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by

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Final Report Submitted to the
MONTANA University System WATER CENTER
Montana State University
Bozeman, Montana

2000

The project on which this report is based was financed in part by the Department of the Interior, U.S. Geological Survey, through the Montana University System Water Center as authorized under the Water Resources Research Act of 1984 (PL98-242) as amended by Public Law 101-397.

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– a tributary of the Upper Clark Fork River

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Lost Creek, a tributary to the Upper Clark Fork of the Columbia, is listed on Montana's 303(d) list as impaired for a number of beneficial uses, including aquatic life support, drinking water supply, and cold water fishery. Lost Creek is undergoing major riparian restoration and grazing management changes which will be the basis of a Total Maximum Daily Load (TMDL) for nutrients and sediment for the lower 17 stream miles. Therefore the objectives of this project include the following:

1) assess current conditions in Lost Creek including kinds and degrees of impairment,
2) provide baseline data to evaluate benefits of restoration work;
3) evaluate Lost Creek as a nutrient source to the nutrient-impaired Clark Fork River;
4) evaluate nutrient sources along Lost Creek;
5) make recommendations for TMDL development for Lost Creek, and how it should relate to the Clark Fork VNRP (which calls for a 20% reduction in nonpoint sources of nutrients).

Water samples were collected from May through August 1999 at sites along the creek which bracketed suspected sources. Samples were analyzed for nutrients (nitrate/nitrite, total Kjeldahl nitrogen, soluble reactive phosphorus, and total phosphorus) using an EPA-approved protocol. Riparian health assessments were performed on the lower 20 miles of Lost Creek using the University of Montana's Riparian and Wetland Research Program's Lotic Inventory Form. Riparian inventories are used to identify and prioritize problem areas and provide detailed baseline information for gauging the success of restoration projects on Lost Creek.

Lost Creek does not provide good habitat for attached algae growth, but in some areas aquatic plants may be a problem. Hence, the main reason for reducing nutrients in Lost Creek is to reduce the load to the Clark Fork. Phosphorus levels in Lost Creek were below those considered to be a problem for streams according to the Clark Fork VNRP. Total nitrogen (particularly nitrate/nitrite) levels are high enough to be a concern. Nitrate/nitrite levels increase in the area near Dutchman reservoir. Although wetland disturbance by cattle grazing is a likely source of nutrients in this area, it appears likely that irrigation water from the land application of Anaconda's municipal wastewater is leaching into groundwater from nearby hay fields and from storage ponds in the Dutchman Creek drainage. Riparian inventories found 30% of riparian areas were not performing their functions while the other 70% were at risk to become nonfunctional.

In terms of TMDL development for Lost Creek, the conservation practices being undertaken by landowners with state and federal funding will likely improve habitat and reduce nutrient loads. Success should be judged by periodic reevaluation of riparian condition and nutrient loads. Lost Creek does provide a significant TN load to the Clark Fork, and this is probably best addressed by riparian wetland restoration and land application of Anaconda wastewater over a larger area at an appropriate agronomic rate. Additional recommendations for monitoring and TMDL development are detailed in the full report.

This work was supported by the Montana University System Water Center with funds from the USGS Section 104 Program. Our grateful thanks to Montana Dept of Fish, Wildlife and Parks, the US NRCS and landowners in the Lost Creek Basin for their efforts to restore Lost Creek.

Introduction

Lost Creek is a tributary of western Montana's Clark Fork of the Columbia River. Both streams have multiple water quality problems and appear on Montana's list of impaired streams (MDEQ,1998). Hence under the Clean Water Act, the state is to develop restoration plans for these streams that will restore their health and ability to support their beneficial uses. The Clark Fork River is considered impaired by a number of pollutants, including nutrients, a problem recently addressed in a voluntary nutrient reduction plan. Lost Creek is also considered to be impaired by nutrients and other problems. As a result, several restoration and conservation projects are being undertaken on Lost Creek. This paper evaluates the extent to which these actions on Lost Creek are likely to address its problems as well as those of the Clark Fork River.

The Clark Fork River Voluntary Nutrient Reduction Program (VNRP) was established to substitute for a mandatory Total Maximum Daily Load (TMDL)for nutrients in the mainstem of the Clark Fork River. The VNRP is centered around the voluntary efforts of four major point sources of nutrients: Smurfitt Stone Corporation (manufacturers of paperboard), and the municipal wastewater treatment plants of Butte, Deer Lodge and Missoula. From the results of a three year nutrient study, Ingman (1992a) estimated that these sources contribute 80% of the total nutrient load to the Clark Fork River during the summer low flow months (July-September), a period when algae production is at its peak. However, historic data also indicates that tributaries contribute approximately 50% and 75% of the yearly loads of total nitrogen and phosphorus, respectively (Ingman, 1992b). Tributary loads arise predominantly from non-point sources such as irrigated crop production, cattle grazing, forestry, and unsewered residential development. Therefore, in addition to reductions from major point sources, the 10-year VNRP calls for a 20% reduction from nonpoint sources. Incorporating reductions from point sources and nonpoint sources and a margin of safety, the VNRP hopes to achieve nutrient targets in the Clark Fork mainstem set at 300 ppb total nitrogen (TN), 39 ppb total phosphorus (TP) below Missoula, and 20 ppb TP upstream of Missoula (Watson, 1999). These targets are expected to maintain standing crop of algae below nuisance levels (Dodds, 1997).

Based on sampling from 1989-1991, Lost Creek represented a major source of nitrogen to the upper Clark Fork River, particularly with respect to total soluble inorganic nitrogen (TSIN) and was identified as a high priority stream for nonpoint source control of soluble nitrogen (Ingman, 1992a,b). From 1989-91, Lost Creek's TSIN load to the upper river averaged 27.4 kg/day which is comparable to Silver Bow Creek, the receiving waterbody for the Butte wastewater treatment plant. However, Lost Creek was not a significant source of phosphorus to the upper river during the years from 1989-1991.

Lost Creek is listed on the 303d list as moderately impaired over the lower 17 stream miles for the following probable causes: flow alterations, nutrients, habitat alterations, and siltation (MDEQ,1998). The beneficial uses impaired by these probable causes include contact recreation, coldwater trout fishery, and aquatic life support. In addition,

drinking water supply is listed as "nonsupportive" of uses for this reach. The Montana Department of Fish Wildlife and Parks (MDFWP)in cooperation with the Deer Lodge office of the USDA Natural Resources and Conservation Service (NRCS), has assembled funding from a variety of sources for a restoration project which will be developed into a Total Maximum Daily Load (TMDL) for nutrients and sediments. The goals of the MDFWP restoration plan include: habitat improvement for spawning trout (primarily brown trout), riparian habitat restoration, and removal of fish barriers to increase connectivity of Lost Creek with mainstem populations of trout (Reiland, 1999). Specific actions (described in greater detail in the next section) include a number of restoration and management strategies intended to improve fish habitat, such as offstream water development, corral relocation, stream bank revegetation, riparian exclosures and pastures, conservation easements, and the return of several channelized reaches to historic meandering channels.

Considering the existing conditions on Lost Creek and the scope of the proposed restoration, habitat improvements will likely result in reductions in nutrient loading and sediment delivery to Lost Creek and the mainstem of the Clark Fork River. Therefore the goals of this thesis project include the following:

1) Assess current conditions in Lost Creek including kinds and degrees of impairment;
2) Provide baseline data to evaluate benefits of restoration work;
3) Evaluate Lost Creek as a nutrient source to the Clark Fork River;
4) Evaluate nutrient sources along Lost Creek;
5) Make specific recommendations for TMDL development for Lost Creek, and how it should relate to the Clark Fork VNRP.

Description of Lost Creek Basin and History

Lost Creek is 37.5 miles long and drains approximately 62 square miles. A tributary to the Upper Clark Fork of the Columbia River, Lost Creek has a long history of environmental impacts. Once a part of the more extensive Mt. Haggin ranch, the Lost Creek basin has been the site of over 100 years of intensive management, originally sheep ranching and more recently cattle ranching. Irrigated crop production resulted in dramatic hydrologic modification with numerous irrigation withdrawals, including a diversion from adjacent Warm Springs Creek into Lost Creek. Dutchman Creek, a tributary to Lost Creek was also diverted from its original channel into an impoundment designed for irrigation water storage. Other impacts include unsewered residential development near the town of Lost Creek and upland soils contaminated by nearby Anaconda's now defunct copper smelting facilities. In addition, the Ueland Ranch has been irrigating hay fields with Anaconda's municipal wastewater since 1995. Water is stored in ponds located near the ranch's calving facility (near sample site 3 on Map 1) and is pumped to sprinkler systems on the north side of the Lost Creek drainage. This system includes five groundwater infiltration basins which receive excess water from the storage ponds approximately 2-3 months during the spring when wastewater exceeds irrigation demand.

In addition to providing important spawning habitat for brown trout from the mainstem river, Lost Creek and its extensive riparian wetlands provide habitat for waterfowl, raptors, and large mammals such as deer, elk and moose. The main purpose of the MTFWP project is to restore both aquatic and riparian habitat in the basin primarily for the purposes of improving fish habitat. For example, fish habitat has been degraded by the loss of woody vegetation and instream structures and the abundance of sediment delivered to the stream. In addition, fish barriers pose a threat to spawning fish, which stack up below barriers such as Dutchman dike (site 6 on maps). As a result, late spawning fish either destroy existing redds or are forced to utilize substandard habitat which ultimately affects recruitment to the Clark Fork River (Reiland, 1999).

