Suspended Sediment Patterns in the South Fork Clearwater River and Selected Tributaries (2021)



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Prepared by
Jason Williams
Idaho Department of Environmental Quality
Lewiston Regional Office
1118 F St
Lewiston, ID 83501

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Table of Contents

Executive Summary vii
1 Introduction 1
2 Study Area 2
3 Objectives 7
4 TMDL Targets 7
5 Methods 8
5.1 Discharge Measurements 8
5.2 Stream Gage Discharge 10
5.3 Suspended Sediment and Turbidity 11
5.4 Suspended Sediment Loads 12
5.5 Comparison to TMDL Targets 13
5.6 Quality Assurance/Quality Control (QA/QC) 13
6 Results 14
6.1 Stream Discharge 14
6.2 SSC and Turbidity 17
6.3 Suspended Sediment Loads 20
6.4 Comparison to TMDL Targets 22
7 Discussion 22
8 Conclusions 26
9 Data Availability 27
References 28
Appendix A. Tributary Rating Curves 30
Appendix B. LOADEST Model Information 36
Appendix C. Quality Assurance/Quality Control Summary 37

List of Tables

Table 1. Monitoring locations. 3
Table 2. Suspended sediment concentration (SSC) targets defined in the South Fork Clearwater River TMDL (DEQ and EPA 2004) and Cottonwood Creek TMDL (DEQ and EPA 2000) 7
Table 3. Site total study period suspended sediment loads (metric tons) estimated using LOADEST. 21

List of Figures

Figure 1. South Fork Clearwater River watershed, monitoring sites, and stream segments with a sediment TMDL. 3
Figure 2. Main stem at Stites (USGS 13338500) looking upstream (top left) and downstream (top right), main stem at Wimer Bridge near Harpster (USGS 13338100) looking upstream (bottom left), and main stem above Crooked River near Elk City looking downstream (USGS 13337500) (bottom right). 4
Figure 3. Camas Prairie tributary sites. Cottonwood creek looking upstream (top left) and downstream (top right); Threemile Creek looking upstream (center left) and downstream (center right); Butcher Creek looking upstream (bottom left) and downstream (bottom right). 5
Figure 4. Forest tributary site photos. Red River looking upstream (top left) and downstream (top right); South Fork Red River looking upstream (center left) and downstream (center right); Johns Creek looking upstream (bottom left) and downstream (bottom right). 6
Figure 5. Measuring discharge in South Fork Red River using an acoustic doppler current profiler (ADCP) during non-wadable conditions on 5-19-2021 (180 cfs), and example stream channel velocity profile output from one channel transect. 10
Figure 6. Stream discharge (A), suspended sediment concentration (SSC) (B), and turbidity (C) patterns measured by USGS on the main stem South Fork Clearwater River. In (A), lines are gage-predicted discharge and shapes are measured discharge. 15
Figure 7. Daily mean discharge at Stites (13338500) 1964-2022. 16
Figure 8. Seasonal mean daily discharge at Stites (13338500) during April-June each year 1964-2021. The black line represents the seasonal daily discharge trend calculated using locally-weighted smoothing methods described in Hirsch and DeCico (2015). The circled point indicates seasonal mean daily discharge during the study period. 16
Figure 9. Stream discharge (ft^3/s) (A) suspended sediment concentration (SSC) (mg/L) (B), and turbidity (C) patterns for Camas Prairie tributaries. In the discharge plot (A) circles are measured discharge and lines are gage-predicted discharge. 18
Figure 10. Stream discharge (ft^3/s) (A) suspended sediment concentration (SSC) (mg/L) (B), and turbidity (C) patterns for tributaries within the Nez Perce-Clearwater National Forest. In the discharge plot (A) circles are measured discharge and lines are gage-predicted discharge. 19
Figure 11. Estimated daily suspended sediment loads (a, b), study period total suspended sediment loads (c), and total study period total suspended sediment loads per km^2 upstream area (d). Error bars indicate lower and upper bound estimates. Units are metric tons. In a) and b), points are field-measured instantaneous loads, and lines are LOADEST-predicted daily average loads. Note that load estimate time periods differ across sites (see Table 4). 20
Figure 12. Comparison of measured and TMDL target suspended sediment concentration (SSC) values for sites where TMDLs defined targets. 22
Figure 13. Daily mean discharge at Stites (a) and corresponding LOADEST-based SSC loads estimates for the main stem South Fork Clearwater River (b). In (b), colors indicate

agency that collected monitoring data. 'WY' indicates 'water year' (October 1-September 30). 23
Figure 14. Main stem suspended sediment loads expressed per km^2 upstream watershed area. 25
Figure 15. Comparison of suspended sediment concentration (SSC) loads at Stites and Harpster measured in the field on the same day (2009-2021, N= 30, USGS data). The dashed line is a 1:1 line (Harpster load = Stites load). 26

Abbreviations, Acronyms, and Symbols

AIC	Akaike information criterion
ASTM	American Society for Testing Materials
cfs	cubic feet per second
CWA	Clean Water Act
DEQ	Idaho Department of Environmental Quality
EDI	Equal discharge interval
FNU	Formazin nephelometric unit
IASCD	Idaho Association of Soil Conservation Districts
IDAPA	Idaho Administrative Code
LOADEST	USGS load estimation software
NPT	Nez Perce Tribe
NPT-WR	Nez Perce Tribe Water Resources Division
NTU	Nephelometric turbidity unit
NWIS	National Water Information System
QA/QC	Quality assurance/quality control
QAPP	Quality Assurance Project Plan
RAC	Resource Advisory Committee
SFCR	South Fork Clearwater River
SSC	Suspended sediment concentration
TMDL	Total maximum daily load
USEPA	US Environmental Protection Agency
USFS	US Forest Service
USGS	US Geological Survey

Executive Summary

The main stem South Fork Clearwater River (SFCR) and several of its tributaries were listed as impaired by sediment under the Clean Water Act (CWA) in 1994 because excess stream sediment was assessed as negatively affecting aquatic life and salmonids. The CWA requires states to develop a water quality improvement plan called a total maximum daily load (TMDL) for impaired waters, and the U.S. Environmental Protection Agency to review and either approve or disapprove TMDLs. The Idaho Department of Environmental Quality (DEQ), Nez Perce Tribe (NPT), and US Environmental Protection Agency (USEPA) cooperatively developed sediment TMDLs for the SFCR watershed with assistance from the US Forest Service (USFS) and other partner agencies and stakeholders. The TMDLs defined suspended sediment concentration and load targets that must be met to achieve state water quality standards and thereby protect aquatic life and salmonids.

During 2021, DEQ, NPT, USFS, and the U.S. Geological Survey (USGS) collaboratively monitored the main stem SFCR and several tributaries to document sediment loading spatial patterns and evaluate progress towards achieving TMDL goals. Monitored locations included three main stem sites: main stem at Stites (USGS-13338500), the main stem near the Nez Perce-Clearwater Forest boundary (USGS-13338100), the main stem near Elk City (USGS-13337500); three lower watershed tributaries: Cottonwood Creek, Threemile Creek, and Butcher Creek; and three tributaries within the Nez Perce-Clearwater National Forest: Johns Creek, Red River, and South Fork Red River. The monitoring project was funded by a grant from the North Central Idaho Resource Advisory Committee (Project # 17-20-39). This report documents monitoring methods and results.

Objective 1 - Evaluate compliance with TMDL suspended sediment concentration targets.

Measured suspended sediment concentrations (SSC) exceeded the TMDL target during two sample events at the Threemile Creek mouth but did not exceed the TMDL target during the study period at other locations with TMDL targets: Cottonwood Creek, the Butcher Creek mouth, the main stem at Stites (USGS-13338500), and the main stem upstream of Harpster near the forest boundary at Wimer bridge (USGS-13338500). On the main stem, discharge during the spring high flow period when most sediment transport occurs was lower than in most years; daily average discharge peaked at 4,060 cubic feet per second (cfs), whereas in past years all target exceedances at the forest boundary and most target exceedances at Stites occurred in years when flows exceeded 5,000 cfs. In tributaries, spring discharge was also likely lower than most years, but limited historic discharge data are available. The absence of target exceedances during the study period may be due to low spring discharge rather than reduced sediment inputs. Due to inter-annual variability in discharge and its effects on suspended sediment, consistent long-term monitoring would be needed to adequately track progress towards achieving TMDL goals. Targets in the TMDL were developed based on a watershed sediment budget that may not be representative of current conditions. DEQ is evaluating the adequacy of existing TMDL targets as part of a separate ongoing TMDL review process.

Objective 2 - Estimate total suspended sediment loads during the study period for each monitoring site.

Suspended sediment loads were estimated for the three sites on the main stem South Fork Clearwater River, and for five tributaries (Table A1). Loads could not be estimated for Johns Creek due to an equipment failure. For each location, total study period loads and associated upper and lower bound load estimates were developed using USGS LOADEST software. Load estimate time periods differed across sites because monitoring time periods differed across sites. Main stem loads were lower than in prior years where data were available, likely primarily due to relatively low spring discharge.

Table A1. Total estimated study period suspended sediment loads (metric tons).

Site	Time Period	Days	Load Estimate (tons)	Lower (tons)	Upper (tons)	Upstream Area (km^2)	Area load (tons/km^2)
Main stem at Stites (USGS-13338500)	12/10/2020– 11/30/2021	356	5,026	3,278	7,398	3,024	1.66
Main stem at forest boundary (USGS-13338100)	12/10/2020-11/29/2021	355	4,138	2,665	6,154	2,217	1.87
Main stem near Elk City (USGS-13337500)	11/19/2020-10/17/2021	333	1,014	763	1,323	677	0.46
Cottonwood Creek	2/10/2021-12/6/2021	300	204	128	309	499	0.41
Threemile Creek	2/22/2021-12/6/2021	288	47	21	94	86	0.55
Butcher Creek	3/2/2021-12/6/2021	280	14	9	20	44	0.32
Red River	4/26/2022-12/7/2021	226	78	56	105	129	0.60
South Fork Red River	4/29/2021-12/7/2021	223	50	30	767	98	0.51

Objective 3 - Evaluate the relative contribution of the upper (forested) and lower (Camas Prairie) watershed areas to total suspended sediment loads in the main stem South Fork Clearwater River by comparing loads in the main stem near the forest boundary (main stem at Wimer Bridge, USGS 13338100) and at Stites (USGS 13338500).

During December 2020-November 2021, the total suspended sediment load estimated for the main stem at the forest boundary was 82% of the suspended sediment load in the main stem at Stites. When loads were expressed on an area basis (i.e. tons per upstream km^2 watershed area), loading rates were similar for main stem upstream at the forest boundary (1.87 tons/km^2) and at Stites (1.66 tons/km^2). These general patterns are consistent with those observed based on main stem suspended sediment monitoring conducted 2006-2011. Across years where data were available, main stem load estimates near the forest boundary represented 65-91% of loads at Stites, 76.9% on average. Multiple lines of evidence strongly

suggest sediment loading in the main stem comes primarily from the upper forested portion of the watershed. The relative contribution of human and background sources to these sediment loading patterns is beyond the scope of this report and merits further investigation.

1 Introduction

The main stem South Fork Clearwater River (SFCR) and several of its tributaries were listed as impaired by sediment under the Clean Water Act (CWA) (Figure 1) in 1994 because excess stream sediment was identified as negatively affecting aquatic life and salmonids (USEPA 1994). The CWA requires states to develop a water quality improvement plan called a total maximum daily load (TMDL) for impaired waters, and the U.S. Environmental Protection Agency to review and either approve or disapprove TMDLs. The Idaho Department of Environmental Quality (DEQ), Nez Perce Tribe (NPT), and US Environmental Protection Agency (USEPA) cooperatively developed sediment TMDLs for the SFCR watershed with assistance from the US Forest Service (USFS) and other partner agencies and stakeholders. Separate sediment TMDLs were developed and approved for the Cottonwood Creek watershed (Figure 1) (DEQ and EPA 2000) and the remainder of the SFCR watershed (DEQ and EPA 2004). The TMDLs defined suspended sediment concentration (SSC) and suspended sediment load targets that must be met to achieve state water quality standards and thereby protect aquatic life and salmonids (DEQ and EPA 2000; DEQ and EPA 2004).

From 2000-2020, at least $25 million dollars were spent across at least 60 water quality and stream habitat improvement projects in the watershed (DEQ 2020), but it is not clear if these efforts have achieved TMDL goals or decreased suspended sediment loads because limited TMDL compliance monitoring data are available. In 2020, DEQ began a TMDL progress review required by Idaho Code §39-3611(7) and summarized available monitoring data (DEQ 2020). Available data indicated TMDL SSC targets were not yet achieved, but most available monitoring data were from 2012 or prior. Suspended sediment concentration and loading trends could not be determined because trend analysis requires consistent long-term flow and SSC monitoring data that were not available. The Nez Perce-Clearwater National Forest developed (USFS 2006) and from 2006-2010 implemented a TMDL compliance monitoring program on the main stem SFCR, but very limited main stem suspended sediment data were available after 2011. The Idaho Association of Soil Conservation Districts (IASCD), NPT, DEQ, and USFS monitored suspended sediment in some tributaries, but monitoring was sporadic across years, and most data were from 2012 or prior.

In 2020, DEQ collaborated with USFS, Nez Perce Tribe Water Resources (NPT-WR), and the US Geological Survey (USGS) to develop a North Central Idaho Resource Advisory Committee (RAC) grant proposal to fund suspended sediment monitoring for TMDL compliance evaluation and other purposes. The ‘Secure Rural Schools and Community Self-Determination Act of 2000’ passed by the U.S. Congress requires a portion of funds generated by timber production, grazing, special use permits, and other activities on USFS lands to be distributed to counties with USFS lands and established local citizens committees (RACs) to advise USFS on how to allocate these funds (USFS 2022). In 2020, DEQ, USFS, NPT, and USGS requested funding for three years of suspended sediment monitoring on the main stem SFCR and several tributaries, and the RAC committee funded one year of monitoring ($86,496, RAC Project # 17-20-39). This

report documents methods and results for monitoring conducted November 2020 through December 2021 using North Central Idaho RAC funds.

2 Study Area

The SFCR watershed is in north central Idaho (Figure 1). The SFCR is a fifth order river that drains approximately 1,175 square miles within Idaho County, Idaho. The watershed extends from the headwaters above Elk City (elevation 6,382 feet) to the confluence with the Middle Fork of the Clearwater River at Kooskia (1,280 ft). Watershed land use is primarily forest (69%), dryland farming (15%), and grassland (7.5%), with less than 1% developed area. Most of the watershed upstream from Harpster is within the boundaries of the Nez Perce-Clearwater National Forest (Figure 1). The lower 12.8 miles of the main stem South Fork Clearwater River flows through the Nez Perce reservation, with approximately 11% of total subbasin area (~131 square miles) within the reservation. Much of the non-forested area within the lower watershed falls within the Camas Prairie, characterized by relatively flat topography, dryland farming land use, and basalt geology, whereas the upper watershed is more topographically complex, primarily forest, and has schist, gneiss, quartzite, and granitic underlying geology. Subbasin physical and biological characteristics are described in detail with the *Cottonwood Creek Total Maximum Daily Loads* (DEQ and EPA 2000) and *South Fork Clearwater River Subbassin Assessment and TMDLs* (DEQ and EPA 2004).

Project monitoring sites include three sites on the main stem SFCR and six tributary streams (Figure 1, Table 1, Figures 2-4). The main stem at Stites (USGS-13338500), main stem at Wimer Bridge near the USFS boundary (USGS-13338100), Threemile Creek mouth, and Butcher Creek mouth were included because the *South Fork Clearwater River Subbassin Assessment and TMDLs* (DEQ and EPA 2004) defined site-specific SSC and loading goals for these sites; evaluating TMDL compliance requires monitoring these sites and comparing monitoring data to TMDL goals. Cottonwood Creek was included to evaluate compliance with suspended sediment targets established for Cottonwood Creek in the *Cottonwood Creek Total Maximum Daily Loads* (DEQ and EPA 2000). The Johns Creek, Red River, and South Fork Red River sites were included because USFS historically operated a stream gage and monitored suspended sediment at these sites.

