Total Maximum Daily Loads for Indicator Bacteria in the Houston Metropolitan Area

Contract No. 582-6-70860
Work Orders No. 582-6-70860-04 and 582-6-70860-07

Quarterly Report No. 2

Prepared by
University of Houston

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PREPARED IN COOPERATION WITH THE
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CHAPTER 1

INTRODUCTION

1.1 PROBLEM STATEMENT

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 that are established within Texas Water Code, §26.023 and Title 30 Texas Administrative 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 in this project are on the 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 twenty-seven (27) impaired segments being addressed under this project are listed in Table 1.1 and their locations are shown in Figure 1.1.

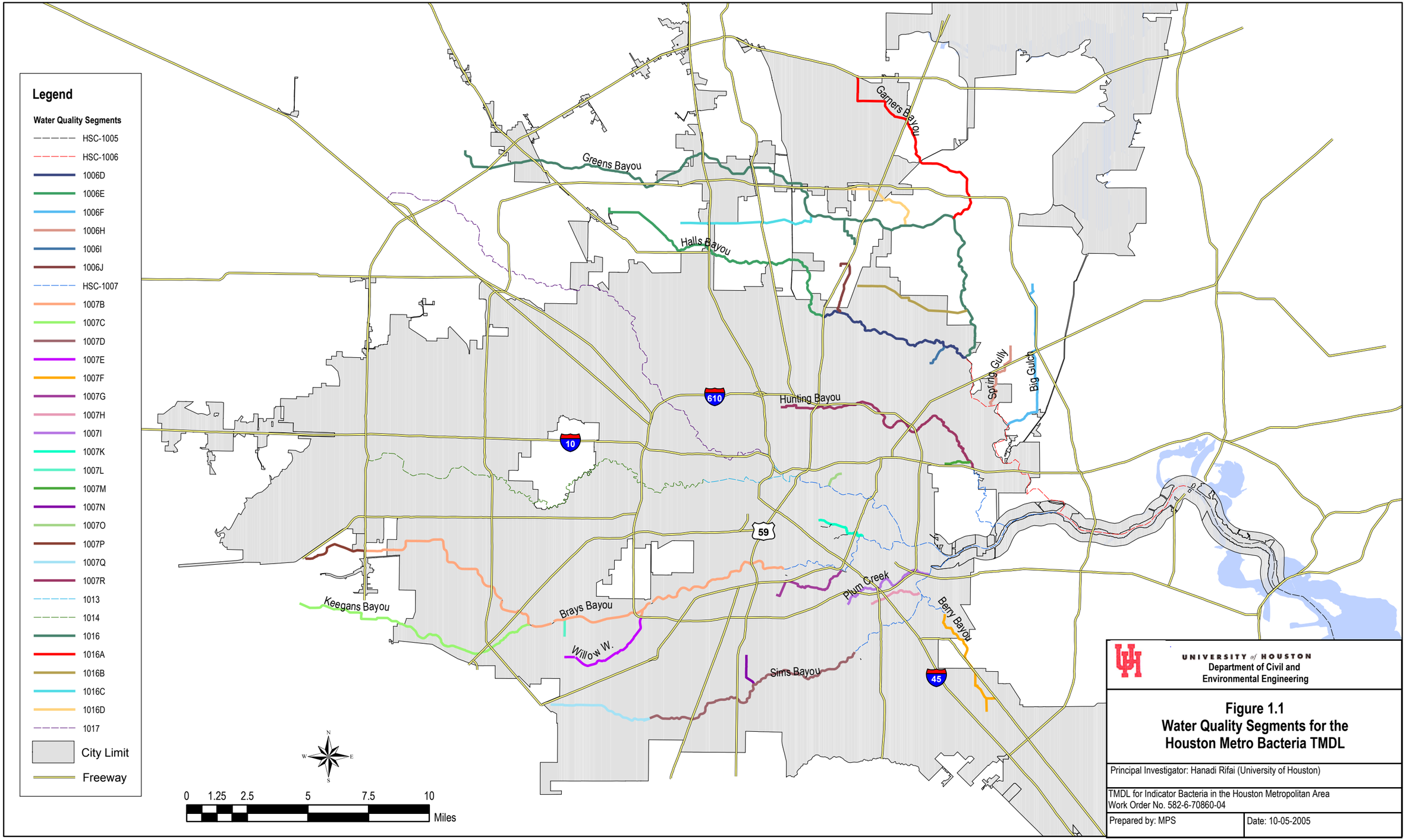

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Figure 1.1
Water Quality Segments for the Houston Metro Bacteria TMDL

Principal Investigator: Hanadi Rifai (University of Houston)

TMDL for Indicator Bacteria in the Houston Metropolitan Area
Work Order No. 582-6-70860-04

Prepared by: MPS

Date: 10-05-2005

Table 1.1 TMDL Segments

Segment Number	Segment Name
1006D	Halls Bayou below US 59
1006E	Halls Bayou above US 59
1006F	Big Gulch Above Tidal
1006H	Spring Gully Above Tidal
1006I	Unnamed Tributary of Halls Bayou
1006J	Unnamed Tributary of Halls Bayou
1007B	Brays Bayou Above Tidal
1007C	Keegans Bayou above tidal
1007D	Sims Bayou Above Tidal
1007E	Willow Waterhole Bayou Above Tidal
1007F	Berry Bayou Above Tidal
1007G	Kuhlman Gully Above Tidal
1007H	Pine Gully Above Tidal
1007I	Plum Creek Above Tidal
1007K	Country Club Bayou
1007L	Unnamed Non-Tidal Tributary of Brays Bayou
1007M	Unnamed Non-Tidal Tributary of Hunting Bayou
1007N	Unnamed Non-Tidal Tributary of Sims Bayou
1007O	Unnamed Non-Tidal Tributary of Buffalo Bayou
1007P	Brays Bayou Above Tidal
1007Q	Sims Bayou Above Tidal
1007R	Hunting Bayou Above Tidal
1016	Greens Bayou Above Tidal
1016A	Garners Bayou
1016B	Unnamed Tributary of Greens Bayou
1016C	Unnamed Tributary of Greens Bayou
1016D	Unnamed Tributary of Greens Bayou

The overall objective of this project is to develop the TMDL allocation equation for the segments listed above. An important part of this objective is to determine the data analysis technique that will be used for determining and supporting the TMDL allocation equation. An extensive study of the Buffalo and Whiteoak watersheds has been conducted by UH for the development of the TMDL allocation equation for bacteria. The information and experience gained from the previous TMDL study is being used to expedite the development of the TMDL allocation.

There are three main tasks to be completed for WO 582-6-70860-04:

1. Project administration;
2. Participation in stakeholder process; and
3. Determination of Project Strategy.

In addition, data gathering and sampling activities to support the development of TMDLs for indicator bacteria in the segments listed above will be conducted under WO 582-6-70860-07. The goal of the data gathering activity is two-fold: (i) to complete an assessment of the fecal pathogen and E. coli levels and trends in the project watersheds based on historical data, and (ii) to prepare an inventory of major sources and fate and transport of E. coli and fecal contamination in the target waterbodies based on historical data. The goal of the sampling effort is to provide sufficient data for the development of Load Duration Curves (LDC) to support TMDL development.

There are four main tasks to be completed for WO 582-6-70860-07:

1. Administer project;
2. Participate in stakeholder process;
3. QAPP/Sampling Plan/Data Management; and
4. Data Collection

1.2 DESCRIPTION OF THE REPORT

This document constitutes the second quarterly report for Work Orders No. 582-6-70860-04/582-6-70860-07 of the Bacteria in the Houston Metropolitan Area TMDL Project and summarizes the activities undertaken by the University of Houston during the period December 1, 2005 to February 28, 2006.

This report reflects the progress made towards the following subtasks delineated in the Project Work Plans:

Subtask 3.4.1/WO4 - Assess the fecal pathogen and *E. coli* levels and trends in the project watersheds based on historical data.

Subtask 3.1/WO7 – Submit a detailed Sampling Plan.

Subtask 3.2/WO7 – Prepare and submit for approval a draft and final QAPP prior to the first scheduled monitoring event.

Subtask 4.1/WO7 – Conduct data collection activities to complete an assessment of the fecal pathogen and *E. coli* levels and trends in the project watersheds.

Statistical analyses to determine temporal trends and differences in datasets collected under different flow conditions are presented in Chapter 2. Chapter 3 presents a detailed sampling plan for the activities to be conducted in 2006. A description of the activities completed towards the development of a Quality Assurance Project Plan (QAPP) for this study is included in Chapter 4. Finally, a summary of activities as well as a list of activities to be conducted in the next quarter of the project is presented in Chapter 5.

CHAPTER 2

REVIEW OF HISTORICAL INDICATOR BACTERIA DATA

This section describes the analysis of historical monitoring data for the Houston Metro area watersheds. The analysis focused on data collected by four different sources: the Texas Commission on Environmental Quality (TCEQ), the City of Houston, Houston-Galveston Area Council (HGAC), and data collected through Senate Bill 835. The four listed agencies are the major sources that have performed continuous monitoring of the bayous.

A statistical test (*t*-test) was first conducted to determine if data sets obtained from the different organizations were significantly different. This evaluation is important in deciding whether the data sets could be combined for analysis or they should be treated independently. Subsequently, the data were analyzed for temporal trends and spatial patterns. Analyses were also performed to demonstrate the effect of flow on EC concentrations. Spatial analyses are not included in this report since they were discussed in the first quarterly report.

2.1 COMPARISON OF DATASETS COLLECTED BY DIFFERENT AGENCIES

Figure 2.1 shows the locations of the sampling stations that have historical bacteria data. Time series for the various stations were plotted by reporting agency in order to complete a visual screening of differences among the datasets. Time series for segments 1007, 1006, and 1016 are shown in Figures 2.2, 2.3, and 2.4, respectively.

