

**APPENDIX A**  
**SAMPLING PLAN**

**Total Maximum Daily Load for Fecal Pathogens  
in the Clear Creek Watershed**

**Contract No. 582-0-80121  
Work Order No. 582-0-80121-09**

**Monitoring Plan**

Prepared by  
*University of Houston*  
*Parsons Water and Infrastructure*  
Principal Investigators  
*Hanadi Rifai*  
*Mel Vargas*

Prepared for  
Total Maximum Daily Load Program  
Texas Commission on Environmental Quality  
P.O. Box 13087, MC - 150  
Austin, Texas 78711-3087

TCEQ Contact

Ronald Stein  
TMDL Team (MC-150)  
P.O. Box 13087, MC - 150  
Austin, Texas 78711-3087  
RStein@tnrcc.state.tx.us

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## **Total Maximum Daily Load for Fecal Pathogens in the Clear Creek Watershed**

### **Monitoring Plan**

#### **INTRODUCTION**

A number of segments in the Clear Creek (CC) watershed, south of Houston, Texas, have been listed for *E. coli* and *Enterococci* exceedances. The University of Houston, Department of Civil & Environmental Engineering (UH) in collaboration with Parsons were contracted by the Texas Commission on Environmental Quality (TCEQ) to conduct a project that will assist in the completion of a Total Maximum Daily Load (TMDL) and allocation analysis for the Creek.

As part of the TMDL project, the University of Houston and Parsons will collect additional field data on concentrations of fecal pathogens in the segments of concern to assess sources and current contamination levels and trends. The monitoring will have four main components: (i) monitoring of *E. coli* and *Enterococci* in the project segments, (ii) an assessment of dry-weather discharge locations, (iii) an assessment of contributions from sediment; and (iv) flow measurements at various locations within the project segments.

This document is the Monitoring Plan for the sampling activities for the Fecal Pathogen Clear Creek TMDL Project.

#### **DESCRIPTION OF THE BACTERIA TMDL PROJECT**

The Texas Commission on Environmental Quality (TCEQ) is responsible for administering provisions of the constitution and laws of the State of Texas to promote judicious use of and the protection of the quality of waters in the State. A major aspect of this responsibility is the continuous monitoring and assessment of water quality to evaluate compliance with state water quality standards which are established within Texas Water Code, §307.1-307.10. Texas Surface Water Quality Standards 30 TAC 307.4(d) specify that surface waters will not be toxic to aquatic life. Pursuant to the federal Clean Water Act §303(d), states must establish total maximum daily loads (TMDLs) for pollutants contributing to violations of water quality standards. The target water bodies, segments 1101 (Clear Creek Tidal), 1101B (Chigger Creek), 1102 (Clear Creek Above Tidal), 1102A (Cowarts Creek), 1102B (Mary's Creek/North Fork Mary's Creek), and 2425C (Robinson Bayou) are located within the Clear Creek Watershed; these segments are on Texas' Clean Water Act §303(d) List for frequency and magnitude

of exceedances of fecal coliform and *E. coli*-based water quality criteria for contact recreation.

The objectives of the Clear Creek TMDL project include: (i) an assessment of the *E. coli* and fecal pathogen levels and trends in the Clear Creek watershed based on historical data, (ii) an assessment of major sources and fate and transport of *E. coli* and fecal contamination in the target water bodies based on historical and current data, (iii) development of a sampling plan and quality assurance project plan to collect current data, (iv) an assessment of the methods that may be used to determine the components of the TMDL equation, and (v) participation in the stakeholder project.

## **OBJECTIVES AND SCOPE OF THE MONITORING PLAN**

The listed Clear Creek Segments have been and continue to be monitored for a range of conventional water quality parameters. The monitoring data have been analyzed and indicate that a number of the segments exhibit exceedances of the pathogen standards relatively frequently.

