



# Wastewater Treatment Plant Sampling Study

October 15-16, 2007

## Background Information

- Study conducted in response to the TMDL study of Buffalo Bayou and White Oak Bayou
- TCEQ draft allocations showed JTF storm water outfalls as the primary source of bacteria into these bayous
- JTF asked TCB to look at the model and its assumptions
- Initial assumption in the U of H model was no bacteria produced by wastewater treatment plants (WWTPs)
- Re-growth of bacteria assumed a minor contributor
- HC then asked TCB to conduct this study

## Objective of the Study

- Identify potential contributions of bacteria from two other sources:
  - WWTP effluent
  - Sludge deposits or sludge banks located in the stream (re-suspension into the water column)



## Study Design

- Selected plants that were at 50 percent of design capacity or greater
- Selected plants for ease of access and ability to sample at the end of the pipe (safely accessible)
- Identified 26 plants for the study that met above criteria
- Conducted initial reconnaissance to determine flow regimes at the plants, condition of the pipes and obtain measurements for flow calculations
- Determined that there were 14 plants with observable sludge plumes on the bottom of the receiving stream that could be sampled
- Determined times of peak dry weather flows

## Study Design (cont.)

- Sampled outfalls because they were accessible without notification to the plant operations personnel
- Sampled outfalls because the intent was to determine what was coming into the streams from the plants
- Samples in no way could be construed as regulatory samples since they were not collected at the effluent weir

