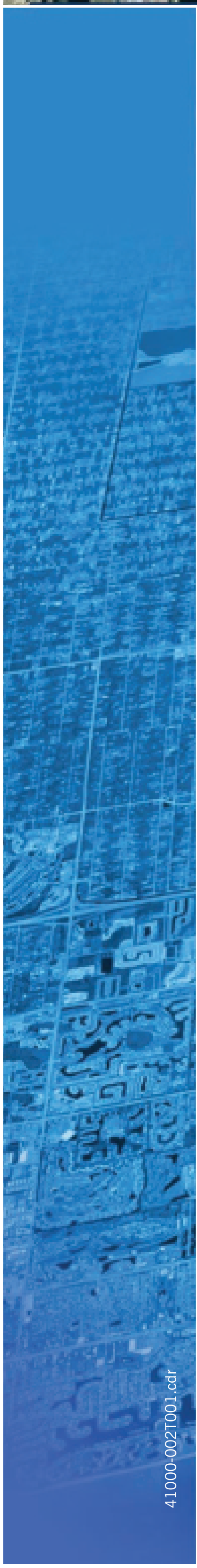
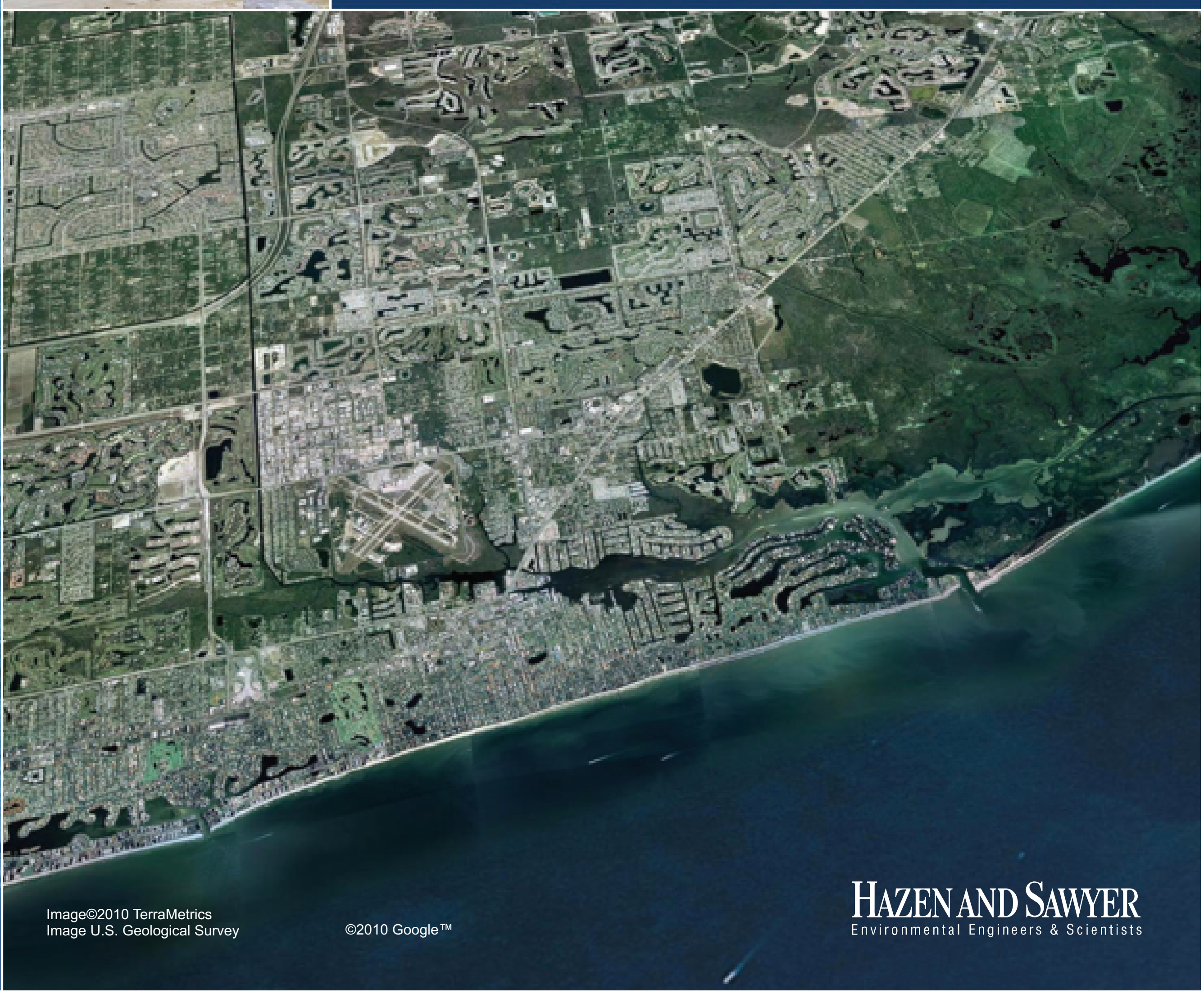
City of Naples
Well Completion Report for Aquifer Storage and Recovery Well No. 1

April 2010





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April 30, 2010

Robert Middleton
Utilities Director
CITY OF NAPLES
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City of Naples
ASR Test Well No. 1
Well Completion Report

Dear Mr. Middleton:

Enclosed please find a copy of the Well Completion Report summarizing the construction and testing activities of aquifer storage and recovery (ASR) test well number 1 (i.e., ASR-1). We sincerely appreciate the opportunity to assist the City of Naples with this challenging project.

As always, please feel free to call should you have any questions.

Very truly yours,
HAZEN AND SAWYER, P.C.

Albert Muniz, P.E. / Project Director
Vice President

c: David Graff / City of Naples
Ken Kemlage / City of Naples
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H&S – 41000-002.4.7

Acknowledgements

On behalf of Hazen and Sawyer, we would like to sincerely thank all of the individuals who assisted in making this project a success. We would especially like to thank the following:

City of Naples

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Mr. Robert Middleton / Utilities Director
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Mr. Ben Copeland / Budget and CIP Manager
Mr. Ken Kemlage / Water Reclamation Facility Superintendent
Ms. Alicia Acevedo
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Ms. Zayli Perez

Florida Department of Environmental Protection

Mr. David Rhodes
Mr. James Alexander
Mr. Joseph Haberfeld

South Florida Water Management District / Big Cypress Basin

Mr. Craig Boomgaard
Mr. Max Guerra

Diversified Drilling Corporation

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Executive Summary

EXECUTIVE SUMMARY

The City of Naples is seeking alternative water supplies in an effort to reduce potable water consumption. Historically, irrigation demands have been the largest demand on the City's potable water system. To reduce the stress on the potable water system and reduce the City's per capita consumption, the City has moved forward with development of alternative water supplies. This initiative is being implemented with regulators to ensure permit compliance. The City's alternative water supply plan consists of a strategy that includes close coordination with the Big Cypress Basin and the South Florida Water Management District (District), as well as the Florida Department of Environmental Protection (FDEP).

The City was issued a Water Use Permit (WUP) No. 11-00017-W on June 12, 2003. A renewal WUP application was prepared and submitted to the District in June 2008. A key component of the WUP is the implementation of an alternative water supply program to assist with reduction of potable water consumption. The proposed alternative water supply program consists of development of an ASR system that utilizes both reclaimed water and excess surface water.

This project represents completion of the first reclaimed water ASR well to assist the City in addressing irrigation demands. Supplemental water (i.e., surface water) from the Golden Gate Canal is also planned to further enhance recycling of excess waters. Excess reclaimed water and excess surface water are presently discharged to tide and lost as a resource. This project will enable the City to optimize use of resources and provide replacement water for irrigation. Discharge to tide will be reduced and possibly eliminated as a result of this program. In addition, the decrease of potable water use will extend the useful life of the wellfields and water treatment facilities.

Conclusions from the construction and testing of the ASR Test Well No. 1 (ASR-1) are as follow:

- The fresh water raw water sources located in the Tamiami Formation extend to a depth of approximately 175 feet below land surface at the project site

- The first brackish aquifer, known as the Hawthorn Zone 1, is present from a depth of approximately 320 to 420 feet below land surface. This aquifer contains brackish water and is not used by the City of Naples for raw water supply

- The deepest production horizon, known as the Lower Hawthorn, exists between depths of approximately 670 to 740 feet below land surface. This zone is highly brackish and is not used by the City for raw water supply purposes

- The 10,000 mg/L total dissolved solids interface was estimated to occur at a depth of approximately 760 feet below land surface based on information collected via geophysical logging and straddle packer tests. The 10,000 mg/L total dissolved solids interface is the base of potential sources of underground drinking water (USDW). This depth is important as FDEP has separate criteria for regulating systems completed below USDWs

- A potential storage zone was identified to exist between depths of 1,080 and 1,350 feet below land surface. This zone has been targeted as a potential storage horizon as it contains water with total dissolved solids greater than 10,000 mg/L and there appears to be separation between the targeted storage horizon and the USDW

- Adequate confinement appears to be present between the base of the USDW and the top of the potential storage zone based on packer test data

- The storage zone has adequate hydraulic conductivity to allow injection and recovery at rates from 700 gpm (~1 mgd) to possibly 1,400 gpm (~2 mgd) based on results of the step drawdown test. Specific capacity was estimated to range between 124 to 115 gpm/ft at pumping rates of 700 and 1,400 gpm, respectively

- The 24-inch diameter final casing successfully passed a casing pressure test and demonstrated mechanical integrity for an ASR type well

- The storage zone contains water with a total dissolved solids concentration of 28,600 mg/L

