# *Effectiveness Monitoring for Brownsville and Sodom Dam Removals*

Prepared for:
Oregon Watershed Enhancement Board
Calapooia Watershed Council
Oregon Parks and Recreation Department

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## *Abstract*

The substantial costs, public interest, and benefits associated with removing Brownsville and Sodom dams warrant the documentation of outcomes on the Calapooia River. Physical, chemical, and biological responses are all relevant to these two dam removals, and the proposed monitoring plan describes an efficient and informative series of monitoring activities to document the extent of these responses over time. Specifically, we propose an integration of activities to be performed by the investigators (e.g., channel surveys, bed material characterizations, turbidity, temperature, benthic macroinvertebrate sampling, analysis of aerial photos, analysis of current and historical streamflow), outside agencies such as ODFW (fish surveys), and the Calapooia Watershed Council and Oregon Parks and Recreation (photo points, staff gage observations) for a comprehensive record of the changes in the river associated with the removal of the two dams. This effectiveness monitoring strategy will both assess recovery of the river and contribute to a larger study to (1) document dominant geomorphic processes associated with dam removal and (2) evaluate the reliability of bioindicators for detecting change following dam removal. .

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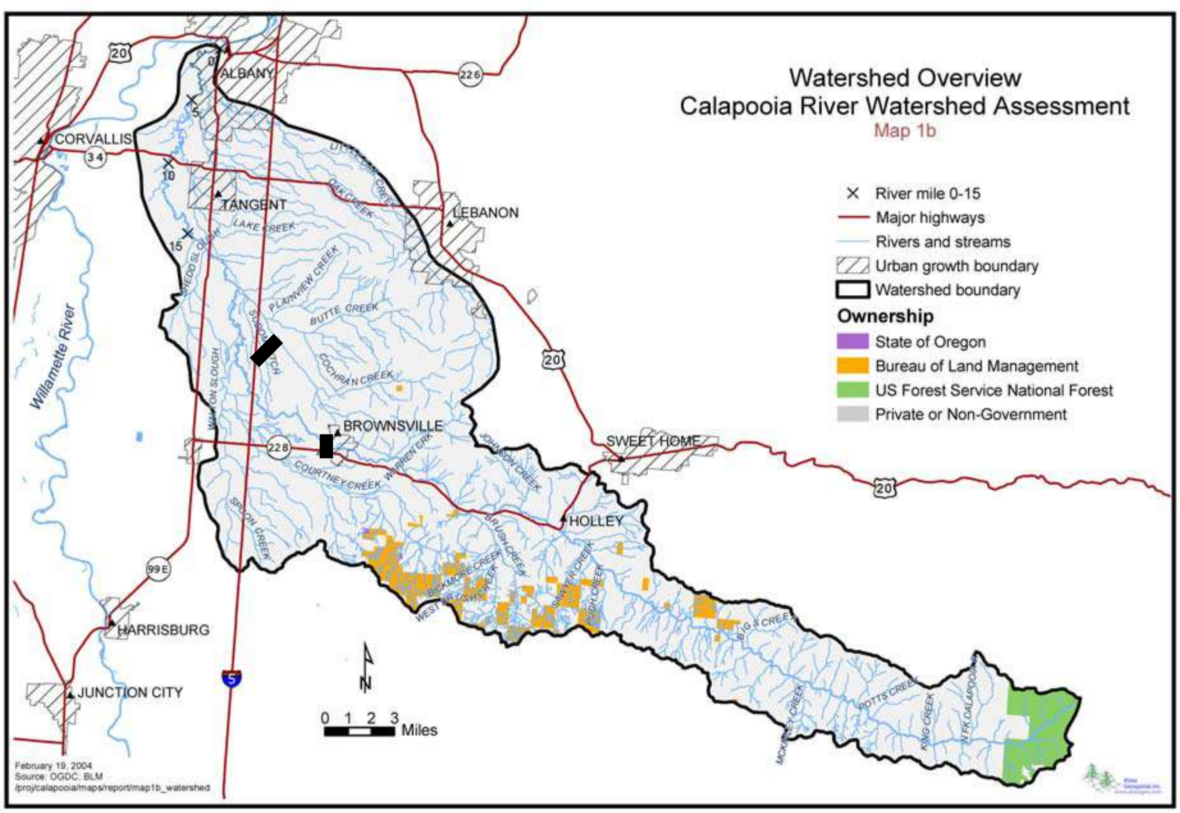
**1.0 Background -** The removal of two dams, the Brownsville Dam as managed by the Calapooia Watershed Council (CWC) and the Sodom Dam as managed by Oregon Parks and Recreation, are scheduled on the Calapooia River. It is expected that the removal of Brownsville and Sodom dams will affect local hydrology, sedimentation processes (erosion, transport, and deposition), and the ecology of the Calapooia channel, floodplain, and riparian zone. This proposed effectiveness monitoring strategy is designed to document the short-term effects of these removals, including the benefits and risks associated with the removal of Brownsville and Sodom dams, while improving future predictions of ecosystem responses to future dam removal. A study of the social and community influences and outcomes of dam removal at Brownsville and Sodom dams will be proposed under another monitoring program.

