BALFOUR BEATTY REQUEST TO DISCUSS DEWATERING PRIOR TO COMPLETION OF CDSM WALL AT FIRST/FREMONT ST.

Balfour Beatty
Infrastructure Inc.

Balfour Beatty Infrastructure, Inc.
Western Division
143 2nd Street, San Francisco, CA 94105
T: 415-495-1920 F: 415-495-1930
www.bbinfrastructureinc.com

December 14, 2011 4225-000-0275

Kirk Nielsen
Project Manager
Webcor Builders/Obayashi Corporation, a Joint Venture
183 Fremont St.
San Francisco, CA 94105

Re: Transbay Transit Center
Buttress / Shoring / Excavation (BSE) Package Trade Subcontract TG-03

Subject: Request for Meeting to Discuss Dewatering Impacts from Non-Completed CDSM Walls

Dear Mr. Nielsen,

In reference to discussions with Webcor Obayashi (W/O) and the revise and resubmit requirement pertaining to the Dewater Submittal, Balfour Beatty Infrastructure Inc. (BBII) is requesting the following.

The original contract plan was to complete the CDSM walls around the perimeter of Zones 1 through 4 prior to dewatering, therefore providing a completed enclosed structure to minimize the impact of dewatering outside the limits of the Zones. Due to the delay in completing the PG&E / Verizon utility relocation work on First St and Fremont St the portion of CDSM wall in these areas to date are not completed and will not be completed prior to the need to dewater Zones 1 and 2.

Upon W/O's review of the dewatering submittal illustrating the impacts of these areas on the control of the ground water, W/O is concerned for possible subsidence of the surrounding buildings and required BBII to revise and resubmit the submittal. BBII recognizes this concern and requirement and is submitting this request for information as a result.

BBII is requesting a meeting as soon as possible with ARUP, TJPA and W/O to discuss the parameters and possible alternative methods to implement the dewatering system due to the CDSM wall not being completed and resulting in a non-enclosed work zone, as delaying the start of dewatering until the CDSM wall is complete, will result in delays to the project schedule.

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Should you have any questions regarding the above, please do not hesitate to contact me.

Sincerely,

Dean Wallahan
Senior Engineering Manager
Balfour Beatty Infrastructure, Inc.

REVISED DEWATERING DESIGN AND ANALYSIS

TA2010-312319A03.1

Balfour Beatty
Infrastructure Inc.

TG0300-520 .1

Dewatering

Specification Section 32-23-19

~~November 14, 2011,~~
~~December 12, 2011,~~
January 18th, 2012,

This submittal has been reviewed by BBII for conformance with the contract documents.

- **Submittal TA-2010-312319A03 Dewatering Design Data**

Review Stamp:

WEBCOR BUILDERS OBAYASHI
JOINT VENTURE

Reviewed by Webcor/Obayashi

951 Mariners Island Blvd
San Mateo, CA 94404

Review is for general coordination and conformance with design intent only and for submittal in accordance with the contract documents. Review by Webcor Builders does not relieve the subcontractor and/or supplier of responsibility for full coordination, accurate dimensions, correct quantities and full compliance with the contract documents. In the event subcontractor and/or supplier intends to propose any substitution or deviation to the contract documents, each substitution or deviation must be submitted and approved prior to submitting it in a shop drawing or other submittal. Review by Webcor does not imply acceptance of any substitution or deviation.

Submittal Pkg. Number: TG0300-520.1

Submittal Number: TA2010-312319A03

Webcor Job No.: 30100 Transbay Transit Center

Reviewed By: jfilipas

Date: 01/20/2012

Subcontractor: Balfour Beatty

Exhibit 3231
Date: 10/19/18 Name: Wallahan
Lana L. Loper, RMR, CRR, CCP, CSR No. 9667

Balfour Beatty
Infrastructure Inc.

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January 18, 2012

4225-000-0337

Kirk Nielsen
Project Manager
Webcor Builders/Obayashi Corporation, a Joint Venture
183 Fremont St.
San Francisco, CA 94105

Re: Transbay Transit Center
Buttress / Shoring / Excavation (BSE) Package Trade Subcontract TG-03

Subject: Dewatering Design Data Submittal TA2010-312319A03

Dear Mr. Nielsen,

Balfour Beatty Infrastructure Inc ("BBII") is submitting the following dewatering design data plan to fulfill the submittal requirement of section 31 23 19 1.5.D. BBII would like to clarify the following criteria associated with this submittal.

- Due to the delay to completion of the CDSM walls at First and Fremont Streets, the dewatering model was reconfigured to accommodate the dewatering needs for Zone 1 and 2 excavation levels with the completion of the CDSM walls at First Street in March 2012 and Zone 3 and 4 excavation levels with the completion of the CDSM walls at Fremont Street in June 2012.
- The modeling is based on the pumps elevations being adjusted to accommodate the schedule of excavation. For instance, the pumps are not placed at the final elevation of –67 until the time needed to dewater level 4/5 excavation per the schedule. This "just in time" pump elevation modeling allows control of softening of foundation subgrade within the work area.
- The use of cut-off wells in the middle of the zones allow for zone dewatering to occur while minimizing the use of pumps located in adjacent zones. For instance, the use of the cut-off wells located in Zones 1 and 2 minimize the use of pumps in Zone 3 to dewater and complete excavation in Zones 1 and 2.

Balfour Beatty
Infrastructure Inc.

TA2010-312319A03.1

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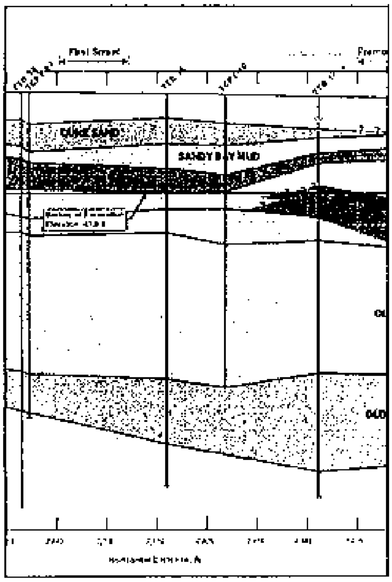
Note: If PG&E or Verizon encounters delays to completion of the utility cross-over work at First (completion of March 16, 2012) and Fremont (completion of May 25, 2012) Streets this plan may need to be reanalyzed to address the impact of the incomplete CDSM walls on the dewatering requirements.

Should you have any questions regarding the above, please do not hesitate to contact me.

Regards,

Dean Wallahan
Senior Engineering Manager
Balfour Beatty Infrastructure, Inc.

January 2012



Draft Technical Report

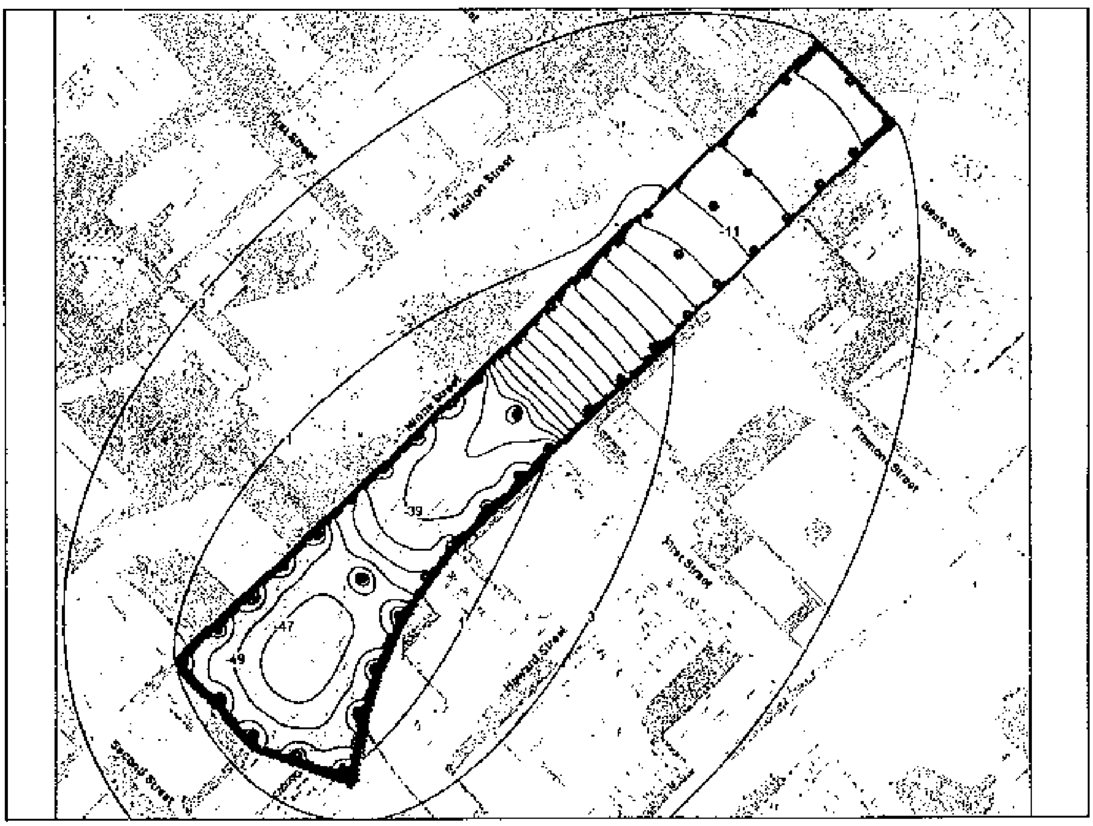
Transbay Transit Center Dewatering Analysis

Prepared By:

HSI Hydrologic Systems
936-B 7th Street, Suite 303
Novato, California 94945

Prepared For:

Balfour Beatty Infrastructure
Transbay Transit Center BSE
143 2ed Street
San Francisco, CA 94104



TG0300-520.1

Draft Technical Report

Transbay Transit Center
Dewatering Analysis

Prepared By:

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Balfour Beatty Infrastructure
Transbay Transit Center BSE
143 2ed Street
San Francisco, CA 94104

REGISTERED PROFESSIONAL ENGINEER
THOMAS K. BURKE
No. 50051
Exp. June 2013
CIVIL
STATE OF CALIFORNIA

Signed: Thomas K. Burke   Date: January 15, 2012

Thomas Burke P.E., Registered Civil Engineer
License No. 50051, Expires 6/2013

January 2012   Project No. 1323

Table of Contents

<u>Appendices</u>

1 Introduction

This report presents a dewatering analysis for dewatering the foundation excavation for the Transbay Transit Center in downtown San Francisco, California. The multi billion dollar project will replace the current Transbay Terminal at First and Mission streets in San Francisco with a modern regional transit hub connecting 11 transit systems. Figure 1-1 is a location map for the project. The project specifications require that the excavation be conducted in the dry. To achieve that, the excavation will be dewatered through a series of well points that will be placed inside the secant pile wall that will be constructed around the perimeter of the excavation. The dewatering wells will draw the groundwater down to a level 5 feet below the bottom of the excavation.

The foundation excavation for the terminal will be rectangular in shape, running 1,480 feet long in the east-west direction, and will be approximately 180 feet wide. The existing ground surface along the excavation slopes down from an elevation of 22 ft. on the west side of the project to 13 ft. on the eastern end of the excavation. The bottom of the excavation is set at elevation -41.5 ft. NAVD. Several isolated pits within the foundation will be excavated to elevations ranging from -44.8 ft. to -52 ft. NAVD. This results in an excavation that will be approximately 74 feet deep on the west end of the project to 67 feet at the east end of the project. Figure 1-2 is a map of the project vicinity.

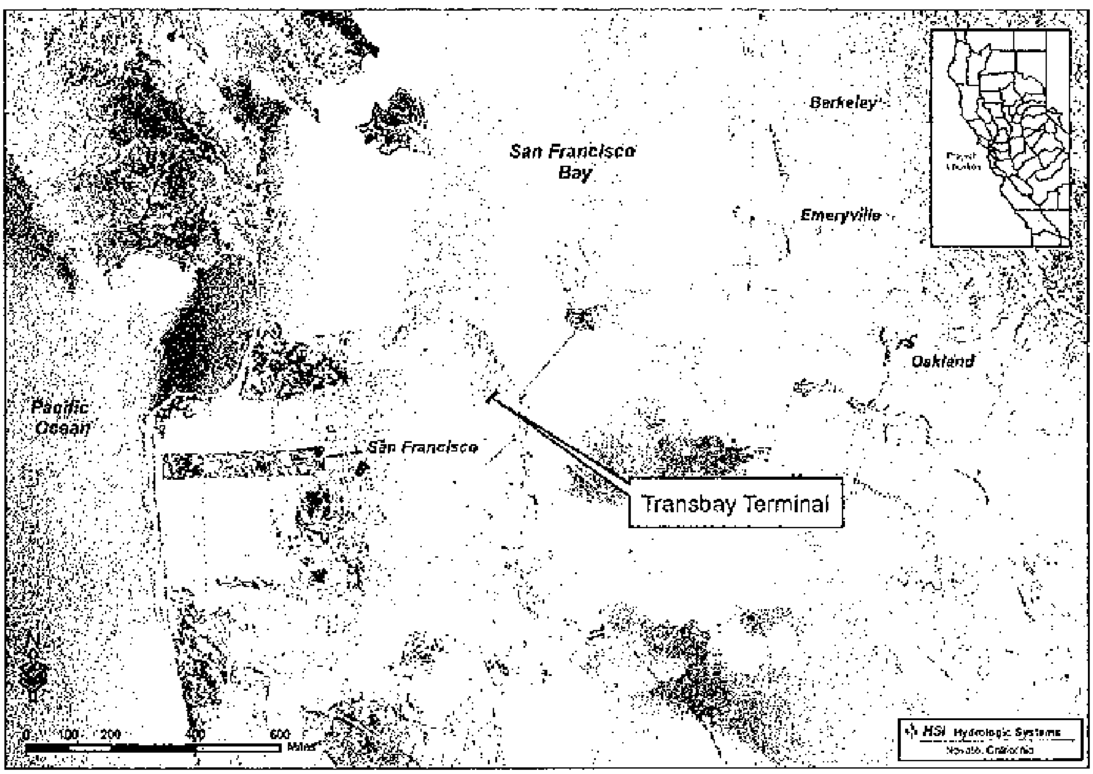


Figure 1-1 Transbay Transit Center Location Map

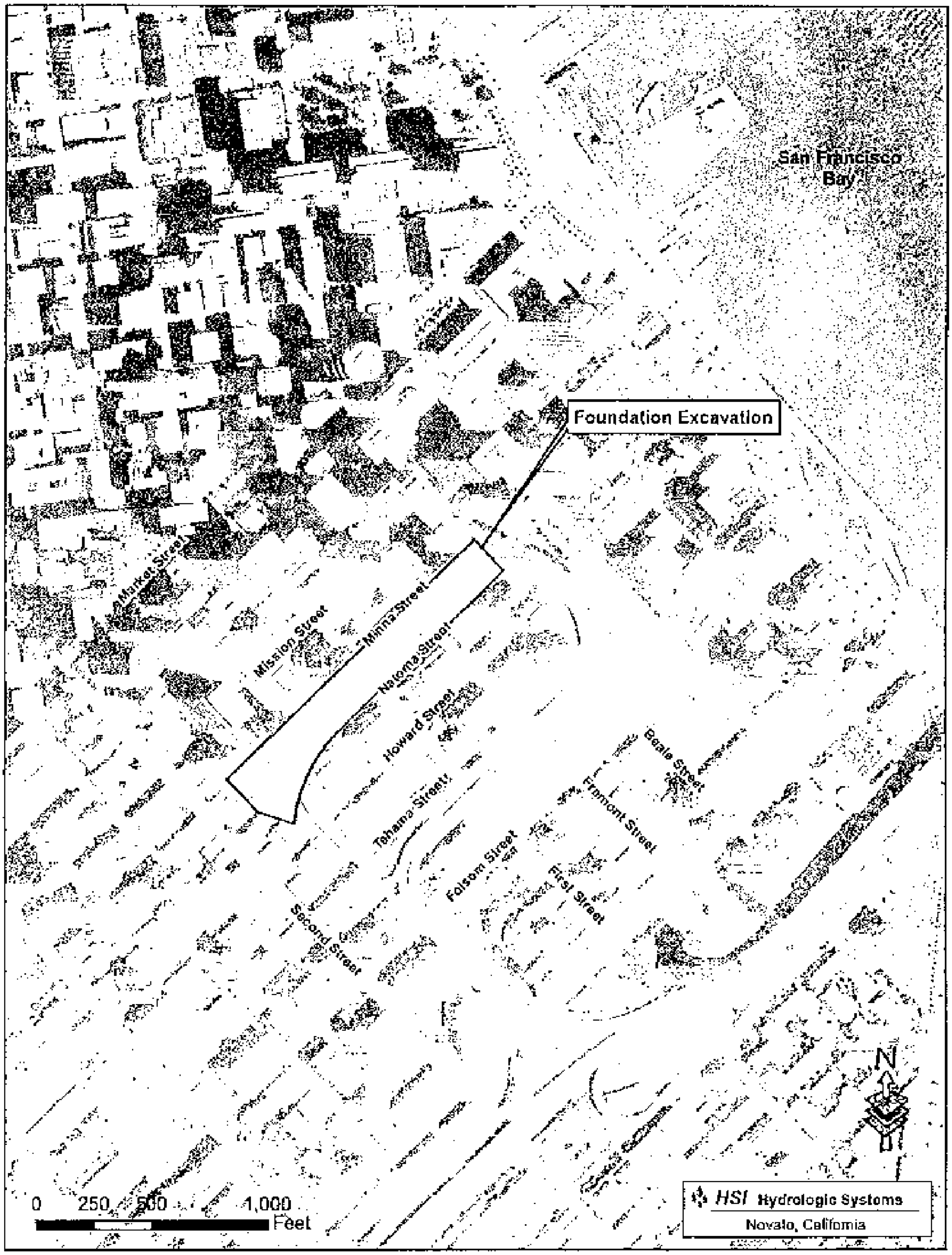


Figure 1-2 Site Map

Groundwater elevation in the project area varies from season to season as well as from year to year. It can be influenced by precipitation and based on observations at the site, it shows some variation from tidal variations in San francisco Bay. The west end of the excavation is 1,300 feet from San Francisco Bay, so tidal influence is possible. Based on measured groundwater data, a design groundwater elevation of +5 ft. NAVD was selected for the dewatering analysis.

The geology below the project site consists of layered beds of clay and sand lenses. The clay deposits are primarily San Francisco Bay bay mud deposits separated by layers of dense marine sands. The nature of the layering will result in a slow dewatering process.

The dewatering requirements were evaluated through the use of the USGS groundwater model MODFLOW. MODFLOW is a 3-d finite element groundwater model that is able to evaluate the movement of water through layered geologic strata. Dewatering wells were added to the model to simulate the movement of groundwater through the aquifer and into the wells for specific pumping rates. The model provides the change in groundwater elevation for each time-step throughout the dewatering process.

This report has been developed to document the analysis that was conducted to evaluate the required dewatering. The report has been divided into five sections: 1. Introduction, 2. Hydrogeologic Setting, 3. Dewatering Analysis, 4. Conclusions and 5. Bibliography.

2 Hydrogeologic Analysis

2.1 Introduction

This section presents a discussion of the hydrogeologic conditions located within the project area. This discussion is based on the information extracted from geologic data collected at the project site as well as geotechnical core borings and groundwater monitoring wells adjacent to the project area. All of the geologic information was compiled and mapped in a GIS to determine its location with respect to the project features. The geologic stratification below the site and associated groundwater aquifer characteristics were extracted from this information. These geologic characteristics were then used to develop the aquifer layers in the ground water model that was used to evaluate the dewatering activity.

2.2 Subsurface Geology

The subsurface geology in the area of the excavation consists of multiple layers of sand, bay mud, and layers of old San Francisco Bay clay. A series of core logs were collected around the project site. Figure 2-1 is a map showing the location of the logs. Based on the logs, a series of geologic profiles were created across the project site. The logs and geologic cross-sections were presented in the project geotechnical report "Transbay Transit Center, Final Geotechnical Data Report" prepared by ARUP North America ltd. (ARUP 2010). A copy of the pertinent core logs has been included in Appendix E. A geologic Cross-Section along Natoma Street and Minna Street are provided in Figures 2-2 and 2-3.

As can be seen in the figures, the upper layer at the site consists of fill and natural sand deposits. Below that layer is a thin layer of Bay Mud, followed by a relatively thick layer of Colma and Marine Sands. Below these sands lays two thick layers of Old Bay Clay. These clay layers consist of thick dense clay deposits that have a very low hydraulic conductivity.

The secant pile shoring wall that surrounds the excavation was extended down into the clay layer in an attempt to slow down groundwater, that exists outside the shoring wall, from entering the excavation during dewatering. To do that, the shoring wall generally extends down 95 feet from the ground surface. The wall extends down to elevation -83 on the west end of the project, and gradually deepens to elevation -92 at the eastern end. The wall will be embedded several feet into the old bay clay and provide for an effective barrier to groundwater on the outside of the excavation. A plot of the bottom of the secant pile shoring wall is shown on Figures 2-2 and 2-3. Figures 2-4 and 2-5 show the geologic profile along first street, and between Beale and Freemont Streets.

The secant pile shoring wall was assumed to be slightly permeable. Four samples of the wall soil-cement mix from the depth corresponding to the Colma Sand layer (the material that was likely to be the most permeable) was selected for permeability testing. The tests were performed by Sierra Testing Laboratories of El Dorado Hills, California, under subcontract to Raito, Inc.(Pelli 2010). The permeability tests showed the that the hydraulic conductivity of the cement mix varied between $1x10^{-7}$ and $1x10^{-8}$ cm/sec. These values exceed the wall hydraulic conductivity specification of $1x10^{-6}$ cm/sec. The hydraulic conductivity required by the specifications was used in this analysis.

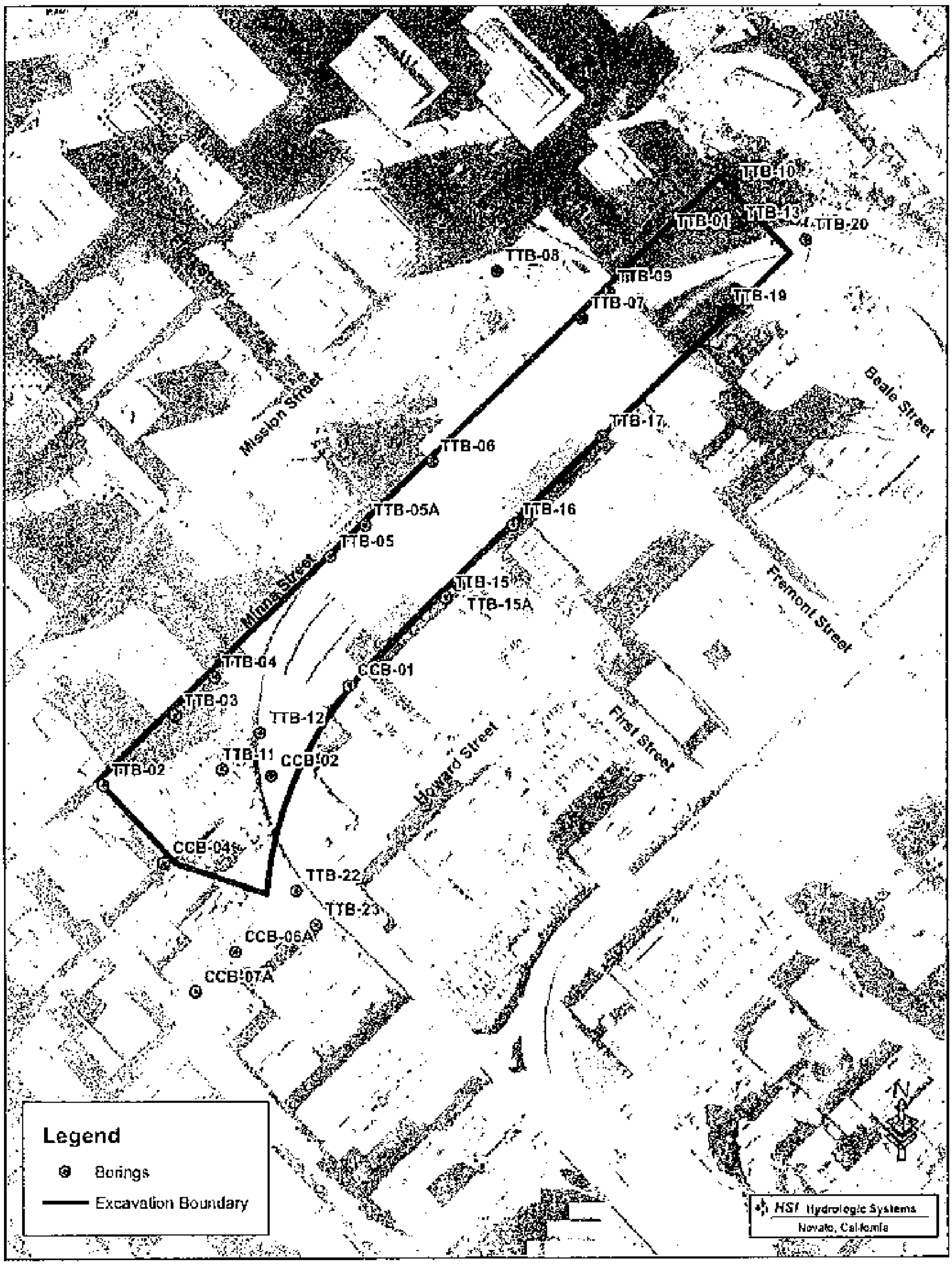


Figure 2-1 Core Boring Locations

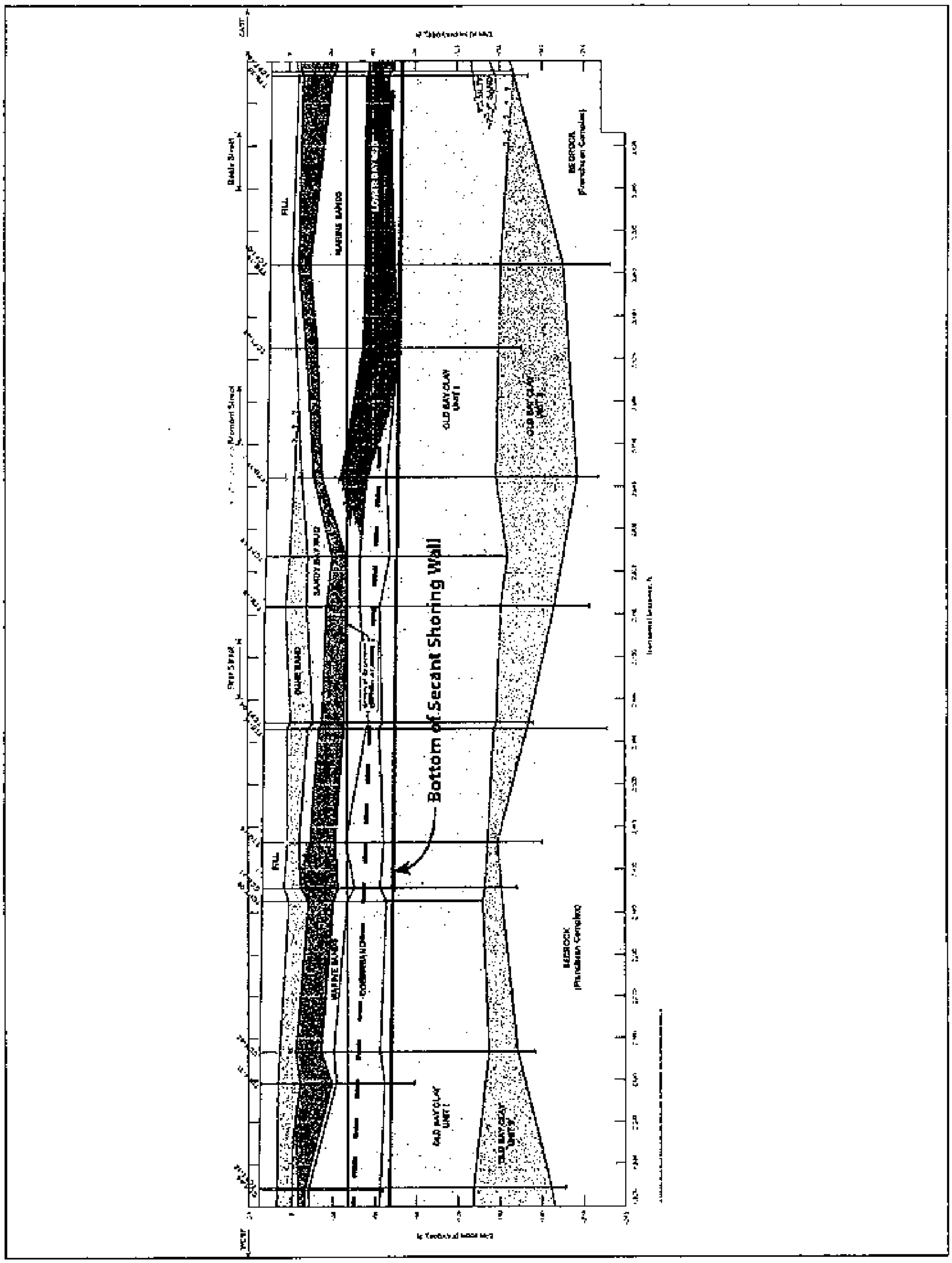


Figure 2-2 Geologic Cross-Section Along Natoma Street.

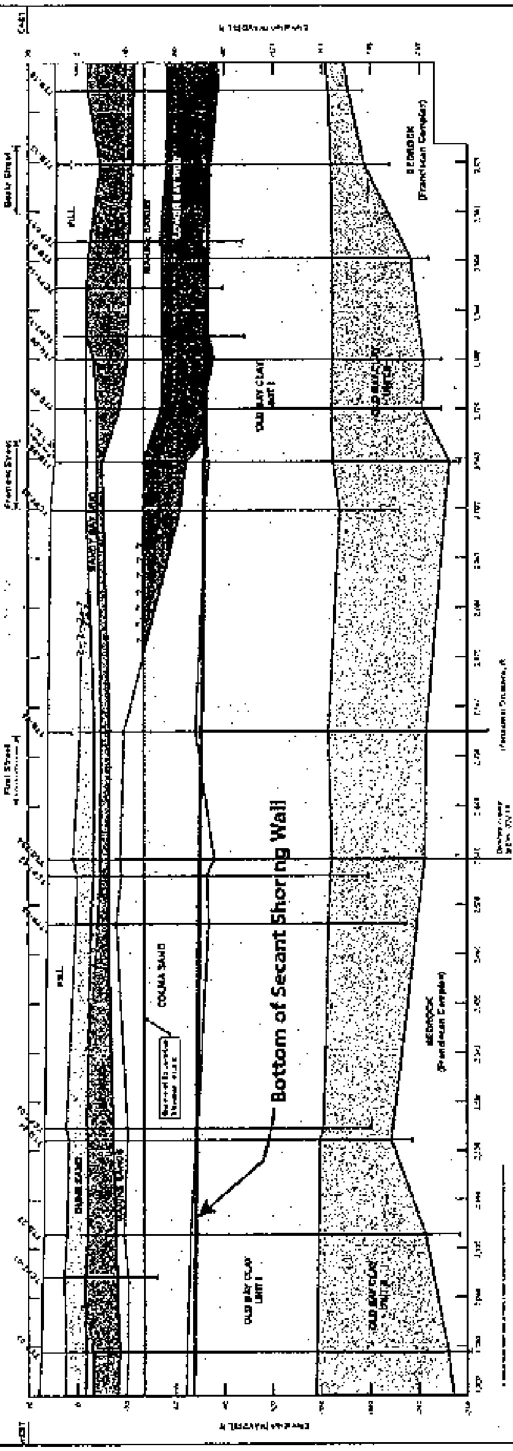


Figure 2-3 Geologic Cross-Section Along Minna Street.

