FINAL REPORT

Dry Gulch Stream Restoration

Biological and Agricultural Engineering Department
North Carolina State University
Raleigh, North Carolina

Town of Carrboro
Carrboro, North Carolina

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Introduction

Faculty, staff, and students associated with the North Carolina State University (NCSU) Department of Biological and Agricultural Engineering worked with the Town of Carrboro (Town) to implement watershed restoration practices and water quality monitoring as a component of an EPA 319 project in the Bolin Creek Watershed. The purpose was to improve ecosystem health and water quality by restoring natural stream functions and implementing stormwater best management practices (BMPs) demonstration sites to treat runoff in degraded areas in the watershed. This report outlines Task 2 of the approved scope of work between NCSU and the Town: Dry Gulch stream restoration.

Background

Natural stream functions in many areas of North Carolina are threatened by historical and ongoing alterations in watershed hydrology and land use, resulting in unstable streams with poor habitat and water quality. Causes of degradation include channelization, sediment inundation, stormwater runoff, road crossings, and loss of riparian vegetation.

The project site is located along Dry Gulch, which is an unnamed tributary to Bolin Creek. The area is primarily wooded and is situated in a residential area between Hanna Street and Bolin Creek Drive. The Dry Gulch reach had the following problems prior to restoration:

- Streambank erosion:
    - Channel cutting into adjacent hillslope resulting in significant sediment loss
    - Channel cutting into adjacent sewer line
- Poor riparian vegetation
- Poor instream habitat due to sediment and plain bedform
- Channel incised and over-wide
- Unstable sewer easement crossing
- Eroding stormwater outfall from adjacent development
- Poor water quality

Based on field evaluation of bank erodiblity, it was estimated that the streambanks from this reach were contributing 21 tons of sediment per year directly to the stream. NCSU was contracted to design and manage a stream restoration project along the Dry Gulch reach.

Stream restoration can be defined as the application of engineering, geologic, and biological principles to improve hydrological and biological functions of the stream corridor. Components of a successful stream restoration project may include:

1. adjusting the stream channel size and shape;
2. establishing a hydrological connection between the channel and floodplain;
3. adding in-stream structures for stability and habitat enhancement;
4. stabilizing streambanks by regrading and/or establishing native vegetation; and
5. establishing a forested riparian corridor.

The natural channel design approach makes use of reference stream morphology and biology information to devise a comprehensive project aimed at restoring and maintaining natural stream functions over the long term. The purpose of this project was to design and implement a natural channel design project to achieve the highest water quality and habitat potential for Dry Gulch, while providing opportunities for ongoing education, training, and research.

Project Summary

Approximately 460 linear feet of degraded stream in Dry Gulch were restored using natural stream channel design and construction techniques, including channel realignment, floodplain grading, in-stream boulder structures, and planting native riparian vegetation. Additionally, an eroding sewer easement crossing was stabilized with an improved ford and an eroding stormwater outfall was stabilized. Project design and permitting occurred in 2011 and 2012, with construction by North State Environmental, Inc. during April 2012. Permanent riparian vegetation was planted in December 2012. Specific project components included:

Permitting

Preconstruction notification was provided to North Carolina Department of Environmental and Natural Resources and U.S. Army Corps of Engineers regulatory staff, and permits received in compliance with federal and state (401/404 and Jordan buffer rules) requirements. This permitting included written approval from affected landowners. With regard to requirements to avoid or minimize impacts, the stream stabilization project was designed to create floodplain access, reduce future channel erosion, and improve aquatic habitat at the project site and downstream as further described in this report. The permit included, at a minimum, level 3 monitoring, as described in the Army Corps Stream Mitigation Guidelines. Additionally, a total station as-built survey with permanent cross sections and longitudinal profile was completed to provide a baseline for surveys in subsequent monitoring years. Avoidance and minimization measures included pursuing construction in dry periods to the maximum extent possible, and stabilizing disturbed areas by the end of each day. Sediment and erosion control measures were implemented. Significant mature trees were protected where feasible. A project engineer was onsite to oversee construction to make sure the contractor followed these directions.

