# Billy Creek Natural Area
# Riparian Restoration Project

# Task 9: FINAL REPORT

## AWPF Grant 08-154WPF
**Town of Pinetop-Lakeside, AZ**

**January 2014**

Natural Channel Design, Inc.

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# Riparian Restoration Project

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**January 2014**

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River Engineering and
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***The staff of Natural Channel Design, Inc. would like to thank the Town of Pinetop – Lakeside and the Arizona Water Protection Fund for their support of this worthwhile project.  John Vuolo of Pinetop – Lakeside and Rodney Held of the Arizona Water Protection Fund were especially helpful.  Without their advice, support and enthusiasm the project would not have been as successful.***

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## GLOSSARY

**Exotic species**
Species (plant or animal) not native to an ecosystem, often established purposefully or inadvertently by human activity. Some exotic species have fewer natural population controls in their new environment, becoming a pest, nuisance, or invasive species.

**Geomorphic**
Related to the physical properties of the rock, soil, and water in and around the stream.

**Hydraulics**
In contrast to hydrology, hydraulics is the science of water movement in confined pipes, pipe systems, and natural and artificial channels (such as canals and rivers).

**Hydrology**
The study of the movement, distribution, and quality of water throughout the Earth, and thus addresses both the hydrologic cycle and water resources.

**Riparian area**
The interface between land and a stream. Riparian zones occur in many forms including grassland, woodland, wetland or even non-vegetative. In some regions the terms **riparian woodland**, **riparian forest**, **riparian buffer zone, riparian strip, or riparian corridor** are used to characterize a riparian area.

**Sinuosity**
The amount of bending, winding and curving in a stream or river.

**Stream morphology**
The form and structure of the stream or river.

**Watershed**
A region or area in which all the water drains into a specific river, stream, or body of water.

## EXECUTIVE SUMMARY

The final report of the Billy Creek Natural Area Riparian Restoration Project summarizes each step of the project from its commencement to completion. The report is organized into Background, Inventory and Assessment, Design, Construction and Implementation, Monitoring, and Public Outreach. At the end of the report, a Lessons Learned section summarizes stumbling blocks, modifications, or successes that occurred while working six years to complete this worthwhile restoration project.

The project site lies at 6,800 feet elevation in the eastern Arizona community of Pinetop-Lakeside. The project lies within properties managed by the Town, but surrounded by private residences. The goal of the restoration project is to enhance the aquatic, biological, and physical resources of the riparian corridor. During the initial assessment, the channel profile was determined to be stable; however two locations within the project area had abandoned, and failing earthen berms that were causing instability and erosion as the water was being rerouted around the structures. This contributed to high sediment loads entering the channel on a regular basis and the erosion was encroaching onto private lands.

Project tasks included in the AWPF grant were:

- Task 1: Permits, Clearances and Personnel
- Task 2: Site Assessment Plan
- Task 3: Design Plan
- Task 4: Monitoring/Outreach Plan
- Task 5: Implement Earthwork and Construction
- Task 6: Implement Revegetation
- Task 7: Implementation of Monitoring Plan
- Task 8: Public Outreach
- Task 9: Final Report

The contract was awarded in 2008 and the project completed in 2013. The initial implementation of the restoration design plan took place for two weeks in October 2009. A second construction phase to repair flood damage and install additional plantings took place in October 2011. The project was monitored five times post-construction starting during the fall of 2009 with the final monitoring taking place October 2013. Monitoring methods included cross-section surveys, bed particle analysis, and repeat photo monitoring. Structural elements and vegetation were visually inspected each year to evaluate structural soundness and growth, respectively.
Public outreach for the project occurred several times throughout the life of the grant, with a final openhouse to showcase the final results occurring in October 2013. A sign outlining the project was installed during the fall of 2012.

The project site has responded well to the applied restoration practices. The eroding banks have become vegetated and plantings are becoming established. The weir grade control structure is functioning and maintaining the pond in Reach 1. The Town as well as the landowners adjacent to the project areas are pleased with the results.

# BACKGROUND

## PROJECT DESCRIPTION

The project is located on Billy Creek in the Town of Pinetop-Lakeside; Section 25, Township 9N, and Range 22E. The project area is located behind the Moonridge Mountain Estates subdivision. The Town of Pinetop-Lakeside is rapidly growing with development encroaching upon the natural landscapes that are the area's trademark. See Figure 1 for project site location. Billy Creek flows through land owned by Navajo County that is on a 100-year lease to the Town of Pinetop-Lakeside. The Town wishes to protect the riparian corridor and long term plans are to eventually create a linear natural park through the length of the community.

Billy Creek is largely undeveloped but several homes have been built along the creek in recent years. Improvements at some properties and added recreational pressure have unknowingly placed stresses on or impacted stream function and the associated riparian vegetation and habitats. The Town completed a survey of the project area in 2007. Two large earthen dams are located within the project area and were constructed sometime in the past to impound flows. Both dams had breached and the stream flowed around them resulting in gullying as the stream attempted to return to the natural stream elevation. The breaches initiated active lateral erosion downstream of both structures decreasing water quality and impairing the riparian community. The project was divided into two Reaches. In Reach 1, at the upstream berm, two private landowners and the city own adjacent property where improvements took place. At the second berm, downstream, the city owns all of the property surrounding the area where improvements took place.

The "natural channel" or geomorphic approach was used in the assessment and restoration design. The approach uses reference conditions to assess the existing condition of the project area, determine the potential, and create a design to move toward the stream channel's potential condition. A variety of low impact structural and non-structural practices are used to restore system function including toe rock and bioengineering with native vegetation. A rock weir was installed as a grade control structure. The aim, by implementing these specially engineered practices, is to increase stream stability and restore stream function, improve water and sediment transport functions and enhance associated aquatic and riparian habitat. U.S. Fish and Wildlife Service personnel were especially interested in maintaining existing pool habitat above the berm in Reach 1 to support potential Chiricahua leopard frog (*Lithobates chiricahuensis)* populations. Additional benefits that the Town of Pinetop-Lakeside can plan on receiving from this project include a healthy natural area to enjoy and take pride in, less safety hazards usually associated with high creek flows, cleaner water, and less property damage that occurs because of a poorly functioning stream channel.

## PROJECT OBJECTIVES

The purpose of the Billy Creek Natural Area Riparian Restoration Project was to enhance, restore, and protect the riparian function and habitats in two reaches of Billy Creek and create a community constituency to support long-term protection and enjoyment of the urban riparian corridor through Pinetop-Lakeside. Specific objectives include:

1. Identify/remove impairments to restore natural stream function to Billy Creek and reduce flood event related damage.
2. Enhance native riparian vegetation and habitats.
3. Increase public awareness and support for the riparian corridor and associated habitats of Billy Creek by facilitating access in a way that will enhance educational value and protect resources.

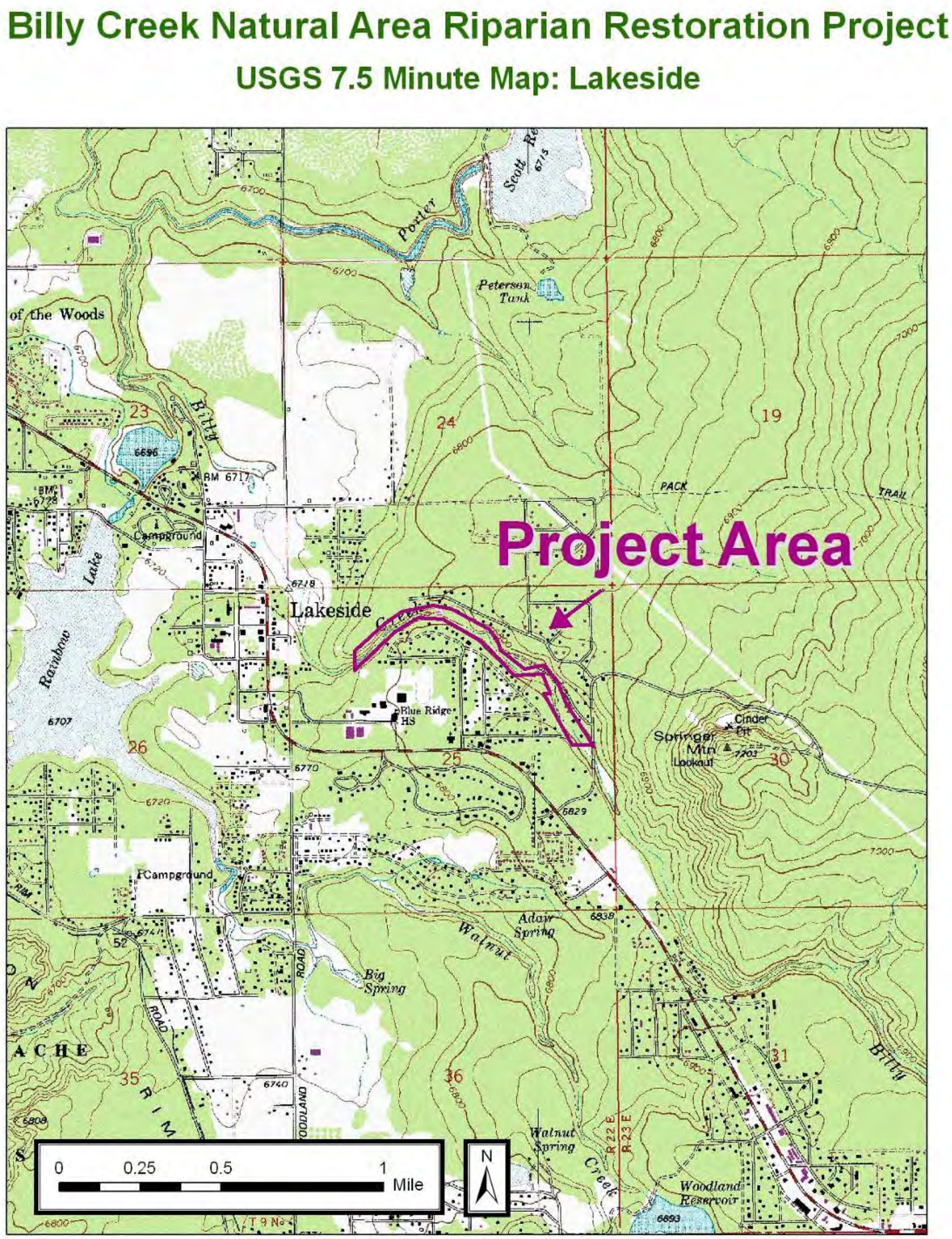



**Figure 1. Project site location in Town of Pinetop-Lakeside, AZ.**

## PROJECT TIMELINE

*The following table shows significant milestones for the project.*

**Table 1. Project Timeline**

| Year | Month | Task |
|---|---|---|
| 2007 | June | AWPF Application |
| 2008 | July | Project Contract Finalized |
| 2008 | September | Site Assessment Plan Completed |
| 2009 | August | Initial Design and Permitting Completed |
| 2009 | October | Initial Construction & Revegetation |
| 2009 | December | Baseline Monitoring |
| 2011 | October | 2nd Construction & Revegetation |
| 2013 | May | 8 Month Contract Extension Approved |
| 2013 | September | Final Monitoring |
| 2013 | October | Final Public Outreach |
| 2013 | December | Final Report |

## PROJECT BUDGET

**Table 2. Estimated and actual budget.**

| Task | | Original Budget | % of Project Funds | Actual Budget Spent | % of original budget |
|---|---|---|---|---|---|
| Task 1 | Permits, Clearances & Authoizations | $10,419.00 | 4.2% | $10,384.66 | 99.7% |
| Task 2 | Site Assessment Plan | $3,045.00 | 1.2% | $3,045.00 | 100.0% |
| Task 3 | Design Plan | $16,912.00 | 6.8% | $16,887.15 | 99.9% |
| Task 4 | Monitoring/Outreach Plan | $9,150.00 | 3.7% | $9,132.38 | 99.8% |
| Task 5 | Construction | $100,215.00 | 40.3% | $96,020.85 | 95.8% |
| Task 6 | Revegetation | $49,886.00 | 20.0% | $48,934.70 | 98.1% |
| Task 7 | Monitoring | $38,160.00 | 15.3% | $38,158.85 | 100.0% |
| Task 8 | Public Outreach | $14,567.00 | 5.9% | $10,140.96 | 69.6% |
| Task 9 | Final report | $6,472.00 | 2.6% | $6,472.00 | 100.0% |
| | | | | | |
| | Total | $248,826.00 | 100% | $239,176.55 | 96.1% |

## TECHNICAL APPROACH

A stream adjusts its size, slope, and sinuosity to accommodate a range of stream flows and to move sediment through the system. Generally speaking, a stream is constantly dissipating energy as it moves downstream. In a low gradient channel, bars, meanders and a broad floodplain are important features for dissipating excess energy. If unable to expend this energy the channel is inherently unstable and prone to lateral and/or vertical erosion, especially during large flow events.

Stream channels are created and maintained by moderate, frequent flood events (Leopold 1994) with return intervals in the range of one to two years (Moody et al 2003). In many gravel bed streams, these moderate, frequent flows have been shown to carry the greatest amount of sediment over time (Andrews, 1980) and is considered the stream forming flow, channel maintenance flow, or bankfull flow. The stability of any natural channel is dependent on an appropriate dimension, pattern, and profile of the bankfull channel and associated floodplain (Leopold, Wolman, & Miller, 1964). A natural channel approach to design seeks to identify the stable geomorphic dimensions of a channel and incorporate those into designs to meet specific objectives. In this project, self-maintaining bedforms and associated aquatic habitats were carefully characterized and evaluated to meet project enhancement objectives. Closely matching the central tendencies of the natural channel, results in a design that works with the existing channel rather than against it. The approach achieves greater success with least maintenance cost.

The geomorphic design approach involves four distinct steps: 1) characterization of existing physical and biological parameters, 2) identification and characterization of reference conditions that represent the full potential of the system, 3) evaluation of existing conditions against reference to determine enhancement needs and 4) development of specific design prescriptions to move the system towards “reference” condition.

The goal of the project was to restore stream function and enhance the physical and ecological resources of the riparian corridor within the project area. Within the framework of the natural channel morphology, a thorough assessment of existing conditions of the physical and biological components within the project reaches was undertaken. The existing channel/floodplain and associated riparian vegetation community was evaluated against a  morphologic “reference” condition developed from assessment surveys. The reference condition represents the full potential of the system consistent with project objectives. Figure 2 diplays an aerial view of the project site and the two reaches targeted for work.

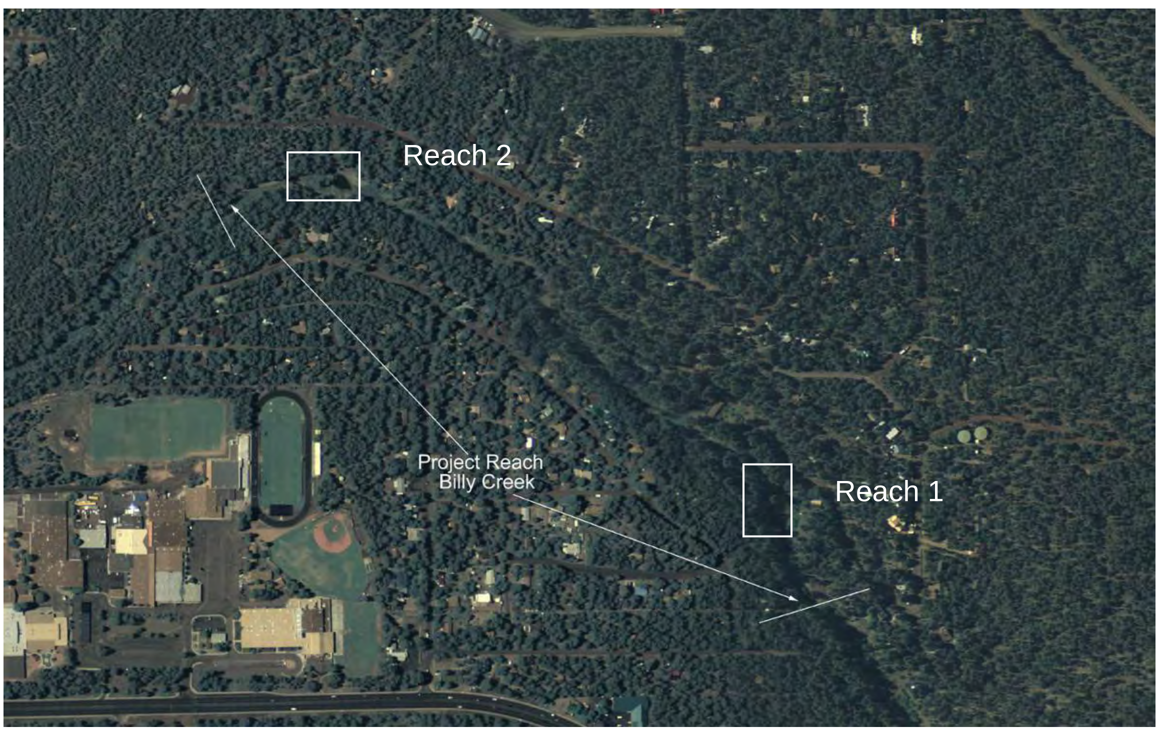



**Figure 2. Aerial view of the extent of project site.**

## INVENTORY/ASSESSMENT

An inventory and assessment of the project area was required to understand existing problems and conditions, and helps identify the potential of the project area. An assessment was conducted along a 1-mile stretch of Billy Creek. Within the project area, two reaches of intense work were identified (Figure 2 and Table 3). Aerial photos were obtained for the area and superimposed on a topographic survey conducted as part of the project assessment at the site. These photos and maps served as the foundation for inventory, assessment, and design.

**Table 3. Project reach information.**

| Property | STA | Reach Length | Avg. Slope | Sinuosity |
|---|---|---|---|---|
| Reach 1 | 0+00 to 6+00 | 600 ft | 0.002 | 1.1 |
| Reach 2 | 10+00 to 16+00 | 600 ft | 0.005 | 1.1 |

## HYDROLOGY

Billy Creek at the project area has a total watershed area of approximately 15.2 square miles (Figure 3). The stream originates near Little Brushy Mountain at an elevation of approximately 7600 feet and 7 miles away from the project area. The project area is at an elevation of approximately 7000 feet, the vegetation is dominated by Ponderosa Pine and Gambel Oak. It is situated in a narrow basalt canyon within the town of Pinetop-Lakeside. There are numerous homes along the banks of the stream. Billy Creek typically flows in the spring with snow runoff and in the late summer due to monsoon storms, it freezes in the winter and is intermittent in dry periods.

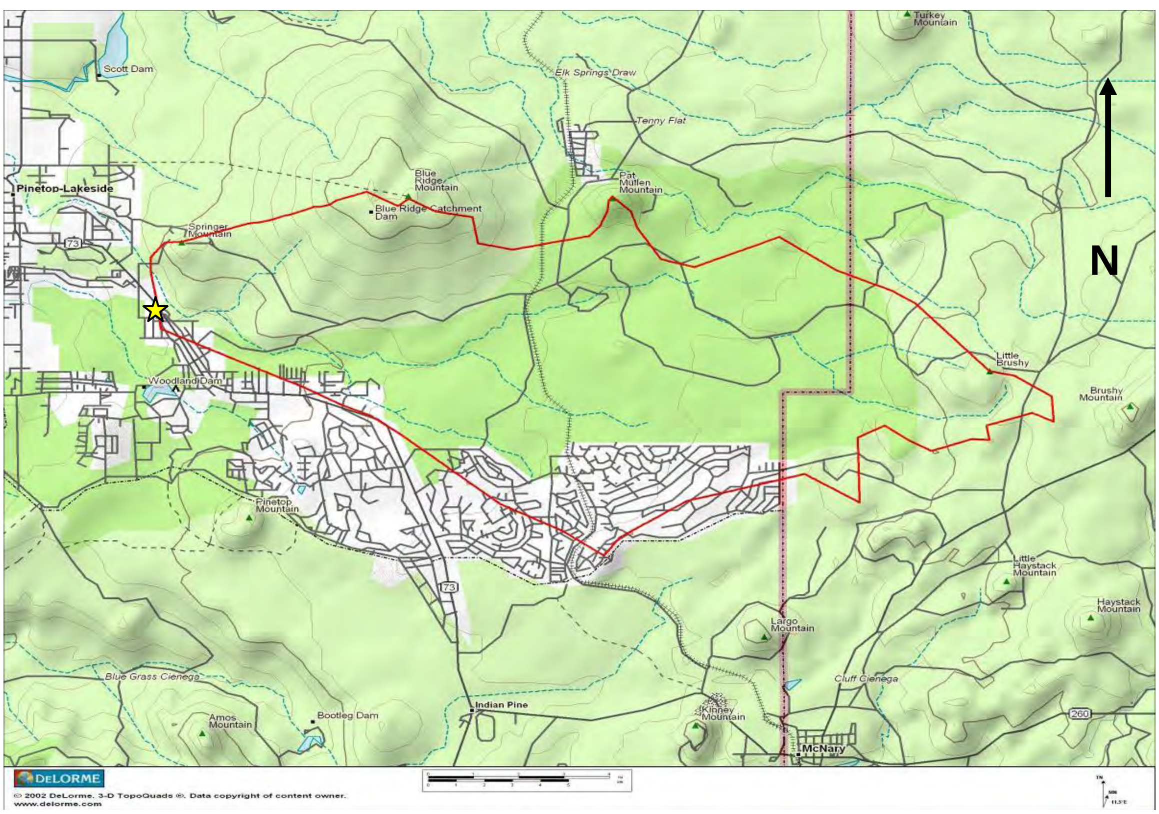



**Figure 3. Billy Creek Watershed.**

*The red line delineates the watershed and yellow star shows approximate project location.*

### REGIONAL HYDROLOGY ASSESSMENT

The purpose of a hydrological analysis is to estimate the amount of water that flows through the project site during various frequency runoff events, thus providing information about what type of treatments work, as well as how large and how strong they need to be in order to function properly.

There is no stream flow data from Billy Creek at the project site so project hydrology was characterized by estimating discharges for various recurrence intervals (RI) using an analysis of flood frequency. Recurrence interval is the probability of a flood of a certain magnitude or greater will occur. The most accurate method to evaluate flood frequency is through the direct use of stream flow data at the site. However, often this data is not available and other methods using data from nearby gages is used to create regional discharge relationships.

A combination of methods was used in this analysis. First, the NRCS regional hydrology method that uses regression equations based on watershed areas generated from nearby gages was used to estimate discharges (SCS 1972). Nine regional gage sites with relatively long flow records provided a robust data set and increases confidence in these results (see Appendix B for data). Second, regression equations developed by USGS based on watershed area and mean annual precipitation under the National Flood Frequency (NFF) program was used for comparison (USGS 2002). These discharge values are based on 165 regional gage stations but have standard errors ranging from 46% to 59% depending on the discharge. The estimates for each model were different but within the margin of error for each model. A rounded average of the two methods was used to provide an estimated flood discharge for the project area. The discharge from each model and estimate for the project are shown in Table 4.

**Table 4. Estimated discharges for Billy Creek at the project site for various flood frequencies.**

| Method | Estimated Discharge | | | | |
|---|---|---|---|---|---|
| | 1.5 -year (cfs) | 2-year (cfs) | 5-year (cfs) | 10-year (cfs) | 25-year (cfs) |
| NRCS Reg Hydrology | 64 | 97 | 219 | 329 | 521 |
| NFF program | 72 | 120 | 199 | 255 | 328 |
| Project Site Estimates | 70 | 110 | 210 | 290 | 425 |

## STREAM CHANNEL MORPHOLOGY

Billy Creek is a relatively low gradient, gravel bed, low sinuosity stream with a well-vegetated channel through the project reach. The valley is narrow and confined by basalt. Two ponds affect the gradient of the stream and other impacts include retaining walls built by homeowners that affect the flow of the stream and promote ponding. The channel is quite straight as it is confined by bedrock, and steep valley slopes. The following sections describe the characterization of the channel dimension, pattern and profile.

### CHANNEL DIMENSION

In addition to the topographic survey, representative cross-sections were surveyed to characterize channel dimension. Bankfull elevation was determined by identifying consistent physical features representing floodplain elevation along the longitudinal profile (Dunne & Leopold, 1978). The bankfull elevation was transferred to cross-sections to develop channel dimension (Table 5). Delineative criteria are used to describe channel morphology and classify the site in the Natural Channel Classification System (Rosgen 1996) are given in Table 6.

Natural fluvial processes have shaped and maintained the channel for the past decades and it is assumed that channel and floodplain dimensions represent natural conditions. To validate this hypothesis, bankfull morphology was compared with regional data. Project morphological data was compared with regional curves (the correlation of bankfull channel cross-sectional area as a function of watershed area) and found to be consistent (Figure 4). As a result, existing channel dimension at the representative cross-sections for all reaches appear to represent natural, stable conditions and the values were used for design purposes. The existing channel and floodplain dimension is considered stable and appropriate.

**Table 5. Channel dimension values.**

| XS | XS Area (sq ft) | Bkf Width (ft) | Mean Depth (ft) | Max Depth (ft) | Floodprone Width* (ft) | Super Floodprone Width (ft) |
|---|---|---|---|---|---|---|
| **1** | 19.1 | 14 | 1.4 | 1.6 | 59 | 70 |
| **2** | 18.4 | 14 | 1.3 | 1.4 | 58 | 65 |
| | | | | | | |
| **Average** | 18.8 | 14 | 1.35 | 1.5 | 58.5 | 67.5 |
| *Floodprone width is defined as the width of the floodplain at an elevation twice maximum depth of the bankfull channel and describes the area available for spreading moderate flood flows. | | | | | | |
| **Super Floodprone | | | | | | |

**Table 6. Delineative criteria.**

| XS | W/D Ratio* | Ent Ratio** | Super Ent Ratio*** | Slope (ft/ft) | D50 | Sinuosity**** | Stream Type |
|---|---|---|---|---|---|---|---|
| **1** | 10.2 | 4.2 | 5 | -0.002 | gravel | 1.1 | C4c |
| **2** | 10.7 | 4.1 | 4.6 | -0.005 | gravel | 1.1 | C4c |

*Width-Depth Ratio is defined as bankfull channel width divided by mean bankfull depth and describes the bankfull channel shape.
**Entrenchment Ratio is defined as floodprone width divided by bankfull channel width and describes the floodplain area available for spreading moderate flow events.

***Sinuosity is defined as stream length divided by valley length and describes the relative meander of the stream.

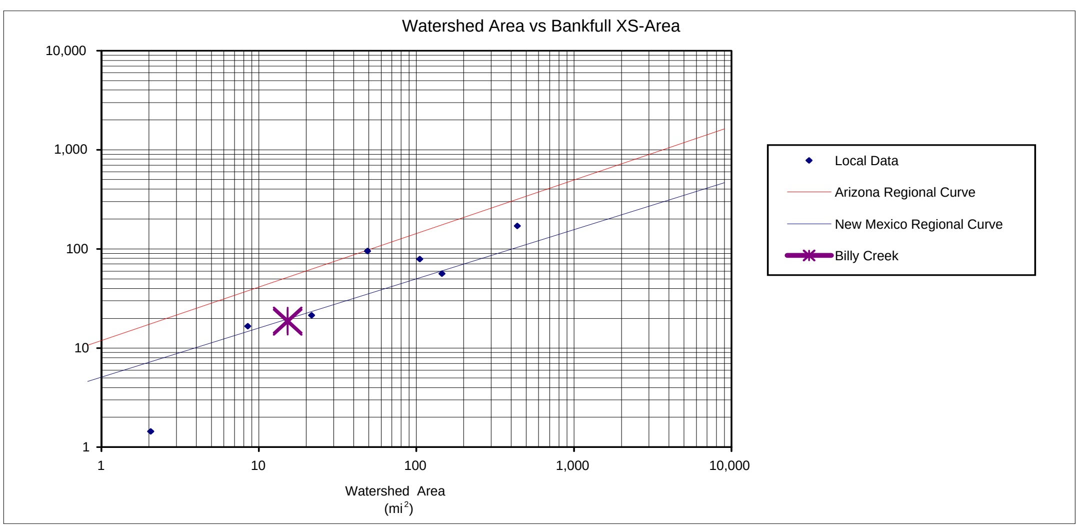



**Figure 4. Local calibration curve.**

*Project cross-sectional area (star data point) is consistent with local and regional data.*

### CHANNEL SUBSTRATE

Channel substrate was sampled using the Wolman Pebble Count protocols (Wolman 1954). One hundred particles were randomly collected within the streambed through both project reaches. The median axis of each particle was measured, recorded and graphed as a cumulative distribution (Figure 5 and 7) and as a percentage of total substrate (Figures 6 and 8). A summary of substrate values is presented in Table 7.

**Table 7. Channel bed substrate.**

| Category | Average Size XS 1 | Average Size XS 2 |
|---|---|---|
| D15 | 0.5mm | 0.2mm |
| D50 | 50mm | 15mm |
| D85 | 150mm | 80mm |
| D100 | 1500mm | 200mm |

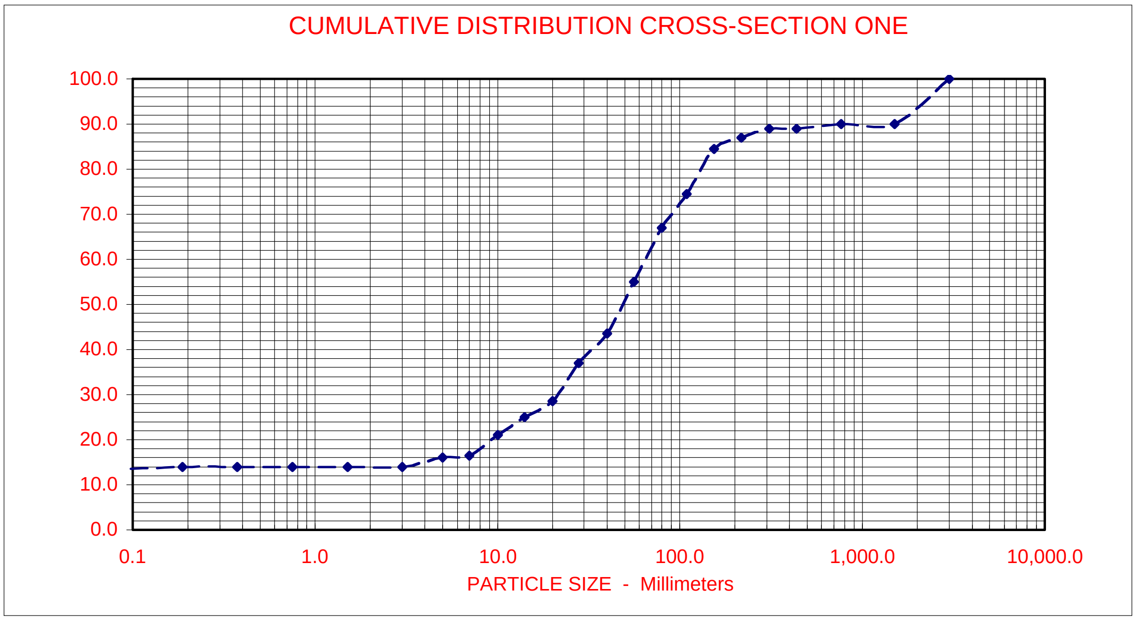



**Figure 5. Cross-section 1: Cumulative distribution of channel bed substrate.**

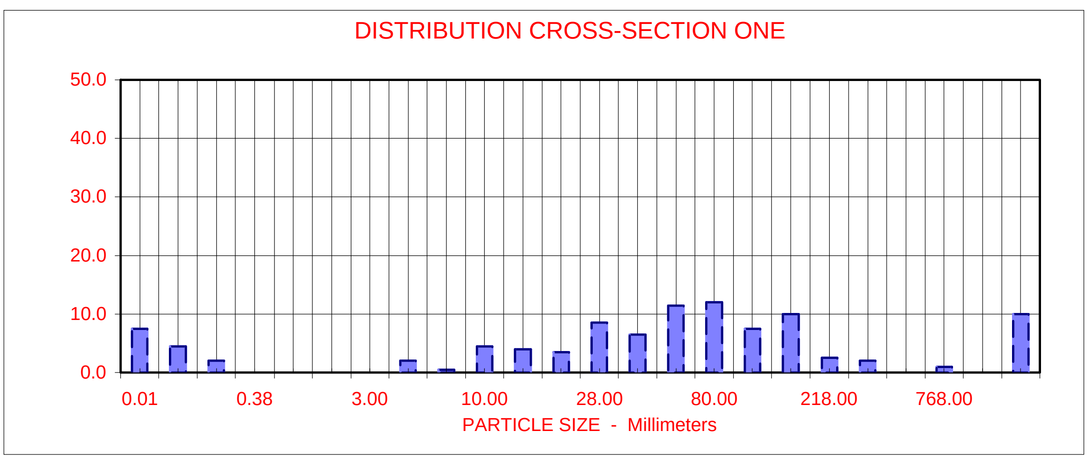



**Figure 6. Cross-section 1: Channel bed substrate; percent of total.**

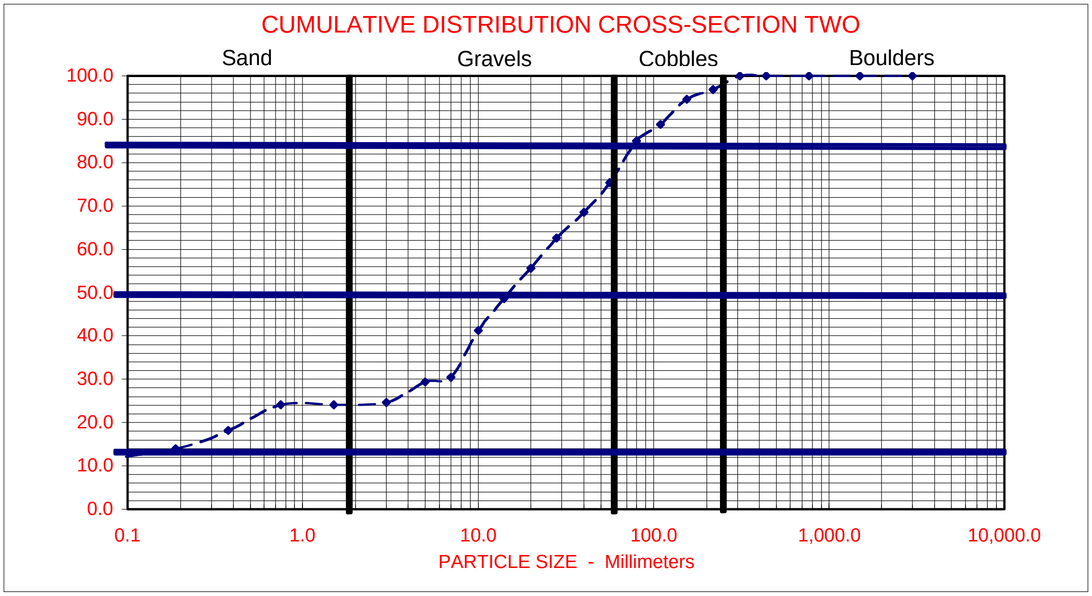



**Figure 7. Cross-section 2: Cumulative distribution of channel substrate.**

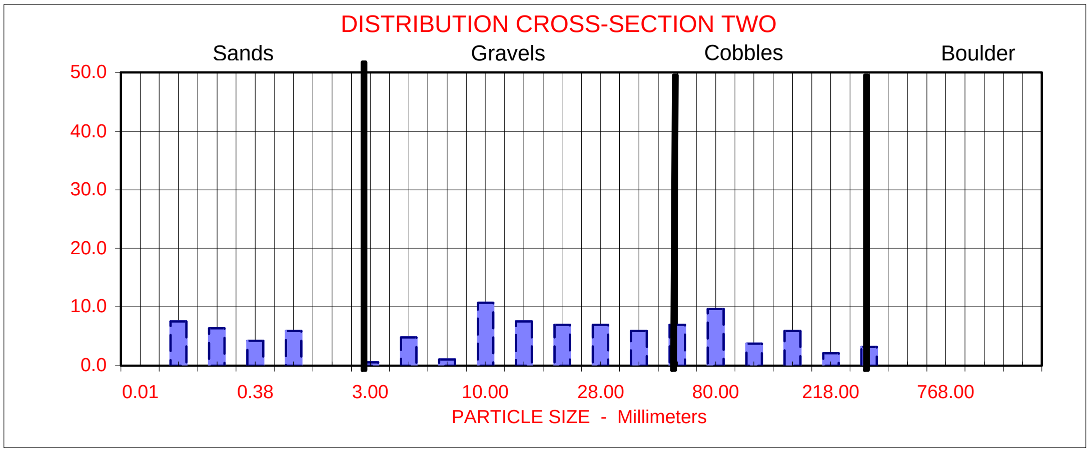



**Figure 8. Cross-section 2: Channel substrate; percent of total.**

Figures 6 and 8 clearly displays a small, but apparent bimodal distribution of substrate particles with a substantial measurement of fine sediment present and a more normal distribution of gravel sized substrate. The fine sediments are of concern because, in excess, they reduce the quality of aquatic habitat. The major source of these fine sediments is assumed to be from eroding banks and berms in the project reaches. Some may originate from overland flow outside the project reach. Cross-section 1 located in Reach 1, has more bedrock present, which resulted in a higher D100 particle size, but both reaches display similar patterns. Fine sediment may decrease as the stream heals from restoration efforts and less fine sediment enters the stream from eroding banks.

## CHANNEL PATTERN

Billy Creek in the project area is quite straight. The general sinuosity of the stream is 1.1 (Table 6). In many places, the stream is not able to meander because of bedrock. Where bedrock is not present, fill and terracing along private property has confined the stream to its present channel and has reduced the potential for channel meander.

### CHANNEL PROFILE

Local channel gradients vary from 0.2% to 0.5% within the project area. Downstream of the project area, the stream enters into a bedrock canyon and has a steeper gradient. Bedrock formations appear to control overall channel slope.

### HYDRAULICS

The average velocity at bankfull stage was estimated in order to link and validate hydrology and channel morphology assessments. Hydraulics can be assessed by a variety of methods. One common practice is to estimate these values using a cross-section analyzer; a computer program utilizing cross-sectional survey information, slope, and a composite roughness factor. Utilizing the computer model along with field observations and other stream morphology analyses helps determine what kind of velocities to expect and what kind of velocities can be tolerated by the system. Table 8 reports the estimated velocities for various return intervals from the computer model.

**Table 8. Velocities associated with various size flows for the project area.**

| Q (cfs) | Return Interval | Stage (ft) | Velocity (ft/s) | Alluvial Feature |
|---|---|---|---|---|
| 70 | 1.5 | 1.4 | 4.1 | Bankfull stage |
| 110 | 2 | 1.7 | 4.5 | Floodplain |
| 210 | 5 | 2.3 | 4.75 | Floodplain |
| 290 | 10 | 2.7 | 4.8 | Floodplain |
| 425 | 25 | 3.1 | 4.9 | Floodprone |

Regional data collected at gauged stream channel sites throughout the southwest suggest that values for average velocity at bankfull stage are commonly found in the range of 3 to 7 feet per second (Moody et al. 2003). Based on an average cross-sectional area of 18.8 square feet (see Stream Channel Morphology section) and an estimated bankfull discharge of 70 cubic feet per second (see Hydrology section), the estimated average velocity is 4.1 feet per second and consistent with expectations. As flood stages increase, velocities also increase. However, as flows spread across the flood plain and encounter additional roughness in the form of riparian vegetation, velocities are mediated. The modeled velocities follow this pattern, indicating moderate increases of velocity with higher stages. It appears that the channel and flood plain are adequately sized to dissipate the energy of higher flows.

In summary, the assessment of stream channel morphology found no evidence of down cutting or incision other than where the stream profile had been mechanically altered (earthen berms). The size and shape of stream channel and floodplains are adequate and appropriate. Channel bed substrate contains larger amounts of fine material than expected which, while it doesn’t appear to impact stream function, could seriously impair aquatic habitats and general water quality. Streambank erosion is common along the outside of channel meanders but the presence of a few well-vegetated and stable banks suggests that the problem is a result of mechanical alteration by humans rather than excessive hydraulic forces.

## EXISTING RIPARIAN VEGETATION

Plant diversity is high in the riparian corridor within the Billy Creek project area. However, the plant community has been altered in the areas where mechanical man-made changes have taken place. The woody plant community next to the channel is dominated by small, flexible species such as strapleaf willow (Salix ligulifolia), coyote willow (Salix exigua), with an occasional native rose (Rosa spp). Tree species further from the channel include ponderosa pine and Gambel oaks interspersed with the occasional juniper or cottonwood. The herbaceous community is comprised of a variety of sedge/rush and a mixture of warm and cool season grass species (Figure 9). For this project, re-vegetation was focused on stabilizing disturbed and newly restored areas during project implementation (Figure 10).