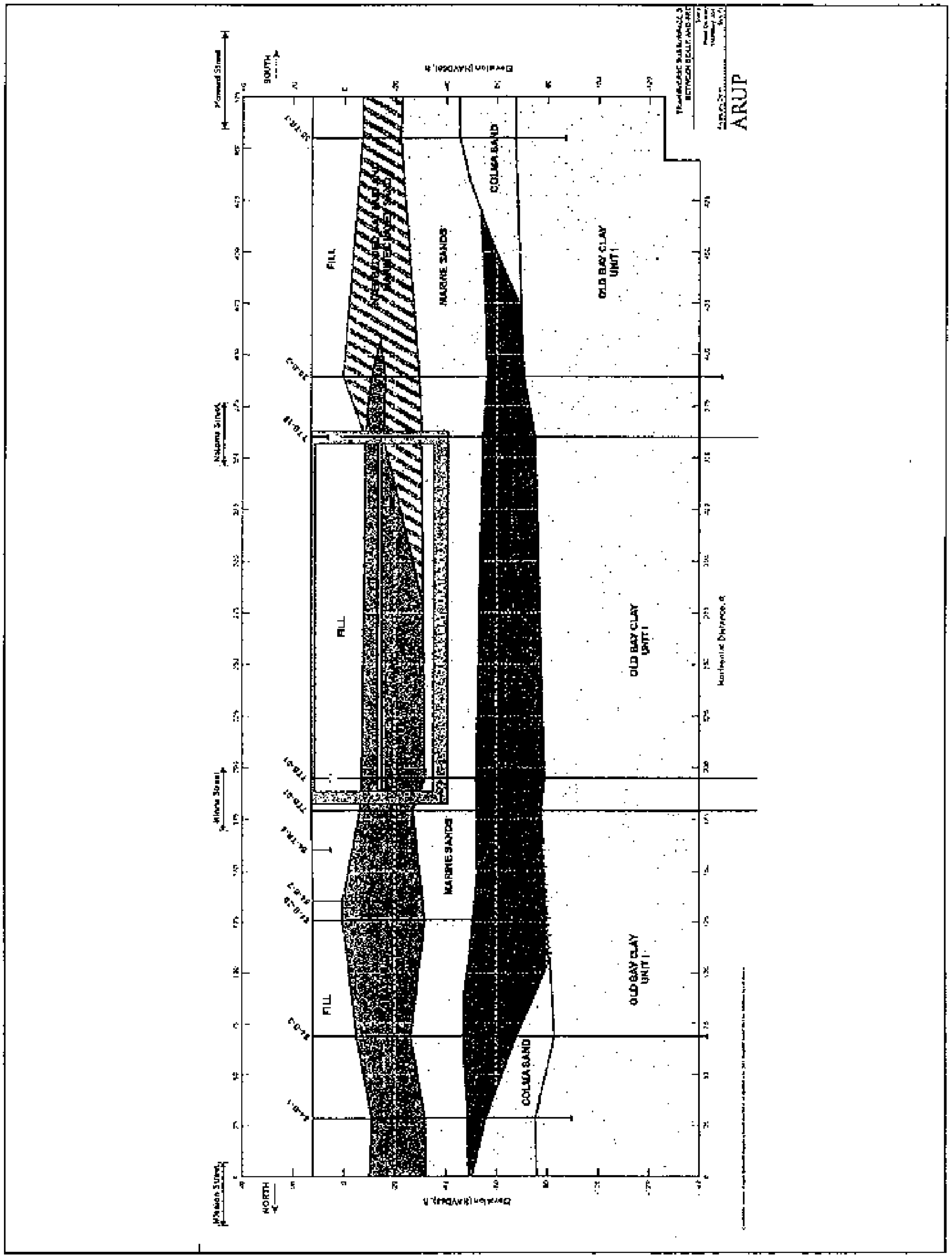


Figure 2-4 Geologic Profile Between Beale and Freemont Streets.

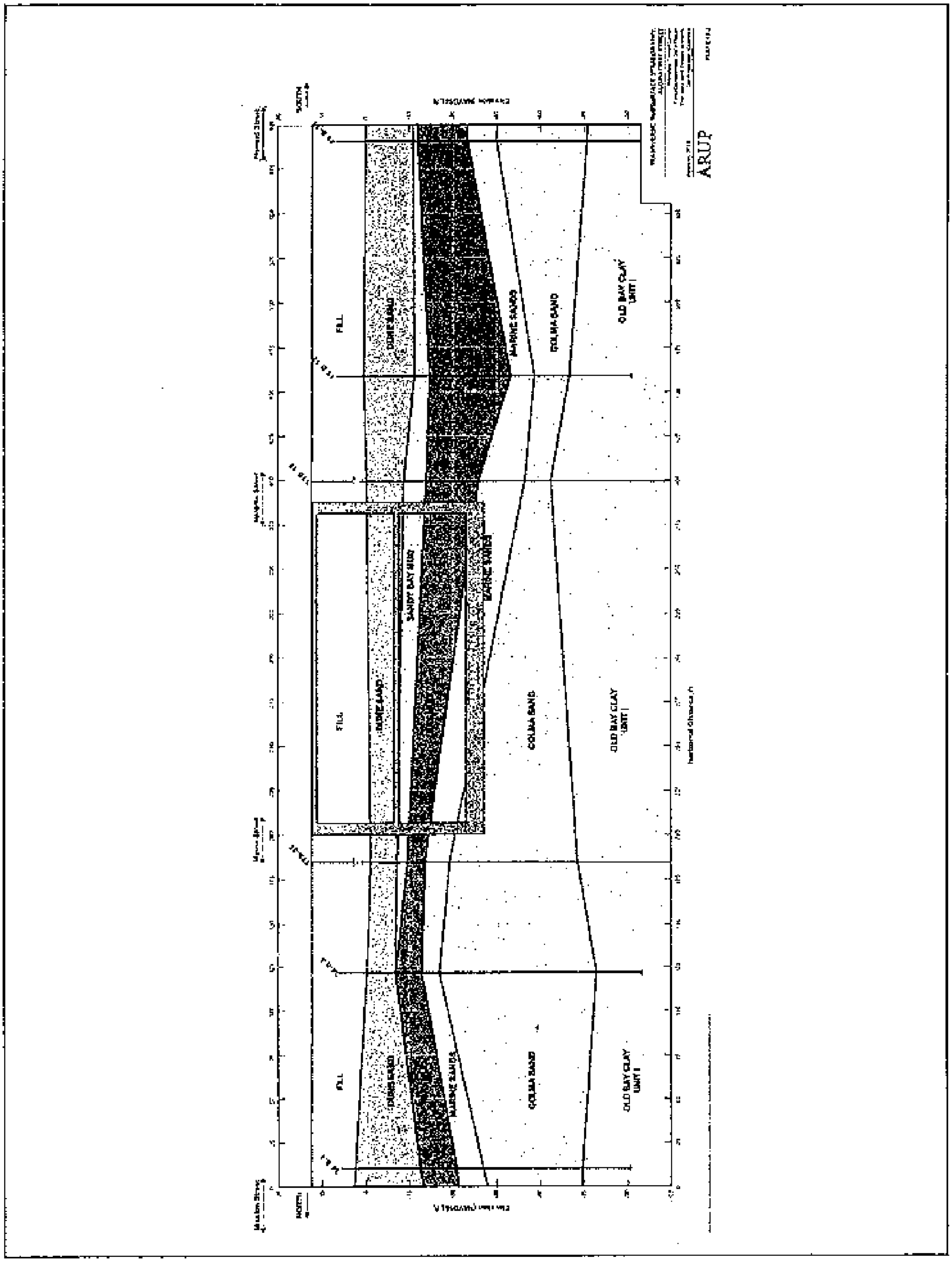


Figure 2-5 Geologic Profile Along First Street.

2.3 Groundwater Levels

Groundwater levels in the project area can fluctuate by several feet from season to season as well as fluctuations resulting from existing site-specific conditions such as water leaks or other dewatering activities in the vicinity of the project. The Geotechnical Data Report for the project (ARUP 2010) provides data on 7 piezometers that were installed at the project. The piezometers collected data for approximately a year and a half, and showed the groundwater elevation ranging from elevation 0 ft. NAVD to 6 ft. NAVD. Figure 2-6 is a plot of the collected data.

The depth to groundwater that was identified in the core logs that were drilled for the project was plotted up in the Geotechnical Data Report. That contour map is shown in Figure 2-7. The depth to groundwater varies from 17 feet at the western end of the excavation to 8 at the eastern end of the site. Given the ground elevation of 22 and 13 at the western and eastern end of the excavation respectively, the groundwater elevation at the time the cores were drilled was relatively flat, with an elevation of 5.0 ft. NAVD. This value may have been high since it was collected during the boring process, before the groundwater had a chance to reach equilibrium. Given the collected data, a conservative estimate of 5.0 ft. NAVD was used for the dewatering analysis.

2.4 Aquifer Characteristics

The aquifer characteristics at the project site were developed from the soil characteristics observed in the collected soil logs (ARUP 2010). The primary core logs used in the analysis are provided in Appendix E. The soil structure below the site is a mix of mud, Colma and Dune Sands, and Old Bay Clay. The primary strata that will carry water through the site will be the sand layers.

2.4.1 Hydraulic Conductivity

A series of rising head permeability tests were conducted to determine the relative hydraulic conductivity of the sand layers. Those tests were described in ARUP 2010, a copy of which is provided in Appendix B of this report.

Rising-head permeability tests were performed in seven piezometers that were installed in boreholes at the project. The rising-head permeability tests involve lowering of the water level in the standpipe piezometer and then monitoring the rate of recovery of the water in the standpipe, as water flows from the surrounding soil into the piezometer. The results of the permeability tests are included in Appendix B. Five of the seven piezometers were screened in the Colma Sand layer, one of the piezometers was screened in the dune sand layer, and the last one was screened in the marine sand layer that is sandwiched between the upper and lower Bay Mud layers. The hydraulic conductivity results ranged from 1.1x10-4 cm/sec to 2.6x10-3 cm/sec. A summary of the results are provided in Table 2-1.

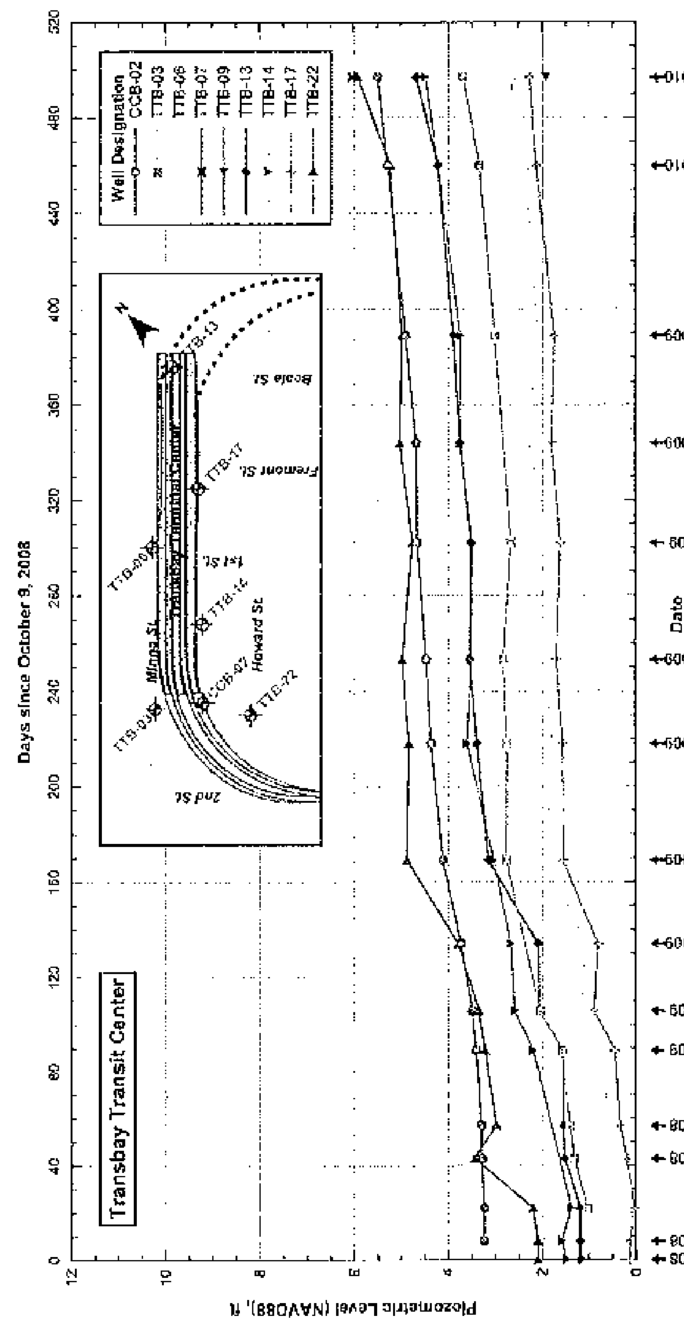
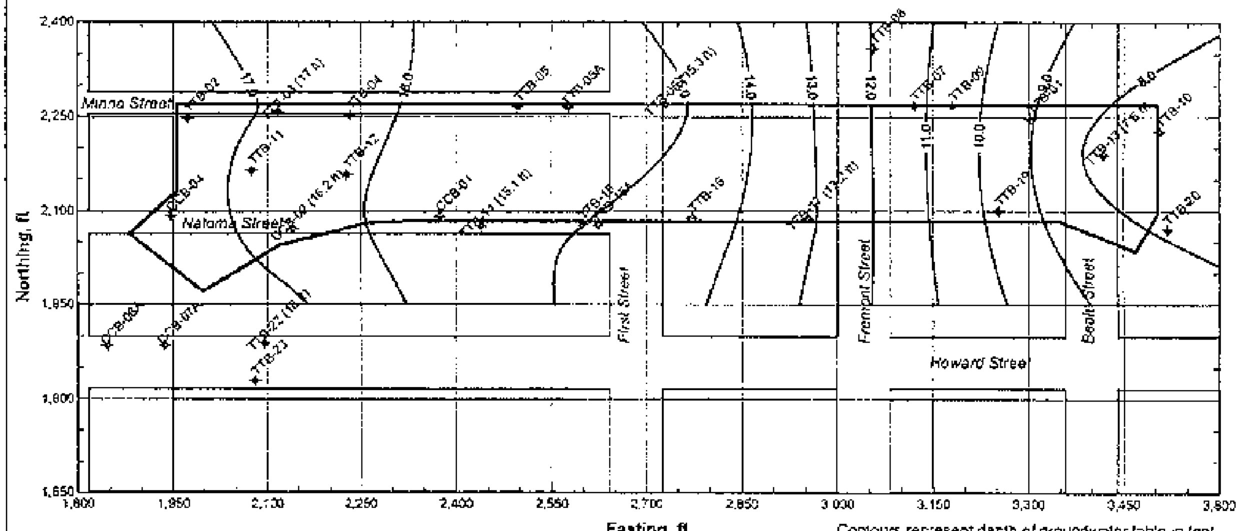


Figure 2-6 Time Series of Groundwater Elevation at 7 Piezometers

Figure 2-7 Depth to Groundwater Contours



Borehole ID	Piezo Depth (ft)
CCB-02	16.2
TTB-03	17.0
TTB-06	15.3
TTB-13	7.6
TTB-14	15.1
TTB-17	13.2
TTB-22	18.0

Scale 1 inch = 150 feet

CONTOURS OF THE DEPTH TO THE GROUNDWATER TABLE

Transbay Transit Center
Final Geotechnical Data Report
Transbay Joint Powers Authority
San Francisco, California

February 2010

ARUP

PLATE 16-2

Table 2-1 Summary of Rising Head Permeability Tests

Strata	High Permeability	Low Permeability	Median Permeability
Colma Sand	1.8x10-3	1.4x10-4	9.7x10-4
Dune Sand			9.6x10-4
Marine Sand	4.5x10-4	2.5x10-4	3.5x10-4

To bracket in the expected dewatering pumping rate and drawdown rate, a high and low value of hydraulic conductivity was used in the analysis. contractor. A hydraulic conductivity of 1.4 x10-4 cm/sec was used as a low value and 1.8x10-3 cm/sec was used as a high value for all sand layers. Based on the different soil types, estimates for the remaining values of hydraulic conductivity, specific yield, and transmissivity were developed.

The hydraulic conductivity for each clay layer was developed by comparing the observed soil types to typical hydraulic conductivity characteristics as described by David McWhorter (McWhorter 1977). Table 2-2 lists the various soil types and characteristic hydraulic conductivity.

The transmissivity was computed by multiplying the average hydraulic conductivity by the saturated depth from the water table to the bottom of the partially embedded wells. In our case, the wells extend an average of 77 feet into the saturated layer.

To calculate the composite transmissivity for an aquifer, the following equation was used:

$$\sum(K_i \times B_i)$$

Where: K = hydraulic conductivity of soil type "I"
b = total depth in aquifer attributed to soil type "I"

The transmissivity for this 77-foot depth was calculated to be 157 ft^2/d. Detailed information about the individual core borings that were used to construct the groundwater model are presented in Appendix E.

The aquifer characteristics at the project site were developed from the soil characteristics observed in the core borings and the geologic profiles.

Table 2-2 Typical Hydraulic Conductivities of Soil Strata (K_h) [1]

Aquifer Material	No. of Analyses	Low	High	Arithmetic Mean	Arithmetic Mean
		(cm/sec)	(cm/sec)	(cm/s)	(ft/d)
Igneous Rocks					
Weathered granite	7	3.30×10^{-4}	.0052	.00165	4.677
Weathered gabbro	4	5.00×10^{-5}	3.80×10^{-4}	.000189	0.536
Basalt	93	2.00×10^{-9}	4.25×10^{-5}	.00000945	0.027
Metamorphic Rock					
Schist	17	2.00 x10-9	.00113	1.90 x10-4	0.54
Sedimentary Materials					
Clay	19	1.00 x10-9	4.70 x10-7	9.00 x10-8	0.00026
Siltstone	8	1.00 x10-9	1.40 x10-6	1.90 x10-7	0.00054
Silt	39	9.00 x10-9	7.09 x10-4	2.83 x10-5	0.08
Sandstone (fine)	20	5.00 x10-7	.00227	3.31 x10-4	0.94
Sandy Silts[2]		5.00 x10-4	.00200	.00125	3.5
Sand (fine)	159	2.00 x10-5	.0189	.00288	8.2
Silty Sands[2]		.005	.02	.0125	35.4
Sand (medium)	255	9.00E-05	5.67E-02	1.42E-02	40
Sand (coarse)	158	9.00E-05	6.61E-01	5.20E-02	147
Clean Sands[2]		2.00E-02	2.00E-01	1.10E-01	312
Gravel	40	3.00E-02	3.12E+00	4.03E-01	1142

(1) Adopted From McWhorter and Sunada 1977; (Adapted from Morris & Johnson, 1967)

(2) From Dewatering and Groundwater Control, Army TM 5-818-5, 1983

2.4.2 Storage Coefficient Values

The storage coefficient for confined aquifers is referred to as the storativity (S_s), while the storage coefficient for unconfined aquifers is referred to as the specific yield (S_y). A typical range for storativity is 0.00005 to 0.005, while a typical range of specific yield is 0.01 to 0.30. For purposes of this analysis, we used a specific yield of 0.32 for sand and 0.06 for clay. Table 2-3 lists various soil types and their characteristic specific yields. Tables 2-4 and 2-5 lists typical values for storage coefficient and porosity.

Table 2-3 Specific Yield of Aquifer Materials (S_y) [1]

Aquifer Material	No. of Analyses	Range	Arithmetic Mean
Sedimentary Materials			
Sandstone (fine)	47	0.02-0.40	0.21
Sandstone (medium)	10	0.12-0.41	0.27
Siltstone	13	0.01-0.33	0.12
Sand (fine)	287	0.01-0.46	0.33
Sand (medium)	297	0.16-0.46	0.32
Sand (coarse)	143	0.18-0.43	0.3
Gravel (fine)	33	0.13-0.40	0.28
Gravel (medium)	13	0.17-0.44	0.24
Gravel (coarse)	9	0.13-0.25	0.21
Silt	299	0.01-0.39	0.2
Clay	27	0.01-0.18	0.06
Limestone	32	~0-0.36	0.14
Wind-Laid Materials			
Loess	5	0.14-0.22	0.18
Eolian Sand	14	0.32-0.47	0.38
Tuff	90	0.02-0.47	0.21
Metamorphic Rock			
Schist	11	0.22-0.33	0.26

1. Adapted from McWhorter & Sunada 1977

Table 2-4 Ranges of Values of Specific Storage (S)

Material	Min (1/m)	Max (1/m)	Min (1/ft)	Max (1/ft)	Average (1/ft)
Plastic clay	0.00260	0.02000	0.00853	0.06562	0.03707
Stiff clay	0.00130	0.00260	0.00427	0.00853	0.00640
Medium-hard clay	0.00092	0.00130	0.00302	0.00427	0.00364
Loose sand	0.00049	0.00100	0.00161	0.00328	0.00244
Dense sand	0.00013	0.00020	0.00043	0.00066	0.00054
Dense sandy gravel	0.00005	0.00010	0.00016	0.00033	0.00024
Rock, fissured jointed	0.00000	0.00007	0.00001	0.00023	0.00012
Rock, sound		0.000003		0.00001	

From Table 3.4, Anderson and Woessner, adapted from Domenico, 1972.

Table 2-5 Range of Values of Porosity

Material Type	n (%)
Unconsolidated deposits	
Gravel	25-40
Sand	25-50
Silt	35-50
Clay	40-70
Rocks	
Fractured basalt	5-50
Karst limestone	5-50
Sandstone	5-30
Limestone, dolomite	0-20
Shale	0-10
Fractured crystalline rock	0-10
Dense crystalline rock	0-5

3 Dewatering Analysis

3.1 Introduction

The project specifications require that dewatering should be conducted to allow for the excavation of the foundation in a dry condition. The specifications call for lowering the groundwater table a minimum of 5 feet below thew bottom of the excavation. That requires that the groundwater be lowered from the design background condition at elevation of 5 ft. NAVD to elevation -46.5 ft. NAVD. To analyze the requirements for dewatering, a groundwater model was developed to evaluate the effects that dewatering wells will have on the groundwater in and around the structure. The model incorporated the dewatering wells and the geologic strata that were described in Section 2 of this report.

The proposed dewatering plan has been designed to lower the existing groundwater elevation to a minimum of five feet below the bottom of the excavation. Given the close proximity of the adjacent buildings, the dewatering system was designed to minimize the time and amount of groundwater drawdown. To that end the dewatering pumps will be operated to achieve only that drawdown that is required for the excavation and construction of the foundation.

The analysis also took into account the shoring wall that will surround the excavation. The foundation will be surrounded by a secant pile shoring wall that will help to isolate the foundation excavation from the groundwater on the opposite side of the wall. The wall was assumed to be semi permeable and leakage was accounted for in the model.

3.2 Methodology

Because of the relatively complex flow patterns developed from a pumping operation, the groundwater flow model for the project was developed using the USGS computer program "MODFLOW" (Harbaugh 2000). This model has been widely used to simulate aquifer response to both pumping and recharge wells. There are many versions of this model being used throughout the United States. The version of the model used in this analysis is the MODFLOW 2005 model. This is the basic MODFLOW model, with modifications added to allow for pumping from various geologic layers. This methodology allowed for the evaluation of various pumping rates within the distinct soil layers below the project. This methodology not only computes the groundwater drawdown at the structure, but also within the region around the building.

MODFLOW is a three-dimensional finite-difference groundwater model that can simulate steady and unsteady flow and pumping in aquifers. The project area is simulated using a rectangular grid consisting of cells and nodes. The fundamental groundwater equation is solved for each cell using finite difference approximation. The aquifer may consist of one or multiple layers, with each layer having identical grids. Flow caused by external stress, such as flow to a well or recharge from a river system, can also be simulated. The primary output from the model is head (groundwater elevation) for each grid cell. These head values can then be used to create contours, providing a plan view of the groundwater elevation across the project area.

Within the MODFLOW model, the three-dimensional movement of groundwater of constant density through porous earth material may be described by the partial differential equation:

Within the MODFLOW model, the three-dimensional movement of groundwater of constant density through porous earth material may be described by the partial differential equation:

$$\frac{\partial}{\partial x}\left(K_{xx}\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_{yy}\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_{zz}\frac{\partial h}{\partial z}\right)-W = S_s \cdot \frac{\partial h}{\partial t}$$

Where:

K_{xx}, K_{yy}, and K_{zz} are values of hydraulic conductivity along the x, y, and z coordinate axes, which are assumed to be parallel to the major axes of hydraulic conductivity. [L-1]

h is the potentiometric head [L];

W is a volumetric flux per unit volume and represents sources and/or sinks of water [t-1]

Ss is the specific storage of the porous material [L-1]; and t is time (t)

For a derivation of equation (1) see for example Rushton and Redshaw (1979). In general, S_s, K_{xx}, K_{yy}, and K_{zz} may be functions of space $S_s = S_s$ (x, y, z), $K_{xx} = K_{xx}$ (x, y, z etc) , and W may be a function of space and time W = W(x, y, z, t); equation (1) describes groundwater flow under non-equilibrium conditions in a heterogeneous and anisotropic medium, provided the principal axes of hydraulic conductivity are aligned with the coordinate directions.

Equation (1), together with specification of flow and/or head conditions at the boundaries of the aquifer system and specification of initial-head conditions, constitutes the mathematical representation of the groundwater flow system. A solution of equation (1), in an analytical sense, is an algebraic expression giving h(x,y,z,t) such that, when the derivatives of h with respect to space and time are substituted into equation (1), the equation and its initial and boundary conditions are satisfied. A time-varying head distribution of this nature characterizes the flow system, in that it measure both the energy of flow and the volume of water in storage, and can be used to calculate directions and rates of movement.

3.3 Model Description

The Transbay Transit Center groundwater model grid consists of six layers, representing the strata described in Section 2.2. The purpose of constructing a model with multiple layers was to provide a tool to account for vertical as well as horizontal gradients and conductivities within the aquifer. Vertically, the model extends from the ground surface down to elevation -240 ft. NAVD. The model covered a spatial extent of 5,200 feet along the northeast-southwest axis and 6,000 feet along the northwest-southeast axis, with the project element located in the center of the model space. The eastern boundary of the model terminates at the edge of the San Francisco Bay.

The model space was subdivided into a matrix of variable sized cells, with cells near the dewatering wells 3-feet wide to cells further away increasing in size to a maximum of 40-feet wide, for a total of 101,000 elements. This matrix was repeated for each of the 6 layers. The cell thickness varied according to the soil layer thickness as described in Section 2. The outermost elements of each grid were set as specified head boundaries, based upon the design groundwater table at elevation of 4.

The implementation of Equation 3-1 within the model grid space allows for the analysis of the drawdown at any location in the system due to the dewatering wells. The equations were used to determine the drawdown necessary to ensure that the groundwater level would be at least 5 foot below the bottom of the excavation.

Figure 3-1 is a map of the model grid extent used in the project. Figure 3-2 is a close up of the grid in the area around the excavation. The proposed alignment is shown in the figure along with the proposed 43 dewatering wells along the edges of the excavation and 3 cutoff well inside the excavation. The wells will be drilled down 90 feet from the ground surface, with the bottom of the well varying from to elevation -68 at the western end of the excavation to -77 at the eastern end of the model. The well depth and dewatering equipment specifications are provided in Appendix D.

The hydraulic conductivity of the aquifer was based on the soil characteristics found in the project core borings and described in Section 2 of this report. This was primarily sand and clay formations. The average elevation for each of the soil formations was used to develop the thickness of each of the layers in the model. The layers used in the model and the soil types for each layer are shown in Table 3-1.

TABLE 3-1 Conceptual Model Layer Data

Layer	Strata	Top of Layer	Bottom of Layer
1	Fill/Sand	18	-9
2	Bay Mud	-9	-25
3	Colma/Marine Sands	-25	-78
4	Old Bay Clay Unit I	-78	-150
5	Old Bay Clay Unit II	-150	-195
6	Bedrock	-195	-240

There are a total of 43 dewatering wells spaced along the perimeter of the excavation and 3 cutoff wells in the center of the excavation. The dewatering wells are approximately 77 feet on center. Each of the dewatering wells will be drilled down 90 feet from the existing ground surface.

