

**Harris County Water Control and Improvement District 96**

**P133-00-00 Maintenance & Erosion Repairs  
Harris County, Texas**

**Mitigation and Monitoring Plan**

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June 2016



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## TABLE OF CONTENTS

TABLE OF CONTENTS .....	ii
Section 1 Introduction .....	3
1.1 General .....	3
1.2 Existing Stream Condition .....	3
Section 2 Mitigation Plan .....	4
2.1 Stream Mitigation Design .....	4
2.2 Compensatory Mitigation .....	5
2.3 Post Construction Monitoring .....	6
2.4 Long Term and Adaptive Management Plans .....	7
2.5 Maintenance Plan .....	7
2.6 Financial Assurances .....	7

### List of Appendices

Appendix A: USACE Galveston District Level 1 Stream Assessment Data Form  
Post Construction Condition

### List of Exhibits

Exhibit 1: Project Map  
Exhibit 2: Detail Drawing  
Exhibit 3: Monitoring Event Map

# Section 1

## Introduction

### 1.1 General

Brown & Gay Engineers, Inc. (BGE) has been contracted by Harris County Water Conservation and Improvement District 96 (HCWCID 96) to obtain environmental clearances for a 4.8-acre project area along P133-00-00 (P133), a tributary to Greens Bayou, for the construction of stream stabilization structures. The project area is located approximately 1 mile southwest of the intersection of Mesa Drive and the North Sam Houston Parkway, Harris County, Texas.

The project goal is to stabilize the stream channel and banks of P133-00-00 (P133) and thereby prevent continued erosion into the Falls Creek residential development. Severe erosion threatens both existing occupied residences along the eastern bank of the stream and a functioning detention basin along the western bank of the stream. Impacts to P133 were calculated using the U.S. Army Corps of Engineers (USACE) Galveston District Level 1 Stream Condition Assessment Tool (Level 1).

Level 1 baseline data was collected by USACE personnel during a site visit and ordinary high water mark (OHWM) verification on February 5, 2015. This OHWM verification was in conjunction USACE evaluation of a request for extension to a previously approved permit (SWG-2007-00119). Level 1 baseline data was considered when developing project designs to meet permittee responsible mitigation requirements, this is prior to the close of the public comment period notice for the Level 2 Stream Condition Assessment Tool on April 1, 2015.

### 1.2 Existing Stream Condition

The project area is bisected by the P133 stream channel and includes a riparian area dominated by pine and hardwood bottomland forest plants such as water oak (*Quercus nigra*, FAC), loblolly pine (*Pinus taeda*, FAC), yaupon (*Ilex vomitoria*, FAC), woodoats (*Chasmanthium latifolium*, FAC), and southern dewberry (*Rubus trivialis*, FACU) with residential housing and a detention basin adjacent to the project area.

Level 1 baseline data was collected by USACE personnel for the section of stream to be impacted as well as downstream of the proposed bank stabilization structures during a site visit on February 5, 2015. This data was summarized and provided to BGE personnel on February 18, 2015. The existing P133 stream channel within the project area has a total length of 1,026 LF.

USACE personnel calculated an average reach condition index (RCI) for the project area of 2.55. BGE personnel requested the level 1 stream assessment field data forms used to calculate the RCI above from USACE on December 3, 2015, but never received data forms for individual transect.

## Section 2

### Mitigation Plan

#### 2.1 Stream Mitigation Design

The low impact alternative (Alternative 2) was developed from comments received from the USACE during a meeting on February 26, 2015 and the results of a hydrogeomorphic study. The proposed design will temporarily impact 963 linear feet (LF) and permanently impact 63 LF of P133 through the placement of clean fill and riprap below the existing OHWM. The project design will also require relocation of high banks, stream benches, and the restoration of 963 LF of stream channel to repair and prevent erosional damage to both banks of P133. All permanent work will be completed within the existing high banks of P133.

Restoration efforts will take place within and outside of the proposed OHWM but within the existing high bank of P133.

Outside of the proposed OHWM this design will relocate and repair the top of bank (TOB) and protect the streambed and adjacent property from further erosion. In areas requiring additional erosion protection, 18 inches of riprap will be installed beginning at the high bank to a minimum of 1 foot below the designed stream bed. This riprap will then be covered by at least 6 inches of clean fill material on side slopes and up 12 feet of clean fill material along the stream banks in order to create bankfull benches and a natural stream bed. The design will include a 2:1 side slope from the designed stream bed to bankfull benches approximately 12 feet wide, and 3:1 side slopes from bankfull benches to TOB. Bank full benches and side slopes will then be planted with live transplant trees, shrubs, and grasses in order to provide stabilization of the shelves and slopes and create a riparian buffer where available (**Exhibit 1**).

Within the proposed OHWM of P133 this design calls for four types of structures designed by HydroGeo Designs to insure natural stream function and bank stability post construction (**Exhibits 2A-2F**):

- Toe Wood
- Rock Veins
- Riffle and Pool complex
- Drop structure plunge pool

Toe wood will be incorporated into the upper third of the stream channel along the cutting banks at two locations within the restoration area. Toe logs will be 16ft long and approximately 12-18 inches in diameter with root mass still attached. These toe wood structures are designed to add additional protection along cutting banks and aid sediment deposition along point bars on the parallel bank (**Exhibits 2A-2B and 2D**).

Rock veins will be placed at five locations within the designed stream channel. These rock veins are designed to only slow water during high flow events. These rock veins will be placed along the cutting bank of P133 at a 20-30 degree angle running upstream of flow. These veins will be constructed using 3-foot diameter boulders placed to minimize gaps and anchored below the designed bankfull benches. The terminus of these rock veins will be even with the OHWM of the proposed P133, and be constructed in association with a pool located 5 feet downstream of each rock vein to serve as an energy dissipation pool (**Exhibits 2A-2B and 2E**).

