OPPORTUNITY PONDS WETLANDS CONSTRUCTION AND REVEGETATION[1]

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Abstract. The Opportunity Ponds Wetlands project is a 2.2 km^2 (544 acre) man-made wetland located 5 km (2.4 miles) east of Anaconda, Montana. A 0.9 km^2 (222 acre) area of wetland was planted in 2009, and a 0.65-km^2 (161 acre) area was planted in 2010. Careful design, excavation, site shaping, and diligent quality assurance have resulted in exceptional plant establishment. The area west of the wetland site was used as a repository for tailings from the smelting of copper ore. Remediation of the repository includes capping the tailings with soil material obtained from nearby borrow areas. The Opportunity Ponds Wetlands are being developed on depleted borrow areas. The goal of the Opportunity Ponds Wetlands revegetation is to create functional vegetation communities that reflect natural wetland habitats. Revegetation plans correlate to the topography and hydrology that have been established. Plants utilized are species observed within native wetland areas close to the site, and plant communities are arranged in "planting zones". Seed for plant production is collected locally and plants are grown under contract by a native plant nursery. Stringent specifications for plant production and placement were developed with EPA oversight. Planting and maintenance activities continue at the site, with final planting to be concluded in 2011. The survival of the 2009 and 2010 plantings has been very good and the water fowl and wildlife use is increasing. Preliminary monitoring results indicate that this project will achieve the goals of providing valuable cover material and creating valuable wetlands for habitat and mitigation.

Additional Key Words: Mitigation, Revegetation Design, Plant Specifications, Mycorrhizal Inoculation.

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Introduction

The Opportunity Ponds Wetlands is a 2.2 km^2 (544 acre) wetland creation project located 5 km (2.4 miles) east of Anaconda, Montana. The purpose of the excavation of the site and revegetation of the excavated area is to supply borrow material for capping the Opportunity Ponds Tailings Repository and for creation of mitigation wetlands. The first 0.9 km^2 (222 acres) of wetland were excavated in 2007 and planted in 2009, and an additional 0.65 km^2 (161 acres) were excavated and planted in 2010. Final excavation and shaping of an additional 0.63 km^2 (161 acres, the remainder of the project) has been completed and planting will occur in 2011. This paper briefly describes design and construction of the site, with a more detailed discussion of the revegetation design, plant and planting specifications, project oversight, results after two seasons, and lessons learned.

Background

Site Description

The project site is south of Highway 48 between Warm Springs and Anaconda, Montana, and west of the frontage road that follows I-90 (Fig. 1). The area west of the wetland project was historically used as a repository for tailings from the smelting of copper ore at the Anaconda Smelter. Remediation is being conducted by capping the tailings with soil material obtained from nearby borrow areas. The excavation of one of those borrow areas resulted in creation of the proper hydrology for supporting wetland vegetation. The Opportunity Ponds Wetlands is a mitigation wetland that is resulting from the successful establishment of wetland plant communities on that borrow area.

The climate of the site is semi-arid, with long, cold winters and periods of strong winds. The average precipitation is about 35 cm (14 inches) per year, about half of which typically occurs in May and June. The growing season is short; the last frost occurs about June 8, and the average first frost on August 28.

Typical emergent wetland vegetation in the vicinity includes sedge (*Carex spp.)* and rushes (*Juncus spp.)*. Shrub communities are primarily willows (*Salix spp.*) and water birch (*Betula occidentalis*). There are also extensive patches of aspen (*Populus tremuloides*). The wetlands of the area provides valuable habitat for white tail deer, moose, and waterfowl.

Figure 1. Vicinity map.

Project Goals

The goal of this project is to utilize the wet areas resulting from the excavation of materials for capping of tailings to create wetlands as mitigation for natural wetlands lost as a result of past mining or remediation activities. The excavated site was shaped to mimic nearby wetland reference sites, and planting was designed to create plant communities similar in species composition and community arrangement to native wetlands in the area.

