

Note: This manual is a work in progress. The latest amendments to the document were made on 3-24-2018.



ENDANGERED SPECIES ACT COMPLIANCE FOR DREISSENID MUSSEL RESPONSE IN THE COLUMBIA RIVER BASIN STATES



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INTRODUCTION AND PURPOSE

The Endangered Species Act (ESA) of 1973 (16 U.S.C. 1531 et seq.), as amended, establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat on which they depend. Section 7(a)(2) of the ESA requires federal agencies to insure, in consultation with the U.S. Fish and Wildlife Service (FWS or Service) and the National Marine Fisheries Service (NMFS), as appropriate, that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitats. Section 7(a)(4) of the ESA requires federal agencies to confer with USFWS and NMFS (the Services), as appropriate, in cases where the agency or the Services have determined that a proposed or ongoing federal action is likely to jeopardize the continued existence of species proposed to be listed under section 4 of the ESA, or result in the destruction or adverse modification of critical habitat proposed to be designated for such species.¹ The USFWS encourages federal agencies to conference on actions that may affect a proposed species or proposed critical habitat. In such cases, conference concurrence determinations or conference opinions can be adopted as formal concurrences or biological opinions, respectively, after a proposed species is listed or the critical habitat is designated. Such an approach can avoid disruption of project implementation due to the need to initiate and complete formal consultation at the time of listing or designation. It also facilitates or promotes action agency consideration of the conservation needs of proposed species and the recovery function of proposed critical habitat.

The purpose of this manual is to delineate a suite of most-likely rapid response eradication actions for a potential introduction of dreissenids in Columbia River Basin states, and to assess the potential for those actions to affect Endangered Species Act-listed species and critical habitats. Information in this manual is intended to facilitate future conference actions associated with an introduction of dreissenids in the basin.

No Action Alternative

Under the No Action Alternative, no actions would be taken in the Columbia River Basin states to address an introduction of dreissenids to water bodies within the Columbia River Basin. Dreissenids would be allowed to establish, reproduce, and spread throughout the Columbia River Basin. The results of no action would include long-lasting significant detrimental economic, environmental, and social effects that would change ecosystem function and processes throughout the Columbia River Basin and affect quality of life for people who live in the Basin.

¹ US Fish and Wildlife Service and National Marine Fisheries Service. 1998. Procedures for conducting consultation and conference activities under Section 7 of the Endangered Species Act. https://www.fws.gov/endangered/esa-library/pdf/esa_section7_handbook.pdf

FORMAT OF THIS MANUAL

This manual provides general information applicable to all four Columbia River Basin states in the event of an introduction of dreissenids (see Literature Review). In addition, each state has designated four waterbodies that best represent both the geography of the state as well as a diversity of water body types and associated threatened and endangered species and critical habitats. Information is compiled for each water body as follows:

Federal Agencies

A list of federal agencies associated with the water body and a potential dreissenid introduction action.

Authorities

Authorities that exist to support an action.

Key Points of Contact

Points of contact for endangered species act consultations.

Existing Rapid Response Plans

A list of existing rapid response plans (e.g., water body, state, jurisdictional manager)

Project Location

A description of the waterbody a description of characteristics of the waterbody that would inform a potential action (e.g., a reservoir with wide fluctuations in water levels). Water body monitoring is included.

Treatment Sites

A description of the most likely sites within the waterbody for an action to occur. An [online USGS database of boat ramps within the Columbia River Basin](#) (Figure X) as well as information posted online from state and local communities was used to identify public access sites associated with identified water bodies.

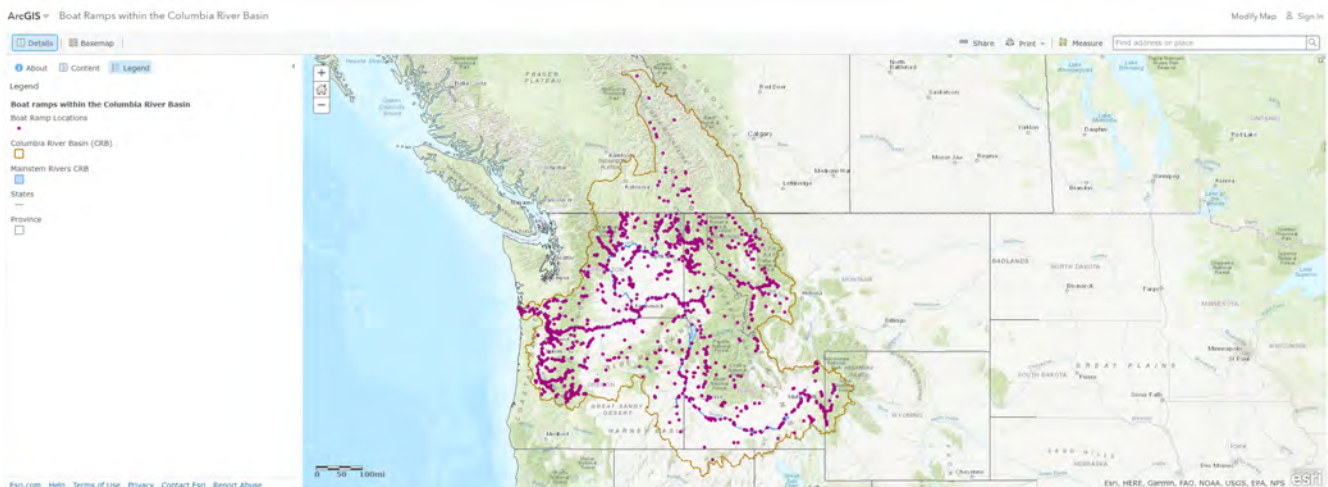


Figure X. Major boat ramps within the Columbia River Basin.

Control Action

A description of the control action, including the states action and action agency, details associated with the action (e.g., chemical identification, method of application, application rate and quantity, number of applications).

Action Area

Delineation of the geographic area that is likely to be affected, directly or indirectly, by the response, including a discussion of topography, vegetation, critical habitat and listed species conditions and trends, and maps as well as potentially affected cultural/archeological resources via consultation with Tribes, when appropriate. Key uncertainties and recommendations to address those uncertainties are included. Conservation measures and best management practices (e.g., timing restrictions that avoid or minimize adverse effects to ESA-listed species and critical habitat that do not compromise the effectiveness of the response action) for incorporation into the project design are included.

Proposed/Listed Species/Critical Habitat Considered

Species or critical habitat that “may be present” are identified, including listed, proposed and candidate species, and proposed and designated critical habitat. Species that may be present in the general area, but not necessarily in the action area, are included. The ESA Section 7(a)(2) Process (Step 1) portion of the USFWS website (insert link) is used to complete this section of the assessment. Ongoing monitoring for species and critical natural resources that may be threatened by dreissenids, or a potential dreissenid response, is included. Key uncertainties and recommendations are listed.

Effects Analysis

Descriptions of how the action (and no response action) may affect each protected resource, including conclusions and supporting rationale are provided. Key uncertainties and recommendations are listed. For each species and their designated critical habitat, recommendations on the short and long-term effects for each protected resource are provided.

No effect - the appropriate conclusion when the action agency determines its proposed action will not affect a listed species or designated critical habitat.

Is not likely to adversely affect - the appropriate conclusion when effects on listed species are expected to be discountable, insignificant, or completely beneficial. Beneficial effects are contemporaneous positive effects without any adverse effects to the species. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur. Based on best judgment, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur.

Is likely to adversely affect - the appropriate finding in a biological assessment (or conclusion during informal consultation) if any adverse effect to listed species may occur as a direct or indirect result of the proposed action or its interrelated or interdependent actions, and the effect is not: discountable, insignificant, or beneficial (see definition of “is not likely to adversely affect”). In the event the overall effect of the proposed action is beneficial to the listed species, but is also likely to cause some adverse effects, then the proposed action “is likely to adversely affect” the listed species. If incidental take is anticipated to occur as a result of the proposed action, an “is likely to adversely affect” determination should be made. An “is likely to adversely affect” determination requires the initiation of formal Section 7 consultation.

Status of ESA Listings & Critical Habitat Designations for West Coast Salmon & Steelhead

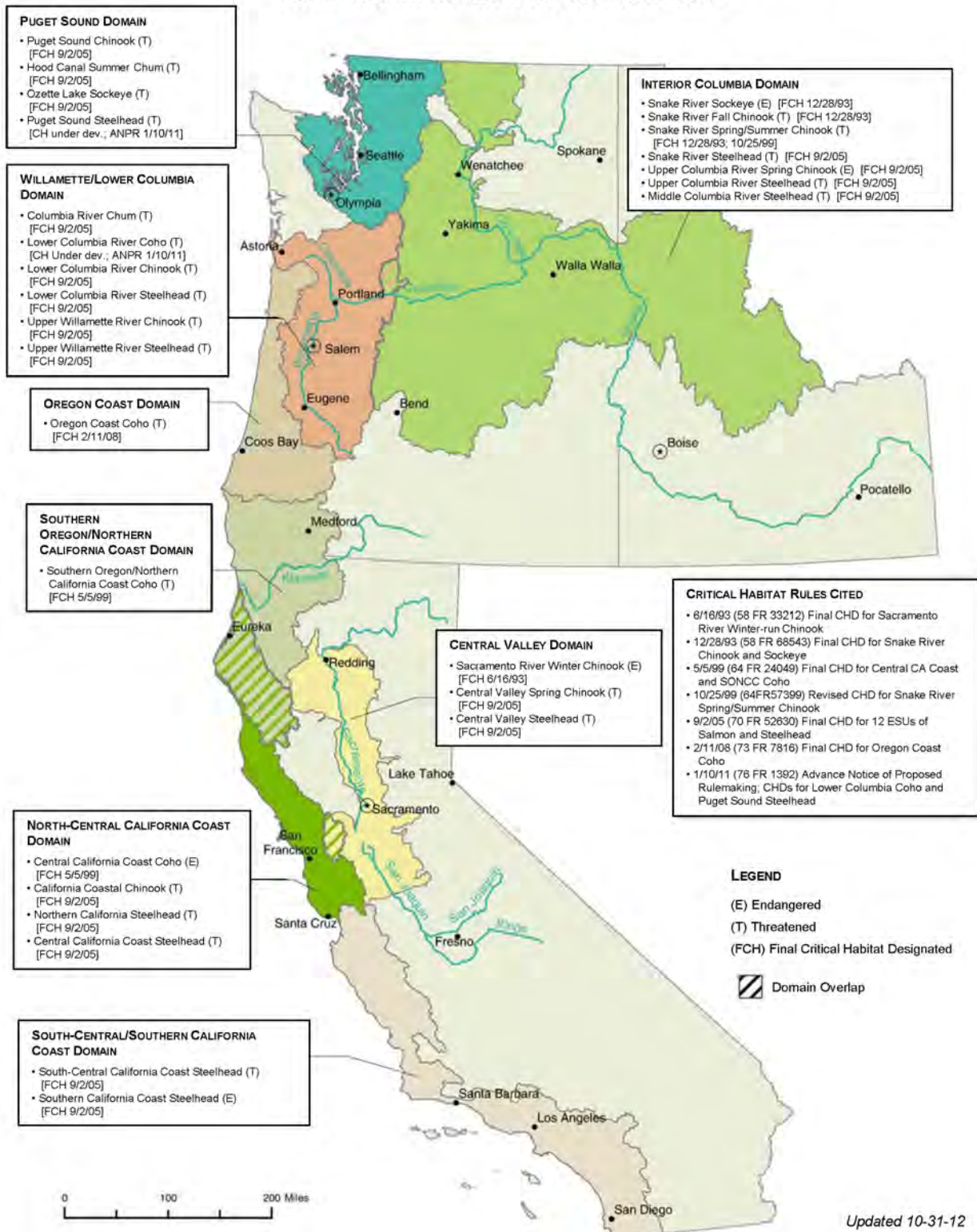


Figure X. Status of ESA listings and critical habitat designations for West Coast salmon and steelhead.

STATE OF WASHINGTON

The State of Washington provided six waterbodies for consideration in this analysis—Lake Roosevelt, Potholes Reservoir, Waitts Lake, Lake Washington, Columbia River, and Lake Sawyer (Figure X). Of the six that were provided, we selected Potholes Reservoir, Lake Washington, Lake Roosevelt, and the Columbia River for our analysis.

	Lake Roosevelt	Potholes Reservoir	Lake Washington	Columbia River
Waterbody	Columbia River	Columbia River	Lake Washington	Columbia River
Reservoir	Roosevelt	Potholes	n/a	n/a
Comments	Represents one of the higher risk lakes in eastern Washington	Comparable to Washington Lake for eastern Washington	Located in the nucleus of the state, although calcium barely gives it a high-risk designation	Downstream from Bonneville dam
Latitude	48.733	46.98954	47.57494	46.20774
Longitude	-118.0592	-119.21042	-122.19039	-123.38826
County	Stevens	Grant	King	Wahkiakum
Ecoregion Level 3	Northern Rockies	Columbia Plateau	Puget Lowland	Coast Range
Drainage	Columbia Basin	Columbia Basin	Columbia Basin	Columbia Basin
Inflow	Columbia River (89%), Spokane River (7%), Colville River, Kettle River and Sanpoil Rivers (4%)	Moses lake	Sammamish River (north) and Cedar River (south); small creeks and rivers that feed the lake—Coal, Fairweather, Forbes, Juanita, Kelsey, Lyon, May, McAleer, Ravenna, Taylor, Thornton, Yarrow and Yesler Creeks as well as Mercer Slough	Columbia River
Outflow	Columbia River	Crab Creek	Lake Washington Ship Canal	Columbia River
Surface Elevation (ft)	1,288	1,042	16	
Basin Area (mi ²)	123.6	3,920	28 ²	258,000
Surface Area (ac)	80,000	14,281	21,000	n/a
Volume (ac ft)	1,653,043	332,800	2,400,000	
Max. Depth (ft)		142	214	
Mean Depth (ft)	375	18	108	
Shoreline length (mi)	602	180	72 ³	
Trophic state	mesotrophic	eutrophic	mesotrophic	
pH (mean) (min–max) ⁴	7.9 (7.0–8.6)	8.14	7.77	
Average Ca mg/L ⁵	19.8	26.4	10.2	16.7
High-risk establishment (>10 Ca mg/L)	Yes	Yes	Yes	Yes

² Chrzastowski (1983).

³ Troost (2011).

⁴ Wells, S.W., T. D. Counihan, A. Puls, M. Sytsma, and B. Adair. 2011. Prioritizing zebra and quagga mussel monitoring in the Columbia River Basin. Center for Lakes and Reservoirs Publications and Presentations. Paper 10.

⁵ Ibid.

	Lake Roosevelt	Potholes Reservoir	Lake Washington	Columbia River
Average Secchi (range)		8.8		
Dam	Grand Coulee	O'Sullivan	None	Lock and Dam
Owned/ Administered by:	National Park Service (Lake Roosevelt NRA); Bureau of Reclamation (management zone directly behind dam and management zone on the east side of lake at China Bar); Bureau of Indian Affairs	Bureau of Reclamation	King County Water and Land Resources Division	US Army Corps of Engineers
URL	http://www.nps.gov/laro/index.htm ; http://www.bia.gov/ ; https://www.usbr.gov/pn/grandcoulee/lakelevel/	https://www.usbr.gov/pn/programs/ea/wash/potholes/index.html	www.KingCounty.gov	http://www.nwp.usace.army.mil/bonneville/
Dam type	Concrete gravity dam	earthfill	None	Run-of-the-river dam structures
Draw down y/n		Y	N	N
Irrigation y/n		Y	N	
Irrigation District		East and South Columbia Basin Irrigation Districts		

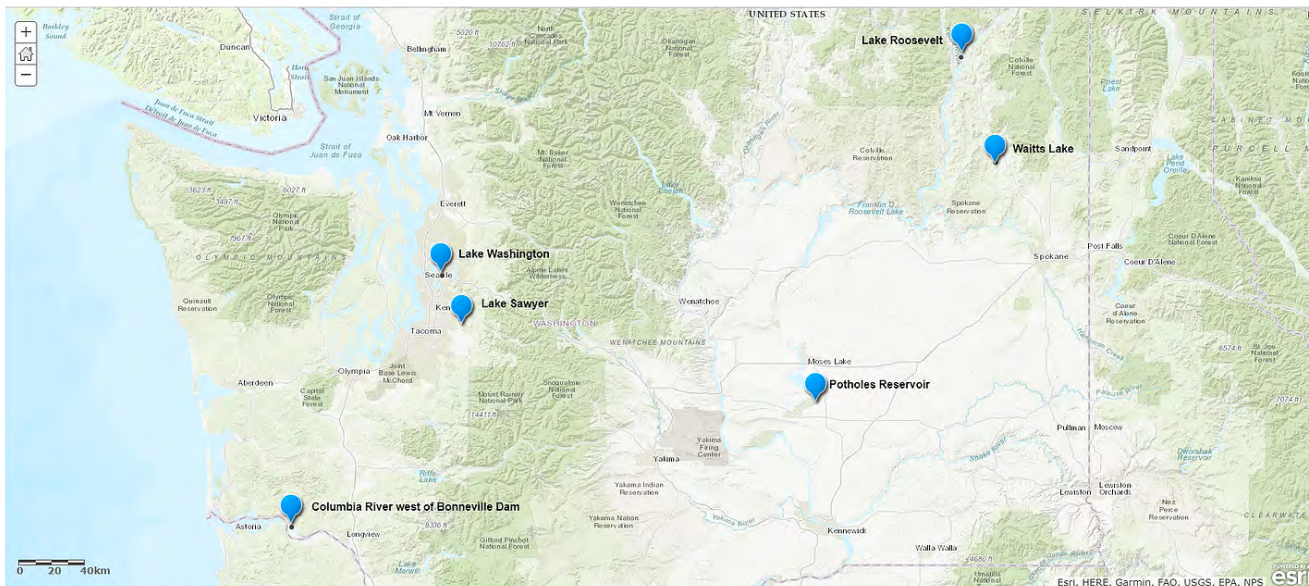


Figure X. Six waterbodies proposed for analysis by the State of Washington.

Potholes Reservoir

Federal Agencies

US Bureau of Reclamation, US Fish and Wildlife Service

Authorities

BOR would issue a federal permit under 106 U.S.C. 1531Z et seq. to authorize the federal action.

The Washington Department of Fish and Wildlife would be the agency responsible for implementing the control action based on the following authorities:

- The Washington Department of Ecology issued the Washington Department of Fish and Wildlife an [NPDES permit](#) on August 17, 2016 (Permit #WAG993002) - Aquatic Invasive Species Management General Permit that covers management activities for non-native aquatic invasive animals that results in the discharge of chemicals or control products into surface waters of the State of Washington.
- The U.S. Bureau of Reclamation (USBR) manages the diversion of Columbia River water into Potholes Reservoir and the canal system for delivery of the water to irrigators through the USGS/USBR collaborative Watershed and River Systems Management Program (WARSMP).
- The Washington State Parks and Recreation Commission (SPRC) and Washington Department of Fish and Wildlife (WDFW) administer and manage the Potholes Reservoir area with oversight provided by the Ephrata Field Office of the Bureau of Reclamation. The Grant County Sheriff's Office will also remain a management partner at the reservoir providing general law enforcement services and periodic patrols within the Grant County Off-Road Vehicle (ORV) Area.

Key Points of Contact

Note: The 100th Meridian Rapid Response Plan [Appendix C](#) provides an updated list of all relevant state and federal agency representatives in the event of an introduction of dreissenids.

Endangered Species Acts Points of Contact for Consultations:

Pacific Region Office

503-231- 6151

Fw1_AEAinbox@fws.gov

Washington Fish and Wildlife Office

360-753-9440

<http://www.fws.gov/wafwo/>

Existing Rapid Response Plans

[Washington State Rapid Response Plan](#)

Project Location

Potholes Reservoir (46.98954, -119.21042) is a 28,200-acre reservoir in Grant County in the Columbia Plateau (Figures X and X). The reservoir was formed by the construction of O’Sullivan Dam across the Crab Creek valley in 1949. Water flows into the reservoir from the outlet of Moses Lake via Crab Creek, and irrigation return water from Winchester Wasteway, Frenchman Hills Wasteway, and Lind Coulee. Water discharge occurs through O’Sullivan Dam to the Potholes Canal to irrigate farmlands in Adams and Franklin Counties. Owned by the Bureau of Reclamation, Potholes Reservoir is renowned for its warmwater fishery, wetland habitat for colonial nesting birds, and attracts large numbers of migrant and wintering waterfowl. The purpose of the reservoir, which is managed by the Bureau of Reclamation, is to receive and store irrigation return, flood, and public surface waters and to provide irrigation supply to the East Columbia Basin and South Columbia Basin Irrigation Districts via the Potholes East Canal.

