MEMORANDUM

TO: OWEB Grants Committee, March 21, 2023

FROM: Ken Fetcho, Effectiveness Monitoring Coordinator

SUBJECT: Stage 0 Restoration Effectiveness Monitoring Funding

I. Background

Recently, there has been increased interest in process-based restoration approaches that create complex river channels and floodplains. One such approach for wide alluvial valleys is referred to as Stage 0 restoration, which restores fluvial processes at the valley scale. There are a variety of approaches for restoring floodplain connection, and one approach involves filling previously incised channels with native materials (e.g., gravels, soil, and large wood), then letting the river valley shape itself in response to environmental drivers, such as floods, and biological drivers such as riparian forest development and beaver damming. The intent of this approach is to restore geomorphic processes that encourage and maintain deposition and habitat development over time rather than designing and dictating a channel pattern, profile, and dimension.

Restoring stream reaches to a Stage 0 condition have recently taken place in Western and Central Oregon, including several large-scale, multi-phased restoration projects in Whychus Creek and the South Fork McKenzie River sub-basins that have been supported with OWEB funding. This is a relatively new practice, and the evaluation of long-term responses including riparian vegetation response, aquatic species habitat availability, and the dynamic geomorphic responses over time, need to be assessed. For more information on Stage 0 and the benefits of restoring to this condition please see Attachment A and visit the Stage Zero Information Hub.

OWEB's spending plan line item, Quantifying Conservation Outputs and Outcomes, supports investments to evaluate specific types of restoration actions at broad geographic and/or temporal scales through targeted funding. At the July 2019 meeting, the board approved a staff request for up to $360,000 for monitoring and information sharing associated with restoring a stream channel to a Stage 0 condition. This award was framed as a staged funding request for these work items, with initial funding requested during the 2019-21 biennium and subsequent funding to be provided to continue monitoring in the 2021-2023 biennium, based on progress reporting to the board. Three grants were awarded as a result of the July 2019 board award.

1. A monitoring grant to the McKenzie Watershed Council (MWC) for effectiveness monitoring of a multi-phased restoration project in the South Fork McKenzie River (Upper Willamette Basin) and data compilation and synthesis of existing data about restoring to a Stage 0 condition;
2. A monitoring grant to the Upper Deschutes Watershed Council (UDWC) for effectiveness monitoring—including developing and implementing remote sensing approaches—of a multi-phased restoration project in Whychus Creek (Upper Deschutes Basin); and

3. A stakeholder engagement grant to the Institute for Natural Resources at Oregon State University to plan and convene a workshop to bring together a range of partners to share knowledge, describe concerns and considerations about this restoration approach, identify monitoring and information needs, and articulate best practices for restoration to a Stage 0 condition.

At the July 2021 meeting, the OWEB Board received a presentation from OWEB staff, the MWC and the UDWC to hear an update from the monitoring grantees and understand the progress to date to discuss ongoing monitoring and communication needs. Both restoration and monitoring efforts were impacted by the COVID-19 pandemic and the restoration timing was significantly delayed in the SF McKenzie River due to the 2020 Holiday Farm Fire.

OWEB staff has continued to work with the grantees as these initial monitoring grants near completion to discuss the needs for a second phase of funding for effectiveness monitoring during the 2021-23 biennium. Staff will provide a summary of the two funding proposals that we plan to bring to the Board at the April 2023 Board meeting to continue effectiveness monitoring of restoration to a Stage 0 condition.

II. Proposal

At the April 2023 OWEB Board meeting staff will request up to $470,000 from the Quantifying Conservation Outputs and Outcomes line item in the 2021-23 spending plan to continue effectiveness monitoring of large-scale restoration projects in Whychus Creek and the SF McKenzie River. The details of each proposal are described below and in more detail in attachments B and C.

<u>Whychus Creek</u>

OWEB funding will support UDWC to assess the effects of restoration on up to four reaches along Whychus Creek. This monitoring proposal will directly build on information gained through monitoring efforts co-funded by OWEB in 2020 and by interim funding provided by The Nature Conservancy (TNC) and Portland General Electric (PGE) in 2022.

OWEB proposes to provide $295,000 to the UDWC to continue this monitoring effort from November 2023 to December 2026. OWEB funding will support effectiveness monitoring project development, contracting, imagery acquisition and processing, ground-based field measurements and analysis and reporting for up to 3.2 miles of Whychus Creek. It also fully funds two years of macroinvertebrate monitoring to support evaluation of the biological response to post-restoration conditions in these reaches. **See attachment B for more information.**

<u>South Fork McKenzie River</u>

OWEB funding will support MWC to assess the effects of restoration on three reaches along the SF McKenzie River. This monitoring proposal will provide support to continue monitoring before a third phase of habitat restoration is anticipated to be completed in 2025.

The September 2020 Holiday Farm Fire (HFF) dramatically altered short- and long-term planning for restoration and associated effectiveness monitoring on the SF McKenzie River. The Phase 1 and 2 restoration project areas and surrounding riparian areas primarily experienced low intensity burns and exhibited a substantial degree of resiliency to the wildfire. Wildfire impacts to surrounding floodplain forests were more severe, including on the US Forest Service-operated Delta Campground, northeast of the SF McKenzie River where restoration has already occurred. The HFF has caused a delay in a future phase of restoration that is to be monitored with OWEB funds and is likely to be implemented in 2025.

Due to this delay, there is a need to maintain key datasets by continuing monitoring and applying lessons learned during the initial phase of effectiveness monitoring so that long-term responses to the restoration can be better evaluated. After restoration is completed in 2025, we envision that there will be an additional monitoring grant provided to the MWC to support a final phase of effectiveness monitoring in 2026 to measure effects of that subsequent phase of restoration to maintain the original monitoring design that was initially funded in 2020. This is a key distinction between the effectiveness monitoring that is occurring in Whychus Creek. UDWC was able to navigate monitoring delays associated with COVID-19 and restoration permitting by accessing interim funding provided by TNC and PGE**. See Attachment C for more information.**

OWEB proposes to provide $175,000 to the MWC to continue this monitoring effort from July 2023 to June 2025. The proposed work will continue ODFW's monitoring of juvenile Chinook salmon, OSU and USFS's remote sensing and ground-based monitoring activities and ensure long-term public availability of remote sensing data collected during the initial monitoring phase as well as those data collected during this proposed work.

The results from both these effectiveness monitoring projects will 1) build on the geospatial monitoring and analysis methods piloted from 2020 - 2022 and advance their utility for monitoring Stage 0 stream restoration projects across Oregon, 2) incorporate ground based physical and biological data with low elevation imagery to document changes, and 3) continue to advance the state of knowledge regarding the effectiveness of restoration designed to achieve a Stage 0 condition and the resulting benefits.

To date, the monitoring grantees and their partners have participated in numerous workshops and presentations to share what they have been learning from these restoration and monitoring efforts. After the final phases of restoration and monitoring are completed, we envision hosting another workshop to continue to share information that has emerged. This is an important and deliberate step to disseminate the findings to describe the short-term outcomes associated with these restoration actions and inform future restoration approaches.

V. Next Steps

Staff are seeking feedback from the OWEB board Grants Committee in March and based on feedback, will bring a proposal to the April board meeting.

Attachment A. Stage 0 Stream Evolution Model Background

The benefits of this restoration approach is well described in the literature by [Cluer and Thorne (2014)] as Stage 0 of the Stream Evolution Model. Stage 0 refers to an anastomosing stage of stream evolution as a precursor to the sinuous, single-thread Stage 1 channel described in Simon and Hupp's (1986) Channel Evolution Model. Cluer and Thorne's analyses of habitat and ecosystem benefits in nine stages of stream evolution suggest that anastomosing Stage 0 streams provide far greater habitat and ecosystem benefits (see figures 1 and 2 below) and are more resilient to climate change and disturbances such as floods and droughts when compared to the sinuous single-thread Stage 1 channel which in past decades has often represented the desired outcome of stream restoration projects.

