KLAMATH
RIVER RENEWAL
CORPORATION

VIA U.S. MAIL AND EMAIL

October 10, 2018

State Water Resources Control Board
Division of Water Rights - Water Quality Certification Program
Attn: Parker Thaler
P.O. Box 2000
Sacramento, CA 95812-2000

Subject: Proposed Update to Definite Plan – Appendix I - AR-7 Freshwater Mussels

Dear Mr. Thaler:

This correspondence follows recent discussions between the Klamath River Renewal Corporation (KRRC) and the State Water Resources Control Board (SWRCB) and California Department of Fish and Wildlife (CDFW) concerning KRRC's proposed revision to Aquatic Resource (AR-7), the measure to reduce project effects to freshwater mussels located between Iron Gate Dam and Cottonwood Creek. On a short-term basis, mussels located in this reach are expected to experience moderate to high mortality due to bedload burial associated with the sediment release during the removal of the Klamath River dams. The management objective of this measure during this period is to reduce this mortality by relocation of individual animals.

The three mussel taxa in the Klamath River include *Gonidea angulata* (Western ridged mussel), *Margaritifera falcata* (Western pearlshell mussel), and *Anodonta sp.* (floater mussel) (Davis et al. 2013). Mussels are abundant and widely distributed throughout the mainstem Klamath River and tributaries. *G. angulata* is more widely distributed and more abundant than the other species (Davis et al. 2013). *Anodonta sp.* are located immediately below Iron Gate Dam, but are uncommon elsewhere. *M. falcata* is most abundant between the Salmon River and Trinity River confluences, and are nearly equally common as *G. angulata* in the vicinity of the Trinity River (Davis et al. 2013). Mussel abundance also generally declines with increasing distance downstream from Iron Gate Dam, suggesting the effects of the increasing hydrologic variability of the Klamath River with distance from Iron Gate. Davis et al. (2013) concluded that habitats

located further downstream had lower probabilities of supporting mussels due to more variable conditions.

During meetings in 2017, the Aquatic Technical Working Group (ATWG) reviewed relocation opportunities including moving mussels to the Keno to J.C. Boyle Reservoir reach. In June 2018, KRRC reviewed habitat conditions in the Keno to J.C. Boyle Reservoir reach and determined there is insufficient suitable freshwater mussel habitat in the reach. As there is insufficient habitat in the Keno to J.C. Boyle Reservoir reach, KRRC is now proposing to relocate mussels to the Klamath River downstream from the Trinity River confluence, or upstream of Copco Reservoir in the J.C. Boyle Dam to Copco Reservoir reach. In 2019, KRRC will be completing a more comprehensive freshwater mussel habitat reconnaissance to document existing freshwater mussel locations in the Iron Gate Dam to Cottonwood Creek reach, and to determine appropriate relocation sites in the two aforementioned reaches. *G. angulata* and *M. falcata* will mainly be targeted for relocation as there is appropriate habitat downstream from the Trinity River for both taxa (Davis et al. 2013). *G. angulata* have also been found upstream from Copco Reservoir (Byron and Tupen 2017). There are no recent published records of *M. falcata* upstream of Copco Reservoir.

The attached document summarizes the proposed updated language for the Detailed Plan – Appendix I. Narrative updates include the AR summary section, and Chapter 9 - Freshwater Mussels.

We appreciate your consideration of this proposed revision to measure AR-7. Please acknowledge receipt of this correspondence. If you have any questions on the application, please feel free to contact me at 510-679-6929 or mark@klamathrenewal.org.

Mark Bransom
Chief Executive Officer
Klamath River Renewal Corporation

cc: Erin Ragazzi, State Water Resources Control Board

encl: Appendix I – Freshwater Mussel Updated Language dated September 21, 2018.