Reservoir water levels are subject to wide fluctuations—the project’s purpose is to gather wastewater and return flows from irrigated lands upstream and store water for reuse on farmland downstream.⁶ At full pool in spring there are 20,000 acres of surface water. The dam initially inundated the Crab Creek channel and about 800 small ponds scattered among the sand dunes of the area. With several thousand acres of water covering the sand dune area, perhaps 1,000 islands were formed in the north and west parts of the reservoir. The higher elevation wetlands on the northern and western fringes of the reservoir have cattail and bulrush communities. The western part still has many active sand dunes with shrub steppe vegetation, except for the wetland areas along the Winchester and Frenchman Hills wasteways. The original Crab Creek channel is exposed just below O’Sullivan Dam and west of Potholes Canal, the outlet of the reservoir. Wildlife use includes waterfowl, wintering bald eagles, mule deer and one of the two known populations of northern leopard frogs in Washington.

Potholes Reservoir and Moses Lake are monitored for both water quality parameters and adult and juvenile dreissenids by the Washington Department of Fish and Wildlife (Appendix A includes monitoring results from 2010–2017).



Figure 2. Photos of Potholes Reservoir courtesy of WA Department of Ecology.

⁶ WDFW Lands [website](#).

Treatment Sites

Likely action sites within Potholes Reservoir include areas in and around the eight boat launch sites and marinas (Figure X), including one launch site managed by the Washington State Parks and Recreation Commission, and seven launch sites managed by the Washington Department of Fish and Wildlife:

Washington Department of Fish and Wildlife

- Blythe Boat Launch
- Glen Williams Boat Launch
- West Lind Coulee Boat Launch
- Road “M” Boat Launch
- Powerline Boat Launch
- Cartop Boat Launch (informal/unmaintained)
- Job Corps Dike Boat Launch (informal/unmaintained)

Washington State Parks and Recreation Commission

- Potholes State Park

Mar Don Resort Lessee

- Mar Don Resort

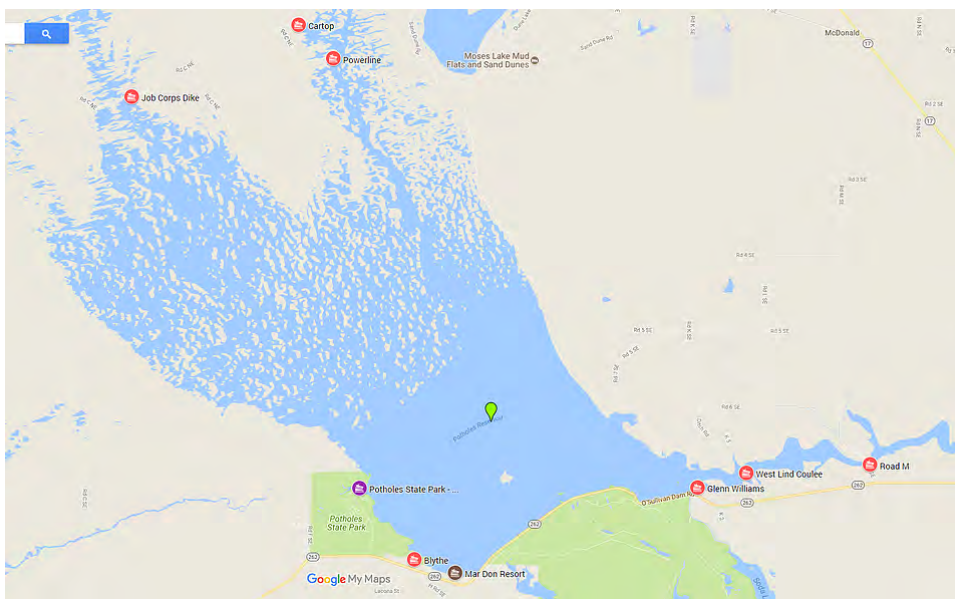


Figure X. Photos of Potholes key public access sites.

A USGS

Control Action

Stated Action/Action Agency

The State of Washington, through a federal permit issued by the US Bureau of Reclamation, will apply KCl to Potholes Reservoir to prevent the establishment of dreissenids that have been detected as a result of monitoring efforts. The lead federal agency for this action is the US Fish and Wildlife Service.

Method of Application

KCl would be applied in liquid form, as a mixed slurry, similar to treatment studies conducted in Millbrook Quarry, Virginia, USA (Fernald and Waterson, 2014), Lake Winnipeg, Manitoba, Canada (DFO 2014), and Truman Lake, Missouri (2013). A pesticide applicator, licensed by the Washington State Department of Agriculture, will be responsible for all applications of potash. Granular KCl will be mixed on board the applicators watercraft and agitated throughout the treatment. The pesticide will be applied to the surface water using a spray wand and allowed to mix with the water column.

Application Rate & Pesticide Quantities

The potassium (K⁺) concentration in potash required to kill dreissenids is generally 100 ppm. Fernald and Watson (2014) achieved 100% mortality of zebra mussels between 98-115 ppm. Following the initial dosing for each treatment area, potassium (K⁺) concentrations will be measured either in the field with a potassium ion electrode or analyzed by a certified lab. The pesticide applicator may also monitor for chloride concentrations in the field (as a surrogate for potassium (K⁺)). Follow-up applications(s) may be required to maintain 100 ppm potassium (K⁺) for a sufficient duration, which will be determined by dreissenid mussel bioassays in lake (caged dreissenid mussels within the treatment area monitored daily for mortality) and dreissenid mussels in aquaria lab trials. According to a report by ASI project E9015 (1997) potassium does not require continual addition to the water column, except to account for leakage. Total amount of pesticide proposed for each treatment area depends upon in-lake potassium (K⁺) concentration achieved for up to 2 weeks after the initial dosing treatment. Additional application(s) of potash may be necessary to maintain 100 ppm potassium for up to two weeks.

Number of Applications

The total number of applications in the initial two-week treatment period will depend on the dispersal and dissolve rates determined during and between applications as well as achieving 100% mortality in the dreissenid mussel bioassays. Water samples will be collected at surface and near bottom (3-4 ft.) depths every 48-96 hours and analyzed at a professional lab. Because the area is enclosed with curtains, it is anticipated potassium (K⁺) concentrations to dissipate quickly. Dosing will be adjusted accordingly and upon achieving 100% mussel mortality, the floating curtain will be removed from the water body, allowing the treated water to mix. One or more additional two-week treatment periods may be necessary depending on the results of mussel monitoring. Monitoring results will determine the total acreage to be treated.

Applicable Restrictions and Requirements Concerning the Proposed Use Not on Label

Although there are no immediate effects of KCl to human health and non-target species (Fernald and Watson, 2014), the Washington Department of Fish and Wildlife will continue to monitor K concentrations (and other water quality parameters) in Potholes Reservoir upon barrier removal and achieved 100% dreissenid mortality. This monitoring will take place over the next consecutive years.

Action Area

Potholes Reservoir is a 28,200-acre reservoir formed by the construction of O'Sullivan Dam across the Crab Creek Valley in 1949, and is part of the Columbia Basin Project (CBP). The CBP was authorized in 1933, and was created to irrigate and attract settlement to this portion of eastern Washington. Water flows into the reservoir from the outlet of Moses Lake via Crab Creek, and irrigation return water from Winchester Wasteway, Frenchman Hills Potholes Supplemental Feed Route Wasteway, and Lind Coulee. Water discharge occurs through O'Sullivan Dam to the Potholes Canal to irrigate farmlands in Adams and Franklin Counties. Owned by Reclamation, Potholes Reservoir is renowned for its warmwater fishery, wetland habitat for colonial nesting birds, and attracts large numbers of migrant and wintering waterfowl.

The action area includes the entirety of Potholes Reservoir. Any potential action to control dreissenids could occur in any portion of the reservoir, especially at boat launch locations. Areas that could experience indirect effects from a control action would include areas downstream of the reservoir, including the Potholes Canal, area downstream of Lind Coulee, and the waterway leading to, and including, Soda Lake.

Potholes Reservoir is located in the interior Columbia Basin, where land topography is rolling, there are xeric weather patterns, soil is loamy to deep sandy and windblown, and vegetation is primarily bunchgrass and sagebrush.

Vegetation

Areas not converted to agriculture consist of shrub-steppe communities, layers of perennial grasses (native bunchgrasses - *Poa*, *Stipa*, and *Agropyron* spp. as well as non-native downy brome - *Bromus tectorum*) with a discontinuous overstory layer of shrubs (sagebrush - *Artemisia* spp., rabbitbrush - *Chrysothamnus* spp., bitterbrush - *Purshia tridentate*, grease wood - *Sarcobatus* spp., and spiny hopsage - *Grayia spinosa*). Riparian vegetation includes willows (*Salix* spp.), rose (*Rosa* spp.), water birch (*Betula occidentalis*), black cottonwood (*Populus angustifolia*), hawthorn (*Crataegus douglasii*), and serviceberry (*Amelanchier anifolia*).

Hydrology

There are three feed routes currently being used to deliver water into Potholes Reservoir. The primary route is through the ELC to Rocky Coulee Wasteway then into Upper Crab Creek, Moses Lake, and finally into Potholes Reservoir. The two secondary routes are through Lind Coulee Wasteway and through Frenchman Hills Wasteway. Water is spilled from the ELC to Lind Coulee Wasteway, which flows directly to Potholes Reservoir. The other secondary route spills water from the West Canal to the Frenchman Hills Wasteway, which also flows directly to Potholes Reservoir. The use of the existing feed routes is limited to spring and fall during the irrigation season when unused canal and wasteway capacity is available because of low irrigation demand.

Groundwater in the CBP is predominantly associated with the flood basalts of the Columbia River Basalt Group, but also with sediments that overlie or are interbedded with the basalts. The entire aquifer system underlies approximately 50,600 square miles of the Columbia Plateau in Washington, Oregon, and parts of northwest Idaho (Bauer 2000).

Water temperatures at the outlet of Moses Lake are in the low 20s (degree C); winter temperatures range from 1-3 (degree C).

Climate

Grant County is located in a semi-arid, dry, hot area, with temperatures ranging from 51 degrees F to 83 degrees F in the summer and 21 degrees F to 36 degrees F in the winter (Kurz 2006).

Geology/soils (partially extracted from Potholes Reservoir Resource Management Plan 2002)

The landscape in the Columbia Basin area is called "Channeled Scablands" because of the floodwaters that scoured the landscape when Glacial Lake Missouri broke through ice dams during the Pleistocene Epoch. The Potholes Reservoir Management area lies within the Columbia Basin subprovince of the Columbia Intermontane Province. The Columbia Intermontane Province is the product of Miocene flood basalt volcanism and regional deformation that occurred over the past 17 million years. The Columbia Plateau is that portion of the Columbia Intermontane Province that is underlain by the Columbia River Basalt Group. The Potholes Reservoir is located in the Quincy Basin, a synclinal trough in the folded Columbia Plateau. The Pleistocene floodwaters formed a fast draining lake as they entered this broad basin and as a result dumped large quantities of sediment completely burying the basalt bedrock. Most of the floodwater drained through the Drumheller channels south of the Potholes Reservoir into the Othello Basin where it ponded again to make another temporary lake. Since the end of the Pleistocene, winds have locally reworked the flood sediments, depositing dune sands in the lower elevations and loess at higher elevations.

The Eastern Bluffs management zone area has a steep relief, generally unvegetated, with the slopes composed of unconsolidated materials (i.e., silt/sand, cobble). These slopes are highly vulnerable to erosion and border directly on the reservoir. This limits possible development and use of the area. The Potholes Reservoir has a continuing inflow of suspended sediment from the wasteways that result in a build-up of sediment which is deposited near mouths of these wasteways. The boat launch area at the State Park is highly impacted by this sediment build-up.

Grant County resides in a regional structural basin. The County rests on the lower limb of the Grand Coulee Monocline to the north/northwest and the northern limb of the Frenchman Hills Anticline to the southwest. The region to the northeast, including the Potholes Management Area, is subjected to a 0 to 5-degree dip in the southwest direction. The effect of these structural features is the formation of a regional sediment and groundwater cache basin in and around Potholes Reservoir. Nearly all of the soils on the Columbia Plateau and in the Columbia drainage basin have been formed under grassland or shrub-grassland vegetation. Soil parent materials in this region include basalt, volcanic ash, sedimentary deposits, glacial outwash, and alluvial, fluvial, and colluvial deposits. Soils are generally covered with windblown sand and silt. Caliche layers occur in most of the soils and are generally seven feet deep. Loess dominated subsoils are moderately saline and contain a moderate amount of exchangeable sodium.

The most recent and comprehensive soils data available for the Potholes Management Area was obtained from the Soil Survey of Grant County Washington (SCS 1984) prepared by the U.S. Department of Agriculture's Natural Resources and Conservation Service (NRCS). The soil survey is an inventory and evaluation of the soils found in Grant County which includes the Potholes Management Area. The survey can be used to adjust existing land uses and land use plans to the limitations and natural potentials of soil resources and their environment (USDA, 1984).

Potholes Reservoir is in the southeast part of Grant County. The RMP Management Area in and around the reservoir includes about 36,200 acres. At high water, about 18,500 acres of soil are exposed, and at low water this number increases considerably. Soils in the RMP management area

consist of two broad soil groups and a total of seven general soil map units. Each of the general soil units identifies a broad area that has a distinctive pattern of soils, relief, drainage, and landscape. There is a total of 56 detailed soil map units within the Potholes Reservoir Management Area.

Potentially affected cultural/archaeological resources

State, federal and tribal cultural resource contacts

Surveys and other investigations for historic resources have occurred in the general project area sporadically, beginning in the late 1940's, largely because of the creation of the Columbia Basin Project. The River Basin Survey of the Smithsonian Institute surveyed the land to be inundated by both Banks Lake and Potholes Reservoir, and several sites were investigated (Drucker 1948). Surveys were conducted in the late 1970s by the University of Washington on numerous parcels of the Columbia Basin Project. Reclamation has conducted a number of surveys in the CBP:

- A Cultural Resources Survey of Potholes Reservoir, Grant County, Washington (Axton, Boreson and Regan 2000). This survey covered nearly 40,000 acres in the Potholes Reservoir area and identified ten sites and 48 isolated finds. The ten sites were all from the historic period and consisted of habitations, temporary habitations associated with sheep raising operations, and refuse dumps. The isolated finds were other historic artifacts, but also included some prehistoric lithic flakes. No significant historic properties were identified during this survey.
- An Ethnographic Overview of the Potholes Reservoir Study Area of Central Washington (Ellis and Fagan 2000). This report detailed the ethnographic history of the Potholes area and included information on the traditional and current American Indian use of the area.
- A Cultural Resources Overview of the United States Bureau of Reclamation's Scattered Tracts/Potholes Study Area, Adams, Franklin, Grant, and Walla Walla Counties, Washington (Gundy 1998). The study area for this report encompassed 313 non-contiguous parcels of land under Reclamation jurisdiction, totaling approximately 90,000 acres. The report identified 514 previously recorded sites within the study area from both the historic and prehistoric periods. These sites included lithic scatters, campsites, habitation, caves or rock shelters, cairns, quarries, burials, petroglyphs or pictographs, fish weirs, and shell deposits.
- Aboriginal groups known to have occupied or used the project area include a variety of Plateau groups: the San Poil, Nespelem, Middle Columbia Salish, Wanapum, Yakama, Lower Spokane, as well as others who frequented the Columbia and Snake River confluence (Ellis and Fagan 1999). However, the Columbia people were indigenous to the area, with settlements on and surrounding Moses Lake. The general area, including Moses Lake, provided excellent resource gathering opportunities including root crops, fish, turtles, and waterfowl, among other natural resources (Axton, Boreson and Regan 2000).
- Euro-American exploration prior to 1870 included fur traders, road and railroad surveyors, miners, freighters, and stockmen. Early settlers attempted raising livestock including cattle and horses; however, lack of water and overgrazing caused the industry to decline. Dryland farming proved equally short-lived and unsuccessful (Boreson 1998).

- The Columbia Basin Project, authorized in 1933, was created to irrigate and attract settlement to the semi-arid and sparsely settled land of east-central Washington. The water diverted from the lake formed by Grand Coulee Dam, through Banks Lake, now irrigates more than 650,000 acres. Water first flowed onto project land in 1948 through pumps near Pasco, and in 1952 through the Main Canal. Winchester Wasteway is one of several channels that capture return flows of irrigation water for storage in Potholes Reservoir (Gundy 1998).
- The reservoir is in a part of the interior Columbia Basin characterized by rolling topography; xeric weather patterns; loamy to deep sandy, windblown soil; and vegetation dominated by bunchgrass and sagebrush. Human impacts to the study area include previously constructed weirs, ditches, dikes, and basins associated with the CBP. Additionally, several towns with varying populations are located in close proximity to the reservoir, including Ephrata and Moses Lake.

Traditional Cultural Properties

The majority of the area in and surrounding the project area is within lands ceded in the Yakama Treaty of June 9, 1855. The treaty established the Yakama Reservation and reserved rights and privileges to hunt, fish, and gather roots and berries on open and unclaimed lands to the 14 signatory Tribes and bands. In addition to the Yakama Nation, the Spokane Tribe of Indians, Wanapum, the Nez Perce Tribe, and the Confederated Tribes of the Colville Indian Reservation may also have interests in the project area.

Traditional Cultural Properties (TCPs) are addressed in the National Register Bulletin Guidelines for Evaluating and Documenting Traditional Cultural Properties (King and Parker 1998). A TCP is defined as a site eligible for inclusion in the National Register when it is associated with cultural practices or beliefs of a living community that are rooted in the community's history and are important in maintaining the continuing cultural identity of the community. Some TCPs co-occur with archaeological sites, while other TCPs may include landscape features or simple locations. Under the Archaeological Resource Protection Act, most TCP locations are considered confidential.

No sacred sites were identified in the project area when the site was assessed in 2007 (BOR 2007).

Proposed/Listed Species/Critical Habitat Considered and Effects Analysis

(Elements excerpted from Potholes Reservoir Supplemental Feed Route – Environmental Assessment)⁷

Potholes Reservoir is populated by warmwater gamefish species, such as largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), black crappie (*Pomoxis nigromaculatus*), yellow perch (*Perca flavescens*), brown bullhead (*Ictalurus nebulosus*), and non-gamefish such as largescale sucker (*Catostomus macrocheilus*), bridgelip sucker (*Catostomus columbianus*), longnose sucker (*Catostomus catostomus*), and common carp (*Cyprinus carpio*). These species are believed to have been present in the backwaters of Crab Creek prior to reservoir impoundment and may have drifted down from Moses Lake. Lake whitefish and burbot (*Lota lota*) were also discovered in Potholes Reservoir and likely migrated from Banks Lake via irrigation canals from Billy Clapp and Moses Lakes (Fletcher 1997).

In the early 1970s, walleye (*Sander vitreus*) and yellow bullhead (*Ictalurus natalis*) entered the reservoir most likely by the same method as whitefish. Smallmouth bass (*Micropterus dolomieu*) were released into Frenchman Hills Wasteway from 1958 to 1964 by the Washington Department of Game and the Richland Rod and Gun Club (Duff 1974) and are now a species of major importance to the fishery of Potholes Reservoir. Hatchery releases of rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and channel catfish (*Ictalurus punctatus*) also contribute to the fishery of this reservoir (Fletcher 1997).

Potholes Reservoir has a diverse population of colonial nesting birds that include ring-billed gull (*Larus delawarensis*), California gull (*L. californicus*), Caspian tern (*Hydroprogne caspia*), Forester's tern (*Sterna forsteri*), black-crowned night heron (*Nycticorax nycticorax*), double-crested cormorant (*Phalacrocorax auritus*), great blue heron (*Ardea herodias*), great egret (*Casmerodius albus*), western grebe (*Aechmophorus occidentalis*), and Clark's grebe (*Aechmophorus clarkia*).

Hundreds of small, sandy islands are found within Potholes Reservoir. These dunes contain such vegetation as willow (*Salix* spp.), sand dock (*Rumex venosus*), wild alfalfa (*Psoralea tenuiflora*), and mustard (*Lysimbrium* spp.) which provide ideal breeding, nesting, and rearing sites for these colonial birds (Finger 1997).

