SMALL WATERSHED STUDY
FINAL REPORT
HOUSTON-GALVESTON AREA COUNCIL

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SMALL WATERSHED STUDY
FINAL REPORT

Prepared for:

Houston-Galveston Area Council

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and the Texas Commission on Environmental Quality
under the authorization of the Texas Clean Rivers Act

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Acronyms and Abbreviations

AMC	Antecedent Moisture Condition
BMP	Best Management Practices
CN	Runoff Curve Number
COC	Chain-of-Custody
CRP	Clean Rivers Program
FGDC	Federal Geographic Data Committee
GIS	Geographic Information System
GPS	Global Positioning System
HCFCD	Harris County Flood Control District
HCOEM	Harris County Office of Emergency Management
H-GAC	Houston-Galveston Area Council
HSG	Hydrologic Soil Group
LULC	Land Use/Land Cover
NRCS	National Resource Conservation Service
OHWM	Ordinary High Water Mark
PDA	Personal Digital Assistant
QAPP	Quality Assurance Project Plan
SSURGO	Soil Survey Geographical Database
TAG	Technical Advisory Group
TCEQ	Texas Commission on Environmental Quality
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
WWTP	Waste Water Treatment Plant

1.0 INTRODUCTION

PBS&J was retained by through funding provided by the Texas Clean Rivers Program, Houston-Galveston Area Council ("H-GAC"), on September 17, 2002, to conduct an investigation into the sources of ammonia and bacteria in small urban watersheds in the Houston area. Houston's urban watersheds experience elevated indicator bacteria concentrations that exceed the criteria for contact recreation. A TMDL study is being conducted on two major streams, Buffalo and White Oak Bayous, and most of the other urban streams have been listed for not meeting the criteria for contact recreation. H-GAC's 2001 Urban Bacteria Study notes that there are often higher concentrations of bacteria in the tributaries that feed the main stems of Buffalo and White Oak Bayous. According to the Texas Commission on Environmental Quality ("TCEQ") Draft 2002 305(b) Report, many of the tributaries that have high bacteria counts also contain high concentrations of ammonia.

In an effort to begin addressing the reduction of high levels of these constituents, H-GAC selected four small tributaries of varying land use types that flow into the main stem of Buffalo, White Oak, and Greens Bayous for additional study. These tributaries were:

- **Brickhouse Gully**, a highly urbanized tributary of White Oak Bayou
- **Garner's Bayou**, a mixed use tributary of Greens Bayou
- **Turkey Creek**, a tributary of Buffalo Bayou that flows through both undeveloped (park) and highly developed land
- **Mason Creek**, a highly residential tributary of Buffalo Bayou

1.1 WORK TASKS

Three objectives were identified for the project:

- To define a method of small watershed analysis that can be applied to similar watersheds to identify bacteria and ammonia sources and loadings
- To develop a water quality baseline data set to be used in future 319 NPS projects in the watersheds studied
- To provide information that can be used in future work to define possible NPS mitigation strategies for these types of pollutants

To achieve these objectives and to complete the project the following work tasks were performed:

- Conduct Watershed Reconnaissance (Task 1)
- Prepared Watershed Maps/Databases (Task 2)

- Prepare Quality Assurance Project Plan and Sampling Plan (Task 3)
- Conduct Field Sampling and Analysis (Task 4)
- Perform Runoff Analysis (Task 5)
- Evaluate Data and Report Results (Task 6)

These tasks are more fully described in the following subsections.

1.1.1 Conduct Watershed Reconnaissance (Task 1)

The project team and our geographic information system ("GIS") analysts developed field reconnaissance data sheets to guide field information gathering. The following types of potential pollutant sources were identified during the field work:

- Dry weather storm sewer system discharges
- Wastewater discharges
- Significant animal populations (birds or livestock)
- Dumping areas or accumulations of trash

For each type of pollutant source, an electronic data sheet was developed to record descriptive information. Data were recorded using a hand-held global positioning system ("GPS") unit and later downloaded to in-house computers. All sources and objects identified in the field were assigned a unique identification number to facilitate database creation. The location and extent of all sources were geo-referenced using a GPS in accordance with TCEQ standards. Existing digital aerial photography (obtained from H-GAC) was used to prepare watershed maps for use during field work. As field crews located sources, the sources were noted on the field maps and the data sheets were completed.

Reconnaissance was conducted by teams of two for safety. The reconnaissance focused on the bayou channel itself, but did include some windshield survey of the out-of-bank watershed area. Bayou survey work was conducted with waders on-foot where feasible, but was also performed using kayaks as was appropriate to individual stream conditions.

To maximize use of the available budget, field reconnaissance of one watershed (Mason Creek) was conducted first and then procedures and data sheets were adjusted to increase efficiencies in subsequent field work. This allowed the project team to learn from the first survey and improve effectiveness.

1.1.2 Prepare Watershed Maps/Databases (Task 2)

Based upon the field data collected during Task 1, the project team developed watershed maps that identify illicit discharges, storm water outfalls with dry weather flows, permitted wastewater outfalls, significant animal populations, and significant dumping or trash accumulation areas.

GPS field-collected information was converted to GIS. Corresponding identification and data classification fields were added to assist in generating tabular inventory data sheets from the corresponding GIS. Each digital data file created is in ArcView shapefile format, Texas State Plane, NAD83, South Central Zone, with units in feet. In addition, corresponding Federal Geographic Data Committee ("FGDC") metadata was generated for each file.

Dry weather discharges from outfalls other than storm sewers found during Task 1 were distinguished as either unknown or permitted discharges by comparison to existing wastewater discharge coordinates obtained from TCEQ. All dry weather discharges not associated with a known wastewater permit were assumed to be potentially illicit discharges.

USGS flow gauge data, when available, were included in the database.

1.1.3 Prepare Quality Assurance Project Plan and Sampling Plan (Task 3)

Based upon the field reconnaissance conducted in Task 1 and the maps prepared in Task 2, the project team identified appropriate dry weather and wet weather sampling locations and frequencies. A Quality Assurance Project Plan ("QAPP") was prepared in accordance with Clean Rivers Program ("CRP") and H-GAC guidelines and using H-GAC QAPP shell. A draft QAPP was submitted electronically for review and comments. A final QAPP was prepared addressing all comments. No field sampling was conducted prior to formal QAPP approval. The QAPP included a figure for each watershed that illustrated the proposed sampling locations and the identified sources.

To facilitate field work, sampling station maps were prepared for sampling team use. Monitoring parameters included: flow, dissolved oxygen, temperature, pH, specific conductance, and days since last precipitation event, *E. coli* (using the IDEXX Method), ammonia-nitrogen, total suspended solids, total dissolved solids, and turbidity.

1.1.4 Conduct Field Sampling and Analysis (Task 4)

Both dry weather and wet weather sampling was performed in accordance with the approved QAPP. In general, field procedures conformed to TCEQ's *Surface Water Quality Monitoring Procedures Manual* (GI-252, as amended).

During dry weather we attempted to sample 28 locations four times to characterize the pollutant contributions from significant pollutant sources in the study area. The 28 sites were distributed among the four watersheds by the project team during the reconnaissance process. Wet weather sampling was conducted at four sites in the study area (one downstream site per watershed). Six samples were collected from the same site during each storm event to characterize the wet weather flow. These samples were collected as close to the start of runoff as possible. Samples were collected at 15- to 30-minute intervals until the end of the storm event or until the maximum number of samples was achieved.

Both dry weather and wet weather flows were either measured or estimated using TCEQ procedures described in their *Surface Water Quality Monitoring Procedures Manual* (GI-252, as amended). This included in-stream flows as well as illicit discharge flows. Flow measurements were made to the extent practical as field conditions and safety allowed.

1.1.5 Perform Runoff Analysis (Task 5)

A runoff analysis was conducted using the National Resource Conservation Service ("NRCS") Runoff Curve Numbers ("CN"). The analysis produced a method for automatically determining composite CN's for watersheds with H-GAC-provided land use and soil type data coverage. The method was applied to determine the composite CN for each of the four watersheds under study.

The project team compared the land use and soil type categories provided by H-GAC with the NRCS CN Table. A method of combining the H-GAC and the NRCS land use and soil type categories was developed. Based on the definition and the hydrologic application of the land use and soil type categories, the project team prepared two tables under this effort. The first table includes a connection between the H-GAC soil types and the four NRCS Hydrologic Soil Groups. For example, if the H-GAC soil database were the same as the NRCS Soil Survey Geographical Database ("SSURGO") for Harris County, it would include about 57 different soil types. We examined the characteristics of these 57 soil types and assign them into the four Hydrologic Soil Groups. Next, we prepared the second table by examining the H-GAC land use categories. We assigned each H-GAC land use category to fit the NRCS categories. An approach to group some of the NRCS categories into one H-GAC land use category was necessary (e.g., grouping both industrial and commercial together). We then presented and discussed both tables with H-GAC personnel to obtain consensus. Then, maps and GIS databases of the four project watersheds were prepared using the land use and soil type database and the two developed tables. A GIS tool was also developed that will allow the calculation of an area-weighted CN of any selected area.

1.1.6 Evaluate Data and Report Results (Task 6)

Field results (including identified sources and sampling results) were reviewed and evaluated. The evaluation included the identification of any significant ammonia and bacteria sources in the four study watersheds based on the field reconnaissance and sampling data obtained under this project. Bacteria and ammonia loadings were also calculated where reliable flow data were obtained.

This report describing the project approach, methods, QA/QC, and results was prepared in draft form for H-GAC and TCEQ review. A final report will be prepared addressing all review comments. This report also presents findings and lessons learned during the project. This report also describes how the approach used on this project could be applied to other watersheds to identify and mitigate similar pollutant sources.

2.0 FIELD RECONNAISSANCE

2.1 INTRODUCTION

This section describes field reconnaissance activities executed during the project.

2.2 PRELIMINARY RECONNAISSANCE

In December 2002 preliminary field reconnaissance was performed by vehicle to determine feasibility, accessibility, study limits, monitoring approach, and possible pollutant sources. From the preliminary reconnaissance efforts, the delineated watershed boundaries and main creek channels were verified or adjusted as appropriate. Also, preliminary access points were identified to facilitate the use of kayaks, and the preliminary pollutant source types were grouped into six subdivisions: Waste Water Treatment Plant (WWTP) Pipe Outfall, Tributary, Animal Population, Dump, and Other. The "Other" type was created for any area that did not distinctly fall within the definition of the aforementioned pollutant source types.

2.3 AERIAL PHOTOGRAPHY REVIEW

After the preliminary field reconnaissance, aerial photography was reviewed to identify potential pollutant sources. Imagery reviewed was obtained from H-GAC and consisted of 0.25-meter^2 resolution aerial photography that was flown in 2002. The photo review was intended to identify and locate discernable pollutant sources like WWTP's, large dumping areas, and to identify land use. Coordinates of permitted WWTP's were obtained from TCEQ and were digitally overlaid on the existing aerial photography. This combined interpretation was used to help ensure that all WWTP's were included in the field surveys. Project and watershed boundaries were obtained from Harris County Flood Control District (HCFCD) delineations. Photography was reviewed to identify land use and features along tributaries within the study areas to determine if any further reconnaissance or sampling should be conducted in these waters. The majority of field reconnaissance time was devoted to the main stem of the study watersheds.

2.4 DATASHEET DEVELOPMENT

Based on the preliminary field reconnaissance and the photo interpretation, field data sheets were developed to facilitate rapid and efficient field data collection. Figure 2-1 presents the first version of the field data sheet developed for use on Mason Creek. For each identified discharge into the main channel, a separate data sheet was completed. The data sheet included the following fields: stream name, date, time, geographic position, source type, observers, weather, and antecedent dry period. The field data sheet then included site-specific information such as: picture number, outfall identification, and flow and source information. The pollutant source types were derived from standard TCEQ point source categories, known existing sources and photographs, and the preliminary field reconnaissance. If the source was flowing additional information was also recorded including: presence or absence of foam, odor, color, oil sheen, algae, and floatables. These fields were adapted from information contained in A guidance manual for identifying and eliminating illicit connections to municipal separate storm sewer systems (MS4) (Galveston County Health District, Pollution Control Division, 2002).

2.5 MASON CREEK RECONNAISSANCE

Mason Creek is located in west Harris County, between Houston and Katy. The main channel of Mason Creek is approximately 53,300 feet long with nine connecting tributaries. The total drainage area of Mason Creek is approximately 8,180 acres. The headwaters currently provide drainage to a land use dominated by farmland. The remainder of the watershed provides drainage to residential development. The end waters of Mason Creek flow into the Barker Cypress Reservoir and confluence with Buffalo Bayou. Mason Creek originates as a roadside drainage system and quickly turns into a maintained channelized system. The main source of perennial flow comes from WWTP's within the small watershed.

Field reconnaissance of Mason Creek was conducted on February 4, 5, 11, and 15, 2003, using the first data sheet. Reconnaissance was performed using a combination of kayaks and four-wheel-drive vehicles. With adequate water depth, kayaks could easily be maneuvered and data collection was fairly rapid. The use of kayaks limited out-of-bank observations, however pipe outfalls were readily investigated.

A large percentage of the outfalls on Mason Creek were merely back slope drains. Back slope drains are short storm drainage pipes that serve shallow drainage swales constructed in the top-of-bank area of an engineered channel. They drain runoff from the swale, in a buried inlet and pipe, directly to the main channel. These are typically installed to prevent sheet flow erosion of the channel banks. For Mason Creek, these drains occurred approximately every 100 to 200 feet. Since these sources service very small drainage areas (sheet flow areas adjacent to the creek) they were typically not flowing during dry weather. To expedite data collection, coordinates for these facilities were recorded, but full datasheets were not prepared.

During the survey, 182 potential pollutant sources were identified within the Mason Creek small watershed. All found sources are included in the results database described in Section 4.0. Thirty-seven of the potential sources were flowing at the time of the reconnaissance survey. The flow sources from Mason Creek are provided in Table 2-1. The 37 flowing sources included 24 pipe outfalls, six WWTP's, five tributaries, and one source classified as "Other." Site M-302 was an active construction site. Site M-300 was the downstream end of the creek.

2.6 DATA SHEET REVISION

Based upon the reconnaissance experience in Mason Creek the minor revisions to the field datasheet were made. These revisions included adding specific data for designated sources. The revised datasheet is presented in Figure 2-2. The revised datasheet was utilized in conducting reconnaissance of the remaining three watersheds.

2.7 TURKEY CREEK RECONNAISSANCE

Turkey Creek is located in central Harris County, on the west side of Houston, between State Highway 6 and Beltway 8. The main channel of Turkey Creek is approximately 29,000 feet long with one connecting tributary. The total drainage area of Turkey Creek is approximately 9,650 acres. It was discovered that the headwaters of Turkey Creek as previously delineated did not in fact connect with the main channel of Turkey Creek. A large levee, which was created for Addicks Reservoir, now separates the historical Turkey Creek headwaters from the main channel. The present headwaters provide drainage to a land use dominated by industrial and residential development. The remainder of Turkey Creek provides drainage for industrial, commercial, and residential areas. The end waters flow into Buffalo Bayou at the intersection of Buffalo Bayou and Eldridge Parkway. Turkey Creek originates as a maintained channelized storm water runoff drainage. The main source of perennial flow within Turkey Creek comes from the tributary that joins the main channel at the location where the Addicks Reservoir levee separates the historical headwaters of Turkey Creek from the main channel of Turkey Creek.

Field reconnaissance of Turkey Creek was conducted on March 10 and 11, 2003, using the revised datasheet. Field reconnaissance was conducted on foot and using a four-wheel-drive vehicle in the area outside of Addicks Reservoir. The upstream portion of the field survey included a detailed investigation of the headwaters to ensure that no underground or man-made diversions existed that would link the historical headwaters of Turkey Creek back to the main channel.

During the survey, 52 potential pollutant sources were identified within the small Turkey Creek watershed. All sources found are included in the results database described in Section 4.0. Four sources were flowing at the time of the reconnaissance survey. The flowing sources from Turkey Creek are provided in Table 2-2. The four flowing sources included one pipe outfall, one tributary, one dump, and Site T-068. The last site was the downstream end of the creek.

2.8 GARNER'S BAYOU RECONNAISSANCE

Garner's Bayou is located in north Harris County, north of Houston and east of Bush Intercontinental Airport. The main channel of Garner's Bayou is approximately 51,000 feet long with 10 connecting tributaries. The total drainage area of Garner's Bayou is approximately 15,200 acres. Garner's Bayou begins inside the airport property. The headwaters currently provide drainage for Bush Intercontinental

Airport and rural development. The remainder of Garner's Bayou provides drainage for a range of land uses consisting of farming, residential, and industrial. The end waters of Garner's Bayou flow into Greens Bayou south of Beltway 8. Garner's Bayou originates as a storm water runoff drainage channel for the airport.

Since the upper end of Garner's Bayou is located inside George Bush Intercontinental Airport, which is subject to federal and state storm water regulations and must maintain compliance with TCEQ's General Permit for Industrial Activities (TXR050000), the airport property was excluded from the study. The remaining (lower portion) of Garner's Bayou was surveyed on March 10 and 11, 2003, using four-wheel drive vehicles and kayaks.

During the survey, 129 potential pollutant sources were identified within the small Garner's Bayou watershed. All found sources are included in the results database described in Section 4.0. Seventeen of the potential sources were flowing at the time of the reconnaissance survey. The flow sources from Garner's Bayou are provided in Table 2-3. The 17 flowing sources included one pipe outfall, five WWTP's, six tributaries, one dump, one animal population (pigeons and swallows residing under bridge), and two sources classified as "Other." Site G-001 was the headwater site coming from the airport, and Site G-302 was a tributary with active construction within a detention pond associated with airport expansion. Site G-066, labeled "Creek," was the downstream end of the bayou.

2.9 BRICKHOUSE GULLY RECONNAISSANCE

Brickhouse Gully occurs in north-central Harris County in the northwest part of Houston. The main channel of Brickhouse Gully is approximately 36,600 feet long with 10 connecting tributaries. The total drainage area of Brickhouse Gully is approximately 7,450 acres. The watershed land use includes residential and significant commercial and industrial development. The end waters of Brickhouse Gully flow into White Oak Bayou north of the Loop 610 and Highway 90 intersection. Brickhouse Gully originates as roadside drainage and quickly incorporates a housing development and corresponding WWTP. The main source of perennial flow comes from residential and WWTP drainage.

Brickhouse Gully was surveyed on February 18, 19, 24, and 25, and March 13 and 17, 2003. Initial surveys were completed using a vehicle. Access to the main channel proved to be difficult since most of the adjoining land was fenced by subdivisions. The main channel was completely concrete-lined and provided no vehicle access. Kayaks could not be utilized because the channel was concrete-lined and the water depth was approximately 4 inches. An all-terrain vehicle was used to access much of the concrete-lined main channel during later survey days. In areas that did not permit all-terrain vehicle access, the survey was completed on-foot.

During the survey, 223 potential pollutant sources were identified within the small Brickhouse Gully watershed. All identified sources are included in the results database described in Section 4.0. Sixty-one of the potential sources were flowing at the time of the reconnaissance surveys. The flow sources to Brickhouse Gully are provided in Table 2-4. The 61 flowing sources included 49 pipe outfalls, eight tributaries, two sources classified as "Other," one area of significant animal population, and one WWTP. Site B-142 was located in the main channel where a large amount of residential debris (yard clippings) had accumulated, and Site B-380 was the downstream end of the creek.

2.10 RECONNAISSANCE SUMMARY

In all, 586 potential pollutant sources were identified during the field reconnaissance work. Due to the large number of back-slope drains found in the more urbanized watersheds, complete reconnaissance information for these sources was not obtained. Only latitude, longitude, date, time, and source type were recorded for these types of sources. The results of the reconnaissance work including all data fields and photographs are provided on the CD provided in Appendix A

Table 2-1
Mason Creek Pollutant Sources Found During Field Reconnaissance

Pollutant Source Type	Source Identification	Sample Period	Date Observed	Time Observed	Side of Channel Observed[1]	Days Since Last Rain	Flow Rate (cfs)[2]
Pipe	M002	Dry	05-FEB-03	10:28	L	8	0.00
Pipe	M245	Dry	11-FEB-03	16:57	R	2	0.00
Pipe	M235		11-FEB-03	16:16	L	2	0.00
Pipe	M077		13-FEB-03	10:36	L	4	0.00
Pipe	M241		11-FEB-03	16:36	L	2	0.00
Pipe	M250		11-FEB-03	17:29	R	2	0.00
Pipe	M131		13-FEB-03	14:35	L	4	0.01
Pipe	M063		05-FEB-03	16:23	L	8	0.01
Pipe	M254		11-FEB-03	17:49	R	2	0.02
WWTP	M331		04-FEB-03	11:18	R	7	0.02
Pipe	M234		11-FEB-03	16:12	R	2	0.03
Pipe	M123		13-FEB-03	14:06	L	4	0.03
Pipe	M065		05-FEB-03	16:29	L	8	0.03
Pipe	M126		13-FEB-03	14:15	L	4	0.03
Pipe	M252		11-FEB-03	17:47	L	2	0.03
Pipe	M132		13-FEB-03	14:41	R	4	0.05
Pipe	M127		13-FEB-03	14:26	R	4	0.13
Pipe	M111		13-FEB-03	12:11	R	4	0.17
Pipe	M230		11-FEB-03	15:29	R	2	0.19
Pipe	M106		13-FEB-03	11:58	R	4	0.25
Pipe	M137		13-FEB-03	15:19	L	4	0.32
Pipe	M243		11-FEB-03	16:44	L	2	0.46
Pipe	M109		13-FEB-03	12:06	R	4	1.70
WWTP	M136	alt Dry	13-FEB-03	15:16	R	4	6.18
WWTP	M332		04-FEB-03	12:26	L	7	8.43
WWTP	M353	alt Dry	04-FEB-03	13:11	R	7	39.74
Pipe	M134	Dry	13-FEB-03	15:09	R	4	41.28
Other[3]	M302		13-FEB-03	10:16	L	4	113.74
WWTP	M004	Dry	05-FEB-03	12:03	L	8	147.99
Tributary	M304		13-FEB-03	14:49	L	4	172.01
Tributary	M326		05-FEB-03	12:33	L	8	192.18
Tributary	M231		11-FEB-03	15:48	L	2	306.62
Tributary	M301	alt Dry	13-FEB-03	09:43	R	4	324.09
WWTP	M119	Dry	13-FEB-03	12:22	R	4	559.89
Creek[4]	M300	Dry/Wet	13-FEB-03	15:35	L	4	726.97
Tributary	M303		13-FEB-03	13:04	R	4	818.42
Pipe	M229		11-FEB-03	15:22	L	2	Dripping

Notes:
[1] Observed facing downstream
[2] Low flows reported as zero due to rounding
[3] Active construction site
[4] Downstream end of creek

Table 2-2
Turkey Creek Pollutant Sources Found During Field Reconnaissance

Pollutant Source Type	Source Identification	Sample Period	Date Observed	Time Observed	Side of Channel Observed[1]	Days Since Last Rain	Flow Rate (cfs)[2]
Dump	T156	Dry	10-MAR-03	09:57	R	5	0.00
Pipe	T139	Dry	10-MAR-03	09:17	R	5	0.07
Tributary	T092	Dry	11-MAR-03	16:17	L	6	107.37
Creek[3]	T068	Dry/Wet	11-MAR-03	15:10	R	6	115.90

Notes:
[1] Observed facing downstream
[2] Low flows are reported as zero due to rounding
[3] Downstream end of creek

Table 2-3
Garner's Bayou Pollutant Sources Found During Field Reconnaissance

Pollutant Source Type	Source Identification	Sample Period	Date Observed	Time Observed	Side of Channel Observed[1]	Days Since Last Rain	Flow Rate (cfs)[2]
Dump	G317	Dry	10-MAR-03	13:15	L	5	0.04
Tributary	G257	Dry	10-MAR-03	11:39	L	5	0.21
Pipe	G057	Dry	11-MAR-03	11:46	R	6	1.06
Tributary	G008		11-MAR-03	08:22	L	6	5.58
Tributary	G007		11-MAR-03	08:11	L	6	15.92
WWTP	G324		10-MAR-03	13:23	R	5	26.42
WWTP	G021	alt Dry	11-MAR-03	10:22	R	6	28.18
WWTP	G043	alt Dry	11-MAR-03	11:01	L	6	30.31
WWTP	G026	Dry	11-MAR-03	10:28	L	6	42.15
Tributary	G038	alt Dry	11-MAR-03	10:41	L	6	52.14
Other	G001		11-MAR-03	07:22	L	6	79.06
Tributary	G303	Dry	10-MAR-03	12:24	L	5	98.10
WWTP	G006	Dry	11-MAR-03	08:01	R	6	163.01
Tributary	G058		11-MAR-03	12:02	L	6	232.84
Creek[3]	G066	Dry/Wet	11-MAR-03	12:43	R	6	601.97
Animal[4]	G042	Dry	11-MAR-03	11:00	R	6	0.00
Other[5]	G302	Dry	10-MAR-03	12:22	R	5	0.00

Notes:
[1] Observed facing downstream
[2] Low flows are reported as zero due to rounding
[3] Downstream end of creek
[4] Bird population under bridge
[5] Airport detention pond outlet

Table 2-4
Brickhouse Gully Pollutant Sources Found During Field Reconnaissance

Pollutant Source Type	Source Identification	Sample Period	Date Observed	Time Observed	Side of Channel Observed[1]	Days Since Last Rain	Flow Rate (cfs)[2]
Pipe	B199		18-FEB-03	16:54	L	3	0.01
Pipe	B204		19-FEB-03	09:40	R	4	0.01
Pipe	B215		19-FEB-03	11:00	L	4	0.01
Pipe	B246	Dry	19-FEB-03	12:50	L	4	0.01
Pipe	B198		18-FEB-03	16:54	R	3	0.03
Pipe	B203	Dry	19-FEB-03	09:31	R	4	0.03
Animal	B170	Dry	18-FEB-03	13:27	L	3	0.04
Pipe	B009		13-MAR-03	09:25	L	8	0.04
Pipe	B267		19-FEB-03	14:45	R	4	0.04
Pipe	B183		18-FEB-03	15:59	R	3	0.06
Pipe	B294		19-FEB-03	16:41	R	4	0.06
Pipe	B295		19-FEB-03	16:42	R	4	0.06
Pipe	B266		19-FEB-03	14:40	R	4	0.07
Pipe	B018	Dry	13-MAR-03	09:57	L	8	0.11
Pipe	B276		19-FEB-03	15:16	R	4	0.11
Pipe	B282		19-FEB-03	15:52	R	4	0.13
Pipe	B005		13-MAR-03	09:07	R	8	0.14
Pipe	B180		18-FEB-03	15:21	R	3	0.15
Pipe	B012		13-MAR-03	09:30	R	8	0.21
Pipe	B251		19-FEB-03	13:02	R	4	0.23
Pipe	B271		19-FEB-03	15:04	R	4	0.25
Pipe	B174		18-FEB-03	14:18	R	3	0.26
Tributary	B157		18-FEB-03	11:35	R	3	0.31
Pipe	B155		18-FEB-03	11:07	R	3	0.42
Pipe	B270		19-FEB-03	14:56	R	4	0.54
Pipe	B243		19-FEB-03	12:45	L	4	0.72
Pipe	B179		18-FEB-03	15:06	L	3	1.07
Pipe	B269		19-FEB-03	14:51	R	4	1.12
Pipe	B289		19-FEB-03	16:25	R	4	1.54
Pipe	B178		18-FEB-03	14:49	L	3	2.20
Tributary	B168		18-FEB-03	13:03	L	3	2.59
Pipe	B040	Dry	13-MAR-03	10:28	L	8	3.00
Pipe	B283		19-FEB-03	16:03	R	4	3.35
Pipe	B260	alt Dry	19-FEB-03	14:25	R	4	4.90
Pipe	B288		19-FEB-03	16:24	R	4	4.94
Pipe	B281	alt Dry	19-FEB-03	15:43	R	4	5.23
Pipe	B162		18-FEB-03	12:34	L	3	6.53
Tributary	B014		13-MAR-03	09:52	R	8	7.00
Other[3]	B142		18-FEB-03	09:28	L	3	7.15
Pipe	B284		19-FEB-03	16:07	R	4	8.89
Pipe	B213		19-FEB-03	10:44	L	4	8.90
Pipe	B240	Dry	19-FEB-03	12:31	L	4	10.60
Pipe	B149		18-FEB-03	10:55	R	3	12.66
Pipe	B212		19-FEB-03	10:40	L	4	13.50
Tributary	B182		18-FEB-03	15:36	R	3	17.92
Pipe	B211		19-FEB-03	10:34	L	4	20.18

Pollutant Source Type	Source Identification	Sample Period	Date Observed	Time Observed	Side of Channel Observed[1]	Days Since Last Rain	Flow Rate (cfs)[2]
Tributary	B256		19-FEB-03	13:32	R	4	22.93
Tributary	B254		19-FEB-03	13:13	L	4	23.99
Pipe	B218		19-FEB-03	11:31	L	4	24.97
Pipe	B146		18-FEB-03	10:34	R	3	25.10
Pipe	B172		18-FEB-03	13:46	L	3	26.63
Tributary	B046		13-MAR-03	10:56	L	8	27.03
Pipe	B173		18-FEB-03	14:12	L	3	27.47
Tributary	B210		19-FEB-03	10:31	L	4	27.61
Pipe	B279	alt Dry	19-FEB-03	15:34	R	4	29.48
WWTP	B300		18-FEB-03	14:44	R	3	30.53
Pipe	B265	Dry	19-FEB-03	14:34	R	4	32.65
Pipe	B219	Dry	19-FEB-03	11:32	L	4	35.95
Pipe	B171		18-FEB-03	13:32	L	3	42.11
Pipe	B201		19-FEB-03	09:16	L	4	49.62
Creek[4]	B380	Dry/Wet	17-MAR-03	08:56	R	3	184.56

Notes:
[1] Observed facing downstream
[2] Low flows are reported as zero due to rounding
[3] Residential yard clippings
[4] Downstream end of creek

Creek Name: ________________ Date: __________ Observers:__________________ Weather: ____________________________ Last Rain (days): __________

Category							
Source ID #							
Creek Width (ft)							
Time							
Side Observed[2]							
Days since last rainfall							
Creek Flow Rate[3]							
Outfall Flow Rate[3]							
If flow present:	Foaming? (Y / N)						
	Odor						
	Color						
	Oil Sheen						
	Algae						
	Floatables						
Photo #							
Conduit size:							
Conduit type:							
TECQ Permit #							
Associated Land Use [4]							
Creek Substrate							
Area of Source [4]							
Debris Type							
Distance to OHWM							
Animal Type							
Population size estimate							
Additional							
Description							
Remarks							

[1] Waypoints in NAD 83 CONUS in Decimal Degrees [2] Looking downstream [3] ft3/sec [4] Document on aerial photo

Categories: WWTP Discharge, Pipe Outfall, Tributary, Illegal Dump, Animal Population, Other

Figure 2-1 **Small Watershed Reconnaissance Data Sheet**

Data	Known WWTP Discharge	Pipe Outfall	Tributary	Illegal Dump	Animal Population	Other
Creek Name						
Source ID #						
Creek Width (ft)						
Latitude[1]						
Longitude[1]						
Observers						
Date						
Time						
Side Observed[2]						
Days since last rainfall						
Outfall Flow Rate[3]						
If flow present: Foaming? (Y / N)						
If flow present: Odor						
If flow present: Color						
If flow present: Oil Sheen						
If flow present: Floatables						
Weather cond.						
Photo #						
Source Specific Info.	Conduit size:	Conduit size:	Trib. name:	Area of source[4]:	Animal type:	
	TCEQ Permit #:		Trib. Width:	Debris type:	Pop. Size:	
			Land use:			
			Substrate:	Distance to water's edge:	Area of source[4]:	
			Watershed area[4]:		Distance to water's edge:	

Creek Flow[3] - Headwaters: ______________________________________ Creek Flow[3] - Outlet: _________________________________

Remarks:____

____

[1] NAD 83 CONUS in Decimal Degrees

[2] Looking downstream

[3] ft^3/sec

[4] Document on aerial photo

Figure 2-2 **Small Watershed Reconnaissance Data Sheet**

3.0 QUALITY ASSURANCE PROJECT PLAN

3.1 INTRODUCTION

This section describes the development and approval of the Quality Assurance Project Plan ("QAPP"), the sampling site selection process employed and key provisions of the QAPP.

3.2 QAPP DEVELOPMENT

QAPP development was initiated in February and March 2003. The document was based on H-GAC's basin-wide QAPP (HGAC, 2001) and Version 5 of the H-GAC special study QAPP shell (H-GAC, 2003). The majority of the document was prepared in February and March and the draft was finalized after the completion of field reconnaissance.

3.2.1 Sampling Site Selection

Field reconnaissance results (including photographs, flow estimates, and characterizations of the nature of the flow coming from potential pollutant sources) were reviewed to determine appropriate sampling locations. Resources were available to conduct sampling at 28 dry weather locations and four wet weather locations. One wet weather sampling site was located at the outlet to each of the watersheds under study. Dry weather sampling sites were selected and distributed among the four watersheds so that:

- Sources with the highest anticipated load based on reconnaissance information would be sampled.
- At least one example of the five types of pollutant sources (WWTP, Pipe Outfall, Animal Population, Dump, and Other) would be sampled.
- Sources more likely to be flowing would be sampled (based on size of drainage area served, type of source, etc).

Alternative sampling sites were selected and identified in the QAPP to provide additional sampling locations in case primary locations were not flowing at the time of sampling. Primary and alternate sampling sites and their sampling frequencies are listed in Table 3-1. Sampling locations for all watersheds are presented in Figures 3-1 through 3-4.

3.3 QAPP APPROVAL

A draft QAPP was submitted to TCEQ and H-GAC in March. Comments on the document were addressed and QAPP finalized in April 2003. The QAPP was approved by TCEQ and H-GAC also in April.

3.4 KEY PROVISIONS

The QAPP contained EPA and TCEQ required components, including:

- Project/Task Description
- Quality Objectives and Criteria for Measurement Data
- Special Training/Certification
- Sampling Methods
- Sample Handling and Custody
- Analytical Methods
- Quality Control
- Instrument/Equipment Testing, Inspection, and Maintenance
- Instrument Calibration and Frequency
- Inspection/Acceptance for Supplies and Consumables
- Non-Direct Measurements
- Data Management
- Assessment and Response Actions
- Reports to Management
- Data Review, Verification, and Validation
- Verification and Validation Methods

In addition, the QAPP addressed how E. coli levels would be quantified in project samples. Dilutions of 2:1 and 100:1 were prepared from each collected sample. As shown in Table 3-2, this allowed quantification of *E. coli* levels between 2 and 241,920 MPN/100 mL. Since there was some overlap in the coverage provided by the two dilutions, IDEXX staff were consulted to determine which result should be used for reporting and analysis if both dilutions yielded quantified results. Based on their recommendations, the 2:1 dilution results were used for samples with up to 3,000 MPN/100 mL. Above that value the 100:1 results were used.

Table 3-1
Sample Sites and Monitoring Frequencies

Number of Stations	Source Identification Number[1]	Pollutant Source Type[2]	Monitoring Frequencies[3]
BRICKHOUSE GULLY			
16	B-018	Pipe Outfall	Dry
17	B-040	Pipe Outfall	Dry
18	B-170	Pipe Outfall	Dry
19	B-203	Pipe Outfall	Dry
20	B-219	Pipe Outfall	Dry
21	B-240	Pipe Outfall	Dry
22	B-246	Pipe Outfall	Dry
23	B-265	Pipe Outfall	Dry
24	B-380	Creek	Dry-Wet
Alternate 1	B-279	Pipe Outfall	Dry
Alternate 2	B-281	Pipe Outfall	Dry
Alternate 3	B-146[4]	Pipe Outfall	Dry
GARNER'S BAYOU			
7	G-006	Pipe Outfall (WWTP)	Dry
8	G-026	Pipe Outfall (WWTP)	Dry
9	G-042	Animal Population	Dry
10	G-057	Pipe Outfall	Dry
11	G-066	Creek	Dry-Wet
12	G-257	Tributary	Dry
13	G-302	Other	Dry
14	G-303	Tributary	Dry
15	G-317	Illicit Dumping Site	Dry
Alternate 1	G-021	Pipe Outfall (WWTP)	Dry
Alternate 2	G-043	Pipe Outfall (WWTP)	Dry
Alternate 3	G-038	Tributary	Dry
MASON CREEK			
1	M-134	Pipe Outfall	Dry
2	M-004	Pipe Outfall (WWTP)	Dry
3	M-119	Pipe Outfall (WWTP)	Dry
4	M-245	Pipe Outfall	Dry
5	M-002	Pipe Outfall	Dry
6	M-300	Creek	Dry-Wet
Alternate 1	M-301	Pipe Outfall (WWTP)	Dry
Alternate 2	M-136	Pipe Outfall (WWTP)	Dry
Alternate 3	M-353	Pipe Outfall (WWTP)	Dry
TURKEY CREEK			
25	T-068	Creek	Dry-Wet
26	T-092	Tributary	Dry
27	T-139	Pipe Outfall	Dry
28	T-156	Illicit Dumping Site	Dry

Notes:

[1] Numbers assigned to potential pollutant sources during field reconnaissance.

