Appendix H

Supplemental Monitoring and Assessment Strategy

Framework Water Quality Restoration Plan and Total Maximum Daily Loads (TMDLs) for the Lake Helena Watershed Planning Area:

Volume II – Final Report

August 31, 2006

Prepared for the Montana Department of Environmental Quality

Prepared by the U.S. Environmental Protection Agency,
Montana Operations Office
With Technical Support from Tetra Tech, Inc.
and PBS&J, Inc.

Project Manager: Ron Steg

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1.0 INTRODUCTION

This supplemental monitoring and assessment strategy presents an overview of future monitoring needs in the Lake Helena watershed that have been identified during the development of the draft water quality restoration plan and TMDLs. The monitoring strategy is described in general terms at this time, and a more detailed Sampling and Analysis Plan (SAP) should be developed during the implementation phase of the TMDL. Focused monitoring and assessment efforts are needed to fulfill three primary goals:

- Obtain additional data to address information gaps and uncertainty in the current analysis (data gaps monitoring and assessment)
- Ensure that identified management actions are undertaken (implementation monitoring)
- Ensure that management actions are having the desired effect (effectiveness monitoring)

Data gaps monitoring and assessment needs are described in Section 2.0, and implementation and effectiveness monitoring are presented in Sections 3.0 and 4.0, respectively. Specific sampling and analysis methods are described in more detail in Section 5.0.

2.0 DATA GAPS MONITORING AND ASSESSMENT

Monitoring to fill data gaps and improve certainty in the assumptions applied within the Lake Helena water quality restoration plan is the highest priority because these data are needed to confirm the appropriateness of specific restoration measures. For example, only interim nutrient targets have been established for the streams in the Lake Helena watershed due to uncertainties associated with specific impairment thresholds, as well as the technical and economic feasibility of attaining the proposed in-stream targets. Similarly, nutrient targets have not yet been selected for Lake Helena due to limited water quality data and an incomplete understanding of the inter-relationships between Lake Helena and Hauser Reservoir. Limited recent data have also precluded a complete understanding of metals and temperature impairments for some stream segments. Additional monitoring and assessment is therefore needed to address these and other data gaps and should include the following:

- *Watershed Hydrology and Groundwater/Surface Water Interactions* - Additional investigation is needed to more fully understand surface water/groundwater inter-relationships in the Lake Helena watershed and to discern the effects of various water management practices on surface water quality. Specific needs include a water balance study for the Helena Valley portion of the watershed to examine the effects of inter-basin transfers (Missouri River via the Helena Valley Irrigation District), surface water withdrawals, storm water and wastewater discharges, gains and losses from groundwater, and flow reversal from Hauser Reservoir to Lake Helena. A focused study is also needed to evaluate natural and artificial sources of groundwater recharge in the Helena Valley, including canal losses, storm water discharges, individual and community septic systems, irrigated fields, and their implications to ground and surface water quality.

- *In-stream Nutrient Target Setting and Source Assessment* - Additional monitoring is needed to understand the relationships between in-stream nutrient concentrations and beneficial use impairments in the Prickly Pear and Tenmile Creek drainages. Furthermore, some data gaps remain with regard to identifying specific sources of nutrient loading, particularly in lower Prickly Pear Creek.

- *Lake Helena and Hauser Reservoir Nutrient Dynamics and Target Setting* – Recent water quality and limnological data for Lake Helena and the Causeway Arm of Hauser Reservoir are extremely limited. Seasonal, multi-year data are needed to more fully document present conditions, to refine a nutrient loading/lake response model, to understand water quality and hydrologic relationships between Lake Helena and Hauser Reservoir, and to provide a basis for nutrient target setting.

- *Metals Impairment Confirmation and Source Assessment* - Additional metals data are needed for some segments to confirm and define suspected impairments, and to help characterize the magnitude and seasonality of contributing source areas.

- *Temperature* – Factors contributing to temperature impairments in Prickly Pear Creek are not well understood due to limited data. Specifically, the influences of irrigation water withdrawals, groundwater/surface water interactions, wastewater discharges, riparian vegetation, and stream channel characteristics should be further quantified in order to allow fine-tuning of restoration prescriptions.

