FRENCH STREAM AQUIFER INVESTIGATION

SOUTH SHORE TRI-TOWN DEVELOPMENT CORPORATION

WEYMOUTH, MASSACHUSETTS
OCTOBER 2001

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICIES

1. INTRODUCTION

South Shore Tri-Town Development Corporation (SSTTDC) engaged the services of Woodard & Curran Inc. (W&C) to investigate the feasibility of developing an on-site water supply source as part of the plan to reuse the South Weymouth Naval Air Station (SWNAS) property. This report summarizes the results of that investigation. This section presents the goals for water supply development, and a summary of the SWNAS reuse plan and the role of SSTTDC.

This water supply investigation is a first step in a multi-step process that provides validity to the concept of developing a water supply for the property, with a source located on the property. Should this prove not feasible, it will be necessary to purchase water elsewhere. The investigation was performed in three phases: 1) compile and enter into a database existing subsurface data that has been generated at the base over the previous decades; 2) conduct a geophysical survey on the western side of the base to determine the most favorable locations for test wells and; 3) conduct a test well program to assess groundwater quality and potential well yield.

We are pleased to report that the test well investigation successfully identified two potential locations for permanent water supply wells. We recommend that these two locations be investigated further to verify yield and water quality, to assess water quality protection needs and to determine the ability of the wells to operate in harmony with nearby ecosystems.

The SSTTDC was created by the Commonwealth to manage the redevelopment of the SWNAS. In the October 20, 2000 ENF certificate for the redevelopment, Secretary Durand stated, “It is my hope and belief that this project can serve as a model of sustainable development for Southeastern Massachusetts and the entire state. To achieve that goal, we must incorporate the principles of sustainable development into every element of project planning and design.” Thus, SSTTDC is considering, as part of the redevelopment, the impacts to infrastructure, including water supply systems. The redevelopment of the SWNAS is one of the largest commercial developments in Massachusetts and the SSTTDC recognizes that whatever land uses are implemented, a reliable source of water is critical for project success.

While the results of the test well investigation indicate that one or more wells can be constructed on the SWNAS, the aquifer has a limited recharge area and therefore it may be necessary to augment the well by artificially recharging the aquifer with storm water and treated wastewater. The on-site water supply source can be part of a state-of-the-art water infrastructure system that incorporates a managed storm water collection system, treated wastewater re-use, artificial aquifer recharge, and water conservation practices such as drought-resistant landscaping.

The water supply solution for the SWNAS redevelopment will impact the design of the final build-out. We recommend that SSTTDC prepare a Water System Management Plan that will evaluate water supply alternatives. The plan should include an Alternatives Analysis of all the water supply options (on-site groundwater wells, Massachusetts Water Resources Authority, Weymouth, Abington-Rockland and Bluestone). This will help SSTTDC to prepare its strategy for long term solutions as well as help to determine the types and locations of land uses such that water quality is protected and on-base water resources are used efficiently.

The next section presents the first screening step in locating potential well sites.

2. BORING LOG REVIEW AND INTERPRETATION (GIS/KEY)

2.1 METHOD

GIS Solutions' GIS\Key™ environmental data management software was used to consolidate and manage geologic and hydrologic data from the former SWNAS to characterize the surficial geology of the site. These data were then compared with published maps of regional wetlands (both current and historic), sand and gravel aquifers, and surficial geology for in-depth interpretation of the extent and saturated thickness of stratified drift at the site.

Published information, digitized and overlain on an electronic basemap of the site, was derived from the following sources: Brackley, 1974; Williams, 1974 and; U.S.G.S., 1941. Full references are listed in Section 6-References of this report.

Site-specific data were derived from selected boring and well installation logs constructed for the former SWNAS. Following an analysis of available data, new logs and geophysical information collected for this investigation were input to GIS\Key™ for production of the figures included in Appendix A.

