



Sediment Beneficial Use Support Assessment for Whitefish Lake

Addresses Assessment Unit MT76P004_010

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Prepared by:

Christian Schmidt

Montana Department of Environmental Quality
Water Quality Planning Bureau
1520 E. Sixth Avenue
P.O. Box 200901
Helena, MT 59620-0901



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ABSTRACT

An oligotrophic lake located at an elevation of 914 meters above sea level, Whitefish Lake is 9.2 km long and approximately 2.3 km wide with 25.7 km of shoreline; Swift Creek, the largest tributary to the lake, comprises 64% of the watershed area. In sample data from 2007 to 2013, which included 15 paired sampling events, Swift Creek comprised a mean of 82% of the total TSS load from sampled tributaries. Normalized by drainage area, a two-sample t-test assuming unequal variances failed to reject the null hypothesis that average TSS loads were not significantly different in each tributary; the TSS load per km² in Swift Creek was not significantly different from areal loading in other tributaries. As Swift Creek is unimpaired by sediment, it may be assumed that all other tributaries are also unimpaired. An analysis of permanent lake monitoring location data observed 68% of the TSS observations at IP1 and 62% of the observations at IP2 were less than the detection limit (1.0 mg L⁻¹) with year to year trends in TSS and Secchi depth tied to spring runoff magnitude. LSPC landscape modeling results, combined with DEQ assessment narratives, determined that TSS loading to the lake is >85% natural in origin. Observed changes in lake sediment water quality are the result of naturally occurring seasonal processes with few anthropogenic sources, and are primarily influenced by spring runoff dynamics. The assessment finds that beneficial uses in Whitefish Lake are not currently threatened or impaired by sediment.

1.0 INTRODUCTION

In the spring of 2014, the Water Quality Planning Bureau of the Planning, Prevention and Assistance Division of Montana DEQ decided to re-assess the existing sediment threatened listing on Whitefish Lake in northwestern Montana. On the 2014 303(d) list, Whitefish Lake is threatened by sediment but is fully supporting all assessed beneficial uses. Whitefish Lake was last formally assessed by DEQ in 2000. Aquatic life was first listed as threatened by sedimentation/siltation in 1996, and the lake remains listed for this reason on the 2014 303(d) list. In addition to sediment, Whitefish Lake is also listed as threatened by polychlorinated biphenyls (PCBs) and mercury. There are no listings for habitat alterations (non-pollutant listings) on Whitefish Lake.

The 2014 Whitefish Lake sediment assessment is a weight-of-evidence approach that examined several different metrics to gauge if an existing threat from sedimentation/siltation exists for Whitefish Lake. The approach reviewed the listing history for the watershed, recent Secchi depth and TSS water quality data for the lake and multiple tributaries, and the results of landscape model prediction for TSS loading to the lake.

2.0 WHITEFISH LAKE WATERSHED

Whitefish Lake is an oligotrophic lake located in northwestern Montana at an elevation of 914 meters above sea level. The lake is 9.2 km long and approximately 2.3 km wide with 25.7 km of shoreline (Whitefish Lake Institute, 2012). At its deepest point, the lake is approximately 71 meters deep (Reller, 2006). Whitefish Lake is classified as an A-1 waterbody meaning the lake is “suitable for drinking, culinary, and food processing purposes after conventional treatment for removal of naturally present impurities. Under this classification, water quality must be suitable for bathing, swimming and recreation, growth and propagation of salmonid fishes and associated aquatic life; waterfowl and furbearers; and agricultural and industrial water supply”. In addition to surface water diversions from Haskill Creek, Whitefish Lake is part of the municipal water supply for Whitefish, MT. Many local residents not on municipal supply draw domestic supplies directly from the lake.

The Whitefish Lake watershed has a total area of 309.8 km² from headwaters to the outlet of Whitefish Lake (Whitefish River). Of the total watershed area, 64% lies within the Swift Creek watershed (**Figure 1**); one of six tributary streams that discharge to the lake. The Whitefish Lake watershed includes two Level III ecoregions: Canadian Rockies and Northern Rockies, and is almost entirely forested upstream of Whitefish Lake. In contrast, much of the lake shoreline has been developed with the highest urban and residential densities occurring near the southern end of the lake around the community of Whitefish, MT. For the entire watershed, 51% of the area is administered by the State of Montana (DNRC), and 15% by the United State Forest Service (USFS; Flathead National Forest). A ski resort, Whitefish Mountain Resort, lies almost entirely outside the Whitefish Lake watershed with only a very small proportion in the Hell Roaring Creek drainage. This small proportion appears to only include a ski run and no resort buildings.

