Alaska Department of Environmental Conservation
555 Cordova Street
Anchorage, Alaska 99501

Public Notice Draft Total Maximum Daily Load for Turbidity in the Waters of Upper Goldstream Creek near Fairbanks, Alaska

May 2015 DRAFT

CONTENTS

TABLES

FIGURES

ACRONYMS

AAC	Alaska Administrative Code
ACWA	Alaska Clean Water Actions
ACGP	Alaska Construction General Permit
ADEC	Alaska Department of Environmental Conservation
APDES	Alaska Pollutant Discharge Elimination System
ADOT&PF	Alaska Department of Transportation and Public Facilities
ATV	All-terrain vehicle
BLM	Bureau of Land Management
BMP	Best Management Practice
CFR	Code of Federal Regulations
cfs	Cubic feet per second
cm	Centimeters
CWA	Clean Water Act
DFG	Department of Fish and Game
DNR	Department of Natural Resources
DMR	Discharge monitoring report
EPA	United States Environmental Protection Agency
°F	Degrees Fahrenheit
FNSB	Fairbanks North Star Borough
GIS	Geographic information system
HUC	Hydrologic Unit Code
in	Inches
LA	Load allocation
lbs/day	Pounds per day
mg/L	Milligrams per liter
mi^2	Square miles
MOS	Margin of safety
MS4	Municipal separate storm sewer system
MSGP	Multi Sector General Permit for Stormwater Discharges Associated with Industrial Activity
NED	USGS National Elevation Dataset
NLCD	National Land Cover Database
NPDES	EPA's National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NTU	Nephelometric turbidity units
PCS-ICIS	Permit Compliance System and Integrated Compliance Information System
SSURGO	Soil Survey Geographic database

SWPPP	Storm Water Pollution Prevention Plan
TMDL	Total Maximum Daily Load
TSS	Total suspended solids
USGS	United States Geological Survey
WLA	Wasteload allocation
WQS	Water quality standards
WWTF	Wastewater treatment facility
WWTP	Wastewater treatment plant

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Total Maximum Daily Load (TMDL) for Turbidity in Upper Goldstream Creek, Alaska

TMDL at a Glance:

Water Quality Limited?	Yes
Alaska ID Number:	40509-001
Criteria of Concern:	Turbidity
Designated Uses Affected:	(1) Water supply, (2) water recreation, and (3) growth and propagation of fish, shellfish, other aquatic life, and wildlife
Environmental Indicator:	Total suspended solids
Major Source(s):	Placer mining, construction and municipal stormwater; nonpoint source runoff from historically disturbed landscape
Loading Capacity:	Flow dependent, see table below
Wasteload Allocation:	Flow dependent, see table below
Load Allocation:	Flow dependent, see table below
Margin of Safety:	Implicit and explicit; flow dependent, see table below
Future Wasteload Allocation:	None for Urban; Construction and Industrial Stormwater and Placer Mining Reserves included in a consolidated future WLA
Necessary Reductions:	Flow dependent, see table below

Numeric targets by flow regime

Parameter (units)	Extreme	High[a]	Moist	Mid[b]	Dry	Low
	(0-1%)	(1-10%)	(10-40%)	(40-60%)	(60-90%)	(90-100%)
Turbidity (NTU)	199.5	9.45	9.45	9.85	9	7.17
TSS (mg/L)	331.71	15.71	15.71	16.38	14.96	11.92

[a] No data were available for the high flow condition; therefore, the numeric target calculated for the moist flow regime was applied for high flow.

[b] Targets for the mid-range flows are slightly higher than the targets for high and moist flows. In this dataset, higher turbidity was observed during mid-range flow conditions (when compared to the moist flow conditions). This might be due to the limited dataset (less than 10 samples during each flow condition). The observed turbidity values are similar at Pedro Creek for the moist, mid, and dry flow regimes, suggesting that implementation considerations will be similar. The TSS *concentrations* calculated from the turbidity values in the high, moist, and mid ranges all round to the same value; however, the TMDL TSS *load* targets for mid-range flows will be lower than those during moist and high range flows due to the increased flows in those upper ranges.

TMDL by flow regime and watershed (loads are cumulative in downstream watersheds)

TMDL Subwatershed (cumulative area in acres)	TMDL Category or Input	Total Suspended Solids Load by Flow Regime (units in lbs/day unless noted)					
		Extreme	High	Moist	Mid	Dry	Low
		(0-1%)	(1-10%)	(10-40%)	(40-60%)	(60-90%)	(90-100%)
Reductions required to meet the loading capacity and WQS							
HUC-01 (26,451 acres)	Median Flow (cfs)	30.7	22.6	17.7	13.3	8.7	5.1
	TSS Target (mg/L)	331.71	15.71	15.71	16.38	14.96	11.92
	Loading Capacity	54,905	1,915	1,497	1,175	700	330
	Wasteload Allocation	112	4	3	2	1	1
	Load Allocation	51,763	1,805	1,411	1,108	660	311
	Margin of Safety	2,745	96	75	59	35	16
	Future Wasteload Allocation	285	10	8	6	4	2
	Maximum Observed Existing Load at GS-2	118,070	76,569	53,560	29,685	32,730	6,417
	Percent Load Reduction (%)	53%	97%	97%	96%	98%	95%
TMDL subwatersheds currently meeting loading capacity and WQS							
HUC-02[a] (51,527 acres)	Median Flow (cfs)	60	44	34	26	17	10
	TSS Target (mg/L)	331.71	15.71	15.71	16.38	14.96	11.92
	Loading Capacity	107,019	3,733	2,918	2,290	1,364	643
	Wasteload Allocation	596	21	16	13	8	4
	Load Allocation	100,724	3,513	2,747	2,156	1,284	605
	Margin of Safety	5,351	187	146	114	68	32
	Future Wasteload Allocation	348	12	9	7	4	2
	Maximum Observed Existing Load at Ballaine	40,689	ND	1,869	1,479	1,148	637
	Percent Load Reduction (%)[b]	0%	ND	0%	0%	0%	0%
HUC-03[a] (83,211 acres)	Median Flow (cfs)	97	71	56	42	27	16
	TSS Target (mg/L)	331.71	15.71	15.71	16.38	14.96	11.92
	Loading Capacity	172,826	6,028	4,713	3,698	2,202	1,038
	Wasteload Allocation	643	22	18	14	8	4
	Load Allocation	162,962	5,685	4,443	3,487	2,077	979
	Margin of Safety	8,641	301	236	185	110	52
	Future Wasteload Allocation	580	20	16	12	7	3
	Maximum Observed Existing Load at Sheep Creek	ND	ND	4,256	1,659	1,402	891
	Percent Load Reduction (%)[b]	ND	ND	0%	0%	0%	0%

Note: Based on the cumulative watershed drainage area; ND = No data

[a] Loads for the HUC-02 subwatershed are equal to the sum of the loads from the HUC-01 and HUC-02 subwatersheds in Table 5-1. Similarly, loads for the HUC-03 subwatershed are equal to the sum of the loads of the HUC-01, HUC-02, and HUC-03 subwatersheds presented in Table 5-1.

[b] Currently meeting the loading capacity for TSS when data are available; however, the data are limited to grab samples and indicate that loads are sometimes close to the loading capacity. TMDLs are assigned to ensure that existing loads do not increase and the subwatersheds continue to meet numeric targets, especially considering current mining activities and the potential for additional construction in these drainages (see Section 4).

Executive Summary

Goldstream Creek begins at the confluence of Pedro and Gilmore creeks, just north of Fairbanks, Alaska in the Fairbanks North Star Borough (FNSB). The entire Goldstream Creek watershed is 618 square miles (mi^2), but this document focuses on the 130 mi^2 Upper Goldstream Creek subwatershed, an area of major and continuous gold mining for nearly 100 years. This portion of the watershed begins at the headwaters and includes three 12-digit hydrologic unit code (HUC) subwatersheds: 190405097-01, -02, and -03.

Alaska's Department of Environmental Conservation (ADEC) first included Goldstream Creek on the Clean Water Act (CWA) Section 303(d) list as impaired for turbidity in 1992. The original listing was associated with placer mining activities in the watershed. In 1994, the U.S. Environmental Protection Agency (EPA) completed a waterbody assessment for Goldstream Creek and confirmed that placer mining was contributing to elevated turbidity (EPA 1994).

In 2009, ADEC prepared a monitoring and sampling plan. The University of Alaska at Fairbanks conducted sampling between 2010 and 2012 and ADEC collected additional data in 2013 (Misra et al. 2012). Results indicate that Goldstream Creek is not attaining its designated uses, because the creek is still exceeding the water quality criteria for turbidity; therefore, a Total Maximum Daily Load (TMDL) is needed. Current turbidity sources are a combination of point sources (placer mining; municipal and construction stormwater) and nonpoint sources (other non-permitted runoff).

A TMDL is established in this document to meet the requirements of Section 303(d)(1)(C) of the CWA and the EPA's implementing regulations (40 Code of Federal Regulations Part 130), which require the establishment of a TMDL for the achievement of water quality standards (WQS) when a waterbody is water quality-limited. A TMDL is composed of the sum of individual wasteload allocations for point sources of pollution and load allocations for nonpoint sources of pollution and natural background loads. In addition, the TMDL must include a margin of safety, either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. A TMDL represents the amount of a pollutant the waterbody can assimilate while maintaining compliance with applicable WQS.

Applicable WQS for turbidity in Goldstream Creek establish water quality criteria for the protection of designated uses for water supply, water recreation, and growth and propagation of fish, shellfish, other aquatic life, and wildlife. The TMDL is developed for the most stringent turbidity criterion, which protects the water recreation use. This criterion that states that turbidity may not exceed 5 nephelometric turbidity units (NTU) above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than 10 percent increase in turbidity when the natural turbidity is more than 50 NTU, not to exceed a maximum increase of 15 NTU (18 AAC 70.020(b)(12)(B)(i)). The turbidity criteria for Goldstream Creek are based on background/natural turbidity values. Turbidity data from Pedro Creek, at the headwaters to Upper Goldstream Creek, were used to establish the natural condition and to calculate turbidity targets based on the water quality criteria. Flow conditions affect both turbidity and sediment measurements; therefore, target values are based on the background conditions present during varying flow conditions.

Turbidity data are not conducive to the calculation of target loads. Therefore, numeric targets are expressed as both turbidity values and sediment concentrations. There is a strong correlation between turbidity and total suspended solids (TSS) samples collected at the same time throughout the watershed ($R^2 = 0.87$). The equation derived from the linear relationship between actual turbidity samples and TSS was used to estimate target sediment concentrations as a surrogate for the target turbidity values established at Pedro Creek at varying flow conditions. The target TSS concentrations were combined with flow values to determine existing loads and sediment loading capacity.

The observed TSS loads ranged from 118,070 pounds per day (lbs/day) in the uppermost subwatershed (HUC-01) during extreme high flow events to 637 lbs/day during low flows in the middle subwatershed (HUC-02). TSS loads will need to be reduced from 0 to 98 percent to meet the TMDL. Based on the current data, all reductions are needed in the most upstream area. Specifically, the HUC-01 subwatershed will require a 54 percent reduction to TSS loads during extreme flows and a 95 to 98 percent reduction during all other flow regimes.

Potential sources of turbidity in the Upper Goldstream Creek watershed include point sources (such as discharges from active placer mines, municipal areas and construction sites) and nonpoint sources (such as runoff from historic placer mine sites, residential and commercial developments, and winter road maintenance). Reducing turbidity in Upper Goldstream Creek will involve efforts to control point source and nonpoint source inputs through implementation of best management practices (BMPs). Follow-up monitoring is recommended to further evaluate sources, track the progress of TMDL implementation, BMP effectiveness, and the water quality of Upper Goldstream Creek to evaluate progress towards meeting WQS.

1. Overview

Section 303(d)(1)(C) of the Clean Water Act (CWA) and the U.S. Environmental Protection Agency's (EPA) implementing regulations (40 CFR Part 130 [note: CFR is the Code of Federal Regulations]) require the establishment of a Total Maximum Daily Load (TMDL) to achieve state water quality standards (WQS) when a waterbody is water quality-limited. A TMDL identifies the amount of a pollutant that a waterbody can assimilate and still comply with applicable WQS. TMDLs quantify the amount a pollutant must be reduced to achieve a level (or "load") that allows a given waterbody to fully support its designated uses. TMDLs also include an appropriate margin of safety (MOS) to account for uncertainty or lack of knowledge regarding the pollutant loads and the response of the receiving water. The mechanisms used to address water quality problems after the TMDL is developed can include a combination of best management practices (BMPs) for nonpoint sources and/or effluent limits and monitoring required through EPA's National Pollutant Discharge Elimination System (NPDES) permits (or in Alaska, the Alaska Pollutant Discharge Elimination System [APDES] permits) for point sources.

Alaska's Department of Environmental Conservation (ADEC) first included Goldstream Creek on the CWA Section 303(d) list as impaired for turbidity in 1992. Table 1-1 summarizes the information included in Alaska's *Final 2012 Integrated Water Quality Monitoring and Assessment Report* for Goldstream Creek (ADEC 2013).

Potential sources of turbidity in the Upper Goldstream Creek watershed include point sources (such as discharges from active placer mines, municipal areas and construction sites) and nonpoint sources (such as runoff from historic placer mine sites, residential and commercial developments, and winter road maintenance).

In 1994, EPA completed a waterbody assessment for Goldstream Creek and confirmed that placer mining was contributing to elevated turbidity (EPA 1994). In 2009, ADEC prepared a monitoring and sampling plan. The University of Alaska at Fairbanks conducted sampling from 2010–2012, while ADEC sampled in 2013 (Misra et al. 2012). Results indicate that Goldstream Creek is not protecting its designated uses because it is still exceeding the turbidity water quality criteria; therefore, it is in need of a TMDL. Current turbidity sources are a combination of point sources (placer mining; municipal and construction stormwater) and nonpoint sources (other non-permitted runoff).

Table 1-1. Goldstream Creek Section 303(d) listing information from ADEC's 2012 Integrated Report

Alaska ID Number	Waterbody	Area of Concern	Water Quality Standard	Pollutant Parameters	Pollutant Sources
40509-001	Goldstream Creek	70 miles	Turbidity	Turbidity	Placer Mining
Goldstream Creek was placed on the 1992 Section 303(d) list for nonattainment of the turbidity standard. A waterbody assessment was completed and confirmed the pollutant and pollutant source. The assessment determined that existing controls were sufficient to address the turbidity issue and that a formal TMDL was not needed. Nevertheless, the water quality assessment was prepared (September 30, 1994) and submitted to EPA for technical review for Goldstream Creek. The assessment contains a section on development of a management plan and a pollution control strategy. No further sampling was conducted until 2010. Monitoring continued through 2013.					

Source: ADEC (2013)
Note: Alaska's Final 2012 Integrated Report was submitted to EPA in December 2013 and is pending approval.

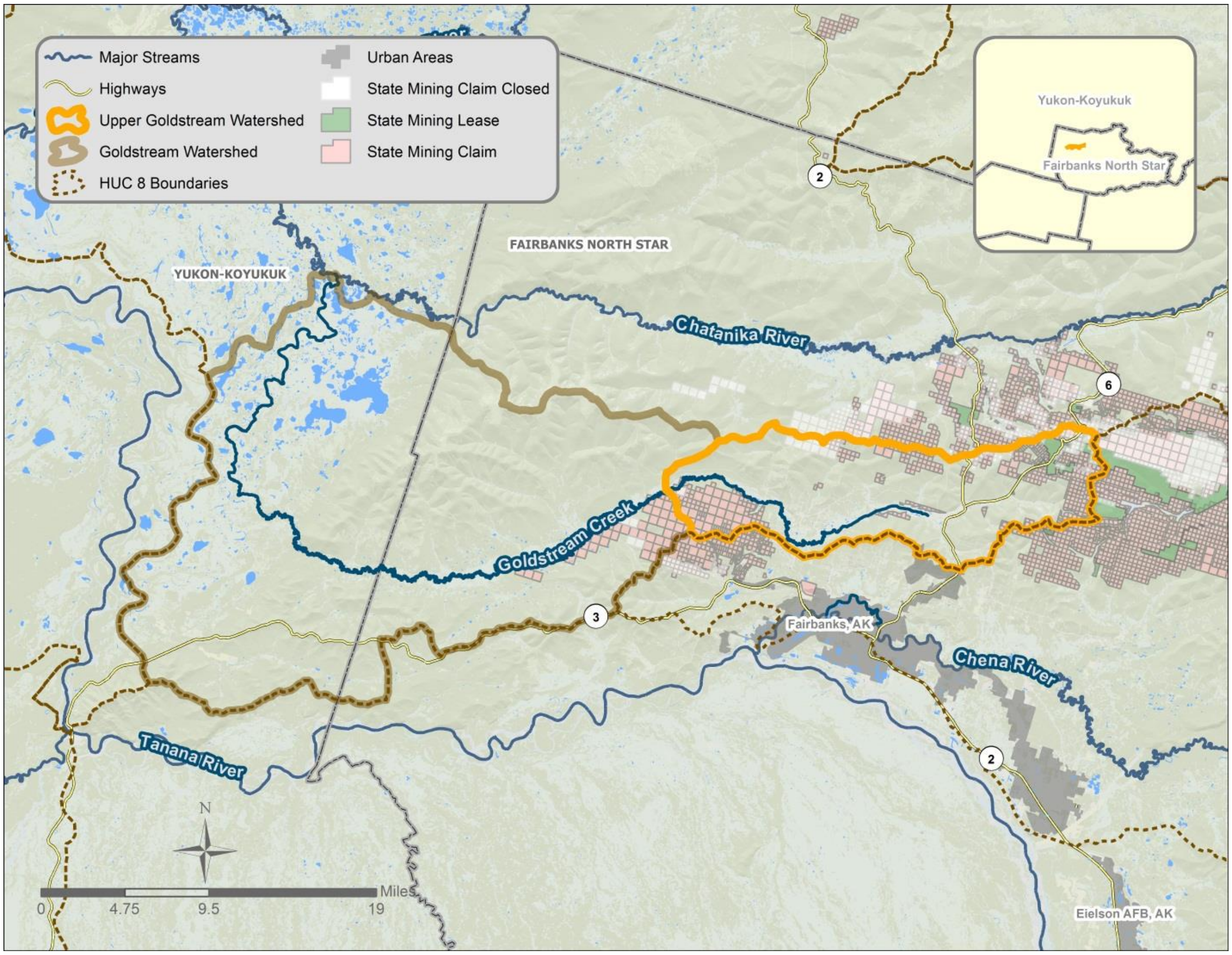

Figure 1-1. Regional location of the Goldstream Creek watershed.

1.1. Location and Identification of TMDL Study Area

Goldstream Creek begins at the confluence of Pedro and Gilmore creeks just north of Fairbanks, Alaska in the Fairbanks North Star Borough (FNSB). The entire Goldstream Creek watershed is 618 square miles (mi^2), but this document focuses on the 130 mi^2 Upper Goldstream Creek subwatershed, an area of major and continuous gold mining for nearly 100 years (Figure 1-1). The Upper Goldstream Creek subwatershed has different geographic characteristics than the lower watershed, which is downstream of wetland areas and includes a state forest area (see Station GS-3 discussion in Appendix B). This portion of the watershed consists of the Goldstream Creek headwaters and includes three 12-digit hydrologic unit code (HUC) subwatersheds: 190405097-01, -02, and -03 (Figure 1-2), referred to as HUC-01, HUC-02, and HUC-03 throughout the remainder of this document.

Numerous tributaries flow into Upper Goldstream Creek, including Fox, Big Eldorado, O'Connor, Moose, Engineer, and Sheep creeks. The watershed has two distinct areas: semi-mountainous uplands and the lower creek (below Ballaine Road). The uplands have been a major and continuous gold mining area for nearly 100 years and the terrain is highly mineralized. Due to past mining activities, the stream channels are characterized by a loss of riparian vegetation and associated soils, which has contributed to elevated turbidity levels (Appendix A).

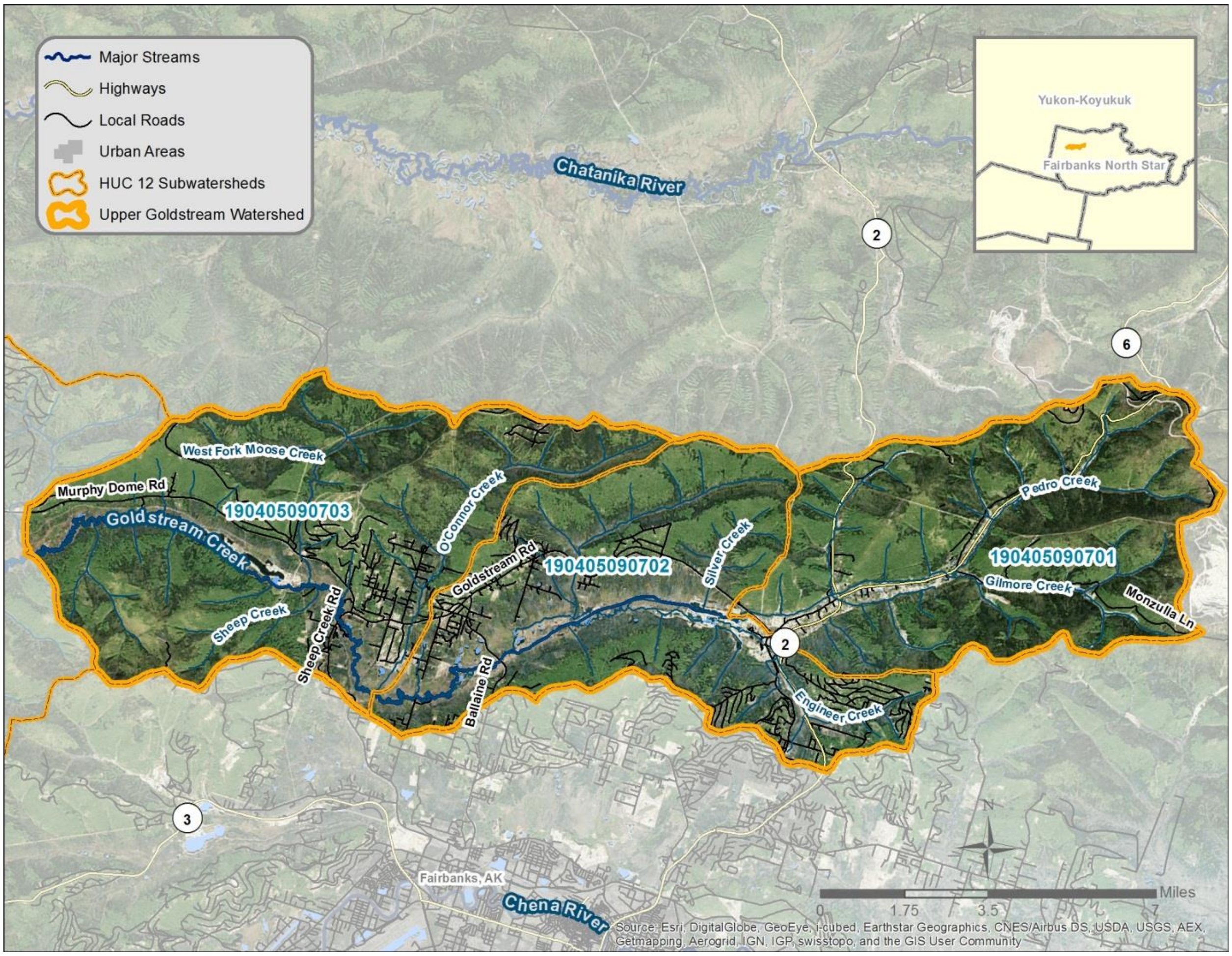

Figure 1-2. Upper Goldstream Creek watershed.

1.2. Population

Population in the Upper Goldstream Creek watershed is low, with approximately two percent of the watershed designated as low-density residential in the 2001 U.S. Geological Survey (USGS) National Land Cover Database (NLCD). Population has increased 2.5 to 3.3 percent in and around the Upper Goldstream Creek area from 2010 to 2012 (State of Alaska 2013). The Upper Goldstream Creek watershed is in the FNSB. The population for the FNSB recorded in the 2012 U.S. Census is 100,343, with 32,070 of those residents residing in the city of Fairbanks (U.S. Census Bureau 2013).

1.3. Topography

Elevation data were obtained from the USGS National Elevation Dataset (NED). The topography is generally steep in the uplands, with low relief in the lower portion of the creek. Specifically, the elevation of the Upper Goldstream Creek watershed ranges from 460 to 2,595 feet (140 to 791 meters) (USGS 2013). Elevation at the confluence of Gilmore Creek and Pedro Creek is near 890 feet (271 meters) while the elevation at the downstream portion of the Upper Goldstream Creek watershed is near 472 feet (144 meters) (Figure 1-3).

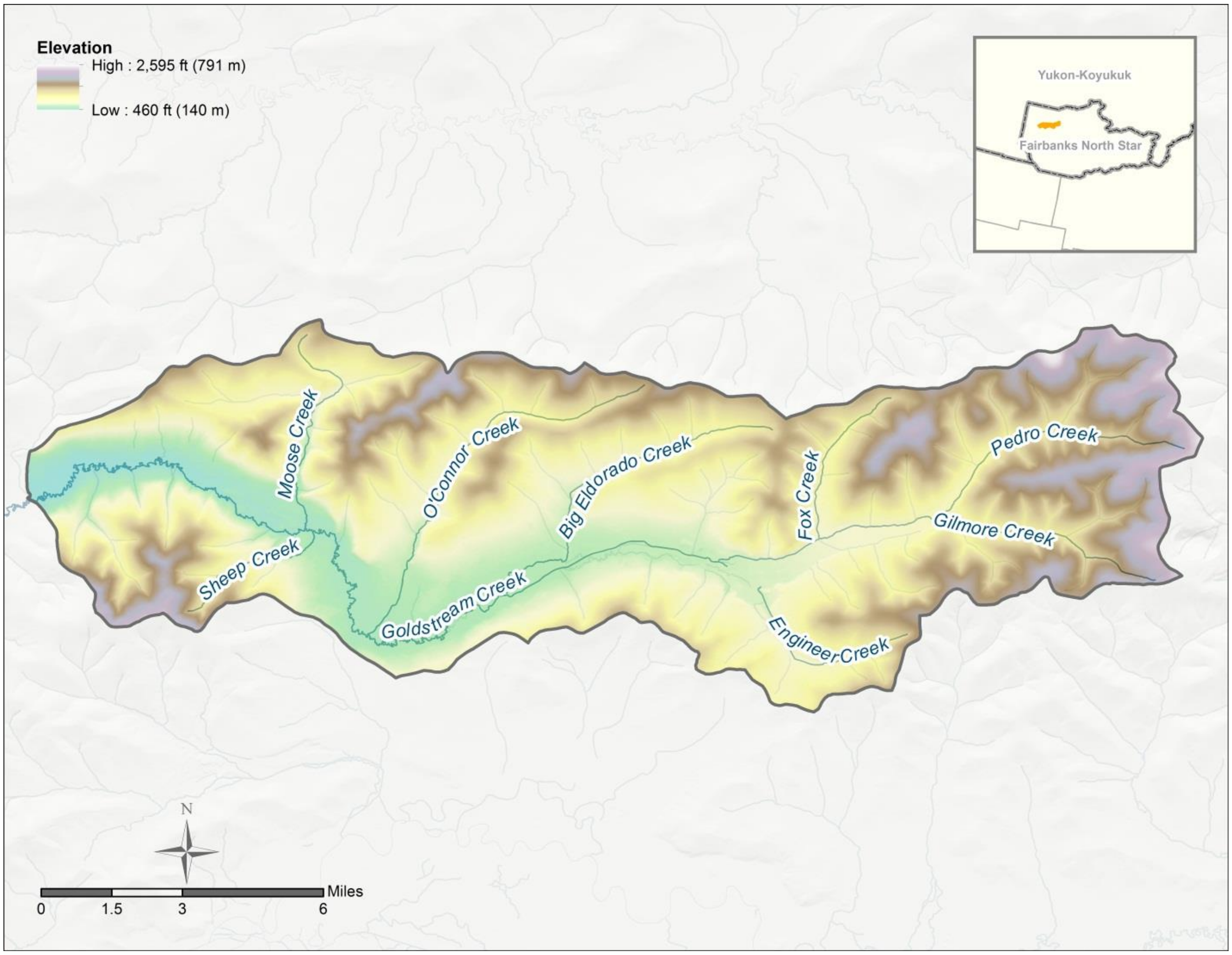

Figure 1-3. Elevation in the Upper Goldstream Creek watershed (Source: NED; USGS 2013).

1.4. Land Use and Land Cover

The Upper Goldstream Creek watershed is within the area covered by the Tanana Basin Area Plan for State Lands, which designates uses that will occur on state lands within the Tanana Basin (ADNR 1991). Management intent for the public lands includes agriculture, fish and wildlife, minerals, recreation and settlement. Publicly owned lands are a small fraction of the entire watershed; however, the Goldstream Public Use area (zoned Outdoor Recreational) surrounds Goldstream Creek for a significant section of HUC-02 (Figure 1-4 and Table 1-2).

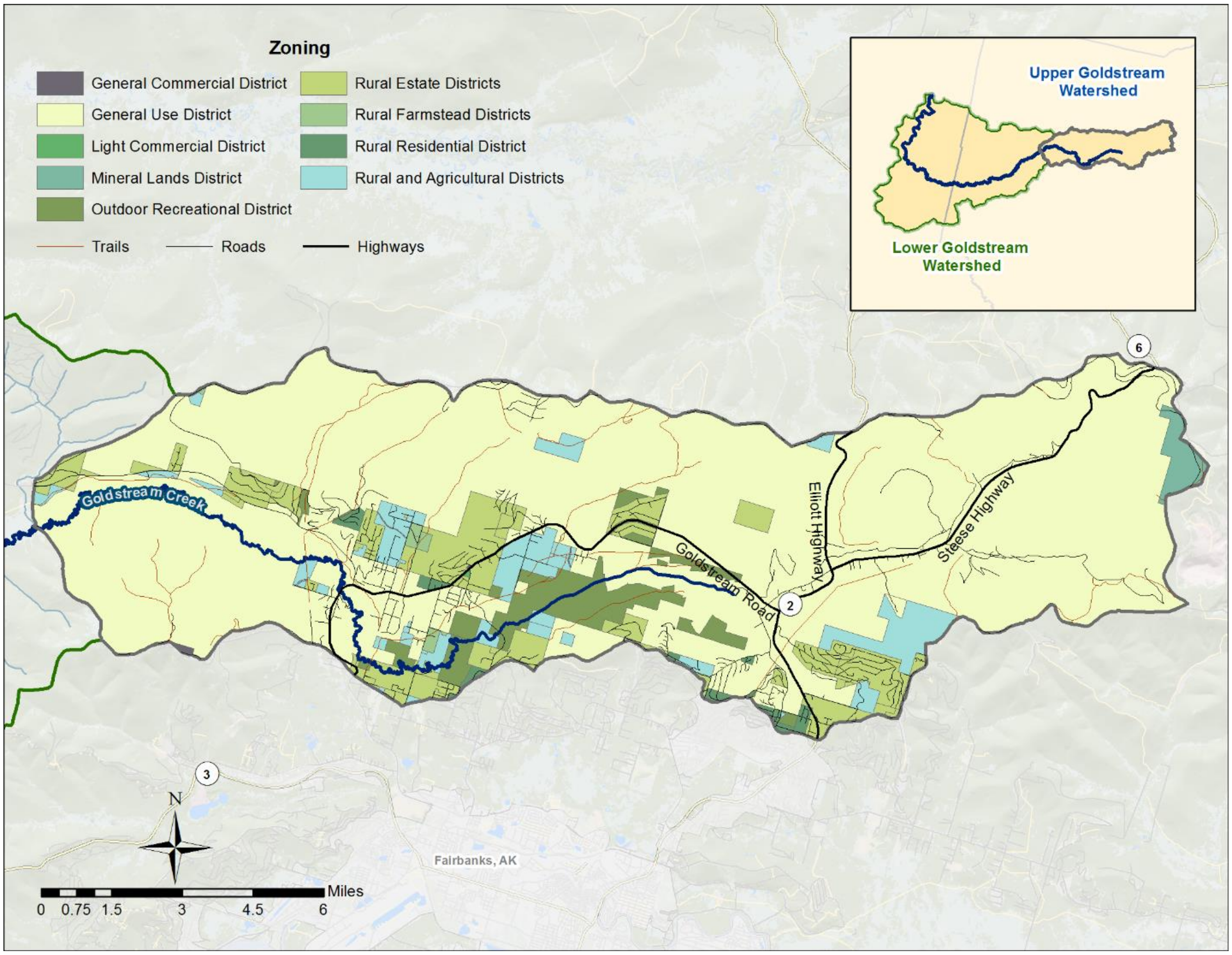

Figure 1-4. Zoning in the Upper Goldstream Creek watershed.

Table 1-2. Land use (zoning) distribution in the Upper Goldstream Creek watershed

Code	Description	Area (acres)	Percent of total area
GC	General Commercial District	37	0.0
GU-1	General Use District	66,642	80.1
LC	Light Commercial District	11	0.0
ML	Mineral Lands District	672	0.8
OR	Outdoor Recreational District	3,563	4.3
RA-10	Rural and Agricultural Districts	4,145	5.0
RA-20	Rural and Agricultural Districts	0	0.0
RA-40	Rural and Agricultural Districts	0	0.0
RA-5	Rural and Agricultural Districts	0	0.0
RE-2	Rural Estate Districts	7,294	8.8
RE-4	Rural Estate Districts	0	0.0
RF-2	Rural Farmstead Districts	230	0.3
RF-4	Rural Farmstead Districts	0	0.0
RR	Rural Residential District	614	0.7
TOTAL		**83,209**	**100.0%**

The majority of land in the watershed is zoned GU-1 for General Use with a much smaller proportion zoned either General or Light Commercial, Rural Estate, Rural and Agricultural, Rural Residential and Mineral Lands (Table 1-2). The GU-1 zone is intended for rural areas and has few limitations (FNSB 2015).

There are approximately 75 miles of trails in the watershed (Figure 1-4 and Table 1-3). Winter uses include dog-mushing, snow-machining and skiing. Summer use includes all-terrain vehicles (ATV) and mountain biking. There are 46 miles of major roads and 182 miles of small roads (Figure 1-4 and Table 1-3).