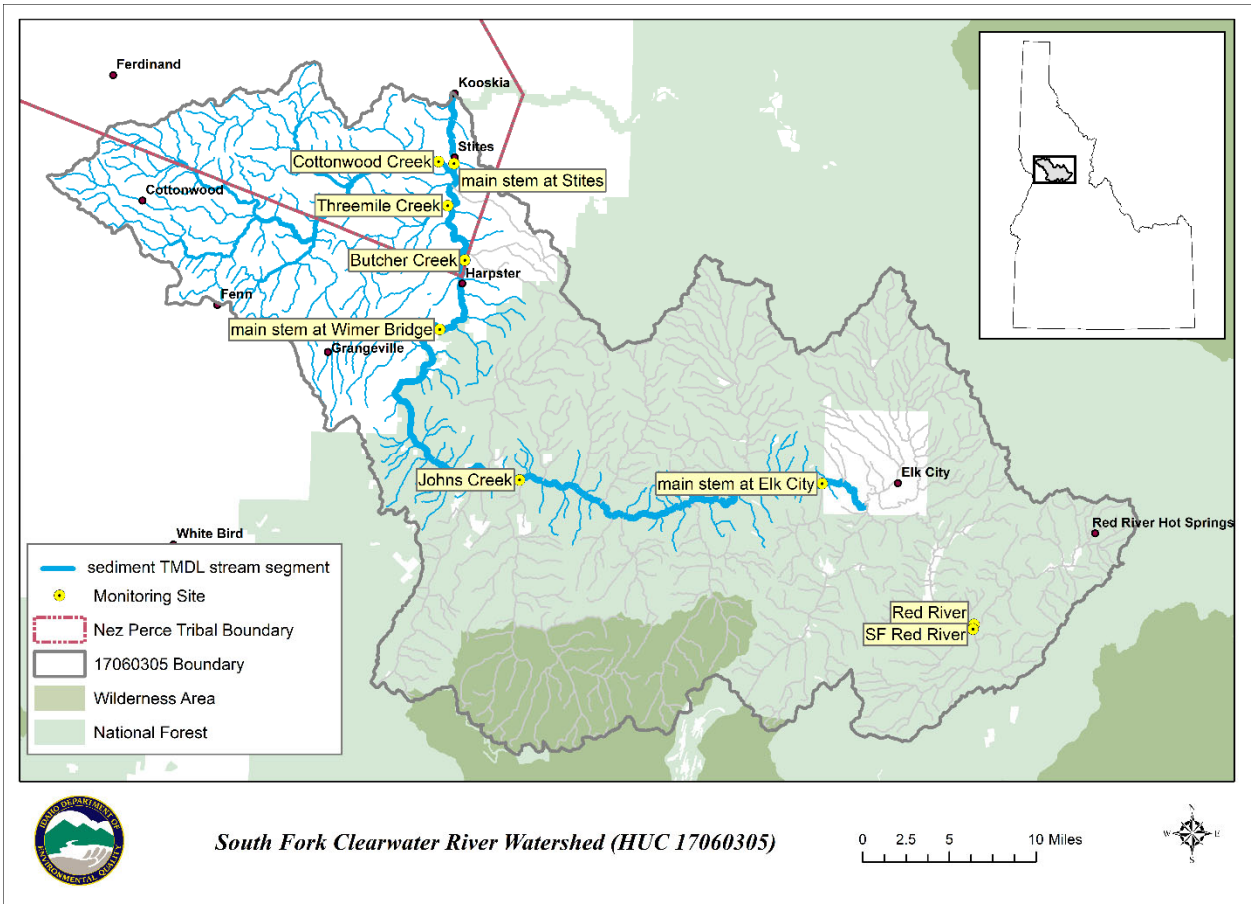


Figure 1. South Fork Clearwater River watershed, monitoring sites, and stream segments with a sediment TMDL.

Table 1. Monitoring locations.

Site	Latitude	Longitude	Monitoring Start	Monitoring End	# Flow Samples	# SSC Samples
Main stem at Stites (USGS 13338500)	46.08638	-115.97666	12-10-2020	11-30-2021	16	16
Main stem at Wimer Bridge (USGS 13338100)	45.94777	-115.98888	12-10-2020	11-29-2021	16	16
Main stem near Elk City (USGS 13337500)	45.82527	-115.52722	11-18-2020	11-29-2021	17	17
Cottonwood Creek near mouth	46.08772	-115.99535	2-10-2021	12-6-2021	14	12
Threemile Creek mouth	46.05113	-115.98291	2-22-2021	12-6-2021	12	12
Butcher Creek mouth	46.00621	-115.96350	3-2-2021	12-6-2021	10	10
Johns Creek mouth	45.82301	-115.88902	5-26-2021	12-7-2021	8	8
South Fork Red River	45.70061	-115.34406	4-29-2021	12-7-2021 [a]	11	11
Red River	45.70995	-115.34298	4-26-2021	12-7-2021 [a]	10	11

[a]: continuous flow monitoring ended 12-7-2021, but one flow and SSC measurement were collected 5/27/2022



Figure 2. Main stem at Stites (USGS 13338500) looking upstream (top left) and downstream (top right), main stem at Wimer Bridge near Harpster (USGS 13338100) looking upstream (bottom left), and main stem above Crooked River near Elk City looking downstream (USGS 13337500) (bottom right).



Figure 3. Camas Prairie tributary sites. Cottonwood creek looking upstream (top left) and downstream (top right); Threemile Creek looking upstream (center left) and downstream (center right); Butcher Creek looking upstream (bottom left) and downstream (bottom right).



Figure 4. Forest tributary site photos. Red River looking upstream (top left) and downstream (top right); South Fork Red River looking upstream (center left) and downstream (center right); Johns Creek looking upstream (bottom left) and downstream (bottom right).

3 Objectives

1. Evaluate compliance with TMDL suspended sediment concentration targets (Table 2).
2. Estimate total suspended sediment loads during the study period for each monitoring site.
3. Evaluate the relative contribution of the upper (forested) and lower (Camas Prairie) watershed areas to total suspended sediment loads in the main stem South Fork Clearwater River during the study period by comparing measured loads in the main stem near the forest boundary (main stem near Wimer Bridge, USGS 13338100) and at Stites (USGS 13338500) (Figure 1, Table 1).

Table 2. Suspended sediment concentration (SSC) targets defined in the South Fork Clearwater River TMDL (DEQ and EPA 2004) and Cottonwood Creek TMDL (DEQ and EPA 2000)

TMDL Control Point	TMDL Target
Main Stem at Stites	Suspended sediment concentration (mg/L) at turbidity 25 Nephelometric turbidity units (NTU) over site background, where site background is flow-dependent.a
Main Stem at Wimer Bridge	
Threemile Creek mouth	
Butcher Creek mouth	
Cottonwood Creek (entire watershed, including tributaries)	50 mg/L daily average SSC

[a]Target SSC (mg/L) = SSC_{25NTU} + (SSC * R_{BG}), where SSC_{25NTU} = SSC at 25 NTU turbidity (45 mg/L at Stites, 60 mg/L at Wimer Bridge, 17 mg/L at Threemile Creek, and 25.25 mg/L at Butcher Creek per DEQ and EPA 2004, Tables 49–52, p 193–196), SSC = ambient measured SSC (mg/L), R_{BG} = site-specific proportion of suspended sediment load attributed to background loading in the TMDL based on a sediment budget analysis (DEQ and EPA 2004, appendix L). The TMDL set R_{BG} as 0.22 at Stites, 0.72 at Harpster, 0.08 at Threemile Creek, and 0.24 at Butcher Creek (DEQ and EPA 2004, Tables 49–52, p 193–196).

4 TMDL Targets

For the main stem at Stites, main stem at Wimer Bridge, Butcher Creek mouth, and Threemile Creek mouth, the South Fork Clearwater River TMDL defined site-specific suspended sediment targets as the concentration where turbidity is 25 nephelometric turbidity units (NTU) greater than background (Table 3). These targets were developed based on the numeric turbidity criteria in Idaho water quality standards, which states “Turbidity, below any applicable mixing zone set by the Department, shall not exceed background turbidity by more than fifty (50) NTU instantaneously or more than twenty-five (25) NTU for more than 10 consecutive days” (IDAPA 58.01.02 250.02(e)). For each site, the TMDL estimated SSC at 25 NTU (SSC_{25NTU}) based on paired concentration and turbidity measurement data available prior to 2003 (see DEQ and EPA 2004, Appendix M). For each site, the TMDL estimated the proportion of suspended sediment from background sources (R_{BG}) based on a watershed sediment budget; the budget used

modeling to estimate the average annual total sediment load and background sediment load for the main stem and each tributary (DEQ and EPA 2004, Appendix L). Comparing data collected in this study to these targets assumes SSC_{25NTU} and R_{BG} values developed when the TMDL was developed are representative of current conditions and R_{BG} does not vary seasonally or with flow, among other assumptions. Evaluating the validity of these assumptions is part of DEQ's TMDL review process and is beyond the scope of this monitoring report.

The Cottonwood Creek TMDL defined a 50 mg/L daily average target that applies to all stream segments within the Cottonwood Creek watershed. This target was selected based on DEQ's sediment TMDL guidance (DEQ 1999), which reviewed available relevant scientific literature about the relationship between suspended sediment concentration and reported ecological effects. The selected target was "intended to account for the acute and chronic effects of suspended sediment on the various life stages of salmonids" (DEQ and EPA 2000, p3-3).

5 Methods

Main stem South Fork Clearwater River sites were monitored by USGS following standard USGS protocols (Edwards and Glysson 1999; Davis, 2005; Turnipseed and Sauer 2010; Meuller et al. 2013). Tributary sites were collaboratively monitored by DEQ, USFS and NPT-WR (Table 1) following protocols defined in a quality assurance project plan (QAPP) (DEQ 2021) and described below in sections 4.1-4.6. For both main stem and tributary sites, 8-16 paired stream flow, SSC and turbidity measurements were collected (Table 1). At each site, continuous flow and daily average flow data were collected using either existing stream gage infrastructure or a temporary stream gage installed for this project. Appendix C documents project quality assurance/quality control procedures and outcomes. All data and R software code used for analyses are publicly available (see Section 9).

5.1 Discharge Measurements

At the three main stem sites, USGS measured instantaneous discharge using standard USGS wading velocity methods (Turnipseed and Sauer 2010) or using an acoustic doppler current profiler (ADCP) (Mueller et al. 2013).

At the six tributary sites, instantaneous discharge monitoring methods depended on if the stream could be waded safely. When the stream was wadable, instantaneous stream discharge was measured using a Hach FH950 electromagnetic velocity meter and the velocity-area method. The stream channel was divided into multiple cells and water depth and velocity were measured within each cell. The number of cells varied based on stream width and flow conditions and was selected based on flow meter manufacturer recommendations and with the goal of no cell representing more than 10% of total discharge. Equal width cells were used if flow appeared relatively homogenous. If there was a pronounced thalweg, cell width varied, with smaller width cells used within the thalweg, and minimum cell width of 0.5 ft. Water depth and velocity were measured at the horizontal center point of each cell, and velocity was

measured at 60% of cell water depth. Cell discharge was calculated as the product of cell area and velocity, and cell discharge values were summed to calculate stream discharge.

Non-wadable conditions were present at forest tributary sites on several occasions. Conditions were not wadable at Johns Creek during three sample events (5/26, 6/8, and 6/24), and flow was measured by connecting the Hach FH950 velocity meter and a 75-pound sounding weight connected to a cableway system present at the site. When conditions were not wadable at Red River and South Fork Red River, flow was measured either from a bridge using a bridge crane and a sounding weight with the Hach FH950 velocity meter (Red River on 5/25) or using a Teledyne RD STREAMPRO ADCP (4/26 at Red River, 4/29 and 5/19 at South Fork Red River) based on methods from Mueller et al 2013 (Figure 5).

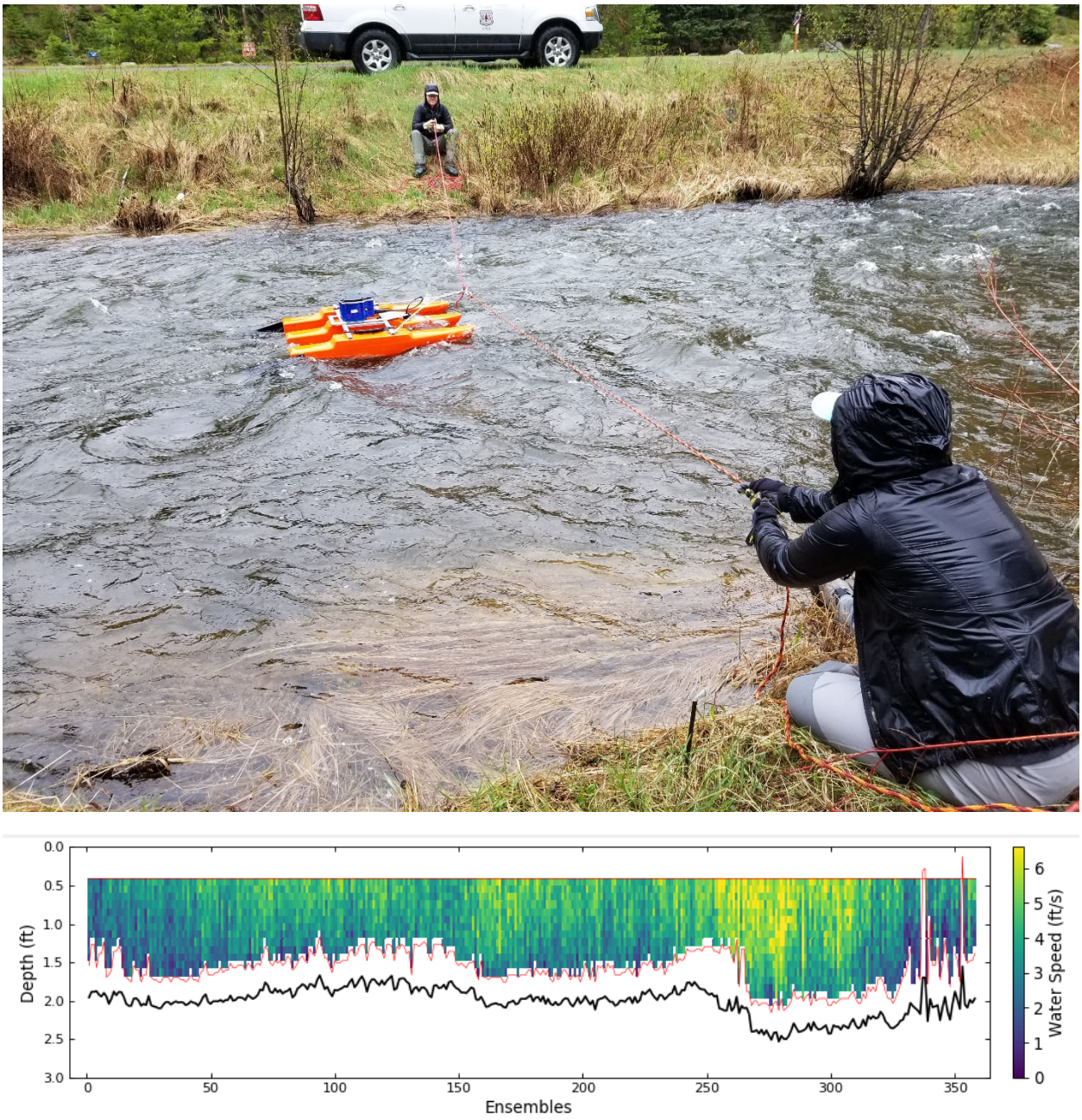


Figure 5. Measuring discharge in South Fork Red River using an acoustic doppler current profiler (ADCP) during non-wadable conditions on 5-19-2021 (180 cfs), and example stream channel velocity profile output from one channel transect.

5.2 Stream Gage Discharge

On the main stem, USGS operated stream gage equipment at Stites (USGS-13338500) and near Elk City (USGS-1337500) during the study period. USGS has operated the Stites stream gage since 1964. At the main stem site near Elk City (USGS-13337500), USGS operated the gage site

from 2002-2016, and then stopped operating the gage in 2016 due to funding constraints. USGS re-established and operated the gage from 11/20/2020 through 10/17/2021 using funding from this project. Main stem continuous and daily average flow data at Stites and Elk City were obtained from the USGS National Water Information System (NWIS).

USGS does not have a stream gage or water level monitoring equipment on the main stem at Wimer Bridge (USGS-13338100). Daily average flow at Wimer Bridge was calculated using a linear regression between paired 2006-2010 flow measurements at Stites and Wimer bridge developed by USGS ($y = 0.9962x - 31.947$, $R^2 = 0.99$) (Clark et al. 2013).