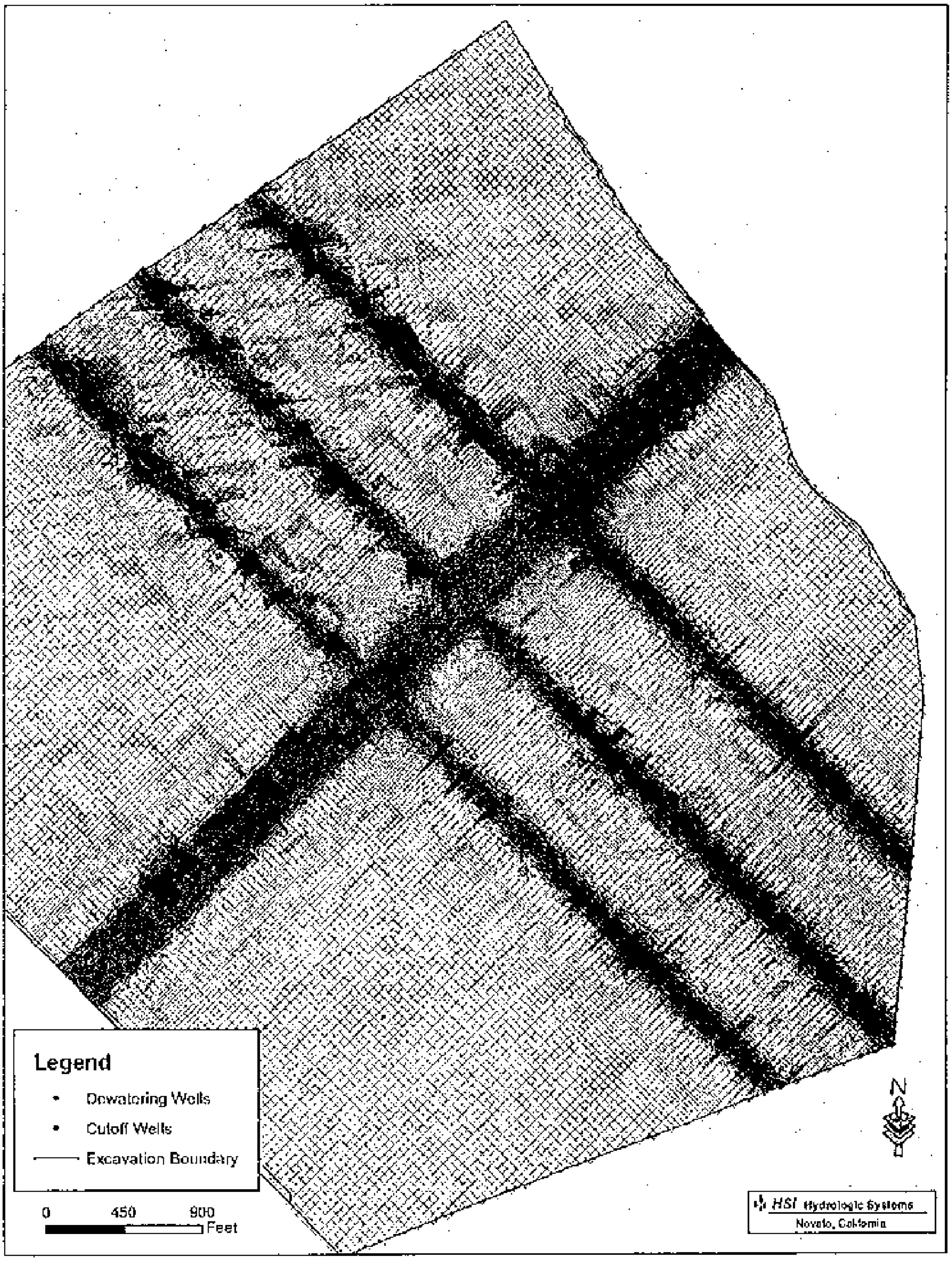


Figure 3-1 Groundwater Model Grid Extent.

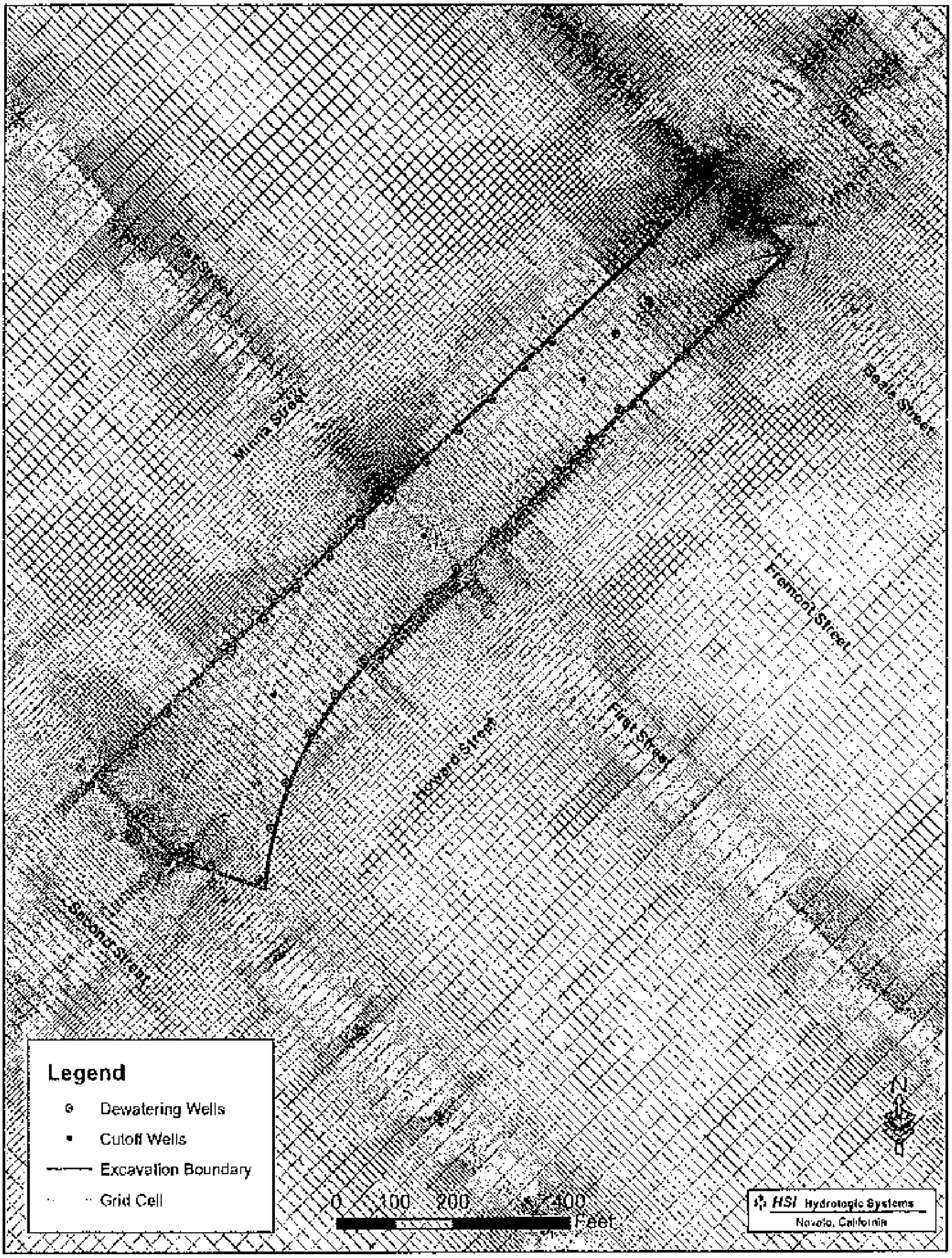


Figure 3-2 Groundwater Model Grid In The Vicinity of the Excavation.

The excavation was divided into 4 separate zones. Zone 1 extends from the western end of the project to Shaw Alley. Zone 2 extends from Shaw Alley to First Street. Zone 3 extends from First Street to Fremont Street. Zone 4 extends from Fremont Street to the end of the excavation. There are a total of 13 wells spaced along the perimeter of Zone 1, and 11 in Zones 2 through 4. This number includes the center cutoff wells. A plan view of the different zones is shown in Figure 3-3. Each of the zones will be excavated down in 5 stages, with each stage being excavated to a lower depth. Table 3-2 lists the excavation inverts for each of the 5 levels. The schedule for reaching each of the 5 levels for each zone is shown in Figure 3-4.

TABLE 3-2 Excavation Levels

Level	Bottom Elevation (ft. NAVD)
1	-6
2	-20
3	-32
4	-42
5	-42

The secant pile shoring wall was entered into the model as semi-permeable barrier to flow. The barrier element in MODFLOW simulates a thin, vertical low-permeability geologic feature. These geologic features are approximated as a series of horizontal-flow barriers situated on the boundaries between pairs of adjacent cells in the finite-difference grid. Barrier width is not explicitly considered in the model but is included implicitly in a hydraulic characteristic defined as the barrier hydraulic conductivity divided by barrier width. The barrier extended down to the top of the Old Bay Clay Unit II. The barrier was assigned a hydraulic characteristic of 1×10^{-6} cm/sec (0.0011 /day).

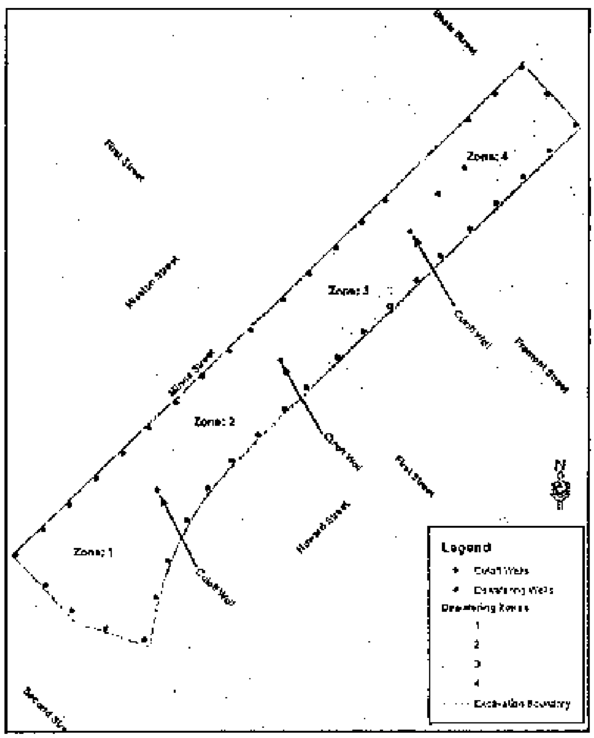


Figure 3-3 Excavation Dewatering Zones.

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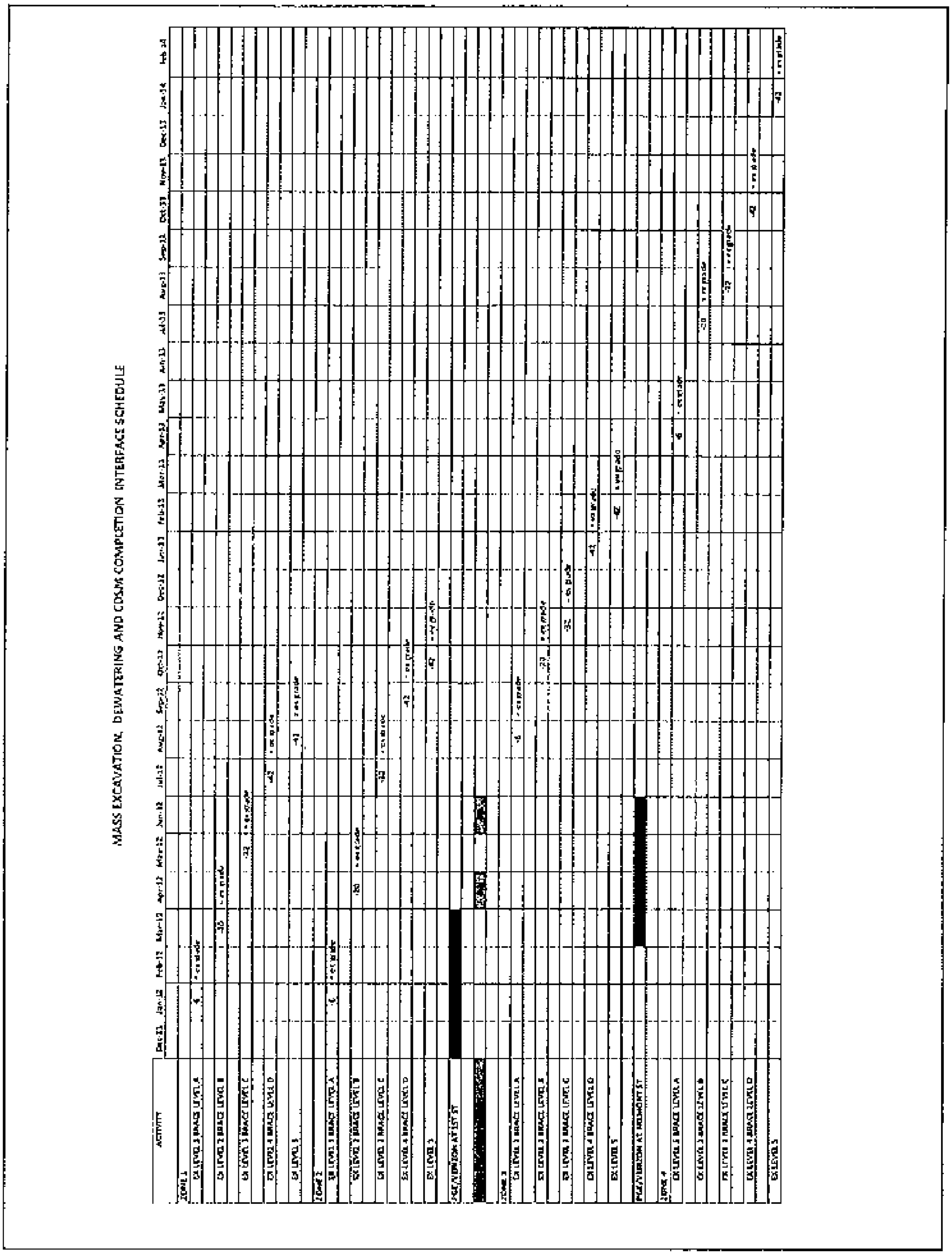

Figure 3-4 Project Excavation Schedule

Three cutoff wells will be used in addition to the perimeter dewatering wells. The cutoff wells will be drilled to the same depth as the dewatering wells, and are used to allow the dewatering of Zones 1 through 3 without having to turn on the dewatering wells in the adjacent zone.

3.4 Dewatering Limits

The dewatering system was designed to be capable of lowering the groundwater to a depth 5 feet below the bottom of the excavation. The bottom of the excavation is generally at -41.5 ft., which will require the groundwater be drawn down to elevation -46.5 NAVD. There are several localized pits within the overall excavation that are deeper than -41.5. Figure 3-4 is a plan view of the project showing the different excavation elevation zones. The deepest pit goes down to elevation -51.1, which would require the groundwater elevation be drawn down to elevation 56.1 ft. NAVD. These localized pits will likely require sumps be installed adjacent to the pit to assist in the dewatering. Given the background groundwater elevation of 5.0, the groundwater will need to be lowered an average of 51.5 feet.

3.5 Dewatering Plan Results

The configuration of the excavation and dewatering wells, as described in the previous sections, were entered into the MODFLOW groundwater model. The required pumping rate for each well was based on the ability for water for flow through the different strata to each of the wells. The model was run for a period of 2-years on a 6 hour time step. Three scenarios, reflecting the high, low, and mid range of hydraulic conductivity of the soils, were evaluated for the proposed dewatering plan.

The hydraulic conductivity for a specific soil type can vary significantly between different soil samples or from one location to another, and groundwater flow can be very sensitive to the hydraulic conductivity of the soil. Thus, the required pumping rate and the time to draw the groundwater down to the target level can change significantly depending on the value of hydraulic conductivity that is used in the analysis. The range of hydraulic conductivities can often vary by orders of magnitude for the same soil type, depending on how the soil strata initially formed. To understand the impact of this potential variability, the groundwater model was run with the low, medium, and high values of hydraulic conductivity. The range of values were calculated from the rising head permeability tests that were conducted on several of the sand strata identified at the site. A range of hydraulic conductivities were calculated from those tests, and are described in Section 2 of this report (see Table 2-1). The three scenarios evaluate the impact that high, medium, and low values of hydraulic conductivity at the site will have on the proposed dewatering plan.

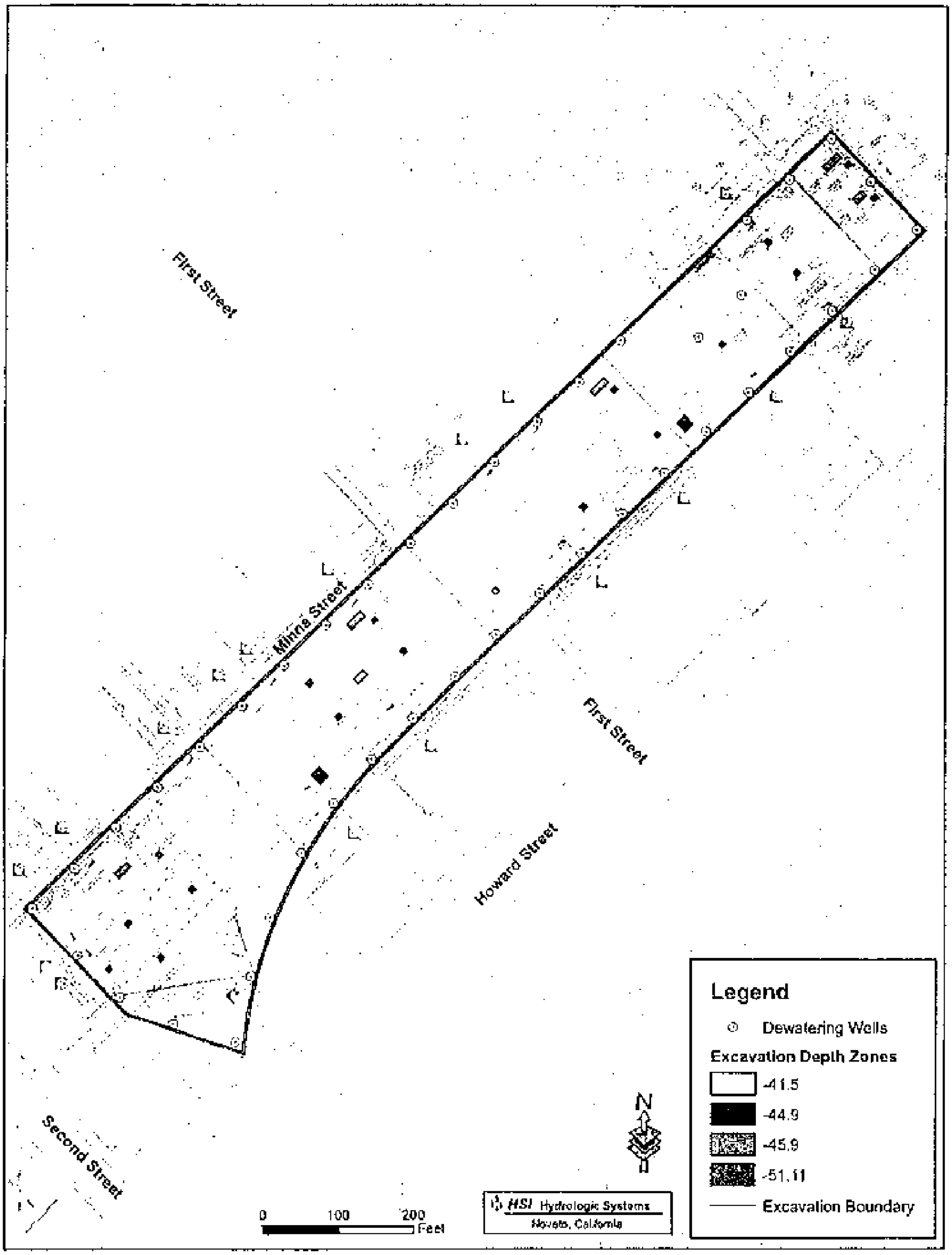

Figure 3-5 Excavation Elevation Zones.

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The dewatering plan calls for the dewatering wells to be staged according to the schedule indicated in Figure 3-4. The wells should be turned on approximately 10 to 15 days prior to starting excavation of each level. The groundwater elevation should be monitored to insure that the excavation is not over dewatered for each level. The average initial and equilibrium discharge rate for the dewatering operation is shown in Table 3-3. Once the target groundwater level is achieved, the discharge from each well will be adjusted to maintain the groundwater at that level. The time to achieve groundwater drawdown from the background groundwater level of 5 ft. NAVD was computed from the model results. Figure 3-6 shows the groundwater drawdown time series for Zone 1, which is typical of each zone. The discharge from the wells will gradually decrease from an initial high rate to a lower equilibrium rate that corresponds to a steady groundwater drawdown condition.

Table 3-3 Estimated Dewatering Pumping Rates For The Low, Medium, and High Hydraulic Conductivity Scenarios.

	Low Hydraulic Conductivity (k)		Medium Hydraulic Conductivity (k)		High Hydraulic Conductivity (k)	
No of Wells	Initial	Equilibrium	Initial	Equilibrium	Initial	Equilibrium
43						
Total Discharge (gpm)	65	21	287	23	408	30
Gallons per Day (gpd)	93,850	30,240	414,293	33,299	587,520	43,200

The discharges shown in Table 3-3 represent the pumping rates using the high, medium, and low estimates of hydraulic conductivity in the dewatering model. The initial and equilibrium pumping rates shown in the table, reflect the change in pumping rate as the flow through the aquifer slowly approaches equilibrium after each step in lowering the groundwater elevation from one level to the next. Using the medium conductivity that was developed from the permeability tests, it was found that the initial pumping rate was approximately 287 gpm, or approximately 414,293 gpd. That rate will eventually decrease to 23 gpm or 33,299 gpd.

The groundwater contours after the beginning of excavation of Level C of Zone 2 is shown in Figure 3-7. These contours represent the groundwater condition in July 2012. Figure 3-8 shows the groundwater contours in January of 2014, just after Zone 4 has been dewatered to its final elevation. The starting groundwater elevation for both conditions is +5.0.

The time to achieve the target groundwater drawdown can very significantly for a lower or higher soil hydraulic conductivity. The model was revised to use the high estimate of hydraulic conductivity that was identified in the permeability tests. Using the high estimate of hydraulic conductivity, the time to achieve the target drawdown was roughly cut in half. As would be expected, the discharge rate for the high hydraulic conductivity alternative is higher than the medium hydraulic conductivity alternative (Table 3-3).

Using the low estimate of hydraulic conductivity, the time to achieve the target groundwater drawdown will be longer than the medium hydraulic conductivity model. To reduce this drawdown time, additional sumps with trench drains can be used in each of the zones as it is being dewatered. The discharge for the low hydraulic conductivity alternative is lower than the medium hydraulic conductivity alternative (Table 3-3).

To prevent excessive drawdown, once the target groundwater drawdown is achieved, the pumping rate should be reduced to a flow rate that will maintain the target level. Monitoring wells at the site should be used to track the rate of groundwater decline.

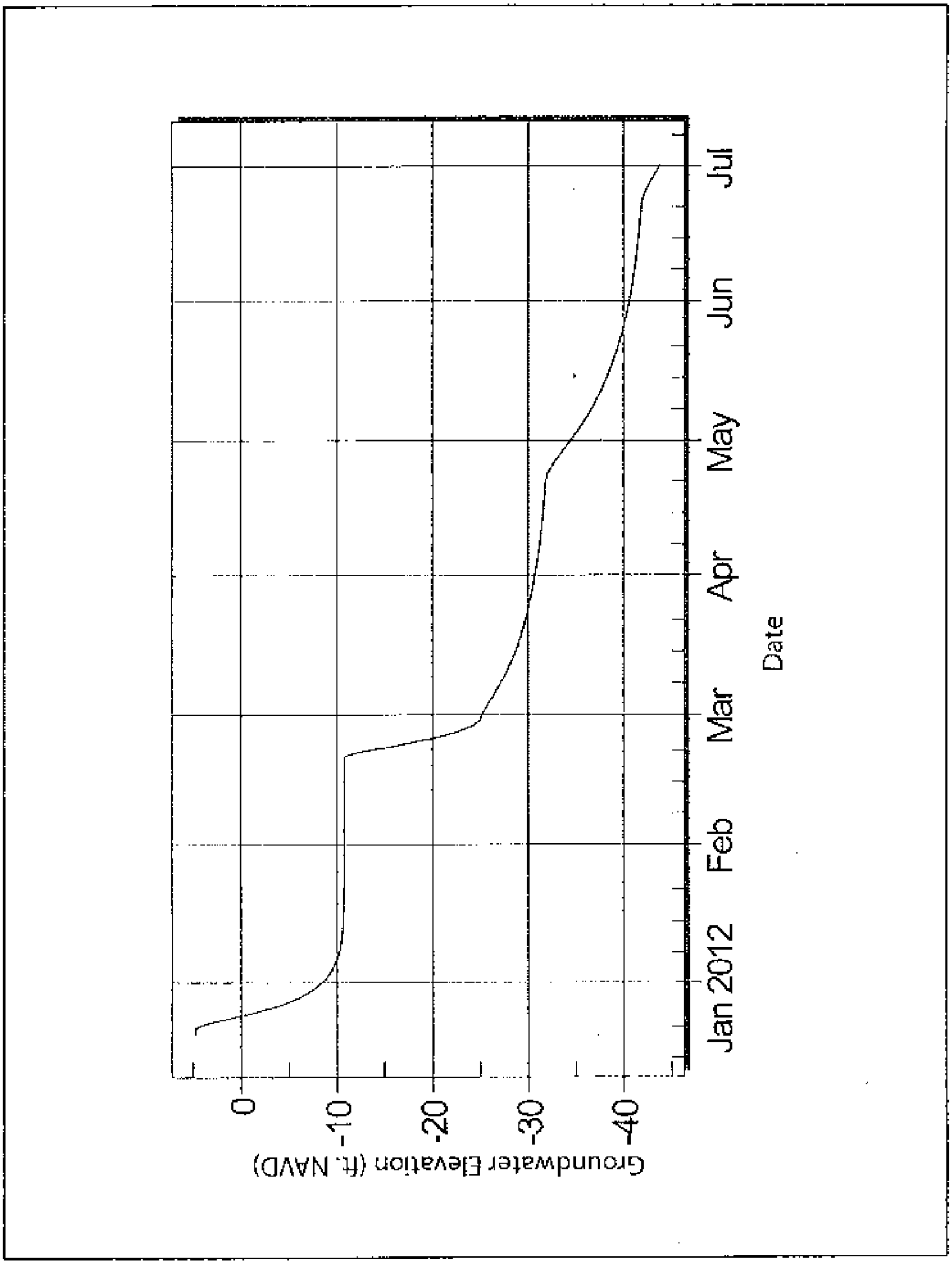

Figure 3-6 Time Series of Groundwater Drawdown in Zone 1, Medium Conductivity.

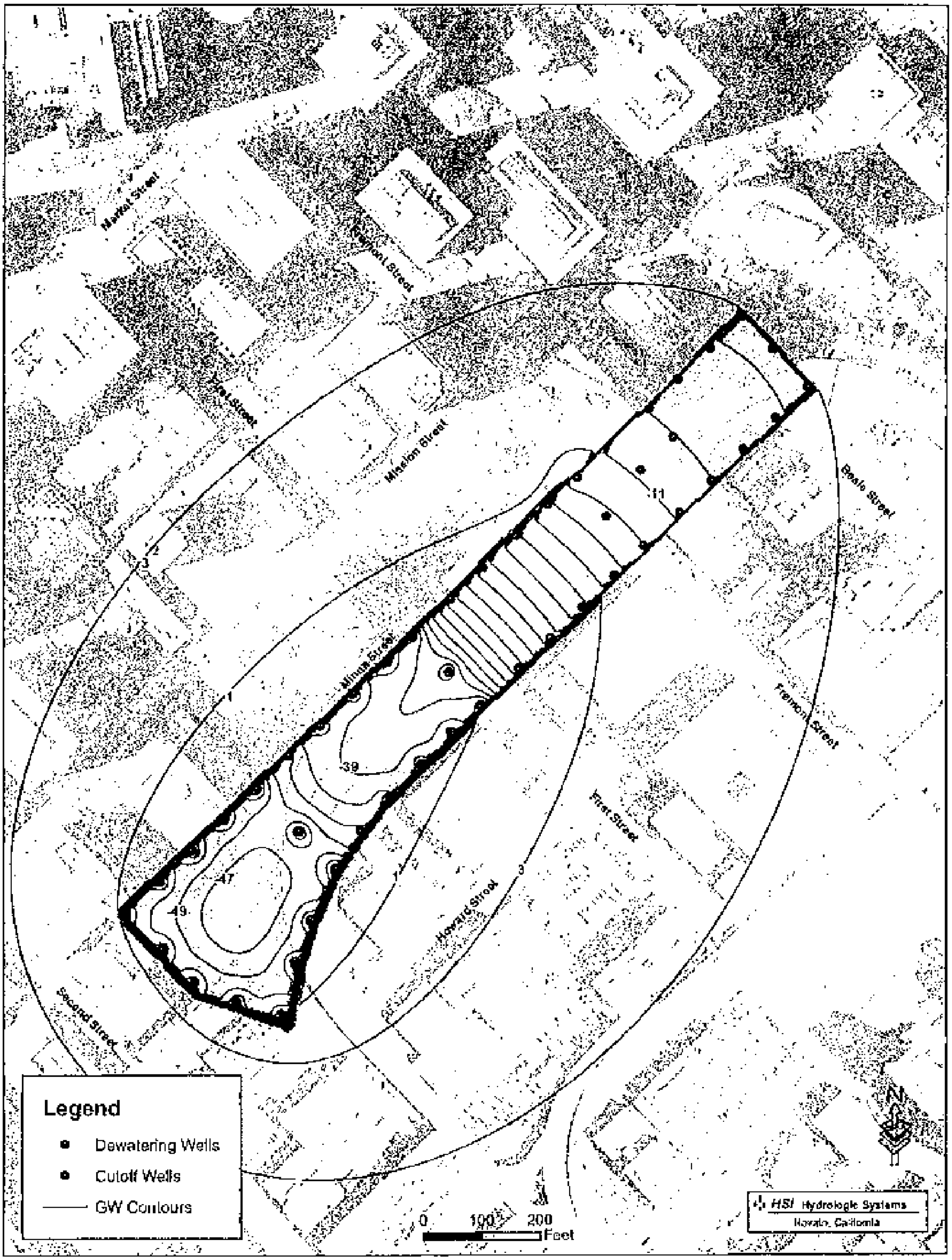

Figure 3-7 Groundwater Elevation Contours (ft. NAVD), July 2012, Medium Conductivity.