Channel relocation

Approximately 150 feet of channel was relocated away from an eroding hillslope and sewer easement. A new channel was constructed, the gravel and cobble bed material was transferred from the old channel, then flow was turned into the new channel. The old channel adjacent to the eroding hillslope was filled in and stabilized. (Photographs 1 - 4).


Photograph 1. Eroding hillslope before construction.


Photograph 2: Old channel filled in and eroding hillslope stabilized


Photograph 3: New channel constructed


Photograph 4: View of new channel facing downstream

Biodegradeable matting, seed, and straw

A biodegradeable matting (coir) made from coconut fibers was installed along all graded streambanks throughout the project area. The matting was secured with wooden stakes. Temporary and permanent native riparian seed and straw mulch were placed under the matting. The matting provides short term bank erosion protection while the riparian vegetation gets established (photographs 4 and 5)


Photograph 5: View of matting after a bankfull event a few weeks after construction

Boulder sills and j-hook vanes

Boulder sill structures were constructed in the channel to provide grade control, create bedform diversity, and help maintain pool scour. J-hook boulder vanes were constructed to direct flow away from streambanks while providing grade control and maintaining scour pools (Photograph 6)

Photograph 6: J-hook boulder structure

Floodplain benches

Floodplain benches were graded adjacent to the channel in incised areas. Floodplain benches allow flood flows to spread out on a floodplain to dissipate energy and minimize erosion (Photograph 7).

Photograph 7: View of floodplain benches after a bankfull event

Sewer easement crossing

An improved ford was installed at the upstream extent of the project along an eroding sewer easement crossing. The steep and eroding banks were graded to a stable 5:1 side slope and the channel bed was stabilized with a boulder sill and a mix of Class A and Class B stone (Photographs 8 and 9).

Photograph 8: Eroding sewer crossing before construction

Photograph 9: Stabilized sewer easement crossing

Native riparian planting

In December 2012, NCSU staff, Town staff, and about a dozen volunteers installed native riparian plants along the project reach (photographs 10 & 11). The following species were planted: <u>Live Stakes:</u> Silky dogwood, Elderberry, Black willow. <u>Container Plants:</u> Tag alder, River birch, Witch hazel, Sycamore, Swamp chestnut oak, Arrow wood, Dwarf azalea. <u>Plugs:</u> Soft rush, River oats, Cardinal flower.

Plant survival will be monitored over the next couple of growing seasons and replanting will occur as needed

Photograph 10: Plant installation

Photograph 11: Plant installation

<u>Project Monitoring</u>

A Quality Assurance Project Plan (QAPP) was developed and approved to guide monitoring efforts (Exhbit 1). Benthic preconstruction monitoring was conducted by Dave Lenat (Lenat, 2009). Water quality monitoring was limited to preconstruction base flow and storm flow suspended sediment and nutrient grab samples. There was not sufficient time in the project to collect enough post-contruction samples for a valid comparison. In addition, it was beyond the resources available and scope to use an automated sampler. The pre-construction data can be used as a baseline for comparison to future post-construction monitoring efforts. The project team determined that the most useful approach to evaluating demonstrable improvements from the restoration efforts during the project period was therefore to focus on measures of channel stability and morphology rather than water quality.

Exhibit 1: Dry Gulch QAPP Excerpt

For Dry Gulch, water quality monitoring will include baseflow and stormflow grab samples for suspended sediment and nutrients. Annual monitoring will include cross-section and longitudinal surveys, evaluation of vegetation survivorship, pebble counts, bank erosion hazard index (BEHI) measurements, and instream morphology. The primary reason for this monitoring will be to demonstrate measurable improvement in this subwatershed. Chemical, hydrological, biological, and morphological conditions before restoration will be compared to conditions after restoration. The primary aims of monitoring are to detect changes in streambank erosion and reductions in export of nitrogen, phosphorus, and suspended sediment. While we would like to observe an improved biological community as a result of changes in morphology, hydrology, and chemistry, sampling of benthic macroinvertebrates for one or two years after construction may be insufficient to detect changes in the community, as it can take well over 5 years for the community to respond to changes in chemistry, flow, or habitat. However, samples taken as part of this project can be compared to samples taken in 5 years or more to detect changes in the macroinvertebrate community. As an intermittent stream, the Dry Gulch watershed size is also marginal for adequate use of benthos as a strong indicator.