Because a final removal strategy and scope has not yet been defined for Sodom Dam, revisions to this effectiveness monitoring strategy for Sodom may be made following acceptance of a final removal scope of work. Further, due to the limited pre-removal data at the Brownsville and Sodom sites, this effectiveness monitoring strategy allows for some flexibility for the final monitoring design following a comprehensive baseline assessment.

**Figure 1 – Project location map** (courtesy of Calapooia Watershed Council) Approximate locations of Brownsville and Sodom Dams are indicated in bold lines, with Brownsville Dam located just south of Brownsville along the main channel of the Calapooia and the Sodom Dam located further downstream within the Sodom Ditch.



**2.0 Effectiveness monitoring framework -** We propose the following framework for effectiveness monitoring at Brownsville and Sodom Dams. This framework is also proposed at the Chiloquin and Savage Rapids dam removal sites as part of a larger effort to more systematically predict, document, and evaluate effects of dam removals.

**Effectiveness monitoring framework:**

2.1 define monitoring objectives
2.2 identify relevant and accessible existing data resources
2.3 baseline assessment
2.4 determine dam 'effect size' and define appropriate monitoring questions and metrics
2.5 final design and implementation of study design
2.6 drawdown and removal monitoring
2.7 post-removal monitoring

**2.1 Monitoring objectives -** The first questions in designing an effectiveness monitoring strategy are "what effects and responses do we expect to see" and "in what timeframe are we expecting to see them"? Thus, we have designed a monitoring strategy to address specific effects and responses anticipated in the removal of Brownsville and Sodom Dams, with the broader **goal** of documenting the physical, chemical, and biological short-term responses of two reaches of the Calapooia river to the removal of Brownsville and Sodom Dams. We propose a strategy that will include observations prior to, during, and following the removal of features such as hydrologic, hydraulic and morphologic characteristics, geomorphic processes, interactions among flow and sediment transport, and responses of dependent aquatic and riparian habitats. The monitoring strategy will both assess recovery of the river following the dam removals and contribute to a larger study (including Chiloquin and Savage Rapids dam removals) with **objectives** to

(1) document dominant geomorphic processes and responses to with the dam removals

(2) evaluate the change in and reliability of bioindicators for detecting change following the dam removals.

**2.2 Identify relevant and accessible existing data resources -** Sources of existing relevant data in this basin (e.g. City of Brownsville, BLM, DEQ, USDA, OSU, EPA) have already been identified by the Calapooia Watershed Council and the investigator will explore these and additional resources to develop the final monitoring strategy and place the data from the dam removals into context with the larger Calapooia system. This project will contribute to a larger effort to develop systematic tools to utilize and integrate existing information, ranging from fisheries and water quality data to GIS layers.

**2.3 Baseline assessment -** Baseline questions must be addressed prior to removal of the dam and finalization of a monitoring program to target resources for relevant and measurable responses. The questions refer to the general nature of the site and will provide insight into the design of a targeted and feasible monitoring program. Baseline questions relevant to the physical processes of the Calapooia River include:

- how much sediment is stored?
- what is the texture and size of the sediment stored?
- what is the average annual sediment discharge of the river for sand and gravel?

