers from the TRWG. Based on analysis of these data, it is apparent the existing TMDL is being met only 56% of the time. However, the average SC values do meet the 1,000 µS/cm target (Table 4-2). Water quality samples taken in the Teton River above the Priest Butte Lakes discharge and in the Muddy Creek drainage indicate that salinity levels are below the 1,000 µS/cm target threshold (Figures B-1a, B-1c). Although there are no data for the lower reaches of Muddy Creek, data collected by MDEQ in the Teton River above and below the Muddy Creek confluence do not show a change in ambient SC (Figure B-1a). This would indicate that Muddy Creek has, at least, equivalent water quality (in terms of total dissolved solids) as the Teton River or was dewatered during the July/August sampling period.

Salinity targets were developed that will support existing beneficial uses in Priest Butte Lakes and the Teton River (Tables 4-6 and 4-7) as well as the delicate balance that exists between Freezeout and Priest Butte Lakes. Translated to TMDLs these targets can be expressed as a percent reduction in SC or TDS concentration from current existing conditions to desired future conditions (Table 4-8). *Concentration-based* reduction targets are functionally equivalent to *load-based* reduction targets, in that a load is a *function* of concentration and flow. Therefore, any percent reduction in concentration at a given flow level would have an equivalent reduction in load. The percent reductions in Table 4-8 would be the same if presented as a load, and would be less understandable to local landowners/managers or field monitoring staff.

For the Teton River, the salinity target is expressed as the season average of less than 1,000 µS/cm (May 1 to September 30) with no instantaneous measurement to exceed 1,400 µS/cm. Currently this target is being met and thus no reduction is necessary, however, maximum values have been recorded greater than 1,400 µS/cm and thus a 23% reduction is needed at State Highway Bridge 221 for Priest Butte Lakes discharge and a 14% reduction is needed in maximum values as recorded at the USGS gaging station near Loma (Table 4-8).

In addition to the salinity TMDL for the Teton River, a TMDL for Priest Butte Lakes is assigned even though the current 303(d) list does not have it listed specifically for salinity. The target, as stated in Section 4.2.2, is based on support waterfowl, for which the lake is currently being managed (Personal Communication, Mark Schlepp, MFWP). The associated in-lake TMDL for Priest Butte Lakes is presented as a 34% reduction from the current average SC levels (Table 4-8).

Managing the salinity levels in both the Freezout/Priest Butte Lakes WMA and its receiving water – the Teton River – is a delicate balance. In addition to managing the loading of salts to the lake/wetland system, enhancing instream flows in the middle Teton River below the Deep Creek confluence would afford greater flexibility toward this goal (Personal Communication, Mark Schlepp, MFWP).

Table 4-8. Salinity TMDLs Priest Butte Lakes and Teton River.

Location	Parameter	Existing Condition: Average	Existing Condition: Maximum	Desired Future Condition	TMDL as Percent Reduction [4]
Priest Butte Lakes: In lake	TDS (mg/L)			< 5,000	
	SC (µS/cm)	8,360	9,350	< 6,200 [1]	34 %
Priest Butte Lakes: Discharge @ Hwy 221	TDS[1] (mg/L)	914	1,483	< 820 [2] < 1,145 [3]	0 % 23 %
	SC (µS/cm)	983	1,820	< 1,000 [2] < 1,400 [3]	0 % 23 %
Teton River (USGS gage near Loma)	TDS [1] (mg/L)	890	1,320	< 820 [2] < 1,145 [3]	8 % 14 %
	SC (µS/cm)	1,085	1,620	< 1,000 [2] < 1,400 [3]	8 % 14 %

[1] Calculated using desired future condition TDS and the regression equation in Figure 3-1.
[2] Average value measured from May 1 – September 30.
[3] Any instantaneous measured value.
[4] Calculated as the percent reduction from average or maximum of existing condition, as appropriate, to desired future conditions.

4.1.4 Seasonal Variation

The salinity targets for Priest Butte Lakes and the Teton River are meant to be protective of irrigated agriculture, aquatic biota, and waterfowl production/habitat. To that end, instream salinity (SC) targets are geared to the general irrigation season of May 1 to September 30, where SC concentrations during this period must average 1,000 µS/cm or less. In addition, to be supportive of fisheries and aquatic biota the maximum, instantaneous SC concentration may not exceed 1,400 µS/cm at any time or location throughout the year.

4.1.5 Allocation

Saline seeps manifest in areas down gradient of locations where landuse practices (i.e. dryland farming and crop/fallow) that elevate natural groundwater levels occur on salt-rich soils and geologic parent material. Soils in the Teton River watershed with EC values greater than 2 mS/cm (2,000 µS/cm) include Trudau and Marcott (4 mS/cm), Haploborolls and Argiborolls (8 mS/cm), and Lardell (33 mS/cm). Geologic formations with elevated salt levels include Colorado Shale (Figure A-2) and the quaternary glacial drift and glacial lake deposits east of Priest Butte Lakes (Figure 4-8).

Priest Butte Lakes

Within the Priest Butte Lakes watershed the two sources of dissolved salts that have associated field data are the Yeager seep and Freezeout Lake discharge. Other sources include the intermittent drainages below the Cascade Canal, small drainages on the northeast side of the lake, and shallow groundwater flow. However, these later three sources have no associated field data with which to assess the relative magnitude of their contribution. Therefore, the full TMDL allocation for TDS to Priest Butte Lakes is assigned to Yeager seep and Freezeout Lake. Each source needs to be reduced by 34% (Table 4-9).

Salinity loading allocation to Priest Butte Lakes should be managed using an adaptive management scheme. This approach would review and update the loading allocations defined in Table 4-9 when new and additional data is collected quantifying loads from all sources to the lake. The loading burden may shift, as appropriate, from the current quantified sources to other significant sources while maintaining the minimum necessary reduction in loading to achieve in-lake salinity targets.

Table 4-9. Loading Allocation for Salinity (TDS) in Priest Butte Lakes.

Source	**Existing Load [1] (lbs/day)**	**Allocation (lbs/day)**	**Load Reduction (lbs/day)**
Freezeout Lake Discharge	83,500	55,000	28,500
Yeager seep	15,000	10,000	5,000
West Side drainages/seeps	?	To be determined	?
East Side drainages/seeps	?	To be determined	?
Shallow Groundwater	?	To be determined	?

[1] existing loads are calculated using Equation 4-1 in Section 4.1.1.

General Teton River Watershed

The dominant geologic parent material in the lower two thirds of the watershed (roughly from Choteau east) consists of the Colorado Shale formation (Figure A-2). Dryland farming is the most prevalent land use or agricultural practice in the middle and lower Teton River (Figure A-9a) and is also very common in the Muddy Creek watershed (Figure A-9b). In addition, flood irrigation also leads to increased shallow groundwater flow, which contributes to increased saline seeps and salinity loading to streams and coulees. Soil EC values typically increase in areas down gradient of dryland farming areas and irrigated acres (Figures A-13a). Specifically, note the darker red colors located in the northeast corner of the Teton River watershed, along the south central portion of the watershed in Teton County (i.e. Teton Ridge area), surrounding Priest Butte Lakes, and in the Deep Creek - Willow Creek sub-watershed in Figure A-13a. These locations are concentrated along coulee and stream bottoms and are surrounded by areas of dryland cropping (Figure A-9a). SC values in the middle and lower Teton River are greater than 1,000 µS/cm downstream of each of these locations (compare Figures A-13a and B-1c).

The Muddy Creek sub-watershed also has large areas high soil EC values (Figures A-13a), which concentrate near regions of dryland cropping or irrigated fields (Figures A-9b).

Reduction in river SC levels in the middle and lower Teton River is allocated to agricultural lands employing practices that elevate soil water levels and/or increase shallow groundwater flows (i.e. dryland cropping and flood irrigation). This allocation is supported by the spatial location of high soil EC and these agricultural practices evident in Figures A-9a, A-9b, and A-13a. However, the amount of acreage in these areas that would need to alter land management practices to insure instream SC values are reduced to below the 1,000 and 1,400 µS/cm targets is uncertain at present. It is recommended that an adaptive management approach be employed. Meaning that all opportunities for positive changes in land management, in terms of reducing salinity loading, be implemented wherever they can be identified beginning with the most economical alternatives. Additional measures may be needed as necessary if monitoring data suggests that targets are not yet being attained.

4.1.6 Margin of Safety

Salinity targets have built in to them explicit margins of safety for Priest Butte Lakes where the in-lake reduction target of 34% is sought via load reductions from both Freezeout Lake and Yeager seep. Additional reductions should also be gained from adjustments in agricultural and irrigation practices in the other small drainages on east and west side of the lake. The Teton River salinity not-to-exceed target of 1,400 µS/cm was set 100 µS/cm below the general mid-point of the reported literature values where chronic toxicity to crustaceans begins to be manifested or shifts in the aquatic biota are evident. This value is also below calculated threshold levels adverse to alfalfa, which is the dominant irrigated crop in the Teton River watershed. Support of beneficial uses should thus be achieved once all reasonable land, soil, and water conservation practices for related to dryland and irrigated agriculture have been implemented.

4.2 Selenium

Selenium is an element that is an essential mineral in trace amounts but becomes toxic at greater concentrations. Once dissolved in surface water or groundwater and delivered to a wetland or lake ecosystem, selenium can bioaccumulate in the food chain.

4.2.1 Existing Conditions and Source Assessment

Priest Butte Lakes is the only water body in the Teton River watershed listed with a water quality impairment due to selenium. Between 1990 and 1992, the U.S. Geological Survey studied selenium in glacial lake deposits, wetlands, and biota of the Freezout Lake Wildlife Management Area, which includes Priest Butte Lakes (Nimick et al., 1996). The report identifies surficial glacial-lake deposits and Colorado group geology surrounding the lakes as the primary source of selenium loading to the Freezout Lake WMA. Kendy et al. (1999) also confirmed these findings. These geologic deposits/formations also surround Priest Butte Lakes with the glacial-lake deposits laid over the Colorado group on the eastern and northern sides of the lake (Figures 4-7 and 4-8).

Four water quality samples of the lakes' water column taken near the south end of Priest Butte Lakes between April 1991 and June 1992 found total recoverable selenium concentrations as high as 15 µg/L and an average concentration of 11µg/L (Lambing et al., 1994). Individual sample values were 9, 9, 11, and 15 µg/L. By comparison, selenium concentrations measured in Freezeout Lake pond 1, near the pond's discharge outlet to Priest Butte Lakes, were only 1 µg/L (n=2). This sharp increase in selenium concentration measured in the Priest Butte Lakes' water column indicates significant loading is coming from other sources as opposed to strictly from the Freezeout Lake pond 1 discharge and the concentrating effects of evaporation (Nimick et al., 1996).

The USGS study also measured total recoverable selenium concentration in the surface waters of the "seep east of Priest Butte Lakes" (i.e. Yeager seep). The average total recoverable selenium from 5 samples collected between April 1991 and May 1992 was 876 µg/L, with sample values ranging from 720 to 1,000 µg/L (Lambing et al., 1994, Table 14, pg 71). The study estimated that the seep accounted for about 12% of the annual total selenium load to the Freezout Lake WMA as a whole (Figure 4-10), which was primarily a result of the extremely high concentrations in the seep water. Flow from the seep was noted as relatively small (0.1 – 0.2 cfs) but generally sustained (Nimick et al., 1996). Overall, the seep accounted for just 0.5% of the total annual inflow to the entire Freezeout/Priest Butte Lakes lake/wetland complex. By comparison, this seep represented the major source of selenium loading from non-irrigated lands in the Freezout Lake WMA. Since none of the land surrounding Priest Butte Lakes is irrigated, the seep is considered to be a major source, if not the greatest source, of selenium loading to Priest Butte Lakes when viewed on its own.

Additional seeps along both the east and west sides of the lake are evident from aerial photos (Figures 4-4 and 4-5). Given that land use and/or geology around the lake are similar (Figures 4-3 and 4-8) it is reasonable to suspect that some amount of selenium loading occurs from surface water sources other than the Yeager seep. In addition, shallow ground water is also a likely source of selenium to the lakes. However, at present the only documented and quantified selenium source to Priest Butte Lakes is the Yeager seep. A monitoring strategy is recommended in Section 6 that is geared to collect data and characterize these other potential sources.

4.2.2 Targets

The selenium target for Priest Butte Lakes is set at Montana's aquatic life chronic water quality standard for selenium, or 5 µg/L, which is defined as a calculated 96-hour average (MDEQ, 2002b). However, where only one sample is available during any 96-hour period, it may be assume that this sample is representative of the 48 hours preceding and following the sampling event (MDEQ, 2002a, Appendix A, Table 9). The target is to be measured in the lake's water column at the monitoring location (S-34) established by the USGS in the early 1990's (Lambing et al., 1994).

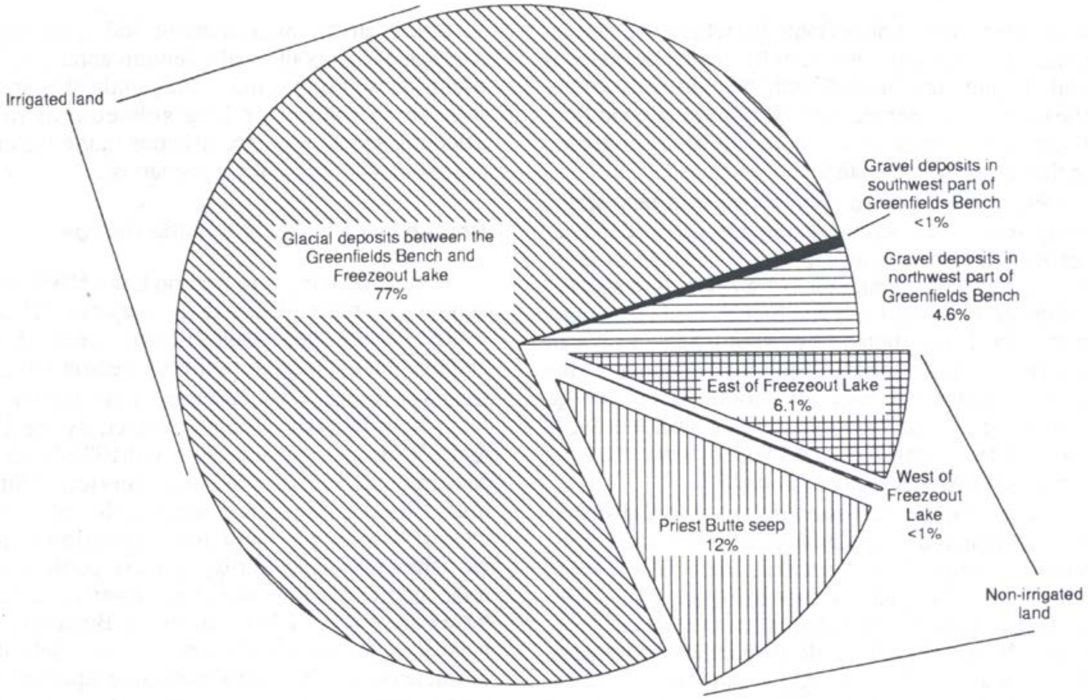


Figure 4-10. Percentage of total estimated annual selenium loading to Freezout Wildlife Management Area. The Yeager seep is denoted here as "Priest Butte seep." (Figure 34 from Nimick et al., 1996, pg 71.)

4.2.3 TMDLs

The USGS (Nimick et al. 1996, pg 78) estimated the Priest Butte Lakes in-lake selenium concentration based on a loading rate from the available monitoring data and four simplifying assumptions:

1) The lake has a constant volume of 3,360 acre-ft (480 acres with an average depth of seven feet);
2) The initial Priest Butte Lakes water column selenium concentration is 1 µg/L, which is equivalent to the measured concentration in Freezeout Lake pond 1 that drains into Priest Butte Lakes;
3) The Yeager seep and outflow from Freezeout Lake pond 1 are the only sources of selenium to Priest Butte Lakes;
4) Selenium is chemically conservative (non-reactive) in the lake water.

Based on a loading rate from the seep of 172 lbs/yr (0.471 lbs/d) the resultant water column concentration would be 20 µg/L for Priest Butte Lakes. However, the measured selenium concentrations in Priest Butte Lakes have ranged from 9 to 15 µg/L (average 11 µg/L), so either there are inaccuracies in the data used in the calculation or, more likely, selenium is not completely conservative in Priest Butte Lakes.

Calculation of the selenium TMDL for Priest Butte Lake must, at present, also rely on the available data from the USGS study in the early 1990's and the selenium target set at Montana's numeric aquatic life chronic criteria (5 µg/L). The average in-lake water column selenium concentration recorded has been 11 µg/L, which is a factor of 2.2 greater than the numeric standard (target in-lake water column concentration) of 5 µg/L. Since the only existing, quantified source is the Yeager seep, the initial TMDL will be based solely on its load. Appling the same set of assumptions as stated above, a load reduction in the Yeager seep's estimated load (172 lbs/yr) by 2.2 would result in an annual load of 78.2 lbs/yr, or 0.214 lbs/d.

However, given uncertainty in the simplifying assumptions and the low number and age of samples available, the initial TMDL will be calculated based on the maximum concentration measured. The maximum in-lake water column selenium concentration of 15 µg/L, is a factor of 3 greater than the target in-lake water column concentration of 5 µg/L. Reducing the Yeager seep's estimated load of 172 lbs/yr by a factor of three would result in a load of 57.3 lbs/yr, or 0.157 lbs/d (Table 4-10). When other sources are quantified, and all sources are put into relative context, the TMDL present in Table 4-10 will be adjusted.

Table 4-10. Selenium TMDL for Priest Butte Lakes.

Loading Sources	**Annual Load (lbs/yr)**	**Daily Load (lbs/d)**
Natural Background	Unknown	Unknown
Yeager seep [1]	172	0.471
Other identified potential sources	Unknown	Unknown
Total **Known** Load	172	0.471
Load Reduction	-114.7 (66.7%)	-0.314 (66.7%)
Total Maximum Daily Load	**57.3**	**0.157**

[1] Nimick et al., 1996

4.2.4 Seasonal Variation

Nimick et al. (1996, pg 64) indicates that there are no consistent differences between in-lake selenium concentrations during different hydrologic periods - spring (pre-irrigation) and summer (irrigation). Therefore, no seasonal variation in the selenium TMDL appears to be warranted.

4.2.5 Allocation

Sources of selenium to the Freezout Lake WMA and Priest Butte Lakes have been documented by the USGS (Nimick et al., 1996) and tend to mirror the salinity sources described in Section 4.1.1. The Yeager seep (Figure 4-4) has been identified the major source of selenium loading from non-irrigated lands to the Freezout Lake WMA (Figure 4-10). Given that all the lands surrounding Priest Butte Lakes are non-irrigated, the seep must be considered one of the primary, if not the most significant, sources of selenium to Priest Butte Lakes.

Additionally, given that the only quantified source of selenium to Priest Butte Lakes is the Yeager seep, 100% of the load reduction is allocated to this source at this time (Table 4-11). An adaptive management plan is recommended (refer to Section 6) such that monitoring is conducted to better define other source loading into the lake. Similar to salinity, other seeps and drainages around the lake, as well as groundwater flow, may contribute selenium and warrant a load allocation. When selenium loading from other sources is identified and quantified, an appropriate percentage of the present load allocated to the Yeager seep would be reallocated, thus reducing the burden placed at present on the Yeager seep.

Table 4-11. Loading Allocation for Selenium to Priest Butte Lakes.

Source	**Existing Load (lbs/year)**	**Allocation (lbs/year)**	**Load Reduction (lbs/year)**
Yeager seep [1]	172	57.3	114.7
Freezeout Lake Discharge [2]	Unknown	To be determined	To be determined
West Side drainages/seeps [2]	Unknown	To be determined	To be determined
East Side drainages/seeps [2]	Unknown	To be determined	To be determined
Shallow Groundwater [2]	Unknown	To be determined	To be determined

[1] existing load from Nimick et al. (1996)
[2] refer to Section 6 for monitoring plan discussion

4.2.6 Margin of Safety

The TMDL for selenium is stated as “not to exceed five µg/L.” Montana’s aquatic life chronic water quality standard is set at 5 µg/L (96-hour average) and the acute water quality standard is 20 µg/L. The target of 5 µg/L is set to ensure that the aquatic life and fisheries beneficial uses are consistently supported. Moreover, to be conservative, and error toward a worst-case scenario, the TMDL was calculated using maximum in-lake concentration value instead of average value. In addition, an adaptive management strategy is presented in Section 5 (Table 5-2) that establishes a set of practices that should be implemented with the goal of ultimately reducing selenium loading to target levels.