Table 1 summarizes some measures of Lost Creek's condition and the details of the MT FWP restoration plan. However, some particulars of historic management and future changes are worth mentioning in terms of the goals of this project. For instance, the Ueland Ranch historically contained an over-wintering area and calving facility where high concentrations of cattle had free access to the stream channel. The lower floodplain of Lost Creek contains a predominance of fine bank material, and the loss of woody vegetation in this area has resulted in severe down-cutting and lateral movement. This area was chosen for nutrient monitoring as well as riparian health assessment, since the proposed corral relocation and off-stream watering will likely have a positive effect on water quality as well as on revegetation of woody species and bank stability. Similar conditions exist elsewhere on the Ueland ranch, and a combination of riparian fencing and grazing regimes are proposed to improve riparian habitat and the stability of the stream banks. The Heggelund Ranch is marked by extensive areas devoid of mature woody vegetation, a result of herbicide use to remove woody vegetation in favor of increased forage production. A 30 year conservation easement is sought for riparian and wetland recovery for this reach.

It should be noted that "channel relocation" and "channel reconstruction" refer to removing unnecessary diversions and returning channelized reaches of Lost Creek to historic channels which are now dry. In one case, the historic channel of the creek had been obliterated so new channel meanders will be constructed. In addition, habitat improvements will entail the installation of root wads and placement of large woody material to stabilize revegetating banks and provide needed fish habitat.

Monitoring and Assessment Design and Methods

Where access was granted, sample stations were positioned upstream and downstream of areas suspected to yield substantial nutrient loads to the creek. In addition, two stations were selected on a major tributary (Dutchman Creek) and an irrigation ditch (Gardiner Ditch). Station 1 (refer to map) was sampled to provide a reference of ambient nutrient levels in Lost Creek above impacts of cattle ranching and unsewered residential development. Except where conditions prevented access, these

sites were sampled weekly during spring high flow (May-June) and twice monthly during summer low flow (July-August), yielding 9 sample dates for most sites.

Grab samples were collected for nutrients at each site following the protocol described by Ingman (1992a) in order to be consistent with data collected by the MT DEQ. Samples for nutrient analysis were frozen with dry ice in the field and shipped to the Montana State Environmental Laboratory in Helena for nutrient analysis. Analysis included total Kjeldahl nitrogen (TKN), nitrite plus nitrate (NO2/NO3), total phosphorus (TP), and soluble reactive phosphorus (SRP), which was filtered on site with a .45μm membrane filter. Detection limits for analysis were <0.1 mg/l for TKN, <0.01 mg/l for nitrate/nitrite, and <0.001 mg/l for SRP and TP. All nutrient sampling equipment was acid washed in 50% instranalyzed HCl and triple-rinsed in deionized water. Field blanks were prepared for each sampling date for quality assurance. Sample results for TKN and NO2/NO3 were summed to estimate total nitrogen (TN). Total nutrient loads were estimated using discharge data collected using standard pygmy flow meter. Gardiner ditch (Station 3) and the Dutchman diversion (Station 6) are exceptions since discharge could not be measured and only TN and TP concentrations were determined.

Temperature and pH determinations were made at each site on each visit using a Orion Model 250A portable pH meter. Turbidity samples were brought to the laboratory and analyzed using a Hach 2100A turbidimeter within 24 hours. Samples were collected for total suspended sediment determination by filtration method.

A combination of spreadsheet (Microsoft Excel) and statistical software (SPSS) was used to manage and analyze physical and water quality data. Simple descriptive statistics (i.e. means and 95% confidence intervals) were used to generate summary tables and graphs to assess differences between sites. Because initial analysis of water quality data based on flow period (i.e. high spring flow vs. low summer flow) did not reveal any additional significant information, tables and graphs of water quality data are presented in terms of summer (May through August) mean values (See Fig. 1 through 9).

Riparian inventories were performed using the UM School of Forestry's Riparian and Wetland Research Program's Lotic inventory (detailed inventory). Forms and description of protocols are available online at **http://www.rwrp.umt.edu**. The study area was divided into areas called polygons, covering approximately 0.5 stream miles and bordered by the edge of the riparian zone. Ending and starting points for polygons were delineated by a combination of GPS coordinates, photo documentation and narrative descriptions. Specific areas of concern (i.e. severely eroding banks, headcuts, etc.) were recorded in a similar manner. Riparian inventories were completed for the entire length of the proposed restoration area (see map), except where the creek entered wetland and beaver complexes above the reservoir. In this area, there was a lack of distinct channel or riparian boundaries so assessments were not feasible.

Lotic inventories involved recording the presence and coverage of plant species, infestation by invasive species, and age class and utilization of woody species. In

addition, information about human-caused bare soil, eroding banks, lateral cutting and other physical factors were recorded. These completed Lotic inventories will be available through the MT Department of Fish, Wildlife, and Parks. This information was used to generate health scores for riparian vegetation, soils and hydrology, from which a total score was derived to indicate the level of functionality for each polygon. Protocol for the health assessment scoring system is available from the RWRP. A summary of these scores and major problems is provided in Tables 5 through 7.

Within the framework of this project, performing lotic health evaluations served several purposes:

(1) provides "baseline" vegetation and soils/hydrology information necessary for gauging the success of the restoration at some time in the future.

(2) provides information which may assist land managers with grazing strategies, weed control and prioritizing areas of greatest concern.

(3) Helps identify nature of problems in specific areas and potential for recovery.

However, it is not within the scope of this study to make management recommendations but only to identify problems and document conditions. Grazing strategies and restoration goals are currently in the development stage, and funding and implementation for some (such as offsite watering) have already begun. The results of this study are intended to assist the MDFWP, NRCS and land-owners to identify and assess priority areas for restoration along Lost Creek. Therefore, discussion of riparian conditions will concentrate on how existing riparian conditions relate to water quality and the potential for monitoring changes in the watershed.

Results and Discussion

Flow, Temperature, Turbidity, TSS, and pH

Mean summer discharge from May through August of 1999 is presented in Figure 1, and mean, minimum and maximum values are also summarized in Table 2. Highest peak discharge (75.2 cfs) occurred at Station 1 above any diversions of water. A minimum flow of 2.5 cfs was recorded at Station 7 just below Dutchman dike. Based on summer means there appeared to be a decrease in discharge moving downstream. The exception to this trend is station 8, with discharge decreasing again at station 9. Unfortunately, very little historic discharge data is available for Lost Creek. Summer discharge data from 1989-1990 (see appendix) indicates that discharge at the mouth of Lost Creek in 1999 was within the range of normal flow . A review of historic discharge data from nearby Warm Springs Creek (1984-1999) suggests that the 1999 water year was average in terms of summer mean discharge (May-Aug) and mean high flow (May – June).

Measuring stream discharge was complicated by diversions and inputs to Lost Creek too numerous to gauge in this study. For instance, Gardiner Ditch carries water from Warm Springs Creek and represents a significant input to Lost Creek, yet discharge

in the creek decreases just below its confluence due to several irrigation withdrawals in the area of the over-wintering facility. In addition, Dutchman Creek is diverted above its natural confluence into a reservoir, which empties into Lost Creek and another irrigation ditch. From visual estimates, the discharge in this ditch (running to the north of Station 7) often greatly exceeded the discharge in Lost Creek particularly in July and August when irrigation demand was high. These withdrawals are responsible for the downstream trend of decreasing discharge seen in Fig 1. The increase in discharge at Station 8 is likely due to groundwater and surface return flow from water that has pooled in extensive wetlands below the Dutchman dike and resurfaced as flow in the natural channel of Dutchman Creek and numerous seeps feeding Lost Creek. Overall, Lost Creek did not exhibit the typical downstream increase in flow during runoff in reaches below Station 2 where intensive irrigation (which includes storage behind Dutchman dike) moderated the effect of high spring flow.

Temperature also exhibited a downstream trend as mean summer values increase downstream (see Fig. 2). Note that this apparent increase is likely the result of diurnal variation in temperature, since downstream stations were sampled at times as much as 6 hours later in the day than upper stations. No historic temperature data exists for comparison. Flow alteration may also be responsible for the downstream increase in temperature since decreasing discharge volume reduces the heat absorbing capacity of the creek. In addition, the stream reach between stations 8 and 9 has a marked lack of shade-providing woody vegetation, and station 9 exhibits the largest temperature increase between sites from a mean summer value of 14.0 C at station 8 to 17.1 C at station 9 (Note: these sites were sampled within one hour of each other). In the future, diurnal temperature should be assessed in Lost creek with continuous data loggers.

Turbidity, TSS, and pH are summarized in Table 2 . Turbidity measurements were low, with the exception of one sample date on which turbidity samples were inadvertently frozen, creating a floc. TSS was also low for most sites (<20 mg/l) with highest values measured at Stations 2 and 9. Irrigation diversions appear to have had a positive effect on TSS, providing an opportunity for suspended material and sediment to settle behind diversions like those located above Stations 4 and 7. These diversions, which have depressed peak spring flows may have kept TSS at a minimum. Conversely, Station 2 is not located downstream from any major diversions and exhibited the highest values for TSS with a mean of 49 mg/l and a peak of 173 mg/l. Station 2 is also located along a higher gradient reach than are lower stations, since Lost Creek shifts from a B3/4 channel type into a C4 type as it enters the area of the Ueland ranch - roughly between Stations 2 and 4 (Rosgen, 1996). As mentioned above, much of Lost Creek's bed load is comprised of sand and fine sediment , mainly as a result of eroding and slumping banks, with the stream bottom in several reaches composed largely of bank materials.

Nutrients

Table 3 presents the results of nutrient samples gathered from May to August of 1999. Load calculations were not possible for stations 3 and 6 since discharge was

difficult to estimate. Table 4 compares nutrient loads and concentrations for Station 9 (near mouth) and the mainstem of the Clark Fork River utilizing 1999 water data for Lost Creek and Clark Fork and data collected by the DEQ between 1989-1990.