In addressing these questions, the 'effect size' of the dam's influence on the Calapooia can be evaluated, providing critical information for targeting monitoring parameters. Utilizing existing but incomplete surveys, preliminary calculations have already been made to address these baseline questions at Brownsville dam. We have estimated that 12-61 $yd^3$ of sediment is stored behind the dam (Walter and Tullos 2007), and that the river transports approximately $0.1m^3/s/W$ of gravel as bedload through the reach around the dam in the winter. These preliminary calculations indicate that storm-based, vertical incision is the dominant geomorphic process influencing the reach above the dam, with surficial deposition of fines affecting the channel downstream of the dam following removal. Additional baseline surveys should be implemented prior to final design of the effectiveness monitoring plan, including:

- analysis of aerial photograph/historical records
- comprehensive bathymetric surveys of reservoir and downstream facies/features (e.g. bars, margins, islands, pools, riffle crests)
- assessment of habitat quality
- documentation of surface and subsurface bed material size and texture
- analysis of hydrology and sediment regimes

From our preliminary analyses, we have defined a set of targeted effectiveness monitoring questions (Section 2.4) relative to the anticipated geomorphic processes and expected biological responses to these processes. Again, we emphasize that with only limited baseline information about the structure at Brownsville and essentially no information about the Sodom ditch and dam, the proposed strategy is preliminary and will require further refinement as more, higher resolution information becomes available.

**2.4 Determine dam dominant processes and define appropriate effectiveness monitoring questions and metrics -** Based on findings of the baseline assessment, targeted questions are selected to document and evaluate anticipated geomorphic processes and biological responses, including:

Geomorphic processes

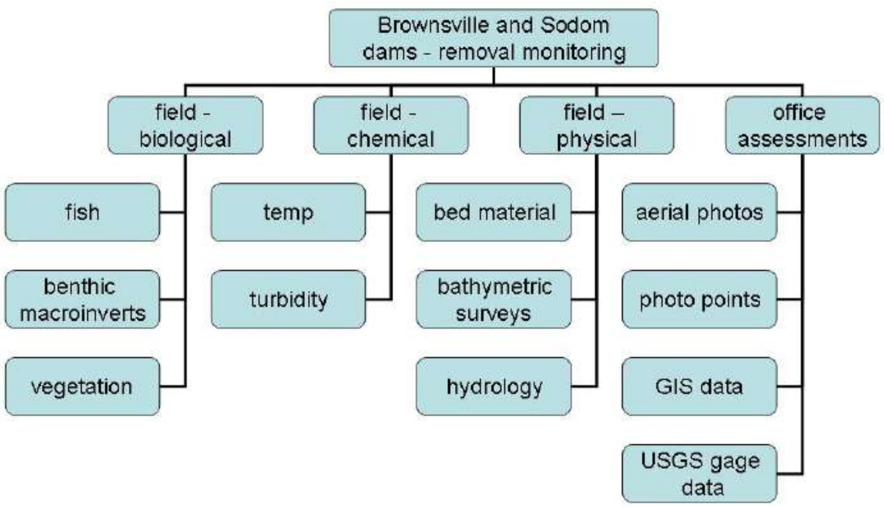
- For how long and to what extent does turbidity change upstream of the dam prior to, during, and following dam removal?
- What are the sediment erosion rates (volumes and times) from the reservoir during and following dam removal?
- What plan form evolution changes develop in the reservoir areas both during and after the dam removal?
- What fraction of reservoir sediments are eroded and transported downstream during and for how long after dam removal?
- Where will eroded sediment be deposited downstream?
- What depth/volume of sediment has deposited through time on the downstream channel features/facies following dam removal?
- How does base elevation of the channel change downstream of the dam following removal over space and time?
- At what return year intervals do high flows flush the sediment deposited on riffles, margins, bars, and pools downstream from the surface?
- How does the downstream grain size distribution change over time and across channel facies/features?
- How will the upstream (reservoir) and downstream channel change (w,d, ER, BHR, WDR, R/D84) and migrate relative to historical change?
- How do new floodplains develop (width, vegetation, inundation and sediment accumulation) over the short term in response to dam removal?
- Does the downstream riverbed elevation decrease or increase over the short term following removal?
- Where, when, and why do bed habitat features (e.g., pools, riffles, bars) form?
- Within what accuracy do hydraulic models predict channel change and distribution of sediment?
- Does the location of the upstream channel post removal match predicted location?

