Middle Bear Subbasin
Water Quality Monitoring Report

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Technical Report Summary
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Introduction

The Idaho Association of Soil Conservation Districts (IASCD) recently completed a water quality monitoring project in the Middle Bear subbasin in southeastern Idaho. The subbasin includes the Bear River and tributaries from Alexander Reservoir to the Utah state line. The Middle Bear subbasin is bounded by the Bear River Range to the east and the Portneuf and Bannock mountain ranges to the west. This monitoring was conducted as part of a basin-wide effort to assess water quality on §303(d) listed tributaries to the Bear River. Eight streams were monitored within the Franklin and Caribou Soil Conservation Districts (SCDs): Densmore, Whiskey, Williams, Cottonwood, Battle, Deep, Fivemile, and Weston creeks.

The Bear River TMDL was written by the Idaho Department of Environmental Quality (IDEQ) and approved by the Environmental Protection Agency (EPA) in June 2006. IDEQ identified sediment and phosphorus as the major pollutants of concern in the Bear Basin (Table 1, IDEQ 2006). The streams included in this report are on the state of Idaho §303(d) list for having water quality limited segments. Most of these streams are listed for sediment and nutrients. Fivemile and Deep creeks are §303(d) listed, but for unknown pollutants. All eight streams received TMDLs for sediment and total phosphorus. The beneficial uses designated for these streams are cold water aquatic life (CWAL), secondary contact recreation, agricultural water supply, industrial water supply, wildlife habitat, and aesthetics.

Table 1. Pollutant targets for stream segments in the Middle Bear subbasin (IDEQ 2006).

Pollutant of Concern	Pollutant Targets for the Middle Bear subbasin
Suspended Sediment Concentration (SSC)	Not to exceed 68 mg/L or 45 mg/L (Cottonwood)
Total Phosphorus (TP)	Not to exceed 0.075 mg/L or 0.05 mg/L (Cottonwood)
Nitrate + Nitrite (not specified in TMDL)	Not to exceed 0.8 mg/L

The geology of the area may have important implications for water quality. The watershed marks the northern extent of ancient Lake Bonneville that covered this area 30,000 to 14,500 years ago (Link and Phoenix 1996). As Lake Bonneville retreated, fine lake bottom sediments were deposited at the lower elevations of the subbasin. These areas remain dominated by clay, silt, and sand sediments that are highly erodible and prone to landslides (SCS 1993).

The Middle Bear River monitoring project was initiated with the support of the Franklin and Caribou SCDs. The project goal was to provide water quality

data to districts to allow for identification of potential pollutant sources and to quantify pollutant concentrations in the tributaries. The data will be used to plan implementation of voluntary agricultural best management practices (BMPs) throughout the subbasin. IASCD has worked cooperatively with Idaho State Department of Agriculture (ISDA), the Franklin Soil and Water Conservation District (SWCD), and the Caribou SCD to implement this project.

Monitoring Schedule and Site Descriptions

Water quality monitoring began on eight streams in March 2005 (Table 2). After one year, the data were analyzed and modifications to the monitoring locations were made. Specifically, efforts on Williams and Cottonwood creeks were discontinued because these streams exhibited good water quality in 2005. Weston, Deep, Battle, and Whiskey creeks were prioritized for intensive monitoring to further investigate the sources of pollutants that were observed in 2005. Sites were added on these streams to investigate longitudinal changes in pollutant levels (Figure 1).

Table 2. Names and locations of IASCD water quality monitoring sites in the Middle Bear subbasin.

Site Name	Site Location
Densmore	Upstream of Gentile Valley Canal
Whiskey 1	Upstream of Highway 34
Williams[a]	Upstream of Highway 34
Cottonwood[a]	2.5 mi from Bear River
Weston 1	Upstream of 2400 West
Fivemile	Upstream of Frawhill Rd
Deep 1	0.2 mi upstream of Hot Springs Rd
Battle 1	0.75 mi upstream of Bear River
Sites Added in 2006	
Whiskey 2	Downstream of Highway, 0.25 mi from Bear River
Weston 2	Near town of Weston
Weston 3	Upstream of Highway 36
Deep 2	0.75 mi below Syphon Rd
Deep 3	Downstream of North 4200 West
Battle 2	Upstream of 5000 North
Battle 3	Upstream of North 1600 West
Battle 4	Downstream of Treasureton Res.