2.2 GEOLOGY

The geology of the former SWNAS consists of Dedham Granite overlain by glacial till, stratified drift, glaciolacustrine (lake) deposits, and/or peat. Extensive filling has added a layer of miscellaneous debris and reworked native materials to developed portions of the site. Bedrock and unconsolidated deposits from the surface downward are described as follows:

<u>Fill</u> - Fill materials consist of iron-stained sand, silt, and gravel mixed with asphalt and debris (TTI, 2000a, p3-6; TTI, 2000b, p3-7). Fill in the north central portions of the site may constitute re-worked glacial till. Fill materials are present across the site, in thicknesses ranging from less than 1 foot to a potential 27 feet (ft) at the bridge spanning the Old Swamp River.

<u>Peat</u> - Peat deposits, comprised of discernible root matter and woody materials (TTI, 2000a, p3-7), occur along French Stream and the Old Swamp River at locations characterized by existing or historic wetlands. In some areas, such as the West Gate Landfill, the unit underlies fill. At most locations peat overlies stratified drift. The thickness of this organic unit ranges from 3 to 19 ft at the Old Swamp River and from 1.5 to 22 ft at French Stream.

<u>Stratified Drift</u> - Stratified drift overlies lacustrine materials, glacial till or bedrock in the Weymouth area and consists of outwash or deltaic gravel, sand, and/or silt deposited by running water (Williams and Tasker, 1974). At the former SWNAS, the drift consists of beds and lenses of predominantly poorly sorted sand and gravel (or gravelly sand), well sorted sand, and poorly sorted sand-silt mixtures. Drift extent is shown on Figure A-1 (Appendix A) relative to published descriptions of surficial materials. The thickness of this unit varies from 0.3 to 18 ft in the central portions of the site and west toward the Old Swamp River to at least 50 ft along French Stream.

Lacustrine Deposits - The lacustrine deposits consist of silt and clay lying beneath or within relatively thin deltaic sand and gravel deposits. The unit may lie above stratified drift but commonly rests directly upon compacted glacial till (Williams and Tasker, 1974). At the former SWNAS, lacustrine deposits have been mapped adjacent to the west bank of French Stream (Williams and Tasker, 1974), but soil borings here suggest the presence of stratified drift (see Figure A-1). Where evaluated, these fine grained sediments ranged up to 10.5 ft in thickness.

Glacial Till - Glacial till deposits include both ablation and basal till, each consisting of a stratified (ablation) or unstratified (basal) mixture of cobbles, gravel, sand, silt, and/or clay (TTI, 2000a, p3-7; Williams and Tasker, 1974). Till is present largely where bedrock is highest: in the northern and central portions of the site (where it outcrops or underlies fill), at the ground surface east of Old Swamp River, and beneath stratified drift in the Old Swamp River channel way. Where evaluated, the thickness of this unit ranged from about 5 to 20 ft.

Dedham Granite - The Dedham Granite formation consists of a Proterozoic intrusive rock of light grayish-pink to greenish-gray, equigranular to slightly porphyritic, variably-altered and deformed granite (TTI, 2000a, p3-7). Top of bedrock elevations range from approximately 95 to 177 ft above mean sea level. The bedrock surface slopes gently east and west from a north-south trending ridge in the center of the site but becomes much steeper in the Old Swamp River and French Stream channels along the property boundaries to the east and west (Figure A-2). Depth to bedrock below ground surface varies from 10 ft or less in the east and southeast portions of the site to greater than 50 ft along French Stream.

According to a study commissioned by the Navy, information on bedrock fractures was collected from the area of Building 81 from core samples and bedrock outcrops (Tetra Tech NUS, December 2000). Bedrock core fracture angles ranged from nearly vertical (85° to 90°) to low angle. Many fractures were filled with quartz and therefore do not transmit groundwater. Some of the fractures reportedly were open and stained with iron, indicating that they may contain groundwater. The orientations (strike and dip) of 45 fractures were measured at bedrock outcrops. The most common orientation observed in the outcrops was 30° east of north (N30E) with a high angle of dip (56° to 71°), with secondary orientations of N50W to N70W and N70 E.

