Report

Infiltration Loading Tests

Town of Chatham, MA

July 2006

INFILTRATION LOADING TESTS

TOWN OF CHATHAM, MASSACHUSETTS

Prepared for

TOWN OF CHATHAM, MASSACHUSETTS

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July 2006

Project No. 70098

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INFILTRATION LOADING TESTS

TOWN OF CHATHAM, MASSACHUSETTS

SECTION 1 – INTRODUCTION

1.1 PURPOSE OF REPORT

The Town of Chatham (Town) is undertaking Comprehensive Wastewater Management Planning to develop strategies for collecting, treating, and recharging treated wastewater. A key element of that planning process is identifying a site in the Town where treated wastewater can be recharged to the groundwater. This report describes the testing that was completed to determine the site's suitability for receiving and infiltrating treated wastewater.

1.2 BACKGROUND

In the course of completing Comprehensive Wastewater Management Planning, the Town determined that additional wastewater collection and treatment at the existing wastewater treatment facility (WWTF) was an appropriate remedy to water quality concerns in the Town.

To accommodate an increase in treated effluent from the treatment facility, the Town has been evaluating alternative locations for the recharge of highly treated effluent. The Town undertook an extensive screening process to identify areas of Town that would be most suitable for wastewater recharge. They then identified six specific sites that were considered favorable for recharge. Preliminary investigations, including completion of soils borings, observation wells, test pits, and percolation tests, were completed at each of the sites. At the culmination of that testing, the Town determined that the area between the existing WWTF infiltration beds and Middle Road (see Figure 1, Potential Effluent Recharge Sites and Site Location Map) would be the priority candidate site. This decision was based on a number of factors, including location, distance to the WWTF, surrounding land use, proximity of sensitive receptors, size, and hydrogeologic properties.

1.3 PRELIMINARY SITE CHARACTERIZATION

The site occupies approximately 80 acres. The eastern portion of the site contains the capped municipal landfill and transfer station. The western portion is the site of the municipal wastewater treatment plant along with several acres of wooded terrain. The preliminary investigation completed in the spring of 2004 indicated generally favorable conditions for treated wastewater recharge. Test pits revealed the surficial material was comprised of medium to coarse sand. Percolation test rates were all less than 2 minutes per inch. The soil boring at the Middle Road site indicated medium to coarse sands to a depth of 25 feet and fine to medium sands to a depth of 60 feet.

1.4 RECOMMENDATIONS BASED ON PRELIMINARY SITE CHARACTERIZATION

After the initial screening process and the preliminary site evaluations, the Town selected the WWTF site as the priority candidate site. Existing sand beds have functioned well, indicating that the site would be favorable for expansion of the sand beds. However, larger-scale loading tests were proposed to further evaluate the infiltration capacity of the site soils. The proposed loading tests would evaluate the site's infiltration capacity using thousands of gallons of water rather than a few gallons of water, as are used for percolation tests.

The Massachusetts Department of Environmental Protection (MADEP) accepted standard application rate is 5 gallons per day per square foot (gpd/sf). The existing effluent sand beds have been in use for more than 30 years. Discussions with Town personnel indicated that the WWTF site appears to have a significantly larger infiltration capacity than 5 gpd/sf. The loading tests were set up to determine whether this loading rate can be increased at the existing sand beds and any future sand beds.

SECTION 2 - FIELD INVESTIGATION

2.1 LOADING TESTS

Loading tests are essentially large-scale percolation tests. They are accomplished by applying large quantities of water to basins with a specific surface area to allow the calculation of an infiltration rate in minutes per inch and in gallons per day per square foot. The general protocol

for completing loading tests is described in the USEPA *Process Design Manual–Land Treatment of Municipal Wastewater (1981)*. A work plan (Appendix C) was developed describing the proposed loading test and was submitted to MADEP for review and approval.

2.2 TEST PREPARATION

Two locations were selected as test sites – one adjacent to Middle Road and one in the existing WWTF sand beds. One 10-foot diameter basin was installed at each test site. Both of the test sites were located in close proximity to existing monitoring wells. Figure 2 is a site map showing the approximate locations of the test basins and monitoring wells. The basins served as the infiltration sites for the loading tests and the observation wells were used for monitoring the water table response to the infiltration tests. The basins were provided by an outside contractor and consisted of prefabricated 10-foot diameter, 30-inch tall, 3/16-inch thick, aluminum "rings" which served as the walls of the basin. A schematic of a completed test basin is shown in Figure 3.

Both basins were provided with water by means of fire hydrants on the WWTF property. A 2.5-inch fire hose was laid from the hydrants to the basins. The WWTF basin was nearly 500 feet from the hydrant, whereas the Middle Road basin was closer to 1,500 feet from the hydrant. The Chatham Water Department provided a meter and a backflow preventer. A valve for controlling flow was located at each test basin.

WWTF Test Basin. This test basin was installed in one of the existing effluent sand beds. For this reason, no site preparation was needed. The aluminum ring was installed in the corner of the sand bed closest to the monitoring wells (MW 23-D and MW 23-S). The ring was placed on the sand and pushed down approximately 6 inches until it was securely positioned in the sand so as to promote vertical flow from the basin rather than lateral flow.

A subsurface clay layer exists in the vicinity of the WWTF, dividing the groundwater into upper and lower aquifers. The MW 23 wells were installed at different elevations, one in the upper aquifer and one in the lower aquifer. The 2-inch wells were installed in 1993 and included 10 feet of screen at the bottom of the well. The wells were finished with cast iron protective casings and locking caps. Boring logs are provided in Appendix A.

Middle Road Test Basin. Test site preparation for this basin included sufficient clearing and grading at the Middle Road site to allow installation of the test basin. The soil was cleared to a depth sufficient to remove top soil and roots and to get beyond the organic layer of soil. The test ring was then placed on the soil and pushed down until it was securely situated in the soil. The contractor then backfilled behind the walls of the test ring to a depth of about 4-5 inches.

The monitoring well that was used as part of this hydraulic loading tests was MW 1-1 that was installed in 2004 and was constructed with 10' of screened pipe at the bottom of the well. Boring logs are provided in Appendix A.

2.3 CONSTANT HEAD AND FALLING HEAD TESTS

A series of tests were conducted at the basins over a two-week period. Appendix B includes selected photographs taken during the testing. The Water Department was only able to provide one water meter, so only one basin test was conducted at a time. Each round of tests took three days. The testing was completed on the schedule as illustrated in Table 1.

The basin testing included three phases, as indicated on the schedule: saturation, constant head testing, and falling head testing. Each phase is described below.

A. **Saturation.** The soils at each basin were saturated before testing began. This was done by supplying water to the basin for a 24-hour period. Flow into each basin was sustained at a rate that would keep a generally constant level of water in the test basin, although the exact level was not a factor. As saturation progressed, the infiltration rate of the underlying soils declined. By the end of the day, it was possible to adjust the flow into the basins to a rate that kept water in the basins overnight at a relatively constant head.

B. **Constant Head Test.** The constant head tests were started after the basins had been saturated for 24 hours. The constant head test was performed by noting the water level in the basin and supplying enough flow to maintain this level over the course of an eight hour test period. In the early stages of the test, the flow rate had to be adjusted periodically to keep the water level in the basin constant. The water level was noted, the flow rate was measured, and the observation well water levels were measured throughout the testing. In the constant head tests, the infiltration capacity is measured in gallons per minute (gpm) as water is added to the 10-foot infiltration basin at the same rate that the water infiltrates out of the basin. Flow rate was

measured at the spigots using containers of known volume and a stop watch. By dividing the rate of flow by the square foot area of the basin, an infiltration capacity in gallons per day per square foot is calculated.

At the end of the day of constant head testing, the basins were again supplied with a constant flow overnight to maintain saturated conditions.

C. **Falling Head Test.** The falling head tests were started the day after the constant head tests. These tests were performed by filling the basin to a specific level and then cutting off the water supply and observing the rate at which the water level in the basin dropped. The falling head tests were repeated six times by refilling the basin after the water level had dropped a minimum of 6 inches for each test. In the falling head tests, infiltration is measured in inches per hour. This result is converted to cubic feet per hour and subsequently to gallons per day per square foot. Water levels in the monitoring wells were observed at the beginning and the end of the falling head tests.

SECTION 3 - FINDINGS AND CONCLUSIONS

3.1 SUBSURFACE CONDITIONS

The surface elevation at the two test sites is 70 feet, plus or minus a few inches. Depth to groundwater at the sites ranges from 51 to 57 feet, depending on the surface elevation and whether or not the well is in the upper or lower aquifer; and groundwater at the site is found in the elevation interval between 13 and 18 feet. Based on data obtained from the ongoing groundwater monitoring program, groundwater flows south toward Cockle Cove Creek.

Overall, the subsurface conditions are generally homogeneous, comprised of sand and gravel with lenses of finer grained materials. The predominance of the sand suggests suitable conditions for infiltration of treated wastewater.

3.2 CONSTANT HEAD TEST RESULTS

The first set of testing at each basin was constant head testing. As described above, the constant head testing entailed adding water to the basins at the same rate that water drained out of the basin. As expected, from the time saturation was initiated to the time the constant head tests were initiated, the infiltration rate decreased considerably as the soils became more saturated.

During the testing period, flow was measured with a 5-gallon bucket and a stopwatch. The valve used for flow control consisted of six spigots. The spigots were adjusted as necessary to increase or decrease the flow. As a result, conversion from gallons per minute (based on 5 gallons of water) to gpd/sf showed some variation as a result of minor adjustments of the spigots. This being considered, the infiltration rates from constant head tests remained generally constant. Apparently large differences in infiltration rates may be accounted for by considering the minor adjustments that were made to achieve a flow rate equivalent to the infiltration rate. For example, at the beginning of the day of constant head testing, the water level was brought to the desired water level (between 2 and 4 inches). This may have required increasing the flow temporarily, then decreasing the flow to achieve a balance. As the fine tuning of the flow was done, differences in flow rate resulted. The infiltration rates for the two constant head infiltration tests are illustrated on Figure 4.

The raw data from the constant head tests is presented on Table 2 and summarized on Table 3. The basins generally accepted a flow of 26 to 29 gpm. For general discussion, a rate of 25 gpm will be used as a conservative generalization. Twenty-five gpm equates to 36,000 gallons per day (gpd). The discharge of 36,000 gpd in a 10-foot diameter basin (surface area 78 sq. ft.) equates to 460 gpd/sf.

USEPA protocols for conducting loading tests suggest that, although loading tests are probably the most accurate means of estimating loading rate, loading tests have a greater horizontal flow component than full-scale installations; therefore, loading tests overestimate full-scale capacity. Therefore, USEPA recommends design rates that are only 10 to 15 percent of observed rates in loading tests. The loading tests suggest an infiltration rate of approximately 460 gpd/sf, hence a design loading rate of up to 46 gpd/sf can be considered reasonable. MADEP suggests a maximum design loading rate of 5 gpd/sf, but allows proponents to make a demonstration for a greater loading rate through hydraulic loading tests and through longer-term operations.

Based on the results of the constant head testing, which indicated an infiltration rate of at least 460 gpd/sf, a design loading rate of up to 46 gpd/sf is reasonable. Hence, the MADEP-recommended rate of 5 gpd/sf for rapid infiltration beds is conservative for this site.

3.3 FALLING HEAD TEST RESULTS

To supplement the constant head test results, falling head tests were performed in each of the basins after the constant head tests were completed. Between the tests, water was continuously added to the basins to retain the saturated soil conditions.

To complete the falling head tests, basins were filled to a specific measured mark. The water supply was then turned off and the rate at which the water level in the basin dropped was recorded. The falling head tests were repeated six times in each basin, with the basin being refilled at the beginning of each test run. The results of the falling head tests are presented on Tables 4 and 5. Infiltration rate is presented in three different units on the tables: minutes per inch, inches per hour, and gallons per day per square foot (gpd/sf). Infiltration rates in minutes per inch (the units used in MADEP guidance) are illustrated on Figures 5 and 6. Infiltration rates in gpd/sf for all of the tests are summarized on Figure 7. The average infiltration rates in gpd/sf for the two basins were 270 gpd/sf (WWTF) and 324 gpd/sf (Middle Road). The average result was 297 gpd/sf. Using the EPA criteria of 10 percent of the average infiltration test rate, a design loading rate of 30 gpd/sf is appropriate

3.4 MOUNDING IMPACTS

Two observation wells were located in close proximity to the test basins. The water levels in these wells were noted throughout the three days of testing at each location. Water level data is depicted graphically on Figures 8 and 9.

There was minimal precipitation during the testing, which was initiated on June 26. Table 1 includes precipitation data for the testing period. However, the month of June saw much higher than average rainfalls. Rainfall from June 1 through June 24, 2006 totaled 9.13 inches, whereas the average rainfall for June is 3.44 inches (www.weather.com). Due to the excessive rain, the water tables were higher than normal.

A slight rise in the water table elevation can be seen over the course of the three days of testing, though not in the deeper of the MW-23 wells. It should be noted that a silt/clay layer exists throughout a large portion of the site, according to groundwater monitoring reports by Metcalf & Eddy, Inc. The silt/clay layer divides the water table into an upper and a lower aquifer. Both MW 1-1 and MW 23-S were installed within this upper aquifer. This is likely the reason why no response was seen in MW 23-D.