The main reason for monitoring in this TMDL project is to understand and document the sources of these elevated bacteria levels so that development of appropriate control measures can be accomplished. The monitoring program includes four major components:

- Monitoring of *E. coli* and Enterococci in the project segments,
- Searches for dry-weather discharges in both sewer and unsewered areas,
- Sediment sampling, and
- Flow measurements within the creek and its tributaries.

### **1. EC and *Enterococci* Monitoring**

The TCEQ has adopted the use of *E. coli* (EC) and Enterococci concentrations as pathogen indicators for current and proposed Texas water quality standards. Clear Creek and its tributaries have been designated for contact recreation use and must meet the standards that have been set for this use. While historical data exist for the tidal segments of Clear Creek, less data are available for much of the non-tidal segments and many of the tributaries. Thus, in this TMDL, samples will be collected to determine concentrations of *E. coli* and *Enterococci* in Clear Creek and its tributaries during dry-weather conditions. As specified by the TCEQ, the fresh water segments, 1101B (Chigger Creek), 1102 (Clear Creek Above Tidal), 1102A (Cowarts Creek), and 1102B (Mary's Creek/North Fork Mary's Creek), will be sampled for *E. coli*; the marine

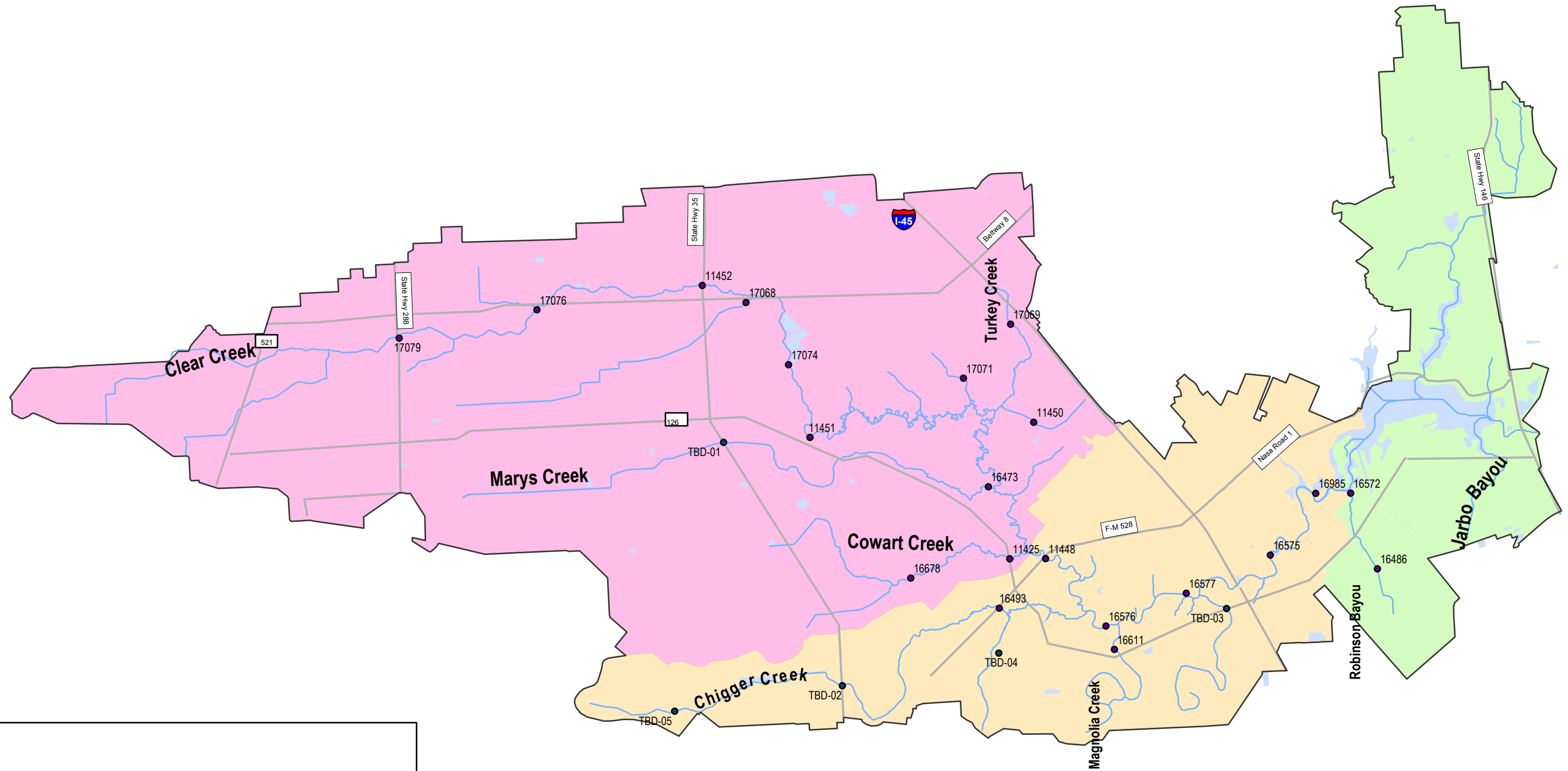
segments, 1101 (Clear Creek Tidal) and 2425C (Robinson Bayou), will be sampled for *Enterococci*. The sampling locations have been identified in Figure 1 and listed in more detail in Table 1. In addition to EC and *Enterococci*, the samples will be tested for standard water quality parameters as shown in Table 1. Table 2 lists the methods that will be used for the various analyses.