Riffle and pool complexes will be used to slow water and add stream geometry throughout the 963 LF of restored stream channel. This design calls for riffles to be placed at three locations along the length of the project; one at the upstream terminus of the designed stream channel, one just downstream of the stormwater outfall located near the center of the project, and one at the downstream terminus of the project. This design will allow for natural riffles over Grade 2 riprap and large moss rock as well as runs and pools located downstream of riffle locations (**Exhibits 2A-2B and 2F**).

In order to dissipate energy generated by the approximately 15-foot elevation drop of stormwater through the stormwater outfall located near the center of the 963 LF of designed stream channel, a riprap lined plunge pool is planned at the outfall location. This plunge pool is located in conjunction with a designed pool within the stream channel. A riffle will be located directly upstream of the outfall pipe (**Exhibits 2A-2B**).

## 2.2 Compensatory Mitigation

Mitigation for the 63 LF of permanent impacts to P133 will be completed by the permittee (HCWCID 96) through improvements to channel condition, riparian buffer, and channel alteration variables within the remaining 963 LF of restored stream channel according to the USACE Galveston District Level 1 Stream Condition Assessment tool.

USACE personnel collected Level 1 stream tool assessment data and provided BGE personnel with a Level 1 pre-construction reach condition index (RCI) of 2.55 for the 1,026 LF of existing stream within the project area. Post-construction designs are expected to have a RCI of 3.59 within 963 LF of designed natural stable stream channel. Theoretical post construction stream assessment data form can be found as **Appendix A**; description for each Level 1 variable can be found therein.

At the time of data collection by USACE, the pre-construction Level 1 aquatic use variable was assumed to have a score of 2.00, this score remained a 2.00 within the post construction Level 1 RCI calculation.

Despite the 6 percent loss in stream channel length, the designed stream RCI will have a 29 percent increase and will balance debits to stream function caused by the loss of total linear feet. **Table 1** details the length and RCI for the existing stream, proposed permanent impacts, and designed stream along with stream debit compensation.

**Table 1. Compensatory Mitigation Summary.**

	Stream Length (LF)	Reach Condition Index	Impact Factor	Calculated Debits
Existing Stream	1,026	2.55	1	2,616.3
Permanent Stream Loss	63	2.55	4	642.6
<b>Total Debits</b>				<b>3,258.9</b>
Designed Stream	963	3.59	<b>Total Credits</b>	3,457.2
<b>Total Balance</b>				<b>198.3</b>

The design is based on natural stable channel concepts and allows for natural stream processes to perpetuate the desired section and channel behavior.

### 2.3 Post Construction Monitoring

Post-construction monitoring will occur quarterly upon completion of the project construction for 1 year and semi-annually for an additional 2 years using the USACE Level 1 Stream Assessment Tool.

Monitoring events will consist of Level 1 stream assessment along three transects within the project area following Level 1 assessment guidance (**Exhibit 3**). Monitoring reports will be submitted to USACE personnel within 30 days of the monitoring event. These monitoring reports will contain a description of the site's overall stability and include an average RCI of the three transects (**Exhibit 3**). Any potential problems that could endanger the stream restoration efforts will be reported to the USACE in these monitoring event reports along with potential solutions.

At the time of data collection by USACE, the Level 1 aquatic use variable was assumed to have a score of 2.00, this score will be assumed to remain a 2.00. Monitoring events will focus upon the following Level 1 Stream Assessment parameters.

- Channel Condition
- Riparian Buffer
- Channel Alteration

If the measurable criteria is not met within 3 years of completion of construction, additional monitoring events will be held annually until performance standards are met. Upon the time at which the average RCI is greater than or equal to 3.4 the pre-construction and post construction Level 1 scores within the project area will be equal.

Should the average RCI collected during any monitoring event be greater to or equal to 3.4, mitigation requirements of this permit will be considered complete and a release from further monitoring will be made to the USACE.

## 2.4 Long Term and Adaptive Management Plans

At the time all performance standards are met, monitoring and short term management efforts will cease. At this time HCWCID 96 will assume responsibility for insuring removal of invasive woody species and maintaining mitigation site security.

If performance standards are not met within 5 years of the completion of construction, this stream design will be reevaluated by the same methods, Level 1 stream assessment and regional curve, in order to determine if any additional design features can be implemented in order to meet or exceed measureable performance standards. Any adaptive management plans will be discussed with USACE personnel prior to implementation.

## 2.5 Maintenance Plan

P133 is controlled by Harris Country Flood Control District (HCFCD); HCFCD has a 30 ft maintenance easement on either side of the centerline of flow for this stream. This minimum maintenance easement pertains to removal of large debris that could potentially cause flooding during high flow events. P133 does not meet HCFCD's criteria for acceptance of full maintenance activities, and HCFCD considers P133 at the project location to be private property and any structures within the OHWM of P133 to be private structures.