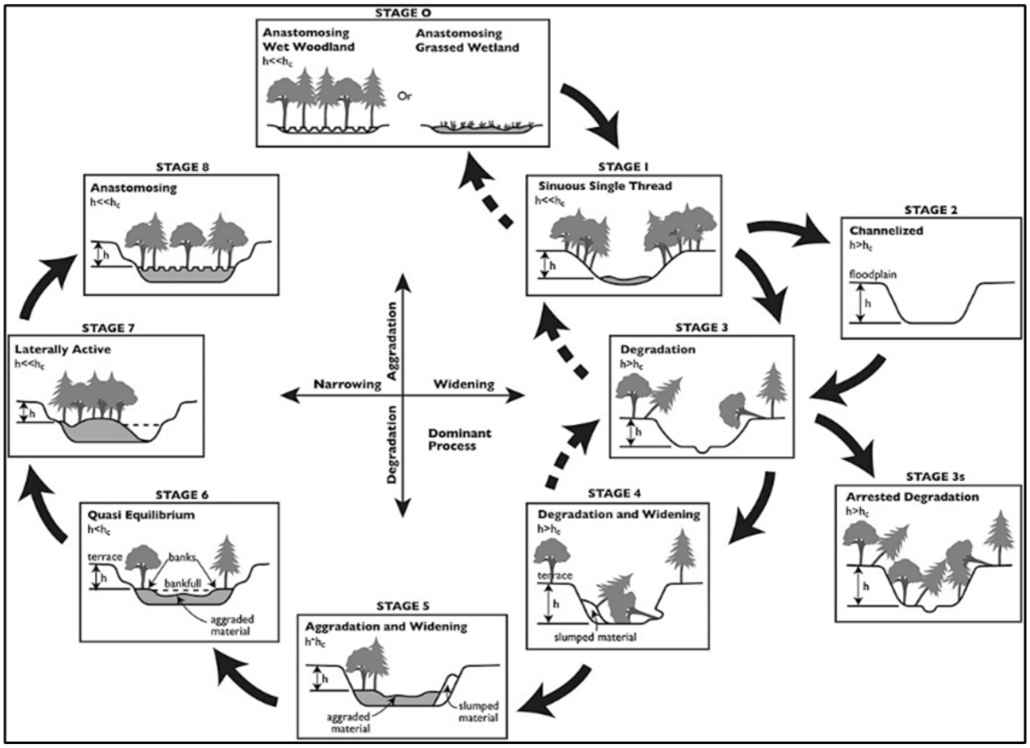

Figure 1. Cluer and Thorne Stream Evolution Model

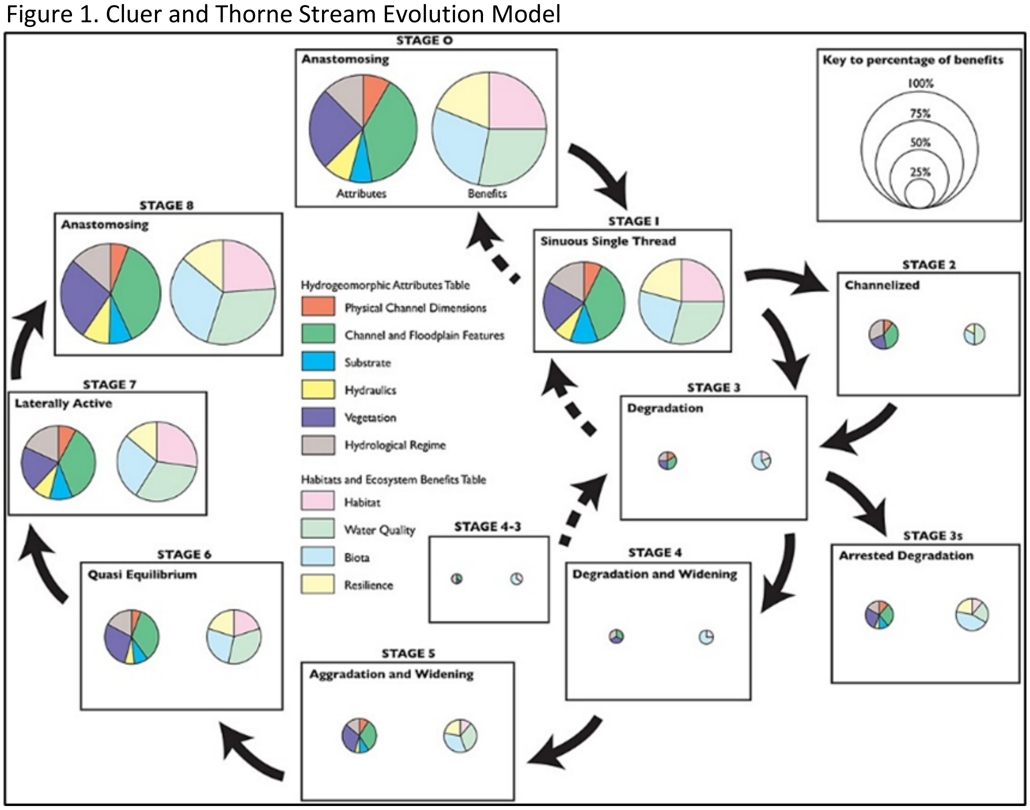

Figure 2. Cluer and Thorne SEM Hydrogeomorphic, Habitat, and Ecosystems Attributes

UPPER DESCHUTES WATERSHED COUNCIL

Whychus Creek Phase 2 Stage 0 Restoration Geomorphic and Habitat Analysis Study

Submitted by Upper Deschutes Watershed Council
Bend, Oregon
January 26, 2023

Problem Statement

Stream habitat along Whychus Creek, a tributary to the Deschutes River, has been degraded and simplified by more than a century of flow diversions for irrigation along with channel and floodplain modification for homesteading, agriculture, and flood control. The Upper Deschutes Watershed Council (UDWC) has worked with non-profit and agency partners, including the Deschutes Land Trust and USFS, for over a decade to restore stream habitat on Whychus Creek in key ecologically important, low-gradient, historically depositional valley reaches.

In 2016, UDWC, in partnership with USFS and Deschutes Land Trust, implemented our first restoration project designed to re-activate the valley bottom, re-establish geomorphic processes, and ultimately promote evolution of a Stage 0 condition, in Reach 4 of Deschutes Land Trust's Whychus Canyon Preserve. Process-based restoration toward Stage 0 aims to improve the outcomes of stream restoration projects by restoring reach- and watershed-scale stream processes to create abundant, complex, self-sustaining stream habitat. Stage 0 refers to an anastomosing stage of stream evolution proposed by Cluer and Thorne (2013) as a precursor to the sinuous, single-thread Stage 1 channel described in Simon and Hupp's (1986) Channel Evolution Model. Cluer and Thorne's analyses of habitat and ecosystem benefits in nine stages of stream evolution suggest that anastomosing Stage 0 streams provide far greater habitat and ecosystem benefits and are more resilient to climate change and disturbances such as floods and droughts when compared to the sinuous single-thread Stage 1 channel which in past decades has often represented the desired outcome of stream restoration projects.

Practitioners across the Pacific Northwest have started using an active, high-tech Geomorphic Gradeline design approach (Powers et al 2019) to restore stream and floodplain function in depositional valleys, with over 20 projects implemented to date throughout Oregon. The Geomorphic Gradeline approach determines the historic valley slope and elevation and identifies areas within a project reach to be graded (lowered) or filled relative to that historic, now target, elevation for the purpose of constructing a new, connected floodplain surface. In contrast to other habitat restoration methods that focus on restoring form through construction of single-thread channels with specific channel geometry and habitat features, process-based restoration projects that aim to restore a Stage 0 condition are designed to address root causes of channel and ecological degradation and rely on re-establishing stream processes such as floodplain connectivity, floodplain-wide riparian cover, erosion, deposition, and avulsion to create and maintain resilient riparian and aquatic habitat that can support all life stages of fish and wildlife species over time. This approach promotes channel, bedform and geomorphic unit evolution by allowing the river system to easily access and dynamically move across its floodplain. The goal of this method is to restore the underlying natural processes necessary for sustained evolution of a dynamic, complex network of anastomosing channels. A building body of evidence from projects throughout the Pacific Northwest and Rocky Mountains suggests this type of restoration approach can lead to increased quantity, diversity, and quality of aquatic and riparian habitat at an equivalent or lower cost per acre of stream and floodplain habitat restored compared to form-based restoration approaches.

The complexity and large, typically valley-wide spatial extent of resulting habitat presents challenges for monitoring geomorphic, fish habitat, and biological outcomes of this restoration approach. Additionally, researchers and practitioners hypothesize that traditional stream habitat monitoring metrics (e.g. deep pools per mile, LWD per mile, % fines in riffles), which were developed from simplified, degraded, single-channel streams, likely describe an impoverished, minimum set of habitat features (forms) that provide the physical conditions necessary for fish life stages, and conversely do not describe the diversity of habitat features and functioning processes (e.g. hyporheic exchange) that anadromous and native resident fish utilize at various life-history stages (e.g. spawning and rearing) in remnant or restored anastomosing systems. As more large-scale Stage 0 projects continue to be implemented across the Pacific Northwest, monitoring methods that incorporate remote sensing and geospatial analysis to quantify key hydrogeomorphic conditions across large spatial extents are proving to be essential to learning about the geomorphic and habitat conditions and biological responses resulting from this restoration approach.

Proposed Solution

In 2019, to advance learning about the geomorphic, habitat and biological outcomes of Stage 0 restoration in depositional valleys, UDWC submitted a successful grant proposal and application to OWEB to further development of methods for using geospatial analysis of remotely sensed data to quantify hydrogeomorphic and habitat conditions in Stage 0 stream restoration projects. The proposed project aimed to:

1) Recruit the expertise of remote sensing and geospatial analysts to identify key geomorphic and habitat metrics characterizing Stage 0 restoration for which preliminary remote sensing methods existed;
2) Through development and application of those methods, determine which methods were well-suited for quantifying key Stage 0 metrics while accelerating learning about design and monitoring of Stage 0 restoration;
3) Produce data to support longer-term analysis of fish habitat and ecosystem benefits of Whychus Creek and other Stage 0 projects; and, in so doing, to
4) Increase the pace, scale, and effectiveness of stream habitat restoration that will benefit salmon, steelhead, and native resident fish populations throughout the Pacific Northwest.

During the spring of 2020, UDWC convened and met with a Technical Advisory Committee (TAC) of remote sensing experts and consulted with our restoration design team to identify a set of highest-priority geomorphic and habitat metrics that showed promise for analysis from imagery based on published methods. The TAC included, among others, Steve Wondzell, research riparian ecologist and Jon Burnett, research forester with the USFS PNW Research Station, and Matt Barker, a graduate student in the OSU Aerial Information Systems lab collaborating with Willamette National Forest on remote sensing, to allow for shared learning across Stage 0 restoration projects east and west of the Cascades and to create efficiencies and consistency in development and application of imagery acquisition and analysis methods. Through this process we identified 6 metrics for analysis from imagery that represent key characteristics of Stage 0 systems. These included wetted area, wood, riparian vegetation, geomorphic units, velocity, and sediment grain size. UDWC worked with TAC members and contractors in summer 2020 to acquire multi-spectral imagery and true-color video, conduct ground-based surveys to complement and inform metrics to be analyzed from imagery, and guide development of an analysis approach for the selected metrics. Five metrics (wetted area, wood, riparian vegetation, geomorphic units, and velocity) were analyzed successfully from imagery; methods for riparian vegetation and velocity especially warrant continued development. Geomorphic unit and wood survey data from ground-based surveys were used to complement data from imagery where tree canopy obscured active channels and the floodplain surface. Analysis of sediment grain size from imagery using the methods employed was found to be less accurate and effective than conducting pebble counts. A final report from UDWC's 2020, Phase 1 Stage 0 Effectiveness Monitoring project on Whychus Creek is forthcoming in April 2023.