4.3 Sediment

Two different, yet related, impairment issues on the Montana 303(d) list are addressed under the guise of sediment - siltation and suspended sediment. Siltation refers to situations where a stream’s sediment load has exceeded its capacity, or competence, to transport it. Excessive fine sediments, sand-sized or smaller particles, are deposited in the spaces surrounding gravel-sized or larger substrate and in pool areas. Coarse sediments, gravels and cobbles, are deposited on the stream bottom and/or flood plain aggrading the channel bed.

Gravel-sized particles in pool-tail outs and riffles comprise critical aquatic habitats for both fish and macroinvertebrates. Many species of fish use pool-tail outs for spawning while riffle areas provide the primary living area for macroinvertebrates - the primary food source for fish. Pools are deeper areas in streams with slower velocities and cooler temperatures, which provide critical holding and hiding areas for fish. Siltation reduces inter-gravel oxygen levels, pool volume, and thus the holding capacity, which can lead to increased stress in the fisheries due to overcrowding, heat-related stress, and increased competition.

In a stable river the grade, or slope, is delicately balanced over a long time period based on the amount of stream flow and sediment supply (Leopold et al., 1964; Rosgen, 1992). When this balance is disrupted by changes to stream flow and/or sediment supply, instability in the channel form results (Rosgen, 1992; 1996). Deposition of excessive coarse sediments, relative to stream flows, results in channel aggradation, lateral instability and bank erosion, and a decrease in stream power necessary to transport sediments (Rosgen, 1992). The shift in stream pattern and form is then to a wider and shallower stream channel that is laterally unstable, and may shift its location in the flood plain when higher flows occur.

Suspended sediment refers to small, clay-sized particles that are transported in the water column. Turbidity, the cloudiness of water, is often used to measure suspended particles of all kinds: silt, clay, organic particles, and colloids. Suspended sediment can clog fish gills, limit the ability of fish to find food, reduce available sunlight to submerged vegetation, and cause excessive wear to irrigation pumps.

In addition, adequate stream flows (i.e. bankfull or flood flows) are critical to a stream’s ability to transport sediments while healthy riparian areas, with natural vegetative communities, are important for a stream “system” to withstand these high stream flow and maintain stable banks. Flow alteration, riparian degradation, and/or “other habitat alterations” have an influence on the sediment regimes of streams and will be addressed in this section of the water quality management plan.

Montana’s 1996 303(d) lists the following segments for siltation: the middle and lower Teton River, Clark Fork of Muddy Creek, Deep Creek, Willow Creek, Blackleaf Creek, Bynum and Eureka Reservoirs and the following segments for suspended sediment: the middle Teton River and Deep Creek (Table 3-1). The upper Teton River and lower Blackleaf Creek will be included due to flow alteration, riparian habitat degradation, and/or bank erosion listings (Tables 3-1 and 3-2). Section 3.0, “Existing Water Quality Concerns and Status,” outlines the current beneficial use support determinations (Table 3-2) along with textual discussion as to the basis for use support determinations relative to sediment-related issues (Section 3.3.1).

4.3.1 Existing Conditions and Source Assessment

Sources related to or influencing sediment production in the watershed will be discussed in terms of two geographic areas – the upper Teton River watershed (headwaters to Deep Creek) and the remainder of the watershed, which includes the middle and lower Teton River, and Deep, Willow, Teton Spring, Lower Blackleaf, and Muddy Creeks. Rationale for this breakout is that there are some specific physical processes affecting the sediment regime in the upper Teton that are not relevant to the remainder of the watershed. Sediment issues in the remaining areas of the watershed are all generally similar in nature.

An aerial flight cataloging water quality threats and sources of sediment was conducted in 1998 (Hawn et al., 1998). The assessment flight covered the Teton River, and most of Muddy Creek, Deep Creek, and Willow Creek cataloging eroding banks, unhealthy riparian areas, aggraded channels, (naturally) sloughing banks, and channelized stream (Tables 4-12 and 4-13) as well as point impacts to the riparian corridor or stream channel (Table 4-14). Distances and points were located and mapped using GPS from a flight altitude of approximately 200-300 feet at speeds of 20 – 60 mph (Hawn et al., 1998). GPS data was brought into a GIS environment where point and line features were translated into spatially relevant point and arc features that could mapped and evaluated using GIS tools. The GIS (ArcView) project also identifies locations where channels are braided or incised as well as the linear extent of riprap sites, which are not included in the summary Tables 4-12 or 4-13. Linear distances reported likely underestimate the actual lengths of disturbance features due to mapping inaccuracies (Figure 4-11). It is assumed that the extent of unstable channels, eroding banks, and degraded riparian areas is greater than that reported. Moreover, the assessment did not provide any measure or quantification of unstable/eroding bank heights or relative magnitude of impairment/impact. Thus, the value of this assessment is in the identification of unstable and/or degraded areas. Each section will need additional, more detailed evaluation and assessment prior to crafting site-specific designs for stabilization or revegetation.

Table 4-12. Length and number of reaches assessed with unstable channels or unhealthy riparian areas (Hawn et al., 1998).

Waterway	**Total Length Assessed** [1]	**Bank Erosion**	**Unhealthy Riparian**	**Aggraded Channel**	**Mass Bank Sloughing** [2]	**Channelized**
Teton River	182.6	56.2 (266)	67.0 (56)	23.6 (1)	16.8 (82)	0.4 (3)
Muddy Creek	62.2	54.2 (21)	44.2 (8)	N/A	N/A	N/A
Deep Creek	32.0	11.3 (9)	6.1 (6)	N/A	N/A	N/A
Willow Creek	17.7	4.9 (13)	N/A	N/A	N/A	N/A
Total	**294.5**	**126.6 (309)**	**117.3 (70)**	**23.6 (1)**	**16.8 (82)**	**0.4 (3)**

[1] Length is for only the stretch of river covered during the assessment in statute miles.
[2] Authors defined these banks conditions as “natural” erosional features.
- (#) Indicates the number of stretches identified for a given disturbance type.
- N/A indicates that no stretches were identified for this disturbance type.
- Row totals may exceed Length Assessed total due to parameter overlap.

Table 4-13. Impacts to stream channels and riparian areas by percent of assessed stream length (Hawn et al., 1998).

Waterway	Total Length Assessed [1]	Bank Erosion	Unhealthy Riparian	Aggraded Channel	Mass Bank Sloughing [2]	Channelized
Teton River	182.6	30.8%	36.7%	12.9%	9.2%	0.2%
Muddy Creek	62.2	87.1%	71.1%	N/A	N/A	N/A
Deep Creek	32.0	35.3%	19.1%	N/A	N/A	N/A
Willow Creek	17.7	27.7%	N/A	N/A	N/A	N/A
Total	**294.5 mi**	**43.0%**	**39.8%**	**8.0%**	**5.7%**	**0.1%**

[1] Total length is expressed as that stretch covered during the assessment in statute miles.
[2] Hawn et al. defined these banks conditions as “natural” erosional features.
- N/A indicates no stretches were identified for this disturbance type.
- Row totals may exceed Length Assessed total due to parameter overlap.

Table 4-14. Point impacts/threats to riparian areas or stream corridor (Hawn et al., 1998).

Point Classifications [1]	Teton River	Muddy Creek	Deep Creek	Willow Creek	Total
Dump Site	2	---	---	---	2
Headcut	12	---	---	---	12
Irrigation Diversion	9	6	8	5	28
Pump Site	1	---	2	2	5
Return Flow	---	1	---	---	1
Instream Structure	1	---	---	---	1
Bridges & Crossings	21	9	3	2	35
Car Bodies	3	---	1	---	4
Riprap	9	---	3	1	13
CAFO [2]	---	---	---	1	1
Total	**58**	**16**	**17**	**11**	**102**

[1] Specific locations where a particular disturbance was observed and recorded.
[2] Confined Animal Feeding Operations
- "---" indicates no points were identified for this disturbance type.

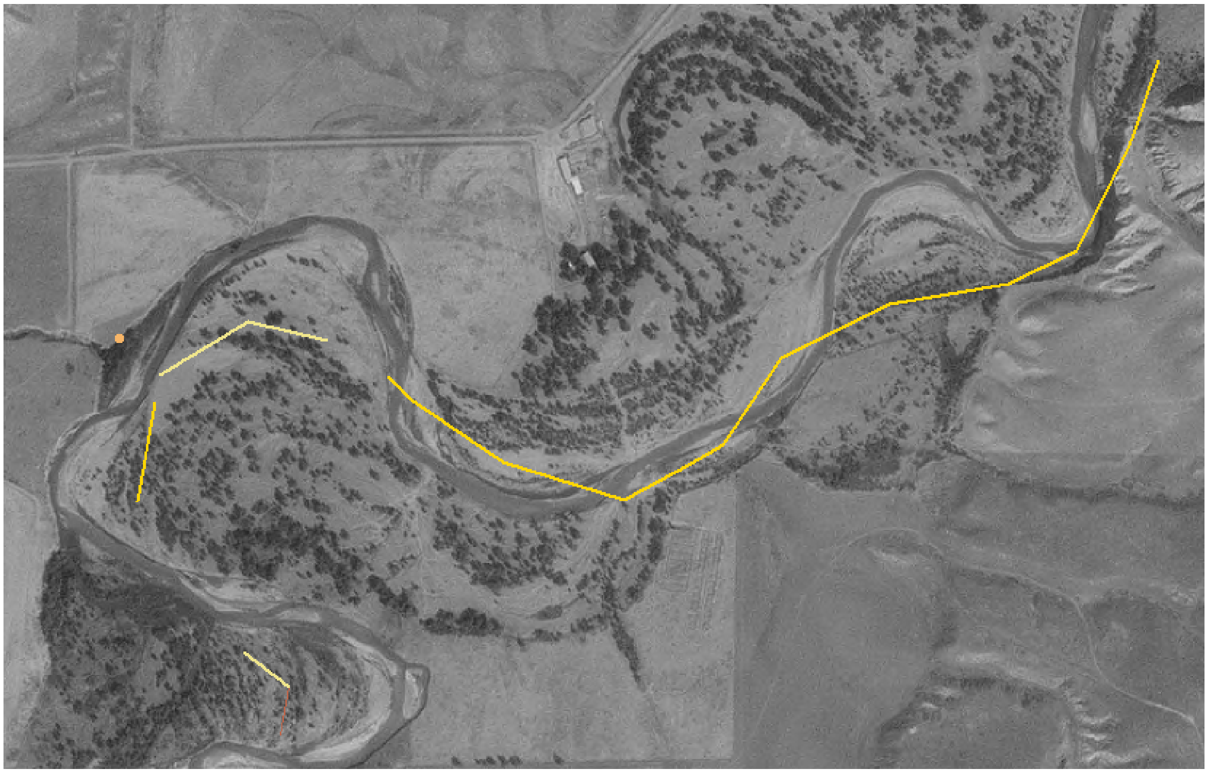


Figure 4-11. An example of linear feature mapping from the rapid aerial assessment and characterization (Hawn et al., 1998). Refer to text for greater explanation. Photo scale is approximately 1:7,000.

Upper Teton River Watershed

This section references the Teton River watershed from the headwaters down to the confluence of Deep Creek. The upper Teton River is the only stream segment in this portion of the watershed listed on the 303(d) lists (Figure A-10b).

Headwaters for the Teton River emanate from the Rocky Mountain Front along the extreme western edge of the watershed (Figure A-1). Cordilleran (mountain) glaciers of the Wisconsin glaciation (18,000 to 12,000 years BP) largely shaped the current valleys and ridges of this overthrust belt, with glacial lobes pushing out approximately eight to ten miles onto the plains (Keller, 2001). The tilted beds of this overthrust area are moderately to highly erosive (Figure A-13b) and, with steeper valley and stream gradients, is the source of a large annual load of coarse sediments. These sediments are transported from the mountain valleys out onto the plains during high flow/snow melt events where they are deposited as the valley (and stream) gradient lessens. The soils along the stream course from a point roughly five miles east of the front downstream to the mouth of the watershed also have higher relative erodibility as noted by the soils "Kw-factor" (Figure A-13b). The soil K-factor is "*an erodibility factor which quantifies the susceptibility of soil particles to detachment and movement by water*" where the Kw-factor "*adjusts for the effect of rock fragments*" (NRCS, 1995).

Sediment deposited in the stream channel would be naturally transported downstream through the watershed during subsequent high flow events, however this process is severely interrupted as a direct result of human works and activities. At least seven instream structures for water diversion impact the sediment transport and flow regimes of this part of the river (Watershed Consulting, 1999).

The upper Teton River was evaluated for channel morphology, stability, and restoration priorities in 1992 (Rosgen, 1992). Rosgen provided a detailed discussion concerning stream channel response to the excessive sediment load (relative to stream flow) and how these two issues relate and interact. The primary destabilizing events identified were the floods of 1964 and 1975 (Rosgen, 1992). Although these events were of no doubt significant in their magnitude, the impact to the stream channel and riparian corridor was undoubtedly exasperated by more than 100 years of human activities in the riparian area that weakened its resiliency. These activities include riparian grazing, timber harvesting, road and bridge construction, and agricultural practices. In fact, during the 1964 flood the river braided around the “South Fork” bridge crossing, just below the North and South Fork confluence, leaving it stranded between two stream channels (Personal Communication, Alan Rollo TRWG Coordinator).

The subsequent result of these high-flow events on the Teton River was to deliver a vast amount of coarse sediments to the stream channel and erode stream banks that were previously weakened or less resilient to large flood flows. Instability created by this excessive sediment load is compounded by both instream diversion structures (Figure 4-12) (Rosgen, 1992), as well as greatly reduced stream flows. Diversion structures on the upper river (depending on their design) may capture bedload, which generates both a backwater effect behind the structures, as well as “hungry-water” downstream due to the reduction in the stream’s sediment load. Hungry-water actively recruits new sediments by eroding into the stream bottom sediments and stream banks. This is a natural response for streams deprived of their sediment loads by dams or diversion structures (Collier et al., 1996). Diminished stream flows due to water diversions reduces the ability of the stream channel to heal itself by regaining a more appropriate dimension, pattern, and profile accomplished with periodic bankfull or channel forming flows. Diversion of spring runoff to fill irrigation reservoirs does not allow for these channel-forming events to occur that would begin to move stored sediment out of the upper river and reshape it into a more sinuous single thread stream characterized by a Rosgen C-type channel.

The destabilizing effects of the large flow events on this section of river, combined with the continued influence of greatly reduced stream flows and unhealthy riparian vegetative communities has resulted in a D-3 classification (Rosgen, 1992; 1996). The Teton River would be a C-3 channel type if it were functioning properly with a stable channel dimension, pattern, and profile (Rosgen, 1992). Field evaluations conducted by MDEQ between 1998 and 2000 also identified a D-type channel at three monitoring locations while a site above the South Fork confluence was classified as C-type channel (Figure A-12).

The “rapid aerial assessment” conducted by the NRCS (Hawn et al., 1998) covered the upper Teton River to the confluence of the North and South Forks and, in addition, traveled up the South Fork roughly 2½ km (~ 1½ mi). The GIS project associated with this report provides locations of riparian disturbances or degraded channel as well as the point impacts. Ninety or more percent of the stream channel above Deep Creek, to the confluence of the North and South Forks, was assessed as braided, aggraded or channelized, and/or as having unstable banks and/or unhealthy riparian areas. Additionally, there were 18 point-disturbance sites identified, mainly

Figure 4-12. Example of an instream diversion structure on the upper Teton River (photo scale is 1:4,000).

riprap, instream diversions, and bridges (Table 4-14). Gross visual estimation of the percent-disturbed area on this segment of the Teton River was made since the report provided only a composite value of linear impairments by length along the entire Teton River (Table 4-12).

Choteau WWTP (Waste Water Treatment Plant)

The wastewater treatment plant for the city of Choteau discharges to the Teton River through a discharge pipe on the left bank of the stream (facing downstream) approximately one-half mile above the mouth of Deep Creek. The Montana Pollutant Discharge Elimination System (MPDES) permit for the facility specifies concentration and load limits for 5-day biochemical oxygen demand (BOD_5) and TSS, a load limit for both total phosphorus and total nitrogen, and a concentration limit for ammonia. Permit load limits are expressed as annual averages in pounds per day. Discharge monitoring requirements in the permit call for monthly grab samples for chemical constituents and instantaneous monthly flow measurements.

Teton River Watershed (exclusive of the Teton River above Deep Creek)

This section will reference stream segments with sediment-related impairments in the Teton River watershed exclusive of the Teton River above Deep Creek. These segments include the middle and lower Teton River (Deep Creek to the mouth), Deep Creek, Willow Creek, Teton Spring Creek, Lower Blackleaf Creek, and Muddy Creek (Figure A-10b).

Sediment-related impairments are more a result of the accumulation of fine sediment/silt than from coarse sediments and the inability of the river to transport these sediments through the watershed due to diminished stream flow (i.e. stream power). Sediments may be delivered from upstream reaches during flood flow events of sufficient magnitude to allow stream flow to reach the middle and lower Teton River. These flows erode bare and unstable banks carrying with it suspended sediment and bed load. During these same flow events unstable, bare and eroding banks, as well those banks termed "naturally" sloughing, will also be delivering sediments to the stream channel from the middle/lower Teton and its tributary streams. Stream reaches with unhealthy riparian vegetation are also susceptible to erosion during higher flow events since their overall resistance has been diminished.

Hawn et al. (1998) cataloged the locations of these features on most of the streams on the 303(d) list with the exception of Teton Spring and Blackleaf Creeks (Tables 4-12, 4-13). In addition, the flight cataloged point features that may adversely impact the stream channel (Table 4-14). Individual reaches may have several (up to three) impacts or classifications cataloged and often these overlaps are bank erosion and unhealthy riparian. Where these cases occur can be ascertained only with careful inspection of the ArcView GIS project associated the report.

"Incised Channels" was not a disturbance category included in the tables of Hawn's report, but was one of the possible categories used during the flight. There were two locations (reaches) identified in the GIS project as an "incised channel," which were located along the lower portion of Deep Creek. Combined these two reaches total about one-half mile (790 m) of lower Deep Creek. These reaches also coincide with eroding banks in one instance, and unhealthy riparian in the other.

Bank erosion and degraded riparian vegetation were identified as the most pervasive problems on the streams in this area of the watershed. The fact that the amount of impacted stream from these two categories is nearly identical, 126.6 and 117.3 miles, respectively, speaks to a key underlying cause – riparian conversion from a natural riparian vegetative community to a land cover or vegetative community that is less resistant to the erosive energy of higher stream flows. This conversion is a result of channel migration during past flood events, the inclusion of riparian areas into agricultural fields/crops, unmanaged riparian grazing practices, and/or diminished stream flows that also lower groundwater levels such that natural riparian communities cannot remain viable or healthy.

Soils in the watershed also tend to have a higher erodibility as measured by the soil Kw-Factor (Figure A-13b). The Kw-Factor, as noted earlier, is a measure of the soils susceptibility to detachment and movement by water. With exception of a small section of Muddy Creek downstream of Bynum, the lower portion of Willow Creek and the east bank of upper Teton Spring Creek, streams listed with sediment-related impairments traverse through relatively more erodibile soils.

4.3.1.1 Stream Flow Related Issues

Stream flow is one of the most, if not the most, critical issue related to water quality in the Teton River watershed. At the most basic level, without adequate stream flows basic agricultural, municipal, drinking water, and aquatic life/fisheries beneficial uses cannot be fully supported. In addition, adequate stream flows are a necessity to maintain the proper pattern, form, and function of the stream channel itself. A stream system is considered in geomorphic equilibrium when stream flows are sufficient to transport the sediment supply. When either of these deviate from that which was present during a stream's current evolutional condition, or otherwise is out of balance with the other, major or minor adjustments will occur (Leopold et al., 1964).

Currently, the Teton River (Bynum Reservoir diversion to the mouth), Deep Creek (lower five miles), and Teton Spring Creek (lower five miles) are chronically dewatered (MFWP, 1997b). Many local residents contend that, for the Teton River, this has always been the case, especially for the upper section of the river. However, based on an evaluation of historical data from USGS gaging stations operating early last century, it is unlikely that the Teton River was historically a naturally intermittent stream. Section 2.1.4 provides a discussion of the Teton River hydrology from a current and historical prospective.

