Application and Case Study of Sediment Augmentation on the Clackamas River, Oregon

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Extended abstract

Channel restoration via sediment augmentation in the Clackamas River basin is being conducted by Portland General Electric Company to help restore geomorphic processes below key hydroelectric facilities on the mainstem Clackamas River (2,430 km^2 drainage area) and on the Oak Grove Fork (a major tributary, 370 km^2 drainage area). Measurable geomorphic changes to both the Clackamas River and Oak Grove Fork have been attributed to facilities operations (e.g., sediment trapping, flow regulation), and include changes in channel geometry, sediment supply, grain size, and bed elevation (McBain et al. 2001, Wampler and Grant 2003; McBain and Trush 2004). The overarching sediment augmentation program goal at both locations is to resupply sediment to help restore geomorphic processes and channel form under the contemporary flow regime using a portion of the historic sediment supply. It is expected that sediment augmentation will result in restorative and beneficial geomorphic, biological, and water quality changes.

Variations in geology and natural basin sediment yield and flow regime between the mainstem Clackamas River and Oak Grove Fork requires different augmentation scales and strategies, and provides a unique opportunity to compare augmentation and monitoring methods under the same program. The Clackamas River sediment augmentation site is located below River Mill and North Fork Dams, at 93 m elevation in the eastern Willamette Valley (45.300927°, -122.354126°). Annual peak flows typically occur in fall or winter and are rainfall or rain-on-snow events ($Q_{2.0}$ = 702 cms). The Oak Grove Fork augmentation sites (n=2) are located approximately 56 km upstream of the mainstem augmentation site, at 450 m and 625 m elevation, and are located below Lake Harriet Dam (45.077034°, -121.974364°). Annual peak flows typically occur as winter rainfall and spring snowmelt events ($Q_{2.0}$ = 28.3 cms). Natural sediment yield on the Oak Grove Fork is small compared to the mainstem Clackamas River (9.1 $t/km^2/yr$ and 92 $t/km^2/yr$, respectively) (McBain and Trush 2002, Wampler and Grant 2003).

Sediment augmentation in the basin began at both sites in 2016. Sediment for the Oak Grove Fork augmentation is screened to a specific particle size distribution ranging from 101 mm – 10 mm, and is added directly to the wetted channel. Sediment is placed along the bank at two sites, approximately 6 km apart, where recruitment begins immediately. Placement at the upstream site is in a steep canyon and sediment is added via chute, forming a temporary cone, and placement at the downstream site is along a vertical cutbank where sediment is placed by excavator, forming a prism. In contrast, mainstem Clackamas River augmentation sediment is mined from an adjacent upslope terrace and is not screened or washed prior to placement. This results in both coarse and fine sediment being placed and a substantially broader particle size range, with the largest particles (D_{max}) up to 256 mm. Mainstem sediment augmentation occurs during summer, when sediment is placed on a dry bedrock shelf adjacent to the channel where it is recruited during fall and winter high flow events. Annual augmentation volumes between the two locations differ by up to two orders of magnitude, e.g., August 2018 augmentation volumes were 470 t on the Oak Grove Fork and 18,200 t on the mainstem Clackamas River.

The placement sites are visited several times annually to observe augmentation pile evolution in response to peak flow events. On the Oak Grove Fork, sediment recruitment has occurred as expected and no changes to the placement strategy have been made. Conversely, sediment augmentation pile behavior on the mainstem Clackamas River has required some finessing to optimize augmentation pile recruitment. The inaugural (2016) augmentation pile placement showed little recruitment following the first peak flow events (up to $Q_{1.4}$), while modeling suggested sediment mobility thresholds should have been met. Based on observations during these peak flow events, the pile was reshaped to a configuration that increased its hydraulic exposure and resulted in greater sediment recruitment during subsequent similar magnitude peak flows. This active, adaptive management has been a critical component to the early success at this location. Subsequent placements have followed this strategy and are showing improved sediment recruitment and downstream transport.

Differences in scale between the two locations also allows for a range of monitoring techniques to track downstream transport, deposition, and resulting geomorphic response. While monitoring objectives for both the Oak Grove Fork and the mainstem Clackamas River focus on evaluating augmentation-related geomorphic changes, site size and scale requires different data collection and analytical methods. The Oak Grove Fork monitoring reach is a 2 km-long wadable channel, allowing data collection to be ground-based. Geomorphic monitoring objectives focus on tracking downstream transport and deposition, which are accomplished by (a) annual reconnaissance to identify and document downstream deposition distance, which is aided by a unique-lithology visual tracer gravel added to the augmentation mix (5 percent), and (b) high resolution ground-based photogrammetry and Digital Elevation Model (DEM) differencing to measure depositional volumes and patterns, compare results to sediment transport model predictions, and evaluate whether geomorphic objectives are being met (Curran 2017).

In contrast, monitoring on the much larger mainstem Clackamas River is conducted over a 10 km reach, and requires a boat. A pre-augmentation “baseline” monitoring program was conducted from 2011-2013 that focused on documenting pre-project conditions in downstream areas determined most likely to be influenced by sediment augmentation (Wampler and Grant 2003, PGE and McBain and Trush 2011). Monitoring resumed in 2017 and is repeating the baseline monitoring so comparisons can be made to (1) evaluate how augmented sediment is routing and depositing downstream, (2) evaluate resulting geomorphic, biological, and water quality changes, and (3) assess whether adverse effects are occurring as a result of sediment augmentation that require corrective action. Like the Oak Grove Fork, monitoring objectives on the mainstem Clackamas River include assessing geomorphic change from DEM differencing, but the larger channel requires data collection using a combination of aerial LiDAR and boat-based channel bathymetry to capture surfaces. Additional mainstem geomorphic monitoring evaluates the overall abundance and composition of alluvial features, including bar frequency and particle size distribution, bedrock exposure, and side channel entrance flow thresholds.

While still early in the program, monitoring has already documented successful sediment recruitment, transport, and downstream deposition from each augmentation location, showing a positive start to meeting program objectives. Success can be attributed to both natural recruitment and routing, and (on the mainstem Clackamas River) active adaptive management of the augmentation pile by observing pile response to multiple peak flow events and reshaping the pile to maximize the opportunity for sediment to be recruited and transported downstream. Data collection for a full evaluation of geomorphic and biological objectives is underway and a data synthesis and program review are scheduled for 2022.

References

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