- *Modeling Tool Development* – The Lake Helena restoration plan recommends the development of modeling tools to help predict the water quality consequences of land use changes and various management measures (see Section 3.2.3.2 of Volume II). Additional data collection is recommended to support recalibration and fine-tuning of the existing watershed-scale nutrient loading and lake response models.

Plans for addressing each of these primary data deficiencies are described in more detail in the following paragraphs.

2.1 Watershed Hydrology and Groundwater/Surface Water Interactions

The hydrology of the Lake Helena watershed is relatively complex and is further complicated by intensive land and water management. Preliminary analyses have shown that the hydrology of the lower watershed is heavily influenced by the seasonal importation of Missouri River water via the Helena Valley Regulating Reservoir and the Helena Valley Irrigation Canal. Some of this imported water is directly discharged back to Lake Helena in the form of canal surplus water or irrigation return flows. Other portions enter the valley groundwater system through canal losses and from irrigated fields. At the same time, the lower reaches of Prickly Pear and Tenmile Creeks are seasonally dewatered because of irrigation, while Prickly Pear Creek is the receiving water body for several wastewater discharges. Hundreds of individual septic systems, storm water outfalls, canals and ditches, and irrigated fields discharge water to the Helena Valley aquifer, and an extensive network of tile drains throughout the valley artificially lowers the elevation of the shallow groundwater and discharges the drainage directly to Lake Helena. To further complicate matters, evidence suggests that where Lake Helena discharges to Hauser Reservoir at the Lake Helena Causeway, flow direction sometimes reverses depending upon the operation of Hauser Dam and/or the magnitude of local storm/runoff events. Understanding how water moves through the watershed on a seasonal and annual basis, and how groundwater and surface waters interact, is a critical first step in managing for improved water quality.

This study element would establish a water balance for the Helena Valley portion of the Lake Helena watershed. A comprehensive flow gaging network would be established on lower Prickly Pear and Tenmile creeks, in various canals and ditches, and at the Lake Helena Causeway. Irrigation diversions and wastewater discharges would also be monitored, either directly or through permit and water rights records. A series of flow recorders (Aquarods) would be installed at strategic locations and surface flows would be gaged periodically over the course of several years representing wet and dry conditions. The temporal and spatial extent of stream dewatering and points of irrigation withdrawal would be documented. An additional study element would evaluate and quantify the potential water quality benefits that could accrue from supplementing chronically low summer stream flows in lower Prickly Pear and Tenmile Creeks. We will also support the Lewis and Clark County Water Quality Protection District's continuing efforts to fund and initiate a groundwater monitoring program in the Helena Valley for purposes of identifying and quantifying sources of recharge and to help define groundwater/surface water interactions. The ultimate goal of this monitoring element is to improve our understanding of basin hydrology and to provide a basis for fine-tuning watershed models and predictive capabilities.

2.2 In-stream Nutrient Target Setting and Source Assessment

To better understand the relationship between in-stream nutrient concentrations, benthic algae, and dissolved oxygen (DO) levels in lower Prickly Pear Creek, water quality data should be collected to support the development of a more refined water quality model. Options include using the existing LSPC modeling framework (i.e., using/refining the LSPC model that has been set up for the metals analysis) or a steady-state dissolved oxygen model such as QUAL2K. Setting up and calibrating nutrient/DO models typically require data that describe physical channel characteristics and in-stream processes that control DO concentrations. Two intensive water quality surveys and two hydraulic studies (transect measurements and dye studies) are proposed during two different flow/temperature conditions in order to provide the necessary data. Proposed monitoring stations are listed below and study elements are described in the paragraphs that follow:

- City of Helena wastewater treatment plant (WWTP) effluent ditch at confluence with Prickly Pear Creek
- Prickly Pear Creek immediately upstream of City of Helena WWTP
- Prickly Pear Creek immediately downstream of City of Helena WWTP
- Prickly Pear Creek below confluence with Tenmile Creek
- Prickly Pear Creek at Lake Helena

2.2.1 Hydraulic Studies

Hydraulic studies are required to estimate the velocity of Prickly Pear Creek throughout the study area. Physical channel measurements (cross sections and longitudinal profiles) should be performed at transects throughout the study area to determine the physical channel dimensions. Additionally, dye studies should be performed to estimate stream velocities for use in the estimation of flow/velocity relationships and prediction of travel times. Distribution of dye concentrations will help calculate longitudinal dispersion while peak-to-peak time will support velocity estimates. Two separate dye sampling events should be performed to estimate the velocities under two flow regimes (snowmelt runoff and summer low flow). The timing of these studies would require that no significant rainfall events (> 0.5 inches) have occurred in the previous seven days, and the creek has reached steady state flows during the sampling period. Daily flow measurements should also be recorded for Tenmile and Prickly Pear creeks during the studies.