Biological Responses

- How quickly and what type of vegetation establishes in the reservoir post-removal?
- How does vegetation establishment correlate with reductions in surface (sheet, rill and gully) erosion of reservoir sediments?
- What are the changes in vegetation mosaic in the riparian zone upstream and down stream of the dam?
- What are the changes in vegetation mosaic in the riparian zone?
- Is habitat quality improved upstream and downstream of the dam following removal over the short term?
- How quickly do benthic macroinvertebrates in the reservoir shift from lentic to lotic communities?
- What are the downstream responses of benthic macroinvertebrates to dam removal over time?
- What benthic macroinvertebrate metrics are reliable for detecting downstream signal associated with release of stored sediment during dam removal?

**2.5 Final design and implementation of study design -** Dam removal monitoring is typically well-suited for a Before After Control Impact (BACI) design. However, one limitation of this study design is the requirement of substantial pretreatment (pre-removal) data to characterize the variability of the system.  In the absence of extensive pre-removal datasets, as is the case at Brownsville and Sodom dams, a reference site, complimented with historical maps, photos, surveys, hydrographs, and other similar data, will be used to detect signals from noise in response metrics (**Fig. 2**).  Sites will be divided into three reaches, (a) a reference or control, (b) along the reservoir immediately above the dam, and (c) immediately below the dam, each r defined as 40 bankfull widths.  Reaches will be further divided into a series of transects for habitat surveys and will be surveyed by features or facies to directly measure anticipated response areas.  We will select and permanently monument and map transect locations and channel features.

**Figure 2 – Organization of the monitoring framework for Brownsville and Sodom Dam Removal.**




The proposed effectiveness monitoring strategy combines data to be collected in the field and obtained in the office, as described in greater detail in the following sections.

**2.5.1 aerial photos and GIS data layers -** Aerial photographs will be used to compare the current, historical, and future channel alignment and features and vegetation patterns.  By providing a means for calculating valley features (e.g., meander length, belt width, channel location, land use change, etc.) over time, aerial photos can be fundamental to predicting where the new channels will form behind the dams following removal and to evaluating the lateral variability of the post-removal channel, both upstream and downstream of the structures, within the context of the historical variability of the channel. GIS data layers will provide insight into landscape characteristics (e.g. land use, soils, drainages, etc.) that will provide further context for analysis and interpretation.

**2.5.2 photo points -** Photo points will include regular, periodic photos, taken at specified points (e.g., overlooking each reservoir, downstream of each dam) by volunteers with the Calapooia Watershed Council and OSU research assistants during field visits. These photos will provide valuable information both for the scientific perspective (i.e., the position of the advancing delta front will be monitored from photo points) and the public perspective (i.e., posted online and used in presentations about the projects). Additionally, field crews will photograph and document any active bank erosion and the presence of log jams with the study reaches found outside of the regular photo points.

**2.5.3 current and historical streamflow -** Historical USGS streamflow data will be used to characterize the flow regime for (a) determining effect size of the dam on the Calapooia River and (b) interpreting the observed responses of the channel to dam removal. One USGS gage (14172000) was located approximately 11 miles upstream at Holley, OR and recorded streamflow from 1936 to 1990. A second USGS gage (14173500) was located approximately 25 miles downstream on the Queen River bridge at the confluence of the Calapooia and Willamette Rivers near Albany, OR and recoded streamflow from 1941 to 1980. Analysis of these data will be performed to evaluate how the flow regimes changed in the watershed relative to changes in the channel, as measured through aerial photographs, over the period of record, and in combination with current stage-discharge relationships to be developed under the proposed activities for this project. This analysis will provide insight into the degree to which any changes in the Calapooia channel post-removal are outside of historical changes associated with the hydrology of the watershed.

In addition, researchers at the United State Department of Agriculture (USDA) have developed a sophisticated hydrologic model of the Calapooia watershed, which can be coupled with staff gage readings to provide the most accurate discharge estimates at the two dam removal sites. The Soil and Water Assessment Tool (SWAT), a continuous, basin-scale hydrologic model, has been used to model the Calapooia River and is capable of long-term simulations of hydrology, pesticide and nutrient cycling, and erosion and sediment transport. Utilizing this model, the user can set locations of the dams as ‘outlets’ to estimate the various features of the river under numerous current and historical conditions. This tool will be fundamental in evaluating channel change over time when paired with analyses of aerial photos and USGS streamflows as described above.