2.3 HYDROGEOLOGY

Groundwater at the former SWNAS occurs in the glacial deposits at depths ranging from 0 to 10 ft and flows into the Weymouth River and Southeastern Massachusetts Drainage Basins. The divide between the two basins splits the former SWNAS in a northwest-southeast direction so that property in the western portion of the site drains southwestward into French Stream, while property to the east drains northeastward into the Old Swamp River (ATSDR, 1999).

Stratified sand and gravel aquifers are the principle source of groundwater in the Weymouth River and adjacent basins, and portions of the former SWNAS overlie potentially productive aquifers (ATSDR, 1999). Where thick and proximal to surface water bodies, these types of aquifers may yield more than 300 gallons per minute (gpm) to wells (USGS, 2001).

Figure A-3 compares available groundwater in the unconsolidated deposits above glacial till with the estimated extent of stratified drift at the site. The sand and gravel deposits along French Stream and the Old Swamp River (aka the French Stream and Old Swamp River aquifers) exhibit the highest potential well yields, exceeding an estimated 300 gpm in the aquifer just south of the West Gate Landfill. Well yields are based on the estimated transmissivity of the aquifer and local variations in hydraulic conductivity and saturated thickness (which determine transmissivity) may result in actual yields higher or lower than those predicted.

The hydraulic conductivity of the stratified drift at the site has been calculated at 1.50×10^{-3} to 1.70×10^{-3} centimeters per second in the French Stream aquifer just south of the West Gate Landfill (TTI, 2000a, p3-8). The saturated thickness of the drift (including peat deposits) is shown on Figure A-4. The greatest thicknesses occur in the French Stream aquifer south of the West Gate Landfill.

Figure 2-1 is a three-dimensional depiction of the surface and subsurface features of the SWNAS. The top layer shown is the land surface, which is highest northern to northeastern portions of the site and slopes downward to the south and west. The top of the stratified drift, shown in light brown, indicates that the stratified drift is not present over the entire site. The water table, glacial till and bedrock surfaces are similar to the ground surface, sloping to the south and west. The direction of groundwater flow is generally from lighter-colored area to darker ones, following the slope of the till and bedrock.