2.2.2 General Water Quality Characterization

Field sampling for general water quality parameters (temperature, pH, conductivity, DO, streamflow) should be performed at all transect locations, intensive survey sites, and at the mouth of significant tributaries to Prickly Pear Creek. Sampling will be performed using handheld instruments and all pertinent data will be recorded in a field log. Data from this sampling effort would be used to characterize the overall water quality in the study area and to identify changes in water quality that would indicate previously unidentified pollutant sources. Streambed descriptions of channel roughness, available area for plant growth (%), sediment thickness, percent sediment/silt coverage, and percent cloud cover and shade cover should also be recorded.

2.2.3 Dissolved Oxygen Sag Point Analysis

The point in a stream below a wastewater discharge where in-stream dissolved oxygen concentrations reach their lowest level is referred to as the DO sag point. Field measurements can be used to identify the location of the sag point and to determine the distance required for the dissolved concentrations to return to ambient levels. Field results for general water quality parameters should be collected at several locations (approximately every 250 meters) in the section of Prickly Pear Creek between the City of Helena wastewater outfall and the Tenmile Creek confluence. These data would be used to support the model calibration/validation efforts and would provide a basis for assessing model accuracy for critical in-stream locations.

2.2.4 Detailed Water Quality Characterization (Intensive Survey)

Detailed intensive surveys are required to gain a more complete understanding of water quality conditions in Prickly Pear Creek. These surveys would combine field observations with the collection of water samples for analysis of parameters such as ammonia and biological oxygen demand in order to characterize the effects of oxygen demanding wastes. Two separate intensive sampling events are recommended to provide a detailed understanding of in-stream water quality. As with the hydrologic studies, timing would require that no significant rainfall events (> 0.5 inches) have occurred in the previous seven days, and that the creek has reached steady state flows during the sampling period.

Sediment samples should also be collected for analysis. These samples will be analyzed for sediment composition (sand, silt, and clay fractions) and total organic content for comparison with the sediment oxygen demand component in the model.

The intensive surveys should consist of field measurements as well as the collection of water quality samples for lab analysis (Table 2-1). Field measurements would include the same general water quality monitoring to be performed at the transect locations as well as diel (24-hour) monitoring of DO at a location near the observed maximum in-stream sag. This diel survey would be used to characterize the rates and extent of DO and pH fluctuations downstream of the City of Helena wastewater outfall.

Table 2-1. Prickly Pear Creek nutrient/DO intensive survey parameter list.

Variable	Number of Surveys	Sampling Frequency	Sampling Locations
Temperature	2	4/Day	All
Dissolved Oxygen	2	4/Day	All (plus diel study)
Conductivity	2	4/Day	All
pH	2	4/Day	All
Sediment Composition	2	1/Day	All
$CBOD_5$ (Filtered)	2	4/Day	All
$CBOD_5$ (Unfiltered)	2	2/Day	All
$CBOD_{20}$ (Filtered)	2	4/Day	All
$CBOD_{20}$ (Unfiltered)	2	2/Day	All
BOD_{20}	2	2/Day	All
Kjeldahl-N	2	2/Day	All
NH_3	2	4/Day	All
NO_3	2	4/Day	All
NO_2	2	2/Day	All
TSS	2	2/Day	All
VSS	2	2/Day	All
TOC	2	4/Day	All
Total Phosphorus	2	2/Day	All
Orthophosphorus	2	2/Day	All
Macrophytes	2	2/Day	All
Benthic Chlorophyll *a*	2	2/Day	All

2.2.5 Nutrient Source Assessment Monitoring

Existing monitoring data that can be used to identify specific nutrient sources in lower Prickly Pear Creek are limited. In many cases, monitoring stations bracketed long reaches of the creek and assumptions have been made about the nature of sources that are likely to be present between these stations. The City of Helena wastewater has traditionally been used to irrigate hay fields located to the west of Prickly Pear Creek during much of the summer season. As such, direct discharges to Prickly Pear Creek occur intermittently and at variable rates. Additionally, Prickly Pear Creek through its lower reaches receives tile drainage and groundwater discharge, and adjacent lands sustain a variety of uses that may contribute nutrients to the creek.

