APPENDIX A: FINAL
PROVO RIVER DELTA RESTORATION PROJECT
VEGETATION MANAGEMENT PLAN

September 2019

Prepared for:
Allred Restoration, Inc., and
Utah Reclamation Mitigation and Conservation Commission

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1 INTRODUCTION

The Provo River Delta Restoration Project (PRDRP) is located at the Provo River/Utah Lake interface (hereafter referred to as the project area) (Figure 1). The project is needed to restore rearing habitat for June sucker recovery. A Final Environmental Impact Statement (FEIS) for the PRDRP was issued April 2015 with the Record of Decision (ROD) signed May 2015 to implement the Proposed Action in the FEIS (Figure 2). The Utah Reclamation Mitigation and Conservation Commission (URMCC) contracted with Allred Restoration, Inc., (Allred Restoration) to obtain contractor services for development of final restoration designs, agency consultation, permitting coordination, preconstruction field surveys, and reporting for aquatic ecosystem restoration in the project area. Allred Restoration subcontracted with BIO-WEST, Inc., (BIO-WEST) to develop a vegetation management plan (VMP), concurrent with channel and delta restoration designs as described in the PRDRP Design Report. Updated descriptions of hydrology, hydraulics, project design maps, cross sections, and details for all project features are included in the design report. This report presents a Final Pre-Construction VMP for the PRDRP and was developed iteratively with the design report.

The goal of the VMP for the PRDRP is to restore aquatic, wetland, riparian, and upland vegetation communities that are native to the Provo River/Utah Lake ecosystem and considered important for June sucker recovery (USFWS 1999). Revegetation with native species is also necessary to prevent the spread of invasive weeds, especially phragmites (*Phragmites australis*), which is currently being treated around Utah Lake and Great Salt Lake by numerous agencies. This VMP is consistent with the initial vegetation management plan developed for the FEIS, and is being developed in coordination with June sucker technical experts, ecologists, Provo City, Federal Aviation Administration, and US Department of Agriculture—Wildlife Services to include compatible wildlife hazard-reduction measures to minimize bird-aircraft strike risks for airplanes taking off from and landing at the Provo Municipal Airport, located south of the project area.

In summary, the goal of the PRDRP VMP is to establish native plant communities in a naturally functioning delta ecosystem that:

1. are beneficial for the recovery of June sucker,
2. are aesthetically pleasing for enhanced recreational opportunities,
3. are compatible with wildlife hazard-reductions measures for the nearby airport, and
4. minimize the spread of noxious and invasive weeds.

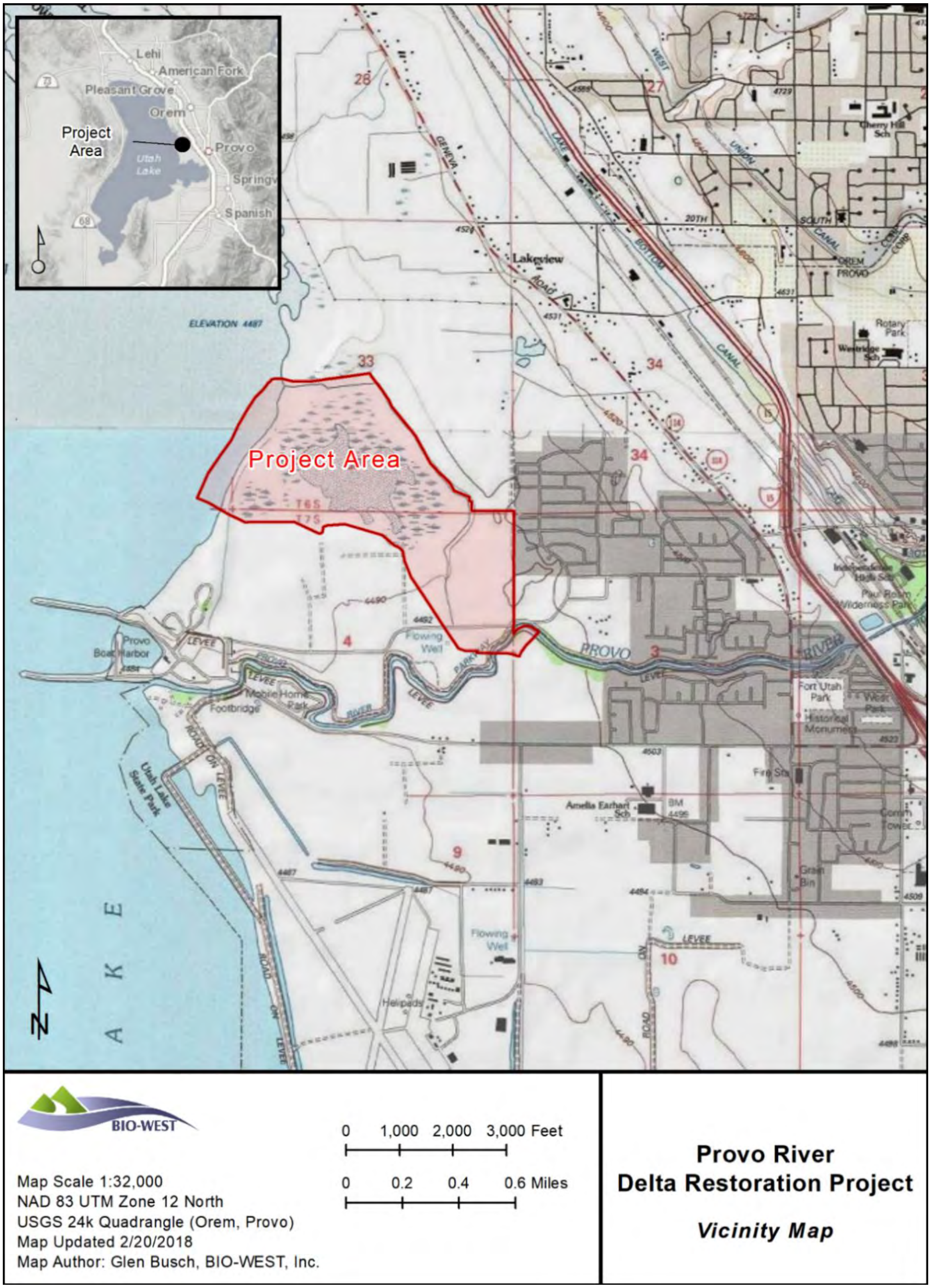

Figure 1. **Provo River Delta Restoration Project (PRDRP) vicinity map. Notice that the majority of the project area was mapped by the US Geological Survey in the 1970s as open water surrounded by marsh wetlands. This area was historically referred to as the “Skipper Bay” portion of Utah Lake.**

Figure 2. Preferred alternative of the Provo River Delta Restoration Project (PRDRP) Final Environmental Impact Statement.

2 ENVIRONMENTAL SETTING

2.1 CLIMATE

The project area experiences four seasons: cold snowy winters, hot dry summers, and two relatively short wet periods in the spring and fall. Average precipitation is approximately 13 inches near Utah Lake (WRCC 2019). The coolest month is January with an average low temperature of 20°F. The hottest months are July and August with average high temperatures of 91°F and 89°F, respectively. High-intensity, monsoonal rainstorms occur occasionally in late summer. Most of the annual evaporation from Utah Lake occurs from June through September.

The majority of precipitation in the watershed comes in the form of snow during the winter months, which melts and runs off during the spring snowmelt. The project area's annual hydrograph (magnitude and duration of spring runoff) is driven by the amount of wintertime snow accumulation in various parts of the watershed combined with springtime climatic conditions controlling the rate and timing of snowmelt. There is typically an early spring snowmelt combined with rainstorms and saturated conditions in the lower valley elevations February–April, followed by rising temperatures, drier soils, and high-elevation snowmelt in May–June that cause peak flows and occasional flooding during the early summer months. The peak of the annual hydrograph is generally dominated by the high-elevation snowmelt in late May; however, early valley snowmelt is important for vegetation because of its influence locally on soil moisture.

Depending on conditions such as temperature, wind speed, and radiational cooling, winter ice cover can be present on Utah Lake during winter months. In early spring, as the ice breaks up, wind-driven ice sheets 10–20 feet high can occasionally be observed along the lake's eastern shoreline (Merritt 2004). The effects of the wind-driven ice sheets can be seen currently on the northern portions of Skipper Bay dike as a result of high lake levels in 2011, but the effects of wind-driven ice sheets on channels and vegetation along the eastern shoreline of Utah Lake is relatively unknown. Wind-driven ice sheets are assumed to occur infrequently, but also assumed to be very destructive when active.

Annual and decadal fluctuations in streamflow and lake levels are influenced by variations in the climate. These include year-to-year fluctuations in snowpack accumulations during the winter and runoff conditions during the spring and early summer. The long-term average lake elevation during the growing season was determined in the PRDRP FEIS to be 4,488 feet. This is according to simulations of 1949–1999 hydrology data and the Utah Lake water level fluctuation study (CUWCD 2007), which was performed for the Utah Lake System Environmental Impact Statement, with results plotted in a flood-duration curve for Utah Lake (Figure 3). However, according to the most recent (2003–2019) lake-elevation data (Figure 4), the current average lake elevation during the growing season has been approximately 1.5 feet lower than originally estimated, and actual average lake elevations have been closer to 4,486.5 feet in recent years. In recent low-runoff years, it appears that the lake is not being managed to fill full to 4,489 feet (the Compromise elevation) every spring as shown in the Utah Lake water level fluctuation study,

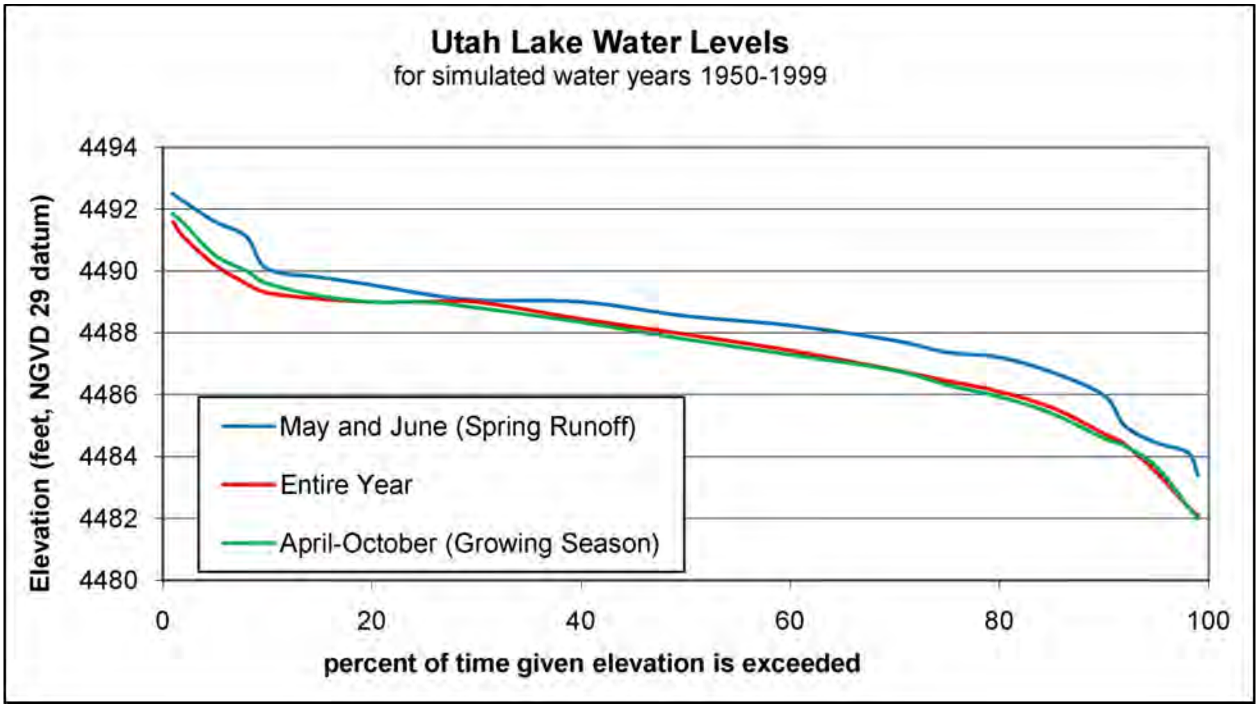

Figure 3. **Simulated long-term flood-duration curves developed for Utah Lake based on Utah Lake water level fluctuation study (CUWCD 2007).**

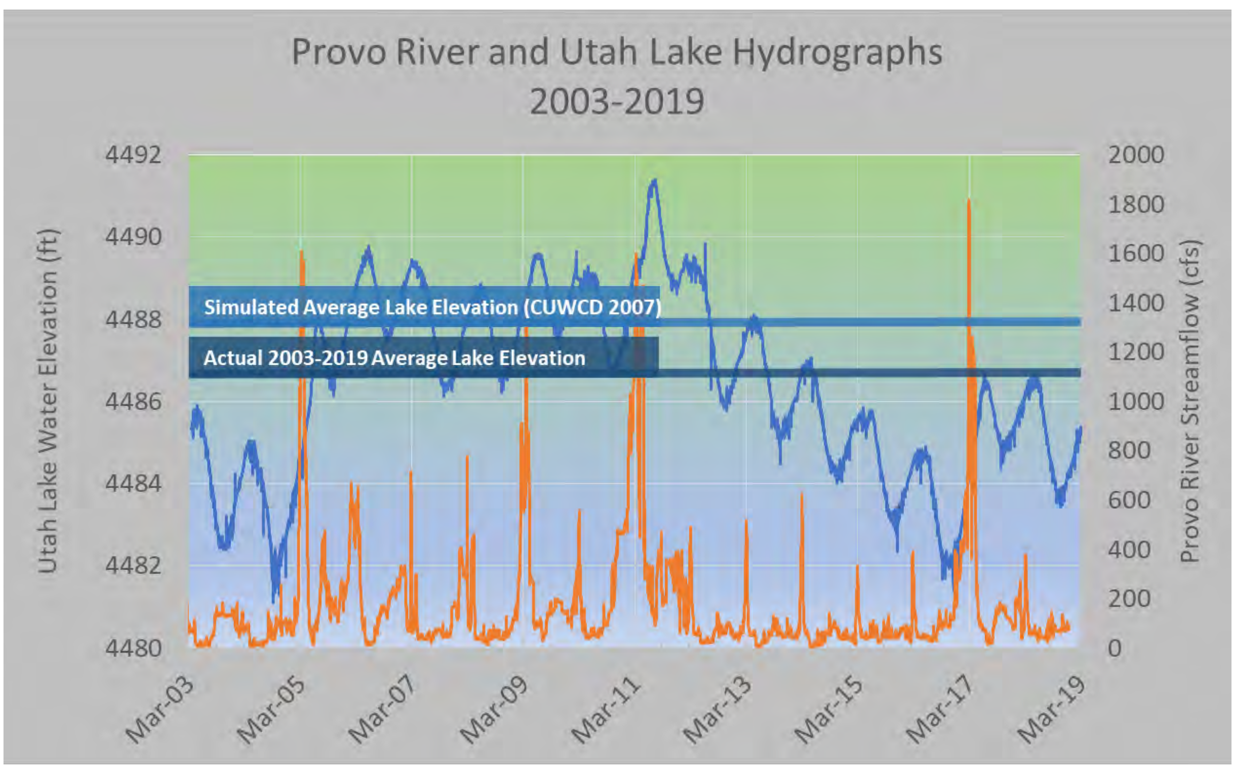

Figure 4. **Provo River Flows (orange) and Utah Lake Water Elevations (blue), 2003–2019.**

and spends more time annually at lower lake elevations than originally indicated in Figure 3. Utah Lake water elevations generally fluctuate between 2 and 3 feet annually (see Figure 4), but can fluctuate up to 6 feet in a given season, which is what happened in 2005 when a wet spring followed consecutive years of drought.

An important design feature of the delta is the partial removal of Skipper Bay dike. The majority of Skipper Bay dike and trail (which is currently at an elevation of 4,491–4,493 feet) along the western boundary of the delta will be excavated to approximately 4,488 feet of elevation with outlet channels at 4,487 feet. This design is intended to fully connect the lake and delta at high lake elevations and maintain water elevations in the delta at or above 4,488 feet of elevation, even when the lake drops below 4,487 feet. This design detail is intended to provide ideal conditions to re-establish submerged aquatic and emergent vegetation communities, which are known to be important for June sucker recruitment . This "perched bay" situation occurs at a much larger scale in Provo Bay.

2.2 RIVER AND DELTA PROCESSES

The PRDRP is located in the lowest 1.5 miles of the 673-square-mile watershed, where Provo River terminates at Utah Lake (Figure 1). Provo River originates in the Uinta Mountains, at an elevation approximately 10,800 feet, and flows from the high mountains through Jordanelle Reservoir, Heber Valley, Deer Creek Reservoir, and Provo Canyon, and then across a very populated portion of Utah Valley before reaching Utah Lake at an elevation of approximately 4,489 feet. There are multiple water diversions on the river in Utah Valley, each of which has an impact on water discharges, sediment loads, and organic materials delivered to the lower river, the river/lake interface (delta), and ultimately Utah Lake.

Stream channels experience changes in both process and form as they flow from their headwaters to mouth (Figure 5). Channel width and depth typically increase in the downstream direction due to increases in drainage area and associated increases in discharge. Even among different types of streams, a common sequence of structural changes is generally observable from the stream's headwaters to its mouth (FISRWG 1998), with the longitudinal profile roughly divided into three zones: (1) headwaters zone, (2) transfer zone, and (3) depositional zone (Schumm 1977). The PRDRP project area is situated at the downstream end of the depositional zone (Zone 3), in which Utah Lake represents the base elevation controls.

Deltas are formed from the deposition of the sediment carried by the river as the flow enters a flat waterbody (Utah Lake). When flow that is transporting sediment enters the backwater area of a standing water body, it experiences a decrease in flow velocity, which reduces its competence to transport sediment. When the velocity decreases enough, the shear stress is no longer of sufficient magnitude to transport the coarse sediment that is moving as bedload, and it stalls on the bed of the channel. As velocity decreases further, suspended sediment also drops out of the flow and deposits, sometimes forming natural levees along the margins of the main channel.

Over time, the channel will build a deposit called a "deltaic lobe," which pushes out into the standing waterbody (Figure 6). As this lobe builds over time, the energy within the river channel decreases further. This happens because the slope is decreased due to the added channel length.

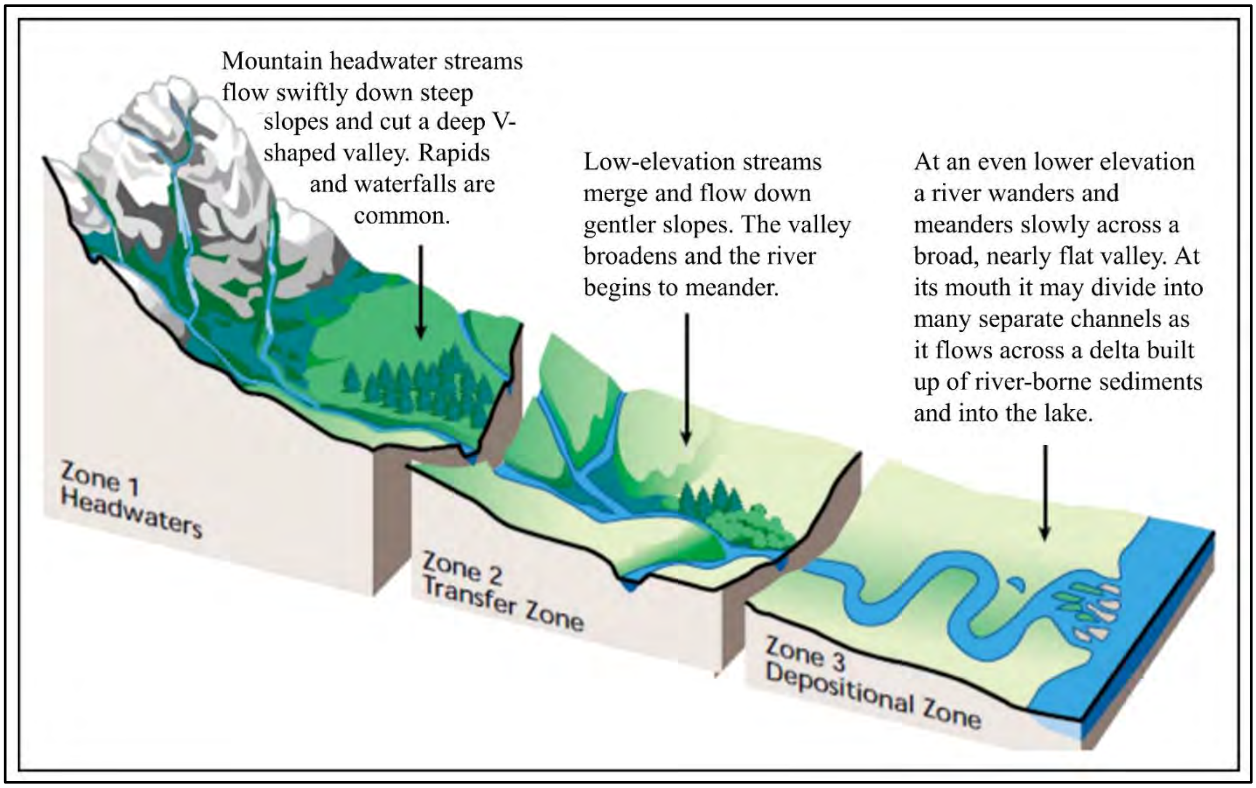

Figure 5. Longitudinal profile of natural rivers. The Provo River Delta Restoration Project (PRDRP) area in its natural historic state fits into the lower portion of Zone 3, showing multiple channels flowing across the sediment-rich delta before terminating in Utah Lake (adapted from Miller 1990).

Figure 6. A deltaic lobe forming in Utah Lake from a small, spring-fed stream just north of the PRDRP.

The complex interactions between these factors can lead to a myriad of delta shapes and sizes depending on the most dominant fluvial and marine forces (Figure 7). The relative importance and interactions between each of these processes dictate the form of a delta (Antonov 2011), type and amount of vegetation, and associated aquatic and riparian habitats.

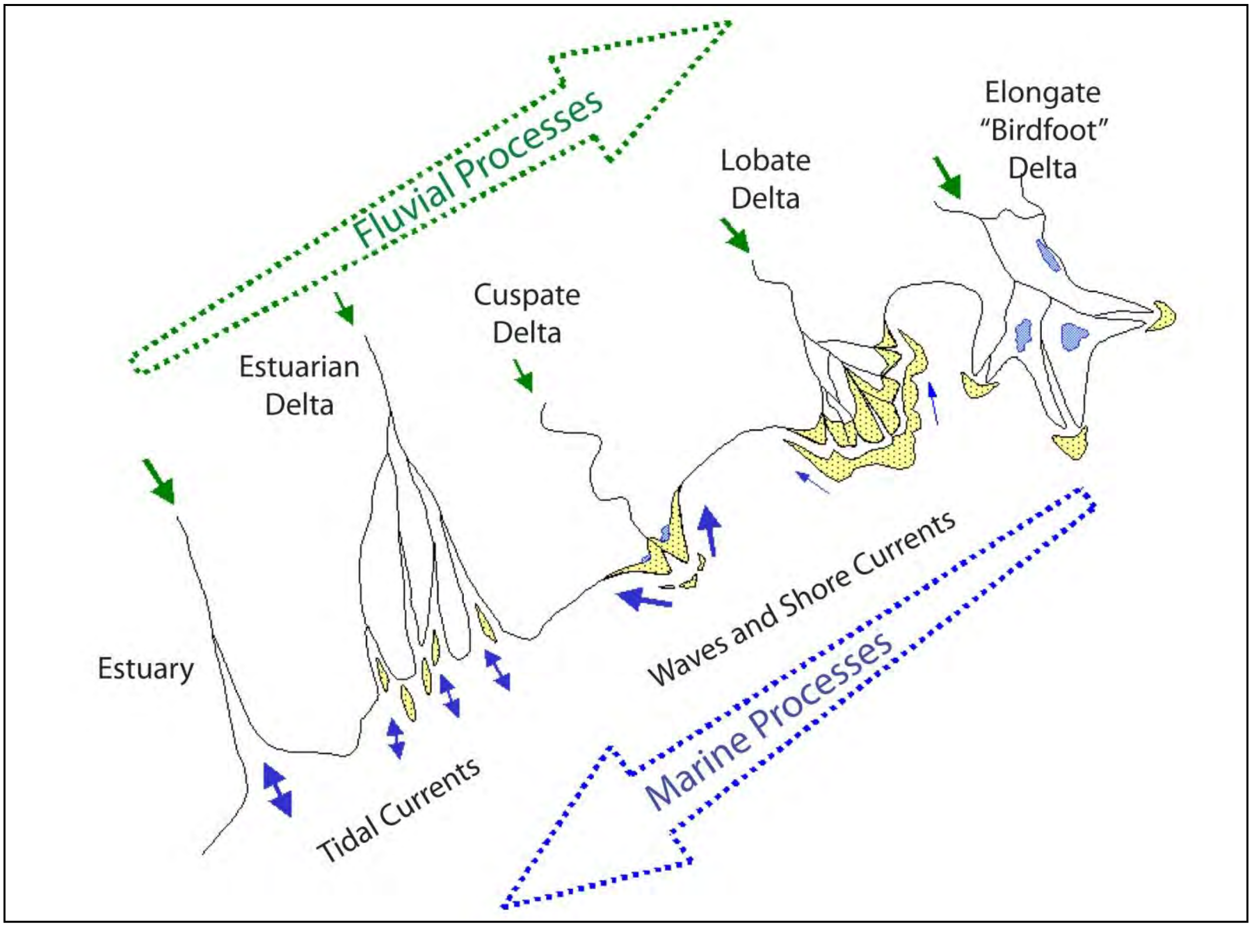

Figure 7. **Deltas form as a function of dominant processes. Source: Antonov (2011). The Provo River Delta at the Utah Lake interface resembles a strong tendency toward the lobate delta form.**

The Provo River delta at the Utah Lake interface would develop into a lobate, fan-shaped delta (see Figure 6). Sometimes called a "Gilbert Delta" (named after Grove Karl Gilbert) this is a specific type of delta that is formed by coarse sediments entering a fresh water lake, as opposed to gently sloping, muddy deltas entering an ocean (e.g., the Mississippi River entering the Gulf of Mexico). Gilbert used deltas that formed around Lake Bonneville for this description.

Historically, June sucker larva passively migrated downstream after hatching, settling into a naturally forming delta marsh ecosystem at the mouth of Provo River (Figure 8 and example photographs of marsh vegetation). This delta form would have historically provided channel and off-channel low-velocity habitats that were considerably more complex than those presently found in the project area. River flow into the delta would have been distributed among multiple channels, adding complexity to water depth, velocity, and habitat conditions for June sucker at a variety of streamflow and lake-elevation combinations.

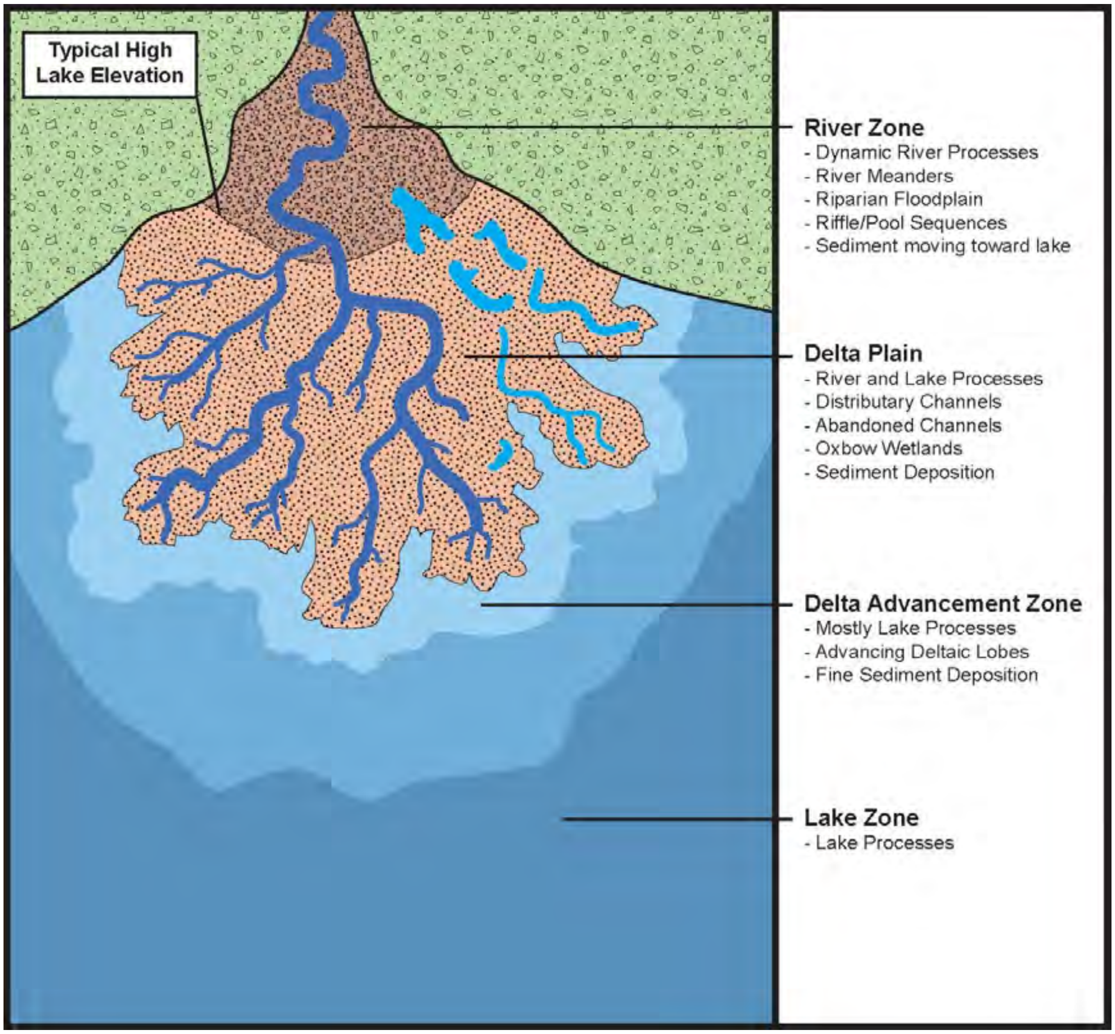

Figure 8. **Schematic drawing of distributary channels and dominant depositional process typical of a delta at the Provo River-Utah Lake interface.**

Photographs of emergent and submerged aquatic plant communities are from a recent USU Extension publication: Wetland Plants of Great Salt Lake (Downard, et al, 2017).

2.3 EXISTING SOILS AND VEGETATION

Existing soils and vegetation communities within the project area were previously described in detail in the FEIS based on available Web Soil Survey (NRCS 2010) maps of the project area, vegetation surveys associated with wetland delineations (2010–2016), and surveys involving federally listed threatened Ute ladies'-tresses orchid (*Spiranthes diluvialis*) (referred to hereafter as ULT) (BIO-WEST 2016). A more-detailed, pre-construction investigation of project area soils, weed and vegetation community mapping, and a final pre-construction ULT survey were completed in 2018 (BIO-WEST 2018a and 2018b).

2.3.1 Soils

Agriculturally productive loam soils are found generally in the southern and central portions of the project area, while peat soils are found to the east and north (Figure 9).

The 2018 soils investigation (BIO-WEST 2018a) focused on providing construction- and revegetation-related information on soil types, grain-size distribution, and fertility. Thirty-three borings dispersed around the project area were installed 10-15-feet deep using a track-mounted, direct-push rig. Continuous cores were collected and logged by an experienced geologist. Soils were classified according to the Uniform Soil Classification System (USCS).

2.3.2 Grain-size Distribution

Samples were collected from the A horizon for standard soil fertility analyses and thirty samples were also be analyzed for grain size distribution. The topsoil ranged from clay loam to silt loam (ML or silt in the USCS). The deeper soils were fairly heterogeneous as expected in a former shoreline/delta depositional environment and included peat (PT), clay (CL), silt (ML) and sand (SM and SW). The only borings that encountered gravel (GW) where those in the Skipper Bay dike and boring STS-22.

2.3.3 Stratigraphy

As noted about the subsurface was heterogeneous. The topsoil layer in the borings was fairly uniform and consisted mostly of silt (ML). Soil samples of the top layer collected as part of the various wetland delineations encountered silt in most of the test holes, but clay was also encountered in 8 holes and peat was found on the surface in 13 holes. In areas that had been plowed as part of agricultural activities in the past, there was no peat from 0–1 foot because it had been incorporated into the other topsoil. The underlying layers consisted of silt (ML) or clayey silt (CL-ML), or silty sand (SM), or well-sorted sand (SW). See Attachment 1 for maps of soil type by depth.

In the southeast portion of the project area, near the current Provo River (riverine area), sand was more prevalent and was interbedded with silt, and present on top or beneath peat layers. These sandy layers are uncohesive, and banks constructed of this material will likely be prone to erosion where intercepted during construction, especially in the main channel—until vegetation becomes established. Sand was also encountered below 4 feet in most of the borings near the Skipper Bay dike. These sands are probably former beach deposits. Boring STS-13 contained shell fragments in the sand from 4–10 feet (Attachment 1 – Soil Types and Design Features).

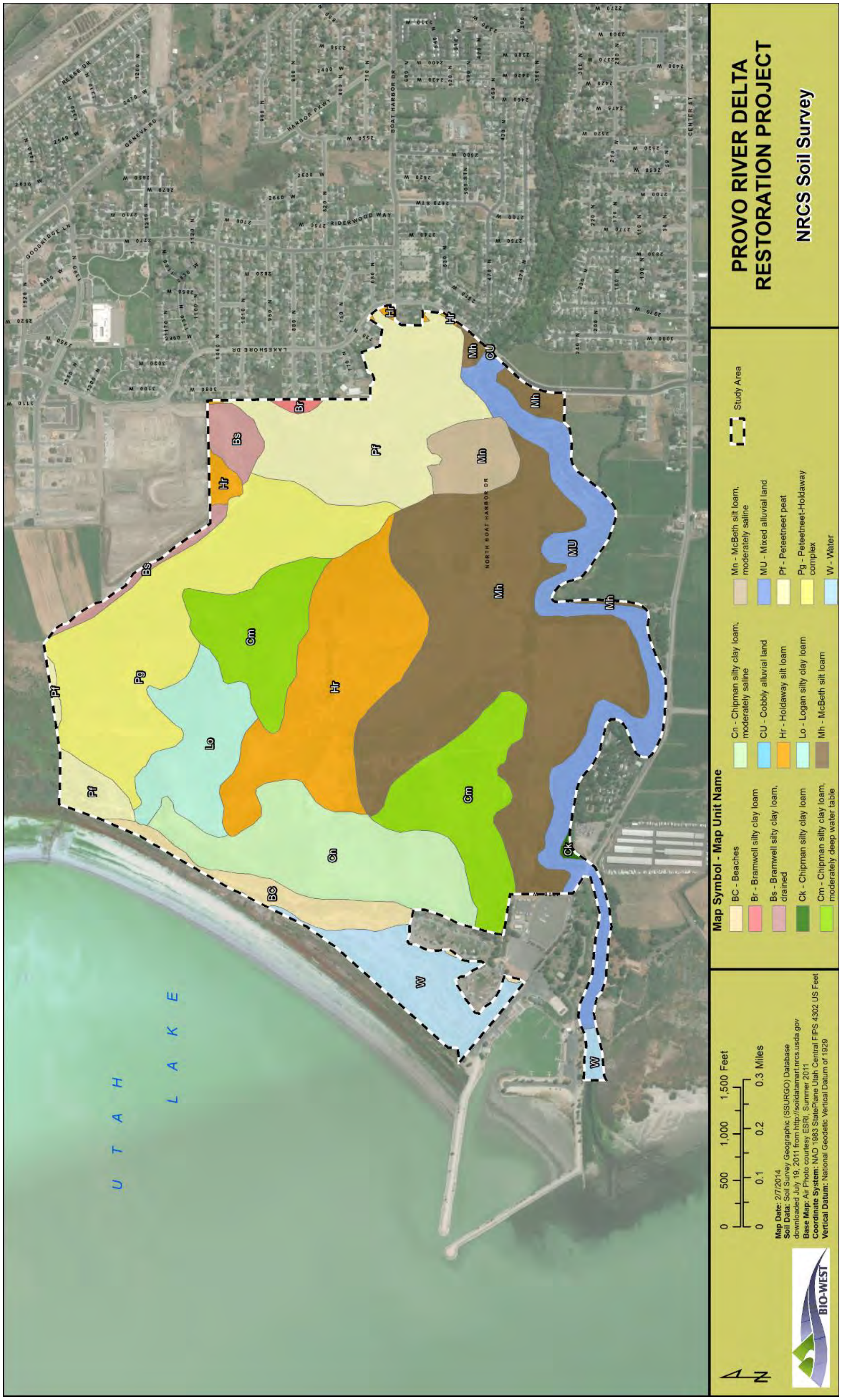

Figure 9. Provo River Delta Restoration Project (PRDRP) area soils map (NRCS 2010).

Twenty-eight of the borings encountered at least one sand layer (SM or SW), usually (but not always) deeper than 5 feet. These sand layers were fairly permeable and will act as conduits for groundwater movement, and during construction of the project these layers will likely let groundwater fill in excavated features and also spread from areas with high water tables to other areas of the site. Also, the sand layers will likely be uncohesive during excavation operations and prone to slumping or flowing, especially when saturated.

2.3.4 Peat

Peat was encountered in 13 of the soil borings and in several of the wetland delineation test holes. The thickest peat layer was 12.5 feet in soil boring STS-12 (Attachment 1 – Soil Types and Design Features). The ground vibrated noticeably during core-drilling in areas of peat. The peat layers were generally damp but not saturated. All of the peat layers encountered were at least 2 feet thick. The excavation of the channels and ponds will encounter these peat layers. The peat will be poor material for the edges of channel and ponds because it is fairly uncohesive, very compressible, and may erode or float away. It is also very porous, and areas where the peat has dried out may swell when hydrated. The peat is an excellent substrate for plant growth and care should be taken to salvage peat encountered for reuse in the topsoil. Salvage and reuse methods used for excavated peat soils are described in subsequent sections of this report. The peat is very permeable and will likely allow rapid groundwater migration.

Peat soils within the project area were formed as dead marsh vegetation deposited into standing water on the edge of Utah Lake. Anaerobic conditions within the marsh kept the organic matter from fully decaying. This organic matter deposition has accumulated over the thousands of years since Lake Bonneville drained, which occurred nearly 15,000 years ago. In recent decades, these soils have become generally dryer and degraded (because of hydrologic alterations, such as construction of river levees, lake dikes, drains, and annual mechanical pumping), but the soils are still capable of supporting rare wetland vegetation communities, primarily in the areas surrounding relatively unaffected springs and seeps. Peat wetlands are defined as wetlands with waterlogged substrates and at least 30 centimeters of peat accumulation (Bursik and Moseley 1992). According to a statement regarding the wise use of peatlands by the International Peat Society and International Mire Conservation Group (2002), peat wetlands "are important ecosystems for a wide range of wildlife habitats supporting important biological diversity and species at risk, freshwater quality and hydrological integrity, carbon storage and sequestration, and geochemical and paleo-archives". Numerous wetland types can occur within the peat soils, including fens and bogs (Chadde et. al. 1998).

The existing peat soils have also been impacted by cattle grazing. Raised peat mounds within the project area are located within the greater area of peat soils. These mounds generally exhibit upwelling groundwater at the highest point in the center of the mound (even when the adjacent surrounding peat wetlands are dry) and a relatively diverse herbaceous plant community. In some cases, the mounds provide habitat for and support existing populations of ULTs. Due to the rarity of peat wetland habitats, including the raised peat mounds and the species they support, special consideration is warranted.

It is likely that many historic, raised peat mounds within the project area have subsided (flattened) due to the drying of the peat soils and trampling and overgrazing by livestock. The existing raised peat mounds have not subsided to the same extent, likely due to the continued influence of the upwelling groundwater, which provides continuous wetted conditions for the peat soils. Based on observations by BIO-WEST scientists, it appears that the peat soils within the project area are primarily sedge peat formed by vegetation growth flooded by surface water and not the more common *Sphagnum* peat. This conclusion is supported by the existing vegetation communities of sedges and rushes. The NRCS (2010) Peteetneet soil series description lists sedges, cattails (*Typha latifolia*), rushes, and other water-loving plants as the vegetation types native to this soil type.

2.3.5 Soil Fertility

A total of 20 soil samples from the topsoil layer (0–1 foot) of the soil borings were submitted to Utah State University Analytical Laboratories of Logan, Utah, for soil fertility analysis. Roughly two out of three borings were selected for sample analyses of the surface soil. The soil fertility analysis included texture, pH, salinity, phosphorus, potassium, nitrate, zinc, iron, copper, manganese, sulfate, and organic matter. Overall, the topsoil layer contained fertile soils with adequate nutrients to support plant growth. A few of the borings encountered moderately and strongly saline soils, but the salinity is not expected to limit post-construction plant growth because once the area is flooded, the salts will be diluted and flushed out of the soil.

2.3.6 Existing Vegetation

Vegetation community data for the PRDRP were collected during the comprehensive weed inventory conducted in August 2018. The study area for the weed inventory encompasses, but is larger than the restoration project area, and includes the riparian zone and areas adjacent to the Provo River. One of the greatest challenges of any restoration project is controlling non-indigenous (species not native to North America) and noxious, weedy species that could possibly be introduced to the project area from nearby seed sources. Therefore, expanding the weed inventory study area outside the restoration design project area was deliberate and was undertaken to understand existing conditions adjacent to the project area with the objective of controlling, to the greatest extent possible, any weeds that might come from adjacent properties, inflowing streams and ditches, and the wind.

Identified vegetation communities within the project area were grouped into associations using NatureServe Explorer, an online database for ecological community information. Associations are classified by diagnostic species, usually from multiple growth forms or layers with similar composition that are influenced by climatic factors and disturbance regimes (NatureServe 2018). A total of 58 unique associations were classified within the PRDRP during the comprehensive weed inventory (See Attachment 1 – Inventoried Vegetation Communities by Association Map). Although classifying vegetation communities into associations is useful for analyzing distinct variations in plant groups across the landscape, a broader level of classification is more appropriate for a restoration project of this scale from a management standpoint. Therefore, the 58 unique associations were grouped into general habitat types.

Existing habitat types found within the project area include aquatic, emergent wetland, riparian forested, riparian scrub shrub and upland plant communities (See Attachment 1 – Existing Habitat Types). Unique, raised peat mounds are contained within the emergent wetland habitat type. Most of the project area has been heavily disturbed for grazing and farming and presently supports a mix of native and nonnative vegetation. Several nonnative species are invasive and listed as noxious by the State of Utah. These are further discussed in later sections of this report.

2.3.6.1 Aquatic Vegetation

In Utah Lake and the associated aquatic ecosystems, aquatic and emergent wetland vegetation has been historically abundant and diverse with as many as 483 individual aquatic and emergent wetland plant species and 7 major aquatic and emergent plant communities identified (Brotherson 1981). These plant communities played a vital role in the ecology and life history of lake inhabitants, including endemic species such as June sucker. Aquatic vegetation includes both submerged (rooted) and floating plant species, which are currently found within the project area only in areas of permanent standing water (including ditches and the Provo River). Many of the submerged aquatic and floating plant species that were historically present in lower Provo River and Utah Lake have been significantly reduced or eliminated, presumably from decades of river channelization, lake diking, pumping, shoreline farming, and water quality impairments. The lower Provo River and Utah Lake continues to be impacted by invasive species, such as carp (*Cyprinus* spp.) and phragmites. Several site visits have been conducted to find aquatic plants. Only a few native aquatic plant species have been observed within the vicinity the Provo River and Utah Lake. These include *Stuckenia pectinata* and *Potamogeton filiformis.* Small habitat areas can currently be found for aquatic vegetation within the project area, and a majority of the suitable habitat for aquatic plants will be formed during PRDRP construction. This includes re-connecting the hydrology of the project area with water from the river and lake.

2.3.6.2 Emergent Wetland Vegetation

The majority of the wetland habitat within the project area consists of emergent wetland vegetation. Areas identified as “raised peat mounds” also support emergent wetland vegetation (Attachment 1 – Existing Habitat Types). Emergent wetlands within the project area are hydrologically connected to the groundwater table and historically exhibited surface water connections to the Provo River and Utah Lake. It is common for portions of these areas to be inundated with several feet of water in spring and early summer. Emergent wetland habitat is found both east of Skipper Bay dike and also west of the dike along the Utah Lake shoreline (shown as “Palustrine emergent” in Figure 10). The areas east of and inside the dike are currently being grazed, mowed, or hydrologically altered for agricultural purposes.

Hydrologic alterations include isolation from Utah Lake by the Skipper Bay dike, draining by ditches, and draining and drying by mechanically pumping water out of the wetlands during the growing season. Some emergent wetland areas may also be irrigated during summer for hay production. Parts of the emergent wetland habitat in the northern portion of the project area can be classified as hydrologically altered peat wetlands that have subsided due to grazing and hydrologic alterations. Peat wetlands exhibit anaerobic, acidic, and nutrient-poor conditions, which lead to the extensive accumulation of partially decayed organic matter (Chadde et al. 1998).

Figure 10. Lower Hobble Creek Restoration Project 10 years after construction, showing submerged and emergent vegetation communities, which provide June sucker rearing habitat.

Typical wetland plant species present in the emergent wetland habitat type include native species such as hardstem bulrush (*Schoenoplectus acutus*), chairmaker's bulrush (*Schoenoplectus americanus*) (also called Olney's three square bulrush), cattail, and some extensive monocultures of nonnative phragmites in areas at lower elevations that remain inundated early in the growing season . Figure 10 shows an example of a restored emergent marsh at Hobble Creek with many of the same species, including an unexpected native giant bur reed (*Sparganium eurycarpum*), which voluntarily came into the restored site. Phragmites is an invasive emergent weed that is being treated around Utah Lake. Treatment efforts to control this weed throughout Utah Lake are ongoing and are described in more detail in the Weed Management section of this report.

Native species present within slightly higher areas of the emergent wetland habitat where the hydrology is driven more by groundwater sources (such as springs and seeps) and less by seasonal surface water ponding include Nebraska sedge (*Carex nebrascensis*), common ragweed (*Ambrosia artemesiifolia*), Arctic rush, also known as Baltic rush or mountain rush (*Juncus arcticus* ssp. *littoralis*), chairmaker's bulrush, spikerush (*Eleocharis* spp.), common paintbrush (*Castilleja exilis*), Nuttall's sunflower (*Helianthus nuttallii*), scratchgrass (*Muhlenbergia asperifolia*), pickleweed (*Salicornia rubra*), and saltgrass (*Distichlis spicata*).

Some of the emergent wetland habitat in the westernmost portion of the project area appears to be affected by salts and alkali as indicated by the dominance of salt tolerant vegetation such as salt grass (*Distichlis spicata*) and fox-tail barley (*Hordeum jubatum*). The most common species present within and not native to the project area wet meadows are redtop (*Agrostis gigantea*) and reed canarygrass (*Phalaris arundinacea*).

Raised Peat Mounds

These unique, raised-wetland features have formed above upwelling springs. The raised peat mounds exhibit a soil surface elevation ranging from 1 foot or less to 3 feet higher than the surrounding landscape. This raised condition, which would have developed slowly over a very long historic period, is the result of partial decomposition of the dense annual emergent vegetation growth, supported by the upwelling springs and Utah Lake floodwaters. Like other project area wetlands, some of these features have been hydrologically altered in more recent times by agricultural drainage and the construction of the Skipper Bay dike. However, there are raised peat mounds that are still supported by appropriate sources of hydrology, and these contain some of the most diverse habitat in the project area. These areas contain a dense concentration of blooming native forbs such as swamp milkweed (*Asclepias speciosa*), common paintbrush (*Castilleja minor*), swamp verbena (*Verbana hastata*), Canada goldenrod (*Solidago canadensis*), rough bugleweed (*Lycopus asper*), Nuttall's sunflower (*Helianthus nuttallii*), spotted joe pye weed (*Eutrochium maculatum*), and alkali marsh aster (*Aster pauciflorus*). These relatively intact fens also support a collection of native wetland graminoids including water sedge (*Carex aquatilis*), woolly sedge (*Carex lanuginosa*), clustered field sedge (*Carex praegracilis*), and common spikerush (*Eleocharis palustris*).

