WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER QUALITY DIVISION
MONITORING AND ASSESSMENT REPORT

Waterbody:	Little Goose Creek - WYTR10090101
Segment Assessed:	From headwaters 6 miles southwest of Bighorn, WY to its confluence with Big Goose Creek in Sheridan, WY.
Class:	2AB
Designated Uses:	General aquatic life, fish consumption, protection and propagation of cold water fish, contact recreation, drinking water, wildlife, aesthetic value, agricultural and industrial.
1996 305(b) Report and 303(d) List:	WYTR10090101 was listed as not supporting aquatic life use, partially supporting cold water fish, and threatened for agricultural and aquifer protection uses.
Causes of Impairment:	Siltation, nutrients, salinity/TDS/chlorides, flow alterations, other habitat, organic, suspended solids, pesticides, pathogens, pH, oil and grease, unionized ammonia, chloride, turbidity, unknown.
Sources of Impairment:	Range land, irrigated crop, pasture land, channelization, flow problems, streambank, removal of riparian, recreational activities.
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INTRODUCTION

Little Goose Creek originates on the northwest side of Little Goose Peak in the Big Horn Mountains of north-central Wyoming. The stream flows north where it joins Big Goose Creek in the city of Sheridan to form Goose Creek. Little Goose Creek is classified in Chapter 1, Appendix A of the Water Quality Rules and Regulations as a Class 2AB (cold water) stream (WDEQ/WQD, 2001b). The segment assessed includes Little Goose Creek from the headwaters to the confluence with Big Goose Creek (26.3 miles).

Credible impairment data collected by the U.S. Geological Survey during a five-year period encompassing water years 1993 through 1997 (Clark and Norris, 2000) supported listing Little Goose Creek as non-supporting of the contact recreation designated use due to fecal coliform bacteria counts above Wyoming water quality standards.

REPORT OBJECTIVE

Little Goose Creek was included on Wyoming's 303(d) list of impaired waterbodies because anecdotal data suggested the stream did not support aquatic life, only partially supported cold water fish, and was threatened for agriculture and aquifer protection designated uses. Recognizing the repercussions of such a listing, Little Goose Creek was removed from the impaired waters list, and placed on a separate list of waters needing credible assessment data before impairment status could be determined. The purpose of this report is to document the Department of Environmental Quality assessment data, and provide a determination of whether the designated uses of Little Goose Creek are supported.

METHODS

Five assessment stations were established on Little Goose Creek (Table 1). Stations were chosen for various reasons. LGC-1 was selected to assess Little Goose Creek water quality near the headwaters, upstream of most potential human impacts. LGC-2 was selected to assess the influence of the City of Big Horn and two tributaries, Jackson Creek and Sackett Creek, on Little Goose Creek water quality. In 1999, Jackson Creek and Sackett Creek were identified by WDEQ as having fecal coliform concentrations above Wyoming water quality standards. LGC-3 was selected to assess Little Goose Creek water quality before potential urban influences in the City of Sheridan. LGC-4 was selected to assess effects of urbanization on Little Goose Creek water quality. Finally, LGC-5 was selected to assess the influence of urban stormwater runoff on Little Goose Creek water quality. A map of the Little Goose Creek sites and the surrounding area is provided in Appendix A.

Water samples were collected, preserved, transported, and analyzed in accordance with procedures outlined in WDEQ/WQD (2001) and WDEQ/WQD (2001a). Temperature, pH, dissolved oxygen, and conductivity were measured in the field. Turbidity samples were analyzed in the Sheridan, WY field office laboratory. All other parameters were analyzed in the WDEQ/WQD laboratory in Cheyenne.

Physical (habitat quality) data were collected and analyzed according to WDEQ/WQD bioassessment protocols (King, 1993; WDEQ/WQD, 2001). Components included stream substrate composition and silt cover, a pool quality assessment, and a qualitative habitat assessment.

The qualitative habitat assessment was conducted on a reach upstream of the sampling riffle at the established station. Thirteen sampling assessment parameters were evaluated. Evaluation of these parameters allows for a total habitat score ranging from zero to 200 points. High total point scores equate to high quality habitat. Specifics of the individual habitat parameters are discussed in King (1993), Platfkin (1989), and WDEQ/WQD (2001). See Table 2 for a listing of each habitat parameter.

Pool quality (as related to fish habitat) was assessed at four consecutive pools upstream of the sampling riffle in accordance with WDEQ/WQD (2001). Assessed parameters include residual pool depth (maximum minus tailout depth), substrate size, overhead cover, subsurface cover, and bank cover. Each parameter scored 0, 1, or 2; the maximum pool quality score is 10.

Macroinvertebrate samples were collected and preserved according to WDEQ/WQD bioassessment protocols (King, 1993; WDEQ/WQD, 2001). Macroinvertebrate samples were sent to Aquatic Biology Associates, Corvallis, OR, where they were processed and subsampled according to WDEQ/WQD protocol and standard taxonomic effort (King, 1993). The macroinvertebrate data were summarized into individual metrics according to WDEQ/WQD bioassessment protocols (King, 1993). A metric is a descriptor of one facet of a macroinvertebrate community that responds to physical and chemical stressors in a predictable manner.

Primary evaluation of macroinvertebrate data was conducted using two methods: 1) the Wyoming Stream Integrity Index (WSII; Stribling et al., 2000; Jessup et al., 2002) and 2) the Wyoming Biotic Condition Index (WBCI; Barbour et al., 1994).

The WSII (Jessup et al., 2002) is a regionally-calibrated multi-metric biological index for assessing aquatic life use support in Wyoming streams. The current version of WSII is a revision of an earlier index (Stribling et al., 2000) that was updated with two additional years of benthic macroinvertebrate data. Because biological communities of Wyoming streams vary across natural gradients of environmental conditions, a two-tiered site classification scheme was used to group sites into relatively homogenous units. The primary classification was the level III ecoregions of Omernik and Gallant (1987); The secondary classification was an aggregation of ecoregions into areas of relative biological similarity (bioregions); mountains and non-mountains. Nine macroinvertebrate metrics in the mountain index and ten in the non-mountain index with pronounced discrimination efficiency (degree of separation between metric value distributions of reference and degraded sites within each bioregion) were incorporated into the WSII. Scoring of individual metric values was based on a comparison to the 5th or 95th percentile of bioregional reference stream data for each specific metric. Specific metric scoring formulae are presented in Jessup et al. (2002). The final index score is calculated by averaging the individual metric scores. Criteria for narrative assessment of final index scores and determination of aquatic life use attainment are ecoregion -specific (rather than bioregion-specific) (Jessup et al., 2002). In addition, the Middle Rockies Central is sub-divided into two elevation zones (>6500 ft, and <6500 ft). Separate criteria for the Middle Rockies Central and the Northwestern Great Plains ecoregion are presented in Table 3.

The WBCI (Barbour et al. 1994) is a multi-metric biological criteria developed specifically for streams within the central Middle Rockies ecoregion of Wyoming (Bighorn Mountains). The classification scheme of Stribling et al (2000) was not needed because of the regional specificity of this index. However, specific criteria were developed for streams above and below 6500 ft. WBCI criteria for streams at elevations less than 6500 feet differ from the Rockies criteria of the WSII in that the % Ephemeroptera metric includes the family Baetidae, % Plecoptera instead of Plecoptera taxa is used, no Trichoptera metrics are used, and % Chironomidae, EPT taxa, and predator taxa are included in the WBCI. The % scraper metric is included but sets a lower threshold for attaining optimal scoring.

Metric values of assessed streams were assigned a score of 5, 3, or 1 based on comparison to the reference stream data. Scoring ranges were established by assigning the highest score to metric values falling above the 75^{th} percentile of the reference stream data (or below the 25^{th} percentile for metrics that decrease with increasing stress); the range below the 75^{th} percentile (or above the 25^{th} percentile for metrics that decrease with increasing stress) was bisected for the assignment of scores of 3 or 1. The total score is a summation of the individual metric scores. The total score was used to determine a biological condition rating of optimal, suboptimal, or poor. Optimal condition indicates full-support of aquatic life use; ratings of suboptimal or poor indicate partial- or non-support of aquatic life use.

All chemical, physical, and biological data were collected in accordance with appropriate quality assurance and quality control methodology, and were evaluated for completeness and precision (WDEQ/WQD, 2001).

PHYSICAL SETTING

Little Goose Creek originates in the Bighorn National Forest of the Middle Rockies ecoregion (Omernik and Gallant, 1987). Ecoregions are defined as regions of relative homogeneity with respect to ecological systems involving interrelationships among organisms and their environment (Omernik, 1995). Chemical, physical, and biological conditions are expected to be more similar within ecoregions than among ecoregions, Therefore, the ecoregion is the primary framework within which chemical, physical, and biological conditions of streams are compared and assessed.

The predominant geology of LGC-1, which is in the Middle Rockies Central ecoregion, is a KC Cody Shale (U.S. Geological Survey, 1994). The predominant soil type is a Nesda stony silt loam. This soil is very deep, somewhat poorly drained soil on low terraces and flood plains formed in alluvium, derived from limestone, granite and sandstone. It has rapid permeability with a slight hazard of water erosion (U.S. Department of Agriculture, 1986).

The remaining stations are in the Northwestern Great Plains ecoregion (Omernik and Gallant, 1987). The predominant geology underlying these stations is alluvium and colluvium containing clay, silt, sand and gravel in flood plains, fans, terraces, and slopes (U.S. Geological Survey, 1994). Soil type varies among stations. LGC-2 is dominated by a Nesda variant - Havertel complex, found on low terraces and flood plains containing approximately 50 % Nesda variant gravelly sandy loam and 30 % Havertel silt loam (U.S. Department of Agriculture, 1986). Nesda variant soil is very deep and well drained, and formed in alluvium derived from sedimentary rock. Havertel soil is very deep and moderately well drained with a very rapid permeability. Formed in alluvium and derived from sedimentary rock, its permeability is moderate in the surface layer and very rapid in the underlying material.

The predominant soil type of LGC-3 is a Coaliams - Worthenton complex found on flood plains and low terraces adjacent to perennial streams (U.S. Department of Agriculture, 1986). Composition is approximately 40% coaliam loam on low terraces and flood plains and 40 % worthenton silty clay loam in depressions and oxbows on flood plains. Coaliam soil is very deep and moderately well drained. Formed in alluvium derived from sedimentary rock, it has a moderate permeability. Worthenton soil is very deep and poorly drained. It is formed in alluvium derived from sedimentary rock and has a slow permeability.

The predominant soil type of LGC-4 and LGC-5 is a Kishona-Clarkelan complex found on flood plains, alluvial fans and terraces (U.S. Department of Agriculture, 1986). Kishona soil is very deep and well drained. Formed in alluvium derived from sedimentary rock, it has a moderate permeability. Clarkelan soil is very deep and somewhat excessively drained. It is formed in alluvium derived from sedimentary rock, and has a rapid permeability.

Human impacts exist within the entire Little Goose Creek watershed. Livestock grazing occurs throughout much of the watershed. Industry and urbanization affects the stream in and around the City of Sheridan. Recreation and wildlife uses also have an effect on the water quality of Little Goose Creek. During 1998-99, Little Goose Creek and several of its tributaries were monitored for fecal coliform bacteria. Fecal coliform bacteria are present in Little Goose Creek and several of its tributaries at levels that exceed Wyoming water quality standards (WDEQ/WQD, 2001c). Sources of the fecal coliform bacteria are unknown at this time. Monitoring of fecal coliform bacteria is ongoing within the Little Goose Creek watershed.

Little Goose Creek at LGC-1 is predominantly a B3 channel type (Rosgen, 1996). This channel type exhibits little sinuosity, a moderate to high gradient, a moderate width/depth ratio, slight entrenchment, and substrate dominated by cobble. At LGC-2 and LGC-3, the stream is a C4 channel type (Rosgen, 1996). This channel type has similar sinuosity and width/depth ratio as a B3 channel, but has a lower gradient, greater entrenchment, and substrate dominated by gravel. At LGC-4 and LGC-5, the stream has a F4 channel type. This channel type is similar to a C4, but has greater entrenchment.

Photos taken at all of the sites include: upstream, downstream, panoramic of surrounding area, and other site descriptive photos. These photos can be found in the Little Goose Creek file. Select representative photos are presented in Appendix B.