Potholes Reservoir also attracts large numbers of migratory waterfowl. The most abundant migratory waterfowl includes mallards (*Anas platyrhynchos*), green-winged teal (*Anas carolinensis*), American wigeon (*Mareca americana*), gadwall (*Mareca strepera*), and Canada goose (*Branta canadensis*). Migratory waterfowl that use Potholes Reservoir for breeding include Canada goose, mallard, gadwall, and cinnamon teal (*Anas cyanoptera*). This area contains one of the largest rookeries of great blue herons and great egrets in the State. In late summer and early fall, it is one of the largest staging areas for American white pelicans (*Pelecanus erythrorhynchos*) in the State. Winter brings large numbers of bald eagles (*Haliaeetus leucocephalus*), which use the area as a nighttime roost. North Potholes Reservoir also hosts one of the only known communities of bushtit (*Psaltirparus minimus*).

⁷ Bureau of Reclamation. 2007. Potholes Reservoir Supplemental Feed Route: Finding of No Significant Impact Environmental Assessment. Columbia Basin Project; Grant County, Washington.

Threatened and Endangered Species

Grant County, WA

Upper Columbia steelhead (“threatened”) and Chinook salmon (“endangered”), are federally listed in Grant County, specifically in the Columbia River. Bull trout are listed as “threatened” in Grant County, but this species and its associated critical habitat does not occur in the project area. There are no critical habitats in and about (1,400 square miles) Potholes Reservoir (IPac Accessed 23 January 2018). Table 2 lists the threatened and endangered species in Grant County, Washington.

The proposed project includes in-water activity, including installation of curtain barriers and addition of potash to the water body. These activities have the potential to result in short-term effects, including temporary water quality impacts (e.g., increased water temperature, changes in chemical composition of the water) and temporarily elevated turbidity levels during installation of curtain barriers.

Because no threatened or endangered species, or critical habitat, occur within the project area, the effects analysis for this water body is brief. See the Literature Review section of this manual for detailed information on effects analyses associated with potash.

Table 2. Threatened and Endangered Species in Grant County, Washington.¹²

	Common Name	Scientific Name	Status	Determination (Impact/Effect on Breeding [B], Feeding [F], Sheltering [S], Migration [M], and Nutrition [N])
Mammals	Columbia Basin Pygmy rabbit	<i>Brachylagus idahoensis</i> ⁸	Endangered	No effect
	Gray wolf	<i>Canis lupus</i> ⁹	Endangered	No effect
Fish	Bull trout	<i>Salvelinus confluentus</i> ¹⁰	Threatened Recovery plan for bull trout	No effect – no critical habitat for bull trout exists within the project area
Birds	Yellow-billed Cuckoo	<i>Coccyzus americanus</i> ¹¹	Threatened	No effect
	Marbled murrelet	<i>Brachyramphus marmoratus</i>	Threatened	Not in project area
Flowering Plants	White Bluffs bladderpod	<i>Physaria douglasii</i> ssp. <i>tuplashensis</i>	Threatened	Not in project area
	Spalding's Catchfly	<i>Silene spaldingii</i>	Threatened	No effect
	Ute ladies'-tresses	<i>Spiranthes diluvialis</i>	Threatened	Not in project area

There are no endangered species or critical habitat potentially affected by activities within the project area.

⁸ No critical habitat has been designated for this species.

⁹ Location of critical habitat is not available.

¹⁰ Bull trout critical habitat includes 3,793 stream miles, 66,308 acres of lakes/reservoirs, and 754 miles of marine shoreline in the State of Washington; Grant County has designated critical habitat for bull trout ([USFWS. 2010. Final Bull Trout Critical Habitat Designation](#)). No designated bull trout critical habitat exists within the geographic scope of this project ([Federal Register Vol 75, No. 200, 18 October 2010](#)).

¹¹ There is proposed critical habitat for this species, but the location of the action area is outside the critical habitat (546,335 acres in AZ, CA, CO, ID, NV, NM, TX UT, and WY) - [Federal Register \(79\)158: Friday, August 15, 2014](#)

¹² (USFWS ECOS database: <https://ecos.fws.gov/ecp0/reports/species-by-current-range-county?fips=53025>)

There are five endangered species and 15 migratory birds identified as existing within the project action area (IPaC accessed 23 January 2018). These include:

Endangered Species—Columbia Basin Pygmy Rabbit, Gray wolf, Yellow-billed cuckoo, Bull trout, and Spalding's catchfly

Migratory birds potentially affected by activities within the project area:

- Bald eagle (*Haliaeetus leucocephalus*) - Not a Bird of Conservation Concern, but listed here because of [Eagle Act](#).
- Black swift (*Cypseloides niger*) - A Bird of Conservation Concern throughout its range in the continental US and Alaska.
- Brewer's sparrow (*Spizella breweri*) - A Bird of Conservation Concern in particular Bird Conservation Regions in the continental US.
- Clark's grebe (*Aechmophorus clarkii*) - A Bird of Conservation Concern throughout its range in the continental US and Alaska.
- Golden eagle (*Aquila chrysaetos*) - A Bird of Conservation Concern in particular Bird Conservation Regions in the continental US.
- Lesser yellowlegs (*Tringa flavipes*) - A Bird of Conservation Concern throughout its range in the continental US and Alaska.
- Lewis's woodpecker (*Melanerpes lewis*) - A Bird of Conservation Concern throughout its range in the continental US and Alaska.
- Long-billed curlew (*Numenius americanus*) - A Bird of Conservation Concern throughout its range in the continental US and Alaska.
- Marbled godwit (*Limosa fedoa*) - A Bird of Conservation Concern throughout its range in the continental US and Alaska.
- Olive-sided flycatcher (*Contopus cooperi*) - A Bird of Conservation Concern throughout its range in the continental US and Alaska.
- Sage thrasher (*Oreoscoptes montanus*) - A Bird of Conservation Concern in particular Bird Conservation Regions in the continental US.
- Tricolored blackbird (*Agelaius tricolor*) - A Bird of Conservation Concern throughout its range in the continental US and Alaska.
- Willet (*Tringa semipalmata*) - A Bird of Conservation Concern throughout its range in the continental US and Alaska.
- Williamson's sapsucker (*Sphyrapicus thyroideus*) - A Bird of Conservation Concern in particular Bird Conservation Regions in the continental US.
- Willow flycatcher (*Empidonax traillii*) - A Bird of Conservation Concern in particular Bird Conservation Regions in the continental US.

Conservation Measures and BMPs

The conservation measures and BMPs in this manual (pages XX–XX) would be implemented to avoid, reduce, or eliminate adverse effects or benefit protected species as part of this action.

Lake Washington

Federal Agencies

US Army Corps of Engineers, US Fish and Wildlife Service

Authorities

The US Army Corps of Engineers controls the level of Lake Washington (averages 18–19 feet) via the Hiram M. Chittenden Locks.

The Washington Department of Fish and Wildlife would be the agency responsible for implementing the control action based on the following authorities:

- The Washington Department of Ecology issued the Washington Department of Fish and Wildlife an [NPDES permit](#) on August 17, 2016 (Permit #WAG993002) - Aquatic Invasive Species Management General Permit that covers management activities for non-native aquatic invasive animals that results in the discharge of chemicals or control products into surface waters of the State of Washington.
- The U.S. Bureau of Reclamation (USBR) manages the diversion of Columbia River water into Potholes Reservoir and the canal system for delivery of the water to irrigators through the USGS/USBR collaborative Watershed and River Systems Management Program (WARSMP).
- The Washington State Parks and Recreation Commission (SPRC) and Washington Department of Fish and Wildlife (WDFW) administer and manage the Potholes Reservoir area with oversight provided by the Ephrata Field Office of the Bureau of Reclamation. The Grant County Sheriff's Office will also remain a management partner at the reservoir providing general law enforcement services and periodic patrols within the Grant County Off-Road Vehicle (ORV) Area.

Key Points of Contact

Note: The 100th Meridian Rapid Response Plan [Appendix C](#) provides an updated list of all relevant state and federal agency representatives in the event of an introduction of dreissenids.

Endangered Species Acts Points of Contact for Consultations:

Pacific Region Office

503-231- 6151

Fw1_AEAinbox@fws.gov

Washington Fish and Wildlife Office

360-753-9440

<http://www.fws.gov/wafwo/>

Existing Rapid Response Plans

[Washington State Rapid Response Plan](#)

Project Location¹³

Lake Washington ([47°37'0"N 122°15'53"W](#)) is the largest of the three major lakes in King County, and the second largest natural lake in the State of Washington (Figure X). Lake Washington's two major influent streams are the Cedar River at the southern end, which contributes about 57 percent of the annual hydraulic load. From the north, water from Lake Sammamish via the Sammamish River contributes 27 percent of the hydraulic load. The majority of the immediate watershed is highly developed and urban in nature with 63 percent fully developed. The upper portion of the watershed is the headwaters of the Cedar River that lie in the closed Seattle Water Department watershed. The basin of Lake Washington is a deep, narrow, glacial trough with steeply sloping sides, sculpted by the Vashon ice sheet, the last continental glacier to move through the Seattle area. The lake is 20.6 feet above mean lower low tide in Puget Sound, to which it is connected via Lake Union and the Lake Washington Ship Canal, constructed in 1916. The Ship Canal is the only discharge from lakes Sammamish and Washington via the locks and dam at the western end. Prior to construction of the canal, the only significant inflow was from the Sammamish River in the north. Construction of the canal resulted in the lowering of the lake 9 feet to its present level, leaving the Black River dry and the Cedar River diverted into Lake Washington. Mercer Island lies in the southern half of the lake, separated from the east shore by a relatively shallow and narrow channel, and from the west shore by a much wider and deeper channel. In comparison to Lake Sammamish, Lake Washington is about twice as deep, four times the area and flushes about as frequently.



Figure X. Location of Lake Washington relative NW Washington watersheds, and aerial photo of Lake Washington. Photo credit: WDFW.

Treatment Sites

A total of 13 incorporated cities border Lake Washington. Bulkheads occur on 82% of the shoreline of the lake. More than 2,700 piers and floats occur along the shoreline of the lake, covering about 4% of the lake's surface within 100 feet of shore (

There are thousands of private boat docks on Lake Washington as well as numerous marinas and public boat launches.

Marinas

¹³ Excerpted from King County, WA government website.

Bellevue Marina - 60 open and covered slips
 Carillon Point Marina - 200 open slips
 Kenmore Harbor Village Marina - north end of the lake; permanent and temporary boat moorage.
 Seaplane base next to the marina.
 Kirkland Homeport Marina - monthly lease marina
 Kirkland Transient Moorage
 Lakewood Moorage - monthly lease marina
 Leschi Marina - monthly and day moorage
 Marina Park - 77 slips
 Newport Yacht Basin - monthly lease and condominium marina - 400 slips
 Parkshore Marina - condominium association marina with slips
 Spinnaker Bay Marina - monthly lease marina
 Yarrow Bay Marina - monthly boat moorage and boat rentals - 120 open and covered slips

Public boat launches

[Atlantic City boat ramp](#)

Day Street Park

[Kenmore boat launch](#)

[Magnuson Park boat launch](#)

[Mercer Island boat launch](#)

SE 40th Street boat ramp

South Ferdinand Street Park

[Stan Sayres Memorial Park](#)

Control Action

Stated Action/Action Agency

The State of Washington will apply KCL to Lake Washington to prevent the establishment of dreissenids that have been detected as a result of monitoring efforts. The lead federal agency for this action is the US Fish and Wildlife Service.

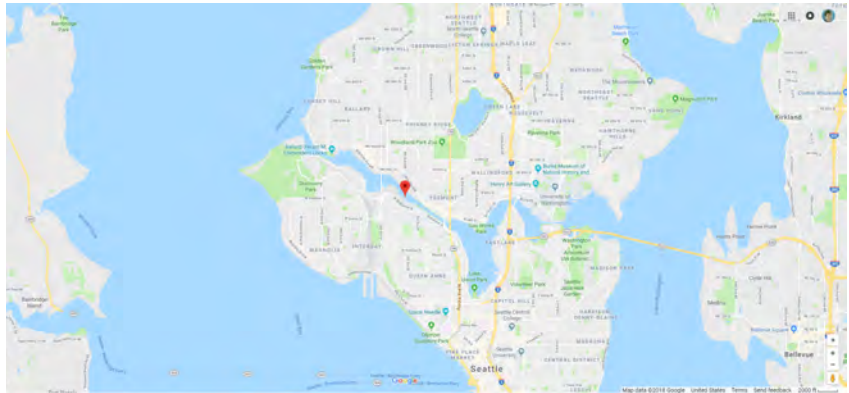
For method of application, application rate and pesticide quantities, number of applications, and applicable restrictions and requirements concerning the proposed use not on label, please refer to page 11 of this document (information for Potholes Reservoir).

Action Area

The action area would consider of areas in and around infrastructure, such as docks and marinas, in close proximity to shore, and in association with public use areas (because the vector of introduction will likely be some form of watercraft). The shoreline of the lake consists of a 10-foot-high-bench, embayments, gentle slopes, steep slopes, and several peninsulas (Troost 2011).

The action area includes the entirety of Lake Washington, with a focus on shallow areas in and near public access sites. Areas that could experience indirect effects from a control action would include outflow areas, and specifically, the Lake Washington Ship Canal (Figure X), which is the waterway that connects Lake Washington to Puget Sound. The ship canal opened in 1916 (Troost 2011), and is eight miles long and at least 30 feet deep.

Figure X. Location of the Lake Washington Ship Canal relative to Lake Washington and Puget Sound.



Vegetation

Embayments on Lake Washington contain marshes growing on organic sediment that was once part of the lake bottom.

Hydrology

Lake Washington drains to Puget sound via the Ship Canal and the Hiram Chittenden Locks. Primary inflow (55% of mean annual flow) into the lake is the Cedar River whereas the Sammamish River contributes 27% of mean annual flow. Thornton Creek, Juanita Creek, Kelsey Creek, Lyon Creek, and May Creek drain into the lake.

Currently, the lake is not allowed to fluctuate more than two feet.

Climate

The Puget Sound region has an average annual temperature of 44 °F, with predictions to increase rapidly in the coming decades. The area receives 37.7 inches of rain annually.

Geology/soils

The bottom of Lake Washington consists of glacial lake clay/silt with a weathered surface and a thin layer of marine/estuarine silt, overlain by diatomaceous ooze and organic matter (Troost 2011).

Potentially affected cultural/archaeological resources

State, federal and tribal cultural resource contacts

No cultural resources were discovered in a 1997 study (Forsman et al. 1997) and 1998 study (Forsman and Larson 1998) of Lake Washington Ship Canal. The 1997 study identified the probability and location of archaeological resources in the Hiram M. Chittenden Government Locks. The 1998 study identified seven ethnographic place names in the locks area (e.g., shell midden deposits that provided evidence of prolonged subsistence and refuse activity commonly associated with villages).

Figure X depicts known historic resource locations (red) and shorelines of statewide significance (blue with hatched lines) in King County, Washington. The map does not include archaeological sites.

In advance of the action, the specific site at which the action will take place should be investigated for archeological and cultural resource past studies, and state, federal and tribal cultural resource representatives should be contacted.

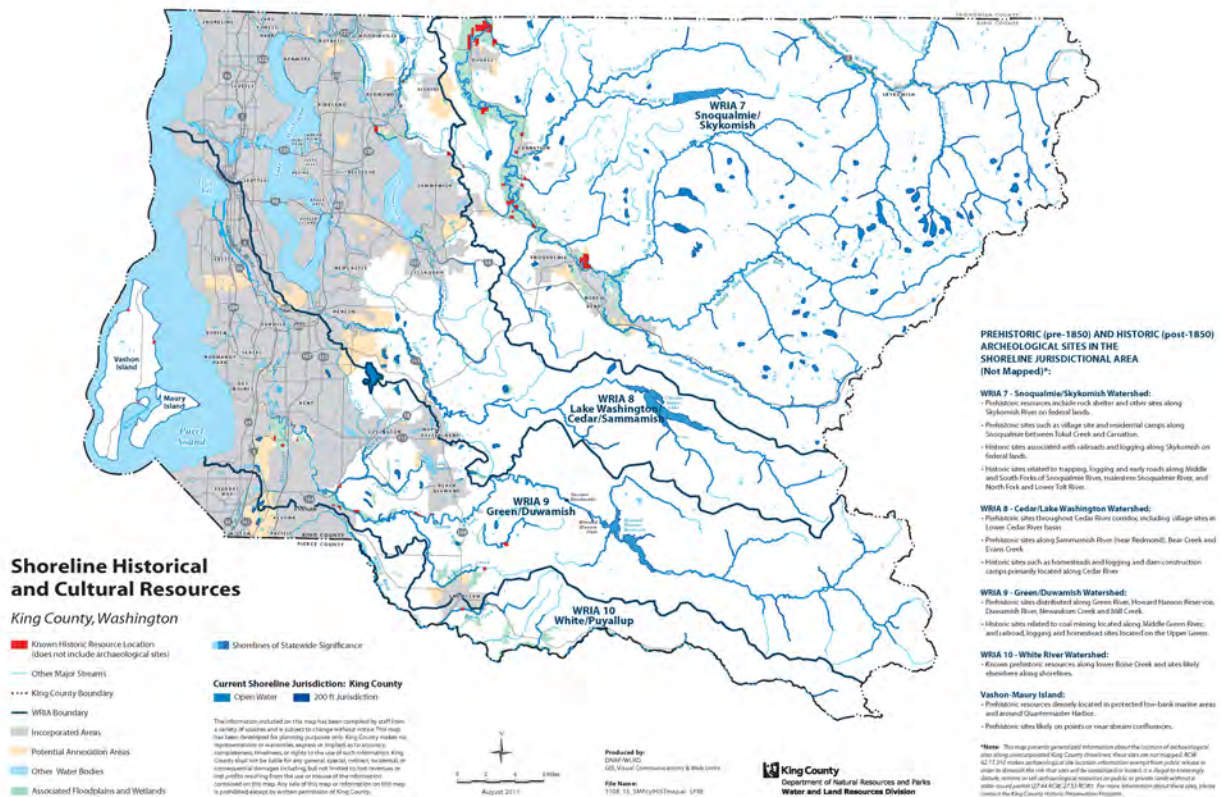


Figure X. 2011 Shoreline Historical and Cultural Resources. Source: King County Dept. of Natural Resources and Parks, Water and Land Resources Division.

Proposed/Listed Species/Critical Habitat Considered

Lake Washington is designated as critical habitat for bull trout (Unit 28 – Puget Sound) (Federal Register 50 CFR 17; September 26, 2005; 56212), and Lake Washington, the Sammamish River, and all accessible tributaries are identified by the draft Bull Trout Recovery Plan (USFWS 2004) as important foraging, migration, and overwintering (FMO) habitat (Lake Washington FMO).

(Excerpted from ESA 2014)

Two natural Chinook salmon spawning populations (the north Lake Washington population and the Cedar River population) occur in the Action Area and use Lake Washington for rearing and migration. A third population, the Issaquah stock, is a nonnative stock from the Issaquah Hatchery, which has been in operation since the 1930s (WDFW, 2004; Ruckelshaus et al., 2006). Lake Washington populations have shown some of the steepest declines of the 22 extant populations of the Puget Sound Chinook ESU, greater than 5 percent per year since the peak returns during the mid-1980s (Myers et al., 1998; Weitkamp and Ruggerone, 2000). The status of the Lake Washington populations is based on their abundance, productivity, diversity, and spatial structure, but substantial development in the basin has degraded their

spawning and rearing habitat.

The status of Chinook stocks in the 2002 Salmonid Stock Inventory was reported as depressed for the Cedar population and healthy for the Sammamish population components (WDFW, 2006). During recent years, the Cedar River Chinook salmon run has declined about 10 percent per year, while the Issaquah Creek (hatchery) run has declined about 8 percent per year and the north Lake Washington run has declined about 17 percent per year (Weitkamp and Ruggerone 2000). The recent (1994 to 2007) average Chinook salmon escapement level to Lake Washington is estimated at 824 fish (Exhibit 2-2) (City of Seattle and USACE 2008). Adult Chinook return to Lake Washington in August and September (City of Seattle and USACE 2008).

The North Lake Washington and Lake Washington/Sammamish populations of Chinook and sockeye/kokanee salmon are considered “healthy”; the Lake Washington/Sammamish population of coho salmon is considered “depressed”; and the Lake Washington winter steelhead population is regarded as “critical” (WDFW 2002).