- The construction and testing was completed slightly above the contract amount due to additional testing suggested by FDEP

The following recommendations are suggested based on the information collected and evaluated to date:

- Collect core data to further assess the hydraulic characteristics of the confining zone between the base of the USDW at approximately 760 feet and the top of the storage zone at 1,080 feet

- Convert the existing exploratory well into a dedicated single zone monitor well that monitors the proposed storage zone (i.e., 1,080 to 1,350 feet) per discussions with FDEP

- Construct a single zone monitor well that monitors the first permeable zone near the USDW. The recommended monitoring interval is from 670 feet to 740 feet

- Conduct a pumping test to collect aquifer characteristics on the targeted storage horizon. The pumping test should use ASR-1 or ASR-2 for pumping and the other for monitoring purposes

- Submit Class V permit applications for all of the ASR wells

- Design temporary surface facilities to allow testing of the storage zone at ASR-1. The temporary facilities should also include wellheads at the monitor well and ASR-2 which will allow monitoring of water levels and collection of water samples during storage zone development at ASR-1

- Submit a request to FDEP to allow testing of the storage zone using highly treated reclaimed water at ASR-1

- Continue with implementation of the reclaimed water / surface water ASR system in a phased approach to allow for go / no-go checkpoints based on data collection

- Continue with implementation of the City's integrated water resources plan in support of the City's overall strategy to develop alternative water supplies

- Continue with the funding partnership with the South Florida Water Management District / Big Cypress Basin

Chapter 1.0
Introduction

1.1 Scope of Work

The City of Naples is seeking alternative water supplies in an effort to reduce potable water consumption. Historically, irrigation demands have been the largest demand on the City's potable water system. To reduce the stress on the potable water system and reduce the City's per capita consumption, the City has moved forward with development of alternative water supplies. This initiative is being implemented with regulators to ensure permit compliance. The City's alternative water supply plan consists of a strategy that includes close coordination with the Big Cypress Basin and the South Florida Water Management District (District), as well as the Florida Department of Environmental Protection (FDEP).

This element of the overall alternative water supply program includes construction and testing of an aquifer storage and recovery (ASR) test well. The ASR test well, identified as ASR-1, is the first of several planned ASR wells. This report summarizes the drilling and testing of ASR-1 as identified in the City's task order with Hazen and Sawyer, P.C. (H&S). A notice-to-proceed was issued to H&S on June 4, 2009 (Purchase Order No. 054219). This scope of work included design, permitting assistance and construction oversight for an ASR well. Also included is the preparation of a well completion report.

1.2 Background

The City of Naples was issued a Water Use Permit (WUP) No. 11-00017-W on June 12, 2003. The permit has an expiration date of June 12, 2008. A renewal WUP application was prepared and submitted to the South Florida Water Management District (District) in June 2008. To date, two requests for additional information have been issued by the District and responded to by the City. A key component of the WUP is the implementation of an alternative water supply program to assist with reduction of potable water consumption. The proposed alternative water supply program consists of development of an ASR system that utilizes both reclaimed water and excess surface water.

As previously mentioned, the City of Naples is implementing a reclaimed water ASR system to meet irrigation demands which will result in reduction of potable water use. Supplemental water (i.e., surface water) from the Golden Gate Canal is also planned to further enhance recycling of excess waters. Excess reclaimed water and excess surface water are presently discharged to tide and lost as a resource. This project will optimize use of resources and provide replacement water for irrigation. Discharge to tide will be reduced and possibly eliminated as a result of this program. In addition, the decrease of potable water use will extend the useful life of the wellfields and water treatment facilities.

Implementation of the City's water supply plan to use reclaimed water and excess surface water as replacement water to meet irrigation demands is well underway. The first ASR well has been constructed and permitting to allow testing with reclaimed water is ongoing. Future testing will incorporate storage of excess surface water from the Golden Gate Canal in addition to available reclaimed water. Reclaimed water is currently available and it is anticipated that the surface water component will be available within 3 to 5 years. In addition, the City Council has approved the 5-year water supply plan which, along with the Integrated Water Resources Plan, includes use of excess surface water presently lost to tide for underground storage and subsequent recovery to meet irrigation demands. Milestones for implementation of the various programs initiated by the City are presented below:

- Integrated Water Supply Plan – Approved by Resolution on October 2, 2008
- Expansion of reclaimed water distribution system – Ongoing
- Implementation of a reclaimed water / surface water ASR program
  - Construct exploratory well – Complete
  - Construct ASR Well No. 1 – Completed (Mar-10)
  - Design and Construction of additional ASR wells – Ongoing
  - Permitting of Class V ASR wells – Ongoing
  - Design and construction of surface water ASR facilities – Ongoing, Pre-design due July 2010
  - Anticipated completion of reclaimed water ASR program – 2014
- Investigation of stormwater ASR – Initiated

The ASR Test Well will complete the first step in the City's integrated water resources plan to implement strategies for prudent use of resources and meet future demands. Other ongoing and upcoming activities associated with this project are described below:

1. Prepare and submit conceptual ASR Plan
2. Prepare and submit Class V ASR Permit for ASR-1 to allow operational testing of well (i.e., cycle testing)
3. Prepare revised specifications for construction of second ASR well (i.e., ASR-2) at the WWTP site which include conversion of the exploratory well into a monitor well
4. Commence preliminary design and permitting for construction of intake structure and transmission piping to transport water from the Golden Gate Canal to the City's WWTP
5. Begin construction and testing of ASR-2.

6. Prepare and submit Class V ASR Permit for ASR-2 to allow testing of well with reclaimed water
7. Begin operational testing of ASR-1 using the existing irrigation distribution system
8. Begin operation testing of ASR-2 using the existing irrigation distribution system

It should be noted that the City has entered into a partnering agreement with the Big Cypress Basin / District as part of the District's grant program associated with development of alternative water supplies. The first year of this agreement has been successfully completed and the City is pursuing additional funding for the ASR program.

The above describes near-term activities that are planned by the City to implement an ASR system to address irrigation demands and reduction in potable consumption. An important aspect of this program will be additional data collection needed to address permit related issues. It is understood that additional testing will be required to clearly assess the void / cavity that is present at ASR-1 just below 1,160 feet. Design criteria used for construction of the City's ASR system includes identification of a storage zone below the USDW, providing separation between the storage zone and the USDW, and selection of a storage zone that will optimize recovery efficiency. The proposed plan to further evaluate this zone includes the following:

- Conduct cycle testing of the entire proposed storage zone and evaluate recovery efficiency. If recovery efficiencies are acceptable to the City, FDEP, and engineer, proceed with additional cycle testing and storage zone development. If system performance is unacceptable, implement a plan to plug the void, then continue cycle testing and storage zone development

- Convert the exploratory well to a monitor well which monitors the productive zone from 670 to 740 feet

- While Class V permitting is ongoing for ASR-1, collect addition information during construction of ASR-2 to further assess the targeted storage zone. Additional testing will include coring and packer testing. A smaller diameter pilot-hole will be proposed at ASR-2 to facilitate packer testing. The void at ASR-1 will be monitored during packer testing to evaluate hydraulic characteristics

- Conduct operational testing of ASR-1 and ASR-2 to provide confirmation of system performance and serve as the basis for final permitting of the ASR system

1.3 Purpose

The purpose of this report is to summarize the construction and testing activities of the first ASR well located at the City's water reclamation facility. Drilling sequence, testing results, geology encountered, and storage zone information (i.e., water quality and estimated hydraulic characteristics) is summarized. Copies of applicable permits and regulatory correspondence are also included. This information will be used in support of future permits and as a record of construction and testing activities in the referenced area.

Chapter 2.0
Well Construction and Testing

2.1 Well Construction

Construction and testing of ASR-1 was performed in accordance with the Contract Documents titled "Aquifer Storage and Recovery (ASR) Test Well Project – Wastewater Treatment and Reclamation Facility" City of Naples Bid # 034-09. The bid was approved by the City Council on July 16, 2009.

Construction of ASR-1 well commenced with the issuance of a Notice-to-Proceed (NTP) letter dated July 23, 2009. Per the NTP letter, the successful contractor, Diversified Drilling Corporation (DDC), was notified to commence work as of July 23, 2009. In addition, the contractor was instructed to mobilize within two weeks of the NTP and complete all work within 150 calendar days. Final completion was set for December 19, 2009.

Figure 1 shows the general location of the project site. A site plan of the water reclamation facility is presented in Figure 2. As shown in Figure 2, ASR-1 was constructed approximately 252 feet from the existing exploratory well. During the drilling of the well, geophysical logging and testing was performed in accordance with the contract documents. Table 1 presents a summary of the key dates during the construction and testing of ASR-1.

The drilling of ASR-1 generally proceeded as identified in the project specifications. The project specifications identified an outline of a drilling plan with the intention of making modifications to the plan as site specific conditions warranted. The plan included setting casing at selected depths to maintain the borehole integrity during drilling and to facilitate the proposed testing.

