MOSES LAKE SEDIMENT MANAGEMENT PLAN

PREPARED FOR:

MOSES LAKE IRRIGATION AND REHABILITATION DISTRICT
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SEPTEMBER 21, 2009

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1. PROBLEM STATEMENT

Sedimentation in Moses Lake is due to natural and human-accelerated processes. Specific impacts of accumulated sediment are: 1) decreased open water habitat for fish and wildlife; 2) blocked access to boating facilities; 3) limited open water for recreational boating; 4) degraded water quality; and 5) nuisance growth of submerged aquatic vegetation. In the absence of active management actions, many portions of the lake will proceed through a process of succession that reduces the value of the lake as a community resource and as habitat for some important species of fish and wildlife.

2. INTRODUCTION

The purpose of this Sediment Management Plan is to establish a framework for managing the sediment processes in specific areas of Moses Lake. This plan is to be incorporated into the City of Moses Lake Shoreline Master Program update as part of the restoration plan. This document presents existing conditions and processes within the lake, addresses negative consequences of sedimentation in the lake, and provides recommendations for sediment management and removal measures.

The specific goals of this Sediment Management Plan are to:

- Describe the current physical conditions in specific areas of Moses Lake with regard to sedimentation processes.
- Discuss sediment management needs at eight problem areas.
- Establish a framework for present and future management of sediment in Moses Lake in general.

This Sediment Management Plan is in line with the Environmental Goals stated in the Vision Statement of the Moses Lake Comprehensive Plan, which include:

- Promote the restoration of Moses Lake to a healthy state that supports natural habitat while providing recreational benefits to the community
- Acknowledge the integral role of the natural environment to our quality of life
- Increase public access to the lake

2.1 BACKGROUND ON THE MOSES LAKE IRRIGATION AND REHABILITATION DISTRICT

The Moses Lake Irrigation and Rehabilitation District (MLIRD) is the primary agency for planning and implementation of efforts to revitalize Moses Lake. The Moses Lake Irrigation District was formed in 1928 and authorized to manage irrigation water distribution in the Moses Lake region. MLIRD has held a Certificate of Water Right for storage of 50,000 acre feet of water since 1952.

In 1962, the state of Washington authorized certain irrigation districts to convert to irrigation and rehabilitation districts (RCW 87.84.010)—legislation specifically enacted for this district. The Moses Lake Irrigation and Rehabilitation District (MLIRD) was formed at that time and is authorized to "further the rehabilitation or improvement of inland lakes and shorelines, and the modification or improvement of existing or planned control structures located in the district in order to further the health, recreation, and welfare of the residents in the area" (RCW 87.84.050) .

The following is a list of past and ongoing contributions of the MLIRD to improving Moses Lake:

- Water management actions to control nutrient input from agricultural lands through partnering with farmers and adjacent conservation districts via the Clean Lakes project in the 1980's. This has improved water quality and recreational opportunities in Moses Lake.
- Constructed a pumping station, using grants from the Washington Department of Ecology and the U.S. Environmental Protection Agency that pumps water between Parker Horn and Pelican Horn. This has improved water quality in Pelican Horn.
- Developed an ongoing program to harvest and dispose of nuisance submerged vegetation using mechanical weed harvesters. This has maintained open channels free of excessive vegetation, debris and foreign material and has improved fish habitat and recreational opportunities.
- In cooperation with Washington Department of Fish and Wildlife (WDFW), installation and maintenance of a screened carp barrier in Pelican Horn, which has increased the amount of rearing habitat available for key sport fish species.
- Conducted water quality studies in Moses Lake in collaboration with the Washington Department of Ecology and the University of Washington.
- Sponsors annual lakeshore clean-up efforts by volunteers, involving trash removal of 30 to 50 cubic yards per year.
- Manages the operation of Connelly Park, formerly Airman's Beach, on Rocky Ford Arm for the benefit of recreational users and area residents.
- Coordinates irrigation water flow management through Moses Lake to Potholes Reservoir with the Bureau of Reclamation. These inputs have a major beneficial effect on water quality in the lake.
- Supports efforts to control the carp population.

3. PHYSICAL SETTING

3.1 LAKE AREA AND DRAINAGE AREA

Moses Lake has approximately 111 miles of shoreline and a surface area of approximately 6,800 acres. At a water surface elevation of 1047 feet, the depth ranges from 2 to 35 feet deep.

The Moses Lake watershed includes portions of Lincoln, Adams, Grant, and Spokane Counties and receives perennial flow from Crab Creek and Rocky Ford Creek (Figure 1). Rocky Ford Creek contributes substantial flow but is a spring-fed stream with a very small surface drainage area. The Crab Creek drainage is approximately 2,200 square miles as measured upstream of the U.S Bureau of Reclamation (USBR) gage at Road 7 (located 3 miles upstream of Moses Lake). Rocky Coulee Wasteway drains to Crab Creek approximately 1½ miles below the USBR gage on Crab Creek (Figures 1 and 2).

The Rocky Coulee Wasteway, a concrete channel, was built in 1954 by the USBR to provide a means to divert water from the East Low Canal into Crab Creek, Moses Lake, and Potholes Reservoir. The upstream end of this concrete wasteway begins at a 0.35 mile-long rock dam that diverts surface flows from Rocky Coulee to the wasteway. Approximately 0.6 mile downstream of the diversion dam, the gated diversion channel from the East Low Canal converges with the wasteway and flows approximately 4 miles to Crab Creek.

Prior to construction of the wasteway, Rocky Coulee drained south to Lind Coulee and not to Moses Lake. During spring runoff a temporary lake would form in the area of Rocky Coulee near the location of the diversion dam. The construction of Rocky Coulee Wasteway added approximately 185 square miles to the natural drainage area of Crab Creek and Moses Lake. The drainage area of Rocky Coulee contains a high proportion of dryland wheat farms and a much smaller area of irrigated lands. There is no defined stream channel in the reach of Rocky Coulee immediately upstream of the diversion dam due to tilling of the entire width of the coulee. However, during infrequent surface flow events in the coulee, a channel is cut through the tilled fields by flowing water.

3.2 WATER LEVELS AND INFLOW

Although Moses Lake was originally a natural lake, it was designated for irrigation water storage and distribution for the Columbia Basin irrigation project by the USBR in the 1950’s and is thereby a managed waterbody. Moses Lake is connected to Potholes Reservoir, a USBR facility to the southwest. The water level in Moses Lake is controlled at the southern end of the lake by two outflow structures, one owned by the MLIRD and one owned by the USBR. The current operating regime entails drawing the water level of Moses Lake down to an elevation of 1042 feet in November to allow off-season access for maintenance and construction and to provide flood storage to Potholes Reservoir. The water level naturally increases starting in February or March, and by April, it reaches an elevation of 1047 +/-feet to store and convey irrigation water and support recreation and all other beneficial uses.

The two major sources of surface inflow to Moses Lake are Crab Creek, which flows into the northern tip of Parker Horn, and Rocky Ford Creek, which flows into the north end of the lake (Figure 1). Overall, Crab Creek where it enters Moses Lake exhibits a highly unusual flow regime that is sustained by groundwater, affected by flood episodes fed by snowmelt in the watershed, and by Bureau of Reclamation feed route released through Rocky Coulee Wasteway just above Moses Lake. Most of the annual discharge volume of Crab Creek is contributed by Rocky Coulee Wasteway during several months of the spring and summer. The wasteway enters Crab Creek approximately one and one-half miles above Moses Lake and contributes approximately 85% of the total inflow to the lake from all surface sources. The Columbia Basin irrigation project's East Low Canal is the source of water for Rocky Coulee Wasteway except during infrequent winter storms. Rocky Ford Creek and the mainstem of Crab Creek (Gloyd Seeps springs) contribute approximately 10% and 5% respectively of the total flow into Moses Lake (WDOE 2002).