The Teton River watershed is now a "closed basin" in terms of surface water right applications (85-2-330, MCA; also Appendix D, Section D-1.2), however exceptions are made for permit applications related to groundwater, non-consumptive, domestic, municipal, and stock uses, and the storage of water during high spring flows (85-2-330(2), MCA; also Appendix D, Section D-1.2). There is no apparent limit as to the size or amount of groundwater that may be applied for, or appropriated. However, groundwater is commonly connected hydrologically to streams in alluvial aquifers (Uthman, 2002). Thus groundwater withdrawals from an alluvial aquifer will likely have a detrimental affect on stream flow regimes (Glennon, 2003). Groundwater withdrawals that lower groundwater levels below streambed elevation can change a stream reach from a "gaining reach" where groundwater seeps into the stream channel to a "losing reach" where surface water seeps into the aquifer thereby diminishing stream flows (Kazmann, 1948; Uthman, 2002).

The aquifer around the Choteau area was evaluated in the early 1990's for a source water delineation and assessment report (MDEQ, 2001). In this report, the Teton River Valley Aquifer surrounding Choteau was characterized by a professional hydrogeologist as "*unconsolidated alluvium and highly sensitive to contamination from surface activities*." Translated, this would indicate that surface and ground waters are well connected by highly permeable sands and gravels. In fact, the 2001 report further describes the underlying geology as "*layers of sand and gravel reaching 78 feet thick deposited by the migrating Teton River*" and found "*no evidence of continuous layers of fine-grained sediments that could act as a barrier to water or contaminants infiltrating the aquifer*." Groundwater flows in the aquifer "*generally flows parallel to the river and has identified both gaining and losing reaches depending on location along its channel and season*." Subsequently, an impact to surface water flows from groundwater pumping, for any reason, is likely and wells located closer to the stream would have a more direct impact on induced infiltration rates that those located at greater distances (i.e. > ½ mile). The long-term, cumulative impact of groundwater pumping on surface flows has been well documented in the scientific literature (Uthman, 2002, Glennon, 2003).

4.3.1.2 Highway Related Issues

Highway structures (i.e. bridges and culverts) often create chronic, long-term impacts to stream systems. Impacts include restricted access to floodplains, elimination of the streams ability to meander across its flood prone area from bank armoring and reduction in channel length (i.e.

channelization), constriction points that locally increase stream velocity and stream power. Many of these impairments are evident in Figure 4-13. The elimination of sinuosity, or reduced channel length, increases the local channel slope and therefore generates local increases in stream velocity, which in turn increases stream power. The result of greater stream power is usually bank erosion and/or channel incision. Once these structures are in place great effort and expense is spent to protect them from the continual attack of the stream as it seeks to regain proper pattern, form, and function.

The force that high stream flows can exert on these types of structures was evident during the 1964 flood that brought flows as great as 71,000 cfs to parts of the Teton River. The USGS had a surveyed channel cross-section near Dutton were the valley is wide and flat with few obstructions. At this location very little scour was evident in the channel as a result of the flood (Boner and Stermitz, 1967). However, much of the channel widening that occurred was a result of scour around the bridge abutments prior to the bridge washing out (Figure 4-14).

Mitigation of highway-related impacts is also viewed as critical to reestablishing a properly functioning stream system where the sediment budget is in balance with stream flow. Efforts should be taken to evaluate all highway locations where stream channel or flood prone areas are impinged upon. Culverts should be evaluated for the capacity to pass bankfull discharge with out changing stream velocity and bridge crossings should be evaluated for any restrictions to bankfull discharge. Where bridge structures constrict the bankfull channel, additional channel capacity should be developed. This may be accomplished by using larger bridge spans, properly sized relief culverts placed at bankfull elevation, or a combination of both. Funding for highway mitigation projects could potentially be secured via MDOT Wetland Mitigation Program or the MFWP Montana Wetland Legacy program.

4.3.2 Targets

Montana water quality standards for B-classified waters relating to sediment (Section 3.2) state, *"no increases are allowed above naturally occurring concentrations of sediments or settleable solids…"* (ARM 17.30.623-625[f]). Naturally occurring is further defined as *"…conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil and water conservation practices have been applied"* (ARM 17.30.602[17]). A naturally evolving stream system develops and responds to events within the boundaries of "dynamic equilibrium" where the stability of the system fluctuates thru geologic time-scales (Leopold et al., 1964). Within dynamic equilibrium it is assumed that a percentage of a stream corridor will be in a disturbed or erodibile state and still be deemed in natural or reference condition.

Figure 4-13. An undersized highway structure (bridge in circle) on the upper Teton River that limits floodway access and creates a constricted stream channel (photo scale is 1:5,000).

Furthermore, there are no numeric standards for parameters associated with sediment. However, narrative standards do not allow for harmful or other undesirable conditions related to increases above naturally occurring levels or from discharges to state surface waters. Narrative standards translated into water quality goals should strive toward a reference condition that reflects a water body's greatest potential for water quality given current and historical land use activities, where *all reasonable land, soil, and water conservation practices* have been applied. In defining a reference condition and determining compliance with water quality standards, consideration must be given to variations in natural systems, as well as sampling and analyses methods used to compare conditions in one stream with conditions in another. This variability can justify the use of a statistical range around any given reference condition parameter when making sediment-related impairment determinations and when setting water quality target conditions. Where the variability and/or uncertainty is relatively high, a 25% deviation from reference condition indicators has been used for beneficial use support determinations associated with some biota indicators (MDEQ, 2002a, Appendix A). This value should be reduced however to less than 25% deviation in situations where reference conditions can be better defined.

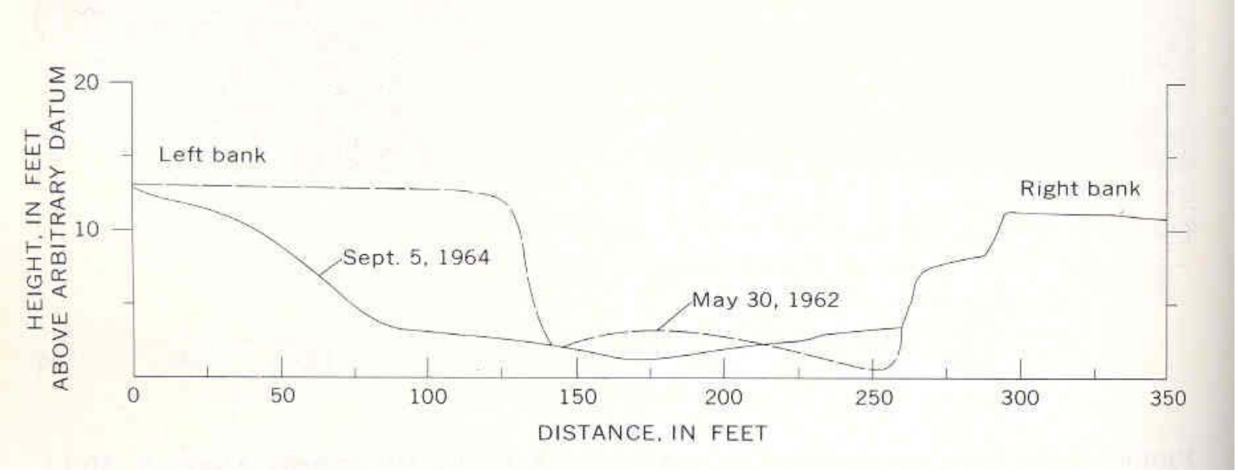


Figure 4-14. Channel cross-sections near the USGS Dutton gaging station before and after the 1964 flood. From Boner and Stermitz (1967)

Given the overall lack of detailed, quantifiable sediment source assessments for the Teton River watershed, sediment targets will be presented using surrogate measures defining instream flow regimes, riparian vegetation, and stream channel morphology. The exception is for the Teton River above Choteau where assessments of channel geomorphology have been conducted in the past ten years (Rosgen, 1992; Watershed Consulting, 1999). Based on these reports the Teton River above Choteau (approximately 30 miles in length) has been identified as chronically destabilized by an imbalance in the sediment and stream flow regimes.

Sediment targets will center on attainment of 1) establishment of critical instream flow regimes, 2) the establishment or enhancement of a riparian zone vegetation community, and 3) stream channel morphology (Tables 4-15, 4-16, and 4-17). In addition, attainment of sediment targets is contingent on the redesign of instream diversion structures in the upper Teton River and the mitigation of highway-related impacts.

Sediment targets were developed on the theory of channel morphology and riparian management. A stream system in which the sediment supply is balanced with stream flow will have a predictable pattern and form (Rosgen, 1996). Critical to stable channel geometry is a properly functioning riparian zone. Natural riparian vegetation, such as willows and cottonwoods, provide the necessary rooting strength to stabilize eroding banks and provide resistance to high stream flows. For example, one study reported in Gordon et al. (1992, pg 338) found that stream banks with a 50 mm-thick root mat of 16-18% root volume provided 20,000 times more protection from erosion than comparable banks without vegetation. In addition, properly functioning riparian areas will assist in reducing any tendency toward channel incision and thus helps in maintaining current water table elevations.

Sediment targets for the Teton River watershed reflect the conditions of a “naturally occurring” or reference stream system. Target conditions are sought for 80% or more of the watershed or stream corridors. That is, for any given stream system, at least 80% of the linear distance should have the appropriate channel pattern, form, and function (e.g. Table 4-15). The 80% minimal target allows for unstable eroding cut-banks and/or riparian vegetation in a younger seral stage as a result of natural perturbations in the watershed (e.g. floods, fire, etc) as well as anthropogenic activities.

Table 4-15. Channel Morphology and stream flow targets.

Stream / Location	**Rosgen Channel Type**	**W/D Ratio**	**MW Ratio [1]**		**Instream Flow [2]**
			Ave.	**Range**	
Teton River (N-S Forks to Deep Ck)	C	> 12	11.4	4 - 20	35 cfs
Teton River (Deep Ck to Mouth)	C	> 12	11.4	4 - 20	--- [3]
Deep Creek	C	> 12	11.4	4 - 20	18 cfs
Teton Spring Creek	E	< 12	24.2	20 – 40	4.5 cfs
Muddy Creek	C	> 12	11.4	4 – 20	--- [4]
Willow Creek	C	> 12	11.4	4 – 20	--- [4]
McDonald Creek[5]	C	> 12	11.4	4 – 20	10 cfs

[1] Meander Width Ratio: Meander Belt Width / Bankfull Width (Rosgen, 1992).
[2] In-stream Flow Reservation requested by MFWP (refer to Table 2-6)
[3] To be determined by MFWP using wetted perimeter models and life history needs based on fish habitat requirements (Personal communication, Bill Gardner, MFWP).
[4] needs to be calculated
[5] McDonald Creek is listed as fully supporting all beneficial uses in 2002; it is included in this table because minimum instream flows have been calculated.

Table 4-16. Riparian vegetative community: cottonwoods (see also Figure A-14).

Community Type	**Community Type - Common Name**	**Elevation (ft.)**	**Dominant Soils**
Populus angustifolia / Cornus stolonifera	Narrowleaf Cottonwood / Red-Osier Dogwood	3,100-6,700	Entisols
Populus angustifolia / Recent Alluvial Bar	Narrowleaf Cottonwood / Recent Alluvial Bar	3,100-6,700	Entisols
Populus angustifolia /Symphoricarpos occidentalis	Narrowleaf Cottonwood / Western Snowberry	3,100-6,700	Entisols
Populus deltoids / Cornus stolonifera	Great Plains Cottonwood / Red-Osier Dogwood	1,900-3,600	Entisols
Populus deltoids / Recent Alluvial Bar	Great Plains Cottonwood / Recent Alluvial Bar	1,900-3,600	Entisols
Populus deltoids / Symphoricarpos occidentalis	Great Plains Cottonwood / Western Snowberry	1,900-3,600	Entisols

Table 4-17. Riparian vegetative community: willows and other (see also Figure A-14).

Community Type	Community Type - Common Name	Elevation (ft.)	Dominant Soils
Salix amygdaloides	Peach-Leaf Willow	1,950-3,900	Entisols or Mollisols
Salix exigua	Sandbar Willow	2,550-5,750	Entisols
Salix lutea / Calamagrostis canadensis [1]	Yellow Willow / Bluejoint Reedgrass	3,660-4,400	Entisols or Mollisols
Artemisia cana / Agropyron smithii [1]	Silver Sagebrush / Western Wheatgrass	1,860-3,150	Clay loam to loam
Shepherdia argentea	Thorny Buffaloberry	2,200-3,750	Entisols or Mollisols
Agropyron smithii [1]	Western Wheatgrass	2,000-3,750	clay to silt loam

[1] Indicates Habitat Type rather than Community Type

During the most significant hydrologic events of the recent past (i.e. 1964 and 1975 floods) the Teton River lost stream length and channel complexity and the river is still in the process of recovering stream length (pattern) lost during the floods. During this readjustment period eroding banks and young seral-stage riparian areas are anticipated to exist at levels possibly greater than would be otherwise naturally occurring. Effort may be needed to assist the natural recovery process by stabilizing eroding banks, where appropriate, using the best and most current information and technology to achieve at least 80% stable stream corridors. However, to attain support for all beneficial uses it is possible that some level greater than 80% may be necessary, assuming, that level or condition is attainable. Beneficial use support will be evaluated during the five-year review process that is called for in Montana's Water Quality Act.

Assuming an overall stream length of 184 miles for the Teton River (Table 4-13) then roughly 147 miles (184 * 0.8) should have stable stream banks and natural riparian areas with associated stream flows that would support both the riparian community as well as aquatic life and fisheries beneficial uses. Target stream mileage is based on the existing GIS streams network generated by the USGS for the 303(d)-listed segments inventoried by the DNRC (Table 4-18). Future target mileage should be adjusted whenever digital stream networks are updated.

Table 4-18. Target stream lengths for stable banks and healthy riparian zones (length in miles).

Waterway	Total Stream Length [1]	303(d) Listed Stream Length [1]	Total Length Assessed [2]	Existing Stable Banks [3]	Existing Healthy Riparian [4]	80% Target Stream Length [5]
Teton River	184	184	182.6	126.4	115.6	**147**
Muddy Creek	81	81	62.2	8	18	**65**
Deep Creek	38	9	32.0	20.7	25.9	**7**
Willow Creek	19	19	17.7	12.8	17.7	**15**
Teton Spring Creek	14	14	N/A	Unknown	Unknown	**11**
McDonald Creek[6]	12	N/A	N/A	Unknown	Unknown	**N/A**
Total	348	307	294.5	167.9	117.2	**245**

[1] Length of stream measured using ArcView GIS and 1:100,000 streams layer.
[2] Length assessed is the stretch of river covered by the Hawn et al. (1998) assessment.
[3] Unstable banks from Table 4-12 subtracted from Total Length Assessed.
[4] Unhealthy riparian from Table 4-12 subtracted from Total Length Assessed.
[5] Target lengths are calculated as 80% of GIS-measured stream length of the 303(d)-listed stream segments.
[6] McDonald Creek is listed as fully supporting all beneficial uses in 2002.

4.3.3 TMDLs

Development of true sediment TMDLs using numeric load or reduction limits is not possible at this time due to a general paucity of specific, quantifiable source loading data. Therefore, the sediment TMDL for the Teton River watershed was developed using a performance-based allocation approach as described in Section 4.3.5 below.

4.3.4 Seasonal Variation

Sediment-related issues are inextricably tied to variation in stream flows. The “work” of a river is to move sediment through and out of a watershed and this is accomplished during periods of high stream flow and thus greater stream power. Stream systems may become overloaded with sediment as a result of high stream flows eroding bare or unstable stream banks (i.e. creating an imbalance due to excessive sediment) or from the lack of stream flows with sufficient magnitude to transport the current sediment supply (i.e. creating an imbalance due to diminished stream power). The latter situation is a result of diversions that remove peak runoff in spring to fill storage reservoirs for use later during the irrigation season.

When high flows do occur and stream banks are bare or destabilized, erosion occurs at a much greater rate. Moreover, where a stream’s sediment load is removed as a result of human activity (i.e. instream reservoirs or diversion structures) the resultant downstream flow is “hungry” for new sediments and actively erodes streambeds and banks. At times of peak stream flow instream suspended solids are naturally elevated as the stream moves the sediment load through the system, however these levels become excessive and detrimental to aquatic life when riparian areas lose their naturally protective vegetative communities.

Seasonal variation in sediment transport is accounted for through the recommendations contained in this document relative to managing riparian buffer zones as well as those provided by Rosgen (1992) and Watershed Consulting (1999) concerning instream diversion structures on the Teton River above Choteau. It should be noted however, that even (if and) when these activities and recommendations are accomplished that balancing the sediment and flow budgets in the Teton River watershed would be a long-term process. For example, in the 30-mile segment of river above Deep Creek sediment supply exceeds the transport capacity of the stream resulting in an unstable channel form (Rosgen, 1992). During the recovery process where the Teton River works to regain its appropriate channel pattern, form, and function elevated sediment levels can be anticipated to persist during periods of stream forming flows (i.e. bankfull discharge).

4.3.5 Allocation

Sediment sources in the Teton River watershed are attributed to impacts from highway and road-related structures, instream diversion structures, irrigation practices, unmanaged riparian grazing, and crop production in riparian areas with out natural buffer zones. In addition, the Choteau Wastewater Treatment Plant delivers suspended sediments to the Teton River and is the only permitted municipal point source in the watershed that has an allocated waste load for total suspended solids (TSS).

The annual average TSS waste load limit in Choteau's WWTP discharge permit is 250 pounds per day (MDEQ, 1995). Discharge monitoring records obtained from the USEPA Permit Compliance System (PCS), for the period of February 2, 1996 through June 30, 2003, indicate an average monthly TSS concentration of 16 mg/L and an average monthly TSS load of approximately 20 pounds per day. The contribution of TSS from the Choteau WWTP to the Teton River may be put into perspective by comparing it to ambient TSS concentrations in the river above and below the discharge (Figure 4-15).

An average TSS concentration of 16 mg/L in the Choteau WWTP discharge compares with an average TSS concentration of 20 mg/L for the same period of record in the Teton River upstream of the discharge at the USGS gage near the South Fork. These concentrations are lower by comparison than the first available downstream TSS data from the USGS gage near Dutton with an average concentration of 22 mg/L. This difference reflects the influence of suspended solids contributed by Deep Creek and Muddy Creek that enter the Teton River below the Choteau WWTP discharge point. However, comparison of the average annual daily loads is far more telling of the relative contribution that Choteau's WWTP discharge has to the river's suspended sediment load. The WWTP has a computed average annual load of **20 lbs/d**, where, by comparison, the average annual TSS load in the Teton River measured upstream of Choteau near the South Fork for the same period of record is **9,516 lbs/d** and downstream at the Dutton gage station is **78,976 lbs/d** (Figure 4-16).

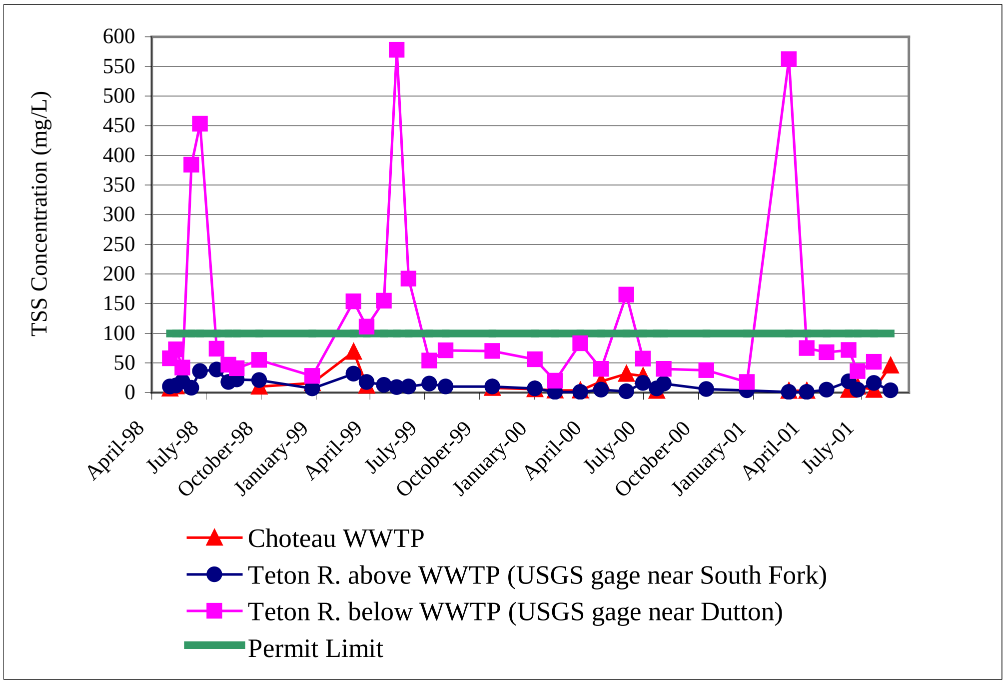


Figure 4-15. TSS concentrations from the City of Choteau's WWTP discharge and the Teton River upstream and downstream of the discharge in relation to the TSS concentration limit set in the Choteau's MPDES permit.