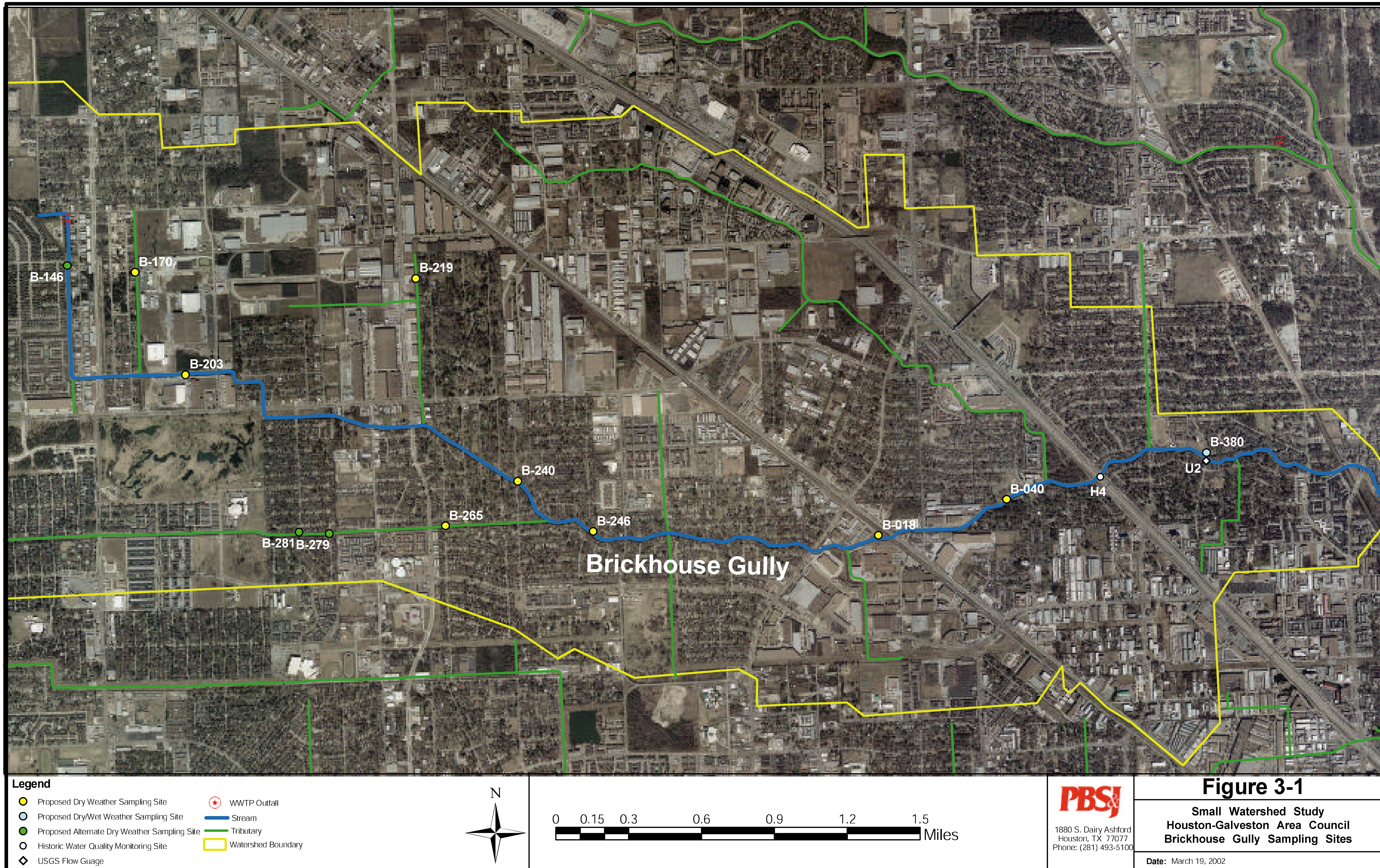
[2] Pollutant source category assigned during field reconnaissance. Pipe outfalls associated with wastewater treatment plants are noted with (WWTP). "Creek" sources are intended to characterize creek flow at the sampling location.

[3] "Dry" sampling consists of four grab samples obtained during dry weather conditions. "Wet" sampling consists of six grab samples obtained during one runoff event during wet weather conditions.

[4] Table SS-2 of the QAPP listed Site B-260 as the third alternate sampling site. This was inconsistent with planned sites depicted in Figure SS-2C. The third alternate site was intended to be B-146 as shown correctly in Figure SS-2C of the QAPP. This table reflects consistent information.

Table 3-2
***E. coli* Dilution Levels and Quantitation Levels**

Dilution	Sample Water	Dilution Water	Low Quantitation	High Quantitation
A	50 mL	50 mL	2 MPN/100 mL	4,838 MPN/100 mL
B	1 mL	99 mL	100 MPN/100 mL	241,920 MPN/100 mL



PBS&J

1880 S. Dairy Ashford
Houston, TX 77077
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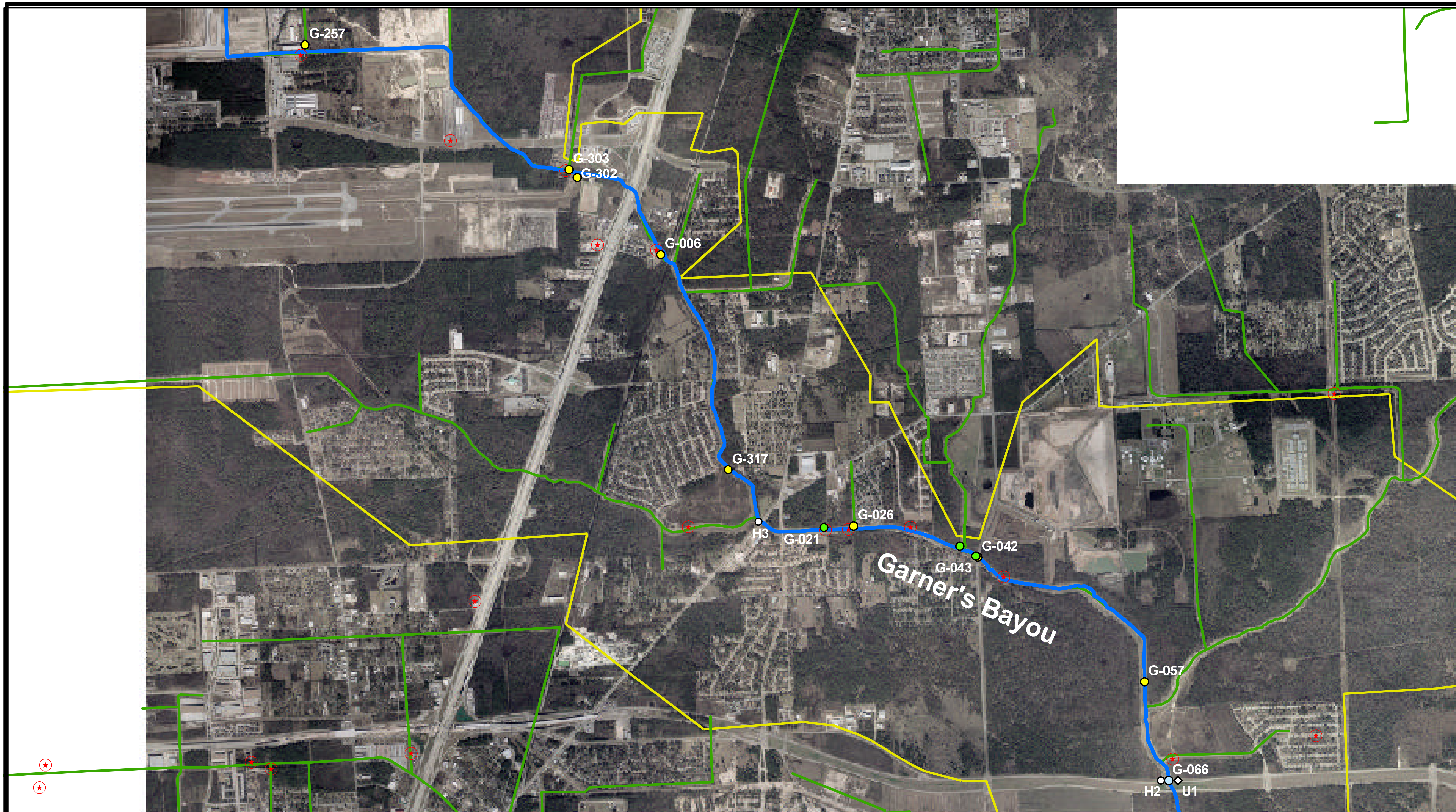
Figure 3-1

Small Watershed Study
Houston-Galveston Area Council
Brickhouse Gully Sampling Sites

Date: March 19, 2002



Legend

- Proposed Dry Weather Sampling Site
- Proposed Dry/Wet Weather Sampling Site
- Proposed Alternate Dry Weather Sampling Site
- Historic Water Quality Monitoring Site
- USGS Flow Guage
- WWTP Outfall
- Stream
- Tributary
- Watershed Boundary

N

0 0.2 0.4 0.8 1.2 1.6 2 Miles

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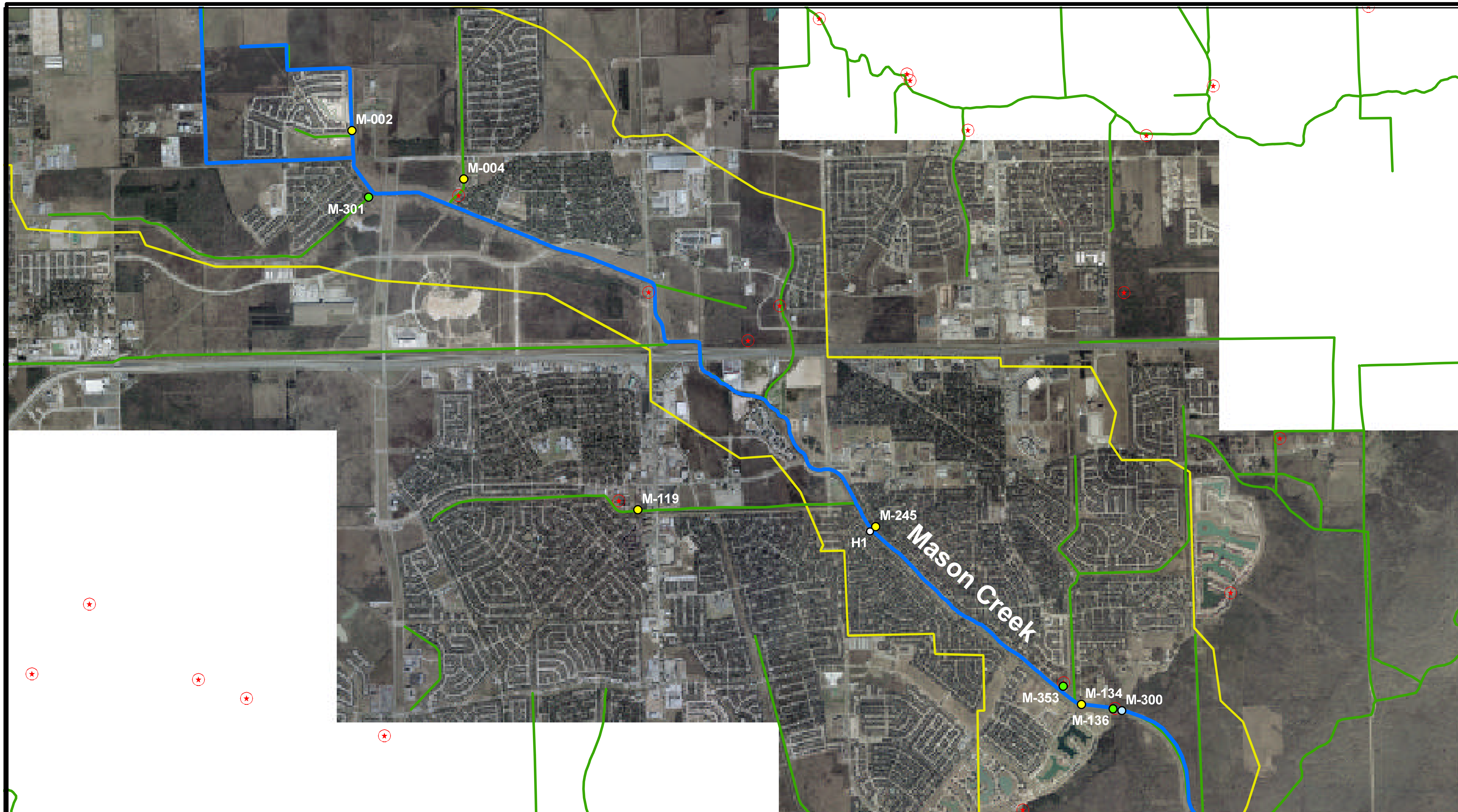
Figure 3-2

Small Watershed Study
Houston-Galveston Area Council
Garner's Bayou Sampling Sites

Date: March 19, 2002



Legend

- Proposed Dry Weather Sampling Site
- Proposed Dry/Wet Weather Sampling Site
- Proposed Alternate Dry Weather Sampling Site
- Historic Water Quality Monitoring Site
- WWTP Outfall
- Stream
- Tributary
- Watershed Boundary

N

0 0.25 0.5 1 1.5 2 2.5 Miles

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Figure 3-3

Small Watershed Study
Houston-Galveston Area Council
Mason Creek Sampling Sites

Date: March 19, 2002

Legend

- Proposed Dry Weather Sampling Site
- 068 Proposed Dry/Wet Weather Sampling Site
- Historic Water Quality Monitoring Site
- WWTP Outfall
- Stream
- Tributary
- Watershed Boundary

N

0 0.05 0.1 0.2 0.3 0.4 0.5 Miles

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Figure 3-4

Small Watershed Study
Houston-Galveston Area Council
Turkey Creek Sampling Sites

Date: March 19, 2002

4.0 WATERSHED SAMPLING AND RESULTS

4.1 INTRODUCTION

This section describes sampling and analytical methods, sampling results, and the structure of the results database.

4.2 SAMPLING AND ANALYSIS METHODS

Sampling and analysis were conducted in accordance with the project QAPP (PBS&J, 2003). To facilitate the field effort all selected sampling sites and alternates were plotted on aerial photography maps with a base layer of city streets. Field sampling staff used the maps to identify access points and to establish driving directions and sampling order by individual watersheds.

All field-sampling procedures followed the Texas Natural Resource Conservation Commission (TNRCC) *Surface Water Quality Monitoring Procedures Manual* (TNRCC, 1999) and updates. Additional aspects outlined below reflect specific requirements for sampling under the Clean Rivers Program and/or provide additional clarification.

4.2.1 Training

Prior to sampling, PBS&J laboratory staff and sampling staff were trained in and reviewed the TCEQ *E. coli* Colilert Quanti-tray 2000 Method Standard Operating Procedure. Training included viewing an instructional training video provided by IDEXX to demonstrate proper operation and maintenance of the equipment and a trial procedure using tap water. Training was lead by staff with prior experience running the specified method for projects conducted to support TCEQ's bacteria TMDL.

4.2.2 Dry Weather Sites

Dry weather sampling was conducted from April 29 through May 21, 2003. Each dry weather sample site was visited on four separate occasions for dry weather sampling, approximately seven days apart. Dry weather sampling only occurred if the antecedent dry period exceeded 36 hours within the designated watershed prior to sample collection. During the first week of dry weather sampling, when a selected sample site was observed to not be flowing, the closest alternative sample site was then sampled. If an alternative sample site was not identified for that particular watershed or was located too far away to facilitate sampling under the time constrictions, an alternative site from the next watershed to be sampled was selected. For selected sample sites that stopped flowing after the first sampling week, no additional alternative sites were selected.

All sampling started at the most upstream sampling site and continued downstream. All sampling transportation was by vehicle. Some sites required a short walk due to insufficient accessibility to the channel, but for the majority of the sample sites we were within 100 feet of vehicle access. Additionally, all selected sample sites and alternative sample site locations were loaded onto the hand-held GPS units. This allowed confirmation of sample site and permitted quick access to alternative sample site locations.

4.2.3 Wet Weather Sites

Wet weather sampling was conducted during June 4 through 26, 2003. The wet weather sampling events occurred when adequate rainfall was predicted and visible on regional Doppler radar. Additional rainfall information was obtained from the Harris County Office of Emergency Management ("HCOEM") web page, which contains real-time rain gauge data across the county. Wet weather sampling only occurred if an antecedent dry period of 36 hours or more was observed within the watershed. All wet weather sampling targeted the initial rise in the water column after rainfall had begun. This was to focus the sample collection in an attempt to collect the initial flush of the watershed. However, unpredictability of rainfall and mobilization time did not promote the collection of samples during the rising limb of the hydrograph at sites that were located away from the office.

During wet weather sampling events, the watershed discharge measurements were obtained either from USGS gauge, if nearby, or by field estimates based on water depth and channel size. In-stream flow measurements were not recorded by sampling crews during high flows due to safety concerns.

4.2.4 Sampling Activities

Photographs were taken of each sample site when samples were obtained. Initial observations and standard sample site information were recorded on field data sheets. Field data sheets for both dry weather and wet weather are presented in Figures 4-1 and 4-2.

Two 110-ml jars of water were collected in sealed, laboratory-sterilized, plastic jars that already contained the dechlorination chemical sodium thiosulfate. The sample was collected directly from the source and placed in a cooler on ice for *E. coli* analysis. Next, two additional water samples were collected for TSS, TDS, and ammonia-nitrogen analysis. These samples were also placed in a cooler on ice. All sample jars were labeled prior to sample collection. Standard water parameters were then recorded using either a Hydrolab Surveyor 4A with a Mini-sonde or a YSI 650 display with a data sonde. Turbidity readings were recorded by a Hanna turbidity meter or by the YSI 650 data sonde. Standard water parameters were recorded by placing the probe directly in the flow discharge. If the water level of the discharge did not facilitate this, a 5-gallon bucket was used to collect enough discharge to completely cover the probe sensors. All water parameters were recorded on the field data sheets.

Before moving to the next sample site, a flow velocity measurement was obtained if possible. If the water depth permitted, a Marsh McBirney and USGS wading rod was used to obtain velocity. For flows that were relatively minor, a graduated cylinder and stopwatch was used. Velocity, coupled with water depth and either stream width or discharge dimensions, were used to obtained discharge rates.

Collected water samples were transported in ice chests from the point of collection to the laboratory where IDEXX sealing and incubation was performed. In addition, a bottle of DI water was packed with the samples to ensure proper holding temperature of samples. As soon as the samples were received, the bottle of DI water was opened and the temperature of the contained water was measured.

The PBS&J laboratory data manager received the chain-of-custody ("COC") and logged in the samples at the laboratory. Both time of collection and time of reception of each sample, as well as the temperature measured from the tester, were recorded. All collected samples arrived to the laboratory within six hours of collection. Copies of all the COC's for the bacteria testing are provided in Appendix B. All samples arrived to the laboratory with a temperature between 2°C and 6°C.

Sealed samples were placed in an incubator at 35.0ºC ±0.5°C. The starting incubation time, sample identification, dilution, and temperature were recorded in the lab logbook and on each sample. Copies of the lab logbook are presented in Appendix C. All samples were run with the 18-hour reagent. Samples were removed from the incubator only after 18 hours had past but prior to the passage of 22 hours. Counting of the sample tray cells was initiated upon each tray's removal from the incubator. The time at which the samples were removed from the incubator was recorded in the laboratory logbook.

Additional water samples were collected for the analysis of TDS, TSS, and ammonia-nitrogen. These samples were analyzed by Northern Water District Laboratory Services, (NWDLS).

4.3 DRY WEATHER RESULTS

Table 4-1 presents a summary of the water quality observations in dry weather along with the average and median flows. Criteria or screening levels are shown on the bottom of the table, and where the data exceed these levels the values are shown in bold print. Individual flow observations are presented in Table 4-2.

4.3.1 Brickhouse Gully

Flow in Brickhouse Gully averaged 2.6 cfs in dry weather, and flow did not exceed 1.1 cfs except for a measured flow of 7.3 cfs on May 7. The major source of the flow increase on May 7 appeared to be Outfall B-265, which exhibited a flow of 6.6 cfs on that date but no more than 0.033 cfs on other dates. Sources B-240 and B-040 exhibited flows into the creek on the first sampling date but later dried up as the period without rainfall increased over the course of the study.

Water quality observations under dry weather conditions are summarized in Table 4-1. *E. coli* levels in Brickhouse Gully ranged from 10 to 1,454 per 100 ml. A geometric mean of 180 exceeded the water quality criterion for contact recreation. Two of the four dry weather samples from Brickhouse Gully exceeded the single-sample water quality criterion of 394 *E. coli* per 100 ml. *E. coli* levels in Outfall B-246 were very high, ranging from 36,540 to more than 241,900 per 100 ml. *E. coli* levels in a number of other outfalls were also elevated. On one date, *E. coli* levels exceeded 241,900 in Outfall B-279. The geometric mean of dry weather *E. coli* levels in Outfalls B-146, B-203, B-219, and B-040 were 1,020, 1,641, 929, and 3,291, respectively. *E. coli* levels in Outfalls B-240 and B-265 typically met *E. coli* water quality criteria.

Dry weather in-stream ammonia nitrogen levels ranged from <0.02 to 0.28 mg/l in Brickhouse Gully, with an average of 0.083 mg/l. However, ammonia nitrogen levels at some outfalls were very high. Outfall B-246 ammonia nitrogen levels ranged from 33.4 to 72.7 mg/l, while at Outfall B-203 they ranged from 2.16 to 18.9 mg/l. Except for a single date when levels reached 1.33 mg/l at Outfall B-279, ammonia nitrogen levels did not exceed 1 mg/l at other outfalls.

TSS levels in Outfalls B-203 and B-246 reached 1,100 mg/l while TSS levels in other sources in Brickhouse Gully did not exceed 28 mg/l. TDS levels in Brickhouse Gully ranged from 390 to 490 mg/l. For comparison, the water quality criterion for TDS in Segment 1017 is 600 mg/l. On one date, a TDS level of 3,452 was observed at Outfall B-203. Dissolved oxygen levels in Brickhouse Gully were very high, ranging from 15.8 to 20 mg/l. A 3.0 mg/l dissolved oxygen water quality criterion is applied to Brickhouse Gully. Dissolved oxygen levels in Outfalls B-240, B-246, and B-219 sometimes fell below the 3 mg/l in-stream criterion, but averaged 4 to 7 mg/l in all other sources. A pH range of 9.2 to 9.8 was measured in Brickhouse Gully, which is more alkaline than the 6.5 to 9.0 criterion for Segment 1017. However, pH criteria do not apply to Brickhouse Gully and are included for comparison purposes only. The pH of Outfall B-040 also reached 9.8 on one occasion, while a pH of 4.7 was measured in Outfall B-203 on one date. All measured water temperatures in Brickhouse Gully fell below the 92ºF (33.3ºC) criterion applied to Segment 1017. Outfall B-040 reached 34.2ºC on one date.

Foam was typically present in Outfalls B-203, B-279, B-265, and B-219 (Table 4-3). Foam was sometimes present in Brickhouse Gully. Outfalls B-203 and B-246 typically exhibited an odor of raw sewage while Outfall B-040 exhibited an odor of paint on one date. Water from Outfall B-246 exhibited colors ranging from blackish-green to gray, black, and even milky white. Brickhouse Gully water exhibited a green color on one date. Oil was observed in Outfall B-219 on one date and in Brickhouse Gully on another. Floating algae were present in Brickhouse Gully on three of four dates and occasionally in Outfalls B-203 and B-279. Floating vegetation and organisms were present at Outfalls B-203, B-279, B-240, and B-246.

4.3.2 Garner's Bayou

Flow in Garner's Bayou averaged 11.6 cfs and did not appear to decline throughout the sampling period. Two major sources of inflow were G-006 (a pipe outfall) and G-042 (an animal population). Flow from Tributary G-257 declined to zero during the project period since there was no rainfall. Flows from Tributary G-303 did not decline, probably from WWTP discharges.

Water quality observations under dry weather conditions are summarized in Table 4-1. *E. coli* levels in Garner's Bayou ranged from 97 to 449 per 100 ml with a geometric mean of 181, which exceeded the water quality criterion for contact recreation. One of the four dry weather samples from Garner's Bayou also exceeded the single sample water quality criterion of 394 *E. coli* per 100 ml. *E. coli* levels in Tributary G-257 reached 2,240 per 100 ml with a geometric mean of 158 per 100 ml while levels in Tributary G-303 met all water quality criteria for *E. coli*. Source G-302 exhibited a very high *E. coli* level of 17,220 per 100 ml on one date. While the highest *E. coli* level measured at Source G-042 was 210 per 100 ml, the geometric mean concentration of 153 per 100 ml did exceed the in-stream criterion. The other sources investigated met in-stream criteria.

In-stream ammonia nitrogen levels ranged from 0.12 to 4.23 mg/l in Garner's Bayou with an average of 1.32 mg/l. Ammonia nitrogen levels at Outfall G-006 were relatively high with an average of 5.12 mg/l and a maximum of 7.87 mg/l. Ammonia nitrogen levels in sources G-026, G-042, and G-043 also sometimes exceeded 1 mg/l.

TSS levels in Tributary G-257 ranged from 91.3 to 165 mg/l with an average of 120 mg/l. These results were far higher than levels measured in Garner's Bayou or other sources of inflow. Sources G-302 and G-043 occasionally exceeded a TSS of 100 mg/l. In-stream TSS concentrations ranged from 26 to 38 mg/l. TDS levels in all Garner's Bayou sources were similar to those found in-stream (408 to 645 mg/l) except that Tributaries G-257 and G-303 were sometimes lower. The water quality criterion for TDS in Segment 1016 is 1,000 mg/l. Dissolved oxygen levels in Garner's Bayou ranged from 2.5 to 6.3 mg/l. A 3.0-mg/l dissolved oxygen water quality criterion is applied to Garner's Bayou. Dissolved oxygen levels in sources G-302, G-006, G-021, and G-042 were sometimes lower than the 3-mg/l in-stream criterion. However, all sources averaged 5 to 7 mg/l except Tributary G-257. G-257 averaged 3.6 mg/l dissolved oxygen. A pH range of 7.4 to 7.8 was measured in Garner's Bayou, well within the 6.5 to 9.0 criterion for Segment 1016. All sources to Garner's Bayou also fell within this criteria range. All measured water temperatures in Garner's Bayou and all sources fell below the 92ºF (33.3ºC) criterion applied to Segment 1016.

Foam was typically present in Outfalls G-006, G-021, G-026, and G-043 (Table 4-3). Foam was not present in Garner's Bayou. Source G-042 exhibited an ammonia odor on one date. Water from Outfall G-043 had a green tint on one date while that from Outfalls G-026, Tributaries G-257 and G-303, and Garner's Bayou itself was occasionally brownish or turbid. There were no observations of oil in the creek or sources. Floating materials such as algae, vegetation, and dead organisms, were sometimes observed in Garner's Bayou and several sources but it was only prevalent in Tributary G-257 where floating vegetation was common.

4.3.3 Mason Creek

Flow in Mason Creek was 7.5 cubic feet per second (cfs) on the first sampling date but on three later dates ranged from 2.8 to 3.0 cfs (Table 4-1). Pipe Outfall M-119 represented the largest flow into Mason Creek, averaging 4.2 cfs. Pipe Outfalls M-004, M-353, and M-136 were also significant sources of inflow to Mason Creek. Some sources (Outfalls M-002 and M-134) exhibited small flows into the creek on the first sampling date but later dried up as the period without rainfall increased over the course of the study.

Water quality observations under dry weather conditions are summarized in Table 4-1. *E. coli* levels in Mason Ceek ranged from 15 to 476 per 100 ml with a geometric mean of 126 just meeting the water quality criterion for contact recreation. One of the four dry weather samples from Mason Creek did exceed the single-sample water quality criterion of 394 *E. coli* per 100 ml. Among the sources investigated, *E. coli* levels in Outfalls M-134 and M-353 sometimes exceeded the in-stream water quality criterion by a large margin while the other sources investigated met in-stream criteria. Although minor in terms of flow, Outfall M-134 exhibited high levels of *E. coli*, ranging from 731 to 9,900 per 100 ml on the two dates when water was present (Table 4-2). Outfall M-353 exhibited a high *E. coli* concentration (4,040 per 100 ml) on one date.

In-stream ammonia nitrogen levels ranged from 0.39 to 1.15 mg/l with an average of 0.69 mg/l. Specific numeric water quality criteria for ammonia nitrogen have not been established by the State of Texas. Instead, biomonitoring criteria and monitoring requirements ensure that wastewater discharges do not cause toxicity due to elevated ammonia levels. Ammonia nitrogen levels at Outfall M-353 reached 13.7 mg/l with an average of 4.64 mg/l. Ammonia nitrogen levels at Outfall M-136 reached 2.93 mg/l with an average of 1.22 mg/l. No other source to Mason Creek exhibited ammonia nitrogen levels exceeding 1 mg/l.

TSS and turbidity levels in all sources to Mason Creek were lower than those measured in-stream. In-stream TSS concentrations ranged from 34 to 71 mg/l. Dissolved solids levels in all Mason Creek sources were similar to those found in-stream (410 to 673 mg/l) with the exception of Outfall M-002 in which dissolved solids levels averaged 148 mg/l. Dissolved oxygen levels in Mason Creek ranged from 5.4 to 12.2 mg/l exceeding the 4.0 mg/l water quality criterion applied to Mason Creek. Dissolved oxygen levels in most sources to Mason Creek were sometimes lower than 2 or 3 mg/l, but averaged 6 to 7 mg/l in all sources. A pH of 9.3 was measured on one date in Mason Creek exceeding the 6.5 to 9.0 criterion for Segment 1014. While this criterion does not apply to Mason Creek because it is an unclassified water body, it provides a useful comparison level. No source to Mason Creek exhibited a pH above 8.7. All measured water temperatures in Mason Creek and all sources fell below the 92ºF (33.3ºC) criterion applied to Segment 1014.

Foam was typically present in Outfalls M-004, M-119, M-353, and M-136, but not Outfalls M-002 or M-134 (Table 4-3). Foam was present in Mason Creek on one of the four dry weather observation dates. Outfall M-136 exhibited an odor of raw sewage on one date while Outfalls M-002 and M-134 exhibited a musty odor. Water from Outfall M-002 was sometimes brownish in color and sometimes turbid in Outfalls M-002, M-134, and Mason Creek itself. There were no observations of oil in the creek or sources. Floating materials such as algae, vegetation, or other materials, were occasionally observed in Mason Creek and several sources, but it was not prevalent.

4.3.4 Turkey Creek

Flow in Turkey Creek averaged 0.80 cfs declining from 1.2 to 0.55 cfs as the period without rainfall increased. The tributary T-092 provided the major source of flow averaging 0.68 cfs.

Water quality observations under dry weather conditions are summarized in Table 4-1. *E. coli* levels in Turkey Creek ranged from 731 to 141,360 per 100 ml, with a geometric mean of 4,543, exceeding the water quality criterion for contact recreation by a large margin. Each of the four dry weather samples from Turkey Creek also exceeded the single-sample water quality criterion of 394 *E. coli* per 100 ml. *E. coli* levels in Tributary T-092 were substantially lower but still exceeded water quality criteria for contact recreation with a geometric mean of 394 per 100 ml and a maximum level of 870 per 100 ml. *E. coli* levels in pipe Outfall T-139 exceeded the single-sample water quality criterion on three of four dates with a geometric mean level of 691 per 100 ml. While high, the sources investigated did not appear to support the high *E. coli* levels measured in the main creek.

In-stream ammonia nitrogen levels were low, ranging from 0.04 to 0.16 mg/l in Turkey Creek with an average of 0.12 mg/l. Ammonia nitrogen levels at Outfall T-139 ranged from 0.03 to 0.74 mg/l with an average of 0.30 mg/l while levels in Tributary T-092 did not exceed 0.09 mg/l.

TSS levels in Turkey Creek ranged from 13.6 to 54.0 mg/l with an average of 28.4 mg/l. TSS levels in Tributary T-092 were similar while those in Outfall T-139 were lower. TDS levels in Turkey Creek ranged from 398 to 679 mg/l with an average of 508 mg/l. For comparison purposes, the water quality criterion for TDS in Segment 1014 is 600 mg/l. TDS levels in Tributary T-092 were similar to those in Turkey Creek while they were somewhat lower in Outfall T-139. Dissolved oxygen levels in Turkey Creek ranged from 4.2 to 11.8 mg/l with an average of 8.1 mg/l. A 4.0-mg/l dissolved oxygen water quality criterion is applied to Turkey Creek. Dissolved oxygen levels in Tributary T-092 and Outfall T-139 were similarly high. A pH range of 8.0 to 8.3 was measured in Turkey Creek well within the 6.5 to 9.0 criterion for Segment 1014. Similar pH ranges were observed in Tributary T-092 and Outfall T-068. All measured water temperatures in Turkey Creek and all sources fell below the 92ºF (33.3ºC) criterion applied to Segment 1016.

A slight foaming was present on one occasion in Outfall T-139. Foam was not present in Turkey Creek or Tributary T-092. Outfall T-139 exhibited a raw sewage odor on one date. Water from Outfall T-139 also exhibited a range of colors, from blue to yellow and brown. There were no observations of oil in the creek or sources. Floating vegetation and algae were observed in Tributary T-092 on each date and on one date in Outfall T-139, but floating materials were not observed in Turkey Creek

4.3.5 Summary of Dry Weather Results

E. coli and ammonia nitrogen concentrations for all sampled sources are presented in Figure 4-3 and Figure 4-4. As dry weather sampling proceeded, little rain fell in the Houston area. This caused some flowing sources to dry up as the drought continued. Table 4-7 lists sampling sites that did not have flow at the time of sampling.

Some general observations can be made of the results in Table 4-1. First, almost the entire flow during dry weather is contributed by the WWTP sources. These sources are required under their permits to disinfect, usually by maintaining at least 1 mg/L of chlorine for at least 20 minutes. When that is achieved, experience with the older fecal coliform (FC) test frequently resulted in no bacteria being detected. That is not the case with these *E. coli* data. While residual chlorine was not one of the monitoring parameters, it is reasonable to expect that most of the time the chlorination facilities were functioning properly. Very few of the *E. coli* observations were non-detects but at the same time the levels were rarely very high. The geometric mean *E. coli* levels from WWTP sources ranged from 3 to 133 MPN/100 mL. This finding is consistent with monitoring of wastewater discharges in the ongoing bacteria TMDL study (U of H and PBS&J, 2003). The results to date suggest that the IDEXX *E. coli* test tends to show higher levels in wastewater than the older FC test, even though the ambient water geometric mean criterion for the *E. coli* test is lower than the corresponding criterion for the FC test (126 versus 200).

A second general observation is that the pipe outfalls, most often storm drains, that had small flows during dry weather periods frequently had elevated concentrations of *E. coli*. These concentrations tended to vary substantially (large differences between the minimum and maximum concentration values). With some exceptions, these small flows do not appear to make a major contribution to the bacteria concentrations observed at the downstream end of the bayous. The relative loads of various parameters contributed by sources is addressed in more detail in Section 6.

4.4 WET WEATHER RESULTS

4.4.1 Brickhouse Gully

The Brickhouse Gully wet weather observations took place on June 4, 2003. Only a trace of rain was measured at Hull Field in Sugar Land that day but more than 2″ of rain was observed at Hobby Airport and 0.34″ fell at Bush Intercontinental Airport. The quantity that fell in the Brickhouse Gully watershed is difficult to estimate. The prior significant rainfall event had occurred more than 30 days earlier. Flow in Brickhouse Gully during the wet weather sampling event averaged 60 cfs (Table 4-4) rapidly declining from 100 to 20 cfs over the course of the 75-minute observation. This flow was roughly 20 times higher than the average flow observed under dry weather conditions.

E. coli levels in Brickhouse Gully under wet weather conditions ranged from 9,330 to 23,820 per 100 ml with a geometric mean of 17,104 per 100 ml. This average level is approximately 100 times higher than that observed in dry weather. Ammonia nitrogen levels ranged from 0.28 to 0.42 mg/l and were somewhat higher than those measured under dry weather conditions. TSS levels averaged 157 mg/l, approximately 10 times higher than those of dry weather, while TDS levels averaged 110 mg/l, much less than those observed in dry weather. Dissolved oxygen levels averaged 5.9 mg/l. Foam and odors were not observed but floatable materials were observed on the surface. The water was turbid due to the high TSS levels. Some oil was also observed on the water.

4.4.2 Garner's Bayou

The Garner's Bayou wet weather observations took place on June 30, 2003. The rainfall measured at Houston's Bush Intercontinental Airport that day was only 0.04″ though locally it may have been greater. Flow in Garner's Bayou during the wet weather sampling event averaged 16.9 cfs (Table 4-4) gradually declining from 17.5 to 16 cfs over the course of the 75-minute observation. This flow was less than 50 percent higher than the average flow observed under dry weather conditions. This event was only a marginal success at sampling wet weather conditions.