In all years, Lost Creek contribution of SRP and TP is insignificant in terms of Clark Fork River concentrations, and mean concentrations for most sites on Lost Creek fall well below the VNRP target of 20 ppb (Figures 3 and 4). Similarly, mean phosphorus loads (Fig. 5) were typically low (< 1 kg/day) and results indicated only slight differences between sites. A maximum daily load of 0.7 kg/day was recorded at Station 9 near the mouth. Mean loading at the mouth (0.3 kg/day) was only 1% of the Clark Fork river load of 28 kg/day. Station 2 exhibited the highest concentrations of TP in Lost Creek ranging from 14-53 ppb with a summer mean of 24 ppb. The area upstream from this station contains the greatest concentration of unsewered residential development in the basin and may be the source of most of the Total P load to Lost Creek.

Nitrate/nitrite levels (Fig. 6) were lowest at the 4 upstream stations; below these stations nitrate/nitrite were much higher. Station 5 results are based on only two sample dates in May where access to the channel was permitted, and mean value is highly variable. Dutchman Creek (Station 6) exhibited the highest mean values and the highest peak value of 720 ppm. Stations downstream from this area exhibited a gradual decrease in mean nitrate/nitrite concentrations ending with a mean value of 179 ppb at Station 9, considerably higher than most upstream stations.

Nitrogen, particularly nitrate, shows the greatest increases in concentrations and loads in the middle and lower reaches of Lost Creek. Like the 3 upstream stations, station 4 (located below the overwintering and calving area) exhibited low nutrient levels during the sampling period (May-August). Although this area is a likely source of nutrients, its effect on nutrient levels would occur earlier in the spring when low elevation snow melt would deliver nutrients from animal waste to the creek. The area including Stations 5-7 all exhibit high mean levels of nitrate relative to upstream values. Likely explanations for these high levels vary from site to site. Station 5 is located above the Dutchman reservoir and high levels of nitrate may be influenced by subsurface return of irrigation from the land application of wastewater to fields occupying the ridge north of this station. Upstream from Station 5 are several wet meadow complexes that form against the base of this ridge where a number of seeps have formed. Station 6 on Dutchman Creek drains the southern portion of the basin, which includes the site of the wastewater storage ponds and the groundwater infiltration basins that receive excess wastewater 2-3 months of the year depending on supply and demand. Groundwater nitrate data is scant yet one sample obtained from the Montana Department of Environmental Quality Groundwater Section from 1995 indicates that levels are significant (9.38 mg/l) from a sample taken from a well just east (down gradient) from storage ponds.

Station 7 is located below the outfall of the Dutchman reservoir, and Lost Creek nitrate levels here may be affected by the water table fluctuations caused by the filling

and draining of the reservoir for irrigation purposes. While the extensive wetlands influenced by the presence of the dike may act as a sink for organic matter and nutrients, periodic drops in the water table caused by irrigation withdrawal may result in increased decomposition of stored organic matter and releases of nutrients (Mitsch and Gosselink, 1986).

Similarly, Station 8 is located downstream from the natural confluence of Dutchman Creek which is recharged by water from the extensive wetlands that have formed below the dike. Discharge at this station is the highest on the lower reaches of the Creek, which indicates the influence of subsurface water recharge by groundwater, despite significant withdrawals for irrigation. As a result of increased flow, Lost Creek carries its highest mean load of TN (37.2 kg/day) in this reach, despite a drop in TN concentrations.

Kjeldahl nitrogen levels (Fig. 7) were highly variable for most sites, with Station 6 on Dutchman Creek having the highest mean concentration of 363 ppb. Station 9, near the creek's mouth had the second highest mean value of 290 ppb. Peak daily values exceeded 280 ppb for all sites with maximum levels at Stations 6 (860 ppb) and 8 (850 ppb). Highest levels for all sites occurred during peak runoff in May and June.

Total nitrogen levels (Fig. 8) at Stations 1-4 were all approximately 200 ppb. Due mostly to the high levels of nitrate/nitrite recorded for Stations 5 through 9, total nitrogen levels exhibit a similar pattern with a sharp increase in TN in the area above and in Dutchman Creek. Dutchman had the highest levels of TN with a mean of 950 ppb and a maximum value of 1360 ppb on 6/24/99. Mean values near the mouth of Lost Creek were 470 ppb TN, with a maximum value of 740 ppb. On most sample dates, Station 9 exceeded the VNRP target of 300 ppb TN.

Average TN loads of all stations (Fig. 9) were within range of Station 1. Station 8 had the highest average loads of 37 kg/day TN. Lost Creek's TN loads relative to Clark Fork River loads are summarized in Table 4. From 1989-1999 summer mean TN load for Lost Creek near its mouth varied from 12-31 kg/day which is 11-18% of the Clark Fork River TN load just above Lost Creek. Mean loading of nitrate/nitrite represented nearly half Lost Creek's TN load at mouth and 23-44% of the Clark Fork's nitrate loads. Amazingly, on 5/13/99, Lost Creek's nitrate load equaled the load carried by the river (~40 kg/day).

Although average 1999 loads of TN at the confluence were within the range of historic values (Table 4), nitrate levels were higher in 1999 and comprised a greater proportion of the total nitrogen concentration than in prior sampling years. Again, this may be a result of applying Anaconda's wastewater in the Lost Creek basin, which began in 1994. Prior to that, Anaconda pumped its wastewater into the Opportunity Ponds which would have contributed nutrients to the headwaters of the Clark Fork. However, mean nitrate concentrations in the Clark Fork River appear higher (if only slightly) in 1999 than 1989-1990.

In general, variation in loading was more affected by discharge than concentration, and linkages between land-uses such as grazing and loads cannot be made with the exception that irrigation withdrawals exert a strong influence over discharge and loads carried by Lost Creek. In addition, groundwater return in the area above Station 8 likely results in both increased flow and nitrogen rich water from multiple sources. In this case, groundwater (which may include loads from land application of wastewater) and Dutchman Creek, may represent the largest TN loads to the system based on flow contribution and concentration of nitrate.

Riparian Health Assessment

Results of riparian inventories are summarized in Table 5 through 7 indicating the health scores for vegetation, soils/hydrology and total health scores. Specific concerns were listed under Problem Summary heading if category received a score of 33% or less than its potential score. For example, if the infestation of invasive species resulted in an actual score of 1 point out of a potential of 3 points it was included in the table as a factor responsible for lowering the overall score for the polygon.

Overall, 70 % of the polygons surveyed were scored as "not functional", and the remaining 30 % were scored as "functional / at risk". The greatest proportion of non-functional polygons was found on the middle to lower reaches (see Map 2). In general, the majority of polygons exhibited severe noxious weed problems (mainly thistle), loss of woody vegetation and/or over-utilization of woody vegetation. In addition, bank instability caused by the loss of deep binding rootmass and trampling of banks by cattle were common problems.

Lateral cutting and channel incisement were commonly observed, with several reaches possessing moderate headcuts and channel braiding in heavily impacted areas. Cannel bottom composition of fine sediment was also calculated by summing silt and sand coverage from lotic inventories. Fine sediment coverages ranged from 13% to 80% of total bottom cover, with the highest coverages observed in the middle to lower reaches below the Dutchman reservoir.

As mentioned above, riparian health assessments were performed to provide a current inventory and health evaluation of vegetation and soil/hydrology processes. Ideally, the RWRP Lotic Inventories will be performed on a periodic basis to gauge the success of the proposed restoration. As such, the health scores (70% not functioning, 30% at risk) derived in this study re-emphasize the need for habitat improvement in the basin and should help managers focus on areas of concern. Although the results of the health assessments are consistent with problem areas identified by the MDFWP, detailed information in the Lotic Inventory form, such as noxious weed infestation, shrub regeneration, and vegetation cover and type, should prove invaluable to managers developing the grazing management and riparian restoration plans on Lost Creek.

This project intended to link nutrient loads with land-use and grazing practices in the basin. Although the peak nitrogen levels measured at Stations 5-9 coincide with polygons exhibiting severely impaired riparian areas, it doesn't appear that grazing is the predominant factor influencing nutrients in this reach. As discussed above, high levels of nitrogen in the area of Dutchman reservoir appear to be influenced more by additions of flow from numerous potential sources than by the presence of cattle. However, it is likely that impairment of the riparian wetlands by grazing and flow manipulation may reduce nutrient trapping and uptake by riparian vegetation.

Although this discussion does not intend to critique proposed restoration work, several comments regarding its potential success should be noted. First of all, despite severe impacts from grazing on woody vegetation (and in some areas the complete absence of mature woody species), shrub regeneration was high for nearly all the polygons inventoried. This suggests a strong potential for relatively rapid re-establishment of mature woody vegetation through proposed management that would reduce grazing intensity and duration. Allowing mature vegetation to develop is likely to confer multiple benefits to water quality, such as moderating temperature by shading, increasing bank stability, and trapping sediments and nutrients. Periodic inventories, both for riparian health and water quality, may yield a closer relationship between land management and parameters such as nutrients, temperature and sediment. In this sense, the main value of riparian inventories on Lost Creek may lie in their continued application as a monitoring and adaptive management tool, which will be discussed further in the section on TMDL recommendations.

Recommendations for TMDL Development on Lost Creek

This discussion is not intended to represent an exhaustive set of TMDL recommendations, since much information is still unknown concerning the relationship between land-use and water quality in Lost Creek, particularly with respect to possible groundwater loads. Therefore, this discussion will evaluate the components of TMDL development for sediments and nutrients utilizing what information currently exists for TMDL decisions. In addition, specific recommendations for additional information and monitoring are discussed. The following questions will be addressed:

1) Are there sufficient credible data for beneficial use determinations?
2) What, if any, beneficial uses are impaired?
3) What are the causes and sources for impairment?
4) What are reasonable targets for water quality?
5) What actions are planned to address the problem?
6) What monitoring should be required?