Table 1-3. Roads in the Upper Goldstream Creek watershed

Road Type	Length (miles)
Trails	75
Major roads	47
Small roads	182

Land cover data were obtained from the 2001 USGS NLCD. The NLCD data are based on satellite imagery from 2001. Land in the Upper Goldstream Creek watershed is predominantly forest (83 percent),while 9 percent is wetlands, and just over 5 percent is developed (Figure 1-5 and Table 1-4).

Figure 1-5. Land cover in the Upper Goldstream Creek watershed (Source: NLCD 2001).

Table 1-4. Land cover distribution in the Upper Goldstream Creek watershed

Land Use	Area (acres)	Percent of total area
Open Water	310	0.4%
Developed	4,433	5.3%
Barren	617	0.7%
Forest	69,180	83.1%
Shrub/Scrub	1,381	1.7%
Pasture/Hay	0	0.0%
Cropland	38	0.1%
Wetlands	7,254	8.7%
TOTAL	**83,212**	**100.0%**

Vegetation consists mainly of mixed evergreen, such as white and black spruce, and deciduous, such as Alaskan birch, quaking aspen and balsam poplar, trees on well-drained hill slopes (Weber and Robus 1987). Low areas are dominated by muskeg, consisting of low willow, alder, dwarf birch, dwarf black spruce, blueberry and cranberry, mosses and sedges (Weber and Robus 1987).

1.5. Soils and Geology

1.5.1. Soils

Data from the Natural Resources Conservation Service (NRCS) were used to characterize soils in the watershed. General soils data and map unit delineations are available through the Soil Survey Geographic database (SSURGO). A map unit is composed of several soil series having similar properties. Identification fields in the geographic information system (GIS) coverages can be linked to a database that provides information on chemical and physical soil characteristics. SSURGO data were only available for portions of the Upper Goldstream Creek watershed, and many soil properties were not provided for areas that were surveyed. Specifically, erodibility factors that would be of interest in this TMDL were not available.

The hydrologic soil group classification is a means for grouping soils by similar infiltration and runoff characteristics during periods of prolonged wetting. Typically, clay soils that are poorly drained have lower infiltration rates, while sandy soils that are well drained have the greatest infiltration rates. NRCS has defined four hydrologic groups for soils (Table 1-5). The majority of the soils in the Upper Goldstream Creek watershed belong to Hydrologic Soil Group D, while the rest are Hydrologic Soil Group B (NRCS 2009). Group D soils have high runoff potential and very low infiltration rates with a clay layer at or near the surface. Group B soils typically have moderate infiltration rates with moderately well to well-drained soils. Figure 1-6 and Table 1-6 summarize the Upper Goldstream Creek watershed soil information.

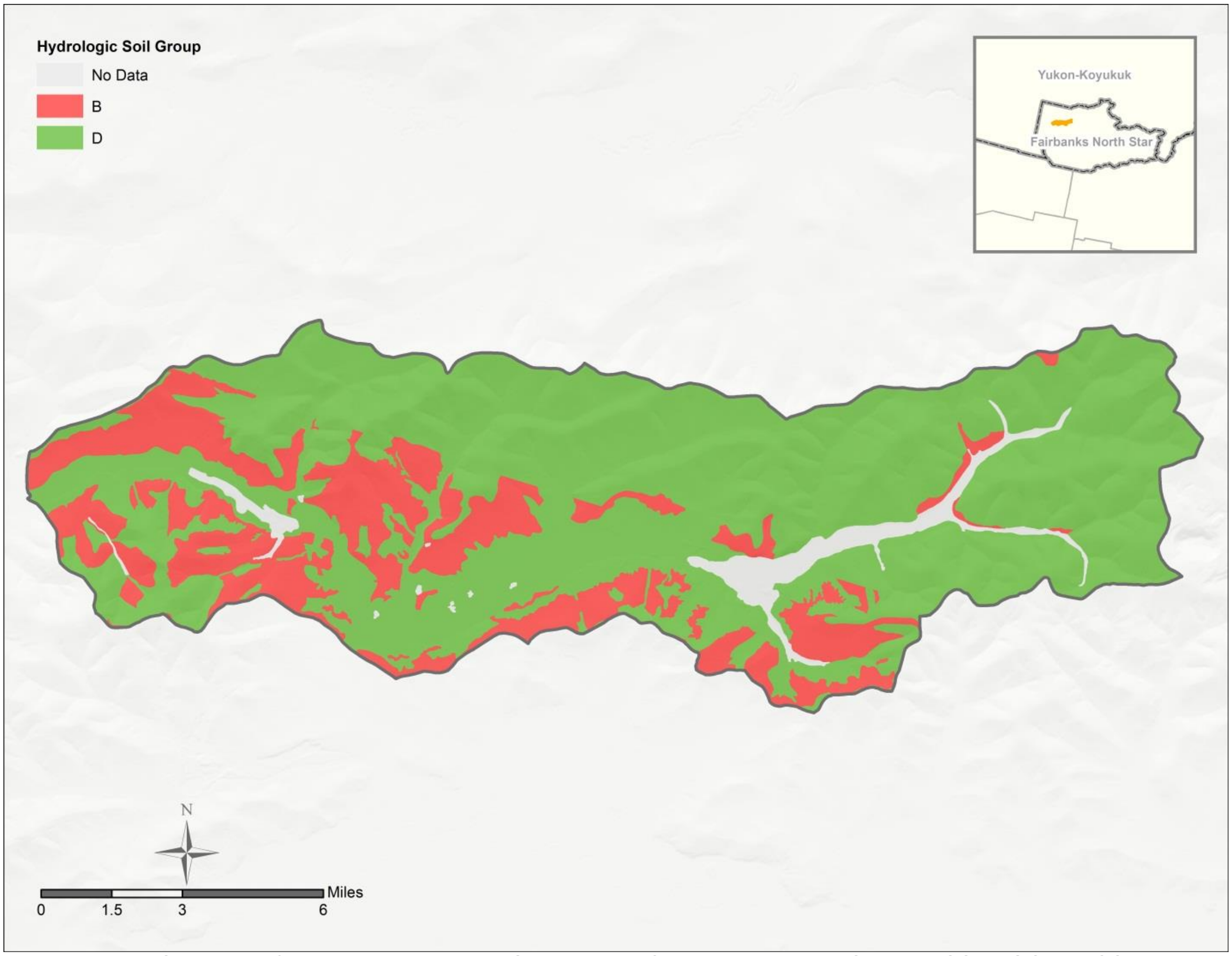

Figure 1-6. Soil classification in the Upper Goldstream Creek watershed (Source: SSURGO; NRCS 2009).

Table 1-5. Characteristics of hydrologic soil groups

Soil Group	Characteristics	Minimum Infiltration Capacity (inches/hour)
A	Sandy, deep, well drained soils; deep loess; aggregated silty soils	0.30 to 0.45
B	Sandy loams, shallow loess, moderately deep and moderately well-drained soils	0.15 to 0.30
C	Clay loam soils, shallow sandy loams with a low permeability horizon impeding drainage (soils with a high clay content), soils low in organic content	0.05 to 0.15
D	Heavy clay soils with swelling potential (heavy plastic clays), water-logged soils, certain saline soils, or shallow soils over an impermeable layer	0.00 to 0.05

Source: NRCS 1972

Table 1-6. Soil distribution in the Upper Goldstream Creek watershed

Hydrologic Soil Group	Area (Square Miles)	Percent Area	Drainage Class - Wettest
B	3	2%	Poorly drained
	6	4%	Moderately well drained
	21	15%	Well drained
D	44	30%	Very poorly drained
	11	8%	Poorly drained
	6	4%	Somewhat poorly drained
	2	1%	Moderately well drained
	45	31%	Well Drained
Unclassified	5	4%	Unknown

1.5.2. Geology

In the upper portion of the watershed, Goldstream Creek flows through reworked tailing piles (Qht), consisting of sub-rounded to angular gravel with cobbles and boulders up to 0.5 meters in diameter (Figure 1-7). Clasts are mostly quartzite, gneiss, and schist. In the middle and lower portions of the watershed, the creek flows through re-transported, Quaternary windblown silt (Qer) from the surrounding hills (Figure 1-7). This silt is unconsolidated and well-sorted with less than 10 percent clay that may overly benches of Tertiary gravel. The grains mostly consist of quartz, feldspar, and micas, locally cemented by iron oxides. Organic material is noticeable and discontinuous permafrost is abundant with ice lenses visible in some areas. The creek also flows through a more organic rich silt unit (Qos) in the lowland bogs. This consists mostly of decomposed vegetation with less than 20 percent clay.

The surrounding hills of the watershed are comprised mainly of the Fairbanks Schist (Zf, Zfa, Zfw) and the Fairbanks Loess (Qef). Nearly 90 percent of the Fairbanks schist is composed of quartzite and quartz muscovite schist. However, a wide range of metamorphic rocks can be observed in these units, including hydrothermally altered marble, chlorite schist, and magnetite-rich biotite schist. Upper regions of the watershed also contain areas of granite and granodiorite (Kg, Kgd) with smaller regions of tonalite and quartz diortite (Ktn).

Full unit descriptions of the area can be found at https://www.uaf.edu/files/olli/Units.pdf and geologic map data of the Fairbanks area can be downloaded from http://www.dggs.alaska.gov/pubs/id/1740.

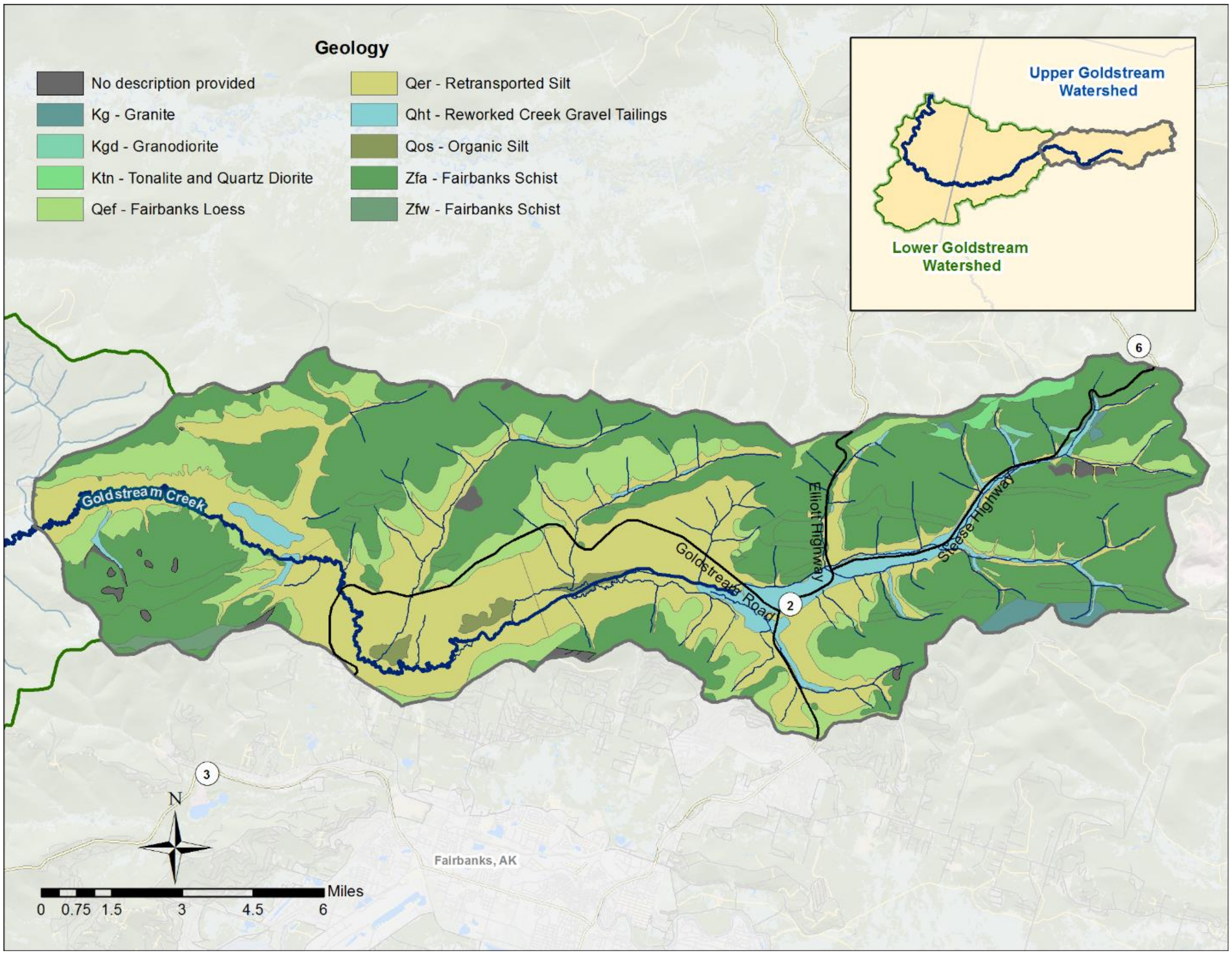

Figure 1-7. Geology in the Upper Goldstream Creek watershed.

1.6. Drinking Water

Drinking water protection programs exist to prevent the contamination of drinking water sources. Both surface and groundwater sources are protected under the national Wellhead Protection and Source Water Assessment and Protection programs. In Alaska, DEC's Drinking Water Program integrates the requirements of both programs.[1]

There are Zone A and Zone B drinking water protection areas and both public and other regulated water sources within the Upper Goldstream watershed (Figure 1-8). In the Fox area, the drinking water protection areas are for the following water systems: Hilltop Truck Stop, NESDIS CDA Station, Fox Roadhouse, DOT&PF, Pioneer Wells at Fox and the Turtle Club. Further down in the watershed, there are additional protection areas for the Vallata, Ivory Jacks, Moose Mountain and Bear Run apartments.

[1] http://dec.alaska.gov/eh/dw/DWP/DWP_Overview.html

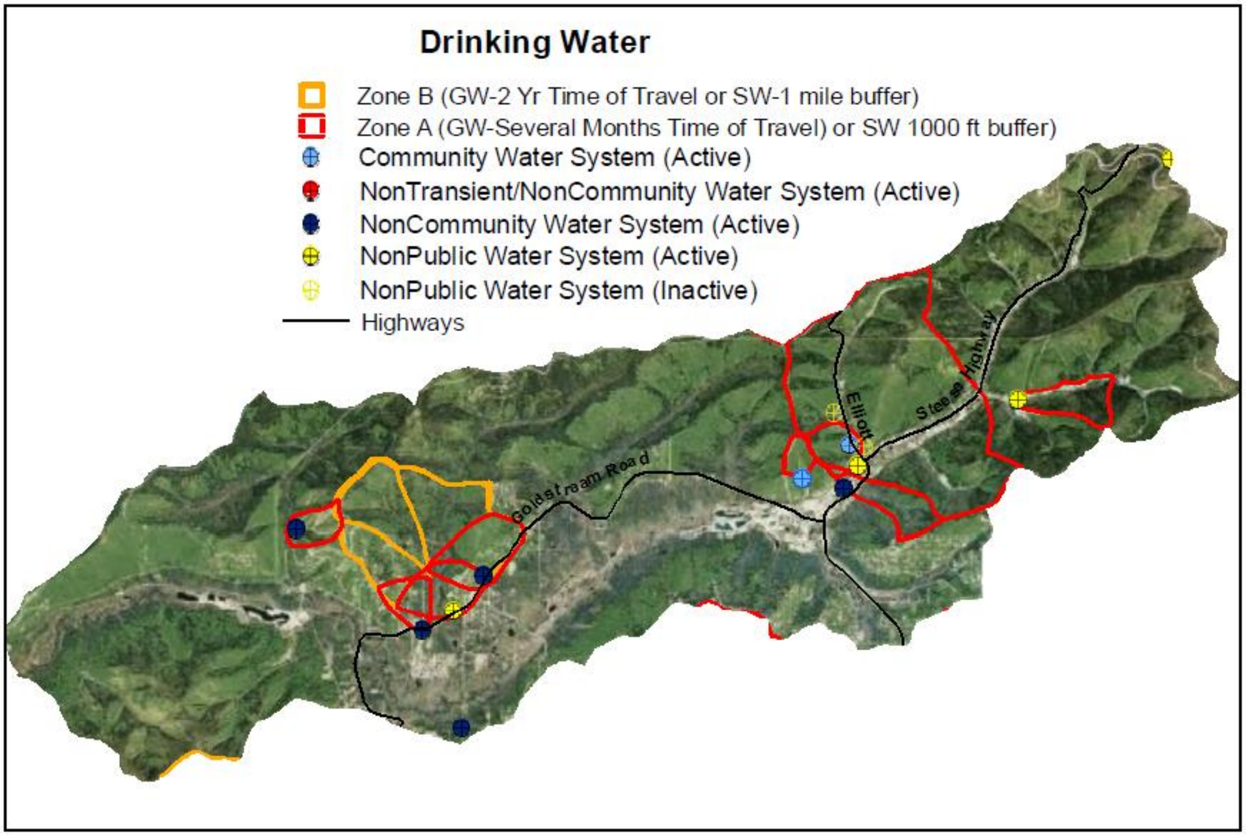

Figure 1-8. Drinking water resources in the Upper Goldstream Creek watershed.

1.7. Climate

The Upper Goldstream Creek watershed is in the “interior” climate zone of Alaska, between the transitional and arctic zones. Temperatures in the interior zone near the city of Fairbanks can range from a high of 90 degrees Fahrenheit (°F) in the summer and below -60 °F in the winter (Western Regional Climate Center 2013). Climate is typically cold with dry winters and warm but short summers. Average annual precipitation was 12.78 inches (in) for the period of record (1976–2012) at the College 5 NW weather station near the Upper Goldstream Creek watershed. The average monthly precipitation for the period of record ranges from 0.29 inches in April to 2.29 inches in July. The highest temperatures occur in July on average with an average high temperature of about 60.75 °F. The lowest air temperatures occur in January with minimum average temperature of about 0.65 °F.

Autumn begins in early September and ends in mid-October, with temperatures falling in September and snowfalls increasing in October. Winter lasts from mid-October to early April. Spring begins in late April and May with less precipitation and increasing temperatures. The summer months of June through August are warm and have the highest rainfall amounts. Figure 1-9 and Table 1-7 present a summary of monthly averages for rainfall, snowfall and temperature at the College 5 NW station.

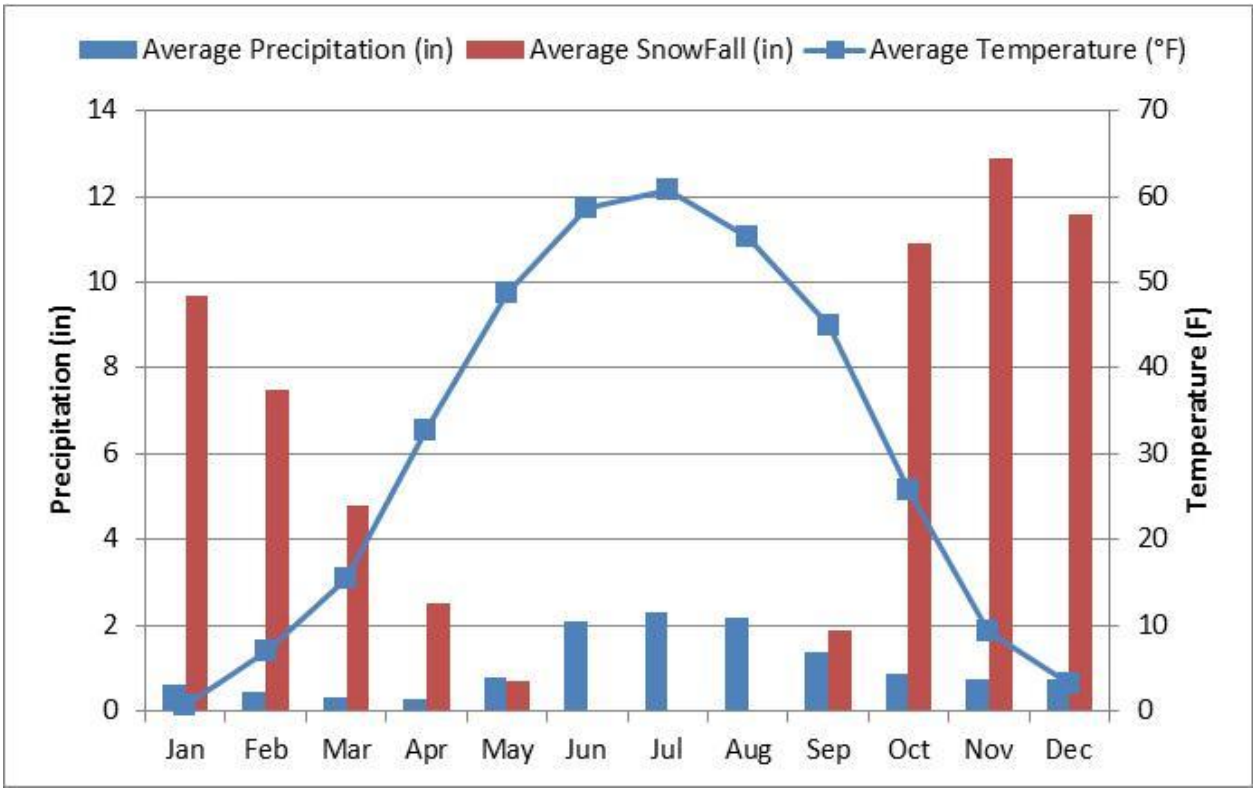

Figure 1-9. Monthly average precipitation and temperatures at College 5 NW station.

Table 1-7. Monthly average precipitation, snowfall, and temperatures at College 5 NW station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Precipitation (in)	0.62	0.47	0.32	0.29	0.79	2.1	2.29	2.18	1.4	0.86	0.73	0.73
Average Snowfall (in)	9.7	7.5	4.8	2.5	0.7	0	0	0	1.9	10.9	12.9	11.6
Average Temperature (°F)	0.65	7.05	15.4	32.8	48.8	58.65	60.75	55.3	44.9	25.7	9.35	3.2

1.8. Hydrology and Waterbody Characteristics

Upper Goldstream Creek and its headwater tributaries pass through highly mineralized terrain with moderately swift flow through shallow sand, gravel, and cobble bottoms with low banks. The headwaters of Pedro and Gilmore creeks are just west of Cleary Summit (2,233 feet above sea level) near the Pedro and Gilmore Domes.

Upper Goldstream Creek and its tributaries are frozen from mid-October through April, with flow starting to decrease in September and increase in mid-May following spring breakup (EPA 1994). Discharge from Goldstream tributary streams is highly variable. Peak flows typically occur during the spring. Summer storms interacting with permafrost, impermeable or saturated ground conditions, and lack of surface storage in the upper basin can cause heavy floods. Localized flooding in the smaller drainages typically occurs during events generating an inch or more of precipitation (EPA 1994).

Upper Goldstream Creek flows through undifferentiated silt and a small amount of organic silt. Above Ballaine Road, Goldstream Creek is characterized by a sand, gravel and cobble bottom, shallow water, low banks and overhanging vegetation primarily of dense willows while below Ballaine Road it is characterized by a mud and silt bottom and a channel with high banks and deep water (Weber and Robus 1987).

1.9. Available Data

1.9.1. Recent Data

ADEC sampled five stations in the Upper Goldstream Creek watershed from upstream to downstream (Figure 1-10 and Table 1-8):

- Pedro Creek: Pedro Creek just above confluence with Gilmore Creek (reference site)
- GS-1: Gilmore Creek just above confluence with Pedro Creek
- GS-2: Goldstream Creek at Goldstream Road
- Ballaine: Goldstream Creek at the Ballaine Road bridge
- Sheep Creek: Goldstream Creek near Sheep Creek Road

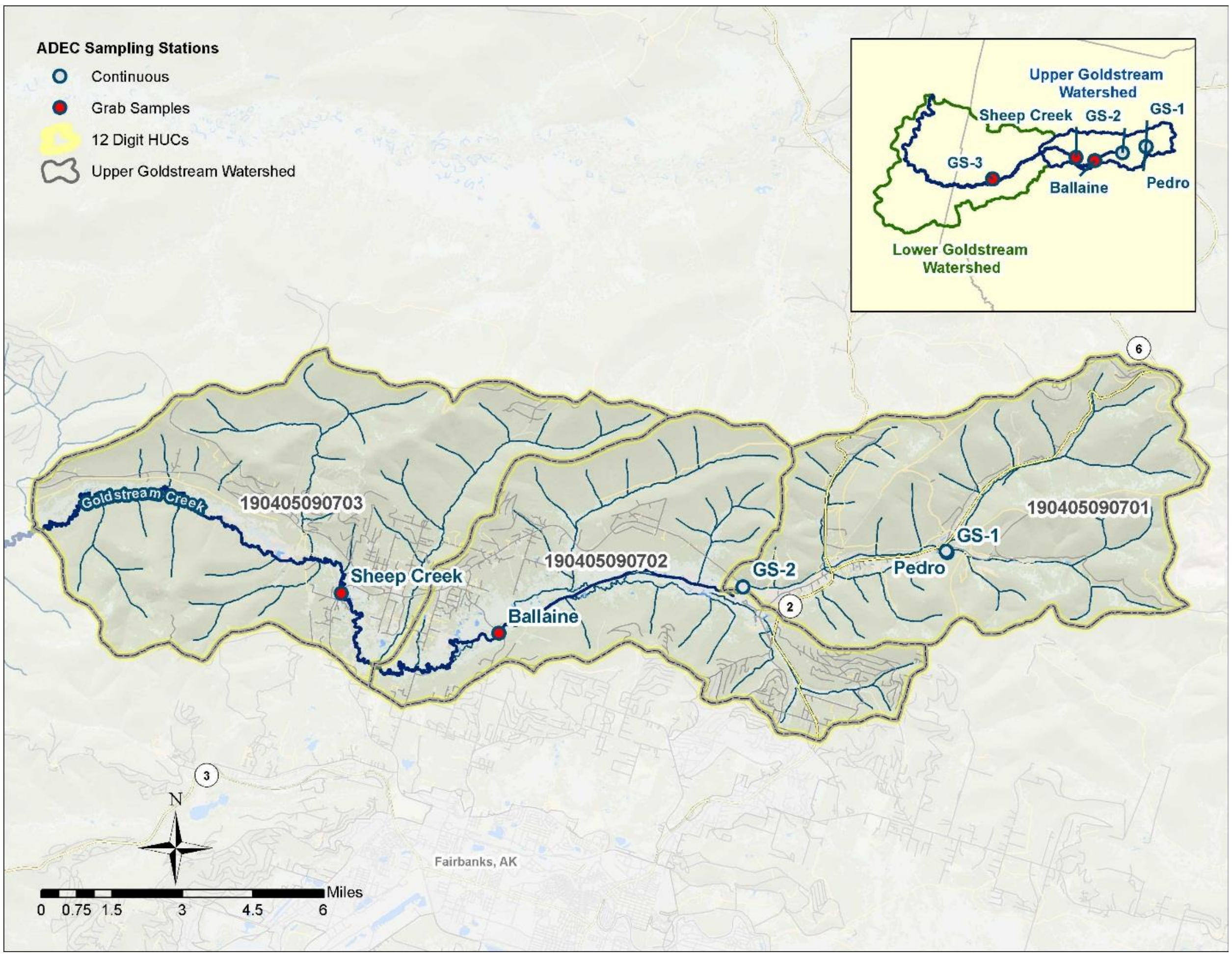

Figure 1-10. Continuous and grab water quality monitoring stations in the Upper Goldstream Creek watershed.

Table 1-8. TMDL stations and their associated watershed

Station Name	HUC-12 Number	HUC-12 Name	TMDL Subwatershed
GS-1	190405090701	Fox Creek	HUC-01
Pedro	190405090701	Fox Creek	HUC-01
GS-2	190405090701	Fox Creek	HUC-01
Ballaine	190405090702	Big Eldorado-Goldstream Creek	HUC-02
Sheep Creek	190405090703	O'Connor Creek	HUC-03

A summary of the turbidity and total suspended solids (TSS) data at the four sampling stations as well as the reference station at Pedro Creek is shown in Table 1-9. The data are presented in Table 1-9 from the upper most station near the headwaters (Pedro Creek) moving downstream to Sheep Creek. The stations at GS-1, Pedro Creek, and GS-2 have both continuous monitoring data and grab sample data. All other sites have only grab sample data.

Table 1-9. Summary of available TSS and turbidity data for Upper Goldstream Creek

Parameter (units)	Sample Type[a]	Station Name	Number of Observations	Start Date	End Date	Minimum	Average	Maximum
TSS (mg/L)	Grab	Pedro	4	6/17/2013	9/16/2013	2.0	15.6	39.0
	Grab	GS-1	23	9/12/2011	9/16/2013	1.6	92.0	940.0
	Grab	GS-2	25	9/11/2011	9/16/2013	1.9	31.6	237.0
	Grab	Ballaine	7	5/24/2013	9/16/2013	1.8	21.5	131.0
	Grab	Sheep Creek	4	7/9/2013	9/16/2013	1.3	1.8	2.5
Turbidity (NTU)	Cont.	Pedro	535	8/16/2013	9/9/2013	1.5	6.5	26.4
	Grab	Pedro	20	6/10/2011	9/16/2013	0.5	22.0	216.0
	Cont.	GS-1	7,693	5/24/2011	9/9/2013	1.5	60.9	674.0
	Grab	GS-1	47	5/20/2011	9/16/2013	3.0	60.2	526.0
	Cont.	GS-2	7,650	5/24/2011	9/23/2013	0.7	25.0	380.3
	Grab	GS-2	68	5/5/2011	9/16/2013	3.3	32.0	433.0
	Grab	Ballaine	12	8/13/2012	9/16/2013	2.9	6.6	25.0
	Grab	Sheep Creek	9	6/17/2013	9/16/2013	4.4	6.7	12.0

Note: mg/L = milligrams per liter; NTU = nephelometric turbidity units

[a] Grab = Grab samples that were taken once a day; Cont. = Continuous sampling that was performed hourly (or more frequently) at data logger sites.

The USGS collects samples on streams near Goldstream Creek, but does not have any active USGS flow monitoring gages in the Upper Goldstream Creek watershed. ADEC collected limited instantaneous flow and water level data from 2011 to 2013 at GS-1 and GS-2 (see Figure 1-10 for station locations). A summary of available flow and surface water level data is provided in Table 1-10.

Table 1-10. Summary of available flow and water level data for Upper Goldstream Creek

Parameter (units)	Station Name	Number of Observations	Start Date	End Date	Minimum	Average	Maximum
Flow (cfs)	GS-1	15	6/3/2011	9/4/2013	1.00	4.04	8.30
	GS-2	27	4/25/2011	9/4/2013	3.30	15.64	52.30
Water Level (cm)	GS-1	8,249	5/24/2011	9/9/2013	0.14	25.57	82.80
	GS-2	6,260	5/24/2011	9/23/2013	0.22	22.67	61.11

Note: cfs = cubic feet per second; cm = centimeters

Table A-1 in Appendix A presents a summary of all available data by month. An additional downstream site (GS-3) was sampled during 2011–2012, but is not included in this TMDL because it is outside the Upper Goldstream Creek watershed (see Appendix B for GS-3 data).

1.9.2. Historical Data

Water quality data from the Upper Goldstream Creek watershed were collected during the 1970s to early 1990s. The data show highly variable turbidity, based on land use in the watershed at the time (Table 1-11). Several of the sites correspond to the recent sampling stations.

Table 1-11. Summary of historical turbidity for Upper Goldstream Creek

Site Name	TMDL Subwatershed	Year	Months	Number of Samples	Average Turbidity (NTU)	Median Turbidity (NTU)	Source
Pedro Creek	HUC-01	1983	Aug	2	63.00	63.00	Weber and Robus 1987
		1984	Aug	2	60.00	60.00	Weber and Robus 1987
		1986	Sept	3	406.00	359.00	Weber and Robus 1987
		1987	May-June	23	17.99	19.60	ADFG 1987
		1990	unknown	10	11.10	3.20	Ray 1993
		1991	unknown	13	22.00	14.00	Ray 1993
		1992	unknown	6	7.30	3.60	Ray 1993
		1994	June-Sept	58	1.10	0.90	Noll and Vohden 1994
Gilmore Creek	HUC-01	1983	Aug	3	926.67	1040.00	Weber and Robus 1987
		1984	Aug	2	555.00	555.00	Weber and Robus 1987
		1986	May-Sept	2	611.00	611.00	Weber and Robus 1987
		1987	May-June	7	39.04	28.20	ADFG 1987
		1993	June-Sept	54	8.50	4.70	Noll and Vohden 1994
Fox Creek	HUC-01	1993	June-Sept	52	38.40	19.00	Noll and Vohden 1994
Goldstream Creek at Fox	HUC-01	1970	Aug-Oct	7	6.71	5.00	Peterson 1972
		1971	Mar-Oct	7	14.23	7.00	Peterson 1972
		1983	Aug	34	271.18	260.00	Weber and Robus 1987
		1984	Aug	3	418.00	400.00	Weber and Robus 1987
		1991	unknown	75	6.30	4.50	Ray 1993
		1992	unknown	125	7.10	5.20	Ray 1993
		1993	Apr-Sept	151	12.90	8.00	Noll and Vohden 1994
Goldstream Creek above Goldstream Rd	HUC-01	1984	May-June	9	409.67	225.00	Weber and Robus 1987
		1986	Sept	1	334.00	334.00	Weber and Robus 1987
Goldstream Creek at Ballaine	HUC-02	1970	Aug-Oct	6	13.83	14.50	Peterson 1972
		1971	Jan-Oct	9	13.94	11.00	Peterson 1972
		1984	May-June	9	220.56	240.00	Weber and Robus 1987
		1986	Sept	1	80.00	80.00	Weber and Robus 1987
		1987	May-June	37	41.55	30.00	ADFG 1987

Site Name	TMDL Subwatershed	Year	Months	Number of Samples	Average Turbidity (NTU)	Median Turbidity (NTU)	Source
Goldstream Creek at Sheep Creek Rd.	HUC-03	1970	Aug-Oct	6	19.50	18.50	Peterson 1972
		1971	Jan-Oct	10	20.51	12.50	Peterson 1972
		1983	Aug	5	338.00	260.00	Weber and Robus 1987
		1984	Aug	3	282.00	348.00	Weber and Robus 1987
		1986	Sept-Oct	30	236.13	238.00	Weber and Robus 1987
		1993	May-Sept	82	6.20	4.10	Noll and Vohden 1994

2. WQS and TMDL Target

WQS designate the "uses" to be protected (e.g., water supply; recreation; growth and propagation of fish, shellfish, other aquatic life and wildlife) and the "criteria" for their protection (e.g., how much of a pollutant can be present in a waterbody without impairing its designated uses). TMDLs are developed to meet applicable water WQS, which may be expressed as numeric water quality criteria or narrative criteria for the support of designated uses. The TMDL target identifies the numeric goals or endpoints for the TMDL that equate to attainment of the WQS. When a numeric water quality criterion is available, the TMDL target is set equal to this value. Alternatively, the TMDL target may represent a quantitative interpretation of a narrative (or qualitative) water quality criterion. This section reviews the applicable WQS and identifies an appropriate target for calculation of the turbidity TMDL for Upper Goldstream Creek.