**Figure 9. Existing, robust riparian plant community.**

**Figure 10. An area that was shaped and re-vegetated during project implementation.**

The dominant plant communities were compared with a set of riparian planting zones (Figure 11, Hoag et al 2001). These zones represent differing levels of disturbance and soil moisture, the two dominant influences on the composition and distribution of riparian plant species. Understanding the composition by zone assists in assessment and, ultimately, in the enhancement design.

***Toe and Bank Zones*** (streambanks to floodplain elevation): Herbaceous wetland/grass species
***Overbank Zone*** (low and high floodplains): Herbaceous wetland/grass with some willows
***Transition Zone*** (wet meadows): Rose, assorted native/non-native tree species, grasses, willows/wetland species were moisture is sufficient (generally irrigated)
***Upland Zone*** (above meadow) not included in project area.

These plant communities and zones are represented in all project areas, though they tend to be compressed and narrow, with the upland zone coming right up to the stream in many cases.

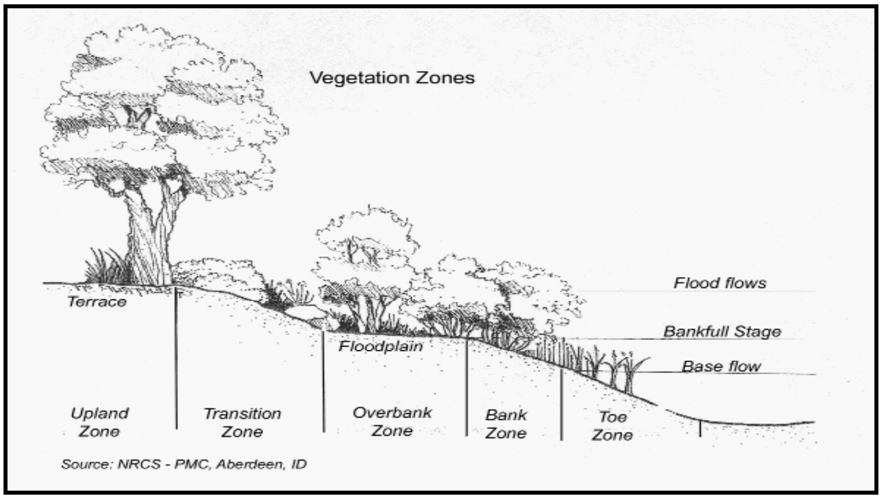



**Figure 11. Riparian vegetation zones.**

The existing riparian vegetation was divided into six habitat types depending on habitat structure, however only three of the habitat structure types are available in the two project reaches (Table 9). These categories represented varying heights of intermediate class (2-15 feet in height) and herbaceous species (< 2 feet).

**Table 9. Riparian habitat types by structure.**

*Estimates of riparian vegetation community structure composition in Billy Creek project reaches (1 and 2)*

| Community Type | Description | Billy Creek |
|---|---|---|
| I | Overstory more than 15 feet tall; Intermediate class is 2-25 feet tall; | 0% |
| II | Overstory more than 15 feet tall; no intermediate class 2-15 feet tall | 0% |
| III | No overstory >15 feet; native intermediate class 2-15 feet tall | 50% |
| IV | Native grasses/wetland species; no overstory or intermediate class | 48% |
| V | No overstory >15 feet; mixed exotic/native or impaired native intermediate class 2-feet tall | 0% |
| VI | Mixed exotic/native or impaired native grasses/wetland species; no overstory or intermediate class | 2% |

The riparian vegetation zones within the project area are well established and typical of less disturbed and functional reaches of Billy Creek. The most common type of riparian communities consists of shrub type willows with an understory of grasses/sedges. Since exotic/invasive plants within the project area are minimal, community type V and VI have a very low percent of cover. A mixture of native herbaceous wetland and grass species that provide a functional and appropriate riparian plant community dominate the toe, bank, and overbank zones. Woody species, such as willows, are well established in these zones. There are few tall riparian tree species within the project area; however some of the willow species are over 10 feet tall. The transition zone is limited in this system, with upland species being established down to the overbank zone. However, the area is generally well vegetated. In the upland zone, Ponderosa pine and Gambel oak provide much overstory and shade.

Because the existing riparian vegetation consists of appropriate species for the area, is robust and diverse throughout the project area, the design did not focus on changing the mosaic of riparian plantings. Flexible, woody species were used in bioengineering practices to stabilize newly disturbed banks. Wetland plugs also were added in the toe zone of disturbed areas and native seed applied to all disturbed areas. Natural recruitment and continued natural flood events should sustain a healthy riparian plant community into the future.

## OTHER SITE CHARACTERISTICS

Annual precipitation, soil type, soil salinity, depth to water, and presence of exotic species are factors that determine types of species to be planted, planting practices, need for supplemental irrigation and ultimate project success

Annual precipitation affects the success of plantings as well as their growth rate. The project is in the Town of Pinetop-Lakeside and Pinetop has a weather station utilized by the Western Regional Climate Center. Average annual rainfall is approximately 22.6 inches with mean monthly values ranging from 0.72 to over 3.72 inches. Total snowfall is approximately 62.2 inches a year. Bi-modal precipitation, summer monsoons and winter snow, is common for this region.

Depth to water is a critical component to successful re-vegetation. Billy Creek is a perennial/intermittent stream and the water table is near the surface as observed by the presence of riparian plant species. In some locations, it is possible that the water table is perched because of exposed bedrock in the area. In this case, the water table lies even closer to the surface than usual which aids re-vegetation efforts.

The soil type for the project area is unmapped, however the existing vegetation conditions indicate that the soil type and soil salinity are not limiting to the growth of native riparian species local to the area.

There is no major exotic species threat at the project site at this time and the few individuals present do not appear to be aggressively expanding.

## ENHANCEMENT DESIGN

Based on the assessment, the dimension, pattern, and profile are relatively intact with well-developed and functional channel, floodplain, and terrace features. However, in two areas, man-made alterations had affected stream stability. Streambank erosion was generally located around the man-made berms where the stream has moved laterally to circumvent the berm and had down cut to natural stream elevation. Berm removal and channel realignment with extensive re-vegetation was recommended to meet project objectives (Figures 12 and 13).

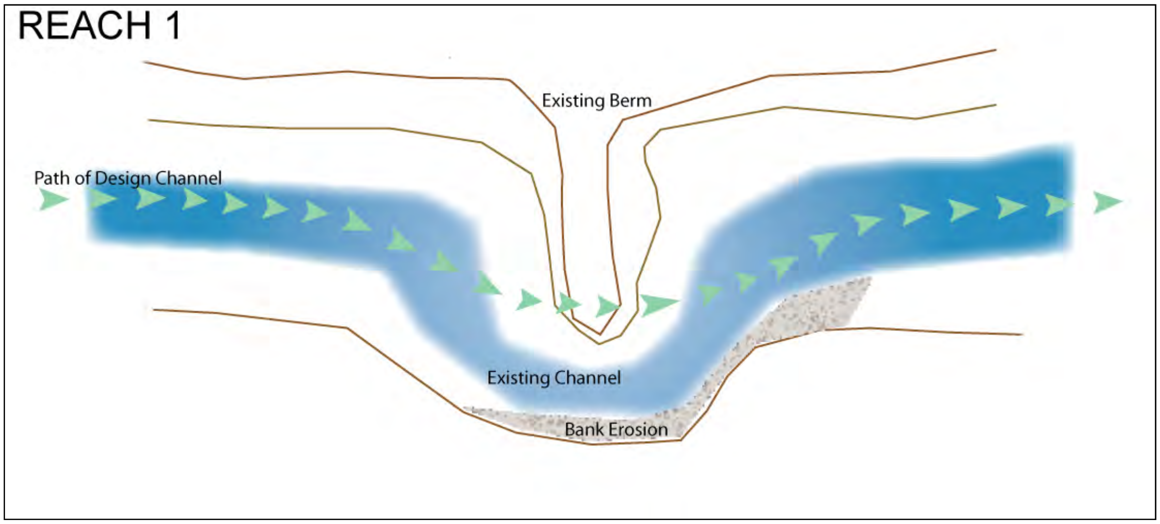



**Figure 12. Graphic of channel realignment in Reach 1.**

*In Reach 1, bank erosion existed on the outside of the current meander. The meander bank was repaired, the berm removed and the channel realigned. The light green arrows indicate the approximate placement of the new channel.*

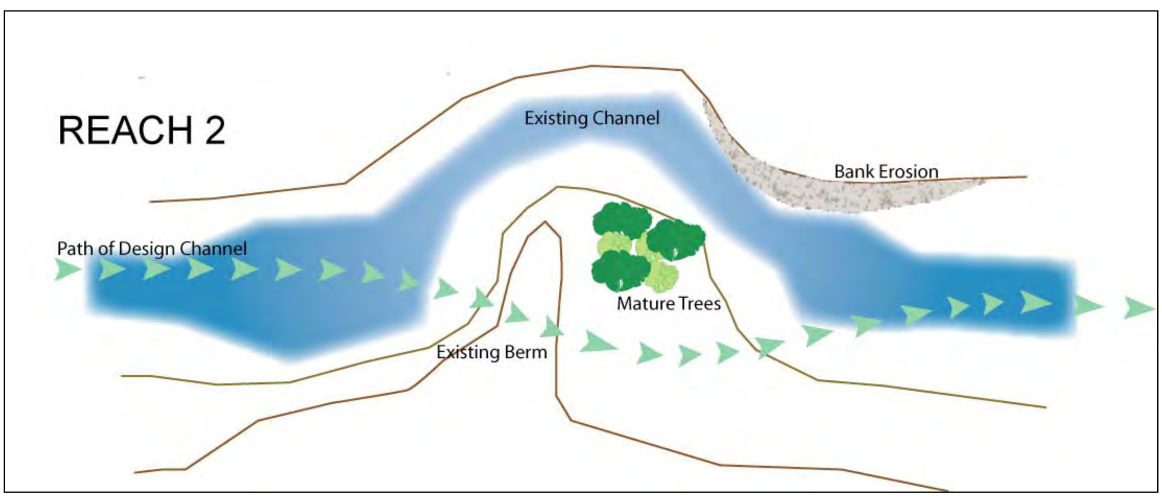



**Figure 13. Graphic of channel realignment in Reach 2.**

*In Reach 2, bank erosion existed on the outside of the current meander. The meander bank was repaired and the channel realigned. The light green arrows indicate the approximate placement of the new channel. The existing channel was backfilled and extensively re-vegetated. Mature trees located just downstream of the berm were preserved.*

A major design consideration was a forced main sewer line running from the lift station toward the city at approximately 5 feet under the streambed in Reach 2. Construction efforts went less than one foot under the current channel bed and there were no negative impacts to existing infrastructure.

A full set of design sheets is provided in Appendix A.

## SPECIFIC ENHANCEMENT TREATMENTS

Actions needed to restore stream function to Billy Creek were relatively straightforward. The system is a relatively stable C4c stream type with a gravel and sand substrate and well-vegetated floodplains. However, bank instability was a concern in several specific areas due to man-made alterations and was addressed with methods described below.

### STRUCTURAL TREATMENTS

#### *Berm Removal and Channel Re-alignment*

Earthen berms are removed using an excavator. Soil is stockpiled and used during channel re-alignment or as backfill in the old channel. The stream channel is re-aligned before the berm is removed in order to maintain a dry work area. After the channel is re-aligned the berm is removed and water released. The old channel is backfilled and smoothed to match the surrounding landscape.

#### *Concrete Removal*

Concrete debris is removed using an excavator and hauled to an appropriate disposal facility.

#### *Bank re-sloping*

Bank re-sloping significantly increases vegetation establishment. If banks are too steep (> 2:1) vegetation simply struggles to establish and erosion persists. Therefore, bank sections are reshaped to a 3:1 slope to provide a stable surface for streamside vegetation. This slope has been identified at stable bank sites in this region when combined with herbaceous or woody native vegetation. Banks are re-sloped using a backhoe or track excavator. Every effort is made to pull excavated materials up the bank and away from the stream. Material is smoothed on higher terraces or removed. These banks are then be treated with a structural or bioengineering practice as described below to provide further stabilization. All disturbed areas are be reseeded and protected with erosion fabric.

#### *Toe Rock*

Toe rock consists of graded angular rock placed along the base of an eroding stream bank and is designed to protect the vulnerable bank toe. Rock is graded from a minimum diameter of 4 inches to a maximum of 8 inches. Minimum thickness of toe rock is 18 inches placed on a maximum slope of 1.5:1. Rock extends upward only to the elevation of the floodplain to minimize the structural component and encourage revegetation. Bioengineering practices are integrated with this toe protection. This structural treatment is limited to the most highly erodible banks.

#### *Log Sills*

This structural stabilization practice consists of logs placed within a section of fill in a pre-existing channel. It is designed to slow and minimize any water flow, which may occur over, or within, the fill. Logs are stacked horizontally to depth of approximately one foot below the old channel bottom and to a height equal to the top of the fill.

## BIOENGINEERING BANK STABILIZATION

The series of practices described here serve dual purposes. Primarily, they provide long-term stabilization for stream banks but as important is their function of providing riparian habitats. All plantings utilize native species harvested locally.

### *Willow Clusters*

Willow clusters are a group of 3-4 bare pole willows planted in stream banks on 4-foot centers. The clusters are inserted holes in the moist bank created mechanically or hydraulically. When utilized behind log sills, the clusters are placed on 1-foot centers to slow overland flow. When utilized in conjunction with vertical bundles, the clusters are placed on 8-foot centers in between each vertical bundle.

### *Vertical Bundles*

This practice consists of the planting of a series of willow bundles (4 stems) vertically along the stream bank. The base of each bundle is placed in permanent water and the bundle is placed in a shallow trench extending up the bank. The stems are buried and sprout along their entire length providing willow roots well above the groundwater table. Vertical bundles are installed in between willow clusters on 8-foot centers.

### *Coir Log*

Coir logs are long rolls of coconut fiber tightly woven together and installed at the toe of the bank to provide temporary structural protection. The logs are secured in place with rope and long stakes driven into the toe. After sediment builds up, often the logs become vegetated and biodegrade. In addition, coir logs are planted with sedge plugs to quicken the re-vegetation process.

### *Wetland Plugs*

Wetland plugs are harvested from the project area and planted in the toe zone of newly disturbed areas. Wetland plugs harvested from local sources are specifically adapted to the climate, soil, and moisture regime particular to that area and establish most successfully. One plug per foot is planted in the coir logs or toe zone of the project area.

### *Erosion Cloth over Reseeding*

All disturbed areas are reseeded using native grass and riparian seed. To maximize moisture retention and protect the seed and seedlings from wind and predation, erosion fabric is installed with wooden stakes and metal staples and applied to reseeded banks and disturbed areas.

## PROJECT FENCING

The Town of Pinetop-Lakeside manages the area as a greenway for the community to enjoy. Currently, ATV use through the area can be of concern, but the city is working to reduce negative impacts and manage the area for sustained green space use into the future.  Limited fencing along existing ATV use corridors is used to block ATV access from the project where it threatens project objectives.  Wooden, open fencing is used to blend into the natural setting and be as unobtrusive as possible.  The length of the fence is limited to the minimal amount needed to block existing use paths.  It is expected that fencing and education will change use patterns by ATV riders in the project corridor.

## ENHANCEMENT TASKS BY REACH

### REACH 1

Reach 1 work items consisted of removing the earthen berm and re-aligning the channel, using excavation material to back fill the existing channel, stabilizing critical areas with toe rock, and planting the new channel banks with willow clusters, vertical bundles, and wetland plugs (Figure 14). Coir logs were inserted in areas not protected by toe rock for additional toe protection. The following list is a summary of activities that took place within Reach 1:

- **Berm removal and channel re-alignment** that included approximately 1,290 cubic yards of soil excavation.
- **Toe rock** placed along 110 feet of the new channel utilizing approximately 110.2 cubic yards of angular rock.
- **Willow clusters on 1-foot centers** installed behind the toe rock (132 feet) equaling approximately 132 clusters.
- **Willow clusters on 4-foot centers** installed along the bank and over the floodplain equaling approximately 121 additional clusters.
- **Vertical bundles** installed among willow clusters in specific areas equaling approximately 24 bundles.
- **Coir log with wetland plugs** installed along 215 feet of disturbed bank.
- **Seeding and erosion control fabric** installed over all disturbed areas equaling approximately 15,800 square feet.

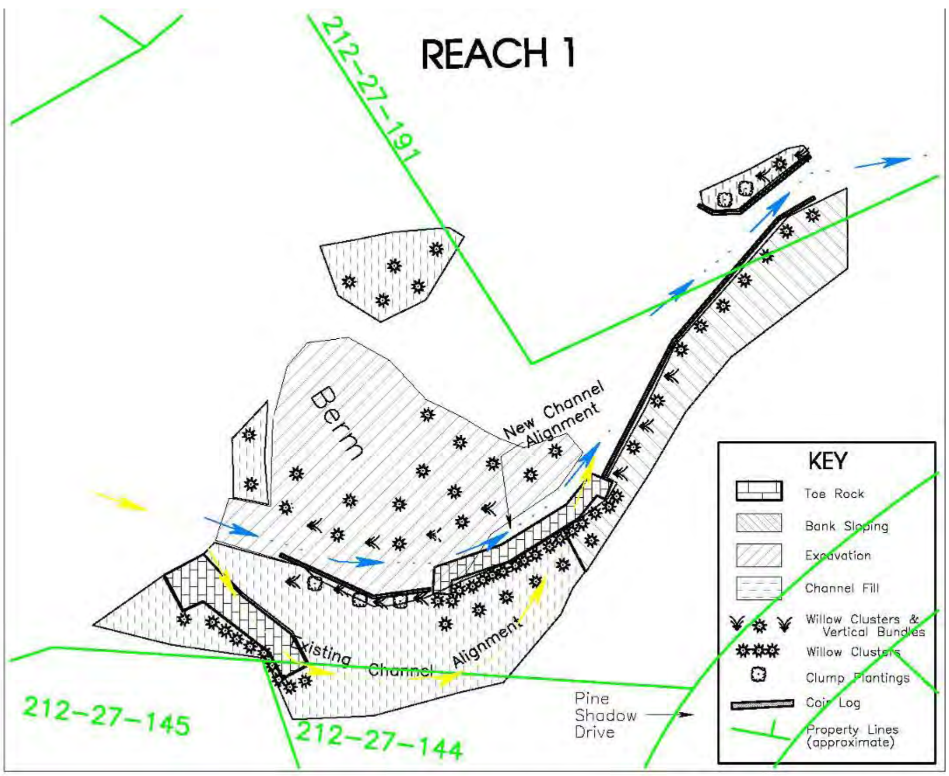



**Figure 14. Plan view of Reach 1.**

*The yellow arrows represent the existing stream channel, while the blue arrows indicate the new alignment for the channel after the berm was removed.*

***Concrete Debris Area***

Downstream of Reach 1 and directly downstream of the existing bridge on river right, concrete debris was removed. Specific work tasks included:

- **Concrete debris removal** along approximately 70 feet of bank and bank sloping where necessary.
- **Coir log with wetland plugs** installed along 70 feet of disturbed bank where necessary.
- **Willow clusters on 4-foot centers** installed along disturbed bank equaling approximately 18 clusters.
- **Rock lining the existing drainage ditch** entering Billy Creek that included 20 feet of ditch and approximately 4.5 cubic yards of angular rock.
- **Seeding and erosion control fabric** installed over all disturbed areas equaling approximately 850 square feet.

### REACH 2

Reach 2 work items consists of removing the earthen berm and re-aligning the channel, using excavation material to back fill the existing channel, stabilizing critical areas with toe rock, and planting the new channel banks with willow clusters, vertical bundles, and wetland plugs. Coir logs were inserted in areas not protected by toe rock for additional toe protection (Figure 15). The following list is a summary of activities that took place within Reach 2:

- **Berm removal and channel re-alignment** include approximately 675 cubic yards of soil excavation.
- **Toe rock** placed along 47 feet of bank utilizing approximately 38.8 cubic yards of angular rock.
- **Bank sloping** took place along approximately 68 feet of bank.
- **Two log sills** are 29 feet wide and installed perpendicular to flow in the backfilled channel.
- **Willow clusters on 1-foot centers** installed behind the toe rock (47 feet) and log sills (58 feet) equaling approximately 105 clusters.
- **Willow clusters on 4-foot centers** installed along the bank and over the floodplain equaling approximately 157 additional clusters.
- **Vertical bundles** installed among willow clusters in specific areas equaling approximately 8 bundles.
- **Coir log with wetland plugs** installed along 130 feet of disturbed bank.
- **Seeding and erosion control fabric** installed over all disturbed areas equaling approximately 11,600 square feet.

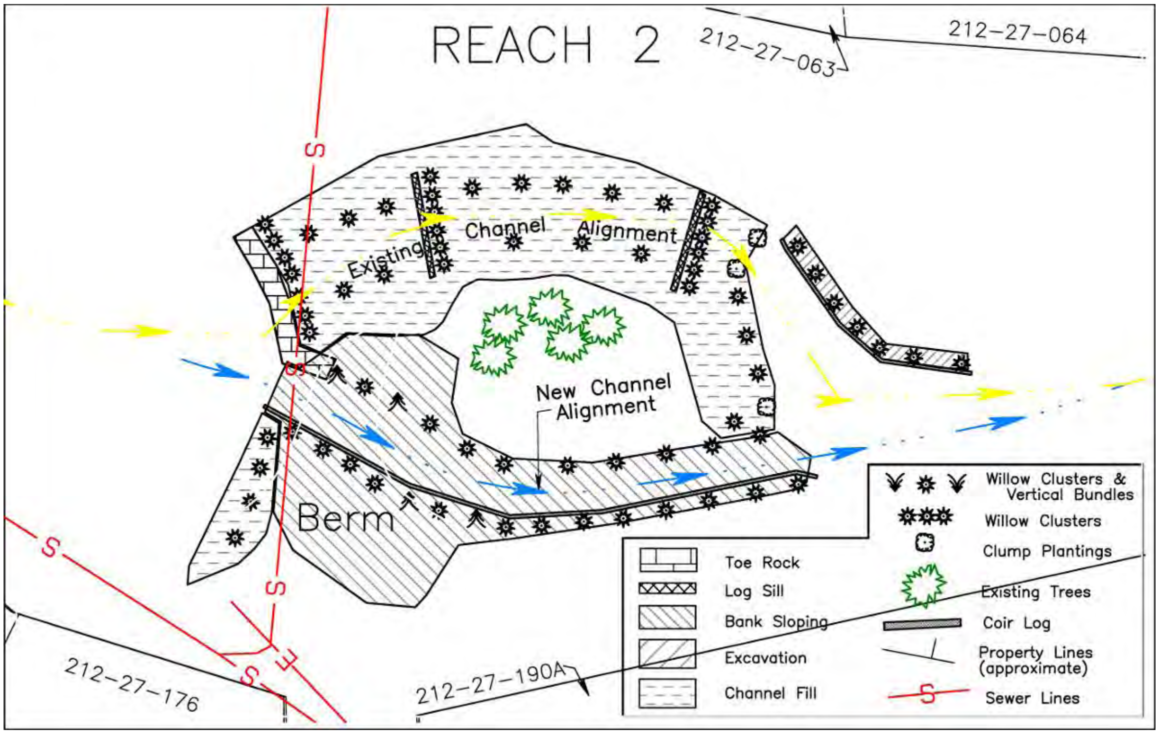



**Figure 15. Plan view of Reach 2.**

*The yellow arrows represent the existing stream channel, while the blue arrows indicate the new alignment for the channel after the berm is removed.*

## POLLUTION PROTECTION

Restoration tasks required the use of heavy equipment. Impacts from this use were minimized with the following methods:

- All heavy equipment used in the project is cleaned prior to use and without oil leaks. Equipment is checked daily for oil leaks and removed from service immediately until repaired.
- Equipment works from the bank areas whenever possible and minimize contact with the live stream. This is expected to represent the majority of time. Working within the river is unusual and limited to necessity.
- Stream crossings take place only at sites designated in the plans and kept to a minimum.
- Materials excavated during bank sloping, channel re-alignment, or berm removal are removed from the active, bankfull channel and floodplain and used as backfill in the old channel.
- All disturbed areas are reseeded. Those disturbed areas exposed to erosive stream flows are reseeded and protected by erosion matting and other means of toe protection.
- All channel and floodplain work take place during the dormant growing season and outside the spawning periods for fish species and nesting periods of bird species.

## REVEGETATION DESIGN

Revegetation efforts focus on stabilizing and establishing vegetation in the channel realignment area, stabilization of currently eroding banks, and restoration of areas disturbed during construction.

Three vegetation zones addressed in the vegetation design include bank, overbank, and transition zones. Bioengineering practices take place within these zones. The project area currently supports a well-established native riparian plant community. Additional planting strategies incorporate only native species found within the current system. Because natural hydrology, well-established communities, and an ample upstream seed sources for herbaceous and wetland species, the primary focus is on the establishment of clonal species that quickly provide adequate stability to the banks and more structure and diversity in restored areas.

There is no need for exotic/invasive plant species removal at the project site. Additionally, no supplemental water or irrigation is needed for plant establishment.

### GENERAL PLANTING SPECIFICATIONS

Basic planting guidelines apply to the entire project area and increase vegetation design success. They are listed below:

1) All planting mimics existing vegetation distributions. For example, willows and other woody species are planted along the floodplain and to a depth of ground water. In most cases that is the elevation of minimum stream base flows. Woody species are planted in trenches dug to ground water level or in holes drilled by auger or water jet.
2) All disturbed areas are reseeded with native grasses, with those prone to hydraulic forces (stream flow) covered with straw or other mulch and protected with erosion cloth or other netting. It is anticipated that precipitation will produce sufficient moisture for establishment.
3) Planting takes place during the fall months when plants are going into dormancy for greatest establishment success.

### SOURCES AND TYPES OF PLANT MATERIALS

From the site assessment, species are researched and chosen that are appropriate for the elevation, precipitation, and specific location. Species already present at the project site are used as an indicator for other appropriate native plant species. In many cases, many of the present species are used in seed mixes to ensure continuity. Sources for wild-harvested plants are identified.

#### *Wetland Species*

Herbaceous emergent species are wild-harvested from the project area. Plugs are *Juncus* and *Carex* species and include species that are dormant in the plug's seed bank. Wetland plugs are installed in coir log or other appropriate areas along the treated banks. Deer grass (*Muhlenbergia rigens*) is another wetland species that is easily cultivated from plugs, providing stability to the toe of the bank.

#### *Grass/Wildflower Species*

All disturbed areas are seeded with a mixture of grass and forb native seed (Table 10). The estimated area covered with the grass seed equals approximately 1.0 acre at 9.15 lbs per acre.

**Table 10. Grass and Wildflower species selected for the Billy Creek Natural Area project.**

| Species | Scientific Name | % of Mix | lb PLS/ac for Pure Stand* | lb PLS/ac for Desired Comp | **lb PLS for 1 acre** |
|---|---|---|---|---|---|
| Western Wheatgrass | (*Pascopyrum smithii*) | 35% | 16 | 5.6 | **5.6** |
| Blue Grama | (*Boutelua gracilis*) | 30% | 3 | 0.9 | **0.9** |
| Spike Muhly | (*Muhlenbergia wrightii*) | 15% | 3 | 0.45 | **0.45** |
| Little Bluestem | (*Schizachyrium scoparium*) | 20% | 11 | 2.2 | **2.2** |
| TOTAL | | 100.00% | | 9.15 | **9.15** |
| | | | | lb PLS/ac | **lb PLS** |

* Planting to be done by hand broadcasting, values have been increase by a factor of 2.

### *Woody Species*

Willow species are wild-harvested from nearby sources and planted appropriately throughout the project as part of bioengineering practices. The estimated number of assorted willow shoots needed for the project is 2,230 stems. Species include:

Coyote willow (*Salix exigua*) will be applied selectively for pole planting along the floodplain elevation.

Strapleaf willow (*Salix ligulifolia*) is found at the site and will be planted along upper banks and terrace areas.

Geyer willow (*Salix geyeri*) is near the site and may be harvested for clump planting, pole plantings, and vertical bundles.

### HARVESTING/COLLECTION

Live, bare root cuttings from native species (willow) are collected and harvested from identified local sources. During the collection of bare poles, a maximum of one third of any single plant is harvested. Poles have a minimum diameter of 0.5-inches. After cutting, the poles are bundled and submerged in water for 3 to 7 days prior to planting to maximize water retention. Should there be a delay between harvesting and planting, poles are stored in a cool, dry, dark area. Plant materials are never be allowed to dry out during harvesting, transportation, or storage.

Wetland plants are readily transplanted because of their well-developed root systems and the remaining plants fill in the harvest hole rapidly. It is best to harvest no more than one square foot of plant material from a four square foot area. It is not necessary to dig deeper than 5-6 inches below ground level. One square foot of plant material provides 6-9 individual plugs. Plugs can be harvested any time of year. Soil should be left on the plug when planted to increase establishment success. The bottom of the plug should have contact with the saturation zone of the channel.

## VEHICULAR CONTROL PLAN

The Town of Pinetop-Lakeside manages the area as a greenway for the community to enjoy. Currently, ATV use through the area can be of concern, but the city is working to reduce negative impacts and manage the area for sustained green space use into the future. Fencing along existing ATV use corridors ia used to block ATV access from the project at four locations where it threatens project objectives. Wooden, open fencing is used to blend into the natural setting and be as unobtrusive as possible. Three sections are 8 feet wide, and the fourth 16 feet wide. All four fences are located on City of Pinetop-Lakeside property.

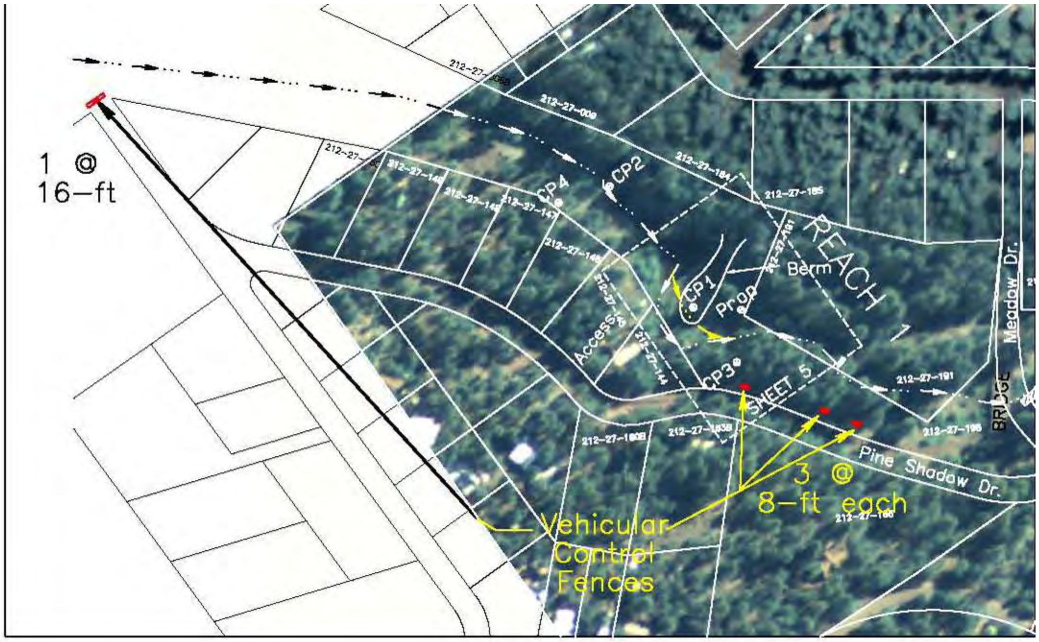



**Figure 16. Plan view of Vehicular Control Fence locations.**
*The red rectangles represent the locations of the four installed fences. Sizes are noted near the rectangles.*

## PERMITS, CLEARANCES, AGREEMENTS & AUTHORIZATIONS

Required permits included U.S. Army Corp. 404 and accompanying ADEQ 401 permits. Access to the project area for construction had been obtained from the affected landowners and NCD personnel met with landowners on site the first week of July 2009 to map specific routes across private properties. Letters of agreement for access across private property were be forwarded to the AWPF.

## INITIAL CONSTRUCTION

The initial construction and implementation of re-vegetation (Tasks 5 & 6) for Billy Creek Natural Area Riparian Restoration Project took place during the weeks of October 12-26, 2009. Five Natural Channel Design personnel worked on the project at various times. Equipment utilized during the initial construction and re-vegetation included a flatbed trailer, backhoe, one bulldozer, one dump truck, one large excavator and one mini-excavator. Revegetation labor was provided by an American Conservation Experience or “ACE” crew of 9 people.

The following list summarizes the work accomplished during the initial construction and re-vegetation implementation:

## WORK ACCOMPLISHED

| | |
|---|---|
| <u>TASK 5 – Implement Construction</u> | |
| Excavated/Removed Berms | 1965cubic yards |
| Re-Sloped Banks | 535 linear ft |
| Cross-Vane Weir Installed | 1 structure |
| Riprap Installed | 90 cubic yards |
| Log Sills Installed | 2 structures (30 ft ea) |
| Removed Concrete & Metal Debris | 6 tons |
| ATV Access Restrictions | 15 Logs Placed |
| | |
| <u>TASK 6 – Implement Revegetation</u> | |
| Non-Woven Geotextile Fabric Installed | 15 ft x 240 ft |
| Erosion Fabric (Double net straw/coconut) | 8 ft x 720 ft (12 rolls @ 60 ft ea) |
| Erosion Fabric (Single net straw) | 8 ft x 2640 ft (44 rolls @ 60 ft ea) |
| Erosion Control Logs Installed | 43 (12 in x 10 ft ea) |
| Willow Clusters and Vertical Bundles Planted | 500 each (~1740 willow stems) |
| Willow Trenches Planted | 120 linear ft (~200 willow stems) |
| Wetland Grass Plugs Planted | 350 Plugs |

### SUMMARY OF WORK ACCOMPLISHED

(See Figure 16 and Figure 29 for a map of project locations)
`

#### CROSS-VANE WEIR INSTALLATION

A Cross-Vane weir is a rock structure with sloped sides that creates a controlled drop and directs the flow of water into its armored center apron. One location was determined to require installation of a Cross-Vane weir structure.

- Station 2+00 in Reach 1, at the beginning of the new channel excavation, starts at an existing pond that was to be left full. During the excavation process it was determined that the soil at the mouth of the channel was too soft to withstand erosion. This would have allowed the possibility of the channel cutting deeper over time and eventually draining the pond. To alleviate this situation, a Cross-Vane weir was installed at the mouth of the new channel. The boulders for this structure were obtained from the material being excavated at the site. After work was completed, the area at the mouth of the structure was planted with wetland plugs, and willow clusters were planted behind the structure.

### ROCK INSTALLATION

Four different locations required installation of rock for channel and streambank protection – two in Reach 1 and two in Reach 2. One additional location in Reach 1 utilized boulders uncovered during excavation.

- A rock cutoff sill was installed at Station 2+20 in Reach 1, leading off of the right wing of the installed Cross-Vane weir structure. This sill serves to protect high flows from cutting through the filled channel. The sill contains approximately 7.8 cubic yards of rock.
- Station 2+75 to 3+45 in Reach 1 had approximately 47.7 cubic yards of toe rock installed along the right side of the newly excavated channel. This area was armored due to its location on the outside of a meander, at the end of a steeper sloped section of channel. Four, 10-foot willow trenches were planted behind the structure.
- Boulders uncovered during excavation in Reach 1 were installed as toe protection at Station 14+20 to 14+50 in Reach 1. This location was chosen because it is a newly sloped bank on the outside of a corner. The boulders were placed in a row and partially embedded along the toe of the channel. Willow clusters were planted behind them.
- Station 12+35 in Reach 2 had approximately 30 cubic yards of rock installed on the left side as a combination of toe rock to keep the creek from re-capturing the old channel, and to protect fill at the mouth of the new channel from erosion. Willow clusters were planted behind the toe rock and in front of portions of the trench. Wetland grass plugs were planted at the base of portions of the toe rock.
- Station 14+00 in Reach 2 had approximately 4.5 cubic yards of rock apron installed as armoring over the end of the fill in the old channel. Larger rocks, which appeared during excavation, were embedded at the base of the apron to anchor it. Willow clusters were planted within the armoring, and wetland plugs were planted at the base.

### LOG SILL INSTALLATION

Log sills consist of logs stacked vertically within an excavated trench, secured together with cable. They act to prevent erosion as water flows over the area. Two log sills were installed within the fill of the old channel in Reach 2, at Station 13+00 and 13+75. The logs came from trees removed from Reach 1 prior to excavation. Willow poles were planted in the trenches on the downstream side of the logs.

## BIOENGINEERING PRACTICES

### *Seeding and Fabric*

After the banks were sloped they were then seeded with a native grass & forb mix and covered with erosion control fabric (double and single layer fabrics) to protect the seed from wind and provide cover to reduce evaporation (Table 11). The final seed mix was modified from the planned mix to include flowering species and improve aesthetics as well as wildlife/pollinator value.

**Table 11. Native seed mix used to re-vegetate disturbed areas.**

| Species | Scientific Name | % of Mix | lb PLS/ac for Pure Stand* | lb PLS/ac for Desired Comp | **lb PLS for 1 acre** |
|---|---|---|---|---|---|
| Western Wheatgrass | (*Pascopyrum smithii*) | 28% | 18 | 5.04 | **5.04** |
| Bottlebrush Squirreltail | (*Elymus elymoides*) | 22% | 12 | 2.64 | **2.64** |
| Blue Grama | (*Boutelua gracilis*) | 12.5% | 3 | 0.38 | **0.38** |
| Sideoats Grama | (*Bouteloua curtipendula*) | 10% | 15 | 1.50 | **1.50** |
| Little Bluestem | (*Schizachyrium scoparium*) | 10% | 9 | 0.90 | **0.90** |
| Sand Dropseed | (*Sporobolus cryptandrus*) | 7% | 0.5 | 0.06 | **0.06** |
| Upright Prairie Coneflower | *(Ratibida columnifera)* | 4.5% | 2 | 0.09 | **0.09** |
| Common Sunflower | *(Helianthus annuus)* | 4% | 20 | 0.80 | **0.80** |
| Rocky Mountain penstemon | *(Penstemon strictus)* | 2% | 6 | 0.12 | **0.12** |
| TOTAL | | 100.00% | | 11.53 | **11.53** |
| | | | | lb PLS/ac | **lb PLS** |

* Planting to be done by hand broadcasting, values have been increase by a factor of 2.

The seed was hand broadcast by crewmembers. The fabric was rolled out and staked to the ground to secure it. Wooden stakes were used approximately every 4-foot of sloped bank.

### *Willow Pole Clusters, Vertical Bundles & Trenches*

Bioengineering practices included planting willow pole clusters, vertical bundles and trenches. Willows were wild harvested from the immediate surrounding areas. Each pole cluster planting included 3-4 stems, which were placed in an augered hole, watered, and backfilled. Clusters were planted approximately every 4 feet. They were planted on newly sloped banks. Willow vertical bundles consist of excavating of a shallow trench, which extends eight feet up the bank, and augering a hole at its base. The willows are inserted into the hole and bent over to lay in the trench. They are tied to a stake to hold them down and the trench is backfilled. Willow trenches were also planted where augering was not practical. This practice consists of digging a long, deep trench with a backhoe, and planting clusters of willows in the trench. In instances where the depth did not reach standing ground water, a 3-inch pump was used to pump large quantities of water into the trench prior-to, and during backfilling.

### *Erosion Control Log Installation*

Erosion control logs are composed of aspen tree shavings contained in a burlap wrapping. They were secured in place using wooden stakes on both sides with rope tied over the top, as well as wooden stakes driven through them. They were installed along the toe of newly sloped banks to prevent erosion. Wetland grass plugs were planted into the logs every two-feet.

### *Wetland Grass Plugs*

Wetland grass plugs were wild harvested from the immediate surrounding areas. Plugs were 3-5 inches across, containing approximately 5-6 inches of vertical root mass. They were planted into the erosion control logs, which had previously been installed along the toe of re-sloped banks. They were also planted into the native soil in various other locations along the channel edges.

## ATV ACCESS RESTRICTIONS

Limiting access for all-terrain-vehicles (ATVs) to the area was another aspect of the project. Reach 1 had several places where evidence of ATV traffic could be seen. Fifteen, ten-foot logs, removed from that reach during excavation, were placed in a manner to block these, and several other potential traffic paths. A second location that had been determined to need fencing was found to have already been installed by another party.