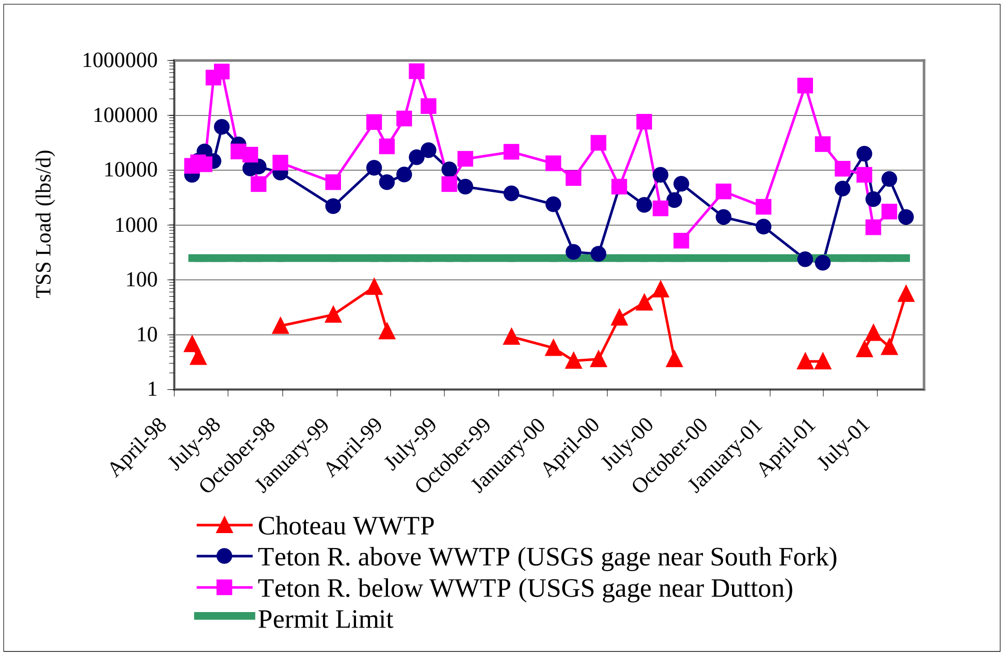


Figure 4-16. Average annual TSS loads from the City of Choteau's WWTP discharge and the Teton River upstream and downstream of the discharge in relation to the TSS load limit set in the Choteau's MPDES permit. Note: the y-scale is logarithmic and is used to accommodate the full range of measured load values.

The waste load allocation (WLA) component for the TMDL will thus remain the amount allocated by Choteau's permit, 100 mg/L or 250 lbs/d. The remainder of the acceptable sediment load is allocated to the non-point source load allocation (LA) and natural sources.

The TMDL relies on a performance-based allocation as a way of describing sediment control practices that can be implemented to address specific sources of concern. The primary sectors identified - agriculture (crops), grazing, highways, water users (diversion structures), and stream flow (water withdrawals for agriculture, municipal, and domestic use) – will need to work together and contribute to activities that build a solution to the Teton River watershed's sediment issues.

Attaining support for all beneficial use (fisheries, aquatic life, human consumption, and agriculture) is inextricably dependant on achieving, and maintaining, appropriate instream flows and flow regimes through out the year. However, no adjudicated water right may be diminished via implementation of this water quality management plan. Thus it is critical that the adjudication process be completed as expediently as possible, and then, all adjudicated water right holders will need to continue to work in a cooperative manner to share the limited water resource that is available (in any given year).

4.3.6 Margin of Safety

The establishment of protective riparian vegetation zones on all unstable banks that could not be considered naturally eroding cut banks will reduce sediment loading to the stream system to more "natural" levels. However, there still remains a significant load of stored instream sediments that must be transported out of the watershed, which must rely upon sufficient stream flows and stream power. Given that there has been only a limited source assessment undertaken to date in the Teton River watershed (i.e. Hawn et al., 1998 covering less than 300 miles on only four streams) the targets presented in Section 4.3.2 are applicable to all stream/waters bodies in the watershed. Additionally, reestablishment of more natural stream flows will allow for a sufficient vegetative buffer to attain support of currently impaired beneficial uses.

4.4 Thermal Modification

Water quality impairments as a result of thermal modification – increased stream temperatures – have been determined for the Teton River and Teton Spring Creek. It should be noted that the listed segment of the Teton River changed from the lower segment (Muddy Creek to the mouth) in 1996 to the middle segment (Deep Creek to Muddy Creek) in 2002 (refer to Section 3.3.5). Teton Spring Creek (headwater to Choteau) was added to the list as impaired from thermal modifications in 2002.

Montana's water body use classification classifies the lower Teton River as B-3, a warm-water fishery, the middle Teton River as B-2, an intermediate cold-water fishery, and Teton Spring Creek as B-1, a cold-water fishery (Figure A-11). Detailed description of the relevant temperature standards found in the Administrative Rules of Montana is provided in Section 3.2.

4.4.1 Existing Conditions and Source Assessment

Stream temperature data and a general assessment of stream conditions influencing stream temperature are presented in Section 3.3.5. The USGS gaging station near Dutton on the Teton River (Figure A-3) is the only location in the watershed with a substantially long-term data set. The current data record spans the past 20 years with 167 grab-samples taken throughout the year. The highest monthly <u>median</u> temperature recorded during this period is 22.0 °C (71.6 °F) during in July (Table 3-10, Figure 3-15).

Detailed evaluation quantifying all of the sources of thermal energy loading to the streams listed on the 303(d) list has not been completed to date. However, a general assessment of the Teton River corridor was conducted by the NRCS (Hawn et al., 1998) and is described in Section 4.3.1. Since similar issues adversely influence stream temperature and sediment, the impacts to the riparian areas on the Teton River presented in Table 4-12 can also be applied to thermal modifications. Although Deep Creek and Muddy Creek are not specifically listed for thermal impairments, the condition of their stream channel, riparian areas, and stream flows is of concern since they are major tributaries to the Teton River and can influence its temperature regime.

The upper section of Teton Spring Creek (headwaters to Choteau) was listed as impaired using a combination of stream temperature data and supporting site data collected relative to riparian vegetation and stream channel geometry. Although there is only one data point of 25.1 °C (77.2 °F) on August 1, 2000 at 12:00 pm, MDEQ finds it appropriate to list this stream segment as temperature impaired given that it is both a spring creek and the section closest to its source (a natural spring). In fact, the stream temperature sampled near its source on August 1, 2000 at 10:00 am was 13.4 °C (56.1 °F). The measured change in stream temperature of 11.7 °C (21.1 °F), from the near creek's spring source to just above Choteau, represents a 183% increase in degrees Celsius over approximately eight river miles spanning a two hour time difference.

The upper section of Teton Spring Creek was evaluated as a C-type Rosgen stream channel (Figure 3-13) based on field measurements of stream channel geometry. Given the nature of stream flow (i.e., spring creek) and a valley type that is a broad, gently sloping riverine valley an E-type channel would be expected (e.g., Figures 3-11 and 3-14). These two channel types differ significantly in the amount of surface area of stream that is exposed to incident solar radiation. C-type channels have bankfull width-to-depth ratios (W/D) greater than 12 while E-type channels have W/D ratios less than 12 (Rosgen, 1996). In other words, C-type channels are wider and shallower relative to E-type channels, which are more narrow and deep. Thus, given the same amount of thermal energy and stream flow, a C-type channel will increase in temperature more quickly and readily than an E-type channel.

The condition of Teton Spring Creek's channel geometry, riparian vegetation, and stream flow is of concern, not only for the temperature regime of Teton Spring Creek itself, but also as it may affect temperatures in its receiving water - the Teton River. This is because stream temperatures are affected by the quantity of water in a channel, the source of water to the stream, the amount of short-wave solar radiation incident on the stream surface, and the amount of long-wave terrestrial radiation from near-by land surfaces. If the volume of water in a stream is diminished, any heat input will increase stream temperatures more rapidly, and to higher levels, than under more "natural" conditions. Warm water inputs from agricultural "return flows" where water temperatures are elevated will warm stream temperatures while sites of groundwater upwelling tend to provide a cooling effect. Tributary streams may have either a cooling or warming effect on its "receiving stream" depending on its temperature and relative size compare to the stream it is flowing into. Tributary streams with a stream flow that is five percent or more of the larger receiving stream has been considered to be a significant influence (ODEQ, 1999). Also, groundwater withdrawals, especially those in close proximity to the stream (≤ ¼ mile), can have a depleting effect on stream flows (Uthmann, 2002) and thus affect the streams temperatures. Finally, decreased riparian shading will increase solar energy in and near a stream channel and thus, degraded riparian (shading) vegetation is considered a major source of thermal loading and heating of streams.

4.4.2 Targets

Temperature targets have been developed using surrogate measures that address primary controlling factors that humans can affect some level of control over. Targets apply generally across the riparian areas of the streams listed as thermally impaired. Targets center on 1) establishment of critical instream flow regimes, 2) establishment or enhancement of a shade-providing riparian vegetative community, and 3) stream channel morphology (Tables 4-15, 4-16, and 4-17). Implementation of management actions that lead to the enhancement of instream flow and/or riparian condition is encouraged on all reaches that are evaluated as lacking in one or more of these components.

The development of temperature targets is based on the theory of thermal heating as described in Maidment (1992) (see also Brown, 1969 or Wunderlich, 1972). Heating of a water body is primarily a function of how much solar and long-wave radiation passes through the water surface. The critical factors that can be affected by human-activity relate to the surface area of the stream, amount of area exposed to direct heat energy (i.e. amount of shade), and the volume of water present to absorb the heat energy. Thus, channel geometry (morphology), streamside riparian management, and stream flow are the critical elements that need to be addressed.

Critical to stable channel geometry is a properly functioning riparian zone. Natural riparian vegetation, such as willows and cottonwoods, provide the necessary rooting strength to stabilize eroding banks, provide resistance to high stream flows, and provide shading to the stream channel. In addition, properly functioning riparian areas will reduce any tendency of channel incision and thus maintain current water table elevations. Groundwater inputs can have an important influence on stream temperatures by delivering cooler waters to the stream during late summer base-flow periods when heat inputs from solar and long-wave radiation are greatest.

4.4.3 TMDLs

Development of true temperature TMDLs using numeric load or reduction limits is not possible at this time due to a general paucity of specific, quantifiable source loading data. Therefore, temperature TMDLs for the Teton River watershed were developed using a performance-based allocation approach as described in Section 4.4.5 below.

4.4.4 Seasonal Variation

Since water quality targets are surrogate measures developed around channel geometry, natural riparian vegetation, and stream flows communities resultant stream temperatures should reflect a more naturally occurring temperature regime for the system. Thus, any variation in temperature experienced during the year would be that which is naturally anticipated and would therefore be capable of supporting the historical aquatic biota and fisheries.

4.4.5 Allocation

Thermal loading sources in the Teton River watershed are attributed to impacts from agricultural use of riparian areas for crop production or livestock grazing, water withdrawals, and highway and roads impinging on riparian areas. Source areas are not limited to only the middle Teton River and Teton Spring Creek, but also all major tributary systems, and specifically Muddy and Deep Creeks.

The TMDL relies on a performance-based allocation as a way of describing land management practices that can be implemented to address specific sources of concern. The primary sectors identified - agriculture (crops), riparian grazing, highways, water users (diversion structures), and stream flow (water withdrawals for agriculture, municipal, and domestic use) – will need to work together and contribute to reducing any temperature issues in the Teton River watershed. These include active revegetation of the riparian area with natural vegetative communities, active management or elimination of riparian grazing, irrigation BMPs, and the equitable sharing of an over-allocated river system with all users and beneficial uses.

Attaining support for all beneficial use (fisheries, aquatic life, human consumption, and agriculture) is inextricably dependant on achieving, and maintaining, appropriate instream flows and flow regimes through out the year. However, no adjudicated water right may be diminished via implementation of this water quality management plan. Thus it is critical that the adjudication process be completed as expediently as possible, and then, all adjudicated water right holders will need to continue to work in a cooperative manner to share the limited water resource that is available (in any given year).

4.4.6 Margin of Safety

To ensure a margin of safety for Teton River stream temperature, all major tributaries are included in the allocation strategy. The assumption is that when stream channel geometries, riparian vegetative communities, and stream flows achieve a more natural condition the resultant aquatic environments within the stream systems will then become supportive of the aquatic life and fisheries beneficial uses.

4.5 Nutrients

Water quality impairments as a result of excessive nutrient concentration or nutrient enrichment have been determined for Deep Creek and lower Teton Spring Creek. Section 3.3.6 outlines existing water quality data and field analysis used in the beneficial use support determinations.

4.5.1 Existing Conditions and Source Assessment

Assessment of the existing conditions and all sources related to nutrient enrichment has been limited in breadth and scope. However, based on existing water chemistry data collected during the past four years by MDEQ, nitrogen and phosphorus concentrations appear to be elevated in Deep, Teton Spring and Willow Creeks relative to USEPA ecoregion guidelines (USEPA, 2001) explained below (Table 4-19, also Section 3.3.6). Elevated nutrient levels are corroborated by chlorophyll *a* measurements and field observations in Deep and Teton Spring Creeks but not Willow Creek. The low chlorophyll *a* values in Willow Creek were the basis for not listing the stream as impaired because of nutrient enrichment. However, the reason for such low chlorophyll *a* values, relative to the nutrient concentrations, is unclear at present. Existing TSS data (Figure B-3) does not indicate an overwhelming problem with water column suspended sediment such that algal growth would be impeded by diminished light penetration and, additionally, no reliable turbidity data is available.

Plants require a balance of nutrients for growth. Most aquatic algae contain nitrogen, phosphorus, and carbon in a ratio by weight of 41/ 7/ 1 (Redfield, 1958.). Increases in plant production may occur if the limiting nutrient, or all nutrients, are elevated. Most aquatic plants in Montana are not limited by carbon, however, either nitrogen or phosphorus can limit growth. Nitrogen to phosphorus (N/P) ratio of around 10 is generally thought to be optimal for algae growth (Personal Communication M. Suplee, MDEQ WQ Standards Section). If the N/P ratio is lower than 7.2 a stream is most likely limited by nitrogen, if the ratio is greater than 7.2 it is most likely to be limited by phosphorus (Chapra, 1997). Conditions that affect the nitrogen to phosphorus ratio may change in streams daily or seasonally and either nutrient may be limiting at different times. The N/P ratio in a stream can be used as an indicator of which nutrient is most likely limiting algae growth. For Deep, Willow, and Teton Spring Creeks, phosphorus appears to be the limiting nutrient (Table 4-19).

Table 4-19. Nutrient concentrations, nutrient ratios, and Chlorophyll *a* biomass in select watersheds.

Sample location	**Total N (µg/L)**	**Total P (µg/L)**	**N/P Ratio**	**Chl *a* (mg/m^2)**
Deep Creek, below Willow Creek	701	49	14	54
Deep Creek, below Hwy 287 bridge	1020	107	10	58
Willow Creek, near headwaters	701	41	17	18.6
Willow Creek, near mouth	1010	53	19	16.8
Teton Spring Creek, near source	720	11	65	N/A
Teton Spring Creek, u/s of Choteau	510	19	27	N/A
Teton Spring Creek, in Choteau	410	19	22	134
Teton Spring Creek, near mouth	810	22	37	52

- Data presented is from one sample/site collected by MDEQ in Aug. 2000 on Teton Spring Creek at the “near source” and “above Choteau” sites and May 2001 at all other sites.

Deep Creek Watershed

Nutrient concentrations in Deep Creek increase by 118% for total phosphorus and 46% for total nitrogen from the Willow Creek confluence to below Highway 287. The primary potential sources of nutrients are considered to be unstable, eroding banks for phosphorus and agricultural lands for nitrogen. The Willow Creek watershed, being the major tributary to Deep Creek is also considered a significant source of nutrients and sediments.

Agricultural lands comprise a significant portion of the riparian areas in Deep and Willow Creeks (Figure A-5). These lands are generally hay pasture or dryland cropping fields, although some irrigated pastures are evident (Figure A-9a). It should be noted that the amount of irrigated acreage might have changed since the time of Teton County's water resources survey (MSEO, 1962), which is depicted in Figure A-9a. Unstable and eroding banks comprise 16.2 miles or 63% of the combined Deep and Willow Creek channel as assessed by Hawn et al. (1998). This amount represents approximately 28% of the total combined channel length (not just the 303(d) listed segments), as measure by GIS (Table 4-18). Not surprising is the significant amount of erodible soils present along the stream channels in these watersheds (Figure A-13b). These elements combined – agricultural practices that might reduce riparian vegetative cover and rooting strength on top of erodible soils – are then suspected as the primary source of elevated nutrient concentrations.

Teton Spring Creek Watershed

Nutrient concentrations in Teton Spring Creek near its source (Table 4-19) are typical of spring creeks (Stumm et al., 1981). However, phosphorus concentrations increased by 42% from near its source to the sampling site above Choteau in August 2000. Nitrogen concentrations decrease from near its source to Choteau in August 2000, as would be expected as nitrogen becomes bioavailable and plants use it. However, from Choteau to the mouth nitrogen concentrations increased by 98% during the May 2001 sampling event.

Agricultural lands also comprise the majority of landuse within this watershed (Figure A-5), and like Deep Creek, they are generally hay pastures or dryland cropping fields, although some irrigated pastures may also be present (Figure A-9a). Bank stability or riparian health has not had a comprehensive evaluation so specific source areas cannot be quantified at present. However, given that phosphorus is typically bound to sediments, it can be reasonably assumed that landuse practices that alter naturally occurring riparian vegetation and lead to reduced rooting strength and bank stability are a key source of sediment-bound phosphorus. Soils on the west bank of Teton Spring Creek are rated as more erodible (Figure A-13b) and thus are potentially more prone to bank instability than soils on the east bank. However, depending on how the stream has been managed or altered in recent decades, the actual location of the stream channel relative to the soils mapped on Figure A-13b may be somewhat different. Additionally, in the town of Choteau there is an industrial storm water discharge permit issued to Western States Industries that potentially contributes sediment washed off of impervious surfaces into the creek.

Teton Spring Creek also traverses through Choteau, the second most populous area in the Teton River watershed. Nutrient enrichment via groundwater loading from septic systems is extremely likely, although not presently quantified. Regardless, septic densities bordering 2½ miles of stream are rated as medium to high (Figure A-15) and must be considered as a potentially significant source of nitrogen to the creek. In addition, the creek runs through residential areas and city park lands where typical non-native turf grass is planted and managed up to the stream bank (e.g. Figure 3-10). Although this landscape is generally preferred in residential and urban environments care for it requires greater application of water and nutrients than native turf grass (e.g. buffalo grass). Often, even more water and fertilizer are applied than required, such that a lush, green turf is maintained. Excessive application of irrigation water and fertilizer leads to leaching of nutrients into the nearby stream channel, as well as further reduction in stream flow from irrigation water withdrawal.

Channel geometry also influences the instream environment affecting growth of algae and aquatic flora. Spring creeks in gentle gradient valleys are more typically Rosgen E-type channels that are narrow and deep (e.g. Figures 3-11 and 3-14) where less light penetrates to the channel bottom, stream temperatures tend to remain cooler and macrophytes dominate. Periphyton and filamentous algae have a preference to warmer, high sunlight environments (Chapra, 1997). Channels that tend to be wide and shallow propagate algae in preference to macrophytes. Field investigations by MDEQ monitoring staff have documented where Teton Spring Creek has changed to a Rosgen C-type stream channel in Choteau (Figure 3-13). Algal growth is prolific at this location, as measured by benthic chlorophyll *a* (Table 4-19). Upstream landuse practices that alter natural riparian vegetation often results in the widening of the stream channel which also decreases stream depth. Instream water temperatures then increase due to greater water surface area. Irrigation return flows and reduced overall flow volumes due to consumptive losses also contribute to thermal warming of the stream.