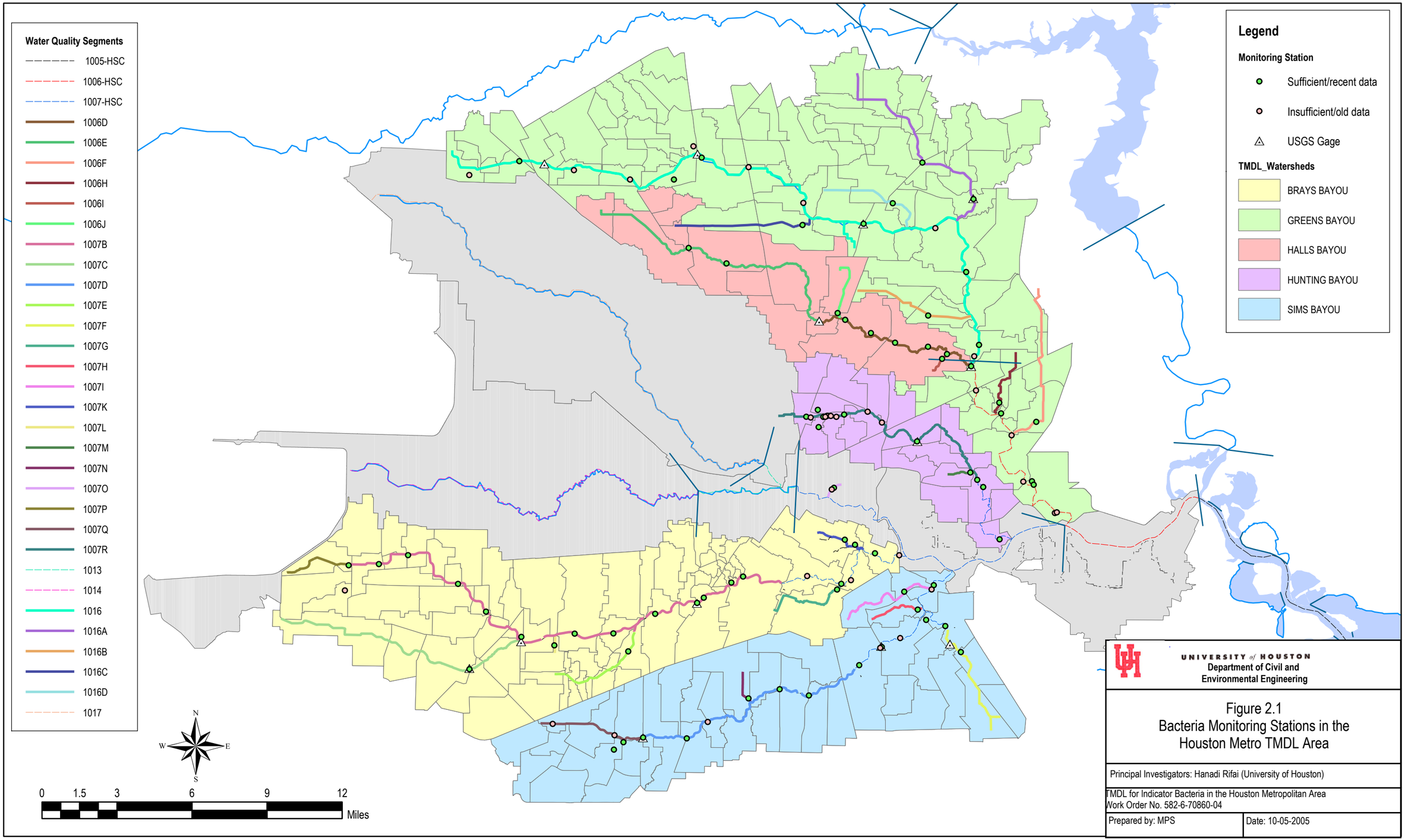

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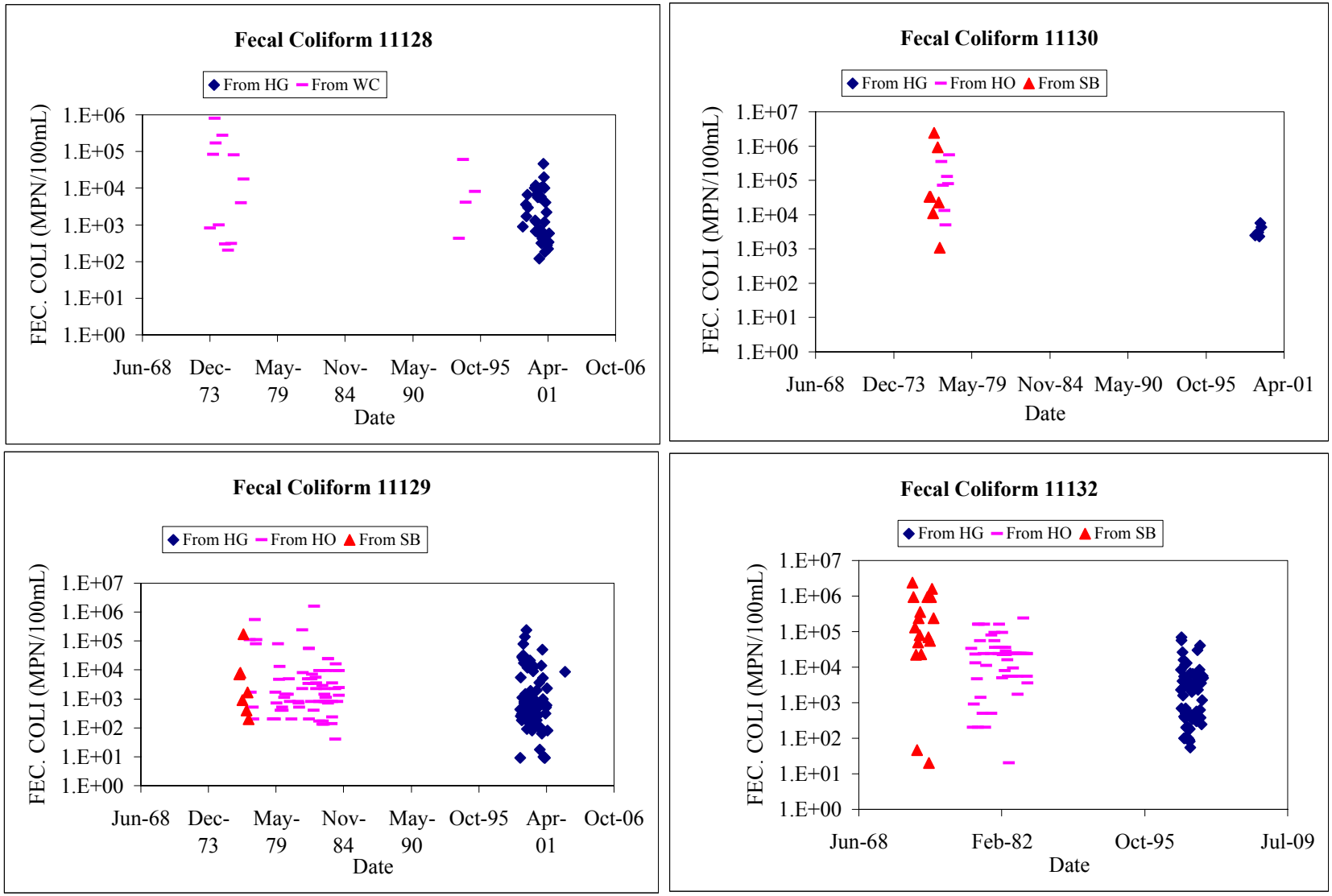
Figure 2.1
Bacteria Monitoring Stations in the Houston Metro TMDL Area

Principal Investigators: Hanadi Rifai (University of Houston)

TMDL for Indicator Bacteria in the Houston Metropolitan Area
Work Order No. 582-6-70860-04

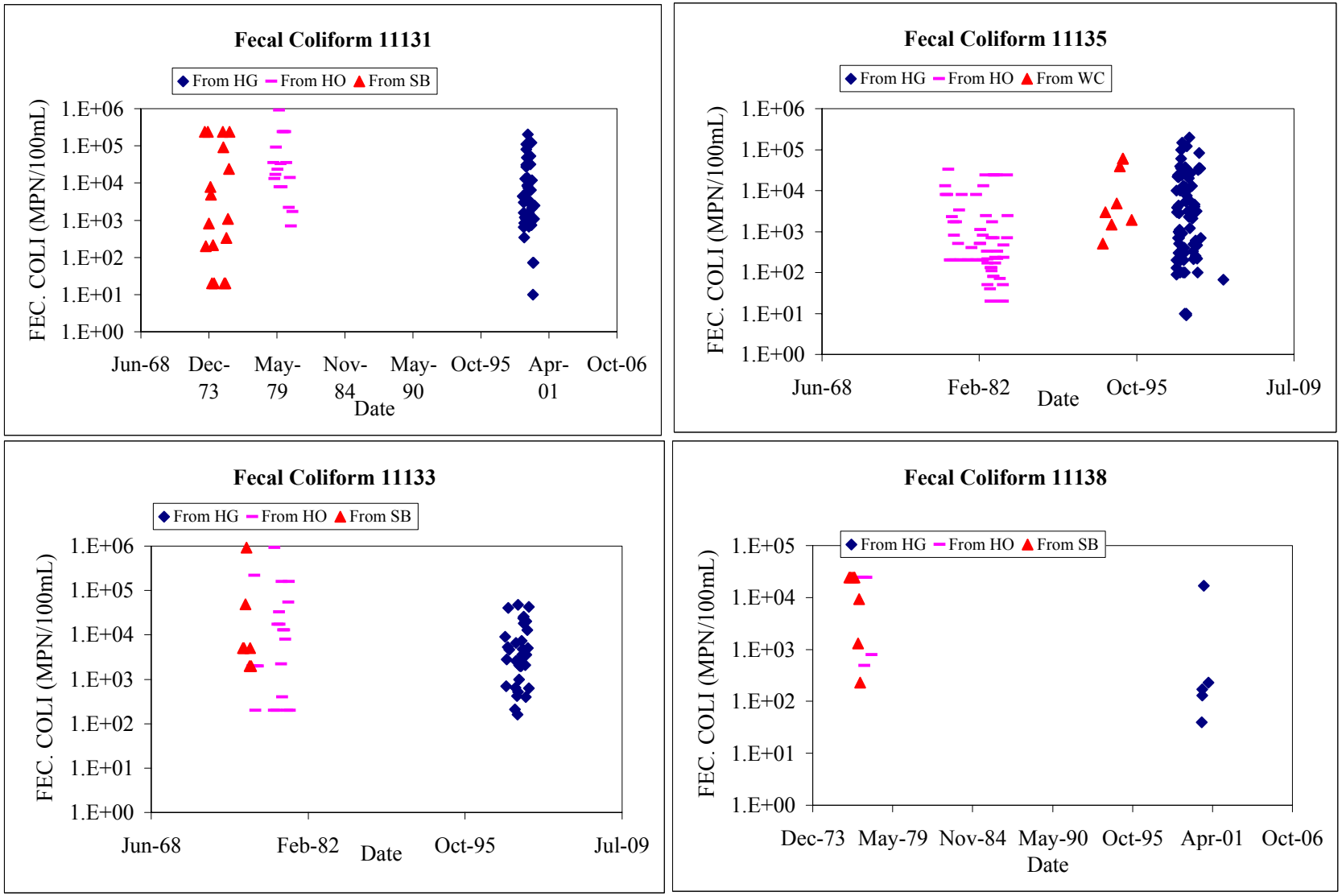
Prepared by: MPS

Date: 10-05-2005



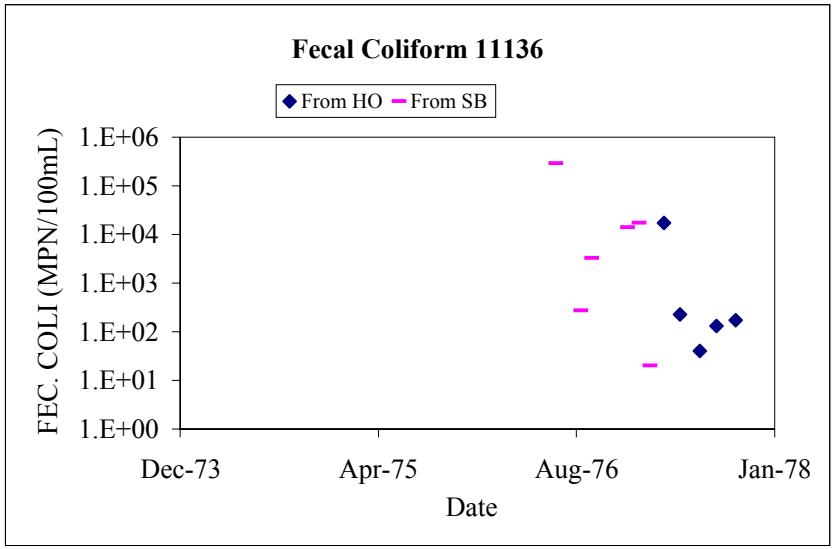
HG=H-GAC, WC=TCEQ, HO=City of Houston, SB=Senate Bill 835

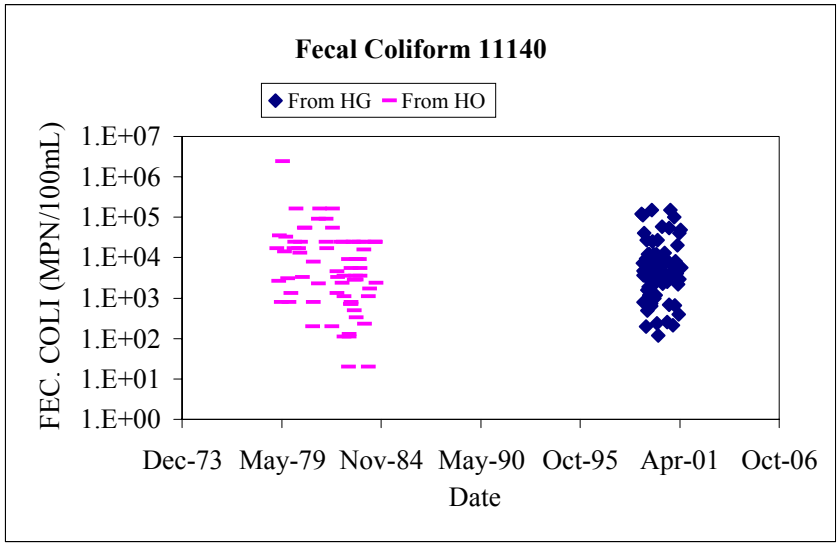
Figure 2.2 Time Series of Indicator Bacteria in Segment 1007