**2.5.4 Physical -** Data regarding the physical responses to Brownsville and Sodom Dams will be collected to scientifically document the geomorphic processes and to link these processes to ecological responses for informing future dam removals. For example, modification of current geomorphic processes, including bed-load sediment transport, channel degradation/aggradation, feature formation, and large woody debris accumulations, may trigger lateral channel adjustment and changes in channel geometry.  As a result, the quality and quantity of the local habitats may increase or decrease, resulting in biological responses and transformation of property adjacent to the river.  By integrating physical, biological, and chemical monitoring, mechanisms and trajectories can be documented and interpreted. Details of the physical monitoring parameters are described in further detail below.

*2.5.4.1 bathymetry, topography, and channel change* - Bathymetric surveys may utilize technology ranging from hand levels, total stations, survey-grade GPS and Acoustic Doppler Profiling, to LiDAR, mostly in order of increasing accuracy and resource commitment.  Depending on the outcome of a research grant proposed to OWEB in February 2007, either total stations or GPS and ADP technologies will be used at the Calapooia for bathymetric surveys.  These surveys will document changes in (a) elevations along the location of the delta front and downstream of the removed dams, and (b) channel alignment, (c) longitudinal slope, and (d) hydraulic geometry (e.g., width, depth, cross-section shape, local gradient and hydraulic roughness) at critical erosional/depositional areas both upstream and downstream of the dam.  Plan-view changes will be plotted on orthorectified aerial photographs and surveyed elevations will be used to generate DEMs of the Calapooia River bed for estimating various metrics associated with channel erosion and deposition (e.g. rates and timing of depths and volumes). Channel surveys will follow mapped facies/features of the channel over time where deposition is predicted to occur based on the baseline assessment.

*2.5.4.2 hydrology* - The climate and consequent discharge of the Calapooia River will largely drive the outcomes of the Brownsville and Sodom Dam removals.  Because discharge is related to nearly all physical, chemical, and biological processes in the river, it is critical to collect accurate measurements of changes in hydrology.  In addition to USGS gage analysis, monitoring will include staff gage and continuous stage monitoring of water table elevations.  We believe that staff gages installed upstream and downstream of the dam will be sufficient to document local changes in hydrology resulting from dam removal.  Staff gages will be surveyed and installed by investigators with OSU prior to removal, while trained volunteers from the watershed council will be utilized to observe, record, and report water elevations from the staff gage.

*2.5.4.3 sediment* - The greatest uncertainty in removing a dam may be the fate of the sediment stored behind it.  Hypotheses regarding sediment processes to be tested through this effectiveness monitoring strategy will include:

- fine sediments may intrude into channel substrates downstream

- coarse sediments will deposit downstream of the removed dam in pools, backwater channels, eddies (recirculation zones), and margins
- sheet, rill and gully erosion of the exposed reservoir sediments, as well as hillslope mass failure, may occur
- short-term decreases in average bed material particle size will occur downstream due to deposition of sand and gravel
- variability of particle size distributions will increase over space and time
- high magnitude, short duration spikes in suspended sediment/turbidity will occur as associated with the dam removal

The testing of these hypotheses requires field surveying and analysis of sediment, hydrologic, and channel data over space and time. Due to the relatively small volume of stored sediment behind the Brownsville and Sodom Dams, we believe that a detailed sediment budget is neither warranted nor constructive. However, observations of erosion and deposition in the Calapooia River, as well as sediment and habitat characteristics, are clearly worthwhile to evaluate changes in geomorphic processes driving biological responses. Therefore, in addition to detailed bathymetry, we recommend the monitoring of (1) bank erosion pins, (2) turbidity, and (3) grain sizes of surface sediments (via pebble counts and bulk samples) and subsurface sediment (bulk samples) on the channel bed downstream and in the reservoir delta. From these three monitoring elements, we can address hypotheses posed above.

*2.5.4.4 Large woody debris* **-** Brownsville and Sodom dams reportedly do not trap woody material (Denise Hoffert Hay – personal communication) and it is therefore not recommended that monitoring of large woody debris be performed.