UDWC secured external funding to refine imagery and video acquisition, riparian vegetation classification, and velocity analysis methods in 2022 in Whychus Canyon Phase IIa, where a GGL Stage 0 restoration project had been implemented in 2021 subsequent to pre-restoration imagery acquisition and data collection during the 2020 Phase 1 Stage 0 Effectiveness Monitoring project. We worked with Wolf Water Resources to acquire multi-spectral and Red-Green-Blue (RGB) imagery, and in consultation with USGS to acquire overlapping video frames and ground-based velocity and flow direction measurements to support velocity analysis. This 2022 effort allowed UDWC and partners to acquire imagery and video and collect ground-based measurements to capture and describe geomorphic and habitat conditions in this project reach one year post-restoration. The 2022 project also further advanced 2020 methods for analyzing metrics, including piloting a new analysis approach to classify riparian vegetation communities; using classification instead of manual digitization to map and quantify wood in this newly restored reach; and achieving preliminary spatially continuous mapping of velocity and flow direction from video.

The Phase 2 Stage 0 Effectiveness Monitoring (EM) project we are proposing for summer 2024 will allow UDWC to acquire and analyze post-restoration imagery for up to four restoration reaches along Whychus Creek (Figure 1; Table 1). These include Camp Polk Reaches 1 and 2, implemented following a modified Natural Channel Design but where a Stage 0 condition has evolved, and Whychus Canyon Phases I and IIa, where restoration was implemented following a GGL Stage 0 restoration design in 2016 and in 2021, respectively. The fourth reach, Whychus Canyon Phase IIb, is slated to be restored in 2023 or 2024 pending permitting, and we will tailor 2024 Stage 0 effectiveness monitoring under this project for this reach in response to the restoration status of the reach and need for monitoring data as of summer 2024; one option could be to collect imagery and perform analysis for reaches restored as of 2024, and defer imagery acquisition and analysis for Phase IIb only until 2025 if the reach remains unrestored as of 2024. A fifth Whychus Creek restoration reach included in UDWC's Phase 1 Stage 0 Effectiveness Monitoring project, Willow Springs, was implemented in 2022 using a Low-Tech Process Based Restoration Design. This project experienced high flows (> 600 cfs) in November 2022, triggering monitoring of medium-term project response in summer 2023 for physical indicator metrics. This monitoring effort, to be led by Anabranch Solutions in consultation with UDWC, will produce geomorphic metrics consistent with those produced through Phase 1 Stage 0 effectiveness monitoring and support a change detection analysis for metrics including wetted area, riparian vegetation, wood and wood aggregate density, and geomorphic units. This reach will not be included in this proposal unless restoration of Phase IIb has not been implemented as of 2024, in which case contracted services funding for imagery acquisition, processing, and analysis may be re-allocated to highest-priority information needs in Phase IIb, Willow Springs, or restoration reaches already included in the Phase 2 Stage 0 EM project.

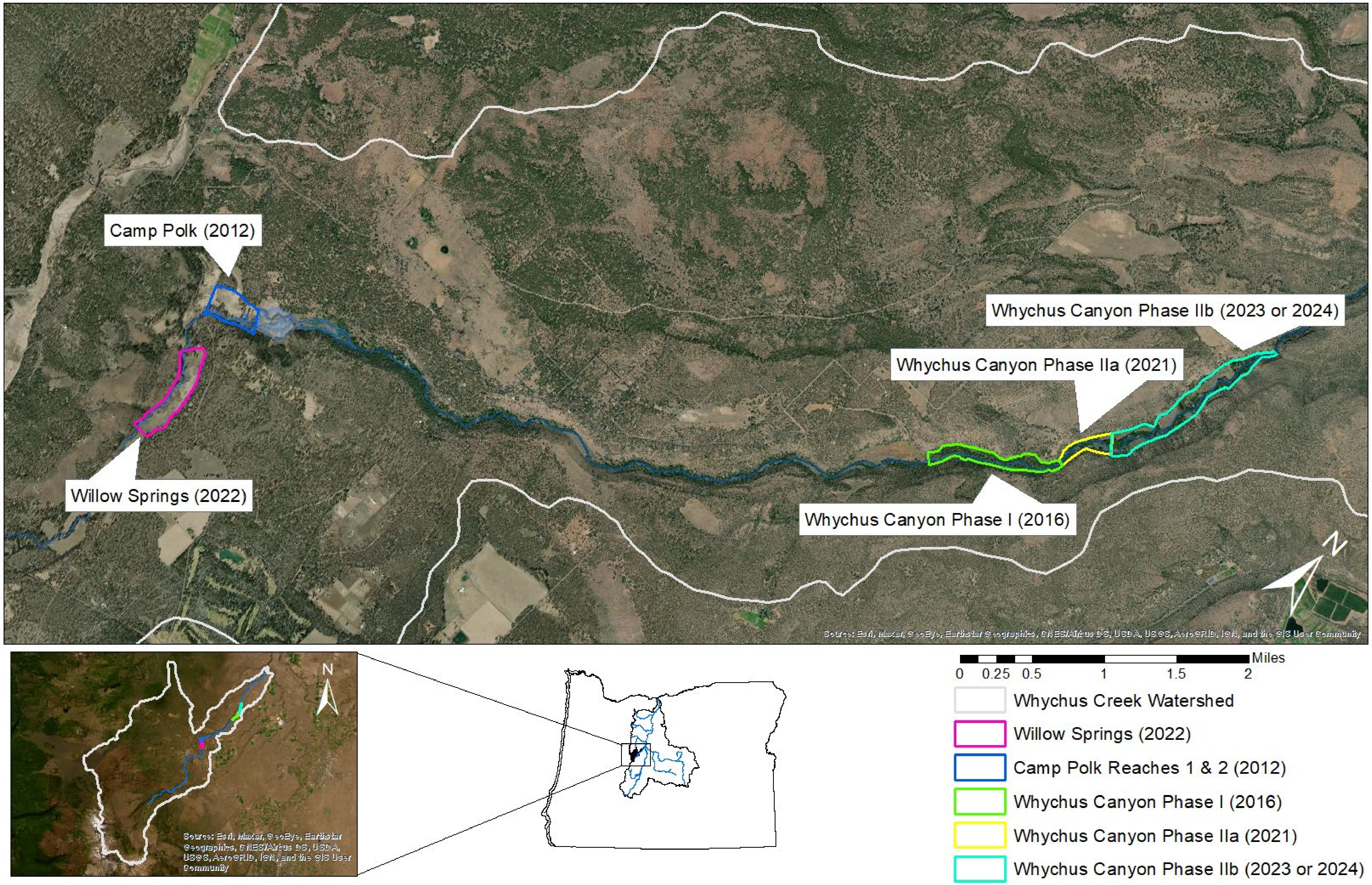

Figure 1. Five Whychus Creek restoration reaches included in Phase 1 Stage 0 Effectiveness Monitoring. Imagery acquisition and data analysis will be completed in the four downstream reaches in 2024 or 2025. Imagery acquisition will occur at Willow Springs in 2023 to evaluate effects of a November 2022 high flow event; analysis from imagery for this reach will occur in 2023 and 2024.

Table 1. Restoration reaches, miles, acres, year restored or to be restored, and phases of Stage 0 Effectiveness Monitoring in which each reach was or will be included in imagery acquisition and data analysis.

Restoration Reach	Miles	Acres	Year Restored	2020 Stage 0 EM Phase 1	2022 Stage 0 EM Interim	2023 Willow Springs EM	2024 Stage 0 EM Phase 2
Camp Polk Reaches 1-2	0.2	16	2012	x			x
Whychus Canyon R4 Phase I	1	68	2016	x	x		x
Whychus Canyon Phase IIa	0.5	26	2021	x	x		x
Willow Springs	1	59	2022	x		x	
Whychus Canyon Phase IIb	1.5	100	2023 or 2024	x			tbd

Through the proposed project, we will build on information gained through 2020 and 2022 imagery and video acquisition and analysis to continue to refine specifications for acquisition to better support analysis from imagery; especially so for velocity analysis from video, for which methods and software packages available have been dramatically improved since 2020. We will also build on 2020 and 2022 analysis methods and products for wetted area, wood, vegetation (with a focus on differentiation of riparian from upland communities), geomorphic units, and velocity. For velocity, the proposed project will apply analysis methods developed since 2020 to 2020 and 2022 videos to complete analysis and assess accuracy for these years and refine specifications for 2024 video and imagery acquisition and ground-based measurements, but will not include velocity analysis from 2024 video, pending funding not requested under this proposal. For all other metrics, we will evaluate change in metrics since 2020 and since 2022 for the reaches monitored using these methods in these years under our Phase 1 Stage 0 Effectiveness Monitoring project and our 2022 interim effort.

Collection and analysis of macroinvertebrate community data in 2024 and 2025 will add to a long-term dataset and support continued evaluation of the biological response to the geomorphic and habitat conditions that are evolving in Stage 0 restoration projects on Whychus Creek as documented through Stage 0 effectiveness monitoring in 2020, 2022, and 2024. Similarly, continuous stream temperature monitoring at 11 established sites along Whychus, to be funded through matching grants for 2024 and 2025, will contribute to that long-term dataset, and provide data to evaluate rate of change in stream temperature through Whychus Creek restoration project reaches, a metric that supports programmatic Biological Opinion compliance with UDWC's bull trout adaptive management plan for Whychus Canyon Phase I and IIa restoration projects.

Goals and Objectives

The goal of the proposed project is to repeat and continue to refine imagery and video acquisition and analysis and complementary ground-based sampling design and measurements to better characterize and quantify pre- and post-project hydrogeomorphic and habitat conditions in Whychus Creek Stage 0 stream restoration reaches, and to evaluate the biological response to those conditions using macroinvertebrate and other available biological data. Hydrogeomorphic, habitat, and biological data will also be evaluated in the context of data produced through ongoing monitoring of additional metrics (see Complementary Monitoring Efforts below).

This project represents Phase 2 of UDWC's Stage 0 Effectiveness Monitoring project and builds on UDWC's and the SFMR's Phase 1 Stage 0 Effectiveness Monitoring projects concurrently funded by OWEB and developed and implemented beginning in 2020. The current effort is also informed by a refined definition of and measures for characterizing a Stage 0 condition, developed in collaboration with Stage 0 researchers and practitioners through the parallel Stage 0 Practitioners Workshops also funded by OWEB and hosted by USFS's PNW Research Station in late 2019 and early 2020. Metrics to be analyzed under UDWC's Phase 2 project are aligned with those identified in the Structured Decision Model produced through the Practitioners Workshops. The proposed Phase 2 project presents a valuable opportunity to repeat the remote sensing methods developed in Phase 1 to compare pre- and post-restoration conditions at Camp Polk Reaches 1 & 2, Whychus Canyon Phase I and IIa, and possibly in Whychus Canyon Phase IIb depending on restoration status as of 2024.

