Freezout Wildlife Management Area Water Quality Monitoring 2006

Montana State University Extension Water Quality Program in cooperation with Sun River Watershed Group and Montana Dept. of Environmental Quality

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Background

Freezout Lake Wildlife Management Area (WMA), established in 1952, is located approximately 40 miles west of Great Falls, Montana along U.S. Highway 89 between Fairfield and Choteau. The WMA consists of 12,000 acres of shallow lakes and ponds, marsh and grasslands. At maximum water levels, standing water in lakes, ponds and canals covers about 6,000 acres. Management and maintenance of the WMA is the responsibility of Montana Department of Fish, Wildlife and Parks (MT FWP). The WMA is primarily managed to promote waterfowl and upland game-bird production, hunting and viewing. This area is considered to be a key staging area along the Pacific Flyway during spring and fall migration of waterfowl. It is estimated that up to a million waterfowl, including snow geese and tundra swans, utilize the area. Other special species that have been observed include trumpeter swan, bald eagle, peregrine falcon, common loon, American white pelican, white-faced ibis and ferruginous hawk. Of the 226 bird species that have been observed at the WMA, 67 species, including 12 waterfowl and 27 other water-bird species, nest within the area.

Prior to the start of large-scale irrigation on surrounding lands, Freezout Basin contained several shallow, non-discharging lakes that would completely evaporate during dry years. With the construction of Greenfields Irrigation District (GID) on Fairfield Bench, water flow into Freezout basin through groundwater seepage, on-farm waste and irrigation canal wasting increased to the point these lakes became permanently flooded. As a result, a drainage canal system from Freezout Lake to Teton River was constructed to prevent unacceptable flooding of roads and surrounding agriculture lands. An aqueduct was then constructed to connect Priest Butte Lakes to the Teton River to enable management of water levels within Freezout WMA. Montana FWP is thus able to move water from the Freezout Lake system to Priest Butte Lakes eventually discharging into the Teton River.

Some storm-related runoff events on dryland cropping parcels around the perimeter of Freezout Lake contribute to its water balance. For the most part however, flows and/or sources of flows into Freezout Lake and originating from Greenfields Irrigation District and Fairfield Bench are controlled, occurring primarily in response to flows in delivery and wasteway canals and drainage ditches.

Since 1952, both water quality and quantity have been issues of concern to managers of the wildlife management area. Water quality into the Teton River is an issue for water users in that basin. Both Teton River and Priest Butte Lakes have been listed as impaired on Montana's 303D list. Primary causes of water quality impairments and relevant to this study include salinity/TDS, selenium, and nutrients. Some probable sources of impairment include irrigation withdrawals and return flows, farming and grazing practices, and naturally occurring sources (MDEQ, 2003). According to the Teton River Watershed TMDL (2003) "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)". The TDML recommends, "all opportunities for positive changes in land management, in terms of reducing salinity loading, be implemented wherever they can be identified, beginning with

most economical alternatives".

In addition to salinity, selenium is a major constituent of concern within Freezout WMA. USGS Water Resources Investigations Report 95-4170 (1996) describes that due to natural geology containing selenium that surrounds the WMA, man-induced actions such as irrigation and farming have increased salinity and selenium levels in Freezout that can impact many bird species using the WMA. Levels of selenium entering Freezout Lake from farms drains in the area range from <1 to 232 *u*g/L. Some levels exceed selenium aquatic-life criterion for chronic toxicity of 5 *u*g/L. No historic nutrient source assessments have been conducted in the irrigated areas adjacent to Freezout Lake but selenium, salt, and nutrient sources entering the lake are often from agricultural practices that surround Freezout Basin. As a compounding factor, insufficient amounts of clean water into Freezout have become a major concern, especially during ongoing drought years with corresponding decrease in discharge capabilities.

Objectives and Study Design

This project was designed according to suggestions laid out in the "Water Quality Restoration Plan and Total Maximum Daily Loads for the Sun River Planning Area", December 2004, Montana Department of Environmental Quality. The target of this project was to determine current water quality conditions with respect to TMDL targets and identify and refine loading estimates for selenium, salinity, nutrients, and sediment from irrigated cropland to Freezout Lake. Primary objectives of the study were to:

- Determine current concentrations of selenium and salinity from drains to Freezout Lake and compare levels with historic data in order to detect changes over time.

- Characterize nutrient and sediment sources on the south and southeast side of Freezout Lake. Total phosphorus, nitrate + nitrite nitrogen, total nitrogen, and suspended sediment concentration were monitored along with associated flow volumes at six drains flowing to Freezout.

- Complete a water budget analysis and/or inventory of flows within the project area.

This monitoring project was initiated as a result of plans by the NRCS to fund an irrigation restoration project on lands adjacent to the lake. Implementation of the NRCS project began in 2006 and is intended to impact quality and quantity of water that drains into Freezout Lake by reducing irrigation return flows and increasing irrigation efficiencies. The Montana Department of Environmental Quality and Sun River Watershed Group felt this monitoring project was necessary to ascertain current conditions of water quality and quantity entering Freezout Lake via field drains and wasteway canals.

The selected sites were monitored in 2006 from March through November, which includes both irrigation and non-irrigation influences. These months were selected because previous USGS study results showed that highest selenium concentrations within drains to Freezout

occur during non-irrigation months (USGS, 1996). The same field and analytical methods used in previous studies by the USGS were used so that results are comparable and objectives could be appropriately addressed.

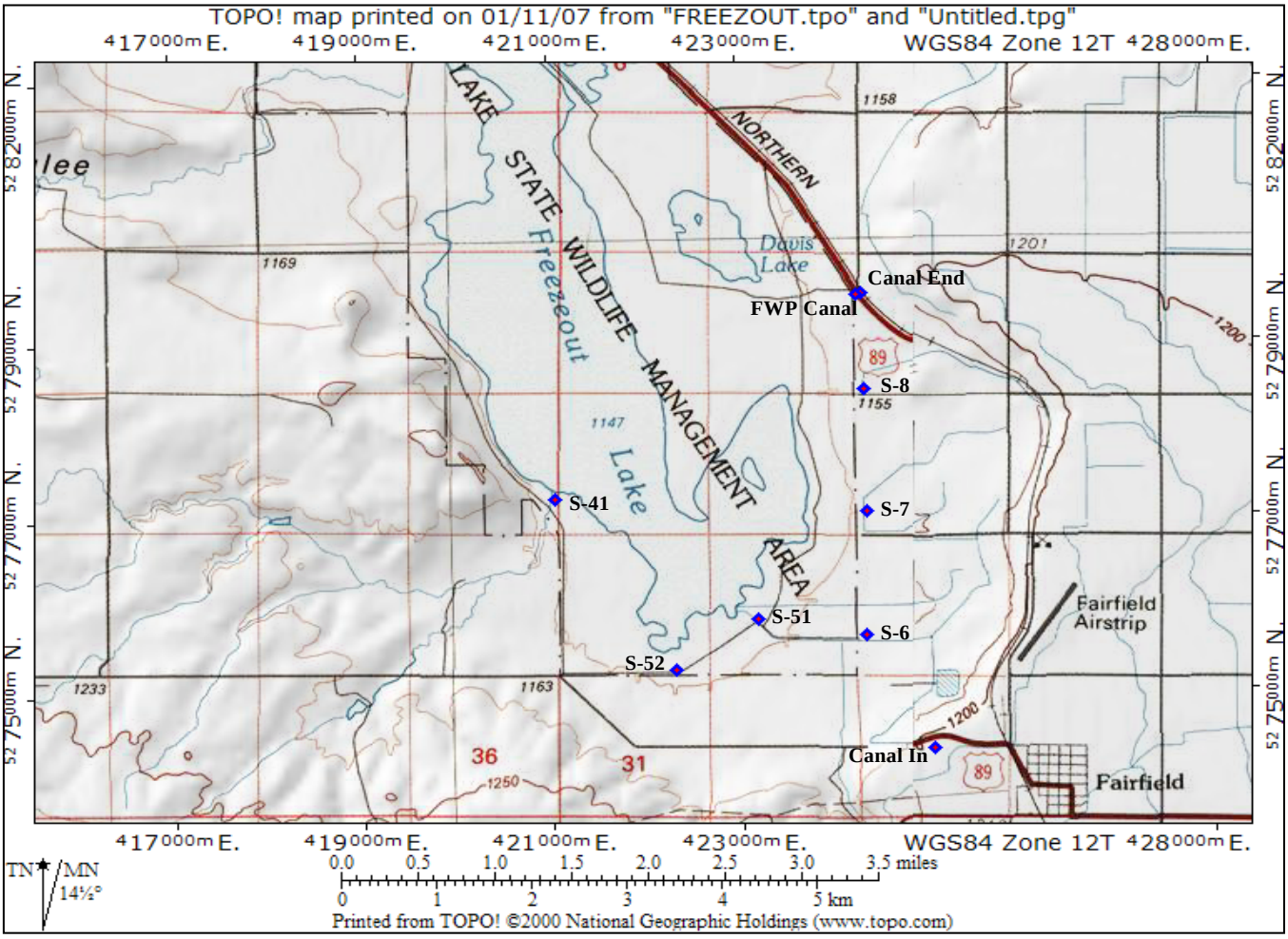


Figure 1. Locations of 2006 monitoring sites including: Canal In, S-6, S-7, S-8, S-41, S-51, S-52, Canal End and FWP Canal.

Water quality (selenium, salinity, total phosphorus, nitrate + nitrite nitrogen, total nitrogen, and total suspended sediment) was monitored at six drains on the south and southeast side of Freezout Lake. Flow in each drain was monitored on a continuous basis to establish flow volumes from drains. The six sites selected for monitoring were previously monitored by the USGS for selenium and salinity, which allows for comparison with MSU collected data. Collection sites are referred to as S-6, S-7, S-8, S-41, S-51, and S-52 by both MSU and USGS.

Three additional sites were monitored for flow during the 2006 study period to address the water budget objective. Two of these sites were within canals from GID. The two canal sites are located on the canal GM47-11, one at the inflow point of the canal (Canal In) into the basin and one at the outflow point (Canal End) as the canal leaves the Freezout Lake area.

The third canal site was located at a FWP-operated canal to account for surplus irrigation water being diverted toward the south and southeast side of the lake. Figure 1 shows the location of all water quality and flow monitoring sites within the 2006 study.

Sampling Methods/Quality Assurance and Quality Control

A Tru-Track data logger was installed in a stilling well at each monitoring site. Tru-Tracks log water level on user-determined increments. Tru-Tracks used in this project were set to record stream height every 30 minutes. Additionally, several of these sites had staff gauges previously installed during the USGS studies in the 90's. Instantaneous flow measurements were made during site visits using a Marsh-McBirney Model 2000 Flo-Mate portable velocity meter and depth rod. Flow measurements made with the flow meter were correlated with Tru-Track stage height measurements to develop rating curves for the water level measurements logged by the Tru-Tracks at each gauging station. In some cases, flow measurements were not possible as water velocity was either very low or stagnant. Rating curves for monitoring sites are included within the appendix.

Water quality samples were collected via grab samples and sent to Energy Laboratories in Helena, MT for analysis for nitrate + nitrite nitrogen, total kjeldahl nitrogen, total nitrogen, total phosphorus, total suspended sediment, total selenium, and electrical conductivity. Total phosphorus, nitrate + nitrite nitrogen, total kjeldahl nitrogen, and total nitrogen of collected samples were preserved with H_2SO_4, added by the sampler at the time of collection. Selenium samples were preserved with HNO_3, also added by the sampler at the time of collection. Samples were refrigerated overnight after collection and shipped the next morning. Chain of custody procedures were followed, as described in Section 14.0 (Sample Handling and Custody Requirements) of the MT DEQ's Non-Point Source Water Quality and Standard Operating Procedures (MT DEQ, 1995). All samples arrived at the lab within two days of sample collection in the field. Additional in-field measurements of salinity, water temperature, pH, and dissolved oxygen were made, using a Horiba Water Checker U-10 probe.

Energy Labs routinely analyzes five to ten percent of all samples in duplicate. Duplicate test results must be within the control limits established for each analysis type. Energy Labs also analyzes method blanks and instrument blanks one in every 20 samples at a minimum. Additionally, one field blank was collected by MSU Extension Water Quality (MSUEWQ) staff during each sampling event to provide for negative controls of fieldwork.

In addition to quality control procedures performed by Energy Labs, five percent of samples were collected as replicates by MSUEWQ and sent to the USGS laboratory in Denver, Colorado via the USGS office in Helena, MT. A 30% or less RPD (relative percent difference) was deemed acceptable between labs (Table 1). RPD between USGS and Energy Labs reported values were calculated to identify data not meeting acceptance criteria. Two samples exceeded 30% RPD. The S-7 site sample had a 31.5% RPD for total nitrogen between labs and the S-52 site selenium sample yielded a 55.3% RPD between the two labs. However, the selenium sample in question had very low reported values by each lab, with

concentrations under 5 *u*g/L. The appendix includes all laboratory analytical results.

Table 1. Replicate samples analyzed by the USGS laboratory and Energy Labs. Relative percent differences greater than 30% in reported concentrations represent differences greater than allowable in the acceptance criteria.

SITE	DATE	**Total nitrogen** (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, mg/L			**Phosphorus** water, unfiltered, mg/L			**Selenium** water, unfiltered, *u*g/L		
		USGS	Energy	RPD (%)	USGS	Energy	RPD (%)	USGS	Energy	RPD (%)
S-7	8/28/2006	1.31	1.8	**31.5%***	.05	0.045	10.5%	50.7	50	1.4%
S-51	8/28/2006	1.42	1.7	17.9%	.07	0.062	12.1%	1.2	1	18.2%
S-52	8/28/2006	1.75	2.1	18.2%	.05	0.046	8.3%	1.7	3	**55.3%***

*exceeds project control limit

Analytical methods between Energy Laboratory and USGS labs are comparable. Table 2 lists methods and detections limits/reporting limits (RL) for both labs.

Table 2. Methods and detection limits for USGS Laboratory and Energy Laboratories.

PARAMETER	USGS LAB	ENERGY LAB
Total Phosphorus	1-4650-03 RL – 0.02 mg/L	E365.1 RL – 0.01 mg/L
Nitrate + Nitrate-N	E353.2 RL – 0.01 mg/L	E353.2 RL – 0.01 mg/L
Total Nitrogen	1-4650-03 (persulfate digestion) RL – 0.06 mg/L	E351.2 (persulfate digestion) RL – 0.1 mg/L
Total Recoverable Selenium	1-4020-05 (ICPMS) RL – 0.00008 mg/L	E200.8 (ICP/ICPMS) RL - 0.001 mg/L
Total Suspended Sediment (TSS)	Available in USGS File Report 93-131 RL – 1 mg/L	E160.2 RL – 1 mg/L

Flow patterns - 2006

Figure 2 depicts average daily flows within drains monitored during the 2006 study. Average daily flows were calculated for each monitoring station from April 18th – November 20th, with the exception of S-8 and S-41. Daily flows were calculated from April 18th – September 26th only for the S-8 monitoring station due to equipment related problems after this date. The S-41 drain dried up completely by the August sampling event, thus precluding a full season of measurements. Flows were extremely low even before the S-41 drain dried up and at all times when MSUEWQ personnel measured the drain no flows exceeded 0.1 cfs. Thus a rating curve was unable to be developed, and 0.1 cfs was assigned for each day that a positive water level was recorded by the Tru-Track.