Raised peat mounds outside the Provo City Wetland Mitigation Site (Attachment 1—Existing Habitat Types) are grazed and exhibit a vegetation community similar to the palustrine emergent wetlands. Other degraded raised peat mounds may exist in the project area within the emergent wetland habitat, but were not apparent under existing conditions when wetland delineation field investigations were conducted. As discussed earlier, the surrounding peat wetlands have likely subsided due to hydrologic alterations (drying), making it difficult to determine the height to which the existing peat mounds would have been raised above the surrounding peat wetlands under natural, saturated conditions. The raised peat mounds are located primarily along the historic shoreline of Utah Lake, which is on the eastern side of the project area, and also scattered along the Despain ditch. The location of the raised peat mounds is related to their formation at naturally occurring springs and seeps, and in conjunction with the natural annual flooding cycles of Utah Lake over the course of thousands of years since Lake Bonneville drained.

Ute Ladies'-tresses

Some of the emergent wetland habitat, including the raised peat mounds, contain known occurrences of and suitable habitat for ULT, a federally threatened plant species. Ute ladies'-tresses is a white-flowered orchid that occurs in low to mid-elevation wetlands and riparian zones in the central Rocky Mountains. The species was listed as threatened under the Endangered Species Act (ESA) on January 17, 1992, because of its rarity, low population sizes, and threats of loss or modification of riparian habitats (USFWS 1992). The majority of ULT suitable habitat within the survey area is situated at unique microsites within the emergent wetlands and on several of the existing raised peat mounds.

Ute ladies'-tresses populations are found on sites that maintain moist soil conditions throughout the growing season and on sites that support particular associated species of grasses, sedges, rushes, and riparian shrubs and trees. The plant is most often seen growing along old stream channels and on recently deposited material within the floodplain, but can sometimes be found in highly organic, loamy, and peat soils (USFWS 1995), which is characteristic of most of the suitable habitat within the project area. Groundwater, lake water, and river water contribute to the wetland hydrology of such sites. Ute ladies'-tresses plants appear to be tolerant of moderate levels of disturbance such as periodic seasonal flooding, early spring grazing, and mowing, and have been observed in inundated conditions and in merely moist conditions (Murphy 2003, Fertig et al. 2005).

Ute ladies'-tresses occurrences and suitable habitat within the project area (See Attachment 1—Ute Ladies'-Tresses Known Locations and Suitable Habitat 2010–2018) includes areas of mowed, seasonally wet pasture, low depressions within wet meadow habitat or along the margins of marsh areas, sloped areas adjacent to drainage ditches, and the aforementioned raised peat mounds. Soil textures within these areas are loamy, organic and peat, and they range from moist to saturated for most of the growing season. The most common species associated with ULT occurrences within the project area include graminoids such as mountain rush (*Juncus arcticus* spp. *Litoralis*), creeping bentgrass (*Agrostis stolonifera*), chairmaker's bulrush (*Schoenoplectus americanus*), Nebraska sedge (*Carex nebraskensis*), common spikerush (*Eleocharis palustris*), beaked spikerush (*Eleocharis rostellata*), and hot springs fimbry (*Fibristylus thermalis*), and forbs such as common paintbrush, Canada goldenrod, swamp verbena, rough buggleweed, spotted joe pye weed, swamp milkweed, and Nuttall's sunflower.

Ute ladies'-tresses suitable habitat within the project area has been disturbed by various land uses including grazing, altered hydrology, mowing for hay production, and adjacent transportation development. Much of the suitable habitat contains nonnative weedy species that are either on the State and County noxious weed lists, and are known to be problematic within the project area. These weed species are more prevalent in suitable habitat that has been more heavily disturbed, such as the hydrologically altered raised peat mounds. Weed species common in within suitable habitats include creeping bentgrass, reed canarygrass, Canada thistle (*Cirsium arvense*), common ragweed, meadow fescue (*Schedonorus pratensis*), quackgrass (*Elymus repens*), silverweed cinquefoil (*Argentina anserine*), rough cocklebur (*Xanthium strumarium*), and field sowthistle (*Sonchus arvensis*). In addition, ULT suitable habitat is sometimes found in open, grassy areas of Russian olive (*Elaeagnus angustifolia*) woodlands.

Restoration and enhancement of existing degraded wetlands and peat mounds may increase the amount of overall suitable habitat for ULT in the study area once hydrology is restored. Potentially dormant individuals currently occupying areas of low habitat suitability may reemerge if more appropriate conditions are met (Fertig et al. 2005). This is especially true for the large degraded peat mounds identified in the northwestern portion of the survey area. Restoring site hydrology, fluvial processes, and dynamics to the riparian corridor and delta wetlands is anticipated to benefit ULT populations in the study area by reversing many human-made drying trends.

2.3.6.3 Riparian Vegetation

Riparian vegetation that has been documented in the project area vicinity includes riparian forest, woodland, and shrubland communities. The forested riparian habitat within the project area is dominated by large eastern cottonwood (*Populus deltoides*) overstory trees with a herbaceous understory of reed canary grass, annual ragweed, crackgrass and perennial pepperweed. Some areas of riparian forest within the project area contain a small shrub component of Russian olive. Areas along the Skipper Bay dike and the Despain ditch are dominated by Russian olive woodlands with a variable herbaceous understory of weedy grasses and forbs such as reed canary grass, meadow fescue, and common ragweed. The disturbance level for these areas is high due to heavy grazing.

The riparian forest along the existing Provo River channel is dominated by eastern cottonwood, crack willow (*Salix fragilis*), silver poplar (*Populus alba*), and boxelder (*Acer negundo*), with stands of a few riparian species including coyote willow (*Salix exigua*), Bebb's willow (*Salix bebbiana*), bigtooth maple (*Acer grandidentatum*), chokecherry (*Prunus virginiana*), peachleaf willow (*Salix amygdaloides*), redosier dogwood (*Cornus sericea*), Rocky Mountain juniper (*Juniperus scopulorum*), skunkbrush sumac (*Rhus tribobata*), wax currant (*Ribes cereum*), woods' rose (*Rosa woodsii*), and Fremont cottonwood (*Populus fremontii*). Native riparian shrub species occur in areas along the existing river channel with floodplain features (e.g., gravel and sand bars). Occasionally, dense native willow communities can be found in these areas. However, much of this section of the Provo River is incised with steep banks of native soils and fill intermixed with riprap. Therefore, little or no understory or shrub growth is common in sections along the existing channel.

The majority of existing riparian forests along the existing channel have become disconnected from water in the channel. The vegetation composition is a mixture of native, invasive, and introduced species. Many of the existing trees were, presumably, planted by people. Alteration of the natural river processes resulting from channelization and flood-control measures have prevented natural recruitment of native riparian species within the majority of the project area. The result is large, single-aged stands of trees with very little riparian vegetation understory. The existing riparian corridor does provide considerable shade along the trail, which is a recreational benefit to the public in its existing condition, but without recruitment or replanting in the future, the existing trees are expected to slowly die off.

2.3.6.4 Upland Vegetation

The existing uplands within the project area and vicinity are mainly grazed pastures, cultivated alfalfa fields, rural grassland, and weedy fields dominated by nonnative species including lambsquarters (*Chenopodium album*), meadow fescue (*Festuca pratensis*), annual ragweed (*Ambrosia artemisiifolia*), intermediate wheatgrass (*Thinopyrum intermedium*), Canada thistle, and prickly lettuce (*Lactuca serriola*). Native upland shrubs and bunch grasses are almost completely absent from the project area. Some portions of the project area contain native grasses and forbs mixed with nonnative species. The majority of these areas occupy the wetland/upland transition boundary and have more mesic conditions or are areas of higher soil salinity. Native grasses and forbs in these areas include salt grass, Nuttal's sunflower, foxtail barley, western goldentop (*Euthamia occidentalis*), and slender wheatgrass (*Elymus trachycaulis*).

2.3.6.5 Weedy Plant Species

The project area has a history of intensive land management since the 1980s and before. Various disturbances, such as grazing management practices, farmland irrigation, plowing and tillage, off-road vehicle use, recreation trail development, and the alteration of site hydrology have created vectors for weed invasion, which has allowed nonnative, noxious, and problematic weed species to become well established. As mentioned previously, a comprehensive weed inventory was conducted in August of 2018 to map existing weedy plant populations within the project area and its vicinity. Weed species inventoried within the project area include nonnative, native, and nonnative plants known to be invasive and problematic, state- and county-listed noxious species, and other problematic weed species that present challenges to overall project goals. Attachment 1 includes Weed Location Maps illustrate weedy plant populations within the project area and vicinity. Areas that were primarily monospecific and less than 0.25 acres in coverage area are represented by point locations. Areas greater than 0.25 acres, which are vegetation communities dominated by one or more weedy species, are represented by polygons.

Weed dominance was not limited to a specific habitat type and consists of all growth forms including some trees and shrubs. Dominant weedy species commonly found in emergent wetlands include reed canary grass, phragmites, perennial pepperweed, Canada thistle, burningbush (*Bassia scoparia*), and cocklebur. Within riparian areas common weedy species include saltcedar (*Tamarix ramosissima*), crack willow, and Russian olive. The most prevalent weeds in the upland areas include Canada thistle, prickly lettuce, lambsquarters, hoary cress (*Cardaria draba*), and scotch cottonthistle (*Onopordum acanthium*).

Due to the history of land disturbance in the project area vicinity and as illustrated on in Attachment 1 – Weed Location Maps, nonnative weedy vegetation communities are fairly widespread throughout the project area. This presents a challenge to overall project goals, one of which is to restore native plant communities essential for June sucker recovery. Controlling all nonnative weedy vegetation within the project area would be expensive, require extensive effort through many treatment applications, would require considerable long-term applications, and could be impractical. As a solution, which is detailed in the weed-management plan in this document (Section 4.0), nonnative weedy species within the project area considered particularly problematic to project success have been organized by treatment priority. These treatment priorities include high, medium, and low, and are defined in Section 4.0.

2.3.6.6 Salvageable Resources Areas

The unique habitats associated with the Utah Lake shoreline and lake/river interface have not been irreversibly impacted nor non-equally throughout the project area. Areas dominated by native plant species with minor amounts of nonnative weedy species were delineated as "Salvageable Resource Areas" and are to be undisturbed as much as possible and soil salvaged and reused on constructed surfaces as topsoil. These areas include contextually high plant diversity, given that much of the project area is disturbed and consists of a mix of nonnative and native species with low species diversity or monospecific stands. Higher-quality salvageable resource areas were mapped in order to flag during construction to minimize disturbance while implementing the restoration project design, where excavation is planned in a Salvageable Resource Area to utilize existing native plant and soil materials at alternative onsite locations where soil is needed for revegetation. Attachment 1—Existing Habitat Types and Salvageable

Resource Areas shows salvageable resource areas overlaid onto existing habitat types identified during the 2018 comprehensive weed inventory.

Salvageable resource areas are defined as having 50 percent or greater native plant species relative cover, contextually high plant biodiversity, and 20 percent or less nonnative, invasive, State/County noxious or problematic species relative cover, and no phragmites. The raised peat mound areas are an example of salvageable resource areas, because their unique soils are rich in organic material, which provides conditions suitable for ULT and also support high relative plant diversity. Observations within the project area indicate the raised peat mounds seem to be more resilient to grazing pressure because of their independent spring hydrology and extremely high moisture-holding capacities, despite recent periods of drought. Impacts to Salvageable Resource Areas will be avoided and minimized where possible, and salvaged and re-used where excavation is needed during construction. Soils excavated from salvageable resource areas will be set aside and reused as topsoil.

3 PRDRP REVEGETATION PLAN

This VMP prescribes methods and quantities to revegetate the PRDRP for an anticipated 4-year, phased construction schedule starting in spring 2020. Work during the first 3 years will be focused on constructing all delta features, building the diversion structure/plug, and lowering Skipper Bay dike. During the fourth year, once river flows have been redirected into the new delta, construction activities will be focused on the existing channel. As much seeding and planting as possible will occur each year starting in fall 2020 for completed portions of the project area, with the most extensive planting efforts occurring in 2022, just before and while the delta is filling. Temporary irrigation will be used in areas to establish seed and plantings before site hydrology is restored. Permanent sprinklers will be installed at some high-use areas along the berm and trailhead parking.

The primary goal of the VMP for the PRDRP is to effectively revegetate the newly constructed project area with aquatic, wetland, riparian, and upland vegetation communities using species that are native to the Provo River/Utah Lake ecosystem for the purpose of re-establishing nursery habitats considered essential for June sucker recruitment (USFWS 1999). A diversity of native species are being used for these purposes because: (1) they provide the greatest habitat diversity known to be important for June sucker, (2) they are naturally acclimated to the project area's natural hydrologic regimes, yet do not become invasive and create undesirable monocultures, and (3) native vegetation provides the best probability of revegetation success and provides the best long-term solution to prevent the spread of invasive weeds. Specifically, inundated and overhanging vegetation at the river/lake interface is needed to provide cover, structure, and other functions at a variety of lake elevations important for survival of young fish in the presence of many predator fish. Inundated and overhanging vegetative cover at higher lake levels is also important to minimize predation of spawning adult fish by other larger fish and predatory birds, such as the American white pelican. The revegetation plan is also intended to provide aesthetically pleasing recreational areas and trails for the public to enjoy.

3.1 UTAH LAKE AQUATIC VEGETATION COMMUNITIES

3.1.1 Background

Aquatic plants play a vital role in multiple ecosystem processes. In ecosystems where they are abundant, aquatic plant species improve or maintain water quality by taking up nutrients, heavy metals, and other pollutants (Singh et al. 2012). Aquatic plants also hold sediment in place, which reduces turbidity, stream-bed and lake-bed scour and erosion, and maintains a clear-water stable state. Dense beds of aquatic plants along lake shores may also limit wind-driven shoreline erosion (Carpenter and Lodge 1986). Biologically, aquatic plant species provide habitat for ecologically important aquatic invertebrates and growing medium for bacteria, algae, and other microbes, all of which play a vital role in maintaining the health and stability of an aquatic ecosystem and provide nursery habitat and food for larval and young of year fish (Thomaz and Cunha 2010).

In Utah Lake and associated aquatic and shoreline ecosystems, aquatic vegetation has been historically abundant, with as many as 483 individual aquatic and wetland plant species and 7 major plant communities with 1 submerged aquatic plant community, the pondweed community identified (Brotherson 1981). These plant communities played a vital role in the ecology of and life history of lake inhabitants, including endemic species such as the June sucker. Before European settlement, these species, native only to Utah Lake, migrated from the lake into the in-flowing tributary rivers for spawning. Once spawning was completed, larval fish returned to the lake to feed in the littoral, submerged and floating aquatic plant communities.

This life history regime has changed significantly with modern changes in land and water use. Currently, June sucker recruitment is low, attributed to lack of survival of larval June sucker as they passively drift down the degraded channel of the Provo River and its degraded interface with Utah Lake. The absence of historical aquatic plant communities contributes to a decrease in nursery and rearing sites for young fish.

3.1.2 Basic Ecology

The aquatic and wetland plant communities of Utah Lake have been highly disturbed and disrupted by human intervention, as noted by Coombs (1970), but were originally zonal (Figure 11) and interconnected, which created complex aquatic habitat mosaics. There are two vegetation assemblages common to Utah Lake. These are (1) fringe/littoral wetlands, which are located along the water's edge, and (2) deep-water aquatic vegetation, which occur in water 3 to 6 feet deep (depending on lake conditions). Fringe wetlands may consist of multiple communities. Brotherson (1981) noted as many as six. Only one historical community (the bulrush/cattail marsh) occurs in semi-permanently saturated conditions, not exceeding 2 feet of water depth, and was widespread around Utah Lake, Provo Bay, and the spring inflows along the eastern shoreline. Other fringe wetland communities, occurring at higher elevations along the edges of the lake, are considered seasonally inundated, except during times of prolonged flooding, such as occurred in 1983–1985.

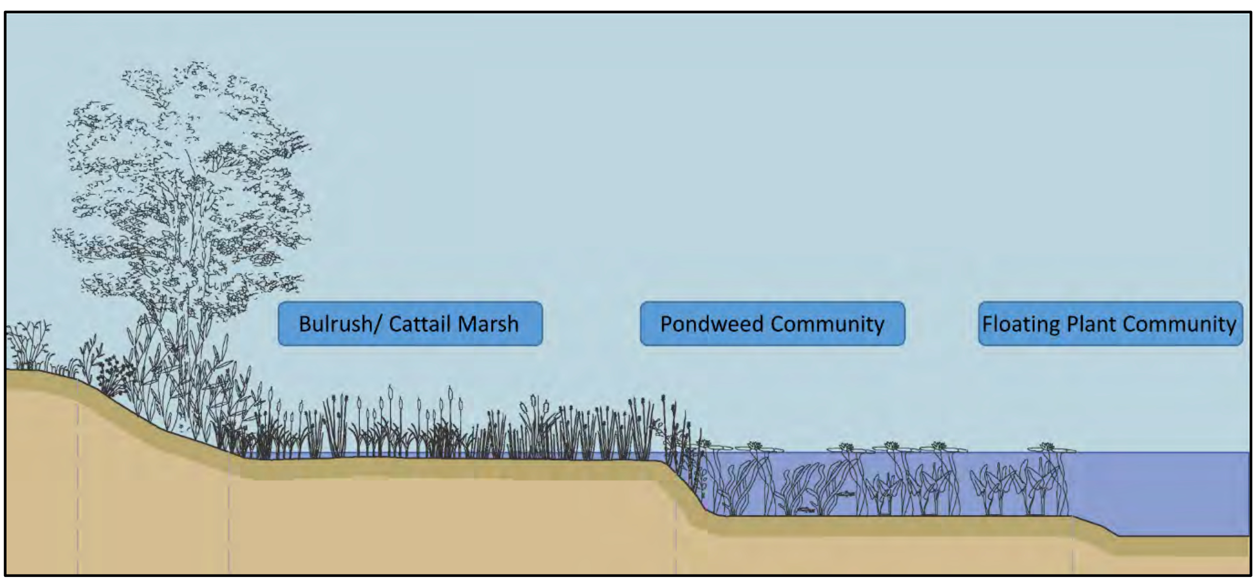

Figure 11. Cross section of the historic aquatic and shoreline plant communities of Utah Lake.

The open-water vegetation assemblage historically contains two aquatic plant communities—the submerged pondweed community and the floating vegetation community. The pondweed community is well documented by Brotherson (1981) and others. This community references the dominant plant species in the genus *Potamogeton*, which is commonly referred to as "pondweeds." The pondweed community consists of rooted, submersed aquatic plant species found in the deeper waters of Utah Lake, at depths between 3 and 5 feet. The pondweed community can be distributed along the outward edges of fringe wetlands, can continue into the open waters. This community type once covered vast areas of Utah Lake. In 1926 Cottam wrote:

> Utah Lake today is astonishingly free from aquatic vegetation yet it is within the memory of many when various species [sic] of Potamogeton and similar forms made rowing almost impossible along the shores and in the protected parts of the lake.

The submersed pondweed community matures into a colonial plant "stand." As the community matures, it produces more branching structure in the water column, and canopy cover at the surface increases in density to take advantage of sunlight. The pondweed plant colony is notorious for producing dense rhizomatous root structures, which help hold the plants in place, anchored against the onslaught of wave and wind action. Growth is limited by water clarity and water depth. This community provides dense structure throughout the water column. Isolated patches of pondweed can provide shade and cover to fish species inhabiting the open waters of Utah Lake and the deep water pools within the PRDRP.

The floating aquatic vegetation community consists of non-rooted aquatic plants, which is mostly dominated by coonstail (*Ceratophyllum demersum*), common water nymph (*Najas guadalupensis*), and a mixture of living plant fragments (or "propagules") of pondweeds and many other species. The species that make up the aquatic floating plant community are not rooted and can live with no attachment to the sediment, gaining all of their nutrients directly from the water. This plant community has the advantage of not being limited by water turbidity, since it is always at the surface, or water depth. As the biomass increases in these mats, they self-divide. Although historical accounts are scarce, it is likely these floating plant communities were carried around Utah Lake by winds and currents, providing much-needed structure, shade, dissolved oxygen sources, overhead protection from diving birds, and food sources for all species of fish.

The fringe wetlands most likely provided the refugia where propagules (floating turions, tubers, and stem fragments) of these submersed and floating plants would accumulate along the shoreline before winter. They would likely be driven from their mother colonies into the fringe wetlands by wind, and then over-winter in these protected areas during lake freeze. As water temperatures increased, these propagules would break dormancy and begin growing biomass. Prevailing winds, waterfowl, or other vectors would move the propagules back out to deeper water, where they would settle to the bottom to begin colonizing new locations or (in the case of floating vegetation) communities would settle around or along immersed structure (e.g., sunken logs, debris) to continue growing and expanding along the water's surface until they were redistributed across the lake by currents and prevailing winds.
One additional aquatic plant community indirectly associated with Utah Lake but included in the Provo River delta restoration are riverine aquatic macrophyte beds. These communities are found

within multiple tributaries (Provo River, Hobble Creek, and others) that flow into Utah Lake. While some plant species can be found in both stream and lake ecosystems, the ecology and growth pattern of in-stream macrophyte beds is quite different from the fringe wetlands and the aquatic plant communities. These beds are subjected to many more stressors, including high water velocities, accretion and scouring of stream bed sediment, and varying sediment nutrient loads. The plant species dominating this community have multiple physical and biological adaptations to constantly flowing water and other variable growing conditions.

Since European settlement, many nonnative plant species have been introduced into the Utah Lake environment. These species have had detrimental effects on less-competitive native wetland and aquatic plant communities. Among the long list of noxious and invasive plant species is phragmites, which has become a dominant species in the historical bulrush/cattail marshes. Phragmites has grown into expansive monospecific stands, which reduce wetland plant diversity. Curly leaf pondweed (*Potamogeton crispus*) is another invasive aquatic weed that has taken hold in the aquatic plant community of Utah Lake. This species, commonly found in the streams feeding into Utah Lake and among the fringe wetland marshes, can replace the more desirable native pondweeds.

3.1.3 June Sucker/Vegetation Relationship

June sucker were historically found throughout Utah Lake in open water, where adults feed on midwater plankton and migrate into lake tributaries to spawn. Although Kreitzer et al. (2012) investigated the growth of June sucker in emergent vegetation communities, knowledge of the utilization of the submerged and floating aquatic plant communities by June sucker is limited because both June sucker and the vegetation communities have been greatly reduced in Utah Lake in the past 60 years or more. It can be inferred that June sucker utilized submerged and floating aquatic plant communities throughout their life cycle, with more reliance upon these types of vegetation during the larval and fingerling stage. Restoration of submerged aquatic and floating vegetation has been targeted as a key component to recovery (USFWS 1999).

Historically, June sucker larva would migrate passively downstream after hatching, and then settle into aquatic plant habitat in channels, pools, lake edges, and (eventually) open water. This habitat would have included fringe wetlands consisting of bulrush/cattail-dominated plant communities; the submersed plant community, consisting of native pondweeds; and the floating plant community. These communities offer a wide diversity of structure providing not only protection for June sucker larva but also various growth surfaces for algae, bacteria, rotifers, daphnia, and other microfauna, microflora, and macroinvertebrates essential for June sucker foraging at all larval growth stages. Most likely, fingerling June suckers retain their association with these plant communities beyond their larval stages for the benefit of protection from larger avian and fish predators as they begin foraging in open water. This behavior relies heavily on "edge effect" (Smith et al. 2008) and the aquatic plant community mosaic. As June suckers mature, plant communities in the deeper water farther from shorelines become utilized until the fish reaches full maturation and leaves the structure for open-water feeding. Adults most likely still relied on drifting, floating vegetation found throughout Utah Lake as a source of both food and protection. When mature June suckers would stage themselves for spawning migration, adults likely would move into the open-water plant communities first to feed and to take advantage of the protection from avian predators, and then progress into shallower water with fringe wetlands, before finally progressing upstream for spawning. Woody riparian vegetation such as willows and dogwoods are important to provide cover and structure for young June sucker and adult spawning fish during times of high water elevations.

3.1.4 Delta Ecosystem Restoration

The PRDRP is proposed to recreate a small portion of the historical Provo River delta ecosystem in order to provide functional aquatic and emergent plant communities and improve the recruitment potential for the June sucker. The PRDRP proposes to re-route a majority of the flow of the Provo River through a constructed matrix of channels, irregularly shaped open-water ponds, and shallow flooded wetlands to enhance contact of June sucker larvae with optimal habitat as they migrate downstream to Utah Lake proper. It is expected that June sucker larvae will utilize the matrix of aquatic, emergent, and riparian plant communities within the delta until they grow larger and move farther into Utah Lake, at which time they can utilize established aquatic vegetation along the lake edge and deeper water. Therefore, the restored Provo River delta will provide a vital corridor from the river spawning grounds all the way to open water. The delta will also supply plant propagules into Utah Lake, which will potentially lead to establishment of more in-lake aquatic habitat at the same time carp populations have been significantly decreased by commercial fishing. While the river delta project will comprise multiple wetland, riparian and upland plant communities, a major focus will be the incorporation and establishment of submersed, floating, and riverine aquatic plant communities, detailed below, along with some unvegetated, deeper open water. For restoration purposes, the species composition of these communities are best chosen based on the historical records, many of which were noted above, because known species with historical accounts of existence in Utah Lake are adapted to local growing conditions, were most likely effectively utilized by the June sucker, and are therefore most ecologically appropriate.

The following criteria were used in selecting the plant species proposed for revegetation of the PRDRP:

- Plant species that are native to the project area. Native species are adapted to local growing conditions and ecologically appropriate for June sucker rearing.

- Plant species documented in Utah Lake historical records. Such species are adapted to local growing conditions and ecologically appropriate for June sucker rearing.

- Plant species that are already present/common within the project area. Such species are adapted to local growing conditions and will be likely to establish rapidly and successfully.

- Plant species known to be present in the restored Hobble Creek delta ponds. The lower Hobble Creek restoration project was completed in 2008 and remains the only location where naturally recruited young June sucker have been documented in the past 30 years.

- Plant species with a proven track record of successful establishment when used as part of revegetation efforts on other restoration projects in northern Utah.
- A revegetation plan that includes a diversity of species for each community type. Inclusion of several species is necessary to maximize the likelihood of rapid, successful establishment of

desirable plants. Species diversity also reduces the susceptibility of plant communities to diseases.

- An aggressive revegetation plan that will increase the likelihood of rapid, successful establishment of desirable plants. This will be a key component in limiting the invasion of undesirable invasive nonnative species like phragmites that could undermine PRDRP success.

- Phragmites is already present in the project area, and if allowed to establish unchecked, could block connectivity between open water, submersed aquatic, and emergent plant communities—connectivity that is essential for survival of young June sucker. Aggressive revegetation is also important to limit invasion by other undesirable species, such as Russian olive (*Elaeagnus angustifolia*), reed canary grass (*Phalaris arundinacea*), and other noxious weeds that require control under Utah state law (Utah Code Title 4 Ch. 17).

- A revegetation plan that includes woody riparian shrub and tree species. These types of plants are important for adding stability to streambanks, providing cover for June sucker and habitat during floods, and for providing shade to help keep soil and water temperatures cooler.

3.1.5 Airport Wildlife Hazard-Reduction Measures

This Final VMP for the PRDRP is consistent with the VMP and weed controls developed for the PRDRP FEIS and was developed in coordination with June sucker technical experts, ecologists, Provo City, Federal Aviation Administration (FAA), and US Department of Agriculture—Wildlife Services to include compatible wildlife hazard-reduction measures to minimize bird-aircraft strike risks. Several bird hazard-reduction measures were incorporated into the design based on comments provided by FAA and recommendations from Rick Jones who is the airport wildlife biologist that has been monitoring bird populations and movements surrounding the airport and project area. An important hazard reduction measure was identified during design to minimize bare- and short-grass shorelines and open-water habitats that are attractive to shore birds, diving birds, and nesting waterfowl. Periodically and permanently inundated gradual slopes will be common landforms throughout the delta, especially surrounding oxbow ponds and distributary channels. Quickly establishing desirable emergent vegetation will not only benefit June sucker, it will be less of an attractant for wading birds and nesting waterfowl. Transitions between emergent and deep submerged vegetation were designed with steep, abrupt, well-vegetated slopes to minimize shallow, bare- and short-grass shorelines that are attractive to wading and nesting birds, and avoid creating easy access for birds to enter and exit loafing areas from the water.

Specific design elements used to reduce the attractiveness of the restored delta to hazardous bird species include the use of:

- Irregular shaped (ink-blot) ponds
  - *Less attractive to birds considered hazardous to aircraft*
  - *Research shows that bird use on ponds decreases with the greater amount of pond perimeter irregularity*
  - *Deeper water areas broken up by shallower vegetated areas to limit landing areas and attractiveness of ponds to large bird flocks*

- Upland/riparian woody areas next to ponds
  - *Thick shrubs and tall vegetation on shorelines to discourage loafing by birds*

- Thick emergent vegetation throughout shallow inundated areas
  - *Thick vegetation is preferred so birds can't detect predators and it disrupts intra-flock communication*

- Steep banks/slopes leading into ponds
  - *Discourages birds from moving between ponds and uplands/riparian woody areas*
  - *Helps reduce bird predation on fish & bird attractiveness for foraging*

- Submerged aquatic vegetation
  - *Helps reduce bird predation on fish & bird attractiveness for foraging*

The FAA has been involved with reviewing preliminary plant species lists from previous draft versions of the VMP. In general, FAA recommends using plant species of low nutritional quality or palatability whenever possible to reduce the attractiveness of the PRDRP to hazardous wildlife. The FAA reviewed draft species lists in preliminary versions of this report and the following non-critical species were excluded from the final PRDRP revegetation seed mixes and plantings plans:

- Duckweed
- Common water meal
- Water buttercup
- Woods rose
- Serviceberry
- Chokecherry
- Great basin wildrye
- Alkali bulrush

Also due to airport safety concerns, the following species will only be used sparingly and in small amounts for revegetation in the project area:

- Water sedge
- Sporobolus alkali sacton
- Virginia wildrye

3.1.6 Revegetation Details: Plan View, Cross Sections and Quantities

The PRDRP revegetation plan involves re-establishing permanently inundated rooted and floating aquatic plant communities adjacent to deeper open water, seasonally inundated emergent wetlands, occasionally inundated wooded riparian areas, and rarely inundated upland vegetation communities at specified elevation ranges based on frequency, depth, and duration of inundation. Revegetation zones within the majority of the project area are based primarily on post-construction topography and restored hydrology of the project area, as described in the main body of the PRDRP design report, developed by Allred Restoration. Elevation ranges and species being used for each revegetation habitat type are shown in Table 1 and Figure 12.

Table 1. Elevation ranges identified for revegetation plantings and seeding habitat types.

HABITAT TYPE	CONSTRUCTED GRADE ELEVATION	FLOODING DEPTH AT GROWING SEASON AVERAGE ELEVATION IN DELTA (4,488 FEET)
Uplands	>4,493 feet	Rare Flooding
Riparian	4,489–4,493 feet[a]	Shallow Seasonal Flooding, Wettest Conditions at Lowest Elevation
Emergent	4,486–4,489 feet	Frequent Flooding 0–2 feet
Submerged Aquatic	4,482–4,486 feet in delta, and 4,484–4,486 feet in lake (with less water clarity)	2–6 feet in delta and 2–4 feet in lake (with less water clarity)
Open Water	<4,482 feet in delta, and <4,484 feet in lake (with less water clarity)	>6 feet in delta and >4 feet in lake (with less water clarity)

[a] Supplemental irrigation is recommended for upland and riparian plantings located above naturally flooded areas for 3–5 years, until such time as they grow large enough for root systems to reach adequate soil moisture depth.

Restoration design features include: new river zone channels and ponds, multiple delta zone channels, ponds and depressions, and woody riparian wetland areas to be constructed along the new berm and on mounds created at a few locations within the delta as shown in the revegetation design plan-view and cross-section maps of the project area (Attachment 2). The project will lower Skipper Bay dike and create four delta outfall channels that are designed to maintain fish passage from the lake to the delta for adult June sucker even when Utah Lake elevations drop below 4,487 feet, which is the elevation of the hardened channel bottom at Skipper Bay dike.

The river zone upstream of the proposed Lakeview Parkway (upper river zone, as shown in Attachment 2—Cross Section AA) will be constructed with riprap banks and will remain channelized between constructed berms east of the proposed Lakeview Parkway bridge. Willow and dogwood cuttings will be installed in the rocky banks during the time the banks are constructed. The lowest floodplain surface adjacent to the river will be constructed near the 2-year flood elevation and will be seeded and planted with riparian vegetation. Areas above the 2-year flood elevation will be seeded and planted with upland vegetation.

An important revegetation detail is that the new berms will have upland grasses only on the structurally important portions of the berm (applied to all plan view maps and cross sections in Attachment 2). An upland seed mix was created without shrub seed for this 44-foot-wide, grass-only corridor. This no-shrub seed mix will also be used on the 12-foot-wide access path along the north side of the project area, as shown on the plan-view map. Shrubs and trees can be planted outside of the structurally important portions of the berm, with shrubs only for approximately 10 feet in each direction beyond the 44-foot, grass-only corridor, and then trees outside of the approximate 64-foot "no-tree" corridor.

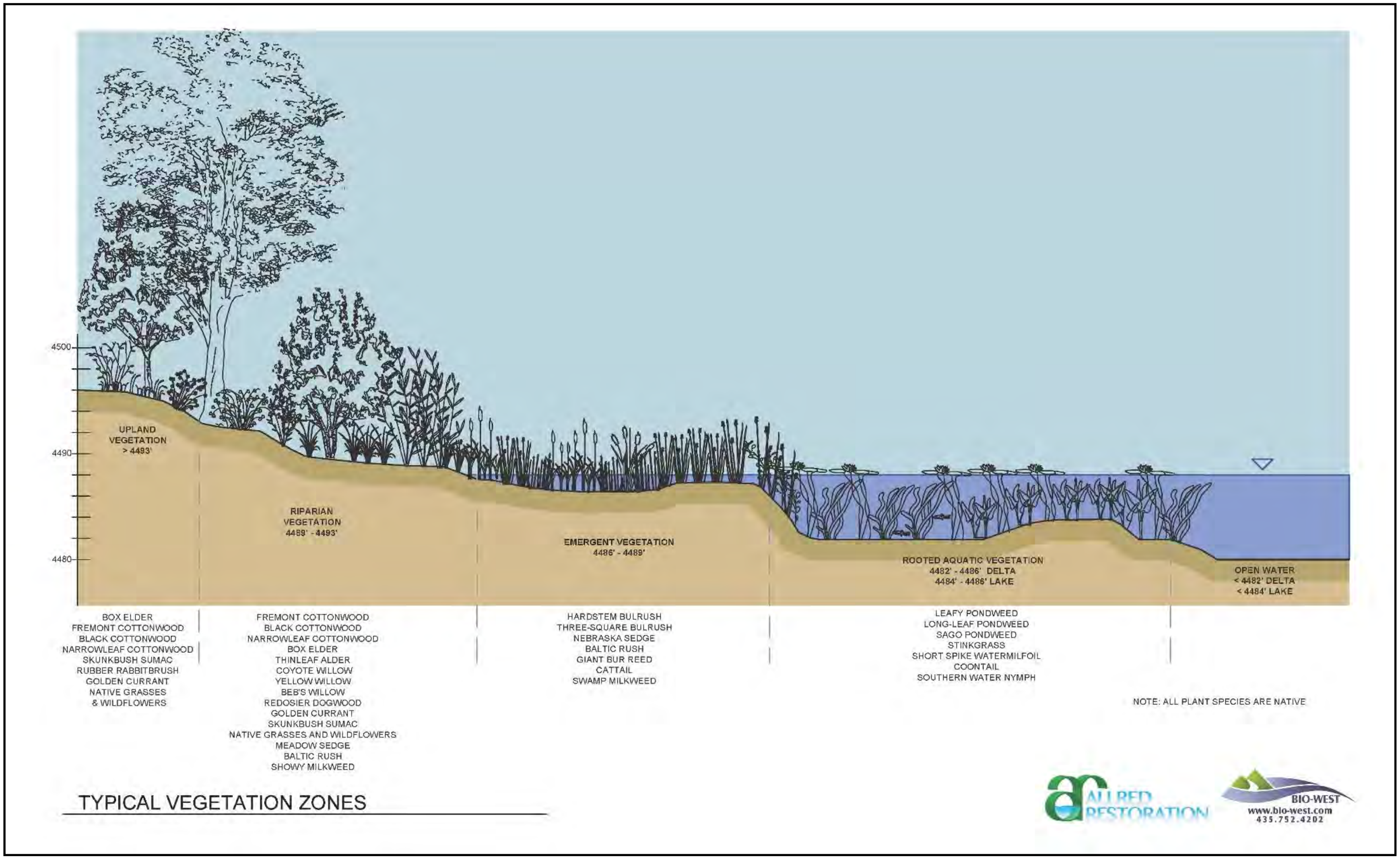

Figure 12. **Typical cross section and vegetation types of the Provo River Delta Restoration Project (PRDRP).**

Fill will be placed in the upper portions of the existing channel to create a small channel with emergent/riparian vegetation immediately below the plug/diversion and upstream of the proposed Lakeview Parkway crossing. A plan view map and typical cross-section view of this small channel section is shown in Attachment 2. The small channel in this section was designed for a minimum flow of 10 cfs and a maximum flow of 50 cfs. Notice that 50 cfs inundates the emergent vegetation surface. Lower portions of the existing channel downstream of the proposed Lakeview Parkway bridge will not need revegetation because this section of the existing channel is deep and the water will be ponded at an elevation near the existing ordinary high-water mark (4,489 feet), assuming the small dam will be installed downstream at Utah Lake State Park. Trees and other vegetation already exists in this section above this elevation along the Provo River Parkway trail and along the south levee.

Two cross sections of the lower river zone (cross sections A and B) are shown in Attachment 2. Coir fiber blocks will be used in this section of the river to stabilize the banks and to help get willow and dogwood established as soon as possible after construction to minimize bank erosion. A close-up detail of the coir fiber block bankline treatment with plantings is also provided in Attachment 2, showing blocks stacked on a steep bank (indicating that it is on the outside of a bend) and on a gentle sloped bank (indicating that that is on the inside of a bend).

Delta zone cross sections (cross sections C, D, and E) show where channels, ponds, and depressions will be excavated and where fill will be placed within the delta to create woody riparian wetland mounds. Delta channels, ponds, and depressions will consist of a combination of open water interspersed with areas of submerged aquatic vegetation, mostly surrounded by emergent wetlands. Close-up cross sections are included in Attachment 2 to show delta channel and delta depression revegetation details.

Cross section F in Attachment 2 is oriented longitudinally (west to east) to show the lowering of Skipper Bay dike and how that reconnects Utah Lake with the delta when lake levels reach compromise elevation (4,489 feet). The “green” lake water on the left side of cross section F is shown at compromise elevation, which without Skipper Bay dike increases inundation depths in the delta. The excavated area under Skipper Bay dike and west along the shorelines will be revegetated with emergent wetland seed and plantings. Desirable woody vegetation will be preserved and re-used along the shoreline as much as possible during construction.

Delta ponds and depressions were designed to include areas deep enough to provide open water during the winter, where temporarily isolated fish can overwinter. The delta zone cross sections illustrate a significant increase in topographic and habitat diversity in the restored delta compared to existing conditions. Revegetation details and quantities are described for each restored habitat type below.

3.2 SUBMERGED AQUATIC VEGETATION

Restoration of aquatic plant communities can be complex. Unlike terrestrial plants, aquatic plants are subjected to many more stressors and factors that influence establishment, growth, and expansion. Additionally, aquatic plant species might not be available from commercial growers or nurseries because the logistics of growing true aquatic species are complex and demand is limited. There are four key stages to aquatic plant restoration (Smart et al. 1998):

1. Acquire the propagative material for desirable species.
2. Grow the plant material in sufficient quantity and quality for the restoration site.
3. Successfully establish the plants on site.
4. Monitor success and controlling unwanted species.

3.2.1 Sourcing Selected Aquatic Plant Species

Based on the historical literature of Cottam (1926) and Brotherson (1981), comments from FAA and airport hazard wildlife biologists, we propose the following aquatic plant species for the pondweed and floating aquatic vegetation community (Table 2). These species are best adapted to the growing conditions in the proposed restoration area, ecologically appropriate for June sucker rearing, and present in nearby waterbodies as sources for transplanting or propagation.

Table 2. List of proposed selected aquatic plant species for the Provo River Delta Restoration Project (PRDRP).

SPECIES	COMMON NAME	COMMUNITY	PROPAGATION METHOD
Stuckenia pectinata	Sago pondweed	Pondweed	seed, sprig, plug
Potamogeton nodosus	Longleaf pondweed	Pondweed	seed, sprig, plug
Potamogeton foliosus	Leafy pondweed	Pondweed	seed ,sprig, plug
Myriophyllum sibiricum	Shortspike watermilfoil	Pondweed	sprig, plug
Ruppia cirrhosa	Spiral ditchgrass	Pondweed	seed, sprig
Chara sp.	Stinkgrass	Pondweed	Sprig
Ceratophyllum demersum	Coon tail	Floating	Sprig
Najas guadalupensis	Southern water nymph	Floating	Sprig
Potamogeton foliosus	Pondweed	River Zone	seed, sprig, plug

The first step in developing an aquatic plant restoration project is sourcing propagules for the selected species. The selected species for this project were chosen for their known adaptability to local growing conditions. Tolerance to seasonal changes, soil type, and water quality are among the most important characteristics in plant selection for this project.

While Brotherson (1981) indicates the historical pondweed community consisted mostly of a monoculture of *Potamogeton latifolius* (now *Stuckenia striata*) we propose using a variety of species to increase diversity in the restored delta, which will hopefully improve aquatic plant diversity throughout Utah Lake. Most of the selected species can be acquired locally from nearby streams, canals, and reservoirs. The numerous wildlife management areas around Utah and the Great Salt Lake would most likely furnish bountiful supplies of propagules for collection. References such as the Intermountain Herbarium Network (Hestmark and Barkworth 2019) and Wetland Plants of Great Salt Lake (Downard et al. 2017) provide good sources for proper identification and location of native aquatic plant propagules.

3.2.2 Propagation of Aquatic Plants

Little information exists regarding the successful propagation of the selected species, though *Potamogeton* and *Myriophyllum* are generally prolific. Several methods of propagation can be utilized. The easiest method for the propagation of aquatic plants is clonal division of rhizomes, stolons, or stem fragments (typically referred to as “sprigs”). This method is how aquatic plants spread naturally in the environment. Sexual reproduction via seed is less common in aquatic plant species, although it is a common method for seagrass restoration. Seed production can be prolific, but the success of seedling recruitment is determined by growing conditions, and this can be greatly improved under controlled conditions.

While production of aquatic plants via seedlings may be somewhat more challenging, the benefits of a genetically diverse species population can be advantageous for large-scale restoration. Propagation methods can be species-dependent; some species are best produced clonally and some can be produced only clonally (e.g., *Ceratophyllum demersum*). Other species can be produced from seed and clones (*Potamogeton* sp.). Field collection of seed may be difficult to achieve given the growth location, but seed-based propagation is worth investigating.

Grow-out methods for aquatic plants can be simple, consisting primarily of sprigging plant propagules into pots filled with proper growing media, and then placing pots into tanks, ponds, pools, or raceways of water where they can be protected and nurtured until well-rooted plant "plugs" are produced (Figure 13). Greenhouses would serve best for aquatic plant production because they can prolong the growing period, but a temporary field nursery site or ponds can be utilized if no other resources are available (Figure 14).

Figure 13. Bare-rooted propagules (left) versus rooted plants (right).

Figure 14. Growing conditions can be better controlled in greenhouses (A). Field nursery sites can be easily assembled (B).

If seed is used as a starting point, this can be mixed with growing media into pots and placed into a nursery-type setting. Broadcasting seed directly onto the restoration site would probably not be successful unless large amounts of seed were available and seeded during the right conditions, because reproduction from seed is dependent on many factors. Therefore, we are not recommending seeding the delta for submerged aquatic vegetation.

Potted plants are best allowed to grow until the roots become matted and root-bound within the pot, at which time they would be considered ready for planting. While this is a time-consuming step, mature plants are better able to handle the stresses of being planted into a new environment. With a fully formed root system, they transplant well and are able to expend energy into growth rather than growing new roots and shoots (as bare-rooted propagules would). Fully formed roots also play a strong role in anchoring the plant underwater. However, bare-rooted propagules added directly to the restoration site may be sufficient and timelier for establishment in some circumstances. For some species, such as *Ceratophyllum demersum*, this may be the only viable method of establishment.

3.2.3 Establishment of Aquatic Plants

Plant establishment methods for the delta will be dependent on the quality of supplied plants and planting conditions. Dependent variables may include (but are not limited to) the size of the plants, depth of water at the planting site, water clarity, season at the time of planting, and soil type. Some effort can be made to improve establishment success during the propagation phase if the final planting conditions can be known. For instance, if planting will occur in deeper water, then plants should be propagated in water at approximately the depth of *in situ* planting. Additionally, if plants are propagated under controlled water-quality and substrate conditions, those conditions should mimic water quality *in situ* as closely as possible.

For the Provo River delta restoration, there are two kinds of aquatic vegetation establishment sites (Figure 15). Naturalized, braided channels moving through the delta will provide planting locations for riverine aquatic vegetation. These braided channels will move through irregular, deep-water pools, which will provide establishment sites for both the pondweed community and the floating vegetation community. It will also provide some degree of deep, open water, which is essential to promote zooplankton food sources for June sucker larvae. This combination of vegetated structure and open water will provide highly preferred habitat for the June sucker (Billman 2008, Kreitzer et al. 2012).

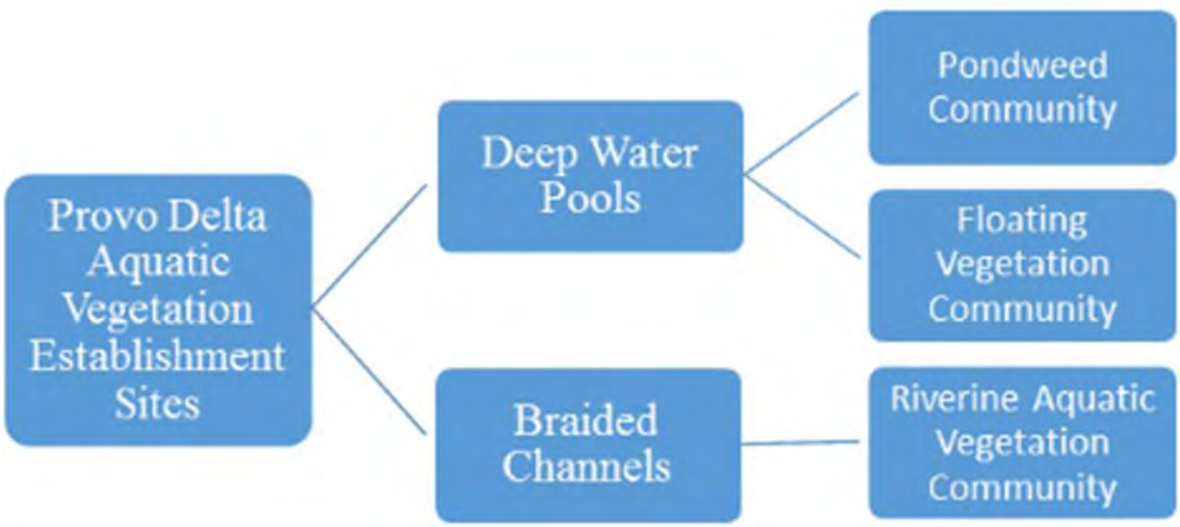

Figure 15. Two planting sites will provide habitat for three different aquatic plant communities.