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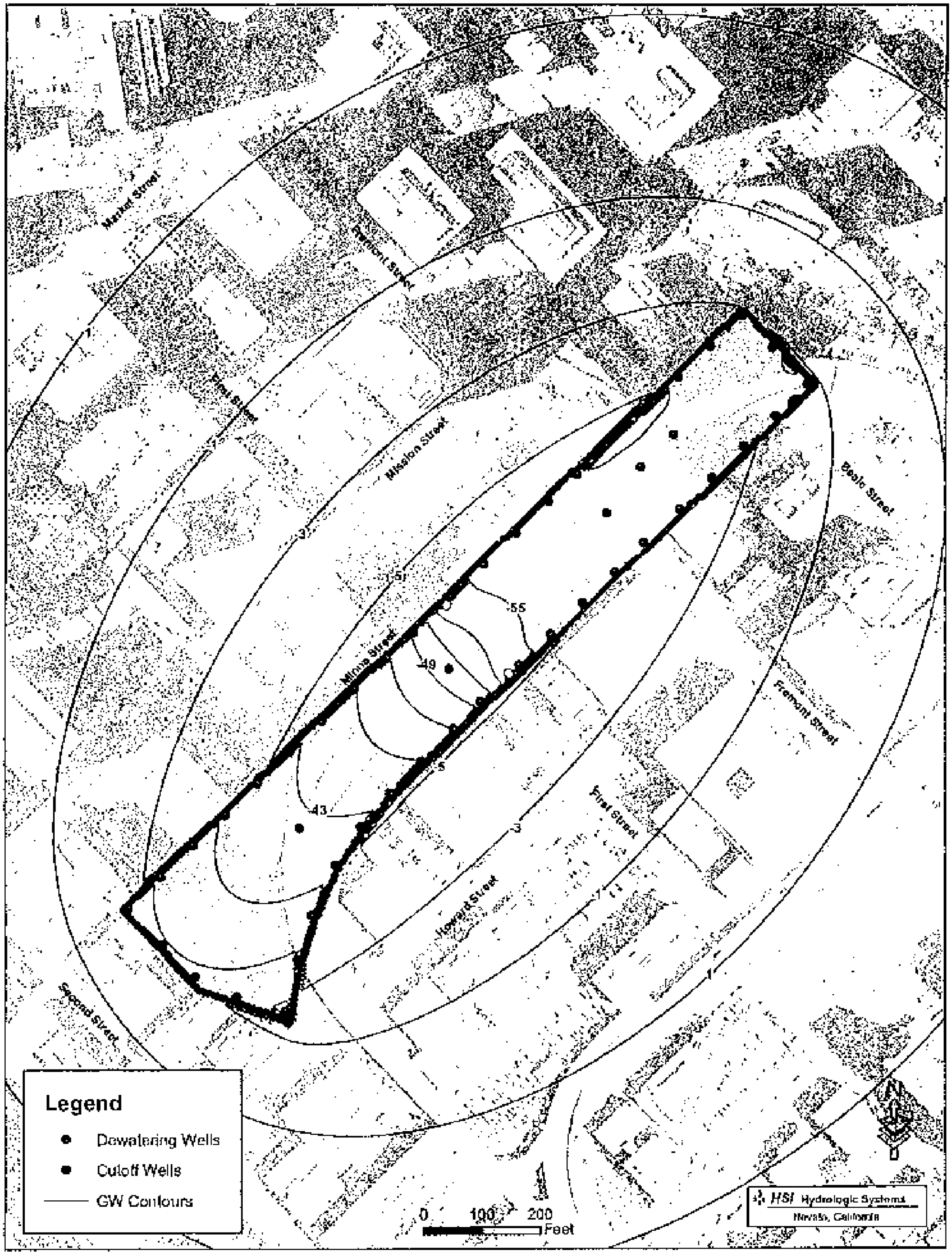

Figure 3-8 Groundwater Elev. Contours (ft. NAVD), January 2014, Medium Conductivity.

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4 Summary

This report presents a dewatering analysis for dewatering the foundation excavation for the Transbay Transit Center in downtown San Francisco, California. The project will replace the current Transbay Terminal at First and Mission streets in San Francisco with a modern regional transit hub connecting 11 transit systems.

The foundation excavation for the terminal will be rectangular in shape, running 1,480 feet long in the east-west direction, and will be approximately 180 feet wide. The existing ground surface along the excavation slopes down from an elevation of 22 ft. on the west side of the project to 13 ft. on the eastern end of the excavation. The bottom of the excavation is set at elevation -41.5 ft. NAVD. Several isolated pits within the foundation will be excavated to elevations ranging from -44.8 ft. to -52 ft. NAVD. This results in an excavation that will be approximately 74 feet deep on the west end of the project to 67 feet at the east end of the project.

The subsurface geology in the area of the excavation consists of multiple layers of sand, bay mud, and layers of old San Francisco Bay clay. Based on core logs collected at the site, a series of geologic profiles were created across the project. A geologic Cross-Section along Natoma Street and Minna Street is shown in Figure 4-1.

As can be seen in the figure, the upper layer at the site consists of fill and natural sand deposits. Below that layer is a thin layer of Bay Mud, followed by a relatively thick layer of Colma and Marine Sands. Two thick layers of Old Bay Clay lie below the sands. These clay layers consist of thick dense clay deposits that have a very low hydraulic conductivity.

A secant pile shoring wall will surround the excavation and extend down into the clay layer in an attempt to prevent groundwater from entering the excavation. The shoring wall extends down approximately 95 feet from the ground surface. The wall extends down to elevation -83 on the west end of the project, and gradually deepens to elevation -92 at the eastern end. The wall was assumed to be semi permeable and leakage was accounted for in the model.

Three cutoff wells will be used in addition to the perimeter dewatering wells. The cutoff wells will be drilled to the same depth as the dewatering wells, and are used to allow the dewatering of Zones 1 through 3 without having to turn on the dewatering wells in the adjacent zone.

The depth to groundwater that was identified in the core logs that were drilled for the project as well as piezometers that were installed and operated for approximately 1.5 years. The depth to groundwater varies from 17 feet at the western end of the excavation to 8 at the eastern end of the site. Given the ground elevation of 22 and 13 at the western and eastern end of the excavation respectively, the groundwater elevation at the time the cores were drilled was relatively flat, with an elevation of 5.0 ft. NAVD.

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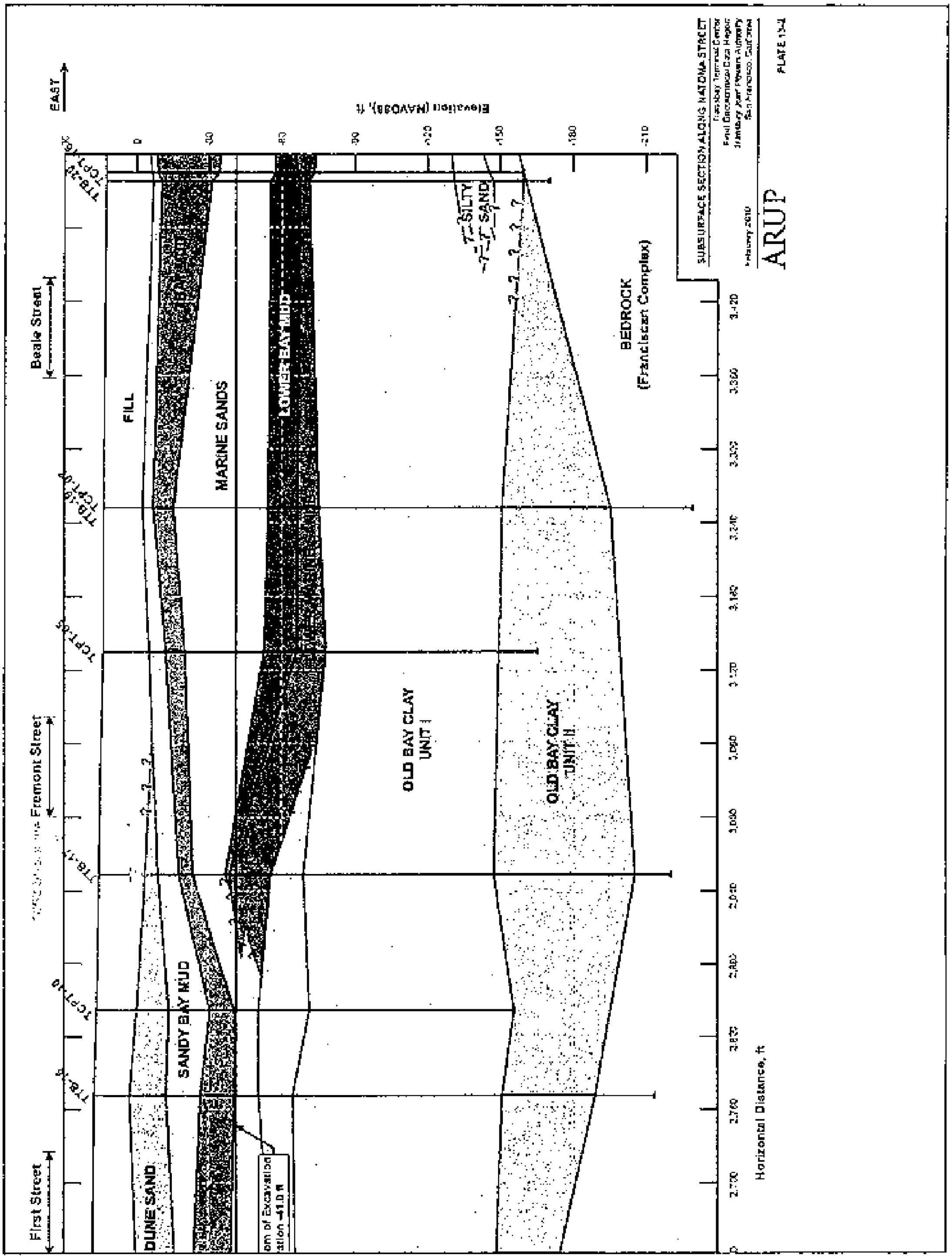

Figure 4-1 Geologic Cross-Section at Natoma Street.

ALTD-830-0461456

This value may have been high since it was collected during the boring process, before the groundwater had a chance to reach equilibrium. Data from the piezometers show groundwater ranging from elevation 2 to elevation 6 across the site. Given the collected data, a conservative estimate of 5.0 ft. NAVD was used for the dewatering analysis.

The project specifications require that dewatering should be conducted to allow for the excavation of the foundation in a dry condition. The specifications call for lowering the groundwater table a minimum of 5 feet below thew bottom of the excavation. That requires that the groundwater be lowered from the design background condition of 5 ft. NAVD to elevation -46.5 ft. NAVD.

Forty-three wells were spaced around the interior of the secant pile shoring wall. The wells extend down 90 feet below the existing ground surface. To analyze the requirements for dewatering, a groundwater model was developed to evaluate the effects that dewatering wells will have on the groundwater in and around the structure. The model incorporated the dewatering wells and the geologic strata that were described in Section 2 of this report. The model also provided information on changes to groundwater elevation in the area surrounding the project that would result from the dewatering activities. The model that was developed for the project was a 3-dimensional MODFLOW model. This is a finite element model that is capable of evaluating the movement of groundwater from pumping systems. The aquifer flow characteristics within the model were based on the geologic stratification that was observed in core logs collected at the project site.

The analysis provides for an estimate of the well spacing and groundwater pumping necessary to achieve the required groundwater drawdown. An estimate is also made of the resulting change in the groundwater level surrounding to the project due to the dewatering activity. It was assumed that the groundwater wells within each zone of the excavation will be staggered according to the needs of the excavation schedule. The wells will not be turned off until the structural components of the project achieve sufficient mass to resist the uplift forces of the potential groundwater rise that would occur if the wells are turned off.

The hydraulic conductivity for a specific soil type can vary significantly between different soil samples or from one location to another, and groundwater flow can be very sensitive to the hydraulic conductivity of the soil. Thus, the required pumping rate and the time to draw the groundwater down can change significantly depending on which value of hydraulic conductivity is used. To understand the impact of this potential variability, the groundwater model was run with the low, medium, and high estimates of hydraulic conductivity. The estimates were calculated from rising head permeability tests conducted on the soils at the site. The results of the different hydraulic conductivity alternatives show that it could take up to 7 time longer to dewater each zone for the lowest of the computed hydraulic conductivities, than it does for the medium hydraulic conductivity alternative. Under a high hydraulic conductivity alternative, the groundwater can dewater in approximately half the time as it takes in the medium hydraulic conductivity alternative.

The discharge rate for the proposed dewatering system is shown in Table 4-1. The discharge rates show the initial pumping rate as well as the equilibrium pumping rate that was taken as the pumping rate after several months of dewatering. The table shows the pumping requirements for the high and low estimates of hydraulic conductivity.

Table 4-1 Estimated Dewatering Pumping Rates For The Low, Medium, and High Hydraulic Conductivity Scenarios.

	Low Hydraulic Conductivity (k)		Medium Hydraulic Conductivity (k)		High Hydraulic Conductivity (k)	
No of Wells	Initial	Equilibrium	Initial	Equilibrium	Initial	Equilibrium
43						
Total Discharge (gpm)	65	21	287	23	408	30
Gallons per Day (gpd)	93,850	30,240	414,293	33,299	587,520	43,200

Figure 4-2 is a groundwater elevation contour plot for representing the conditions in July 2012 for the medium conductivity scenario. The groundwater elevation contours for the January 2014 period is shown in Figure 4-3. The starting groundwater elevation for both conditions is +5.0.

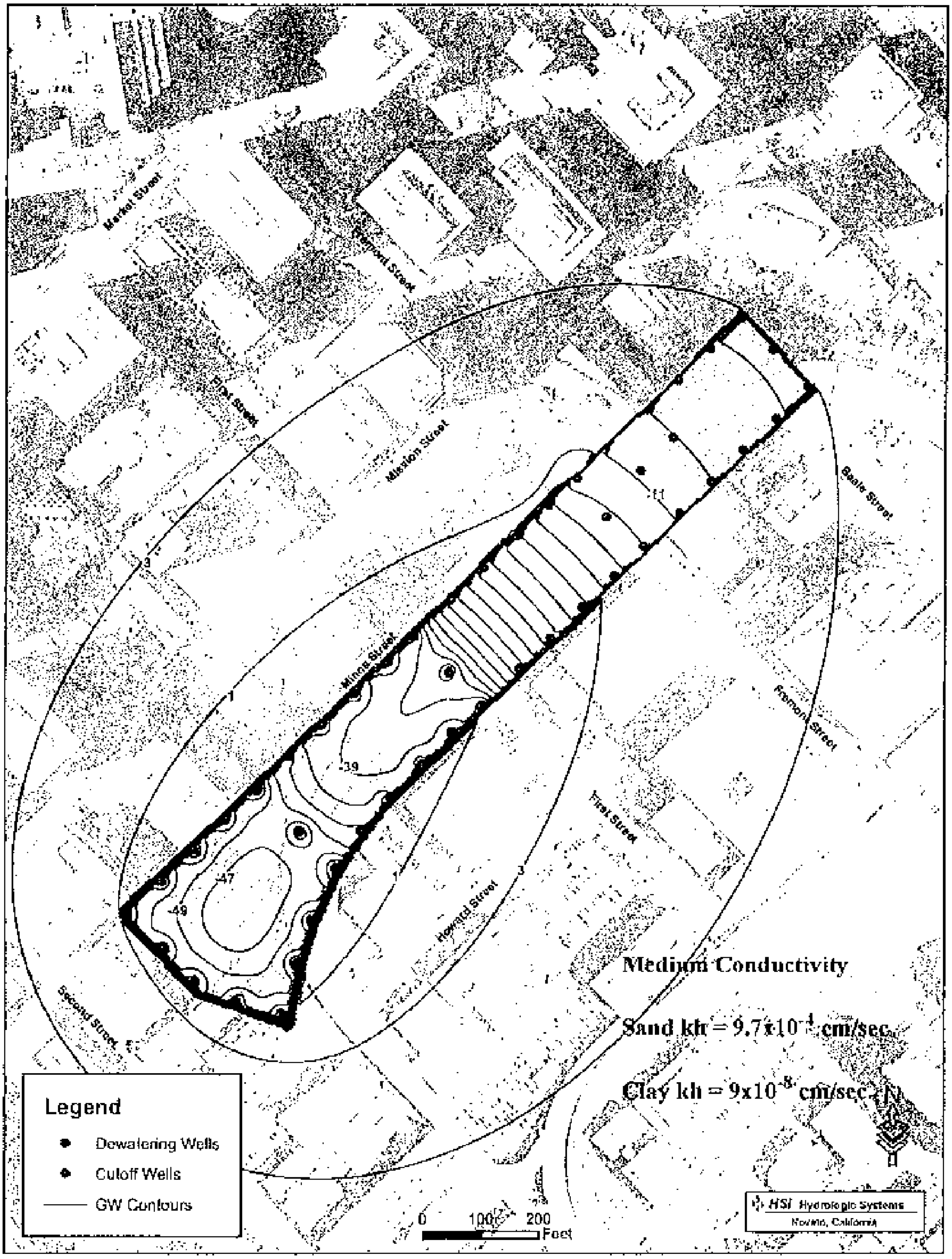

Figure 4-2 Groundwater Elevation Contours (ft. NAVD), July 2012, Medium Conductivity.

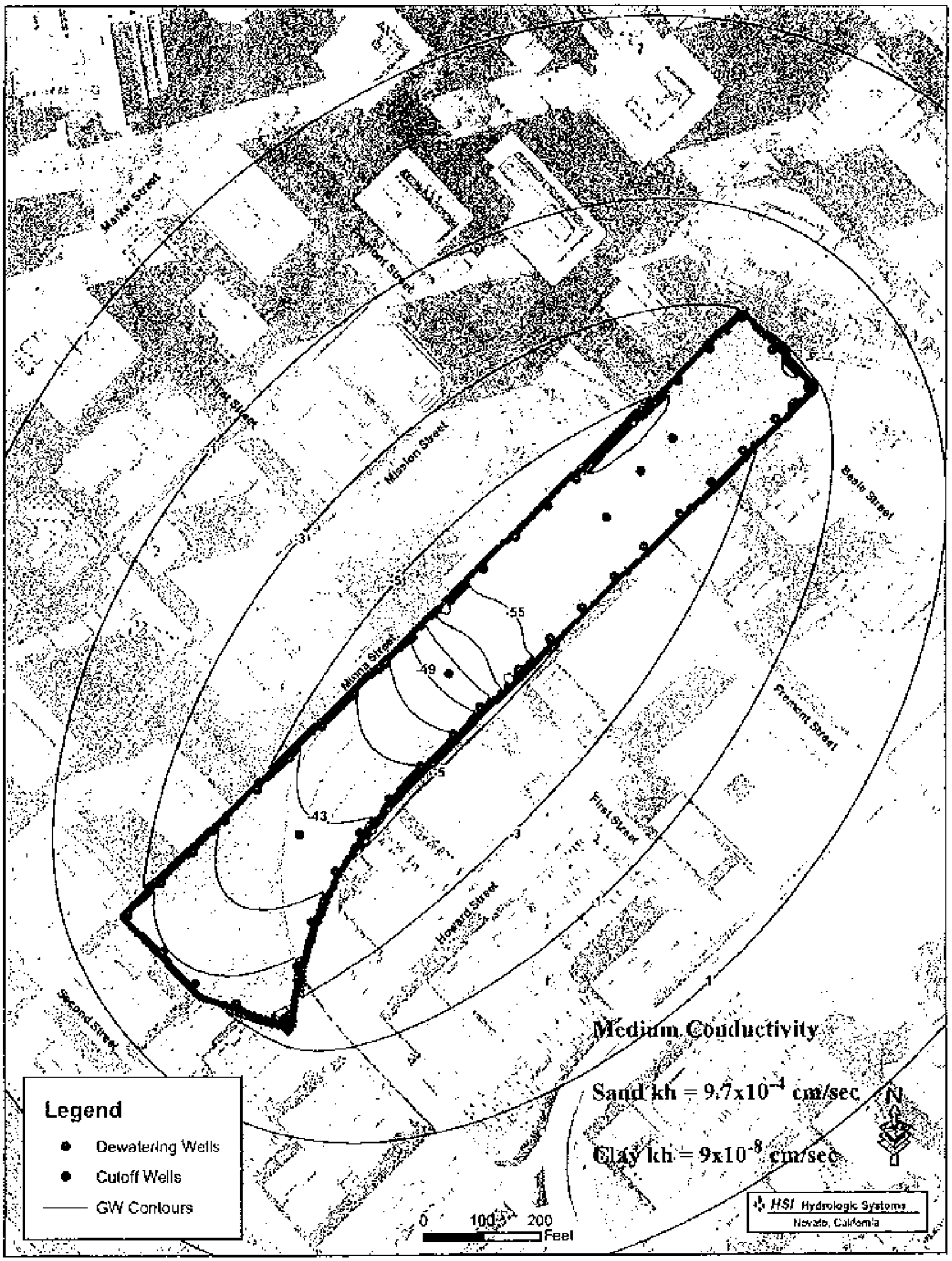

Figure 4-3 Groundwater Elev. Contours (ft. NAVD), January 2014, Medium Conductivity.

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Appendices

Appendix A - Groundwater Elevation Data

TABLE 6 SUMMARY OF GROUNDWATER LEVELS MEASURED DURING DRILLING						
Borehole ID	Groundwater Level Measurements					
	During Dry Drilling			During Rotary Wash Drilling		
	Date	Water Depth	Piezometric Level (NAVD88)	Date	Water Depth	Piezometric Level (NAVD88)
TTB-10	-	-	-	9/23/2008	15.0	-1.2
				9/24/2008	16.0	-2.2
TTB-11	-	-	-	9/18/2008	20.1	+2.9
				9/19/2008	25.0	-2.0
TTB-12	-	-	-	8/7/2008	18.5	+1.9
				8/8/2008	22.3	-1.9
				8/11/2008	21.3	-0.9
TTB-13	-	-	-	8/21/2008	7.3	+5.0
				8/22/2008	11.7	+0.6
				8/25/2008	14.5	-2.2
TTB-14	-	-	-	8/15/2008	17.0	+2.6
				8/19/2008	21.0	-1.4
TTB-15	8/11/2008	16.0	+2.2	8/12/2008	8.7	+9.5
				8/15/2008	18.1	+0.1
TTB-16	-	-	-	9/5/2008	16.2	+1.3
				9/8/2008	21.8	-4.3
TTB-17	9/9/2008	13.5	+1.9	9/11/2008	23.0	-7.6
TTB-19	-	-	-	10/8/2008	19.0	-5.4
				10/9/2008	7.3	+6.3
TTB-20	-	-	-	9/25/2008	11.5	+1.2
				9/26/2008	9.5	+3.2
TTB-22	-	-	-	9/30/2008	22.0	+1.9
				10/1/2008	23.0	+0.9
TTB-23	-	-	-	9/2/2008	21.5	+1.9
				9/3/2008	22.0	+1.4

TABLE 7-1

PIEZOMETER INSTALLATION DETAILS

Piezometer ID	Elevation (NAVD88) (ft)	Screened Interval			Soil Type within Screened Interval	Lower Bentonite Seal		Sand Filter		Upper Bentonite Seal	
		Length (ft)	Top Depth (ft)	Bottom Depth (ft)		Top Depth (ft)	Bottom Depth (ft)	Top Depth (ft)	Bottom Depth (ft)	Top Depth (ft)	Bottom Depth (ft)
CCB-02	21.74	10	20.0	30.0	Dune Sand	30.0	197.2	19.0	30.0	5.0	19.0
TTB-03	20.63	15	50.0	65.0	Colma Sand	*		48.5	67.0	44.5	48.5
TTB-06	18.02	15	55.0	70.0	Colma Sand	71.0	271.0	51.0	71.0	49.0	51.0
TTB-07	13.90	5	160.0	165.0	Old Bay Clay Unit I	Grout below sand filter		158.0	167.0	156.0	158.0
TTB-09	13.70	5	100.0	105.0	Old Bay Clay Unit I	Grout below sand filter		98.0	107.0	96.0	98.0
TTB-13	12.29	15	50.0	65.0	Colma Sand	66.0	204.0	48.0	66.0	45.5	48.0
TTB-14	19.58	10	65.0	75.0	Marine Deposits	75.5	200.0	63.5	75.5	61.0	63.5
TTB-17	15.43	15	65.0	80.0	Colma Sand	81.0	236.0	63.5	81.0	60.5	63.5
TTB-22	23.90	15	60.0	75.0	Colma Sand	Grout below sand filter		58.0	80.0	56.0	58.0

* Piezometer location is adjacent to the location of borehole TTB-03 and was drilled to the depth of the sand filter.

TABLE 7-2

GROUNDWATER DEPTH AND PIEZOMETRIC LEVEL READINGS

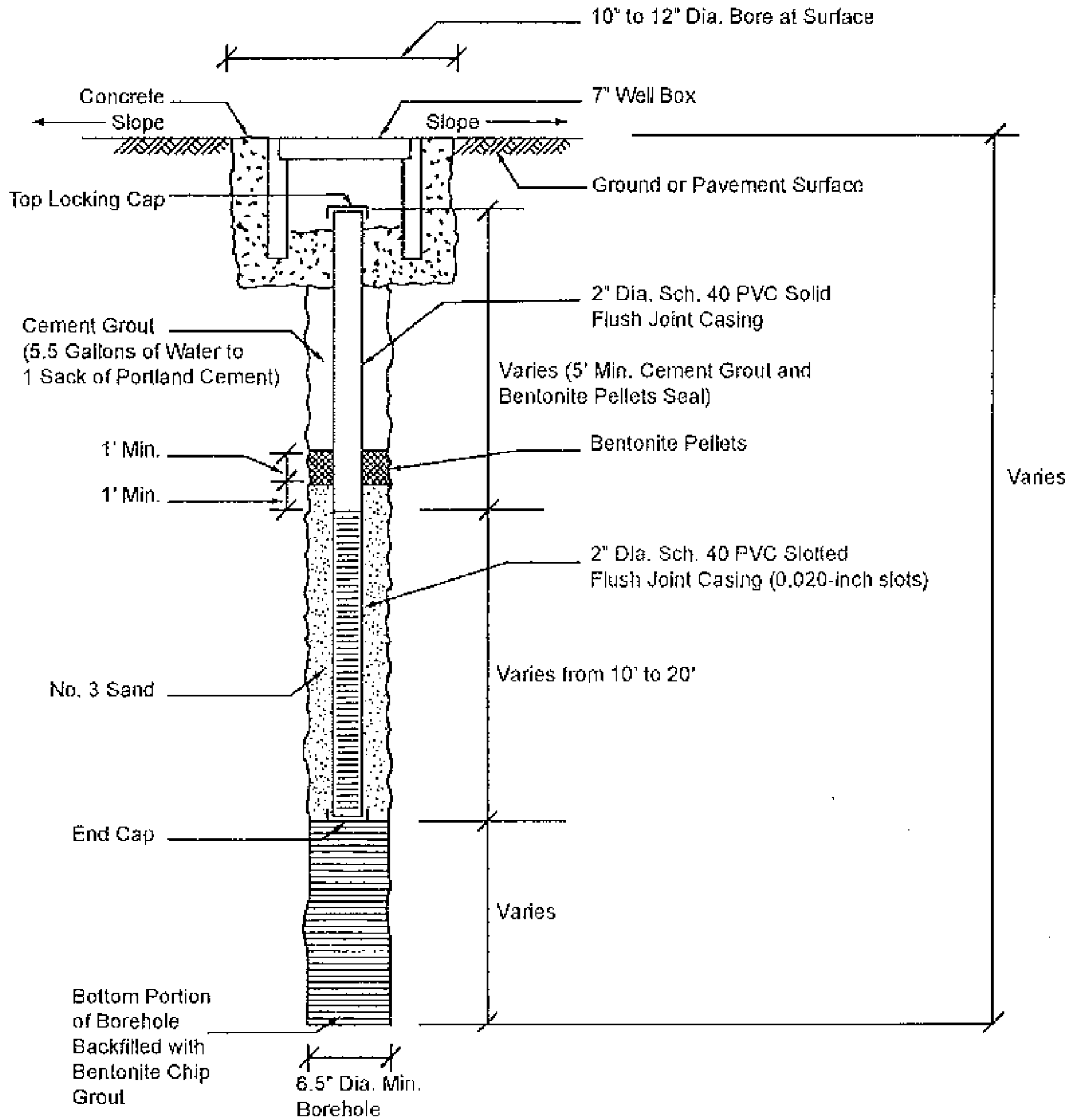
Piezometer ID	CCB-02	TTB-03	TTB-06	TTB-07	TTB-09	TTB-13	TTB-14	TTB-17	TTB-22
Elevation, NAVD88 (ft)	21.74	20.63	18.02	13.90	13.70	12.29	19.58	15.43	23.90
PVC Screen Depth Interval (ft)	20.0-30.0	50.0-65.0	55.0-70.0	160.0-165.0	100.0-105.0	50.0-65.0	65.0-75.0	65.0-80.0	60.0-75.0
Sand Screen Depth Interval (ft)	20.0-30.0	48.5-67.0	51.0-71.0	158.0-167.0	98.0-107.0	48.0-66.0	63.5-75.5	63.5-81.0	58.0-80.0
Material Type	Dune Sand	Colma Sand	Colma Sand	Old Bay Clay Unit I	Old Bay Clay Unit I	Marine Deposits	Colma Sand	Colma Sand	Colma Sand
Date Installed	08/01/05	10/16/08	09/08/08	12/23/09	12/16/09	06/25/08	08/19/08	09/12/08	10/02/08

Date Read	Water Level Depth, ft								
10/09/08	NA	NA	17.60			11.10	18.10	15.30	21.80
10/17/08	18.50	11.70	17.60			11.10	18.00	15.30	21.80
10/31/08	18.50	19.60	17.60			11.10	18.20	15.40	21.70
11/21/08	18.45	19.32	17.66			10.77	NA	15.24	20.45
12/05/08	18.44	19.22	17.42			10.74	NA	15.10	20.92
01/06/09	18.33	19.05	17.32			10.72	17.39	14.98	20.68
01/23/09	18.25	18.58	16.88			10.23	17.00	14.55	20.55
2/20/2009	18.02	NA	16.94			10.20	16.92	14.63	20.12
3/27/2009	17.63	17.87	16.13			9.14	16.55	13.88	19.03
5/15/2009	17.38	17.68	16.23			8.90	15.99	13.87	19.07
6/19/2009	17.28	17.80	16.08			8.75	16.08	13.73	18.93
8/7/2009	17.09	17.97	16.21			8.78	16.09	13.82	19.15
9/18/2009	17.07	NA	15.73			8.55	15.84	13.63	18.88
11/2/2009	16.84	17.62	15.93			8.40	15.65	13.69	18.92
1/12/2010	16.46	17.29	15.65			8.07	NA	13.30	18.67
2/18/2010	16.24	16.95	15.34	7.87	11.77	7.61	15.11	13.16	17.98

(shaded) Reading taken before piezometer was developed.

