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THE FLATHEAD BASIN COMMISSION

The Flathead River Basin Long-term Surface Water Quality and Supply Monitoring Plan

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Summary

This monitoring plan is intended to provide a framework for determining long-term base-line conditions and changes in water quality (i.e, physical, chemical and biological) of the Flathead River Basin. The Flathead Basin Commission (FBC) is responsible for ensuring that data on water quality, water supply, and bio-physical condition are collected for making an evaluation of conditions and trends within the Basin. The statutory purpose and duties of the FBC for monitoring are:

"The purpose of the Flathead Basin Commission is to protect the existing high quality of the Flathead Lake aquatic environment; the waters that flow into, out of, or are tributary to the lake; and the natural resources and environment of the Flathead Basin." MCA 75-7-302

Duties of the Commission are:

(1) To monitor the existing condition of natural resources in the basin and coordinate development of an annual monitoring plan. This plan must involve a cooperative strategy among all land and water management agencies within the Flathead basin and identify proposed and needed monitoring, which emphasizes but is not limited to the aquatic resources of the Flathead basin.

(2) To encourage close cooperation and coordination between federal, state, provincial, tribal, and local resource managers for establishment of compatible resource development standards, comprehensive monitoring, and data collection and interpretation; MCA 75-7-304

(3) To encourage and work for international cooperation and coordination between the state of Montana and the Province of British Columbia concerning the undertaking of natural resource monitoring and use of consistent standards for management of resource development activities throughout the transboundary North Fork Flathead River drainage portion of the Flathead basin.

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I. Scope

The goals of the Monitoring and Data Collection Committee of the Flathead Basin Commission are to foster and coordinate the development and maintenance of a long-term, basin-wide monitoring program (see Appendix I). The scope of the monitoring plan is to:

1. Describe water quality monitoring goals and objectives.

2. Develop and implement a Memorandum of Understanding (MOU) among participants involved with the development, implementation and funding of the FBC monitoring plan.

3. Identify monitoring approach, sites, sampling frequencies, and the variables that are to be measured at each site.

4. Encourage and support transboundary cooperation and coordination between the State of Montana and the Province of British Columbia concerning the implementation of a monitoring plan.

5. Identify and develop a funding strategy, then work with partners to secure continuous funding for the monitoring program.

6. Annually evaluate the monitoring plan for meeting objectives and security of funding.

II. Background

The FBC developed a monitoring plan in 1985 (updated in 1994) that has guided Flathead Lake water quality monitoring for the past 20 years. In 2002, the Monitoring Committee of the FBC identified the need to increase information sharing between monitoring agencies and to update the FBC surface water-quality monitoring plan. In late 2002, the FBC received a grant from Montana DNRC to accomplish three tasks related to surface water quality in the basin:

1. Assist the Montana Natural Resource Information System (NRIS) in creating a surface water quality monitoring sites geographic information system (GIS) layer for the Flathead Basin.
2. Convene a Water Summit conference to share monitoring information between State, Tribal, Federal, and local agencies and organizations active in monitoring in the Flathead Basin.
3. Initiate development of a revised surface water-quality monitoring plan.

In late 2002, all agencies and organizations active in monitoring in the Flathead Basin were contacted and were requested to provide metadata regarding past monitoring

activities. Much of this information is accessible via the internet through the NRIS web site at http://nris.state.mt.us/.

The Water Summit, held April 28, 2002, included presentations by 12 monitoring entities and participation by 46 attendees. A number of issues, opportunities and constraints to coordinated monitoring in the Flathead Basin were identified during the Water Summit and subsequent FBC meetings.

Development of a revised surface water quality monitoring plan began in early 2003 through the work of the FBC Monitoring Committee. A preliminary monitoring plan revision including monitoring goals, objectives, and core monitoring sites was presented at the Water Summit. This monitoring plan is responsive to the directives of the FBC Commissioners and recommendations coming from the Water Summit.

Participation on the FBC Monitoring Committee is open to all agencies and individuals who collect or use monitoring data in the Flathead Basin and are interested in furthering collaborative monitoring efforts.

III. Monitoring Goals and Objectives

Alarmed by loss of water quality in the nation's streams and lakes, as well as the loss of wetlands and the valuable benefits they provide, the U.S. government instituted the Federal Water Pollution Control Act (33 United States Congress sections 1251–1387) of 1972. This landmark legislation, later known as the Clean Water Act (CWA), included requirements to improve water quality. The fundamental purpose of the CWA is to "*...restore and maintain the chemical, physical, and biological integrity of the waters of the United States."* [1] The Flathead Basin Monitoring Plan is based, in part, on the enabling language of the Federal Clean Water Act.

Surface Water Quality Monitoring Plan Goals:

1. Guide acquisition of necessary water quality data and information using proven protocols and methodologies.
2. Identify long-term trends in water quality.
3. Provide crucial information for sound planning and policy decisions that will protect water quality in the Flathead Basin and meet prescribed Total Maximum Daily Load (TMDL) targets.

While this monitoring plan is limited to surface water, the FBC recognizes that other monitoring (e.g., groundwater, air, natural resources) is needed to fulfill the duties of the Commission. Additional monitoring and assessment plans for other environmental components will be developed and integrated into a comprehensive monitoring plan.

[1] The Clean Water Act. http://www.epa.gov/region8/water/cwa.htm

Surface Water Quality Plan Objectives:

A) Monitor long-term water quality and pollutant trends in **Flathead Lake – Sentinel Sites**[2].