Specific Phase 2 project objectives and monitoring tasks are as follows:

Objective 1. Apply findings from Phase 1 (2020) and interim, 2022 project implementation (i.e. metrics to be analyzed from imagery; flight planning, imagery and video acquisition and processing; ground-based measurements to provide complementary data and for training and validation as needed; and data analysis) to Phase 2 Stage 0 imagery and video acquisition and remote sensing analysis at Camp Polk Reaches 1 & 2 (~0.2 mi), Whychus Canyon Phase I (1 mi), IIa (0.5 mi), and possibly IIb (1.5 mi) depending on restoration status as of 2024.

Monitoring task 1.1. Identify and recruit or re-engage 2024 Stage 0 EM technical experts to serve as 2024 monitoring technical team including consulting and advising on final 2024 imagery acquisition specifications, ground-based sampling design, and ground-based survey methods to train and validate data as needed (November 2023 – January 2024).

Monitoring task 1.2. Review 2020 and 2022 Stage 0 EM findings and recommendations and discuss with technical experts to incorporate and build on Phase 1 findings and recommendations (November 2023 – January 2024).

Monitoring task 1.3. With monitoring team, finalize imagery and video specifications, ground-based sampling design, and ground-based survey methods for 2024 Stage 0 EM (January - June 2024).

Monitoring task 1.4. Refine scopes of work and establish contracts with contractors (January - June 2024).

Monitoring task 1.5. Develop imagery acquisition and ground-based survey schedule with contractors and UDWC staff (March - April 2024).

Monitoring task 1.6. Communicate and work with contractors to acquire imagery along up to 3.2 miles of Whychus Creek restoration reaches at base flow (July 2024)

Monitoring task 1.7. Collect ground-based measurements to complement analysis from imagery and as needed train and validate classification and other analyses from imagery (June – August 2024).

Monitoring task 1.8. Transfer and manage imagery, data, and data products (August 2024 – September 2025).

Monitoring task 1.9. Consult with contractors and provide guidance on classification and analysis specifications and progress, data summarization, and reporting (August 2024 – September 2025).

Monitoring task 1.10. Analyze ground-based data from 2020, 2022, and 2024 and summarize findings in technical memo (October 2024 – September 2025).

Monitoring task 1.11. Compile reports from individual geomorphic and habitat analyses, synthesize and integrate with macroinvertebrate, stream temperature, and other complementary monitoring data, and interpret results in final project report (October 2025 – March 2026).

Monitoring task 1.12. Final project and grant reporting (January 2026 – June 2026).

Objective 2. Collect up to nineteen macroinvertebrate samples in August 2024 and 2025 in established and as needed new restoration reach and Whychus Creek index sites to support comparison of macroinvertebrate community metrics pre- and post-restoration, in untreated restoration reaches, and in Whychus Creek index sites, and inform biological response to restoration.

Monitoring task 2.1. Contract with CASM Environmental, LLC in 2024 and 2025 to: plan and prepare for two-day macroinvertebrate sampling event in each of two years; manage samples and sample identification by sub-contractor Cole Ecological; manage and analyze data; and report on macroinvertebrate community metrics in the context of restoration projects along Whychus Creek.

Monitoring task 2.2. Identify macroinvertebrate sampling reaches, recruit agency and non-profit partner staff and community volunteers, and create sampling teams for two-day macroinvertebrate sampling event in each of two years.

Monitoring task 2.3. With UDWC monitoring staff, flag up to nineteen sampling reaches along Whychus Creek, record and manage reach location data, prepare sampling reach maps and Google Maps location links for each sampling reach, and provide to volunteers.

Monitoring task 2.4. With CASM Environmental, LLC, volunteers, and UDWC staff, collect macroinvertebrate samples from up to nineteen sampling reaches over two-day sampling event in each of two years.

Monitoring task 2.5. Consult with CASM Environmental, LLC during report preparation as needed and provide review of draft and final macroinvertebrate reports (1 per year in 2024 and 2025).

Monitoring task 2.6. Format macroinvertebrate data for submittal to DEQ, submit macroinvertebrate data to DEQ, and request confirmation of data submittal.

Objective 3. Monitor continuous stream temperature at 11 established monitoring stations from Whychus Creek River Mile 0.25 to 38.00 in 2024 and 2025 to support evaluation of rate of stream temperature change through Stage 0 restoration project reaches and comparison to stream temperature at index monitoring stations. *This objective will be completed with match funding and will not be funded under the OWEB dollar amount requested in this proposal.*

Monitoring task 3.1. Prepare continuous temperature monitoring equipment and deployment assemblies, including managing datalogger inventory, returning NIST-certified equipment to DEQ for certification, and as needed fabricating new deployment assemblies.

Monitoring task 3.2. Perform pre-deployment audits and initialize dataloggers for continuous temperature monitoring.

Monitoring task 3.3. Deploy dataloggers at 11 monitoring stations along Whychus Creek and perform deployment audit.

Monitoring task 3.4. Perform field audits monthly, and bi-weekly at key stations in key months.

Monitoring task 3.5. Retrieve dataloggers and perform retrieval audit.

Monitoring task 3.6. Download data, perform post-deployment audits, and complete QC for dataloggers and data.

Monitoring task 3.7. Manage datalogger inventory, including decommissioning and returning to DEQ loggers that do not meet QA/QC criteria and requesting and receiving loggers for subsequent monitoring, and store deployment assemblies for winter.

Monitoring task 3.8. Manage data, including populating DEQ continuous temperature data submittal form, submitting data to DEQ, and requesting confirmation of data submittal.

Monitoring task 3.9. Analyze 2024 and 2025 data and summarize monitoring methods and results in one technical report for both years.

Products for Phase 2 are projected to include:

1) Multi-spectral and RGB imagery; videos to support velocity analysis; ground-based measurements for training and validation of remote sensing analysis and to complement metrics analyzed from imagery; and analysis data products for up to ~3.2 miles of Stage 0 restoration project reaches;
2) Technical memos summarizing:
    a. Imagery and video acquisition, imagery processing, semi-automated classification of wetted area and vegetation, and wood where methods are well-suited, and results;
    b. Video processing and LSPIV velocity analysis and results;
    c. Geomorphic unit digitization and wood digitization where semi-automated classification of wood is less well-suited (restoration reaches older than 5 years); and
    d. Sampling design, data collection and analysis methods and results for sediment grain size and associated geomorphic and habitat ground-based measurements;
3) A final project report compiling technical memos and integrating and interpreting monitoring findings in the context of information from complementary monitoring efforts to describe how habitat, geomorphic, and biological conditions as measured by these datasets differ before and after restoration;
4) Macroinvertebrate community data and reports for 2024 and 2025 detailing monitoring methods, data analysis, and findings with a focus on macroinvertebrate community response in Whychus Creek Stage 0 restoration project reaches (two reports).

Continuous stream temperature monitoring in 2024 and 2025 will be funded through matching grants. Stream temperature monitoring products will include:

1) Continuous stream temperature data from 11 monitoring stations from Whychus Creek, including from stations upstream and downstream of restoration reaches that support evaluation of rate of temperature change through restoration project reaches;
2) A 2024-2025 stream temperature report summarizing monitoring methods and discussing stream temperature status, trends, and restoration needs on Whychus Creek; and
3) An analysis of change in rate of warming pre- and post-restoration for reaches restored as of 2024, including Camp Polk, Whychus Canyon Phases I and IIa and possibly IIb, and Willow Springs.

A potential additional product, to be funded through a separate, future grant, could be a 2-4 page fact sheet or story map to communicate project findings.

Complementary Monitoring Efforts

The proposed project will leverage macroinvertebrate, fish, continuous stream temperature, ODFW AIP stream habitat survey, and other physical and biological data collected through completed and ongoing monitoring efforts described below to provide additional information about the habitat and ecosystem benefits associated with remote sensing results (Table 2).

Macroinvertebrate and fish sampling

UDWC has contracted with consultants in 2005, 2009, and every year from 2011 to present to collect macroinvertebrate samples from sites along Whychus Creek using a targeted riffle sampling protocol. Beginning in 2017 UDWC added a multi-habitat sampling protocol to support description of the macroinvertebrate community in the diverse habitats created by Stage 0 restoration projects. Since 2017 macroinvertebrate community data analysis has included a focus on describing and quantifying changes in key macroinvertebrate community metrics in restored reaches compared to before restoration and compared to index sites.

ODFW and USFS and other basin partners continue to collaborate to conduct pre- and post-restoration fish sampling in restoration project reaches along Whychus Creek, and have produced juvenile densities and length distributions for steelhead and redband trout (*Oncorhynchus mykiss*) and spring Chinook salmon in project reaches. PGE, ODFW, and USFS compile data from redd counts conducted annually at up to 18 sites along Whychus Creek. PGE additionally tracks returning adult Chinook salmon and steelhead using radio telemetry, providing valuable data about fish movement to and through restoration project reaches.

Pre- and post-restoration macroinvertebrate and fish data provide information about the habitat benefits associated with the geomorphic attributes of Stage 0 projects that will be quantified through the proposed remote sensing project.

Water quality

UDWC has conducted continuous stream temperature monitoring at 11 sites along Whychus Creek since 2009. Data from these sites support evaluation of rate of temperature change through restoration project reaches pre- and post-project and provide information about suitability and quality of stream temperatures for native fish including reintroduced salmon and steelhead and resident redband and bull trout.

Macroinvertebrate community data, specifically the temperature and amount of fine sediment preferred by macroinvertebrate taxa present in the community, provide information about the stream temperature and amount of fine suspended sediment experienced by the macroinvertebrate community.

