CROOKED RIVER GRAVEL AUGMENTATION PLAN

Date: *May 1, 2020*

Prepared for: Oregon Department of Fish and Wildlife

BACKGROUND

Ochoco Irrigation District, the City of Prineville, and Crook County (applicants) are seeking a Fish Passage Waiver (FPW) from the Oregon Department of Fish and Wildlife (ODFW) for installation of hydropower at Bowman Dam. In order to secure a FPW the applicants must agree to implement mitigation measures with net benefits for native migratory fishes (NMF) that exceed the estimated value of passage at Bowman Dam. The applicants have worked collaboratively with ODFW and local nonprofit organizations over the past six months to put together the best mitigation package possible. Gravel augmentation in the lower Crooked River is one mitigation measure that was proposed by the applicants and supported by ODFW. However, both parties agreed that additional details on the project implementation are needed to accurately assess the benefit of the project to NMF. Here, we describe the scope of the proposed gravel augmentation project. We recognize that this project will benefit from an adaptive management approach as well as collaboration with ODFW staff.

GRAVEL AUGMENTATION

Due to the construction of Bowman Dam and several irrigation dams, suitable spawning substrates for NMF are depleted in many reaches of the lower Crooked River (Figure 1). Gravel composes less than 50% of the substrate in most reaches, and less than 20% in the 10 lowest reaches of the Crooked River (approximately 40 km). This is a concern for salmonids like Chinook Salmon, which typically spawn in areas where gravel constitutes approximately 60-80% of the substrate (Raleigh et al. 1986). We propose to implement passive gravel augmentation in the Crooked River between Bowman Dam and Rice Baldwin Dam (ODFW reaches 26-30) to improve the availability of spawning substrates and increase production of NMF. Passive gravel augmentation presents an opportunity to minimize the costs while still achieving biologically meaningful habitat restoration (Bunte 2004; McManamay et al. 2010). The section of the Crooked River downstream of Bowman Dam provides an ideal location for passive gravel augmentation as it is accessible at many locations and there is sufficient flow for movement of substrate. Furthermore, this section of the river has favorable water quality and quantity for NFM such as resident Redband Trout and introduced summer steelhead trout, but the lack of gravel recruitment is likely limiting these species (Carmichael & Taylor 2010).

Available hydraulic data suggests water releases from Bowman Dam are sufficient to transport substrates of appropriate sizes for spawning salmonids. Redband trout require substrate ranging in size from 0.08 – 2.5 inches (Muhlfeld 2002; Holecek and Walters 2007; Rife 2011), while steelhead trout require substrate ranging from 0.24 – 4 inches and Chinook Salmon use larger substrate 0.79 – 4 inches (Raleigh et al. 1986; Bjornn and Reiser 1991). The shear stress required to move gravel substrate (0.08 – 1.3 inches) ranges from 0.03 – 0.54 lb/ft2 while the shear stress required to mobilize cobble (2.5 – 5 inches) ranges from 1.1 – 2.3 lb/ft2 (Table 1). In most of the riffles downstream of Bowman Dam, a flow of 400 cfs generates enough sheer stress to mobilize very coarse gravel 1.3 inches or smaller, but higher flows are needed to mobilize cobble. Similarly, most glides in this section of river are expected to generate enough sheer stress to mobilize very course gravel at 400 cfs, but cobbles are likely to deposit until they experience higher flows (Table 2). In an average year (1985-2019), mean daily flows exceed 400 cfs for approximately 47 days. Larger flow events needed to transport cobbles and substrate in low gradient areas (i.e. scour pools) happen less frequently, with releases exceeding 2,500 cfs occurring at a 3-year recurrence interval. Depending on the frequency and magnitude of high flow events, it would likely take several years to fully disperse a deposit of gravel.

We propose placing approximately 500 cubic yards of gravel just downstream of Bowman Dam (Figure 2). Initial placement of gravel would occur in 2022, with additional gravel placed during subsequent years as needed to replenish the recruitment pile. Whenever possible, gravel would be sourced from the Crooked River basin in areas where a dam has trapped course sediments. The augmented substrates would be of suitable size for Redband Trout, spring Chinook Salmon, and steelhead trout, approximately 0.38 – 5.0 inches in diameter. The amount of spawning habitat created by the augmented gravels would be dependent on the proportion that is deposited in areas with suitable depth and velocity (Table 3). In addition to spawning habitat, augmented gravels will benefit NMF by improving production of benthic invertebrates and increasing forage for these fish.