Coastal-Puget Sound bull trout (*Salvelinus confluentus*)

Listing Status: Threatened 11/1/99; 64 FR 58910

Critical Habitat: 10/18/10; 75 [FR 63898 \(19,729 miles of stream, including 754 miles of marine shoreline in the Olympic Peninsula and Puget Sound\); 488,251.7 acres of reservoirs and lakes. Puget Sound is a designated critical habitat - 1,143.5 miles of critical habitat in Puget Sound and 425 miles of Puget Sound Marine. The Puget Sound Critical Habitat Unit \(CHU\) consists of 40,181.5 acres. There are 13 CHSUs \(subunits\) within the Puget Sound CHU. 10 Foraging, Migration, and Overwintering \(FMO\) areas occur outside of core boundary areas and may be used by bull trout originating from core areas - these include marine, estuarine, and freshwater habitats outside of natal core areas, and are important to anadromous and fluvial life history forms because of their complex migratory patterns associated with foraging and overwintering \(USFWS 2015a\). Lake Washington is a shared FMO.](#)

Protective Regulations: 11/1/1999; 64 FR 58910

Legal status - The coterminous United States population of the bull trout (*Salvelinus confluentus*) was listed as threatened on November 1, 1999 (USFWS 1999a, entire). The bull trout generally occurs in the Pacific Coast drainages of Washington, including Puget Sound; major rivers in Idaho, Oregon, Washington, and Montana, within the Columbia River Basin; and the St. Mary-Belly River, east of the Continental Divide in northwestern Montana (Bond 1992, p. 4; Brewin and Brewin 1997, pp. 209-216; Cavender 1978, pp. 165-166; Leary and Allendorf 1997, pp. 715-720).

Throughout its range, bull trout are threatened by habitat degradation, fragmentation, and alterations associated with dewatering, road construction and maintenance, mining, grazing, the blockage of migratory corridors by dams or other diversion structures, poor water quality, entrainment into diversion channels, and introduced non-native species (USFWS 1999a, p. 58910). Bull trout are especially vulnerable to climate change given that spawning and rearing are constrained by their location in upper watersheds and the requirement for cold water temperatures (Battin et al. 2007, entire; Rieman et al. 2007, entire; Porter and Nelitz. 2009, pages 4-8). Poaching and incidental mortality of bull trout during other targeted fisheries are additional threats.

Life history - Bull trout typically spawn from August through November during periods of increasing

flows and decreasing water temperatures. Preferred spawning habitat consists of low-gradient stream reaches with loose, clean gravel (Fraley and Shepard 1989, p. 141). Redds are often constructed in stream reaches fed by springs or near other sources of cold groundwater (Goetz 1989, pp. 1516; Pratt 1992, pp. 6-7; Rieman and McIntyre 1996, p. 133). Depending on water temperature, incubation is normally 100 to 145 days (Pratt 1992, p. 1). After hatching, fry remain in the substrate, and time from egg deposition to emergence may surpass 220 days. Fry normally emerge from early April through May, depending on water temperatures and increasing stream flows (Pratt 1992, p. 1; Ratliff and Howell 1992, p. 10).

Early life stages of fish, specifically the developing embryo, require the highest inter-gravel dissolved oxygen (IGDO) levels, and are the most sensitive life stage to reduced oxygen levels. The oxygen demand of embryos depends on temperature and on stage of development, with the greatest IGDO required just prior to hatching.

A literature review conducted by the Washington Department of Ecology (WDOE 2002, p. 9) indicates that adverse effects of lower oxygen concentrations on embryo survival are magnified as temperatures increase above optimal (for incubation). Normal oxygen levels seen in rivers used by bull trout during spawning ranged from 8 to 12 mg/L (in the gravel), with corresponding instream levels of 10 to 11.5 mg/L (Stewart et al. 2007, p. 10). In addition, IGDO concentrations, water velocities in the water column, and especially the intergravel flow rate, are interrelated variables that affect the survival of incubating embryos (ODEQ 1995, Ch. 2 pp. 2324). Due to a long incubation period of 220+ days, bull trout are particularly sensitive to adequate IGDO levels. An IGDO level below 8 mg/L is likely to result in mortality of eggs, embryos, and fry.

Coastal Recovery Unit Implementation Plan for Bull Trout (USFWS 2015a)

of local populations: Lake Washington has no designated number of local populations.

Primary threats are described as: *Factors known or likely (i.e., non-speculative) to negatively impact bull trout populations at the core area level, and accordingly require actions to assure bull trout persistence to a degree necessary that bull trout will not be at risk of extirpation within that core area in the foreseeable future (4 to 10 bull trout generations, approximately 50 years).*

Habitat - none

Nonnatives - none

Demographic - Connectivity impairment - Temperature barriers - seasonal temperature limitations in Ship Canal.

Actions to Address Demographic Threats: The Lake Washington Ship Canal has been identified as the most thermally impaired water bodies for salmon in western Washington, with extreme summertime water temperatures inhibiting the upstream migration of adult Chinook and sockeye salmon (Mantua et al. 2010). The ship Canal serves as the sole migratory corridor for salmon and bull trout between Puget Sound and the Lake Washington Basin. Develop mitigation strategies to ensure continued use of Lake Washington FMO habitats by anadromous bull trout.

Action area includes Ship Canal, North and South Lake Washington

Bull trout from throughout DPS may be present in Lake Washington and Ship Canal area

Critical habitat - Lake Washington and Ship Canal (Figure 7). The lateral extent of the critical habitat boundaries for bull trout is the width of the stream channel as defined by the OHW. In areas where the OHW has not been defined, the width of the channel is defined by bankfull elevation. In lakes and reservoirs, critical habitat is delineated by the perimeter of the waterbody as mapped on standard 1:24,000 scale maps. The inshore extent of critical habitat for marine nearshore areas is the MHHW, including tidally influenced freshwater heads of estuaries.

The Coastal Bull Trout Recovery Plan (USFWS 2015) notes that, relative to the Lake Washington geography, there are no primary habitat or nonnative threats, but there are seasonal temperature limitations in Ship Canal (which is considered a primary demographic threat). "The Lake Washington Ship Canal has been identified as the most thermally impaired water bodies for salmon in western Washington, with extreme summertime water temperatures inhibiting the upstream migration of adult Chinook and sockeye salmon (Mantua et al. 2010). The Ship Canal serves as the sole migratory corridor for salmon and bull trout between Puget Sound and the Lake Washington Basin. Develop mitigation strategies to ensure continued use of Lake Washington FMO habitats by anadromous bull trout."

Limiting Factors Analysis

Washington State Conservation Commission's Limiting Factors Analysis (Smith 2005) has been conducted on watersheds within the State of Washington. Limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon, including all species of the family Salmonidae." Information on the current condition of Lake Washington is as follows:

"From Lake Washington through South Puget Sound, habitat conditions are generally poor or unknown with the exception of Nisqually (WRIA 11) and Kitsap (WRIA 15). Overwhelmingly percentages of poor habitat ratings were found in the Lake Washington and Green River WRIs (WRIs 8 and 9), and no fair or good ratings existed on a WRIA scale for the Chambers/Clover Basin.

Even though habitat conditions were predominantly poor in this area, 40% of the wild salmonid stocks in this area are healthy. Depressed or critical stocks account for 35% with the remaining stocks being unknown status. Kennedy (WRIA 14) has the greatest percentage of healthy wild stocks (56%), followed by Kitsap (55%), Chambers (50%), Nisqually and Puyallup (33%), Lake Washington (29%), Deschutes (20%) and Green (0%). When looking at depressed or critical stocks, WRIs are ordered from better to worse as Kennedy (11% depressed or critical wild stocks), Kitsap (15%), Deschutes (20%), Nisqually (33%), Chambers (50%), Puyallup (67%), Lake Washington (71%) and Green (100%).

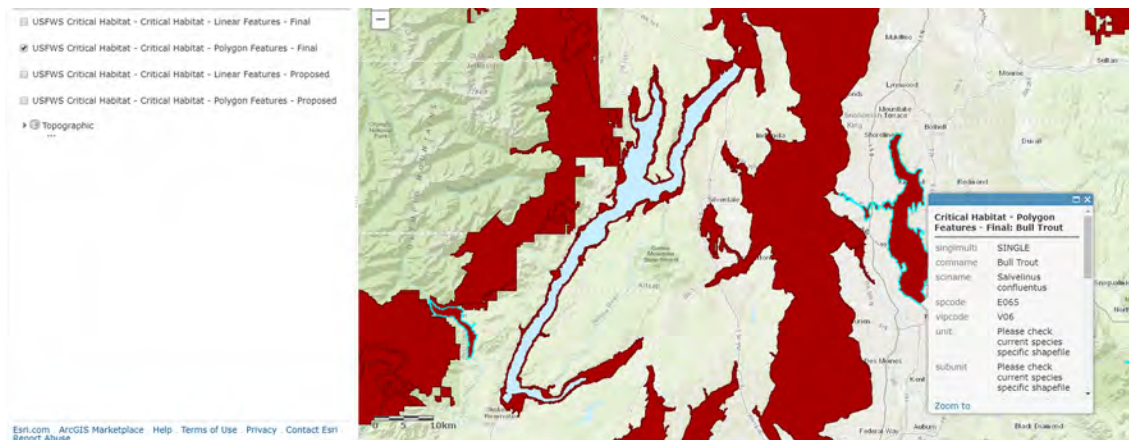


Figure X. Bull trout critical habitat at and in the vicinity of Lake Washington. Graphic credit: USFWS.

Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*) - Threatened

Action area includes North and South Lake Washington

2 populations - Sammamish River and Cedar River

Critical habitat - Lake Washington and Ship Canal. NMFS designated critical habitat for this ESU on September 2, 2005 (70 FR 52630). Critical habitat is defined in section 3 of the ESA as the following: “(i) the specific areas within the geographical area occupied by a species, at the time it is listed in accordance with the ESA, on which are found those physical or biological features (I) essential to the conservation of the species, and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographic area occupied by a species at the time it is listed, upon a determination that such areas are essential for the conservation of the species.” Critical habitat boundaries for Puget Sound Chinook salmon include stream channels within the designated stream reaches, and include a lateral extent as defined by the OHW (33 CFR 319.11).

Puget Sound steelhead (*Oncorhynchus mykiss*) - Threatened

Action area includes North and South Lake Washington

4 spawning populations: Lake Washington, Cedar River, Lake Sammamish, Sammamish River

No critical habitat

Critical habitat for Puget Sound steelhead was proposed on January 14, 2013. The boundaries for Puget Sound steelhead include stream channels within the designated stream reaches, and include a lateral extent as defined by the OHW (33 CFR 319.11). In areas where OHW has not been defined, the lateral extent of critical habitat will be defined by the bankfull elevation. Bankfull elevation is the level at which water begins to leave the channel and move into the floodplain. The bankfull level is reached at a discharge that generally recurs at an interval of 1 to 2 years on the annual flood series. Critical habitat in lake areas is defined by the perimeter of the waterbody as displayed on standard 1:24,000 scale topographic maps or the elevation of OHW, whichever is greater.

(Excerpted from ESA 2014)

There are two steelhead populations in the Lake Washington watershed: the natural-origin Cedar River population and the introduced north Lake Washington population (WDFW, 2006). There is insufficient information to evaluate whether this resident form contributes to the viability of the anadromous steelhead population over the long-term (NMFS, 2007). Both the Cedar River and the north Lake Washington populations of winter-run steelhead have undergone steep declines in recent decades (Busby et al., 1996). WDFW (2004) identified the Lake Washington population of winter steelhead as depressed in 1992 and as critical by 2002 (WDFW, 2004). These assessments were based on the chronically low escapement and short-term severe decline in escapements. WDFW (2006) still considers the stock to be depressed because recent escapement estimates of this stock have been consistently low; escapement rates were 20 to 48 fish between 2000 and 2004 (Table 2-3 (WDFW, 2006). Based on these numbers, the relative risk of extinction for the Lake Washington winter steelhead population is considered very high.

Conservation Measures and BMPs

The conservation measures and BMPs in this manual (pages XX–XX) would be implemented to avoid, reduce, or eliminate adverse effects or benefit protected species as part of this action.

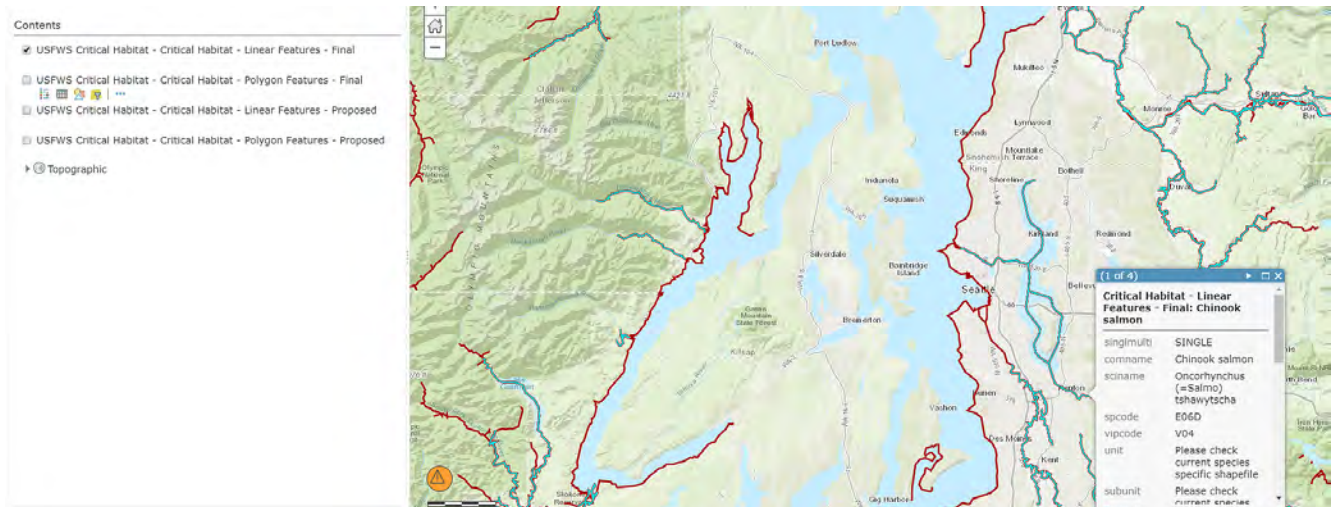


Figure X. Chinook salmon critical habitat at and in the vicinity of Lake Washington and Puget Sound. Credit: USFWS.

Water Body Monitoring

The Washington Department of Fish and Wildlife monitors Lake Washington for dreissenids on an annual basis (click [here](#) for 2017 monitoring data). Monitoring consists of visual shoreline surveys, water collected for eDNA analysis, horizontal and vertical plankton tows, artificial substrates, and collection of water samples for water chemistry (e.g., calcium) analysis.

Lake Roosevelt

Federal Agencies

National Park Service, Bureau of Reclamation, Bureau of Indian Affairs

Authorities

The tribes and the state share the responsibility for managing Lake Roosevelt.

BOR would issue a federal permit under 106 U.S.C. 1531Z et seq. to authorize the federal action.

The Washington Department of Fish and Wildlife would be the agency responsible for implementing the control action based on the following authorities:

- The Washington Department of Ecology issued the Washington Department of Fish and Wildlife an [NPDES permit](#) on August 17, 2016 (Permit #WAG993002) - Aquatic Invasive Species Management General Permit that covers management activities for non-native aquatic invasive animals that results in the discharge of chemicals or control products into surface waters of the State of Washington.
- The U.S. Bureau of Reclamation (USBR) manages the diversion of Columbia River water into Potholes Reservoir and the canal system for delivery of the water to irrigators through the USGS/USBR collaborative Watershed and River Systems Management Program (WARSMP).
- The Washington State Parks and Recreation Commission (SPRC) and Washington Department of Fish and Wildlife (WDFW) administer and manage the Potholes Reservoir area with oversight provided by the Ephrata Field Office of the Bureau of Reclamation. The Grant County Sheriff's Office will also remain a management partner at the reservoir providing general law enforcement services and periodic patrols within the Grant County Off-Road Vehicle (ORV) Area.

Key Points of Contact

Note: The 100th Meridian Rapid Response Plan [Appendix C](#) provides an updated list of all relevant state and federal agency representatives in the event of an introduction of dreissenids.

Endangered Species Acts Points of Contact for Consultations:

Pacific Region Office

503-231- 6151

Fw1_AEAinbox@fws.gov

Washington Fish and Wildlife Office

360-753-9440

<http://www.fws.gov/wafwo/>

Existing Rapid Response Plans

[Washington State Rapid Response Plan](#)

Project Location

Franklin D. Roosevelt Lake (also called Lake Roosevelt) is the reservoir created in 1941 by the impoundment of the Columbia River by the [Grand Coulee Dam](#) in Washington state (Figures X and X). It is named for Franklin D. Roosevelt, who was President during the construction of the dam. Covering 125 square miles (80,000 acres), it stretches about 150 miles (240 km) from the Canada–US border to Grand Coulee Dam, with over 600 miles (970 km) of shoreline; by surface area it is the largest lake and reservoir in Washington. It is the home of the [Lake Roosevelt National Recreation Area](#). Lake Roosevelt National Recreation Area is a [U.S. National Recreation Area](#) under the supervision of the [National Park Service](#). It encompasses the 130-mile (210 km) long [Franklin D. Roosevelt Lake](#) between [Grand Coulee Dam](#) and Northport, Washington, in eastern Washington state. The NPS maintains visitor centers, boat-in campsites, shoreline camping, and conducts marine patrols for compliance with United States Coast Guard marine safety rules.

The reservoir lies in parts of five counties in northeastern Washington; roughly in descending order of lake acreage they are Ferry, Stevens, Lincoln, Okanogan, and Grant counties.

The lake and lands are managed under the Lake Roosevelt Cooperative Management Agreement dated 5 April 1990. Per the agreement, the management and regulations of Lake Roosevelt Management Area set out in the agreement are not intended to nor shall they interfere with or be inconsistent with the purposes for which the Columbia Basin Project was established, is operated and maintained; those purposes being primarily flood control, improved navigation, streamflow regulation, providing for storage and for the delivery of stored waters thereof for the reclamation of public and private lands and Indian reservations, for the generation of electrical power and for other beneficial uses, nor it is in intended to modify or alter any obligations or authority of the parties.

Bureau of Reclamation Grand Coulee Dam Reclamation has two management zones. One is directly behind the dam. It follows the log boom line from the west bank of the river to about mid-channel. Then at the Grant and Okanogan county line (in the middle of the lake) the boundary goes uplake for a short distance until it cuts across to the east shoreline. The other zone is located on the east side of the lake at China Bar, [48°49'23"N 117°55'57"W](#). Reclamation operates a log collection facility. Reclamation captures logs and other large debris before it enters Lake Roosevelt.

(Excerpted from Riedel 1997): Several native tribes have reservations and historic use areas in the Columbia River Basin. The native tribes have historic and treaty rights to take fish from the Columbia River and its tributaries and have treaty rights to fish in usual and accustomed places. The federal government has a trust responsibility to provide services that protect and enhance the treaty rights of native people. The tribes implement fish and wildlife management programs in the Columbia River Basin and participate in river governance decisions. Tribes with a primary interest in the operation of Lake Roosevelt are the Confederated Tribes of the Colville Reservation and Spokane Tribe of Indians, as well as the Yakama Nation and the Nez Perce, Umatilla, and Warm Springs Tribes.

The state has developed cooperative agreements with CCT and with the STI regarding management of Lake Roosevelt.



Figure X. Photo of Lake Roosevelt. Source: WDFW.

the

Fisheries

Lake Roosevelt currently supports 20 species of game fish and 12 non-game species. Primary harvest fisheries include rainbow trout, kokanee salmon, and walleye. The lake is a popular fishery and supports fishing tournaments for trout, walleye, and bass. Other game fish include smallmouth and largemouth bass, perch, whitefish species, other trout species, crappie, bullhead, sunfish, and catfish. Non-game species such as suckers, shiners, dace, and sculpin provide prey base to the fishery. Bull trout, listed as Threatened under the ESA, are rare, but a few have been documented in Lake Roosevelt. State regulations protect white sturgeon, another rare fish species in the lake, from harvest (Lake Roosevelt Forum 2011).

Kokanee salmon and rainbow trout fisheries are supplemented via hatchery and net-pen operations through a multi-agency effort, the Lake Roosevelt Fishery Enhancement Program (LRFEP). LRFEP is a cooperative effort between the STI, CCT, WDFW, Eastern Washington University, and the Lake Roosevelt Development Association (now known as the Lake Roosevelt Voluntary Net Pen Program) (Lake Roosevelt Forum 2011; Reclamation 2009).



Figure X. Map of Lake Roosevelt. Source: USFWS.

Treatment Sites

There are numerous boat launches and public access sites on Lake Roosevelt.