## STATION-BY-STATION SUMMARY

The following section is a narrative of mechanical work completed and/or bioengineering practices installed.

## REACH 1

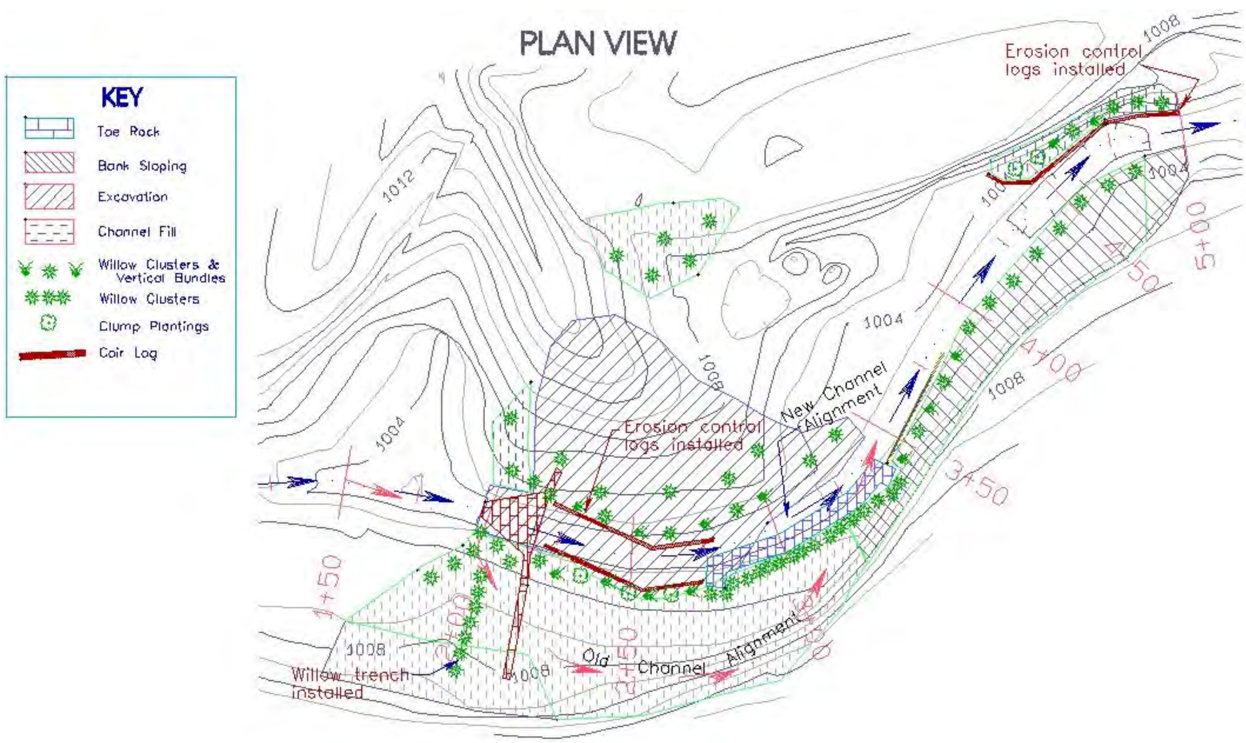



**Figure 16. Plan view of Reach 1.**

*The red arrows represent the pre-construction stream channel, while the blue arrows indicate the new alignment for the channel after the berm was removed.*

**BERM REMOVAL AND CHANNEL REALIGNMENT**

This section had approximately 1290 cubic yards of material excavated from the existing berm. This material was placed in the old channel alignment and used to build back the eroded bank section and to form a new channel. (Figures 17 & 18).

**Figure 17: Excavation at Station 2+00 to 3+50**

*Photo is looking upstream at initial excavation at Reach 1. The old channel at left of photo was kept open until a culvert was installed to carry the creek's flows during excavation of the new channel.*

**Figure 18: Station 2+00 to 3+50 after construction and re-vegetation.**

*Photo shows the same upstream view of Reach 1 after construction and re-vegetation have taken place. Toe rock is left of center, and a portion of the cross-vane-weir can be seen at center by workers. Installed erosion control fabric and erosion control logs are shown, as well as the tops of willow clusters through the fabric.*

Approximately 165 linear feet of vertical bank downstream from the berm were re-sloped. An area of fill was compacted and shaped into the right bank. The banks were then planted with willows, seeded and covered with erosion control fabric. Erosion control logs were also installed on the outside of meanders. The whole channel then had wetland plug plantings installed along the toe of the channel (Figure 19).

**Figure 19. Completed channel restoration at end of Reach 1.**

*Looking upstream at re-sloped and bioengineered banks in the lower section of Reach 1.*

### CROSS-VANE WEIR AT STATION 2+00

A Cross-Vane Weir was installed at the outlet of the pond at the berm to maintain and stabilize the new channel grade, and prevent draining the existing pond. Boulders uncovered during excavation were used for construction (Figure 20 & 21).

**Figure 20: Cross-Vane Weir installation.**

**Figure 21: Completed Cross-Vane Weir.**

*These pictures show the cross-vane weir at station 2+00 during construction and after completion.*

### ROCK CUTOFF SILL

A rock cutoff sill was installed across the old filled channel and tied into the right wing of the Cross-Vane Weir structure. This sill is used to prevent downcutting through the old filled channel section (Figure 22). The rock will prevent a gully from forming if concentrated water flows over this area of floodplain.

**Figure 22: Rock Cutoff Sill installed.**

*Photo shows approximately 30 linear feet of rock installed at Station 2+20. Photo taken from across creek looking east.*

### TOE ROCK

The bank downstream of the weir had approximately 47.7 cubic yards of toe rock installed along the right side of the newly excavated channel. This rock was placed to protect the streambank from potential lateral erosion. Non-woven geotextile was installed behind the rock to prevent fine soils behind the rock from being removed (**Error! Reference source not found.** & 24).

**Figure 23: Completed Toe Rock**

*Photo shows completed toe rock at Station 2+75 to 3+45. Photo taken from upstream looking north.*

**Figure 24: Preparation for Toe Rock.**

*Excavation and installation of geotextile for toe rock at Station 2+75 to 3+45. Photo taken from upstream looking north.*

### ROCK & BIOENGINEERING AT STATION 4+20 TO 4+50

This section is located at the downstream end of Reach 1. Boulders that were found during excavation were installed at the toe of the newly shaped left bank. Erosion control logs were also installed off either end of the rock to protect more of the toe. Willow clusters were planted in the bank and wetland plugs planted in the excelsior logs, as well as seeding and erosion control fabric installation (Figure 25).

Error! Reference source not found.**Figure 25: Rock & Bioengineering at Station 4+20 to 4+50**

*These photos shows toe rock and bioengineering installed in the lower section of Reach 1. Some of the rock is partially covered by the erosion control fabric. Photos taken from downstream looking southwest, prior to installation of the wetland plugs.*

### DEBRIS REMOVAL BY BRIDGE

Six tons of concrete and metal debris were removed from a section of streambank just downstream of the Meadow Lane Bridge. The debris was removed using a mini-excavator and removed to a commercial waste disposal site by dump truck. Approximately 60 feet of bank was re-sloped and bioengineered with willow clusters, seed, erosion control fabric and excelsior logs with wetland plugs (Figure 26 – 28)

**Figure 26: Debris downstream of the bridge.**

**Figure 27: Debris removed from channel**

*This photo shows the six tons of debris that was taken out of the bank below the Meadow Lane Bridge. Photo taken looking northwest.*

**Figure 28: Bioengineered bank after debris removal.**

*This photo shows the bank below the bridge after removal of six tons of debris and re-sloping. The bank was planted with willow clusters, seeded, and covered with erosion control fabric. The downstream portion, at water's edge, had excelsior logs installed at the toe. The logs were then planted with wetland grass plugs. Photo taken from the bridge looking downstream to the north.*

## REACH 2

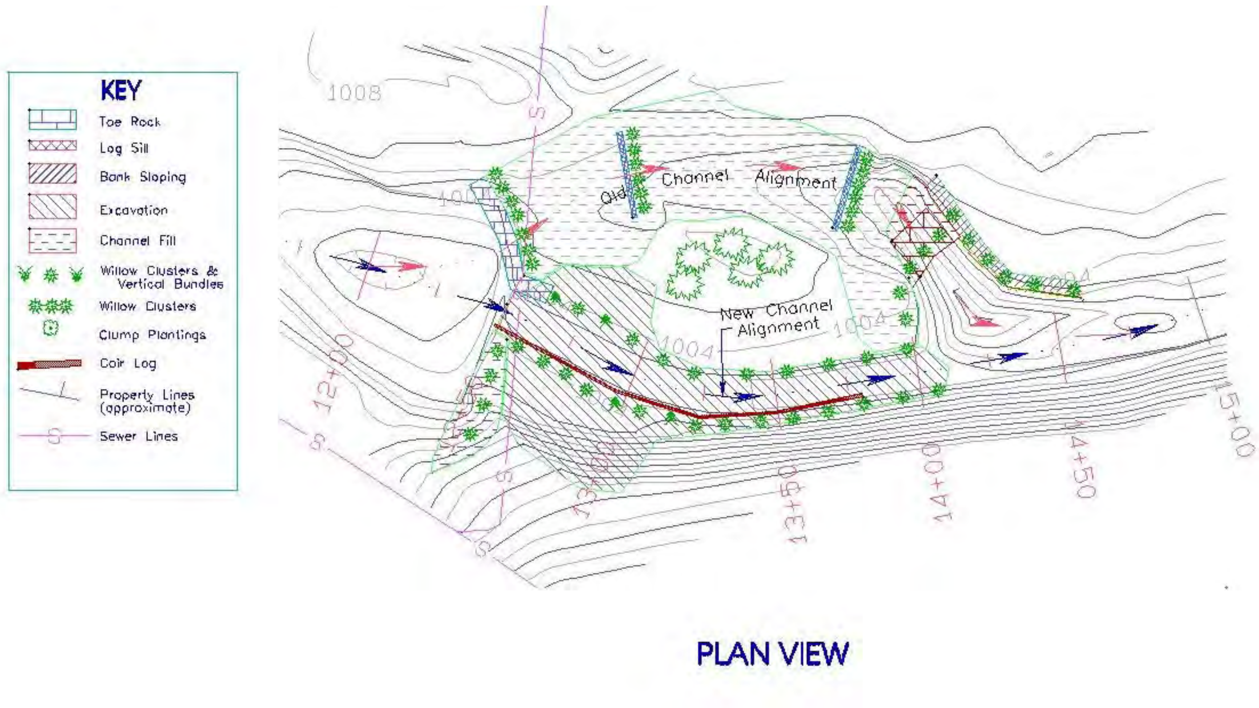



**Figure 29. Plan view of Reach 2.**

*The red arrows represent the old stream channel, while the blue arrows indicate the new alignment for the channel after the berm is removed.*

### BERM REMOVAL & CHANNEL ALIGNMENT

Downstream at Reach 2, approximately 675 cubic yards of material was excavated from the existing berm to form a new channel. The excavated material was used to fill the old eroded channel alignment. Bioengineering practices include seed and fabric, willow clusters, excelsior logs and wetland plugs (Figure 30 & 31).

**Figure 30: Berm in Reach 2 prior to excavation.**

*This photo shows the berm in Reach 2 prior to excavation. Photo taken from upstream, looking north in January of 2009.*

**Figure 31: Reach 2 after work was completed.**

*Completed work at Station 12+50 to 14+20. The berm has been removed and the new stream channel excavated, rock installed at the mouth of the old channel (left side of photo) and bioengineering installed.*

At the downstream end where the channel spills into another pool, a section of the left bank, from Station 14+00 to 14+60, was re-sloped to eliminate a vertical bank (Figure 32 & 33).

**Figure 32: View looking upstream at Reach 2 before construction.**

*This photo shows the cutbank along the old channel in Reach 2, at the right of the photo, prior to excavation.*

**Figure 33: View looking upstream at Reach 2 after construction.**

*This photo looking upstream of Reach 2 shows the new channel on the left and the overflow channel on the right. Rock armoring at the outlet of the overflow channel can be seen right of center. The bank in the right foreground was re-sloped. Photo taken from downstream looking south.*

### TOE ROCK

Toe rock was installed at the mouth of the old channel where it exited from the pool. After the old channel was filled, approximately 30 cubic yards of toe rock was installed at this point. Willow clusters and wetland plants were planted around the rock (Figure 34).

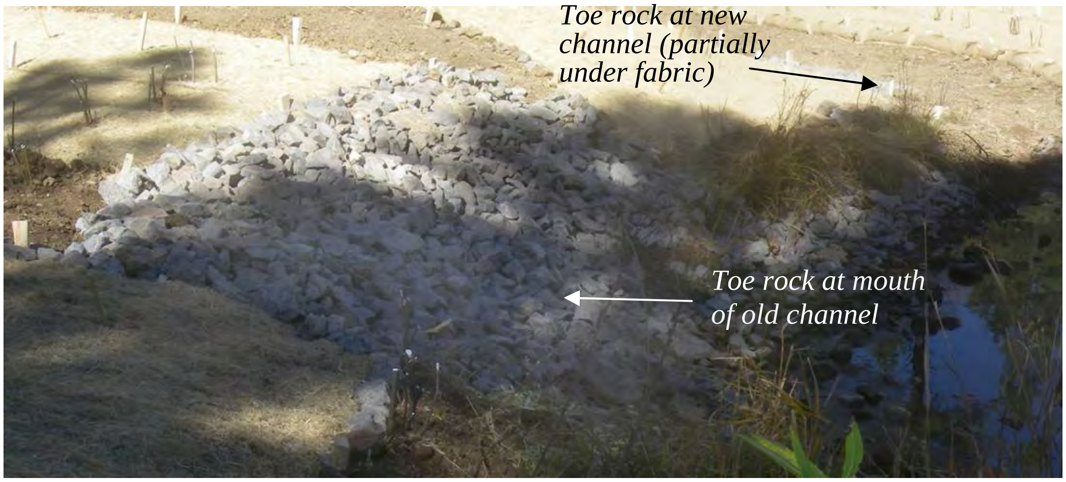



**Figure 34. Toe rock at Station 12+35.**

*Photo shows toe rock installed at the mouth of the old channel and left side of the new channel. Photo taken from left side looking northeast.*

### LOG SILLS

Log sills were installed in two locations within the fill of the old channel. The first location used five, 20-30 foot logs, and the second used three, 25-30 foot logs. Willow poles were planted in the trenches on the downstream side of the logs (**Error! Reference source not found.**).

**Figure 35. Log sill installation**

*These photos show excavation for the first log sill at Station 13+00, and the logs as they are stacked in the trench. Cable used to secure the logs together was placed in the trench before the first log was placed, and the ends clamped after the top log was in place. Willows are placed in trench prior to backfilling.*

### ROCK APRON AT STATION 14+00

The downstream end of the old channel alignment had approximately 4.5 cubic yards of riprap rock armoring installed. Larger rocks, which appeared during excavation, were embedded at the base of the apron to anchor it. Willow clusters were planted within it (Figure 36 & 37).

**Figure 36: Boulders harvested from site used as footer rock for apron.**

*Boulders uncovered during excavation were embedded in the base of the overflow channel's outlet to act as footer rocks for the rock apron. Photo taken from across main channel looking southwest.*

**Figure 37: Rock Apron at Station 14+00.**

*Completed rock apron at Station 14+00. Willow clusters can be seen planted within the apron. Photo taken from downstream looking south.*

## BIOENGINEERING INSTALLATIONS IN REACH 1 & 2

### *Willow Cluster & Vertical Bundle Plantings*

500 willow clusters, utilizing approximately 1740 willow poles, were planted: 290 in Reach 1, 27 at the debris site at the bridge, and 183 in Reach 2. Twenty-four of the clusters were planted as Vertical Bundles. Willows were wild harvested in the surrounding area. An auger attached to the mini-excavator was used to bore holes. After inserting 3-4 willow poles, they were backfilled, trimmed, and the cut tips sealed with latex paint (Figure 38 and 39).

**Figure 38: Willow Cluster Planting.**

*Willow cluster planting using the mini-excavator to bore holes. Clusters were inserted, backfilled, trimmed, and tips coated with latex paint. Photo taken in Reach 2 looking north.*

**Figure 39: Willow Vertical Bundle Planting.**

*This photo shows planting vertical bundles in holes that have been augered at the base of trenches. The poles are then bent and secured into the trench with stakes and the trench is backfilled. Photo taken in Reach 1 looking west.*

### *Willow Trench Plantings*

Willow trenches are planted by digging a long, deep trench with a backhoe, and planting clusters of willows in the trench. The trenches in Reach 2 found only damp soil, so a pump was used to fill them with water prior to backfilling. 160 linear feet of willow trenches, utilizing approximately 235 willow stems, were installed: 70-feet in Reach 1 and 90-feet in Reach 2 (Figure 40).

**Figure 40: Willow Trench Planting.**

*This photo shows planting willow trenches behind the toe rock. The trench has been dug to standing water and the willows inserted. They are then backfilled, trimmed, and the cut ends sealed with latex paint.*

### *Erosion Control Fabric Installation*

12 rolls of double net and 44 rolls of single net fabric were installed along disturbed areas along the new channel and old channel alignments. The top, bottom and ends of fabric areas are trenched and the fabric ends buried. It is also secured with wooden stakes every four feet along the edges and through the center of the rolls (Figure 41).

**Figure 41: Erosion Control Fabric Installation.**

*Installation of erosion control fabric. Trenching for the edge of the fabric can be seen at the right of photo. Photo taken in Reach 2, looking north.*

### *Erosion Control Log Installation*

Forty-three 12-in. x 10-ft erosion control logs were installed: 28 in Reach 1 and 15 in Reach 2. They were installed at the base of newly sloped or excavated banks, in areas determined to require extra toe protection. They were partially embedded in the ground and secured using wooden stakes and rope. They were then planted with wetland grass plugs (Figure 43).

**Figure 42: Erosion Control Log Installation.**

*This photo shows erosion control logs being installed and wetland plugs being planted into the logs after installation. Photo taken in Reach 2 looking north.*

### *Wetland Grass Plug Planting*

A total of 350 wetland grass plugs were planted (200 in Reach 1, 35 in the Debris area at the bridge, and 115 in Reach 2). They were wild harvested in the immediate area and transported in buckets. They were planted into the excelsior logs and/or directly into the ground (Figure 43 & 44). The channel in Reach 2 was dry at construction time, so the excelsior logs were not obtaining moisture to keep the plugs wet.

**Figure 43: Wetland plugs planted in excelsior logs.**

*This photo shows wetland plugs planted into excelsior logs. Photo taken in Reach 1.*

**Figure 44: Wetland plugs planted in the ground.**

*This photo shows wetland plugs planted into the ground by the Cross-Vane weir in Reach 1.*

### ATV ACCESS RESTRICTIONS

Fifteen, ten-foot logs (12-24 inch diameter), removed from Reach 1 during excavation, were placed in a manner to block several traffic paths through the trees that exited the paved road. The planned installation of a fence at another location was cancelled when it was found that another party had already installed one (Figure 45).

**Figure 45: Logs blocking ATV access.**

*This photo shows one of several places where logs were placed to limit ATV access.*

## FLOODING IN 2010

There are no stream gages located within the project site, therefore a determination of the type and duration of flows conveyed are estimated. There is a stream gage located at Show Low Creek, approximately 4.2 miles downstream from the project area. Since the watershed area is considerably larger at the gage than at the project site, a direct correlation of flows cannot be made, but can be inferred. Billy Creek is the only tributary that is not impounded by a reservoir. Therefore, high flows recorded at the gage more than likely originate in Billy Creek. This estimate of flow magnitude can be verified by analyzing monitoring cross sections with a Cross-Section Hydraulic Analyzer model. This spreadsheet provides a rating curve (stage-discharge) for a given stream channel cross-section based on the Manning Equation (USDA NRCS, 2013). The elevation of flood debris measured at monitoring cross-sections is run through the model with the output being an estimated discharge.

During the spring and summer of 2010, the site experienced flood flows that exceeded the bankfull flow of approximately 70 cfs. During March of 2010, the gage recorded two flow events that were close to 300 cfs (this would be a 10 year flood event at the project site). Then in August of 2010, a monsoon generated flood of approximately 675 cfs was recorded at the gage site. Based on flood debris recorded at the cross-sections and analyzed with the model, this flow represents an approximate 25 year flood event which flowed through the site (Figure 46).

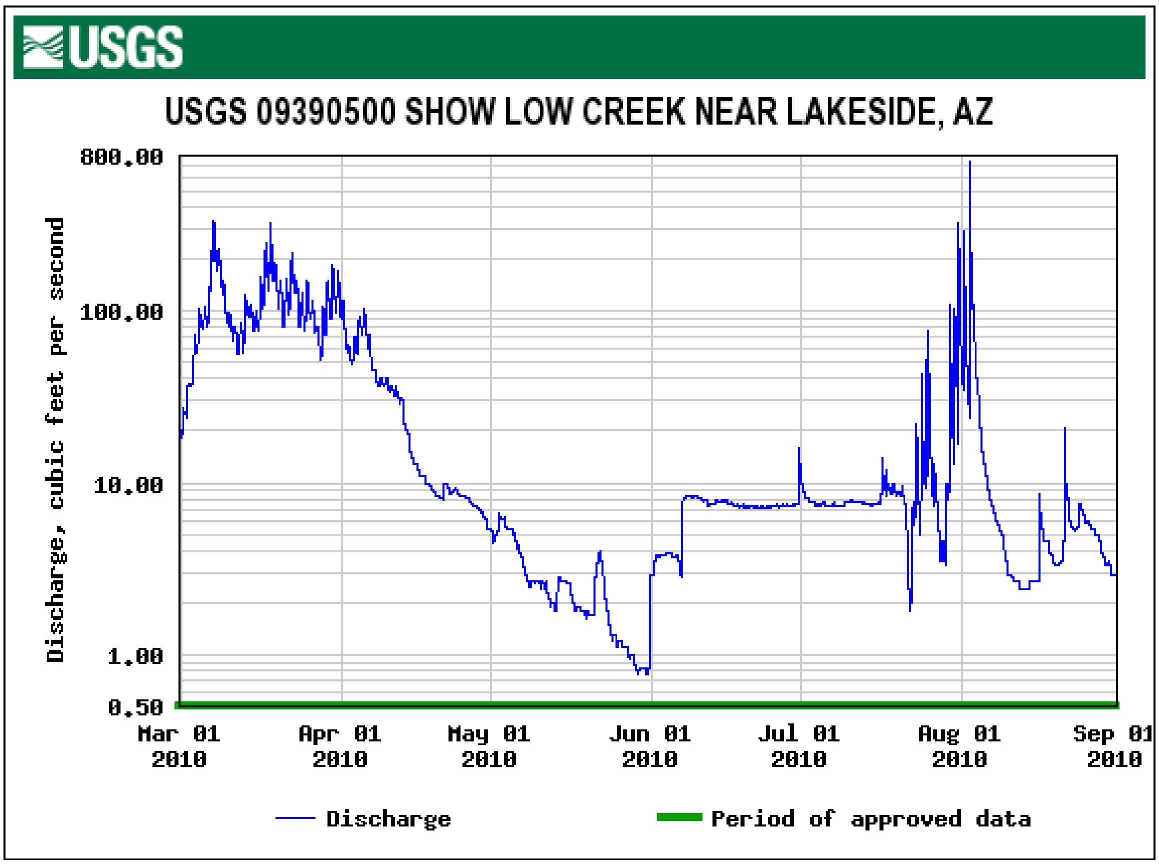



**Figure 46. Daily discharge at Show Low Creek.**

During the annual monitoring, it became clear that the two project areas saw relatively little disturbance from the flows that occurred that year. The one exception was the rock weir in Reach 1. The high water flowing over the structure caused some of the rock to fall away and also resulted in a deep scour hole at the base of the structure. During the following spring and summer, a new topographic survey was completed at the site and a new modified grade stabilization structure was designed. The second phase of construction to repair the weir and to install additional plantings commenced in October of 2011.

# PHASE II CONSTRUCTION & REVEGETATION

Phase II construction and re-vegetation (Tasks 5 & 6) for Billy Creek Natural Area Riparian Restoration Project (No. 05-126WPF) took place during the week of October 23-28, 2011. Three Natural Channel Design personnel worked on the project at various times. Equipment utilized during the construction and re-vegetation included a flatbed trailer, one large excavator, a large front-end loader and a stinger attachment for the excavator. An American Conservation Experience Crew (ACE) provided the labor for the revegetation efforts.

## WORK ACCOMPLISHED

| TASK 5 – Implement Construction | |
|---|---|
| Install modified grade stabilization structure | - 38 cubic yards basalt boulders |
| Replace ATV access restriction | - Rock and earthen berm |
| Loosen soil and re-grade disturbance | - scarifying |

| TASK 6 – Implement Revegetation | |
|---|---|
| Erosion fabric (single net straw) | 8 ft x 195 ft (3rolls @ 66 ft ea) |
| Willow clusters and vertical bundles planted | 75 plantings (~200 willow stems) |
| Wetland sedge plugs planted | 285 Plugs |
| Native grass plugs planted | 23 Plugs |
| Native grass seeding | 1.0 Acre |

In the next section, a more in-depth look at the Phase II work is outlined.

## REACH 1

See As-Built Drawings, Appendix A.

### MODIFIED GRADE STABILIZATION STRUCTURE

During the second phase of construction, a modified grade stabilization structure was designed and installed to replace the original weir structure. The flow event that damaged the first structure was large (~25-yr recurrence interval event), so the site and structure was first analyzed to determine the cause of failure.

The original structure utilized rock found on site during the initial construction and the structure was ultimately too small for the elevation drop of the stream. The replacement structure utilized more and larger rock and also incorporated two smaller step-pools to aid in energy dissipation. This new structure was tested in 2013 when several flows over bankfull occurred (the largest at 259 cfs or ~10-year event). No damage to the structure occurred during that flow.

**Figure 47: Layout of the new weir structure.**

The modified grade stabilization structure took just over a day to install. The structure is built out of a series of two and three-foot rocks aligned in a chevron shape with the point of the “v” pointing upstream (Figure 47). The construction sequence included excavating a trench along each vane arm three to four feet deep and installing 2-ft footer rocks along the base. Then 3-ft rocks were installed on top of the footers to complete the weir outline (Figure 48). Between the vane arms, a rock apron consisting of smaller 1.5 foot graded rock was installed to prevent undermining of the structure. This apron was extended downstream from the weir to the existing section of rock rip-rap bank protection installed during the previous construction phase.

A total of 38 cubic yards of basalt rock was installed for this practice. This includes 40 each, 3 ft dia. boulders, 60 each, 2 ft diameter boulders and 190 each, 1.5 ft diameter boulders. Larger voids in the rock structure were filled by hand with smaller cobbles and then gravel excavated from the bed was placed over the apron of the structure to help lock the rocks together (Figure 49 - 50).

**Figure 48: Completion of the left vane arm.**

**Figure 49: Filling larger voids in completed structure.**

**Figure 50: Looking downstream on completed structure.**

## REVEGETATION

### *Willow Clusters*

After the rock structure was completed, the American Conservation Experience (ACE) crew went to work re-vegetating the work site. A "stinger" (a long, pointed metal rod) was attached to the excavator and used to punch holes into the ground surrounding the rock structure to allow for willow cluster plantings (Figure 51). Clusters were planted on approximate 2-foot centers around the weir and on 4-foot centers along the rock rip-rap downstream. Two to three bare-stem willow poles were planted in each hole and slurry of mud and water poured into the holes to displace any air pockets. A total of 56 willow clusters were planted in Reach 1.

**Figure 51: Stinger attachment on excavator arm.**

In addition to the willow clusters, there were nine vertical willow bundles planted on the left bank downstream from the weir. Vertical willow bundles consist of three to four willow stems tied into a bundle and placed into a shallow trench that is dug from the channel bed vertically up the bank. The stems are anchored to the bank with a 1.5 foot stake, then the stems are covered with soil, leaving approximately one foot of stem sticking out the top (Figure 52).

**Figure 52: Installing vertical willow bundles and wetland plugs downstream from weir.**

### *Wetland and Grass Plugs*

Wetland plugs transplanted in Reach 1 were harvested from the stream banks immediately upstream from the work area and consisted of native sedge and smaller rush species. Plugs were 3-5 inches across, containing approximately 5-6 inches of vertical root mass. A total of 160 wetland plugs were planted within Reach 1, along both banks from the weir structure down to the end of the reach. These plugs were planted along the toe of the banks, from the channel bed up to approximately bankfull elevation (approximately 1.5 ft above channel bed). Plugs were planted on approximately 2 – 3 foot centers in areas disturbed during construction or areas devoid of vegetation.

In addition to the wetland plugs, 23 grass plugs were harvested and transplanted to the right bank above the weir structure. These grass plugs were derived from local deer grass clumps (*Muhlenbergia spp)* growing on the upper banks upstream from the project area. Grass plugs averaged 6 inches across and contained approximately 6 inches of vertical root mass. The plugs were planted on the upper banks, above the elevation of the sedge plugs (Figure 53).

**Figure 53: Grass and wetland plugs planted downstream from weir structure.**

Downstream from the weir location, the rock rip-rap that was installed during the first phase of construction was covered with soil. This allowed for the installation of wetland plugs along the toe of this portion of the bank for aesthetic reasons (Figure 54 and Figure 55).

**Figure 54: Rock rip-rap downstream from weir structure, 2010**

**Figure 55: Rock rip-rap section covered with soil and planted, 2011.**

### *Seeding*

After the rock structure was completed, all areas impacted by heavy equipment traffic were scarified to break up soil compaction (Figure 56). On the area most heavily impacted by the machinery (approximately 2,000 sq ft), a light layer of composted mulch (50 cu ft) was spread over the scarified surface and raked into the soil to help break up the clay and provide a more suitable seed bed (Figure 57). All disturbed areas (0.5 acre) were then seeded with a native grass mixture (Table 12). Flowering plants were eliminated from the seed mix due to the high density of sunflower in the area the previous season. A light layer of pine needles collected from adjacent forested lands was then spread over the seeded areas to help protect the seed.

**Figure 56: Scarifying the ground to break up compaction.**

**Table 12. Native seed mix used to revegetate disturbed areas.**

| Season | Species | Scientific Name | % of Mix | lb PLS for 1 acres |
|---|---|---|---|---|
| Cool Season | Western wheatgrass | (*Pascopyrum smithii*) | 20% | 7.2 |
| Warm Season | Arizona Fescue | *(Festuca arizonica)* | 20% | 1.6 |
| Cool Season | Sand Dropseed | *(Sporobolus cryptandrus)* | 10% | 0.1 |
| Warm Season | Blue Grama | *(Boutelua gracilis)* | 15% | 0.9 |
| Warm Season | Spike Muhly | *(Muhlenbergia wrightii)* | 20% | 0.56 |
| Warm Season | Mountain Muhly | *(Muhlenbergia montana)* | 15% | 1.5 |
| | **TOTAL** | | 100% | **11.90 lb PLS** |

* Planting to be done by hand broadcasting, rate has been increased by a factor of 4.

**Figure 57: ACE crewmembers spreading composted mulch and pine needles.**

As the equipment was leaving the site, the access point from the paved road was scarified and a rock and earthen berm and a log were placed at the base of the embankment to prevent ATV access to the stream (Figure 58).

**Figure 58: Closed access point**

## REACH 2

### REVEGETATION

See As-Built Drawings, Appendix A, for location information.

Reach 2 did not require any earth moving activities during this second phase of construction and revegetation. Work in this reach focused on additional revegetation to supplement areas that did not have successful plant establishment.

***Vertical Willow Bundles***

Ten vertical willow bundles were installed along a 24 foot long bank at the downstream end of this reach. Installation included digging a six inch deep trench vertically up the bank starting at the channel bed and extending 4-5 feet up the bank. A bundle of four willow stems was laid in each trench and secured by a 1.5 foot stake. The trenches were then covered with soil, leaving approximately one foot of the stems exposed (Figure 59 and 60).

**Figure 59: Digging trenches for vertical willow bundles.**

**Figure 60: Completed bank plantings.**

### *Wetland Plugs*

Wetland plugs for Reach 2 were harvested from areas adjacent to the channel immediately upstream from the project reach. Plugs consisted of a mixture of native sedge and rush species. As in Reach 1, plugs averaged 3-5 inches across and contained approximately 5-6 inches of vertical root mass. A total of 125 wetland plugs were planted in this reach in areas lacking in vegetation along the toe of the banks. This included the rock plug installed in the old channel location (Figure 61). At this location a small pocket was pushed between the rocks, soil added, and sedge plugs planted.

**Figure 61: Sedge plugs planted in rock plug in Reach 2.**

### *Mulch and Seed*

The last item for Reach 2 was the preparation and re-seeding of the right bank where the berm was removed. The old netting and stakes were removed to expose the ground surface. Once exposed, the top 2-3 inches of the ground was tilled with picks and shovels. Once scarified, 155 cubic feet of composted mulch was spread over the 1,400 square feet of bank. This mulch was then mixed into the soil in preparation for seeding. A native seed mix blend (Table 1) was hand broadcast over the bank. Finally the bank was covered with a single net straw erosion control fabric to provide temporary protection from wind and water erosion (Figure 62-64). Existing grass plants were pulled through cuts in the fabric to allow them to continue to grow.

**Figure 62: Right berm bank in Reach 2 prior to seeding.**

*Vegetation on this bank has been struggling due to aspect and poor soil conditions.*

**Figure 63: Preparation of the right bank in Reach 2.**

*During bank preparation, any grass species found growing on the bank were avoided and left to grow.*

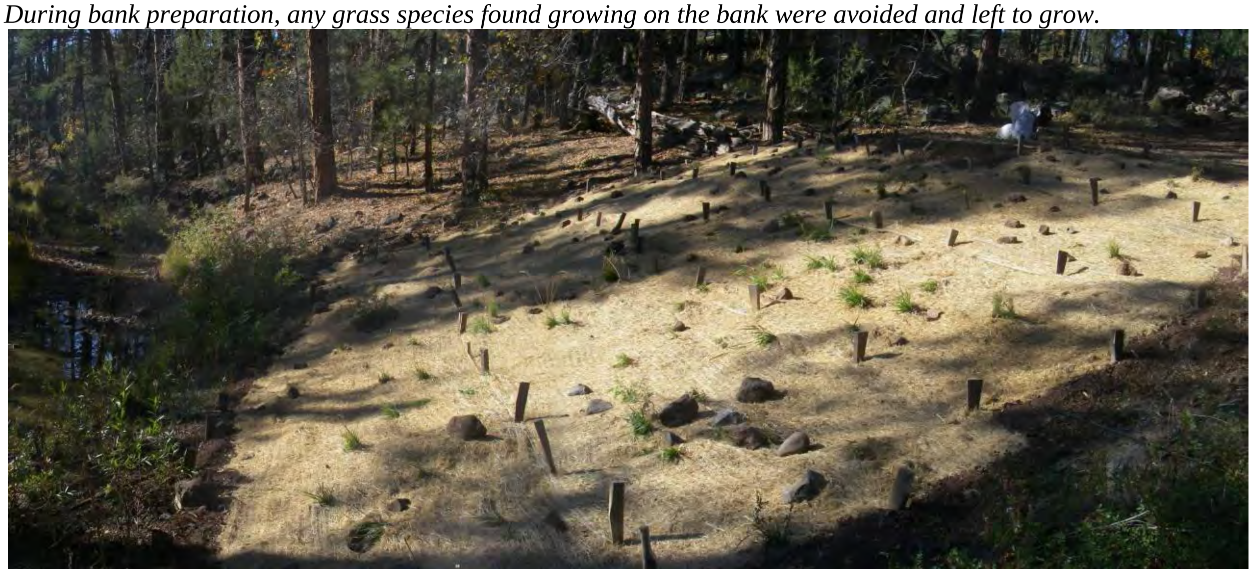


**Figure 64: Completed bank in Reach 2.**

*Existing grass plants were pulled through the fabric during installation.*

At the top of this bank, runoff from the access road had been concentrating and flowing down this bank, causing some minor erosion. Two small drainage dips were dug across the road uphill from this bank. This will help to redirect the flow from the road down across an undisturbed grassy area (Figure 65).


**Figure 65: Redirecting road runoff away from the bank.**

# MONITORING

Monitoring of a project is essential to determine if the enhancement techniques and installed structures are meeting the objectives. It can also help determine if any detrimental changes are occurring that need to be addressed. Stream channel monitoring is conducted to detect changes in channel dimensions and channel substrate within the project area over time. Channel cross-sections and stability of installed structures were monitored to assess stability over time. Change is quantified by comparing repeat surveys against each other and baseline conditions that were measured post-construction in November of 2009. Photo points were used to create a qualitative photo record of changes over time to the stream channel and vegetation within the project area. All bioengineering treatments were monitored to determine success of re-vegetation efforts.

Since the initial construction was completed in the fall of 2009, the Billy Creek project has been monitored for four consecutive seasons. Each monitoring effort was done at the end of the growing season and post-monsoon. As part of the monitoring effort, an estimate of the peak flow event that occurred the previous season was obtained. This data was used to determine the duration and force of water that the banks would have had to withstand that year. This information can be found in the Annual Monitoring Reports associated with this project.

## STREAM CHANNEL STABILITY MONITORING

Four representative channel cross-sections were established throughout the project site to measure any changes in channel width and bed elevation over time. Structural stability of all installed structures is also monitored in areas where weirs, toe rock or coir logs were placed along the stream channel for erosion control.

The relative stability of the channel is determined by repeat measurements of four permanent cross-sections throughout the project area (Harrelson et al 1994). The locations of the four cross-sections are shown in Figure 66 and the coordinates of the cross-section markers consisting of ½ inch rebar pin are given in Table 13. All channel dimensions were surveyed using a laser level. Riffle sections are chosen for cross-sections because they are the most stable, least dynamic areas of a river. Bankfull stage is identified at each cross-section to provide a common reference point using standard protocols (Dunn & Leopold 1978). The cross-sections are re-surveyed each fall to evaluate changes in the width and depth of the stream channel measured at bankfull stage.

**Table 13. Cross-section locations**

| | Left Pin | Right pin |
|---|---|---|
| XS# | UTM (NAD83) | UTM (NAD83) |
| 1 | 12S N0596060 E3779273 | 12S N0596091 E3779272 |
| 2 | 12S N0596012 E3779343 | 12S N0596046 E3779359 |
| 3 | 12S N0595485 E3779702 | 12S N0595483 E3779680 |
| 4 | 12S N0595446 E3779671 | 12S N0595448 E3779688 |

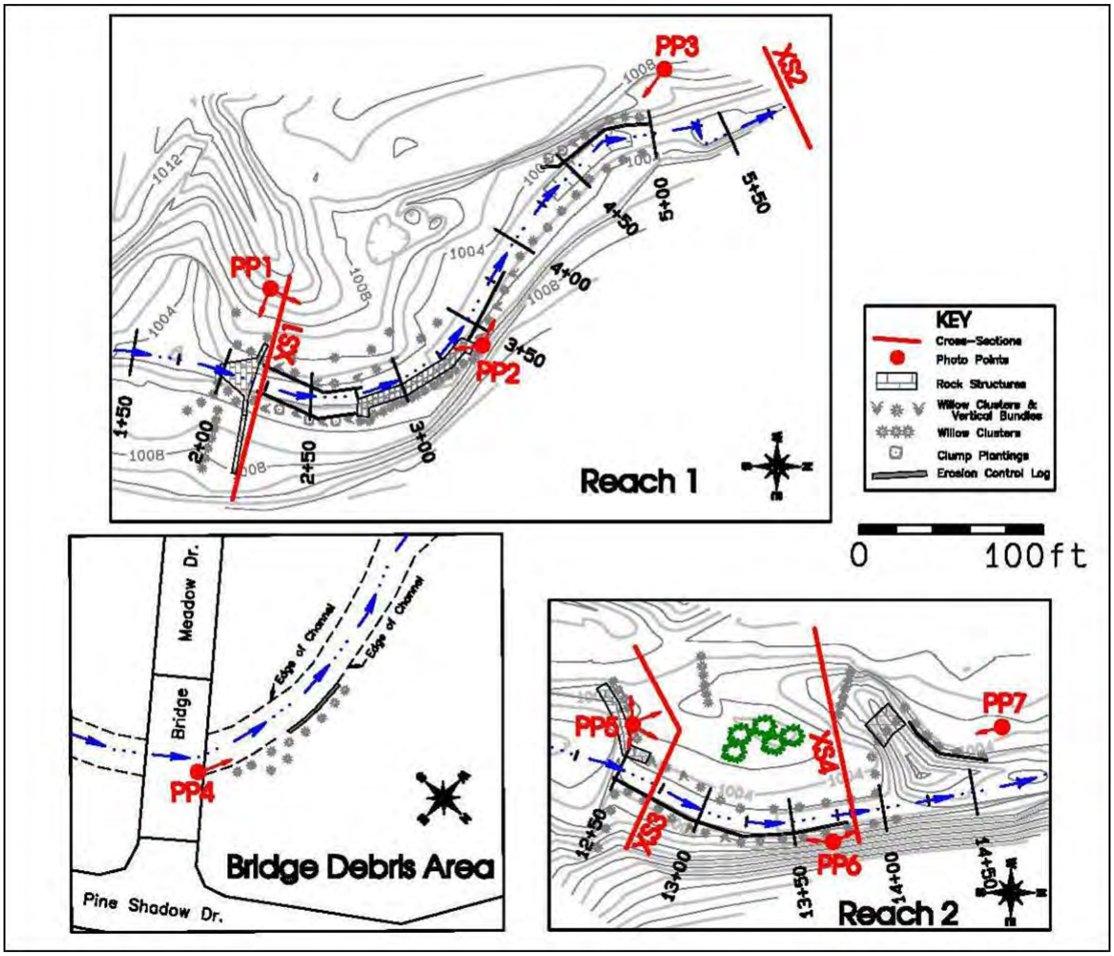



**Figure 66 Location of cross-sections and photo points.**

There have been no significant changes to the stream channel geometry throughout the project area during the monitoring period as measured at the monitoring cross-sections. The channel has remained stable with no major erosion, scour or aggradation. The only exception is at cross-section one, which is located at the site of the grade control structure. After the initial structure was replaced in 2011, there has been no further change at this cross-section.