Synoptic surveys should be performed on a quarterly basis at a series of stations beginning at the Wylie Drive crossing just north of East Helena and continuing to Lake Helena. The surveys would document sequential nutrient loading from all sources through this segment of the creek during multiple seasons and under a range of streamflow conditions. All surface discharges and water withdrawals will be monitored to account for gains and losses of nitrogen and phosphorus loading. Groundwater contributions (or losses to groundwater) will also be accounted for. The City of Helena's wastewater would be monitored for nutrient content and flow rates at the facility and at the point of discharge to Prickly Pear Creek, and irrigation usage and volumes would be recorded. Collectively, the data will be used to establish a nutrient loading budget and source quantification for each of the synoptic sampling events. The study results would be used to adjust the nutrient allocations and control strategy for Prickly Pear Creek, if warranted.

2.3 Lake Helena and Hauser Reservoir Nutrient Dynamics and Target Setting

Available data that can be used to describe the trophic status and trends in Lake Helena and Hauser Reservoir are extremely limited. A concerted monitoring program is needed to confirm the degree of nutrient impairment that may be present, to provide a basis for nutrient target setting, and to understand how discharged water from how Lake Helena affects water quality and beneficial uses in Hauser Reservoir. Furthermore, because Lake Helena is a manmade water body with unusual hydraulic and water quality characteristics, it may prove to be more appropriate to set nutrient targets for the Causeway Arm of Hauser Reservoir instead of for Lake Helena proper. Lastly, a nutrient TMDL and restoration plan will eventually need to be developed for Hauser Reservoir and the Missouri River, and it is important that restoration strategies for Lake Helena watershed are consistent with those developed for downstream water bodies.

In addition to the hydrologic investigations and water quality modeling studies that are described in other sections of this appendix, we propose to undertake a concerted three-year limnological and water quality study of Lake Helena and Hauser Reservoir together with selected inflows. A series of nine fixed reservoir stations, shown in Table 2-2 below, should be monitored on a monthly or more frequent basis.

Table 2-2. Proposed Lake Helena and Hauser Reservoir nutrient monitoring stations.

Waterbody	Site ID	Site Type	Description	Lat	Long
Lake Helena	M09LHLNO01	Historic	Lake Helena PPL Inlet Station, 150 yards off FWP boat access off mouth of Silver Creek	46.69869	111.95731
	M09LHLN101	Historic	Lake Helena PPL Outlet Station, Lake Helena side of the causeway	46.70259	111.9014
	M09LHLNC01	Historic	EPA/FWP # 2 middle of the lake/deep station	46.69678	111.9178
	M09LHLNE01	Historic	EPA/FWP Lake Helena Deep Station	46.69875	111.9013
Causeway Arm	C3	Historic	BOR Causeway Station, downstream of Lake Helena	46. 70432	111.90142
	C2	Historic	BOR Causeway Station in middle of the Causeway Arm	46.71839	111.87737
	C1	Historic	BOR Causeway Station, near mouth of Hauser Reservoir	46.73539	111.89065
Hauser Reservoir	HA4	Historic	BOR, Upstream of Causeway Inflow Station	46.73549	111.87840
	HA5	Historic	BOR, Montana Fish, Wildlife and Parks Buoy at Dam	46.76302	111.88460

Recommended reservoir monitoring variables include total water depth, water temperature, pH, alkalinity, specific conductance, turbidity, total suspended sediment, Secchi depth, chlorophyll *a*, the full complement of nutrient variables, total recoverable metals (arsenic and lead), and dissolved oxygen. Water samples should be taken at three different depths at each sample location: 0.5 meters below the surface, at mid-depth, and one meter from the bottom. The chlorophyll samples should be collected as a composite from throughout the euphotic zone. Field parameters (temperature, dissolved oxygen, pH, and conductivity) should be measured 0.5 meters below the surface and at one meter intervals throughout the water column.