First Round					Chlorine			Conventional					Bacteria (water)					Bacteria (sediment)				
Permit # (TCEQ)	Date Sampled	Time	#	Flow (cfs)	Free Chlorine	Total Chlorine	Combined Chlorine	NO <sub>2</sub> +NO <sub>3</sub>	OPO <sub>4</sub>	NH <sub>3</sub> -N	TPO <sub>4</sub>	TSS	E. Coli	Shigella	Fecal Coliform	Campy	Staph	E. Coli	Shigella	Fecal Coliform	Campy	Staph
1	5/11/2006	6:13	1	0.0477	0.47	n/a	n/a	9.8	1.8	0.2	2.58	16.0	70	<2	70	300	208	n/a	n/a	n/a	n/a	n/a
2	5/11/2006	6:51	2	1.8937	0.59	n/a	n/a	9.2	1.9	<0.1	2.66	<2.5	5,000	<2	5,200	1,000	230	22,000	<2	24,000	>20,000	18,800
3	5/11/2006	7:20	3	3.0250	0.19	n/a	n/a	11.1	1.8	0.1	2.37	3.7	6,300	<2	6,300	500	100	1,000	<2	1,300	1,100	2,500
4	5/11/2006	7:58	4	1.0238	0.35	n/a	n/a	16.5	4.0	<0.1	4.93	12.6	42	<2	42	300	46	60,000	<2	78,000	2,700	4,900
5	5/16/2006	6:10	5	0.9565	0.10	0.13	0.03	21.5	3.8	0.2	4.11	6.0	196	<2	198	<2	12	5,200	<2	5,200	<100	<100
6	5/25/2006	8:00	5	2.2381	0.09	0.15	0.06	15.9	3.4	0.1	3.19	9.5	260	<2	264	4,400	206	n/a	n/a	n/a	n/a	n/a
7	5/16/2006	6:45	6	0.3717	1.62	2.30	0.68	0.9	1.5	<0.1	1.64	3.6	<2	<2	<2	<2	<2	700	<2	1,000	<100	<100
8	5/16/2006	7:15	7	0.9396	0.10	0.26	0.16	13.9	3.1	0.1	3.66	4.0	56	<2	62	6	<2	n/a	n/a	n/a	n/a	n/a
9	5/18/2006	9:20	7	1.7533	0.10	0.26	0.16	18.6	3.3	<0.1	3.40	7.3	106	<2	106	272	2,800	n/a	n/a	n/a	n/a	n/a
10	5/16/2006	7:35	8	1.9881	0.02	0.03	0.01	14.8	2.5	<0.1	2.89	7.0	94	<2	94	2	2	n/a	n/a	n/a	n/a	n/a
11	5/16/2006	7:55	9	0.7009	3.99	>4.00	>0.01	25.3	2.9	<0.1	3.55	5.4	<2	<2	<2	<2	<2	1,600	<2	1,800	<100	<100
12	5/18/2006	7:10	10	0.1650	0.23	0.58	0.35	12.3	2.1	<0.1	2.27	6.2	2	<2	2	4	136	4,200	<2	4,600	2,200	9,300
13	5/18/2006	7:25	11	0.9811	0.75	1.36	0.61	16.1	3.3	<0.1	3.48	<2.5	2	<2	2	<2	4	400	<2	400	900	500
14	5/18/2006	7:45	12	3.0000	0.04	0.15	0.11	8.0	3.4	1.1	3.60	6.5	298	<2	306	<2	392	n/a	n/a	n/a	n/a	n/a
15 (duplicate)	5/18/2006	7:45	12	3.0000	n/a	n/a	n/a	8.1	3.5	1.1	4.21	4.4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16	5/18/2006	8:25	13	1.7700	0.86	1.21	0.35	35.9	4.0	0.1	4.53	5.4	700	<2	700	386	900	n/a	n/a	n/a	n/a	n/a
17	5/23/2006	7:26	14	0.2784	0.33	0.75	0.42	1.7	5.4	0.2	7.2	6.3	104	<2	104	44	90	n/a	n/a	n/a	n/a	n/a
18	5/23/2006	8:05	15	0.6583	1.63	2.20	0.57	5.0	0.3	0.2	0.54	10.9	108	<2	108	1,300	292	1,200	<2	1,200	2,500	600
19	5/23/2006	8:30	16	1.0248	2.26	2.66	0.40	3.7	1.7	<0.1	2.42	3.6	116	<2	126	4	326	<100	<2	<100	6,900	1,300
20	5/23/2006	9:10	17	3.6063	0.18	0.19	0.01	23.1	2.5	<0.1	3.16	6.2	52	<2	52	328	92	39,000	<2	39,000	13,200	5,200
21	5/23/2006	10:35	18	0.0382	0.94	1.33	0.39	39.5	4.1	<0.1	5.6	<2.5	<2	<2	<2	324	800	n/a	n/a	n/a	n/a	n/a
22	5/23/2006	11:55	19	19.2000	0.13	0.16	0.03	5.1	<0.1	<0.1	0.15	8.7	10	<2	10	96	48	100	<2	100	9,200	900
23	5/24/2006	7:20	20	0.6684	1.99	2.59	0.60	15.6	2.3	<0.1	2.85	6.0	4	<2	4	32	10	n/a	n/a	n/a	n/a	n/a
23B (blank)	5/24/2006	7:20	20	n/a	n/a	n/a	n/a	<0.1	<0.1	<0.1	<1	<2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24	5/24/2006	7:30	21	1.3509	3.01	3.67	0.66	4.1	1.3	<0.1	1.77	3.3	<2	<2	<2	12	56	400	<2	400	4,100	2,300
25	5/24/2006	8:00	22	5.1374	0.20	0.23	0.03	2.8	2.3	0.4	2.94	7.6	102	<2	104	7,200	364	10,400	<2	12,400	17,400	44,000
26	5/24/2006	9:30	23	1.2657	0.12	0.95	0.83	14.4	10.4	<0.1	13.2	31.9	32	<2	32	96	170	n/a	n/a	n/a	n/a	n/a
27	5/25/2006	6:55	24	0.3213	1.07	2.60	1.53	17.7	1.4	0.1	1.67	26.7	2	<2	2	22	2	n/a	n/a	n/a	n/a	n/a
27D (duplicate)	5/25/2006	6:55	24	0.3213	n/a	n/a	n/a	17.7	1.8	<0.1	1.78	27.3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27B (blank)	5/25/2006	6:55	24	n/a	n/a	n/a	n/a	<0.1	<0.1	<0.1	<0.05	<2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28	5/25/2006	7:35	25	0.0267	3.38	3.84	0.46	10.6	0.7	<0.1	1.26	2.8	<2	<2	<2	<2	2	n/a	n/a	n/a	n/a	n/a
29	5/25/2006	10:00	26	0.0535	3.42	3.85	0.43	0.4	<0.1	<0.1	0.20	5.1	<2	<2	<2	<2	<2	n/a	n/a	n/a	n/a	n/a