Figure 2 shows that flow within the drains varied throughout the study period. Flow volumes within these drains vary as a result of precipitation events and irrigation runoff. The monitoring station located on S-51 (pink line) shows that this drain contributes significantly more flow than any of the other drains monitored within this study. Average daily flows at S-51 ranged from a couple of cfs to a maximum flow of approximately 28 cfs. With two exceptions, flow was less than 5 cfs within all other drains monitored.

The first spike in flow noticeable in Figure 2 occurred on June 10th and corresponds to a rainfall event. The Agrimet station, maintained by the Bureau of Reclamation, located near Fairfield, recorded a total 3.88 inches between June 7 and 10. The Agrimet station recorded 8.89 inches of precipitation between April 18 and November 20.

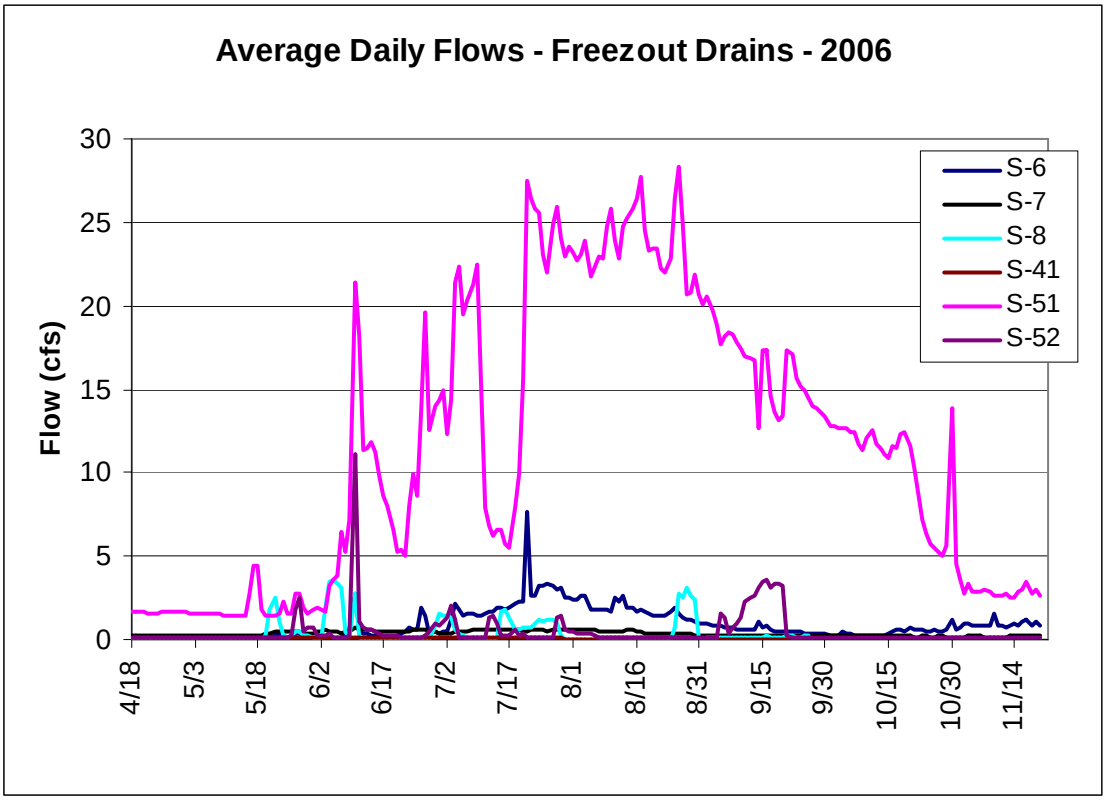


Figure 2. Average daily flows within drains from April 18 – November 20, 2006.

Figure 3 shows average daily flows for two of the three ditches measured (Canal End and FWP Canal) and an estimated daily flow for Canal In. Assessment of the stage-flow data collected at the Canal In site revealed what appeared to be a confinement in flow within this section of the GID canal. Consequently, although continuous stage measurements were recorded, the stage-flow rating curve developed for the Canal In site proved to be of only limited reliability. A rough estimate of Canal In flows was calculated using the average of all flow measurements taken of 12.51 cfs. If the canal stage was greater than 200 mm (as measured by the Tru Track), flow was assumed to be 12.51 cfs. If canal stage was less than

200 mm and greater than 0 mm, flow was assumed to be 6 cfs. Because of these rough assumptions, confidence in the Canal In flow estimation is highly limited.
The dark blue line in Figure 3 represents a flow monitoring station identified as Canal End. Water at this monitoring station is surplus irrigation water, i.e., spilled from GID. FWP personnel can either divert this water towards the north side of Freezout Lake or south toward drains monitored in this study. The monitoring station identified as 'FWP canal' monitored these flows diverted south from the GID Canal End site. Figure 3 shows that flow at these two monitoring sites tracked each other. The difference in flow between these stations is likely a function of the rating curves developed for these sites, and flows should be considered nearly the same at these sites. Mark Schlepp, wildlife area manager for Freezout Lake, commented along these same lines, indicating that most all of the water at Canal End was diverted past the FWP canal gauge during the irrigation season.

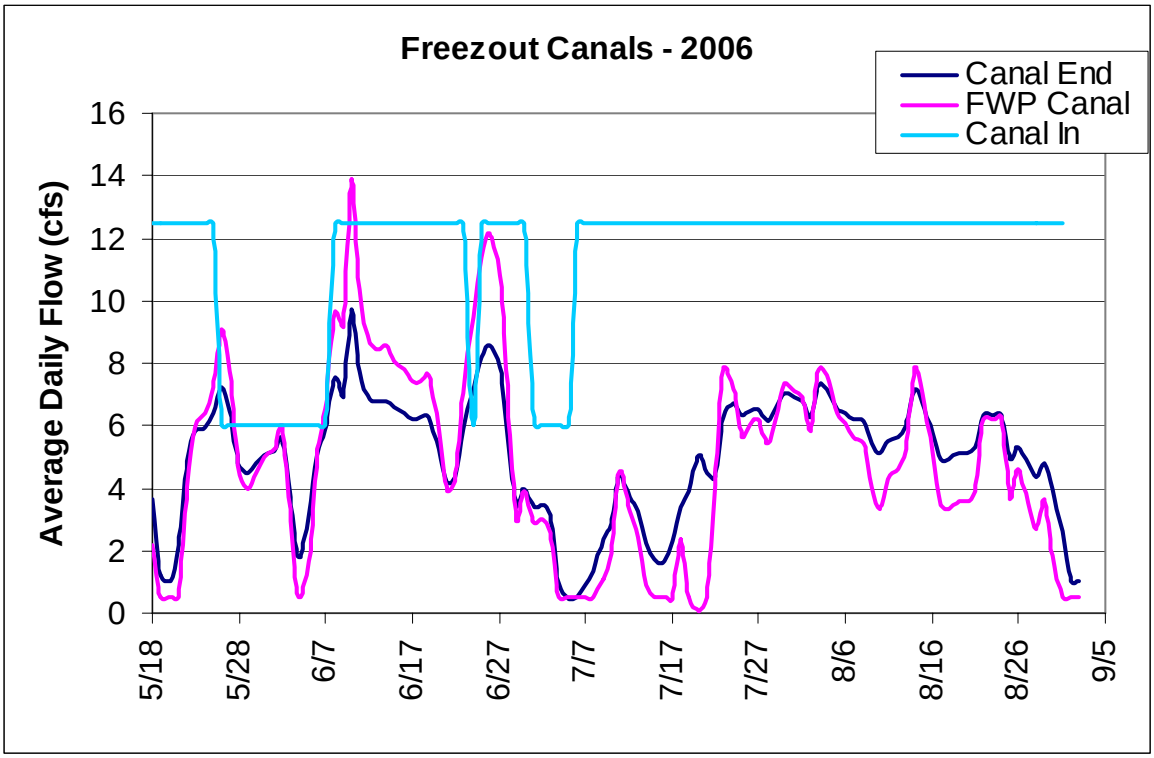


Figure 3. Average daily flows for Canal End and FWP Canal, estimated average daily flow for Canal In.

Table 3 shows total flow for each monitoring station in acre-feet for the period of May 18th – August 31st, 2006. With the exception of S-51, the drains contribute only a small amount of flow to Freezout Lake. Flow within the S-51 drain is made up of flow from the S-6 drain as well as other unmeasured flow from Jaden ditch and an additional unnamed drain. Jaden ditch flows year round and is comprised of drain water, spring runoff, and possibly some spring water. The unnamed drain flows only during the irrigation season (Mark Schlepp, personal comm., Jan.12, 2007). Total flow from measured drains into Freezout Lake was calculated through the following equation:

Flow to Freezout Lake = S-6 + S-7 + S-8 + S-41 + (S-51 – S-6) + S-52 + FWP Canal

For the period of record, total flow into Freezout Lake from the measured drains and from canal wastage was 4,478 acre-feet.

Table 3. Total flow in acre-feet from May 18 – August 31, 2006

Monitoring Station	Flow (acre-feet)
S-6	279
S-7	102
S-8	127
S-41	19
S-51	3,104
S-52	99
FWP Canal	1,027
Canal Out	1,063
Canal In	2,384*

*Canal In is an estimated flow volume based on assumptions.

Water Chemistry Results - 2006

Three types of measurements were made in 2006 to assess nitrogen presence and concentrations within drains to Freezout Lake – total kjeldahl nitrogen (TKN), nitrate + nitrite – N, and total nitrogen (TN). Nitrogen sample test results for the six drain sites measured during all sampling trips in 2006 are illustrated in Figures 4-6. While Freezout Lake is listed in the 2002 303D list as impaired from nutrients, a numeric standard has not been set for nutrients within the Lake. Rather, the narrative standard applied to the lake reads: nutrients should be maintained at levels below "conditions that produce undesirable aquatic life" (MDEQ, 2004). However, some general standards can be used to assess measured concentrations. The human drinking water standard for nitrate + nitrite nitrogen in surface water systems is 10 mg/L, and the trigger value for possible non-degradation exceedance is 5 mg/L for surface waters (MDEQ, 2006). Generally, a background ambient nitrate-nitrogen concentration of 1 mg/L would be considered a reasonable upper limit. For instance, the Ohio EPA set the nitrate-nitrogen concentration limit at 1.0 mg/L to be protective of aquatic life in Ohio streams. The National Sanitarian Federation (NSF) standard for nitrate-nitrogen is in the range of 1.0 mg/L for surface water systems.

Figure 4 shows that nitrate + nitrite nitrogen concentrations measured were well below the human health standard and below the surface water trigger concentration of 5 mg/L established by the MDEQ. Highest nitrate + nitrite nitrogen concentrations are found at the S-6 and S-8 drains, although concentrations that would be considered elevated above ambient conditions were measured in samples from all drains except S-41.

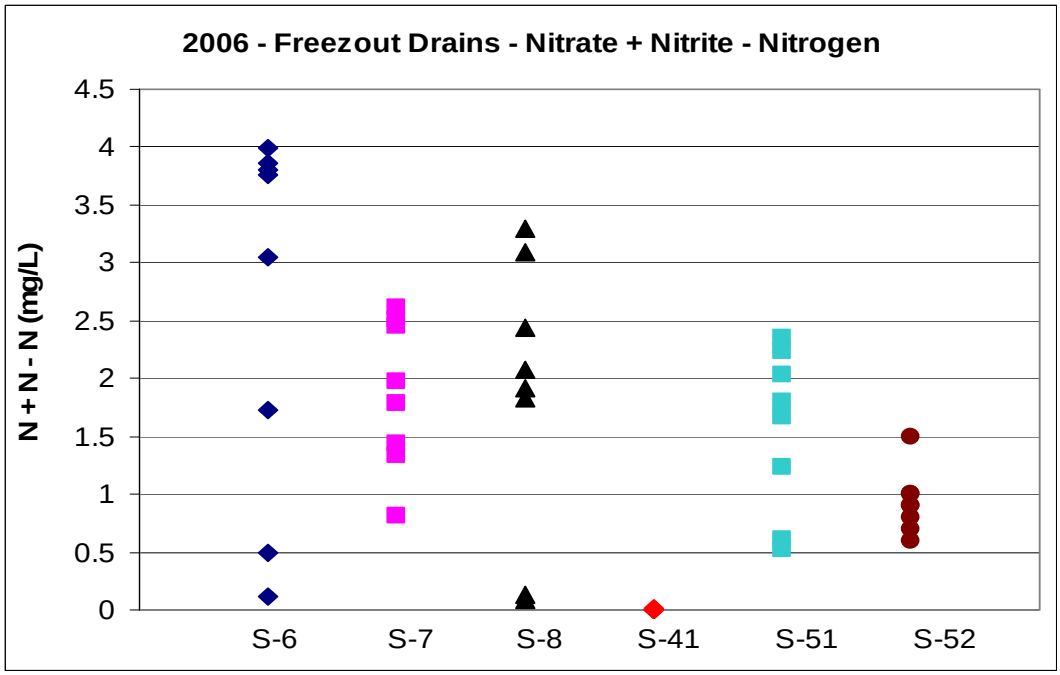


Figure 4. Nitrate + Nitrite-Nitrogen concentrations measured within drains discharging to Freezout Lake, 2006.

Figure 5 presents total kjeldahl nitrogen (TKN) results measured in 2006. TKN analysis is a measure of the sum of ammonia nitrogen and nitrogen present in organic material (suspended particulate, algae) in water. In the absence of ammonia, TKN provides a measure of organic-sourced nitrogen.

The largest TKN concentration occurred in the S-7 drain and corresponds with an extremely high TSS measurement as well. This measurement was made during the June 26th sampling trip; field notes and pictures indicate extremely murky water coming from the drain. With exception of this sample, all other results show that TKN concentrations are between 0 and 3 mg/L and are within the same range as nitrite + nitrite nitrogen concentrations (Figure 4).

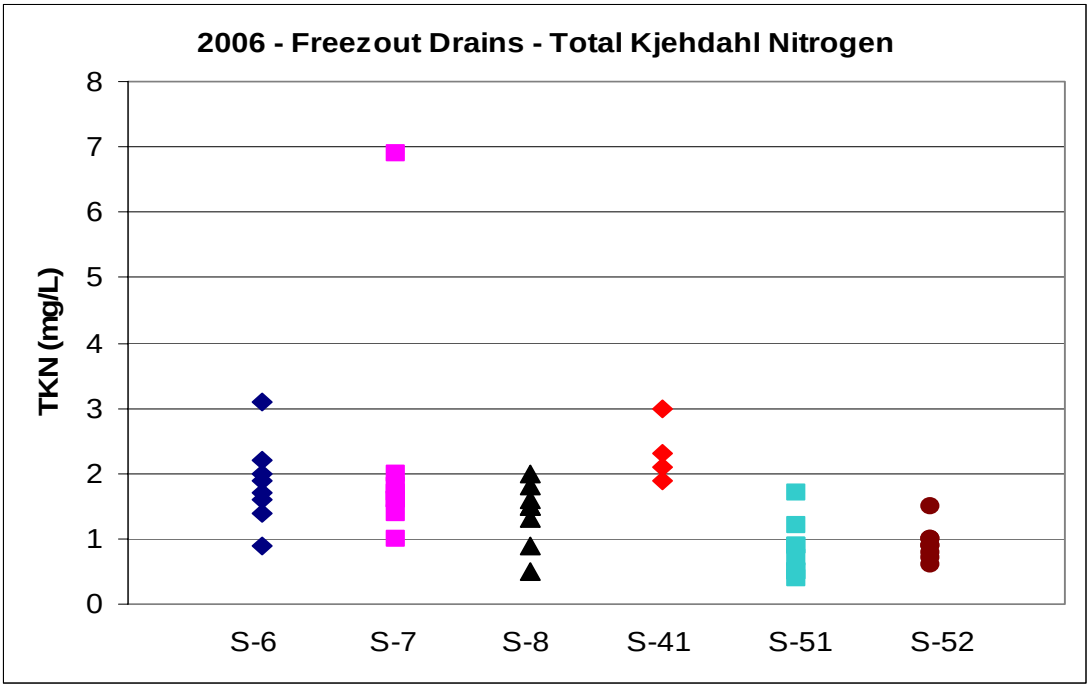


Figure 5. Total kjeldahl nitrogen concentrations measured at the six drain sites, 2006.