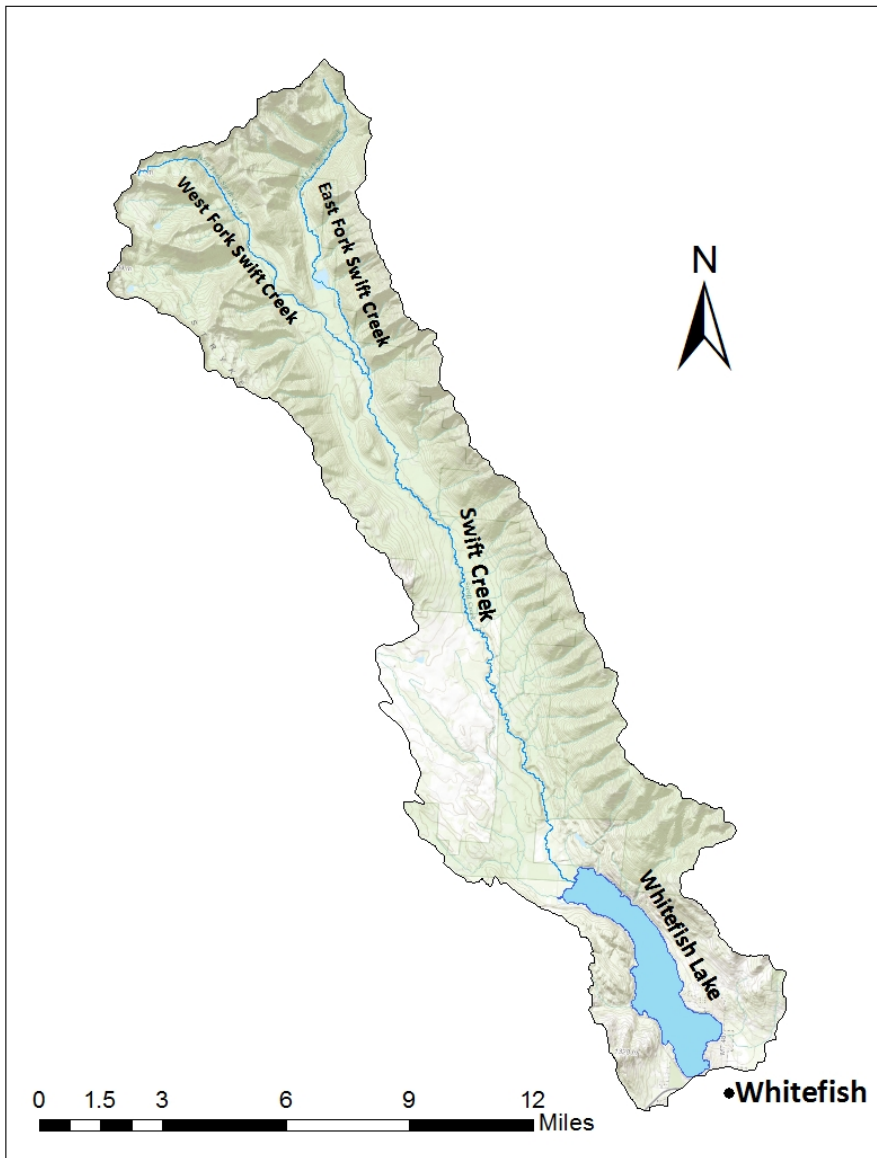


Figure 1. Whitefish Lake watershed

It is worth noting that Swift Creek was listed for a sediment impairment in 1996. However, a re-assessment by DEQ in 2008 indicated that Swift Creek was fully supporting all beneficial uses for sediment and the sediment listing was removed using data collected by the Whitefish Institute (2002-2003) and the Montana Department of Natural Resources and Conservation (DNRC) (1976-2006). In addition, a Total Phosphorus impairment listing for Swift Creek was delisted in 2012 based on data collection completed in 2010.

3.0 EFFECTS OF SEDIMENT ON BENEFICIAL USES

The weathering and erosion of land surfaces and the transport of sediment to, and via, streams and lakes/reservoirs are natural phenomena and important in building and maintaining natural processes. Yet, excessive erosion and/or the absence of natural sediment barriers (e.g., riparian vegetation, woody

debris, beaver dams, and overhanging vegetation) can cause high levels of suspended sediment in streams and potential in-filling of lakes/reservoirs. In addition, excess suspended sediment in lakes/reservoirs can have adverse impacts to beneficial uses including recreation, aquatic life, and drinking water.

High levels of suspended sediment reduce light penetration through water, which can limit the growth of aquatic plants. As a result, aquatic insect populations could also decline. In turn, this can limit fish populations. Deposited sediments can also obscure sources of food, habitat, hiding places, and nesting sites for invertebrate organisms.

Excess sediment is known to impair certain biological processes, including reproduction and survival, of individual aquatic organisms by clogging gills and causing abrasive damage, reducing the availability of suitable spawning sites, and smothering eggs or hatchlings. When fine sediments accumulate on stream bottoms it can also reduce the flow of water through gravels harboring incubating eggs, hinder the emergence of newly hatched fish, deplete oxygen supplies to embryos, and cause metabolic wastes to accumulate around embryos, all resulting in higher mortality rates.

High concentrations of suspended sediment in lakes and reservoirs can create murky or discolored water, decreasing recreational use potential and aesthetic appreciation. Excessive sediment can also increase filtration costs for water treatment facilities that provide safe drinking water.

4.0 SEDIMENT WATER QUALITY STANDARDS

Narrative standards are developed when there is insufficient information to develop numeric standards and/or the natural variability makes it impractical to develop numeric standards. Narrative standards describe the allowable or desired condition. This condition is often defined as an allowable increase above “naturally occurring.” DEQ often uses the naturally occurring condition, called a “reference condition,” to help determine whether or not narrative standards are being met. Reference defines the condition a waterbody could attain if all reasonable land, soil, and water conservation practices were put in place. Reasonable land, soil, and water conservation practices usually include, but are not limited to, best management practices (BMPs).

In developing targets, natural variation throughout the system must be considered. DEQ uses the reference condition to gauge natural variability and assess the effects of pollutants with narrative standards, such as sediment. The preferred approach to establishing the reference condition is using reference site data, but modeling, professional judgment, and literature values may also be used. DEQ defines “reference” as the condition of a waterbody capable of supporting its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. In other words, the reference condition reflects a waterbody’s greatest potential for water quality given historic and current land-use activities.

Sediment (i.e., coarse and fine bed sediment) and suspended sediment are addressed via the narrative criteria;

No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except as permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.

The relevant narrative criteria do not allow for harmful or other undesirable conditions related to increases above naturally occurring levels or from discharges to state surface waters. This is interpreted to mean that water quality goals should strive toward a condition in which any increases in sediment above naturally occurring levels are not harmful, detrimental or injurious to beneficial use.

For the Whitefish Lake assessment, the narrative sediment water quality standard will be applied by examining data from DEQ assessment files, tributary and lake water quality data and watershed modeling results to determine whether measured TSS loads and concentrations are at naturally occurring levels.

5.0 WHITEFISH LAKE SEDIMENT ASSESSMENT

DEQ has not developed an updated assessment methodology that evaluates whether beneficial uses are being attained for lakes or reservoirs. For the purposes of this assessment, DEQ applies a weight of evidence approach to evaluate possible excess fine sediment impacts to lakes. This approach includes the following indicators:

- 303(d) listing history
- Swift Creek TSS data analysis and comparison to other tributaries
- Whitefish Lake TSS and Secchi depth trend analysis
- Shoreline erosion
- Flathead Lake watershed model

The 2014 Whitefish Lake sediment assessment is a weight-of-evidence approach examining several different metrics to gage if an existing threat from sedimentation/siltation exists for Whitefish Lake. The approach reviews sediment loading dynamics from incoming tributaries with particular attention paid to Swift Creek, recent Secchi depth and TSS water quality data for the lake and multiple tributaries, and the results of landscape model prediction for TSS loading to the lake.

The assessment will seek to answer the question of whether fine sediment loading to Whitefish Lake is currently a threat to beneficial uses by examining the different metrics outlined above.

5.1 WHITEFISH LAKE WATERSHED 303(D) LISTING HISTORY

In the Whitefish Lake watershed, only two waterbodies have a listing history on the 303(d) list: Swift Creek (MT76P003_020) and Whitefish Lake (MT76P004_010). The listing history of the two waterbodies is provided in **Figure 2**. It should be noted that while the Whitefish Lake sediment threatened listing is shown as 1996, the lake was listed as threatened by sediment on the 1988 303(d) list and the 1992 303(d) list with breaks in listing in 1990 and 1994 (**Figure 2**). The breaks in listing are the reason why the 1996 threatened listing is considered the cycle first listed (CFL). The 1988 threatened listing for Whitefish Lake cites silviculture (harvesting, roads) with Swift Creek given as the specific source of the threat to beneficial uses in the lake (Montana Department of Health and Environmental Sciences, 1988).