As seen in Table 14, most measurements changed very little. The biggest variations were due to cross-section pins being lost. The cross-section pins were replaced, but they were not necessarily in the exact location. Hence the cross-section measurements would reflect a small change that was due to measurement error.

**Table 14. 2009 to 2012 stream cross-section dimensions**

**Cross Section 1**

| | Year | Bankfull Area (ft$^2$) | Bankfull Width (ft) | % Width Change | Floodprone Width (ft) | Bankfull Max Depth (ft) | % Depth Change | Bankfull Mean Depth (ft) | Width/Depth Ratio | Entrench. Ratio | Substrate D50 | Channel Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 18.0 | 17.0 | | 39.0 | 1.7 | | 1.1 | 16.1 | 2.3 | gravel | C4 |
| | 2010 | 42.1 | 20.0 | 18% | 80.0 | 4.7 | 64% | 2.1 | 9.5 | 4.0 | gravel | C4 |
| New Baseline | 2011* | 35.8 | 20.0 | na | 62.0 | 3.6 | na | 1.8 | 11.2 | 3.1 | boulders | C2 |
| | 2012 | 35.0 | 20.0 | 0% | 62.0 | 3.6 | 0% | 1.7 | 11.4 | 3.1 | boulders | C2 |
| | 2013** | 29.4 | 20.0 | 0% | 60.0 | 3.4 | 6% | 1.5 | 13.6 | 3.0 | boulders | C2 |

* location of new stabilization structure.

** Left pin was missing during survey, cross section not measured along same alignment as last year resulting in change in bankfull area.

**Cross Section 2**

| | Year | Bankfull Area (ft$^2$) | Bankfull Width (ft) | % Width Change | Floodprone Width (ft) | Bankfull Max Depth (ft) | % Depth Change | Bankfull Mean Depth (ft) | Width/Depth Ratio | Entrench. Ratio | Substrate D50 | Channel Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 22.9 | 23.2 | | 37.0 | 1.4 | | 1.0 | 23.5 | 1.6 | gravel | B4 |
| | 2010 | 19.2 | 23.2 | 0% | 36.0 | 1.1 | 21% | 0.8 | 28.0 | 1.6 | gravel | B4 |
| | 2011 | 20.2 | 23.0 | 1% | 36.0 | 1.1 | 0% | 0.9 | 26.2 | 1.6 | gravel | B4 |
| | 2012 | 19.9 | 23.0 | 0% | 36.0 | 1.2 | 9% | 0.9 | 26.6 | 1.6 | gravel | B4 |
| | 2013 | 20.0 | 23.0 | 0% | 36.0 | 1.3 | 8% | 0.9 | 26.5 | 1.6 | gravel | B4 |

Old Cross section **Cross Section 3**

| | Year | Bankfull Area (ft$^2$) | Bankfull Width (ft) | % Width Change | Floodprone Width (ft) | Bankfull Max Depth (ft) | % Depth Change | Bankfull Mean Depth (ft) | Width/Depth Ratio | Entrench. Ratio | Substrate D50 | Channel Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| New Cross Section | | | | | | | | | | | | |
| | 2009* | 16.5 | 20.0 | | 37.0 | 1.7 | | 0.8 | 24.2 | 1.9 | gravel | B4 |
| | 2010 | 26.8 | 17.0 | na | 30.5 | 2.5 | 32% | 1.6 | 10.8 | 1.8 | gravel | B4 |
| | 2011 | 18.1 | 16.5 | 3% | 30.5 | 1.7 | 32% | 1.1 | 15.1 | 1.8 | gravel | B4 |
| | 2012 | 17.3 | 16.5 | 0% | 30.5 | 1.8 | 6% | 1.1 | 15.7 | 1.8 | gravel | B4 |
| | 2013 | 15.2 | 16.0 | 3% | 30.0 | 1.5 | 17% | 0.9 | 16.9 | 1.9 | gravel | B4 |

* old cross section data, new cross section established in 2010

**Cross Section 4**

| | Year | Bankfull Area (ft$^2$) | Bankfull Width (ft) | % Width Change | Floodprone Width (ft) | Bankfull Max Depth (ft) | % Depth Change | Bankfull Mean Depth (ft) | Width/Depth Ratio | Entrench. Ratio | Substrate D50 | Channel Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 18.2 | 18.0 | | 31.0 | 1.4 | | 1.0 | 17.8 | 1.7 | gravel | B4 |
| | 2010 | 16.7 | 18.0 | 0% | 31.0 | 1.7 | 21% | 0.9 | 19.5 | 1.7 | gravel | B4 |
| | 2011 | 18.1 | 18.0 | 0% | 33.0 | 1.6 | 6% | 1.0 | 17.9 | 1.8 | gravel | B4 |
| | 2012 | 17.6 | 18.0 | 0% | 33.0 | 1.6 | 0% | 1.0 | 18.4 | 1.8 | gravel | B4 |
| | 2013 | 17.1 | 18.0 | 0% | 33.0 | 1.6 | 0% | 1.0 | 18.7 | 1.8 | gravel | B4 |

### CROSS-SECTION 1

This cross section is located at the beginning of the project area. The original rock weir installed in 2009 was modified in 2011 after high flood waters caused erosion at the structure. This monitoring cross section was originally set up downstream from the rock weir, but the improvements of the weir extend through this location. This cross section now measured the rock structure and helped to detect any changes to the structure.

During the 2013 survey, the left end pin for this cross section was found to be missing, so the cross section in 2013 does not line up perfectly with previous years. This resulted in a slight shift in the cross section and is the reason that some of the cross section data is different in 2013 compared with the previous two years.  This cross section is stable and in the throat of the rock weir. No rocks have moved since the previous survey. The vegetation continues to grow and fill in around the channel and weir. There was a small amount of scour around the top end of the right side of the weir but it is not threatening the integrity of the structure and the weir is intact and functioning properly.

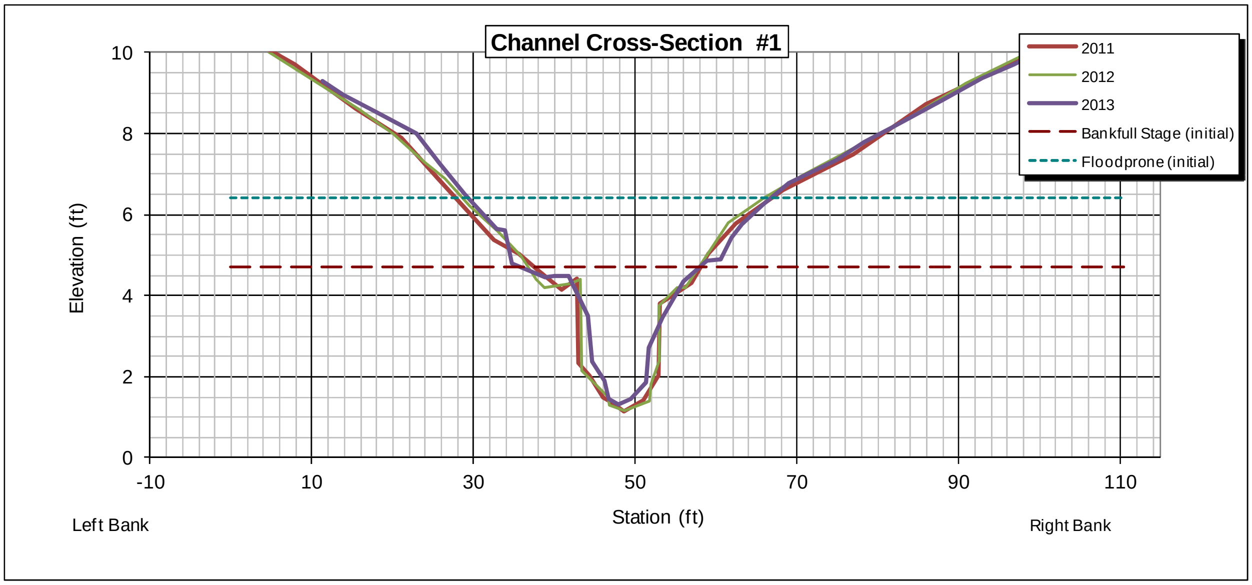



**Figure 67: Cross-section 1, 2011 to 2013 profiles**



**Figure 68: Cross-section 1 Photos.**

*These photos are looking down through the weir at cross-section 1.*

## CROSS-SECTION 2

Cross-section 2 is located at the end of Reach One, in a location that did not receive any ground disturbing activities. Other than vegetation growing, no change occurred at this cross section.

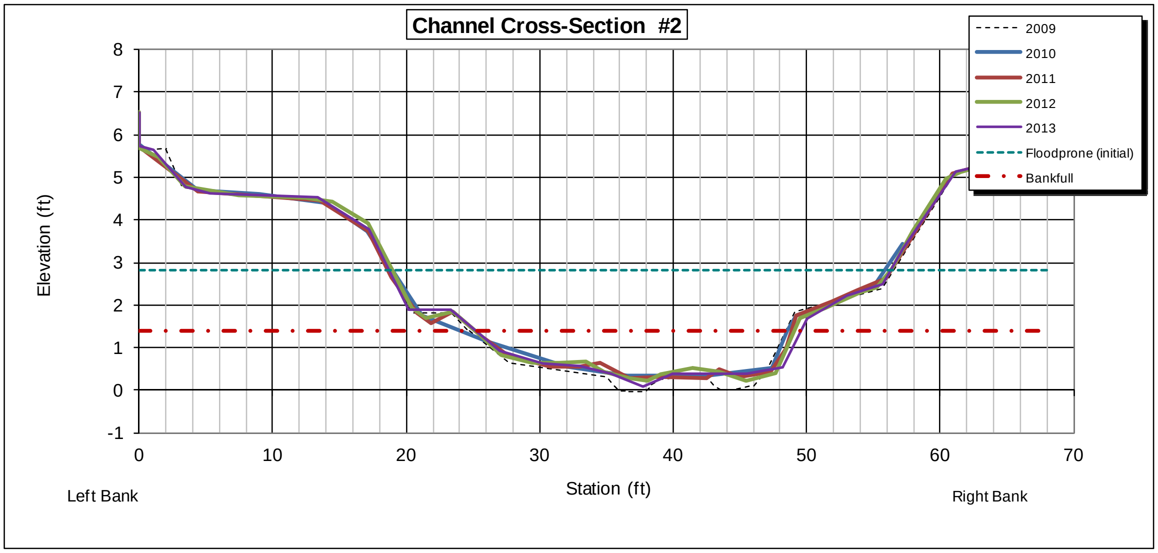



**Figure 69: Cross-section 2, 2009 to 2013 profiles**



**Figure 70: Cross-section 2 Photos.**

**CROSS-SECTION 3**

Cross-section 3 is located at the outlet of the pool in Reach 2. The flood in 2010 causes some scour in the soft, newly constructed bed that has since filled to the current, stable elevation.

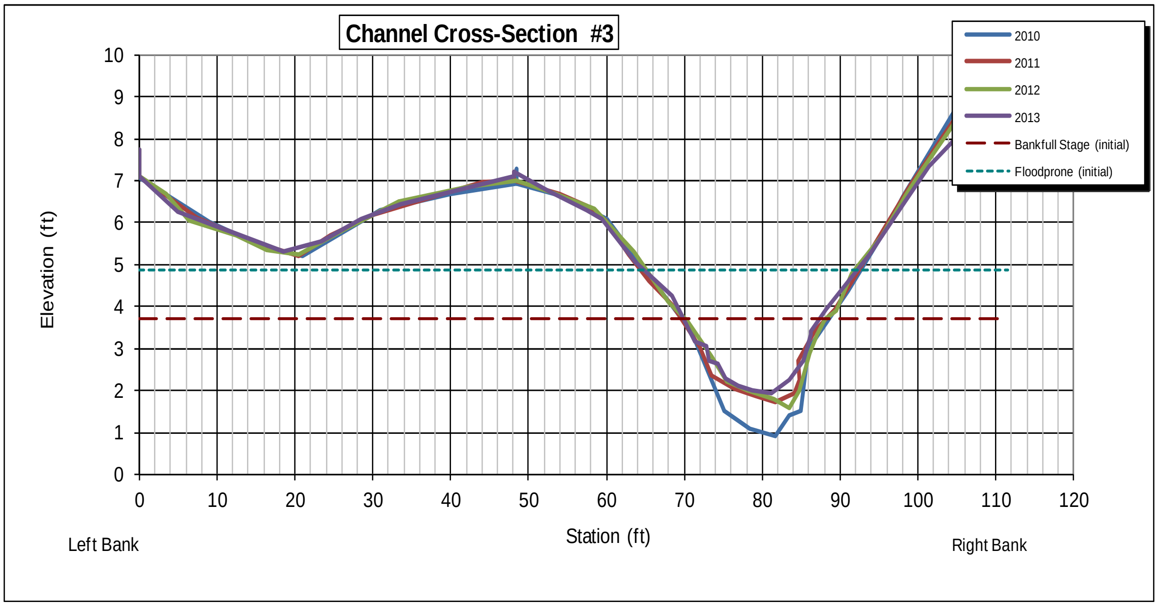



**Figure 71. Cross-section 3, 2010 to 2013 profiles**

**Figure 72. Cross-section 3, September 2010.**

The channel at this site is starting to narrow as vegetation fills in along the edges as seen in Figure 73.

**Figure 73. Cross-section 3, September 2013.**

## CROSS-SECTION 4

Cross-section four is located at just over one hundred feet downstream from Cross-section 3. No change to the cross section was noted during the 2013 monitoring. The cross section remains stable.

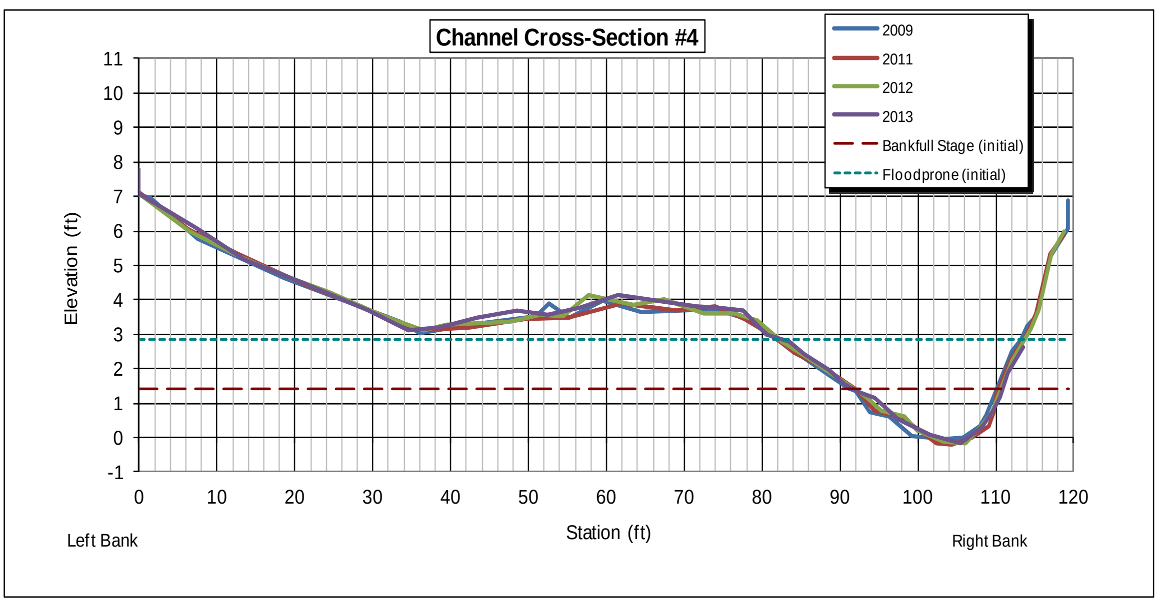



**Figure 74. Cross-section 4, 2011 to 2013 profiles**



**Figure 75. Cross-section 4 Photos.**

## CHANNEL SUBSTRATE

Another item measured during the annual monitoring was the channel substrate. The substrate is monitored to detect changes in bed particle size over time. A modified Wolman Pebble Count is used to determine benthic substrate size distribution (Wolman 1954). The procedure consists of the random sampling of at least 100 particles within the channel bed at each of the cross-sections. Measurements of these particles allow for the development of a range of particle diameters. Tracking the size of particles in specific distribution classes provides an indication of changes in channel substrate over time (Table 15). Substrate in the excavated channels was expected to become coarser over the first couple of years after construction before reaching a new equilibrium.

**Table 15 Channel substrate at cross sections.**

| XS # | Distribution | 2009 (mm) | 2010 (mm) | 2011 (mm) | 2012 (mm) | 2013 (mm) |
|---|---|---|---|---|---|---|
| 1 | $D_{15}$ | 0.01 | * | BOULDERS | BOULDERS | BOULDERS |
| | $D_{50}$ | 22 | | | | |
| | $D_{85}$ | 60 | | | | |
| | $D_{100}$ | 115 | | | | |
| 2 | $D_{15}$ | 3.2 | 6 | 12 | 3 | 4 |
| | $D_{50}$ | 25 | 20 | 25 | 22 | 22 |
| | $D_{85}$ | 65 | 50 | 50 | 55 | 55 |
| | $D_{100}$ | 220 | 220 | 110 | 190 | 200 |
| 3 | $D_{15}$ | 0.01 | 5 | 10 | 10 | 4 |
| | $D_{50}$ | 20 | 20 | 22 | 25 | 25 |
| | $D_{85}$ | 34 | 45 | 36 | 45 | 60 |
| | $D_{100}$ | 95 | 150 | 150 | 130 | 190 |
| 4 | $D_{15}$ | 0.01 | 0.3 | 9 | 7 | 8 |
| | $D_{50}$ | 15 | 15 | 28 | 23 | 25 |
| | $D_{85}$ | 40 | 45 | 51 | 45 | 65 |
| | $D_{100}$ | 160 | 110 | 150 | 240 | 130 |

During the assessment of the project area, the particle distribution included a high percentage of fine materials resulting in a bi-modal distribution (Table 7 and Figures 6 and 8) and is a possible indicator of erosion happening in the system. As seen in the above table, he fine sediments that were present during assessment and after construction (seen in the D15) have been removed by the subsequent flows, resulting in a stable gravel bed system. All cross-sections (with the exception of cross section 1) are very similar in size distribution. Reduction in fine sediments within the bed should increase habitat quality for aquatic life. If the very fine particles were to increase again, it would indicate possible erosion or another source of sediment somewhere in the system.

## STABILITY OF ROCK STRUCTURES

Rock structures were assessed qualitatively to determine whether they are meeting their intended purpose and for any signs of failure through scour and/or bank erosion. Integrity of all structural features was assessed qualitatively by visually observing whether the structure is continuing to function (Table 16). It is expected that all structures will accomplish their intended purpose without failure, short of an extremely large (>25 year) flood event.

**Table 16. Rock structure stability**

| Location | Structure | Stability (Good/Poor) | | | | |
|---|---|---|---|---|---|---|
| | | 2009 | 2010 | 2011 | 2012 | 2013 |
| **Reach 1** | | | | | | |
| STA 2+00 | Cross-Vane Weir | good | good | new installation | good | good |
| STA 2+15 | Cutoff Sill | good | good | good | good, difficult to find now due to vegetation | good |
| STA 2+75 - 3+40 | Toe Rock | good | good | good | good | good |
| **Reach 2** | | | | | | |
| STA 12+35 - 12+55 | Toe Rock | good | good | good | good | good |
| STA 14+00 | Rock Apron | good | good | good | good | good |

All installed structures are intact and functioning. No detrimental effects on the structures were noted during the 2013 monitoring period. Photos of each structure are shown on the following pages (Figures 76-81).

**Figure 76: Looking upstream through modified weir in Reach 1**
*Rocks are all still in place and functioning. Planted willows are filling in around the structure.*

**Figure 77. Rock sill location in Reach 1**
*The cutoff rock sill in Reach 1 is hidden beneath vegetation.*

**Figure 78: Toe rock at Reach 1.**

*The toe rock in Reach 1 is stable. Willows planted along the toe in 2011 are growing and filling in.*

**Figure 79: Toe rock boulders on left bank in Reach 1.**

**Figure 80. Toe rock installed in Reach 2.**

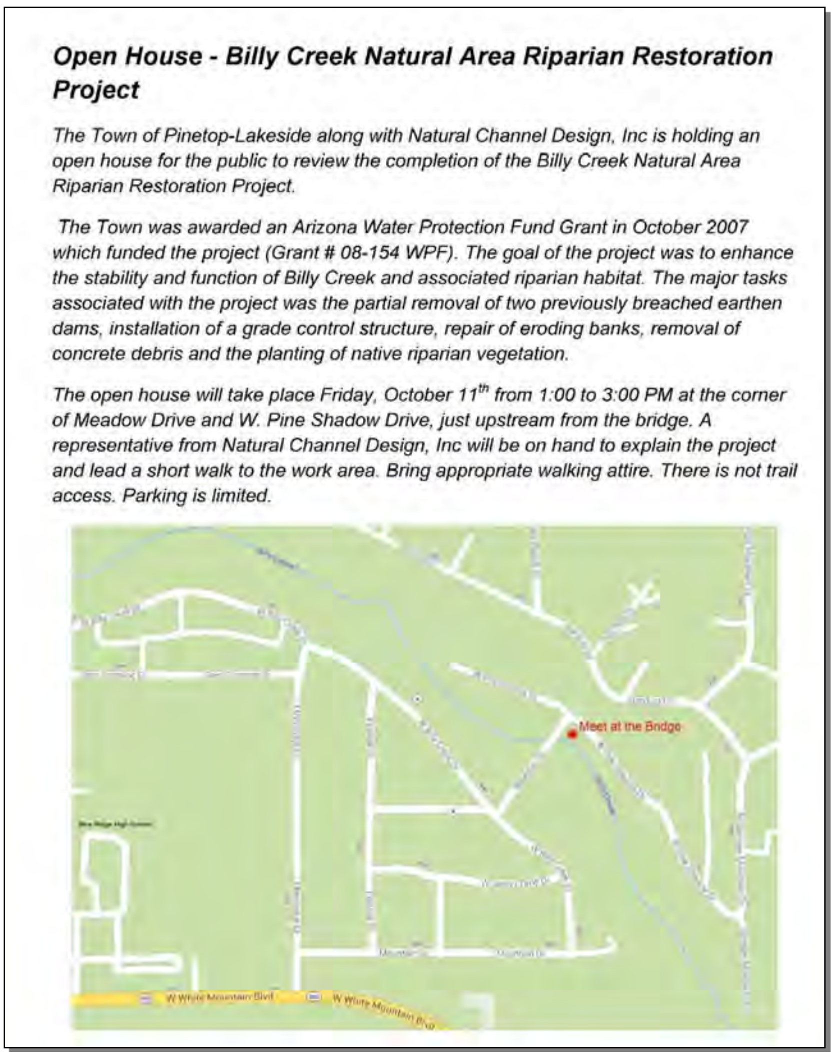
**Figure 81. Rock apron at outlet of old channel, Reach 2**

*The rock apron is becoming more obscured with vegetation.*

## PUBLIC OUTREACH

The goal of public outreach is to develop the interpretive mechanisms and information necessary to educate visitors and community stakeholders about the Billy Creek Natural Area Riparian Restoration Project. Public outreach efforts began back in 2007 with landowner meetings regarding the potential project. Though the project is located on Town property, it was important to get feedback from landowners whose property abutted the project. During this meeting, an outline of the project was presented along with the role of the Water Protection Fund as the funding source.

Two more formal meetings were held in 2009 to meet with local citizens to update them on the design for restoration. Additionally, affected landowners met with NCD and Pinetop-Lakeside personnel separately to walk property lines, access points and discuss specific aspects of the project prior to implementation and informal discussions were held with the landowners as needed during the monitoring periods when citizens noticed personnel on site. The final formal outreach activity took place in October, 2013 with an invite to the local citizens to attend an open house on the project. The outreach was advertised in the local paper two separate times a couple of weeks prior to the open house. Figure 82 shows the announcement.



***Open House - Billy Creek Natural Area Riparian Restoration Project***

*The Town of Pinetop-Lakeside along with Natural Channel Design, Inc is holding an open house for the public to review the completion of the Billy Creek Natural Area Riparian Restoration Project.*

*The Town was awarded an Arizona Water Protection Fund Grant in October 2007 which funded the project (Grant # 08-154 WPF). The goal of the project was to enhance the stability and function of Billy Creek and associated riparian habitat. The major tasks associated with the project was the partial removal of two previously breached earthen dams, installation of a grade control structure, repair of eroding banks, removal of concrete debris and the planting of native riparian vegetation.*

*The open house will take place Friday, October 11th from 1:00 to 3:00 PM at the corner of Meadow Drive and W. Pine Shadow Drive, just upstream from the bridge. A representative from Natural Channel Design, Inc will be on hand to explain the project and lead a short walk to the work area. Bring appropriate walking attire. There is not trail access. Parking is limited.*



**Figure 82. Public outreach announcement.**


**Figure 83. Local Scout members being briefed on the project.**

On the day of the outreach event, John Vuolo with the Town of Pinetop-Lakeside and Mark Wirtanen with Natural Channel Design, were present to lead the outreach (Figure 83). Twelve members from the local Boy Scouts and Cub Scouts along with two pack leaders came to the outreach to learn about the restoration techniques and to volunteer for clean-up and to plant sedges. Only a few other members of the public stopped by for brief periods.

**Figure 84. Scouts pulling wood stakes from along the channel.**

The Scouts cleaned up wooden stakes that had been used to hold down erosion control fabric, but were no longer needed. In addition, non-native scotch thistles were located within the project area. These noxious weeds were flowering and setting seed, so several Scout members cut, bagged and removed them from the site. Also, all trash along the adjacent road was cleaned up (Figure 86).

**Figure 85. Digging non-native Scotch thistle plants.**

**Figure 86. Removing trash from the site.**

The final activity was to plant sedges along the channel edge. Native sedge plants growing upstream from the project area were dug out and transplanted to sites along the channel edge that were devoid of vegetation (Figure 87).

**Figure 87. Scouts planting sedges.**

## LESSONS LEARNED

One of the greatest assets of the AWPF grant program is the time allowed for monitoring the restoration/enhancement effort and the ability to improve upon the original design or plan if natural conditions prove to challenge the enhancements or practices plainly fail.

The flooding that happened during 2010 reinforced the need to plan on at least two construction periods or at a minimum have a plan to repair any work that may be damaged by natural events.

Having a second year plan for revegetation is also a good recommendation. After the first year, you can typically tell which plantings were successful and where additional plantings may be needed to fulfill the desired planting design.

Adding soil amendment and mulch can help to increase the success of germination and establishment of seeded plants. This was especially helpful in Reach 2 where previous construction activities had removed the topsoil.

Addition of sunflower seeds to the planting mix is not recommended for this region. While they are excellent habitat plants they grow aggressively, shading out shorter plants and the seeds are likely abundant in the seed bank at most sites.

Successful implementation of the public outreach was delayed due to the seasonal residency of property owners near the project area. The open house had to be rescheduled to insure that residents were in the area.
Permitting for the project took longer than anticipated and delayed the construction start. Ample time should be given to insure that the permitting process has enough time.

The public outreach prior to the project application and during the design phase was very helpful in building support for the project. While the project occurred entirely on public lands, having access across private property for machinery and materials was extremely helpful to the construction process. Additionally, the public meetings opened a dialogue between the residents and the city concerning the best use for the restored stream and greenspace.

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# APPENDIX A
## AS-BUILT CONSTRUCTION SHEETS

# Billy Creek

## Natural Area Riparian Restoration Project

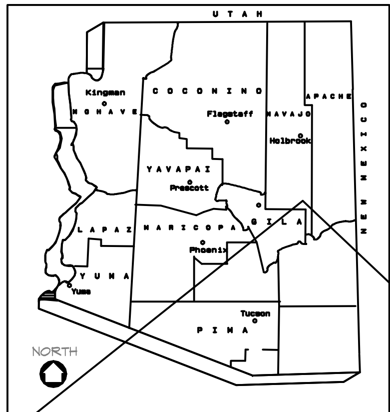
## Prepared for

## Town of Pinetop-Lakeside, AZ

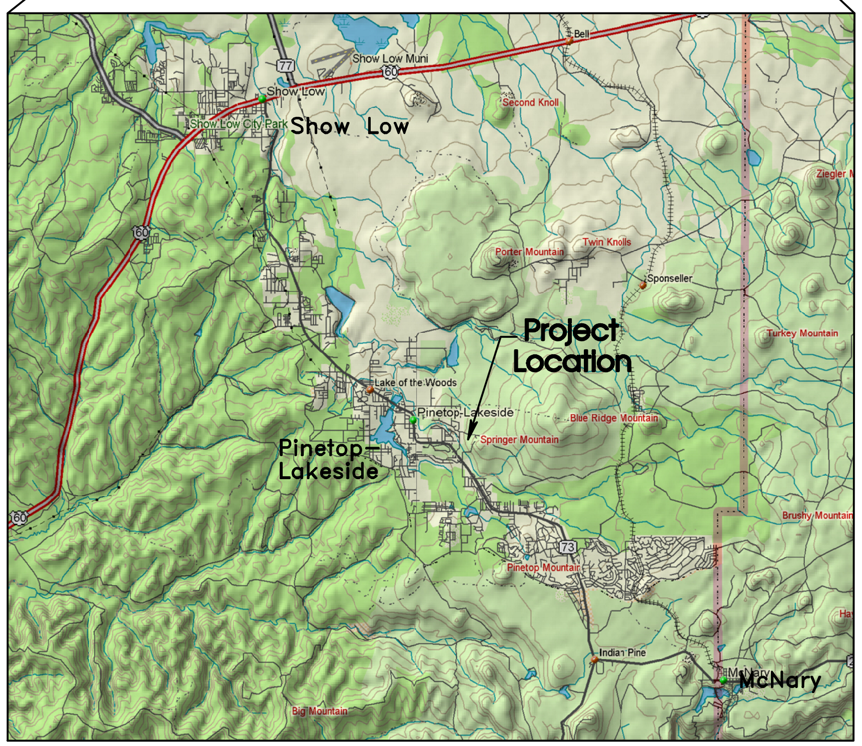
## Arizona Water Protection Fund Project #08-154WPF

PINETOP/LAKESIDE
Celebrate the Seasons

# AS BUILT DRAWINGS




LOCATION MAP




NE 1/4 Section 25, T9N, R22E
Pinetop-Lakeside, Navajo County, Arizona

CALL TWO WORKING DAYS BEFORE YOU DIG
263-1100
1-800-STAKE-IT
(OUTSIDE MARICOPA COUNTY)

Billy Creek, Pinetop, Arizona
Watershed Area = 15.2 square miles

Stream Project Length: 1 mile

Construction Period: October 12 – 26, 2009
Construction Inspections: October 22 & 26, 2009
Subcontractors: Rob Overacker Contracting LLC
D&S Tree Service
American Conservation Experience

## INDEX OF DRAWINGS



## MATERIAL LIST

| | |
|---|---|
| EARTHWORK | |
| Channel & Berm Excavation (incl. Bank Sloping & Channel Realignnment listed below) | |
| REACH 1 | 1290 cy |
| REACH 2 | 675 cy |
| Bank Sloping &/or Channel Realignment | |
| REACH 1 | 295 ft |
| Debris Area | 70 ft |
| REACH 2 | 170 ft |
| STRUCTURES | |
| Toe Rock, Rock Trench, Apron: REACH 1 | 55.5 cy |
| REACH 2 | 34.5 cy |
| Cross-Vane Weir (REACH 1) | 15 cy |
| Log Sill (REACH 2) | 170 log-ft |
| Non-Woven Geotextile (300 ft x 15 ft) | 1 roll |
| VEGETATION | |
| Willow Cuttings: REACH 1 | 980 ea |
| Debris Area | 126 ea |
| REACH 2 | 834 ea |
| Seedlings/Plugs: REACH 1 | 200 ea |
| Debris Area | 35 ea |
| REACH 2 | 115 ea |
| Seeding: REACH 1 | 9 lbs |
| Debris Area | 1.5 lbs |
| REACH 2 | 5.5 lbs |
| Erosion Control Fabric (60 ft x 8 ft) | |
| REACH 1: Double | 7 rolls |
| Single | 24 rolls |
| Debris Area: Double | 1 roll |
| REACH 2: Double | 4 rolls |
| Single | 20 rolls |
| Erosion Control Logs: REACH 1 | 22 ea |
| Debris Area | 7 ea |
| REACH 2 | 14 ea |
| Logs to block ATV access: REACH 1 | 15 ea |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(928) 774-2336


DRAWN BY: R.Lyman

DESIGNED BY: M.Wirtanen, R.Lyman, S.Yard

| REV | DATE | BY | REVISION |
|---|---|---|---|
| 1 | 5/4/09 | R.L. | Reach 1 Excavation |
| 2 | 7/22/09 | R.L. | Reach 1 Fill/Toe Rock |
| 3 | 11/17/09 | R.L. | As Built |

COVER SHEET: Location, Index, Materials

Billy Creek Natural Area Riparian Restoration
AWPF Grant #08-154WPF

*AS-BUILT DRAWINGS construction period 10/12-26/09*

FILE NAME: Billy Creek.pro

DATE: March 11, 2009

PROJECT NO: 07-143 AZ

AS BUILT DRAWINGS

# PROJECT DESCRIPTION

The purpose of this project is to restore and enhance riparian vegetation/habitats and proper hydrologic conditions and functions along a one mile perennial reach of Billy Creek in the Town of Pinetop-Lakeside. The applicant proposes to remove two separate failed earthen berms and other debris, stabilize eroding stream banks, implement bioengineering practices, close existing ATV access points, address private property encroachments, install signage, and revegetate areas of disturbance or impaired habitats with native vegetaion.

# GENERAL NOTES

1. Site survey data was collected by NCD in October 2008, and January 2009.
2. All stationing refers to base line of construction and is measured horizontal distance.
3. Project survey data provides the most accurate representation of site topographic conditions. All existing conditions are to be verified in the field prior to construction.
4. No representation is made as to the existence or nonexistence of any utilities, public or private. Absence of utilities on these drawings IS NOT assurance that no utilities are present. The existence, location and depth of any utility must be determined by the contractor prior to any excavation. Call before you dig, 1-800-STAKE-IT
5. Construction activities will be conducted in a manner consistent with all safety regulations, requirements of Section 404 of the Clean Water Act (ACOE), and other permitting required by the Town of Pinetop-Lakeside and others.
6. Installation shall be constructed to the lines and grades as shown on the drawings or as staked in the field by the ENGINEER or authorized representative, recognizing there is variation in nature.

# CONSTRUCTION MANAGEMENT

Construction shall be timed to allow for the driest conditions, the lowest chance of flood flows, to provide the least disturbance to wildlife and the optimum establishment of native plant species. Earthwork and revegetation activities will be completed as quickly as possible to reduce and maximize the healing of disturbed areas and establishment of native vegetation.

Construction Supervision

Supervision shall be provided for the earthwork, structural and revegetation tasks.

Earthmoving Equipment

All equipment shall be washed and weed free prior to arrival at the project site.
The following equipment are expected to be utilized during the construction:

- Trackhoe: Channel excavation and channel filling, bank sloping, toe rock installation.
- Loader: Moving earthwork material and moving and placing of rock.
- Dozer: Moving earthwork material and smoothing channel and floodplain.
- Dump Truck: Moving earthwork material and hauling rock.
- Mini-Excavator with Auger: Dormant woody plantings

Permitting Requirements

No construction shall begin until all necessary permits and easements are obtained.

Construction Sequence

The following is a recommended construction sequence:

1. Coordinate with Town of Pinetop-Lakeside and private land owners for scheduling of construction activities and access.
2. REACH 1 (Upstream Area): Construct temporary diversion to direct stream flow away from site. Excavate new channel alignment beginning at downstream end and place spoils in compacted lifts in old channel. Slope banks where necessary. Install toe rock and coir logs.
3. Remove concrete and metal debris downstream of bridge. Reslope bank, install rock lined drainage ditch and seed disturbed areas.
4. REACH 2 (Downstream Area): Excavate new channel alignment beginning at downstream end keeping stream in old channel. Slope banks where necessary. Redirect stream flow into new channel and place spoils in compacted lifts in old channel. Install toe rock, coir logs, log trench cutoffs.
5. Implement Revegetation Plan
   - Install dormant pole plantings and clump plantings along new channel alignments and specified areas.
   - Seed all disturbed areas. Install erosion control fabric in specified areas.
6. Install ATV access barriers.

# CONSTRUCTION SPECIFICATIONS

## POLLUTION CONTROL and RESOURCE PROTECTION

Construction operations shall be carried out in such a manner and sequence that erosion and air and water pollution are minimized and held within legal limits. The measures and works shall include, but are not limited to, the following:

1. Diversions: Diversion to divert water from work area is temporary and shall be removed and the area restored to its near original condition when no longer required or when permanent measures are installed.
2. Equipment Access and Staging Areas: Transportation routes for materials, personnel, and equipment to, from, and within the project area shall be limited to access areas located on the drawings or determined in the field.
3. Revegetation: Impacts to existing vegetation and habitats shall be minimized. All disturbed areas shall be replanted with native vegetation.
4. Equipment Use in Streams: The use of heavy equipment in the stream will be kept to an absolute minimum.

## REMOVAL OF WATER

The work shall consist of the removal of surface water and ground water as needed to perform the required construction. It shall include furnishing, constructing and operating of all temporary facilities and equipment.

- Protective measures needed to divert stream flow and other surface water shall be built, maintained and operated during construction.
- The construction site shall be dewatered and kept free of standing water or excessively muddy conditions as needed for proper execution of the construction work. Dewatering shall include furnishing, installing, operating and maintaining all equipment including pumps as needed.
- After the temporary works have served their purposes, they shall be removed or graded to present a neat appearance without interfering with permanent drainage systems or stream flows.
- All temporary works shall be accomplished in such a manner that erosion and the transmission of sediment and other pollutants are minimized.

## EARTHWORK

The earthwork shall consist of channel excavation, channel filling, and bank sloping. (see SHEETS 5, 6, 7, 8, 9, and 11)

Excavation

Excavation shall be limited to the channel realignment as shown on the drawings or as staked in the field. All finished surfaces shall be generally smooth and pleasing in appearance.

Excavated material shall be placed in sections of the old channel as shown on the drawings or as staked in the field. Disturbance of existing native vegetation shall be minimized to the greatest extent possible during excavation.

Earthfill

*Materials:* All fill materials shall be obtained from the required excavations and approved borrow sources. Fill materials shall not contain sod, brush, roots, perishable or frozen materials.

*Placement:* The placement of fill materials shall follow these guidelines:

- Any vertical bank shall be sloped before placement of fill material.
- Fill material shall be compacted to obtain a density similar to the surrounding bank material.
- Material when placed shall contain sufficient moisture so that a sample taken in the hand and squeezed shall remain intact when released.
- The placing and spreading of fill material shall be started at the lowest point and the fill brought up in horizontal layers not to exceed: six (6) inches of loose fill for wheel compaction and four (4) inches of loose fill for dozer compaction. Construction equipment shall be operated over the areas of each layer of fill to insure that the required compaction is obtained.
- Fill shall not be placed on frozen soil, snow or ice.