Update for 20170929_krrc-tech_report.pdg

PDF p.262, report p. 7-8

First paragraph: “beds that will be salvaged and translocated is predicated on the available habitat in the Klamath River downstream from the Trinity River confluence (RM 43.4), and between J.C. Boyle Dam (RM 230.6) and Copco Reservoir (RM 209.0), and the abundance of mussels between Iron Gate Dam…”

9. FRESHWATER MUSSELS

The objective of the freshwater mussels measure is to address reservoir drawdown and project effects on freshwater mussels located in the Klamath River in the Hydroelectric Reach and downstream from Iron Gate Dam (RM 193.1). The 2012 EIS/R AR-7 focused conducting a freshwater mussel relocation pilot study followed by the salvage and relocation of freshwater mussels prior to reservoir drawdown. Salvaged mussels were to be held in a temporary location for later placement following reservoir drawdown, and placed in locations that will not be affected by the reservoir drawdown. Based on a review of the information discussed in greater detail below, KRRC and the ATWG concluded that a moderate scale freshwater mussel relocation effort is warranted. The proposed measure includes a freshwater mussel reconnaissance in 2019 followed by a limited freshwater mussel salvage prior to reservoir drawdown. Specifically, KRRC will salvage freshwater mussels from the 8-mile long Iron Gate Dam (RM 193.1) to Cottonwood Creek (RM 185.1) reach and translocate these mussels to one or more appropriate locations in the Klamath River downstream from the Trinity River confluence (RM 43.4), and between J.C. Boyle Dam (RM 230.6) and Copco Reservoir (RM 209.0). The translocation sites will be determined following the 2019 reconnaissance and discussion with the ATWG.

9.1 Proposed Measure

Based on a review of the 2012 EIS/R AR-7 presented in Section 9.2 below, input from the ATWG, and current freshwater mussels literature, the KRRC concluded that revisions to AR-7 are necessary to offset the anticipated short-term effects of the Project on freshwater mussels. The proposed measure includes a reconnaissance, salvage, and relocation of freshwater mussels from the 8-mile reach between Iron Gate Dam and the Cottonwood Creek confluence with the Klamath River. The monitoring and adaptive management plan has two specific actions.

- Action 1: KRRC will complete a reconnaissance in 2019 to assess the distribution and density of freshwater mussels in the 8-mile long bedload deposition reach from Iron Gate Dam (RM 193.1) downstream to the Cottonwood Creek confluence (RM 185.1). The reconnaissance effort will determine if the mussel beds identified in the 2007-2010 surveys are still present, and estimate abundance of a subset of the mussel beds in the reach.

- Action 2: Based on the reconnaissance and discussions with ATWG, KRRC will salvage and relocate a portion of the freshwater mussels located between Iron Gate Dam and Cottonwood Creek prior to drawdown to reduce project effects to the mussel community. Up to 20,000 mussels are planned for translocation to appropriate habitats in the Klamath River downstream from the Trinity River confluence (RM 43.4), and between J.C. Boyle Dam (RM 230.6) and Copco Reservoir (RM 209.0). Translocation sites will be located in areas that are anticipated by KRRC to experience minimal changes in channel bed elevation due to sediment deposition associated with the Project.

The proposed measure is intended to reduce project effects on freshwater mussels located downstream from Iron Gate Dam. The following sections provide additional detail on the proposed measure actions.

9.1.1 Action 1: Freshwater Mussel Reconnaissance

The KRRC will prepare a reconnaissance plan to assess freshwater mussels in the Iron Gate Dam to Cottonwood Creek reach in 2018. Habitat conditions will also be evaluated downstream from the Trinity River confluence, and between J.C. Boyle Dam and Copco Reservoir to determine the habitat capacity for translocated mussels. An existing freshwater mussel data set (base data for Davis et al. 2013), compiled by the Karuk Tribe, USFWS, and other collaborators from 2007 to 2010 for the Klamath River downstream from Iron Gate Dam, will be reviewed and used to plan the reconnaissance. The reconnaissance will confirm mussel beds identified in the 2007-2010 surveys and estimate abundance at a subset of the mussel beds locations. Habitat metrics in the potential translocation reach will be evaluated to maximize translocation success. The freshwater mussel reconnaissance and translocation reach habitat assessment are anticipated to take 5 days.