SECTION 4 - CONCLUSIONS

4.1 Test Summary and Conclusions

Hydraulic loading tests were completed between June 26 and July 7, 2006. Testing was performed at two 10-foot basins. Testing was comprised of:

1. One day of saturating the soils beneath the basins for a 24-hour period by sustaining a water level in the basins equivalent to what was infiltrating out of them.

2. One day of constant head testing, during which water was fed to the basin at the same rate that water drained from the basin, as indicated by a constant water level in the basin.

3. One day of falling head testing, recording the rate at which the water level in the basins dropped. This was repeated six times.

For the constant head testing, an average infiltration rate of 460 gpd/sf for the two basins was calculated. Applying the USEPA design factor of 10 percent to that result, an appropriate design loading rate is 46 gpd/sf.

In the falling head testing, an average infiltration rate of 297 gpd/sf for the two basins was calculated. If this rate is used and the USEPA design factor of 10 percent is applied to that result, an appropriate design loading rate is 30 gpd/sf.

The Town is in the process of completing their CWMP and needs to present the size of the future effluent recharge facilities for the proposed future flows at the treatment plant site. The Town

will be able to save significant amounts of money if it can avoid having to build redundant infiltration beds that would be based on an overly conservative design rate of 5 gpd/sf.

Stearns & Wheler believes that the observed rate of 300 to 460 gpd/sf is not appropriate for sizing future facilities. As a result we have followed USEP guidance and have used 10% of the observed rate for the recommended design rate of 30 gpd/sf. We recommend this rate be used to plan for future infiltration facilities. We believe that the Town will have several years of operational time to check the performance of this rate with the first beds to be used as the flows at the plant increase. The Town should reserve additional space nearby in case the sand beds do not perform as expected with this rate.

TABLES

TABLE 1
TOWN OF CHATHAM
HYDRAULIC LOADING TESTS
TESTING SCHEDULE

	Monday	Tuesday	Wednesday	Wednesday	Thursday	Friday
	6/26/2006	6/27/2006	6/28/2006	7/5/2006	7/6/2006	7/7/2006
WWTF Test Basin	Saturation	Constant Head Test	Falling Head Test			
Middle Road Test Basin				Saturation	Constant Head Test	Falling Head Test
Precipitation				0.37"	0.97"	

TABLE 2
TOWN OF CHATHAM
HYDRAULIC LOADING TESTS
CONSTANT HEAD TESTING DATA

WPCF Site

Tues 6/27/06

Time	Flow (gpm)	Water Level (inches)*	Average Infiltration Rate (gpd/sq ft)
8:10	-	2.0	-
8:40	33.3	2.5	611
9:30	27.3	3.0	500
10:30	27.3	3.0	500
11:30	30.0	3.5	550
12:30	23.1	3.3	423
1:30	23.1	2.8	423
2:30	21.4	2.8	393
3:30	23.1	3.0	423
Average	26.1		459

* - Refers to water level in the test basin. 0 inches of water level was set at a point above the highest point of the test basin floor.

Middle Road Site

Thur 7/6/06

Time	Flow (gpm)	Water Level (inches)*	Average Infiltration Rate (gpd/sq ft)
8:23	-	-	-
9:30	33.3	1	611
10:30	33.3	1	611
11:30	33.3	3	611
12:30	27.3	3	500
1:30	27.3	3	500
2:30	27.3	3	500
5:30	27.3	3	500
4:30	25.0	3.5	459
Average	29.3		537

TABLE 3
TOWN OF CHATHAM
HYDRAULIC LOADING TESTS
CONSTANT HEAD TESTING RESULTS

Basin	Final Stabilized Flow Rate in gpm (1)	Final Stabilized Flow Rate in gpd	Basin Area Square Feet (2)	Infiltration Capacity gpd/sq. ft	Allowable Loading Rate gpd/sq. ft (3)
WWTF	21	30857	78	396	40
Middle Road	25	36000	78	462	46
				429	43

(1) To be conservative, based on lowest flow rate recorded

(2) $A = 3.14 \times (5\ ft)^2$

(3) Based on EPA guidance indicating loading rates should be based on 10-15% of measured basin infiltration rates

TABLE 4
TOWN OF CHATHAM
HYDRAULIC LOADING TESTS
FALLING HEAD TEST RESULTS - WWTF SITE

Run #1

Inches	Time (minutes, cumulative)	Minutes/Inch	Inches/Hour	Average Infiltration Rate (gpd/sf)
11	0.0			
10	2.8	2.8	21.6	322
9	5.1	2.3	25.7	385
8	8.4	3.3	18.2	272
7	11.2	2.8	21.4	321
6	14.1	2.9	20.8	311
5	17.6	3.5	17.0	254
4	20.6	2.9	20.5	306
3	24.1	3.5	17.1	255
2	27.5	3.4	17.6	264
1	31.6	4.2	14.5	216
0	36.0	4.3	13.8	207
	Average	3	19	283

Run #2

Inches	Time (minutes, cumulative)	Minutes/Inch	Inches/Hour	Average Infiltration Rate (gpd/sf)
11	0.0	0		
10	3.2	3.2	18.9	283
9	5.9	2.7	22.2	332
8	9.0	3.1	19.1	286
7	12.1	3.1	19.7	294
6	14.9	2.9	20.9	313
5	18.3	3.4	17.6	263
4	21.8	3.4	17.6	263
3	25.3	3.5	17.1	256
2	28.8	3.5	17.1	255
1	32.9	4.1	14.7	220
0	37.2	4.4	13.7	205
	Average	3	18	270

Run #3

Inches	Time (minutes, cumulative)	Minutes/Inch	Inches/Hour	Average Infiltration Rate (gpd/sf)
11	0.0	0		
10	3.0	3.0	19.8	296
9	5.8	2.7	22.0	328
8	8.7	2.9	20.5	306
7	12.2	3.5	17.1	256
6	15.2	3.0	19.8	296
5	18.5	3.2	18.6	278
4	21.8	3.3	18.0	269
3	25.3	3.5	17.0	254
2	28.9	3.6	16.7	250
1	33.1	4.2	14.4	215
0	37.6	4.6	13.2	197
	Average	3	18	268

TABLE 4
TOWN OF CHATHAM
HYDRAULIC LOADING TESTS
FALLING HEAD TEST RESULTS - WWTF SITE

Run #4

Inches	Time (minutes, cumulative)	Minutes/Inch	Inches/Hour	Average Infiltration Rate (gpd/sf)
11	0.0	0		
10	2.9	2.9	20.8	311
9	5.5	2.7	22.6	339
8	8.8	3.2	18.7	279
7	11.8	3.0	19.9	298
6	15.0	3.2	18.8	281
5	18.4	3.4	17.7	265
4	21.7	3.4	17.8	267
3	25.6	3.9	15.4	230
2	29.1	3.5	17.3	259
1	33.5	4.4	13.6	204
0	37.5	4.0	15.1	226
	Average	3	18	269

Run #5

Inches	Time (minutes, cumulative)	Minutes/Inch	Inches/Hour	Average Infiltration Rate (gpd/sf)
11	0.0	0		
10	2.8	2.8	21.3	319
9	5.6	2.8	21.6	322
8	8.7	3.1	19.7	294
7	11.9	3.2	18.7	279
6	14.9	3.0	19.8	296
5	18.1	3.2	18.8	281
4	21.7	3.6	16.6	248
3	25.1	3.4	17.7	265
2	29.1	4.0	14.9	223
1	33.3	4.1	14.5	217
0	37.6	4.3	14.0	210
	Average	3	18	269

Run #6

Inches	Time (minutes, cumulative)	Minutes/Inch	Inches/Hour	Average Infiltration Rate (gpd/sf)
11	0.0	0		
10	3.2	3.2	19.0	285
9	5.8	2.7	22.4	335
8	9.0	3.1	19.1	286
7	12.2	3.2	18.8	281
6	15.5	3.3	18.1	271
5	18.6	3.1	19.1	286
4	22.2	3.6	16.6	248
3	25.7	3.5	17.2	258
2	29.5	3.8	15.9	238
1	33.9	4.4	13.7	205
0	38.2	4.3	14.0	210
	Average	3	18	264

TABLE 5
TOWN OF CHATHAM
HYDRAULIC LOADING TESTS
FALLING HEAD TEST RESULTS - MIDDLE ROAD SITE

Run #1

Inches		Time (minutes, cumulative)	Minutes/Inch	Inches/Hour	Average Infiltration Rate (gpd/sf)
11		-			
10	1	1.9	1.9	31.9	477
9	2	4.3	2.4	25.2	377
8	3	6.5	2.3	26.5	396
7	4	9.1	2.6	23.5	352
6	5	11.5	2.4	24.7	369
5	6	14.1	2.6	22.9	343
4	7	16.9	2.7	22.1	330
3	8	19.9	3.1	19.7	294
2	9	22.8	2.9	21.1	315
1	10	26.1	3.4	17.9	268
0	11	29.9	3.8	15.8	236
		Average	3	23	342

Run #2

Inches		Time (minutes, cumulative)	Minutes/Inch	Inches/Hour	Average Infiltration Rate (gpd/sf)
11		-			
10	1	2.1	2.1	28.8	431
9	2	4.6	2.5	24.2	361
8	3	7.0	2.4	24.7	369
7	4	9.6	2.6	23.5	352
6	5	12.2	2.6	22.9	343
5	6	14.8	2.7	22.6	339
4	7	17.8	3.0	19.9	298
3	8	20.8	3.0	20.3	304
2	9	23.6	2.8	21.4	321
1	10	27.0	3.4	17.6	264
0	11	30.8	3.8	15.9	238
		Average	3	22	329

Run #3

Inches		Time (minutes, cumulative)	Minutes/Inch	Inches/Hour	Average Infiltration Rate (gpd/sf)
11		-			
10	1	2.1	2.1	28.6	427
9	2	4.7	2.6	22.8	341
8	3	7.0	2.3	26.7	399
7	4	10.0	3.0	19.8	296
6	5	12.5	2.5	24.5	366
5	6	15.1	2.6	23.2	347
4	7	18.1	3.0	20.0	299
3	8	21.0	3.0	20.2	303
2	9	24.0	3.0	20.2	303
1	10	27.2	3.2	18.8	281
0	11	30.8	3.6	16.7	249
		Average	3	22	328

TABLE 5
TOWN OF CHATHAM
HYDRAULIC LOADING TESTS
FALLING HEAD TEST RESULTS - MIDDLE ROAD SITE

Run #4

Inches		Time (minutes, cumulative)	Minutes/Inch	Inches/Hour	Average Infiltration Rate (gpd/sf)
11		-			
10	1	2.3	2.3	26.5	396
9	2	4.7	2.5	24.5	366
8	3	7.2	2.5	24.0	359
7	4	10.2	3.0	20.1	301
6	5	12.6	2.4	25.2	377
5	6	15.5	3.0	20.3	304
4	7	18.1	2.6	23.4	350
3	8	21.1	3.0	19.9	298
2	9	24.3	3.2	18.8	282
1	10	28.1	3.8	15.9	238
0	11	31.9	3.8	15.7	235
		Average	3	21	319

