Honey Creek Restoration Project

OKLAHOMA CONSERVATION COMMISSION

…restoration of wetland, stream & riparian habitat

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

OKLAHOMA DEPARTMENT OF WILDLIFE CONSERVATION

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FINAL REPORT

Acknowledgements

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Introduction

Restoration of degraded wetlands and stream reaches is of key importance to a number of natural resource agencies. The Environmental Protection Agency (EPA), Oklahoma Conservation Commission (OCC) and Oklahoma Department of Wildlife Conservation (ODWC) have partnered to establish "on the ground" wetland and stream restoration demonstration projects. This partnership has generated two projects, one complete and one in progress, thus far.

In 2003 OCC conducted an extensive preliminary assessment and scoping process of the site, owned by Tom Steen, through Fisch Engineering. This work produced a detailed assessment of the causative factors of instability and established tractable restoration alternatives. OCC subsequently contacted the ODWC in July 2005 requesting creation of a cooperative partnership to initiate a restoration initiative. Since both agencies are concerned with management of Honey Creek, and ODWC's streams management program staff has the necessary stream rehabilitation expertise, an interagency cooperative endeavor was formed. ODWC completed project deliverables, including site assessment, restoration design, implementation and monitoring, in Spring of 2006. The restored site has endured one large and a few smaller floods successfully. Further, biotic habitat is significantly more abundant and the restored riparian corridor is growing rapidly.

Currently in progress is a 3,200 foot wetland and restoration project approximately one mile downstream of the Steen project. Owner Bill Berry, who operates a large tree farm on adjacent lands, will supply trees for the riparian component of the project.

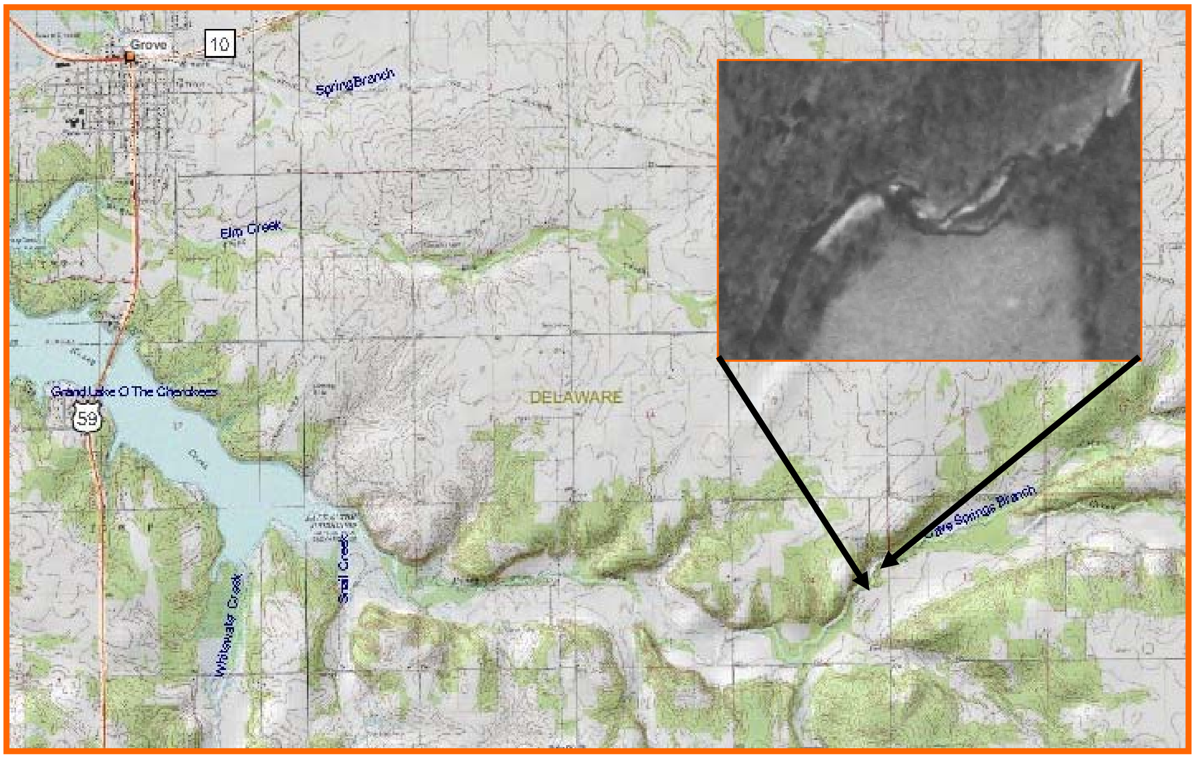
Specific objectives of these initiatives are to: 1) increase abundance of wetlands habitat; 2) improve living conditions for biota; 3) reduce property loss from accelerated erosion; and 4) improve flow and sediment transport regimes. The benefits are diverse and include improvements to biodiversity, species density, enhanced in-stream and riparian habitat, development of adjacent wetlands, establishment of a protective riparian buffer zone and preservation of adjacent lands. The projects may also serve as an outdoor classroom for the education of private landowners and educators and a research site for scientists.

Phase I

Project Site Description

The project area is an approximately 400-foot long reach of Honey Creek located in Delaware County (SE1/4 of S24, T24N, R24E; **Figure 1**) near Grove, Oklahoma owned by Tom Steen.

Figure 1: Phase I restoration site



meandering pattern and a riffle/pool sequence located in a well developed flood plain. Channel morphology consists of a relatively low gradient (mean = 0.002; Fisch 2003) and the substrate is predominately gravel with, prior to restoration, a significant portion of fine-grained particles causing localized encumberedness. The site is in valley type VIII (wide, gentle valley slope with extensive floodplain) but resembles type VI (limestone bluff structural controls) in some areas (Rosgen 1996).

Before implementation of the restoration plan the composition of the biotic community at and adjacent to the study site was structured, in part, by the sharp contrast in stream state. The primary action reach was absent of woody vegetation on the left descending bank while the adjacent reaches were populated with willow, oak, alder, cottonwood and various grasses.

Various fish species populated adjacent reaches which had more desirable habitat. Contrastingly, fish populations appeared to be less successful at the disturbed site which was likely due to degraded habitat conditions. Other species of waterfowl, reptiles, amphibians and invertebrates were common in the diverse and stable reaches found above and below the project area. An additional and extensive description of the action area, including watershed and hydrology dynamics, is provided in the Fisch Engineering (Fisch 2003) report.

Watershed and Hydrology

The Honey Creek watershed is relatively healthy (Fisch 2003) inferring even greater importance for restoration initiatives. Influences on the overall physical stability of the stream likely include road crossings, gravel mining and local land management practices. Grand Lake, of which Honey Creek is an inflowing tributary, appears to have no morphological influence on the study area. The Fisch Engineering report (Fisch 2003) projected a base flow of 10-cfs, bankfull discharge of 750-cfs and 10-year flood of 2000-cfs. Field investigations, flood frequency analysis and channel resistance equations used by ODWC delineated a bankfull discharge under present conditions of about 700 cfs. This and related hydraulic geometry data were used to generate target design criteria for restoration of the Honey Creek site.

Scope of Problem

Prior to restoration, the study site was experiencing accelerated lateral migration (mean ~ 2'/year; Fisch 2003) inferring significant channel instability. A vertical bank of 7 to 8-feet in height was contributing excessive erosional materials to the stream. Incorporated in this bank was a lens of gravel approximately 2 feet above the bank tow that further complicated site stability (**Figure 2**). An estimated 1500 cubic yards of material were added to the stream from this single bank during the last 10 years (Fisch 2003). Much of this material consisted of fine-grained particles which filled interstitial substrate space causing emburcation of otherwise mobile bed materials and associated channel aggradation. The negative consequences of these processes are well documented and include reduced biodiversity, disruption of food web mechanics, poor fish and insect reproduction, reduced year-class success and diminished water quality.

Figure 2: Vertically eroding bank with gravel lens

Left alone, sediment contributions from this reach to the Honey Creek system would likely exponentially increase as the radius of curvature continued to decrease. This trend in curvature tightening, which further increases near-bank shear and subsequent erosion, would probably continue until the meander evulsed. Impacts from this scenario would have included loss of adjacent lands and significantly higher sediment contributions to the stream. Ultimately, the physical complications of the reach would limit its overall biological productivity, hydrology and sediment transport regimes. Completion of the restoration endeavors presented below should circumvent these consequences and improve the stability of the study and adjacent downstream reaches.

The restoration site was bordered by relatively stable stream segments up and downstream. Typically, the potential for successful restoration efforts increases when adjacent reaches are relatively stable. Some instability does occur in these regions but should not limit restoration objectives. The Fisch Engineering report (Fisch 2003) should be referenced for a more detailed description of the problems and causative factors associated with the action area.

