SFCTA Contract Number 06/07-29

SOUTH ACCESS TO THE GOLDEN GATE BRIDGE

DOYLE DRIVE

DOYLE DRIVE REPLACEMENT PROJECT
FINAL REPORT – AQUIFER TESTING

July 2009

Prepared By:

BASELINE Environmental Consulting

BASELINE

ENVIRONMENTAL CONSULTING

July 23, 2009
Y0239-04.A1.01179

Mr. Frank Greguras
Arup PB Joint Venture
560 Mission Street, Suite 700
San Francisco, CA 94105

Subject: FINAL REPORT, Aquifer Testing, Doyle Drive Replacement Project, Presidio, San Francisco, California

Dear Mr. Greguras:

This letter documents the activities and findings of aquifer testing performed by BASELINE Environmental Consulting (BASELINE) and Arup PB Joint Venture (Arup PB JV) during September through November 2008 in support of the Doyle Drive Replacement Project. The aquifer test was requested by the California Department of Transportation (Department) and was authorized under funding by the San Francisco County Transportation Authority (SFCTA). The testing was performed in accordance with the work plan presented in the Doyle Drive Replacement Project, License to Enter and Conduct Geotechnical Investigation, Exhibit No. 2, Aquifer Work Plan, dated July 25, 2008.

The aquifer testing included installation of a six-inch diameter well (to be used as the pumping well in the constant-rate pumping test), a step-drawdown test of that pumping well, slug tests at six monitoring wells, and a constant-rate pumping test involving 38 observation wells, eighteen of which were equipped with automated water level-recording pressure transducers/data recorders (pressure transducers) for continuous water level measurements. Buildings near the pumping well were surveyed and ground settlement markers installed so that any settlement associated with groundwater extraction could be monitored. The objectives of the aquifer test program were to determine: 1) the aquifer properties of the uppermost water-bearing zone and the deeper confined zone with artesian pressures; 2) whether the local groundwater conditions are affected by tidal fluctuations in San Francisco Bay; and 3) to further characterize the multi-layer aquifer system (e.g., defining heterogeneities, leaky aquitards). In the future, this information may be used by the Doyle Drive facility designers to estimate the quantity of groundwater that may need to be pumped during dewatering activities associated with construction of the depressed section of Girard Road.

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HYDROGEOLOGIC SETTING

The description of the hydrogeologic setting is based on review of available drilling logs and previous geotechnical investigations for the project vicinity. The bedrock material underlying the Presidio is the Franciscan formation, a complex assemblage of shale, sandstone, chert, volcanics, and metamorphic rocks (including serpentinite). The Franciscan is highly deformed (folded and faulted) and extends hundreds to thousands of feet below the surface at the Presidio.

Overlying the Franciscan bedrock is the Colma formation, an unconsolidated to weakly consolidated fine- to medium-grained sand unit with lesser amounts of silt and clay. Marine sands and Bay Mud overly the Colma formation. Near-surface materials in the testing vicinity include several feet of artificial fill, composed of locally-derived soils and lesser amounts of construction debris (brick, mortar, road base, concrete, and metal).

Three distinct water-bearing zones have been identified in the testing vicinity: a shallow, unconfined zone, above the Bay Mud (typically located from 7 to 10 feet below ground surface (bgs)); an intermediate marine sand zone located approximately 10 to 30 feet bgs; and the deeper Colma formation at approximately 30 to 70 feet bgs.

FIELD ACTIVITIES

Field activities were performed from September 18 through November 21, 2008. Wells used during the testing are shown on Figures 1A and 1B. Details regarding well construction and aquifer characteristics are included on Table 1. Aquifer characteristics identified on Table 1 were based on well drilling logs, where available, or from cross sections generated during previous geotechnical investigations,[1] for those wells where drilling logs were unavailable. Drilling logs for wells referenced during this testing are included as Attachment A.

Borehole PW-1A

The borehole for the pumping well was drilled on September 18, 2008 by Gregg Drilling and Testing, Inc. (Gregg Drilling) under the direction of the Arup PB JV. Dave Nesbitt and Ed Kretschmer, both of the Department, were also present for the drilling.