**2.5.5 Chemical -** Water quality is most likely to be affected by short-term changes in turbidity or TSS and temperature. Suspended Sediment Concentrations (SSC) are expected to be the primary water quality constituent affected by dam removal and fluvial system restoration. The temperature response is largely dictated by the dam type and operation (i.e., run of the river vs. storage), the outlet structure, and the extent of the reservoir. While it is not expected that a significant temperature response will be seen in the Calapooia River, due to the low cost and important implications (TMDL for temperature in Calapooia), we recommend that temperature probes be installed to confirm this hypothesis. Other water quality parameters that may respond to dam removal include dissolved oxygen, pH, organic carbon, and nutrient loading, but are not expected to change significantly in response to the removal of Brownsville and Sodom Dams. Therefore, we do not recommend chemical monitoring aside from turbidity, as a surrogate for SSC, and temperature.

**2.5.6 Biological -** Data on the physical responses of the Calapooia River system will provide mechanistic explanations for any dam-related changes in the biotic communities. Anticipated changes include communities both upstream and downstream of Brownsville and Sodom Dams and monitoring of the populations and habitats of fish, benthic micro- and macro-invertebrates, and vegetation. For example, a shift from lentic to lotic benthic macroinvertebrate taxa is expected immediately above the dams and increased presence of migrating salmon should be observed in the reaches above the dams following removal. Immediately downstream of the post-removal dam site, short-term changes in benthic macroinvertebrate communities may occur with temporary fine sediment deposition along the margins of the Calapooia River.

Changes in the riparian vegetation mosaics will be documented as part of the EMAP habitat quality assessments, which include vegetation cover, bank vegetative protection, and riparian vegetated zone width. It is expected that ongoing fish sampling by Oregon Department of Fish and Wildlife will continue to characterize fish communities and distributions in the Calapooia River and is therefore beyond the scope of this study.

Benthic macroinvertebrate monitoring will be conducted to integrate mechanistic changes in physical structure of the channel with the food web that supports resident and migrating salmon. Because the structure and organization of these aquatic insect communities reflect both the short and long-term physical, chemical, and biological stressors in a river system, they can provide insight into ecosystem responses not evident in instantaneous sampling of the stressors alone (Klemm et al., 1990). To compare the changes in these insect communities with the dam removal, we propose to sample benthic macroinvertebrates according to the schema described in the ‘targeted riffle’ method proposed by Peck et al. (2001) for wadable rivers. Eight benthic macroinvertebrate samples will be collected at transects across each reach with a 500μm mesh D-frame kicknet for 30 seconds. Each kick net sample includes a total area of 0.09 $m^2$ (1 $ft^2$) each, which are then composited for a reach-wide assessment of the invertebrate community, with subsamples of 500 organisms identified to the lowest taxonomic level possible. Invertebrates from these samples can be compared based on community structure (e.g. diversity, EPT richness, % non-insects) and function (e.g. feeding groups, life history traits, productivity). These metrics will then be analyzed for reliability and relevance in a two step analysis.

Further, to complement the fish and invertebrate data, we will also perform the assessment of physical habitats, according to the EPA EMAP method (Kaufmann et al. 1999) for wadable streams. This randomized, systematic sampling design prescribes that eleven transect positions are set at 1/10th of the sample reach length, defined as 40 channel width, to characterize the reach-wide habitat features and minimize bias in locating measurements. Habitat features covered in this method include the stream size, channel gradient, channel substrate size and type, habitat complexity and cover, riparian vegetation cover and structure, anthropogenic alterations, and channel-riparian interactions (Kaufman et al. 1999). These data will be used to document changes in habitat quality both upstream and downstream of the dams, as well as in comparison with other EMAP sites in the region for variability and recovery context (i.e. stressor-response curves and recovery trajectories).