Establishment of aquatic vegetation may consist of passive and active methods. In some cases, vegetation may establish naturally from propagules transported downstream. While this method would be beneficial because it would incur zero expense, it would mean species diversity would likely be limited to the few, locally abundant species, some of which may be unsuitable or nonnative. However, active establishment of selected species would ensure a diverse community of aquatic plants, which would recreate known functional assemblages. Given the scale and scope of this project, active methods of establishment may be as simple as collecting propagules of selected species from one area and introducing them into the restoration site to establish and expand on their own. This would be the preferred establishment method for species in the floating vegetation community. Additional options would include transferring propagules into ponds or holding tanks first (allowing the initial biomass to expand and divide under optimal growing conditions), and then transfer the bare-rooted propagules into the restoration site. This method would be most beneficial if propagules of the selected species were limited at the collection site.

For some chosen species in the pondweed or riverine planting sites, bare-rooted propagules could be collected, transferred, and planted directly on site. Active establishment of vegetation in these planting sites would be enhanced by including the production of rooted, mature plants. As discussed previously, rooted plants are more robust and quicker to establish, but require much more labor for installation because each potted plant must be individually planted. Pre-planted "sod" has been successfully utilized in other projects. Instead of potted plants, bare-rooted sprigs are established into a sheet of bio degradable growing fabric and allowed to root in a nursery setting. For planting, this sod is simply rolled up, transported to the site, unrolled, and staked in contact with the sediment where the roots can then establish themselves (Figure 16). This is an option to be used in the future as needed but not included in the planting numbers in this report.

Figure 16. Rooted aquatic plant "turf" established in a bio-degradable mat.

Planting design is an important factor in establishing a variety of vegetation and open-water mosaics. Two types of planting designs (Figure 17) can be implemented for all vegetation communities, especially aquatic plant establishment (Silliman et al. 2015) and these can be used exclusively or interchangeably, based on the desired outcome for the site. Planting conditions can also play a factor in design choice.

"Uniform dispersion" spaces individual plants or active propagules (plantings) evenly throughout an area, ensuring the entire area receives planting, which is thought to limit competition from neighboring individuals and allows better estimation of the number of plants needed per area. "Clumped dispersion" aggregates plantings and mimics a natural vegetation community, especially for submersed aquatic plants, which allows neighboring plants to protect each other from herbivory, erosion, and other impacts. Clumped dispersion can focus planting in specific locales where soil or water depth are optimal, and it allows the positive benefits of edge effect because clumped plantings will eventually mature into solid but discrete plant stands. If larger patches are desired, clumps can be planted closer together, eventually coalescing into irregularly shaped patches or more isolated clumps that retain an open water border. Most plantings in the PRDRP will be installed using the clumped-dispersion planting design.

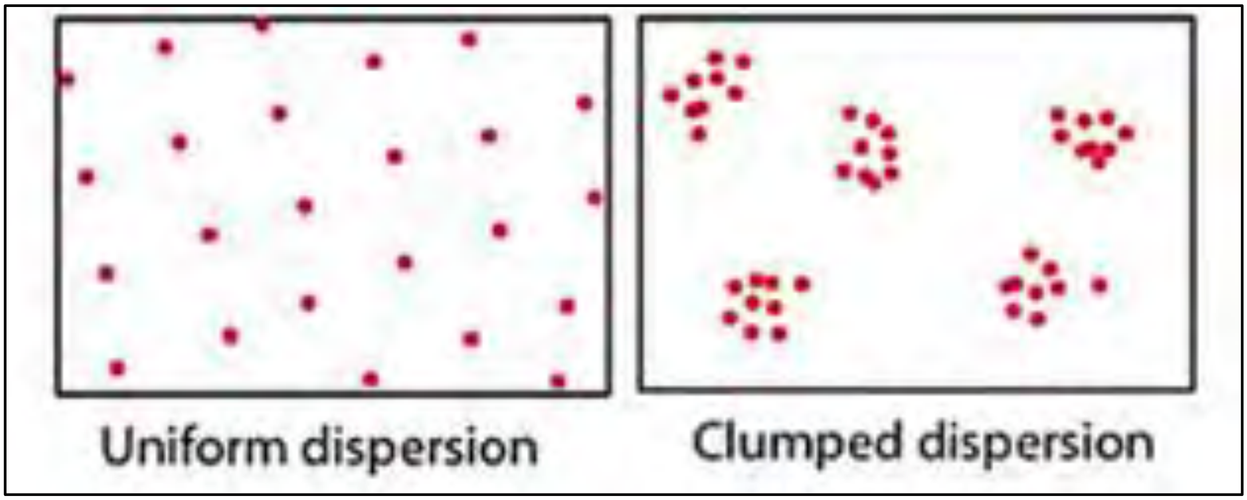

Figure 17. Plantings for the PRDRP will be installed using a clumped dispersion planting design.

The total plantings needed for each planting site depends on the desired density of planting. One planting per square foot is a typical standard for aquatic revegetation projects for smaller project areas, but this can range up to one planting per 6 square feet (Fonseca 1994) with lower coverage expectations the first few years following implementation compared to higher density plantings. A planting rate of one planting per square foot was used to estimate the total number of submerged aquatic vegetation plants needed.

There are 20.2 acres of submerged aquatic vegetation planting areas needed for the restored delta. A coverage rate of 20 percent of the total planting area per plant community type would be considered suitable and realistic. This estimate equals 172,063 submerged aquatic vegetation planting (Table 3). As discussed previously, multiple propagation and planting methods can be utilized to provide this coverage.

Table 3. Submerged Aquatic Vegetation Planting Numbers.

PLANTING SITE	ACRES	% AREA PLANTED	COMMUNITY	ACRES PLANTED	PLANTING DENSITY	# OF PLANTS
Delta Zone Channels	10.0	20	Pondweed	2.0	1 planting/ ft^2	87,120
Delta Zone Ponds	6.4	20	Floating	1.3	1 planting/ ft^2	55,757
River Zone Channels	3.5	20	Riverine	0.6	1 planting/ ft^2	26,572
River Zone Ponds	0.3	20	Pondweed	0.1	1 planting/ ft^2	2,614
Total submerged aquatic plantings						172,063

The total number of submerged aquatic plants would be closer to 30,000 if the density of plantings were reduced to 1 planting per 6 square feet. This lower density is not recommended for the PRDRP because of the habitat and weed control needs described in previous sections.

In addition to planting techniques and design, plant establishment relies on protection of newly planted areas from (among other influences) perturbation (e.g., herbivory or animal disturbances), excessive wave action, or high-velocity water. Initial protection from herbivory is a crucial but difficult step for large-scale restoration projects. Common carp (*Cyprinus carpio*) are a known problem in Utah Lake and the initial loss of native aquatic vegetation is directly attributed to their presence (Kreitzer et al. 2012). Carp typically damage newly planted vegetation by uprooting as they feed along the bottom. Protection methods from carp and other issues can include protecting individual plantings by securely anchoring propagules with turf staples and stakes or planting plugs into benthic barrier material to prevent uprooting (Figure 18).

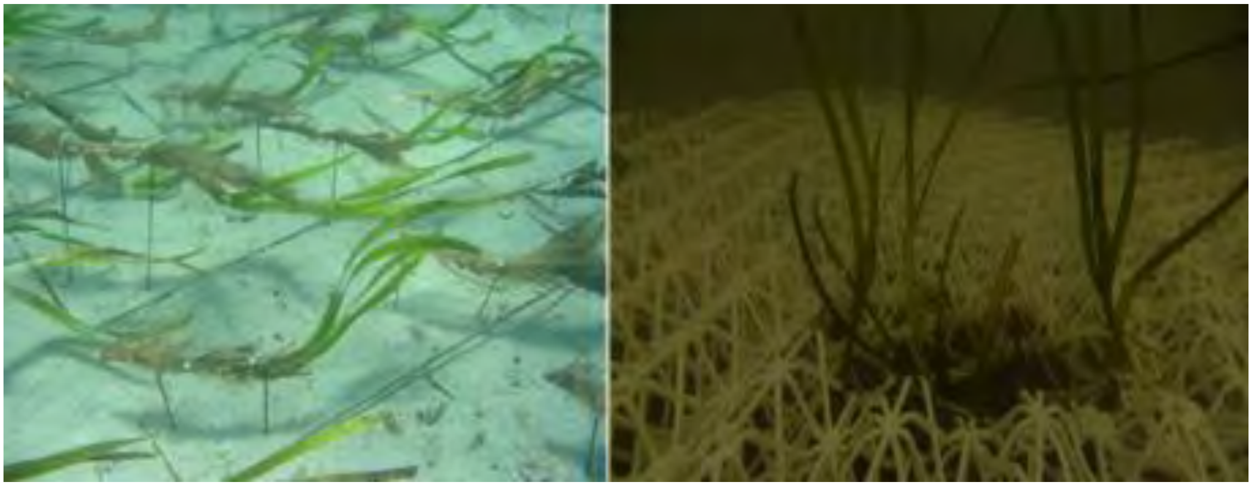

Figure 18. Ground staples can be used to anchor bare-rooted propagules in place (left). Bottom barriers protect newly planted plugs from being uprooted by carp foraging (right).

Pre-planted "turf" can also be beneficial in this regard (see Figure 16), as can anchored plantings made in the braided channel where there is moving water. Plantings in moving water should be limited to areas of the channel where velocities are lower, where the plants could be allowed to grow into faster-moving water on their own. Velocities around 3 feet per second or above are typically inhibitory to aquatic plant growth (Chambers et al. 1991). Planting plugs or sprigs in dense, consolidated sediment at any site will also help hold plants in place.

One consideration to improve the establishment of native aquatic vegetation is to include the use of physical barriers. This "founder colony" approach offers large-scale protection where stands are surrounded by floating booms attached to curtain nets weighted or secured to the bottom (Figure 19). These netted exclosure areas can be anchored in desired locations to further protect planted plugs and propagules exclusively from foraging carp. Unlike the rigid fencing typically used as herbivore protection in other aquatic plant restoration projects (Smart et al. 1996, Smiley and Dibble 2006), which is easily overtopped by changing water depths, floating exclosures can maintain themselves at variable water depths, can be deployed in open water, and easily moved and removed. Protection devices can be used for either short or long time periods. Large-scale exclosures can be deployed for short periods but of sufficient duration to allow plants to establish and expand free from pressure of carp foraging. After sufficient time and establishment, the exclosures are removed. Protective exclosures can be left in place for longer durations to provide for protection of founder colonies. Under persistent protection, these founder colonies can expand outside of their protected zones and supply propagules to the rest of the restoration site.

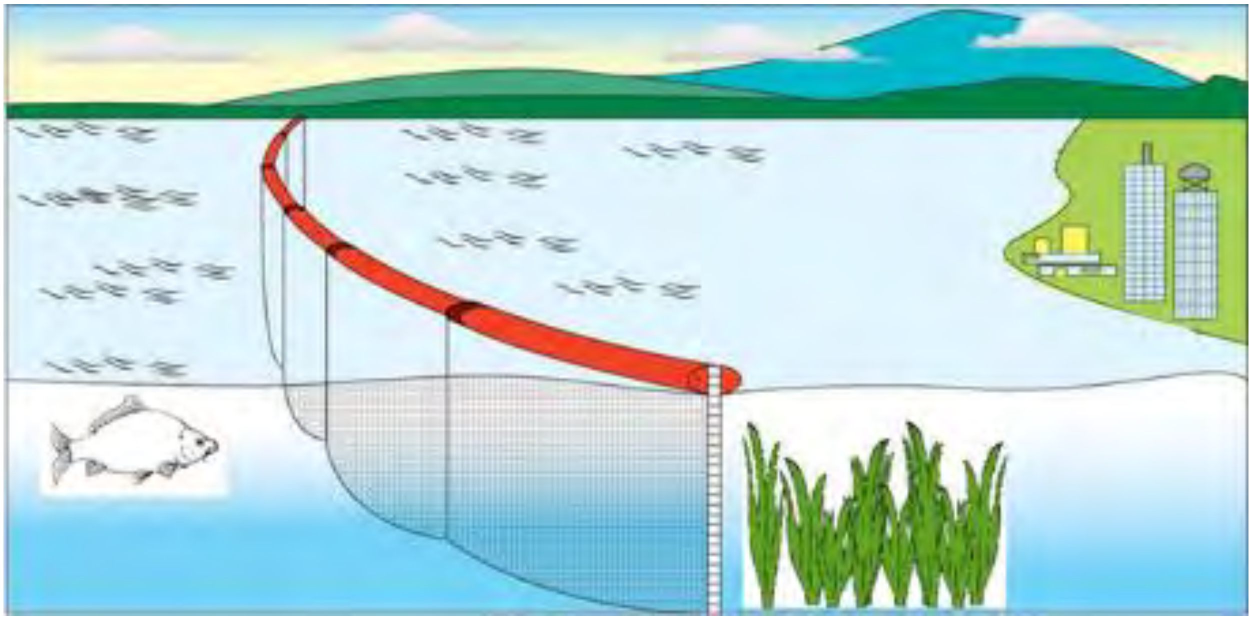

Figure 19. Floating barriers can provide exclosures to prevent carp from foraging on newly planted plants.

While floating vegetation will not be rooted to the bottom, it will be necessary to secure propagules in place so that new floating vegetation can establish where desired instead of floating into Utah Lake. This can be accomplished by placing floating vegetation propagules into floating rings strategically anchored in desired locations throughout the deep-water pools of the delta (Figure 20). These colonies can be left in place as long as necessary to provide as many propagules to the delta as possible. Propagules may spread or be transported from these protected areas throughout the delta to establish a self-sustaining propagule load.

3.3 EMERGENT WETLAND VEGETATION

The majority of the PRDRP restoration area is currently and will remain dominated by emergent wetland vegetation. Not all of the emergent vegetation areas within the restored delta will require seeding and planting because the majority of the area already has some assemblage of native emergent vegetation present. Disturbance in existing emergent vegetation areas will be minimized during construction, and weed treatment activities must limit overspray to preserve as much existing desirable vegetation as possible. The presence of large, adjacent, and historic stands of phragmites present a unique challenge to successful establishment of native emergent wetland vegetation in these areas. These wetlands have been drained and grazed for numerous decades and now contain a mixture of upland weeds, grasses, and emergent wetland vegetation, including phragmites. The areas west of Skipper Bay dike have been dominated by phragmites for approximately 30 years, which has also has likely produced a large seed bank throughout the project area.

Figure 20. A floating vegetation community can be held in place by anchored floating booms until the vegetation is self- sustaining. These structures also provide immediate and desirable habitat for June Sucker larvae after only a little establishment time.

Therefore, the revegetation strategy in emergent vegetation types begins with limiting ground disturbance where possible. Phragmites thrive in recently disturbed areas that become saturated or flooded with nutrient-rich water like that of Utah Lake. Any disturbed emergent wetland areas will need aggressive revegetation efforts to prevent phragmites from invading, and includes the use of coyote willow plantings within transition zones between emergent and riparian vegetation communities at approximately 4,489 feet. Coyote willow is a specialist that thrives in disturbed wetland and riparian environments and are one of the few species that can effectively outcompete phragmites.

Areas planned for emergent wetland vegetation seeding and planting total approximately 42 acres adjacent to and within the newly constructed channels, ponds and depressions, and 8 acres associated with the Skipper Bay dike lowering and shoreline excavation, for a total of 50 acres. The majority of the project area under and west of Skipper Bay dike will be seeded and planted with emergent vegetation, including coyote willow, following excavation. Care will be taken to leave as much existing desirable woody vegetation as possible along the shoreline. There would be no revegetation efforts planned within undisturbed emergent wetland areas other than where aggressive weed control efforts require revegetation.

Emergent wetland species that will be seeded and planted in the emergent wetland revegetation zone are shown in Table 4. These native wetland species are known to occur within or in the vicinity of the project area. These species are also likely to have occurred within the historic delta prior to human disturbances. In addition to the emergent species described, an assumption has been made that relatively large clumps of coyote willow would naturally occur within this type of dynamic delta environment. To account for this natural condition, coyote willow plantings are included within the emergent wetland revegetation areas, as well as the woody riparian wetland revegetation area.

Table 4. Emergent wetland revegetation target species.

COMMON NAME	SCIENTIFIC NAME	ESTABLISHMENT METHOD
Hardstem bulrush	*Schoenoplectus acutus*	Seed and plugs/containerized
Olney's three-square bulrush	*Schoenoplectus americanus*	Seed and plugs/containerized
Giant bur reed	*Sparganium eurycarplantingsm*	Seed and plugs/containerized
Nebraska sedge	*Carex nebrascensis*	Seed and plugs/containerized
Arctic (Baltic, mountain) rush	*Juncus arcticus* (*balticus*)	Seed and plugs/containerized
Spikerush	*Eleocharis palustris*	Seed and plugs/containerized
Water sedge	*Carex aquatilis*	Seed and plugs/containerized
Swamp milkweed	*Asclepias incarnata*	Seed and plugs/containerized
Coyote willow	*Salix exigua*	Containerized/cuttings

The recommended emergent wetland seed mix for PRDRP is shown in Table 5. This seed mix includes pounds of live seed per acre and number of seeds per square foot for each species, and consists of all emergent species being planted, except coyote willow. The NRCS (2011) document was used as a guide in determining seeding rates for all habitat types associated with the PRDRP. With 50 acres of seeding and a total of 39.5 pounds of live seed per acre, the estimated total quantity of emergent wetland seed is 1,975 pounds for the entire construction area. The final percentage of seed mix by species and weight will be determined, depending on species availability, at the time of the seed order once the construction area for that year and seed availability has been determined.

Table 5. Emergent wetland seed mix.

SEED NO.	SPECIES NAME		Number of seeds per pound	BROADCAST SEED		
	Botanical Name	Common Name		Pounds of pure live seed per acre	Percent of mix	Seeds per square foot
1	*Eleocharis palustris*	Spikerush	1,335,000	1	19.55%	31
2	*Carex aquatilis*	Water sedge	485,000	0.75	4.49%	7
3	*Juncus arcticus (balticus)*	Arctic (Baltic, mountain) rush	3,000,000	0.25	10.98%	17
4	*Sparganium eurycarpum*	Giant bur reed	22,000	28	9.02%	14
5	*Carex nebrascensis*	Nebraska sedge	1,225,000	1	17.94%	28
6	*Asclepias incarnata*	Swamp milkweed	68,100	2	1.99%	3
7	*Schoenoplectus americanus*	Olney's three-square bulrush	300,000	4	17.57%	28
8	*Schoenoplectus acutus*	Hardstem bulrush*	504,000	2.5	18.45%	29
	TOTAL			**39.5**	**100.00%**	**157**

As mentioned in the existing vegetation description, ULTs are known to occur in portions of the project area as shown in the ULT Known Locations and Suitable Habitat (2010–2018) map shown in Attachment 1. Although direct impacts to known occupied locations from delta restoration have been minimized as much as possible, there will be approximately 0.8 acres of occupied habitat that will excavated for delta channels and impacted during the second or third year of construction as shown in Attachment 2—ULT Impact and Relocation Map. Strategies are being developed to give the relocated plants and seed bank the best chance of survival at their new location. Therefore a special ULT seed mix (Table 6) was developed to only include species associated with existing ULT-occupied habitat and reviewed by FAA. To seed the 0.8 acres of occupied ULT habitat soils that will be excavated and relocated at 17.05 pounds of live seed per acre, the estimated total quantity of emergent wetland seed specifically for the ULT relocation area is 13.6 pounds.

Table 6. Emergent wetland seed mix specifically for Ute ladies'-tresses relocation area.

SEED NO.	SEED SPECIES NAME		NUMBER OF SEEDS PER POUND	BROADCAST SEED		
	Botanical Name	Common Name		Pounds of pure live seed per acre	Percent of mix	Seeds per square foot
1	*Eleocharis palustris*	Spikerush	1,335,000	1.5	20.31%	46
2	*Muhlenbergia asperifolia*	Scratchgrass	2,400,000	0.8	19.48%	44
3	*Carex aquatilis*	Water sedge	485,000	0.75	3.69%	8
4	*Carex nebrascensis*	Nebraska sedge	1,225,000	1.5	18.64%	42
5	*Asclepias incarnata*	Swamp milkweed	68,100	4	2.76%	6
6	*Schoenoplectus americanus*	Olney's three-square bulrush	300,000	6	18.26%	41
7	*Carex praegracilis*	Clustered field sedge	664,900	2.5	16.86%	38
	TOTAL			**17.05**	**100.00%**	**226**

The emergent wetland areas will most likely be broadcast seeded and raked in by dragging a harrow behind the 4-wheeler/seeder. The harrow is used to make sure there is good soil-seed contact. Drill seeding would be preferable but it is likely that emergent wetland seeding areas will be too wet for drill seeding.

It will be important to mulch all seeded areas immediately after seeding to ensure seeds stay in place, and that soils are protected against raindrop impacts and erosion. Crimped straw mulch works for this purpose but using a hydromulch with tackifier to cover the seed is preferred as it doesn't introduce new non-native species that are often found in "seed-free" straw. The best time to seed is in the late fall before the ground freezes or gets covered by snow, and second best time to seed is in the early spring before April 15. Hardstem bulrush must be treated (cold stratified) for months prior to seeding to prevent seed dormancy if seeding occurs in the spring or summer. Summer and winter seeding is generally not recommended.

The containerized plantings and transplants from Salvagable Resource Areas and other donor sites will provide more immediate ground cover than seeding alone, and will prevent phragmites establishment better than just seed because wetland seed can take several years to establish dense ground cover. Whenever possible, native bulrush communities will be utilized as donor sites for the disturbed emergent wetland areas. A track hoe and small truck will be used to excavate clumps of existing bulrush and transplant them into appropriate emergent wetland areas. Each clump will contain approximately 8 square feet of dense bulrush containing several hundred stems. The transplant effort is entirely dependent on the availability of donor sites that are close to the transplant areas. A reasonable expectation would be approximately 750 bulrush transplant scoops placed throughout the emergent wetland area. Transplanting clumps with existing tubers is a highly effective way to establish bulrush into recently disturbed areas.

Emergent wetland species will be planted in groupings (clumped dispersion as shown in Figure 17) throughout the disturbed emergent vegetation areas using species and planting densities shown in Table 5. The specific locations of the clumps will be designated at the time of planting based on observed post-construction hydrology and soil conditions. When grouped, the plantings will be installed on 1-foot centers for all emergent species except coyote willow that are to be installed on 3-foot centers. The groups will be installed by species and generally not intermixed. Tall plants like hardstem bulrush and giant bur reed will be planted in deeper water conditions whereas shorter Olney's three square bulrush spike rush, and water sedge will be planted in areas with expected shallower water conditions.

Assuming the containerized plantings effort groupings will cover 10 percent of the 50-acre emergent wetland planting area, approximately 5 acres (217,800 square feet) will have immediate cover. Over time, the plant groupings will expand and combine with transplants, emergent wetland seed mix, and native volunteer seeding to hopefully achieve 100 percent cover of desirable vegetation within 3–5 years, assuming aggressive, targeted weed control efforts are implemented as planned. Table 7 provides the approximate number of emergent wetland plantings recommended for the project area over the 2020–2024 construction period.

Table 7. Emergent wetland planting numbers.

COMMON NAME	SCIENTIFIC NAME	DENSITY	NUMBER OF CONTAINERIZED plantings
Hardstem bulrush	*Schoenoplectus acutus*	1-foot centers	43,560 (20% of area)
Olney's three-square bulrush	*Schoenoplectus americanus*	1-foot centers	34,848 (16% of area)
Giant bur reed[a]	*Sparganium eurycarplantingsm*	1-foot centers	8,712 (4% of area)
Nebraska sedge	*Carex nebrascensis*	1-foot centers	34,848 (16%of area)
Arctic (Baltic, mountain) rush	*Juncus arcticus (balticus)*	1-foot centers	26,136 (12%of area)
Spikerush	*Eleocharis palustris*	1-foot centers	26,136 (12%of area)
Water sedge	*Carex aquatilis*	1-foot centers	10,890 (5% of area)
Coyote willow	*Salix exigua*	3-foot centers	43,560 (20% of area)
Total plantings recommended for 50 acres			228,690

This large planting order will occur over a three-year time frame, which should allow sufficient time for nurseries to grow the plantings. If possible, it would be advantageous to contract planting orders two growing seasons prior to planting to allow for larger and more robust plantings.

The emergent plantings can be installed any time during the growing season as long as they have sufficient soil moisture or flooding. The coyote willows should be installed in spring prior to leaf out, or in the late fall after plants have gone dormant. Aggressive targeted weed control by expert applicators will be required to prevent phragmites establishment while at the same time not over spraying the plantings or any other desirable native vegetation.

3.4 WOODY RIPARIAN WETLAND VEGETATION

As with the emergent wetland areas, the revegetation strategy for the riparian habitat begins with avoiding disturbance as much as possible in areas with good existing riparian vegetation, and in areas identified as Salvagable Resource Areas. With this regard, existing riparian vegetation along the existing along Skipper Bay dike and in the northwest corner of the project area will be preserved or salvaged as much as possible. Woody riparian seeding and planting areas include the portions of the river zone along Provo River that are inundated during the 2-year flood, the northeast edge of the delta zone (not including raised peat mounds as they all remain emergent wetland), fill areas to create riparian habitat in the delta zone adjacent to the south berm, fill areas to create woody riparian mounds in the delta, portions of the lowered Skipper Bay dike near the existing riparian area in the northwest corner, the predicted riparian areas within Provo City's wetland mitigation site, and fill areas adjacent to the small channel that will be constructed in the old Provo River channel downstream of the plug as shown in the plan view map in the Planting and Seeding Areas plan view map in Attachment 2. Table 8 describes the recommended riparian species for the PRDRP and the most common establishment method for each species.

Table 8. Woody riparian wetland species targeted for the PRDRP.

COMMON NAME	SCIENTIFIC NAME	PREFERRED HABITAT	ESTABLISHMENT METHOD
Meadow sedge	*Carex praegracilis*	Early growing season flooding to permanent soil saturation	Seed and plugs/containerized
Inland saltgrass	*Distichlis spicata*	Early growing season saturation and flooding	Seed
Arctic (Baltic, mountain, wiregrass) rush	*Juncus arcticus (balticus)*	Early growing season flooding to permanent soil saturation	Seed and plugs/containerized
Western wheatgrass	*Pascopyrum smithii*	Early growing season saturation and flooding to well drained	Seed
Wild geranium	*Geranium viscosissimum*	Early growing season saturation to well drained	Seed
Thickspike wheatgrass	*Elymus lanceolatus*	Brief flooding to well drained	Seed
Nuttall's alkaligrass	*Puccinellia nuttalliana*	Early growing season flooding to permanent soil saturation	Seed
Rocky Mountain Beeplant	*Cleome serrulata*	Well drained	Seed
Virginia wildrye	*Elymus virginicus*	Well drained	Seed
Scarlet globemallow	*Sphaeralcea coccinea*	Well drained	Seed
Lewis blue flax	*Linum lewisii*	Well drained	Seed
Wild geranium	*Geranium viscosissimum*	Well drained	Seed
Showy milkweed	*Asclepias speciosa*	Well drained	Seed and containerized
Swamp milkweed	*Asclepias incarnata*	Grows best in damp to wet soil	Seed and containerized
Rubber rabbitbrush	*Ericameria nauseosa*	Well drained	Seed
Alkali sacaton	*Sporobolus airoides*	Prefers moist but not saturated soils	Seed
Golden currant	*Ribes aureum*	Early growing season flooding then well drained	Seed and containerized
Skunkbush sumac	*Rhus trilobata*	Moist soil to well drained	Seed and containerized
Coyote willow	*Salix exigua*	Significant flooding to nearly permanent soil saturation	Containerized and cuttings[a]
Bebb's willow	*Salix bebbiana*	Significant flooding to nearly permanent soil saturation	Containerized and cuttings[a]
Yellow willow	*Salix lutea*	Significant flooding to nearly permanent soil saturation	Containerized and cuttings[a]
Peachleaf willow	*Salix amygdaloides*	Significant flooding to nearly permanent soil saturation	Containerized and cuttings[a]
Redosier dogwood	*Cornus sericea*	Early growing season flooding then well drained	Containerized and cuttings[a]
Thinleaf Alder	*Alnus incana*	Early growing season flooding then well drained	Containerized
Box elder	*Acer negundo*	Early growing season flooding then well drained	Containerized
Narrow leaf cottonwood	*Poplantingslus angustifolia*	Brief flooding and soil saturation then well drained	Containerized and cuttings[a]
Black cottonwood	*Poplantingslus balsamifera* L. ssp. *trichocarpa*	Brief flooding and soil saturation then well drained	Containerized and cuttings[a]
Fremont cottonwood	*Poplantingslus fremontii*	Brief flooding and soil saturation then well drained	Containerized and cuttings[a*]

[a] Cuttings are only recommended for installation in areas with loamy, sandy, or cobbly alluvial substrates with adequate depth to water table and adequate surface water drainage. Cuttings installed in permanent anaerobic muck and organic soils or permanently flooded areas will likely rot and fail.

The recommended woody riparian wetland seed mix for PRDRP is shown in Table 9. This seed mix includes pounds of live seed per acre and number of seeds per square foot for each species, and consists of most but not all of the riparian species being planted. With 28.3 acres of woody riparian wetland seeding and a total of 26.0 pounds of live seed per acre, the estimated total quantity of woody riparian wetland seed is 736 pounds for the entire construction area. The final percentage of seed mix by species and weight will be determined, depending on species availability, at the time of the seed order once the construction area for that year and seed availability has been determined.

Table 9. Woody riparian wetland seed mix.

SEED NO.	SPECIES NAME		NUMBER OF SEEDS PER POUND	DRILL SEED		
	Botanical Name	Common Name		Pounds of pure live seed per acre	Percent of mix	Seeds per square foot
1	*Carex praegracilis*	Meadow sedge	664,900	1.50	13.14%	23
2	*Elymus lanceolatus*	Thickspike wheatgrass	154,000	6.00	12.18%	21
3	*Juncus arcticus (balticus)*	Arctic (Baltic, mountain, wiregrass) rush	3,000,000	0.30	11.86%	21
4	*Distichlis spicata*	Coastal saltgrass	520,000	1.50	10.28%	18
5	*Muhlenbergia asperifolia*	Scratchgrass	2,400,000	0.40	12.65%	22
6	*Pascopyrum smithii*	Western wheatgrass	110,000	6.00	8.70%	15
7	*Puccinellia nuttalliana*	Nuttall's alkaligrass	2,108,000	0.50	13.89%	24
8	*Cleome serrulata*	Rocky Mountain Beeplant	65,500	0.50	0.43%	1
9	*Elymus virginicus*	Virginia wildrye	74,000	5.00	4.88%	8
10	*Sphaeralcea coccinea*	Scarlet globemallow	500,000	0.20	1.32%	2
11	*Linum lewisii*	Lewis blue flax	170,000	0.25	0.56%	1
12	*Geranium viscosissimum*	Wild geranium	52,000	1.00	0.69%	1
13	*Asclepias speciosa*	Showy milkweed	100,000	0.50	0.66%	1
14	*Asclepias incarnata*	Swamp milkweed	68,100	0.50	0.45%	1
15	*Ericameria nauseosa*	Rubber rabbitbrush	693,000	0.10	0.91%	2
16	*Ribes aureum*	Golden current	233,000	0.50	1.54%	3
17	*Rhus trilobata*	Skunkbush sumac	20,000	1.00	0.26%	0
18	*Sporobolus airoides*	Alkali sacaton	1,700,000	0.25	5.60%	10
	TOTAL			**26**	**100.00%**	**174**

It is preferred to drill seed the woody riparian wetland areas. As with emergent wetlands, it will be important to mulch all seeded areas immediately after seeding to ensure seeds stay in place, and that soils are protected against raindrop impacts and erosion. Hydromulch with tackifier immediately following seeding is preferred. The best time to seed is in the late fall before the ground freezes or gets covered by snow, and the second best time to seed is in the early spring before April 15. Summer and winter seeding is generally not recommended.

The total planting area for woody riparian wetland is 29.5 acres. This is 1.2 acres more than the riparian seeding area because it includes plantings for the predicted riparian areas within the Provo City wetland mitigation site that is currently mostly reed canary grass. As with the emergent wetland revegetation effort, approximately 10 percent of the riparian area will be planted, providing nearly 3.0 acres of immediate vegetation cover that will fill in over time.

Containerized plantings will be grouped and placed according to the localized hydrology and the predicted mature size of the particular species. The woody riparian wetland species and planting numbers for the PRDRP are shown in Table 10.

Table 10. Riparian plant numbers recommended for the Provo River Delta Restoration Project (PRDRP).

COMMON NAME	SCIENTIFIC NAME	PLANTING DENSITY	NUMBER OF CONTAINERIZED PLANTINGS
Meadow sedge	*Carex praegracilis*	1-foot centers	13,068 (10% of area)
Arctic rush	*Juncus arcticus*	1-foot centers	10,454 (8% of area)
Golden currant	*Ribes aureum*	5-foot centers	2,613 (10% of area)
Skunkbush sumac	*Rhus trilobata*	5-foot centers	1,307 (5% of area)
Bebb's willow	*Salix bebbiana*[a]	5-foot centers	523 (2% of area)
Yellow willow	*Salix lutea*[a]	5-foot centers	523 (2% of area)
Coyote willow	*Salix exigua*[a]	1.5-foot centers	17,424 (20% of area)
Redosier dogwood	*Cornus sericea*	3-foot centers	4,356 (10% of area)
Peachleaf willow	*Salix amygdaloides*[a]	10-foot centers	261 (2% of area)
Box elder	*Acer negundo*	20-foot centers	327 (5% of area)
Narrow leaf cottonwood	*Poplantingslus angustifolia*	20-foot centers	130 (2% of area)
Black cottonwood	*Poplantingslus balsamifera L. ssp. trichocarpa*	30-foot centers	87 (2% of area)
Fremont cottonwood	*Poplantingslus fremontii*	30-foot centers	871 (20% of area)
Total plantings required for woody riparian wetlamd areas (3 acres total)		**51,944**	

Meadow sedge and arctic rush plantings will be located in low areas outside of the river channel that exhibit saturated soils during the growing season or prolonged seasonal flooding. These two species will be planted in groups of 100–500 plants on 1-foot centers. Willows, dogwoods and alders will be planted along channel and pond banks and other areas that are seasonally flooded, at elevations generally between 4,489 and 4,490 feet. Cottonwood and box elder trees, and current/sumac shrubs will be planted at higher elevations where flooding durations are low and occur infrequently. The 3.0-acres woody riparian wetland planting area was used to determine planting quantities; however, the actual plantings will be spread over the entire habitat based on the soil moisture conditions observed during the time of planting. The end goal of the mature restored habitat would contain groups of taller canopy level trees with woody shrubs growing in the understory and mid-level strata, and pockets of emergent riparian vegetation dispersed throughout. In drier planting areas, irrigation of the woody species will be required for better establishment. Protection from beaver damage in the form of fencing may also be required for the tree species.

3.5 UPLAND VEGETATION

Areas suitable for upland vegetation are for the most part located on higher surfaces in the river zone and along the edges the delta zone as shown in Attachment 2—Planting and Seeding Areas plan view map. It is likely that most if not all of the upland areas will be disturbed during construction and will need to be revegetated. Table 11 describes the upland species recommended for the PRDRP.

Table 11. Upland revegetation target species.

SPECIES	SCIENTIFIC NAME	WATER REQUIREMENTS
Western wheatgrass	*Pascopyrum smithii*	Early growing season saturation and flooding to well drained
Bluebunch wheatgrass	*Pseudoroegneria spicata*	Well drained
Slender wheatgrass	*Elymus trachycaulus*	Well drained
Bottlebrush squirreltail	*Elymus elymoides*	Well drained
Prairie junegrass	*Koeleria macrantha*	Well drained
Sandberg bluegrass	*Poa secunda* ssp. *sandbergii*	Well drained
Wild geranium	*Geranium viscosissimum*	Early growing season saturation to well drained
Rocky Mountain penstemon	*Penstemon strictus*	Well drained
Firecracker penstemon	*Penstemon eatonii*	Well drained
Scarlett globemallow	*Sphaeralcea coccinea*	Well drained
Rocky Mountain beeplant	*Cleome serrulata*	Well drained
Lewis blue flax	*Linum lewisii*	Well drained
Rubber rabbitbrush	*Ericameria nauseosa*	Well drained
Skunkbush sumac	*Rhus trilobata*	Moist soil to well drained
Golden currant	*Ribes aureum*	Early growing season flooding then well drained
Box elder	*Acer negundo*	Early growing season flooding then well drained
Narrowleaf cottonwood	*Poplantingslus angustifolia*	Brief flooding and soil saturation then well drained
Black cottonwood	*Poplantingslus balsamifera* L. ssp. *trichocarpa*	Brief flooding and soil saturation then well drained
Fremont cottonwood	*Poplantingslus fremontii*	Brief flooding and soil saturation then well drained

The recommended upland seed mix for PRDRP is shown in Table 12. This seed mix includes pounds of live seed per acre and number of seeds per square foot for each species, and consists of all upland species being planted, except cottonwood and box elder trees. With 31.5 acres of upland seeding and a total of 23.05 pounds of live seed per acre, the estimated total quantity of upland seed is 726 pounds for the upland portions of the project area that allow shrubs.

Revegetation on the structurally important portions of south berm and on the north access path will have upland seed but with grasses only. An upland seed mix was created without shrub seed for this 44-foot-wide, grass-only corridor and will also be used on the 12-foot-wide access path along the north side of the project area shown on the plan view map in Attachment 2. The recommended "no-shrub" upland seed mix for PRDRP is shown in Table 13. This seed mix includes pounds of live seed per acre and number of seeds per square foot for each species. With 5.4 acres of seeding and a total of 20.95 pounds of live seed per acre, the estimated total quantity of upland "no-shrub" seed is 113 pounds.

It is preferred to drill-seed all upland revegetation areas. As with other habitats, it will be important to mulch all seeded areas immediately after seeding to ensure seeds stay in place, and that soils are protected against raindrop impacts and erosion. Hydromulch with tackifier immediately following seeding is preferred. Revegetation timing for uplands is the same as that of riparian areas.

Table 12. **Upland seed mix.**

SEED NO.	SPECIES NAME		SEEDS PER POUND	DRILL SEED		
	Botanical Name	Common Name		Pounds of pure live seed per acre	Percent of mix	Seeds per square foot
1	*Pseudoroegneria spicata*	Bluebunch wheatgrass	140,000	4	12.37%	13
2	*Elymus trachycaulus*	Slender wheatgrass	160,000	3	10.61%	11
3	*Elymus elymoides*	Bottlebrush squirreltail	191,000	3	12.66%	13
4	*Koelaria macrantha*	Prairie junegrass	2,315,400	0.25	12.79%	13
5	*Poa secunda* ssp. *Sandbergii*	Sandberg bluegrass	925,000	0.75	15.33%	16
6	*Pascopyrum smithii*	Western wheatgrass	110,000	5	12.15%	13
7	*Ericameria nauseosa*	Rubber rabbitbrush	693,000	0.10	1.53%	2
8	*Ribes aureum*	Golden current	233,000	0.50	2.57%	3
9	*Linum lewisii*	Lewis blue flax	170,000	0.50	1.88%	2
10	*Rhus trilobata*	Skunkbush sumac	20,000	1.50	0.66%	1
11	*Geranium viscosissimum*	Wild geranium	52,000	1.00	1.15%	1
12	*Asclepias speciosa*	Showy milkweed	100,000	0.50	1.10%	1
13	*Cleome serrulata*	Rocky Mountain Beeplant	65,500	1.00	1.45%	2
14	*Penstemon strictus*	Rocky Mountain penstemon	286,000	1.00	6.32%	7
15	*Penstemon eatonii*	Firecracker penstemon	315,000	0.75	5.22%	5
16	*Sphaeralcea coccinea*	Scarlet globemallow	500,000	0.20	2.21%	2
	TOTAL			**23.05**	**100.00%**	**104**

Table 13. **Upland seed mix without shrubs to be used on the engineered portions of the south berm and north access path.**

SEED NO.	SPECIES NAME		SEEDS PER POUND	DRILL SEED		
	Botanical Name	Common Name		Pounds of pure live seed per acre	Percent of mix	Seeds per square foot
1	*Pseudoroegneria spicata*	Bluebunch wheatgrass	140,000	4	12.37%	13
2	*Elymus trachycaulus*	Slender wheatgrass	160,000	3	10.61%	11
3	*Elymus elymoides*	Bottlebrush squirreltail	191,000	3	12.66%	13
4	*Koeleria macrantha*	Prairie junegrass	2,315,400	0.25	12.79%	13
5	*Poa secunda* ssp. *Sandbergii*	Sandberg bluegrass	925,000	0.75	15.33%	16
6	*Pascopyrum smithii*	Western wheatgrass	110,000	5	12.15%	13
7	*Linum lewisii*	Lewis blue flax	170,000	0.50	1.88%	2
8	*Geranium viscosissimum*	Wild geranium	52,000	1.00	1.15%	1
9	*Asclepias speciosa*	Showy milkweed	100,000	0.50	1.10%	1
10	*Cleome serrulata*	Rocky Mountain Beeplant	65,500	1.00	1.45%	2
11	*Penstemon strictus*	Rocky Mountain penstemon	286,000	1.00	6.32%	7
12	*Penstemon eatonii*	Firecracker penstemon	315,000	0.75	5.22%	5
13	*Sphaeralcea coccinea*	Scarlet globemallow	500,000	0.20	2.21%	2
	TOTAL			**20.95**	**95.23%**	**99**

The total planting area for uplands is 31.5 acres. Assuming 10 percent coverage, a total of 3.2 acre would be planted with upland species. Table 14 shows plantings and numbers recommended for the upland habitat type. Shrubs and trees can be planted adjacent to the engineered portions of the south berm but not on it, with shrubs only for approximately 10 feet in each direction beyond the 44-foot-long, grass-only corridor, and then trees outside of the approximate 64-foot "no-tree" corridor. Planting zones will be marked in the field during plant installation. Woody shrub species will be planted in groups and larger tree species placed throughout the entire upland portions of the project area, concentrated in areas where irrigation is possible.

Table 14. Upland plant numbers recommended for the Provo River Delta Restoration Project (PRDRP).

COMMON NAME	SCIENTIFIC NAME	PLANTING DENSITY	NUMBER OF CONTAINERIZED PLANTINGS
Golden currant	*Ribes aureum*	5-foot centers	2,788 (10% of area)
Rubber rabbitbrush	*Ericameria nauseosa*	5-foot centers	1,394 (5% of area)
Skunkbush sumac	*Rhus trilobata*	5-foot centers	1,394 (5% of area)
Box elder	*Acer negundo*	20-foot centers	350 (5% of area)
Narrow leaf cottonwood	*Populus angustifolia*	20-foot centers	70 (1% of area)
Black cottonwood	*Populus balsamifera L.* ssp. *trichocarpa*	30-foot centers	46 (1% of area)
Fremont cottonwood	*Populus fremontii*	30-foot centers	465 (10% of area)
Total plantings recommended for upland areas (3.2 acres total)			**6,507**

Upland species would most likely require supplemental irrigation for 3–5 years until the new plantings are established. Each woody species will be planted using the quantity and the density illustrated in Table 14. The 3.2-acre planting area was used to determine planting quantities; however, the actual planting will be spread over the entire habitat type based on the conditions observed during the time of planting. The planting process should be approached with flexibility in determining the most appropriate locations and groupings for plantings. Protection from beaver damage in the form of fencing may also be required for the tree species. If supplemental irrigation is not available, then upland plantings are not recommended unless specific planting areas are selected that appear naturally moist enough during the dry season to support plantings.

3.6 REVEGETATION BEST MANAGEMENT PRACTICES (BMPS)

Several recommended best management practices (BMPs) for revegetation efforts at PRDRP were identified during the planning process for the PRDRP, some of which are imbedded in the previous sections by habitat type. One of the most important BMP is to limit the area and duration of time soils are left disturbed and unvegetated. It will be important to revegetate and mulch completed areas where possible during the fall of each construction season. This task will be complicated because the aquatic and wetland plants require standing water and saturated soils in the completed areas to survive, whereas the adjacent construction areas will need to be dry so that construction equipment doesn't sink. Water levels in the revegetated areas will be kept as high as possible using pumps and existing artesian wells in completed ponds and depressions with a target water level of 4,486 feet to support aquatic and wetland plantings. Temporary irrigation will be used to support plantings on completed riparian areas. Irrigation shall utilize available water sources conveyed by an irrigation centrifugal pump station, above-grade PVC lateral pipe, and above-grade impact-rotor spray heads. Each pump station shall include a concrete intake box at the water access point, filters, and an appropriately sized electrical pump.

Irrigation water will most likely be pumped from excavated ponds. The pumps may be powered by one or more mobile generators.

The next BMP is to limit disturbance outside of the planned excavation and fill areas to the greatest degree possible during construction, especially in emergent wetlands and relatively high-quality habitats labeled as Salvageable Resource Areas (see Attachment 1 for Existing Habitat Types and Salvageable Resource Areas map). Flagging and fencing will be placed around all occupied ULT habitat as shown in Attachment 2 – ULT Impact and Relocation map to avoid disturbance in occupied areas.

Construction within 300 feet of known occurrences will be avoided during the flowering period of July 31–September 15. The beginning and ending of the flowering period will be documented to narrow this timing requirement based on the specific flowering period at the project area. Flowering ULT have been observed as early as July 25 in the project area, which means abstaining construction around ULTs starting July 15 is recommended. Other BMPs will be implemented for dust control during the flowering period if any known occurrences are being impacted by dust. Best management practices will be followed for sediment control throughout construction to ensure that bare soil and sediment are not transported to ULT areas. To the extent feasible, construction impacts to peat wetlands will be avoided, and this includes degraded springs.

As per conservation measures included in the project's Biological Opinion, required by the USFWS, relocation methods for impacted ULT habitat will attempt to keep the upper 2 feet of the soil profile intact if the salvage area(s) are small (less than 100 square feet); however, this method may not be feasible if larger areas are salvaged. For larger impact areas, the top 12 inches of soil will be relocated to the transplant site.

Careful attention will be given to top soil excavation, stockpiling, and preparation to provide good topsoil where needed for revegetation using the following guidelines:

- Excavated soils from weed infested areas will not be used as topsoil but rather buried deep in non-structural fill areas. Weed infested areas will be identified during construction.
- The top 15 inches of excavated soils and plant material from Salvageable Resource Areas (areas with desirable vegetation and few weeds) will be stockpiled and reused as topsoil. These areas will be marked during construction.
- The upper 3 inches of topsoil and plant material from areas not mapped as Salvageable Resource Areas is assumed to be full of weed seed and will be scraped and hauled off and/or buried deep in non-structural fill areas. The next 12 inches of excavated topsoil will be stockpiled and reused as topsoil.
- Excavated peat is a very valuable resource and will be separated during excavation, stockpiled, and then mixed with good topsoils identified above. The mixing ratio will be approximately 50 percent peat soil mixed with 50 percent topsoils.
- A thin layer of mineral topsoil will be spread on top of the topsoil/peat mixture in areas where peat is more concentrated at the surface. This depends on the mixing effectiveness of the construction equipment during initial spreading.

Seedbed preparation will take place after the final contouring and shaping have been completed. Seedbed preparation will consist of preparing the topsoil for seeding to: (1) improve soil aeration; (2) increase water infiltration and control erosion; (3) reduce excessive soil compaction; (4) provide looser, cooler, moister soil for seed germination; and (5) improve the potential for seed-to-soil contact.

It is important that the final seedbed exhibits the following characteristics:

- Firm soil that is not compacted below the seeding depth
- Well-pulverized and friable soil on top
- A soil surface that is not cloddy or puddled
- Soil free of seeds of competitive weed species

Prior to topsoil placement, surface scarification to reduce compaction will likely be required. This will provide a better interface between topsoil and subsoils, resulting in improved infiltration, greater root penetration, and increased adhesion of topsoil to subsoil on slopes. Replaced topsoil that is extremely loose will be firmed, using appropriate equipment, to reduce the erosion potential and improve the seedbed. Surfaces of accessible sites will be ripped or disked and cat-tracked to help scarify the topsoil surface to promote root aeration and growth, and to facilitate water and nutrient absorption. Ripping or disking should not bring undesired subsurface material to the surface.