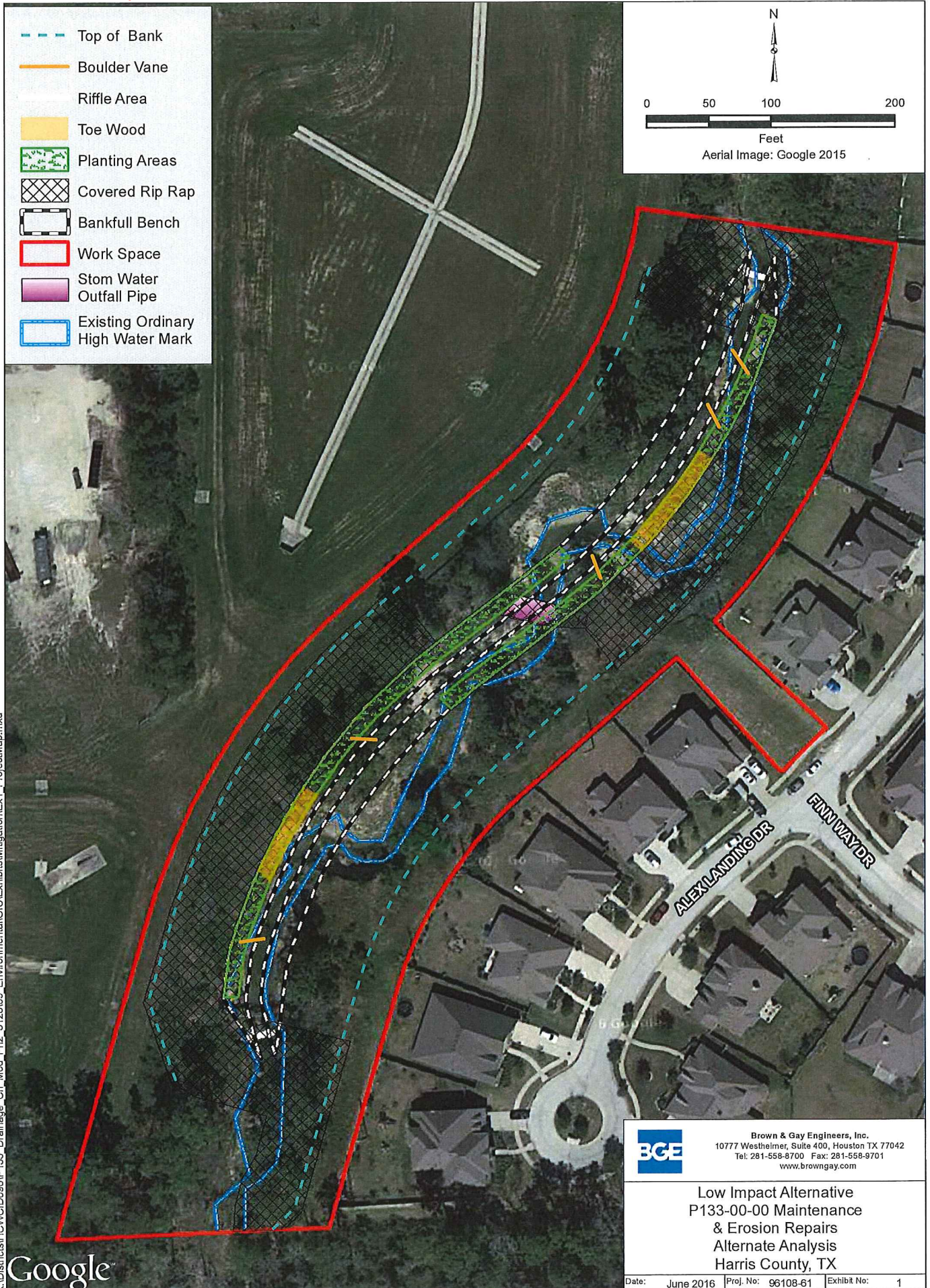
The removal of invasive woody species, such as Chinese tallow (*Triadica sebifera*), through manual herbicide application and hand clearing will be completed by the permittee. No maintenance activities should be required below the OHWM of P133 if the designed stream channel functions naturally and meets the performance standards listed above.

## 2.6 Financial Assurances

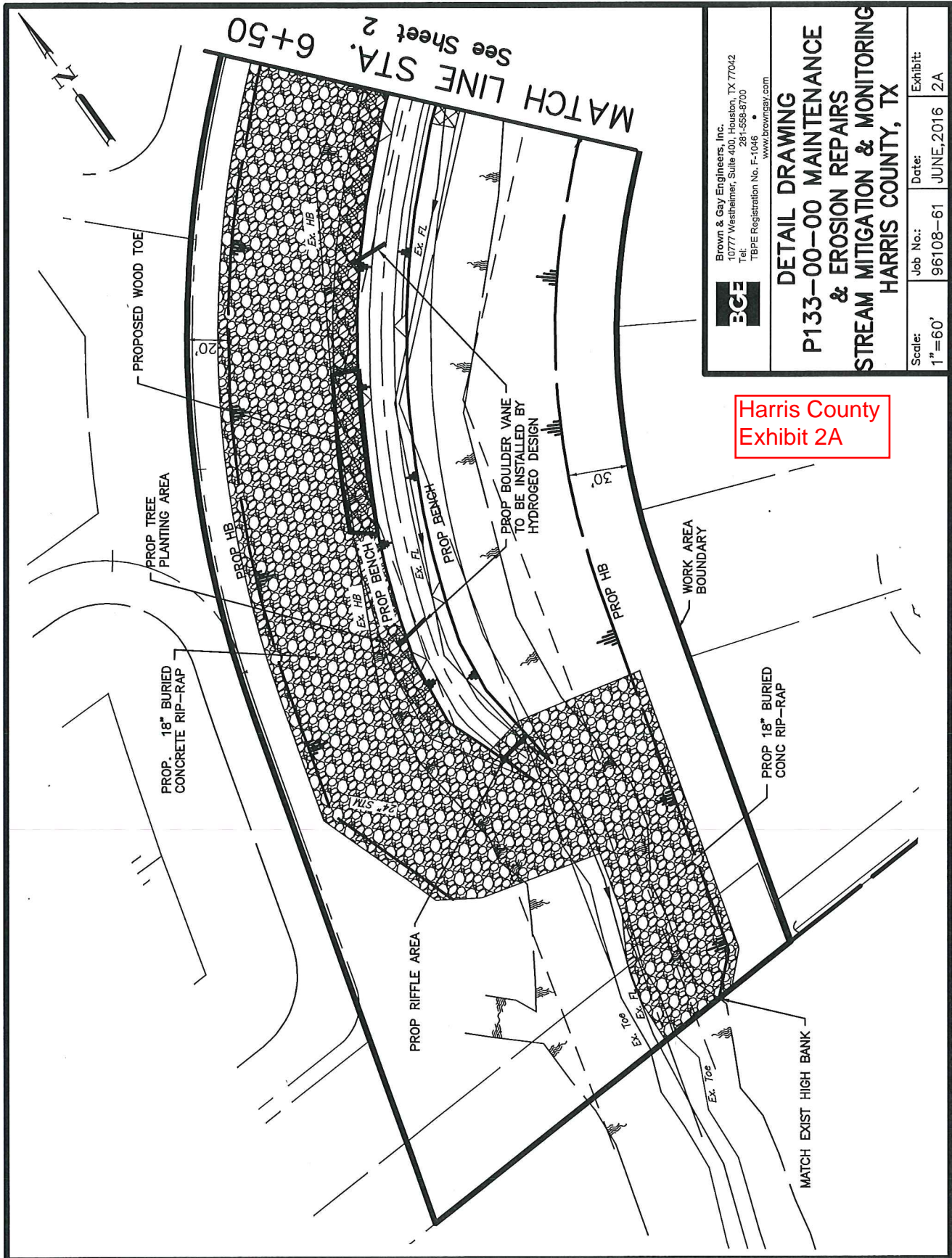
HCWCID 96 assumes all financial risks associated with short term failure and long term management of the designed stream channel. A 1-year bond will be required for the cost of initial construction as part of the construction contract. This bond will cover failure of the constructed stream channel and designed structures.