4.5.2 Targets

Nutrient targets are based on Montana's narrative standards that states, "*surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will: create conditions which produce undesirable aquatic life" (ARM 17.30.637[e])*. The undesirable aquatic life most commonly associated with elevated nutrient concentrations are excess benthic algae and macrophytes. Aquatic plant growth becomes a nuisance when it affects the fisheries or aesthetics of a stream (i.e. a stream covered with filamentous, slippery algae vs. a clean, stony streambed). In shallow streams and rivers, benthic chlorophyll *a* concentration is commonly used to measure the amount of aquatic plant growth on the stream bottom. Therefore, TMDL targets are based on preventing excess algae and macrophytes, which can be measured as chlorophyll *a*. Targets are presented as concentration-based at levels presumed to prevent excessive growth of benthic algae and macrophytes for Deep Creek and Teton Spring Creek. Secondary targets of stream flow, channel morphology, and algal biomass are also presented for Teton Spring Creek such that channel conditions favor macrophytes over benthic algae. Flow and channel morphology targets are also set for Deep Creek although no secondary target for benthic chlorophyll *a* is developed.

Nutrient concentration targets were developed through comparison of nutrient ecoregion analyses and nutrient studies conducted in similar watersheds (Table 4-20). Algal and nutrient targets are based upon USEPA's Ambient Water Quality Criteria Recommendations (USEPA, 2001), Clark Fork River numeric algal and nutrient standards (ARM 17.30.631), preliminary

MDEQ monitoring data (Personal Communication M. Suplee, MDEQ WQ Standards Section) and New Zealand's Periphyton Guidelines (Biggs, 2000).

Analysis of the relationship between benthic chlorophyll *a* concentrations and nutrient concentrations has been conducted in the Clark Fork River (Watson and Berlind, 1990; Watson and Gestring 1996). Portions of the Clark Fork River and Deep Creek lie within the same ecoregion, the *Montana valley and foothill prairies*. The lower section of Teton Spring Creek, for which nutrient targets are being developed, lies on the periphery of the *northwestern glaciated plains* ecoregion but emanates from the *Montana valley and foothill prairies* ecoregion (Figure A-6). Benthic chlorophyll *a* standards for the Clark Fork River are 100 mg/m^2 as an average summer concentration and 150 mg/m^2 maximum summer concentration.

Montana DEQ has also conducted field sampling for setting algal biomass and nutrient standards in wadeable streams of the *northwestern glaciated plains* ecoregion (Personal Communication M. Suplee, 2002). Preliminary results from this effort show that average summer chlorophyll *a* concentrations for streams that have filamentous algae and macrophyte growth are in the 10-130 mg/m^2 range. It appears that even though the *northwestern glaciated plains* ecoregion contains soils and geology with higher nutrient composition than the *Montana valley and foothill prairies* ecoregion, the 100 mg/m^2 average and 150 mg/m^2 maximum benthic chlorophyll *a* concentrations are reasonable and appropriate for this ecoregion as well.

Table 4-20. Criteria used to develop Teton River watershed nutrient targets.

Location [1]	**Criteria**	**Total Phosphorus (µg/L)**	**Ortho Phosphorus (µg/L)**	**Total Nitrogen (µg/L)**	**NO_2+NO_3 (µg/L)**	**Benthic Chl *a* (mg/m^2)**
Clark Fork River	Standards	39 [2]	NA	300	NA	100 ave.[3] 150 max.
USEPA Nutrient Ecoregion II/16	25th Percentile of average summer concentration	10	17	250	30	---
USEPA Nutrient Ecoregion II/16	Median of average summer concentration	30	20	350	70	---
USEPA Nutrient Ecoregion V/42 [4]	25th Percentile of average summer concentration	980	18	980	20	---
USEPA Nutrient Ecoregion V/42 [4]	Median of average summer concentration	1,370	30	1,370	100	---

[1] II/16 - Montana Valley and Foothill Prairies
V/42 - Northwestern Glaciated Plains

[2] Clark Fork Nutrient Standards Downstream of Missoula

[3] Applied during summer growing season June 21 – September 21

[4] Data used for deriving USEPA nutrient criteria in this region is very limited. USEPA cautions the use of the criteria (TP, n=50; Ortho P, n=5; TN, n=13; $NO_{2/3,}$ n=38)

Chlorophyll *a* targets are also comparable to benthic chlorophyll *a* concentration guidance for trout streams outlined in a New Zealand periphyton guideline document (Biggs, 2000). In New Zealand, gravel-bottomed trout streams are recommended to have no more than 120 mg/m^2 chlorophyll *a*. Although New Zealand is geographically distant, water quality information from this country is comparable to many of Montana's streams because landscape, water uses, and climates are similar.

British Columbia has also established chlorophyll *a* criteria for attached growth in streams to protect recreation/aesthetics and aquatic life at 50 and 100 mg/m^2, respectively (Nordin, 1985). However, caution should be used in applying British Columbia's criteria as they are quite low and meant for use in mountainous stream settings that do not compare directly with Deep and Teton Spring Creeks.

In determining benthic chlorophyll *a* targets all guidance pointed to a similar range of values for settings across a relatively broad range of stream and region types. Using the chlorophyll *a* criteria in Table 4-20, numeric targets were established as late summer (i.e. July – September) concentrations of no greater than 100 mg/m^2 on average or 150 mg/m^2 maximum. In addition, targets for spring and early summer (i.e. May – June) Chlorophyll *a* concentrations are established at 50 mg/m^2 (Table 4-21). This was done so that algal growth can be monitored early in the growing season to identify adverse trends or excessive growth in the event that late season monitoring is not possible due to dewatering of the stream channels.

Table 4-21. Existing conditions and primary nutrient targets for Deep and Teton Spring Creeks.

Target Compliance Location		**Total Phosphorus (μg/L)**	**Total Nitrogen (μg/L)**	**Benthic Chlorophyll *a* (mg/m^2)**
Deep Creek at Hwy 287 Bridge	Existing Conditions [1]	49	1020	58
Deep Creek at Hwy 287 Bridge	**Targets -** Based on Regional Criteria	40	650	50 May-June Max 100 July-Sept. Ave. 150 July-Sept. Max.
Teton Spring Creek, in Choteau	Existing Conditions [1]	19	410	134
Teton Spring Creek, in Choteau	**Targets -** Based on Regional Criteria	40	650	50 May-June Max 100 July-Sept. Ave. 150 July-Sept. Max.
Teton Spring Creek, near mouth	Existing Conditions [1]	22	810	52
Teton Spring Creek, near mouth	**Targets -** Based on Regional Criteria	40	650	50 May-June Max 100 July-Sept. Ave. 150 July-Sept. Max.

[1] Sample size is one/site collected by MDEQ in Aug. 2000 on Teton Spring Creek at the "near source" and "in Choteau" sites and May 2001 for Deep Creek site.

Secondary targets for stream flow, channel morphology, and algal biomass are also established (Table 4-22). Secondary targets are designed to measure the channel geometry and stream environment such that it is optimal for either a C- or E-type channel. In the case of Teton Spring Creek the target stream channel should resemble a typical spring creek that is narrow, deep and runs cool water. In such spring creeks, macrophytes may out compete filamentous algae, therefore the provision for no algal biomass, measured as *cladophora*, is included.

Also using the criteria in Table 4-20, numeric total nitrogen and total phosphorus concentration targets were established for Deep and Teton Spring Creeks (Table 4-21). Clark Fork River nutrient standards, 25th percentile and median summer concentrations for USEPA nutrient ecoregions II/16 and V/42 guided professional judgment on appropriate nutrient targets. When USEPA's regional nutrient criterion are refined for the *northwestern glaciated plains* ecoregion or the state of Montana adopts numeric nutrient criteria, the targets presented in Table 4-21 should be updated to reflect attainment of acquired knowledge.

Table 4-22. Secondary nutrient TMDL targets for Deep and Teton Spring Creeks.

Location	**Rosgen Channel Type**	**W/D Ratio**	**MW Ratio [1]**		**Instream Flow [2]**	**Algae**
			Ave.	**Range**		
Deep Creek, - at Hwy 287	C	> 12	11.4	4 – 20	18 cfs	---
Teton Spring Creek - in Choteau - near Mouth	E	< 12	24.2	20 – 40	4.5 cfs	No filamentous green algae, i.e. *cladophora*

[1] Meander Width Ratio – Meander Belt Width / Bankfull Width (Rosgen, 1992).

[2] In-stream Flow Reservation requested by MFWP to support fish, wildlife, and recreation and is based on current stream channel geometry and could be adjusted as channel geometry reaches target values.

4.5.3 TMDLs

Nutrient TMDLs for Deep Creek and Teton Spring Creek are developed as both percent reductions from existing to target condition (Table 4-23) and as performance-based. Benthic chlorophyll *a* reductions are based on the early season target of 50 mg/m^2 during May and June since this was the timing of the samples available for TMDL calculation. Nitrogen and phosphorus concentrations at the "in Choteau" monitoring site on Teton Spring Creek are already below target levels, as is the nitrogen concentration near the mouth. However, some reduction in chlorophyll *a* concentration is necessary at both sites.

Performance activities associated with the TMDLs relate to measures designed to facilitate reductions in nutrient loading from the sources allocated to in Section 4.5.4.

Management activities will be further outlined in Section 5 Implementation Strategies and will focus on agricultural BMPs, irrigation water management (IWM) strategies, municipal/residential lawn care BMPs, and management of septic systems in the Choteau area.

4.5.4 Seasonal Variation

Montana's water quality narrative standard for nutrients, referenced in 4.5.2, is designed to protect streams or water bodies from discharges that lead to "*undesirable aquatic life*." In the case of nutrients, aquatic plant growth only occurs during the spring and summer growing season when light and stream temperature conditions are appropriate. Targets established in Section 4.5.3 target the summer growing period. However, the chlorophyll *a* target is further parsed into early and late seasons. This was done so that algal growth can be monitor early in the growing season to identify adverse trends or excessive growth in the event that late season monitoring is not possible due to dewatering of the stream channels.

Table 4-23. Nutrient TMDL Reduction Targets for Deep and Teton Spring Creeks.

Stream and Target Location	**Total Phosphorus (µg/L)**	**Total Nitrogen (µg/L)**	**Benthic Chlorophyll *a* (mg/m^2)**
Deep Creek [1] at Hwy 287 Bridge	23%	57%	16% (May-June)
Teton Spring Creek [2] in Choteau	N/A	N/A	168% (May-June)
Teton Spring Creek [2] near mouth	N/A	25%	4% (May-June)

[1] Based on one MDEQ sample collected in May 2001.
[2] Based on one MDEQ sample collected in August 2000.

4.5.5 Allocation

Nutrient sources in the Deep Creek watershed are attributed to the impacts from agricultural use of riparian areas for crop production or livestock grazing and water withdrawals. Source areas are not only limited to Deep Creek, but includes Willow Creek given its influence as a major tributary stream to Deep Creek. However, no loading calculations have been conducted such that a true load allocation could be generated at this time, therefore land practices in both watersheds are equally allocated to for purposes of this document.

Nutrient sources to Teton Spring Creek are attributed to the impacts from agricultural use of riparian areas for crop production or livestock grazing and water withdrawals and in addition, include stormwater runoff, septic systems, and municipal/residential lawn care.

The primary sectors identified - agriculture (crops), riparian grazing, water withdrawals for agriculture, municipal and domestic use, septic systems, lawn care, and stormwater runoff – will need to work together and participate in activities that contribute to reducing nutrient loading or altering the stream environment. These include active revegetation of the riparian area with natural vegetative communities, active management or elimination of riparian grazing, irrigation BMPs, improved efficiencies and controls of septic systems, revegetation of non-native turf grass with natives or reduction in lawn fertilizer use/application, and the equitable sharing of an over-allocated river system with all users and beneficial uses.

Attaining support for all beneficial use (fisheries, aquatic life, human consumption, and agriculture) is inextricably dependant on achieving, and maintaining, appropriate instream flows and flow regimes through out the year. However, no adjudicated water right may be diminished via implementation of this water quality management plan. Thus it is critical that the adjudication process be completed as expediently as possible, and then, all adjudicated water right holders will need to continue to work in a cooperative manner to share the limited water resource that is available (in any given year).

4.5.6 Margin of Safety

Primary water quality nutrient targets were developed for both benthic algae and water column nitrogen and phosphorus concentrations. In addition, secondary targets were established that focus on channel morphology and stream flow. Benthic chlorophyll *a* targets are intended to specifically measure beneficial use support as stated in Montana's water quality standards. Algal targets were also established for early in the (algal) growing season so that chlorophyll *a* concentrations could be monitored when stream flows are more likely to exist.

As a backup, or margin of safety, targets were also developed for water-column nutrient concentrations, steam flow and channel morphology. Concentration-based targets are established at levels that should result in non-nuisance levels of benthic chlorophyll *a* (Suplee, 2001). Channel morphology targets are presented as part of secondary targets with the intent of re-establishing stream channel pattern, form and function that is appropriate for the given stream and valley types per the Rosgen classification system (Rosgen, 1996). Stream flows are also presented as part of secondary targets and were calculated by MFWP as the minimal instream flows necessary to support aquatic life and fisheries habitats given the current channel geometries. Minimum instream flows were calculated using wetted perimeter models and life history needs of the fisheries (Personal Communication, Bill Gardner, MFWP).

Finally, given the small sample size that was available by which to develop the nutrient TMDLs an adaptive management strategy is appropriate. By using this type of strategy TMDL reduction needs can be reviewed as additional data is collected and as new management strategies are implemented.

SECTION 5.0
IMPLEMENTATION STRATEGIES

Montana's water quality standards allow for some level of anthropogenic (human-caused) impacts to water quality while still maintaining adequate support of beneficial uses assuming that "*all reasonable land, soil, and water conservation practices*" are followed. However it should be noted that "*all reasonable land, soil, and water conservation practices*" is not synonymous with BMP's or Best Management Practices. The intent of "*all reasonable land, soil, and water conservation practices*" is to include any and all practices, beginning with currently established BMPs, which may be necessary to maintain or restore water quality to levels that supports all beneficial uses. Measures or practices beyond "standard" BMPs may be needed where water quality has not been adequately restored. Implementation of measures intended to reduce non-point source impairments is voluntary as provided in the Montana Water Quality Act [17-5-703(5), MCA] and may not infringe upon water rights (75-5-705, MCA), however Montana's water quality standards state, "*no person may violate the following specific water quality standards…*" [ARM 17.30.621- 629]. Therefore, where waters are identified as impaired, which by definition is a result of not attaining state water quality standards; pollutant reduction measures should be implemented as a matter of course.

Implementation of the Teton River watershed Water Quality Plan will be the primary responsibility of the Teton River Watershed Group (TWRG) in conjunction with the Teton and Chouteau County Conservation Districts. The TWRG is made up of landowners, conservation and weed district personnel, educators, interested citizens, and representatives of local, county, state, and federal government agencies who live or work in Teton and Chouteau counties. The group strives to improve water quality in the watershed by assisting in water quality monitoring, project area identification, solicitation of project funding, project implementation and oversight, and through promoting public education and participation.

Given the active role played by the TRWG, this water quality plan will present broad-brush strategies and BMPs that, when implemented, are intended to directly lead to improved water quality in the watershed. General BMPs that are intended to reduce impacts from sediment, temperature, and nutrient enrichment can be broken down into three broad categories, irrigation water management, riparian management on agricultural landscapes, and riparian management on municipal/residential landscapes (Table 5-1). Site-specific designs and plans will need to be developed on a case-by-case basis by individuals qualified and experienced in watershed or riparian restoration techniques. It is important that the most up-to-date information, strategies, and technologies are sought out and applied in all cases. In addition, an evaluation of economic trade-offs should be conducted before implementing any measures that will entail a significant investment or shift in land management strategies.

Securing adequate funding to implement project level work in watersheds can be challenging. However, to assist in this search, the EPA has developed a catalogue of 84 federal funding sources for watershed protection projects, which is now available through an on-line searchable web site. The web site is located at: **http://www.epa.gov/watershed funding** or by calling the EPA at (800) 490-9198 and requesting the "Catalog of Federal Funding Sources of Watershed Protection" (EPA 841-B-99-003). In addition, the MDEQ is committed to working with local watershed groups dedicated to implementing on-the-ground projects aimed at maintaining or improving water quality to the enhancement of all beneficial uses.

Table 5-1. General Best Management Practices for irrigation and agriculture activities applicable watershed-wide.

Category	**Activity**
Irrigation Water Management (IWM)	• Develop and implement a water salvage credit program such that any salvaged water is dedicated to instream beneficial uses • Redesign instream diversions using head gates and natural weir structures that allow for the passage of stream bedload • Eliminate the use of instream "push-up" dams to facilitate water diversions • Line canal and ditches in areas where saline seeps are prevalent or in areas characterized by high soil EC • Improve water use efficiencies by developing low-pressure sprinkler systems where practical • Reduce early/late season water delivery demands solely for stock by switching to off-stream watering or pumps • Increase the use of water management tools (i.e. Agrimet) to manage irrigation rates to actual plant/crop needs • Install/maintain head gates or meters to monitor actual water deliveries • Work with Water Master(s) to identify and stop illegal water diversions
Riparian Management – Agricultural Lands	• Eliminate open/unmanaged riparian grazing using fenced exclusions, water gaps, and/or closely managed rest-rotation schemes during the sensitive growing season • Establish a riparian buffer zone/strip of natural woody vegetation at least 25 feet in width or greater where possible. Larger buffer zones may be necessitated on unstable outside stream bends • Eliminate cropping and irrigation up to the bank edge
Riparian Management – Municipal & Residential Areas	• Establish a riparian buffer zone/strip of natural herbaceous and/or woody vegetation that is as large as practical • Minimize application of lawn fertilizers and irrigation watering • Re-vegetate non-native turf grass areas with native turf grasses (e.g. buffalo grass) • Construct storm water detention basins to settle sediments prior to delivery to stream channel • Active management of septic systems such that optimal treatment is achieved

5.1 Salinity and Selenium

Source areas for salinity and selenium are often one in the same and such is the case for Priest Butte Lakes. Therefore, strategies that are targeted to reduce loading for one will also benefit (reduce) loading from the other. As presented in Section 4, land management practices that elevate shallow groundwater levels or enhance the magnitude of groundwater flows are of primary concern. These practices include dryland cropping, crop-fallow, and flood irrigation and are of special concern where they occur over sensitive soils and geology.

The Montana Salinity Control Association (MSCA) has been working with producers to developed mitigation strategies for saline seeps and salinity problems (MSCA, 2000). Problems from saline seeps and soil salinity can be mitigated through the implementation of land use practices and farming systems that reduce the affect on groundwater levels. Implementation of these measures in critical or sensitive source areas of the Teton River watershed (Table 5-2) will have a positive impact on water quality throughout the watershed. All activities related to salinity control and abatement should be coordinated with the Montana Salinity Control Association.

Priest Butte Lakes Area
A critical data gap that needs to be addressed is identification of the groundwater source area for the Yeager Seep east of the lake. The greatest loading rates for both salinity and selenium in the entire Freezout Lake WMA is from this source. Most of its surface water drainage area is in dryland cropping practices, as is the area east of the Priest Butte Lakes surface water drainage. Recognizing the impact of this small drainage on Priest Butte Lakes, the current landowners in the Yeager Seep have already implemented a buffer of perennial grasses along the seep bottom (Personal Communication, Mark Schlepp, MFWP).

In conjunction with the strategies outlined in Table 5-2 and the assessment of the groundwater recharge area, a revised water quality-monitoring program is recommended that includes all surface water source areas, as well as at previously monitored in-lake sites. An adaptive management strategy can then be employed for the Priest Butte Lakes watershed such that if water quality monitoring does not indicate sufficient reductions in salinity and selenium loadings then additional measures will need to be implemented.

5.2 Sediment and Temperature

Sediment and temperature-related problems are generally the result of activities that alter riparian vegetation communities, change the stream’s sediment load, or stream flow characteristics. Any of these activities can have an adverse effect on a stream pattern, form, and function. Many of these activities are identified in Section 4.0, however not all specific source locations have been identified or quantified. Land and water management practices outlined in Table 5-1 will have a direct positive effect on the stream’s pattern, form, and function and thus are directly applicable for all streams that have sediment- and temperature-related impairments. Again, site-specific prescriptions and design need to occur on a case-by-case basis.