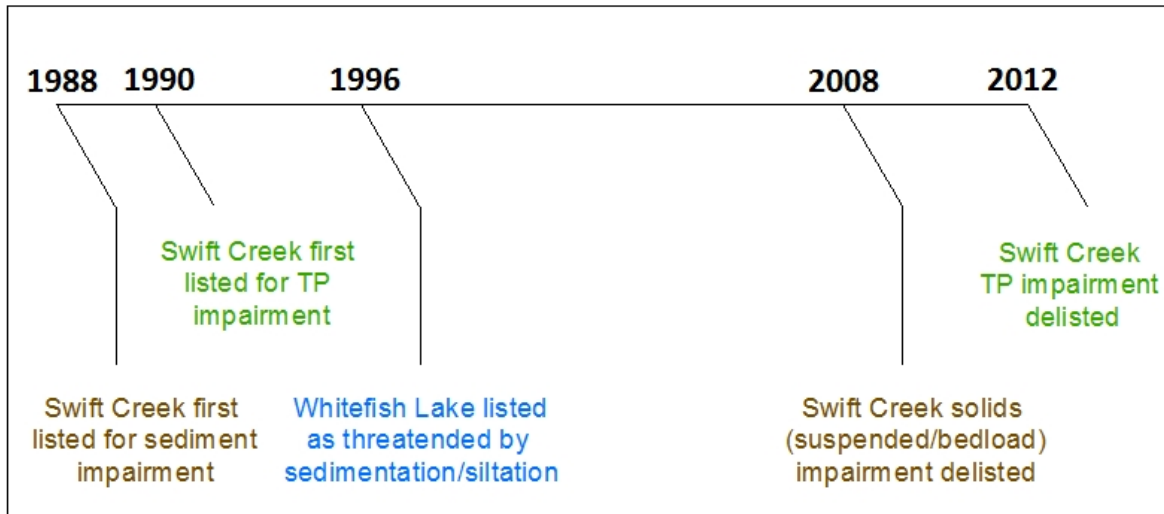


Figure 2. Whitefish Lake watershed listing timeline for 303(d) list

For clarity, the threatened listing for Whitefish Lake means that the lake is fully supporting all beneficial uses, but a threat exists that may lead to an exceedance of the standards in the future. The threatened status reflects either: (1) an adverse trend in water quality data; or (2) planned activities (e.g. timber harvesting, large mine operation) which would lead to a sediment impairment in the future.

Swift Creek was first listed for a Total Phosphorus (TP) impairment in 1990, but the TP impairment was delisted in 2012. In addition, Swift Creek was first listed for a sediment impairment (suspended solids) in 1988. In 2008, the Swift Creek sediment impairment was also delisted. From the Swift Creek assessment files comes the following description of sediment loading to the stream:

The stream is a naturally high bedload system. Most of the sediment loading occurs on mid to lower reaches of Swift Creek, and is attributed predominately to naturally eroding hillslopes that are intercepted by the channel, and to minor bank erosion. Ninety-three percent of the Swift Creek streambanks are stable. Human-caused sediment loads are negligible. The stream and its tributaries have had several restoration projects, including the replacement of about 15 culverts, and 3 well engineered bridges; these projects were aimed at reducing sediment from road and bridge sources. The stream transports fine sediment well; larger material may result in areas of deposition. High TSS concentrations are most likely to occur during runoff, as expected; low flow TSS concentrations are low. The effects of the natural sediment supply account for the predominant sources of suspended sediment and bedload.

For the sediment delisting rationale, sediment loading in the Swift Creek drainage was determined to be overwhelming a function of naturally occurring stream processes.

The 1996 sedimentation/siltation threatened listing (and original 1988 threatened listing) was supported by findings in Spencer (1991) who shows that lake sedimentation rates (as determined from Whitefish Lake sediment cores) were much higher in the 20th century compared to the 1880s prior to the time the first sawmill was established in the watershed. Spikes in sedimentation rates corresponded to periods of intensive logging or road/rail construction (e.g. 1900; early 1930s). Spencer (1991) notes that logging BMPs and better road construction practices implemented in recent decades might explain drops in

sedimentation rates observed since the mid-1960s, but the study was inconclusive. It is important to note here that the Streamside Management Zone law first went into effect on March 15, 1993, which has been shown to be very effective at buffering streams from timber harvesting practices.

The existing threatened listing for sediment on Whitefish Lake is attributed to the determination in 1996 (and 1988 originally) that land uses activities in the Swift Creek watershed, the largest tributary to Whitefish Lake, were threatening beneficial uses in Whitefish Lake. Currently, there are no impairment listings on Swift Creek (delistings of sediment in 2008, TP in 2012) and Swift Creek is fully supporting all beneficial uses.

5.2 WATER QUALITY DATA

Although DEQ has not conducted recent monitoring on Whitefish Lake, efforts by the Whitefish Lake Institute (Whitefish Lake Institute, 2012) and by the Northwest Montana Lakes Volunteer Monitoring Network have included collection of multiple water quality parameters at several locations in the lake and from most of the tributaries to Whitefish Lake since 2007. The DNRC also has an extensive dataset for Swift Creek from 1976 to the present. For all tributaries where data has been collected, stage-discharge relationships have been established.

The Whitefish Lake Institute has two permanent lake monitoring locations: IP1 (deep site) and IP2 (shallow site). This dataset includes water quality parameters from 2007 to the present, and, in addition to the two lake sites, includes water quality monitoring on Whitefish Lake tributaries (**Figure 3**).

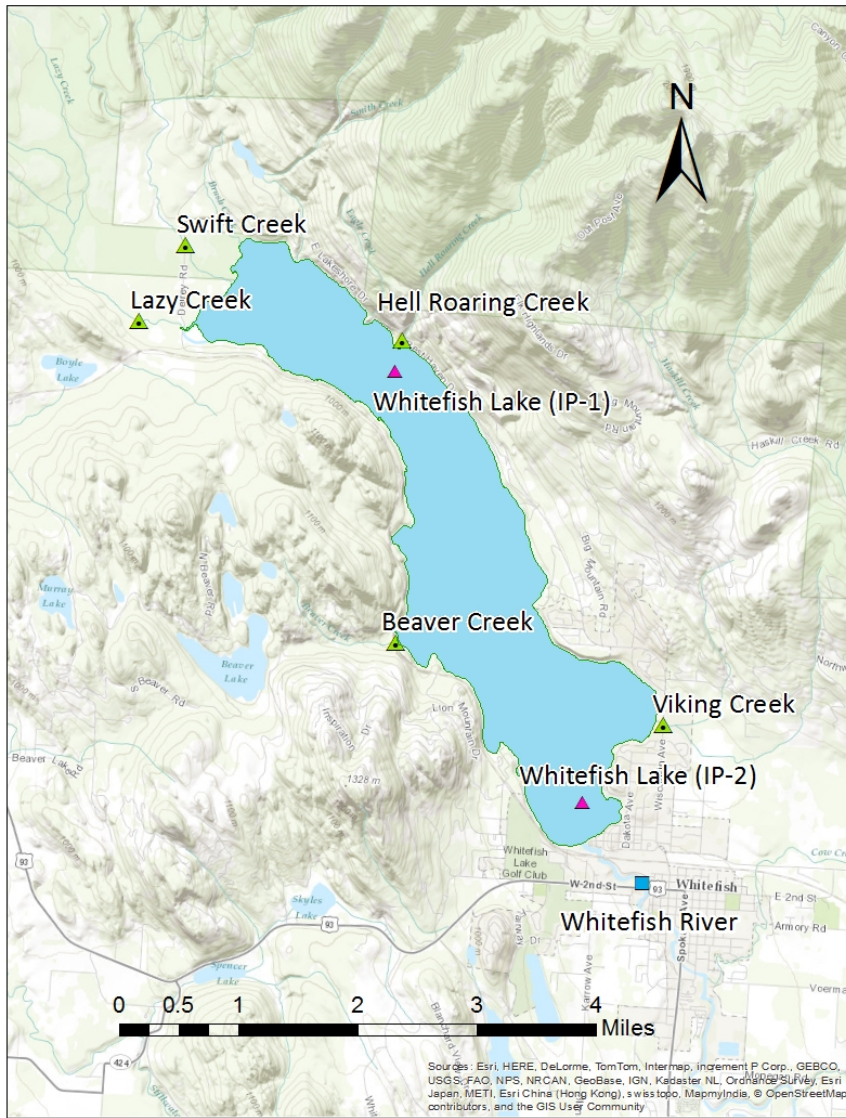


Figure 3. Whitefish Lake Institute water quality monitoring locations around Whitefish Lake (Swift Creek @ Olney Road (12.2 miles upstream of mouth) not shown)