Upon transition to long term management, HCWCID 96 will rely on tax base to provide removal of invasive woody species and maintaining mitigation site security.

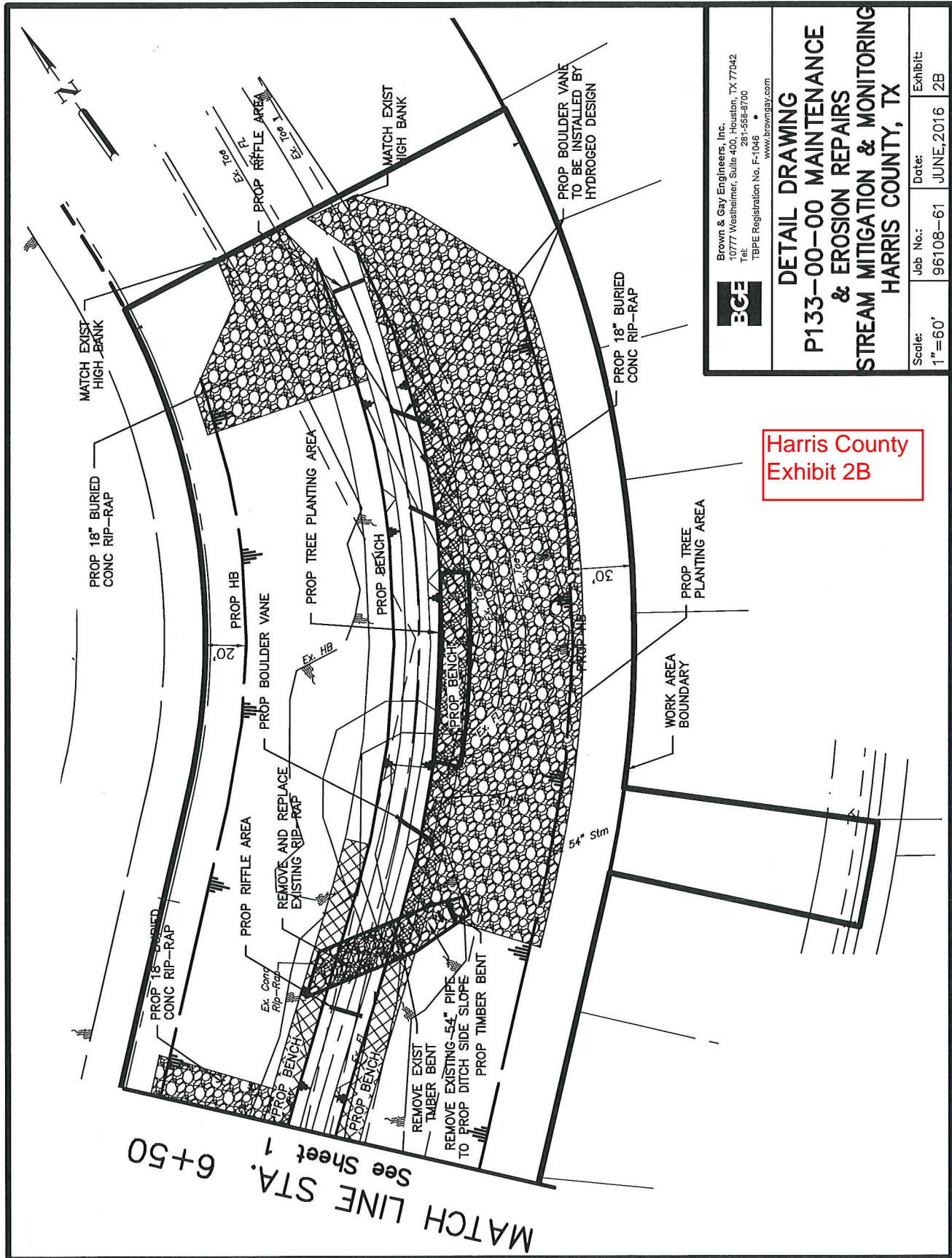








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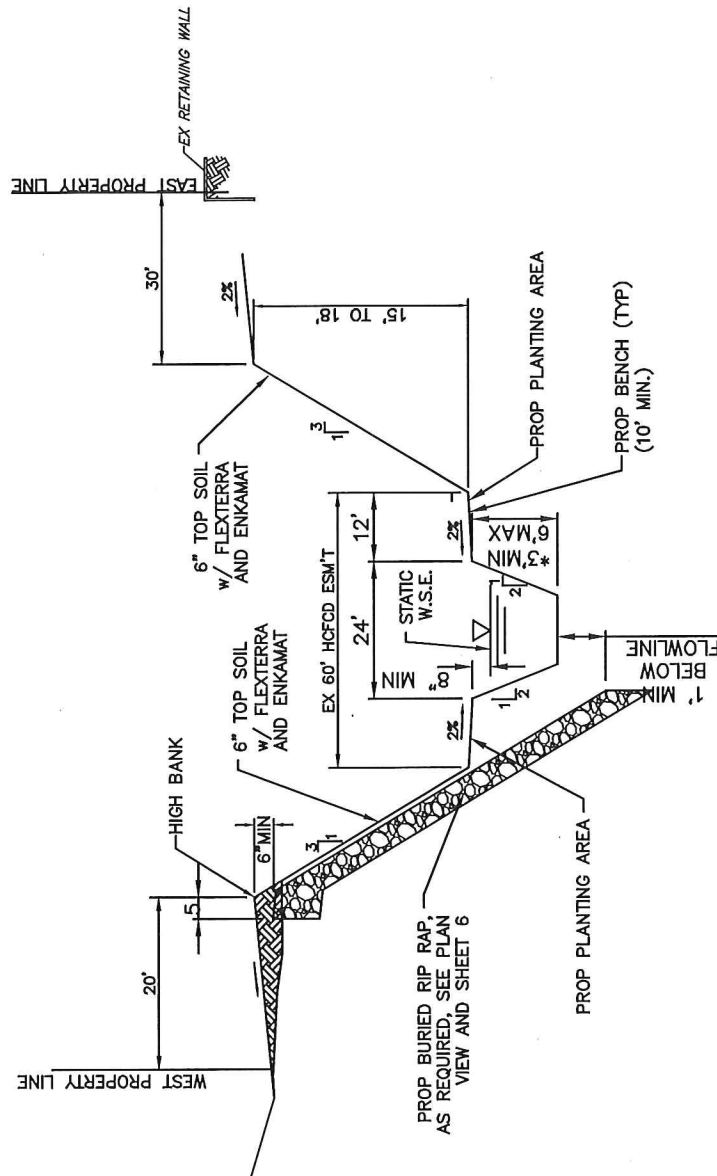
**DETAIL DRAWING**  
**P133-00-00 MAINTENANCE**  
**& EROSION REPAIRS**  
**STREAM MITIGATION & MONITORING**  
**HARRIS COUNTY, TX**

Scale:	Job No.:	Date:	Exhibit:
1" = 60'	96108-61	JUNE, 2016	2B

Harris County  
Exhibit 2B



Harris County  
Exhibit 2C



TYPICAL CROSS SECTION

N.T.S.

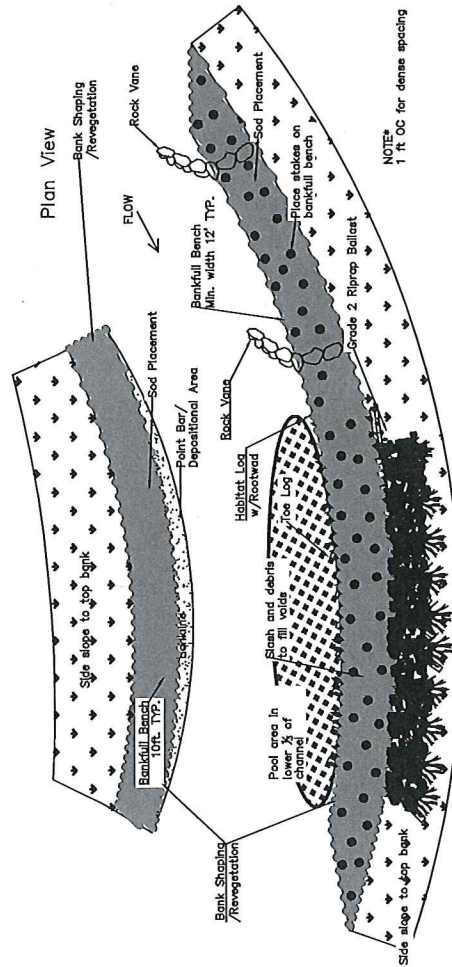
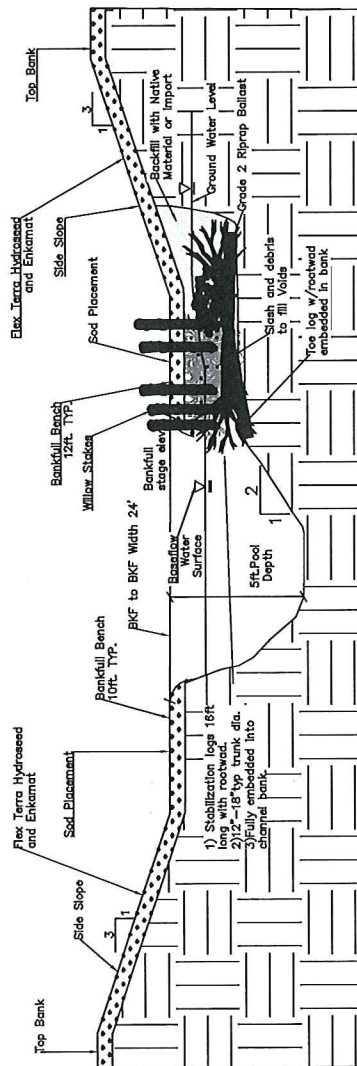
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**DETAIL DRAWING**  
**P133-00-00 MAINTENANCE**  
**& EROSION REPAIRS**  
**STREAM MITIGATION & MONITORING**  
**HARRIS COUNTY, TX**