At the six tributary sites, continuous and daily average discharge were estimated by developing and applying a site-specific rating curve predicting stream discharge from water level. At each site, stream water level was recorded every 15 minutes using a pressure transducer. At Cottonwood, Threemile, Butcher, and South Fork Red River, a temporary stream gage was installed; a Hobo MX-2001 vented transducer was installed inside a polyvinyl chloride (PVC) stilling well attached to a t-post driven into the stream bed within the stream channel (Figure 3). At Red River and Johns Creek, existing USFS stream gage infrastructure was used.

For each tributary site, a rating curve was developed using the following equation (Hauer and Lamberti 2007):

$Q = a*(h-z)^b$, (equation 1)

Where Q = stream flow (cfs), h = water level (ft), z is water level (ft) at zero stream flow (parameterized as the distance between the pressure transducer sensor and stream bed), and a and b are regression coefficients. Site-specific regression coefficients were estimated using the R software 'nls' function for fitting nonlinear least-squares regression. Pressure transducer water level data were used to parameterize h values in equation 1 and apply rating curves to estimate discharge every 15 minutes. Daily average discharge was then calculated by averaging all discharge estimates each day. Detailed rating curve information is included in Appendix A.

5.3 Suspended Sediment and Turbidity

On the main stem, USGS collected flow-weighted SSC samples using equal width increment protocols (Edwards and Glysson 1999) and an isokinetic depth-integrated US DH-81, US D-96, or US D-95 suspended sediment sampler (Davis, 2005). The stream transect was divided into cells of equal width and a depth-integrated suspended sediment subsample was collected at the horizontal center of each cell using a sampler appropriate for the depth and velocity conditions and standard USGS protocols (Edwards and Glysson 1999; Davis, 2005). The samples were then composited prior to laboratory analysis. USGS measured main stem turbidity in formazin nephelometric turbidity units (FNU) by submerging a turbidity sensor below the water surface near the stream bank (Keith Hein, USGS personal communication to Jason Williams, 9/26/2022).

At tributary sites, SSC and turbidity collection methods depended on stream flow conditions. If the stream was wadable, sufficiently deep, and water velocities were within the range required

for using a DH-48 isokinetic depth-integrated sediment sampler (1-9 ft/s) (FISP 2021), flow-weighted samples were collected using equal discharge-increment (EDI) methods. After measuring discharge, the stream was divided into four cells of equal discharge, depth-integrated equal-volume samples were collected at the horizontal center point of each cell using a DH-48 sampler, and those four samples were combined in a 1 L cubitainer to create one composite sample.

If a tributary stream was wadable but water depth or velocity were below that required for using a DH-48, a grab sample was collected at four different locations along a horizontal stream transect by submerging a quart glass bottle below the stream surface. The four samples were then combined in a 1 L cubitainer to create one composite sample. Samples were collected using this method for most tributary sample events during summer low flow periods. If the tributary stream was not wadable, flow-weighted samples were collected using a DH-59 depth-integrated sediment sampler from bridge board or cableway. However, in two cases during very high flow conditions (5/27/22 at Red River and SF Red River), four equal-volume grab samples were collected from shore or a bridge using a bottle and composited, assuming the stream channel was well mixed vertically and horizontally.

All SSC samples were analyzed in a laboratory using American Society for Testing Materials (ASTM) method D3977-97 B. Main stem samples were analyzed at the USGS-Cascades Volcano Observatory Sediment Analysis Laboratory in Vancouver, WA, and tributary samples were analyzed by Anatek Labs in Moscow, ID.

For tributaries, turbidity was measured on a subsample of each composite suspended sediment sample, either on-site immediately after collection or within four days after sample collection prior to sample submission to the laboratory. SSC samples were stored in a refrigerator between sample collection and submission to the laboratory. Turbidity was measured using a YSI EXO1 sonde with EXO optical turbidity sensor or a Hach 2100Q turbidity sensor. The YSI EXO1 sonde measures turbidity in formazin nephelometric turbidity units (FNU), and the Hach 2100Q turbidity sensor measures turbidity in nephelometric turbidity units (NTU). Sensors measuring FNU turbidity use a near infrared light source with a 90 degree detection angle and comply with European drinking water protocol ISO 7027, whereas sensors measuring NTU turbidity use a white light source with a 90 degree detection angle and comply with EPA method 180.1. Monitoring protocols required the same type of field turbidity sensor to be used across sample events for consistency, and to document within-site temporal turbidity patterns. However, at Cottonwood Creek, Threemile Creek, and Johns Creek, a mixture of FNU and NTU turbidity measurements were collected due to staffing and logistical challenges. Comparability of FNU and NTU turbidity measurements is discussed in Appendix C. Turbidity sensors were calibrated within 24 hours prior to turbidity measurements.

5.4 Suspended Sediment Loads

For both main stem and tributary sites, instantaneous loads were calculated for each sample event by multiplying measured site SSC and measured stream flow values. In addition, daily and total study period suspended sediment loads (metric tons/time) were estimated using USGS

load estimator (LOADEST) FORTRAN software (version MOD48, March 2013) (Runkel et al. 2004). LOADEST uses paired flow and concentration data (called the calibration dataset) to develop a regression model estimating loads from flow. Users can select one of several built-in regression models, create a user-defined model, or select the best-fit regression equation based on Aikaike Information Criteria (AIC) values (Runkel et al. 2004). The selected regression model is then used to estimate daily loads from daily average flow values for a user-specified estimation time period. For the user-specified estimation period, LOADEST generates mean load estimates, standard errors, and 95% confidence intervals.

For each site, paired discharge and SSC measurements were used with LOADEST software to develop a site-specific adjusted maximum likelihood estimation regression model to estimate SSC load from discharge. The software requires at least 12 paired concentration and flow measurements to develop a regression model; for sites with < 12 sample events (Butcher, South Fork Red, Red River), field duplicate SSC samples were included when developing the site regression model. The best-fit regression equation for each site was selected by LOADEST software based on regression AIC values. The site regression model was then used to estimate daily loads from stream gage daily average flows. In addition to daily loads, outputs included average daily loads for each month (tons/day) and associated upper and lower 95% confidence intervals (Runkel et al. 2004). Total site study period loads were calculated as Σ (AL_{month} * D_{month}), where AL_{month} is the mean daily load (tons/day) for the month, and D_{month} is the number of days in the month with daily average flow data during the study period. Total study period load upper and lower bound estimates were calculated using monthly upper and lower bound 95% confidence intervals for monthly mean daily loads. LOADEST input and output files are included in supporting materials (see Section 9).

5.5 Comparison to TMDL Targets

Measured SSC values were compared to TMDL concentration targets defined in Table 2. The TMDLs defined targets for Cottonwood Creek, the Butcher Creek mouth, Threemile Creek mouth, main stem at Stites, and main stem at Harpster; the TMDLs did not define concentration targets for Johns Creek, Red River, or South Fork Red River sites.

5.6 Quality Assurance/Quality Control (QA/QC)

Before sampling, planned tributary sampling protocols, QA/QC procedures, laboratory methods, and data quality objectives were defined in a project quality assurance project plan (QAPP) (DEQ 2021). Quality assurance procedures included consultation with DEQ's quality assurance manager, completion of standardized quality assurance checklists, a project field audit by DEQ quality assurance staff, and a detailed review and evaluation of all project quality assurance information by project staff and quality assurance staff. Appendix C documents project QAQC information and outcomes in detail.

Three monitoring results were rejected and excluded from analyses. USGS rejected 5/12/2021 and 7/12/2021 SSC results collected on the main stem at Harpster (USGS-13338100) based on

USGS QA/QC protocols; SSC values were unrealistically high for the associated flow conditions (Dave Evetts, USGS, personal communication). DEQ rejected one flow measurement at Red River on 5/25/2021 because the measured flow value was unrealistically low for the associated staff plate water depth. A detailed description of rejected data is included in Appendix C. All other project data were assessed as suitable for achieving the three project objectives (Section 3). For other applications, data users should consider project methods and QAQC information included in Appendix C and evaluate if project data are suitable for other specific applications.

6 Results

6.1 Stream Discharge

On the main stem South Fork Clearwater River, stream gage discharge at Stites ranged from 106 to 4,060 cubic feet per second (cfs) during the study period, with peaks in May-June (Figure 6). Discharge on the main stem near Elk City ranged from 21.5 to 1,480 cfs during the study period (Figure 6). During calendar year 2021, spring discharge was lower than in most years, but was not the lowest on record (Figure 7, Figure 8).

Among Camas Prairie tributaries, stream gage discharge ranged from 0.3-354 cfs at Cottonwood Creek, 0.6-88 cfs at Threemile Creek, and 0.3-54 cfs at Butcher Creek during the study period (Figure 9). Gage-measured discharge peaked during February or March (Figure 9). These tributaries have flashy hydrology, typically with brief discharge peaks driven by rapid snowmelt and significant winter and spring rain events. Because gages were installed in February for Cottonwood and Threemile Creek and in March for Butcher Creek, it is likely some earlier discharge peaks during the calendar year were not captured by this project, especially for Butcher Creek.

Among forest tributaries, stream gage discharge ranged from 0.67 to 426 cfs at Red River, and 5.6-169 cfs at South Fork Red River (Figure 10). Stream gage discharge is not available for Johns Creek due to an equipment malfunction, but measured flows ranged from 35.4 to 565 cfs. Flow monitoring at forest sites did not begin until late April or early May due to limited USFS staff availability, so this project did not measure early spring discharge patterns.

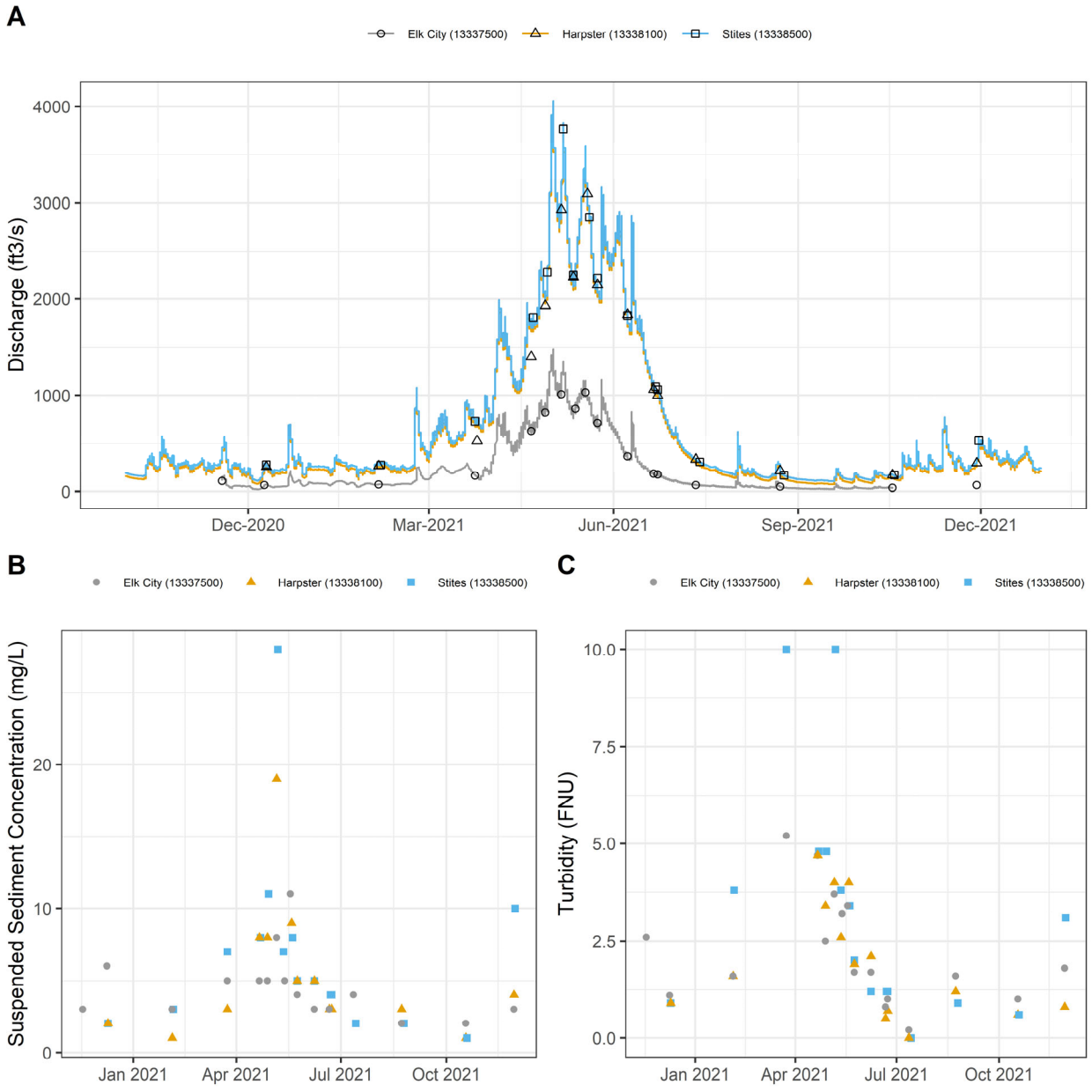


Figure 6. Stream discharge (A), suspended sediment concentration (SSC) (B), and turbidity (C) patterns measured by USGS on the main stem South Fork Clearwater River. In (A), lines are gage-predicted discharge and shapes are measured discharge.

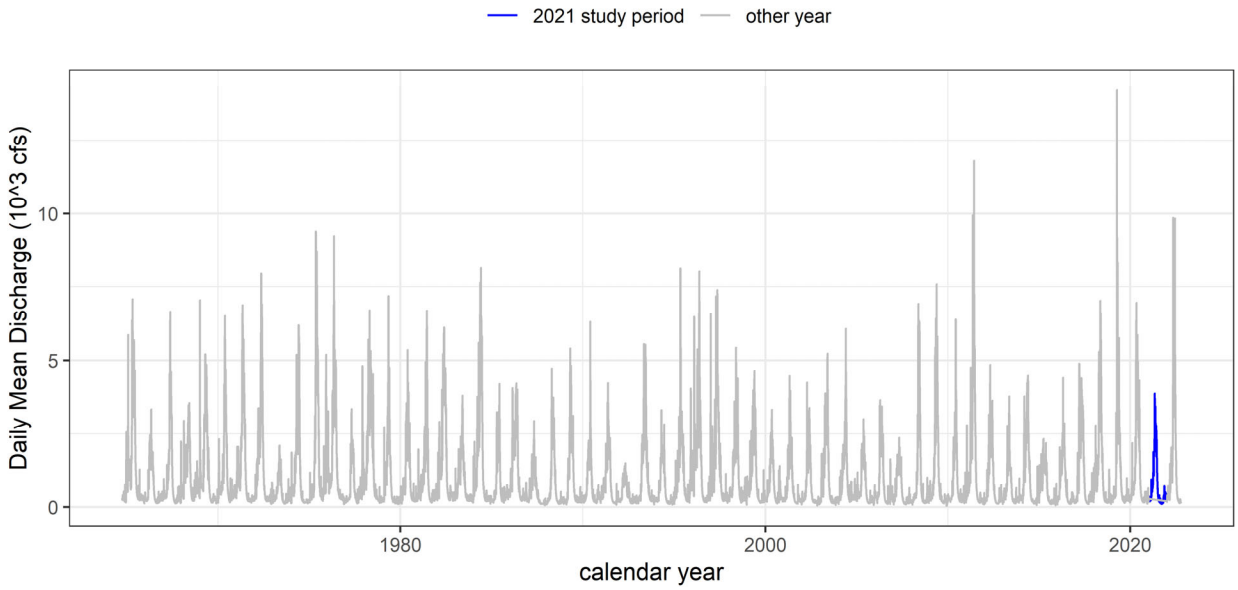


Figure 7. Daily mean discharge at Stites (13338500) 1964-2022.