Objective A Subset:

a. Determine and evaluate long-term trends in nutrient concentrations and cycling in Flathead Lake.
b. Determine and evaluate long-term trends in nutrient loading from all major tributaries to Flathead Lake.
c. Determine and evaluate long-term trends in nutrient loading from selective and representative minor tributaries to Flathead Lake.
d. Determine and evaluate long-term trends in nutrient loading from the airshed to Flathead Lake.
e. Identify and evaluate long-term trends in key ecological response variables in Flathead Lake.
f. Establish baseline and evaluate long-term trends in known or potential pollutants to Flathead Lake.
g. Detect new and emerging water quality problems that threaten water quality in Flathead Lake; establish protocols for monitoring existing and potential invasive species in Flathead Lake (e.g., flowering rush, zebra mussel).
h. Collect and evaluate daily discharge of direct inflow tributaries and the lake outlet (i.e., daily discharge is needed to calculate accurate nutrient loading to the Lake).

B) Monitor long-term water quality and pollutant trends in the **Upper Flathead Basin – Sentinel Sites**.

Objective B Subset:

a. Collect and evaluate continuous and/or daily discharge in major tributaries
b. Determine and evaluate long-term trends in basic water chemistry variables
c. Determine and evaluate long-term trends in nutrient concentrations and loading
d. Determine and evaluate long-term trends in sediment loading
e. Identify and evaluate long-term trends in key ecological response variables
f. Establish baseline and evaluate long-term trends in known or potential pollutants
g. Detect new and emerging water quality problems that threaten water quality in major tributaries

C) Monitor long-term water quality and biological condition in all perennial flowing water of the **Flathead River Basin (Survey Sites)**[3].

Objective C Subset:

[2] Sentinel Site: hand-picked (via a model or judgement-based design) sampling site, often co-located with USGS gauge station locations.

[3] Survey Site: sample locations selected via a probability survey design ("random") from all flowing waters in the North Fork of the Flathead River, using a spatially balanced design method (GRTS)

a. Quantify the proportion, with known confidence, of perennial stream length in the basin that exceeds state or federal water quality criteria during late summer index periods[4]
b. Quantify the proportion, with known confidence, of perennial stream length in the basin that exceeds macroinvertebrate and periphyton assemblage biocriteria (using an Index of Biotic Integrity[5] and Observed to Expected ratios[6]) during late summer index periods
c. Quantify the proportion, with known confidence, of perennial stream length in the basin that exceeds physical habitat (e.g., sediment, bedform) criteria during late summer index periods
d. Establish the relative importance (or risk) of the stressors impacting biological and physical habitat response measures at the basin-scale
e. Quantify basin-wide trend in mean water quality, biological, and physical habitat indicators

D) Monitor water quality and pollutant trends of **Swan and Whitefish Lakes**.

Objective D Subset:

a. Determine and evaluate long-term trends in nutrient concentrations and cycling
b. Determine and evaluate long-term trends in nutrient loading from all major tributaries; daily discharge measures are required to accurately estimate loading
c. Determine and evaluate long-term trends in nutrient loading from selective and representative minor tributaries; daily discharge measures are required to accurately estimate loading
d. Identify and evaluate long-term trends in key ecological response variables
e. Establish baseline and evaluate long-term trends in known or potential pollutants
f. Detect new and emerging water quality problems that threaten water quality

E) Integrate results from other long-term monitoring efforts in the basin.

Objective E subset:

a. Stormwater Monitoring
b. Whitefish Lake Institute Monitoring
c. National Park Service (NPS) Vital Signs Program
d. Flathead Lake Biological Station (FLBS)

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[4] Index Periods: Index-period sampling focuses the time of sampling on the most ecologically relevant or seasonally consistent period(s) for a given response measure so the data collected will function as the most useful barometer of a vital sign or of the condition of target populations within a given sampling interval (Larsen et al. 1995; Kaufmann et al. 1988; Landers et al. 1988; Messer et al. 1986). Index-period sampling also reduces inter-annual variability. Examples of index periods might be the late summer period of maximum standing crop for a given plant community (if total growth is most critical), or the early-fall, base-streamflow period, when aquatic communities might be most stressed.

[5] Index of Biological Integrity (IBI): an integrative expression of site condition across multiple metrics. IBI are composed of multiple metrics. that describe the response of assemblage to stressors (Karr and Chu, 1999).

[6] Observed to Expected Ratio (O : E): Approach to biologic assessment that statistically calculates departure from a "reference condition" based on the ratio of taxa observed at a site to that to expected based on multivariate model predictions (Hawkins et al, 2000).

e. Confederated Salish and Kootenai Tribes (CSKT)
f. United States Geological Survey (USGS)
g. Montana Department of Environmental Quality (MT DEQ)

IV. Monitoring Approach: Site Types and Analysis/Inference Methods

Two types of monitoring sites are defined in the FBC plan. First, a classic, fixed or "Sentinel Site" (also known as "Integrator" or "Core" sites; Hirsch et al. 2006) is used to monitor key points in the hydrologic network of the basin. These include river confluences, tributary junctions, mid-lake locations, basin pour points[7], sites where known stressors can be determined, etc. Sentinel Sites are sampled more than once a year for hydrologic data and water physiochemistry (Table 1). Because Sentinel Sites are hand picked or targeted, the only way to infer data from them to non-sampled sites is via a model (either statistical, simulation or a process-based approach). For example, the USGS uses the LoadEst to estimate the flux and loading of a constituent at a site and the SPARROW model to estimate conditions at unsampled locations based on monitoring data (Langland et al. 2004; Cohn et al.1989). Sentinel Sites allow temporally intense monitoring at established locations with a long-term record in the basin and as such remain a central focus of the FBC plan.