Once annually, bottom sediment samples should be collected for analysis of metals concentrations (see Section 2.5 below). During summer, samples should be collected for identification and relative quantification of resident phytoplankton algae, and the occurrence of any algae blooms should be noted. Missouri River sampling locations should include all of the above sampling variables except for Secchi depth, chlorophyll *a*, DO depth profiles, sediment quality, and phytoplankton.

Synoptic monitoring would be conducted in the inflows to Lake Helena, including Prickly Pear, Tenmile and Silver creeks, as well as tile drains and irrigation waterways. Monitoring would be timed to coincide with spring runoff, summer storm events, and baseflow conditions to further refine the understanding of potential nutrient, sediment, and metals sources. The proposed tributary monitoring sites and main irrigation drains are shown in Table 2-3.

Grab water samples would be analyzed for the following field and laboratory parameters:

- *Field Parameters* – Temperature, stream flow, pH, dissolved oxygen, turbidity.
- *Laboratory Parameters* – the full complement of nutrient variables, total suspended solids (TSS), hardness, and total recoverable metals (arsenic, cadmium, copper, lead, and zinc).

The Lake Helena inflow monitoring should be closely coordinated with water quality and hydrology monitoring activities described in Sections 2.1 and 2.2 of this appendix.

Table 2-3. Proposed Lake Helena inflow monitoring stations.

Waterbody	Site ID	Site Type	Description	Lat	Long
Tributary Streams	M09SLRC01	Historic	Silver Creek downstream of frontage road	46.67638800	112.01055500
	USGS 06064150	Historic	Tenmile Creek above Prickly Pear Creek near Helena	46.66076917	111.98999560
	USGS 463939111582801	Historic	Prickly Pear Creek above Tenmile Creek near East Helena	46.66076940	111.97527250
Irrigation Ditches	M09SCIDC01	Historic	Silver Creek Ditch, near mouth above Lake Helena	46. 6928000	111.9721
	M09HVIFD01	Historic	Helena Valley Field Drain, near mouth near Valley Drive	46.6848000	111.91010000
	M09HVIFD02	Historic	Helena Valley Field Drain, near mouth @ Helberg Lane	46.6798000	111.9463000

Reservoir and inflow monitoring data would be interpreted annually and combined with the results of the hydrologic investigations and modeling efforts to refine nutrient targets and source allocations for Lake Helena and/or Hauser Reservoir. Water column and sediment metals and turbidity data will be used to reevaluate/confirm suspected metals and sediment impairments in Lake Helena and its inflows.

2.4 Metals Monitoring Strategy

Future metals monitoring in the Lake Helena watershed to address existing data gaps should address the following objectives:

- Uncertainties associated with impairment determinations
- Refinement of metals sources and seasonality
- Uncertainties associated with the modeling process

Each of these objectives is detailed below.

2.4.1 Addressing Metals Impairment Uncertainties

Table 2-4 identifies stream segments in the Lake Helena watershed with limited metals data. These segments should be sampled a minimum of 5 to 10 times each over a representative time period which includes wet, dry and normal precipitation years in order to better determine impairment status. Samples should be taken during both base flow periods and during episodic storm events. Data would be used be used to confirm suspected impairment issues and to refine TMDLs and source allocations. The data would also be used to determine if a TMDL is required for mercury in Silver Creek.

Table 2-4. Lake Helena watershed segments requiring impairment status confirmation.

Segment	Reason for Additional Monitoring
Prickly Pear Creek from the Headwaters to Spring Creek (MT41I006_060)	Borderline levels of cadmium and copper
Prickly Pear Creek from Spring Creek to Lump Gulch (MT41I006_050)	Borderline levels of arsenic and copper
Prickly Pear Creek from Wylie Drive to Helena Wastewater Treatment Plant Discharge (MT41I006_030)	Limited data
Prickly Pear Creek from Helena WWTP Discharge Ditch to Lake Helena (MT41I006_020)	Limited data
Golconda Creek from the Headwaters to the Mouth (MT41I006_070)	Limited data; borderline levels of zinc
Corbin Creek from the Headwaters to the Mouth (MT41I006_090)	Limited data for current conditions
Spring Creek from Corbin Creek to the Mouth (MT41I006_080)	Limited data
North Fork Warm Springs Creek from the Headwaters to the Mouth (MT41I006_180)	Borderline levels of lead
Skelly Gulch (Tributary of Greenhorn Creek) (MT41I006_220)	Limited data
Granite Creek from headwaters to mouth (Austin Creek – Greenhorn Creek – Sevenmile Creek) (MT41I006_179)	No representative data
Jennie's Fork from the Headwaters to the Mouth (MT41I006_210)	Limited data
Silver Creek from the Headwaters to the Mouth (MT41I006_150)	Borderline copper levels, limited mercury data
Lake Helena	Borderline cadmium