Scale:	Job No.:	Date:	Exhibit:
N.T.S.	96108-61	JUNE, 2016	2C

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## Section View



## TOE WOOD DETAIL

SCALE: NTS

Harris County  
Exhibit 2D

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DETAIL DRAWING  
P133-00-00 MAINTENANCE  
& EROSION REPAIRS  
STREAM MITIGATION & MONITORING  
HARRIS COUNTY, TX

Scale:	Job No.:	Date:	Exhibit:
N.T.S	96108-61	JUNE, 2016	2D



Harris County  
Exhibit 2E

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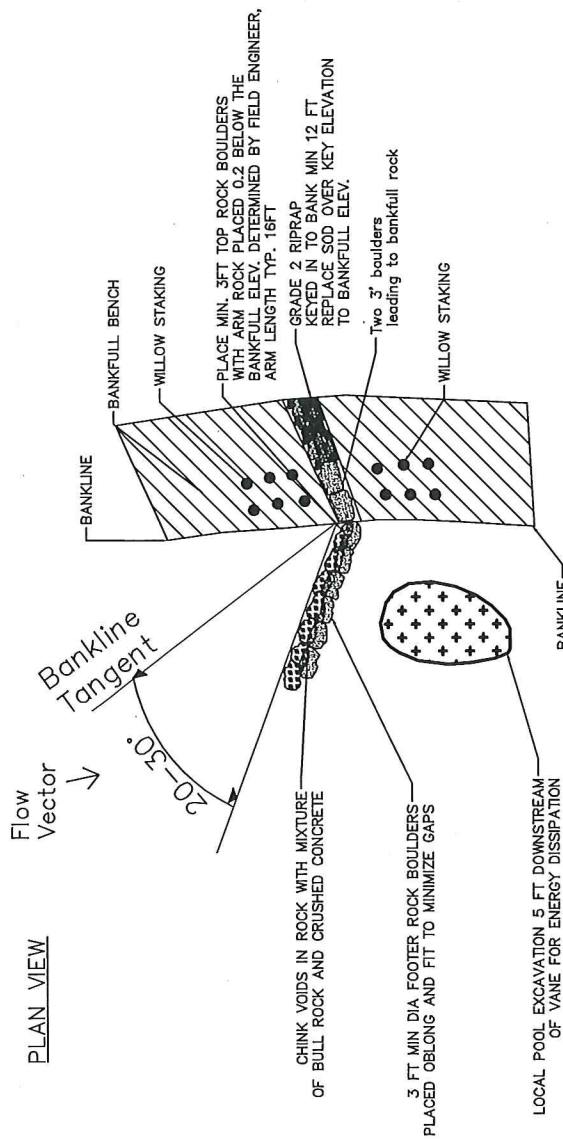


**DETAIL DRAWING**  
**P133-00-00 MAINTENANCE**  
**& EROSION REPAIRS**  
**STREAM MITIGATION & MONITORING**  
**HARRIS COUNTY, TX**

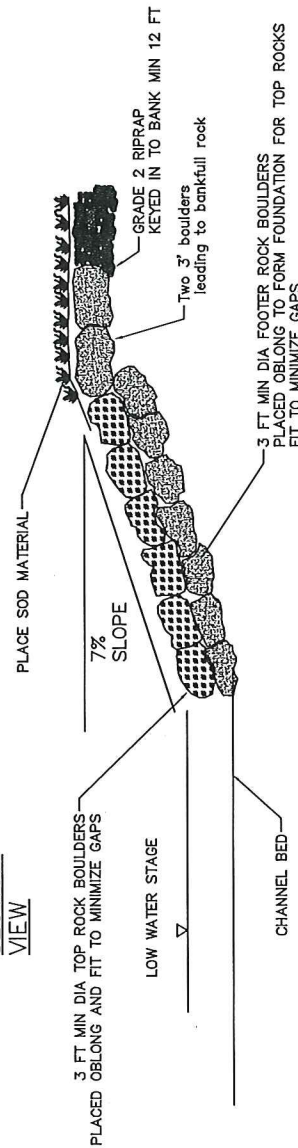
Scale:	Job No.:	Date:	Exhibit:
N.T.S	96108-61	JUNE, 2016	2E