E. coli levels in Garner's Bayou ranged from 1,733 to 3,106 per 100 ml with a geometric mean of 2,487 per 100 ml. These levels are more than 10 times higher than those observed in dry weather and indicate the likely presence of some runoff. Ammonia nitrogen levels ranged from 0.15 to 0.25 mg/l and were lower than most of those measured under dry weather conditions. TSS levels averaged 95 mg/l, approximately three times higher than those of dry weather, while TDS levels averaged 446 mg/l, not much less than those observed in dry weather. Dissolved oxygen levels averaged 3.4 mg/l. Foam, oil, and odors were not observed, but some floatable materials were observed on the surface. The water was turbid due to the high TSS levels.

4.4.3 Mason Creek

The Mason Creek wet weather observations took place on June 26, 2003. The rainfall measured at Hull Field in Sugar Land that day was 1.14″. The prior significant rainfall event had occurred on June 23, when 0.45″ of rain fell. Flow in Mason Creek during the wet weather sampling event averaged 11 cfs (Table 4-4) gradually declining from 12 to 10.3 cfs over the course of the 75-minute observation. This flow was roughly three times higher than the average flow observed under dry weather conditions.

Water quality observations under wet weather conditions are summarized in Table 4-5. *E. coli* levels in Mason Creek ranged from 16,740 to 20,350 per 100 ml, with a geometric mean of 18,256 per 100 ml. These levels are more than 100 times higher than those observed in dry weather. Ammonia nitrogen levels ranged from 0.07 to 0.13 mg/l and were substantially lower than those measured under dry weather conditions. TSS levels averaged 104 mg/l, approximately double those of dry weather, while TDS levels averaged 312 mg/l or roughly half of those observed in dry weather. Dissolved oxygen levels averaged 5.4 mg/l. Foam, oil, and odors were not observed but floatable materials were observed on the surface (Table 4-6). The water was turbid due to the high TSS levels.

4.4.4 Turkey Creek

The Turkey Creek wet weather observations took place on June 5, 2003. The rainfall measured at Hull Field in Sugar Land that day was 0.64″. Some rain likely fell the previous day, but prior to that no significant rainfall had fallen for more than 30 days. Flow in Turkey Creek during the wet weather sampling event averaged 82.6 cfs (Table 4-4) increasing from 54 to 107 cfs then declining to 63 cfs over the course of the 100-minute observation. This flow was more than 10 times higher than the average flow observed under dry weather conditions.

E. coli levels in Turkey Creek ranged from 20,630 to 104,600 per 100 ml with a geometric mean of approximately 37,000 per 100 ml. These levels are approximately 10 times higher than those observed in dry weather. Ammonia nitrogen levels ranged from 0.06 to 0.33 mg/l, higher than most of those measured under dry weather conditions. TSS levels averaged 227 mg/l, almost 10 times higher than those of dry weather, while TDS levels averaged only 199 mg/l, less than half of those observed in dry weather. Dissolved oxygen levels stayed relatively high, averaging 6.5 mg/l. Foam and oil were not observed, but floatable materials were observed on the surface. The water was turbid due to the high TSS levels. A raw sewage odor was present at the time of the initial observation but not at later times. A musty odor was also present for a limited time.

4.5 QUALITY ASSURANCE FINDINGS

Data validation procedures defined in the QAPP were performed and no analytical results were rejected.

4.6 RESULTS DATABASE

The results database was developed to store all the spatial and non-spatial data associated with this project as one single geodatabase. A geodatabase can be defined as a relational database that contains geographic information. It contains feature classes and tables. A feature class is a collection of features with the same geometry: point, line, or polygon. Following are the feature classes and tables that are stored in this geodatabase:

Feature Classes:

- WATERSHEDS
- STREAMS
- TRIBUTARIES
- OUTFALL_LOCATIONS
- SAMPLE_SITES

Non-Spatial Tables:

- RECON_RESULTS
- DRY_SAMPLING_RESULTS
- WET_SAMPLING_RESULTS
- VALIDATION_DRY_SAMPLING_RESULTS
- VALIDATION_WET_SAMPLING RESULTS

4.6.1 Feature Class Description

WATERSHEDS - This feature class stores all the information related to the four watersheds. The various fields that are associated with this feature class are:

- WUID - This field stores a unique identifier for each watershed.
- WTSHNAME - This field stores the watershed name.
- ACRES - This field stores area in acres for each watershed.
- SHAPE_LENGTH - This is an auto-generated field that stores perimeter of each watershed in map units.
- SHAPE_AREA - This is an auto-generated field that stores area of each watershed in map units.
- STREAMS - This feature class stores information related to all the creek segments in each watershed. The various fields that are associated with this feature class are:
- WUID - This field stores the unique identifier of the watershed.
- UNIT_NO - This field stores the unit number associated with each creek.
- CHAN_NAME - This field stores the creek name.
- DIT_TYPE - This field stores information on the type of channel (natural or man-made).
- SHAPE_LENGTH - This is an auto-generated field that stores the length of the stream segment in map units.

TRIBUTARIES - This feature class stores information related to all the tributaries associated with each stream. The various fields that are associated with this feature class are:

- WUID - This field stores the unique identifier of the watershed.
- UNIT_NO - This field stores the unit number associated with each stream.
- CHAN_NAME - This field stores the name of the tributary.
- DIT_TYPE - This field stores information on the type of ditch (natural or man-made).

- SHAPE_LENGTH - This is an auto-generated field that stores the length of the stream segment in map units.

OUTFALL_LOCATIONS - This feature class stores information related to all the outfall locations. The various fields that are associated with this feature class are:

- WUID - This field stores the unique identifier of the watershed.
- SRCID - This field stores the unique identifier assigned to each outfall location.
- CRK - This field stores the name of the creek associated with each outfall.

SAMPLE_SITES - This feature class stores information related to all the sample sites. The various fields that are associated with this feature class are:

- WUID - This field stores the unique identifier of the watershed.
- SRCID - This field stores the unique identifier assigned to each outfall location.
- CRK - This field stores the name of the creek associated with each outfall.

All these feature classes also have an "OBJECTID" field and a "SHAPE" field in their respective tables. These fields are auto-generated while creating the geodatabase and are essential for proper functioning of the geodatabase.

4.6.2 Non-Spatial Table Description

RECON_RESULTS - This table stores all the information that was collected during the preliminary reconnaissance discussed in the previous sections. This table is in direct relationship with the "OUTFALL_LOCATION" feature class. The various fields that are associated with this table are:

- CRK - This field stores the name of the creek associated with each outfall.
- TYPE - This field stores information on the pollutant source type (WWTP Discharge/Pipe Outfall/Tributary/Illegal Dump/Animal Population/Other).
- SRC_ID - This field stores the unique identifier assigned to each outfall.
- SMPL - This field stores information on the period of sampling for that outfall.
- SYM_LAT - This field stores the latitude symbol information.
- LAT - This field stores the latitude of the outfall in decimal degrees.
- SYM_LON - This field stores the longitude symbol information.
- LONG - This field stores the longitude of the outfall in decimal degrees.
- OB - This fields stores the initials of the field observer.

- DATE - This field stores the date on which the outfall was observed.
- TIME - This field stores the time at which the outfall was observed.
- SIDE_OBSV - This field stores the side (left/right) of the channel that the outfall occurs on.
- RAIN - This field stores information on the antecedent dry period recorded in days.
- RATE - This field stores the outfall flow rate information.
- FOAM - This field stores information on the presence of foam coming from the outfall.
- ODOR - This field stores information on the presence of any non-typical odor coming from the outfall.
- COLOR - This field stores information on the presence of any non-typical color coming from the outfall.
- OIL - This field stores information on the presence of any oil sheen coming from the outfall.
- ALGAE - This field stores information on the presence of any algae at the outfall.
- FLOAT - This field stores information on the presence of any floatables coming from the outfall.
- WTHR - This field stores information on the weather conditions at the time of the outfall observation.
- PHOTO - This field stores the photo number associated with each outfall.
- TCEQ_PMT - This field stores the TCEQ permit number associated with each WWTP outfall.
- PIPE_SIZE - This field stores the pipe diameter of the outfall.
- TRIN_NAME - This field stores the tributary name.
- TRIB_LAND - This field stores the land use drained by the tributary.
- TRIB_SUB - This field stores the substrate of the tributary.
- TRIB_AREA - This field stores the watershed area drained by the tributary in acres.
- DUMP_SRC - This field stores the area of the illegal dump in acres.
- DUMP_TYPE - This field stores the type illegal dump.
- DUMP_WTR - This field stores the distance between the illegal dump source and the water edge.
- ANML_POP - This field stores information on the species of animals present.

- POPSIZE - This field stores information on the population size of the animals.
- AREA_SRC - This field stores the area of the animal source in acres.
- ANML_WTR - This field stores the distance from the animal source to water edge.
- COM - This field stores any additional comments associated with each outfall.

DRY_SAMPLING_RESULTS/WET_SAMPLING_RESULTS - Both these tables share the same table structure excepting for the naming convention. The DRY_SAMPLING_RESULTS table stores information collected during dry weather sampling and the WET_SAMPLING_RESULTS table stores information collected during wet weather sampling. These two tables are in direct relationship with the "SAMPLE_SITES" feature class. The various fields associating these tables are:

- SRC_ID - This field stores the unique identifier assigned to each outfall.
- DS1_sam - This field stores the unique identifier assigned to each sample site.
- DS1_ob - This field stores the initials of the field sampler.
- DS1_date - This field stores the date on which the sample was collected.
- DS1_time - This field stores the time at which the sample was collected.
- DS1_wthr - This field stores information on the weather conditions at the time of sample collection.
- DS1_rain - This field stores information on the antecedent dry period in days.
- DS1_photo - This field stores the photo number associated with each sample.
- DS1_DO - This field stores the level of dissolved oxygen in mg/L of the sample.
- DS1_Sp_C - This field stores the specific conductivity in mS/cm of the sample.
- DS1_Ph - This field stores the pH level of the sample.
- DS1_Turb - This field stores the turbidity level in units of NU of the sample.
- DS1_W_Temp - This field stores the sample temperature at the time of collection.
- DS1_A_Temp - This field stores the ambient temperature at the time of sample collection.
- DS1_foam - This field stores information on the presence of foam coming from the outfall.
- DS1_odor - This field stores information on the presence of any non-typical odors coming from the outfall.
- DS1_color - This field stores information on the presence of any non-typical color coming from the outfall.

- DS1_oil - This field stores information on the presence of any oil sheen coming from the outfall.
- DS1_float - This field stores information on the presence of any floatables coming from the outfall.
- DS1_rate - This field stores the outfall flow rate at the time of sample collection.
- 1Am-N_sym - This field stores the < or > symbol for the DS1_Am-N field.
- DS1_Am-N - This field stores the level of ammonia/nitrogen in mg/L found within the collected sample.
- 1Col_A_sym - This field stores the < or > symbol for the DS1_Coli_A field.
- DS1_Coli_A - This field stores the detected amount of *E. coli* in MPN/100 ml found by the 1:2 Dilution sample test.
- 1_Co_A_DS - This field stores the < or > symbol for the DS1_Co_A_D field.
- DS1_Co_A_D - This field stores the detected amount of *E. coli* in MPN/100 ml found by the 1:2 dilution duplicate sample test.
- 1Col_B_sym - This field stores the < or > symbol for the DS1_Coli_B field.
- DS1_Coli_B - This field stores the detected amount of *E. coli* in MPN/100 ml found by the 1:100 dilution sample test.
- DS1_TDS - This field stores the level of TDS in mg/L found within the collected sample.
- 1TSS_sym - This field stores the < or > symbol for the DS1_TSS field.
- DS1_TSS - This field stores the level of TSS in mg/L found within the collected sample.
- DS1_Com - This field stores any additional comments associated with each outfall sample.

4.6.3 Relationships

In a relational database, all or some of the tables are in relationship with one another. Information stored in each of the tables can be linked using fields that are common to each table or feature class. Following are the relationships that were established in this database:

- WATERSHEDS-TO-STREAMS (One to Many relationship using WUID)
- WATERSHEDS-TO-TRIBUTARIES (One to Many relationship using WUID)
- WATERSHEDS-TO-SAMPLE_SITES (One to Many relationship using WUID)
- OUTFALL_LOCATIONS-TO-SAMPLE_SITES (One to One relationship using SRC_ID)
- OUTFALL_LOCATIONS-TO-RECON_RESULTS (One to One relationship using SRC_ID)

- SAMPLE_SITES-TO-DRY_SAMPLING_RESULTS (One to Many relationship using SRC_ID)
- SAMPLE_SITES-TO-WET_SAMPLING_RESULTS (One to Many relationship using SRC_ID)
- DRY_SAMPLIG_RESULTS-TO-VALIDATION_DRY_SAMPLING_RESULTS (One to One relationship using SRC_ID)

WET_SAMPLIG_RESULTS-TO-VALIDATION_WET_SAMPLING_RESULTS (One to One relationship using SRC_ID)

Table 4-1
Water Quality Observations, Dry Weather

		Flow (cfs)		*E. coli* (MPN/100 ml)			Ammonia Nitrogen (mg/l)			Turbidity (NTU)			Total Suspended Solids (mg/l)			Total Dissolved Solids (mg/l)			Specific Conductance (µmho/cm)			Dissolved Oxygen (mg/l)			pH		Temperature degrees C		
Source Number	Source Type	Average	Median	Min	Max	Geometric Mean	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Min	Max	Average
Mason Creek																													
M-002	Pipe Outfall	0.0002	0.00007	27	288	110	<0.02	**0.22**	0.14	13.4	53.5	35.6	8.0	70.0	34.0	127	176	148	52	187	141	**2.7**	9.8	6.1	7.4	8.7	21.6	24.7	23.0
M-004	Pipe Outfall (WWTP)	1.64	1.56	22	46	33	0.09	**0.55**	**0.29**	4.0	11.0	6.3	4.8	8.4	6.2	**606**	**797**	**665**	292	954	781	**1.5**	8.5	6.1	7.6	7.7	25.3	27.2	26.2
M-119	Pipe Outfall (WWTP)	4.15	3.70	<2	53	6	<0.02	**0.35**	0.14	0.4	9.8	3.3	<4	4.4	2.6	518	**741**	594	271	876	708	**2.3**	7.6	6.0	7.5	7.6	25.2	27.2	26.1
M-353	Pipe Outfall (WWTP)	0.79	0.76	4	**4,040**	**133**	**0.37**	**13.7**	**4.64**	2.0	8.3	3.9	<4	6.0	4.2	568	**758**	**643**	309	1,081	692	**1.5**	7.7	5.9	7.6	7.9	25.7	27.5	26.6
M-134	Pipe Outfall	0.04	0.000001	**731**	**9,900**	**3,441**	**0.24**	**0.51**	**0.34**	20.7	31.4	27.1	22.0	32.0	27.0	453	**688**	553	225	842	635	**3.8**	8.1	6.6	8.4	8.5	24.0	26.9	25.4
M-136	Pipe Outfall (WWTP)	0.88	1.01	6	24	13	**0.35**	**2.93**	**1.22**	8.2	10.4	9.1	8.0	21.0	14.0	509	**700**	582	840	877	854	6.5	7.6	7.0	7.6	7.7	25.6	26.8	26.3
M-300	Mason Creek	4.08	3.00	15	**476**	126	**0.39**	**1.15**	**0.69**	17.2	82.5	43.8	34.0	71.0	51.5	410	**673**	543	206	860	689	5.4	12.2	9.4	8.5	**9.3**	27.8	31.0	29.1
Garner's Bayou																													
G-257	Tributary	0.020	0.0013	15	**2,240**	**158**	<0.02	0.09	0.06	91.3	165	120	44.0	202	135	272	463	378	140	574	428	3.0	4.6	3.6	7.4	8.1	21.9	25.1	23.2
G-303	Tributary	0.059	0.068	34	209	107	<0.02	**0.61**	0.16	5.5	19.8	14.0	9.2	29.0	15.0	283	413	352	83	598	439	5.9	8.0	6.9	7.6	7.9	22.5	26.3	24.3
G-302	Other	0.32	0.25	61	**17,220**	**310**	<0.02	0.11	0.04	40.1	115	63.7	21.2	142	62.6	504	617	581	273	1,001	797	**2.6**	6.8	5.2	7.5	7.8	21.9	26.3	24.0
G-006	Pipe Outfall (WWTP)	4.80	5.25	24	89	40	**3.61**	**7.87**	**5.12**	2.2	12.0	6.2	4.8	7.0	6.0	489	586	551	207	939	581	**2.3**	7.9	6.1	7.7	7.8	26.2	28.0	27.1
G-021	Pipe Outfall (WWTP)	0.55	0.42	<2	<100	3	<0.02	0.14	0.05	2.5	12.6	7.2	<4	<4	<4	248	521	423	238	774	605	**2.9**	8.5	6.8	8.0	8.1	25.0	27.1	26.0
G-026	Pipe Outfall (WWTP)	0.37	0.31	<2	29	5	0.09	**1.78**	**0.58**	4.3	18.3	10.8	4.4	9.6	6.6	448	546	488	108	704	532	6.9	8.7	7.7	7.4	7.5	24.4	26.6	25.4
G-042	Animal Population	3.95	3.94	129	210	**153**	**0.88**	**3.89**	**1.94**	19.4	43.9	32.5	15.0	29.0	22.6	467	620	526	239	859	673	**2.3**	8.6	6.2	7.6	8.0	24.7	28.2	26.3
G-043	Pipe Outfall (WWTP)	0.23	0.18	4	208	44	**0.78**	**2.11**	**1.47**	10.5	98.0	35.5	8.8	154	49.4	439	596	490	117	737	569	7.3	8.5	8.0	7.7	7.9	24.9	27.0	25.8
G-066	Garner's Bayou	11.6	11.1	97	**449**	**181**	0.12	**4.23**	**1.32**	22.4	53.0	36.3	26.0	38.0	29.8	408	645	510	245	846	628	**2.5**	6.3	5.2	7.4	7.8	25.7	29.2	26.7
Turkey Creek																													
T-092	Tributary	0.68	0.71	163	**870**	**394**	<0.02	0.09	0.04	5.3	28.9	14.2	16.4	30.8	22.3	378	**687**	503	181	773	589	4.6	11.0	8.1	7.9	8.4	27.7	30.4	29.0
T-139	Pipe Outfall	0.0028	0.0023	49	**3,500**	**691**	0.03	**0.74**	**0.30**	0.2	17.1	7.2	<4	26.0	13.3	199	545	343	97	622	364	5.5	8.2	6.8	7.6	8.3	22.0	25.3	23.3
T-068	Turkey Creek	0.80	0.71	**731**	**141,360**	**4,543**	0.04	0.16	0.12	9.1	33.9	21.7	13.6	54.0	28.4	398	**679**	508	210	908	625	4.2	11.8	8.1	8.0	8.3	27.9	31.1	29.1
Brickhouse Gully																													
B-146	Pipe Outfall	0.098	0.099	**551**	**1,842**	**1,020**	0.06	0.15	0.10	19.1	64.1	31.8	16.0	38.0	23.6	489	524	511	121	761	554	4.9	7.7	6.4	8.0	8.2	23.5	25.2	24.3
B-203	Pipe Outfall	0.016	0.0036	192	**4,640**	**1,641**	**2.16**	**18.9**	**10.6**	5.2	346	99.9	84.0	1110	394	381	**3,452**	**1,182**	203	1,950	806	3.4	5.2	4.0	**4.7**	8.2	22.1	23.8	23.3
B-279	Pipe Outfall	0.0053	0.0051	2	**>241,920**	**453**	<0.02	**1.33**	**0.53**	1.3	19.2	7.9	<4	14.0	7.3	429	499	462	114	724	513	4.9	6.2	5.8	7.9	8.0	23.7	24.8	24.5
B-265	Pipe Outfall	1.66	0.023	<2	**821**	96	0.04	0.09	0.073	3.1	15.4	10.7	6.0	20.8	14.6	218	**989**	**727**	0	1,676	911	3.3	8.9	6.5	7.5	8.0	23.2	26.2	24.3
B-240	Pipe Outfall	0.0063	0.0011	13	37	25	0.04	**0.52**	**0.22**	0.0	10.8	4.4	<4	2.0	2.0	**604**	**690**	**633**	276	928	656	**1.7**	7.4	5.5	7.9	8.2	22.5	26.2	24.2
B-246	Pipe Outfall	0.0049	0.0011	**36,540**	**>241,920**	**121,307**	**33.4**	**72.7**	**50.5**	55.0	502	196	84.0	1110	363	485	**757**	**639**	234	1,308	868	**2.0**	5.9	4.3	8.1	8.3	25.0	30.3	27.4
B-219	Pipe Outfall	0.063	0.054	158	**17,220**	**929**	<0.02	0.13	0.05	0.5	8.0	3.9	<4	2.0	2.0	464	524	485	221	737	575	**2.7**	7.7	6.3	7.7	8.0	22.6	24.6	23.9
B-040	Pipe Outfall	0.053	0.00015	**651**	**16,640**	**3,291**	<0.02	0.04	0.025	12.6	14.6	13.6	22.4	146	84.2	543	**643**	593	297	692	494	5.0	15.2	10.1	8.7	**9.8**	27.1	**34.2**	30.6
B-380	Brickhouse Gully	2.59	1.11	10	**1,454**	**180**	<0.02	**0.28**	0.083	3.7	26.3	11.2	<4	28.0	12.5	390	490	427	103	711	473	15.8	20.0	18.8	**9.2**	**9.8**	27.9	30.5	29.6
Instream Water Quality Criteria					397	126		None, but 0.17 mg/l is			NA			NA			1016*: 1,000			NA		Mason Creek: 4.0			6.5 - 9.0*			33.33*	
								used as a screening									1014*: 600					Garner's Bayou: 3.0							
								value for concerns in									1017*: 600					Turkey Creek: 4.0							
								freshwater streams*														Brickhouse Gully: 3.0							

* Except for dissolved oxygen and E. coli, these criteria are for the designated segment that these creeks flow into and are included for comparison purposes only

Table 4-2
Dry Weather Flows

Source Number	Source Type	Estimated Flow in Cubic Feet per Second					
MASON CREEK							
		29-Apr-2003	5-May-2003	12-May-2003	19-May-2003	Average	Median
Antecedent Period without Rainfall:		4 days	11 days	18 days	25 days		
M-002	Pipe Outfall	0.0007	0.0001	0	0	0.0002	0.00007
M-004	Pipe Outfall (WWTP)	2.07	1.55	1.57	1.40	1.64	1.56
M-119	Pipe Outfall (WWTP)	3.92	5.83	3.48	3.38	4.15	3.70
M-353	Pipe Outfall (WWTP)	0.63	0.86	1.02	0.67	0.79	0.76
M-134	Pipe Outfall	0.17	0	0.000002	0	0.04	0.000001
M-136	Pipe Outfall (WWTP)		1.06	1.01	0.57	0.88	1.01
M-300	Creek	7.50	3.05	2.83	2.95	4.08	3.00
GARNER'S BAYOU							
		30-Apr-2003	6-May-2003	13-May-2003	20-May-2003	Average	Median
Antecedent Period without Rainfall:		5 days	12 days	19 days	26 days		
G-257	Tributary	0.079	0.0025	0.00015	0	0.020	0.0013
G-303	Tributary	0.090	0.0090	0.054	0.082	0.059	0.068
G-302	Other	0.23	0.28	0.20	0.56	0.32	0.25
G-006	Pipe Outfall (WWTP)	5.83	5.78	4.73	2.85	4.80	5.25
G-021	Pipe Outfall (WWTP)	0.57	0.25	0.27	1.09	0.55	0.42
G-026	Pipe Outfall (WWTP)	0.65	0.39	0.21	0.23	0.37	0.31
G-042	Animal Population	5.40	4.68	3.20	2.50	3.95	3.94
G-043	Pipe Outfall (WWTP)	0.17	0.20	0.17	0.39	0.23	0.18
G-066	Creek	10.9	10.3	11.3	14.1	11.6	11.1
TURKEY CREEK							
		30-Apr-2003	8-May-2003	14-May-2003	21-May-2003	Average	Median
Antecedent Period without Rainfall:		5 days	14 days	20 days	27 days		
T-092	Tributary	0.89	0.77	0.40	0.66	0.68	0.71
T-139	Pipe Outfall	0.000007	0.0065	0.0023	0.0023	0.0028	0.0023
T-068	Creek	1.22	0.79	0.62	0.55	0.80	0.71
BRICKHOUSE GULLY							
		1-May-2003	7-May-2003	14-May-2003	21-May-2003	Average	Median
Antecedent Period without Rainfall:		6 days	13 days	20 days	27 days		
B-146	Pipe Outfall	0.16	0.18	0.037	0.019	0.098	0.099
B-203	Pipe Outfall	0.00014	0.0015	0.057	0.0058	0.016	0.0036
B-279	Pipe Outfall	0.0080	0.0010	0.0023	0.0098	0.0053	0.0051
B-265	Pipe Outfall	0.018	6.58	0.0037	0.029	1.66	0.023
B-240	Pipe Outfall	0.023	0.0020	0.00033	0	0.0063	0.0011
B-246	Pipe Outfall	0.018	0.0000	0.0000	0.0022	0.0049	0.0011
B-219	Pipe Outfall	0.14	0.10	0.0045	0.0070	0.063	0.054
B-040	Pipe Outfall	0.21	0.0003	0	0	0.053	0.00015
B-380	Creek	1.10	7.27	0.87	1.12	2.59	1.11

Table 4-3
Aesthetic Observations, Dry Weather

Source Number	Source Type	Foam	Odor	Color	Oil	Floatables
			MASON CREEK			
M-002	Pipe Outfall	N,N,N	M,M,M	T,Br,Br	N,N,N	Y,N,A
M-004	Pipe Outfall (WWTP)	Y,Y,Y,Y	N,N,N,N	N,N,N,N	N,N,N,N	Y,N,N,N
M-119	Pipe Outfall (WWTP)	Y,Y,Y,Y	N,N,N,N	N,N,N,N	N,N,N,N	N,N,N,N
M-353	Pipe Outfall (WWTP)	Y,Y,Y,Y	N,N,N,N	N,N,N,N	N,N,N,N	V,N,N,N
M-134	Pipe Outfall	N,N,N	M,M,M	T,T,N	N,N,N	N,V,N,
M-136	Pipe Outfall (WWTP)	Y,Y,Y	N,N,**RS**	N,N,N	N,N,N	N,N,N
M-300	Mason Creek	N,N,N,Y	N,N,N,N	T,T,T,T	N,N,N,N	N,N,N,V
			GARNER'S BAYOU			
G-257	Tributary	N,N,N	N,N,N,	T,Br,T	N,N,N	V,V,V
G-303	Tributary	N,N,N,N	N,N,N,N	Br,Br,N,T	N,N,N,N	N,V,N,A
G-302	Other	N,N,N,N	N,N,N,N	T,N,N,T	N,N,N,N	N,N,N,N
G-006	Pipe Outfall (WWTP)	Y,Y,Y,Y	Y,N,N,N	N,N,N,N	N,N,N,N	O,N,N,N
G-021	Pipe Outfall (WWTP)	Y,Y,Y,S	N,N,N,N	N,N,N,N	N,N,N,N	N,N,N,N
G-026	Pipe Outfall (WWTP)	Y,Y,Y,Y	N,N,N,N	N,Br,N,N	N,N,N,N	Y,N,N,N
G-042	Animal Population	N,N,S,S	N,N,N,**Ammonia**	T,T,N,T	N,N,N,N	V,N,N,N
G-043	Pipe Outfall (WWTP)	Y,Y,Y,Y	N,N,N,N	N,Gre,N,N	N,N,N,N	V,N,N,V
G-066	Garner's Bayou	N,N,N,N	N,N,N,N	T,T,T,T	N,N,N,N	V,N,N,N
			TURKEY CREEK			
T-092	Tributary	N,N,N,N	N,N,N,N	T,N,T,T	N,N,N,N	V,V,V,A
T-139	Pipe Outfall	N,N,S,N	**RS**,N,N,N	**Blu**,N,**Ye**,Br	N,N,N,N	V,N,N,N
T-068	Turkey Creek	N,N,N,N	N,N,N,N	N,N,N,N	N,N,N,N	N,N,N,N
			BRICKHOUSE GULLY			
B-146	Pipe Outfall	N,N,N,N	N,N,N,N	T,N,N,T	N,N,N,N	N,N,N,N
B-203	Pipe Outfall	N,Y,Y,Y	**RS,RS,RS,RS**	Br,N,T,N	N,N,N,N	A,V,O,O
B-279	Pipe Outfall	Y,Y,N,Y	N,N,N,N	N,N,N,N	N,N,N,N	V,V,A,N
B-265	Pipe Outfall	N,Y,N,Y	N,N,N,N	N,N,N,T	N,N,N,N	N,N,N,V
B-240	Pipe Outfall	N,N,N	N,N,N	N,N,N	N,N,N	V,V,N
B-246	Pipe Outfall	N,N,N,N	**RS,RS**,M,**RS**	**Bla/Gre,Gra,Bla,Wh**	N,N,N,N	V,O,O,N
B-219	Pipe Outfall	S,Y,S,Y	N,N,N,N	N,N,N,N	**Y**,N,N,N	N,N,A,N
B-040	Pipe Outfall	N,Fog	**Paint**,M	N,N	N,N	N,N
B-380	Brickhouse Gully	N,S,N,Y	N,N,N,N	N,N,Gre,N	N,**Y**,N,N	N,A,A,A
		Y=Yes	Y=Yes	N=None, T=Turbid	Y=Yes	Y=Yes
		N=No	N=No	Bla=Black, Blu=Blue	N=No	N=No
		S=Slight	M=Musty	Br=Brown, Wh=White		V=Vegetation
			RS=Raw Sewage	Gre=Green, Gra=Gray		A=Algae
				Ye=Yellow		O=Organisms

Table 4-4
Wet Weather Flows

Source Number	Source Type	Date	Estimated Flow in Cubic Feet per Second							
MASON CREEK										
M-300	Creek	26-Jun-2003	3:10 PM	3:25 PM	3:40 PM	3:55 PM	4:10 PM	4:25 PM	Average	Median
			12.0	11.1	11.1	10.6	10.6	10.3	11.0	10.9
GARNER'S BAYOU										
G-066	Creek	30-Jun-2003	9:35 AM	9:50 AM	10:05 AM	10:20 AM	10:35 AM	10:50 AM	Average	Median
			17.5	17.5	17.5	16.8	16.0	16.0	16.9	17.2
TURKEY CREEK										
T-068	Creek	5-Jun-2003	1:15 PM	1:35 PM	1:55 PM	2:15 PM	2:35 PM	2:55 PM	Average	Median
			53.7	99.3	107	85.8	86.6	62.8	82.6	86.2
BRICKHOUSE GULLY										
B-380	Creek	4-Jun-2003	9:05 AM	9:20 AM	9:35 AM	9:50 AM	10:05 AM	10:20 AM	Average	Median
			100	84.0	68.0	52.0	36.0	20.0	60.0	60.0

Table 4-5
Water Quality Observations, Wet Weather

Source Number	Water Body	*E. coli* (MPN/100 ml)			Ammonia Nitrogen (mg/l)			Turbidity (NTU)			Total Suspended Solids (mg/l)			Total Dissolved Solids (mg/l)			Specific Conductance			Dissolved Oxygen (mg/l)			pH		Temperature C		
		Min	Max	Geometric Mean	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Min	Max	Average
M-300	Mason Creek	16,740	20,350	18,256	0.07	0.13	0.09	--	--	--	76	216	104	270	350	312	305	467	414	4.8	5.9	5.4	8.5	8.6	27.0	29.6	28.9
G-066	Garner's Bayou	1,733	3,106	2,487	0.15	0.25	0.19	--	--	--	68	120	95	425	463	446	534	540	538	3.3	3.5	3.4	7.5	7.5	27.4	28.7	27.8
T-068	Turkey Creek	20,630	104,620	36,976	0.06	0.33	0.21	91	191	143	124	332	227	128	250	199	228	382	312	6.1	6.8	6.5	7.3	7.7	24.5	25.3	24.9
B-380	Brickhouse Gully	9,330	23,820	17,104	0.28	0.42	0.34	54	579	182	132	181	157	84	130	110	212	248	228	5.3	6.2	5.9	7.6	7.9	23.0	23.5	23.2

Table 4-6
Aesthetic Observations, Wet Weather

Source Number	Water Body	Foam	Odor	Color	Oil	Floatables
M-300	Mason Creek	N,N,N,N,N,N	N,N,N,N,N,N	T,T,T,T,T,T	N,N,N,N,N,N	Y,Y,Y,Y,Y,Y
G-066	Garner's Bayou	N,N,N,N,N,N	N,N,N,N,N,N	T,T,T,T,T,T	N,N,N,N,N,N	S,Y,S,S,N,N
T-068	Turkey Creek	N,N,N,N,N,N	**RS**,N,M,N,N,N	T,T,T,T,T,T	N,N,N,N,N,N	Y,Y,Y,Y,Y,Y
B-380	Brickhouse Gully	N,N,N,N,N,N	N,N,N,N,N,N	T,T,T,T,T,T	S,N,N,N,N,N	Y,Y,Y,Y,Y,Y
		Y=Yes	Y=Yes	N=None	Y=Yes	Y=Yes
		N=No	N=No	T=Turbid	N=No	N=No
		S=Slight	M=Musty		S=Slight	S=Slight
			RS=Raw Sewage			

Table 4-7
Sample Sites Not Flowing at Time of Sampling

Watershed	Source Identification Number	Pollutant Source Type	Sampling Period Not Flowing
Mason	M-245	Pipe Outfall	Week 1
Garner's	G-317	Illicit Dumping Site	Week 1
Garner's	G-057	Pipe Outfall	Week 1
Turkey	T-156	Illicit Dumping Site	Week 1
Brickhouse	B-170	Pipe Outfall	Week 1
Brickhouse	B-018	Pipe Outfall	Week 1
Brickhouse	B-040	Pipe Outfall	Week 3
Mason	M-002	Pipe Outfall	Week 4
Mason	M-134	Pipe Outfall	Week 4
Garner's	G-257	Tributary	Week 4
Brickhouse	B-240	Pipe Outfall	Week 4

Sheet of

Watershed Name: ______________________ Samplers: _________________________ Date: _______________

Location: (Lat) _________________ (Long) ________________ Source Type: _______________________ Source ID: ___________

Weather: ____ Antecedent Dry Period: _______ (days) Photo #: ____________

Water Quality

Time	DO (mg/L)	Specific Cond (mS/cm)	pH (SU)	Turbidity (NU)	Water Temp (°C)	Ambient Temp (°C)	Foaming	Odor	Color	Oil sheen	Floatables

Source Flow

Stream Height Gauge		
Stream Height (ft)	Stream Width (ft)	Flow Rate (ft^3/sec)

Discharge Pipe				
Conduit Size (ft)	Conduit Type	Depth of Water (ft)	Velocity (ft/sec)	Flow Rate (ft^3/sec)

Stream Cross-section												
											Average	Flow Rate (ft^3/sec)
Stream Width (ft)												
Depth (ft)												
Velocity (ft/sec)												

Samples Collected

Ammonia - N (500 mL): _____ E. Coli (100 mL): _____ TDS / TSS (1000 mL): _____

<u>Figure 4-1</u> **Dry Weather Sampling Data Sheet**

Sheet of

Watershed Name: ____________________ Samplers: ________________________ Date: ______________

Location: (Lat) ________________ (Long) _______________ Source Type: ______________________ Source ID: __________

Weather: _______________________________________ Antecedent Dry Period: _______ (days) Photo #: ___________

Water Quality

Time	DO (mg/L)	Specific Cond (mS/cm)	pH (SU)	Turbidity (NU)	Water Temp (°C)	Ambient Temp (°C)	Foaming	Odor	Color	Oil sheen	Floatables

Rainfall

Observations	
HC OEM Guage (in)	Sample Site Rain Guage (in)

Source Flow

Stream Height Gauge		
Stream Height (ft)	Stream Width (ft)	Flow Rate (ft^3/sec)

Discharge Pipe				
Conduit Size (ft)	Conduit Type	Depth of Water (ft)	Velocity (ft/sec)	Flow Rate (ft^3/sec)

Stream Cross-section												
											Average	Flow Rate (ft^3/sec)
Stream Width (ft)												
Depth (ft)												
Velocity (ft/sec)												

Samples Collected

Ammonia - N (500 mL): _____ E. Coli (100 mL): _____ TDS / TSS (1000 mL): _____

<u>Figure 4-2</u> **Wet Weather Sampling Data Sheet**

<u>Figure 4-3</u> **Measured *E. coli* Levels for Each Source in Dry Weather (Low, High, and Geometric Mean)**