2.4.2 Refinement of Metals Sources and Seasonality

The presently available metals monitoring data include limited runoff sampling events and, as such, the importance of wet weather-related metals sources may be under-represented in the source allocations. The data generated from the metals impairment confirmation monitoring described above would be screened to examine general locations of metals sources. In instances where very large in-stream increases are noted, especially during wet weather monitoring events, additional source assessment monitoring and field reconnaissance may be required to positively identify and quantify sources of metals loading.

2.4.3 Addressing Modeling Uncertainties

Additional metals monitoring are needed to better refine the LSPC modeling analysis. For example, one limitation of the LSPC model is that, in the absence of better data, it assumed the same metals soil concentrations on a unit-weight basis throughout the watershed. Sampling of sediment metals concentrations by sediment source and by geographic location is recommended to improve this aspect of the model. In addition, it was difficult to calibrate the model to storm events because of a lack of available data during these periods. Monitoring of storm water runoff from representative sources should therefore be performed to better estimate the concentration of metals during wet weather events.

2.5 Temperature Monitoring Strategy

Future water temperature monitoring in the Lake Helena watershed should address the following objectives:

- Uncertainties associated with impairment determinations
- Refinement of impairment causes and seasonality

2.5.1 Addressing Temperature Impairment Uncertainties

The frequency, magnitude, and timing of temperature impairments in Prickly Pear and McClellan creeks are not well documented and additional data collection is recommended to confirm suspected problems and to fine-tune restoration approaches. In-stream temperature monitoring should be conducted at several locations from June to October for a representative time period that includes wet, dry, and normal precipitation years. This time period is when flow levels and warmer air temperatures create concerns for resident fisheries. Continuous recording thermographs set to record temperature every half hour should be deployed at established Prickly Pear Creek sampling sites in the segments of concern, as well as at additional monitoring sites to fill voids in the available data. The Montana DEQ's Standard Operating Procedures (SOP) for Temperature Data Loggers should be employed to ensure that quality data are collected (see Section 5.0 of this appendix).

2.5.2 Refinement of Temperature Impairment Causes

The various causes that contribute to temperature impairments in Prickly Pear and McClellan creeks are poorly quantified and additional data collection is recommended to determine their relative importance and to adjust restoration approaches, if warranted. At a minimum, additional temperature data need to be collected for wastewater discharges, and additional streamflow/hydrologic information is needed for Prickly Pear Creek and its tributaries. Riparian condition assessments or percent shade measurements along Prickly Pear Creek are also desirable but are a much lower priority than the other monitoring needs.

The permitted point source dischargers along lower Prickly Pear Creek should monitor the temperature of their effluent at least monthly during a representative one-year time period (Table 2-5). Ambient temperature monitoring upstream and well downstream of the point source outfall locations is also recommended.

Table 2-5. Point source discharge temperature monitoring stations for lower Prickly Pear Creek.

Segment	MPDES Permit	Description
MT41I006_040	MT0000451	Ash Grove Cement Company*
MT41I006_040	MT0000426	Air Liquide America Corporation
MT41I006_040	MT0030147	ASARCO
MT41I006_040	MT0022560	City of East Helena WWTP
MT41I006_020	MT0000949	City of Helena WWTP

*Should discharge occur.

Late-season (August and October) synoptic streamflow monitoring runs should be conducted on Prickly Pear Creek from Montana City downstream to Lake Helena in at least two years representing wet and dry weather conditions. Flow gaging sites should be adequately spaced such that inflows from tributaries and outflows from diversions are adequately captured. Streamflow gaging should be conducted according to the Montana Water Quality Monitoring Standard Operating Procedures (SOP) (see Section 5.0). This task could be readily accomplished as an add-on to the hydrologic studies that are described in Section 2.1 above.

