Upper Deschutes Watershed Council
Community Report

Ecological Outcomes of Stream Restoration on Whychus Creek

Upper Deschutes Watershed Council
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INTRODUCTION

Whychus Creek originates as a small headwaters stream on the eastern slope of the Cascade Mountains. The creek flows 40 miles, descending through forested canyons and wide alluvial valleys before joining the Deschutes River on its journey north to the Columbia River. Abundant summer steelhead and Chinook salmon historically swam up from the Columbia to spawn in Whychus, the young fish nourished by the stream before making their own journey to the Columbia and the ocean.

With European-American settlement in the late 1800s, the stream was harnessed for irrigation, in many summers running dry. In the alluvial valleys, the stream was straightened, its meadow floodplains converted to dry pastures, its spawning gravels choked with silt. The steelhead and salmon persisted until the 1958 construction of the Pelton dam on the Deschutes blocked their migration to the Columbia, to the ocean, and back. By the end of the 20th century, Whychus Creek was a vestige of the flourishing ecosystem that had greeted those first settlers.

In the late 1990s, individuals from the local community to the state level began to re-envision Whychus Creek and other tributary streams as dynamic ecosystems. Deschutes River Conservancy (DRC), Deschutes Land Trust (DLT), and Upper Deschutes Watershed Council (UDWC) were formed to protect and restore Whychus Creek and other Deschutes River tributaries. DRC began working with irrigation districts and water rights holders to conserve and lease water, leaving more and more water in the stream during hot summer months. DLT purchased or acquired conservation easements on streamside properties, protecting ecological values on lands threatened by development. UDWC started work with water rights holders, land owners, and partner organizations to provide fish passage at diversion dams, screen diversions, and restore the stream channel to its historic meadow meanders. The restoration actions of the three partner organizations are designed to restore functioning stream channel and floodplain ecosystems, including the physical and biological conditions necessary to support self-sustaining populations of native redband as well as the steelhead trout and Chinook salmon re-introduced to the creek beginning in 2007.

What are the ecological outcomes of stream restoration on Whychus Creek? While we can count stream miles constructed and floodplain acres planted, we also need to understand the ecological response to these actions. The purpose of this report is to summarize complex information about ecological outcomes in an approachable, easily referenced format by presenting a handful of indicators that we expect to change in response to each restoration action.

We report on three restoration actions implemented by DRC and UDWC in collaboration with restoration partners: stream flow restoration; fish passage; and diversion screening. Stream channel and floodplain restoration is the fourth restoration action employed by UDWC; we will report on the ecological outcomes of stream channel and floodplain restoration in a future community report.

STREAM FLOW RESTORATION

PROBLEM AND NEED: Stream flow performs critical functions in streams. Sufficient flow creates diverse stream habitat, keeps streams cool for native fish and macroinvertebrates, maintains stream structure, and transports sediment.

Dramatically reduced flows in Whychus Creek have resulted in reduced habitat quantity and quality, high stream temperatures, altered channel-forming processes, and altered sediment transport.

Stream flow restoration in Whychus Creek is expected to: 1) Increase minimum flows, available habitat, and habitat quality during critical low-flow periods; 2) Reduce stream temperatures to meet state temperature standards more often; and 3) Restore channel-forming processes and sediment transport.

BACKGROUND: In Whychus Creek, up to 90% of stream flow is diverted during irrigation season (April 15 –October 15), reducing flows in the creek to less than 20 cfs at times when redband and steelhead trout are spawning and rearing. Low flows diminish the quantity and quality of stream habitat available for fish and other aquatic organisms, and result in stream temperatures that are too warm for trout to spawn and rear successfully. Whychus Creek has been listed for exceeding the State of Oregon salmon and trout rearing temperature of 64°F (18°C) since 1998. The dramatic reductions in stream flow that occur in Whychus Creek have also disrupted the channel-forming and sediment-transporting processes performed by the flowing action of water under natural flow conditions.

Three factors affect magnitude and frequency of low flows in Whychus Creek downstream of irrigation diversions: 1) water availability, determined by snow pack, snow melt, and runoff; 2) water rights protected instream; and 3) irrigation district management of irrigation infrastructure.

Stream flow in Whychus Creek can be increased through transferring and leasing water rights instream, and through attentive management by the irrigation district to track fluctuations in runoff, ensuring the amount of flow protected is in fact released downstream.