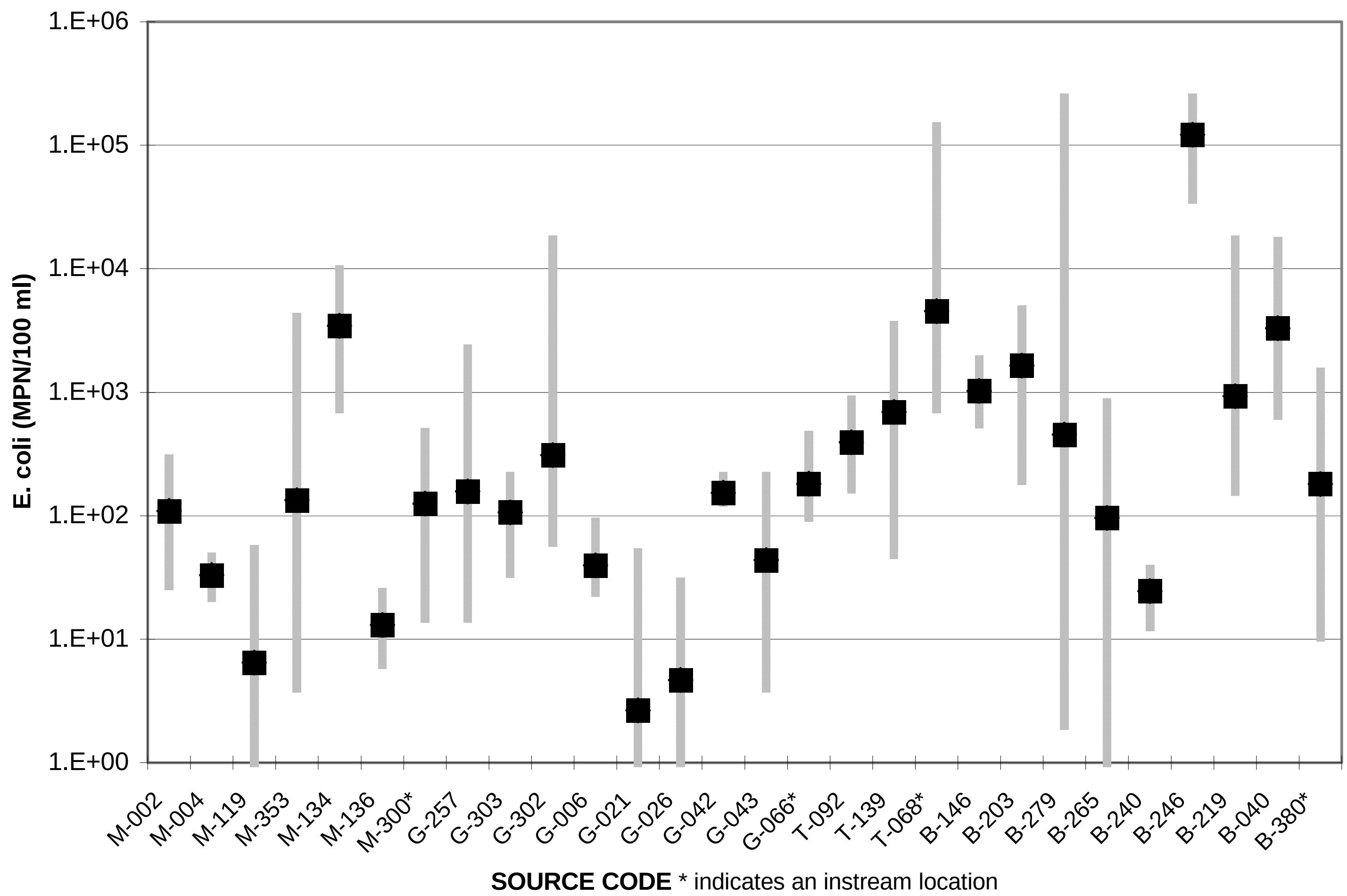
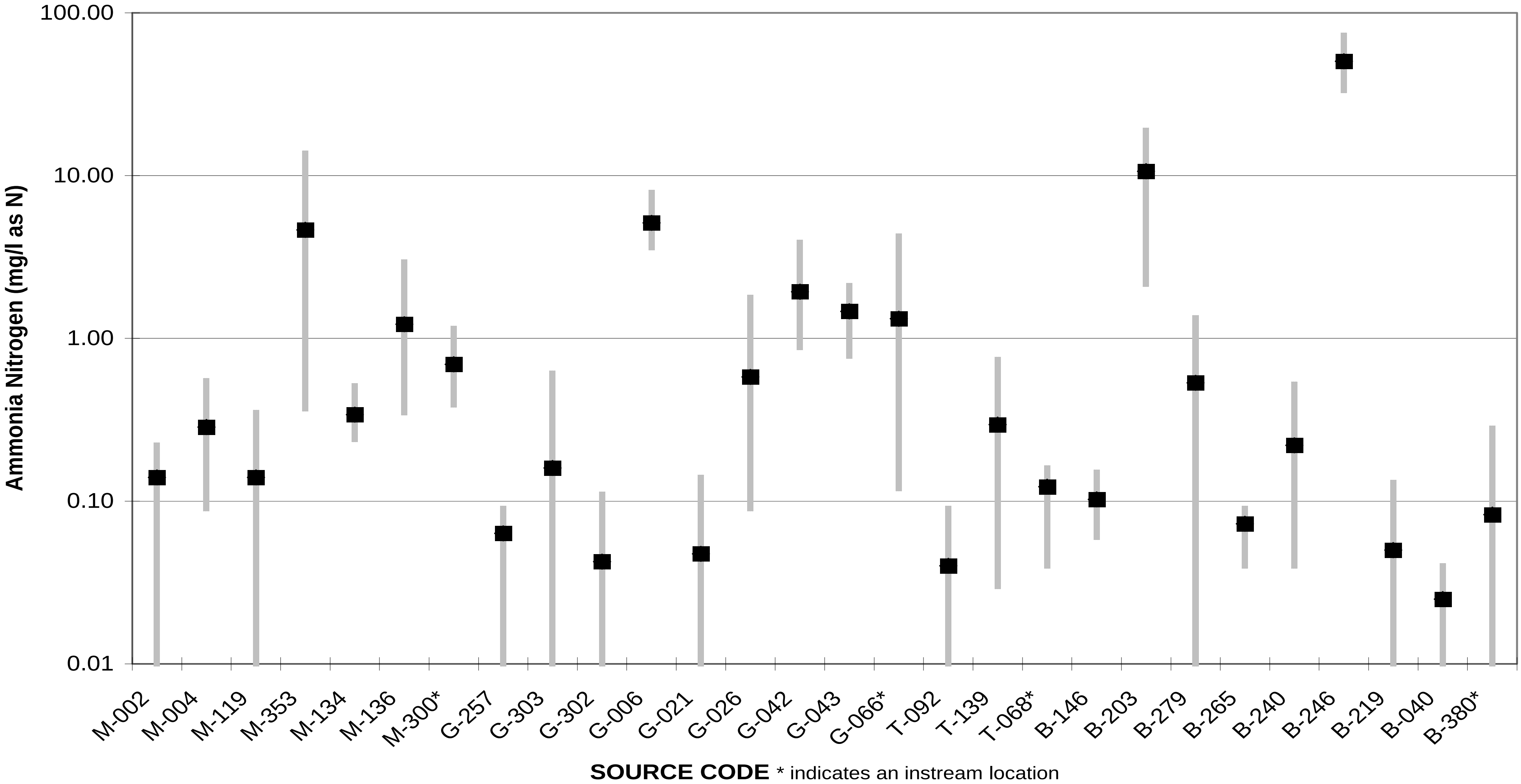


Figure 4-4 **Measured Ammonia Nitrogen Levels for Each Source in Dry Weather (Low, High, and Average)**



5.0 DEVELOPMENT OF A GIS-BASED CURVE NUMBER TOOL

5.1 INTRODUCTION

This section provides a description of the development of a GIS-based Curve Number ("CN") Tool that can automatically calculate a composite CN for any user-specified watersheds or areas. The CN Tool involves the use of the GIS-based land use/land cover ("LULC") database developed by H-GAC and the Soil Survey Geographical Database ("SSURGO") developed by the NRCS. The objective is to provide H-GAC users with a tool to use information in the LULC and SSURGO databases to calculate an area-weighted CN so that direct runoff volumes can be calculated. The developed CN Tool can be further expanded in the future to conduct calculations of flow hydrographs that can be used for the evaluation of water quality and BMP's.

The development of the CN Tool started with a comparison of the LULC and soil type categories provided by H-GAC with the NRCS CN Table. Because of the differences between the H-GAC categories and the NRCS Table, a method was developed to combine the H-GAC and the NRCS LULC and soil type categories. The developed method was proposed to and approved by H-GAC after thorough discussion. A GIS program was then developed to intercept the LULC and soil data in the databases, calculate area of and assign CN to each of the LULC/soil interceptions, and then calculate an area-averaged CN for any specified polygons or areas. The developed tool was then applied to the four small watersheds studied under this project. The following subsections provide details on the development of this CN Tool and the results of its application to the four small watersheds.

5.2 CURVE NUMBER METHOD BY NRCS

The CN method developed by NRCS (1986) was to calculate precipitation loss and runoff volume. The formulae developed by NRCS for this purpose include the following:

$$V = (P - I_a)^2 / [(P - I_a) + S]$$
$$I_a = 0.2S$$
$$S = 1000/CN - 10$$

where

V = runoff volume in inches (in)
P = precipitation volume (in)
S = potential maximum retention after runoff begin (in)
I_a = initial abstraction (in)
CN = Curve Number

The runoff volume (V) is the portion of the total precipitation (P) that flows from the watershed into receiving water bodies. The precipitation that does not run off includes water retained in surface depressions, intercepted by vegetation and structures, and lost through evaporation and infiltration. These losses are highly variable but found to be generally correlated to soil types, moisture conditions, and LULC parameters. Based on experimentation and experience, NRCS developed the CN ranging from 0 to 100 to relate these precipitation loss parameters.

Antecedent moisture condition ("AMC") is another important factor in determining runoff volume, but it can only be evaluated at specific times. The developed CN Tool is designed to determine CN's under normal AMC's only. Adjustments to other AMC's should be made using standard NRCS formulas. As shown in Tables 5-1 and 5-2, major geographic factors that determine CN include the hydrologic soil group ("HSG") and LULC of the area. NRCS classified soils into four HSG's according to the minimum infiltration rates of the soils that were obtained for bare soil after prolonged wetting. The infiltration rate is the rate at which water enters the soil at the soil surface and is controlled by the conditions of soil surface. The HSG's also indicate a water transmission rate, which is the rate at which the water moves within the soil and is controlled by the soil profile. The four HSG classifications are defined in Table 5-3.

Table 5-1
Runoff Curve Numbers for Urban Areas (NRCS, 1986)

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

Table 5-2
Runoff Curve Numbers for Cultivated Agricultural Lands (NRCS, 1986)

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment [2]	Hydrologic condition [3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

Table 5-3
Definition of Hydrologic Soil Groups (NRCS, 1986)

HSG	Soil textures	Water Transmission Rate (in/hr)
A	Sand, loamy sand, or sandy loam	> 0.30
B	Silt loam or loam	0.15 – 0.30
C	Sandy clay loam	0.05 – 0.15
D	Clay loam, silty clay loam, sandy clay, silty clay, or clay	0.00 – 0.05

5.3 DEVELOPMENT OF CN TABLE

The development of the CN Tool started with the LULC database provided by H-GAC, which includes the following 10 LULC categories:

- No Data
- Low Intensity Developed
- High Intensity Developed
- Agriculture
- Grassland
- Woody Land
- Open Water
- Woody Wetland
- Wetland
- Bare or Transitional

These LULC categories were compared against the CN table by NRCS (Tables 5-1 and 5-2). Comparable CN values were then assigned to the H-GAC LULC categories using CN values of similar LULC in the NRCS tables. Table 5-4 shows the assignment of CN values and the assumptions/remarks of the assignments.

Next, the SSURGO database for Harris County was obtained from NRCS and confirmed with H-GAC for its use in the development of the CN Tool. The SSURGO database contained 51 soil types in Harris County and their corresponding permeability ranges were retrieved from the Soil Survey of Harris County (NRCS, 1976). By comparing the ranges of soil permeability against the defined water transmission rates of HSG's, a preliminary assignment of HSG's to the 51 soil types was made. In addition, it was found that some soil types have HSG's already defined in TR-55 (NRCS, 1986) that may or may not be consistent with those obtained based on permeability.

A meeting with H-GAC was held on April 10, 2003, to discuss the CN value assignment and the HSG issues and the following decisions were made during the meeting:

- The assignment of CN values to the 10 H-GAC LULC categories was approved.
- For soils with one HSG classification based on permeability, the HSG should be adopted.

- For soils with a range of HSG's based on permeability (e.g., A-D), the HSG's should be adopted according to the soil type. If the soil type is clay or sand, then an HSG of C or B should be adopted, respectively. If the soil type is unclear and there is one HSG associated with the soil in TR-55, then the TR-55 HSG should be adopted. If none of the above is applicable, then an HSG of C should be adopted.

- For Open Water, Wetland, and Woody Wetland, a CN of 50, 40, and 30 should be used, respectively, for the development of a look-up table and the CN Tool. These values may be changed in the future. The selection of these CN values was discussed because of the uncertainty associated with these areas. If the areas would retain all rainfall on the areas, then a CN of 0 should be used because no runoff would result. On the other hand, if the areas had no water storage capacity left, then all rainfall would run off and a CN of 100 should be used. Due to these uncertainties, a CN of 50 was chosen for open water areas as a temporary solution to allow finalization of the CN Tool. These values may be changed in the future.

Appendix D provides a summary of the 4/10/03 meeting. Following the meeting, an MS Access file called "Landuse&CN.mdb" was developed. The "Landuse&CN.mdb" file includes two look-up tables, a query, and a result table. The first look-up table, called "Soil&HSG," contains the soil map unit system (MUSYM) ID's, soil names, and the assigned HSG's. Table 5-5 lists the content of this look-up table. The second look-up table, called "Landuse&CN," contains the assigned CN values for each of the 10 H-GAC LULC categories. This look-up table is essentially the same as Table 5-4.

A query called "CNlink1" was developed to link the two look-up tables together and produce a result table. As shown in Figure 5-1, the query links the two tables by the HSG's. The result table called "CN-1" contains a complete list of LULC and soil type combinations, as shown in Appendix E. This table is then used in the CN Tool to assign CN values to each combination of LULC and soil type intercepted by the tool. The development of these tables and query allows H-GAC to make changes in the future to include different LULC categories or soil types (e.g., to include other watersheds). When such changes occur, the query can be re-executed to generate an updated CN-1 table. The CN Tool can then be used to update the CN calculations.

<u>Table 5-4</u>
H-GAC LULC Categories and CN Values

Land Use	HSG	CN	Remarks
Agriculture	A	72	Without Conservation Treatment
Agriculture	B	81	Without Conservation Treatment
Agriculture	C	88	Without Conservation Treatment
Agriculture	D	91	Without Conservation Treatment
Bare or Transitional	A	74	Description similar to Gravel and Dirt
Bare or Transitional	B	83	Description similar to Gravel and Dirt
Bare or Transitional	C	88	Description similar to Gravel and Dirt
Bare or Transitional	D	90	Description similar to Gravel and Dirt
Grassland	A	39	Assume good conditions
Grassland	B	61	Assume good conditions
Grassland	C	74	Assume good conditions
Grassland	D	80	Assume good conditions
High Intensity Developed	A	89	Assume Commercial and business areas (85% impervious)
High Intensity Developed	B	92	Assume Commercial and business areas (85% impervious)
High Intensity Developed	C	94	Assume Commercial and business areas (85% impervious)
High Intensity Developed	D	95	Assume Commercial and business areas (85% impervious)
Low Intensity Developed	A	77	Assume Residential - 1/8 ac or less (65% impervious)
Low Intensity Developed	B	85	Assume Residential - 1/8 ac or less (65% impervious)
Low Intensity Developed	C	90	Assume Residential - 1/8 ac or less (65% impervious)
Low Intensity Developed	D	92	Assume Residential - 1/8 ac or less (65% impervious)
No Data	A	50	Assume average
No Data	B	50	Assume average
No Data	C	50	Assume average
No Data	D	50	Assume average
Open Water	A	50	This LULC is dependent on soil capacity
Open Water	B	50	This LULC is dependent on soil capacity
Open Water	C	50	This LULC is dependent on soil capacity
Open Water	D	50	This LULC is dependent on soil capacity
Wetland	A	40	This LULC is dependent on soil capacity
Wetland	B	40	This LULC is dependent on soil capacity
Wetland	C	40	This LULC is dependent on soil capacity
Wetland	D	40	This LULC is dependent on soil capacity
Woody Land	A	25	Assume Wood or Forest Lands with good cover
Woody Land	B	55	Assume Wood or Forest Lands with good cover
Woody Land	C	70	Assume Wood or Forest Lands with good cover
Woody Land	D	77	Assume Wood or Forest Lands with good cover

Land Use	HSG	CN	Remarks
Woody Wetland	A	30	This LULC is dependent on soil capacity
Woody Wetland	B	30	This LULC is dependent on soil capacity
Woody Wetland	C	30	This LULC is dependent on soil capacity
Woody Wetland	D	30	This LULC is dependent on soil capacity

Table 5-5
Soil and HSG Look-up Table

MUSYM	NAME	HSG
Ad	Addicks loam	A
Ak	Addicks-Urban land complex	A
Am	Aldine very fine sandy loam	A
An	Aldine-Urban land complex	A
Ap	Aris fine sandy loam	A
Ar	Aris-Gessner complex	A
As	Aris-Urban land complex	A
AtB	Atasco fine sandy loam, 1 to 4 percent slopes	A
Ba	Beaumont clay	C
Bc	Beaumont-Urban land complex	C
Bd	Bernard clay loam	C
Be	Bernard-Edna complex	D
Bg	Bernard-Urban land complex	D
Bn	Bissonnet very fine sandy loam	A
Bo	Boy loamy fine sand	A
Bp	Borrow Pit	A
Cd	Clodine loam	A
Ce	Clodine-Urban land complex	A
Ed	Edna fine sandy loam	A
Ge	Gessner loam	A
Gp	Gravel Pit	A
Gs	Gessner complex	A
Gu	Gessner-Urban land complex	A
Ha	Harris clay	C
Hf	Hatliff loam	A
HoA	Hockley fine sandy loam, 0 to 1 percent slopes	A
HoB	Hockley fine sandy loam, 1 to 4 percent slopes	A
Is	Ijam soils	D
Ka	Kaman clay	D
Kf	Katy fine sandy loam	A
Kn	Kenney loamy fine sand	A
Ku	Kenney-Urban land complex	A
LcA	Lake Charles clay, 0 to 1 percent slopes	C
LcB	Lake Charles clay, 1 to 3 percent slopes	C
Lu	Lake Charles-Urban land complex	D
Md	Midland silty clay loam	C
Mu	Midland-Urban land complex	C
Na	Nahatche loam	A
Oa	Ozan loam	A
On	Ozan-Urban land complex	A
SeA	Segno fine sandy loam, 0 to 1 percent slopes	A
SeB	Segno fine sandy loam, 1 to 3 percent slopes	A
Ur	Urban land	D
VaA	Vamont clay, 0 to 1 percent slopes	C
VaB	Vamont clay, 1 to 4 percent slopes	C
Vn	Vamont-Urban land complex	D
Vo	Voss sand	A
Vs	Voss soils	A
W	Waters	D
Wo	Wockley fine sandy loam	A
Wy	Wockley-Urban land complex	A

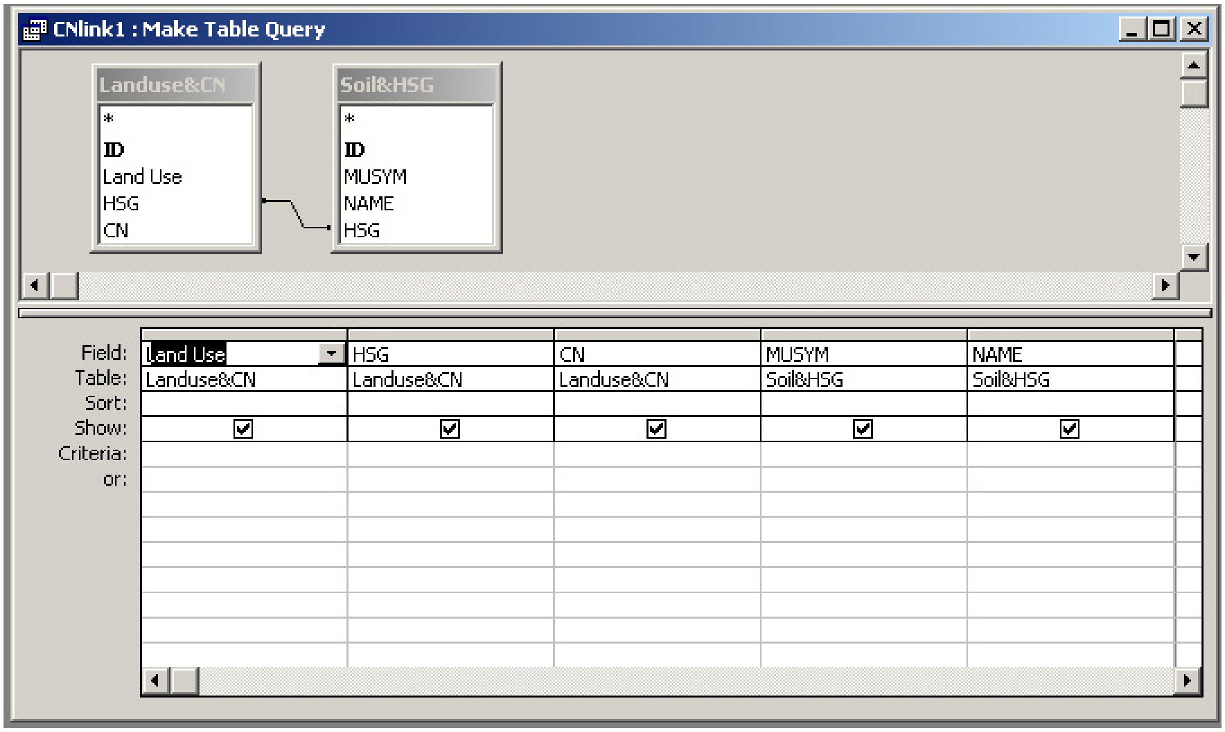


Figure 5-1 **CNlink1 Query**

5.4 DEVELOPMENT OF GIS-BASED CN TOOL

A GIS-based CN Tool was developed to conduct the following operations under the ArcGIS/ArcMap environment:

1. Within a user-specified area (e.g., a subwatershed), intercept the LULC and SSURGO database to develop polygons of all LULC and soil type combinations.
2. Calculate areas of each of the polygons.
3. Assign CN values to the polygons based on the CN-1 table.
4. Calculate an area-averaged CN for the specified area.

Basins, LULC, and soils polygon feature classes are required to execute the tool. Results are generated and stored back into the basins' feature class.

The CN Tool was developed with C#, one of the languages in the Microsoft .Net Framework. The C# compiler is provided with the .Net Framework and Framework SDK. The ESRI .Net Interop Assemblies for working with ArcObjects in .Net are provided with the ESRI ArcGIS 8.3 installation or may be created manually using ArcMap type libraries. The installer is Inno Setup that may be obtained from www.jrsoftware.org. C# has a C syntax style programming language similar to Java and is entirely object oriented. The programming was performed using a visual IDE called SharpDevelop. This tool may be obtained from SourceForge: www.sourceforge.net.

After the installation of CN Tool to a computer, the user should:

- Select Tools Menu, and then the Customize menu item in ArcMap.
- Select the Command Tab.
- Drag the following two sub-tools under the CN Tool category onto any toolbar:
- Hydrologic Intersection - This tool performs an intersection of basin, land use, and soils ArcMap layers.
- Aggregate - This tool computes the area-averaged CN values.

The CN Tool installation directory contains a configuration file. The file controls the column names in the table that appear when running the command. There is currently only one column for Curve Number. If it is desired to perform area averaging on other attributes, the user may add additional single words as separate lines in the configuration file.

The Hydrologic Intersection sub-tool was developed to intersect the basin, LULC, and soils polygon layers together. It performs the same analysis as the ArcMap geo-processor except it does it twice. The intersection of these layers must be performed first either through the geo-processor or with this tool before using the area-averaging tool. Figure 5-2 shows the pop-up window when executing the Hydrologic Intersection tool.

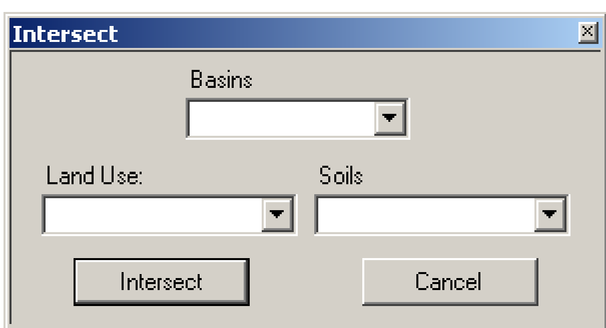


Figure 5-2 **Hydrologic Intersection Sub-Tool**

In Figure 5-2, the Basins, Land Use, and Soils windows allow the users to select the basin, land use, and soil polygon layers, respectively. The pressing of the Intersect button will intersect the basins, land use, and soil layers and outputs an intersection layer.

Figure 5-3 shows a dialog of the Aggregate sub-tool that computes the area-averaged CN values based on unique combinations of land use and soils values. The look up table (CN-1) must be created prior to performing this analysis. If the combo boxes on the right side of the dialog shown in Figure 5-3 are all filled in with data and the table is empty, unique combinations of land use and soils fields will be automatically populated into the table. The user must then enter the CN values for each combination.

In Figure 5-3, the Basin Layer is the layer where the calculated area-averaged values will be output and stored. The Intersection Layer contains the basin, land use, and soils data intersected by the Hydrologic Intersection sub-tool. The Land Use Field and Soils Field store land use and soil values used when looking up information in the look-up table to assign a CN value, respectively. The Basin Name Field identifies the basin name used to link with the area-averaging analysis. The Save button allows the saving of current look-up table to a file in Comma Separated Values (CSV) format for external editing purposes. The Load button allows the loading/importing of a saved look-up table. The pressing of the OK button will execute the area-averaging computations.

5.5 APPLICATION OF CN TOOL TO SMALL WATERSHEDS

The developed CN Tool was QA/QC by conducting an independent calculation of area-weighted average CN in Excel and comparing the results against the ones produced by the CN Tool. The Mason Creek watershed data were used for this purpose. As listed in Table 5-6, the results produced by the CN Tool match very well with the Excel calculations.

The CN Tool was then applied to the four small watersheds studied under this project. As listed in Table 5-7, the CN Tool calculated area-weighted average CN values of 51.71, 37.32, 72.26, and 52.21 for Mason Creek, Turkey Creek, Brickhouse Gully, and Garner's Bayou, respectively. These values indicate that Brickhouse Gully has a mostly urban watershed with a higher CN value and Turkey Creek has a more undeveloped watershed and therefore a lower CN value. These results match the general perception of the watersheds. Therefore, the developed CN Tool appears to be a useful GIS tool for calculating averaged CN values.

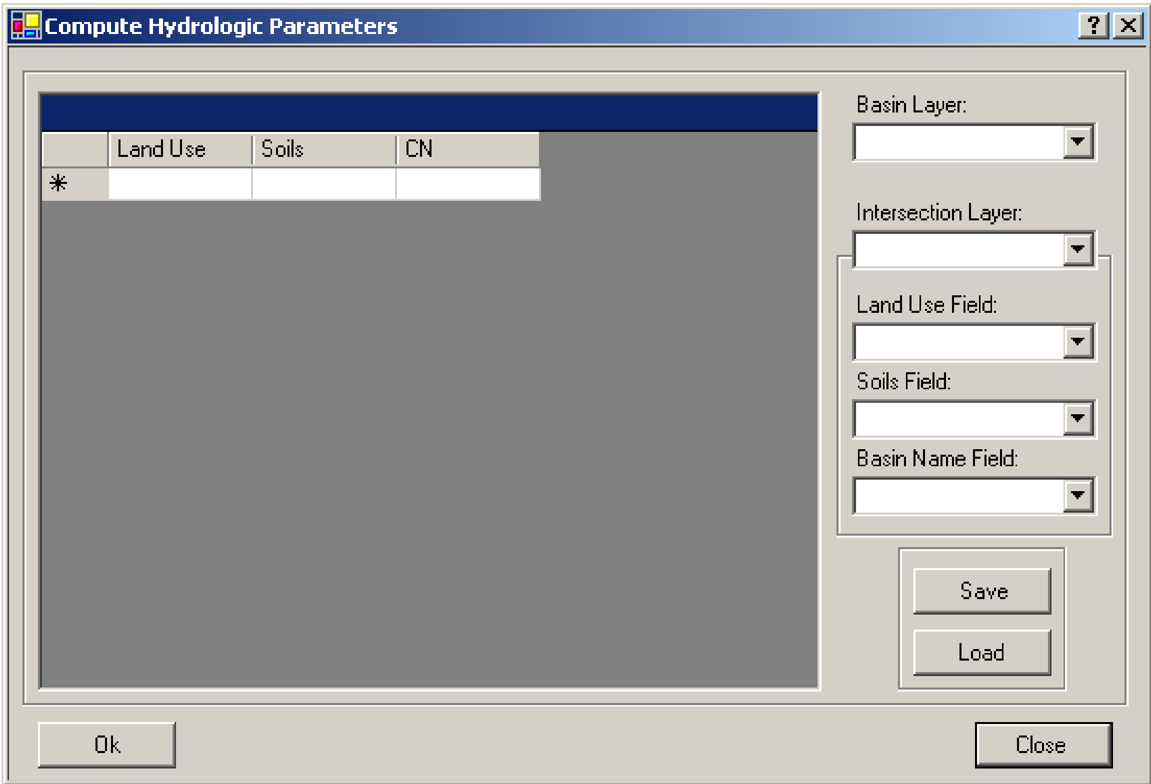


Figure 5-3 Aggregate Sub-Tool

Table 5-6
QA/QC of CN Tool Using Mason Creek Watershed Data

Methods	Area (acres)	Area-Weighted Average CN
Excel	8,180.321	51.78
CN Tool:	8,179.282	51.71
Difference	-0.013%	-99.988%

Table 5-7
Application of CN Tool to Small Watersheds

Watershed	Area (acres)	Area-Weighted Average CN
Mason Creek	8,179.282	51.71
Turkey Creek	9,650.983	37.32
Brick House Gully	7,447.177	72.26
Garner's Bayou	15,213.401	52.21

6.0 DISCUSSION OF RESULTS

This section discusses the results of the sampling effort in terms of the loadings of contaminants in each stream and the sources to that stream. The dry weather sampling was a near synoptic measurement of most of the inputs to the streams and the output at the downstream end. A load analysis gives a measure of how much of the flow and load was characterized by the input (source) sampling and which sources had the biggest influence on downstream concentrations. Additionally, the results of this sampling effort are compared to historical monitoring data from these streams.

6.1 BACTERIA LOADS

Dry weather and wet weather bacteria loads are summarized in Tables 6-1 and Table 6-2 and are depicted in Figures 6-1 through 6-4. As expected, wet weather loads are significantly larger than dry weather loads. Observed loads in each watershed are discussed below.

6.1.1 Brickhouse Gully

Dry weather loads are summarized in Table 6-1 and Figure 6-1. Brickhouse Gully had no WWTP sources sampled and all of the sampled sources tended to have low flow rates. The sampled flows did not account for the creek flow at the downstream station. In dry weather, in-stream *E. coli* loads in Brickhouse Gully ranged from 1.85×10^{9} to 3.89×10^{10} per day with a geometric mean of 7.37×10^{9} per day. The average load is similar to that in Mason Creek. Outfalls B-146, B-246, and B-219 represented the major sources of *E. coli* load to Brickhouse Gully (in descending order of importance) under dry weather conditions. Outfalls B-203, B-279, B-040, and B-265 were occasionally significant loads to Brickhouse Gully. Outfall B-240 was not a significant source of *E. coli* to Brickhouse Gully. These eight sources represented from 180 to 657 percent of the measured in-stream load of *E. coli* for the four dry weather events. The high *E. coli* load of 5.85×10^{10} per day from Source B-279 on May 21 far exceeded the in-stream load measured to be 1.09×10^{10} per day. Based on geometric mean loads, these eight sources accounted for 45 percent of the in-stream bacteria load. However, if the very large flow at B-265 is disregarded, the flows measured account for only about 10 percent of the downstream flow.

Wet weather *E. coli* loads are summarized in Table 6-2 and Figure 6-1. Wet weather *E. coli* loads in Brickhouse Gully ranged from 8.46×10^{12} to 5.83×10^{13} per day, approximately 3,000 times higher than those under dry weather conditions, indicating the importance of runoff source loads of *E. coli* to Brickhouse Gully.

6.1.2 Garner's Bayou

Dry weather loads are summarized in Table 6-1 and Figure 6-2. In dry weather, in-stream *E. coli* loads in Garner's Bayou ranged from 2.45×10^{10} to 1.20×10^{11} per day with a geometric mean of 5.12×10^{10} per day. Sources G-042, G-006, and G-302 represented the major sources of *E. coli* load to Garner's Bayou (in descending order of importance) under dry weather conditions. Outfalls G-043, G-026, G-021, and Tributaries G-303 and G257 were occasionally significant loads to Garner's Bayou. These eight sources represented from 22 to 575 percent of the measured in-stream load of *E. coli* for the four dry weather events. The high *E. coli* load of 2.35×10^{11} per day from Source G-302 on May 20 far exceeded the in-stream load measured to be 4.28×10^{10} per day. Based on geometric mean loads, these eight sources accounted for 41 percent of the in-stream load.

Wet weather *E. coli* loads are summarized in Table 6-2 and Figure 6-2. Wet weather *E. coli* loads in Garner's Bayou ranged from 6.78×10^{11} to 1.21×10^{12} per day, which are approximately 20 times higher than those under dry weather conditions. However, as noted earlier, the amount of rainfall that occurred during the wet weather event may not have contributed a great deal of runoff. Flow was only about 50 percent higher than under dry weather conditions. Some runoff influence was apparent.

6.1.3 Mason Creek

Dry weather loads are summarized in Table 6-1 and Figure 6-3. During dry weather, wastewater flows account for the downstream flow. The in-stream *E. coli* loads in Mason Creek ranged from 1.07×10^{10} to 8.75×10^{10} per day, with a geometric mean of $1.14 \times 1{,}010$ per day. Outfalls M-353, M-004, M-119, and M-136 represented the major sources of *E. coli* load to Mason Creek (in descending order of importance) under dry weather conditions. Outfalls M-002 and M-134 were of negligible importance regarding *E. coli* loading. These six sources represented from 7 to 934 percent of the measured in-stream load of *E. coli* for the four dry weather events. A very high load of 8.47×10^{10} *E. coli* observed on one day from Outfall M-353 exceeded the load measured in-stream by almost an order of magnitude.

Based on geometric mean loads, these six sources accounted for 42 percent of the in-stream load. Considering that bacteria concentrations vary on a logarithmic scale, the mean sum of source loads (4.76×10^{9} per day) is in reasonable agreement with the mean in-stream load (1.14×10^{10} per day).

Wet weather *E. coli* loads are summarized in Table 6-2 and Figure 6-3. Loads in Mason Creek ranged from 4.35×10^{12} to 5.43×10^{12} per day, approximately 400 times higher than those under dry weather conditions. Higher bacteria loads under runoff conditions are expected because rain washed much of the fecal material into streams that was recently deposited on the land surface by numerous sources, including wildlife, birds, livestock, humans, and domestic pets. Rainfall also contributes to sewer and septic system leaks, overflows, and other failures, as well as overloading sewage treatment systems through sewer infiltration. Finally, elevated flows associated with runoff can resuspend bacteria that were previously deposited to the sediment surface through sedimentation.

6.1.4 Turkey Creek

Dry weather loads are summarized in Table 6-1 and Figure 6-4. In dry weather, a single tributary accounts for essentially all in-stream flow. In-stream *E. coli* loads in Turkey Creek ranged from 1.11×10^{10} to 1.91×10^{12} per day with a geometric mean of 8.43×10^{10} per day. The average load is more than seven times higher than that in Mason Creek, and also higher than that of Garner's Bayou and Brickhouse Gully. Tributary T-092 represented the major source of *E. coli* loading to Turkey Creek that was identified under dry weather conditions. Outfall T-139 was not a significant source of *E. coli* to Garner's Bayou. These two sources represented from 0.3 to 35 percent of the measured in-stream load of *E. coli* for the four dry weather events. Based on geometric mean loads, these two sources accounted for only 7 percent of the in-stream load. It appears that there must be other sources of *E. coli* to Turkey Creek in dry weather that were not identified in this investigation particularly based on the May 21 result.

Wet weather *E. coli* loads are summarized in Table 6-2 and Figure 6-4. Wet weather *E. coli* loads in Turkey Creek ranged from 2.71×10^{13} to 2.74×10^{14} per day with a geometric mean of 7.26×10^{13} per day. This loading is more than 800 times higher than those under dry weather conditions, indicating the magnitude of non-point sources of *E. coli* loading in the Turkey Creek watershed.

