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NIROP FRIDLEY
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DESIGN CONSIDERATIONS FOR EXTRACTION WELLS AT-11, AT-12 AND AR-13 NIROP FRIDLEY MN

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NAVFAC MIDWEST

Design Considerations for Extraction Wells AT-11, AT-12, and AT13

Naval Industrial Reserve Ordnance Plant (NIROP)
Fridley, Minnesota

Naval Facilities Engineering Command
Midwest

Contract Number N624670-08-D-1001
Contract Task Order F271

March 2011

DESIGN CONSIDERATIONS FOR EXTRACTION WELLS AT-11, AT-12, AND AT-13 AT

NAVAL INDUSTRIAL RESERVE ORDNANCE PLANT

FRIDLEY, MINNESOTA

REVISION 1

1.0 INTRODUCTION

These design considerations for extraction wells AT-11, AT-12, and AT-13 have been prepared by Tetra Tech NUS, Inc., under Contract Task Order (CTO) F27C, as part of the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract Number N62470-08-D-1001, which is part of the Navy's Installation Restoration Program (IRP). These instructions present details for extraction well locations, drilling methodology, sampling procedures, and extraction well construction details for installation of the extraction wells at NIROP Fridley, Minnesota. All activities and procedures will be conducted in accordance with applicable regulations.

2.0 EXTRACTION WELL LOCATIONS

The new extraction well locations were proposed as a part of the Hydrogeologic Analysis Revision 1 (Tetra Tech, January 2011). The locations for extraction wells AT-11, AT-12, and AT-13 are shown as the red well locations on Figure 1 and the global positioning system (GPS) coordinates are provided in Table 1. The locations should be marked onsite prior to the utility clearance activities using a GPS with submeter accuracy. Locations should be adjusted as necessary to avoid utilities. Locations may be adjusted up to 10 feet of the original location to avoid utilities. If adjustment of more than 10 feet is necessary, then the Field Operations Leader (FOL) will contact the Navy Remedial Project Manager (RPM).

TABLE 1

GPS COORDINATES (NAD 83) FOR EXTRACTION WELLS AT-11, AT-12, and AT-13

Location	Easting	Northing
AT-11	2811037.68	1078220.63
AT-12	2811093.91	1078098.53
AT-13	2811150.16	1077990.25

3.0 DRILLING AND SAMPLING METHODOLOGY

Cable tool drilling is recommended to be used to advance the holes at each extraction well location; however, other methods may be reviewed and approved. No additives will be used during the drilling process; only potable water may be used in drilling/development activities. Due to previous and

pervasive issues with local formation fouling, introducing additives such as drilling mud could increase the severity of existing problems, and also will likely require additional time for well development to ensure that the formation is clear of drilling additives. A split barrel sampler (or similar soil sampling device) will be advanced ahead of the drill casing and used to collect samples for lithology. A detailed boring log will be completed for each well. The hole will be advanced to at least 105 feet below ground surface (bgs) and will be drilled to at least 18 inches in diameter. The Navy's remedial action contractor (RAC) will generate a waste management plan to address handling of all waste materials generated. Continuous sampling will be conducted in order to observe and document the lithology at each location. Representative samples of each lithological unit will be collected. Laboratory analysis (sieve analysis) will be conducted on a representative sample of each lithology type encountered within the projected screened interval. The field geologist's discretion should be exercised on the necessity to collect and analyze samples slightly below and above this interval. It is recommended that Johnson Well Screen conduct the sieve analysis and provide recommendations regarding well screen slot size and filter pack materials based on the sieve analysis.

4.0 EXTRACTION WELL CONSTRUCTION

Extraction well design detail is shown on Figure 2. The Hydrogeologic Analysis (Tetra Tech, January 2011), recommended a well diameter of 10 inches based on the text *Groundwater and Wells* (Johnson Division, 1986); however, to help ensure that the recommended pumping rate of 200 gpm for each well be more achievable, the well casing diameter will be 12 inches. The casing, riser, and sump materials will be fabricated from carbon steel, but the screen must be corrosion-resistant Type 304 stainless steel. Joints will be threaded and flush or welded.