Total nitrogen (TN) concentrations are illustrated in Figure 6. Inserted as a red line into Figure 6 is the numeric target for TN in Deep Creek (Teton River watershed) and Muddy Creek (Sun River watershed) of 650 *u*g/L (equivalent to 0.65 mg/L) during summer months. This standard is not entirely applicable to the drains, but both creeks are described as receiving nutrients from agricultural uses. Deep Creek nutrient sources are attributed to agricultural use of riparian areas for crop production and livestock grazing and water withdrawals (MDEQ, 2003). Muddy Creek nutrient sources are described as drainage from Greenfield's Bench, runoff from dryland crops, ground water discharge into the channel, and channel erosion along the stream corridor (MDEQ, 2004). Therefore, Deep Creek and Muddy Creek targets provide some level of comparison and indicate that TN levels in the drains may be elevated beyond desirable levels.

Generally, TKN comprises less than 20% of TN, suggesting that the principal source of nitrogen is leachate from agricultural fields or drainage from geologically rich nitrate areas. Nitrate-nitrogen is an anion frequently found in association with geologically sourced selenium (Pottorff et al., 2005). Numerous other references to this circumstance are also available in the scientific literature.

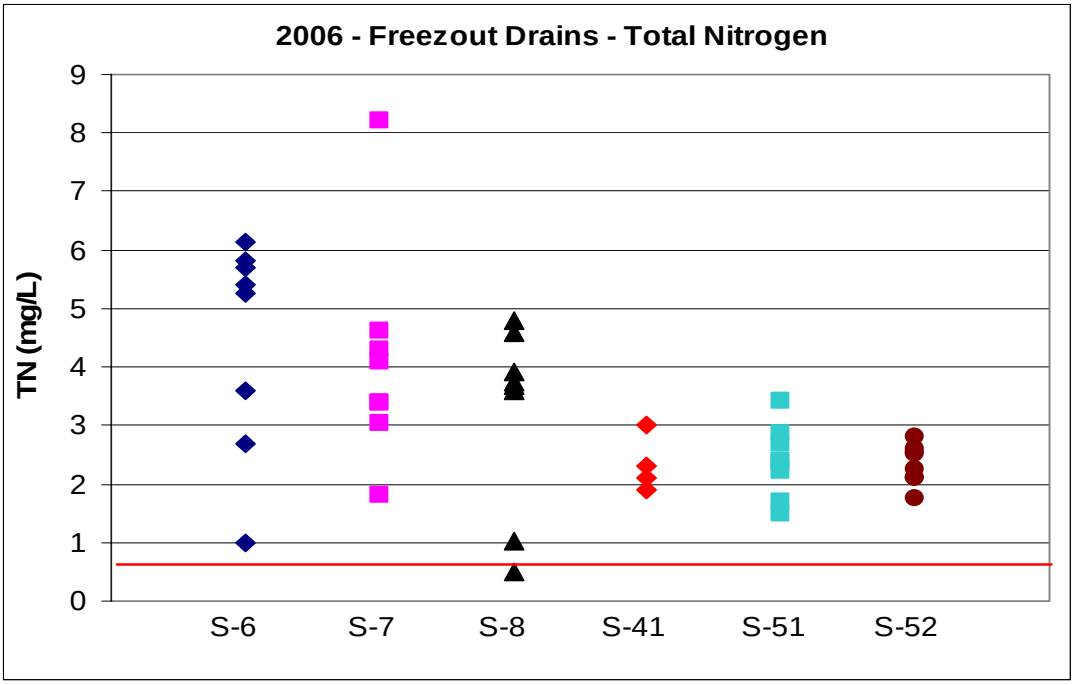


Figure 6. Total nitrogen (TN) concentrations for the six drain sites. The red line represents Deep Creek and Muddy Creek TN target of 650 *u*g/L.

Total phosphorus (TP) concentrations were also monitored during this study. Total phosphorus tests include phosphorus contributions from orthophosphate (dissolved/soluble), condensed phosphorus, and organic phosphorus. Elevated levels of phosphorus promote excessive growth of aquatic plants and other organisms, and, like nitrogen, can exacerbate eutrophication. Phosphorus is generally strongly adsorbed to soil particles and can be transported into surface water with suspended sediment sourced from runoff water from agricultural fields. Phosphorus can also attach to organic debris and livestock waste eroded into surface water.

Phosphorus results for six drain sites and all sampling trips are illustrated in Figure 7. A red line is inserted at 40 *u*g/L (equivalent to 0.04 mg/L) to represent the Deep Creek TP target. As with TN, the target is not necessarily applicable to the drains, but serves as a reference point. The Muddy Creek TP target is slightly higher at 50 *u*g/L (equivalent to 0.05 mg/L). Concentrations ranged from nearly 0 to 0.8 mg/L (equivalent to 800 *u*g/L), although only a few measured concentrations were less than the 40 *u*g/L reference. Greatest total phosphorus concentrations were measured in the S-6 drain, but when concentrations are measured downstream in S-51 (S-51 is combination of water from S-6 and other drains), concentrations decreased. Lowest phosphorus concentrations were measured in S-8 and S-52. An elevated TP concentration for one sample from drain S-7 corresponds to an elevated TN, elevated TKN, and elevated TSS (Figure 8), suggesting that flow in the drain at the time of collection of this sample was significantly influenced by surface runoff or mechanical disturbance in the drain upstream of the sampling location. Elevated TP levels are generally indicative of some surface water influence on the drains. While the presence of livestock was not noted by samplers, elevated concentrations of TP, TKN, and TSS are typical of channel disturbance and may be a result of livestock or wildlife in the S-7 drain.

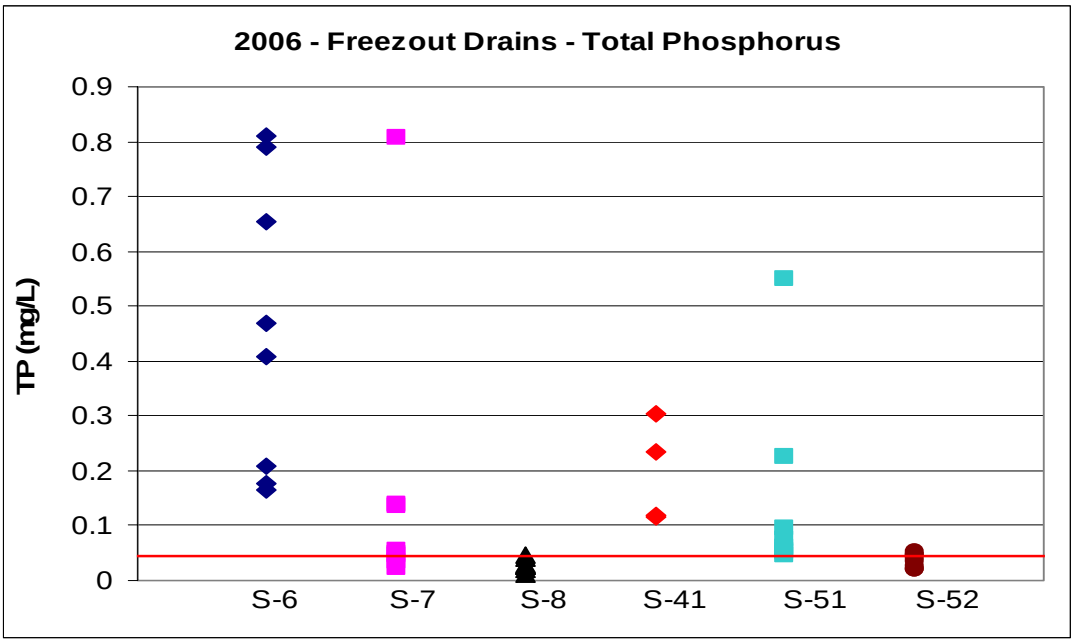


Figure 7. Total phosphorus (TP) concentrations for the six drain sites. The red line represents the Deep Creek TP target of 40 *u*g/L.

Sediment concentrations were measured in drains via measurements of total suspended solids (TSS). TSS is made up of organic and mineral particles that are transported in the water column. Figure 8 represents total suspended sediment concentrations for the six sites and all sampling events. There is no TSS target for Freezout Lake, but as with TP, elevated TSS may be indicative of surface water influences on the drains. The S-6 and S-7 drains had the largest TSS concentrations. One extremely high value of 1,260 mg/L TSS for site S-7 was removed from the data set in order to show the range of TSS values measured.

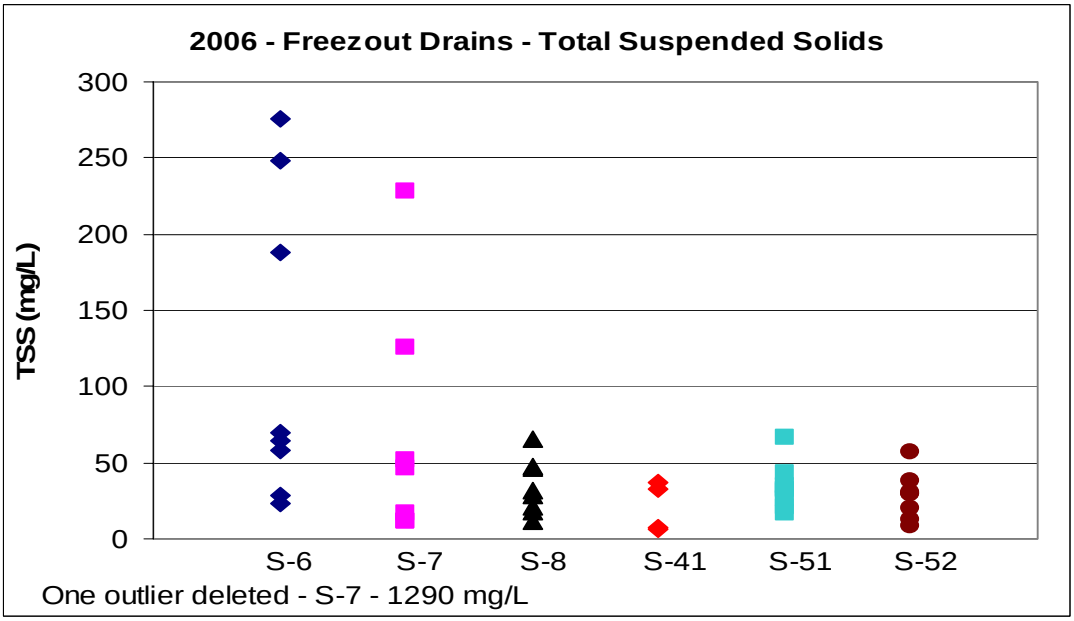


Figure 8. Total suspended solids (TSS) concentrations for the six drain sites.

Figure 9 represents in-field pH values measured for the six drains and all sampling trips. The pH of water is an indicator of acidity/alkalinity of water, which affects biological availability and solubility of chemical constituents in water. The inserted red line represents the upper acceptable pH range of 9.5 units for Class I waters. The range in pH was relatively narrow and all measured pH values were below 9.5.

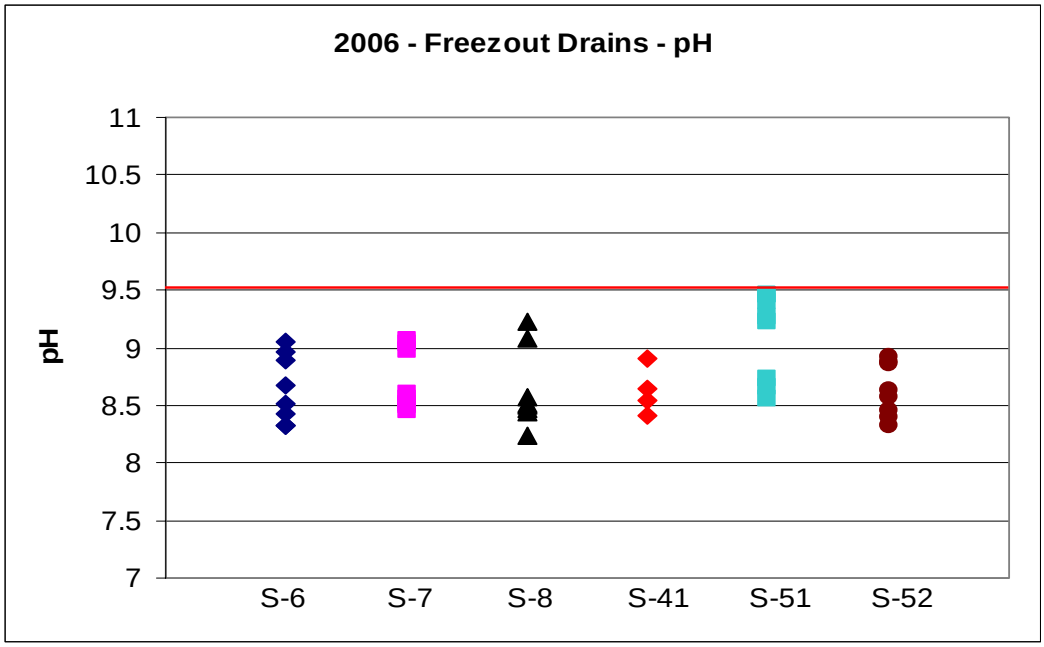


Figure 9. pH for the six drain sites. The red line represents the upper acceptable pH range of 9.5 for Class I waters.

Total selenium results for the six sampling sites and all sampling trips are illustrated in Figure 10. The red horizontal line inserted in the graph represents the Montana aquatic life chronic toxicity criterion of 5 *u*g/L (0.005 mg/L) and the selenium standard applied to Freezout Lake in the Water Quality Restoration Plan and Total Maximum Daily Loads for the Sun River Planning Area (MDEQ, 2004). Notably, selenium concentrations for S-6, S-7, and S-8 repeatedly exceeded the standard, while selenium concentrations for the other sites were below or very near the standard. The acute aquatic life toxicity criterion for the state and applied to Freezout WMA is 20 *u*g/L (0.020 mg/L) and was exceeded by one sample from site S-8. Generally, the highest selenium concentrations were measured in October and November, following the end of the irrigation season, and in March and April during base-flow levels.