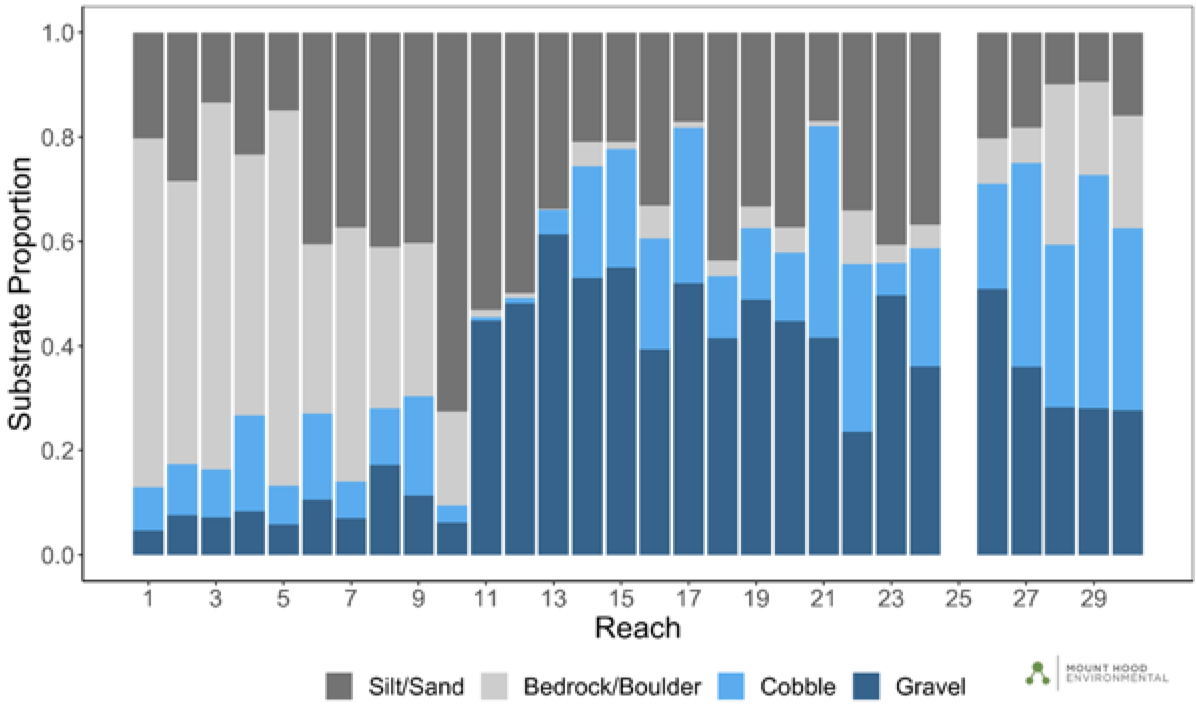

Figure 1. Substrate composition by reach in the lower Crooked River based upon data collected in the Oregon Aquatic Inventories Project. Reach numbers increase from the mouth of the river (1) to Bowman Dam (30). Data is not available for reach 25.

Figure 2. Potential locations for the gravel augmentation site downstream of Bowman Dam.

Table 1. Limiting shear stress for uniform non-cohesive sediments. Adapted from VANR (2004).

Substrate	Size Class	Diameter (in)	Shear Stress (lb/ft2)
Boulder	Very large	>80	37.4
	Large	>40	18.7
	Medium	>20	9.3
	Small	>10	4.7
Cobble	Large	>5	2.3
	Small	>2.5	1.1
Gravel	Very coarse	>1.3	0.54
	Coarse	>0.6	0.25
	Medium	>0.3	0.12
	Fine	>0.16	0.06
	Very fine	>0.08	0.03
Sands	Very coarse	>0.04	0.01
	Coarse	>0.02	0.006
	Medium	>0.01	0.004
	Fine	>0.005	0.003
	Very Fine	>0.003	0.002
Silts	Coarse	>0.002	0.001
	Medium	>0.001	0.001

Table 2. Estimated shear stress for riffles and glides in the Crooked River mainstem from RM 56.6-70.6. Shear stress values were estimated for flows of 400 cfs using data from the Oregon Aquatic Inventories Project (AIP) and hydraulic data from Courter et al. (2014).

AIP Reach	**Riffle**			**Glide**			**Pool**
	Avg. Slope	Shear Stress (lb/ft^2)	% Reach[a]	Avg. Slope	Shear Stress (lb/ft^2)	% Reach[a]	% Reach[a]
26	0.0055	0.68	64.2	0.0026	0.48	23.9	11.4
27	0.0021	0.26	46.1	0.0009	0.16	53.9	0.0
28	0.0059	0.72	37.2	-	-	0.0	59.8
29	0.0055	0.67	42.6	0.0037	0.68	7.2	47.4
30	0.0054	0.66	59.5	0.0030	0.55	8.4	32.1

[a] Only channel units from the primary channel were included.