To consistently record down-hole depth, well measurements were recorded in terms of depth below land surface and / or elevations. Actual depths of casings are identified in the record drawings of the well. Construction and testing of ASR-1 generally proceeded as follows:

- Mobilize equipment and perform necessary site work including installation of pad monitor wells
- Install 42-inch diameter (0.375-inch wall thickness) steel pit casing to a depth of approximately 65 feet below land surface
- Drill a nominal 14-¾ inch diameter pilot-hole to approximately 450 feet below land surface using the mud rotary drilling method (Note: contractor elected to drill a 14-¾ inch pilot-hole in-lieu of the propose 8-inch diameter pilot-hole)
- Perform geophysical logging
- Ream borehole to nominal 42-inch diameter to a depth of 430 feet below land surface
- Perform geophysical logging

- Set and cement 34-inch diameter (0.375-inch wall thickness) steel surface casing to a depth of 430 feet below land surface
- Drill 14-¾ inch diameter pilot-hole to a depth of 1,500 feet below land surface using reverse-air drilling method
- Perform geophysical logging
- Conduct straddle packer tests at depths selected by the Engineer
- Ream pilot-hole to nominal 34-inch diameter to a depth of 1,080 feet below land surface
- Set and cement 24-inch diameter (0.500 inch wall thickness) seamless steel final casing to a depth of 1,080 feet below land surface
- Re-drill 14-¾ inch diameter pilot-hole to a depth of 1,500 feet below land surface using reverse-air drilling method
- Perform geophysical logging
- Cement pilot-hole to approximately 1,350 feet below land surface
- Drill a nominal 24-inch diameter borehole to approximately 1,350 feet below land surface using the reverse-air method
- Develop well
- Collect background water samples
- Perform step drawdown test
- Perform geophysical logging
- Disinfect well and install wellhead
- Demobilize and restore site

Information pertaining to the construction and testing of ASR-1 is included in the attached Appendices. Data collected during construction and testing was also forwarded to FDEP and the City with the weekly progress reports. Pertinent permitting information is included in Appendices 1 and 2.

2.2 Data Collection

Data was collected during the construction of the ASR test well (ASR-1) using various methods and procedures as described in this Section. Geophysical logging was performed by MV Geophysical, a subcontractor to Diversified Drilling Corporation. Water analyses were performed by a certified laboratory.

Measurements of footage in the wells are referenced in feet. A professional land surveyor established an elevation on the crown of the road using an existing manhole rim. Elevations at this location are as follow:

North American Vertical Datum (NAVD) of 1988	= 4.80 feet
National Geodetic Vertical Datum (NGVD) of 1928	= 6.06 feet
Difference	= 1.26 feet

To convert NGVD elevation to NAVD, 1.26 feet is subtracted from the NGVD elevation

Top of bottom flange elevation is 7.80 feet NAVD (88)

A copy of the survey information is included in the Appendices.

Daily progress and activities were monitored and recorded during construction and testing. The Engineer prepared daily progress reports during well construction along with weekly summaries. The Contractor prepared independent daily reports. Problems encountered during drilling were observed and noted. Activities related to the installation of well casings, cementing or other materials, as well as their quantities, were recorded. Detailed descriptions of test procedures and data collection were described and recorded. Copies of the daily and weekly progress reports were transmitted on a weekly basis to the Fort Myers and Tallahassee offices of FDEP.

2.3 Geologic Samples

Samples of drilled cuttings were collected and analyzed from the drilling of the ASR well. Circulation time (the time required for drilled cuttings to reach the surface) was calculated regularly to ensure that accurate sample depths were recorded. After initial examination, the Engineer's on-site personnel described the samples. A geologic description of each sample was entered into a log. The cuttings were classified in accordance with the scheme of Dunham (1962). A generalize hydrogeologic column and descriptions of each sample is included in Appendix No. 3. Two sets of drill cuttings were bagged in 5-foot intervals. After the wells were completed, the Contractor sent one set of these samples to the Florida Bureau of Geology in Tallahassee, Florida.

2.4 Casing

Casing heat numbers stamped on the casing were verified with the mill certificates prior to running casings in the hole. Copies of the casing mill certificates are presented in Appendix No. 4. Cementing plans for each casing string were proposed by the Contractor and reviewed by the Engineer prior to cementing. After accepting the proposed plan, casing was set and cemented. A summary of cementing is also included in Appendix No. 4. Figure 3 presents well completion information of the exploratory test well located adjacent to ASR-1. Information from construction of the exploratory well was utilized during construction of ASR-1 to identify underground conditions. The City intends to convert this exploratory well into a monitor well during the next phase of the reclaimed water ASR program. Construction details of ASR-1 are presented in Table 2 and shown graphically in Figure 4.

2.5 Geophysical Logs

Geophysical logging was used to obtain information of underground conditions at various stages during the construction and testing of ASR-1. In general, geophysical logging was conducted at the completion of each stage of borehole drilling. These logs assisted in identifying the geologic formations encountered, quantifying water quality with respect to depth, identifying confining sequences and production horizons. The geophysical logs performed, including a brief description of the information provided by the logs, are as follows:

- X-Y Caliper – Identification of borehole diameter and geometry
- Gamma Ray – Measurement of the natural gamma ray radiation of the formation, used as a tie-in between logs

- Dual Induction Log (A resistivity log) – Identifies differentiation between limestone and dolomite beds, and, along with the gamma ray log, is useful in the correlation of lithologic units
- Borehole Compensated Sonic Variable Density Log (VDL) – Identification of the confining sequences, as well as identification of zones that could cause problems during cementing
- Flow Meter Surveys – Determination of where fluid may be entering or exiting the borehole
- Temperature – Provides a profile of static and dynamic temperature of the borehole, may be useful in determining changes in fluid movement
- Televisions Survey – Determination of where structural features (bedding planes, fractures, vugs and voids) are located

Geophysical logs were transmitted to FDEP members on a weekly basis during construction once the logs were available. Copies of the logs can be found in CD format in Appendix No. 5. A summary of the geophysical logs is presented in Table 3. Information obtained from the geophysical logs was reviewed along with geologic samples to prepare a hydrogeologic profile of the formations encountered. Figure 5 presents a generalized hydrogeologic section from data collected during drilling and testing of ASR-1.

2.6 Video Logs

Color video surveys were made with the camera lens in two positions; down-hole with a radial view and up-hole with a horizontal rotating position. Air development and / or artesian flow were used to displace suspended solids from the well prior to performing the television survey. The open-hole survey allowed for visual inspection of formations encountered in the borehole, as well as to observe potential fractures and water-producing zones. Acceptable picture clarity was obtained in the surveys.

A video survey of the 14-¾ inch pilot-hole was performed on October 5, 2009. Appendix No. 5 contains a copy of the video survey and a log describing the formation and structural features observed in the open-hole of the ASR well. On April 15, 2010, a video survey of the completed well was conducted. As with the previous video survey, a copy along with descriptions of features observed is included in Appendix No. 5.

2.7 Packer Tests

Straddle packer tests were performed on the 14-¾ inch diameter pilot-hole of ASR-1. Packer tests were conducted at intervals to support demonstration of confinement, to determine water quality so as to define the base of the Underground Source of Drinking Water (USDW), and to identify potential zones of interest. Results of the composite water samples collected during drilling of the pilot-hole are included in Appendix No. 6.

Packer testing was performed by setting two inflatable packers (plugs) at a selected depth and pumping from the interval between the packers. The packers were used to isolate zones to perform drawdown and recovery tests. The straddle packer intervals were selected based on reviewing and interpreting information from geophysical logs, lithology, and other packer tests. A total of four straddle packer tests were performed in ASR-1.

The packers were lowered into the pilot-hole to the selected interval on the 6-⅝ inch (outside) diameter drill pipe, inflated and seated against the formation. A 4-inch diameter submersible pump was lowered into the drill pipe approximately 200 feet to introduce stress on the isolated interval. Prior to starting the tests, each zone was developed free of any drilling fluids by means of air lifting and pumping until the specific conductance stabilized. The isolated zone was then allowed to recover from development before beginning the pumping test. During drawdown and recovery, water level measurements were obtained using a data logger attached to a pressure transducer (In-situ Hermit 3000). The method of analysis used on the data collected and recorded during the packer tests was the Modified Non-Equilibrium Formula derived by Cooper and Jacob (1946). The equation of the Cooper-Jacob method is as follows:

$$T = \frac{264Q}{\Delta s}$$

T = coefficient of transmissivity (gallons per day / foot)
Q = pumping rate (gallons per minute)
Δs = change in drawdown over one log cycle (feet)

The calculated hydraulic conductivity from the packer tests are presented in Table 4. The raw packer test data and data plots are presented in Appendix No. 7. Based on the stabilization of the fluid specific conductance prior to starting the packer tests and the drawdown characteristics of the data shown in this Appendix, the hydraulic conductivity values presented from the packer tests are considered valid.

2.8 Water Quality

Water samples obtained during the packer tests were analyzed in the field for temperature and conductivity. These water samples, which were collected during the drawdown phase of the packer tests, were also sent to an independent laboratory for additional analysis. The samples were analyzed and the results are presented in Appendix No. 7. A compilation of the packer test water quality data is presented in Table 5. Log derived water graphs were prepared to compare to the packer test water quality test. This graph shows good correlation, and is presented in Appendix No. 6.

2.9 Casing Pressure Test

On February 22, 2010, the 24-inch diameter final casing was pressurized to 153.00 pounds per square inch (psi). The pressure test was started at 1:50 PM. Mr. Rhodes from FDEP was onsite to witness the casing pressure test. Pressure readings were recorded at five minute increments for a period of one hour. The final pressure reading after 60 minutes was 152.50 psi. FDEP allows a variance of up to 5% of the initial pressure which would allow an increase or decrease of 7.65 psi during the one hour test period. The actual pressure change observed at the end of 60 minutes was 0.50 psi or 0.33%, which is within the allowable 5% limits.

Results of the casing pressure test are included in Appendix No. 8 along with the pressure gauge calibration certificate.

2.10 Pumping Test

A step drawdown test was conducted in March 2010 to obtain information on the selected storage zone. The testing included collection of background water levels, pumping water levels, and recovery water levels. A copy of the test data is included in Appendix No. 9. Test data is presented in both tabular and graphical form.