Channel stability and morphology was evaluated in a manner that allows for replication and comparison in future years. Preconstruction data and asbuilt data (collected in May 2012) was compared to that collected in November 2012. During the period between construction and post construction measurement, several significant storm events (including a 50 year storm in early September) occurred and tested the channel stability. The channel stability and morphology evaluation included the following items. The data is included as Appendix A of this report.

Pattern and Profile

A three-dimensional survey was conducted at the project site. This survey included the collection of location and elevation data for point features of interest. Such points included:

-thalweg features (heads of riffle, run, pool, glide, and max pool)

- top of bank

-permanent cross-sections

This three-dimensional data allows for visualization of the stream in plan view (to evaluate pattern changes over time) and as a longitudinal profile (to evaluate bedform changes over time).

The planform does not show significant changes from the asbuilt condition. The November thalweg measurement shifted slightly to the left between Stations 2+25 to 2+65 when compared to the asbuilt position. The two j-hook structures in this location should keep the stress off of the left bank.

The longitudinal profile also does not show significant changes from the asbuilt condition. Some minor bed scour occurred at the upstream portion of the reach and below a bedrock riffle in the middle portion of the reach. Minor bed adjustments are expected in natural stream systems. Additionally, the boulder step structures are designed to maintain and scour out the pools.

Cross-sections

Two permanent cross-sections were installed at the site. These allow for the measurement of channel dimension changes over time at the project site. Cross-section 1 is located at a riffle and cross-section 2 is located at a pool within the reach.

The area, width, and depth of both cross sections increased from the asbuilt survey to the November survey. Some channel dimension adjustment is expected in the short term after construction. The cross sections should stabilize once permanent vegetation becomes established. Streambank slopes remained stable and no erosion was observed in the field along the cross sections.

BEHI / Near Bank Stress

The Near Bank Stress (NBS) and Bank Erosion Hazard Index (BEHI) were determined throughout the project reach in order to assess bank stability. Both the NBS and BEHI were determined in accordance with methods developed by Dave Rosgen (Rosgen 2001).

The NBS was designated as Low, Moderate, High, Very High, or Extreme; based on the relative position of the thalweg to the streambank and the radius of curvature. The BEHI was designated as Very Low, Low, Moderate, High, Very High, or Extreme; based on a composition of the bank height ratio, bank angle, relative root depth, root density, surface protection, and bank material.

For all observed combinations of BEHI and NBS, a bank erosion rate was predicted using relationships by the NRCS for North Carolina. A total volume (cubic yards per year) and mass (tons per year) of streambank erosion were estimated for the entire project reach.

Before construction, BEHI values ranged from very low (bedrock) to extreme (eroding hillslope). The resulting estimated annual erosion from the project reach was 16 cubic yards or 21 tons. After construction, BEHI values ranged from very low to moderate. The resulting estimated annual erosion was 2 cubic yards or 2.7 tons. This represents an almost 90 percent reduction in erosion per year. Additionally, the BEHI values should continue to improve (i.e., less expected erosion) as the permanent riparian vegetation establishes.

Educational Component

The project team integrated educational activities on an ongoing basis, and put elements in place to facilitate future educational opportunities. Major educational components are outlined below.

- Town staff provided a public presentation on the project at a Board of Aldermen meeting (June 2011; http://www.townofcarrboro.org/BoA/Agendas/2011/06_21_2011.htm [item 2]) and at a well attended symposium on creek stewardship at the North Carolina Botanical Gardens (February, 2012; http://bolincreek.org/blog/symposium-2/presentations/).
- The Friends of Bolin Creek and Town and NCSU staff organized a tour of watershed friendly sites (April,2011) and included the Dry Gulch site on the tour
- Several site tours (pre, during, and post construction) were held with Town staff, landowners, neighbors, and the general public. Signage was installed referring visitors to Town staff.
- NCSU created an 11x17 poster summarizing the project components that is being distributed electronically to a diverse audience, and will also be available during future site tours (Appendix B)
- Pre and post-construction site visits were held with OWASA staff.
- A workday was held on planting and maintenance and attended by NCSU and Town staff, landowners, Boy Scouts, and other interested parties and neighbors.

