ELWHA PLANECAM: AFFORDABLE NEAR-REAL-TIME ORTHOIMAGERY AND DIGITAL ELEVATION MODELS IN SUPPORT OF ADAPTIVE SEDIMENT MANAGEMENT AND MODELING DURING ELWHA AND GLINES CANYON DAM REMOVAL.

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Topic Area: [Remote sensing]; Dam Removal/Rehabilitation; sediment yield and transport modeling, Fluvial Geomorphology

Subthemes: Innovation in measurement, management, and prediction of sediment in water and watersheds; dam removal, dam rehabilitation, and stream restoration; adaptive management

Elwha and Glines Canyon dams impounded about 28 million yd^3 ± 4 million yd^3 of sediment in Lake Mills and Lake Aldwell. Removal of these dams represents the largest dam removal and managed sediment release in U.S. history, with roughly a 20 year supply of coarse sediment and a 5 year supply of fine sediment released from October 2012 to March 2013 alone. Monitoring changes during dam removal presents a significant challenge due to limited monitoring resources, the large area affected by dam removal (approximately 16.5 river miles with an average valley width of about 3000 ft) and the near-real-time need for data from both reservoir and river reaches for adaptive project management decisions.

A rapid-deployment, low-cost method was developed to collect aerial imagery and generate orthoimagery and digital elevation models (DEMs) of the Elwha River during removal of Elwha and Glines Canyon dams. Imagery is collected with a firmware-modified consumer-grade camera and processed using structure from motion algorithms to produce a spatially accurate DEM with sub-foot resolution and orthoimagery with ~5 inch ground sample distance. A network of RTK GNSS surveyed ground control points (GCPs) with aerial targets are used to reference the DEM and orthoimagery to a geographic coordinate system and enable surface comparison using GIS tools. Flights are conducted on a weekly to monthly basis depending on hydrology and project progress, at a cost of roughly $300/flight. Imagery can be processed to produce DEMs and orthophotos of a specific reach in as little as 24 hours if needed.

Orthoimage resolution allows identification and measurement of features such as individual logs and sediment texture differences. Data are used to determine maximum inundation/erosion width, map banklines and evolution of depositional and erosional features such as midchannel bars and logjams, and to evaluate significant features affecting river morphology such as logjams and channel braidedness. The temporal frequency of flights makes it possible to compute bank erosion rates, meander migration rates, and the evolution of potential hazards.

DEMs are produced at 0.5 meter resolution. Features such as terraces, small channels, and individual logs can be identified. DEMs are used to calculate erosion volumes by comparing DEMs between flights, as well as comparing DEMs to LiDAR data, profile and cross-section surveys, and the pre-project surface model. DEMs also provide a measure of erosion slope along the reservoirs, and are used to calibrate the reservoir erosion model guiding dam removal. Comparison with LiDAR and RTK GNSS survey data indicate that DEMs provide an accurate tool with quantifiable error estimates and can be used to measure slopes and make volume calculations.

Elwha PlaneCam data have proven instrumental in monitoring difficult-to-reach areas, providing near-real-time updates to sediment erosion volumes during the project, and providing a high resolution spatial and temporal record of changes throughout the area affected by the removal of Elwha and Glines Canyon dams. Data from this survey method will produce a record of the project that is detailed enough to be mined for future research, yet rapid enough to provide feedback to calibrate models and guide project managers during dam removal.