SEDIMENT MONITORING DURING SHORT-TERM DRAWDOWNS OF FALL CREEK LAKE, UPPER WILLAMETTE BASIN, OREGON

Liam Schenk, Hydrologist, USGS Oregon Water Science Center, Klamath Falls field office, lschenk@usgs.gov; Heather Bragg, Hydrologic Technician, USGS Oregon Water Science Center, hmbragg@usgs.gov;

INTRODUCTION

In December 2012 and December 2013, the U.S. Army Corps of Engineers (USACE) conducted operational drawdowns of Fall Creek Lake, Oregon, to enhance downstream passage of Endangered Species Act-listed juvenile spring Chinook salmon in response to requirements in the 2008 Biological Opinion on continued operations of the Willamette Valley Project (National Marine Fisheries Services, 2008). During these drawdowns the lake elevation was lowered from the normal winter low-pool elevation of 728 feet to approximately 690 feet, allowing inflowing water to pass freely through the regulating outlets of the Fall Creek Dam. The U.S. Geological Survey (USGS) monitored the resulting suspended sediment release and has estimated sediment loads transported during these events. Data generated from the monitoring efforts provides the USACE with important information regarding the amount of sediment transported during these operational drawdowns.

DATA COLLECTION

The USGS monitored turbidity and suspended sediment over a range of hydrologic and sediment transport conditions before, during, and after drawdown operations at Fall Creek Lake. Monitoring occurred from November 2012 through February 2013 during water year (WY) 2013 and November 2013 through March 2014 (during WY 2014). In WY 2013, six monitoring stations were established for the lake and at strategic locations downstream, including the two main inflows to Fall Creek Lake, Fall Creek below Fall Creek Dam (Fall Creek Outflow in Figure 1), Little Fall Creek (a tributary to Fall Creek), and two sites on the Middle Fork Willamette River (Dexter and Jasper, Figure 1). During WY 2014, only the station at Fall Creek Outflow was monitored. Turbidity sensors measuring in Formazin Nephelometric Units (FNUs) were deployed and Equal-Width-Increment (EWI) suspended-sediment concentration (SSC) samples were collected at all sites. Automatic pump samplers were installed at several sites to provide additional SSC data. Correction coefficients were calculated to adjust the pump sample concentrations to cross section EWI samples. All samples were analyzed for SSC (in milligrams per liter [mg/L]) and percent finer than 63 microns (percent fines) at the USGS Cascades Volcano Observatory sediment lab. Each discrete SSC sample was assigned an associated turbidity and streamflow (in cubic feet per second [cfs]) value from the continuously monitored instream data.