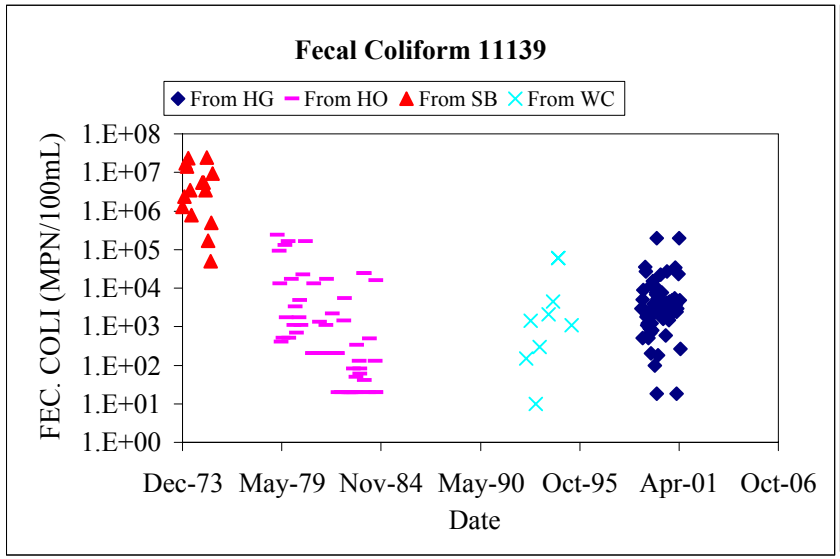


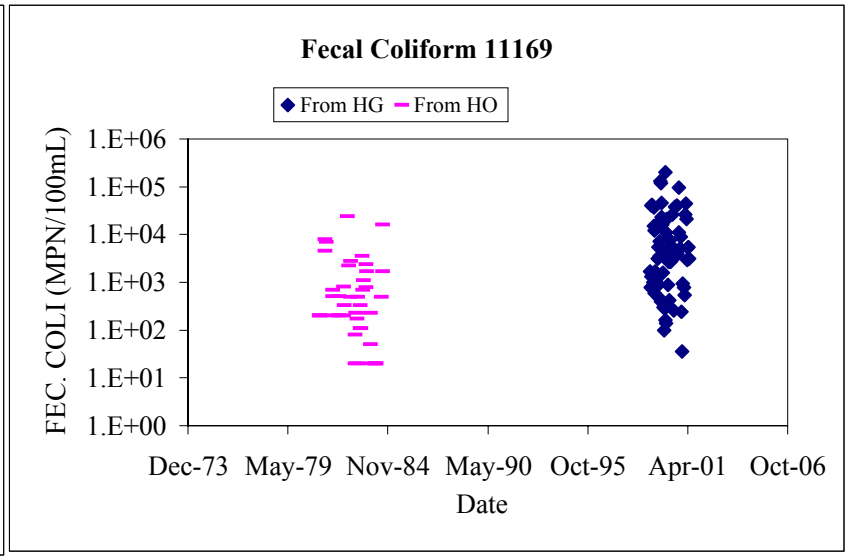
HG=H-GAC, WC=TCEQ, HO=City of Houston, SB=Senate Bill 835

Figure 2.2 Time Series of Indicator Bacteria in Segment 1007 - Cont'd









HG=H-GAC, WC=TCEQ, HO=City of Houston, SB=Senate Bill 835

Figure 2.2 Time Series of Indicator Bacteria in Segment 1007 - Cont'd

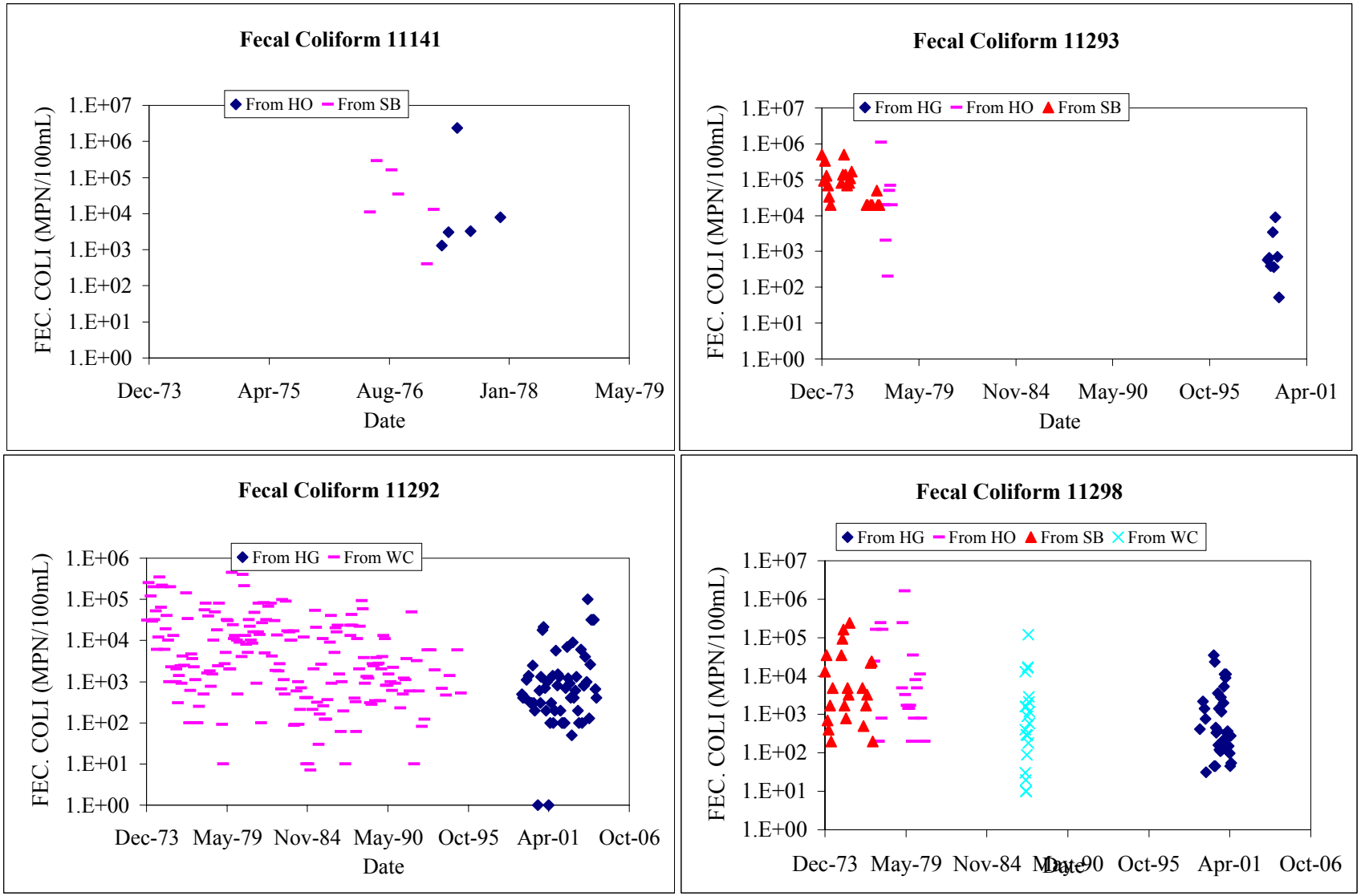


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Figure 2.2 Time Series of Indicator Bacteria in Segment 1007 - Cont'd

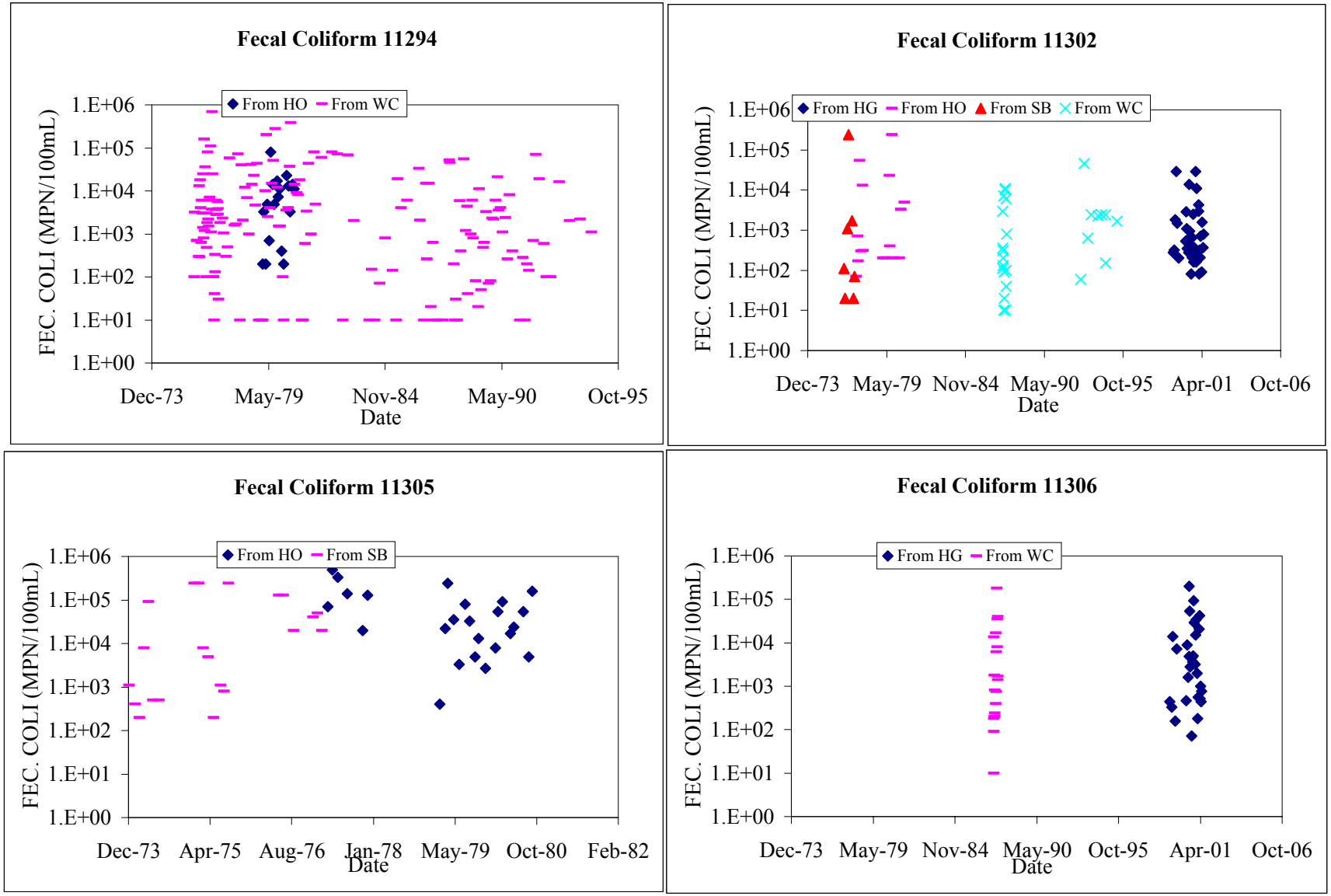

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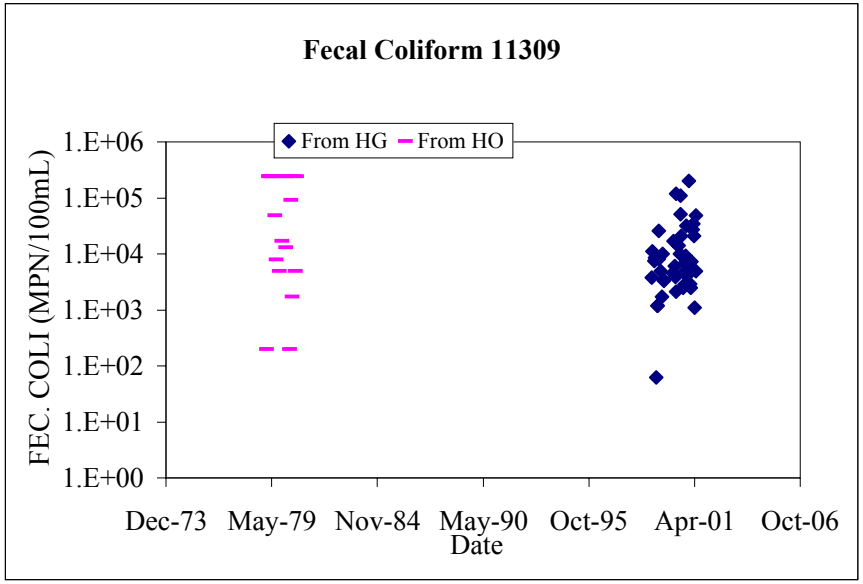
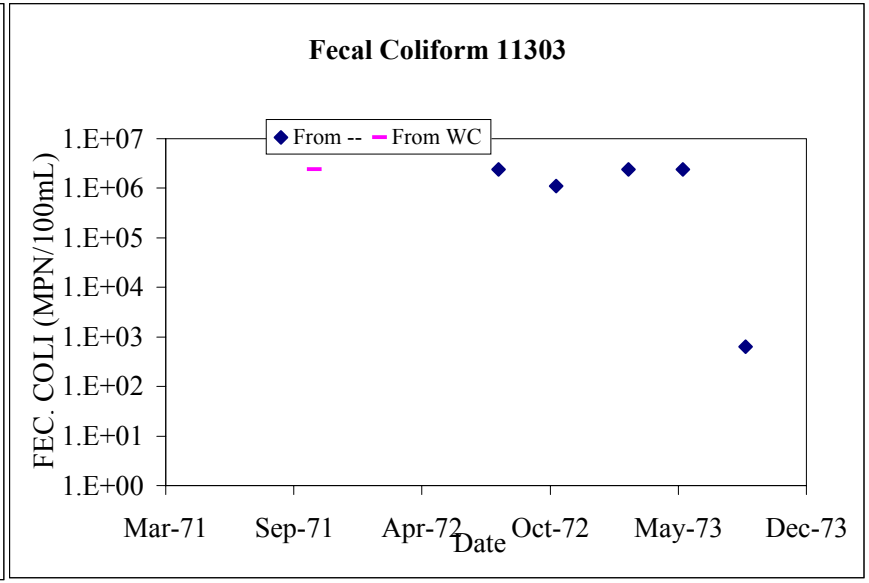
Figure 2.2 Time Series of Indicator Bacteria in Segment 1007 - Cont'd