The step drawdown testing was conducted in two parts. The first part consisted of a three step test whereby the well was pumped at rates of approximately 700, 1400, and 2,100 gpm. Drawdown measurements were collected and an estimate of the specific capacity calculated. The second part of the step drawdown test consisted of a single pumping rate. The pumping rate for the second test was approximately 1,000 gpm. As with the previously test, drawdown measurements were collected and the specific capacity was estimated. Below is a summary of the testing results:

Step Drawdown Test Results		
Pumping rate (gpm)	**Drawdown** (feet)	**Specific Capacity** (gpm/ft)
700	5.64	124
1,400	12.18	115
2,100	19.45	108

In addition to the step drawdown test, a short withdrawal test was conducted to estimate the transmissivity of the storage zone. The withdrawal test was conducted at a pumping rate of approximately 1,000 gpm and a transmissivity of 105,600 gpd/ft was estimated using the Modified Non-Equilibrium Formula derived by Cooper and Jacob (1946). A withdrawal test with a monitor well completed in the same horizon is recommended to obtain a more accurate estimate of the characteristics of the storage zone.

Background water samples were collected at the completion of the step drawdown testing. Results from the laboratory testing are included Appendix No. 10.

2.11 Construction Costs

The City of Naples bid the referenced work in one bid package. Bids were advertised on June 9, 2009. Two addendums were issued on July 25, 2009, to clarify questions raised during the pre-bid meeting held on June 17, 2009. The bid opening was held on July 2, 2009 and a recommendation letter was submitted on July 14, 2009, recommending award of the contract to DDC in the amount of $783,783.00. The City Council approved award of the contract on July 16, 2009. As previously noted, a Notice-to-Proceed was issued on July 23, 2009 (City Bid No. 034-09; City Project Number 09K53). A final completion date, based on 150 calendar days, was set for December 19, 2009.

A summary of the contract is provided below:

Contractor	Diversified Drilling Corporation
Part 1 – Construction of ASR-1	$758,783.00
Part 2 – Allowance	$25,000.00
Total Bid	$783,783.00

Contractor – Diversified Drilling Corporation

Contract Amount	$ 758,783.00
Allowance	$ 25,000.00
Change Order No. 1[A]	$ 41,118.50 +
Total	$ 824,901.50
Variance	$ 41,118.50 (5.2%)

[A] – *Change Order Includes work directives*

2.12 Project / Program Schedule

The City of Naples issued a NTP on July 23, 2009. The contract noted that work was to be completed within 150 days of issuance of the NTP, or by December 19, 2009. Substantial completion was to be completed by November 19, 2009, which is within 120 days of issuance of the NTP.

DDC was able to mobilize immediately upon receipt of the NTP. Some delays were experienced due primarily to revisions to the drilling and testing plan. Substantial completion was achieved on March 9, 2010. Demobilization and site restoration was concluded in April 2010 representing final completion.

This project is one component of a multi-phase ASR program that the City of Naples is implementing to develop a reclaimed water / surface water ASR system to meet irrigation demands which will result in a reduction of potable water consumption.

Completion of this project represents closure of one element of the City's water supply plan to use reclaimed water and excess surface water as replacement water to meet irrigation demands and reduce potable water use. Permitting to allow testing with reclaimed water at ASR-1 is ongoing. Future testing will incorporate storage of excess surface water from the Golden Gate Canal in addition to available reclaimed water. Reclaimed water is currently available and it is anticipated that the surface water component will be available within 3 to 5 years. In addition to this project, the City Council has approved the 5-year water supply plan which along with the Integrated Water Resources Plan includes use excess surface water presently loss to tide for underground storage and subsequent recovery to meet irrigation demands. Milestones for implementation of the various programs initiated by the City are presented below:

- Integrated Water Supply Plan – Approved by Resolution on October 2, 2008
- Expansion of reclaimed water distribution system – Ongoing
- Implementation of a reclaimed water / surface water ASR program
  - Construct exploratory well – Complete
  - Construct ASR Well No. 1 – Complete
  - Design and Construction of additional ASR wells – Ongoing
  - Permitting of Class V ASR wells – Ongoing
  - Design and construction of surface water ASR facilities – Ongoing, Pre-design due July 2010
  - Anticipated completion of reclaimed water ASR program – 2014
- Investigation of stormwater ASR – Initiated

Chapter 3.0
Subsurface Conditions

3.1 Generalized Geologic Setting

Geophysical logging, review of drill cuttings, and packer testing were used to confirm the presence of a suitable confining sequence and identify a potential storage zone. Results of the evaluation and analysis to formulate the general geologic setting at the project site are presented herein.

The stratigraphic sequence underlying the City of Naples water reclamation facility site was determined from microscopic analysis of drill cuttings, correlation with geophysical logs run on 14 ¾ -inch diameter pilot-holes drilled for the ASR test well, and comparison with similar projects in southwest Florida. The stratigraphic units penetrated by the site wells were, from the surface downward, the undifferentiated Quaternary Deposits (Pleistocene to Holocene), the Tamiami Formation (Pliocene), the Hawthorn Group consisting of the Peace River Formation and the Arcadia Formation (Micoene), and the Suwannee Limestone (Oligocene). A lithologic description of the cuttings is included in Appendix No. 3. Copies of the geophysical logs, which were previously submitted with weekly reports, are included in Appendix No. 5 and contain a CD of the logs.

Pleistocene to Holocene Series

Undifferentiated Quaternary Sediments – The undifferentiated sediments at the project site are characterized by yellowish brown to light gray, organics, fine to medium-grained quartz sand and shell. The undifferentiated sediments extended to a depth of approximately 60 feet at ASR-1.

Pliocene Series

Tamiami Formation – The Tamiami Formation at the site is characterized by brownish gray sandy limestone, shelly sandstone, and quartz sandstone. The Tamiami Aquifer is layered and contains several horizons that can be used for water supply purposes. This aquifer is present from depths of approximately 40 feet to 130 feet in the area of the City's wellfields. The deeper portions of the Tamiami Aquifer are commonly known as the Lower Tamiami and are the primary unit used by the City for water supply. The Coast Ridge Wellfield withdraws from a horizon between 48 feet to 96 feet in depth, while the East Golden Gate Wellfield withdraws from a production zone between 37 feet to 137 feet below land surface. An important aspect of the Lower Tamiami is the natural separation that exists between the upper water table aquifer and the Lower Tamiami; and between the Lower Tamiami and the deeper Sandstone Aquifer and a production horizon known as Hawthorn Zone 1. The unit is indicated by a low uniform gamma ray responses noted in the geophysical logs. The contact of the sandy limestone in the Tamiami Formation with the underlying greenish clay of the Hawthorn Group is distinctive. Evaluation of data suggests that the Tamiami Formation extends from approximately 60 feet to 175 feet below land surface at the ASR test well site.

<u>Miocene Series</u>

Hawthorn Group – The Hawthorn Formation contains both the Peace River Formation and the underlying Arcadia Formation. At the ASR test well site, the Hawthorn Group is characterized by greenish-gray calcareous sandy clay, clayey-sand, and light brownish-gray sandy limestone. The unit is indicated by a consistent, moderate gamma ray signature with a sharp peak in the gamma ray response at the base of the unit at. There is a distinct change in lithology from light-colored sandy limestone of the overlying Tamiami Formation to greenish clay at the top of the unit at around 175 feet. The base of the Hawthorn Group is estimated to be around 790 feet below land surface.

The slightly brackish Hawthorn Zone 1 production horizon is present at the ASR test well site between the approximate depths of 320 feet and 420 feet. This aquifer is used in some parts of the region for water supply purposes, but there are no wells within several miles of the project site. The City does not use the brackish Hawthorn Zone 1 production zone for water supply purposes. Additional separation is present between the Hawthorn Zone 1 production zone and the Lower Hawthorn production zone. The brackish Lower Hawthorn production zone extends from 670 feet to 740 feet at the project site and is not used for water supply purposes by the City. This production zone is used by others several miles away for water supply purposes. Underlying the Hawthorn Group is the Suwannee Limestone which extends from approximately 790 feet to the total depth of the ASR test well (i.e., 1,500 feet).

<u>Oligocene Series</u>

Suwannee Limestone – The Suwannee formation at the site is characterized by shelly sandy clay. The top of the unit is indicated by a shift in the gamma ray log to higher counts, and by a reduction in borehole size, indicated by the caliper log, at approximately 790 feet. The reduction in borehole size appears to be related to the greater competency of the Suwannee formation relative to the overlying Arcadia Formation. The base of the Suwannee formation was not established as the pilot-hole only extended to 1,500 feet.

A summary of the estimated geologic formations conditions encountered at the City of Naples water reclamation facility is presented below:

FORMATION NAME	INTERVAL		APPROXIMATE THICKNESS
	from	to	
Undifferentiated Quaternary Deposits	0	~ 60	60
Tamiami Formation	~ 60	~175	115
Hawthorn Group	~ 175	~790	615
Suwannee Limestone	~ 790	1,500 ?	710 ?

Note: All numbers are in feet below land surface

3.2 Hydrogeologic Setting

There are several production horizons in the area surrounding the project site. The primary and closest raw water supply source is the Tamiami Formation. This unit is the primary source for raw water supply for the City of Naples. Production from this horizon is low to moderate. Water quality is generally fresh, but may become brackish near the Gulf of Mexico.

A production zone known as the Hawthorn Zone 1 is moderately productive. This production zone is found at the project site from approximately 320 to 420 feet below land surface. The zone is artesian and contains water that is considered brackish. The City of Naples does not use this zone for raw water supply.