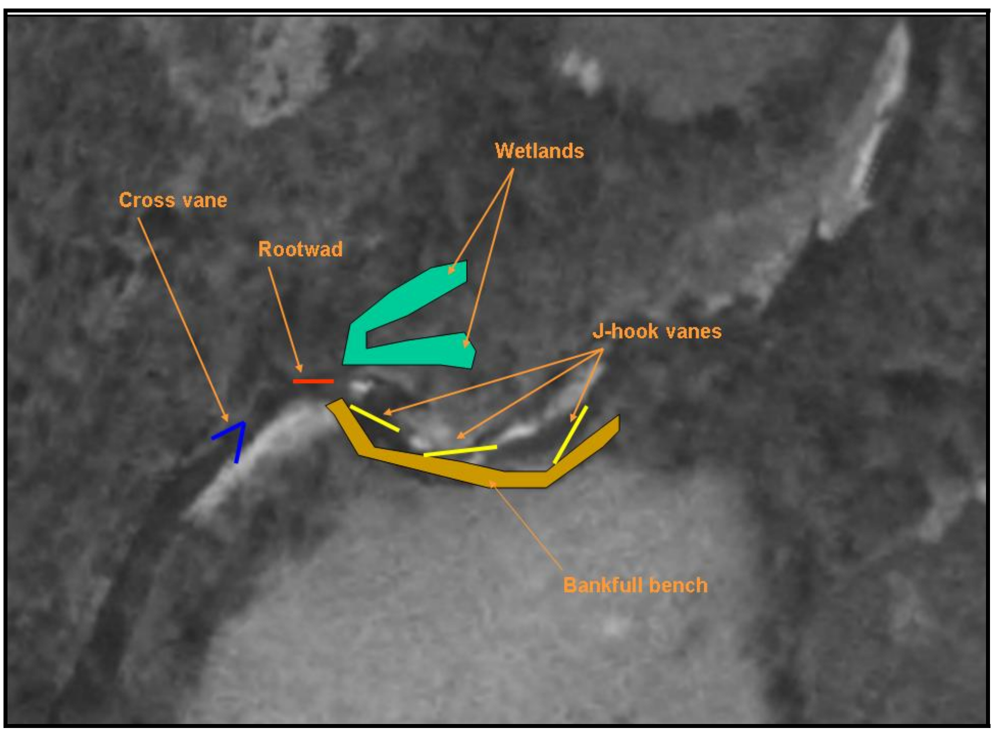
Project Objectives

Specific objectives of this demonstration project were to: 1) increase abundance of wetlands habitat; 2) improve living conditions for biota; 3) reduce property loss from accelerated erosion; and 4) improve flow and sediment transport regimes. The benefits are diverse and include improvements to biodiversity, species density, enhanced in-stream and riparian habitat, development of adjacent wetlands, establishment of a protective riparian buffer zone and preservation of adjacent lands. The project may also serve as an outdoor classroom for the education of private landowners and educators and a research site for scientists.

Overview of Solution

Enhanced in-stream habitat, sediment transport, biological productivity and stability of the restoration site were achieved using applied fluvial geomorphology techniques. **Figure 3** depicts the general location of the constructed bankfull bench and stabilization structures and enhanced wetlands. The following portion of the plan includes a discussion of each restoration component.

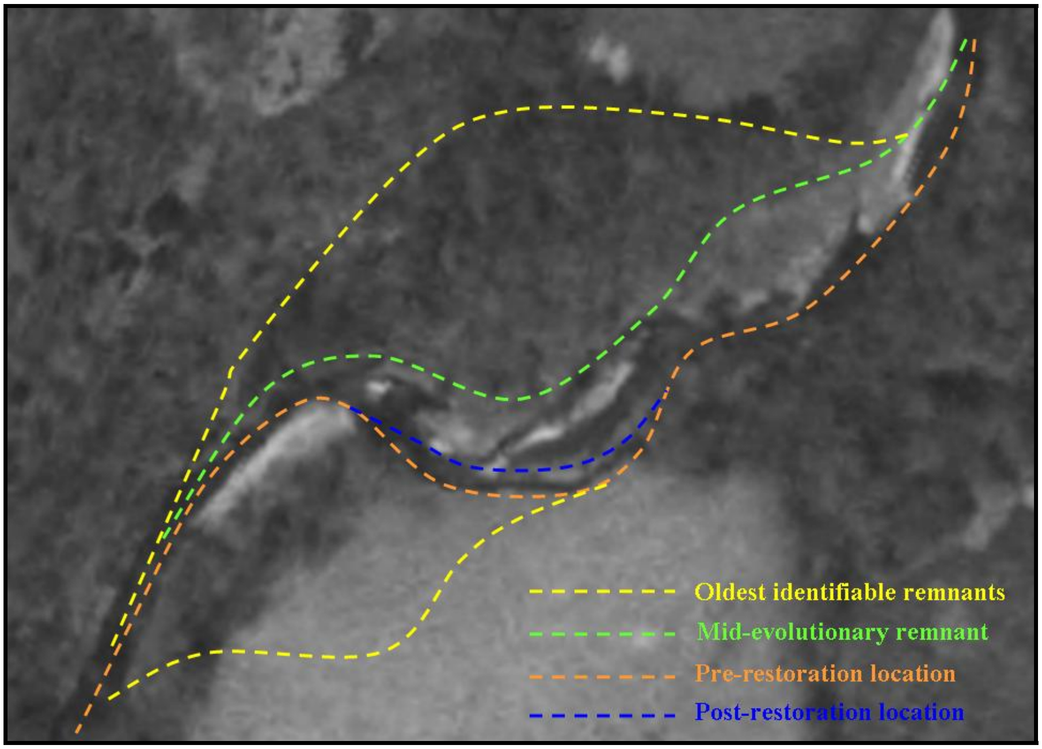
Figure 3: Restoration plan overview



Channel Dimensions

The degraded channel had migrated a significant distance across the valley floor (**Figure 4**) illustrating deviation from stable conditions. Much of the noted historic channel movement is likely associated with larger scale adjustments made by Honey Creek. A new left bank line was established about 10-feet from the existing bank to gain proper channel alignment. Adjacent reaches indicated stability could be achieved with the target radius of curvature once appropriate vegetation buffers and bank slopes were instituted.

Figure 4: Historic channel locations



Improved width/depth relationships were achieved using channel shaping techniques and maintained with hard structural controls (i.e. rock vanes; see below). A bankfull width of about 65-feet was targeted. This represents a slight reduction in width relative to upstream and downstream conditions where some local channel adjustments may have occurred. We erred slightly on the side of a reduced width/depth ratio which is a common restorative technique. The benefit of this practice is that the stream can more easily adjust its boundaries laterally rather than trying to transport its sediment load in a higher width/depth ratio channel. Sediment transport in the less desirable wide and shallow condition usually results in bed aggradation and increased lateral erosion.

An average longitudinal water surface slope of about 0.002 was targeted for the restoration site. The facet slopes of individual mesohabitat features varied with riffles and runs providing steeper gradients whereas pools and glides had flatter slopes. Additional structural controls were used to establish target gradients.

Bankfull Bench

A bankfull bench with an average width of 10 to 15-feet was constructed along the entire vertically eroding bank (**Figure 5**). A natural bench occurring upstream of the vertical bank was surveyed and used as a general template for bench construction. The dorsal surface of the constructed bench was relatively flat while the slope from channel toe to bench top mimicked adjacent stable conditions. The bankfull bench was vegetated subsequent to construction. The vertical bank, stabilized at lower portions by the vegetated bankfull bench, was returned to a < 1:3 ratio slope.

Figure 5: Constructed and vegetated bankfull bench

Physical Stabilization

Hard structures constructed from natural materials, including three J-hook vanes (**Figure 6**) and a cross-vane (**Figure 7**), were used to maintain appropriate energy gradients. Additional benefits of these structures include grade control, bank stabilization and in-stream fish habitat improvement. All vanes were constructed of large boulders (> 30" diameter) with root wads or logs integrated when possible. The vanes were built with an interior departure angle of 20 to 30-degrees. The proximal end of the vanes have an elevation at or near the bankfull stage then decrease toward the distal end to an elevation slightly above bed grade. A single cross-vane was used below the primary site to insure upstream grade control and reduce the chance for headcut disturbance of the site. Similarly, a rock sill was constructed across the entire bankfull channel width at a grade commensurate with the uppermost J-hook vane.

Figure 6: J-Hook Vane

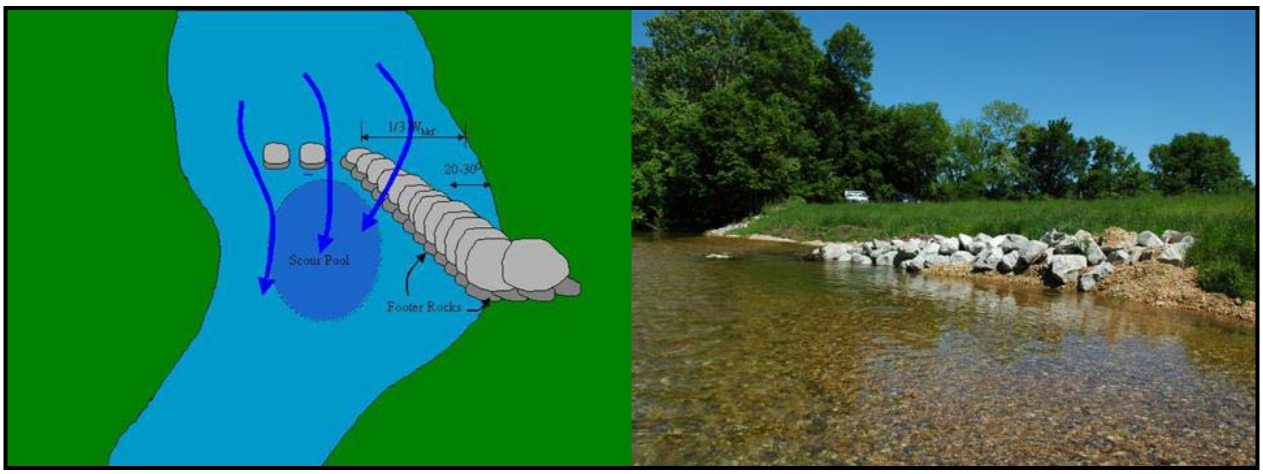
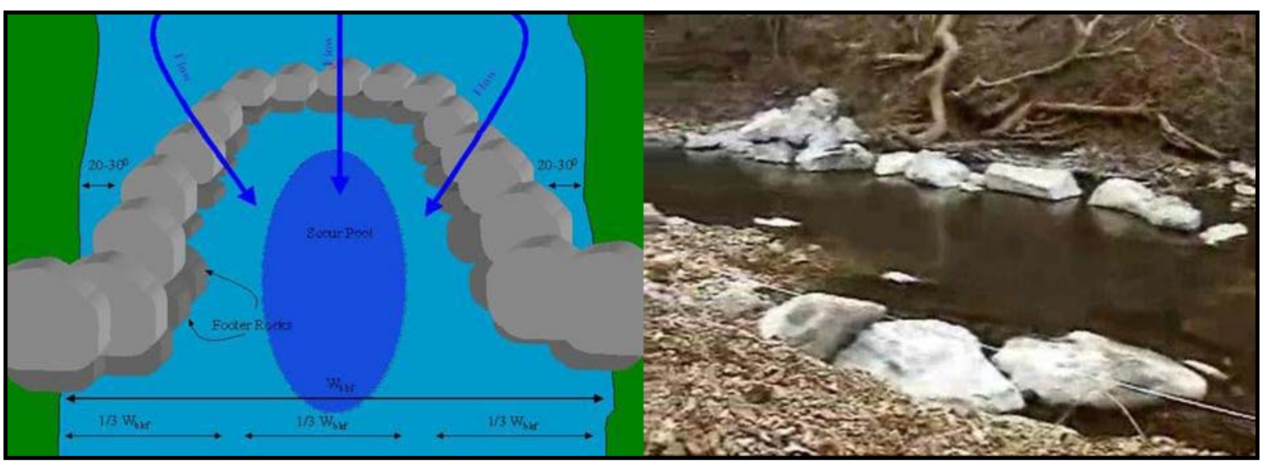


Figure 7: Cross Vane



Vegetative Stabilization

Bioengineering techniques using native vegetation were used to further insure project success. Vegetation in adjacent stable reaches served as a guide for vegetation of the restoration site. Coconut fiber erosion control matting was installed across the barren upper slope along the entire left bank. Prior to installation, and beneath the matting, a wild grass seed and fertilizer mix was placed to encourage the rapid establishment of vegetation along the bank. Woody seedlings were inserted through the matting to facilitate their stability to maturity.