A second type of monitoring sites ("Survey Sites") is needed in the basin to focus on biological measures. These sites will be located using a probability, or random, survey design. Data from these sites will allow statistically valid estimates of stream condition at the scale of the basin (Paulsen et al 1998; Stevens and Olsen 2004). This monitoring framework is based on recent guidance from EPA (2006), the General Accounting Office (2000), the National Research Council (2001) and the Heinz Center (2002). The Montana Department of Environmental Quality has adopted a similar bioassessment approach for much of its stream monitoring in the State (MT DEQ 2005) and the NPS has an identical program in Glacier National Park (Britten et al, 2006). With this approach, monitoring sites are selected using a spatially-balanced survey design for all flowing water in the basin. Sites are sampled once a year during a late summer index period. Sites are revisited through time using a panel structure[8] that allows robust estimation of status and trend. The focus at a site is on biological condition as measured through benthic macroinvertebrate and periphyton assemblage composition (fish assemblages are optional) and physical habitat attributes. Traditional water quality sampling is also conducted, largely as an aid in classifying site condition and in generating snapshot status estimates of basin-scale water quality.

These two approaches to monitoring are not independent, rather they are complementary. Sentinel sites allow more frequent monitoring and more intensive measurement of hydrology and long term changes in water quality. They can be placed downstream of known areas of degradation. Survey sites extend monitoring across the

[7] Basin Pour Points: Locations at the "bottom" of a watershed that are assumed to be an "integrator" of water quality within the basin when data is analyzed via f;low adjusted models.

[8] Panel Structure: sets of samples sites grouped by time periods where all sites in a panel are visited in the same time block.

entire basin. The FBC plan will allow integrated analysis of the two forms of data, generating more robust and comprehensive assessment of basin conditions.

V. Partners in Monitoring Program

The FBC works and coordinates with many partners that are responsible for monitoring water supply, water quality and other ecosystem parameters within the Flathead River Basin. These partners include: the Flathead Lake Biological Station ($_1$**FLBS**), the U.S. Geological Survey ($_2$**USGS**), the Confederated Salish and Kootenai Tribes ($_3$**CSKT**), the MT Department of Natural Resources and Conservation ($_4$**DNRC**), MT Department of Fish, Wildlife and Parks ($_5$**DFWP**), MT Department of Environmental Quality ($_6$**DEQ**), Lake County ($_7$**LC**), Flathead County ($_8$**FC**), the Bureau of Reclamation ($_9$**BOR**), the Bonneville Power Administration ($_{10}$**BPA**), US Environmental Protection Agency ($_{11}$**EPA**), Flathead National Forest ($_{12}$**FNF**), National Park Service ($_{13}$**NPS**), and the British Columbia Ministry of the Environment ($_{14}$**BC MoE)**.

VI. Monitoring Sites

The monitoring sites correspond to the five Surface Water Quality Plan Objectives, as out-lined in A-E above. The key to sampling parameters is provided in Table 1. Site locations are listed after the site name and referenced in the map in Appendix I.

Table 1. Physiochemical and biological variables

Symbol	Variable(s)
Q	Discharge
T/phys	Temperature, pH, conductivity, DO, redox
Nuts	Nutrients (NO_3, NH_4, Total N, SRP, Total P, TOC, DOC, SiO_2)
Cat	Cations (Na, K, Ca, Mg)
An	Anions (SO_4, Cl)
M	Metals (Ar, B, Be, Ca, Cd, Cr, Cu, Fe, Mg, Mn, Na, Ni, Pb, Se, and Zn
Hg	Mercury (Hg)
TSS	Sediment (TSS)
Phyto	Phytoplankton (Taxa/frequency, AFDM, Chlorophyll a)
Zoop	Zooplankton (Taxa/frequency)
Mys	*Mysis* (Taxa/frequency)
PP	Primary Productivity (lake-^{14}C)
Peri	Periphyton (Taxa/frequency, AFDM, Chl a)
BMacro	Benthic macroinvertebrates (Taxa/frequency)
Seds	Benthic sediment (AFDM)

A. FLATHEAD LAKE – SENTINEL SITES

Flathead Lake sentinel monitoring sites include lake and critical tributary sites. These monitoring sites are essential to establish long-term trend analysis of the physical, chemical and biological integrity of Flathead Lake.

** Note: "Monitoring partner" refers to the research entity or agency that collects and administers the data. "Current funding sources" reflect funds coming from agencies via federal or state sources or FLBS via the state legislature

Existing Sentinel Sites:

Flathead Lake at Mid Lake Deep (1)

Site justification: This sampling site is the primary site for assessing change in water quality within Flathead Lake. This site is critical for assessing trends in nutrient loading, cycling, and ecological response. This site was calibrated against 7 additional Lake sites over several years and was determined to be representative, with the exception of Big Arm Bay (Polson Bay was not examined in that study). (FLBS site since 1977)

Sampling frequency: 15 times per year
Sampling variables: $_1$T/phys, Nuts, Cat, An, TSS, Phyto, Zoop, Mys, PP
Monitoring partner: $_1$FLBS
Current funding sources: DEQ and FLBS

Note: The cations, Cl, HG and metals are not current variables, *mysis* is only sampled once per year.