Construction

Hydrology

The primary hydrologic source for wetlands in the Opportunity Pond Wetlands is groundwater. Historic groundwater data were used to develop a minimum groundwater elevation map (lowest recorded groundwater data) and corresponding 2001 maximum groundwater elevations. Based upon these determinations a low groundwater elevation map was developed for wetland design. The excavation plans ensure that historic low groundwater contours are intercepted by using the contours as the design water surface elevation.

The plans were then adjusted to restore a wetlands environment in each of the wetland cells (defined by wetlands dikes) such that the intercepted groundwater establishes a hydrologic gradient from un-saturated soil, to saturated soil, to surface water. This gradient provides a variety of hydrologic regimes that facilitate the establishment of heterogeneous wetlands plant communities.

The final shaping was conducted by using "Caterpillar Trimble Controls Technologies" machine control technologies that utilize digital site design information combined with accurate positioning technology (provided by a GPS base station) to automatically control dozer blades. This resulted in final contours that meet the goals of the design to provide proper hydrology for the planned plant communities without time consuming surveying and staking.

Contour dikes (e.g., cross-slope dikes) are located at key positions within the wetlands area to break the area into wetland cells, capitalizing on the natural slope of the land and the groundwater gradient. Islands and depressions are added to the regime to increase diversity and add irregularity. Adjustable water control structures within the dikes provide regulation of surface water levels and pool depths to control variations between high and low groundwater seasons or years.

Fine-grained cover soil material was applied to a depth of 15 cm (6 inches) in the planting zones at the upper elevation tapering to 5 cm (2 inches) at the lowest level of the planting design. De-watering activities were stopped after construction and soil placement was complete and the hydrology of the site was allowed to reach equilibrium (Fig. 2).

Figure 2. Site construction complete and ready for planting.

Revegetation

Species

The site was seeded immediately following the completion of construction. A hydrologically diverse wetlands seed mix was seeded in the planting zones as each cell was completed. The transition (upland grassland) mix was designed to apply 861 seeds per m^2 (80 seeds per square foot) and consisted of western wheatgrass (*Agropyron smithii*), sideoats grama (*Bouteloua* *curtipendula*), saltgrass (*Distichlis spicata)*, Great Basin wildrye (*Leymus cinereus*), thickspike wheatgrass (*Elymus lanceolatus*), sheep fescue (*Festuca ovina*), slender wheatgrass *(Elymus trachycaulus*), Canada wildrye *(Elymus canadensis*), red fescue *(Festuca rubra*), switchgrass *(Panicum virgatum*), and fowl bluegrass *(Poa palustri*). The wetland mix was designed at 861 seeds per m^2 (40 seeds per ft^2), and included western wheatgrass, blue joint reedgrass (*Calamagrostis canadensis*), water sedge (*Carex aquatalis*), Nebraska sedge (*Carex nebrascensis*), beaked sedge (*Carex utriculata*), tufted hairgrass (*Deschampsia caespitosa*), sloughgrass *(Beckmannia syzigachne*), fowl mannagrass (*Glyceria striata*), switchgrass, and weeping alkaligrass (*Puccinellia distans*). Immediately following seeding, monitoring plots were set up and located by GPS to provide information about seeding success.

Container-grown plants are species observed within the vegetative communities near the site. They were selected upon the hydrologic regime or indicator status (i.e., water depth, inundation tolerance) and documented plant association. Plants within communities are situated in niches along the topographic gradient in relation to hydrology (Table 1 and Table 2).

Table 1. Woody plant species.

Common name	Scientific name	Hydrologic zone
coyote willow	*Salix exigua*	Wet not saturated
Bebb willow	*Salix bebbiana*	Moist
Booth’s willow	*Salix boothii*	Moist
Drummond’s willow	*Salix drummondiana*	Moist
Geyer’s willow	*Salix geyeriana*	Moist
thin-leaf alder	*Alnus incana*	Moist
river birch	*Betula occidentallis*	Moist in Spring
red-osier dogwood	*Cornus stolonifera*	Moist
chokecherry	*Prunus virginiana*	Moderately dry
golden currant	*Ribes aureum*	Dry
Wood’s rose	*Rosa woodsii*	Very dry
common snowberry	*Symphoricarpos occidentallis*	Very dry

Table 2. Herbaceous plant species.