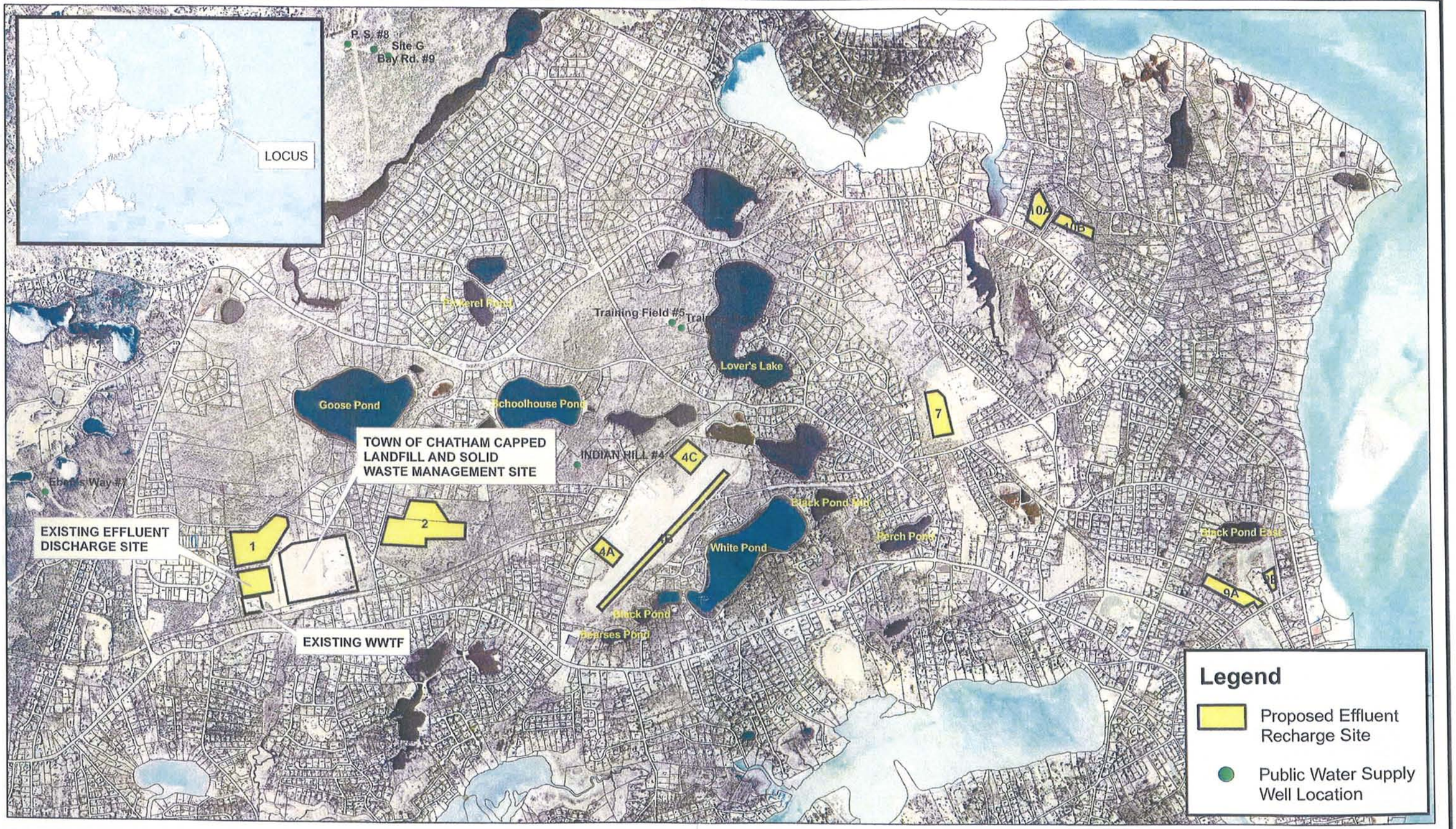
Run #5

Inches		Time (minutes, cumulative)	Minutes/Inch	Inches/Hour	Average Infiltration Rate (gpd/sf)
11		-			
10	1	2.4	2.4	25.0	374
9	2	4.7	2.3	25.7	385
8	3	7.4	2.6	22.9	343
7	4	10.0	2.6	23.1	345
6	5	12.9	2.9	20.6	308
5	6	15.5	2.6	22.8	341
4	7	18.5	3.0	19.8	296
3	8	21.6	3.1	19.7	294
2	9	24.9	3.3	18.3	273
1	10	28.7	3.8	15.7	235
0	11	32.5	3.8	15.9	237
		Average	3	21	312

Run #6

Inches		Time (minutes, cumulative)	Minutes/Inch	Inches/Hour	Average Infiltration Rate (gpd/sf)
11		-			
10	1	2.3	2.3	26.1	390
9	2	4.8	2.5	23.8	357
8	3	7.5	2.7	22.4	335
7	4	10.3	2.8	21.7	324
6	5	12.4	2.1	28.8	431
5	6	15.8	3.5	17.4	260
4	7	18.8	3.0	20.1	301
3	8	21.9	3.1	19.1	286
2	9	25.3	3.4	17.9	268
1	10	28.7	3.4	17.6	264
0	11	32.4	3.8	15.9	238
		Average	3	21	314

FIGURES



Data Source: Mass GIS .5 meter Orthophoto (2001)

File Location: D:\GIS Project Folder\Job#\70098 Chatham\USGS Shapefiles\USGS Files 5_05_05\usgs\Final Figures\70098F01.mxd

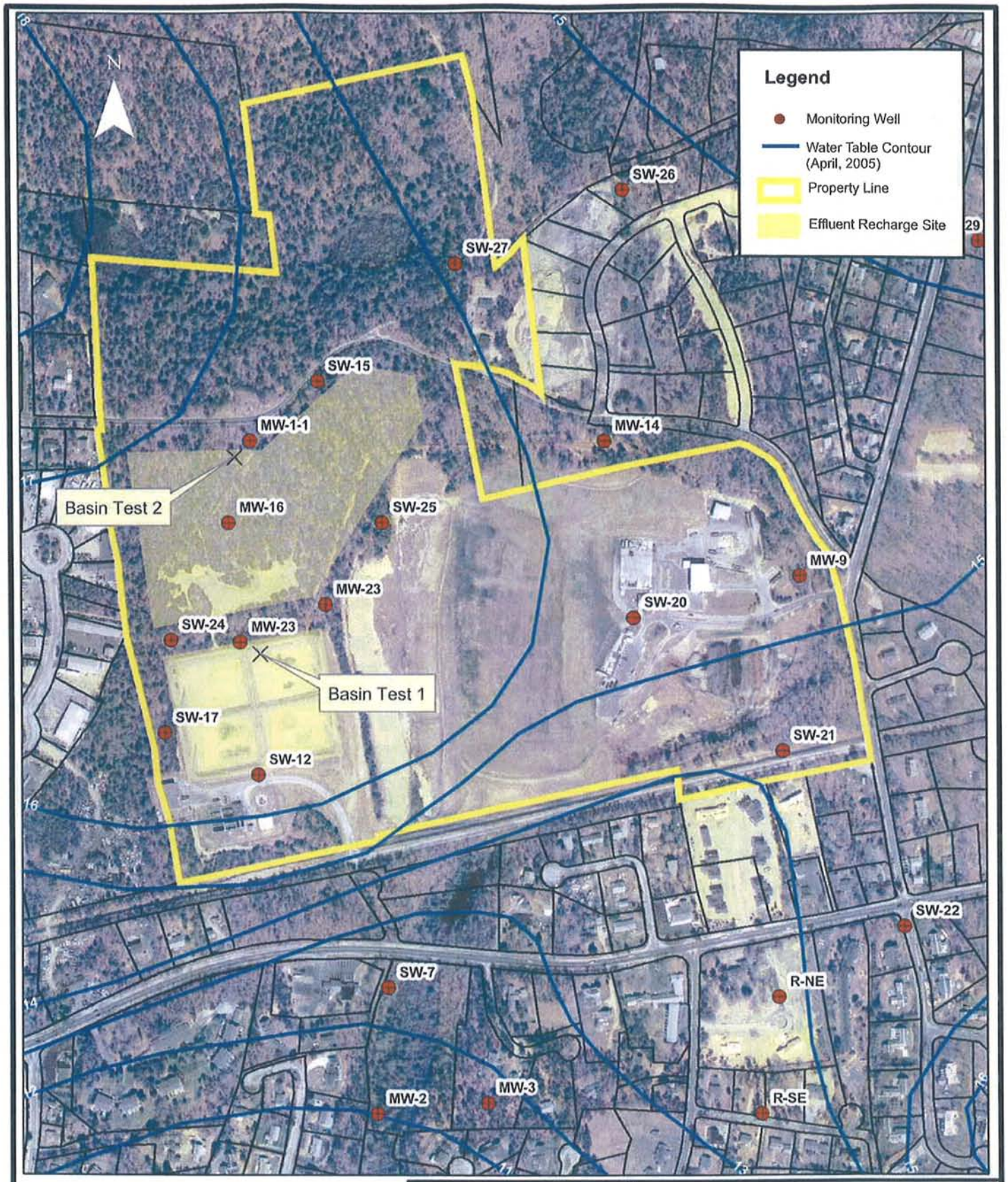
Stearns & Wheler, LLC
Environmental Engineers and Scientists
HYANNIS MASSACHUSETTS