Flathead River near Holt (Sportsman's Bridge) (2)

Site justification: This sampling site is important for measuring and calculating total loads of nutrients and sediment that enter Flathead Lake. Continuous flow measurements have not been taken at this site, as it is located in backwater from Flathead Lake when the lake is full. Discharge calculations for this site are determined by adding discharges from (identify gauges here).Beginning in June 2007, however, the USGS is measuring flow using a Doppler system from Sportsman's Bridge and collecting water quality samples 6 times per year for nutrients, suspended solids and major ions and once per year for Chl a, Hg and TOC. (FLBS site since 1977)

Sampling frequency: 15 times per year
Sampling variables: $_1$T/phys, Nuts, Cat, An, M, Hg, TSS, $_2$Q
Monitoring partner: $_1$FLBS, $_2$USGS
Current funding source: DEQ, FLBS, USGS

Note: Metals and Cl are not current variables.

Swan River at Bigfork steel bridge (3)

Site justification: This sampling site is located where Swan River flows into Bigfork Bay in Flathead Lake. The FLBS has measured and calculated total loads of nutrients and sediment that enter Flathead Lake from the Swan River since 1977. There is no continuous flow measurement taken at this site, as it is located in backwater from Flathead Lake when the lake is full. Continuous discharge is measured in the Swan River immediately downstream from Swan Lake by the USGS (site 12370000) where flows have been measured since 1922. (FLBS site since 1977)

Sampling frequency: 15 times per year
Sampling variables: $_1$T/phys, Nuts, Cat, An, M, Hg, TSS, $_2$Q (USGS12370000)
Monitoring partner: $_1$FLBS, $_2$USGS
Current funding source: DEQ, FLBS, USGS

Note: The cations, metals, Hg and Cl are not current variables.

Stillwater River, 1 km below confluence with Whitefish River (4)

Site justification: This sampling site is located below the confluence of the Stillwater and the Whitefish Rivers and is used to measure combined nutrient loads entering Flathead Lake from both the Whitefish and Stillwater Rivers. Stillwater River status is "impaired" on the DEQ 303(d) list[9]. (FLBS site since 1984)

Sampling frequency: 15 times per year
Sampling variables: $_1$T/phys, Nuts, Cat, An, M, Hg, TSS, $_2$Q
Monitoring partner: $_1$FLBS, $_2$USGS
Current funding source: DEQ, FLBS, USGS

Note: This site should be maintained with the two new USGS gage sites on the Stillwater and Whitefish rivers, which are slightly above their confluence. USGS has recorded flows at these river sites intermittently since 1930 and continuously since 1999. There is strong evidence that groundwater nutrient loading occurs between the USGS gage sites and this site below their confluence. The cations, metals, Hg and Cl are not current variables.

Stoner Creek at Flathead Lake (5)

Site justification: This is a large tributary stream that flows into Flathead Lake at Lakeside. This site is important to monitor the potential effects of new land use developments within this high growth area. FLBS maintains a permanently mounted data recording instrument that measures creek discharge hourly.

Sampling frequency: 15 times per year
Sampling variables: $_1$T/phys, Nuts, Cat, An, M, Hg, TSS, Q

[9] DEQ's 303(d) list: Section 303 (d) of the Clean water Act (CWA) establishes that states are to list (the 303(d) list) waters for which technology-based limits alone do not ensure attainment of applicable water quality standards (WQS).

Monitoring partner: [1]FLBS
Current funding source: FLBS

Note: The cations, metals, Hg and Cl are not current variables.

Ashley Creek below Kalispell Sewage Treatment Plant (6)

Site justification: This sampling site-provides information to determine the changes in water quality in Ashley Creek, which has been shown to deliver a significant amount of nutrients and sediment loads first to the Flathead River and then to Flathead Lake. Ashley Creek status is "impaired" on the DEQ 303(d) list. FLBS maintains a permanently-mounted data recording instrument that measures creek discharge hourly. (FLBS site since 1984)

Sampling frequency: 15 times per year
Sampling variables: T/phys, Nuts, Cat, An, M, Hg, TSS
Monitoring partner: FLBS, USGS, DEQ
Current funding source: FLBS and cost shared between the USGS and DEQ.

Note: The cations, metals, Hg and Cl are not current variables.

Ashley Creek near Mouth

Site justification: Due to the long-term point-source of nutrients from the Kalispell sewage treatment plant there is an accumulation of nutrients in the bed sediments of Ashley Creek between the STP and the confluence with the Flathead River. This site addresses the difference in nutrient loading between the STP and the river confluence. USGS has established a new continuous stream flow gage near the mouth in June 2007 and is collecting nutrients, suspended solids and major ions 6 times per year and Chl a and TOC once per year.

Sampling frequency: 6 times per year
Sampling variables: [2]Q, T/phys, Nuts, Cat, An, M, Hg, TSS, Chl a
Monitoring partners: [2]USGS
Current funding source: USGS

Dayton Creek at Flathead Lake (7)

Site justification: Dayton Creek flows from Lake Mary Ronan through grazed pasture - lands and cattle ranches and into Big Arm Bay of Flathead Lake. Research in the Big Arm area has shown elevated nutrient concentrations and oxygen deficits near the bottom of the lake in the bay.