Common name	Scientific name	Hydrologic zone
small fruited bulrush	*Schoenoplectus microcarpus*	Standing water
three-square bulrush	*Schoenoplectus pungens*	Standing water
softstem bulrush	*Schoenoplectus tabernaemontani*	Standing water
creeping spikerush	*Eleocharis palustris*	Saturated
sloughgrass	*Beckmannia syzigachne*	Saturated
Nebraska sedge	*Carex nebrascensis*	Seasonally saturated
beaked sedge	*Carex utriculata*	Saturated
water sedge	*Carex aquatilis*	Saturated
woolly sedge	*Carex lanuginosa*	Saturated
Torrey's rush	*Juncus torreyi*	Saturated
fowl mannagrass	*Glyceria striata*	Moist to dry
blue joint reedgrass	*Calamagrostis canadensis*	Seasonally saturated
meadow sedge	*Carex praegracilis*	Moist to dry
tufted hairgrass	*Deschampsia caespitosa*	Moist
alkali cordgrass	*Spartina gracilis*	Moist
inland saltgrass	*Distichlis spicata*	Moist
Rocky Mountain iris	*Iris missouriensis*	Moist to dry
Colorado Rush	*Juncus confusus*	Moist to dry
weeping alkaligrass	*Puccinellia distans*	Moist to dry

Plant Specifications

Specifications for container plants for the project were developed to ensure optimum plant survival under the harsh conditions at the site. The plants were grown from seed or cuttings (both collected from the Upper Clark Fork River Basin in Deerlodge or Silver Bow Counties). Submission of data sheets listing the collection locations, amount of raw seed collected, and collection date were required to document appropriate seed sources. Acquisition of seed or cuttings for all species was the responsibility of the native plant nursery.

Plants were required to be well shaped, vigorous, and healthy, with a well-branched root system, and also free from disease, harmful insect and insect eggs, sun-scald injury disfigurement, or abrasion. Herbaceous plants and willows were grown in 164 cm^2 (10 cubic inch) containers, and shrub containers had a volume of 983 cm^2 (60 cubic inch) . All plants were required to have fibrous roots established. They were also to be easily removed from containers while maintaining their shape and intact root mass. Specifications called for all plants to be hardened off in climatic conditions similar to the planting site, and willows were to be stored in coolers in a dormant condition until planted. All woody plants were inoculated (in the nursery) with mycorrhizal fungi, and the grower was responsible for verification of colonization. Plants were delivered in a covered truck and shipped in cardboard boxes labeled with both botanical and common names and the quantity of plants in each box.

All deliveries were coordinated with planting oversight staff and staged to meet the needs of the planting crews and minimize the need to hold plants on site. Unacceptable plants (those not meeting the specifications listed above) were rejected and replaced. The determination of acceptable or unacceptable plants was made by an on-site wetland ecologist.

Planting Quality Assurance

Quality assurance is critical for successful wetland restoration. Since many variables cannot be controlled (e.g., weather, precipitation, soil conditions, and wildlife herbivory), it is critical to maintain the quality of factors that can be controlled. Oversight staff maintained copies of all submittals and certificates of compliance for plant materials in the field office. As the planting proceeded, a map of areas receiving plant materials along with the corresponding types and estimated quantity of vegetation planted in each area was completed. Oversight staff conducted a sampling procedure for plant installation, randomly sampling 20 plants twice a day to verify that plants were installed at proper hydrologic zones, spacing, and depth, and with good soil contact and proper vertical alignment. The results of this sampling were recorded on a “Plant Installation QA Checklist”. Based upon the results, oversight staff discussed any planting quality issues with the planting contractor and led a discussion with the entire planting crew at the next morning meeting. Daily logs were completed to document the activities of the contractor for each day worked. These logs outlined progress, problems, and resolutions, and areas of concern and potential future problems were addressed with the contractor the next day.

A plant placement chart was developed that illustrated proper planting zones for all species in relation to the water elevation (Fig. 3), and “Planting Prescriptions” were provided to the planting contractor and oversight staff. This included not only the size of patches to plant and the optimum hydrologic conditions, but also tolerance to inundation and salts and other factors that would guide proper placement and installation of each species.