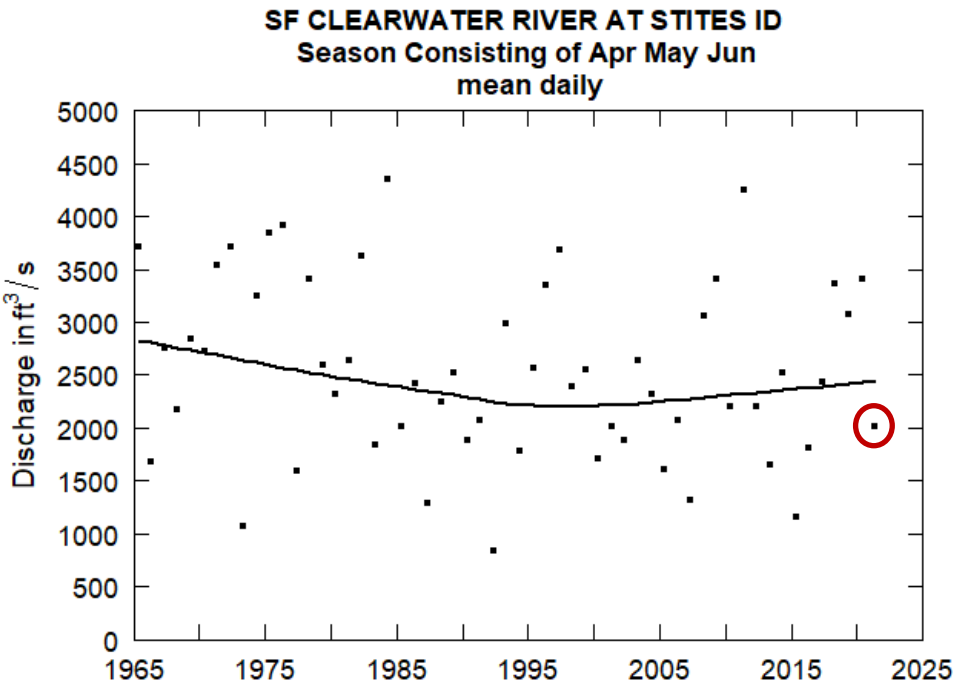


Figure 8. Seasonal mean daily discharge at Stites (13338500) during April-June each year 1964-2021. The black line represents the seasonal daily discharge trend calculated using locally-weighted smoothing methods described in Hirsch and DeCico (2015). The circled point indicates seasonal mean daily discharge during the study period.

6.2 SSC and Turbidity

On the main stem, measured SSC ranged from 1-28 mg/L, and concentration peaks coincided with discharge peaks (Figure 6). Concentrations ranged from 1-28 mg/L at Stites, 1-19 mg/L at Harpster, and 2-11 mg/L at Elk City. Turbidity ranged from 0-10 formazin nephelometric units (FNU), with relatively similar values across the three main stem sites. USGS reported hydrologic conditions during sample events as either “stable, normal stage”, “stable, low stage”, “falling stage”, or “not determined”; no samples were reported as collected during rising stage conditions. Sample collection was more frequent during spring high flows and captured the range of discharge values observed during the study period (Figure 6).

For Camas Prairie tributaries, SSC ranged from below the laboratory practical quantitation limit (1 mg/L) to 45.1 mg/L (Figure 9). All samples were less than 10 mg/L SSC except four samples collected at Cottonwood Creek and three collected in Threemile Creek during spring high flows (Figure 9). Turbidity temporal patterns were similar to those for discharge and SSC, with highest turbidity measured at Cottonwood Creek and Threemile Creek during sample events with high discharge and SSC (Figure 9). Turbidity was consistently < 10 FNU or NTU in Camas Prairie tributaries outside of high flow periods (Figure 9).

For forest tributaries, SSC ranged from below the laboratory practical quantitation limit (1 mg/L) to 12.1 mg/L, with only one result at Johns Creek, and one result at South Fork Red River exceeding 10 mg/L (Figure 10). Consistent with measured SSC, turbidity was low at forest tributary sites, with values < 7 FNU or NTU across all sample events (Figure 10).

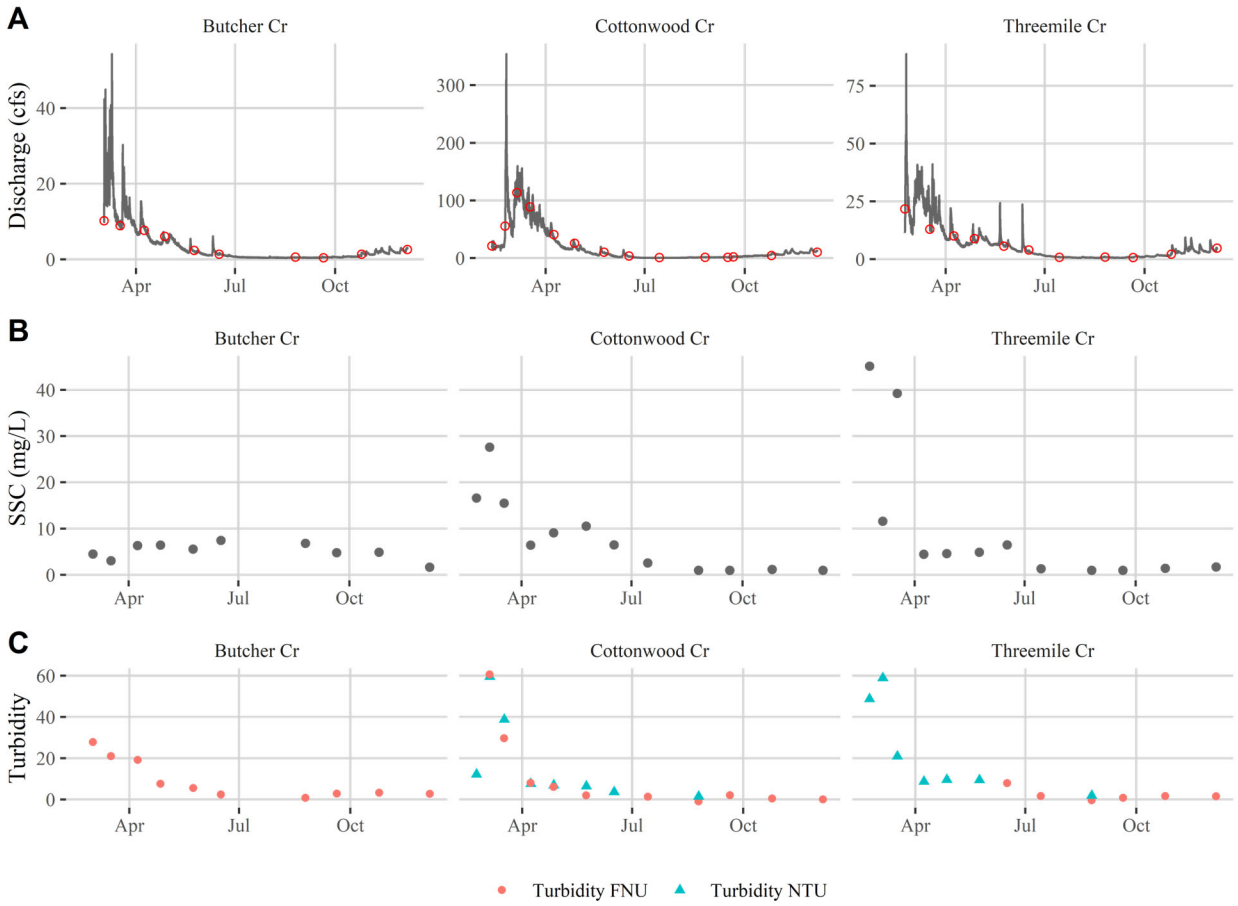


Figure 9. Stream discharge (ft^3/s) (A) suspended sediment concentration (SSC) (mg/L) (B), and turbidity (C) patterns for Camas Prairie tributaries. In the discharge plot (A) circles are measured discharge and lines are gage-predicted discharge.

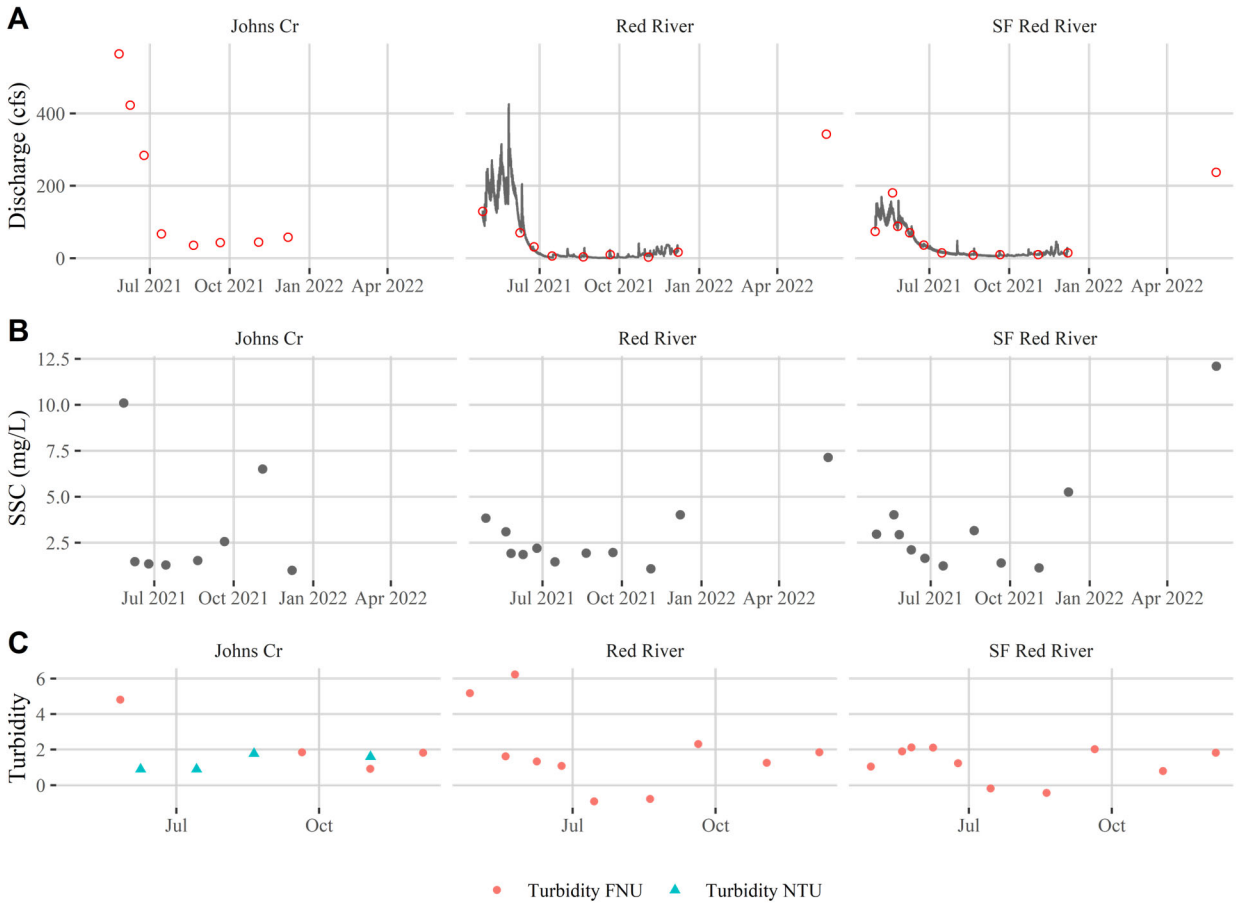


Figure 10. Stream discharge (ft^3/s) (A) suspended sediment concentration (SSC) (mg/L) (B), and turbidity (C) patterns for tributaries within the Nez Perce-Clearwater National Forest. In the discharge plot (A) circles are measured discharge and lines are gage-predicted discharge.

6.3 Suspended Sediment Loads

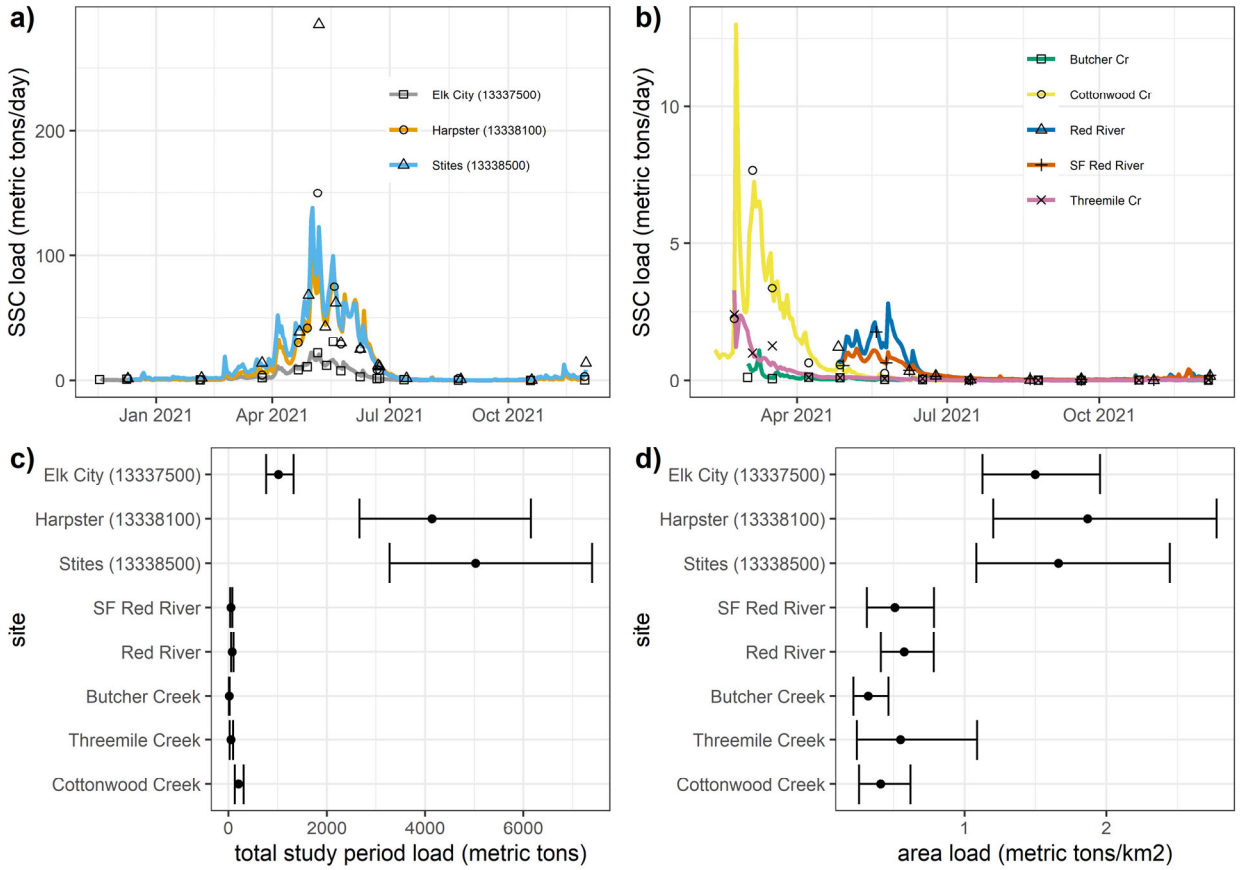


Figure 11. Estimated daily suspended sediment loads (a, b), study period total suspended sediment loads (c), and total study period total suspended sediment loads per km^2 upstream area (d). Error bars indicate lower and upper bound estimates. Units are metric tons. In a) and b), points are field-measured instantaneous loads, and lines are LOADEST-predicted daily average loads. Note that load estimate time periods differ across sites (see Table 4).

On the mainstem, daily suspended sediment loads estimated using LOADEST were similar at Stites and Harpster, peaking April-June (Figure 11a). Daily suspended sediment loads near Elk City also peaked April-June, but peak loads were much smaller (Figure 11a). Total study period loads estimated using LOADEST were 5,026 metric tons at Stites (range: 3,278-7,398), 4,138 metric tons at Harpster (range 2,665-6,154), and 1,014 metric tons at Elk City (range 763-1,323) (Table 3). Estimated total study period loads near the forest boundary at Harpster were 82% of loads estimated downstream of the Camas Prairie at Stites.

In sampled tributaries, daily suspended sediment loads estimated using LOADEST mirrored stream flow patterns and peaked during February-March on the Camas Prairie, and April-June in sampled forest tributaries (Figure 10b). Peak loads were highest for Cottonwood Creek (Figure 11b). Estimated total study period loads were 204 tons for Cottonwood Creek, compared to < 80 tons for other sampled tributaries. However, monitoring periods and therefore the time period over which loads were estimated varied across tributaries (Table 3).