Near the base of the Hawthorn Group is a production horizon known as the Lower Hawthorn. The zone can be brackish to almost saline. At the project site, the zone has moderate to high productivity and is artesian. Concentrations of total dissolved solids (TDS) are near 10,000 mg/L in this horizon at the project site. The 10,000 mg/L TDS interface is important as this marks the location of the lowermost potential underground source of drinking water (USDW). The base of the USDW is defined as water having a TDS concentration of less than or equal to 10,000 mg/L.

A potential storage zone below the USDW was identified during testing. A flow log was conducted when the pilot-hole reach the 1,500 feet. This log was used to locate production zones with respect to depth and to estimate yield from respective flow zones. The flow log in conjunction with other logs was analyzed to estimated flow zones. It was observed that some intervals which show increased porosity did not appear to be productive. A copy of the flow log and caliper log is included in Appendix No. 5.

The flow log shows that the majority of flow originates from the Lower Hawthorn production zone between 670 and 740 feet in depth. This production horizon accounts for almost 60 percent of the total flow observed. Slight production was observed around 860 feet and then again around 890 feet in depth. There is little production observed from 900 feet to approximately 1,080 feet. Three small production zones appear to exist between 1,080 and 1,240 feet. Another small production zone appears between 1,330 and 1,345 feet. It should be noted that the void from approximately 1,160 to 1,185 feet did not result in major flow, suggesting that this void is not indicative of a highly fractured formation that yields significant amounts of water. Data from the temperature logs and fluid resistivity logs correlate well with the observed production zones. While the sonic porosity log indicates that the interval from 1,080 to 1,140 appears to have higher porosity, the productive interval appears to begin around 1,160 feet and extends to approximately 1,220 based on the temperature and flow logs. It is noted that the porosity is not necessarily indicative of hydraulic conductivity as evident by the fact that the flow log shows production at depths slightly below 1,150 while the porosity appears relatively high between 1,080 and 1,150 feet.

Based on the above findings and discussions with FDEP, a potential storage zone between 1,080 and 1,350 feet was selected for further testing and analysis. The depth of 1,080 was chosen as this interval appears to have relatively high porosity as indicated by the sonic porosity log. In addition, natural separation appears to exist between this depth and the estimated base of the potential

USDW. Hence, a request to set the 24-inch diameter casing at 1,080 feet with an open hole to 1,350 feet was submitted and approved by FDEP.

3.3 Water Quality

A key factor in the design of the reclaimed water ASR system was identifying the base of the USDW. Water samples were collected from isolated sections of the borehole during straddle packer testing. The water samples from the packer tests were analyzed for selected parameters to establish background water quality and to identify the 10,000 mg/L TDS interface. Table 6 summarizes the results of the laboratory analyses from the packer tests.

The base of the USDW was identified by performing water quality analysis on samples obtained from packer tests and geophysical log interpretation. Data compiled from geophysical logs, including the dual induction log, was useful in determining the base of the USDW. This data along with the log derived water quality log places the base of the USDW at approximately 760 feet below land surface. This data was confirmed by the water quality results of the packer test conducted in ASR-1 between 785 and 805 feet that yielded a TDS concentration of 12,000 mg/L. A copy of the log derived water quality graph from ASR-1 is included in Appendix No. 5. Figure 6 shows the location of the USDW with respect to the production zones.

3.4 Confinement Analysis

The approach to the evaluation of vertical confinement at the City of Naples water reclamation facility site included review of available borehole geophysical, and analysis of geological data and open-hole testing data. This information was used to identify intervals from 760 feet (i.e., base of the USDW) to 1,080 feet that exhibited confining properties. The vertical confinement provided by each interval was then evaluated. Particular attention was paid to locating beds of limestone, dolomite, clay or marl that have low vertical hydraulic conductivities and are not penetrated by fractures and/or solution cavities. Such tight beds provide the primary vertical confinement of the injected fluids.

3.4.1 Identification of Confining Units

The presence of satisfactory confining sequences between 760 and 1,080 feet below land surface was established during the drilling of ASR-1. A letter previously submitted to the FDEP documented the presence of this confinement on site. This letter from the Engineer is dated December 7, 2009, and is referred to as “the 24-inch diameter casing seat request”.

3.4.2 Geophysical Logs

The geophysical logs for ASR-1 were examined in detail for the presence of units of rock that could provide vertical confinement for injected fluids. A combination of sonic, caliper and resistivity logs were used to identify well-cemented limestone and/or dolomite beds that would be expected to have low matrix porosities and hydraulic conductivities. The television survey was used to locate fractures and / or cavernous zones that could be conduits for vertical fluid flow. Information on the orientation and thickness of beds was also obtained from the television survey.

The development and conditioning of the wells prior to logging is not an issue for the sonic, caliper, gamma ray, temperature, resistivity logs and television survey as these logs were designed to and are often run in mudded boreholes. Fine scale features, such as bed contacts, are readily distinguishable on the television survey, which indicates that borehole conditions did not have a significant adverse effect on log quality.

Flow meter, temperature, and fluid resistivity / conductivity logs provide information on the location of flow zones into wells and on changes in the salinity of formation waters. These logs did not provide useful information concerning vertical confinement. Flow meter logs provide limited value for identifying individual beds with low vertical hydraulic conductivities because a single zone of high hydraulic conductivity very often dominates the flow for the entire tested interval

3.4.3 Characterization of Well Cuttings

Cuttings collected during the pilot-hole drilling of ASR-1 (land surface to 1,500 feet) were examined in detail for lithology. The cuttings were grab samples collected at 5-foot intervals during the construction of the well. The lithology of the limestone cuttings was characterized using the limestone classification scheme of Dunham (1962). The most common grain types were silt to fine-sand sized rounded carbonate grains that are described as either peloids (fecal pellet-shaped grains of indeterminate origin) or as bioclasts (transported fossil fragments). The mineralogy of the samples (calcite versus dolomite) was confirmed by reaction with dilute hydrochloric acid. Dolomite was classified according to crystal size as being either microcrystalline (crystals are not visible with the low-powered microscope), finely crystalline (1/64 to 1/16 mm) or medium crystalline (1/16 to 1/4 mm).

3.4.4 Packer Test Data

Straddle packer test data collected during the drilling of ASR-1 were designed to collect water quality data and for information on the hydraulic conductivity. The straddle packer data collected to evaluate hydraulic characteristics were analyzed using the Cooper and Jacob (1946) modification of the Theis (1935) non-equilibrium equation (i.e., the straight line method). The transmissivity values calculated from both the pumping and recovery phase data for each test were similar. The summarization of the results of the packer tests is attached.

A total of four packer tests were conducted at ASR-1. The packer tests were designed to collect information on hydraulic characteristics and / or to collect depth specific water quality data. The packer test conducted from 900 to 920 feet was intended to collect water quality data for confirmation of the log derived water quality log. Modifications to the packer elements were required for the contractor to seal off the borehole. The contractor equipped the packer elements with sleeves to allow extension of the packer elements. Results from the packer testing are presented in Appendix No. 7. A summary of the packer test water quality results is presented in Table 4.

It should be noted that the transmissivity and average hydraulic conductivities values calculated from the packer test data are largely a function of horizontal hydraulic conductivities. Packer test data thus tend to overestimate vertical hydraulic conductivities. For example, a packer test performed on an interval containing one or more high hydraulic conductivity beds inter-bedded between very low hydraulic conductivity beds would give a high transmissivity and average hydraulic conductivity value whereas the interval would have a very low vertical hydraulic conductivity. Table 5 summarizes the hydraulic conductivity derived from the packer tests.

Packer test data collected between the estimated USDW and the targeted storage zone indicated good confining characteristics. Additional data collection is planned during construction of the second ASR well at this site to further define the confining intervals.

3.4.5 Criteria for Identification of Confinement Units

Beds or intervals of rock that are likely to offer good vertical confinement were identified using the following criteria:

- Low sonic transit times
- Variable density log (VDL) pattern consisting of straight parallel vertical bands, where lithology is relatively uniform, or a "chevron" pattern of continuous parallel bands, where the formation consists of inter-bedded rock with differing densities and/or degrees of consolidation. Fractured rock typically has an irregular VDL log pattern
- Low hydraulic conductivities calculated using packer pump test data
- A high degree of cementation (hardness) as observed in microscopic examination of cuttings and core samples
- Borehole diameters on caliper logs close to the bit size.
- Absence of evidence of fractures on the television survey

3.4.5.1 Confinement Intervals

An analysis of confinement was performed to evaluate units that provide separation between the proposed storage zone and the USDW. This analysis was conducted using the confinement properties of the strata between the base of the USDW (760 feet) and 1,080 feet (i.e., the top of the storage zone).

Interval from 750 to 1,000 feet below land surface – This interval consists predominantly of light-colored limestone. Wackestones and packstones are the most common lithologies. The wackestones and packstones are interbedded with beds of carbonate-mud rich lithologies (fossiliferous mudstones and grainstones). The borehole television log indicates that the beds are horizontal and range in thickness from approximately 0.5 to 10 feet. The bedding appears to consist of stacked sequences of carbonate sand-rich (wackestones and packstones) and carbonate mud-rich (packstones to mudstones) limestones. The mudstone and wackestone beds, which have low macroporosities and are well cemented, can provide better vertical confinement than the thicker grainstone and packstone beds

Interval from 750 to 1,000 feet below land surface – This interval consists of interbedded light-colored limestones and dolomites. Grainstones and packstones are the most common lithologies. The grainstones and packstones are interbedded with beds of carbonate-mud rich lithologies (fossiliferous mudstones and wackestones). The borehole television log indicates that the beds are horizontal and range in thickness from approximately 0.5 to 10 feet. The bedding appears to consist of stacked sequences of carbonate sand-rich (grainstones and packstones) and carbonate mud-rich (packstones to mudstones) limestones. The mudstone and wackestone beds, which have low macroporosities and are well cemented, can provide better vertical confinement than the thicker grainstone and packstone beds.