9.1.2 Action 2: Freshwater Mussel Salvage and Relocation

The KRRC will coordinate and implement a freshwater mussel salvage plan with freshwater mussel specialists. Based on the reconnaissance, a portion of the freshwater mussels located between Iron Gate Dam and Cottonwood Creek will be salvaged and relocated to reduce project effects to the freshwater mussel community. The freshwater mussel salvage and translocation effort is anticipated to require 10 days. The percentage of the existing mussel beds that will be salvaged and translocated is predicated on the available habitat in the Klamath River downstream from the Trinity River confluence, and between J.C. Boyle Dam and Copco Reservoir, and the abundance of mussels between Iron Gate Dam and Cottonwood Creek. Approximately 15,000 to 20,000 mussels are planned for translocation. During the course of these actions, it is not anticipated that the entire population of mussels residing below Iron Gate Dam will be recovered.

9.2 Summary of the Affected Species, Anticipated Project Benefits and Effects, Recent Literature, 2012 EIS/R AR-7, and Proposed Measure

The following sections review the components of the 2012 EIS/R AR-7, anticipated project effects and long-term benefits on freshwater mussels, and current freshwater mussel literature.

9.2.1 Affected Species

Species intended to be addressed in the 2012 EIS/R AR-7 include:

- Oregon floater *(Anodonta oregonensis)*
- California floater *(A. californiensis)*
- Western ridged mussel *(Gonidea angulata)*
- Western pearlshell mussel *(Margaritifera falcata)*

9.2.2 Anticipated Project Effects on Measure Species

Short-term effects of the Project (prolonged exposure to high suspended sediment levels and bedload movement) are predicted to be deleterious to freshwater mussels in the Hydroelectric Reach and in the lower Klamath River downstream from Iron Gate Dam (Reclamation and CDFG 2012). Substantial freshwater mussel population reductions are expected due to sediment effects and possibly low dissolved oxygen levels. The change in hydrological properties following project implementation may also disrupt the current distribution of freshwater mussels downstream from Iron Gate Dam (Davis et al. 2013). Table 9-1 includes the likely and worst-case effects on freshwater mussel species in the Klamath River.

Table 9-1 2012 EIS/R anticipated effects summary for freshwater mussels

Species	Life Stage	Likely Effects	Worst Effects
California Floater Oregon Floater Western Ridged Western Pearlshell	All	Substantial reduction in populations	Substantial reduction in populations

Source: USBR and CDFG 2012

The following sections include descriptions of anticipated effects to freshwater mussels based on information 2012 EIS/R (Reclamation and CDFG 2012; Vol. 1, pp. 3.3-173 to 3.3-175) as well as additional information from additional freshwater mussel studies, some of which were completed after the publication of the 2012 EIS/EIR.

Freshwater Mussels

Available studies have evaluated Klamath River Basin freshwater mussel age structure, growth rates, and size distribution (*G. angulata*; Tennant 2010); population distribution and habitat use (Krall 2010; Davis et al. 2013; May and Pryor 2015); and habitat associations (Westover 2010; Davis et al. 2013). Klamath River mussels are long lived (from 10 to more than 100 years, depending on species) and may not reach sexual maturity until 4 years of age or more. *Anodonta* species are found primarily downstream from Iron Gate Dam, and likely benefit from the stable hydrology and fine sediment deposits attributed to hydroregulation below the dam (Davis et al. 2013). *G. angulata* is the most abundant freshwater mussel in the Klamath River and the species is widely distributed between Iron Gate Dam and the Trinity River (Westover 2010;

Davis et al. 2013). *M. falcata* is the least abundant freshwater mussel found in the Klamath River and seems to be mostly found downstream from the confluence of the Salmon River (Westover 2010; Davis et al. 2013).