Table 5-2. Salinity and Selenium-related water quality restoration activities.

Location	Activity
Priest Butte Lakes: Yeager Seep Recharge Area [1]	• Increase area of perennial grasses along seep bottom • Line any irrigation canals and ditches • Place additional acreage into CRP (Conservation Reserve Program) • Retire Yeager Seep topographic watershed from agricultural production
Priest Butte Lakes: Freezeout Lake inflow	• Increase deliveries fresh water via Greenfields Irrigation District irrigation waste water and/or salvaged water from improved irrigation efficiencies.
Priest Butte Lakes: "East-Side" Seeps (Refer to Fig. 4-5)	• Eliminate wind breaks designed to capture snow and increase soil water moisture levels • Increase the area of perennial grasses along seep bottom • Line any irrigation canals and ditches • Place additional acreage into CRP (Conservation Reserve Program)
Priest Butte Lakes: "West-Side" Seeps and Drainages (Refer to Fig. 4-6)	• Line the Cascade canal • Develop stock watering holding tanks such that spillage into surface water drainage is minimized • Maintain canal and manage water diversions such that water is not spilled from the canal
General Watershed: - Teton Ridge - NE corner of Teton River watershed - Muddy Creek (Bynum area)	• Eliminate wind breaks designed to capture snow and increase soil water moisture levels • Increase cover of perennial grasses along seep bottoms • Adopt a five- to ten-year rotation from crop to perennial forage for haying/grazing • Establish perennial vegetation in recharge areas under the CRP (Conservation Reserve Program) • Switch crop/fallow to annual or flex cropping system

[1] The Yeager Seep Recharge Area includes its surface water drainage area defined by surface topography as well as, the shallow groundwater drainage area that has yet to be defined.

SECTION 6.0
EFFECTIVENESS MONITORING

An *adaptive management* approach to monitoring will be used in the Teton River watershed. Adaptive management is a process that uses monitoring, research, and evaluation to determine results of land management changes and/or restoration activities. It monitors conditions and provides a "*basis for future review and revision of the TMDL*" (USEPA, 1999b). The effectiveness monitoring presented in this section represents Phase II of the adaptive management plan that will measure the progress made toward target attainment. It will provide the critically needed data and information that will enable sound adaptive management in the watershed.

To determine the progress made through restoration projects or management changes, current (or baseline) conditions must first be reasonably estimated. MDEQ has an idea of the impairments facing the Teton River watershed; however, the extent of the impairments is not well understood. Monitoring is essential to establish current conditions as well as evaluate trends and use-support levels. A combination of GIS analysis, field sampling, and working with local stakeholders, as well as funding, will control the extent of monitoring.

In preparing this document, MDEQ found data gaps that will need to be addressed in the monitoring plan. A "data gap" is where insufficient or limited data and information exists concerning current conditions for a specific issue or geographic area. The data gaps currently identified are:

1) *Muddy Creek water quality and source assessment* – Eroding banks, stream channel incisement, riparian removal, and saline seep evidence have been described along Muddy Creek; however the MDEQ lacks sufficient and credible data to make beneficial use support determinations. Because of the stream length and large area it drains, Muddy Creek is a major tributary to the Teton River; therefore, its potential for adding pollutants needs to be characterized.

2) *Basin-wide sediment source assessment* – Although basic knowledge of sediment impairments to streams in the Teton River watershed is known (refer to Sections 3.3.4 and 4.3.1) a more detailed sediment source identification effort should be made. Data that is needed include sediment inputs that come from banks and tributaries. Baseline conditions, including riparian health, must be gathered and are the essence of Tier 1 outlined below (Table 6-1). Sediment inputs from the tributaries should include inputs from McDonald, Blackleaf, and Muddy Creeks; although these streams are not currently listed as impaired for sediment.

3) *Watershed surface water temperature characterization* – The middle section of the Teton River is listed for temperature exceedences; however, the station that provides the data is located at the end of the reach where the river changes from B-2 to B-3, or becomes a warm-water fishery. Temperature data collected with data loggers stationed between the headwater and the mouth are needed to show the characteristics of the watershed's temperature regime, the contributions from tributaries, wastewater

discharge(s), Priest Butte Lakes, and potential groundwater inputs. Supplemental fishery information is also needed to confirm what temperature tolerances resident fish have. Teton Spring Creek is also listed for temperature impairment, and although limited, the data shows a large temperature increase from the source and downstream at least eight miles. More information regarding flows and riparian cover need to be gained along with temperature data.

4) *Groundwater characteristics* - Priest Butte Lakes has been briefly studied in the past, but the characteristics of the shallow groundwater that drain into the lake have not. An extensive groundwater study was completed around Freezeout Lake, Benton Lake, and the surrounding areas. For a better understanding of the load contributed to Priest Butte Lakes from the geology and groundwater, a groundwater-monitoring plan needs to be implemented. As for the remainder of the watershed, groundwater studies should take place in irrigated areas between Choteau and Bynum (Figure A-9b) and along the Teton River to determine losing/gaining reaches of a stream. Identification of land practices that contribute to increased salts and salinity should be used to supplement or support groundwater data.

5) *Nutrient sources* – A statistically significant upward trend was seen in total phosphate values for the middle reach of the Teton River. Also, the tributary streams of Deep, Willow, and Teton Spring Creeks have shown increased algae growth and higher than the recommended total phosphate levels. The city of Choteau releases wastewater from its lagoons into the Teton River. Effects from all of these sources, plus any other non-regulated, un-permitted, or non-point source of nutrients need to be studied. The available data also leaves the status of Willow Creek in question. Water quality samples for Willow Creek showed higher nutrient values, yet Chl *a* results were well below impairment criteria. Additional plant and nutrient analyses should be completed for all the Teton River mainstem and its tributaries.

6) *Dissolved oxygen (DO)* – Low, one time measurements of DO have been collected during the summer and winter in Priest Butte Lakes. However, the extent and effects of stratification are not known. Also, data known to MDEQ has not been collected recently, or within the past ten years. To fully understand the impacts of DO, comprehensive study of daily DO levels, as well as the extent of aquatic plant life in Priest Butte Lakes, must be determined.

A “tiered approach” for monitoring is presented here (Table 6-1) and is designed to outline data that can be gathered based on time, funding, personnel, and stakeholder(s) interest/willingness to participate. Each tier is progressively more involved then the previous one. Tier 1 outlines the essential data needed to establish baseline conditions, identify sources, and better define loads. It is intentionally basic and geared towards being the most economical and fundamental but is the most critical and essential data needed for improving water quality in the Teton River watershed. Tiers 2 and 3 have progressively more detailed monitoring. Tier 2 builds on the basic data needs from Tier 1, while Tier 3 is almost geared towards specific, specialized projects and would rely on more funding and greater technical staff and oversight.

Table 6-1. Data needed to fill gaps, establish baseline, and determine trends, based on a "tiered" approach.

Tier 1 – Essential data collection		
Physical	**Chemical**	**Biological**
- Establishment of permanent cross sections (minimal number per stream), w/ 1 internal reference - Pebble counts - Permanent photo points - Riparian surveys w/ % estimate of desirable species & age diversity of woody species - Addition of turbidity with TSS at USGS gaging stations - Continuous temperature collection	- Diurnal dissolved oxygen in Priest Butte Lakes - Seasonal sampling (Spring, Summer, Fall) for SC, common ions, and selenium in Priest Butte Lakes - Groundwater source area characterization around Priest Butte Lakes - SC, temperature, and flow monitoring on the Teton River and tributaries by the USGS, MFWP, and the TRWG (volunteer monitoring group) - Nutrient samples, collected during summer, for all streams (including Muddy Creek)	- Algae collection (as outlined by MDEQ SOP) - Aquatic plant inventory of Priest Butte Lakes - Chl *a* samples - Macroinvertebrate samples bracketing Choteau wastewater treatment facility outlet & Priest Butte Lakes
Tier 2 – Detailed data collection		
- Additional cross sections (approximately 10-15% of total stream length) - Use of scour chains and bank pins for load estimations - Measurement of eroding banks, including length & height estimates, including soil erodibility determination at each site	- Groundwater characterization of Lower Teton (Choteau to mouth), including Priest Butte Lakes - Increased volunteer sites for collection of field parameters (temperature, specific conductivity, and flow estimates) - Nutrient data collection for non-growing season in mainstem and tributaries	- Macroinvertebrate samples on Teton River mainstem at 1998 sites - Fish surveys by MFWP characterizing the fisheries for all sections of the Teton River and its tributaries, including Muddy Creek
Tier 3 – Detailed and elaborate data collection		
- Additional cross sections (statistically based using a desired confidence interval, e.g. 90%) - Additional scour chains &/or bank pins - Detailed survey of eroding banks including specifics on locations, lengths & height - Sediment and hydrograph study with detailed suspended sediment and bedload movement	- Groundwater characterization of entire watershed	- Macroinvertebrate samples coinciding with stream restoration projects

6.1 Physical Data Collection

Cross sections, pebble counts, riparian surveys, turbidity and suspended sediment, and temperature collection are examples of data needed to establish the physical conditions of a stream. Sediment and riparian monitoring require the use of photo points, riparian conditions evaluations, cross-section surveys, and pebble counts. Temperature monitoring uses continuously recording data loggers placed in the stream to monitor the period of interest - June through September for summer temperatures.

6.1.1 Sediment and Riparian

For sediment monitoring, several components are essential for establishing current conditions and future improvements. These include:

- Photo documentation,
- Riparian characterization,
- Channel morphological features, and
- Sediment quantification.

Some sites will be made permanent, using benchmarks, survey equipment, and GPS. Other sites will be developed for quick and efficient data collection geared towards 2-3 hours for sampling time to supplement the permanent sites. Site selection is key to physical data collection; therefore, site prioritization guidance is also included in this discussion. Identification and development of “reference site(s)” must be worked into any sampling plan.

A “phased” approach is needed for monitoring of sediment, beginning with baseline conditions, then moving through progressively more intensive studies. At present, a very basic indication of sediment impairment was established through evidence provided by field observations, photos, and consideration of reduced habitat for biota. However, the extent and magnitude of sediment loading is unknown. The next step is to establish a more definitive base-line condition for the watershed, including establishment of permanent cross-sections and photo points. Tier 1 monitoring is aimed towards establishing the current watershed condition and to narrow the focus areas for further work. Tiers 2 and 3 should take monitoring further, based on resources, funding, and interest.

Tier 1 will require a combination of GIS analysis and fieldwork. First, office source identification using GIS mapping, aerial photos, known sources of alteration (e.g. roads, railroads, bridges, crop-land), and communication with local stakeholders needs to begin. Data found during the initial GIS analysis will show areas that warrant an actual field visit. Then, based on a combination of information from GIS analysis and landowner interest/cooperation, field investigations will be needed.

During the summer of 2003, baseline (or current) conditions in the field must be determined. Data to be collected will have a combination of photo documentation, riparian characterization, channel morphology measurements, and possibly installation of bank pins for erosion rate estimates.

6.1.1.1 Photo Documentation

Photos are ideal for documenting baseline conditions and/or future comparisons due to the relative ease and low cost associated with data collection. Photos of the stream should include upstream and downstream views taken from both sides of the stream. Care should be taken to insure good representation of riparian and bank conditions. Use of a graduated staff to show scale is a good idea (e.g. heights of un-vegetated banks). More photo documentation is certainly encouraged where needed. For photos taken at permanent locations, one should attempt to capture the view from the same location and time of day as past photos. Record keeping for site locations (including latitude and longitude), time of day, and photo and negative numbers will be extremely important in ensuring use of the photos. Several sites should be made "permanent" and tied into cross-section work (refer to Section 6.1.1.3).

6.1.1.2 Riparian characterization

A properly functioning, diverse riparian is a key component for long-term bank stabilization. Several agencies (e.g. NRCS, USEPA, USGS, USFS, and MDEQ) provide methodologies for riparian characterization, all of which attempt to consider species diversity, woody species age classification, and presence of opportunistic species or weeds. A method that selects a representative plot area for estimation of species within that area is necessary for both establishment of baseline conditions and determining effectiveness over time.

Care should be taken when determining the methodology to use for riparian characterization. Data forms that are completed in the field should be completed exactly as outlined by supported documentation. NRCS (Riparian Assessment), USEPA (EMAP), and USGS (NAQWA) methods require percentage estimations of plant species. These methods would be the most advantageous in determining changes in field plots.

For Tier 1, riparian characterizations need to be completed at the permanent monitoring sites (outlined in Section 6.1.1.3). Two to three supplemental assessments should be completed between each of the permanent sites, which include the use of photo points. Latitude and longitudes, as well as maps and complete narrative description of the site must always be included with each survey.

6.1.1.3 Channel morphology measurements

Permanent sites will need to be established for detailed channel cross-sections using a Rosgen Type II characterization or the methodology outlined in Harrelson et al. (1994). Stream channel cross-sectional surveys provide specific information regarding channel form. Parameters to be measured include bankfull width, bankfull depth (including both mean and maximum depth), flood prone width, and stream slope. From these data, width-to-depth (W/D) ratio and bankfull cross-sectional area can be calculated. Substrate data and stream discharge measurements are also collected at the cross-sections. Using aerial photographs, meander belt width must also be determined. The combination of the data listed above provides stream classification as defined by Rosgen (refer to Section 3.3.4.1). Measurements of bankfull width, depth, and flood prone area should be measured between permanent sites, which will correspond with riparian characterization and photo point locations, but do not require the precision gained by survey equipment.

Permanent sites need surveyed benchmarks (Harrelson et al., 1994) to ensure the sites can be revisited for many years in the future. Benchmarks will be tied to “reaches” or length of the stream that will be surveyed. Benchmark locations will need to have latitude and longitude determined using a GPS and also have their locations described in detail. Reach length will vary from stream to stream and should relate to the bankfull width of the stream. Rosgen (1996) recommends the reach length to be 20-30 times the bankfull width. For the Teton River where the bankfull width may be 100 feet, reach length will range from 2,000-3,000 feet in length. The same physical feature of the stream (i.e. riffle or pool) will be used to mark the upper and lower most portions measured during the survey. Longitudinal profiles and meander geometry will be measured using survey equipment.

Tier 1 monitoring calls the number of cross-sections to be “very minimal number per stream.” Further detail to support “minimal” sites and selection are provided in Section 6.1.2 Site prioritization. For each stream reach that was listed on the 2002 303(d) list, at minimum two sites need to be used for permanent cross sections. One of the two sites should be a reference condition. Rosgen (1996), EMAP, NAWQA, and/or Harrelson et al. (1994) provide guidance and methodologies for determining reference sites. Reference conditions should indicate the range of geomorphic values for the stream channel’s desired future condition.

For the middle and lower reaches of the Teton River (Choteau to mouth), using percent fines might also be used to establish current conditions and determine trends. Percent fines looks at sediments that are smaller than 6 mm whose deposition would fill interstices or clog gravels. The middle to lower reaches of the Teton River have gravel dominated substrate; yet, fine sediment deposition was identified as limiting aquatic life habitat. At the permanent cross-sections, six samples of stream substrate particles less than 6 mm should be collected, targeting all physical features of the stream (riffles, runs, pools, and glides). MDEQ SOP manual (MDEQ, 2002c) outlines the methodology, modified from USFS procedures.

Tier 2 and 3 call for increased number of cross sections. For Tier 2, the number of permanent sites should be increased to match 10-15% of the total 303(d) listed stream length (e.g. upper reach of Teton River is approximately 30 miles long; 10-15% of stream length is 3-4.5; using Tier 2 outline, the upper reach of the Teton River should have 3-5 permanent cross-sections). Tier 3 incorporates statistics and confidence intervals to determine the number of sites per stream. To use this method, a specific confidence interval would be specified (e.g. 90%), and the number of sites would be statistically determined based on that confidence interval.

6.1.1.4 Sediment quantification measurements

Many methods are available that might be used to quantify sediment loads in a stream. For Tier 1 monitoring, turbidity measurements should be collected by the USGS with all total suspended sediment (TSS) measurements.

Channel substrate characterization is also an essential component of Tier 1 monitoring. At all permanent cross-sections, substrate data needs to be collected. Pebble counts are used to determine the grain-size distribution of the channel substrate. Wollman pebble counts can be used in one of two ways. First requires over 100 pebbles be measured at one selected cross-section of the stream. Rosgen (1996) suggests a modified version of the Wollman Pebble Count that uses 10 passes through a 2-meander length of the stream. At each pass, the sampler picks up and measures 10 pebbles. Locations for each pebble count are based on proportional sampling, or statistically weighing the occurrence of stream's physical features (e.g. pool or riffle).

Tier 2 requires sediment input measurements from eroding banks found through use of bank pins, scour chains, and measurement of eroding banks. Bank pins are simply lengths of rebar that are installed horizontally into an eroding bank, with a predetermined length left exposed. After spring run-off, a measurement of exposed rebar is made and compared to the previous year. Measurements can be made at other times during the year, but for the Teton River and tributaries, spring run-off has the most erosion energy. Scour chains are placed in the substrate of the active channel. The chain is driven into the substrate with some links left exposed and a cork attached to the last link with string/twine so that it will float in the stream. The cork will aid in relocating the scour chain. After run-off, the length of exposed links or the depth at which the chain is buried is measured. Scour chains can measure how much sediment has scoured the reach where the chains are installed or may be used to determine aggradation, or the amount of bedload deposited. Scour chains may work well in the upper reach of the Teton River to determine the extent of aggration/degration after spring run-off.

Actual vertical and horizontal measurements of eroding banks, is another method for determining sediment input. Tier 2 states that "measurements of eroding banks, including length and height estimate" should be made. This level of detail could be worked into both permanent and supplemental data collection sites. A site map sketch could be prepared in the notes, indicating areas of erosion and bank heights. Tier 3 goes a step farther by adding survey methods. For a given reach, a tape, survey methods, or GPS could be used to locate and determine lengths of eroding banks. Likewise, banks that are well vegetated and are not actively contributing sediment should also be measured. If lateral movement of the stream is obvious, an estimated effective depth should be made for volume estimation. Bank pins could also show depth. Depending on available resources, GIS layers may be a product of bank measurements.

6.1.1.5 Site prioritization

Sample locations should be found with a combination of source area analysis using maps, aerial photos, GIS layers, personal communication with stakeholders and supported through field visits. For Tier 1 monitoring, a minimal number of permanent sites will be required. For the Teton River mainstem, this means two to three sites upstream of Choteau, and three to four between Choteau and the mouth. Each tributary stream should have two to three sites each although Muddy Creek should have three. A reference site for each stream needs to be determined. For streams that are similar in flow regimes and have reasonably comparable geology and geomorphology, one reference could be used for several streams (e.g. Willow Creek and Deep Creek). Use of an "internal" reference reach can be used if a reach with in a specific stream is suitable for reference.

To support data from the permanent sites, supplemental data collection is recommended. For Tier 1, a site between each permanent site would be ideal for supplemental data collection. At each site, data collection would include a riparian survey, pebble count, photos, and measurements of bankfull indicators. Through the use of photos and riparian field forms, long-term trends might be determined, although quantification of sediment inputs would not. Tiers 2 and 3 increase the number of permanent cross-sections. Additional sites for supplemental data collection would also increase.

6.1.1.6 Sediment reduction schedule

A timeline for sediment reduction monitoring should include revisiting permanent sites after two years from establishment (2005). Then, revisited again at the five-year mark of this TMDL (2007). Revegetation and reestablishment of stream length will require much more time than the state imposed five-year time frame. Therefore, long term monitoring of riparian health and eroding banks will be required. After the state required five years, though, one might be able to see positive changes in areas where reconstruction or revegetation has occurred. Areas that are left to heal naturally will require more time.

6.1.2 Temperature

Continuous recording temperature thermistors (data loggers) will be placed in the Teton River main stem and tributary streams to record summer water temperatures (Figure A-16). Reference condition considerations should be made and targeted with placement of data loggers in the streams. By bracketing areas that are either well or poorly vegetated, an indication of the effects of shading and riparian vegetation might be determined. Approximately 25 data collectors will be placed in streams from mid-April through mid-October for five consecutive years (Table 6-2). Care should be taken to insure that the data collectors are 1) placed in a location that has relatively deep, well-mixed stream flow; 2) secured to the substrate with a weight; and 3) placed in an inconspicuous location, out of sight, and out of harm’s way.