To optimize seed coverage and success, secondary tillage, which consists of disking or harrowing, might be necessary to break up extremely cloddy surfaces or any crust that has formed. The avoidance of excess clods should not be confused with a “roughened” seedbed. A roughened seedbed is desirable, particularly with broadcast or hydroseeding, because it provides microhabitats for native vegetation establishment. Upon completion of slope scarification and topsoil firming, the surface will be rough enough to effectively retain seed, mulch, and moisture. Seeding will occur annually in the fall shortly after final seedbed preparation.

Part of seedbed preparation includes preventing the establishment of noxious and invasive weeds, particularly in the river and delta zone portions of the project areas. This is important because access to these areas will be more difficult after water is diverted into the delta. The project area will be treated for noxious weeds using the appropriate method(s) for one or more years before ground disturbing activities begin; this BMP is currently being implemented. During project construction, disturbed areas will be regularly inspected for weed growth during the growing season (April–September) and treated as necessary. All seeded areas will be mulched using crimped straw or hydromulch with tackifier to protect the seeds and hold moisture in the soil.

Stockpiles of topsoil that would remain barren for extended periods will be protected with mulch and/or temporary vegetation to control erosion and to avoid proliferation and spread of noxious weeds and undesirable plants. Disturbed areas will be reclaimed with desirable plant communities as soon as possible after construction. Erosion-control measures will be implemented to prevent or reduce wind and water erosion, and to help establish vegetation in areas subject to erosion. Specific, USFWS-provided herbicide-treatment recommendations will be followed within ULT occurrence areas.

The need to control phragmites is referenced throughout this report. In an attempt to reduce off-site phragmites seed from contaminating project area soils during construction, phragmites seed sources outside of the project area were mapped (Figure 21) so that URMCC and project partners can work with the Utah County Weed Control Board to encourage adjacent land owners to treat these existing populations and minimize incoming seed sources, in addition to controlling on-site phragmites populations.

Figure 21. **Potential phragmites seed source areas outside of the project area.**

4 WEED MANAGEMENT PLAN

Weed management within the PRDRP will be accomplished by implementing a phased approach of Integrated Pest Management (IMP) practices along with succession focused adaptive strategies during the different phases of reclamation efforts. Weed management is applied to facilitate overall project goals and will be appropriated based on relative phases of construction, reclamation, and monitoring. Weed management encompasses methods to support the reduction of aerial canopy cover of noxious, invasive, and nonnative plant species while supporting conditions for the restoration of native dominated, resilient plant communities.

Overall, the approach to weed management within the PRDRP includes:

- eradiation of State listed Noxious Weeds,
- prevention of new infestations (i.e. new species introductions to the PRDRP or introductions of currently documented noxious and/or invasive species to an area previously not infested),
- manage current crop of noxious and invasive species to minimize seed bank inputs, and
- facilitate reclamation planting establishment through precise weed control and removal so not to impair the development of resilient native plant communities.

4.1 STATE-LISTED NOXIOUS WEEDS

The state of Utah currently classifies 55 plant species as noxious and has placed them in one of four classes:

Class 1A: Early Detection Rapid Response (EDRR)
Watch List Declared Noxious and Invasive—weeds not native to the State of Utah and not known to exist in the state that pose a serious threat to the state and should be considered as a very high priority (Table 15).

Table 15. Class 1A State Listed Noxious Weed Species.

CLASS 1A: EARLY DETECTION RAPID RESPONSE			
Botanical Name	**Common Name**	**Life Cycle**	**Monocot / Dicot**
Anchusa arvensis	Small bugloss	annual	Dicot
Carduus acanthoides	Plumeless thistle	biennial	Dicot
Centaurea militensis	Malta starthistle	annual /biennial	Dicot
Crupina vulgaris	Common crupina	annual	Dicot
Milium vernale	Spring millet	annual	Monocot
Peganum harmala	African rue	perennial	Dicot
Salvia aethiopis	Mediterranean sage	biennial	Dicot
Ventenata dubia	Ventenata (North African grass)	annual	Monocot

Class 1B: Early Detection Rapid Response (EDRR)
Declared noxious and invasive weeds not native to the State of Utah that are known to exist in the state in very limited populations and pose a serious threat to the state and should be considered as a very high priority (Table 16).

Table 16. Class 1B State Listed Noxious Weed Species.

CLASS 1B: EARLY DETECTION RAPID RESPONSE			
Botanical Name	**Common Name**	**Life Cycle**	**Monocot / Dicot**
Alhagi maurorum	Camelthorn	perennial	Dicot
Alliaria petiolate	Garlic mustard	annual / biennial	Dicot
Arundo donax	Giant reed	perennial	Monocot
Brassica elongata	Elongated mustard	perennial	Dicot
Brassica tournefortii	African mustard	annual / biennial	Dicot
Centaurea calcitrapa	Purple starthistle	annual / biennial/ perennial	Dicot
Echium vulgare	Blueweed (vipers bugloss)	annual / biennial / perennial	Dicot
Galega officinalis	Goatsrue	perennial	Dicot
Hypericum perforatum	Common St. Johnswort	perennial	Dicot
Leucanthemum vulgare	Oxeye daisy	perennial	Dicot
Polygonum cuspidatum	Japanese knotweed	perennial	Dicot

Class 2 (Control)

Declared noxious and invasive weeds not native to the State of Utah that pose a threat to the state and should be considered a high priority for control. Weeds listed in the control list are known to exist in varying populations throughout the state. The concentration of these weeds is at a level where control or eradication may be possible (Table 17).

Table 17. Class 2 State Listed Noxious Weed Species.

CLASS 2 (CONTROL)			
Botanical Name	**Common Name**	**Life Cycle**	**Monocot / Dicot**
Centaurea diffusa	Diffuse knapweed	annual / perennial	Dicot
Centaurea stoebe	Spotted knapweed	biennial / perennial	Dicot
Centaurea solstitialis	Yellow starthistle	annual	Dicot
Centaurea virgata	Squarrose knapweed	perennial	Dicot
Chondrilla juncea	Rush skeletonweed	perennial	Dicot
Euphorbia esula	Leafy spurge	perennial	Dicot
Hyoscyamus niger	Black henbane	annual / biennial	Dicot
Linaria dalmatica	Dalmatian toadflax	perennial	Dicot
Linaria vulgaris	Yellow toadflax	perennial	Dicot
Lythrum salicaria	Purple loosestrife	perennial	Dicot

Class 3 (Containment)

Declared noxious and invasive weeds not native to the State of Utah that are widely spread. Weeds listed in the containment noxious weed list are known to exist in various populations throughout the state. Weed control efforts may be directed at reducing or eliminating new or expanding weed populations. Known and established weed populations, as determined by the weed control authority, may be managed by any approved weed control methodology, as determined by the weed control authority. These weeds pose a threat to the agricultural industry and agricultural products (Table 18).

Table 18. Class 3 State Listed Noxious Weed Species.

CLASS 3 (CONTAINMENT)			
Botanical Name	**Common Name**	**Life Cycle**	**Monocot / Dicot**
Acroptilon repens	Russian knapweed	perennial	Dicot
Aegilops cylindrica	Jointed goatgrass	annual	Monocot
Cardaria spp.	Hoary cress	perennial	Dicot
Carduus nutans	Musk thistle	biennial / perennial	Dicot
Cirsium arvense	Canada thistle	perennial	Dicot
Conium maculatum	Poison hemlock	biennial	Dicot
Convolvulus spp.	Field bindweed	perennial	Dicot
Cynodon dactylon	Bermudagrass	perennial	Monocot
Cynoglossum officianale	Houndstongue	biennial	Dicot
Elymus repens	Quackgrass	perennial	Monocot
Lepidium latifolium	Perennial pepperweed	perennial	Dicot
Phragmites australis spp.	Phragmites (common reed)	perennial	Monocot
Onopordum acanthium	Scotch thistle (cotton thistle)	biennial	Dicot
Sorghum almum	Perennial sorghum spp.	perennial	Monocot
Sorghum halepense	Perennial sorghum spp.	perennial	Monocot
Tamarix ramosissima	Tamarisk (saltcedar)	perennial	Dicot
Tribulus terrestris	Puncturevine (goathead)	annual	Dicot

Class 4 (Prohibited)

Declared noxious and invasive weeds, not native to the State of Utah, that pose a threat to the state through the retail sale or propagation in the nursery and greenhouse industry. Prohibited noxious weeds are annual, biennial, or perennial plants that the commissioner designates as having the potential or are known to be detrimental to human or animal health, the environment, public roads, crops, or other property (Table 19).

Table 19. Class 4 State Listed Noxious Weed Species.

CLASS 4 (PROHIBITED)			
Botanical Name	**Common Name**	**Life Cycle**	**Monocot / Dicot**
Cytisus scoparius	scotch broom	perennial	Dicot
Elaeagnus angustifolia	Russian olive	perennial	Dicot
Euphorbia myrsinites	myrtle spurge	biennial / perennial	Dicot
Hesperis matronalis	dames rocket	biennial / perennial	Dicot
Imperata cylindrica	congongrass (Japanese blood grass)	perennial	Monocot

Any state or Utah County noxious species encountered within the project area will be treated during the appropriate growth stage and season. Other species identified as problematic or undesirable will also be treated.

4.2 INTEGRATED WEED MANAGEMENT AS APPLIED TO THE PROVO RIVER DELTA RESTORATION PROJECT

The successful control of nonnative, invasive and noxious plant species is essential to facilitate the re-establishment of self-perpetuating, native-dominated plant communities reflective of habitats that once characterized the shores and wetlands surrounding Utah Lake. Recommendations in this management plan focus on treatment and control options specific to the problematic noxious and invasive plant species documented in the PRDRP boundaries during a weed inventory conducted in 2018. The outlined approaches for weed control implement elements of IWM. Details and recommendations adapted from *Weed Science Principles and Practices* (Monaco et al. 2002) are applied throughout.

The IWM includes the application of many types of technology and supportive knowledge in the deliberate selection, integration, and implementation of effective weed control strategies, including:

- Scouting / Mapping / Documentation,
- Prevention,
- Mechanical,
- Cultural,
- Biological,
- Chemical, and
- Monitoring

The following sub-sections outline details of each control strategy as applied to the PRDRP.

4.2.1 Scouting, Mapping, Documentation

Scouting involves knowing specifically what weeds are present in a given project area, an estimation of their number (density), location, and over time, shifts in location or weed types occurring. Weeds within and surrounding the project area were mapped in 2018. Noxious and invasive weed mapping in the PRDRP follow general methodologies of field procedures and terminology adapted from those developed and used by Utah State University (Dewey et al. 2007) and North American Invasive Species Management Association (NAISMA).

4.2.2 Prevention

Prevention includes stopping a new weed from invading an area or limiting weed buildup in a field. Prevention is practiced by (1) not planting seed contaminated with weed seed, (2) not transferring weed seeds or vegetative propagules into an area with machinery, contaminated manure, irrigation water, transplants (on nursery stock, growth media or soil), (3) not allowing weeds to go to seed and recharge the soil seedbank, (4) eliminating weeds from fencerows and other areas adjacent to fields, and (5) stopping the spread of vegetatively reproducing perennial weeds.

4.2.3 Mechanical Control

Tillage, hand weeding, mowing, clipping, mulching and other activities involving the physical removal of pest species is considered mechanical control. When thoughtfully applied, mechanical control methods can provide excellent control for many noxious and invasive plant species, without chemical inputs. In addition, mechanical controls can also allow for the removal of unwanted plants in sensitive areas where damage to nearby plants is a concern.

4.2.4 Cultural Control

Cultural control activities include prescribed burning, and cultivation of more desirable, competing vegetation to prevent the establishment or replace a weedy species in an area. In addition, specific crop selections, rotation and varieties are considered for non-chemical methods for control of noxious, invasive and nonnative species. Plant timing, spacing, soil fertility and irrigation management also present control options.

Some cultural control methods will not result in effective, long-term control; however, they may present the most effective option for environmentally sensitive sites or public recreation areas. Cultural methods may provide short-term solutions by preventing invasive plants from setting seed until a long-term technique may be used. Cultural methods may also enhance the effectiveness of other techniques when integrated with chemical or biological control methods.

4.2.5 Biological Control

Biological control methods include the introduction of insects, bacterial and fungal diseases or other living organisms (including grazing by domestic livestock), to control populations of a pest species. Introduced biological control agents are only practical if populations of the pest are high enough to support a population of the control agent. The area and density of the infestation must be large enough to support the establishment of the biological control agent.

To reduce any possible use of pesticides, mechanical controls, or cultural controls that may impact established biological control agents used on reservoir lands, the following documentation and management should be undertaken:

- Locations of release sites should be located on maps and the following information should be recorded: (1) species, (2) number released, (3) date of release, and (4) legal description of release site.
- The release site should be identified by installing a fence post and the site should be photographed, if possible, to determine effectiveness to the treatment.
- Release sites should be monitored annually for both the presence of the biological control agent and its effect on the pest species.

4.2.6 Chemical Control

Chemical control methods include the use of any manufactured or extracted chemical compound that is applied to control a pest species. Herbicides, insecticides, and rodent poisons are all considered chemical control methods. The chemical applications described in this plan include both current applications and those proposed for future use. The application rates in this plan are based on the guidance provided in current product labels, Extension Service and other publications. Future editions of this guide will be used to develop trial rates for new pesticides.

From year to year, the prescribed chemicals and application rates may change depending upon a number of factors. These include weed species, densities of weeds, native plants, climatic factors, and physical factors (e.g., soil types, temperature, rainfall). In the interest of efficiency, to avoid constantly changing the tank mix, selection of the chemical and application rate should be based on the requirement for controlling the pest species of greatest concern.

4.2.7 Monitoring

The process of invasive species control and the re-establishment of native plant communities is a dynamic endeavor. Monitoring treated areas and responding to issues that arise is a critical component to foster positive changes to terrestrial and aquatic ecosystems within the PRDRP. In part, monitoring has been initiated by establishing a baseline of existing conditions (i.e., vegetation community and invasive species mapping) prior to the commencement of construction.

4.3 PROVO RIVER DELTA RESTORATION PROJECT (PRDRP) PRIORITY WEEDS

During August and September 2018, a comprehensive weed inventory was completed in the PRDRP. The weed inventory and other vegetation surveys that have occurred within the project area identified 30 noxious and non-indigenous plant species (Table 20) that have the greatest potential to interfere with restoration goals set forth for the PRDRP. This document details problematic species distributions and severity of infestations. These include several non-indigenous (plants species not native to North American) that conflict with restoration and habitat creation goals, in addition to plant species listed by the State of Utah as “noxious.”

A data collection template was adapted (Dewey et al 2007) and used to inventory noxious and invasive plant species within the project boundaries. Data elements collected complied with standards provided by the NAISMA. Data collected include: species, percent aerial cover, size (acreage) of infestation (0.01, 0.1, 0.25, 0.5, 1 acre buffered point locations), phenology, date collected, and crew member collecting data. The entirety of the project was covered on foot, using a handheld Trimble® GPS (Global Positioning System) units running Terasync® data recording software to collect point data locations of infestations. All data were collected in NAD 1983, UTM 12 North.

In addition, infestations greater in area than 0.5 acre were mapped using current aerial imagery on physical field maps, marking boundaries of infestations where obvious demarcations could be made. In part, methodology was adapted from the publication *Measuring and Monitoring Plant Populations* (Elzinga et al. 1998), particularly when estimating cover of plant species within each polygon.

Estimating percentages of aerial cover allows imagery to be linked to quantitative and qualitative observations being observed on the ground, specifically emphasizing dominant plants (Fehmi 2010). Cover based species composition is a common way to quantify functional diversity (Lavorel et al. 2008), identify problematic infestations of noxious or non-indigenous plant species, and eventually visually represent distribution patterns of plant communities and species within a landscape. When estimating cover of individual plant species within a polygon, a visual assessment of absolute cover was recorded. Absolute cover estimates were implemented in order to more accurately represent levels of dominance within a vegetation association, record dominant and sub-dominant species, account for various layers of canopy, and represent bare ground when applicable between basal cover where plant species are fixed / rooted. Absolute cover allows the total percent cover in a given vegetation association (polygon) to tally greater than 100 percent, which in turn can present as an inflated representation of acreage of infestations when comparted to the actual size of the project area when looking at numbers alone.

Table 20. List of noxious and invasive species observed within the PRDRP that are particularly problematic.

SPECIES	BOTANICAL NAME	COMMON NAME	NOXIOUS LISTING STATUS
Submerged Aquatic Invasive Species	*Didymosphenia geminate*	Rock snot	Not listed – potentially invasive within Utah Lake
	Potamogeton crispus	Curly leafed pondweed	Not listed – potentially invasive within Utah Lake
	Myriophyllum spicatum	Eurasian watermilifoil	Not listed – potentially invasive within Utah Lake
	Nasturtium officinale	Water-cress	Not listed- known invasive throughout Intermountain west
Emergent Invasive Species	*Lythrum salicaria*	Purple loosestrife	Class III Weed (Contain)
	Phragmites australis	Phragmites	Class III Weed (Contain)
Wetland Meadow – Transitional Mesic Invasive Species			
	Arctium minus	Common burdock	Not listed – regionally invasive
	Cardaria draba	Whitetop	Class III Weed (Contain)
	Carduus nutans	Musk thistle	Class 1A Weed (Early Detection Rapid Response Watch List)
	Chenopodium album	Lambsquarter	Not listed – regionally invasive
	Cirsium arvense	Canada thistle	Class III Weeds (Contain)
	Cirsium vulgare	Bull thistle	Not listed – regionally invasive
	Cynoglossum officanale	Houndstongue	Class III Weed (Contain)
	Dipsacus fullonum	Common teasel	Not listed – regionally invasive
	Echinochloa crus-galli	Barnyard grass	Not listed – regionally invasive
	Elymus repens	Quackgrass	Class III Weed (Contain)
	Lactuca serriola	Prickly lettuce	Not listed – regionally invasive
	Lepidium latifolium	Perennial pepperweed	Class III Weed (Contain)
	Onopordum acanthium	Scotch thistle	Class III Weed (Contain)
	Phalaris arundinacea	Reed canarygrass	Likely a nonnative variant, observed to overwhelm wetland habitats and create mono-typic stands
	Xanthium strumarium	Cocklebur	Not listed – regionally invasive
Riparian Woodland – Invasive Species	*Elaeagnus angustifolia*	Russian olive	Class IV Weed (Prohibited)
	Salix fragilis	Crack willow	Not listed – regionally invasive
	Tamarix ramosissima (chinensis)	Five-stamen tamarisk / saltcedar	Class III Weed (Contain)
	Ulmus pumila	Siberian elm	Not listed – regionally invasive
Upland	*Bassia scoparia*	Burningbush (formerly kochia)	Not listed – regionally invasive
	Bromus tectorum	Cheatgrass	Not listed – regionally invasive
	Convolvulus arvense	Field bindweed	Class III Weed (Contain)
	Tribulus terrestris	Puncturevine	Class III Weed (Contain)

Each polygon mapped was assigned the following attributes:

- Polygon number.
- Dominant invasive plant species and percentage estimation of absolute aerial cover.
- Sub-dominant plant species and respective percentage of absolute aerial cover.
- Percentage of bare ground or open water.
- Notes – general site observations, as applicable

Table 21 details dominant weed species and acreage of each as documented during the 2018 weed mapping effort, including areas within and outside of the PRDRP final project area.

Table 21. Acreage of dominant noxious, invasive and nonnative plant species mapped within the Provo River Delta Restoration Project (PRDRP) study area, listed from highest aerial cover to least.

BOTANICAL NAME	COMMON NAME	ACREAGE
Phalaris arundinacea	Reed canarygrass	55.46
Phragmites australis	Phragmites	50.52
Cirsium arvense	Canada thistle	24.07
Salix fragilis	Crack willow	20.95
Xanthium strumarium	Cocklebur	17.76
Elaeagnus angustifolia	Russian olive	16.33
Cirsium arvense / Cirsium vulgare	Canada thistle, Bull thistle	15.18
Bassia scoparia	Burningbush	10.92
Lactuca serriola	Prickly lettuce	10.01
Elymus repens	Quackgrass	9.41
Bassia scoparia / Lactuca serriola	Burningbush, Pricklylettuce	6.70
Onopordum acanthium	Scotch thistle	6.58
Bassia scoparia / Chenopodium berlandieri	Burningbush / Lambsquarters	6.03
Tamarix chinensis	Tamarix	5.29
Chenopodium berlandieri	Lambsquarters	3.55
Cirsium arvense / Elaeagnus angustifolia	Canada thistle / Russian olive	2.12
Convolvulus arvensis	Field bindweed	1.30
Bromus tectorum	Cheatgrass	0.86
Phalaris arundinacea / Salix fragilis	Reed canary grass / Crack willow	0.76
Phalaris arundinacea / Lactuca serriola	Reed canary grass / Prickly lettuce	0.57
Elaeagnus angustifolia / Lepidium latifolium	Russian olive, Perennial pepperweed	0.46
Echinochloa crus-galli	Barnyardgrass	0.43
Lactuca serriola / Chenopodium berlandieri	Prickly lettuce / Lambsquarters	0.37
Phalaris arundinacea / Lepidium latifolium	Reed canary grass / Perennial pepperweed	0.33
Salix fragilis / Xanthium strumarium	Crack willow / Cocklebur	0.30
Nasturtium officinale	Water-cress	0.20
Cardaria draba	Whitetop (Hoary cress)	0.13
Total Acres:		**266.58**

Some invasive plant species are anticipated to be more problematic and interfere with goals related to the creation of desired habitat types, and subsequent management. For example, field bindweed (*Convolvulus arvensis*) was observed to occur sporadically throughout the PRDRP, while phragmites (*Phragmites australis*)is widespread, infesting large areas forming dense, monotypic stands. As with many invasive species, phragmites not only displaces native, more ecologically productive aquatic plant species communities but directly interferes with the establishment and dynamic successional trajectory of palustrine and emergent wetlands. Table 22 outlines species prioritized for treatment in the PRDRP.

Table 22. Noxious and invasive plant species treatment priorities.

PRIORITIES FOR TREATMENT		
High	**Moderate**	**As Encountered or Watch List**
1. *Phragmites australis* (Phragmites)	14. *Lepidium latifolium* *(perennial pepperweed)*	24. *Ambrosia artemisifolia* (annual ragweed)
2. *Phalaris arundinacea* (reed canarygrass)	15.*Echinochloa crus-galli* (barnyard grass)	25. *Bassia scoparia* (burningbush)
3. *Myriophyllum spicatum* (Eurasian water milifoil)	16. *Nasturtium officinale*[a] (water-cress)	26. *Bromus tectorum*[a] (cheatgrass)
4. *Potamogeton crispus* (curly leafed pondweed)	17. *Cardaria draba* (hoary cress)	27. *Chenopodium berlandieri* (lambsquarters)
5. *Didymosphenia geminata* (rock snot)	18. *Arctium minus* (burdock)	28. *Cirsium vulgare*[a] (bull thistle)
6. *Cirsium arvense* (Canada thistle)	19. *Cynoglossum officanale* (houndstongue)	29. *Dipsacus fullonum* (Fuller's teasel)
7. *Elaeagnus angustifolia* (Russian olive)	20. *Elymus repens* (quackgrass)	30. *Aegilops cylindrica* (jointed goatgrass)
8. *Carduus nutans* (musk thistle)	21. *Convolvulus arvense* (field bindweed)	31. *Lythrum salicaria* (purple loosestrife)
9. *Onopordum acanthium* (scotch thistle)	22. *Xanthium strumarium* (cocklebur)	
10. *Tribulus terrestris* (puncturevine (goathead))	23. *Lactuca serriola* (prickly lettuce)	
11. *Tamarix ramosissima / chinensis* (saltcedar)		
12. *Ulmus pumila*[a] (Siberian elm)		
13. *Salix fragilis*[a] (crack willow)		

[a] Non-indigenous plant species known to be problematic within the project area, not listed by the State or Utah County as "noxious".

Priority species were identified and organized by considering the following criteria:

- Baseline distribution and dominance of an invasive plant species within the PRDRP;
- Invasive plant species that present greatest conflicts with project goals (e.g. creation of habitat suitable to the June sucker and establishment and long-term value of all habitat niches: aquatic, emergent wetland, wetland meadow, riparian woodland, and upland inclusions);

The level of effort needed to control or eradicate the invasive plant. Plant species that are known to be more difficult to control were given a higher priority.

Generally, native emergent plant species appropriate the establishment and persistence of increased species diversity within a vegetation community, in turn, providing critical cover to June sucker in near-shore transition zones between open water habitats and emergent plant communities. Emergent wetland habitats once populated by *Bolboschoenus maritimus*, *Schoenoplectus acutus*, *S. americanus*, *S. pungens*, *Typha domingensis,* and *T. latifolia* have largely been converted to monotypic, dense stands of phragmites that reduce ecosystem qualities beneficial to June sucker populations.

Weed Location Map A in Attachment 1 shows the distribution of the high treatment priority weeds, classifying areas with dense infestations as "high" treatment priority and areas of sparse infestations as "low" treatment priority. In addition, Weed Location Map B in Attachment 1 shows the distributions of medium and low treatment priority species, which often occur in the areas interstitially situated between dense and sparse populations of weeds, forming a gradient of aerial cover. A weed treatment priority map for the project area is included in Atteachment 2, which shows both the density of the identified weed species and the treatment priority areas.

Further challenging weed management and habitat creation goals are land use and management practices on adjacent properties, specifically properties that allow dense infestations of problematic noxious and invasive plant species to proliferate unchecked. Critical to the successful creation and long-term management of desired habitats within the PRDRP is the identification, treatment, and successful control of phragmites infestations on adjacent and upstream lands which would continue to inundate the project area with viable seed. Figure 21 shows areas identified offsite to contain stands of phragmites. It is imperative that adjacent land owners and managers are part of phragmites control planning and treatment implementation before construction begins and control efforts continue during the entire construction operation. Otherwise, air and waterborne seeds will find idea habitat on disturbed soils in the project area and potentially exacerbate costly long-term management issues.

4.3.1 Species Descriptions and Control Measures

Detailed descriptions and control options respective to priority species are given below. These descriptions are adapted from multiple sources, including *A Utah Flora* (Welsh 2008), *Weeds of the West* (Whitson 2000), *Weed Control in Natural Areas in the Western United States* (DiTomaso and Kyser 2013), *Noxious Weed Field Guide for Utah* (Lowry et al. 4th Edition), and Utah Department of Agriculture and Food, State of Utah Noxious Weed List (2018) unless otherwise cited. In concert with Table 22, species are organized first by the type of habitat plant species is most likely to be encountered growing, and secondarily listed in alphabetical order by botanical name.

Each species description includes the following details:

1. Growth habits and field identifying characteristics

2. Seasonal phenology and life-cycle (e.g. vegetative, bud, bloom, seed, and dormancy/senescence)

3. Habitat preferences

4. Reproduction and dispersal methods

5. Methods by which species interfere with restoration and management goals

6. Control options

7. Growth habits and field identifying characteristics

8. Seasonal phenology and life-cycle (e.g. vegetative, bud, bloom, seed, and dormancy/senescence)

9. Habitat preferences

10. Reproduction and dispersal methods

11. How the species interferes with restoration and management goals

12. Control options

4.3.1.1 Aquatic Submerged and Floating Invasive Species Description

***Didymophenia geminata* (rock snot).** Rock snot is an aquatic, microscopic algae (diatom) that was originally described from the Faroe Islands of north Scotland and historically limited to the cold-water streams of North America and Europe. Currently, the species has spread to a cosmopolitan distribution, becoming recognized as a nuisance aquatic species. Rock snot is known to produce large amounts of extracellular stalk material, forming thick brown mats in both moving and non-moving waters of lakes streams and rivers. Rivers with regulated stable flows are particularly at risk. Rock snot growth is not spurred by nutrient spikes; instead, this alga prefers oligotrophic waters with good water quality (Table 23).

Table 23. Rock snot phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Single-celled diatom algae that forms thick mats of vegetative material on living and non-living substrate
	Seasonal Phenology:	Blooms can occur at anytime
	Habitat:	Slow stable flowing, Oligotrophic streams and rivers especially below reservoirs
	Wetland Indicator Status:	Obligate (OBL)*
	Reproduction and Dispersal:	Single celled forming into large fibrous looking colonies during a bloom. Can be spread via fishing gear, boats, transfer of infected substrate
	State and/or County Noxious Listing Status:	Not listed as a noxious weed in Utah
TREATMENT SUMMARY	Mechanical:	Hand removal or scraping blooming colonies from substrate
	Cultural:	Cleaning and drying fishing or recreational equipment between use
	Biological:	None
	Chemical:	Research is ongoing but copper sulfate based chemicals show some promise

*OBL = occurs in aquatic resources > 99% of time.

***Potamogeton crispus* (curly leafed pondweed).** Curly leafed pondweed was originally native to Europe and Africa but has become widespread in North America since introduction in the 1800s. This species has become problematic in northern tier states of the United States but its distribution is widespread across the country. This species can produce dense growth, out-competing many native aquatic plants. It can also survive in water with poor growing conditions including high turbidity and low light. Curly leafed pondweed can survive under ice and can begin to grow earlier in the year compared to other aquatic plants, giving curly leaf pondweed a competitive advantage. Curly leafed pondweed is predominate in small lakes, shallow reservoirs and streams, but can be found in most any waterbody. It is known to be present in the Provo River. Curly leafed pondweed can be confused with native species of pondweeds, so proper identification is essential for management purposes (Table 24).

Table 24. Curly leafed pondweed phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Spreading, rhizomatous, upright and submerged aquatic perennial
	Seasonal Phenology:	As with most aquatic plants biomass production is related to increasing water temperatures. This species can produce bio-mass in colder water temperatures allowing for competitive advantage.
	Habitat:	Can grow in low light and highly turbid conditions with poor water quality. Streams, rivers and reservoirs.
	Wetland Indicator Status:	Obligate (OBL)*
	Reproduction and Dispersal:	Mostly spreads by rhizomatous propagules attached to recreational equipment.
	State and/or County Noxious Listing Status:	Not listed as noxious in Utah
TREATMENT SUMMARY	Mechanical:	Benthic barrier mats, hand or rake removal
	Cultural:	Clean and dry recreational equipment between uses. Drain boats and clean boat trailers
	Biological:	None known except grass carp
	Chemical:	Endothall-based herbicide

*OBL = occurs in aquatic resources > 99% of time.

***Myriophyllum spicatum* (Eurasian watermilfoil).** Eurasian watermilfoil is one of the most common aquatic invasive plants in the United States. Originating from Europe, Northwestern Asia, and likely Africa, Eurasian watermilfoil can be aggressive, creating dense stands in deep water to 10 feet or greater if growing conditions allow. This allows the plant to colonize areas of waterbodies too deep for native plant species. However, this plant is not as aggressive as some other introduced species. In some instances, Eurasian watermilfoil has been noted to not compete well with native aquatic plant species. Prolonged presence of Eurasian watermilfoil can allow it to spread or become dominate if circumstances allow. The species can spread easily by stem fragments or leaf fragments that contain small pieces of a node. Eurasian watermilfoil can be confused with native milfoils, so proper identification is essential for management purposes (Table 25).

Table 25. Eurasian watermilifoil phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Submerged aquatic perennial.
	Seasonal Phenology:	As with most aquatic plants biomass production is related to increasing water temperatures. This species is tolerant of a variety of water conditions.
	Habitat:	Reservoirs and ponds. This is not typically found in flowing water
	Wetland Indicator Status:	Obligate (OBL)*
	Reproduction and Dispersal:	Stem fragments or other fragments containing a small piece of the node.
	State and/or County Noxious Listing Status:	Not listed as noxious in Utah
TREATMENT SUMMARY	Mechanical:	Benthic barriers, hand removal or raking, water level manipulation
	Cultural:	Clean drain and dry fishing and recreational equipment between uses
	Biological:	Some research has been conducted with biological control agents which have shown some promise in control of the species most notably the moth *Acentria ephemerella.*
	Chemical:	Fluridone, 2,4, D and Diquat and Endothall are all common herbicides used to control Eurasian watermilfoil however eradication by herbicide is rarely achieved.

*OBL = occurs in aquatic resources > 99% of time.

Nasturtium officinale **(watercress).** Watercress is a perennial floating or emergent herb native to Eurasia and Asia but has become cosmopolitan, most likely as a result of its culinary uses. Watercress is typically found along streams and moving water bodies and rarely in stagnant water. It is known to be present in the Provo River. This species can freely float on the water's surface, creating large mats. It may also loosely root in mud along stream edges. Submerged forms are possible but less prevalent. Watercress has naturalized into the native plant communities in many regions, but under prime growing conditions can become dominant and out-compete native plants, especially when it grows into dense floating mats. This species can reproduce from vegetative fragments as well as seed (Table 26).

Table 26. Watercress phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Floating, emergent and occasionally submersed
	Seasonal Phenology:	As with most aquatic plants biomass production is related to increasing water temperatures. However this species is hardy in cold temperatures.
	Habitat:	Typically found along the edges of flowing water
	Wetland Indicator Status:	Obligate (OBL)*
	Reproduction and Dispersal:	Stem fragments or seed
	State and/or County Noxious Listing Status:	Not listed as noxious in Utah
TREATMENT SUMMARY	Mechanical:	Benthic barriers, hand removal or raking
	Cultural:	Clean drain and dry fishing and recreational equipment between uses
	Biological:	None known
	Chemical:	Glyphosate or 2,4D based herbicide

*OBL = occurs in aquatic resources > 99% of time.

4.3.1.2 Emergent Invasive Species Descriptions

***Lythrum salicaria* (purple loosestrife).** Purple loosestrife is an introduced European ornamental that has escaped cultivation and has been observed to be invasive throughout wetland habitats, often crowding out native species and reducing habitat value for wildlife. In addition, infestations can inhibit water flow (Table 27).

Table 27. Purple loosestrife phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Herbaceous species 6 to 8 feet tall, rose-purple flowers with 5 to seven petals. Stems green with coarse hairs, lance-shaped leaves with smooth margins, opposite or whorled
	Seasonal Phenology:	Perennial
	Habitat:	Moist or marshy sites – palustrine and lacustrine habitats
	Wetland Indicator Status:	Obligate (OBL)*
	Reproduction and Dispersal:	Seed and creeping rhizomes / rootstocks
	State and/or County Noxious Listing Status:	Class II Weed (Control)
TREATMENT SUMMARY	Mechanical:	Digging and pulling effective for early infestations. Important to remove all crown and root material to prevent re-sprouting
	Cultural:	*Lythrum salicaria* has poor palatability, making grazing not an effective control measure
	Biological:	Biocontrol available, suggest contacting county weed specialist for details
	Chemical:	Glyphosate or imazapyr. Apply post emergence to rapidly growing plants in the full to late flowering stage until killing frost.

*OBL = occurs in aquatic resources > 99% of time.

Phragmites australis **(Phragmites, common reed).** Phragmites is native to North America and Europe and has become common and known to be invasive within emergent wetland habitats and waterways. This species now dominates thousands of acres of Utah shorelines, including those surrounding Utah Lake. Early reports about habitat surrounding Utah Lake were recorded in the 1850s, notably by Lieutenant John W. Gunnison, who wrote, "a belt of land about one mile wide which is covered with cane and rushes, and at present stage of the Lake will be a wet marsh." Surveyors wrote that bulrush grew in plenty from the Jordan River to the mouth of American Fork Creek (Carter 2005). Much of this habitat, which was once populated with dense stands of native, perennial rushes have been overtaken by phragmites. The shallow-water habitats provided ideal conditions for monotypic stands of phragmites to establish and dominate, profoundly altering habitat quality (Kettenring et al. 2015). Phragmites has proved to be a particularly problematic species within the Utah Lake ecosystem, overtaking critical habitat for shorebirds and waterfowl, while reducing the availability of areas suitable for to birds to loaf, nest, and forage. In addition, phragmites makes large areas of wetlands inaccessible to wildlife and humans (Rohal et al. 2018), introduces additional fire hazards from dry plant material (Michigan Department of Environmental Quality). The dense monoculture of phragmites present within the Utah Lake is likely a result of multiple factors, including declining native populations and hybridization of non-indigenous parental lineages (Meyerson et al. 2010) and introduced varieties. Other agencies around Utah Lake are also working with Utah Reclamation and Conservation Commission on managing phragmites and other weeds. These agencies include Utah County Public Works Weed Control Division, Utah Lake Commission, and Utah Division of Forestry, Fire and State Lands. Approximately 7,000 acres of the shoreline of Utah Lake have been treated to remove phragmites (Utah Lake Commission 2018). See Table 28 for phenology and treatment.

Table 28. Phragmites phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Rhizomatous that is often strongly stoloniferous 6 to 10 feet tall. Leaf blades up to 2 feet long, 1-2 inches wide. Inflorescence (seed head) large, dense and feathery.
	Seasonal Phenology:	Perennial
	Habitat:	Brackish and freshwater waterways and marshes. Shallow marshes and wetland habitats.
	Wetland Indicator Status:	Facultative Wet (FACW)*
	Reproduction and Dispersal:	Spreads by rhizomes, stolons (runners). Can spread by seed, although seeds are short-lived (<2 years) and persistent seed banks do not accumulate.
	State and/or County Noxious Listing Status:	Class III Weed (Control)
TREATMENT SUMMARY	Mechanical:	Digging and removal not typically feasible, given dense root and rhizome system. Mowing can be effective when integrated with chemical control options
	Cultural:	Grazing can be effective in reducing biomass, spread, and seed production, combine with chemical for control
	Biological:	Research ongoing for biological controls; contact state or county weed specialist for updated information. No bio control available at this time.
	Chemical:	Glyphosate or imazapyr. Summer and Fall treatment integrated with mowing

* FACW = occurs in aquatic resources 67–99% of time.

4.3.1.3 Riparian Invasive Species Descriptions

Wetland Meadow and Mesic Invasive Species

***Aegilops cylindrica* (jointed goatgrass).** Jointed goatgrass was introduced to the United States around 1930 and is native to Eurasia. This species is widespread and is particularly problematic in disturbed sites, along roadsides, fallow fields, rangelands and pastures. It often forms monocultures that exclude nearly all other plant species. It is characterized by cylindrical, jointed seed heads that are tightly stacked (strongly appressed) (Table 29).

Table 29. Jointed goatgrass phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Grass species, characterized by cylindrical, jointed seed heads tightly stacked (strongly appressed), 15 – 30 inches tall with one to many erect stems.
	Seasonal Phenology:	Winter annual, flowering and seed production occur from May to July
	Habitat:	Upland, disturbed sites
	Wetland Indicator Status:	NI*
	Reproduction and Dispersal:	At maturity, the spike falls intact and spikelets separate with a segment of the rachis still attached. Spread by seed.
	State and/or County Noxious Listing Status:	Utah Class III (Control)
TREATMENT SUMMARY	Mechanical:	Hand pulling / hoeing is effective for small infestations. Mowing can reduce seed production, but timing is critical. Early mowing will result in proliferation of tiller growth and late mowing will only spread seed. Mow at "soft boot stage" (transition between vegetative and reproductive phase)
	Cultural:	Grazing has been documented to increase plant density
	Biological:	No known biological controls in natural areas and rangelands have not been established
	Chemical:	Glyphosate; apply post emergence in late winter to early spring to rapidly growing plants before flower.

* NI = indicator status not known in this region.

Ambrosia artemisiifolia (annual ragweed)

Annual ragweed is a native species that can reach up to 4 feet tall. This species is common throughout the west, causing hay fever and allergies (Table 30).

Table 30. Annual ragweed phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Erect stems reach 4 feet tall; stems and leaves are blue-green and covered with fine hairs. Leaves are pinnately divided and are both opposite and alternate. Flowers terminal.
	Seasonal Phenology:	Annual
	Habitat:	Can become problematic in ranges and pastures where overgrazing occurs. Also adapted to mesic and wetland meadow habitats.
	Wetland Indicator Status:	Facultative Upland (FACU*)
	Reproduction and Dispersal:	Reproduces by seed, which can remain viable in the soil for decades.
	State and/or County Noxious Listing Status:	Not listed by the state or Utah County as noxious
TREATMENT SUMMARY	Mechanical:	Can be controlled by hand weeding and mowing.
	Cultural:	This species has been reduced by planting a cover crop to reduce the overall bio-mass produced.
	Biological:	Biological controls available internationally; check with local county weed extension specialist for details on locally available bio controls.
	Chemical:	2,4D and dicamba or imazapic (spring treatment); 2,4D and dicamba (summer treatment)

* FACU = occurs in aquatic resources 1-33% of time.

***Arctium minus* (common burdock).** A robust plant, common burdock was first reported in the Intermountain West in 1929, although was likely present well before documentation. This species is a native to Europe and has been associated with its troublesome burs that have long been associated with economic loss as they attach and accumulate in the hair of animals, especially wool of sheep, manes and tails of horses. Burs also attach to clothing and easily break apart, spreading further when attempting to remove (Table 31).

Table 31. Common burdock phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Coarse, robust plant producing a rosette of thickly hairy leaves the first year and an erect, multi-branched stem 3 to 10 feet tall the second year. Produces purple flowers encased within a persistent prickly, hooked bur-like structure from mid-summer through late fall. The heart-shaped leaves are dark green on the top surface and a woolly, whitish bottom surface.
	Seasonal Phenology:	Biennial, flowering and seed production occur from June to October
	Habitat:	Mesic rangelands, disturbed landscapes including ditches, pastures and notably within disturbed wetland habitat affected by grazing
	Wetland Indicator Status:	Facultative Upland (FACU)*
	Reproduction and Dispersal:	Seed dispersal via waterways, attached seeds heads to animal fur etc.
	State and/or County Noxious Listing Status:	Not listed as noxious
TREATMENT SUMMARY	Mechanical:	Mowing or cutting can eliminate seed production; should occur after the plant has bolted, prior to seed set
	Cultural:	Intolerant of cultivation / tillage
	Biological:	No official form of biocontrol noted
	Chemical:	2,4D and dicamba; aminopyralid

* FACU = occurs in aquatic resources 1–33% of time.

Bassia scoparia (burningbush—previously known as kochia)

Native of Eurasia, burningbush is a plant species that escaped cultivation as an ornamental and is now found throughout North America. (Table 32).

Table 32. Burningbush phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Stems much branched, round, slender, usually soft hairs but occasionally smooth, this species grows from 1 to 6 feet tall. Leaves alternate and lance-shaped. Flowers inconspicuously, sessile in the axils of upper leaves. Seeds are wedge-shaped, dull brown, slightly ribbed.
	Seasonal Phenology:	Summer annual
	Habitat:	Roadsides, fallow fields, crop fields, ditch margins, seasonal wetlands and residential areas. Burningbush predominantly inhabits upland sites, especially following soil disturbance. Often associated with alkaline areas, species tolerant of alkaline or saline soils, drought, and frost. This species spreads rapidly and form dense stands that compete with desirable species and have shown evidence of allopathic properties.
	Wetland Indicator Status:	Facultative Upland (FAC*)
	Reproduction and Dispersal:	Reproduces by seed, which typically survive only 1 to 2 years.
	State and/or County Noxious Listing Status:	Not listed by the state or Utah County as noxious although other western states (Arizona, Oregon and Washington) have classified this species as noxious.
TREATMENT SUMMARY	Mechanical:	Digging and hand pulling can be effective; when digging, must be severed below the soil surface to prevent regrowth. Shallow tillage will control emerged plants but can stimulate recruitment.
	Cultural:	Species will frequently regrow following grazing, although grazing can reduce populations when small plants are grazed intensively. Burningbush can be a good livestock forage in small amounts, although can be toxic in large quantities due to nitrites. Promoting competitive vegetation can slow spread and help prevent establishment.
	Biological:	No known biological controls.
	Chemical:	2,4D and dicamba or imazapic (spring treatment); 2,4D and dicamba (summer treatment)

* FAC = occurs in aquatic resources 34-66% of time.

Bromus tectorum **(cheatgrass).** Cheatgrass was introduced from the Mediterranean region in packing material, first found in Colorado. This species is now so widespread it is ubiquitous to nearly all upland vegetation communities in the Intermountain West (Table 33).

Table 33. Cheatgrass phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	This species ranges from 4 to 30 inches tall and is characterized by the slender inflorescence usually drooping. Awns are long, usually purplish at maturity.
	Seasonal Phenology:	Annual or winter annual
	Habitat:	Open disturbed areas, roadsides, fields, rangelands, agronomic crops, orchards, forestry sites, and many natural communities. Grows well in most soil types.
	Wetland Indicator Status:	NI*
	Reproduction and Dispersal:	Reproduces by seed only, producing a large number of achenes (small one seeded fruit) that remain viable for 7 to 39 years. Seed dispersal is primarily by wind, but can also occur via water, rodents, livestock or vehicles.
	State and/or County Noxious Listing Status:	Not listed by the State or Utah County as noxious.
TREATMENT SUMMARY	Mechanical:	Individual plants or small patches can be pulled by hand or hoed in early spring before seeds are ripe. Mowing not usually recommended, but can reduce seed production if conducted shortly after flower initiation and before seeds mature. Shallow cultivation shortly after the main flush of germination and again a little later can eliminate most seedlings.
	Cultural:	Overgrazing or frequent soil disturbance can increase dominance of cheatgrass by reducing or eliminating desirable native species. Moderate grazing can be effective when used in combination with herbicides. .
	Biological:	No biocontrol agents available. Several soil fungi have been tested, although none have proven effective.
	Chemical:	Glyphosate or Imazapic in early spring or fall.

* NI = indicator status not known in this region.

***Cardaria draba* (hoary cress/whitetop).** Hoary cress is classified as a *Brassicacea* (Mustard family) and has invested landscapes throughout North America. This species originates in Europe and is highly competitive with other species once it is established (Table 34).

Table 34. Hoary cress phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Herbaceous broad-leaved plant, leaves are finely toothed with upper leaves clasping the stem. Bloom characterized by a flush of white flowers, each flower includes 4 petals transitioning to heart-shaped bladders (ovate) that contain two seeds. One plant can produce from 1,200 to 4,800 seeds.
	Seasonal Phenology:	Perennial, blooming late spring and seed set occurs by mid-summer
	Habitat:	Disturbed open site, ditch banks, roadsides, wetlands and riparian areas, agricultural fields
	Wetland Indicator Status:	NI*
	Reproduction and Dispersal:	Root segments and seed
	State and/or County Noxious Listing Status:	Class III Weed (Contain)
TREATMENT SUMMARY	Mechanical:	Hand-pulling is impractical due to extensive root system. Mowing and competitive cropping has been shown to control this species, at least in part.
	Cultural:	Sheep and goats will forage *Cardaria draba*, although cows generally find it unpalatable. Flooding can be highly effective, although inundation needs to be present for at least 2 months. Burning is not effective due to extensive, below ground root system.
	Biological:	Due to taxonomic similarities to other native mustard species, no biological control agents are currently available, although research for such a control is in the early stages.
	Chemical:	2,4D and dicamba during spring, prior to flowering, or to new growth in the fall. Control is minimal after blooms close. Metsulfuron is also effective through the bloom stage.

* NI = indicator status not known in this region.

***Carduus nutans* (musk thistle/nodding plumeless thistle).** Musk thistle/nodding plumeless thistle was introduced to North America from southern Europe and western Asia in the early part of the 20th century and is now widespread. Within the upland and mesic habitats bordering Utah Lake, this species is typically observed in conjunction with *Onopordum acanthium* (scotch thistle) infestations in mesic locations trending to upland habitats (Table 35).