6.1.5 Dry Weather Load Discussion

With three of the four streams, the observed sources account for the majority of the bacteria observed at the downstream station. Only on Turkey Creek was the downstream bacteria concentration much higher than could be explained by sampled sources. In this load analysis, there is considerable scatter. There are a number of possible explanations why the sum of identified source loads may not match the measured in-stream load. First, there is temporal variability in flow and *E. coli* concentrations. There is also error in the single, unreplicated measurements of flow and *E. coli* concentrations from which the loads are calculated. *E. coli* die off and settling to sediments also likely reduces *E. coli* concentrations in the stream between the source and the in-stream sampling point. Finally, of course, it is likely if not certain that not all *E. coli* sources to the streams were investigated.

6.2 AMMONIA LOADS

Dry weather and wet weather ammonia loads are summarized in Tables 6-3 and Table 6-4 and are depicted in Figures 6-5 through 6-8. Observed loads in each watershed are discussed below.

6.2.1 Brickhouse Gully

Dry weather ammonia loads are summarized in Table 6-3 and are depicted in Figure 6-5. In dry weather, in-stream ammonia nitrogen loads in Brickhouse Gully ranged from 0.047 to 11 pounds per day with an average of 2.8 pounds per day. The average dry weather load is intermediate between Turkey Creek and Mason Creek, far lower than Garner's Bayou. Outfalls B-246, B-203, and B-265 represented the major sources of ammonia nitrogen load to Brickhouse Gully (in descending order of importance) under dry weather conditions. Outfalls B-146, B-279, B-240, B-040, and B-219 were seldom or never significant sources of ammonia nitrogen loads to Brickhouse Gully. These eight sources represented from 28 to 12,300 percent of the measured in-stream load of ammonia nitrogen for the four dry weather events. The elevated ammonia nitrogen loads from Outfalls B-246, B-265, and B-203 occurred episodically but were usually low. The observation that in-stream ammonia nitrogen levels tended to be so much lower than the sum of loading from sources may indicate that ammonia is efficiently transformed to nitrite in the stream. Based on average loads, these eight sources accounted for 147 percent of the in-stream load, similar to the result in Mason Creek.

Wet weather ammonia loads are summarized in Table 6-4 and are depicted in Figure 6-5. Wet weather ammonia nitrogen loads in Brickhouse Gully ranged from 31.3 to 210 pounds per day, with an average load of 145 pounds per day. These wet weather loads were approximately 50 times higher than those under dry weather conditions. The presence of such an increase in ammonia loading indicates additional non-point sources of pollution (i.e., fertilizers) or the presence of raw or incompletely treated sewage in runoff. The sources of sewage may include sewer overflows, cross-connections between sanitary sewers and storm drains, malfunctioning septic systems, or incomplete sewage treatment caused when inflow and infiltration of sewers by rain overwhelms sewage treatment facilities.

6.2.2 Garner's Bayou

Dry weather ammonia loads are summarized in Table 6-3 and are depicted in Figure 6-6. In dry weather, in-stream ammonia nitrogen loads in Garner's Bayou ranged from 9.1 to 234 pounds per day with an average of 75 pounds per day. The in-stream load on May 6 was much higher than on other dates, apparently due to the elevated loading from Outfall G-006. The average load is roughly six times higher than that in Mason Creek. Outfall G-006 represented the major load on most dates with an average load of 136 pounds per day. Source G-042 was another significant ammonia nitrogen source to Garner's Bayou under dry weather conditions. Outfalls G-043 and G-026 were minor ammonia sources while Tributaries G-257 and G-303, Source G-302, and Outfall G-021 were negligible ammonia nitrogen sources. These eight sources combined represented from 127 to 871 percent of the measured in-stream load of ammonia nitrogen for the four dry weather events. Based on average loads, these eight sources accounted for 239 percent of the in-stream load, similar to the result in Mason Creek.

Wet weather ammonia loads are summarized in Table 6-4 and are depicted in Figure 6-6. Wet weather ammonia nitrogen loads in Garner's Bayou ranged from 12.9 to 23.6 pounds per day similar to typical loads under dry weather conditions. However, as noted earlier, the amount of rainfall that occurred during the wet weather event may not have contributed a great deal of runoff and flow was only about 50 percent higher than under dry weather conditions, though some runoff influence was apparent.

6.2.3 Mason Creek

Dry weather ammonia loads are summarized in Table 6-3 and are depicted in Figure 6-7. In dry weather, in-stream ammonia nitrogen loads in Mason Creek ranged from 5.95 to 28.7 pounds per day with an average of 15.5 pounds per day. Outfalls M-353, M-136, M-119, and M-004 represented the major sources of ammonia nitrogen load to Mason Creek (in descending order of importance) under dry weather conditions. Outfalls M-002 and M-134 were of negligible importance regarding ammonia nitrogen loading, as with *E. coli*. These six sources represented from 61 to 364 percent of the measured in-stream load of ammonia nitrogen for the four dry weather events. A very high load of 63.3 pounds per day of ammonia nitrogen from Outfall M-353 on May 5 exceeded the load measured in-stream by a factor of three. *E. coli* concentrations and loads were also high on this date indicating a possible operational upset.

Based on average loads, these six sources accounted for 193 percent of the in-stream load. As with *E. coli*, there are a number of possible explanations why the sum of identified source loads may not match the measured in-stream load. First, there is temporal variability in flow and ammonia nitrogen concentrations. There is also error in the single, unreplicated measurements of flow and ammonia nitrogen concentrations from which the loads are calculated. Ammonia tends to be oxidized somewhat rapidly to nitrite under ambient in-stream conditions. This is likely the major reason why in-stream ammonia levels are less than the sum of ammonia levels in sources. Finally, of course it is likely if not certain that not all ammonia nitrogen sources to the streams were investigated.

Wet weather ammonia loads are summarized in Table 6-4 and are depicted in Figure 6-7. Wet weather ammonia nitrogen loads in Mason Creek ranged from 4.01 to 8.41 pounds per day and were similar to typical dry weather loads. This may indicate that the bayou was not influenced by fertilizers or raw or minimally treated sewage, which is high in ammonia, due to the influence of rainfall through sewer and septic system leaks, overflows, and other failures.

6.2.4 Turkey Creek

Dry weather ammonia loads are summarized in Table 6-3 and are depicted in Figure 6-8. In dry weather, in-stream ammonia nitrogen loads in Turkey Creek ranged from 0.12 to 1.05 pounds per day with an average of 0.57 pounds per day. The average load is much lower than that in Mason Creek, Garner's Bayou, or Brickhouse Gully. This observation is interesting given that the *E. coli* loads were higher in Turkey Creek than other streams. Tributary T-092 represented the major source of ammonia nitrogen loading to Turkey Creek that was identified under dry weather conditions. Outfall T-139 was not a significant source of ammonia nitrogen to Garner's Bayou. These two sources represented from 7 to 39 percent of the measured in-stream load of ammonia nitrogen for the four dry weather events. Based on average loads, these two sources accounted for only 23 percent of the in-stream load. It appears that there must be other sources of ammonia nitrogen to Turkey Creek in dry weather that were not identified in this investigation.

Wet weather ammonia loads are summarized in Table 6-4 and are depicted in Figure 6-8. Wet weather ammonia nitrogen loads in Turkey Creek ranged from 20 to 173 pounds per day with an average of 129 pounds per day. This loading is more than 200 times higher than those under dry weather conditions. The presence of such an increase in ammonia loading indicates additional non-point sources of pollution (i.e., fertilizers) or the presence of raw or incompletely treated sewage in runoff. The sources of sewage may include sewer overflows, cross-connections between sanitary sewers and storm drains, malfunctioning septic systems, or incomplete sewage treatment caused when inflow and infiltration of sewers by rain overwhelms sewage treatment facilities.

6.3 COMPARISON WITH HISTORICAL MONITORING DATA

The Houston Department of Health and Human Services has performed routine water quality monitoring in each of the streams investigated for a number of years. TCEQ routinely monitored water quality in Garner's Bayou from 1994 to 1996, and the Texas Watch citizen volunteer monitoring program performed a limited amount of water quality monitoring on Turkey Creek in early 2001. The stations where monitoring has taken place historically are listed in Table 6-5. Water quality measurements recorded in these streams since 1993 (that is recorded in the TCEQ surface water quality monitoring database) is statistically summarized in Table 6-6.

E. coli and fecal coliform levels have historically exceeded water quality criteria for contact recreation by a large margin in each of the four streams investigated. In their latest (2002) draft assessment, TCEQ determined that the contact recreation use is impaired in Turkey Creek, Garner's Bayou, and Brickhouse Gully, and added them to the draft §303(d) List. An insufficient number of measurements were available in the most recent assessment to assess the contact recreation use in Mason Creek.

Comparing *E. coli* levels measured in this study with historical data from the same streams (Table 6-7), it is apparent that the levels recorded in dry weather during this study were substantially lower than the historical mean in Mason Creek, Garner's Bayou, and Brickhouse Gully. *E. coli* levels observed in Turkey Creek in this study, however, exceeded the historical mean levels by a large margin. The limited term of monitoring in this study prevents any conclusions about possible improvements or declines in water quality in these streams.

While there are no numeric criteria for ammonia nitrogen levels in Texas surface waters, TCEQ has used a screening level of 0.17 mg/l to indicate secondary concerns over ammonia nitrogen in freshwater streams. Ammonia nitrogen levels have frequently exceeded this screening level in each of the streams investigated and the draft 2002 §305(b) Water Quality Inventory lists a concern over ammonia nitrogen levels in Turkey Creek, Garner's Bayou, and Brickhouse Gully. Mason Creek was not assessed due to insufficient data.

Table 6-8 compares the ammonia nitrogen levels observed in this study with historical average levels. In Mason Creek, the ammonia nitrogen levels observed in this study were substantially higher than the historical mean levels. Average ammonia nitrogen levels measured during this study in Garner's Bayou, Turkey Creek, and Brickhouse Gully were consistent with levels measured in the past.

Table 6-1
Dry Weather *E. coli* Loads

Source Number	Source Type	E. coli Load in MPN/day					
Mason Creek							
		29-Apr-2003	5-May-2003	12-May-2003	19-May-2003	Geometric Mean	Median
M-002	Pipe Outfall	4.98E+06	8.59E+04	0	0	8.09E+02	4.29E+04
M-004	Pipe Outfall (WWTP)	1.10E+09	1.31E+09	1.30E+09	1.58E+09	1.31E+09	1.31E+09
M-119	Pipe Outfall (WWTP)	3.84E+08	1.17E+09	4.51E+09	8.27E+07	6.40E+08	7.77E+08
M-353	Pipe Outfall (WWTP)	1.85E+09	8.47E+10	4.05E+09	6.50E+07	2.54E+09	2.95E+09
M-134	Pipe Outfall	3.01E+09	0	2.30E+05	0	5.13E+03	1.15E+05
M-136	Pipe Outfall (WWTP)		6.23E+08	3.66E+08	8.62E+07	2.70E+08	3.66E+08
Sum Load of Identified Sources		6.35E+09	8.78E+10	1.02E+10	1.81E+09	4.76E+09	5.40E+09
M-300	Creek	8.75E+10	9.41E+09	1.93E+10	1.07E+09	1.14E+10	1.44E+10
Source Load Sum as a % of Instream Load		7%	934%	53%	169%	42%	38%
Garner's Bayou							
		30-Apr-2003	6-May-2003	13-May-2003	20-May-2003	Geometric Mean	Median
G-257	Tributary	4.34E+09	7.23E+06	5.43E+04	0	2.03E+05	3.64E+06
G-303	Tributary	7.53E+07	2.43E+07	2.78E+08	3.25E+08	1.13E+08	1.77E+08
G-302	Other	7.56E+08	4.47E+08	2.93E+08	2.35E+11	2.20E+09	6.02E+08
G-006	Pipe Outfall (WWTP)	3.39E+09	1.25E+10	3.35E+09	2.81E+09	4.47E+09	3.37E+09
G-021	Pipe Outfall (WWTP)	1.40E+07	3.00E+08	6.60E+06	2.67E+07	2.94E+07	2.04E+07
G-026	Pipe Outfall (WWTP)	1.59E+07	1.89E+07	4.11E+07	1.62E+08	3.76E+07	3.00E+07
G-042	Animal Population	1.74E+10	1.78E+10	1.64E+10	7.88E+09	1.41E+10	1.69E+10
G-043	Pipe Outfall (WWTP)	4.55E+08	1.92E+07	8.59E+08	3.79E+08	2.31E+08	4.17E+08
Sum Load of Identified Sources		2.64E+10	3.11E+10	2.13E+10	2.46E+11	2.12E+10	2.15E+10
G-066	Creek	1.20E+11	2.45E+10	5.44E+10	4.28E+10	5.12E+10	4.86E+10
Source Load Sum as a % of Instream Load		22%	127%	39%	575%	41%	44%
Turkey Creek							
		30-Apr-2003	8-May-2003	14-May-2003	21-May-2003	Geometric Mean	Median
T-092	Tributary	1.90E+10	8.60E+09	1.60E+09	5.96E+09	6.28E+09	7.28E+09
T-139	Pipe Outfall	2.64E+05	5.54E+08	2.79E+06	4.86E+07	1.19E+07	2.57E+07
Sum Load of Identified Sources		1.90E+10	9.15E+09	1.60E+09	6.01E+09	6.29E+09	7.31E+09
T-068	Creek	5.47E+10	4.34E+10	1.11E+10	1.91E+12	8.43E+10	4.91E+10
Source Load Sum as a % of Instream Load		35%	21%	14%	0.3%	7%	15%
Brickhouse Gully							
		1-May-2003	7-May-2003	14-May-2003	21-May-2003	Geometric Mean	Median
B-146	Pipe Outfall	4.83E+09	2.39E+09	1.66E+09	3.94E+08	1.66E+09	2.03E+09
B-203	Pipe Outfall	6.65E+05	1.01E+08	6.41E+09	4.08E+08	1.15E+08	2.54E+08
B-279	Pipe Outfall	3.89E+05	4.69E+05	2.53E+08	5.85E+10	4.05E+07	1.27E+08
B-265	Pipe Outfall	2.44E+08	1.61E+08	1.65E+07	5.75E+08	1.39E+08	2.03E+08
B-240	Pipe Outfall	2.09E+07	1.51E+06	1.01E+05	0	4.23E+04	8.04E+05
B-246	Pipe Outfall	6.10E+10	6.47E+07	1.05E+07	8.97E+09	7.81E+08	4.52E+09
B-219	Pipe Outfall	5.45E+08	2.14E+09	3.43E+07	2.97E+09	5.87E+08	1.34E+09
B-040	Pipe Outfall	3.37E+09	1.25E+08	0	0	2.55E+04	6.24E+07
Sum Load of Identified Sources		7.01E+10	4.98E+09	8.39E+09	7.18E+10	3.32E+09	8.53E+09
B-380	Creek	3.89E+10	1.85E+09	3.75E+09	1.09E+10	7.37E+09	7.34E+09
Source Load Sum as a % of Instream Load		180%	269%	223%	657%	45%	116%

<u>Table 6-2</u> **Wet Weather *E. coli* Loads**

Source Number	Source Type	Date	E. coli Load in MPN/Day							
MASON CREEK										
M-300	Creek	26-Jun-2003	3:10 PM	3:25 PM	3:40 PM	3:55 PM	4:10 PM	4:25 PM	Geometric Mean	Median
			5.43E+12	4.85E+12	4.85E+12	5.29E+12	4.35E+12	4.65E+12	4.89E+12	4.85E+12
GARNER'S BAYOU										
G-066	Creek	30-Jun-2003	9:35 AM	9:50 AM	10:05 AM	10:20 AM	10:35 AM	10:50 AM	Geometric Mean	Median
			1.21E+12	9.68E+11	1.03E+12	1.07E+12	1.02E+12	6.78E+11	9.81E+11	1.02E+12
TURKEY CREEK										
T-068	Creek	5-Jun-2003	1:15 PM	1:35 PM	1:55 PM	2:15 PM	2:35 PM	2:55 PM	Geometric Mean	Median
			2.71E+13	6.05E+13	2.74E+14	1.22E+14	7.75E+13	3.45E+13	7.26E+13	6.90E+13
BRICKHOUSE GULLY										
B-380	Creek	4-Jun-2003	9:05 AM	9:20 AM	9:35 AM	9:50 AM	10:05 AM	10:20 AM	Geometric Mean	Median
			5.83E+13	4.18E+13	1.55E+13	2.62E+13	1.37E+13	8.46E+12	2.20E+13	2.09E+13

Table 6-3
Dry Weather Ammonia Nitrogen Loads

Source Number	Source Type	Ammonia Nitrogen Load in Lbs/day					
MASON CREEK							
		29-Apr-2003	5-May-2003	12-May-2003	19-May-2003	Average	Median
M-002	Pipe Outfall	0.00004	0.00015	0	0	0.00005	0.00002
M-004	Pipe Outfall (WWTP)	1.44	3.10	4.66	0.68	2.47	2.27
M-119	Pipe Outfall (WWTP)	2.54	0.31	6.56	1.46	2.72	2.00
M-353	Pipe Outfall (WWTP)	13.0	63.3	2.04	2.26	20.2	7.64
M-134	Pipe Outfall	0.46	0.0	0.000002	0	0.12	0.000001
M-136	Pipe Outfall (WWTP)		2.00	2.12	8.98	4.37	2.12
Sum Load of Identified Sources		17.47	68.75	15.40	13.38	29.84	14.03
M-300	Creek	28.7	18.9	5.95	8.30	15.5	13.6
Source Load Sum as a % of Instream Load		61%	364%	259%	161%	193%	103%
GARNER'S BAYOU							
		30-Apr-2003	6-May-2003	13-May-2003	20-May-2003	Average	Median
G-257	Tributary	0.038	0.0001	0.00007	0.00000	0.010	0.0001
G-303	Tributary	0.005	0.0005	0.18	0.004	0.047	0.005
G-302	Other	0.138	0.030	0.032	0.030	0.057	0.031
G-006	Pipe Outfall (WWTP)	113	245	120	66	136	117
G-021	Pipe Outfall (WWTP)	0.43	0.01	0.04	0.06	0.14	0.05
G-026	Pipe Outfall (WWTP)	0.53	3.70	0.33	0.11	1.17	0.43
G-042	Animal Population	33.8	45.7	67.2	11.9	39.6	39.8
G-043	Pipe Outfall (WWTP)	1.93	2.21	0.81	1.62	1.64	1.78
Sum Load of Identified Sources		150.36	297.02	188.84	79.57	178.94	158.93
G-066	Creek	23.6	234.3	32.2	9.1	74.8	27.9
Source Load Sum as a % of Instream Load		638%	127%	587%	871%	239%	570%
TURKEY CREEK							
		30-Apr-2003	8-May-2003	14-May-2003	21-May-2003	Average	Median
T-092	Tributary	0.24	0.042	0.19	0.036	0.13	0.12
T-139	Pipe Outfall	0.00003	0.003	0.004	0.0004	0.002	0.002
Sum Load of Identified Sources		0.24036	0.04433	0.19828	0.03590	0.12972	0.11940
T-068	Creek	1.05	0.60	0.50	0.12	0.57	0.55
Source Load Sum as a % of Instream Load		23%	7%	39%	30%	23%	22%
BRICKHOUSE GULLY							
		1-May-2003	7-May-2003	14-May-2003	21-May-2003	Average	Median
B-146	Pipe Outfall	0.096	0.057	0.030	0.009	0.048	0.044
B-203	Pipe Outfall	0.006	0.108	5.76	0.067	1.49	0.088
B-279	Pipe Outfall	0.0004	0.0001	0.010	0.071	0.020	0.005
B-265	Pipe Outfall	0.008	2.84	0.002	0.006	0.71	0.007
B-240	Pipe Outfall	0.012	0.005	0.0001	0	0.004	0.003
B-246	Pipe Outfall	6.92	0.003	0.002	0.57	1.87	0.29
B-219	Pipe Outfall	0.008	0.005	0.003	0.002	0.005	0.004
B-040	Pipe Outfall	0.011	0.0001	0	0	0.003	0.000
Sum Load of Identified Sources		7.062	3.021	5.806	0.724	4.153	0.436
B-380	Creek	0.059	11.0	0.047	0.18	2.82	0.12
Source Load Sum as a % of Instream Load		11967%	28%	12345%	398%	147%	362%

Table 6-4
Wet Weather Ammonia Nitrogen Loads

Source Number	Source Type	Date	Ammonia Nitrogen Load in Lbs./Day							
MASON CREEK										
M-300	Creek	26-Jun-2003	3:10 PM	3:25 PM	3:40 PM	3:55 PM	4:10 PM	4:25 PM	Average	Median
			8.41	6.01	5.40	4.01	4.01	4.44	5.96	5.70
GARNER'S BAYOU										
G-066	Creek	30-Jun-2003	9:35 AM	9:50 AM	10:05 AM	10:20 AM	10:35 AM	10:50 AM	Average	Median
			23.6	19.8	17.9	15.4	14.7	12.9	19.2	18.9
TURKEY CREEK										
T-068	Creek	5-Jun-2003	1:15 PM	1:35 PM	1:55 PM	2:15 PM	2:35 PM	2:55 PM	Average	Median
			95.6	144.6	173.4	101.8	42.1	20.3	128.9	123.2
BRICKHOUSE GULLY										
B-380	Creek	4-Jun-2003	9:05 AM	9:20 AM	9:35 AM	9:50 AM	10:05 AM	10:20 AM	Average	Median
			210.4	149.5	102.7	117.8	58.3	31.3	145.1	133.7

Table 6-5
Historical Water Quality Monitoring Stations in Study Watersheds

Station ID	Station Description	Responsible Agency
17494	Mason Creek at Park Pine Drive West of Houston	City of Houston Health & Human Services
11143	Mason Creek at Mason Road	Not Active
15847	Turkey Creek at Memorial Drive in West Houston	City of Houston Health & Human Services
17483	Turkey Creek Immediately Southeast of Tanner Road and North Eldridge Parkway Intsct.	City of Houston Health & Human Services
17330	Turkey Creek Immediately Upstream of North Dairy-Ashford Street in Houston	Texas Watch Citizen Monitoring
11180	Turkey Creek 0.5 Km Upstream of Buffalo Bayou	Not Active
11164	Turkey Creek at Addicks Fairbanks Road	Not Active
11125	Garner's Bayou at North Belt, SR8 Loop NE of Houston	TCEQ, City of Houston Health & Human Services
16589	Garner's Bayou at Atascosita (Old Humble Rd at Confluence with Reinhardt Bayou	City of Houston Health & Human Services
16594	Brickhouse Gully at US 290 just north of intersection of Saxon Drive in northwest Houston	City of Houston Health & Human Services
11153	Brickhouse Gully at Mangum Rd.	Not Active

Table 6-6
Statistical Summary of Historical Water Quality Measurements, 1993 to Present

Station Description	*E. Coli* MPN/100ML				Fecal Coliform (Colonies/100 ml)				Ammonia Nitrogen (mg/l as N)				Total Suspended Solids (mg/l)				Total Dissolved Solids (mg/l)			
	N	MIN	MAX	GM*	N	MIN	MAX	GM*	N	MIN	MAX	AVG	N	MIN	MAX	AVG	N	MIN	MAX	AVG
Mason Creek at Park Pine Drive	15	63	**18,000**	**1,320**	0				14	<0.03	0.48	0.095	14	10	83	25	0			
Turkey Creek at Memorial Drive	17	200	**240,000**	**1,220**	69	36	**75,000**	**867**	80	<0.03	0.59	0.071	95	<2	430	35	75	106	486	315
Turkey Creek Immediately Southeast of Tanner Road	15	340	**14,000**	**2,488**	0				14	<0.03	0.85	0.18	14	17	595	125	0			
Turkey Creek Immediately Upstream of N. Dairy-Ashford Rd.	0				0				0				0				0			
Garner's Bayou at North Loop, SR8 Loop	17	41	**21,000**	**682**	76	9	**>200,000**	**597**	93	<0.05	1.79	0.52	103	<2	350	41	84	145	**2920**	497
Garner's Bayou at Old Humble Rd	17	42	**10,000**	**466**	53	36	**>200,000**	**1,238**	77	<0.03	7.36	1.94	92	<2	520	44	72	122	**3270**	491
Brickhouse Gully @ US290	17	**680**	**46,000**	**4,725**	68	90	**>200,000**	**7,175**	84	<0.03	2.18	0.18	97	<2	577	24	77	128	**673**	389

* Geometric Mean

Station Description	Specific Conductance (umhos/cm at 25C)				Dissolved Oxygen (mg/l)				pH			Temperature (degrees C)			
	N	MIN	MAX	AVG	N	MIN	MAX	AVG	N	MIN	MAX	N	MIN	MAX	AVG
Mason Creek at Park Pine Drive	6	138	**869**	539	14	4.8	12.9	8.69	14	6.8	8.5	14	9.4	31.6	19.9
Turkey Creek at Memorial Drive	67	103	**844**	478	95	**1.4**	13.9	6.29	46	6.7	8.1	95	5.25	32	21.5
Turkey Creek Immediately Southeast of Tanner Road	6	179	**740**	347	14	4.4	14	8.63	14	7	8.2	14	9.9	32.6	20.2
Turkey Creek Immediately Upstream of N. Dairy-Ashford Rd.	3	290	560	397	3	5.3	8.5	6.57	0			3	12.5	21.5	18.0
Garner's Bayou at North Loop, SR8 Loop	74	184	**4480**	777	109	**0.3**	12.3	6.31	50	7	8.6	108	5.9	**34.2**	22.3
Garner's Bayou at Old Humble Rd	59	12.5	**5200**	731	92	**2.3**	9.99	5.27	39	6.9	7.8	92	6	29.7	22.3
Brickhouse Gully at US 290	62	142	**1050**	**619**	96	**2.9**	21.9	11.2	40	7.4	**9.9**	95	6.8	**34.7**	22.7

<u>Table 6-7</u>
Comparison of *E. coli* Concentrations Measured in this Study with Historical Averages

Stream	*E. coli* Geometric Mean (MPN/100 ml)		
	This Study (Dry)	This Study (Dry+Wet Avg.)	Historical Data
Mason Creek	126	340	1,320
Garner's Bayou	181	306	564
Turkey Creek	4,543	6,910	1,571
Brickhouse Gully	180	448	4,725

Table 6-8
Comparison of Ammonia Nitrogen Levels Measured in this Study with Historical Averages

Stream	Average Ammonia Nitrogen (mg/l)		
	This Study (Dry)	This Study (Dry+Wet Avg.)	Historical Data
Mason Creek	0.69	0.57	0.095
Garner's Bayou	1.32	1.09	1.17
Turkey Creek	0.12	0.14	0.089
Brickhouse Gully	0.083	0.13	0.18

Figure 6-1 *E. coli* Loads in Brickhouse Gully and Sources in Dry and Wet Weather

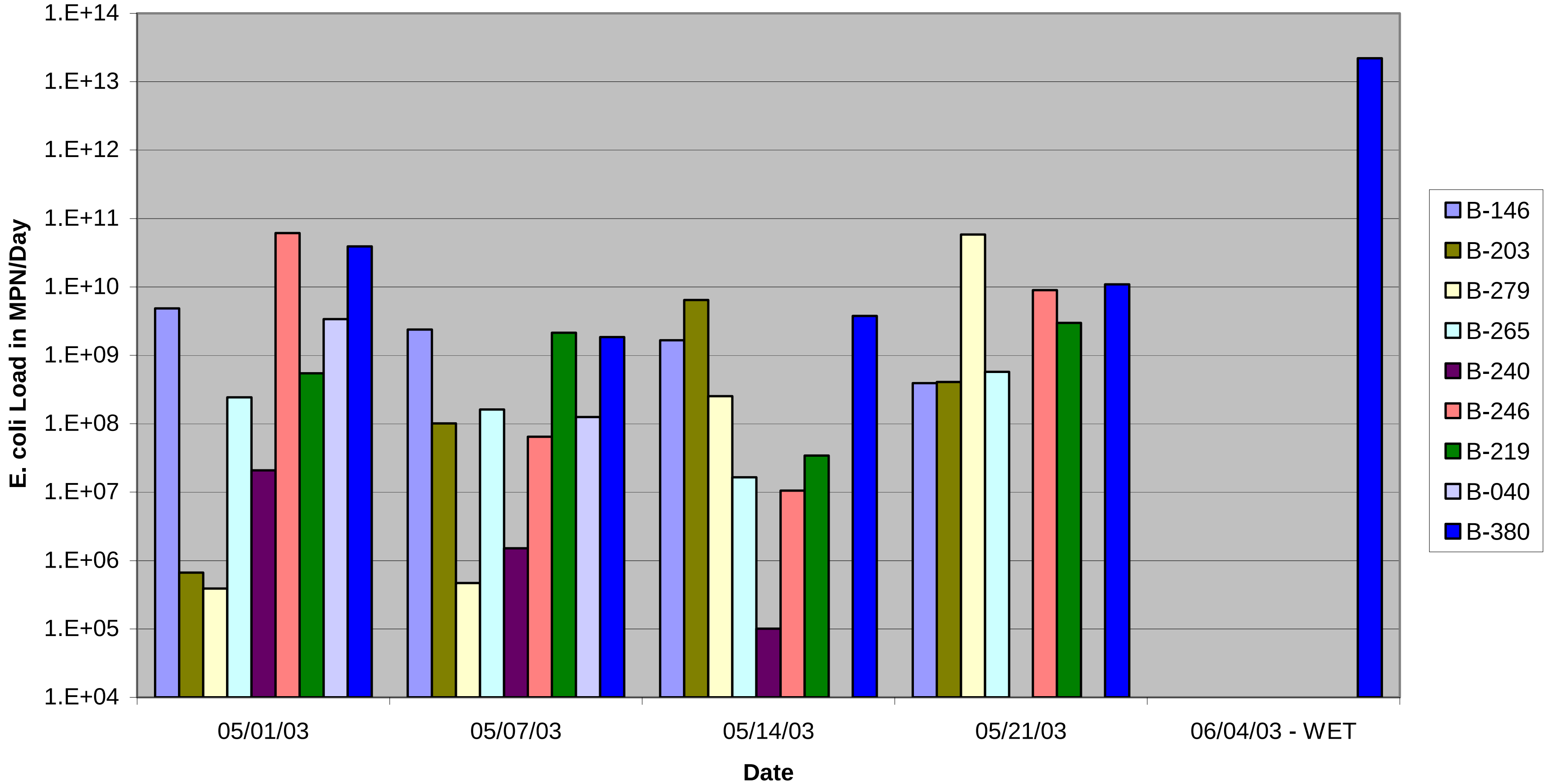


Figure 6-2 *E. coli* Loads in Garners Bayou and Sources in Dry and Wet Weather

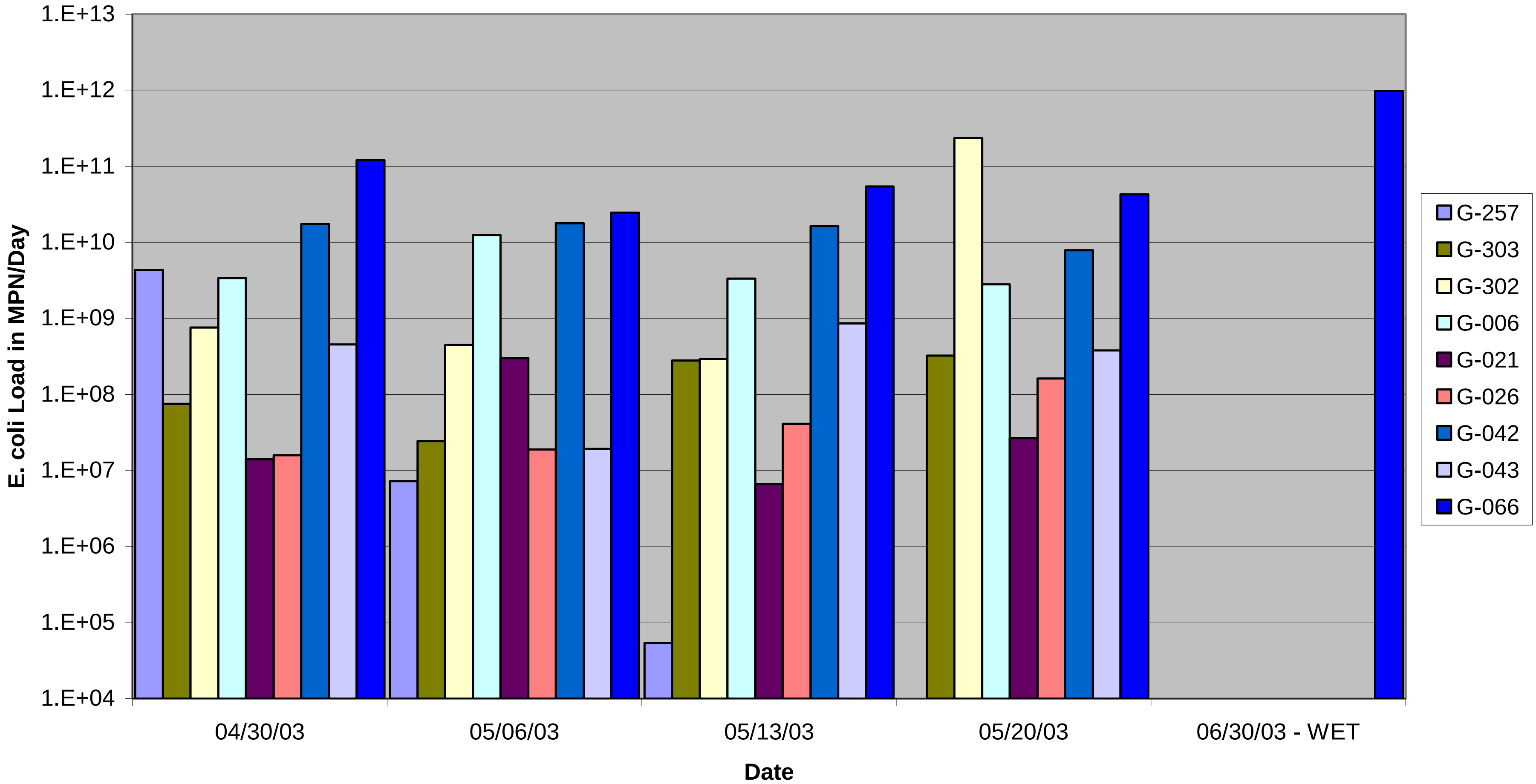


Figure 6-3 *E. coli* Loads in Mason Creek and Sources in Dry and Wet Weather

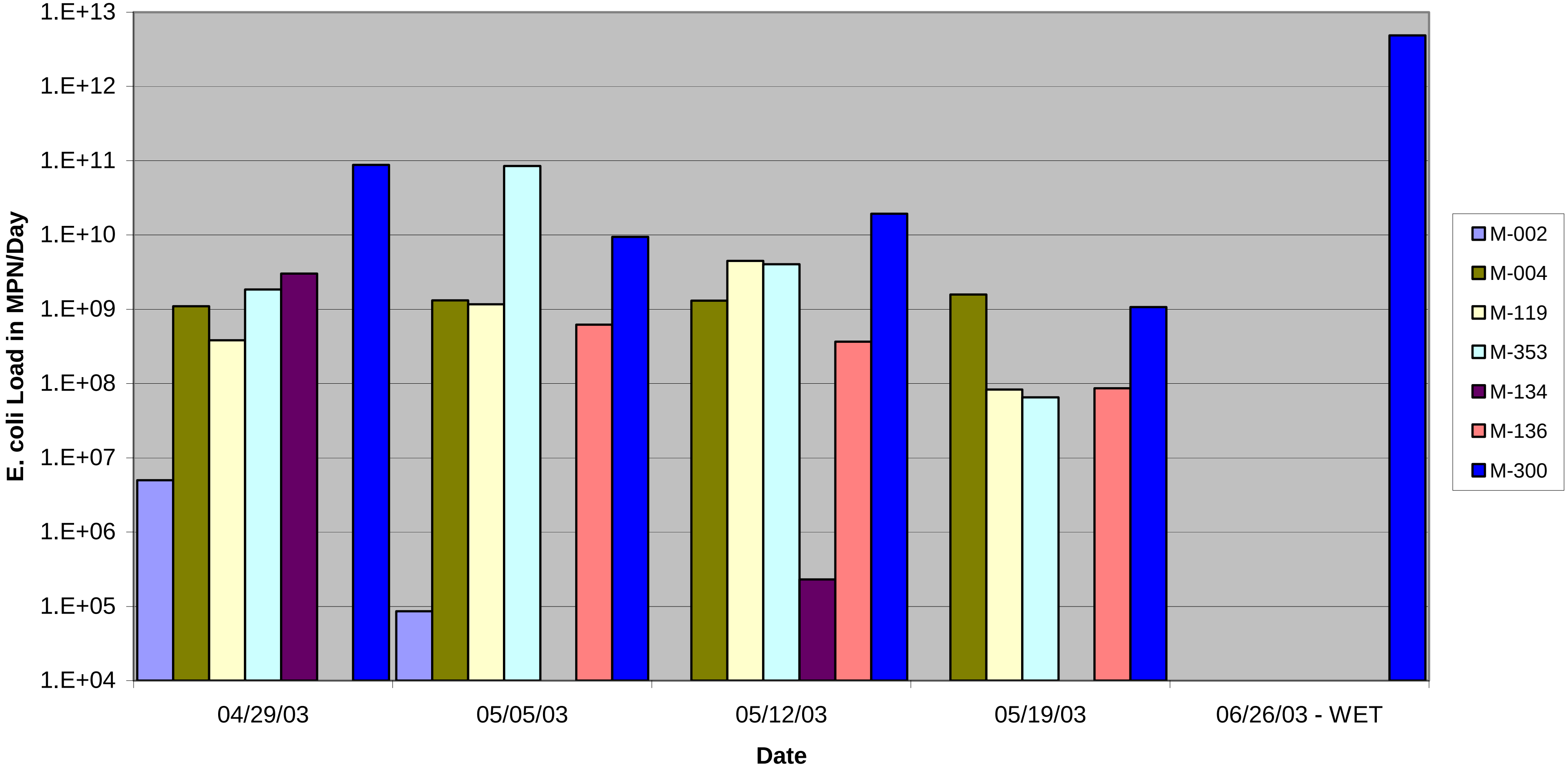


Figure 6-4 *E. coli* Loads in Turkey Creek and Sources in Dry and Wet Weather

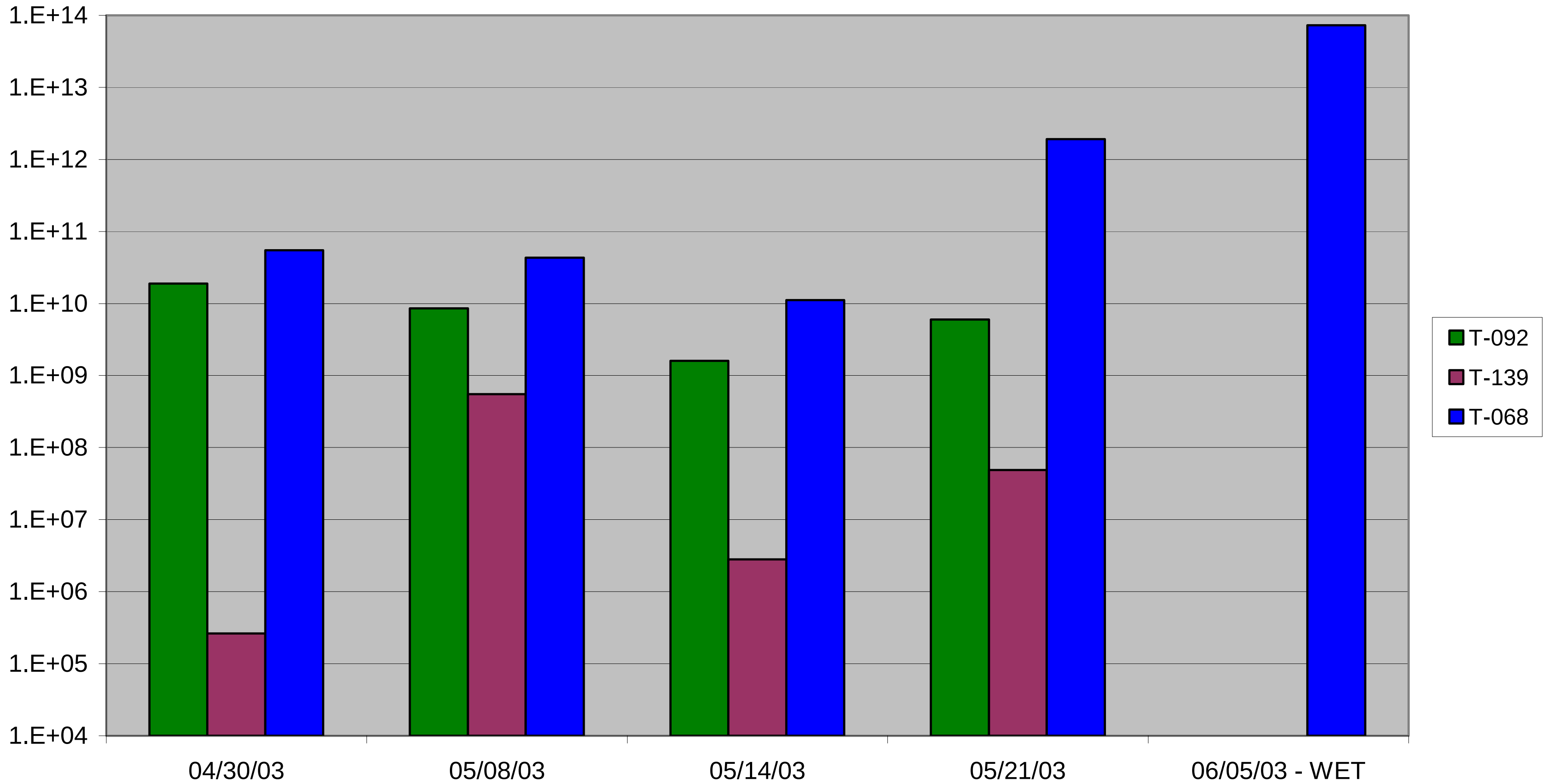


Figure 6-5
Ammonia Nitrogen Loads in Brickhouse Gully and Sources in Dry and Wet Weather