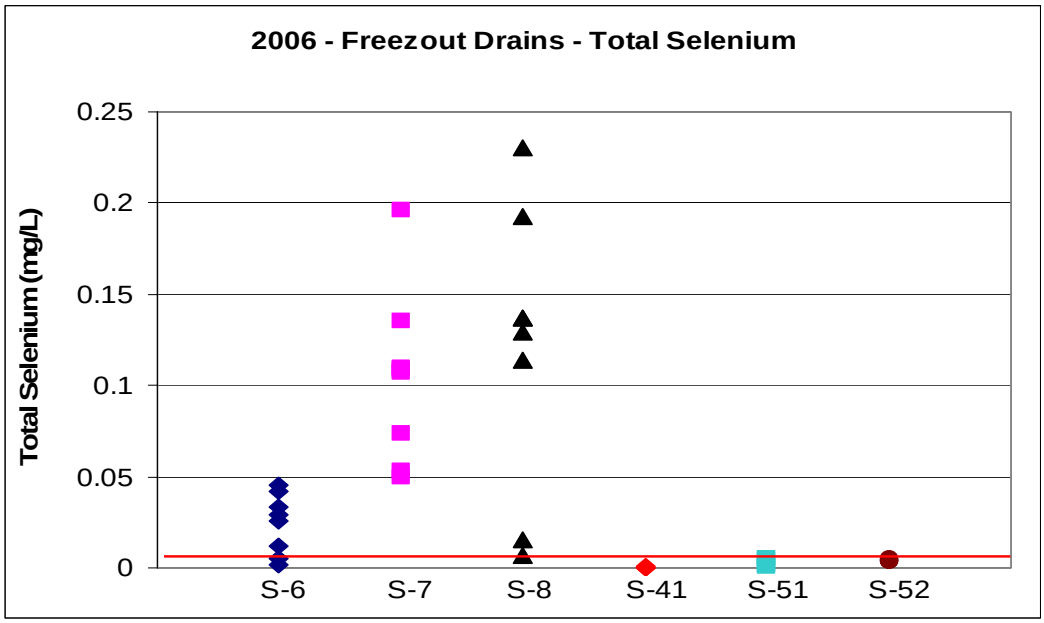


Figure 10. Total selenium concentrations for the six drain sites. The red line represents the Freezout Lake selenium target of 5 *u*g/L, which is equivalent to the aquatic life chronic toxicity criterion for selenium.

Electrical conductivity (EC) results for the six sites and all sampling trips are illustrated in Figure 11. The red horizontal line inserted in the graph represents the EC equivalent to the in-lake beneficial use TDS target set for Freezout WMA in the Sun River Restoration Plan (MDEQ, 2004) and for Priest Butte Lakes in the Teton River Watershed TMDL (MDEQ, 2003) of 5,000 mg/L TDS (converted to 6,200 *u*mhos/cm). The standard is based on the effects of salinity on waterfowl. EC measurements in all drains measured were well below this target. Yet, 16 of the 44 samples measured had values greater than 3,000 *u*mhos/cm (equivalent to 3 dS/m), a value used to define saline conditions.

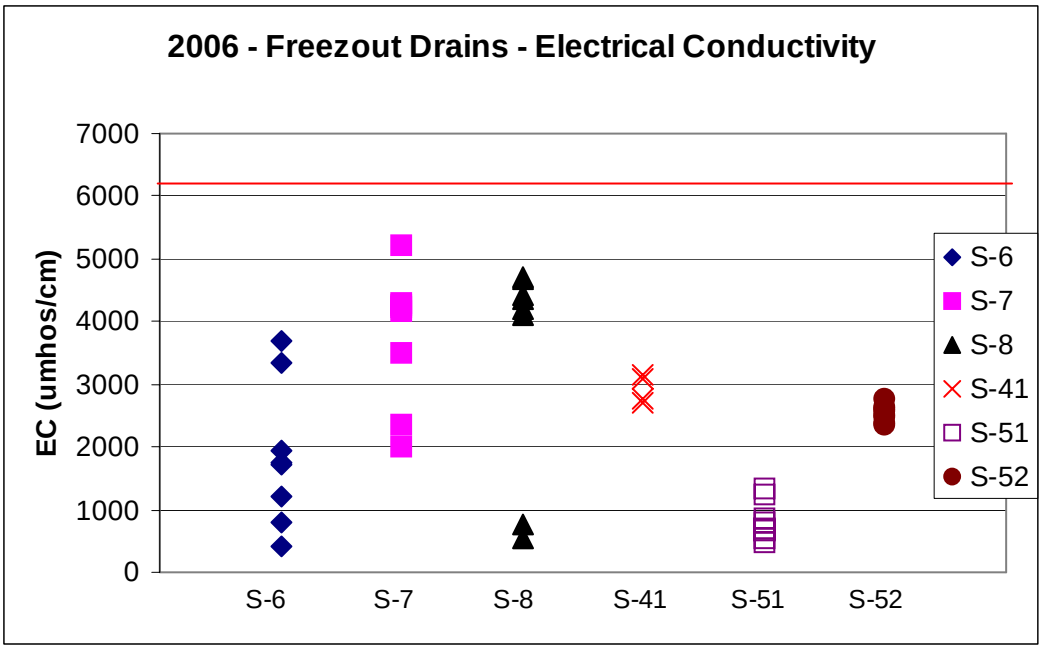


Figure 11. Electrical conductivity (*u*mhos/cm) for the six drain sites. The red line represents the Freezout Lake salinity target, equivalent to 6,200 *u*mhos/cm EC.

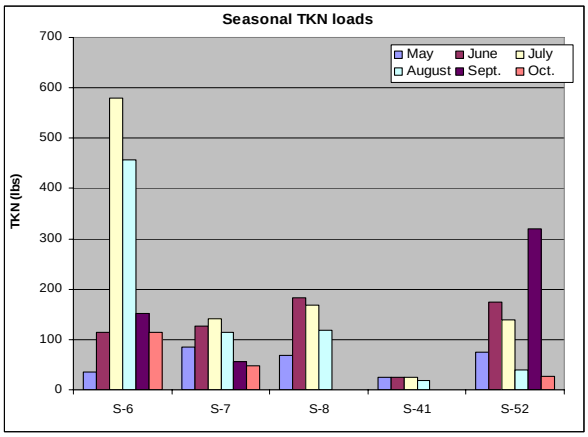
Total loads for the period of record were calculated (Table 4) for TDS, TSS, TKN, Nitrate + Nitrite Nitrogen (N+N-N), Total Nitrogen (TN), Total Phosphorus (TP), and Total Selenium (Se). When a relationship between flow and concentration existed, loads were calculated from regression equations. Regression was used to calculate all selenium loads, along with Total Dissolved Solid (TDS) loads, and TN and N+N-N loads for site S-6. When no apparent relationship between flow and concentration existed, loads were calculated using either the sample average concentration or cumulative sample average concentration (depending on distribution of the data). For site S-41, the majority of samples had N+N-N and Se concentrations below detection limits, therefore no load was calculated. All loads are in tons per season.

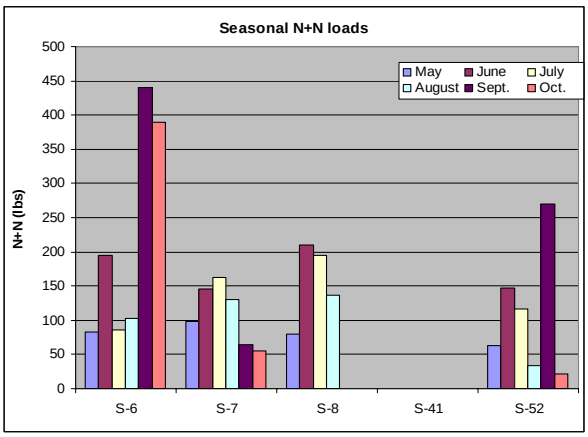
Table 4. Total loads from drains for the period or record (May 18 to August 31, 2006) for TDS, TSS, TKN, N+N-N, TN, TP, and Se. Units are in tons or pounds per period of record.

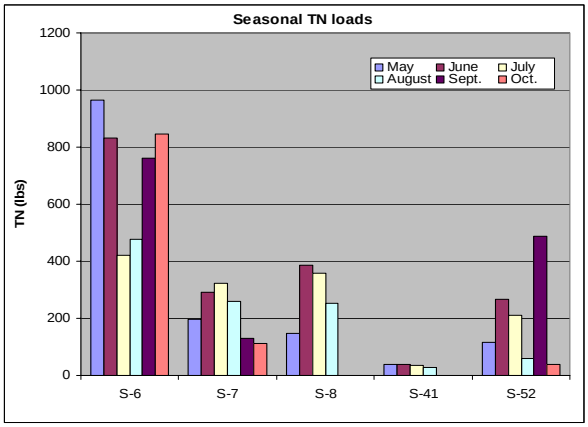
Drain ID	**TDS (tons)**	**TSS (tons)**	**TKN (lbs)**	**N + N-N (lbs)**	**TN (lbs)**	**TP (lbs)**	**Se (lbs)**
S-6	180	46	1,172	434	2,158	352	12
S-7	293	5	429	493	987	22	36
S-8	108	6	536	616	1,131	28	166
S-41	53	1	80	< detection	122	4	< detection
S-51	104	139	13,049	15,011	20,469	674	1
S-52	136	4	414	349	631	21	1
Total seasonal load	**874 tons**	**201 tons**	**15,680 lbs**	**16,903 lbs**	**25,498 lbs**	**1,101 lbs**	**216 lbs**

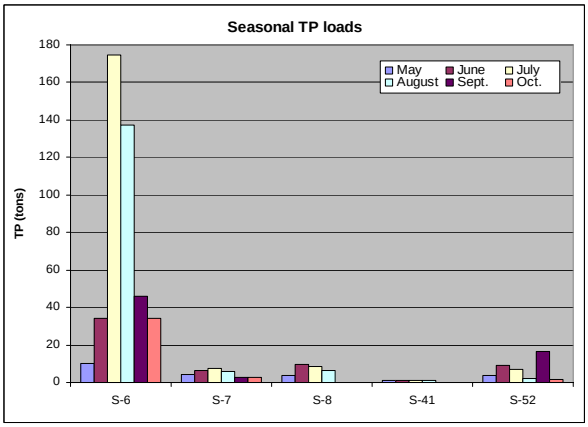
Seasonality of loads

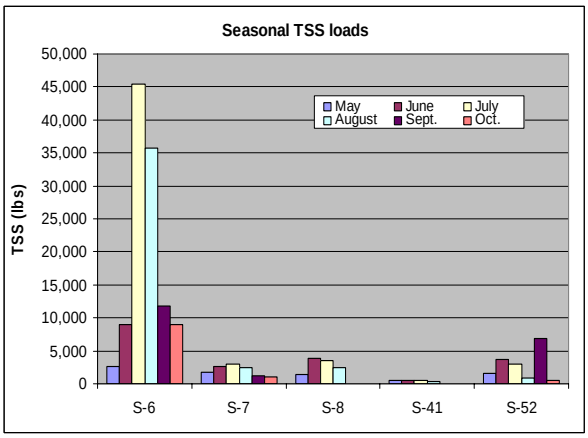
Monthly loading of all parameters was calculated for each site (Figures 12-25). Site S-51 is graphed separately due to disproportionately high loading from this site for some parameters.

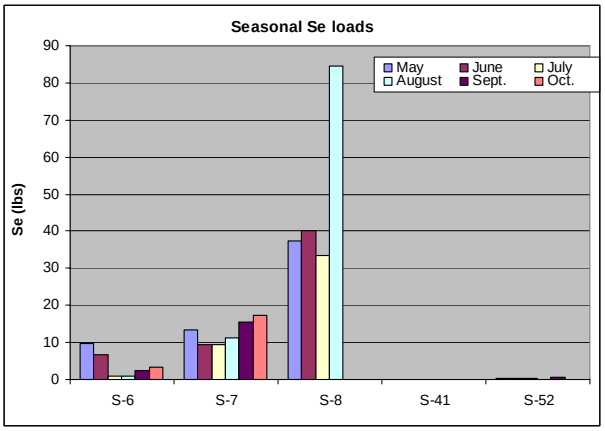


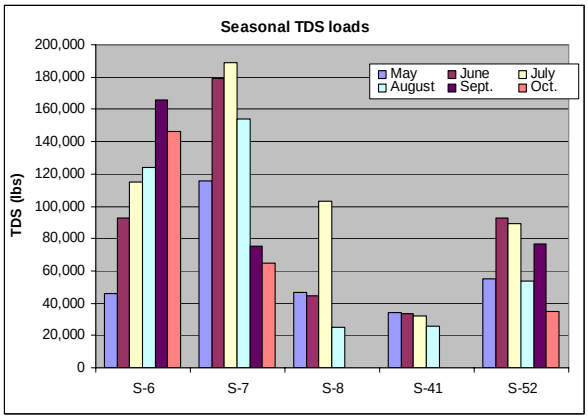




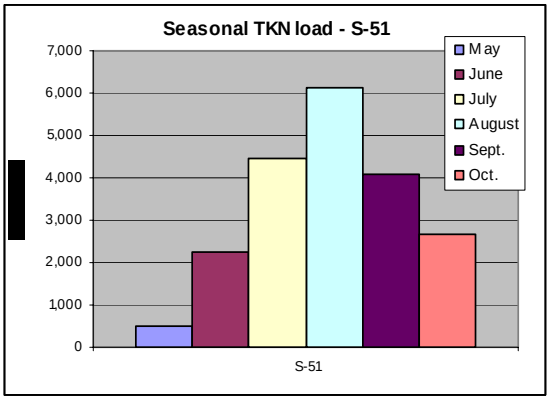


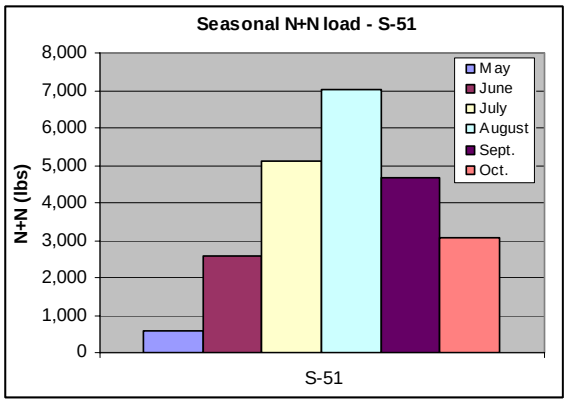


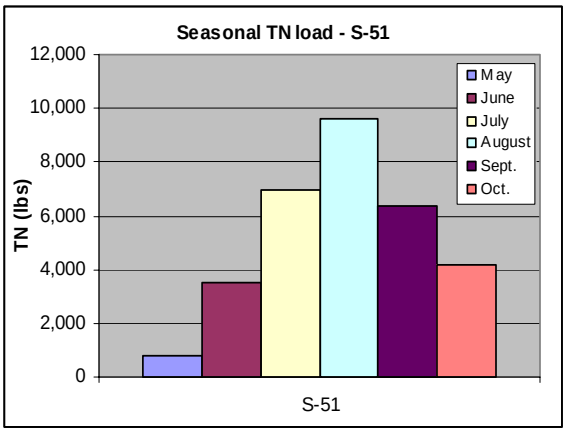


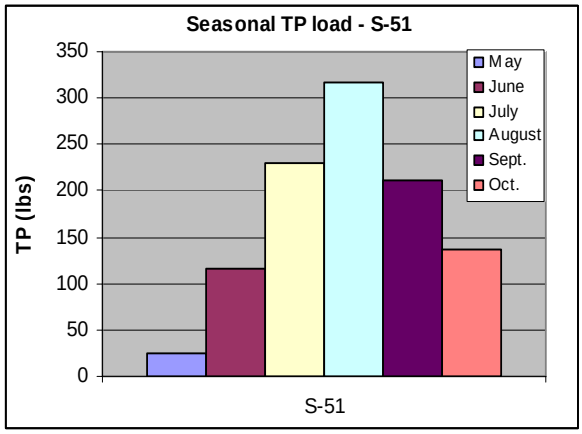


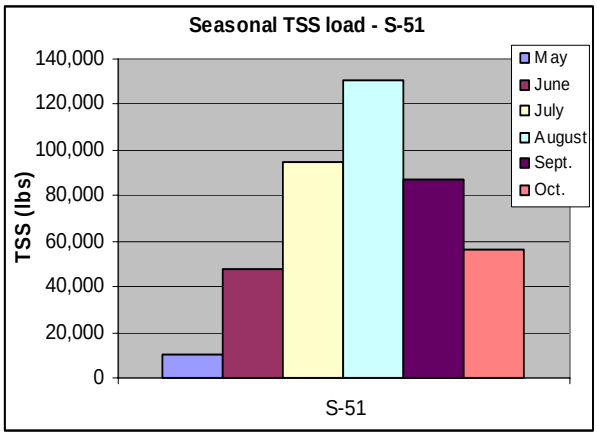
Figures 12-18. Monthly loads from sites S-6, S-7, S-8, S-41, and S-52 for the period of record for each site. Units are in pounds per month.