Appendix B - Permeability Tests

TA2010-312319A03.1



Not to Scale

TYPICAL PIEZOMETER INSTALLATION

Transbay Transit Center
Final Geotechnical Data Report
Transbay Joint Powers Authority
San Francisco, California

February 2010

Q:\132242\4 Internal Project Data\4-05 Reports & Narratives\027 Geotechnical Data Report\Plates\Illustrator Plates\Plate 33 Typical Piezometer Installation.ai

TG0300-520.1

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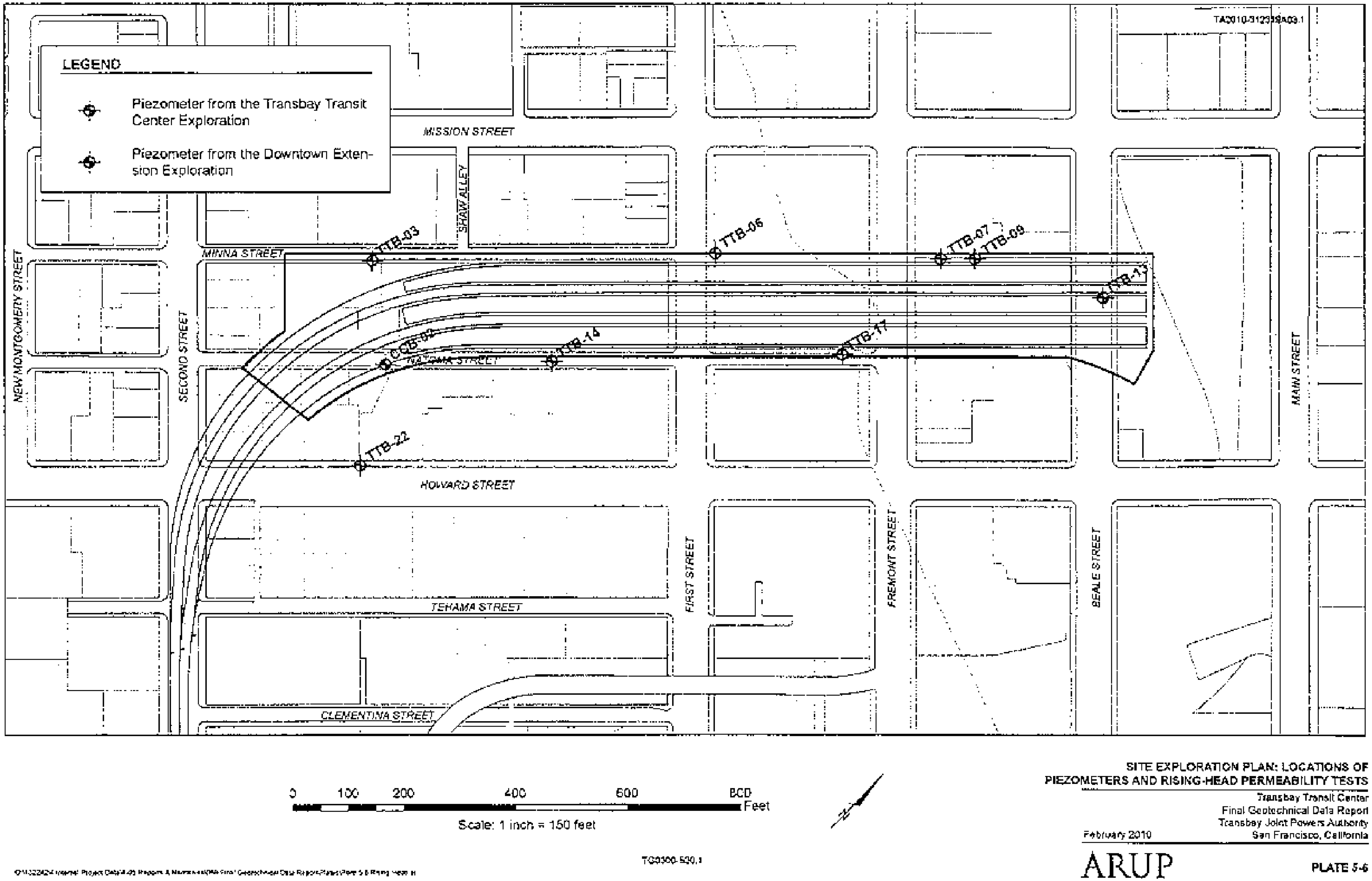
PLATE 33



SITE EXPLORATION PLAN: LOCATIONS OF PIEZOMETERS AND RISING-HEAD PERMEABILITY TESTS

Transbay Transit Center
Final Geotechnical Data Report
Transbay Joint Powers Authority
San Francisco, California

February 2010

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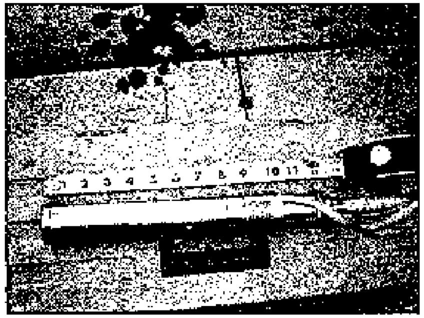
PLATE 5-6

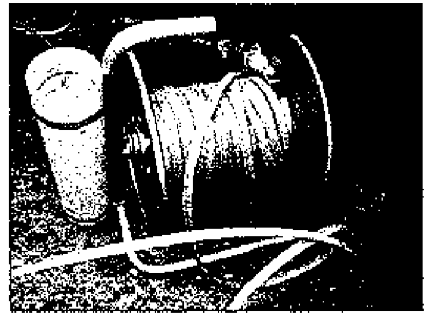
ALTD-830-0461469

RISING-HEAD PERMEABILITY TEST EQUIPMENT

Picture 1: Water level meter used to measure depth to water in the rising-head permeability tests.

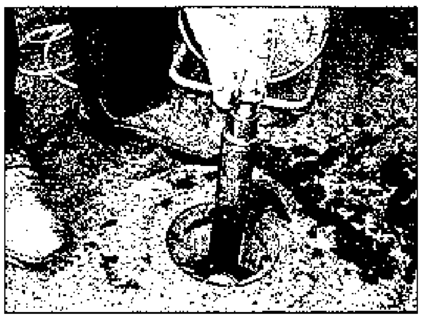


Picture 2: Submersible pump used in the rising-head permeability tests.



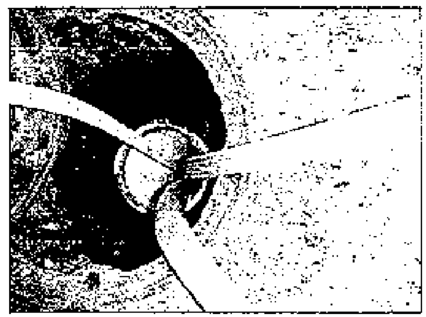
Picture 3: Reel with electrical/hoisting cable.

Picture 4: Power generator and pump control box.



Picture 5: Beginning of pump tests. Photo shows insertion of submersible pump inside piezometer.

Picture 6: Typical setup during pump test.



Picture 7: Detailed pump test fitting of water level measuring tape, and submersible pump hoisting cable and discharge line.

PHOTOGRAPHS OF TEST EQUIPMENT USED FOR RISING-HEAD PERMEABILITY TEST

Transbay Transit Center
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San Francisco, CA

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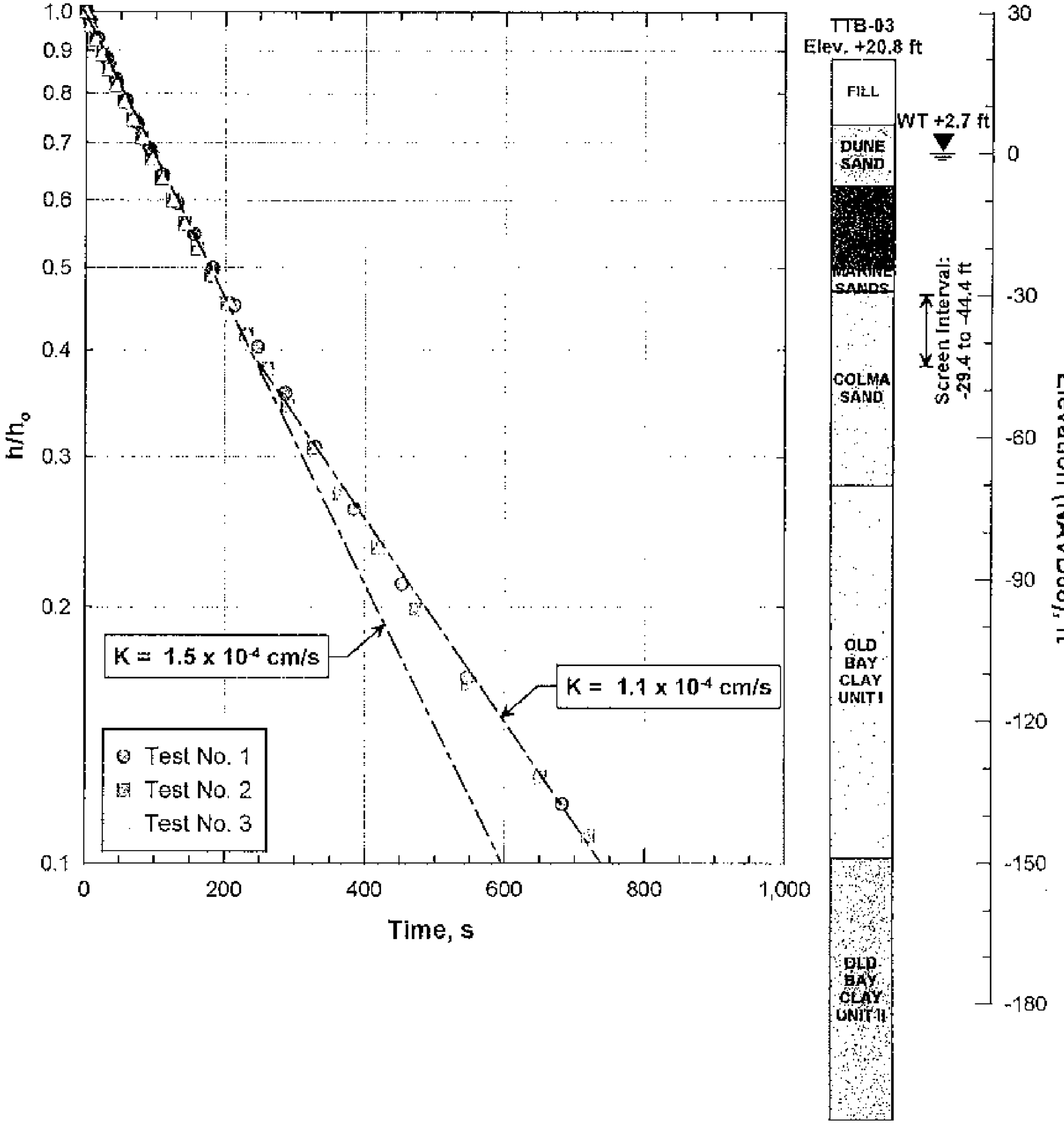
PLATE 34

TA2010-312319A03.1



RESULTS OF RISING-HEAD PERMEABILITY TEST PERFORMED IN A STANDPIPE PIEZOMETER

Transbay Transit Center
Final Geotechnical Data Report
Transbay Joint Powers Authority
San Francisco, California

February 2010

TG0300-520.1 ARUP

PLATE 35

Q:\132242\4 Internal Project Data\4-05 Reports & Narratives\056 Final Geotechnical Data Report\Plates\Plate 35 RH - Typical Results.gif

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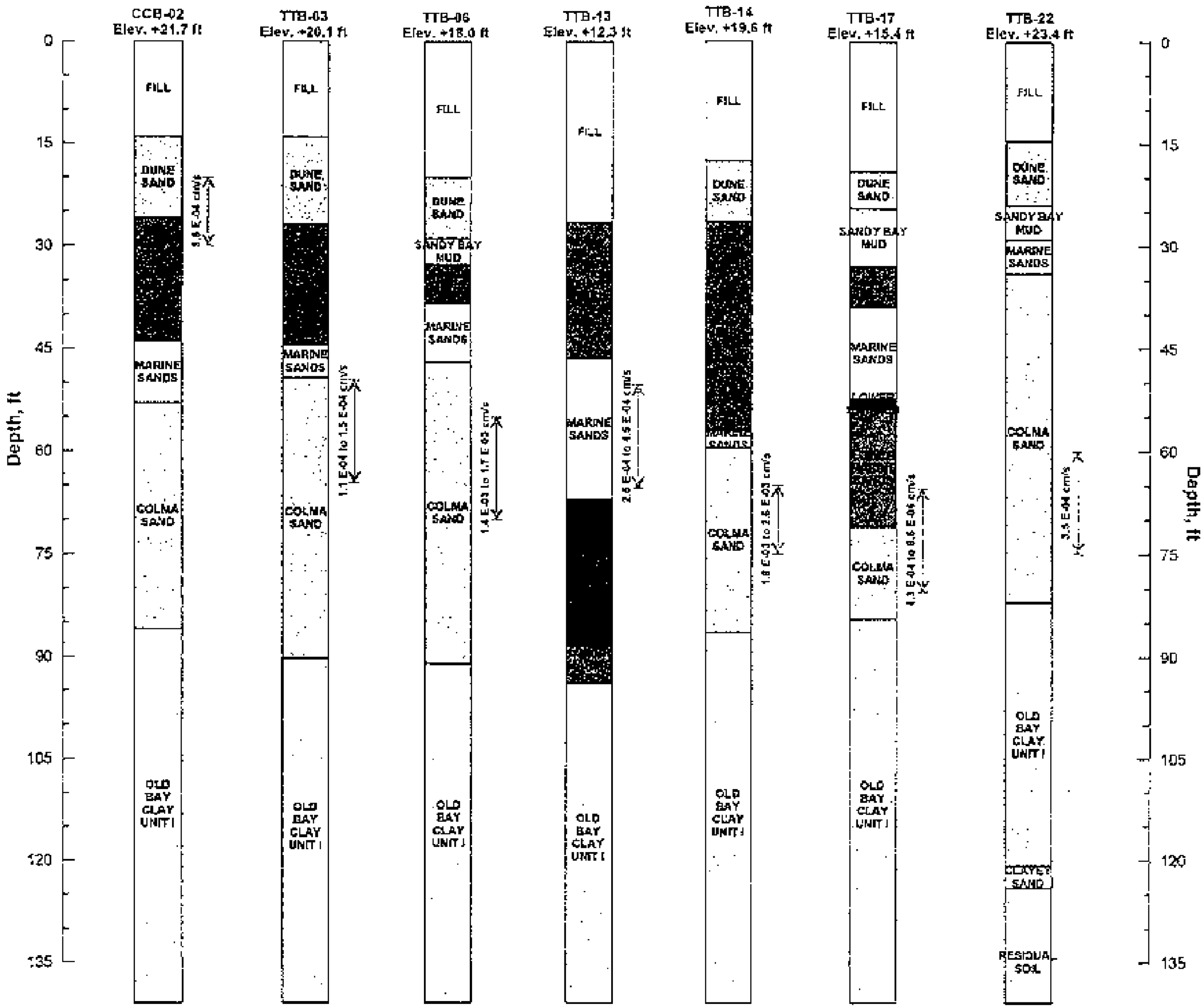

TG0000-520.1

CORRELATION OF STRATIGRAPHY WITH PERMEABILITIES DETERMINED FROM RISING-HEAD TESTS PERFORMED IN SANDY SOILS

Transbay Transit Center
Final Geotechnical Data Report
Transbay Joint Powers Authority
San Francisco, California

February 2010

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PLATE 36

ALTO-630-0461472

TABLE 7-1

PIEZOMETER INSTALLATION DETAILS

Piezometer ID	Elevation (NAVD88)	Screened Interval			Soil Type within Screened Interval	Lower Bentonite Seal		Sand Filter		Upper Bentonite Seal	
		Length	Top Depth	Bottom Depth		Top Depth	Bottom Depth	Top Depth	Bottom Depth	Top Depth	Bottom Depth
	(ft)	(ft)	(ft)	(ft)		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
CCB-02	21.74	10	20.0	30.0	Dune Sand	30.0	197.2	19.0	30.0	5.0	19.0
TTB-03	20.53	15	50.0	65.0	Colma Sand	*		48.5	67.0	44.5	48.5
TTB-06	18.02	15	55.0	70.0	Colma Sand	71.0	271.0	51.0	71.0	49.0	51.0
TTB-07	13.90	5	160.0	165.0	Old Bay Clay Unit I	Grout below sand filter		158.0	167.0	156.0	158.0
TTB-09	13.70	5	100.0	105.0	Old Bay Clay Unit I	Grout below sand filter		98.0	107.0	96.0	98.0
TTB-13	12.29	15	50.0	65.0	Colma Sand	66.0	204.0	48.0	66.0	45.5	48.0
TTB-14	19.58	10	65.0	75.0	Marine Deposits	75.5	200.0	63.5	75.5	61.0	63.5
TTB-17	15.43	15	65.0	80.0	Colma Sand	81.0	236.0	63.5	81.0	60.5	63.5
TTB-22	23.90	15	60.0	75.0	Colma Sand	Grout below sand filter		58.0	80.0	56.0	58.0

* Piezometer location is adjacent to the location of borehole TTB-03 and was drilled to the depth of the sand filter.

TABLE 7-2

GROUNDWATER DEPTH AND PIEZOMETRIC LEVEL READINGS

Piezometer ID	CCB-02	TTB-03	TTB-06	TTB-07	TTB-09	TTB-13	TTB-14	TTB-17	TTB-22
Elevation, NAVD88 (ft)	21.74	20.63	18.02	13.90	13.70	12.29	19.58	15.43	23.90
PVC Screen Depth Interval (ft)	20.0-30.0	50.0-65.0	55.0-70.0	160.0-165.0	100.0-105.0	50.0-65.0	65.0-75.0	65.0-80.0	60.0-75.0
Sand Screen Depth Interval (ft)	20.0-30.0	48.5-67.0	51.0-71.0	158.0-167.0	98.0-107.0	48.0-66.0	63.5-75.5	63.5-81.0	58.0-80.0
Material Type	Dune Sand	Colma Sand	Colma Sand	Old Bay Clay Unit I	Old Bay Clay Unit I	Marine Deposits	Colma Sand	Colma Sand	Colma Sand
Date Installed	08/01/05	10/16/08	09/08/08	12/23/09	12/15/09	08/25/08	08/19/08	09/12/08	10/02/08

Date Read	Water Level Depth, ft								
10/09/08	NA	NA	17.60			11.10	18.10	15.30	21.80
10/17/08	18.50	11.70	17.60			11.10	18.00	15.30	21.80
10/31/08	18.50	19.60	17.60			11.10	18.20	15.40	21.70
11/21/08	18.45	19.32	17.66			10.77	NA	15.24	20.45
12/05/08	18.44	19.22	17.42			10.74	NA	15.10	20.92
01/06/09	18.33	19.05	17.32			10.72	17.39	14.98	20.68
01/23/09	18.25	18.58	16.88			10.23	17.00	14.55	20.55
2/20/2009	18.02	NA	16.94			10.20	16.92	14.63	20.12
3/27/2009	17.63	17.87	16.13			9.14	16.55	13.88	19.03
5/15/2009	17.38	17.88	16.23			8.90	15.99	13.87	19.07
6/19/2009	17.28	17.80	16.08			8.75	16.08	13.73	18.93
8/7/2009	17.09	17.97	16.21			8.78	16.09	13.82	19.15
9/18/2009	17.07	NA	15.73			8.55	15.84	13.63	18.88
11/2/2009	16.84	17.62	15.93			8.40	15.85	13.69	18.92
1/12/2010	16.46	17.29	15.65			8.07	NA	13.30	18.67
2/18/2010	16.24	16.95	15.34	7.87	11.77	7.61	15.11	13.16	17.98

Reading taken before piezometer was developed.

TABLE 9

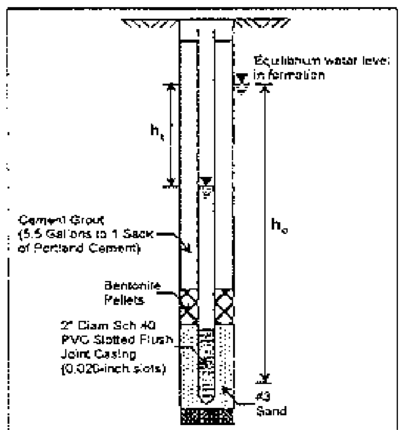
SUMMARY OF RISING-HEAD PERMEABILITY TEST RESULTS

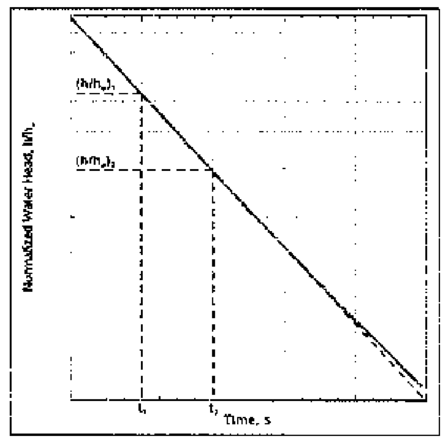
Borehole ID	Depth Interval	Elevation Interval [NAVD88]	Soil Type	Screen Length, L_1	Well Inside Radius, R_1	$(h/h_o)_1$	t_1	$(h/h_o)_2$	t_2	Area, A	Shape Factor, F	Permeability, K	
	(ft)	(ft)		(ft)	(in)		(s)		(s)	(ft^2)	(ft)	(ft/s)	(cm/s)
CCB-02	20 to 30	1.7 to -8.3	Dune Sand	10	0.066	0.760	15	0.169	100	0.023	13.2	3.1E-05	9.6E-04
TTB-03	50 to 65	-29.4 to -44.4	Colma Sand	15	0.086	0.254	400	0.147	500	0.023	18.3	3.5E-06	1.1E-04
						0.456	200	0.670	100			4.9E-06	1.5E-04
TTB-06	55 to 70	-37.0 to -52.0	Colma Sand	15	0.066	0.286	30	0.199	40	0.023	18.3	4.7E-05	1.4E-03
						0.647	10	0.421	20			5.5E-05	1.7E-03
TTB-07	160 to 165	-146.0 to -151.0	Old Bay Clay Unit I	5	0.066	0.648	27,000	0.331	72,000	0.023	7.7	4.5E-08	1.4E-06
						0.320	186,000	0.193	360,000			9.4E-09	2.9E-07
TTB-13	50 to 55	-37.7 to -52.7	Marine Sands	15	0.086	0.740	25	0.413	75	0.023	18.3	1.5E-05	4.5E-04
						0.273	120	0.118	250			8.3E-06	2.5E-04
TTB-14	65 to 75	-45.4 to -55.4	Colma Sand	10	0.086	0.564	10	0.347	20	0.023	13.2	8.6E-05	2.6E-03
						0.312	25	0.138	50			5.8E-05	1.8E-03
TTB-17	65 to 80	-49.6 to -64.6	Lower Marine Sands (65-71'); Colma Sand (71-80')	15	0.086	0.769	15	0.428	50	0.023	18.3	2.1E-05	6.5E-04
						0.235	90	0.122	150			1.4E-05	4.3E-04
TTB-22	60 to 75	-36.1 to -51.1	Colma Sand	15	0.066	0.407	100	0.167	200	0.023	18.3	1.1E-05	3.5E-04

$$K = A \cdot \ln \frac{\left(\frac{h}{h_o}\right)_1 / \left(\frac{h}{h_o}\right)_2}{F \cdot (t_1 - t_2)}$$

where,

A = Cross-sectional area of well
F = Shape Factor
h_o = drawdown below hydrostatic water level at beginning of test
h = depth of water level at time, t, below the equilibrium water level





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ALTD-830-0461475

Appendix C - Dewatering Specifications

SECTION 31 23 19 - DEWATERING

PART 1 - GENERAL

1.1 SUMMARY

A. The work specified in this section includes designing, furnishing, installing, maintaining, operating and transferring ownership of dewatering systems and control, as required to lower groundwater levels and hydrostatic pressures associated with the demolition, pre-trenching for CDSM shoring wall, excavation and construction for the Transbay Transit Center (TTC) project; and storage, treatment, and discharge of dewatering effluent in accordance with applicable regulations and standards.

1. Dewatering system.
2. Surface water control system.
3. System operation and maintenance.
4. Water disposal.

B. Reference Documents:

1. Refer to 00 03 20 – Geotechnical Data.

a. "Final Geotechnical Data Report" prepared by Arup dated February 2010.
b. "Prototype Test Program and Monitoring During Construction of Drilled Shafts" prepared by Arup dated May 2010.
c. "Results of Prototype Test Program Installation of Shoring Walls using the Cement Deep Soil Mixing Method" prepared by Arup dated May 2010.

1.2 REFERENCES

A. State of California, Department of Water Resources

1. Well Driller Reports

B. California Stormwater Quality Association (CASQA)

1. Stormwater Best Management Practice (BMP) Handbook, January 2003

C. ASTM International:

1. ASTM C33 – Standard Specification for Concrete Aggregates.
2. ASTM D5299-99(2005) - Standard Guide for Decommissioning of Ground Water wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities
3. ASTM D6725-04 – Standard Practice for Direct Push Installation of Prepacked Screen Monitoring wells in Unconsolidated Aquifers
4. ASTM D5092-04e1 – Standard Practice for Design and Installation of Ground Water Monitoring wells
5. ASTM D6724-04 – Standard Guide for Installation of Direct Push Ground Water Monitoring wells

D. U.S. Department of the Interior, Bureau of Reclamation (USBR)

1. Ground Water Manual: A Guide for the Investigation, Development, and Management of Ground-Water Resources, April 2005

E. Standard Specifications of the City and County of San Francisco, Department of Public Works, Bureau of Engineering (SSDPWSF), dated November 2000

1.3 SYSTEM DESCRIPTION

A. System Responsibility: Contractor is responsible to select, design, install, operate, monitor, and maintain the dewatering system until directed by the TJPA's Representative that the system shall be terminated.

B. Potential Dewatering Methods: Sump pumping, single or multiple-stage well point systems, eductor and ejector-type systems, deep wells, interception, diversion, combinations thereof, or other techniques as approved by the TJPA's Representative.

C. Location: Locate system components to allow continuous dewatering operations without interfering with installation of permanent Work and existing public rights-of-way, sidewalks, and adjacent buildings, structures, improvements and construction operations performed under this Contract or other contracts

D. Surface Water Control: Provide for intercepting and diverting precipitation and surface water away from excavations through the use of dikes, curb walls, ditches, berms, pipes, sumps and other Best Management Practices (BMP) devices, in accordance with CASQA's Stormwater BMP Handbook.

E. Drainage of excavated areas: provide and maintain adequately sized ditches to collect surface and seepage water which may enter the excavations. Divert the water into sumps and pump or drain it into temporary holding tanks.

F. Water Discharge: Discharge collected water in accordance with requirements of San Francisco Bureau of Environmental Management (BEM). These requirements may include containing the collected water in holding tanks temporarily until suspended soil particles and other solids have settled to the bottom before discharging it so that the water contains no soil particles or other solids when discharged.

G. Monitoring: Provide monitoring wells and monitoring equipment to obtain the data necessary to evaluate and control the performance of the dewatering system.

1. Install monitoring wells to observe ground water conditions at various levels during excavation and below the final excavation subgrade.
2. Contractor shall identify elevations where groundwater must be monitored. Monitoring may be required at several elevations to provide indications of hydrostatic pressures and ground water elevations when water is present at different strata.
3. Piezometers shown on Drawings GT-1301, GT-1302 and GT-2201 and described in Section 31 09 13 Geotechnical Instrumentation and Monitoring will be accessible to the Contractor to supplement his monitoring program.
4. Provide, install and maintain instruments and supporting hardware that are capable of transmitting data to the Global Analyzer described in Section 31 09 13. The data shall be transmitted as measures of piezometric elevation and time in a format which can be plotted on "x" and "y" axes in real time. A base line to which subsequent readings are compared shall be provided for entry into the Global Analyzer. An alarm mechanism which alerts all concerned parties that a measure has exceeded a trigger level shall be embedded in the instruments' data logging system.

H. Furnish standby equipment stored at Project site and ready for immediate use in the event of failure of dewatering equipment. Provide the following standby equipment, but not less than one of each type:

1. Dewatering Centrifugal Pumps: 50 percent; maximum 5 pumps.
2. Dewatering Turbine Pumps: One for every 5 installed pumps; maximum 5 pumps.
3. Pump Power Units: 50 percent; maximum 3 units.
4. Dewatering Jet Eductor Pressure Pumps: 50 percent; maximum 2 pumps.
5. Portable Electric Generators (if used): 100 percent; maximum 5 generators.
6. Commercial Electric Power: 100 percent standby electric generating equipment.

I. Dewatering system design and procedures shall meet the relevant requirements of Section 01 35 65 – Mitigation Measures and Monitoring.

1.4 PERFORMANCE REQUIREMENTS

A. Design the dewatering systems to comply with the following requirements:

1. Provide dewatering and surface water control systems to permit Work to be completed on dry and stable subgrade.
2. Lower water table within areas of excavation to an average depth not less than five feet below the bottom of the excavation at any given time, or to an average depth not less than five feet but not greater than ten feet below the bottom of the maximum proposed excavation shown on the Drawings. Maintain the level below the bottom of the maximum proposed excavation until directed by the TJPA's Representative that the system shall be terminated.
3. Relieve hydrostatic pressures in confined water bearing strata below excavation to eliminate risk of uplift, heaving, or other instability of excavation.
4. Lower the groundwater level only in the excavation areas. Prevent loss of fines, quick condition, or softening of foundation subgrade.
5. Maintain stability of sides and bottoms of excavations and shafts.

B. Design surface water control systems to:

1. Collect and remove surface water and seepage entering excavation in accordance with applicable regulations and standards.

1.5 SUBMITTALS

A. Section 01 13 00 – Submittals: Requirements for submittals.

B. Contractor's Drawings and Dewatering Design Report:

1. Indicate the proposed type of dewatering system.
2. Indicate dewatering system arrangement, layout, locations, and depths of system components, including well depths, dewatering pump locations.
3. Provide complete description of equipment and instrumentation to be used, with installation, operation, and maintenance procedures.
4. Indicate types and sizes of filters, such as filter sand gradations.
5. Provide information on well screen lengths, pipe sizes and capacities, grades, and valves.
6. Provide complete description of surface water control devices.
7. Indicate primary and standby power system location and capacity.
8. Indicate layout and depth of monitoring wells, piezometers and flow measuring devices for system performance measurement.
9. Include detailed description of dewatering and monitoring system installation procedures and maintenance of equipment.
10. Include description of emergency procedures to follow when system failure or other problems arise.
11. Indicate the methods and location for disposal of pumped and drained water.

C. Product Data: Submit data for each of the following:

1. Dewatering Pumps: Indicate sizes, capacities, priming method, engine and motor characteristics.
2. Pumping equipment for control of surface water within excavation.
3. Gout: Contractor's mix design.
4. Electronic monitoring equipment to replace 24-hour supervision of dewatering system by personnel; see Article 3.6 B.

D. Design Data:

1. Indicate design values, analyses, and calculations to demonstrate the adequacy of the proposed system and equipment.
2. Include description and profile of geology, soil, and groundwater conditions.
3. Provide duration of time dewatering is required for a given well, amount of drawdown that dewatering system will cause, and area of influence of dewatering.

E. Field Reports: Test and monitoring reports as specified in Field Quality Control article.

1.6 CLOSEOUT SUBMITTALS

A. Section 01 17 00 – Contract Closeout: Requirements for submittals.

B. Project Record Documents: Record actual locations and depths of capped wells and piping abandoned in place.

1.7 QUALITY ASSURANCE

A. Comply with authorities having jurisdiction for the following:

1. Drilling and abandoning of wells used for dewatering systems.
2. Water discharge and disposal from pumping operations.

B. Prior to any subsurface drilling activities, including installing dewatering or monitoring wells, Contractor needs to submit an application for Monitoring Well Construction/Destruction or Soil Borings to Monitoring Wells Program, Environmental Health Section, City and County of San Francisco Department of Public Health, 1390 Market Street, Suite 910, San Francisco, CA 94102, Telephone: (415) 252-3849, Fax: (415) 252-3894.