[a] These sites were discontinued after one year of monitoring

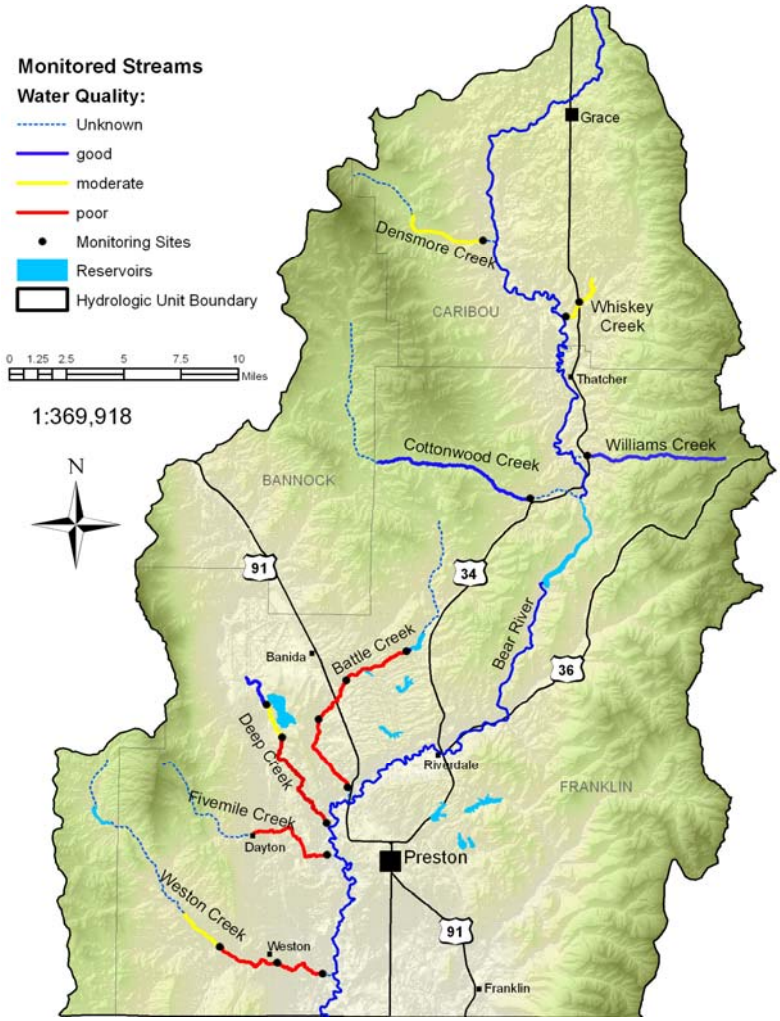

Figure 1. IASCD monitoring locations in the Middle Bear subbasin (black circles). Streams are colored coded to indicate relative water quality.

IASCD monitored twice a month from March through September and once a month during winter months. During each visit, samples were collected and analyzed for suspended sediment concentration (SSC), total phosphorous (TP), orthophosphorus, nitrate + nitrite, and ammonia. Stream discharge, temperature, dissolved oxygen, pH, and conductivity were monitored in the field.

Results

Discharge

Discharge rates in many of the streams fluctuated seasonally as is common in systems that are largely influenced by snow melt (Figure 2). Stream flow peaked during spring months and declined to base flows for the remainder of the year. The one exception

to this was Whiskey Creek, a spring creek, where flows remained relatively constant throughout the year. In both years Densmore Creek dried completely by late summer (August 2005, July 2006). Stream discharge rates in Whiskey and Weston creeks were significantly higher in 2006 than in 2005 (ANOVA, $p \leq 0.032$).