The Bureau of Reclamation recently studied options for increasing the overall flow rate year-round via Crab Creek from the Billy Clapp Reservoir through Moses Lake to provide supplemental feed water to Potholes Reservoir for use by the South Columbia Irrigation District (U.S. Department of the Interior 2007). This would involve discharges from Lake Billy Clapp through the natural channel of Crab Creek, increasing the flow in Crab Creek by 100 to 500 cfs. During late summer and fall of 2006, the USBR tested this feed route with discharge of approximately 150 cfs. During the test period, flow at the mouth of Crab Creek was attenuated by entrance of the feed water into the ground. No appreciable increases in discharge at the mouth of Crab Creek were noted during the Fall 2006 feed route test. A NEPA Environmental Assessment for all proposed supplemental feed options has been prepared by USBR.

In contrast to Crab Creek, Rocky Ford Creek exhibits a typical stable flow pattern as seen for most spring-fed streams. Annual mean flow in Rocky Ford Creek is approximately 78.2 cfs (WDOE 2000). The USBR plans to increase feed water to Crab Creek that would likely increase flows in Rocky Ford, perhaps substantially in the spring.

Flows through Moses Lake vary substantially on a seasonal basis. In early April, Rocky Coulee Wasteway (and therefore Crab Creek) is at its peak annual flow (2238 cfs, April 1st average 2000-2001) and is used to transfer water from the USBR's East Low Canal through Moses Lake into Potholes Reservoir for use by irrigators in the South Columbia Basin Irrigation District. By December, Crab Creek typically reaches its annual low flow (20 cfs, 2000-2001 average). The 100-year flood peak discharge for Crab Creek is predicted to be 14,100 cfs.

3.3 WATER QUALITY

Moses Lake exhibited hypereutrophic conditions prior to implementation of the Clean Lakes Project in the 1980s. During the Clean Lakes Project, about $8 million dollars in projects were implemented to clean the lake with grant funding from EPA and Ecology. Key projects that significantly improved lake water quality in the lake were: 1) eliminating direct disposal of wastewater in the lake; 2) Columbia River water diversion from East Low Canal down Rocky Coulee Wasteway and into Moses Lake; and 3) conversion of rill irrigation to center pivot irrigation on surrounding agricultural land. The MLIRD was the lead agency managing these projects and the lake.

Large algal mats that were common and contributed to fish kills were eliminated. However, as is common in lakes, the clear water provided a better habitat for submerged aquatic vegetation. Both native and invasive aquatic plants became well established due to the clearer water coupled with the ever increasing sediment deposits on the lake bottom. The MLIRD owns and operates two weed harvesters to remove excessive growth of aquatic plants that hinder recreation and boating in the lake.

Despite the improvements to water quality, the phosphorus concentrations in the lake still exceed state water quality standards. Therefore, Moses Lake was placed on the Clean Water Act 303(d) list in 2004 for elevated concentrations of phosphorus.

Annual inflows of feed water from Rocky Coulee Wasteway during the summer months continue to have positive impacts on water quality in Moses Lake by mitigating the water quality concerns for significant parts of the year. The efforts of the MLIRD, such as the water pumping station from Parker Horn to Pelican Horn and the weed harvesting program, have also contributed to improvement of water quality in the lake.

3.4 SEDIMENT SOURCES

There has been no specific study that addresses sedimentation or sources of sediment to Moses Lake. However, major processes contributing to the sediment load in the lake are believed to be the following: 1) wind-borne soil from open-till farming practices; 2) erosion of soils in the Crab Creek drainage; 3) soil erosion from areas without defined channels that drain to Moses Lake, particularly Rocky Coulee; 4) shoreline erosion due to wind-driven currents; 5) shoreline erosion resulting from degraded emergent or riparian vegetation; and 6) decomposition of aquatic vegetation in the lake.

3.4.1 Wind-Borne Soil

In the Columbia Basin, the climate is dry, vegetation cover is relatively thin, and soils are typically composed of silt or fine sand, making them susceptible to wind and water erosion (WDOE 2006). Wind erosion of tilled soils is recognized as a major contributor to air quality problems in the Columbia Basin, and ongoing research is addressing means to reduce soil losses (Papendick 2004).

The following quote from Papendick (2004) describes the potential for wind erosion to contribute to Moses Lake sediments:

> "Most soils on the Columbia Plateau are derived from windblown sediments deposited over the last 15,000 years, although dust deposition has been ongoing in the region for two million years resulting in loess deposits up to 75 m (250 ft) thick. Many of the soils contain significant amounts of fine particulates and if exposed when dry can produce massive clouds of dust during high wind events that may be carried for hundreds of miles or farther in turbulent eddies (Busacca and Sweeney, 2004)."

In contrast to dust that is deposited on land and possibly remobilized by future wind storms, dust which contacts the surface of Moses Lake becomes a permanent component of the sediment load. The Columbia Basin experiences seasonal (March, April, May) wind storms which cause erosion of bare soil from spring seed bed tillage and field preparation on agricultural land to the west of Moses Lake (D. Beckley, consultant to MLIRD, personal communication). Specific measurements of dust deposition are not available for Moses Lake; however, based on the nature of the adjacent soils and the frequent wind storms, we conclude that wind-borne material is a significant source of sediment to Moses Lake.

3.4.2 Crab Creek

The stream banks of Crab Creek are subject to erosion due to their fine texture and are likely a source of sediment. In addition, irrigation return flow transports relatively small volumes of suspended material to the stream that is either deposited in the channel or conveyed downstream.

Substantial volumes of stored sediment are apparent in the channel of Crab Creek upstream of the confluence of Rocky Coulee Wasteway. This sediment may be the result of ongoing small-scale erosion processes as described above or may be the result of past large-scale movements of sediment into Crab Creek. The channel of Crab Creek is poorly defined downstream of Adrian (Figure 1). Consequently, much of the upland drainage area of Crab Creek could only contribute large volumes of sediment irregularly when flow occurs overland. Further, sediments stored in Crab Creek's channel upstream of the confluence with Rocky Coulee Wasteway are unlikely to be transported out of the Creek except during extreme flows. Sediment is less apparent in the channel of Crab Creek between its confluence with Rocky Coulee Wasteway and Moses Lake. The feed water from the East Low Canal, conveyed through Rocky Coulee Wasteway, increases the capacity of Crab Creek to transport sediment out of this reach and to Moses Lake; therefore, deposited sediments do not persist in Crab Creek below the confluence with Rocky Coulee Wasteway.

3.4.3 Rocky Coulee Wasteway

Based on a site reconnaissance and a review of flow data from Rocky Coulee, it is concluded that Rocky Coulee, above the diversion dam and easterly to near Ritzville, is a major source of sediment to Moses Lake. Surface water flow from Rocky Coulee is typically very limited; however, during specific years heavy snow melt causes substantial flows to occur at a time of year when it can convey a large volume of sediment to Moses Lake via the Rocky Coulee Wasteway.

Figure 3 shows the peak mean daily flow and the total discharge from Rocky Coulee Wasteway for the months of January and February (note: March is included for selected years as stated on Figure 3). These months were chosen because it is a period when releases from East Low Canal typically don't occur, and nearly all of the flow would originate from Rocky Coulee upstream of the diversion dam. This is the time of year that substantial flow can be generated in the normally dry drainages of central Washington due to the occurrence of "rain-on-snow" precipitation events that rapidly melt snow. Figure 3 only shows years in which the peak mean daily flow exceeded 100 cfs for at least one day and when increased flows in Crab Creek are apparent based on USGS gage data. The 100 cfs flow threshold was selected as a level that is expected to mobilize a substantial volume of sediment from the tilled lower reaches of Rocky Coulee and the upslope fallow uplands.