3.4.5.2 Confinement Summary

During the drilling and testing of the ASR test well (ASR-1) at the City's water reclamation facility site, an extensive program was implemented to identify confinement between the base of the USDW estimated to occur at 760 feet and the top of the proposed storage zone at 1,080 feet. A number of packer tests were performed over this interval during this preliminary investigation. It should be noted that additional smaller intervals also may also exist up to the base of the USDW that provide additional confinement. Additional information on the confining interval will be collected and submitted to FDEP during construction of the second ASR well to further define the characteristics of this interval.

Chapter 4.0
Conclusions and Recommendations

4.1 Conclusions

The purpose of this report is to summarize the construction and testing activities of the ASR Test Well located at the City of Naples Water Reclamation Facility. This information will be used in support of future permits and as a record of construction and testing activities.

Conclusions from the construction and testing of the ASR Test Well No. 1 (ASR-1) are as follow:

- The fresh water raw water sources located in the Tamiami Formation extend to a depth of approximately 175 feet below land surface at the project site

- The first brackish aquifer, known as the Hawthorn Zone 1, is present from a depth of approximately 320 to 420 feet below land surface. This aquifer contains brackish water and is not used by the City of Naples for raw water supply

- The deepest production horizon, known as the Lower Hawthorn, exists between depths of approximately 670 to 740 feet below land surface. This zone is highly brackish and is not used by the City for raw water supply purposes

- The 10,000 mg/L total dissolved solids interface was estimated to occur at a depth of approximately 760 feet below land surface based on information collected via geophysical logging and straddle packer tests. The 10,000 mg/L total dissolved solids interface is the base of potential sources of underground drinking water (USDW). This depth is important as FDEP has separate criteria for regulating systems completed below USDWs

- A potential storage zone was identified to exist between depths of 1,080 and 1,350 feet below land surface. This zone has been targeted as a potential storage horizon as it contains water with total dissolved solids greater than 10,000 mg/L and there appears to be separation between the targeted storage horizon and the USDW

- Adequate confinement appears to be present between the base of the USDW and the top of the potential storage zone based on packer test data

- The storage zone has adequate hydraulic conductivity to allow injection and recovery at rates from 700 gpm (~1 mgd) to possibly 1,400 gpm (~2 mgd) based on results of the step drawdown test. Specific capacity was estimated to range between 124 to 115 gpm/ft at pumping rates of 700 and 1,400 gpm, respectively

- The 24-inch diameter final casing successfully passed a casing pressure test and demonstrated mechanical integrity for an ASR type well

- The storage zone contains water with a total dissolved solids concentration of 28,600 mg/L

- The construction and testing was completed slightly above the contract amount due to additional testing suggested by FDEP

4.2 Recommendations

The following recommendations are suggested based on the information collected and evaluated to date:

- Collect core data to further assess the hydraulic characteristics of the confining zone between the base of the USDW at approximately 760 feet and the top of the storage zone at 1,080 feet

- Convert the existing exploratory well into a dedicated single zone monitor well that monitors the proposed storage zone (i.e., 1,080 to 1,350 feet) per discussions with FDEP

- Construct a single zone monitor well that monitors the first permeable zone near the USDW. The recommended monitoring interval is from 670 feet to 740 feet

- Conduct a pumping test to collect aquifer characteristics on the targeted storage horizon. The pumping test should use ASR-1 or ASR-2 for pumping and the other for monitoring purposes

- Submit Class V permit applications for all of the ASR wells

- Design temporary surface facilities to allow testing of the storage zone at ASR-1. The temporary facilities should also include wellheads at the monitor well and ASR-2 which will allow monitoring of water levels and collection of water samples during storage zone development at ASR-1

- Submit a request to FDEP to allow testing of the storage zone using highly treated reclaimed water at ASR-1

- Continue with implementation of the reclaimed water / surface water ASR system in a phased approach to allow for go / no-go checkpoints based on data collection

- Continue with implementation of the City's integrated water resources plan in support of the City's overall strategy to develop alternative water supplies

- Continue with the funding partnership with the South Florida Water Management District / Big Cypress Basin

TABLES

TABLE 1 - Summary of Testing Dates

City of Naples ASR Test Well No. 1 (ASR-1)

INDENTIFICATION	DESCRIPTION	TESTING DATE
ASR Test Well No. 1 (ASR-1)	Notice-to-Proceed	July 23, 2009
	Begin mobilization	July 29, 2009
	Set pit casing	August 7, 2009
	Set 34" casing to 430 feet	September 15, 2009
	Set 24" casing to 1,080 feet	January 5, 2010
	Conduct casing pressure test	February 22, 2010
	Conduct aquifer withdrawal test	March 5 & 6, 2010
	Collect background water samples	March 8 & 9, 2010

TABLE 2 - Casing Schedule

City of Naples ASR Test Well No. 1 (ASR-1)

CASING RUN	DIAMETER (inches)		DEPTH	MATERIAL	WALL THICKNESS
	Inside	*Outside*	(feet)		(inches)
ASR Test Well No. 1 (ASR-1)					
Pit Casing	41.250	42.000	65	Steel	0.375
Surface Casing	33.250	34.000	430	Steel	0.375
Final Casing	23.000	24.000	1,080	Steel	0.500
Total Well Depth	---	---	1,350	---	---

TABLE 3 - Geophysical Logging Schedule

City of Naples ASR Test Well No. 1 (ASR-1)

ASR Test Well No. 1 (ASR-1)

CONSTRUCTION PHASE	INTERVAL	DATE	GEOPHYSICAL LOGS
14-3/4 inch pilot-hole	0 to 450 feet	28-Aug-09	X-Y capliper, Gamma ray, Borehole compensated sonic w/ variable density, Dual induction LL3, Spontaneous potential
42-inch reamed hole	0 to 435 feet	05-Sep-09	X-Y capliper, Gamma ray
42-inch reamed hole	0 to 435 feet	05-Sep-09	X-Y capliper, Gamma ray
14-3/4 inch pilot-hole	430 to 1,500 feet	05-Oct-09	Television survey
14-3/4 inch pilot-hole	430 to 1,500 feet	07-Oct-09	X-Y capliper, Gamma ray, Borehole compensated sonic w/ variable density, Dual induction LL3, Spontaneous potential
14-3/4 inch pilot-hole	430 to 1,500 feet	07-Oct-09	X-Y capliper, Gamma ray, Fluid conductivity, Temperature, Flowmeter
34-inch reamed hole	430 to 1,080 feet	16-Dec-09	X-Y capliper, Gamma ray
34-inch reamed hole	430 to 1,080 feet	28-Dec-09	X-Y capliper, Gamma ray
14-3/4 inch pilot-hole	1,080 to 1,500 feet	01-Feb-10	X-Y capliper, Gamma ray
24-inch reamed hole	1,080 to 1,350 feet	10-Mar-10	X-Y capliper, Gamma ray
24-inch reamed hole	0 to 1,350 feet	18-Mar-10	X-Y capliper, Gamma ray
24-inch hole	430 to 1,500 feet	15-Apr-10	Television survey

TABLE 4 - Estimated Hydraulic Conductivities from Packer Testing

City of Naples ASR Test Well No. 1 (ASR-1)

INTERVAL	WELL	PUMPING RATE (gpm)	DRAWDOWN (feet)	SPECIFIC CAPACITY (gpm / ft)	ESTIMATED HYRDAULIC CONDUCTIVITY	
					Drawdown (cm / sec)	Recovery (cm / sec)
785 - 805	ASR-1	69.0	47.3	1.46	0.00776310	0.00321110
1,005 - 1,025	ASR-1	65	21.6	3.00	0.00815970	0.00189980
1,105 - 1,125	ASR-1	26.0	71.49	0.36	0.00093157	0.00078574

gpm = gallons per minute
gpm / ft = gallons per minute per foot
cm / sec = centimeters per second

TABLE 5 - Estimated Hydraulic Conductivities from Packer Testing

City of Naples ASR Test Well No. 1 (ASR-1)

INTERVAL	WELL	WATER QUALITY			PURPOSE OF TEST
		Chloride (mg/L)	TDS (mg/L)	Conductivity (µmhos/cm)	
785 - 805	ASR-1	6,400	12,000	16,600	To assess hydraulics and water quality
900 - 920[A]	ASR-1	12,800	23,400	32,400	To assess water quality
1,005 - 1,025	ASR-1	14,200	27,900	34,600	To assess hydraulics
1,105 - 1,125	ASR-1	14,500	25,600	35,600	To assess hydraulics