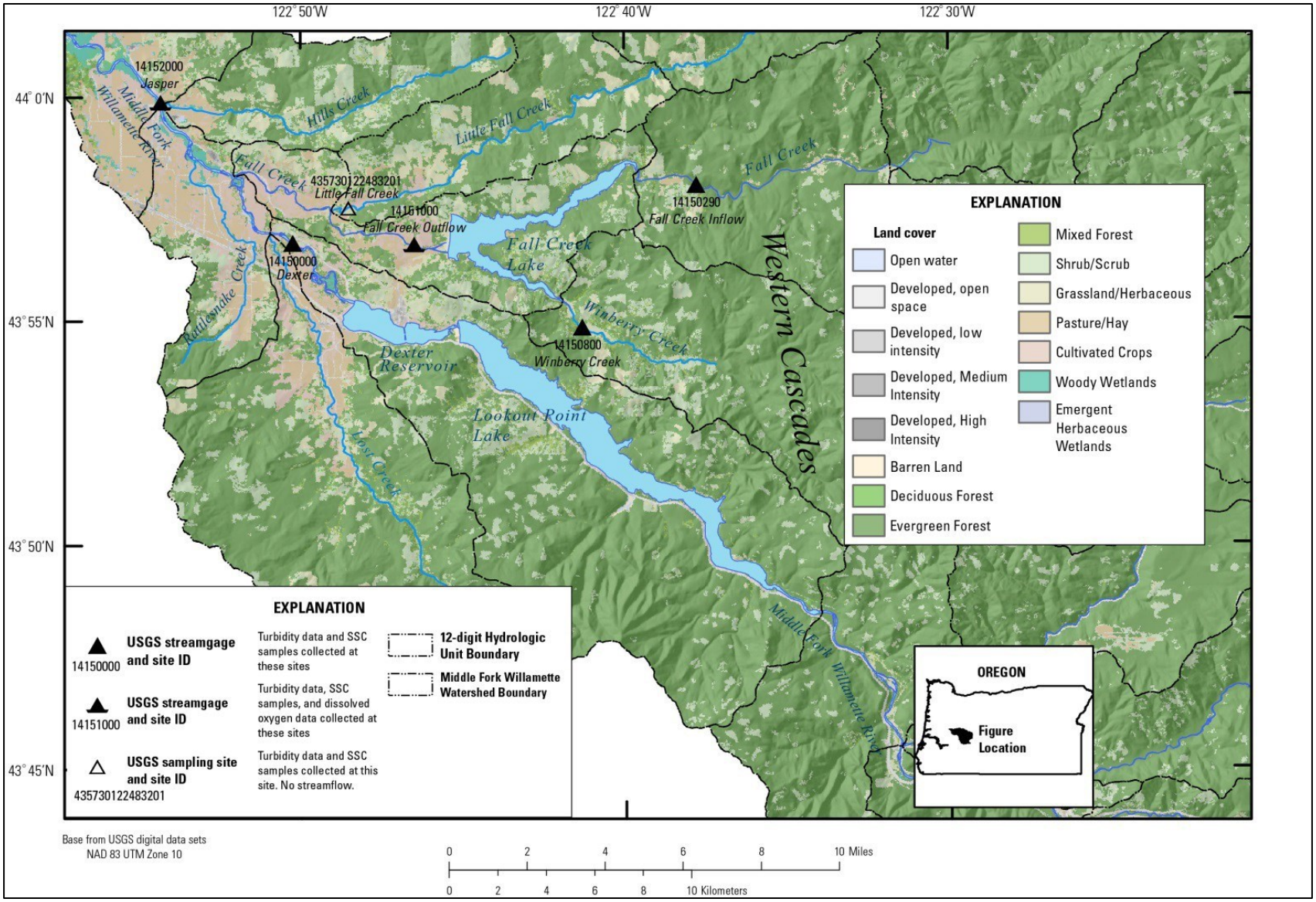

Figure 1 Location of study area and monitoring stations, Middle Fork Willamette Basin, Oregon (from Schenk and Bragg, 2014)

DATA ANALYSIS

Site-specific regression models were developed from discrete turbidity, streamflow, and SSC data. Sample data for sites downstream of the dam were divided into pre-drawdown, drawdown, and post-drawdown analysis periods. Log10-transformed and untransformed turbidity and streamflow data were used to create both simple and multiple linear regression models which were evaluated on residual plots and summary statistics. Model development followed USGS guidelines outlined in Rassumussen and others (2009). The preferred models were used to compute continuous SSC records for each of the sites. Continuous suspended-sediment loads were computed from the SSC and streamflow records. For WY 2013, suspended-sediment loads were computed for all six stations. For WY 2014, suspended-sediment loads were only computed for the single station (Fall Creek Outflow) before, during, and after the drawdown for comparison to the suspended sediment loads calculated in WY 2013.

RESULTS

The FY 2013 drawdown occurred for six days in December 2012 (Figure 2) and resulted in the net transport of approximately 50,300 tons of sediment from the lake, accounting for approximately 83% of the total suspended-sediment load delivered from Fall Creek Lake during the study period. The drawdown also resulted in approximately 16,300 tons of sediment deposited in the river reaches between Fall Creek Lake and a site on the Middle Fork Willamette River (Jasper), which was ten miles downstream of the lake (Schenk and Bragg, 2014).