Project Timeline

April 2011: Site topographic survey
May – September 2011: Stream restoration design, review, and permitting
November 2011: 401/404 permits obtained
March 2012: Construction contract bid and award to North State Environmental, Inc
April 2011: Dry Gulch construction completed.
April 2011: Creek Action Tour and post construction tour with OWASA and property owners
May 2011: Asbuilt survey
June 2011: Board of Aldermen presentation
November 2012: Monitoring survey
December 2012: Planting workday with NCSU, town staff, and volunteers
Ongoing: project site visits and informal tours, and maintenance

References

Lenat, D. March, 2009. Supplemental Biological Monitoring of Tributaries in the Bolin Creek Catchment, Carrboro, North Carolina. Available at
http://www.townofcarrboro.org/pzi/Env/PDFs/Bolin%20Creek%20Report%2003-09.pdf

Rosgen, David L. 2001. A practical method of computing streambank erosion rate. Proceedings of the Seventh Federal Interagency Sedimentation Conference, Vol. 2, Reno, NV, March 25-29.

Appendix A:

Asbuilt & Monitoring Survey Results

DRY GULCH STREAM ENHANCEMENT PROJECT
CARRBORO, NC

ASBUILT & MONITORING PLAN SHEET

DATE	06/03/2011
PROJECT NO.	
FILENAME	FILE.DWG
SHEET NO.	3
DRAWING NO.	