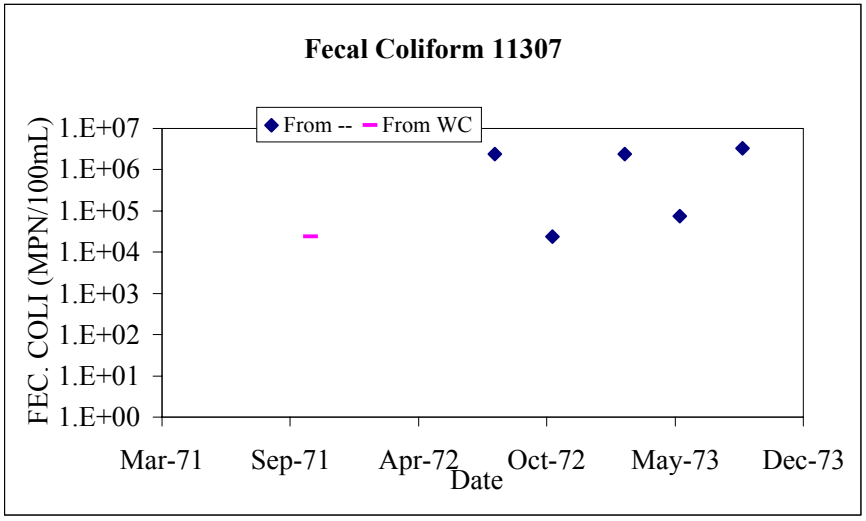


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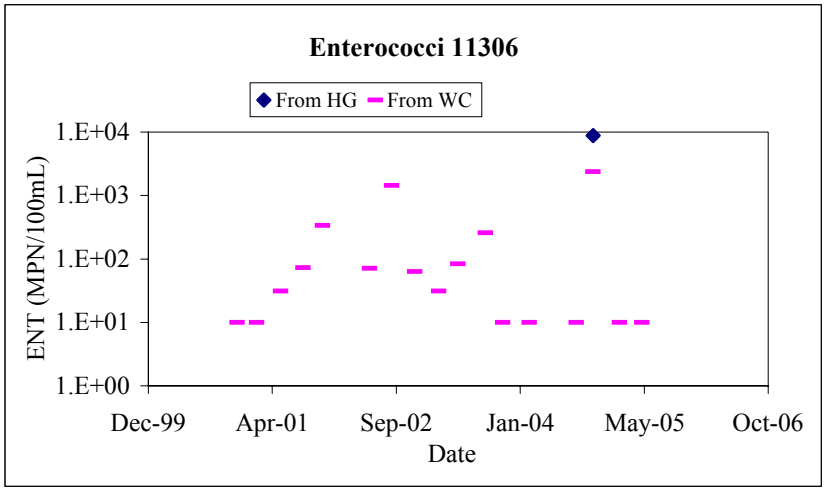
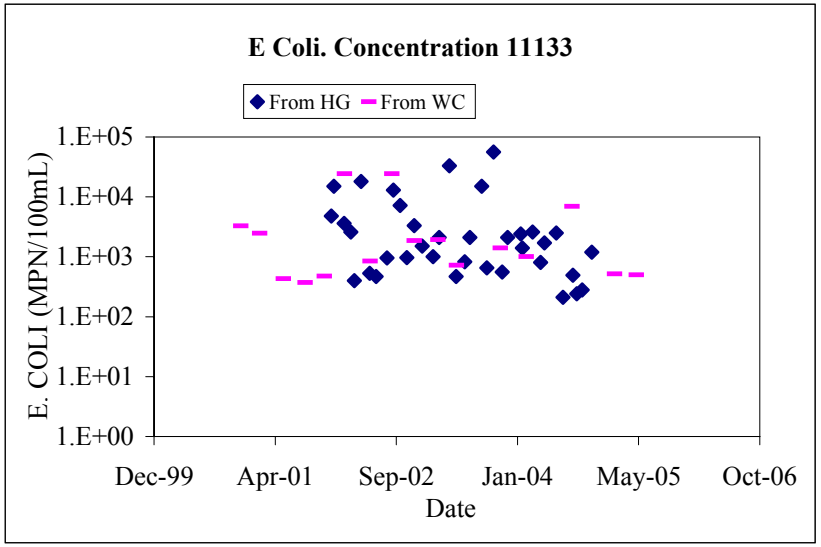
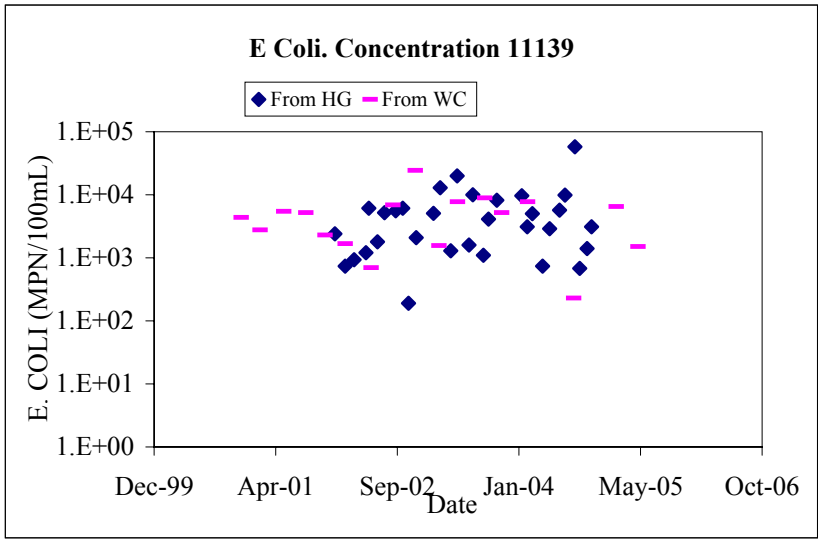
Figure 2.2 Time Series of Indicator Bacteria in Segment 1007 - Cont'd

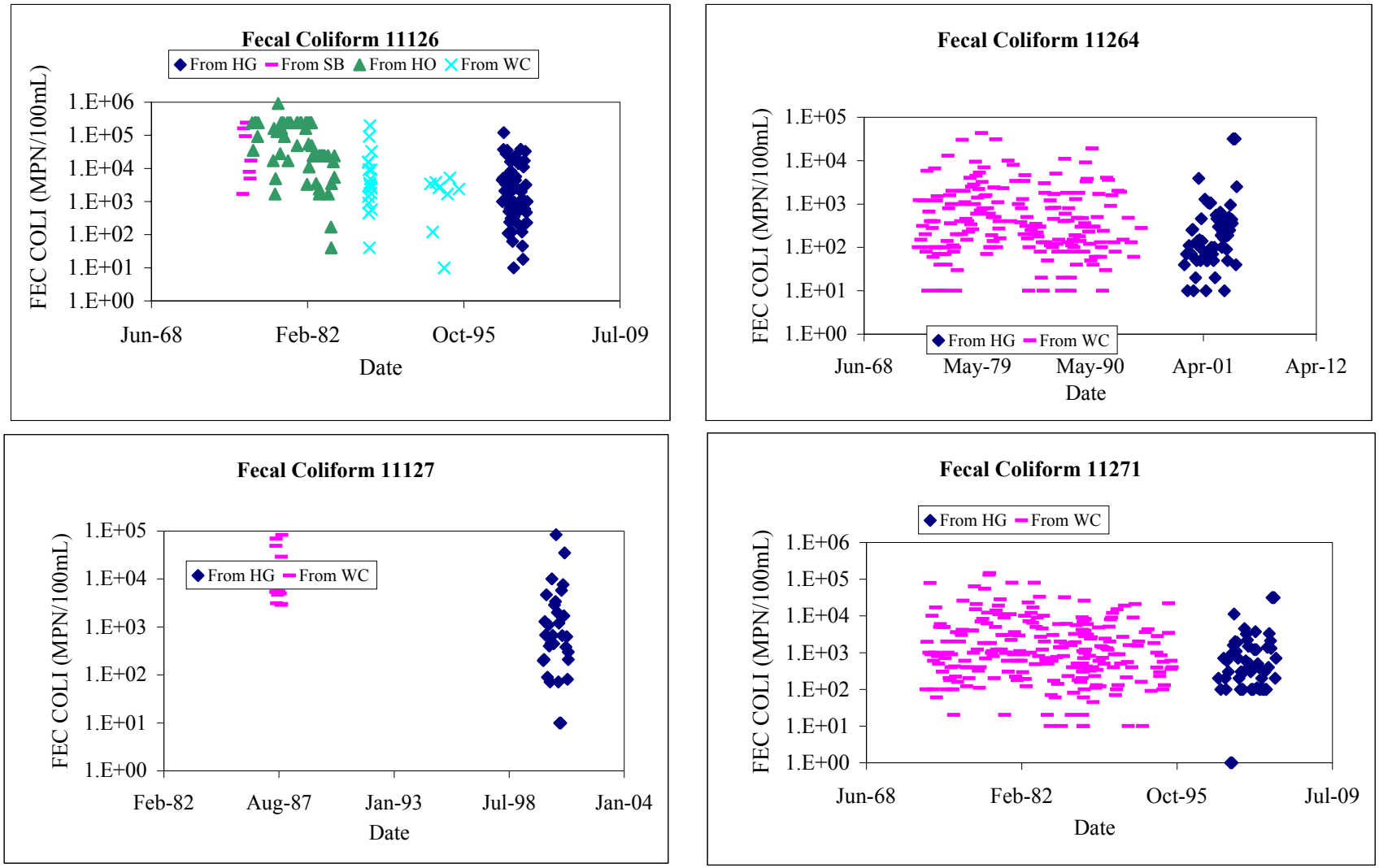






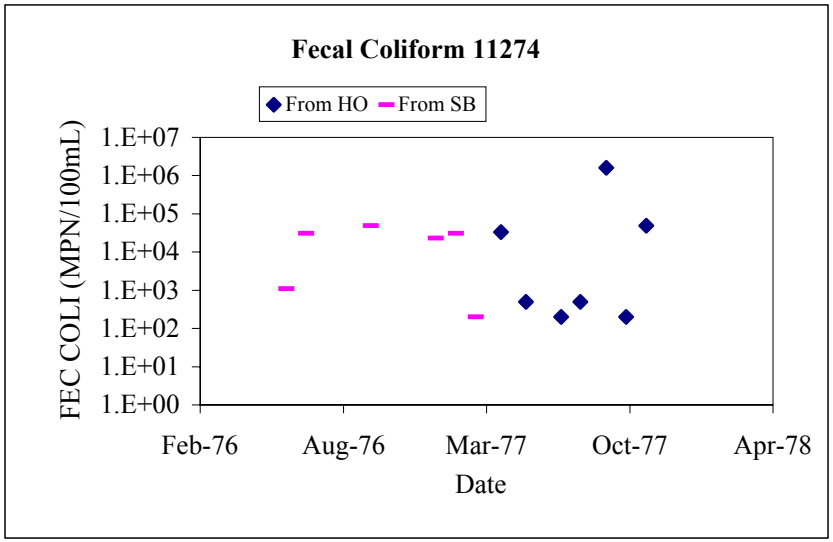
HG=H-GAC, WC=TCEQ, HO=City of Houston, SB=Senate Bill 835

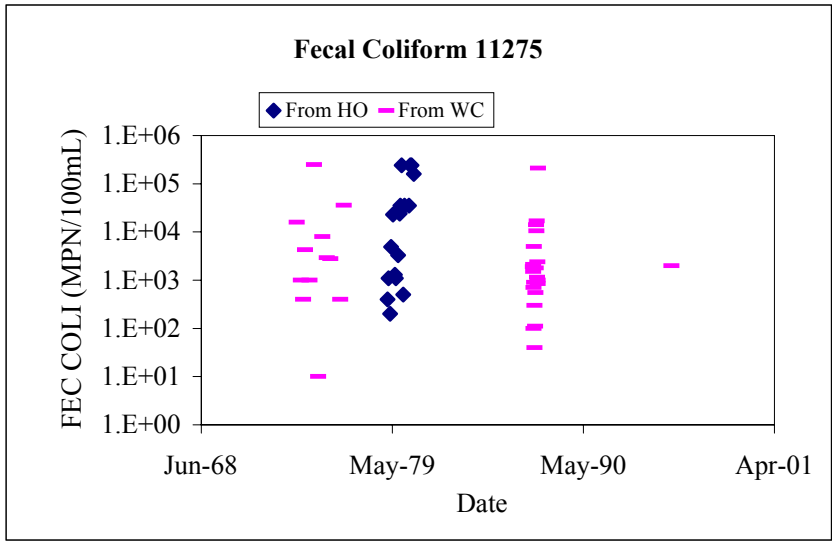
Figure 2.2 Time Series of Indicator Bacteria in Segment 1007 - Cont'd