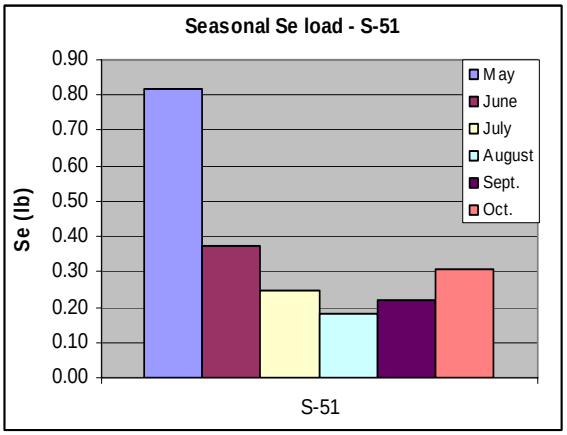


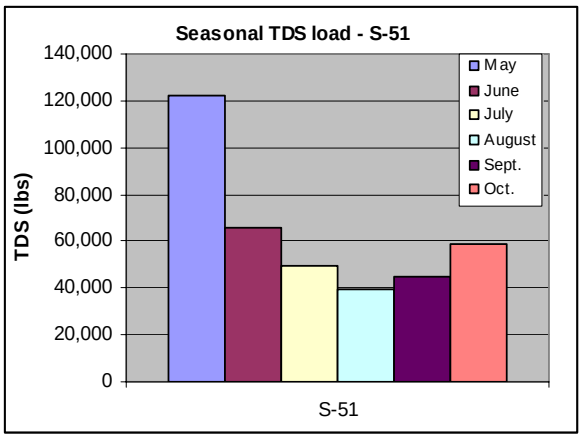












Figures 19-25. Monthly loads from S-51 for the period of record. Units are in pounds per month.

In general, nutrient loads tend to increase during the summer months of June, July, and August. For all sites, selenium loads tend to decline during the summer months and peak contributions occur in spring and fall. Monthly nutrient load estimates reveal some discrepancy between monthly nutrient load calculations that is likely a function of limited data and assumptions made to calculate loads. In terms of total loads, site S-51 accounts for 80% of total nitrogen loading, 61% of total phosphorus loading, and 69% of total suspended solid loading. Site S-8 accounts for 77% of total selenium loading.

Comparisons between 2006 and previously collected data

One objective of this project was to compare data collected in 2006 with historic data collected within the six drains monitored. Salinity and selenium have been monitored in these same drains intermittently by the USGS since 1990.

Selenium concentrations for MSU 2006 collected samples and USGS samples ('90 – '92, '95, '01) are illustrated in Figure 26. USGS selenium values include both total selenium and dissolved selenium, while MSU samples were only analyzed for total selenium. Nimick and Lambing (1996) found in their study of Freezout that dissolved and total recoverable selenium concentrations were nearly equal, with no significant difference at the .05 level and therefore were able to combine dissolved and total recoverable selenium values to have a more robust data set. As in the 1990's USGS study, selenium concentrations in 2006 for sites S-6, S-7, and S-8 are well above the aquatic life chronic threshold. In general, concentrations measured in 2006 were within the same range as concentrations reported previously by the USGS.

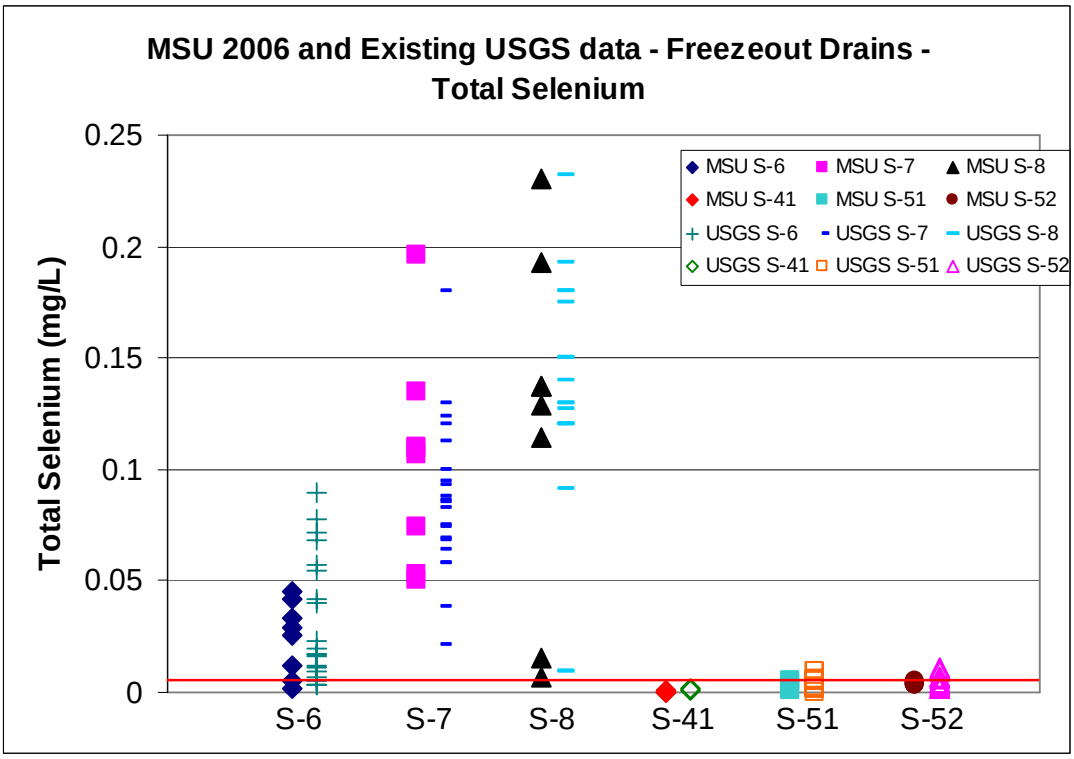


Figure 26. MSU 2006 and USGS 1990-1992 selenium concentrations for the six drain sites. The red line represents the Freezout Lake selenium target concentration of 5 *u*g/L, which is equivalent to the aquatic life chronic toxicity criterion for selenium.

Electrical conductivity measured during 2006 and USGS measurements of EC are illustrated in Figure 27. As with selenium, there is no remarkable difference between salinities for the two data sets.

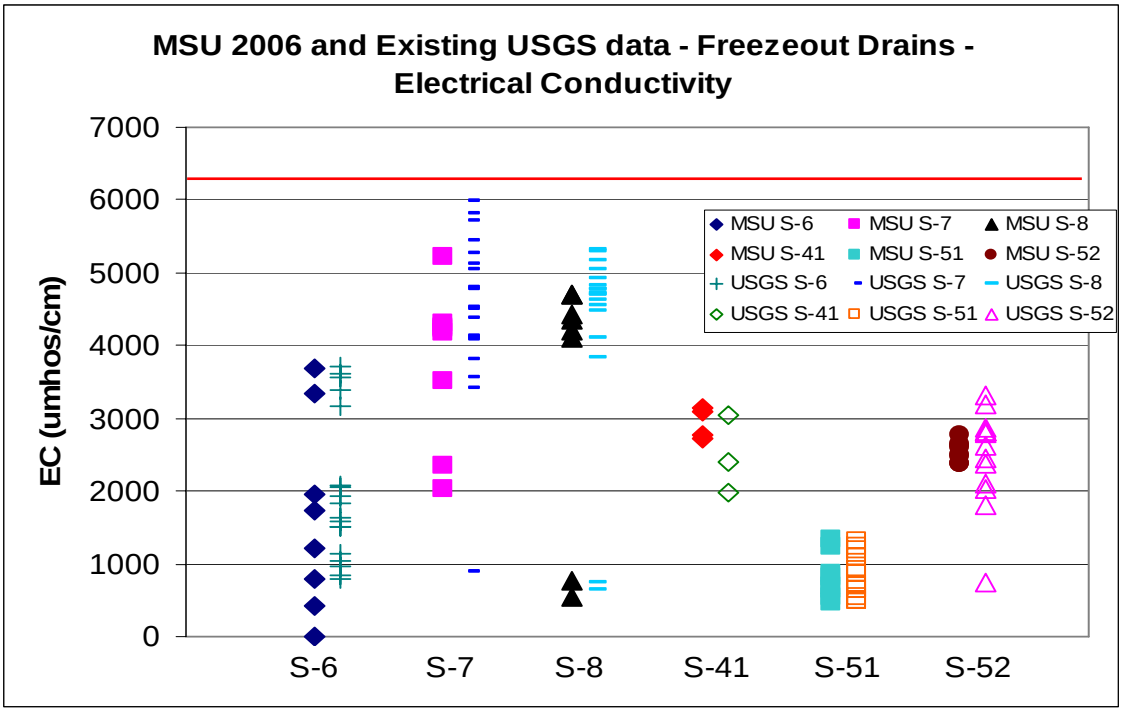


Figure 27. MSU 2006 and USGS 1990-1992 electrical conductivity values for the six drain sites. The red line represents the Freezout Lake salinity target, equivalent to 6,200 *u*mhos/cm EC.

Conclusions

Nine sites were located and instrumented on the south and southeast side of Freezout Lake in 2006 to monitor water quality and flow within drains and GID wasteway canals contributing water to Freezout Lake. Nitrogen, phosphorus, salinity, sediment, pH, and selenium were measured in water samples collected from each drain. Additionally selenium and salinity concentrations were compared with concentrations previously measured by the USGS.

Average daily flows in the drains were less than 5 cfs for the monitoring period, with the exception of one drain (S-51), where flows ranged from a couple of cfs to a maximum flow of approximately 28 cfs.

Due to improper location of one Tru-Track recorder and limited variation in stage-flow relationships at the times when measurements were made (i.e., Canal In), it was not possible to complete a water budget from the flow data collected in 2006. However, the collected data revealed that major contributors of flow to Freezout Lake were determined to be 1,027 acre feet via the GID wasteway canal (i.e., FWP Canal by way of Canal Out), 3,104 acre feet via S-51, which is a collection from numerous drains.

Water quality measurements indicated elevated concentrations of nitrate+nitrite nitrogen, total nitrogen, and total phosphorus concentrations contributed from nearly all drains. Elevated concentrations of selenium were prevalent in water from drains S-6, S-7, and S-8.

Concentrations of selenium and salinity measured during 2006 were within the same range as values previously reported. Two of the nine split samples sent to different laboratories had RPD exceeding project control limits. Decisions and conclusions drawn from this study should reflect an understanding of these results.

Implementation of Best Management Practices (BMP) specific to irrigated crop production and irrigation systems are beginning to be installed on irrigated lands surrounding Freezout Lake. Presumably, this BMP implementation will impact water quality and quantity within the drains monitored during this study. Therefore, it will be important to continue monitoring efforts to document possible changes in water quality and quantity.

References

Montana Dept. of Environmental Quality (MDEQ). 2006. Circular DEQ-7 Montana Numeric Water Quality Standards. Available online at http://www.deq.state.mt.us/wqinfo/Standards/CompiledDEQ-7.pdf (verified Jan. 16 2007)

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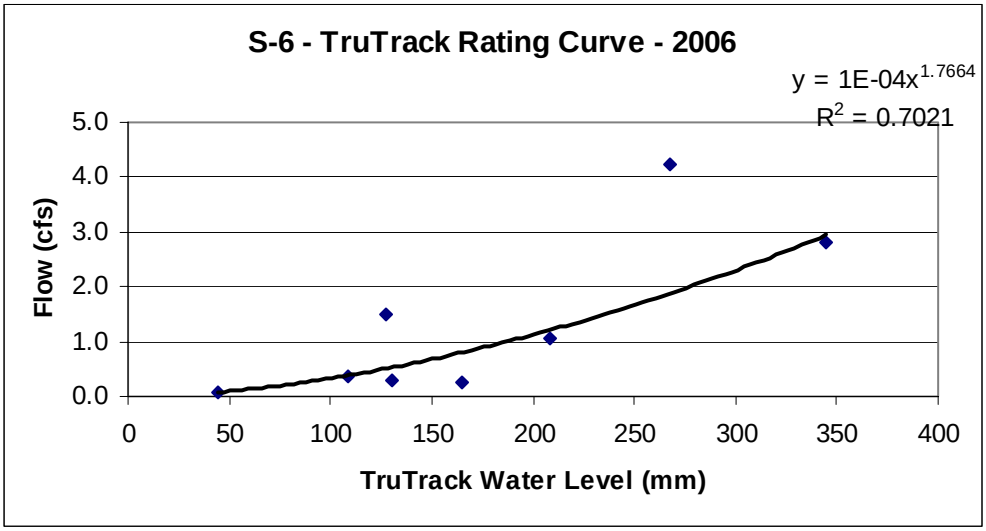
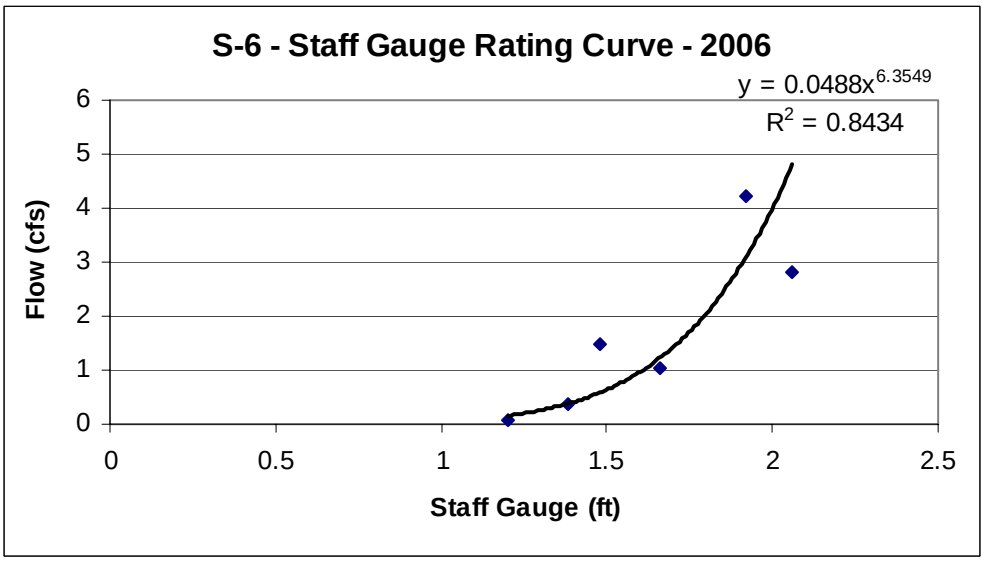
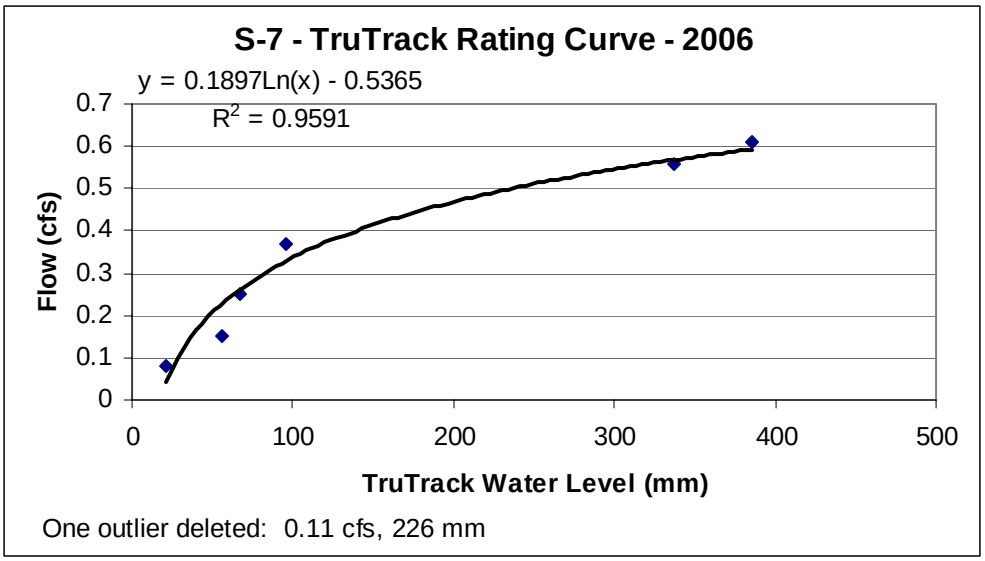
Nimick D. and J. Lambing, 1996. Detailed study of selenium in soil, water, bottom sediment, and biota in the Sun River Irrigation Project, Freezout lake Wildlife Management Area, and Benton lake National Wildlife Refuge, west-central Montana, 1990-92.