2.1. Applicable WQS

Title 18, Chapter 70 of the Alaska Administrative Code (AAC) establishes WQS for the waters of Alaska (ADEC 2012), including the designated uses to be protected and the water quality criteria necessary to protect the uses, as described below. State water quality criteria are defined for both marine and fresh waterbodies. The fresh water criteria apply to Goldstream Creek.

2.1.1. Designated Uses

Designated uses for Alaska's waters are established by regulation and are specified in the Alaska WQS (18 AAC 70). For fresh waters of the state, these designated uses include (1) water supply, (2) water recreation, and (3) growth and propagation of fish, shellfish, other aquatic life, and wildlife. All designated uses must be addressed for any water in Alaska except where one or more uses have been removed for specified waters listed under 18 AAC 70.230(e). Therefore, the TMDL must use the most stringent of the water quality criteria protecting any of the uses. In this case, the most stringent criterion is for contact recreation (see Section 2.1.2).

2.1.2. Water Quality Criteria

Upper Goldstream Creek does not fully support its designated uses because of anthropogenic sources of turbidity in the water column (Section 3.1). Turbidity water quality criteria for all designated uses are applicable to Upper Goldstream Creek. Table 2-1 shows the water quality criteria for turbidity, on which the Section 303(d) listing for Upper Goldstream Creek is based.

Table 2-1. Alaska fresh water quality criteria for turbidity (18 AAC 70.020)

Designated use	Criteria
Turbidity (Not applicable to groundwater)	
(A) Water supply	
(i) Drinking, culinary, and food processing	May not exceed 5 nephelometric turbidity units (NTU) above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than 10% increase in turbidity when the natural turbidity is more than 50 NTU, not to exceed a maximum increase of 25 NTU.
(ii) Agriculture, including irrigation and stock watering	May not cause detrimental effects on indicated use.
(iii) Aquaculture	May not exceed 25 NTU above natural conditions. For all lake waters, may not exceed 5 NTU above natural conditions.

Designated use	Criteria
(iv) Industrial	May not cause detrimental effects on established water supply treatment levels.
(B) Water recreation	
(i) Contact recreation	May not exceed 5 NTU above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than 10% increase in turbidity when the natural turbidity is more than 50 NTU, not to exceed a maximum increase of 15 NTU. May not exceed 5 NTU above natural turbidity for all lake waters.
(ii) Secondary recreation	May not exceed 10 NTU above natural conditions when natural turbidity is 50 NTU or less, and may not have more than 20% increase in turbidity when the natural turbidity is greater than 50 NTU, not to exceed a maximum increase of 15 NTU. For all lake waters, turbidity may not exceed 5 NTU above natural turbidity.
(C) Growth and propagation of fish, shellfish, other aquatic life, and wildlife	Same as (A)(iii)

Source: 18 AAC 70.020 (ADEC 2012)

2.2. Antidegradation

Alaska's WQS also include an antidegradation policy (18 AAC 70.015), which states that existing water uses and the level of water quality necessary to protect the existing uses must be maintained and protected. The policy also states that high quality waters must be maintained and protected unless the state finds that allowing lower water quality is necessary to accommodate important economic or social development in the area in which the water is located. In allowing permitted discharges that degrade water quality, the state must ensure water quality is adequate to fully protect existing uses of the water.

The methods of pollution prevention, control, and treatment found to be the most effective and reasonable will be applied to all discharges. All discharges will be treated and controlled to achieve the highest statutory and regulatory requirements for point sources and all cost-effective and reasonable BMPs for nonpoint sources.

The antidegradation policy also states that state waters that are designated as an outstanding national resource must be maintained and protected. In such waters, no degradation of water quality is allowed.

2.3. Designated Use Impacts

Goldstream Creek was placed on the CWA 1992 Section 303(d) list for nonattainment of the freshwater quality criteria for turbidity (ADEC 2013). The nonattainment affects the designated uses of (1) water supply, (2) water recreation, and (3) growth and propagation of fish, shellfish, other aquatic life, and wildlife. Increased levels of turbidity negatively affect drinking water sources, diminish fish rearing success, and impair recreational uses.

2.4. TMDL Target

The TMDL target is the numeric endpoint that represents attainment of applicable WQS. This value is used to calculate the loading capacity and necessary load reductions.
The water quality criterion for contact recreation (see section 2.1.2) used as the basis for this TMDL states that turbidity "may not exceed 5 NTU above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than 10 percent increase in turbidity when the natural turbidity is

more than 50 NTU, not to exceed a maximum increase of 15 NTU." Use of the contact recreation criterion will address all other designated uses.

As shown in Table 2-1, one must establish natural background conditions to establish a site-specific numeric TMDL target based on the contact recreation criterion. The calculated natural conditions for turbidity were used to determine numeric water quality targets by flow condition based on Alaska's water quality criteria for turbidity. Pedro Creek (Figure 1-10) was used to represent natural conditions for this TMDL.

Pedro Creek is part of the headwaters to Upper Goldstream Creek. Therefore, this drainage is topographically and geographically a good representation of reference conditions in the watershed. The Pedro Creek subwatershed includes some Alaska Department of Natural Resources (DNR) state mining claims, but there are no active ADEC mining permits. In addition, no mine discharges have occurred during the recent three-year monitoring period. Based on the NLCD 2001 land cover data, the Pedro Creek drainage has only 0.4 square miles of developed land; most of this subwatershed is undisturbed forest or scrub (Homer et al. 2007). Monitoring data from 2010-2013 (Misra et al. 2012) show low turbidity values on Pedro Creek, except during spring break-up, which is a natural occurrence. This collective geographic and water quality data analysis confirms that Pedro Creek is a good representation of natural conditions in the Upper Goldstream Creek watershed.

Several factors are important for identifying the TMDL numeric targets. The water quality criteria are based on turbidity. Turbidity is a measure of the water's optical properties that cause light to be scattered or absorbed. Because it does not incorporate a measurement of mass, turbidity values are not conducive to the calculation of loads. Therefore, numeric targets are expressed as both turbidity values and sediment concentrations (which do measure mass in a volume of water), using a correlation with watershed-specific TSS concentrations. For this watershed, flow conditions affect turbidity and sediment measurements; therefore, analyses were conducted to represent numeric target values during varying flow conditions. Specific analyses and decisions associated with numeric target calculations are described below (note: these are also applied to the calculation of existing loads and the loading capacity).

2.4.1. Time Period

From mid-October through April, Upper Goldstream Creek and its tributaries are completely frozen. The creeks generally open up and begin flowing in mid-May, following spring break-up, and remain free-flowing until mid-September when streams begin freezing as the temperatures fall. This coincides with the period of available data (end of May to mid-September for 2011–2013). The TMDL was developed based on flow regimes from mid-May to mid-September to best use available data and accurately represent stream conditions.

2.4.2. TSS-Turbidity Relationship

All available turbidity and TSS data in the watershed were analyzed to evaluate the relationship between these two parameters (Appendix A). For the correlation, TSS grab samples were assigned to a turbidity measurement based on the closest sample time. It was determined that a strong relationship exists ($R^2 = 0.87$) and the resulting equation can be used to estimate TSS concentrations associated with available turbidity values (Figure 2-1). This correlation is largely driven by samples in late May or early June that were collected during spring break-up. The spring break-up samples are important to include because they represent water quality during a natural seasonal event in the watershed.

The TMDL uses the equation for the relationship presented in Figure 2-1 to estimate TSS concentrations associated with the turbidity water quality criteria, resulting in TSS numeric targets.

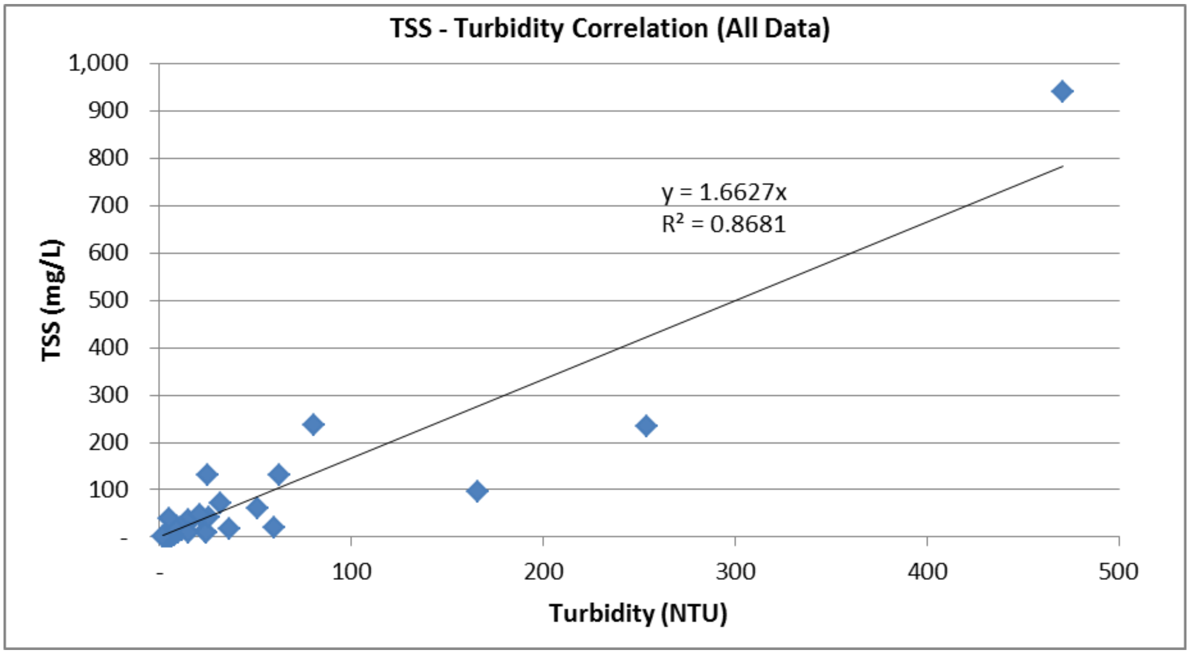

Figure 2-1. TSS and turbidity relationship for Goldstream Creek watershed.

2.4.3. Flow Data

No continuous flow data were available within the Goldstream Creek watershed to develop flow regimes; limited instantaneous flow data were available to calculate loads. However, continuous water level data were collected from 2011–2013 at sampling stations GS-1 and GS-2 (see Figure 1-10 for station locations). This period of record overlaps with nearly all of the continuous turbidity data and most of the grab samples collected. Relationships associated with the available water level data were used to develop continuous flow datasets for Goldstream Creek, as described below.

Instantaneous flow measurements at GS-1 and GS-2 are strongly correlated, when evaluating both instantaneous flow values and unit-area flow (cfs per mi^2 [cfs/mi^2]) (Figure 2-2 and Table 2-2). These relationships indicate that flow measurements at one site can be used to predict flow measurements at the other site.

The next data evaluated were the continuous water level data. These data were compared to the unit area flow measurement for each station. Data analysis showed a good relationship between GS-1 unit area flow and water level (R^2 = 0.74), but not at GS-2 (R^2 = 0.03) (Figure 2-3).

Because GS-1 and GS-2 flows have a strong relationship, the equation associated with the water level to unit area flow relationship at GS-1 (Figure 2-3) was used to estimate flow for the TMDL. Specifically, the continuous water level data at GS-1 was included and the equation was solved to estimate the associated unit area flow, resulting in a continuous unit area flow dataset. This continuous unit area flow dataset can be extrapolated to any point in the watershed based on drainage area. These continuous flow values were then used to develop flow duration curves and resulting flow regimes, which were combined with turbidity and TSS data to investigate water quality conditions under different flow regimes and calculate sediment loads (using TSS values).

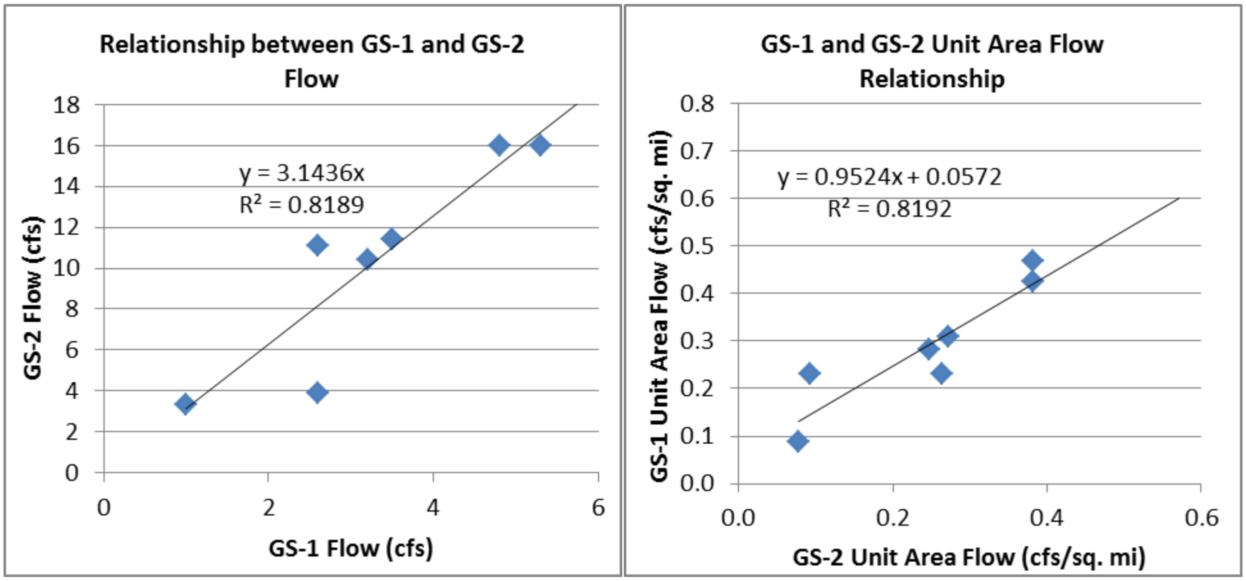

Figure 2-2. Flow relationships between GS-1 and GS-2.

Table 2-2. Unit area flow statistics at GS-1 and GS-2

Summary statistic (in cfs/mi^2)	Station GS-1	Station GS-2
Minimum	0.09	0.08
Average	0.36	0.37
Maximum	0.73	1.25

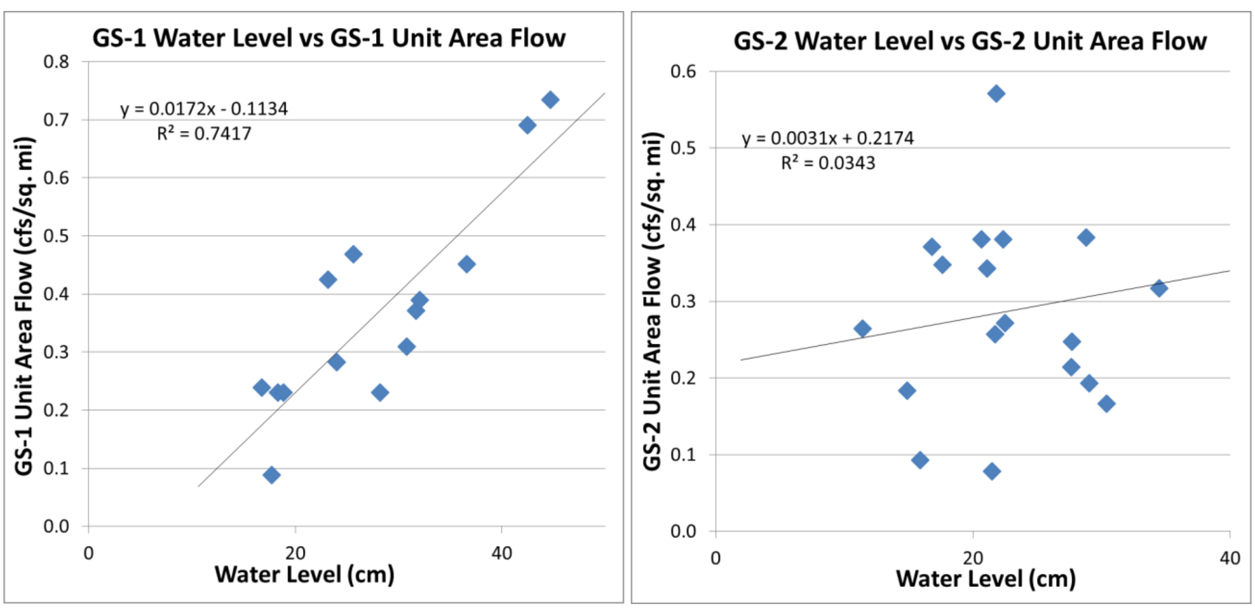

Figure 2-3. Water level and unit area flow relationships at GS-1 and GS-2.

2.4.4. Numeric Target Calculation

Natural conditions at a reference station are needed to determine numeric water quality targets based on Alaska's water quality criteria for turbidity. As described above, data at Pedro Creek were used to represent natural conditions and to calculate the TMDL numeric targets.

To account for seasonal variability in the Upper Goldstream Creek watershed, natural conditions are evaluated using different flow regimes. This first requires assigning a representative flow for each day with measured turbidity, which was performed using the following steps:

- Flow regimes are based on a continuous flow dataset developed by applying the GS-1 water level to unit area flow equation (Figure 2-3) to the 14.4-square-mile Pedro Creek watershed. This calculated continuous flow dataset was then compared to the date range of the turbidity dataset.
- There were four dates in 2013 with turbidity measurements at Pedro Creek that fell outside of the calculated continuous flow dataset (based on the water level dataset at GS-1) (three dates were before the continuous flow monitoring began and one was after the data collection stopped for the season). To incorporate these data, the flow regime for that date at the nearby L Chena USGS gage (station #15511000, located approximately 10 miles southwest of the Goldstream Creek watershed) was applied to determine an applicable flow value in Pedro Creek.
- The full range of calculated flows at Pedro Creek from mid-May to mid-September were broken into high, moist, mid-range, dry, and low flow regimes, as well as an extreme high flow regime that represents the spring break-up (0 to 1 percent of flows). These data were ready to incorporate into the daily turbidity dataset.
- The continuous (i.e., multiple measurements in a single day) turbidity data were summarized into daily values representing each day analyzed. Specifically, the median continuous measurement on a given day was used to represent turbidity conditions on that date. The median value was used because it is lower than the average and is, therefore, more conservative, yet it allows for some variability in the measurements (as opposed to the minimum value). Using this more conservative measurement is important because it sets a lower value for comparison with other data in the watershed, thereby requiring slightly higher pollutant load reductions and ensuring attainment of WQS (note: this is included as an implicit MOS in the TMDL; Section 5.4).
- A flow percentile was assigned to each daily turbidity value based on the corresponding calculated flow on that date.
- These data are summarized using a water quality duration curve with box and whisker plots to represent the turbidity data by flow regime (Figure 2-4) (note: no data were available for the high flow condition).

Summary statistics for each flow regime (Table 2-3) were calculated to evaluate the turbidity measurements at the reference station. The summary statistics include the minimum and maximum values, as well as the 25^{th}, 50^{th} (i.e., median), and 75^{th} percentiles for each flow regime. There were no turbidity measurements collected during the high flow regime. These data show that the extreme high flow regime has the highest turbidity measurements. When evaluating the median values, higher turbidity was observed during mid-range flow conditions (when compared to the moist flow conditions). This is likely due to the limited dataset for these two flow conditions. As expected, the low flow condition had the lowest turbidity concentrations.

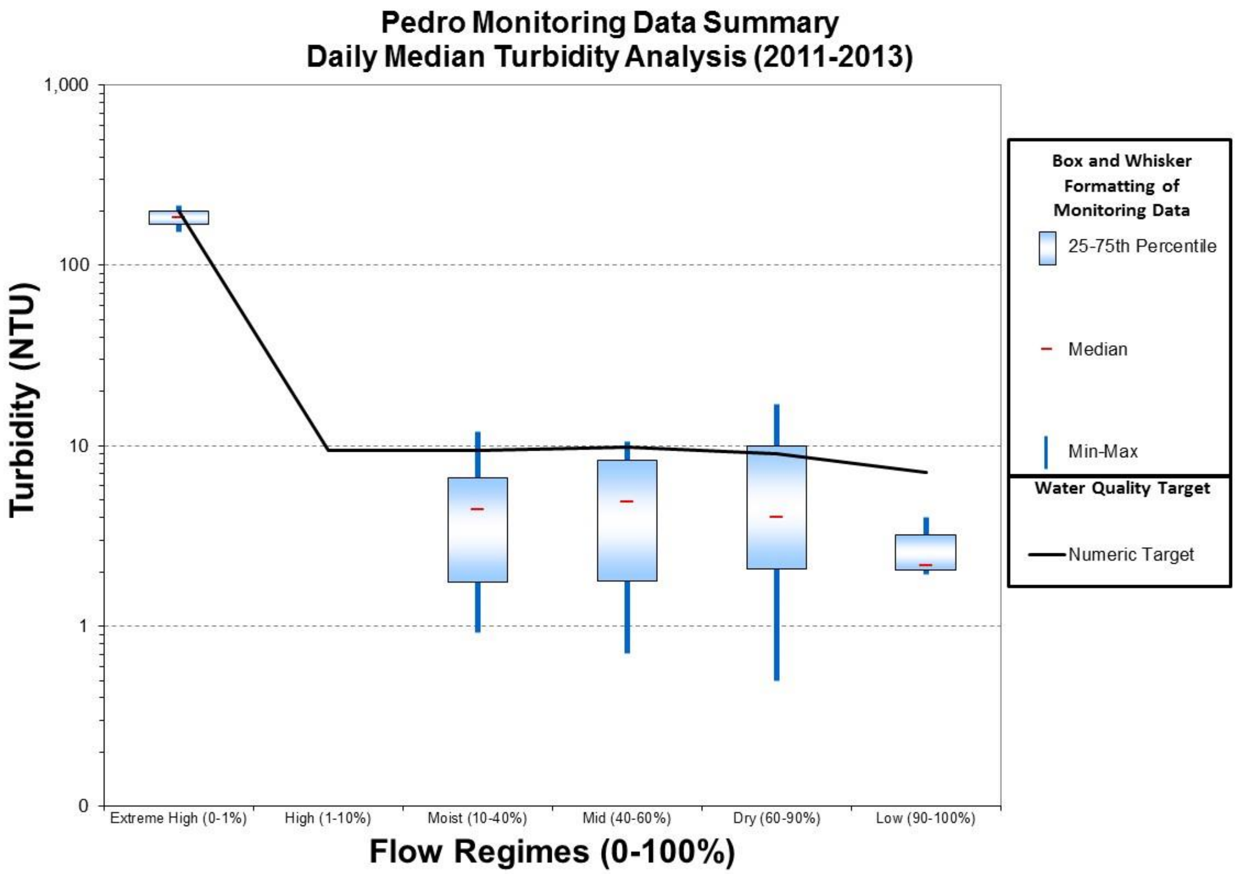

Figure 2-4. TMDL targets based on median daily turbidity measurements at Pedro Creek.

The median value for each flow regime (Table 2-3) was used to calculate the TMDL numeric targets using the following steps:

- The applicable water quality criterion was identified. This is associated with the contact recreation use, which is the most conservative:

  May not exceed 5 NTU above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than a 10% increase in turbidity when the natural turbidity is more than 50 NTU, not to exceed a maximum increase of 15 NTU.

- As noted in the criterion, the flow regimes with turbidity measurements below 50 NTU have a target based on the median NTU +5 NTU. The data at Pedro Creek indicate that the natural background turbidity is less than 50 NTU during all flow regimes except the extreme high flow regime that occurs during spring break-up.

- When natural turbidity was above 50 NTU, the target was based on the median NTU + 15 NTU. Specifically, the criterion allows for a 10 percent increase in turbidity when natural turbidity is more than 50 NTU, with a maximum increase of 15 NTU. Because a 10 percent increase in a turbidity of 150 NTU is equal to 15 NTU, a 15 NTU increase applies when the natural condition turbidity measurements are above 150 NTU (note: this condition occurs at Pedro Creek during the extreme high flow condition).

- Using these conditions, the turbidity numeric targets for this TMDL were calculated using the two equations below and are presented in the bottom row of Table 2-3.

Extreme high flow regime: *Median Pedro Creek NTU + 15 NTU = Numeric Target NTU*
All other flow regimes: *Median Pedro Creek NTU + 5 NTU = Numeric Target NTU*

Table 2-3. Pedro Creek turbidity summary statistics and numeric target

Turbidity Statistics	Turbidity Values by Flow Regime (NTU)					
	Extreme (0-1%)	High [a] (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Number of Days Sampled	n = 2	n = 0	n = 7	n = 8	n = 17	n = 7
25th Percentile	168.75	N/A	1.76	1.78	2.08	2.05
Minimum	153.00	N/A	0.92	0.71	0.50	1.92
Median	184.50	N/A	4.45	4.85	4.00	2.17
Maximum	216.00	N/A	12.00	10.60	16.92	4.00
75th Percentile	200.25	N/A	6.60	8.29	9.96	3.21
Numeric Target	**199.50**	**9.45**	**9.45**	**9.85** [b]	**9.00**	**7.17**

Note: median values (first blue row) were used to calculate numeric targets (bottom row) using the equations presented above.

[a] No data were available for the high flow condition (N/A = not applicable); therefore, the numeric target calculated for the moist flow regime was applied for high flow. Use of the moist flow regime is a conservative assumption applied to the TMDL numeric target.

[b] Targets for the mid-range flows are slightly higher than the targets for high and moist flows. In this dataset, higher turbidity was observed during mid-range flow conditions (when compared to the moist flow conditions). This might be due to the limited dataset (fewer than 10 samples during each flow condition). The observed turbidity values are similar at Pedro Creek for the moist, mid, and dry flow regimes, suggesting that implementation considerations will be similar. The TSS *concentrations* calculated from the turbidity values in the high, moist, and mid ranges all round to the same value; however, the TMDL TSS *load* targets for mid-range flows will be lower than those during moist and high range flows due to the increased flows in those upper ranges.

The calculated turbidity numeric targets (Table 2-3) were then used to calculate TSS numeric target concentrations (in mg/L), which can be used to determine sediment loads in the Upper Goldstream Creek watershed. Specifically, TSS numeric targets were calculated based on the equation representing the linear relationship between TSS and turbidity described above (Figure 2-1). Following the equation, $y = 1.6627x$, where y is equal to TSS and x is equal to turbidity, the turbidity numeric target for each flow regime (Table 2-3) was multiplied by 1.6627 to calculate the corresponding TSS value. These values are presented in Table 2-4. They are applied below to calculate the loading capacity and are also used for comparison with existing loads to determine required reductions.

Table 2-4. Turbidity and TSS TMDL numeric targets

Parameter (units)	Numeric Targets by Flow Regime					
	Extreme (0-1%)	High [a] (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Turbidity (NTU)	199.50	9.45	9.45	9.85	9.00	7.17
TSS (mg/L)	331.71	15.71	15.71	16.38	14.96	11.92

[a] No turbidity data were available for the high flow condition; therefore, the numeric target calculated for the moist flow regime was applied for high flow.

3. Data Review

Compilation and analyzing data and information is an essential step in understanding the general water quality conditions and trends in an impaired water. This section outlines and summarizes all of the data reviewed, including impairment analyses and temporal and spatial trends.

3.1. Impairment and Temporal Analyses

The following sections discuss data analyses conducted to evaluate any important trends or impairments of water quality in the Upper Goldstream Creek watershed. Detailed analyses of turbidity and TSS data are described below, from upstream to downstream (see Figure 1-10 and Table 1-8), including a comparison to the TMDL numeric targets by flow regime for both turbidity and TSS. Data analyzed in this section consist of a combination of both continuous and grab sample data (at Pedro Creek, GS-1, and GS-2) for ease of comparison to the water quality target, which is based on all data available at the Pedro Creek station. Data separated by continuous and grab sampling, where applicable, are presented in Appendix B for a more refined look at the data based on sampling protocol. In addition to the impairment analyses presented below, data were evaluated temporally to observe any month-to-month trends.

3.1.1. Pedro Creek Station (reference site)

Pedro Creek station is just above the confluence with Gilmore Creek. Turbidity data (continuous or grab) are available for all flow regimes except high at Pedro Creek, which drains 14.4 square miles of the HUC-01 TMDL subwatershed. There were only four TSS grab samples. As noted previously, median observed turbidity data at Pedro Creek were used to set the references condition for turbidity in the Upper Goldstream Creek watershed. Table 3-1, Table 3-2, and Figure 3-1 summarize the daily maximum continuous observed turbidity and grab sample turbidity concentrations at the Pedro Creek station. Figure 3-1 also shows the numeric targets for each flow regime that are based on these data (Section 2.4). Figure 3-2 looks at Pedro Creek data seasonally over the observed months of May through September. Turbidity values rise in May with the spring break-up period and dip in June and July before rising again in late summer or fall. Continuous and grab sample data are separated and discussed further in Appendix B.

Table 3-1. Pedro Creek: Summary of turbidity data (combination of continuous daily maximum and daily grab samples)

Turbidity (NTU)	Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Number of Days Sampled	n = 2	n = 0	n = 7	n = 8	n = 17	n = 7
25th Percentile	168.75	ND	1.76	2.28	3.99	3.00
Minimum	153.00	ND	0.92	0.71	0.50	1.96
Median	184.50	ND	8.00	7.20	10.87	3.45
Maximum	216.00	ND	14.80	26.42	20.75	4.78
75th Percentile	200.25	ND	10.73	9.06	16.43	3.93
Numeric Target*	199.50	9.45	9.45	9.85	9.00	7.17

ND = no data
*The numeric target is equal to the median daily continuous Pedro Creek turbidity value plus 5 NTU.

Table 3-2. Pedro Creek: Grab sample TSS data summary table

TSS (mg/L)	Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Number of Samples	n = 0	n = 0	n = 3	n = 0	n = 1	n = 0
25th Percentile	ND	ND	10.46	ND	2.31	ND
Minimum	ND	ND	2.02	ND	2.31	ND
Median	ND	ND	18.90	ND	2.31	ND
Maximum	ND	ND	39.00	ND	2.31	ND
75th Percentile	ND	ND	28.95	ND	2.31	ND
Numeric Target*	331.71	15.71	15.71	16.38	14.96	11.92

ND = no data

*The numeric target is equal to the median daily continuous Pedro Creek turbidity value plus 5 NTU converted to a TSS concentration based on the equation in Figure 2-1.

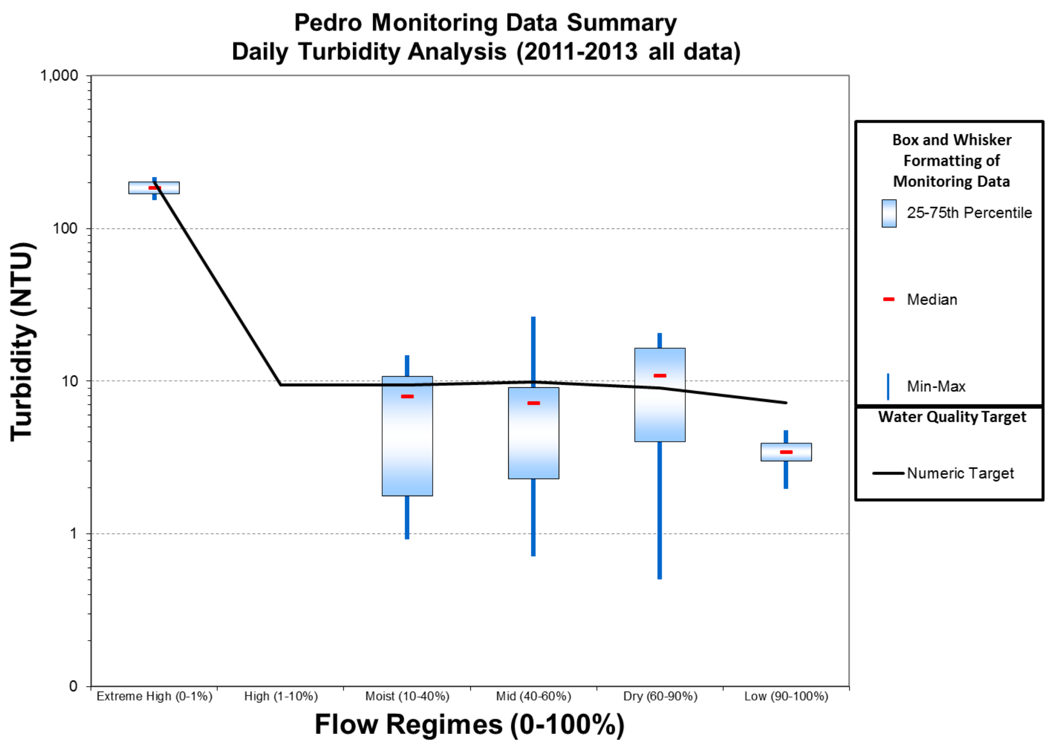

Figure 3-1. Pedro Creek water quality duration curve for continuous daily maximum and daily grab sample turbidity.