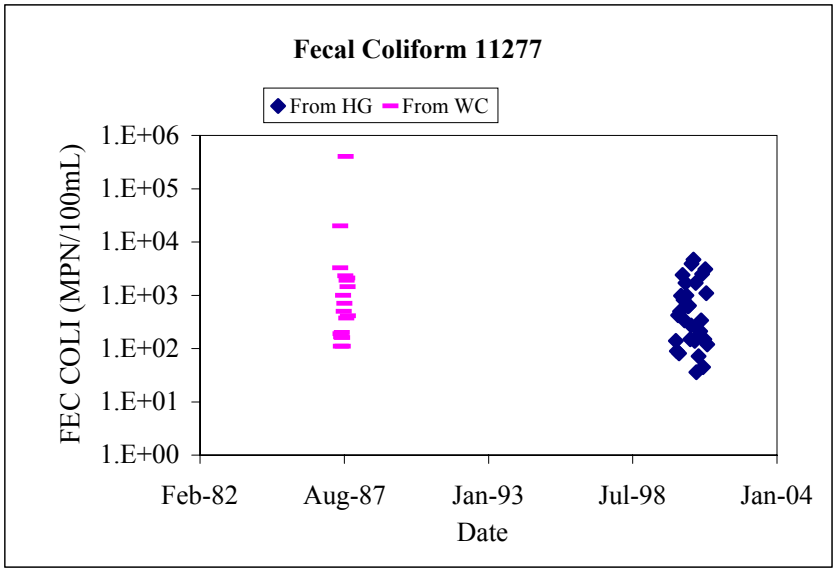


HG=H-GAC, WC=TCEQ, HO=City of Houston, SB=Senate Bill 835

Figure 2.3 Time Series of Indicator Bacteria in Segment 1006







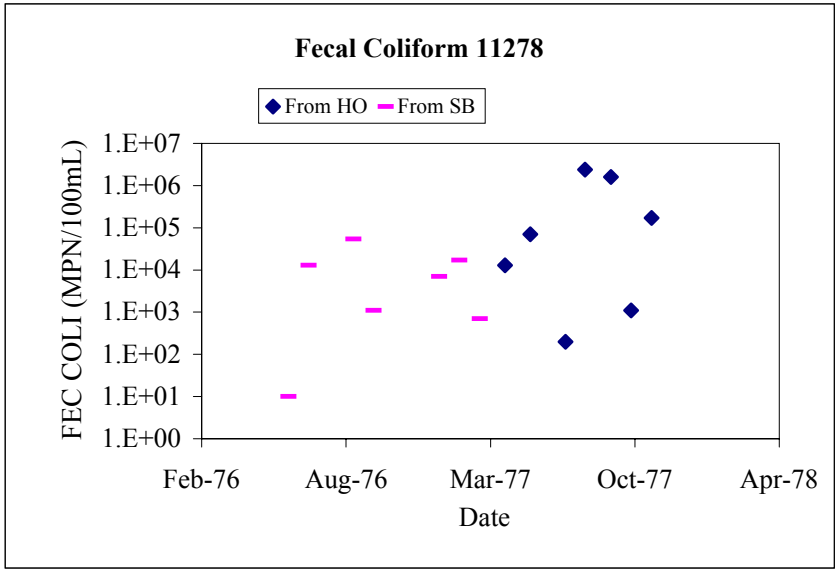


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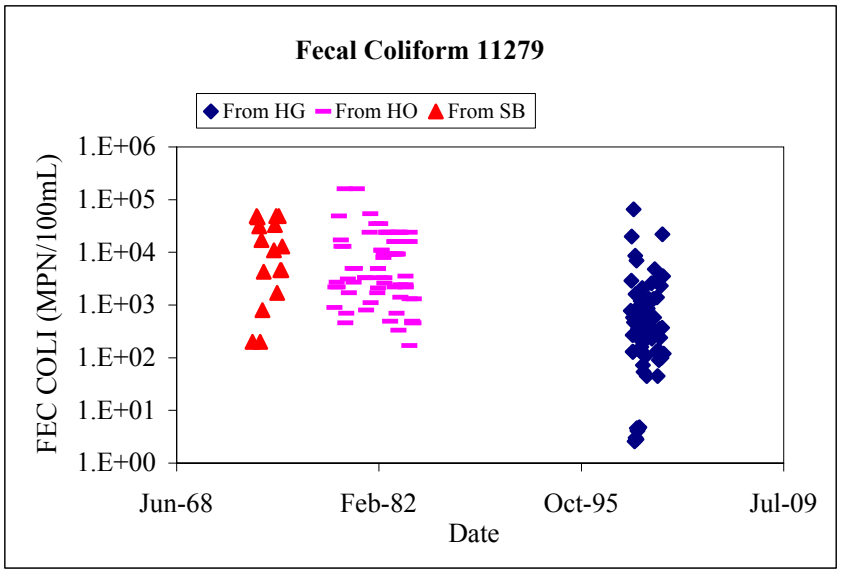
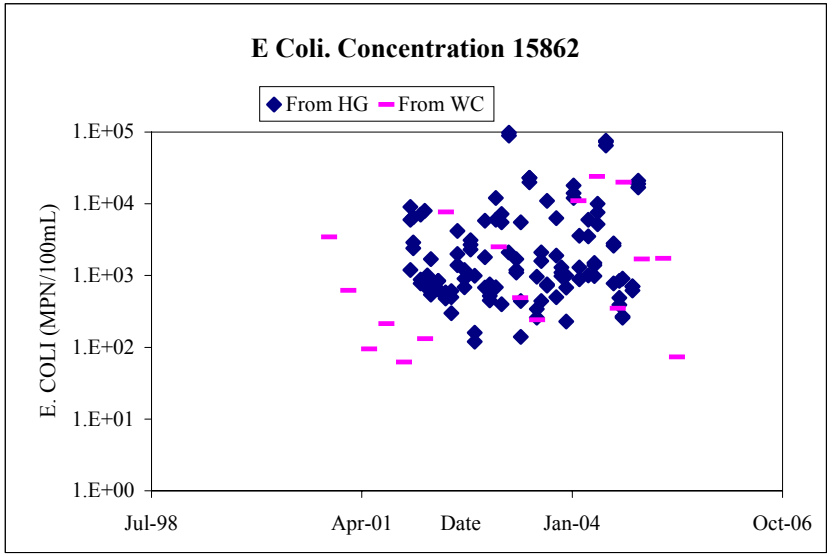
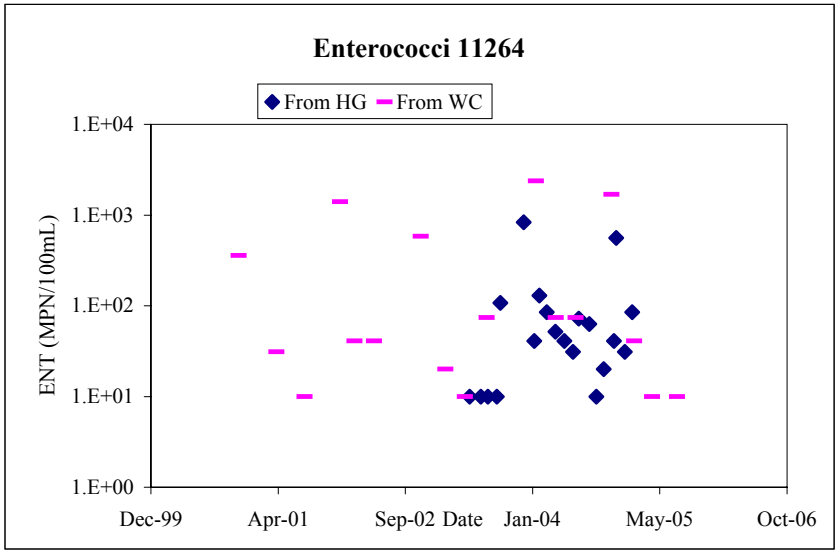
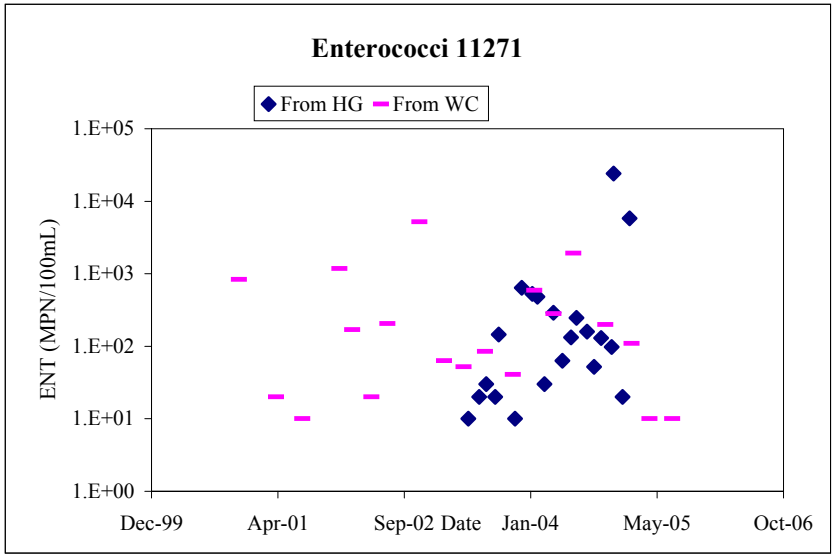
Figure 2.3 Time Series of Indicator Bacteria in Segment 1006 - Cont'd