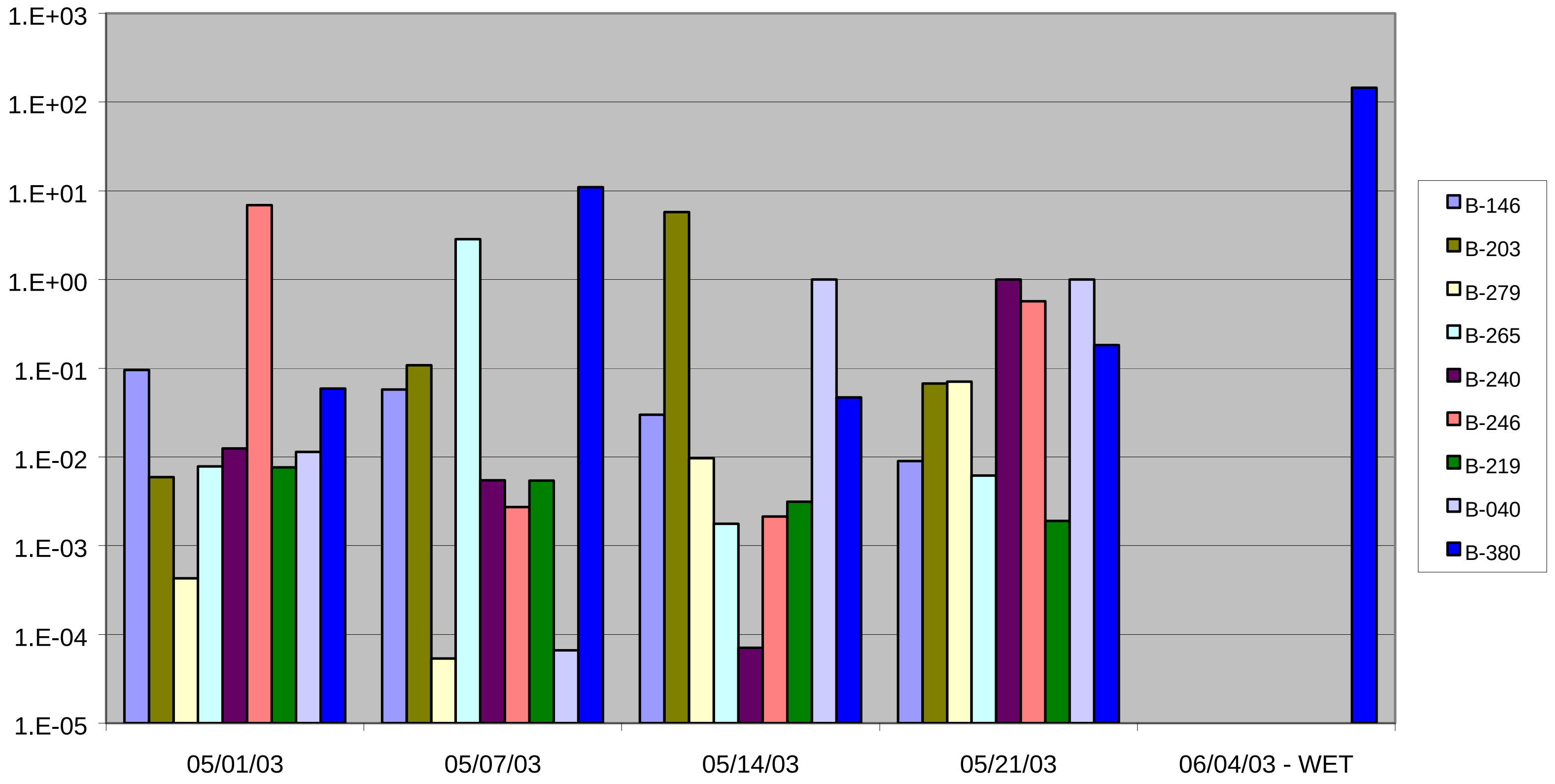


Figure 6-6
Ammonia Nitrogen Loads in Garners Bayou and Sources in Dry and Wet Weather

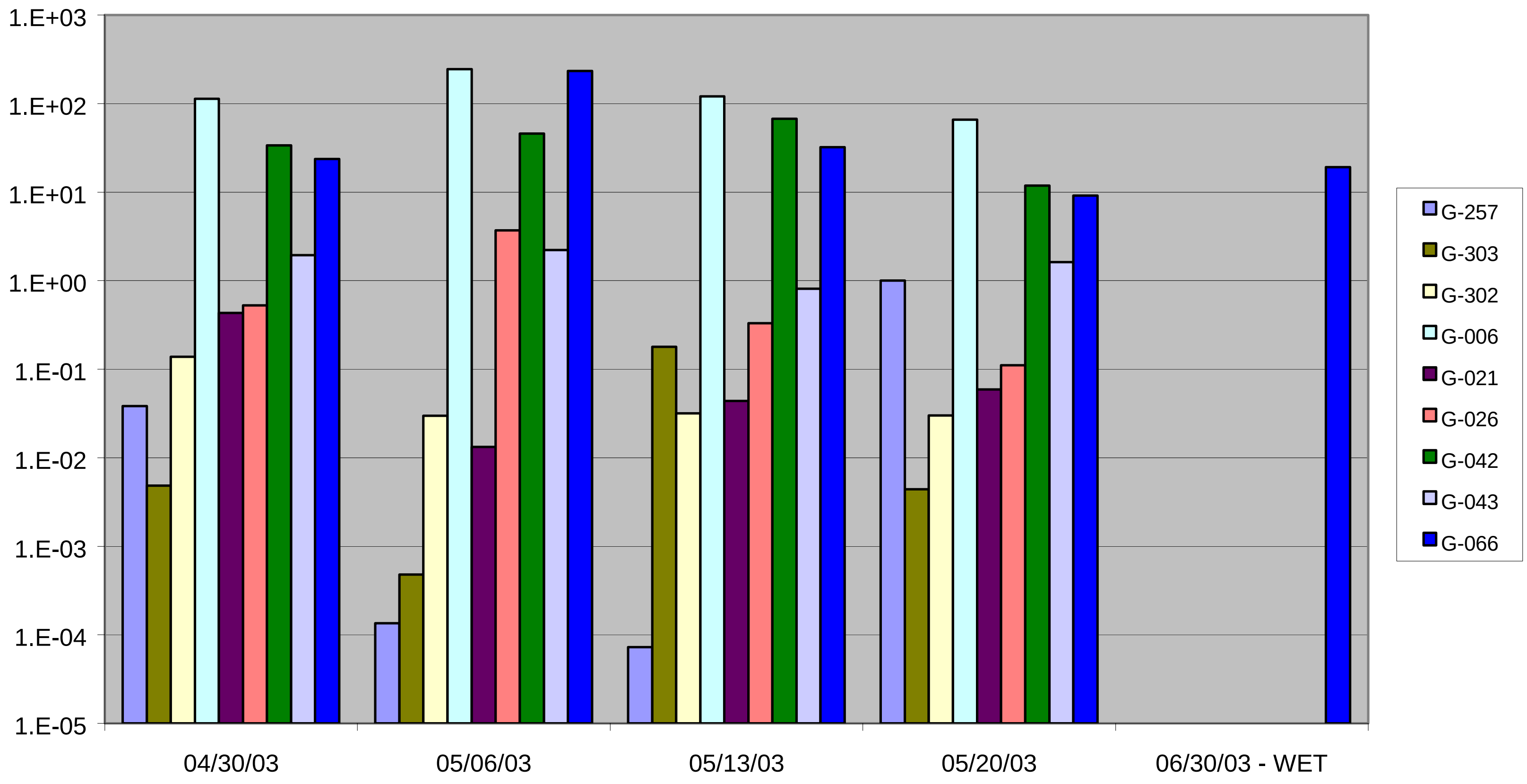


Figure 6-7
Ammonia Nitrogen Loads in Mason Creek and Sources in Dry and Wet Weather

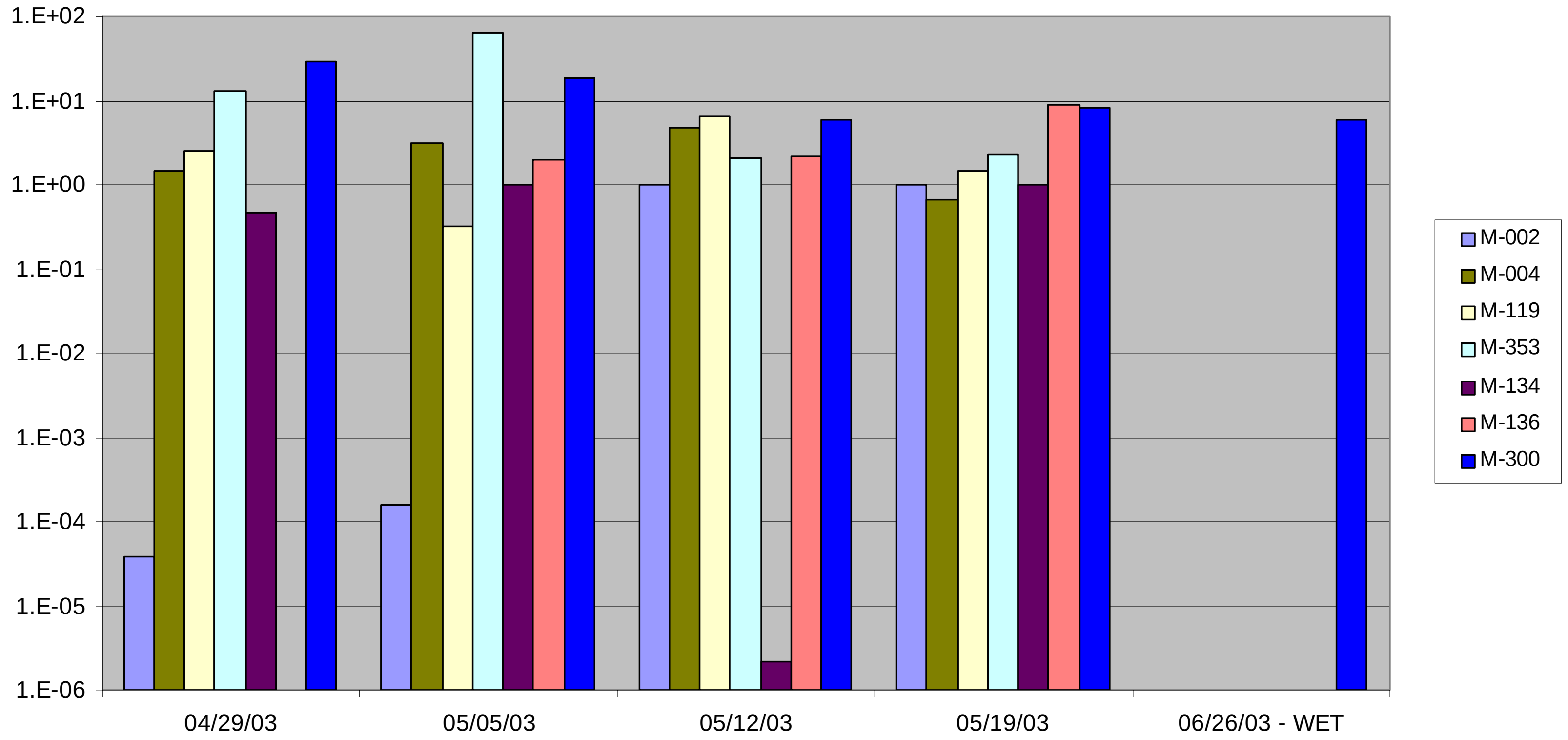
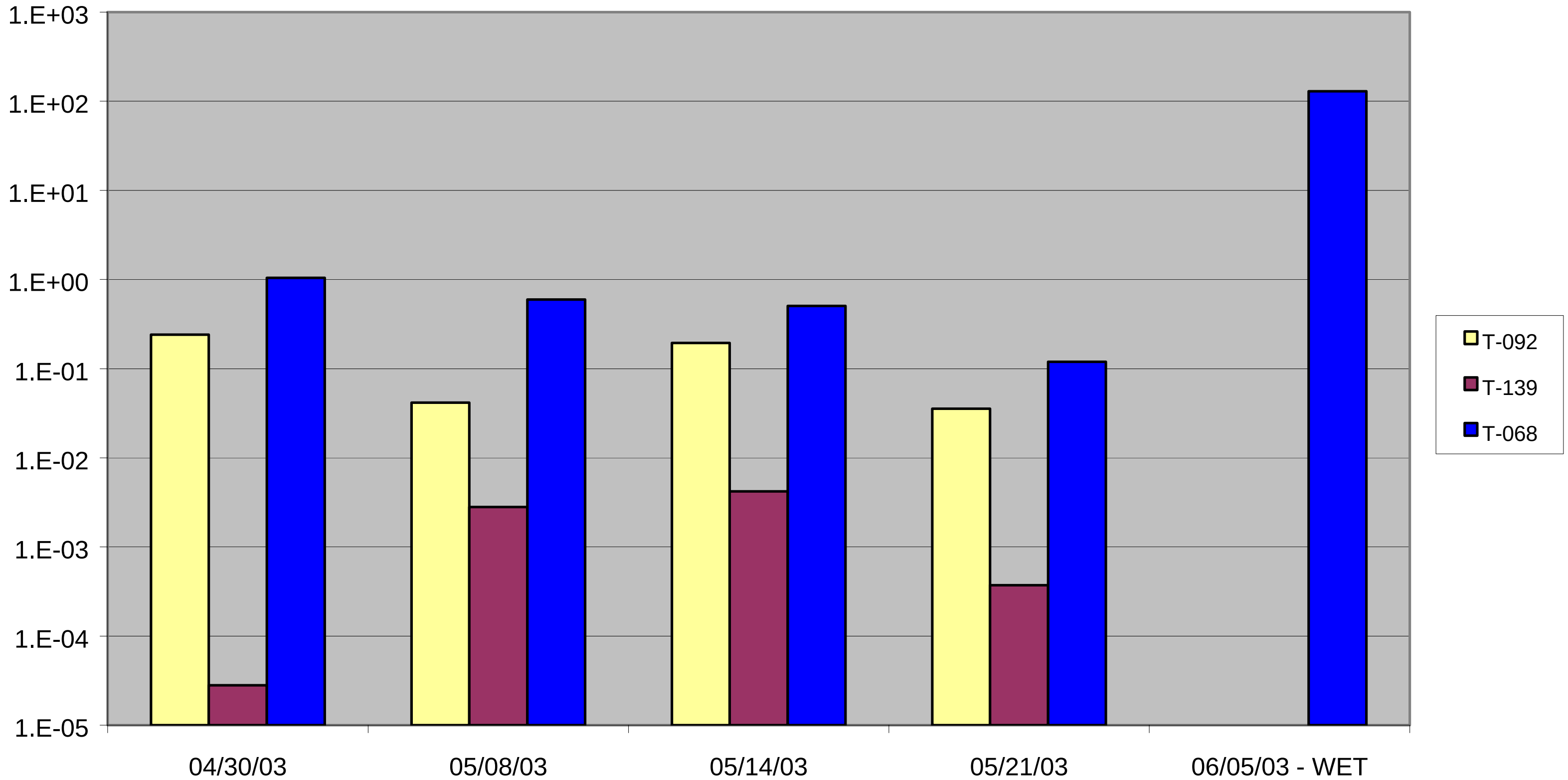


Figure 6-8
Ammonia Nitrogen Loads in Turkey Creek and Sources in Dry and Wet Weather



7.0 CONCLUSIONS

This section summarizes the project findings, discusses the application of these field techniques to other watersheds and reports on lessons learned during the effort.

7.1 SUMMARY

PBS&J was retained by Houston-Galveston Area Council ("H-GAC"), through funding provided by the Texas Clean Rivers Program, on September 17, 2002, to conduct an investigation into the sources of ammonia and bacteria in four small urban watersheds in the Houston area, including:

- Brickhouse Gully, a highly urbanized tributary of White Oak Bayou
- Garner's Bayou, a mixed use tributary of Greens Bayou
- Mason Creek, a highly residential tributary of Buffalo Bayou
- Turkey Creek, a tributary of Buffalo Bayou that flows through both undeveloped (park) and highly developed land

7.1.1 Findings

Five-hundred eighty-six potential pollutant sources (places where flows can enter the streams) were identified during field reconnaissance efforts. Twenty-eight sites were selected for sampling and analysis during dry weather. These sites were sampled on four separate trips. In addition, the downstream station on each creek was sampled during wet weather. Concentration and loads of ammonia and bacteria were determined from flow estimates and analytical results for both the dry and wet weather samples. These results were compared to historical values and relevant water quality criteria or screening values.

A GIS-based runoff tool was developed to determine area-weighted curve number for any selected watershed area. The tool was applied to the study watersheds and CN values were reported.

All results, including field reconnaissance information, photographs, analytical results, and field monitoring results were arranged in a geo-database for future use and analysis.

7.1.2 Sources Recommended for Mitigation

Sources with geometric mean bacteria levels greater than 126 MPN/100 mL and average ammonia-N levels greater than 0.17 mg/L are identified in Tables 7-1 and 7-2. These sources can be considered as candidates for action but are not necessarily in excess of specific criteria. For example, WWTP discharges will typically have a permit limit on a discharge of 2 or 3 mg/L for ammonia-N. Only two of the WWTP outfalls would be above their permit value. The first two pipe outfalls appear to have concentrations well beyond expected values and should be corrected. The 0.17 mg/L concentration for ammonia-N is a screening level for nutrient enrichment concerns, but not a basis for administrative action at this time. In the case of bacteria, the screening level of 126 MPN/100 mL is the criteria for contact recreation (swimming) in ambient water. Most of the samples compared are not technically ambient water but discharges to ambient water. The one that is ambient water, the downstream station on Turkey Creek, is already part of an ongoing TMDL study. The other top five outfalls have bacteria concentrations high enough to suggest the presence of a sanitary sewer leak. Investigations should be conducted to determine the source of the higher bacteria concentration flow in dry weather.

7.2 APPLICATION TO OTHER WATERSHEDS

The field investigation techniques used in this project can be applied to other urban watersheds to identify significant pollutant sources. Once sources are identified, sewer system operators can be notified and mitigation actions taken to reduce pollutant loads due to malfunctioning wastewater treatment systems, cross connections to the storm sewer, illegal dumping sites, or other sources.

7.3 LESSONS LEARNED

To improve and streamline the execution of this type of investigation PBS&J recommends that H-GAC or its consultant consider the use of electronic field data collectors or personal digital assistants ("PDA's") for recording field information in electronic format.

Some work efficiencies were realized by using GPS technology to quickly record in an electronic format the observation time, location, and general type (outfall, back-slope drain, etc.) of non-flowing potential pollutant sources. This was accomplished using "waypoints" that can be defined in most handheld GPS units. This technology did not, however, allow field staff to record additional detailed information, such as pipe diameter or other information.

To record more complete information, particularly for flowing pollutant sources, more complete written information was collected and recorded on field datasheets. Over 200 field data sheets were manually prepared during the field reconnaissance work. A large labor effort and a fair amount of time was required to convert the written field information into electronic format. Projects of this type could be facilitated by recording field information electronically.

Smaller and more durable hand-held computers are now available that can be adapted to field data collection. The advancement of Personal Digital Assistants ("PDA's") has enabled them to accept and store Excel formatted field data sheets. Other surveys could incorporate this technology to reduce the amount of data transfer from the field data sheets to the office and database.

Unfortunately, current PDA's do suffer from some shortcomings. The battery life currently only provides limited usage. To use the PDA over an entire day, one must carry extra batteries and be very power-conscious. To conserve battery power the unit must be repeatedly powered-down and restarted between each data collection station. This tends to increase the field effort (time) required to obtain the same amount of data recorded using paper. The small screen requires the user to continuously scroll around the data sheet; this could lead to incomplete field data collection. Another aspect is the structured format of the data sheet that limits note taking. Preparing quick field sketches and making brief notes on the back of a paper field data sheet are not possible. The major concern of collecting field data electronically is the possible loss of the data due to user or computer error. This can, however, be almost completely negated by data back-ups to memory sticks and data file copies to mainline computers.

There are many significant advantages of PDA's for field data collection. The units are very small and portable. Field crews do not need to carry big notebooks and stacks of data sheets into the field every day. Some models are even capable of connecting to a GPS receiver for storing field maps and additional study-related reference resources. Another advantage is that the field personnel directly enter their own observations and data. This eliminates third party (data entry clerk) error. Once field crews become accustomed to data entry on the field computers, it becomes more efficient and accurate. Overall, the main advantage for electronic field data collection is the dramatic decrease in time to enter field data into electronic formats. Field data is recorded neatly, concisely, and more accurately.

Table 7-1
Sources with the Highest Dry Weather *E. coli* Concentrations in Descending Order

Source Number	Source Type	Geometric Mean *E. coli* Concentration (MPN/100 mL)
B-246	Pipe Outfall	**121,307**
T-068	Turkey Creek	**4,543**
M-134	Pipe Outfall	**3,441**
B-040	Pipe Outfall	**3,291**
B-203	Pipe Outfall	**1,641**
B-146	Pipe Outfall	**1,020**
B-219	Pipe Outfall	**929**
T-139	Pipe Outfall	**691**
B-279	Pipe Outfall	**453**
T-092	Tributary	**394**
G-302	Other	**310**
G-066	Garner's Bayou	**181**
B-380	Brickhouse Gully	**180**
G-257	Tributary	**158**
G-042	Animal Population	**153**
M-353	Pipe Outfall (WWTP)	**133**

Table 7-2
Sources with the Highest Dry Weather Ammonia Nitrogen Concentrations in Descending Order

Source Number	Source Type	Average Ammonia Nitrogen (mg/L)
B-246	Pipe Outfall	**50.5**
B-203	Pipe Outfall	**10.6**
G-006	Pipe Outfall (WWTP)	**5.12**
M-353	Pipe Outfall (WWTP)	**4.64**
G-042	Animal Population	**1.94**
G-043	Pipe Outfall (WWTP)	**1.47**
G-066	Garner's Bayou	**1.32**
M-136	Pipe Outfall (WWTP)	**1.22**
M-300	Mason Creek	**0.69**
G-026	Pipe Outfall (WWTP)	**0.58**
B-279	Pipe Outfall	**0.53**
M-134	Pipe Outfall	**0.34**
T-139	Pipe Outfall	**0.30**
M-004	Pipe Outfall (WWTP)	**0.29**
B-240	Pipe Outfall	**0.22**

8.0 REFERENCES

Galveston County Health District Pollution Control Division, 2002. A Guidance Manual for Identifying and Eliminating Illicit Connections to Municipal Separate Storm Sewer Systems (MS4). Galveston, Texas.

Houston-Galveston Area Council, 2001. *FY 2002/2003 Monitoring Program Activities for the Texas Clean Rivers Program, Quality Assurance Project Plan*. Houston-Galveston Area Council, Houston, Texas.

Houston-Galveston Area Council, 2003. *Appendix X to the FY 2002/2003 H-GAC/Clean Rivers Program FY 2001/2003 QAPP (Version 5.0)*. Houston-Galveston Area Council, Houston, Texas.

TNRCC, 1999. Surface Water Quality Monitoring Procedures Manual. Texas Natural Resource Conservation Commission. Austin, Texas.

National Resource Conservation Service, 1976. Soil Survey of Harris County, Texas.

National Resource Conservation Service, 1986. Urban Hydrology for Small Watersheds, Technical Release 55.

PBS&J, 2003. *Appendix M to the FY 2002/2003 H-GAC/Clean Rivers Program FY2001/2003 QAPP – Small Watershed Analysis.* Prepared for Houston-Galveston Area Council, Houston, Texas, April.

University of Houston and PBS&J, 2003. TMDL for Federal Pathogens in Buffalo Bayou and Whiteoak Bayou, TCEQ Work Order No. 582-0-80121-06, Work Plan 6.

Appendix A

Results Geo-database (CD-ROM)

Appendix B

Bacteria Chain-of-Custody Forms

PBS&J

1880 South Dairy Ashford Suite 300
Houston Texas 77077

Chain of Custody Record for *E. coli*

Job Name: HGAC Smallwatershed Job No. ________ Cooler Temp: 4°C

Samplers: Neil Bossert Sampling Location: Mason Creek

Station No.	Date	Time	Station Location/Description	Sample Type	Analysis	No. Items
M-002	4/29/03	0920	Mason Creek discharge	water	E. coli	2 jars
M-004	|	~~1005~~ 0955	|	|	|	|
M-119	|	1039	|	|	|	|
~~M-245~~	|	~~1137~~	|	|	|	|
M-353	|	1137	|	|	|	|
M-134	|	1205	|	|	|	|
M-300	|	1254	|	|	|	|

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Cooler Temp 3 °C

Chain of Custody Record for ~~NWDLS~~ E. coli

Job Name: HGAC Stormwater

Job No. ___________

Page 1 of 1

Samplers: N. Bossert & B McBride

Sampling Location: Garners Bayou

Station No.	Date	Time	Station Location/Description	Sample Type	Analysis	No. Items
G-257	4/30/03	0755	Garners Bayou Discharge	water	E. coli	2 jars
G-303		0819				
G-302		0845				
W– G-006		0931				
W– G-021		1021				
W– G-026		1039				
G-042		1101				
G-066		1150				
W– G-043		1210				

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Chain of Custody Record for *E. coli*

Job Name: HGAC Smallwater   Job No. ________   Cooler Temp: ________

Samplers: N Bossart FBM   Sampling Location: Turkey Creek

Station No.	Date	Time	Station Location/Description	Sample Type	Analysis	No. Items
T092	4/30/03	1357	Turkey creek discharge	water	E. coli	2 jars
T139	|	1434	|	|	|	|
T-068	|	1548	|	|	|	|

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Chain of Custody Record for *E. coli*

Job Name: HGAC Smallwater   Job No. ________   Cooler Temp: 4°C

Samplers: N. Bossart   Sampling Location: Brickhouse

Station No.	Date	Time	Station Location/Description	Sample Type	Analysis	No. Items
B-146	5/1/03	0754	Brickhouse Gully discharge	water	E. coli	2 jars
B-203		0852				
B-279		0914				
B-265		0947				
B-240		1020				
B-246		1058				
B-219		1151				
B-040		1237				
B-380		1258				

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Chain of Custody Record for *E. coli*

Job Name: HGAC Smellwater Job No. ________ Cooler Temp: 4.5

Samplers: NB CR Sampling Location: Mason Creek

	Station No.	Date	Time	Station Location/Description	Sample Type	Analysis	No. Items
	M-002	5/5/03	11:12	Mason Creek discharges	~~E. coli~~ Water	E. coli	2 jars
W	M-004	|	1140	|	|	|	|
W	M-119	|	1216	|	|	|	|
W	M-353	|	1251	|	|	|	|
	M-134	|	1320	|	|	|	|
W	M-136	|	1344	|	|	|	|
	M-300	|	1410	|	|	|	|

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Chain of Custody Record for *E. coli*

Job Name: HGAC Smallwatershed Job No. ____ Cooler Temp: 3°C

Samplers: NB CR Sampling Location: Garners Bayou

	Station No.	Date	Time	Station Location/Description	Sample Type	Analysis	No. Items
	G-257	5/6/03	0810	Garners Bayou Discharge	Water	E. coli	2 jars
	G-303	↓	0840	↓	↓	↓	↓
	G-302	↓	0854	↓	↓	↓	↓
W	G-006	↓	0947	↓	↓	↓	↓
W	G-021	↓	1021	↓	↓	↓	↓
W	G-026	↓	1037	↓	↓	↓	↓
	G-042	↓	1059	↓	↓	↓	↓
W	G-043	↓	1109	↓	↓	↓	↓
	G-057	↓	1203	↓	↓	↓	↓

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Chain of Custody Record for *E. coli*

Job Name: HG AC Small wate   Job No. ________   Cooler Temp: 4°C

Samplers: NB CR   Sampling Location: Brickhouse

Station No.	Date	Time	Station Location/Description	Sample Type	Analysis	No. Items
B-146	5/7/03	0927	Brickhouse Gulley discharge	water	E. coli	2 jars
B-203	⎮	0958	⎮	⎮	⎮	⎮
B-279	⎮	1018	⎮	⎮	⎮	⎮
B-265	⎮	1030	⎮	⎮	⎮	⎮
B-240	⎮	1054	⎮	⎮	⎮	⎮
B-219	⎮	1146	⎮	⎮	⎮	⎮
B-246	⎮	1218	⎮	⎮	⎮	⎮
B-320	⎮	1305	⎮	⎮	⎮	⎮
B-040	⎮	1351	⎮	⎮	⎮	⎮

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Chain of Custody Record for *E. coli*

Job Name: HGAC Smallwater   Job No. ________   Cooler Temp: 4°C

Samplers: Neil Bossart   Sampling Location: Turkey Creek

Station No.	Date	Time	Station Location/Description	Sample Type	Analysis	No. Items
T-092	5/8/03	1321	Turkey Creek discharge	Water	E. coli	2 jars
T-139	|	1340	|	|	|	|
T-068	|	1403	|	|	|	|

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Chain of Custody Record for *E. coli*

Job Name: HGAC Stormwater   Job No. ______   Cooler Temp: 4°C

Samplers: NB KA   Sampling Location: Mason

	Station No.	Date	Time	Station Location/Description	Sample Type	Analysis	No. Items
	M-002	5/12/03	1004	Mason Creek discharge	water	E. coli	2 jars
W	M-004	|	1019	|	|	|	|
W	M-119	|	1107	|	|	|	|
W	M-353	|	1130	|	|	|	|
	M-134	|	1148	|	|	|	|
W	M-136	|	1204	|	|	|	|
	M-300	|	1233	|	|	|	|

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Chain of Custody Record for *E. coli*

Job Name: HGAC Small water Job No. ________ Cooler Temp: 4°C

Samplers: Neil Bossart & KA Sampling Location: Garners Bayou

	Station No.	Date	Time	Station Location/Description	Sample Type	Analysis	No. Items
	G-257	5/13/03	0819	Garners Bayou Discharge	Water	E. coli	2 jars
	G-303	↓	0842	↓	↓	↓	↓
	G-302	↓	0902	↓	↓	↓	↓
W	G-006	↓	0938	↓	↓	↓	↓
W	G-021	↓	0959	↓	↓	↓	↓
W	G-026	↓	1015	↓	↓	↓	↓
W	G-043	↓	1040	↓	↓	↓	↓
	G-042	↓	1053	↓	↓	↓	↓
	G-066	↓	1119	↓	↓	↓	↓

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Chain of Custody Record for *E. coli*

Job Name: HGAC Smallwater Job No. ________ Cooler Temp: 4°C

Samplers: NB KA Sampling Location: Brickhouse

Station No.	Date	Time	Station Location/Description	Sample Type	Analysis	No. Items
B-146	5/14/03	0806	Brickhouse Gulley	water	E. coli	2 jars
B-203	|	0827	|	|	|	|
B-279	|	0858	|	|	|	|
B-265	|	0925	|	|	|	|
B-240	|	0947	|	|	|	|
B-246	|	1021	|	|	|	|
B-219	|	1032	|	|	|	|
B-038	|	1130	|	|	|	|

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Chain of Custody Record for *E. coli*

Job Name: HGAC Smallwater Job No. ________ Cooler Temp: 4°C

Samplers: NB HA Sampling Location: Turkey Creek

Station No.	Date	Time	Station Location/Description	Sample Type	Analysis	No. Items
T-092	5/14/03	1342	Turkey Creek discharges	water	E. coli	2 jars
T-139	|	1401	|	|	|	|
T-068	|	1428	|	|	|	|

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Chain of Custody Record for *E. coli*

Job Name: HGAC Small water Job No. ________ Cooler Temp: 4°C

Samplers: NB TH Sampling Location: Mason Creek

	Station No.	Date	Time	Station Location/Description	Sample Type	Analysis	No. Items
W	m-004	5/19/03	1014	Mason Creek discharges	Water	E. coli	2 jars
W	m-119		1045				
W	m-353		1112				
W	m-136		1140				
	m-300		1159				