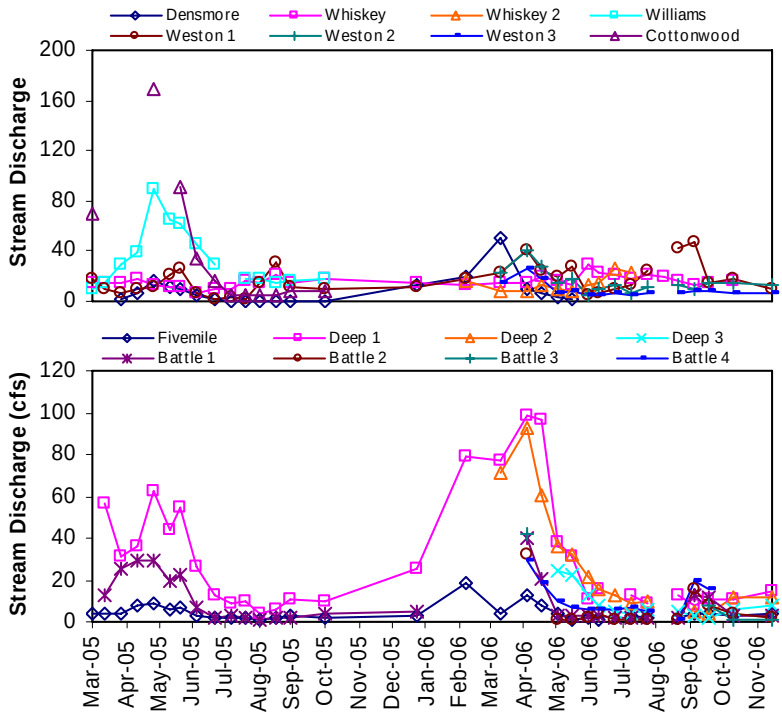

Figure 2. Stream discharge (cfs) from March 2005 to November 2006.

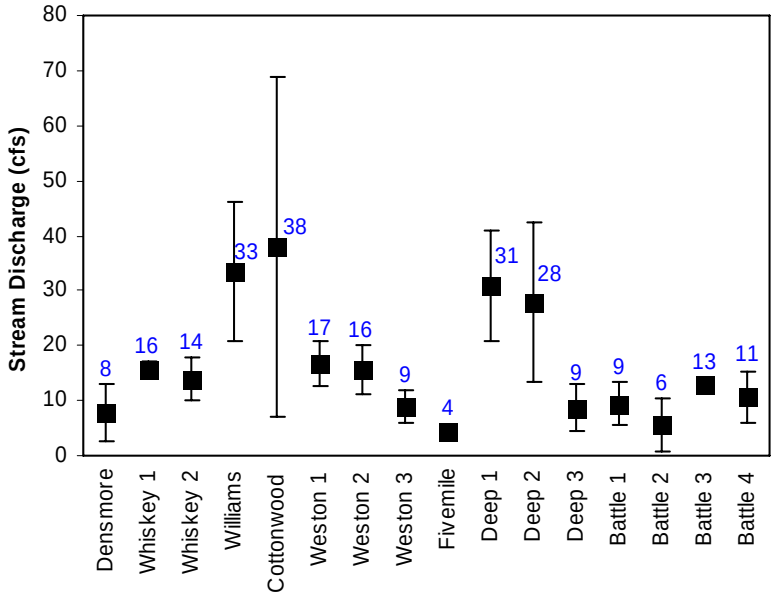

Figure 3. Mean stream discharge (± 95% CI) at the 16 sites.

Differences between years were not detected in the other streams. High flows often made it impossible to measure discharge in Cottonwood Creek and our measurements do not accurately reflect peak discharge in the creek.

Discharge rates in the streams were highly variable. Cottonwood, Williams, and Deep creeks exhibited the highest flows while Fivemile and Densmore creeks experienced the lowest flows (Figure 3).

Suspended Sediment Concentration

Suspended sediment concentrations (SSC) varied significantly across sites. Mean SSC concentrations at many of the sites exceeded the IDEQ target of 68 mg/L (Figure 4). Over the two year monitoring period mean SSC was significantly higher at the Fivemile and Battle 1 sites than all sites ($p \leq 0.031$) except Deep 1. SSC levels in Whiskey and Williams creeks were well below the water quality target of 68 mg/L. Despite the low suspended sediment levels in Whiskey Creek, we did observe a lot of fine sediment deposited on the stream bed. Cottonwood Creek drains directly to Oneida Narrows Reservoir and therefore received a target of 45 mg/L (IDEQ 2005). SSC levels in Cottonwood Creek were below this reduced target.

The high degree of variation in Fivemile Creek (Figure 4) was due to a catastrophic event that input a massive amount of sediment into the stream in 2006. The event resulted in SSC levels of nearly 12,000 mg/L and impacted SSC levels in Fivemile Creek for the remainder of the year. Consequently, SSC levels in Fivemile Creek were significantly higher in 2006 than in 2005 ($p = 0.045$). The source of the original sediment input is unclear, but should be investigated.

There were longitudinal differences in SSC within streams. The upper sites on Deep and Battle creeks met the SSC target, while their lower sites exceeded the target. SSC increased significantly from the upstream to downstream sites on Deep ($p = 0.030$) and Battle creeks ($p = 0.003$). SSC did not differ significantly among the Whiskey or Weston creek sites.