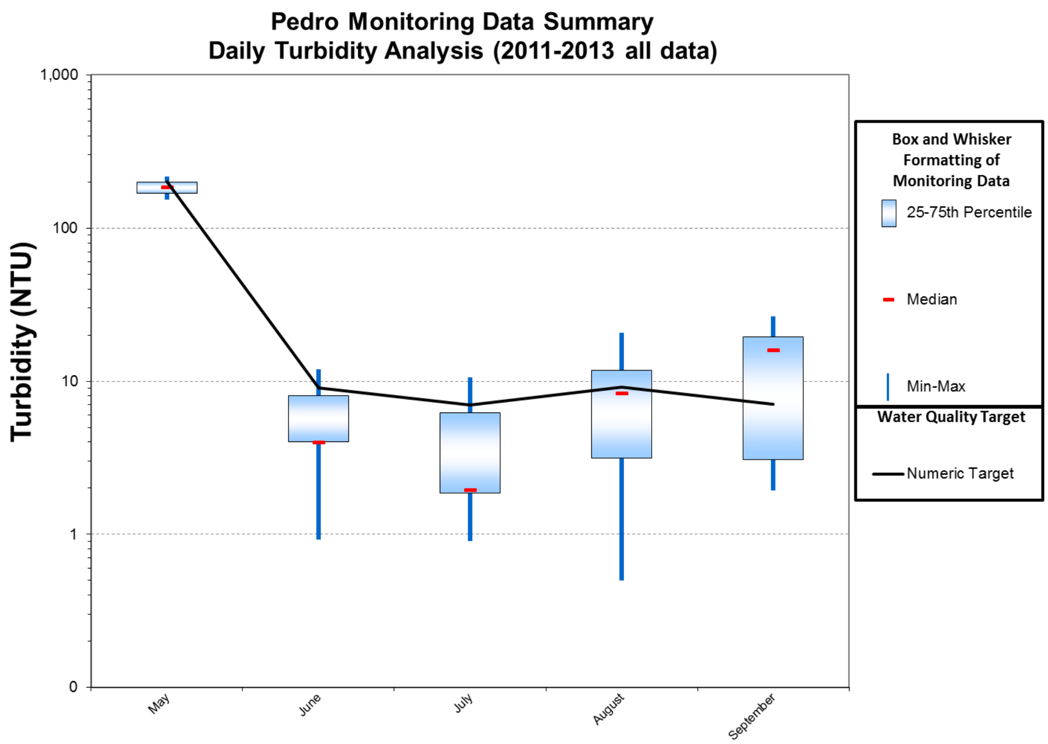

Figure 3-2. Pedro Creek seasonal analysis for continuous daily maximum and daily grab sample turbidity.

3.1.2. Station GS-1 (Gilmore Creek)

Station GS-1 is located on Gilmore Creek just above the confluence with Pedro Creek. Turbidity and TSS data are available for all flow regimes at GS-1 on Gilmore Creek, which drains 11.3 square miles of the HUC-01 TMDL subwatershed. Observed turbidity data (based on a combination of continuous and grab samples) exceed the turbidity numeric targets in all flow regimes (Table 3-3). When comparing with the TMDL numeric targets, necessary reductions of the maximum observed turbidity measurements range from 68 to 98 percent. Fewer TSS data were available because these were only based on grab samples. TSS concentrations during the dry and low flow regimes did not exceed the TSS numeric target; however, exceedances during the extreme high, high, moist, and mid flow regimes ranged from 64 to 94 percent (Table 3-4).

Table 3-3. GS-1: Summary of turbidity data (combination of continuous daily maximum and grab samples)

Turbidity (NTU)	Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Number of Days Sampled	n = 5	n = 28	n = 102	n = 69	n = 104	n = 34
25th Percentile	310.20	63.98	29.84	38.89	8.94	4.75
Minimum	187.00	8.91	8.87	9.14	3.97	2.07
Median	370.00	124.30	63.23	82.50	22.46	10.71
Maximum	639.10	626.70	665.20	674.00	366.30	387.10
75th Percentile	471.00	253.83	140.68	261.00	82.78	25.75
Numeric Target*	199.50	9.45	9.45	9.85	9.00	7.17
Load Reduction	68.78%	98.49%	98.58%	98.54%	97.54%	98.15%

*The numeric target is equal to the median daily continuous Pedro Creek turbidity value plus 5 NTU.

Table 3-4. GS-1: Summary of grab sample TSS data

TSS (mg/L)	Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Number of Samples	n = 1	n = 1	n = 6	n = 2	n = 5	n = 1
25th Percentile	940.00	132.00	9.05	42.13	1.65	2.25
Minimum	940.00	132.00	5.20	31.50	1.60	2.25
Median	940.00	132.00	17.85	52.75	3.02	2.25
Maximum	940.00	132.00	262.00	74.00	18.80	2.25
75th Percentile	940.00	132.00	21.60	63.38	5.99	2.25
Numeric Target*	331.71	15.71	15.71	16.38	14.96	11.92
Load Reduction	64.71%	88.10%	94.00%	77.87%	20.40%	0.00%

*The numeric target is equal to the median daily continuous Pedro Creek turbidity value plus 5 NTU converted to a TSS concentration based on the equation in Figure 2-1.

Turbidity data are also represented graphically in Figure 3-3. This figure shows that the data are well above the numeric targets for all flow regimes. Figure 3-4 looks at GS-1 data seasonally over the observed months of May through September. Turbidity values at Gilmore Creek do not appear to follow the same seasonal trend as Pedro Creek. Extreme flows were observed in May, June, and July at Gilmore Creek, which explains why all of these months have high turbidity values. Median concentrations of daily maxiumum observed turbidity are highest in September on Gilmore Creek. Continuous and grab sample data are separated and discussed further in Appendix B.

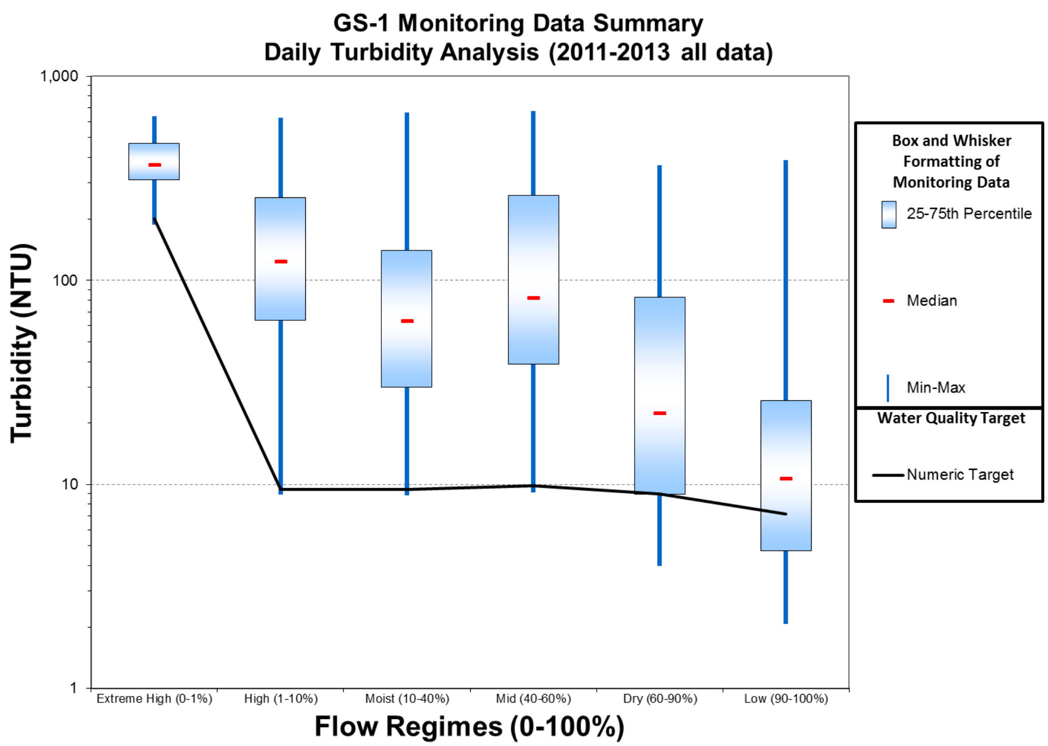

Figure 3-3. GS-1 water quality duration curve for continuous daily maximum and daily grab sample turbidity.

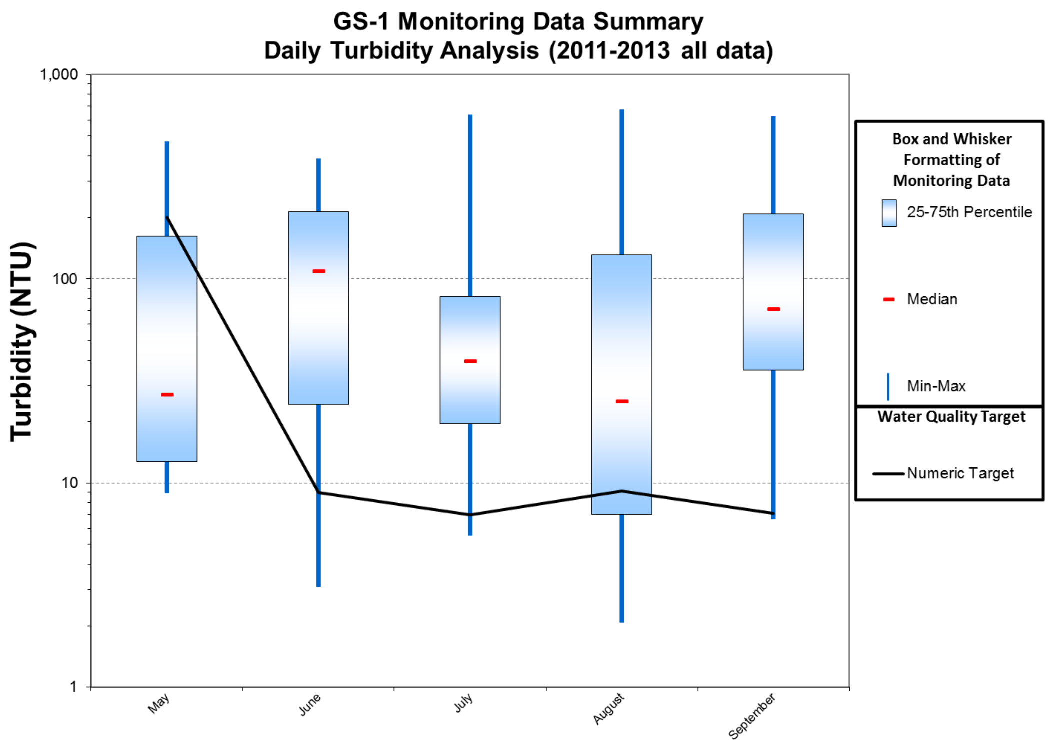

Figure 3-4. GS-1 seasonal analysis for continuous daily maximum and daily grab sample turbidity.

3.1.3. Station GS-2 (Goldstream Creek)

GS-2 is located on Goldstream Creek at the downstream end of the HUC-01 TMDL subwatershed. This station has a 41.9-square-mile drainage area and includes inputs from Pedro Creek and Gilmore Creek. Turbidity and TSS data for 2011 to 2013 at station GS-2 were summarized. In addition, the maximum values for each flow regime were compared to the TMDL numeric targets. Turbidity values were nearly two orders of magnitude above the numeric targets for the high through low flow regimes and nearly 50 percent above the extreme high flow condition numeric target (Table 3-5). TSS data were well above the associated numeric target for the high to mid flow regimes, but below the targets for the extreme high, dry, and low regimes (Table 3-6).

Table 3-5. GS-2: Summary of turbidity data (combination of continuous daily maximum and daily grab samples)

Turbidity (NTU)	Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Number of Days Sampled	n = 3	n = 30	n = 111	n = 63	n = 101	n = 34
25th Percentile	82.57	40.95	17.47	16.81	9.16	10.77
Minimum	38.73	17.68	4.27	6.40	4.89	5.88
Median	126.40	101.00	39.81	53.24	16.89	16.67
Maximum	380.30	300.30	376.20	221.70	314.20	110.40
75th Percentile	253.35	163.40	83.60	108.55	51.57	52.44
Numeric Target*	199.50	9.45	9.45	9.85	9.00	7.17
Load Reduction	47.54%	96.85%	97.49%	95.56%	97.14%	93.50%

*The numeric target is equal to the median daily continuous Pedro Creek turbidity value plus 5 NTU.

Table 3-6. GS-2: Summary of grab sample TSS data

TSS (mg/L)	Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Number of Samples	n = 1	n = 1	n = 6	n = 2	n = 3	n = 1
25th Percentile	237.00	71.00	10.80	39.90	5.51	4.80
Minimum	237.00	71.00	7.35	20.70	1.91	4.80
Median	237.00	71.00	15.90	59.10	9.10	4.80
Maximum	237.00	71.00	43.00	97.50	10.30	4.80
75th Percentile	237.00	71.00	32.55	78.30	9.70	4.80
Numeric Target*	331.71	15.71	15.71	16.38	14.96	11.92
Load Reduction	0%	77.87%	63.46%	83.20%	0%	0%

*The numeric target is equal to the median daily continuous Pedro Creek turbidity value plus 5 NTU converted to a TSS concentration based on the equation in Figure 2-1.

Turbidity data are also represented graphically in Figure 3-5. This figure shows that the median of maximum observed daily data are well above the numeric targets for all flow regimes (but less for for the extreme high flows). Figure 3-6 looks at GS-2 data seasonally over May through September. Similar to Pedro Creek, median daily maximum observed turbidity values rise in May with the spring break-up period, and then dip in June, July, and August before rising again in September. Continuous and grab sample data are separated and discussed further in Appendix B.

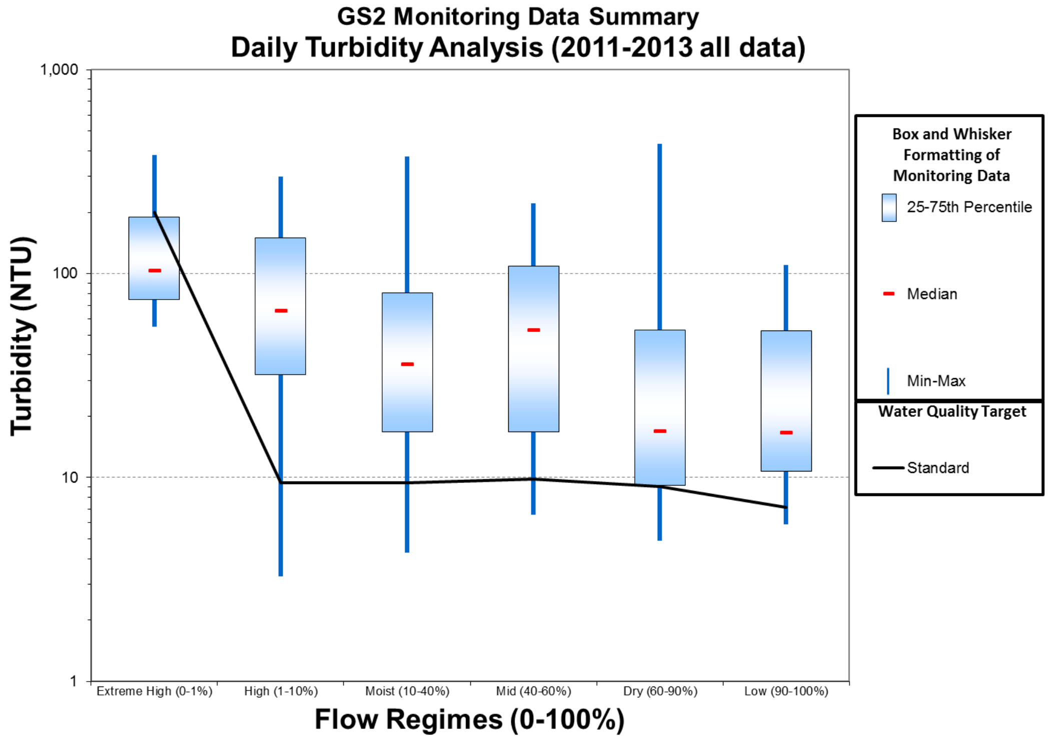

Figure 3-5. GS-2 water quality duration curve for continuous daily maximum and daily grab sample turbidity.

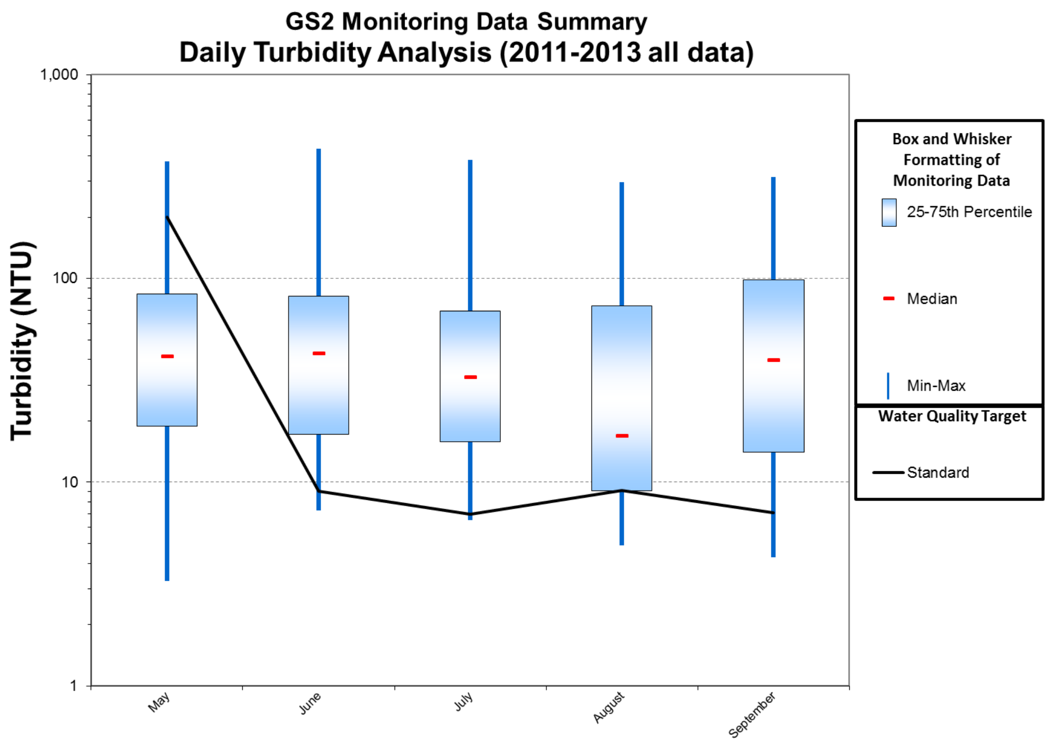

Figure 3-6. GS-2 seasonal analysis for continuous daily maximum and daily grab sample turbidity.

3.1.4. Ballaine Road Station (Goldstream Creek)

The Ballaine Road station, located in the HUC-02 TMDL subwatershed and draining 77.5 square miles, was represented with grab samples for turbidity and TSS from 2012 and 2013. The number of samples varied from zero to five, depending on the flow regime. Data are summarized in Table 3-7 and Table 3-8 for turbidity and TSS, respectively. No turbidity or TSS exceedances were observed (note: no data were available for the high flow regime). Turbidity data are also represented graphically in Figure 3-7. This figure shows that the data are below the numeric targets for all flow regimes. Figure 3-8 looks at Ballaine Road data seasonally over the observed months of May through September. Even with these limited data, the turbidity values follow a similar pattern to the other stations, with higher values in May and then a decrease until September.

Table 3-7. Ballaine Road: Summary of grab sample turbidity data

Turbidity (NTU)	Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Number of Samples	n = 1	n = 0	n = 2	n = 2	n = 5	n = 2
25th Percentile	25.00	ND	5.67	5.89	3.46	4.71
Minimum	25.00	ND	5.59	5.68	2.85	4.28
Median	25.00	ND	5.74	6.09	3.98	5.14
Maximum	25.00	ND	5.89	6.50	5.94	6.00
75th Percentile	25.00	ND	5.82	6.30	4.46	5.57
Numeric Target*	199.50	9.45	9.45	9.85	9.00	7.17
Load Reduction	0.00%	ND	0.00%	0.00%	0.00%	0.00%

ND = no data
*The numeric target is equal to the median daily continuous Pedro Creek turbidity value plus 5 NTU.

Table 3-8. Ballaine Road: Summary of grab sample TSS data

TSS (mg/L)	Extreme (0-1%)	High (1-10%)	Moist 10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Number of Samples	n = 1	n = 0	n = 2	n = 1	n = 2	n = 1
25th Percentile	131.00	ND	4.35	2.73	1.97	2.69
Minimum	131.00	ND	3.74	2.73	1.78	2.69
Median	131.00	ND	4.96	2.73	2.17	2.69
Maximum	131.00	ND	6.18	2.73	2.55	2.69
75th Percentile	131.00	ND	5.57	2.73	2.36	2.69
Numeric Target*	331.71	15.71	15.71	16.38	14.96	11.92
Load Reduction	0.00%	ND	0.00%	0.00%	0.00%	0.00%

ND = no data

*The numeric target is equal to the median daily continuous Pedro Creek turbidity value plus 5 NTU converted to a TSS concentration based on the equation in Figure 2-1.

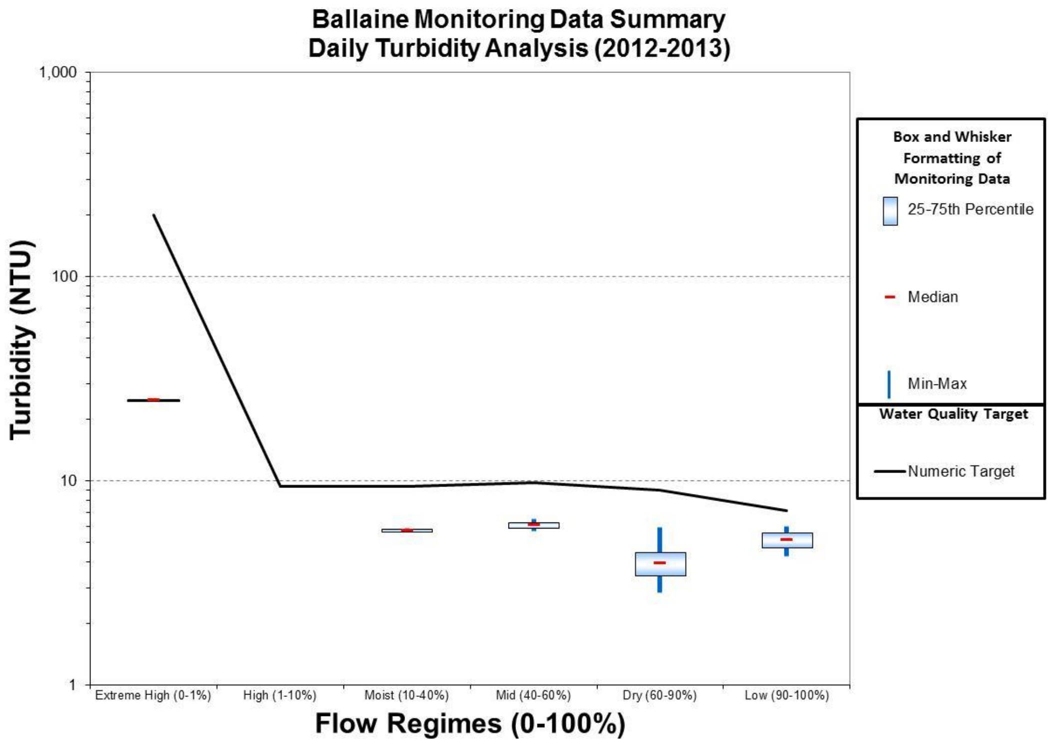

Figure 3-7. Ballaine Road water quality duration curve for daily grab sample turbidity.

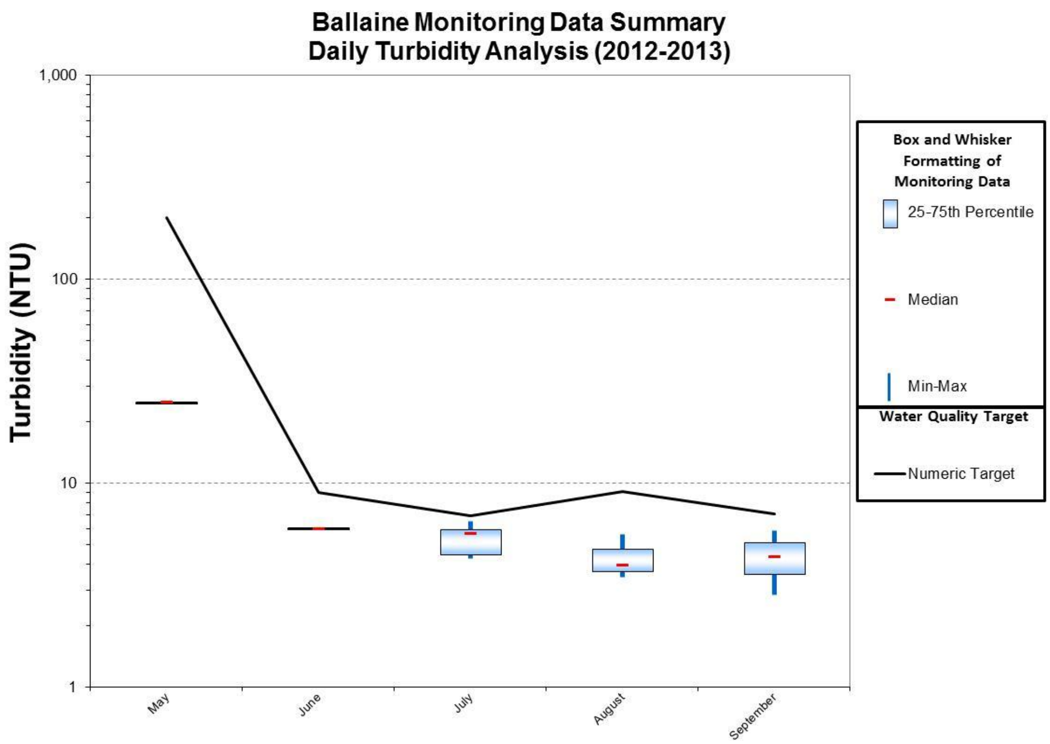

Figure 3-8. Ballaine Road seasonal analysis for daily grab sample turbidity.

3.1.5. Sheep Creek Road Station (Goldstream Creek)

The Sheep Creek Road station, located in the HUC-03 TMDL subwatershed and draining 98.2 square miles, was represented with grab samples for turbidity and TSS. The number of samples varied from zero to three, depending on the flow regime. Data are summarized in Table 3-9 and Table 3-10 for turbidity and TSS, respectively. The Sheep Creek Road station lies between the Upper Goldstream Watershed's steep mountainous terrain (upstream) and the Lower Goldstream Watershed's flatter terrain (downstream). Target loads are given to the Sheep Creek Station to ensure that water quality targets are met in the future, despite no TSS exceedances being observed. In addition, turbidity exceeded the numeric target for the moist and low flow regimes (note: no data were available for the extreme high and high regimes). Compared to other stations, these exceedances were only slightly above the numeric targets and are within an order of magnitude. Turbidity data are also represented graphically in Figure 3-9. This figure shows that the data are limited and only above targets during moist and low flow regimes. Figure 3-10 looks at Sheep Creek road data seasonally from June to September. Turbidity values are highest in June and dip from July through September.

Table 3-93-9. Sheep Creek Road: Summary of grab sample turbidity data

Turbidity (NTU)	Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Number of Samples	n = 0	n = 0	n = 3	n = 1	n = 3	n = 2
25th Percentile	ND	ND	5.59	6.22	5.39	6.43
Minimum	ND	ND	4.51	6.22	4.38	6.00
Median	ND	ND	6.66	6.22	6.39	6.85
Maximum	ND	ND	12.00	6.22	6.73	7.70
75th Percentile	ND	ND	9.33	6.22	6.56	7.28

Turbidity (NTU)	Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Numeric Target*	199.50	9.45	9.45	9.85	9.00	7.17
Load Reduction	ND	ND	21.25%	0.00%	0.00%	6.87%

ND = no data
*The numeric target is equal to the median daily continuous Pedro Creek turbidity value plus 5 NTU.

Table 3-10. Sheep Creek Road: Summary of grab sample TSS data

TSS (mg/L)	Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Number of Samples	n = 0	n = 0	n = 2	n = 0	n = 2	n = 0
25th Percentile	ND	ND	1.34	ND	2.07	ND
Minimum	ND	ND	1.25	ND	1.93	ND
Median	ND	ND	1.43	ND	2.22	ND
Maximum	ND	ND	1.60	ND	2.50	ND
75th Percentile	ND	ND	1.51	ND	2.36	ND
Numeric Target*	331.71	15.71	15.71	16.38	14.96	11.92
Load Reduction	ND	ND	0.00%	ND	0.00%	ND

ND = no data
*The numeric target is equal to the median daily continuous Pedro Creek turbidity value plus 5 NTU converted to a TSS concentration based on the equation in Figure 2-1.

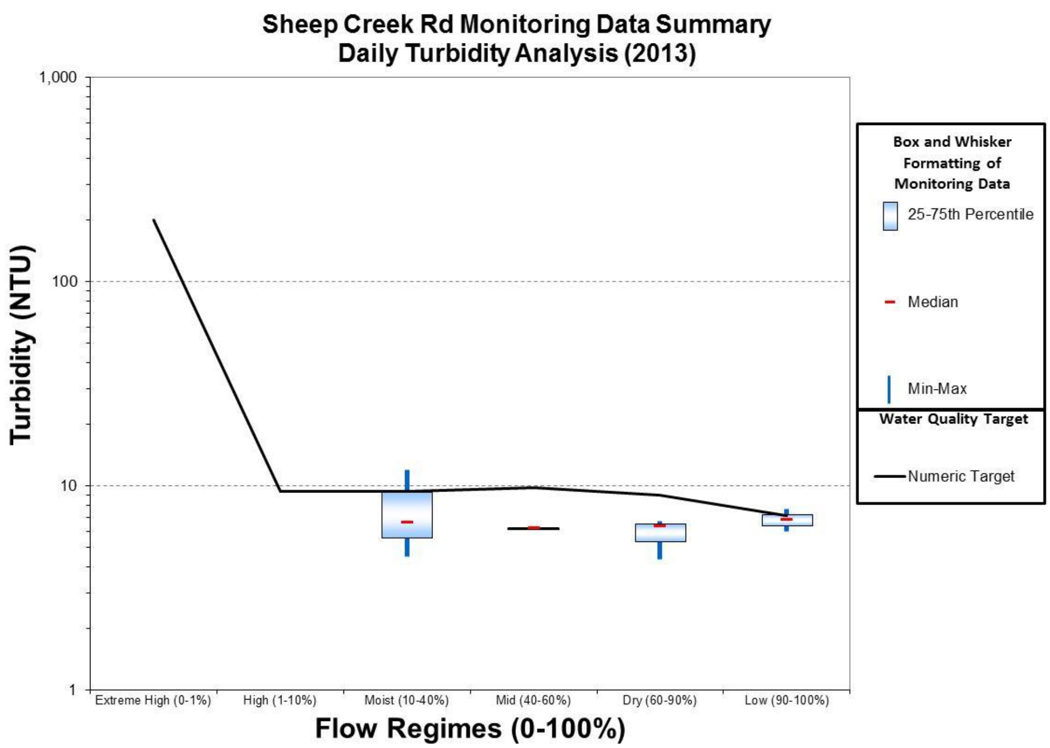

Figure 3-9. Sheep Creek Road water quality duration curve for daily grab sample turbidity.

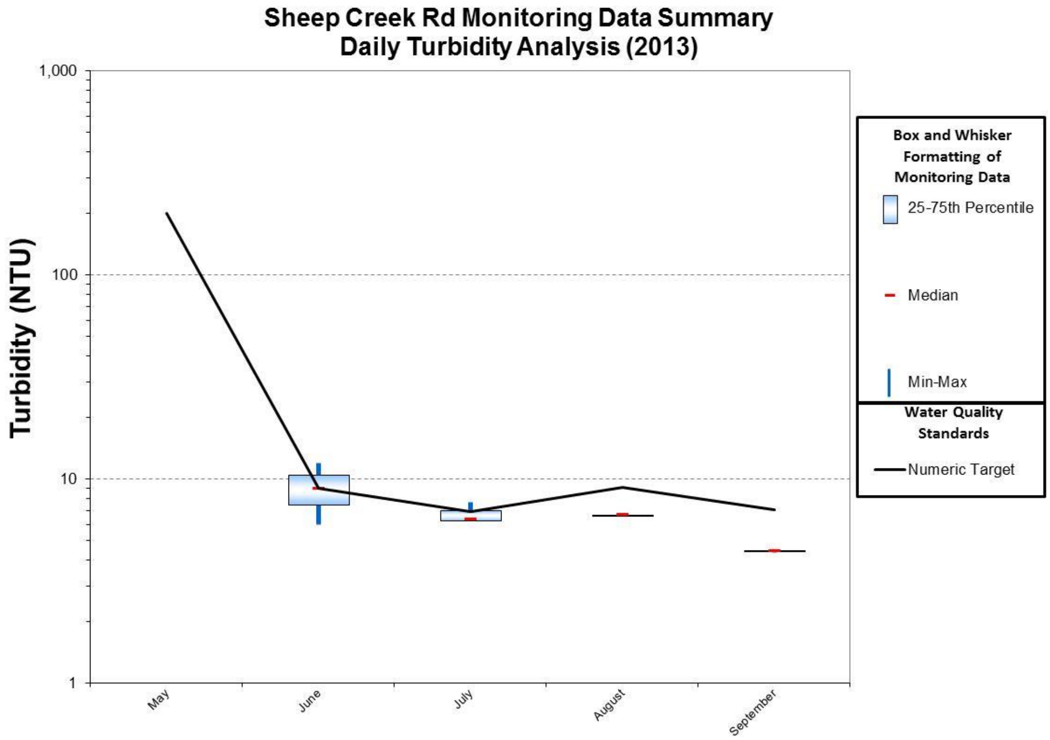

Figure 3-10. Sheep Creek Road seasonal analysis for daily grab sample turbidity.

3.2. Spatial Analysis

Turbidity and TSS data were analyzed for spatial patterns in the Upper Goldstream Creek watershed (see Figure 3-11 and Figure 3-12). Data are displayed left to right from upstream to downstream in both figures. Turbidity concentrations are highest at GS-1 and lowest at the Pedro Creek station. From GS-1, turbidity concentrations decrease moving downstream and rise again slightly at Sheep Creek Road. TSS data are limited but they show a similar spatial trend, with the highest observed TSS at GS-1 and decreasing TSS moving downstream. It is also important to note that only Pedro Creek, GS-1, and GS-2 have continuous data, which limits the conclusions that can be drawn at the stations farther downstream. Where available, the continuous and grab sample data were separated in Figure 3-12 for more accurate comparison (continuous data represented by green boxes). At all three stations with both types of data, the continuous data are higher than the grab samples and the same overall spatial trend exists when solely evaluating the continuous data (highest values at GS-1 and then decreasing moving downstream).