Stream habitat surveys

As co-licensee of the Portland Round Butte Hydroelectric Project, Portland General Electric (PGE) contracts with ODFW to conduct stream habitat surveys using ODFW's Aquatic Inventory Project (AIP) methods. The resulting data provide information about channel length and complexity, wetted area, and geomorphic or habitat units including pool and wood metrics.

Metrics derived from remotely sensed imagery, such as wetted area, woody vegetation, and wood on the floodplain and in active channels, can be used in place of AIP stream habitat survey data when these data are not available, and provide more detailed spatially referenced information than is provided by

AIP data. AIP survey data were last collected in Whychus Canyon and Camp Polk reaches in 2022 (but not in Willow Springs). In Whychus Canyon Phase IIa especially we expect to see dynamic evolution between 2022 and 2024 as geomorphic and biological processes build a network of stream channels, geomorphic units, bars, and vegetated islands. AIP survey data can also be used to provide measures UDWC is not analyzing from imagery, such as depth and wood volume.

Groundwater monitoring

Groundwater wells installed in restoration project reaches provide continuous depth to groundwater data pre- and post-restoration in Whychus Canyon Phase I and IIb and in Willow Springs. Depth to groundwater is an indicator of vertical hydrologic connectivity, a hallmark of a Stage 0 stream condition.

Riparian vegetation monitoring

The proposed project will continue to build on 2017, 2020, and 2022 efforts on Whychus Creek to map and measure riparian vegetation communities from imagery.

In 2017, under OWEB grant (216-8200-15458), UDWC contracted with Earth Designs Consultants, Inc. (EDC), to acquire high-resolution true-color (Red-Green-Blue) aerial imagery and produce a cover classification from the resulting orthomosaic images using heads-up digitization to manually delineate cover classes. Aerial imagery was flown in 2017 and a cover classification was completed during 2017 and 2018, as well as a historic cover classification and riparian vegetation change analysis for restoration projects implemented prior to 2017 totaling ~4.5 miles valley length. Vegetation plot survey data to validate the classification from 2017 imagery were collected in 2019 with a focus on herbaceous vegetation, perceived to present the greatest challenge and uncertainty for accurately classifying the community as riparian or upland. Although analysis of these data showed relatively good accuracy (71-78%) in some restored reaches, in a third, unrestored reach, accuracy was low (47%); classification of trees as riparian versus upland from pre- to post-restoration imagery also showed some discrepancies in consistency. For the 2017 project a decision had been made to acquire more cost-effective true color imagery for the large target spatial extent (~16 mi), even though this imagery would not support an automated or semi-automated classification approach that requires spectral bands included in multi-spectral imagery. As a result the classification process relied on human interpretation of classification rules, introducing subjectivity and a need for local knowledge into the classification and limiting the repeatability of the approach.

For the 2020, Phase 1 Stage 0 Effectiveness Monitoring project, UDWC worked with the USFS Geospatial Technology and Applications Center (GTAC) to create a workflow for semi-automated classification of vegetation classes as well as wetted area from imagery. Vegetation classes included riparian tree and shrub, upland tree and shrub, herbaceous, and other. GTAC used elevation bands provided by UDWC, representing height above the target floodplain elevation or the water surface depending on reach, to differentiate riparian from upland vegetation, and used vegetation rapid assessment survey data to assess the accuracy of the classification. The accuracy assessment showed wide variation in accurately assigning vegetation to cover classes, with average accuracy for riparian tree and shrub at 68%. Misclassification was attributed in part to use of height and elevation thresholds for differentiating between shrubs and herbaceous vegetation and between riparian and upland vegetation. GTAC recommended revising elevation bands to better define riparian zones, but also recognized dynamically changing vegetation conditions in response to restoration as a potential factor in misclassification using elevation bands.

In 2022 UDWC worked with Wolf Water Resources to acquire imagery in Whychus Canyon Phase IIa and pilot a work flow to use data from individual riparian and upland indicator tree species identified and spatially referenced in the field concurrent with imagery acquisition to inform classification of riparian and upland communities from imagery. The initial model showed promising results with 90% accuracy with the training dataset and 60% accuracy with the validation dataset. The small size of the training and validation dataset from field (ground-based) measurements limited the ability to improve the model.

Riparian vegetation monitoring proposed under this project will incorporate information from 2020 and 2022 efforts to continue to advance a cost-effective, semi-automated approach to differentiating riparian woody vegetation from upland woody vegetation from multi-spectral data. Spatial extent (proportion of valley bottom) of riparian vegetation is a key attribute of a Stage 0 condition; in combination with a network of channels and shallow groundwater, riparian vegetation indicates continued vertical hydrologic connectivity. Although upland trees and shrubs are less likely than riparian trees and shrubs to be present or abundant in post-restoration reaches, it is important to be able to differentiate between riparian and upland trees and shrubs in a vegetation classification to be able to compare change in vegetation communities after restoration.

Ground-based survey data (vegetation transects) from Whychus Canyon Phases I and IIa and from Camp Polk pre- and post-restoration, as well as from Whychus Canyon Phase IIb and Willow Springs pre-restoration, describe or will support description of changes in native riparian and wetland species abundance and richness as well as any change in non-native species.

2022 Topographic-bathymetric LiDAR and thermal imagery

In 2022, USFS acquired topographic and bathymetric ("topo-bathy") LiDAR and thermal imagery along Whychus Creek restoration reaches including Whychus Canyon Phases I, IIa, and IIb. There may be opportunities to leverage this imagery to better inform or improve 2024 analyses from imagery, recognizing that topo-bathy LiDAR and thermal imagery currently remain expensive to acquire and are not expected to be available on a regular basis. Data products from thermal imagery will include a color ramp that visualizes spatial variability of stream temperatures, longitudinal temperature profiles, significant thermal features, and temperature statistics including mean, median, maximum, minimum, and standard deviation. LiDAR data products remain to be determined. Examples of applications for measuring Stage 0 restoration outcomes include: using canopy heights from LiDAR to inform riparian vegetation classification; using bathymetric LiDAR to analyze depths; and using significant thermal features from imagery to identify and further investigate areas that are cooler and warmer.

Table 2. Summary of existing monitoring data from Whychus Creek Stage 0 restoration reaches. "X" indicates pre- and/or post-restoration data have been collected in the specified reach. Stage 0 Effectiveness Monitoring data from imagery and from ground-based measurements are from the Phase 1 Stage 0 EM project and were collected in 2020; ODFW AIP stream habitat survey data were collected in 2022 for all reaches except for Willow Springs, where they were collected in 2020. Data from complementary UDWC and partner monitoring have been collected in multiple years and include pre- and post-restoration data, except for adult fish access data which were only collected post-restoration.

Monitoring	What it tells us about	Camp Polk	Whychus Canyon Phase I	Whychus Canyon Phase IIa	Willow Springs	Whychus Canyon Phase IIb
Stage 0 Effectiveness Monitoring: Metrics from imagery						
Wetted area	Lateral and vertical connectivity and amount of aquatic habitat at low flow	x	x	x	x	x
Woody riparian vegetation	Area of woody riparian vegetation; topographic roughness; wood supply	x	x	x	x	x
Wood (area)	Topographic roughness on floodplain, structure in active channels, and aquatic habitat complexity	x	x	x	x	x
Velocity	Geomorphic and hydrologic complexity, diversity of velocity and flow direction	x	x	x	x	x
Geomorphic units	Bedform evolution, structural complexity, fish habitat diversity	x	x	x	x	x
Stage 0 Effectiveness Monitoring: Ground-based measurements						
Sediment size	Sediment sizes for spawning and rearing, stream energy, geomorphic and hydrologic heterogeneity	x	x	x	x	x
Depth	Depth distribution	x	x	x	x	x
Unit	Provides additional information about habitat and stream energy associated with sediment size	x	x	x	x	x
Wood (presence in plot)	Provides additional information about habitat and stream energy associated with sediment size	x	x	x	x	x
Velocity & flow direction	Velocity measurements to provide complementary dataset and train and validate velocity analysis from imagery	x	x	x	x	x
Vegetation surveys	Used to train and validate classification from imagery	x	x	x	x	x
Metrics from ODFW AIP stream habitat survey data						
Sediment size	Sediment sizes for spawning and rearing, stream energy, geomorphic and hydrologic heterogeneity	x	x	x	x	x
Depth distribution at baseflow	Depth distribution	x	x	x	x	x
Geomorphic units	Bedform evolution, structural complexity, fish habitat diversity	x	x	x	x	x
Secondary channel to primary channel ratio	Channel network complexity, velocity diversity, habitat diversity	x	x	x	x	x
Wood (key pieces & volume)	Wood as fish habitat and structure in active channels	x	x	x	x	x
Metrics from complementary UDWC & partner monitoring						
Deposition and erosion	Channel elevations relative to GGL and/or floodplain, vertical hydrologic connectivity, access to floodplain	x	x			
Groundwater	Vertical hydrologic connectivity, ability to support riparian species	x	x		x	x
Stream temperature	Rate of change in stream temperature through project reach, suitability for native fish	x	x	x	x	x
Riparian plant community	Species richness, proportions of native and wetland indicator, community structure	x	x	x	x	x
Benthic macroinvertebrate community	Biological response to stream conditions e.g. temperature and sediment, taxa richness, biological integrity	x	x	x	x	x
Adult fish access	Total length along a continuous flow path through project reach that does not provide sufficient depth for steelhead and bull trout migration		x	x		
Adult fish spawning	Chinook spawning	x	x		x	x
Fish density	Fish density, habitat use, natural production of brown trout and Chinook		x			

Project Success Measures and Benefits

This project aims to build on the progress made through 2020 and interim 2022 Stage 0 Effectiveness Monitoring on Whychus Creek to continue to advance the state of knowledge and practice regarding monitoring the complex geomorphic and habitat conditions resulting from large-scale Stage 0 stream restoration projects. We will do this by continuing to test and refine applications of remotely sensed data, including: acquiring imagery and video using specifications refined through 2020 and 2022 acquisitions and analysis in post-restoration reaches; repeating classifications of wetted area and vegetation, and wood in reaches where restoration was implemented within five years; repeating manual digitization of geomorphic units, and wood in reaches where restoration was implemented more than five years prior; collecting ground-based measurements needed to train and validate analysis from imagery (velocity, vegetation, possibly wood) and supplemental ground-based measurements in dynamically evolving reaches where change is expected to have occurred since these measurements were last collected (sediment size, depth, unit, and wood presence and influence); and comparing metrics pre- and post- restoration and over time since restoration using 2020 and 2022 data products. We will also summarize available biological data including macroinvertebrate community data in the context of Stage 0 geomorphic and habitat metrics produced in 2020, 2022, and 2024 to evaluate biological response to the conditions described. Individual technical memos and reports summarizing components of this effort will be compiled into a final report that will be submitted to OWEB and available on the UDWC website. The project will be considered successful when these items have been completed.