Sampling frequency: 15 times per year
Sampling variables: [3]T/phys, Nuts, Cat, An, M, Hg, TSS
Monitoring partner: [3]CSKT
Current funding source: CSKT

Precipitation at Yellow Bay Point (8)

Site justification: Precipitation is measured at the bulk precipitation collection site at Yellow Bay Point. Precipitation input has been shown to be a significant source of nutrients to Flathead Lake. This station needs an upgrade in equipment in order to more accurately quantify the nutrient input to Flathead Lake from aerosol sources. (FLBS site since 1981)

Sampling frequency: 30 bulk precipitation (wet plus dry) samples per year
Sampling variables: [1]Nuts, Cat, An, M, Hg
Monitoring partner: [1]FLBS
Current funding source: FLBS

Note: More accurate collection of dry deposition is needed and would add approximately 53 samples per year. The approximate cost for this equipment upgrade is $5,000. The cations, metals and Hg are not current variables.

Flathead River at Polson (9)

Site justification: This elevation site is used to measure elevations for calculating storage content in Flathead Lake. It is also necessary for measurement of water quality in lake outflows and calculation of lake nutrient mass balance. The USGS has measured lake level elevation at this site intermittently since 1900 and continuous between1941-1998 and 1998 to current. (FLBS site since 1977)

Sampling frequency: Water quality 15 times per year[a]; Lake level recorded daily[b]
Sampling variables: [1]T/phys, Nuts, Cat, An, M, Hg, TSS
Monitoring partners: [1][a]FLBS and [b]USGS
Current funding source: [a]FLBS; [b]USGS

Note: The cations, metals, Hg and Cl are not current variables.

FLBS B-Beach on the East Shore and at Horseshoe Island (10)

Site justification: These two sites are monitored for periphyton by the FLBS annually, for periphyton biomass (chlorophyll *a* and ash free dry mass).

Sampling frequency: annually
Sampling variables: [1]Peri
Monitoring partner: [1]FLBS
Current funding source: FLBS

Note: Monitoring began in 1999 but has been sporadic due to inadequate funding. Increases in periphyton have been noted by long-time residents and this biological indicator is sensitive to increased nutrient regeneration and loading.

Recommended Additional Lake Sentinel Sites:

Flathead Lake at Big Arm Bay (Ross Deep) (11)

Site justification: Big Arm Bay is significantly shallower than the main body of the lake and there is strong evidence that it behaves differently. It should be noted that the greatest dissolved oxygen depletion in Flathead Lake is found at Ross Deep (the FLBS monitoring site in Big Arm Bay) and that some forms of nitrogen were significantly higher at this site than the Mid Lake station. Monitoring at the Mid Lake Deep site may not adequately represent conditions in Big Arm Bay and may not be sufficient to improve our understanding of the impacts to the ecology of Flathead Lake from chemical, physical and biological stresses.

Sampling frequency: 15 times per year
Sampling variables: $_1$T/phys, Nuts, Cat, An, TSS, Phyto, Zoop, Mys, PP
Monitoring partner: $_1$FLBS
Current funding source: Full monitoring is unfunded. Only dissolved oxygen, temperature, pH, cond and ORP profiles are collected in late summer by FLBS with State General Fund.

Flathead Lake at South Bay (Polson Bay) (12)

Site justification: South Bay (Polson Bay) is very shallow (<30 ft) and though it receives water from the main body of the lake, it is limnologically very different. Warmer and shallower regions of large, cold oligotrophic lakes are often sites where nonnative fish and plant species get a firm hold in the system.

Sampling frequency: 15 times per year
Sampling variables: $_1$T/phys, Nuts, Cat, An, TSS, Phyto, Zoop, Mys, PP
Monitoring partner: $_1$FLBS
Current funding source: unfunded

Note: Currently *Mysis* is a lake wide sampling effort (40 sites) done annually, however there are no sites in Polson Bay since previous research has not detected any *Mysis* there.

B. UPPER FLATHEAD BASIN – SENTINEL SITES

The Flathead River Basin sentinel monitoring sites include an array of major tributary and mainstem sites. Many of these sites are locations where the USGS has continuous discharge sites, in some cases for an extended period. These monitoring sites are essential for long-term trend analysis of the physical, chemical and biological integrity of the upper Flathead River Basin.

Sentinel Sites:

North Fork of the Flathead River at the International Border (USGS 12355000) (13)

Site justification: The USGS measures continuous river flow at this site since 1952 to 1995 and 1999 to current and collects water quality samples 4 times per year since 1999. The USGS has begun to take 4 additional water quality samples/year for nutrients, suspended solids and major ions and once per year for Chl a and TOC..This site provides baseline information that allows the determination of potential changes in water quality from resource management decisions in British Columbia. It is essential to long-term trend analysis. This site is particularly important as a site for monitoring water quality at the international border between the USA and Canada.

Sampling frequency: Water quality 8 times per year; continuous discharge and temperature
Sampling variables: $_2$Q, T/phys, Nuts, Cat, An, M, TSS, Seds, Chl a, TOC, $_1$BMacro
Monitoring partner: $_2$USGS, $_4$DNRC, $_6$DEQ, $_1$FLBS
Current funding sources: The cost of for water quality is shared 50:50 between the DNRC and USGS for 4 samples and the DEQ and USGS for the other four samples. The continuous flow measurement costs are born by the USGS.

Note: Sampling frequency at this site is currently at 8 times per year. Funding permitted, sampling should be increased to 15 times/year.