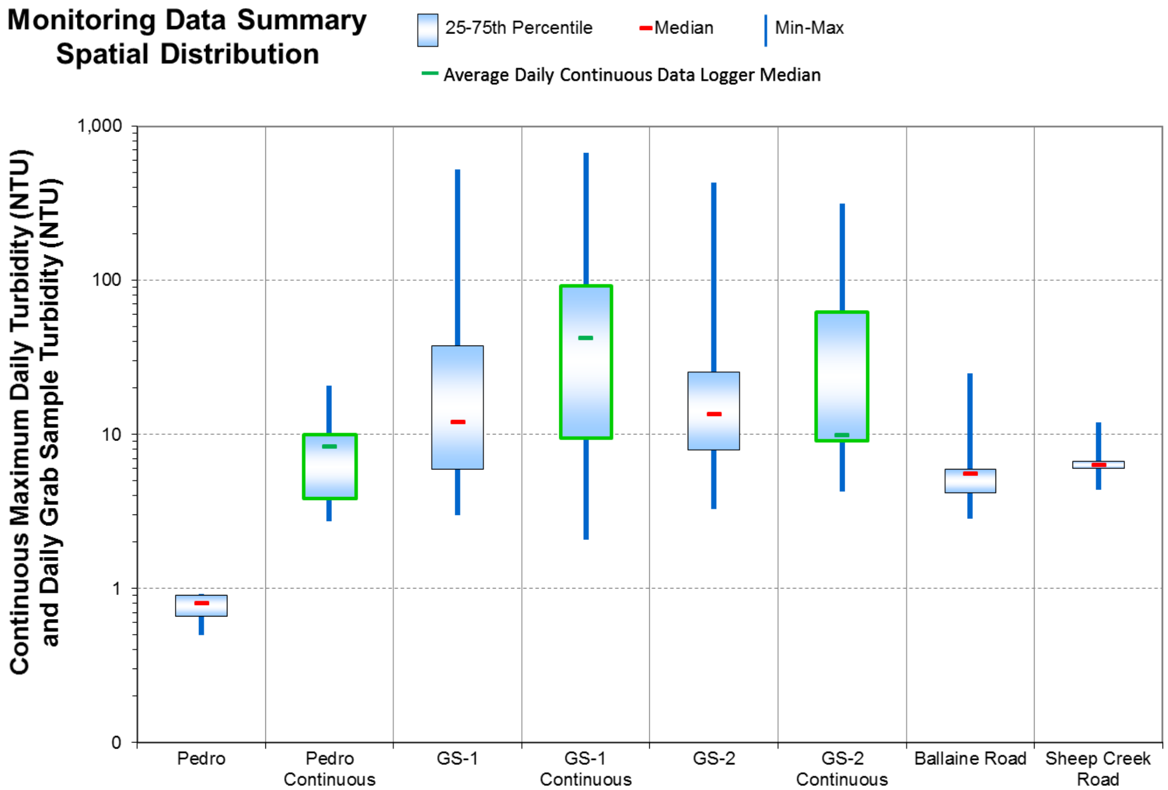

Figure 3-11. Spatial analysis for continuous daily maximum observed turbidity and daily grab data.

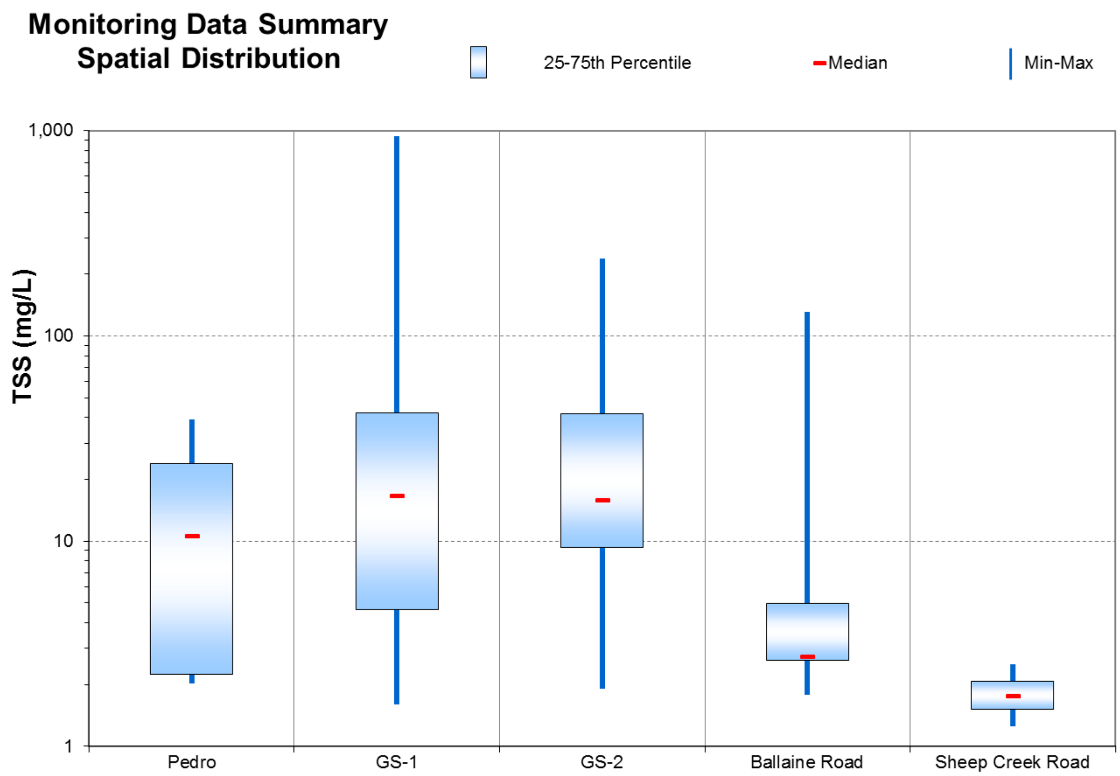

Figure 3-12. Spatial analysis for daily grab sample TSS measurements.

3.3. Summary

Data analyses characterize and quantify the existing conditions in the Upper Goldstream Creek watershed. Turbidity measurements were evaluated at four stations (from upstream to downstream): GS-1 (blend of continuous and grab data), GS-2 (blend of continuous and grab data), Ballaine Road (grab sample data only) and Sheep Creek Road (grab sample only data) stations. The highest observed turbidity data were taken at GS-1 during mid-range flows and the lowest observed were at GS-1 during low flows. Turbidity exceeded the numeric targets during all flow regimes and months, with observed data at GS-1 and GS-2 stations based on continuous and grab samples. Though exceedances were not observed at the Ballaine Road station, it should be noted that turbidity data were limited to a handful of grab samples with only one sample during extreme high flows and none during high flows. Turbidity data (based on grab samples) at the Sheep Creek Road station slightly exceeded targets during moist and low flows and during the months of June and July. No high or extreme high flow turbidity data were available for this station.

Exceedances of the TSS numeric target were noted at GS-1 and GS-2. No TSS exceedances were noted downstream of GS-2; however, assessments at Ballaine and Sheep Creek Road stations are based on limited data. The TMDL is calculated using the TSS numeric targets. Based on evaluation of available data, Ballaine Road and Sheep Creek Road stations are currently meeting the TSS numeric targets. To prevent future exceedances, even if TMDL subwatersheds are meeting numeric targets, each subwatershed is assigned a loading capacity in Section 5.

4. Source Assessment

This section discusses the potential sources of turbidity to Upper Goldstream Creek, including point and nonpoint sources. There are many potential sources including permitted sources such as active placer mines, construction stormwater, construction fill material and a municipal separate storm sewer (MS4) as well as nonpoint sources such as runoff from historically disturbed sites, winter road maintenance, residential and commercial development and ATV trail use. The following sections summarize the available information for these potential sources.

4.1. Point Sources

Point sources of turbidity currently regulated by permits include active placer mines, construction stormwater, construction fill material, and an MS4. A wastewater facility is also located in the watershed. These point sources, which were evaluated to receive wasteload allocations (WLAs) in this TMDL, are summarized in Table 4-1, illustrated in Figure 4-1, and discussed below.

Table 4-1. Upper Goldstream Creek permitted discharger summary

Permit	Permit Type	TMDL Subwatershed	Disturbed[a]/ Impacted[b]/ Urban[c] Area (Acres)
AKG370356	Placer Mine	HUC-02	5[a]
AKG370894	Placer Mine	HUC-01	5[a]
AKG370927	Placer Mine	HUC-01	5[a]
AKG370970	Placer Mine	HUC-01	5[a]
AKG370391	Placer Mine	HUC-01	5[a]
AKG370336	Placer Mine	HUC-01	5[a]
AKG370949	Placer Mine	HUC-01	5[a]
AKG370717	Placer Mine	HUC-01	5[a]
AKG870614	Placer Mine	HUC-01	5[a]
AKG370786	Placer Mine	HUC-01	5[a]
AKG370A43	Placer Mine	HUC-03	5[a]
AKG370A86	Placer Mine	HUC-03	5[a]
AKR10EK52 AKR10EK53	Construction Stormwater	HUC-02	85.5[a]
AKR10EK14	Construction Stormwater	HUC-03	5[a]
AKR10EK71	Construction Stormwater	HUC-03	5[a]
AKR10EP52	Construction Stormwater	HUC-01	9[a]
POA-2013-402	Fill Material	HUC-01	2.7[b]
POA-1991-243-M2	Fill Material	HUC-03	2.6[b]
POA-2012-43	Fill Material	HUC-03	1.47[b]
AKG570062	Wastewater	HUC-03	0
AKS053414	MS4	HUC-02	154.79[c]

Note: Permit information retrieved from Permit Compliance System and Integrated Compliance Information System (PCS-ICIS) (http://www.epa.gov/enviro/facts/pcs-icis/search.html) and ADEC in January 2014.
[a] Discussions with ADEC and EPA determined that placer mining operations typically do not disturb more than five acres at a time. For the purposes of calculating WLAs it is assumed that mining operations will not disturb more than five acres at a time. Stormwater construction disturbed acreage came directly from ADEC permit information.
[b] Impacted areas for fill material permits came from ADEC permit information.
[c] MS4 urban area is based on the 2010 census urban area maps (see Figure 4-1, MS4 area shaded in purple).

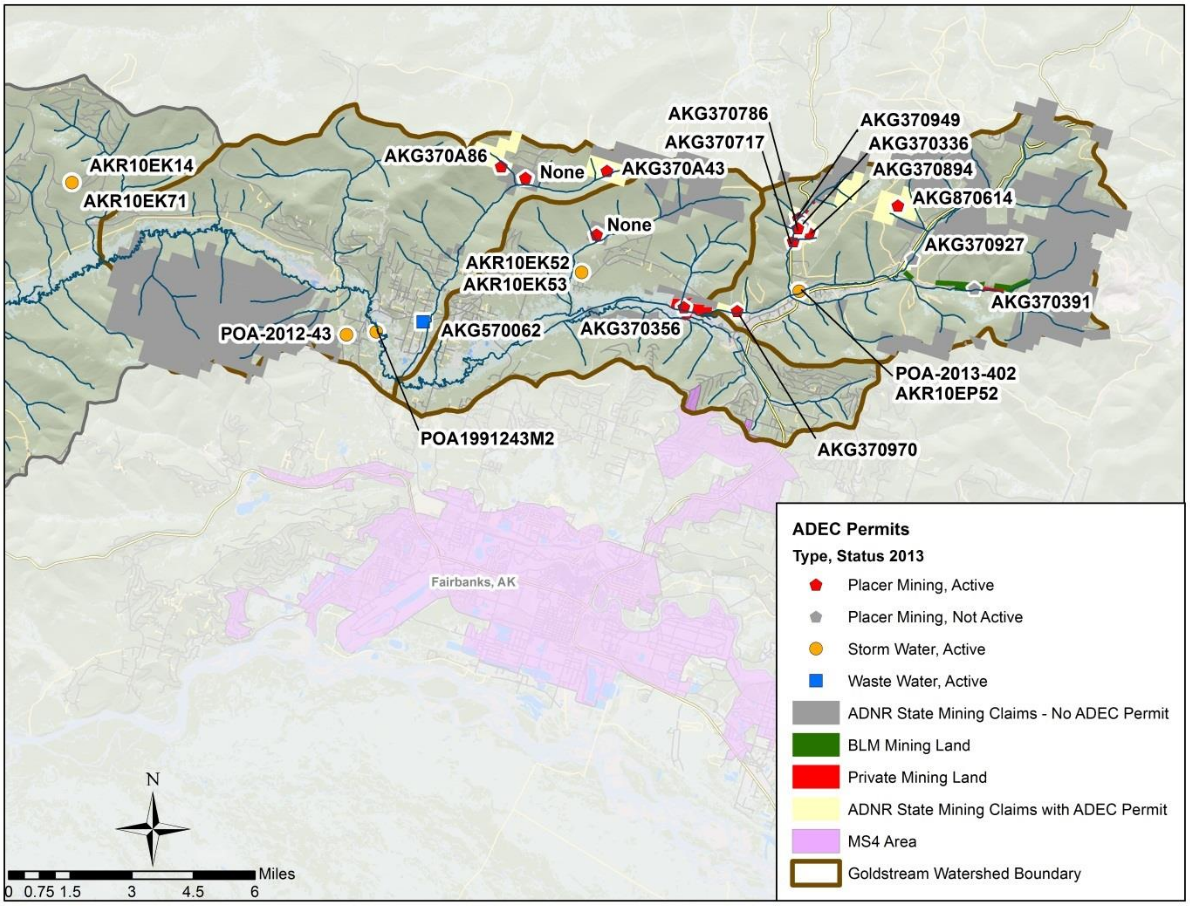

Figure 4-1. Permitted discharges to Upper Goldstream Creek.

4.1.1. Active Placer Mines

Upper Goldstream Creek is within the Fairbanks Mining District and was one of the earliest major gold mining areas in Interior Alaska. The uplands of the watershed have been a major placer mining area for nearly a century. Placer mining strips away vegetation and soil to gain access to placer gravels (Figure 4-2). The process uses large volumes of water, resulting in wastewater that is full of sediment (EPA 1994). Permitted mine discharges are subsequently routed through a settling pond and wastewater is recycled, therefore discharges to a stream from fully compliant mines should be minimal.

Mining has historically been documented as a source of turbidity in the Upper Goldstream Creek drainage (Noll and Vohden 1994). Placer mining removes vegetation, as illustrated in Figure 4-2. The headwaters areas of the watershed are largely disturbed with tailing piles. The tailings can extend for up to a mile across the Goldstream Valley and the watershed has been mined almost continuously from the confluence of Gilmore and Pedro creeks to below Fox Creek.[2] The early mining-related disturbance occurred before regulation and sources from these areas will be covered as nonpoint sources (Section 4.2). Regulation has reduced potential loadings from placer mining to downstream receiving waters. APDES permits include stabilization requirements for placer mines, which are important to reduce erosion potential. However, the permits do not include revegetation requirements. Some vegetation regrowth has occurred in disturbed areas, which helps to reduce erosion; however, some of regrowth is on top of inadequately stabilized and mitigated tailings piles from historically mined sites (i.e., nonpoint source [Section 4.2]).

[2] http://www.mindat.org/loc-197747.html

Figure 4-2. Aerial photographs downstream of station GS-2.
Source: Chandra McGee, ADEC (photos taken in 2013)

The extent of mining in the Upper Goldstream Creek watershed is considerable. There are 612 mining claims in the Upper Goldstream Creek watershed (Figure 4-1). Of these, 12 placer mining operations are permitted by ADEC for discharge to surface waters; these are associated with 61 mining claims in the Upper Goldstream Creek watershed (Table 4-1). Nine of the twelve permitted mining operations were active in 2013. State, Bureau of Land Management (BLM), and private mining claims indicate there are 33 additional active mining operators of 551 claims in the watershed (Figure 4-1) that are not currently permitted by ADEC to discharge wastewater.

Review of recent discharge monitoring report (DMR) summary reports indicated that there was ‘no mining’ or ‘no discharge’ for all permittees with available information. Permit limits indicate that permittees (Table 4-1) can discharge up to water quality criteria; therefore, under optimal (i.e., full compliance) conditions, these facilities should not contribute turbidity to Upper Goldstream Creek.

The proposed 2015 mechanical placer mining discharge permit covers both discharging and non-discharging mines using the same limits and monitoring requirements whenever discharges occur. Therefore, these sources receive WLAs in this TMDL.

Mining activities in the state of Alaska require permits and licenses from several state and federal agencies. As noted in Figure 4-3, BLM, U.S. Forest Service, and U.S. Park Service are responsible for approving plans of operation on federal land. Alaska DNR is responsible for issuing miscellaneous land use permits for state land. ADEC authorizes wastewater discharge from mining operations to surface waters through their APDES General Permit. Additional approvals are required from the Alaska Department of Fish and Game (DFG) and U.S. Army Corps of Engineers.

Agencies involved in the permitting process, along with the respective permits/licenses managed, follows:

AGENCY	RESPONSIBILITY
Alaska Department of Fish & Game	Fish Habitat Permit or Special Area Permit
Alaska Department of Revenue- Tax Division	Mining Licenses
Department of Environmental Conservation	Wastewater Discharge, Compliance Inspections, & Technical Assistance
Department of Environmental Conservation	Alaska Pollution Discharge Elimination System permit
DNR, Division of Mining, Land & Water Mining Section	Miscellaneous Land Use Permit (On claim activity only, including surface use)
DNR, Division of Mining, Land & Water Land Section	Miscellaneous Land Use Permit (Access across state land)
DNR, Division of Mining, Land & Water Water Section	Temporary Water Use Authorizations, Permit to Appropriate Water, or a Certificate of Appropriation
DNR, Division of Parks	Special Park Use Permit or SHPO requirements
DNR, Division of Forestry	Timber Purchase may be required
Bureau of Land Management	Approved Plan of Operation or Notice of Operation
U.S. Forest Service	Approved Plan of Operation
U.S. Park Service	Approved Plan of Operation
U.S. Army Corps of Engineers (USACE)	Dredge and Fill Permit in Waters of the U.S.

Figure 4-3. Agencies involved in the Alaska mining permitting process (ADNR 2014).

4.1.2. Stormwater

Stormwater runoff from both municipal areas and construction activities are other likely sources of turbidity. Unlike most constant point sources (e.g., wastewater treatment plant [WWTP] discharges), stormwater is precipitation-driven. Stormwater permits regulate point source discharges of stormwater into receiving waters. Table 4-1 identifies the stormwater permits in the watershed; these are described in further detail below.

Municipal Stormwater

For municipalities meeting specific size requirements, MS4 permits are issued. There is currently an APDES MS4 permit for the FNSB (AKS053414, issued June 2013) that addresses stormwater discharges in the borough (Table 4-1 and Figure 4-1). This MS4 permit applies to a very small portion of the Upper Goldstream Creek watershed; however, this area does not include a piped stormwater conveyance system. It is specifically 155 acres of primarily residential land use located along the very northern edge of the MS4 area, which is based on the 2010 census urban area maps (see purple shading in Figure 4-1 above).

Industrial Stormwater

Industrial activities can also generate contaminated stormwater. No industrial stormwater permittees discharge directly into Upper Goldstream Creek; therefore, there is no WLA for industrial stormwater included in this TMDL and any future industrial facilities must meet WQS and all terms and conditions of their Multi-Sector General Permit for Stormwater Discharges Associated with Industrial Activity (MSGP) (AKR060000, Effective April 2015). The MSGP requires industrial facilities to implement control measures and develop site-specific storm water pollution prevention plans (SWPPP), among other things, to comply with APDES requirements and meet WQS for turbidity (see Section 2 for a discussion of WQS). It is anticipated that, in some cases, current placer mining permits may need MSGP coverage in the future to address their industrial activities.

Construction Stormwater

Construction activities can also result in stormwater discharge. Five Alaska construction general permits (ACGPs) for four separate construction sites currently list the impaired segments of Upper Goldstream Creek as the receiving water (Table 4-1 and Figure 4-1). Additional construction permits are anticipated in the future (note: given the temporary nature of construction activities, some, but not necessarily all, of the existing permits might be closed before new permits are issued). According to their permits, construction facilities must meet specific BMP requirements and WQS for turbidity (see Section 2 for a discussion of WQS).

Transportation/Highway Stormwater

Two highways (Steese Highway and State Highway 2) in the watershed are potential sources of stormwater to Upper Goldstream Creek; however, these highways do not have ADPES permits at this time and are not assigned a WLA in this TMDL.

4.1.3. Fill Material

Activities that involve dumping, placing, depositing, or discharging dredged material or fill material into waters or wetlands of the U.S. require federal authorization under a CWA Section 404 permit and do not need additional coverage under the ACGP. Three fill material permits currently affect nearly 7 acres of wetlands in the Upper Goldstream Creek watershed (Table 4-1 and Figure 4-1). Discharges of fill material at these sites have the potential to affect water quality in Goldstream Creek and are therefore assigned WLAs based on their impacted wetland area.

4.1.4. Wastewater

One wastewater treatment facility (WWTF) with an APDES permit is in the watershed. This WWTF is associated with the Ivory Jacks Restaurant (Table 4-1 and Figure 4-1) and is in the Sheep Creek drainage. It has a design capacity of 1,000 gallons per day. According to the permit, this facility discharges to “tundra” and is not expected to discharge to Upper Goldstream Creek or its tributaries. Therefore, it is not assigned a WLA in this TMDL.

4.2. Nonpoint Sources

Nonpoint sources in the Upper Goldstream Creek watershed include runoff from historically disturbed sites, winter road maintenance, residential and commercial development, and ATV trail use. These sources are discussed below and receive load allocations (LAs) in this TMDL.

4.2.1. Historic Mining

Erosion from historically disturbed mining areas is a nonpoint source of turbidity to Upper Goldstream Creek. This area has been mined extensively since 1903 with dredging as much as a mile wide at some locations.[3] During 1929-1959 four dredges of difference sizes worked Goldstream, Pedro and Engineer creeks (Peterson 1973). As shown in Figure 4-2, a significant portion of the landscape is disturbed and much of this disturbance is associated with historic placer mining. Mine sites that are not stabilized or reclaimed are susceptible to erosion, thereby increasing sediment loads, especially during high water flow and surface runoff (EPA 1994). Specific features include old settling ponds, cutbacks, overburden piles, unstabilized disturbed areas, and reestablishment of diverted stream channels (EPA 1994); loading varies by land use, slope, and other site-specific factors.

4.2.2. Winter Road Maintenance

Another source of sediment to Upper Goldstream Creek is the application of sand to road surfaces, which generally occurs from November through February. The volume and location of sand applied affects the amount of sediment transferred to the stream because only a portion of the material is likely to reach the creek and contribute to turbidity problems. Sand and gravel are applied to roads by the Alaska Department of Transportation and Public Facilities (ADOT&PF) and local jurisdictions. This material is a potential source of sediment to Upper Goldstream Creek and its tributaries after snow melts and runs off to the receiving waters.

4.2.3. Residential and Commercial Developments

Much of the Upper Goldstream Creek watershed is zoned GU-1, which allows multiple uses with few limits (see Figure 1-4 and Table 1-2 Section 1.4). There is also land zoned for commercial and residential developments. In Fox, in HUC-01, there are many industrial commercial businesses as well as a brewery, bar, and restaurant. At the upper end of HUC-01 is a large National Oceanic and Atmospheric Administration satellite operations facility. In addition, there is state land allocated for subdivision developments within the Tanana Basin Area Plan (ADNR 1991). All developed land, residential or commercial, has the potential to contribute turbidity from stormwater runoff due to increased impervious surface area.

4.2.4. ATV Trail Use

There are over 70 miles of trails in the Upper Goldstream Creek watershed that are used year round. Although winter use likely has little impact on turbidity, summer use that degrades trail conditions near the stream could impact water quality.

[3] http://www.mindat.org/loc-197747.html

5. TMDL Allocation Analysis

A TMDL represents the total amount of a pollutant that can be assimilated by a receiving waterbody while still achieving WQS—also called the *loading capacity*. In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL's loading capacity must be established and thereby provide the basis for establishing water quality-based controls.

A TMDL is composed of the sum of individual WLAs for point sources, LAs for nonpoint sources and natural background loads, and a MOS that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is denoted by the equation

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS$$

The analytical approach used to estimate the loading capacity and allocations for Upper Goldstream Creek is based on the best available information to represent the impairment and expected sources. Loading capacity curves were based on the numeric target, while existing loads were calculated from data at the most downstream station in each TMDL subwatershed (i.e., GS-2 for HUC-01, Ballaine for HUC-02, and Sheep Creek for HUC-03) (see Table 1-8 and Figure 5-1).

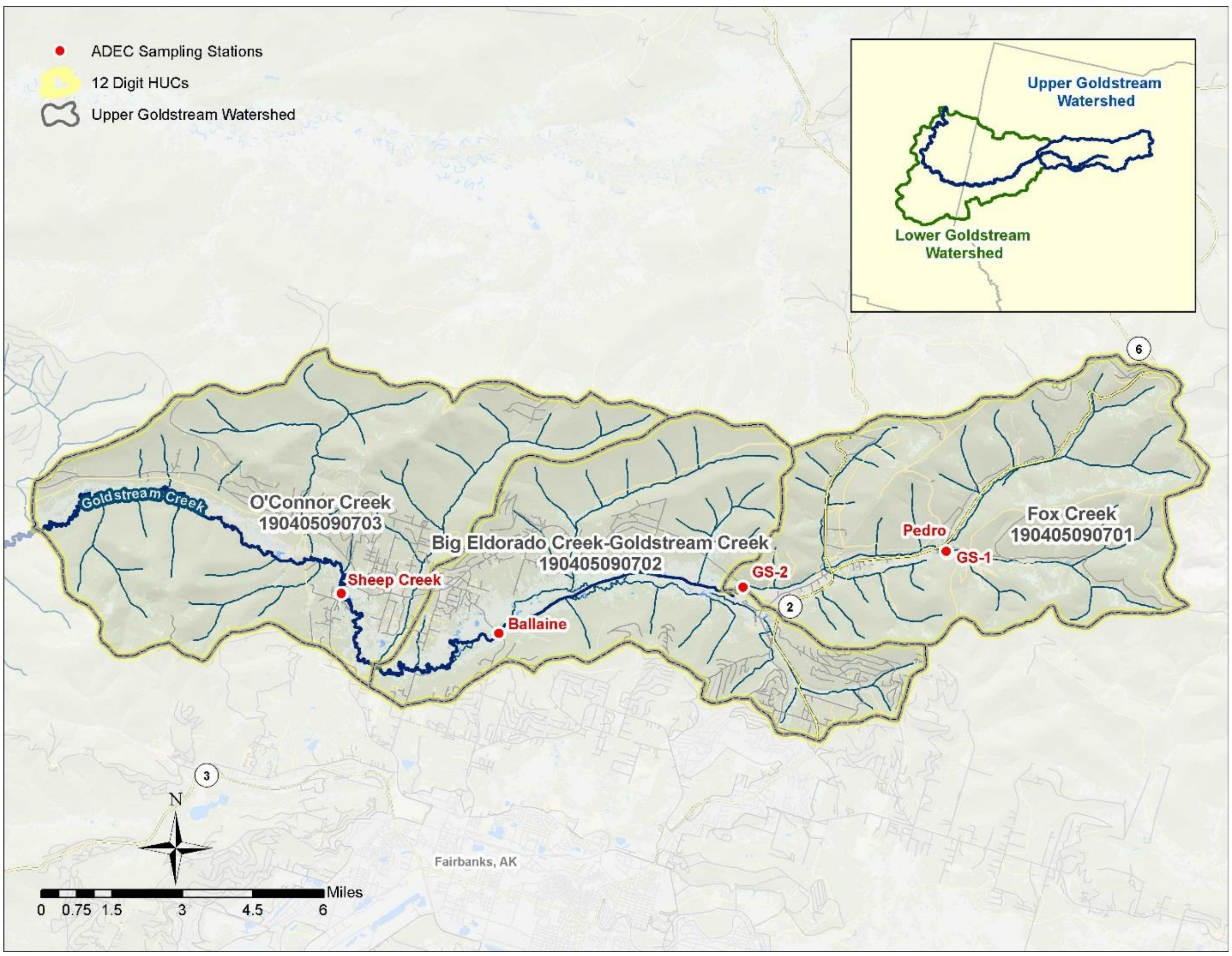

Figure 5-1. Extent of impairment on Upper Goldstream Creek and representative sampling stations.

5.1. Loading Capacity

The loading capacity for a given pollutant is the greatest amount of pollutant that a waterbody can receive without exceeding the applicable water quality criteria. TMDLs are typically expressed on a mass loading basis (e.g., pounds per day [lbs/day]). The pollutant for Upper Goldstream Creek is turbidity. Turbidity is a measure of the water's optical properties that cause light to be scattered or absorbed and does not incorporate a measurement of mass. Therefore, it does not lend itself to developing a loading capacity and allocations to different sources. Because turbidity does not work well as the basis for calculating a target loading capacity, turbidity TMDLs typically use a surrogate parameter, such as TSS, to establish the load and percent reduction. Turbidity can be affected by different suspended particles such as clay, silt, and microorganisms, many of which are the same substances that form TSS. Turbidity can also be affected by algae. Algae have been noted on sensors during monitoring. However, because of the strong relationship between TSS and turbidity and the lack of algae data, for this TMDL TSS is assumed to be the dominant source of turbidity.

Local TSS data provide a measure of the amount of sediment suspended in the stream at a given moment in time. Because Alaska has not developed numeric criteria for TSS, a statistical relationship between turbidity and TSS can be developed and applied. This relationship should be based on local data because sediment can vary significantly from stream to stream. As described in Section 2.4.2, a strong TSS-turbidity relationship has been established for Upper Goldstream Creek (Figure 2-1).

The loading capacity for Upper Goldstream Creek is derived from the water quality criterion for recreational uses, which states that turbidity may not exceed 5 NTUs above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than a 10 percent increase in turbidity when the natural turbidity is more than 50 NTU, not to exceed a maximum increase of 15 NTU. By relating sediment (expressed as TSS) and turbidity, a single measure, the TSS load, can be used to represent the turbidity impairment. The loading analysis conducted using in-stream measurements of TSS provides an estimate of the existing sediment load, accounting for various in-stream processes (e.g., transport, deposition) that affect the fate of sediment delivered to the stream from the watershed.

A load duration curve approach is being used to evaluate the relationships between hydrology and water quality and to calculate the TSS loading capacity. The primary benefit of duration curves in TMDL development is to provide insight regarding patterns associated with hydrology and water quality concerns. The duration curve approach is particularly applicable because water quality is often a function of stream flow. For instance, sediment concentrations typically increase with rising flows as a result of various factors, such as channel scour from higher water velocities or sediment from the land carried to the stream by runoff during a storm event. Other parameters, such as chloride, could be more concentrated at low flows and more diluted by increased water volumes at higher flows. The use of duration curves in water quality assessment creates a framework that enables data to be characterized by flow conditions. The method provides a visual display of the relationship between stream flow and water quality.

Allowable pollutant loads (loading capacity) have been determined through the use of load duration curves (Table 5-1 and Table 5-2 provide additional detail). Discussions of load duration curves are presented in *An Approach for Using Load Duration Curves in the Development of TMDLs* (EPA 2007). This approach involves calculating the allowable loadings over the range of flow conditions expected to occur in the impaired stream through the following steps:

1. A flow duration curve for the stream is developed by generating a flow frequency table and plotting the data points to form a curve (Figure 5-2). The data reflect a range of natural occurrences from extremely high flows to extremely low flows.

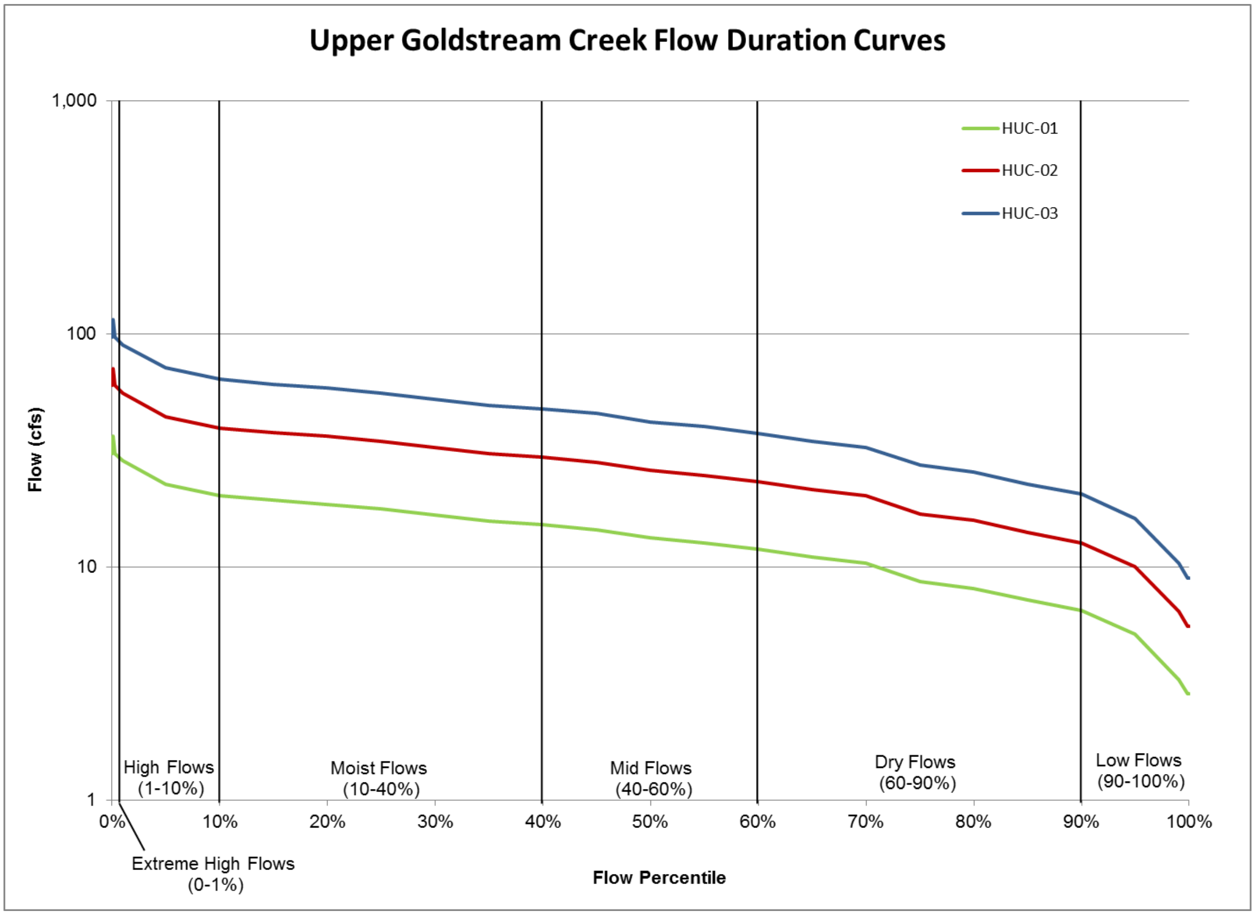

Figure 5-2. Flow duration curves for all flow regimes in each TMDL subwatershed.