A transitional hardwood mix was established in the transitional zone between the bankfull elevation and top of the high bank. A composite of green ash, hackberry, plum and silver leaf maple were planted across the sloped upper bank and into the adjacent field or high terrace. These measures should ensure long-term vitality of an extensive riparian buffer zone.

Willow plantings were integrated along the bankfull bench. Water table elevations necessary for willow success should occur relatively near the dorsal surface of the bankfull bench (within three feet) during base flows. Shading from established and overhanging willows will minimize summertime stream temperatures and increase production of invertebrates. Also, the root fiber network will increase the bank's armorment and resistance to erosion.

Wetland Development

An existing wetland feature occurring adjacent to the active channel was enlarged and deepened. Additionally, a remnant channel was reconnected for wetland and backwater habitat near the limestone bluff, located on the right descending floodplain perimeter (**Figure 8**). Highly permeable gravel lenses accommodate filling of disconnected wetlands during low flow periods. Reinforced floodplain plugs increase stability of these features. Lastly the uppermost J-hook vane was positioned to preserve a small wetland feature occurring upstream of the study reach.

Figure 8: Image of newly constructed wetland

Spoils Placement

Spoils excavated from the newly constructed channel were used in construction of the bankfull bench situated along the vertically eroding bank. Materials excavated from the wetlands were used for construction of floodplain plugs. Additional materials were spread on adjacent benches.

Evaluation of Success

Three J-hook vanes and one cross vane were installed. As indicated in the restoration plan, woody elements were incorporated into the reach when possible to increase mesohabitat diversity. This included a bank oriented rootwad installed immediately above the cross vane and incorporation of rootwads into two of the J-hook vanes. Project construction was completed in March 2006 when the riparian component of the project was installed.

Approximately 1200 trees were planted in the project riparian area including willows, green ash, hackberry, plum and silver leaf maple. As they mature, this plant community will promote long-term stability of near bank stream regions via tensile resistance, enhance habitat, provide shading and buffer local overland flow and associated nutrient inputs. In addition, erosion control matting, rye and Bermuda grass seed and fertilizer were spread across bare soil regions to promote rapid stabilization of the topsoil strata.

Immediately following completion of the restoration project, a Level II morphological survey was repeated. Following is a discussion of important comparative metrics:

Profile/Slope:

Channel slope was assessed with longitudinal profiles (**Figures 9** and **10**). Hydraulic slope was reduced from approximately .0055 to .0040, more typical of stable reference conditions (.0020 to .0038), by installing a cross-vane at the terminal end of the project reach. Further, a bankfull bench was constructed along the vertically eroding bank at a longitudinal slope of .0030. The energy gradient (.040) of the stream will likely evolve towards the bankfull slope (.030) as sediment transport is performed and the reach finds equilibrium in its restored condition. The stable energy gradient should be maintained because of: 1) downstream structural control via the cross vane; 2) upstream structural control via a rock sill installed at grade in association with the upper-most J-hook vane; and 3) proper energy distribution and sediment transport attributed to re-establishment of a stable pattern, dimension and profile.

Figure 9: Pre-restoration longitudinal profile

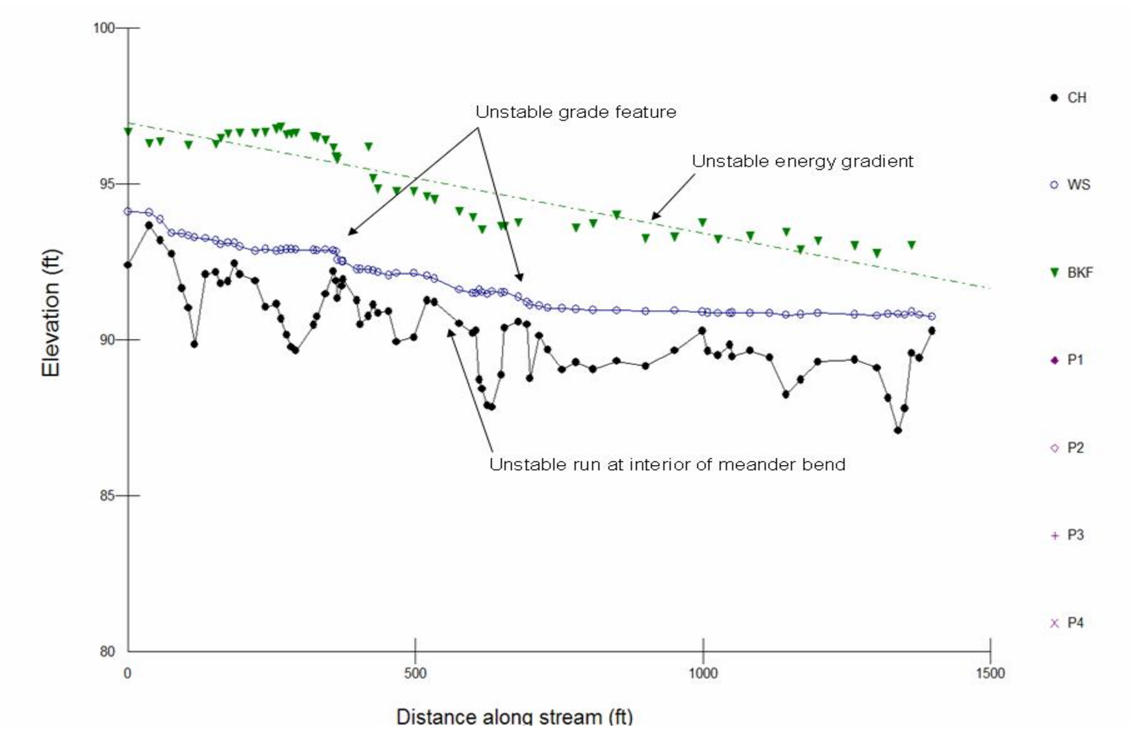
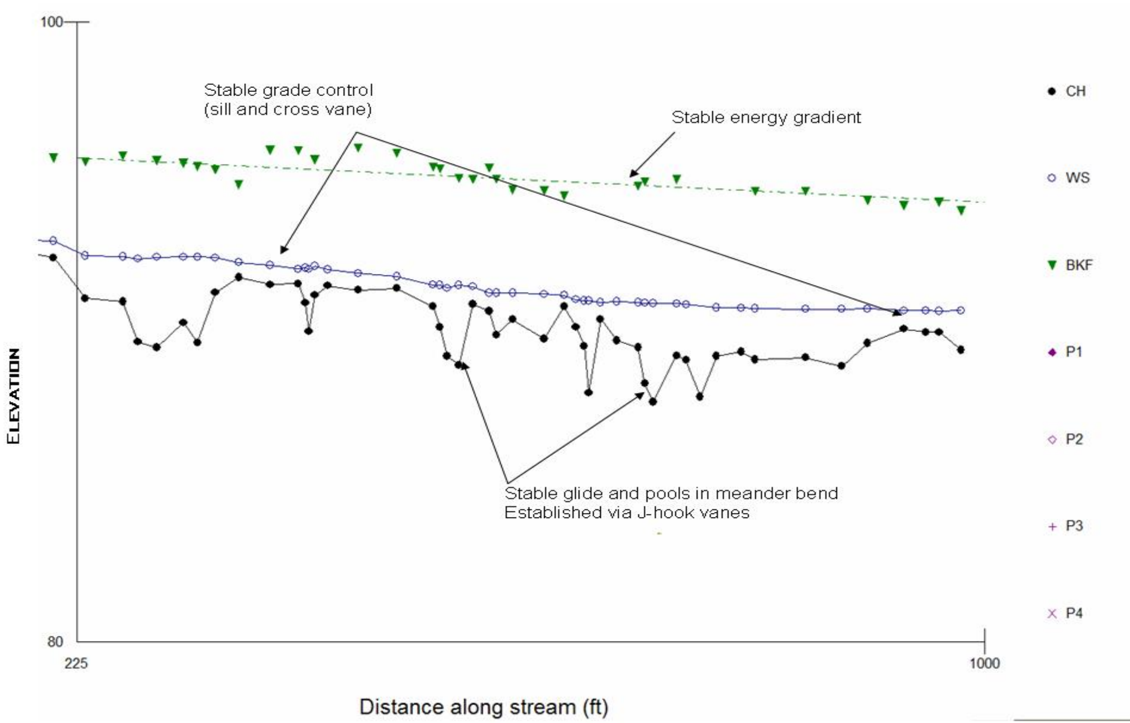


Figure 10: Post-restoration longitudinal profile



<u>Channel dimension:</u>

Six cross-sections were measured to quantify changes following restoration. Two representative cross-sections depicting pre- and post-restoration conditions (**Figures 11** and **12)** are presented below. It is important to note the constructed bankfull bench (post-restoration cross section; **Figure 12**) which improves dissipation of near bank shear stress.