*Pre-removal: Summary of activities*

In summary, specific activities recommended for preliminary instrumentation and pre-removal monitoring include:

- aggregate relevant, existing data from various agencies, especially long-term data
- create project website for photos and data dissemination, field data sheets
- articulate and document field methods and analysis
- orthorectify all old aerial photos
- establish a GPS control network along the river corridor
- inspect potential erosive and landslide areas above Brownsville and Sodom Dams
- establish photo points
- establish permanent cross sections and survey points, survey in monuments, bank erosion pins, scour chains, and staff gages
- bathymetric survey of the upstream reservoir and downstream river channel and floodplains
- install gages to measure river stage/discharge, temperature, and turbidity
- characterize the bed-material size distribution upstream and downstream of the dam at cross sections and along geomorphically and ecologically significant facies/features
- estimate the volume of sediment stored behind the dam
- estimate the average annual sediment transport of the river
- benthic macroinvertebrate sampling
- assessment of habitat quality

**2.6 Drawdown and removal monitoring -** Greater intensity monitoring should occur during the drawdown and removal of Brownsville and Sodom Dams. Proposed activities include:

- continued turbidity and temperature observations should occur during drawdown, through removal
- bathymetric resurvey of reservoir (delta front, channel, longitudinal, terraces) following drawdown and prior to removal
- bathymetric resurvey of reservoir immediately following removal
- benthic macroinvertebrate sampling immediately following removal
- bed size characterizations immediately following removal

All sampling and surveying will occur during the low flow season (summer) and after leaf out for safety and consistency.

**2.7 Post-removal monitoring -** The post removal monitoring strategy will be used to address questions regarding the outcomes of the Brownsville and Sodom dam removals and to contribute to state of the science for future dam removals in Oregon. The post removal strategy will complement data collected in the prior two strategies (Sections 2.5 and 2.6).

*Short-term (<5 years)* - Data collected during this period include:

- continuous turbidity, temperature, and discharge observations
- annual channel surveys (targeted cross sections, longitudinal profile, bed material, bank pins, scour chains)
- annual, seasonal biological sampling and habitat assessment
- biennial comparison with current aerial photos
- monthly photo points

*Long-term (>5 years)* - It is expected that the sediment stored behind Brownsville and Sodom Dams will be eroded downstream and that the river will recover within five years of removal. Therefore, no long-term monitoring strategy is proposed.

**3.0 Data Quality and Management -** The need for accurate, reliable, relevant, timely, and spatially robust data on dam removal is critical. Due to the great potential of the data collected on the Brownsville and Sodom Dam removals for supporting predictions of future dam removals, it is essential that data collection, management, and analysis be high quality and include estimates of variability. Quality Assurance/Quality Control and analysis of data will be performed by the investigators, with support from Faculty Research Assistants (FRAs) and a Graduate Research Assistant (GRA). Variability of datasets will be reported with all analyses. Data will be stored at Oregon State University, with summaries provided online, through annual reports, and in annual presentation to OWEB and CWC annually. Raw data will eventually be available online through the project website.

**4.0 Project deliverables -** A fundamental outcome of the proposed research is the documentation of physical and biological responses of the Calapooia River to dam removal. The proposed monitoring strategy is critical as these two dam removals represent important opportunities "as a major, but partially controllable, perturbation that can help scientists test and refine models of complex ecosystems (Hart et al. 2002)." Our approach will be to inform and engage local stakeholders in an assessment of river recovery while addressing important research questions of interest to the broader science community. Our analyses and documentation will articulate and test procedures for reliability in predicting responses to dam removal, making tools more accessible for future dam removals. Thus, in addition to documenting the outcomes of the two dam removals, a second fundamental outcome is the demonstration, testing, and documentation of effectiveness monitoring procedures for small dam removals. This will occur through the release of a public-access website on effectiveness monitoring for dam removal as a guidance document, including (1) example monitoring plans, study designs, and data analysis approaches for systematic effectiveness monitoring, (2) detailed cost estimates (per-hours/year) and features of various methods for future monitoring planning, and (3) development and documentation of monitoring and prediction methods, such as estimating stored sediment volumes behind dams. Additional deliverables include annual presentation and documentation of findings to OWEB and local stakeholders, a master's thesis and PhD dissertation, and peer-reviewed publications advancing dam removal science.