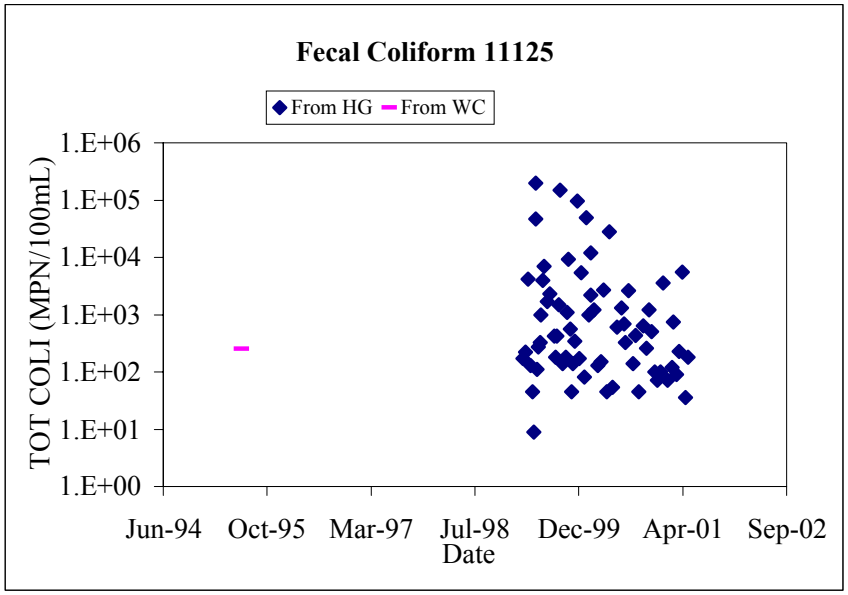


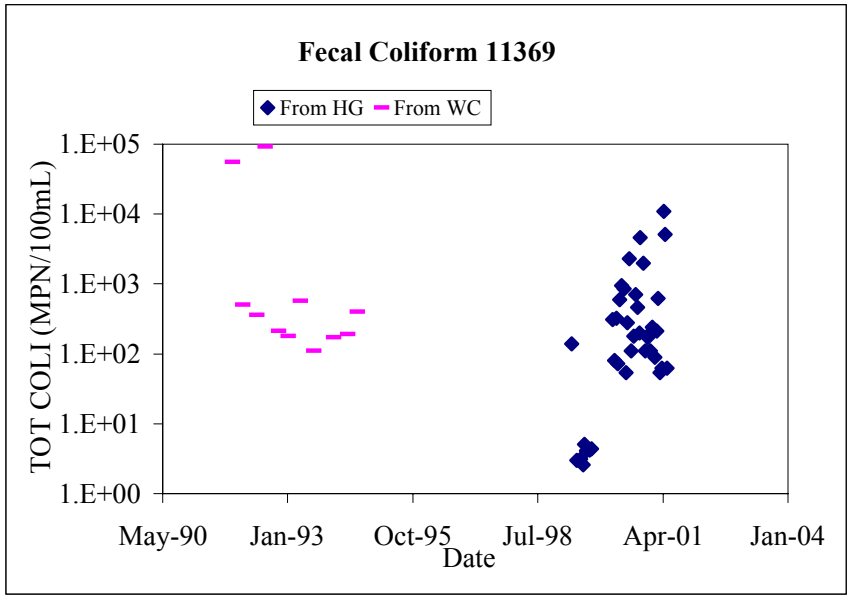


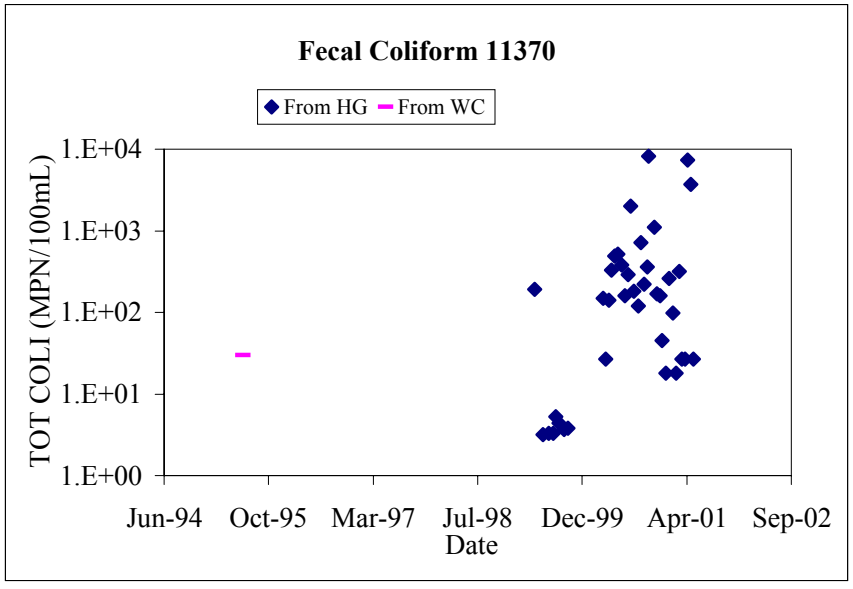


HG=H-GAC, WC=TCEQ, HO=City of Houston, SB=Senate Bill 835

Figure 2.3 Time Series of Indicator Bacteria in Segment 1006 - Cont'd







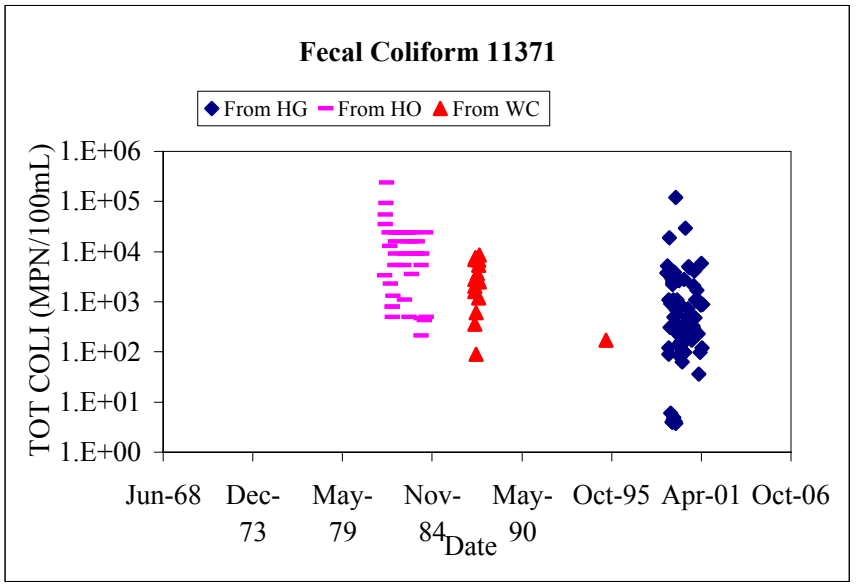


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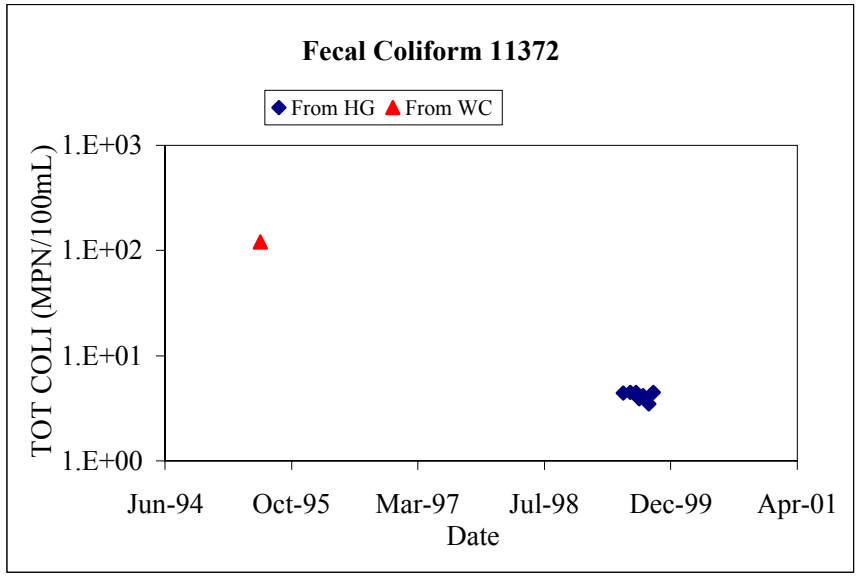
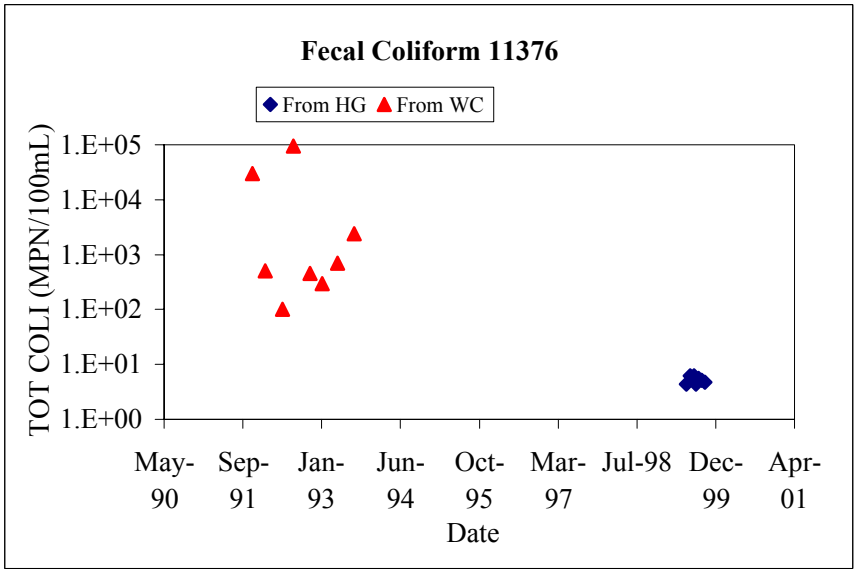
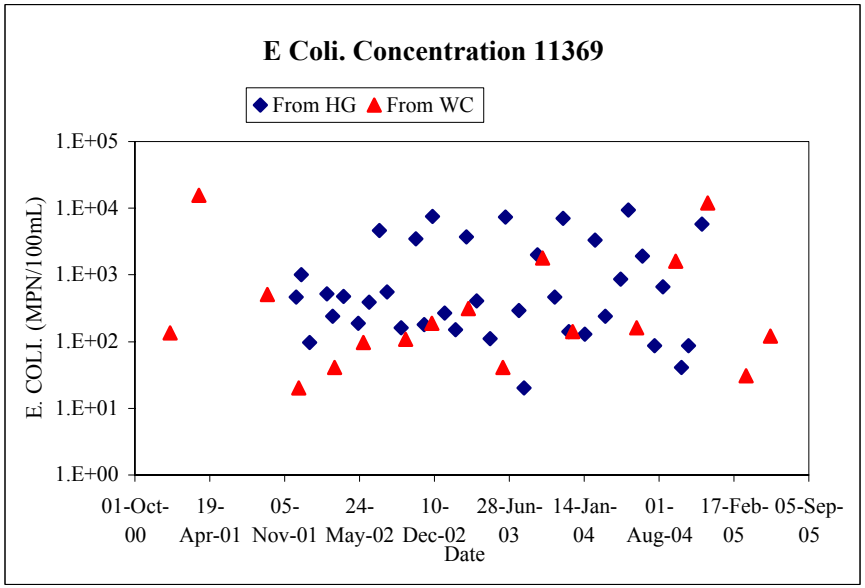
Figure 2.4 Time Series of Indicator Bacteria in Segment 1016







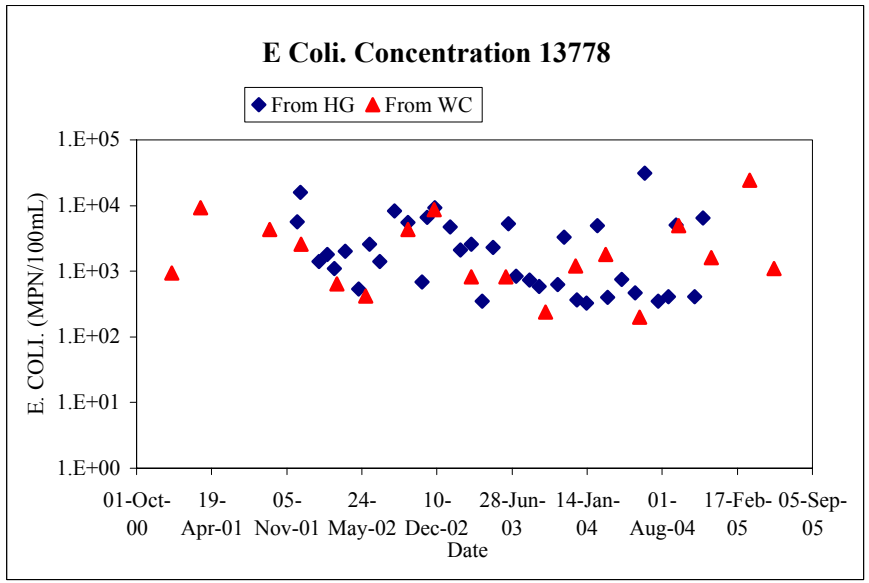
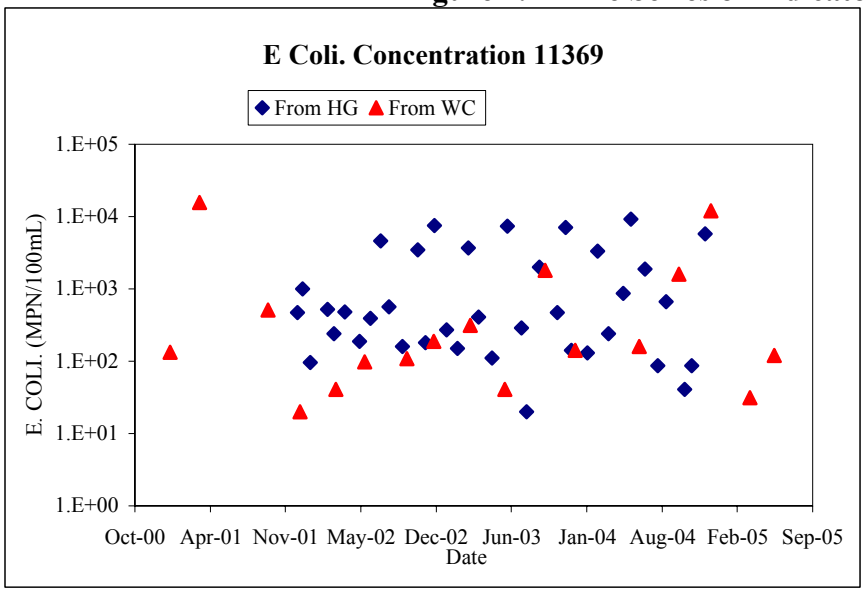
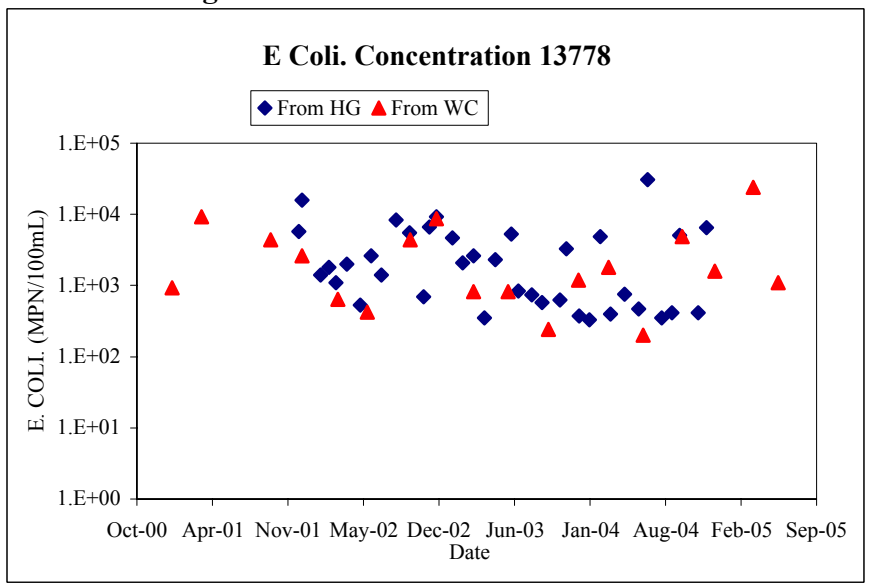


Figure 2.4 Time Series of Indicator Bacteria in Segment 1016 - Cont'd





HG=H-GAC, WC=TCEQ, HO=City of Houston, SB=Senate Bill 835

Figure 2.4 Time Series of Indicator Bacteria in Segment 1016 - Cont'd

Visual inspection of the time series plots indicates that for most of the stations, there does not appear to be a significant difference in the datasets collected by the different agencies. This observation, however, needed to be confirmed by statistical testing.