=**Figure 11: Pre-restoration cross-section (typical)**

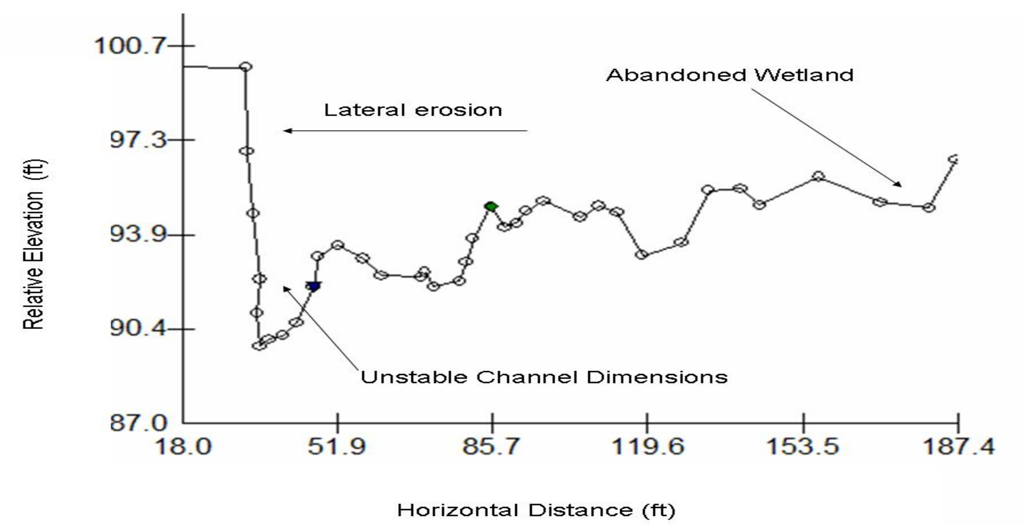
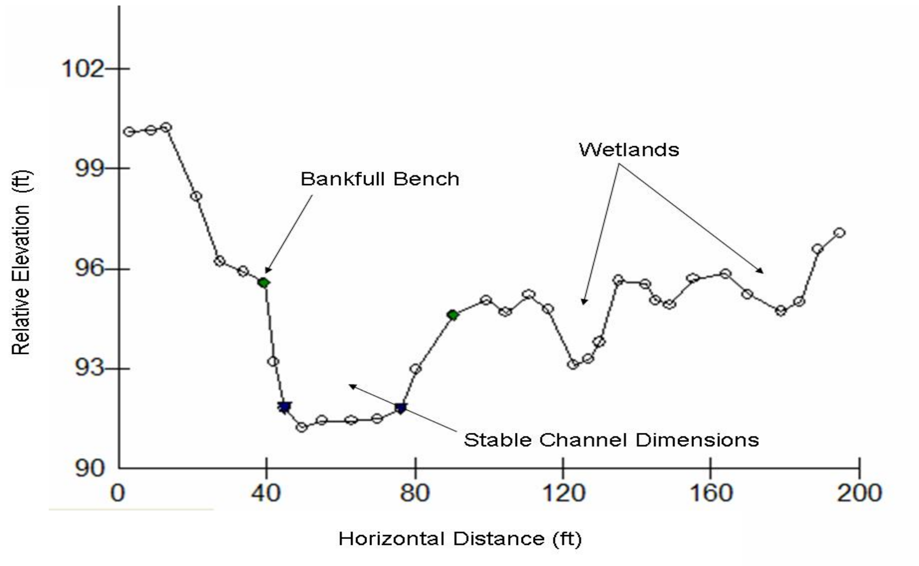


Figure 12: Post-restoration cross-section (typical)



A table showing cross-sectional metrics (**Table 1**) is presented below. Cross-sectional area was relatively unaffected by the restoration initiative. Mean depth of the reach increased by 0.32 feet. A significant reduction in width to depth ratio (7.45) occurred. The entrenchment ratio was improved (the larger the entrenchment ratio the lower the entrenchment of the reach).

Table 1: Cross-section metrics (pre- vs. post-construction)

	AREA		MEAN DEPTH		W/D RATIO		ENTREN. RATIO	
	PRE	POST	PRE	POST	PRE	POST	PRE	POST
XS1	94.6	96.1	1.56	1.58	38.9	34.8	2.9	3.28
XS2	145.4	144.1	1.9	2.4	40.7	25.2	2.3	3.2
XS3	138.3	121.4	2.2	2.5	27.6	20.2	2.8	3.5
XS4	99.3	127.3	1.8	3.0	31.8	14.5	2.5	3.6
XS5	168.6	158.1	2.69	3.08	23.3	16.7	3.4	4
XS6	159.2	145	2.8	2.3	20.9	27.1	2.6	1.9
Mean ▲	-2.23		+0.32		-7.45		+.50	

Bank stability

Using RiverMorph, near bank shear stress values were predicted for the pre- and post-restoration channel. Unstable channel pattern, dimension and profile (manifested in a vertically eroding bank) produced excessive shear stress and average channel velocity values in the pre-restoration condition (blue line, **Figures 13** and **14**). Re-establishment of reference conditions decreased shear stress and velocity predictions (pink line; **Figures 13** and **14**) thus increasing channel stability.

Figure 13: Mean channel velocity (pre- vs. post-construction)

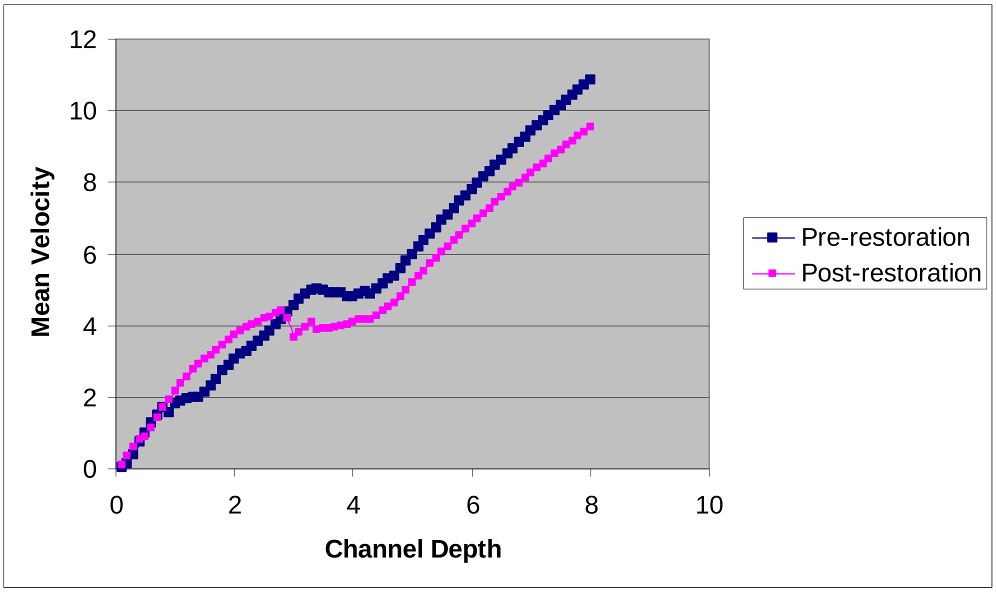
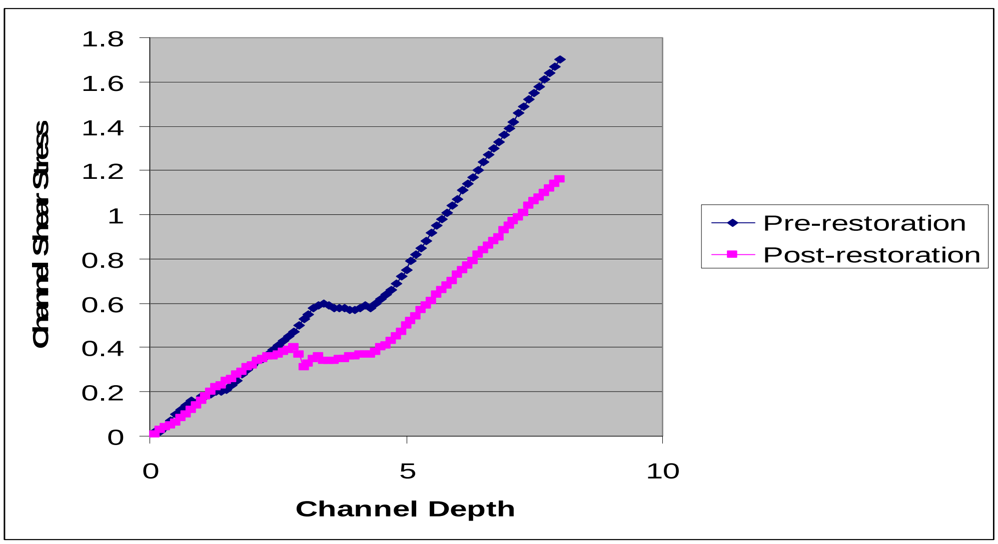
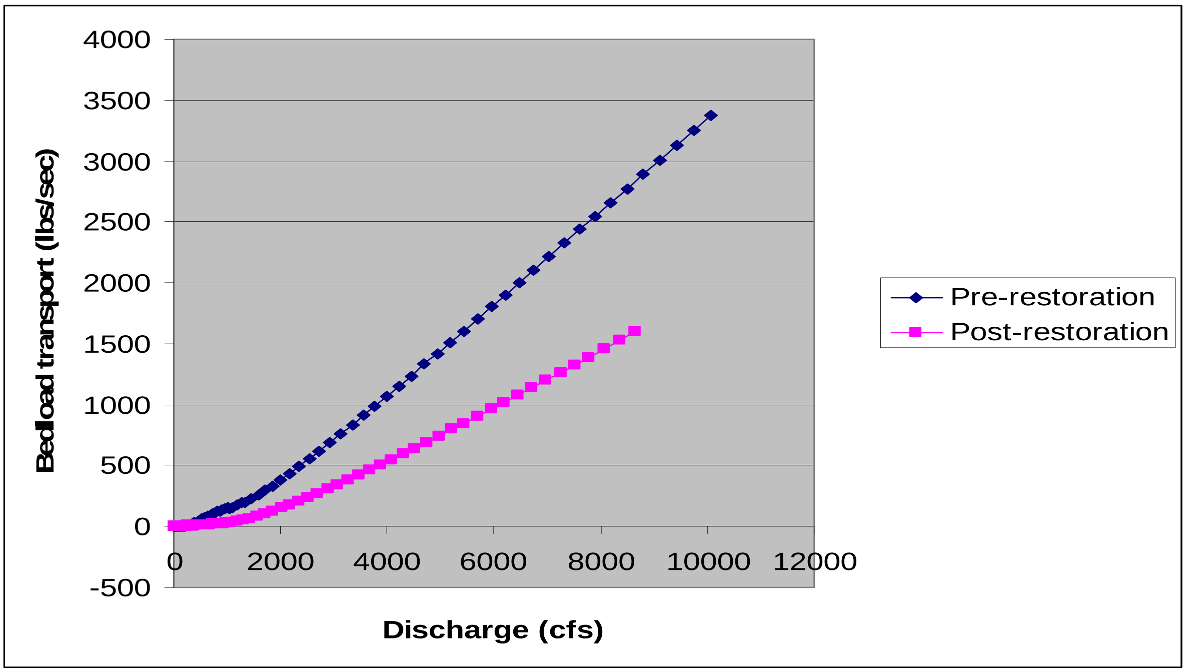