Table 3. Site total study period suspended sediment loads (metric tons) estimated using LOADEST.

Site	Time Period	Days	Load Estimate (tons)	Lower (tons)	Upper (tons)	Upstream Area (km^2)	Area load (tons/km^2)
Stites (13338500)	12/10/2020– 11/30/2021	356	5,026	3,278	7,398	3,024	1.66
Harpster (13338100)	12/10/2020-11/29/2021	355	4,138	2,665	6,154	2,217	1.87
Elk City (13337500)	11/19/2020-10/17/2021	333	1,014	763	1,323	677	0.46
Cottonwood Creek	2/10/2021-12/6/2021	300	204	128	309	499	0.41
Threemile Creek	2/22/2021-12/6/2021	288	47	21	94	86	0.55
Butcher Creek	3/2/2021-12/6/2021	280	14	9	20	44	0.32
Red River	4/26/2022-12/7/2021	226	78	56	105	129	0.60
South Fork Red River	4/29/2021-12/7/2021	223	50	30	767	98	0.51

Note: see Appendix B for LOADEST model equations and performance statistics

Total study period loads were divided by upstream watershed area for each site to compare sediment production per unit watershed area across sites (Figure 11d, Table 3). On the main stem, the area load was slightly higher at Harpster near the forest boundary (1.87 tons/km^2) than downstream at Stites (1.66 tons/km^2) during the study period. Among Camas Prairie tributaries, area load was highest for Threemile Creek (Table 3). The study period area load for Red River was slightly higher than for South Fork Red River (Table 3).

6.4 Comparison to TMDL Targets

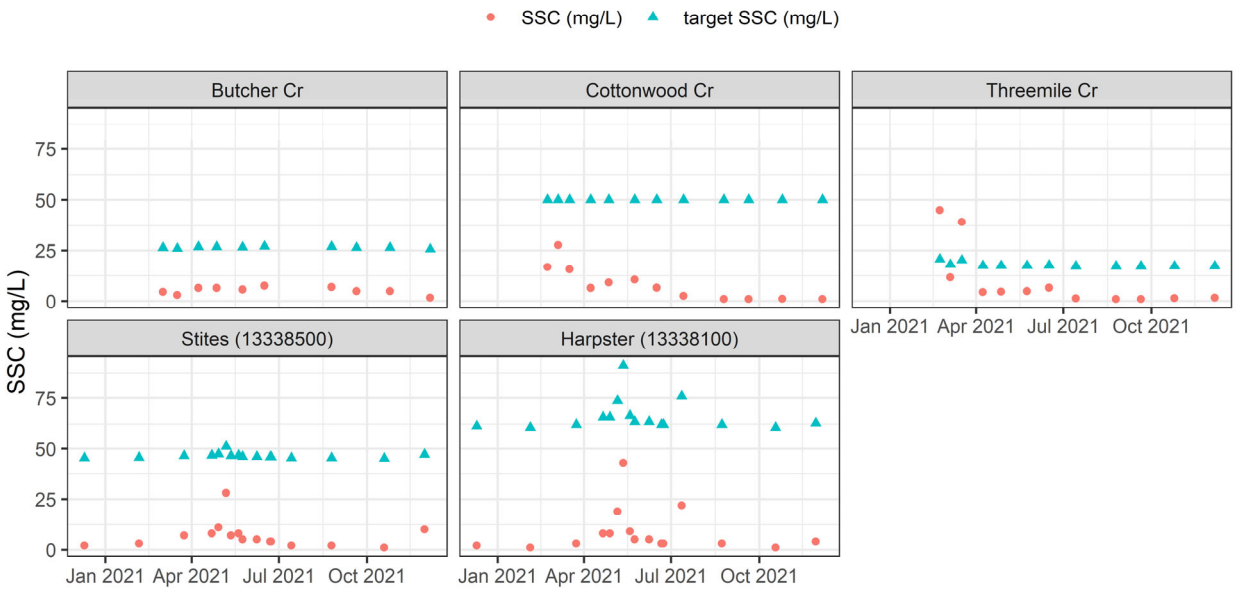


Figure 12. Comparison of measured and TMDL target suspended sediment concentration (SSC) values for sites where TMDLs defined targets.

Measured SSC exceeded the associated site-specific TMDL target (Table 2) during two sample events at Threemile Creek but did not exceed the TMDL target during the study period at any of the other sites (Figure 12).

7 Discussion

Suspended sediment patterns in the SFCR watershed and project results are strongly affected by discharge patterns. In the main stem, most sediment transport occurs during the April-June high discharge period. Mean daily average discharge during April-June 2021 was among the lowest on record (Figure 8), and suspended sediment loads were also among the lowest measured (Figure 13). The presence/absence of significant rain-on-snow events can also cause large discharge and suspended sediment loading peaks (Clark et al. 2013), but there were no such events during the study period. Because inter-annual variability in discharge patterns and suspended sediment loads is large, consistent long-term monitoring is necessary to track progress towards achieving TMDL goals and reducing suspended sediment loads.

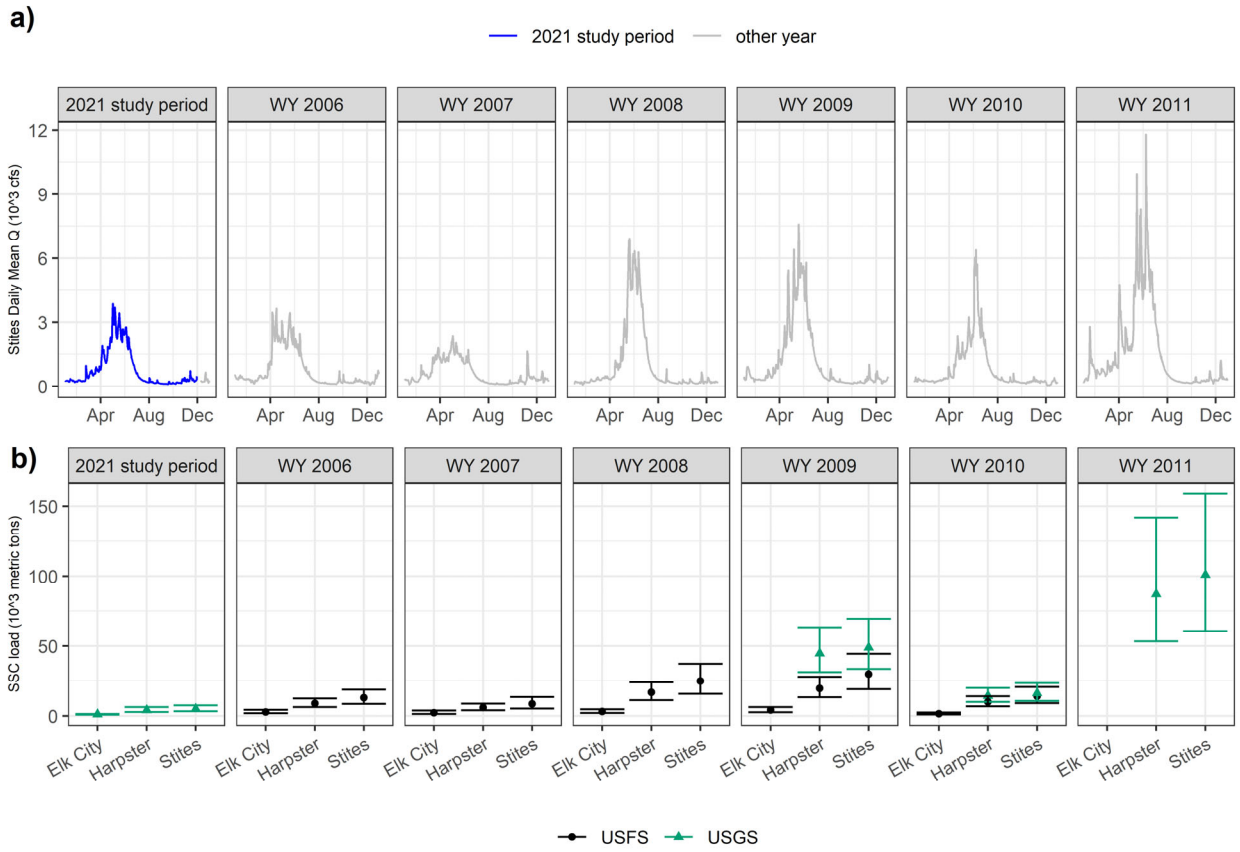


Figure 13. Daily mean discharge at Stites (a) and corresponding LOADEST-based SSC loads estimates for the main stem South Fork Clearwater River (b). In (b), colors indicate agency that collected monitoring data. 'WY' indicates 'water year' (October 1-September 30).

Comparisons of SSC to TMDL targets in Section 5.4 have several important limitations. First, in past years all target exceedances at the forest boundary and most target exceedances at Stites occurred in years when flows exceeded 5,000 cfs, but main stem daily average discharge peaked at 4,060 cfs during the study period. The absence of target exceedances during the study period may be due to low spring discharge rather than reduced sediment inputs. Second, targets for Stites, Harpster, Butcher Creek, and Threemile Creek are based on assumptions that may not be accurate. The TMDL targets were calculated based in part on concentrations at 25 NTU turbidity (45 mg/L at Stites, 60 mg/L at Harpster, 17 mg/L at Threemile Creek, 25.25 mg/L at Butcher Creek) observed when the TMDL was developed. Whether these values are representative of current conditions could not be evaluated using project data because measured turbidity was < 10 FNU during the study period. Targets were also calculated assuming that a specific proportion of sediment at each site comes from natural background sources (0.72 at Harpster, 0.22 at Stites, 0.08 at Threemile Creek, 0.24 at Butcher Creek). These background ratios were calculated based on a watershed sediment budget included in the TMDL. However, the sediment budget did not accurately predict large-scale sediment-loading patterns; the budget predicted the forested portion of the watershed upstream of Harpster contributed ~20% of overall SFCR sediment loading, whereas monitoring data from 2006-2011 and this study indicate the forested portion contributes 65-91% of loads at Stites, 76.9% on

average across years where data are available (Figure 13). As a result, TMDL targets for Stites, Harpster, Butcher Creek, and Threemile Creek may not accurately reflect SSC at 25 NTU over background as intended.

For Cottonwood Creek, Threemile Creek, and Butcher Creek, target exceedances historically appeared highly dependent on hydrologic conditions and monitoring timing. Because the hydrographs for these streams have sharp peaks, both flow and associated concentration peaks are generally short-duration and capturing target exceedances requires sampling during pulse flow and sediment load events. While SSC samples were collected during some high flow events on these tributaries (Figure 9), it is possible additional target exceedances occurred associated with unsampled discharge peaks.

Load estimates generated using LOADEST software for the study period also have several important limitations. First, because regression models developed using LOADEST use daily average flow as an input to predict daily loads, the model does not account for sub-daily changes in discharge, concentration, or load (Donato et al. 2005). Daily load estimates therefore represent predicted daily average loads, can have high uncertainty, and should not be expected to accurately predict instantaneous load measurements in cases where sub-daily variability or concentration differences between rising limb and falling limb of the hydrograph (hysteresis) is significant. Second, the regression approach used by LOADEST assumes a constant relationship between discharge and concentration over time within each site (Runkel et al. 2004) and, therefore, does not account for hysteresis. In general, the accuracy of load estimates using LOADEST and other load-estimation tools is highest at sites with relatively small discharge and concentration variability, when based on frequent sampling (>26 samples/year) biased towards high flow conditions, when multiple consecutive years of paired discharge and concentration data are available, and when tools allowing concentration-discharge relationship variability are used (Lee et al. 2019). LOADEST was selected for this project because it has been used previously to estimate SFCR annual loads (Clark et al. 2013), and because a larger dataset would be required to use load estimation tools that do not assume a constant concentration-discharge relationship. The relatively small number of samples and short study period duration (1 year versus multiple years) is likely the greatest source of uncertainty for load estimates in this study. However, main stem loading patterns observed here are similar to those observed by Clark et al. (2013) based on LOADEST predictions developed using multiple years of monitoring data.

Despite these limitations, multiple lines of evidence strongly suggest sediment loading in the main stem comes primarily from the upper forested portion of the watershed. Across years where data are available (Figure 13), load estimates at Harpster represented 65-91% of loads at Stites, 76.9% on average. When loads are expressed per unit upstream watershed area, area load rates are very similar at Harpster and Stites (Figure 14). If the Camas Prairie was the primary source of river suspended sediment, much higher percent annual load rates and area load rates at Stites than Harpster would be expected. Subtracting the load estimate at the forest boundary (4,138 metric tons) from the load estimate at Stites (5,026 metric tons) estimates the Camas Prairie contributed 888 metric tons during the study period. This appears consistent with tributary load estimates. Summing load estimates from Cottonwood Creek (207

metric tons), Threemile Creek (47 metric tons), and Butcher Creek (14 metric tons) yields 268 metric tons. This number is smaller than that calculated by subtracting loads at Stites and the forest boundary because the monitoring period for these tributaries was shorter than on the main stem (Table 3), and because Stites loads also reflect inputs from additional unsampled lower watershed tributaries (Sally Ann Creek, Wall Creek, Rabbit Creek, and others). Instantaneous loads calculated based on paired discharge and SSC measurements collected on the same date at the forest boundary and Stites were also very similar, except for two days where Stites loads greatly exceeded Harpster loads (5-20-2010, 5-16-2011) (Figure 15). Large pulse-like sediment load inputs from Camas Prairie streams do occur but are brief relative to main stem discharge peaks due to flashy Camas Prairie discharge patterns. However, available annual load estimates (Figure 13) suggest these pulse events are a small fraction of total annual main stem sediment loads, and most sediment loading comes from the upper forested portion of the watershed.

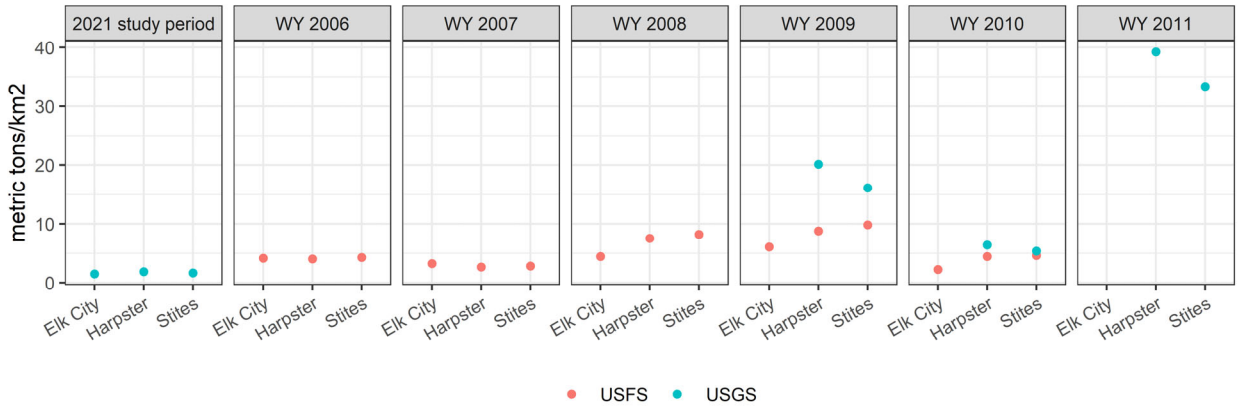


Figure 14. Main stem suspended sediment loads expressed per km^2 upstream watershed area.