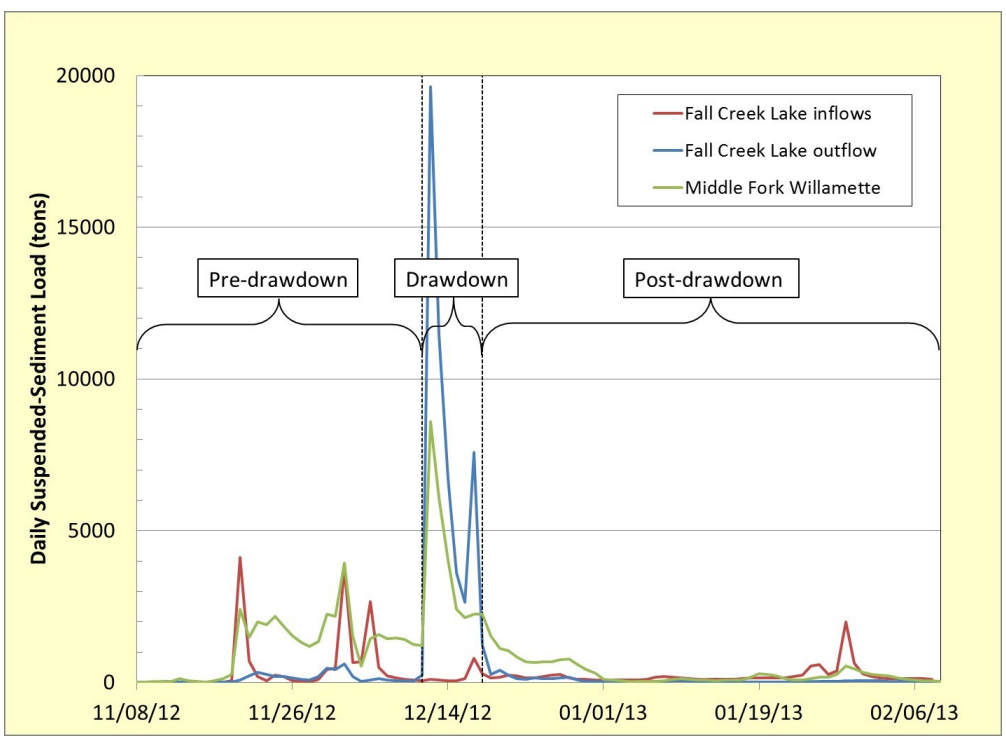

Figure 2 Water year 2013 daily suspended-sediment loads for Fall Creek Lake inflows, Fall Creek Lake outflow, and the monitoring site ten river miles downstream of Fall Creek Lake (Jasper) on the Middle Fork Willamette River.

Due to unseasonably cold weather, the suspended-sediment load during the WY 2014 drawdown was particularly low. The area received 8–10 inches of snow followed by air temperatures consistently below freezing for most of the drawdown period. The sediment exposed in the lakebed was frozen and unavailable for transport. During the first 5½ days of the ten-day drawdown in December 2013, only 3,300 tons of sediment was transported from the lake (Figure 3). Turbidity data were lost for the last 4½ days of the drawdown due to sensor fouling, and sediment loads were computed using daily mean values of SSC and streamflow, resulting in a total sediment load of approximately 5,220 tons during the ten-day drawdown period. This accounted for approximately 19% of the total sediment load during the study period and was 90% less than the previous drawdown in WY 2013.

Most of the sediment transport in WY 2014 occurred in February 2014, when the lake elevation dropped to approximately 700 feet, which was concurrent with extremely high streamflows (>3,500 cfs, peak streamflow of the WY). Monitoring was not conducted at the inflows to the lake in WY 2014, so how much of the suspended- sediment load came from upstream inflows compared to bank erosion or sediment re-suspension within the lake is unknown. However, given the limited contribution from the inflows in WY 2013 (approximately 2.5% of total sediment load) it is likely their contribution was similarly small in WY 2014. A preliminary analysis for the WY 2015 drawdown conducted in November 2014 suggests that approximately 20,000 to 35,000 tons of sediment was transported during a s e v e n - day period, further highlighting the inter-annual variability in sediment transport during the operational drawdowns.