The results of this Phase 2 Stage 0 Effectiveness Monitoring project will 1) provide new information about the geospatial analysis methods piloted in 2020 and 2022 and advance their utility for monitoring Stage 0 stream restoration projects across the Pacific Northwest region, 2) provide methods for acquiring imagery and performing these analyses, and 3) continue to advance the state of knowledge regarding the effectiveness of restoration designed to achieve a Stage 0 condition and benefits.

Cost Estimate

UDWC proposes to complete Phase 2 at a cost of $374,620 over 3 years from November 2023 to December 2026, with the work largely concentrated within 2.5 years from January 2024 to June 2026, including $295,000 in OWEB funding and $79,620 (27%) in match funding. This estimate allocates OWEB funding for Stage 0 Effectiveness Monitoring project development, contracting, imagery acquisition and processing, ground-based field measurements for training and validation of remote sensing analysis, and analysis and reporting for up to 3.2 miles of Whychus Creek restored or to be restored toward a Stage 0 condition. It also fully funds two years of macroinvertebrate monitoring including staff time and contracting, with a focus on the reaches to be monitored under the Stage 0 Effectiveness Monitoring project and additional Whychus Creek restoration reaches and index sites, to support evaluation of the biological response to post-restoration conditions in these reaches. Matching grants will fund continuous stream temperature monitoring at 11 Whychus Creek monitoring stations over two years as well as analysis and reporting. The OWEB amount includes indirect costs associated with grant administration expenses.

We based our cost estimate for Phase 2 project implementation on UDWC staff time expended during Phase 1 project implementation and for annual macroinvertebrate and continuous stream temperature monitoring, and on estimates from contractors with whom we have worked previously and who are familiar with Whychus Creek restoration reaches and planned analyses. There is potential for UDWC to work with a PGE Project Zero intern or with a student intern from institutions with which we have established relationships (e.g., OSU Cascades) in summer 2024 to support collection of field measurements required to train and validate remote sensing analyses.

Phase 2 Budget

	External Amount	OWEB Amount	Project Total
Salaries, Wages and Benefits			
[1]UDWC monitoring program manager	$49,700	$137,500	$187,200
[2]UDWC monitoring technician	$14,400	$0	$14,400
[3]UDWC habitat restoration manager	$6,400	$0	$6,400
[4]UDWC restoration program manager	$6,000	$0	$6,000
[5]UDWC executive director	$3,120	$0	$3,120
Contracted Services			
RGB & multi-spectral imagery acquisition and processing; video acquisition (3.2 mi)	$0	$6,750	$6,750
Imagery analysis: Wetted area, vegetation; wood - reaches < 5 years old)	$0	$25,172	$25,172
Technical report preparation	$0	$11,600	$11,600
USGS video processing & velocity analysis	$0	$21,000	$21,000
Imagery analysis: Geomorphic units; wood - reaches > 5 years old	$0	$12,000	$12,000
Macroinvertebrate sampling, analysis & reporting 2024 & 2025	$0	$40,000	$40,000
Contracted Services TOTAL		$116,522	
Materials and Supplies			
Field measurement supplies	$0	$500	$500
Travel			
[6]Mileage for site visits	$0	$2,000	$2,000
Sub-total	$79,620	$256,522	$336,142
Indirect Costs			
OWEB Negotiated Indirect Cost Rate: Cost Allocation	$0	$38,478	$38,478
Total	$79,620	**$295,000**	**$374,620**

[1]UDWC monitoring program manager hours calculated as 0.6 FTE over 30 months for Stage 0 Effectiveness, macroinvertebrate, and continuous temperature monitoring, including: grant and contract management; project development; preparing for, scheduling, and meeting with staff, contractors and technical experts; supervising water quality equipment and data management and continuous temperature monitoring schedule; daily project implementation over two months including consulting with and supporting contractors and training and supervising field staff (flight planning, imagery acquisition, ground-based measurements); actively recruiting and managing volunteers over 6 months; preparing maps, directions, and datasheets for sampling and surveying; preparing for and supervising macroinvertebrate sampling (10 field days over 2 years); consulting with contractors and advising on and reviewing analyses and reports; data management; analysis and reporting for Stage 0 Effectiveness monitoring ground-based measurements and continuous temperature and associated data; synthesis, interpretation, and reporting of geomorphic and habitat conditions and biological responses; compilation of technical memos and reports for various project elements; and project completion reporting.

[2]UDWC monitoring technician hours calculated as 300 hours per year over two years including: water quality equipment management, performing water quality QA/QC, deploying stream temperature dataloggers, auditing dataloggers monthly over 7 months per year over two years, retrieving dataloggers, downloading and managing data; assisting with all macroinvertebrate sampling field preparation and sampling; and participating in all ground-based data collection for Stage 0 Effectiveness monitoring in summer 2024.

[3]UDWC restoration project manager hours calculated as ten, 8-hour field days per year over two years to assist with data collection for Stage 0 Effectiveness and macroinvertebrate monitoring.

[4]UDWC restoration program manager hours calculated as four, 8-hour field days per year over two years for site visits to evaluate and discuss conditions on the ground in light of monitoring findings; and 18 hours per year over two years to consult with monitoring program manager on Stage 0 Effectiveness monitoring, monitoring results, and implications for restoration design and adaptive management.

[5]UDWC executive director hours calculated as 20 hours per year over 2 years including: oversight and management;
[6]Mileage for site visits calculated as 40, 70-mile trips from Bend to Whychus Canyon over 2 years at $0.655 per mile.

Phase 2 Timeline

Task	Q4 2023	Q1 2024	Q2 2024	Q3 2024	Q4 2024	Q1 2025	Q2 2025	Q3 2025	Q4 2025	Q1 2026	Q2 2026	Q3 2026	Q4 2026
Phase 2 Stage 0 Effectiveness Monitoring													
Identify and recruit or re-engage 2024 Stage 0 EM monitoring team													
Review 2020 and 2022 Stage 0 EM findings and recommendations													
With monitoring team, finalize imagery acquisition specifications, ground-based sampling design, and ground-based survey methods for 2024 Stage 0 EM													
Refine scope of work and establish contracts with contractors													
Develop imagery acquisition and ground-based survey schedule with contractors and UDWC staff													
Work with contractors to acquire imagery along 7.2 miles of Whychus Creek restoration reaches at base flow													
Collect ground-based measurements to complement analysis from imagery and as needed train classification													
Transfer and manage imagery, data, and data products													
Consult with contractors and provide guidance on classification and analysis specifications and progress, data summarization, and reporting													
Analyze ground-based data from 2020, 2022, and 2024 and summarize findings in technical memo													
Compile reports from individual analyses and integrate and interpret results in final project report													
Final project and grant reporting													
Macroinvertebrate and Stream Temperature Monitoring													
Macroinvertebrate monitoring year 1													
Macroinvertebrate sample identification, data delivery, management and analysis, and reporting year 1													
Macroinvertebrate report review year 1													
Macroinvertebrate monitoring year 2													
Macroinvertebrate sample identification, data delivery, management and analysis, and reporting year 2													
Macroinvertebrate report review year 2													
Stream temperature monitoring year 1													
Stream temperature equipment and data management year 1													
Stream temperature monitoring year 2													
Stream temperature equipment and data management year 2; data analysis and reporting (2024 and 2025 data)													

References

Cluer, B., and C. Thorne. 2014. A stream evolution model integrating habitat and ecosystem benefits. River Research and Applications 30(2): 135-154.

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Evaluating Ecological and Geomorphic Responses to Stage 0 Restoration Monitoring Project 2023-2025 Interim Funding Request March 6, 2023

1.0 Background and Watershed Context

Over the past several decades, stream habitat restoration practitioners throughout the Pacific Northwest have developed and implemented numerous valley-scale projects focusing on restoring natural processes. The intent of this design approach is to restore geomorphic processes that encourage and maintain deposition and habitat development over time rather than designing and dictating a channel pattern, profile, and dimension. The desired outcome is well described in the literature by Cluer and Thorne (2014) as Stage 0 of the Stream Evolution Model (Figure 1). Powers et al. (2018) describe the development and application of Stage 0 design methodology. Much of this work has taken place in Western and Central Oregon, including several large-scale projects in the McKenzie River sub-basin.

In early 2020, OWEB funded a project to monitor the effectiveness of the largest Stage 0 restoration project completed to date on the lower South Fork McKenzie River (SFMR). The *Evaluating Ecological and Geomorphic Responses to Stage 0 Restoration Monitoring Project* (220-7000-17342) is a multi-disciplinary study to examine the linked physical and ecological responses to the multi-phase Stage 0 SFMR restoration project (Figure 2). Partners include the US Forest Service Pacific Northwest Research Station (PNWRS), US Forest Service (USFS) Willamette National Forest (WNF), Oregon Department of Fish and Wildlife (ODFW), Oregon State University (OSU), and the McKenzie Watershed Alliance (MWA). The MWA is the fiscal sponsor of the McKenzie Watershed Council.