A *t*-test comparing the means of the different datasets was conducted and the results are summarized in Table 2.1. For the statistical tests the null hypothesis is that there is no significant difference between the means of the data. The level of confidence selected was 95%. It can be seen in Table 2.1 that for most of the stations the datasets did not show statistically significant differences, the only exceptions were stations 11132, 11135, 11139, 11292, 11309, 11126, 11279, 11271, and 11371. It is noted, however, that the tests were not performed on log-normalized datasets. For the stations showing differences between datasets from different agencies, the test was repeated on log-normalized data. In this latter case, the datasets collected for the various agencies did not appear to be significantly different. The log-transformation is justified by the fact that the geometric mean is the parameter to be used to compare to the water quality standard.

Based on this analysis, it would appear that data from all agencies could be grouped. Even then care will need to be taken to assure proper comparisons because at least one agency, the TCEQ, appears to have changed monitoring strategies in recent years.

2.2 TEMPORAL ANALYSIS

The temporal analysis was conducted to determine if correlations existed between indicator concentrations and time. Linear regressions were performed on the log-transformed data and significance was evaluated at a 95% confidence level (α=0.05), assuming the data are normally distributed. The regression analysis was performed for

Table 2.1 Statistical Comparison of Means between Datasets Collected by Different Agencies

Segment	Station ID	HG vs WC	HG vs HO	HG vs SB	HO vs SB	HO vs WC	SB vs WC
	Fecal Coliform						
	11128	0.1014					
	11129		0.1780	0.5087	0.6721		
	11130		0.0710	0.2068	0.3936		
	11131		0.1057	0.0928	0.4253		
	11132		0.0000	0.0120	0.0168		
	11133		0.1385	0.3496	0.6260		
	11135	0.6933	0.0010			0.1055	
	11136				0.3346		
	11138		0.0687	0.0598	0.9360		
	11139	0.7395	0.5381	0.0031	0.0031	0.9189	0.0031
1007	11140		0.2771				
	11141				0.4548		
	11292	0.0000					
	11293		0.2775	0.0006	0.8934		
	11294					0.1068	
	11298	0.3638	0.1455	0.0407	0.2719	0.1698	0.1475
	11302	0.8230	0.2552	0.3920	0.6794	0.2703	0.3990
	11305				0.9286		
	11306	0.8532					
	11309		0.0010				
	E. coli						
	11133	0.6809					
	11139	0.6997					
	Fecal Coliform						
	11126	0.3066	0.0000	0.1049	0.3296	0.0000	0.1482
	11279		0.0006	0.0033	0.3802		
	11127	0.0678					
	11277	0.3090					
	11274				0.3738		
	11278				0.1599		
1006	11264	0.8080					
	11271	0.0146					
	11275					0.0908	
	E. coli						
	15864	0.8712					
	Enterococci						
	11264	0.1235					
	11271	0.4135					
	Fecal Coliform						
	11369	0.1985					
	11371	0.9590	0.0040			0.0033	
1016	11376	0.2128					
	E. coli						
	11369	0.9356					
	13778	0.9674					

Probability values less than 0.05 are in red font, indicating significant statistical difference between the data compared.
HG=H-GAC, WC=TCEQ, HO=City of Houston, SB=Senate Bill 835

segments 1007, 1006, and 1016 within the watershed. For fresh water streams, EC data were used, while for tidal streams Enterococci data were included in the analysis. In the absence of sufficient data, fecal coliform data were used, whenever possible.

Segment 1007 Analysis

Time-series of indicator bacteria for this segment are shown in Figure 2.2. This section presents the statistical analysis to warrant any correlations that may exist between indicator bacteria concentrations and time. Segment 1007 contains freshwater streams and, thus, the analysis is presented for EC data. The trend values and probability associated with these have been included in Table 2.2. For stations, which did not have sufficient EC data, the FC data were used in the analysis. A summary of the statistics for the temporal analysis is also presented in Table 2.2. Most of the stations within the segment showed no significant trends, with the exception of stations 11307, 16620 (1007) and 11133 (1007D). Station 11133 exhibited a decreasing trend although the correlation coefficient was very low (R^2= 0.296). In addition, station 11307 exhibited a decreasing trend but the dataset is too small to confirm the trend. Station 16620 exhibited a slightly increasing trend as suggested by the correlation coefficient (R^2=0.0855).

Segment 1006 Analysis

Regression analysis for segment 1006 revealed that the EC concentrations do not have a significant correlation with time except for station 11279 that exhibits a decreasing trend (Table 2.3). A significant correlation between indicator concentrations and time could not be evaluated, thus it may be concluded that like the other segments, that bacteria levels are not changing over time.

Table 2.2 Summary of Temporal Trends for Segment 1007

Segment	Station	Slope	Trend	P value	Indicator	No. Obs
1007	11306	-0.0001	Decreasing	0.7227	E.coli	36
	11307	-0.0002	Decreasing	0.0089	FC	22
	11299	-0.0002	Decreasing	0.4523	FC	35
	11298	0.0002	Increasing	0.6007	E.coli	36
	16620	0.0005	Increasing	0.0246	FC	59
	11302	-0.0002	Decreasing	0.5646	E.coli	37
1007B	11138	0.0001	Increasing	0.6905	E.coli	37
	11139	0.0000	Increasing	0.8258	E.coli	50
	11140	0.0001	Increasing	0.8707	E.coli	34
	15849	-0.0003	Decreasing	0.3933	E.coli	34
	15854	0.0002	Increasing	0.4023	E.coli	32
	15859	0.0002	Increasing	0.5835	E.coli	31
1007C	11169	-0.0001	Decreasing	0.6818	E.coli	34
1007D	11132	-0.0001	Decreasing	0.6797	E.coli	37
	15861	0.0023	Increasing	0.5187	FC	14
	15877	-0.0005	Decreasing	0.0937	E.coli	36
	15878	0.0002	Increasing	0.5409	E.coli	37
	11133	-0.0004	Decreasing	0.0382	E.coli	54
1007E	16652	0.0003	Increasing	0.5058	E.coli	32
1007F	16661	-0.0005	Decreasing	0.1460	E.coli	37
1007G	16653	-0.0006	Decreasing	0.2705	E.coli	37
1007H	16659	0.0001	Increasing	0.8483	E.coli	37
1007I	16658	-0.0009	Decreasing	0.0999	E.coli	37
1007K	16651	-0.0010	Decreasing	0.1145	E.coli	37
	16650	-0.0002	Decreasing	0.6208	E.coli	37
1007L	16654	-0.0001	Decreasing	0.6755	E.coli	34
1007M	16657	-0.0007	Decreasing	0.0852	E.coli	37
1007N	16655	-0.0001	Decreasing	0.8032	E.coli	36
1007O	16649	0.0000	Increasing	0.9939	E.coli	37
1007P	15848	-0.0006	Decreasing	0.0618	E.coli	33
1007Q	16656	-0.0001	Decreasing	0.6997	E.coli	36
	11135	-0.0002	Decreasing	0.6433	E.coli	36
	15875	-0.0006	Decreasing	0.1529	E.coli	36
1007R	15869	-0.0005	Decreasing	0.3286	E.coli	37

Highlighted cells indicate statistical significance (P<0.05)

Table 2.3 Summary of Temporal Trends for Segment 1006

Segment	Station	Slope	Trend	p value	Indicator	No. Obs
1006	11264	-0.0002	Decreasing	0.4572	Enterococci	38
	11275	-0.0001	Decreasing	0.2943	Fecal Coliform	50
	11279	-0.0002	Decreasing	0.0000	Fecal Coliform	161
	17154	-0.0010	Decreasing	0.0532	Enterococci	9
1006D	15864	0.0001	Increasing	0.6120	E.coli	61
	15863	0.0004	Increasing	0.2064	E.coli	39
	15862	0.0005	Increasing	0.2086	E.coli	38
	11127	0.0001	Decreasing	0.8147	E.coli	38
1006E	11126	0.0002	Increasing	0.5951	E.coli	39
1006F	16662	-0.0007	Decreasing	0.0832	E.coli	39
1006H	16663	-0.0003	Decreasing	0.2008	E.coli	39
1006J	16665	0.0003	Increasing	0.3708	E.coli	39

Highlighted cells indicate statistical significance (P<0.05)

Segment 1016 Analysis

The analysis for temporal variations for segment 1016 is presented in Table 2.4. A close observation of the results reveals that no significant trend is evident except for stations 13778 and 16676, which present a statistically significant trend. Overall based on the regression analysis conducted using the log transformed EC data, it may be concluded that temporal variations do not exist for this segment.

Table 2.4 Summary of Temporal Trends for Segment 1016

Segment	Station	Slope	Trend	p value	Indicator	No. Obs
1016	11369	0.00002	Increasing	0.9232	E.coli	59
	11370	0.0001	Increasing	0.8512	E.coli	39
	11376	0.0001	Increasing	0.6474	E.coli	37
	13778	-0.0004	Decreasing	0.0116	E.coli	59
1016A	11125	0.00004	Increasing	0.9155	E.coli	38
	16589	-0.00001	Decreasing	0.9670	E.coli	39
1016B	16590	-0.0006	Decreasing	0.1538	E.coli	39
1016C	11124	-0.0001	Decreasing	0.8321	E.coli	39
1016D	16676	0.0008	Increasing	0.0144	E.coli	39

Highlighted cells indicate statistical significance (P<0.05)

2.3 EFFECT OF FLOW ON INDICATOR CONCENTRATIONS

To determine the effect of flow conditions on bacterial concentrations, a statistical *t*-test was performed between the low flow and high flow data to estimate if significant differences exist between the data obtained at the two flow periods. This involved separating the data in two sets based upon the flow conditions under which the samples were collected. Since all the stations listed in the segment do not have USGS gages installed, for the analysis only those stations were picked where a USGS gage could be located sufficiently close to it. Flow measurements that were below the 50% or median flow were categorized as low flow conditions, while flow values that were between the median flow and the 90th percentile were separated as high flow data. Generally EC data were used, however, in the absence of sufficient EC data, FC data were used in the analysis. Geometric means were calculated for each station that had flow data obtained from the nearest USGS gage. Standard deviation across bacterial concentrations was also calculated to indicate the high variability associated with the data.

Segment 1007 Analysis

An inventory of data under low and high flow conditions is presented in Table 2.5. As observed in Table 2.5, the geometric mean ranges from 813 MPN/100 mL to 22,231 MPN/100mL for data collected under high flow conditions. The geometric means at all the stations analyzed for high flow are above the recommended standard for EC. This is also true for stations that were associated with low flow. Data were collected mainly under high flow periods for the stations in this segment. Thus, the observations for low flow were relatively few as compared to those under high flow. The results for the *t*-test are summarized in Table 2.6 and reveal that the indicator concentrations

observed for the low and high periods are not statistically different except for station 16657.

Table 2.5 Flow Analysis for Segment 1007

USGS gage	Station ID	Low Flow Data			High Flow Data		
		Obs Nos	GM	Std Dev	Obs Nos	GM	Std Dev
8075000	11138	5	EC data not available		23	2791	4524
	11139	10	EC data not available		38	6010	2892
	15855	Low Flow not reported			26	2394	5140
	15859	Low Flow not reported			29	2819	4437
8074810	11140	13	3463	27644	16	6764	10695
	15849	13	585	2313	16	990	1736
	15853	10	4170	23242	17	4501	32932
	15852	13	1966	3966	14	5012	12772
	15851	13	1709	17722	16	6027	27835
8074800	11169	No flow data available					
8075500	15877	No flow data available					
8075000	16652	Low Flow not reported			25	1310	49632
8075650	16661	No flow data available					
8075500	16655	13	709	577	15	813	35906
8075770	15869	10	30201	111631	20	22231	100866
8075000	16653	Low Flow not reported			23	1137	69715
8075500	11132	16	19218	422904	66	17082	301672
	11133	5	3865	94965	22	6490	267859
	11658	No flow data available					
8075000	16650	Low Flow not reported			23	5603	78689
	16651	Low Flow not reported			24	3599	76974
	16654	Low Flow not reported			23	1137	69715
8075770	16657	10	213	197	20	885	31047

Fecal coliform data were used for the highlighted stations

It is noted that because of the limited size of some datasets, the analyses may not be conclusive. Aside from this, the criteria for evaluating the low flow and high flow may also affect the number of observations that fall in either category. Based on the *t*-test analysis, it may be concluded that indicator concentrations are not correlated to flow conditions.