Below the screened interval, a 3-foot long sump (i.e., blank casing) will be installed from 100 feet bgs to 103 feet bgs to help prevent formation or filter pack material from building up within the screened interval and thereby interfering with the well performance. Regular maintenance will include checking to see if the formation/filter pack material has reached the top of the sump and has begun to encroach upon the lower portion of the screened interval. If sediment has accumulated significantly, then it should be removed as part of routine well maintenance activities. It is anticipated that the screened interval will be from approximately 70 feet bgs to 100 feet bgs; however, unexpected subsurface conditions (such as clay/silt layers present in the desired screen interval) may necessitate the need for a decision to make a change in the screened interval. The on-site geologist will communicate the need for this change to the Navy RPM rather than making a field decision to change the screened interval of the well. The information will be communicated to the Partnering Team, and a final decision will be made.

The well screen will be a stainless steel, continuous slot, wire-wound design of triangularly shaped wire around a circular array of internal rods. The screen will be manufactured by Johnson Division Screen, and screen slot size will be determined based on sieve analysis results. The sieve analysis will be also

be conducted by Johnson Division. Once the sieve analysis results are completed and screen slot size/filter pack recommendations provided, the results will be sent to the RPM. The RPM will forward results to the Partnering Team, and a final decision will be made regarding the filter pack material and screen slot size. The filter pack material will be selected based on the sieve analysis results.

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineer's rule to ensure proper placement. The well screen and casing shall be lowered into the completed borehole, with centralizers used as necessary to keep the well screen and casing centered within the borehole. The filter pack will be installed from one foot below the bottom of the well screen to four feet above the top of the screen, with the drill casing withdrawn as the filter pack is added. The filter pack material will be slowly poured into the annulus between the temporary casing and the well screen/casing as the temporary casing is withdrawn. Sand should always be kept slightly up in the temporary casing as it is withdrawn, to ensure an adequate filter pack.

5.0 EXTRACTION WELL DEVELOPMENT

The extraction wells will be pre-developed immediately after drilling and installing the filter pack. Adding the bentonite seal will be delayed until pre-development is completed. During pre-development, the filter pack may shift and/or settle. The depth of the top of the filter pack should be checked following pre-development, and additional filter pack added to maintain the required filter pack height if needed prior to adding the bentonite seal.

The purpose of well development is to stabilize and increase the permeability of the filter pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells will be developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity, turbidity, and temperature will be taken during development at regular intervals, and stabilized measurements will indicate when sufficient development has been performed. Records of the above-mentioned parameters, time measured, and quantity of water removed will be kept.

The wells should be developed by surging and pumping. The surge plunger will be approximately the same diameter as the well casing and will be aggressively moved up and down within the screened interval to agitate the water, causing it to move in and out of the screen. This movement of water pulls fine materials into the well (where fines will be removed by pumping), and prevents bridging of the sand particles in the filter pack. The water level should not be allowed to drop below approximately 10 feet above the top of the screened interval, to prevent cascading and fouling of the screen. Air-lift pumping methods will not be used during development activities, due to the propensity for extraction well and formation fouling at this site. Following completion of development activities, the depth of the top of the filter pack will be checked, and more filter pack will be added until the top of the filter pack is at least four feet above the top of the screen.

6.0 EXTRACTION WELL CONSTRUCTION COMPLETION

A minimum 3-foot-thick seal of 100 percent sodium bentonite chips or pellets will be installed above the primary filter pack and allowed to hydrate as per the manufacturer's recommendations. Pellets should be added slowly and their fall monitored carefully so that bridging does not occur.