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DRAWN BY: R.Lyman
DESIGNED BY: M.Wirtanen, R.Lyman, S.Yard

| REV | DATE | BY | REVISION |
|---|---|---|---|
| | | | |
| | | | |
| 3 | 11/17/09 | R.L. | As Built |

GENERAL NOTES & CONSTRUCTION SPECIFICATIONS

Billy Creek Natural Area Riparian Restoration
AWPF Grant #08-154WPF

AS-BUILT DRAWINGS
construction period 10/12-26/09

FILE NAME: Billy Creek.pro
DATE: March 11, 2009
PROJECT NO: 07-143 AZ

# STRUCTURES PLAN

Structures plan shall consist of installing toe protection (rock, erosion control logs), log cutoff sills, rock lined drainage ditch, and ATV access barriers.

Toe Rock with Willow Cluster Trench: The work shall consist of furnishing and installing loose rock structures including placement of filter fabric as specified on the drawings or staked in the field. Willow cluster trench shall be installed behind the toe rock. See SHEETS 5 & 7 for location, SHEETS 6 & 8 for Cross–Sections, and SHEETS 10 & 11 for Details.

- The rock shall be well graded from a minimum of 4 inches to a maximum size of 9 inches with greater than 50% by weight being larger than 6 inches.
- The rock shall be angular, dense, sound and free from cracks, seams, or other defects conducive to accelerated weathering. The least dimension of an individual rock shall not be less than one–half the greatest dimension.
- The rock source shall be approved by the ENGINEER or authorized representative and have a bulk specific gravity of not less than 2.5 per ASTM C127.
- Non–woven geotextile shall be placed behind the toe rock. Fabric shall have a minimum grab tensile strength of 90 lb, greater than 50% elongation at failure, a minimum of 40 lb puncture strength, and UV resistance of 70% strength retained. The geotextile shall be joined by overlapping a minimum of 18 inches and secured against the underlying foundation material. Securing pins shall be installed as necessary to prevent undue slippage or movement of the geotextile. Recommend 3/16–inch steel bars pointed on one end and fabricated with a head to retain a steel washer (1.5–inch diameter). Pin length shall be not less than 18 inches. U–shaped pins are acceptable.

Erosion Control Logs: These flexible logs are made of Coir, Straw, Aspen Excelsior, or other natural materials and installed to protect the streambank by stabilizing the toe of the slope and by trapping sediment. Cuttings and herbaceous riparian plants can be planted into the log and behind it. Secure the logs with 24 to 36 inch long wedge–shaped stakes at 5 foot intervals. Stakes can be driven through center of log or both sides of log and tied with twine. See SHEET 13 for Details.

Log Cutoff Sill: This structural stabilization practice consists of logs placed in the abandoned filled channel for grade stabilization. Logs will be stacked horizontally to a depth of approximately one foot below the old channel bottom, and to a height equal to the top of the fill. Willow cluster trench shall be planted downstream of the logs. See SHEETS 9 and 11 for Details.

Rock Lined Drainage Ditch: Runoff enters the channel downstream of the bridge. After removing debris, a rock lined drainage ditch shall be installed o prevent erosion from runoff. Rock–lined ditch shall be 1 ft thick using 2 to 6 inch fractured quarry spalls. Install non–woven geotextile (use specification from toe rock) before placing rock. See SHEET 9 for Detail.

ATV Access Barriers: See SHEET 13 for Detail.

# DEBRIS REMOVAL

Several large pieces of concrete and pieces of metal pipe shall be removed from the area on the downstream side of the bridge, and disposed of properly. The bank shall be resloped, where neccessary, to a 2:1 slope. Willow clusters shall be planted along the toe of the bank. The bank shall be seeded and covered with erosion control fabric. See SHEET 4 for Location and SHEET 11 for Details.

# REVEGETATION PLAN

Revegetation Plan includes native grass seeding (with fabric), willow plantings, grass seedlings and wetland propagule plantings.

Erosion Control Fabric

Biodegradable erosion control fabric made of Jute, Coir, Straw, Coconut or other natural material shall be placed over the seed on banks for protection. Fabric is laid and anchored over seeding to reduce soil erosion and provide a good environment for vegetative regrowth. Fabric shall be installed for slope protection and seed germination enhancement along the stabilized bank. Two types of fabric will be installed. Coconut and straw matting (Western Excelsior CS3 or comparable) will be installed along the lower bank. Straw matting (Western Excelsior SR1 or comparable) will be installed above the toe rock and above the coconut straw matting (CS3). See SHEET 11 for fabric installation.

Deer Grass Seedlings

Deer grass seedlings shall not be less than 1/4–in. in caliper at 1–in. above the root collar. The planting hole shall be roughened and deeper than the planting container and at least twice the width. Loosen roots slightly and place plant in hole spreading roots. Fill hole and water thoroughly. Check to make sure that top of root is covered with soil. See SHEET 13 for seedling and propagule planting Details.

AS BUILT DRAWINGS

Native Seed Mix

Disturbed areas will be seeded with native grasses. Prepare seedbed where needed. Seed can be drilled or broadcast by hand. Seed shall be incorporated into the soil, but not more than 1–inch deep. Successful plant establishment may require reseeding as well as placement of fabric over the seed. Seed shall be purchased from a reliable supplier. The grass seed mix will consist of the following species as available. The seeding rates below are for broadcast planting. Native seed will be applied at a rate of 9.15 pounds to the acre. Estimated area of disturbance is 1 acre.

| | | | | 1 Acre |
|---|---|---|---|---|
| GRASS | Western Wheatgrass | *(Pascopyrum smithii)* | 5.60 lb/ac PLS | 5.60 lbs PLS |
| | Blue Grama | *(Bouteloua gracilis)* | 0.90 lb/ac PLS | 0.90 lbs PLS |
| | Spike Muhly | *(Muhlenbergia wrightii)* | 0.45 lb/ac PLS | 0.45 lbs PLS |
| | Little Bluestem | *(Schizachyrim scoparium)* | 2.20 lb/ac PLS | 2.20 lbs PLS |
| | | | 9.15 lb/ac PLS | 9.15 lbs PLS |

# WOODY PLANT MATERIAL PROCUREMENT and HANDLING

Woody Plant Materials:

All woody species shall be native and collected from designated local sources. Coyote willow (Salix exigua) or similar species will be planted in pole clusters and vertical bundles as shown on the drawings or determined in the field. This includes willow cluster trenches, alternatiing bundles and clusters along channel banks and in staggered matrix in floodplain areas and filled channel areas. See SHEET 11 for Planting Details.

Dormant unrooted hardwood cuttings can be taken after leaf fall and before bud burst in the spring. The best rooting success is from cuttings that are disease–free, green plants that are 2–10 years old. The best diameters for pole planting, vertical bundles, and trenches are 1/2 to 1 inches and 2 to 3 inches for tree post plantings. Cutting length varies depending on the application. It shall be long enough to reach 6 to 8 inches into the lowest water level of the year and high enough to expose at least one to two buds. Root primordia will develop when good soil–to–stem contact is made and exposed sections of the cutting will sprout stems and leaves.

Cuts shall be made with clean, sharp tools. The bottom end of the stem cutting shall be cut to a 45–degree angle and the tip end shall be cut square across or horizontal to the stem. Trim off all side branches and the terminal bud (bud at the growing tip) so energy will be rerouted to the lateral buds for more efficient root and stem sprouting. Do not trim terminal bud from cuttings for vertical bundles and willow trench until after planted. Trimmed tip ends shall be sealed by dipping in latex paint or similar. Cuttings should be soaked in water long enough (commonly 5–7 days) to allow the buds to swell. Do not allow the roots to emerge from the bark.

# INSTALLATION OF WOODY PLANTS

Installation of vegetation shall start when the general excavation operations are being completed.

POLE CLUSTERS

Pole clusters utilize multiple willow stems (~3 poles per cluster) that are planted in holes dug with an auger. Clusters shall be planted in the Bank and Overbank Zone and are spaced 4 feet apart. Willow trenches use pole clusters at 1 foot spacings, clusters planted in the abandoned channel section are matrix pattern at ~4 ft centers. Backfill holes with soil and water slurry. In multiple row plantings, spacing between rows shall be staggered with respect to those in adjacent rows. See SHEET 11 for Details.

VERTICAL BUNDLES

Vertical bundles are placed in shallow trenches vertically up the slope. It will protect the toe, bank, and overbank zones. Vertical bundle diameters should be from 3 to 6 inches (typically 3 to 6 stems). Bundle heights should be tall enough to extend from about 8 inches into the water table to about 1 foot above the top of the bank. Vertical bundles can be installed on 4 foot centers between waters edge and top of bank as designated. See SHEET 11 for Detail.

CLUMP PLANTINGS

This technique uses existing willow or cottonwood clumps and transplants them in holes excavated at designated locations. The live clumps of willow or cottonwoods are harvested with stems and roots intact. The clumps are already rooted and are quick to establish. The clump plantings can be installed along the toe of banks. See SHEET 12 for Detail.

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(928) 774-2336

DRAWN BY: R.Lyman

DESIGNED BY: M.Wirtanen, R.Lyman, S.Yard

| REV | DATE | BY | REVISION |
|---|---|---|---|
| | | | |
| | | | |
| 3 | 11/17/09 | R.L. | As Built |

CONSTRUCTION SPECIFICATIONS

Billy Creek Natural Area Riparian Restoration
AWPF Grant #08-154WPF

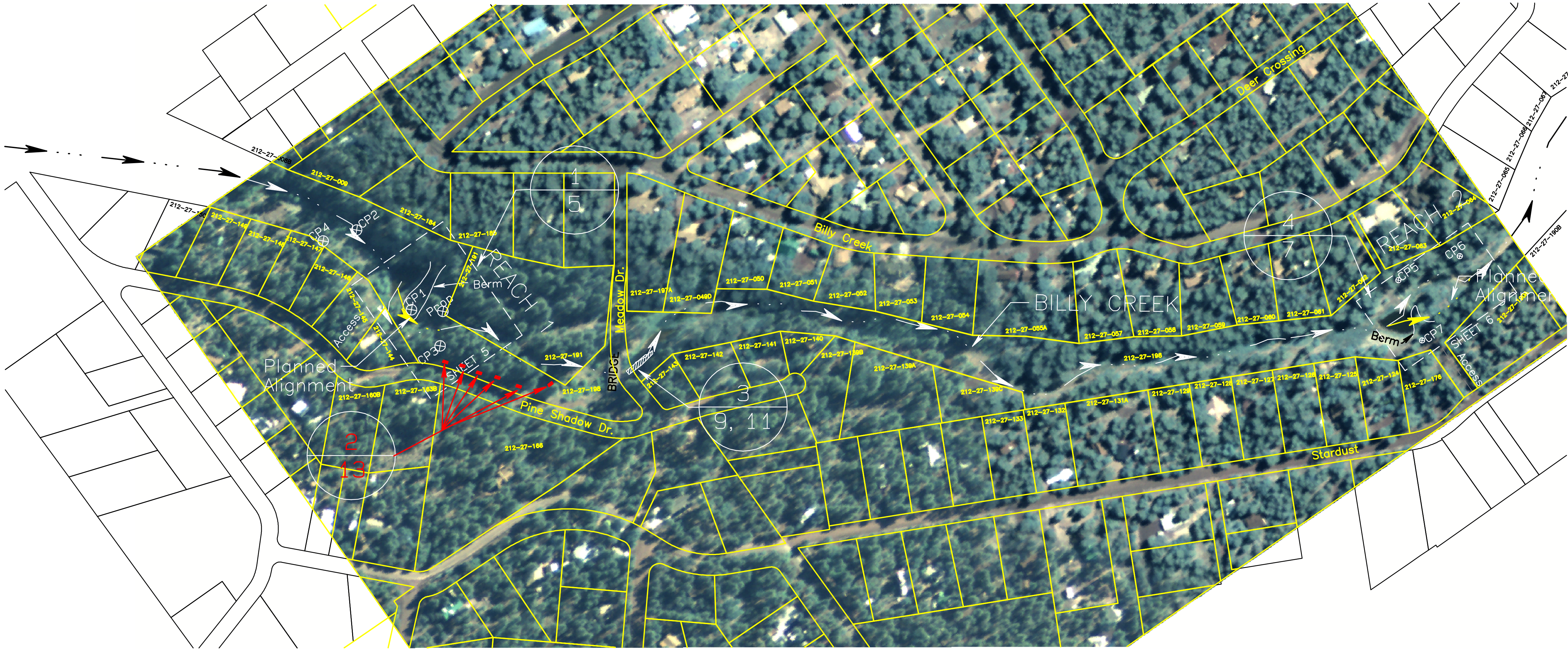
AS–BUILT DRAWINGS
construction period 10/12–26/09

FILE NAME: Billy Creek.pro

DATE: March 11, 2009

PROJECT NO: 07–143 AZ

AS BUILT DRAWINGS




## PLAN VIEW

NOTE: Property lines shown are approximate locations only.

### Items of Work

1. Realign stream channel through berm to reduce erosion. Install toe rock to prevent erosion reclaiming old channel. Reslope cutbank on right bank. Install coir logs. Plant willows and grass seedling/plugs. Seed and fabric disturbed areas. See SHEET 5 for detailed items of work.
2. Install 15 logs (12–24 in. diam.) across paths and openings in trees to block ATV access.
3. Remove large concrete debris. Reslope bank if neccessary. Install coir logs. Install rock lining in lower twenty feet of drainage ditch. Plant willows and grass seedling/plugs. Seed and fabric disturbed areas. See SHEETS 9, 11 & 13.
4. Realign stream channel through berm to closer match old streambed and reduce erosion. Install toe rock and log sills to prevent erosion reclaiming old channel. Backfill/reslope cutbank on left bank. Install coir logs. Plant willows and grass seedling/plugs. Seed and fabric disturbed areas. See SHEET 7 for detailed items of work.

SHEET Notes

| | |
|---|---|
| # | Note No. |
| #, # | Ref SHEET |

### Control Points

REACH 1 (upstream)

| | Northing | Easting | Elevation | Notes |
|---|---|---|---|---|
| CP1 | 6018.56 | 3190.38 | 1015.31 | 1/2" Rebar, NCD Yellow Cap |
| CP2 | 5788.40 | 3188.74 | NA | 1/2" Rebar, NCD Yellow Cap |
| CP3 | 6128.14 | 3183.86 | 1010.63 | 1/2" Rebar, NCD Yellow Cap |
| CP4 | 5763.90 | 3268.85 | 1013.25 | 1/2" Rebar, NCD Yellow Cap |

REACH 2 (downstream)

| | Northing | Easting | Elevation | Notes |
|---|---|---|---|---|
| CP5 | 7307.78 | 1224.91 | 1010.07 | 1/2" Rebar, NCD Yellow Cap |
| CP6 | 7344.60 | 1072.33 | 1008.26 | 1/2" Rebar, NCD Yellow Cap |
| CP7 | 7457.48 | 1260.80 | 1012.35 | 1/2" Rebar, NCD Yellow Cap |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DESIGNED BY: M.Wirtanen, R.Lyman, S.Yard

| REV | DATE | BY | REVISION |
|---|---|---|---|
| 1 | 5/4/09 | R.L. | Reach 1 Excavation |
| 2 | 7/22/09 | R.L. | Reach 1 Fill/Toe Rock |
| 3 | 11/17/09 | R.L. | As Built |

PLAN VIEW
Project Overview & Control Points

Billy Creek Natural Area Riparian Restoration
AWPF Grant #08-154WPF

AS-BUILT DRAWINGS construction period 10/12-26/09

SCALE: 1" = 300'

300 0 300

S W E N

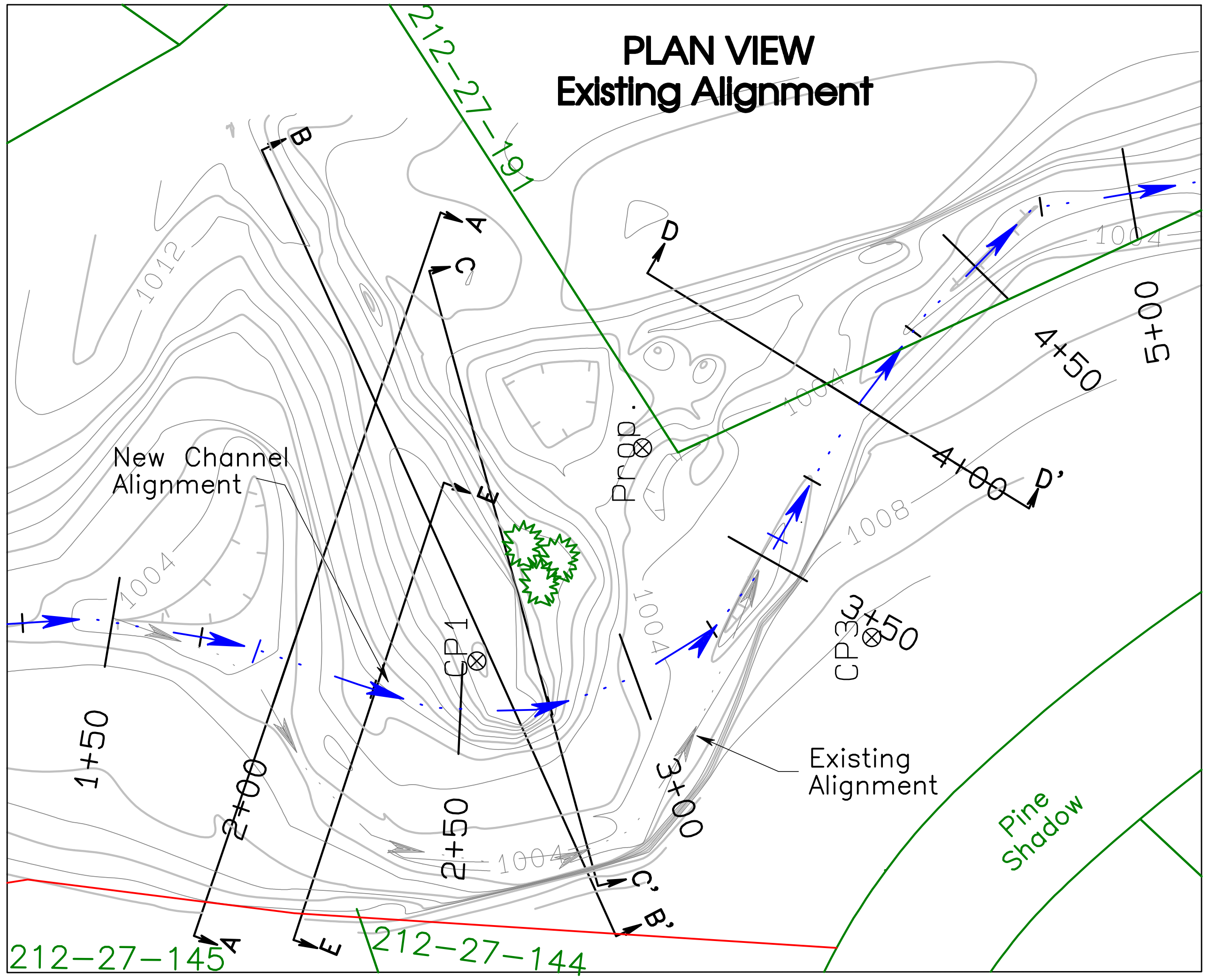
FILE NAME: Billy Creek.pro

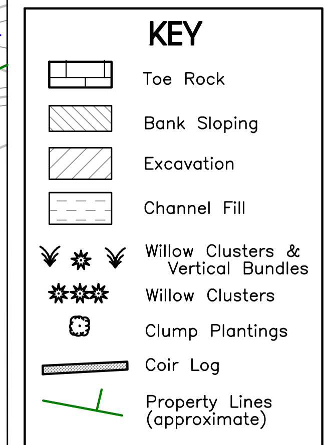
DATE: March 11, 2009

PROJECT NO: 07-143 AZ

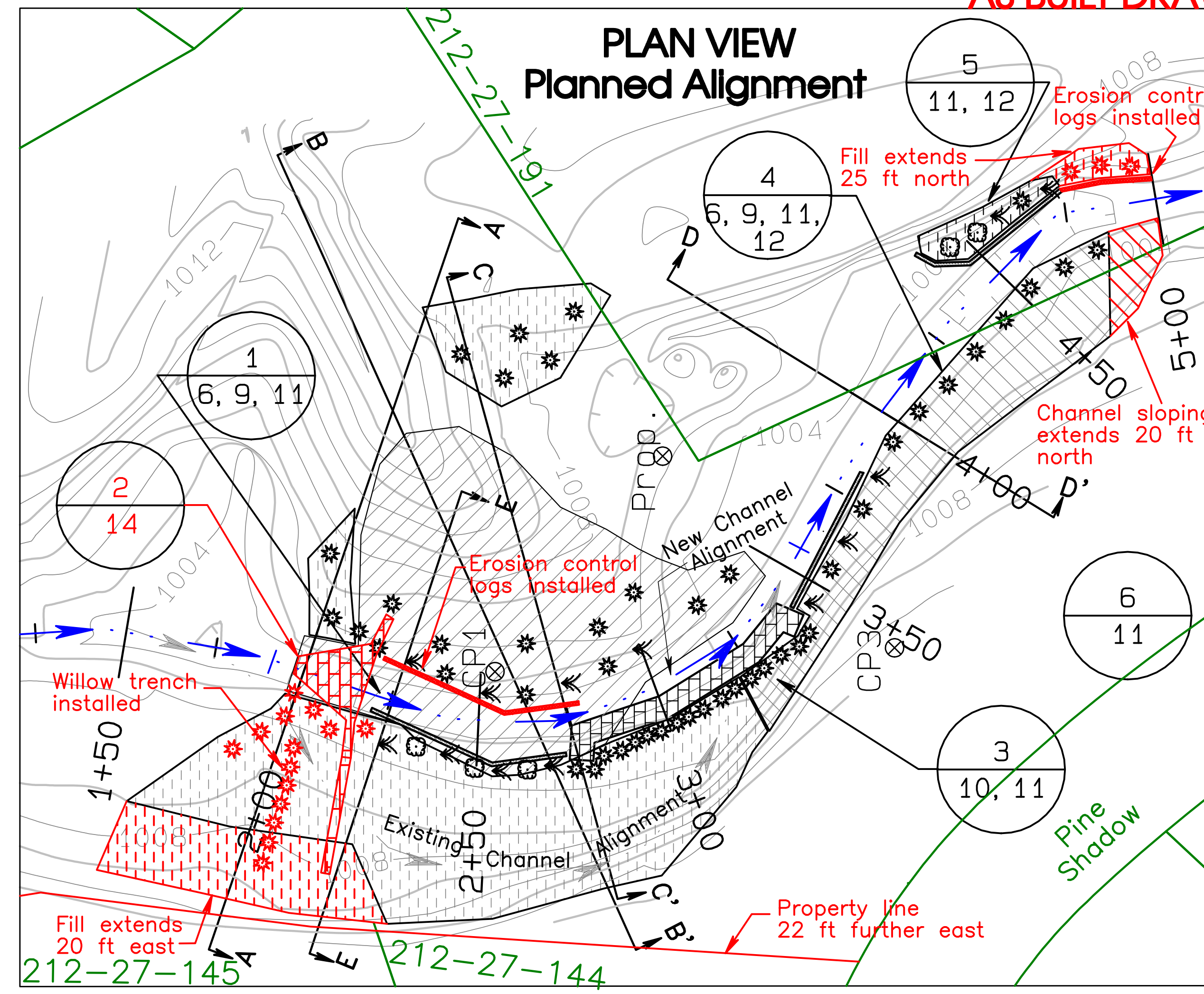
SHEET: 4 of 13

AS BUILT DRAWINGS



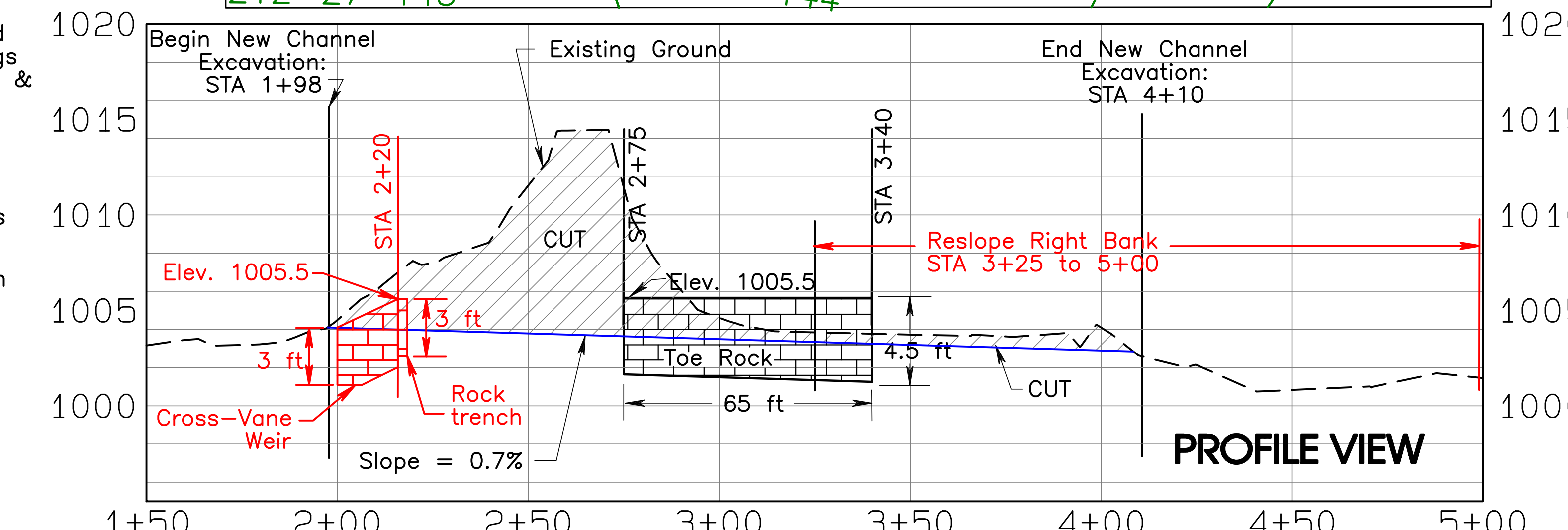




NOTE: Property lines shown are approximate locations only.




## Items of Work

1. EXCAVATE 250 feet of new channel through right end of existing berm. Use spoils to fill existing channel. Seed and install erosion control fabric. Plant willow clusters and vertical willow bundles as indicated. Install erosion control logs as indicated and plant grass seedlings/plugs in them. See SHEETS 6 & 9 for Cross–Sections, SHEET 11 for Fabric & Willow Planting Details, SHEET 13 for Erosion Control Log and Grass Seedling/Plug Planting Details.
2. INSTALL CROSS–VANE WEIR at head of newly excavated channel. Use native boulders uncovered during excavation. Install 30–feet of rock cutoff sill running up–slope from right wing of cross–vane weir. See SHEET 10B for Cross–Vane Weir Details.
3. INSTALL 77 feet of TOE ROCK where existing channel rejoins new channel, STA 2+75 to 3+40. Install willow clusters at one ft. o.c. downstream of toe rock. See SHEET 10 for Toe Rock Details & SHEET 11 for Willow Cluster Details.
4. RESLOPE 175 feet of RIGHT BANK from Station 3+25 to 5+00. Remove 12 trees along existing cut bank. Logs from felled trees shall be used in construction of log sills in Reach 2. Install clump platings, seed and install erosion control fabric. Install erosion control logs and plant with grass seedling/plugs. Plant willow clusters and vertical willow bundles as indicated. See SHEET 6 & 9 for Cross–Sections, SHEET 11 for Bank Sloping, Fabric Installation & Vertical Bundle Details & SHEET 12 for Clump Planitngs, SHEET 13 for Erosion Control Log and Grass Seedling/Plug Planting Details.
5. FILL LEFT BANK from Station 4+45 to 5+00. Install clump platings, seed and install erosion control fabric. Install erosion control logs and plant with grass seedling/plugs. Plant willow clusters. See SHEET 11 for Fabric Installation & Willow Cluster Details, SHEET 12 for Clump Planitngs & SHEET 13 for Erosion Control Log and Grass Seedling/Plug Planting Details.
6. SEED all distrubed areas. Install erosion control fabric on sloped surfaces. See SHEET 11 for Erosion Control Fabric Detail.

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DRAWN BY: R.Lyman

DESIGNED BY: M.Wirtanen, R.Lyman, S.Yard

| REV | DATE | BY | REVISION |
|---|---|---|---|
| 1 | 5/4/09 | R.L. | Reach 1 Excavation |
| 2 | 7/22/09 | R.L. | Reach 1 Fill/Toe Rock |
| 3 | 11/17/09 | R.L. | As Built |

# PLAN & PROFILE:
# Reach 1 (upstream)

## Billy Creek Natural Area Riparian Restoration
## AWPF Grant #08-154WPF

AS–BUILT DRAWINGS
construction period
10/12–26/09

HORIZ SCALE: 1" = 50'
VERT SCALE: 1" = 10'
50 0 50

FILE NAME: Billy Creek.pro

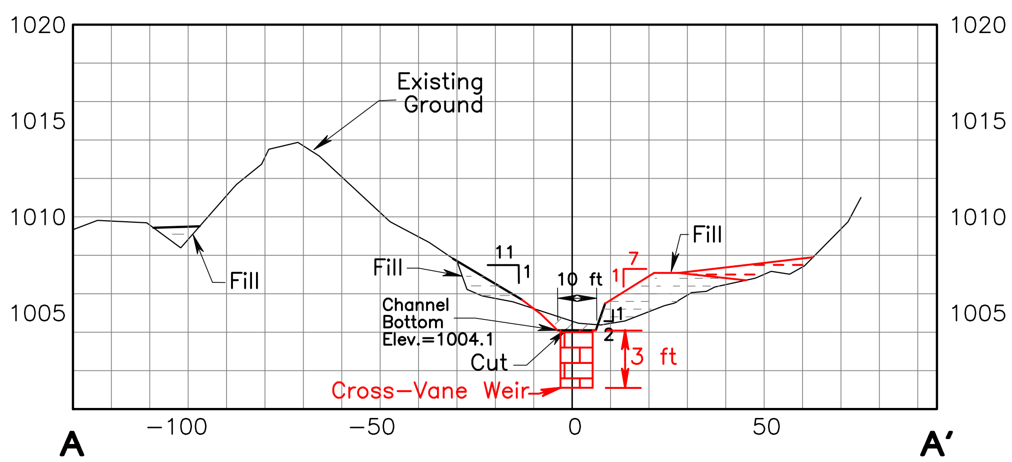
DATE: March 11, 2009

PROJECT NO: 07-143 AZ

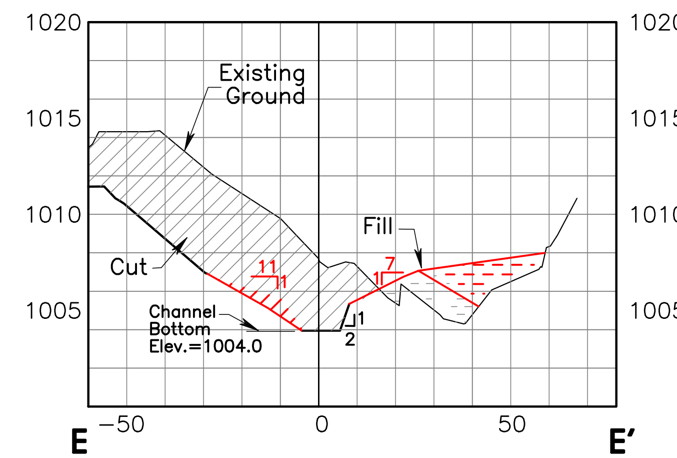
SHEET: 5 of 13

# CROSS-SECTIONS for REACH 1 (upstream)

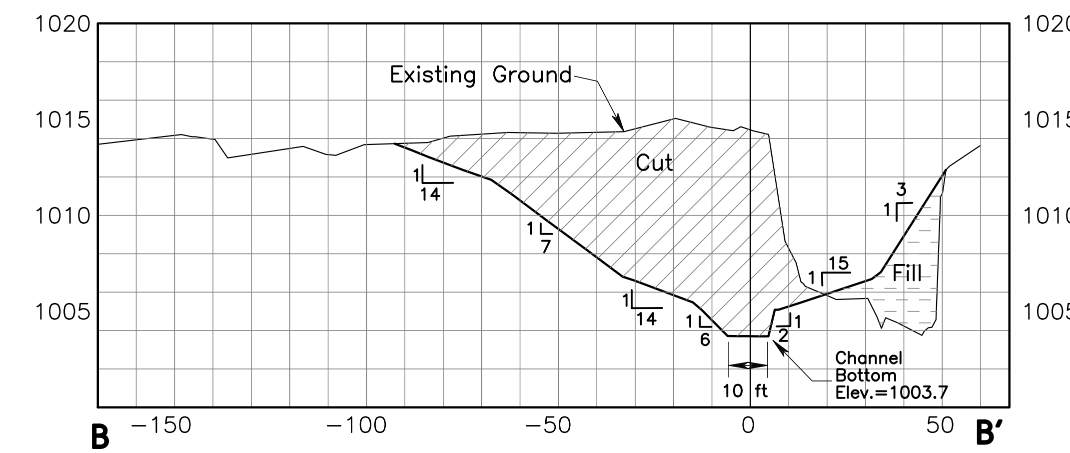
AS BUILT DRAWINGS



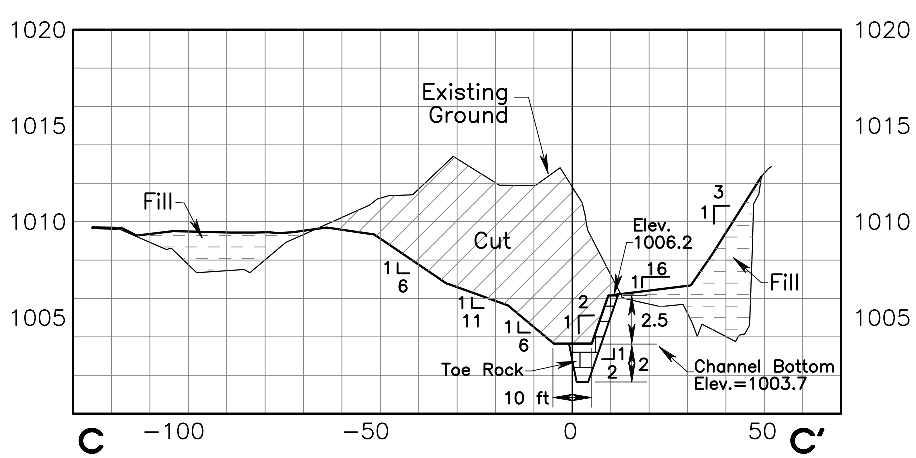

Cross-Section A-A' at STA 2+00



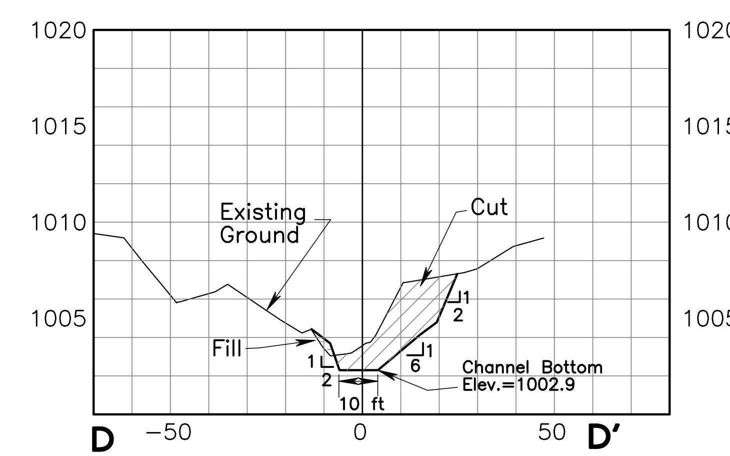

Cross-Section E-E' at STA 2+25




Cross-Section B-B' at STA 2+65
Through entire length of Berm




Cross-Section C-C' at STA 2+75




Cross-Section D-D' at STA 4+00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DRAWN BY: R.Lyman

DESIGNED BY: M.Wirtanen, R.Lyman, S.Yard

| REV | DATE | BY | REVISION |
|---|---|---|---|
| 1 | 5/4/09 | R.L. | Reach 1 Excavation |
| 2 | 7/22/09 | R.L. | Reach 1 Fill/Toe Rock |
| 3 | 11/17/09 | R.L. | As Built |

# CROSS-SECTIONS: Reach 1 (upstream)

## Billy Creek Natural Area Riparian Restoration
## AWPF Grant #08-154WPF

*AS–BUILT DRAWINGS construction period 10/12–26/09*

HORIZ SCALE: 1" = 50'
VERT SCALE: 1" = 10'

50 0 50

FILE NAME: Billy Creek.pro

DATE: March 11, 2009

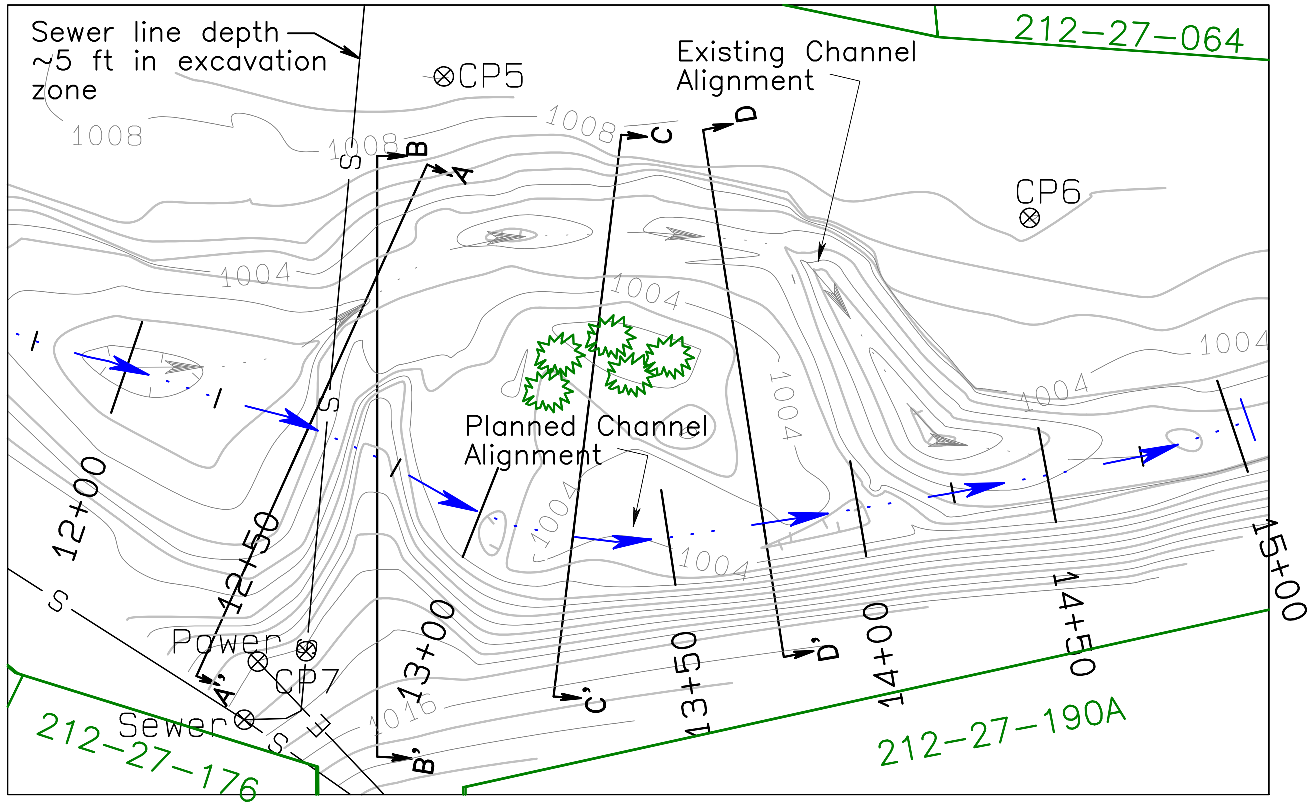
PROJECT NO: 07-143 AZ

SHEET: 6 of 13

AS BUILT DRAWINGS

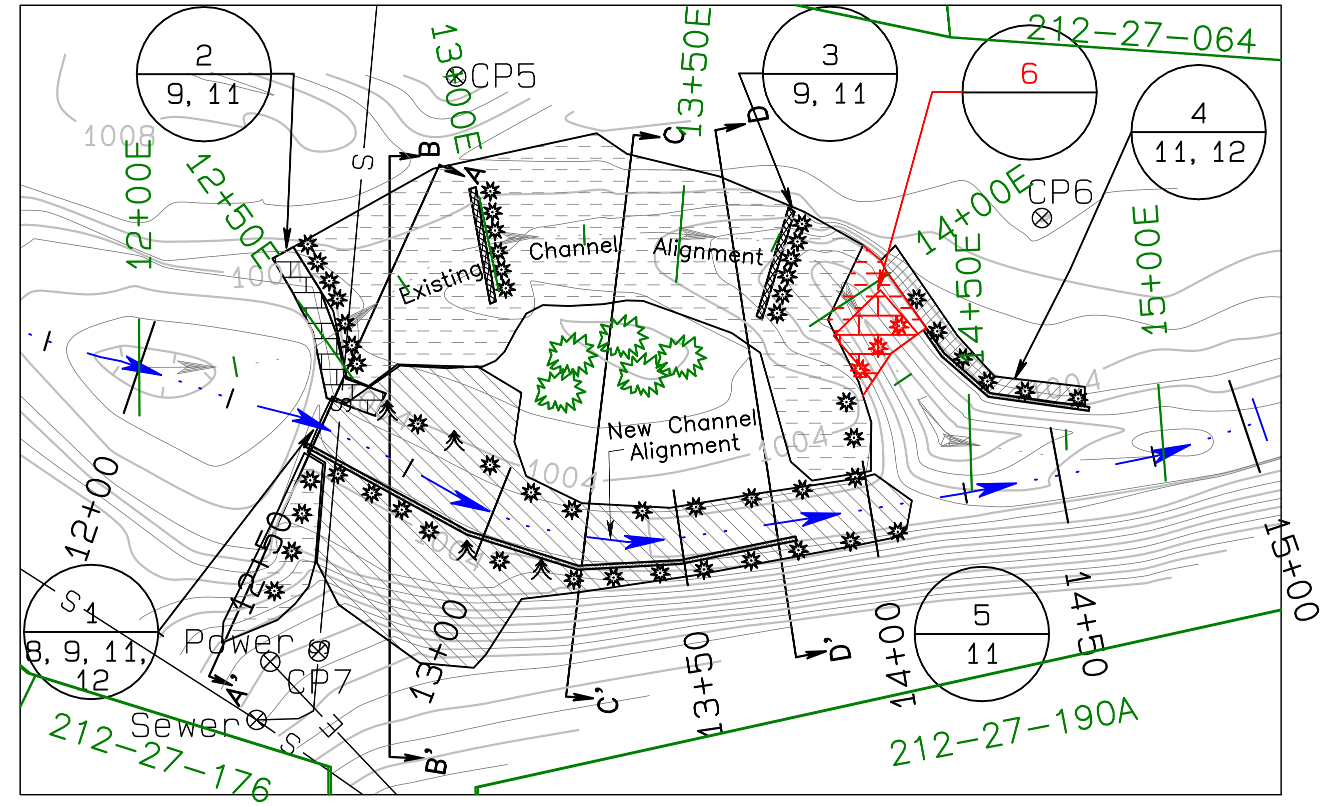
**KEY**

- Toe Rock
- Log Sill
- Bank Sloping
- Excavation
- Channel Fill
- Willow Clusters & Vertical Bundles
- Willow Clusters
- Clump Plantings
- Existing Trees
- Coir Log
- Property Lines (approximate)
- Sewer Lines




NOTE: Property lines shown are approximate locations only.
Sewer Line information from Pinetop–Lakeside Sanitary District As–Built plans, 6/10/92.