BOULDER VANE DETAIL

PLAN VIEW



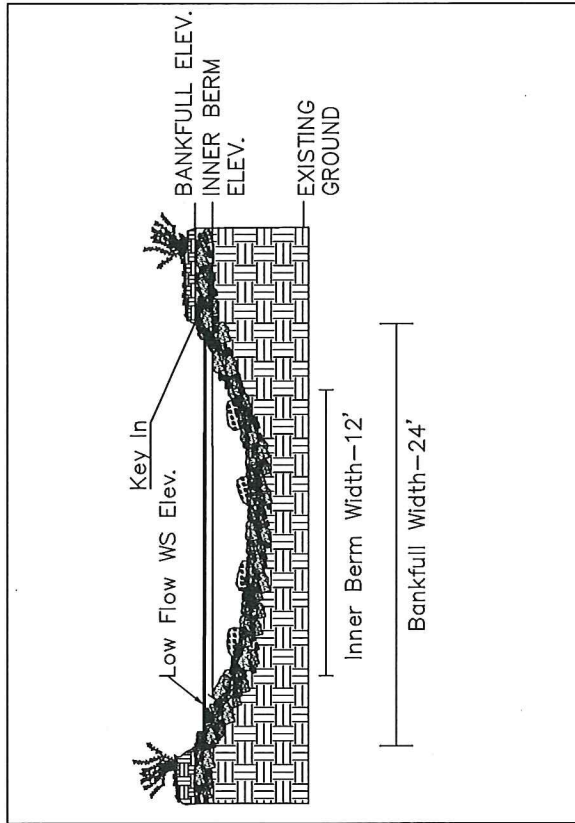
SECTION VIEW



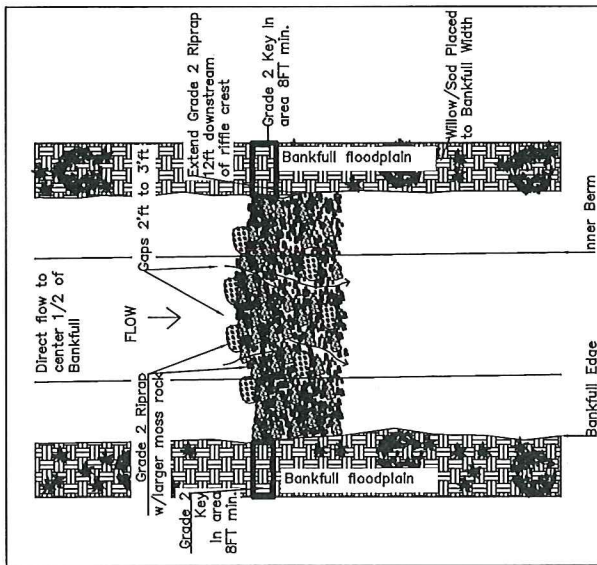
BOULDER VANE DETAIL

SCALE: NTS

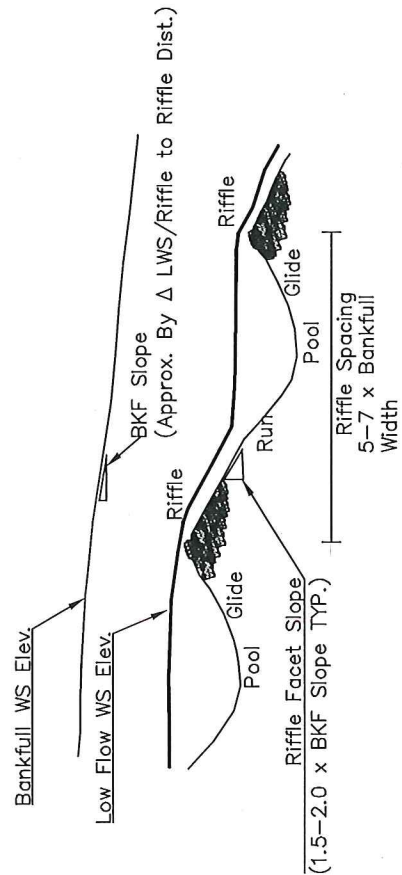
# Cross-Section View



# Plan View



# PROFILE TOP RIFFLE (TR)



# RIFFLE AND POOL DETAIL

SCALE: NTS

Harris County  
Exhibit 2F

PREPARED BY:



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## DETAIL DRAWING

P133-00-00 MAINTENANCE  
& EROSION REPAIRS  
STREAM MITIGATION & MONITORING  
HARRIS COUNTY, TX

Scale:	Job No.:	Date:	Exhibit:
N.T.S.	96108-61	JUNE, 2016	2F

**Appendix A**

USACE Galveston District Level 1 Stream Assessment Data Form

Post Construction Condition

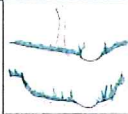
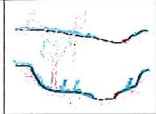

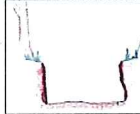



# Stream Assessment Data Form for Level 1

U.S. Army Corps of Engineers Galveston District

File Number	Applicant	Stahler Stream Order	8 Digit HUC	Date	Transect #	Transect Description
	HCWCID		12040104	3/9/2016	1	Post Construction Success
Name(s) of Evaluator(s)			Stream Name and Type			
Logan Smart			P-133-00-00, Perennial Stream			

## 1. Channel Condition: Assess the cross-section of the stream and prevailing condition (erosion, aggradation)

	Optimal	Suboptimal	Marginal	Poor	Severe	
Visual Channel Condition Parameter						
	Channel shows very little incision or widening and little or no evidence of erosion or unprotected banks. Indicators of stability include greater than 80% vegetative cover on the banks, stable point bars and bankfull benches may be present, mid-channel and transverse bars are rare or transient. The stream has access to active floodplain or fully developed bankfull benches. No bulkheading or riprap may be present.	Channel is slightly incised and contains a few areas of active erosion. Indicators of instability include vegetative cover or natural rock protection only present along 60-80% of the Transect, point bars and bankfull benches are likely present and transient sediment is present along 10-40% of the stream bottom. The stream has access to bankfull benches or developed floodplains along portions of the reach. Channel may show evidence of past channel alteration, but should be exhibiting notable recovery of a natural channel. Bulkhead and riprap are limited to 1-25% of the Transect.	Channel is incised or has had its course widened. Indicators of instability include the presence of erosional scars on 40-60% of the Transect, vegetative cover or natural rock only found on 40-60% of the Transect, vertical or undercut banks, or nickpoints associated with headcuts may be present and portions of the channel may be widening while other portions of the channel are narrowing, and transient sediments are found in 40-60% of the natural stream bed or bottom. The stream does not have access to the active floodplain. Bulkheading or riprap is found along 25-50% of the Transect.	Channel is over-widened or incised with vertically or laterally unstable banks. Visual indicators of over-widening and incision include near vertical banks with shallow root depths, erosional scars present along 60-80% of the Transect, vegetative cover or natural rock is limited to 20-40% of the Transect, substantial sediment deposition of uniformed-size material is present along 60-80% of the Transect and point bars and bankfull benches are absent. The stream does not have access to an active floodplain. Bulkheading and riprap are present along 50-80% of the Transect.	Channel is deeply incised or excavated with vertical or lateral instability in the stream bank. Indicators of instability include the streambed elevation located below the rooting depth, both banks are vertical or undercut, vegetative surface protection or natural rock is only found along 20% or less of the Transect, the bank is sloughing and erosional scars or raw banks present on 80-100% of the Transect and 80% or more of the natural streambed is covered by substantial sediment resulting in threaded channels. The stream does not have access to an active floodplain.	
Score	5	4	3	2	1	CV 4.0