### Rationale for Sample Station Selection

Sampling locations were selected based on the number of exceedances of the pathogen indicator standard (historical data from TRACS database), adequate spatial coverage to include different land uses, number of outfalls discharging in drainage area, and proximity to the mouth of tributaries. Table 3 includes the number of exceedances of the EC and *Enterococci* standards for each of the locations selected for sampling in this plan as well as the reason for selection

## **2. Assessment of Dry Weather Discharges**

In dry weather, essentially most of the flow in Clear Creek is theoretically from point source discharges. The Galveston County Health District completed a study in 2001 to “identify and eliminate illicit connections in the Clear Creek Watershed” (Wright 2001). The 2001 study from Galveston County will be used as the starting point for this component of the monitoring plan. All data, maps, findings, and reports from the 2001 study will be obtained and updated on the basis of field reconnaissance and survey. In addition, all other counties encompassing the Clear Creek segments in this TMDL will be contacted for stream geometry data, models, and information on outfalls and drainage infrastructure. Finally, and during the field reconnaissance activities for this component, dry-weather discharges from outfalls will be noted and recorded, and the magnitude of the flow will be determined.



Legend

- Segment1101
- Segment1102
- Segment2425
- Sampling location



<b>Figure 1</b> <b>Proposed Sampling Locations</b>	
University of Houston Parsons Water and Infrastructure	
Prepared By: JED/GCV	Date: 03/03/2005