After hydration of the bentonite seal is complete, the annular space above the bentonite seal will be backfilled with cement-bentonite grout to the desired height for final well completion/hookup at grade. The cement-bentonite grout will be introduced into the annular space using a tremie pipe to prevent bridging and to provide a better seal. The following approximate proportions of materials in cement-bentonite grout should be used: 6-7 gallons of water, one 90-pound bag of Portland Type I cement, and 3 to 5 pounds of granular or flake-type bentonite. Following extraction well completion, the well should be developed following the general procedures in Section 5.0, and in accordance with all applicable regulations.

7.0 EXTRACTION WELL HYDRAULIC TESTING

Following extraction well completion, performance testing of each extraction well will be conducted. Pumping tests will be used to document the aquifer characteristics and well performances, estimate pumping effects on other wells in the area, and for selection of long term pumping rates. Existing operating extraction wells should be shut off so that the hydraulic testing of the new wells is not affected.

7.1 Step Drawdown Testing

For each new extraction well a step test will initially be performed to obtain well performance data for use in selecting the pumping rate for the subsequent constant-rate pumping test. The step test will consist of 3 to 5 pumping "steps" approximately 1 to 2 hours in duration each, with each step an incremental increase (or decrease) in pumping rate from the previous step, and will last approximately 8-10 hours. The initial pumping rate will be selected following well development based on professional judgment, with a preliminary target of 160 gpm for the initial rate. It is anticipated that subsequent pumping rate steps will be at the following rates (subject to revision based on real-time evaluation of testing results): 200 gpm, 240 gpm, and 280 gpm. The rates will be selected to not exceed maximum safe pumping rate that each well can sustain (defined for testing purposes as a rate that will not result in drawdown below 10 feet above the top of the well screen). Between each step, the water level in the pumped well will be allowed to recover to the static level. Subsequent changes in pumping rate will be selected based on real-time evaluation of the water level data collected throughout the step test. Pumping rates and drawdowns in the extraction well will be closely monitored throughout the test to ensure that pumping remains steady at the selected target rate and that the drawdown in the well does not extend down to below 10 feet above the screened interval of the well.

A submersible pump capable of pumping up to approximately 300 gpm will be used for the step test. Flow rates will be measured with an in-line flow meter, and rates adjusted using a valve on the discharge line. Prior to the step test, the accuracy of the flowmeter will be checked using the bucket and stopwatch method (the time required to fill a container of known volume will be determined and a flow rate calculated for comparison to the rate indicated by the flowmeter).

Water levels will be hand-measured in the extraction well and in the monitoring wells listed in Table 2 immediately prior to each step test, at five minute intervals for the first 20 minutes of each step, then 10 minute intervals after that, to facilitate real-time evaluation of the step test drawdown data. Electronic water level meters will be used for collecting water level data. Drawdown data will be field-plotted in both linear and semi-log (time-drawdown) plot formats, with changes in pumping rate noted on the plots. The test data will be reviewed in the field to select a suitable pumping rate for the constant-rate test. The selected rate will be a pumping rate that is estimated to be sustainable at approximately 1/3 to 1/2 of the maximum available drawdown in the extraction well (see Figure 3 for example scenario). The maximum available drawdown is the distance between the static water table and approximately five feet above the top of the screened interval.

7.2 Constant Rate Testing

The constant-rate pumping test for each well will be started after groundwater levels in Table 2 have stabilized to within less than 0.2 feet of the initial static reading before the step test was performed, and no sooner than 12 hours following completion of the step test. Based on the semi-confined conditions of the portion of the aquifer to be tested and a review of the results of the performance testing of AT-3A (USGS, 2000) a constant-rate test duration of approximately 36-48 hours is anticipated be adequate for performance testing.

Individual constant rate tests will be performed on each well separately. Following the individual tests and an appropriate recovery period, a constant rate test will be performed with all three wells running simultaneously. For the simultaneous constant rate test (i.e., when running all three wells together), each of the wells in Table 2 will be used for observation of water levels in response to pumping. However, the results of the individual constant rate tests should be considered when preparing for the simultaneous constant rate test. If the selected wells for any individual test do not show a response during pumping of an individual well, another well can be selected for water level observation. Monitoring wells MS-28I and MS-49I should be used for background water level readings. Up to six readings should be collected for the background wells over two days prior to testing with two daily readings collected throughout the testing period.