NC STATE UNIVERSITY

BIOLOGICAL & AGRICULTURAL ENGINEERING
Weaver Labs Campus Box 7625
North Carolina State University
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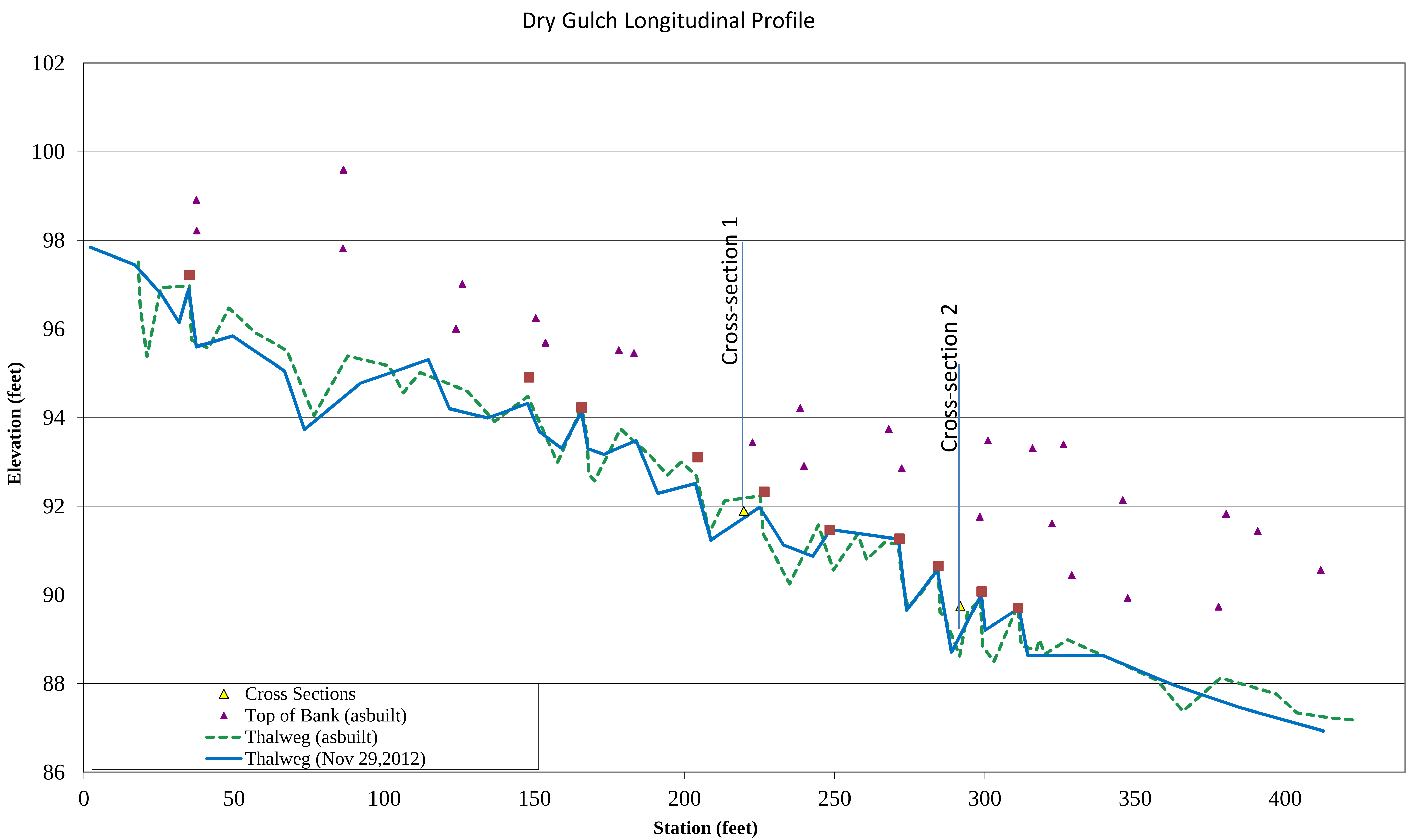
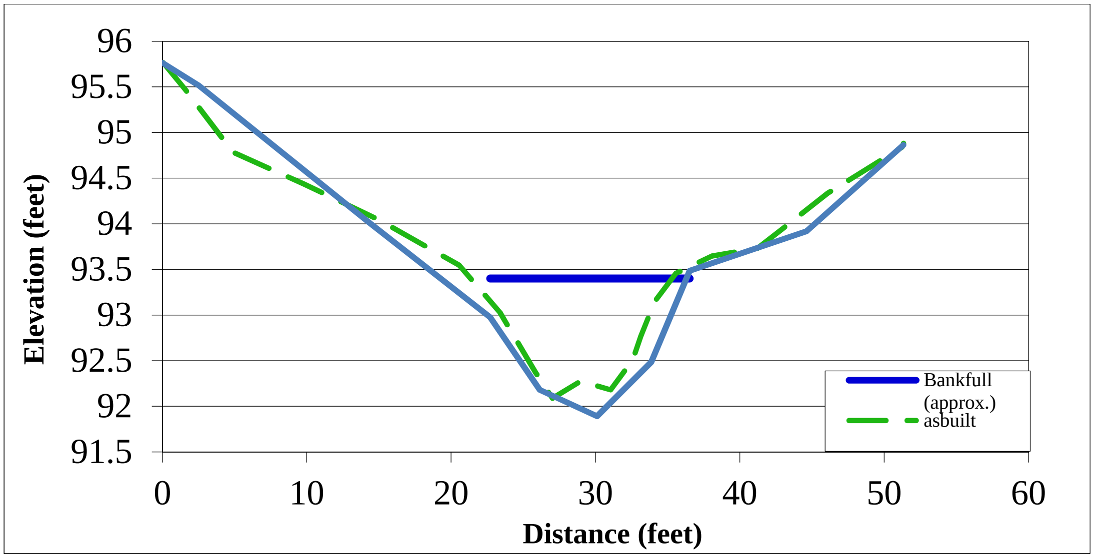
NO	REVISIONS	DRN	CHK	DATE
1	CONCEPTUAL DESIGN	ZP	GJ	06/03/11
2	PCN REVISIONS	ZP	GJ	09/23/11
3	ASBUILT	ZP	GJ	07/22/12
4	MONITORING	ZP	GJ	12/12/12