## First Round Results

- The suspended solids and nutrients values at the end of the pipe would indicate the plants are operating well
- Bacteria levels high in approximately 23% of effluent samples
- Bacteria levels high in 86% of the sediment samples)
- Highest bacteria concentrations - de-chlorinated effluents
- These values indicate a significant re-growth potential in de-chlorinated effluents

Second Round					Chlorine			Conventionals					Bacteria				
Permit # (TCEQ)	Date Sampled	Time	#	Flow (cfs)	Free Chlorine	Total Chlorine	Combined Chlorine	NO2+NO3	OPO4	NH3-N	TPO4	TSS	E. Coli	Shigella	Fecal Coliform	Campy	Staph
1	8/1/2006	6:18	1	0.1026	1.63	2.04	0.41	9.9	1.9	0.1	2.32	19.8	<2	<2	<2	48	11,500
2	8/1/2006	6:47	2	2.5865	0.00	0.09	0.09	16.5	2.8	0.1	1.59	9.2	2,600	<2	2,800	248	10,300
3	8/1/2006	7:18	3	2.7225	0.00	0.02	0.02	7.9	6.0	0.5	3.4	3.5	10,300	<2	10,800	1,700	900
4	8/1/2006	7:45	4	2.2419	0.00	0.02	0.02	16.4	2.7	0.2	1.44	3.3	1,100	<2	1,100	2,100	700
5	8/1/2006	8:00	5	0.7678	0.96	1.32	0.36	12.6	4.3	0.2	2.7	5.5	<2	<2	<2	76	234
6	8/1/2006	8:20	6	0.7669	3.84	>4.0	>0.16	28.0	3.1	0.1	1.58	16.9	<2	<2	<2	<2	800
7	8/1/2006	8:30	7	1.3598	0.13	0.26	0.13	25.6	3.1	<0.1	1.41	5.2	600	<2	600	10,800	298
8	8/2/2006	7:15	8	2.0279	0.00	0.07	0.07	18.3	7.2	0.3	2.36	4.1	1,800	<2	2,500	1,700	2,100
9	8/2/2006	7:28	9	0.3837	2.43	2.92	0.49	1.5	1.8	0.1	0.91	7.5	12	<2	12	14	400
10	8/2/2006	8:10	10	3.3000	0.10	0.10	0.00	6.8	2.9	1.0	2.06	4.0	1,200	<2	1,500	800	1,200
11	8/2/2006	8:40	11	2.1905	0.10	0.28	0.18	19.0	3.4	0.1	1.81	4.7	290	<2	336	256	1,300
12	8/3/2006	6:50	12	0.1217	0.03	0.09	0.06	<0.1	0.6	7.3	0.44	2.7	1,800	<2	2,200	2,200	800
13	8/3/2006	8:30	13	1.0560	1.85	2.43	0.58	17.8	3.0	0.3	1.82	8.4	<2	<2	<2	10	168
13D (duplicate)	8/3/2006	8:30	13	1.0560	n/a	n/a	n/a	17	2.7	<0.1	1.75	<2.5	n/a	n/a	n/a	n/a	n/a
13B (blank)	8/3/2006	8:30	13	n/a	n/a	n/a	n/a	<0.1	<0.1	<0.1	<0.05	<2.5	n/a	n/a	n/a	n/a	n/a
14	8/3/2006	9:00	14	6.6496	0.08	0.09	0.01	23.5	2.9	0.2	1.63	3.5	500	<2	500	900	1,400
15	8/3/2006	10:00	15	0.0267	3.66	4.00	0.34	0.7	0.4	0.1	0.13	<2.5	<2	<2	<2	4	18
16	8/9/2006	9:00	16	2.5673	3.05	3.75	0.70	5.5	0.9	0.2	0.59	<2.5	<2	<2	<2	2	42
16D (duplicate)	8/9/2006	9:00	16	2.5673	n/a	n/a	n/a	4.8	0.8	0.2	0.65	6.3	n/a	n/a	n/a	n/a	n/a
16B (blank)	8/9/2006	9:00	16	n/a	n/a	n/a	n/a	<0.1	<0.1	0.2	<0.05	<2.5	n/a	n/a	n/a	n/a	n/a
17	8/9/2006	10:00	17	0.3186	2.13	2.48	0.35	19.5	3.8	0.2	1.60	<2.5	<2	<2	<2	84	174