The streams we monitored exceeded the SSC target 0 to 100% of the time (Table 2). Whiskey, Williams, and Cottonwood creeks rarely or never exceeded the target. The uppermost Battle Creek site (Battle 4)

never exceeded the target, while the lower sites exceeded the target 80-100% of the time.

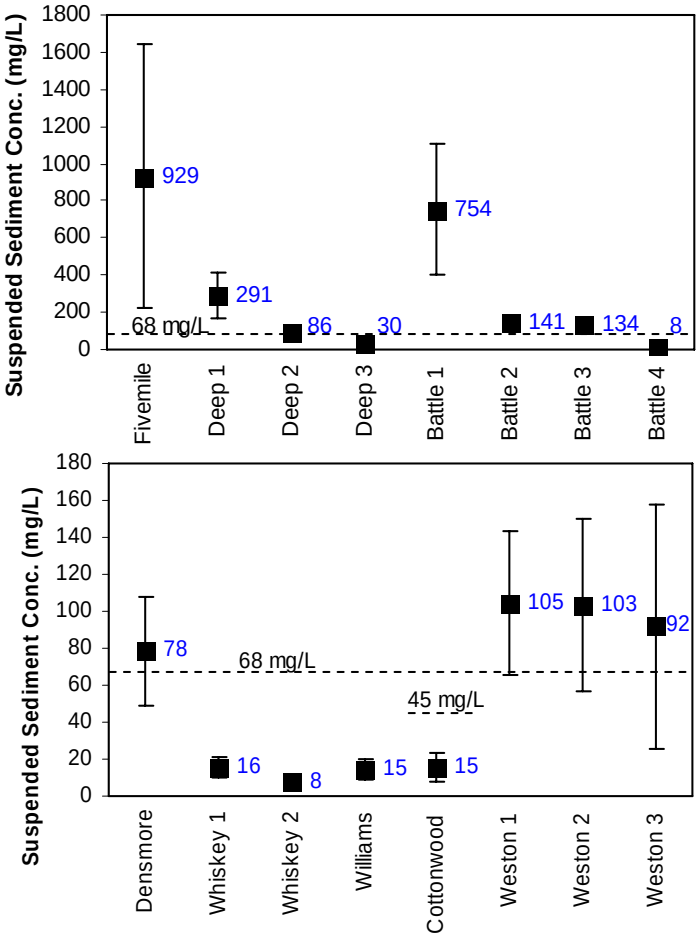

Figure 4. Mean suspended sediment concentration (± 95% CI) measured at the 16 sites. The horizontal dashed lines represent the DEQ targets of 45 and 68 mg/L.

To compare pollutant contributions to the Bear River, average daily SSC loads (lbs/day) were calculated at the lowest site on each stream. Loads were calculated using sediment concentrations and stream discharge rates. Sediment loads were highest in Deep, Fivemile, and Battle creeks (Figure 5). Deep and Battle creeks experienced loads that were significantly higher than in Densmore, Whiskey, Williams, Cottonwood, and Weston creeks ($p \leq 0.014$). While Fivemile Creek experienced the lowest stream discharge rates, the high SSC in the stream resulted in the second highest sediment load. However, due to the amount of variation between years, it was not significantly different from other streams.

Table 2. Percent of samples that exceeded suspended sediment, total phosphorus, and nitrogen targets. Streams have been listed based on their exceedances of pollutant targets to indicate overall water quality.

Site Location	SSC	TP	N
Williams	0%	7%	0%
Cottonwood	7%	20%	0%
Battle 4	0%	77%	31%
Whiskey 2	0%	10%	100%
Whiskey 1	3%	38%	100%
Deep 2	40%	80%	20%
Deep 3	8%	92%	46%
Weston 3	31%	50%	100%
Densmore*	41%	76%	100%
Weston 2*	50%	63%	100%
Weston 1	61%	76%	97%
Battle 2*	80%	100%	53%
Deep 1*	52%	97%	82%
Battle 1	100%	100%	61%
Battle 3	100%	100%	71%
Fivemile	82%	100%	97%