Date:6/27/05

FIGURE 1

POTENTIAL EFFLUENT RECHARGE SITES

TOWN OF CHATHAM CWMP



0 100 200 400 600 800 Feet

1 inch equals 400 feet

Stearns & Wheler, LLC
Environmental Engineers and Scientists

Hyannis, Massachusetts

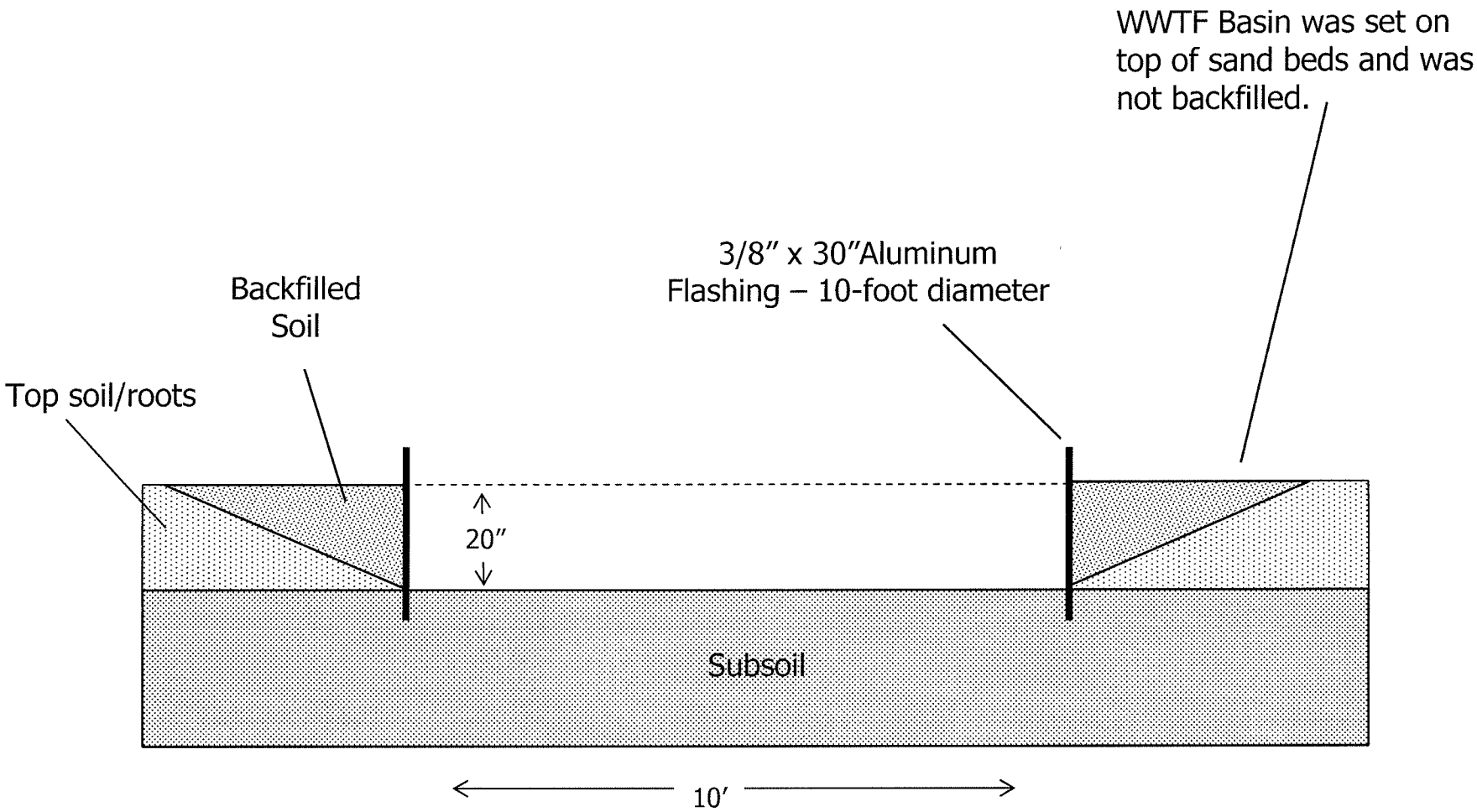
Job No.: 70098 Date: 6/04

Town of Chatham, Massachusetts

EFFLUENT RECHARGE SITE EVALUATIONS

FIGURE 2
CHATHAM WWTF SITE AND PROPERTY

Location: J:\GIS Project Folder\Job#\70098\Figures\2006 Figures\70098F02.mxd

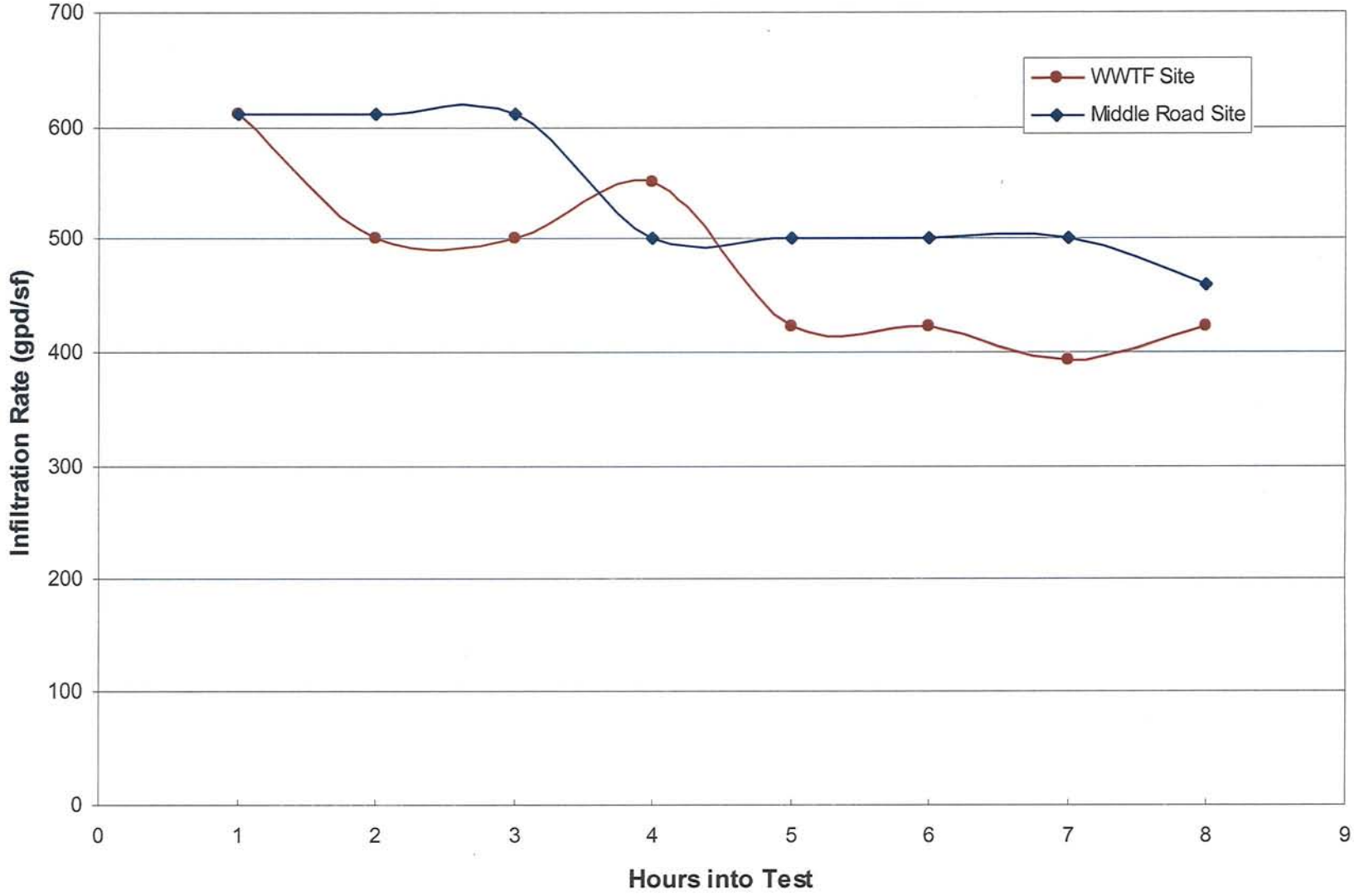


Stearns & Wheler, LLC
Environmental Engineers and Scientists
HYANNIS MASSACHUSETTS

DATE: 7/06 JOB No: 70098

TOWN OF CHATHAM
HYDRAULIC LOADING TESTS

FIGURE 3
BASIN SCHEMATIC



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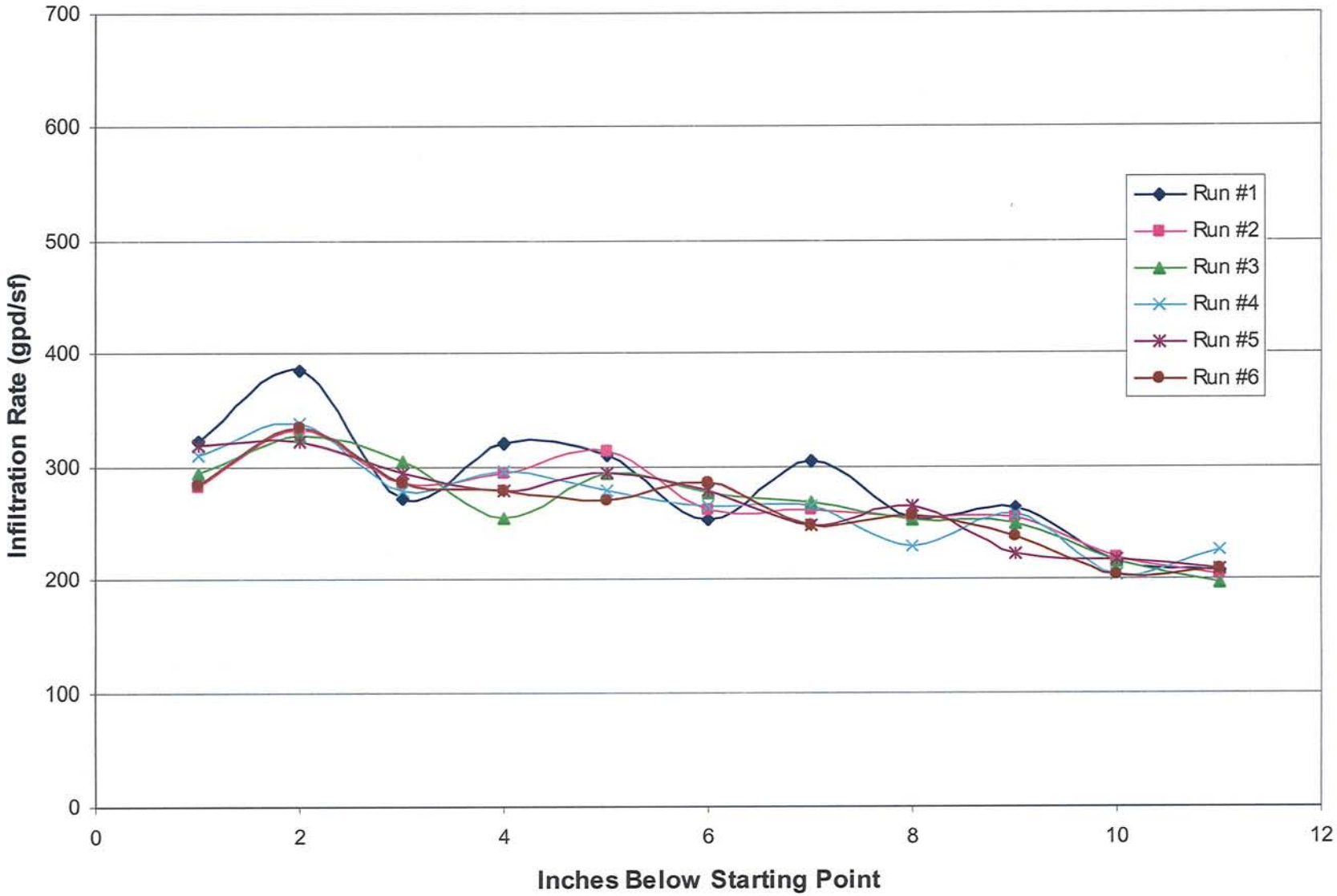
Environmental Engineers and Scientists
HYANNIS MASSACHUSETTS

DATE: 7/06 JOB No: 70098

TOWN OF CHATHAM
HYDRAULIC LOADING TESTS

FIGURE 4
CONSTANT HEAD TEST INFILTRATION RATES

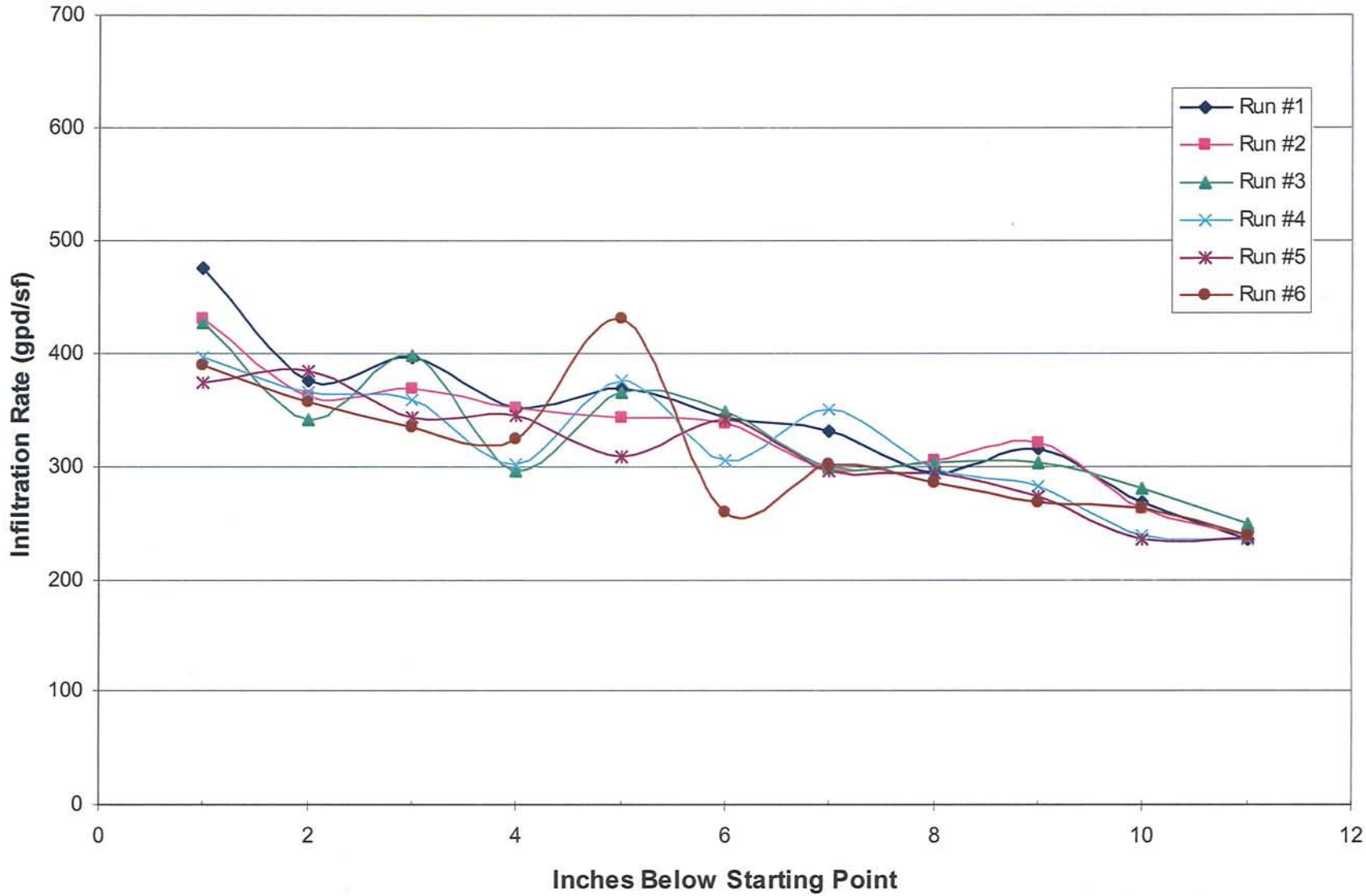


Stearns & Wheler, LLC
Environmental Engineers and Scientists
HYANNIS MASSACHUSETTS

DATE: 7/06 JOB No: 70098

TOWN OF CHATHAM
HYDRAULIC LOADING TESTS

FIGURE 5 - WWTF
FALLING HEAD INFILTRATION RATE



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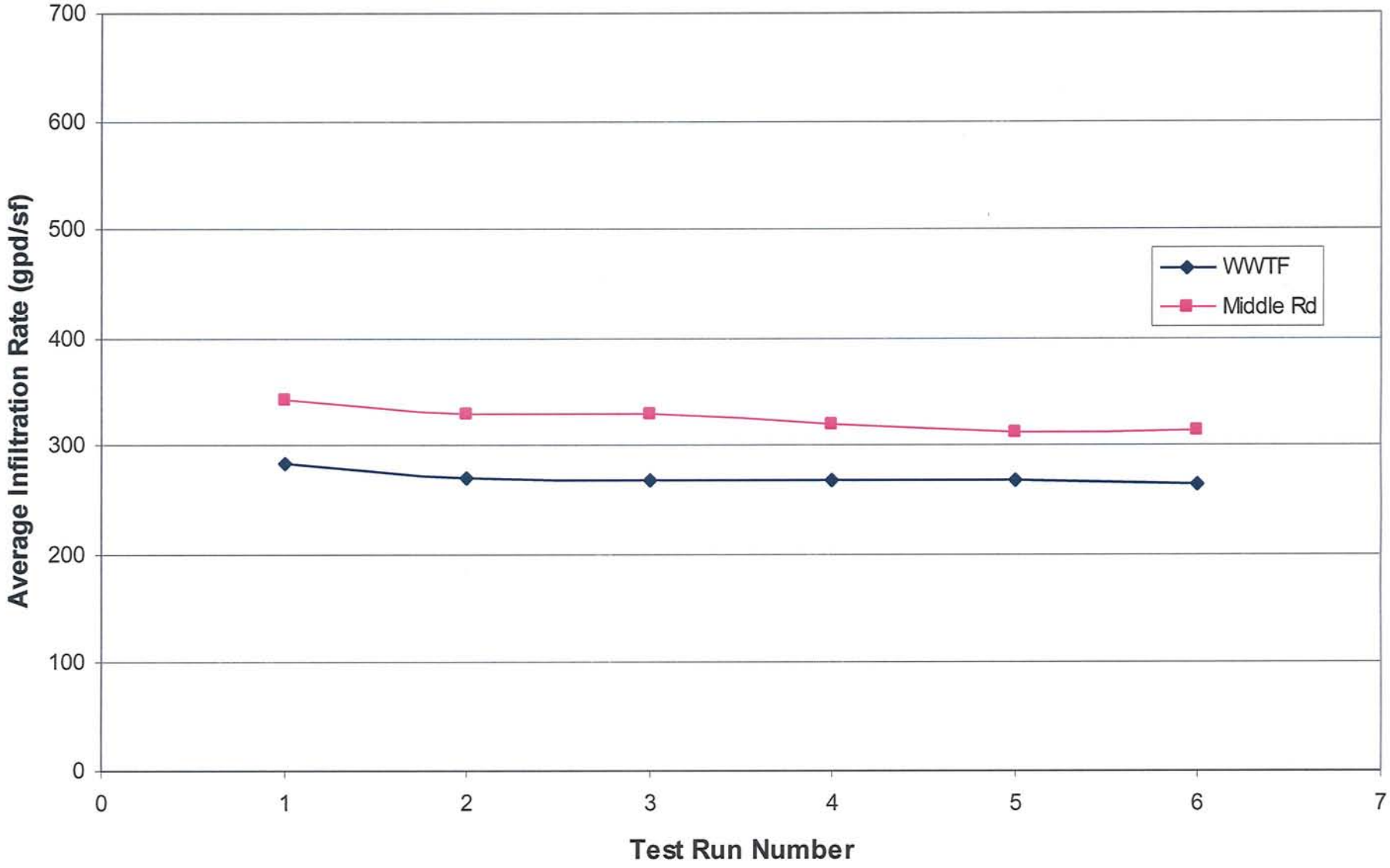
DATE: 7/06 JOB No: 70098