Freshwater mussel tolerance of high suspended sediment, low dissolved oxygen, and bedload deposition are not well understood. Vannote and Minshall (1982) evaluated freshwater mussels in an aggrading river system in Idaho and concluded that *G. angulata* appear to be better adapted for aggrading rivers based on siphon positions, shell morphology, and foot placement in the underlying substrate. *M. falcata* seemed to be less adapted for aggrading rivers due to a less developed siphon for filtering water. *M. falcata* also rarely burrow into substrate more than 25-40 percent of the valve length which may increase the mussel's susceptibility to scour (Vannote and Minshall 1982). *G. angulata* migrate vertically in the channel bed and are capable of maintaining position near the channel bed surface (Vannote and Minshall 1982). *M. falcata* are not known to migrate and are therefore more susceptible to sediment burial. *Anodonta* species are likewise susceptible to sediment scour and burial due to their thinner shells. Mussels that are dislodged from their normal vertical position and fall onto their sides may not regain the normal position and may perish (Vannote and Minshall 1982).

Mussels play important roles in aquatic ecosystems. Mussels influence water quality, nutrient cycling, and habitat and are also known as "ecosystem engineers" that actively modify their environment (Xerces Society 2009; Lopes-Lima et al. 2016; Lummer et al. 2016). They filter fine sediment and organic particles, create byproducts that are food items for macroinvertebrates, and comprise the greatest proportion of animal biomass in some waterbodies (Xerces Society 2009). In the Klamath River Basin, freshwater mussels filter and sequester toxins including toxigenic algae microsystins (Kann et al. 2010) and mercury (Bettaso and Goodman 2010). Filtration of waterborne toxins may result in bioaccumulation in freshwater mussels leading to human consumption risks (Bettaso and Goodman 2010; Kann et al. 2010).

The Project is anticipated to result in high suspended sediment levels and bedload deposition in the 8 miles of the Klamath River between Iron Gate Dam and Cottonwood Creek. Extremely poor water quality due to high suspended sediment concentrations is expected in the first 2 miles of the Klamath River downstream from Iron Gate Dam (Reclamation and CDFG 2012). Fine sediment effects on freshwater mussels include gill clogging, possible growth reduction, and impairment to mussel larval stages (Lummer et al. 2016). Due to both the anticipated deleterious high suspended sediment concentrations and low dissolved oxygen levels, freshwater mussels downstream from Iron Gate Dam may experience substantial mortality with the most significant impacts anticipated to mussels located immediately downstream from Iron Gate Dam.

Over the long-term, freshwater mussels are expected to benefit from the Project through the conversion of Hydroelectric Reach reservoirs to gravel bed rivers which will restore freshwater mussel habitat, reduce water quality and water temperature impairments related to the reservoirs, and restore access for anadromous and resident host fish species that will distribute freshwater mussel larvae throughout the Klamath River upstream from Iron Gate Dam. However, due to the long time freshwater mussels take to reach sexual maturity, the recolonization and/or growth of existing freshwater mussel populations upstream of Iron Gate Dam may be slow and may not be readily noticeable for some time.

9.2.3 2012 EIS/R AR-7

The 2012 EIS/R AR-1 (Vol. I, pp. 3.3-248 to 3.3-249) directed the salvage of freshwater mussels from the Hydroelectric Reach and downstream from Iron Gate Dam. Salvaged mussels were to be relocated to suitable instream habitat unaffected by high suspended sediment concentrations, or could be placed in temporary facilities and returned to the Klamath River following the Project. A salvage and relocation pilot study was also suggested to assess salvage feasibility and relocated mussel survival. Based on the pilot study results, a detailed salvage and relocation plan was to be developed.

9.2.4 KRRC's and the ATWG's Review of AR-7 for Feasibility and Appropriateness

The KRRC assessed the feasibility and appropriateness of AR-7 through multiple planning meetings held with the ATWG between May and August 2017. During these meetings, current information on Klamath River fisheries was presented and information on other dam removal projects conducted in the western United States was reviewed to understand how the aquatic ecosystem might respond, as discussed above. The ATWG's concerns regarding the 2012 AR-7 included:

- Unfamiliarity with successful freshwater mussel relocation efforts.
- Disease transmission concerns.