The peak mean daily flow during January through March for the period 1956-2005 (Rocky Coulee Wasteway was completed in 1954) was 1,660 cfs and occurred on February 22, 1956. In calculations of daily sediment transport, peak daily mean flow should be used rather than peak mean daily flow. Peak daily mean flow is 5-10 times smaller than peak mean daily flow. Therefore, we divided the peak mean daily flow by a factor of ten. No suspended sediment concentrations were measured during that event; however, it is possible to calculate rough estimates of the magnitude of the sediment that could be transported by such an event by applying suspended sediment concentrations reported in the literature for other areas. Based on the fine-grained tilled soils present in Rocky Coulee it is appropriate to select relatively high suspended sediment values from the literature. The highest values are typically measured in the arroyos of the Southwest US and can range as high as 92,500 mg/L (Gellis, USGS). For the calculations below, we have assumed that suspended sediment concentrations would be lower than in the arroyos and would range from 2,150 mg/L (data is from the Bogachiel River on the Olympic Peninsula of Washington, USGS 1982) to 10,000 mg/L (data from urban runoff; Campbell, Laycak et al). Applying these values to an appropriate equation:

> Peak Mean Daily Flow (in cfs) /10 X Concentration (in mg/L) X a constant (0.00270) = tons of sediment per day (D. Simpson and V. Shepsis, Coast and Harbor Engineering, personal communication)

yields an estimated range of 960 to 4,500 tons of sediment transported out of Rocky Coulee in one day. Assuming a conversion of 1.6 tons of sediment per cubic yard, this translates to 600 to 2,800 cubic yards. This sediment would have been transported through Rocky Coulee Wasteway to Crab Creek and Moses Lake. Figures 4, 5, and 6 show sediment-laden water entering Crab Creek and being conveyed to Moses Lake in February of 1980 during another high water event. Applying the same assumptions about sediment concentration as above to the peak flow of 1067 cfs that occurred in February of 1980 yields an estimated range of 620 to 2,900 tons (390 to 1,800 cubic yards) of sediment transported from Rocky Coulee to Crab Creek and Moses Lake during the peak flow day of the event. It is clear that Rocky Coulee is a major source of sediment during specific years; however, Figure 3 demonstrates that flows from Rocky Coulee have not been large over the last 15 years. MLIRD staff observed flow and turbidity in Crab Creek and Rocky Coulee Wasteway during the snowmelt event on February 13, 2008. Crab Creek (above Rocky Coulee Wasteway) was estimated to be flowing at approximately 400 cfs, while Rocky Coulee Wasteway was flowing at approximately 500-600 cfs. Both flows were turbid with secchi disc readings of 12 inches or less. The ground was still frozen in the lower reaches of Rocky Coulee on that date and erosion was not apparent in that area. The source of the turbidity was upstream of that point in either smaller channels or rivulets that feed to the floor of Rocky Coulee. Stream bank erosion and remobilization of stored in-channel sediment was likely the source of the turbidity in Crab Creek, but this was not verified by direct observation. We conclude that

Rocky Coulee can and will contribute large volumes of sediment when weather conditions are appropriate.

3.4.4 Shoreline Erosion

Shoreline erosion is apparent in several portions of the lake as is slumping off steeply constructed shorelines (a notable example is in the Laguna area). Removal of shoreline vegetation (both emergent wetland and riparian) increases shoreline erosion and slumping. Because Moses Lake is only 18 feet deep on average, wind-driven currents can transport a substantial amount of suspended sediment around the lake. The shallow lake bottom allows wind to move considerable volumes of water, which in turn can displace and move sediment. Turbidity in shallow water can be readily observed in the lake when waves hit the shoreline. The consequences of wind-driven sediment transport depend on the direction and duration of wind in specific regions of the lake. The abundant population of carp in Moses Lake also causes increased suspended sediment in the lake. Spawning and feeding carp cause high turbidity in localized areas, which in turn is transported by wind waves to other areas of the lake.

3.4.5 Decomposition of Aquatic Plants

Decomposition of algae and aquatic plants within the wetted region of Moses Lake also contributes sediment on a continuous basis. Examination of a limited number of sediment samples from Wild Goose inlet indicated that sediments typically have less than 10% organic matter. Therefore, organic material accumulation does not appear to be the major source sediment lake-wide, but may contribute a substantial volume in specific locations that retain accumulated plant material due to their physical characteristics.

3.5 FISH AND WILDLIFE

Current sedimentation processes are reducing the depth of Moses Lake. The most notable reductions in depth (and related increases in nuisance submerged aquatic vegetation) are occurring in specific locations that have been identified as problem areas from the perspective of recreational boating and access to docks and other shoreline facilities (see Section 4). Changes in aquatic habitat are also occurring due to the increased growth of submerged aquatic vegetation. A further concern, from both a recreational and habitat consideration, is that continued sediment deposition could lead to large uniform stands of emergent vegetation, primarily cattails and bulrushes in portions of the lake. An increase in emergent vegetation would have an adverse affect on recreation; however, the impacts on aquatic habitat would be mixed. Currently the lake supports specific areas with substantial emergent vegetation, but this habitat type is not dominant. With continued sediment deposition this habitat type is likely to increase dramatically in some locations. Overall, increases in submerged aquatic vegetation and uniform stands of vegetation are likely to decrease habitat complexity in the lake.

The primary fish and wildlife management objective for this Sediment Management Plan is to maintain habitat complexity in Moses Lake. This management objective and the conclusions of the sections below are based on a technical meeting that was held in January of 2007 at the Washington Department of Fish and Wildlife (WDFW) office in Ephrata. The attendees at the meeting were:

Jeff Korth, District Fish Biologist, WDFW
Jim Tabor, District Wildlife Biologist, WDFW
Eric Pentico, Area Habitat Biologist, WDFW
Glenn Grette, Senior Fisheries Biologist, Grette Associates
Josh Robins, Fisheries Biologist, Grette Associates

In addition, the section below incorporates edits addressing comments provided by Jeff Korth and Jim Tabor on a draft of this report.

3.5.1 Fish

Moses Lake supports substantial populations of sport fish species, and recreational fishing use is high. The majority of species in the lake are introduced, non-native species. No federally listed threatened or endangered fish species are present. Key sport fish species are yellow perch, largemouth and smallmouth bass, walleye, black crappie, bullhead, and bluegill. Rainbow trout are stocked regularly and support a popular fishery. The abundance of panfish populations have declined in the past several decades (J. Korth WDFW, personal communication). While many factors have contributed to this decline, changes in species composition and degradation of near-shore habitat have likely played an important role. Carp are very abundant, but are not sought by anglers in proportion to their abundance. The abundance of carp limits populations of other species through competition and their adverse effect on habitat.

Central Washington University (CWU) was contracted by WDFW in 2004 to analyze fish sampling data from Moses Lake. The survey data indicate that key sport fish species in Moses Lake show some preference for specific shoreline substrate types (CWU 2004; Figure 7), but that no strong trends in habitat use exist for any species. This indicates that most key sport fish species in Moses Lake rely on a complex array of habitat types depending on life history stage, rather than one or two specific types (CWU 2004). The data suggest that maintaining habitat complexity within Moses Lake will serve the habitat needs of key sport fish species.

Emergent and submerged vegetation each provide high quality fish habitat when present in modest densities and in a mosaic of open water. Emergent vegetation is beneficial to fish as cover and as habitat for prey. Dense stands of emergent vegetation can preclude access by fish and limit the availability of the prey produced. Overall, areas of fringing emergent vegetation adjacent to open water have benefits for fish and provide complex edge habitat.

Submerged vegetation in moderate densities provide high quality early rearing habitat adjacent to spawning habitat. High densities of submerged vegetation can preclude access by fish to habitat and prey resources.

3.5.2 Waterfowl

Moses Lake is an important habitat for waterfowl within the Pacific Flyway. American widgeon, northern pintail, gadwall, mallards, and Canada geese can be found in high densities. The islands of Moses Lake provide most of the nesting habitat for ducks and geese (Tabor, personal communication).

Many areas of the lake contain valuable nesting and brood rearing habitat for dabbling ducks, herons, grebes, and other species.

Waterfowl require complex habitats where areas of emergent vegetation are adjacent to areas of open shallow water. Emergent vegetation provides cover for dabbling ducks that feed on seeds and aquatic invertebrates, as well as other species such as Western and Clark's grebes. These species are known to use dense mats of submerged aquatic vegetation for nesting in Moses Lake (Tabor, personal communication). Shallow open water allows productivity of submerged vegetation that supplies the forage base for many waterfowl species.