2.6 Modeling Tool Development

Relatively simple models (GWLF and BATHTUB) were chosen to simulate nutrient and sediment loads in the Lake Helena watershed. This was primarily due to the lack of data necessary to calibrate a more complex nutrient and sediment model (see Appendix C). The GWLF and BATHTUB models provided monthly output, and were not capable of simulating daily interactions between nutrients, dissolved oxygen, and in-stream algal growth.

More complex models are available to simulate nutrient and sediment loads and could be used in the ongoing management of the Lake Helena watershed. For example, they could be used to more thoroughly evaluate the impacts of various wastewater treatment controls in Prickly Pear Creek, or to evaluate possible residential development within the watershed. Potential impacts with and without increased levels of controls can be evaluated and compared to expected costs so that water quality impacts are factored into planning decisions.

The Loading Simulation C++ model (LSPC) is a watershed model that is capable of providing hourly output, and is capable of simulating the interactions between nutrient loads, dissolved oxygen, and algae. LSPC has already been set up to model metals in the Lake Helena watershed, and could also be used to model nutrients and sediment loads. Output from LSPC could be directly compared to Montana DEQ's numeric dissolved oxygen criteria, and to potential targets for algae (phytoplankton or periphyton). Furthermore, hourly (or daily) nutrient loads and concentrations are better suited for determining compliance with water quality targets and standards.

Similarly, a more complex lake model such as the Army Corps of Engineers CE-QUAL-W2 model could be used to simulate conditions in Lake Helena and possibly Hauser Reservoir. CE-QUAL-W2 is also capable of modeling nutrient-DO-algae interactions, and provides hourly output. Furthermore, the CE-QUAL-W2 model can be linked to the LSPC watershed model.

Much of the additional data needed to calibrate the LSPC and CE-QUAL-W2 models is described in Sections 2.1, 2.2 and 2.3. Water quality samples should be collected at least at a monthly frequency, and should also target storm events, low-flows events, and baseflow events to allow for model calibration during these periods. Additional data that would allow for a more thorough calibration include:

- Detailed imperviousness study of the urban areas of the watershed.
- Representative sampling of groundwater nutrient concentration throughout the watershed.

3.0 IMPLEMENTATION MONITORING

The purpose of implementation monitoring is to document whether or not management practices were applied as designed. Objectives of an implementation monitoring program include:

- Measuring, documenting, and reporting the watershed-wide extent of BMP implementation and other restoration measures, including point source controls
- Evaluating the general effectiveness of BMPs as applied operationally in the field.
- Determining the need and direction of BMP education and outreach programs

Implementation monitoring consists of detailed visual monitoring of BMPs, with emphasis placed on determining if they were implemented or installed in accordance with approved design criteria. This type of information would create an inventory of where BMPs have been applied as well as their site-specific effectiveness. The various watershed stakeholders should take the lead in performing the implementation monitoring because it is likely to vary by the type of BMPs that are applied, by geographic location and, perhaps, by land ownership or management jurisdiction. For example, the USFS has the most expertise in assessing forestry BMPs whereas the City of Helena personnel are most familiar with urban storm water controls.

Additional discussion regarding implementation monitoring is not presented herein. It is envisioned that the watershed stakeholders responsible for implementation activities will work with EPA, DEQ, and the local watershed protection district under the umbrella of the Lake Helena Watershed Committee to develop implementation monitoring plans on a case-by-case basis.

4.0 EFFECTIVENESS MONITORING AND ADAPTIVE MANAGEMENT

Montana statutes require that MDEQ evaluate all TMDLs for their effectiveness five years after they have been completed and approved (MCA 75-5-703(9)(c)). A formal review of the Lake Helena TMDL will therefore be conducted in 2011. The review will use the water quality targets that have been identified for each pollutant in the Lake Helena restoration plan to assess overall progress toward meeting the stated water quality restoration goals. This effort will include a combination of water quality and biological monitoring and habitat assessments collectively aimed at determining the effectiveness of the various restoration measures. Although this assessment can be made based on data collected by MDEQ only in year five, a much more thorough assessment will be possible if additional data are collected during the intervening years. Due to MDEQ resource constraints, these additional data will need to be collected by watershed stakeholders. Some suggested effectiveness monitoring activities are presented below and additional measures may be selected by stakeholders within the proposed Lake Helena Watershed Committee. In addition to evaluating the overall effectiveness of the Lake Helena plan in restoring water quality, the various proposed effectiveness monitoring elements will provide a feedback mechanism that can be used to verify TMDL assumptions and to fine-tune restoration approaches through adaptive management.