The borehole was initially called PW-1. However, a hard concrete slab was encountered at a depth of 4.8 feet bgs. The location was moved 2 feet to the south and the new borehole was called PW-1A.

Fill was present in the borehole to a depth of 5 feet bgs. The fill consisted of poorly graded sand and gravel. Beneath the fill, from 5 to 7.5 feet, was a layer of Marine Sand characterized by loose poorly-graded sand and clayey sand. From 7.5 to approximately 13 feet bgs, there was a

[1] Pokrywka, Tim, 2008, South Access to the Golden Gate Bridge, Doyle Drive, Results of Doyle Drive Subsurface Investigation, PowerPoint presentation, December 16.

layer of Bay Mud/Marsh Deposits consisting of soft to medium stiff fat clay. From 13 to 36 feet bgs, there was another layer of Marine Sand, similar to the layer above the Bay Mud/Marsh Deposits. From 36 to 58 feet bgs, Colma Sand was encountered. Colma Sand is a medium dense to very dense sand with varying fines content. Bedrock was encountered at 58 feet and consisted of intensely weathered sandstone. Details of the subsurface stratigraphy encountered in PW-1A are presented on the drilling log in Attachment A.

Installation and Development of Well PW-1A

Borehole PW-1A was converted into a well (to be used for the pumping well in the aquifer testing) on September 19, 2008 by Gregg Drilling. Installation began by reaming borehole PW-1A to a diameter of 12 inches to allow for proper annular space around a 6-inch diameter PVC pipe. The borehole was drilled to a final depth of 60 feet. After reaming of the borehole was completed, 35 feet of 6-inch-diameter slotted (0.020 in.) PVC pipe and 25 feet of solid PVC pipe were placed in the hole. After the PVC pipe was placed, No. 3 sand was wet tremied to the bottom of the well up to 23 feet bgs. After the sand was in place, the well was surged by bailing to consolidate the sand pack and 2 feet of bentonite was placed to form a seal over the sand. Neat cement grout was then placed from the top of the bentonite to the top of casing. Finally, a well vault box was concreted into place over the top of the well.

PW-1A was developed on September 22, 2008 by Gregg Drilling under the direction of Arup PB JV. Development began with bailing the well to remove any sediment that settled since installation. After bailing, the well was surged in two foot intervals with a minimum of 40 strokes per interval. After surging, approximately 1,170 gallons were pumped from the well until the water was clear and at least ten well volumes were removed. Measurements of pH, turbidity, and temperature were collected from the development water on a periodic basis during the development process. Details regarding the well installation and development are presented in the Arup PB JV Project Memorandum, enclosed as Attachment B.

Survey of Buildings 1158 and 1167

To determine whether the pumping of groundwater during the step test and constant rate aquifer test affected the surrounding area, surveys were conducted on the two buildings nearest pumping well PW-1A. Preconstruction visual and photographic surveys were conducted by Arup PB JV on October 8 and 9, 2008 that documented the physical condition of Buildings 1158 and 1167 of the Presidio Trust including the location and magnitude of cracking on the interiors and exteriors of the buildings. Also, as part of the aquifer test program, surveys were conducted by Chaudhary & Associates, Inc. (Chaudhary) that recorded horizontal and vertical movements of Buildings 1158 and 1167 that occurred during the step drawdown and constant rate aquifer tests. There was no significant movement that occurred after the two baseline readings taken on October 10 and 13, 2008. A table and figures summarizing the results of the Chaudhary surveys are included as Attachment C.

Slug Testing

Slug tests were conducted on November 13, 2008 in each of the following wells: ENB-R1A-PZ-S, ENB-R1A-PZ-D, DNB-R7A-PZ-S, DNB-R7-PZ-D, RW18-A1A-PZ-S, and RW18-A1-PZ-D (Figure 1A). Pressure transducers were lowered into each well and the water level in each well was allowed to stabilize. At each well, a solid "slug" consisting of copper pipe filled with sand and capped on each end (having a volume of 1.429 cubic feet) was lowered quickly into the wells, displacing an identical volume of water (insertion test). After the water level re-equilibrated, the slug was removed and the water level response was monitored until the water level equilibrated (withdrawal test). Water levels were recorded during each insertion and withdrawal test. Two to six slug tests were performed at each well (Table 2). Field forms for the slug testing are included as Attachment D.