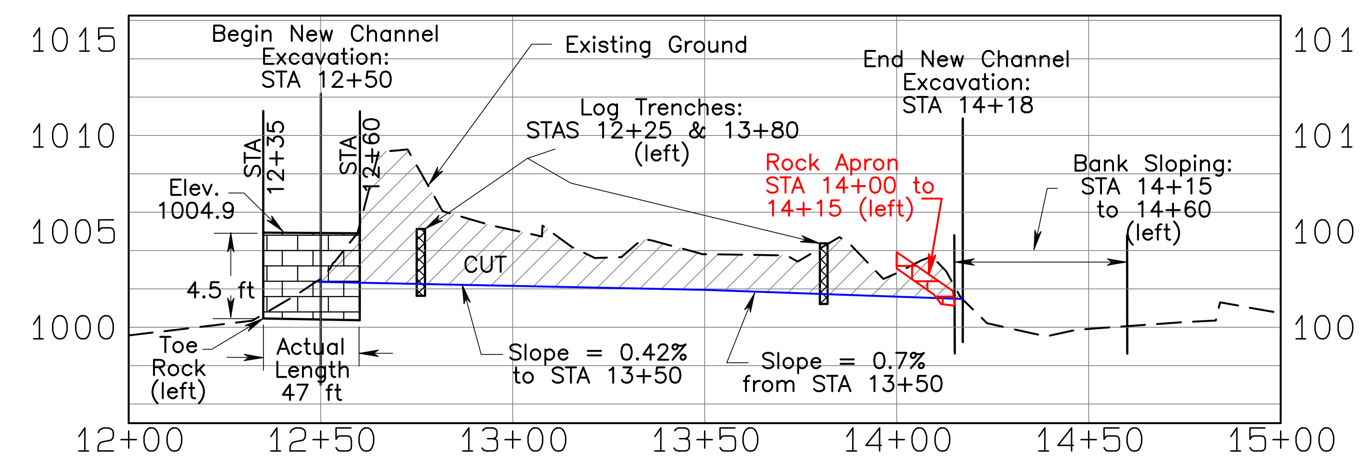
**PLAN VIEW**
**Existing Alignment**




**PLAN VIEW**
**Planned Alignment**

## Items of Work

1. EXCAVATE 170 feet of new channel through end of existing berm. Use spoils to fill existing channel. Install erosion control logs as indicated, plant with grass seedling/plugs. Plant willow clusters and vertical bundles as indicated. See SHEET 8 for Cross–Sections, 9 for Typical Channel Cross–Section, SHEET 11 for Fabric Details, Willow Clusters & Vertical Bundle Details & SHEET 13 for Erosion Control Log & Grass Seedling/Plug Planting Details.
2. INSTALL 47 feet of TOE ROCK at mouth of existing channel, STA 12+35. Install willow clusters downstream of toe rock. See SHEET 10 for Toe Rock Details & SHEET 11 for Willow Cluster Detail.
3. INSTALL 2 LOG SILLS in channel fill at stations 13+00E & 13+80E. Use logs from trees felled in Reach 1. Install willow clusters downstream. See SHEET 9 for Log Sill Detail & SHEET 11 for Willow Cluster Detail.
4. RESLOPE 70 FEET of LEFT BANK from Station 14+15 to 14+60. Install clump plantings. Plant willow clusters. Install erosion control logs as indicated, plant with grass seedling/plugs. Seed and install erosion control fabric. See SHEET 12 for Clump Plantings, SHEET 11 for Fabric Installation & Willow Cluster Details, & SHEET 13 for Erosion Control Log & Grass Seedling/Plug Planting Details.
5. SEED all distrubed areas. Install erosion control fabric on sloped surfaces. See SHEET 11.
6. INSTALL ROCK APRON (15 ft x 15 ft) at downstream end of overflow channel.




**PROFILE VIEW**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DRAWN BY: R.Lyman
DESIGNED BY: M.Wirtanen, R.Lyman, S.Yard

| REV | DATE | BY | REVISION |
|---|---|---|---|
| | | | |
| | | | |
| 3 | 11/17/09 | R.L. | As Built |

# PLAN & PROFILE: Reach 2 (downstream)

# Billy Creek Natural Area Riparian Restoration
# AWPF Grant #08-154WPF

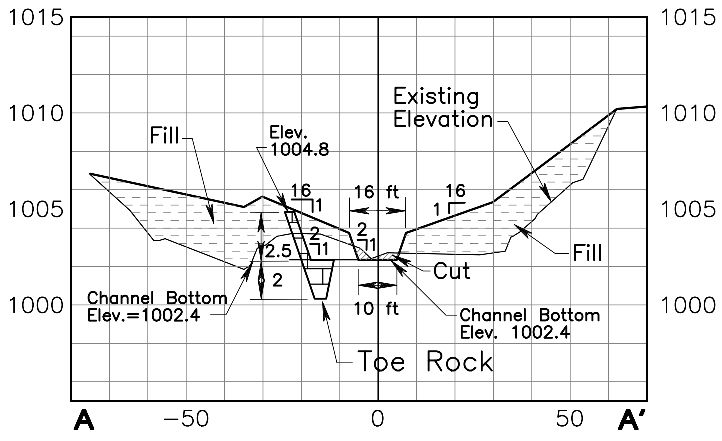
*AS–BUILT DRAWINGS construction period 10/12–26/09*

HORIZ SCALE: 1" = 50'
VERT SCALE: 1" = 10'
50 0 50

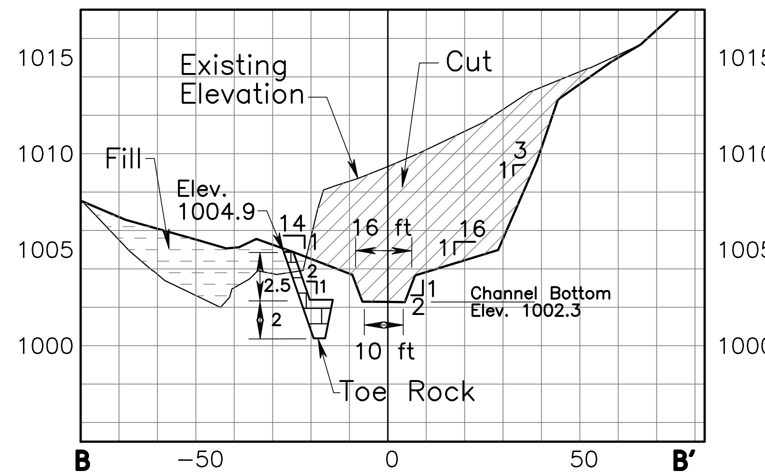
FILE NAME: Billy Creek.pro
DATE: March 11, 2009
PROJECT NO: 07–143 AZ
SHEET: 7 of 13

# CROSS-SECTIONS for REACH 2 (downstream)

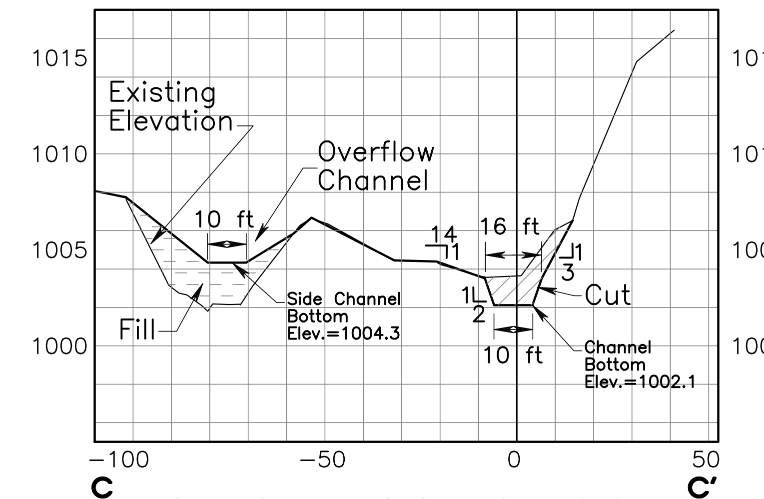
AS BUILT DRAWINGS



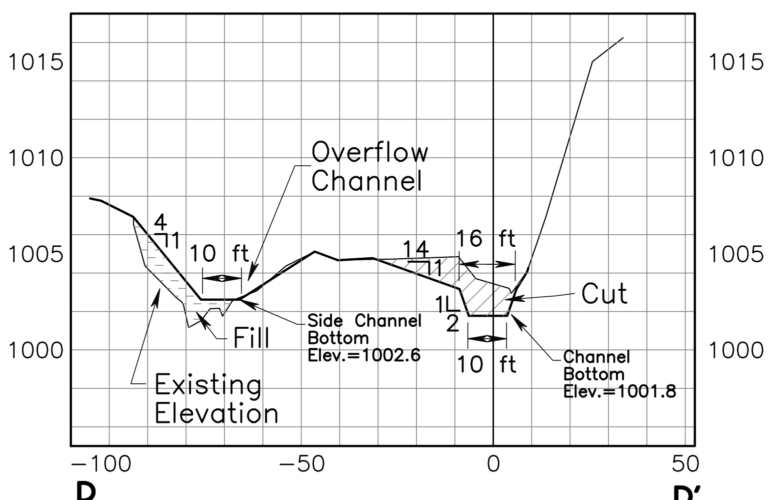

Cross-Section A-A' at STA 12+50



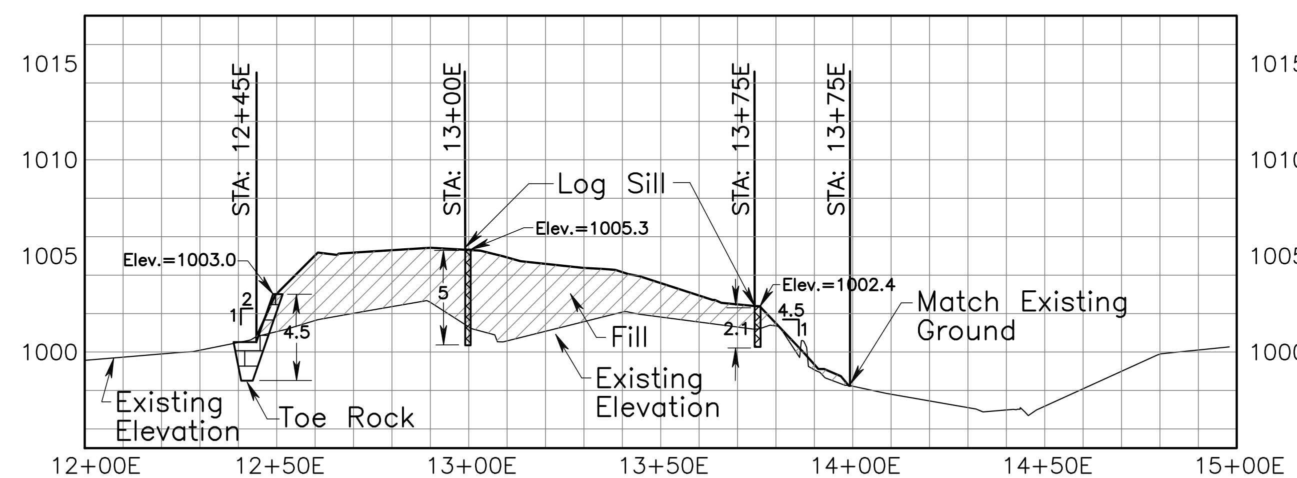

Cross-Section B-B' at STA 12+65
(Through Entire Length of Berm)




Cross-Section C-C' at STA 13+25




Cross-Section D-D' at STA 13+75




Design Profile for Existing Alignment for Reach 2
STA 12+00E to 15+00E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DRAWN BY: R.Lyman

DESIGNED BY: M.Wirtanen, R.Lyman, S.Yard

| REV | DATE | BY | REVISION |
|---|---|---|---|
| | | | |
| | | | |
| 3 | 11/17/09 | R.L. | As Built |

# CROSS-SECTIONS: REACH 2 (downstream)

## Billy Creek Natural Area Riparian Restoration
## AWPF Grant #08-154WPF

AS-BUILT DRAWINGS
construction period
10/12-26/09

HORIZ SCALE: 1" = 50'
VERT SCALE: 1" = 10'

50 0 50

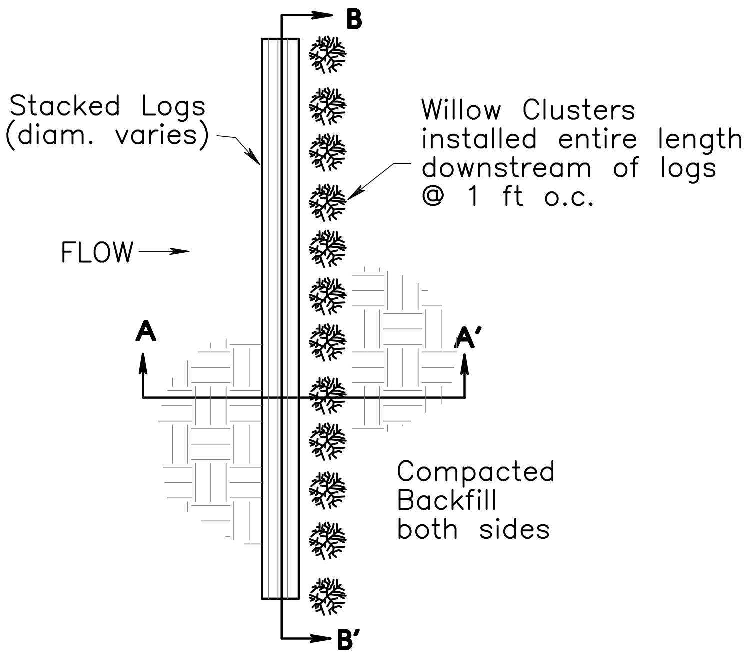
N W E S

FILE NAME: Billy Creek.pro

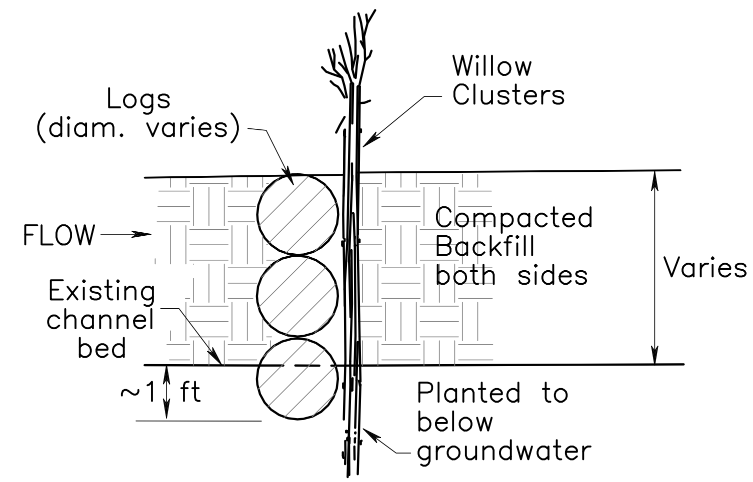
DATE: March 11, 2009

PROJECT NO: 07-143 AZ

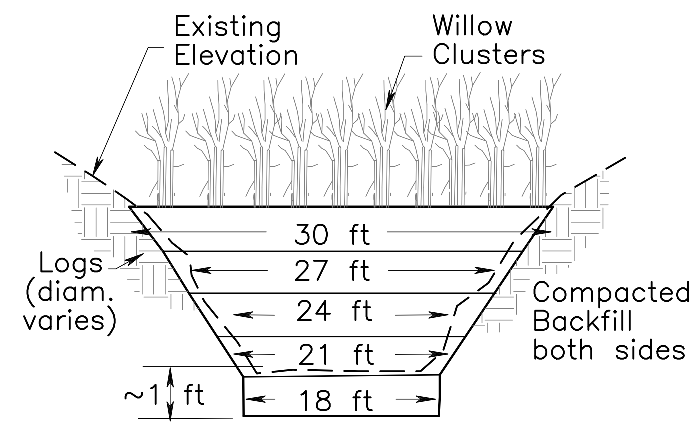
SHEET: 8 of 13




**Plan View**
(Not to Scale)




**Section A-A'**
(Not to Scale)




**Section B-B'**
(Not to Scale)

# AS BUILT DRAWINGS

NOTE: Drawing shown is for first log sill. Second log sill contains only top three log lengths.

LOG QUANTITIES

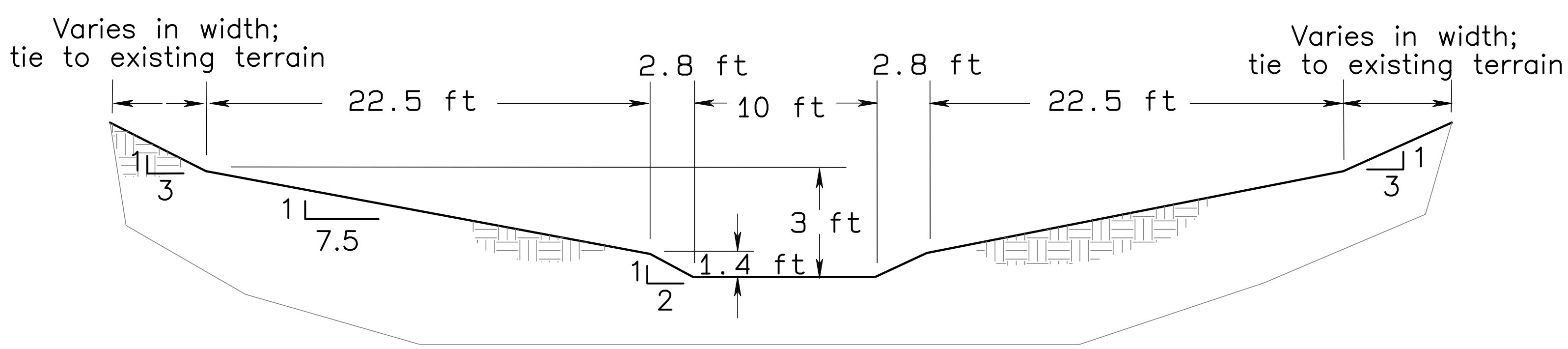
TRENCH AT REACH 2:
120 lin ft for trench #1
80 lin ft for trench #2

TOTAL LOGS = 200 lin ft

LOG SPECIFICATIONS

Use logs of 8 in. min. diam. for one log thick. If smaller logs are used, stack two-deep. Remove branches before installation.

## LOG SILL

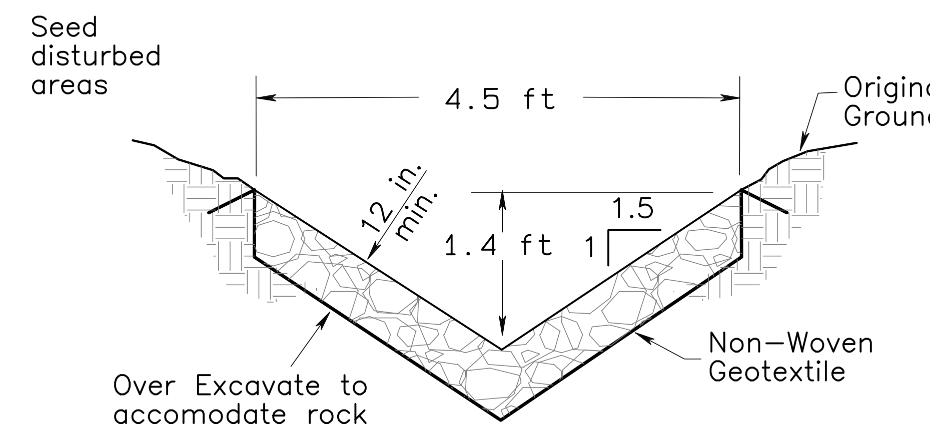



## TYPICAL CHANNEL CROSS-SECTION
(Not to Scale)

BANKFULL CHANNEL SPECIFICATIONS:

BOTTOM WIDTH: 10 FT

SIDE SLOPES:
7.5H:1V Inside meander
(to bankfull stage: 1.4 ft above bed)
2H:1V Outside meander
(to bankfull stage: 1.4 ft above bed)
3H:1V min
(until merging with upper terrain)




**Section View**
(Not to Scale)

ROCK VOLUME

0.2 cubic yards per linear foot
Total Distance = 20 ft

TOTAL VOLUME = 4.5 CY

ROCK SPECIFICATIONS

Use well-graded, angular rock with bulk specific gravity greater than 2.5

Riprap Rocks: Dmin = 2 in.
D50 = 4 in.
Dmax = 6 in.

## ROCK-LINED DRAINAGE DITCH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DESIGNED BY: M.Wirtanen, R.Lyman, S.Yard

| REV | DATE | BY | REVISION |
|---|---|---|---|
| | | | |
| | | | |
| 3 | 11/17/09 | R.L. | As Built |

# DETAILS: Typical Channel Cross-Section, Log Sill & Rock Lined Ditch

# Billy Creek Natural Area Riparian Restoration AWPF Grant #08-154WPF

AS-BUILT DRAWINGS
construction period 10/12-26/09

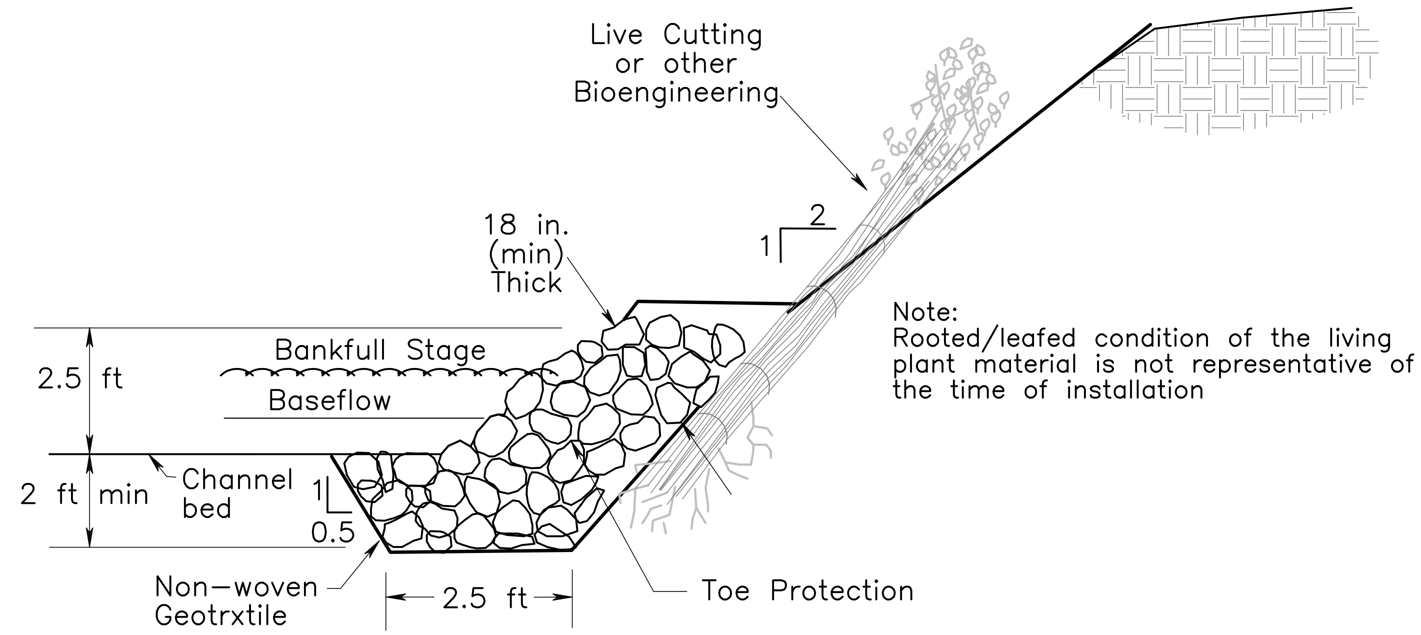
FILE NAME: Billy Creek.pro

DATE: March 11, 2009

PROJECT NO: 07-143 AZ

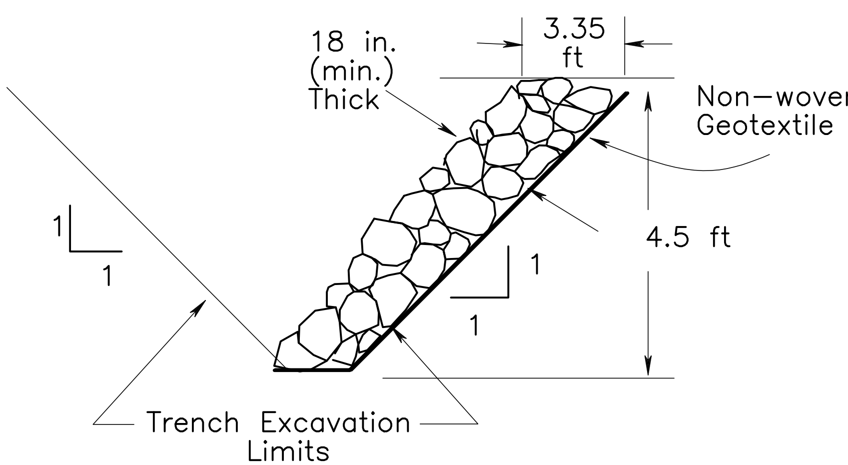
SHEET: 9 of 13

**AS BUILT DRAWINGS**



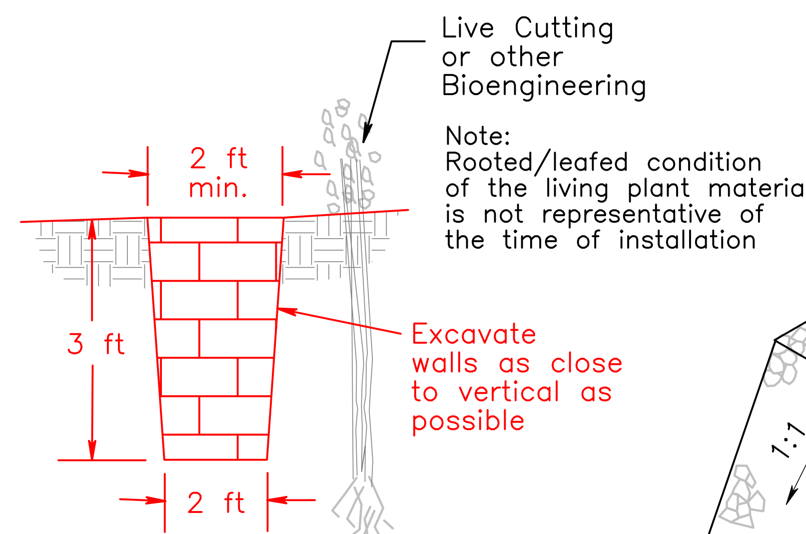

**TYPICAL TOE ROCK SECTION**

(Not to Scale)




**TYPICAL TIEBACK SECTION**

(Not to Scale)




**TYPICAL ROCK CUTOFF SILL SECTION**

(Not to Scale)

GEOTEXTILE SPECIFICATIONS

Geotextile shall be a non−woven fabric with a minimum tensile strength of 120 lb, greater than 50% elongation at failure, a minimum of 65 lb puncture strength, and UV resistance of 70%.

Geotextile shall be joined by overlapping a minimum of 18 inches.

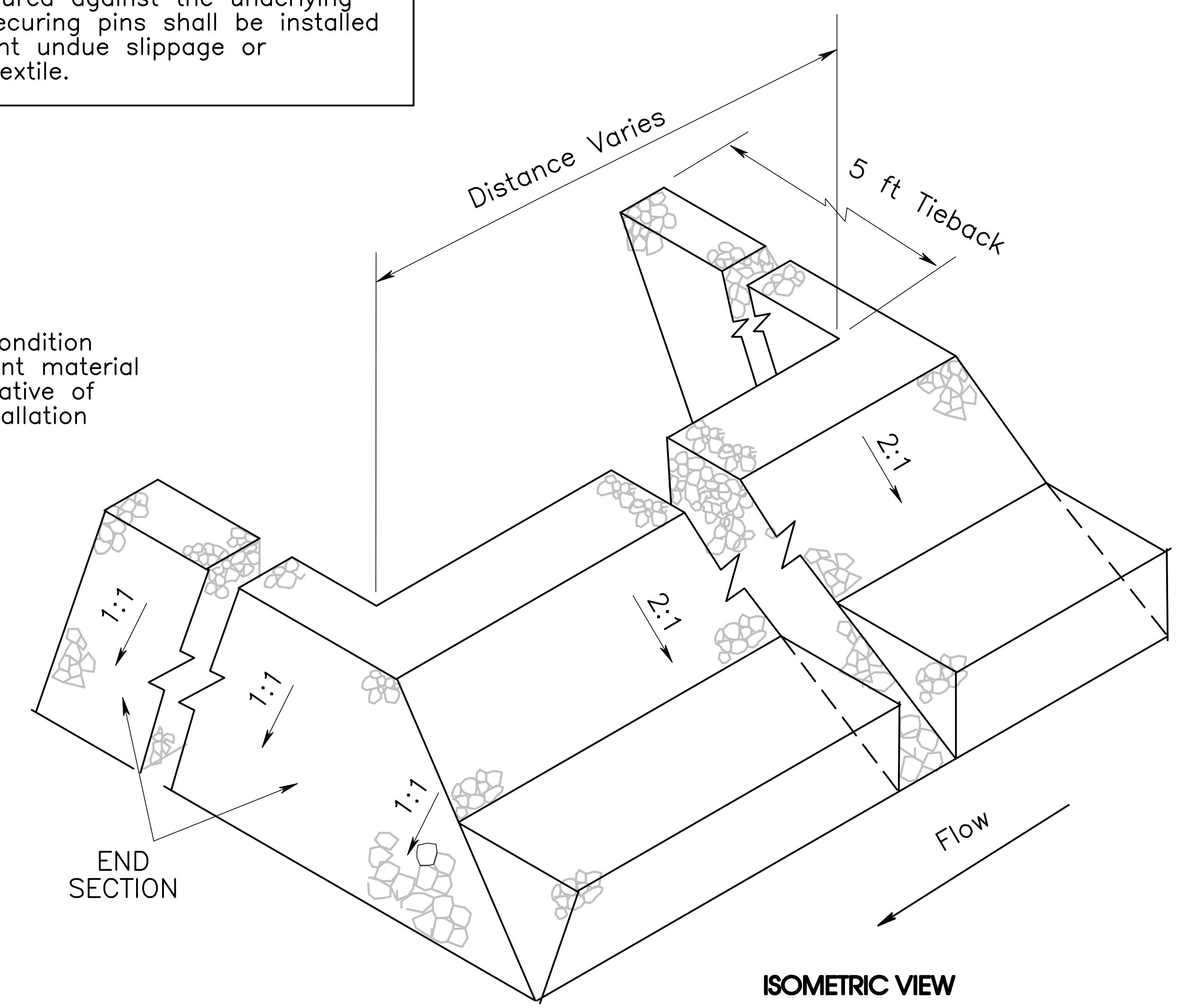
Geotextile shall be anchored in a trench with rock along the top edge of bank.

Geotextile shall be secured against the underlying foundation material. Securing pins shall be installed as necessary to prevent undue slippage or movement of the geotextile.

GEOTEXTILE

15 ft wide x 300 ft long rolls
Total Distance = 242 ft

TOTAL FABRIC = 0.8 roll




**ISOMETRIC VIEW**

(Not to Scale)

ROCK SPECIFICATIONS

Use well−graded, angular rock with bulk specific gravity greater than 2.5

| | | |
|---|---|---|
| Rock Riprap Rocks: | Dmin = | 4 in. |
| | D50 = | 6 in. |
| | Dmax = | 8 in. |

RIPRAP ROCK LOCATIONS

| STA | DISTANCE |
|---|---|
| BERM 1 UPSTREAM: 2+75 to 3+40 (right) | 77 ft |
| ROCK CUTOFF SILL UPSTREAM: 2+20 (right, perp. to stream) | 30 ft |
| BERM 2 DOWNSTREAM 12+25 to 12+50 (left) (at angle) | 47 ft |

RIPRAP ROCK VOLUME

| | |
|---|---|
| Reach 1 Rock Cutoff Sill: | 7.8 cy |
| Reach 1 Toe Rock: | 47.7 cy |
| Reach 2 Toe Rock: | 30 cy |
| Reach 2 Rock Apron: | 4.5 cy |
| TOTAL: | 90 cy |


Natural Channel Design, Inc
206 S. Elden St.
Flagstaff, Arizona 86001
(928) 774-2336


DRAWN BY: R.Lyman

DESIGNED BY: M.Wirtanen, R.Lyman, S.Yard

| REV | DATE | BY | REVISION |
|---|---|---|---|
| | | | |
| | | | |
| 3 | 11/17/09 | R.L. | As Built |

# DETAILS: Toe Rock & Rock Cutoff Sill

# Billy Creek Natural Area Riparian Restoration AWPF Grant #08-154WPF

AS−BUILT DRAWINGS
construction period
10/12−26/09

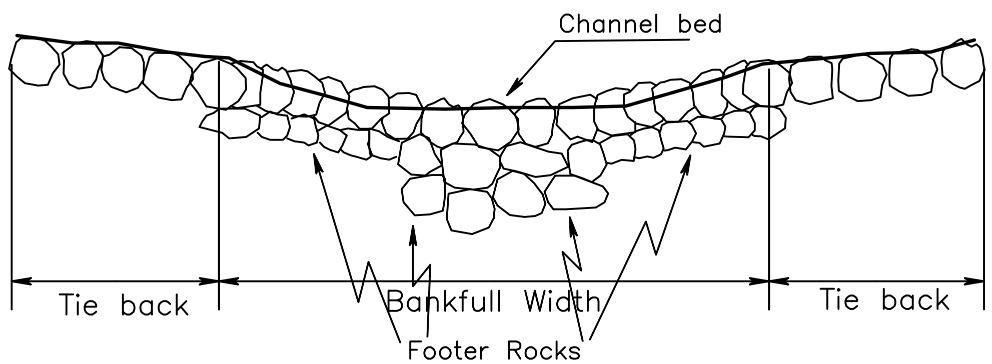
FILE NAME: Billy Creek.pro

PROJECT NO: 07−143 AZ

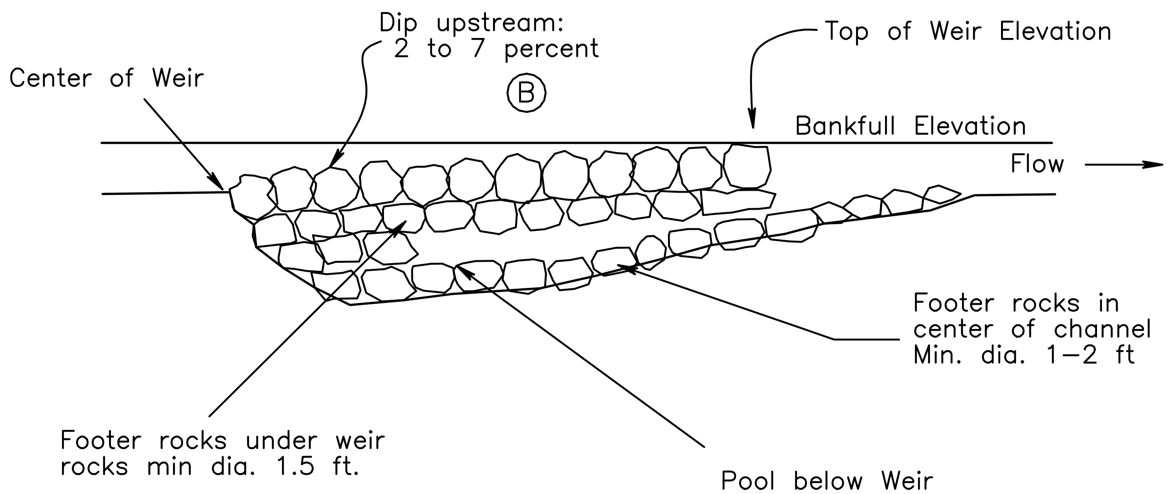
DATE: March 11, 2009

AS BUILT DRAWINGS

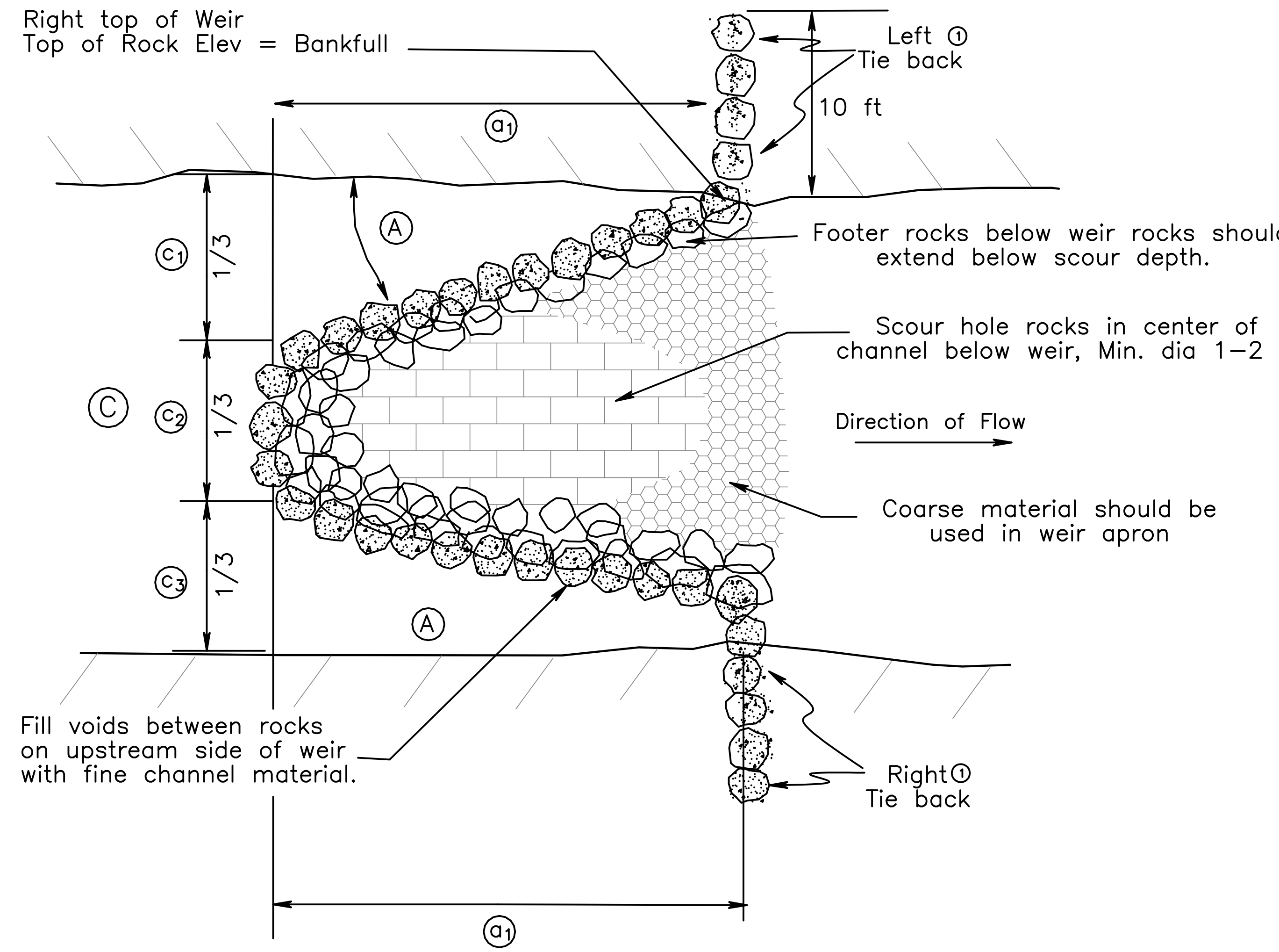
## CROSS-SECTION
(Not to Scale)




## PROFILE
(Not to Scale)




## PLAN VIEW - Cross-Vane Weir
(Not to Scale)




### ROCK SPECIFICATIONS FOR CROSS-VANE WEIR

| | |
|---|---|
| Footer Rocks: | Min. diameter – 24 in. |
| Weir Top Rocks: | Min. diameter – 36 in. |
| Toe Rocks: | Min. diameter – 24 in. |

### DESIGN SPECIFICATIONS FOR CROSS-VANE WEIR

- (A) Angle between bank and weir arm: 20 – 30 degrees
- (B) Upstream dip of weir: 2 – 7 % maximum
- (C) Weir throat should be equal or less than 1/3 bankfull width

### WEIR LOCATIONS & MEASUREMENTS

Main Channel

| STA: | Bankfull Elev | (a1) | (C1,2,3) |
|---|---|---|---|
| 2+00 | 1005.5 (1.5 ft above bed) | 20 ft | 5.3 ft |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| REV | DATE | BY | REVISION |
|---|---|---|---|
| | | | |
| | | | |
| 3 | 11/17/09 | R.L. | As Built |

# DETAILS: Cross-Vane Weir

# Billy Creek Natural Area Riparian Restoration AWPF Grant #08-154WPF

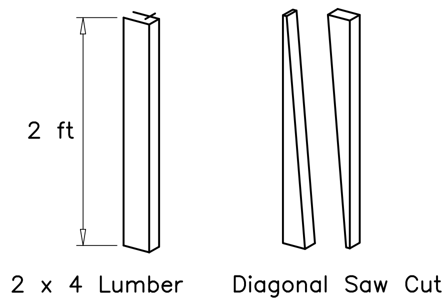
AS–BUILT DRAWINGS
construction period 10/12–26/09

FILE NAME: Billy Creek.pro

DATE: October 15, 2009

PROJECT NO: 07–143 AZ

SHEET: 10 B of 13



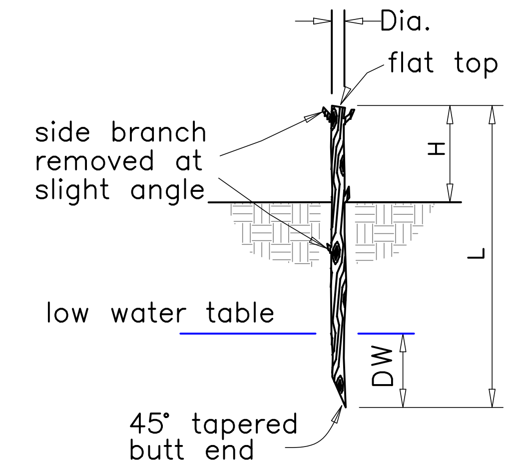

## DEAD STOUT STAKES

### NOTES

1. Cuttings shall be dormant, stripped of side branches, and soaked 3 to 7 days.
2. Cuttings shall be 3/4 to 2 inches in diameter and typically 3 stems per bundle or cluster.