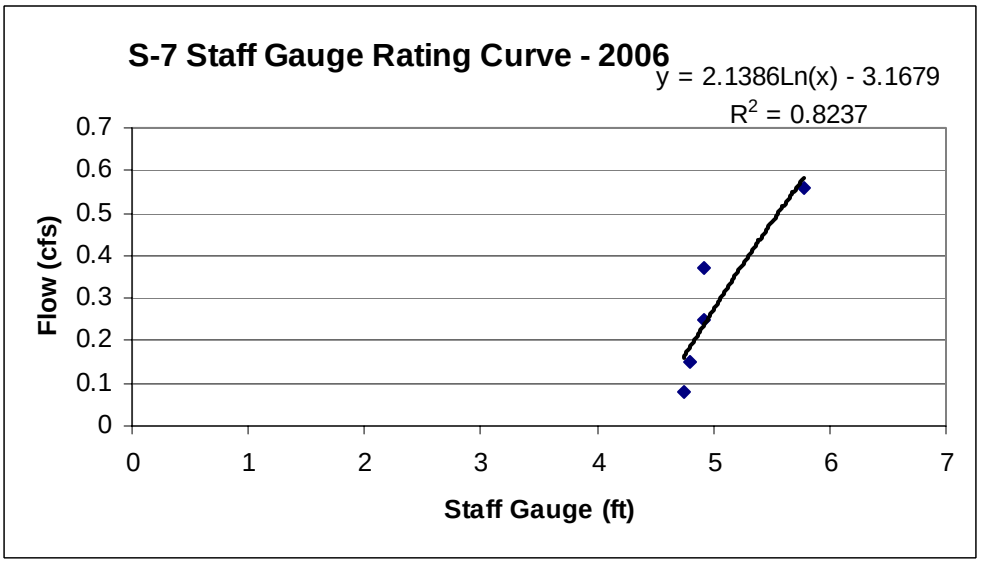
Pottroff, E. J., M. P. Wichham, J. S. Waples, and B. Bertram. 2005. Case study of selenium mobilization from Mancos shale: relationship to nitrate contamination. GSA *Abstracts with Programs*, 37: 6, p. 45.

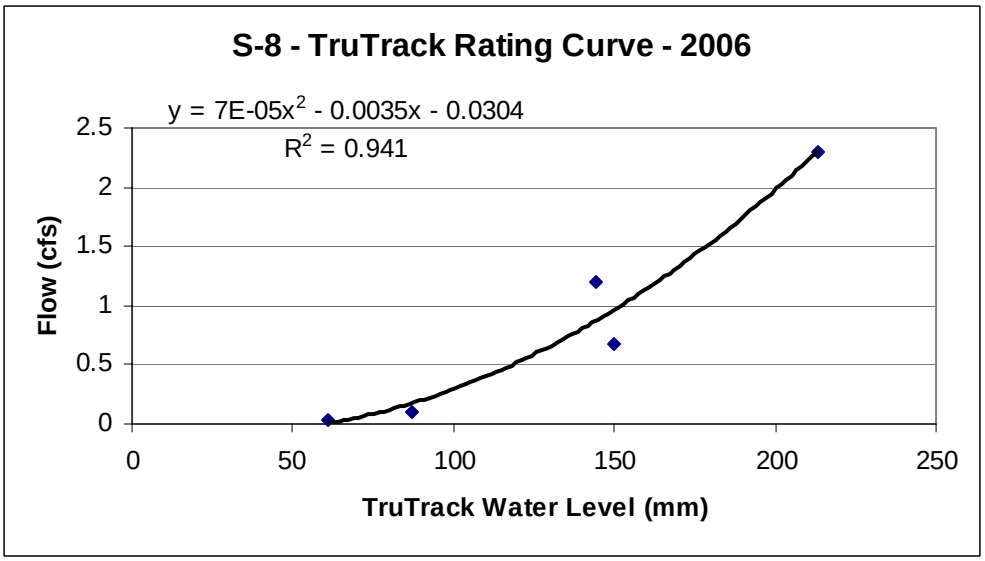
Appendix

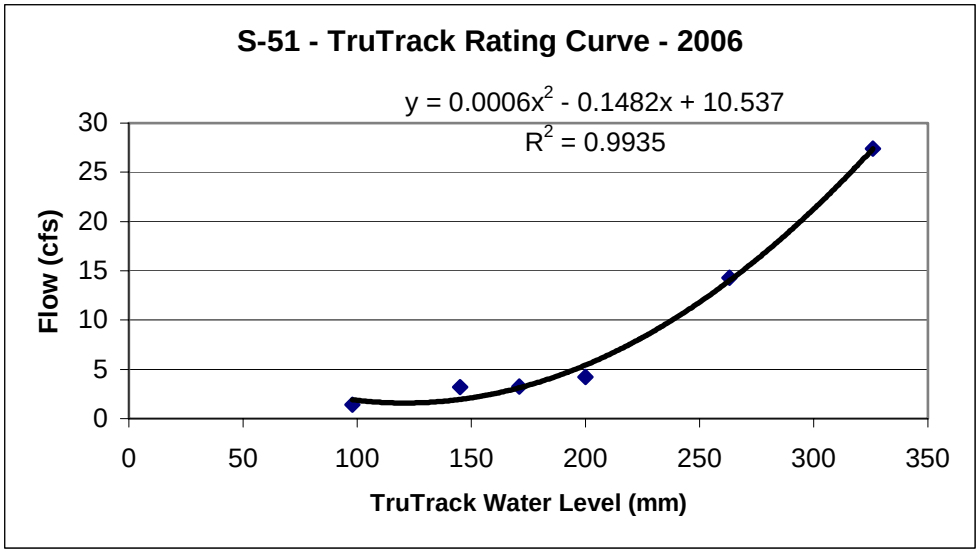

S-6 - TruTrack Rating Curve - 2006
y = 1E-04x^1.7664
R^2 = 0.7021
Flow (cfs)
5.0
4.0
3.0
2.0
1.0
0.0
0
50
100
150
200
250
300
350
400
TruTrack Water Level (mm)

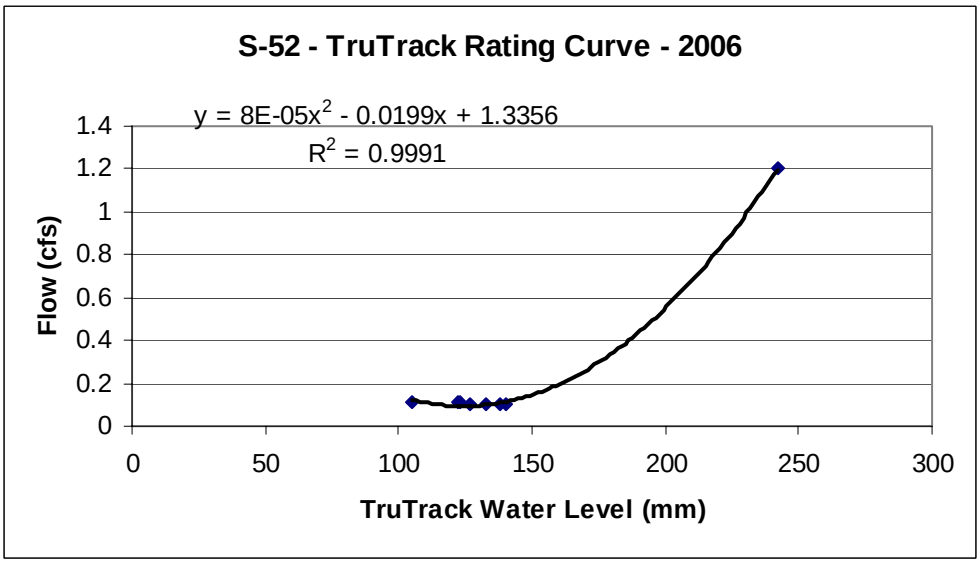

S-6 - Staff Gauge Rating Curve - 2006
y = 0.0488x^6.3549
R^2 = 0.8434
Flow (cfs)
6
5
4
3
2
1
0
0
0.5
1
1.5
2
2.5
Staff Gauge (ft)

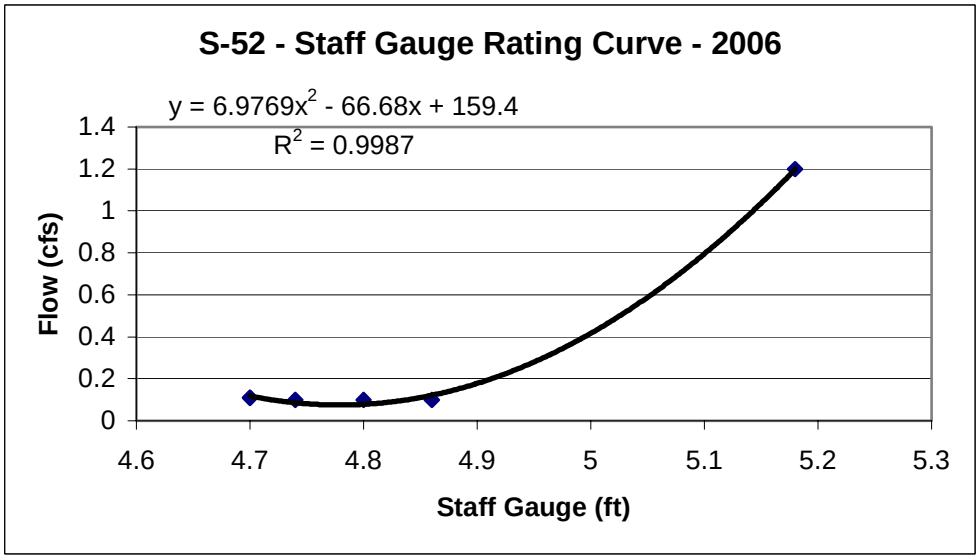

S-7 - TruTrack Rating Curve - 2006
y = 0.1897Ln(x) - 0.5365
R2 = 0.9591
Flow (cfs)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
100
200
300
400
500
TruTrack Water Level (mm)
One outlier deleted: 0.11 cfs, 226 mm

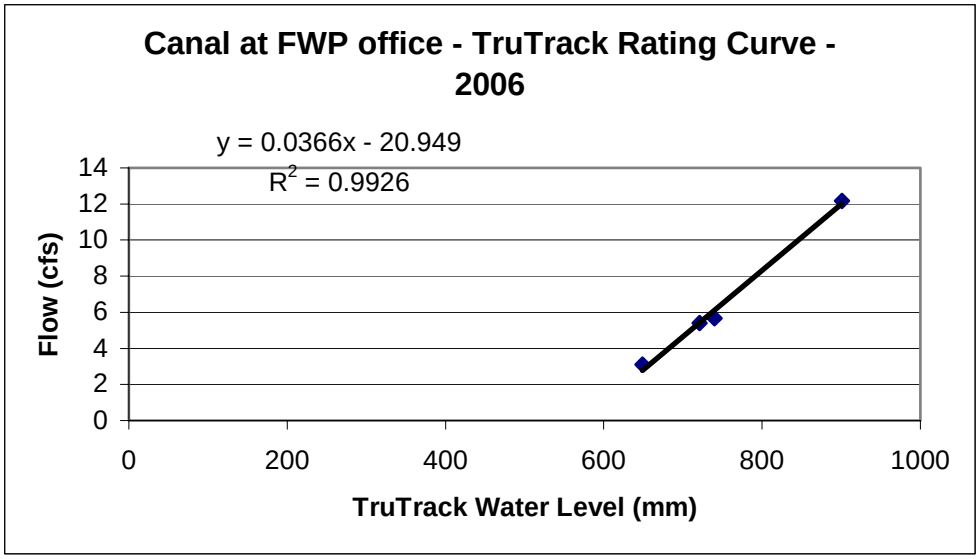

S-7 Staff Gauge Rating Curve - 2006
y = 2.1386Ln(x) - 3.1679
R2 = 0.8237
Flow (cfs)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
6
7
Staff Gauge (ft)

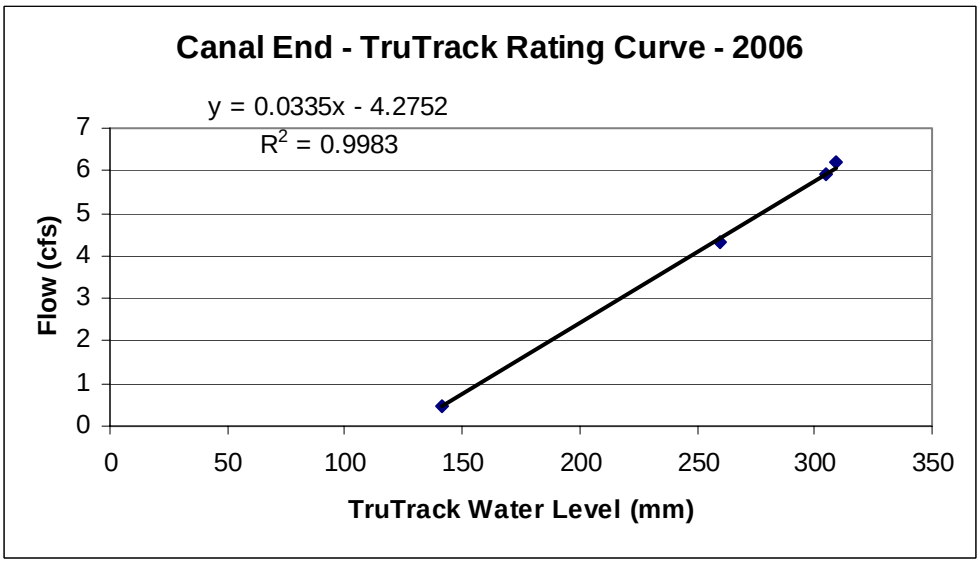

S-8 - TruTrack Rating Curve - 2006
y = 7E-05x2 - 0.0035x - 0.0304
R2 = 0.941
Flow (cfs)
2.5
2
1.5
1
0.5
0
0
50
100
150
200
250
TruTrack Water Level (mm)