Are there sufficient credible data for beneficial use determinations?

At the time of this writing, only the Lost Creek data collected from 1989-1991 were available to supplement water quality data collected in this study. Montana DEQ will only accept biological, not chemical, data over five years old as sufficient credible data. Guidelines for sufficient credible data and beneficial use support determinations are available from the Montana DEQ (**www.deq.state.mt.us**). However, water quality data gathered in this investigation meet minimum requirements for an acceptable level of information to make such determinations. Using impairment guidance, these 1999 Lost Creek data indicate a moderate impairment by nutrients at most sampled stations on Lost Creek. In addition, the assessments of stream and riparian health should also meet the minimum requirements to determine that the majority of stream reaches (>70%) are severely impaired by habitat alterations. However, additional information on the impairment of aquatic life support needs to be gathered to supplement these determinations in order to achieve a clear picture of the impairment. In this case, the DEQ should work with the MFWP to develop fishery guidelines, and the level of information required (i.e. # of assemblages, biotic indexes required).

Are beneficial uses impaired?

Currently, the beneficial uses of coldwater trout fishery, contact recreation, and aquatic life support are listed as moderately impaired over the lower 17 stream miles. At the present time the rationale for this determination is unclear, and the data supporting it is likely outdated. MT DEQ has re-issued the 303(d) list in April 2000 with significant changes in the priority level for TMDL development for Lost Creek. The 1998 303(d) list established a low priority rating for TMDL development for the lower 17 miles of Lost Creek. Based on a new scoring and evaluation method, the DEQ has raised Lost Creeks priority to the second highest priority stream in the Upper Clark Fork River, with a score of 52 points compared to 53 points for The Little Blackfoot River. However, the question remains whether Lost Creek is impaired by nutrients, given that there was very little observable algae growth in the creek, due mainly to insufficient rocky substrate for algae to attach. Abundant aquatic macrophytes were observed in the fine substrate found in the lower reaches. However, it should be determined if their growth constitutes nuisance levels by evaluating diel fluctuations in dissolved oxygen. Without further investigation, gauging impairment caused by elevated nutrients is problematic since the state of Montana has not formulated numeric criteria for nutrients. However, use impairment criteria assume that waters are moderately impaired for nutrients if levels exceed reference conditions by 200% and severely impaired above 400% of reference (MTDEQ, 1998). Although a reference stream was not identified for Lost Creek, several stations (5-9) exceeded background values (represented by upstream Station 1) for nitrate by 200%, and Dutchman Creek nitrate levels were in excess of 400% of Station 1 levels. Although it is unclear whether high nitrate levels impair beneficial uses in Lost Creek itself, TMDL development for nutrients should consider Lost Creek's contribution of total and soluble nitrogen to the Clark Fork River.

Habitat assessments indicate that 70% of the stream length surveyed is not functioning properly. The stream and riparian condition indicated by these surveys, in

conjunction with the MFWP observation of fishery impairment suggest that Lost Creek is impaired as a cold water fishery. Abundant sediment, eroding banks, fish barriers and sub-optimal spawning habitat all contribute to this determination. Whether aquatic life support is impaired depends on several factors. As mentioned above, sampling of diurnal dissolved oxygen levels is needed to determine if low DO conditions persist in Lost Creek as a result of nutrient enrichment and/or dewatering and lack of shade in lower reaches. In the event that DO levels threaten aquatic life in the lower part of Lost Creek, control of aquatic macrophytes could be incorporated into the TMDL taking into consideration all the possible factors that influence macrophyte growth.

What are the causes and sources for impairment?

Since TMDLs are required to establish all causes and sources for impairment, development of a TMDL for Lost Creek should focus on linking sources, or actions, or instream conditions to water quality impairments. This often represents the most difficult and resource consuming component of the TMDL process, particularly for systems impaired by nonpoint sources of pollutants and/or habitat alterations. In the case of nutrients, further study involving continuous temperature loggers and 24 hour DO surveys during critical midsummer conditions should determine whether or not aquatic plants in Lost Creek are responsible for diel fluctuations in dissolved oxygen which may impair aquatic life support. Once determined, the linkage between nutrient levels and their cause and sources can proceed. Quantifying the nutrient load contributed by land application of wastewater seems the higher priority than estimating the nutrient contribution from grazing practices, particularly since significant changes such as offsite watering, corral relocation are already underway to reduce grazing impacts. Conversely, impairment of habitat does not require further study and has obvious sources (eroding banks, lack of woody vegetation, etc.) and causes (cattle grazing, hydrologic modification, etc.). These components are therefore readily addressed through a phased management plan (explained below). Developing nutrient targets to control aquatic plants in Lost Creek would require additional modeling and sampling in the basin, particularly to gauge the influence of land application of wastewater and cattle grazing. Overall, restoring instream habitat and riparian habitat and addressing causes of their impairment are most important to a Lost Creek TMDL, while nutrients from Lost Creek are most relevant as a source to the Clark Fork River mainstem.

Although a strong linkage between water quality targets (or thresholds for maintaining use support) and pollutant sources or habitat degradation is a prerequisite for acceptable TMDLs, a phased approach which relies on adaptive management may be accepted by the EPA if reasonable effort is ongoing to establish these linkages and load allocations (USEPA, 1999a,b). Therefore, without sufficient site specific information to develop targets in advance of action, TMDL development can proceed with flexible targets that may change over time.

What are reasonable targets for water quality?

Once probable causes of water quality impairments are determined, ideally the level of pollution reduction or habitat restoration required to restore beneficial uses can be estimated to guide restoration actions. In the case of nutrients, load reductions and instream targets should be based on maintaining nutrient concentrations below the level that would stimulate aquatic plants to reach nuisance levels, interfering with beneficial uses, and/or depleting dissolved oxygen. Again, a study of this linkage is critical to developing a nutrient loading and instream targets for the Lost Creek TMDL. In the event that aquatic plants are not impairing Lost creek, the nutrient target for the Lost Creek TMDL should be set so as to meet the nutrient targets for the Upper Clark Fork River. Establishing a target of 300 ppb TN and 20 ppb TP for Lost Creek would be a reasonable step towards achieving the Clark Fork VNRP proposed 20% reduction in nonpoint sources. Achieving the Clark Fork VNRP targets in Lost Creek would represent a 36% reduction in nonpoint source of nitrogen to the Upper Clark Fork River mainstem. In the event that summer levels below 300 ppb TN cannot be maintained at the mouth of Lost Creek through reasonable land and water conservation practices then nutrient levels in Lost Creek may exceed Clark Fork targets, providing Lost Creek's load to the river doesn't significantly raise Clark Fork River concentrations below the mixing zone.

Sediment targets should be set to ensure fishery impairment is not resulting from increased bed load sedimentation. Based on the data from this study, TSS may not be a good indicator of sediment problems since stream flow alterations in Lost Creek moderate sediment in the water column. In Lost Creek, sediment targets could focus on bed load sediment in combination with targets for riparian and stream habitat. At present, MFWP estimates that approximately 4,000 cubic yards of sediment in excess of natural background erosion are being delivered to Lost Creek each year (Reiland, pers. comm.). The MFWP further estimates a reduction of 40% in delivery of sediment based on reductions in eroding stream bank and lateral migration of the stream channel. Since sediment loading appears to be dominated by bank instability, setting a target for sediment in terms of readily measured parameters of riparian habitat and stream health is perhaps the best approach. As in the case of the Deep Creek TMDL, reducing the percentage of eroding banks is a justifiable "good faith" approach in an adaptive management plan where numeric load allocations are substituted with effective management and stream restoration (EPA, 1999b). Therefore, targets for riparian health could be set to so that all polygons exhibit improvement in Lotic Inventory scores each year (or management be adapted to ensure their improvement) with all polygons scoring as fully functional at the end of 10-15 years.

It should be noted that, in the absence of point sources, TMDLs are still required to establish all load allocations for existing or future nonpoint sources including background levels, and integrate a margin of safety (EPA, 1999a,b). While a phased TMDL can establish general goals for nutrient and sediment loads, developing a load allocation for the land application of Anaconda's wastewater would be an integral part of the final TMDL. In order to accomplish this, several components should be added to the proposed restoration (see next section).

What actions are planned to address problems?

Table 1 summarizes the MDFWP proposed restoration and management plan for Lost Creek. Although intended for fishery enhancement, these actions are likely to confer multiple benefits to Lost Creek. These actions will be proposed as part of a phased approach TMDL and may require review and adaptation, as more information on their effectiveness for habitat improvement is made available. However, several necessary components of a acceptable TMDL must be developed in terms of water quality. Since the land application of Anaconda's wastewater represents a source of nutrients to the basin, a load allocation should be established for its contribution to Lost Creek. This can be achieved by developing a nutrient and water-use budget for the irrigated fields and using appropriate models (Leaching Index, NGLEAMS) in a irrigation management plan (USDA, 1999; EPA, 1997a,b). If the irrigated fields represent a source of nitrate to the groundwater, adjustments in irrigation practices can optimize water and nutrient availability for specific crop types. Depending on the magnitude of the nutrient load, simple irrigation management such as adjustment in frequency and duration could have a marked effect on meeting load allocations for nitrate. Perhaps the best opportunity for reducing Lost Creek's nutrient loading to the Clark Fork River is the application of Anaconda's municipal wastewater over a greater acreage to reduce seepage from the storage ponds and infiltration basins and leaching to groundwater from over-fertilized and over-watered soils.

What monitoring should be required?