During low water conditions in Moses Lake, waterfowl use exposed sediment bars for loafing and resting. Those areas farthest from human disturbance provide the best habitat. Some areas of Moses Lake are sufficiently devoid of human disturbance to allow substantial waterfowl activity (J. Tabor WDFW, personal communication).

Emergent vegetation can occur in stands dense enough to preclude or reduce use by waterfowl. WDFW is actively removing dense stands of emergent vegetation and other species in other areas of Grant County to enhance waterfowl habitat. Projects have been conducted or are planned for areas near Winchester Wasteway and Frenchman Hills Wasteway where emergent coverage was approximately 90% (Tabor, personal communication). Overall, emergent vegetation provides its greatest benefits to waterfowl when it is part of a complex habitat mosaic that includes substantial areas of open water. For example, the optimum for breeding mallard ducks is 50% coverage of emergent vegetation (Tabor, personal communication).

Submerged vegetation is beneficial as waterfowl forage, with curly leaf pondweed being one of the most valuable species that is common in the lake.

4. PROBLEM AREAS

4.1 PARKER HORN

Parker Horn is the extension of Moses Lake that receives the direct discharge of Crab Creek, and it is the area that poses the greatest sediment management challenge in the lake (Figure 2). The MLIRD's area of concern in Parker Horn consists of two distinct areas separated by Neppel Crossing (formerly known as the Alder Street fill) that are being affected by common sediment delivery processes (Figure 8). The two areas represent different stages in a sediment-driven successional process.

In the area north of the crossing (Figure 8), sediment has essentially filled the available area of the lake with the exception of the channel that is kept open by high stream flows originating from canal feed water that flows down from Rocky Coulee Wasteway. South of Neppel Crossing (Figure 8), sediment deposition has begun more recently, but the pattern for the future is discernable and clear based on conditions north of the crossing. The two areas are discussed separately below because the MLIRD believes that different kinds of actions are desirable in the different locations.

4.1.1 Existing Conditions North of Neppel Crossing

The primary sources of sediment are the bedload and suspended load of sediment delivered by Crab Creek and by Rocky Coulee via Rocky Coulee Wasteway. Sediment has formed a long bar that is apparent at low water along the east shore (Figure 9). The depth of the sediment above the native cobble substrate is typically 3-4 feet, although locations as deep as 7-11 feet have been detected by probing. Based on probe surveys conducted by the MLIRD previously, the bottom of the open water channel is dominated by cobble substrate. Based on the shape of the bar and substrate in the bottom of the channel, we surmise that sediment deposition and transport has nearly reached an equilibrium in this location and that most sediment delivered to this area is now being transported south of the crossing and therefore filling the deeper and more actively-used portion of the lake.

Sediment is transported by varying means depending upon the water level in the lake and inflows from Rocky Coulee Wasteway. At low lake levels and with little discharge from Rocky Coulee Wasteway, sediments are probably not transported out of the reach of Crab Creek between its confluence with Rocky Coulee Wasteway and Moses Lake. At high flows with low water, most of the sediment would be expected to move as bedload in the cobble bottomed channel and be transported south of Neppel Crossing.

At high lake level, the slack water velocity of the lake projects well upstream of the northern end of the bar. This low energy condition causes deposition of sediment in the channel and on the top of the bar (Figure 9). Sediment deposited in the channel under these conditions would be mobilized by the next low lake level/high flow conditions, which would typically occur during early spring. During March of 2007, prior to inputs of East Low Canal feed water from Rocky Coulee Wasteway, MLIRD staff probed the areas of the channel and detected deposits of up to several feet of sediment overlying the cobble substrate. Based on probe sampling conducted by the MLIRD during late spring of 2007, this sediment was transported downstream when water was fed from East Low Canal through Rocky Coulee Wasteway. Assuming that 2 feet of sediment was present in the channel area during the spring, then approximately 40,000 cubic yards of sediment was transported below Neppel Crossing as flows from East Canal increased in late spring 2007.

MLIRD staff probed the channel upstream of Neppel Crossing the second week of March 2008, prior to initiation of inflow from East Low Canal, to assess the depth of the sediment deposit within the channel. The depth of the sediment layer overlying the cobble substrate was measured every 100 ft along the length of the channel and was found to range between 2 and 4.5 ft thick and averaged 2.75 ft. thick. Based on the 2.75 ft average depth, the volume of sediment present within the channel that is subject to downstream transport is estimated to be approximately 55,000 cubic yards.

Although the sediment processes on the bar itself may be in a general state of equilibrium, deposition still occurs on top of the bar during high water. The pattern of sediment moving across the top of the bar can be discerned in Figure 9. In permitting documents prepared previously for MLIRD, the sedimentation rate on top of the bar upstream of Neppel Crossing was estimated to be approximately ½ inch per year based on the depth of the Mt. St. Helens ash layer. Based on this estimated sedimentation rate, the accretion on the bar is estimated to be approximately 1,700 cubic yards per year.

Overall, the sediment measurements conducted over the last two years indicate that sediment volumes on the order of 50,000 cubic yards are being delivered annually to Parker Horn above Neppel Crossing. Observations to date indicate that most of this volume is transported below Neppel Crossing when inflow from East Low Canal is introduced in the spring.

The deposition of sediment has caused the channel to migrate to the west and direct energy against the west bank (Figure 9). The riprap and reed canary grass that line this armored section of the west bank are apparently sufficient to prevent erosion of the west bank, but localized scour in this area could occur. Because the bottom of the channel is cobble, it is not expected that the channel will downcut in this area. The narrowing and redirection of flow that occurs at Neppel Crossing focuses streamflow and energy in this area.

The fine substrate of the bar north of the crossing supports a diverse assemblage of submerged vegetation species, some of which are beneficial as forage to waterfowl. Historically, the shoreline along the bar consisted of larger cobble substrate and supported abundant curly leaf pondweed, an important food for waterfowl (J. Tabor WDFW, personal communication). This species is less abundant with the current fine sediment. During high lake level, the bar is heavily used by waterfowl that forage on the submerged vegetation. This bar is an important brood rearing area for waterfowl, but little nesting occurs north of Neppel Crossing. The absence of tall emergent vegetation is beneficial to waterfowl, allowing open access to submerged vegetation for foraging without impeding flight or detection of predators or humans (J. Tabor WDFW, personal communication). During the fall through early spring, the exposed bar supports large numbers of wintering waterfowl (Tabor, personal communication).

Walleye spawn in reaches of Crab Creek with clean cobble substrate, particularly upstream of the Highway 17 Bridge (Figures 8 and 9). Fishing for walleye is very productive in the channel during the spawning run, and most of the angling effort occurs from the west bank. Angling from boats and recreational boating in this area is possible, but the narrow opening under Neppel Crossing and the occurrence of high water velocity and a narrow passage through this area limit use by boaters. Carp are very abundant near the bar, and their spawning activities disturb the sediment causing it to be transported downstream by the current.

4.1.2 Future Conditions North of Neppel Crossing

Without measures to control sediment from Crab Creek into Moses Lake, modest sediment deposition will continue north of the crossing. Based on the existing configuration of the bar, most of the sediment reaching this area will be transported south of the crossing. At high lake levels, sediment will continue to deposit on the top of the bar, gradually increasing its elevation. This will allow recruitment of emergent vegetation, which will further accelerate deposition on the top of the bar. It is anticipated that in the near future the bar will transition to a dense emergent marsh.

This change in habitat would cause a dramatic decline in waterfowl use on the bar during the fall and early spring. Carp use of the bar continues, but may decrease. Walleye use of the area is expected to be unchanged as would be recreational boating, which is currently limited on the bar due to shallow water depth. Those activities can currently only occur in the channel, which is expected to persist due to regular flows from Rocky Coulee Wasteway.