Each new extraction well will be pumped at a consistent rate (selected for each well based on step test results) and water level readings will be periodically collected from the extraction well and nearby observation wells. The pumping rate selected should limit the drawdown to no more than 1/3 to 1/2 the maximum

available drawdown for the well (i.e. 1/3 to 1/2 the static water column above the top of the screen). The observation wells are identified below in Table 2. Pressure transducers and data loggers will be used for water level monitoring in the observation wells and will be set in the wells at depths below the maximum anticipated drawdown level due to pumping. In addition to the automated water level monitoring with pressure transducers, hand readings will be periodically obtained (approximately every two hours) and recorded as a check of the transducer data. For the deep zone wells listed in Table 2, collecting hand measurements every two hours instead of using transducers should be sufficient for the level of detail required and will also be more cost effective. Water levels will be manually collected from the extraction well and observation wells at least eight times over at least a 24 hour time period (preferably 48, if the schedule allows) prior to each test startup, to verify that water levels have recovered to static conditions prior to the constant-rate test.

Immediately prior to beginning the pumping test, a round of water levels will be obtained from the observation wells (measured with an electronic water level meter). Concurrent with starting the pumping test, the collection of water level readings from the observation wells will begin. Water level data will be collected from observation wells at logarithmic time intervals throughout the test, with at least 10 readings obtained per log cycle of time (1-10 minutes, 10-100 minutes, etc.). The pumping rate will be recorded at least every 10 minutes during the first hour of the test, at 30 minute intervals for the next 3 hours of the test, every hour for the next 4 hours of the test, then every 2 hours until test completion. A valve on the discharge line will be used to adjust the pumping rate to maintain a steady flow rate within +/- 5% of the target flow rate, to the extent possible.

Drawdown data from the pumping and observation wells will be field-plotted on semi-log and log-log paper, to allow for real-time evaluation of the drawdown trends. The field data plots will be used to evaluate drawdown trends, look for boundary conditions, project drawdowns for the latter stages of the test, and to determine whether steady-state drawdown conditions have been reached. Field personnel will be in frequent communication with senior technical personnel to provide updates of the test progress. The test will be run until sufficient data is collected to allow for application of standard pumping test evaluation techniques to the data (i.e., well defined drawdown trends are established), or until otherwise deemed appropriate to terminate the test based on field conditions encountered. The extraction well installation/testing results will be generated for each of the new extraction wells, detailing the well drilling, construction, and performance testing activities and results, and will be included in the final as-built package. It is recommended that the pump test data be forwarded immediately to the RPM, who will then forward it to the Partnering Team.

TABLE 2

MONITORING WELLS TO BE USED FOR OBSERVATION OF GROUNDWATER LEVEL ELEVATIONS DURING PUMPING TESTS

Wells	Screened Interval (feet bgs)	AT-11 pumping	AT-12 pumping	AT-13 pumping
Shallow				
MS-38S	32 - 42			CR
Intermediate				
AT-3A	66.4 - 105		CR	CR
AT-10	68 - 84			CR
AT-11	Proposed 70 - 100	CR	CR	CR
AT-12	Proposed 70 - 100	CR	CR	CR
AT-13	Proposed 70 - 100	CR	CR	CR
7-IS	unknown		SD	CR, SD
8-IS	Assumed 63 - 73			CR
12-IS	54.8 - 74.8		CR	CR, SD
17-D	94.2 - 104.4			CR
MS-28I (background well)	80.5 – 85.5	CR	CR	CR
MS-32I	79.8 - 84.8	CR		
MS-34I	69.5 - 79.5	CR, SD	CR	
MS-35I	72 - 82	CR, SD	CR, SD	
MS-36I	70.5 - 80.5	CR	CR	
MS-44I	70 - 80	CR	CR	CR
MS-49I (background well)	74.7 – 84.9	CR	CR	CR
MS-54I	66 - 76		CR	CR
MS-56I	66 - 76	CR	CR	
Deep				
USGS-10	118 - 128	CR	CR	CR
MS-34D	125.5 - 135.5	CR	CR	CR
MS-35D	122.6 - 132.6	CR	CR	CR
MS-35DPZ	122 - 132	CR	CR	CR

CR – well to be used for groundwater level observations during constant rate pump testing.