5.2.1 Tributary TSS data analysis

The Whitefish Lake Institute monitors water quality and discharge in several streams around Whitefish Lake and on the Whitefish River $\frac{3}{4}$ miles downstream of the lake outlet. In addition, the DNRC also monitors flow and TSS at sampling stations on Swift Creek coordinating with the WLI monitoring work.

2013 stream water quality data includes flow and water quality measurements from seven different sites, five of which are located at the mouth of Whitefish Lake tributaries. For the dataset provided by the WLI, the five largest tributaries were sampled consistently from 2009-2013 with a sixth, Beaver Creek, added in 2013. An analysis of relative TSS concentrations and loads from tributaries to Whitefish Lake for this time period will be presented in the interest of defining TSS loading from the Swift Creek to Whitefish Lake, which is the original basis for the sediment threatened listing on Whitefish Lake.

Total Suspended Solids (TSS) concentration analysis

In **Table 1**, a statistical summary of 2009-2013 TSS concentration data is presented. Comparison between tributaries determined that Swift Creek TSS concentrations are, generally, more than one order of magnitude greater than all other tributaries with the exception of Viking Creek.

Table 1. Summary of TSS concentration data for Whitefish Lake tributaries (2009-2013)

Tributary ¹	# of obs.	# of TSS NDs ²	Min (mg/L)	Max (mg/L)	Average (mg/L)	Median (mg/L)	75 th percentile (mg/L)
Beaver Creek	2	1	<1.0	2.0	NA	NA	NA
Hell Roaring Creek	27	9	<1.0	24.0	3.4	2.0	3.0
Lazy Creek	27	14	<1.0	21.0	3.2	0.5	3.0
Smith Creek	29	15	<1.0	54.0	4.5	0.5	3.0
Swift Creek	56	2	<1.0	447.0	51.6	18.5	52.0
Viking Creek	29	NA	2.0	120.0	16.0	8.0	13.0

¹ All sites are near the tributary mouth; ² 1/2 of detection limit (1.0 mg/L) substituted for non-detects in order to calculate summary statistics

Figures 4 and 5 represent all TSS data for sampled Whitefish Lake tributaries (2009-2013) and present TSS concentration data by day/month and by date. Most apparent in these figures are the relative differences between Swift Creek TSS concentrations and all other stream samples. Important to note, data were not consistently sampled at all locations in all years. In **Figures 4 and 5**, Swift Creek TSS concentrations are the highest of all sampled tributaries seasonally (**Figure 4**) and across years (**Figure 5**).

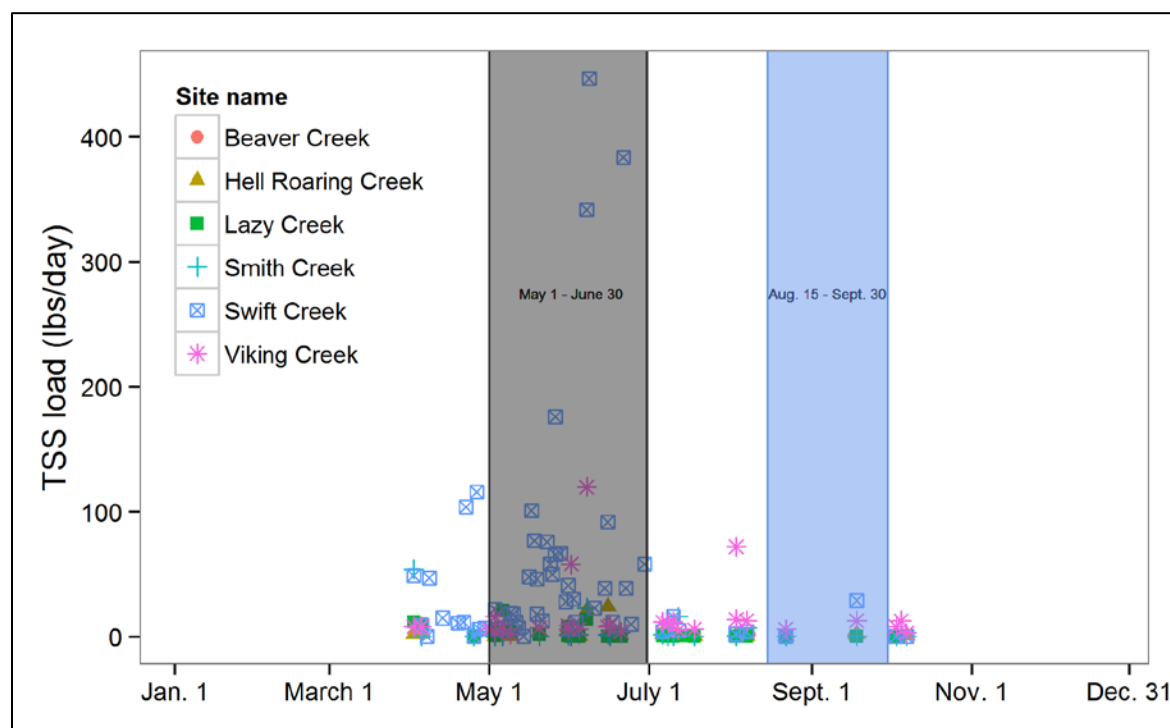


Figure 4. TSS data for Whitefish Lake tributaries by month/day (2009-2013)