### VERTICAL BUNDLES

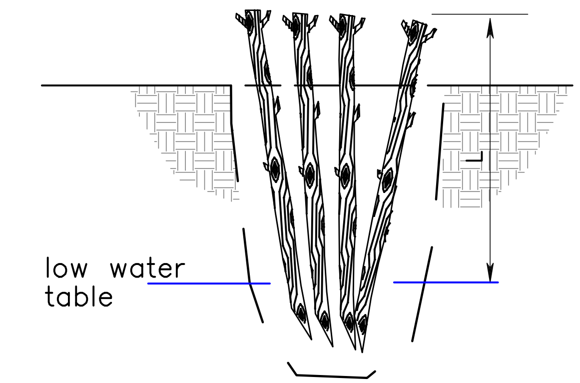
1. Bundles shall be tied with untreated twine about every 2 feet.
2. Excavate a vertical trench with a slope of 2:1 or more in the streambank.
3. Make sure the bottom of the trench will still be under water during low flows.
4. The trenches should be excavated on 4 foot centers alternating with willow clusters to ensure adequate protection and to encourage rapid growth to fill in the bank.
5. Place bundle in the trench with the cut ends in the water.
6. Secure bundles to back of trench with wooden stakes at about 3 foot spacings.
7. "Muddy" in bundles with water and soil (covering the bundles 1 to 2 inches deep)
8. Leave approximately 30 percent of upper branches exposed.
9. Tops of cuttings are cut off after placement.




## POLE PLANTING DETAIL

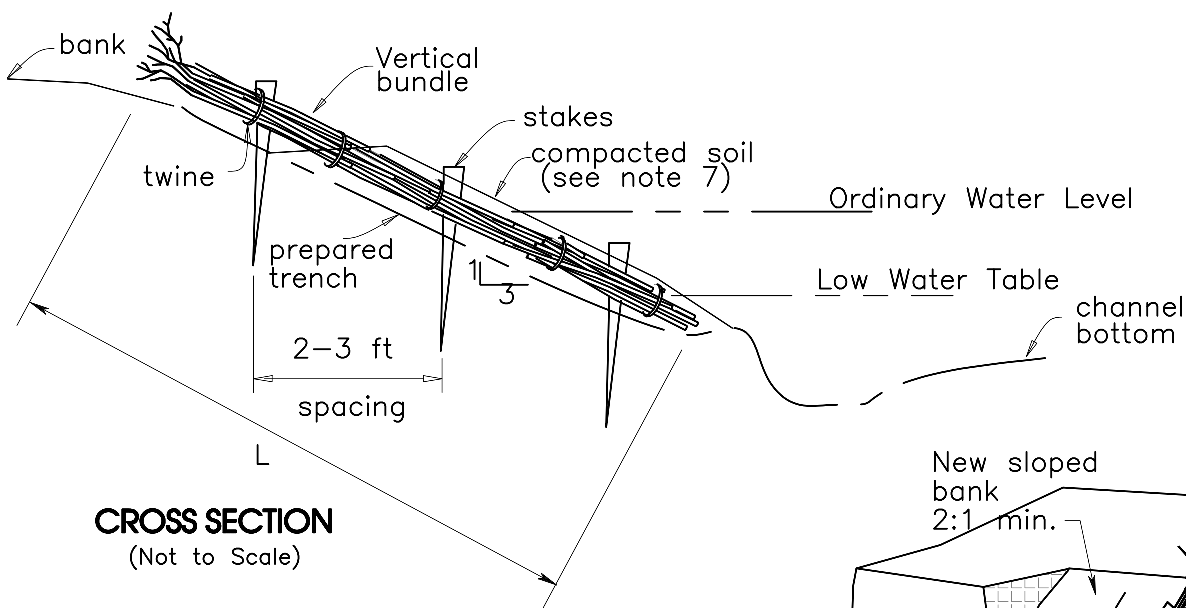
NOTES
Use 1/2 to 2 in. cuttings
Plant cutting perpendicular to the bank.
Holes around poles filled with dirt/water slurry.

AS BUILT DRAWINGS

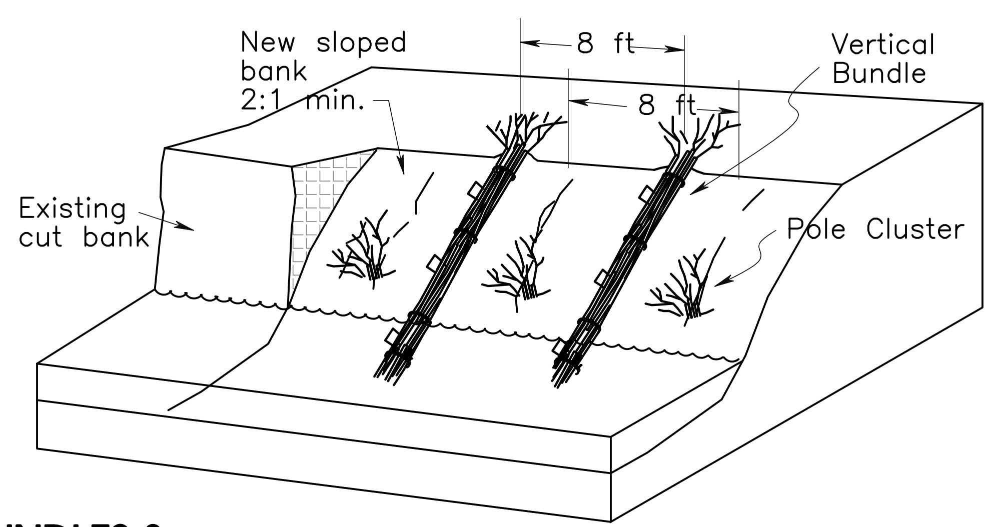



## POLE CLUSTER DETAIL

NOTES
Use 1/2 to 2 in. cuttings.
In holes excavated with an auger, place approximately 4 cuttings in hole to maximize sprouting success per effort. Holes are backfilled with excavated material and watered.




## CROSS SECTION
(Not to Scale)




VERTICAL BUNDLES

Dormant native poles placed in shallow trenches at 8 ft spacings with clusters in between.

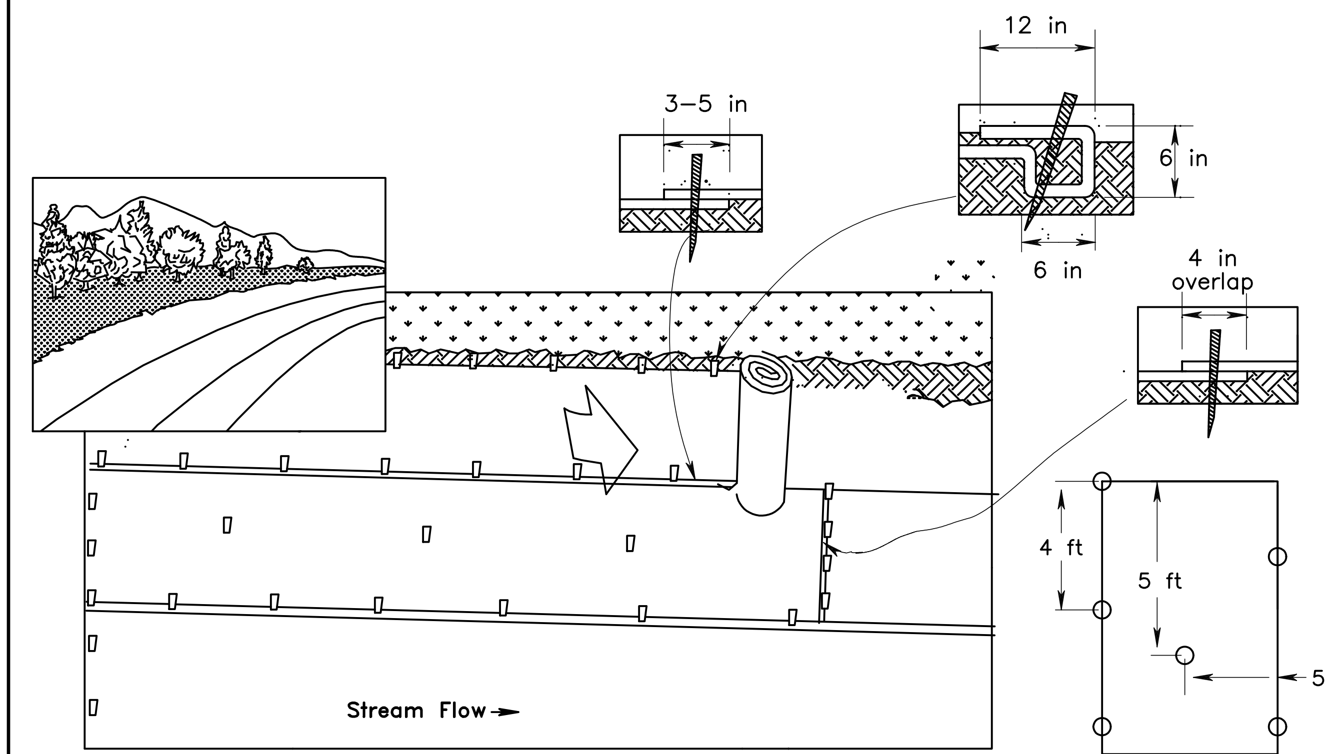
Species Willows

Dia 1/2 to 2 in.

Length 8 to 10 ft.

## VERTICAL BUNDLES & BANK SLOPING

ISOMETRIC VIEW
(Not to Scale)




## EROSION CONTROL FABRIC: SLOPE INSTALLATION
NOT TO SCALE

STAKE PATTERN

Natural Channel Design, Inc
206 S. Elden St.
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(928) 774-2336

DRAWN BY: R.Lyman

DESIGNED BY: M.Wirtanen, R.Lyman, S.Yard

| REV | DATE | BY | REVISION |
|---|---|---|---|
| | | | |
| | | | |
| 3 | 11/17/09 | R.L. | As Built |

# DETAILS: Vertical Bundles, Bank Sloping Willow Clusters, Erosion Control Fabric

# Billy Creek Natural Area Riparian Restoration AWPF Grant #08-154WPF

AS-BUILT DRAWINGS construction period 10/12-26/09

FILE NAME: Billy Creek.pro

DATE: March 11, 2009

PROJECT NO: 07-143 AZ

SHEET: 11 of 13

AS BUILT DRAWINGS

## Description and Use

This technique uses clumps of willows (Salix spp.) or Cottonwood (Populus spp.) placed in holes excavated along an eroding bank. The live clumps of willow or cottonwoods are harvested with stems and roots intact. The clumps are already rooted and can become established more quickly providing faster protection at the problem site.

## Inventory & Planning Considerations

1. Stands of mature willows or young cottonwoods should be available nearby for harvesting. If the harvest site is too far from the planting site for efficient backhoe travel, consider placing clumps on a trailer and trucking them to the planting site.

2. Locate clumps of willows or small cottonwoods that are accessable to a backhoe.

3. Generally, clumps are placed close together along the entire problem section of stream to keep water from cutting around the planting. Pulling or pushing soil from the streambank above the clumps and packing it behind will improve establishment succest and assist in bank shaping.

4. Planting should be done following high water flows in the spring to reduce the chance of ripping clumps out before the roots start to spread.

5. Temporary protection, such as steel posts with woven wire, sunlight degradable netting, etc. may be necessary to hold clumps in place until they are well established which can take 2–3 years. Usually, this is only necessary in areas where high velocities impact the bank.

## How To Install

1. Harvest willow and/or cottonwoods from a local stand that is in a healthy condition. Using a backhoe or excavator, dig straight down and under to the willow clump root mass. Start the hole about 10 inches away from the stems and dig down about the depth of the bucket (approx 2 feet). Try to get about 70% of the root mass. Leaving some roots in the hole willl aid regeneration of the plant in the future (species dependent).

2. If the harvest site gets active flooding with a good sediment load, nature will fill in the hole. If the site does not flood, place clean, weed free topsoil back into the hole after removing the clump.

3. If the planting site is close to the willow clump source, dig the clump and travel to the planting site with it in the bucket. Try to keep as much soil around the root mass as possible.

If the distance to the harvest site requires trucking or trailering, wet down the roots and tarp them with protective plastic or burlap. Drive slowly and plant the clumps as soon as possible when you arrive at the planting site. Avoid leaving the clumps for long periods in the sun.

4. Excavate the hole for the clumps, being sure to get the hole deep enough so you are just above the standing watertable. Ideally you want the root mass of the clump to be in the saturated moisture zone and not in the standing water zone. Remember, willows and cotttonwoods grow in depositional areas. This means the crown of willows or cottonwoods does not have to be at the ground surface. The root system can be planted much deeper ensuring that it is near the low water table. The stems that are buried will eventually grow roots along the buried sections.

5. Fill the hole with soil and water. Muddy in the willow clumps so there are no air pockets around the root mass.

6. Cut off about one third to one half of the willow tops straight across. This decreases the amount of stem that the reduced root mass will have to support. It also stimulates a dense regrowth of stems and leaves. Seal cut ends with latex paint.

7. Spacing between the clumps should be about 6 – 15 feet. This depends on the critical streamflow energy you are trying to protect against.


Transporting Willow Clump

Watering Willow Clump

REFERENCES:
Willow Clump Plantings, TN Plant Materials No. 42 (2003 – NRCS ID PMC)
(Photos courtesy of C.Hoag, Aberdeen PMC, NRCS)

Natural Channel Design, Inc
206 S. Elden St.
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(928) 774-2336

DRAWN BY: R.Lyman

DESIGNED BY: M.Wirtanen, R.Lyman, S.Yard

| REV | DATE | BY | REVISION |
|---|---|---|---|
| | | | |
| | | | |
| 3 | 11/17/09 | R.L. | As Built |

DETAILS:
Willow Clump Plantings

Billy Creek Natural Area Riparian Restoration
AWPF Grant #08-154WPF

AS–BUILT DRAWINGS
construction period 10/12–26/09

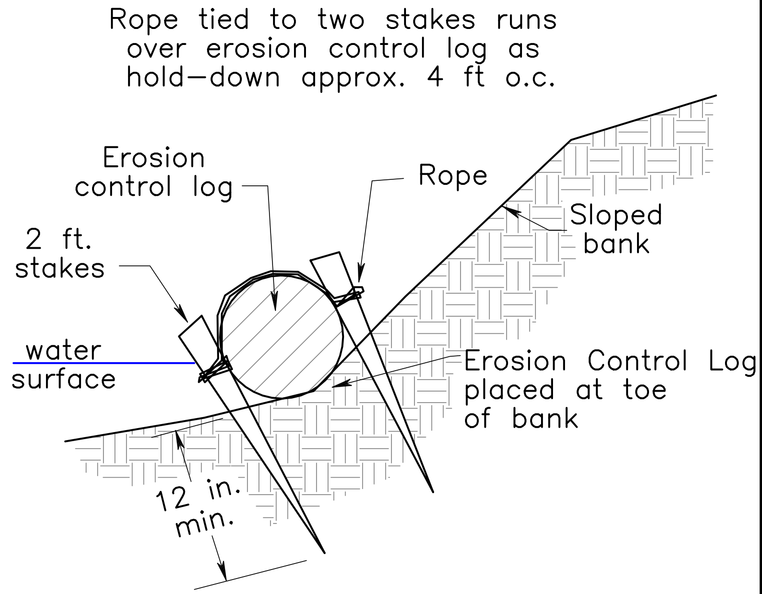
FILE NAME: Billy Creek.pro

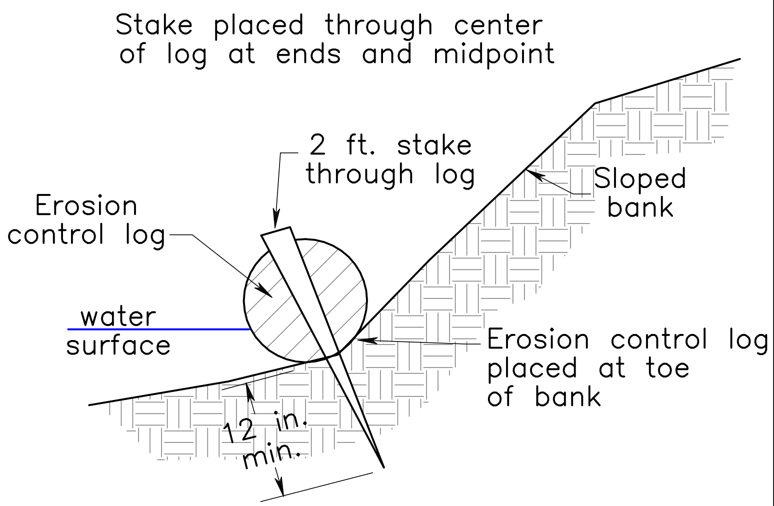
DATE: March 11, 2009

PROJECT NO: 07-143 AZ

SHEET: 12 of 13

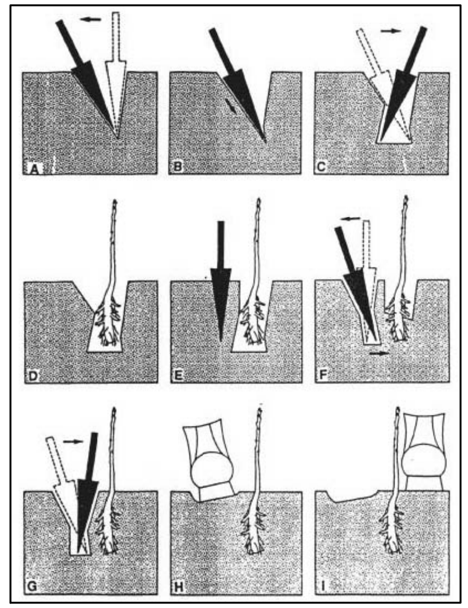
AS BUILT DRAWINGS




## Section Views
(Not to Scale)

## EROSION CONTROL LOG INSTALLATION




A. Insert bar straight down and pull backward
B. Push bar down at same angle to get a new bite
C. Push bar to vertical position
D. Remove bar and set seedling in hole at correct depth.
E. Insert bar about 2 inches behind first hole
F. Pull bar back to pack soil around lower roots
G. Push forward to pack soil around upper roots
H. Repeat steps 5 to 7 and close new hole with shoe heel
I. Firm soil around seedling with foot

### WETLAND PLUGS

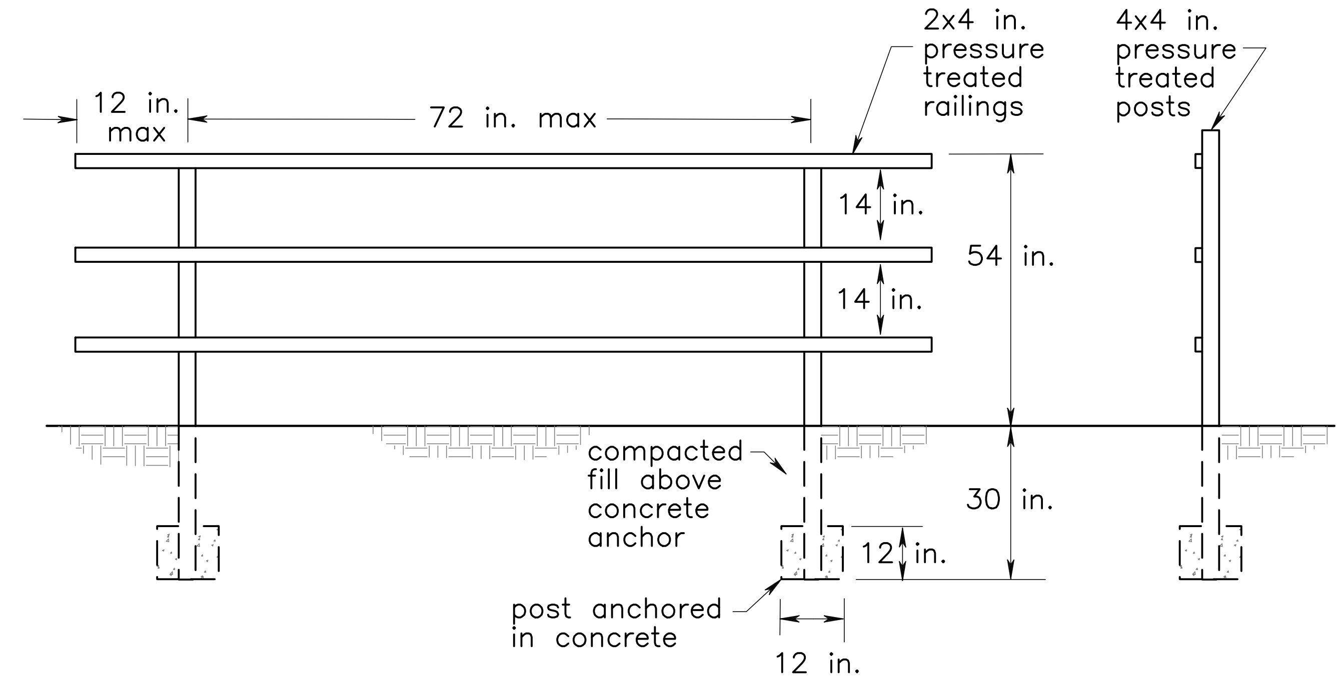
HARVESTING: Dig no more than 1 sq ft of plant material from a 4 sq ft area. It is not necessary to go deeper than 5 to 6 inches.

Cut the top growth to about 4 to 5 inches above the potential standing water height or 10 inches whichever is higher. One sq ft of plant material provides 6 to 9 individual plant plugs.

Make sure the length of the plug is related to the saturation zone at the planting site. The bottom of the plug needs to be in contact with the saturation zone. Where possible, plugs and sod shall be grown and harvested locally.

PLANTING PLUGS: Plant plugs by flooding the planting site. Saturated soil is much easier to plant in than dry soil. The soil should be super saturated so that a hole can be easily dug with a bare hand. Hand planting is more successful with fine soils than with coarse soils. Take the plug trays and place them in a Styrofoam cooler. Cover the roots with water while in transit. At the planting site, drain off most of the water so the cooler will float. Use the cooler to move the plugs around the area as you plant. Plant plugs in the Toe Zone. The plugs can either be chopped with a shovel very rapidly or the plugs can be cut with a small saw so they will easily fit into a predrilled, set diameter hole. To get the right length of plug, lay the large plug on its side on a sheet of plywood and use a saw to cut the bottom off level and to the desired length. After this, stand the plug up and slice smaller plugs off like a cake.

## SEEDLING/PLUG PLANTING DETAIL




**Front View**
(Not to Scale)

**Side View**
(Not to Scale)

NOTES:

Fencing to be installed between existing trees where ATV access has been occurring.

Leave approximately 18 to 24 inches of space between end of railings and trees to accomodate foot traffic.

Pressure treated lumber shall be used. Posts shall have treatment specified for below ground use.

Railings shall be installed on road side of posts using 16d nails.

| MATERIALS (Totals for 4 fences) | |
|---|---|
| 4x4 P.T. posts | 8 ea |
| 2x45 P.T. rails | 12 ea |
| 3/8 in. carridge bolt | 24 ea |
| 60 lb sacks of Quickcrete concrete | 8 ea |

## FENCE INSTALLATION


Natural Channel Design, Inc
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Flagstaff, Arizona 86001
(928) 774-2336


DRAWN BY: R.Lyman

DESIGNED BY: M.Wirtanen, R.Lyman, S.Yard

| REV | DATE | BY | REVISION |
|---|---|---|---|
| | | | |
| | | | |
| 3 | 11/17/09 | R.L. | As Built |

DETAILS: Erosion Control Log, Grass Seedlling/Plug Planting, Fence

Billy Creek Natural Area Riparian Restoration
AWPF Grant #08-154WPF

AS-BUILT DRAWINGS construction period 10/12-26/09

FILE NAME: Billy Creek.pro

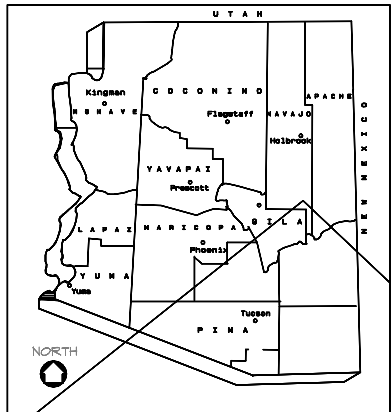
DATE: March 11, 2009

PROJECT NO: 07-143 AZ

SHEET: 13 of 13

# Billy Creek

## Natural Area Riparian Restoration Project
## PHASE II - 2011

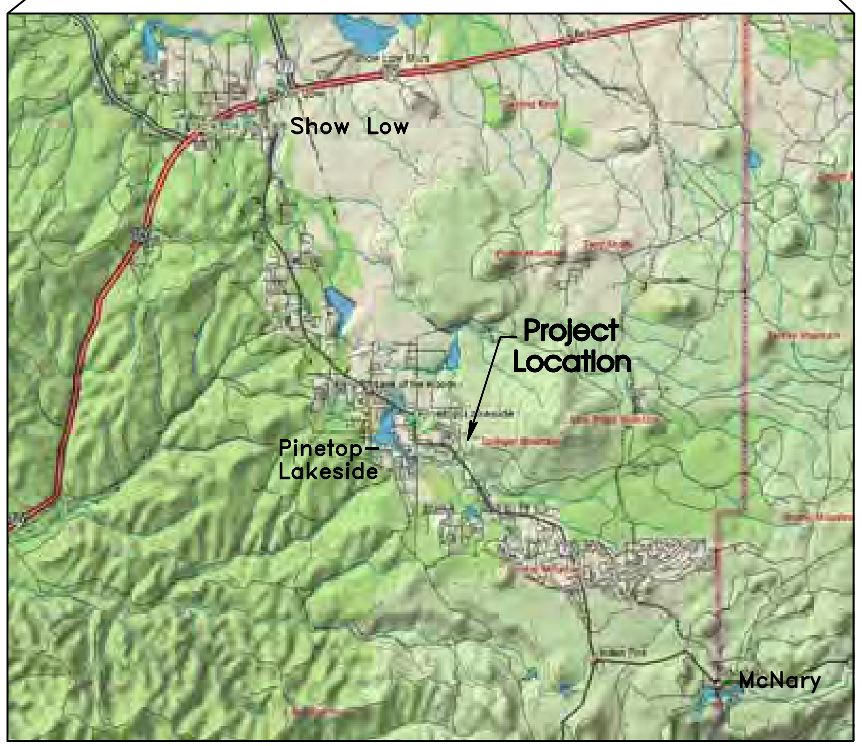



LOCATION MAP

Prepared for
Town of Pinetop-Lakeside, AZ
Arizona Water Protection Fund #08-154WPF

# Record Drawings

Construction Period: October 23-29, 2011
Earthwork Contractor - Reidhead Excavation & Development, Inc.
Revegetation Labor - American Conservation Experience




NE 1/4 Section 25, T9N, R22E
Pinetop-Lakeside, Navajo County, Arizona

Billy Creek, Pinetop, Arizona
Watershed Area = 15.2 square miles

Stream Project Length: 1 mile

## INDEX OF DRAWINGS



## MATERIAL LIST

| | | |
|---|---|---|
| **EARTHWORK** | | |
| Channel Excavation | 4.5 CY | |
| **STRUCTURES** | | |
| Rock | 72 TONS | (38 CY) |
| Non–Woven Geotextile (35 ft x 15 ft) | 60 SQ YDS | |
| **VEGETATION** | | |
| Willow Cuttings | 200 EA | |
| Wetland Plugs | 285 EA | |
| Seeding | 12 LBS | (1 AC) |
| Organic Composted Mulch | 205 CF | |
| Single Organic Net Straw Fabric | 3 ROLLS | |

CALL TWO WORKING DAYS BEFORE YOU DIG
263-1100
1-800-STAKE-IT
(OUTSIDE MARICOPA COUNTY)


Natural Channel Design, Inc
206 S. Elden St.
Flagstaff, Arizona 86001
(928) 774-2336


DRAWN BY: S.Yard, M.Wirtanen

DESIGNED BY: S.Yard

| REV | DATE | BY | REVISION |
|---|---|---|---|
| 1 | 10-2011 | SNY | Revised Weir, Channel Deposits, Control Pts |
| 2 | 11-22-11 | MW | Record Drawings |

COVER SHEET: Location, Index, Materials

Billy Creek
Natural Area Riparian Restoration Project - PHASE II

REGISTERED PROFESSIONAL ENGINEER (CIVIL)
CERTIFICATE NO. 26889
STEPHANIE N. YARD
Date Signed 8/4/11
ARIZONA, U.S.A.
Expires 3-31-2014

FILE NAME: Billy Weir Design.pro

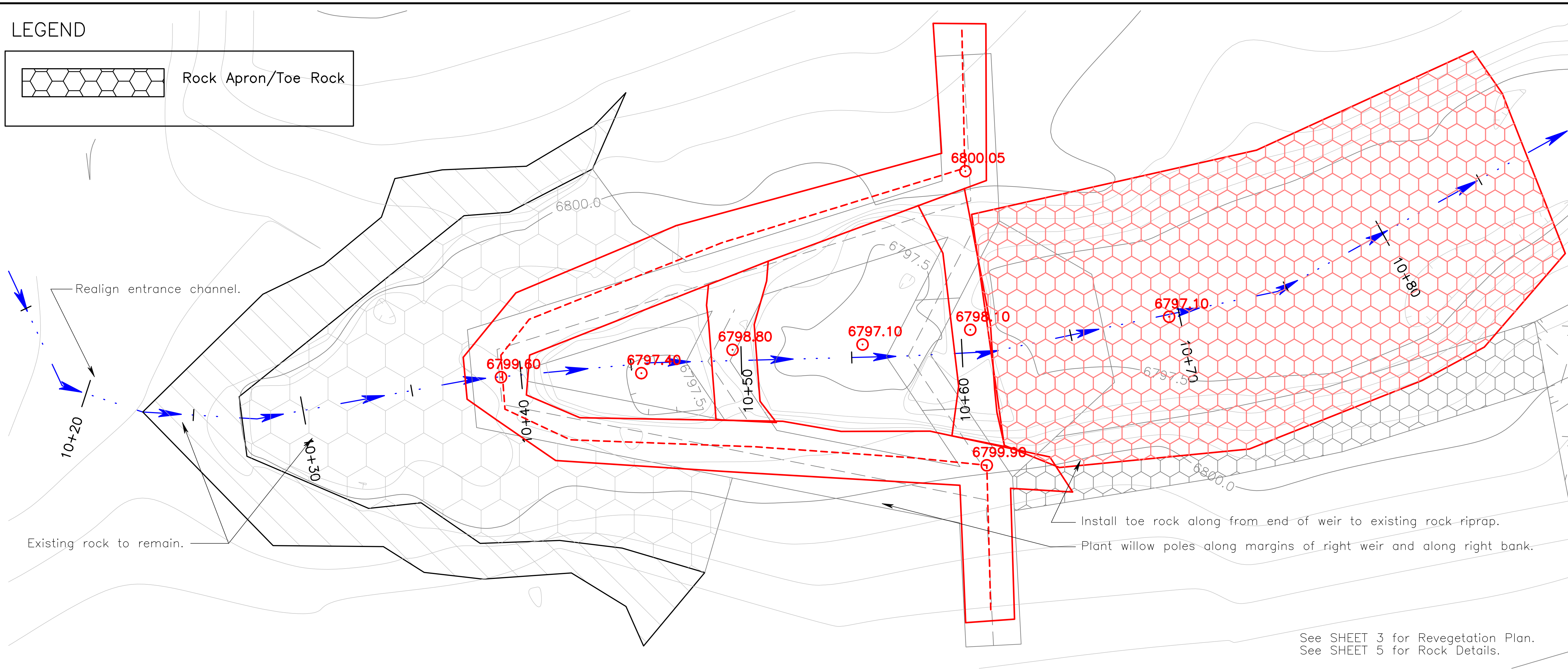
DATE: August 2011

PROJECT NO: 07-143 AZ

SHEET: 1 of 7

LEGEND

Rock Apron/Toe Rock




ROCK QUANTITIES

3 ft dia – 40 ea
2 ft dia – 60 ea
1.5 ft dia – 190 ea

3 ft dia – 23.4 Tons
2 ft dia – 24.2 Tons
1.5 ft dia – 24.4 Tons

Total: 72 Tons
(est 130 lbs/cu ft)

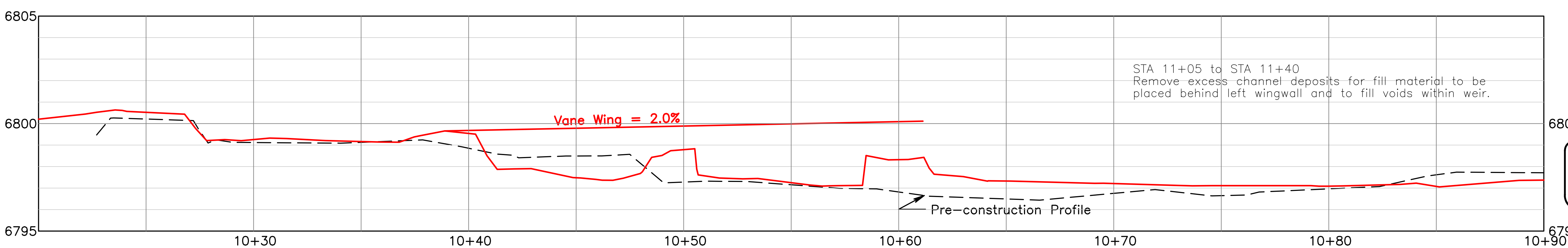
Total: 38 cy

ROCK SIZE

Toe Rocks: 2–3 ft dia
Weir Rocks: 3 ft dia
Footer Rocks: 2 ft dia
Apron Rocks: 1.5 ft dia

See SHEET 3 for Revegetation Plan.
See SHEET 5 for Rock Details.

**Record Drawings**

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DRAWN BY: S.Yard, M.Wirtanen

DESIGNED BY: S.Yard

| REV | DATE | BY | REVISION |
| --- | --- | --- | --- |
| 1 | 10-2011 | SNY | Revised Weir, Channel Deposits, Control Pts |
| 2 | 11-22-11 | MW | Record Drawings |

# PLAN and PROFILE: Reach 1
# Modified Grade Control Structure

## Billy Creek
## Natural Area Riparian Restoration Project - PHASE II

REGISTERED PROFESSIONAL ENGINEER (CIVIL)
CERTIFICATE NO. 26889
STEPHANIE N. YARD
Date Signed 8/4/11
ARIZONA, U.S.A.
Expires 3-31-2014

HORIZ SCALE: 1" = 5'
VERT SCALE: 1" = 5'

5 0 5

W S N E

FILE NAME: Billy Weir Design.pro

PROJECT NO: 07-143 AZ

DATE: August 2011

SHEET: 2 of 7

NOTES:

1. STA 10+20 to 10+30 left bank, 10+50 to 10+90 right bank. Plant willow clusters on 2–ft centers.

2. STA 10+80 to 11+60 right bank. Plant willow clusters in rock riprap on 4–ft centers. Cover riprap with excavated spoils from weir installation. Seed with native grass seed mix.