Monitoring ground and surface water could be limited to monthly sampling during the spring and summer months (April-August) at a few selected sites that would capture the influences of various sources on the concentrations of nutrients and loads in Lost Creek. Sampling for the parameters in this study, future monitoring should include Stations 2, 6, 8 and 9, since these sites bracket important areas of potential loading and demonstrated the peak values for TP (Station 2), TN and nitrate (Station 6) and TN load (Station 8). Station 9 would be needed to estimate loads and concentrations relative to the Clark Fork River. In addition, nocturnal measurements of dissolved oxygen in the lower reaches (between stations 7 and 9) should be performed to determine whether aquatic macrophytes are impairing uses. It is also recommended that temperature data loggers be installed at a number of points to measure differences in temperature between sites and long term changes in Lost Creek.

After the influence of groundwater on Lost Creek is determined, groundwater monitoring may be warranted if nitrate originating from land application of wastewater represents a major source to the system. In the event that nitrate in groundwater exceeds drinking water standards, a well monitoring program should also be included.

Since the main focus of the restoration work planned by the MFWP is intended to improve the fishery in Lost Creek, a suitable biological monitoring plan should be implemented. Since the biological integrity of the Lost Creek fishery is beyond the scope

of this study, no specific recommendations are offered on monitoring these parameters. However, monitoring should be coordinated between the MDFWP and the MDEQ in order to establish an acceptable level of information for future beneficial use support determinations.

Monitoring of riparian habitat and stream health should be performed on a yearly basis. Since the longer Lotic Inventory used in this study is time consuming, it may be reserved for less frequent assessments (~3-5 years) while relying on a shorter version of the inventory for intervening years. Photo documentation and GPS should be used to map and track areas of particular interest, such as severe lateral movement, down cutting, and stream braiding. In general, riparian assessment may prove to be the most powerful monitoring tool in a phased or adaptive management TMDL which is based on targeting a response of habitat improvement.

The restoration work proposed by the MT FWP and NRCS has organized the majority of the stakeholders in the Lost Creek basin, and therefore has satisfied one of the most important ingredients to TMDL development for nonpoint source nutrient pollution - volunteer participation in a basin-wide restoration plan. Ultimately, watershed restoration efforts in small watersheds should concentrate on developing the willingness of landowners to undertake land and water conservation measures likely to improve water quality, rather than developing elaborate and expensive modeling and monitoring plans. In addition, stakeholders in Lost Creek and other tributaries to the Clark Fork River should seek to integrate sub-watershed TMDLs with the Clark Fork VNRP in order to achieve the desired 20% decrease in their nonpoint nutrient contributions.

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Table 1. Summary of channel conditions and proposed restoration by stream reach.

Landowner	Stream Miles	Cattle Nos.	Eroding Banks %	Channelized Length (ft)	Poorly Vegetated % (miles)	Restoration Information (stream feet)
Multiple Landowners (EPA/ARCO Reclamation)	5.5	?	Not Measured	Not Measured	40% (2.2)	Upland soil amendments, revegetation and sediment control
Derzay	0.75	?	10%	Unknown	15% (0.1)	Fish Passage
Ueland	6.1	1780	45-50%	6860	65% (4.0)	Fish passage, off-site water, coral relocation, habitat improvement (15,000'), channel relocation & reconstruction (3,180')
Heggelund	6.5	210	40%	1620	100% (6.5)	30 NRCS conservation easement on 609 riparian/wetland acres, habitat improvement (12,200')
Lord	4.4	125	55-60%	2920	100% (4.4)	Channel reconstruction (2900'), habitat improvement (10,100')
Mathews	0.75	78	25%	0	35% (3.6)	Repair irrigation headgate, habitat improvement (3,100')
Lamperts	3.6	520	100%	19,000 dry channel, irrigation	100% (3.6)	Channel reconstruction (19,000')
TOTAL	27.6	2713	N/A	34,000'	76% (21.1)	65,480'

Source: Montana Department of Fish Wildlife and Parks

Table 2. Summary of physical data from Lost Creek, May-August 1999.

STATION		Discharge (cfs)	Temperature (C)	pH	Turbidity	TSS (mg/l)
1.0	Mean	39	7.4	7.9	.7	2.4
	Min.	16	2.5	7.6	.4	.2
	Max.	75	12.1	8.3	1.4	6.5
2.0	Mean	14	11.0	8.2	1.5	48.7
	Min.	4	6.0	7.7	.9	8.6
	Max.	35	15.4	8.8	3.0	173.3
3.0	Mean		10.9	8.3	2.5	12.1
	Min.		4.5	7.7	1.6	2.7
	Max.		15.1	8.8	3.4	42.2
4.0	Mean	9	11.2	8.2	1.5	9.5
	Min.	6	4.5	7.8	.6	4.2
	Max.	18	16.0	8.5	2.1	20.4
5.0	Mean		11.0	7.8	1.4	16.4
	Min.		7.0	7.8	1.3	8.7
	Max.		15.0	7.8	1.5	24.0
6.0	Mean		13.4	7.7	1.3	
	Min.		9.0	7.6	1.2	
	Max.		16.2	7.9	1.4	
7.0	Mean	11	14.2	8.2	1.7	11.4
	Min.	3	7.0	7.8	.4	.8
	Max.	20	18.1	8.4	5.5	31.8
8.0	Mean	28	14.1	8.1	2.6	9.6
	Min.	17	7.5	7.5	.7	.6
	Max.	45	20.1	8.4	14.0	45.1
9.0	Mean	15	17.1	8.3	3.6	11.7
	Min.	6	7.5	7.6	1.0	.4
	Max.	30	24.0	8.7	18.0	44.6

Table 3. Summary of nutrient data from Lost Creek, May-August, 1999.

STATION		TKN (mg/l)	Nitrate (mg/l)	TN (mg/l)	SRP (mg/l)	TP (mg/l)	TN LOAD (kg/day)	TP LOAD (kg/day)
1	Mean	.172	.021	.192	.003	.009	23	1
	Min.	.050	.005	.055	.001	.004	2	0
	Max.	.380	.060	.385	.005	.014	60	1
2	Mean	.145	.018	.163	.009	.024	6	1
	Min.	.047	.005	.055	.004	.014	1	0
	Max.	.280	.040	.310	.019	.053	25	4
3	Mean	.256	.009	.265		.016		
	Min.	.050	.005	.055		.006		
	Max.	.430	.020	.435		.027		
4	Mean	.187	.008	.194	.005	.016	5	0
	Min.	.050	.005	.055	.001	.009	1	0
	Max.	.440	.020	.450	.013	.026	12	1
5	Mean	.245	.370	.615	.009	.015		
	Min.	.200	.320	.520	.004	.011		
	Max.	.290	.420	.710	.014	.019		
6	Mean	.363	.588	.950		.007		
	Min.	.140	.500	.690		.002		
	Max.	.860	.720	1.360		.010		
7	Mean	.166	.418	.584	.004	.011	17	0
	Min.	.028	.230	.430	.001	.005	4	0
	Max.	.300	.610	.710	.005	.016	30	1
8	Mean	.260	.284	.545	.004	.016	37	1
	Min.	.050	.170	.220	.001	.006	12	0
	Max.	.850	.380	1.180	.006	.047	81	3
9	Mean	.290	.179	.469	.004	.012	19	0
	Min.	.120	.030	.240	.003	.004	4	0
	Max.	.470	.550	.740	.005	.017	49	1

Table 4. Nutrient comparisons between Lost Creek and Clark Fork River

Clark Fork River below Warm Springs									
1989	SRP (mg/l)	TP (mg/l)	Nitrate (mg/l)	TKN (mg/l)	TN (mg/l)	Discharge (cfs)	TN Load (kg/day)	TP Load (kg/day)	Nitrate Load (kg/day)
Mean	0.014	0.057	0.046	0.500	0.546	137	172	18	15
Max.	0.027	0.079	0.070	1.300	1.340	219	498	36	22
Min.	0.003	0.028	0.030	0.200	0.230	30	47	6	2
1990									
Mean	0.027	0.053	0.032	0.400	0.432	111	111	13	9
Max.	0.053	0.077	0.050	0.500	0.510	238	244	25	20
Min.	0.017	0.038	0.010	0.300	0.350	23	29	3	1
1999									
Mean	0.011	0.037	0.060	0.222	0.282	226	160	21	39
Max.	0.019	0.066	0.100	0.380	0.450	373	301	43	91
Min.	0.003	0.011	0.030	0.130	0.160	87	34	2	6
Lost Creek at Frontage									
1989	SRP (mg/l)	TP (mg/l)	Nitrate (mg/l)	TKN (mg/l)	TN (mg/l)	Discharge (cfs)	TN Load (kg/day)	TP Load (kg/day)	Nitrate Load (kg/day)
Mean	0.006	0.023	0.110	0.486	0.596	15	31	1	6
Max.	0.017	0.036	0.300	1.300	1.600	35	138	3	26
Min.	0.002	0.013	0.010	0.200	0.220	2	1	0	0
1990									
Mean	0.005	0.014	0.104	0.283	0.388	12	12	0	4
Max.	0.008	0.019	0.280	0.300	0.580	24	23	1	11
Min.	0.003	0.010	0.005	0.200	0.305	5	4	0	0
1999									
Mean	0.004	0.012	0.179	0.290	0.469	15	19	0	9
Max.	0.005	0.017	0.550	0.470	0.740	30	49	1	40
Min.	0.003	0.004	0.030	0.120	0.240	6	4	0	1