Step-Drawdown Test

A step drawdown test was performed at the site on November 14, 2008 to provide information on the discharge capacity of pumping well PW-1A. This information was used to determine the pumping rate used during the constant-rate pumping test. A 4-inch Grundfos submersible pump was used for the pumping, and a calibrated flowmeter was connected to the pump discharge line to measure the pumping rate. A pressure transducer was installed in pumping well PW-1A to record water levels. The field log and water level chart for the step drawdown test are included as Attachment E.

Four stages were conducted for the step-drawdown test. The pumping rate at each stage was sustained for 20 to 60 minutes. The pumping rate, pumping time, and approximate drawdown at each stage was as follows:

- Stage 1 – 15 gallons per minute – 60 minutes – 7 feet drawdown
- Stage 2 – 20 gallons per minute – 20 minutes – 10 feet drawdown
- Stage 3 – 30 gallons per minute – 20 minutes – 17 feet drawdown
- Stage 4 – 40 gallons per minute – 60 minutes – 23 feet drawdown

Drawdown for stages 1 and 2 were steady, while the drawdown for stages 3 and 4 continued to increase slightly during the tests. Based on the findings of the step-drawdown test, a pumping rate of 21 gallons per minute was chosen for the constant-rate pumping test. This rate was selected to maximize the stress on the aquifer so that effects would be seen in the observation wells while at the same time the drawdown in the pumping well would stabilize.

Constant-Rate Pumping Test

The constant-rate pumping test included the pumping of well PW-1A and the monitoring of that well, 38 observation wells, and tidal fluctuations in the Bay over a 74-hour period from November 18 to 21, 2008. Field logs for the constant-rate pumping test are included as Attachment F.

Pressure transducers were installed in 18 of the observation wells and pumping well. In order to evaluate tidal influence on groundwater levels, if any, a tidal measurement station was installed at the Gulf of Farallones National Marine Sanctuary ("Marine Sanctuary") pier located at the Bay margin on the Presidio at 991 Marine Drive, approximately one-half mile west-northwest of the aquifer testing wells. The tidal station consisted of a 20-foot long, one-inch diameter PVC pipe attached to the edge of the pier of the Marine Sanctuary and extending approximately three feet below the surface of the Bay. A pressure transducer was installed in the PVC pipe.

Well PW-1A was pumped at a rate of 21 gallons per minute (gpm). The pumping rate was checked hourly and the pump adjusted as necessary. Water levels were recorded during the constant-rate pumping test using the automated pressure transducers that were installed in the pumping well and 18 observation wells (Figure 1A). Water level measurements were also collected manually, using a dual-interface probe, every four to eight hours at 20 additional observation wells during the pumping test (Figures 1A and 1B). Logs of the manual water level measurements are included as Attachment G.

Dewatered Groundwater Discharge

Water from the step-drawdown and constant-rate pumping tests was discharged into a 20,000-gallon Baker tank for temporary storage, prior to discharge to the SFPUC sanitary sewer system under an approved SFPUC discharge permit. The approved permit and associated laboratory testing results of the effluent are included as Attachment H. A total of 96,296 gallons were discharged into the sanitary sewer system between 11:10 am on November 18 and 2:00 pm on November 21, 2008.

DATA ANALYSIS AND CONCLUSIONS

Data collected during field activities were compiled and analyzed. The slug test and pumping test data were analyzed with the assistance of the AQTESOLV aquifer test analysis software, which was used to determine aquifer properties, including hydraulic conductivity and storativity. AQTESOLV test files and water level data files used for the analysis are included on a CD-ROM enclosed with this letter report.

Results from the slug tests are summarized in Table 2, and complete AQTESOLV output reports are included as Attachment I. Hydraulic conductivity was calculated using both the Bouwer-Rice and the Hvorselv solution methods.[2] Hydraulic conductivity was consistent for both the shallow and deep wells at each location, averaging 0.10 to 0.14 feet per day at wells DNB-R7A-PZ-S and DNB-R7-PZ-D, 3.06 to 4.28 feet per day at wells ENB-R1A-PZ-S and ENB-R1A-PZ-D, and 0.17 to 0.58 feet per day at wells RW18-A1A-PZ-S and RW18-A1A-PZ-D (Table 2).