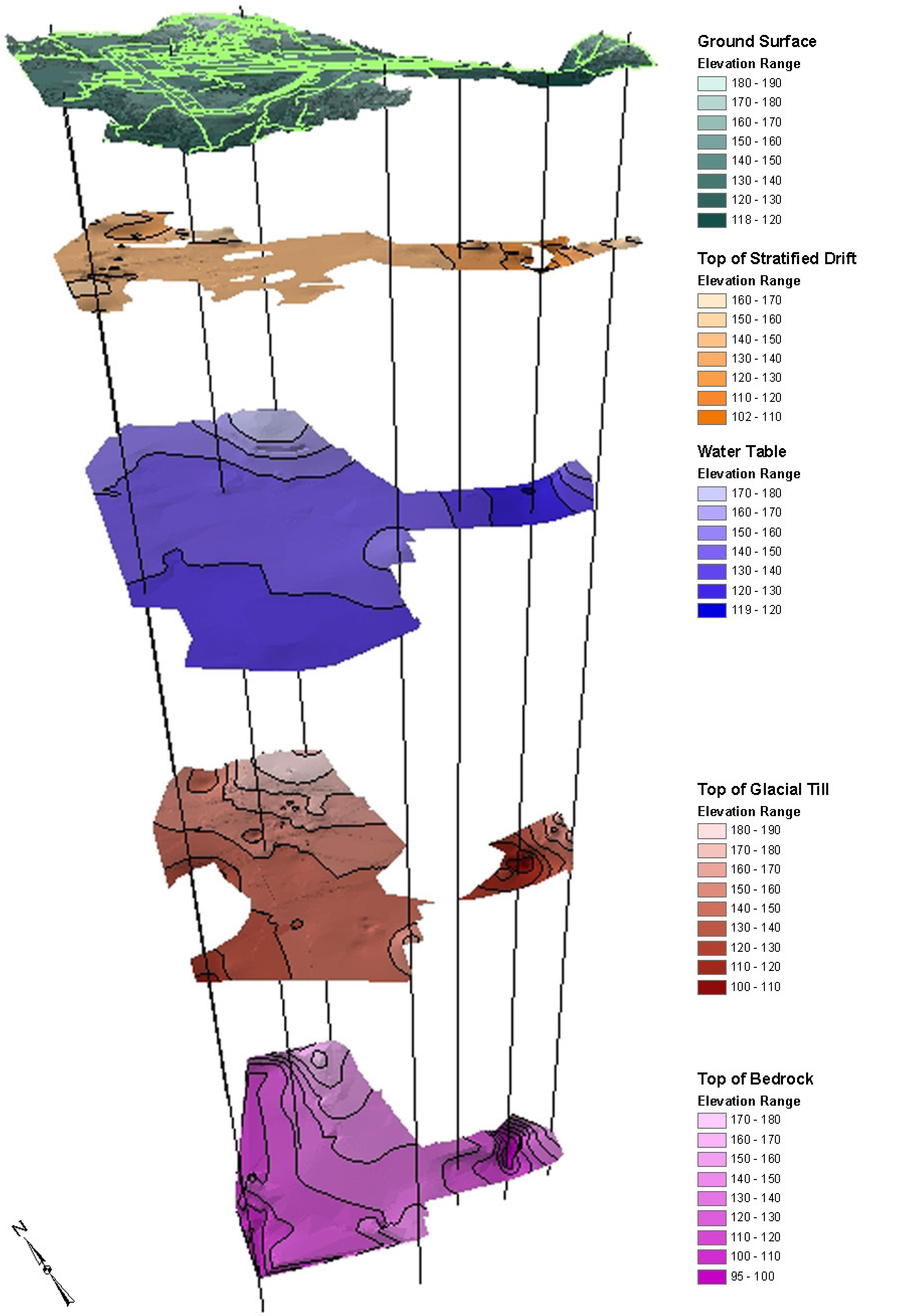

Figure 2-1
Three-Dimensional Depiction of Surface and Subsurface
Features of the Former South Weymouth Naval Air Station
French Stream Aquifer Investigation
South Shore Tri-Town Development Corporation
South Weymouth, Massachusetts
October 2001

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3. GEOPHYSICAL SURVEY

3.1 INTRODUCTION AND PURPOSE

The firm of Kick Geoexploration, Dunstable, Massachusetts conducted a geophysical survey from January 2 to 25, 2001 to determine the thickness of the overburden material and, where possible, to measure the seismic velocities of the overburden. The results of the survey were used to choose the optimal locations for test wells. Kick Geoexploration prepared a Geophysical Survey Report in February 2001 (Appendix B), which includes detailed descriptions of the methods and results of the survey. The locations of the geophysical lines were surveyed for latitude/longitude using the Global Positioning System (GPS). The report includes a map of the survey lines and cross-sections of the subsurface.

3.1 METHODOLOGY

The geophysical survey consisted of measuring the subsurface geophysical properties along five lines using a combination of seismic and gravity methods. Seismic was used where there were no organic peat deposits between the surface and the stratified drift (sand and gravel) deposits. In areas underlain by peat, it was necessary to use the gravity method to determine the thickness of the overburden deposits because the peat interferes with the seismic signals.

The thickness of the peat was determined by measuring the depth to which steel rods could be pushed manually through it. Manual refusal of the rods was assumed to be the top of the underlying stratified drift deposits. Where peat was present, it ranged from 3 to 15 ft thick. The Geophysical Report includes a table summarizing the results of the peat thickness measurements.

3.2 RESULTS

The geophysical survey indicated that the bedrock surface is relatively flat and that there is from 30 to 50 ft of overburden material across the study area. Where seismic velocities were measured, they ranged from 5,100 to 6,200 ft per second (ft/sec) in the overburden. Generally, stratified drift deposits suitable for public water supply wells have seismic velocities below 5,500 ft/sec.

The geophysical survey showed that most of the area investigated is suitable for further exploration with test wells. The overburden deposits are present over the entire study area with enough saturated thickness to support high-yielding wells. The northern end of the study area has seismic velocities in the overburden as high as 6,200 ft/sec, indicating that the overburden in this area is not favored for further exploration.