Table 35. Musk thistle phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Produces rosettes characterized by dark green leaves and a pale mid-rib, deeply lobed and spiny at margins. Leaves extend up stems, creating a winged appearance. Flowers deep rose to purple born on stalks that are “naked” near the flower head.
	Seasonal Phenology:	Winter annual or biennial germinating in winter to early spring forming a rosette the first year and bolting the following year. Flower during summer months and produce seed late summer through fall.
	Habitat:	Occurs in pastures, range and forest lands, along roadsides, and commonly noted along rail road rights-of-ways.
	Wetland Indicator Status:	Facultative Upland (FACU)*
	Reproduction and Dispersal:	Reproduces only by seed, typically falling near parent plant or dispersed by wind to cover greater distances.
	State and/or County Noxious Listing Status:	Class III Weed (Contain)
TREATMENT SUMMARY	Mechanical:	Can manually remove when small. Mowing can be effective to reduce seed production, although multiple mowing may be necessary to account for variability of maturity within vegetative and bloom season
	Cultural:	Large livestock tend to avoid grazing, although horses and cattle documented eating flower heads. Sheep will eat rosettes. Fire can promote invasion. Thistles compete poorly with well-established healthy grassland communities.
	Biological:	Thistle head weevil (*Rhinocyllus conicus*) is an introduced biocontrol agent that attacks this species. Consult State and County weed specialists for availability and current information.
	Chemical:	2,4D and dicamba (spring and summer treatments); aminopyralid (fall treatment)

* FACU = occurs in aquatic resources 1-33% of time.

***Chenopodium berlandieri* (lambsquarter).** Lambsquarter is a native to Europe but has become established throughout most of North America. It is a very competitive weed species due to its rapid growth and high water use (Table 36).

Table 36. Lambsquarter phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Extremely variable annual, 1 to 6 feet tall, stems erect, multi branched and often striped with pink or purple; leaves alternate.
	Seasonal Phenology:	Annual
	Habitat:	Common in cultivated fields, gardens, and waste areas.
	Wetland Indicator Status:	Facultative Upland (FACU)*
	Reproduction and Dispersal:	Reproduces only by seed.
	State and/or County Noxious Listing Status:	Not listed by the State or Utah County as noxious.
TREATMENT SUMMARY	Mechanical:	Grubbing, digging or hand pulling likely the most effective method for control. Fair control results have been observed when using tillage, mowing and cutting.
	Cultural:	Control results following prescribed burning have been fair, while grazing has been observed to provide only poor results for control.
	Biological:	No known biological controls available for this species.
	Chemical:	2,4D and dicamba (spring and summer treatments).

* FACU = occurs in aquatic resources 1-33% of time.

***Cirsium arvense* (Canada thistle).** Canada thistle is native to southeastern Europe and the eastern Mediterranean region. It was introduced to Canada in the late 18th century through contaminated crop seed. It competes aggressively with native plant species, causes extensive loss of crop yield by sequestering sunlight, nutrients, and water, and is a host to a number of agricultural insect and disease pests (Table 37).

Table 37. Canada thistle phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Erect, dioecious (separate male and female plants), perennial species that grows from 1 to 6 feet tall. Stems ordinarily die back over winter with new shoots forming in spring from old stem bases or root buds. Purple to white flower heads borne in clusters of 1 to 5 per branch.
	Seasonal Phenology:	Perennial, over-wintering roots develop new underground roots and shoots and begin to elongate in late in the winter season. Shoots emerge between March and May and form rosettes. Longer days in July and August trigger flowering and seed maturation occurs anytime between July and October.
	Habitat:	Thrives in disturbed areas, open meadows, wetland habitats, riparian woodlands.
	Wetland Indicator Status:	Facultative Upland (FACU)*
	Reproduction and Dispersal:	Primarily reproduces vegetatively, extensive horizontal roots produce shoots, forming dense colonies. Also spreads via seed dispersal.
	State and/or County Noxious Listing Status:	Class III Weed (Contain)
TREATMENT SUMMARY	Mechanical:	Mowing can be used to reduce nutrient storage in roots and suppress flower formation. Although, must occur at least every 3 to 4 weeks over several growing seasons or integrated with other control measures. Tillage or cultivation can actually increase infestation.
	Cultural:	Neither grazing nor prescribed burning have been shown to be effective forms of control.
	Biological:	Several biocontrol agents available that offer moderate success, including insects. Contact state and county weed specialists for current information and availability.
	Chemical:	2,4D and dicamba (spring and summer treatments); aminopyralid (spring or fall treatment), Aminocyclopyrachlor plus chlorsulfuron (spring to budding or fall).

* FACU = occurs in aquatic resources 1–33% of time.

Cirsium vulgare **(bull thistle).** Bull thistle is native to Europe and is now widely established within North America. It is believed that this species was introduced through various incidences of seed contaminations. Although common, it is not considered as problematic as musk or scotch thistle (Table 38).

Table 38. Bull thistle phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	A biennial with a short, fleshy taproot. Stems grow between 2 and 5 feet tall, bearing many spreading branches. Leaves are deep green in color, hairy and prickly on the upper side and cottony underneath. Flowers are 1.5 to 2 inches wide, purple and occur in clusters.
	Seasonal Phenology:	Typically, a biennial, but sometimes exhibits as an annual or monocarpic (flowering only once before dying). During the first year, leaves form a rosette and subsequently followed by a bolting stem and flowering stock the second growing season. Flower during July to September, setting seed during early fall months.
	Habitat:	Pastures, fields, roadsides and disturbed sites. Also found within foothills, dry meadows and riparian areas
	Wetland Indicator Status:	Facultative Upland (FACU)*
	Reproduction and Dispersal:	Reproduces and spreads entirely by seed. Seeds germinate in fall or spring depending on soil moisture. Most seeds either germinate or die within the first year.
	State and/or County Noxious Listing Status:	Not listed by the State or Utah County as noxious.
TREATMENT SUMMARY	Mechanical:	Tillage, hoeing, and hand pulling are effective as long as they are done prior to flowering to prevent seed production. Any mechanical or physical control measure implemented should sever the root below the soil surface, leaving no leaves intact and attached to root.
	Cultural:	Grazing management effective. Sheep, goats, and horses will eat young plants where cattle avoid this species.
	Biological:	Biocontrol are available, although reports of overall effectiveness vary.
	Chemical:	2,4D and dicamba (spring and summer treatments); aminopyralid (fall treatment)

* FACU = occurs in aquatic resources 1–33% of time.

***Cynoglossum officinale* (houndstongue).** Houndstoungue is native to Eurasia and inadvertently introduced in the late 1800s as a seed contaminant in cereal grain. It is toxic to some livestock and not a palatable forage (Table 39).

Table 39. Houndstongue phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Ranging in height from 1 to 4 feet tall, species produces basal leaves 3 inches wide, narrower farther up the stem, while the upper leaves are curled under at the edges and partially clasp the stem. All vegetative parts are covered in soft hairs. Produces maroon flowers in early summer, developing mature fruit, which are teardrop-shaped brown burs covered with barbs (Whitson et al. 1991, Utahweed.org 2016).
	Seasonal Phenology:	Biennial flowering in early summer. Each flower produces four green, bur-like fruits.
	Habitat:	Thrives in disturbed soils along roadsides, trails, pastures, and rangelands
	Wetland Indicator Status:	Facultative Upland (FACU)*
	Reproduction and Dispersal:	Reproduces exclusively via seed. Each plant can produce up to 2,000 seeds which remain for approximately 2 to 3 years
	State and/or County Noxious Listing Status:	Class III Weed (Contain)
TREATMENT SUMMARY	Mechanical:	Digging, pulling or cutting can be effective if root crown is severed. Mechanical control must be done frequently for best results.
	Cultural:	Known for distinctive aroma that deters grazing. In addition, this species has been implicated with the poisoning of horses, possibly due to pyrrolizidine alkaloids therefore grazing is not a viable control measure.
	Biological:	Biocontrol available, specifically two root-mining insects. In addition, native fungal pathogen has been used for control (*Golovinomyces cynoglossus*) and reported to cause some foliar damage. Contact state or county weed specialist for currently available biological controls.
	Chemical:	2,4D and dicamba (spring and summer treatments); aminopyralid (fall treatment)

* FACU = occurs in aquatic resources 1-33% of time.

***Dipsacus fullonum* (Fuller's teasel).** Native to Europe, Fuller's teasel is now widespread and considered a weedy species throughout North America. Mature plants are too prickly and bitter to be eaten by most wildlife and livestock species. In addition, the species is an aggressive competitor and capable of forming dense stands (Table 40).

Table 40. Fuller's teasel phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Stout, tap rooted species growing approximately 6 feet tall. Leaves are dark to bright green with pale to light green vein, with stiff prickles on the lower midrib. Flowers are purple, borne in dense heads, each flower subtended by spine-like bractlets.
	Seasonal Phenology:	Biennial; first growing season produces basal rosette of leaves that usually dies early in the second season during bolt. Flowering occurs from July to August
	Habitat:	Open sites with full sun and adapted to sites that range from wet to dry. Widespread throughout North America occupying areas that are relatively moist along ditches, waterways, roads, and riparian zones. Also found in pastures, abandoned fields and are capable of establishing in healthy perennial grass stands in moist habitats.
	Wetland Indicator Status:	Facultative (FAC)*
	Reproduction and Dispersal:	Reproduces exclusively by seed. Dispersal is primarily near parent plant, seeds remain viable for at least 2 years
	State and/or County Noxious Listing Status:	Not listed as a state or Utah County noxious species
TREATMENT SUMMARY	Mechanical:	Annual control measures usually needed for 4 to 6 years to exhaust persistent seed banks within soils. Small infestations can be controlled by digging or hand-pulling before flowering. Must sever the root below soil surface. Mowing generally ineffective.
	Cultural:	Livestock may graze rosettes, although this species is low in palatability during most stages of growth.
	Biological:	No known biological controls available; although consult with state or county weed specialist for current information.
	Chemical:	2,4D and dicamba (spring and fall treatments)

* FAC = occurs in aquatic resources 34-66% of time.

***Echinochloa crus-galli* (barnyard grass).** Barnyard grass was introduced from Europe and has become widespread throughout the Intermountain West, particularly within irrigated crops, gardens, and along waterways (Table 41).

Table 41. Barnyard grass phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Height varies from 1 to 5 feet, with bases of may stems reddish to dark purple. Leaf blades flat, smooth, and without a ligule or auricles at the junction of sheath and blade.
	Seasonal Phenology:	Annual, warm-season monocot (grass species)
	Habitat:	Problematic in gardens, fields, and other open sites, particularly along waterways. Usually occurs in wetland habitats and thrives when partially submerged.
	Wetland Indicator Status:	Facultative Wet (FACW)*
	Reproduction and Dispersal:	Self-pollinates, production of seeds is variable, ranging from 7,000 to 40,000 per plant (Norris, 1992). Reproduces via seeds that are transported via waterways, insects, birds, animals and anthropogenic methods (machinery, contaminated seed) (OLA and MAFF 2002).
	State and/or County Noxious Listing Status:	Not listed by the state or Utah County as noxious
TREATMENT SUMMARY	Mechanical:	Shallow, repeated tillage during spring can reduce emergence of new individuals. Mowing will likely stimulate new growth from lateral buds, therefore is not recommended (Xuan et al. 2006).
	Cultural:	Potentially toxic to humans, animals and fish, and aquatic invertebrates if ingested.
	Biological:	The fungal pathogen *Exserohilum monoceras* has shown some success in controlling barnyard grass (Catindig et al. 2009). Recommend checking with state and county weed specialists for current information.
	Chemical:	Glyphosate or imazapyr, or monosodium methanearsonate (spring, summer, fall)

*FACW = occurs in aquatic resources 67–99% of time.

***Elymus repens* (quackgrass).** Quackgrass was introduced from the Mediterranean region and Eurasia. In some regions, this species is considered desirable forage, although it is not recommended for planting as it is incredibly invasive (Table 42).

Table 42. Quackgrass phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Erect stems, tufted, and typically 1 to 3 feet tall often growing in large clumps. Herbage dark green and occasionally glaucous (blue-green). Leaves are often constricted near the leaf tips, allowing for identification during vegetative stages. Spikelets are arranged in two long rows, borne flatwise to stem. Florets awnless, or with short straight awns. Believed to exhibit allelopathy.
	Seasonal Phenology:	Aggressive, long-lived perennial
	Habitat:	Well adapted to moist to mesic soils. Common weed of cultivated lands, along waterways and in meadows.
	Wetland Indicator Status:	Facultative (FAC)*
	Reproduction and Dispersal:	Reproduces by both seed and by a shallow mass of long, slender branching rhizomes. These rhizomes can penetrate hard soils and even roots of other plants.
	State and/or County Noxious Listing Status:	Class III Weed (Contain)
TREATMENT SUMMARY	Mechanical:	Extremely difficult to control mechanically; broken rhizomes have the ability to grow and produce new plants.
	Cultural:	Grazing has minimal effect; it is difficult to deplete carbohydrate reserves stored within the extensive rhizome system.
	Biological:	No biological control agents available
	Chemical:	Glyphosate or imazapyr (spring, summer, fall)

* FAC = occurs in aquatic resources 34–66% of time.

Lactuca serriola (prickly lettuce)

Prickly lettuce is a native of Europe that has naturalized throughout most of North America. This species is a competitive invader in disturbed soils of irrigated crops, orchards, and natural areas (Table 43).

Table 43. Prickly lettuce phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Supported by a large taproot with milky juice. Principal stem is 1 to 5 feet tall from the base with leaves alternate, twisting at the base to lie in a vertical plane. Flower heads are yellow, often drying blue and composed of ray flowers only.
	Seasonal Phenology:	Biennial or winter annual
	Habitat:	Adapted to many different habitat types, including wetlands, riparian areas, meadows, vernal pools, salt marshes, flood plains, sand dunes, roadsides, irrigation ditches, ornamental plantings and agronomic crops.
	Wetland Indicator Status:	Facultative Upland (FACU*)
	Reproduction and Dispersal:	Reproduces by seed only
	State and/or County Noxious Listing Status:	Not listed by the state or Utah County as noxious
TREATMENT SUMMARY	Mechanical:	Seedlings easily controlled by hand-pulling or mowing before flower / seed set.
	Cultural:	This species has been documented to be palatable to wildlife and livestock. However, the plants have been implicated in poisoning of cattle.
	Biological:	No biological control agents available.
	Chemical:	2,4D and dicamba or imazapic (spring treatment); 2,4D and dicamba (summer treatment); 2,4D and dicamba or imazapic (fall treatment—rosettes only).

* FACU = occurs in aquatic resources 1-33% of time.

***Lepidium latifolium* (perennial pepperweed).** Perennial pepperweed is native to southern Europe and western Asia. This species is widespread throughout Utah's natural areas. Once it is established, this species is persistent and difficult to control. Perennial pepperweed reduces forage quality in hay and pastures. It extracts salts from deep soil and deposits them on the soil surface, inhibiting the germination and growth of other species that are sensitive to salinity (Table 44).

Table 44. Perennial pepperweed phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Creeping herbaceous species characterized by a spreading lateral rootstock. Leaves smooth, lightly toothed margins borne on a waxy stem up to 6 feet tall. Four-petaled white flowers forming dense clusters at the end of branches. Seed form in round, flattened, two-chambered pods.
	Seasonal Phenology:	Perennial; flowering takes place from summer into early fall.
	Habitat:	Adapted to many different habitat types, including wetlands, riparian areas, meadows, vernal pools, salt marshes, flood plains, sand dunes, roadsides, irrigation ditches, ornamental plantings and agronomic crops.
	Wetland Indicator Status:	Facultative (FAC)*
	Reproduction and Dispersal:	Reproduces primarily vegetatively from roots and root fragments. Species is a prolific seed producer, although seed does not remain viable within soils. Disperse with flooding soil movement, and human and animal activities
	State and/or County Noxious Listing Status:	Class III Weed (Contain)
TREATMENT SUMMARY	Mechanical:	Seedlings easily controlled by hand-pulling, although this technique does not control established plants due to re-sprouting from shoots. Mowing stimulates plant growth
	Cultural:	Sheep, cattle, and goats will graze perennial pepperweed, especially rosettes in early spring. However, once livestock are removed, plants quickly resprout. Seasonal flooding for extended periods during the growing season can significantly reduce populations. Anecdotal information suggests that approximately 6 months of inundation is needed for any measure of control through flooding.
	Biological:	Biological control agents are being evaluated; check with state and
	Chemical:	2,4D and dicamba or imazapic (spring treatment); 2,4D and dicamba (summer treatment); 2,4D and dicamba or imazapic (fall treatment)

*FAC = occurs in aquatic resources 34–66% of time.

***Onopordum acanthium* (scotch thistle).** Scotch thistle is native to Eurasia and, due to its spiny nature, was used in Europe as a fence some centuries ago. Populations can expand rapidly during wet years when seeds break dormancy (Table 45).

Table 45. Scotch thistle phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Large green spiny leaves covered with thick, dense, cottony hairs. Due to the thick pubescence, this species has a grayish, blue-green appearance. Rosettes can grow up to 3 feet in diameter and mature plants are generally 4 to 6 feet tall but have been observed up to 8 feet in height. Stems are winged making it easy to identify. Produces violet to reddish-colored flowers (Whitson et al. 1991).
	Seasonal Phenology:	Biennial, forming rosettes the first year, bolting stalks reach 4 to 6 feet tall. Bloom occurs mid-summer
	Habitat:	Disturbed areas including river and stream corridors, roadsides, rights-of-ways, trails, rangelands, pasture forest clearings, and fallow or abandoned croplands. Often associated with degraded annual plant communities.
	Wetland Indicator Status:	NI*
	Reproduction and Dispersal:	Reproduces by seed only, producing a large number of achenes (small one seeded fruit) that remain viable for 7 to 39 years. Seed dispersal is primarily by wind, but can also occur via water, rodents, livestock or vehicles.
	State and/or County Noxious Listing Status:	Class III Weed (Contain)
TREATMENT SUMMARY	Mechanical:	Small infestations can be removed by manual methods. Digging is effective and the preferred manual removal method. Root should be severed below the soil surface to prevent regrowth.
	Cultural:	Sheep, goats, and horses, but not cattle, have significant effect on thistles in the early stages of an infestation when young thistle rosettes are grazed.
	Biological:	No biological controls are currently available in the U.S. Coordinate with state and county weed specialists for updated information.
	Chemical:	2,4D and dicamba (spring and summer treatments); aminopyralid (fall treatment). Aminocyclopyrachlor plus chlorsulfuron (spring to budding or fall). Glyphosate for large thick stands after bolting.

* NI = indicator status not known in this region.

***Phalaris arundinacea* (reed canarygrass).** Some biotypes of reed canarygrass are known to be native to North America while others originated in Europe. Nonnative populations are far more common in North American wetlands than native populations (Jakubowski et al. 2014). Establishment of this species is promoted by disturbance (e.g., ditching, channelization of streams, overgrazing, flooding, and sedimentation). Reed canarygrass has been commonly observed to colonize wetland habitats, forming dense monocultures by outcompeting and excluding many other native wetland and wetland mesic adapted plant species. It is recommended that this species be noted and closely monitored when encountered within the PRDRP area to deter the establishment of large expanses of monotypic stands (Table 46).

Table 46. Reed canarygrass phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Stout grass species that regenerates from large rootstocks. Stems 2 to 7 feet tall and are covered by a waxy coating.
	Seasonal Phenology:	Cool-season perennial
	Habitat:	Commonly found along waterways and in wetland meadows.
	Wetland Indicator Status:	Facultative Wet (FACW)*
	Reproduction and Dispersal:	Spreads via creeping rhizomes and abundant seeds. Seeds are highly viable and help species disperse over greater distances. Seeds buried below the soil surface have been documented to survive up to approximately 20 years.
	State and/or County Noxious Listing Status:	Not listed by the state or Utah County as noxious.
TREATMENT SUMMARY	Mechanical	Hand pulling is practical for small stands and requires a significant time commitment. Can be effective if repeated 2 to 3 times per year for 5 years. Mowing can be implemented as part of an integrated approach to remove excess biomass and followed up with herbicide once regrowth begins.
	Cultural	Grazing can suppress reed canarygrass, although palatability of this species decreases late season. Fire can suppress growth and increase relative competitiveness of other wetland species.
	Biological	No biocontrol agents are known for reed canarygrass.
	Chemical	Glyphosate or imazapyr

* FACW = occurs in aquatic resources 67-99% of time

Riparian Woodland Invasive Species

***Elaeagnus angustifolia* (Russian olive).** Native to temperate regions in Asia, Russian olive is a species that has escaped cultivation and has infested many areas of the United States. This species can form thickets and be aggressively competitive, even in poor soils (Table 47).

Table 47. Russian olive phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Fast-growing deciduous tree that reaches heights up to 35 feet (Whitson et al. 1991). The leaves are silvery, oblong shaped, approximately 0.5-inch-wide, and slightly powdery on the underside. The young stems are reddish and bear thorns up to 2 inches long. Russian olive produces an abundance of small yellow flowers from May to June. The resulting fruit are 0.4 inch long, yellow in color, and densely covered in silver hairs (Whitson et al. 1991, Utah Weed Control Association 2016).
	Seasonal Phenology:	Deciduous species, flowering in the spring and subsequently producing fruit.
	Habitat:	Riparian areas, floodplains, grasslands, roadsides, fencerows, seasonally moist areas. Tolerant to a wide range of environmental conditions, including clay, sandy and alkaline soils
	Wetland Indicator Status:	Facultative (FAC)*
	Reproduction and Dispersal:	Reproduces from root fragments, and seed. Dispersed by animals, especially birds.
	State and/or County Noxious Listing Status:	Class IV Weed (Prohibited)
TREATMENT SUMMARY	Mechanical:	Young plants can be hand pulled before they mature. Individuals with small diameters of 3.5 inches or less can be pulled out with a weed wrench when soils are moist. Girdling and cutting trees should be done with the integration of chemical controls to prevent resprouting.
	Cultural:	Small seedlings may be susceptible to fire, but does not adequately control larger individuals.
	Biological:	There are no efforts to develop a biological control program for this species.
	Chemical:	2,4D and dicamba, or tryclopyr (summer and fall treatments on larger plants, anytime on seedlings)

* FAC = occurs in aquatic resources 34–66% of time.

***Salix fragilis* (crack willow).** Crack willow is an adaptable species native to southern and central Europe that has been introduced throughout areas historically used for agricultural purposes, along fence lines and along ditches. This species has populated stream and riverbanks throughout Utah, including the Provo River. This species competes for space, water, and nutrients, eventually excluding and displacing native vegetation (Table 48).

Table 48. Crack willow phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Upright and spreading with alternative leaves, elongated with irregularly toothed margins. Older stems are covered in pale, greyish-brown to dark brown colored bark that eventually becomes rough and deeply fissured.
	Seasonal Phenology:	Deciduous, fast growing tree
	Habitat:	Waterways, riparian woodland, lake edges, swamps and wetlands
	Wetland Indicator Status:	Facultative (FAC)*
	Reproduction and Dispersal:	Reproduces by seed and vegetatively via rooting and detached twigs or branches. The light seeds are easily dispersed by wind and water.
	State and/or County Noxious Listing Status:	Not listed by the state or Utah County as noxious.
TREATMENT SUMMARY	Mechanical:	Hand pulling of seedlings less than 1.5 feet tall can be effective for controlling young stands. Cutting is only effective if paired with herbicide treatment, including cut stump or foliar treatment of new growth.
	Cultural:	Neither grazing nor burning is an effective control method for this species.
	Biological:	No biocontrol available. Consult state or county weed specialist for current information.
	Chemical:	Glyphosate

* FAC = occurs in aquatic resources 34–66% of time.

***Tamarix ramosissima* (*chinensis*) (saltcedar or tamarisk).** Tamarisk is an invasive species introduced from Eurasia and is now naturalized throughout the United States. It continues to be widely used as an ornamental but has escaped cultivation and now infests wetland and riparian habitats. Large individuals can transpire up to 200 gallons of water per plant per day, drying up ponds and streams and reducing underground storage of water. In addition, its roots extract salts from deep soil layers, excreting the mineral from leaves. Deposited salts on the soil surface with leaf litter increases salinity of the upper soil profile and inhibits growth, survival, and recruitment of desirable native plant species. Although some species seek cover within Tamarisk thickets, most wildlife does not consume tamarisk foliage, fruits, or seeds, which severely limits this species' value to wildlife and diversity (Table 49).

Table 49. Saltcedar phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Shrub or small tree, 5 to 20 feet tall. Leaves are small and scale-like on multi-branched slender stems. Flowers are pink to white, 5-petalled.
	Seasonal Phenology:	Deciduous or evergreen
	Habitat:	River, lake and pond margins, washes, roadsides, ditches, flats, sand dunes, desert springs
	Wetland Indicator Status:	Facultative (FAC)*
	Reproduction and Dispersal:	Reproduces vegetatively by producing roots from buried or submerged stems or stem fragments from parent plants. Flowers produce copious amounts of seeds, estimated at more than 600,000 to 100,000,000 on large healthy individuals. Seeds are easily dispersed via wind and water.
	State and/or County Noxious Listing Status:	Class III Weed (Contain)
TREATMENT SUMMARY	Mechanical:	Mechanical control methods include mowing, burning chopping chaining, and disking. These methods usually only suppress *Tamarix* temporarily. Hand pulling can be effective in controlling young infestations. Mowing can be effective when integrated with chemical control.
	Cultural:	No effective cultural controls well documented without combination of chemical controls
	Biological:	The release of the saltcedar leaf beetle (*Diorhabda carinulata*) has made significant impacts on many *Tamarix* populations.
	Chemical:	2,4D plus dicamba or triclopyr

*FAC = occurs in aquatic resources 34–66% of time.

***Ulmus pumila* (Siberian elm).** Siberian elm is an introduced, cultivated shade tree native to Europe. This species has naturalized throughout Utah and the Intermountain West and has a tendency to exhibit invasive characteristics (Table 50).

Table 50. Siberian elm phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	Rapidly growing tree reaching 80 feet tall or more. Deeply fissured bark, lanceolate to narrowly elliptic serrate leaves. Prolific samaras (round seeds) glabrous, obviate. Vigorous, brittle tree often infected by an organism that produces a slime or flux on the trunk.
	Seasonal Phenology:	Deciduous tree
	Habitat:	Escaped cultivation and established along stream courses, around lakes, and at lower elevations.
	Wetland Indicator Status:	NI*
	Reproduction and Dispersal:	Prolific seeds germinate readily. Dispersed primarily by wind.
	State and/or County Noxious Listing Status:	Not listed by the State or Utah County as noxious
TREATMENT SUMMARY	Mechanical:	Hand removal, weed wrench and cutting
	Cultural:	Grazing young seedlings can be an effective form of control.
	Biological:	No biocontrol currently available
	Chemical:	2,4D plus dicamba or triclopyr

*NI = indicator status not known in this region.

***Xanthium strumarium* (cocklebur):** Cocklebur is native to North America and commonly observed throughout the west. This species can be a nuisance in cultivated fields, abandoned lands, neglected pastures, road ditches, topographic depressions, and waste areas. Despite being native, this species produces large burs covered with hook-tipped prickles which are irritating to both humans and animals. (see Table 51).

Table 51. Cocklebur phenology and treatment summary.

SPECIES PHENOLOGY	Growth Habit:	
	Seasonal Phenology:	Annual
	Habitat:	Woodlands, pastures, fields, forest margins, agricultural fields, and urban waste areas. Also common along riparian areas and mesic to emergent wetland habitats. Tolerant of many environmental factors, including various soils types and hydrologic cycles (e.g. wetland habitats to ephemeral washes and upland mesic habitats).
	Wetland Indicator Status:	NI*
	Reproduction and Dispersal:	Reproduce by seed
	State and/or County Noxious Listing Status:	Not listed by the State or Utah County as noxious
TREATMENT SUMMARY	Mechanical:	Hand pulling is effective on small populations. Pulling is most effective before bur development and seed dispersal. Individuals handling cocklebur should wear protective clothing as this species can cause dermatitis in sensitive individuals.
	Cultural:	Neither grazing nor burning is considered effective as a control options. Seeds and foliage contain a glycoside that can be fatally toxic to livestock.
	Biological:	No biocontrol currently available.
	Chemical:	2,4D plus dicamba or triclopyr in spring or summer.

*FAC = occurs in aquatic resources 34–66% of time.

4.3.1.4 Upland Invasive Species Descriptions

Convolvulus arvense **(field bindweed).** Found in all contiguous United States, field bindweed is a common and often problematic species that grows well moist, well drained, fertile soils. However, it is also tolerant to poor, dry, gravelly soils. This species is native to Europe (Table 52).

Table 52. Field bindweed phenology and treatment summary.

Species Phenology	Growth Habit:	Prostrate, low growing, vine-like stems and an extensive deep root system.
	Seasonal Phenology:	Long-lived herbaceous perennial
	Habitat:	Adaptable to a variety of habitats, often found in cultivated fields and waste places.
	Wetland Indicator Status:	NI*
	Reproduction and Dispersal:	Reproduces by both seed and rootstock. Seeds have been documented to remain viable in the soil for up to 50 years.
	State and/or County Noxious Listing Status:	Class III Weed (Contain)
Treatment Summary	Mechanical:	Pulling can be effective on seedlings or young plants, although it is not effective when plant has developed a deep, extensive root system. Solarizataion can be effective, although black plastic must be left on the site for 3 to 5 years to eradicate this species.
	Cultural:	No documented cultural control
	Biological:	No biocontrol available
	Chemical:	2,4D plus dicamba or triclopyr

* NI = indicator status not known in this region.

***Tribulus terrestris* (puncturevine, goathead).** Goathead was introduced by way of southern Europe, Eurasia, and Africa and is widely distributed throughout North America. It is found along roadsides, trails, pastures, and disturbed areas. This species produces a spiny fruit that often punctures bicycle tires, can penetrate skin, and causes injury to grazing animals if ingested (Table 53).

Table 53. Puncturevine phenology and treatment summary.

Species Phenology	Growth Habit:	Low-growing with leaves baring four to eight pairs of oval-shaped leaflets. Stems and leaves are covered with tiny hairs. Yellow flowers are born on the axial leaves. Plant supported by a deep taproot.
	Seasonal Phenology:	Annual
	Habitat:	Dry, disturbed sites. Often in gravelly embankments associated with roads and trails
	Wetland Indicator Status:	NI*
	Reproduction and Dispersal:	Reproduces by seed, spreads over a wide area by spiny fruits sticking to animals, foot traffic, vehicle and bicycle tires. Seeds viable for 4 to 5 years making eradication difficult.
	State and/or County Noxious Listing Status:	Class III Weed (Contain)
Treatment Summary	Mechanical:	Hand removal feasible before spiny fruit has developed
	Cultural:	Grazing and burning are not recommended for control. Planting competitive vegetation and or the application of mulch has been shown to suppress infestations.
	Biological:	Insect biocontrol available. Microlarinus Lareynii weevil have reduced plants. Consult state or county weed specialist for current information.
	Chemical:	2,4D plus dicamba or triclopyr

* NI = indicator status not known in this region.

4.3.2 Chemical Treatment Approach in the Provo River Delta Restoration Project

Table 54 summarizes chemical treatment options, ideal treatment windows, and seasonal phenology of those species. Typically, to best control and eradicate noxious and invasive species, seasonal treatment susceptibility was used to recommend treatment timing. BIO-WEST recommends spring, summer, and fall treatments to cover the best treatment window(s) for each species. The majority of the noxious plants identified in the project area are most susceptible to chemical treatment in spring during the active growth cycle, prior to flowering and seed set. However, a few of the target species are most susceptible in the summer or fall. Preferred seasonal windows are ranked and noted in Table 44. The treatment methods as described in the Utah Reclamation Mitigation and Conservation Commission Integrated Pest Management Plan (IVMP) (Commission 2012) are restated below.

4.3.3 Concurrent Weed Management—Construction and Implementation

During construction, it is anticipated that populations of disturbance-adapted noxious and invasive plant species will colonize newly disturbed soils. To help mitigate potential for new infestations of these species, regular monitoring will occur in order to detect problematic species early and apply appropriate control measures. Regular monitoring will occur seasonally, during early spring, mid-summer, and early fall to foster a system of early detection of noxious and invasive species and subsequent treatment.

Table 54. Preferred treatment seasonal rankings and recommended treatment summary for problematic plant species observed within the PRDRP.

BOTANICAL NAME	COMMON NAME	TREATMENT SEASON RANKING (CHEMICAL) [a]			RECOMMENDED TREATMENT		
		SPRING	SUMMER	FALL	SPRING	SUMMER	FALL
Aegilops cylindrical	Jointed goatgrass	1	-	-	glyphosate	-	-
Ambrosia artemisifolia	Ragweed	1	2	-	2,4D and dicamba	2,4D and dicamba	-
Arctium Minus	Burdock	1	3	2	2,4D and dicamba [b]	2,4D and dicamba	aminopyralid [b]
Bromus tectorum	Cheatgrass	1	-	2	glyphosate, imazapic	-	glyphosate, imazapic
Cardaria Draba	Hoary cress	1	-	2	2,4D and dicamba	-	2,4D and dicamba
Carduus nutans	Musk thistle	1	3	2	2,4D and dicamba, Aminocyclopyrachlor and chlorosulfuron	2,4D and dicamba, Aminocyclopyrachlor and chlorosulfuron	aminopyralid, Aminocyclopyrachlor and chlorosulfuron
Chenopodium album	Lambsquarter	1	2	-	2,4D and dicamba	2,4D and dicamba	-
Cirsium vulgare	Bull thistle	1	3	2	2,4D and dicamba, Aminocyclopyrachlor and chlorosulfuron	2,4D and dicamba, Aminocyclopyrachlor and chlorosulfuron	aminopyralid, Aminocyclopyrachlor and chlorosulfuron
Cirsium arvense	Canada thistle	2	3	1	2,4D and dicamba, Aminocyclopyrachlor and chlorosulfuron	2,4D and dicamba	aminopyralid, Aminocyclopyrachlor and chlorosulfuron
Convolvulus arvensis	Field bindweed	1	2	1	2,4D and dicamba	2,4D and dicamba	2,4D and dicamba
Cynoglossum officinale	Houndstongue	1	2	3	2,4D and dicamba	2,4D and dicamba	aminopyralid
Didymospheni a geminata	Rock snot	-	-	-	-	-	-
Dipsacus fullonum	Fuller's teasel	1	-	1	2,4D and dicamba	-	2,4D and dicamba
Echinochloa crus-galli	Barnyard grass	1	1	1	glyphosate, imazapyr, MSM	glyphosate, imazapyr, MSM	glyphosate, imazapyr, MSM
Elaeagnus angustifolia	Russian olive	2	1	1	2,4D and dicamba, tryiclopyr	2,4D and dicamba, tryiclopyr	2,4D and dicamba, tryiclopyr
Elymus repens	Quackgrass	1	1	1	glyphosate, imazapyr	glyphosate, imazapyr	glyphosate, imazapyr
Euonymus	Burningbush	1	2	-	2,4D and	2,4D and	-

BOTANICAL NAME	COMMON NAME	TREATMENT SEASON RANKING (CHEMICAL) [a]			RECOMMENDED TREATMENT		
		SPRING	SUMMER	FALL	SPRING	SUMMER	FALL
alatus	(formerly, kochia)				dicamba	dicamba	
Lactuca serriola	Prickly lettuce	1	2	3	2,4D and dicamba	2,4D and dicamba	2,4D and dicamba
Lepidium latifolium	Perennial pepperweed	1	1	1	2,4D and dicamba or imazapic	2,4D and dicamba	2,4D and dicamba or imazapic
Lythrum salicaria	Purple loosestrife	-	1	1	-	glyphosate, imazapyr	glyphosate, imazapyr
Myriophyllum spicatum	Eurasian watermilifoil	1	1	-	2,4D or endothall	-	-
Nasturtium officinale	Water-cress	1	1	2	2, 4D or glyphosate	2, 4D or glyphosate	2, 4D or glyphosate
Onopordum acanthium	Scotch thistle	1	3	2	2,4D and dicamba	2,4D and dicamba	aminopyralid
Phalaris arundinacea	Reed canarygrass	-	2	1	-	glyphosate, imazapyr	glyphosate, imazapyr
Phragmites australis	Common reed or phragmites	-	1	1	-	glyphosate, imazapyr	glyphosate, imazapyr
Potamogeton crispus	Curly leafed pondweed	1	1	-	Endothall	-	-
Salix fragilis	Crack willow	2	1	1	glyphosate	glyphosate	glyphosate
Tamarix ramosissima (chinensis)	Saltcedar (five-stamen tamarisk)	2	1	1	2,4D and dicamba, tryiclopyr	2,4D and dicamba, tryiclopyr	2,4D and dicamba, tryiclopyr
Tribulus terrestris	Puncturevine	-	1	-	none	2,4D and dicamba	None
Ulmus pumila	Siberian elm	1	1	1	2,4D and dicamba, tryiclopyr	2,4D and dicamba, tryiclopyr	2,4D and dicamba, tryiclopyr
Xanthium strumarium	Cockleburr	1	2	-	2,4D and dicamba	2,4D and dicamba	-

[a] 1 is best, 2 is second best, 3 is still somewhat effective.
[b] Use Weedar 64™ in wet areas—does not contain dicamba.

BIO-WEST has the following recommendations related to the currently planned construction schedule anticipating that construction will start in 2020. Access for typical weed treatment equipment (ATVs) will start to become limited by channel and pond construction during year 1 and year 2. BIO-WEST recommends up to 4 treatments per growing season may be needed to reduce the existing weed population and keep new populations from establishing on the disturbed soils.

2019—Year 0

Phragmites within the project area should be chemically treated and mowed (if accessible for mowing).

Phragmites on the adjacent properties should also be treated. Every possible effort should be made to work with government agencies treat the phragmites along the shore of Utah Lake extending from the Prove River to the south and at least ½ mile to the north of the project area. This area is a huge potential source for airborne seeds that can readily take root on wet disturbed soils. The area should be sprayed in the summer (possibly using a helicopter or spray drone) followed by mowing 4-6 weeks post treatment using both machinery and hand-held equipment. A second treatment should be done in the fall of any re-sprouting or missed plants.

Every possible effort should also be made to work with adjacent landowners and government agencies to control the phragmites on the adjacent and upstream properties, particularly on the properties west of Lakeshore Drive near 880 North, as there are several acres of monoculture phragmites there also with a stream that conveys water onto the project area.

All Russian olive trees in the restoration project area should either be cut down or treated using basal bark or foliar treatment (for trees less than 3 inches in diameter). Some re-sprouting of suckers will occur, and they can be treated in year 1 while access is still good. Removal of Russian olive trees on the adjacent property on the shoreline of Utah Lake will also facilitate more efficient phragmites treatment and mowing.

The other weeds on Table 44 should be treated using a combination of cultural, chemical and biological methods as appropriate. Grazing and harvesting of hay can continue on certain areas.

Volunteers may be effective in controlling cockleburs by pulling.

2020—Year 1

Treatment for all weeds as recommended in Year 0 should continue on both the restoration project area and adjacent lands. Any re-sprouting phragmites or Russian olive trees should be treated. Continued attention on phragmites will be needed on the adjacent properties as it takes multiple years of treatment to achieve eradication. Additional mowing will likely be required. Any mature Russian olive trees in the restoration project area not cut down in Year 0 should be cut down this year.

In addition, the spoil areas, stock piles, roads and other disturbed areas should be monitored and treated as necessary. For some of these areas it may be best to treat with a glyphosate product to prevent any revegetation other than what is reseeded as part of the restoration effort. Glyphosate degrades quickly and treated areas can be planted within 7 days of treatment. The edges of the excavated ponds and channels should be closely monitored for phragmites and reed canary grass. Ongoing monitoring will likely result in additional treatment suggestions or modifications.

Volunteers may be effective in controlling cocklebururs by pulling and Russian olive, salt cedar and Siberian elms seedlings by pulling or using a weed wrench.

2021—Year 2

Treatment would essentially be the same as Year 1. The level of effort for phragmites within and adjacent to the restoration project area should be less this year if previous years treatment efforts have been effective.

Volunteer efforts should continue.

2022—Year 3

Treatment would be similar to year 2. Some areas may become difficult to access with traditional ATVs and tracked or amphibious equipment may be needed. Care would be needed around areas that have been replanted in the previous years. Treatment may be discontinued for upland species in the delta zone areas that are to be inundated except for phragmites, reed canarygrass, Eurasian water millifoil, curly leaf pond weed, and rock snot. Close coordination between the restoration crews and the weed treatment crew would be required related to the schedules for reseeding and plantings.

Volunteer efforts should continue.

After the project is complete and the Prove River is released into the restoration project area, the treatment plan will need to be revised to reflect the new plant habitats and conditions present in the area. Any chemical treatments will need to be evaluated related to the anticipated presence of June suckers in various life stages.

4.3.4 Herbicide Treatment within Ute Ladies'-Tresses Occurrence Areas

In formal consultation with the U.S. Fish and Wildlife Service during the completion of the EIS, the following herbicide treatment stipulations have been made for Ute ladies' –tresses occurrences within the project area:

1. Spot herbicide treatment only within Ute Ladies'- tresses occurrence areas or within 50 feet of Ute Ladies'- tresses occurrences.

2. Use short residual herbicides only within Ute Ladies'- tresses occurrences.

3. Do not use glyphosate or long residual herbicides (Tordon, Banvel, or DuPont's new Perspective).

4. Apply herbicides in the spring or fall months and not within the Ute Ladies'- tresses flowering or fruiting time period (July 1 – October 15).

5. Avoid or minimize the use of heavy machinery within Ute Ladies'- tresses occurrences. Use existing roads to the extent possible.

Incorporate the following herbicide treatment recommendations for specific weeds in Ute Ladies'-tresses occurrence areas:

- Hoary Cress (*Cardaria draba)* – 2,4-D
- Squarrose knapweed, *Centaurea virgate* Milestone as a fall treatment on rosettes or in very early spring.
- Russian knapweed, *Centaurea repens* Milestone in late fall
- Scotch thistle, *Onopordum acanthium* Milestone to rosettes in the fall
- Musk thistle, *Carduus nutans* Milestone to rosettes in the fall
- Leafy spurge, *Euphorbia esula* Paramount in the fall
- Perennial pepperweed, *Lepidium latifolium* 2,4-D. Don't use Telar or similar.
- Spotted knapweed, *Centaurea maculosa* Milestone would be the best as a fall treatment on rosettes or in very early spring.
- Purple loosestrife, *Lythrum salicaria* Milestone
- Dalmatian toadflax, *Linaria genistifolia* No good option that will not harm orchids. Hand-pull only.
- Poison hemlock, *Conium maculatum* 2,4-D only. Do not use the ALS inhibitors such as Ally, Escort, Telar.
- Reed Canarygrass (Phalaris arundinacea), Grass specific herbicides such as sethoxydim or fluazifop.
- Also see commitments for Russian olive treatment noted below.

(Note: Not all of the above listed species are known to occur within the restoration project area)

Russian Olive—Measures to protect Ute Ladies'- tresses.
To protect Ute Ladies-tresses occurrences in the restoration project area, the following commitments are made for treating Russian olive:

1. Russian olive tree removal activities will take place between October 15 and April 1. Removal would be followed by herbicide treatment to freshly cut stumps (item 4 below). Treatment during this period of time helps to ensure that the stumps are actively drawing nutrients to the roots.

2. No wood chips will be piled within or adjacent to Ute Ladies'- tress occurrence areas; maintain a 50-foot buffer between wood chip application areas and occurrence areas.

3. If Russian olive seedlings within Ute Ladies'- tresses occurrence areas are treated, they will be hand-pulled.

4. In Ute Ladies'-tress occurrence areas, herbicide will be applied only to freshly cut stumps; a bucket (with the bottom removed) or cone will be placed around stumps to ensure herbicide drift is negligible.

5. Trees will either be removed from the site or be chipped with the appropriate buffer.

Amphibians
BIO-WEST recommends using Polaris™ (imazapyr) with Agri-Dex™, a crop oil concentrate, to control phragmites during summer and fall treatments. Polaris and Agri-DexTM has been shown to be effective with very low risk to juvenile spotted frogs (Yahnke et al. 2013). Plants can be sprayed any time after reaching 36 inches in height.

4.3.5 Agency, Municipality and Community Involvement

As noted within the PRDRP Environmental Impact Statement, PRDRP Vegetation Management Plan (Commission 2015), there are currently multiple agencies either actively managing weeds around Utah Lake, or take an active interest. Coordination and involvement with a broader agency, municipal and public base will serve an important role while striving to meet project goals. A description of respective previously understood approaches of these managing agencies, municipalities and other potentially interested parties (e.g., broader community and adjacent landowners) are described below.

- Utah County
- Utah County Public Works
- Utah Lake Commission
- Utah Division of Forestry, Fire, and State Lands
- Provo City
- Adjacent Landowners

It is anticipated that an important component of project success is the engagement and education of the surrounding communities. In an effort to involve the broader community, and continue engagement of people, organizations, municipalities and adjacent landowners, various forms of communication and outreach should be implemented throughout the various phases of the project. Recommended efforts include the following:

- Newsletters should be sent to adjacent landowners describing how to identify and control problematic plant species that have been documented within the PRDRP and on adjacent landowners. Details should also include how a species detracts culturally and ecologically from a landscape. Newsletters should be timed to maximize ideal seasonal treatment windows to encourage appropriate use of cultural, mechanical, biological, and chemical control methodologies.

- Signage should be strategically placed to describe and show noxious and problematic invasive species in situ. In addition, signs should be included to educate visitors of vegetation communities that are actively being restored and important functions that they provide.

- Opportunities for surrounding communities, local organizations, municipalities and agencies to participate in reclamation efforts should be developed and overseen. These could include regular weed pulls, successional plantings and seeding.