1. Drillers may not commence work until the application has been approved.
2. Submit application at least 10 days in advance of drilling
3. Advance 48 hour notice is required for inspection of the annular seal.
4. Minimum advanced notice of 24 hours must be provided prior to well development and water sampling.
5. Submit a copy of the California Department of Water Resources Well Drillers Report, Form 188, to the Water Quality Control Section within 30 days after completion of the work.

C. Contractor must obtain a wastewater discharge permit from the City of San Francisco for discharging water into the local municipal waste water collection system. The dewatering permit requires chemical testing for characterizing the water to be discharged. Prior to discharging pumped groundwater, the City will require additional groundwater analytical testing for contaminants.

D. Provide any additional essential information regarding storm water discharge from construction sites for updating the project's National Pollutant Discharge Elimination System (NPDES) permit application.

E. Use methods of ground water discharge, conveying, and transmission to off-site locations approved by of San Francisco Bureau of Environmental Management (BEM).

F. The entity assuming responsibility for the dewatering system at the end of this Contract will obtain new permits.

1.8 QUALIFICATIONS

A. Installer: Company specializing in performing work of this section with minimum 5 years documented experience and responsible for design, installation, operation, and maintenance of dewatering system for shored excavations greater than 40 feet deep on the west coast of the United States within 2 miles of the shoreline of a bay, sound or inlet.

1.9 MEETINGS

A. Section 01 12 00 - Project Meetings: Meeting requirements.

B. Convene pre-installation meeting minimum two weeks prior to commencing work of this section.

C. Convene meeting minimum two weeks, maximum 4 weeks, prior to conclusion of Contract with the entity assuming responsibility for the dewatering system.

1.10 SEQUENCING

A. Section 01 10 10 – Summary of Work.

B. Sequence work to obtain required permits before start of dewatering operations.

C. Sequence work to install and test monitoring systems minimum 14 days before testing and operating dewatering systems.

D. Sequence work to install and test dewatering and surface water control systems minimum 7 days before starting excavation.

1.11 COORDINATION

A. Section 01 10 40 - Coordination.

B. Coordinate work to permit the following construction operations to be completed on dry stable substrate.

1. Subgrade preparation specified in Section 31 23 13.
2. Soil Mixing Stabilization specified in Section 31 23 13.
3. Shoring specified in Section 31 56 13
4. Installing steel piles specified in Section 31 56 13.
5. Installing drilled concrete piers and shafts specified in Section 31 63 29.

C. Coordinate work to avoid clashes with tiedowns, columns, walls and other items to be installed as part of the permanent structure.

PART 2 - PRODUCTS

2.1 DEWATERING EQUIPMENT

A. Select dewatering equipment to meet performance requirements specified herein.

2.2 MONITORING EQUIPMENT

A. Piezometers: Vibrating wire type with sand filter, or push in installation to monitor water elevation, and excess pore pressures.

1. Furnish piezometer complete with signal cable and data logger.

B. Flow Measurement: Furnish devices as follows:

1. Pitometer installed on discharge of pipe from each well.
2. Pitometer installed to measure flow from entire dewatering system.

2.3 TEMPORARY HOLDING TANKS

A. Provide temporary holding tanks for sedimentation of soil particles and other solids prior to discharge in accordance with requirements of agencies having jurisdiction.

2.4 ACCESSORIES

A. Valves and Fittings: Furnish valves and fittings to isolate each well from header pipe and to prevent loss of pump prime.

B. Filter Sand: ASTM C33; natural river or bank sand; washed; free of silt, clay, loam, friable or soluble materials, and organic matter; graded to suit well screen.

C. Grout: Mixture of Portland cement and bentonite clay or sand suitable for sealing abandoned wells and piping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Division 1 - Execution: Verification of existing conditions before starting work.

B. Call the USA North, the Underground Service Alert network, at 8-1-1 or 1-800-227-2600 at least two working days before performing Work.

1. Request underground utilities to be located and marked within and surrounding construction areas, which should be outlined with white paint or chalk by the Contractor

3.2 PREPARATION

A. Obtain appropriate permits prior to installing dewatering system, see Section 1.9 Quality Assurance.

3.3 MONITORING WELLS

A. Install monitoring wells at locations indicated on Contractor's drawings as specified for dewatering well system.

B. Test each monitoring well point to verify installation is performing properly.

C. Install piezometers, calibrate, and test for proper operation.

D. Protect monitoring well standpipes from damage by construction operations.

E. Maintain accessibility to monitoring wells continuously during construction operations.

F. Maintain monitoring wells throughout the duration of the operation of the system.

3.4 DEWATERING SYSTEM

A. Install dewatering system in accordance with approved Contractor's drawings. Advise the TJPA's Representative of changes made to accommodate field conditions, and upon completion of the dewatering system installation, revise and resubmit Contractor's drawings as necessary to indicate the installed configuration.

B. Drill wells in sizes and to depth indicated in the Contractor's drawings. Provide temporary surface casing when required to stabilize soil while advancing well.

C. Develop wells by over pumping, surging, or water jetting, as specified by the Contractor's drawings and approved by the TJPA's Representative, to remove clay, silt, and sand from well screen and immediate vicinity of bore hole.

D. Test well for proper water flow through well screen and pumping rate for dewatering system operation. Repeat development until well meets performance requirements.

E. Cover and seal top of well until pump is installed.

F. Install pumps in accordance with manufacturer's instructions.

G. Connect pumps to discharge header. Install valves to permit pump isolation.

3.5 SURFACE WATER CONTROL SYSTEM

A. Maintain surface water control system to prevent blockage or damming in the event of unexpected precipitation.

3.6 SYSTEM OPERATION AND MAINTENANCE

A. General: Operate, monitor, and maintain dewatering system until directed by the TJPA's Representative that the system shall be terminated.

B. Provide 24-hour supervision of dewatering system by personnel skilled in operation, maintenance, and replacement of system components. At Contractor's option, personnel may be replaced with electronic monitoring equipped with an alarm device that notifies personnel that are on-call to respond.

C. Fill fuel tanks before tanks reach 25 percent capacity.

D. Start emergency generators at least twice each week to check operating condition.

E. When dewatering system cannot control water within excavation, notify TJPA's Representative and stop excavation:

1. Supplement or modify dewatering system and provide other remedial measures to control water within excavation.
2. Demonstrate dewatering system operation complies with performance requirements before resuming excavation operations.

F. Correct unanticipated pressure conditions affecting dewatering system performance.

G. Do not discontinue dewatering operations without the TJPA's Representative's approval.

3.7 WATER DISPOSAL

A. If required as a result of testing, discharge water from dewatering system into temporary holding tanks prior to discharging in accordance with requirements of agencies having jurisdiction.

3.8 CLEANING

A. Sewer drains: After making arrangements with the authority having jurisdiction, clean each sewer drain which becomes blocked or the capacity of which is restricted due to discharge from dewatering operations.

B. Temporary Holding Tanks: Clean settlement from temporary holding tanks, and dispose of sediment in accordance with requirements for disposing of excavated soil.

3.9 SYSTEM REMOVAL

A. Do not remove dewatering systems unless required by the TJPA's Representative.

B. Do not remove piezometers and monitoring wells unless required by the TJPA's Representative.

C. Cut off and cap abandoned wells minimum 36 inches below completed subgrade elevation.

D. Fill abandoned piping with grout.

3.10 FIELD QUALITY CONTROL

A. Section 01 14 00 - Quality Control: Field inspecting, testing, adjusting, and balancing and Division 1 - Execution.

B. Pumping Test:

1. After dewatering system is installed, perform pumping test to determine when the selected pumping rate lowers water level in well below pump intake.
2. Adjust pump speed, discharge volume, or both to ensure proper operation of each pump.

C. Pumping Data:

1. Observe and record the daily flow rates and time of operation of each pump used in the dewatering system.
2. Provide appropriate devices, such as flow meters, for observing the flow rates.
3. Submit the data, on a form approved by the TJPA's Representative, during the period that the dewatering system is in operation. The data shall be submitted once per week, or at more frequent intervals if requested by the TJPA's Representative.

D. Ground Water Elevation:

1. Monitor and record daily ground water elevations at monitoring wells, until groundwater drawdown is stabilized, then change to weekly until as directed by TJPA's Representative.
2. Submit the results of groundwater monitoring to the TJPA's Representative on a weekly basis.

E. Discharged Water Testing:

1. Discharged water testing will be conducted by the TJPA's Representative.

F. Submit Initial Installation Reports to the TJPA's Representative including the following:

1. Installation and development reports for wells and pumps.
2. Results of well development and pump tests.
3. Installation and baseline reports for monitoring wells and piezometers.
4. Test reports of monitoring well water analysis.
5. Initial dewatering flow rates.

G. Submit weekly Monitoring Reports to the TJPA's Representative as follows:

1. Dewatering flow rates.
2. Piezometer readings.
3. Maintenance records for dewatering and surface water control systems.

END OF SECTION 31 23 19

SPECIFICATION ISSUES LOG

REV NO.	ISSUE	DATE
0	Issued for Construction – Buttress/Shoring/Excavation	2010-12-10

Appendix D - Dewatering Equipment Specifications

VIKING DRILLERS, INC.
Dewatering Systems
801 Northport Drive
West Sacramento, CA 95691-2153
(916) 372-4993 • FAX (916) 372-1337
www.vikingdrillersinc.com
California License #476668
A Woman Owned Business

April 1, 2011

SBE CERTIFIED
#20783

Ernie Cortez
Balfour Beatty Infrastructure, Inc.
Transbay Transit Center BSE
143 2nd Street
San Francisco, CA 94104

RE: Transbay Terminal – San Francisco, CA

Dear Ernie:

The following exhibits are submitted to you for the temporary dewatering for the above mentioned project

Exhibit # 1 – Well Layout (pg 1- 4)

Exhibit # 2 – Dewatering Well Profiles

Exhibit # 3 – Piezometer Profile

Exhibit # 4 – Well Filter Pack – Gravel Gradation

Exhibit # 5 – Submersible Pump Spec (pump curve)

Exhibit # 6 – Pump Liquid Level Controller

Exhibit # 7 – Disconnect Switch

Exhibit # 8 – Junction Box

Exhibit # 9 – 8/4 Electrical Cord Spec

Exhibit # 10 – Well Casing Spec

Exhibit # 11 – Discharge and Riser Pipe Spec

Exhibit # 12 – Flowmeter/Totalizer Spec Wellheads

Exhibit #13 – Flowmeter/Totalizer Spec Discharge Line (pg 1-2)

Exhibit # 14 – 3500 Gallon Sand Tank Spec

Exhibit # 15 – Dewatering Well Drilling and Well Development Procedure

Exhibit # 16 – Standby Generator Spec

Exhibit # 17 – 100 Amp Transfer Switch

Exhibit # 18 - Auto Dialer

Exhibit # 19 – Piezometer Data Loggers

Exhibit # 20 – Check Valve Spec

Exhibit # 21 – Gate Valve Spec

If we can be of further assistance, please contact us.

Respectfully,
VIKING DRILLERS, INC.