WHAT'S BEEN ACCOMPLISHED: Water rights expected to be delivered instream based on their seniority date have increased from 0 cfs in 2000 to 28 cfs in 2017.

WHAT WE'RE MEASURING: UDWC is measuring stream flow as an output of stream flow restoration. We're measuring stream flow, stream temperature and macroinvertebrate community response, to understand how habitat quantity and quality[1], stream temperature, and sediment conditions are changing with stream flow restoration (ecological outcomes).

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[1] Stream habitat quantity and quality are affected by stream flow but are also affected by stream channel geometry. Stream habitat metrics related to flow, such as wetted width, pool residual depth, and pool scour depth, can reflect changes in stream channel geometry rather than changes in stream flow and therefore are not good measures of how habitat quantity and quality are changing as a result of stream flow restoration. For this reason we use stream flow as a proxy measure for habitat quantity and quality.

WHAT WE'RE MEASURING: Stream Flow	
In May, low flows can result in stream temperatures that are too warm for steelhead spawning. Monitoring data shows 33 cfs, the state instream water right, is generally enough flow to keep May stream temperatures cool enough for steelhead spawning. More stream temperature data from May are needed to better understand what flows are needed for steelhead trout spawning. In July and August, the hottest months of the summer, low flows can result in stream temperatures that are too warm for juvenile redband and steelhead trout. Approximately 65 cfs are needed to keep stream temperatures at or below 64°F (18°C), the temperature redband and steelhead need to thrive. Because stream flow affects habitat quantity and quality differently depending on channel geometry, we do not have a stream flow goal related to habitat quantity and quality or an amount of stream flow that indicates good or improving habitat quantity and quality. Instead we use stream flow goals related to stream temperature, a more linear relationship and one which has been extensively studied in Whychus Creek. However, we assume that increasing stream flow will improve stream habitat quantity and quality within the existing channel geometry. We use four stream flow metrics to understand how stream flow is changing in Whychus Creek:	
	PROGRESS:
1. Water rights protected and deliverable instream *Interim Goal: 33 cfs*	• Deliverable senior or straddle water rights protected instream have increased from 0 cfs in 2000 to 28 cfs in 2017
2. Minimum 30-day Flow *Interim Goal: 33 cfs* The minimum 30-day flow is the lowest 30-day average flow for a year and represents annual low flow conditions. This metric tells us how much the lowest flows delivered in Whychus Creek have increased since stream flow restoration began. It also tells us when the lowest flows are occurring.	• The minimum 30-day flow increased from 2.6 cfs in 2001 to 22 cfs in 2013 and 2014. • The 2017 minimum 30-day flow was 21 cfs.
3. May Median Flow *Interim Goal: 33 cfs* May median flow is a measure of how low flow conditions are changing at a time when irrigation demand and air temperature are increasing, reducing flows and heating the stream, and redband spawning activity is at its peak.	• May median flow increased from 5 cfs in 2003 to a high of 96 cfs in 2017; the 2017 water year was characterized by a record snowpack.
4. August Median Flow *Interim Goal: 33 cfs* August median flow measures how low flow conditions are changing at a time when flows have historically been lowest and air temperatures are high.	• August median flow increased from less than 5 cfs in 2000 to a high of 32 cfs in 2011. • The 2017 August median flow was 24 cfs.

WHAT WE'RE MEASURING: Stream Temperature	
Stream temperature is a key factor limiting native trout populations in Whychus Creek. Just like high air temperatures affect humans, stream temperatures that are too warm make it difficult for trout to perform basic activities like foraging for food and even swimming. Living in temperatures that are chronically too warm can keep fish from growing, and trout can die at temperatures as low as 75°F (24°C). In Whychus Creek, stream temperature is directly related to how much water is in the stream. When flows are too low, the stream heats up quickly, even more so on hot summer days. Increasing summer flows through stream flow restoration reduces the rate of warming and keeps stream temperatures cooler for fish. We use the percent of days meeting the state temperature standard to understand how stream temperature is changing in Whychus Creek:	
	PROGRESS:
1. Percent of days meeting the state temperature standard *Goal: 100%* The percent of irrigation season days meeting the temperature standard tells us how the amount of time when stream temperatures are suitable for trout has changed as minimum flows have increased with stream flow restoration. From April 1 to May 15 the temperature standard is 55°F (13°C) to provide suitable temperatures for steelhead spawning[2]; from May 15 to October 31 the 64°F (18°C) temperature standard protects rearing and migrating juvenile trout.	• Stream temperatures met the state temperature standard for two and a half months or 74 days (45% of days for which data were available) between May 6 and September 21, 2017. • The 2017 percent of days meeting the state standard is higher than from 2000 to 2005 and in 2007, 2013, 2015, and 2016, but lower than from 2009 to 2012 and in 2014.