Within the Lake Roosevelt National Recreation Area, the following boat launches exist:

- Upper Lake Roosevelt
 - China Bend
 - Evans
 - Kettle Falls (Marina)
 - Marcus Island
 - Napoleon Bridge
 - North Gorge
 - Snag Cove
- Middle Lake Roosevelt
 - Bradbury Beach
 - Daisy
 - French Rocks
 - Gifford
 - Hunters
 - Inchelium Ferry
- Confluence and Spokane Arm
 - Fort Spokane
 - Hawk Creek
 - Porcupine Bay
 - Seven Bays (Marina)
 - Two Rivers (Marina)
- Lower Lake Roosevelt
 - Crescent Bay
 - Hanson Harbor
 - Jones Bay
 - Keller Ferry (Marina)
 - Lincoln Mill
 - Spring Canyon

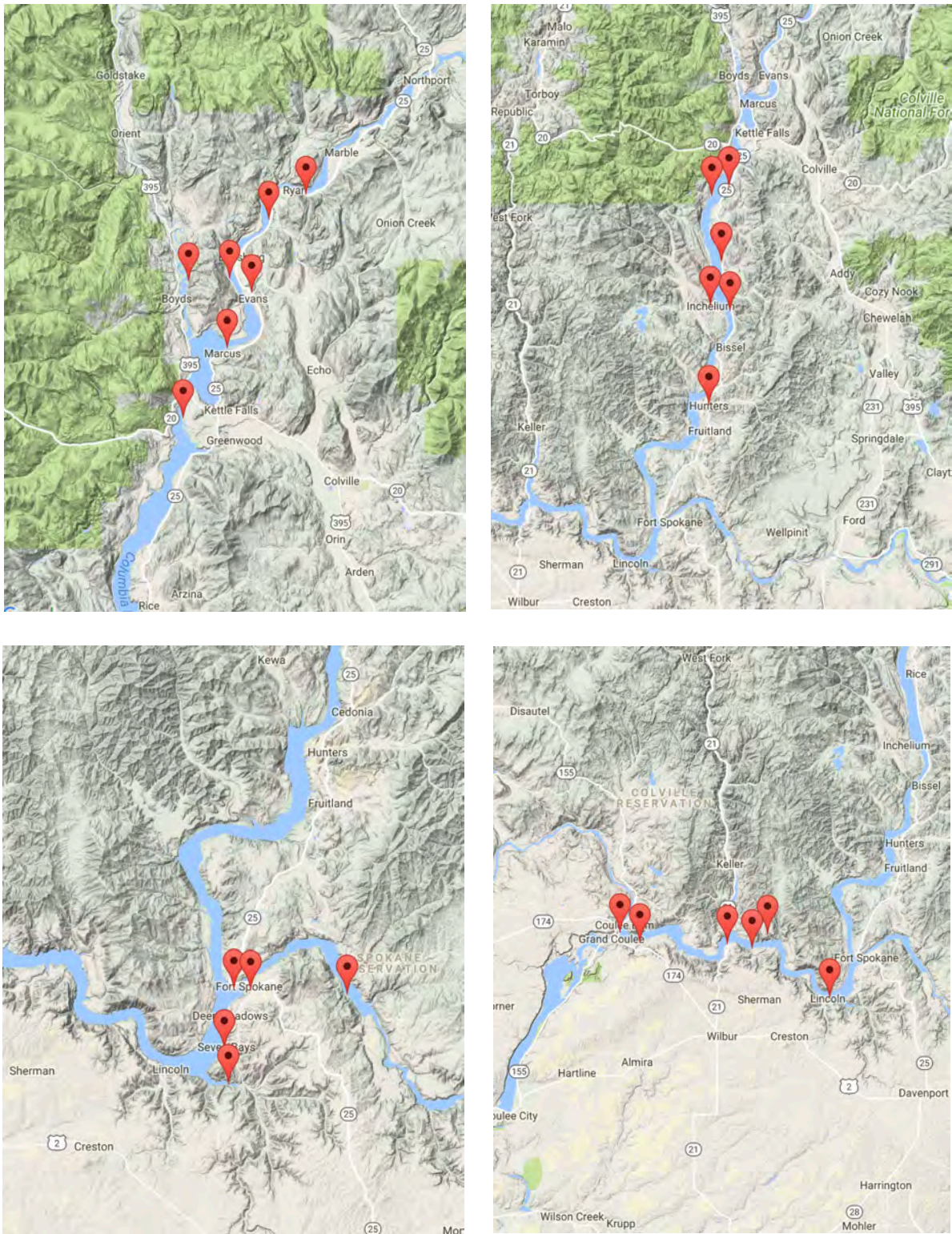


Figure X. Boat launch locations on Lake Roosevelt National Recreation Area. Upper left: Upper Lake Roosevelt. Upper right: Middle Lake Roosevelt. Lower left: Confluence and Spokane Arm of Lake Roosevelt. Lower right: Lower Lake Roosevelt.

Control Action

Stated Action/Action Agency

The State of Washington will apply KCL to Lake Roosevelt to prevent the establishment of dreissenids that have been detected as a result of monitoring efforts. The lead federal agency for this action is the Bureau of Reclamation.

For method of application, application rate and pesticide quantities, number of applications, and applicable restrictions and requirements concerning the proposed use not on label, please refer to page 11 of this document (information for Potholes Reservoir).

Action Area

The action area would consider areas in and around infrastructure, such as docks and marinas, in close proximity to shore, and in association with public use areas (because the vector of introduction will likely be some form of watercraft).

The action area includes the entirety of Lake Roosevelt, with a focus on shallow areas in and near public access sites. Areas that could experience indirect effects from a control action would include outflow areas.

Hydrology (excerpted from Riedel 1997)

The State of Washington Department of Ecology regulates the water quality of Lake Roosevelt under the framework of the Clean Water Act. Washington has established water quality standards for specific physical and chemical parameters to provide suitable conditions to support designated and potential uses. The designated uses of Lake Roosevelt include core salmonid summer habitat and extraordinary primary contact recreation, as well as nine additional standard uses. These standard uses include agriculture water supply, domestic water supply, stock water supply, industrial water supply, commercial navigation, boating, wildlife habitat, harvesting, and aesthetics (Ecology 2006).

Water from Lake Roosevelt is pumped up to Banks Lake at Grand Coulee Dam, and delivered to farm lands stretching from around Soap Lake to Pasco and east from the Columbia River to around the Connell and Warden areas. The water is delivered through a series of reservoirs, canals, laterals and pumping stations.

In addition to seasonal fluctuations, Lake Roosevelt fluctuates daily because of load following and other operations for power. Grand Coulee Dam is one of 11 hydropower generating facilities on the Columbia River mainstem. Grand Coulee Dam has three power plants with 32 turbines and a maximum generating capacity of 6,809 megawatts. The amount and timing of power generation is coordinated through the Pacific Northwest Coordination Agreement (PNCA) and the Canadian Treaty.

Climate and Vegetation¹⁴

The landscape and vegetation regimes surrounding Lake Roosevelt vary across the area, from mixed conifer and ponderosa pine forests in the northern and eastern portions, to semi-arid vegetation classes along the western portions of the reservoir (BOR 2015). Additionally, grasslands, pastures, and occasional wetlands add to the wide range of plant diversity.

The northern areas of Lake Roosevelt receive about 17 inches of rain annually. Moving south, however, the climate becomes far more arid. In the mid-lake area there is a transition from ponderosa pine to sage-steppe. Bluebunch, wheatgrass, hard fescue, and forbs such as balsamroot, northern buckwheat, brittle prickly pear, alum root and lupine are common here.

By the time the river/lake reaches Grand Coulee dam, average annual precipitation is only 10 inches. This precipitation occurs mostly in the winter and spring. The summers are hot and dry. So instead of dense forests, the environment is that of a high desert where shrub steppe species like sagebrush and bitterbrush predominate.

Geology/soils¹⁵

The Columbia River watershed spans several physiographic provinces. In Canada, the watershed is largely within the Columbia, Rocky and numerous other mountain provinces (McKee 1972). These mountains are composed of a wide range of igneous, metamorphic and sedimentary rocks. Mineral deposits of lead, zinc and copper are found throughout the upper watershed in British Columbia.

Low mountain ranges trend north-south along upper Lake Roosevelt. They are composed primarily of pre-Tertiary metamorphic rocks, Paleozoic sedimentary rocks, and small outcrops of Mesozoic granites east of Lake Roosevelt. Beneath the upper reach of the reservoir are Triassic/Permian metasedimentary rocks, while south of Kettle Falls Carboniferous/Ordovician metasedimentary and metacarbonate rocks dominate. The middle reach of the reservoir curves from southeast to west around Tertiary/Cretaceous granitic bedrock before turning due west. The lower stretch of the reservoir follows the boundary between Tertiary granites, with thick accumulations of Quaternary deposits to the north and basalt flows of the Columbia Plateau province to the south. More detailed information on bedrock geology is available from the Spokane Tribe's GIS, and from 1:100,000 scale maps published by the State of Washington Department of Natural Resources, Division of Geology and Earth Resources in Olympia.

Forest vegetation dominates in the mountain portions of the upper watershed, and includes ponderosa pine, western larch and Douglas fir. On the Columbia Plateau, semi-arid shrub steppe vegetation dominates, including grasses on wetter sites and rabbit brush and sage on drier sites. Fire is an important ecological process in the ponderosa pine and other coniferous communities.

Glaciers have played a large role in the development of the Lake Roosevelt National Recreation Area landscape. The Columbia Lobe of the continental glacier, which reached its southernmost extent at the mouth of the Spokane River, left relatively thin deposits of gravel and boulders in various places along present day Lake Roosevelt.

Eruptions from distant volcanoes located several hundred miles away in the Cascade Range,

¹⁴ Excerpted from <http://www.lrf.org/lake-roosevelt/geography-community/climate-and-vegetation>, accessed 3/24/2018.

¹⁵ Excerpted from Reidel, J. (1997).

have influenced the geology and soils of the watershed. The 1980 eruption of Mount St. Helens caused a huge amount of volcanic ash to wash into the Spokane River. This ash eventually reached Lake Roosevelt and created a distinct plume in Spokane Arm. Deposits from eruptions of Mount Mazama (Crater Lake) and Glacier Peak have also spread ash over the area.

Broad classification of soils in the upper Columbia watershed reflect the geology and climate of the mountain and plateau physiographic provinces. Soil orders found in the mountainous areas are primarily entisols, while aridosols dominate the plateau. Detailed large scale soil surveys by the Natural Resources Conservation Service provide detail on soil types and distribution as well as information on land use, erosion potential and engineering properties. Additional soil and surficial geology information is available for Colville National Forest, and for certain private, state, county and tribal lands within the watershed.

Potentially affected cultural/archaeological resources¹⁶

State, federal and tribal cultural resource contacts

Executive Order 13007, dated May 24, 1996, instructs federal agencies to promote accommodation of access and protect the physical integrity of American Indian sacred sites on Federal lands. Sacred site means any specific, discrete, narrowly delineated location on federal land that is identified by an Indian tribe, or Indian individual determined to be an appropriately authoritative representative of an Indian religion, as sacred by virtue of its established religious significance to, or ceremonial use by an Indian religion. A sacred site can only be identified if the Tribe or appropriately authoritative representative of an Indian religion has informed the agency of the existence of a site.

There are more than 400 documented ethnographic sites around Lake Roosevelt as a result of the construction of the Grand Coulee Dam, which entombed burial sites, gathering places, utensils and tools, structures, and pictographs. Both the Colville and Spokane tribes have cultural resource departments that manage these resources.

The area in and around Kettle Falls is one of the most important cultural resource areas. In addition, habitation and fishing sites were often sited on the lower terraces of the Columbia and Spokane Rivers whereas burial and sacred sites were often location on the higher benches. When lake levels are low, burial, sacred, and other sensitive sites can be exposed.

¹⁶ <http://www.lrf.org/100-lake-roosevelt/cultural-resources>

Proposed/Listed Species/Critical Habitat Considered

	Common Name	Scientific Name	Status	Determination (Impact/Effect on Breeding [B], Feeding [F], Sheltering [S], Migration [M], and Nutrition [N])
Mammals	Canada lynx	<i>Brachylagus idahoensis</i> ¹⁷	Threatened	No effect
	Grizzly bear	<i>Ursus arctos horribilis</i>	Threatened	No effect
	Gray wolf	<i>Canis lupus</i>	Endangered	No effect
	Columbia Basin Pygmy rabbit	<i>Brachylagus idahoensis</i> ¹⁸	Endangered	No effect
	North American wolverine	<i>Gulo gulo luscus</i>	Proposed threatened	No effect
Fish	Bull trout	<i>Salvelinus confluentus</i> ¹⁹	Threatened Recovery plan for bull trout	No effect
Birds	Yellow-billed Cuckoo	<i>Coccyzus americanus</i> ²⁰	Threatened	No effect
Plants	Spalding's catchfly	<i>Spiranthes diluvialis</i>	Threatened	No effect

No anadromous species occur in Lake Roosevelt because fish passage is blocked downstream at Chief Joseph Dam, and no critical habitat is present (BOR 2009). With the exception of bull trout, the other listed species present in or near Lake Roosevelt would occur in either upland areas or shallow wetland areas. Lynx, gray wolf, grizzly bear, pygmy rabbit, and wolverine would be found in terrestrial and upland habitats removed from the proposed treatment areas. None of these species are known to occur in the vicinity of Lake Roosevelt. Spalding's catchfly is found predominantly in the Pacific Northwest bunchgrass grasslands and sagebrush-steppe, and occasionally in open-canopy pine stands.²¹ The range of Yellow-billed cuckoo exists within the Lake Roosevelt area, however, the project area is outside of critical designated habitat.

Due to the annual large and rapid fluctuations of water levels within the reservoir, there are limited aquatic bed and wetland communities in the littoral zone (BOR 2015). For about 3-months, the lake drawdown separates the riparian habitats from the reservoir by an expanse of barren land. Aquatic plants, such as bulrushes, sedges, reeds, and cattail, provide food and cover for an estimated 200 species of birds, 75 species of mammals, 10 species of amphibians, and 15 species of reptiles (Reclamation 2009).

The draft bull trout recovery plan (USFWS 2002) reports that bull trout have been documented in Lake Roosevelt but the only core area identified for the Northeast Washington Recovery Unit, which includes Lake Roosevelt, is in the Pend Oreille basin. The 1997 stock status report for bull trout

¹⁷ No critical habitat has been designated for this species.

¹⁸ No critical habitat has been designated for this species.

¹⁹ Bull trout critical habitat includes 3,793 stream miles, 66,308 acres of lakes/reservoirs, and 754 miles of marine shoreline in the State of Washington; Grant County has designated critical habitat for bull trout ([USFWS. 2010. Final Bull Trout Critical Habitat Designation](#)). No designated bull trout critical habitat exists within the geographic scope of this project ([Federal Register Vol 75, No. 200, 18 October 2010](#)).

²⁰ There is proposed critical habitat for this species, but the location of the action area is outside the critical habitat (546,335 acres in AZ, CA, CO, ID, NV, NM, TX UT, and WY) - [Federal Register \(79\)158: Friday, August 15, 2014](#)

²¹ <https://ecos.fws.gov/ecp0/profile/speciesProfile?sl=3681>

(WDFW 1997) reports that, while a few adults have been observed in the lake, there are no known bull trout spawning populations in tributaries to Lake Roosevelt. The proposed action is not expected to significantly alter physical conditions in the reservoir, e.g. temperature or total dissolved gases, and is not expected to affect other fish species present in the lake. The prey available to any adult bull trout that might be in the lake is not expected to change. Because no known spawning sites exist in tributaries to the lake, potential access to spawning tributaries is not a concern. As a result, the proposed action would have no effect on bull trout in this area.

Listed species:

- Yellow-billed Cuckoo (*Coccyzus americanus*)
- Bull trout (*Salvelinus confluentus*)
- Canada lynx (*Lynx canadensis*)
- Grizzly bear (*Ursus arctos horribilis*)

Yellow-billed Cuckoo

Life History and Ecology Yellow-billed cuckoos (*Coccyzus americanus*) are medium-sized birds that average about 12 inches long and weigh approximately 2 ounces. They are brownish above and white below, with rust-colored flight feathers and a long black-and-white tail. Unlike some species of cuckoo, the yellow-billed is not a brood parasite (laying eggs in other bird's nests), but rather typically builds its own nest and raises its own young. The yellow-billed cuckoo prefers floodplain forests with thick deciduous vegetation. They fly south in September to wintering habitat and return around mid-May. Large insects, including caterpillars and cicadas, make up the bulk of the bird's diet, although they will occasionally eat small frogs and lizards. Breeding corresponds with the occurrence of the tent caterpillar and cicadas.

Status and Distribution

On October 3, 2014, the U.S. Fish and Wildlife Service (USFWS) issued a final rule under the Endangered Species Act of 1973 listing the western distinct population segment (western distinct population segment (DPS)) of the yellow-billed cuckoo as a threatened species (USFWS 2014b). The yellow-billed cuckoo has historically bred throughout much of North America; however, available data suggest that there have been significant declines in the species distribution west of the Rocky Mountains due to streamside habitat loss (USFWS 2014b). The yellow-billed cuckoo (western DPS) is known to, or believed to, occur in all Washington State counties (USFWS 2015c).

Reasons for Decline

The loss of riparian habitat is reportedly the greatest threat to the species. Biologists have estimated that riparian habitat degradation due to agriculture, streamflow management, overgrazing, and exotic plant competition has reduced the yellow-billed cuckoo's riparian habitat by 90 percent in the West (USFWS 2014b).

Designated Critical Habitat

On August 15, 2014, the U.S. Fish and Wildlife Service (USFWS) proposed a rule to designate critical habitat for the western DPS of the yellow-billed cuckoo. The agency has proposed 546,335 acres in Arizona, California, New Mexico, Colorado, Idaho, Nevada, Texas, Utah, and Wyoming as critical habitat. The project areas are not located within the designated critical habitat (USFWS 2014c).

Bull Trout

Life History and Ecology

Bull trout (*Salvelinus confluentus*) are a cold-water fish that live in pristine stream and lake habitats. They have specific habitat requirements, including cold water temperatures, clean stream substrates for spawning and rearing, and complex habitats with riffles, deep pools, undercut banks, and large woody debris, as well as connectivity between headwater spawning habitats and mainstem river or lake overwintering habitats (USFWS 2011a). Bull trout express both resident and migratory life history forms, with migratory fish spawning in cold, high-mountain tributaries in the fall, and overwintering in mainstem river habitats and lakes. Juvenile migratory fish typically rear in tributaries for 2 years, and then out-migrate to lakes and mainstem rivers. Residents stay in spawning tributaries for their entire life cycle. Adults eat primarily fish, with juveniles feeding on aquatic invertebrates (NatureServe 2011).

Status and Distribution

The U.S. Fish and Wildlife Service (USFWS) issued a final rule listing the Columbia River and Klamath River populations of bull trout as threatened species under the ESA on June 10, 1998 (USFWS 1998). The most recent status review reaffirmed the listing (USFWS 2010).

Bull trout are known to use the mainstem Columbia River for feeding, migration, and overwintering habitat (USFWS 2008). Bull trout are rare in Lake Roosevelt, but a few have been documented (Spotts et al. 2000; Lake Roosevelt Forum 2011).

Reasons for Decline

Habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, and past fisheries management practices such as the introduction of non-native species threaten the Columbia River DPS (USFWS 1998).

Designated Critical Habitat

The mainstem Columbia River downstream of Chief Joseph Dam is included in critical habitat that was designated for bull trout on October 18, 2010 (USFWS 2010). Designated critical habitat did not include Lake Roosevelt, the Columbia River below Grand Coulee Dam to Chief Joseph Dam, or tributaries entering these water bodies.

Canada Lynx

Life History and Ecology

The Canada lynx (*Lynx canadensis*) is a medium-sized cat with grayish-brown and pale brown fur on the back, and grayish-white or buff-white fur on the belly. The long-legged cat has large, well-furred paws and is adapted for hunting in deep snow. Snowshoe hares are the principal prey, and the lynx is most likely to persist in areas that receive deep snow with large populations of the hare (USFW 2015b). Forests with minimal disturbance by humans that contain downed logs, windfalls, and other large woody debris provide denning sites for the lynx. These sites supply thermal cover and security for the kittens. Additionally, the lynx prefers denning habitat in forests of at least 2.5 acres (USFW 2009).

Status and Distribution

The U.S. Fish and Wildlife Service (USFWS) issued a final rule on April 24, 2000, listing the contiguous U.S. DPS of the Canada lynx as a threatened species under the Endangered Species Act of 1973 (USFWS 2000). Lynx populations range from the classic boreal forest in the north, south into the western United States subalpine forests. The lynx is known to or believed to occur in Ferry and Okanogan Counties, among other Washington counties (USFW 2015b).