Table 2.6 *t*-test for low flow and high flow data for segment 1007

Station ID	*t* Stat	*t* Critical two-tail	*p* value
11140	-1.65	2.12	0.12
15849	-1.38	2.08	0.18
15851	-1.7	2.06	0.1
15852	-1.93	2.06	0.07
15853	-0.27	2.13	0.79
16655	-0.25	2.12	0.8
15869	0.84	2.08	0.41
16657	-2.8	2.06	0.01
11132	-0.06	2.12	0.95
11133	-0.67	2.78	0.54

Highlighted stations presented statistical significant differences between the two datasets.

Segment 1006 and 1016 Analysis

For most of the stations within segments 1006 and 1016 data were collected under high flows only, while for some stations no flow data were available. Thus, for these segments, a comparison could not be made between high flow and low conditions. Tables 2.7 and 2.8 show the inventory of data for segments 1006 and 1016, respectively.

Table 2.7 Low and High flow analysis for EC in segment 1006

USGS gage	Station ID	Low Flow Data			High Flow Data		
		Obs Nos	GM	Std Dev	Obs Nos	GM	Std Dev
8076700	11127	No flow data available					
	11264	No flow data available					
	16666	No flow data available					
	16667	No flow data available					
8076500	15862	Low flow not reported			29	1731	16725
	15863	Low flow not reported			30	2236	17950
	16665	Low flow not reported			30	1934	10193
	11126	Low flow not reported			82	12279	88601

Table 2.8 Low and high flow analysis for EC in segment 1016

USGS gage	Station ID	Low Flow Data			High Flow Data		
		Obs Nos	GM	Std Dev	Obs Nos	GM	Std Dev
8076000	11371	Low Flow not reported			28	1072	5546
	11369	Low Flow not reported			39	421	3315
	11124	Low Flow not reported			25	1429	22891
	16676	Low Flow not reported			26	1346	30432
8075900	13778	No flow data available					
	11376	No flow data available					
8076810	11125	Low Flow not reported			24	441	2227
	16589	Low Flow not reported			23	277	635

CHAPTER 3

DETAILED SAMPLING PLAN FOR ACTIVITIES TO BE CONDUCTED IN FY 2006

3.1 INTRODUCTION

As part of the Houston Metro TMDL project, the University of Houston and Parsons Water and Infrastructure will collect additional field data on concentrations of fecal pathogens in the segments of concern to provide sufficient data for the development of Load Duration Curves (LDCs) to support development of total maximum daily loads (TMDLs).

The listed Metro Area 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 the single sample exceedance criterion for EC (394MPN/dL) is exceeded on average in more than 80% of the samples. Most of the segments exhibit exceedances of the pathogen standards relatively frequently (Table 3.1).

3.2 MONITORING AND DATA COLLECTION

The monitoring program includes two major components: (1) data gathering including field reconnaissance and survey and (2) preliminary sampling. Flow and *E.coli* data will be collected as part of the preliminary sampling as discussed below.

Table 3.1 Exceedances of Indicator Standards for Proposed Locations in the Project Area

Station ID	Station Description	Segment	# Samples	Geometric Mean (MPN/dL)	# samples exceeding 394 MPN/dL	% Samples exceeding single sample criteria
TBD–1[a]	Halls Bayou at Mouth	1006D	0	-	-	-
16662	Big Gulch at Wallisville Rd	1006F	37	1766	27	73
16663	Spring Gully at Barnesworth D	1006H	37	643	27	73
16666	Trib Halls Bayou at Talton St	1006I	37	1852	33	89
16665	Trib Halls Bayou at Langley R	1006J	37	2083	33	97
11138	Brays Bayou at Almeda Rd	1007B	37	5078	36	97
11132	Sims Bayou at Telephone (SH35)	1007D	37	2014	36	97
16652	Willow Waterhole at Mcdermed	1007E	32	1761	25	78
16653	Kuhlman Gully at Brock St	1007G	37	1830	22	59
16659	Pine Gully at Old Galveston R	1007H	36	3994	30	83
16658	Plum Creek at Old Galveston R	1007I	37	7375	34	92
16650	Country Club Bayou at Wayside	1007K	37	6932	35	95
16657	Trib of Hunting Bayou at Ralston	1007M	37	661	24	65
16655	Trib of Hunting Bayou at Ralston	1007N	36	829	25	69
16649	Trib of Buffalo Bayou/Clinton Dr.	1007O	37	1289	27	73
15848	Brays Bayou at SH 6	1007P	33	918	23	70
11128	Hunting Bayou at IH 10	1007R	35	866	25	71
15438	Greens Bayou at El Dorado Golf Course	1016	1	-	-	-
TBD-2[a]	Unnamed trib of Halls Bayou at Mouth	1016B	0	-	-	-
11124	Unnamed trib of Greens Bayou	1016C	37	1283	32	86
16676	Unnamed trib of Greens Bayou	1016D	37	1655	29	78

[a] New station, station ID to be defined following submittal of a SLOC form.

3.2.1 *E.coli* Sampling

The TCEQ has adopted the use of *E. coli* (EC) concentrations as pathogen indicators in freshwater for current and proposed Texas water quality standards. Twenty-seven segments within the Houston Metro Area have been identified as "impaired" for contact recreation use and must meet the standards that have been set for this use. The sampling approach is designed to provide sufficient data for development of the load duration curves. Thus, in this TMDL, an intensive survey will be completed for obtaining flow and EC data in the twenty-one proposed locations. Preliminary locations for sampling are included in Figure 3.1. However, it is noted that the monitoring and data collection program is dynamic and may change as data are collected and analyzed. If the monitoring and data collection program is to change, TCEQ project management will be notified, and if necessary, the QAPP will be updated accordingly. In addition to EC, the samples will be tested for standard water quality parameters. Sampling frequencies and parameters are listed in Table 3.2.

3.2.2 Flow Measurements

While flow data for a number of USGS gages throughout the study area are available, there are no flow data available for the twenty-one stations proposed for intensive survey. The only exception is station 11132, however, recent flow data are not

Legend

Proposed Locations

USGS Gages

BASIN

- 1006
- 1006D
- 1006E
- 1006F
- 1006H
- 1006J
- 1007
- 1007B
- 1007C
- 1007D
- 1007E
- 1007F
- 1007G
- 1007H
- 1007I
- 1007K
- 1007L
- 1007M
- 1007N
- 1007P
- 1007Q
- 1007R
- 1016
- 1016A
- 1016B
- 1016C
- 1016D

8075900
8075780
8076180
16676
8076000
11124
15438
8076500
2
16666
1
8076700
16663
16662
8075770
16657
11128
16649
16650
15848
11138
16653
16658
16659
8075000
8074810
16652
8074800
11132
8075500
8075650
16655
8075400

N
W
E
S

0 1.5 3 6 9 12
Miles

UNIVERSITY of HOUSTON
Department of Civil and Environmental Engineering

Figure 3.1
Proposed Locations for Intensive Survey

Principal Investigators: Hanadi Rifai (University of Houston)

TMDL for Indicator Bacteria in the Houston Metropolitan Area
Work Order No. 582-6-70860-04

Prepared by: MPS

Date: 10-14-2005

Table 3.2 Monitoring Sites and Frequencies

Location ID	TCEQ Short Description	Segment	Monitoring frequencies				
			Field parameters[a]	Flow	*E. Coli* in water	Turbidity	TSS
TBD – 1[b]	Halls Bayou at Mouth	1006D	15-18	15-18	15-18	15-18	15-18
16662	Big Gulch at Wallisville Rd	1006F	15-18	15-18	15-18	15-18	15-18
16663	Spring Gully at Barnesworth D	1006H	15-18	15-18	15-18	15-18	15-18
16666	Trib Halls Bayou at Talton St	1006I	15-18	15-18	15-18	15-18	15-18
16665	Trib Halls Bayou at Langley R	1006J	15-18	15-18	15-18	15-18	15-18
11138	Brays Bayou at Almeda Rd	1007B	15-18	15-18	15-18	15-18	15-18
11132	Sims Bayou at Telephone (SH35)	1007D	15-18	15-18	15-18	15-18	15-18
16652	Willow Waterhole at Mcdermed	1007E	15-18	15-18	15-18	15-18	15-18
16653	Kuhlman Gully at Brock St	1007G	15-18	15-18	15-18	15-18	15-18
16659	Pine Gully at Old Galveston R	1007H	15-18	15-18	15-18	15-18	15-18
16658	Plum Creek at Old Galveston R	1007I	15-18	15-18	15-18	15-18	15-18
16650	Country Club Bayou at Wayside	1007K	15-18	15-18	15-18	15-18	15-18
16657	Trib of Hunting Bayou at Ralston	1007M	15-18	15-18	15-18	15-18	15-18
16655	Trib of Hunting Bayou at Ralston	1007N	15-18	15-18	15-18	15-18	15-18
16649	Trib of Buffalo Bayou/Clinton Dr.	1007O	15-18	15-18	15-18	15-18	15-18
15848	Brays Bayou at SH 6	1007P	15-18	15-18	15-18	15-18	15-18
11128	Hunting Bayou at IH 10	1007R	15-18	15-18	15-18	15-18	15-18
15438	Greens Bayou at El Dorado Golf Course	1016	15-18	15-18	15-18	15-18	15-18
TBD – 2[b]	Unnamed trib of Halls Bayou at Mouth	1016B	15-18	15-18	15-18	15-18	15-18
11124	Unnamed trib of Greens Bayou	1016C	15-18	15-18	15-18	15-18	15-18
16676	Unnamed trib of Greens Bayou	1016D	15-18	15-18	15-18	15-18	15-18

[a] Field parameters include temperature, DO, pH, conductivity, and flow severity

[b] TBD- to be defined following submittal of Station Location request form (SLOC). A SLOC request will be submitted once GPS readings are completed during reconnaissance activitie

available for this station as well. Thus, during water sample collection for EC, flow and velocity measurements will be made for all the stations included in this sampling plan as listed in Table 3.2, or as close to the sample location as possible taking into account stream access and sampling crew safety.

CHAPTER 4

QUALITY ASSURANCE PROJECT PLAN DEVELOPMENT

The goal of this task was to develop a Quality Assurance Project Plan (QAPP) for additional data collection that meet the needs for the TMDL. The QAPP is a document that describes the tasks, management, structure, and policies that will be implemented in the monitoring program for this project. The QAPP will ensure that the data collected under this work order will be reliable, scientifically valid, and legally defensible.

During the reporting period, the first draft of the QAPP was prepared based on the proposed sampling activities outlined in the previous chapter. Revision 0 of the QAPP (included in Appendix A) was submitted to the TCEQ on March 7, 2006. The project team is awaiting comments on this first draft.

CHAPTER 5

SUMMARY AND FUTURE ACTIVITIES

5.1 SUMMARY

During the second quarter of this TMDL project, the historical data collected during the previous quarter were analyzed to determine temporal trends and differences among data collected under different flow conditions.

Linear regressions of time-series of indicator bacteria for the majority stations located in the study area showed no statistically significant trends. Thus, it may be concluded that bacteria levels in the project area remain unchenged over time.

Statistical *t*-tests comparing indicator bacteria concentrations collected under low flow conditions (flows lower than the long term median flow) to those collected under high flow conditions (flows higher than the median and lower than the 90^{th} percentile) for stations in segment 1007 showed no significant difference between the two dataseries. Most of the data for segments 1006 and 1016 were collected under high flow conditions and, thus, the effect of flow on concentrations of indicator bacteria could not be assessed.

In addition to analysis of historical data, a detailed monitoring plan and a first draft of the Quality Assurance Project Plan for this TMDL study were completed and submitted to TCEQ.

5.2 PLANNED ACTIVITIES FOR THE THIRD QUARTER OF THE PROJECT TIME FRAME

During the period March 1 to May 31, 2006, the project team will be focusing on the following activities (numbered as they appear in the Work Plans for WO# 582-6-70860-04 and 07):

Subtask 3.4.2/WO4 - Prepare an inventory of major sources and fate and transport of E. coli and fecal contamination in the target waterbodies based on historical data.

Subtask 3.2/WO7 - Prepare and submit a revised QAPP to address comments received by TCEQ (if any) until the document is approved.

Subtask 4.1/WO7 - Conduct sample collecting in accordance with the approved QAPP.

APPENDIX A

QUALITY ASSURANCE PROJECT PLAN

(Electronic)