Table 5. Riparian Health Summary for the Ueland Ranch, Lost Creek

Polygon	Vegetation Rating	Soil / Hydrology Rating	Overall Rating	Descriptive Category	Problem Summary
1	70.8	83 3	78.3	Functional At Risk	Invasive Weeds Exposed soil
2	66.7	61.1	63 3	Functional At Risk	Invasive Weeds, Exposed Soil Dead/decadent woody material, Lateral Cutting
3	58 3	55.6	56.7	Non-Functional	Invasive Weeds, Exposed Soil, Undesirable Cover, Dead/decadent woody material, Lateral Cutting
4	70.8	61.1	65	Functional At Risk	Invasive Weeds, Exposed Soil Dead/decadent woody material, Lateral Cutting, High Tree/Shrub Utilization
5	52 4	44.4	47.3	Non-Functional	Invasive Weeds, Exposed Soil, Low Total Cover High Tree/Shrub Utilization, Lateral Cutting
6	71 4	83.3	78 9	Functional At Risk	Invasive Weeds, Exposed Soil High Tree/Shrub Utilization
7	57.1	72.2	66.7	Functional At Risk	Invasive Weeds, Undesirable cover, High Tree/Shrub Utilization
8	61.9	50	54.4	Non-Functional	Invasive Weeds, Exposed Soil, High Tree/Shrub Utilization, Lateral Cutting, Channel Incisement
9	52.4	44.4	47.4	Non-Functional	Invasive Weeds, Exposed Soil, Lateral Cutting, High Tree/Shrub Utilization, Low Total Cover, Low Deep Binding Rootmass
10	42 9	33.3	36.8	Non-Functional	Invasive Weeds, Exposed Soil, Undesirable Cover, Lateral Cutting, High Tree/Shrub Utilization, Low Deep Binding Rootmass, Channel Incisement
11	47.6	44 4	45.6	Non-Functional	Invasive Weeds, Exposed Soil, Lateral Cutting, High Tree/Shrub Utilization, Undesirable Cover, Channel Incisement
12	52 4	50	50.9	Non-Functional	Invasive Weeds, Exposed Soil, Lateral Cutting, High Tree/Shrub Utilization, Undesirable Cover, Channel Incisement
13	61.9	50	54.4	Non-Functional	Invasive Weeds, Exposed Soil, Lateral Cutting, High Tree/Shrub Utilization,
14	57.1	61.1	59.6	Non-Functional	Invasive weeds, Exposed Soil, Undesirable Cover, Lateral Cutting, High Tree/Shrub Utilization
15	52.4	61.1	57.9	Non-Functional	Invasive Weeds, Exposed Soil, High Tree/Shrub Utilization, Lateral Cutting
16	57.1	50	52.6	Non-Functional	Invasive Weeds, Exposed Soil, Undesirable Cover, Lateral Cutting, High Tree/Shrub Utilization, Low Deep Binding Rootmas
17	61.9	50	54.4	Non-Functional	Invasive Weeds, Exposed Soil, High T/S Utilization Lateral Cutting, Low Deep Binding Rootmas

Table 6. Riparian Health Summary for Lost Creek (Heggelund Ranch)

Polygon	Vegetation Rating	Soil / Hydrology Rating	Overall Rating	Descriptive Category	Problem Summary
18	71 4	66 7	68 4	Functional At Risk	Invasive Weeds, Lateral Cutting
19	57 1	66.7	63.2	Functional At Risk	Invasive Weeds, Low Woody Cover, High Tree/Shrub Utilization, Lateral Cutting, Low Deep Binding Rootmass
20	57.1	38.9	45 6	Non-Functional	High Tree/Shrub Utilization, Low Woody Cover, Lateral Cutting, Low Deep Binding Rootmass, Low Total Cover, Exposed Soil
21	57 1	50	52.6	Non-Functional	Invasive Weeds, High Tree/Shrub Utilization, Low Woody Cover, Lateral Cutting, Low Deep Binding Rootmass, Exposed Soil
22	47.6	44.4	45.6	Non-Functional	Invasive Weeds, High Tree/Shrub Utilization, Low Woody Cover, Lateral Cutting, Low Deep Binding Rootmass, Low Total Cover, Exposed Soil

Table 7. Riparian Health Summary for Lost Creek (Lord Ranch and Matthews Ranch*)

Polygon	Vegetation Rating	Soil / Hydrology Rating	Overall Rating	Descriptive Category	Problem Summary
23	61 9	66.7	64.9	Functional At Risk	Invasive Weeds, High Tree/Shrub Utilization, Lateral Cutting
24	57.1	44.4	49.1	Non-Functional	Invasive weeds, High Tree/Shrub Utilization, Undesirable Cover, Exposed Soil, Lateral Cutting, Low Deep Binding Rootmass
25	42 9	50	47.4	Non-Functional	Invasive Weeds, High Tree/Shrub Utilization, Low Woody Cover, Low Total Cover, Low Deep Binding Rootmass, Exposed Soil, Channel Incisement
26*	47.6	38.9	42.1	Non-Functional	Invasive Weeds, High Tree/Shrub Utilization, Low Woody Cover, Low Total Cover, Low Deep Binding Rootmass, Exposed Soil,