Dry Gulch Longitudinal Profile
Elevation (feet)
Station (feet)
102
100
98
96
94
92
90
88
86
0
50
100
150
200
250
300
350
400
Cross-section 1
Cross-section 2
Cross Sections
Top of Bank (asbuilt)
Thalweg (asbuilt)
Thalweg (Nov 29,2012)

Cross Section 1 – Dry Gulch



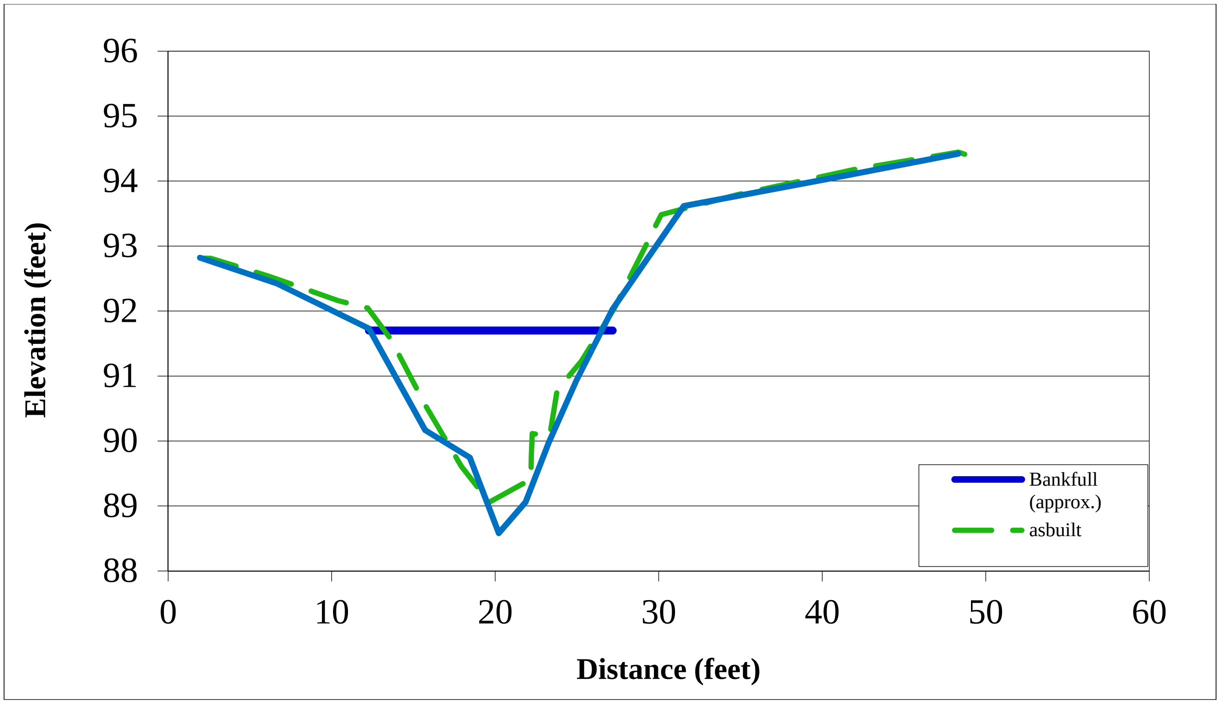
Asbuilt May 3, 2012

November 29, 2012

Cross Section Dimensions

	Asbuilt	November 29, 2012	
Area	10.9	14.6	square feet
Width	13.9	17.0	feet
Mean Depth	0.8	0.9	feet
Max Depth	1.3	1.5	feet
W/D Ratio	17.8	19.8	

Cross Section 2 – Dry Gulch



Asbuilt May 3, 2012

November 29, 2012

Cross Section Dimensions

	Asbuilt	November 29, 2012	
Area	19.0	22.4	square feet
Width	13.2	14.2	feet
Mean Depth	1.4	1.6	feet
Max Depth	2.6	3.1	feet