S-51 - TruTrack Rating Curve - 2006
y = 0.0006x2 - 0.1482x + 10.537
R2 = 0.9935
Flow (cfs)
30
25
20
15
10
5
0
0
50
100
150
200
250
300
350
TruTrack Water Level (mm)


S-52 - TruTrack Rating Curve - 2006
y = 8E-05x2 - 0.0199x + 1.3356
R2 = 0.9991
Flow (cfs)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
300
TruTrack Water Level (mm)


S-52 - Staff Gauge Rating Curve - 2006
y = 6.9769x2 - 66.68x + 159.4
R2 = 0.9987
Flow (cfs)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
4.6
4.7
4.8
4.9
5
5.1
5.2
5.3
Staff Gauge (ft)


Canal at FWP office - TruTrack Rating Curve - 2006
y = 0.0366x - 20.949
R2 = 0.9926
Flow (cfs)
0
2
4
6
8
10
12
14
0
200
400
600
800
1000
TruTrack Water Level (mm)


Canal End - TruTrack Rating Curve - 2006
y = 0.0335x - 4.2752
R2 = 0.9983
Flow (cfs)
0
1
2
3
4
5
6
7
0
50
100
150
200
250
300
350
TruTrack Water Level (mm)

Energy Laboratory Results

SampleID	Date	Characteristic	ResultValue	CharUnits	ValueType
S41	03/29/2006	(*Unmatched) Conductivity	2760	umhos/cm	Actual
S41	03/29/2006	Nitrogen, Kjeldahl	2.1	mg/l	Actual
S41	03/29/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	*Non-detect	mg/l	Actual
S41	03/29/2006	(*Unmatched) Nitrogen, Total	2.1	mg/l	Calculated
S41	03/29/2006	Phosphorus as P	0.117	mg/l	Actual
S41	03/29/2006	Selenium	*Non-detect	mg/l	Actual
S41	03/29/2006	Total Suspended Solids (TSS)	6	mg/l	Actual
S51	03/29/2006	(*Unmatched) Conductivity	1240	umhos/cm	Actual
S51	03/29/2006	Nitrogen, Kjeldahl	0.9	mg/l	Actual
S51	03/29/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.80	mg/l	Actual
S51	03/29/2006	(*Unmatched) Nitrogen, Total	2.7	mg/l	Calculated
S51	03/29/2006	Phosphorus as P	0.047	mg/l	Actual
S51	03/29/2006	Selenium	0.005	mg/l	Actual
S51	03/29/2006	Total Suspended Solids (TSS)	17	mg/l	Actual
S52	03/29/2006	(*Unmatched) Conductivity	2370	umhos/cm	Actual
S52	03/29/2006	Nitrogen, Kjeldahl	0.8	mg/l	Actual
S52	03/29/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.29	mg/l	Actual
S52	03/29/2006	(*Unmatched) Nitrogen, Total	2.09	mg/l	Calculated
S52	03/29/2006	Phosphorus as P	0.026	mg/l	Actual
S52	03/29/2006	Selenium	0.003	mg/l	Actual
S52	03/29/2006	Total Suspended Solids (TSS)	8	mg/l	Actual
S6	03/29/2006	(*Unmatched) Conductivity	3330	umhos/cm	Actual
S6	03/29/2006	Nitrogen, Kjeldahl	3.1	mg/l	Actual
S6	03/29/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	3.05	mg/l	Actual
S6	03/29/2006	(*Unmatched) Nitrogen, Total	6.15	mg/l	Calculated
S6	03/29/2006	Phosphorus as P	0.177	mg/l	Actual
S6	03/29/2006	Selenium	0.033	mg/l	Actual
S6	03/29/2006	Total Suspended Solids (TSS)	29	mg/l	Actual
S7	03/29/2006	(*Unmatched) Conductivity	4180	umhos/cm	Actual
S7	03/29/2006	Nitrogen, Kjeldahl	1.6	mg/l	Actual
S7	03/29/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.44	mg/l	Actual
S7	03/29/2006	(*Unmatched) Nitrogen, Total	3.04	mg/l	Calculated
S7	03/29/2006	Phosphorus as P	0.048	mg/l	Actual
S7	03/29/2006	Selenium	0.074	mg/l	Actual
S7	03/29/2006	Total Suspended Solids (TSS)	17	mg/l	Actual
S8	03/29/2006	(*Unmatched) Conductivity	4200	umhos/cm	Actual
S8	03/29/2006	Nitrogen, Kjeldahl	2.0	mg/l	Actual
S8	03/29/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.91	mg/l	Actual
S8	03/29/2006	(*Unmatched) Nitrogen, Total	3.91	mg/l	Calculated
S8	03/29/2006	Phosphorus as P	0.041	mg/l	Actual
S8	03/29/2006	Selenium	0.114	mg/l	Actual
S8	03/29/2006	Total Suspended Solids (TSS)	48	mg/l	Actual
S41	04/18/2006	(*Unmatched) Conductivity	3140	umhos/cm	Actual
S41	04/18/2006	Nitrogen, Kjeldahl	1.9	mg/l	Actual
S41	04/18/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	*Non-detect	mg/l	Actual

SampleID	Date	Characteristic	ResultValue	CharUnits	ValueType
S41	04/18/2006	(*Unmatched) Nitrogen, Total	1.9	mg/l	Calculated
S41	04/18/2006	Phosphorus as P	0.118	mg/l	Actual
S41	04/18/2006	Selenium	*Non-detect	mg/l	Actual
S41	04/18/2006	Total Suspended Solids (TSS)	7	mg/l	Actual
S51	04/18/2006	(*Unmatched) Conductivity	1340	umhos/cm	Actual
S51	04/18/2006	Nitrogen, Kjeldahl	1.2	mg/l	Actual
S51	04/18/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	2.23	mg/l	Actual
S51	04/18/2006	(*Unmatched) Nitrogen, Total	3.43	mg/l	Calculated
S51	04/18/2006	Phosphorus as P	0.056	mg/l	Actual
S51	04/18/2006	Selenium	0.005	mg/l	Actual
S51	04/18/2006	Total Suspended Solids (TSS)	35	mg/l	Actual
S52	04/18/2006	(*Unmatched) Conductivity	2650	umhos/cm	Actual
S52	04/18/2006	Nitrogen, Kjeldahl	1.0	mg/l	Actual
S52	04/18/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.54	mg/l	Actual
S52	04/18/2006	(*Unmatched) Nitrogen, Total	2.54	mg/l	Calculated
S52	04/18/2006	Phosphorus as P	0.019	mg/l	Actual
S52	04/18/2006	Selenium	0.003	mg/l	Actual
S52	04/18/2006	Total Suspended Solids (TSS)	13	mg/l	Actual
S6	04/18/2006	(*Unmatched) Conductivity	3690	umhos/cm	Actual
S6	04/18/2006	Nitrogen, Kjeldahl	1.7	mg/l	Actual
S6	04/18/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	3.99	mg/l	Actual
S6	04/18/2006	(*Unmatched) Nitrogen, Total	5.69	mg/l	Calculated
S6	04/18/2006	Phosphorus as P	0.165	mg/l	Actual
S6	04/18/2006	Selenium	0.042	mg/l	Actual
S6	04/18/2006	Total Suspended Solids (TSS)	23	mg/l	Actual
S7	04/18/2006	(*Unmatched) Conductivity	5220	umhos/cm	Actual
S7	04/18/2006	Nitrogen, Kjeldahl	2.0	mg/l	Actual
S7	04/18/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	2.61	mg/l	Actual
S7	04/18/2006	(*Unmatched) Nitrogen, Total	4.61	mg/l	Calculated
S7	04/18/2006	Phosphorus as P	0.024	mg/l	Actual
S7	04/18/2006	Selenium	0.196	mg/l	Actual
S7	04/18/2006	Total Suspended Solids (TSS)	12	mg/l	Actual
S8	04/18/2006	(*Unmatched) Conductivity	4350	umhos/cm	Actual
S8	04/18/2006	Nitrogen, Kjeldahl	1.6	mg/l	Actual
S8	04/18/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	2.08	mg/l	Actual
S8	04/18/2006	(*Unmatched) Nitrogen, Total	3.68	mg/l	Calculated
S8	04/18/2006	Phosphorus as P	0.025	mg/l	Actual
S8	04/18/2006	Selenium	0.137	mg/l	Actual
S8	04/18/2006	Total Suspended Solids (TSS)	18	mg/l	Actual
S41	05/23/2006	(*Unmatched) Conductivity	2720	umhos/cm	Actual
S41	05/23/2006	Nitrogen, Kjeldahl	2.3	mg/l	Actual
S41	05/23/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.02	mg/l	Actual
S41	05/23/2006	(*Unmatched) Nitrogen, Total	2.32	mg/l	Calculated
S41	05/23/2006	Phosphorus as P	0.233	mg/l	Actual
S41	05/23/2006	Selenium	*Non-detect	mg/l	Actual
S41	05/23/2006	Total Suspended Solids (TSS)	33	mg/l	Actual
S51	05/23/2006	(*Unmatched) Conductivity	699	umhos/cm	Actual

SampleID	Date	Characteristic	ResultValue	CharUnits	ValueType
S51	05/23/2006	Nitrogen, Kjeldahl	1.7	mg/l	Actual
S51	05/23/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.52	mg/l	Actual
S51	05/23/2006	(*Unmatched) Nitrogen, Total	2.22	mg/l	Calculated
S51	05/23/2006	Phosphorus as P	0.226	mg/l	Actual
S51	05/23/2006	Selenium	0.002	mg/l	Actual
S51	05/23/2006	Total Suspended Solids (TSS)	67	mg/l	Actual
S52	05/23/2006	(*Unmatched) Conductivity	2480	umhos/cm	Actual
S52	05/23/2006	Nitrogen, Kjeldahl	1.0	mg/l	Actual
S52	05/23/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.76	mg/l	Actual
S52	05/23/2006	(*Unmatched) Nitrogen, Total	1.76	mg/l	Calculated
S52	05/23/2006	Phosphorus as P	0.041	mg/l	Actual
S52	05/23/2006	Selenium	0.003	mg/l	Actual
S52	05/23/2006	Total Suspended Solids (TSS)	20	mg/l	Actual
S6	05/23/2006	(*Unmatched) Conductivity	801	umhos/cm	Actual
S6	05/23/2006	Nitrogen, Kjeldahl	2.2	mg/l	Actual
S6	05/23/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.50	mg/l	Actual
S6	05/23/2006	(*Unmatched) Nitrogen, Total	2.70	mg/l	Calculated
S6	05/23/2006	Phosphorus as P	0.407	mg/l	Actual
S6	05/23/2006	Selenium	0.005	mg/l	Actual
S6	05/23/2006	Total Suspended Solids (TSS)	248	mg/l	Actual
S7	05/23/2006	(*Unmatched) Conductivity	3510	umhos/cm	Actual
S7	05/23/2006	Nitrogen, Kjeldahl	1.6	mg/l	Actual
S7	05/23/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.79	mg/l	Actual
S7	05/23/2006	(*Unmatched) Nitrogen, Total	3.39	mg/l	Calculated
S7	05/23/2006	Phosphorus as P	0.036	mg/l	Actual
S7	05/23/2006	Selenium	0.110	mg/l	Actual
S7	05/23/2006	Total Suspended Solids (TSS)	12	mg/l	Actual
S8	05/23/2006	(*Unmatched) Conductivity	755	umhos/cm	Actual
S8	05/23/2006	Nitrogen, Kjeldahl	0.9	mg/l	Actual
S8	05/23/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.13	mg/l	Actual
S8	05/23/2006	(*Unmatched) Nitrogen, Total	1.03	mg/l	Calculated
S8	05/23/2006	Phosphorus as P	0.027	mg/l	Actual
S8	05/23/2006	Selenium	0.015	mg/l	Actual
S8	05/23/2006	Total Suspended Solids (TSS)	46	mg/l	Actual
S-41	06/26/2006	(*Unmatched) Conductivity	3100	umhos/cm	Actual
S-41	06/26/2006	Nitrogen, Kjeldahl	3.0	mg/l	Actual
S-41	06/26/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	*Non-detect	mg/l	Actual
S-41	06/26/2006	(*Unmatched) Nitrogen, Total	3.0	mg/l	Calculated
S-41	06/26/2006	Phosphorus as P	0.303	mg/l	Actual
S-41	06/26/2006	Selenium	0.001	mg/l	Actual
S-41	06/26/2006	Total Suspended Solids (TSS)	37	mg/l	Actual
S-51	06/26/2006	(*Unmatched) Conductivity	479	umhos/cm	Actual
S-51	06/26/2006	Nitrogen, Kjeldahl	0.9	mg/l	Actual
S-51	06/26/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.61	mg/l	Actual
S-51	06/26/2006	(*Unmatched) Nitrogen, Total	1.5	mg/l	Calculated
S-51	06/26/2006	Phosphorus as P	0.096	mg/l	Actual
S-51	06/26/2006	Selenium	0.001	mg/l	Actual