Fig. 1. Mean discharge in Lost Creek, May-Aug. 1999

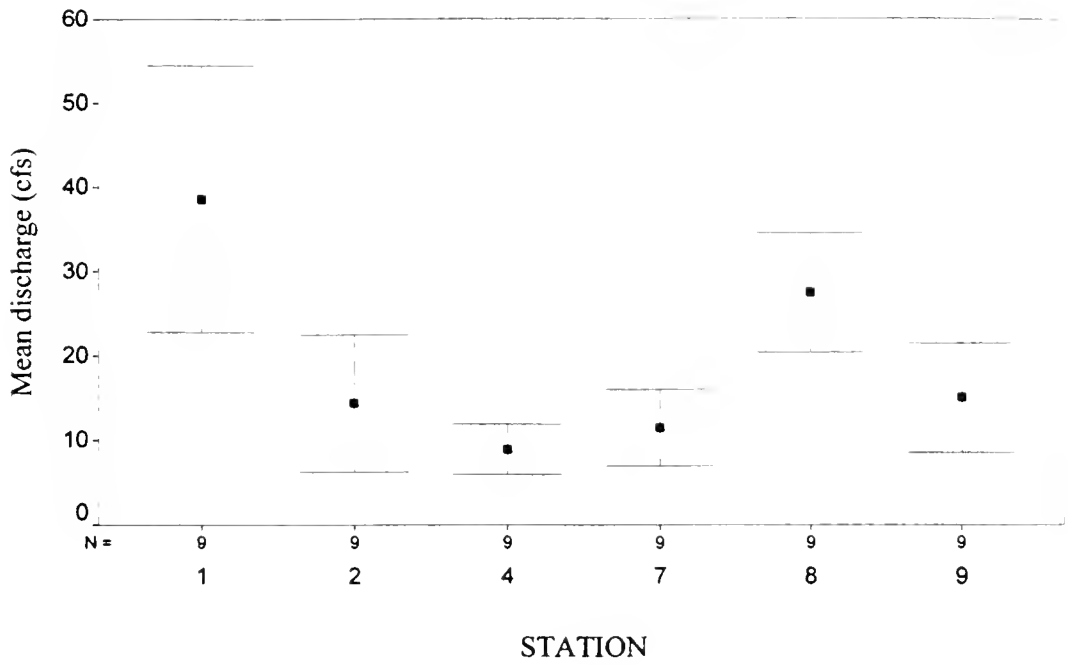


Fig. 2. Mean temperature in Lost Creek, May-Aug. 1999

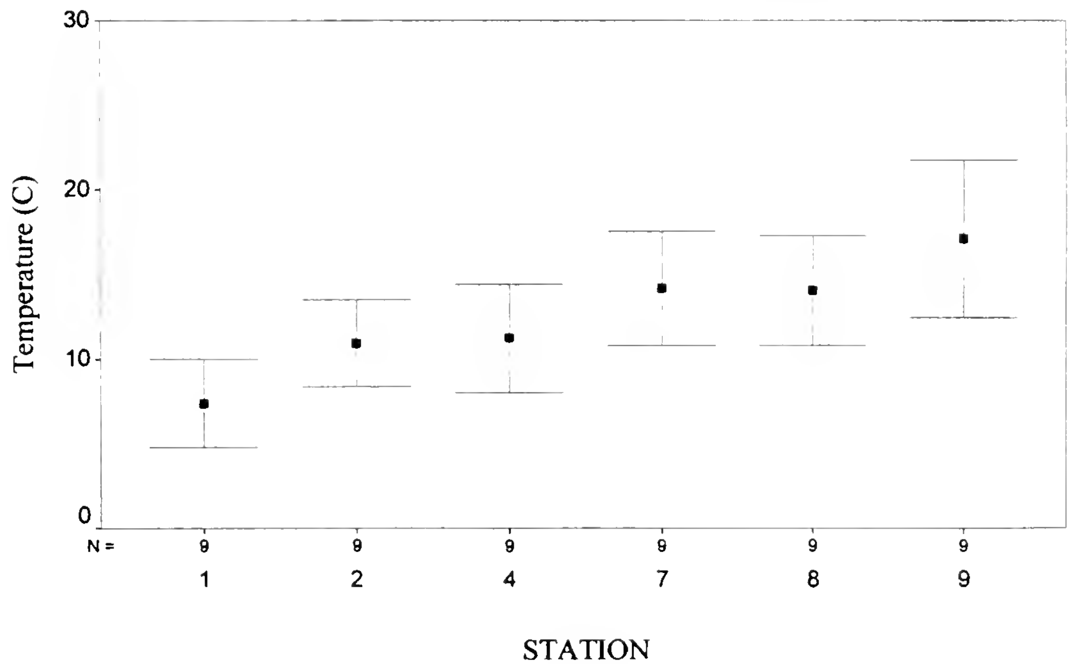
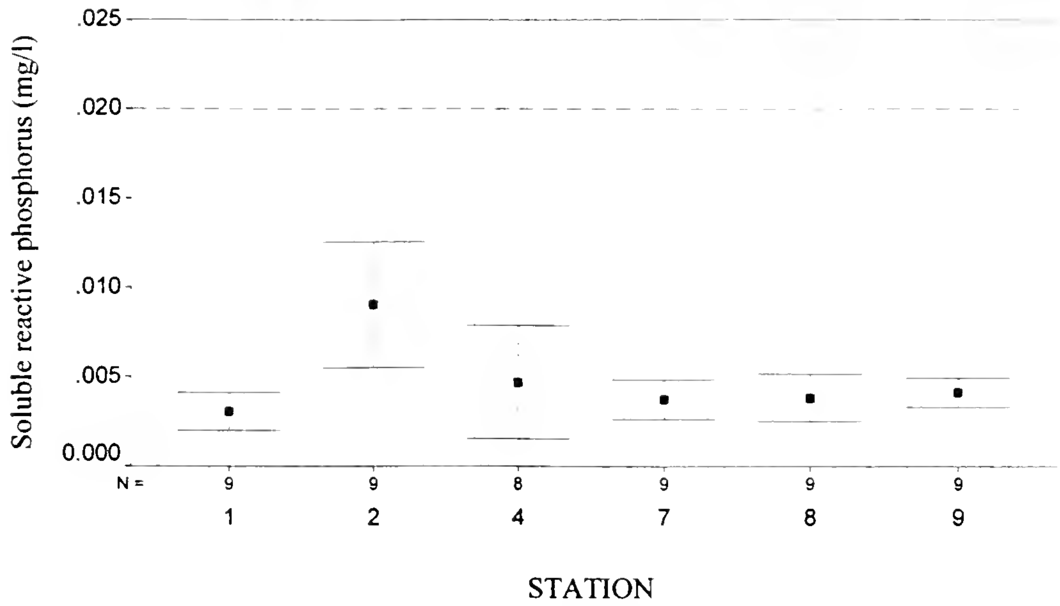
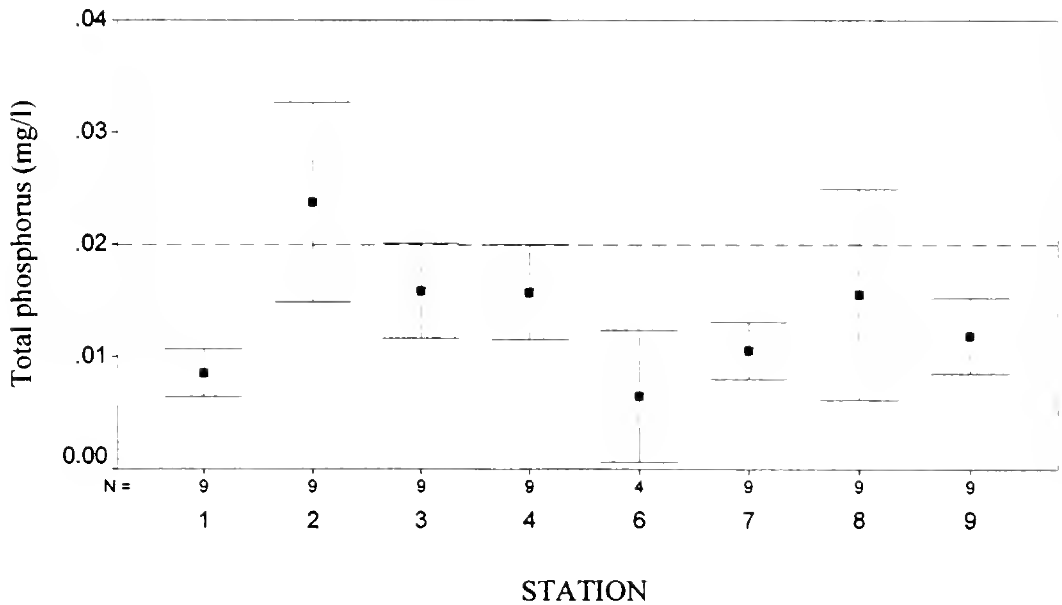


Fig. 3. Mean SRP in Lost Creek, May-Aug. 1999



Dotted line represents VNRP target of 20 ppb TP

Fig. 4. Total phosphorus in Lost Creek, May-Aug. 1999



Dotted line represents the VNRP target of 20 ppb TP

Fig. 5. Total phosphorus load in Lost Creek, May-Aug. 1999

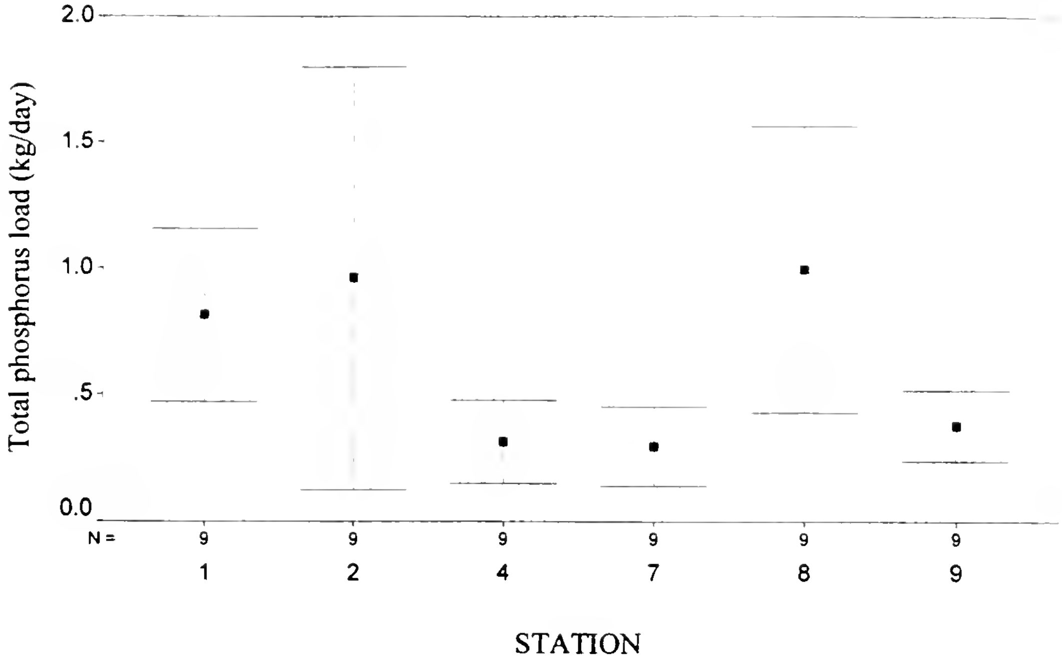
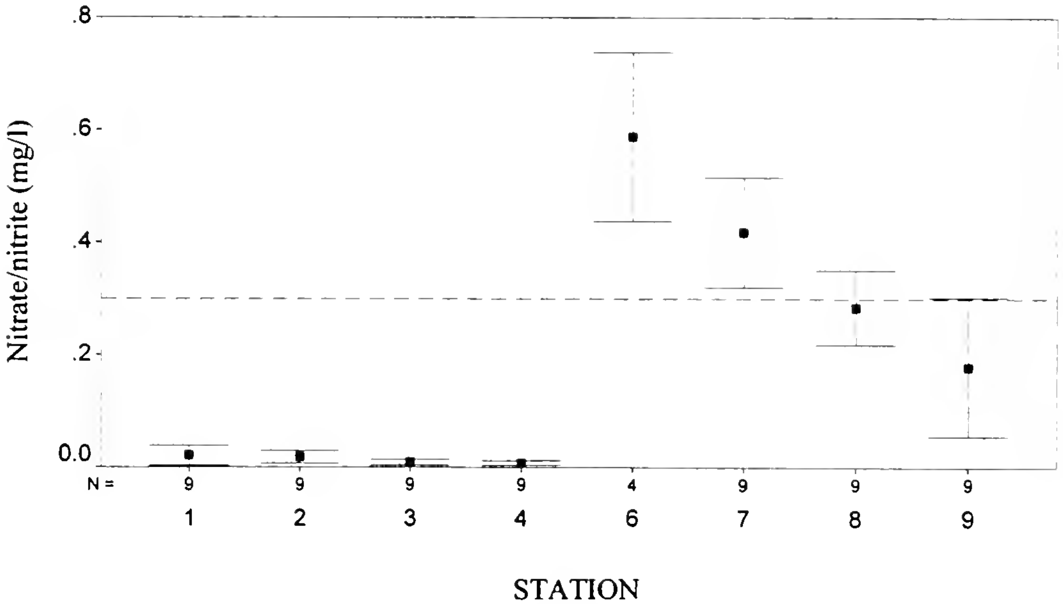
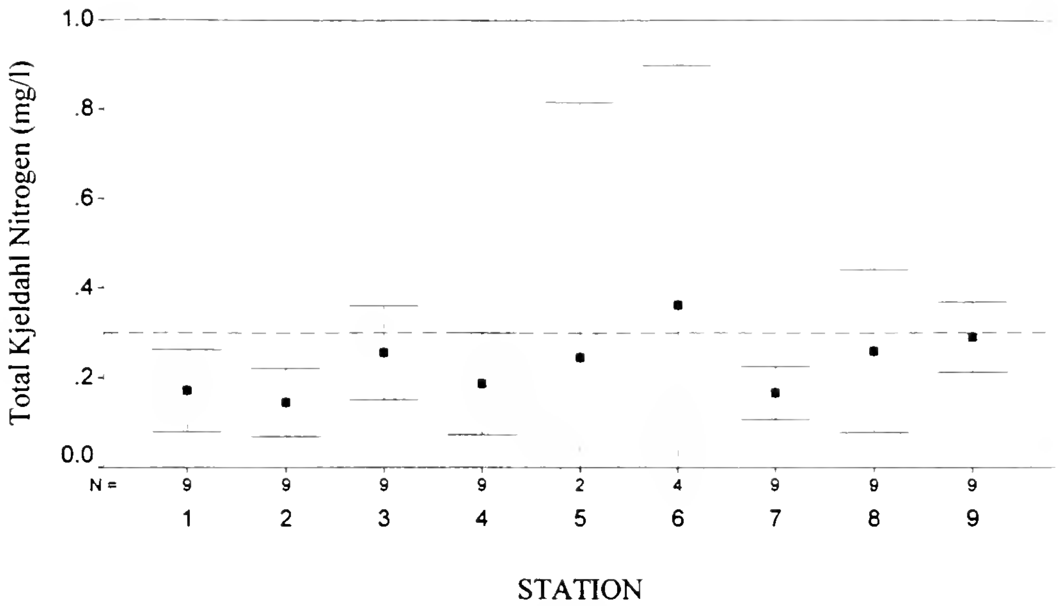