Notes: Mitigation planting plans include planting along bankfull benches which are within FEMA 100-Yr floodplain. The placement of clean fill material, rock veins, riffle and pool complexes, and toe wood along the designed stream channel will allow for natural sedimentation and point bars to develop, as well as reduce the appearance of past alteration. Designed channel geometry is consistent with a suboptimal score (Exhibit 2C).

## 2. RIPARIAN BUFFERS: Assess both bank's 100 foot riparian areas along the entire Transect.

	Optimal	Suboptimal	Marginal	Poor	Severe	
Riparian Buffers	Native woody species represent greater than 60% of the coverage and wetlands are present.	Native woody community species represent greater than 60% coverage with NO wetlands present within the buffer OR native woody community species represent 30-60% coverage with wetlands present. No maintenance or grazing activities.	Native woody community species represent between 30-60% coverage with NO wetlands present. No maintenance or grazing activities.	Native woody community represents less than 30% coverage with no maintenance or grazing activities.	The buffer is dominated by one or more of the following: lawns, mowed or maintained right-of-way, no-till cropland, actively grazed pasture, sparsely vegetated non-maintained area, recently seeded and stabilized or other comparable condition.	The area is dominated by impervious surfaces, mine spoil lands, denuded surfaces, conventional tillage row crops, active feed lots or comparable conditions.
Condition Scores	5	High = 4.5 Low = 4	3	2	1	

Notes: The designed bankfull benches will be planted with black willow (*Salix nigra*) via live staking.

Right Bank	% Riparian Area >	75%	25%				100%		
	Score >	4.5	2						
Left Bank	% Riparian Area >	74%	26%				100%	Rt Bank CI >	3.88
	Score >	4.5	2					Lt Bank CI >	3.85

3. AQUATIC USE: The Transect is assessed based on the aquatic life use category score assigned to the stream segment by the TCEQ.									
	Optimal	Suboptimal	Marginal	Poor	Severe				
AQUATIC USE	Aquatic Life Score of Exceptional.	Aquatic Life Score of High. Perennial streams that have not been assessed are also assumed to have an Aquatic Life Score of High	Aquatic Life Score of Intermediate.	Aquatic Life Score of Limited. Intermittent Streams with Perennial Pools that have not been assessed are also assumed to have an Aquatic Life Score of Limited.	Aquatic Life Score of Minimal. Intermittent and ephemeral streams that have not been assessed are also assumed to have an Aquatic Life Score of Minimal.				
Score	5	4	3	2	1			UV	2.00

Notes: At the time of the data collection, this variable was assumed to score as 2.

Harris County-Post Conditions  
APPENDIX A



## Stream Impact Assessment Form Page 2

Project #	Applicant	Locality	Cowardin Class.	HUC	Date	Transect #	Transect Description
	HCWCID		PFO1A	12040104	3/9/2016		

**4. CHANNEL ALTERATION:** Stream crossings, riprap, concrete, gabions, or concrete blocks, straightening of channel, channelization, embankments, spoil piles, constrictions, livestock

	<b>Optimal</b>	<b>Suboptimal</b>	<b>Marginal</b>	<b>Poor</b>	<b>Severe</b>	
<b>Channel Alteration</b>	Channelization, dredging, alteration or hardening absent. Stream has unaltered pattern or has normalized. No dams, dikes, levees, culverts, riprap, bulkheads, armor, drop structures or withdrawal structures within the Transect.	Less than 30% of the Transect is impacted by dredging, dams, dikes, levees, culverts, riprap, bulkheads, armor, drop structures or withdrawal structures. Evidence of past alteration may be present, but stream pattern and stability have recovered. Withdrawals, if present, have no observable effect on flow.	Between 30-60 % of the Transect is impacted by dredging, dams, dikes, levees, culverts, riprap, bulkheads, armor, drop structures or withdrawal structures. Evidence of past alteration may be present, but stream pattern and stability are beginning to recover. Withdrawals, if present, may have an observable effect on flow, but no observable effect on habitat or biota.	Between 60-90 % of the Transect is impacted by dredging, dams, dikes, levees, culverts, riprap, bulkheads, armor, drop structures or withdrawal structures. Evidence of past alteration is present, and stream pattern and stability are not recovering. Withdrawals, if present, may have an observable effect on both flow and habitat or biota.	Between 90-100% of the Transect is impacted by dredging, dams, dikes, levees, culverts, riprap, bulkheads, armor, drop structures or withdrawal structures. Withdrawals, if present, are large enough to have severe loss of flow and cause little to no habitat or biota.	AV
<b>SCORE</b>	5	4	3	2	1	4.50

Only 1 outfall drop structure is located within the reach totaling <3% of the 963 LF of designed stream channel (Exhibit 1).

<b>REACH CONDITION INDEX and STREAM CONDITION UNITS FOR THIS REACH</b>						
						THE CONDITION INDEX (CI) >>
						3.59

INSERT PHOTOS:

Harris County-Post Conditions  
APPENDIX A





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