RESULTS AND DISCUSSION

Water Quality

Water temperature is an important factor in streams because it affects growth, distribution, and survival of aquatic organisms. Water temperature is affected by natural and anthropogenic factors. Seasonal air temperatures, snowmelt runoff, groundwater infiltration, irrigation returns, and loss or modification of riparian vegetation and instream habitat are common influences on water temperature. Water temperature varied from 6.2°C at LGC-1 to 9.8°C at LGC-5 (Table 4). These temperatures were well below the WDEQ/WQD (2001c) water quality standard of 20° C for a cold water fishery. While the samples were collected at a time of day expected to produce the daily maximum water temperature, the mid-October sampling date is well beyond the date expected to produce water temperatures great enough to exceed water quality standards. The sample date may also miss the period of the year with the poorest water quality (summer).

The pH is a measure of the hydrogen ion (H^+) concentration in water. A pH less than 7.0 indicates acidic conditions; a pH greater than 7.0 indicates basic conditions. Most freshwater is slightly basic, with pH ranging from 7.0 to 9.0 su. The pH varied from 7.6 at LGC-1 to 8.5 at LGC-2. These values are typical of streams spanning the transition between mountainous and plains regions and were within the WDEQ/WQD (2001c) water quality limit of between 6.5 and 9.0.

Conductivity is an indirect measure of total dissolved solids (TDS) in solution. As solids concentrations increase, conductivity also increases. Conductivity and TDS may be affected by point source discharges, and irrigation delivery and return systems. As expected, conductivity and TDS increased in a downstream direction on Little Goose Creek. These parameters normally increase as a stream progresses from mountainous to a plains regions due to changes in geology and increased drainage area.

Dissolved oxygen is the amount of free oxygen available to aquatic organisms for respiration. Oxygen enters the aquatic environment via diffusion from the atmosphere or by photosynthesis by aquatic plants. Dissolved oxygen concentrations tend to increase in cold, well-mixed waters. Low dissolved oxygen concentrations can affect fish and invertebrate community composition.. Dissolved oxygen concentrations progressively decreased in a downstream direction. However, concentrations were well above the one day cold water criteria of 4.0 mg/L for non-early life stages of cold water fish and the criteria of 8.0 mg/L for early life stages (WDEQ/WQD, 2001c).

Turbidity is an optical property of water where total suspended solids (TSS) and some dissolved material can cause light to be scattered. As turbidity and TSS concentrations increase, light available for aquatic organisms will decrease. Elevated turbidity and TSS can result in decreased photosynthesis which, in turn, results in decreased plant biomass and potentially depressed dissolved oxygen concentrations. Decreased abundance of fish can result from levels greater than 10 nephalometric turbidity units (ntu) and 18 mg/L, respectively (Newcombe and Jensen, 1996; Lloyd, 1997). The WDEQ/WQD (2001c) numeric standard for turbidity addresses increases attributable to anthropogenic activities. WDEQ/WQD (2001c) states that anthropogenic activities shall not result in a turbidity increase of more than 10 ntu in a class 1 or 2 cold water fishery. Turbidity and TSS were well below the criteria of Lloyd (1987) and Newcombe and Jensen (1996), and no turbidity increases of 10 ntu or more were observed.

Alkalinity is a measurement of the acid neutralizing or buffering capacity of water (Rand, 1995). High alkalinity waters are better able to neutralize acidic inputs than low alkalinity waters.

Alkalinity is important for primary producers (bacteria and algae) in streams, therefore directly affecting macroinvertebrate communities. In general, stream productivity increases as alkalinity increases (King, 1993). Wyoming does not have a numeric alkalinity standard, but a minimum of 20 mg/l was established by the U.S. Environmental Protection Agency (1986). Alkalinity was above this criterion at each Little Goose Creek assessment station.

Chloride and sulfate are two principal dissolved components in water. Increased chloride or sulfate concentrations have a negative effect on benthic macroinvertebrates. WDEQ/WQD (2001c) acute and chronic aquatic life chloride standards are 860 mg/L and 230 mg/L, respectively. There is no numeric surface water standard for sulfates in Wyoming, however, King (1993) reviewed pertinent literature and suggested that sulfate levels below 150 mg/L are optimal for macroinvertebrates. Chloride concentrations were below the limit of detection at all of the sampling stations. Sulfate concentrations increased in a downstream direction but remained below concentrations thought to have negative effects on aquatic life.

Total hardness is a measure of the concentration of metallic ions in solution, commonly calcium and magnesium. When hardness is numerically greater than the sum of carbonate and non-carbonate alkalinity, the excess is called non-carbonate hardness. Metallic ions that contribute to non-carbonate hardness are aluminum, zinc, iron, strontium, and manganese. While there is no total hardness water quality standard in Wyoming, a large departure from reference conditions may warrant sampling for specific metals. Total hardness was lowest at LGC-1 (60 mg/L) and increased downstream to 260 mg/L at LGC-3, LGC-4, and LGC-5. Hardness slightly exceeded total alkalinity at each station, indicating presence of metallic ions in addition to calcium and magnesium.

Phosphorus is an essential element for plant growth and is considered to be one of two primary nutrients associated with human-induced (anthropogenic) pollution. Low levels of phosphorus (>0.2 mg/L) can stimulate primary production in streams in the presence of adequate light and other nutrients. Naturally occurring phosphorus enters the stream primarily by soil erosion and sediment transport. Anthropogenic sources of phosphorus can include municipal and industrial effluents, and runoff from animal feeding areas and fertilized lands (King, 1993). Wyoming has not established water quality standards for phosphorus, however, King (1993) reviewed pertinent literature to conclude that total phosphorus concentrations should not exceed 0.05 mg/L in a stream that enters a lake or reservoir and suggests a target total phosphorus concentration of 1.0 mg/L for streams that do not enter into a lake or reservoir. Phosphorus was not detected in any of the Little Goose Creek water samples.

Nitrogen is present in nature in several forms. Nitrate nitrogen is considered the other of the two primary nutrients associated with anthropogenic pollution. Anthropogenic sources of nitrate can occur from municipal and industrial effluents, animal feeding operations, fertilizer use, and other human and animal waste runoff (King, 1993a). Wyoming does not have a nitrate standard for aquatic life, however, the human health standard for nitrate nitrogen is 10 mg/L (WDEQ/WQD, 2000). Nitrate-nitrogen was not detected in any of the Little Goose Creek water samples.

Ammonia is normally present in surface waters and is largely the result of metabolic processes of aquatic organisms . The presence of un-ionized ammonia (NH_3) can be toxic to aquatic life. In general, ammonia concentrations greater than 0.1 mg/L indicate polluted waters, with toxicity increasing as temperature and pH increase. Ammonia concentrations were above 0.1 mg/L at LGC-1 and LGC-2, and equaled that concentration at LGC-5. These results suggests that ammonia may contribute to partial support or non-support of aquatic life uses in Little Goose Creek.

Fecal coliform bacteria are found in the gut or feces of warm blooded animals. These bacteria ferment lactose with the production of acid and gas under standard culturing conditions (24 hours at 44.5°C). These bacteria are indicator species; their presence above acceptable limits suggests contamination of the waterbody by fecal material and that there is the potential for pathogens to be present. The indicator species themselves may not be pathogenic. During the recreational season, concentrations of fecal coliform bacteria should not exceed a geometric mean of 200 colony forming units (cfu) per 100 milliliters of water (based on a minimum of not less than 5 samples obtained during separate 24 hour periods for any 30 day period) (WDEQ/WQD, 2000). Fecal coliform concentrations ranged from 20-148 cfu per 100 ml which is below the Wyoming water quality standard of 200 cfu per 100 ml. A fecal coliform synoptic study conducted by DEQ during the summer of 1998 and 1999 found concentrations above water quality standards (see Historical and Ancillary Data section below). Mid-summer sampling (recreational season) is most appropriate for monitoring fecal coliform contamination and determining contact recreation and drinking water designated use attainment. At this time human contact is at a maximum level and water temperatures are most conducive to bacterial growth.

Biological Oxygen Demand (BOD) is a measure of the quantity of oxygen consumed by aerobic microorganisms during the decomposition of readily degradable organic material (Ramalho 1983). In general, BOD increases as organic material (or wastes) increase in a waterbody. Significant reduction of dissolved oxygen may result in increased abundance of tolerant organisms such as leeches, worms, and midges, and reduced abundance of more sensitive organisms like stoneflies and mayflies. Unpolluted waters are expected to have BOD of 1 to 2 mg/L; BOD of 8 mg/L or greater indicates substantial organic pollution. BOD was not detected at any of the Little Goose Creek assessment stations

Surface sheens or odors were not observed at any stations. Water had a very light brown color at LGC-3, increasing to a light brown color at LGC-4 and LGC-5.

Habitat Quality

Substrate composition was relatively diverse at each station but varied among stations (Table 5). Cobble and coarse gravel are optimal substrate for macroinvertebrate colonization in riffle habitats. These substrates comprised over 70% of the substrate at LGC-1, LGC-2, and LGC-4. LGC-3 and LGC-5 had considerably less of these substrates and more fine gravel and sand than the other stations. Sand is the least productive of macroinvertebrate habitats and may be from natural or anthropogenic sources. Silt substrate was only present at LGC-5, where it constituted 25 % of the substrate. Although silt is a more productive macroinvertebrate habitat than sand, increases in deposited sediment can result in decreased macroinvertebrate abundance and increased relative abundance of tolerant macroinvertebrate taxa.

Weighted embeddedness values decreased from LGC-1 to LGC-4. Decreasing weighted embeddedness values indicate increasing silt covering on gravel-sized or larger substrate. At LGC-1, 2 % of the substrate had greater than 5 % silt cover. At LGC-2, 84% of the substrate had greater than 5% silt cover; 13% of the substrate had greater than 50% silt cover. At LGC-3, 30% of the substrate had greater than 5% silt cover; 37% of the substrate had greater than 50% silt cover. Silt cover was greatest at LGC-4, with 98% of the substrate having greater than 5% silt cover and 67% of the substrate having greater than 50% silt cover. Silt cover decreased at LGC-5; 75% of the substrate had greater than 5% silt cover and 14% had silt cover greater than 50%.

Habitat scores decreased from LGC-1 to LGC-5 (Table 2). The largest differences were observed for substrate embeddedness and parameters associated with stream channel alteration (velocity/depth, channel shape, pool/riffle ratio, channelization, and riparian vegetative zone width).

The total habitat score for LGC-1 was 106% of the mean habitat score for the two reference-quality Middle Rockies ecoregion streams used for comparison (Table 6). The habitat scores for LGC-2, LGC-3, LGC-4, and LGC-5 were 103%, 95%, 76%, and 75% of the mean habitat score for the three minimally-impaired Northwestern Great Plains streams used for comparison. Plafkin et al. (1989) suggests a criterion of ≥90% comparability with reference streams in order for a stream to be clearly supporting habitat requirements of aquatic life. Comparability of 75-89% indicates that biological impairment may be due to degraded habitat or water quality. LGC-1, LGC-2, and LGC-3 meet the requirement for full-support suggested by Plafkin et al. (1989). LGC-4 and LGC-5 are well below the 90% comparability criterion, indicating that any observed biological impairment is likely due to habitat degradation as water quality appeared conducive to aquatic life uses.

The average pool quality score varied from a low of 4 at LGC-5 to a high of 7 at LGC-4. Pool frequency decreased from LGC-1 to LGC-5, with only one pool being found within the assessed reach at LGC-4 and LGC-5. The reduced frequency of pools at LGC-4 and LGC-5 are reflective channel modifications (channelization) within the City of Sheridan.

Macroinvertebrates and Biological Condition

Biological condition at LGC-1 was assessed as "good" in both 1996 and 1998 based on the WSII for the Middle Rockies Central bioregion, indicating full support of aquatic life use (Table 7). Based on the WBCI conditions were "suboptimal" in 1996 and increased to "optimal" in 1998 (Table 9). Sources of biological impairment were not apparent at LGC-1. Water quality and habitat quality appeared conducive to full-support of aquatic life use.

The Northwestern Great Plains bioregion WSII was applied to LGC-2 through LGC-5 (Table 8). Data was collected at two of the sites (LGC-3 and LGC-5) in 1994, and rated the condition as "poor" at both sites, indicating that they were not supporting aquatic life use. LGC-3 and LGC-5 were also assessed in 1998. The condition increased considerably at both stations and rated "fair" during the 1998 assessment, indicating partial support of aquatic life use. Biological condition at LGC-2 and LGC-4 was also assessed as "fair" in 1998, indicating that all sites in the Northwestern Great Plains were only partially supporting aquatic life.