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Chain of Custody Record for *E. coli*

Job Name: HGAC Smallwater   Job No. ____   Cooler Temp: 3°C

Samplers: NB TH   Sampling Location: Garner's Bayou

Station No.	Date	Time	Station Location/Description	Sample Type	Analysis	No. Items
G-303	5/20/03	0847	Garners Bayou Discharges	Water	E. coli	2 jars
G-302	|	0904	|	|	|	|
W G-006	|	0950	|	|	|	|
W G-021	|	1024	|	|	|	|
W G-026	|	1033	|	|	|	|
W G-043	|	1058	|	|	|	|
G-042	|	1111	|	|	|	|
G-066	|	1138	|	|	|	|
~~1138~~						

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Chain of Custody Record for *E. coli*

Job Name: HGAC Small Watershed Job No. ________ Cooler Temp: 4°C

Samplers: NB TH Sampling Location: Brickhouse Gully

Station No.	Date	Time	Station Location/Description	Sample Type	Analysis	No. Items
B-146	5/21/03	0811	Brickhouse gully discharges	Water	E. coli	2 jars
B-203	|	0837	|	|	|	|
B-279	|	0858	|	|	|	|
B-265	|	0921	|	|	|	|
B-246	|	1023	|	|	|	|
B-219	|	1011	|		|	|

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Chain of Custody Record for *E. coli*

Job Name: H G A C Smallwater Job No. ________ Cooler Temp: 30C

Samplers: NB TH Sampling Location: Brickhouse & Turkey

Station No.	Date	Time	Station Location/Description	Sample Type	Analysis	No. Items
B-380	5/21/03	1259	Brickhouse	Water	E. coli	2 jars
T-092	|	1401	Turkey Creek	|	|	|
T-139	|	1427	|	|	|	|
T-068	|	1448	|	|	|	|

Relinquished by: [signature] Date 5/21/03 Time 1521 Received by: [signature: RaPowell]

Relinquished by: Date Time Received by:

Relinquished by: Date Time Received by:

Relinquished by: Date Time Received by:

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Houston Texas 77077

Chain of Custody Record for *E. coli*

Job Name: HGAC Small watershed Job No. ________ Cooler Temp: 4°C

Samplers: NB BM Sampling Location: Brickhouse Gulley

Station No.	Date	Time	Station Location/Description	Sample Type	Analysis	No. Items
B-380 A	6/4/03	0905	Wet Sample Endwater	Water	E.coli	2 jars
B-380 B		0920				
B-380 C		0935				
B-380 D		0950				
B-380 E		1005				
B-380 F		1020				

Relinquished by: [signature] Date 6/4/03 Time 1109 Received by: James D [signature]

Relinquished by: Date Time Received by:

Relinquished by: Date Time Received by:

Relinquished by: Date Time Received by:

PBS&J

1880 South Dairy Ashford Suite 300
Houston Texas 77077

Chain of Custody Record for *E. coli*

Job Name: HGAC Smallwater Job No. ______ Cooler Temp: 4 °C

Samplers: NB HO Sampling Location: Turkey Creek

Station No.	Date	Time	Station Location/Description	Sample Type	Analysis	No. Items
T-068A	6/5/03	1315	Turkey Creek wetweather	Water	E.coli	2 jars
T-068B	|	1335	|	|	|	|
T-068C	|	1355	|	|	|	|
T-068D	|	1415	|	|	|	|
T-068E	|	1435	|	|	|	|
T-068F	|	1455	|	|	|	|

Relinquished by: [signature] Date 6/5/03 Time 15:29 Received by: Susan Bunch

Relinquished by: Date Time Received by:

Relinquished by: Date Time Received by:

Relinquished by: Date Time Received by:

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Houston Texas 77077

Chain of Custody Record for *E. coli*

Job Name: Smallwatershed Job No. ______ Cooler Temp: 3°C

Samplers: ND Sampling Location: Mason Creek

Station No.	Date	Time	Station Location/Description	Sample Type	Analysis	No. Items
m300 A	6/26/03	1510	Mason Creek wet	Water	E. coli	2 jars
m300 B	|	1525	|	|	|	|
m300 C	|	1540	|	|	|	|
m300 D	|	1555	|	|	|	|
m300 E	|	1610	|	|	|	|
m300 F	|	1625	|	|	|	|

Relinquished by: [signature] Date 6/26/03 Received by: [signature]
Time 1708

Relinquished by: Date Received by:
Time

Relinquished by: Date Received by:
Time

Relinquished by: Date Received by:
Time

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Houston Texas 77077

Chain of Custody Record for *E. coli*

Job Name: HCAC Smallwater Job No. ___ Cooler Temp: 3°C

Samplers: N B Sampling Location: Garners Bayou

Station No.	Date	Time	Station Location/Description	Sample Type	Analysis	No. Items
G-066 A	6/30/03	0935	Garners Bayou wet weather	water	E. coli	2 jars
G-066 B	|	0950	|	|	|	|
G-066 C	|	1005	|	|	|	|
G-066 D	|	1020	|	|	|	|
G-066 E	|	1035	|	|	|	|
G-066 F	|	1050	|	|	|	|

Relinquished by: [signature] Date 6/30/03 Received by: Susan Bunch
Time 11:41

Relinquished by: Date Received by:
Time

Relinquished by: Date Received by:
Time

Relinquished by: Date Received by:
Time

Appendix C

PBS&J Laboratory Log Book Copies

Small Watershed Bacteria Daily Log

E. coli data sheet (Fluorescence Positive Indicator)

Date: 4/28/03 Observers: S. Banch Watershed: Quanti-cult Control

Incubator Temp: 35°C Time: 0900 Incubator Temp: 35°C Time: 1400

Sample ID	Watershed	Dilution	Start Time	Read Time	Sample Reading		Conversion	Dilution x Conversion	Comments
					Large Cell	Small Cell			
EC	Quanti-Cult		1400	0920	17	3	~~24.1~~ (1)	~~24.1~~ (1)	
KP	"		1400	0920	0	0	<1	<1	
PA	"		1400	0920	0	0	<1	<1	

(1) DC SB 7/1/03 → [24.0]

Small Watershed Bacteria Daily Log

E. coli data sheet (Fluorescence Positive Indicator)

Date: 4/29/03

Observers: Susan Bunch/Rachael Brown
Yu Cang/Jim Horne

Watershed: Mason

Incubator Temp: 35°C

Time: 0940

Incubator Temp: 35° C

Time: 1500

Sample ID	Watershed	Dilution	Start Time	Read Time	Sample Reading		Conversion	Dilution x Conversion	Comments
					Large Cell	Small Cell			
M-002	Mason	1:100	1515	0940	2	0	2.0	200	
M-002	Mason	1:2	1515	0941	~~46~~ ①	12	143.9	287.8	
M-004	Mason	1:100	1516	0943	1	0	1.0	100	
M-004	Mason	1:2	1520	0944	9	1	10.9	21.8	
M-119	Mason	1:100	1520	0944	0	0	<1	<100	
M-119	Mason	1:2	1523	0945	1	1	2.0	4	
M-353	Mason	1:100	1524	0946	1	0	1.0	100	
M-353	Mason	1:2	1525	0947	35	2	60.5	121	
M-134	Mason	1:100	1526	0947	8	0	8.6	860	
D1 M-134	Mason	1:2	1527	0948	49	21	365.4	730.8	
D2 M-134	Mason	1:2	1529	0948	49	21	365.4	730.8	~~RPD=0%~~ SB
M-300	Mason	1:100	1531	0949	3	0	3.1	310	
M-300	Mason	1:2	1534	0950	48	17	238.2	476.4	

① pc SB 4/30/03 → <45>

Small Watershed Bacteria Daily Log

E. coli data sheet (Fluorescence Positive Indicator)

Date: 4/30/03 Observers: S. Bunch, Yu Cang Watershed: Garners Bayou

Incubator Temp: 35°C Time: 1000 Incubator Temp: 35°C Time: 1415

Sample ID	Watershed	Dilution	Start Time	Read Time	Sample Reading Large Cell	Sample Reading Small Cell	Conversion	Dilution x Conversion	Comments
Blank	~~G~~ ①	NA	1450	0943	0	0	<1.0	<1.0	
G-257	Garners	1:100	1451	0943	23	0	29.9	2990	
G-257		1:2	1451	0944	49	40	~~119.85~~ ⑤	~~2239.7~~ ⑥	
G-303		1:100	1453	0944	0	0	< 1.0	<100	
G-303		1:2	1455	0945	~~30~~ ②	2	17.1	34.2	
G-302		1:100	1459	0946	0	0	<1.0	<100	
D1 G-302		1:2	1500	0947	~~35~~ ③	5	66.3	132.6	
D2 G-302		1:2	1500	0947	34	7	66.9	133.8	~~RPD=0.9%~~ SB
G-006		1:100	1501	0948	1	0	~~<1.0~~ ④	100	
G-006		1:2	1502	0948	8	3	11.9	23.8	
G-021		1:100	1503	0949	0	0	< 1.0	<100	
G-021		1:2	1504	0949	0	0	< 1.0	< 2.0	
G-026		1:100	1505	0950	0	0	< 1.0	< 100	
G-026		1:2	1506	0950	0	0	< 1.0	< 2.0	
G-042		1:100	1506	0951	3	0	3.1	310	
G-042		1:2	1507	0951	33	8	65.7	131.4	
G-066		1:100	1507	0952	5	0	5.2	520	
G-066		1:2	1509	0953	33	2	54.7	109.4	
G-043		1:100	1510	0953	4	0	4.1	410	
G-043		1:2	1511	0954	49	12	224.7	449.4	

① DC SB 4/30/03 → [NA]
② DC SB 5/1/03 → [13]
③ DC SB 5/1/03 → [35]
④ DC SB 5/1/03 → [1.0]
⑤ DC SB 7/1/03 → [1119.9]
⑥ DC SB 7/1/03 → [2239.8]

Small Watershed Bacteria Daily Log

E. coli data sheet (Fluorescence Positive Indicator)

Date: 4/30/03 Observers: S. Bunch, R. Brown, Y. Cang, J. Horne Watershed: Turkey Creek

Incubator Temp: 35° C Time: 1000 Incubator Temp: 35°C Time: 1600

Sample ID	Watershed	Dilution	Start Time	Read Time	Sample Reading		Conversion	Dilution x Conversion	Comments
					Large Cell	Small Cell			
T-092	Turkey Cr.	1:100	1640	1056	5	2	7.3	730	
T-092		1:2	1640	1056	49	24	435.2	870.4	
T-139		1:100	1641	1057	7	0	7.4	740	
T-139		1:2	1642	1058	49	34	770.1	1540.2	
T-068		1:100	1643	1058	8	0	8.6	860	
D1 T-068		1:2	1643	1059	49	37	920.8	1841.6	
D2 T-068		1:2	1644	1059	49	30	613.1	1226.2	~~RPD = 40%~~ SB

Small Watershed Bacteria Daily Log

E. coli data sheet (Fluorescence Positive Indicator)

Date: 5/1/03　Observers: S. Bunch, Y. Cang　Watershed: Brickhouse Gully discharge

Incubator Temp: 35°C　Time: 0900　Incubator Temp: 35°C　Time: 1425

	Sample ID	Watershed	Dilution	Start Time	Read Time	Sample Reading Large Cell	Sample Reading Small Cell	Conversion	Dilution x Conversion	Comments
	B-146	Brickhouse	1:100	1500	1018	4	0	4.1	410	
	B-146		1:2	1502	1019	49	30	613.1	1226.2	
	B-203		1:100	1503	1019	2	0	2.0	200	
	B-203		1:2	1504	1019	41	7	95.9	191.8	
	B-279		1:100	1505	1020	0	0	<1.0	<100	
	B-279		1:2	1505	1020	1	0	1.0	2	
	B-265		1:100	1506	1020	6	0	6.3	630	
D1	B-265		1:2	1506	1021	49	16	275.5	551	
D2	B-265		1:2	1507	1021	48	14	209.8	419.6	~~27%~~ SB
	B-240		1:100	1508	1022	0	0	<1.0	<100	
	B-240		1:2	1508	1022	14	2	18.5	37	
	B-246		1:100	1509	1023	49	43	1413.60	141360	
	B-246		1:2	1510	1023	49	48	>2419.2	>4838.4	
	B-219		1:100	1510	1023	0	0	<1.0	<100	
	B-219		1:2	1511	1024	39	4	78.9	157.8	
	B-040		1:100	1511	1024	1	1	2.0	200	
	B-040		1:2	1511	1024	49	19	325.5	651	
	B-380		1:100	1512	1025	7	0	7.4	740	
	B-380		1:2	1512	1025	49	33	~~726.0~~ ①	~~1452~~ ②	

① DC SB 7/1/03 → [727.0]
② DC SB 7/1/03 → [1454]

Small Watershed Bacteria Daily Log

E. coli data sheet (Fluorescence Positive Indicator)

Date: 5/5/03 Observers: S. Bunch / Y. Cang Watershed: Mason Creek

Incubator Temp: 35° C Time: 1000 Incubator Temp: 35°C Time: 1520

	Sample ID	Watershed	Dilution	Start Time	Read Time	Sample Reading		Conversion	Dilution x Conversion	Comments
						Large Cell	Small Cell			
	M-002	Mason Cr	1:100	1600	1017	2	0	2.0	200	①
	M-002		1:2	1600	1017	12	0	13.5	27	①
	M-004		1:100	1600	1018	0	0	<1	<100	
D1	M-004		1:2	1601	1018	14	1	17.3	34.6	
D2	M-004		1:2	1601	1019	15	1	18.7	37.4	~~RPD = 7.8%~~ SB
	M-119		1:100	1602	1019	0	0	<1	<100	
	M-119		1:2	1602	1019	4	0	4.1	8.2	
	M-353		1:100	1603	1020	27	2	40.4 ②	4040	
	M-353		1:2	1603	1021	49	47	~~2419.17~~	~~4838.34~~ ③	
	M-134		1:100	1604	1021	43	4	~~98.0~~ ④	~~9800~~ ⑤	
	M-134		1:2	1605	1022	49	48	>2419.2	>4838.4	
	M-136		1:100	1605	1022	0	0	<1	<100	
	M-136		1:2	1606	1023	9	2	~~11.0~~ ⑥	~~22.0~~ ⑦	
	M-300		1:100	1607	1023	1	0	1.0	100	
	M-300		1:2	1607	1024	34	5	63.1	126.2	

① Sample contained high suspended solids, SB
② DC SB 7/1/03 → [2419.2]
③ DC SB 7/1/03 → [4838.4]
④ DC SB 7/1/03 → [99.0]
⑤ DC SB 7/1/03 → [9900]
⑥ DC SB 7/1/03 → [12.0]
⑦ DC SB 7/1/03 → [illegible]

Small Watershed Bacteria Daily Log

E. coli data sheet (Fluorescence Positive Indicator)

Date: 5/6/03 Observers: Y Cang/S Bunch/J. Horne Watershed: Garners

Incubator Temp: 35°C Time: 1000 Incubator Temp: 35°C Time: 1410

	Sample ID	Watershed	Dilution	Start Time	Read Time	Sample Reading: Large Cell	Sample Reading: Small Cell	Conversion	Dilution x Conversion	Comments	
	G-257	Garners	1:100	1445	0925	0	0	<1	<100		
	G-257		1:2	1445	0925	32	6	59.1	118.2		
	G-303		1:100	1446	0926	1	0	1.0	100		
	G-303		1:2	1446	0926	32	4	55.6	111.2		
	G-302		1:100	1447	0926	0	0	<1	<100		
D1	G-302		1:2	1448	0927	24	1	33.1	66.2		
D2	G-302		1:2	1448	0928	28	4	45.7	91.4	~~RPD = 32%~~	SB
	G-006		1:100	1449	0930	0	0	<1	<100		
	G-006		1:2	1450	0931	26	6	44.3	88.6		
	G-021		1:100	1450	0931	0	0	<1	<100		
	G-021		1:2	1451	0931	0	0	<1	<100		
	G-026		1:100	1451	0932	0	0	<1	<100		
	G-026		1:2	1452	0932	1	0	1.0	2.0		
	G-042		1:100	1452	0932	0	0	<1	<100		
	G-042		1:2	1453	0932	37	7	77.6	155.2		
	G-043		1:100	1453	0933	0	0	<1	<100		
	G-043		1:2	1454	0933	2	0	2.0	4.0		
	G-057		1:100	1455	0933	1	0	1.0	100		
	G-057		1:2	1455	0933	30	3	48.7	97.4		

Small Watershed Bacteria Daily Log

E. coli data sheet (Fluorescence Positive Indicator)

Date: 5/7/03 Observers: J. Horne / S. Bunch Watershed: Brickhouse

Incubator Temp: 35°C Time: 0915 Incubator Temp: 35°C Time: 1500

	Sample ID	Watershed	Dilution	Start Time	Read Time	Sample Reading		Conversion	Dilution x Conversion	Comments
						Large Cell	Small Cell			
	B-146	Brickhouse	1:100	1515	1036	2	2	4.1	410	
	B-146		1:2	1515	1036	49	16	275.5	551	
	B-203		1:100	1516	1037	23	2	32.7	3270	
	B-203		1:2	1516	1037	49	43	1413.60	2827.2	
	B-279		1:100	1517	1038	0	0	<1	<100	
	B-279		1:2	1518	1039	8	1	9.7	19.4	
	B-265		1:100	1518	1039	0	0	<1	<100	
	B-265		1:2	1518	1040	0	0	<1	<100	
	B-240		1:100	1519	1040	1	0	1.0	~~1.00~~ ①	
	B-240		1:2	1519	1040	12	2	15.8	31.6	
	B-219		1:100	1520	1041	1	0	1.0	100	②
D1	B-219		1:2	1520	1041	49	24	435.2	870.4	②
D2	B-219		1:2	1520	1042	49	20	344.8	689.6	~~RPD=23.2%~~ SB
	B-246		1:100	1521	1042	49	48	>2419.2	> 4838.4	
	B-246		1:2	1521	1043	49	48	>2419.2	>4838.4	
	B-380		1:100	1522	1043	47	11	166.4	16640	
	B-380		1:2	1522	1044	49	48	>2419.2	>4838.4	
	B-040		1:100	1523	1044	0	0	<1	<100	
	B-040		1:2	1523	1044	5	0	5.2	10.4	

① QC SB 5/8/03 → [100]

② Sample contained high suspended solids SB

Small Watershed Bacteria Daily Log

E. coli data sheet (Fluorescence Positive Indicator)

Date: 5/8/03 Observers: S. Bunch Watershed: Turkey Creek

Incubator Temp: 35°C Time: 0940 Incubator Temp: 35°C Time: 1500

Sample ID	Watershed	Dilution	Start Time	Read Time	Sample Reading		Conversion	Dilution x Conversion	Comments
					Large Cell	Small Cell			
T-092	TurkeyCr	1:100	1505	0951	1	1	2.0	200	
T-092			1:2	1506	0951	48	16	228.2	456.4	
T-139			1:100	1506	0952	19	9	~~34.0~~ (1)	~~3400~~ (3)	
T-139			1:2	1507	0952	49	46	~~1986.28~~ (4)	~~3972.56~~ (5)	
T-068			1:100	1508	0953	11	0	12.2	1220	
T-068			1:2	1508	0954	49	40	~~1119.85~~ (6)	~~2239.7~~ (7)	

~~(1) DC SB 5/8/03~~ (2)
(2) DC SB 7/1/03 → [35]
(3) DC SB 7/1/03 → [3500]
(4) DC SB 7/1/03 → [1986.3]
(5) DC SB 7/1/03 → [3972.6]
(6) DC SB 7/1/03 → [1119.9]
(7) DC SB 7/1/03 → [2239.8]

Small Watershed Bacteria Daily Log

E. coli data sheet (Fluorescence Positive Indicator)

Date: 5/12/03 Observers: S. Bunch, Y. Cang Watershed: Mason

Incubator Temp: 35°C Time: 0930 Incubator Temp: 35°C Time: 1430

Sample ID	Watershed	Dilution	Start Time	Read Time	Sample Reading		Conversion	Dilution x Conversion	Comments
					Large Cell	Small Cell			
M-002	Mason	1:100	1506	0943	3	0	3.1	310	
M-002		1:2	1506	0943	36	12	84.5	169	
M-004		1:100	1507	0944	0	0	<1	<100	
M-004		1:2	1508	0944	12	3	16.9	33.8	
M-119		1:100	1508	0945	0	0	<1	<100	
M-119		1:2	1509	0945	21	0	26.5	53	
M-353		1:100	1510	0945	3	0	3.1	310	
M-353		1:2	1510	0946	40	3	80.9	161.8	
M-134		1:100	1511	0946	31	6	56.3	5630	
M-134		1:2	1512	0946	49	48	>2419.2	>4838.4	
M-136		1:100	1512	0947	1	0	1.0	100	①
D1 M-136		1:2	1513	0947	6	1	7.4	14.8	①
D2 M-136		1:2	1513	0947	9	0	9.8	19.6	~~RPD=27.9~~ SB
M-360		1:100	1514	0948	5	0	5.2	520	
M-300		1:2	1515	0949	45	11	139.6	279.2	

① Sample contained high suspended solids. SB

Small Watershed Bacteria Daily Log

E. coli data sheet (Fluorescence Positive Indicator)

Date: 5/13/03 Observers: Y. Cang, S. Bunch Watershed: Garners

Incubator Temp: 35°C Time: 0930 Incubator Temp: 35°C Time: 1340

Sample ID	Watershed	Dilution	Start Time	Read Time	Sample Reading: Large Cell	Sample Reading: Small Cell	Conversion	Dilution x Conversion	Comments
G-257	Garners	1:100	1350	0937	0	0	<1	<100	
G-257		1:2	1350	0937	6	1	7.4	14.8	
G-303		1:100	1351	0938	3	0	3.1	310	
G-303		1:2	1352	0938	42	8	104.6	209.2	
G-302		1:100	1353	0938	0	0	<1	<100	
G-302		1:2	1353	0939	21	3	30.5	61.0	
G006		1:100	1354	0940	0	0	<1	<100	
G-006		1:2	1354	0940	11	2	14.5	29	
G-021		1:100	1355	0940	0	0	<1	<100	
D1 G-021		1:2	1356	0940	0	0	<1	<2.0	
D2 G-021		1:2	1356	0941	0	0	<1	<2.0	~~RPD = 0%~~ SB
G-026		1:100	1357	0941	0	0	<1	<100	
G-026		1:2	1358	0941	4	0	4.1	8.2	
G-043		1:100	1400	0941	0	0	<1	<100	
G-043		1:2	1400	0941	0	0	<1	<2	
G-042		1:100	1401	0942	1	0	~~<1~~ ①	100	
G-042		1:2	1402	0942	43	6	~~104.0~~ ②	~~208~~ ③	
G-066		1:100	1403	0942	1	0	1.0	100	
G-066		1:2	1403	0943	41	8	98.7	197.4	

① DC SB 5/14/03 → [1.0]
② DC SB 7/1/03 → [105.0]
③ DC SB 7/1/03 → [210.0]

Small Watershed Bacteria Daily Log

E. coli data sheet (Fluorescence Positive Indicator)

Date: ~~0920~~ ① Observers: Y. cang, S. Bunch Watershed: Brickhouse Gulley

Incubator Temp: 35°C Time: 0915 Incubator Temp: 35°C Time: 1330

	Sample ID	Watershed	Dilution	Start Time	Read Time	Sample Reading		Conversion	Dilution x Conversion	Comments
						Large Cell	Small Cell			
	B-146	Brickhouse	1:100	1339	0933	14	4	20.9	2090	
D1	B-146		1:2	1339	0933	49	37	920.8	1841.6	
D2	B-146		1:2	1340	0934	48	32	478.6	957.2	~~63.2% RPD~~ SE
	B-203		1:100	1340	0934	29	3	46.4	4640	
	B-203		1:2	1340	0935	49	48	>2419.2	>4838.4	
	B-279		1:100	1341	0935	27	5	~~44.0~~ ②	~~4400~~ ③	
	B-279		1:2	1341	0936	49	47	~~2419.17~~ ④	~~4838.34~~ ⑤	
	B-265		1:100	1342	0936	0	0	<1	<100	
	B-265		1:2	1342	0936	42	4	93.2	186.4	
	B-240		1:100	1343	0937	0	0	<1	<100	
	B-240		1:2	1343	0937	6	0	6.3	12.6	
	B-246		1:100	1344	0937	49	21	365.4	36540	
	B-246		1:2	1344	0938	49	48	>2419.2	>4838.4	
	B-219		1:100	1345	0938	2	1	3.0	300	
	B-219		1:2	1345	0938	45	15	157.6	315.20	
	B-038		1:100	1346	0938	2	0	2.0	200	
	B-038		1:2	1346	0939	41	4	88.0	176	

① DC SB 5/14/03 → [5/14/03]
② DC SB 7/1/03 → [45.0]
③ DC SB 7/1/03 → [4500]
④ DC SB 7/1/03 → [2419.2]
⑤ DC SB 7/1/03 → [4838.4]

Small Watershed Bacteria Daily Log

E. coli data sheet (Fluorescence Positive Indicator)

Date: 5/14/03 Observers: S. Bunch Watershed: Turkey Creek

Incubator Temp: 35°C Time: 0915 Incubator Temp: 35°C Time: 1330

Sample ID	Watershed	Dilution	Start Time	Read Time	Sample Reading		Conversion	Dilution x Conversion	Comments
					Large Cell	Small Cell			
T-092	Turkey Cr	1:100	1520	0941	1	0	1.0	100	
T-092	|	1:2	1520	0941	38	7	81.6	163.2	
T-139	|	1:100	1521	0942	0	0	<1	<100	
T-139	|	1:2	1522	0942	18	2	24.3	48.6	
T-068	|	1:100	1522	0942	10	2	13.2	1320	
T-068	|	1:2	1523	0943	49	21	365.4	730.8	

Small Watershed Bacteria Daily Log

E. coli data sheet (Fluorescence Positive Indicator)

Date: 5/19/03 Observers: S. Bunch, Y. Cang Watershed: Mason Creek

Incubator Temp: 35°C Time: 10 30 Incubator Temp: 35°C Time: 1330

Sample ID	Watershed	Dilution	Start Time	Read Time	Sample Reading: Large Cell	Sample Reading: Small Cell	Conversion	Dilution x Conversion	Comments
M-004	Mason	1:100	1400	0940	1	0	1.0	100	
M-004		1:2	1400	0941	18	1	23.1	46.2	
M-119		1:100	1401	0941	0	0	<1	<100	
D1 M-119		1:2	1401	0942	0	0	<1	<2	
D2 M-119		1:2	1402	0942	2	0	2.0	4.0	~~RPD=67%~~ SB
M-353		1:100	1402	0942	0	0	<1	<100	
M353		1:2	1402	0943	2	0	2.0	4.0	
M-136		1:100	1403	0943	0	0	<1	<100	
M-136		1:2	1403	0943	3	0	3.1	6.2	
M-300		1:100	1404	0944	0	0	<1	<100	
M-300		1:2	1404	0944	~~6~~ ①	1	7.4	14.8	

① DC SB 5/20/03 → [6]

Small Watershed Bacteria Daily Log

E. coli data sheet (Fluorescence Positive Indicator)

Date: 5/20/03 Observers: Y. Cang, S. Bunch Watershed: Garners Bayou

Incubator Temp: 35°C Time: 0930 Incubator Temp: 35°C Time: 1350

Sample ID	Watershed	Dilution	Start Time	Read Time	Sample Reading		Conversion	Dilution x Conversion	Comments
					Large Cell	Small Cell			
G-303	Garners	1:100	1425	0931	1	0	1.0	100	
G-303		1:2	1425	0931	39	5	81.3	162.6	
G-302		1:100	1426	0932	48	9	172.2	17220	
G-302		1:2	1426	0932	49	48	>2419.2	>4838.4	
G-006		1:100	1427	0932	0	0	<1	<100	
G-006		1:2	1428	0932	16	1	20.1	40.2	
G-021		1:100	1428	0933	0	0	<1	<100	
G-021		1:2	1428	0933	0	0	<1	<2	
G-026		1:100	1429	0933	1	0	1.0	100	
G-026		1:2	1429	0934	11	2	14.5	29	
G-043		1:100	1430	0934	0	0	<1	<100	
G-043		1:2	1430	0934	16	1	20.1	40.2	
G-042		1:100	1431	0936	2	0	2.0	200	
G-042		1:2	1431	0936	35	4	64.4	128.8	
G-066		1:100	1432	0936	5	0	5.2	520	
D1 G-066		1:2	1433	0937	33	6	~~61.0~~ ①	~~122~~ ②	
D2 G-066		1:2	1434	0937	27	7	48.1	96.2	~~RPD = 23.6%~~ ①

~~① DC SB 5/21/03 → [23.5%]~~ SB

① DC SB 7/1/03 → [62.0]

② DC SB 7/1/03 → [124]

Small Watershed Bacteria Daily Log

E. coli data sheet (Fluorescence Positive Indicator)

Date: 5/21/03 Observers: Y. Cang/S. Bunch Watershed: Brickhouse

Incubator Temp: 35°C Time: 0930 Incubator Temp: 35°C Time: ~~13~~ ①

Sample ID	Watershed	Dilution	Start Time	Read Time	Sample Reading Large Cell	Sample Reading Small Cell	Conversion	Dilution x Conversion	Comments
B-146	Brickhouse	1:100	1300	0938	9	2	~~11.0~~ ②	~~1100~~ ③	
D1 B-146		1:2	1300	0938	49	24	435.2	870.4	
D2 B-146		1:2	1301	0939	49	27	517.2	1034.4	~~RPD=17.2%~~ SB
B-203		1:100	1301	0939	20	3	28.8	2880	
B-203		1:2	1301	0940	49	47	~~2419.17~~ ④	~~4838.34~~ ⑤	
B-279		1:100	1302	0940	49	48	>2419.2	>241920	
B-279		1:2	1302	0940	49	48	>2419.2	>4838.4	
B-265		1:100	1303	0941	7	0	7.4	740	
B-265		1:2	1303	0941	49	23	410.6 ⑥	821.2	
B-246		1:100	1304	0942	49	45	~~1732.87~~	~~173287~~ ⑦	
B-246		1:2	1304	0943	49	48	>2419.2	>4838.4	
B-219		1:100	1305	0943	48	9	172.2	17220	
B-219		1:2	1305	0943	49	48	>2419.2	>4838.4	
B-380		1:100	1555	1019	2	0	2.0	200	
B-380		1:2	1555	1019	47	16	198.9	397.8	

① DC SB 5/21/03 → [1230]
② DC SB 7/1/03 → [12.0]
③ DC SB 7/1/03 → [1200]
④ DC SB 7/1/03 → [2419.2]
⑤ DC SB 7/1/03 → [4838.4]
⑥ DC SB 7/1/03 → [1732.9]
⑦ DC SB 7/1/03 → [173,290]

Small Watershed Bacteria Daily Log

E. coli data sheet (Fluorescence Positive Indicator)

Date: 6/4/03 Observers: Y. Cang Watershed: Brickhouse Gulley

Incubator Temp: 35°C Time: 1000 Incubator Temp: 35°C Time: 1400

Sample ID	Watershed	Dilution	Start Time	Read Time	Sample Reading		Conversion	Dilution x Conversion	Comments
					Large Cell	Small Cell			
B-380A	Brickhouse	1:100	1240	0946	48	17	238.2	23820	
B-380A		1:2	1240	0946	49	48	>2419.2	>4838.4	
B-380 B		1:100	1241	0947	46	20	203.5	20350	
B-380 B		1:2	1241	0947	49	48	>2419.2	>4838.4	
B-380 C		1:100	1241	0948	40	8	93.3	9330	
B-380 C		1:2	1242	0948	49	48	>2419.2	>4838.4	
B-380 D		1:100	1250	0949	47	17	206.3	20630	
B-380 D		1:2	1250	0949	49	48	>2419.2	>4838.4	
B-380 E		1:100	1255	0950	47	9	155.3	15530	
B-380 E		1:2	1255	0950	49	48	>2419.2	>4838.4	
B-380 F		1:100	1300	0951	43	24	172.8	17280	
B-380 F		1:2	1300	0951	49	48	>2419.2	>4838.4	

Small Watershed Bacteria Daily Log

E. coli data sheet (Fluorescence Positive Indicator)

Date: 6/5/03 Observers: S. Bunch / Y. Cang Watershed: Turkey Creek

Incubator Temp: 35°C Time: 1000 Incubator Temp: 35°C Time: 1600

Sample ID	Watershed	Dilution	Start Time	Read Time	Sample Reading		Conversion	Dilution x Conversion	Comments
					Large Cell	Small Cell			
T-068 A	Turkey Creek	1:100	1600	1005	47	17	206.3	20630	
T-068 A		1:2	1600	1005	49	48	>2419.2	> 4,838.4	
T-068 B		1:100	1601	1006	48	18	248.9	24,890	
T-068 B		1:2	1602	1006	49	48	>2419.2	>4838.4	
T-068 C		1:100	1603	1007	49	39	~~1046.24~~ ①	~~104624~~ ②	
T-068 C		1:2	1603	1007	49	48	>2419.2	>4838.4	
T-068 D		1:100	1604	1008	49	29	579.4	57940	
T-068 D		1:2	1604	1008	49	48	>2419.2	>4838.4	
T-068 E		1:100	1605	1009	49	21	365.4	36540	
T-068 E		1:2	1605	1009	49	48	>2419.2	>4838.4	
T-068 F		1:100	1606	1010	49	12	224.7	22470	
T-068 F		1:2	1606	1010	49	48	>2419.2	>4838.4	

① DC SB 7/1/03 → {1046.2}

② DC SB 7/1/03 → {104,620}

Small Watershed Bacteria Daily Log

E. coli data sheet (Fluorescence Positive Indicator)

Date: 6/26/03　Observers: NB/S Bunch　Watershed: Mason

Incubator Temp: 35°C　Time: 1711　Incubator Temp: 35°C　Time: 1320

Sample ID	Watershed	Dilution	Start Time	Read Time	Sample Reading		Conversion	Dilution x Conversion	Comments
					Large Cell	Small Cell			
m-300 A	Mason	1:2	1810	1320	49	48	>2419.2	>4838.4	
m-300 A		1:100			47	14	185.0	18500	
m-300 B		1:2			49	48	>2419.2	>4838.4	
m-300 B		1:100			46	16	178.2	17820	
m-300 C		1:2			49	48	>2419.2	>4838.4	
m-300 C		1:100			46	16	178.2	17820	
m-300 D		1:2			49	48	>2419.2	>4838.4	
m-300 D		1:100			46	20	203.5	20350	
m-300 E		1:2			49	48	>2419.2	>4838.4	
m-300 E		1:100			45	17	167.4	16,740	
m-300 F		1:2			49	48	>2419.2	>4838.4	
m-300 F		1:100			47	14	185.0	18500	
m-300 F		1:100			47	13	178.5	17,850	

Small Watershed Bacteria Daily Log

E. coli data sheet (Fluorescence Positive Indicator)

Date: 6/30/03 Observers: Y. Cang, S. Bunch Watershed: Garners

Incubator Temp: 35°C Time: 1300 Incubator Temp: 0915 Time: 35°C

Sample ID	Watershed	Dilution	Start Time	Read Time	Sample Reading: Large Cell	Sample Reading: Small Cell	Conversion	Dilution x Conversion	Comments
G-066 A	Garners	1:100	1330	0920	18	0	21.8	2180	
G-066 A	|	1:2	|	|	49	43	1413.6	2827.2	
G-066 B	|	1:100	|	|	16	3	22.6	2260	
G-066 B	|	1:2	|	|	49	44	1553.1	3106.2	
G-066 C	|	1:100	|	|	17	0	20.3	2030	
G-066 C	|	1:2	|	|	49	41	1203.3	2406.6	
G-066 D	|	1:100	|	|	18	0	21.8	2180	
G-066 D	|	1:2	|	|	49	42	1299.7	2599.4	
G-066 E	|	1:100	|	|	14	4	20.9	2090	
G-066 E	|	1:2	|	|	49	42	1299.7	2599.4	
G-066 F	|	1:100	|	|	16	0	18.9	1890	
G-066 F	|	1:2	|	|	49	36	866.4	~~1738.~~ ①	

① DC SB 7/1/03 → [1732.8]

Total Residual Chlorine Log

Date	Sample ID	Buffer Lot #	DPD Lot #	KI Pillow Lot #	FAS Titrant Volume (mL)			TRC mg/L	RPD (%)	Initials
					Initial	Final	Vol. Used			
4/29/03	M-004 Mason Creek	2301343	~~A2312~~ (1)	A2312	—	—	—	<0.1		SB
4/29/03	M-119 Mason Creek		1302529		—	—	—	<0.1		SB
4/29/03	M-353 Mason Creek				—	—	—	<0.1		SB
4/30/03	G-006 Garners B.				—	—	—	<0.1		SB
4/30/03	G-021 Garners B.				—	—	—	<0.1		SB
4/30/03	G-026 Garners B.				—	—	—	<0.1		SB
4/30/03	G-043 Garners B.				—	—	—	<0.1		SB
5/5/03	M-004 Mason Creek				—	—	—	<0.1		SB
5/5/03	M-119 Mason Creek				—	—	—	<0.1		SB
5/5/03	M-353 Mason Creek				—	—	—	<0.1		SB
5/5/03	M-136 Mason Creek				—	—	—	<0.1		SB
5/6/03	G-006 Garners				—	—	—	<0.1		SB
5/6/03	G-021				—	—	—	<0.1		SB
5/6/03	G-026				—	—	—	<0.1		SB
5/6/03	G-043				—	—	—	<0.1		SB
5/12/03	M-004 Mason				—	—	—	<0.1		SB
	M-119				—	—	—	<0.1		SB
	M-353				—	—	—	<0.1		SB

(1) DC SB 4/29/03 → [1302529]

Total Residual Chlorine Log

Date	Sample ID	Buffer Lot #	DPD Lot #	KI Pillow Lot #	FAS Titrant Volume (mL)			TRC mg/L	RPD (%)	Initials
					Initial	Final	Vol. Used			
5/12/03	M-136 Mason	2301343	1302529	A2312	–	–	–	<0.1		SB
5/13/03	G-006 Garners	|	|	|	–	–	–	<0.1		|
|	G-021	|	|	|	–	–	–	<0.1		|
|	G-026	|	|	|	–	–	–	<0.1		|
|	G-043	|	|	|	–	–	–	<0.1		|
5/19/03	M-004 Mason	|	|	|	–	–	–	<0.1		SB
|	M-119	|	|	|	–	–	–	<0.1		|
|	M-353	|	|	|	–	–	–	<0.1		|
|	M-136	|	|	|	–	–	–	<0.1		|
5/20/03	G-006 Garners	|	|	|	–	–	–	<0.1		SB
|	G-021	|	|	|	–	–	–	<0.1		|
|	G-026	|	|	|	–	–	–	<0.1		|
|	G-043	|	|	|	–	–	–	<0.1		|

Appendix D

April 10, 2003, Meeting Summary

APPENDIX D

APRIL 10, 2003, MEETING SUMMARY

Location: H-GAC Office, 5th Floor Conference Room
Date: 4/10/2003
Time: 10:45 a.m.-11:50 a.m.