In addition to these prescriptions, two 1-day plant installation training sessions were held each planting season. One session was for the planting of willows and shrubs, and the other for planting bulrush and herbaceous plants. These sessions covered proper use of planting tools, safety, care of plants, placement of plants and proper planting techniques. The training sessions also gave the background for the project and the potential benefits to the site, wildlife and future generations of Montanans. This ensured that all planters were aware of proper planting techniques and the need to adhere to them. Many of the planters and crew leaders were students or recent graduates with background in mining, environmental studies or biology. In response to requests from many of the crew, after work discussion and question and answer sessions were provided by EPA, Atlantic Richfield, and Herrera staff. These sessions provided a venue for increasing crew member understanding of the importance of the project. The value of these sessions was clearly demonstrated through the quality of the workmanship and the success of the revegetation efforts.

Planting Layout

Each planting zone was divided into discrete planting units so plant numbers could be determined based upon area (Fig. 4). This facilitated proper distribution of plants in the appropriate locations across the entire site. Boundaries of planting zones were marked on the ground as located by GPS. These boundaries were then reviewed and modified to reflect actual hydrology. The “on the ground” modifications resulted in proper placement of plant material based upon site conditions, and ultimately resulted in high survival rates.

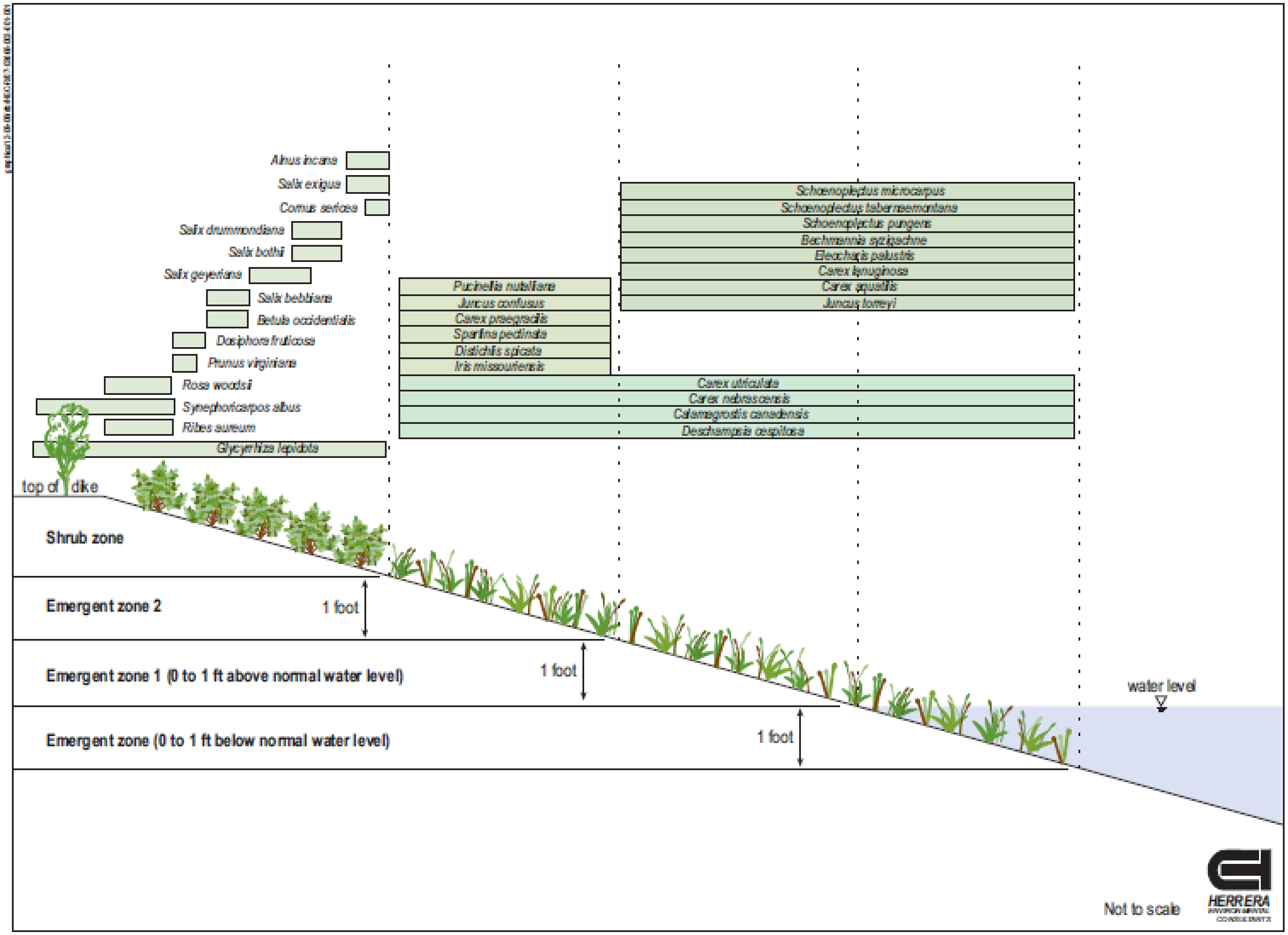

Figure 3. Planting zones.