A - packer test conducted prior to retro-fitting packers with sleeves

FIGURES

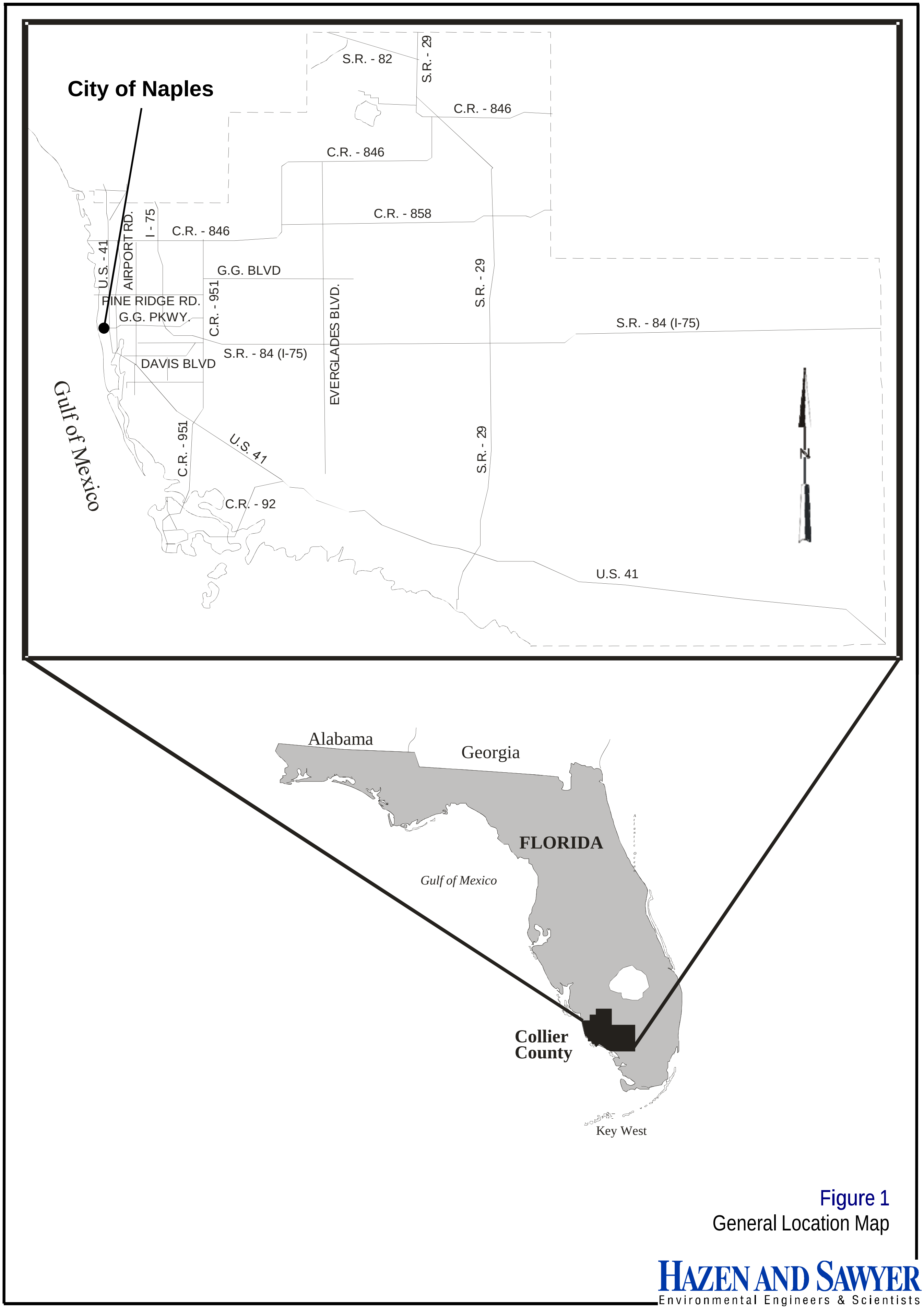

Figure 1
General Location Map

HAZEN AND SAWYER
Environmental Engineers & Scientists

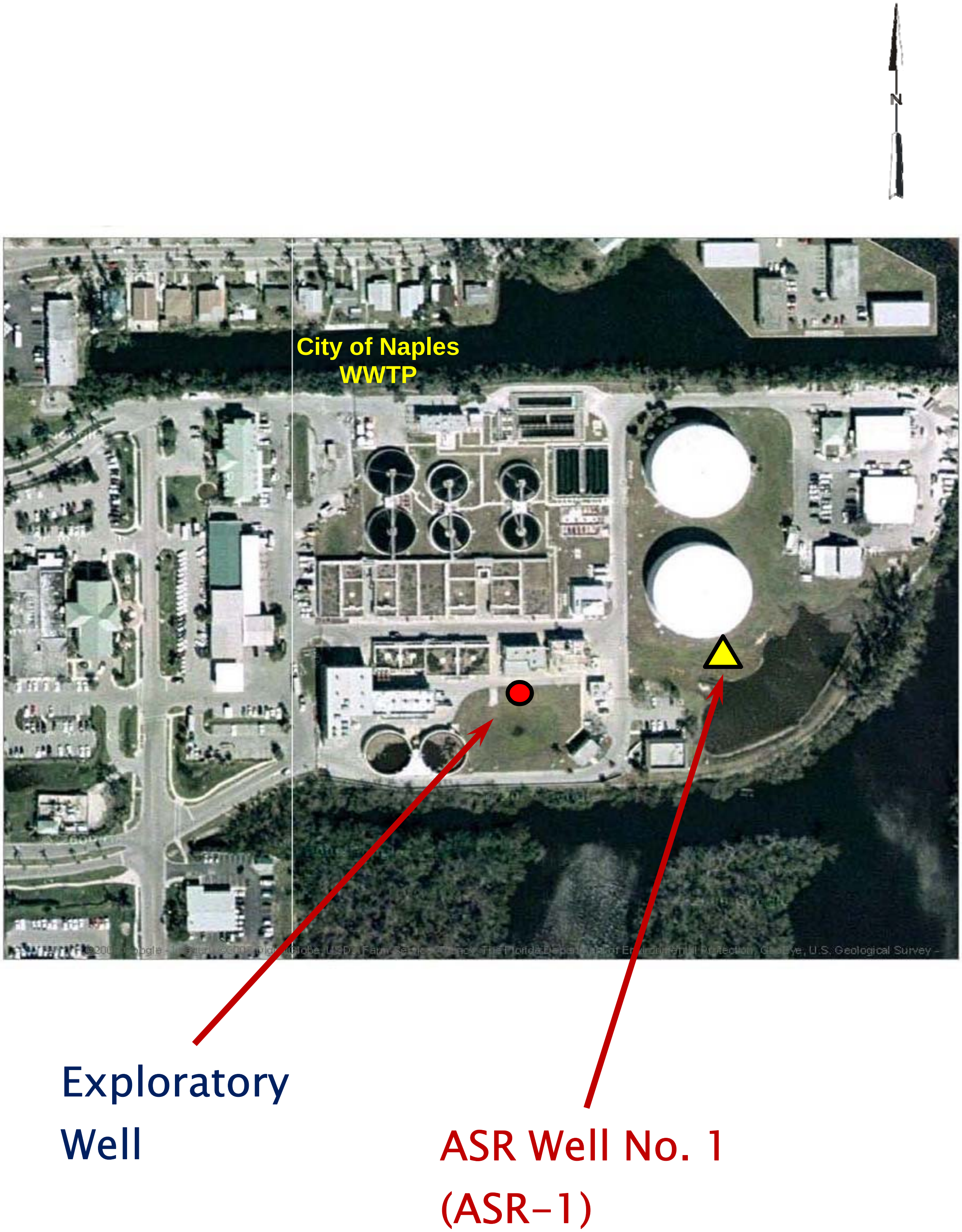

Figure 2
Site Layout

HAZEN AND SAWYER
Environmental Engineers & Scientists

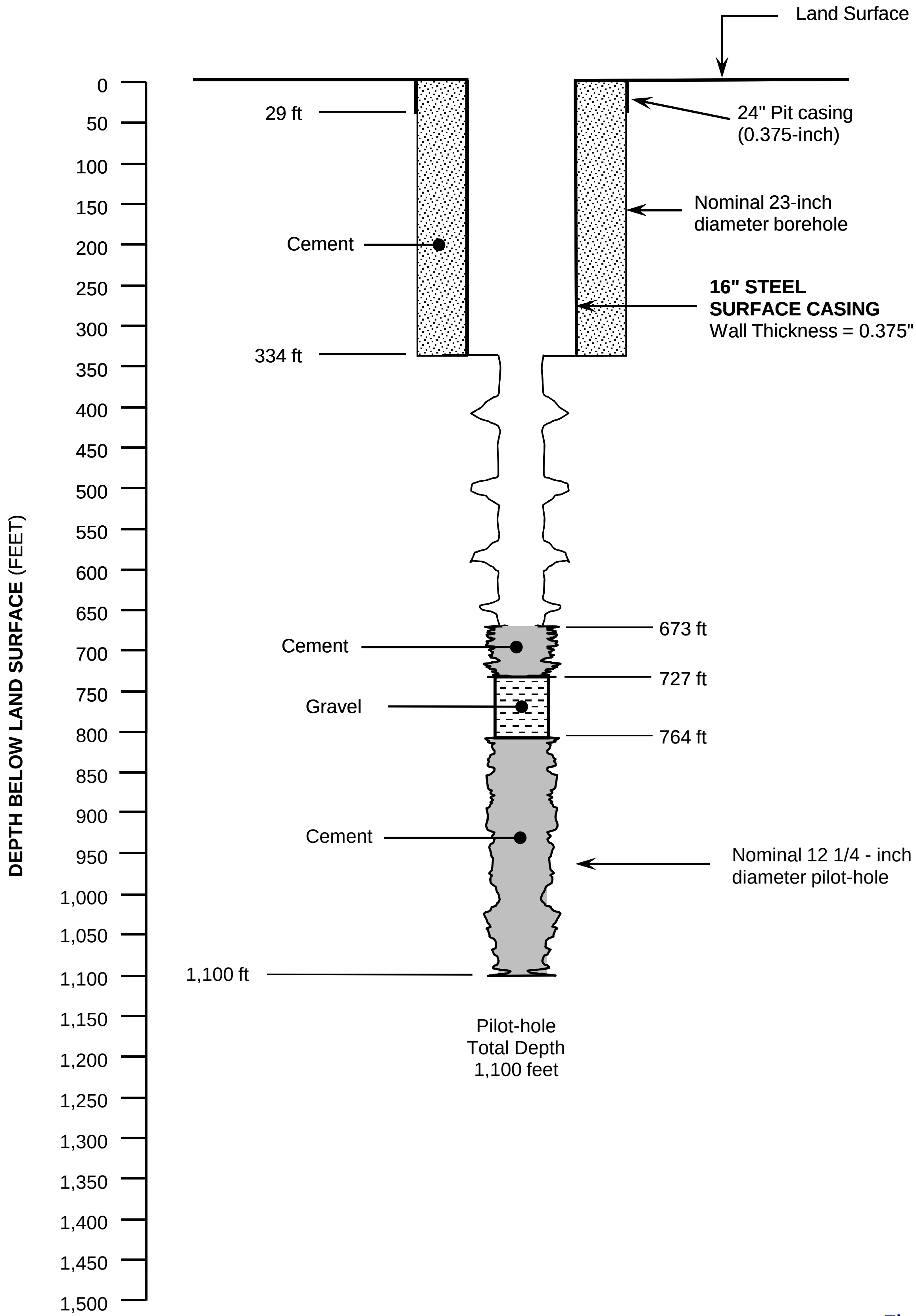

Figure 3