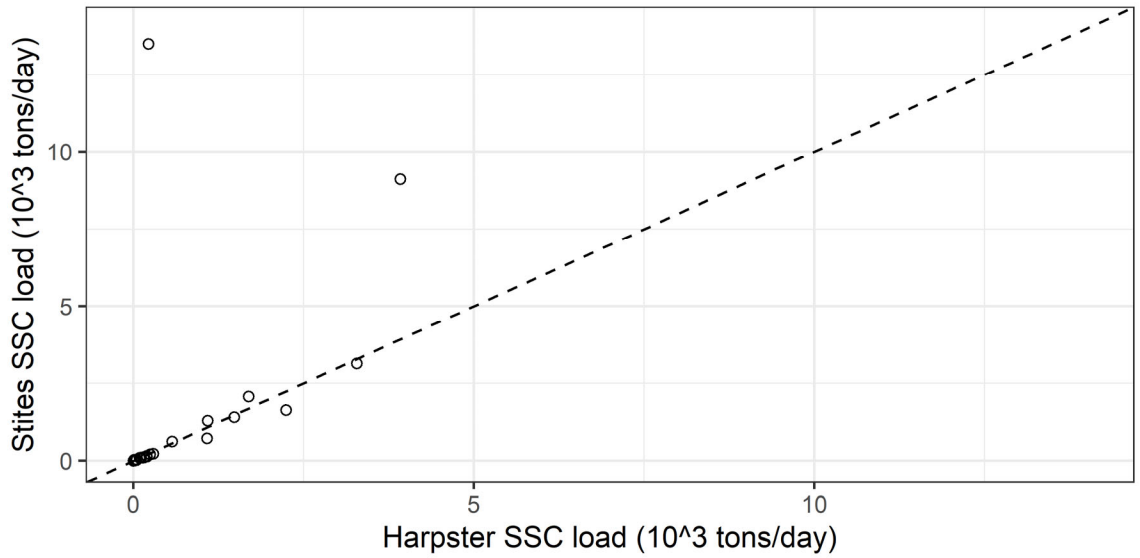


Figure 15. Comparison of suspended sediment concentration (SSC) loads at Stites and Harpster measured in the field on the same day (2009-2021, N= 30, USGS data). The dashed line is a 1:1 line (Harpster load = Stites load).

It is important to note that this study estimated total (background plus anthropogenic) sediment loads. While available data indicate most sediment loading comes from the upper forested portion of the watershed, this does not necessarily mean that most sediment loading comes from human activities in the upper watershed. Loads quantified here reflect both anthropogenic and background sediment inputs. The TMDL assumed 72% of sediment loading at the forest boundary came from background sources, whereas only 22% of sediment loading at Stites came from background sources (DEQ and EPA 2004, Tables 51-52). These background ratios were calculated based on a watershed sediment budget that did not accurately predict the relative contribution of the Camas Prairie and forested watershed areas to river sediment loads. The relative contribution of human activities and background sediment sources to observed loading patterns beyond the scope of this monitoring report and merits further investigation.

8 Conclusions

Objective 1 - Evaluate compliance with TMDL suspended sediment concentration targets (Table 2).

Measured SSC exceeded the TMDL target during two sample events at the Threemile Creek mouth, but did not exceed the TMDL target during the study period at other locations with TMDL targets: Cottonwood Creek, the Butcher Creek mouth, the main stem at Stites (USGS-13338500), and the main stem upstream of Harpster near the forest boundary at Wimer Bridge (USGS-13338500). On the main stem, discharge during the spring high flow period when most sediment transport occurs was lower than in most years; daily average discharge peaked at 4,060 cfs, but in past years all target exceedances at the forest boundary and most target exceedances at Stites occurred in years when flows exceeded 5,000 cfs. In tributaries, spring

discharge was also likely lower than most years, but limited historic discharge data are available. The absence of target exceedances during the study period may be due to low spring discharge rather than reduced sediment inputs. Due to inter-annual variability in discharge and its effects on suspended sediment, consistent long-term monitoring would be needed to adequately track progress towards achieving TMDL goals. Targets in the TMDL were developed based on a watershed sediment budget that may not be representative of current conditions. DEQ is evaluating the adequacy of existing TMDL targets as part of a separate ongoing TMDL review process.

Objective 2 – Estimate total suspended sediment loads (tons) during the study period for each monitoring site.

Suspended sediment loads were estimated for the main stem at Stites (USGS-13338500), main stem upstream of Harpster near the forest boundary at Wimer Bridge (USGS-13338500), main stem near Elk City (USGS-13337500) during December 2020-November 2021. Suspended sediment loads were also estimated for Cottonwood Creek, Threemile Creek, Butcher Creek during February-November 2021, and for Red River and South Fork Red River May-November 2021 (Table 3). For each location, total study period loads and associated upper and lower bound load estimates were developed using USGS LOADEST software. Annual load estimates were not developed for Johns Creek due to an equipment failure.

Objective 3 – Evaluate the relative contribution of the upper (forested) and lower (Camas Prairie) watershed areas to total suspended sediment loads in the main stem South Fork Clearwater River by comparing measured loads in the main stem near the forest boundary (main stem near Wimer Bridge, USGS 13338100) and at Stites (USGS 13338500) (Figure 1, Table 1).

During December 2020-November 2021, the total suspended sediment load from the forested portion of the watershed upstream of Harpster was 82% of the suspended sediment load in the main stem South Fork Clearwater River at Stites. When loads were expressed on an area basis (i.e., tons per upstream km^2 watershed area), loading rates were similar for main stem upstream at the forest boundary (1.87 tons/km2) and at Stites (1.66 tons/km2). These general patterns are consistent with those observed based on main stem suspended sediment monitoring conducted 2006-2011. Across years where data are available main stem load estimates near the forest boundary represented 65-91% of loads at Stites, 76.9% on average. Multiple lines of evidence strongly suggest sediment loading in the main stem comes primarily from the upper forested portion of the watershed. The relative contribution of human and background sources to these sediment loading patterns is beyond the scope of this report and merits further investigation.

9 Data Availability

All discrete stream flow, turbidity, and SSC measurement data collected through this project are publicly available through Water Quality Portal (*www.waterqualitydata.us*), a national public

water quality data repository. USGS stream gage data are publicly available through the USGS National Water Information System (NWIS) (*https://waterdata.usgs.gov/nwis*). Data and R code used for analyses described in this document are publicly available at: *https://github.com/jjwill2/SFCR_sediment_patterns_2021_report.* This report and all supporting materials are also publicly available through Open Science Framework at: *https://doi.org/10.17605/OSF.IO/N4FGQ* (DOI 10.17605/OSF.IO/N4FGQ).

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Appendix A. Tributary Rating Curves

Table A1. Tributary rating curve performance statistics.

Site	N	r^2	mean bias (cfs)	mean error (cfs)	Error range (cfs)	Mean % difference
Cottonwood Creek	15	0.97	-0.98	2.22	0.05-20.3	9.3
Threemile Creek	10	0.99	0.04	0.23	0.08-0.55	6.8
Butcher Creek	10	0.98	-0.36	0.45	0.08-1.5	-5.0
Johns Creek	8	--	--	--	--	--
Red River	9	0.91	9.56	15.21	1.5-91.5	40.9
South Fork Red River	11	0.98	0.17	5.61	0.07-25.5	0.61

A1 Cottonwood Creek

Idaho Department of Environmental Quality (DEQ) and Nez Perce Tribe Water Resources (NPT-WR) staff measured stream flow at Cottonwood Creek. A temporary stream gage with a pressure transducer was installed on 2/10/2021 and recorded water depth every 15 minutes through 12/6/2021. Sixteen paired flow and water depth measurments were collected during the project.

Stream water levels declined to very low levels during the summer, and on 6/16/21 the pressure transducer was moved to keep it submerged during summer low flows. The pressure transducer was moved back to its original location on 9/15/21 after water levels increased. Therefore, 2 separate rating curves were developed, one for the summer low water level period (6/16/21-9/15/21) and one for the rest of the study period (2/10/21-6/16/21, and 9/15/21-12/6/21). Rating curve performance statisticss are presented in Table 3.

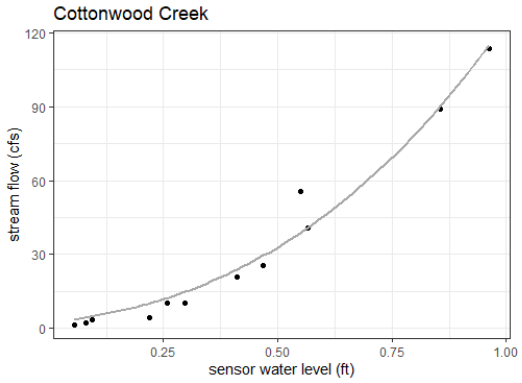


Figure A1. Cottonwood Creek rating curve for 2/10/21-6/16/21 and 9/15/21-12/6/21. Q = 57.20676 * (level - -0.03)$^{2.98153}$.

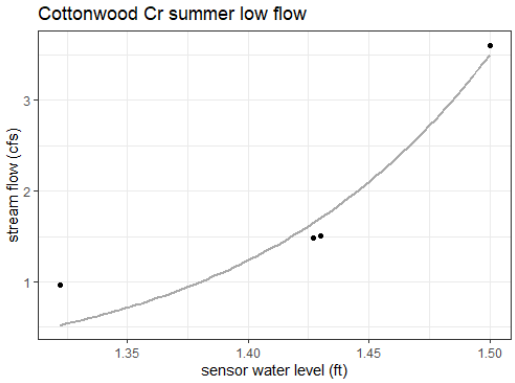


Figure A2. Cottonwood Creek rating curve for 6/16/21 - 9/15/21. Q = 0.006645 * (level - -0.01)$^{15.208805}$.

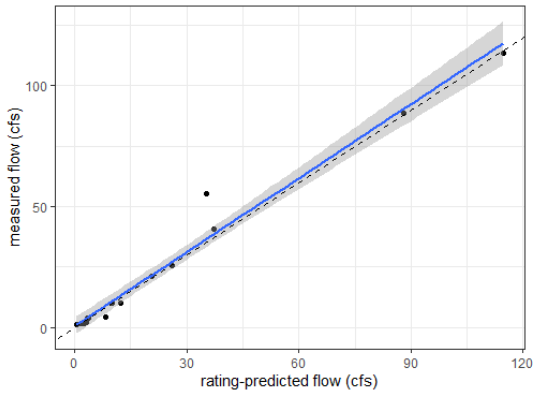


Figure A3. Relationship between measured and rating-predicted flows at Cottonwood Creek. The blue line is a linear regression line, grey shading is the regression 95% confidence interval, and the dashed line is the line of perfect fit.

A2 Threemile Creek

Threemile Creek was monitored by DEQ and NPT-WR. A temporary stream gage with a pressure transducer was installed on 2/22/2021 and recorded water depth every 15 minutes. The gage was damaged during a storm event after installation, was re-installed on 3/17/2021. A rating curve was developed for Threemile Creek using 10 paired water depth and stream flow measurements collected between 3/17/21 and 12/6/21. A linear regression between Cottonwood Creek and Threemile Creek measured flows (TC flow = 1.63692 + 0.24612*CC flow, r^2 = 0.86) was used to estimate Threemile Creek flow between 2/22 and 3/17.

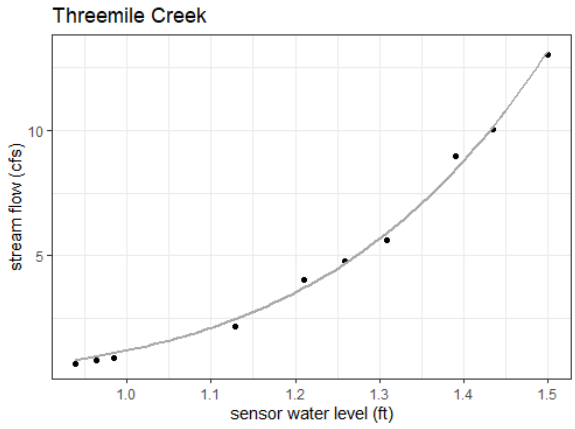


Figure A4. Threemile Creek rating curve for 3/17/21 – 12/6/21. Q = 1.13112*(level - -0.01)$^{5.96050}$.

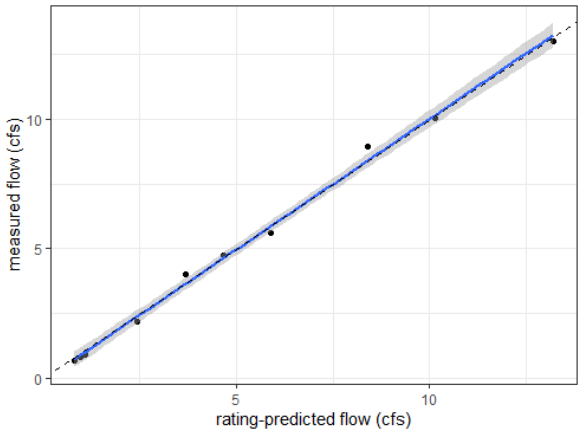


Figure A5. Relationship between measured and rating-predicted flows at Threemile Creek. The blue line is a linear regression line, grey shading is the regression 95% confidence interval, and the dashed line is the line of perfect fit.

A3 Butcher Creek

Butcher Creek was monitored by DEQ. The site is located near the mouth of Butcher Creek on private property. DEQ signed a writen access agreement with the property owner. DEQ installed a temporary stream gage with a pressure transducer on 03/02/2021, and removed the stream gage on 12/6/2021. The pressure transducer recorded water depth every 15 minutes. A rating curve was developed based on 10 paired water depth and flow measurements.

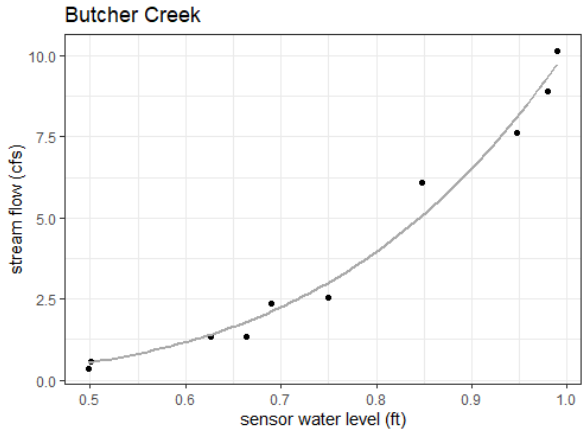


Figure A6. Butcher Creek rating curve for 3/2/21 – 12/6/21. Q = 9.7532*(level - -0.01)$^{4.2864}$.

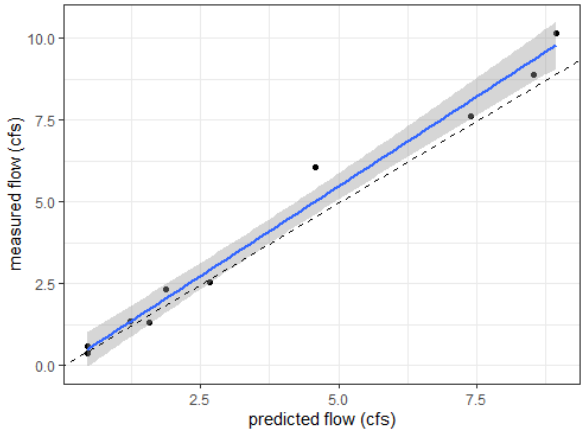


Figure A7. Relationship between measured and rating-predicted flows at Butcher Creek. The blue line is a linear regression line, grey shading is the regression 95% confidence interval, and the dashed line is the line of perfect fit.

A4 Red River

Red River was monitored by USFS and DEQ using existing USFS stream gage infrastructure. Water level was recorded every 15 minutes from 4/26/21 though 12/7/2021. Ten paired flow and water level measurements were collected during the project, and 9 were used to develop a rating curve. A 5/25/21 stream flow measurement (64.47 cfs, 4.88 staff plate reading) was rejected and excluded from rating curve development. The measurement was collected using a bridge board by USFS staff using a bridge board for the first time, and was unrealistically low for the associated staff plate water depth.

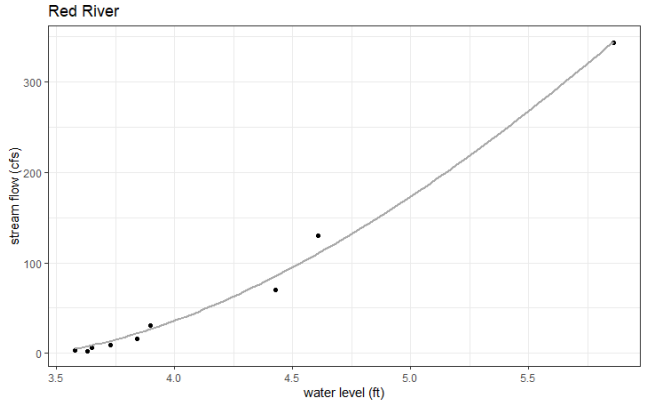


Figure A8. Red River rating curve for 4/26/21 – 12/7/21. $Q = 81.54931*(level - 3.4)^{1.60077}$.