Reasons for Decline

Intrusion into habitat with roads, trails, off-road vehicles, and snowmobiles, as well as human alterations to forests such as logging, fire suppression, and thinning, threaten the contiguous U.S. population segment of the Canada lynx (USFW 2009).

Designated Critical Habitat

On September 12, 2014, the U.S. Fish and Wildlife Service revised the designated critical habitat for the contiguous U.S. DPS of the Canada lynx. Under the final rule, the revised critical habitat includes Chelan and Okanogan Counties in Washington State. Maps included in the final rule indicate there is critical habitat in the western portion of Okanogan County, but not in the project areas (USFWS 2014b).

Grizzly Bear

Life History and Ecology

The average weight of the grizzly bear (*Ursus arctos horribilis*) is in the range of 400 to 1,500 pounds. Male bears, on average, weigh nearly twice that of females. Fur colors range from blond to deep brown or black, depending on the diet and temperature in the geographic regions the bears inhabit. Additionally, they have humped shoulders and long, curved claws (USFW 2014d). Grizzlies lead primarily solitary lives when not mating or raising young. The home range of male bears is 200 to 500 square miles, and females use 50 to 300 square miles. The landscapes of grizzly habitat include diverse forests with moist meadows, and grasslands situated near or in mountainous regions. Green vegetation, wild fruits and berries, nuts, and bulbs or roots of certain plants make up 80 to 90 percent of grizzly bears' diet. Insects are also a large part of their diet, and they sometimes tear apart rotten logs or turn over stones in their search for adult insects or their larvae (USFW 2007).

Generally, grizzly bears will seek remote, high mountain slopes with deep snow to dig their dens for winter. The bears will often build the den at the base of large trees, digging under the tree roots, and pushing rocks and soil to the surface. The bears will winter for 5 to 6 months, not eating or drinking the whole time. Male bears typically emerge from the den in March or April, and females emerge in late April or May. Grizzlies will usually travel back to lower elevations in the spring to reach vegetated areas (USFW 2007).

Status and Distribution

The U.S. Fish and Wildlife Service (USFWS) listed the grizzly bear as a threatened species in the 48 conterminous United States on July 28, 1975. The August 2011 status review by the USFWS confirmed that the lower 48-state listing qualified as a DPS and recommended that the species should remain in the threatened status (USFWS 2011b). Today in the lower 48 states, ecosystems that biologists have identified to contain suitable habitat for grizzly bears are: the Yellowstone (northwestern Wyoming, southwestern Montana, and eastern Idaho), the Northern Continental Divide (northwestern Montana), the Cabinet-Yaak (northwestern Montana), the Selkirks (northern Idaho and eastern Washington), the North Cascades (Washington), and the Bitterroots (central Idaho and western Montana) (USFWS 2007). Grizzly bears are known or believed to occur in Ferry and Okanogan counties, as well as several other counties in Washington State (USFWS 2015d).

Reasons for Decline

Habitat loss and mortality are the leading causes for the decline of the grizzly bear in the lower 48 states. The bears require large areas of undisturbed habitat. Human encroachment through gas and oil development, recreational development, road building, and poorly designed timber harvest has led to habitat degradation (NRCS 2011). Despite protection under the Endangered Species Act, humans kill between 70 and 90 percent of the adult grizzlies killed in the U.S. Rocky Mountains. The bears are

primarily killed because of they are mistaken for black bears, they threaten human safety, or they destroy property or livestock (USGS 2015).

Designated Critical Habitat

In 1976, the U.S. Fish and Wildlife Service proposed a determination of critical habitat for the grizzly bear. The proposal included numerous areas in the northwestern United States, which were divided into four regions. Region 4 includes extreme northwestern Montana and northern Idaho in the Cabinet Mountains, mostly in the Kootenai, Kaniksu, and Lolo National Forests, as well as extreme northern Idaho and northeastern Washington, mostly in the Kaniksu National Forest (USFWS 1976).

Conservation Measures and BMPs

The conservation measures and BMPs in this manual (pages XX–XX) would be implemented to avoid, reduce, or eliminate adverse effects or benefit protected species as part of this action.

Water Body Monitoring

The Washington Department of Fish and Wildlife monitors Lake Roosevelt for dreissenids on an annual basis (click [here](#) for 2017 monitoring data). Monitoring consists of visual shoreline surveys, water collected for eDNA analysis, horizontal and vertical plankton tows, artificial substrates, and collection of water samples for water chemistry (e.g., calcium) analysis.

Columbia River

STATE OF OREGON

Lake Billy Chinook

Detroit Lake

Lake Owyhee

Upper Klamath Lake

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LIST OF CONTACTS, PARTICIPANTS, AND PREPARERS

LITERATURE REVIEW

Dreissenid Life History

Zebra and quagga mussels are closely related filter-feeding freshwater mussels (Table 1), capable of filtering about one liter of water per day while feeding on algae (Benson et al. 2017). These bivalves produce free-swimming planktonic larvae that eventually settle out of the water column and attach to hard surfaces using byssal threads. Zebra mussels tend to prefer hard surfaces, whereas quagga mussels can inhabit both hard and soft substrates up to depths of 130 meters (USGS 2016). Although quagga mussels can colonize more surfaces in a lake, zebra mussels are more likely to successfully invade river systems (but will not settle in currents greater than 2m/sec) because zebra mussels have stronger byssal threads and a distinctive flat edge that may increase their stability and grip on hard surfaces (Oregon Sea Grant 2010).

Dreissenids are highly invasive because they are dioecious (fertilization occurs in the water column), and they have a high reproductive capacity (they can produce millions of eggs in one spawning season) (Oregon Sea Grant 2010). Males and females release their eggs and sperm simultaneously into the water, where they are fertilized and develop into microscopic planktonic larvae, called veligers. The veligers settle, attach to a substrate using byssal threads, and develop into adult mussels in the first or second year of life. The threads can be broken, enabling the mussels to translocate to new areas (Ackerman et al. 1994).

Zebra mussels can survive in waters as warm as 86°F. Both species can survive cold waters near freezing, but cannot tolerate freezing. Zebra mussels need waters above 54°F to reproduce whereas quagga mussels need waters above 48°F to reproduce. The temperature preference for zebra and quagga mussels is 64°F and 61°F, respectively (US Fish and Wildlife Service 2007). Neither species can survive salinity tolerances greater than 5 parts per thousand (Spidle et al. 1995).

Bacteria are the main food for the larval stage of dreissenids. Adult quagga and zebra mussels filter feed on phytoplankton and zooplankton from the water column; one mussel can filter one liter of water per day (Oregon Sea Grant 2010).

Table 1. Zebra and quagga mussel traits.

Trait	Zebra Mussels	Quagga Mussels
Shell	Triangular shape, underside flat. Obvious ridge between side and bottom. When placed on its ventral side, it will remain upright.	Rounder sides, convex underside. No ridge. When placed on its underside, the quagga mussel will topple.
Color	Variable colors and patterns, usually dark.	Pale near hinge, dark concentric rings on the shell.
Underside	Large groove in middle of flat side; allows tight hold on rocks.	Small ventral groove near the hinge.
Depth in lake	3 to 98 feet; rarely found below 50 feet	3 to 540 feet; expected to go deeper over time.
Temperature tolerance	54°F to 68°F	39°F to 68°F
Spawning temperature	Minimum 56°F; can survive in stagnant water with uniform temperature, but cannot reproduce there.	Minimum 50°F; a female quagga mussel with mature reproductive organs was found in Lake Erie at a temperature of 42°F
Habitat occupied	Lakes, waterways, ponds, and rivers with current less than 2m/sec	Lakes, waterways, and ponds
Substrate colonized	Hard only	Hard and soft

Economic and Environmental Damages

Many of the potential impacts of dreissenids are unclear due to the limited time scale of North American colonization (Benson et al. 2017), however because they are polymorphic and rapidly adapt to extreme environmental conditions, dreissenids have potential significant long-term impacts to North American waters (Mills et al. 1996). Establishment of dreissenid mussels in the Columbia River Basin (CRB) would be expensive, requiring extensive maintenance to the nuclear power plant and hydroelectric dams, fish ladders, fish bypass facilities, navigation locks, and irrigation pumping. In an economic impact report prepared for Bonneville Power Administration, the one-time cost to install mussel treatment systems was estimated at more than \$23 million dollars and annual costs were estimated at \$1.5 million (Independent Economic Analysis Board 2010). Because of the high value of fishery and aquatic resources in the CRB, and because no controls exist for mussels in open natural systems, the ecological costs of a CRB invasion could be much larger than other costs (Independent Economic Analysis Board 2013).

Flow restriction

Dreissenid mussels can cause substantial economic damage by infesting municipal, industrial, and agricultural water systems and attaching themselves to the substrates of pipes, dams, and diversion pathways. This restricts the flow of water through the systems, impacting component service life, system performance, and maintenance activities. The annual cost to power plants and municipal drinking water systems in North America has been estimated between \$267 million and \$1 billion dollars (Pimental 2005; Connelly et al. 2007).

Drinking water intakes

Mussels foul intake piping and water processing infrastructure, increasing maintenance costs and degrading water flavor due to mussel waste and decomposition in water lines (National Invasive Species Advisory Committee 2016). O'Neill (1997) estimated an annual cost of \$4.2 million to address projected mussel infestations in 100 Idaho water treatment facilities (\$42,000 per facility). Zebra mussel densities were as high as 700,000/square meter at one power plant in Michigan, and the diameters of pipes have been reduced by two-thirds at water treatment facilities (Benson et al. 2017).

Irrigation

The total economic impact on irrigation facilities is influenced by the number of points of diversion; each point of diversion or point of use could potentially be affected by dreissenids (National Invasive Species Advisory Council 2016). Mussels can foul water conveyances that are seasonally dry, and fouling and shell production from mussel establishment is cumulative (National Invasive Species Advisory Council 2016). Although mussel establishment in pipes and pumps is well documented, research on mussel-related flow reduction in irrigation systems is minimal.

Ecological function

Once established, dreissenid mussels can dramatically alter the ecology of a water body and associated fish and wildlife populations. As filter feeders, they remove phytoplankton and other particles from the water column, shifting production from the pelagic to the benthic portion (Sousa et al. 2009). In Lake Michigan, dreissenid invasions have caused significant phytoplankton community structure shifts, including dominance in cyanobacteria (DeStasio et al. 2014). In Lake Simcoe, Ontario, Canada, there

were significant and sustained declines in phytoplankton biovolumes and chlorophyll a concentrations during the 12 years following invasion by dreissenids (Baranowska et al. 2013).

Native mussels are significantly threatened by the presence of invasive mussels. By attaching themselves to the surfaces of other bivalves, dreissenid mussels can starve freshwater mussels and drive indigenous populations to local extinction (Montgomery and Wells 2010). Dreissenid mussels can also affect dissolved oxygen through respiration, and dissolved calcium carbonate concentrations through shell building (Strayer 2009). The filtering capabilities of dreissenids increase water transparency, decrease chlorophyll concentrations, and increase the amount of pseudofeces (Claxton et al. 1998). Increases in pseudofeces reduce oxygen levels, which makes water pH more acidic and toxic. Increased water clarity increases light penetration and causes growth in aquatic plants. Dreissenids also bioaccumulate pollutants, which can be passed up the food chain, increasing wildlife exposure to organic pollutants (Snyder et al. 1997). Polychlorinated biphenyl (PCB) concentrations in mussel tissue are correlated to sediment PCB levels, indicating mussels may provide an entry point for PCBs into nearshore benthic food webs (Macksasitorn et al. 2015).

Boating facilities

Marinas, docks, and boat launches experience increased costs from dock and boat launch fouling and infrastructure deterioration (O'Neill 1997).

Fish hatcheries and aquaculture

Hatchery and aquaculture facilities are vulnerable to dreissenid fouling, including pipes, pumps, and raceway structures (O'Neill 1997). Invasive mussels have the potential to disrupt operations at fish hatcheries (Stephenson and Koger 2011). Seasonal stocking of fish from a contaminated facility poses a risk to any water receiving these fish (Stephenson and Koger 2011).

Boater costs

Boaters experience increased costs estimated at \$265 per boat (Vilaplana and Hushak 1994) for anti-fouling paints and per-boat maintenance costs and permit fees. Recreational and navigational vessels can be affected by increased drag associated with attached mussels, and small mussels can enter engine cooling systems, causing overheating and damage (Benson et al. 2017).

Recreational fishing

To date, research on the impacts of mussels to recreational fishing is limited, however, Vilaplana and Hushak (1994) documented a four percent decrease in boater recreation because of mussel introduction. Fishing gear can be fouled if left in the water for long periods (Benson et al. 2017).

Estimating Water Body Risk of Introduction and Establishment

Many factors contribute to the risk of dreissenid introduction and establishment, including environmental parameters (e.g., dissolved calcium, pH), and the extent and types of public use (e.g., total day use, presence of boat ramps and marinas, proximity to transportation corridors, motorized boating, fishing). Total day use of a water body, presence of boat ramps and marinas, water body size and access, motorized boating, fishing, and angling tournaments are important determinants of risk of introduction (Wells et al. 2010). Once introduced, pH and calcium concentrations, considered critical environmental parameters for dreissenid mussel survival and growth (Hincks and Mackie 1997; McMahon 1996), are likely to determine the success of establishment (Wells et al. 2010).

In general, dreissenid adults in North America inhabit waters with calcium concentrations greater than or equal to 15 mg Ca²⁺/L, and populations become dense at concentrations greater than or equal to 21 mg Ca²⁺/L (McMahon 1996).

Dreissenid veligers are found in North America at pH levels between 7.4 and 9.4; pH 8.4 is optimal (McMahon 1996). Adult dreissenid mussel growth is generally limited at pH less than 6.5 to 6.9 and pH greater than 10, because dreissenids lose calcium to the external environment (Hincks and Mackie 1997; McMahon 1996).

Water temperature is not expected to limit growth as dreissenids inhabit a wide range of temperatures in North America. They are found in the Great Lakes at temperatures less than 41°F, and in the lower Mississippi where temperatures reach and exceed 86°F (McMahon 1996).

Adult and veliger dreissenid survival increases with an increase in calcium concentration (Davis et al. 2015) (Figure 3).

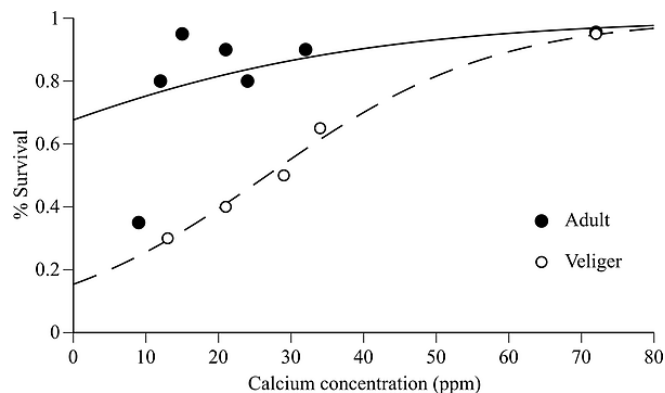


Figure 3. Adult and veliger quagga survival versus calcium concentration in experimental water. Survival of adults (after 90 days) and veligers (after 30 days) versus calcium concentrations in experimental water from Tahoe Cave Rock (9ppm), Tahoe Keys (12ppm), Tahoe Ca amended water (15–34ppm), and Lake Mead (72ppm). Logistic regression model fit to data shown for adult (solid line) and veliger (dotted line). Graphic credit: Davis et al. 2015.

Several entities have developed criteria to determine the levels of dreissenid infestation in the temperature zone of North America and Europe (Mackie and Claudi 2010) (Table 3). Calcium is necessary for shell production, alkalinity signals availability of calcium, and pH influences the form of carbon available—calcium is available in the HCO₃ form when pH values are less than 8.2 (Pucherelli et al. 2016).

Fort Peck Lake is categorized as a high-risk water body for dreissenid introduction and establishment based on total fishing pressure, total non-resident fishing pressure, and Ca²⁺ expressed as mg/L (Wells et al. 2011). The mean Ca²⁺ for Fort Peck Lake is 47.0, total fishing pressure and non-resident fishing pressure is categorized as high, and the mean pH is 8.6 (minimum of 8.5 and maximum of 8.8) (Wells et al. 2011).

Table 3. Criteria used in determining the levels of dreissenid infestation in the temperature zone of North America and Europe (Mackie and Claudi 2010).

Parameter	Adults do not survive long-term	Uncertainty of veliger survival	Moderate infestation level	High infestation level
Calcium (mg/L)	<8 to <10	<15	16–24	≥24
Alkalinity (mg CaCO ₃ /L)	<30	30–55	45–100	>90
Total hardness (mg CaCO ₃ /L)	<30	30–55	45–100	≥90
pH	<7.0 or >9.5	7.1–7.5 or 9.0–9.5	7.5–8.0 or 8.8–9.0	8.2–8.8
Mean summer temperature (June 1–August 31) (°F)	<64	64–68 or >83	68–72 or 77–83	72–75
Dissolved oxygen mg/L	<3 (25%)	5–7 (25–50%)	7–8 (50–75%)	≥8 (75%)
(% saturation)				
Conductivity (μS/cm)	<30	<30–60	60–110	≥100
Salinity (mg/L) (ppt)	>10	8–10 (<0.01)	5–10 (0.005–0.01)	<5 (0.005)
Secchi depth (m)	<0.1 or >8	0.1–0.2 or >2.5	0.2–0.4	0.4–2.5
Chlorophyll a (μ/L)	<2.5 or >25	2.0–2.5 or 20–25	8–20	2.5–8
Total phosphorus (μg/L)	<5 or >50	5–10 or 30–50	15–25	25–35

Products Used to Control Dreissenids

Both non-chemical and chemical controls have varying levels of success in controlling dreissenids. Any likely control activity will result in physical and chemical changes to the environment. Best management practices call for minimizing both short- and long-term effects to the environment and to all non-target species. Numerous studies spanning several fish species have demonstrated that exposures to common metals and pesticides interfere with fish olfaction, ultimately disrupting life history processes that affect survival and reproductive success. Recovery of sensory function occurs more quickly for pesticides than for metals, such as copper (Tierney et al. 2010).

Mussel life cycle and behavior influence the strategies and tactics of chemical control, as well as choice of molluscicidal compound. Dreissenids cannot survive in saline conditions, but are well adapted to water temperatures (12 °C to 32 °C [55 °F to 90 °F]), pH range (6.5 to >8), and turbidity levels found in the CRB.

The application of chemical molluscicides is limited by:

- How well it removes or kills the various dreissenid life stages.
- It's ability to be compatible with possible potable water use.
- It's toxicity to native fish and wildlife and their ecosystems.
- Whether or not the system in which the chemical application occurs is closed, helping to ensure no release to the environment; or whether the system is open, requiring consideration of the effect of the chemical release downstream from the application site.
- Cost effectiveness.

The following pesticides are currently registered products in the state of Oregon, Washington, and Idaho (Table 1). In addition, two products, Lo Temp Sanitizer (813-16-48211) and Sodium Hypochlorite – 12.5 Bacticide (72315-6), are registered in Washington and Idaho, but not in Oregon.

The two main categories of chemicals that have been used to treat dreissenid introductions are oxidizing biocides and non-oxidizing biocides (CRB Plan 2011).

Table 1. Formulation name and EPA registration number for all Section 3 pesticides registered in Washington that are listed as capable of controlling zebra mussels.

Product	EPA Reg.#
7000	748-295-1677
Accu-Tab® SI Calcium Hypochlorate	748-295
Acti-Brom® 1318	5185-467-1706
Anthium Dioxide	9150-2
Chlorine Liquified Gas Under Pressure	72315-1
High Strength Sodium Hypochlorite EP	72315-16
K-Brom 40®	88714-3
Multibrom Liquid	8622-49-1677
Spectrus OX109®	3876-159
Spectrus OX1201®	3876-159
Stericlean Sodium Hypochlorite 12.5	72315-6-74225
Zequanox®	84059-15
Nalco® H150M	6836-235-1706

Fate and Transport Analyses

The objective of fate and transport analyses is to identify how chemicals degrade and where chemicals travel in the environment when they are intentionally or unintentionally released ([US Department of Energy](#)). Fate and transport analyses describe how a chemical moves through the environment—air, water and soil—as well as how it changes in the presence of other chemicals and substances.

Technical fact sheets on the most commonly used chemicals to control dreissenids can be found in (Appendix B). Technical fact sheets provide information on the chemical class and type, uses, physical and chemical properties, mode of action, non-target organisms, acute toxicity, chronic toxicity, endocrine disruption, carcinogenicity, reproductive and developmental effects, fate in the body, medical tests and monitoring, environmental fate, ecotoxicity studies, and regulatory guidelines. While these studies base effects on populations, the Endangered Species Act is concerned with effects to individual organisms.