4. AQUIFER TESTING

4.1 INTRODUCTION AND PURPOSE

Subsurface exploration for water supply was undertaken by installing 2½-inch diameter test wells within the study area of the geophysical survey to estimate aquifer yield and water quality. This is the first step to identify potential water supply well sites. The data collected during the test well investigation will be included in the Request for Site Exam, the first step of the New Source approval process for permitting public water supplies through the Massachusetts Department of Environmental Protection (MADEP). The Layne-Christensen Company of Dracut, Massachusetts, performed the drilling.

4.2 METHODOLOGY

Test wells were installed at nine locations, numbered 1-01 through 9-01. The approximate locations of the test wells are shown on Figure 4-1. In consultation with SSTTDC staff, W&C chose the test well locations considering the results of the geophysical survey, MADEP setback requirements (Zone I protective radius) and the proposed location of the access road to Route 18.

Test wells were installed using the drive-and-wash drilling method, which is standard practice for overburden groundwater exploration in New England. At each test well location, 7-foot long sections of threaded 2.5-inch diameter steel pipe were driven into the subsurface. After each section was driven, the pipe was washed out with re-circulated water to remove soil from within the pipe using a centrifugal pump. The soil was settled out of the water in a small tub. Potable water from the Weymouth public system was brought on-site for wash water. This was repeated until the pipe reached refusal at till, a boulder or bedrock. After the pipe reached refusal, a 5-foot long, 1.25-inch diameter steel well screen was installed by lowering it into the pipe and pulling the pipe back to expose the screen to the formation. The depth at which to expose the screen was determined based on observation of the grain size and grain size distribution of the material that was washed out of the pipe during drilling. The driller's logs of the test wells are in Appendix C.

To maximize pumping capacity, the wells were developed to remove fine-grained material from near the well screen by pumping the well with a suction lift pump until they became clear of sediment. Once each well was developed, its pumping rate was measured. If the well produced appreciable water, a well of the same construction was installed two feet from the first well and was also developed. Aquifer response to pumping was measured by pumping one well in the pair while measuring water levels in the other.

Test wells installed at four of the sites, 1-01, 5-01, 8-01, and 9-01, produced enough water to warrant installation of a second well. At each of these four sites, a short-term pumping test (two hours) of the test well pair was performed to collect water quality samples and estimate well yield. One of the wells was pumped using a suction lift pump while water levels were measured in the other well. The amount of drawdown (water level decline) in the non-pumped well in the pair is a measure of the approximate yield of a larger well at that location.

Just before the end of the two-hour pumping tests, water samples were collected from the end of the discharge line connected to the pump and laboratory analyzed for the parameters outlined in the MADEP publication "Guidelines and Policies for Public Water Systems," November, 1996. These parameters are: total dissolved solids (TDS), color, odor, pH, total alkalinity (as $CaCO_3$), hardness, calcium, manganese, potassium, iron, magnesium, sulfate, chloride, silver, turbidity, aluminum, zinc, copper and volatile organic compounds (VOCs) by EPA method 524. These are the analyses necessary for submitting a Request for Site Exam for test wells, the first step in the MADEP New Source approval process. In addition, three of the samples were analyzed for nitrates because the presence of high levels of nitrates (above 5 milligrams per liter (mg/L) could pose a permitting and/or treatment obstacle. Samples were collected from two of the three sites located close to each other and analyzed for VOCs because it was unnecessary to collect samples from all three in order to determine the presence of VOCs in the groundwater in the area. The laboratory analytical reports are in Appendix D.

In order to prevent potentially contaminated groundwater from being dispersed during the test well program, the water from the test wells was containerized on-site until analyses of the water indicated that it could be discharged to the ground surface. Wash water from the drilling containing soil was first pumped to an open container to settle out the solids. The water was then pumped into temporary storage tanks.