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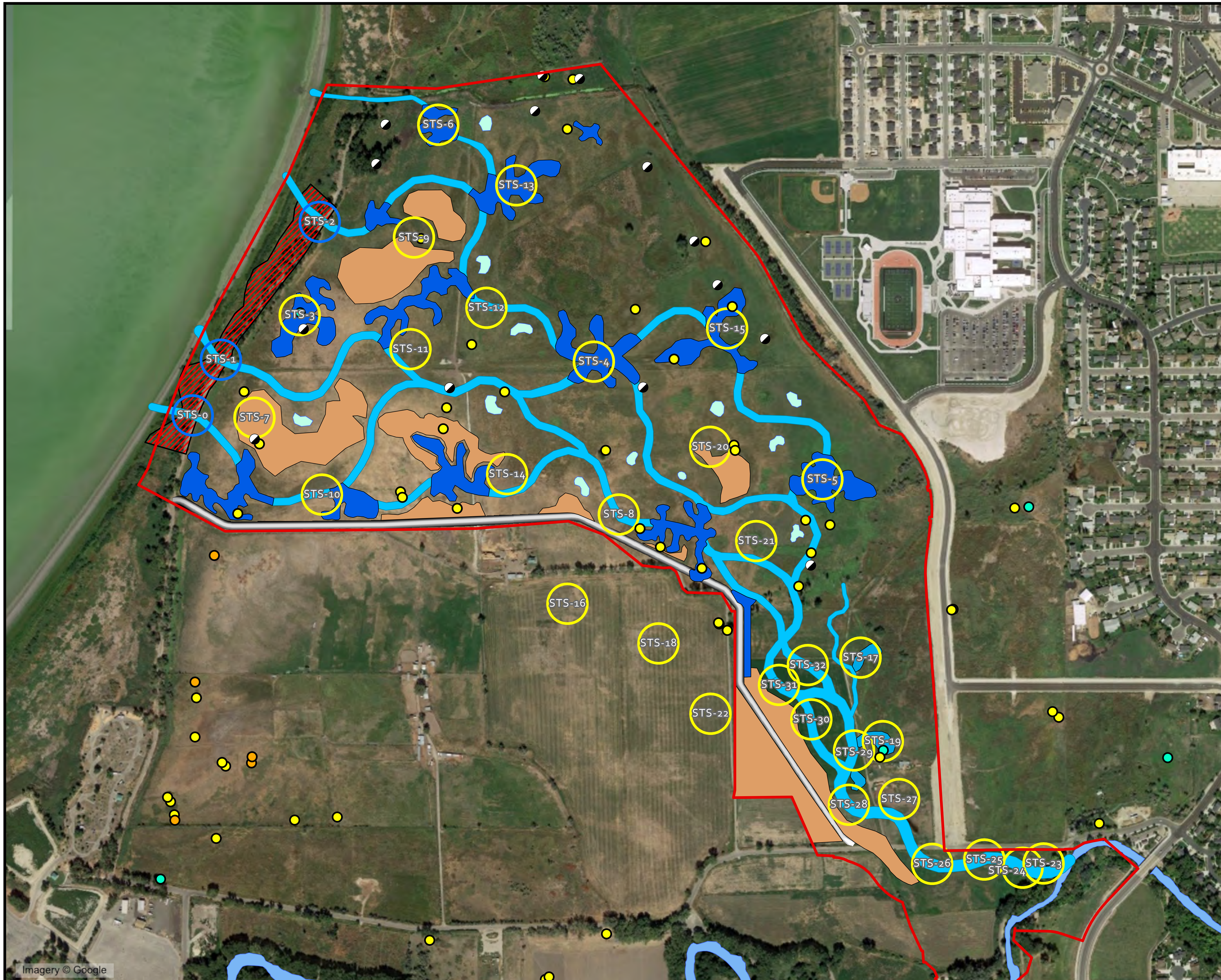
ATTACHMENT 1
EXISTING CONDITIONS MAPS



Provo River Delta Restoration Project

Soil Types & Design Features

FIGURE XX
Sheet 1
Depth 0-1 foot

Project Area
River Ponds
Provo River Channels
Skipper Bay Cut Polygon

Soil Type

- PT- Peat
- ML- Mixed Clay/Sand Loam
- SM- Sand Silt Mixture
- SW- Well Graded Sands
- GW- Well Graded Gravels

Soil Type

0 to 0.5 feet type

- Peat
- CH; CL
- ML
- SM; SW; SP
- GW

Design Features

- Delta Depressions
- Possible Fill Areas
- Delta Ponds

Map shows a 120 foot buffer around sample points

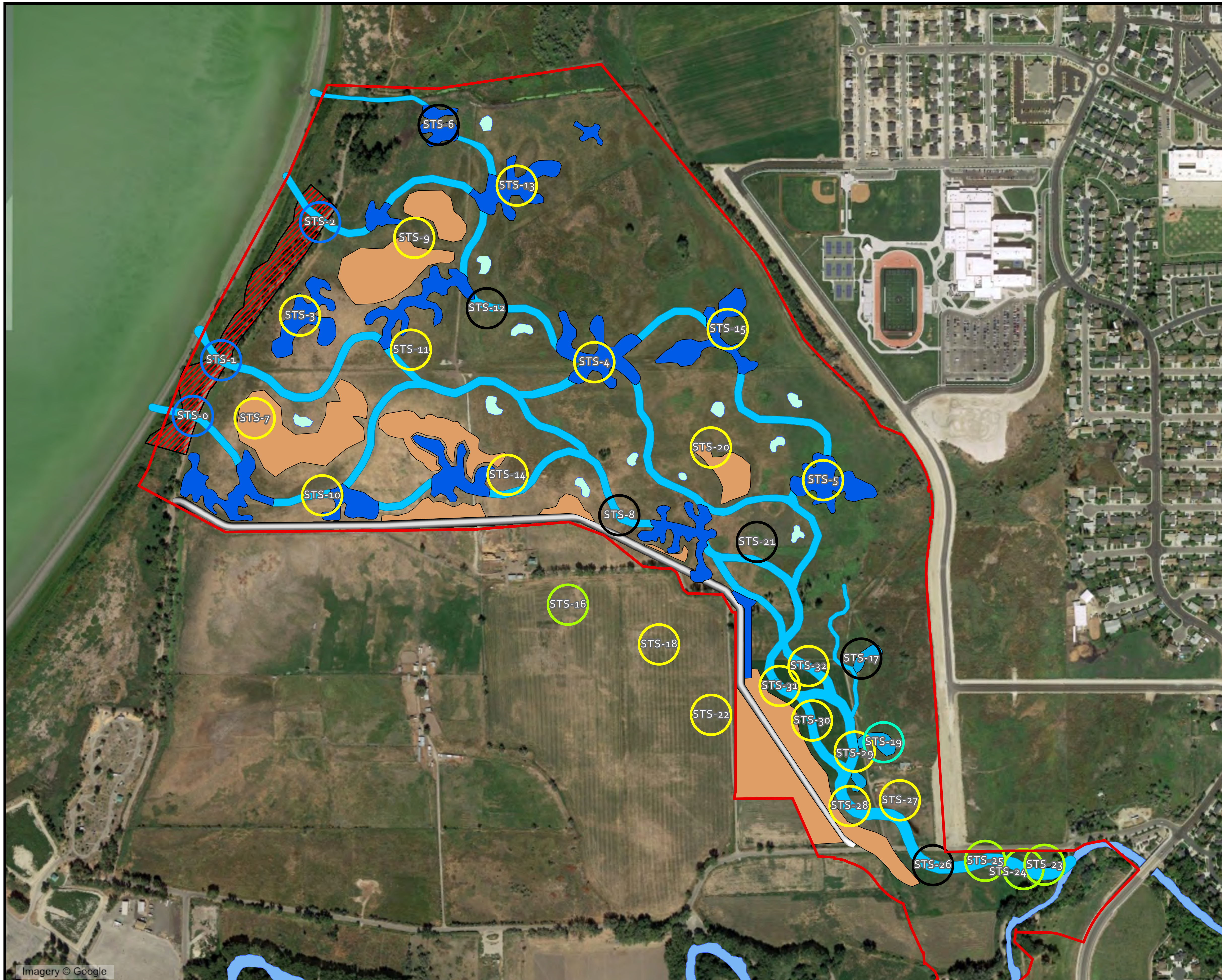
Map by BIO-WEST, Inc.

Miles: 0, 0.1, 0.2

Feet: 0, 500, 1,000, 1,500

N

Map Scale 1:7,000
Projection: NAD 83 UTM Zone 12 North
Elevation Datum: NGVD 1929
Imagery Date: September 10, 2018 (AGRC/Google)
Map Updated 6/5/2019
Map Authors: G Busch/K Wells, BIO-WEST, Inc.



Provo River Delta Restoration Project

Soil Types & Design Features

FIGURE XX

Sheet 2

Depth 1 - 4 Feet

Project Area

Soil Type

- PT- Peat
- ML- Mixed Clay/Sand Loam
- SM- Sand Silt Mixture
- SW- Well Graded Sands
- GW- Well Graded Gravels

Design Features

- Delta Depressions
- Possible Fill Areas
- Delta Ponds
- River Ponds
- Provo River Channels
- Skipper Bay Cut Polygon

Map shows a 120 foot buffer around sample points

Map by BIO-WEST, Inc.

0 0.1 0.2 Miles

0 500 1,000 1,500 Feet

N

Map Scale 1:7,000
Projection: NAD 83 UTM Zone 12 North
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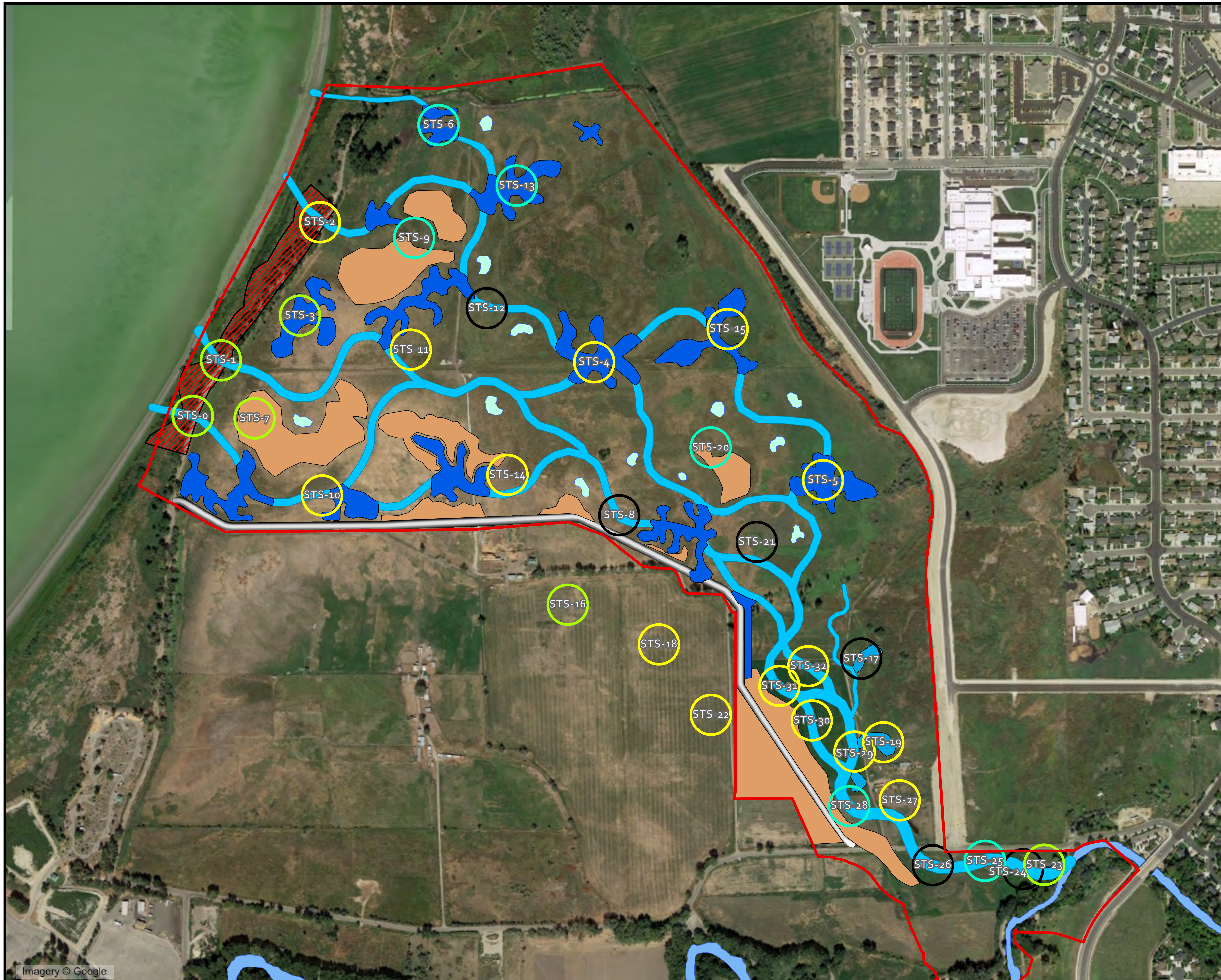

Provo River Delta Restoration Project

Soil Types & Design Features

FIGURE XX
Sheet 3
Depth 4 - 7 Feet

Project Area

Soil Type
- PT- Peat
- ML- Mixed Clay/Sand Loam
- SM- Sand Silt Mixture
- SW- Well Graded Sands
- GW- Well Graded Gravels

Design Features
- Delta Depressions
- Possible Fill Areas
- Delta Ponds
- River Ponds
- Provo River Channels
- Skipper Bay Cut Polygon

Map shows a 120 foot buffer around sample points

Map by BIO-WEST, Inc.

Miles: 0, 0.1, 0.2
Feet: 0, 500, 1,000, 1,500
N

Map Scale 1:7,000
Projection: NAD 83 UTM Zone 12 North
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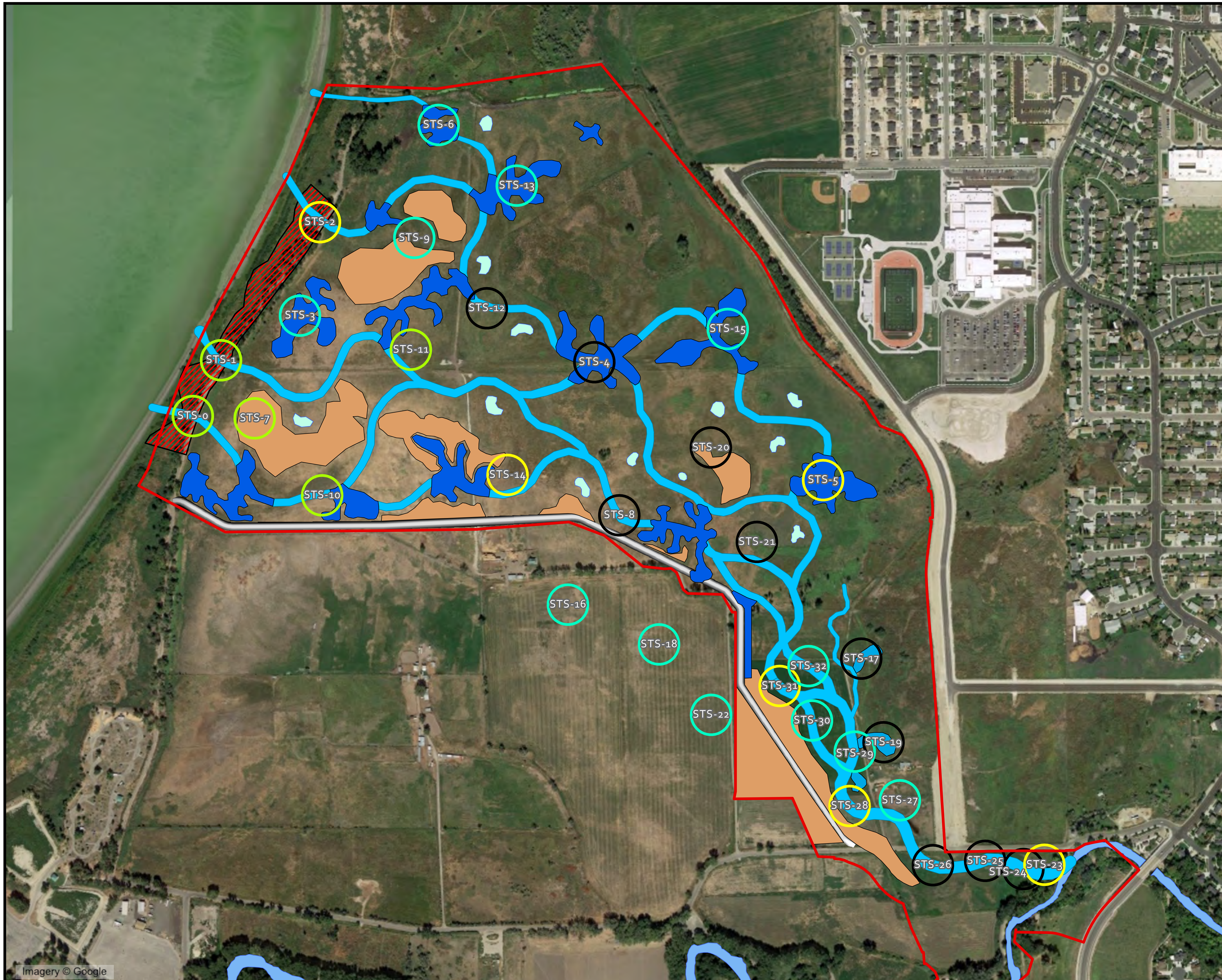
Map Updated 6/5/2019
Map Authors: G Busch/K Wells, BIO-WEST, Inc.



Provo River Delta Restoration Project

Soil Types & Design Features

FIGURE XX
Sheet 4
Depth 7 - 10 Feet

Project Area

Soil Type

- PT- Peat
- ML- Mixed Clay/Sand Loam
- SM- Sand Silt Mixture
- SW- Well Graded Sands
- GW- Well Graded Gravels

Design Features

- Delta Depressions
- Possible Fill Areas
- Delta Ponds
- River Ponds
- Provo River Channels
- Skipper Bay Cut Polygon

Map shows a 120 foot buffer around sample points

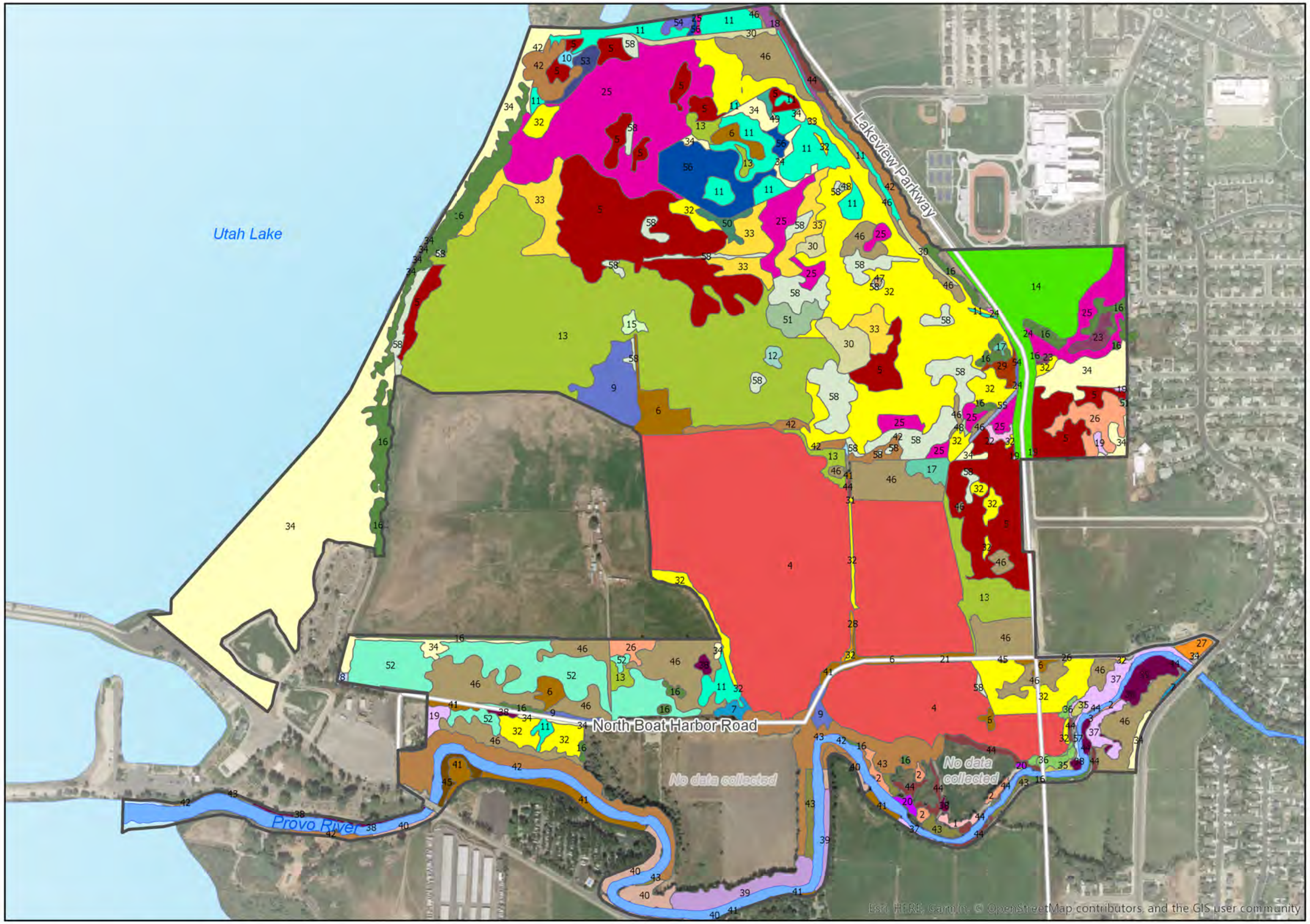
Map by BIO-WEST, Inc.

0 0.1 0.2 Miles

0 500 1,000 1,500 Feet

N

Map Scale 1:7,000
Projection: NAD 83 UTM Zone 12 North
Elevation Datum: NGVD 1929
Imagery Date: September 10, 2018 (AGRC/Google)
Map Updated 6/5/2019
Map Authors: G Busch/K Wells, BIO-WEST, Inc.



Legend

- Study Area Boundary
- Roads
- Provo River

Association

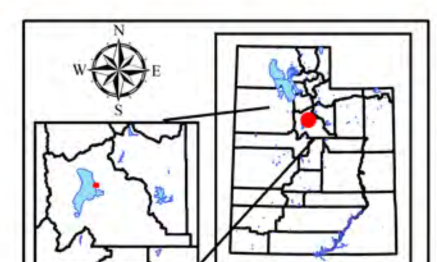
1. Acer negundo Floodplain Forest
2. Acer negundo Ruderal Floodplain Forest
3. Acer negundo Ruderal Riparian Woodland
4. Agriculture - Cultivated Herbaceous Vegetation
5. Ambrosia artemisiifolia Ruderal Herbacous Vegetation
6. Bassia Ruderal Herbacesous Vegetation
7. Bromus tectorum Ruderal Grassland
8. Cardaria draba Ruderal Herbaceous Vegetation
9. Chenopodium album Ruderal Herbaceous Vegetation
10. Cirsium arvense - Ruderal Herbaceous Vegetation
11. Cirsium arvense - Ruderal Herbacesous Vegetation
12. Cleome serrulata Herbaceous Vegetation
13. Distichlis spicata Alkaline Wet Meadow
14. Disturbed
15. Echinochloa crus-gali Ruderal Wet Meadow
16. Elaeagnus angustifolia Ruderal Riparian Woodland
17. Eleocharis palustris - Juncus arcticus ssp. littoralis Marsh
18. Elymus Mesic Meadow
19. Elymus repens Ruderal Grassland
20. Fraxinus pennsylvanica Riparian Woodland
21. Glycyrrhiza lepidota Ruderal Wet Meadow
22. Helianthus nuttallii - Euthamia occidentalis Wet Meadow
23. Helianthus nuttallii - Solidago canadensis Wet Meadow
24. Iva xanthifolia Herbaceous Vegetation
25. Juncus arcticus ssp. littoralis Wet Meadow
26. Lactuca serriola Ruderal Wet Meadow Alliance
27. Landscaped / City Development
28. Nasturtium officinale Seepage Meadow
29. Onopordum acanthium Ruderal Forb Alliance
30. Onopordum acanthium Ruderal Forb Alliance
31. Phalaris arundinacea - Apocynum cannabinum Wet Shrubland
32. Phalaris arundinacea Western Marsh
33. Phleum pratense Ruderal Meadow
34. Phragmites australis ssp. australis Western Ruderal Wet Meadow
35. Populus alba Cultivated Riparian Forest
36. Populus alba Cultivated Riparian Forest
37. Populus deltoides / Acer negundo Floodplain Forest
38. Populus deltoides / Salix exigua Riparian Woodland
39. Populus deltoides / Salix fragilis Floodplain Forest
40. Populus deltoides / Salix fragilis Ripaian Woodland
41. Populus deltoides / Salix fragilis Riparian Woodland
42. Populus deltoides Ruderal Floodplain Forest
43. Salix amygdaloides / Salix exigua Riparian Woodland
44. Salix exigua Riparian Shrubland
45. Salix fragilis Riparian Shrubland
46. Schedonorus (arundinaceus, pratensis), Ruderal Grassland
47. Schenoplectus acutus Western Marsh
48. Schoenoplectus acutus Western Marsh
49. Schoenoplectus american Western Marsh
50. Schoenoplectus americanus Western Marsh
51. Schoenoplectus pungens - Distichlis spicata Marsh
52. Thinopyrum intermedium Ruderal Grassland
53. Trifolium fragiferum Herbaceous Vegetation
54. Typha (latifolia, angustifolia) Western Marsh
55. Typha latifolia - Schoenoplectus acutus Western Marsh
56. Typha latifolia - Schoenoplectus americanus Marsh
57. Ulmus americana / Populus deltoides Ruderal Floodplain Forest
58. Xanthium strumarium Ruderal Wet Meadow

PROVO RIVER DELTA RESTORATION PROJECT

Inventoried Vegetation Communities by Association 2018

Associations adapted from NatureServe, available at www.explorer.natureserve.org

Prepared By:



Spatial Reference
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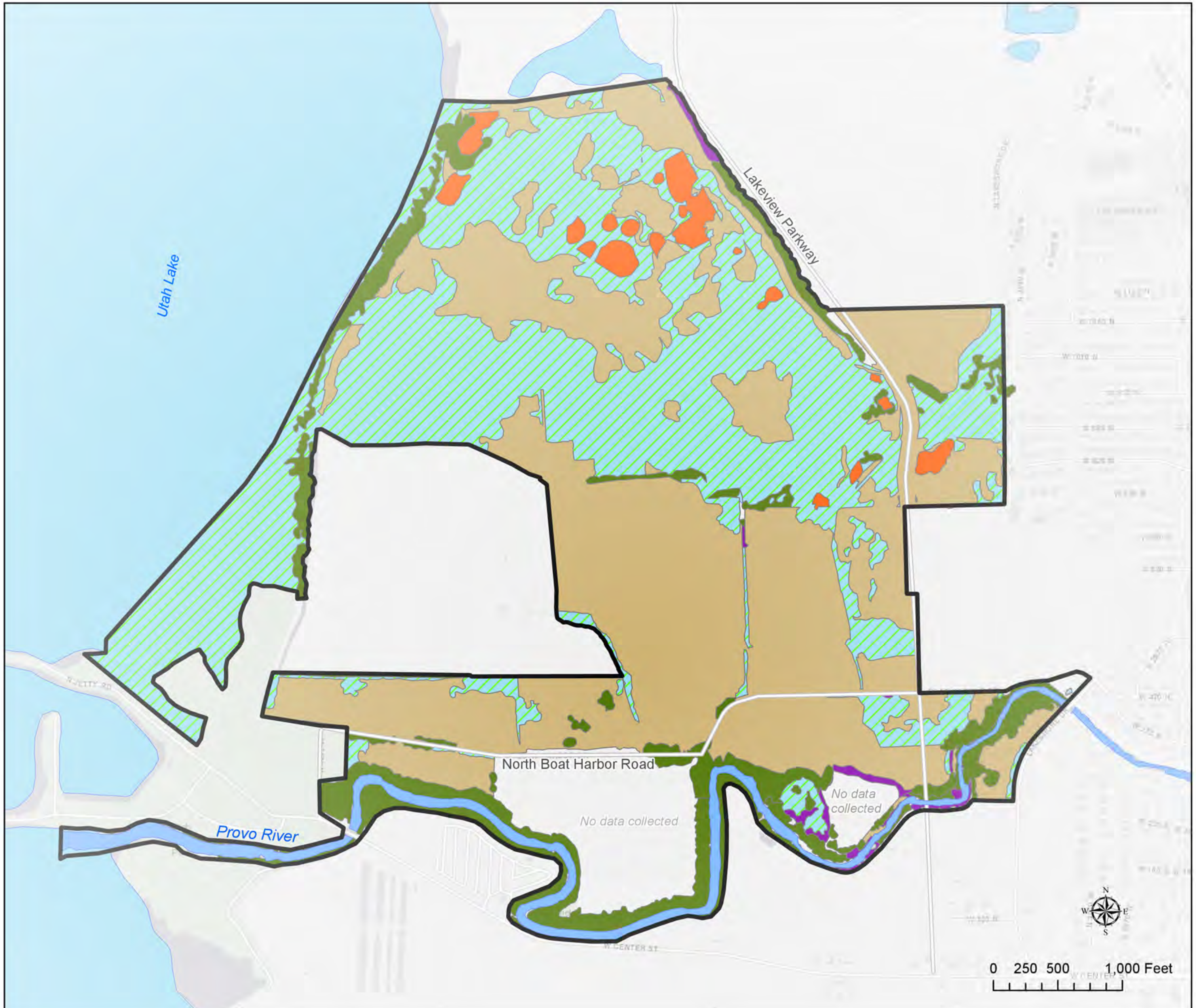
Datum: North American 1983
Projection: Transverse Mercator
Elevation Datum: NGVD 1929

Map Date: 4/24/2019
Image Date: 9/10/2018
Map Author: Lyndi Perry, BIO-WEST, Inc.

1 inch equals 802 feet when printed at 11"x17"



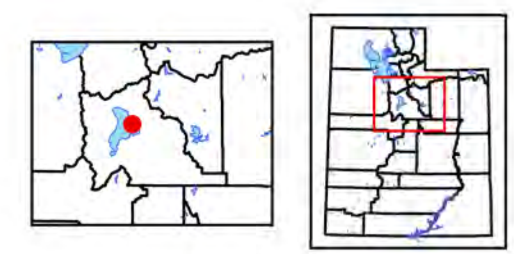
PROVO RIVER DELTA RESTORATION PROJECT

Existing Habitat Types

Habitat types assigned during 2018 vegetation community mapping, based on dominance of relative plant species cover.

*Inclusions of contextually high quality habitat characterized by peat soils and relatively high plant diversity.

- Study Area Boundary
- Provo River
- Roads
- Raised Peat Mounds
- Emergent Wetland Type
- Riparian Forested
- Riparian Scrub Shrub
- Upland



Prepared By:

BIO-WEST

ALLRED RESTORATION

1 inch equals 790 feet when printed at 11"x17"

Spatial Reference

Name: NAD 1983 StatePlane Utah Central FIPS 4302 Feet

Datum: North American 1983

Projection: Lambert Conformal Conic

Elevation Datum: NGVD 1929

Map Date: 4/24/2019

Map Author: Lyndi Perry/Chuck Jenkins, BIO-WEST, Inc.

SENSITIVE INFORMATION

Provo River Delta Restoration Project

Ute Ladies'-Tresses Known Locations and Suitable Habitat 2010-2018

Legend

- 2018 ULT Survey Points
- ULT Locations (SWCA 2016)
- ULT Occurrences (BIO-WEST 2010-2013)
- Suitable Habitat- Unoccupied
- Suitable Habitat- Occupied
- ULT Occurrences (BIO-WEST 2010-2013)
- 2018 Survey Area
- Provo City Mitigation Site*
- Provo River
- Lakeview Parkway

*ULT documented within the Provo City Mitigation Site by K.A. Smith, Inc. from 2009-2012. Exact locations unknown

Map by BIO-WEST, Inc.

Miles: 0, 0.1, 0.2

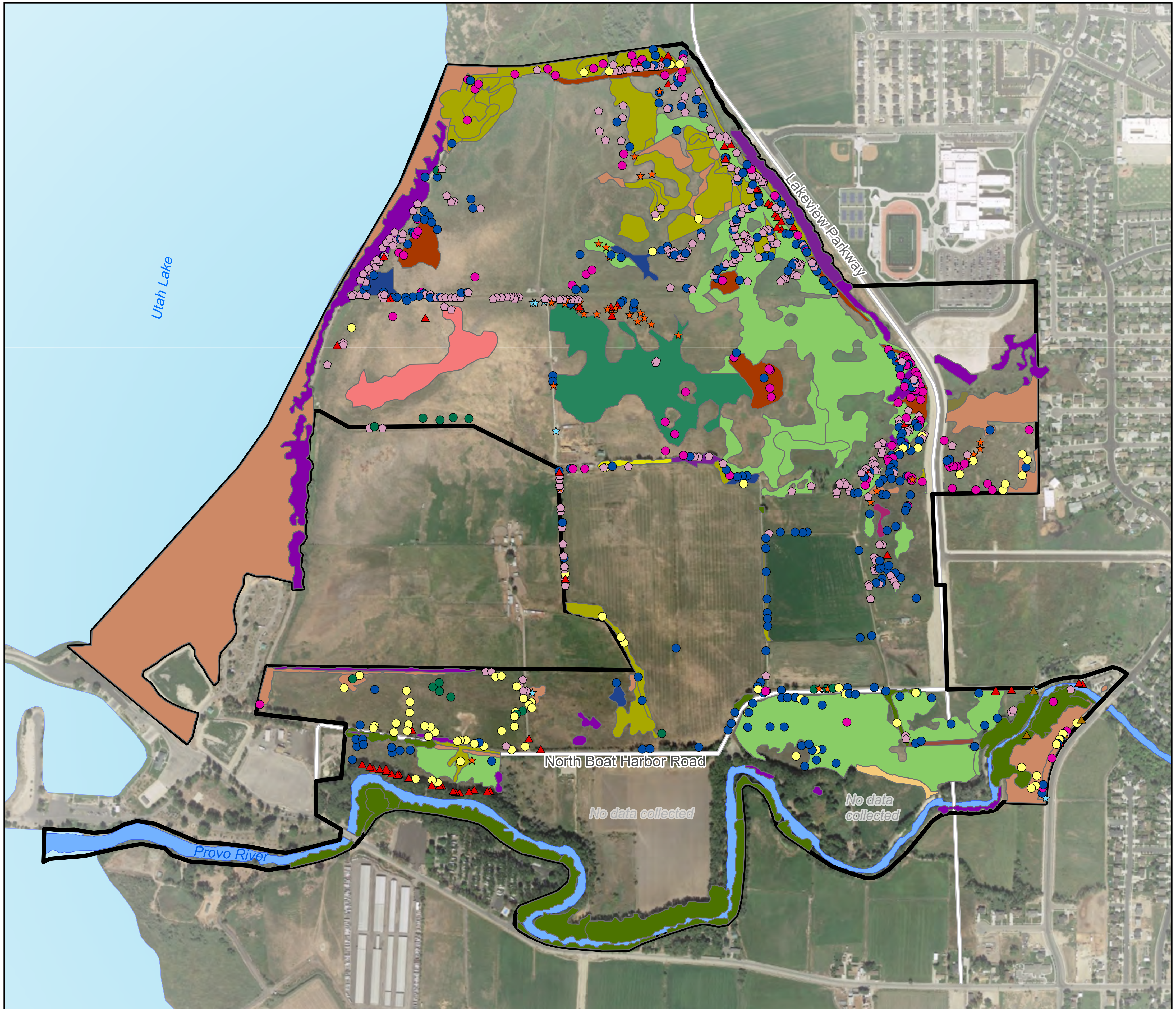
Feet: 0, 500, 1,000, 1,500

N

1 inch = 700 feet

Map Scale 1:8,400
Projection: NAD 83 UTM Zone 12 North
Imagery Date: Sept. 11, 2018 (AGRC/Google)
Map Date 10/17/2019
Map Author: G. Busch

Document Path: Q:\projects\2062_PDRP\Final_Design\ULT_Survey_2018\ULT_LocationMap_Fig5_GB.mxd



PROVO RIVER DELTA RESTORATION PROJECT

Weed Location Map A - High Treatment Priority Species

Weed point data represents weedy areas less than 0.25 acres in size. Weed polygon data represents vegetation communities dominated by weedy species. Priority species were identified and organized by considering the following criteria*:
-Distribution and dominance of invasive plant species
-Plant species that present the greatest conflicts with project goals
-Level of effort needed to control or eradicate the invasive plant
(Plants harder to control were given a higher priority).

Weedy Species are defined as: Non-native, invasive, State/County noxious or problematic species.

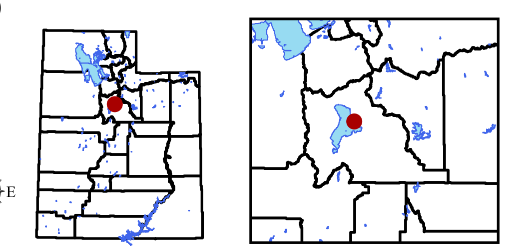
**Priority Species are listed in Table 16 of the Provo River Delta Restoration Project Vegetation Management Plan.*

Weed Dominated Vegetation Communities

- Canada thistle (24.1 acres)
- Canada thistle, Bull thistle (15.2 acres)
- Canada thistle, Russian olive (2.1 acres)
- Crack willow (20.9 acres)
- Crack willow, Cocklebur (0.3 acres)
- Phragmites (50.5 acres)
- Reed canary grass (55.5 acres)
- Reed canary grass, Crack willow (0.8 acres)
- Reed canary grass, Perennial pepperweed (0.3 acres)
- Reed canary grass, Prickly lettuce (0.6 acres)
- Russian olive (16.3 acres)
- Russian olive, Perennial pepperweed (0.5 acres)
- Scotch thistle (6.6 acres)
- Saltcedar (5.3 acres)
- Study Area
- Roads
- Provo River

Weed Point Locations

- Bull thistle
- Canada thistle
- Musk thistle
- Phragmites
- Puncturevine
- Russian olive
- Scotch thistle
- Siberian elm
- Saltcedar



Prepared By:

BIO-WEST
ALLRED RESTORATION

Map Author: Lyndi Perry, BIO-WEST, Inc.

1 inch equals 749 feet
when printed at 11"x17"

Spatial Reference
Name: NAD 1983 UTM Zone 12N
Datum: North American 1983
Projection: Transverse Mercator
Elevation Datum: NGVD 1929

Map Date: 8/26/2019
Image Date: 9/10/2018

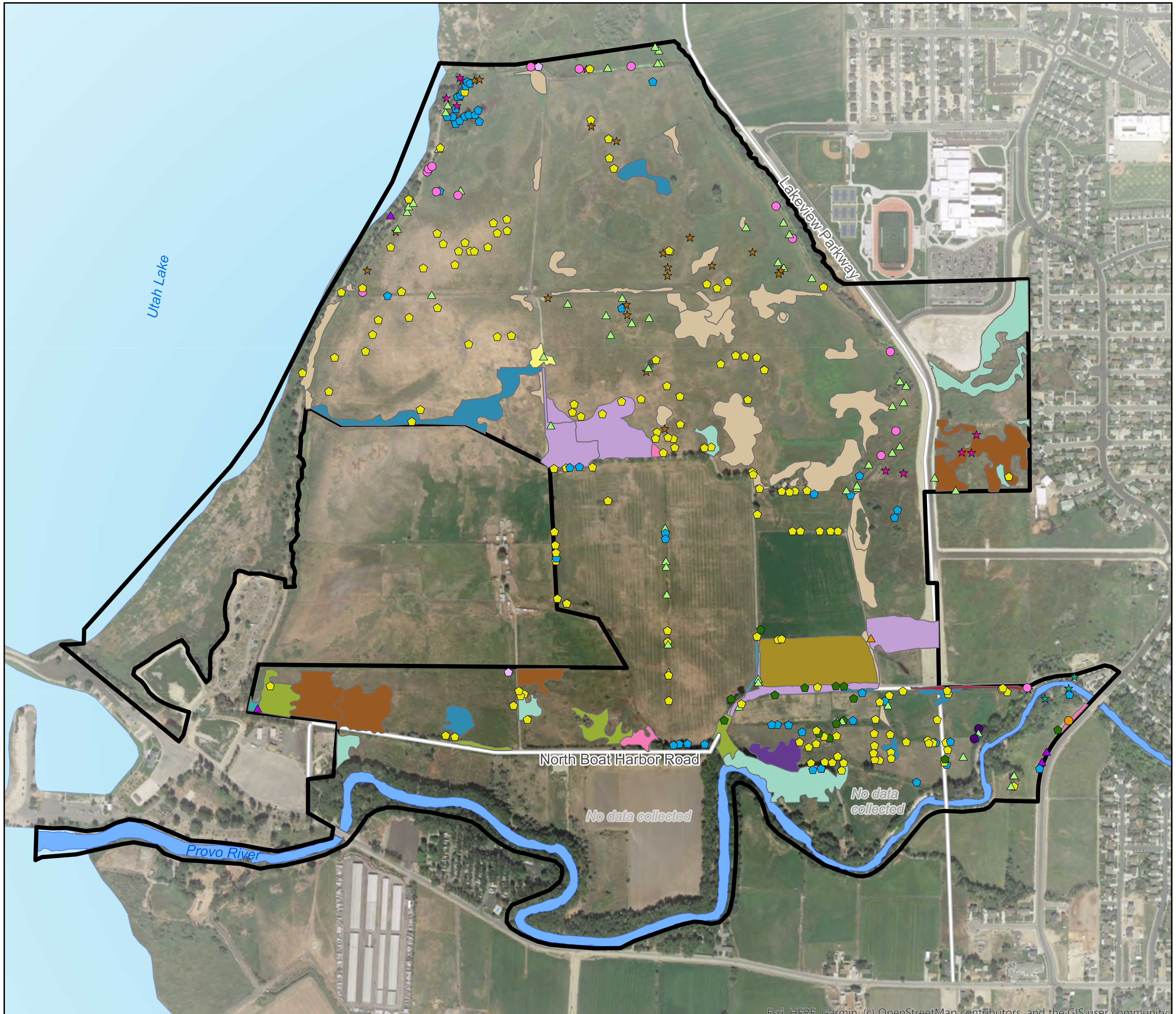
PROVO RIVER DELTA RESTORATION PROJECT

Weed Location Map B - Medium and Low Treatment Priority Species

Weed point data represents weedy areas less than 0.25 acres in size. Weed polygon data represents vegetation communities dominated by weedy species. Priority species were identified and organized by considering the following criteria*:
-Distribution and dominance of invasive plant species
-Plant species that present the greatest conflicts with project goals
-Level of effort needed to control or eradicate the invasive plant (Plants harder to control were given a higher priority).

Weedy Species are defined as: Non-native, invasive, State/County noxious or problematic species.

**Priority Species are listed in Table 16 of the Provo River Delta Restoration Project Vegetation Management Plan.*



Weed Dominated Vegetation Communites

- Barnyardgrass (0.4 acres)
- Burningbush (10.9 acres)
- Burningbush, Lambsquarters (6.0 acres)
- Burningbush, Prickly lettuce (6.7 acres)
- Cheatgrass (0.9 acres)
- Cocklebur (17.8 acres)
- Field bindweed (1.3 acres)
- Hoary Cress (0.1 acres)
- Lambsquarters (3.5 acres)
- Prickly lettuce (10.0 acres)
- Prickly lettuce, Lambsquarters (0.4 acres)
- Quackgrass (9.4 acres)
- Water-cress (0.2 acres)

Weed Point Locations

- Barnyardgrass
- Bermudagrass
- Burdock
- Cocklebur
- Field bindweed
- Fuller's teasel
- Hoary cress
- Houndstounge
- Jointed goatgrass
- Perennial pepperweed
- Sulfur cinquefoil
- Tree of Heaven
- White poplar

- Study Area
- Roads
- Provo River

Prepared By:

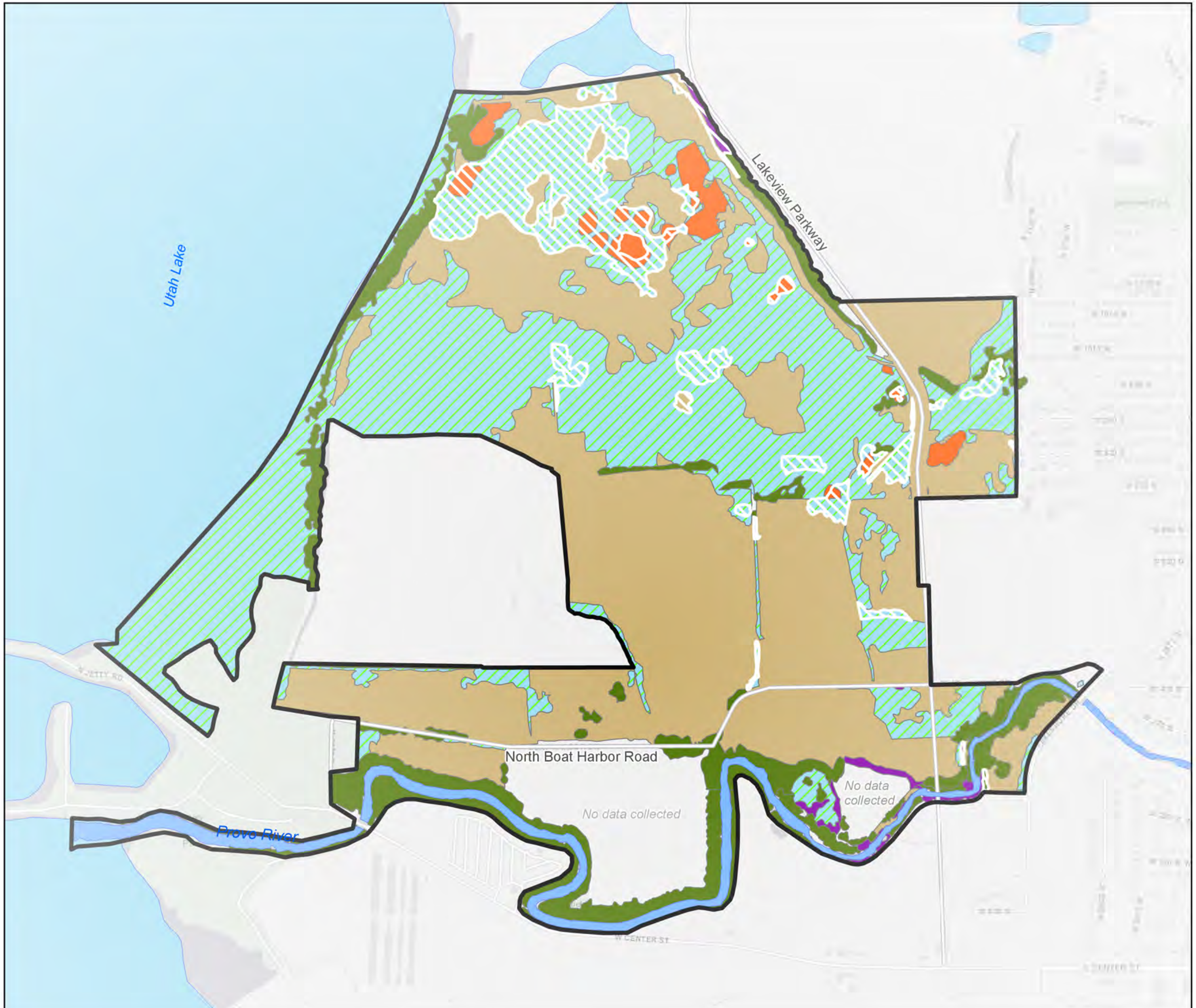
BIO-WEST
ALLRED RESTORATION

Map Author: Lyndi Perry, BIO-WEST, Inc.

1 inch equals 749 feet
when printed at 11"x17"

Spatial Reference
Name: NAD 1983 UTM Zone 12N
Datum: North American 1983
Projection: Transverse Mercator
Elevation Datum: NGVD 1929

Map Date: 8/26/2019
Image Date: 9/10/2018



PROVO RIVER DELTA RESTORATION PROJECT

Existing Habitat Types and Salvageable Resource Areas

Salvageable Resource Area defined as:
- 50% or greater native plant species relative cover
- Contextually high plant biodiversity
- 20% or less non-native, invasive, State/County noxious, or problematic plant species relative cover

Study Area Boundary
Roads
Salvageable Resource Areas*
Emergent Wetland Type
Riparian Forested
Riparian Scrub Shrub
Upland
Raised Peat Mounds
Provo River

Habitat types assigned during 2018 vegetation community mapping, based on dominance of relative plant species cover.

*Inclusions of contextually high quality habitat characterized by peat soils and relatively high plant diversity.