The following sections provide additional information regarding AR-7 feasibility and appropriateness, based on fisheries literature and ATWG input.

Unfamiliarity with Successful Freshwater Mussel Relocation Efforts

The ATWG was unfamiliar with successful freshwater mussel translocation efforts. Anecdotal information discussed during the ATWG planning meeting (Yreka, CA, May 23, 2017) alluded to low translocation success for the Elwha Dam Removal Project and highway construction projects. Additional information was acquired by the KRRC on the Elwha Dam Removal Project freshwater mussel (*M. falcata*) translocation. For that project, freshwater mussels were translocated to two sites and remained in one site prior to the dam removal project (P. Crain, U.S. Park Service, personal communication, 2017). The relocated freshwater mussels had high survival following the translocation and prior to the dam removals. Subsequent events that impacted the translocated mussels resulted in high mussel mortality. The events included raccoon predation due to shallow habitat at the first translocation site, and excessive sediment deposition at a side channel translocation site. The third monitored site was an artificial outfall channel from the water treatment facility that went dry due to inadvertent project operations. Mussels that remained in the Elwha River downstream from Elwha Dam are suspected to have experienced high mortality due to excessive sediment deposition following dam removal, followed by channel scour during the post-dam sediment sorting process.

Freshwater mussel translocation project monitoring results are not well represented in the fisheries literature. Unpublished freshwater mussel translocation monitoring manuscripts were reviewed to better

understand the range of potential translocation success. Fernandez (2013) described the translocation success of 265 individual *M. falcata* in coastal southwest Washington. Between 55 percent and 95 percent of the transplanted *M. falcata* were accounted for in the translocation sites between one and three years following the translocation.

A review of translocation projects found mean mortality of relocated mussels was 49 percent based on an average recovery rate of 43 percent (Cope and Waller 1995). Cope and Waller (1995) found that survival of relocated mussels was generally poor and the factors influencing the survival of relocated mussels were poorly understood. For mussel relocation to be successful, more consideration must be given to habitat characterization at both the source and translocation sites. Olden et al. (2010) and Germano et al. (2015) offer considerations for successful freshwater organism and wildlife translocation efforts, respectively Luzier and Miller (2009) offer suggestions and considerations for freshwater mussel translocations.

Disease Transmission Concerns

The role of freshwater mussels in freshwater disease transmission is not well understood. Freshwater mussels are known to provide habitat for polychaete worms, one of the hosts in the life *C. shasta*. Polychaetes have been infrequently collected from freshwater mussel shells in the Hydroelectric Reach of the Klamath River (PacifiCorp 2004). Mussels may serve as a vector for other fish pathogens like *Flavobacterium columnare* and *Ichthyophthirius multifiliis* that are endemic to the Klamath River Basin (K. Kwak, CDFW, personal communication 2017).

Freshwater mussels inhabit the Klamath River upstream from Iron Gate Dam (Byron and Tupen 2017) and in tributaries upstream (Byron and Tupen 2017) and downstream from Iron Gate Dam (Davis et al. 2013; Howard et al. 2015; May and Pryor 2015), disease transmission may be less of a concern.

9.3 Summary

The Project is anticipated to have significant short-term effects, but long-term benefits for freshwater mussels. The 2012 EIS/R AR-7 included a freshwater mussel salvage and relocation pilot study followed by an informed salvage and relocation plan prior to the Project. The proposed measure includes completing a reconnaissance of existing freshwater mussels from Iron Gate Dam to Cottonwood Creek and potential translocation habitat on the Klamath River downstream from the Trinity River confluence, and between J.C. Boyle Dam and Copco Reservoir. KRRC will salvage and relocate freshwater mussels prior to the reservoir drawdown. It is not anticipated that the entire population of mussels residing below Iron Gate Dam will be recovered.