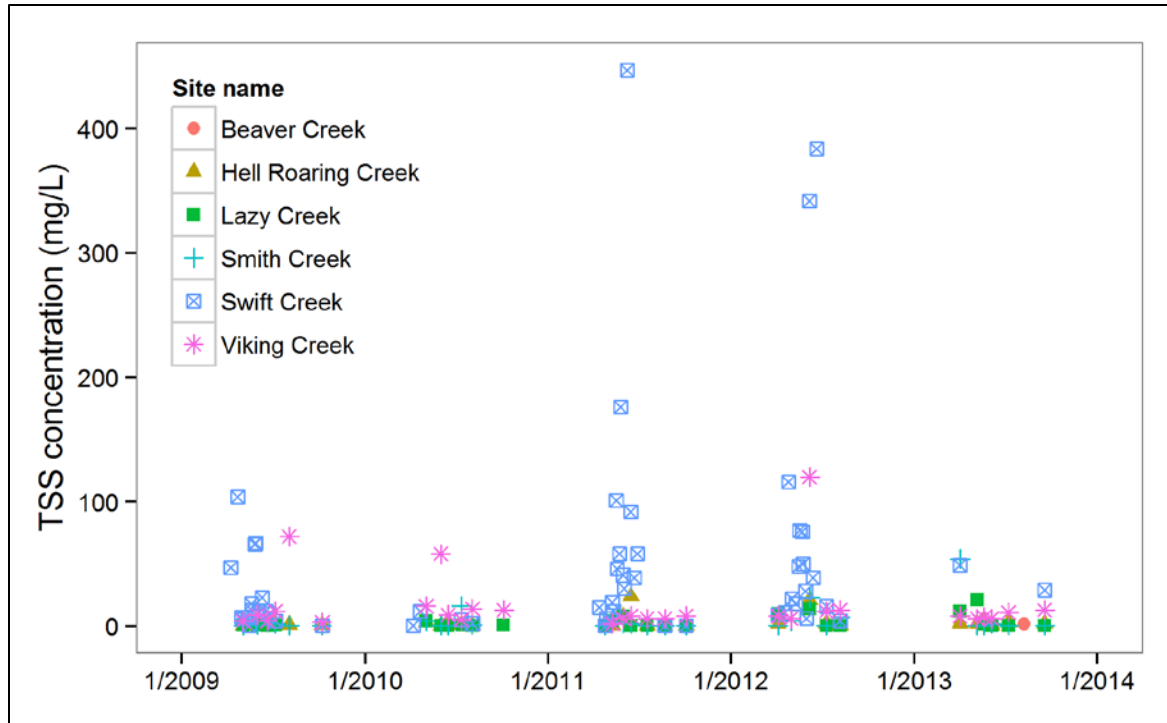


Figure 5. TSS data for Whitefish Lake tributaries over time (2009-2013)

Total Suspended Solids (TSS) loading analysis

In order to assess tributary TSS loading to Whitefish Lake, stage/discharge relationships developed by WLI and DNRC (Swift Creek) were used to calculate TSS loads (lbs/day) for the time period 2009-2013. In **Table 2**, summary TSS load (lbs/day) statistics are presented. Average TSS loading from Swift Creek to Whitefish Lake was between two to four orders of magnitude greater than the other measured Whitefish Lake tributaries.

Table 2. Summary of TSS concentration data for Whitefish Lake tributaries (2009-2013)

Tributary¹	# of obs.	# of TSS NDs²	Min	Max	Average	Median	75th percentile
Beaver Creek	2	1	0.5	11.2	5.9	5.9	8.5
Hell Roaring Creek	27	9	8.6	2,006.5	195.6	44.3	106.3
Lazy Creek	27	14	35.5	4,466.6	478.3	69.1	304.4
Smith Creek	29	15	4.9	860.2	84.8	15.1	96.6
Swift Creek	56	2	25.9	2,488,591.6	199,839.8	34,463.3	187,382.2
Viking Creek	29	NA	23.1	4,693.0	287.6	84.0	113.0

¹ All sites are near the tributary mouth; ² 1/2 of detection limit (1.0 mg/L) substituted for non-detects in order to calculate summary statistics

To further analyze the TSS load from Swift Creek relative to the other Whitefish Lake tributaries for which data is available, the full dataset was queried for sampling dates where Swift Creek and four other Whitefish Lake tributaries were sampled (Hell Roaring Creek, Lazy Creek, Smith Creek and Viking Creek). This resulted in 15 sampling dates (2008-2013) where all 5 sites were sampled for discharge and TSS on the same date. In 15 events, Swift Creek comprised an average of 82% of the total TSS load from

sampled tributaries with a median of 88% of the total TSS load (**Figure 6**). All other tributaries combined contributed an average of 18% (median of 12%) of the total TSS load to Whitefish Lake.

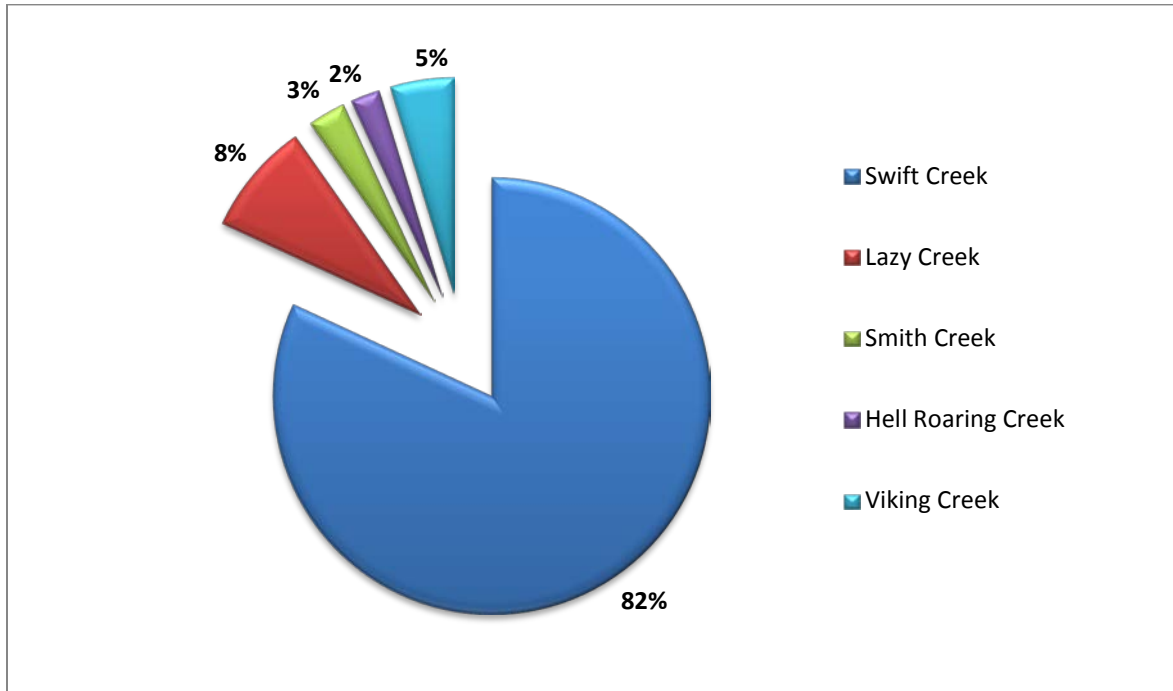


Figure 6. Average relative TSS loads to Whitefish Lake from tributary inputs for paired sampling events (n=15) (2008-2013)

Using the paired sampling date/TSS load dataset presented in **Figure 6**, an analysis of variance using a natural log transformation of TSS load (lbs/day) and using site as the predictor rejected the null hypothesis ($P=0.000$) that average TSS loads were not significantly different in each tributary. A Tukey test determined Swift Creek had a significantly greater average TSS load than the other Whitefish Lake tributaries. This is not surprising given the marked differences in the average loads between drainage basins when reviewing paired data, and the relative drainage area of Swift Creek versus the other tributaries.