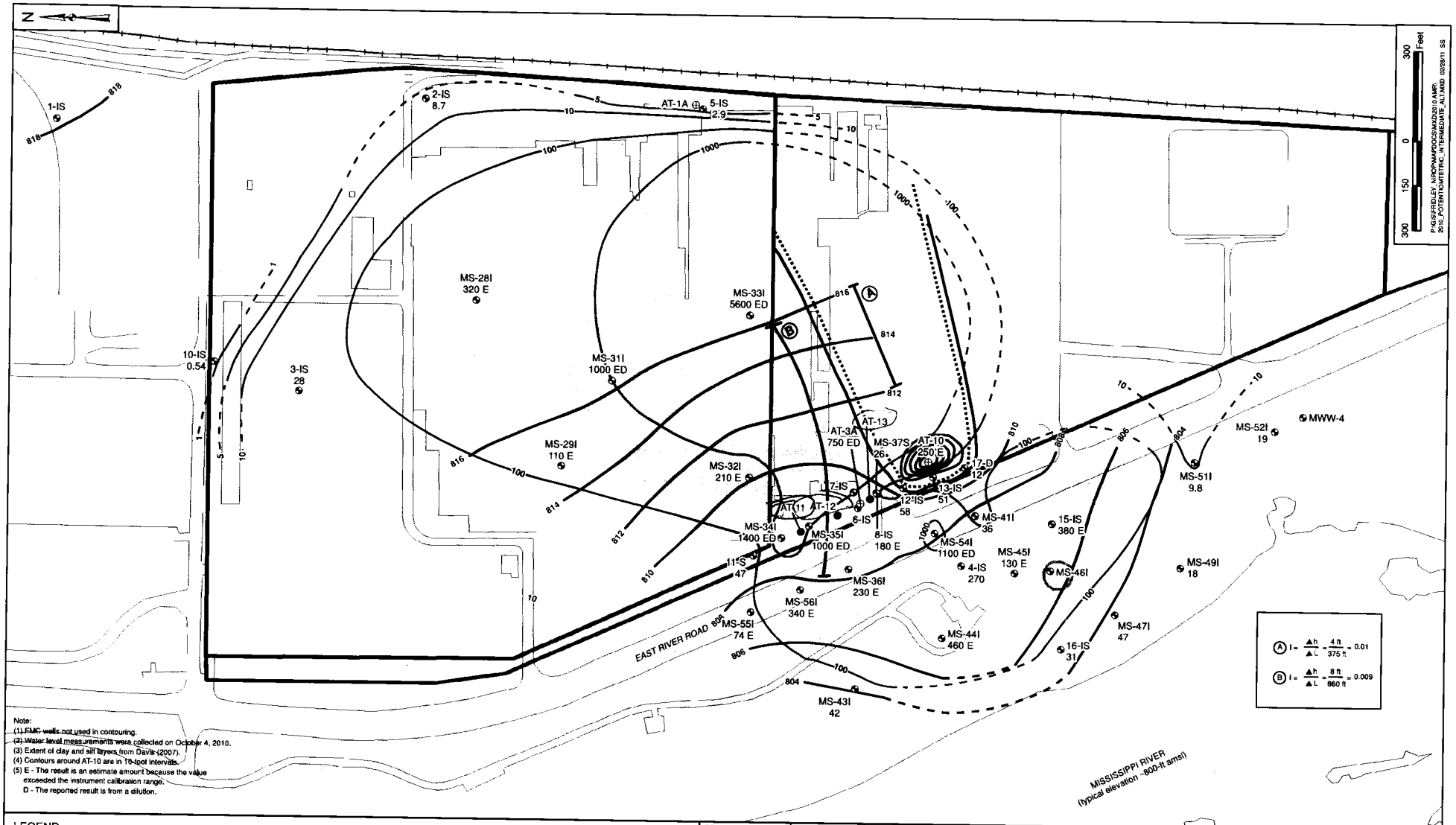
SD – well to be used for groundwater level observations during step drawdown pump testing.