Figure 14: Channel shear stress (pre- vs. post-construction)



Estimations of local bedload transport in the pre-restoration channel demonstrate the unstable characteristics which exist between high energy and bedload transport. Excessive bedload transport rates are a product of the unstable energy conditions at the restoration site. Bedload transport rates (**Figure 15**) should be reduced in the new channel as the energy gradient has been stabilized both longitudinally and cross-sectionally.

Figure 15: Predicted bedload transport (pre- vs. post-construction)



Summary

A 400-foot reach of Honey Creek was successfully restored using applied fluvial geomorphology techniques. Since project completion the largest daily mean discharge at the site was 238-cfs. Some beneficial scouring associated with this event occurred near stabilization structures. Slight channel adjustments will likely continue during the first few significant flow events. Introduced vegetation has become well established. Both wetlands remain connected as extensive backwater habitat. Ultimately, increases in wetlands habitat, improved conditions for biota, reduced property loss and enhanced local flow and sediment regimes resulted from this initiative.

Phase II

ODWC Deliverables to OCC

ODWC will provide the following to OCC through execution of the Phase II cooperative partnership:

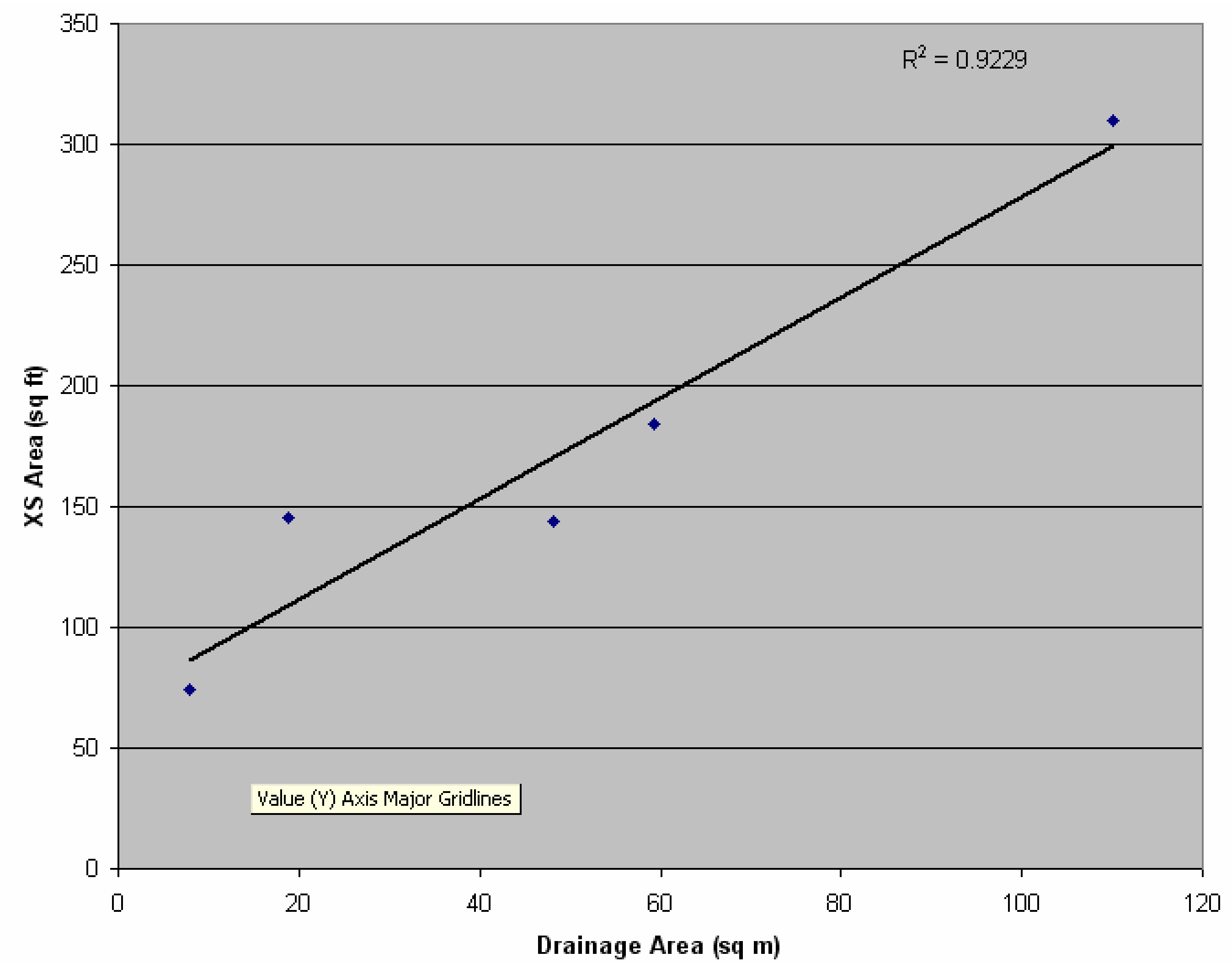
- Pre-monitoring morphological assessment of restoration site with total station.
- Design of restoration plan using 3D data and AutoCAD software.
- Presentation of restoration plan to OCC prior to implementation.
- Management of permitting process.
- Project supervision throughout all phases of construction.
- Provision of equipment, operators and materials necessary to complete project.
- Post-monitoring morphological assessment of the restoration site.
- Final report (hard and digital copies).

Regional Curve Development

Accurate identification of bankfull stage is critical to all restoration efforts. Physical features used to identify bankfull in the field such as point bars, lichen lines and vegetation are not always obvious and occasionally can misrepresent bankfull. Regional curves enable accurate identification of bankfull elevation. Bankfull floods have recurrence intervals between one and two years. Gauging sites provide historical records of discharge and their frequency. By determining bankfull discharge at gage sites and subsequent calculation of bankfull metrics, regional curves can be developed. Regional curves are plots of drainage area (known at gage sites) against bankfull metrics of width, depth, cross-sectional area and velocity. Curves are developed after several data points, each from different gauging stations, are graphed.

Data were collected from five gage stations to enhance existing regional hydrology data (Dutnell 2000). Figure 16 depicts the regional curve, for cross-sectional area, from the smaller drainages.

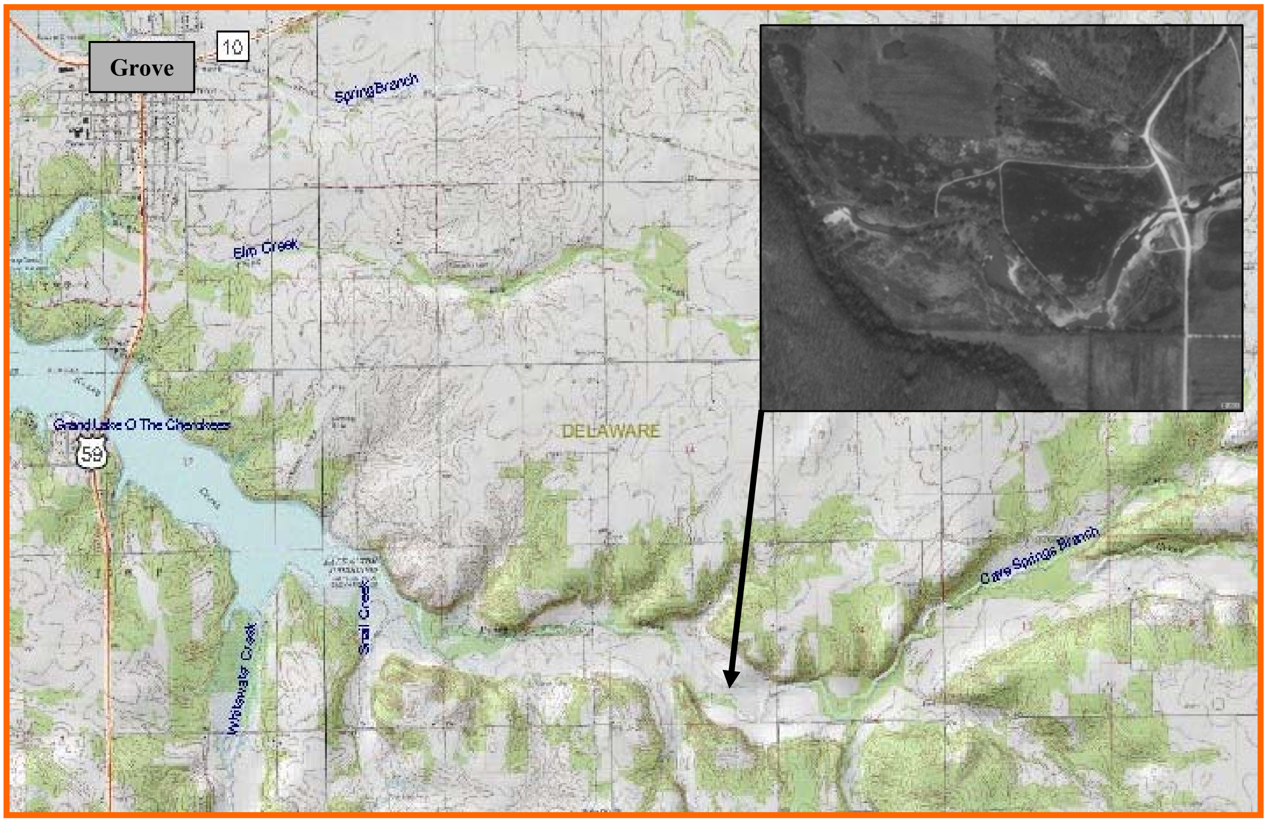
Figure 16: Enhanced regional curve (drainage area vs. cross-sectional area)