Table 1. Proposed Sampling Locations for the Clear Creek Watershed

Proposed Sampling Locations	Location ID	Potential Alternate Stations	TCEQ Short Description	Segment	Start Date	End Date	Monitoring frequencies										
							Field parameters <sup>a</sup>	Conventional parameters <sup>b</sup>	Flow <sup>c</sup>	E. Coli in water	Enterococci in water	Moisture content	Solids Content	Volatile Solids	TOC	E. Coli in sediment	Enterococci in sediment
1	11425		COWART CREEK AT FM 518	1102B	5/1/2005	6/30/2005	1	1	1	1	1	1	1	1	1	1	1
2	11448		CLEAR CREEK TIDAL AT FM528	1101	5/1/2005	6/30/2005	1	1			1						1
3	11450		CLEAR CREEK AT FM 2351	1102	5/1/2005	6/30/2005	1	1	1	1	1	1	1	1	1	1	1
4	11451	nearby station	CLEAR CREEK AT COUNTRY CLUB R	1102	5/1/2005	6/30/2005	1	1									
5	11452		CLEAR CREEK AT TELEPHONE RD	1102	5/1/2005	6/30/2005	1	1	1	1	1	1	1	1	1	1	1
6	16473		MARYS CREEK AT MARYS CROSSING	1102B	5/1/2005	6/30/2005	1	1	1	1	1	1	1	1	1	1	1
7	16486		ROBINSONS BAYOU AT WEBSTER	2425	5/1/2005	6/30/2005	1	1	1	1	1	1	1	1	1	1	1
8	16493	16472	CHIGGER CREEK AT FM528 BRIDGE	1101B	5/1/2005	6/30/2005	1	1	1	1	1	1	1	1	1	1	1
9	16572		CLEAR CK TDL AT ROBINSONS BAY	1101	5/1/2005	6/30/2005	1	1									1
10	16575		CLEAR CK TDL AT WALTER HALL	1101	5/1/2005	6/30/2005	1	1									1
11	16576		CLEAR CREEK TIDAL AT BROOKDALE	1101	5/1/2005	6/30/2005	1	1									1
12	16577	11447	CLEAR CK TDL AT CHALLENGER PK	1101	5/1/2005	6/30/2005	1	1	1	1	1	1	1	1	1	1	1
13	16611	or Magnolia Ck	MAGNOLIA CREEK UPSTM OF FM518	1101	5/1/2005	6/30/2005	1	1	1	1	1	1	1	1	1	1	1
14	16678		COWART CREEK AT BAKER ROAD	1102A	5/1/2005	6/30/2005	1	1									1
15	16985		CLEAR CK TDL AT NASSAU WWTP	1101	5/1/2005	6/30/2005	1	1	1	1	1	1	1	1	1	1	1
16	17068		HICKORY SLOUGH ROBINSON DRIVE	1101	5/1/2005	6/30/2005	1	1	1	1	1	1	1	1	1	1	1
17	17069		TURKEY CREEK DIXIE FARM ROAD	1102	5/1/2005	6/30/2005	1	1	1	1	1	1	1	1	1	1	1
18	17071		MUD GULLEY DIXIE FARM ROAD	1102	5/1/2005	6/30/2005	1	1									
19	17074		CLEAR CREEK AT BARRY ROSE	1101	5/1/2005	6/30/2005	1	1	1	1	1	1	1	1	1	1	1
20	17076		CLEAR CREEK AT STONE ROAD	1102	5/1/2005	6/30/2005	1	1									1
21	17079		CLEAR CREEK AT SH288 BRIDGE	1102	5/1/2005	6/30/2005	1	1	1	1	1	1	1	1	1	1	1
22	TBD-01		Mary's Ck at Hwy35	1102B	5/1/2005	6/30/2005	1	1									1
23	TBD-02		Chigger Ck at Hwy35	1101B	5/1/2005	6/30/2005	1	1									1
24	TBD-03	near confl to Clr Ck	Trib E of Magnolia Ck <unnamed>	1101	5/1/2005	6/30/2005	1	1	1	1	1	1	1	1	1	1	1
25	TBD-04		Tributary of Chigger Creek	1101B	5/1/2005	6/30/2005	1	1									1
26	TBD-05		Chigger Ck West of Hwy 35	1101B	5/1/2005	6/30/2005	1	1									1

Notes:

TBD- to be defined following submittal of Station Location request form (SLOC)

<sup>a</sup> Field parameters include temperature, DO, pH, conductivity, days since significant rainfall, and flow severity

<sup>b</sup> Conventional parameters include TSS, turbidity, orthophosphorous, Ammonia-N, and TOC