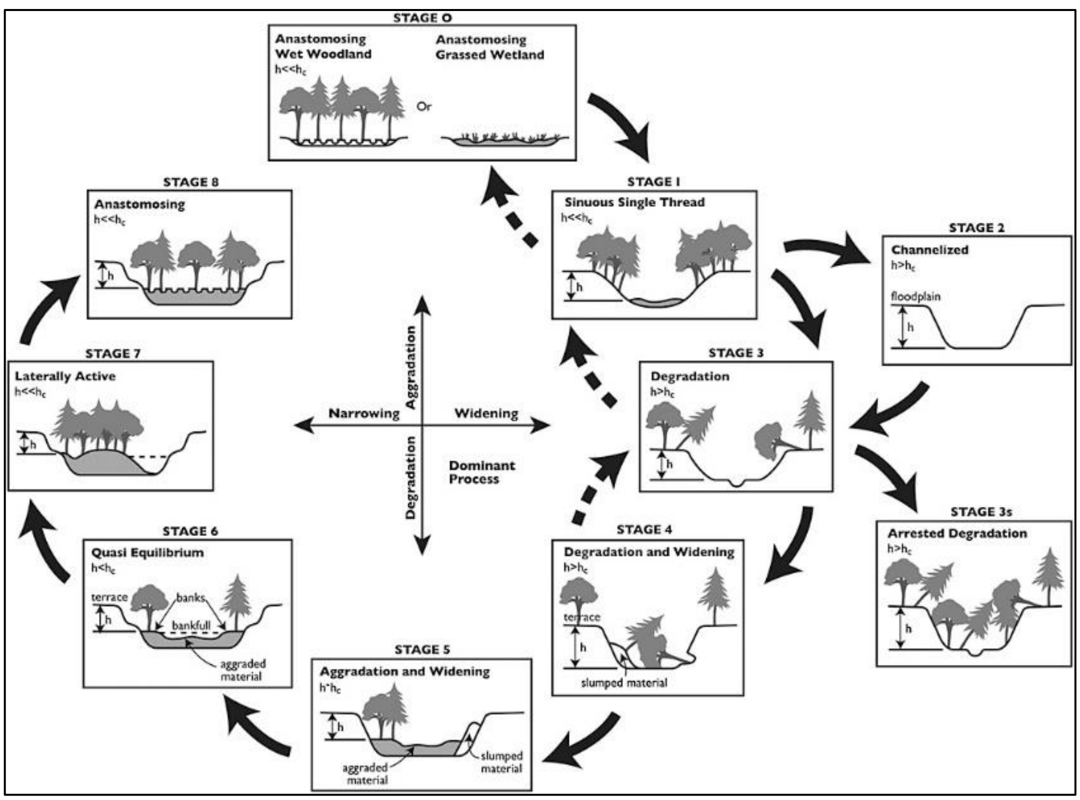

Figure 1. Cluer and Thorne Stream Evolution Model (SEM)

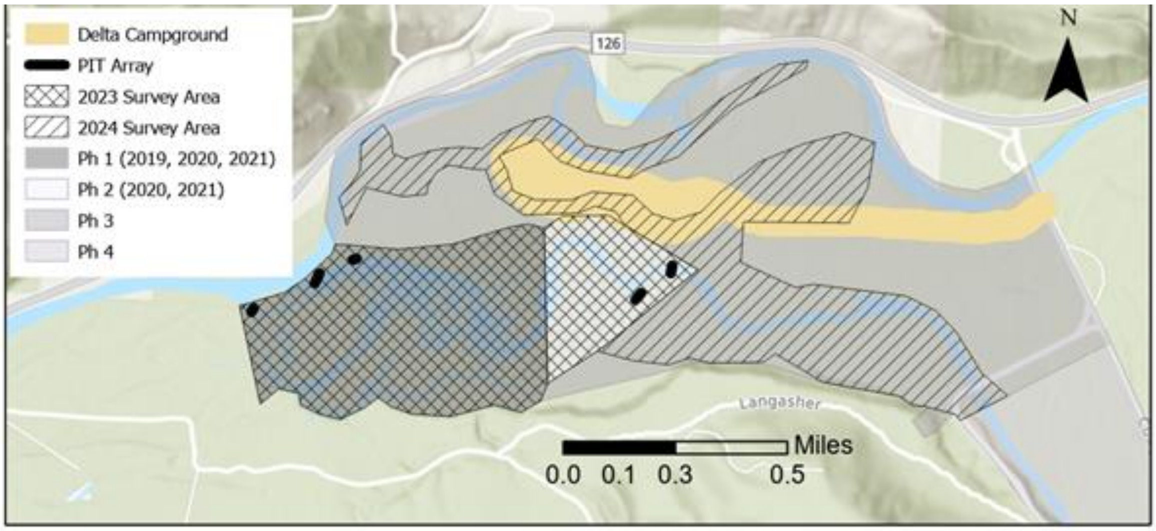

Figure 2. South Fork McKenzie River Floodplain Restoration project by phase (Ph) with proposed monitoring 2023 and 2024 survey areas.

The initial phase of the monitoring project was completed in 2022 after an extended delay caused by the 2020 Holiday Farm Fire. Results of the initial study documented rapid water table recovery, increased salmonid spawning and rearing habitat and increases in the abundance and diversity of macroinvertebrates within project sites (Flitcroft et al. 2022). These results corroborate several hypotheses regarding short-term restoration responses and represent years of coordination among partners to develop and integrate a range of monitoring approaches.

The September 2020 Holiday Farm Fire dramatically altered short- and long-term planning for restoration and associated effectiveness monitoring on the SFMR. The fire encompassed over 173,000 acres in the McKenzie River sub-basin, destroyed over 500 homes, and burned the entirety of the SFMR project area. The Phase 1 and Phase 2 project areas (Figure 2) experienced relatively low intensity burns and exhibited a substantial degree of resilience to the wildfire (Pugh et al. 2022). Wildfire impacts to surrounding riparian forests were more severe, including on the USFS-operated Delta Campground in the Phase 3 project area along the NF-400 road (Figure 2).

In 2021, after an extended public comment period, the WNF chose to decommission Delta Campground due to safety risks posed by hazardous trees and extensive damage to campground infrastructure. The decommissioning created an opportunity to restore over 200 acres in and around the campground by removing roads, campsites, stream crossings, and streamside berms. The decommissioning of Delta Campground began in January 2023 through a partnership between the MWA and WNF and is expected to be completed by March 2023 (Figure 2). The former Delta Campground area is now part of the Phase 3 project area and designs for the restoration are currently under development with restoration slated to begin in 2025.

The delay caused by the Holiday Farm Fire is an opportunity to expand baseline monitoring and apply lessons learned during the initial phase of effectiveness monitoring so that long-term responses to the restoration can be better evaluated. Project partners are seeking $175,000 of OWEB funding (Section 5) to continue baseline monitoring on the South Fork McKenzie River in 2023 – 2024 while a third phase of habitat restoration is developed. The proposed work will continue ODFW's monitoring of juvenile Chinook salmon, OSU and PNWRS's remote sensing activities, and ensure long-term public availability of remote sensing data collected during the initial monitoring phase as well as those data collected during this proposed work.

2.0 Purpose and Need

Restoration to a Stage 0 condition is a relatively new practice, and the evaluation of long-term responses including riparian vegetation, aquatic species habitat availability, and the geomorphic dynamism over time, still need to be assessed. Further, the unforeseen 2020 Holiday Farm Fire altered on-site conditions and is likely to complicate the long-term restoration response. The delay of the Phase 3 restoration activity to 2025 and continuation of monitoring on the SFMR through this bridge funding proposal will provide an opportunity to address limitations of the initial 2019 - 2022 monitoring effort and further expand the tool chest of monitoring and analytical methods that will support valley bottom restoration monitoring in the years to come. These products will provide valuable insight to land stewards regarding restoration effectiveness and best practices for implementing, monitoring, and analyzing valley bottom transformation.

The OSU Aerial Information Survey (AIS) lab has collected imagery for effectiveness monitoring at SFMR since 2019. These data currently reside on servers at OSU and are only available by contacting AIS staff and requesting data transfer permissions. These data need to be preserved and documented with appropriate metadata to ensure they are available in the future for scientists and managers. The development of a spatial database for the imagery products collected over the SFMR will ensure the long-term availability of the data in a public-facing research data archive for future research on Stage 0 restoration.

The collection of additional imagery on the SFMR Phase 1 and Phase 2 project areas (Figure 2) during the low-flow 2023 period is necessary to fill a gap in the remote sensing monitoring record as additional remote sensing monitoring would not otherwise occur until 2026. Given the history of disturbance on the site via the restoration activity itself and the Holiday Farm Fire, remote sensing monitoring to date has been capturing influences from these two disturbances. As time since disturbance increases, the dynamic response of the river to the disturbances is expected to decrease, allowing the more subtle influences from natural processes to become more evident. Continuing to fill in the remote sensing monitoring record is key to understanding the timing of cross-over to a process-dominated response and thus a better understanding of the trajectory of the restored reaches through time.

Restoration practitioners and managers need to understand how the system is changing across space and through time to understand the degree of wood mobility, the variability of surface temperature change, and how inundated area is changing as a function of subtle geomorphic changes. This aspect of the restoration response was not specifically examined through the initial monitoring effort. The previously published analyses on wood area (Barker et al. 2022), surface temperature (Barker et al. In Prep), and inundated area (Flitcroft et al. 2022) were limited by virtue of the fact that they were focused on the 2020 post-restoration low-flow condition. Applying the wood area, inundated area, and surface temperature processing methods to the remotely sensed survey data for the entire monitoring record would facilitate a spatio-temporal change analysis. The results would improve our understanding of how these characteristics are changing in the system and provide much desired feedback on approach and design that would inform future Stage 0 implementations elsewhere.

A remote sensing survey of the Phase 3 restoration area needs to occur during a low-flow period prior to the onset of restoration activities. Establishment of pre-restoration baseline conditions using consistent remote sensing monitoring methods that will be applied in the post-restoration surveys is a critical component in effectiveness monitoring. Such consistency facilitates an 'apples-to-apples' comparison between pre- and post-restoration conditions. The previous remote sensing monitoring campaign (2019-2021) was limited because the first remote sensing surveys did not take place until after restoration occurred, making a pre- to post-restoration analysis using identical methods impossible. Expansion of the remote sensing survey methods into the Phase 3 survey area will facilitate additional refinement of the remote sensing and analysis practices. It will also provide an enhanced understanding of the broad applicability of the methods by testing the developed methods on a stream component that is different from the previously surveyed Phase 1 and Phase 2 areas.