Data was collected by Western EcoSystems Technology, Inc. in response to a Wyoming DOT oil spill at both LGC-4 and LGC-5. In both cases the biological condition was assessed as "fair" and increased in 1998.

Consistently low scoring metrics at the sites in the Northwestern Great Plains included % Trichoptera, % scrapers, and % Plecoptera. All of these metrics are dependant on a stable substrate for good scores, suggesting that the lower than expected scores may be attributed to prevalence of smaller, more unstable substrates.

While water quality did not appreciably change from LGC-2 and LGC-3 to LGC-4 and LGC-5, habitat quality decreased considerably, suggesting that habitat degradation may be causing biological impairment of Little Goose Creek.

Taxa richness refers to the total number of taxa in the benthic sample. Richness of total and insect taxa tend to decrease with decreasing water quality, whereas richness of non-insect taxa increases with decreasing water quality. Total taxa richness varied among stations; however there is a general trend of decreasing insect taxa richness and increasing non-insect taxa richness from LGC-1 to LGC-4 (Appendix C). At LGC-5, insect and non-insect taxa richness increase. The percentage of total taxa comprised of non-insect taxa increases from 5% at LGC-1 to 20% at LGC-5. Percent non-insect abundance is variable among stations, but is greatest at LGC-5 (22.8%).

Ephemeroptera (mayflies) occur in an extremely wide variety of standing and running water habitats and may be the most sensitive to pollution of aquatic insects. The most diverse composition is generally found in riffles. Richness and percent composition of mayflies generally decrease with decreasing water quality or habitat quality. Mayfly taxa richness decreased from the more upstream stations to the more downstream stations. Among Plains stations, LGC-2 met expectations for mayfly taxa richness, whereas LGC-3. LGC-4, and LGC-5 did not. Five mayfly taxa (*Cinygmula, Epeorus, Ameletus, Rhithrogena, Paraleptophlebia*) present at LGC-1, LGC-2, or both stations were not present at downstream stations. With the exception of *Epeorus*, the common thread between each taxa is that they are primarily gatherers or scrapers of diatoms. The disappearance of these taxa may suggest a reduction in diatom abundance. In general, diatoms are associated with cool, unpolluted waters, and tend to be replaced by green and blue-green algae as environmental stress (e.g., sedimentation, eutrophication) increases.

Two taxa that were present at LGC-2 through LGC-5 were not present at LGC-1 (*Acentrella insignificans, Tricorythodes minutus*). These ubiquitous taxa tend to occupy fine sediment, sand, and fine gravel substrates of warmer, lower elevation streams. They feed primarily on fine particulate organic matter deposited along stream margins. Therefore, changes in mayfly community composition are likely related to habitat differences rather than water quality differences. Habitat quality decreased from LGC-2 to LGC-5, while no major changes in water quality were observed.

Plecoptera (stoneflies) are primarily associated with clean, cool running waters and are most commonly found in riffle habitats, as well as in leaf packs and debris accumulations (Merritt and Cummins, 1996). High richness and percent composition of stoneflies in benthic samples is generally an indicator of good water quality. Stonefly taxa richness decreased from seven taxa at LGC-1 to zero taxa at LGC-4 and LGC-5. Percent composition of stoneflies decreased from 8.1 % at LGC-1 to 0% at LGC-4 and LGC-5 (Appendix C). Similar to mayfly richness, the reduction in stonefly richness and percent composition is more likely to be related to decreases in habitat quality than decreases in water quality.

Trichoptera (caddisflies) collectively occupy a diverse array of habitats and feeding types. Most caddisflies are restricted to cool lotic habitats, although they are also well represented in warm lotic and lentic waters (Ward and Kondratieff, 1992). Tolerance of caddisflies ranges from very intolerant to mildly tolerant of various stressors. Therefore caddisflies are expected to be present in all riffles with the exception of streams with very poor water quality. LGC-1 had the greatest caddisfly taxa richness (10 taxa). Among Plains bioregion stations, caddisfly taxa richness ranged from 4 to 6, which is well below what is expected of an unimpaired stream in this bioregion. Seven taxa present at LGC-1 were not present at the other assessment stations (*Arctopsyche grandis, Brachycentrus americanus, Micrasema, Lepidostoma, Dolophilodes, Rhyacophila coloradensis* gr.*, and Oligophlebodes*). Each of these taxa are considered very intolerant to organic pollution (Hilsenhoff, 1987), suggesting that this factor may be contributing to biological impairment, although the effects of other factors (e.g., habitat and temperature changes) cannot be separated.

The percent contribution of the dominant taxa is an indication of community balance. A community dominated by relatively few taxa generally indicates environmental stress due to poor water quality or habitat quality. The dominant taxa are those that are adapted to or specialized for those conditions. Results were contrary to what was expected based on patterns observed in the other core Plains bioregion WSII metrics. The percent contribution of the ten most abundant taxa decreased from LGC-1 to LGC-5. However, of the ten most abundant taxa at LGC-1, eight were relatively intolerant Ephemeroptera, Plecoptera, or Trichoptera (EPT) taxa. Only four or five of the most abundant taxa were EPT taxa at LGC-2 through LGC-5.

The Biotic Condition Index-Actual Community Tolerance Quotient (BCI CTQa) is the product of values derived from a taxon's tolerance to levels of alkalinity and sulfate plus it's selectivity for or against fine substrate materials and shallow stream gradients (Platts *et al.*, 1983). Values range from 2 to slightly greater than 100 with the larger values indicating greater taxon tolerance (Winget and Mangum, 1979; Platts *et al.* 1983). Scores increased from LGC-1 to LGC-4 and decreased slightly from LGC-4 to LGC-5, generally corresponding with alkalinity and sulfate concentrations.

Scrapers are macroinvertebrates that scrape hard substrates for food such as periphyton. Common scrapers include many caddisfly and mayfly taxa. Rarity or absence of scrapers often suggest elevated suspended or streambed sediment concentrations. Elevated suspended sediment concentrations limit light availability for photosynthesis; increased streambed sediment may limits periphyton production by covering rock surfaces. Chemical stressors that limit periphyton growth would also affect macroinvertebrate scrapers. Scraper taxa richness decreased slightly from LGC-1 to LGC-5; however scraper taxa richness was not low enough to suggest non-support or partial support of aquatic life use.

The Hilsenhoff Biotic Index (HBI) is a measure of the average tolerance of a macroinvertebrate community to organic pollution (Hilsenhoff,1987; 1988a; 1988b). Calculation of the HBI involves multiplying the abundances of each taxon by the tolerance value of that taxon. The resulting products for each taxon are summed and divided by the total abundance of macroinvertebrates. The final value is the average tolerance of the macroinvertebrate community. HBI values increase greatly from LGC-1 to LGC-2. HBI continues to increase downstream of LGC-2, although in smaller increments. The HBI value at LGC-1 suggests excellent water quality (no apparent organic pollution). The HBI value at LGC-2 suggests very good water quality (some organic pollution possible). Finally, the HBI values at LGC-3, LGC-4 and LGC-5 suggest good to fair water quality (mild to fairly significant organic pollution).

Non-insects tend to be more tolerant to environmental stresses, and most are dependant on the presence of sediments. The percentage of non-insects at the two sites (LGC-3 and LGC-5) sampled in 1994 were high (39.43 and 55.66, respectively), indicating that the macroinvertebrate population was stressed. Subsequent sampling in 1997 and 1998 showed a far lower percentage of non-insects at all sites, ranging from 1.25-22.75%, and resulted in good metric scores.

Collector-filterers can be indicative of organic enrichment and/or sedimentation. Percent composition of collector-filterers increased greatly from LGC-1 to LGC-2. Percent composition decreased slightly downstream of LGC-2, ranging from 16-20%. When combined with % collector-gatherer, a very high 71-89% of the macroinvertebrates collected at LGC-2 through LGC-5 were classified in one of these two groups suggesting organic enrichment downstream of LGC-1.

Voltinism refers to the life cycle durations of macroinvertebrate taxa (Supplemental metrics can be found in Table 10). Multivoltine taxa complete several life cycles in a single year. Univoltine taxa require one year to complete a life cycle. Semivoltine taxa require more than one year to complete a life cycle. Dominance of multivoltine taxa suggests that seasonal or more frequent pulses of pollutants are limiting survival of longer-lived taxa. Percent composition of multivoltine taxa increased from LGC-1 to LGC-3, decreased slightly at LGC-4, and again at LGC-5. Clearly, multivoltine taxa are not dominant at any of the stations. However, the increasing percentage of multivoltine taxa, decreasing percentage of univoltine taxa, and overall low percentage of semivoltine taxa suggest a moderately stressed macroinvertebrate community.

HISTORICAL AND ANCILLARY INFORMATION

WDEQ/WQD Fecal Coliform Bacteria Data (1998-99)

A fecal coliform bacteria synoptic study was conducted on Little Goose Creek by WDEQ/WQD during 1998-99 in response to U.S. Geological Survey data which suggested fecal coliform bacteria contamination. Seven stations were sampled as part of the 1998 effort. Little Goose # 1 was located in the City of Sheridan at the Coffeen Avenue Bridge. Little Goose # 2 was located at the southern edge of Sheridan at the Brundage Lane Bridge. Little Goose # 3 was located at the bridge crossing near Woodland Park, approximately 1.5 miles south of Sheridan. Little Goose # 4 was located at the Highway 87 bridge crossing approximately 4 miles south of Sheridan. Little Goose # 5 was located at Bird Farm Road near the town of Big Horn. Little Goose # 6 was located above Big Horn near the Bradford Briton Memorial. Little Goose # 7 was located at the County Road 77 bridge crossing near the mouth of Little Goose Canyon. Five separate samples were taken at each of these stations between July 30 and August 25, 1998.

All Little Goose Stations, with the exception of No. 7 (Little Goose Canyon), showed geometric mean counts exceeding the water quality standard of 200 colonies per 100 ml with a range of 220 to 620 colonies/100ml (Table 11). All stations, with the exception of No. 7, also showed greater than 10 percent of the samples exceeding 400 colonies/100ml.

Due to these exceedances, a second sampling regime of five separate samples was conducted between July 27 and August 18, 1999. Additional sampling sites were added on Little Goose Creek and three tributaries; Kruse Creek, Sacket Creek, and Jackson Creek irrigation canal were sampled near their confluences with Little Goose Creek to discern possible sources of fecal coliform bacteria to Little Goose Creek. All Little Goose Stations, with the exception of No. 6 and No. 7, had geometric mean counts exceeding the water quality standards of 200 colonies / 100 ml (range= 274-640 colonies/100 ml), and 10 percent or more of the samples exceeding 400 colonies/100 ml (Table 7). These data support the declaration of Little Goose Creek being impaired due to elevated fecal coliform bacteria from just upstream of the town of Big Horn to the City of Sheridan, a stream segment 15.3 miles in length. Further, all three tributaries had geometric mean counts that exceeded the fecal coliform water quality standards (range= 469-586 colonies/100 ml).

WDEQ/WQD also collected water quality samples during the fecal coliform synoptic study (Appendix D). Ambient parameters (temperature, pH, conductivity, dissolved oxygen) were measured each time a fecal coliform sample was collected (five samples within thirty days during each year). Remaining parameters were sampled at the time of the first and the last of the five fecal coliform samples. Of particular interest were turbidity, total suspended solids, and ammonia.

Total suspended solids concentrations and turbidity reached levels which may have negative effects of aquatic life (particularly trout) at Site1 and Site 2 (Lloyd, 1987; Newcombe and Jensen, 1996). Ammonia concentrations varied from <0.1 mg/L to 0.8 mg/L, with the greatest concentrations observed at Site 2 through Site 5. Ammonia concentrations greater than 0.1 mg/L generally are indicative of polluted waters and may be toxic to aquatic life.

Credible impairment data collected by the U.S. Geological Survey during a five-year period encompassing water years 1993 through 1997 (Clark and Norris, 2000) supported listing Little Goose Creek as non-supporting of the contact recreation designated use due to fecal coliform bacteria counts above Wyoming water quality standards.

Wyoming Game and Fish Department Lakes and Streams Database

There are four classes of surface water in Wyoming. Criteria for class designations are discussed in Chapter 1 of the Wyoming Water Quality Rules and Regulations (WDEQ/WQD, 2001c). Little Goose Creek is listed as a class 2, “coldwater” fishery. Waters of this classification must 1) presently support game fish, 2) have the hydrologic or water quality potential to support game fish, or 3) include nursery areas or food sources for game fish. The Wyoming Game and Fish Department Lakes and Streams Database is the primary data source for these designations. Fish species found clearly support the designation of Little Goose Creek as a class 2. “coldwater” stream (Table 12). However, the absence of the most sensitive species in the city limits, including all of the trout species, is a reason for concern.