**Table 2 – Analytical Methods for Water and Sediment Samples**

<b>PARAMETER</b>	<b>UNITS</b>	<b>METHOD TYPE</b>	<b>METHOD</b>	<b>METHOD DESCRIPTION</b>	<b>STORET</b>
PH	pH units		EPA 150.1 and TCEQ SOP		00400
DO	mg/L		EPA 360.1 and TCEQ SOP		00300
Conductivity	mS/cm		EPA 120.1 and TCEQ SOP		00094
Temperature	° Celcius		EPA 170.1 and TCEQ SOP		00010
Flow	cfs		Project SOP		00061
Flow Severity	1-no flow, 2-low, 3-normal, 4-flood, 5-high, 6-dry	TCEQ SOP	TCEQ SOP <sup>1</sup>		01351
TSS	mg/L	gravimetric	EPA 160.2		00530
TOC	mg/L	oxidation	EPA 415.2		00680
Ammonia-N	mg/L	colorimetric	EPA 350.1		00610
<i>o</i> -Phosphorous	mg/L	colorimetric	EPA 365.3		00671
Turbidity	NTU	nephelometric	EPA 180.1		82079
TOC	mg/L	oxidation	EPA 415.2		00680
E. coli in water	MPN/100 mL	Primary direct	SM 9223B	IDEXX Colilert	31699
Enterococci in water	MPN/100 mL	Primary direct	ASTM D6053	IDEXX Enterolelet	31701
E. coli in sediment	MPN/100 g	Primary direct	SM 9223B and Project SOP	IDEXX Colilert	NA
Enterococci in sediment	MPN/100 g	Primary direct	ASTM D6053	IDEXX Enterolelet	NA

<sup>1</sup> TCEQ. 2003 Surface Water Quality Monitoring Procedures



Table 3. Exceedances of Indicator Standards for Stations to be Sampled in this Project

Location ID	TCEQ Short Description	USGS Station	Reason to Include	E Coli				Enterococci				
				Geo Mean >126 MPN/100ml	Single Sample >394		% of Exceedance of Single Sample Criteria	Geo Mean >35 MPN/100ml	Single Sample >200		% of Exceedance of Single Sample Criteria	
					# Exceedances	# Samples			# Exceedances	# Samples		
17079	CLEAR CREEK AT SH288 BRIDGE		To monitor west portion of Clear Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17076	CLEAR CREEK AT STONE ROAD		Located at inlet of tributary into Clear Ck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11452	CLEAR CREEK AT TELEPHONE RD	USGS 08077000 inactive since 1993	Upstream of junction with trib of Clear Ck	196	3	12	25	N/A	N/A	N/A	N/A	N/A
17068	HICKORY SLOUGH ROBINSON DRIVE		No other Stations chosen on this tributary	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17074	CLEAR CREEK AT BARRY ROSE		Located along wetland region of Clear Ck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11451	CLEAR CREEK AT COUNTRY CLUB R		Located along woody land region of Clear Ck	93	3	10	30	7500	3	3	100	100
17071	MUD GULLEY DIXIE FARM ROAD		Monitor Tributary into Clear Ck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17069	TURKEY CREEK DIXIE FARM ROAD		Only station located on Turkey Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11450	CLEAR CREEK AT FM 2351	USGS 08077540 inactive since 1997	Only Station located on trib to Turkey Ck	131	4	16	25	268	19	38	50	50
TBD-02			To monitor upstream portion of Mary's Ck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16473	MARYS CREEK AT MARYS CROSSING		To monitor downstream portion of Mary's Ck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16678	COWART CREEK AT BAKER ROAD		Only one Station on Cowart Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11425	COWART CREEK AT FM 518		Furthest downstream station on Cowart Ck	N/A	N/A	N/A	N/A	127	5	15	33	33
11448	CLEAR CREEK TIDAL AT FM528	USGS 08077600 active 2005	Downstream of mouth of Cowart Ck	128	2	11	18	244	11	26	42	42
TBD-06			Monitor upstream portion of Chigger Ck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TBD-03			undeveloped upstm of here (background)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16493	CHIGGER CREEK AT FM528 BRIDGE		To monitor downstream portion of Chigger Ck	130	4	11	36	301	13	24	54	54
TBD-05			No other Stations chosen on this tributary	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16576	CLEAR CREEK TIDAL AT BROOKDALE		Upstream of Magnolia Creek	N/A	N/A	N/A	N/A	88	8	26	31	31
16611	MAGNOLIA CREEK UPSTM OF FM518		Only Station on Magnolia Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16577	CLEAR CK TDL AT CHALLENGER PK		most eColi data in area, public access	56	1	12	8	192	9	26	35	35
TBD-04			Urban creek without WWTP	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16575	CLEAR CK TDL AT WALTER HALL		Fair amount of eColi data, public access	21	0	5	0	75	10	30	33	33
16486	ROBINSONS BAYOU AT WEBSTER		Located at upstream end of Robinsons Bayou	87	2	9	22	684	16	19	84	84
16572	CLEAR CK TDL AT ROBINSONS BAY		Located downstream on Robinsons Bayou	193	1	2	50	15	2	20	10	10
16985	CLEAR CK TDL AT NASSAU WWTP		Downstream end of Clear Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes:  
 N/A - data has not been obtained at these proposed sampling locations  
 \* up to 20 flow measurements will be made, some are at locations other than identified stations