[2] DEQ has not applied the steelhead spawning temperature standard to Whychus Creek because steelhead runs in the creek were not occurring at the time designations of use were made. Steelhead spawning is anticipated to resume in Whychus Creek as adult steelhead return to the creek following reintroduction in 2007.

WHAT WE'RE MEASURING: Macroinvertebrates	
Macroinvertebrates are the aquatic life form of mayflies, caddisflies, stoneflies, and other insects. They are an important food source for native redband trout, steelhead, and salmon. Different macroinvertebrates have different habitat needs: while some macroinvertebrates will tolerate warm water and high sediment conditions, others will only live in cool, clear streams. Information on macroinvertebrates tells us how this sensitive biological community is responding to changes in stream temperature. We use three macroinvertebrate metrics to understand how stream flow restoration is changing stream temperature and sediment transport in Whychus Creek:	
	PROGRESS:
1. Number of sensitive taxa *Goal: ≥ 4 sensitive taxa per site* Sensitive taxa are found in streams characterized by cooler temperatures and clear water with little suspended sediment. The number (richness) of sensitive taxa in the macroinvertebrate community tells us about the stream conditions influencing the community.	• Sensitive taxa richness varies by reach along Whychus Creek, with the consistently highest values at cooler, upstream sites. • Mean sensitive taxa richness in 2017 was low (less than 2) for sites downstream of river mile 19.5, but was high, meeting the goal of four sensitive taxa, at upstream sites.
2. Community temperature optima *Goal: Temperature optima ≤ 18°C* [3] Community temperature optima is related to the sensitivity of taxa to stream conditions. Each macroinvertebrate taxon has an optimal stream temperature at which it thrives. The temperature optima of the community is an indicator of the temperature conditions to which the community is responding.	• Community temperature optima has decreased significantly in downstream reaches of Whychus Creek since 2005, to a mean of 17.1°C in 2017, suggesting a biological response to lower stream temperatures resulting from stream flow restoration. • Temperature optima has increased upstream of river mile 11.5 since 2013, possibly in response to short-term effects of stream channel and floodplain restoration projects, but remain below 18°C.
3. Community sediment optima *Goal: Decreasing trend* Community sediment optima describes the sensitivity of taxa to fine suspended sediment (%FSS) in the stream. Each macroinvertebrate taxon has an optimal %FSS at which it thrives. The sediment optima of the community is an indicator of the fine suspended sediment conditions to which the community is responding.	• Community sediment optima has decreased steadily in upstream reaches of Whychus Creek since 2005, showing a biological response to lower fine suspended sediment conditions resulting from stream flow restoration. • Sediment optima has fluctuated downstream of river mile 19.5 since 2014, possibly in response to short-term effects of stream channel and floodplain restoration projects.

[3] Taxa characterized by temperature optima > 18°C are designated as ORDEQ warm temperature indicator taxa, while taxa with optima < 16°C are designated as cool temperature indicator taxa. Eighteen degrees Celsius (18°C) aligns with the state temperature standard for salmon and trout juvenile rearing and migration.

FISH PASSAGE RESTORATION

PROBLEM AND NEED: Stream connectivity, the state of stream habitat in the absence of artificial barriers to fish passage, allows fish to travel freely within their natural range and between populations, and allows access to all historically available habitat, potentially including otherwise inaccessible high quality habitat.

Fish passage barriers in Whychus Creek have historically fragmented stream habitat during the April 15 to October 15 irrigation season, blocking upstream and downstream access to habitat, in some cases potentially stranding fish in reaches as short as 0.4 miles in length.

Restoration of fish passage is expected to provide stream connectivity along the length of Whychus Creek, increase accessible habitat, and allow fish movement between previously fragmented reaches.

BACKGROUND: At UDWC's baseline inventory in 2009, six diversion dams posed barriers to fish passage in Whychus, fragmenting the creek into seven disconnected reaches below the natural passage barrier at Whychus Falls, ranging in length from 0.4 to 15.5 miles. The resulting habitat fragmentation reduced habitat accessible to fish, potentially also reducing the quality of habitat fish were able to access.