Prepared By:

BIO-WEST   ALLRED RESTORATION

1 inch equals 790 feet when printed at 11"x17"

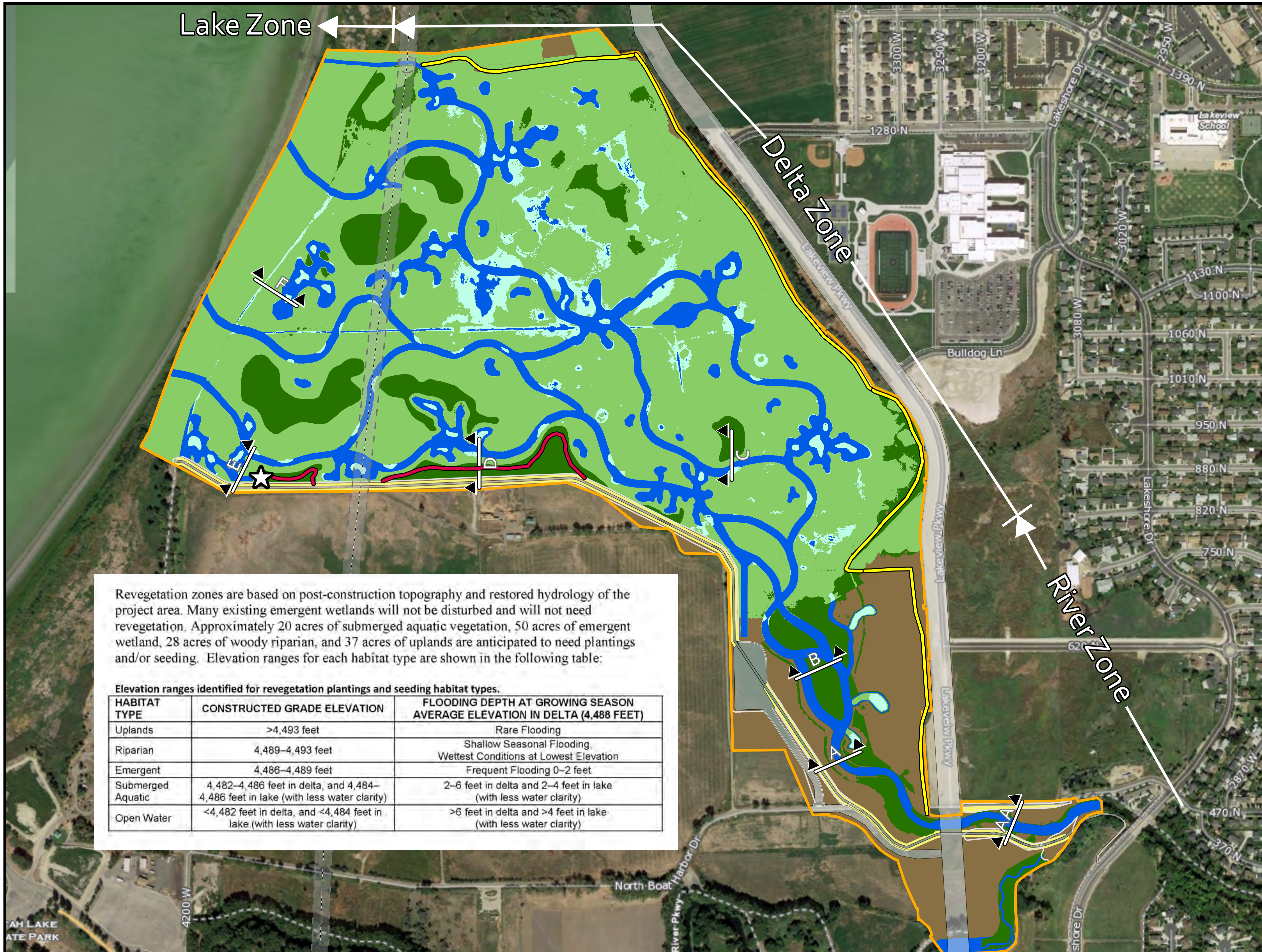
Spatial Reference
Name: NAD 1983 StatePlane Utah Central FIPS 4302 Feet
Datum: North American 1983
Projection: Lambert Conformal Conic
Elevation Datum: NGVD 1929
Map Date: 4/25/2019
Map Author: Lyndi Perry/Chuck Jenkins, BIO-WEST, Inc.
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community

ATTACHMENT 2
PROJECT DESIGN PLAN VIEW AND CROSS SECTIONS

Provo River Delta Restoration Project

Revegetation Plan: Planting and Seeding Areas

September 2019



Revegetation zones are based on post-construction topography and restored hydrology of the project area. Many existing emergent wetlands will not be disturbed and will not need revegetation. Approximately 20 acres of submerged aquatic vegetation, 50 acres of emergent wetland, 28 acres of woody riparian, and 37 acres of uplands are anticipated to need plantings and/or seeding. Elevation ranges for each habitat type are shown in the following table:

Elevation ranges identified for revegetation plantings and seeding habitat types.

HABITAT TYPE	CONSTRUCTED GRADE ELEVATION	FLOODING DEPTH AT GROWING SEASON AVERAGE ELEVATION IN DELTA (4,488 FEET)
Uplands	>4,493 feet	Rare Flooding
Riparian	4,489–4,493 feet	Shallow Seasonal Flooding, Wettest Conditions at Lowest Elevation
Emergent	4,486–4,489 feet	Frequent Flooding 0–2 feet
Submerged Aquatic	4,482–4,486 feet in delta, and 4,484–4,486 feet in lake (with less water clarity)	2–6 feet in delta and 2–4 feet in lake (with less water clarity)
Open Water	<4,482 feet in delta, and <4,484 feet in lake (with less water clarity)	>6 feet in delta and >4 feet in lake (with less water clarity)

Legend

- Project Area
- Cross Section
- Plug and Berm
- Open Water
- Viewing Tower
- 12-ft Grass Access Path
- 5-ft Gravel Path

Seeding and Planting Areas

- Submerged Aquatic Vegetation
- Emergent Wetland
- Woody Riparian
- Upland
- Grass Only

Pipeline Overlay

- Dominion Natural Gas Pipeline
- Pipeline Buffer (50' each side)

Feet: 0, 250, 500, 750, 1,000

N

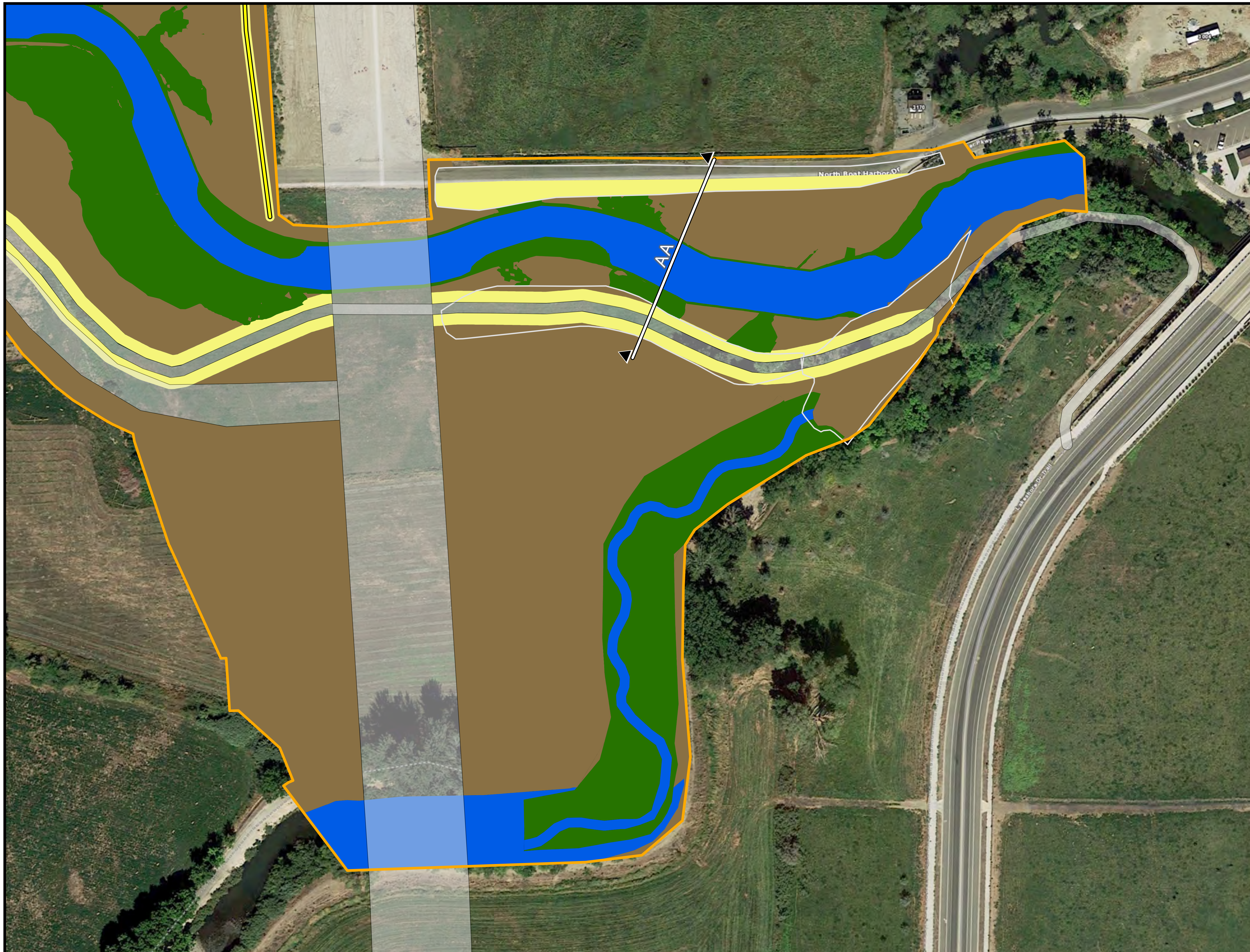
Map Date: 10/2/2019

BIO-WEST www.bio-west.com 435.752.4202

ALLRED RESTORATION

Scale: 1:7,000 (1 Inch = 583 feet when printed at 11"x17")
Projection: State Plane Utah Central FIPS 4302 US Feet
Elevation Datum: NGVD 1929
Imagery Date: 9/11/18 (AGRC, Google)
Map Author: Lyndi Perry & Glen Busch, BIO-WEST, Inc.

Document Path: Q:\projects\2062_PDRP\Final_Design\LP_wetlandImpacts\lp_wetlandImpacts\lp_wetlandImpacts_20190813.aprx



Provo River Delta Restoration Project

Revegetation Plan: Planting and Seeding Areas

Existing Channel

September 2019

Legend

- Project Area
- Cross Section
- Future Lakeview Parkway
- Plug and Berm
- Open Water

Seeding and Planting Areas

- Submerged Aquatic Vegetation
- Emergent Wetland
- Woody Riparian
- Upland
- Grass Only
- 5-ft Gravel Path
- 12-ft Grass Access Path
- Viewing Tower

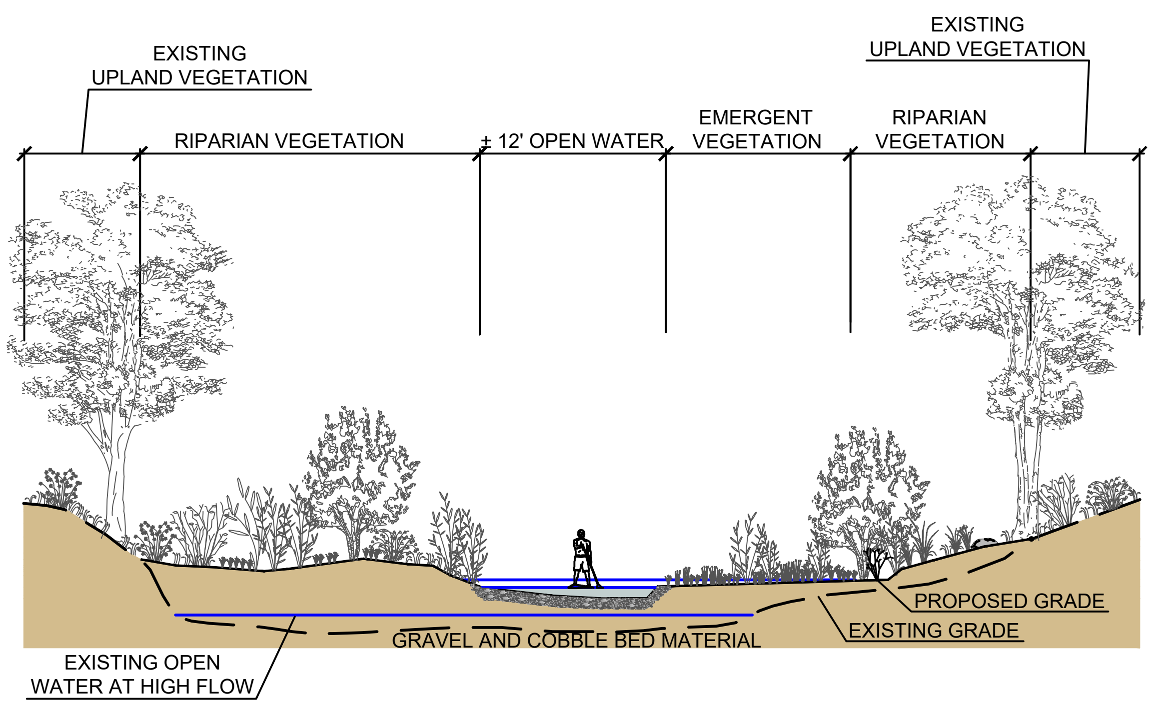
Feet
0 50 100 150 200

N

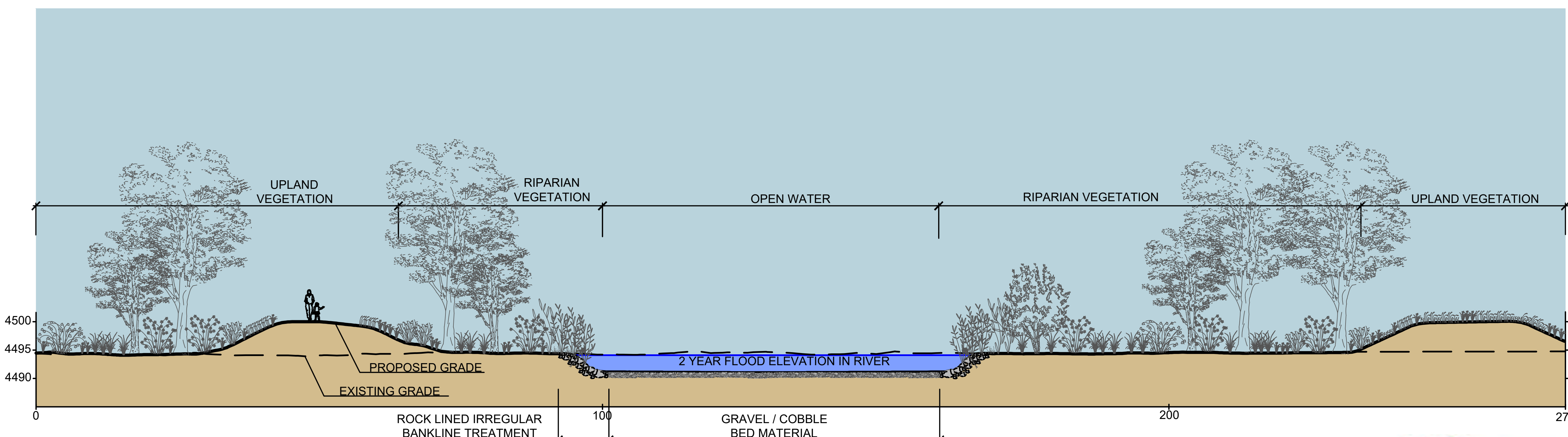
Map Date: 10/2/2019

Scale: 1:2,000 (1 Inch = 125 feet when printed at 11"x17")
Projection: State Plane Utah Central FIPS 4302 US Feet
Elevation Datum: NGVD 1929
Imagery Date: 9/11/18 (AGRC, Google)
Map Author: Lyndi Perry & Glen Busch, BIO-WEST, Inc.

Document Path: Q:\projects\2062_PDRP\Final_Design\LP_wetlandImpacts\lp_wetlandImpacts\lp_wetlandImpacts_20190813.aprx



SMALL CHANNEL SECTION OF THE EXISTING PROVO RIVER
(TYPICAL CROSS SECTION VIEW DOWNSTREAM OF PLUG)



AA UPPER RIVER ZONE (CROSS SECTION)

ALLRED RESTORATION

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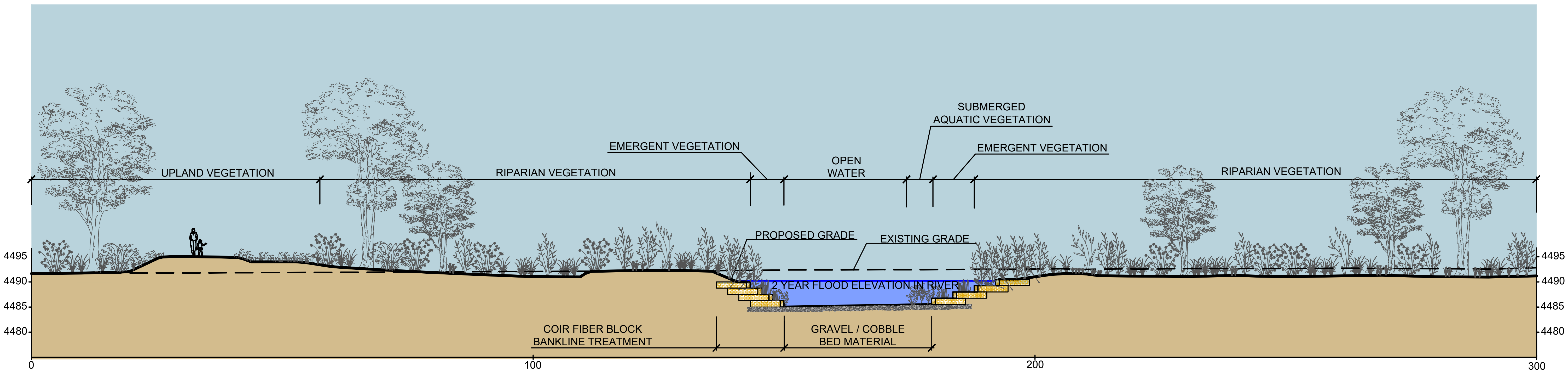
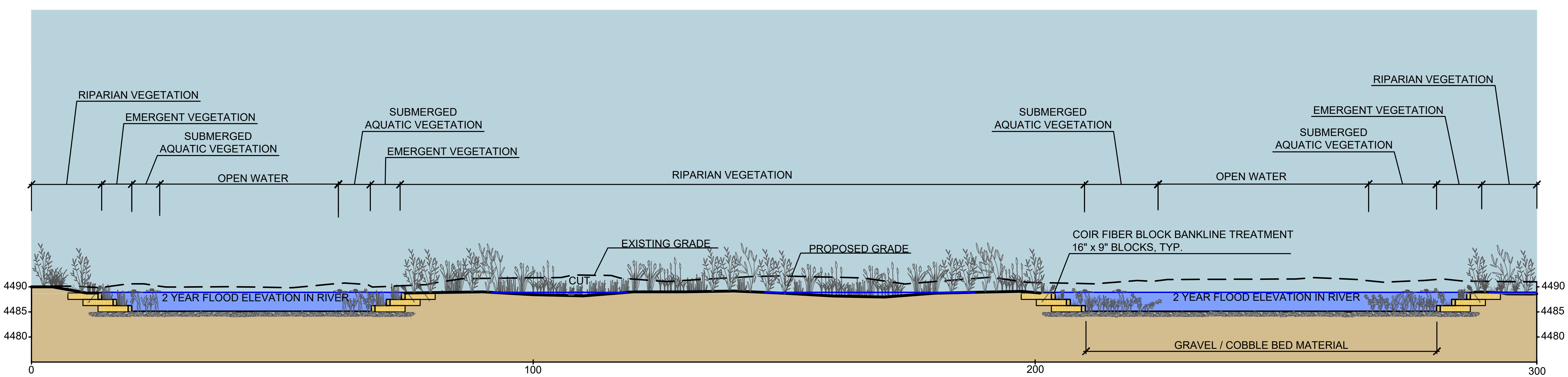


A RIVER ZONE CROSS SECTION



B RIVER ZONE CROSS SECTION

ALLRED RESTORATION

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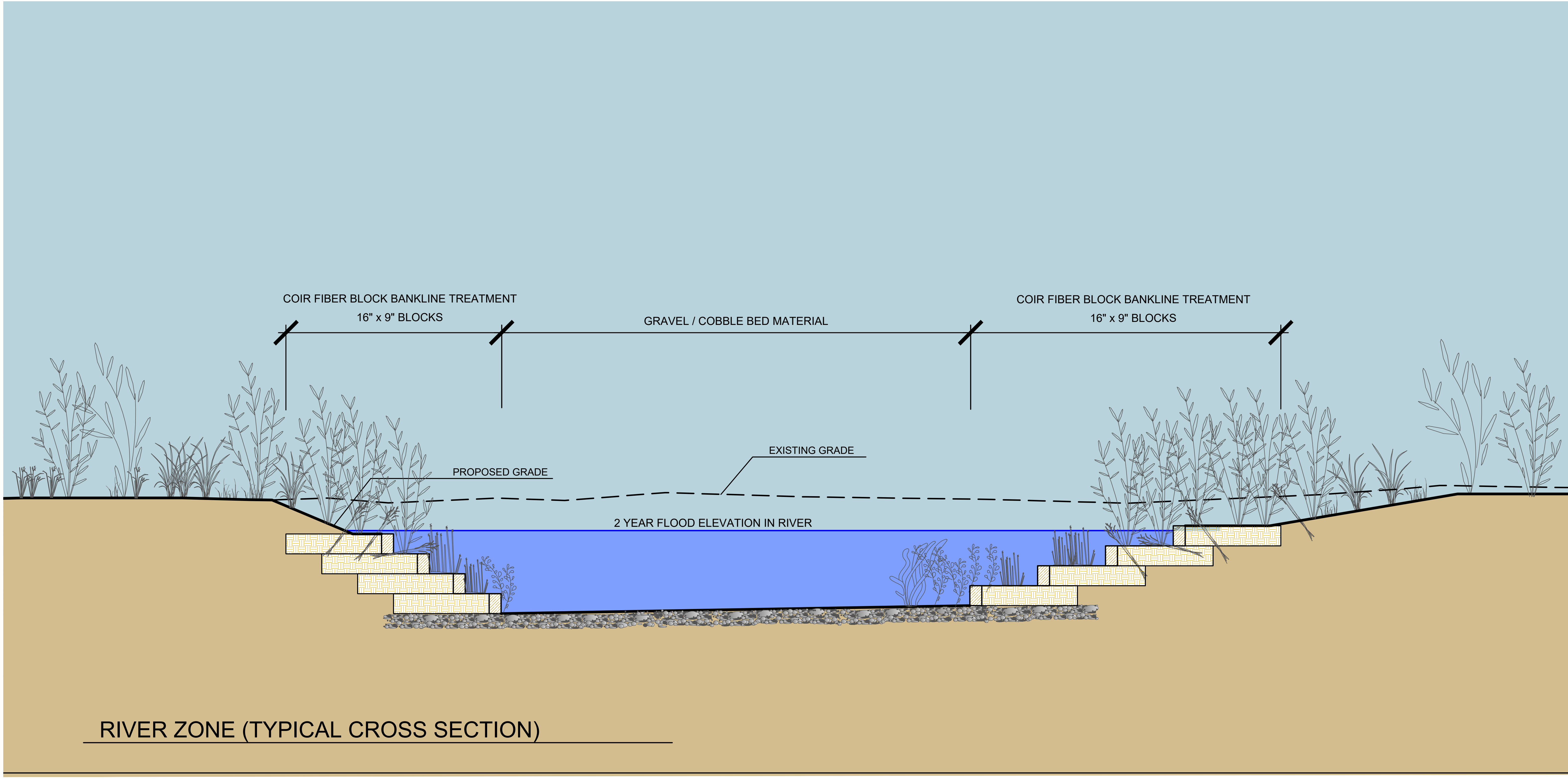
435.752.4202



RIVER ZONE (TYPICAL CROSS SECTION)

ALLRED RESTORATION

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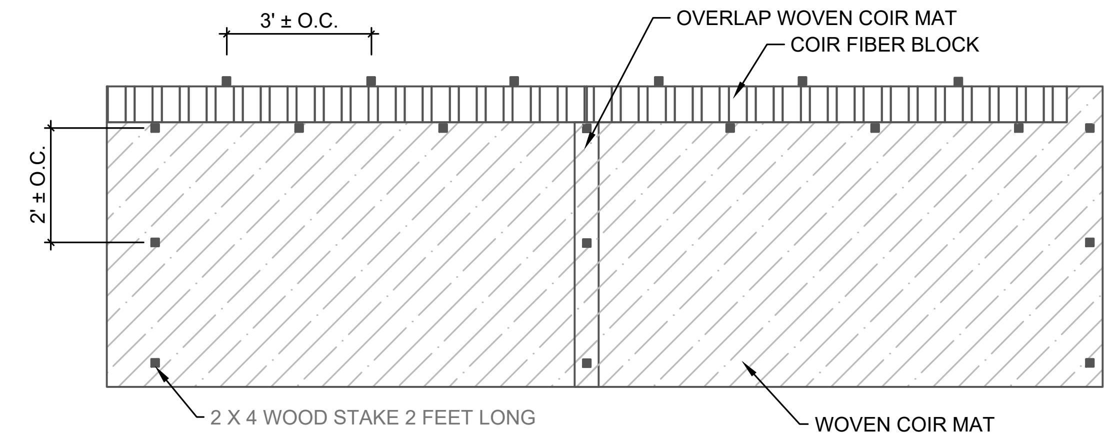
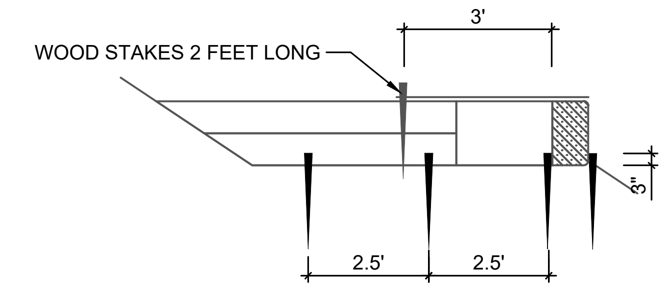
435.752.4202

COIR FIBER BLOCK BANKLINE NOTES:

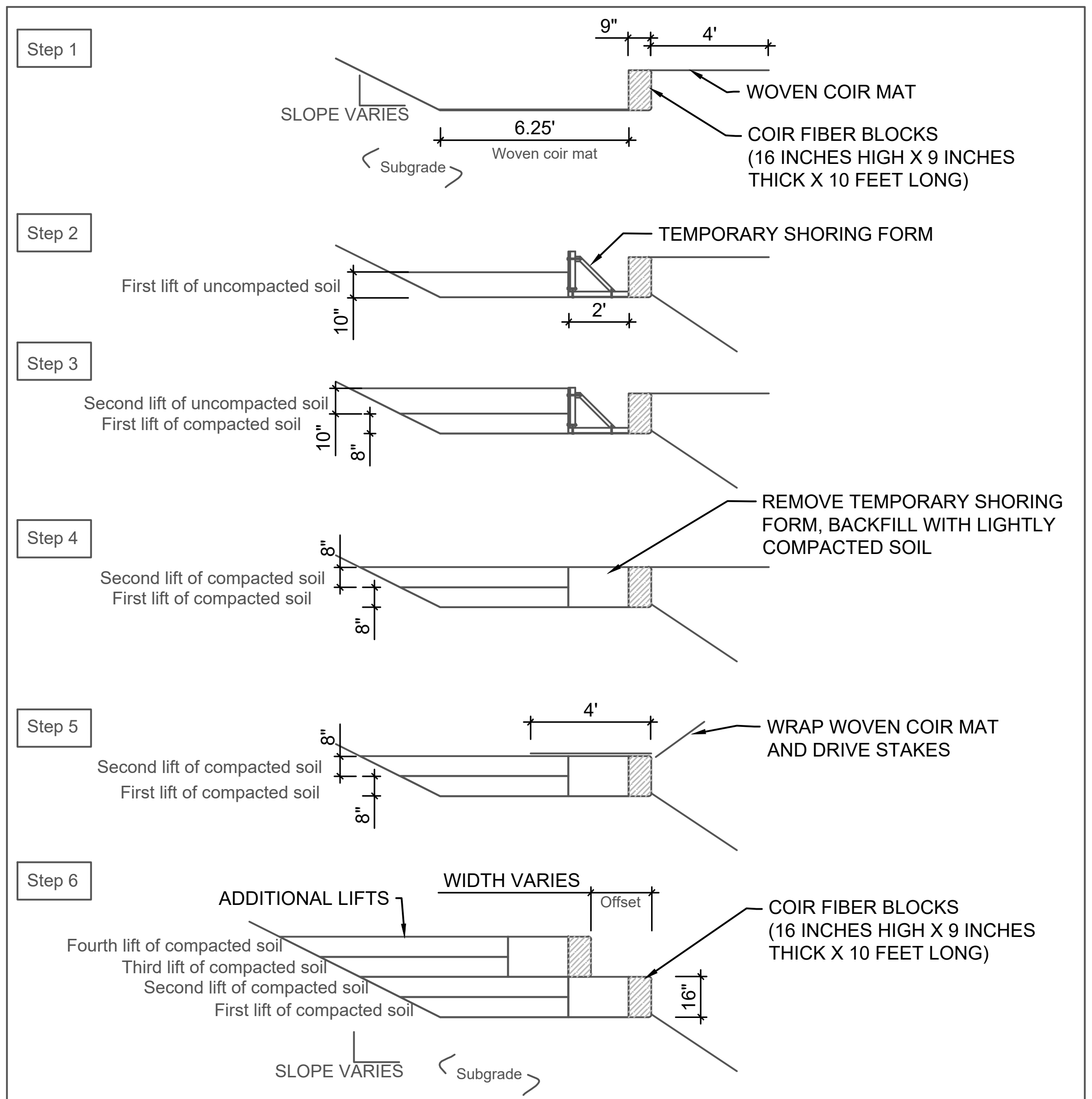
1. CONSTRUCT THE BANKLINE USING COIR FIBER BLOCK WITH ATTACHED COIR FABRIC TO ENCAPSULATE THE SOIL INTO FABRIC WRAPPED LAYERS. COIR BLOCK AND FIBER TO BE BioD-Block 16-400 AVAILABLE THROUGH ROLANKA INTERNATIONAL, INC. INSTALL ACCORDING TO MANUFACTURER'S SPECIFICATIONS.
2. ANCHOR THE ENDS TO THE TOP AND BOTTOM FABRICS WITH A 2 FOOT LONG WOOD STAKE. STAKE EVERY ± 30 INCHES, ASSURING THAT THE SEAM WHERE THE TWO ENDS OF THE FABRIC STRIP OVERLAP IS ANCHORED.
3. THE COIR FIBER BLOCK WITH ATTACHED COIR FABRIC IS 120 INCHES LONG AND 16 INCHES HIGH WITH A 9 INCH WIDTH FIBER BLOCK ON THE END. THE TOP FABRIC LENGTH IS 48 INCHES AND THE BOTTOM FABRIC LENGTH IS 75 INCHES. THERE IS A MINIMUM OF 12 INCHES OVERLAP ON TOP FABRIC.
4. OVERLAP MALE AND FEMALE ENDS WITH A MINIMUM OF 6 INCHES TO CREATE CONTINUOUS LONG SECTIONS.
5. MATERIAL OBTAINED FROM EXCAVATION MAY BE USED AS FILL FOR COIR FIBER BLOCK TERRACE LIFT OF COMPACTED SOIL, PROVIDED ORGANIC MATERIAL, RUBBISH, DEBRIS, AND OTHER OBJECTIONABLE MATERIALS ARE REMOVED.



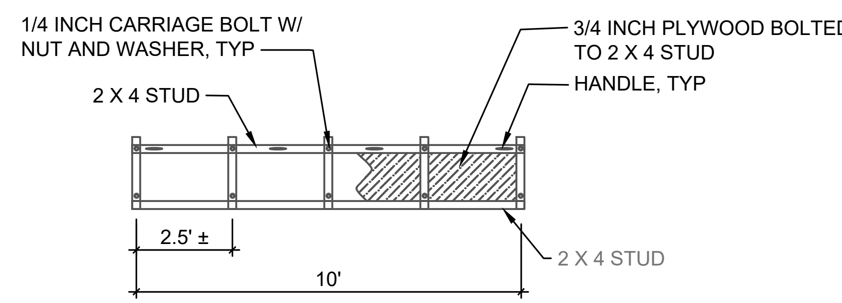
COIR FIBER BLOCK STAKING PATTERN PLAN VIEW



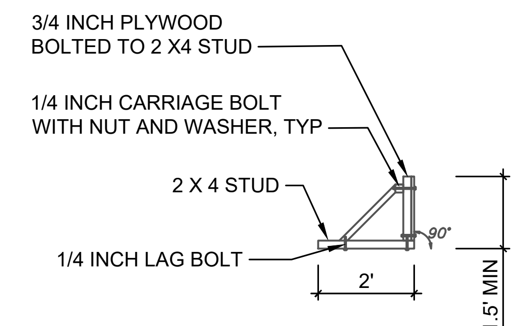
SECTION VIEW



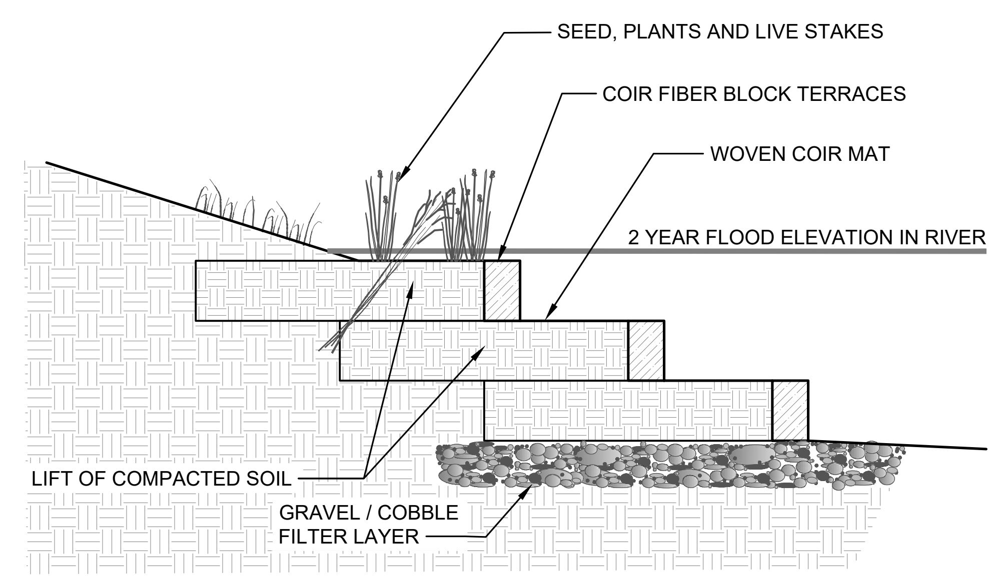
SECTION VIEW



COIR FIBER BLOCK TEMPORARY SHORING FORM
FRONT VIEW FROM CREEK



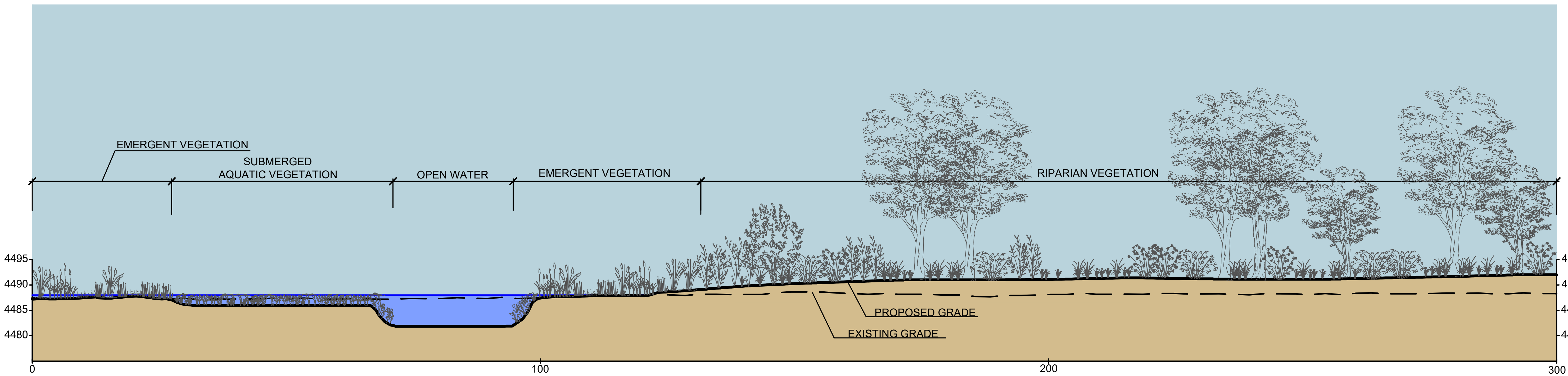
SIDE VIEW



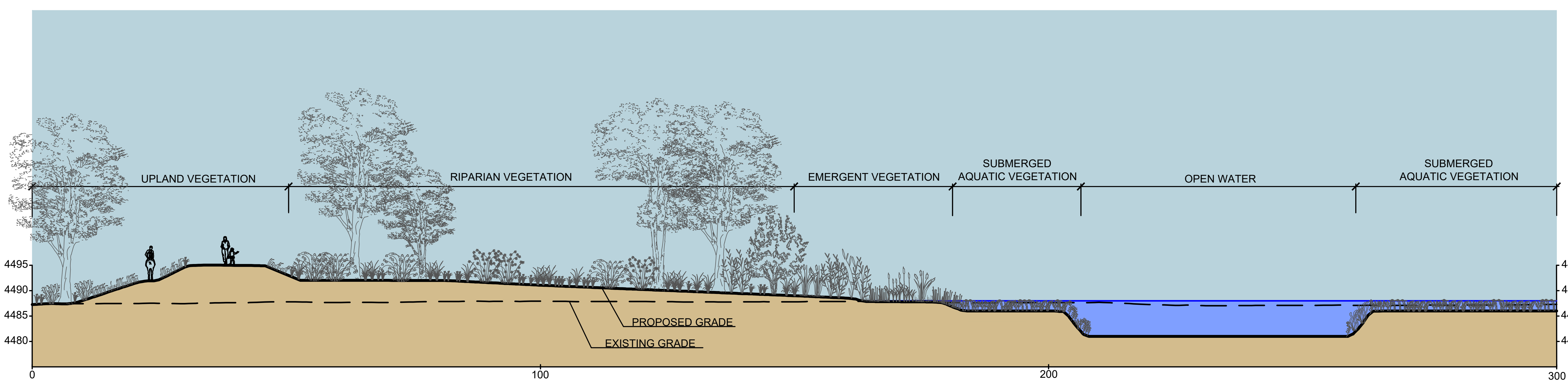
COIR FIBER BLOCK BANKLINE SECTION VIEW

CONSTRUCTION SEQUENCE OF COIR FIBER BLOCK BANKLINE TREATMENT

N.T.S.



C DELTA ZONE CROSS SECTION



D DELTA ZONE CROSS SECTION

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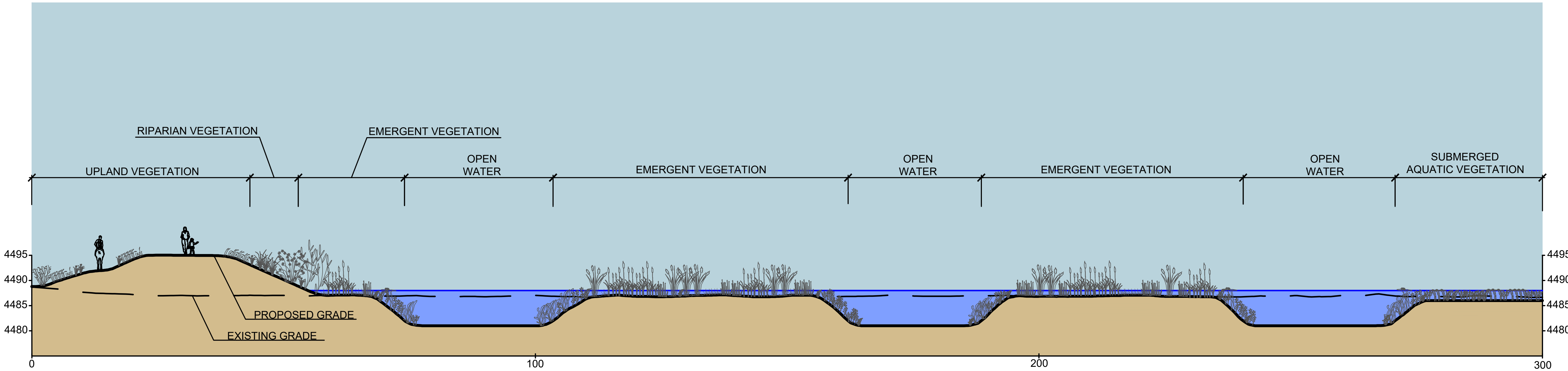
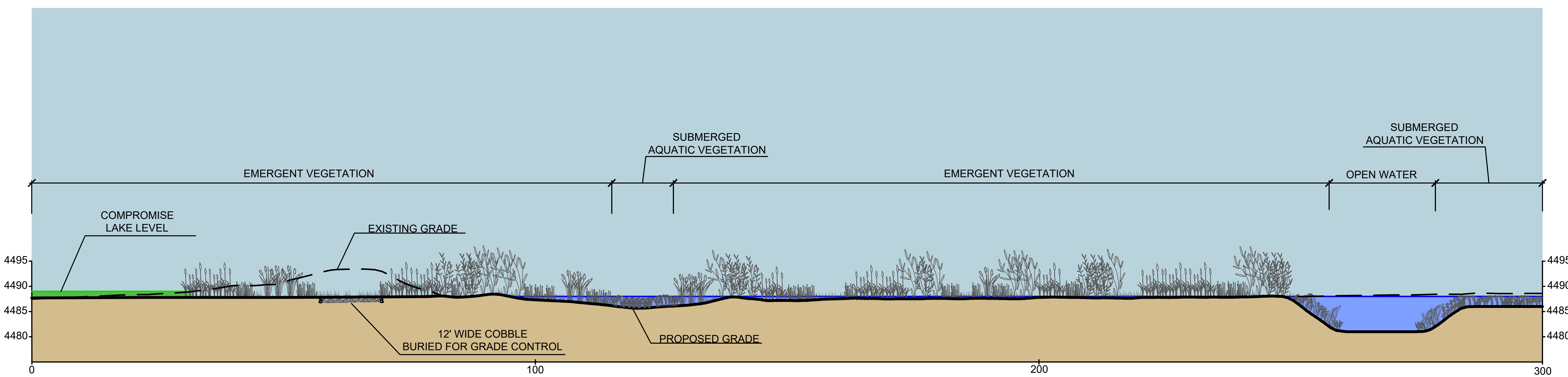


E DELTA ZONE CROSS SECTION



F DELTA ZONE LONGITUDINAL PROFILE

ALLRED RESTORATION

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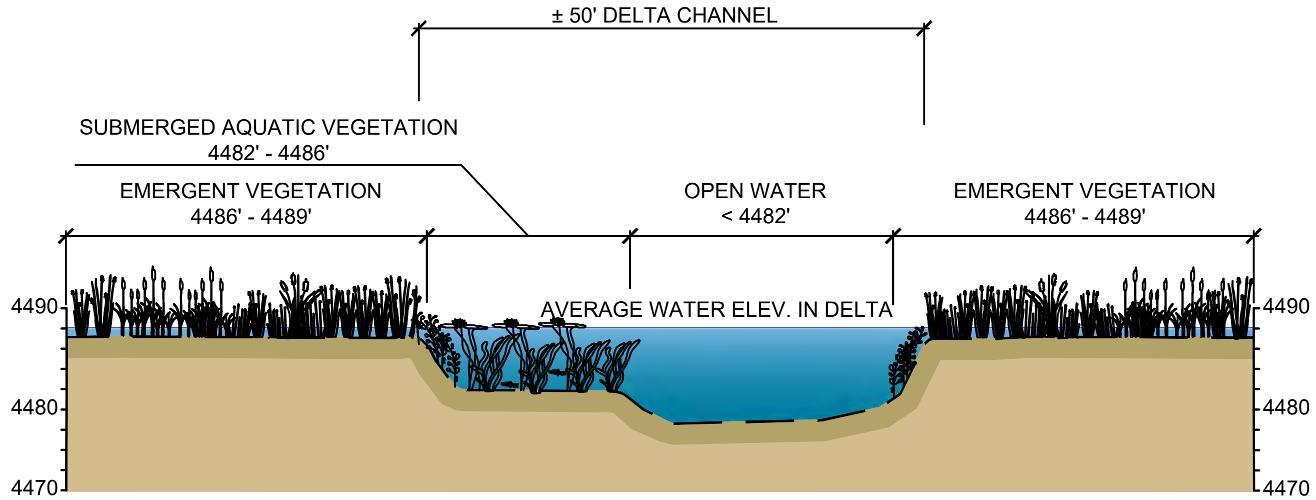
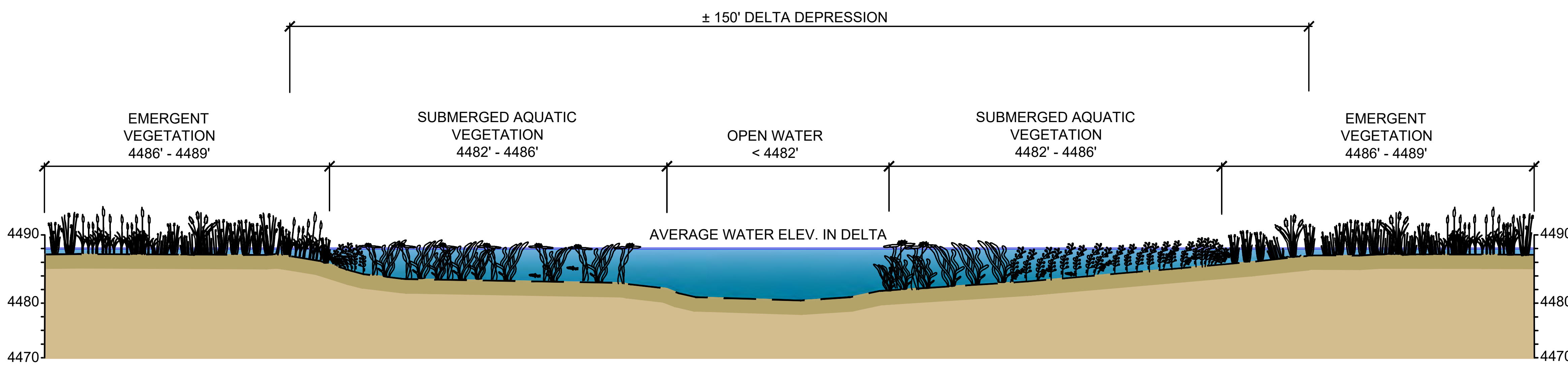
435.752.4202



Delta Channel Typical Cross Section



Delta Depression Typical Cross Section

ALLRED RESTORATION

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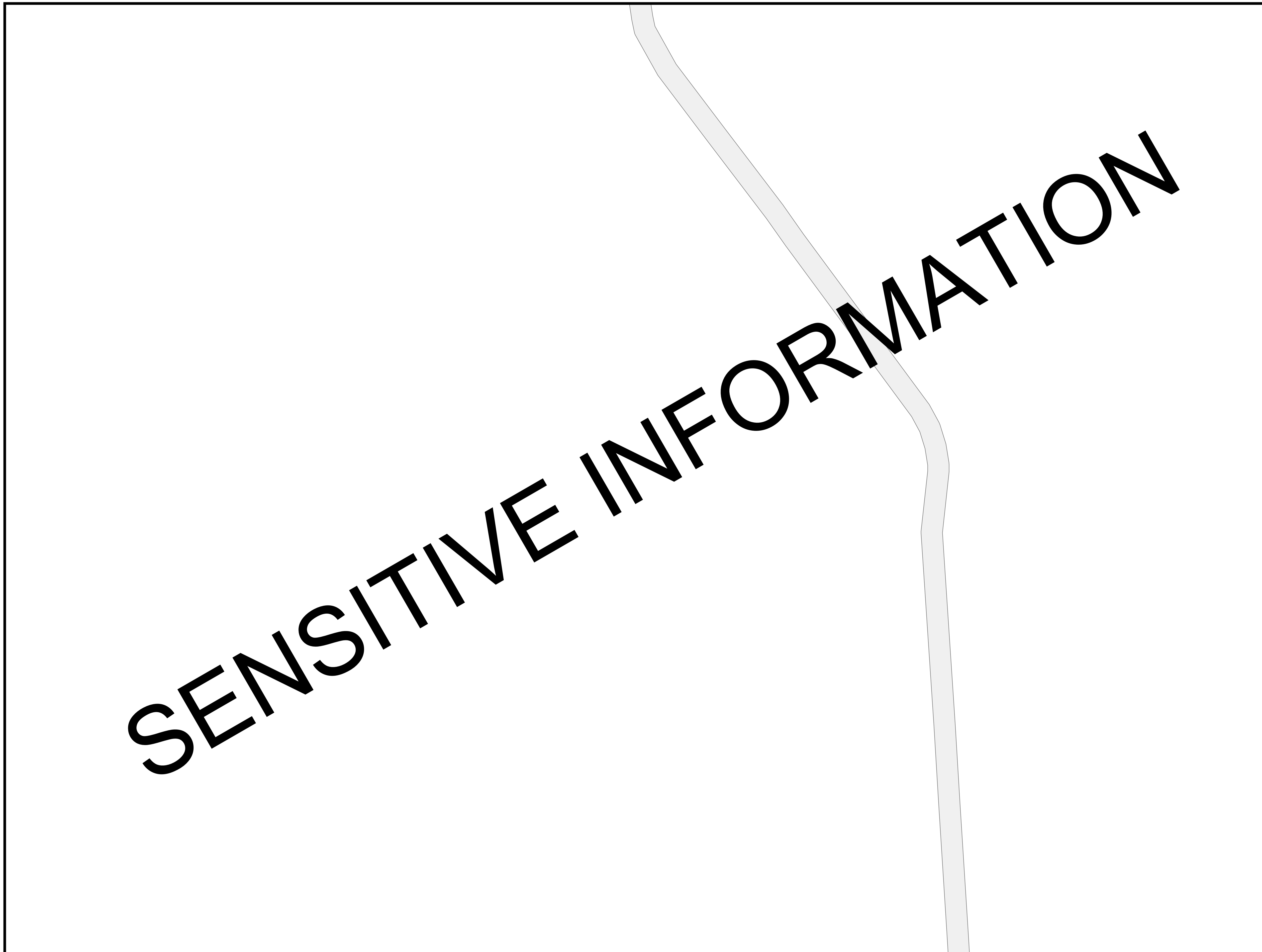
435.752.4202



Provo River Delta Restoration Project

Ute Ladies' - Tresses Impact & Relocation Map

September 2019

Legend

- Dominion Natural Gas Pipeline
- Pipeline Buffer (50' each side)
- Lakeview Parkway & Boatharbor Dr.
- Project Area

ULT Suitable Habitat

- ULT Occupied Habitat
- ULT Unoccupied Habitat
- ULT Fencing/Flagging (8,570 Liner Ft)
- Impacted Occupied ULT Habitat (0.8 acres)
- Potential ULT Transplant Area (0.8 acres)

Project Design

- Provo River Channels
- Delta Pond
- Delta Depression
- Woody Riparian
- Recreation Features
- Berm Trail Centerline

Feet
0 250 500 750 1,000

N

Map Date: 10/15/2019

BIO-WEST www.bio-west.com 435.752.4202

ALLRED RESTORATION

Scale: 1:7,000 (1 Inch = 583 feet when printed at 11"x17")
Projection: State Plane Utah Central FIPS 4302 US Feet
Elevation Datum: NGVD 1929
Imagery Date: 9/11/18 (AGRC, Google)
Map Author: Lyndi Perry & Glen Busch, BIO-WEST, Inc.