Scott Philliber
Project Manager

TA2010-312319A03.1

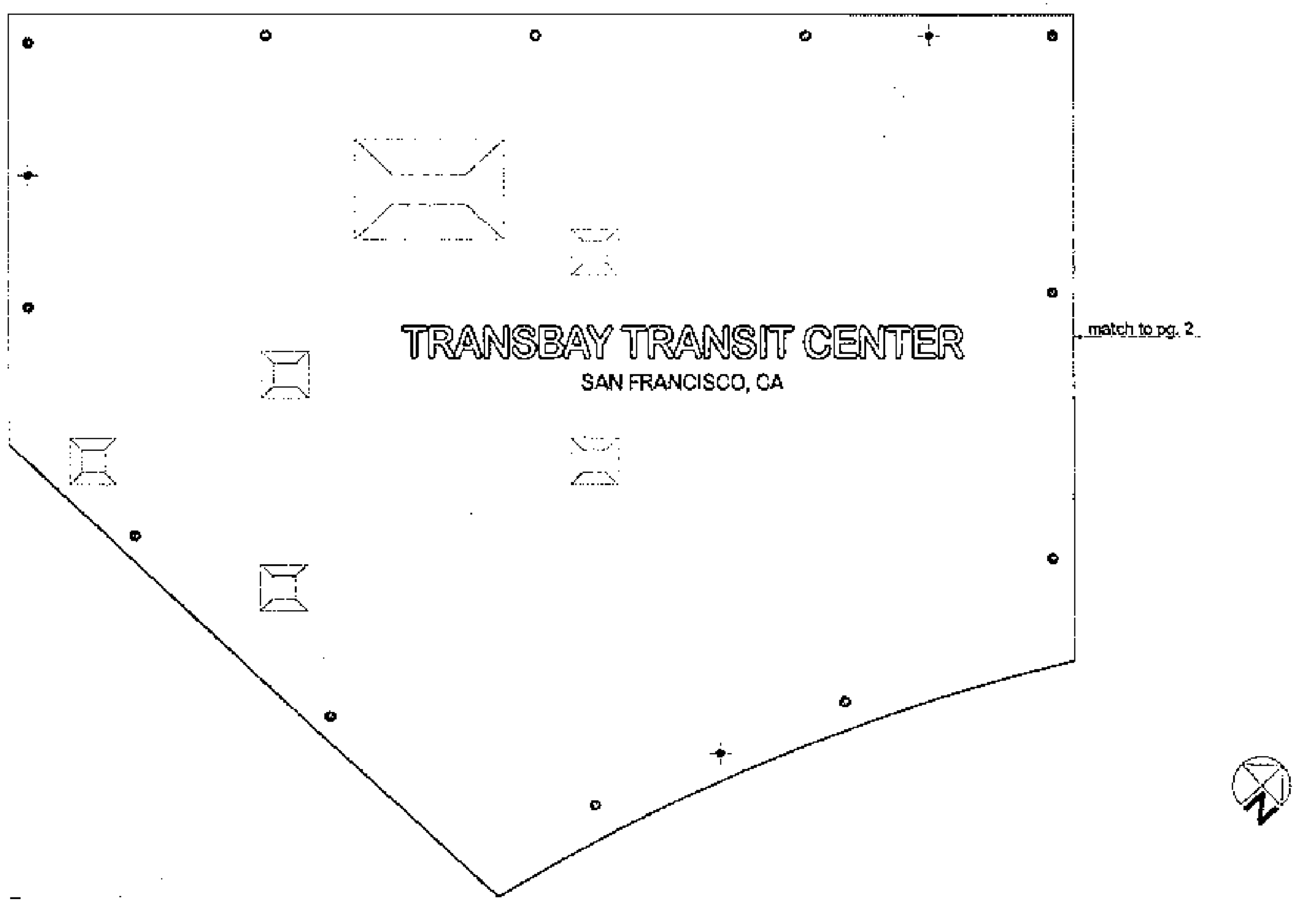

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EXHIBIT #1 pg. 1 of 4

WELL LAYOUT

DRAWING NO. WL | SCALE: NONE

LEGEND

- DEWATERING WELL
- PIEZOMETER

TG0300-520.1

ALTD-830-0461488

TA2010-312319A03.1

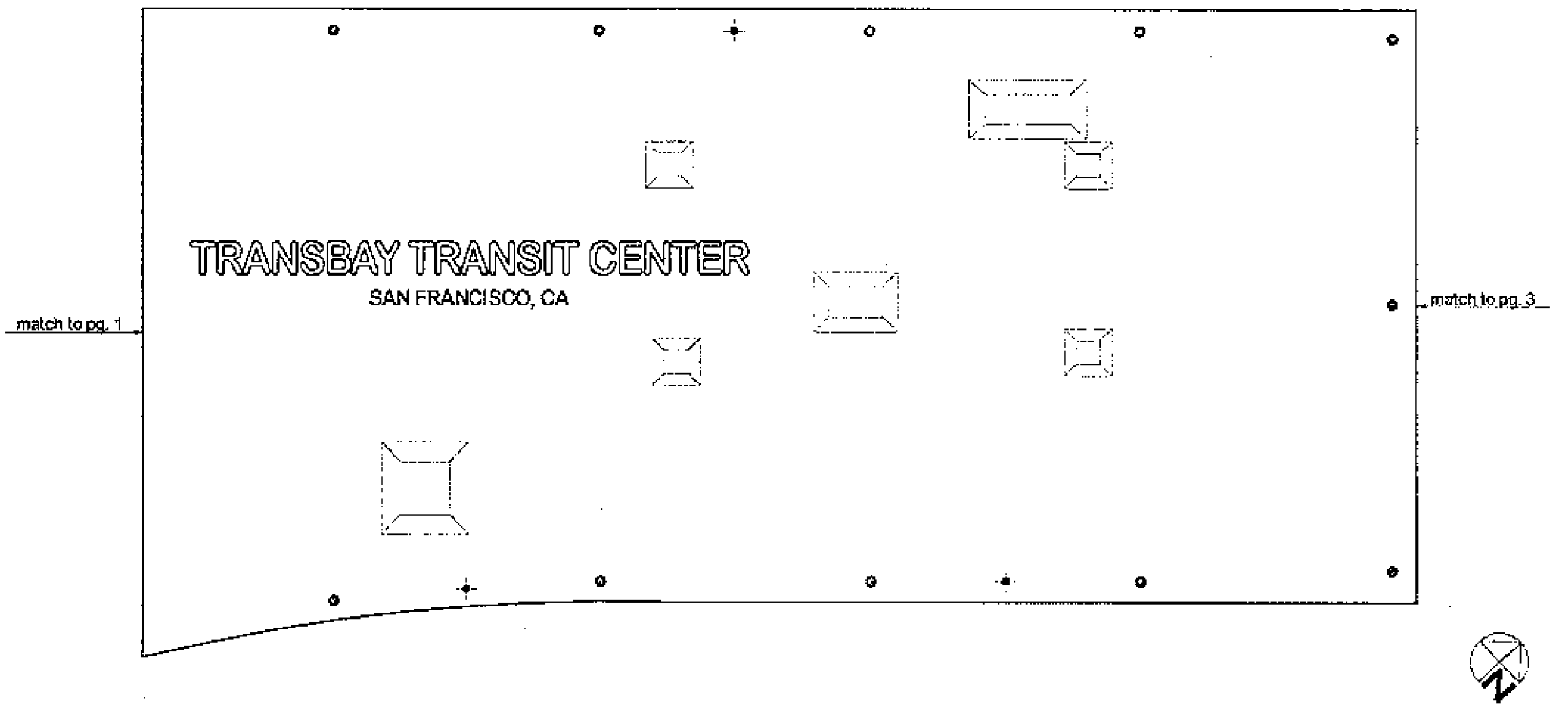

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EXHIBIT #1 pg. 2 of 4

WELL LAYOUT

LEGEND

- DEWATERING WELL
- PIEZOMETER

DRAWING NO. WL SCALE: NONE

TG0300-520.1

ALTD-830-0461489

TA2010-312319A03.1

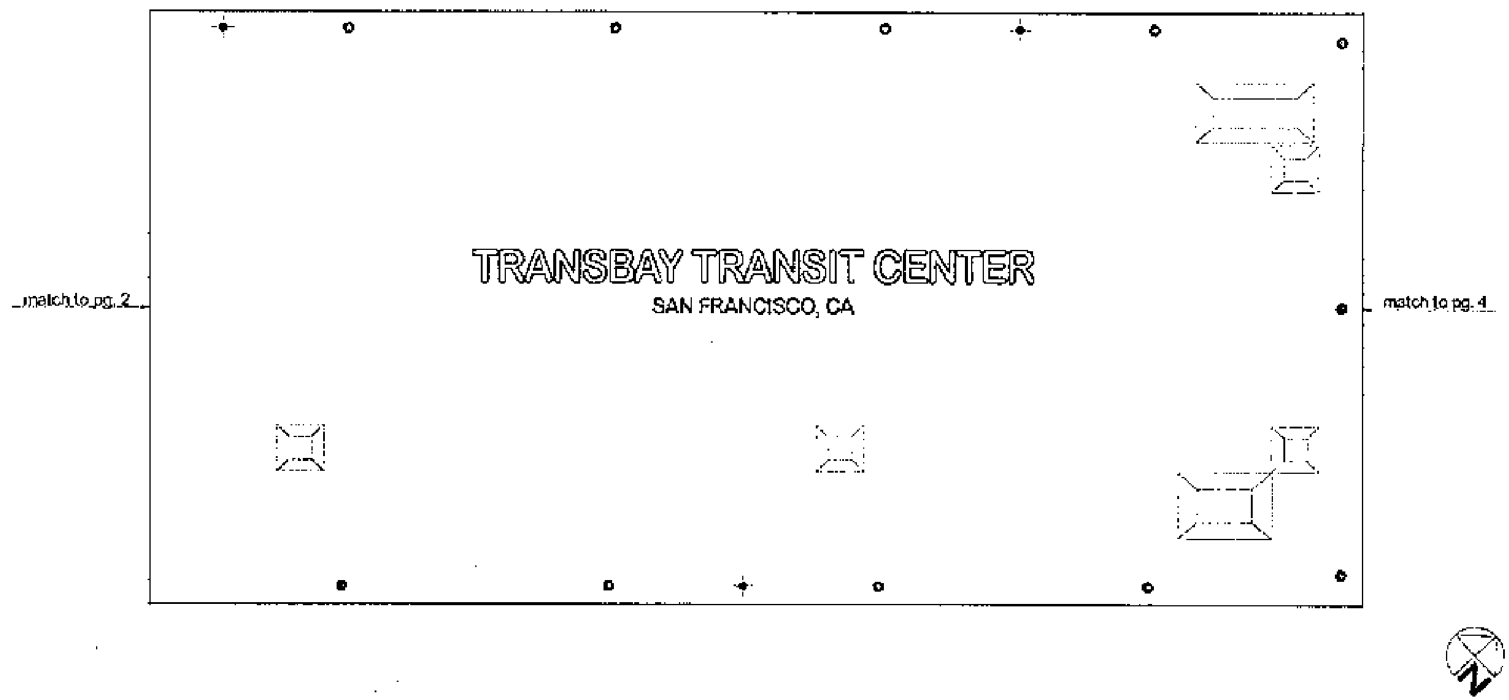

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EXHIBIT #1 pg. 3 of 4

WELL LAYOUT

DRAWING NO. WL SCALE: NONE

LEGEND

- DEWATERING WELL
- PIEZOMETER

TG0300-520.1

ALTD-830-0461490

TA2010-312319A03.1

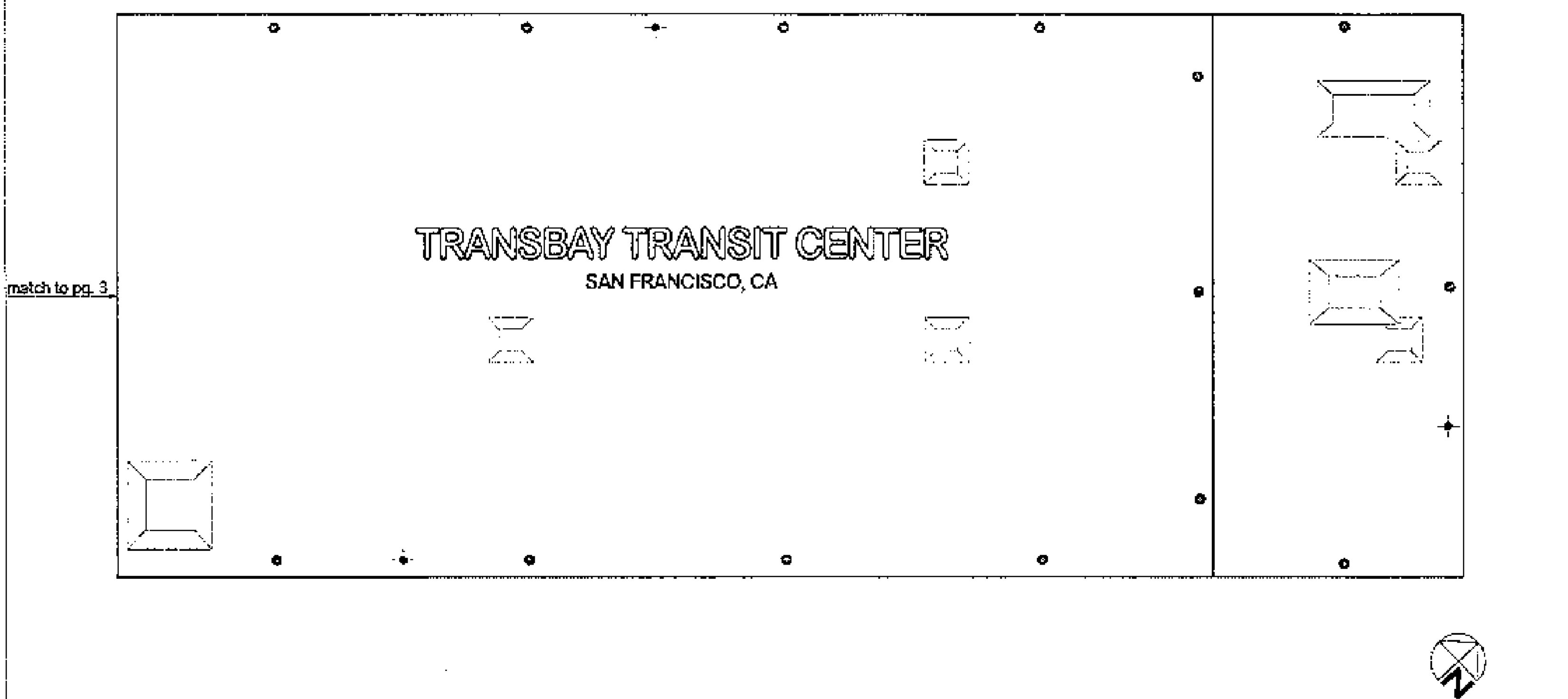

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EXHIBIT #1 pg. 4 of 4

WELL LAYOUT

DRAWING NO. WL | SCALE: NONE

LEGEND

- ● DEWATERING WELL
- ✛ PIEZOMETER

TG0300-520.1

ALTD-830-0461491

TA2010-312319A03.1

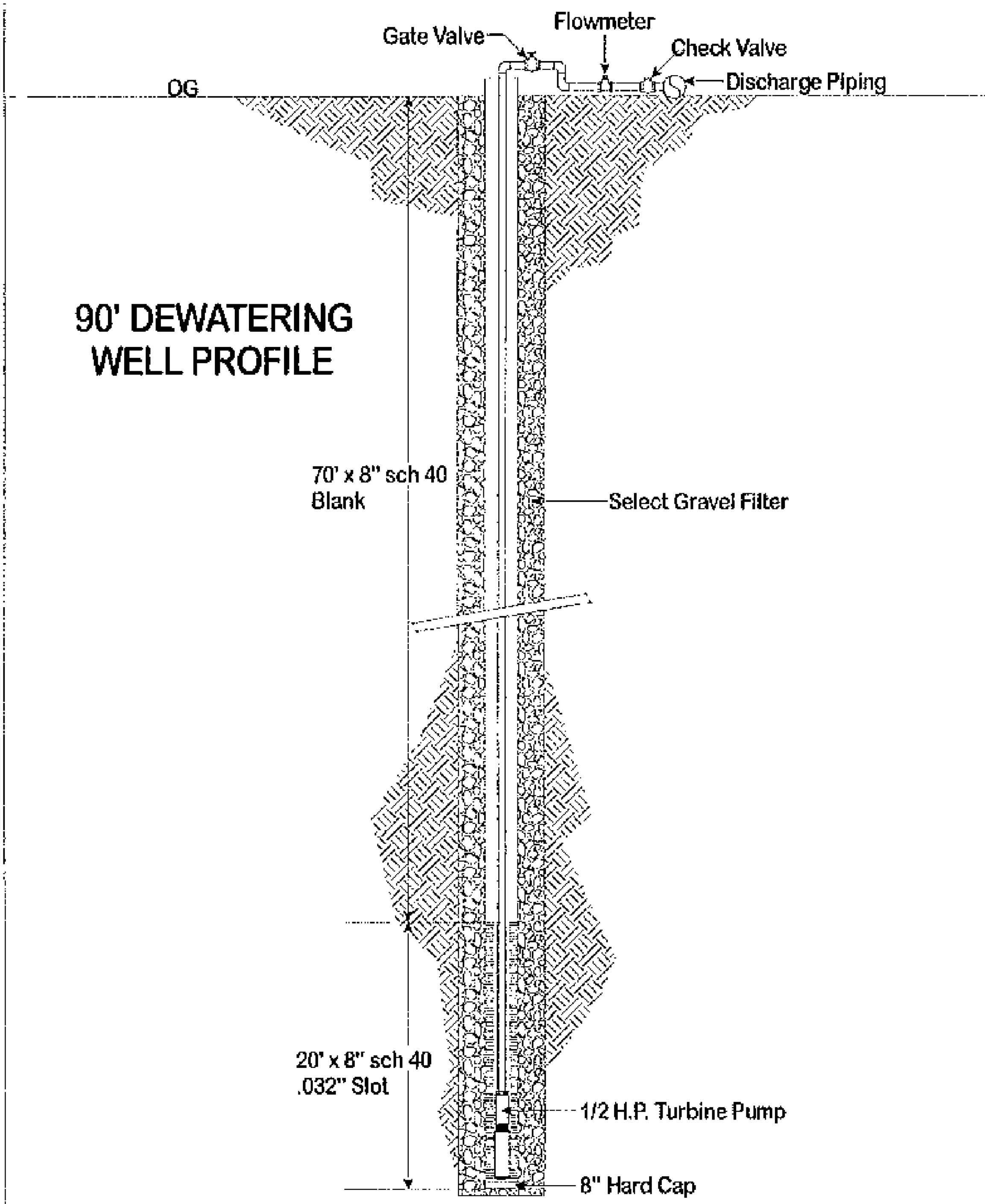

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EXHIBIT #2

WELL PROFILE

DRAWING NO. WP | SCALE: NONE

TG0300-520.1

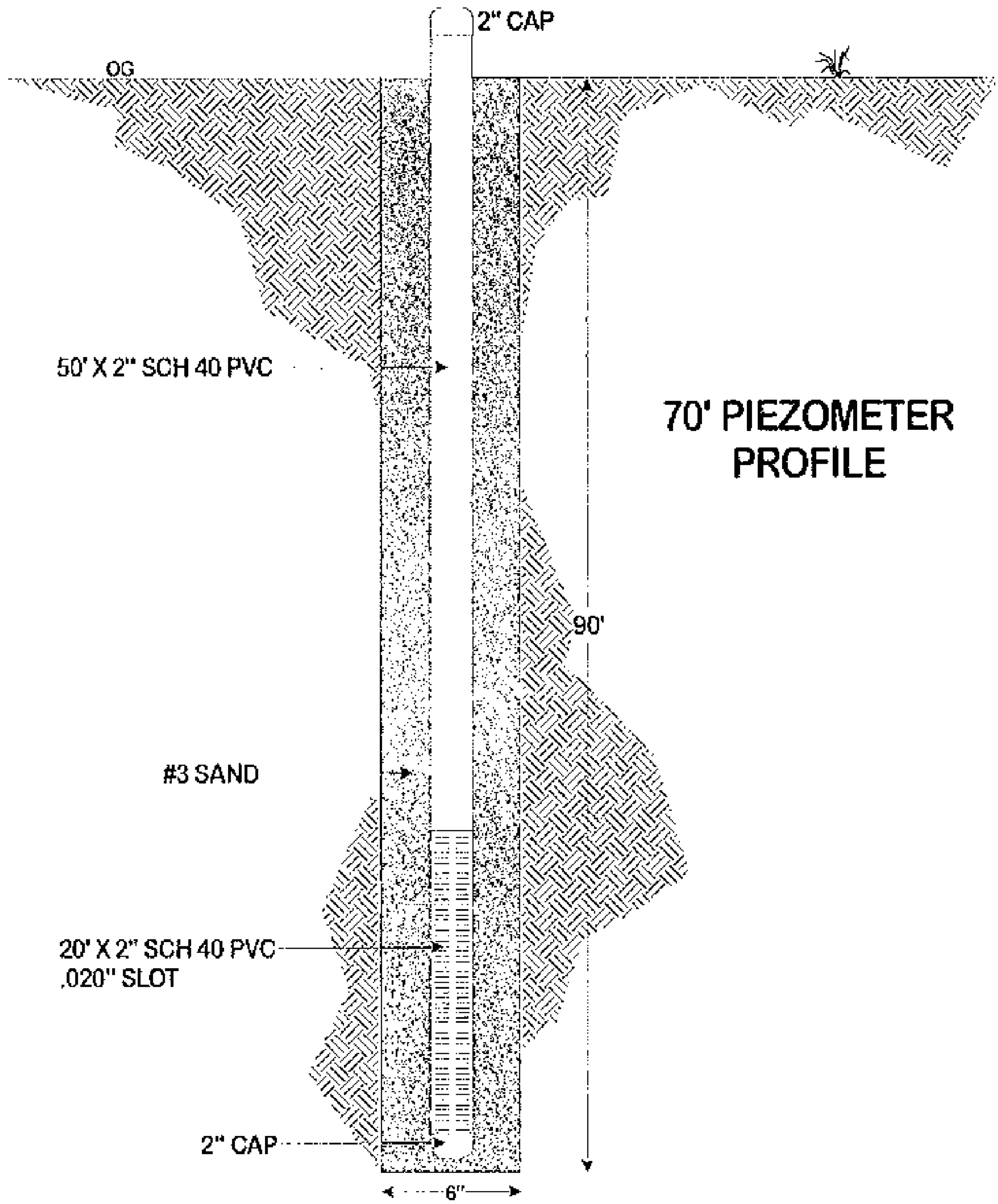

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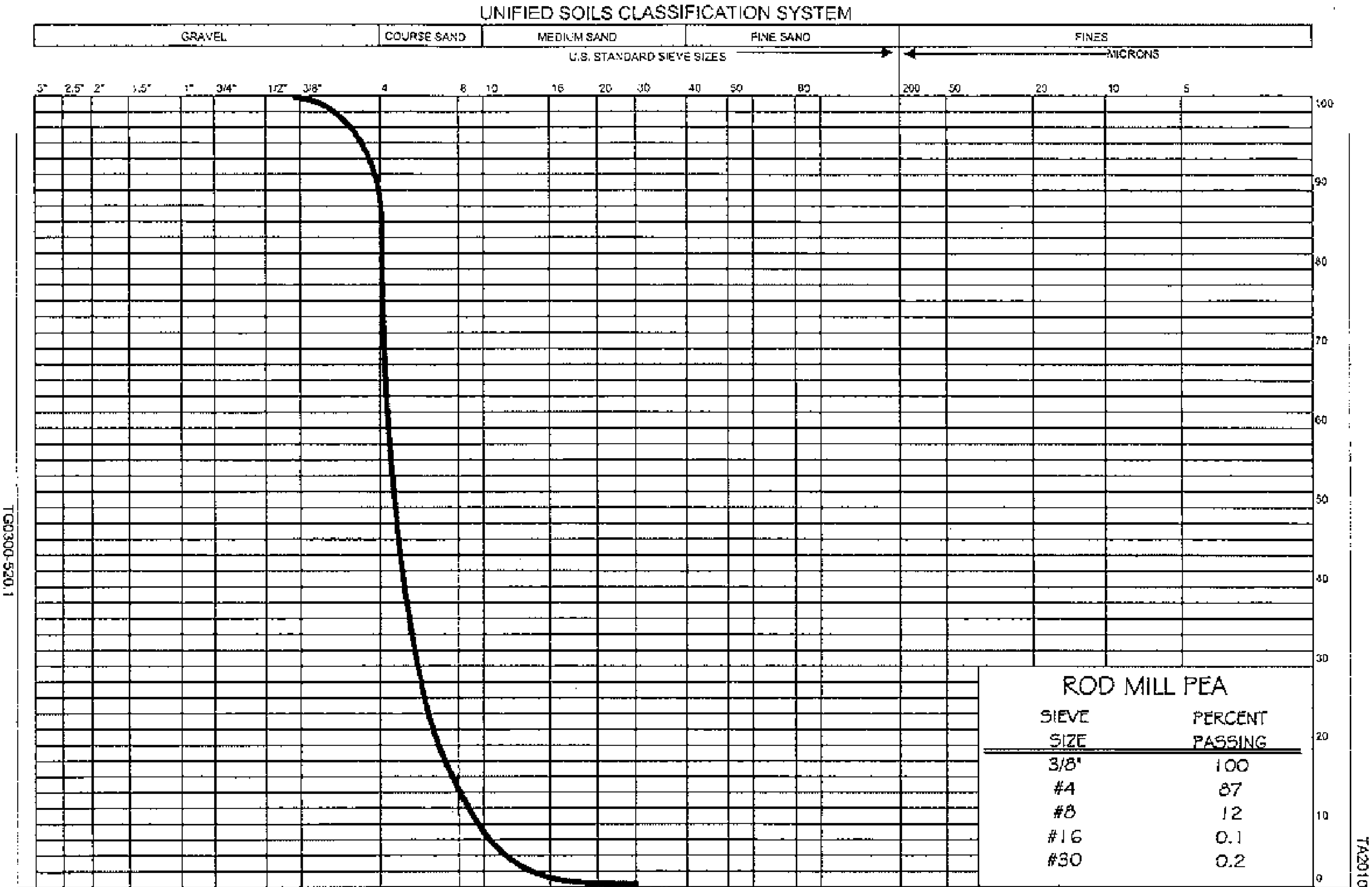
EXHIBIT #3

PIEZOMETER

DRAWING NO. PP | SCALE: NONE



ROD MILL PEA

SIEVE SIZE	PERCENT PASSING
3/8"	100
#4	87
#8	12
#16	0.1
#30	0.2

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EXHIBIT #4

GRAVEL FILTER GRADATION

DRAWING NO. GF SCALE: NONE

4" Submersible Pumps

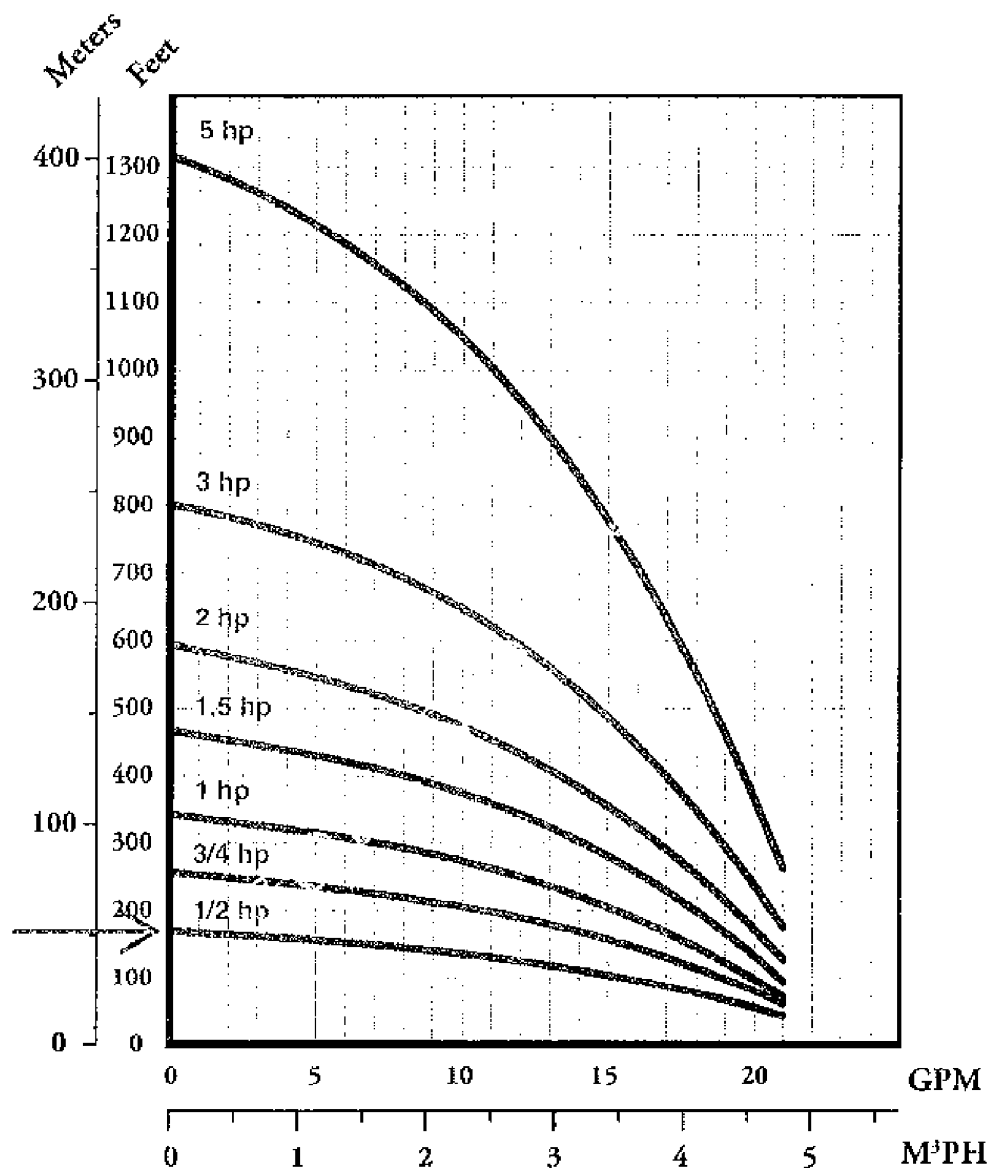

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EXHIBIT #5

1/2 H.P. PUMP

DRAWING NO. P | SCALE: NONE

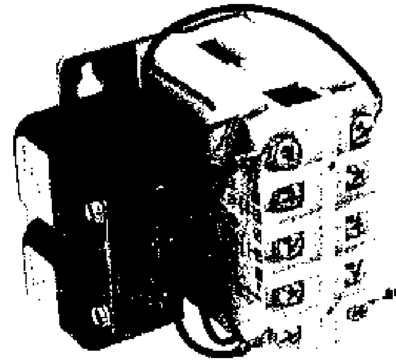
Gems Sensors

GENERAL PURPOSE CONTROL

WARRICK CONDUCTIVITY SENSORS

Series 1 – Electromechanical Controls

- 2 or 3 Pole Output Contact
- U.L. "Limit Control"
- Up to 20K Ohms/cm Sensitivity
- U.L. "Motor Control"



One of Warrick's first products, Series 1 electromechanical controls offer 2 or 3 pole output contacts with 16 amp rating. These versatile controls can be configured for single level service, differential control, low water cutoff (with manual reset or lock out capability) control and many other functions.

Specifications

Contact Design	2 or 3 pole, single throw, electromechanical relay
Contact Rating (110 VAC)	16 amp Resistive 1 hp
Mode of Operation	Direct only
Sensitivity	0 - 20K ohm maximum, factory set
Primary Voltage	24 VAC, 115 VAC, 230 VAC, 460 VAC, 575 VAC (+10%/-15%)
Power Consumption	4 watts (15 VA)
Secondary Voltage	25 VAC, 75 VAC, 150 VAC, 300 VAC, 500 VAC*
Temperature	-30°F to 130°F
Approvals	U.L. Rec., FM, CSA, U.L. Listed Limit Control, U.L. 353
Connections	All screw type connections

* Due to high secondary voltage, if personnel can come in contact with electrodes, we suggest using Series 16, 26 or 19 controls.

Applications

- General Purpose
- On/Off Control
- Pump Control
- Boiler Level Control
- Boiler LLCO

How to Order

Use the Bold characters from the chart below to construct a product code.

1 X X X X

Series 1

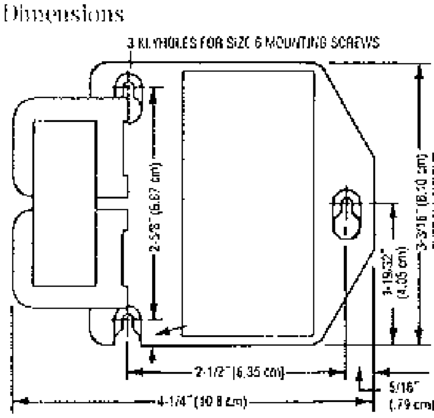
Contact Configuration
- **C** – 2 (N.O.), 0 (N.C.)
- **D** – 1 (N.O.), 1 (N.C.)
- **E** – 0 (N.O.), 2 (N.C.)
- **F** – 3 (N.O.), 0 (N.C.)
- **G** – 2 (N.O.), 1 (N.C.)
- **H** – 1 (N.O.), 2 (N.C.)
- **J** – 0 (N.O.), 3 (N.C.)

Supply Voltage
- **1** – 115 VAC
- **2** – 230 VAC
- **4** – 460 VAC
- **5** – 575 VAC
- **6** – 115VAC/230VAC
- **7** – 24 VAC

Secondary Voltage (Sensitivity)
- **A** – 25 (50 Ω)
- **B** – 75 (450 Ω)
- **C** – 150 (1.5K Ω)
- **D** – 300 (7K Ω)
- **E** – 500 (20K Ω)

Enclosure
- **0** – None
- **1** – NEMA 1
- **4** – NEMA 4

Dimensions



Typical Single Level Wiring

Typical Differential Wiring

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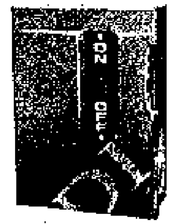
EXHIBIT #6	
LIQUID LEVEL CONTROL	
DRAWING NO. LC	SCALE: NONE

SPECIFICATIONS

Category	General Duty
Voltage	240
Fusing	No Fuse
Poles	3
Wires	3
Amperage	60A
Enclosure	NEMA 3R (Outdoor)
Height	13.75 in
Depth	4 in
Width	8.75 in
Weight	10 lb
Viewing Window	No
Wire Range (Cu/Al)	12-2 / 12-2
240Vac, NEC Std, 1-ph	10 hp
240Vac, NEC Std, 3-ph	15 hp
240Vac, Time Delay, 1-ph	10 hp
240Vac, Time Delay, 3-ph	15 hp
GO Schedule	131A



Publications/Resources

TGN3322R

Additional Resources for General Duty

Application and Technical

Drawings-Outline and Dimensional
Buy Log :2-5

- Designed for residential and light commercial applications where duty is not severe
- Listed per UL Standard 98, Enclosed and Dead Front Switches
- CSA certified
- UL Service Entrance rated when installed in accordance with the National Electrical Code
- Meets NEMA Enclosed Switch Standard KS1-1990 for Type General Duty
- 60°C and 75°C conductor rating
- Features quick-make, quick-break mechanisms (30-200 amps)
- 30-200 amp fusible switches are rated 100,000 rms amps, sym IC when used with Class R fuses. Refer to BuyLog to order appropriate Class R Fusing Kit
- Bottom-feed version available for 200-600 amp, NEMA 1 only
- Fusible and Non-Fusible switches available(consult BuyLog for interrupt ratings)

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EXHIBIT #7

DISCONNECT SWITCH

DRAWING NO. DS | SCALE: NONE

TA2010-312319A03.1

J-BOX FOR 480 VOLT DEWATERING WELL POWER

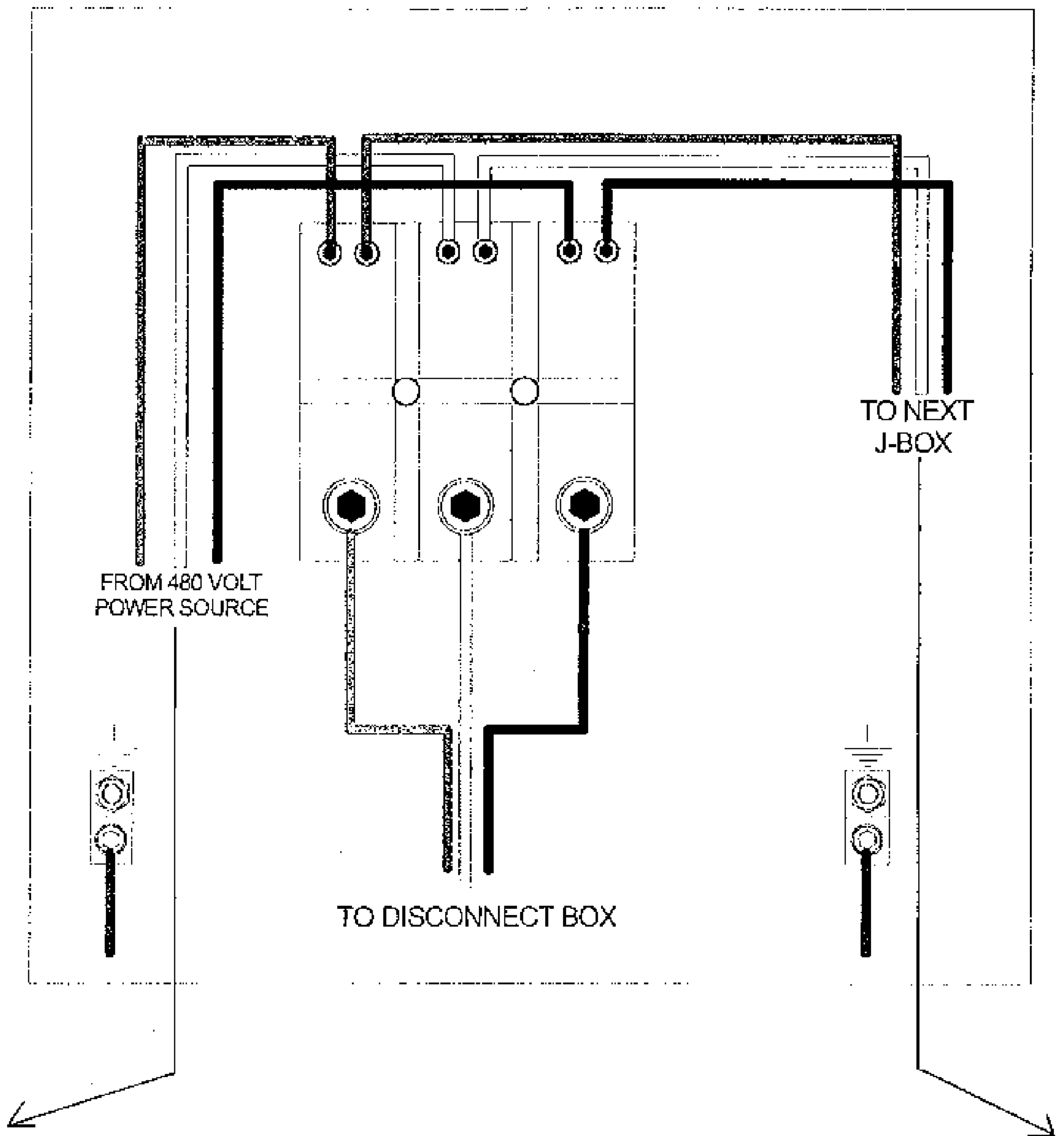

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EXHIBIT #8

JUNCTION BOX

DRAWING NO. JB | SCALE: NONE

8 AGW - Stranding Bare Copper (133/29)

P/N	# Of Cond.	Nom. Insulation Thickness (Inches)	Nom. O.D. (inches)	Lbs. / M'
66352	2	.045"	.615"	280
66353	3	.060"	.655"	354
→ 66354	4	.060"	.715"	450
66355	5	.060"	.785"	560
66356	6	.045"	.890"	655

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EXHIBIT #9

8/4 S/O CORD

DRAWING NO. SC | SCALE: NONE

WELL CASING

Slotted PVC and Underdrain Pipe Specifications

This chart illustrates standard manufacturing capabilities only. Not all prod

Slot configurations not included on this chart are covered under CertainTeed's non-standard product warranty.

						O.D. OPEN AREA; SQ. INCHES PER FOOT OF SCREEN (.25" SLOT SPACING)										
						SLOT WIDTH INCHES										
						0.010	0.013	0.016	0.020	0.025	0.032	0.040	0.050	0.065	0.100	0.125
2"	2.375	4	SCH40	0.154	SW	2.4	3.1	3.7	4.6	5.6	7.0					
3"	3.500	4	SCH40	0.216	SW	2.6	3.4	4.1	5.0	6.2	7.7					
4"	4.500	4	SDR26	0.173	SW											
			SDR21	0.214	SW	3.0	3.9	4.8	6.0	9.7	12.2	14.8	18.2	27.2		
			SCH40	0.237	SW,CLIB											
4 1/2"	4.950	4	SDR26	0.190	SW,CLIB											
			SCH40	0.248	SW,CLIB	3.0*	4.5*	5.4*	9.2	11.3	14.1	17.1	21.0	31.5		
			SDR17	0.291	SW,CLIB											
5"	5.563	4	SDR26	0.214	SW											
			SDR21**	0.265	SW,CLIB		4.5*	5.4*	10.0	12.3	15.4	18.7	23.0	34.4		
			SDR17	0.327	SW,CLIB											
			SCH80	0.375	CLIB											
6"	6.625	6	SDR26	0.255	SW											
			SCH40	0.280	SW,CLIB			8.2*	12.6	15.4	19.2	23.4	28.7	43.0		
			SDR21	0.316	SW,CLIB											
			SDR17	0.390	SW,CLIB											
6 1/4"	6.900	6	DR27.6	0.250	SW											
6 1/8"			SDR21	0.329	SW,CLIB				12.6*	15.4	19.2	23.4	28.7			
			SDR17	0.406	SW,CLIB											
8"	8.625	6	SDR26	0.332	SW											
			SDR21	0.410	SW				14.2*	20.3	25.4	30.8	37.9	56.7	63.8	74.6
			SDR17	0.508	CLIB											
10"	10.750	6	SDR26	0.413	SW											
			SDR21	0.511	SW					22.5*	28.1	34.1	41.9	62.7	70.7	82.5
			SDR17	0.632	CL											
12"	12.750	8	SDR26	0.490	SW											
			SDR21	0.606	SW					30.0*	37.4	45.5	55.9	83.7	94.2	110.1
			SDR17	0.750	CL											
14"	14.000	8	SCH40	0.437	SW					32.9*	41.1	49.9	61.3	91.8	103.4	120.7
			SDR17	0.823	CL											
16"	16.000	10	SCH40	0.500	SW					36.3	45.3	55.1	67.6	101.2	114.0	133.1
		10	SDR26	0.616	SW,CL											
		8	SDR21	0.762	CL					31.0	38.7	47.0	57.7	86.4	97.3	113.6
		8	SDR17	0.941	CL						43.5	52.8	64.9	97.2	109.4	127.8
17.4" O.D.	17.400	8	SDR17	1.024	CL							52.8	64.9	97.2	109.4	127.8

VIKING DRILLERS, INC.

DEWATERING SYSTEMS

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CA Lic. #476668 NV Lic. #0034680

EXHIBIT #10

WELL CASING

DRAWING NO. WC | SCALE: NONE

TG0300-520.1

JM Eagle *Building essentials for a better tomorrow™*

PVC SOLVENT WELD - (SCHEDULE SERIES)

Dual marking for both Pressure and Drain, Waste, Vent (DWV) Applications

JM EAGLE™ PVC SCHEDULE 40/DWV PIPE

Specifications: ASTM D1785 & ASTM D2665 : :

Listed : ANSI/NSF-PW NSF-DWV
Standard 61, Standard 14

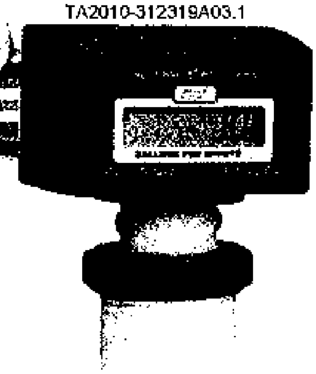
NOM. PIPE SIZE (IN)	O.D. (IN)	NOM. I.D. (IN)	MIN. T. (IN)	WATER PRESSURE RATING AT 23°C (73°F)	APPROX. WEIGHT (LBS/FT)
1/2	0.840	0.609	0.109	600	0.164
3/4	1.050	0.810	0.113	480	0.218
1	1.315	1.033	0.133	450	0.324
1-1/4	1.660	1.363	0.140	370	0.439
1-1/2	1.900	1.593	0.145	330	0.525
2	2.375	2.049	0.154	280	0.705
2-1/2	2.875	2.445	0.203	300	1.118
3	3.500	3.042	0.216	260	1.463
4	4.500	3.998	0.237	220	2.083
6	6.625	6.031	0.280	180	3.663
8	8.625	7.942	0.322	160	5.512
10	10.750	9.976	0.365	140	7.815
12	12.750	11.889	0.406	130	10.333
14	14.000	13.073	0.437	130	12.220
16	16.000	14.940	0.500	130	15.980

: : Standard Color: White, Standard Length 10' & 20', Plain End and Belled End

VIKING DRILLERS, INC. *DEWATERING SYSTEMS*	EXHIBIT #11	
801 Northport Drive West Sacramento, Ca 95691-2153 (916) 372-4993 FAX (916) 372-1337 www.vikingdrillersinc.com CA Lic. #476668 NV Lic. #0034680	DISCHARGE & RISER PVC PIPE	
	DRAWING NO. SS	SCALE: NONE

TA2010-312319A03.1

BW DIGI-METER F-1000 PADDLEWHEEL FLOWMETER



Blue-White's carefully engineered BW DIGI-METER F-1000 Series include premier features and provide outstanding performance.

Three versions of the BW DIGI-METER F-1000 are offered. The F-1000RB Unit is a rate meter only; the F-1000TB Unit is a flow totalizer; and the F-1000RT Unit is both a Rate Meter and Flow Totalizer. BW DIGI-METERS are available with a number of configuration and mounting style options. If you don't see the unit that meets your requirements here, please contact our courteous and knowledgeable staff for assistance.

F-1000 BENEFITS

- Easy to read six digit LCD, up to four decimal positions.
- Tamper proof.
- Battery operated (2 AAA batteries included).
- Three model variations:
  - **RB** = RATE ONLY
  - **TB** = TOTAL ONLY
  - **RT** = RATE & TOTALIZER
- Total reset function can be disabled.
- Display update time: Rate 1.5 sec., Total 0.5 sec.
- Factory calibrated - nothing to program.
- Custom calibration units available. Contact the factory.
- Weather resistant ABS enclosure. NEMA 4X
- Calibration Units: GPM, LPM, m3/min, oz/min, GPH,LPH.
- LCD is not recommended for direct sunlight applications.

F-1000 SPECIFICATIONS

with Saddle Mount Body

Max. Working Pressure.......300 psig (20 bar) @ 70° F (21° C)
Max. Fluid Temperature.......200° F (93° C) @ 0 PSI (all PVDF saddle fittings)
140° F (60° C) @ 0 PSI (all PVC saddle and TEE fittings)
Note: Temperature rating of F-1000 only. Actual pipe rating may vary.
Full scale accuracy.......+/- 2%
Saddle material.......PVDF (1-1/2", 2", 3", 50mm, 63mm, 90mm sizes)
.......PVC (all other sizes)
Sensor/Paddle/Axle material....PVDF
O-ring seals.......Viton
Max. pressure drop.......0 psi (no significant drop)
Approximate shipping wt.......2 lb. (.91 kg)

with Solvent TEE Body

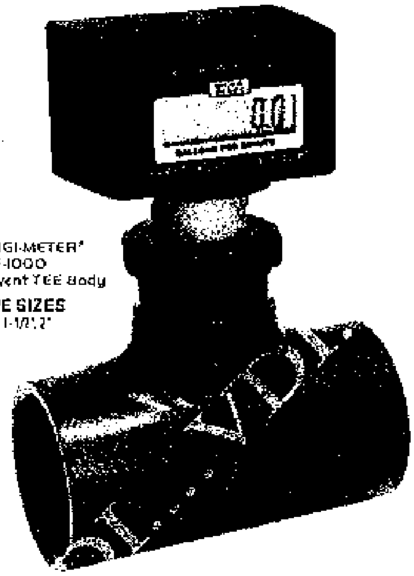
Max. Working Pressure
316 SS Tee fittings.......300 psig (20 bar) @ 70° F (21° C)
PVC Tee fittings.......200 psig (13.8 bar) @ 70° F (21° C)
Max. Fluid Temperature
316 SS Tee fittings.......200° F (93° C) @ 0 PSI
PVC Tee fittings.......140° F (60° C) @ 0 PSI
Full scale accuracy.......+/- 2%
Tee material options.......316 Stainless Steel, PVC
Body, Paddle, Axle material.......PVDF
Axle options.......Ceramic, Hastelloy, Titanium
O-ring seals.......Viton
Max. pressure drop.......0 psi (no significant drop)
Approximate shipping wt.......2 lb. (.91 kg)

with Molded In-Line Body ←

Max. Working Pressure.......300 psig (20 bar) @ 70° F (21° C)
Max. Fluid Temperature.......200° F (93° C) @ 0 PSI
Full scale accuracy.......+/- 2%
Meter body material.......Polysulfone
Sensor/Paddle/Axle material....PVDF
O-ring seals.......Viton
Max. pressure drop.......8 psi (varies per model)
Approximate shipping wt.......2 lb. (.91 kg)

with Machined In-Line Body

Max. Working Pressure.......300 psig (20 bar) @ 70° F (21° C)
Max. Fluid Temperature.......200° F (93° C) @ 0 PSI
Full scale accuracy.......+/- 2%
Sensor/Paddle/Axle material....PVDF
O-ring seals.......Viton
Max. pressure drop.......8 psi (varies per model)
Approximate shipping wt.......5 lb. (2.31 kg)

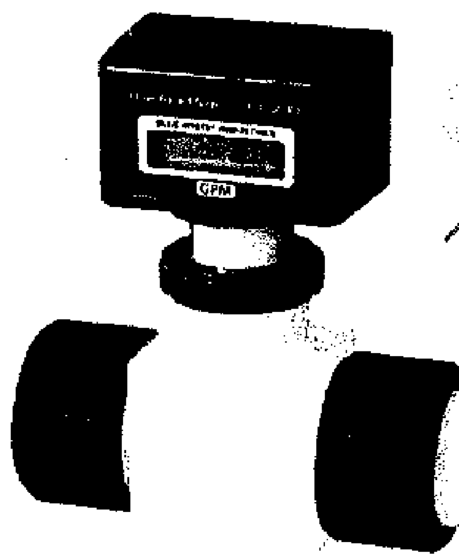


BW DIGI-METER® F-1000
with Solvent TEE Body

PIPE SIZES
1", 1-1/2", 2"

BW DIGI-METER® F-1000
with Saddle Mount

PIPE SIZES
1-1/2", 2", 2-1/2", 3", 4", 6", 8", 10", 12"



BW DIGI-METER®
F-1000
with Molded In-Line Body

PIPE SIZES
1/4", 3/8", 1/2", 3/4", 1", 2" M/NPT

BW DIGI-METER®
F-1000
with Machined In-Line Body

PIPE SIZES
1/4", 3/8", 1/2", 3/4", 1", 2" F/NPT

VIKING DRILLERS, INC. — *DEWATERING SYSTEMS* — 801 Northport Drive, West Sacramento, Ca 95691-2153, (916) 372-4993 FAX (916) 372-1337, www.vikingdrillersinc.com, California License #476668	**EXHIBIT #12**
	FLOWMETER

TG0300-520.1

ALTD-830-0461502

THREADED END FLOWMETER MODEL MT100

SPECIFICATIONS

PERFORMANCE

ACCURACY/REPEATABILITY: ±2% of reading guaranteed throughout full range; ±1% over reduced range; Repeatability 0.25% or better

MAXIMUM TEMPERATURE: (Standard Construction) 160°F constant

PRESSURE RATING: 150 psi

MATERIALS

BEARING ASSEMBLY: Impeller shaft is 316 stainless steel. Ball bearings are 440C stainless steel.