Dry Gulch Preconstruction BEHI Data
Measured 2/17/12
By: Zan Price
Stationing starts at upstream stream crossing and follows original channel alignment

Bank	Start Station	End Station	BEHI Rating	NBS	Length	Bank Ht	Erosion/yr (NC Curve)	vol cu ft	
Right	0	14	High	mod	14	3	0.15	6.3	
Right	14	95	Mod	mod	81	3	0.05	12.15	
Right	95	117	High	mod	22	3	0.15	9.9	
Right	117	130	Mod	high	13	3	0.12	4.68	
Right	130	160	Low	mod	30	3	0.05	4.5	
Right	160	180	Mod	low	20	3	0.02	1.2	
Right	180	200	Low	low	20	3	0.02	1.2	
Right	200	210	Mod	mod	10	3	0.05	1.5	
Right	210	276	Low	mod	66	4	0.05	13.2	
Right	276	300	Mod	high	24	3	0.12	8.64	
Right	300	345	High	mod	45	3	0.15	20.25	
Right	345	400	Mod	mod	55	3	0.05	8.25	
Right	400	460	Mod	mod	60	3	0.05	9	
Left	0	9	High	low	9	3	0.1	2.7	
Left	9	71	Mod	low	62	3	0.02	3.72	
Left	71	155	Low	mod	84	3	0.05	12.6	
Left	155	177	Mod	mod	22	4	0.05	4.4	
Left	177	185	High	mod	8	5	0.15	6	
Left	185	195	Very High	high	10	7	0.9	63	
Left	195	205	Extreme	high	10	8	2.2	176	
Left	205	210	Very High	high	5	8	0.9	36	
Left	210	215	High	mod	5	8	0.15	6	
Left	215	220	Very Low	mod	5	4	0	0	(Bedrock)
Left	220	271	Low	mod	51	3	0.05	7.65	
Left	271	290	Mod	low	19	3	0.02	1.14	
Left	290	314	Low	low	24	3	0.02	1.44	
Left	314	325	Mod	low	11	3	0.02	0.66	
Left	325	345	Low	low	20	2	0.02	0.8	
Left	345	360	Mod	low	15	2	0.02	0.6	
Left	360	460	Low	low	100	2	0.02	4	
							Total Estimated Annual Erosion	427.5	cu ft
								15.8	cu yards
								42748.0	lb
								21.4	tons

Dry Gulch Post-construction BEHI Data
Measured11/26/12
By: Zan Price
Stationing starts at upstream stream crossing and follows new channel alignment

Bank	Start Station	End Station	BEHI Rating	NBS	Length	Bank Ht	Erosion/yr (NC Curve)	vol cu ft
Right	0	17	VL	Mod	17	2	0.008	0.272
Right	17	97	Low	Mod	80	2.5	0.05	10
Right	97	107	Mod	Mod	10	3.5	0.05	1.75
Right	107	116	Low	Mod	9	3.5	0.05	1.575
Right	116	125	Mod	Mod	9	3.5	0.05	1.575
Right	125	175	VL	low	50	2	0.008	0.8
Right	175	213	Mod	Mod	38	2.5	0.05	4.75
Right	213	285	low	low	72	2	0.02	2.88
Right	285	315	mod	mod	30	3.5	0.05	5.25
Right	315	376	low	low	61	1.5	0.02	1.83
Right	376	400	mod	low	24	3	0.05	3.6
Right	400	415	VL	low	15	2.5	0.008	0.3
Left	0	17	VL	VL	17	2	0.008	0.272
Left	17	43	VL	low	26	2.5	0.008	0.52
Left	43	80	Mod	low	37	3	0.05	5.55
Left	80	185	VL	low	105	1.5	0.008	1.26
Left	185	215	Mod	mod	30	2	0.05	3
Left	215	300	Low	Mod	85	2	0.02	3.4
Left	300	415	Low	low	115	2.5	0.02	5.75

Total Estimated Annual Erosion	54.3	cu ft
	2.0	cu yards
	5433.4	lb
	2.7	tons

Appendix B:

Educational Project Poster