Table 3. Estimated number of trout and salmon redds that could be created through gravel augmentation depending on the percent of gravel deposited in suitable spawning areas. Estimates rely on average size of redds for each species (Bell 1990, Gallagher & Gallagher 2005) and assume a substrate thickness of 2.5 feet (Bell 1990).

Total Augmented Gravel (yd^3)	Gravel Deposited in Suitable Areas	# Redband Trout Redds	# Steelhead Trout Redds	# Chinook Salmon Redds
8500	1%	340	48	13
8500	5%	1,700	240	63
8500	10%	3,400	479	127
8500	25%	8,500	1,198	317
8500	50%	17,000	2,396	635
8500	100%	34,000	4,791	1,269

MONITORING

The project would include a monitoring component to quantify the mobility of augmented gravel, ensure project goals are being met, and inform subsequent augmentation efforts. The gravel recruitment pile would be monitored annually via direct observation to determine the quantity of gravel needed to replenish the pile. Additionally, augmented gravels would be monitored using tracer gravel to determine downstream distribution and transportation rates. These evaluations would occur each of the first three years following initial placement of gravel and then on a five-year interval for the life of the FERC license. Evaluations may also occur following a high flow event (e.g. 2,000 cfs or greater). If monitoring reveals insufficient transport of augmented gravels, the applicants would work collaboratively with ODFW staff to make modifications to the gravel augmentation methodology and enhance the effectiveness of the project.

PROJECT COSTS

Table 4. Cost estimate for implementation of gravel augmentation project.

Task	Unit Cost		Units	Total Cost	
	Low	High		Low	High
Gravel Augmentation Total (50 years)	$ 11,795.00	$ 20,050.00	17	$ 200,515.00	$ 340,850.00
Monitoring Total (50 years)	$ 5,000.00	$ 10,000.00	13	$ 65,000.00	$ 130,000.00
Project Total (50 years)				$ 265,515.00	$ 470,850.00
Project Total (Annual)				**$ 5,310.30**	**$ 9,417.00**

REFERENCES

Bell, M.C., 1990. *Fisheries handbook of engineering requirements and biological criteria*. Corps of Engineers Portland and North Pacific Div.

Bjornn, T., and D. Reiser. 1991. Habitat Requirements of Salmonids in Streams. Pages 83–138 Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. American Fisheries Society Special Publication.

Bunte, K. 2004. Gravel mitigation and augmentation below hydroelectric dams: a geomorphological perspective. Engineering Research Center, Colorado State University, Fort Collins, Colorado.

Carmichael, R. W., and B. J. Taylor. 2010. Conservation and recovery plan for Oregon steelhead populations in the middle Columbia River steelhead disctinct population segment. Oregon Department of Fish and Wildlife.

Courter, I., K. Ceder, M. Vaughn, R. Campbell, F. Carpenter, and G. Engelgau. 2014. Evaluation of steelhead trout and Chinook salmon summer rearing habitat, spawning habitat, and fish passage in the upper Deschutes Basin. Report prepared for the Deschutes Basin Board of Control and City of Prineville, OR. 63 pp.

Holecek, D. E., and J. P. Walters. 2007. Spawning Characteristics of Adfluvial Rainbow Trout in a North Idaho Stream: Implications for Error in Redd Counts. North American Journal of Fisheries Management 27(3):1010–1017. Taylor & Francis.

Gallagher, S.P. and Gallagher, C.M., 2005. Discrimination of Chinook salmon, coho salmon, and steelhead redds and evaluation of the use of redd data for estimating escapement in several unregulated streams in northern California. *North American Journal of Fisheries Management*, *25*(1), pp.284-300.

McManamay, R. A., D. J. Orth, C. A. Dolloff, and M. A. Cantrell. 2010. Gravel addition as a habitat restoration technique for tailwaters. North American Journal of Fisheries Management 30(5):1238–1257.

Muhlfeld, C. C. 2002. Spawning Characteristics of Redband Trout in a Headwater Stream in Montana. North American Journal of Fisheries Management 22(4):1314–1320.

Raleigh, R. F., W. J. Miller, and P. C. Nelson. 1986. Habitat Suitability Index Models and Instream Flow Suitability Curves: Chinook Salmon. National Ecology Center, Portland, Oregon.

Rife, D. 2011. Ochoco National Forest and Crooked River National Grassland aquatic MIS analysis - redband trout. Ochoco and Deschutes National Forest Fisheries Program.

Vermont Agency of Natural Resources (VANR). 2004. Stream geomorphic assessment handbooks. Appendix O: Particle entrainment and transport.