Attendants:

H-GAC: Todd Running, Karen Brettschneider
PBS&J: Jeff Scarborough, Yu-Chun Su

Meeting Summary:

1. Yu-Chun Su provided a summary of project status regarding the development of the GIS tool for calculating area averaged Curve Number (CN).

2. H-GAC agreed to PBS&J's approach of incorporating land use, soil, and CN data.

3. Jeff Scarborough presented several slides showing the Weighted Runoff Curve Number Tool being developed for this project. Jeff also presented the Watershed Analyst software PBS&J has been developing and discussed its potential applications in the H-GAC area.

4. H-GAC agreed that PBS&J should provide a demonstration of Watershed Analyst to H-GAC personnel in the near future.

5. The following specific decisions were made after discussions between H-GAC and PBS&J personnel:

   a. For soils with one HSG classification based on permeability, the HSG should be adopted.

   b. For soils with a range of HSG's based on permeability (e.g., A-D), the HSG's should be adopted according to the soil type. If the soil type is clay or sand, then a HSG of C or B should be adopted, respectively. If the soil type is unclear and there is one HSG associated with the soil in TR-55, then the TR-55 HSG should be adopted. If none of the above is applicable, then an HSG of C should be adopted.

For Open Water, Wetland, and Woody Wetland, a CN of 50, 40, and 30 should be used, respectively, for the development of a look-up table and the CN Tool. These values may be changed in the future.

Appendix E

Complete List of LULC and Soil Type Combinations

APPENDIX E
COMPLETE LIST OF LULC AND SOIL TYPE COMBINATIONS

Land Use	HSG	CN	MUSYM	NAME
Agriculture	A	72	Ge	Gessner loam
Agriculture	A	72	Kn	Kenney loamy fine sand
Agriculture	A	72	Kf	Katy fine sandy loam
Agriculture	A	72	Gp	Gravel Pit
Agriculture	A	72	Ar	Aris-Gessner complex
Agriculture	A	72	Ad	Addicks loam
Agriculture	A	72	HoA	Hockley fine sandy loam, 0 to 1 percent slopes
Agriculture	A	72	Hf	Hatliff loam
Agriculture	A	72	HoB	Hockley fine sandy loam, 1 to 4 percent slopes
Agriculture	A	72	Gs	Gessner complex
Agriculture	A	72	Ku	Kenney-Urban land complex
Agriculture	A	72	Ed	Edna fine sandy loam
Agriculture	A	72	Ce	Clodine-Urban land complex
Agriculture	A	72	Cd	Clodine loam
Agriculture	A	72	Bo	Boy loamy fine sand
Agriculture	A	72	Bn	Bissonnet very fine sandy loam
Agriculture	A	72	As	Aris-Urban land complex
Agriculture	A	72	AtB	Atasco fine sandy loam, 1 to 4 percent slopes
Agriculture	A	72	Gu	Gessner-Urban land complex
Agriculture	A	72	On	Ozan-Urban land complex
Agriculture	A	72	Am	Aldine very fine sandy loam
Agriculture	A	72	Vs	Voss soils
Agriculture	A	72	Ak	Addicks-Urban land complex
Agriculture	A	72	Wo	Wockley fine sandy loam
Agriculture	A	72	Wy	Wockley-Urban land complex
Agriculture	A	72	Vo	Voss sand
Agriculture	A	72	SeA	Segno fine sandy loam, 0 to 1 percent slopes
Agriculture	A	72	An	Aldine-Urban land complex
Agriculture	A	72	Oa	Ozan loam
Agriculture	A	72	Na	Nahatche loam
Agriculture	A	72	Bp	Borrow Pit
Agriculture	A	72	Ap	Aris fine sandy loam
Agriculture	A	72	SeB	Segno fine sandy loam, 1 to 3 percent slopes
Agriculture	C	88	Bd	Bernard clay loam
Agriculture	C	88	Bc	Beaumont-Urban land complex
Agriculture	C	88	LcA	Lake Charles clay, 0 to 1 percent slopes
Agriculture	C	88	VaA	Vamont clay, 0 to 1 percent slopes
Agriculture	C	88	LcB	Lake Charles clay, 1 to 3 percent slopes
Agriculture	C	88	Ha	Harris clay
Agriculture	C	88	Mu	Midland-Urban land complex
Agriculture	C	88	Ba	Beaumont clay
Agriculture	C	88	Md	Midland silty clay loam
Agriculture	C	88	VaB	Vamont clay, 1 to 4 percent slopes
Agriculture	D	91	Be	Bernard-Edna complex
Agriculture	D	91	Bg	Bernard-Urban land complex
Agriculture	D	91	Ka	Kaman clay
Agriculture	D	91	Lu	Lake Charles-Urban land complex
Agriculture	D	91	Ur	Urban land
Agriculture	D	91	Vn	Vamont-Urban land complex
Agriculture	D	91	W	Waters
Agriculture	D	91	Is	Ijam soils
Bare or Transitional	A	74	Ge	Gessner loam
Bare or Transitional	A	74	Kn	Kenney loamy fine sand
Bare or Transitional	A	74	Kf	Katy fine sandy loam
Bare or Transitional	A	74	Gp	Gravel Pit
Bare or Transitional	A	74	Ar	Aris-Gessner complex
Bare or Transitional	A	74	Ad	Addicks loam
Bare or Transitional	A	74	HoA	Hockley fine sandy loam, 0 to 1 percent slopes
Bare or Transitional	A	74	Hf	Hatliff loam
Bare or Transitional	A	74	HoB	Hockley fine sandy loam, 1 to 4 percent slopes

Land Use	HSG	CN	MUSYM	NAME
Bare or Transitional	A	74	Gs	Gessner complex
Bare or Transitional	A	74	Ku	Kenney-Urban land complex
Bare or Transitional	A	74	Ed	Edna fine sandy loam
Bare or Transitional	A	74	Ce	Clodine-Urban land complex
Bare or Transitional	A	74	Cd	Clodine loam
Bare or Transitional	A	74	Bo	Boy loamy fine sand
Bare or Transitional	A	74	Bn	Bissonnet very fine sandy loam
Bare or Transitional	A	74	As	Aris-Urban land complex
Bare or Transitional	A	74	AtB	Atasco fine sandy loam, 1 to 4 percent slopes
Bare or Transitional	A	74	Gu	Gessner-Urban land complex
Bare or Transitional	A	74	On	Ozan-Urban land complex
Bare or Transitional	A	74	Am	Aldine very fine sandy loam
Bare or Transitional	A	74	Vs	Voss soils
Bare or Transitional	A	74	Ak	Addicks-Urban land complex
Bare or Transitional	A	74	Wo	Wockley fine sandy loam
Bare or Transitional	A	74	Wy	Wockley-Urban land complex
Bare or Transitional	A	74	Vo	Voss sand
Bare or Transitional	A	74	SeA	Segno fine sandy loam, 0 to 1 percent slopes
Bare or Transitional	A	74	An	Aldine-Urban land complex
Bare or Transitional	A	74	Oa	Ozan loam
Bare or Transitional	A	74	Na	Nahatche loam
Bare or Transitional	A	74	Bp	Borrow Pit
Bare or Transitional	A	74	Ap	Aris fine sandy loam
Bare or Transitional	A	74	SeB	Segno fine sandy loam, 1 to 3 percent slopes
Bare or Transitional	C	88	Bd	Bernard clay loam
Bare or Transitional	C	88	Bc	Beaumont-Urban land complex
Bare or Transitional	C	88	LcA	Lake Charles clay, 0 to 1 percent slopes
Bare or Transitional	C	88	VaA	Vamont clay, 0 to 1 percent slopes
Bare or Transitional	C	88	LcB	Lake Charles clay, 1 to 3 percent slopes
Bare or Transitional	C	88	Ha	Harris clay
Bare or Transitional	C	88	Mu	Midland-Urban land complex
Bare or Transitional	C	88	Ba	Beaumont clay
Bare or Transitional	C	88	Md	Midland silty clay loam
Bare or Transitional	C	88	VaB	Vamont clay, 1 to 4 percent slopes
Bare or Transitional	D	90	Be	Bernard-Edna complex
Bare or Transitional	D	90	Bg	Bernard-Urban land complex
Bare or Transitional	D	90	Ka	Kaman clay
Bare or Transitional	D	90	Lu	Lake Charles-Urban land complex
Bare or Transitional	D	90	Ur	Urban land
Bare or Transitional	D	90	Vn	Vamont-Urban land complex
Bare or Transitional	D	90	W	Waters
Bare or Transitional	D	90	Is	Ijam soils
Grassland	A	39	Ge	Gessner loam
Grassland	A	39	Kn	Kenney loamy fine sand
Grassland	A	39	Kf	Katy fine sandy loam
Grassland	A	39	Gp	Gravel Pit
Grassland	A	39	Ar	Aris-Gessner complex
Grassland	A	39	Ad	Addicks loam
Grassland	A	39	HoA	Hockley fine sandy loam, 0 to 1 percent slopes
Grassland	A	39	Hf	Hatliff loam
Grassland	A	39	HoB	Hockley fine sandy loam, 1 to 4 percent slopes
Grassland	A	39	Gs	Gessner complex
Grassland	A	39	Ku	Kenney-Urban land complex
Grassland	A	39	Ed	Edna fine sandy loam
Grassland	A	39	Ce	Clodine-Urban land complex
Grassland	A	39	Cd	Clodine loam
Grassland	A	39	Bo	Boy loamy fine sand
Grassland	A	39	Bn	Bissonnet very fine sandy loam
Grassland	A	39	As	Aris-Urban land complex
Grassland	A	39	AtB	Atasco fine sandy loam, 1 to 4 percent slopes
Grassland	A	39	Gu	Gessner-Urban land complex
Grassland	A	39	On	Ozan-Urban land complex
Grassland	A	39	Am	Aldine very fine sandy loam

Land Use	HSG	CN	MUSYM	NAME
Grassland	A	39	Vs	Voss soils
Grassland	A	39	Ak	Addicks-Urban land complex
Grassland	A	39	Wo	Wockley fine sandy loam
Grassland	A	39	Wy	Wockley-Urban land complex
Grassland	A	39	Vo	Voss sand
Grassland	A	39	SeA	Segno fine sandy loam, 0 to 1 percent slopes
Grassland	A	39	An	Aldine-Urban land complex
Grassland	A	39	Oa	Ozan loam
Grassland	A	39	Na	Nahatche loam
Grassland	A	39	Bp	Borrow Pit
Grassland	A	39	Ap	Aris fine sandy loam
Grassland	A	39	SeB	Segno fine sandy loam, 1 to 3 percent slopes
Grassland	C	74	Bd	Bernard clay loam
Grassland	C	74	Bc	Beaumont-Urban land complex
Grassland	C	74	LcA	Lake Charles clay, 0 to 1 percent slopes
Grassland	C	74	VaA	Vamont clay, 0 to 1 percent slopes
Grassland	C	74	LcB	Lake Charles clay, 1 to 3 percent slopes
Grassland	C	74	Ha	Harris clay
Grassland	C	74	Mu	Midland-Urban land complex
Grassland	C	74	Ba	Beaumont clay
Grassland	C	74	Md	Midland silty clay loam
Grassland	C	74	VaB	Vamont clay, 1 to 4 percent slopes
Grassland	D	80	Be	Bernard-Edna complex
Grassland	D	80	Bg	Bernard-Urban land complex
Grassland	D	80	Ka	Kaman clay
Grassland	D	80	Lu	Lake Charles-Urban land complex
Grassland	D	80	Ur	Urban land
Grassland	D	80	Vn	Vamont-Urban land complex
Grassland	D	80	W	Waters
Grassland	D	80	Is	Ijam soils
High Intensity Developed	A	89	Ge	Gessner loam
High Intensity Developed	A	89	Kn	Kenney loamy fine sand
High Intensity Developed	A	89	Kf	Katy fine sandy loam
High Intensity Developed	A	89	Gp	Gravel Pit
High Intensity Developed	A	89	Ar	Aris-Gessner complex
High Intensity Developed	A	89	Ad	Addicks loam
High Intensity Developed	A	89	HoA	Hockley fine sandy loam, 0 to 1 percent slopes
High Intensity Developed	A	89	Hf	Hatliff loam
High Intensity Developed	A	89	HoB	Hockley fine sandy loam, 1 to 4 percent slopes
High Intensity Developed	A	89	Gs	Gessner complex
High Intensity Developed	A	89	Ku	Kenney-Urban land complex
High Intensity Developed	A	89	Ed	Edna fine sandy loam
High Intensity Developed	A	89	Ce	Clodine-Urban land complex
High Intensity Developed	A	89	Cd	Clodine loam
High Intensity Developed	A	89	Bo	Boy loamy fine sand
High Intensity Developed	A	89	Bn	Bissonnet very fine sandy loam
High Intensity Developed	A	89	As	Aris-Urban land complex
High Intensity Developed	A	89	AtB	Atasco fine sandy loam, 1 to 4 percent slopes
High Intensity Developed	A	89	Gu	Gessner-Urban land complex
High Intensity Developed	A	89	On	Ozan-Urban land complex
High Intensity Developed	A	89	Am	Aldine very fine sandy loam
High Intensity Developed	A	89	Vs	Voss soils
High Intensity Developed	A	89	Ak	Addicks-Urban land complex
High Intensity Developed	A	89	Wo	Wockley fine sandy loam
High Intensity Developed	A	89	Wy	Wockley-Urban land complex
High Intensity Developed	A	89	Vo	Voss sand
High Intensity Developed	A	89	SeA	Segno fine sandy loam, 0 to 1 percent slopes
High Intensity Developed	A	89	An	Aldine-Urban land complex
High Intensity Developed	A	89	Oa	Ozan loam
High Intensity Developed	A	89	Na	Nahatche loam
High Intensity Developed	A	89	Bp	Borrow Pit
High Intensity Developed	A	89	Ap	Aris fine sandy loam
High Intensity Developed	A	89	SeB	Segno fine sandy loam, 1 to 3 percent slopes

Land Use	HSG	CN	MUSYM	NAME
High Intensity Developed	C	94	Bd	Bernard clay loam
High Intensity Developed	C	94	Bc	Beaumont-Urban land complex
High Intensity Developed	C	94	LcA	Lake Charles clay, 0 to 1 percent slopes
High Intensity Developed	C	94	VaA	Vamont clay, 0 to 1 percent slopes
High Intensity Developed	C	94	LcB	Lake Charles clay, 1 to 3 percent slopes
High Intensity Developed	C	94	Ha	Harris clay
High Intensity Developed	C	94	Mu	Midland-Urban land complex
High Intensity Developed	C	94	Ba	Beaumont clay
High Intensity Developed	C	94	Md	Midland silty clay loam
High Intensity Developed	C	94	VaB	Vamont clay, 1 to 4 percent slopes
High Intensity Developed	D	95	Be	Bernard-Edna complex
High Intensity Developed	D	95	Bg	Bernard-Urban land complex
High Intensity Developed	D	95	Ka	Kaman clay
High Intensity Developed	D	95	Lu	Lake Charles-Urban land complex
High Intensity Developed	D	95	Ur	Urban land
High Intensity Developed	D	95	Vn	Vamont-Urban land complex
High Intensity Developed	D	95	W	Waters
High Intensity Developed	D	95	Is	Ijam soils
Low Intensity Developed	A	77	Ge	Gessner loam
Low Intensity Developed	A	77	Kn	Kenney loamy fine sand
Low Intensity Developed	A	77	Kf	Katy fine sandy loam
Low Intensity Developed	A	77	Gp	Gravel Pit
Low Intensity Developed	A	77	Ar	Aris-Gessner complex
Low Intensity Developed	A	77	Ad	Addicks loam
Low Intensity Developed	A	77	HoA	Hockley fine sandy loam, 0 to 1 percent slopes
Low Intensity Developed	A	77	Hf	Hatliff loam
Low Intensity Developed	A	77	HoB	Hockley fine sandy loam, 1 to 4 percent slopes
Low Intensity Developed	A	77	Gs	Gessner complex
Low Intensity Developed	A	77	Ku	Kenney-Urban land complex
Low Intensity Developed	A	77	Ed	Edna fine sandy loam
Low Intensity Developed	A	77	Ce	Clodine-Urban land complex
Low Intensity Developed	A	77	Cd	Clodine loam
Low Intensity Developed	A	77	Bo	Boy loamy fine sand
Low Intensity Developed	A	77	Bn	Bissonnet very fine sandy loam
Low Intensity Developed	A	77	As	Aris-Urban land complex
Low Intensity Developed	A	77	AtB	Atasco fine sandy loam, 1 to 4 percent slopes
Low Intensity Developed	A	77	Gu	Gessner-Urban land complex
Low Intensity Developed	A	77	On	Ozan-Urban land complex
Low Intensity Developed	A	77	Am	Aldine very fine sandy loam
Low Intensity Developed	A	77	Vs	Voss soils
Low Intensity Developed	A	77	Ak	Addicks-Urban land complex
Low Intensity Developed	A	77	Wo	Wockley fine sandy loam
Low Intensity Developed	A	77	Wy	Wockley-Urban land complex
Low Intensity Developed	A	77	Vo	Voss sand
Low Intensity Developed	A	77	SeA	Segno fine sandy loam, 0 to 1 percent slopes
Low Intensity Developed	A	77	An	Aldine-Urban land complex
Low Intensity Developed	A	77	Oa	Ozan loam
Low Intensity Developed	A	77	Na	Nahatche loam
Low Intensity Developed	A	77	Bp	Borrow Pit
Low Intensity Developed	A	77	Ap	Aris fine sandy loam
Low Intensity Developed	A	77	SeB	Segno fine sandy loam, 1 to 3 percent slopes
Low Intensity Developed	C	90	Bd	Bernard clay loam
Low Intensity Developed	C	90	Bc	Beaumont-Urban land complex
Low Intensity Developed	C	90	LcA	Lake Charles clay, 0 to 1 percent slopes
Low Intensity Developed	C	90	VaA	Vamont clay, 0 to 1 percent slopes
Low Intensity Developed	C	90	LcB	Lake Charles clay, 1 to 3 percent slopes
Low Intensity Developed	C	90	Ha	Harris clay
Low Intensity Developed	C	90	Mu	Midland-Urban land complex
Low Intensity Developed	C	90	Ba	Beaumont clay
Low Intensity Developed	C	90	Md	Midland silty clay loam
Low Intensity Developed	C	90	VaB	Vamont clay, 1 to 4 percent slopes
Low Intensity Developed	D	92	Be	Bernard-Edna complex
Low Intensity Developed	D	92	Bg	Bernard-Urban land complex

Land Use	HSG	CN	MUSYM	NAME
Low Intensity Developed	D	92	Ka	Kaman clay
Low Intensity Developed	D	92	Lu	Lake Charles-Urban land complex
Low Intensity Developed	D	92	Ur	Urban land
Low Intensity Developed	D	92	Vn	Vamont-Urban land complex
Low Intensity Developed	D	92	W	Waters
Low Intensity Developed	D	92	Is	Ijam soils
No Data	A	50	Ge	Gessner loam
No Data	A	50	Kn	Kenney loamy fine sand
No Data	A	50	Kf	Katy fine sandy loam
No Data	A	50	Gp	Gravel Pit
No Data	A	50	Ar	Aris-Gessner complex
No Data	A	50	Ad	Addicks loam
No Data	A	50	HoA	Hockley fine sandy loam, 0 to 1 percent slopes
No Data	A	50	Hf	Hatliff loam
No Data	A	50	HoB	Hockley fine sandy loam, 1 to 4 percent slopes
No Data	A	50	Gs	Gessner complex
No Data	A	50	Ku	Kenney-Urban land complex
No Data	A	50	Ed	Edna fine sandy loam
No Data	A	50	Ce	Clodine-Urban land complex
No Data	A	50	Cd	Clodine loam
No Data	A	50	Bo	Boy loamy fine sand
No Data	A	50	Bn	Bissonnet very fine sandy loam
No Data	A	50	As	Aris-Urban land complex
No Data	A	50	AtB	Atasco fine sandy loam, 1 to 4 percent slopes
No Data	A	50	Gu	Gessner-Urban land complex
No Data	A	50	On	Ozan-Urban land complex
No Data	A	50	Am	Aldine very fine sandy loam
No Data	A	50	Vs	Voss soils
No Data	A	50	Ak	Addicks-Urban land complex
No Data	A	50	Wo	Wockley fine sandy loam
No Data	A	50	Wy	Wockley-Urban land complex
No Data	A	50	Vo	Voss sand
No Data	A	50	SeA	Segno fine sandy loam, 0 to 1 percent slopes
No Data	A	50	An	Aldine-Urban land complex
No Data	A	50	Oa	Ozan loam
No Data	A	50	Na	Nahatche loam
No Data	A	50	Bp	Borrow Pit
No Data	A	50	Ap	Aris fine sandy loam
No Data	A	50	SeB	Segno fine sandy loam, 1 to 3 percent slopes
No Data	C	50	Bd	Bernard clay loam
No Data	C	50	Bc	Beaumont-Urban land complex
No Data	C	50	LcA	Lake Charles clay, 0 to 1 percent slopes
No Data	C	50	VaA	Vamont clay, 0 to 1 percent slopes
No Data	C	50	LcB	Lake Charles clay, 1 to 3 percent slopes
No Data	C	50	Ha	Harris clay
No Data	C	50	Mu	Midland-Urban land complex
No Data	C	50	Ba	Beaumont clay
No Data	C	50	Md	Midland silty clay loam
No Data	C	50	VaB	Vamont clay, 1 to 4 percent slopes
No Data	D	50	Be	Bernard-Edna complex
No Data	D	50	Bg	Bernard-Urban land complex
No Data	D	50	Ka	Kaman clay
No Data	D	50	Lu	Lake Charles-Urban land complex
No Data	D	50	Ur	Urban land
No Data	D	50	Vn	Vamont-Urban land complex
No Data	D	50	W	Waters
No Data	D	50	Is	Ijam soils
Open Water	A	50	Ge	Gessner loam
Open Water	A	50	Kn	Kenney loamy fine sand
Open Water	A	50	Kf	Katy fine sandy loam
Open Water	A	50	Gp	Gravel Pit
Open Water	A	50	Ar	Aris-Gessner complex
Open Water	A	50	Ad	Addicks loam

Land Use	HSG	CN	MUSYM	NAME
Open Water	A	50	HoA	Hockley fine sandy loam, 0 to 1 percent slopes
Open Water	A	50	Hf	Hatliff loam
Open Water	A	50	HoB	Hockley fine sandy loam, 1 to 4 percent slopes
Open Water	A	50	Gs	Gessner complex
Open Water	A	50	Ku	Kenney-Urban land complex
Open Water	A	50	Ed	Edna fine sandy loam
Open Water	A	50	Ce	Clodine-Urban land complex
Open Water	A	50	Cd	Clodine loam
Open Water	A	50	Bo	Boy loamy fine sand
Open Water	A	50	Bn	Bissonnet very fine sandy loam
Open Water	A	50	As	Aris-Urban land complex
Open Water	A	50	AtB	Atasco fine sandy loam, 1 to 4 percent slopes
Open Water	A	50	Gu	Gessner-Urban land complex
Open Water	A	50	On	Ozan-Urban land complex
Open Water	A	50	Am	Aldine very fine sandy loam
Open Water	A	50	Vs	Voss soils
Open Water	A	50	Ak	Addicks-Urban land complex
Open Water	A	50	Wo	Wockley fine sandy loam
Open Water	A	50	Wy	Wockley-Urban land complex
Open Water	A	50	Vo	Voss sand
Open Water	A	50	SeA	Segno fine sandy loam, 0 to 1 percent slopes
Open Water	A	50	An	Aldine-Urban land complex
Open Water	A	50	Oa	Ozan loam
Open Water	A	50	Na	Nahatche loam
Open Water	A	50	Bp	Borrow Pit
Open Water	A	50	Ap	Aris fine sandy loam
Open Water	A	50	SeB	Segno fine sandy loam, 1 to 3 percent slopes
Open Water	C	50	Bd	Bernard clay loam
Open Water	C	50	Bc	Beaumont-Urban land complex
Open Water	C	50	LcA	Lake Charles clay, 0 to 1 percent slopes
Open Water	C	50	VaA	Vamont clay, 0 to 1 percent slopes
Open Water	C	50	LcB	Lake Charles clay, 1 to 3 percent slopes
Open Water	C	50	Ha	Harris clay
Open Water	C	50	Mu	Midland-Urban land complex
Open Water	C	50	Ba	Beaumont clay
Open Water	C	50	Md	Midland silty clay loam
Open Water	C	50	VaB	Vamont clay, 1 to 4 percent slopes
Open Water	D	50	Be	Bernard-Edna complex
Open Water	D	50	Bg	Bernard-Urban land complex
Open Water	D	50	Ka	Kaman clay
Open Water	D	50	Lu	Lake Charles-Urban land complex
Open Water	D	50	Ur	Urban land
Open Water	D	50	Vn	Vamont-Urban land complex
Open Water	D	50	W	Waters
Open Water	D	50	Is	Ijam soils
Wetland	A	40	Ge	Gessner loam
Wetland	A	40	Kn	Kenney loamy fine sand
Wetland	A	40	Kf	Katy fine sandy loam
Wetland	A	40	Gp	Gravel Pit
Wetland	A	40	Ar	Aris-Gessner complex
Wetland	A	40	Ad	Addicks loam
Wetland	A	40	HoA	Hockley fine sandy loam, 0 to 1 percent slopes
Wetland	A	40	Hf	Hatliff loam
Wetland	A	40	HoB	Hockley fine sandy loam, 1 to 4 percent slopes
Wetland	A	40	Gs	Gessner complex
Wetland	A	40	Ku	Kenney-Urban land complex
Wetland	A	40	Ed	Edna fine sandy loam
Wetland	A	40	Ce	Clodine-Urban land complex
Wetland	A	40	Cd	Clodine loam
Wetland	A	40	Bo	Boy loamy fine sand
Wetland	A	40	Bn	Bissonnet very fine sandy loam
Wetland	A	40	As	Aris-Urban land complex
Wetland	A	40	AtB	Atasco fine sandy loam, 1 to 4 percent slopes

Land Use	HSG	CN	MUSYM	NAME
Wetland	A	40	Gu	Gessner-Urban land complex
Wetland	A	40	On	Ozan-Urban land complex
Wetland	A	40	Am	Aldine very fine sandy loam
Wetland	A	40	Vs	Voss soils
Wetland	A	40	Ak	Addicks-Urban land complex
Wetland	A	40	Wo	Wockley fine sandy loam
Wetland	A	40	Wy	Wockley-Urban land complex
Wetland	A	40	Vo	Voss sand
Wetland	A	40	SeA	Segno fine sandy loam, 0 to 1 percent slopes
Wetland	A	40	An	Aldine-Urban land complex
Wetland	A	40	Oa	Ozan loam
Wetland	A	40	Na	Nahatche loam
Wetland	A	40	Bp	Borrow Pit
Wetland	A	40	Ap	Aris fine sandy loam
Wetland	A	40	SeB	Segno fine sandy loam, 1 to 3 percent slopes
Wetland	C	40	Bd	Bernard clay loam
Wetland	C	40	Bc	Beaumont-Urban land complex
Wetland	C	40	LcA	Lake Charles clay, 0 to 1 percent slopes
Wetland	C	40	VaA	Vamont clay, 0 to 1 percent slopes
Wetland	C	40	LcB	Lake Charles clay, 1 to 3 percent slopes
Wetland	C	40	Ha	Harris clay
Wetland	C	40	Mu	Midland-Urban land complex
Wetland	C	40	Ba	Beaumont clay
Wetland	C	40	Md	Midland silty clay loam
Wetland	C	40	VaB	Vamont clay, 1 to 4 percent slopes
Wetland	D	40	Be	Bernard-Edna complex
Wetland	D	40	Bg	Bernard-Urban land complex
Wetland	D	40	Ka	Kaman clay
Wetland	D	40	Lu	Lake Charles-Urban land complex
Wetland	D	40	Ur	Urban land
Wetland	D	40	Vn	Vamont-Urban land complex
Wetland	D	40	W	Waters
Wetland	D	40	Is	Ijam soils
Woody Land	A	25	Ge	Gessner loam
Woody Land	A	25	Kn	Kenney loamy fine sand
Woody Land	A	25	Kf	Katy fine sandy loam
Woody Land	A	25	Gp	Gravel Pit
Woody Land	A	25	Ar	Aris-Gessner complex
Woody Land	A	25	Ad	Addicks loam
Woody Land	A	25	HoA	Hockley fine sandy loam, 0 to 1 percent slopes
Woody Land	A	25	Hf	Hatliff loam
Woody Land	A	25	HoB	Hockley fine sandy loam, 1 to 4 percent slopes
Woody Land	A	25	Gs	Gessner complex
Woody Land	A	25	Ku	Kenney-Urban land complex
Woody Land	A	25	Ed	Edna fine sandy loam
Woody Land	A	25	Ce	Clodine-Urban land complex
Woody Land	A	25	Cd	Clodine loam
Woody Land	A	25	Bo	Boy loamy fine sand
Woody Land	A	25	Bn	Bissonnet very fine sandy loam
Woody Land	A	25	As	Aris-Urban land complex
Woody Land	A	25	AtB	Atasco fine sandy loam, 1 to 4 percent slopes
Woody Land	A	25	Gu	Gessner-Urban land complex
Woody Land	A	25	On	Ozan-Urban land complex
Woody Land	A	25	Am	Aldine very fine sandy loam
Woody Land	A	25	Vs	Voss soils
Woody Land	A	25	Ak	Addicks-Urban land complex
Woody Land	A	25	Wo	Wockley fine sandy loam
Woody Land	A	25	Wy	Wockley-Urban land complex
Woody Land	A	25	Vo	Voss sand
Woody Land	A	25	SeA	Segno fine sandy loam, 0 to 1 percent slopes
Woody Land	A	25	An	Aldine-Urban land complex
Woody Land	A	25	Oa	Ozan loam
Woody Land	A	25	Na	Nahatche loam

Land Use	HSG	CN	MUSYM	NAME
Woody Land	A	25	Bp	Borrow Pit
Woody Land	A	25	Ap	Aris fine sandy loam
Woody Land	A	25	SeB	Segno fine sandy loam, 1 to 3 percent slopes
Woody Land	C	70	Bd	Bernard clay loam
Woody Land	C	70	Bc	Beaumont-Urban land complex
Woody Land	C	70	LcA	Lake Charles clay, 0 to 1 percent slopes
Woody Land	C	70	VaA	Vamont clay, 0 to 1 percent slopes
Woody Land	C	70	LcB	Lake Charles clay, 1 to 3 percent slopes
Woody Land	C	70	Ha	Harris clay
Woody Land	C	70	Mu	Midland-Urban land complex
Woody Land	C	70	Ba	Beaumont clay
Woody Land	C	70	Md	Midland silty clay loam
Woody Land	C	70	VaB	Vamont clay, 1 to 4 percent slopes
Woody Land	D	77	Be	Bernard-Edna complex
Woody Land	D	77	Bg	Bernard-Urban land complex
Woody Land	D	77	Ka	Kaman clay
Woody Land	D	77	Lu	Lake Charles-Urban land complex
Woody Land	D	77	Ur	Urban land
Woody Land	D	77	Vn	Vamont-Urban land complex
Woody Land	D	77	W	Waters
Woody Land	D	77	Is	Ijam soils
Woody Wetland	A	30	Ge	Gessner loam
Woody Wetland	A	30	Kn	Kenney loamy fine sand
Woody Wetland	A	30	Kf	Katy fine sandy loam
Woody Wetland	A	30	Gp	Gravel Pit
Woody Wetland	A	30	Ar	Aris-Gessner complex
Woody Wetland	A	30	Ad	Addicks loam
Woody Wetland	A	30	HoA	Hockley fine sandy loam, 0 to 1 percent slopes
Woody Wetland	A	30	Hf	Hatliff loam
Woody Wetland	A	30	HoB	Hockley fine sandy loam, 1 to 4 percent slopes
Woody Wetland	A	30	Gs	Gessner complex
Woody Wetland	A	30	Ku	Kenney-Urban land complex
Woody Wetland	A	30	Ed	Edna fine sandy loam
Woody Wetland	A	30	Ce	Clodine-Urban land complex
Woody Wetland	A	30	Cd	Clodine loam
Woody Wetland	A	30	Bo	Boy loamy fine sand
Woody Wetland	A	30	Bn	Bissonnet very fine sandy loam
Woody Wetland	A	30	As	Aris-Urban land complex
Woody Wetland	A	30	AtB	Atasco fine sandy loam, 1 to 4 percent slopes
Woody Wetland	A	30	Gu	Gessner-Urban land complex
Woody Wetland	A	30	On	Ozan-Urban land complex
Woody Wetland	A	30	Am	Aldine very fine sandy loam
Woody Wetland	A	30	Vs	Voss soils
Woody Wetland	A	30	Ak	Addicks-Urban land complex
Woody Wetland	A	30	Wo	Wockley fine sandy loam
Woody Wetland	A	30	Wy	Wockley-Urban land complex
Woody Wetland	A	30	Vo	Voss sand
Woody Wetland	A	30	SeA	Segno fine sandy loam, 0 to 1 percent slopes
Woody Wetland	A	30	An	Aldine-Urban land complex
Woody Wetland	A	30	Oa	Ozan loam
Woody Wetland	A	30	Na	Nahatche loam
Woody Wetland	A	30	Bp	Borrow Pit
Woody Wetland	A	30	Ap	Aris fine sandy loam
Woody Wetland	A	30	SeB	Segno fine sandy loam, 1 to 3 percent slopes
Woody Wetland	C	30	Bd	Bernard clay loam
Woody Wetland	C	30	Bc	Beaumont-Urban land complex
Woody Wetland	C	30	LcA	Lake Charles clay, 0 to 1 percent slopes
Woody Wetland	C	30	VaA	Vamont clay, 0 to 1 percent slopes
Woody Wetland	C	30	LcB	Lake Charles clay, 1 to 3 percent slopes
Woody Wetland	C	30	Ha	Harris clay
Woody Wetland	C	30	Mu	Midland-Urban land complex
Woody Wetland	C	30	Ba	Beaumont clay
Woody Wetland	C	30	Md	Midland silty clay loam

Land Use	HSG	CN	MUSYM	NAME
Woody Wetland	C	30	VaB	Vamont clay, 1 to 4 percent slopes
Woody Wetland	D	30	Be	Bernard-Edna complex
Woody Wetland	D	30	Bg	Bernard-Urban land complex
Woody Wetland	D	30	Ka	Kaman clay
Woody Wetland	D	30	Lu	Lake Charles-Urban land complex
Woody Wetland	D	30	Ur	Urban land
Woody Wetland	D	30	Vn	Vamont-Urban land complex
Woody Wetland	D	30	W	Waters
Woody Wetland	D	30	Is	Ijam soils