3. Relocate vegetative clumps upstream of weir above existing left wingwall.

4. Harvest and plant ~~125~~ 160 sedge plugs along channel margins in areas devoid of vegetation.

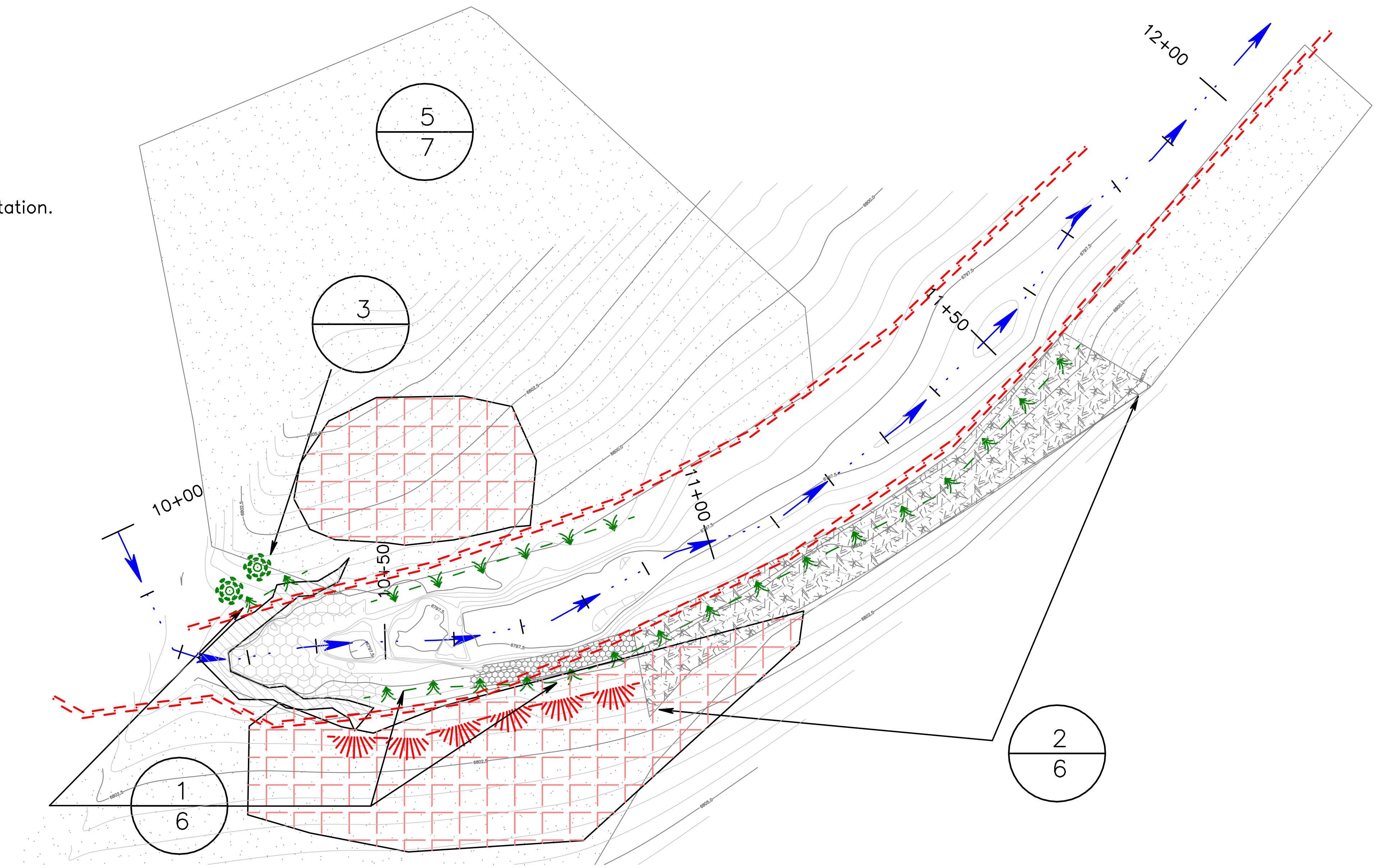
5. Seed all disturbed areas.

6. Harvest and plant 23 grass plugs on right bank above weir.

See SHEET 2 for rock work.
See SHEET 6 for Willow Cluster and Sedge Plug planting details
See SHEET 7 for Seeding and Fabric Installation

LEGEND

| | |
|---|---|
| | Willow Clusters/ Vertical Bundles |
| | Grass Plugs |
| | Willow Clump Plantings |
| | Wetland Plugs |
| | Existing Rock Riprap |
| | Grass Seeding |
| | Compost Added To Soil |




REACH 1: MATERIAL QUANTITIES

| | |
|---|---|
| Willow Clusters: | 56 ea |
| Vertical Bundles: | 9 ea |
| Seeding: | 0.5 acre |
| Sedge Plugs: | 160 ea |
| Grass Plugs: | 23 ea *(Muhlenbergia spp.)* |
| Composted Mulch: | 50 cf |

SHEET Notes

\# Note No.
\#, # Ref SHEET

Record Drawings

CALL TWO WORKING DAYS BEFORE YOU DIG
263-1100
1-800-STAKE-IT
(OUTSIDE MARICOPA COUNTY)

Natural Channel Design, Inc
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Flagstaff, Arizona 86001
(928) 774-2336

DRAWN BY: S.Yard, M.Wirtanen

DESIGNED BY: S.Yard

| REV | DATE | BY | REVISION |
|---|---|---|---|
| 1 | 10–2011 | SNY | Revised Weir, Channel Deposits, Control Pts |
| 2 | 11–22–11 | MW | Record Drawings |

# REVEGETATION
# Reach 1 - Upstream

## Billy Creek
## Natural Area Riparian Restoration Project - PHASE II

REGISTERED PROFESSIONAL ENGINEER (CIVIL)
CERTIFICATE NO. 26889
STEPHANIE N. YARD
Date Signed 8/4/11
ARIZONA, U.S.A.
Expires 3-31-2014

HORIZ SCALE: 1" = 20'
20 0 20

W S N E

FILE NAME: Billy Weir Design.pro

DATE: August 2011

PROJECT NO: 07–143 AZ

SHEET: 3 of 7

LEGEND

| | |
|---|---|
| - ⩔ – ⩔ – ⩔ - | Vertical Bundles |
| - - - - - - - | Wetland Plugs |
| (brick pattern) | Mulch, Seed & Fabric |
| (stippled pattern) | Native Seeding |

SHEET Notes

# / #, #
Note No.
Ref SHEET

REACH 2: MATERIAL QUANTITIES

| | |
|---|---|
| Vertical Willow Bundles: | 10 ea |
| Seeding: | 0.5 acre |
| Sedge Plugs: | 125 ea |
| Erosion Control Fabric: | 1,400 sq ft |
| Wood Stakes: | 70 ea |
| Compost Mulch: | 155 cu ft |

NOTES:

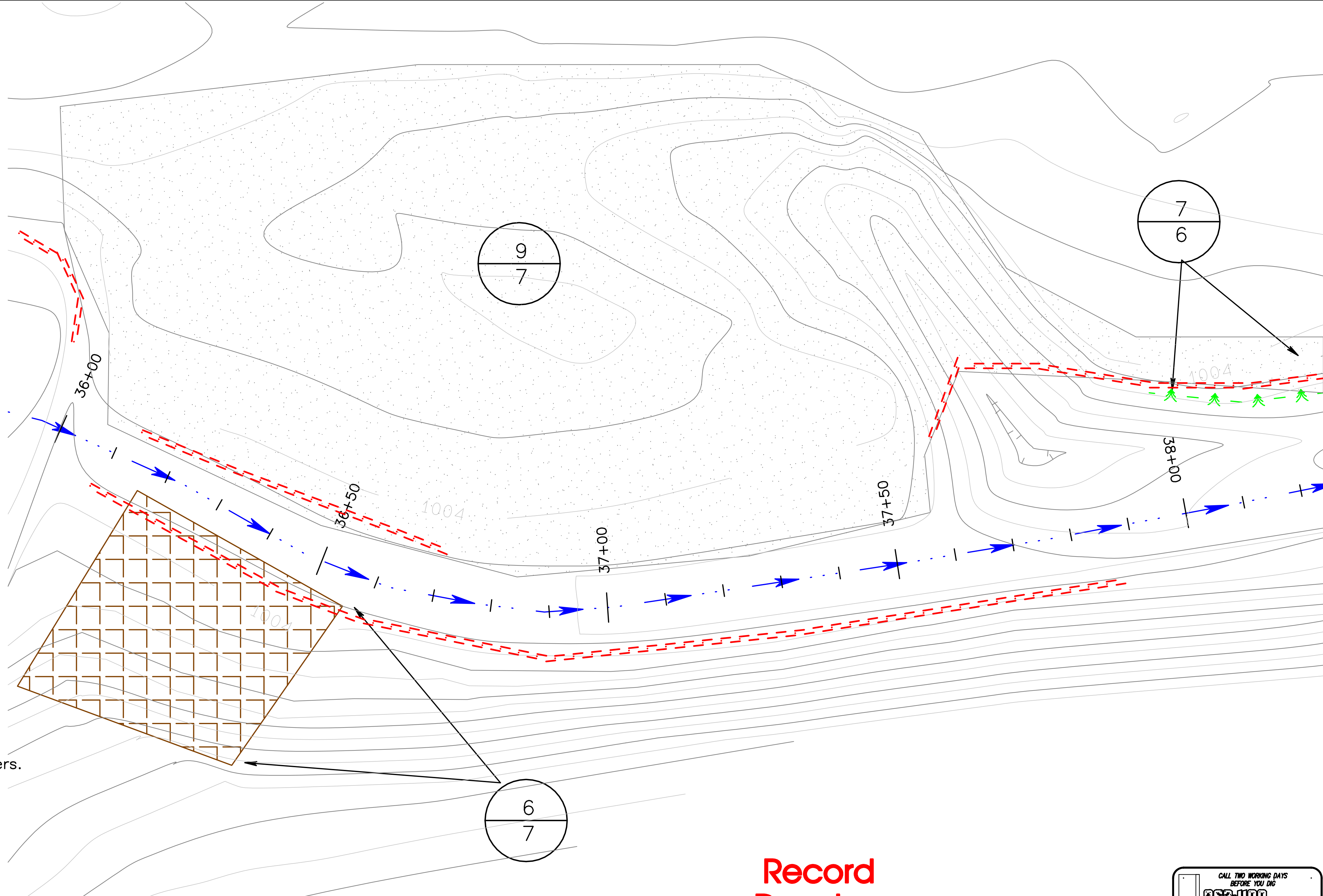
6. STA 36+15 to 36+50
   Prep disturbed bank by incorporating composted mulch. Rake smooth and seed. Install single organic net straw erosion control fabric over disturbed area.

7. STA 38+00 to 38+24 left bank.
   Plant willow clusters/vertical bundles along bank on 4–ft centers.

8. Harvest and plant 125 sedge plugs along channel margins in areas devoid of vegetation.

9. Seed all disturbed areas.

See SHEET 6 for Willow Cluster and Sedge Plug planting details
See SHEET 7 for Seeding and Fabric Installation




Record Drawings


Natural Channel Design, Inc
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(928) 774-2336


DRAWN BY: S.Yard, M.Wirtanen

DESIGNED BY: S.Yard

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| 1 | 10-2011 | SNY | Revised Weir, Channel Deposits, Control Pts |
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# REVEGETATION
## Reach 2 - Downstream

## Billy Creek
## Natural Area Riparian Restoration Project - PHASE II

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CERTIFICATE NO. 26889
STEPHANIE N. YARD
Date Signed 8/4/11
ARIZONA, U.S.A.
Expires 3-31-2014

HORIZ SCALE: 1" = 20'
20 0 20

S
E W
N

FILE NAME: Billy Weir Design.pro

DATE: August 2011

PROJECT NO: 07-143 AZ

SHEET: 4 of 7

## WEIR ROCK VOLUME & QUANTITIES

ROCK SIZE (Min. diameter)
Footer Rocks: 24 in.
Weir Rocks: 36 in.
Apron Rocks: 18 in.

Total Distance = 30 ft
Total Volume = 38 CY
(1 CY/ft)

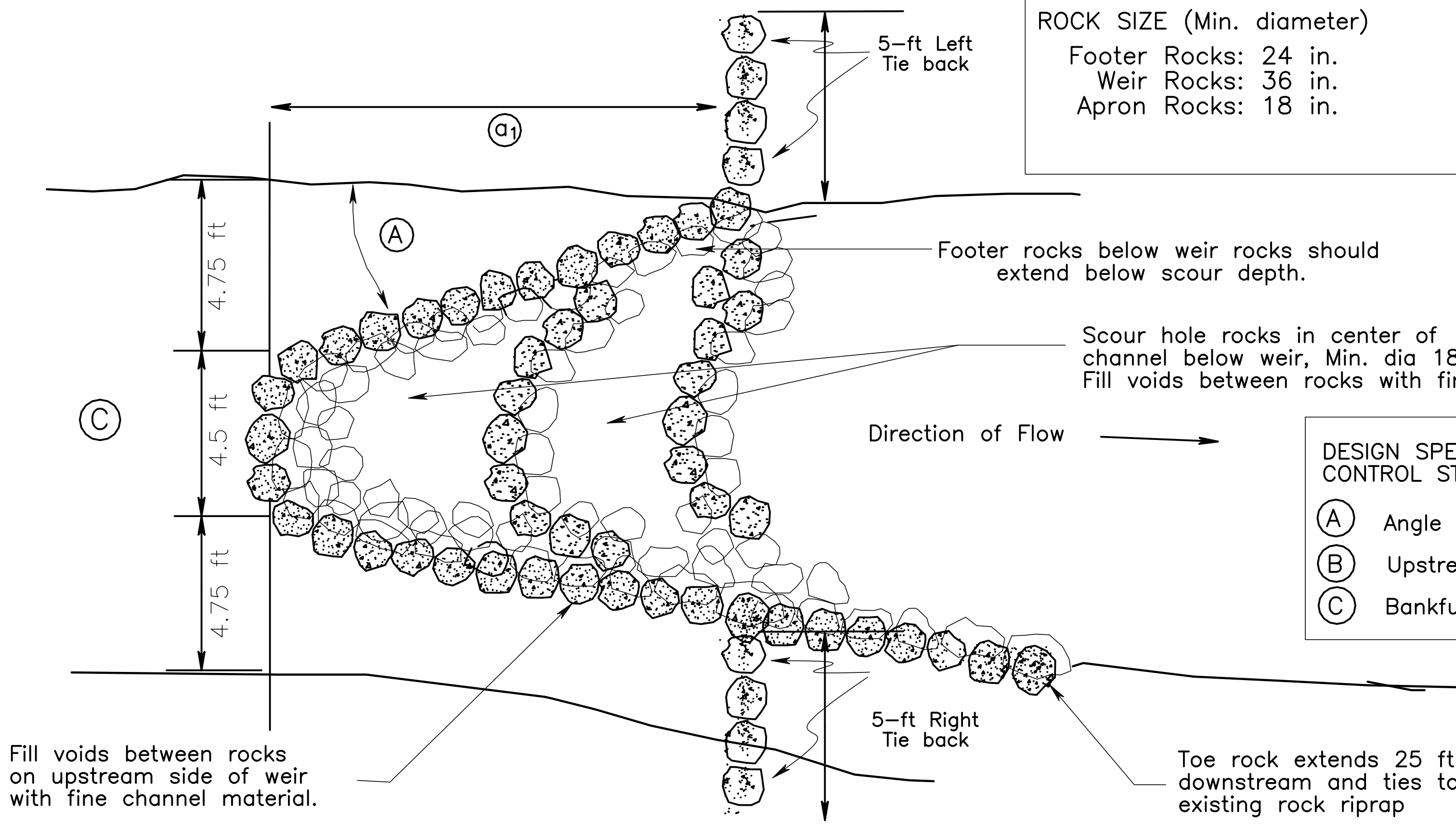
3 ft dia – 40 ea
2 ft dia – 60 ea
18 in. dia – 190 ea

## TOE ROCK VOLUME & QUANTITIES

Total Distance = 25 ft
Total Volume = 7 CY
(0.3 CY/ft)

3 ft dia – 9 ea
2 ft dia – 14 ea

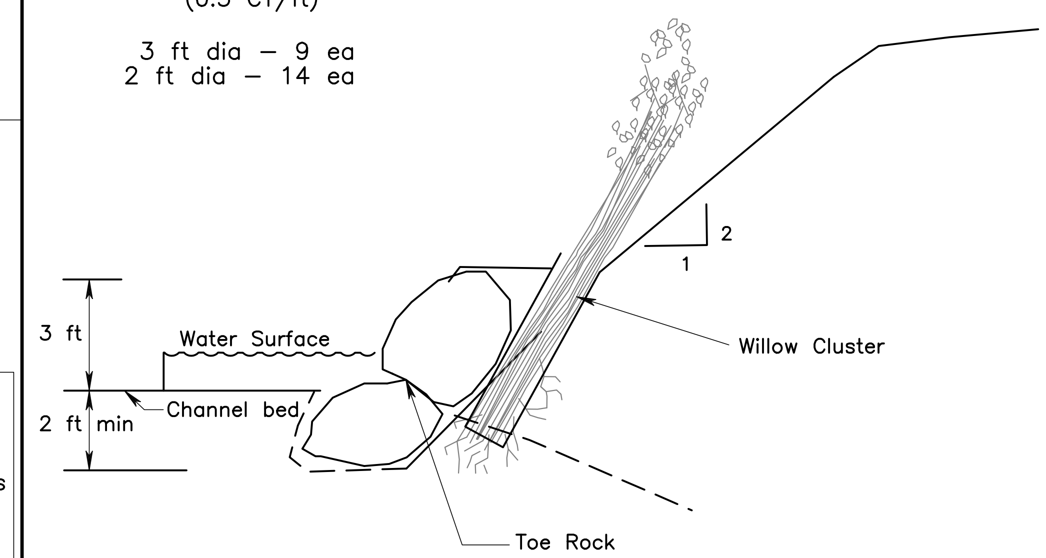
Note:
Rooted/leafed condition of the living plant material is not representative of the time of installation




## MODIFIED GRADE CONTROL STRUCTURE PLAN VIEW
(Not to Scale)

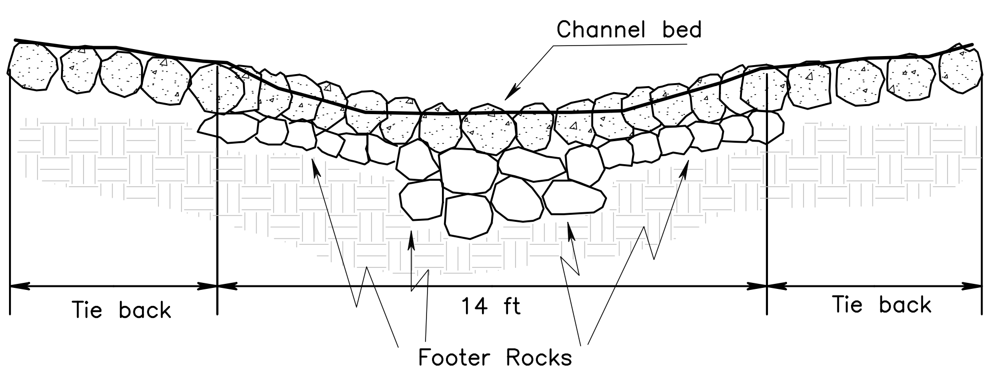
### DESIGN SPECIFICATIONS FOR MODIFIED GRADE CONTROL STRUCTURE

- (A) Angle between bank and weir arm: ~15 degrees
- (B) Upstream dip of weir: ~4 %
- (C) Bankfull width: 14 ft

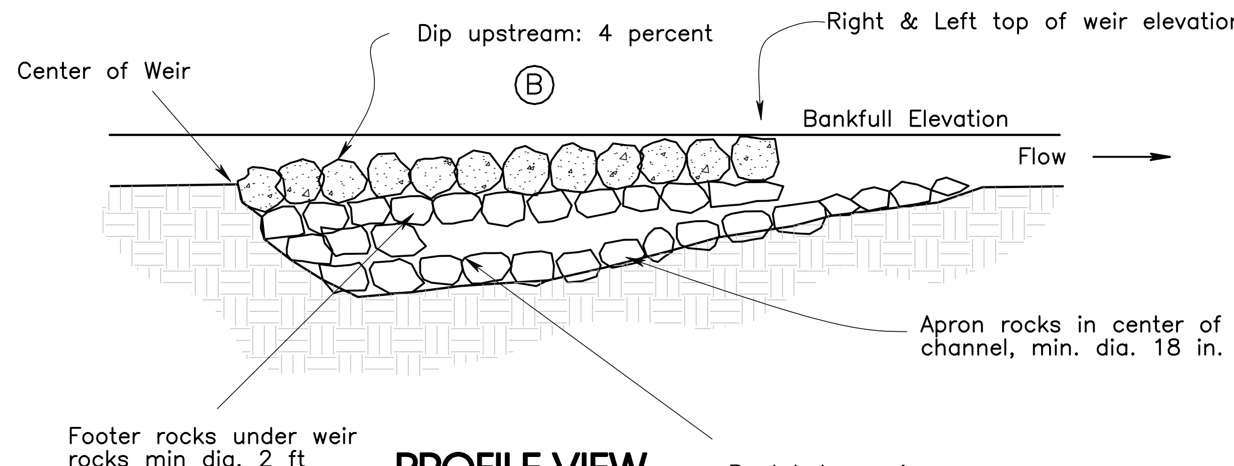



## TYPICAL TOE ROCK SECTION
(Not to Scale)

**Record Drawings**




## SECTION VIEW
(Not to Scale)




## PROFILE VIEW
(Not to Scale)

## ROCK SPECIFICATIONS

Rock for stream structures shall be dense, sound, and free from cracks, seams, or other defects conducive to accelerated weathering. The rock shall range in size from 18 to 36 inches. The least dimension of an individual rock shall not be less than one-half the greatest dimension. The rock source shall be approved by the ENGINEER or authorized representative and have a bulk specific gravity of not less than 1.7 per ASTM C127.

Whenever possible, it is best to individually select boulders for use in a project.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# DETAILS: Modified Grade Control Structure and Toe Rock

# Billy Creek

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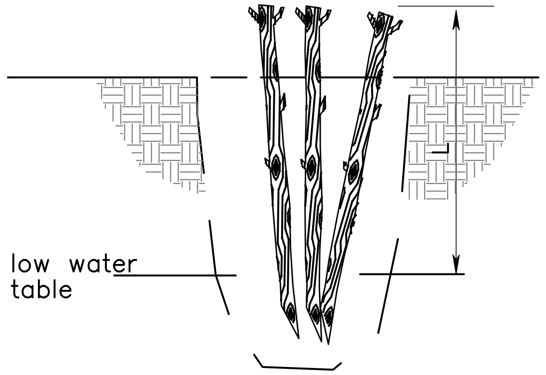
DATE: August 2011

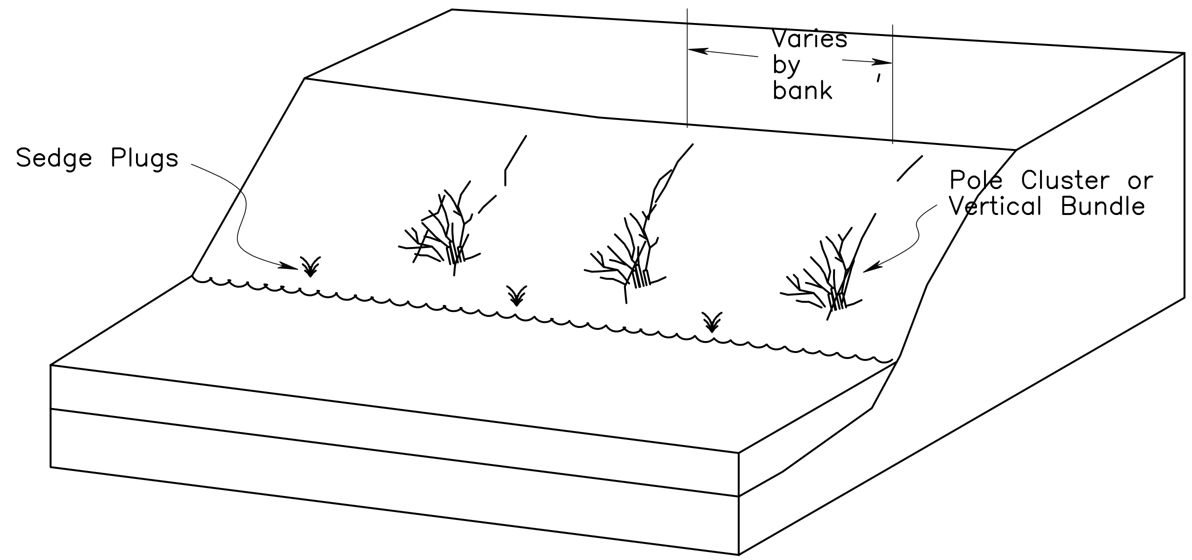
PROJECT NO: 07-143 AZ

SHEET: 5 of 7



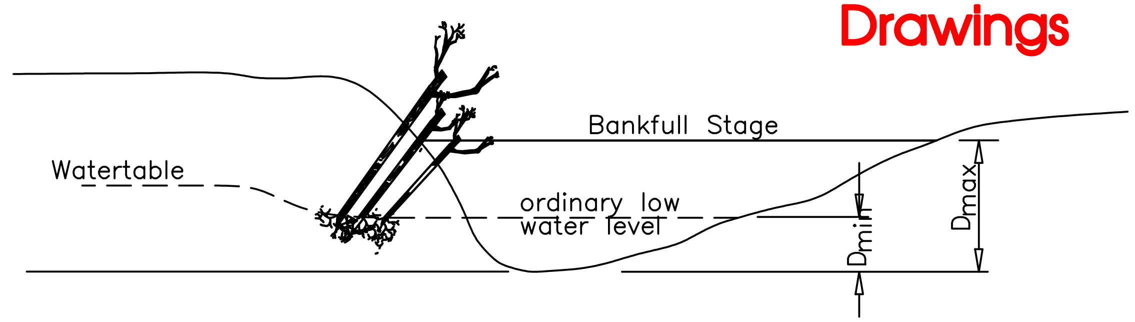

## POLE CLUSTER DETAIL

NOTES
Use 1/2 to 2 in. cuttings.
In holes excavated with an auger, place approximately 3 cuttings in hole to maximize sprouting success per effort. Holes are backfilled with excavated material and watered.



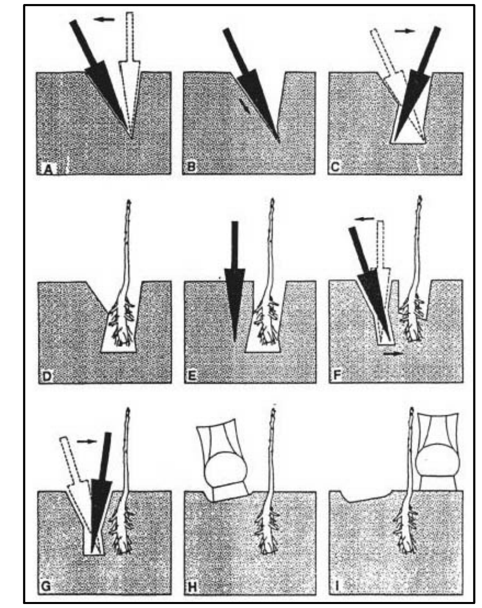

## ISOMETRIC VIEW
(Not to Scale)

Record Drawings




## SECTION VIEW
(Not to Scale)

## SEDGE PLUG PLANTING DETAIL




A. Insert bar straight down and pull backward
B. Push bar down at same angle to get a new bite
C. Push bar to vertical position
D. Remove bar and set seedling in hole at correct depth.
E. Insert bar about 2 inches behind first hole
F. Pull bar back to pack soil around lower roots
G. Push forward to pack soil around upper roots
H. Repeat steps 5 to 7 and close new hole with shoe heel
I. Firm soil around seedling with foot

## WILLOW PLANTINGS

MATERIAL: The live cuttings shall be from native woody plant materials or woody plant materials adapted to the site. Willow (Salix spp.) is best to propagate from hardwood cuttings. Relatively small– to medium–sized species (upon maturity) that are rhizomatous or have creeping–roots are most appropriate.

HARVESTING and HANDLING: Dormant unrooted hardwood cuttings can be taken after leaf fall and before bud burst in the spring. The best rooting success is from cuttings that are from disease–free, green plants that are at least 2 years old and not older than 10 years old; old "corky" growth shall be avoided. In general, cuttings shall be taken from a source–population located close as possible to the project site as approved by the Grantee or authorized representative. Cuttings shall be taken from the center of the plant rather than the perimeter when possible. Never remove more than 1/3 of any single donor plant during harvesting.

The diameter of cuttings for pole and cluster plantings shall be between ½ to 2 inches at the butt end and not smaller than ¼ inch at the tip. Sucker growth (less than 3/8 inch diameter) shall be avoided. The cutting diameter for post plantings ranges from 2 to 3 inches. Cutting lengths vary between 6 and 8 feet depending on the application and site conditions. The cuttings shall be long enough to reach 6 to 8 inches into the lowest water level of the year and leave a minimum of one foot exposed above ground.

Cuts shall be made with clean, sharp tools. The bottom end of the stem cutting shall be cut to a 45–degree angle and the tip end shall be cut square across or horizontal to the stem. Trim off all side branches and the top terminal bud (bud at the growing tip) so energy will be rerouted to the lateral buds for more efficient root and stem sprouting. The top cut end of each cutting can be coated with a sealant (50–50 mixture of light–colored water–based latex paint and water) prior to storage. The bottom end is not coated. Scatter trimmed material and other organic debris around the harvest site.

Cuttings can be tied into bundles to help with transporting and soaking. Immediately after harvesting, the cuttings shall be soaked in water for 5–7 days prior to planting. Do not allow the roots to emerge from the bark.

PLACEMENT: Cuttings shall be placed within the limits as indicated on the plans or as staked in the field. Root primordia will develop when good soil–to–stem contact is made and exposed sections of the cutting will sprout stems and leaves. In multiple row plantings, spacing between rows shall be staggered with respect to those in adjacent rows. Cuttings are placed in the ground deep enough to reach the lowest water table of the year and high enough to expose at least one to two buds. Holes around poles shall be filled with a soil–water slurry; root primordia develops when good soil–to–stem contact is made.

Willow Pole Clusters shall be planted in the overbank zone as shown on the plans. Willow Pole Clusters utilize multiple stems that are planted into larger holes excavated by a mini–excavator or tractor–mounted auger then backfilled with soil and water. Willow Pole Clusters shall have 3–4 cuttings per hole. Willow Pole Clusters are planted at 2–foot spacings along the rock weir and 4–foot spacings within the existing toe rock.

## WETLAND PLUGS

HARVESTING: Dig no more than 1 sq ft of plant material from a 4 sq ft area. It is not necessary to go deeper than 5 to 6 inches.

Cut the top growth to about 4 to 5 inches above the potential standing water height or 10 inches whichever is higher. One sq ft of plant material provides 6 to 9 individual plant plugs.

Make sure the length of the plug is related to the saturation zone at the planting site. The bottom of the plug needs to be in contact with the saturation zone. Where possible, plugs and sod shall be grown and harvested locally.

PLANTING PLUGS: Plant plugs by flooding the planting site. Saturated soil is much easier to plant in than dry soil. The soil should be super saturated so that a hole can be easily dug with a bare hand. Hand planting is more successful with fine soils than with coarse soils. Take the plug trays and place them in a Styrofoam cooler. Cover the roots with water while in transit. At the planting site, drain off most of the water so the cooler will float. Use the cooler to move the plugs around the area as you plant. Plant plugs in the Toe Zone. The plugs can either be chopped with a shovel very rapidly, or the plugs can be cut with a small saw so they will easily fit into a predrilled, set diameter hole. To get the right length of plug, lay the large plug on its side on a sheet of plywood and use a saw to cut the bottom off level and to the desired length. After this, stand the plug up and slice smaller plugs off like a cake.

Plugs may also be planted in coir logs at water level. Make a hole in the coir log using a digging–bar and inserting the plug.

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| 2 | 11–22–11 | MW | Record Drawings |

# DETAILS: Willow Clusters and Sedge Plugs

# Billy Creek
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FILE NAME: Billy Weir Design.pro

DATE: August 2011

PROJECT NO: 07-143 AZ

SHEET: 6 of 7

## SEEDING

MATERIAL: Seed shall be purchased from a reliable supplier. Seed that has become wet, moldy, or otherwise damaged in transit or storage will not be accepted. The percent of noxious weed seed allowable shall be as defined in the current State laws relating to agricultural seeds. The seeding rates below are for planting by hand broadcasting. Forbs (wildflowers) can be added to seed mix to increase diversity and improve aesthetics.

SEEDBED PREPARATION and TREATMENT:
Areas to be treated shall be dressed to a smooth, firm surface. On sites where equipment can operate on slopes safely, the seedbed shall be adequately loosened (4 to 6 inches deep) and smoothed. Depending on soil and moisture conditions, disking or cultipacking, or both, may be necessary to properly prepare a seedbed. Where equipment cannot operate safely, the seedbed shall be prepared by hand methods by scarifying to provide a roughened soil surface so that broadcast seed will remain in place.

If seeding is to be accomplished immediately following construction operations, seedbed preparation may not be required except on a compacted, polished, or freshly cut soil surface. Seedbed preparation shall be discontinued when soil moisture conditions are not suitable for the preparation of a satisfactory seedbed as determined by the Grantee or authorized representative.

SEEDING:
All seeding operations shall be performed in such a manner that the seed is applied in the specified quantities uniformly in all disturbed and other designated areas at an application rate of 11.9 pounds to the acre. Estimated area of seeding is 1.0 acre. Seed can be drilled or broadcast by hand. Seed shall be incorporated into the soil, but not more than 1-inch deep. Seeding should occur before installation of erosion control fabric or mulching.

| SEASON | SPECIES | SCIENTIFIC NAME | lb PLS for 1 Acre |
|---|---|---|---|
| Warm Season | Blue grama | *(Bouteloua gracilis)* | 0.9 lb/ac PLS |
| Cool Season | Western wheatgrass | *(Elymus elymoides)* | 7.2 lb/ac PLS |
| Cool Season | Sand dropseed | *(Sporobolus cryptandrus)* | 0.1 lb/ac PLS |
| Warm Season | Arizona Fescue | *(Festuca arizonica)* | 1.6 lb/ac PLS |
| Warm Season | Spike Muhly | *(Muhlenbergia wrightii)* | 0.56 lb/ac PLS |
| Warm Season | Mountain Muhly | *(Muhlenbergia montana)* | 7.5 lb/ac PLS |
| | | | 11.9 lb PLS |

## MULCHING - SOIL AMENDMENT

Soil at the project site is heavy clay which needs extra preparation to help plants grow.
Soil Amendment will improve both aeration and drainage.

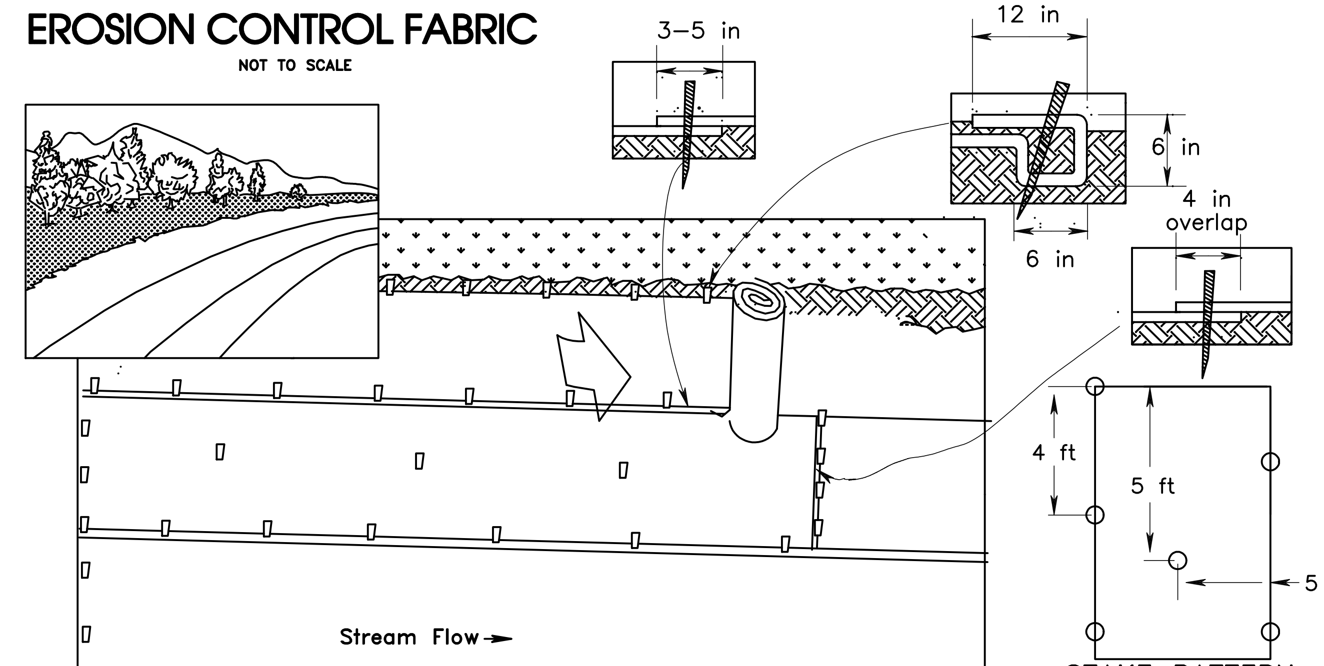
MATERIAL:
Greenhouse soil such as potting soil or planting compost will be mixed with the existing soil to improve the planting area.

MULCHING:
Mulch shall be applied at a rate of 1 cubic foot per nine square feet, or approximately 1.5 inchs in depth.
Mulch will be mixed into the top 2 to 3 inches of soil.

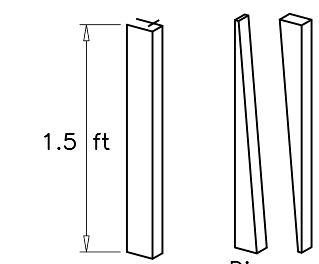
Record Drawings

## EROSION CONTROL FABRIC

NOT TO SCALE




STAKE PATTERN




2x4 Lumber
Diagonal Saw Cut

DEAD STOUT STAKES

## FABRIC INSTALLATION

Biodegradable erosion control fabric made of Jute, Coir, Straw, Coconut or other natural material with all natural netting shall be placed over the seeding in the designated areas for protection and to provide a good environment for vegetative re-growth.

MATERIALS:
Fabric: Erosion Control Blanket (ECB) containing 100% certified weed free agricultural wheat straw with single net biodegradable netting and thread (Western Excelsior SR-1 All Natural or comparable).
ECB shall meet the following properties:

| Property | Test Method | Value | Unit |
|---|---|---|---|
| Tensile Strength | ASTM D6818 | 6.3 (MD), 6.3 (TD) | lb/in |
| Elongation | ASTM D6818 | 5.0 (MD), 5.0 (TD) | % |
| Mass per Unit Area | ASTM D6566 | 8.0 | $oz/yd^2$ |
| Thickness | ASTM D1777 | 7.5 | mm |
| Light Penetration | ECTC TASC 00197 | 15 | % open |
| Water Absorption | ASTM D1117 | 425 | % |

Fasteners: Fasteners used to secure the erosion control fabric shall be a combination of 1.5-foot wood stakes and metal staples. Wood fasteners shall be dead stout, untreated, 2 by 4 lumber. Each length should be cut again diagonally across the 4-inch face to make two wedge stakes from each length. Only new, sound lumber shall be used, and any stakes that shatter upon installation should be discarded. Staple fasteners shall be 11-gauge "U" shaped staples with 1 inch crowns and 6 inch legs.

PLACEMENT:
Fabric is laid and anchored over seeding to reduce soil erosion and provide a good environment for vegetative regrowth. Fabric shall be installed for slope protection and seed germination enhancement along the constructed channel banks. The ends and edges shall be overlapped or shingled a minimum of 4 inches in the direction of flow and anchored. The upper and lower ends of fabric shall be anchored by burial in a 6 inch deep trench, covered and staked. The fabric shall be secured by staking in a diamond pattern which includes all edges and ends fastened at a maximum spacing of four foot on center as shown on the plans.

Fasteners used to secure the erosion control fabric shall be a combination of 2-foot wood stakes along the toe of bank in the Bank Stabilization Planting Zone 6 only; and 1.5-foot wood stakes along all fabric edges and seams, and staples in the field area throughout all installation planting zones.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# DETAILS: Seeding, Mulching and Fabric Installation

# Billy Creek

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