TOWN OF CHATHAM
HYDRAULIC LOADING TESTS

FIGURE 6 – MIDDLE ROAD
FALLING HEAD INFILTRATION RATE



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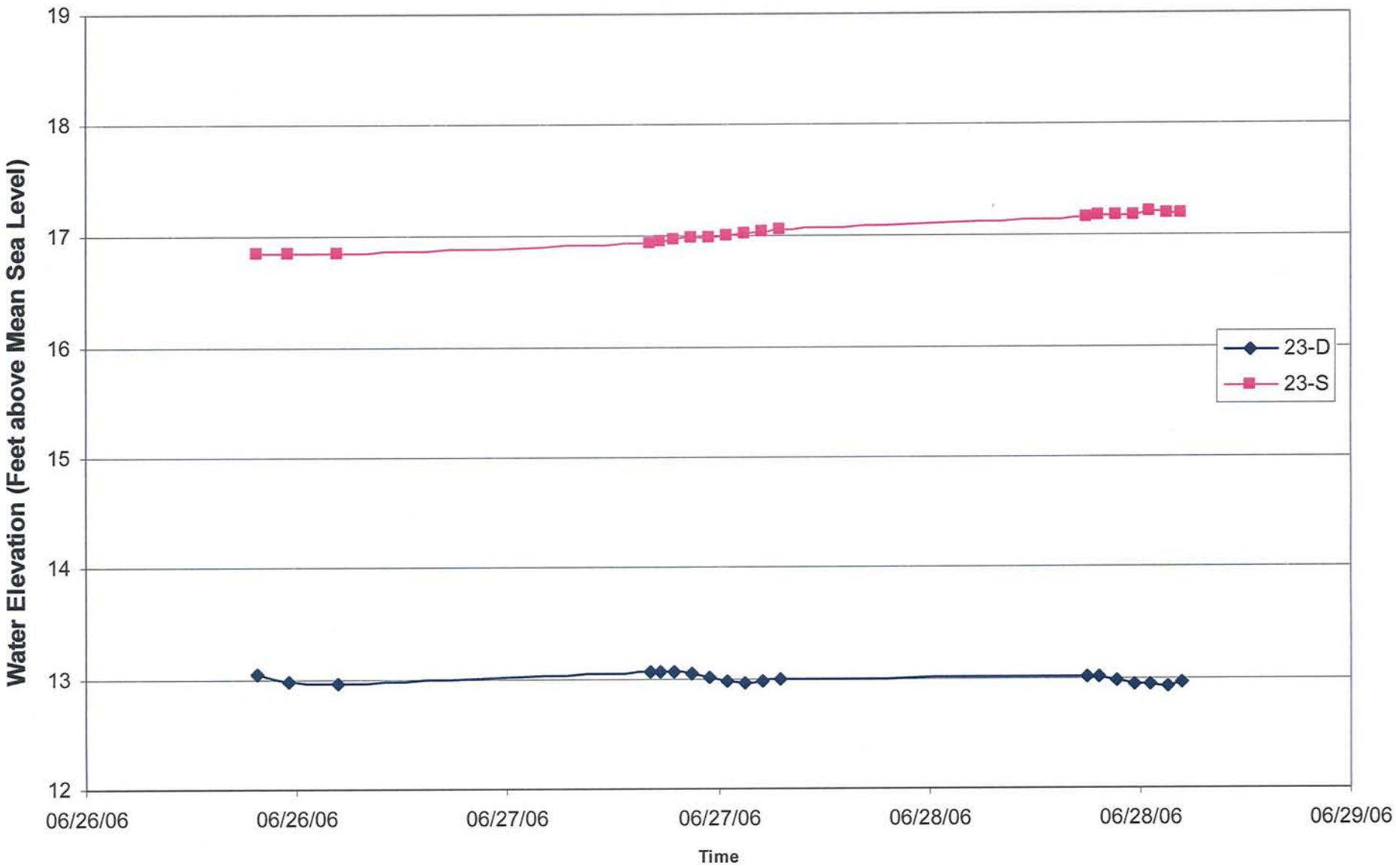
HYANNIS MASSACHUSETTS

DATE: 7/06 JOB No: 70098

TOWN OF CHATHAM
HYDRAULIC LOADING TESTS

FIGURE 7 – FALLING HEAD
AVERAGE INFILTRATION RATES

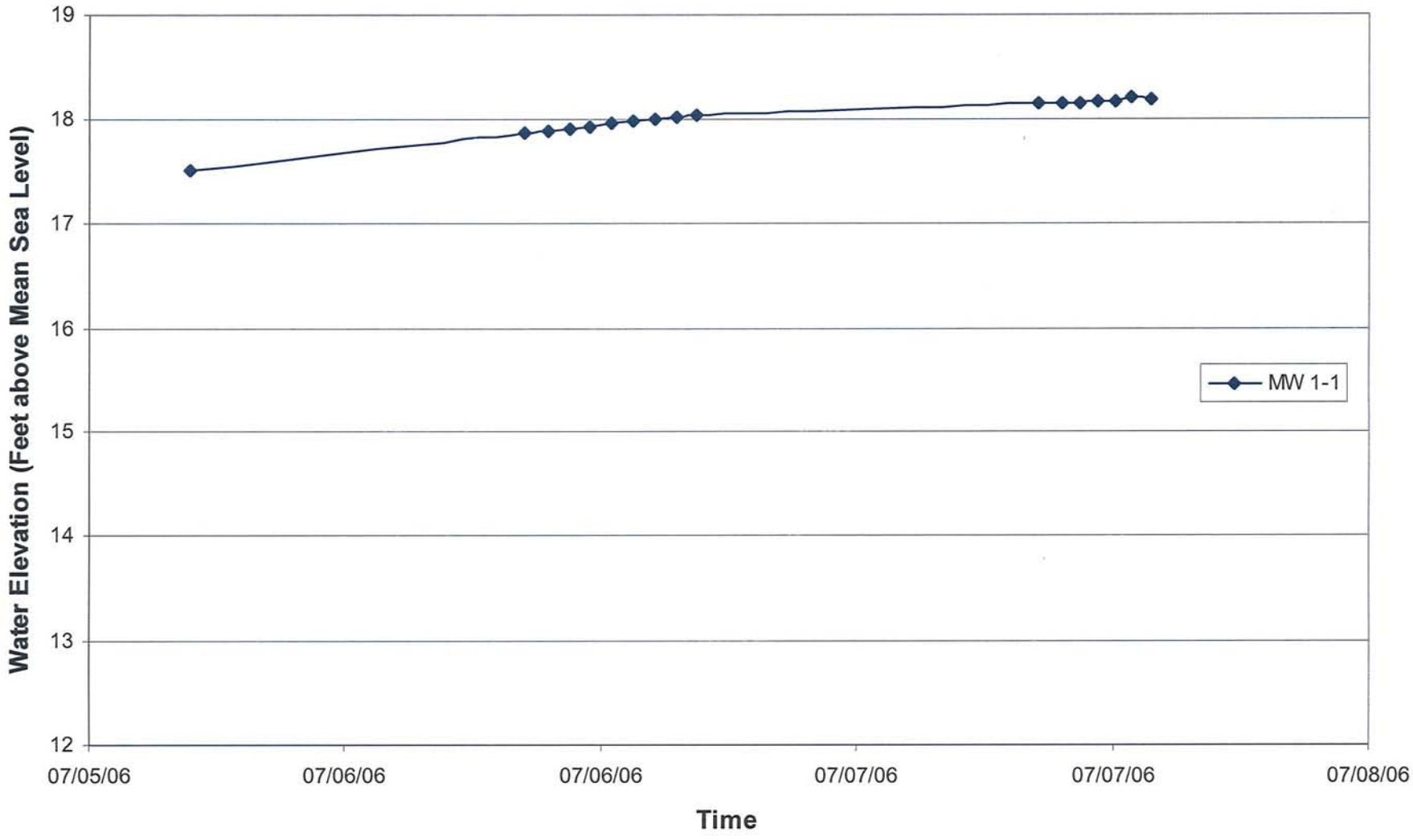


Stearns & Wheler, LLC
Environmental Engineers and Scientists
HYANNIS MASSACHUSETTS

DATE: 7/06 JOB No: 70098

TOWN OF CHATHAM
HYDRAULIC LOADING TESTS

FIGURE 8
MW 23 WATER ELEVATIONS



Stearns & Wheler, LLC
Environmental Engineers and Scientists
HYANNIS MASSACHUSETTS

DATE: 7/06 JOB No: 70098

TOWN OF CHATHAM
HYDRAULIC LOADING TESTS

FIGURE 9
MW 1-1 WATER ELEVATIONS

APPENDIX A

BORING LOGS

NEW ENGLAND BORING CONTRACTORS OF CT, INC.
129 KREIGER LANE
GLASTONBURY, CT 06033
(203) 633-4649 — (413) 733-1232
FAX (203) 657-8046

CLIENT: Metclaf & Eddy
PROJECT NAME: Chatham Mound Test
LOCATION: Chatham, MA

BORING NUMBER: MW-23S
SHEET No. 1 of 1

DRILLER: T. Carpenter
INSPECTOR: K. Harten
DATE START: 7-22-93
DATE FINISH: 7-28-93

ARCHITECT ENGINEER:

	Casing	Sampler	Core Barrel
TYPE	HSA	S/S	
SIZE I.D.	4-1/4"	1-3/8"	
HAMMER WT.		140	
HAMMER FALL		30"	

FILE NO.:
SURFACE ELEV.:
LINE & STATION:
OFFSET:

DEPTH	SAMPLE NO.	DEPTH RANGE	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	REC.	COL. A	STRATA CHANGE	FIELD CLASSIFICATION AND REMARKS
									No Samples Taken Until 55.0
45'									Brown Fine to Medium Sand, Trace of Silt
50'									
55'	S-1	55.0-57.0	40	32					
				40	35	5"			
60'									
65'								65.0	
									End of Boring @ 65.0
70'									Water @ 51.0
75'									
80'									

NOTES: 1) The stratification lines represent the approximate boundary between soil types, transitions may be gradual.
2) Water level readings have been made in the drill holes at times and under conditions stated on the boring logs. Fluctuations in the level of groundwater may occur due to other factors than those present at the time measurements were made.

SAMPLE PENETRATION RESISTANCE
140 lb. Wt. falling 30" on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency	
0-4	Very Loose	0-2	Very Soft
5-9	Loose	3-4	Soft
10-29	Med. Dense	5-8	M/Stiff
30-49	Dense	9-15	Stiff
50 +	Very Dense	16-30	V-Stiff
		31 +	Hard

PROPORTIONS

trace	0 to 10%
little	10 to 20%
some	20 to 35%
and	35 to 50%

REMARKS:

COL. A

NEW ENGLAND BORING CONTRACTORS OF CT. INC.