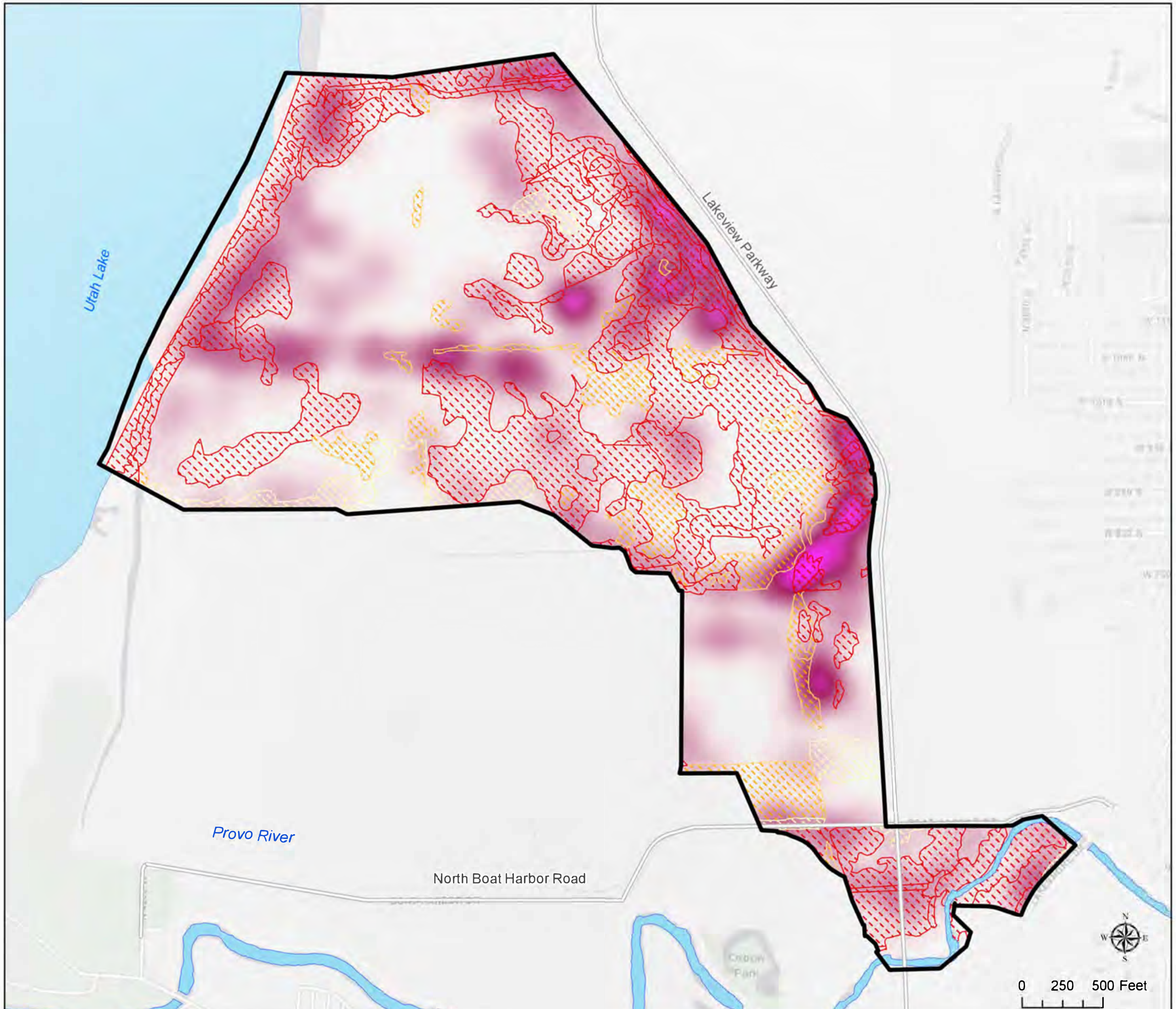
Document Path: Q:\projects\2062_PDRP\Final_Design\LP_wetlandImpacts\lp_wetlandImpacts\lp_wetlandImpacts_20190813.aprx

PROVO RIVER DELTA RESTORATION PROJECT

Weed Treatment Priority Map

Priority species were identified and organized by considering the following criteria*:
-Distribution and dominance of invasive plant species
-Plant species that present the greatest conflicts with project goals
-Level of effort needed to control or eradicate the invasive plant. Plants harder to control were given a higher priority

**Priority Species are listed in Table 16 of the Provo River Delta Restoration Project Vegetation Management Plan.*

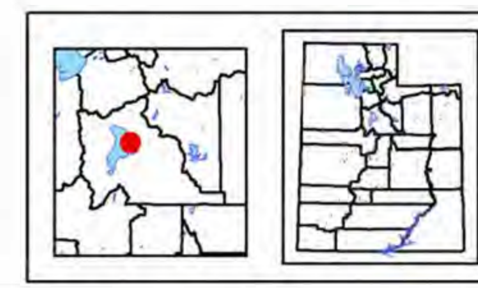


Legend

weedHeatMap_Mask
Project Area
Roads
Provo River

Weed Density:
Sparse
Dense

Treatment Priority:
High
Medium
Low



Prepared By:

BIO-WEST
ALLRED RESTORATION

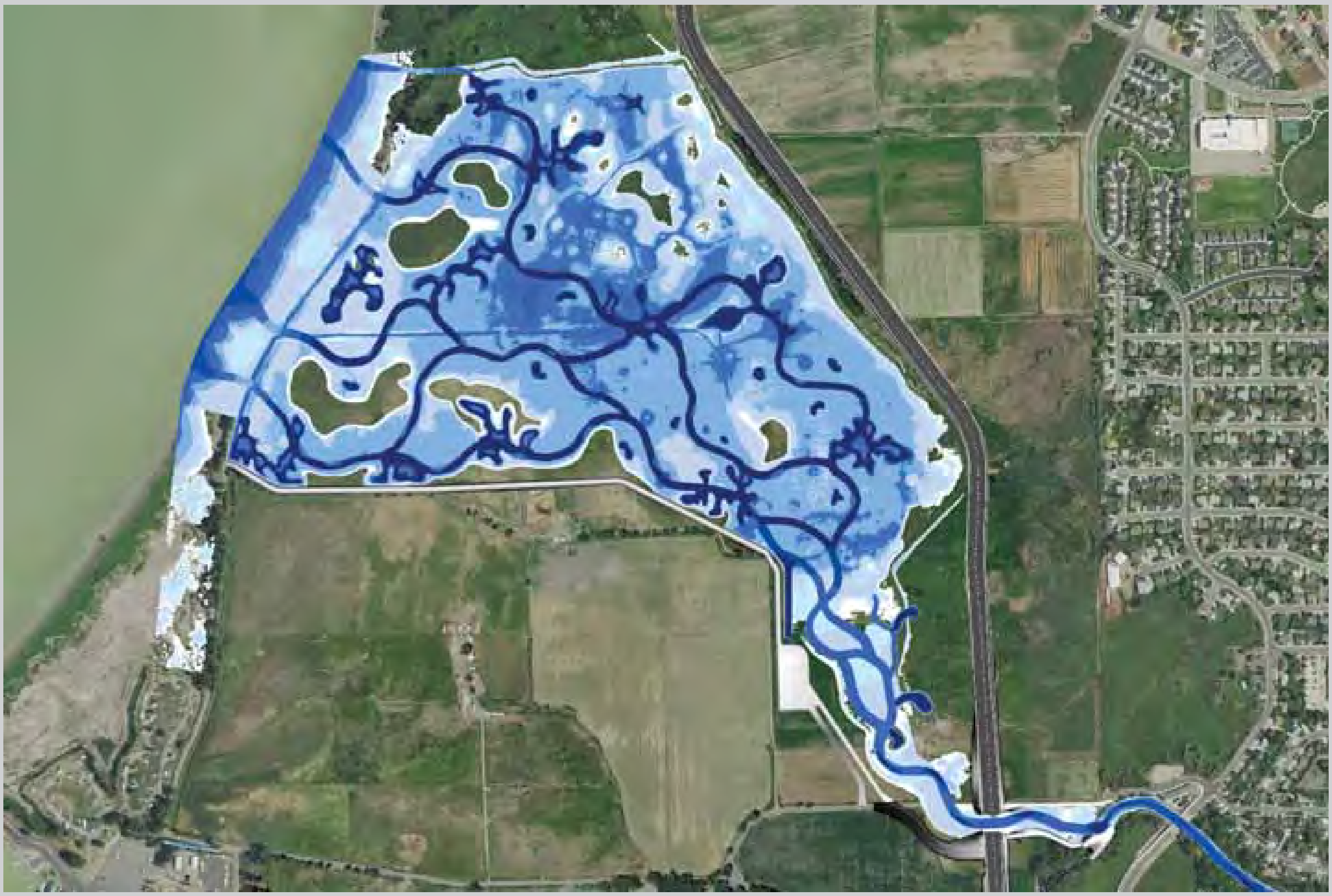
1 inch equals 628 feet when printed at 11"x17"

Spatial Reference
Name: NAD 1983 UTM Zone 12N
Datum: North American 1983
Projection: Transverse Mercator
Elevation Datum: NGVD 1929
Map Date: 4/24/2019
Map Author: Lyndi Perry, BIO-WEST, Inc.
Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community

APPENDIX B

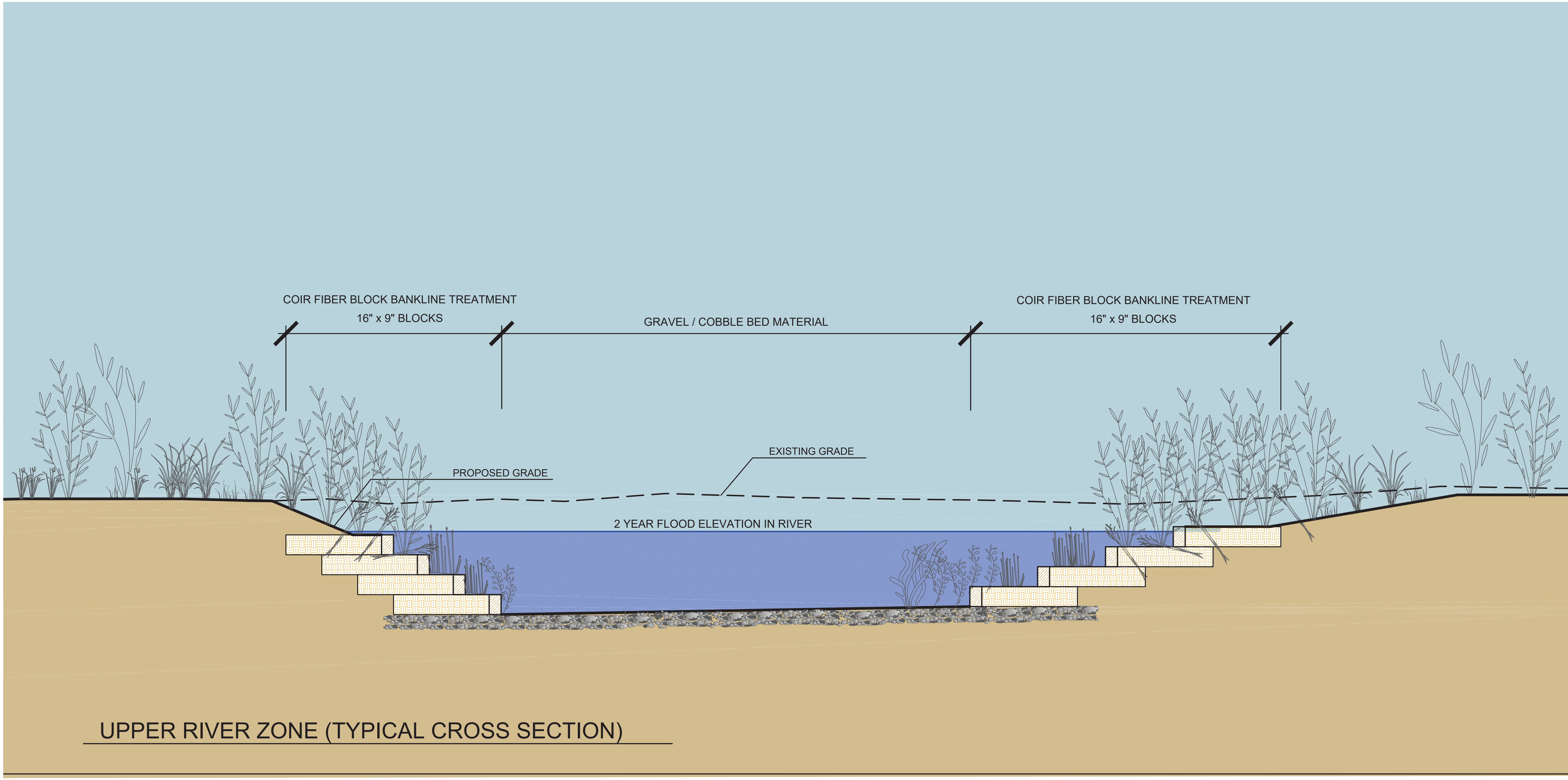
Coir Fiber Fabric and Block Installation Details

Provo River Delta Restoration Project
Sept 2019



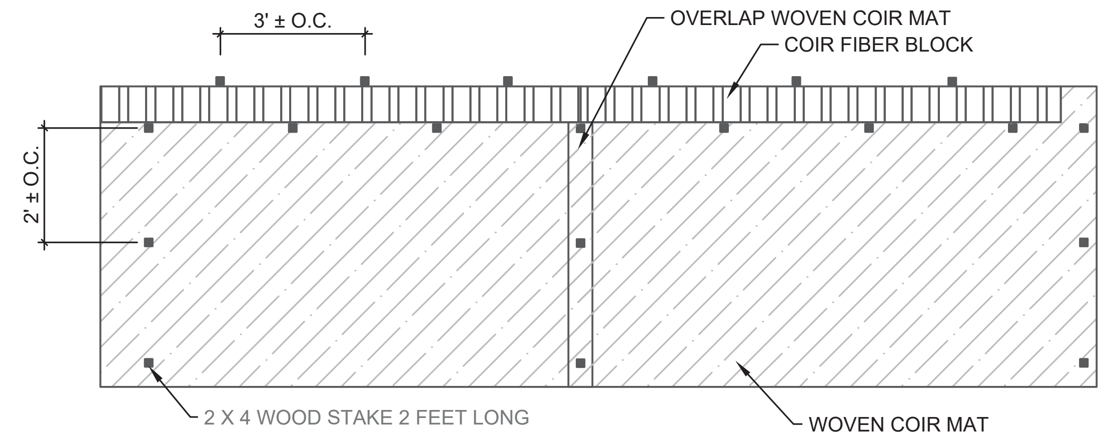
Prepared for: Utah Reclamation Mitigation and Conservation Commission

Prepared by: Allred Restoration and BIO-WEST

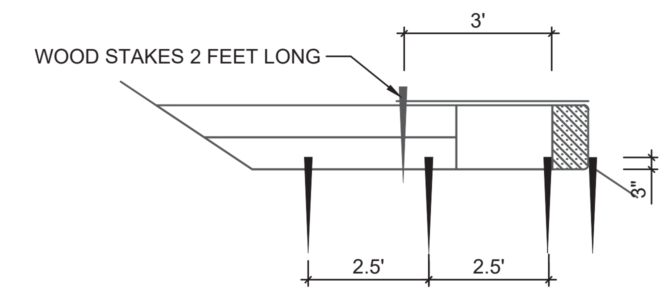

COIR FIBER BLOCK BANKLINE TREATMENT
16" x 9" BLOCKS
GRAVEL / COBBLE BED MATERIAL
COIR FIBER BLOCK BANKLINE TREATMENT
16" x 9" BLOCKS
EXISTING GRADE
PROPOSED GRADE
2 YEAR FLOOD ELEVATION IN RIVER
UPPER RIVER ZONE (TYPICAL CROSS SECTION)

COIR FIBER BLOCK BANKLINE NOTES:

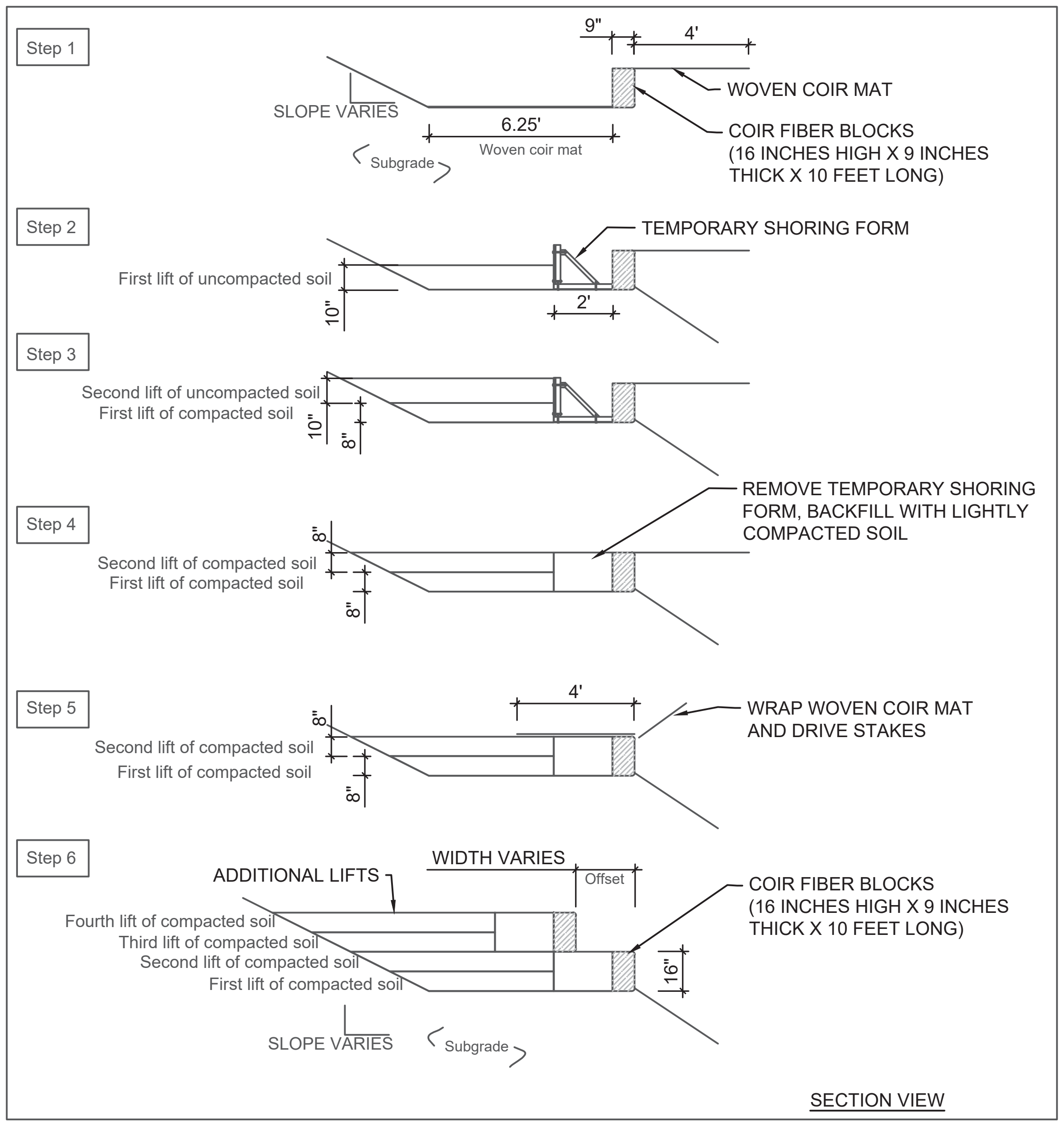
1. CONSTRUCT THE BANKLINE USING COIR FIBER BLOCK WITH ATTACHED COIR FABRIC TO ENCAPSULATE THE SOIL INTO FABRIC WRAPPED LAYERS. COIR BLOCK AND FIBER TO BE BioD-Block 16-400 AVAILABLE THROUGH ROLANKA INTERNATIONAL, INC. INSTALL ACCORDING TO MANUFACTURER'S SPECIFICATIONS.
2. ANCHOR THE ENDS TO THE TOP AND BOTTOM FABRICS WITH A 2 FOOT LONG WOOD STAKE. STAKE EVERY ± 30 INCHES, ASSURING THAT THE SEAM WHERE THE TWO ENDS OF THE FABRIC STRIP OVERLAP IS ANCHORED.
3. THE COIR FIBER BLOCK WITH ATTACHED COIR FABRIC IS 120 INCHES LONG AND 16 INCHES HIGH WITH A 9 INCH WIDTH FIBER BLOCK ON THE END. THE TOP FABRIC LENGTH IS 48 INCHES AND THE BOTTOM FABRIC LENGTH IS 75 INCHES. THERE IS A MINIMUM OF 12 INCHES OVERLAP ON TOP FABRIC.
4. OVERLAP MALE AND FEMALE ENDS WITH A MINIMUM OF 6 INCHES TO CREATE CONTINUOUS LONG SECTIONS.
5. MATERIAL OBTAINED FROM EXCAVATION MAY BE USED AS FILL FOR COIR FIBER BLOCK TERRACE LIFT OF COMPACTED SOIL, PROVIDED ORGANIC MATERIAL, RUBBISH, DEBRIS, AND OTHER OBJECTIONABLE MATERIALS ARE REMOVED.

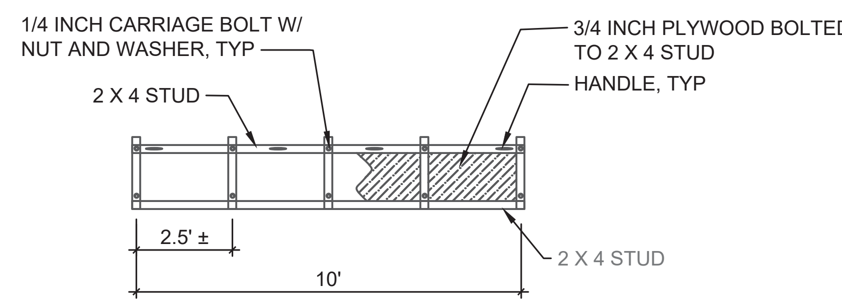


COIR FIBER BLOCK STAKING PATTERN PLAN VIEW

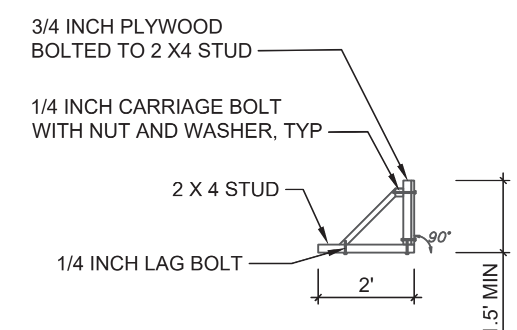


SECTION VIEW

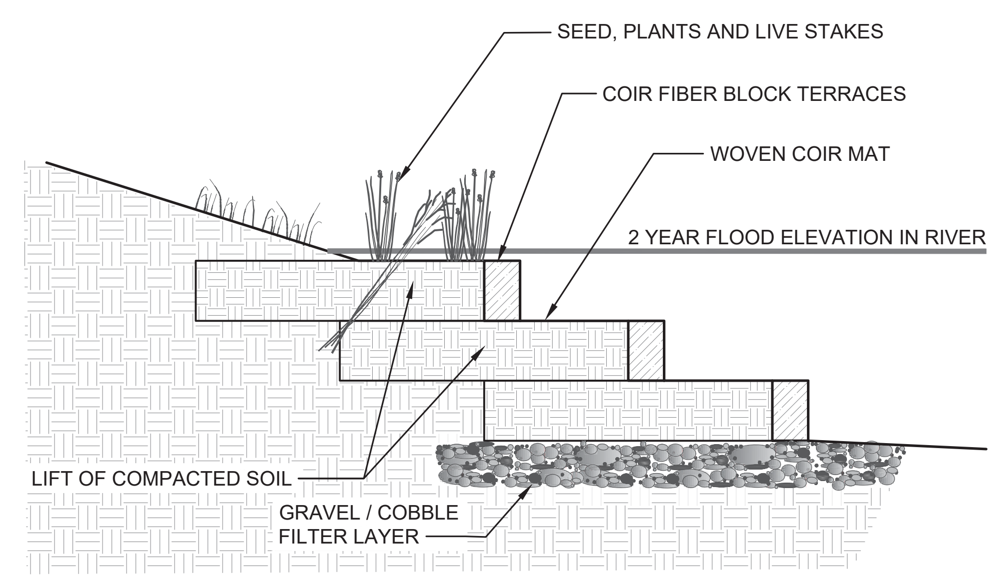




COIR FIBER BLOCK TEMPORARY SHORING FORM
FRONT VIEW FROM CREEK



SIDE VIEW



COIR FIBER BLOCK BANKLINE SECTION VIEW

CONSTRUCTION SEQUENCE OF COIR FIBER BLOCK BANKLINE TREATMENT

N.T.S.

General installation instructions for BioD-Block™ system

1. Before installing BioD-Block™ coir block system, clean and level the base of the eroded streambank. If necessary, strengthen the toe and the foundation using rocks as show in the diagram (Fig. 1). Place at least 2 inches of soil on the top and level the surface well.
2. To make 12-in tall soil lifts, use BioD-Block™ 12-300. To make 16 in tall soil lifts, use BioD-Block™ 16-300 or BioD-Block™ 16-400. BioD-Block™ 16-400 has longer fabric which will increase the safety of the constructed soil lifts.
3. Place a BioD-Block™ unit on level surface, keeping the female end towards direction of extending, and spread the bottom fabric. Anchor the bottom fabric to the ground well with suitable length metal staples or wooden pegs. Fill soil up to the height of the coir block (Fig. 1) and compact the filled soil well. Cover the compacted filled material with top fabric and anchor it well (Fig. 2).
4. If the water table is close to the top of the first soil layer, plant native plants on and around BioD-Block™ (Fig. 3a). If the soil surface is at the water level, do not plant now. Most of the woody plants including willows will not grow in submerged conditions.
5. Repeat the coir block installation procedure described above to make soil lift layers as needed to the top of the bank. On the very top layer, spread grass seeds.
6. The BioD-Block™ system has been further improved with invisible holes in the middle of the coir block for easy planting through the coir block, when necessary. Each planting hole is filled with a coir fiber plug. Live plant cutting can be planted through these holes during construction or later. Coir fiber plugs can be easily pulled out to expose the hole in the middle of the fiber block. When planting through the block is necessary, remove the coir plug and inset live plant through the hole into the middle of the soil layer.
7. Joining BioD-Block™ units can be done easily with their unique connection method. Male and female end connection in BioD-Block™ maintains continuity and structural integrity of the connected section. Fabric extending beyond fiber block at female end provides structural support for inserted male end. Insert male end of second BioD-Block™ to female end of first BioD-Block™ and drive stakes as shown in the picture. Drive stakes through overlapping fabrics of two BioD-Block™ units at their connection to avoid failures through the connection.
8. We recommend using minimum 1 in x 1.5 in x 15 in pine wedges at every 3 ft. to anchor the bottom fabric to the ground before filling with soil and 2 in x 2 in x 24 in pine wedges on the top fabric after filling with soil. These wedges may be substituted with 12 in or longer metal staples if necessary. Use of additional anchors will increase the safety factor of the constructed slope.

Planting through the coir block

Connecting coir blocks

The flexible BioD-Block™ system can be used in several different applications in many different forms of installations up to 1:1 slope. Designers and end users may consider unique site conditions to select best form of installation. Use of additional anchors will increase the safety factor of the constructed slope.

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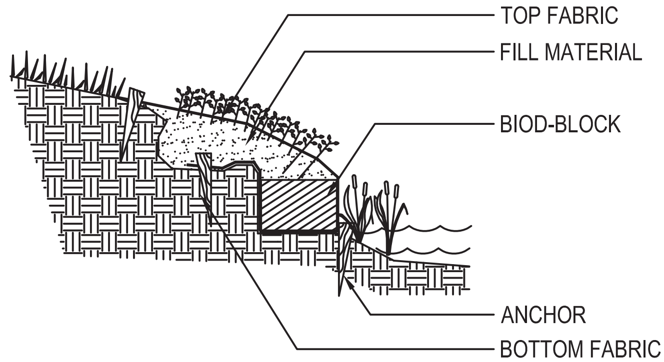

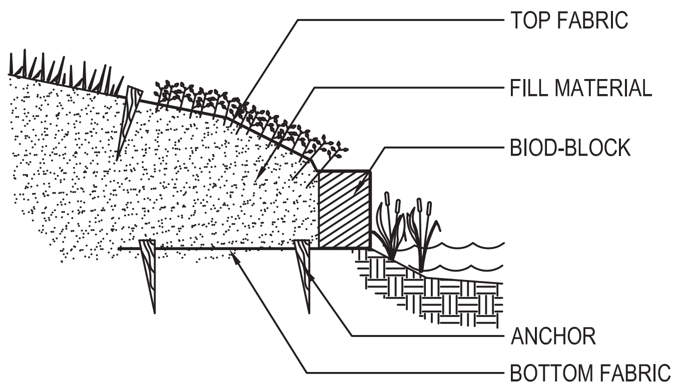

NOTES

1.DO NOT SCALE DRAWINGS.
2. USE NATIVE LIVE PLANTS AND CUTTINGS.

BIOD-BLOCK COIR BLOCK SYSTEM

SINGLE LAYER APPLICATION

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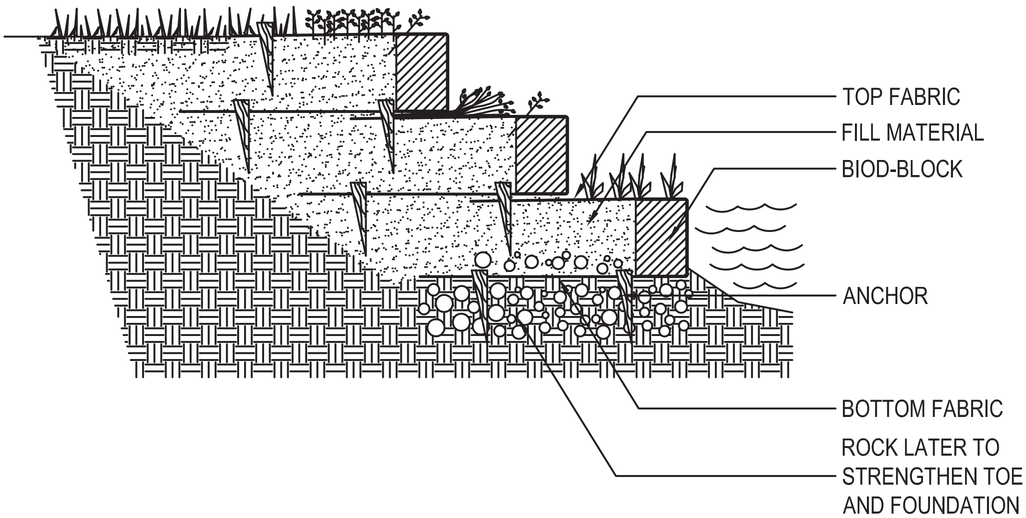

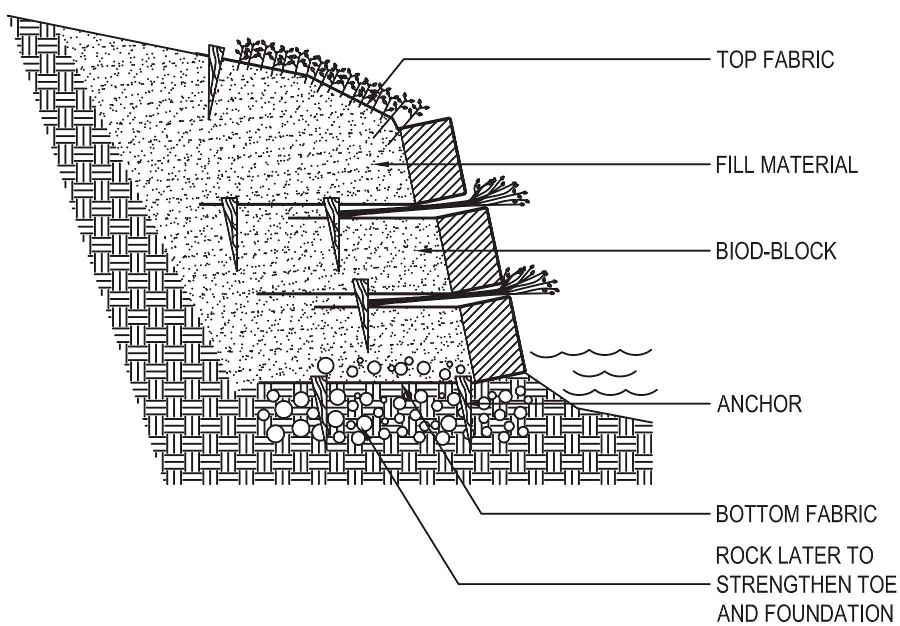

NOTES:

1. DO NOT SCALE DRAWINGS.
2. NATIVE PLANTS AND CUTTINGS SHOULD BE USED IN EITHER SITUATION.

BIOD-BLOCK COIR BLOCK SYSTEM TERRACED APPLICATION

WITH LIVE PLANTS AND CUTTINGS

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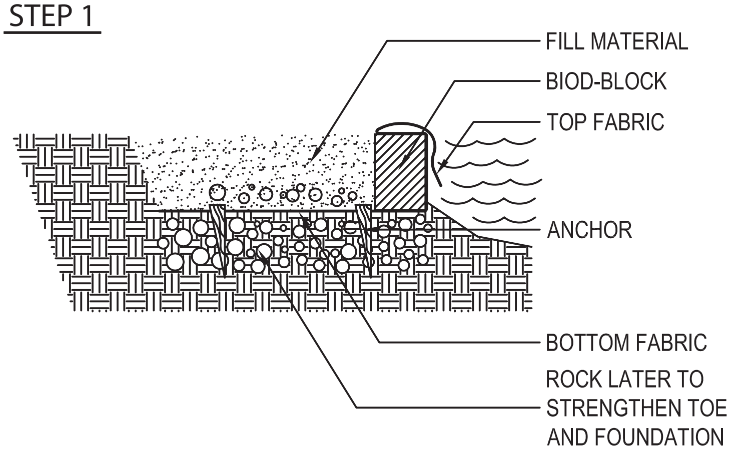
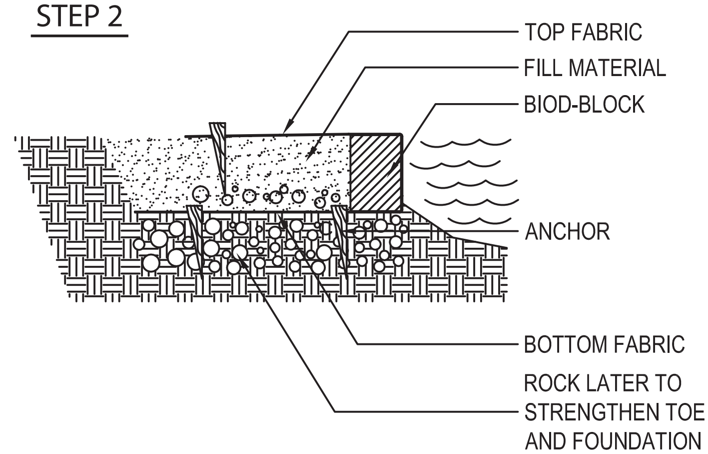
STEP 1



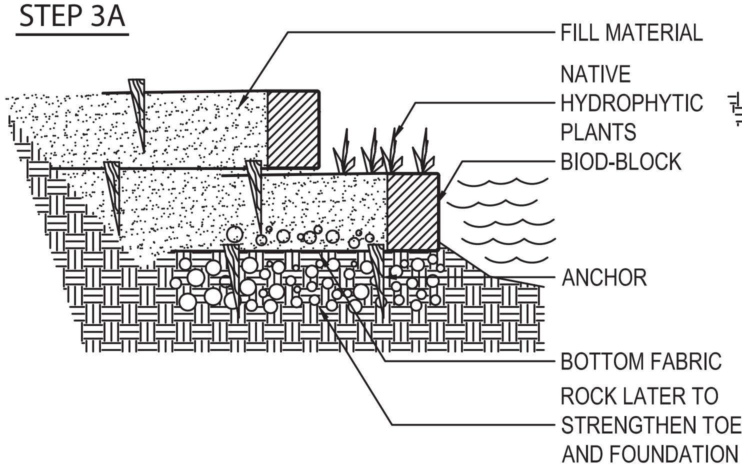
1.BEFORE INSTALLATION, CLEAN AND GRADE BASE OF STREAMBANK. STRENGTHEN TOE AND FOUNDATION USING ROCKS IF NECESSARY. PLACE UNIT ON LEVEL SURFACE, KEEPING FEMALE END TOWARDS DIRECTION OF EXTENDING, AND SPREAD THE BOTTOM FABRIC. ANCHOR DOWN BOTTOM FABRIC AND FILL WITH SOIL TO HEIGHT OF UNIT.

STEP 2



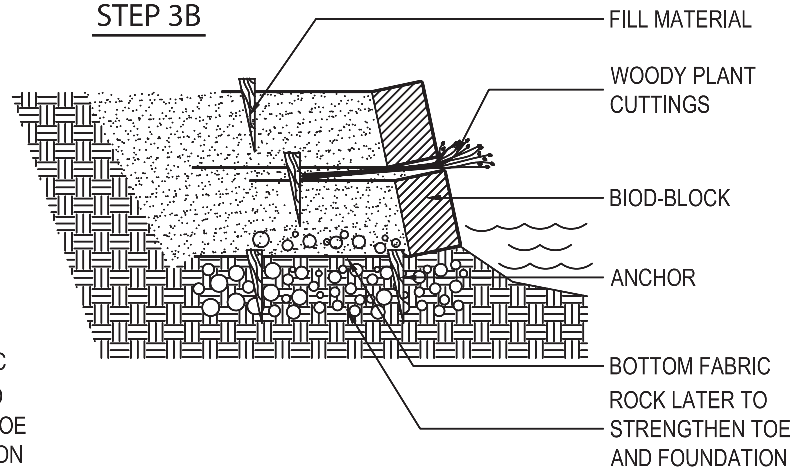
2. COVER THE FILL MATERIAL WITH TOP FABRIC AND ANCHOR IT.

STEP 3A



3A. IF WATER TABLE IS CLOSE TO TOP OF FIRST LAYER, PLANT NATIVE HYDROPHYTIC PLANTS ON AND AROUND BIOD-BLOCK. REPEAT EARLIER PROCEDURE AND INSTALL ANOTHER LAYER OF BIOD-BLOCK.

STEP 3B



3B. IF WATER TABLE IS BELOW FIRST LAYER, PLANT WOODY PLANT CUTTINGS ON THE BIOD-BLOCK. REPEAT EARLIER PROCEDURE AND INSTALL ANOTHER LAYER OF BIOD-BLOCK.

NOTES:

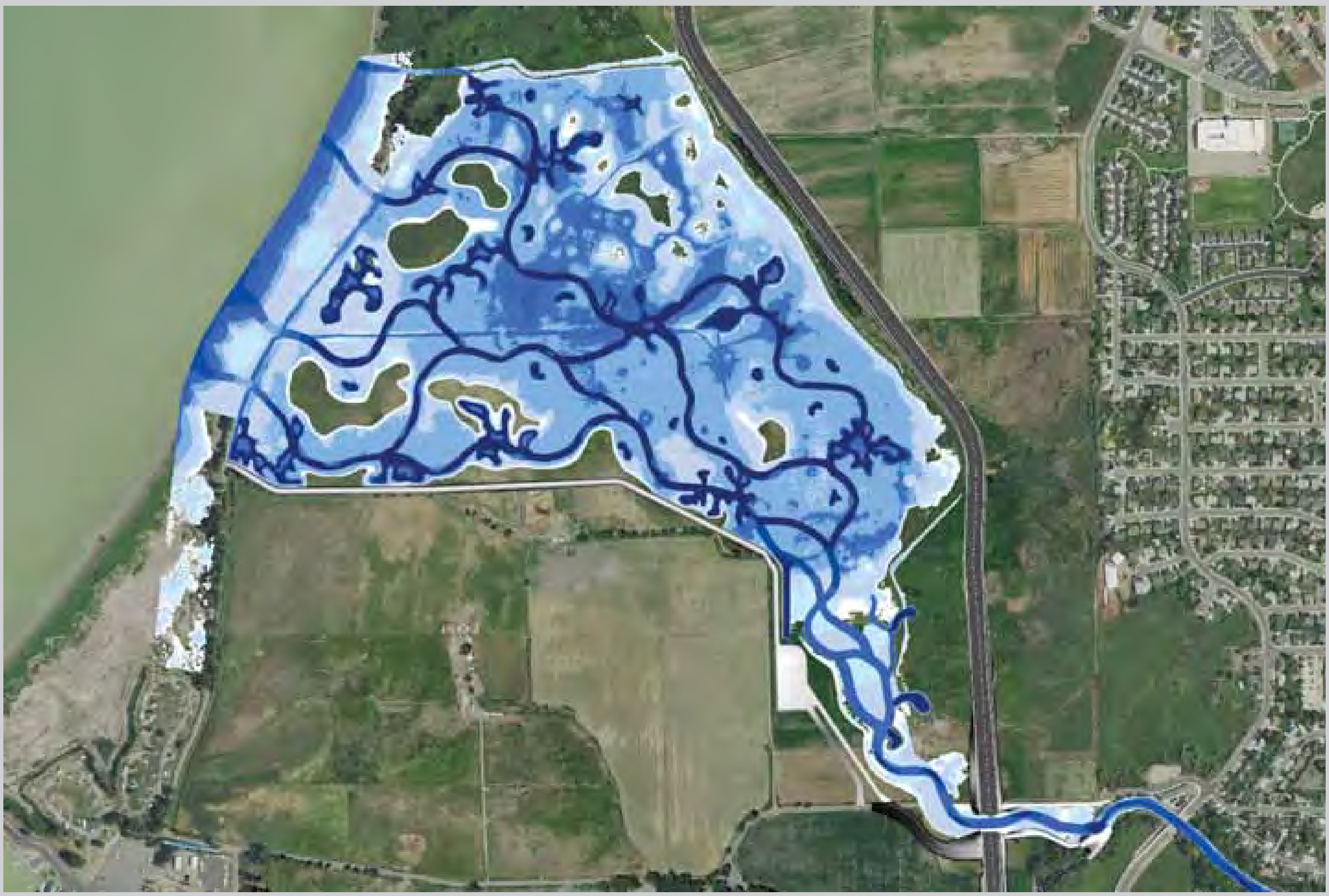
1. DO NOT SCALE DRAWINGS.
2. FABRIC EXTENDING BEYOND FIBER BLOCK FEMALE ENS PROVIDES STRUCTURAL SUPPORT FOR INSERTED MALE END.

BIOD-BLOCK COIR BLOCK SYSTEM INSTALLATION

APPENDIX C

Key Information Tables

Provo River Delta Restoration Project
Sept 2019



Prepared for: Utah Reclamation Mitigation and Conservation Commission

Prepared by: Allred Restoration and BIO-WEST

Key Information Tables

Spot Elevations of Note

Location	Elevation ft	Comments
Sill below Diversion Berm	4492.2	Accurate / Critical
Skipper Bay Outflow Invert	4487	+/- 0.1 ft / Critical
Skipper Bay Wide Connection to Utah Lake	4488 +/-	+/- 0.25 ft, but with scattered higher areas where trees are salvaged / Important
New Sill below Outlet Works on Diversion Berm	4491.5	Accurate/Critical
Bed elevation under Lakeview Parkway Bridge	4489.5 to 4489.9	Accurate/Critical - Finished by others

Delta Zone

Elevation Range	Vegetation Type
>4493	Upland
4488.5 to 4493	Riparian Wetland
4486 to 4489	Emergent Wetland
4482 to 4486	Submerged Aquatic
<4482	Open Water

Rock Sizing

Location / Use	Size Class	Tons
River Zone Bed Matrix & Skipper Bay Cap	3-inch plus	7100
River Zone Bed Mobile	1.5 inch minus	2876
Sill below Diversion Berm & Outflow Arches	18-36 inch	2215
Banks from Diversion Berm to Boat Harbor Drive	6 to 24 inch	2034
Grade Control at Skipper Bay Dike	6 to 12 inch	1800

Typical Widths and Depths

Channel Locations	Bottom Width	Typical Depth Riffles 125 cfs	Typical Depth Pools 125 cfs	Typical Depth Riffles 500 cfs	Typical Depth Pools 500 cfs
River	50 to 60 ft	0.5 to 1 ft	2+ to 3 ft	1.8 to 2.2 ft	3.5 to 5 ft
Delta	40 to 50 ft	N/A	5 to 7+ ft	N/A	5 to 7+ ft
Outflow	40 to 50 ft	0.3 to 1 ft	1-2 ft	0.3 to 1 ft	1-2 ft

Typical Velocities

Channel Locations	Typical Velocity Riffles 125 cfs	Typical Velocity Pools 125 cfs	Typical Velocity Riffles 500 cfs	Typical Velocity Pools 500 cfs
River	2 to 3 ft/s	1 to 2 ft/s	3 to 4 ft/s	2 to 3 ft/s
Delta	N/A	0.1 to 0.15 ft/s	N/A	0.2 to 0.3 ft/s
Outflow	1.7 to 2 ft/s	1.3 to 1.6 ft/sec	2 to 3 ft/s	1.5 to 2 ft/s

Side Slopes

Channel Locations	Typical Range Side Slope Inside of Bends	Typical Range Side Slope Outside of Bends	Typical Range Side Slope
River	3:1 to 4:1	1:1 to 2 : 1	
Delta Channels	1:1	1:1	
Delta Ponds			1:1 to 2:1
Outflow Channels			2:1