Sheridan County Conservation District Goose Creek Watershed Assessment

In response to the coliform data collected by the United States Geological Survey (USGS) and the Wyoming Department of Environmental Quality (WDEQ), the Sheridan County Conservation District (SCCD) prepared a report on the Goose Creek watershed that included 17 stations on Little Goose Creek. Sixteen of the seventeen sites identified violations of fecal coliform, temperature, aquatic life use, or a combination of these standards. The only site that had no violations of these standards was the site closest to the mountains, therefore least impacted by anthropogenic activity. Sites in the SCCD report include:

Site	Description
LG1	Located 30 yards up from Big Goose Creek confluence.
LG2	Located approximately 30 yards upstream of concrete channel.
LG3	Storm drain below Coffeen Avenue.
LG4	Located about 20 yards upstream from Coffeen Avenue bridge.
LG5	Located approximately 100 yards upstream of the Brundage Lane bridge

Site	Description
LG6	Located approximately 20 yards downstream of the County Road 66 bridge.
LG7	Located approximately 75 yards upstream of the Highway 87 bridge (near Woodland Park).
LG8	Located approximately 1/4 mile downstream of McCormick Creek (near Cox Valley Road).
LG9	Located on McCormick Creek approximately 20 yards upstream of the confluence with Little Goose Creek.
LG10	Located approximately 20 yards upstream of the Highway 87 bridge (near the Highway 335 intersection).
LG11	Located on Kruse Creek approximately 100 yards upstream of the confluence with Little Goose Creek.
LG12	Located approximately 30 yards upstream of Kruse Creek.
LG13	Located approximately 20 yards upstream of the County Road 60 bridge (near Knode Ranch subdivision).
LG14	Located 20 yards upstream of the Clubhouse Road bridge (in Powderhorn golf community).
LG15	Located 40 yards upstream of the Gerdle Ditch intake.
LG16	Located approximately 150-200 yards downstream of Jackson Creek.
LG17	Located on Jackson Creek near the confluence with Little Goose Creek.
LG18	Located about 25 yards downstream from the Bird Farm Road bridge and Sackett Creek confluence.
LG19	Located on Sackett Creek 10 yards upstream of the confluence with Little Goose Creek.
LG20	Located 10 yards upstream of the County Road 103 bridge crossing (near Big Horn).
LG21	Located above the County Road 103 bridge crossing (near entrance to Bradford-Brinton Memorial).
LG22	Located above County Road 77 bridge (near entrance to Little Goose Ranch, same as USGS Station No. 06303700).

Water Quality

Fecal Coliform - Geometric means were taken in April, May, August, and October 2001 and 2002. No geometric means exceeded existing standards in April or October at any of the sites on Little Goose Creek or its tributaries. In May, 2001 geometric means exceeded existing standards WDEQ/WQD (2001c) in Jackson Creek, and at LG1 and LG7 in Little Goose Creek. In August LG1, LG2, LG3, LG4, LG6, LG7, LG8, LG9, LG11, LG12, LG17, and LG19 all exceeded standards in either 2001, 2002, or both years.

E. coli - Single samples were collected at eight sites in April, May, and October of 2001, and geometric means were collected in August, 2001. Geometric means exceeded standards set in WDEQ/WQD (2001c) at LG6, LG9, LG11, LG17, and LG1.

Temperature - Temperatures were above the WDEQ/WQD (2001c) standard of 20°C for a cold water fishery at all sites except LG3 (storm drain), LG9 (McCormick Creek), LG19 (Sackett Creek), and LG22. Temperature standard was exceeded at LG22 during a continuous temperature monitoring, but only by a fraction of a degree on two days in 2001. During the 2002 the highest temperature recorded was 18.51°C. Continuous temperature monitoring shows the WDEQ/WQD (2001c) standard was exceeded 110 days (30%) at LG2, 90 days (25%) at LG8, and 45 days (12%) at LG17.

Pesticides and Herbicides - One sample for seven herbicides and six pesticides was collected in June 2002 at LG5. None of the 13 pesticides and herbicides was detected.

Habitat Quality

Habitat quality and macroinvertebrate data were collected at LG2, LG5, LG7, LG10, LG18, LG21, and LG22 in 2001 and 2002. Generally, qualitative habitat scores exhibited a downward trend moving from the upper sites towards Sheridan. Scores ranged from 108 out of 200 at LG2 in 2001 to 164.5 out of 200 at LG22 in 2002. Qualitative habitat at LG7 and LG18 scored lower than sites downstream suggesting a stress on habitat. LG18 is located downstream of Bird Farm Road, Sackett Creek, and the town of Big Horn among small acreage properties. LG7 located downstream of McCormick Creek and a trailer park among small acreage properties with cattle grazing and irrigated haylands.

Embeddedness exhibits the same downward trend described above, without exception. Scores ranged from 28 out of 100 at LG2 in 2002 to 98.8 out of 100 at LG22 in 2002. Embeddedness makes the largest downward change between LG10 (82) and LG7 (44).

Macroinvertebrates and Biological Condition

The seven sites listed above were sampled in 2001 and 2002. WSII scores exhibit a downward trend towards Sheridan, with average scores ranging from 40.6 at LG2 to 85.2 at LG22. Condition decreased at the upper three sites (LG18, LG21, LG22) from 2001 to 2002, increased at the lower three sites (LG2, LG5, LG7), and showed little change at LG10. Narrative ratings are “fair” from LG2 to LG10, and rate “good” at LG18 and LG21, and “very good” at LG22. For ease of comparison Northwestern Great Plains criteria were used to assess LG22 despite being located in the Middle Rockies Central ecoregion. Using Middle Rockies Central ecoregion criteria LG22 was rated “good” in both 2001 and 2002. The conclusion of the findings were that Little Goose Creek was supporting aquatic life use from LG18 to LG22, and aquatic life use was partially supported from LG10 downstream to LG2.

SUMMARY AND CONCLUSIONS

Classification

Little Goose Creek is correctly classified as a class 2AB, coldwater stream. Water temperature was below the WDEQ (2001c) standard at all stations assessed, although data collected by the other agencies suggest the standard is exceeded during the summer months. The Wyoming Game and Fish The Wyoming Game and Fish Department Lakes and Streams Database indicated that cold water fish species are present throughout Little Goose Creek. Of the fish listed as present in Little Goose Creek, only carp, green sunfish, and the bluegill sunfish are preferentially warm water species.

Water Quality

In 1998, six of seven stations on Little Goose Creek showed geometric mean counts exceeding the Wyoming water quality standard of 200 cfu per 100 milliliters of water. In 1999, six of nine stations on Little Goose Creek showed geometric mean counts exceeding the same water quality standard. The presence of fecal coliform bacteria concentrations above Wyoming water quality standards suggests organic enrichment from human or animal waste.

Temperature data collected by the Sheridan County Conservation District found temperatures exceeding the WDEQ/WQD (2001c) standard at all sites downstream of the Little Goose Creek Ranch (USGS station 06303700). Continuous temperature monitoring at select sites shows the temperature standard for class 2AB streams is exceeded for long durations during the summer months.

Data collected in 1998-1999 also showed high levels of TSS, turbidity, and ammonia. These high levels were discovered despite sampling proceeding the season of poorest water quality (summer).

Habitat Quality

Qualitative habitat assessment scores were only 75% comparable to the three least-impacted streams used for reference. This is well-below established criteria for full-support of habitat requirements of aquatic life. Loss of morphologic complexity and riparian vegetation, and increased abundance of fine substrate materials are the primary parameters resulting in the low habitat scores. We must assume that habitat quality is at least contributing to the partial support of aquatic life in Little Goose Creek

Macroinvertebrate and Biological Condition

WSII scores at LGC-2, LGC-3, LGC-4 and LGC-5 indicate partial support of general aquatic life use. Partial support requires that the resource be improved so that aquatic life is fully supported. The absence of Plecoptera and low richness and abundance of Ephemeroptera and Trichoptera indicate conditions unsuitable for these relatively intolerant macroinvertebrate taxa. Analysis of the tolerance and environmental preferences of the sampled macroinvertebrate taxa suggest that habitat degradation and organic enrichment may be the causes of impairment. Although water quality data did not directly indicate organic pollution, macroinvertebrates integrate affects over time and may be an indication of water quality problems during seasons outside the sampled dates (summer).

The report by the Sheridan County Conservation District reinforces that aquatic life was partially supported downstream from the Highway 87 crossing near Highway 335 approximately the same site as LGC-2.

FINAL ASSESSMENTS AND SIGNATURES

Review of chemical, biological and physical data collected in Little Goose Creek indicate that Little Goose Creek is **not fully supporting non-fishery aquatic life use**. The WSII and ratings of "poor" and "fair", indicate a stressed macroinvertebrate community from an undetermined distance upstream of LGC-2 to the confluence with Big Goose Creek.

A review of chemical data collected on Little Goose Creek indicate that Little Goose Creek is **not fully supporting contact recreation use** an undetermined distance upstream of Bird Farm Road. In 1998, six of seven stations on Little Goose Creek showed geometric mean counts exceeding the Wyoming water quality standard of 200 cfu per 100 milliliters of water. In 1999, six of nine stations on Little Goose Creek showed geometric mean counts exceeding the same water quality standard.

Review of chemical, biological and physical data collected in Little Goose Creek indicate that Little Goose Creek is **not fully supporting protection and propagation of cold water fish**. Data collected suggests that the WDEQ/WQD (2001c) temperature standard for class 2AB cold water streams is exceeded from an unknown distance above the Bradford-Brinton Memorial (LG21) downstream to the confluence with Big Goose Creek. The partial support of non-fishery aquatic life also suggest the cold water fish use may be impaired.

Review of biological and chemical data collected on Little Goose Creek indicate that Little Goose Creek is **insufficient to determine support of drinking water, wildlife, industrial, agricultural, aesthetic value uses, and fish consumption uses**. Because aquatic life is only partially supported we cannot assume that these uses are supported. These uses are investigated further when existing data and field observations suggests these uses may be compromised.

Recommendations:

1) A study of the impacts of stormwater is currently being completed on Little Goose Creek.

For a copy of the Goose Creek Watershed Assessment, please contact the Sheridan County Conservation District at: 1949 Sugarland Drive, Suite 102, Sheridan, WY 82801 (307)-672-5820

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Author Date

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Monitoring Program Supervisor Date

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Table 1. Descriptive information for the Little Goose Creek assessment stations.

Station ID	Legal Sec/Twn/Rng	Lattitude	Longitude	Elevation (Feet)	USGS 7.5' Quad	1:100,000 BLM Map
LGC-1	SWNW Sec. 30 T54N, R84W	44° 37' 35.96"	107° 01' 49.30"	4420	Beaver Creek Hills, WY	Burgess Junction
LGC-2	NWSE Sec. 27 T55N, R84W	44° 42' 41.08"	106° 57' 31.57"	3920	Bighorn, WY	Sheridan
LGC-3	SWNW Sec. 2 T55N, R84W	44° 46' 14.91"	106° 57' 02.39"	3780	Sheridan, WY	Sheridan
LGC-4	SWNE Sec. 35 T56N, R84W	44° 47' 07.22"	106° 56' 36.12"	3760	Sheridan, WY	Sheridan
LGC-5	SWNE Sec. 35 T56N, R84W	44° 47' 10.48"	106° 56' 31.38"	3760	Sheridan, WY	Sheridan

Table 2. Qualitative habitat assessment parameters and scoring for each Little Goose Creek assessment station

	Site scores				
Parameter (points possible)	**LGC-1**	**LGC-2**	**LGC-3**	**LGC-4**	**LGC-5**
Bottom substrate/percent fines (20)	14	15	10	13	6
Embeddedness (20)	20	13	11	10	13
Instream cover (for fish)(20)	19	13	16	12	16
Velocity/depth (20)	19	18	15	6	6
Channel flow status (20)	19	16	18	19	19
Channel shape (15)	10	11	10	6	5
Pool/riffle ratio (15)	14	12	12	4	7
Channelization/alteration (15)	13	10	15	3	3
Width/depth ratio (15)	8	6	5	7	5
Bank vegetation protection (10)	9	7.5	7	9	9
Bank stability (10)	7	7.5	7.5	9.5	9
Disruptive pressures (10)	10	10	6	9	9
Riparian vegetative zone width (10)	10	8.5	3	1.5	1
Total score	172	147.5	135.5	109	108

Table 3a. Criteria for narrative assessment and determination of aquatic life use support in the Middle Rockies Central bioregion below 6500 feet.