4.1.3 Existing Conditions South of Neppel Crossing

As sediment has filled the area north of Neppel Crossing, increasing volumes of sediment have been transported south of the crossing. A long bar is beginning to form to the east of the main channel. Deposition is occurring along the west shore where the channel swings away from the shore. Also a pocket of sediment has accumulated south of the crossing along the west bank (Figure 8).

This area is more heavily used for recreational boating than the area north of Neppel Crossing. Further, this area supports a high number of private residences most with docks and a focus toward water-based recreation.

Waterfowl use in this area is very high for both brood rearing and migrant wintering (Tabor, personal communication). Fish species common to the lake would be present in this area; however, it has not been identified as a high use area for any fish species or by anglers.

4.1.4 Future Conditions South of Neppel Crossing

The lack of sediment storage capacity north of the crossing will cause increased deposition to occur south of the crossing. Given the width of the lake in this area and the lack of defined channel through this reach, it is anticipated that all of the sediment that is transported from above the crossing to this portion of the lake will be deposited and persist here. These conditions will persist until the configuration of the channel develops similarly to the area north of the crossing and a more defined set of bars and channels develops. At that point additional sediment inputs would be transported downstream in the channel as is currently occurring upstream of Neppel Crossing.

The developing bar (Figures 8 and 9) will increase in size and decrease the amount of open water surface area, limiting access for fishing and boating in this area, just as has occurred upstream. This change could dramatically affect boat access for fishing and recreation and also boat access to private residences along the west bank. Reduced access for boats would result in increased use by waterfowl.

The MLIRD believes that the USBR's plan to convey increased flows through Crab Creek (see Section 3.2) will increase sediment delivery to Parker Horn. The magnitude of this increase cannot be predicted. It is the MLIRD's goal to implement sediment management actions in Parker Horn prior to flow increases as a means to compare pre-project and post-project sediment delivery to Parker Horn.

4.1.5 Management goals and actions at Parker Horn

The management goals for Parker Horn are to: 1) intercept sediment in Parker Horn before it is transported to further into the lake 2) maintain open water for boating, fishing, and access to docks south of Neppel Crossing by limiting sediment transported from north of the crossing; 3) protect waterfowl habitat complexity along the bar north of the crossing; and 4) maintain fish habitat resources both north and south of the crossing.

North of Neppel Crossing

Management actions proposed in this area to achieve the goals listed above include construction and maintenance of a sediment trap upstream of Neppel Crossing (Figure 10) that entails the following:

1. Removal of deposited sediments on portions of the bar and near the railroad track.
2. Removal of accumulated sediment at the toe of the slope of the bar (Figure 10). The purpose of this action would be to limit mobilization of sediment from this area during high flow.
3. Possible construction of a submerged rock weir in the bottom of the channel to capture bedload sediments that would be dredged before it is transported out of the area.

We envision that the opportunity exists for fine tuning of any dredge actions to alter the channel or bar configuration in a manner to enhance fish or wildlife habitat. WDFW staff will be consulted during design and permitting as a means to identify opportunities that are consistent and compatible with the MLIRD's overall objectives.

South of Neppel Crossing

The actions proposed above for north of the crossing are expected to dramatically reduce sediment delivery south of the crossing. However, the following actions may still be warranted south of the crossing:

1. Removal of accumulated sediment from the pocket area south of the crossing along the west bank (Figure 11). This may be considered as a location for a sediment trap; however, if actions north of the crossing are successful, a maintained trap in this location may not be needed.
2. Removal of accumulated sediment from the west shore to maintain boat access (Figure 11). The necessity for an additional sediment trap downstream of Neppel Crossing would be evaluated based on the efficacy of the sediment trap proposed upstream.
3. Removal of the developing submerged bar may be necessary if it compromises boating.

4.2 LAGUNA

The Laguna site consists of a network of shallow basins interconnected by narrow channels (Figure 2). The basins are connected to Moses Lake by two main channels at the north and south ends (Figure 12). The majority of the Laguna area was excavated from upland to provide waterfront access to residential properties. All of the basins, the interconnecting channels, and the north inlet have become shallow due to accumulation of sediment (Figure 12).

Four processes are affecting the Laguna site: 1) bedload and suspended sediment migrating along the lake shoreline is deposited in the north channel and the south channel; 2) deposition of wind-borne sediment from dunes and exposed construction sites west of the Laguna area; 3) sloughing of shorelines into the basins; and 4) accumulation of organic matter from the heavy growth of aquatic weeds. No natural means exist to transport sediments from this area.

4.2.1 Existing Conditions - Basins and Connecting Channels

Sediment accumulation has reduced the width and depth of the channels connecting the basins at Laguna. This has restricted the circulation of water through the basins and has reduced boat accessibility. Boat access to Moses Lake through the connecting channels is a very valuable feature to the shoreline properties.

Much of the residential shoreline in these basins has been landscaped down to the ordinary high water mark, and varying densities of riparian vegetation exists. Sloughing of banks is apparent in some of the basins and has contributed a large volume of the sediment. Submerged vegetation is dense in the majority of the basins due to the shallow depth, and decomposition of this material may be a major source of sediment, but this has not been verified.

The Laguna basins provide juvenile rearing habitat for key sport fish species. Great Blue Herons and Black Night-Crowned Herons use a large roosting area to the south of the Laguna area (J. Tabor, WDFW, personal communication); however, this area is not as heavily used by waterfowl as other areas of Moses Lake due to high levels of human activity.

4.2.2 Future Conditions - Basins and Connecting Channels

The channels connecting the inland basins (Figure 12) will eventually become blocked with sediment, isolating the individual basins from one another. The connecting channels and the individual basins are expected to gradually be dominated by emergent vegetation if no action is taken. This will eliminate access to docks and open water.

Rearing habitat for juvenile fish is limited by poor connectivity between basins, decreased water depths in the individual basins, and submerged vegetation reducing areas of open water surface area (J. Korth, WDFW, personal communication). These changes will accelerate, causing significant habitat losses for juvenile sport fish species.

4.2.3 Existing Conditions - North and South Inlets

Sediment migrating along the shoreline of Moses Lake at Laguna has reduced the width and depth of the mouth of the north inlet (Figure 12). Currently water depths in the inlet are two to three feet deep making boat access difficult. The south inlet (Figure 12) to the Laguna area is much wider and deeper, and boat access is currently unrestricted; however, deposition is occurring at a slow rate in this inlet.

4.2.4 Future Conditions - North and South Inlets

Without measures to reduce or remove sediment, boat access through the north inlet will be lost, and this area will become dominated by emergent vegetation. The same result could occur in the south inlet, but sediment deposition is not expected to affect boat access in the foreseeable future.

4.2.5 Management Goals and Actions

The sediment management goals at Laguna are to: 1) maintain open channels between the different basins to allow boat and fish access; 2) maintain open channels to Moses Lake to allow boat and fish access; 3) maintain water depth in the basins for boat access and use; and 4) maintain habitat complexity for fish and wildlife.

The following actions are expected to be necessary to meet the goals stated above:

1. Cooperate with the City of Moses Lake to educate shoreline owners to maintain the proper riparian vegetation to reduce erosion.

2. Active restoration of riparian vegetation, by residents, to reduce erosion.
3. Dredging or excavation of portions of the sediments from the north inlet (Figure 13).
4. Possible construction of sediment deflecting structure near bridge under Interstate 90 to deflect sediments from the west shoreline of Moses Lake to disrupt delivery of sediment to the north inlet. No analysis or preliminary design has been developed for such a structure.
5. Dredging or excavation of interconnecting channels and selected basins.
6. Continued weed harvesting.

4.3 WILD GOOSE

4.3.1 Existing Conditions

Wild Goose inlet is a shallow protected inlet that was, or is nearly completely dewatered during winter water levels (Figure 2). During summer the typical water depth in the inlet is approximately 2-3 feet. The substrate consists of fine sand, silt and organic matter. Along the shoreline where wave action interacts with the shore, native cobble substrate is exposed and evident.