Fig. 6. Mean nitrate/nitrite in Lost Creek, May-Aug. 1999



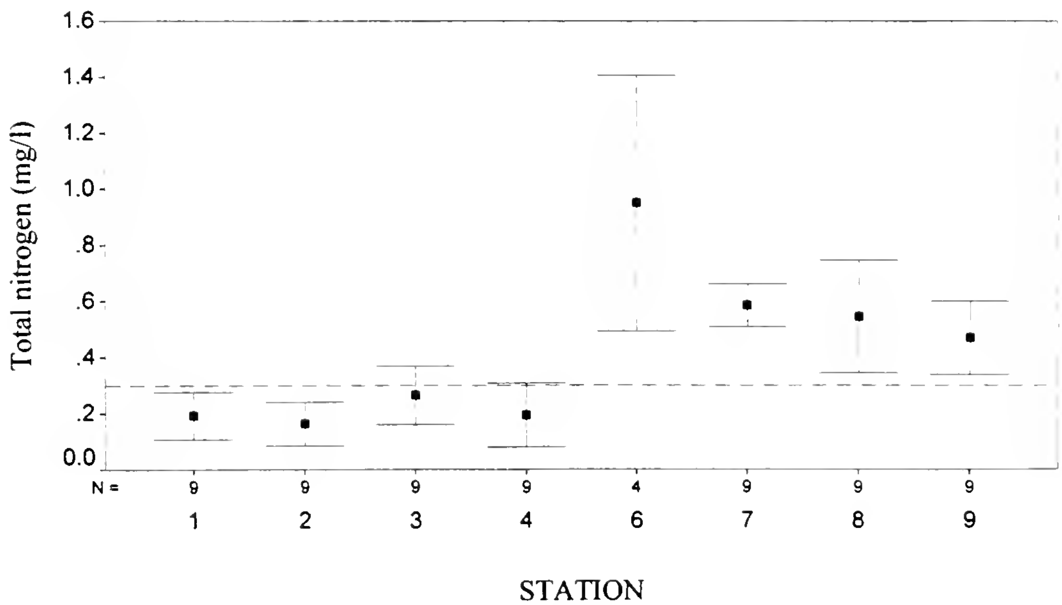
Dotted line represents the VNRP target of 300 ppb TN

Fig. 7. Total Kjeldahl nirtogen in Lost Creek, May-Aug. 1999



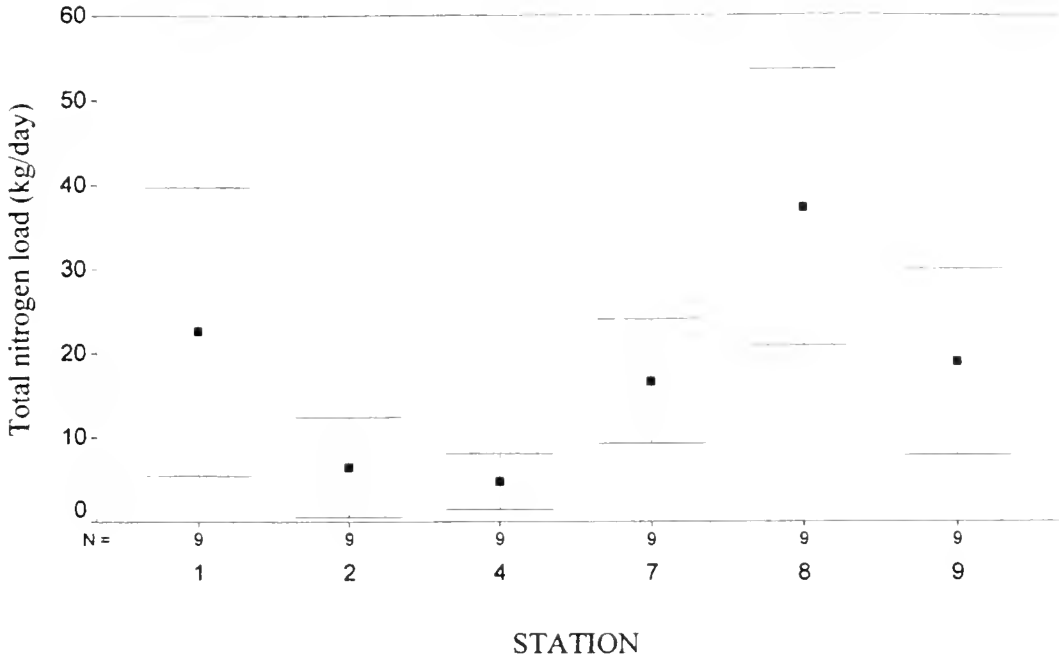
Dotted line represents the VNRP target of 300 ppb TN

Fig. 8. Total nitrogen in Lost Creek, May-Aug. 1999

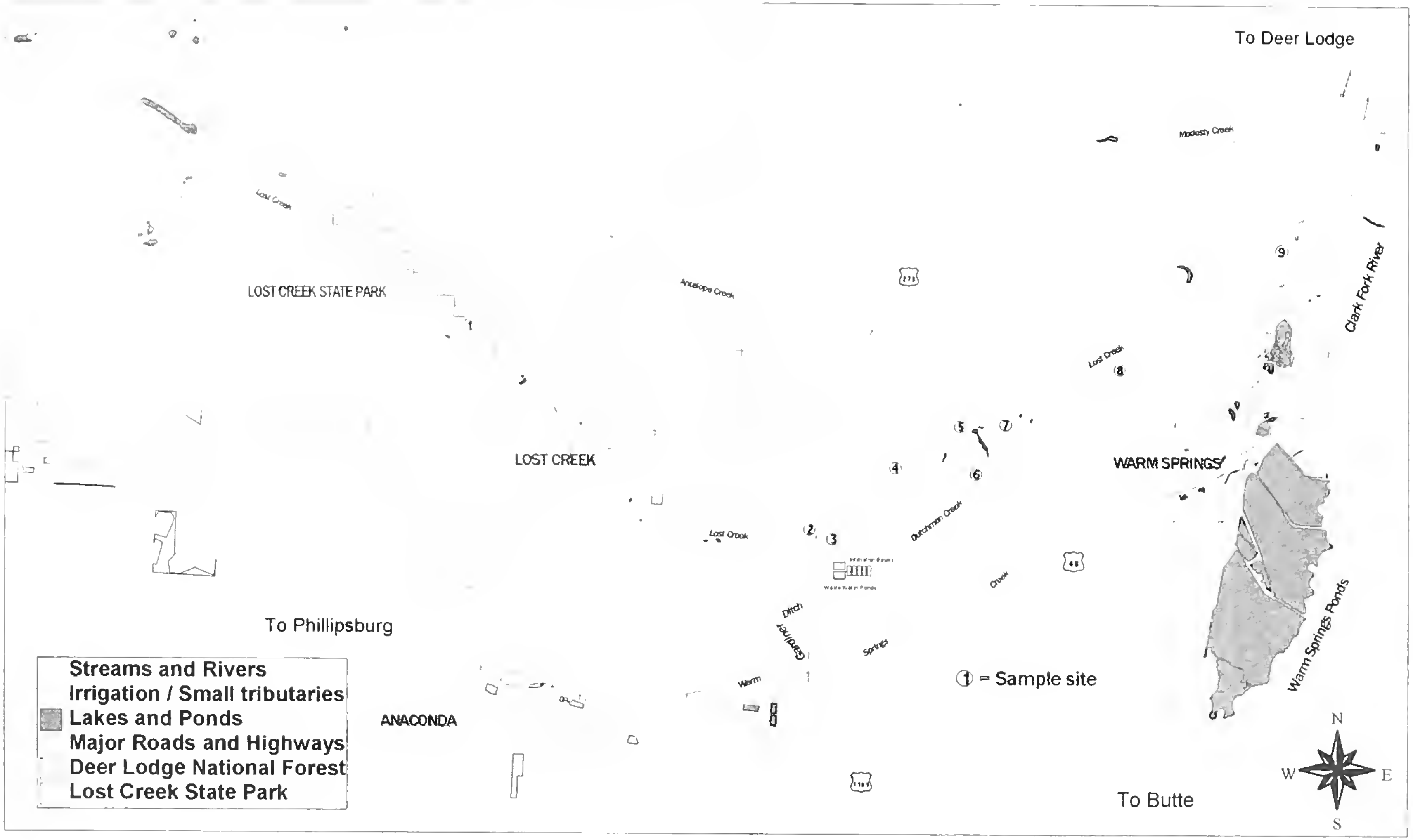


Dotted line represents the VNRP target of 300 ppb TN

Fig. 9. Total nitrogen load in Lost Creek, May-Aug. 1999



Map 1. Lost Creek Nutrient Study Area



Map 2. Location of sample sites and riparian inventory polygons.