Aquatic life use support status	Narrative assessment	Percentile of reference index values	WSII score
Full-support	Very good	-	>79.6
Full-support	Good	≥25th	59.3 - 79.6
Partial-support	Fair	<25th	39.5 - 59.3
Non-support	Poor	-	19.8 - 39.5
Non-support	Very poor	-	<19.8

Table 3b. Criteria for narrative assessment and determination of aquatic life use support in the Northwestern Great Plains bioregion.

Aquatic life use support status	Narrative assessment	Percentile of reference index values	WSII score
Full-support	Very good	-	>77.5
Full-support	Good	≥25th	55.0 - 77.5
Partial-support	Fair	<25th	36.7 - 55.0
Non-support	Poor	-	18.3 - 36.7
Non-support	Very poor	-	<18.3

Table 4. Results of water quality sampling at the Little Goose Creek assessment station. A "<" symbol indicates that the parameter was below the limit of detection.

Parameter (Units)	LGC-1 (1996)	LGC-1 (1998)	LGC-2 (1998)	LGC-3 (1994)	LGC-3 (1998)	LGC-4 (1997)*	LGC-4 (1998)	LGC-5 (1994)	LGC-5 (1997)*	LGC-5 (1998)
Date	10/1	10/28	10/28	10/24	10/28	10/8	10/28	10/24	10/8	10/23
Time (hours)	1540	1443	1550	1115	0942	1115	0917	1138	1130	0900
Temperature (°C)	10.1	6.2	8.6	5.1	9.6	9.0	9.7	5.2	9.0	9.8
pH	7.8	7.6	8.5	7.9	8.4	8.11	8.3	8.1	8.21	8.3
Conductivity (mg/L)	135	80.2	323	673	427	N/A	441	680	N/A	438
Dissolved Oxygen (mg/L)	8.5	10.8	10.1	10.7	9.3	11.5	9.1	11.0	11.5	9.0
Turbidity (NTU)	2.2	0.58	1.6	6	2.0	23.0	3.0	5	24.0	2.4
Total Suspended Solids (mg/L)	3	2	2	8	5	27	6	7	38	3
Total Dissolved Solids (mg/L)	N/A	68	204	N/A	312	N/A	312	N/A	N/A	316
Alkalinity (mg/L)	50	40	150	120	230	262	220	70	261	220
Chlorides (mg/L)	<5	<5	<5	<5	<5	4.2	<5	<5	4.3	<5
Sulfate (mg/L)	17	<10	16	70	48	61.8	54	58	60.2	54
Total Hardness (mg/L)	64	60	180	168	260	311	260	205	307	260
Total Phosphorus (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	0.06	<0.1	<0.1	<0.05	<0.1
Nitrate + Nitrite Nitrogen (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ammonia	N/A	0.3	0.2	N/A	<0.1	N/A	<0.1	N/A	N/A	0.1
Fecal Coliform	N/A	20	56	N/A	64	N/A	64	N/A	N/A	148
BOD	N/A	N/A	<1	N/A	<1	N/A	<1	N/A	N/A	<1

*Data collected by Western EcoSystems Technology, Inc in response to a Wyoming DOT oil spill.

Table 5. Substrate composition (percent), weighted embeddedness scores (silt covering), and average water velocity at the Little Goose Creek assessment sites.

Substrate	LGC-1	LGC-2	LGC-3	LGC-4	LGC-5
Cobble (2.5 - 10")	72	43	13	44	22
Coarse Gravel (1 - 2.5")	9	32	26	33	16
Fine Gravel (0.3 - 1")	6	14	26	16	18
Sand (<0.3", gritty)	13	10	22	7	19
Silt (<0.3", fine)	0	0	0	0	25
Clay (Hard Pack)	0	0	12	0	0
Organic (fine, black)	0	0	0	0	0
Precipitate (Oil, WWTF)	0	0	0	0	0
Silt cover (embeddedness)	100	69	61	36	71
Mean velocity (cfs)	1.11	2.85	1.61	2.14	1.62

Table 6. Qualitative habitat assessment scores for two minimally impaired Middle Rockies streams and three Northwestern Great Plains streams.

Stream or station	Ecoregion	Total Score
Tongue River - Canyon	Middle Rockies	162
Little Bighorn River	Middle Rockies	162
Tongue River - Middle	Northwestern Great Plains	147
Clear Creek - below Buffalo	Northwestern Great Plains	138
M. Fork Crazy Woman Cr.- Old Hwy 87	Northwestern Great Plains	143

Table 7. WSII core metric values, scores and site ratings for the Little Goose Creek assessment site in the Middle Rockies Central ecoregion.

Core Metric	**Metric Value LGC-1**	**Metric Score LGC-1**	**Metric Value LGC-1**	**Metric Score LGC-1**
Date	10/1/1996		10/28/1998	
Ephemeroptera taxa	6	54.5	7	63.6
Plecoptera taxa	2	25.0	6	75.0
Trichoptera taxa	8	72.7	10	90.9
% Ephemeroptera (no Baetidae)	17.09	31.6	12.00	22.2
% Trichoptera (no Hydropsychidae)	55.33	100.0	61.06	100.0
% 5 dominant	72.82	44.1	78.22	33.4
% scrapers	56.12	100.0	7.89	14.5
HBI	1.58	97.9	1.77	95.7
BCI CTQa	58.36	78.4	56.40	81.3
Total Score		**67.1**		**64.1**
Narrative Rating		**Good**		**Good**

Table 8. Core metric values, and site ratings for the Little Goose Creek assessment sites in the Northwestern Great Plains ecoregion.

Core Metric	Metric value LGC-2	Metric score LGC-2	Metric value LGC-3	Metric score LGC-3	Metric value LGC-3	Metric score LGC-3	Metric value LGC-4*	Metric score LGC-4*
Date	10/28/1998		10/24/1994		10/28/1998		10/8/1997	
Ephemeroptera taxa	8	88.9	4	44.4	5	55.6	6	66.7
Plecoptera taxa	3	60.0	1	20.0	3	60.0	0	0.0
Trichoptera taxa	4	40.0	4	40.0	4	40.0	4	40.0
% Trichoptera (no Hydropsychidae)	2.44	7.8	1.03	3.3	1.66	5.3	2.35	7.5
% scrapers	10.12	31.8	2.44	7.7	4.25	13.4	3.87	12.2
BCI CTQa	81.35	60.4	90.2	41.8	82.89	57.2	85.5	51.7
Total taxa	39	86.7	42	93.3	36	80.0	32	71.1
% Plecoptera	2.79	21.5	0.51	3.9	0.92	7.1	0	0.0
% non-insects	6.28	89.4	55.66	0.0	3.88	93.8	2.19	96.9
Semi-voltine taxa	4	57.1	4	57.1	4	57.1	4	57.1
Total score		**54.4**		**31.2**		**46.9**		**40.3**
Narrative rating		**Fair**		**Poor**		**Fair**		**Fair**

*Data collected by Western EcoSystems Technology, Inc in response to a Wyoming DOT oil spill.

Table 8. (Cont.)

Core Metric	Metric value LGC-4	Metric score LGC-4	Metric value LGC-5	Metric score LGC-5	Metric value LGC-5*	Metric score LGC-5*	Metric value LGC-5	Metric score LGC-5
Date	10/28/1998		10/24/1994		10/8/1997		10/23/1998	
Ephemeroptera taxa	4	44.4	5	55.6	6	66.7	5	55.6
Plecoptera taxa	0	0.0	1	20.0	0	0.0	0	0.0
Trichoptera taxa	5	50.0	4	40.0	3	30.0	6	60.0
% Trichoptera (no Hydropsychidae)	8.8	28.1	0.79	2.5	1.61	5.1	9.35	29.9
% scrapers	12.92	40.6	4.89	15.4	3.57	11.2	8.29	26.1
BCI CTQa	91.7	38.6	93.1	35.7	89.2	43.9	87.95	46.5
Total taxa	34	75.6	45	100.0	29	64.4	39	86.7
% Plecoptera	0	0.0	0.16	1.2	0	0.0	0	0.0
% non-insects	3.37	94.7	39.43	28.6	1.25	98.6	22.75	59.2
Semi-voltine taxa	5	71.4	4	57.1	5	71.4	7	100.0
Total score		**44.4**		**35.6**		**39.1**		**46.4**
Narrative rating		**Fair**		**Poor**		**Fair**		**Fair**

*Data collected by Western EcoSystems Technology, Inc in response to a Wyoming DOT oil spill.

Table 9. WBCI criteria for assessing biological condition of streams below an elevation of 6500 feet applied to the Little Goose Creek assessment sites in the Middle Rockies Central ecoregion.

Metric	Metric Value (LGC-1)	Metric Score (LGC-1)	Metric Value (LGC-2)	Metric Score (LGC-2)
EPT Taxa	16	3	24	5
% Ephemeroptera	28.16	5	18.35	3
% Plecoptera	2.14	1	8.05	5
% Chironomidae	2.13	5	3.42	5
Predator taxa	3	1	9	5
% scrapers	56.13	5	7.89	1
HBI	1.58	5	1.77	5
BCI	85.66	5	88.65	5
% collector-filterer	3.89	3	4.46	3
Total Index Score		**33**		**37**
Narrative Rating		**Suboptimal**		**Optimal**

Table 10. Supplemental metrics.

Supplemental Metrics	LGC-1	LGC-2	LGC-3	LGC-4	LGC-5
HBI	1.77	4.42	4.80	5.24	5.41
% Collector-filterer	4.50	32.3	18.3	16.5	19.9
% Multivoltine	9.22	26.18	33.32	30.99	21.87
% Univoltine	85.98	61.21	62.52	60.11	71.25
% Semivoltine	4.80	12.61	4.16	8.90	6.88

Table 11. Summary statistics for fecal colifom samples taken in the Little Goose Creek watershed, 1998-99. Values in bold exceed Wyoming water quality standards.