Project Site Description

The project area is an approximately 3200-foot long reach of Honey Creek located in Delaware County (SE1/4 of S23, T24N, R24E; **Figure 1**) near Grove, Oklahoma owned by Bill Berry. The area is characteristic of a slowly rebuilding C stream type, and occurs inside a relic F channel, with slight entrenchment, meandering pattern and a riffle/pool sequence. Floodplain development is moderate to low. Channel morphology consists of a relatively low gradient (range = 0.001 to 0.005) and the gravel dominated substrate includes a significant burden of fine-grained particles causing localized encumberedness. Approximately one-half of the site-length occurs in the valley type VIII (wide, gentle valley slope with extensive floodplain) but resembles type VI (limestone bluff structural controls) in the remaining length (Rosgen 1996).

Figure 17: Phase II restoration site



Watershed and Hydrology

The Honey Creek watershed is relatively healthy (Fisch 2003) inferring even greater importance for restoration initiatives. Influences on the overall physical stability of the stream likely include road crossings, gravel mining and land management practices. Grand Lake, of which Honey Creek is an inflowing tributary, appears to have no morphological influence on the study area. Bankfull cross-sectional area is projected to be 177.3 square feet from the regional curve.

Overview of Problem

The project site is experiencing accelerated lateral migration inferring significant channel instability. A vertical bank of 6 to 7-feet in height is contributing excessive erosional materials to the stream. Much of this material consists of fine-grained particles which fill interstitial substrate space causing emburcation of otherwise mobile bed materials and channel aggradation. The negative consequences of these processes are well documented and include reduced biodiversity, disruption of food web mechanics, poor fish and insect reproduction, reduced year-class success and diminished water quality.

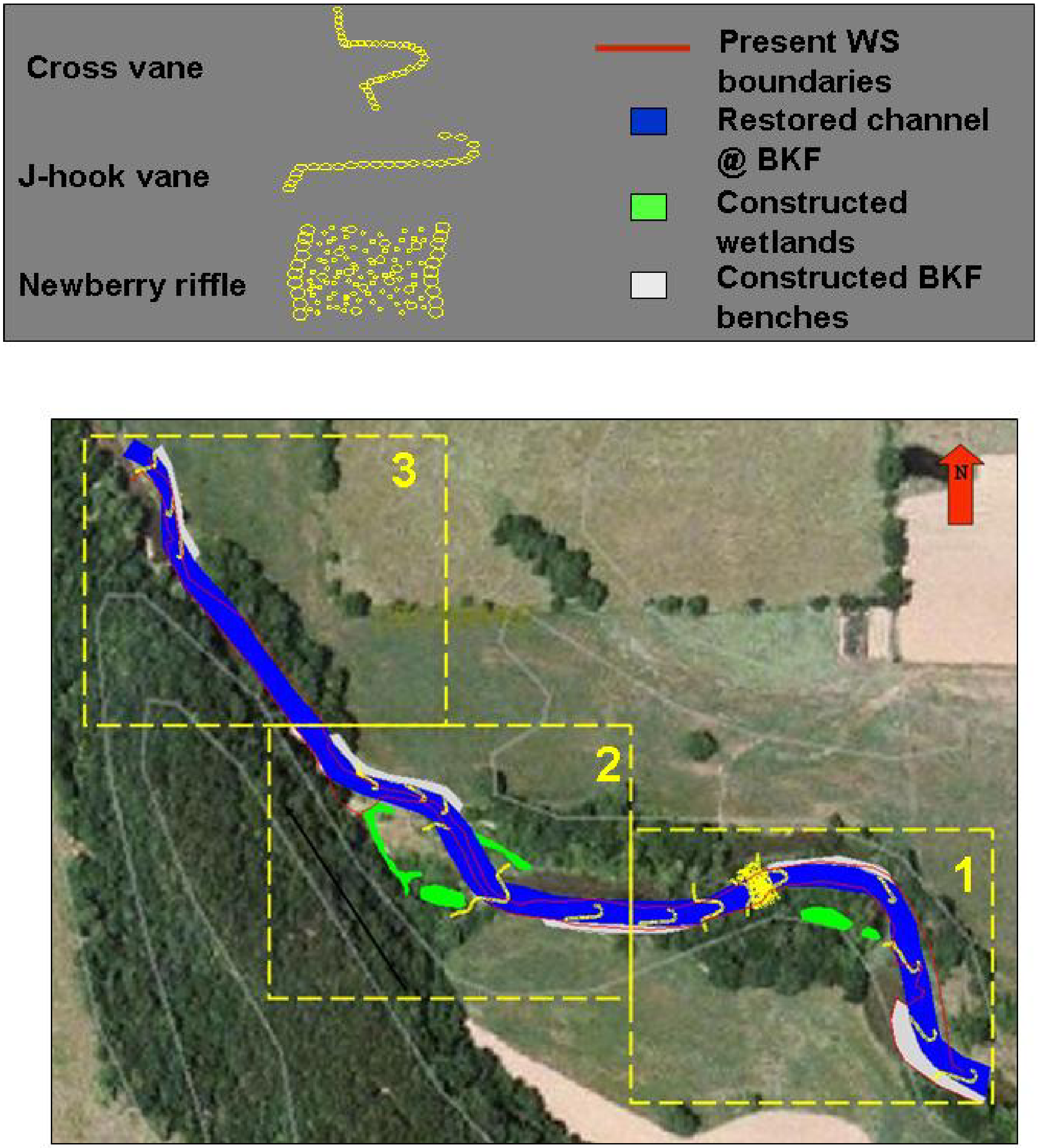
This reach is likely to make exponential increases in sediment contributions to the Honey Creek system as the radius of curvature continues to decrease. This trend in curvature tightening, which further increases near-bank shear and subsequent erosion, will probably continue until the meander evulses. Impacts from this scenario may include loss of adjacent lands and significantly higher sediment contributions to the stream. Ultimately, the physical complications in this reach will limit its overall biological productivity, hydrology and sediment transport regimes. Completion of the proposed restoration endeavors will circumvent these consequences and improve the stability of the study and adjacent downstream reach.

A gravel mining operation, active upstream, is of significant regard to the restoration endeavor. The success of such restoration initiatives relies, in part, upon balancing a reach's sediment budget. Gravel mining alters this sediment regime directly by removal and indirectly by altering of the channel's configuration.

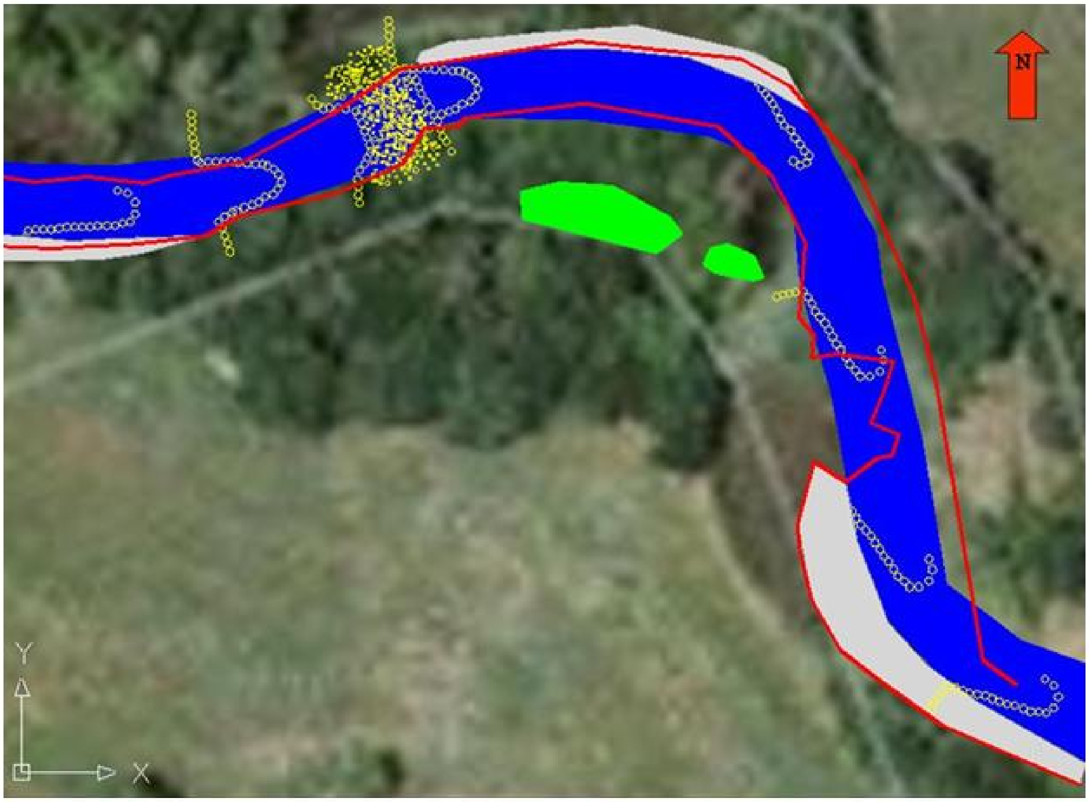
Overview of Solution

Enhanced in-stream habitat, sediment transport, biological productivity and stability of the disturbed reach will be achieved using applied fluvial geomorphology techniques. **Figure 18** depicts the general location of stabilization structures and the constructed bankfull benches. The following portion of the plan includes a discussion of each restoration component.