MONITOR WELL LOG

MW-2

LIENT: Metcalf & Eddy
PROJECT NAME: Chatham Mound Test
OCATION: Chatham, MA

DRILLER: T. Carpenter
INSPECTOR: K. Harten
DATE START: 7-22-93
DATE FINISH: 7-28-93

BORING #: ~~SW~~-23S
CASING:TYPE: HSA
SIZE I.D.: 4-1/4"

Type of Top Cap: 2" Non-Locking

Height of Stick Up: 2.5

roundwater Level: 51.0

op Depth of Seal: 48.0

Bottom Depth of Seal: 51.5

Top Depth of Screen: 55.0

ottom Depth of Screen: 65.0

ottom Depth of Filter Sand: 65.0

Bottom Depth of Boring: 65.0

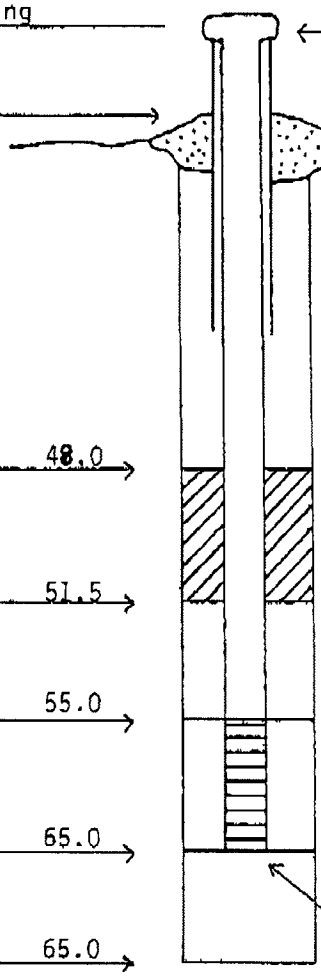
Rock Depth:

evelopment Time: 1/2 Hour

econ Time:

Standby Time:

OT Drums Used:



LPP: 4", RW: , Other:

Backfill/Groutback: Cuttings: X
Top Depth of Groutback:

If Grout: Bags of Cement: 3
Bags of Bentonite Powder: 10 lbs.
Enviroplug:

Length of Riser: 57.5
Diameter: 2"
Type: PVC

Bentonite Seal:
Length: 4.0
Bags Used: 1

Length of Screen: 10.0
Diameter: 2"
Type: PVC
Slot Size: 10

Sand Pack:
Type of Sand: #2
Length of Sand: 13.5
# of Bags: 5

Type of Bottom Plug: Threaded

Backfill: Bags Sand:
Cuttings:
Bags of Bentonite Chips:

NEW ENGLAND BORING CONTRACTORS OF CT. INC.
129 KREIGER LANE
GLASTONBURY, CT 06033
(203) 633-4649 — (413) 733-1232
FAX (203) 657-8046

CLIENT: Metclaf & Eddy
PROJECT NAME: Chatham Mound Test
LOCATION: Chatham, MA

BORING NUMBER: MW-23D
SHEET No. 1 of 2

DRILLER: T. Carpenter
ARCHITECT ENGINEER:
FILE NO.:

INSPECTOR: K. Harten
DATE START: 7-22-93
DATE FINISH: 7-27-93

	Casing	Sampler	Core Barrel
TYPE	HW	S/S	
SIZE I.D.	4"	1-3/8"	
HAMMER WT.	300	140	
HAMMER FALL	25"	30"	

SURFACE ELEV.:
LINE & STATION:
OFFSET:

DEPTH	SAMPLE NO.	DEPTH RANGE	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	REC.	COL. A	STRATA CHANGE	FIELD CLASSIFICATION AND REMARKS
									Pound Casing to 50.0 Before Sampling
45'									Brown Fine to Medium Sand, Trace of Silt, Trace of Gravel
50'	S-1	50.0-52.0	15	20					
				21	24	5"			
55'	S-2	55.0-57.0	125/3"			3"			
60'	S-3	60.0-62.0	11	28					
				45	27	7"			
65'	S-4	65.0-67.0	27	46					
				32	35	6"			
70'	S-5	70.0-72.0	18	15					
				14	16	3"			
75'	S-6	75.0-77.0	11	17					
				18	17	9"			
								78.0	
80'									

NOTES: 1) The stratification lines represent the approximate boundary between soil types, transitions may be gradual.
2) Water level readings have been made in the drill holes at times and under conditions stated on the boring logs. Fluctuations in the level of groundwater may occur due to other factors than those present at the time measurements were made.

SAMPLE PENETRATION RESISTANCE
140 lb. Wt. falling 30" on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency	
0-4	Very Loose	0-2	Very Soft
5-9	Loose	3-4	Soft
10-29	Med. Dense	5-8	M/Stiff
30-49	Dense	9-15	Stiff
50 +	Very Dense	16-30	V-Stiff
		31 +	Hard

PROPORTIONS

trace	0 to 10%
little	10 to 20%
some	20 to 35%
and	35 to 50%

REMARKS:

COL. A

NEW ENGLAND BORING CONTRACTORS OF CT. INC.
129 KREIGER LANE
GLASTONBURY, CT 06033
(203) 633-4649 — (413) 733-1232
FAX (203) 657-8046

CLIENT: Metclaf & Eddy
PROJECT NAME: Chatham Mound Test
LOCATION: Chatham, MA

BORING NUMBER: MW-23D
SHEET No. 2 of 2

DRILLER: T. Carpenter
INSPECTOR: K. Harten
DATE START: 7-22-93
DATE FINISH: 7-27-93

ARCHITECT ENGINEER:

	Casing	Sampler	Core Barrel
TYPE	HW	S/S	
SIZE I.D.	4"	1-3/8"	
HAMMER WT.	300	140	
HAMMER FALL	25"	30"	

FILE NO.:
SURFACE ELEV.:
LINE & STATION:
OFFSET:

DEPTH	SAMPLE NO.	SAMPLE DEPTH RANGE	BLOWS PER 6" ON SAMPLER 0-6	6-12	12-18	REC.	COL. A	STRATA CHANGE	FIELD CLASSIFICATION AND REMARKS
	S-7	80.0-82.0	2	3					Grey Brown Clay, Brown Silt and Fine Sand
				4	4	14"			
	UP-1	83.0-85.0				24"			
85'	S-8	85.0-87.0	3	5					
				7	12	24"			
								89.0	
90'	S-9	90.0-92.0	27	25					Brown Fine to Medium Sand, Trace of Silt
				31	90	10"			
95'								97.0	
100'	S-10	100.0-102.0	10	16					Grey Fine to Medium Sand, Trace of Silt
				22	24	4"			
								103.0	
105'									End of Boring @ 103.0 Water @ 56.0±
110'									
115'									
120'									

NOTES: 1) The stratification lines represent the approximate boundary between soil types, transitions may be gradual
2) Water level readings have been made in the drill holes at times and under conditions stated on the boring logs. Fluctuations in the level of groundwater may occur due to other factors than those present at the time measurements were made

SAMPLE PENETRATION RESISTANCE
140 lb. Wt. falling 30" on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency	
0-4	Very Loose	0-2	Very Soft
5-9	Loose	3-4	Soft
10-29	Med. Dense	5-8	M/Stiff
30-49	Dense	9-15	Stiff
50 +	Very Dense	16-30	V-Stiff
		31 +	Hard

PROPORTIONS

trace	0 to 10%
little	10 to 20%
some	20 to 35%
and	35 to 50%

REMARKS:

COL. A

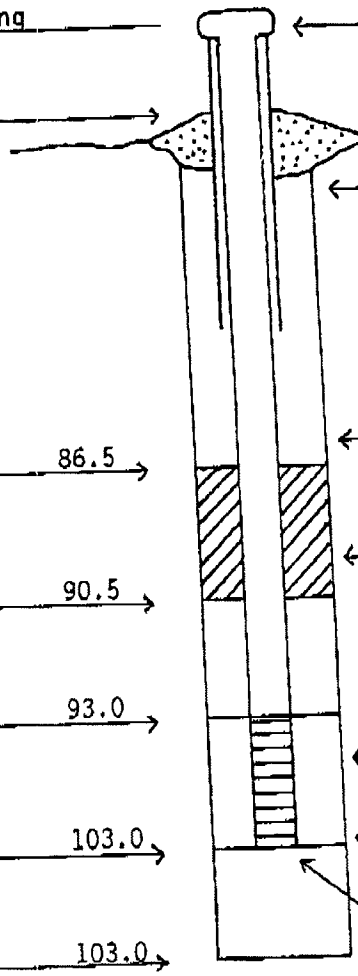
NEW ENGLAND BORING CONTRACTORS OF CT. INC.

MONITOR WELL LOG

IENT Metcalf & Eddy
OJECT NAME Chatham Mound Test
CATION Chatham, MA

DRILLER T. Carpenter
INSPECTOR K. Harten
DATE START 7-22-93
DATE FINISH 7-27-93

BORING # MW-23D
CASING:TYPE HW
SIZE I.D. 4"



'pe of Top Cap 2" Non-Locking

eight of Stick Up 2.9

roundwater Level 56.0±

op Depth of Seal 86.5

Bottom Depth of Seal 90.5

Top Depth of Screen 93.0

ottom Depth of Screen 103.0

ottom Depth of Filter Sand 103.0

Bottom Depth of Boring 103.0

k Depth

Development Time 1/2 Hour

econ Time 1/2 Hour

Standby Time

OT Drums Used

LPP 4", RW _____, Other _____

Backfill/Groutback: Cuttings X
Top Depth of Groutback

If Grout: Bags of Cement 7
Bags of Bentonite Powder 40 lbs
Enviroplug

Length of Riser 96.0
Diameter 2"
Type PVC

Bentonite Seal:
Length 4.0
Bags Used 1

Length of Screen 10.0
Diameter 2"
Type PVC
Slot Size 10

Sand Pack:
Type of Sand #2
Length of Sand 12.5
# of Bags 3

Type of Bottom Plug Threaded

Backfill: Bags Sand
Cuttings
Bags of Bentonite Chips

Boring/Well ID:	Treatment Plant N. MW-1-1

Project Name:	Chatham Effluent Disposal
Job. No.	70098.53.1000
Start Date & Time:	4/28/2004 1:00AM
Finish Date & Time:	4/29/2004 11:00PM
Drilling Co.:	Soil Exploration Corp
Driller:	Tim Flores
S&W Inspector:	RHK
Rig Type:	Truck
Drilling Method:	Auger w/SS samples
Weather:	50s, Sunny

Groundwater Observations	
Time:	
Casing Depth:	
Boring Depth:	
Depth to Water:	
Below Surface:	
Below Meas. Point:	
Surface Elevation:	
Measuring Point El:	
GW Elevation:	

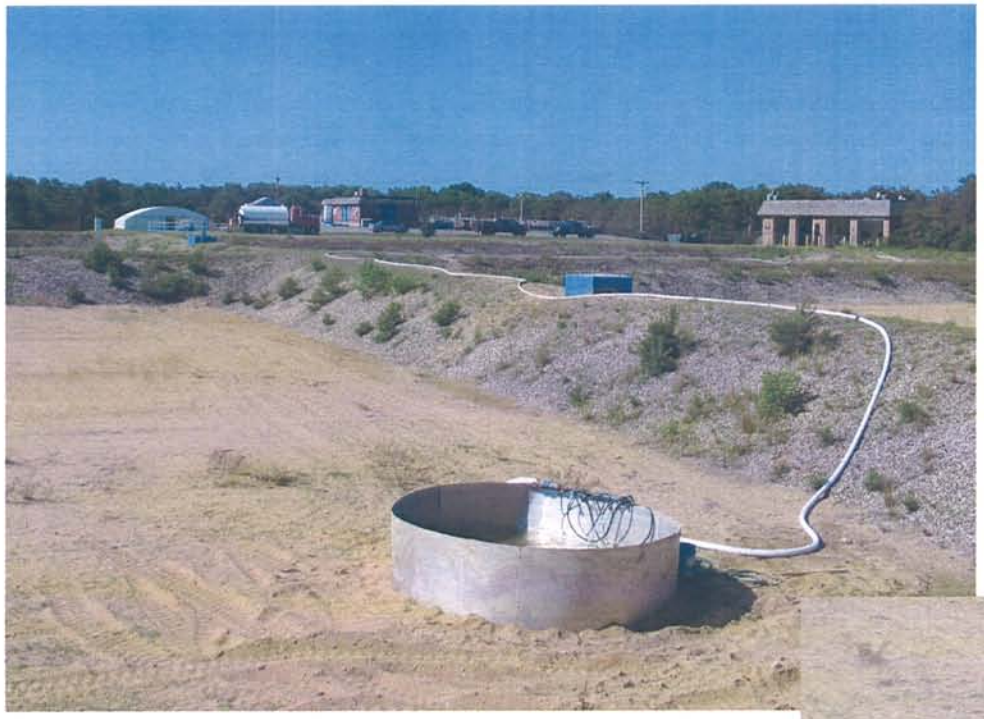
Other Notes Key:

▼ Depth to Ground Water

Depth (ft)	Blow Counts (every 6")	Sample Log	Recovery (in)	Other Notes	Lithology	Sample Description
0						
1						
2						
3						
4						
5	10,12		16			Light Brown, Orange COARSE to MEDIUM SAND, trace FINE GRAVEL
6	15,17					
7						
8						
9						
10	10,10,7,6		12			Light Brown, Orange COARSE SAND and FINE TO COARSE GRAVEL 1/2" Rocks
11						
12						
13						
14						
15	7,8,10,8		16			Light Brown, Orange COARSE SAND and FINE GRAVEL
16						
17						
18						
19						
20	4,5,5,6		14			Orange, Light Brown COARSE SAND
21						
22						
23						
24						
25	6,9,9,11		14			Light Brown, Orange MEDIUM to COARSE SAND
26						
27						
28						
29						
30	10,17		18			Light Brown, Orange MEDIUM to FINE SAND
31	25,31					
32						
33						
34						
35	15,15		2			Light Brown MEDIUM to FINE SAND
36	21,22					
37						
38						
39						
40	8,18		20			Light Brown FINE to MEDIUM SAND Some COARSE SAND
41	25,29					
42						
43						
44						
45	15,25		18			Light Brown MEDIUM to FINE SAND
46	27,29					
47						
48						
49						
50	9,25		18			Light Brown MEDIUM to FINE SAND
51	36,41					
52				▼		
53						
54						
55	9,22		20			Light Brown COARSE to MEDIUM SAND
56	28,29					
57						
58						
59						
60	8,15		24			Light Brown FINE to MEDIUM SAND
61	N/A,N/A					
62						
63						
64						
65	11,23		24			Light Brown FINE to MEDIUM SAND SILTY toward bottom
66	29, N/A					