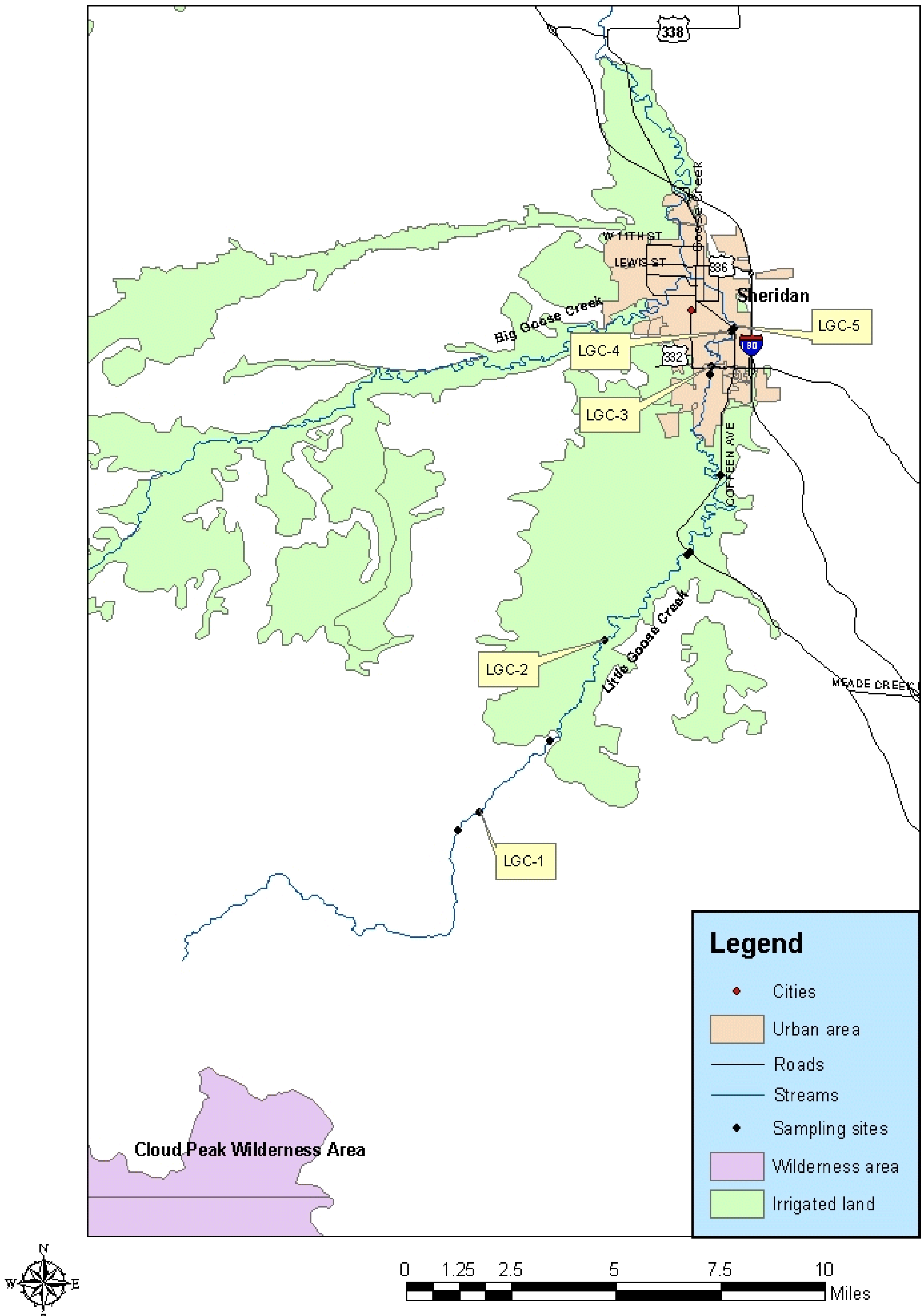
Station	Year (season)	No. samples	Mean	Geometric mean	% Samples >400/100ml
Little Goose Cr. - 1	1998 (rec.)	5	692	**489**	**40**
Little Goose Cr. - 2	1998 (rec.)	5	962	**573**	**60**
Little Goose Cr. - 3	1998 (rec.)	5	956	**611**	**60**
Little Goose Cr. - 4	1998 (rec.)	5	710	**624**	**100**
Little Goose Cr. - 5	1998 (rec.)	5	318	**314**	**20**
Little Goose Cr. - 6	1998 (rec.)	5	273	**218**	**20**
Little Goose Cr. - 7	1998 (rec.)	5	19	16	0
Little Goose Cr. - 1	1999 (rec.)	5	302	**275**	**40**
Little Goose Cr. - 2	1999 (rec.)	5	308	**296**	**20**
Little Goose Cr. - 3	1999 (rec.)	5	672	**642**	**100**
Little Goose Cr. - Woodland Park	1999 (rec.)	5	466	**457**	**80**
Little Goose Cr. - 4	1999 (rec.)	5	306	**294**	**20**
Little Goose Cr. - 5	1999 (rec.)	5	321	**279**	**40**
Little Goose Cr. - N. of Big Horn	1999 (rec.)	5	101	99	0
Little Goose Cr. - 6	1999 (rec.)	5	162	150	0
Little Goose Cr. - 7	1999 (rec.)	5	29	26	0
Sacket Creek	1999 (rec.)	5	710	**587**	**60**
Jackson Creek	1999 (rec.)	5	506	**469**	**40**
Kruse Creek	1999 (rec.)	5	528	**514**	**80**

Table 12. Fish species and dominant thermal regime for species found in Little Goose Creek.

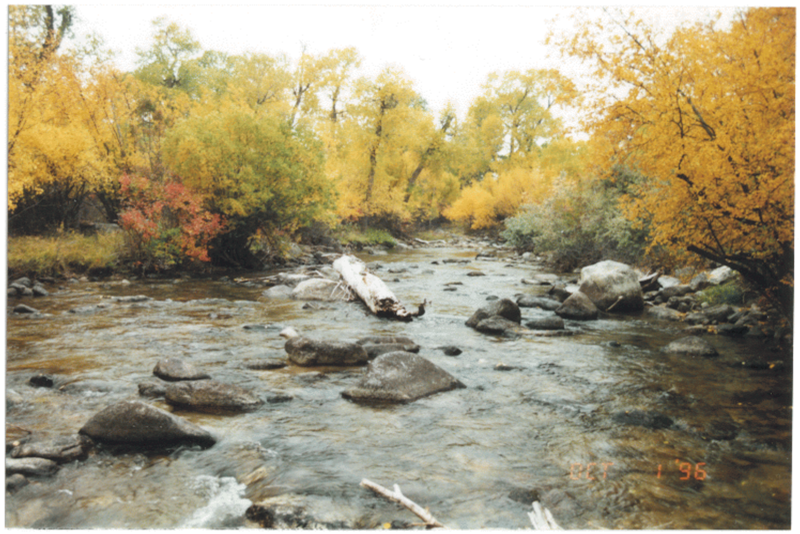
Common name	Scientific name	Warmwater
Longnose sucker	*Catostomus catostomus*	no
Common carp	*Cyprinus carpio*	yes
Brown trout	*Salmo trutta*	no
Flathead chub	*Platygobio gracilus*	no
Rainbow trout	*Oncorhynchus mykiss*	no
Rock bass	*Ambloplites rupestris*	no
White sucker	*Catostomus commersoni*	no
Green Sunfish	*Lepomis cyanellus*	yes
Bluegill Sunfish	*Lepomis macrochirus*	yes
Mountain Whitefish	*Prosopium williamsoni*	no
Lake Chub	*Couesius plumbeus*	no
Brook Trout	*Salvelinus fontinalis*	no
Creek chub	*Semotilus atromaculatus*	no
Longnose dace	*Rhinicthys cataractae*	no
Fathead minnow	*Pimephales promelus*	no

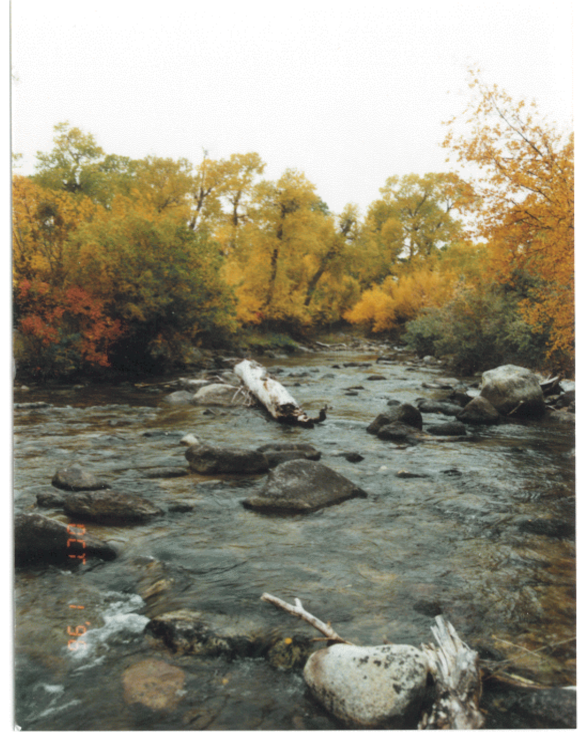
APPENDIX A

Little Goose Creek



APPENDIX B





OFFICIAL PHOTOGRAPH
WATER QUALITY DIVISION
WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY

Subject: Little Goose Creek looking upstream from base of riffle/run sampled

Location:

County: Sheridan

Date: 10-01-96 **Time:** 1600

Photograher: Kurt King

Witness: Paul Wallop

Location of Negative: Sheridan DEQ/WQD

File No. Little Goose Creek (MRC 38)

OFFICIAL PHOTOGRAPH
Water Quality Division
Department of Environmental Quality

Subject:	**PHOTO 7:** Looking upstream near top of reach.
Location/County:	Sheridan County.
Date/Time:	10-27-98 / 1525
Photographer:	Kurt King
Witnesses:	None
Location of Negative:	Sheridan DEQ Water Quality Division
File No.	Little Goose Creek-Hwy 87

OFFICIAL PHOTOGRAPH
WATER QUALITY DIVISION
WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY

Subject: Little Goose Creek - Above Sheridan - Looking Downstream From Near Base of Riffle (Run) Working

Location: ______________________

______________ **County:** ______________

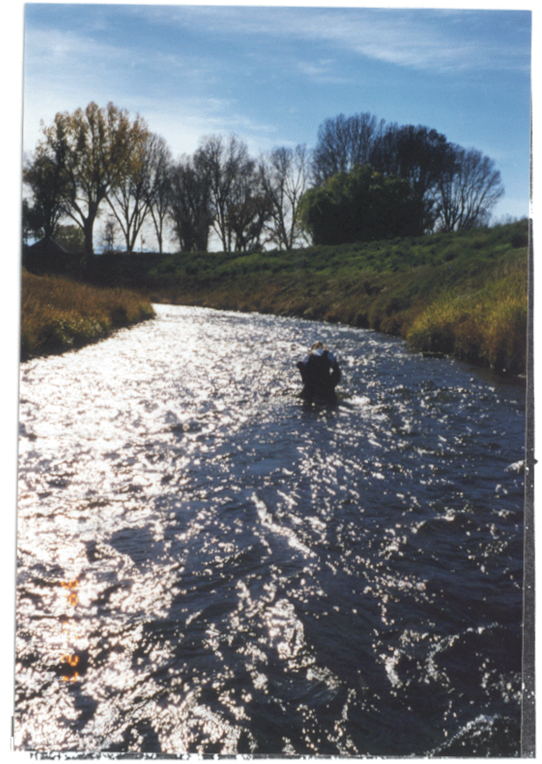
Date: 10-24-94 **Time:** 1415

Photograher: Kurt King

Witness: None

Locatibe of Negative: Sheridan DEQ/WQD

File No. Bioassess. #NGPI 20



OFFICIAL PHOTOGRAPH
Water Quality Division
Department of Environmental Quality

Subject:	**PHOTOS 1 (L) and 2 (R)**: Looking upstream from base of riffle
Location/County:	SW 1/4 NE 1/4 Sec.35, T.56N, R.84W / Sheridan County.
Date/Time:	10-27-98 / 1331
Photographer:	Mark Rogaczewski
Witnesses:	Jamie Krezelok
Location of Negative:	Sheridan DEQ Water Quality Division
File No.	Little Goose Creek-Coffeen (NGPI36)

OFFICIAL PHOTOGRAPH
WATER QUALITY DIVISION
WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY

Subject: LITTLE GOOSE CREEK - UNDER BRIDGE AT COFFEEN AVENUE IN SHERIDAN

Location:

County:

Date: 10-25-94 **Time:** 1450

Photograher: KURT KING

Witness: BRIAN MARK - DEQ/SHERIDAN

Location of Negative: SHERIDAN DEQ/WQD

File No. BIOASS. # NGPI 26

APPENDIX C

Appendix C: Table C-1 (LGC-1 1996 taxa list)

Taxon	Abundance	%
Turbellaria	20	0.39
Nematoda	10	0.19
Acari	40	0.78
TOTAL: NON INSECTS	71	1.36
Baetis tricaudatus	575	11.07
Drunella doddsi	20	0.39
Drunella grandis/spinifera	30	0.58
Ephemerella inermis/infrequens	303	5.83
Cinygmula	10	0.19
Rhithrogena	525	10.10
TOTAL: EPHEMEROPTERA	1463	28.16
Sweltsa	71	1.36
Zapada cinctipes	40	0.78
TOTAL: PLECOPTERA	111	2.14
Brachycentrus americanus	91	1.75
Microsema	30	0.58
Glossosoma	40	0.78
Protoptila	303	5.83
Hydropsyche	182	3.50
Lepidostoma-sand-case larvae	555	10.68
Rhyacophila Brunnea Gr.	30	0.58
Oligophlebodes	1826	35.15
TOTAL: TRICHOPTERA	3057	58.83
Optioservus	212	4.08
Zaitzevia	50	0.97
TOTAL: COLEOPTERA	262	5.05
Pericoma	40	0.78
Simulium	20	0.39
Antocha	61	1.17
TOTAL: DIPTERA	121	2.33

Taxon	Abundance	%
Chironomidae-pupae	30	0.58
Cricotopus Nostococladius	10	0.19
Orthocladius Complex	61	1.17
Thiennemannimyia Gr.	10	0.19
TOTAL: CHIRONOMIDAE	111	2.14
GRAND TOTAL	5196	100.0

Appendix C: Table C-2 (LGC-1 1998 taxa list)