Three processes are affecting Wild Goose inlet: 1) suspended sediment migrating along the shoreline of the lake outside of the inlet is deposited at the west side of the inlet; 2) sediment from local shoreline erosion remains in the inlet; and 3) and possibly accumulation of organic matter from the heavy growth of aquatic weeds (although, samples from Wild Goose Inlet yielded results of less than 10% organic matter). The configuration of the inlet is such that no process exists to transport sediments out of the inlet; therefore, the inlet is expected to continue to fill with sediment.

Residential development is occurring rapidly on the west shore of the inlet, while the east shore, although slower, is also under development with larger lots. The inlet provides boat access to Moses Lake. A community irrigation intake exists near the head of the inlet (Figure 14).

Portions of the inlet were excavated in 2005 by MLIRD to remove sediments down to the natural cobble substrate. These dredged areas have lower densities of submerged vegetation than the surrounding habitat and are thus providing rearing habitat for juvenile fishes. Adjacent areas with substantially higher densities of submerged vegetation on top of the accumulated sediment are expected to provide much lower quality habitat. Overall, the high density of submerged vegetation in much of the inlet limits use by several life history stages of key sport fish species. Currently, stranding of fish may occur in the deeper areas at low lake level.

Carp are abundant in the inlet and spawn in the warm shallow water. The inlet has been identified as a desirable location for installation of a carp barrier similar to that installed in upper Pelican Horn by the MLIRD (J. Korth WDFW, personal communication).

Waterfowl use the inlet for brood rearing.

4.3.2 Future Conditions

Based on the configuration of the inlet and the process that leads to sedimentation, sediment will continue to deposit within Wild Goose inlet. If no action is taken, the inlet will become a densely vegetated emergent marsh, and most or all of the open water habitat will be lost.

This transition would limit or eliminate boat access and water recreation from the inlet and would isolate the irrigation pump intake from the lake. Replacement of open water habitat with dense emergent vegetation would reduce the area of habitat for sport fish species. Carp would still spawn in any available shallow open water portions of the inlet. Waterfowl use would also increase initially as emergent vegetation achieved a coverage of approximately 50% in the inlet, but would decrease as the inlet was completely covered in cattails.

4.3.3 Management Goals and Actions

The sediment management goals at Wild Goose inlet are to: 1) maintain boat access in the inlet; 2) maintain open water habitat and decrease the coverage of submerged vegetation; 3) maintain an open water connection between the lake and the irrigation pump intake; and 4) maintain habitat complexity for fish and wildlife by ensuring a range of habitat types persist through time.

The following actions are expected to be necessary to meet the goals stated above (Figure 15):

1. Remove sediments from the inlet by dredging or excavation.
2. Possible construction of a habitat "island" near the mouth of the inlet to enhance wildlife habitat (one of several possible locations is shown in Figure 15.)
3. Possible construction of a boat-passable barrier to exclude carp.
4. Continued weed harvesting.
5. Cooperate with the City of Moses Lake to educate shoreline owners to maintain the proper riparian vegetation to reduce erosion.

Sediment removal will be a primary action to accomplish the management goals at Wild Goose Inlet. Sediment removal will need to occur from the mouth of the inlet to the irrigation pump intake. Dredging or excavation would be limited to an elevation equal to the top of the native cobble substrate. Removal to this depth will decrease the density of submerged vegetation and may shift the composition of the submerged vegetation community from milfoil to more beneficial species such as curly leaf pond weed. No dredging or excavation should occur in the lake fringe wetland although crossing this fringe may be necessary to remove material from the site. These crossings would then be rehabilitated to their former condition upon completion of the work.

Removing sediments from the inlet will preserve boat access for residential properties in the area. Removal of sediment will also improve fish habitat by preserving open water habitat and limiting the density of submerged vegetation.

If the existing lake fringe wetland (Figure 15) is left undisturbed by excavation or dredging, the resulting open water environment will be beneficial to waterfowl (J. Tabor WDFW, personal communication).

4.4 HIRAI HORN

4.4.1 Existing Conditions

Hirai Horn is a shallow protected inlet that is completely dewatered during winter water levels (Figure 2). During summer the typical water depth is approximately 2-3 feet. The substrate consists of fine sand, silt and organic matter. The inlet is bordered by residential properties with bulkheads present on approximately one-third of the south shore, and emergent marsh (bulrushes and cattails) on the north shore (Figure 16). There is also emergent vegetation along the south shoreline near the mouth of the inlet.

The outer shoreline along Moses Lake at this site was formed from sediment depositing from flow out of upper Parker Horn. Shoreline erosion from Parker Horn flow eddying around the spit, boat wakes, and wind-driven currents have caused movement of sediment along the outer shoreline and between the outer shoreline and the mouth of the inlet (Figure 16). Three processes are affecting the inlet: 1) suspended sediment migrating along the shoreline from wind transport and shoreline erosion; 2) sediment from local bank sloughing within the inlet; and 3) possibly accumulation of organic matter from the heavy growth of aquatic weed. The configuration of the inlet is such that no natural means exist to transport sediments out of the inlet; therefore, it is expected to continue to fill with sediment.

Hirai Horn provides boat access to the lake for shoreline properties and is a popular fishing area for bank anglers.

A portion of the inlet was excavated in 2005 by MLIRD to remove sediments. This work resulted in a deepened basin that is a pond during low water levels. Currently, stranding of fish may occur in the deeper areas at low lake levels. This basin has a lower density of submerged vegetation than the surrounding habitat and is providing rearing habitat for juvenile fishes. Adjacent areas with substantially higher densities of submerged vegetation are expected to provide much lower quality habitat. Overall, the high density of submerged vegetation in much of the inlet limits use for several life history stages of key sport fish species. Carp spawn heavily in this warm shallow water.

Waterfowl use the inlet although use is lower than in other portions of the lake. The emergent vegetation near the outer portion of the north shore supports nesting habitat for grebes (Figure 16).

4.4.2 Future Conditions

Based on the configuration of the inlet and the processes that are leading to sedimentation, it is expected that sediment will continue to deposit within the inlet. If no action is taken, the inlet will become dominated by dense emergent vegetation and most or all of the open water habitat will be lost.

This transition would limit or eliminate boat access to Moses Lake and fishing. Replacement of open water habitat with dense emergent vegetation would reduce the area of habitat for sport fish species. Although current use is not high within the inlet, waterfowl use would increase initially as emergent vegetation achieved coverage of approximately 50% in the inlet, but would decrease as the inlet was completely covered in cattails.

4.4.3 Management Goals and Actions

The sediment management goals at Hirai Horn are to: 1) maintain boat access to open water; 2) maintain open water habitat and decrease the density of submerged vegetation; and 3) maintain habitat complexity for fish and wildlife by ensuring a range of habitat types.

The following actions are expected to be necessary to meet the goals stated above:

1. Removal of sediments from the inlet by dredging or excavation (Figure 17).
2. Weed harvesting.
3. Possibly a carp barrier.
4. Cooperate with the City of Moses Lake to educate shoreline owners to maintain the proper riparian vegetation to reduce erosion.

Dredging or excavation would be to an elevation equal to the top of the native cobble substrate. Removal to this depth should decrease the density of submerged vegetation and may shift the composition of the submerged vegetation community from milfoil to more beneficial species such as curly leaf pond weed. No dredging or excavation of lake fringe wetlands will occur, although crossing this fringe may be necessary to remove material from the site.

Removing sediments from the inlet will preserve boat access to shoreline properties. Removal of sediment will improve fish habitat by preserving open water habitat and limiting the density of submerged vegetation. If the lake fringe wetland (Figure 17) is left undisturbed by excavation or dredging, the resulting complex of habitat that includes open water will be beneficial to waterfowl (J. Tabor, WDFW, personal communication).

4.5 NORTHERN END OF LEWIS HORN

4.5.1 Existing Conditions

Sediment has accumulated in the inlet west of Cascade Marina, at the northern end of Lewis Horn. Sediment has also accumulated in the excavated inlets adjacent to Cascade Marina (Figures 2 and 18). Access at the mouths of the inlets has been compromised by sediment accumulation, and emergent vegetation has become established, further restricting access.