APPENDIX B

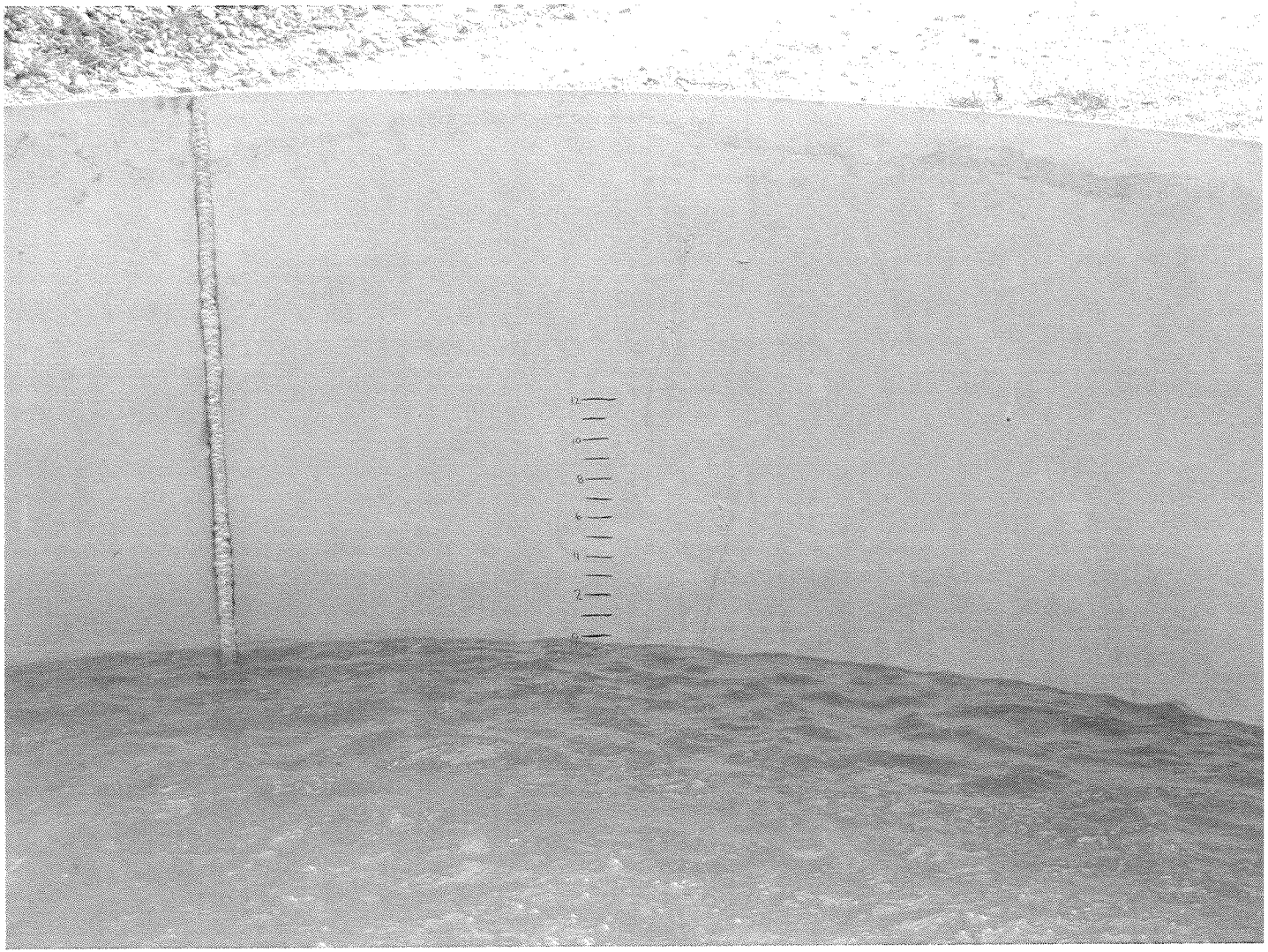
PHOTOGRAPHS



•WWTF Test Basin

•Saturation Phase

•Constant Head Testing



APPENDIX C

HYDRAULIC LOADING TEST WORK PLAN

May 22, 2006

Mr. Steve Hallem
Massachusetts Department of Environmental Protection
One Winter Street
Boston, MA 02108

Re: Town of Chatham
Hydraulic Loading Test Work Plan
S&W Job No. 70098.5

Dear Mr. Hallem:

As we have discussed, the Town of Chatham (Town) is seeking new sites that can be used for the recharge of treated wastewater. Also, the Town is interested in obtaining a design hydraulic loading rate for its existing beds at a value higher than 5 gallons per minute per square foot and one that is more reflective of the actual rate observed at the existing beds. A screening process that evaluated site hydrogeology, area receptors, and general site conditions has been completed for several sites. Additionally, preliminary site evaluations have been completed that included the excavation of a number of test pits, completion of a number of percolation tests, and the installation of observation/test wells. Based on the findings of the site screening and preliminary evaluation, the Town has determined that the site just north of the existing infiltration beds (Site 1) is the best site, and the Town wants to conduct hydraulic load tests at this location.

Figure 1 is the project locus map, and Figure 2 illustrates the Chatham WWTF site and property. There are several monitoring wells located at the site to monitor groundwater quality and elevations with respect to the WWTF and the capped landfill which share the property. Figure 2 also illustrates the groundwater elevations that existed in April 2005 as documented in the WWTF Groundwater Monitoring Report by Metcalf & Eddy. The groundwater in this area flows south to Cockle Cove Creek as illustrated on Figure 5.

To further evaluate the site's infiltration capacity, the Town is planning to conduct a large-volume, long-term loading test at the two locations indicated on Figure 2. This letter describes the planned approach for completing the loading tests. The Town is requesting that the Massachusetts Department of Protection (DEP) review this approach and provide comment regarding the technical and regulatory suitability of the proposed loading test.

PROPOSED LOADING TEST APPROACH

1. **Work Plan Review.** This task includes review and finalization of the Work Plan. We are proposing to complete two loading tests, one in an existing basin that will be retained for future use (Test 1), and one north of the existing basins in an area proposed for additional infiltration beds (Test 2). (The locations are illustrated on attached Figure 2.)

2. **Basin Construction.** Two pre-manufactured, round, 10-foot diameter test rings will be placed at the site. One ring will be pushed down into the existing sand bed to the point of refusal using a loader bucket on the underlying natural material. Pushing to refusal is planned to seal the ring so that infiltrating water will not leak to the surrounding sand in the sand bed. The second ring will be placed in a cleaned area near MW-1-1 in a basin that is 1 to 2 feet deep to remove the topsoil, roots, etc. in the area. It will be pushed into the subsoil to the point of refusal by the loader bucket to seal the ring into the ground.

3. **Water Conveyance.** Fire hydrants are in relatively close proximity to the test site and are expected to be used to supply the water. Water will be conveyed from the hydrants to the test basin using an arrangement of flexible hose or lengths of rigid pipe. The exact configuration, type and length of piping, and necessary fittings and valves will be determined in the near future with the contractor that will supply the pipe.

4. **Basin Testing.** Tests will be conducted sequentially with one basin test being completed at a time. Prior to initiating testing, the soils at each basin will be saturated.

    a. **Basin Saturation**. Each test basin will be flooded to saturate the soils of the test basin. It is anticipated that the saturation period will last 24 hours. Water will be applied day and night at a low enough rate that the basin will not flood.

    b. **Infiltration Testing.** Two types of hydraulic tests will be completed (consistent with USEPA guidance and MADEP direction) to provide information regarding the infiltration capacity of the soils as described below:

        Constant Head Test **-** In this test, water is continuously added to the basin and allowed to infiltrate. The flow rate into the basin is adjusted so that input equals output and the water level in the basin remains constant. This results in a gallon per minute result, that when divided by the surface area

of the basin, yields a gallons per minute per square foot value. This test is sustained over an eight-hour period of time to determine the infiltration capacity of the soil.

Falling Head Test - After the constant head test, water will be applied to the basin during the overnight period at a slow rate to sustain saturation of the soil but not flood the basin. The falling head test will be started by adding water to the basin to a prescribed depth of 10 inches (approximately 500 gallons). The water supply will be shut off and the rate of infiltration in minutes per inch will be measured until the basin is nearly drained. The test is repeated several times (as many cycles as can be completed in a one-day test period) to obtain an average rate. The rate of recharge in minutes per inch is then mathematically converted to an infiltration rate in gallons per day per square foot. Groundwater elevations will be monitored on an hourly basis to check for potential impacts.

During the basin saturation and testing, the groundwater levels in the nearest monitoring well will be checked. The typical depth to groundwater is approximately 20 feet and we may see some change in groundwater elevation, but would not be surprised if no change is evidenced due to the highly permeable soils in that area of Chatham.

5. **Data Evaluation and Preparation Report**. The results of the hydraulic load testing will be evaluated to estimate the infiltration capacity of the site (in gallons per day per square foot). A letter report will be prepared describing the testing, presenting the results, and providing the capacity of the site.

We are also attaching two figures (Figures 3 and 4) that illustrate the particle tracks of USGS modeling a total effluent recharge of 1.5 million gallons per day (mgd) of treated water at this site. The model was run two times: once with the Indian Hill well pumping water and once with the Indian Hill well turned off. As you know, the Indian Hill well has been turned off for several years due to contamination unrelated to the WWTF or the landfill. The Town is currently evaluating effluent recharge at this site from 1.3 to 1.9 mgd on average.

The Town would appreciate the opportunity to discuss this project with you and invites you to visit the site. It is our intent to receive your input prior to May 25, 2006, if possible. I will call you in a few days to set up a time for us to discuss the project in more detail.

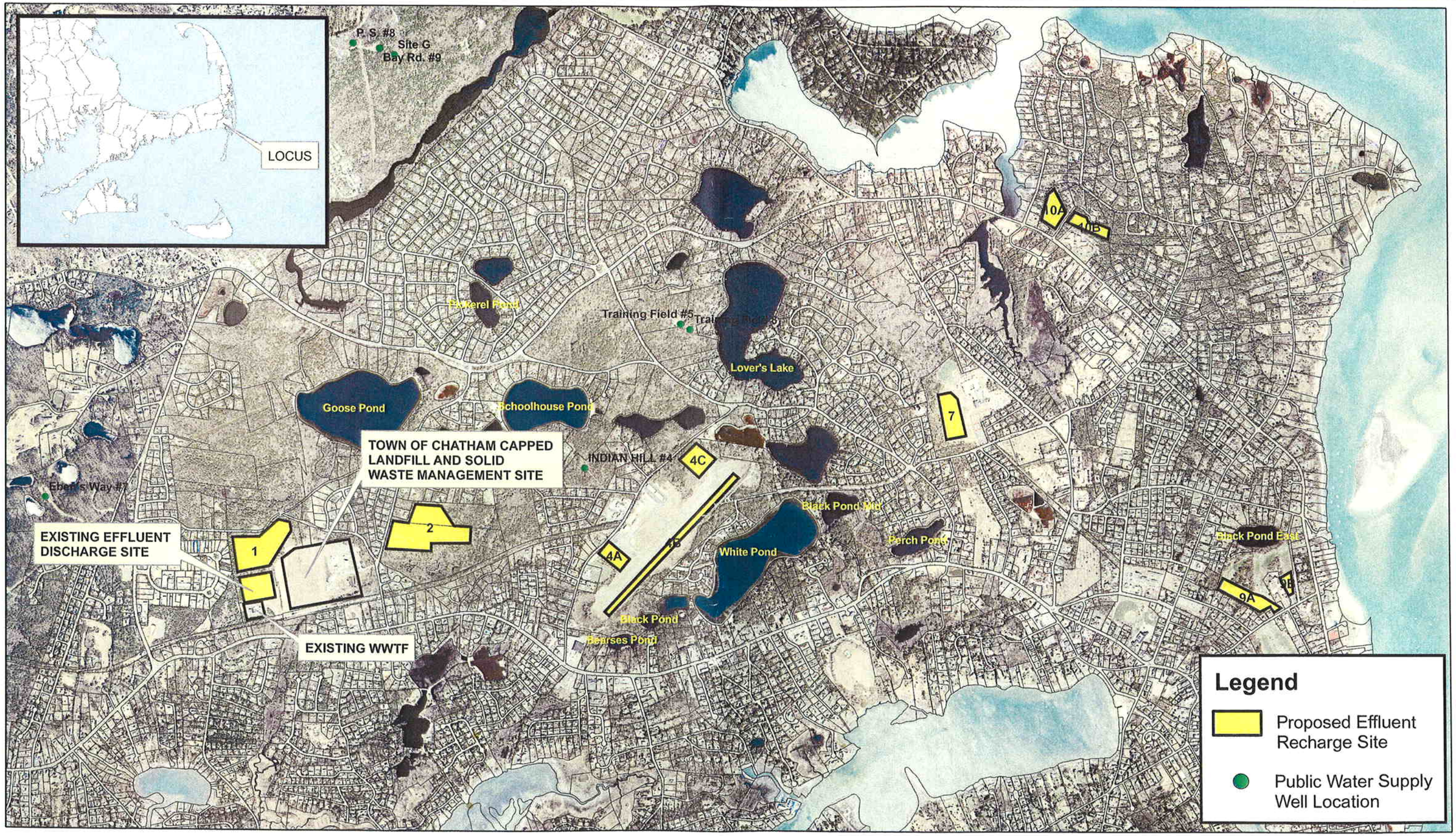
In the meantime, if you have any questions, please call.

Very truly yours,

STEARNS & WHELER, LLC

Nathan C. Weeks, P.E.
Associate

NCW/
Attachments
cc. Robert A. Duncanson, Ph.D., Town of Chatham, w/attach.
Brian Dudley, P.E., MADEP, w/attach.