Once drilling was complete, the field hydrogeologist collected samples of water from the tanks containing the water produced from drilling. The samples were analyzed for extractable petroleum hydrocarbons (EPH), VOCs by EPA method 8260 and priority pollutant metals (antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, zinc). Based on the analytical results of the water from the tanks, the water was allowed to be discharged to the ground surface per the Bureau of Resource Protection of the MADEP. The results of the samples collected from the tanks are included in Appendix D.

4.3 TEST WELL WATER YIELD RESULTS

Five of the test well locations did not yield enough water to warrant further exploration: 2-01, 3-01, 4-01, 6-01 and 7-01. Test wells at these locations produced 10 gpm or less and therefore were not explored further. At four of the test well sites, 1-01, 5-01, 8-01 and 9-01, the test wells produced 35 gpm or more. At these locations, observation wells were installed two feet from the first test wells and two-hour pumping tests were performed to estimate yield and to collect samples for water quality. Sites 5-01, 8-01 and 9-01 are located along a north-south trending line, and are spaced less than 50 ft apart. The 50-foot maximum spacing will allow a well field to be constructed at this site under the MADEP guidelines. Table 4-1 summarizes the results of the test well drilling and pumping tests. The driller's test well boring logs are included in Appendix C.

TABLE 4-1
TEST WELL SUMMARY
FRENCH STREAM AQUIFER INVESTIGATION
SOUTH SHORE TRI-TOWN DEVELOPMENT CORPORATION
OCTOBER 2001

Site ID	Refusal Depth (ft)	Screened Depth Interval (ft)	Yield (gpm)	Observed Drawdown (ft)	Specific Capacity (gpm/ft)
1-01	45	24-29	70	1.38	50.7
2-01	35	30-35	10	No pumping test	
3-01	45.5	40.5-45.5	0.5	No pumping test	
4-01	37	32-37	0	No pumping test	
5-01	30	25-30	50	2.85	17.5
6-01	30	25-30	0	No pumping test	
7-01	30	25-30	0	No pumping test	
8-01	29	20.5-25.5	35	1.55	22.5
9-01	29	20-25	50	2.35	21.3

The specific capacities listed in Table 4-1 are estimates of the yields of permanent wells for each site. Higher specific capacity means higher well yield. The short-term pumping tests at 1-01, 5-01, 8-01 and 9-01 indicate that each of these sites could support a public water supply well and that further testing of these sites is warranted. Site 1-01 has the largest specific capacity, indicating that constructing a single well here may be most appropriate. Sites 5-01, 8-01 and 9-01 all have similar specific capacities to each other. The specific capacities of these three sites indicate that more than one of these sites may need to be developed into public water supply wells. It should be noted that the specific capacities of the 2 ½-inch test wells are indicators of the yields of permanent wells and that determination of actual yields requires multiple-day pumping tests of larger diameter wells, as required by MADEP.

4.4 Test Well Water Quality Results

The water quality analytical results indicate that the water is suitable for public supply, although treatment will probably be required. Table 4-2 summarizes the water quality results and includes the drinking water standard for each parameter. Table 4-2 also includes the ranges of values for the same parameters measured in Weymouth Winter Street Well No. 1 during a prolonged pumping test conducted in February 1999.

Iron and manganese are above their Massachusetts Secondary Maximum Contaminant Levels (SMCLs) for drinking water. SMCLs are used as a guide for evaluating the aesthetic quality of drinking water. Although iron and manganese do not pose a public health threat, treatment for these two metals will be required to achieve acceptable aesthetic quality. This is common for groundwater wells in Massachusetts, including the towns of Weymouth, Abington and Rockland that treat groundwater to reduce iron and manganese. Color and aluminum were also above their SMCLs, also indicating that treatment would be required to improve aesthetic quality of the water. The other inorganic parameters are all within drinking water standards and are within the levels detected in Weymouth's Winter Street Well No. 1.