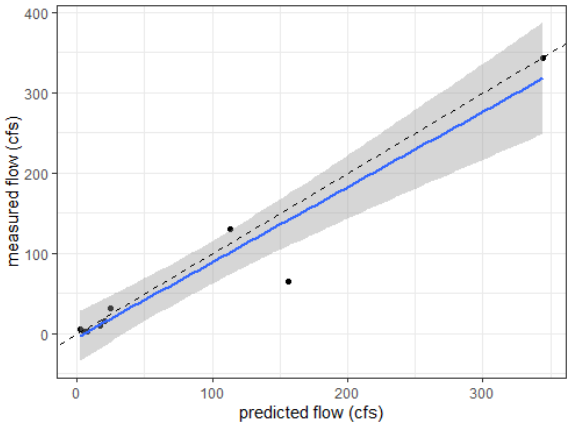


Figure A9. Relationship between measured and rating-predicted flows at Red River. The blue line is a linear regression line, grey shading is the regression 95% confidence interval, and the dashed line is the line of perfect fit.

A5 South Fork Red River

South Fork Red River was monitored by USFS and DEQ using existing USFS stream gage infrastructure. DEQ installed a temporary stream gage with a pressure transducer on 4/29/21. The pressure transducer recorded water level every 15 minutes from 4/29/21 through 12/7/21. Eleven paired flow and water depth measurements were used to develop a rating curve.

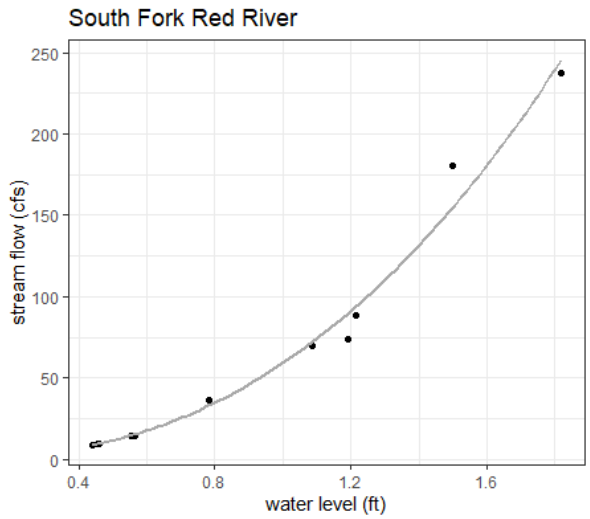


Figure A10. South Fork Red River rating curve for 4/29/21 – 12/7/21. Q = 57.7041*(level - -0.01)$^{2.3982}$.

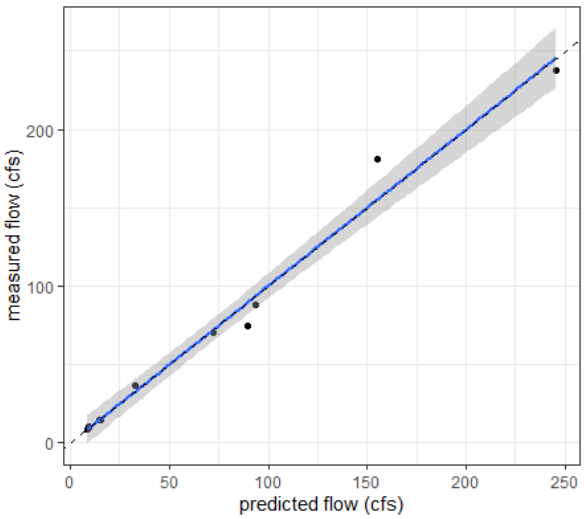


Figure A11. Relationship between measured and rating-predicted flows at South Fork Red River. The blue line is a linear regression line, grey shading is the regression 95% confidence interval, and the dashed line is the line of perfect fit.

A6 Johns Creek

Johns Creek was monitored by USFS and DEQ using existing USFS stream gage infrastructure. A project rating curve was not developed for Johns Creek. Although water level was recorded every 15 minutes from 5/26/21 through 12/7/21, the recorded data could not be recovered due to an equipment failure. Eight paired flow and staff plate water depth measurements were collected during the proejct.

Appendix B. LOADEST Model Information

Table B1. LOADEST models and performance statistics

Site	Model	R^2	Bp	PLR	E
Stites (13338500)	Ln(Load) = a0 + a1 LnQ + a2 Sin(2 pi dtime) + a3 Cos(2 pi dtime) + a4 dtime a0=9.0507, a1=1.6330, a2= -0.5910, a3= -0.2845,, a4 = 1.0598, center of decimal time = 2021.442, center of Ln(Q) = 6.6200	96.05	-12.263	0.877	0.692
Harpster (13338100)	Ln(load) = a0 + a1 LnQ, a0 = 8.7871, a1 = 1.6585, center of decimal time = 2021.442, center of Ln(Q) = 6.5925	93.63	-6.994	0.930	0.739
Elk City (13337500)	Ln(Load) = a0 + a1 LnQ + a2 dtime a0=7.077, a1=1.2446, a2=-0.4337, center of decimal time = 2021.382, center of Ln(Q) = 5.4015	96.08	-6.342	0.937	0.812
Cottonwood Creek	Ln(Load) = a0 + a1 LnQ + a2 dtime a0 = 4.6228, a1 = 1.1822, a2 = -3.6178, center of decimal time = 2021.517, center of Ln(Q) = 2.4056	98.14	0.532	1.005	0.930
Threemile Creek	Ln(Load) = a0 + a1 LnQ + a2 LnQ^2 + a3 Sin(2 pi dtime) + a4 Cos(2 pi dtime) + a5 dtime + a6 dtime^2 a0=1.8304, a1=1.0212, a2=-0.4416, a3=1.6123, a5=-9.5121, a6=34.5629, center of decimal time = 2021.517, center of Ln(Q)=1.4358.	98.12	5.608	1.056	0.837
Butcher Creek	Ln(Load) = a0 + a1 LnQ + a2 Sin(2 pi dtime) + a3 Cos(2 pi dtime) + a4 dtime A0=3.1330, a1=1.7897, a2=1.1718, a3=1.4843, a4=-1.5927, center of decimal time = 2021.534, center of Ln(Q)=0.7591.	98.01	-1.546	0.985	0.936
Red River	Ln(Load) = a0 + a1 LnQ + a2 dtime a0=5.2837, a1=1.2309, a2=0.7738, center of decimal time=2021.832, center of Ln(Q) = 3.3675	98.37	3.509	1.035	0.987
South Fork Red River	Ln(Load) = a0 + a1 LnQ + a2 dtime a0=5.3213, a1=1.2131, a2=0.8168, center of decimal time = 2021.832, center of Ln(Q)=3.4050.	98.17	4.751	1.048	0.989

Notes: load = lbs/day, LnQ = Ln(Q)-center of Ln(Q) where Q = discharge, dtime = decimal time-center of decimal time; R2=, Bp=load bias (%) calculates as the average % difference between observed and estimated loads; PLR=sum of estimated loads divided by sum or observed loads; E=Nash Sutcliffe Efficiency Index, where E ranges from -infinity to 1, and E=1 indicates perfect fit.

Appendix C. Quality Assurance/Quality Control Summary

B1 Background

This appendix reviews quality assurance/quality control (QA/QC) procedures and outcomes for monitoring data collected at tributary sites (Cottonwood Creek, Threemile Creek, Butcher Creek, Johns Creek, Red River, South Fork Red River) by DEQ, NPT, and USFS. USGS applied USGS QAQC procedures to data it collected on the main stem, and reported monitoring results to the National Water Information System (NWIS) and Water Quality Portal (www.waterqualitydata.us).

Before sampling, planned tributary sampling protocols, QAQC procedures, laboratory methods, and data quality objectives were defined in a project quality assurance project plan (QAPP) (DEQ 2021). This appendix documents project compliance with planned project sampling methods, and data quality objectives for precision, bias, sensitivity, rating curves, comparability, representativeness, and completeness.

B2 Sampling Methodology

Sampling methodology required by the project QAPP was followed, except for a few specific departures from protocol for suspended sediment concentration (SSC) and turbidity described below.

The project QAPP required discharge-weighted SSC samples to be collected in tributary streams using equal discharge interval methods (Edwards and Glysson 1999). The QAPP required dividing the stream into four cells of approximately equal discharge, collecting equal-volume samples from each cell with an isokinetic sampler appropriate for the water depth and velocity, and combining the four subsamples to create one composite sample. During very high flow conditions when the stream is not wadable, the QAPP also allowed for collecting and compositing multiple grab samples.

This methodology was followed with a few exceptions. During some summer sample events, water depths and velocities were less than that required by the design of isokinetic sediment samplers, so four grab samples were collected at different locations across the stream cross section and composited. During one high flow sample event at Red River and SF Red River (5-27-22), four grab samples were collected from shore and composited due to a bridge board equipment malfunction. In addition, a review of equal depth interval cell calculations indicated that most EDI cell calculations were approximate rather than exact 25% discharge intervals. No results were qualified or rejected based on sampling methodolgy.

The project QAPP required that only one type (make/model) of turbidity sensor be used within a site across sample events. However, at Johns Creek, Threemile Creek, and Cottonwood Creek, multiple sensor types were used and therefore turbidity measurements did not use consistent equipment across sample events. Turbidity data comparability is discussed further below.

B3 Sampling Frequency

The project QAPP required a minimum of 15 concurrent instantaneous discharge, SSC, and turbidity measurements at each tributary site. This requirement was not met; 8-12 paired

measurements were collected at each tributary site (Table 1). Sample frequency requirements were not met at tributary sites primarily due to agency staffing limitations.

The project QAPP also required stream stage (water level) data to be collected at 15 minute intervals at each tributary during the monitoring period. This requirement was met, with two exceptions. At Johns Creek, USFS stage recording equipment malfunctioned and recorded stage data could not be recovered from the equipment, so instantaneous stage was recorded at each sample event, but continuous stage data were not available. At Threemile Creek, water level data between gage installation on 2/22/2021 and 3/17/2021 were discarded because a high flow event in early March damaged the gage. The gage was re-installed on 3/17/2021. Continuous water level measurements from Cottonwood Creek and a linear regression between Cottonwood Creek and Threemile Creek measured flows ($r^2 = 0.86$) were used to estimate Threemile Creek water level between 2/22 and 3/17.

B4 Sample Handling and Holding Time

The laboratory required a 105 day sample holding time for SSC samples based on Oudyn et al (2012). Sample holding time requirements were met for all tributary SSC samples. The USGS did not flag any main stem samples as exceeding SSC holding time.

DEQ concluded the laboratory mis-reported SSC sample results for samples collected at Butcher Creek on 8-25-2021. A SSC sample, field duplicate, and field blank were collected at Butcher Creek on 8-25-2021. Turbidity values measured on these samples prior to sample submission to Anatek were 0.85 FNU for the sample, 0.82 FNU for the field duplicate, and -1.21 FNU for the field blank. Corresponding SSC results reported by Anatek were 6.80 mg/L for the sample, below detection for the field duplicate, and 9.92 mg/L for the field blank. When DEQ contacted Anatek to ask if results were reported incorrectly, Anatek stated they believed results were reported correctly. Anatek disposed of sample bottles after analysis because the method requires processing the entire sample, and therefore was not able to investigate in detail. Based on the turbidity results, DEQ assumed Anatek accidently switched and mis-reported results for the field duplicate and field blank, and assumed the non-detect lab result was associated with the field blank.

B5 Precision

Precision is a measure of agreement between replicate or duplicate measurements of the same parameter. To assess precision, field duplicate SSC and turbidity measurements were collected. Field duplicate samples were two separate samples collected at the same site and date using the same methodology. Both samples were submited to the laboratory for analysis, and turbidity was measured on both samples using a turbidity meter. The relative percent difference (RPD, Equation A-1) was calculated for each SSC field duplicate and turbidity replicate pair.

$$RPD = \frac{(C_1 - C_2)}{(C_1 + C_2)/2} \times 100$$

Equation A-1. Relative percent difference (RPD).

Where: C_1 = concentration in first sample
C_2 = concentration in the second or duplicate sample

Where both C_1 and C_2 > 5 times the laboratory method detection limit (MDL)

Where one or both C_1 and C_2 are < 5 times the MDL, the results will be considered within control limits where C_1 and C_2 are ± MDL.

The project QAPP defined a target RPD value of +/- 25% and a maximum allowable RPD of 50%. RPD exceeded +/- 25% for one SSC and three turbidity field duplicate pairs (Table A1). In two cases where turbidity RPD exceeded the +/- 25% goal, turbidity values were very low (< 1 FNU) (Table A1). In such cases, RPD values are more sensitive to small differences between original and field duplicate results. Turbidity RPD exceeded the +/- 50 % maximum allowable value for one duplicate pair with turbidity < 1 FNU and SSC below the laboratory practical quantitation limit (1 mg/L) (Table A1). No sample results were qualified or rejected based on precision analyses.

Table B1. Field duplicate SSC and turbidity.

Date	Site	Parameter	Original Result	Field Duplicate Result	PQL	RPD (%)
6/24/21	RR	SSC (mg/l)	2.2	2.08	1	5.6
6/24/21	SFRR	SSC (mg/l)	1.65	1.44	1	13.6
8/25/21	BC	SSC (mg/l)	6.8	9.92	1	-37.2
8/25/21	TC	SSC (mg/l)	< 1	< 1	1	--
10/25/21	BC	SSC (mg/l)	4.87	4.43	1	9.46
11/3/21	JC	SSC (mg/l)	6.5	6.2	1	4.72
12/6/21	BC	SSC (mg/l)	1.63	1.57	1	3.75
6/24/21	RR	Turbidity (FNU)	1.08	0.91	--	17.1
6/24/21	SFRR	Turbidity (FNU)	1.22	1.1	--	10.3
8/25/21	BC	Turbidity (FNU)	0.85	0.82	--	3.6
8/25/21	TC	Turbidity (FNU)	-0.43	-0.8	--	-60.2
8/25/21	TC	Turbidity (NTU)	1.92	2.83	--	-38.3
10/25/21	BC	Turbidity (FNU)	3.3	3.61	--	-9.0
11/3/21	JC	Turbidity (NTU)	1.6	1.27	--	23.0
11/3/21	JC	Turbidity (FNU)	0.91	0.65	--	33.3
12/6/21	BC	Turbidity (FNU)	2.79	2.22	--	22.8

B6 Field Blanks

The QAPP required one field blank to be collected for every 10 regular samples, and associated results below the laboratory practical quantitation limit for SSC (1 mg/L) and at or near 0 for turbidity. Field blanks were collected using either deionized water provided by Anatek labs or store-bought spring water. SSC field blanks were collected by pouring water into pre-rinsed isokinetic sample bottles or grab sample bottles, and then composited into a clean sample container. Turbidity field blanks were collected by taking turbidity measurements on SSC field blank samples. Field blanks met QAPP collection frequency and results requirments (Table B2).

Negative turbidity values were recorded for several field blanks, and also for several regular samples with SSC results below the practical quantitation limit (1 mg/L). In some cases, negative turbidity results can indicate poor turbidity sensor calibration, especially if the turbidity sensor or reagent water used for 0 FNU calibration are not fully clean. Available information does not suggest poor turbidity sensor calibrations were a problem for this project. All YSI EXO turbidity sensor calibrations met manufacturer requirements and received the highest possible calibration quality control score assigned by the manufactuerer's sensor calibration software. In addition, negative turbidity field blank results were within the range of variability observed for field dupicates (Table B1), and also were within manufacturer reported accuracy levels (±0.3 FNU or ±2% of reading, whichever is greater) except two blanks (8/25/21 BC and TC blanks, Table B2). For these reasons, negative turbidity results were assumed to result from normal sensor measurement variability rather than poor sensor calibration.

Table B2. Field blank results.