4.1 Nutrients

Nutrient effectiveness monitoring in Prickly Pear Creek should consist of monthly sampling of general water quality in 2011, as well as targeted collection of attached algae and dissolved oxygen data during the critical summer months. One purpose of this monitoring is to assess the degree to which the implemented point and non-point source controls have reduced ambient nutrient concentrations compared to the available historical data. Another purpose is to determine whether in-stream nutrient reductions have lead to corresponding decreases in algal standing crops and the magnitude of dissolved oxygen sags. Nutrient effectiveness monitoring should also be conducted in Lake Helena and Hauser Reservoir in 2011 using the nutrient/limnologic parameters that were previously described in Section 2.3 above.

4.2 Sediment

Sediment water quality endpoints should be assessed on a maximum interval of five years in order to judge the degree of target acquisition. However, biannual data collection at fixed plots is more applicable, and should be conducted following the implementation of restoration activities, with subsequent data collection in every fifth year. Three years of data collection every five years will provide a basis for trend analysis, and an evaluation of the level of in-stream benefits associated with the various restoration measures. The exception to the biannual data collection strategy is suspended sediment sampling, which should occur on a more frequent basis (quarterly, if resources can support this level of intensity).

4.3 Temperature

Temperature monitoring of Prickly Pear Creek segments should be conducted seasonally for a minimum of three years following the implementation of control measures. Montana DEQ protocols should be used for all sampling events, and the data should be recorded and submitted to the MDEQ. The effectiveness monitoring strategy for temperature should include in-stream temperature and streamflow monitoring and the collection of weather data to determine representativeness of the results. Records from the nearest NOAA weather station should be used to monitor local weather for the area of interest. The three active NOAA climate stations in the Lake Helena watershed are listed in Table 4-1. If a local weather station is not found that can provide the appropriate information, then an optional weather station capable of logging parameters such as temperature, barometric pressures, wind speed, precipitation, dew point, or solar radiation may be deployed.

Table 4-1. Active NOAA climate stations in the Lake Helena Watershed.

Station Name	Coop-ID	Elevation (ft)
Austin 1 W	240375-4	4,790
Helena WSO	244055-4	3,830
Rimini 4 NE	247055-4	4,700

4.4 Metals

Effectiveness monitoring for metals should consist of sampling the metals of concern, along with hardness, pH, and instantaneous flow. Monthly sampling in 2011 is recommended at the mouth of every listed segment throughout the Lake Helena watershed. Additional sampling during runoff events (from snowmelt and summer storms) is also recommended. The data will be evaluated for the presence and spatial persistence of any numeric criteria violations.

5.0 SAMPLING AND ANALYSIS METHODS AND QUALITY ASSURANCE CONSIDERATIONS

Where applicable, MDEQ standard operating procedures should be followed for the sampling described herein to ensure consistency across statewide TMDL monitoring programs. MDEQ methods are described in the following document:

- Montana Water Quality Monitoring Standard Operating Procedures (SOP) (available at: http://deq.mt.gov/wqinfo/monitoring/SOP/sop.asp, specifically sections:
  - 10.0 – Sample Collection
  - 11.0 – Methods for Collecting, Analyzing, and Reporting Water Quality and Sediment Chemical Data
  - 12.0 – Methods of Assessing the Biological Integrity of Surface and Groundwater
  - 13.0 – Methods for Assessing the General Health and Physical Integrity of Surface Waters.

Quality assurance and quality control (QA/QC) procedures for all monitoring, assessment, and reporting activities described in this appendix should be addressed in a monitoring quality assurance project plan (QAPP) developed specifically for the Lake Helena restoration project. The QAPP should be developed following MDEQ guidance available at: http://deq.mt.gov/wqinfo/QAProgram/index.asp.