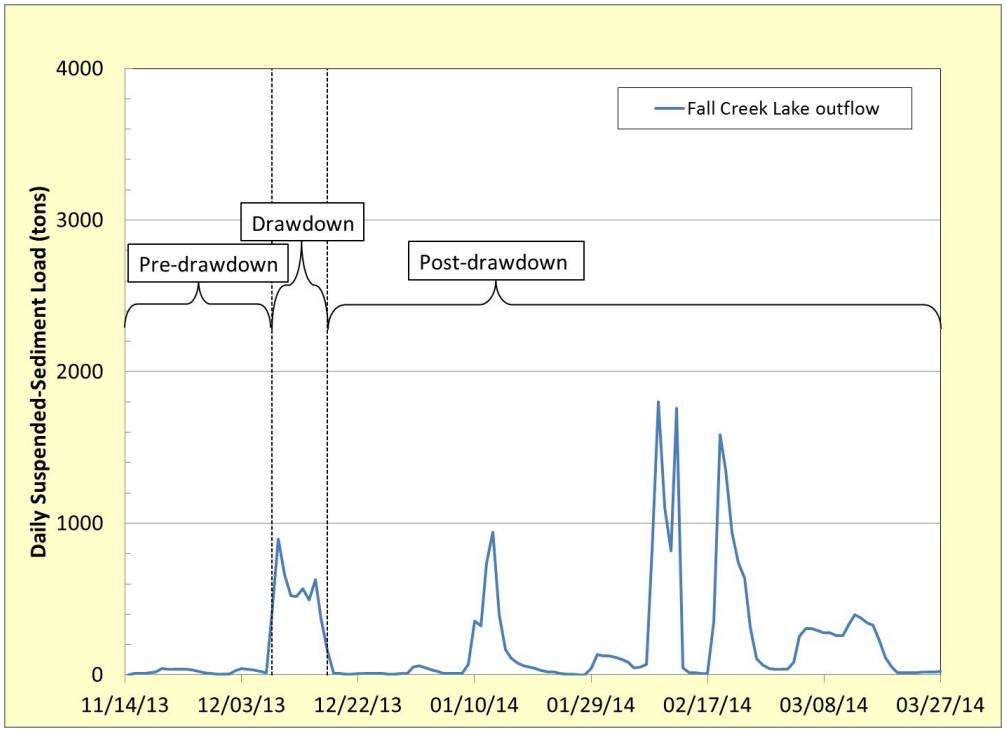

Figure 3 Water year 2014 daily suspended-sediment loads for Fall Creek Lake outflow.

SUMMARY

Results from suspended-sediment monitoring at Fall Creek Lake during two operational drawdowns suggest that variability in hydrologic and climatic conditions and lake elevation play an important role in sediment transport and supply. This is highlighted by the difference in sediment load estimates from the December 2012 and 2013 drawdown operations. Monitoring results suggest a 90% reduction in sediment loads from the 2012 to 2013 drawdown operations, but this decrease in loads was likely forced by weather conditions rather than a reduction in sediment supply after the previous drawdown. Ongoing monitoring and data collection efforts will continue to investigate inter-annual variability in sediment transport during these operational drawdowns, and provide useful information about changes in reservoir storage capacity that is beneficial for future flood control efforts.

REFERENCES

National Marine Fisheries Service. (2008). "PCTS consultation summary – Continued operation of 13 dams and maintenance of 43 miles of revetments in the Willamette basin, Oregon", National Oceanographic and Atmospheric Administration Web page, accessed March 31, 2014 at: *https://pcts.nmfs.noaa.gov/pcts-web/dispatcher/trackable/NWR-2000-2117?overrideUserGroup=PUBLIC&referer=/pcts-web/publicAdvancedQuery.pcts?searchAction=SESSION_SEARCH*

Rasmussen, P.P., Gray, J.R., Glysson, G.D., and Ziegler, A.C. (2009). "Guidelines and procedures for computing time-series suspended sediment concentrations and loads from in-stream turbidity-sensor and streamflow data," U.S. Geological Survey Techniques and Methods, book 3, chap. C4, 52 p.

Schenk, L.N., Bragg, H.M. (2014). "Assessment of suspended-sediment transport, bedload, and dissolved oxygen during a short-term drawdown of Fall Creek Lake, Oregon, winter 2012-13," U.S. Geological Survey Open-File Report 2014-1114, 80 p., *http://dx.doi.org/10.3133/ofr20141114*.