Figure 18: Plan overview with features key (exploded views in figures 19, 20 and 21)



Figures 19 and 20: Plan overviews (exploded views: 1 and 2)



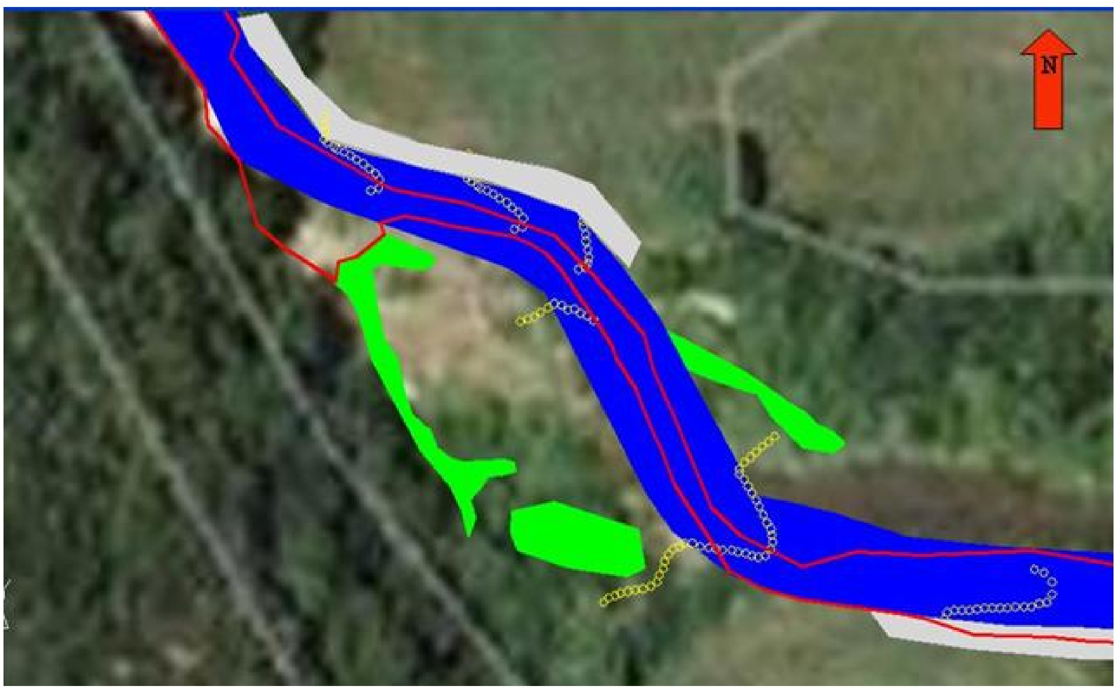
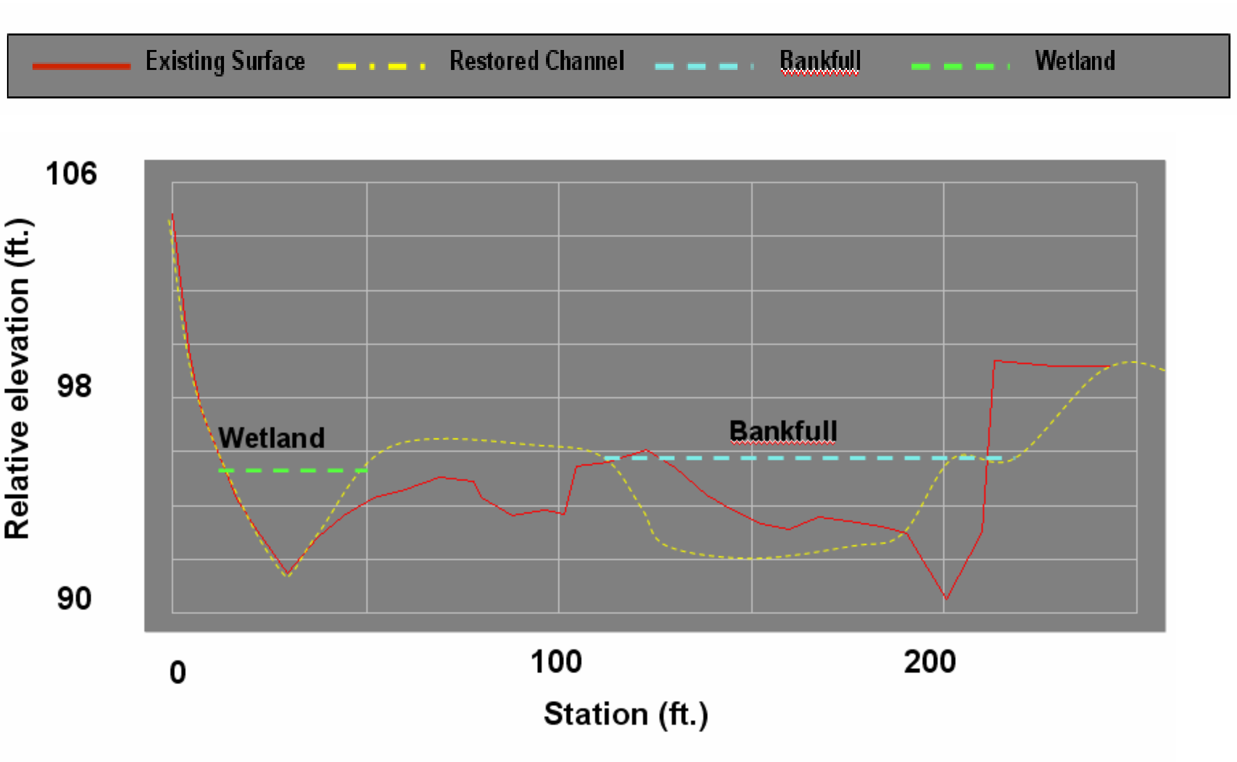


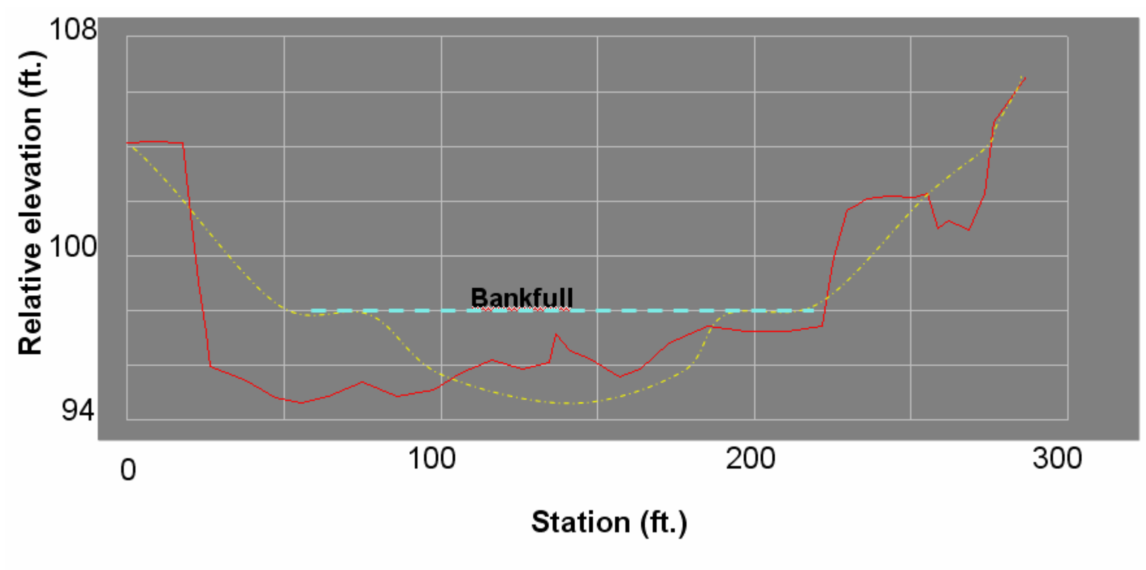
Figure 21: Plan overview (exploded view: 3)

Channel Dimensions

Improved width/depth relationships will be achieved with channel shaping techniques and maintained with hard structural control. A bankfull width of 60- 70 feet will be targeted. This represents a slight reduction in width relative to upstream and downstream conditions where some local channel adjustments may have occurred. We intend to error slightly on the side of a reduced width/depth ratio which is a common restorative technique. The benefit of this practice is that the stream can more easily adjust its boundaries laterally rather than trying to transport its sediment load in a higher width/depth ratio channel. Sediment transport in the less desirable wide and shallow condition usually results in bed aggradation and increased lateral erosion.