### **3. Sediment Sampling**

For this component, sediments at up to 20 locations within the Creek and its tributaries will be sampled to be analyzed for EC or *Enterococci* and physical parameters (moisture content, total solids, volatile solids, TOC, and grain size). As much as possible, sediment samples will be collected at the same locations where water sampling will be conducted, however sediment locations may change once reconnaissance has been conducted. In addition, up to 10 sediment samples will be collected along a cross section and analyzed separately to assess potential differences between the banks and the main channel. Finally, TSS data for the watershed will be gathered to investigate possible correlations with flow and EC/*Enterococci* levels.

### **4. Flow Measurements**

A review of the historical data indicated that there are no flow measuring gages in the watershed. Thus, during water sample collection for EC and *Enterococci* flow measurements will be made at up to 20 stations. Flow measurements will be performed to allow development of a model to assist the TMDL process. Flow will be measured at the sampling locations listed on Table 1, or as close to the sample location as possible taking into account team access and safety.

Flow severity will be recorded for each sample location during each sampling event. as detailed in Chapter 3 of TCEQ *Surface Water Quality Monitoring Procedures, Volume 1: Physical and Chemical Monitoring Methods for Water, Sediment and Tissue*. Texas Commission on Environmental Quality, Document No. RG-415 (December 2003). See Table 2.

Flow measurement will be performed as described in Chapter 3 of TCEQ *Surface Water Quality Monitoring Procedures, Volume 1: Physical and Chemical Monitoring Methods for Water, Sediment and Tissue*. Texas Commission on Environmental Quality, Document No. RG-415 (December 2003) with modification as detailed in this section. Flow measurement will be collected with either a Marsh McBirney electronic meter (with bridge board and weight or wading rod) or an acoustic doppler profiler on a line towed boat configuration (RiverCat®). In the event of flow or velocity regimes which may endanger field team safety, flow measurement procedures will be modified. During dangerous conditions, surface water velocity will be measured at the water surface at the thalweg or mid channel using a float and stopwatch to measure time of travel over a specified distance. This data will be used to make order of magnitude flow estimates for modeling purposes only (not for submittal to TRACS). Cross section depths will be measured as indicated in TCEQ SWQM Chapter 3 to calculate flow. When flow measurement is performed with a Marsh McBirney unit, three equal width flow cross sections will be measured. Flow from outfall structures will be measured by documenting the length of time to fill a graduated beaker.

## **PROJECT SCHEDULE**

The sampling schedule is provided on Figure 2.

**Figure 2. Monitoring Plan Timeline**

COMPONENT	2004-2005											
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
1. Monitoring of EC and <i>Enterococci</i> in water									■	■	■	
2. Dry-weather discharge reconnaissance									■	■	■	
3. Monitoring of EC and <i>Enterococci</i> in sediment									■	■	■	
4. Flow measurements									■	■	■	

## REFERENCES

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