Table 6-2. Thermistor (temperature data collectors) locations for Teton River; one duplicate sampler should also be included. See also Figure A-16.

Stream	Thermistor (data collector) *approximate* locations
Teton River	10 total: 1 at each USGS gage; u/s Hwy 287 x-ing; d/s of Deep Creek (catch wastewater discharge, too); Hwy 221 x-ing; county road x-ing at T25N, R3W, S25; directly downstream of Muddy Creek (T25N, R1W, Sec8), county bridge near T25N, R3E, S22; county bridge near T24N, R6E, S9
McDonald Creek	1 near mouth
Willow Creek	2 total: 1 u/s of mouth; 1 near source
Deep Creek	2 total: 1 u/s of Willow Creek confluence (reference); 1 near dewatered section (u/s of diversion)

Table 6-2. Thermistor (temperature data collectors) locations for Teton River; one duplicate sampler should also be included. See also Figure A-16.

Stream	Thermistor (data collector) *approximate* locations
Teton Spring Creek	4 total: 1 near source, 1 u/s of Choteau, 1 d/s of town; 1 near mouth
Blackleaf Creek	2 total: 1 just downstream of the wildlife management area (reference); 1 near mouth
Muddy Creek	3 total: 1 near headwaters (Miller Colony); 1 d/s of town of Bynum; 1 near mouth

While the thermistors are in the streams, field checks or "audits" will have to be done to insure accuracy of thermistors (cross-check with Horiba meter), estimate flow or identify "dry" stream conditions, and ensure that the data loggers is intact. Field audits should occur at least once, approximately half way through the study period. If time, manpower, and resources allow, more frequent field audits may be done. Increased frequency of audits could range from monthly to bi-weekly.

Calibration of the thermistors and data download will be done by MDEQ, at least for the first year. Data will put into an Excel (or similar program) spreadsheet and organized using a macro for analyzing the data on such specifics as maximum and minimum seasonal temperatures, 7-day averages, 7-day extremes (maximum and minimum), and daily temperature changes.

6.2 Surface Water Chemical Data Collection

6.2.1 Field parameters

Temperature, specific conductivity, and flow estimates should continue to be collected by USGS, MFWP, and volunteers (Figure A-17). USGS sampling should continue as outlined in their work plans and as funding permits, including pH and DO sampling. MFWP will continue to monitor around the Priest Butte Lakes discharge as specified in the 1999 TMDL for the Middle Teton (MDEQ, 1999). Volunteer monitoring sites should be sampled on a monthly basis from March through October after which time semi-monthly samples may be permissible (Table 6.3).

Table 6-3. Locations for field parameters collections. See also Figure A-17.

Stream	Monitoring station location
Teton River	- 3 USGS sites - 3 locations near Priest Butte Lake by MFWP - 7 volunteer sites: S. Fork Gage, near Eureka diversion, Kory Crossing, Dutton Gage, Dent Bridge, Buck Bridge, and Loma Gage
McDonald Creek	- Near source - Near mouth
Willow Creek	- Near mouth - Near source (Tier 2)

Table 6-3. Locations for field parameters collections. See also Figure A-17.

Stream	Monitoring station location
Deep Creek	- Near mouth - Upstream of Willow Creek confluence (Tier 2)
Teton Spring Creek	- Near mouth - Near source (Tier 2)
Blackleaf Creek	- Near mouth - Downstream of Cow Creek Confluence (Tier 2)
Muddy Creek	- Near source (Miller colony) - Near mouth - Downstream of town of Bynum (Tier 2)

For the Teton River mainstem, some of the previous volunteer sites will remain the same, while some will be omitted. The omission of some of the lower sites was done to reduce time needed by field people and to reduce redundancy. In the lower reach of the river downstream of Muddy Creek, inputs from surface water returns are greatly reduced compared to inputs upstream. Therefore, the measured parameters do not experience much change. Sites were chosen to bracket surface inputs, including all major tributary streams. Tributary streams should have a minimum of one site near their mouths with a minimum of two sites for Muddy Creek. One to two sites may be added for Tier 2 data collection.

Surface water-quality samples that include specific conductivity should be collected in Priest Butte Lakes. At a minimum, measurements should be collected monthly at three sites located near the southern end, near the middle, and near the drain outlet structure. If resources allow sample sites and frequency should be increased on Priest Butte Lakes. A grid and statistical method might be used to determine the number of sample sites needed. Also, more surface water samples for common ions and trace metals should be collected for the lake. As MFWP continues to “flush” Priest Butte Lakes, concentrations of dissolved solids should decrease. Surface water quality samples, coupled with SC samples could aid in determining a trend.

Diurnal (daily) dissolved oxygen and temperature samples need to be collected in Priest Butte Lakes. For DO, continuous samples should be collected such that the diurnal pattern of DO can be determined for the different lake “seasons.” This would require special instrumentation that can collect continuous DO values for a 24-hour period over several days during the summer, fall and spring, and winter. MDEQ has equipment that can be used to collect continuous DO data.

Tier 2 SC monitoring for Priest Butte Lakes should include characterization of surface water inputs. Characterization would include mapping of surface inputs and creation of GIS layers. Surface water samples and collection frequency should be scheduled to follow meteorological and agricultural seasons of winter, snow melt, growing season, and post-irrigation. Sampling of surface inputs may be more sporadic, depending on flow conditions. When flowing, drains should be sampled at approximately the same time as the groundwater samples. At a minimum, samples should be collected four times a year during Jan.-Feb., Mar.-Apr., Jul.-Aug., and Sept.-Nov. covering at least two consecutive years. Field measurements and analysis of common ions and trace metals need to be collected from any surface drains, including irrigation returns. Surface water flow measurements are needed to quantify surficial inputs to the lake.

Initially, surface water samples should span a two-year period to obtain enough data to correlate TDS to SC; then, for the following three years, SC could become a surrogate method to gage TDS. After the five years mandated by state law, TDS samples should be collected over the year and compared to the previous samples.

6.2.2 Selenium

Trace metal data, including a Se analysis, needs to be collected in Priest Butte Lakes. The frequency and number of sites will be dependent upon available funding and staff/personnel, but at a minimum, three in-lake sites need to be established and sampled on a seasonal basis (spring, summer, and fall). Critical in-lake sites include a location near the Freezeout Lake input to Priest Butte Lakes, the USGS monitoring site (S-34) near the south end of the lake (Lambing, et. al., 1994), and a site near the lake’s outlet structure on the northern end. The southern site, near the Freezeout Lake input, would require sampling during periods of flow from Freezeout Lake into Priest Butte Lakes. In addition, other monitoring sites should also be established near the bottom of the drainages/seeps found along the western and eastern shores of the lake. This data collection should begin immediately and continue for two-three years. Along with metals samples, field parameters such as SC should be measured and nutrients (as described in section 6.2.3) should be analyzed.

Groundwater monitoring needs to accompany surface water sampling as to identify sources of Se. As outlined by Table 6-1, groundwater characterization is listed as a “Tier 1”, or essential data collection. Funding and personnel will drive the timeline for groundwater studies.

6.2.3 Nutrients

Tier 1 monitoring suggests water column samples be collected in each stream, during the summer. Site selection should consider all potential nutrient source inputs to the stream. Based on currently available data and information, 26 sample sites have been identified (Table 6-4 and Figure A-18). Several potential sites use the term “bracket” which is used to determine the contribution a tributary or source makes relative to another. Two known sources located on the Teton River include the Choteau wastewater treatment plant and the Priest Butte Lakes discharge. Water quality samples for nutrients should bracket these inputs to determine their contribution to the river. Both Deep and Teton Spring Creeks are listed for elevated nutrient levels; therefore, the confluences of these streams with the Teton River should be bracketed. Influences of the town of Choteau on Teton Spring Creek or the town of Bynum on Muddy Creek also need to be considered in the nutrient sampling scheme.

Table 6-4. Suggested nutrient sampling locations (Tier 1). See also Figure A-18.

Stream	Nutrient sample site locations (approximate)
Teton River	Bracket (sample upstream & downstream): 1) Choteau's wastewater treatment discharge, 2) Priest Butte Lake discharge 3) Deep Creek 4) Teton Spring Creek 5) Muddy Creek Other sites to consider: USGS gage near S. Fork Teton Downstream of McDonald Creek confluence 3-4 sites (revisit MDEQ 1998 locations?) between Dutton and Loma USGS gages
Deep Creek	Bracketing Willow Creek confluence Near mouth (or irrigation diversion?)
Willow Creek	Near headwaters Near mouth
Teton Spring Creek	Near headwaters Bracket Choteau (1 upstream & 1 just downstream of Choteau) Near mouth
Muddy Creek	Near headwater (Miller Colony) Bracketing: 1) Blackleaf Creek 2) Town of Bynum Near mouth

Nutrient samples should be collected following MDEQ SOPs (MDEQ, 2002c) and preserved as specified by the analyzing laboratory. Samples should be analyzed for TKN, total recoverable NO_3+NO_2, as N, low level NH_3, and total P (filtered PO_4 optional, depending on funding). TSS and turbidity measurements must also accompany nutrient samples. Also, at all locations where water column samples are collected, algae and Chl *a* will be collected following MDEQ SOPs. Algae samples must be analyzed by a qualified phycologist and associated water quality samples analyzed for nutrient concentrations. Algae samples should be qualified by a biologist and analyzed for nitrogen and phosphorus. Nitrogen and phosphorus analysis will show the limiting nutrient for a reach of stream. Knowing limiting nutrient will aid in refining targets and possibly in source assessment.

Tier 2 monitoring suggests sampling during the "non-growing season," which refers to the time of year when most algae and terrestrial plants are dormant. Sampling during period shows the amounts of nutrients that are in the water prior to plant use and should be conducted at all suggested sites (Table 6-4). Sampling could occur once in late fall and again in early spring.

Early spring sampling is beneficial to nutrient source assessments since run-off is beginning and the load of sediment and nutrients in the streams is elevated. Also, groundwater levels begin to increase, bringing with them any residual nutrients left by the previous year's receding water table.

6.3 Biological Data Collection

Algae, Chl *a*, macroinvertebrates, and fish are examples of biological data. Algae and Chl *a* are used in combination with water quality nutrient samples to determine trophic levels. Macroinvertebrates are good indicators of habitat conditions. Some historical fish surveys have been completed in the Teton River watershed; yet more data is needed, especially in the lower reach of the Teton River.

Algae and Chl *a* samples need to correspond to the sites outlined in Section 6.2.2. Collection of algae should be done following method outlined by the USEPA, in the publication "Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers" (USEPA, 1999). At each monitoring location (Table 6-4 and Figure A-18), algae rapid bioassessment includes use of three transects, three locations at each transect, and statistical characterization of data found using a 50-dot grid on the bottom of a viewing bucket. Samples for lab analysis and biological interpretation should be collected to supplement the field data. Chl *a* samples should be collected as specified by the MDEQ SOP manual (MDEQ, 2002c).

Marcroinvertebrate sampling is listed for all three tiers. Tier 1 lists macroinvertebrate samples to be collected bracketing the Choteau wastewater treatment plant and the Priest Butte Lakes discharges on the Teton River. Data collection should include samples upstream and downstream of both dischargers. Tier 2 calls to sample at the 1998 sites on the Teton River mainstem. If this is done in summer 2003, it will be five years from the previous set of samples. Re-sampling of the tributary streams might also be considered, although the time from past sampling is much shorter. Tier 3 suggests macroinvertebrate sampling before and after the completion of any restoration projects. All macroinvertebrate sample need to follow methods outlined in USEPA "Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers" (USEPA, 1999).

Characterization of the fisheries for all reaches of the Teton River mainstem, its tributaries, the listed reservoirs, and Priest Butte Lakes is requested of MFWP by MDEQ. Portions of the mainstem and few tributaries have some data, while other areas are severely lacking. Instream flow requests have been calculated for the upper and lower portions of the Teton River mainstem and for Deep, Teton Spring, and McDonald Creeks. Further study of minimum flow requirements would be good for the remaining tributaries, including Muddy Creek.

6.4 Groundwater Characterization

Groundwater interaction with the surface waters of the Teton River watershed has a significant influence on both water quality and quantity. Groundwater seeps contribute TDS and/or selenium in areas of the watershed and, specifically, into Priest Butte Lakes. The Teton River aquifer, described briefly in Section 4.3.1.1 for the Choteau area, is a highly conductive groundwater system and appears to have a significant influence on the surface water characteristics.

The level of understanding of the groundwater systems in the Teton River watershed needs to be improved. Groundwater flow and chemical characteristics are critical data supplements to surface water quality data. However, resources may prevent comprehensive, basin-wide studies from occurring in the near future. The first tier, and most important, should focus on the Priest Butte Lakes groundwater source area, where USGS data shows the seep in the southeastern corner of the lake as having very high concentrations of TDS, sodium, magnesium, sulfate, and selenium. If funding is limited, groundwater studies could be parsed into smaller studies that focus initially on each side of Priest Butte Lakes, since the geology differs slightly between the sides (Figure 4-8). The east side of the lake is considered the highest priority.

A groundwater characterization would need to determine flow paths, input rate of water into the lake, and chemical analysis of groundwater. Chemical analysis would include SC, temperature, DO, pH, ionic content (specifically sodium, magnesium, chloride, and sulfate), and trace metals (specifically, selenium). Samples and frequency of data collection should follow meteorological and agricultural seasons of winter, spring snowmelt, summer growing season, and autumn post-irrigation. Timing and frequency of sampling may be directly related to funding. At a minimum, samples should be collected four times a year during Jan.-Feb., Mar.-Apr., Jul.-Aug., and Sept.-Nov., and cover at least two consecutive years.

Tiers 2 and 3 include expansion areas in need of groundwater characterization to the entire Teton River watershed. Further groundwater information should include data collected in agricultural areas around Bynum/Choteau, in losing or gaining reaches, and regarding infiltration rates around irrigation ditches.

Knowledge of losing or gaining reaches, chemical analysis, and information on annual groundwater fluctuation can add a lot of understanding to all listed pollutants and impairments. Linking land use practices to groundwater characteristics is a much-needed step for a more thorough source assessment. Results found from any groundwater characterization should be incorporated into a GIS format.

SECTION 7.0
PUBLIC INVOLVEMENT

MDEQ gave presentations on the TMDL process and document development at annual meetings of the Teton River Watershed Group (TRWG) in 2000, 2002, and 2003. The Choteau Acantha reported on several monthly meetings of the TWRG in which components of a TMDL plan were discussed. The TRWG also sent its newsletters to interested watershed residents with updates on the TMDL document as it was developed.

Several versions of the preliminary draft document were circulated for comment among watershed organizations including the irrigation districts. In early February 2003, prior to release to the public, the draft TMDL was distributed to the Teton River Watershed Group, Teton County Conservation District, Fish Wildlife and Parks, fishery biologists, Freezout Wildlife Management Area, and Greenfields Irrigation District for an “internal” stakeholder review.

The draft Teton Planning Area document was released for public review on February 27, 2003 and a notice of availability and opportunity to provide comments was published on the MDEQ home page http://www.deq.state.mt.us. The TRWG was notified on February 26th that the draft document was being release the following day and fifteen hard copies of the draft document were mailed to the TRWG on February 27th. A press release was posted on MDEQ Press Release Web Page announcing the availability of the TMDL, the comment period, which was open until March 27, 2003 and a public meeting at the Montana Fish, Wildlife, and Parks Office in Great Falls was scheduled for March 17th from 4:00 to 7:00 pm. The press release was posted on the listserve for watershed issues WASHED@listserv.montana.edu and also appeared in the Great Falls Tribune, Choteau Acantha, Dutton Dispatch, Trader Dispatch, and Ft. Benton River Press. In addition, public meeting information was posted on the MDEQ Public Meetings Web Site.

Teton River Watershed Group members were briefed about the availability of the draft TMDL on March 3rd and were provided information on how to access the document via the Internet. On The TRWG coordinator delivered hard copies of the draft on March 10th to the Teton County Conservation District office for each irrigation project and one for the CD. The coordinator than called, left messages or chatted with employees of each irrigation group as to where to pick up a copy of the draft TMDL.

Copies of the draft document were also available to the public in hard copy and on CD at the March 17th public meeting at MFWP in Great Falls. In response to direct requests for the document MDEQ provided a hard copy to MFWP staff in Choteau prior to March 17th and a hard copy and several CD-ROMs of the document to the Teton County Conservation District during the week of March 17th.

The TRWG coordinator met with the irrigation groups on March 20th to discuss the TMDL. This meeting was not a formal public meeting but was designed to help people better understand the complex document. On March 20, TRWG coordinator e-mailed the irrigation group’s request to MDEQ for an extension to the comment period. The extension was not granted by MDEQ for reasons of limited, available staff resources given the current court-ordered schedule and the fact that stakeholders had been informed that the comment period would be thirty days in length.

The comment period closed on March 27, 2003. Eight responses to public comment were received via US mail and three responses were e-mailed. Most responses contained multiple comments.

CITATIONS AND SELECTED REFERENCES

American Fisheries Society, Montana Chapter. Website visited on November 2002. Web address: http://www.fisheries.org/AFSmontana/SSCpages/SSC.htm.

Ayers, R. S. and D. W. Westcot. 1985. Water Quality for Agriculture. FAO Irrigation and Drainage Paper 29 (Rev 1). Food and Agriculture Organization of the United States.

Bahls, L., Bukantis, R., and Horpestad, A. 1992. Benchmark Biology of Montana Reference Streams. Water Quality Bureau, Helena, MT.

Bahls, Loren. 1999. (A) Supplemental Assessment of the Use Support in the Teton River Based on Periphyton Composition and Community Structure. Hannaea, Helena, MT.

Bahls, L. 2002. Periphyton Bioassessments for the Teton River Tributaries. Hannaea, Helena, MT.

Barnes, G., and T. D. Nudds, 1991. Salt Tolerance in American Black Ducks, Mallards, and Their F1 Hybrids. The Auk 108:89-98.

Barry, R. G., 1992. Mountain Weather and Climate. 2nd Edition. Routledge, Chapman, and Hall, Inc. 402 p.

Biggs, B. J. F., 2000. New Zealand Periphyton Guideline: Detecting, Monitoring and Managing Enrichment of Streams. Prepared for Ministry for the Environment, NIWA Christchurch. 122 p.

Board of Natural Resources and Conservation. 1992. Missouri River Basin, Final Order Establishing Reservations above Fort Peck Dam. DNRC, Helena, MT.

Bollman, Wease. 1999. Bioassessment of the Teton River and the North Fork of the Teton River, Teton and Choteau Counties, Montana, July and August 1998. Rhithron Biological Associates, Missoula, MT.

Bollman, Wease. 2001a. An Analysis of the Aquatic invertebrates and Habitat of Four Streams in the Teton River Watershed, May 2001. Rhithron Biological Associates, Missoula, MT.

Bollman, Wease. 2001b. (An) Assessment of Spring Creek, Teton County: Habitat and Aquatic Invertebrate Assemblages, August 2000. Rhithron Biological Associates, Missoula, MT.

Boner, F.C. and F. Stermitz. 1967. Floods of June 1964 in Northwestern Montana. U.S. Geological Survey Water-Supply Paper 1840-B. 242 p.

Brown, G. W. 1969. Predicting temperatures of small streams. Water Resources Research 5(1): 68-75.

Bukantis, Robert. 1997. Rapid bioassessment macroinvertebrate protocols: Sampling and sample analysis SOPs. Work Draft (April 22, 1997). Montana Department of Environmental Quality. Planning Prevention and Assistance Division. Helena, MT.

Carlson, J. 2001. Montana Animal Species of Special Concern. Montana Natural Heritage Program and Montana Fish, Wildlife and Parks, Helena, MT.

CH2M Hill. 1980a. Bynum Reservoir Dam, Bynum, Montana, Teton County. Bellevue, WA.

CH2M Hill. 1980b. Eureka Reservoir Dam and Dikes, Choteau, Montana. Bellevue, WA.

Chapra, Steven C. 1997. Surface Water-Quality Modeling. WCB McGraw-Hill. 844p.

Collier, M., R. H. Webb, and J. C. Schmidt. 1996. Dams and Rivers: A primer on the downstream effects of dams. U.S. Geological Survey, Circular 1126. 94 p.