Water levels in the observation wells during the constant-rate pumping test were graphed and compared to water levels from the tidal measurement station and the pumping well. Graphs are

[2] It is assumed that the wells were properly developed and that low-permeability well skin effects are minimal.

included as Figures 2 through 7. The water level graphs indicate that groundwater levels in the testing areas are not measurably influenced by daily tidal fluctuations in the Bay. Wells screened in the uppermost unconfined water-bearing zone did not show any significant drawdown as a result of pumping from PW-1A (Figure 3), suggesting little or no hydraulic connection between the uppermost zone and the deep (Colma formation) aquifer stressed during the pumping test. Water levels in one of the two wells in the intermediate (marine sand) water-bearing zone, 231GW06, did demonstrate some delayed drawdown, peaking at 0.29 foot, beginning about five hours into the test; the other well, HGB-1(17), with a maximum recorded drawdown of 0.06 foot, did not appear to be significantly affected (Figures 4 and 5). This suggests that the intermediate and deep zones may have some, potentially muted, hydraulic connection. The hydrographs of all the deep observation wells indicate rapid and consistent response to pumping in PW-1A, with greater drawdown in the wells closest to the pumping well (Figures 6 and 7).

Water levels from the pumping well and the eight deep observation wells were analyzed for aquifer properties using the Theis/Hantush solution method, because it is appropriate for confined aquifers and observation wells that do not fully penetrate the aquifer. Three analyses were performed: one with the pumping and observation wells, one for the observation wells alone, and one for the pumping well alone. The results are summarized in Table 3, and the complete AQTESOLV output reports are included as Attachment J. The results for all three analyses were fairly uniform and consistent with other tests of the Colma formation aquifer.

The maximum drawdowns for each of the observation wells during the pumping test, including those wells checked manually, were calculated and plotted versus the distance from the pumping well (Table 4 and Figure 8). Maximum drawdown for the deep wells decreased as a function of distance from the pumping well, while drawdown for the shallow and intermediate wells did not demonstrate the same effect (Figure 8). This result reinforces the findings of the pumping test analysis, which did not identify a significant hydraulic connection between the deep zone and shallow or intermediate zones.

Please contact us at your convenience with any questions regarding this letter and the attached data.

Sincerely,

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List of Attachments

Table 1: Well/Piezometer Details
Table 2: Slug Test Results
Table 3: Constant-Rate Test Results
Table 4: Pumping Test Well Drawdown

Figure 1A: Aquifer Test Well Locations – East
Figure 1B: Aquifer Test Well Locations – West
Figure 2: Water Levels – Shallow Wells
Figure 3: Water Levels – Shallow Wells with Pumping Well
Figure 4: Water Levels – Intermediate Wells
Figure 5: Water Levels - Intermediate Wells with Pumping Well
Figure 6: Water Levels – Deep Wells
Figure 7: Water Levels – Deep Wells with Pumping Well
Figure 8: Maximum Drawdown Versus Distance from Pumping Well

Attachment A: Drilling Logs for Wells Referenced During this Testing
Attachment B: Arup PB JV Project Memorandum
Attachment C: Settlement Survey Table and Figures
Attachment D: Field Forms – Slug Testing
Attachment E: Field Form and Water Level Graph – Step-Drawdown Test
Attachment F: Field Logs – Constant-Rate Pumping Test
Attachment G: Field Logs – Manual Water Level Measurements
Attachment H: SFPUC Discharge Permit and Associated Effluent Laboratory Reports
Attachment I: AQTESOLV Reports – Slug Tests
Attachment J: AQTESOLV Reports – Constant-Rate Pumping Test

Enclosure: CD-ROM with water level and AQTESOLV data files.