Good Water Quality

Poor Water Quality

*Densmore and Weston 2; Battle 2 and Deep 1 ranked the same

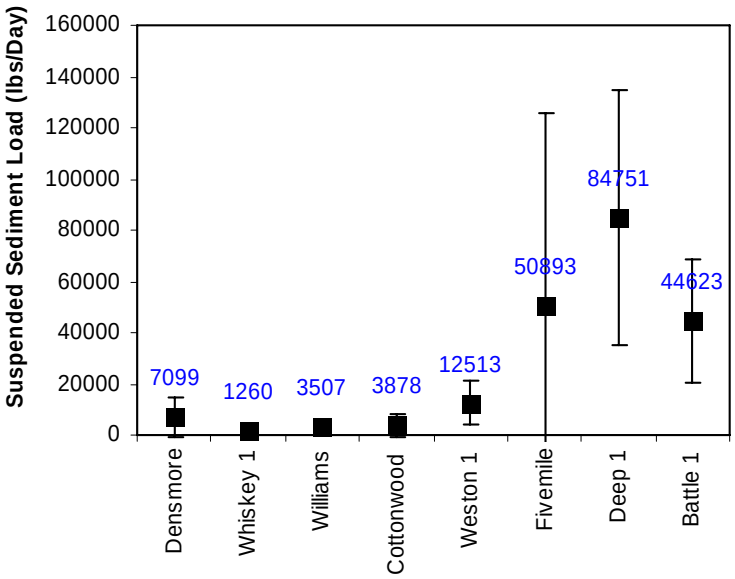

Figure 5. Suspended sediment loads (± 95% CI) in each stream

The sediment loads of these streams can be attributed to natural as well as anthropogenic causes. Natural erosion of ancient Lake Bonneville sediments has been exacerbated by landuse practices such as farming, irrigation, and livestock grazing. This is especially true in Battle, Deep, Fivemile, and Weston creeks where stream channels are deeply incised in some areas.

Total Phosphorus

Total phosphorus (TP) concentrations varied considerably across sites. Battle Creek 1 experienced significantly higher TP levels than all sites ($p \leq 0.006$) except Fivemile Creek. Despite having the second highest mean TP concentration, TP in Fivemile Creek was not significantly different from other sites. This was due to the considerable variation in TP concentrations between years in Fivemile Creek. Average TP levels were lowest in Williams, Cottonwood, and Whiskey creeks. Cottonwood met the more stringent target of 0.05 mg/L that it was assigned because it drains directly into Oneida Narrows Reservoir (IDEQ).

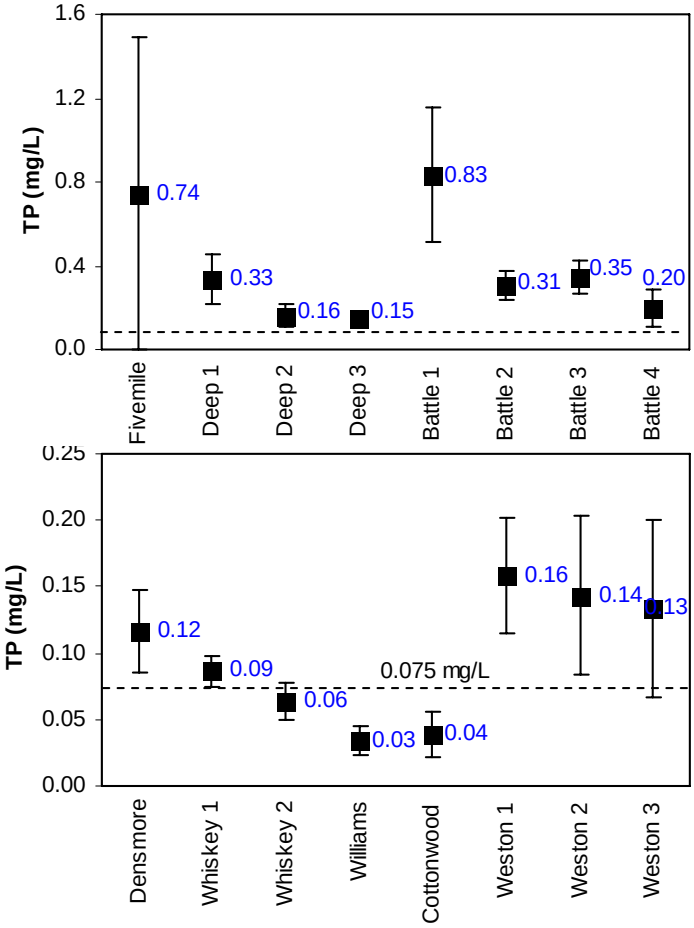

Figure 6. Mean total phosphorus (± 95% CI) measured at the 16 sites. The horizontal dashed line represents the DEQ targets of 0.075 and 0.05 mg/L.