Data Source: Mass GIS .5 meter Orthophoto (2001)

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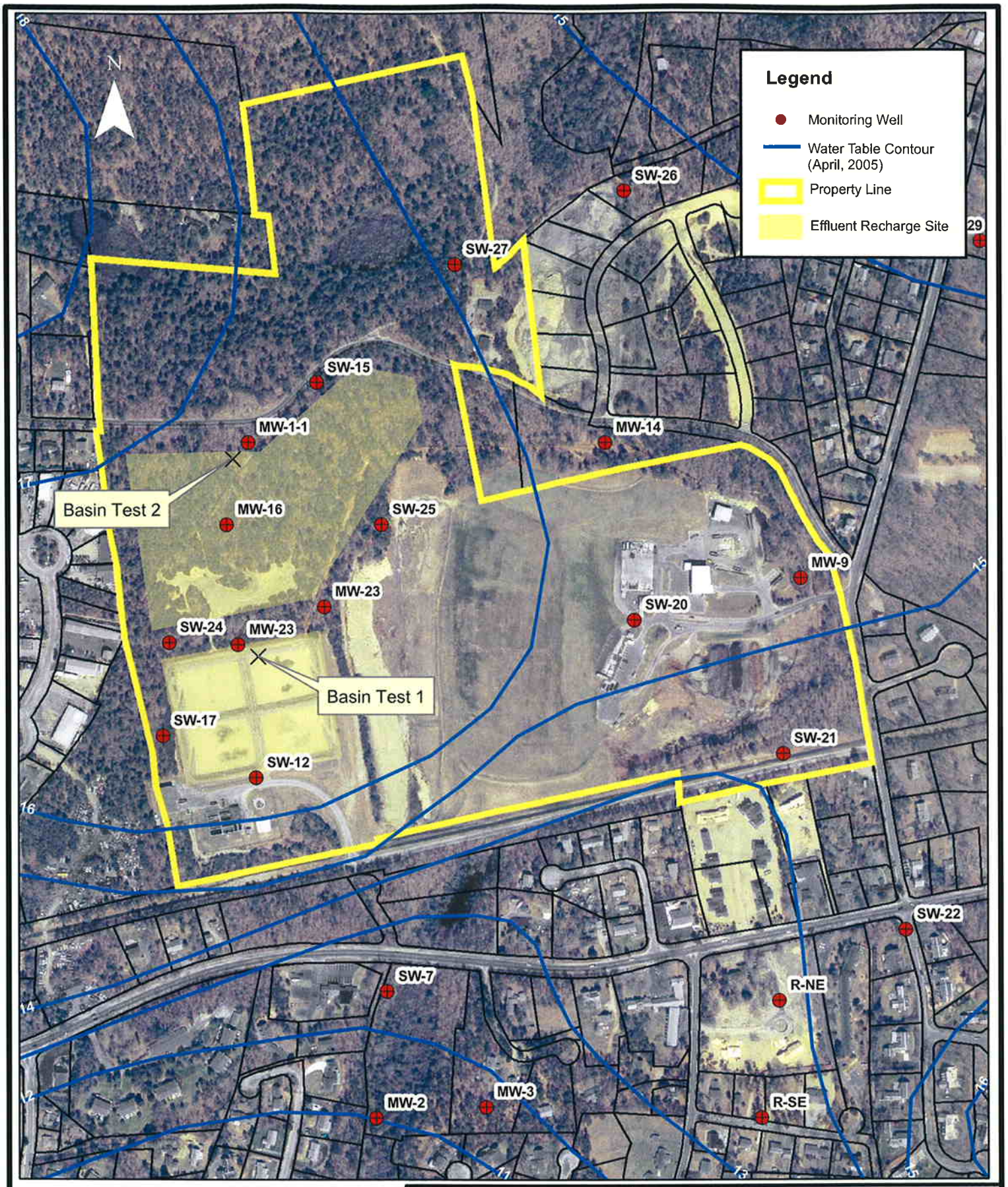
Date:6/27/05

FIGURE 1

POTENTIAL EFFLUENT RECHARGE SITES

TOWN OF CHATHAM CWMP

File Location: D:\GIS Project Folder\Job#\70098 Chatham\USGS Shapefiles\USGS Files 5_05_05\usgs\Final Figures\70098F01.mxd



0 100 200 400 600 800 Feet

1 inch equals 400 feet

Location: J:\GIS Project Folder\Job#\70098\Figures\2006 Figures\70098F02.mxd

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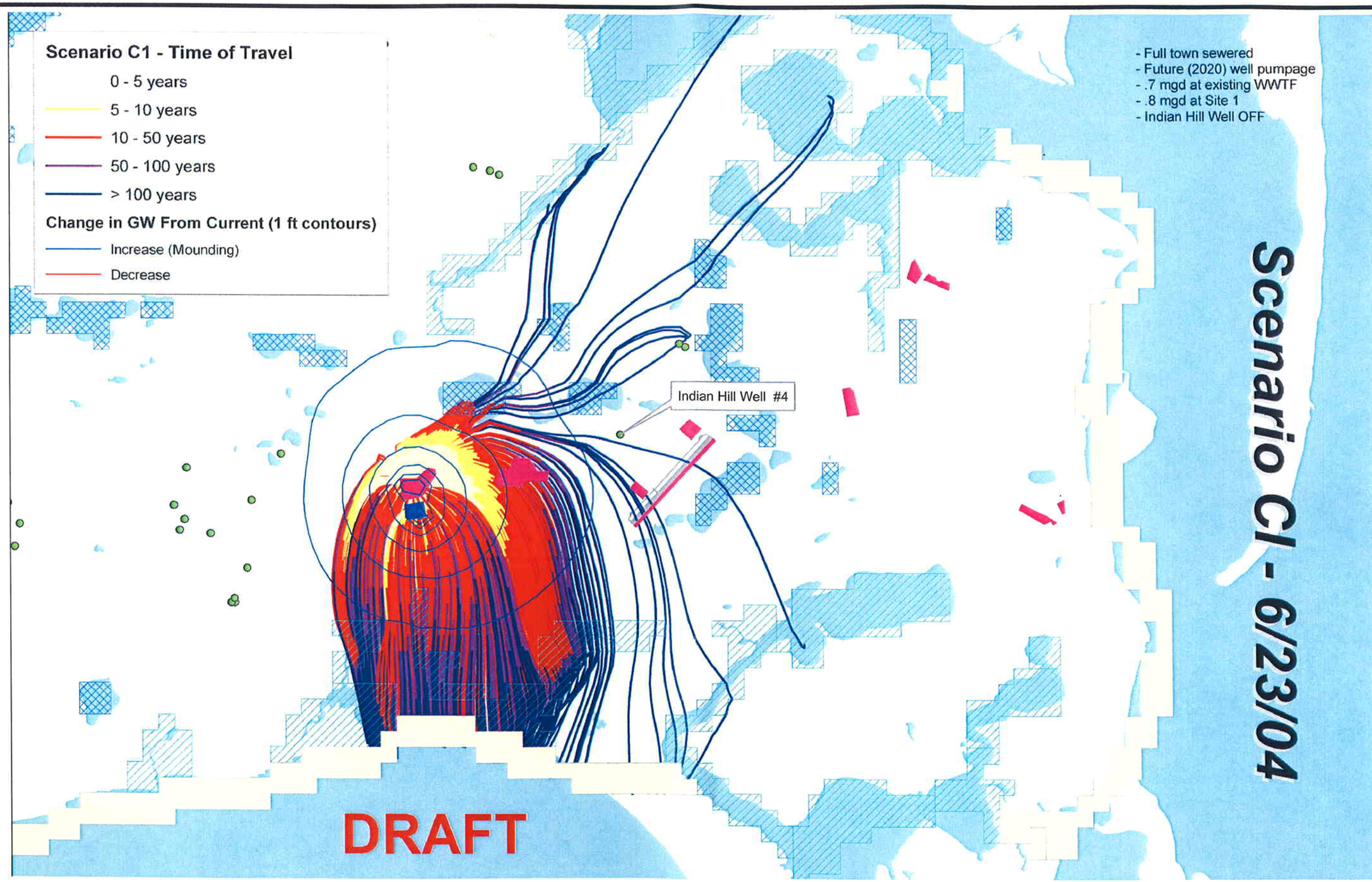
Job No.: 70098 Date: 6/04

Town of Chatham, Massachusetts

EFFLUENT RECHARGE SITE EVALUATIONS

FIGURE 2
CHATHAM WWTF SITE AND PROPERTY



Data Source: Groundwater Modeling by D.A. Walter of USGS. GIS Map Produced by Cape Cod Commision.

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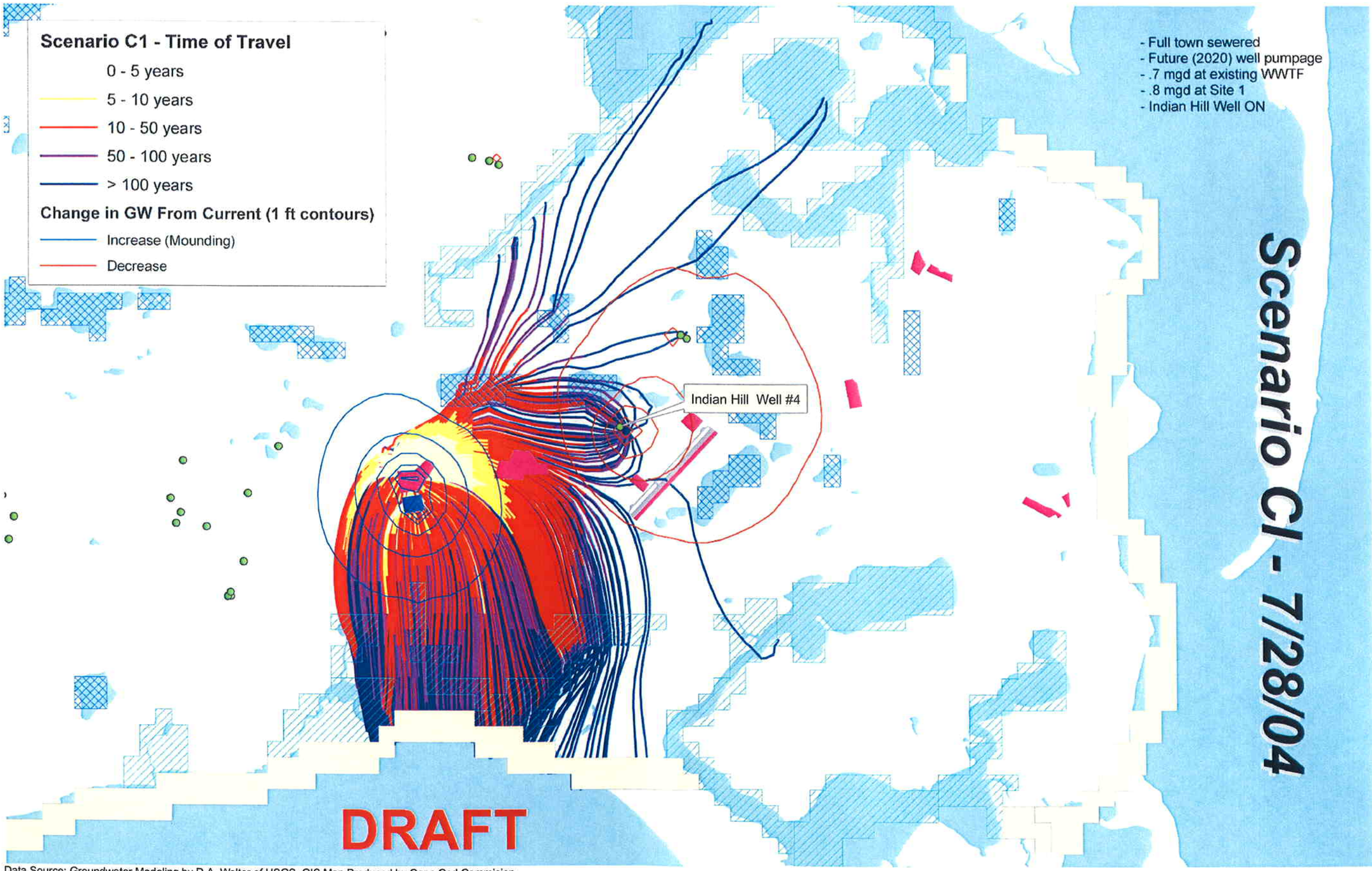
FIGURE 3
SCENARIO C1: EFFLUENT PARTICLE TRACKS WITH INDIAN HILL WELL NOT PUMPING

TOWN OF CHATHAM CWMP

File Location: D:\GIS Project Folder\Job#\70098 Chatham\USGS Shapefiles\USGS Files 5_05_05\usgs\Final Figures\70098F03_C1.mxd



Data Source: Groundwater Modeling by D.A. Walter of USGS. GIS Map Produced by Cape Cod Commision.

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FIGURE 4

SCENARIO C1: EFFLUENT PARTICLE TRACKS WITH INDIAN HILL WELL PUMPING

TOWN OF CHATHAM CWMP

File Location: D:\GIS Project Folder\Job#\70098 Chatham\USGS Shapefiles\USGS Files 5_05_05\usgs\Final Figures\70098F04_C1.mxd