## 5.0 Budget

| Item | Annual rate | Unit | No of units | No. of years | OWEB |
|---|---|---|---|---|---|
| **PROJECT MANAGEMENT** | | | | | |
| 1 – Investigator (Tullos) | $70,000 | | 0.08FTE | 5 | $29,165 |
| **IN-HOUSE PERSONNEL** | | | | | |
| 1 – FRA | $35,000 | | 0.50FTE | 5 | $87,500 |
| 1 - GRA (PhD) | $48,568 | | 0.49FTE | 5 | $118,992 |
| 1 – FRA (Gerth) | $32,400 | | 0.04FTE | 5 | $6,750 |
| 2 – REU | $4,000 | | 0.25FTE | 5 | $40,000 |
| *Fringe Benefits* | | | | | |
| 1 – Investigator (Tullos) | 0.47 | | | 5 | $13,707 |
| 1 – FRA | 0.60 | | | 5 | $52,500 |
| 1 – GRA | $750 | Term | 3 | 5 | $11,250 |
| FRA (Gerth) | 0.67 | | | 5 | $4,522 |
| 2 – REU | | | | | |
| **CONTRACTED SERVICES** | $13,210 | dam | 2 | 1 | $26420 |
| **SUPPLIES AND MATERIALS** | | | | | |
| Misc. field supplies | $1,000 | | | 5 | $5,000 |
| **EQUIPMENT** | | | | | |
| Benthic Macro. nets and survey equipment | ------ | | | | ------ |
| **PRODUCTION COSTS** | | | | | |
| **TRAVEL** | | | | | |
| to and from Brownsville, Sodom, and Salem | $0.44 | Mile | 2520 | 5 | $5,540 |
| to national conference for presentation | $1,000 | | | 5 | $5,000 |
| **FISCAL ADMINISTRATION** | | | | | |
| **Total direct costs** | | | | **Total direct costs=** | **$393,136** |
| OWEB | 10% | | | **OPE=** | $39,313 |
| **Total Indirect costs** | | | | | |
| Other direct costs | | | | | |
| Tuition | $9,565 | Year | | 5 | $51,807 |
| Total Other direct costs | | | | | |
| **10. Total estimated costs** | | | | **Total estimated costs=** | **$480,274** |

## 5.0 Budget Justification

PROJECT MANAGEMENT
One month ($5,833) of salary is requested for the PI (Tullos) to administer the program, direct and mentor the FRA, GRA, and REUs, oversee data collection and analysis, and reporting. Fringe benefits are calculated at the University determined rates for the PI (0.47)

IN-HOUSE PERSONNEL
Support is requested for an FRA at 0.50FTE (@$35,000/yr) to assist in directing the GRA and REUs, data collection and analysis, and reporting. Full support for one Ph.D.-level GRA (@ $48,568*0.49FTE =$23,800 each per year *5 years) is requested to support physical and biological data collection and analysis both during the summer and throughout the year, including analysis of aerial photos, USGS gage data, integrated data from other agencies and collected field data. Support ($6,750) is requested for two weeks of salary for one FRA (Gerth) to identify invertebrate samples. Financial support for 3-month REU positions is requested to assist with habitat assessments, benthic macroinvertebrate monitoring, channel surveys, and bed characterizations under the guidance and training of Tullos, the FRA, and the GRA. Fringe benefits are calculated at the University determined rates FRAs (0.67). Flat rates for GRA include health insurance ($500/term) and student fees ($250), as required by the University. Fringe benefits will not be provided to REU students.

CONTRACTED SERVICES
Construction and installation of turbidity probes will be contracted to Rand Eads of Rivermetrics, at a rate of $13,210 for each of the two dam sites (Brownsville and Sodom). Two probes will be installed at each dam site (upstream and downstream) for a total of four probes/booms/loggers. Detailed estimate of costs and services associated with turbidity probes are attached.

TRAVEL: Travel costs include mileage to and from the site (60miles/trip * 42 trips per year, assuming one month of field work each summer plus year-round monthly trips for downloading turbidity data). In addition, support is requested to travel to a national conference each year to present the methods and findings of the study.

SUPPLIES AND MATERIALS: Annual support ($1,000) for miscellaneous field and office supplies is requested, including temperature probes at each of the sites.

PRODUCTION COSTS

EQUIPMENT
No support for equipment is requested under this monitoring grant. Equipment owned by the Biological and Ecological Engineering Department at OSU will be used for benthic macroinvertebrate sampling and surveying (total station and/or survey grade GPS and ADP and processing computers)

FISCAL ADMINISTRATION

INDIRECT COSTS: Indirect cost requests include tuition for one GRA over 5 years (@ $9,565/year *5yr + 4% annual =$51,807), which includes a 4% annual increase as recommended by OSU.

**6.0 Literature Cited:**

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