Taxon	Abundance	%
Turbellaria	92	0.69
Acari	23	0.17
TOTAL: NON INSECTS	115	0.86
Baetis tricaudatus	853	6.35
Ephemerella inermis/infrequens	1107	8.23
Cinygmula	23	0.17
Epeorus-early instar	92	0.69
Rhithrogena	346	2.57
Paraleptophlebia	23	0.17
Ameletus	23	0.17
TOTAL: EPHEMEROPTERA	2467	18.35
Capniidae	23	0.17
Chloroperlidae	69	0.51
Sweltsa	323	2.40
Zapada cinctipes	600	4.46
Doroneuria	23	0.17
Hesperoperla pacifica	23	0.17
Skwala	23	0.17
TOTAL: PLECOPTERA	1084	8.06
Arctopsyche grandis	23	0.17
Brachycentrus americanus	92	0.69
Microsema	115	0.86
Protoptila	23	0.17
Hydropsyche	553	4.12
Lepidostoma-sand-case larvae	7402	55.06
Dolophilodes	23	0.17
Rhyacophila Brunnea Gr.	184	1.37
Rhyacophila Coloradensis Gr.	46	0.34
Oligophlebodes	300	2.23
TOTAL: TRICHOPTERA	8763	65.18
Cleptelmis	23	0.17

Taxon	Abundance	%
Lara avara	23	0.17
Optioservus	277	2.06
Zaitzevia	46	0.34
TOTAL: COLEOPTERA	369	2.74
Wiedemannia	23	0.17
Pericoma	115	0.86
Simulium	23	0.17
Antocha	23	0.17
TOTAL: DIPTERA	184	1.37
Chironomidae-pupae	23	0.17
Cladotanytarsus	23	0.17
Micropsectra	23	0.17
Orthocladius Complex	300	2.23
Pagastia	23	0.17
Polypedilum	69	0.51
TOTAL: CHIRONOMIDAE	461	3.43
GRAND TOTAL	13444	100.0

Appendix C: Table C-3 (LGC-2 1998 taxa list)

Taxon	Abundance	%
Turbellaria	258	2.79
Nias variabilis	16	0.17
Ophiodonias serpentina	97	1.05
Lumbriculidae	113	1.22
Eiseniella tetraedra	81	0.87
Physella	16	0.17
TOTAL: NON INSECTS	581	6.28
Acentrella insignificans	129	1.40
Baetis tricaudatus	1194	12.91
Ephemerella inermis/infrequens	145	1.57
Epeorus-early instar	16	0.17
Heptagenia/Nixe	16	0.17
Rhithrogena	16	0.17
Paraleptophlebia	242	2.62
Tricorythodes minutus	1098	11.87
TOTAL: EPHEMEROPTERA	2857	30.89
Chloroperlidae	32	0.35
Isoperla	194	2.09
Skwala	32	0.35
TOTAL: PLECOPTERA	258	2.79
Helicopsyche borealis	129	1.40
Hydropsyche	2841	30.72
Oecetis	81	0.87
Rhyacophila Brunnea Gr.	16	0.17
TOTAL: TRICHOPTERA	3067	33.16
Petrophila	355	3.84
TOTAL: LEPIDOPTERA	355	3.84
Dubiraphia	16	0.17
Microcylloepus	97	1.05
Optioservus	307	3.32
Zaitzevia	516	5.58

Taxon	Abundance	%
TOTAL: COLEOPTERA	936	10.12
Ceratopogoninae	16	0.17
Simulium	129	1.40
Stratiomyiidae	16	0.17
Hexatoma	500	5.41
TOTAL: DIPTERA	662	7.16
Chironomidae-pupae	32	0.35
Diamesa	291	3.14
Lopescladius	16	0.17
Orthocladius Complex	48	0.52
Orthocladius Euorthocladius	16	0.17
Pagastia	32	0.35
Polypedilum	16	0.17
Rheocricotopus	32	0.35
Rheotanytarsus	16	0.17
Tvetenia Bavarica Gr.	32	0.35
TOTAL: CHIRONOMIDAE	533	5.76
GRAND TOTAL	9248	100.0

Appendix C: Table C-4 (LGC-3 1994 taxa list)

Taxon	Abundance	%
Turbellaria	40.35	0.13
Oligochaeta	8110.35	25.84
Mesenchytraeus minimus	1371.9	4.37
Ophiodonias serpentina	322.8	1.03
Pristinella jenkinae	322.8	1.03
Imma. Tubificid w/o cap. Setae	5406.9	17.22
Limnodrilus hoffmeisteri	685.95	2.19
Hirudinea	40.35	0.13
Sphaeriidae	201.75	0.64
Ferrissia	40.35	0.13
Lymnaeidae	161.4	0.51
Physella	282.45	0.90
Hyalella azteca	322.8	1.03
Acari	161.4	0.51
TOTAL: NON INSECTS	17471.55	55.66
Baetis tricaudatus	2178.9	6.94
Rhithrogena	40.35	0.13
Chloroterpes	242.1	0.77
Tricorythodes minutus	4075.35	12.98
TOTAL: EPHEMEROPTERA	6536.7	20.82
Isoperla	161.4	0.51
TOTAL: PLECOPTERA	161.4	0.51
Brachycentrus occidentalis	40.35	0.13
Helicopsyche borealis	161.4	0.51
Hydropsyche	1977.15	6.30
Oecetis	121.05	0.39
TOTAL: TRICHOPTERA	2299.95	7.33
Petrophila	161.4	0.51
TOTAL: LEPIDOPTERA	161.4	0.51
Dubiraphia	1331.55	4.24
Microcylloepus	322.8	1.03

Taxon	Abundance	%
Optioservus	40.35	0.13
TOTAL: COLEOPTERA	1694.7	5.40
Ceratopogoninae	605.25	1.93
Forcipomyiinae	40.35	0.13
Simulium	80.7	0.26
Dicranota	121.5	0.39
Hexatoma	161.4	0.51
Tipula	80.7	0.26
TOTAL: DIPTERA	1089.45	3.47
Chironomidae-pupae	40.35	0.13
Chironomini-early instar	40.35	0.13
Cryptochironomus	40.35	0.13
Diamesa	161.4	0.51
Micropsectra	40.35	0.13
Microtendipes	1008.75	3.21
Orthocladiinae-early instar	80.7	0.26
Orthocladius Complex	242.1	0.77
Paratanytarsus	80.7	0.26
Rheotanytarsus	201.75	0.64
Tvetenia	40.35	0.13
TOTAL: CHIRONOMIDAE	1977.15	6.30
GRAND TOTAL	31392.3	100.0

Appendix C: Table C-5 (LGC-3 1998 taxa list)

Taxon	Abundance	%
Turbellaria	54	1.48
Nematoda	7	0.18
Enchytraeidea	20	0.55
Ophiodonias serpentina	34	0.92
Imma. Tubificid w/o cap. Setae	7	0.18
Sphaeriidae	7	0.18
Acari	13	0.37
TOTAL: NON INSECTS	141	3.88
Acentrella insignificans	155	4.25
Baetis tricaudatus	330	9.06
Ephemerella inermis/infrequens	74	2.03
Stenonema	13	0.37
Tricorythodes minutus	1070	29.39
TOTAL: EPHEMEROPTERA	1642	45.10
Capniidae	7	0.18
Isoperla	20	0.55
Taeniopterygidae	7	0.18
TOTAL: PLECOPTERA	34	0.92
Brachycentrus occidentalis	7	0.18
Helicopsyche borealis	7	0.18
Hydropsyche	579	15.90
Oecetis	47	1.29
TOTAL: TRICHOPTERA	639	17.56
Petrophila	87	2.40
TOTAL: LEPIDOPTERA	87	2.40
Dubiraphia	94	2.59
Microcylloepus	40	1.11
Optioservus	7	0.18
TOTAL: COLEOPTERA	141	3.88
Hemerodromia	13	0.37
Simulium	61	1.66

Taxon	Abundance	%
Dicranota	7	0.18
Hexatoma	27	0.74
Tipula	7	0.18
TOTAL: DIPTERA	114	3.14
Chironomidae-pupae	67	1.85
Cricotopus Trifascia Gr.	128	3.51
Cryptochironomus	7	0.18
Diamesa	424	11.65
Eukiefferiella	7	0.18
Microtendipes	87	2.40
Orthocladius Complex	81	2.22
Polypedilum	13	0.37
Rheotanytarsus	27	0.74
TOTAL: CHIRONOMIDAE	841	23.11
GRAND TOTAL	3641	100.0

Appendix C: Table C-6 (LGC-4 1997 taxa list)

Taxon	Abundance	%
Turbellaria	121	0.51
Oligochaeta	202	0.84
Sphaeriidae	40	0.17
Physella	81	0.34
Acari	81	0.34
TOTAL: NON INSECTS	525	2.19
Ophiogomphus	40	0.17
TOTAL: ODONATA	40	0.17
Baetis tricaudatus	1131	4.71
Ephemerella inermis/infrequens	1778	7.41
Rhithrogena	40	0.17
Stenonema	40	0.17
Paraleptophlebia	40	0.17
Tricorythodes minutus	10140	42.26
TOTAL: EPHEMEROPTERA	13170	54.88
Helicopsyche borealis	121	0.51
Hydropsyche	3757	15.66
Nectopsyche	162	0.67
Oecetis	283	1.18
TOTAL: TRICHOPTERA	4323	18.01
Petrophila	525	2.19
TOTAL: LEPIDOPTERA	525	2.19
Dubiraphia	364	1.52
Microcylloepus	162	0.67
Optioservus	40	0.17
TOTAL: COLEOPTERA	566	2.36
Ceratopogoninae	40	0.17
Hemerodromia	323	1.35
Dicranota	40	0.17
Hexatoma	40	0.17
TOTAL: DIPTERA	444	1.85

Taxon	Abundance	%
Chironomidae-pupae	242	1.01
Apedilum	2505	10.44
Cricotopus	81	0.34
Cricotopus Bicinctus Gr.	162	0.67
Cricotopus Trifascia Gr.	687	2.86
Eukiefferiella	121	0.51
Orthocladius Complex	444	1.85
Parakiefferiella	81	0.34
Thienemannimyia Gr.	81	0.34
TOTAL: CHIRONOMIDAE	4404	18.35
GRAND TOTAL	23998	100.0

Appendix C: Table C-7 (LGC-4 1998 taxa list)

Taxon	Abundance	%
Turbellaria	92	1.50
Imma. Tubificid with cap. Setae	35	0.56
Imma. Tubificid w/o cap. Setae	12	0.19
Rhyacodrilus coccineus	12	0.19
Sphaeriidae	12	0.19
Acari	46	0.75
TOTAL: NON INSECTS	208	3.37
Acentrella insignificans	46	0.75
Baetis tricaudatus	461	7.49
Ephemerella inermis/infrequens	58	0.94
Tricorythodes minutus	1395	22.66
TOTAL: EPHEMEROPTERA	1960	31.84
Protoptila	12	0.19
Helicopsyche borealis	81	1.31
Hydropsyche	853	13.86
Nectopsyche	12	0.19
Oecetis	438	7.12
TOTAL: TRICHOPTERA	1395	22.66
Petrophila	208	3.37
TOTAL: LEPIDOPTERA	208	3.37
Dubiraphia	23	0.37
Microcylloepus	450	7.30
Optioservus	46	0.75
Stenelmis	12	0.19
Zaitzevia	12	0.19
TOTAL: COLEOPTERA	542	8.80
Chelifera	12	0.19
Hemerodromia	127	2.06
Simulium	104	1.69
Dicranota	35	0.56
TOTAL: DIPTERA	277	4.49

Taxon	Abundance	%
Chironomidae-pupae	242	3.93
Cricotopus	58	0.94
Cricotopus Trifascia Gr.	415	6.74
Diamesa	438	7.12
Microtendipes	23	0.37
Orthocladius	92	1.50
Pagastia	12	0.19
Polypedilum	69	1.12
Rheotanytarsus	58	0.94
Tvetenia Discoloripes Gr.	161	2.62
TOTAL: CHIRONOMIDAE	1568	25.47
GRAND TOTAL	6157	100.0

Appendix C: Table C-8 (LGC-5 1994 taxa list)