The inlet at the west end of Cascade Marina is developing into an emergent wetland with species such as bulrushes and cattails. The shallow areas within these inlets, as well as at the boat launch of the Cascade Marina, have dense mats of algae and other submerged vegetation. In deeper areas, there is dense milfoil (Figure 18).

The major sources of sediment at this site are shoreline erosion along the south shoreline, and possibly decomposition of organic matter in the west inlet, and wind deposition of upland sediment.

Lewis Horn is a popular fishing destination and represents habitat for many key sport fish species. Carp are also abundant in this area and spawn in the shallow warm inlets. An old artificial inlet along the south shoreline west of Cascade Marina may be an appropriate location for a carp barrier to prevent carp spawning and enhance rearing habitat for juvenile sport fish (J. Korth, WDFW, personal communication).

Waterfowl are prevalent in this section of Lewis Horn; and it is one of the most important waterfowl brood rearing areas in Moses Lake (J. Tabor, WDFW, personal communication).

4.5.2 Future Conditions

The inlets near Cascade Marina will continue to fill in, and emergent vegetation will continue to colonize areas with shallow depths. The excavated inlets along the south shoreline will continue to accumulate sediment until they are separated from the lake (Figure 18) and eventually will develop dense stands of emergent vegetation. Access to the marina will be compromised by continued sediment deposition.

4.5.3 Management Goals and Actions

The sediment management goals at the north end of Lewis Horn are to: 1) maintain boat access to docks and the marina; 2) maintain open water habitat and decrease the density of submerged vegetation; and 3) maintain habitat complexity for fish and wildlife by ensuring a range of habitat types.

Dredging or excavation of sediments and weed harvesting and other, as yet, unidentified actions will be necessary to meet the goals stated above.

4.6 PELICAN HORN NEAR MARSH ISLAND

4.6.1 Existing Conditions

This problem area is located at the Interstate 90 crossing east of Marsh Island. Four 6-foot diameter culverts are blocked by accumulated sediment and debris (Figure 2 and 19). Sediment has filled approximately the lower half of the culverts, and debris is blocking up to two thirds (2/3) of the culvert. These blockages dramatically limit the exchange of water in this portion of Pelican Horn (Figure 20).

The major sources of sediment that block these culverts are 1) sloughing of the I-90 causeway; and 2) sediment migrating along the shorelines and possible decomposition of organic matter from dense algal mats and submerged vegetation that develop in summer.

4.6.2 Future Conditions

The depth of this area will continue to decrease due to sediment accumulation over time. Emergent vegetation will colonize this area, resulting in a dense stand of emergent vegetation and further blocking of the culverts.

4.6.3 Management Goals and Actions

The sediment management goal to the east of Marsh Island in Pelican Horn is to maintain water exchange through the culverts at all ranges of lake elevations.

Sediment removal by excavations or dredging may be necessary to extend a channel from the culverts into the lake on both the north and south side of the Interstate 90. Debris and sediment also need to be removed from the culvert. Based on conversation with the Maintenance Division of Washington Department of Transportation, these culverts have not been maintained since they were installed. The responsibility for maintenance needs to be clearly accepted by the Washington Department of Transportation. The MLIRD will pursue opportunities for cooperative projects for implementation of regular maintenance and/or dredging excavation at these locations.

4.7 DRUMHELLER DAM

This problem area is located at the confluence of Rocky Ford Creek and Moses Lake. The dam serves as 1) a barrier to carp migration into Rocky Ford Creek; and 2) a sediment trap for material from Rocky Ford Creek. Periodic removal of sediment from behind the dam is necessary to ensure its function.

4.8 MLIRD PUMP INTAKE

4.8.1 Existing Conditions

There is an existing pump intake downlake from Neppel Crossing in Parker Horn. The pump is responsible for pumping clean water from Parker Horn into Pelican Horn in order to improve water quality in Pelican Horn. There is currently a 4-6 foot build-up of sediment that is causing the screens to plug, thus causing the pump to transport sediment-laden water to Pelican Horn.

4.8.2 Future Conditions

If action is not taken, future sedimentation will eventually cause the pump intake to no longer be able to pump, thus depriving the nutrient-rich waters of Pelican Horn of the clean water from Parker Horn.

4.8.3 Management Goals & Actions

The sediment management goal regarding the pump intake downlake from Neppel Crossing is to maintain the pump intake in a way that will allow it to continue pumping clean water into Pelican Horn.

The following actions are expected to be necessary:

1) Dredging of sediment in the vicinity of the pump to an elevation that allows continued pumping
2) Continued weed harvesting

Initial dredging will be necessary to open the area around the pump although the frequency of ongoing future dredging is unknown. If the sediment trap located at Neppel Crossing is successful in trapping sediment, maintenance dredging in the location of the pump intake will be infrequent due to reduced sediment delivery from above.

5. IMPLEMENTATION

5.1 PERMITS

It is anticipated that the MLIRD will submit permit applications for each project. A number of these permit applications may entail work schedules that allow for maintenance activities within the life cycle of the permit. As actions are completed and maintenance intervals are clearly understood, it will be desirable to permit actions at specific locations with a series of multi-year HPAs, shorelines and federal Section 404 permits (if applicable).

Some of the MLIRD's actions will provide opportunities for habitat improvements while others may entail impacts. Linking individual permits will be beneficial from the perspective of balancing habitat impacts and mitigation. The mitigation banking concept should be considered. A mitigation agreement could be negotiated with WDFW and Ecology pursuant to RCW 90.74 (see appendix A), and an appropriate means for bringing the Corps of Engineers into the agreement could be devised. Appendix B presents an agreement negotiation between the Port of Anacortes and WDFW that allows the Port to apply excess mitigation credit from one development project against future mitigation needs. This agreement could serve as a model for an agreement between the MLIRD and the agencies.

5.2 HABITAT PERSPECTIVES AND MITIGATION

This Sediment Management Plan is predicated on a general concept of managing in-lake habitats for complexity. In general, all of the important functions and values of the lake from recreational fishing and boating to fish and wildlife habitat can be managed successfully from this perspective. This includes consideration of the proper balance of open-water, emergent vegetation and submerged vegetation habitats in specific areas of the lake.

It is the MLIRD's view that the development of extensive single-species stands of emergent vegetation, dominated by cattails, is an undesirable habitat trajectory for both the functions and values of Moses Lake. On the other hand, variable width bands of emergent vegetation along much of the lakeshore are highly beneficial. For these reasons, the MLIRD believes that avoidance and minimization of impacts to emergent vegetation is appropriate; however, many of the MLIRD's actions are focused on preventing a long-term transition of substantial areas of the lake into dense stands of emergent vegetation (cattails).

It is also the MLIRD's view that it is undesirable from the perspective of the functions and values of the lake if dense stands of submerged vegetation were to dominate the lake. As with emergent vegetation, submerged vegetation in low to moderate densities is a highly desirable component of fish and wildlife habitat in Moses Lake. The MLIRD's actions will be focused on correcting and preventing nuisance levels of coverage of submerged vegetation in Moses Lake that interfere with boating, swimming, and fishing.
In summary, the District's aquatic habitat perspective can be summarized in the following points:

- Reduce or prevent shoreline erosion through encouraging landowners to protect and restore riparian vegetation.
- Avoid, minimize, and when needed mitigate impacts to emergent vegetation wetlands.
- Manage primarily for variable width fringing shoreline emergent vegetation rather than extensive dense single-species stands.
- Avoid, minimize, and when needed mitigate impacts to riparian vegetation.
- Manage primarily for moderate coverage of submerged vegetation.

- No mitigation would be provided for submerged vegetation as it is anticipated that such vegetation will persist in the project areas at more desirable moderate levels of coverage rather than at levels that constitute a nuisance.
- Remove accumulated sediments down to underlying cobble substrate, where present. This will prevent excess deepening while allowing appropriate densities of submerged vegetation to persist.