34S, 35S, AT 11

• 23 WELLS + 2 MORE BASED ON COMMENTS FROM REGS.

35S, AT 12

EPA / MPCA : ADDING WELLS OR CHANGING LOCATIONS



Note:
(1) FMC wells not used in contouring.
(2) Water level measurements were collected on October 4, 2010.
(3) Extent of clay and silt layers from Davis (2007).
(4) Contours around AT-10 are in 10-foot intervals.
(5) E - The result is an estimate amount because the value exceeded the instrument calibration range.
D - The reported result is from a dilution.

LEGEND

- Intermediate Monitoring Well
- Proposed Monitoring Well
- Extraction Well
- Road
- Railroad
- Water
- Building
- NIROP Fridley
- BAE
- Burlington Northern RR
- Vegetable Oil Pilot Study Area
- Intermediate Clay
- Intermediate Silt
- 25-S 815.46 Groundwater Elevation (Feet Above Mean Sea Level)
- NM = Not measured
- Gradient Calculation Line
- Flow Net Capture Zone
- Calculated Capture Zone
- Target Capture Zone
- 810 Intermediate Potentiometric Surface Contour (Feet Above Mean Sea Level) (Dashed where Inferred)
- 10 TCE Isocontour (Dashed where Inferred)

DRAWN BY J. ENGLISH	DATE 12/14/10	
CHECKED BY S. WARINO	DATE 01/26/11	
COST/SCHEDULE-AREA		
SCALE AS NOTED		

NAVFAC

INTERMEDIATE DRIFT GROUNDWATER ELEVATIONS UNDER PUMPING CONDITIONS ON OCTOBER 4, 2010 WITH FALL 2010 TCE ISOCONCENTRATIONS NIROP FRIDLEY, MINNESOTA