However, when TSS loads were normalized based on drainage area (**Table 3**), a two-sample t-test assuming unequal variances failed to reject the null hypothesis; the TSS load per sq. km. in Swift Creek was not significantly different from areal loading in the other sampled Whitefish Lake tributaries. This metric suggests that if Swift Creek is not impaired for sediment, then it is likely that the other tributaries are not sediment impaired either.

Table 3. TSS loads normalized to drainage area per incoming tributary to Whitefish Lake

Drainage	Drainage area (sq. km.)	# of TSS/Q pairs	Average TSS load/sq. km.(lbs/day)	Median TSS load/sq. km. (lbs/day)
Hell Roaring Creek	7.5	15	38.7	6.9
Lazy Creek	42.2		14.9	1.6
Smith Creek	7.4		16.7	4.4
Swift Creek	198.3		798.6	18.2
Viking Creek	7.2		55.6	11.8

The results of the TSS tributary analysis determined that in 15 paired sampling events from 2008-2013 Swift Creek contributed an average of 82% of the total TSS load from the five largest Whitefish Lake tributaries. More importantly, Swift Creek is currently meeting all assessed beneficial uses having been delisted for sediment in 2008 and TP in 2012. As was stated in **Section 5.1**, the 2008 sediment delisting determined that *“Ninety-three percent of the Swift Creek streambanks are stable. Human-caused sediment loads are negligible”*.

5.2.2 Whitefish Lake data analysis

A systematic review and analysis of Whitefish Lake Secchi depth and TSS data was undertaken to provide context and relative magnitude of sediment loading in the Whitefish Lake watershed. As the existing threatened listing is for sediment and not phosphorus, analyses focused on a review of the sediment related water quality data.

Secchi depth

Secchi disk transparency is a function of the reflection of light from its surface, and is therefore influenced by the adsorption characteristics both of the water and of its dissolved and particulate matter (Wetzel, 1975). In general, the Secchi disk transparency depth correlates with the depth of approximately 10 percent of surface light (Wetzel, 1975). It is a useful metric to examine seasonal variations in water clarity in a lake. Among other parameters, TSS at low concentrations can affect light penetration in the water column.

Secchi depth in Whitefish Lake exhibits a seasonal pattern, with the seasonal minimum occurring during spring runoff/spring turnover (May 1 – June 30) and the seasonal maximum occurring in late summer (August 15 – September 30) (**Figure 7**). IP1 is the deep site near Hell Roaring point and IP2 is the shallower site northeast of the Whitefish beach (**Figure 3**).

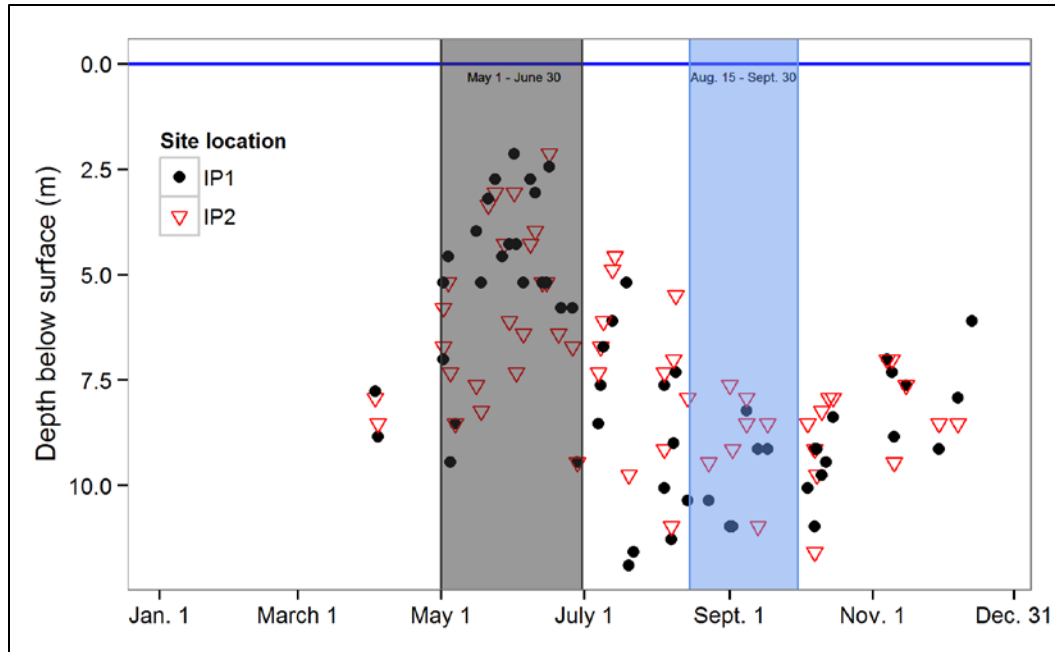


Figure 7. Secchi depth measurements for Whitefish Lake by month/day (2007-2013)

In order to identify potential trends, Whitefish Lake Secchi depth data is presented over time in **Figure 8**. While seasonal patterns are observable in **Figure 8**, there do not appear to be any apparent trends in Secchi depth with minimum and maximum values generally consistent through time.

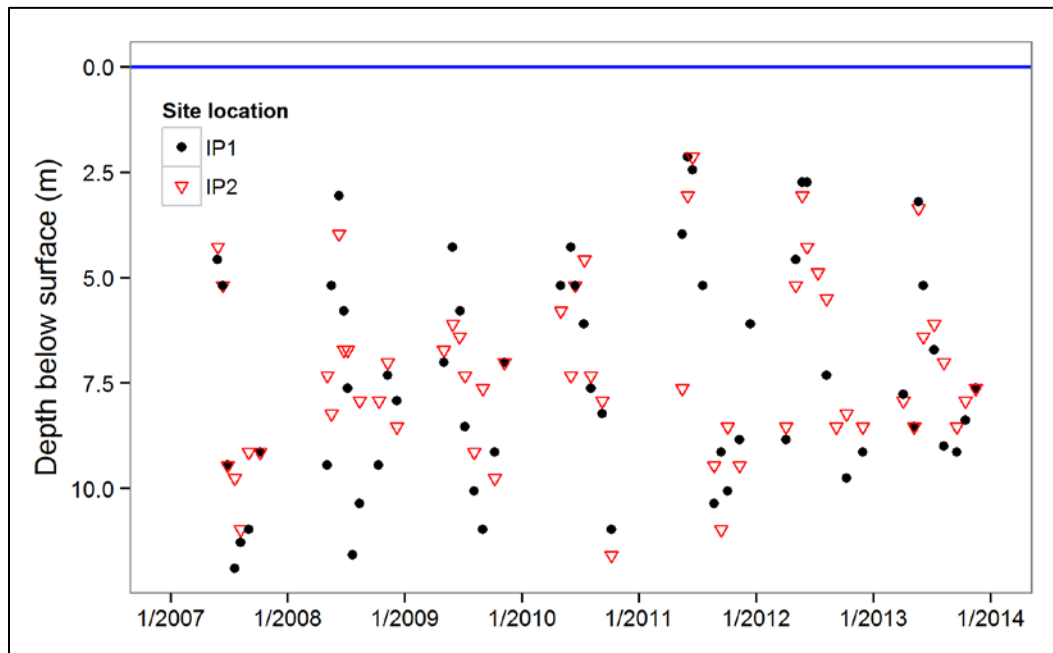


Figure 8. Secchi depth measurements for Whitefish Lake over time (2007-2013)

Total Suspended Solids

Summary TSS statistics for the long-term monitoring locations on Whitefish Lake are presented in **Table 4**. A large percentage of the data is less than the detection limit of 1 mg/L with 68% of the TSS observations at IP1 and 62% of the observations at IP2 less than the detection limit.