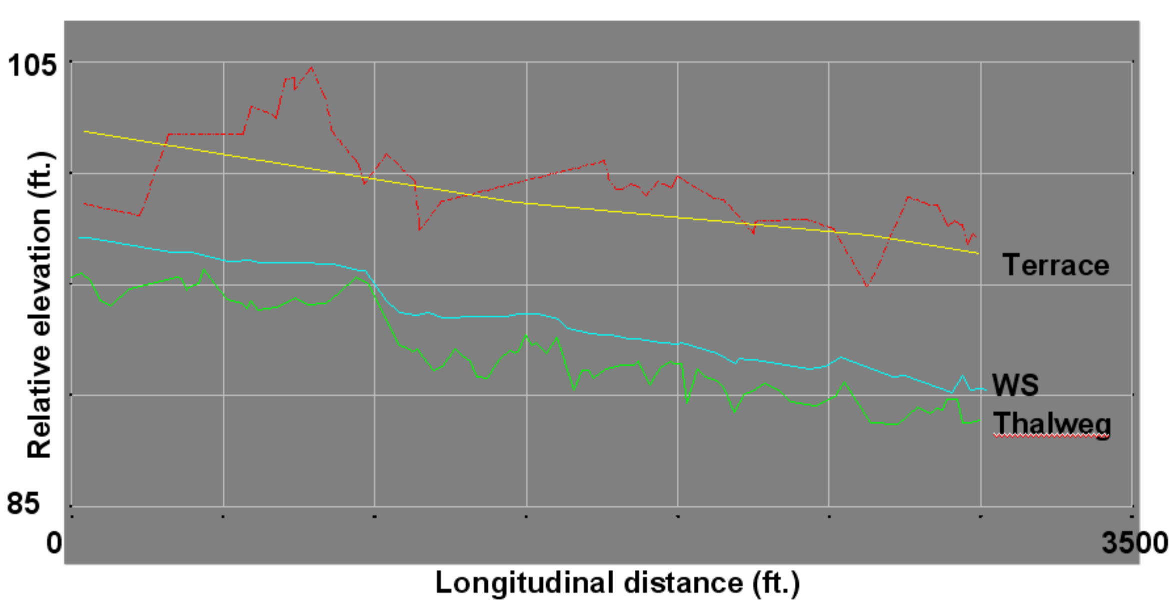
Figures 22 and 23: Cross-sectional survey results with new channel configuration





An average longitudinal water surface slope of 0.003 will be targeted. The facet slopes of individual mesohabitat features will obviously vary with riffles and runs providing steeper gradients and pools and glides flatter slopes. Additional structural controls will be used to establish target gradients. **Figure 24** depicts the longitudinal survey generated from the total station survey.

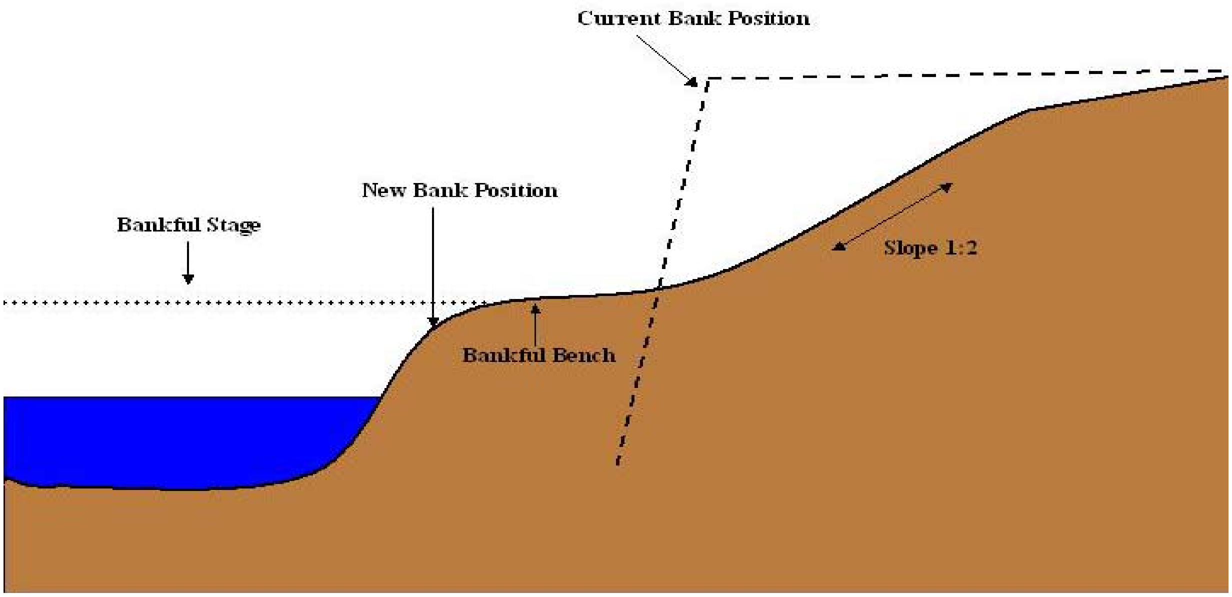
Figures 24: Longitudinal profile survey



<u>Bankfull Bench</u>

A bankfull bench, or floodplain, will be constructed where presently absent. While the distance between the bench and present left bank will vary, depending on target meander geometry, the average distance will be 10 to 40-feet. The vertical bank, stabilized at lower portions by the bankfull bench, will be returned to a target 1:2 ratio slope. **Figure 25** depicts post-restoration condition of the bankfull bench and upper bank slope.

Figure 25: Bank slope and bankfull bench



Physical Stabilization

Hard structures constructed from natural materials will be used for grade control, bank stabilization and in-stream habitat improvement for fish. Approximately ten J-hook vanes, four cross-vanes and a modified Newberry riffle will improve mesohabitat diversity as they perform the primary function of appropriate energy gradient maintenance. All vanes will be constructed of large boulders (> 30" diameter) and root wads or logs will be integrated into the structures when possible. J-hook vanes will possess an interior angle of 20 to 30-degrees. The hook and distal (upstream) portions of the vane will have a surface elevation at 10-percent of bankfull stage and then extend to the proximal end at a cross-sectional (bank to streambed) slope of 2 to 7-degrees. The proximal end will have its origin at or near the bankfull elevation. The cross vein construction metrics will approximate that of the J-hook design on either side. Newberry riffles are designed to mimic stable riffle characteristics located in a reference reach. Plans exist to evaluate the biological response of these structures to this project.

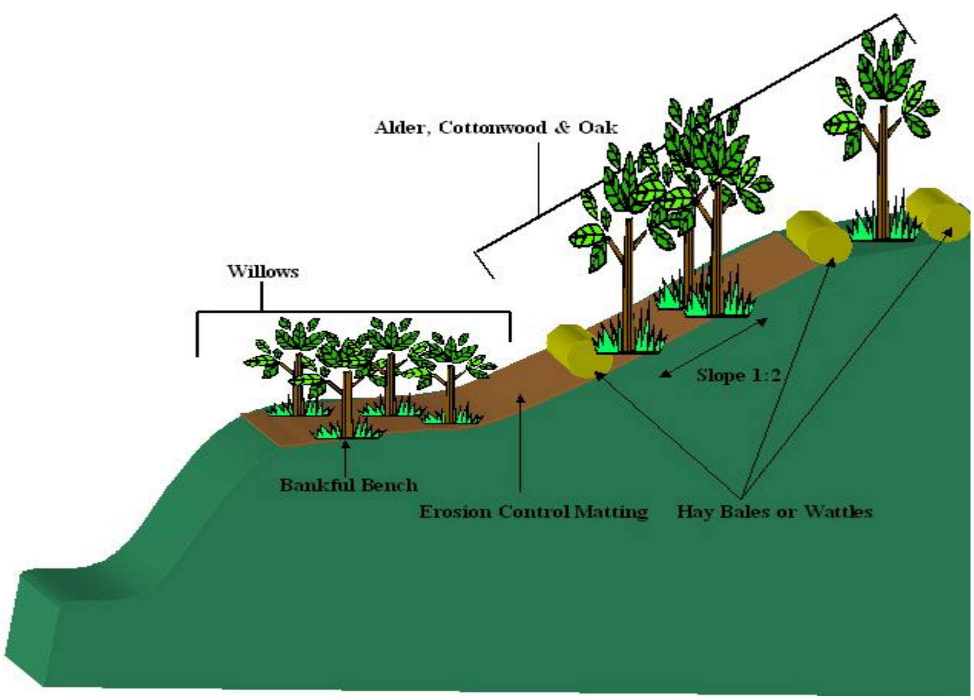
Vegetative Stabilization

Bioengineering techniques using native vegetation will be used to further insure project success. Vegetation in the adjacent reach will serve as a guide for restoration of the riparian zone. Coconut fiber erosion control matting will be installed across the upper barren slope along sensitive bank regions. Plantings will be inserted through the matting to facilitate their stability to maturity.

Willow plantings will be established across the bankfull bench. Water table elevations here should be relatively near the dorsal surface of the bankfull bench during basal flows (within three feet). Shading from overhanging willows will minimize summertime stream warming and increase production of invertebrates. Also, the root fiber network will increase the bank's armorment and resistance to erosion.

A transitional hardwood mix will be established in the transitional zone between bankfull elevation and top of the high bank. These measures should ensure long-term vitality of an extensive riparian buffer zone. **Figure 26** depicts the general plan for re-vegetation of the riparian zone. Watering of the young plants coupled with initial fertilization will be essential to the success of the vegetative stabilization component of the project.

Figure 26: Vegetation profile



Wetland Development

Wetlands that mimic the flood plain's natural features will be constructed where possible along the project. Some will serve as backwater habitat connected to the main stem in base flow while others will be connected only in high flow events. Morphological surveys will be used to establish reference conditions from existing wetland features and then replicated at the project site. Highly permeable gravel lenses will accommodate filling of disconnected wetlands during lower flow periods. Reinforced floodplain plugs will increase stability of these features.

Spoils Placement

Spoils excavated from the newly constructed channel will be used in construction of the bankfull bench along the vertically eroding bank. Material excavated in construction of the wetlands will be used in constructing the floodplain plugs

Restoration Implementation Phases

1. Site preparation and setup including layout and marking of planned channel location and hard structure placement.
2. Excavation of realigned channel.
3. Construction of bankfull benches.
4. Upper bank development (sloping to 1:2).
5. Wetlands excavation and construction.
6. Construction of J-hook and cross vanes.
7. Installation of erosion control matting.
8. Planting, fertilizing and watering of vegetation.
9. Site cleanup.

Summary

A 3200-foot reach of Honey Creek will be restored using applied fluvial geomorphology techniques. Extensive geomorphic and hydraulic data have been collected from the site regional USGS gages and processed with computer models to aid development of the restoration plan. Treatment - response scenarios show significant physical and biological benefits from completion of the proposed actions. The finished project will increase the abundance of wetlands habitat, improve living conditions for biota, reduce property loss and improve local flow and sediment regimes.

Literature Cited

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Appendix A

Phase I

Project Images

Appendix B

Phase II

Bill Berry Site