North Fork of the Flathead River near Columbia Falls (USGS 12355500) (14)

Site justification: This site is the primary gage site on the North Fork of the Flathead River near the confluence with the Middle Fork. It is an important site for monitoring river flows and changes in water quality within the North Fork River watershed. Also, most of the western tributaries of the North Fork are identified on the DEQ 303(d) list as impaired.

Sampling frequency: Water quality 6 times per year; Continuous discharge
Sampling variables: $_2$Q, T/phys, Nuts, Cat, An, M, TSS, Seds, Chl a, TOC, $_1$BMacro
Monitoring partners: $_2$USGS, $_6$DEQ, $_1$FLBS
Current funding sources: The USGS has measured continuous stream flow at this site since 1935 and intermittently before then. Costs are presently shared between the USGS and the Bonneville Power Administration. Water quality was measured by the USGS for 5 years (1999-2003) and then discontinued. Water quality samples were collected four times per year and analyzed for nutrients and sediment. USGS costs were cost-shared 50:50 with the Department of Environmental Quality. Water Quality is currently sample by the USGS 6 times per year and cost shared with the DEQ beginning in June 2007.

Note: Water quality sampling should be increased to a minimum of 8 times per year and a maximum of 15 times per year, to assess the effects of recent large fires on

sediment loads, similar to those parameters collected at the gage site at the International border.

Middle Fork of the Flathead near West Glacier (USGS 12358500) (15)

Site justification: This site is the primary gage site on the Middle Fork of the Flathead River near the confluence with the North Fork. It is an important site for monitoring river flows and changes in water quality within the Middle Fork River watershed. Only Granite and Morrison Creeks, tributaries to the Middle Fork are identified on the DEQ 303(d) list as impaired. Water quality is sampled by the USGS 6 times per year for nutrients, suspended solids, major ions, and 1 time per year for Chl a and TOC since June 2007.

Sampling frequency: Water quality 6 times per year; Continuous discharge
Sampling variables: $_2$Q, T/phys, Nuts, Cat, An, M, TSS, Seds, Chl a, TOC, $_1$BMacro
Monitoring partners: $_2$USGS, $_6$DEQ, $_1$FLBS
Current funding sources: The USGS has measured continuous stream flow at this site since 1939 and the costs are presently shared between the USGS and the Bonneville Power Administration. Water quality was measured by the USGS for 5 years (1999-2003) and then discontinued. Water quality samples were collected four times per year and analyzed for nutrients and sediment. USGS costs were cost-shared 50:50 with the Department of Environmental Quality. Water Quality is currently sample by the USGS 6 times per year and cost shared with the DEQ beginning in June 2007.

Note: Water quality sampling should be increased to a minimum if 8 times per year and a maximum of 15 times per year.

South Fork of the Flathead River near Hungry Horse (USGS 12362500) (16)

Site justification: The USGS has measured continuous stream flow at this site intermittently before 1928 and continuously since then. Flow and water quality downstream of Hungry Horse Reservoir are important for understanding flow releases from the dam and water quality associated with dam and reservoir operations. Water quality is sampled by the USGS 6 times per year for nutrients, suspended solids, major ions, and 1 time per year for Chl a and TOC since June 2007. The lower South Fork of the Flathead has been identified on the 303(d) list as impaired.

Sampling frequency: Water quality 6 times per year [a]; Continuous discharge and temperature [b]
Sampling variables: $_2$Q, T/phys, Nuts, Cat, An, M, TSS, Seds, Chl a, TOC, $_1$BMacro
Monitoring partners: $_2$USGS, $_6$DEQ, $_5$DFWP, $_1$FLBS
Current funding sources: The Bureau of Reclamation has traditionally paid for water quality sampling and analysis by the FLBS but funding was discontinued in fall 2006. The USGS stream flow is paid for by BOR. The DFWP pays for the continuous recording of river temperature monitored by the USGS. Costs for water quality

are shared between USGS and DEQ. Benthic macroinvertebrates are not currently part of the funded monitoring.

Note: Water quality sampling should be increased to a minimum of 8 times per year, and a maximum of 15 times per year.

Flathead River at Columbia Falls (USGS 12363000) (17)

Site justification: This USGS continuous flow river site provides data to assess changes in flows and water quality from upstream tributaries and establishes the baseline of waters entering the Kalispell Valley from the mostly forested lands above Bad Rock Canyon. Continuous flows have been taken since 1928. This site is particularly important for identifying changes in water quality in that region of the watershed dominated by our human population (i.e., between Columbia Falls and Flathead Lake).

Sampling frequency: Water quality 4 times per year; Continuous discharge and temperature
Sampling variables: Q, T/phys, Nuts, Cat, An, M, TSS, BMacro, Seds
Monitoring partners: USGS, DNRC, PP&L MT
Current funding sources: Adequate water quality monitoring is unfunded. The USGS operates the gaging station, and PP&L Montana pays for the costs of flow measurements. The USGS collects water quality samples 4 times per year and analyzes them for nutrients and sediment, and twice per year for metals. Water quality costs are shared equally between DNRC and the USGS and total $6,200.

Note: The sampling frequency at this site should be increased to a minimum of 8 times per year and a maximum of 15 times per year, if an analysis of trends in nutrient loading from the Kalispell reach (i.e., the urbanized portion) of the Flathead River is desired.

Swan River near Bigfork (USGS 12370000) (18)

Site justification: This site, located directly downstream of Swan Lake, is important to understand flows from the Swan drainage and provides the discharge data for the water quality monitoring site at the steel bridge in Bigfork. Continuous discharge measurements are taken by the USGS in the Swan River immediately downstream from Swan Lake (site 12370000) since 1922 and cost shared with DFWP and DNRC. These continuous discharge measures are used to estimate nutrient loading from the Swan River drainage at Bigfork.