2. The flow curve is translated into a loading capacity (or TMDL) curve by multiplying each flow value (in cfs) by the numeric target for a contaminant (mg/L), then multiplying by conversion factors to yield results in the proper unit (i.e., tons per day or year). The resulting points are plotted to create a loading capacity curve (Figure 5-3).

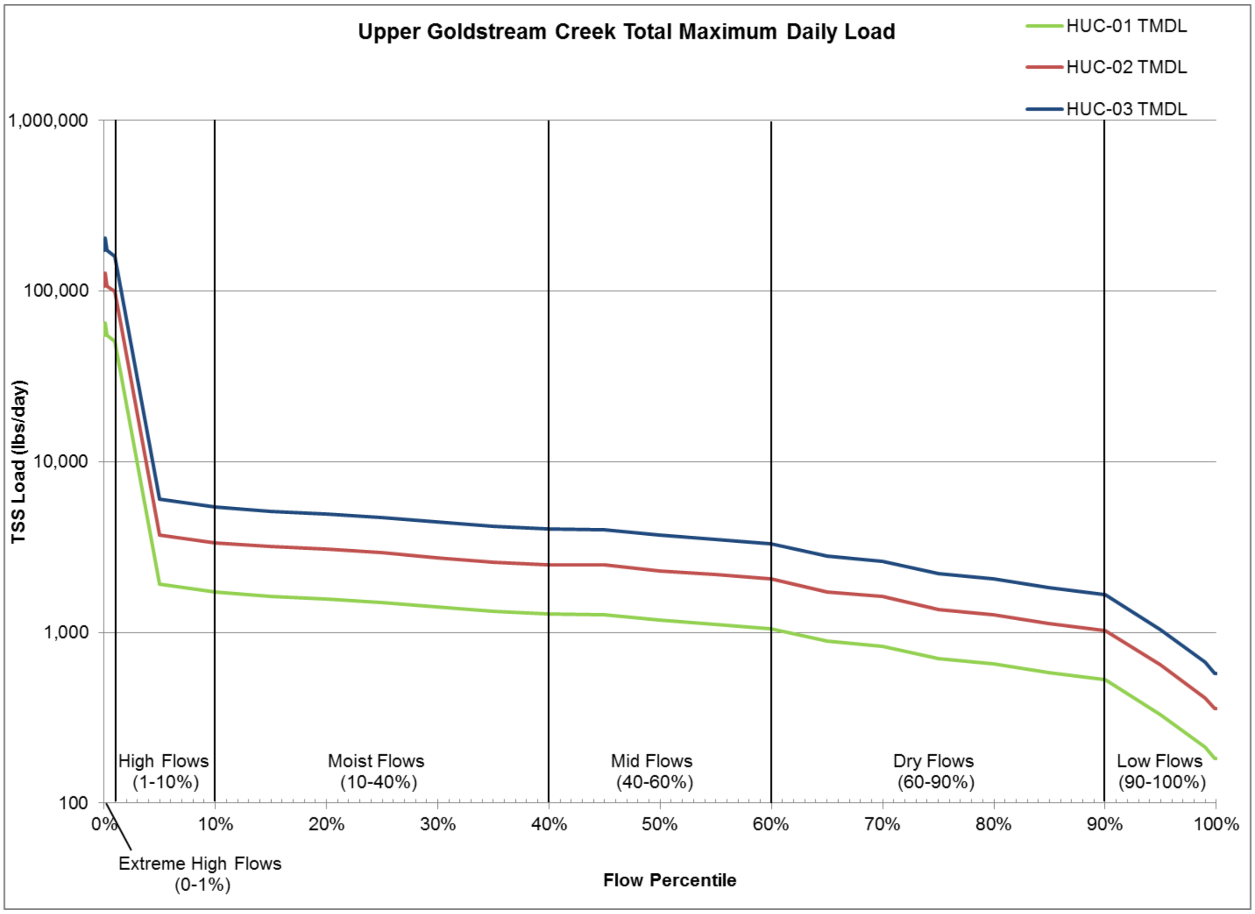

Figure 5-3. Calculated TMDLs for all flow regimes in each TMDL subwatershed.

3. Water quality data are converted to loads by multiplying the water quality sample concentration by the average daily flow on the day the sample was collected. Then, the individual loads are plotted as points on the TMDL graph and can be compared to the loading capacity curve (step 2 above). Figure 5-4 illustrates the load duration curves for TSS in the TMDL subwatersheds using the maximum representative existing load (these values match those presented in Table 5-2 below).

4. Points plotting above the curve in Figure 5-4 represent exceedances from the numeric target and the daily allowable load. Those plotting below the curve represent compliance with WQS and the daily allowable load. Further, it can be determined which locations contribute loads above or below the numeric target.

5. The area beneath the TMDL curve is interpreted as the loading capacity of the stream. The difference between this area and the area representing the current loading conditions is the load that must be reduced to meet numeric targets.

6. The final step is to determine where reductions need to occur. Those exceedances at the right side of the graph occur during low flow conditions. Exceedances on the left side of the graph occur during higher flow events, and might be derived from sources such as runoff. Using the load duration curve approach allows ADEC to determine which implementation practices are most effective for reducing loads on the basis of flow regime. If loads are considerable during wet-weather events (including snowmelt), implementation efforts can target those BMPs that most effectively reduce storm water runoff. Figure 5-4 illustrates that reductions are needed during all

flow regimes for HUC-01. This suggests that implementation measures are needed to control sediment during runoff conditions as well as the dry season in this subwatershed.

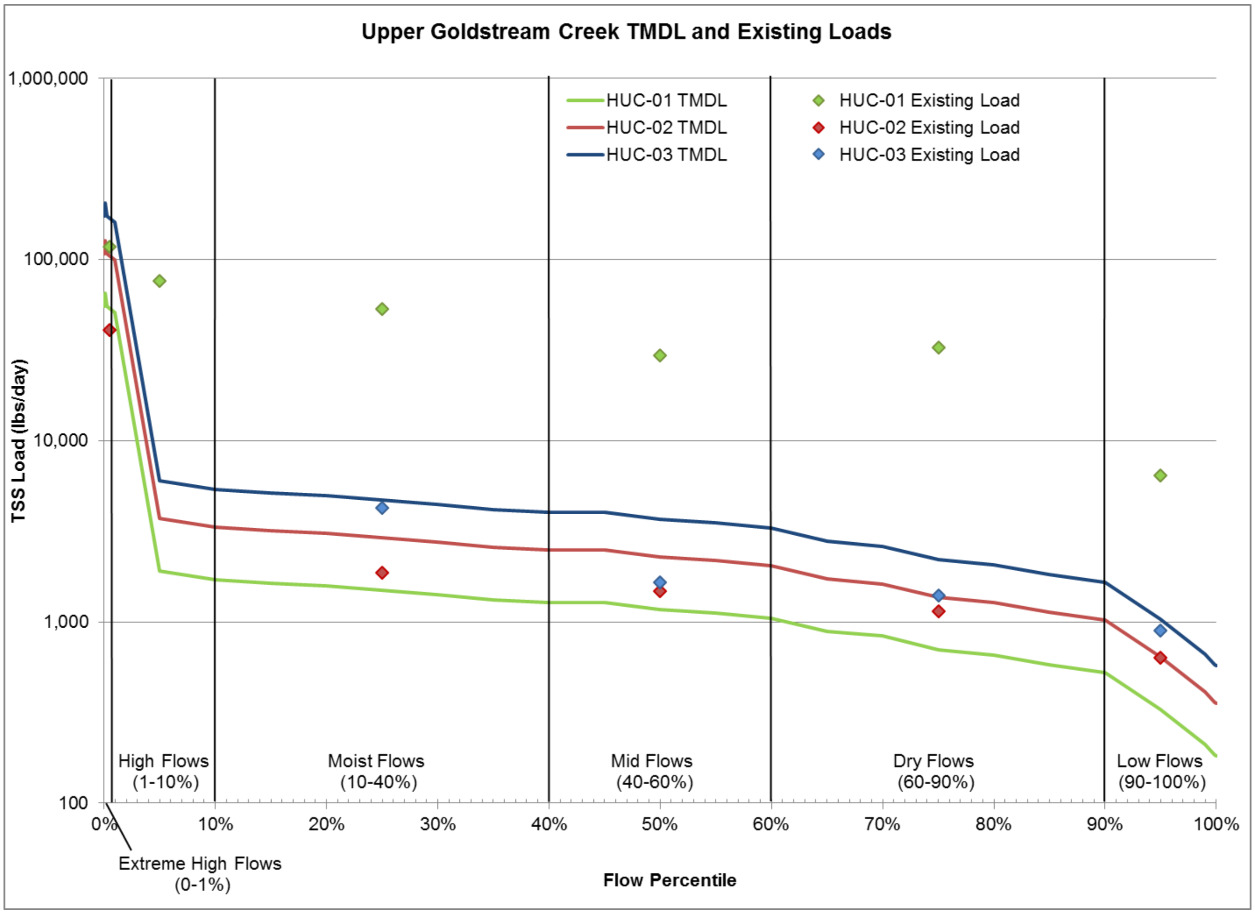

Figure 5-4. Load duration curves with existing loads for all flow regimes in each TMDL subwatershed.

To summarize the TMDL in tabular format (rather than the load duration curves shown above), the target TSS concentration was multiplied by the estimated median flow for each TMDL subwatershed and the appropriate conversion factors to calculate a target load for each flow regime (Table 5-2). This was performed cumulatively because the flow calculation includes the entire drainage area for each TMDL subwatershed.

Table 5-1 and Table 5-2 show the TMDL, allocations, MOS, and required reductions. Table 5-1 presents the loads associated with individual drainage areas (i.e., the loads from the three drainages can be summed to equal the loads of the HUC-03 drainage in Table 5-2). Table 5-2 presents the cumulative TMDL results with values that increase moving downstream in the watershed with increasing drainage area (and associated flow) (note: the HUC-01 results in Table 5-1 and Table 5-2 are identical because they represent the most upstream drainage).

The TMDL for the Upper Goldstream Creek watershed is ultimately equal to the cumulative load presented for the most downstream subwatershed (HUC-03) in Table 5-2; however, the additional detail is provided to support implementation and local compliance efforts.

Using the load reduction approach, required reductions were calculated from the estimated sediment loads for each TMDL subwatershed. Specifically, TSS measurements (the maximum of the observed data or TSS calculated from the observed turbidity and the equation in Figure 2-1) at the station farthest downstream in each TMDL subwatershed were used to represent the existing load within each subwatershed (i.e., GS-2 for HUC-01, Ballaine for HUC-02, and Sheep Creek for HUC-03) (see Figure 5-1). The percent reductions to meet target loads were calculated based on comparing the load associated with existing conditions for each flow regime to the target load in each flow regime, so that, through compliance with the TMDL, water quality will meet numeric targets under all conditions throughout the TMDL subwatersheds.

Reductions needed to TSS loads range from 0 to 98 percent. All reductions are needed in the most upstream HUC-1 subwatershed. The HUC-01 subwatershed requires a 54 percent reduction to TSS loads during extreme flows and a 95 to 98 percent reduction to TSS loads during all other flow regimes (Figure 5-4 and Table 5-2).

Although both the HUC-02 and HUC-03 subwatersheds are currently meeting the loading capacity for TSS, the data are limited to grab samples and indicate that loads are sometimes close to the loading capacity (Figure 5-4 and Table 5-2). TMDLs are assigned to these subwatersheds to ensure that existing loads do not increase and the subwatersheds continue to meet numeric targets, especially considering current mining activities and the potential for additional construction in these drainages (see Section 4). The required reductions are only calculated for the cumulative loads in Table 5-2 because the loads are based on in-stream TSS concentrations, which represent water quality from all upstream sources (i.e., cumulative sources).

Table 5-1. Upper Goldstream Creek individual watershed TMDL allocation summary for TSS

TMDL Subwatershed	Allocation	Total Suspended Solids Load (lbs/day) by Flow Regime					
		Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Reductions required to meet the loading capacity and WQS							
HUC-01	Loading Capacity	54,905	1,915	1,497	1,175	700	330
	Wasteload Allocation	112	4	3	2	1	1
	Load Allocation	51,763	1,805	1,411	1,108	660	311
	Margin of Safety	2,745	96	75	59	35	16
	Future Wasteload Allocation	285	10	8	6	4	2
TMDL subwatersheds currently meeting loading capacity and WQS							
HUC-02	Loading Capacity	52,114	1,818	1,421	1,115	664	313
	Wasteload Allocation	484	17	13	10	6	3
	Load Allocation	48,961	1,708	1,335	1,048	624	294
	Margin of Safety	2,606	91	71	56	33	16
	Future Wasteload Allocation	63	2	2	1	1	0
HUC-03	Loading Capacity	65,807	2,295	1,795	1,408	839	395
	Wasteload Allocation	47	2	1	1	1	0
	Load Allocation	62,238	2,170	1,698	1,332	793	374
	Margin of Safety	3,290	115	90	70	42	20
	Future Wasteload Allocation	232	8	6	5	3	1

Note: Loads are based on only the individual watershed areas, not the cumulative drainage area.

Table 5-2. Upper Goldstream Creek cumulative TMDL allocation summary for TSS

TMDL Subwatershed (cumulative area in acres)	TMDL Category or Input	Total Suspended Solids Load by Flow Regime (units in lbs/day unless noted)					
		Extreme	High	Moist	Mid	Dry	Low
		(0-1%)	(1-10%)	(10-40%)	(40-60%)	(60-90%)	(90-100%)
Reductions required to meet the loading capacity and WQS							
HUC-01 (26,451 acres)	Median Flow (cfs)	30.7	22.6	17.7	13.3	8.7	5.1
	TSS Target (mg/L)	331.71	15.71	15.71	16.38	14.96	11.92
	Loading Capacity	54,905	1,915	1,497	1,175	700	330
	Wasteload Allocation	112	4	3	2	1	1
	Load Allocation	51,763	1,805	1,411	1,108	660	311
	Margin of Safety	2,745	96	75	59	35	16
	Future Wasteload Allocation	285	10	8	6	4	2
	Maximum Observed Existing Load at GS-2	118,070	76,569	53,560	29,685	32,730	6,417
	Percent Load Reduction (%)	53%	97%	97%	96%	98%	95%
TMDL subwatersheds currently meeting loading capacity and WQS							
HUC-02[a] (51,527 acres)	Median Flow (cfs)	60	44	34	26	17	10
	TSS Target (mg/L)	331.71	15.71	15.71	16.38	14.96	11.92
	Loading Capacity	107,019	3,733	2,918	2,290	1,364	643
	Wasteload Allocation	596	21	16	13	8	4
	Load Allocation	100,724	3,513	2,747	2,156	1,284	605
	Margin of Safety	5,351	187	146	114	68	32
	Future Wasteload Allocation	348	12	9	7	4	2
	Maximum Observed Existing Load at Ballaine	40,689	ND	1,869	1,479	1,148	637
	Percent Load Reduction (%)[b]	0%	ND	0%	0%	0%	0%
HUC-03[a] (83,211 acres)	Median Flow (cfs)	97	71	56	42	27	16
	TSS Target (mg/L)	331.71	15.71	15.71	16.38	14.96	11.92
	Loading Capacity	172,826	6,028	4,713	3,698	2,202	1,038
	Wasteload Allocation	643	22	18	14	8	4
	Load Allocation	162,962	5,685	4,443	3,487	2,077	979
	Margin of Safety	8,641	301	236	185	110	52
	Future Wasteload Allocation	580	20	16	12	7	3
	Maximum Observed Existing Load at Sheep Creek	ND	ND	4,256	1,659	1,402	891
	Percent Load Reduction (%)[b]	ND	ND	0%	0%	0%	0%

Note: Based on the cumulative watershed drainage area; ND = no data

* Currently meeting the loading capacity for TSS when data are available; however, the data are limited to grab samples and indicate that loads are sometimes close to the loading capacity. TMDLs are assigned to ensure that existing loads do not increase and the subwatersheds continue to meet numeric targets, especially considering current mining activities and the potential for additional construction in these drainages (see Section 4).

[+] Loads for the HUC-02 subwatershed are equal to the sum of the loads from the HUC-01 and HUC-02 subwatersheds in Table 5-1. Similarly, loads for the HUC-03 subwatershed are equal to the sum of the loads of the HUC-01, HUC-02, and HUC-03 subwatersheds presented in Table 5-1.

5.2. Wasteload Allocations

The WLA is the portion of the loading capacity allocated to point source discharges to the waterbody. Point sources include active placer mines, MS4 discharges, stormwater runoff from construction activities, and stormwater runoff from fill material activities. In addition, a future WLA has been calculated for future permitted activities, including placer mining and stormwater runoff from future industrial and construction activities.

For each point source in the watershed, an estimate of the sediment allowable load was developed for comparison with the in-stream loading capacity calculated for Upper Goldstream Creek. Source-specific loads were calculated by assigning an area-weighted portion of the total allocatable load (i.e., loading capacity minus the MOS) to each source. All point sources within a TMDL subwatershed were area-weighted based on their disturbed area (or impacted area for fill material permits or urban area for the MS4) and the total TMDL subwatershed area.

For example, an active mining permit would receive loads based on five acres (the assumed disturbed area) divided by the applicable TMDL subwatershed area (from Table 5-2) multiplied by the allocatable load for each flow regime (note: see Table 5-2 for the concentration, flow, and MOS). This is illustrated for an active mining permit in the HUC-01 subwatershed with the following calculation for the extreme high flow regime (see Table 5-2 for details by flow regime and Figure 5-2 for an illustration of the flow duration curves):

$$WLA = (\text{Disturbed Area} \div \text{HUC-01 Area}) \times ([\text{Target Concentration} \times \text{Flow} \times \text{conversion}] - \text{MOS})$$

$$WLA_{\text{extreme high}} = (5 \text{ acres} \div 26{,}451 \text{ acres}) \times ([331.71 \text{ mg/L} \times 30.7 \text{ cfs} \times 5.393776] - 2{,}745 \text{ lbs/day})$$

$$= 9.86 \text{ lbs/day}^{4}$$

Permitted point sources in the watershed fall under six categories: construction stormwater, fill material, MS4, wastewater, mining permits, and future permitted activities. Each permitted facility was evaluated for a WLA for this TMDL as follows:

- Construction Stormwater: Where available, the disturbed area was used to calculate and assign WLAs to permittees, based on the proportion of area in the watershed (i.e., a proportion of the loading capacity was assigned to the permittee based on their proportion of disturbed area). Four construction permits, with 105 acres of reported disturbed area, are currently in the watershed.
- Fill Material: Where available, the impacted wetland area was used to calculate and assign WLAs to permittees. Specifically, the impacted wetland area included in the permit was divided by the overall subwatershed area to determine the proportion of area in the watershed, which was then used to determine the WLAs (i.e., a proportion of the loading capacity was assigned to the permittee based on this area).
- MS4: The MS4 permit applies to the census urban area in the city of Fairbanks (155 acres in the Upper Goldstream Creek watershed; see Figure 4-1, MS4 area shaded in purple). A WLA was calculated by applying this proportion of area in the watershed to the overall loading capacity. Additional development regulated through the MS4 permit is unlikely outside of the census urban area; therefore, no future allocation was considered necessary as the MS4 WLA already applies to the entire urban census area in the watershed.

[4] Consistent with the extreme high WLA for an active mining permit in HUC-01 presented in Table 5-3.

- Wastewater: The one WWTF permit in the watershed discharges to "tundra" and does not receive a WLA because it is not expected to discharge to Upper Goldstream Creek (i.e., the permittee is listed in permit tables, but the WLA is listed as "not applicable").
- Placer mines: DMR summary reports indicated that there was 'no mining' or 'no discharge' for all permittees with available information. Although no discharge has been reported, the estimated disturbance area was used to calculate WLAs for each mine. Five acres was used as the current disturbed area for assigning all mine WLAs. The watershed contains 589 active state mining claims and 23 active private and BLM mining claims, representing 22,603 acres (based on the BLM, private, and state mining claim shapefiles from ADEC). The owners of these claims have the right to mine the land for the minerals it might contain. Only 12 owners have ADEC permits (representing 61 claims) in the watershed. These permits receive WLAs.
- Future permitted activities: A future WLA is included in the TMDL as a reserve allocation for any new permits. Separate future WLAs are provided for each TMDL subwatershed based on the calculations described below. The future WLA is the sum of the anticipated future allowable load from the sources below and permittees from any of these sources can work with ADEC to draw upon this reserve allocation.
    - *Future construction stormwater*: Additional construction activities are anticipated in the Upper Goldstream Creek watershed; therefore, these activities may use a portion of the future WLA when authorized under the ACGP. Because planning department and land management offices do not currently have projected growth or plans for development specific to the Upper Goldstream Creek watershed area, the projected growth data that are available for a broader geographic area were used to estimate future construction.

      Fairbanks North Star Borough is projected to add 31,687 to its population from 2012 to 2042 (moving from 100,343 to 132,030—a 31 percent increase in population). Currently 32,070 of the population of the borough resides in the city of Fairbanks (approximately 32 percent). This information was used to estimate projected growth in the Upper Goldstream Creek watershed. Specifically, it was assumed that the borough growth outside of the MS4 areas of Fairbanks will be evenly distributed among the remainder of the borough area. Using an area-weighted population estimate for the remaining population outside of Fairbanks (68,273 people), it is assumed that the Upper Goldstream Creek watershed had 1,209 residents in 2012 (Upper Goldstream Creek is approximately 2 percent of the borough area). Applying the growth projections from the borough results in an estimated population of 1,590 people in 2042. It is assumed that because the current population is supporting 105 acres of ongoing (i.e., permitted) construction, there is the potential for construction needs of 138 acres by 2042 if population growth continues at this estimated rate. Therefore, the future WLA includes 33 disturbed areas associated to consider future construction. Each TMDL subwatershed is assigned a proportional share of the reserve load based on its subwatershed area.
    - *Future placer mines*: There are currently 12 mining claim owners with ADEC permits (which receive WLAs, as described above) and another 33 owners with a total of 551 active mining claims that do not currently have ADEC permits. These 551 mining claims represent potential future mines. To determine a reserve allocation for future mines, it was assumed that if every owner requested an active permit, the maximum number of placer permits possible in the watershed would be 45. Therefore, 165 disturbed acres were included in the future WLA (making up the difference between the current permits [12] and the total assumed, possible permits [45], and assuming a five-acre disturbed area per future permit) to consider future placer mines. Each TMDL subwatershed is assigned

a proportion of the reserve load based on the area of state claims currently in the subwatersheds.

- *Future industrial activities*: Current MSGPs in the city of Fairbanks were used to estimate an area associated with future industrial activities in the Upper Goldstream Creek watershed. To calculate a reserve allocation for future MSGPs, the average area of the current Fairbanks MSGP permittees was calculated (note: this calculation did not include three permits with large areas because operations that large are not expected in the Upper Goldstream Creek watershed). The average area was 31.97 acres. It was then assumed that three future MSGPs could occur in the watershed at any given time, resulting in a total of 95.91 disturbed acres. Each TMDL subwatershed is assigned a proportion of the reserve load based on the area of state mining claims in the subwatershed because future MSGPs are likely to be located near mines. As noted previously, it is anticipated that current placer mining permits may need MSGP coverage in the future to address their industrial activities (particularly under the MSGP Sector J for minerals mining and dressing).

The area-weighted WLAs are presented in Table 5-3 for each permit (note: this can be sorted by TMDL subwatershed to characterize the loading in a particular subwatershed). These WLAs are summarized and incorporated into the TMDL in Table 5-2 for the cumulative watershed areas (note: Table 5-1 presents the allocations associated with individual subwatershed areas).

Table 5-3. Area-weighted WLAs

Permit	Name	Type	TMDL Subwatershed	Disturbed[a]/ Impacted[b]/ Urban[c] Area (Acres)	Area Weighted WLA by Flow Regime TSS (lbs/day) Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
WLAs for HUC-01										
AKG370894	Larry DeGraaf & Willam Bohan|Same|4 N SXX	Placer Mine	HUC-01	5[a]	9.86	0.34	0.27	0.21	0.13	0.06
AKG370927	Marge Kniffen & Helen Warner|Les Underwood|4 N XXP	Placer Mine	HUC-01	5[a]	9.86	0.34	0.27	0.21	0.13	0.06
AKG370970	Mark & Sherry Funk|Same|4 N SXX	Placer Mine	HUC-01	5[a]	9.86	0.34	0.27	0.21	0.13	0.06
AKG370391	Donald and Evelyn Stein | Donald Stein dba DEPEM | 7 Y XFP	Placer Mine	HUC-01	5[a]	9.86	0.34	0.27	0.21	0.13	0.06
AKG370336	Fred Cornelius and Gerald Erikson | Same | 4 Y XFX	Placer Mine	HUC-01	5[a]	9.86	0.34	0.27	0.21	0.13	0.06
AKG370949	Turner | Powelson Fox Creek Mining, LLC	Placer Mine	HUC-01	5[a]	9.86	0.34	0.27	0.21	0.13	0.06
AKG370717	Eileen Crouse | Larry Crouse | 4 N SXX	Placer Mine	HUC-01	5[a]	9.86	0.34	0.27	0.21	0.13	0.06
AKG870614	Raymond Meder | Tracy Fortner & Scott Veigut | 5 N SXX	Placer Mine	HUC-01	5[a]	9.86	0.34	0.27	0.21	0.13	0.06
AKG370786	Rob Robinson|Dexter Clark|3 N SXX	Placer Mine	HUC-01	5[a]	9.86	0.34	0.27	0.21	0.13	0.06
AKR10EP52	Fox Community Park | Fox Lions Club	Construction Stormwater	HUC-01	9[a]	17.75	0.62	0.48	0.38	0.23	0.11
POA-2013-402	Goldstream Creek Fox Lions Club Park | Fox Lions Club	Fill Material	HUC-01	2.7[b]	5.32	0.19	0.15	0.11	0.07	0.03
WLAs for HUC-02										
AKG370356	Goldstream Properties LLC | Polar Mining, Inc. | 9 N XXP	Placer Mine	HUC-02	5[a]	9.87	0.34	0.27	0.21	0.13	0.06
AKR10EK52	Goldstream Rd Improvements Fbks Spot Area Improv | HC Contractors, Inc.	Construction Stormwater	HUC-02	85.5[a]	168.70	5.88	4.60	3.61	2.15	1.01
AKR10EK53	Goldstream Rd Improvements Fbks Spot Area Improv_2 | State of Alaska DOT&PF Northern Region									
AKS053414	Fairbanks North Star Borough	MS4	HUC-02	154.79[c]	305.41	10.65	8.33	6.54	3.89	1.83
WLAs for HUC-03										
AKG370A43	Dan & Jack Adams	Placer Mine	HUC-03	5[a]	9.87	0.34	0.27	0.21	0.13	0.06
AKG370A86	Charlene Seamon	Placer Mine	HUC-03	5[a]	9.87	0.34	0.27	0.21	0.13	0.06
AKR10EK14	Murphy RSA Road Improvements | M & M Constructors	Construction Stormwater	HUC-03	5[a]	9.87	0.34	0.27	0.21	0.13	0.06

Permit	Name	Type	TMDL Subwatershed	Disturbed[a]/ Impacted[b]/ Urban[c] Area (Acres)	Area Weighted WLA by Flow Regime TSS (lbs/day) Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
AKR10EK71	Murphy Dome RSA Road Improvements | Fairbanks North Star Borough	Construction Stormwater	HUC-03	5[a]	9.87	0.34	0.27	0.21	0.13	0.06
POA-1991-243-M2	Goldstream Creek Kuykendall Subdivision | Kuykendall Inc	Fill Material	HUC-03	2.6[b]	5.13	0.18	0.14	0.11	0.07	0.03
POA-2012-43	Sheep Creek ET Construction Subdivision | ET Construction	Fill Material	HUC-03	1.47[b]	2.90	0.10	0.08	0.06	0.04	0.02
AKG570062	IVORY JACKS WW TREATMENT FACILITY | Ivory Jacks Restaurant	Wastewater	HUC-03	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WLA Summary										
N/A	**Total WLA**	**All**	**All**	**326.06**	**643.27**	**22.43**	**17.54**	**13.77**	**8.20**	**3.86**
Future WLAs for HUC-01										
N/A	Future WLA for Mines	Placer Mine	HUC-01	84.77	167.17	5.83	4.56	3.58	2.13	1.01
N/A	Future WLA for Construction	Construction Stormwater	HUC-01	10.49	20.69	0.72	0.56	0.44	0.26	0.12
N/A	Future WLA for MSGP	Industrial Stormwater	HUC-01	49.28	97.17	3.39	2.65	2.08	1.24	0.58
Future WLAs for HUC-02										
N/A	Future WLA for Mines	Placer Mine	HUC-02	13.92	27.46	0.96	0.75	0.59	0.35	0.16
N/A	Future WLA for Construction	Construction Stormwater	HUC-02	9.94	19.62	0.68	0.54	0.42	0.25	0.12
N/A	Future WLA for MSGP	Industrial Stormwater	HUC-02	8.09	15.96	0.56	0.44	0.34	0.20	0.10
Future WLAs for HUC-03										
N/A	Future WLA for Mines	Placer Mine	HUC-03	66.31	130.83	4.56	3.57	2.80	1.67	0.79
N/A	Future WLA for Construction	Construction Stormwater	HUC-03	12.57	24.79	0.86	0.68	0.53	0.32	0.15
N/A	Future WLA for MSGP	Industrial Stormwater	HUC-03	38.54	76.05	2.65	2.07	1.63	0.97	0.46
Future WLA Summary										
N/A	**Total Future WLA**	**All**	**All**	**293.91**	**579.75**	**20.22**	**15.81**	**12.40**	**7.39**	**3.48**

N/A = not applicable.
[a] Discussions with ADEC and EPA determined that placer mining operations typically do not disturb more than five acres at a time. For the purposes of calculating WLAs it is assumed that mining operations will not disturb more than five acres at a time. Stormwater construction disturbed acreage came directly from ADEC permit information.
[b] Impacted areas for fill material permits came from ADEC permit information.
[c] MS4 urban area is based on the 2010 census urban area maps (see Figure 4-1, MS4 area shaded in purple).

5.3. Load Allocations

The LA is the portion of the loading capacity allocated to nonpoint source discharges. There are numerous nonpoint sources including runoff from historically disturbed sites, winter road maintenance, residential and commercial development, and ATV trail use. Historic mining is assigned a LA, while active, permitted mining is assigned a WLA (Section 5.2). The difference between the loading capacity (minus the MOS) and the WLAs was used to assign an overall LA (detailed in Table 5-2 for the cumulative load and Table 5-1 for the individual watershed load).

5.4. Margin of Safety

A MOS must be included in a TMDL to account for any uncertainty or lack of knowledge regarding the pollutant loads and the response of the receiving water. The MOS can be implicit (incorporated into the TMDL analysis through conservative assumptions) or explicit (expressed in the TMDL as a portion of the loadings) or a combination of both. This TMDL includes both an implicit and explicit MOS.

The TMDL includes an explicit 5 percent MOS. A 5 percent explicit MOS is used because the use of load duration curves is expected to provide accurate information on the loading capacity of the stream, but this estimate of the loading capacity could be subject to potential error associated with the method used to estimate flows within the watershed.

In addition to the explicit MOS, the TMDL relies on the use of conservative assumptions where data are lacking (e.g., the establishment of the numeric target for turbidity). The conservative assumptions made were related to both the estimation of the existing loading and the selection of a numeric target for the TMDL, and include the following:

1. The use of the median of the turbidity observations at Pedro Creek to establish the baseline turbidity for Goldstream Creek. The median turbidity observations at Pedro Creek range from 2.17 to 4.85 NTU from low to moist flow conditions, which are lower than the average values of 2.74 to 6.66 NTU. Using a lower turbidity value to establish the background turbidity in the creek represents a conservative approach because it means that the load reductions required to meet the turbidity WQS are more likely to be overestimated than underestimated. There was no observed turbidity measurement during the high flow regime. The target for the moist flow condition was applied for high flows because it is a conservative approach to set the numeric target.
2. The use of maximum (as opposed to average or median) observed measurements to calculate existing conditions and estimate the load reductions necessary. Using the maximum observed measurements reflects the worst case scenario and is the most conservative approach.

5.5. Seasonal Variation and Critical Conditions

Seasonal variation and critical conditions associated with pollutant loadings, waterbody response, and impairment conditions can affect the development and expression of a TMDL. Therefore, TMDLs must be developed to ensure the waterbody will maintain WQS under all expected conditions.

The load duration approach accounts for seasonality by evaluating loads on a daily basis over the entire range of observed flows and by presenting daily allowable loads that vary by flow. For Upper Goldstream Creek, the times of highest loading are during the spring break-up period, which are characterized by the extreme high flow regime in the TMDL.

5.6. Future Growth

The MS4 permit applies to the small urbanized area in the Upper Goldstream watershed (associated with the 155 acres of census urban area north of the city of Fairbanks). Any additional residential and commercial growth outside of this area is characterized as a nonpoint source (Section 4.2.3) and is not associated with an MS4 permit. Therefore, no future allocation for MS4s was considered necessary as the MS4 WLA already incorporates the entire urban area in the watershed (see Section 5.2). Future allocations for mines, construction, and other industrial activities are included in the future WLAs, which provide a reserve load by TMDL subwatershed from which future permittees can draw (see Section 5.2).

5.7. Daily Load

A TMDL is required to be expressed as a daily load, or the amount of a pollutant the waterbody can assimilate during a daily time increment and still meet WQS. The TMDL for TSS is presented as the maximum load allowed during a given flow regime (e.g., extreme, high, moist, mid, dry, low). The allowable loads can be calculated for any flow and can therefore be applied on a daily basis.