Table 4. Summary of Total Suspended Solids data for Whitefish Lake at long term monitoring locations

Site ID ¹	Time period	<i>n</i>	# of NDs ²	≥ 1 mg TSS/L	Average (mg/L)	Median (mg/L)	75 th percentile (mg/L)
IP1	2007-2013	116	79	37	1.20	0.50	1.00
IP2	2007-2013	100	62	38	1.24	0.50	1.00

¹ Both sites are >200 meters from the shoreline; ² 1/2 of detection limit (1.0 mg/L) substituted for non-detects in order to calculate summary statistics

Whitefish Lake TSS data is presented in **Figure 9** and **Figure 10** using different scales for the x-axis. In **Figure 9**, TSS is presented by month/day to display seasonal differences which are highlighted by the May 1 – June 30 spring runoff/spring turnover period and the August 15 – September 30 fall turnover period. In **Figure 10**, data is presented by date to highlight potential trends. Year to year trends appear to be tied to the magnitude of spring runoff. In both figures, the number of observations less than the detection limit stands out.

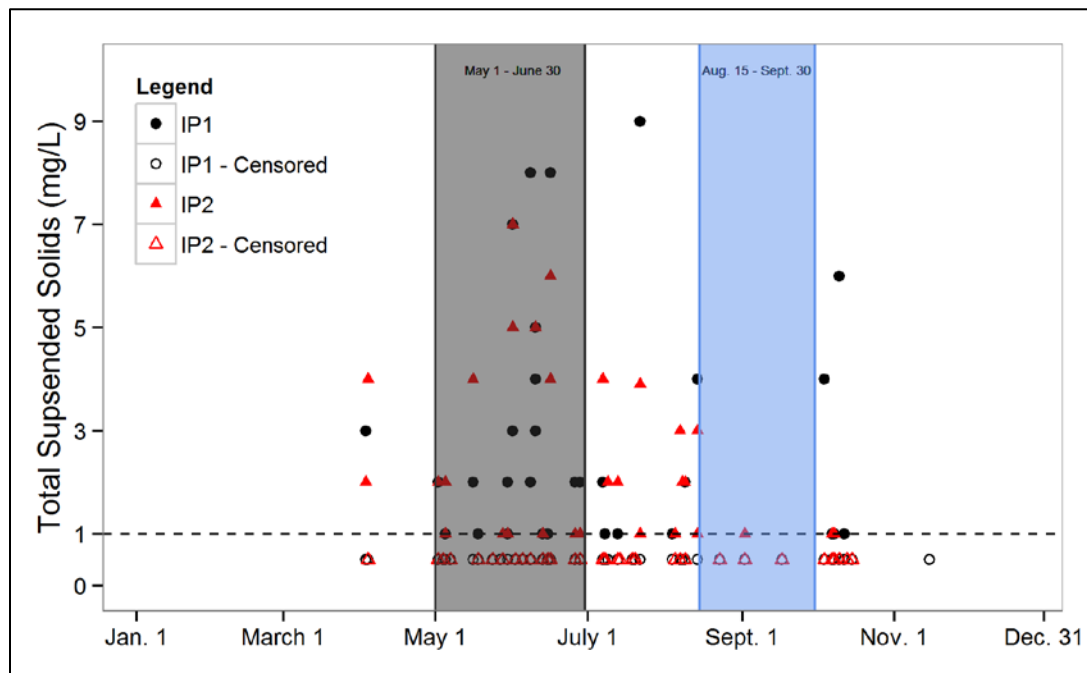


Figure 9. Total Suspended Sediment data for Whitefish Lake by month/day (2007-2013)

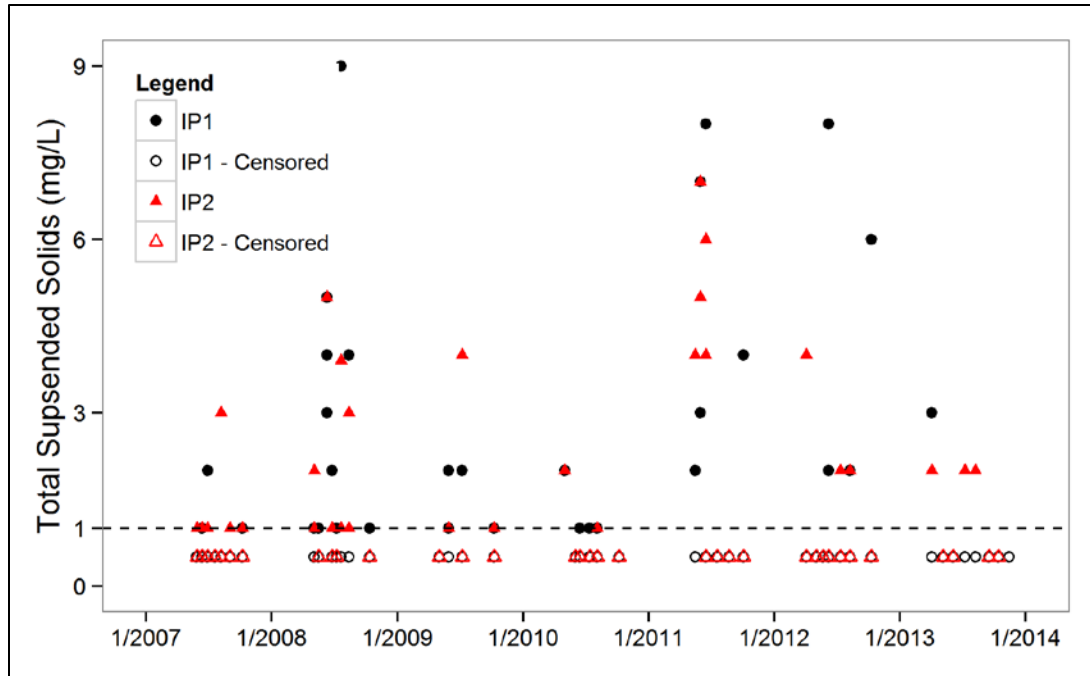


Figure 10. Total Suspended Sediment data for Whitefish Lake by date (2007-2013)

5.2.3 Whitefish Lake shoreline erosion

Being a non-dam regulated system, Whitefish Lake experiences natural lake elevation fluctuations of 5-7 feet per year, which causes some naturally occurring shoreline erosion via wave action and suspension/deposition dynamics. Personnel at the Whitefish Lake Institute were contacted to determine whether specific human caused shoreline erosion occurs on Whitefish Lake. According to WLI, while there are several relatively small shoreline sediment sources attributable to specific landowners and/or residential management actions, there are no large sources or mass wasting occurring near the Whitefish Lake shoreline. For example, a few specific examples of land disturbance events (timber harvest, residential property development) in the Hell Roaring Creek drainage cited by WLI were not reflected in TSS data collected from that waterbody.