TABLE 1 - WELL/PIEZOMETER DETAILS

	Well Construction Details				Aquifer Details		
	Casing diameter (inches)	Borehole diameter (inches)	Well depth (feet bgs)	Screened interval (feet bgs)	Initial Depth to groundwater (feet bgs)	Depth to top of aquifer (feet bgs)	Estimated aquifer thickness (feet)
Pumping Well							
PW-1A	6	12	60	25 - 60	0.40	16	45
Shallow Wells							
1065PZ4A	2	8	11	6 - 11	6.21	--	2.8
231GW11	4	10	9.5	4.5 - 9.5	2.58	--	5.5
231GW21	4	10.5	8.8	4.8 - 8.8	6.19	--	2.6
231GW22	4	10	9.7	3.7 - 9.7	7.66	--	2.0
DNB-R7A-PZ-S	2	5	10	5 - 10	3.78	--	6.2
DSB-R4B-PZ-S	2	5	8	3 - 8	2.40	--	5.6
ENB-R1-PZ-S	2	5	10	5 - 10	3.51	--	6.5
ENB-R1A-PZ-S	2	5	10	5 - 10	3.72	--	5.3
ESB-R2-PZ-S	2	5	8	3 - 8	2.97	--	4.5
ESB-R2A-PZ-S	2	5	10	5 - 10	3.65	--	6.4
RW17-A1B-PZ-S	2	4	8	3 - 8	4.00	--	4.0
RW18-A1A-PZ-S	2	5	9	4 - 9	2.51	--	4.5
RW19-A1A-PZ-S	2	5	9.5	4.5 - 9.5	7.47	--	2.0
TS-R1B-PZ-S	2	5	7	2 - 7	4.34	--	2.7
Intermediate Wells							
231GW06	4	11	23.3	13.3 - 23.3	5.13	6	18.2
HGB-1(17)	2	3.9	17.9	12.9 - 17.9	7.80	6	10.1
Deep Wells							
1065PZ4B	2	8	22	18 - 22	2.97	15.5	50
DNB-R7-PZ-D	2	5	35	25 - 35	1.47	15	50
DSB-R4-PZ-D	2	5	50	40 - 50	3.62	15	50
DSB-R4A-PZ-I	2	5	18	13 - 18	0.70	2	10
ENB-R1A-PZ-D	2	5	29.5	19.5 - 29.5	0.98	15	52
ENB-R1-PZ-D	2	5	60	50 - 60	0.42	15	52
ENB-R1-PZ-I	2	5	25	15 - 25	2.27	15	52
ESB-R2-PZ-D	2	5	50	35 - 50	-0.55	12.5	48.5
ESB-R2-PZ-I	2	5	35	25 - 35	-0.04	12.5	48.5
ESB-R2A-PZ-D	2	5	28	18 - 28	0.97	12.5	48.5
HBG-1(43)	2	3	43	38 - 43	1.17	15	50
HBG-1(62)	2	4.9	64	54 - 64	1.93	15	50
MPTNB-R2-PZ	2	5	45	30 - 45	1.84	15	50
MPTSB-R2A-PZ	2	5	30	20 - 30	3.80	15	50
MPTSB-R3A-PZ	2	8	30	20 - 30	2.11	15	50
RW14-A1-PZ	2	5	40	30 - 40	3.22	15	50
RW17-A1A-PZ-I	2	4	25	15 - 25	0.65	15	50
RW17-A1-PZ-D	2	4	50	30 - 50	0.15	15	50
RW18-A1-PZ-D	2	5	30	20 - 30	-1.55	13.5	50
RW19-A1-PZ-D	2	5	30	20 - 30	3.17	15	50
TS-R1A-PZ-I	2	5	20	15 -20	4.36	15	50
TS-R1-PZ-D	2	5	50	40 - 50	1.81	15	50

Notes:

Bold italics identify wells with pressure transducers installed for slug and/or pumping tests.

Initial depth to groundwater readings collected 11-14-08 and 11-18-08. Readings are from the well rim. For several wells, a temporary PVC casing extension was installed on the well casing; otherwise the groundwater level would have been above the rim.

Well locations are shown on Figures 1A and 1B.