5.8. Reasonable Assurance

EPA requires that there is reasonable assurance that TMDLs can be implemented when the TMDL is a mixed source TMDL (EPA 1991). A mixed source TMDL is one developed for waters that are impaired by both point and nonpoint sources. The WLA in a mixed source TMDL is based on the assumption that nonpoint source load reductions will occur. Reasonable assurance is necessary to determine that a TMDL's WLAs and LAs, in combination, are established at levels that provide a high degree of confidence that the goals outlined in the TMDL can be achieved. This TMDL is a mixed source TMDL; therefore, reasonable assurance has been included.

The TMDL uses available in-stream data and information to quantify sediment loads to the creek within the entire drainage area. This approach characterizes the contribution of sediment from both nonpoint sources and point sources (including future point sources) to Upper Goldstream Creek.

Education, outreach, technical and financial assistance, permit administration, and permit enforcement will all be used to ensure that the goals of this TMDL are met. Although it is anticipated that improvements to water quality will take decades because of the extreme disturbance in the headwaters from historic mining activities, the following rationale helps provide reasonable assurance that the Upper Goldstream Creek watershed TMDL goals will be met.

5.8.1. Programs to Achieve Point Source Reductions

Permit compliance frequently requires implementation of BMPs, monitoring, and reporting. Requirements differ by permit type. Opportunities and resources associated with both placer mining and stormwater control are discussed below. These activities already support this TMDL and add to the assurance that turbidity will meet Alaska WQS. In addition, recommended BMPs are presented in Section 6.

- **Placer Mining Permit Enforcement:** Mining activities in the state of Alaska require permits and licenses from several state and federal agencies. Through the APDES General Permit, ADEC manages mining operation permits addressing the discharge of runoff into surface waters. ADEC inspected five placer mine permittees in the Upper Goldstream Creek watershed between October 2010 and December 2014. Since ADEC began oversight of APDES permits (2010), they have been working more closely with the mining community. As needed, the ADEC inspections included educating mine operators on BMPs to reduce erosion and preventing overflow of settling ponds as well as follow-up visits to ensure compliance with permit requirements and improvements to water quality.

Alaska DNR reviews mine plans on state land and BLM, U.S. Forest Service, and U.S. Park Service are responsible for approving plans of operation on federal land. Permitted mine discharges are routed through a settling pond and wastewater is recycled; therefore, discharges to a stream from fully compliant mines should be minimal. Review of DMR summary reports indicated that there was 'no mining' or 'no discharge' for all permittees with available information. Permit limits indicate that these permittees can discharge water containing sediment, but this discharge water must meet water quality criteria for turbidity; therefore, under optimal (i.e., full compliance) conditions, these facilities should not contribute turbidity to Upper Goldstream Creek. In addition to the permit enforcement and compliance actions, a series of fact sheets and other stream bank protection resources are available at

http://dnr.alaska.gov/mlw/factsht/,
http://www.adfg.alaska.gov/index.cfm?adfg=streambankprotection.main, and
http://www.blm.gov/ak/st/en/prog/minerals/APMA.html

to help mine owners implement the required permit enforcement and compliance actions.

- **Fairbanks Storm Water Management Program:** Many resources for managing storm water in the Fairbanks area are identified by the Fairbanks Storm Water Management Program. These resources are available at http://www.co.fairbanks.ak.us/pworks/stormwatermanagementprogram/resources.htm and include the *BMP Effectiveness Report for Fairbanks, Alaska*; *Alaska Storm Water Pollution Prevention Plan Guide,* and *Erosion and Sediment Control Practices for Small Construction Sites.* Any new permitted development in the Upper Goldstream Creek watershed will result in improved stability, which will reduce erosion and improve water quality.
- **Alaska Stormwater Guide:** The diversity of Alaska's geography, geology, and climate can make designing and implementing stormwater controls particularly challenging. The *Alaska Stormwater Guide* (ADEC 2011) provides detailed guidance on the implementation of stormwater BMPs to comply with WQS. *The Stormwater Guide* addresses some of the unique challenges posed by the diversity of Alaska's climate, soils, and terrain, and makes recommendations about the design and selection of stormwater BMPs in an effort to optimize their effectiveness. Chapter 2 of *The Stormwater Guide* provides stormwater considerations for the various climatic regions in Alaska. Goldstream Creek is in the interior Alaska region.
- **ADEC Follow-Up Actions:** ADEC has the legal authorities that would allow the possibility of requiring more stringent permit limits or more effective nonpoint controls if there is insufficient progress in the expected nonpoint source control implementation. Although ADEC is authorized under Alaska Statutes Chapter 46.03 to impose strict requirements or issue enforcement actions to achieve compliance with state WQS, it is the goal of all participants in the Upper Goldstream Creek TMDL process to achieve clean water through cooperative efforts, including continued inspections and education through the APDES permit process.

5.8.2. Programs to Achieve the NPS Reductions

The load from the area not associated with point sources was assigned a LA. Recommended BMPs are presented in Section 6 and in the programs described below.

- **Alaska Clean Water Action (ACWA) grants** (funded through EPA's CWA Section 319 program) can provide funding to support nonpoint source pollution control practices. More information on ACWA grants can be found at http://dec.alaska.gov/water/acwa/acwa_index.htm.

- **Abandoned Mine Lands Program** funding is available for reclamation of both coal and non-coal abandoned mines (http://dnr.alaska.gov/mlw/mining/aml/).
- **BLM Alaska Mineral Program** has recently (November 2014) developed guidance to facilitate compliance with laws, regulations, and national policies regarding reclamation on BLM lands (note: 1,200 acres of the Upper Goldstream Creek watershed are BLM lands [1.4 percent of the total area], and about 360 acres of this area have mining claims). BLM's goal is to ensure effective reclamation and to ensure that placer mining operations are adequately bonded. The guidelines establish WQS for rehabilitating placer-mined streams. Additional information is available at http://www.blm.gov/ak/st/en/prog/minerals.html.
- **Community Improvement Projects** by various state and municipal programs may develop parks and bike paths in the watershed that will help to improve stability of the stream channel and reduce erosion. These types of community improvements are anticipated in the coming years as other development continues.
- **ADEC Monitoring and Tracking to Evaluate Progress:** The implementation section includes a description of monitoring recommendations to evaluate progress and make adjustments.

To provide additional assurance beyond existing programs and planned activities, the actions described in the Implementation Section (Section 6) are provided to help permittees and property owners better understand how to implement the WLAs and LAs in the TMDL. Given the widespread disturbance in the headwaters, it is anticipated that measurable improvements will take decades to achieve. The implementation section of this TMDL describes BMPs that can be used to achieve these actions.

6. Implementation and Monitoring Recommendations

Implementing management measures in the Upper Goldstream Creek watershed is necessary to improve water quality to the point where the creek can support its designated uses. Additional monitoring is desired to verify TMDL assumptions and measure progress. This section presents recommendations for additional implementation and monitoring to assist in meeting the numeric turbidity targets and TSS loading capacity, and ultimately the WQS for Upper Goldstream Creek.

6.1. Implementation

The bulleted list below identifies implementation options for implementation in the Upper Goldstream Creek watershed. Options have been identified for permitted sources and nonpoint sources.

6.1.1. Point Source Implementation Options

- **Placer mining:** Implementing BMPs on mining operations in the Upper Goldstream Creek watershed should focus on permitting and reclamation, as detailed below:
    - **Permitting:** APDES inspection and enforcement activities are intended to reduce discharges from active mine sites, particularly during storm events.
    - **Reclamation:** Several management measures are traditionally used for restoring mined sites. The first traditional activity includes removing the mining-related material (potentially including tailings dredged from the creek itself) and placing this material in a repository designed to contain contaminants leaching from the tailings. Other traditional activities focus on the critical pathway(s). To prevent surface runoff, mine tailings and related material are capped in place. Revegetation is also critical for stabilization and to minimize erosion.
    - **Education:** Education for placer miners that includes discussions on recommended and appropriate BMPs to protect watersheds from mining-related erosion and sediment input could help the community better understand requirements for stream protection and help foster a sense of watershed ownership.
    - Additional BMPs are identified in the resources listed in Section 5.8.
- **Construction:** The ACGP[5] requires the development of a SWPPP to manage materials, equipment, and runoff from construction sites. To ensure compliance with the TMDL, construction sites need to implement storm water controls described in their SWPPP and maintain erosion and sediment controls as necessary.
    - The City of Fairbanks and FNSB conduct periodic outreach events that include recommendations on appropriate BMPs and how to manage runoff.
- **Fill Material:** The Alaska General Permit 2007-541-M1[6] for fill material in wetlands for residential and community developments requires the following BMPs for fill material operations:

    > **"**Prior to construction, erosion control measures, such as silt fencing, sediment traps, or water diversion structures, must be properly deployed and installed. During construction, silt and sediment from the site work must be prevented from entering wetlands or waterbodies outside the authorized project limits. Methods shall be implemented to filter or settle out suspended sediments from all construction-related wastewater prior to its

[5] http://dec.alaska.gov/water/wnpspc/stormwater/sw_construction.htm
[6] http://portal.hud.gov/hudportal/documents/huddoc?id=23383_akgeneralpermit.pdf

direct or indirect discharge into any natural body of water. During excavation and fill placement, heavy equipment must not be operated in wetlands outside the authorized excavation and fill area. Heavy equipment working in wetlands or mudflats must be placed on mats, or other measures must be taken to minimize soil disturbance. All exposed fills and disturbed areas shall be stabilized immediately after construction to prevent erosion. Re-vegetation of the disturbed areas shall begin as soon as site conditions allow. Species to be used for seeding and planting should be native to the area and at worst native to the state."

- **MS4 Urban Runoff:** The Fairbanks MS4 permit includes BMPs to reduce sediment from runoff include vegetated filter strips, grassed swales, porous pavement, concrete grid pavement, filtration basins and sand filters, and water quality inlets (EPA 2012). Additional BMPs are identified in the resources listed in Section 5.8.

6.1.2. Nonpoint Source Implementation Options

- **Historically Disturbed Sites:** Sites that have been disturbed due to dredging, mining or other land disturbance activity likely have a higher erosion potential and may contribute to elevated turbidity.
  - Restoration BMPs may include revegetation or construction of other erosion control measures.
- **Transportation/Highway and Winter Road Maintenance:** Erosion, sediment, and runoff control for transportation and highways includes construction site BMPs, general maintenance BMPs, permanent control BMPs, and long-term operation and maintenance of BMPs.
  - Construction site BMPs for preventing sediment from transportation and highways include straw bale barriers, filter fabrics, silt fences, sediment basins, and stabilized entrances.
  - General maintenance BMPs include seeding with grass and fertilizing, seeding with grass and overlaying with mulch or mats, wildflower cover, sodding, and salt and sand distribution equipment performance evaluations.
  - Permanent erosion, sediment, and runoff control for transportation and highways include grassed swales, filter strips, terracing, check dams, detention ponds or basins, infiltration trenches, infiltration basins, constructed wetlands, and salt/sand storage and housekeeping BMPs.
  - Operation and maintenance of transportation and highway BMPs should include regularly scheduled inspection and maintenance of both temporary and permanent erosion prevention BMPs and the removal of temporary BMPs (EPA 1995).
  - In addition, preventing runoff of sediment and de-icing from winter maintenance efforts should be a priority. When feasible, maintenance crews should use solutions that effectively de-ice while keeping sand and de-icing agents out of streams. This can be achieved through the use of filtration and retention BMPs as well as treatment options that minimize the loss of sand and de-icing agents from the road surface.
- **Residential and Commercial Development:**
  - Encourage application of green infrastructure and other BMPs to reduce erosion and increase vegetative cover and infiltration of water on-site.

- **ATV Trail Use:**
    - Educate trail users on appropriate trail use and the impacts of degradation on water quality. Encourage trail users to minimize use during wet weather or on wet areas of the trails during the summer.

6.2. Monitoring Recommendations

Sediment-related impacts on designated uses are often difficult to characterize. For this reason, sediment-related TMDLs are likely to have uncertainty associated with selection of numeric targets representative of the desired in-stream condition and estimates of source loadings and waterbody assimilative capacity. The amount of available data used in this TMDL was limited, which resulted in the use of correlations and estimates rather than site-specific data for TSS and flow.

Additional monitoring could support future load reduction estimates using site-specific data to more accurately represent Upper Goldstream Creek. In particular, flow data (cfs), TSS data (mg/L), and turbidity data (NTU) taken simultaneously during all flows regimes at the Pedro Creek, GS-1, GS-2, Ballaine Road, and Sheep Creek Road stations would be beneficial.

Collecting additional monitoring data at these sites could:

- Verify the water depth to flow relationship assumed in the TMDL.
- Indicate improvements in water quality and flow.
- Verify the natural background conditions in the watershed.

Specific data gaps (station, parameter, and flow regime areas that have fewer than five observed samples) that should be targeted for additional data collection are prioritized in Table 6-1. The items identified by an “H” in Table 6-1 represent flow regimes with no data available at that station for that parameter; therefore, these are a high priority for data collection. In general, data during extreme flow regimes are limited and continuous or regularly schedule grab samples of TSS need to be taken to provide data for each flow regime. Whenever possible, flow and turbidity measurements should be taken through continuous sampling protocols, while TSS data are generally represented with grab samples.

Table 6-1. Monitoring recommendations for the Upper Goldstream Creek watershed

Station Name	Parameter (units)	Recommended Additional Baseline Data Collection by Flow Regime					
		Extreme	High	Moist	Mid	Dry	Low
Ballaine	Flow (cfs)	**H**	**H**	**H**	**H**	**H**	**H**
	TSS (mg/L)	M	**H**	M	M	M	M
	Turbidity (NTU)	M	**H**	M	M	L	M
GS-1	Flow (cfs)	M	M	M	M	M	M
	TSS (mg/L)	M	M	L	M	L	M
	Turbidity (NTU)	L	L	L	L	L	L
GS-2	Flow (cfs)	M	M	M	M	M	M
	TSS (mg/L)	M	M	L	M	M	M
	Turbidity (NTU)	M	L	L	L	L	L
Pedro	Flow (cfs)	**H**	**H**	**H**	**H**	**H**	**H**
	TSS (mg/L)	**H**	**H**	M	M	M	M
	Turbidity (NTU)	M	**H**	L	L	L	L

Station Name	Parameter (units)	Recommended Additional Baseline Data Collection by Flow Regime					
		Extreme	**High**	**Moist**	**Mid**	**Dry**	**Low**
Sheep Creek	Flow (cfs)	**H**	**H**	**H**	**H**	**H**	**H**
	TSS (mg/L)	**H**	**H**	M	**H**	M	M
	Turbidity (NTU)	**H**	**H**	M	M	M	M

Note: **H** = high priority data gap as no data are currently available; M = medium priority data gap (some data are available, but data are limited); L = low priority for data collection as sufficient data are available.

Additional data collection is also useful for specific sources, to verify existing loads, and to document compliance. Source-specific monitoring recommendations are identified below.

- **Mining:** ADEC authorizes wastewater discharge from mining operations to surface waters through the APDES General Permit. APDES inspection and enforcement activities for active placers mines should focus on storm events when violations of APDES permit conditions are most likely to occur. Samples (flow, turbidity, and TSS) should be collected during each site visit. Additional data collection by the permit holder and associated annual reporting should be encouraged by ADEC. In addition, for historic sites or stream segments that require reclamation, BLM has developed guidance to support reclamation effectiveness monitoring. These guidelines are available at http://www.blm.gov/style/medialib/blm/ak/aktest/ims.Par.90269.File.dat/im_ak_2015_002-%20%20a2.pdf. Inspection of historic mining areas could help to identify priority sites for reclamation.
- **Construction:** Consistent with the ACGP, construction facilities are required to ensure that their discharge does not exceed specific WLAs or LAs. If a permittee discharges to a waterbody that is included on the state's CWA Section 303(d) list (Category 5 on the Integrated Report) as impaired for turbidity or sediment, and if that permittee disturbs more than twenty (20) acres of land at one time (including noncontiguous land disturbances that take place at the same time and are part of a larger common plan of development or sale), then that permittee must conduct turbidity sampling at locations as required by part 3 of Permit No. AKR100000 to evaluate compliance with the WQS for turbidity.
- **Fill Material:** Discharge of dredged or fill material to waters and wetlands of the United States requires a CWA Section 404 Permit. To meet Section 404 Permit requirements, steps must be taken to avoid or minimize impacts to aquatic resources; compensation must be provided for unavoidable impacts. Compliance with the permit will ensure these discharges meet the TMDL WQS.
- **MS4:** MS4 areas are required to meet TMDL allocations outlined in their NPDES MS4 stormwater permit. The MS4 area within the Upper Goldstream Watershed should monitor BMPs for effectiveness to ensure compliance with WQS.
- **Industrial:** Industrial stormwater discharges are covered under the MSGP[7]. The MSGP requires that discharge must be controlled to meet applicable WQS. Monitoring specifics are dependent on the industrial sector and are applicable to a specific discharge. Although no industrial permits are currently present that discharge to Upper Goldstream Creek, this information is pertinent for any future industrial facilities.
- **Transportation/Highway and Winter Road Maintenance:** Runoff from highways and roads should be monitored to ensure compliance with WQS. Installed BMPs should be monitored for effectiveness.

[7] http://dec.alaska.gov/water/wnpspc/stormwater/docs/AKG060000_-_2015_MSGP_Permit.pdf

7. Public Comments

The notice for the public review period was posted on May 18, 2015, and the review period will close on August 17, 2015. The notice was posted in the local newspaper, the Fairbanks Daily Newsminer, on ADEC's website, and on the State of Alaska's Public Notice Web Site. A fact sheet was also available on ADEC's website.

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Appendix A: Water Quality Data

Table A-1. Monthly turbidity, TSS, and flow data for Goldstream Creek

Parameter	Site	Year	Month	Average	Minimum	Maximum
TSS (mg/L)	Pedro	2013	June	18.90	18.90	18.90
			August	39.00	39.00	39.00
			September	2.17	2.02	2.31
	GS-1	2011	September	112.63	20.70	262.00
		2012	June	40.10	18.60	74.00
			August	2.82	1.60	5.20
		2013	May	940.00	940.00	940.00
			June	76.90	21.80	132.00
			July	12.26	2.25	31.50
			August	14.70	14.70	14.70
			September	6.58	5.99	7.16
	GS-2	2011	September	10.00	8.00	13.20
		2012	June	52.73	8.30	97.50
			August	10.26	1.91	18.60
		2013	May	237.00	237.00	237.00
			June	48.07	36.00	71.00
			July	9.91	4.22	20.70
			August	43.00	43.00	43.00
			September	8.15	6.81	10.30
	Ballaine	2013	May	131.00	131.00	131.00
			July	2.66	2.55	2.73
			August	6.18	6.18	6.18
			September	2.76	1.78	3.74
	Sheep Creek	2013	July	2.50	2.50	2.50
			August	1.25	1.25	1.25
			September	1.77	1.60	1.93
	GS-3	2011	September	4.03	2.50	5.40
		2012	June	35.33	21.90	51.00
Turbidity (NTU)	Pedro	2011	June	0.92	0.92	0.92
			July	0.90	0.90	0.90
		2012	August	0.93	0.50	1.58
		2013	May	184.50	153.00	216.00
			June	7.00	4.00	12.00
			July	5.16	1.85	10.60
			August	7.02	1.65	20.75
			September	5.23	1.52	26.42
	GS-1	2011	May	11.77	6.82	71.30
			June	54.68	3.63	265.00
			July	108.61	5.55	639.10
			August	251.05	9.68	674.00
			September	101.44	5.40	626.70
			September	16.70	16.70	16.70
		2012	May	45.73	11.00	247.10
			June	79.20	1.77	387.10
			July	27.67	9.33	117.00
			August	12.77	3.26	84.30
			September	39.94	3.40	318.10
		2013	May	420.50	370.00	471.00
			June	34.38	2.75	310.20
			July	12.50	3.29	152.80
			August	8.01	1.53	87.80
			September	7.22	4.29	97.70

Parameter	Site	Year	Month	Average	Minimum	Maximum
	GS-2	2011	May	20.09	0.74	107.20
			June	20.71	3.09	279.00
			July	35.47	3.02	380.30
			August	46.25	4.96	297.70
			September	53.05	5.23	314.00
			September	9.60	9.60	9.60
		2012	April	26.50	26.50	26.50
			May	52.13	6.86	376.20
			June	30.01	5.75	433.00
			July	13.36	4.54	158.10
			August	10.16	3.40	255.80
			September	11.87	3.85	105.30
		2013	May	81.00	81.00	81.00
			June	14.80	2.81	108.20
			July	28.28	1.46	314.20
			August	10.00	3.12	86.00
			September	37.54	3.61	262.60
	Ballaine	2012	August	3.46	3.46	3.46
		2013	May	25.00	25.00	25.00
			June	6.00	6.00	6.00
			July	5.37	4.28	6.50
			August	4.79	3.98	5.59
			September	4.37	2.85	5.89
	Sheep Creek	2013	June	9.00	6.00	12.00
			July	6.77	6.22	7.70
			August	6.70	6.66	6.73
			September	4.45	4.38	4.51
	GS-3	2011	May	18.00	10.60	23.50
			June	14.49	8.11	26.30
			July	19.73	10.70	28.00
			August	6.90	6.80	6.99
			September	6.92	6.64	7.19
		2012	June	14.17	6.94	21.40
Water Level (cm)	GS-1	2011	May	34.88	29.55	39.31
			June	30.14	24.87	50.23
			July	31.35	23.15	58.20
			August	27.16	22.50	55.58
			September	31.17	25.17	40.99
		2012	May	34.06	24.56	47.69
			June	19.58	13.55	51.00
			July	21.13	15.23	48.94
			August	24.91	19.89	55.92
			September	34.29	30.47	44.34
		2013	June	26.16	0.14	82.80
			July	19.37	13.74	42.97
			August	15.88	9.83	32.69
			September	22.39	17.87	35.24
	GS-2	2011	May	37.17	32.91	43.17
			June	26.98	16.92	35.44
			July	17.79	10.96	30.23
			August	26.33	12.87	35.61
			September	32.82	28.82	36.86
		2012	May	27.11	12.56	38.24

Parameter	Site	Year	Month	Average	Minimum	Maximum
			June	18.54	1.65	31.59
			July	25.61	12.91	37.96
			August	11.45	0.42	27.27
		2013	June	17.72	0.22	61.11
			July	19.66	15.68	30.25
			August	17.85	13.46	28.65
			September	21.27	18.23	29.29
Discharge (cfs)	GS-1	2011	June	4.87	2.60	7.80
			August	4.33	3.50	5.10
			September	2.50	2.50	2.50
		2012	June	2.27	1.00	3.20
		2013	June	5.45	2.60	8.30
			July	4.00	2.70	5.30
			September	4.80	4.80	4.80
	GS-2	2011	April	17.85	11.40	24.30
			May	25.54	13.30	52.30
			June	11.97	9.00	16.10
			July	18.07	14.60	24.00
			August	9.07	7.70	11.40
			September	8.50	8.50	8.50
		2012	May	7.00	7.00	7.00
			June	5.87	3.30	10.40
		2013	June	11.10	11.10	11.10
			July	16.00	16.00	16.00
			August	14.40	14.40	14.40
			September	16.00	16.00	16.00

Appendix B: Additional Data Summary

Data Analysis (Separation of continuous and grab sampling data)

The following sections discuss data analyses conducted to evaluate any important trends or impairments of water quality in the Upper Goldstream Creek watershed. These analyses are different than those presented in Section 3 of the main TMDL report as they separate the continuous and grab sampling data for stations with multiple data types. This section also includes an analysis of data at station GS-3, which lies downstream of the Upper Goldstream Creek watershed and is outside of the TMDL study area.

Pedro Creek Station

Table B-1, Figure B-1, and Figure B-2 summarize the daily maximum continuous data logger observed turbidity concentrations at the Pedro Creek station. Table B-2, Figure B-3, and Figure B-4 summarize the daily grab sample observed turbidity concentrations at the Pedro Creek station. The continuous monitoring data were consistently higher than the grab samples for all flow regimes. The low flow regime has the most similar results between the two sampling types. When evaluating the data on a log scale, as in the four figures, the data were all within the same order of magnitude.

Table B-1. Pedro Creek: Daily maximum of continuous turbidity data summary table

Daily Maximum Turbidity (NTU)	Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Number of Days	n = 0	n = 0	n = 2	n = 4	n = 14	n = 4
25th Percentile	ND	ND	10.80	6.81	10.41	3.10
Minimum	ND	ND	9.46	2.74	2.94	2.80
Median	ND	ND	12.13	8.36	14.71	3.32
Maximum	ND	ND	14.80	26.42	20.75	4.78
75th Percentile	ND	ND	13.47	13.01	16.72	3.78
Numeric Target*	199.50	9.45	9.45	9.85	9.00	7.17

ND = no data
*The numeric target is equal to the median daily continuous Pedro Creek turbidity value plus 5.

Table B-2. Pedro Creek: Grab sample turbidity data summary table

Turbidity (NTU)	Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Number of Samples	n = 2	n = 0	n = 6	n = 4	n = 4	n = 4
25th Percentile	168.75	ND	2.01	0.85	1.51	2.64
Minimum	153.00	ND	0.92	0.71	0.50	1.96
Median	184.50	ND	3.80	3.56	2.37	3.36
Maximum	216.00	ND	12.00	10.60	4.00	4.00
75th Percentile	200.25	ND	7.35	7.32	3.17	3.89
Numeric Target*	199.50	9.45	9.45	9.85	9.00	7.17

ND = no data
*The numeric target is equal to the median daily continuous Pedro Creek turbidity value plus 5.

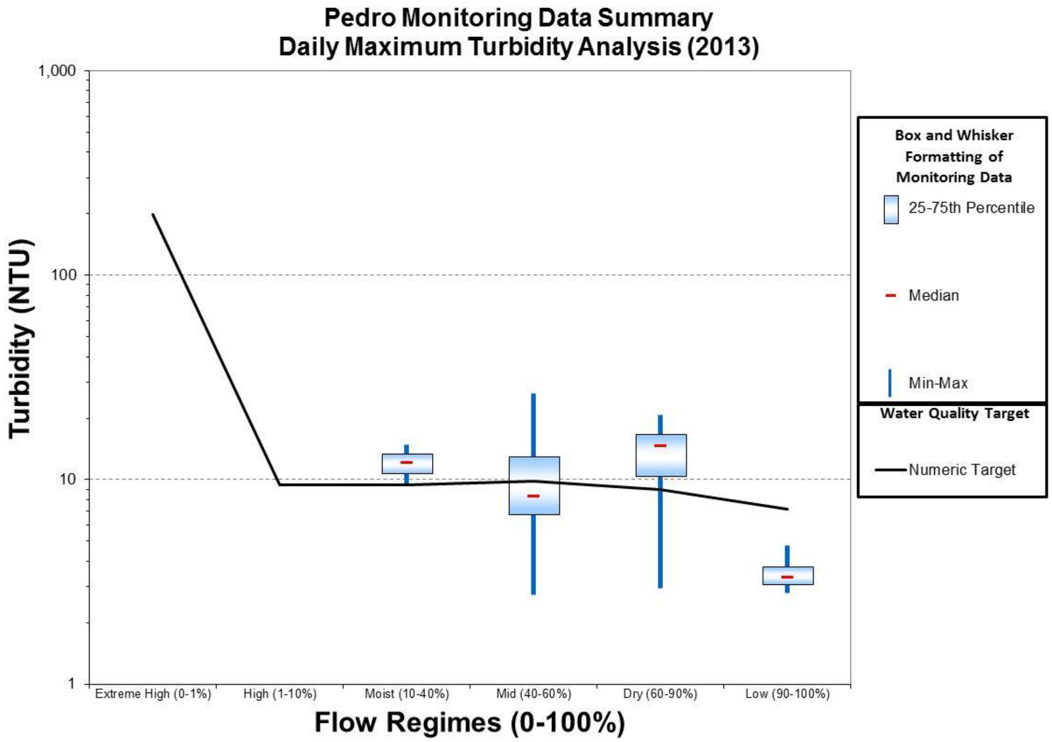

Figure B-1. Pedro Creek water quality duration curve for continuous daily maximum observed turbidity.

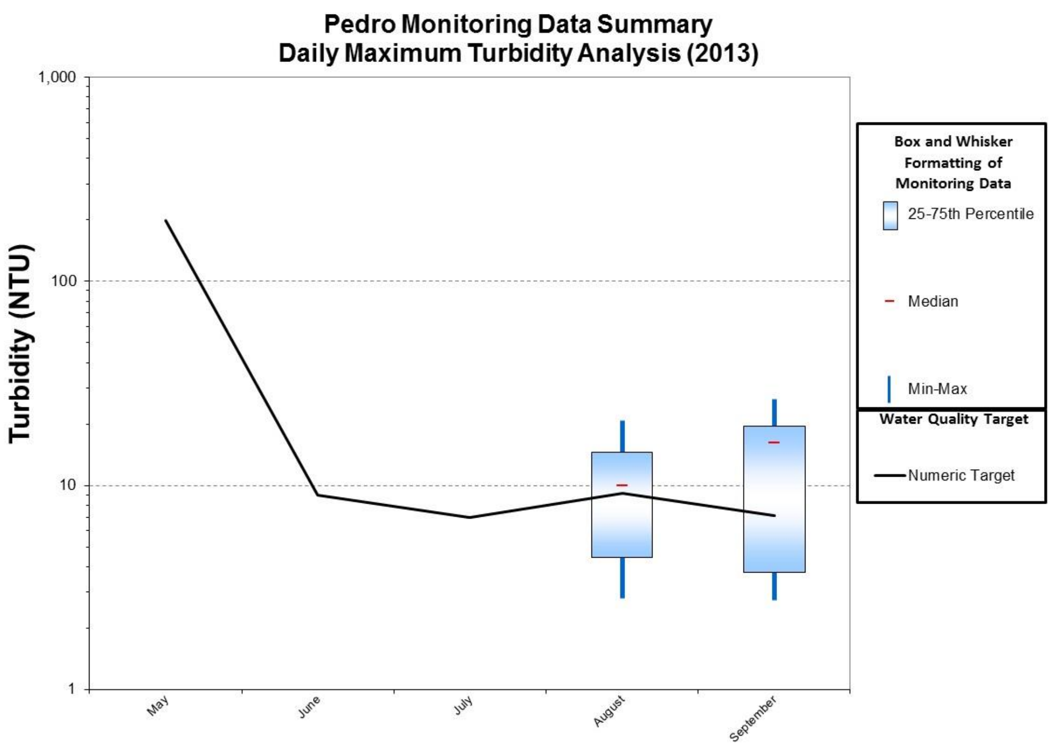

Figure B-2. Pedro Creek seasonal analysis for continuous daily maximum observed turbidity.

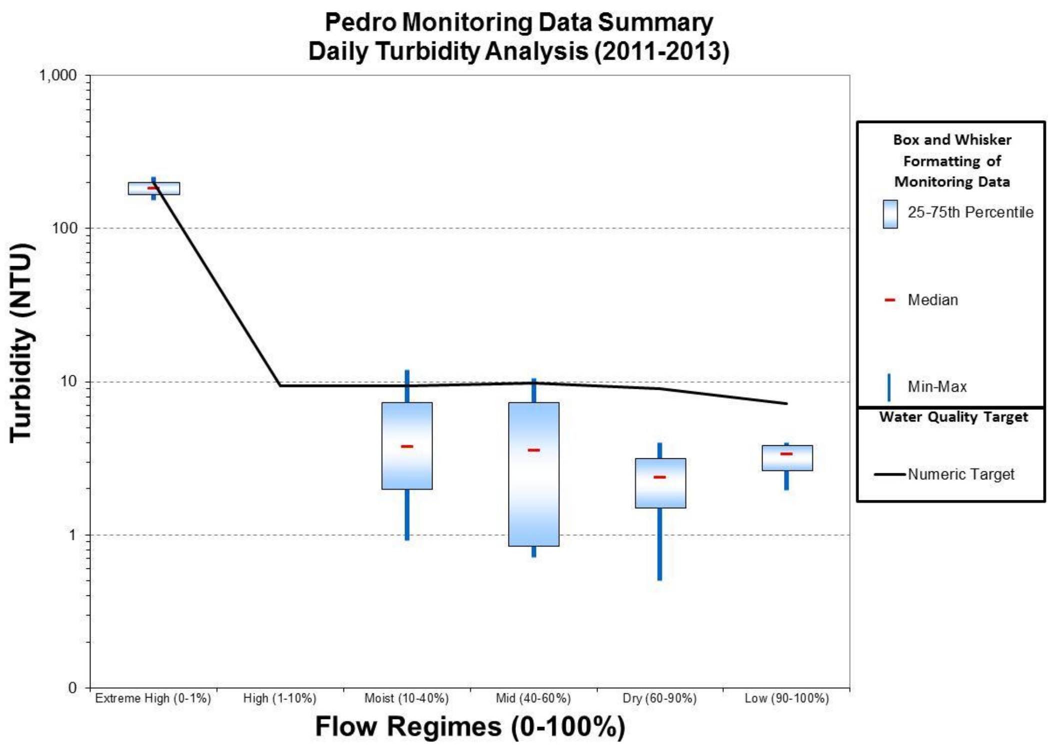

Figure B-3. Pedro Creek water quality duration curve for daily grab sample turbidity.

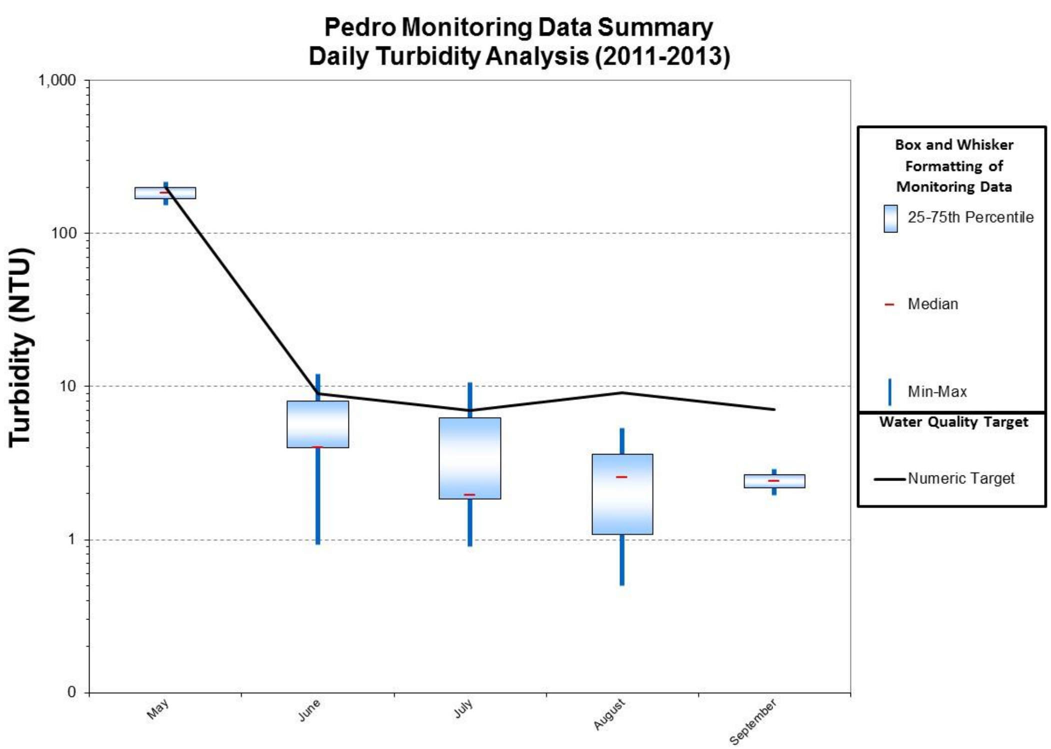

Figure B-4. Pedro Creek seasonal analysis for daily grab sample turbidity.