Sampling frequency: Water quality 15 times per year [a]; continuous discharge [b]
Sampling variables: $_2$Q, $_1$T/phys, Nuts, Cat, An, M, Hg,TSS
Monitoring partners: $_2$USGS, $_1$FLBS, DNRC, DFWP
Current funding source: FLBS; DFWP and DNRC cost share the funding for this gauge with the USGS

Note: The cations, metals, Hg and Cl are not current variables.

Flathead River below Kerr Dam (USGS 12372000) (19)

Site justification: This USGS site measures continuous outflows from Flathead Lake since 1907 and provides the discharge data for the water quality monitoring site for the Flathead River at the bridge in Polson. Continuous discharge data is necessary for the calculation of nutrient mass balance in Flathead Lake.

Sampling frequency: Continuous discharge
Sampling variables: $_2$Q
Monitoring partner: $_2$USGS, PP&L MT
Current funding source: PP&L Montana

Stillwater River above confluence with the Whitefish River (USGS 12365700) (20)

Site justification: This is a new site for the USGS. The old site (USGS 12365000) is too far upriver to establish baseline flow and for determining water quality trends from the Stillwater River. The new site is about two river miles upstream of the confluence with the Stillwater River. This will allow the collection of water quality data from groundwater returning into the Stillwater River. Flows will be measured at both sites for an additional year to establish a correlation with the historical period of record at the two sites. Water quality is sampled by the USGS 6 times per year for nutrients, suspended solids, major ions, and 1 per year for Chl a and TOC since June 2007.

Sampling frequency: Water quality 6 times per year; Continuous discharge
Sampling variables: $_2$Q, T/phys, Nuts, Cat, An, M, TSS, BMacro, Seds, Chl a, TOC
Monitoring partners: $_2$USGS, DNRC, DEQ
Current funding source: Costs for water quality monitoring is shared between DEQ and USGS. Seasonal flow measurements are being collected by the USGS and cost shared with DNRC

Note: Water quality sampling should be increased to a minimum of 8 times per year, and maximum of 15 times annually for nutrients and sediment.

Whitefish River above confluence with the Stillwater River (USGS 12366080) (21)

Site justification: This is a new site for the USGS. The old site (USGS 12366000) is too far upriver to establish baseline flow and for determining water quality trends from the Whitefish River. This site is being abandoned and replaced with a site located 11.1 miles down river or about 1.8 miles above the confluence with the Stillwater River where Reserve Street bridge crosses the Whitefish River. This will allow the collection of water quality data from groundwater within the lower Whitefish River. River flows will be measured at both sites for an additional year to establish a correlation with the historical period of record at the two sites. Water quality is sampled by the USGS 6 times per year for nutrients, suspended solids, major ions, and 1 per year for Chl a and TOC since June 2007

Sampling frequency: Water quality 6 times per year; Continuous discharge
Sampling variables: $_2$Q, T/phys, Nuts, Cat, An, M, TSS, BMacro, Seds, Chl a, TOC
Monitoring partners: $_2$USGS, DNRC, DEQ
Current funding source: Costs for water quality monitoring is shared between the USGS and DEQ. Seasonal flow measurements are being collected by the USGS and cost shared with DNRC.

Note: Water quality sampling should be increased to a minimum of 8 times per year, and a maximum of 15 times annually for nutrients and sediment

Flathead River at Perma (USGS 12388700) (22)

Site justification: This is the farthest down-river site before the Flathead River flows into the Clark Fork River. This site is a good indicator of total changes of flows and water quality within the Flathead River drainage. Continuous flow measures are taken by the USGS (since 1983) and cost shared between USGS and CSKT.

Sampling frequency: Water quality 15 times per year; Continuous discharge
Sampling variables: $_2$Q, $_3$T/phys, Nuts, M, Hg, Seds, TDS, TSS, Fecal coliform, Chlorophyll a
Monitoring partners: $_3$CSKT; $_2$ USGS
Current funding sources: The USGS is measuring continuous stream flow at this site and the costs are paid for by the CSKT. Water quality samples were collected four times per year for nutrients, temperature and sediments between 1999 and 2003.

Note: Water quality sampling should be added at this site for nutrients, sediment and metal for a minimum of 8 times per year and a maximum of 15 times per year. Water Quality is currently unfunded.

Recommended Additional Upper Basin Sentinel Sites:

Upper Whitefish River

Justification; Flow and water quality sampling are needed to establish the baseline condition for determining the nutrient loading that is occurring within the Whitefish drainage and to monitor the effects of meeting the TMDL targets.

Upper Stillwater River

Justification; Flow and water quality sampling are needed to establish the baseline condition for determining the nutrient loading that is occurring within the Stillwater drainage and to monitor the effects of meeting the TMDL targets.

Transboundary (North Fork) of the Flathead River (Canada):

The North Fork of the Flathead River originates in southeast British Columbia and flows south across the international border into Montana, where it forms the western boundary of Glacier National Park. The upper 50 kilometers of the river drains British Columbia and the lower 75 km flows through Montana to the confluence with the Middle Fork of the Flathead River.