Fish passage restoration in Whychus Creek is accomplished through removing or retrofitting diversion dams that present artificial barriers to fish passage.

WHAT'S BEEN ACCOMPLISHED: Since the 2009 inventory restoration partners have removed or retrofitted 5 of the 6 original diversion dams blocking fish passage on Whychus Creek.

WHAT WE'RE MEASURING: In addition to tracking the number of barriers remaining on Whychus Creek, UDWC is tracking the number of fragmented reaches associated with remaining barriers as well as the number of stream miles accessible from the mouth of the creek.

WHAT WE'RE MEASURING: Stream Connectivity		
We use three metrics to understand how stream connectivity is changing in Whychus Creek:		
		PROGRESS:
3. Number of barriers	*Goal: 0 passage barriers*	• From 2010 to 2017, five of six passage barriers were removed or retrofitted; one remains.
4. Number of fragmented reaches	*Goal: 100% connectivity below Whychus Falls*	• Fragmented reaches have been reduced from seven to two
5. Stream habitat accessible from the creek mouth	*Goal: 38.6 miles*	• Stream habitat accessible from the mouth of the creek increased from 15.5 miles in 2009 to 26.8 miles in 2017. • 11.8 miles remain inaccessible upstream of the last remaining passage barrier.

SCREENING IRRIGATION DIVERSIONS

PROBLEM AND NEED: Irrigation diversions divert water from Whychus Creek into irrigation ditches, canals, and pipes. Fish can become entrained in irrigation diversions and diverted with irrigation flows, reducing populations in the creek. Screening diversions reduces the risk of fish becoming entrained in flows diverted for irrigation.

While the direct impact of unscreened irrigation diversions on Whychus Creek fish populations has not been measured, none of the irrigation diversions on Whychus were adequately screened prior to 2009, and a fish salvage effort conducted in one irrigation district canal rescued over 5,000 fish that had been diverted from the creek.

Screening irrigation diversions to meet state and federal criteria is expected to reduce and ultimately eliminate the risk of fish entrainment and mortality in irrigation infrastructure.

BACKGROUND: In 2009, irrigation flows totaling 193.3 cfs were diverted through thirteen active diversions on Whychus Creek. Of the thirteen, only one diversion associated with less than 1% (0.45 cfs) of diverted flow was screened, posing a significant risk of entrainment and mortality in irrigation canals.

WHAT'S BEEN ACCOMPLISHED: Six previously unscreened diversions were screened from 2009 to 2017.

WHAT WE'RE MEASURING: In addition to tracking the number of unscreened diversions remaining on Whychus Creek, UDWC is tracking the flow rate (cfs) and percent of irrigation flows diverted through unscreened diversions.

WHAT WE'RE MEASURING: Risk of Entrainment	
We use three metrics to understand how risk of fish entrainment in irrigation infrastructure is changing in Whychus Creek:	
	PROGRESS:
5. Number of unscreened active diversions *Goal: 0 unscreened diversions*	• From 2009 to 2017, six irrigation diversions on Whychus Creek were screened or decommissioned. Five diversions remain unscreened.
6. Flow rate diverted through unscreened diversions *Goal: 0 cfs unscreened*	• Flow rate diverted through unscreened diversions has been reduced by 143.9 cfs. • 23 cfs remain unscreened. Almost all (21.6 cfs) of this amount is associated with one diversion.
6. Percent of flow diverted through unscreened diversions *Goal: 0 % unscreened*	• Flow rate diverted through unscreened diversions has been reduced by 85%. • 14% of irrigation flows continue to be diverted through unscreened diversions.

NEXT STEPS

Restoration partners in the Whychus Creek watershed continue to work together to return Whychus Creek to a dynamic, evolving stream and floodplain ecosystem that supports abundant and resilient fish, wildlife, and plant communities. Irrigation districts, agencies, non-profits and concerned citizens are collaborating through the Deschutes Basin Study to develop science and solutions that ensure sufficient water for rivers, farms, and cities. UDWC is continuing conversations with water rights holders and landowners to screen or decommission remaining irrigation diversions and remove or retrofit the last diversion dam. Additional stream channel and floodplain projects are expected to restore stream, riparian and floodplain habitat and ecosystem function along 8.5 miles and on 410 floodplain acres of Whychus Creek. UDWC will continue to monitor and evaluate the ecological outcomes of restoration projects to inform development and design of future projects.