Copper-based products

Copper-based algaecides are lethal to all life stages of dreissenids, but are also lethal to many other aquatic species. Their efficacy increases with increasing ambient temperatures. Copper sulfate is an algaecide, bactericide and fungicide, and is one of the most effective chemicals used to control dreissenids in a closed water body. Copper sulfate disrupts the surface epithelia function and enzymes in mussels in all life history stages of mussel, but has a proven efficiency of 50–99% for adult dreissenids (0.5 mg/l copper equivalent with 96 hours of exposure). Its toxicity to fish and other aquatic organisms depends on pH, dissolved organic carbon levels, and other water chemistry parameter, such as calcium. Copper sulfate, however, is highly toxic to salmonids (Griffin and Strauss 2000).

Extensive fate and transport analyses have been conducted on copper sulfate (Appendix B). Three processes control the fate of copper in the environment: transport to lower soil levels by groundwater percolation; binding to soil components; and breakdown into metabolites (Hartley and Kidd 1983). Copper is bound, or adsorbed to organic materials, and to clay and mineral surfaces, depending on the level of acidity or alkalinity of the soil. The distance copper travels in soil is limited by its strong adsorption to many types of surfaces. Copper sulfate is highly water soluble, but the copper ions are strongly adsorbed or precipitated to soil particles (Extoxnet 1996).

The following summarizes fate and transport analyses on copper sulfate (Siemering and Hayworth 2005):

- Mechanism of Toxicity—Photosynthesis and cell growth inhibitor.
- Solubility—230,550ppm at 25 degrees Celcius (anhydrous)
- Fate—Highly water soluble with no degradation. Strong particle and dissolved oxygen concentration affinity causes rapid sediment deposition. Transport occurs between water and sediment (advection/flux).
- Confounding Factors—Toxicity is temperature, pH, and hardness dependent, with greater toxicity in softer water. Bioavailability is influenced by sorption to dissolved oxygen concentration and particles.
- Data Gaps—Toxic effects on embryos and larvae, and chronic effects to benthic invertebrates.
- Environmental Fate (National Pesticide Information Center).

Soil

Copper sulfate can dissociate or dissolve in the environment releasing copper ions. This process is affected by its solubility, which in turn is affected by pH, redox potential, dissolved organic carbon, and ligands present in the soil. Copper in soil may originate from natural sources, pesticides, and other anthropogenic sources such as mining, industry, architectural material, and motor vehicles. Copper accumulates mainly at the surface of soils and it can persist because it has a tendency to bind to organic matter, minerals, and some metal oxides. It may leach from acidic or sandy soil. The more acidic the soil, less binding occurs. Irrigation water treated with copper sulfate as an algacide could lead to soil levels that could damage crops. The presence of calcium ions decreases leaching of copper, increasing its binding capacity. The presence of sodium ions has the opposite effect and causes more copper to leach.

Water

Copper sulfate is an inorganic salt that is highly soluble in water. The disassociated copper ions mainly bind to organic matter or remain dissolved in water. When applied to channel catfish ponds over 16 weeks, 90% of the copper in copper sulfate pentahydrate was bound to the sediments within minutes of application and 99% of it was bound after 2 days. Nearly all of the copper remained in the top 16 cm of sediment. After applying 2,250 kg copper sulfate to a lake in California, researchers noted that 20% of the applied copper left the reservoir by day 70 and most of the remaining copper became bound in the upper layer of the sediment.

Air

No data were found regarding the fate of copper sulfate in the atmosphere.

Plants

Copper is an essential mineral for plant growth and its concentration is regulated by homeostatic mechanisms. However, copper can be toxic to plants by affecting electron transport in photosynthesis. Bioavailability depends on the amount of copper, soil pH, organic carbon, precipitation, and

temperature. Readily soluble copper is the most phytotoxic form, and can inhibit growth of plants, such as onion (*Allium cepa*) bulbs and garden cress (*Lepidium sativum*) seeds by as much as 50% within 48 hours of exposure.

Ecotoxicity Studies

Birds

The U.S. EPA classified copper as moderately toxic to birds based on the acute oral LD50 for bobwhite quail (*Colinus virginianus*) of 384 mg/kg copper sulfate pentahydrate and 98 mg/kg metallic copper. Bobwhite quail fed copper sulfate for 21 days fed less and gained less weight. Then birds in a flock of captive 3-week-old Canada geese (*Branta canadensis*) that used a pond treated with copper sulfate died nine hours after ingestion of about 600 mg/kg copper sulfate. Limited data are available regarding copper sulfate toxicity to wild birds.

Fish and Aquatic Life

The toxicity of copper to fish and other aquatic life depends on its bioavailability, which is strongly dependent on pH, the presence of dissolved organic carbon (DOC), and water chemistry such as the presence of calcium ions. Fish kills have been reported after copper sulfate applications for algae control in ponds and lakes. However, oxygen depletion and dead organisms clogging the gills have been cited as the cause of fish deaths, resulting from massive and sudden plant death and decomposition in the water body.

- Researchers exposed juvenile rainbow trout (*Oncorhynchus mykiss*) to either hard water or soft water spiked with copper for 30 days. Fish in the hard-water, high dose (60 µg/L) treatment groups showed an increased sensitivity to copper.
- The mean 96-hour LC50 (with 95% confidence limits) for copper exposure in alevin, swim-up, parr and smolt steelhead (*Salmo gairdneri*) are 28 (27-30), 17 (15-19), 18 (15-22), and 29 (>20) µg/L of copper respectively. The mean 96-hour LC50 for copper exposure in alevin, swim-up, parr and smolt Chinook salmon (*Oncorhynchus tshawytscha*) are 26 (24-33), 19 (18-21), 38 (35-44), and 26 (23-35) µg/L of copper respectively. The experiments were done by adding copper as CuCl₂.
- Copper sulfate is toxic to shrimp due to damage of the gill epithelium and respiration disruption. Copper also disrupts olfaction in fish, possibly interfering with their ability to locate food, predators, and spawning streams
- The toxicity of copper sulfate to blue tilapia (*Oreochromis aureus*) fingerlings was found to increase with the decrease in total alkalinity.
- Researchers studied the effect of sediment on copper toxicity in three *Daphnia* species, *similis*, *D. magna*, and *D. laevis*. They reported that the toxicity is reduced in the presence of sediments because bioavailability of copper is decreased.
- Researchers exposed 1-day-old freshwater snail eggs (*Lymnaea luteda*) to copper at concentrations from 1 to 320 µg/L of copper for 14 days at 21 °C in a semi-static embryo toxicity test. Embryos exposed to copper at 100 to 320 µg/L died within 168 hours. At lower doses from 3.2-10 µg/L, significant delays in hatching and increased mortality were noted.
- Researchers reported no observed effects concentrations (NOEC) of 8.2-103 mg/L copper in the freshwater rotifer (*Brachionus calyciflorus*). Toxicity increased with decreasing levels of DOC and decreasing pH.

Terrestrial Invertebrates

The U.S. EPA considers copper to be practically nontoxic to bees.

Treatment Options in Various Water Body Types

(This section excerpted and modified from William T. Haller, University of Florida as part of “A Review of the State of Idaho Dreissenid Mussel Prevention and Contingency Plans”)

The discovery of dreissenids in large river run reservoirs would most likely be impossible to eradicate based on the length of time (often weeks or months) between sample collection and analyses with confirmation. This temporal lag allows mussels to reproduce and spread beyond pioneer infestations in marinas or boat moorage locations into the reservoirs proper. The likely cost of eradication, if possible, may be prohibitive in large reservoirs where the isolation of the newly discovered infestation is not possible.

Registered herbicides, such as copper sulfate, chelated copper and endothall are registered in several of the Columbia River Basin (CRB) states and can generally be used for mussel control in ponds, lakes, irrigation and drainage canals and in slow moving or quiescent water such as bays and coves adjacent to reservoirs. Not all labels list rivers as approved sites of application, thus if a river is being considered for treatment, the pesticide chosen must be labeled for use in rivers. It is unlikely that control efforts will be undertaken in Columbia River Basin rivers due to their generally high discharge and velocity of flow. Emerging biocides, such as *Pseudomonas fluorescens* is registered for open water applications (November 2016), however, its efficacy in a large river system is, as yet, untested. All treatment options considered need to chemical fate and transport, threatened and endangered species, and timing of in-water work windows.

Waterbodies in the CRB vary greatly in size and flow characteristics, and could be described in five categories based on the ability of CRB states to manage the water and the likelihood of the successful eradication of dreissenids.

1. Enclosed pond or lake with no water exchange

- Immediately close the water body to all public access to stop the further spread of the infestation;
- Determine and resolve any legal or jurisdictional issues which would impede the entry of state agents to the privately-owned water bodies and the eradication of dreissenids and including collateral damage to other life forms in the water;
- Immediately survey all adjacent or nearby waters for infestations;
- Determine, if possible, the pathway of introduction and implement measures to prevent additional introductions;
- Consider mechanical methods of control, including drawdown to allow desiccation to occur. A minimum of 30 days of exposure is necessary to effect a positive outcome. Water cannot be permitted to contaminate other water bodies;
- A partial drawdown or drainage may enhance chemical treatment efficacy. Chemical treatments should be conducted when water temperature exceeds 15 °C.
- Determine if any seepages or springs are located in the waterbody. Underground water exchange (subterranean inflow into the lake) will allow mussels to survive a chemical treatment.

2. Gravel pits (small lakes or borrow pits common along river bed, with the likely lateral movement of surficial ground or storm water.

The response to detected infestations in these areas will be similar to the response identified above in enclosed ponds or lakes depending on water movement both into and out of the area. Additional considerations include:

- Chemical applications will have to account for potential dilution because of water fluctuations. Sequential treatments will have to be considered to optimize results;
- The proximity of potable water sources would have to be considered if the chemicals of choice would likely reach them.
- The wells, pumps or treatment systems would have to be closed, filtered or otherwise modified if the chemical(s) of choice do not have potable water tolerances. Chlorine would be a likely candidate chemical in these circumstances.

3. Irrigation canals

These canals or canal bottoms are rarely completely dry, even in the off- or non-crop season (October to April). There are generally two types of canals: those with return flow to a natural waterway and those that have no water return flow to the source waterway. Some irrigation canals are currently treated with aquatic herbicides for weed control. All chemicals applied to irrigation canals used to water crops must have established tolerances on the crops receiving the water or be exempt from tolerances. If irrigation return flow is returned to natural waterways, additional restrictions may apply. Chemicals used in irrigation water must be registered by the EPA for that site and use. For exceptions see FIFRA Section 18. Additional considerations include:

Possible potable water uses, cattle watering, and or other domestic water uses;
Whether the return flow be held and, if so, for how long; and
Endangered Species Act compliance.

4. Lakes

Lakes are generally considered to be between 100 and 1,000 acres. Eradication may be possible in any size lake, depending on the size and location of the infestation. Large lakes would be evaluated on a case-by-case basis, and considerations for responses indicated in numbers 1 and 2 above would apply to a large extent. Large lakes can be treated in their entirety much as ponds and borrow pits, but it is much more expensive and difficult. Outflow on large lakes is a concern and must be controlled or stopped before the infestation can move downstream.

5. Reservoirs and river-run impoundments and large lakes

There are many large reservoirs in the CRB, and it is likely that dreissenid eradication is implausible once they become an established and reproducing population. If reproducing populations of exotic mussels are found in open bays outside of closed or restricted water-flow marinas, eradication and downstream movement in river-run reservoirs is likely implausible. The most likely scenario, and one in which eradication in these large systems may be possible, is when an infestation is found in an isolated bay or a restricted-flow or water-movement marina. Another example is if a heavily infested boat with live mussels is launched and moored at a marina. In this case, it may be possible to consider some of the options for water bodies noted in 1 through 3 above with the following considerations:

1. Immediately close the marina or bay to boat traffic and immediately remove any contaminated boats;
2. Establish mandatory decontamination procedures for all existing watercraft;
3. Collect samples inside and outside of the contaminated area for immediate analysis;
4. Determine the feasibility of using silt curtains or barriers to close the bay or marina to open water;
5. Remove and decontaminate all boats;
6. Treat the entire enclosed area to kill all veligers and possible adults.

Pre-control Activities

Temporary impacts: Pre-control activities include planning, design, permit acquisition, and surveying. Vegetation and fluvial geomorphic processes at a project site provide for natural creation and maintenance of habitat function. Pre-control activities that result in removal of vegetation will reduce or eliminate those habitat values (Darnell 1976, Spence et al. 1996).

Denuded areas lose organic matter and dissolved minerals, such as nitrates and phosphates. The microclimate becomes drier and warmer with a corresponding increase in soil and water temperatures. Loose soil can temporarily accumulate in the construction areas and, in dry weather, this soil can be dispersed as dust. In wet weather, loose soil is transported to a stream or water body by erosion and runoff, particularly in steep areas. Erosion and runoff increase the supply of soil to lowland areas, and eventually to aquatic habitats where they increase turbidity and sedimentation. This effect is amplified during high frequency and high duration flow events.

If the control action occurs adjacent to or near a stream, loss of vegetation on the project site will increase the rate of transport of water to the stream during rain events, which can lead to higher peak flows. Higher stream flows increase stream energy that scours stream bottoms and transport greater sediment loads farther downstream than would otherwise occur. Sediments in the water column reduce light penetration, increase water temperature, and modify water chemistry. Once deposited, sediments can alter the distribution and abundance of important instream habitats, such as pool and riffle areas. Fish that spawn in fish gravel require fresh, moving water to survive and grow and then an escape route after they have hatched. The introduction of excess sediment can have disastrous results for the spawning habitat of fish that require gravel substrate for spawning and for the habitat of gravel-dwelling benthic organisms (Castro and Reckendorf 1995). During dry weather, the physical effects of increased runoff appear as reduced ground water storage, lowered stream flows, and lowered wetland water levels.

The combination of erosion and mineral loss can reduce soil quality and site fertility in upland and riparian areas. Concurrent in-water work can compact or dislodge channel sediments, thus increasing turbidity and allowing currents to transport sediment downstream where it is eventually redeposited. Multiple control activities, in which the site is inundated, can significantly increase the likelihood of severe erosion and contamination.

Implementation of conservation measures can reduce, but not eliminate, the risk of soil erosion and increased sediment inputs to streams, thus reducing the likelihood of impacts to stream habitats. At a watershed scale, this risk is not expected to be significant because of the localized nature of the impacts and the anticipated widely dispersed locations of project sites in multiple watersheds across the CRB.

Pre-construction Activities

Temporary impacts: The primary habitat effect from pre-construction activities is a temporary and localized increased in turbidity and suspended sediment. Turbidity may have beneficial or detrimental effects on fish, depending on the intensity, duration, and frequency of exposure (Newcombe and MacDonald 1991). Salmonids have evolved in systems that periodically experience short-term pulses (days to weeks) of high suspended sediment loads, often associated with flood events, and are presumably adapted to high pulse exposures. Adult and larger juvenile salmonids may be little affected by the high concentrations of suspended sediments that occur during storm and snowmelt runoff (Bjornn and Reiser 1991), although these events may produce behavioral effects, such as gill flaring and feeding changes (Berg and Northcote 1985).

Deposition of fine sediments reduces egg incubation success (Bell 1991), interferes with primary and secondary production (Spence et al. 1996), and degrades cover for juvenile salmonids (Bjornn and Reiser 1991). Chronic, moderate turbidity can harm new-emerged salmonid fry, juveniles, and even adults by causing physiological stress that reduces feeding and growth, and increases basal metabolic requirements (Lloyd 1987, Redding et al. 1987, Bjornn and Reiser 1991, Servizi and Martens 1991, Spence et al. 1996). Juveniles avoid chronically turbid streams, such as glacial streams or those disturbed by human activities, unless those streams must be traversed along a migration route (Lloyd et al. 1987). Older salmonids typically move laterally and downstream to avoid turbidity plumes (Sigler et al. 1984, Lloyd 1987, McLeay et al. 1987, Scannell 1988, Servizi and Martens 1991). Fish exposed to moderately high turbidity levels in natural settings are able to feed, although at a lower rate and with increased energy expenditure due to a more active foraging strategy. Over a period of several days or more, reduced feeding resulting from increased turbidity can translate into reduced growth rates.

Turbidity also limits fish vision, which can interfere with social behavior (Berg and Northcote 1985), foraging (Gregory and Northcote 1993, Vogel and Beauchamp 1999) and predator avoidance (Miner and Stein 1996, Meager et al. 2006). This can have varying effects on fish growth and survival, depending on a range factors such as ambient light levels and depth; relative visual sensitivities of predators and prey; and non-visual sensory abilities. Conversely, salmon may benefit from increased turbidity; predation on salmonids may be reduced in water turbidity equivalent to 23 Nephelometric Turbidity Units (NTU) (Gregory 1993, Gregory and Levings 1998), which may improve survival.

Therefore, fish will be exposed to elevated turbidity and suspended sediment during pre-construction activities. Some juvenile salmonids may decrease feeding, experience increased stress, or may be unable to use the action area, depending on the severity of the increase in suspended sediments.

Site Preparation Activities

Temporary impacts: Effects of site preparation activities may involve use of heavy equipment for transport and application of chemicals. New impervious surfaces allow for faster and more delivery of soil and contaminants in stormwater runoff, causing impaired water quality. In-water work may be required to complete some activities, resulting in injury or death of fish due to handling. Site preparation may involve cordoning off a portion of the water body in preparation for biocide or chemical application. Siltation, sedimentation, and other deleterious physical effects to the environment may occur on a short-term basis.

Heavy equipment. Use of heavy equipment compacts soil, thus reducing soil permeability and infiltration of stormwater. Use of heavy equipment also creates a risk that accidental spills of fuel, lubricants, hydraulic fluid, control chemicals and other similar contaminants may occur. Discharge of water used during the control action may carry sediments and a variety of contaminants to the riparian area and stream.

In-water work. Although the most lethal biological effects of the proposed actions on individual listed species will likely be caused by the isolation of in-water areas, lethal and sublethal effects would be greater than without isolation. In-water work area isolation is a conservation measure intended to reduce the adverse effects of erosion and runoff on the population.

Control Activities

Post-control Site Restoration

The direct physical and chemical effects of post-control site restoration included as part of the proposed activities are essentially the reverse of the pre-control activities. Bare earth is protected by

seeding, planting woody shrubs and trees, and mulching. This immediately dissipates erosive energy associated with precipitation and increases soil infiltration. It also accelerates vegetative succession necessary to restore the delivery of large wood to the riparian area and stream (in the case of control efforts in streams or downstream of control areas), root strength necessary for slope and bank stability, leaf and other particulate organic matter input, sediment filtering and nutrient absorption from runoff, and shade. Microclimate will become cooler and moister, and wind speed will decrease.

In addition to revegetation, site restoration may include restoring or repairs to streambanks. Streambank restoration activities require bioengineered solutions that include vegetation and large wood as the major structural elements to increase bank strength and resistance to erosion stabilization (Mitsch 1996, WDFW, WDOT, WDOE, and USACE 2003). The intent of these activities is to restore riparian function and allow habitat to develop, and allow the banks to respond more favorably to hydraulic disturbance than conventional hard alternatives.

Invasive and Non-native Plant Control—The proposed use of chemicals to control dreissenids is designed to minimize the risk of adverse effects on aquatic habitat and the associated native fish and wildlife species. Chemical (including fuel) transport, storage, and emergency spill plans will be implemented to reduce the risk of an accidental spill of fuel or chemicals. A catastrophic spill would have the potential for significant adverse effects to water quality. The risk of an accidental spill is considered to be minor if best management practices are strictly followed.

An environmental fate and transport analysis is provided for three of the most commonly used chemicals and biocides to control dreissenids – potash, copper sulfate, and *Pseudomonas fluorescens*—to evaluate the risk of effects to water quality from this program. The types of dreissenid control actions proposed offer the best and most effective solutions to eradicate dreissenids. Each type of treatment is likely to affect fish and aquatic organisms through a combination of pathways, including disturbance, chemical toxicity, dissolved oxygen and nutrients, water temperature, sediment, forage, and vegetation.

Herbicide applications

Temporary impacts. Surface water contamination with herbicides occurs when herbicides and biopesticides are applied intentionally or accidentally into ditches, irrigation channels or other bodies of water, or when soil-applied herbicides are carried away in runoff to surface waters. Direct application into water sources is generally used for control of aquatic species. Under the proposed action, herbicides and biocides would be applied directly to the surface of the water. Any juvenile fish in the margins of streams and water bodies are more likely to be exposed to herbicides as a result of overspray, inundation of treatment sites, percolation, surface runoff, or a combination of these factors.