Station GS-1 (Gilmore Creek)

Table B-3, Figure B-5, and Figure B-6 summarize the maximum daily continuous data logger observed turbidity concentrations at the GS-1 Gilmore Creek station, while Table B-4, Figure B-7, and Figure B-8 summarize the daily grab sample observed turbidity concentrations at this station. The largest difference between the two datasets at this station was in the dry and low flow regimes, where the upper end of the continuous measurements were much higher than the grab sample data. This is particularly evident when evaluating the figures, including the summer months in the seasonal analyses.

Table B-3. GS-1: Daily maximum of continuous turbidity data summary table

Daily Maximum Turbidity (NTU)	Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Number of Days	n = 3	n = 28	n = 98	n = 69	n = 104	n = 34
25th Percentile	248.60	54.47	32.70	38.89	8.94	4.69
Minimum	187.00	8.91	8.87	9.14	3.97	2.07
Median	310.20	123.00	72.21	82.50	22.46	10.71
Maximum	639.10	626.70	665.20	674.00	366.30	387.10
75th Percentile	474.65	245.53	140.68	261.00	82.78	25.75
Numeric Target*	199.50	9.45	9.45	9.85	9.00	7.17
Load Reduction	68.78%	98.49%	98.58%	98.54%	97.54%	98.15%

*The numeric target is equal to the median daily continuous Pedro Creek turbidity value plus 5.

Table B-4. GS-1: Grab sample turbidity data summary table

Daily Maximum Turbidity (NTU)	Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Number of Samples	n = 2	n = 6	n = 22	n = 8	n = 5	n = 4
25th Percentile	395.25	27.90	8.03	6.78	4.13	3.46
Minimum	370.00	8.30	3.40	5.55	3.82	3.00
Median	420.50	67.15	13.85	7.13	4.29	3.81
Maximum	471.00	265.00	526.00	205.00	12.10	5.00
75th Percentile	445.75	148.33	19.05	30.78	6.00	4.25
Numeric Target*	199.50	9.45	9.45	9.85	9.00	7.17
Load Reduction	57.64%	96.43%	98.20%	95.20%	25.62%	0%

*The numeric target is equal to the median daily continuous Pedro Creek turbidity value plus 5 NTU.

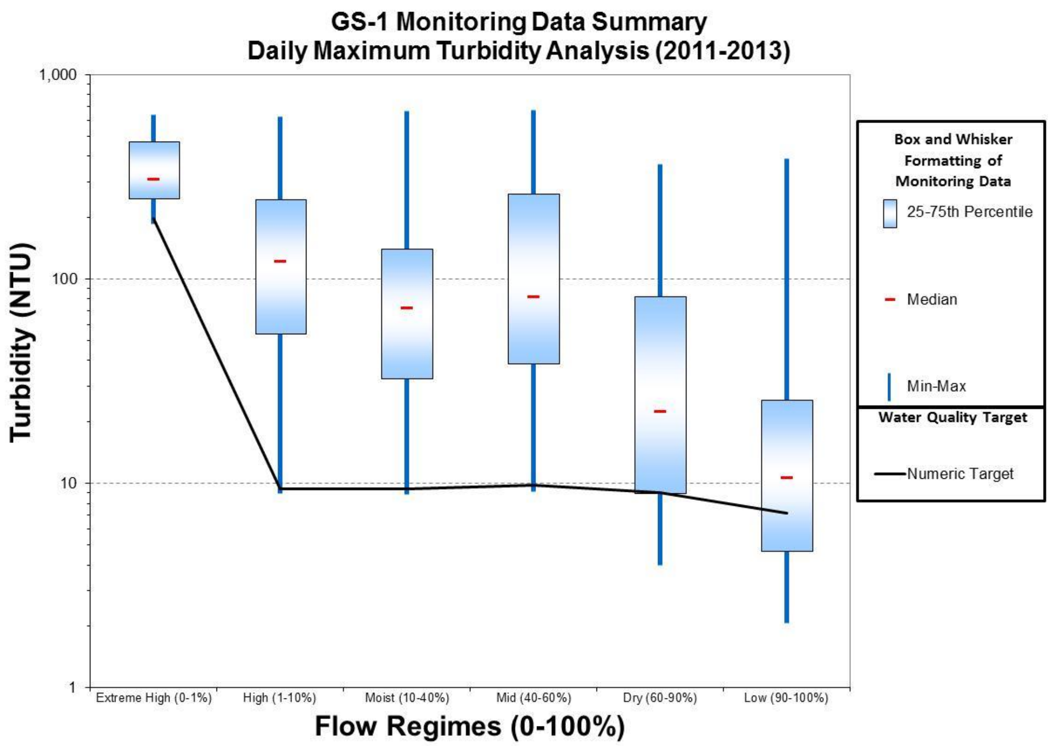

Figure B-5. GS-1 water quality duration curve for continuous daily maximum observed turbidity.

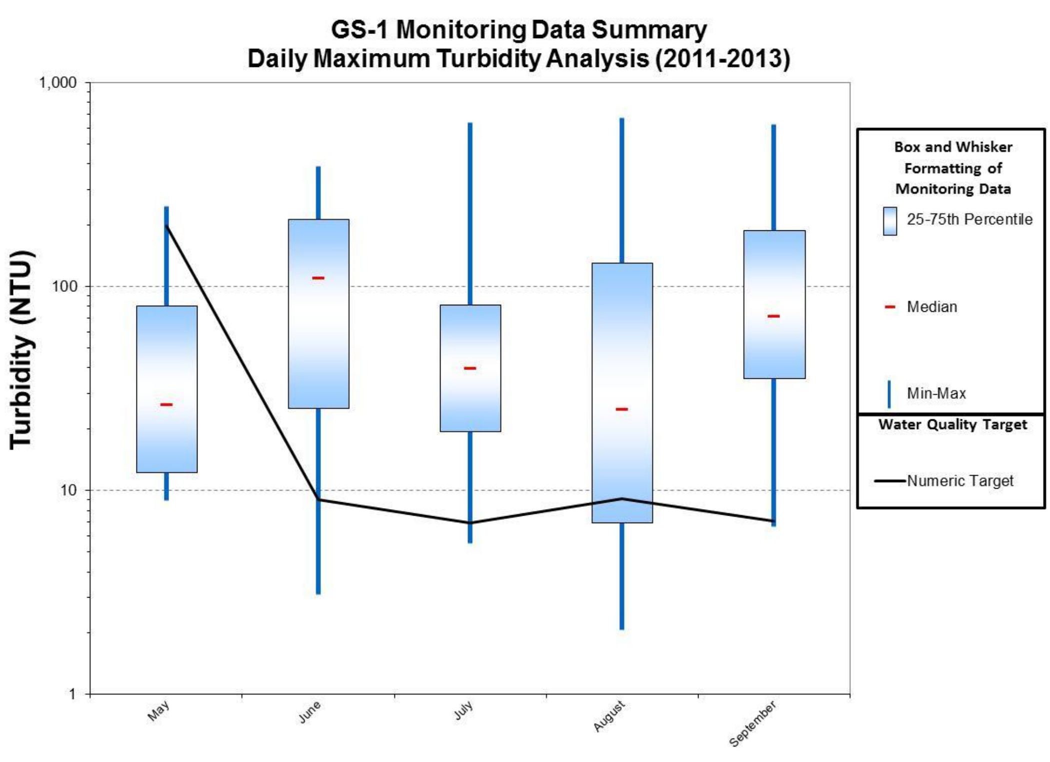

Figure B-6. GS-1 seasonal analysis for continuous daily maximum observed turbidity.

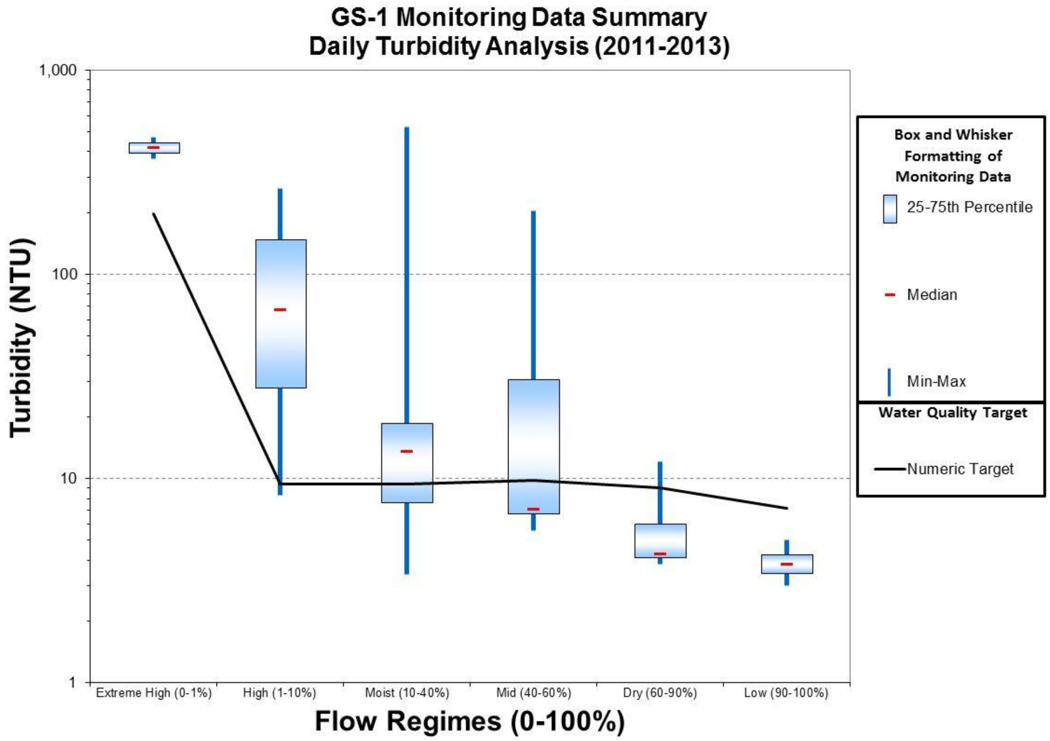

Figure B-7. GS-1 water quality duration curve for daily grab sample turbidity.

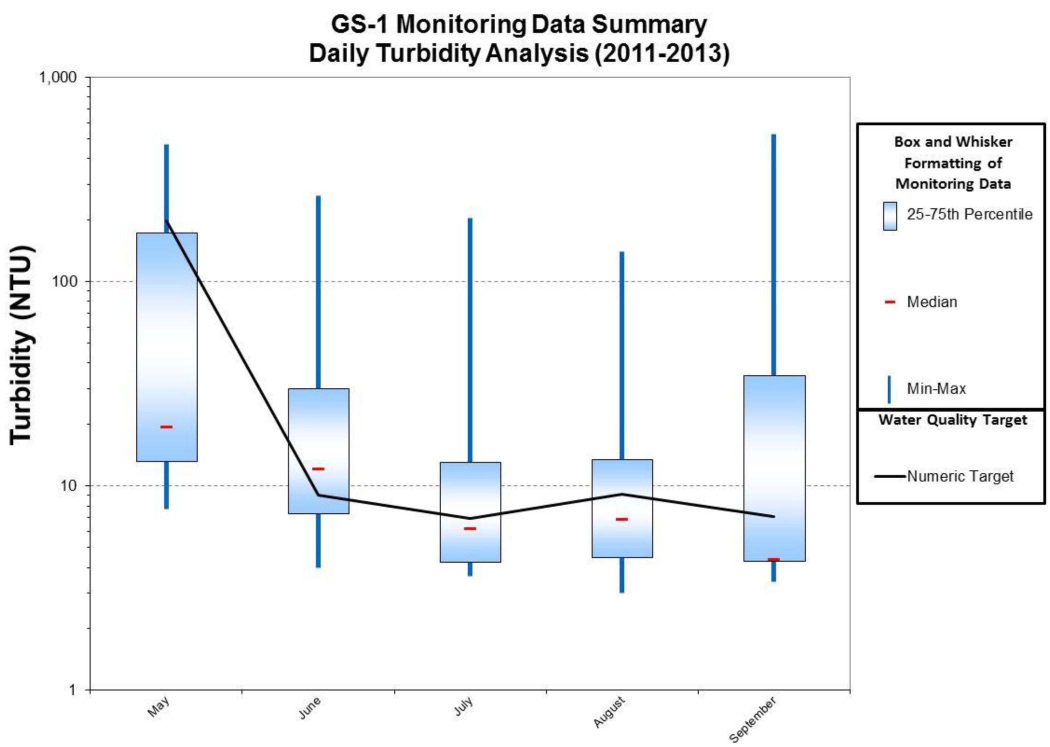

Figure B-8. GS-1 seasonal analysis for daily grab sample turbidity.

Station GS-2 (Goldstream Creek)

The data for the GS-2 Goldstream Creek station are summarized below. Specifically, Table B-5, Figure B-9, and Figure B-10 present the maximum continuous data logger observed turbidity concentrations and Table B-6, Figure B-11, and Figure B-12 summarize the daily grab sample data. The extreme high and low flow regimes show the largest differences in sampling type, with the continuous measurements much higher than the grab sample results. Overall, the two sampling types show similar patterns when evaluating flow regimes and seasonal patterns.

Table B-5. GS-2: Daily maximum of continuous turbidity data summary table

Daily Maximum Turbidity (NTU)	Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Number of Days	n = 3	n = 30	n = 111	n = 63	n = 101	n = 34
25th Percentile	82.57	40.95	17.47	16.81	9.16	10.77
Minimum	38.73	17.68	4.27	6.40	4.89	5.88
Median	126.40	101.00	39.81	53.24	16.89	16.67
Maximum	380.30	300.30	376.20	221.70	314.20	110.40
75th Percentile	253.35	163.40	83.60	108.55	51.57	52.44
Numeric Target*	199.50	9.45	9.45	9.85	9.00	7.17
Load Reduction	47.54%	96.85%	97.49%	95.56%	97.14%	93.50%

*The numeric target is equal to the median daily continuous Pedro Creek turbidity value plus 5.

Table B-6. GS-2: Grab sample turbidity data summary table

Daily Maximum Turbidity (NTU)	Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Number of Samples	n = 2	n = 11	n = 33	n = 10	n = 8	n = 3
25th Percentile	61.50	13.65	8.81	7.44	6.49	7.75
Minimum	55.00	3.28	4.20	4.40	5.27	6.12
Median	68.00	22.90	12.20	11.60	14.35	9.37
Maximum	81.00	279.00	81.30	166.20	433.00	12.00
75th Percentile	74.50	26.40	24.30	17.33	20.05	10.69
Numeric Target*	199.50	9.45	9.45	9.85	9.00	7.17
Load Reduction	0%	96.61%	88.38%	94.07%	97.92%	40.24%

*The numeric target is equal to the median daily continuous Pedro Creek turbidity value plus 5 NTU.

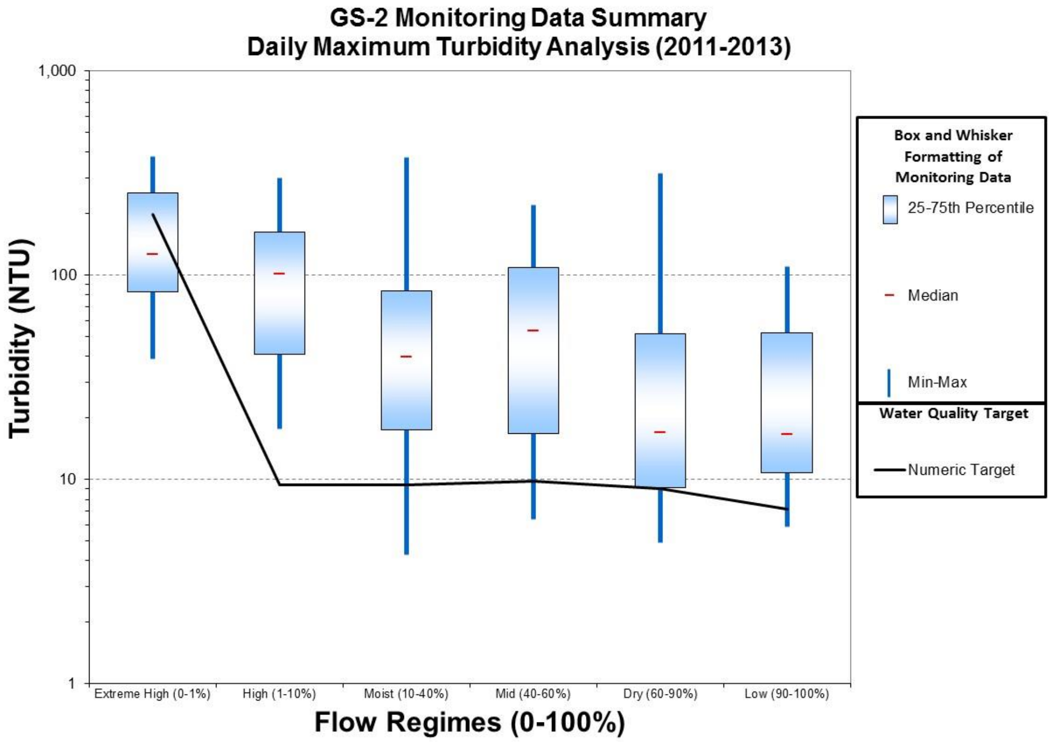

Figure B-9. GS-2 water quality duration curve for continuous daily maximum turbidity.

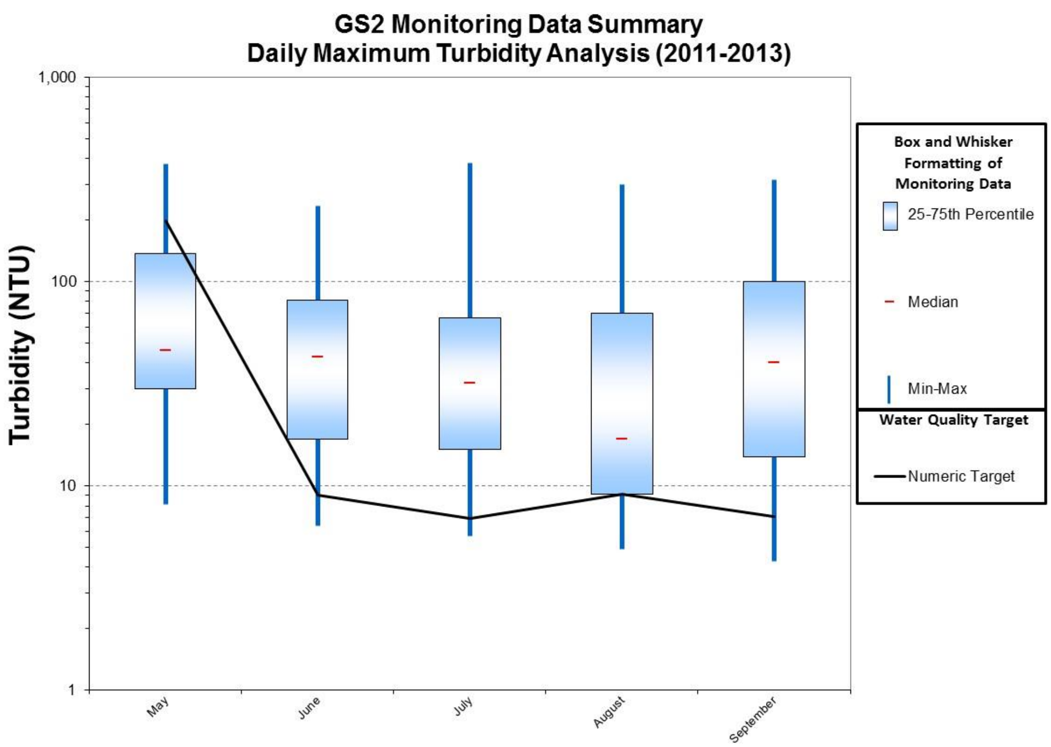

Figure B-10. GS-2 seasonal analysis for continuous daily maximum turbidity.

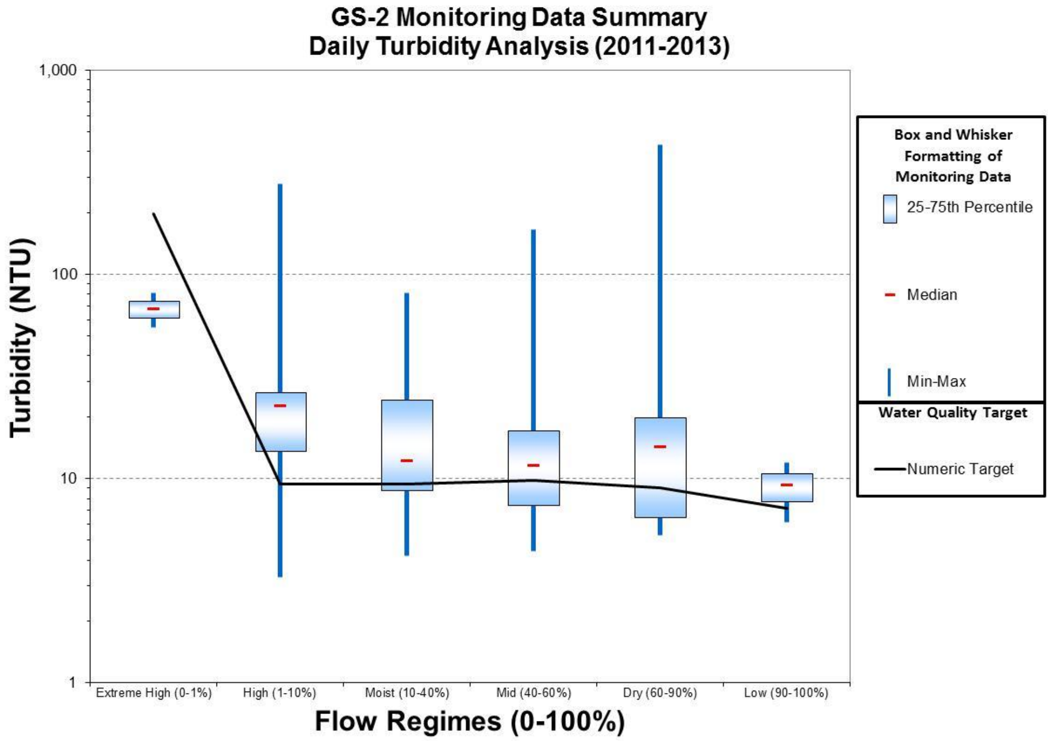

Figure B-11. GS-2 water quality duration curve for daily grab sample turbidity.

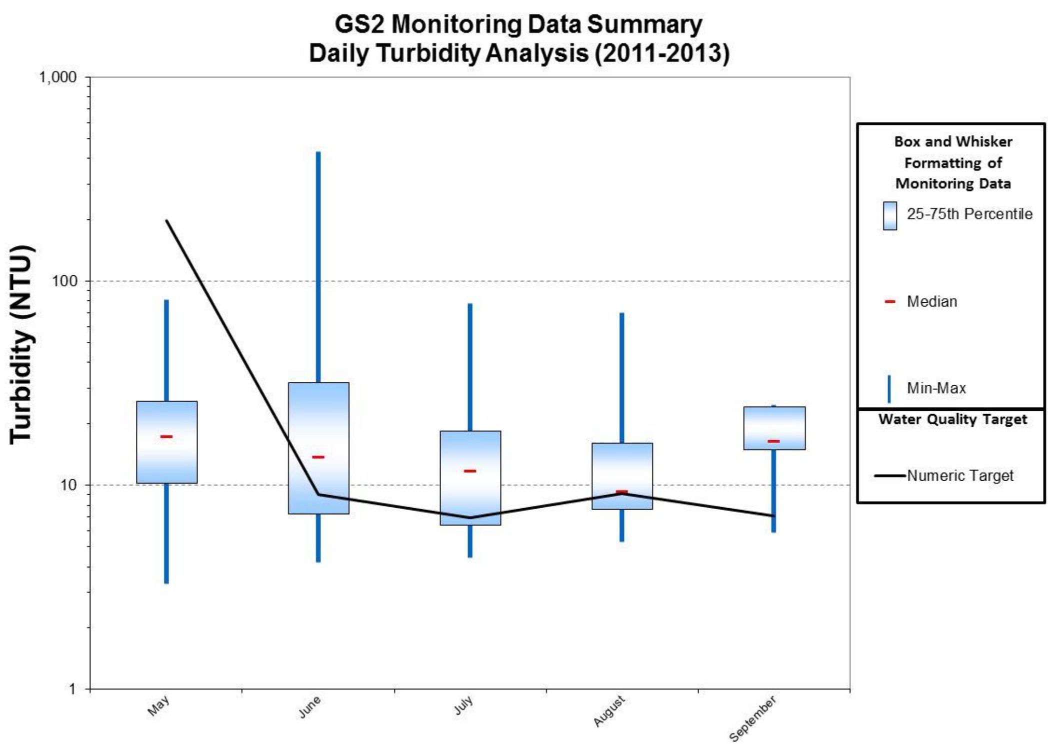

Figure B-12. GS-2 seasonal analysis for daily grab sample turbidity.

Station GS-3 (Goldstream Creek)

Station GS-3, which drains 250 square miles, was sampled from 2011 through 2012 for turbidity and TSS (Table B-7 and Table B-8, respectively). All data were grab samples, so the sample sizes are limited. There are no turbidity and TSS data for the extreme high and low flow regimes; the high flow regime is also lacking TSS data. Turbidity data are represented graphically in Figure B-13. This figure shows that the data are above the numeric targets during high, moist, and mid-range flows. Figure B-14 looks at GS-3 data seasonally. Observed turbidity values are similar in May, June, and July and lower in August. This site is in the lower portion of the watershed, which has low relief and is more forested than the upper semi-mountainous portions of the Upper Goldstream Creek watershed. Although these figures and tables do compare to the TMDL numeric target, this comparison is for illustrative purposes only and does not represent impairment. Specifically, the numeric targets in the TMDL are based on representative natural conditions. These targets are not considered applicable to the GS-3 site because GS-3 represents a separate geographic area, which would have different natural conditions than the Upper Goldstream Creek watershed addressed in this TMDL.

GS-3 is located much further downstream from the other Goldstream Creek stations. This station is located in a flatter, slower moving portion of the creek and is topographically very different from the other upstream stations. It is located downstream of wetland areas and within a state forest area. Because of its location, additional development is not anticipated near GS-3. In addition, mining activities in the watershed primarily take place in the upper portions of the watershed and are not expected to contribute turbidity to Goldstream Creek at GS-3. Given the separate location and different sources involved, the numeric targets based on water quality data from the Pedro Creek station are not considered applicable to water quality at station GS-3, and this station was determined to be outside of the TMDL study area.

Table B-7. GS-3: Daily turbidity data summary table

Turbidity (NTU)	Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Number of Samples	n = 0	n = 1	n = 11	n = 4	n = 1	n = 0
25th Percentile	ND	26.30	7.09	10.29	6.94	ND
Minimum	ND	26.30	6.64	9.06	6.94	ND
Median	ND	26.30	10.60	15.60	6.94	ND
Maximum	ND	26.30	28.00	21.40	6.94	ND
75th Percentile	ND	26.30	20.45	20.73	6.94	ND
Numeric Target*	199.50	9.45	9.45	9.85	9.00	7.17

ND = no data
*The numeric target is equal to the median daily continuous Pedro Creek turbidity value plus 5 NTU.

Table B-8. GS-3: Observed TSS data summary table

TSS (mg/L)	Extreme (0-1%)	High (1-10%)	Moist (10-40%)	Mid (40-60%)	Dry (60-90%)	Low (90-100%)
Number of Samples	n = 0	n = 0	n = 2	n = 1	n = 1	n = 0
25th Percentile	ND	ND	3.35	51.00	22.30	ND
Minimum	ND	ND	2.67	51.00	22.30	ND
Median	ND	ND	4.04	51.00	22.30	ND
Maximum	ND	ND	5.40	51.00	22.30	ND
75th Percentile	ND	ND	4.72	51.00	22.30	ND
Numeric Target*	331.71	15.71	15.71	16.38	14.96	11.92

ND = no data
*The numeric target is equal to the median daily continuous Pedro Creek turbidity value plus 5 NTU converted to a TSS concentration based on the equation in Figure 2-1.

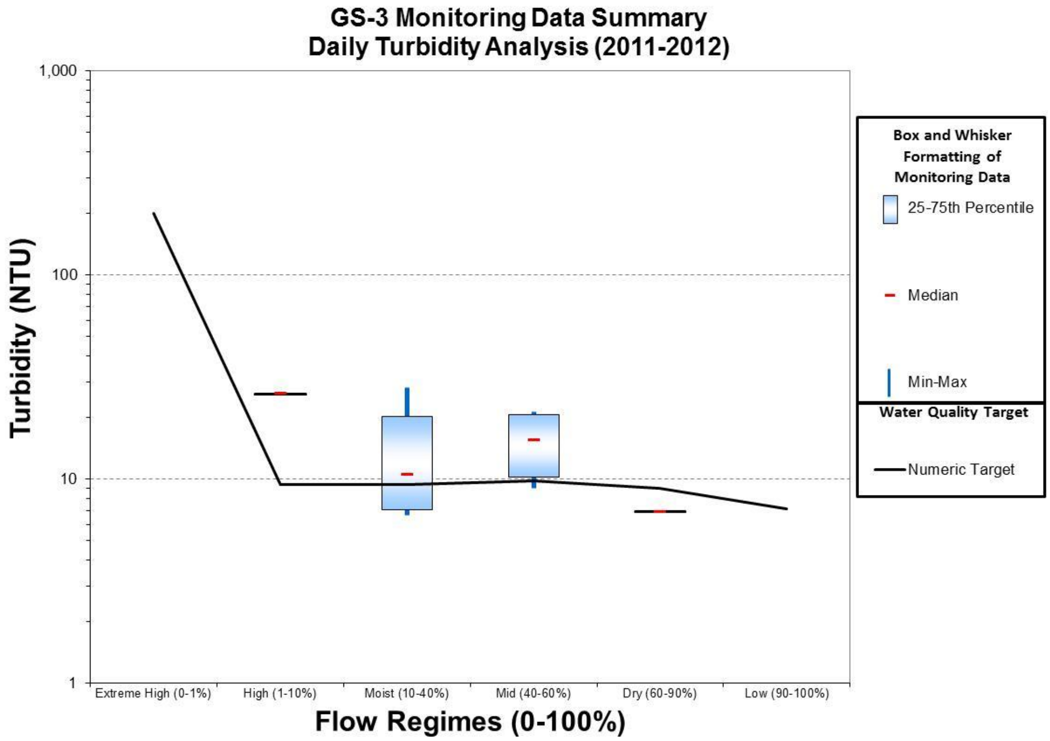

Figure B-13. GS-3 water quality duration curve for daily observed turbidity.

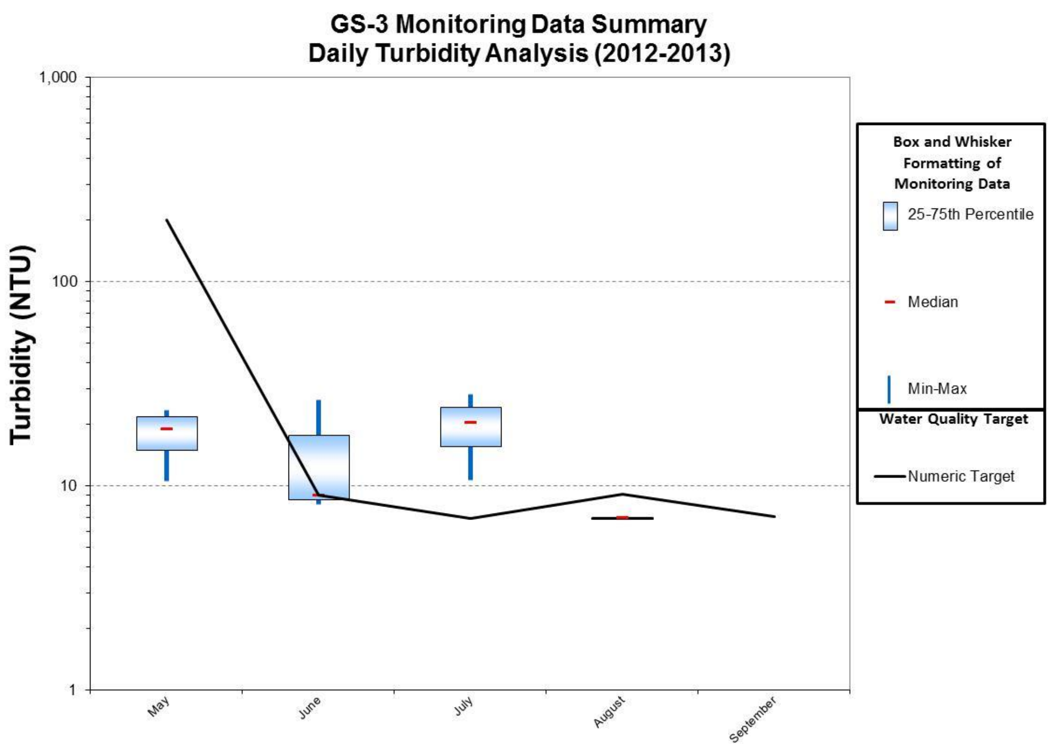

Figure B-14. GS-3 seasonal analysis for daily observed turbidity.