5.3 DEPARTMENT OF NATURAL RESOURCES MATERIALS

Dredging or excavation of materials from the lake bottom may involve removal of DNR-owned materials. The material is anticipated to be inert fine sand and silt with a varying volume of organic material. In general, none of the material is anticipated to have a commercial value for use in building materials (e.g., concrete) or for structural fill. The MLIRD may place dredged or excavated materials at Connelly Park to create ball fields and other amenities. In addition, disposal may occur on private lands that have been volunteered for that purpose.

DNR typically charges private entities for the value of materials removed from state-owned aquatic lands, and this can include dredged material when it is put to a beneficial use. Further, based on state law, DNR is not allowed to charge a fellow public agency for such material when it is intended for a beneficial use (such as Connelly Park). The MLIRD's position is that the placement of dredged or excavated materials on private land is consistent with RCW Title 79, and no fee should be levied by DNR. In these cases, the private landowner is providing a public benefit by allowing disposal at a convenient and cost-effective location for the MLIRD. Consistent with RCW Title 79, the MLIRD would formally request that DNR waive the fee prior to removing state-owned material if it intends to permanently place material on private land.

5.4 SEDIMENT DISPOSAL

There is no formalized method for addressing potential sediment contamination issues for freshwater sediments. In contrast, in marine waters the State of Washington, the Corps of Engineers has a highly refined system of testing and review to approve sediments for disposal in the marine environment.

For the MLIRD's actions, disposal of sediments is expected to occur primarily on uplands. In those situations it is expected that limited testing of sediments will be necessary to demonstrate that they are appropriate for placement in areas of specific land use. For upland disposal sites, MLIRD will coordinate sediment testing/contamination issues with the Grant County Health Department.

If sediments are placed in the lake for habitat enhancement, the MLIRD will coordinate with appropriate agencies including WDFW, Department of Ecology, Department of Natural Resources, the Corps of Engineers, and the City of Moses Lake on an appropriate sediment testing and approval process.

6. CONCLUSIONS

The plan presented above focuses on a number of Problem Areas with identified sediment accumulations that are currently or will shortly negatively affect beneficial uses of the lake. Of particular note is the potentially large volume of sediment that is entering Moses Lake from Crab Creek and Rocky Coulee. Due to the large volumes from these sources, they are a priority for the MLIRD. It is acknowledged that other sediment sources are also important; but in these cases the MLIRD has no direct authority to implement the actions that may be necessary to reduce or control them. However, the MLIRD does plan to address other sediment sources in a manner consistent with its mandate for protecting and enhancing Moses Lake with a focus on dialogue and education. The MLIRD intends to undertake the following actions to control sediment inputs:

1. Permit and construct a sediment trap in Parker Horn upstream of Neppel Crossing.
2. Implement a Monitoring and Adaptive Management Plan to assess the efficacy and direct the operation of the sediment trap.
3. Investigate whether the stream banks of Crab Creek are contributing large volumes of sediment to Parker Horn.
4. Investigate opportunities for trapping sediments in the concrete channel of Rocky Coulee Wasteway upstream of East Low Canal.
5. Discuss crop or tilling options with landowners in Rocky Coulee to determine if opportunities exist for mutually beneficial changes in farm practices.
6. Cooperate with the City of Moses Lake on education programs for shoreline owners that highlight the importance of riparian and emergent wetland vegetation for shoreline erosion control.
7. Coordinate with the USBR on future water feed route studies and proposals.
8. Coordinate with researchers at Washington State University to encourage inclusion of estimates of sediment delivery to Moses Lake via wind-borne dust into future studies and programs addressing dust generated on adjacent farms.

In addition, the MLIRD intends to undertake the following actions to restore beneficial uses in Moses Lake:

1. Implement actions as necessary in the Problem Areas identified in Section 4.
2. Indentify additional Problem Areas and appropriate actions.
3. Coordinate with WDFW on opportunities to incorporate fish and wildlife habitat enhancement into actions at the Problem Areas

7 MONITORING AND ADAPTIVE MANAGEMENT PLAN

The following provides a general framework of the types of monitoring activities that the MLIRD are intending to initiate relative to sediment management. The intent of the monitoring is to provide appropriate information for implementing actions and modifying ongoing operations to ensure that the actions are fulfilling their engineering, environmental, and cost objectives. Further, it is the MLIRD's intent to conduct the outlined monitoring activities with its own staff. The listing of specific monitoring activities does not represent a commitment by the MLIRD to continue these activities indefinitely. Further, the MLIRD may implement other monitoring activities that are not listed here or envisioned at this time.

7.1 MONITORING ACTIVITIES AT PARKER HORN SEDIMENT TRAP

Analysis pertinent to sizing of the sediment trap at Parker Horn is presented in Appendix C. The sediment trap will be sized based on existing estimates of sediment delivery to Parker Horn. The dredging action in conjunction with timely surveys of the extent and depth of the material removed will provide accurate information on the actual volumes reaching Parker Horn. These efforts along with observation of sediment sources along Crab Creek and lower Rocky Coulee will provide a basis for evaluating whether specific years are typical, high, or low sediment production years. The anticipated monitoring activities include:

- Sediment probing to determine the elevation of the sediment surface and the depth to the underlying cobble substrate in the sediment trap and channel before and after regular dredging.
- Additional sediment probing, in the same areas listed above, at specified seasons that correspond to expected periods of sediment accumulation. This activity is intended to refine and optimize the dredging period at that sediment trap.
- Sediment source identification in Rocky Coulee and Crab Creek.

As specific actions are permitted and implemented, greater detail will be provided on the expected scope and duration of the monitoring activities.

8. REFERENCES

Beckley, Don. March 2007. Personal communication between Glenn Grette (Grette Associates Senior Fisheries Biologist) and Don Beckley (consultant to Moses Lake Irrigation and Rehabilitation District).

Campbell, Chris, D. Laycak, W. Hoppes, N. Tran, and F. Shi. Earth Sciences Division, Lawrence Berkeley National Laboratory. High concentration suspended sediment measurements using a continuous fiber optic in-stream transmissometer.

Central Washington University. August 2004. Shoreline Habitat Characterization and Analysis for the Moses Lake Project. WDFW Contract Report # 33030533.

Gellis, Allen. United States Geological Survey (USGS). Sediment budgets for two semi-arid watersheds, Rio Puerto Basin, New Mexico.

Korth, Jeff. January 2007. Personal communication between Glenn Grette (Grette Associates Senior Fisheries Biologist) and Jeff Korth (WDFW District Fish Biologist)

Papendick, R.I. 2004. Farming with the Wind II: Wind Erosion and Air Quality Control on the Columbia Plateau and Columbia Basin. College of Agricultural, Human and Natural Resource Sciences Special Report XB 1042. Washington State University. Pullman, WA.

Simpson, David. 2007. Personal communication of June 22, 2007. Email correspondence between Glenn Grette (Grette Associates Senior Fisheries Biologist) and David Simpson (Coast and Harbor Engineering Principal/Coastal Engineer) regarding sediment discharge equation.

Tabor, Jim. January 2007. Personal communication between Glenn Grette (Grette Associates Senior Fisheries Biologist) and Jim Tabor.(WDFW District Wildlife Biologist).

Washington State Department of Ecology. October 5, 2006. Draft Programmatic Environmental Impact Statement for the Columbia River Water Management Program. Ecology Publication # 06-11-030.

Washington State Department of Ecology. June 2002. Moses Lake Inflow-Outflow Balance-A Component of the Moses Lake Total Phosphorus Total Maximum Daily Load. Publication # 02-03-029.

Washington State Department of Ecology. October 2000. Moses Lake Proposed Phosphorous Criterion and Preliminary Load Allocations Based on Historical Review. Publication 00-03-036.

United States Department of the Interior, Bureau of Reclamation. April 2007. Potholes Reservoir Feed Route Draft Environmental Assessment.

United States Geological Survey (USGS). 1982. Steamflow and sediment transport in the Quillayute River Basin, Washington.