Groundwater contamination is another important pathway. Most herbicide groundwater contamination is caused by “point sources,” such as spills or leaks at storage and handling facilities, improperly discarded containers, and rinses of equipment in loading and handling areas, often into adjacent drainage ditches. Point sources are discrete, identifiable locations that discharge relatively high local concentrations. Proposed conservation measures minimize these concerns by ensuring proper calibration, mixing, and cleaning of equipment. Non-point source groundwater contamination of herbicides is relatively uncommon, but can occur when a mobile herbicide is applied in areas with a shallow water table. Proposed conservation measures minimize this danger by restricting the formulas used, and the time, place and manner of their application to minimize offsite movement. In addition, a thorough analysis of the hydrological and geochemical setting of any project site is integral.

Downstream transport is another important pathway.

Conservation Measures, Minimization Measures, and Best Management Practices

A variety of conservation actions should take effect immediately upon discovery of an introduction of dreissenids to a water body, including following the notification and other steps in Washington's Rapid Response Plan as well as:

- Immediately close the marina or bay to boat traffic and immediately remove any contaminated boats;
- Establish mandatory decontamination procedures for all existing watercraft;
- Collect samples inside and outside of the contaminated area for immediate analysis;
- Determine the feasibility of using silt curtains or barriers to close the bay or marina to open water;
- Remove and decontaminate all boats;
- Treat the entire enclosed area to kill all veligers and possible adults.

The following minimization measures and BMPs will be used during implementation of the project to avoid and minimize adverse environmental effects.

[Nationwide conservation measures](#) would be employed to avoid or minimize impacts to migratory birds.

Treatment areas would be enclosed by a vertical floating curtain barrier that extends from the surface of the water to the bottom of the water body, restricting flow and open water exchange. The barrier outlining the treatment area would make contact with the shoreline and encompass the public boat ramps. Temporarily elevated levels of turbidity during installation of the curtain barriers are not expected to exceed 100 feet from the site of installation of the barriers (note: this is an estimate; the USACE documents a 600-foot distance mixing zone of turbidity associated with dredging. Because the installation of curtain barriers results in much less disturbance to bottom sediment than dredging, we estimate mixing zones will not exceed 100 feet from the curtain barriers).

Potholes Reservoir would be closed off from public use during treatment.

In-water work will be conducted only during the approved in-water work window, as described by the Washington Department of Fish and Wildlife. Receive approval for all appropriate variances to these windows, if necessary.

Any construction associated with the project onsite will be completed in compliance with Washington State Water Quality Standards (Washington Administrative Code [WAC] 173-201A), including:

- Petroleum products, fresh cement, lime, concrete, chemicals, or other toxic or deleterious materials will not be allowed to enter surface waters or onto land where there is a potential for reentry into surface waters.
- Fuel hoses, oil drums, oil or fuel transfer valves, fittings, etc., will be checked regularly for leaks, and materials will be maintained and stored properly to prevent spills.
- A spill prevention, control, and countermeasures (SPCC) plan will be prepared by the contractor and used during all in-water demolition and construction operations. A copy of the plan will be maintained at the work site.
 - The SPCC plan will outline BMPs, responsive actions in the event of a spill or release, and notification and reporting procedures. The plan will also outline management

elements, such as personnel responsibilities, project site security, site inspections, and training.

- o The SPCC plan will outline the measures to prevent the release or spread of hazardous materials found on site and encountered during construction but not identified in contract documents, including any hazardous materials that are stored, used, or generated on the construction site during construction activities. These items include, but are not limited to, gasoline, diesel fuel, oils, and chemicals.
- o Applicable spill response equipment and material designated in the SPCC plan will be maintained at the job site.

In, Over, and Near Water BMPs

Typical construction BMPs for working in, over, and near water will be applied, including activities such as the following.

- Checking equipment for leaks and other problems that could result in the discharge of petroleum-based products or other material into Potholes Reservoir.
- Corrective actions will be taken in the event of any discharge of oil, fuel, or chemicals into the water, including:
 - o Containment and cleanup efforts will begin immediately upon discovery of the spill and will be completed in an expeditious manner, in accordance with all local, state, and federal regulations. Cleanup will include proper disposal of any spilled material and used cleanup material.
 - o The cause of the spill will be ascertained and appropriate actions taken to prevent further incidents or environmental damage.
 - o Spills will be reported to the Ecology's Northwest Regional Spill Response Office at 425/649-7000.
 - o Work barges will not be allowed to ground out.
 - o Excess or waste materials will not be disposed of or abandoned waterward of ordinary high water or allowed to enter waters of the state. Waste materials will be disposed of in an appropriate manner consistent with applicable local, state, and federal regulations.
 - o Materials will not be stored where wave action or upland runoff can cause materials to enter surface waters.
- Flag and identify sensitive resource areas, equipment entry and exit points, road and stream crossings, staging, storage and stockpile areas, and no-spray/application areas and buffers
- Use existing roadways and paths, if possible, and minimize number and length of temporary roads and paths through riparian/floodplains
- Avoid removal of riparian vegetation
- Obliterate all temporary roads and paths upon project completion
- Use properly maintained mechanized equipment that minimizes adverse effects on the environment; store, fuel, and maintain vehicles more than 150 feet from water and wetlands
- Implement any erosion control measures
- Implement any needed dust abatement measures
- Implement appropriate spill prevention, control, and countermeasures to avoid degrading habitat for aquatic species and ESA-listed species.
- Avoid introduction of invasive species by inspecting and following proper cleaning of equipment, vehicles, and personal gear

- Implement construction conservation measures appropriate during control actions (e.g., work area isolation, fish salvage, fish passage, construction and discharge water, sediment control measures, etc.)
- Implement post-construction conservation measures (e.g., site restoration, revegetation, site access, obliteration)
- Consider isolating the project area with a smaller, secondary sediment curtain installed close to the work area.

Potassium Chloride (Potash)

Potassium chloride is an inorganic salt. It is not subject to further degradation processes in the environment and has been shown to be one of the most selective chemicals tested against zebra mussels (Waller et al. 1993; International Programme on Chemical Safety 2001). Review of toxicology literature on the effects of elevated potassium concentrations on zebra mussels and other aquatic organisms is similar to the findings from the Millbrook Quarry eradication project. As shown in the table below, zebra mussels are generally more sensitive to elevated potassium concentrations with expected mortality occurring at 100 ppm. Results also indicate that increased water temperature during treatment with potassium is likely to significantly increase toxicity in zebra mussels. Bivalve toxicity was increased 10-fold when water temperature was increased from 50 degrees Fahrenheit (°F) to 68°F (Aquatic Sciences 1996).

A variety of aquatic species, including certain fish and invertebrates appear to be less susceptible than zebra mussels to the effects of potassium toxicity. In contrast to zebra mussels, no mortality is expected for several common fish species in the 300 to 1,000 ppm potassium range or for planktonic crustaceans at approximately 200 ppm (table below). Several invertebrates and fish show LC501 endpoints far higher than those for zebra mussels.

Derivatives of potassium (e.g., potassium dihydrogen phosphate and potassium chloride) have been shown to kill zebra mussels at relatively low concentration without affecting most nontarget organisms (Fischer et al. 1991). Potassium appears to kill mussels by destroying the integrity of the mussels' gill tissue leading to asphyxiation (Fischer et al. 1991).

Although there is a general lack of significant toxicity information on typical reservoir fish or other invertebrates at target concentrations of 100 ppm potassium, no non-molluscan aquatic wildlife, vegetation, or terrestrial wildlife were harmed during or after treatment at Millbrook Quarry. Virginia DGIF found that turtles, fish, aquatic insects, and snails all "continued to thrive" post treatment (Virginia DGIF 2011).

Table 1. Summary of toxicity literature for general reservoir organisms. LC50=Concentration showing 50% mortality over test period. No-effect concentrations are shaded (BOR 2015).

Taxonomic Group	Species	Endpoint	KCl (mg/L)	Source
Crustaceans	<i>Ceriodaphnia dubia</i> (water flea)	LC50	630	ECOTOX
		Lethal	299-596	ECOTOX
		No-effect	193	Aquatic Sciences 1997
	<i>Hyalella azteca</i> (scud)	LC50 (4 day)	134-630	ECOTOX
	<i>Orconectes limosus</i> (crayfish)	LC50 (30 day)	330-450	ECOTOX
Aquatic insect	<i>Chironomus tentans</i> (midge)	LC550 (4 day)	1,250-6,830	ECOTOX
Annelid Worms	<i>Tubifex tubifex</i>	LC50 (4 day)	813	ECOTOX
	<i>Nais variabilis</i>	LC50 (2 day)	67-75	ECOTOX
Snails	<i>Physa hertostrophia</i>	LC50	940	Daum et al. 1997
	<i>Bimophalaria alexandrina</i>	Lethal	1,000-2,600	ECOTOX
Bivalve molluscs	<i>Corbicula fluminea</i> (clam)	LC50	225	Anderson et al. 1976

	<i>Dreissena polymorpha</i> (zebra mussel)	95% mortality/56 hours at 20 degrees C	100	Aquatic Sciences 1996
		LC50 (1 day)	138	Fisher et al. 1991
Fish	<i>Lepomis macrochirus</i> (bluegill sunfish)	LC50 (4 day)	951-2,010	ECOTOX
		LC50	2,010	Daum et al. 1977
	<i>Gambusia affinis</i> (mosquitofish)	LC50 (4 day)	435-485	ECOTOX
	<i>Pimephales promelas</i> (fathead minnow)	LC50 (4 day)	880	ECOTOX
		Lethal	1,191	ECOTOX
		No-effect	302	Aquatic Sciences 1997
		Near zero	299	ECOTOX
	<i>Cyprinus carpio</i> (carp)	Lethal	5,910-6,590	ECOTOX
	<i>Ictalurus punctatus</i> (catfish)	LC50 (2 day)	720	ECOTOX
	<i>Oncorhynchus mykiss</i> (rainbow trout)	No-effect (7 day)	500-1,000	ECOTOX
Amphibians	<i>Microphyla ornata</i> (frog)	LC50 (4 day)	1,414-2,539	ECOTOX
	<i>Rana breviceps</i> (frog)	Mortality	1,000-10,000	Kegley et al. 2010

Potassium chloride is an essential constituent of the human body for intracellular osmotic pressure and buffering, cell permeability, acid-base balance, muscle contraction and nerve function. Acute oral toxicity of potassium chloride in mammals is low (LC50 = 3,020 milligrams per kg [mg/kg]). In humans, potassium chloride is rapidly excreted in the absence of any pre-existing kidney or circulatory system dysfunction.

The exact mode of action by potassium on mussels is unknown, but evidence suggests that potassium kills mussels by interfering with the organisms' ability to transfer oxygen across gill tissue, resulting in asphyxia (Aquatic Sciences 1997). To ensure lethal concentrations of potassium throughout the water column, yet minimize likelihood of "hotspots" within the waterbody, a "target" potassium concentration of 100 ppm throughout the water column could be established: 50 ppm is used as the minimum concentration to initiate bioassays, though it is estimated that long-term exposure to 30–40 ppm would be sufficient to kill 100% of all dreissenids of all life stages (Aquatic Sciences 2005). At these concentrations, potassium is estimated to pose no human health risks, nor would it likely harm any non-molluscan aquatic wildlife, vegetation, or terrestrial wildlife inhabiting the project site (Aquatic Sciences 2005). The entire water column could be infused with potassium by pumping muriate of potash (potassium chloride – KCl) solution from land-based storage tanks with spill containment through a floating supply line to a work boat outfitted with a specially designed diffuser assembly. Treatment could occur within zones determined by depth and by presence of thermoclines within the water column. Concentrations of potassium would be monitored at various depths along transects established throughout the water body, both during and after "charging" of the waterbody with potash. Mortality of dreissenids would be confirmed by direct and video confirmation of dreissenid mortality by scuba divers. Very little, if any, land disturbance will be required, as the staging area and setup could occur adjacent to the water body in established parking and driving areas as well as boat ramps. No disturbance of substrate or bottom sediments within the water body would likely occur. Monitoring of groundwater infiltration of potassium from the waterbody would occur at adjacent waterbodies for a pre-determined period of time.

APPENDICES

Appendix A. Water body monitoring results for Potholes Reservoir and Moses Lake, 2010–2017.

Appendix A. Water body monitoring results for Potholes Reservoir and Moses Lake, 2010–2017.

Date	Sample Type	Location	Temperature °C	Calcium	DO (mg/L)
9/19/2017	Visual Shoreline Survey	Blue Heron Park - Moses Lake	18		
9/19/2017	Visual Shoreline Survey	Connelly Park - Moses Lake	18		
9/19/2017	Visual Shoreline Survey	Cascade Valley Park Ramp - Moses Lake	18		
9/19/2017	Visual Shoreline Survey	Lower Peninsula Park - Moses Lake	19		
10/18/2017	Visual Shoreline Survey	Connelly Park - Moses Lake	12		
10/18/2017	Visual Shoreline Survey	Cascade Valley Park Ramp - Moses Lake	12		
10/19/2017	Visual Shoreline Survey	Blue Heron Park - Moses Lake	12		
10/19/2017	Visual Shoreline Survey	Lower Peninsula Park - Moses Lake	12		
11/15/2017	Visual Shoreline Survey	Blue Heron Park - Moses Lake	7		
11/15/2017	Visual Shoreline Survey	Lower Peninsula Park - Moses Lake	8		
11/15/2017	Visual Shoreline Survey	Cascade Valley Park Ramp - Moses Lake	8		
11/15/2017	Water for eDNA filtered in field	Lower Peninsula Park - Moses Lake			
11/15/2017	Water for eDNA filtered in field	Blue Heron Park - Moses Lake			
11/15/2017	Water for eDNA filtered in field	Cascade Valley Park Ramp - Moses Lake			
10/19/2017	Horizontal and vertical plankton tows - 1 each per sample	Lower Peninsula Park - Moses Lake	12		
10/18/2017	Horizontal and vertical plankton tows - 1 each per sample	Cascade Valley Park Ramp - Moses Lake	12.1		
10/19/2017	Horizontal and vertical plankton tows - 1 each per sample	Blue Heron Park - Moses Lake	12.1		
10/18/2017	Horizontal and vertical plankton tows - 1 each per sample	Connelly Park - Moses Lake	12.1		
9/19/2017	Horizontal and vertical plankton tows - 1 each per sample	Connelly Park - Moses Lake	18.5		
9/19/2017	Horizontal and vertical plankton tows - 1 each per sample	Lower Peninsula Park - Moses Lake	18.7		
9/19/2017	Horizontal and vertical plankton tows - 1 each per sample	Cascade Valley Park Ramp - Moses Lake	17.8		
9/19/2017	Horizontal and vertical plankton tows - 1 each per sample	Blue Heron Park - Moses Lake	18.2		
9/19/2017	Artificial Substrates	Lower Peninsula Park - Moses Lake	18.7	8.96	8.64

9/19/2017	Artificial Substrates	Cascade Valley Park Ramp - Moses Lake	17.8	8.52	8.61
9/19/2017	Artificial Substrates	Connelly Park - Moses Lake	18.5	9.13	8.58
9/19/2017	Artificial Substrates	Blue Heron Park - Moses Lake	18.2	8.87	8.39
10/19/2017	Artificial Substrates	Lower Peninsula Park - Moses Lake	12	9.51	13.93
10/18/2017	Artificial Substrates	Connelly Park - Moses Lake	12.1	9.43	12.86
10/18/2017	Artificial Substrates	Cascade Valley Park Ramp - Moses Lake	12.1	9.11	12.71
10/19/2017	Artificial Substrates	Blue Heron Park - Moses Lake	12.1	9.47	12.64
11/15/2017	Artificial Substrates	Cascade Valley Park Ramp - Moses Lake	7.5	9.96	14.84
11/15/2017	Artificial Substrates	Lower Peninsula Park - Moses Lake	7.5	10.25	12.67
11/15/2017	Artificial Substrates	Blue Heron Park - Moses Lake	6.9	10.34	14.51
9/19/2017	Water for calcium preserved in field	Connelly Park - Moses Lake	18.5	9.13	8.58
9/19/2017	Water for calcium preserved in field	Cascade Valley Park Ramp - Moses Lake	17.8	8.52	8.61
9/19/2017	Water for calcium preserved in field	Blue Heron Park - Moses Lake	18.2	8.87	8.39
9/19/2017	Water for calcium preserved in field	Lower Peninsula Park - Moses Lake	18.7	8.96	8.64
9/20/2017	Visual Shoreline Survey	Glenn Williams	17		
9/20/2017	Visual Shoreline Survey	Blythe Ramp	17		
9/20/2017	Visual Shoreline Survey	Lind Coulee West Bridge			
9/20/2017	Visual Shoreline Survey	Mar Don Resort	17		
10/19/2017	Visual Shoreline Survey	Lind Coulee West Bridge	12		
10/19/2017	Visual Shoreline Survey	Blythe Ramp	11		
10/19/2017	Visual Shoreline Survey	Glenn Williams	12		
10/19/2017	Visual Shoreline Survey	Mar Don Resort	12		
11/17/2017	Visual Shoreline Survey	Mar Don Resort	7		
11/17/2017	Visual Shoreline Survey	Blythe Ramp	7		
11/17/2017	Visual Shoreline Survey	Lind Coulee West Bridge	8		
6/6/2016	Shoreline survey	Blythe Ramp	18.3		
6/15/2016	Veliger - Plankton Tow	Mar Don Resort	18.2	28	
7/26/2016	Veliger - Plankton Tow	Glenn Williams Ramp	21.4		
7/26/2016	Shoreline survey	Lind Coulee West Bridge	21.7	21.4	
6/13/2016	Artificial substrate	Lower Peninsula Park - Moses Lake	20.6		
6/13/2016	Shoreline survey	Blue Heron Park - Moses Lake	19.9		
7/25/2016	Artificial substrate	Cascade Valley Park Ramp - Moses Lake	22.4		
6/23/2015	Artificial substrate	Glenn Williams Ramp			

6/23/2015	Artificial substrate	Blythe Ramp			
6/23/2015	Artificial substrate	Lower Peninsula Park - Moses Lake			
6/23/2015	Artificial substrate	Blue Heron Park - Moses Lake			
6/23/2015	Artificial substrate	Cascade Valley Park Ramp - Moses Lake			
9/30/2014	Veliger - Plankton Tow	Glenn Williams Ramp			
6/29/2014	Veliger - Plankton Tow	Mar Don Resort			
9/30/2014	Veliger - Plankton Tow	Blythe Ramp			
8/19/2014	Artificial substrate	Connelly park - Moses Lake			
6/29/2014	Veliger - Plankton Tow	Lower Peninsula Park - Moses Lake			
6/29/2014	Artificial substrate	Sunrise Resort - Moses Lake			
6/29/2014	Veliger - Plankton Tow	Blue Heron Park - Moses Lake			
6/29/2014	Veliger - Plankton Tow	Cascade Marina - Moses Lake			
8/5/2014	Veliger - Plankton Tow	Blue Heron Park - Moses Lake			
8/18/2013	Veliger - Plankton Tow	Glenn Williams Ramp			
8/18/2013	Artificial substrate	Mar Don Resort			
8/18/2013	Veliger - Plankton Tow	Blythe Ramp			
8/18/2013	Artificial substrate	Lower Peninsula Park - Moses Lake			
8/18/2013	Artificial substrate	Sunrise Resort (Pier 4) - Moses Lake			
8/18/2013	Artificial substrate	Blue Heron Park - Moses Lake			
8/18/2013	Artificial substrate	Cascade Marina - Moses Lake			
8/5/2013	Veliger - Plankton Tow	Blue Heron Park - Moses Lake			
6/20/2012	Veliger - Plankton Tow	Mar Don Resort			
9/7/2011	Veliger - Plankton Tow	Glenn Williams Ramp			
8/2/2011	Veliger - Plankton Tow	Mar Don Resort			
8/2/2011	Veliger - Plankton Tow	Lower Peninsula Park - Moses Lake			
9/7/2011	Artificial substrate	Sunrise Resort (Pier 4) - Moses Lake			
9/7/2011	Artificial substrate	Blue Heron Park - Moses Lake			
8/14/2010	Veliger - Plankton Tow; Adult - sampler substrate-surface scrapings	Moses Lake near Blue Heron Park			
8/14/2010	Veliger - Plankton Tow; Adult - sampler substrate-surface scrapings	Northern end of Potholes Reservoir			
7/14/2010	Adult - sampler substrate	Middle of Potholes Reservoir			
6/15/2010	Adult - sampler substrate	Mar Don Resort			

Threatened and Endangered Species Profiles