TABLE 4-2 Water Quality Summary

Two VOCs were detected in samples collected from the test wells: methyl tertiary butyl ether (MTBE) and chloroform. The levels of MTBE detected in samples from the test wells are relatively low and are typical of background concentrations. MTBE is a gasoline additive that is commonly found in groundwater, especially in developed areas such as those near the site. MTBE can reach the groundwater through atmospheric deposition of unburned gasoline and in storm water runoff. It is present in many public water supply wells in Massachusetts at levels higher than detected in the test well samples. MTBE can be removed from groundwater using air striping, oxidation or carbon filter technologies.

Chloroform was detected at very low levels in one well only. Chloroform is also a common VOC found in groundwater. One common source of chloroform is septic systems. Previous or current septic systems upgradient of the test well sites could be a source of the chloroform.

The levels of inorganic and organic parameters detected in samples collected from the test wells indicate that the water is suitable for public water supply. The water will probably require treatment for iron and manganese and may also need to be treated to adjust the pH to conform to corrosion control regulations. The low levels of VOCs are below their maximum levels allowed in public water supplies and therefore removal may not be required. Further information will be obtained during more detailed testing phases of these sites.

Two geologic cross-sections were constructed from the boring logs of the test wells, monitoring wells installed for other investigations, and the results of the geophysical survey. Figure 4-2 shows the two cross-sections, A-A' (east-west) and B-B' (north-south). The lines of cross-section are shown on Figure 4-1. The cross-sections show that the thickness of the overburden deposits does not vary greatly, ranging from about 30 to 50 feet. Most of the overburden is composed of stratified drift, with some peat and fill present at the surface. The water table is shallow, being no more than seven feet below the ground surface across the study area.

Insert

Figure 4-2. Cross-Sections A-A’ and B-B’

5. CONCLUSIONS AND RECOMMENDATIONS

The test well investigation undertaken by the SSTTDC indicates that the sand and gravel deposits on the western side of the NAS are capable of producing enough water of good quality that further investigation is warranted. We recommend that aquifer yield and water quality be confirmed through comprehensive testing, as outlined below. We also recommend that the aquifer be protected from potential sources of contamination. This includes making certain that the cleanup of sites on the NAS proceeds such that no contamination will ever reach the wells.

Investigation of the site from this point forward will be regulated under the MADEP New Source approval process. The first step in the New Source process is submittal of a Request for Site Exam (RSE) to MADEP. The RSE includes, at a minimum, the results of the 2½-inch test well investigation, land use data, geologic data, projected potential environmental impacts, and a preliminary aquifer protection area (Zone II). Once MADEP reviews the RSE and conducts the Site Exam (visits the site), a pumping test proposal is submitted which outlines how a prolonged pumping test will be conducted. The prolonged pumping test can then be performed by installing and pumping one or more eight-inch diameter test wells for a minimum of five days to confirm well yield. Additional water quality samples are also collected during the prolonged pumping test to comprehensively characterize water quality.

The aquifer on the western side of the base is 25 to 45 ft thick and may require multiple wells in order to pump the volume required for development of the base without causing excessive drawdown of the water table. Multiple wells reduce drawdown by distributing the withdrawal over a large area. Multiple wells are also desirable because they provide system redundancy in the event of equipment failure or during periodic cleaning.

There are two potential locations for development of a public water supply, Site 1 in the field west of the western end of the east-west runway and Sites 5-01, 8-01 and 9-01, located in the wetlands west of French Stream. W&C recommends that both sites be investigated further to determine the best option. Examination of both sites will identify the potential permitting hurdles associated with each and can guide the SSTTDC in choosing which option is most desirable. This includes developing both sites into water supply sources.

W&C recommends that the New Source approval process be started by preparing and submitting a RSE to MADEP. The RSE will be for both locations (Site 1 and Sites 5-01, 8-01 and 9-01). The RSE will identify all potential environmental receptors, most notably vernal pools, wetlands and French Stream. By identifying environmental receptors and involving State agencies and other stakeholders early in the New Source process, the permitting process will be more predictable and manageable by providing an opportunity for State regulators to identify environmental baseline monitoring requirements, thus reducing the likelihood of project delay while data is collected. The data collected may include stream flow and groundwater level monitoring. The RSE will include data from the wetland and wildlife work already performed by Normandeau Assoc. and Rizzo Assoc.

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