We compared upstream-downstream differences in water quality. In Battle Creek, TP at the upper three sites did not differ from each other; however, they were all significantly lower than the Battle 1 site ($p < 0.025$). Similarly, the two upper Deep Creek sites were not different from each other, but were significantly lower than the lower Deep 1 site ($p < 0.073$). TP in Whiskey and Weston creeks did not differ significantly among sites.

There were numerous exceedances of the water quality target of 0.075 mg/L (0.05 mg/L Cottonwood) by these streams (Table 2). The percent of exceedances ranged from 7% in Williams Creek to 100% in Battle and Fivemile creeks.

Mean phosphorus loads (lbs/day) varied among the eight streams and were highest in Deep, Battle, and Fivemile Creeks. TP loads were significantly higher in Deep and Battle creeks compared to Densmore, Whiskey, Williams, Cottonwood and Weston creeks ($p \leq 0.022$). Again, due to the large variation between years, TP loads in Fivemile Creek did not differ significantly from other sites. Phosphorus is likely entering these streams attached to sediment particles and efforts to decrease sediment inputs may reduce TP levels in these systems.

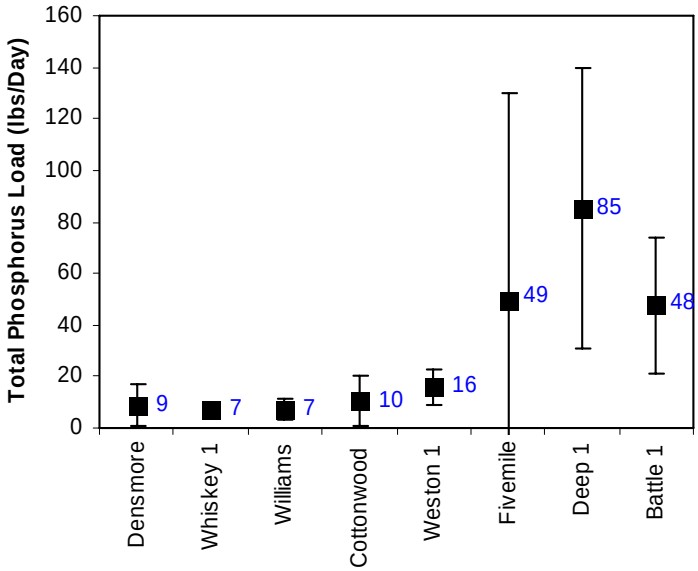

Figure 7. Mean phosphorus loads (± 95% CI) in the eight streams.

Nitrogen

Nitrogen (nitrate + nitrite, mg/L) was not specified by IDEQ as being a pollutant of concern in the watershed.

However, we chose to monitor nitrogen at these sites because of the known impacts of excess nutrients in streams (EPA 2005). We used a target of 0.85 mg/L to evaluate nitrogen concentrations in this report. This target was applied to the Thomas Fork, a tributary to the Bear River (DEQ 2006). Additionally, this is similar to the target for the Portneuf River (0.8 mg/L), a phosphorus limited watershed in southeastern Idaho (DEQ 2001).

Average nitrogen concentrations varied significantly across sites. Average levels at 11 of the 16 sites exceeded the 0.85 mg/L target (Figure 8). Nitrogen concentrations at the Whiskey 1, Whiskey 2, Weston 1, and Weston 2 sites were similar and were significantly higher than other sites in the subbasin ($p \leq 0.052$). Average nitrogen concentrations in Williams and Cottonwood creeks and in the upper reaches of Battle and Deep creeks were low and met the target of 0.85 mg/L.