CONTRACT NO. F27C	OWNER NO. 02583
APPROVED BY	DATE
APPROVED BY	DATE
FIGURE NO. 1	REV. 0

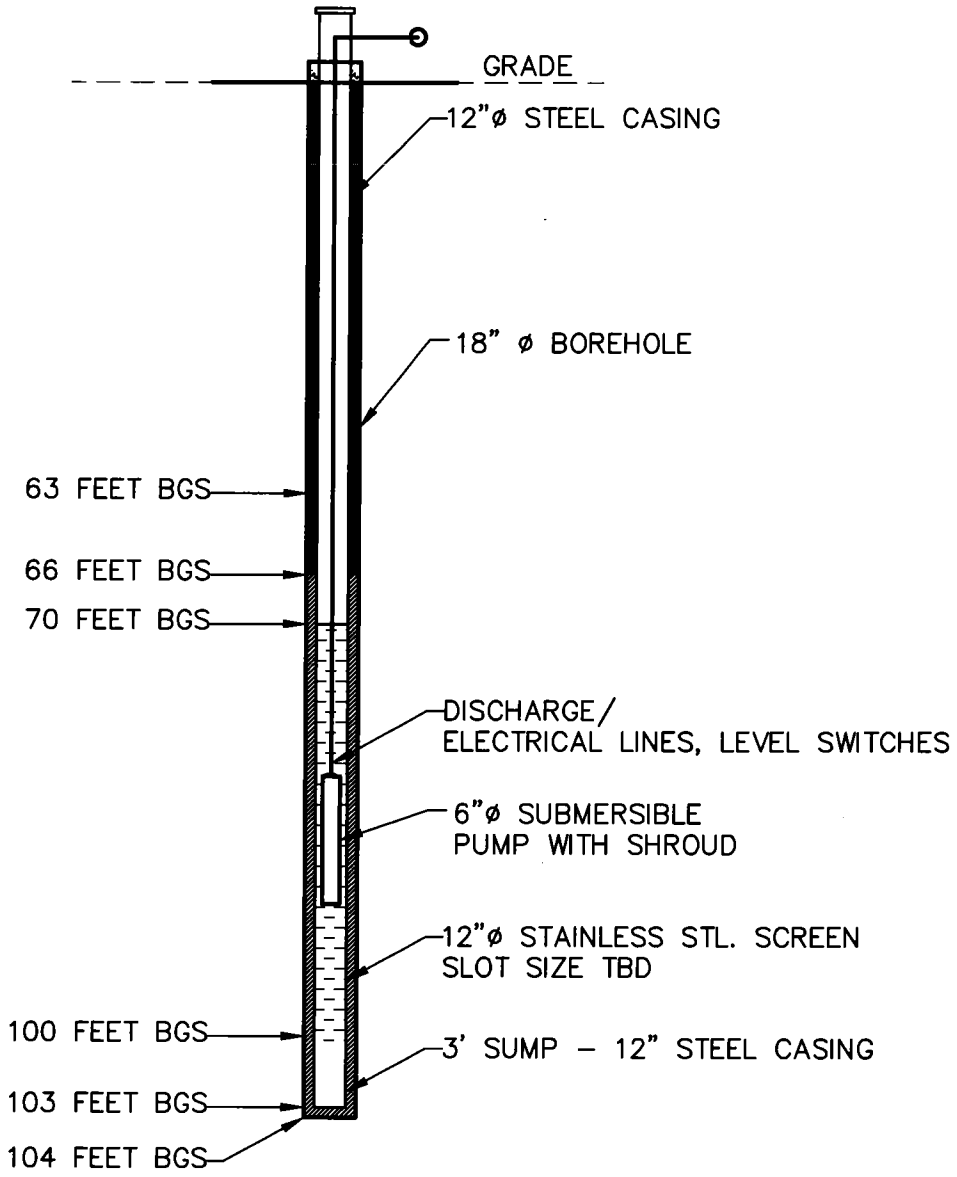
NOTE: EXTRACTION WELLS WILL BE CASED AND SCREENED IN UNCONSOLIDATED MATERIAL.

BGS – BELOW GRADE SURFACE
TBD – TO BE DETERMINED

CEMENT–BENTONITE GROUT

SAND PACK, SIZE TBD

100% SODIUM BENTONITE SEAL



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NIROP
FRIDLEY, MINNESOTA
DESIGN DETAIL FOR EXTRACTION WELLS AT–11, AT–12, AND AT–13
NOT TO SCALE