Exploratory Test Well
Construction Details

HAZEN AND SAWYER
Environmental Engineers & Scientists

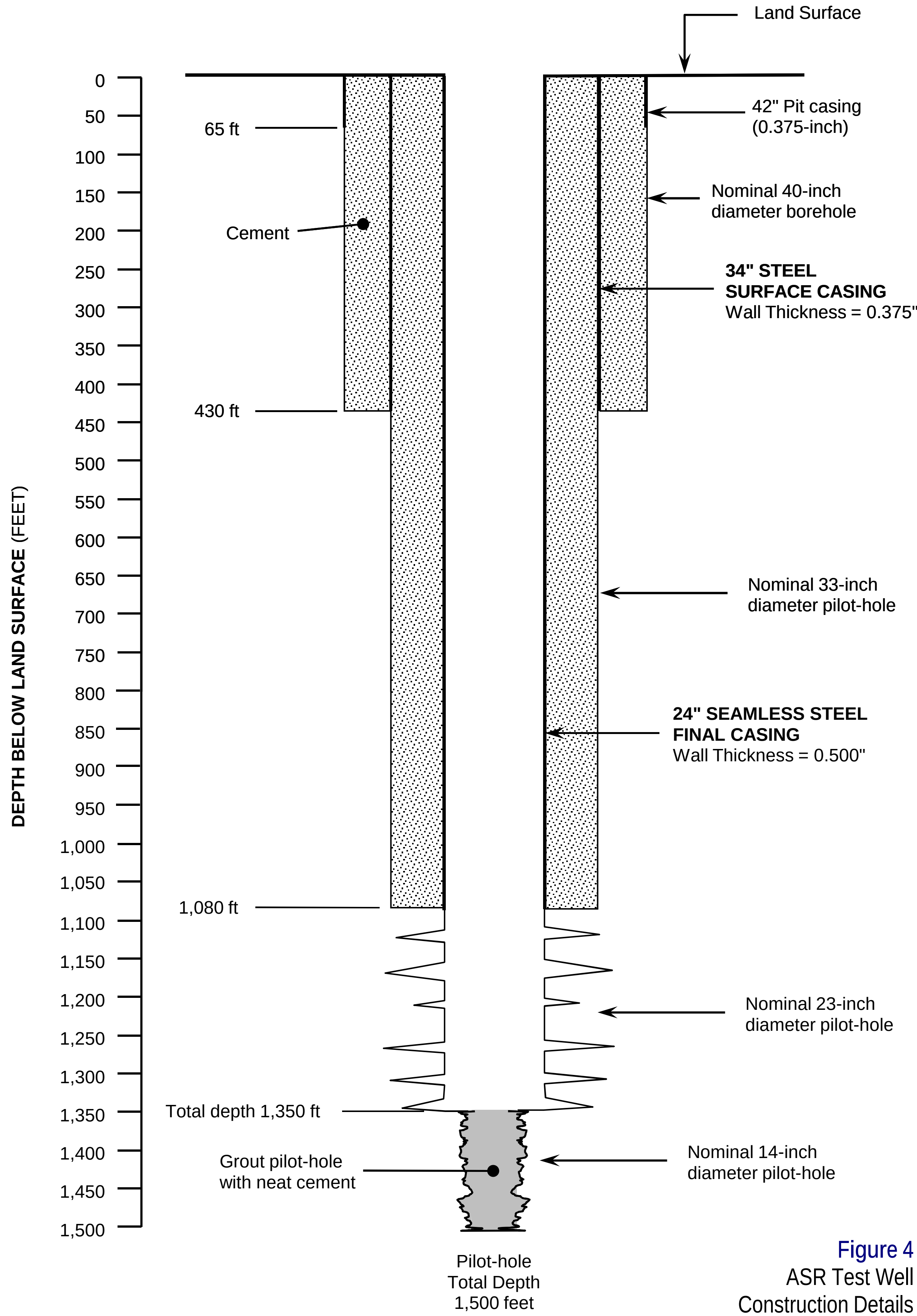

Figure 4
ASR Test Well
Construction Details

HAZEN AND SAWYER
Environmental Engineers & Scientists

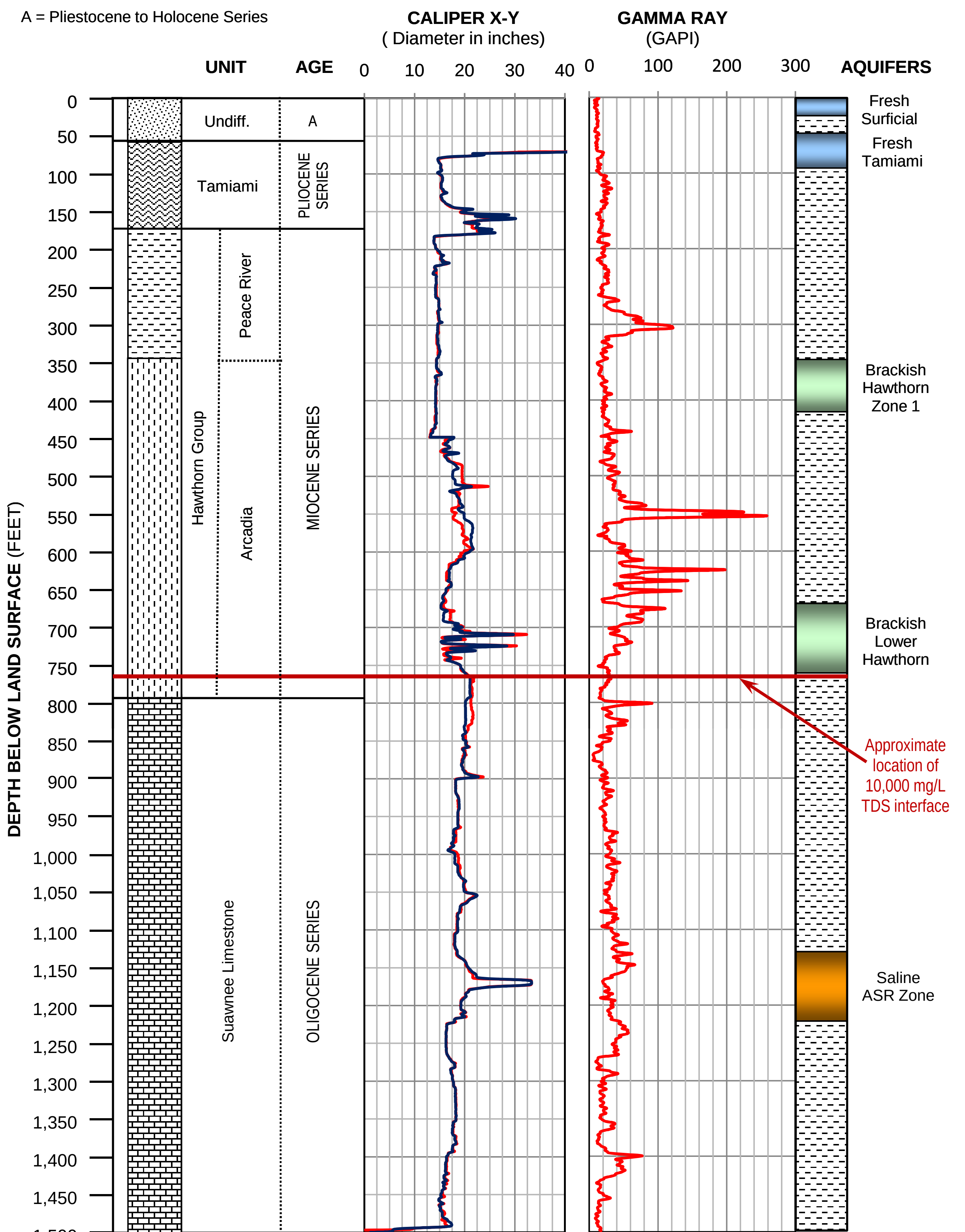

Figure 5
Generalized Hydrogeologic Section from ASR Test Well

HAZEN AND SAWYER
Environmental Engineers & Scientists