SampleID	Date	Characteristic	ResultValue		CharUnits	ValueType
S-51	06/26/2006	Total Suspended Solids (TSS)	43		mg/l	Actual
S-52	06/26/2006	(*Unmatched) Conductivity	2780		umhos/cm	Actual
S-52	06/26/2006	Nitrogen, Kjeldahl	1.5		mg/l	Actual
S-52	06/26/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.97		mg/l	Actual
S-52	06/26/2006	(*Unmatched) Nitrogen, Total	2.5		mg/l	Calculated
S-52	06/26/2006	Phosphorus as P	0.051		mg/l	Actual
S-52	06/26/2006	Selenium	0.004		mg/l	Actual
S-52	06/26/2006	Total Suspended Solids (TSS)	30		mg/l	Actual
S6	06/26/2006	(*Unmatched) Conductivity	414		umhos/cm	Actual
S6	06/26/2006	Nitrogen, Kjeldahl	0.9		mg/l	Actual
S6	06/26/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.12		mg/l	Actual
S6	06/26/2006	(*Unmatched) Nitrogen, Total	1.0		mg/l	Calculated
S6	06/26/2006	Phosphorus as P	0.209		mg/l	Actual
S6	06/26/2006	Selenium	0.002		mg/l	Actual
S6	06/26/2006	Total Suspended Solids (TSS)	64		mg/l	Actual
S-7	06/26/2006	(*Unmatched) Conductivity	2020		umhos/cm	Actual
S-7	06/26/2006	Nitrogen, Kjeldahl	6.9		mg/l	Actual
S-7	06/26/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.33		mg/l	Actual
S-7	06/26/2006	(*Unmatched) Nitrogen, Total	8.2		mg/l	Calculated
S-7	06/26/2006	Phosphorus as P	0.807		mg/l	Actual
S-7	06/26/2006	Selenium	0.053		mg/l	Actual
S-7	06/26/2006	Total Suspended Solids (TSS)	1290		mg/l	Actual
S-8	06/26/2006	(*Unmatched) Conductivity	4100		umhos/cm	Actual
S-8	06/26/2006	Nitrogen, Kjeldahl	1.8		mg/l	Actual
S-8	06/26/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.83		mg/l	Actual
S-8	06/26/2006	(*Unmatched) Nitrogen, Total	3.6		mg/l	Calculated
S-8	06/26/2006	Phosphorus as P	0.045		mg/l	Actual
S-8	06/26/2006	Selenium	0.129		mg/l	Actual
S-8	06/26/2006	Total Suspended Solids (TSS)	66		mg/l	Actual
S-51	08/28/2006	(*Unmatched) Conductivity	538		umhos/cm	Actual
S-51	08/28/2006	Nitrogen, Kjeldahl	0.5		mg/l	Actual
S-51	08/28/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.23		mg/l	Actual
S-51	08/28/2006	(*Unmatched) Nitrogen, Total	1.7		mg/l	Calculated
S-51	08/28/2006	Phosphorus as P	0.062		mg/l	Actual
S-51	08/28/2006	Selenium	0.001		mg/l	Actual
S-51	08/28/2006	Total Suspended Solids (TSS)	26		mg/l	Actual
S-52	08/28/2006	(*Unmatched) Conductivity	2510		umhos/cm	Actual
S-52	08/28/2006	Nitrogen, Kjeldahl	0.9		mg/l	Actual
S-52	08/28/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.21		mg/l	Actual
S-52	08/28/2006	(*Unmatched) Nitrogen, Total	2.1		mg/l	Calculated
S-52	08/28/2006	Phosphorus as P	0.046		mg/l	Actual
S-52	08/28/2006	Selenium	0.003	D	mg/l	Actual
S-52	08/28/2006	Total Suspended Solids (TSS)	57		mg/l	Actual
S-6	08/28/2006	(*Unmatched) Conductivity	1200		umhos/cm	Actual
S-6	08/28/2006	Nitrogen, Kjeldahl	1.9		mg/l	Actual
S-6	08/28/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.73		mg/l	Actual
S-6	08/28/2006	(*Unmatched) Nitrogen, Total	3.6		mg/l	Calculated

SampleID	Date	Characteristic	ResultValue	CharUnits	ValueType
S-6	08/28/2006	Phosphorus as P	0.811	mg/l	Actual
S-6	08/28/2006	Selenium	0.012	mg/l	Actual
S-6	08/28/2006	Total Suspended Solids (TSS)	70	mg/l	Actual
S-7	08/28/2006	(*Unmatched) Conductivity	2340	umhos/cm	Actual
S-7	08/28/2006	Nitrogen, Kjeldahl	1.0	mg/l	Actual
S-7	08/28/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.82	mg/l	Actual
S-7	08/28/2006	(*Unmatched) Nitrogen, Total	1.8 D	mg/l	Calculated
S-7	08/28/2006	Phosphorus as P	0.045	mg/l	Actual
S-7	08/28/2006	Selenium	0.050	mg/l	Actual
S-7	08/28/2006	Total Suspended Solids (TSS)	46	mg/l	Actual
S-8	08/28/2006	(*Unmatched) Conductivity	532	umhos/cm	Actual
S-8	08/28/2006	Nitrogen, Kjeldahl	0.5	mg/l	Actual
S-8	08/28/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.08	mg/l	Actual
S-8	08/28/2006	(*Unmatched) Nitrogen, Total	0.5	mg/l	Calculated
S-8	08/28/2006	Phosphorus as P	0.020	mg/l	Actual
S-8	08/28/2006	Selenium	0.007	mg/l	Actual
S-8	08/28/2006	Total Suspended Solids (TSS)	12	mg/l	Actual
S-51	09/26/2006	Nitrogen, Kjeldahl	0.7	mg/l	Actual
S-51	09/26/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.67	mg/l	Actual
S-51	09/26/2006	(*Unmatched) Nitrogen, Total	2.37	mg/l	Calculated
S-51	09/26/2006	Phosphorus as P	0.055	mg/l	Actual
S-51	09/26/2006	Selenium	0.002	mg/l	Actual
S-51	09/26/2006	Total Suspended Solids (TSS)	21	mg/l	Actual
S-52	09/26/2006	Nitrogen, Kjeldahl	0.9	mg/l	Actual
S-52	09/26/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.35	mg/l	Actual
S-52	09/26/2006	(*Unmatched) Nitrogen, Total	2.25	mg/l	Calculated
S-52	09/26/2006	Phosphorus as P	0.047	mg/l	Actual
S-52	09/26/2006	Selenium	0.004	mg/l	Actual
S-52	09/26/2006	Total Suspended Solids (TSS)	38	mg/l	Actual
S-6	09/26/2006	Nitrogen, Kjeldahl	1.4	mg/l	Actual
S-6	09/26/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	3.86	mg/l	Actual
S-6	09/26/2006	(*Unmatched) Nitrogen, Total	5.26	mg/l	Calculated
S-6	09/26/2006	Phosphorus as P	0.790	mg/l	Actual
S-6	09/26/2006	Selenium	0.026	mg/l	Actual
S-6	09/26/2006	Total Suspended Solids (TSS)	58	mg/l	Actual
S-7	09/26/2006	Nitrogen, Kjeldahl	1.4	mg/l	Actual
S-7	09/26/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.98	mg/l	Actual
S-7	09/26/2006	(*Unmatched) Nitrogen, Total	3.38	mg/l	Calculated
S-7	09/26/2006	Phosphorus as P	0.055	mg/l	Actual
S-7	09/26/2006	Selenium	0.109	mg/l	Actual
S-7	09/26/2006	Total Suspended Solids (TSS)	52	mg/l	Actual
S-8	09/26/2006	Nitrogen, Kjeldahl	1.3	mg/l	Actual
S-8	09/26/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	2.44	mg/l	Actual
S-8	09/26/2006	(*Unmatched) Nitrogen, Total	3.74	mg/l	Calculated
S-8	09/26/2006	Phosphorus as P	0.025	mg/l	Actual
S-8	09/26/2006	Selenium	0.137	mg/l	Actual
S-8	09/26/2006	Total Suspended Solids (TSS)	32	mg/l	Actual

SampleID	Date	Characteristic	ResultValue	CharUnits	ValueType
S-51	10/31/2006	(*Unmatched) Conductivity	808	umhos/cm	Actual
S-51	10/31/2006	Nitrogen, Kjeldahl	0.4	mg/l	Actual
S-51	10/31/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	2.03	mg/l	Actual
S-51	10/31/2006	(*Unmatched) Nitrogen, Total	2.4	mg/l	Calculated
S-51	10/31/2006	Phosphorus as P	0.075	mg/l	Actual
S-51	10/31/2006	Selenium	0.004	mg/l	Actual
S-51	10/31/2006	Total Suspended Solids (TSS)	33	mg/l	Actual
S-52	10/31/2006	(*Unmatched) Conductivity	2590	umhos/cm	Actual
S-52	10/31/2006	Nitrogen, Kjeldahl	0.6	mg/l	Actual
S-52	10/31/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	2.17	mg/l	Actual
S-52	10/31/2006	(*Unmatched) Nitrogen, Total	2.8	mg/l	Calculated
S-52	10/31/2006	Phosphorus as P	0.035	mg/l	Actual
S-52	10/31/2006	Selenium	0.005	mg/l	Actual
S-52	10/31/2006	Total Suspended Solids (TSS)	31	mg/l	Actual
S-6	10/31/2006	(*Unmatched) Conductivity	1740	umhos/cm	Actual
S-6	10/31/2006	Nitrogen, Kjeldahl	1.6	mg/l	Actual
S-6	10/31/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	3.76	mg/l	Actual
S-6	10/31/2006	(*Unmatched) Nitrogen, Total	5.4	mg/l	Calculated
S-6	10/31/2006	Phosphorus as P	0.468	mg/l	Actual
S-6	10/31/2006	Selenium	0.029	mg/l	Actual
S-6	10/31/2006	Total Suspended Solids (TSS)	188	mg/l	Actual
S-7	10/31/2006	(*Unmatched) Conductivity	4300	umhos/cm	Actual
S-7	10/31/2006	Nitrogen, Kjeldahl	1.7	mg/l	Actual
S-7	10/31/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	2.45	mg/l	Actual
S-7	10/31/2006	(*Unmatched) Nitrogen, Total	4.1	mg/l	Calculated
S-7	10/31/2006	Phosphorus as P	0.136	mg/l	Actual
S-7	10/31/2006	Selenium	0.107	mg/l	Actual
S-7	10/31/2006	Total Suspended Solids (TSS)	228	mg/l	Actual
S-8	10/31/2006	(*Unmatched) Conductivity	4690	umhos/cm	Actual
S-8	10/31/2006	Nitrogen, Kjeldahl	1.5	mg/l	Actual
S-8	10/31/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	3.29	mg/l	Actual
S-8	10/31/2006	(*Unmatched) Nitrogen, Total	4.8	mg/l	Calculated
S-8	10/31/2006	Phosphorus as P	0.013	mg/l	Actual
S-8	10/31/2006	Selenium	0.193	mg/l	Actual
S-8	10/31/2006	Total Suspended Solids (TSS)	21	mg/l	Actual
S-51	11/20/2006	(*Unmatched) Conductivity	873	umhos/cm	Actual
S-51	11/20/2006	Nitrogen, Kjeldahl	0.5	mg/l	Actual
S-51	11/20/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	2.35	mg/l	Actual
S-51	11/20/2006	(*Unmatched) Nitrogen, Total	2.85	mg/l	Calculated
S-51	11/20/2006	Phosphorus as P	0.051	mg/l	Actual
S-51	11/20/2006	Selenium	0.005	mg/l	Actual
S-51	11/20/2006	Total Suspended Solids (TSS)	32	mg/l	Actual
S-52	11/20/2006	(*Unmatched) Conductivity	2380	umhos/cm	Actual
S-52	11/20/2006	Nitrogen, Kjeldahl	0.7	mg/l	Actual
S-52	11/20/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.90	mg/l	Actual
S-52	11/20/2006	(*Unmatched) Nitrogen, Total	2.6	mg/l	Calculated
S-52	11/20/2006	Phosphorus as P	0.020	mg/l	Actual

SampleID	Date	Characteristic	ResultValue	CharUnits	ValueType
S-52	11/20/2006	Selenium	0.004	mg/l	Actual
S-52	11/20/2006	Total Suspended Solids (TSS)	30	mg/l	Actual
S-6	11/20/2006	(*Unmatched) Conductivity	1950	umhos/cm	Actual
S-6	11/20/2006	Nitrogen, Kjeldahl	2.0	mg/l	Actual
S-6	11/20/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	3.81	mg/l	Actual
S-6	11/20/2006	(*Unmatched) Nitrogen, Total	5.81	mg/l	Calculated
S-6	11/20/2006	Phosphorus as P	0.655	mg/l	Actual
S-6	11/20/2006	Selenium	0.045	mg/l	Actual
S-6	11/20/2006	Total Suspended Solids (TSS)	276	mg/l	Actual
S-7	11/20/2006	(*Unmatched) Conductivity	4250	umhos/cm	Actual
S-7	11/20/2006	Nitrogen, Kjeldahl	1.8	mg/l	Actual
S-7	11/20/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	2.51	mg/l	Actual
S-7	11/20/2006	(*Unmatched) Nitrogen, Total	4.31	mg/l	Calculated
S-7	11/20/2006	Phosphorus as P	0.138	mg/l	Actual
S-7	11/20/2006	Selenium	0.135	mg/l	Actual
S-7	11/20/2006	Total Suspended Solids (TSS)	126	mg/l	Actual
S-8	11/20/2006	(*Unmatched) Conductivity	4430	umhos/cm	Actual
S-8	11/20/2006	Nitrogen, Kjeldahl	1.5	mg/l	Actual
S-8	11/20/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	3.09	mg/l	Actual
S-8	11/20/2006	(*Unmatched) Nitrogen, Total	4.59	mg/l	Calculated
S-8	11/20/2006	Phosphorus as P	0.028	mg/l	Actual
S-8	11/20/2006	Selenium	0.230	mg/l	Actual
S-8	11/20/2006	Total Suspended Solids (TSS)	29	mg/l	Actual
Field Blank	03/29/2006	Total Suspended Solids (TSS)	*Non-detect	mg/l	Actual
Field Blank	04/18/2006	Total Suspended Solids (TSS)	*Non-detect	mg/l	Actual
Field Blank	05/23/2006	Total Suspended Solids (TSS)	*Non-detect	mg/l	Actual
Field Blank	06/26/2006	Nitrogen, Kjeldahl	0.2	mg/l	Actual
Field Blank	06/26/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.03	mg/l	Actual
Field Blank	06/26/2006	(*Unmatched) Nitrogen, Total	0.3	mg/l	Calculated
Field Blank	06/26/2006	Phosphorus as P	0.006	mg/l	Actual
Field Blank	06/26/2006	Total Suspended Solids (TSS)	*Non-detect	mg/l	Actual
Field Blank	09/26/2006	Nitrogen, Kjeldahl	0.3	mg/l	Actual
Field Blank	09/26/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	*Non-detect	mg/l	Actual
Field Blank	09/26/2006	(*Unmatched) Nitrogen, Total	.3	mg/l	Calculated
Field Blank	09/26/2006	Phosphorus as P	0.005	mg/l	Actual
Field Blank	09/26/2006	Selenium	*Non-detect	mg/l	Actual
Field Blank	09/26/2006	Total Suspended Solids (TSS)	*Non-detect	mg/l	Actual
Field Blank	10/31/2006	(*Unmatched) Conductivity	1	umhos/cm	Actual
Field Blank	10/31/2006	Nitrogen, Kjeldahl	*Non-detect	mg/l	Actual
Field Blank	10/31/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	*Non-detect	mg/l	Actual
Field Blank	10/31/2006	(*Unmatched) Nitrogen, Total	*Non-detect	mg/l	Calculated
Field Blank	10/31/2006	Phosphorus as P	0.002	mg/l	Actual
Field Blank	10/31/2006	Selenium	*Non-detect	mg/l	Actual
Field Blank	10/31/2006	Total Suspended Solids (TSS)	*Non-detect	mg/l	Actual
Field Blank	11/20/2006	(*Unmatched) Conductivity	11	umhos/cm	Actual
Field Blank	11/20/2006	Nitrogen, Kjeldahl	0.3	mg/l	Actual
Field Blank	11/20/2006	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	*Non-detect	mg/l	Actual

SampleID	Date	Characteristic	ResultValue	CharUnits	ValueType
Field Blank	11/20/2006	(*Unmatched) Nitrogen, Total	.3	mg/l	Calculated
Field Blank	11/20/2006	Phosphorus as P	0.004	mg/l	Actual
Field Blank	11/20/2006	Selenium	*Non-detect	mg/l	Actual
Field Blank	11/20/2006	Total Suspended Solids (TSS)	*Non-detect	mg/l	Actual

D = lab duplicate precision did not meet project or method requirements.

USGS Laboratory Results

Site	DATE	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter	Phosphorus, water, unfiltered, milligrams per liter	Selenium, water, unfiltered, micrograms per liter	Suspended sediment, sieve diameter, percent smaller than 0.063 millimeters	Suspended sediment concentration, milligrams per liter
S-7	Aug 28 2006	1.31 D	.05	50.7	89	70
S-51	Aug 28 2006	1.42	.07	1.2	67	37
S-52	Aug 28 2006	1.75	.05	1.7 D	90	69

D = lab duplicate precision did not meet project or method requirements.