Given the transboundary nature of the North Fork, it is the objective of the FBC to include the British Columbia portion of the drainage within the scope of the long-term Water Quality Monitoring Plan. The FBC does not take responsibility for prescribing or implementing monitoring in the B.C. portion of the basin; however, it is imperative that where possible, monitoring efforts in the Montana portion of the North Fork be coordinated and consistent with monitoring efforts in the B.C. portion of the North Fork. This coordination is facilitated by appointment of a Provincial Minister from British Columbia to the FBC, who also sits on both the Transboundary and Monitoring and Data Assessment Committees.

In addition, various agencies represented on the FBC are actively coordinating and implementing monitoring in the B.C. and Montana portions of the North Fork. FBC includes these projects in its description of monitoring in the basin, and will provide support to these projects where appropriate and feasible. The FBC recognizes the need for the Water Quality Monitoring Plan to interface with the multiple agency approaches to baseline characterization and long-term monitoring efforts in the basin, including Provincial approaches in the B.C. portion of the basin[10].

The following sites in Canada are associated with the location of coalfields that are targeted for exploration and commercial development. Each of these sites is critical to the understanding of the effects of coal mine operations on the physical, chemical, and biological integrity of the waters of the North Fork of the Flathead River both in Canada and in the United States.

Flathead River above confluence with Foisey Creek (a)

Sampling frequency: 6-8 times per year (due to limited access fall-spring)
Sampling variables: T/phys, Nuts, Cat, An, M, TSS
Monitoring partners: FLBS; MT DFWP
Current funding source: Funding for these sites as well as an array of additional sites was provided in 2004 and 2005 by a consortium of Glacier National Park, DFWP, and foundations.

Foisey Creek at confluence with Flathead River (b)

Sampling frequency: 6-8 times per year

[10] Montana and British Columbia are engaged in negotations to finalize the Environmental Cooperation Arrangement (Appendix IX) signed by the state and the province in 2003.

Sampling variables: T/phys, Nuts, Cat, An, M, TSS
Monitoring partners: FLBS; MT DFWP
Current funding source: Funding for these sites as well as an array of additional sites was provided in 2004 and 2005 by a consortium of Glacier National Park, DFWP, and foundations.

Flathead River below confluence with Foisey Creek (c)

Sampling frequency: 6-8 times per year
Sampling variables: T/phys, Nuts, Cat, An, M, TSS
Monitoring partners: FLBS; MT DFWP
Current funding source: Funding for these sites as well as an array of additional sites was provided in 2004 and 2005 by a consortium of Glacier National Park, DFWP, and foundations.

Flathead River at McClatchie Bridge (d)

Sampling frequency: 6-8 times per year
Sampling variables: T/phys, Nuts, Cat, An, M, TSS
Monitoring partners: FLBS; MT DFWP
Current funding source: Funding for these sites as well as an array of additional sites was provided in 2004 and 2005 by a consortium of Glacier National Park, DFWP, and foundations. .

McClatchie Creek at bridge above confluence with Flathead River (e)

Sampling frequency: 6-8 times per year
Sampling variables: T/phys, Nuts, Cat, An, M, TSS
Monitoring partners: FLBS; MT DFWP
Current funding source: Funding for these sites as well as an array of additional sites was provided in 2004 and 2005 by a consortium of Glacier National Park, DFWP, and foundations.

Flathead River at Pollock Creek (f)

Sampling frequency: 6-8 times per year
Sampling variables: T/phys, Nuts, Cat, An, M, TSS
Monitoring partners: FLBS; MT DFWP
Current funding source: Funding for these sites as well as an array of additional sites was provided in 2004 and 2005 by a consortium of Glacier National Park, DFWP, and foundations.

Note: Funding is needed for future water quality monitoring and discharge monitoring for the sites in the Canadian portion of the North Fork Flathead River.

C. FLATHEAD BASIN – SURVEY SITES

Sample design: sample size and frequency: The location of Survey Sites in the Flathead Basin will be generated using a sample design approach developed by the US EPA and implemented by the NPS. The design methodology is well-tested and accepted by nearly all state water quality monitoring agencies. The design will be determined by the National Park Service with collaboration by FBC, FLBS, MT DEQ and EPA. Complete documentation for the design process, design-based analytical procedures, and details on the statistical capabilities of the design are available from the NPS or EPA.

Survey Sites will potentially occur within any perennial, natural (e.g., not a ditch or canal) flowing water within the basin. A GIS model will be used to reduce the number of sites in inaccessible locations. Sites will be structured into panels or sets sampled in a single year during a late summer index period (Table 2). Sample sizes will vary with year as follows: large samples of 35 sites will be conducted every 10 years, with smaller samples of 5 or 10 sites revisited in consecutive years in the intervening period. This design results in 90 unique sites after 10 years of monitoring. The same design structure (including approximate sample sizes) is being employed by the NPS in Glacier National Park. Initial pilot work will be done in the portion of the N. Fork basin that falls inside Glacier National Park (FY 2007 – FY 2009). Approximately 10% of the flowing water in the Flathead Basin is in the North Fork watershed in Glacier. Therefore, we can assume that this same percentage of Survey Sites (3 or 4 in large sample years and 1 in smaller sample years) will be accounted for by GNP sites (e.g., they will serve double duty in the two monitoring programs) and the Survey Site sample size within the FBC plan can be reduced by this amount. Most Survey Sites are visited once during their panel. However, 10 - 20% of sites should be revisited within a panel for quality assurance and to develop estimates of within season variability. These revisits may also be used to conduct sampling that requires leaving sampling gear (e.g., sediment plates).