Date	Site	Parameter	Field Blank Result
8/25/21	BC	SSC (mg/L)	ND
8/25/21	BC	Turbidity (FNU)	-1.21
8/25/21	TC	SSC (mg/L)	ND
8/25/21	TC	Turbidity (FNU)	-2.1
10/25/21	CC	SSC (mg/L)	ND
10/25/21	CC	Turbidity (FNU)	0.02
11/3/21	SFRR	SSC (mg/L)	ND
11/3/21	SFRR	Turbidity (FNU)	0.11
11/3/21	RR	SSC (mg/L)	ND
11/3/21	RR	Turbidity (FNU)	-0.15
11/3/21	JC	SSC (mg/L)	ND
11/3/21	JC	Turbidity (FNU)	-0.1

B7 Sensitivity

Sensitivity is a measure of the capability of a method to detect a substance. It is commonly described as a detection limit. Most labs have a method detection limit (MDL), reporting limit (RL) or practical quantitation limit (PQL) set by the lab for a specific analyte and laboratory method. The analytical laboratory specified the practical quantitation limit (PQL) associated with each result. The project QAPP required a maxium PQL of 1 mg/L for SSC data, and this requirement was met because all laboratory SSC results had a 1 mg/L PQL. The project QAPP also required a 0.5 NTU or FNU minimum reporting limit for turbidity. The YSI EXO turbidity smart sensor used had a manufactuer-reported accuracy of 0.3 FNU or +/- 2% of reading, whichever is greater. The Hach 2100Q turbidity meter used had a manufacturer-reported accuracy of +/- 2% of reading plus 0.02 NTU. Both turbidity meters recorded turbidity < 0.5 turbidity units for project samples and turbidity result met project sensitivity requirements.

B8 Tributary Rating Curves

The QAPP stated “a rating curve developed for a tributary site will be considered acceptable for purposes of this project if all rating curve-predicted discharge measurements are within ± 10% of instantaneous discharge measurements at a site.” One or more rating-predicted discharge values differed from field measured values by > 10% at each tributary site, so this requirement was not met. This requirement was typically not met during very low discharge conditions. For example, at Cottonwood creek rating predicted discharged differed by > ± 10% for 6 of 8 discharge measurments < 5 cfs, with error magnitudes ranging from 0.05-3.7 cfs. In contrast, rating-predicted discharge differed from measured discharge by > ± 10% for 2 of 8 Cottonwood Creek discharge measurements > 10 cfs. One exception to this general pattern was Red River, where the difference exceeded ± 10% for all but one discharge measurement. The mean % difference between rating-predicted and measured flows was < 10% for each tributary site except Red River (Appendix A). Based on these results, rating curve-estimated daily average flows were considered suitable achieving the 2 associated project objectives (Section 3): estimating total suspended sediment loads during the study period at each monitoring site, and evaluating the relative contribution of upper (forested) and lower (Camas Prairie) watershed areas to total suspended sediment loads in the main stem South Fork Clearwater River. However, suspended sediment load values estimated with LOADEST based on daily average flow data, especially short-term (daily or monthly) loads, should be interpreted and used with caution.

B9 Comparability

Comparability is the confidence with which one data set can be compared to another data set. The QAPP defined several criteria for assessing comparability of tributary and main stem data.

The QAPP specified that tributary and main stem SSC data would be comparable if tributary SSC data were collected using equal discharge increment or equal interval methods. This requirement was met, except for exceptions described above for low discharge conditions. Main stem and tributary SSC data were assessed as meeting QAPP comparability requirements.

The QAPP specified that tributary and main stem instantaneous discharge data would be comparable if the same measurement methods were applied across sites. This requirement was

met. Main stem and tributary instantaneous flow data were assessed as meeting QAPP comparability requirements.

The QAPP specified that tributary daily average discharge data would be comparable to main stem daily average flow data if tributary rating curve acceptance criteria were met. As described above, tributary rating curve acceptance criteria were not met, but were considered suitable for purposes of comparing relative seasonal or annual suspended sediment loads across sites during the study period. While tributary daily average discharge data have limited accuracy at the daily time scale, there were also large-magnitude differences between main stem and tributary discharge during most of the study period (Figure 6, Figure 9, Figure 10). Main stem and tributary daily average discharge data therefore were assessed as suitable for comparing relative seasonal or annual discharge patterns and suspended sediment loads across sites during the study period.

The project QAPP did not define comparability requirements for turbidity data. Different make/model turbidity sensors were used across sample sites, and in some cases also within sample sites. Both YSI EXO1 and Hach 2100Q turbidity sensors were used at some tributary sites. The YSI EXO1 sonde measures turbidity in formazin nephelometric turbidity units (FNU), and the Hach 2100Q turbidity sensor measures turbidity in nephelometric turbidity units (NTU). Sensors measuring FNU turbidity use a near infrared light source with a 90 degree detection angle and comply with European drinking water protocol ISO 7027, whereas sensors measuring NTU turbidity use a white light source with a 90 degree detection angle and comply with EPA method 180.1. For 6 sample events, both YSI EXO1 and Hach 2100Q turbidity measurements were obtained from the same composite SSC sample. Project turbidity RPD goals (+/- 25%) were met in two cases, and nearly met (RPD -26.6%) in one case (Table B3). In three additional cases, the RPD exceeded +/-25%, though associated turbidity values were relatively low. In such cases, small magnitude turbidity differences translate to large percent differences. Although the sample size for this comparison is small, RPD patterns across sensor types appear similar to but slightly larger than those within a single sensor type (Table B1). Tributary turbidity data from these two different sensor types were therefore assessed as sufficiently comparable for purposes of documenting turbidity temporal trends within sampled tributary sites. However, other applications of turbidity data could be confounded by sensor differences.

Table B3. Comparison of YSI EXO1 and Hach 2100Q turbidity measurements.

Site	Date	YSI EXO 1 (FNU)	Hach 2100Q (NTU)	RPD (%)
Cottonwood Cr	3-5-2021	60.5	58.9	2.7
Cottonwood Cr	3-17-2021	29.7	38.8	-26.6
Cottonwood Cr	4-8-2021	7.99	7.65	4.3
Cottonwood Cr	5-24-2021	1.98	6.48	-106.4
Threemile Cr	8-25-2021	-0.43	1.92	-315.4
Johns Cr	11-3-2021	0.91	1.60	-55.0

B10 Representativeness

Representativeness is the degree to which sample data accurately and precisely represent site conditions. The project QAPP and FSP did not provide specific representativeness criteria; however, the QAPP did provide guidelines for evaluating representativeness. Because field sampling and laboratory analysis followed standard procedures, procedures were consistent with those during previous sampling, laboratory accuracy and precision requirements were met, and there were no issues with laboratory quality assurance review. All project data satisfy representativeness requirements.

B11 Field Audit

On July 12, 2021, the project quality assurance officer observed flow measurement and SSC sample collection at Johns Creek, Threemile Creek, and Cottonwood Creek. Audit notes are summarized below:

> At Johns Creek with USFS:
>
> Flow, using cable, 50lb torpedo, and flow probe: difficult to do when water is shallow. Wading rod used instead, used properly except for a minor correction because of a relocated boulder. Adequate calibration records. Measurements of 91cfs (raw torpedo), 67cfs (wading rod) and 81cfs (corrected torpedo).
>
> Temperature logger properly deployed in metal sleeve. Need to make sure it's not vulnerable to emersion.
>
> DH-48 was used to collect the water sample, and it was used properly. In well-mixed streams (all three sites qualify), a simple grab sample would be adequate.
>
> At Cottonwood and Threemile Creeks:
>
> Flow collected properly, using BURP methods.
>
> Samples collected from quartiles. This was done properly, but may be counterproductive, because sampling in such shallow water may cause algal filaments to enter the sample bottle. If the creek is very shallow (eg Cottonwood Creek), it might be more representative to take a single grab sample from a deep section.
>
> Turbidity probe properly calibrated.
>
> Overall, I was happy with the data collection efforts. Sediment and turbidity samples were collected properly, and in full accordance with the QAPP.

B12 USGS Main Stem Data

Main stem data flow, SSC, and turbidity data collected by the US Geological Survey (USGS) were downloaded from the USGS's National Water Information System (NWIS) using an R script and

the dataRetrieval R package version 2.7.1 (DeCicco et al. 2021, *https://cran.r-project.org/web/packages/dataRetrieval/index.html*).

DEQ staff identified 5/12/2021 and 7/12/2021 SSC results from the Harpster Site (13338100) as abnormally high for the corresponding turbidity result and discharge conditions (Table B4, Figures B1-B3) and contacted USGS. USGS staff conducted an investigation and ultimately rejected the 5/21 and 7/12 Harpster SSC results and made them unavailable to the public through NWIS (Dave Evetts, USGS e-mail to Jason Williams, 9-30-2022). DEQ therefore subsequently excluded the 7/21 and 7/12 results from analyses.

Table B4. Comparison of discharge, turbidity, and SSC results across main stem sites for 5/12/2021 and 7/12/2021.

Site	Date	Measured Discharge (cfs)	Discharge Conditions	Measured Turbidity (FNU)	SSC (mg/L)
Stites (13338500)	5/12/2021	2,250	Stable, normal stage	3.8	7
Harpster (13338100)	5/12/2021	2,230	Stable, normal stage	2.6	**43 (rejected)**
Elk City (13337500)	7/12/2021	66	Stable, low stage	0.2	4
Harpster (13338100)	7/12/2021	335	Stable, low stage	0	**22 (rejected)**
Stites (13338500)	7/14/2021	309	Stable, low stage	0	2

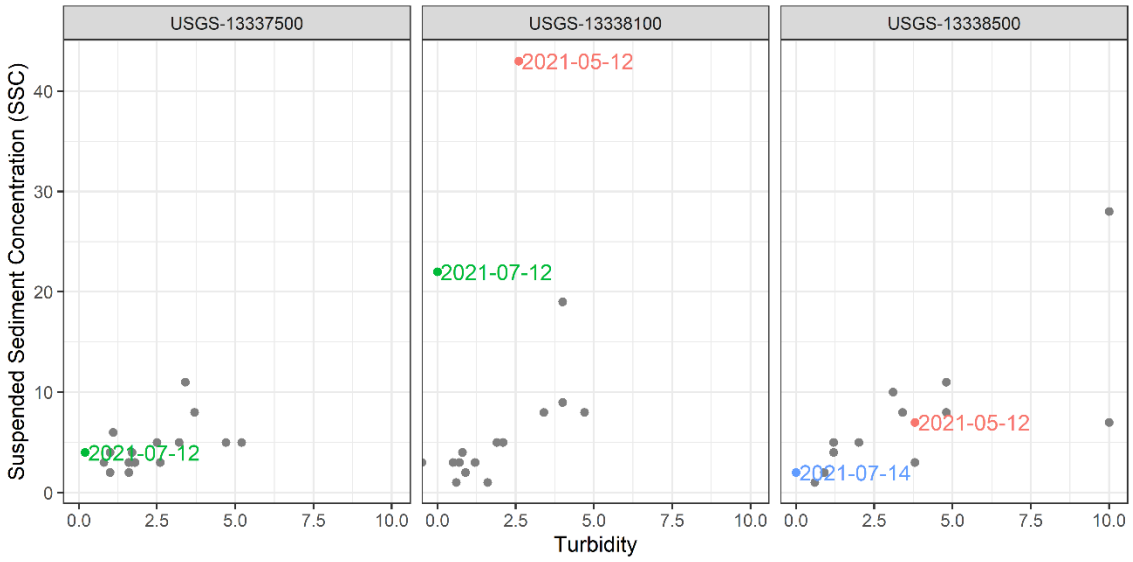


Figure B1. Relationship between measured turbidity (FNU) and SSC (mg/L) for the main stem near Elk City (13337500), near Harpster (13338100), and near Stites (13338500) for calendar year 2021 USGS data.

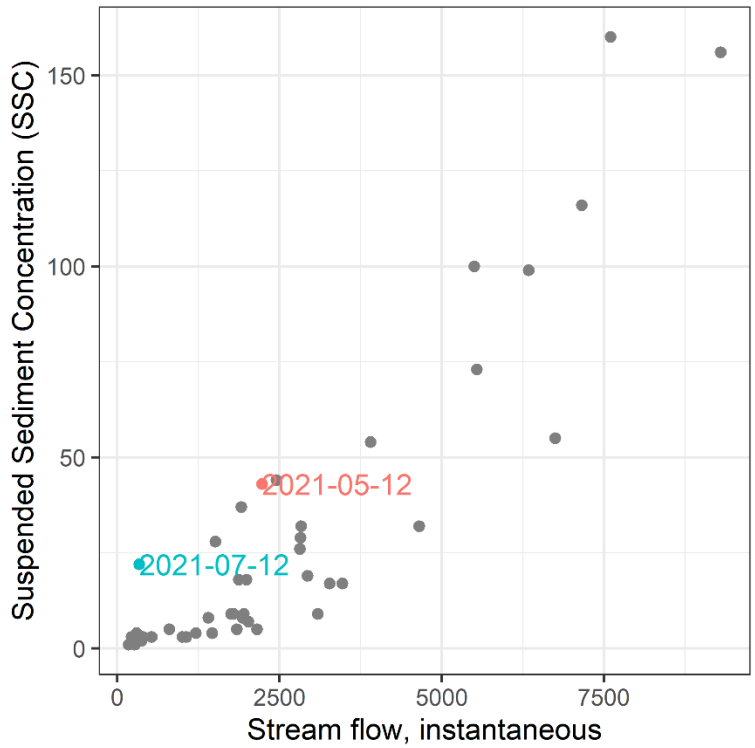


Figure B2. Relationship between measured stream flow (cfs) and SSC (mg/L), using all available USGS measurements across years for Harpster (13338100)

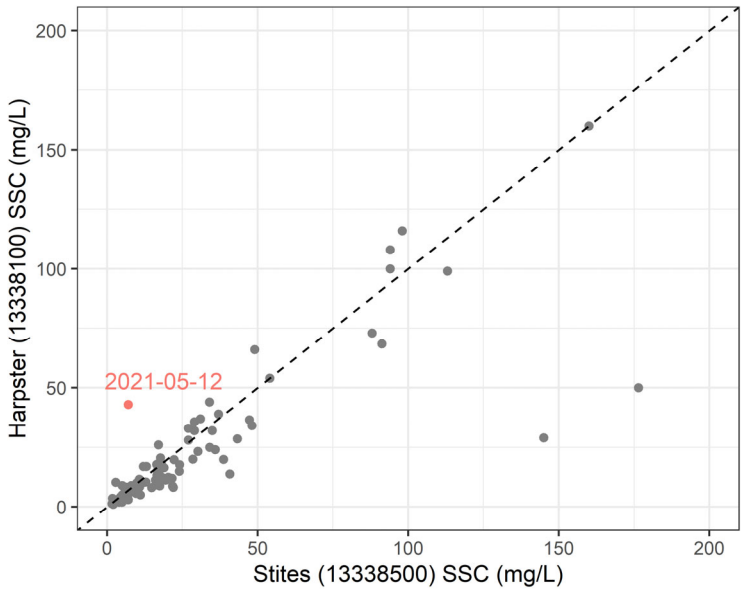


Figure B3. Relationship between SSC measured at Stites and Harpster, using available data across years where SSC samples were collected at both sites on the same day.

B13 Completeness

Completeness is the percentage of valid data relative to the total possible data points. For data to be considered valid, it must meet all of the acceptance criteria, including accuracy and precision, and any other criteria specified by the analytical method used. The QAPP set a 90% completeness target for turbidity and SSC data. The USGS rejected 2 of 50 SSC results collected on the main stem (4%). DEQ did not reject or qualify any SSC or turbidity results collected in tributaries. Project completeness targets therefore were met for SSC and turbidity.

The QAPP did not specify a completeness requirements for water level or continuous flow data, but did set acceptance criteria for rating curves. Although rating curve data did not meet QAPP acceptance criteria, rating curve-estimated daily average flows were considered suitable for achieving the 2 associated project objectives: estimating total suspended sediment loads during the study period at each monitoring site, and evaluating the relative contribution of upper (forested) and lower (Camas Prairie) watershed areas to total suspended sediment loads in the main stem South Fork Clearwater River (section B8).

The QAPP did not specify completeness requirements for flow measurement data. One flow measurement collected 5/25/2021 at Red River (64.47 cfs) was rejected and excluded from analyses. The measurement was collected using a bridge board by USFS staff that were using a bridge board for the first time. Based on analysis of 2021 and historic data available at the gage site, the measured flow value was unrealistically low for the associated staff plate water depth (4.88 ft).

B14 Data Usability Assessment

Except for the one rejected flow measurement at Red River, and the two rejected SSC samples on the main stem at Harpster (USGS-13338100), all project data were considered to meet project usability needs. Specifically, all non-rejected data are suitable for achieving the 3 project objectives (section 3): evaluating compliance with TMDL SSC targets, estimating total suspended sediment loads during the study period at each monitoring site, and evaluating the relative contribution of upper (forested) and lower (Camas Prairie) watershed areas to total suspended sediment loads in the main stem South Fork Clearwater River. For other applications, data users should consider project methods and QAQC information included in this document and evaluate if project data are suitable for other specific applications.