18	8/9/2006	10:45	18	14.33	0.07	0.10	0.03	5.2	0.2	0.2	0.17	3.1	84	<2	84	300	214
19	8/10/2006	7:15	19	1.4160	2.81	3.06	0.25	8.9	2.2	0.2	1.40	2.8	<2	<2	<2	96	2,500
20	8/10/2006	7:35	20	1.5930	2.98	3.61	0.63	15.4	2.1	0.2	0.68	5.1	<2	<2	<2	6,800	36
21	8/10/2006	8:15	21	0.0507	2.51	2.74	0.23	9.5	0.5	0.2	0.64	<2.5	<2	<2	<2	2	80
22	8/15/2006	7:35	22	5.7645	0.04	0.04	0.00	1.8	3.3	0.9	3.4	<2.5	16	TNTC	26	2,200	1,300
22D (duplicate)	8/15/2006	7:35	22	5.7645	n/a	n/a	n/a	1.7	3.4	0.9	3.8	<2.5	n/a	n/a	n/a	n/a	n/a
22B (blank)	8/15/2006	7:35	22	n/a	n/a	n/a	n/a	<0.1	<0.1	0.2	<0.05	<2.5	n/a	n/a	n/a	n/a	n/a
23	8/15/2006	8:15	23	1.8581	>4.0	>4.0	over range	10.4	2.6	<0.1	3.1	<2.5	<2	<2	<2	28	18
24	8/15/2006	10:15	24	0.0446	2.88	3.60	0.72	40.0	4.6	0.1	6.8	17.3	<2	<2	2	4	800
25	8/16/2006	6:45	25	0.4605	3.51	3.79	0.28	18.7	1.5	0.2	1.8	<2.5	<2	<2	<2	<2	26
26	8/16/2006	7:15	26	0.2390	1.38	1.92	0.54	23.2	4.0	0.3	1.3	7.9	2	<2	2	64	10

## Second Round Results

- No sediment samples collected in Round 2
- The suspended solids and nutrients values at the end of the pipe would indicate the plants are operating well
- 35% effluent samples exceeded the e. coli geometric mean standard
- Observed increased chlorine residuals at smaller plants resulting in less bacteria
- Observed decreased chlorine residuals at the larger plants resulting in greater bacteria, possibly as a result of knowledge of scrutiny

## Discussion of Overall Results

- More chlorine means less bacteria potentially
- There was no correlation observed between the indicator organisms and the pathogens monitored
- There appear to be significant reservoirs of bacteria that can be re-suspended in the streams during storm events
- If flows and bacteria content were constant for one hour, the loading from the 26 plants sampled would be equal to approximately 52 billion E.Coli.
- TCEQ estimate of loading is 1 million organisms per day for all 56 plants discharging to White Oak Bayou

## Conclusions

- WWTP bacteria contributions may be a much larger input to White Oak Bayou than currently assumed by TCEQ
- Re-growth appears to be a significant issue
- Re-suspension of bacteria in the water column may be a significant contributor of bacteria in our bayous
- Further study is needed in cooperation with TCEQ to provide better definition
- No correlation was determined to exist between E.Coli or Fecal Coliform and the pathogens tested