Taxon	Abundance	%
Turbellaria	15.12	0.47
Oligochaeta	574.56	17.98
Imma. Tubificid with cap. Setae	498.96	15.62
Limnodrilus hoffmeisteri	75.6	2.37
Lumbricina	15.12	0.47
Helobdella stagnalis	5.04	0.16
Sphaeriidae	15.12	0.47
Physella	10.08	0.32
Hyalella azteca	5.04	0.16
Acari	45.36	1.42
TOTAL: NON INSECTS	1260	39.43
Baetis tricaudatus	15.12	0.47
Heptagenia/Nixe	5.04	0.16
Stenonema	5.04	0.16
Choroterpes	10.08	0.32
Tricorythodes minutus	786.24	24.61
TOTAL: EPHEMEROPTERA	821.52	25.71
Zapada cinctipes	5.04	0.16
TOTAL: PLECOPTERA	5.04	0.16
Helicopsyche borealis	20.16	0.63
Cheumatopsyche	5.04	0.16
Hydropsyche	196.56	6.15
Oecetis	5.04	0.16
TOTAL: TRICHOPTERA	226.8	7.10
Petrophila	5.04	0.16
TOTAL: LEPIDOPTERA	5.04	0.16
Dubiraphia	95.76	3.00
Microcylloepus	95.76	3.00
Optioservus	20.16	0.63
Zaitzevia	10.08	0.32
TOTAL: COLEOPTERA	221.76	6.94

Taxon	Abundance	%
Ceratopogoninae	10.08	0.32
Hemerodromia	5.04	0.16
Simulium	65.52	2.05
Dicranota	5.04	0.16
Tipula	10.08	0.32
TOTAL: DIPTERA	95.76	3.00
Chironomidae-pupae	45.36	1.42
Brillia	10.08	0.32
Chironomini-early instar	5.04	0.16
Chironomus	5.04	0.16
Diamesa	176.4	5.52
Dicrotendipes	5.04	0.16
Microtendipes	20.16	0.63
Orthocladiinae-early instar	25.2	0.79
Orthocladius Complex	100.8	3.15
Pagastia	15.12	0.47
Pentaneura	5.04	0.16
Phaenopsectra	5.04	0.16
Polypedilum	5.04	0.16
Potthastia Geidii Gr.	5.04	0.16
Rheocricotopus	10.08	0.32
Rheotanytarsus	120.96	3.79
TOTAL: CHIRONOMIDAE	559.44	17.51
GRAND TOTAL	3195.36	100.0

Appendix C: Table C-9 (LGC-5 1997 taxa list)

Taxon	Abundance	%
Oligochaeta	194	1.07
Hyalella azteca	32	0.18
TOTAL: NON INSECTS	226	1.25
Acentrella turbida	32	0.18
Baetis tricaudatus	1292	7.14
Ephemerella inermis/infrequens	1195	6.61
Rhithrogena	65	0.36
Stenonema	97	0.54
Tricorythodes minutus	6848	37.86
TOTAL: EPHEMEROPTERA	9529	52.68
Helicopsyche borealis	97	0.54
Hydropsyche	6492	35.89
Oecetis	194	1.07
TOTAL: TRICHOPTERA	6783	37.50
Petrophila	291	1.61
TOTAL: LEPIDOPTERA	291	1.61
Dubiraphia	65	0.36
Microcylloepus	32	0.18
Neoelmis	32	0.18
Optioservus	32	0.18
Zaitzevia	32	0.18
TOTAL: COLEOPTERA	194	1.07
Hemerodromia	129	0.71
Simulium	32	0.18
Hexatoma	32	0.18
TOTAL: DIPTERA	194	1.07
Chironomidae-pupae	32	0.18
Apedilum	291	1.61
Cladotanytarsus	32	0.18
Cricotopus Trifascia Gr.	258	1.43
Orthocladius Complex	32	0.18

Taxon	Abundance	%
Polypedilum	32	0.18
Rheocricotopus	32	0.18
Rheotanytarsus	97	0.54
Thienemanniella	32	0.18
Thienemannimyia Gr.	32	0.18
TOTAL: CHIRONOMIDAE	872	4.82
GRAND TOTAL	18088	100.0

Appendix C: Table C-10 (LGC-5 1998 taxa list)

Taxon	Abundance	%
Turbellaria	89	1.94
Ophidonais serpentina	40	0.88
Uncinais uncinata	24	0.53
Imma. Tubificid w/o cap. Setae	307	6.70
Limnodrilus hoffmeisteri	40	0.88
Rhyacodrilus coccineus	492	10.76
Sphaeriidae	16	0.35
Acari	32	0.71
TOTAL: NON INSECTS	1041	22.75
Ophiogomphus	8	0.18
TOTAL: ODONATA	8	0.18
Acentrella insignificans	40	0.88
Baetis tricaudatus	282	6.17
Ephemerella inermis/infrequens	48	1.06
Rhithrogena	8	0.18
Tricorythodes minutus	775	16.93
TOTAL: EPHEMEROPTERA	1154	25.22
Brachycentrus occidentalis	8	0.18
Protoptila	24	0.53
Helicopsyche borealis	145	3.17
Hydropsyche	759	16.58
Nectopsyche	32	0.71
Oecetis	218	4.76
TOTAL: TRICHOPTERA	1186	25.93
Petrophila	89	1.94
TOTAL: LEPIDOPTERA	89	1.94
Dubiraphia	137	3.00
Microcylloepus	105	2.29
Optioservus	8	0.18
Ordobrevia nubifera	8	0.18
Zaitzevia	32	0.71

Taxon	Abundance	%
TOTAL: COLEOPTERA	291	6.35
Hemerodromia	48	1.06
Simulium	145	3.17
Dicranota	8	0.18
Hexatoma	8	0.18
TOTAL: DIPTERA	210	4.59
Chironomidae-pupae	73	1.59
Cricotopus Bicinctus Gr.	8	0.18
Cricotopus Trifascia Gr.	274	6.00
Diamesa	194	4.23
Eukiefferiella	8	0.18
Microtendipes	8	0.18
Rheocricotopus	8	0.18
Rheotanytarsus	8	0.18
Thienemannimyia Gr.	8	0.18
Tvetenia Discoloripes Gr.	8	0.18
TOTAL: CHIRONOMIDAE	597	13.05
GRAND TOTAL	4576	100.0

APPENDIX D

Appendix D: Table D-1 (Summary of water quality data from the 1998-99 fecal coliform synoptic).

Parameter	Site 1			Site 2			Site 3		
	min.	**median**	**max.**	**min.**	**median**	**max.**	**min.**	**median**	**max.**
Temperature (°C)	16.3	18.5	20.6	16.5	18.45	20.6	15.5	18.05	20.6
pH (S.U.)	8.1	8.2	8.4	8	8.2	8.3	8	8.2	8.3
Conductivity (Umhos/cm)	386	525	716	388	521	706	392	530.5	621
Dissolved Oxygen (mg/L)	6.77	7.9	12.07	6.78	7.6	8.21	6.35	7.565	8.12
Turbidity (NTU)	3.2	8.25	28.5	4.5	8.55	26.5	7.4	8.75	13
TSS (mg/L)	9	24	84	7	21	83	16	26.5	29
T. Residual Chlorine (mg/L)	0.02	0.05	0.06	0.025	0.055	0.08	0.02	0.05	0.07
Chlorides (mg/L)	<5	<5	<5	<5	<5	<5	<5	<5	<5
Sulfate (mg/L)	45	87	124	41	75	110	34	61.5	88
TDS (mg/L)	296	381	472	288	388	476	296	378	444
T. Phosphorus (mg/L)	<0.1	<0.1	0.1	<0.1	0.1	0.1	<0.1	<0.1	0.1
Nitrate + Nitrite Nitrogen (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3
T. Ammonia (mg/L)	<0.1	<0.1	0.1	<0.1	<0.1	0.36	<0.1	<0.1	0.8
Fecal Coliform (#/100ml)	144	290	1900	188	340	3300	280	540	3100

Appendix D: Table D-1 cont. (Summary of water quality data from the 1998-99 fecal coliform synoptic).

Parameter	Site 4			Site 5			Site 6		
	min.	**median**	**max.**	**min.**	**median**	**max.**	**min.**	**median**	**max.**
Temperature (°C)	15	17.25	20.2	14.3	16.3	18.6	14	15.95	19.2
pH (S.U.)	8.1	8.2	8.4	8.1	8.35	10.1	7.9	8.35	8.6
Conductivity (Umhos/cm)	348	476.5	519	232	404	472	116	168.5	227
Dissolved Oxygen (mg/L)	7.75	8.1	8.7	8.6	8.855	9.53	8.6	8.725	9.17
Turbidity (NTU)	3.7	5.3	8.8	1.4	2.75	3.2	1.6	2.3	3.2
TSS (mg/L)	14	19	20	2	7.5	9	2	6.5	9
T. Residual Chlorine (mg/L)	0.01	0.03	0.07	0.01	0.035	0.11	0.02	0.03	0.05
Chlorides (mg/L)	<5	<5	<5	<5	<5	<5	<5	<5	<5
Sulfate (mg/L)	21	33.5	39	10	14	17	<10	<10	<10
TDS (mg/L)	244	280	328	172	257	320	88	102	148
T. Phosphorus (mg/L)	<0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrate + Nitrite Nitrogen (mg/L)	<0.1	0.2	0.3	<0.1	0.15	0.2	<0.1	<0.1	<0.1
T. Ammonia (mg/L)	<0.1	0.1	0.36	<0.1	0.11	0.3	<0.1	0.1	0.1
Fecal Coliform (#/100ml)	220	410	1500	84	320	430	84	188	540

Appendix D: Table D-1 cont. (Summary of water quality data from the 1998-99 fecal coliform synoptic).

Parameter	Site 7			Woodland Park			Little Goose Above Big Horn		
	min.	median	max.	min.	median	max.	min.	median	max.
Temperature (°C)	12.6	14.15	15.4	15.8	18	20.9	15.5	16.1	18.7
pH (S.U.)	7	7.8	8	8.1	8.2	8.3	7.8	8.4	10.2
Conductivity (Umhos/cm)	41.7	47	51	557	579	627	347	391	398
Dissolved Oxygen (mg/L)	8.6	8.9	9.07	6.95	7.83	8.47	8.64	8.91	9.29
Turbidity (NTU)	0.83	1.3	1.6	6	8.9	12	1.2	1.6	2.4
TSS (mg/L)	2	3.5	8	22	23.5	25	6	6	6
T. Residual Chlorine (mg/L)	0.03	0.045	0.07	0	0.04	0.08	0.02	0.04	0.06
Chlorides (mg/L)	<5	<5	<5	<5	<5	<5	<5	<5	<5
Sulfate (mg/L)	<10	<10	<10	68	75	82	11	11.5	12
TDS (mg/L)	34	46	48	384	400	416	220	226	232
T. Phosphorus (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrate + Nitrite Nitrogen (mg/L)	<0.1	<0.1	<0.1	<0.1	0.15	0.2	0.1	0.1	0.1
T. Ammonia (mg/L)	<0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fecal Coliform (#/100ml)	<10	32	48	330	460	570	74	104	128

Appendix D: Table D-1 cont. (Summary of water quality data from the 1998-99 fecal coliform synoptic).

Parameter	Kruse Creek			Sackett Creek			Jackson Creek		
	min.	**median**	**max.**	**min.**	**median**	**max.**	**min.**	**median**	**max.**
Temperature (°C)	16.8	18.1	21.1	15.2	16.7	18.6	16.1	17.1	20.7
pH (S.U.)	8.1	8.2	8.4	8	8.2	9.8	8.5	8.7	10.3
Conductivity (Umhos/cm)	407	432	464	394	400	411	428	476	648
Dissolved Oxygen (mg/L)	7.63	8.08	8.63	7.86	8.12	8.15	8.37	8.41	8.89
Turbidity (NTU)	9.7	14	14.9	3.2	4.5	5.5	1.9	7.2	20
TSS (mg/L)	26	35	44	12	14	16	17	43	69
T. Residual Chlorine (mg/L)	0.02	0.03	0.07	0.01	0.04	0.05	0.01	0.06	0.07
Chlorides (mg/L)	<5	<5	<5	<5	<5	<5	<5	<5	<5
Sulfate (mg/L)	27	29.5	32	24	25	26	26	30.5	35
TDS (mg/L)	260	284	308	260	264	268	312	356	400
T. Phosphorus (mg/L)	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	0.15	0.2
Nitrate + Nitrite Nitrogen (mg/L)	0.4	0.45	0.5	<0.1	<0.1	0.1	0.3	0.7	1.1
T. Ammonia (mg/L)	<0.1	0.12	0.13	<0.1	<0.1	0.1	<0.1	0.1	0.1
Fecal Coliform (#/100ml)	330	530	570	280	490	1520	280	390	760