While ODFW has collected extensive juvenile fish monitoring data specific to the SFMR restoration site, a combination of site conditions and study design challenges have limited the effectiveness of data evaluation. River conditions in the SFMR and water releases from Cougar Dam varied considerably in 2020, 2021, and 2022, presenting challenges for collecting juvenile Chinook salmon. Significant changes in discharge and river temperatures each year require additional data and ongoing analysis to better isolate and understand the effects of restoration on the growth and survival of juvenile Chinook salmon. Adding a second antenna at the upstream end of Phase 2 (Figure 2) in 2021 significantly improved OFDW's understanding of Chinook salmon residency in the restoration area. Collection of additional data before subsequent phases of restoration are completed will help ODFW better evaluate the effects of restoration and restoration activities on juvenile Chinook salmon.

3.0 Methods

3.1 Spatial Data Archive

Monitoring projects utilizing small Unoccupied Aircraft System (sUAS) remote sensing, like the OWEB-funded SFMR monitoring project, need a persistent spatial data archive that allows online public access to remote sensing survey products. The OSU AIS lab will submit data products collected from 2019-2021 during the first phase of monitoring, and data products produced under this proposal, to the USDA Forest Service Research Data Archive (USDA 2022). The AIS lab will perform the necessary formatting and metadata documentation steps in accordance with the requirements of the Research Data Archive (RDA). The anticipated spatial database files would be a collection of TIF (georeferenced tag image file format) and geodatabase (GDB) files. All GDB features, attributes, and entities will be documented in accordance with the Federal Geographic Data Committee (FGDC) Biological Data Profile (BDP) of the Content Standard for Digital Geospatial Metadata (FGDC 1999).

The RDA is a persistent actively managed database that produces a permanent digital object identifier (DOI) for all accepted data. A primary advantage of creating a DOI includes the databases being citable for researchers or other interested parties that want to use them and refer to them in a publication or other form of media. A DOI also provides a link to where a database can be accessed and helps raise the database's visibility. The authors of the DOIs in the resulting citations will be Jonathan Burnett (USFS), Matt Barker (OSU), Michael Wing (OSU), Steve Wondzell (USFS), and any other applicable contributors. This task will complete by fall of 2023.

3.2 Remote Sensing Monitoring

The OSU AIS lab will continue remote sensing monitoring at the SFMR Phase 1, 2, and expand into Phase 3 by conducting sUAS low-flow surveys using multispectral sensors capable of producing sub-meter resolution imagery. These data will support the measurement of three monitoring indicators: 1) inundated area, 2) in-stream wood, and 3) surface temperature. A single low-flow survey will be flown for the Phase 1 and 2 project areas in 2023. In addition, high-flow surveys will be conducted in spring 2024 if possible. In the past, we have found it difficult to fly high-flow surveys in the spring. We need a settled weather window to fly the sUAS during a high-flow period. However, flows are regulated by the USACE dam operations which are governed by legal accords. We will be unable to acquire this imagery if high flows do not occur under suitable sUAS flying conditions but can also target spring 2025 if conditions are unacceptable in 2024. These data will be used in conjunction with the 2019 – 2021 sUAS data to conduct a time series analysis of spatio-temporal trends in an effort to answer questions about wood mobility, surface temperature heterogeneity, and variability in inundated areas.

Pre-restoration low-flow condition sUAS surveys will be conducted summer 2024 in a pre-defined subset of the Phase 3 area (Figure 2). This subset of Phase 3 monitoring is necessary to maximize the efficiency by limiting remote sensing surveys to areas that are anticipated to be inundated following restoration. These surveys will be complemented with contemporaneous field surveys to validate the remote sensing data of the three monitoring indicators. Field surveys will document sub-canopy inundated conditions in an effort to improve remote sensing estimates in areas where ground and stream are obscured. The in-stream wood area will be measured and quantified, and both long-term and in-situ stream temperature data will be recorded to facilitate the validation of modeled outputs. Field work for temperature and wood will be adapted from existing methods (Flitcroft et al. 2022, Hinshaw et al. 2022). This task will complete in 2025 with the completion of a manuscript and the final report.

3.3 Juvenile Chinook Salmon Monitoring

Juvenile Chinook monitoring will use a mark-recapture sampling design to estimate abundance and detection timing at multiple PIT tag arrays to calculate residence time, migration timing, and survival estimates of different groups of juvenile Chinook. ODFW will target 2,000 juvenile spring Chinook salmon collections annually throughout the lower SFMR in 2023 and 2024. Field crews will collect juveniles using seines at multiple locations and immediately anesthetize them, implant them with a PIT tag, and release them. Three separate PIT tag arrays were established at the SFMR/McKenzie River confluence in 2019 and two above the Phase 2 project area in 2021 (Figure 2). ODFW will install and maintain the PIT antennae at these sites on a seasonal basis (June – mid-October), with the goal of having them in place before sampling and tagging begin. Existing detection facilities at the downstream fish bypass for Eugene Water & Electric Board-operated Walterville Canal and in the outlet channels from USACE-operated Cougar Dam will provide additional data from fish tagged during this study. In addition, ODFW will be testing a sampling trap in the Walterville bypass canal, which may provide other data on fish from SF McKenzie once they move to the mainstem McKenzie.

4.0 Project Deliverables

- A final summary report documenting juvenile Chinook salmon abundance, migration time, life history, and habitat use in 2023 and 2024.
- Spatial data archive of 2018 – 2021 orthomosaics (fall 2023)
- Phase 1 and 2 sUAS multispectral orthomosaics of 2023 low flow (summer 2023)
- Phase 1 and 2 sUAS high flow orthomosaics (spring 2024 or spring 2025)
- Phase 3 sUAS multispectral orthomosaics of 2024 low flow (summer 2024)
- Spatial data archive of 2023 – 2024 orthomosaics (summer 2025)
- Multitemporal change analysis on wood, surface temperature, and inundated area Phase 1 and Phase 2 (summer 2025).

- Characterization of Phase 3 existing conditions as it relates to wood area, surface temperature, and inundated area prior to restoration (summer 2025)
- Final summary report (summer 2025)

5.0 Timeline

The project will begin in April 2023 and end in September 2025. The project timeline includes proposed monitoring elements (3.1 – 3.3) and associated restoration project elements on the South Fork McKenzie River. Juvenile Chinook tagging and monitoring will ideally take place in 2023 and 2024. The timeline includes an additional in-stream monitoring period in 2025 as a contingency if unforeseen events preclude juvenile Chinook monitoring in 2023 or 2024.

Table 1. Timeline

Project Element	Description	Start	End
Restoration	Delta Campground Decommissioning	January 2023	March 2023
Restoration	Delta Campground Floodplain Restoration Design (Phase 3) Development	January 2023	December 2023
Monitoring (3.1)	Data release of 2018 – 2021 remote sensing data	April 2023	October 2023
Monitoring (3.2)	Phase 1 and Phase 2 sUAS survey	July 2023	September 2023
Monitoring (3.3)	Juvenile Chinook tagging and monitoring	June 2023	September 2023
Monitoring (3.2)	Phase 1 and Phase 2 sUAS high-flow survey	Spring 2024	June 2024
Monitoring (3.3)	Juvenile Chinook tagging and monitoring	June 2024	September 2024
Monitoring (3.2)	Phase 3 Pre-restoration sUAS survey	June 2024	September 2024
Monitoring (3.3)	Juvenile Chinook tagging and monitoring (Contingency monitoring season)	June 2025	September 2025
Monitoring (3.2)	Add to 2023 & 2024 remote sensing data to data release	October 2024	June 2025
	Final Report of Monitoring Results	May 2025	September 2025
Restoration	South Fork Phase 3 Project Implementation	May 2025	August 2025
Monitoring	Evaluating Ecological and Geomorphic Responses to Stage 0 Restoration Monitoring Project Phase 2	2026	2027 or 2028

5.0 Budget

The MWA is requesting $175,000 in OWEB funding to support the proposed scope of work. Partners will provide $69,690 of in-kind match and the MWA will provide $5,223 of cash match. All match can be considered secured. Total project cost is $249,913. The proposed project budget is listed in Table 2.

Table 2. Project Budget

Line Item	Unit	Unit Type	Unit Cost	OWEB	In-kind	Cash Match	Total
Project Management							
MWA Executive Director	50	hrs	$67	-	-	$3,350	$3,350
MWA Restoration Program Manager	100	hrs	$55	$3,955	-	$1,545	$5,500
Project Management Subtotals				$3,955	$0	$4,895	$8,850
Contracted Services							
ODFW Crew Lead	4	months	$11,500	$23,000	$23,000	-	$46,000
ODFW Season Crew (3 person)	9	months	$6,500	$30,000	$28,500	-	$58,500
PIT tags	4000	each	$2.50	$5,000	$5,000	-	$10,000
OSU graduate student (AIS lab)	9	months	$5,998	$53,982	-	-	$53,982
OSU AIS lab analysis	400	hrs	$51	$20,400	-	-	$20,400
OSU AIS lab piloting	80	hrs	$175	$14,000	-	-	$14,000
OSU AIS seasonal field support	80	hrs	$35	$2,800	-	-	$2,800
OSU vehicle rental	12	days	$35	$420	-	-	$420
OSU vehicle mileage	1000	miles	$0.28	$280	-	-	$280
OSU lodging	12	days	$140	$1,680	-	-	$1,680
OSU per diem (2 people)	12	days	$120	$1,440	-	-	$1,440
Piezometers	2	each	$817	$1,634	-	-	$1,634
Temp loggers	8	each	$125	$500	$500	-	$1,000
USDA Forest Service PNWRS - J. Burnett	15	days	$550	-	$8,250	-	$8,250
USDA Forest Service PNWRS - S. Wondzell	6	days	$740	-	$4,440	-	$4,440
Contracted Services Subtotals				$155,136	$69,690	$0	$224,826
Travel							
MWA staff travel	500	Miles	0.655	-	-	$328	$328
Travel Subtotals				$0	$0	$328	$328
Total Direct Cost Subtotals				**$159,091**	**$69,690**	**$5,223**	**$234,004**
Indirect							
MWA				$15,909	-	-	$15,909
Project Total				**$175,000**	**$69,690**	**$5,223**	**$249,913**