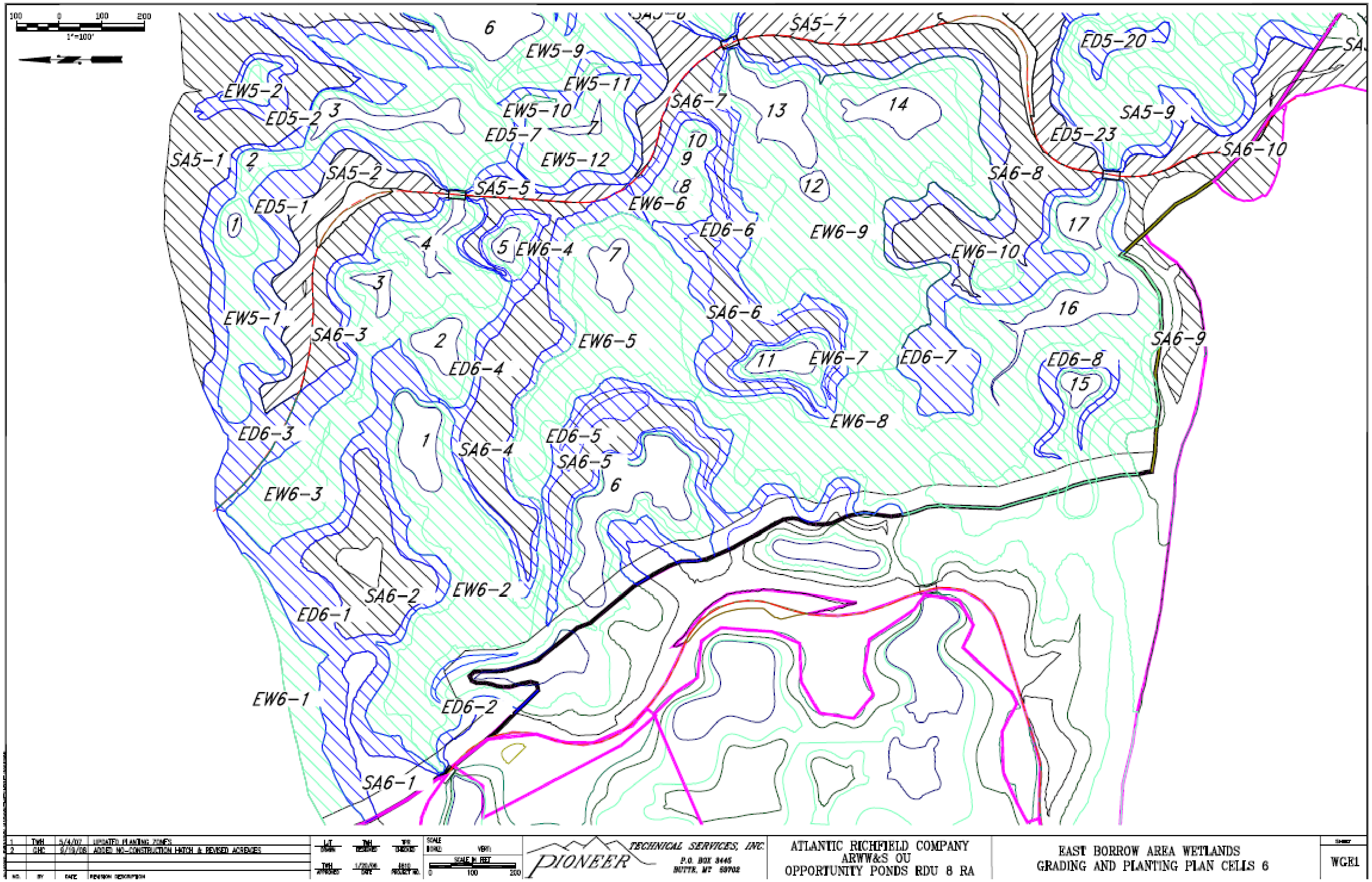

Figure 4. Planting units.

Plant Installation

The revegetation contractor implemented some innovative employee support actions to ensure the success of the project. The potential for injuries on the project was significant and the crew size was as high as 80 planters. Therefore, the importance of safety was highly stressed. Group stretching and yoga was led by a trained staff member following each daily tool box safety meeting. This resulted in no lost time accidents in the 2009 and 2010 planting seasons. Each planting crew was provided with a plant supply and tool trailer along with a portable restroom. Crewmembers were also supplied with backpack hydration systems and lunches were delivered to crews in the field each day. The extra cost of these actions was more than recovered by savings from increased productivity, safety and worker morale.

The planting schedule started in early May of each year with the planting of willows and shrubs. This was completed by June 1. The herbaceous planting started the second week in June and was completed by mid August each year.

Willows were planted in natural appearing bands in the lowest and most moist areas of the shrub areas with the streambank willow planted in a band close to the wettest areas and the other species were planted in patches upgradient from there. In 2009 and 2010, crews hand-planted over 105,000 willows.

Shrubs were planted in the appropriate hydrology for each species using two techniques: a "Rotary Planter" and hand planting in holes excavated by power augers. Shrub planting sites accessible by excavator were planted using a "Rotary Planter" (Fig. 5). This planter has a revolving magazine with a capacity of 50 plants and 3 rings that are controlled by the operator so three different species can be loaded and the operator can choose the best species to plant in any specific spot. The two seasons of shrub planting consisted of 38,000 plants.

Herbaceous plants were planted by hand, starting with bulrushes in areas of standing water. Sedges and rushes were planted in patches of appropriate hydrology, and remaining herbaceous species were planted in moisture conditions suitable for their establishment and long-term survival. Over one million herbaceous plants were installed in 2009 and 2010.