DATE:	01–26–11
PROJECT NO.:	112G02583
DESIGNED BY:	
DRAWN BY:	ZM
CHECKED BY:	
SHEET: 1 OF 1	

FIGURE 2

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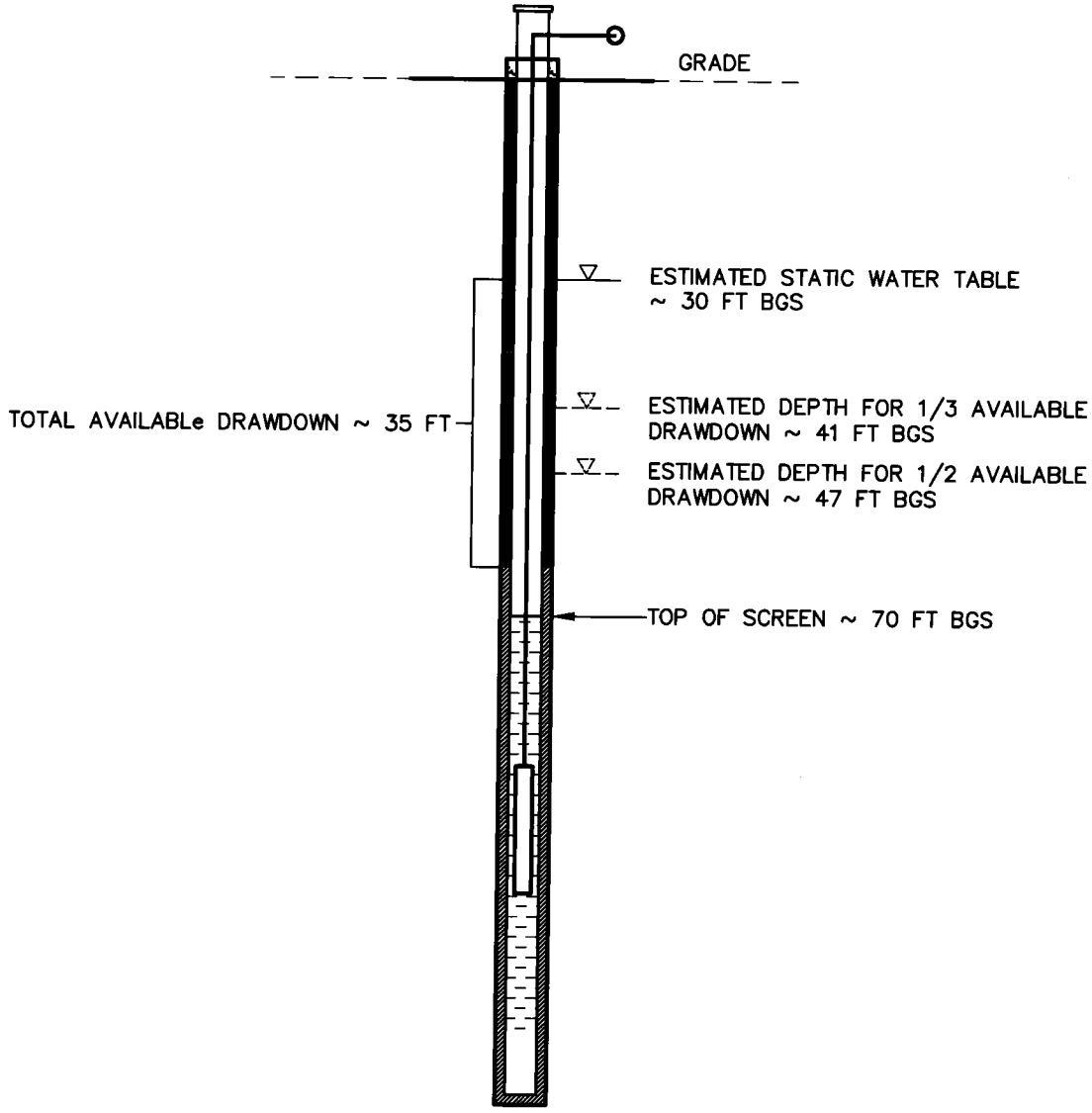

LEGEND

- CEMENT-BENTONITE GROUT
- SAND PACK, SIZE TBD
- 100% SODIUM BENTONITE SEAL

BGS BELOW GRADE SURFACE

NOTE:
EXTRACTION WELLS WILL BE CASED AND SCREENED IN UNCONSOLIDATED MATERIAL.

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NIROP
FRIDLEY, MINNESOTA
POTENTIAL AVAILABLE DRAWDOWN FOR EXTRACTION WELLS AT-11, AT-12, AND AT-13
SCALE: NOT TO SCALE

DATE:	01-26-11
PROJECT NO.:	112G02583
DESIGNED BY:	
DRAWN BY:	ZM
CHECKED BY:	
SHEET: 1 OF 1	

FIGURE 3

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