Daly, C., G. Taylor, and W. Gibson. 1997. The PRISM Approach to Mapping Precipitation and Temperature, 10th Conf. on Applied Climatology, Reno, NV. Amer. Meteor. Soc. 10-12.

Decker-Hess, J. 1989. (An) Inventory of the Spring Creeks in Montana. Montana Fish Wildlife and Parks, Helena, MT

DeMooy, C. J. and W. T. Franklin. 1977. Determination of Maximum Tolerable Salinity Levels for Continuous Irrigation on Various Soils Along the Powder River. Yellowstone-Tongue APO. Fort Collins, CO.

DeVoto, B. 1953. The Journals of Lewis and Clark. Boston, MA.

DNRC. 1991. Draft Environmental Impact Statement for Water Reservation Applications above Fort Peck Dam. Montana Department of Natural Resources and Conservation. Helena, MT. June 1991.

DNRC. 1992. Final Environmental Impact Statement for Water Reservation Applications above Fort Peck Dam. Montana Department of Natural Resources and Conservation. Helena, MT. January 1992.

Fairfield. 1997. Application for renewal of a Facultative Sewage Lagoon-General Discharge Permit-1998.

Gardner, W. M. 1998a. Middle Missouri River Fisheries Evaluations, 1997 Annual Report (Nov 1998, Statewide Fisheries Investigations). MT Department of Fish Wildlife and Parks.

Gardner, W. M. 1998b. “Blue Sucker” Species of special concern. Montana Fish, Wildlife and Parks, Lewistown, Montana. Internet article, accessed on Nov 27, 2002. Web address: http://www.fisheries.org/AFSmontana/SSCpages/Bluesuckstatus.htm.

Gieseker, L. F. 1937. Soils of Teton County. Soil Reconnaissance of Montana, Preliminary Report, Bulletin No. 332. Completed in cooperation with the Bureau of Chemistry and Soils, USDA. MSU Agricultural Experiment Station, Bozeman, MT.

Glennon, R., 2003. The Environmental Consequences of Groundwater Pumping. Water Resources IMPACT, Vol. 5, No. 2, p. 13-15. American Water Resources Association, Middleburg, VA.

Gordon, N. D., T. A. McMahon, and B. L. Finlayson. 1992. Stream Hydrology. An Introduction for Ecologists. John Wiley & Sons. 526 p.

Gould, W. R. 1998. "Sturgeon chub" Species of special concern. Biology Department, Montana State University, Bozeman, Montana. Internet article, accessed on Nov 27, 2002. Web address: http://www.fisheries.org/AFSmontana/SSCpages/sturgeon_chubstatus.htm.

Hansen, B. R.; S. R. Grattan, and A. Fulton. 1999. Agricultural Salinity and Drainage. University of California Irrigation Program, University of California. Davis, Revised 1999.

Harrelson, C. C., C. L. Rawlins, J. P. Potyondy. 1994. Stream Channel Reference Sites: An illustrated Guide to Fiedl Technique. USDA Forest Service. General Technical Report RM-245. Fort Collins, CO.

Hawn, T., W. Kellogg, and S. Henry. 1998. Assessment and Characterization of the Teton River Corridor. Lewistown, MT.

Hirsch, R.M, Alexander, R. B, and Smith, R. A. 1991. Selection of Methods for the Detection and Estimation of Trends in Water Quality. Water Resources Research, Vol. 27, No. 5, pp 803-813, May 1991.

Holzer, J.M., M. Miller, S. Brown, R. Legare, and J. Von Stein. 1995. Dryland Salinity Problems In The Great Plains Region of Montana: Evolution of Hydrogeology Aspects and Control Programs. International Association of Hydrogeologists, Congress XXVI – Dryland Salinity. June 4-10, 1995. Edmonton, Alberta.

Holzer, J. M. 1996. Solving Salinity Through Cropping. Proceedings – 1996 AgriFUTURE Farm Technology Expo and Conservation Workshop, Alberta Conservation Tillage Society 18th Annual Meeting, February 22-24, 1996. Red Deer, Alberta.

Kazmann, R.G., 1948. The induced infiltration of river water to wells. Trans. Amer. Geophys. Union, Vol. 29, No. 1, p. 85-92.

Keller, D. W. 2001. The Making of a Masterpiece, Stewardship History of the Rocky Mountain Front and the Bob Marshall Wilderness Complex (1897-1999). Boone and Crocket Club. Missoula, MT. 63 p.

Kendy, Eloise and Bill Olsen. 1997. Physical, Chemical and Biological Data Associated with Irrigation Drainage in the Freezeout Lake Area, West Central Montana-1994-95. U.S. Geological Survey WRI Report 97-349, 48 p.

Kendy, Eloise, D. A. Nimick, J. C. Malloy, and B. Olsen. 1999. Detailed Study of Selenium in Glacial-Lake Deposits, Wetlands, and Biota Associated with Irrigation Drainage in the Freezeout Lake Area, West Central Montana, 1994-95. US Geological Survey. WRI Report 99-4019. Helena, MT. 59 p.

Klarich, D. A. and S. M. Regele. 1980. Structure, General Characteristics, and Salinity Relationships of Benthic Macroinvertebrate Associations in Streams Draining the Southern Fort Union Coalfield Region of Southeastern Montana. Montana DHES, Water Quality Bureau, Billings Regional Office, Environmental Sciences Division. USGS grant number 14-08-0001-G-503. November 1980. 148 p.

Knapton, J. R., Jones, W. E., and Sutphin, J. W. 1988. Reconnaissance Investigation of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage in the Sun River Area, West-Central Montana, 1986-87. USGS Water-Resources Investigations Report 87-4244.

Lambing, J. H.; D. A. Nimick; J. R. Knapton and D. U. Palawski. 1994. Physical, Chemical and Biological Data For Detailed Study of the Sun River Irrigation Project, Freezeout Lake Wildlife Management Area, and Benton Lake National Wildlife Refuge, West Central Montana, 1990-92, with Selected Data for 1987 – 89. U.S. Geological Survey. Open-File Report 94-120. Helena, MT.

Lemley, D. A. 1999. Selenium Transport and Bioaccumulation in Aquatic Ecosystems: A Proposal for Water Quality Criteria Based on Hydrological Units. Ecotoxicology and Environmental Safety, Volume 42, pg. 150-156; Also available online at: http://www.idealibrary.com, article ID eesa.1998.1737

Leopold, L. B., M. G. Wolman, J. P. Miller. 1964. Fluvial Processes in Geomorphology. Dover Publications, Inc., New York. 522 p.

Maidment, D. R. 1992. Handbook of Hydrology. David R. Maidment, Editor inChief,. McGraw-Hill, Inc.

Margalef, R. 1952. Diversidad de Espicies en las Communidades Naturales. Proc. Inst. Biol., Apl., 9: 5-27.

McKee, J. E. and H. W. Wolf, editors. 1963. Water Quality Criteria. Second Edition. Publication 3-A, California State Water Resources Board, Sacramento. 548 p.

MDEQ. 1984. Water Quality Monitoring to Evaluate the Effectiveness of the Freezeout Lake Management Plan. Helena, MT.

MDEQ. 1984. Priest Butte Lakes Outlet Regulation Schedule. Helena, MT.

MDEQ. 1993. Authorization to Discharge Under the MPDES Permit MPDES Permit #MT-G580003 1993-8 for City of Fairfield. Helena, MT.

MDEQ. 1995. Authorization to Discharge Under the MPDES Permit MPDES Permit #MT-0020052 1996-2000 for City of Choteau. Helena, MT.

MDEQ. 1996a. Montana 303(d) List. A Compilation of Impaired and Threatened Water Bodies in Need of Water Quality Restoration. 1996. Helena MT. http://www.deq.state.mt.us/ppa/mdm/303_d/303d_information.asp.

MDEQ. 1996. Authorization to Discharge Under the MPDES Permit #MT-0020052 for City of Choteau. Helena, MT.

MDEQ. 1998. Authorization to Discharge Under the MPDES Permit #MT0029807 for Triangle Packing Plant. Helena, MT.

MDEQ. 1999. Salinity TMDL for the Teton River below Freezeout/Priest Butte Outlet. Helena, MT.

MDEQ. 2000. Montana 303(d) List. A Compilation of Impaired and Threatened Water Bodies in Need of Water Quality Restoration. 2000. Helena, MT. http://www.deq.state.mt.us/ppa/mdm/303_d/303d_information.asp

MDEQ. 2001. Source Water Protection Plan for the City of Choteau. Montana Source Water Protection Program, Helena, MT.

MDEQ. 2002a. Montana 303(d) List. A Compilation of Impaired and Threatened Water Bodies in Need of Water Quality Restoration. 2002. Helena, MT. http://www.deq.state.mt.us/ppa/mdm/303_d/303d_information.asp

MDEQ. 2002b. Circular WQB-7: Montana Water Quality Standards. Helena, MT.

MDEQ. 2002c. Standard Operating Procedures for Water Resources Investigations. Helena, MT.

MDEQ. 2002d. Technical Basis for Draft EC and SAR Standards with Allocation. July, 2002. Helena, MT. 14 p.

MFWP. 1997a. Water Management Plan for Freezeout Lake Wildlife Management Area. Fairfield, MT. 36 p.

MFWP. 1997b. Dewatered Streams List. Montana Department of Fish, Wildlife and Parks, Helena, MT. 16 p.

MFWP. 2002. Montana's Fishery Information System Reporting Database. Website accessed on Nov, 2002. Web address: http://nris.state.mt.us/scripts/esrimap.dll?name=MFISH&Cmd=INST.

Miller, M.R., P. Brown, J. Donovan, R. Bergantino, J. Sonderegger, and F. Schmidt. 1980. Saline-seep Development and Control in the North American Great Plains: Hydrogeologic Aspects. Land and Stream Salinity Seminar, Perth, Australia.

Miller, M. R., P. Brown, J. Donovan, R. Bergantino, J. Sonderegger, and F. Schmidt. 1981. Saline-seep Development and Control in the North American Great Plains: Hydrogeologic Aspects. MBMG. OFR 81. Butte, MT.

Mitcham, S. A. and G. Wobeser. 1998. Effects of Sodium and Magnesium Sulfate in Drinking Water on Mallard Ducklings: Journal of Wildlife Diseases. Vol. 24, p. 30-44.

Montana Department of Health and Environmental Sciences. 1974. Water Quality Inventory and Management Plan. Helena, MT. 119 p.

Moulton, Gary E. 1999. The Journals of Lewis and Clark Expedition. Gary E. Moulton, Editor. University of Nebraska Press. Lincoln, NE.

Mount, D. R., D. D. Gulley, J. R. Hockett, T. D. Garrison, and J. M. Evans. 1997. Statistical Models to Predict the Toxicity of Major Ions to Ceriodaphnis dubia, Daphnia magna and Pimephales promelas (Fathead Minnows). Environmental Toxicology and Chemistry. Vol. 16. No. 10, pp. 2009-2019.

MSCA. 2000. Salinity Control in Montana. Montana Salinity Control Association, Conrad, MT. Informational Pamphlet.

MSEO. 1962. Water Resources Survey for Teton County, Montana. Parts I and II. Published by the Montana State Engineer's Office, Helena, MT, June 1962.

MSEO. 1964a. Water Resources Survey, Chouteau County, Montana. Parts I and II. Published by the Montana State Engineer's Office, Helena, MT, June 1964.

MSEO. 1964b. Water Resources Survey, Pondera County, Montana. Parts I and II. Published by the Montana State Engineer's Office, Helena, MT, June 1964.

NAS. 1974. Water Quality Criteria, 1972. National Academy of Sciences, National Academy of Engineering. U.S. Government Printing Office, Washington, D.C.

NATC. 1968. Water Quality Criteria. Report of the National Technical Advisory Committee on Water Quality Criteria, Federal Water Pollution Control Administration, United States Department of Interior, Washington, D.C. 234 p.

Newcombe, C. P. and Jensen, J. O. T. 1996. Channel Suspended Sediment and Fisheries: A Synthesis for Quantitative Assessment of Risk and Impact. North American Journal of Fisheries Management, Vol. 16, No. 4, pp 693-727.

Nimick, D. A., J. H. Lambing, D. U. Pawawski, and J. C. Malloy. 1996. Detailed Study of Selenium in Soil, Water, Bottom Sediment, and Biota in the Sun River Irrigation Project, Freezeout Lake Wildlife Management Area, and Benton Lake National Wildlife Refuge, West-central Montana, 1990-1992. USGS Water-Resources Investigations Report 95-4170. Helena, MT. 120 p.

Nordin, R. N. 1985. Water Quality Criteria for Nutrients and Algae. Water Management Branch, Ministry of Environment, Province of British Columbia, Victoria.

NRCS. 1995. Soil Survey Geographic (SSURGO) Data Base Data Use Information. Miscellaneous Publication Number 1527. Fort Worth, TX.

NRCS. 1996. Grazing Best Management Practices. Bozeman, MT.

NRCS. 1998. Preliminary Work Plan for Teton River watershed in Chouteau and Teton Counties. Ft. Benton, MT.

ODEQ. 1999. Sucker-Grayback Water Quality Management Plan, Rogue River Basin, Illinois River Sub Basin. Siskiyou National Forest and Oregon Department of Environmental Quality. March 1999.

Peterson, D. A., Porter, S. D., and Kinsey, S. M. 2002. “Chemical and biological indicators of Nutrient Enrichment in the Yellowstone River Basin, Montana and Wyoming, August 2000: Study Design and Preliminary Results”. Water-Resources Investigations Report 01-4238, Cheyenne, WY

Phillips, H. Wayne. 2003. Plants of the Lewis and Clark Expedition. Mountain Press Publishing Company. 288p.

Plafkin, J. L, Barbour, M.T, Porter, K.D, Gross, S.K, and Hughes, R. M. 1989. Rapid Bioassessment Protocols for Use in Streams and Rivers. Benthic Macroinvertebrates and Fish. EPA 440-8-89-001. Office of Water Regulations and Standards, U.S. Environmental Protection Agency, Washington, D.C.

Raines, G. L. and B. R. Johnson. 1996. Digital Representation of the Montana State Geologic Map: A Contribution to the Interior Columbia River Basin Ecosystem Management Project: U.S. Geological Survey Open File Report 95-691, 19 p.

Redfield, A. C. 1958. The Biological Control of Chemical Factors in the Environment. Am. Sci. 46: 205-221.

Richards, R. P. and Miller, N. 2000. Nutrient Status of Rivers and Streams in Montana.

Rosgen, Dave, P. H. 1992. Restoration Concepts for the Teton River, Choteau Montana. Pagosa Springs, CO.

Rosgen, Dave. 1996. Applied River Morphology. Wildland Hydrology. Lakewood, CO.

Seaber, Paul R., F. P. Kapinos, and G. L. Knapp. 1987. Hydrologic Unit Maps. U.S. Geological Survey Water Supply Paper 2294. 63 p.

Shannon, C. E. and W. Weaver. 1964. The Mathematical Theory of Communication. University of Illinois Press, Urbana. 135 p.

Spritzer, Don. 1999 . Roadside History of Montana. Mountain Press Publishing Company. 449 pp.

Stumm, W. and J. J. Morgan. 1981. Aquatic Chemistry: An Introduction Emphasizing Chemical Equilibria in Natural Waters. Wiley-Interscience, John Wiley and Sons Publishing. New York, NY.

Suplee, Mike. 2001. Nutrient Criteria for the Clark Fork River. MDEQ unpublished report presented to the Water Pollution Control Advisory Council, December 2001.

Swanson, G. A., V. A. Adomaitis, F. B. Lee, J. R. Serie, and J. A. Shoesmith. 1984. Limnological Conditions Influencing Duckling Use of Saline Lakes in South-Central North Dakota. J. Wildl. Manage. 48:340-349.

Thompson, Curt. 1993. Floating and Recreation on Montana Rivers. Falcon Publishing Company, Gilford, CT.

USDA (US Department of Agriculture) – Soil Conservation Service. 1977. Average Annual Precipitation Montana based on 1941 – 1970 base period. Bozeman, MT.

USDA (US Department of Agriculture) – Natural Resources Conservation Service. 1995. Soil Survey Geographic (SSURGO) Data Base. Miscellaneous Publication Number 1527.

US Department of Interior. 1966. Water Quality Control Study, Sun-Teton Unit Montana. Federal Water Pollution Control Administration, Denver, CO.

US Department of Interior. 1996. Detailed Study of Selenium in Soil, Water, Bottom Sediment, and Biota in the Sun River Irrigation Project, Freezeout Lake Wildlife Management Area and Benton Lake National Wildlife Refuge, West Central Montana, 1990-1992. U.S. Geological Survey, WRI Report 95-4170. Helena, MT

US Department of Interior. 1998. Guidelines for Interpretations of the Biological Effects of Selected Constituents in Biota, Water, and Sediment. National Irrigation Water Quality Program Information Report #3. U.S. Geological Survey, Helena, MT.

US Department of Interior. 2002a. Water Resources Data, Water Year 2001. U.S. Geological Survey, Water-Data Report MT-01-1. Helena, MT.

US Department of Interior. 2002b. Loma/Vimy Ridge Watershed Environmental Assessment and Plan Amendment MT064-01-15. Bureau of Land Management, Havre, MT.

US Department of Interior. 2002. USGS Water Resources of Montana. Internet website: http://mt.water.usgs.gov/. Accessed June 2002.

USEPA. 1976. Quality Criteria for Water. Washington, DC. 256 pp

USEPA. 1997. Memorandum entitiled "Nonpoint Sources and Section 303(d) Listing Requirements" from Geoffrey H. Grubbs, Director, Assessment and Watershed Protection Division to FACA Workgroup on Section 303(d) Listing Criteria (May 23, 1997).

USEPA. 1999a. Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers. Publication number: EPA 841-B-99-002. Washington DC.

USEPA, 1999b. Protocols for Developing Sediment TMDLs. EPA 841-B-99-004. Washington, D.C.

USEPA. 2000. Nutrient Critieria – Technical Guidence Manual. EPA website, accessed Dec 2002. Web address: http://www.epa.gov/ost/criteria/nutrient/guidance/rivers/chapter_7.pdf.

USEPA. 2001. Ambient Water Quality Criteria Recommendations. Information supporting the development of State and Tribal nutrient criteria. EPA website, accessed Nov 2002. Web address: http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/rivers/rivers_5.pdf.

USGS. 1958. The Effect of Lake Drainage on the Chemical Quality of Water in the Teton River Near Dutton, Montana. Unpublished report in conjunction with the USGS to the (Montana) State Engineer Office.

USGS. 2002. Water Resources of Montana. Website accessed Nov 2002. Web address: http://mt.water.usgs.gov/.

Uthman, B., 2002. MDNRC Interdepartmental Memo RE: Groundwater - Surface Water Interactions, Groundwater Development, Montana Water Law, and Water Rights Permitting. 19 p. Helena, MT.

Wares, O, Abdur-Rahim Jaouni, and Leon Tsao. 1989. The distribution, speciation, and geochemical cycling of selenium in a sedimentary environment, Kesterson Reservoir, California. Applied Geochemistry. Vol 4. p 543-563.

Watershed Consulting. 1999. Assessment of channel stability of the Teton River from Bynum Diversion to Eureka Reservoir. Unpublished report for Teton County Conservation District.

Watson, V. and P. Berlind. 1990. Control of algal standing crop by P and N in the Clark Fork River. *In* V. Watson, (ed), Proceedings of the Clark Fork River Symposium, April 20, 1990. MSU Bozeman.

Watson, V. and B. Gestring. 1996. Monitoring algae levels in the Clark Fork River. Intermnt. J. Sciences **2**: 17-25.

Western Regional Climate Center. 2003. Website visited in January 2003 at: http://www.wrcc.dri.edu/index.html

Wilkenson, L. 1996. Chapter 13 - Smoothing. SYSTAT 10 Statistics II User's Manual. SPSS Inc. Chicago IL

Wilkins, L. 1996. Set and Canonical Correlation (Chapter 11 of SYSTAT user's manual). SPSS Inc, Science and Marketing Department. Chicago, IL.

Woods, A. J., Omernik, J.M., Nesser, J.A., Sheldon, J., and Azevedo, S.H., 1999. Ecoregions of Montana (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,500,000).

Wunderlich, T. E. 1972. Heat and mass transfer between a water surface and the atmosphere. Water Resources Research Laboratory, Tennessee Valley Authority. Report No. 14. Norris, Tennessee. Pp 4.20.