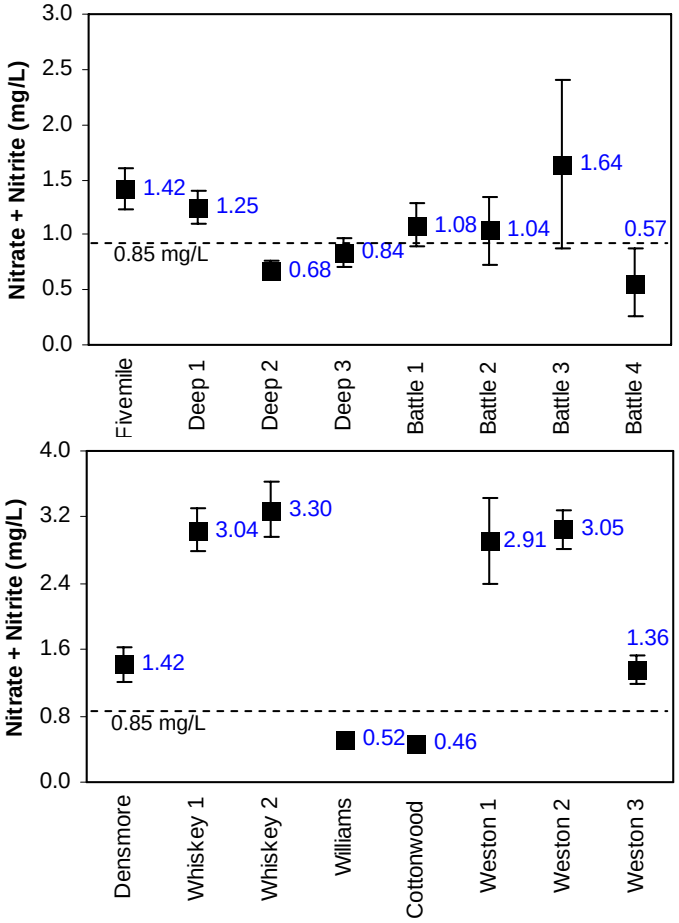

Figure 8. Nitrogen levels (nitrate + nitrite, mg/L) measured in Williams and Cottonwood creeks from March to October 2005.

Within streams there were differences in nitrogen levels. There was a significant increase in nitrogen from the upper Weston Creek site (Weston 3) to the lower sites ($p \leq 0.001$). This may indicate that the city of Weston contributes to the nitrogen load of the stream since the upper site is above the city and the lower sites are below. The upper Deep Creek sites had significantly lower nitrogen levels than the Deep 1 site ($p \leq 0.001$). Similarly, there were significantly lower concentrations at the Battle 4 site compared to the lower Battle Creek sites ($p \leq 0.041$). It appears that agricultural practices on Deep and Battle creeks are impacting nitrogen concentrations between the upper and lower sites. Nitrogen levels did not vary significantly between the Whiskey 1 and Whiskey 2 sites. To determine if nitrogen in Whiskey Creek was due to landuse practices we collected samples at the spring where Whiskey Creek surfaces. Nitrogen levels were significantly higher at the spring compared to the Whiskey 1 site ($p = 0.012$). This indicates that landuse practices in the Whiskey Creek subwatershed do not significantly contribute to elevated nitrogen levels.

Exceedances of the 0.85 mg/L nitrogen target ranged from 0-100% (Table 2). Williams and Cottonwood creeks never exceeded the target while Densmore, Whiskey 1, Whiskey 2, Weston 2, and Weston 3 exceeded the target every time.

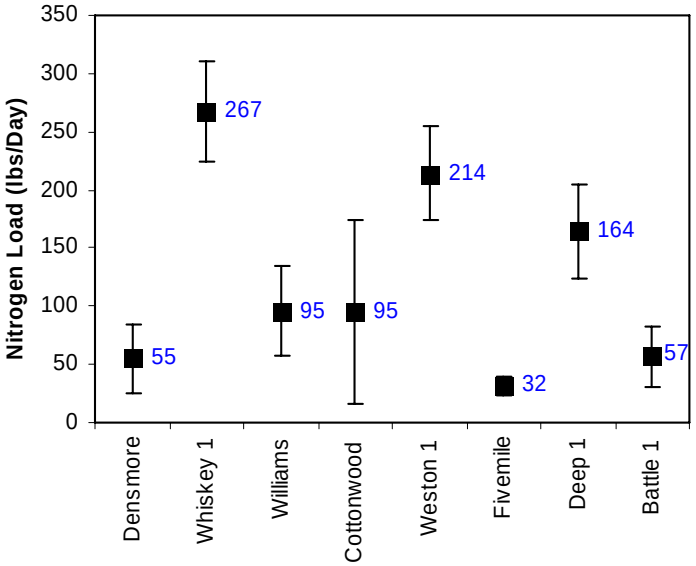

Figure 9. Mean nitrogen loads (± 95% CI) at the eight streams.

Mean nitrogen loads (lbs/day) were higher in Whiskey Creek than all sites ($p \leq 0.001$), with the exception of Weston Creek (Figure 9). Despite having the highest

stream flows, Cottonwood and Williams creeks experienced relatively low nitrogen loads. Nitrogen loads in Fivemile, Densmore, and Battle creeks were significantly lower than in Whiskey, Weston, and Deep creeks ($p \leq 0.001$).