MAGNETS: (Permanent type) Cast or sintered Alnico

BEARING HOUSING: Brass; Stainless Steel optional

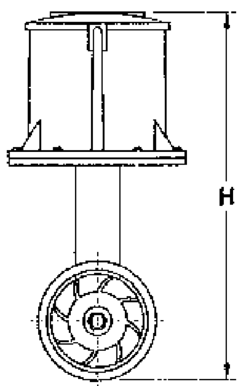
REGISTER: An instantaneous flowrate indicator and six-digit straight-reading totalizer are standard. The register is hermetically sealed within a die cast aluminum case. This protective housing includes a domed acrylic lens and hinged lens cover with locking hasp.

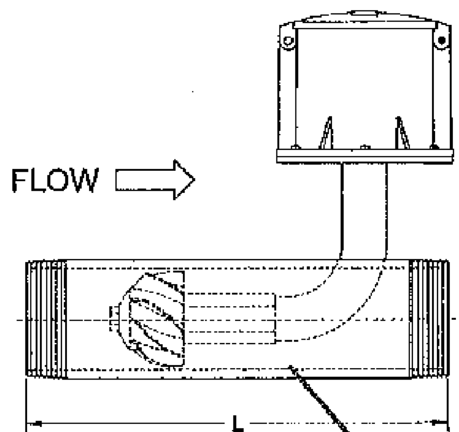
IMPELLER: Impellers are manufactured of high-impact plastic, retaining their shape and accuracy over the life of the meter. High temperature impeller is optional.

FLOW TUBE: Fusion-bonded epoxy-coated carbon steel threaded to NPT. (Other thread standards available.)

OPTIONS

- Forward/reverse flow measurement
- Register extensions
- All stainless steel construction
- High temperature construction
- "Over Run" bearing assembly for higher than normal flowrates
- Electronic Propeller meter available in all sizes of this model
- A complete line of recording/control instrumentation can be driven from this flowmeter
- Certified calibration test results





McCrometer reserves the right to change design or specifications without notice.

MT100	DIMENSIONS					
Meter Size	2"	2 ½"	3"	4"	6"	8"
Maximum Flow U.S. GPM	250	250	250	600	1200	1500
Minimum Flow, U.S. GPM	35	35	40	50	90	100
Approx. Head Loss In inches at Max. Flow	29.50	29.50	29.50	23	17	7
Approx. Shipping Weight-lbs.	* SEE SPECIAL NOTE		17	40	42	68
H (inches)			10	13	14	14
L (inches)			13	20	22	20
O.D. of Meter Tube			3.50	4.500	6.625	8.625

Larger flowmeters on special order.

*SPECIAL NOTE — Reducing fittings are supplied to adapt the 3-inch model to smaller line sizes.

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EXHIBIT #13 Pg. 2 of 2

FLOWMETER

DRAWING NO. FM | SCALE: NONE

MCROMETER MT100

DESCRIPTION

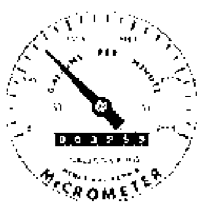
The Model MT100 is manufactured to comply with the applicable provisions of the American Water Works Association Standard No. C704-02 and latest revisions for propeller type flowmeters. The threaded ends of the MT100 allow it to be directly coupled into an existing pipeline. The carbon steel flow tube has a fusion-bonded epoxy coating offering excellent corrosion protection. As with all McCrometer propeller flowmeters, standard features include a magnetically coupled drive, instantaneous flowrate indicator and straight-reading, six-digit totalizer.

Impellers are manufactured of high-impact plastic, capable of retaining their shape and accuracy over the life of the meter. Each impeller is individually calibrated at the factory to accommodate the use of any standard McCrometer register, and since no change gears are used, the MT100 can be field-serviced without the need for factory recalibration. Factory lubricated, stainless steel bearings are used to support the impeller shaft. The shielded bearing design limits the entry of materials and fluids into the bearing chamber providing maximum bearing protection.

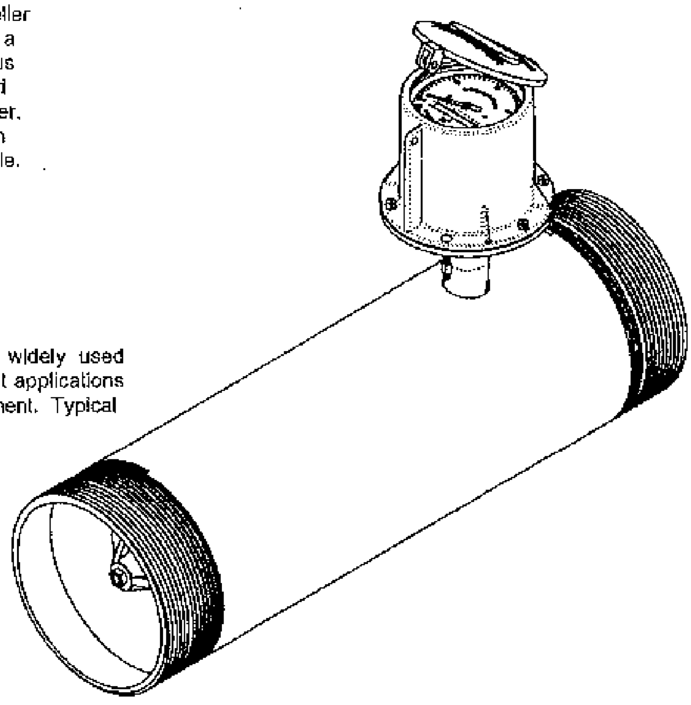
An instantaneous flowrate indicator is standard and available in gallons per minute, cubic feet per second, liters per second and other units. The register is driven by a flexible steel cable encased within a protective self-lubricating liner. The register housing protects both the register and cable drive system from moisture while allowing clear reading of the flowrate indicator and totalizer.

INSTALLATION

Standard installation is horizontal mount. If the meter is to be mounted in the vertical position, please advise the factory. A straight run of full pipe the length of ten pipe diameters upstream and two diameters downstream of the meter is recommended for meters without straightening vanes. Meters with optional straightening vanes require at least five pipe diameters upstream and two diameters downstream of the meter.



The McCrometer Propeller flowmeter comes with a standard instantaneous flowrate indicator and straight-reading totalizer. An optional FlowCom register is also available. *Typical face plates.*



APPLICATIONS

The McCrometer propeller meter is the most widely used flowmeter for municipal and wastewater treatment applications as well as agricultural and turf irrigation measurement. Typical applications include:

- Water and wastewater management
- Truck loading and discharge
- Sprinkler irrigation systems
- Drip irrigation systems
- Golf course and park water management
- Commercial nurseries

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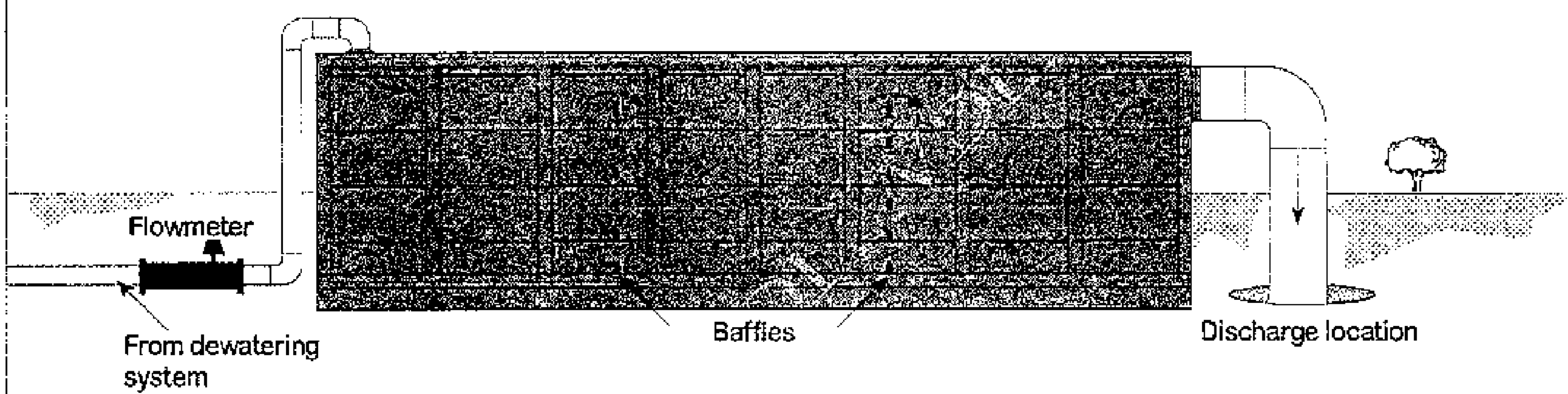
EXHIBIT #13 pg. 1 of 2

FLOWMETER

DRAWING NO. FM | SCALE: NONE



DIMENSIONS: 8' WIDE X 4' HIGH X 16' LONG

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EXHIBIT #14

3500 GALLON SAND TANK

DRAWING NO. ST | SCALE: NONE

TA2010-312319A03.1

TG0300-520.1

ALTD-830-0461505

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EXHIBIT #15

DEWATERING WELLS DRILLING
and
WELL DEVELOPMENT PROCEDURE

The following is what occurs prior to discharging into the sanitary sewer or storm drain.

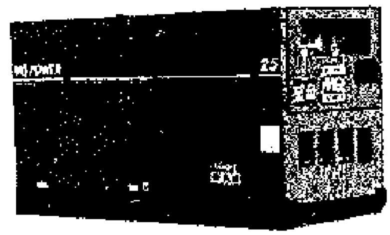
Viking Drillers, Inc. drills a 24" diameter borehole, sets 8" commercially slotted casing (depths vary), backfills the borehole around the casing with a clean, washed pea gravel sand mixture in annulas and sets a pump. Viking then develops the well. This involves pumping from the well to remove the fines in gravel pack that were stirred up during drilling procedure. Viking will pump from well to well for the development process. The last well will be developed into the sand sediment tank.

Once the well has been developed, it is plumbed into the discharge line and run to a sand sediment tank, before it reaches the final discharge point. The well filter pack remains in an undisturbed state throughout the twenty-four hour a day dewatering process. During the developmental stage of the well, the fines are removed through the well filter pack and the resulting discharge will be sediment free.

However, if a well is turned off for a period of time and then turned back on, there will be a small amount of color to the discharge water. This is caused by the increased entrance velocity of the water stored around the well, as a result of the well being turned off for a period of time. Once the stored water has been removed and the well is only controlling the influx of water, the water will be clear, sediment and color free. Inspection of the discharge, after a couple of hours, will again result in clear, sediment free discharge.

Viking Drillers, Inc. performs approximately 100+ projects a year throughout California and Nevada. We have not encountered problems in meeting the criteria for clear, sediment free discharge, on any other project, during our experience in these areas.

DCA-25SSIU



The DCA-25SSIU sports 27kVA/22kW standby output and 25kVA/20kW prime output. The generator is powered by a 4-cylinder, 31-horsepower Isuzu C240 diesel engine and the unit controls voltage regulation to +/-1 percent no load to full load. Sound level is an impressive 65dBA full load at 23 feet while the generator has a 17-gallon (65 liters) fuel tank.

Performance Data	
Standby Output	22 kW , 27 kVA
Prime Output	20 kW , 25 kVA
Generator RPM	1800 RPMs
Generator Design	Revolving Field Self-Ventilated Dip-Proof Single Bearing
Voltage Regulation - (No Load to Full Load)	1 %
Power Factor	0.8
Armature Connection	Star with Neutral / Zigzag
Excitation	Brushless with AVR
No. Poles	4 Pole
Frequency	60 Hz
Available Voltages - 3 Phase	208, 220, 240, 416, 440, 460, 480V Switchable Volts
Available Voltages - Single Phase	120, 127, 139, 240, 254, 277 Switchable Volts
Amps - Single Phase 120V	55.5 (4 Wire) 60x2(Zigzg) Amps
Amps - Single Phase 240V	27.8 (4 Wire) 60 (Zigzg) Amps
Amps - Three Phase 240V	60 Amps
Amps - Three Phase 480V	30 Amps
Insulation	Class F
Sound Level dB(A) - Full Load at 23 feet	67 dB(A)
Power Source	
Engine Make / Model	Isuzu C240
Dimensions	
Overall Length	77 in. , 195 cm
Overall Width	30 in. , 75 cm
Overall Height	39 in. , 100 cm
Approx. Net Wt. Dry	1543 lbs. , 700 kg.

Please note, product information is not up-to-date while we work on our new website.
Please confirm all products and specifications with our sales dep

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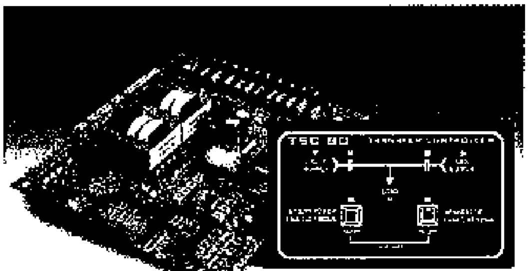
EXHIBIT #16
25 KVA
STANDBY
GENERATOR

DRAWING NO. GS	SCALE: NONE



- Microprocessor-based circuitry provides ultimate reliability and versalility
- Non-volatile memory retains logic and setpoints if control power is lost
- Direct 3 phase voltage sensing inputs on generator and utility supplies from 120VAC up to 600VAC (nominal)
- Self diagnostic features continuously verify processing, I/O and memory circuits
- Simplified controller design is easy to use and requires no software programming
- Superior EMI/RFI noise immunity and voltage surge performance as per IEEE C62.41
- Optional version TSC 80e Enhanced controller is available which provides additional features such as front panel LCD display.

GENERAL DESCRIPTION

The Thomson Technology ***TSC 80 Transfer Switch Controller*** utilizes the latest advancements in microprocessor technology, printed circuit board assembly and software for control of automatic transfer switches. The **TSC 80** is the second generation of microprocessor-based transfer switch controllers from Thomson Technology, and reflects over 30 years of transfer switch control experience. The **TSC 80** is factory configured to monitor, display and control all operational functions of the automatic transfer switch. All voltage sensors and timers are fully user adjustable utilizing potentiometers, which requires no software programming. The microprocessor design provides high accuracy for all voltage sensing and timing functions as well as providing many standard features.

The **TSC 80** Transfer Switch Controller is available in 2 basic model types-**TSC 80** Standard and **TSC 80e** Enhanced Transfer controller. The ***TSC 80e*** Enhanced Transfer Controller includes all of the features available in the standard **TSC 80** plus additional features such as LCD display, front programming buttons, data logging with real time clock, integrated Load Disconnect control and programmable exercise timer.

TSC 80 STANDARD CONTROL FEATURES

- Utility AC voltage sensing (true RMS) – 120-600V single phase or 3 phase
- Generator AC voltage sensing (true RMS) – 120-600V single phase or 3 phase
- Generator AC frequency sensing
- Utility under voltage control setpoint 70 - 95% (adjustable)
- Generator under voltage control setpoint 70 - 95% (adjustable)
- Generator under frequency control setpoint 70 - 90% (adjustable)
- Engine warm-up timer 0-60 sec. (adjustable)
- Utility return timer 0-30 min. (adjustable)
- Engine start timer 0-60 sec. (adjustable)
- Engine cooldown timer 0-30 min. (adjustable)
- Neutral position delay timer 0-60 sec. (adjustable)
- Local utility power fail simulation test pushbutton & LED, door mounted
- Remote utility power fail simulation test pushbutton input (via terminal block)
- Load on utility supply & load on generator supply LED's, door mounted
- Utility and generator source available LED's, door mounted
- Weekly plant exercise timer (30 min. on load) manually initiated
- Local plant exercise initiate pushbutton & LED, door mounted
- Engine start contact (10A, 120/240VAC resistive max.)
- Load on utility auxiliary contact (Qty 1 only, 10A, 120/240VAC, Form C)
- Load on generator auxiliary contact (Qty 1 only, 10A, 120/240VAC, Form C)
- Transfer fail/forced transfer logic
- 50 or 60Hz capable (115V control power)

THOMSON TECHNOLOGY

VIKING DRILLERS, INC.

DEWATERING SYSTEMS

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EXHIBIT #17

AUTO TRANSFER SWITCH

DRAWING NO. AS | SCALE: NONE

SINCE 1948

RACO®

REMOTE ALARMS AND CONTROLS

1948-1998 50th ANNIVERSARY

RACO Mfg. and Eng. Co. • 1400 62nd St., Emeryville, CA 94608 • (510) 658-6713 • 800-722-6999 • FAX (510) 658-3153 • www.racoman.com

ALARMAGENT.COM ® WIRELESS, WEB-BASED MONITORING EQUIPMENT AND SERVICES SPECIFICATION

August 21, 2006

PRODUCT DESCRIPTION

Wireless, web-based alarm detection and notification system from RACO designed specifically for water and wastewater applications. Dependable alarm monitoring and detection. Highly customizable notification preferences. Around-the-clock status access from almost anywhere.

System shall be sufficiently robust to permit direct user on demand management of the following functions via the web; administration and configuration of WRTUs, system preferences, users, reporting parameters, and report generation, requiring no direct participation by the manufacturer.

AlarmAgent.com' s report generation capability is optimized for pump applications. Users can spot clogged or malfunctioning pumps in time to prevent a major disaster. And, for the first time, small pump stations can report flow data without a flow meter.

A service contract with local cellular carriers shall not be required for RTU operation. The WRTU (Wireless Remote Terminal Unit) shall communicate with a dedicated web site via wireless cellular communications.

AlarmAgent.com combines the latest in data communications and wireless technology with the reliability and reputation of RACO's half-century of industry experience.

MANUFACTURER REQUIREMENTS

The Manufacturer of the equipment and provider of related services shall provide evidence of, and warrant compliance with, substantially all below listed requirements.

The Manufacturer/Service Provider shall have been in business providing remote monitoring services to the water distribution / wastewater collection industry or a substantially similar industry for at least five years.

The submitting Company shall have, on staff, engineering and operational personnel with at least twenty years of combined experience in designing, manufacturing and operating wide area monitoring and alarm products for remote facilities in the Water and Wastewater marketplace.

Baro-Diver

TA2010-312319A03.1

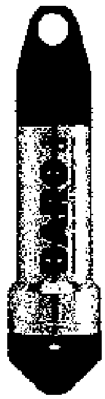
Highlights:
- measures atmospheric pressure for accurate barometric compensation of Divers
- hermetically sealed in stainless steel housing

Compensate barometric pressure

The Baro-Diver™ ensures that you accurately capture changes in atmospheric pressure. Conveniently priced and easy to adjust, one Baro-Diver covers a radius of up to 9 miles, depending on the topography.

Based on proven, innovative technology, the Baro-Diver has an internal memory capable of storing 24000 measurements per parameter.

For each measurement, the Baro-Diver simultaneously registers barometric pressure, air temperature, date and time.



General Specifications

Dimensions	ø0.87 in x 3.54 in.
Memory	24000 measurements
Wetted parts	
housing	stainless steel (316L)
o-rings	Viton ®
pressure sensor	ceramic (Al_2O_3)
cap / nose cone	Nylon PA6 30% glass fibre
Battery life	10 years (dependant on usage)
Sample interval	0.5 second to 99 hours
Mass	0.12 lbs

Temperature specifications

range / compensated	-4 °F to 176 °F / 14 °F to 122 °F
accuracy[1]	±0.18 °F
resolution	0.018 °F

Pressure specifications

Type	DI 500
Range	4.9 ftH$_2$O
- accuracy[1]	±0.2 inH$_2$O
- resolution	0.08 inH$_2$O

[1] typical accuracy

EXHIBIT #19

Mini-Diver

Highlights:
- hermetically sealed in stainless steel housing
- fixed measurements
- cost effective

A proven concept

The Mini-Diver™ is based on an ingenious and proven concept and is acknowledged as the most reliable instrument for the autonomous measuring and recording of groundwater level and temperature. Its internal memory of 24000 measurements per parameter provides sufficient capacity to perform nearly one measurement every ten minutes for six months. For each measurement, the Diver registers the date and time, groundwater level, and temperature.

General Specifications

Dimensions	ø 0.87 in x 3.54 in.
Memory	24000 measurements
Wetted parts	
housing	stainless steel (316L)
o-rings	Viton ®
pressure sensor	ceramic (Al_2O_3)
cap / nose cone	Nylon PA6 30% glass fibre
Battery life	10 years (dependant on usage)
Sample interval	0.5 second to 99 hours
Mass	0.12 lbs

Temperature specifications

range / compensated	-4 °F to 176 °F / 32 °F to 122 °F
accuracy[1]	±0.18 °F
resolution	0.018 °F

Pressure specifications

Type	DI 501	DI 502	DI 505	DI 510
Range	32.8 ftH$_2$O	65.6 ftH$_2$O	164 ftH$_2$O	328 ftH$_2$O
- accuracy[1]	±0.2 inH$_2$O	±0.4 inH$_2$O	±0.98 inH$_2$O	±1.97 inH$_2$O
- resolution	0.08 inH$_2$O	0.16 inH$_2$O	0.4 inH$_2$O	0.79 inH$_2$O

[1] typical accuracy

TG0300-520.1

TA2010-312319A03.1

521 BRASS SWING CHECK VALVE

Threaded Ends Conform to ANSI Standards B2.1
Valves are Tested in Accordance with MSS-SP-82

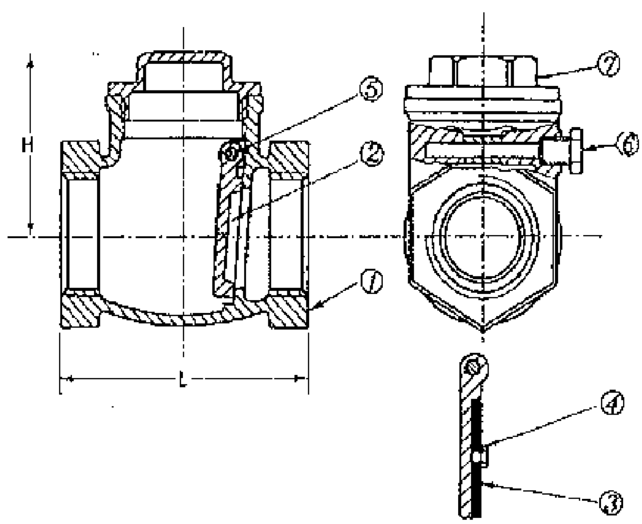
521N Also Available

Same As 521 With Neoprene Disc

DIMENSIONS

SIZE (inches)	H	L	L1	Weights (lbs) 521T	521C	521N
3/8	1.50	-	-	.38	-	.42
1/2	1.50	2.07	2.56	.40	.36	.40
3/4	1.60	2.34	3.15	.52	.52	.54
1	1.69	2.58	3.82	.68	.74	.72
1-1/4	1.85	3.15	4.29	1.24	1.24	1.32
1-1/2	2.17	3.49	4.89	1.72	1.58	1.74
2	2.72	4.20	5.51	2.60	2.62	2.70
2-1/2	2.96	5.16	-	4.40	-	4.56
3	3.82	5.79	-	6.62	7.08	6.90
4	3.94	6.86	-	10.18	-	10.54

NO.	PART	MATERIAL	ASTM SPEC
1	Body	Brass	B584 C857
2	Disc	Brass	B124 C377
3	Seat	BUNA	Commercial
4	Nut	Brass	B16 C360
5	Pin	Brass	B16 C360
6	Plug	Brass	B16 C360
7	Cap	Brass	B584 C857



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www.vikingdrillersinc.com
CA Lic. #476668 1000034680

EXHIBIT #20

CHECK VALVE

DRAWING NO. 5P | SCALE: NONE

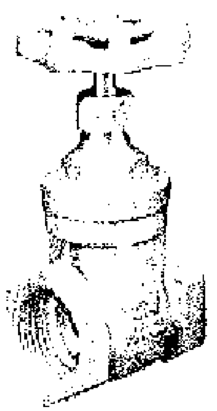
TA2010-312319A03.1

◆ FULL PORT ◆ CAST BRASS ◆ NON-RISING STEM
◆ ADJUSTABLE PACKING GLAND ◆ THREADED OR SOLDER ENDS

200 PSI NON-SHOCK WOG 125 PSI SWP

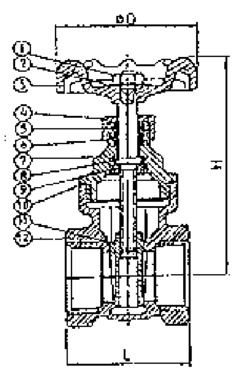
Applications: Commercial and Light Industrial Steam, Water, Oil, or Gas

Threaded Ends Conform to ANSI Standards B2.1
Solder Ends Conform to ANSI Standards B16.18
Valves are Tested In Accordance With MSS-SP-82



[illegible]

SIZE (inch)	L	H	øD	P	WT. (lb) IPS	WT. (lb) C x C
1/4"	1.71	2.83	2.01	-	.62	-
3/8"	1.71	2.83	2.01	1.69	.58	-
1/2"	1.71	2.91	2.01	1.69	.60	.56
3/4"	1.81	3.31	2.21	2.32	.82	.82
1"	2.13	3.91	2.56	2.72	1.18	1.08
1-1/4"	2.24	4.61	2.76	2.93	1.66	1.52
1-1/2"	2.44	5.08	3.11	3.28	2.14	1.88
→ 2"	2.68	6.00	3.70	3.97	3.26	3.04
2-1/2"	3.70	6.89	4.02	4.61	6.08	5.04
3"	4.02	8.50	5.00	5.20	8.34	7.76
4"	4.53	9.89	5.00	-	12.64	-



[illegible]

NO.	PART	MATERIAL	ASTM SPEC
1	Wheel Nut	Plated Steel	Commercial
2	Name Plate	Aluminum	Commercial
3	Hand Wheel	Cast Iron	Commercial
4	Packing Nut	Brass Rod	ASTM B16 GR3600
5	Gland	Brass Rod	ASTM B16 GR3600
6	Gland Packing	Graphite	Non Asbestos
7	Bonnet	Cast Brass	ASTM B584 GRC85700
8	Stem	Brass Rod	ASTM B16 GR3600
9	Lock Nut	Brass Rod	ASTM B16 GR3600
10	Gasket	Fiber (2-1/2"-4")	Non Asbestos
11	Disc	Cast Brass	ASTM B584 GRC85700
12	Body	Cast Brass	ASTM B584 GRC85700

VIKING DRILLERS, INC.
DEWATERING SYSTEMS
801 Northport Drive
West Sacramento, Ca 95691-2153
(916) 372-4993 FAX (916) 372-1337
www.vikingdrillersinc.com
CA Lic. #476668 NV Lic. #0034680

EXHIBIT #21

GATE VALVE

DRAWING NO. GV | SCALE: NONE

ALTD-830-0461512

VIKING DRILLERS, INC.
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West Sacramento, CA 95691-2153
(916) 372-4993 • FAX (916) 372-1337
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California License #476668
A Woman Owned Business

April 22, 2011

SBE CERTIFIED
#30783

Ernie Cortez
Balfour Beatty Infrastructure, Inc.
Transbay Transit Center BSE
143 2nd Street
San Francisco, CA 94104

RE: Transbay Terminal – San Francisco, CA

Dear Ernie:

The following submittal response to your email dated April 20, 2011:

1.5.D.1 – The dewatering was based on the site being a "bathtub" and utilizing 90' deep dewatering wells from OG spaced approximately 80' on center inside the shoring. The pumps will be ½ hp pumps that pump approximately 15 gpm at 100 tdh. The lift from the well will be approximately 85' and the friction loss in the header line will be approximately 6.5'. The total head loss for each well will be 94'. The dewatering wells will pump approximately 10 to 15 gpm at start up until drawdown and then will average approximately 3 to 5 gpm (all based on the integrity of the slurry wall shoring)

The calculations are based on the water content in the material being dewatered:

Fill material 3,986,292 sq ft @ 20% water content = 797,258 sq ft

Marine Sand 5,026,784 sq ft @ 15% water content = 754,017 sq ft

Lower Sand 1,931,730 sq ft @ 20% water content = 386,346 sq ft

Colma Sand 3,475,450 sq ft @ 5% water content = 173,772 sq ft

Total sq ft 2,111,393 sq ft
X 7.48 gallon per sq ft = 15,793,219 gallons

10 gpm per well X 48 wells X 60 min X 24 hours = 691,200 gallons per day

15,793,219 divided by 691,200 = approximately 23 days

These calculations are based on the entire site shored and all 48 dewatering wells installed.

1.5.D.2 - See attached drawing with well profile with drawdown curve.

1.5.D.3 – All the dewatering will be inside the excavation. The area influenced will depend on the material at that given location. Some wells will pump more than others until the all the trapped water in the "bathtub" has been drained. Because of the variations in materials and elevation of the materials there will be areas of perched water, on the clay / Bay Mud material that will not be able to migrate to the wells. As the excavation progresses this water will need to be directed to the dewatering well filter pack to get it to drain and be removed.

1.8 Qualifications – See attached document (job list)

If we can be of further assistance, please contact us.

Respectfully,

VIKING DRILLERS, INC.

Scott Philliber
Project Manager