5.3 FLATHEAD LAKE WATERSHED MODEL

For the Flathead Lake watershed, the EPA-approved Loading Simulation Program in C++ (LSPC) model was selected (<http://www.epa.gov/athens/wwgtsc/html/lspc.html>). LSPC is a watershed modeling system that includes streamlined Hydrologic Simulation Program FORTRAN (HSPF) algorithms for simulating hydrology, sediment, and general water quality on land as well as a stream fate and transport model. The system automatically links upstream contributions to downstream segments, allowing users to freely model subareas while maintaining a top-down approach (i.e., from upstream reaches to downstream segments). The model simulates watershed hydrology and pollutant transport, as well as stream hydraulics and in-stream water quality. It is capable of dynamically simulating flow, nutrients, sediments, as well as other conventional pollutants for pervious and impervious lands and waterbodies of varying order. LSPC has no inherent limitation in terms of modeling size or model operations and was designed to handle very large-scale watershed modeling applications such as the Flathead Lake watershed (Tetra Tech, Inc., 2003).

From the completed LSPC model, existing condition TSS load percentages from the watershed to Whitefish Lake are shown in **Figure 11**.

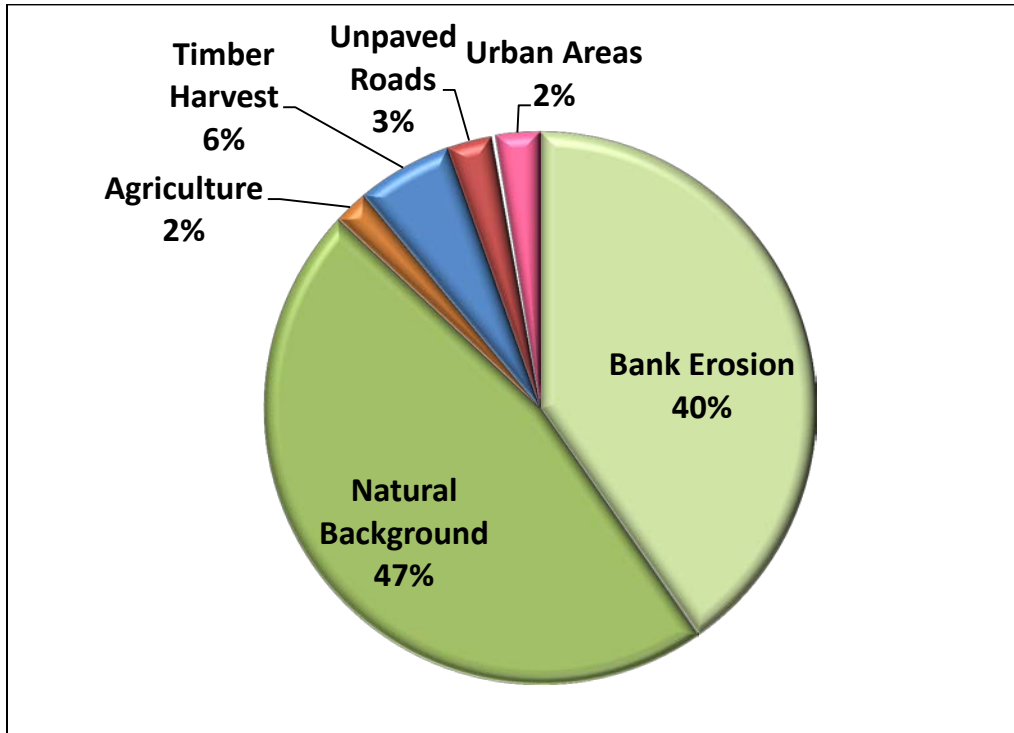


Figure 11. TSS load percentages for the Whitefish Lake watershed

In **Figure 11**, natural background constitutes 47% of the load to Whitefish Lake and bank/bluff erosion within the tributaries is 40% of the TSS load. However, based on quantitative/qualitative data analyses of land uses and land cover in the Whitefish Lake watershed, the bank erosion/bluff erosion is mostly natural given the lack of anthropogenic sources in the watershed and the high power system (Swift Creek) that comprises the majority of the Whitefish Lake watershed. This information suggests that nearly all of the bank/bluff erosion and shoreline erosion and >85% of the overall TSS loading to Whitefish Lake is a result of naturally occurring processes.

6.0 SUMMARY

The 2014 Whitefish Lake sediment assessment is a weight-of-evidence approach that examined several different metrics to gauge if an existing threat from sedimentation/siltation exists for Whitefish Lake. The approach reviewed the listing history for the watershed, recent Secchi depth and TSS water quality data for the lake and multiple tributaries, and the results of landscape model prediction for TSS loading to the lake.

To summarize, Whitefish Lake was originally listed as threatened by sediment on the 1988 303(d) with Swift Creek identified as the primary source of the forest activities (harvesting, roads) identified to be threatening the lake ecosystem¹. The assessment files identify Swift Creek as the primary threat to

¹ Whitefish Lake was listed as threatened by sediment on the 1988 303(d) list and the 1992 303(d) list with breaks in listing in 1990 and 1994. Therefore, 1996 is identified as the cycle first listed (CFL on the 303(d) list).

Whitefish Lake sediment water quality. More recent data show that Swift Creek is not impaired for sediment and is currently meeting all assessed beneficial uses. In addition, the Swift Creek drainage comprises 64% of the Whitefish Lake watershed, and, on average, 82% of the tributary TSS loads to Whitefish Lake. Field observations and aerial assessments document that the majority of the sediment sources are natural.

Analysis of sediment water quality data for Whitefish Lake and multiple tributaries supports the determination that excess fine sediment is not impairing beneficial uses in Whitefish Lake. The analysis suggests that the seasonal loading dynamics and in-lake TSS concentrations identified in **Section 5.2.2** represent naturally occurring fluxes in Whitefish Lake water quality. For the entire Whitefish Lake dataset, 65% of TSS samples were below the detection limit of 1.0 mg/L. These samples well represent the early spring through late fall time period for the years 2007 through 2013 and indicate that TSS is not threatening nor impairing beneficial uses in Whitefish Lake.

Finally, landscape modeling results combined with DEQ assessment narratives provide additional evidence that TSS loading to Whitefish Lake is overwhelmingly (>85%) natural in origin as there are few anthropogenic sources of sediment loading in the Swift Creek drainage or the Whitefish Lake watershed as a whole.

Taken together, these lines of evidence provide firm evidence that observed changes in Whitefish Lake sediment water quality are the result of naturally occurring seasonal processes with few anthropogenic sources, and are primarily influenced by Swift Creek spring runoff dynamics. This reassessment finds that beneficial uses in Whitefish Lake are not currently threatened or impaired by sediment.

7.0 LITERATURE CITED

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