Conclusions

Water quality impairments were common in the streams we monitored in the Middle Bear subbasin. Six of the eight streams experienced elevated pollutant levels, especially during spring runoff events. Exceptions to this were Williams and Cottonwood creeks where pollutant concentrations remained low despite some seasonal fluctuations.

When streams were ranked based on their pollutant concentrations (mg/L) it was clear that Fivemile Creek had the poorest water quality, followed by Battle Creek. However, when streams were ranked by their daily pollutant loads (lbs/day), Deep Creek was found to carry the highest loads of SSC, TP and nitrogen, followed by Weston Creek. Therefore it is recommended that Fivemile, Battle, Deep, and Weston creeks be considered priority areas for water quality improvement projects in the subbasin.

The high SSC and TP concentrations in Fivemile, Battle, Deep, and Weston creeks may largely be due to the geology of the area. However, the natural erosion of Lake Bonneville sediments in these subwatersheds has been greatly exacerbated by human activities such as flood and sprinkler irrigation and livestock grazing.

Recommendations

The results of this monitoring project helped to identify water quality limited streams in the subbasin. While many of the streams indicated water quality concerns, efforts should be focused on Fivemile, Battle, Deep, and Weston creeks as they had the poorest water quality in the subbasin. While a lower priority, Densmore and Whiskey creeks also experienced elevated pollutant levels. Implementation of BMPs aimed at reducing sediment and nutrients in these streams would help to support beneficial uses in the subbasin. Water quality in Williams and Cottonwood creeks was good throughout 2006 and these streams should receive lower priority for BMP implementation.

Fivemile Creek was identified as having some of the highest concentrations of pollutants in the subbasin. The Fivemile Creek watershed is primarily impacted by rangeland, irrigated cropland, and dry cropland. Approximately two miles of Fivemile Creek are deeply incised and are adjacent to the former county dump. The stream should be assessed to identify and address the point or non-point source of the sediment influx during spring 2006. BMPs aimed at reducing sediment (and consequently phosphorus) inputs to the stream such as exclusion fence, nutrient management planning, and grazing management may improve water quality in Fivemile Creek.

Battle Creek experienced high sediment and phosphorus concentrations and loads, especially at the lowest site, Battle 1. Much of Battle Creek is incised due to the erosive characteristics of the soil and landuse activities in the watershed. The stream rapidly accrues sediment below Treasureton Reservoir. BMPs such as irrigation water management, streambank stability projects, and filter strips to capture sediment before it enters the stream may help improve water quality in Battle Creek.

The upper and lower reaches of Deep Creek varied significantly in water quality. The downstream site experienced elevated sediment, phosphorus, and nitrogen concentrations. Efforts should be focused on the five mile stretch of stream between Deep 1 and Deep 2. This reach may be difficult to treat because the stream is deeply incised and is difficult to access. Focus on streambank stability and riparian habitat improvements may reduce pollutant loading to Deep Creek.

Pollutant concentrations in Weston Creek were elevated above water quality targets. The three sites on Weston Creek did not differ significantly in SSC or TP levels, but nitrogen increased significantly from the upper site to the two lower sites. The increase in nitrogen coincided with the stream passing by the city of Weston and may indicate that septic systems are impacting surface water via groundwater inputs. It is recommended that groundwater testing be performed on wells within and down-gradient of the city. This report will be made available to the city of Weston as elevated nitrate levels in groundwater are a public health concern.

Densmore Creek should be considered a moderate to high priority for water quality improvements. On

average, Densmore Creek exceeded water quality targets for SSC, TP, and nitrogen and elevated pollutant concentrations coincided with runoff events. Therefore, efforts to reduce sediment and phosphorus should be focused on reducing erosion from cropland, rangeland, and streambanks as well as trapping sediment before it enters the stream.

The primary water quality concern in Whiskey Creek was elevated nitrogen levels throughout the year. However, testing of the spring at the head of Whiskey Creek revealed that the stream starts off with high nitrogen levels that were actually reduced by the time the stream reached the Whiskey 1 site. This indicates that impacts to groundwater supplies outside of the Whiskey Creek watershed are influencing water quality in Whiskey Creek. While suspended sediment levels were low in Whiskey Creek, the stream is impacted by fine sediment on the streambed. Whiskey Creek does not typically experience high stream flows in the spring, and fine sediments accrue over time. This fine sediment likely impairs beneficial uses such as salmonid spawning and cold water aquatic life. Projects that reduce sediment inputs to Whiskey Creek may improve stream habitat.

Acknowledgements

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