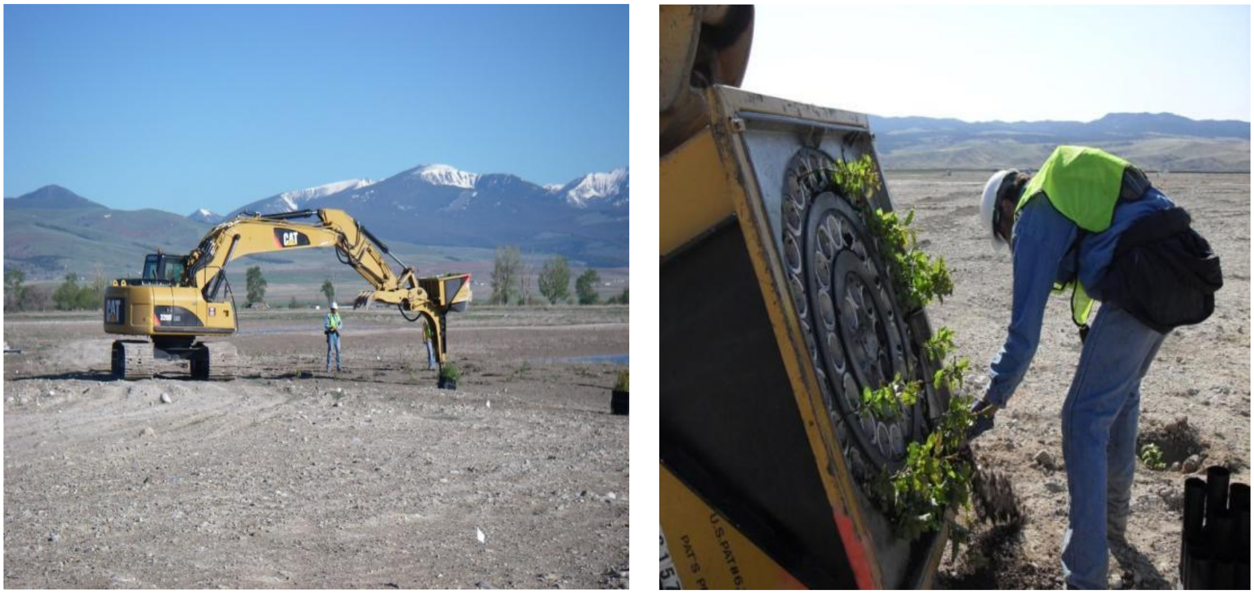

Figure 5. Rotary planter and magazine.

Revegetation Results

Plant survival was measured and documented by establishing circular plots. Plots were established in representative patches of each plant type immediately following installation. A stake was placed in the center of each plot, the location was recorded using a handheld global positioning system (GPS) unit, and the number of installed plants within each plot was recorded. The plot size was 8.1 m^2 (1/500 acre) for herbaceous plants and 4.05 m^2 (1/100 acre) for willows and shrubs, resulting in a sample of 7 to 15 plants per plot.

After two seasons, the 2009 herbaceous and bulrush plantings are rapidly spreading and increasing in density. Shrub and willow survival has decreased less than 10% from the first year results (Table 3), and densities are well within the long term shrub spacing goals of 6-10 feet. Many of the shrubs are also sprouting from the ground and increasing in density of stems per acre above the planted density.

Table 3. 2009 season planting survival.

Plant Type	Fall 2009 Survival	Fall 2010 Survival
Willows	90%	83%
Shrubs	91%	81%
Bulrush species	50% (This poor survival was the result of heavy goose predation on newly installed plants.)	Not measured. Spread of plants resulted in more plants than installed.
Other herbaceous species	95%	Not measured. Spread of plants resulted in more plants than installed.

First season shrub survival of 2010 plantings was down from 91% in 2009 to 66%, and willow survival was down from 90% in 2009 to 74% in 2010 (Table 4). The decrease in shrub survival was primarily due to the attempt in 2010 to plant the shrubs earlier in May to get better root establishment earlier in the season. There was a cold spell during the first week of planting, with temperatures well below freezing, resulting in damage to many of the shrubs delivered to the site but not yet planted. In addition, the attempt to plant shrubs and willows early in the season and at the same time caused a shortage of planting oversight and supervision. It is likely that this resulted in less than optimum placement of plants, and lower survival than the 2009 planting season. However, better initial orientation of crews and more stringent planting oversight of the herbaceous plants resulted in excellent survival of herbaceous plants. Earlier planting and an aggressive program of goose hazing to reduce predation resulted in an increase of bulrush survival from 50% (for the 2009 planting) to 89% (for the 2010 planting)

Table 4. 2010 season planting survival.

Plant type	Fall 2010 survival
Willows	74%
Shrubs	66%
Bulrush species	89%
Other herbaceous species	91%

Lessons Learned

There were a number of important lessons learned in the implementation of this project to date. Most are related to the fact that revegetation projects have a multitude of uncontrollable variables, and it is critical to invest in quality control and quality assurance of those which can be controlled. On this project, we could not control where the actual hydrology of the site would equilibrate, but could control where we placed the planting unit boundaries to match on the ground hydrology. We could not control the invasion of geese that damaged the bulrush planting, but we could modify the timing of the planting to give plants time to establish before the midsummer flocks of geese appeared on the site. We could not control the late spring cold snap, but we could move planting dates later in the spring and provide protection for staged plants to protect them from frost damage. We also learned that careful oversight and quality assurance of planting can result in very successful establishment of wetland vegetation.

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