TABLE 2 - SLUG TEST RESULTS

		Hydraulic Conductivity (feet/day)						
	Data Analysis Method	Test 1 - Insertion	Test 2 - Withdrawal	Test 3 - Insertion	Test 4 - Withdrawal	Test 5 - Insertion	Test 6 - Withdrawal	Average
Shallow Wells								
DNB-R7A-PZ-S	Bouwer-Rice	0.03	0.08	0.13	0.15	--	--	0.10
	Hvorslev	0.05	0.10	0.22	0.20	--	--	0.14
ENB-R1A-PZ-S	Bouwer-Rice	5.18	--[1]	3.75	2.59	1.82	2.46	3.16
	Hvorselv	7.66	--[1]	4.43	4.20	2.07	3.03	4.28
RW18-A1A-PZ-S	Bouwer-Rice	0.20	0.12	0.22	0.14	0.18	0.14	0.17
	Hvorslev	0.40	0.21	0.42	0.32	0.38	0.30	0.34
Deep Wells								
DNB-R7-PZ-D	Bouwer-Rice	--[1]	0.03	0.16	--	--	--	0.09
	Hvorslev	--[1]	0.03	0.24	--	--	--	0.14
ENB-R1A-PZ-D	Bouwer-Rice	4.39	1.73	3.83	2.64	2.73	3.04	3.06
	Hvorslev	5.68	2.14	5.76	3.55	4.04	2.94	4.02
RW18-A1-PZ-D	Bouwer-Rice	0.73	0.59	0.38	0.39	0.69	0.24	0.50
	Hvorslev	0.77	0.23	0.54	0.51	1.22	0.23	0.58

Notes: Field logs for the slug tests are included as Attachment B. AQTESOLV graphs and reports are included as Attachment E. Well locations are shown on Figure 1A.

[1] Data was not available for this test due to a transducer unit error.

TABLE 3 - CONSTANT-RATE TEST RESULTS

Test Run	Data Analysis Method	Hydraulic Conductivity (feet/day)	Aquifer Transmissivity ($feet^2$/day)	Storativity
All observation and pumping wells	Theis/Hantush	16.1	802.7	1.233×10^{-9}
Observation wells only	Theis/Hantush	16.1	802.7	1.233×10^{-9}
Pumping Well only	Theis/Hantush	16.1	803.7	1.322×10^{-9}

Notes: Field logs for the constant-rate test are included as Attachment C. AQTESOLV graphs and reports are included as Attachment G.

Well locations are shown on Figures 1A and 1B.

TABLE 4 - PUMPING TEST WELL DRAWDOWN

	Distance From Pumping Well (feet)	Maximum Drawdown During Pumping Test (feet)
Shallow Wells		
ENB-R1A-PZ-S	17	0.13
ENB-R1-PZ-S	22	0.54
ESB-R2A-PZ-S	40	0.06
ESB-R2-PZ-S	80	0.06
RW18-A1A-PZ-S	203	0.08
DNB-R7A-PZ-S	226	0.15
RW17-A1B-PZ-S	315	0.00
RW19-A1A-PZ-S	329	0.05
DSB-R4B-PZ-S	355	0.00
1065PZ4A	416	0.02
231GW11	486	0.16
TS-R1B-PZ-S	678	0.17
231GW21	680	0.01
231GW22	737	0.04
Intermediate Wells		
HGB-1(17)	334	0.06
231GW06	689	0.29
Deep Wells		
ENB-R1A-PZ-D	15	4.18
ENB-R1-PZ-D	23	5.49
ENB-R1-PZ-I	25	2.62
ESB-R2A-PZ-D	44	3.21
ESB-R2-PZ-I	73	3.26
ESB-R2-PZ-D	75	3.34
RW18-A1-PZ-D	204	1.83
DNB-R7-PZ-D	230	1.81
RW17-A1-PZ-D	309	1.54
RW17-A1A-PZ-I	312	1.53
HBG-1(62)	326	0.69
RW19-A1-PZ-D	326	1.23
HBG-1(43)	329	1.49
DSB-R4-PZ-D	359	1.26
DSB-R4A-PZ-I	364	1.19
RW14-A1-PZ	400	1.03
1065PZ4B	411	0.93
TS-R1-PZ-D	684	0.65
TS-R1A-PZ-I	688	0.54
MPTSB-R3A-PZ	1014	0.24
MPTSB-R2A-PZ	1348	0.14
MPTNB-R2-PZ	1531	0.12

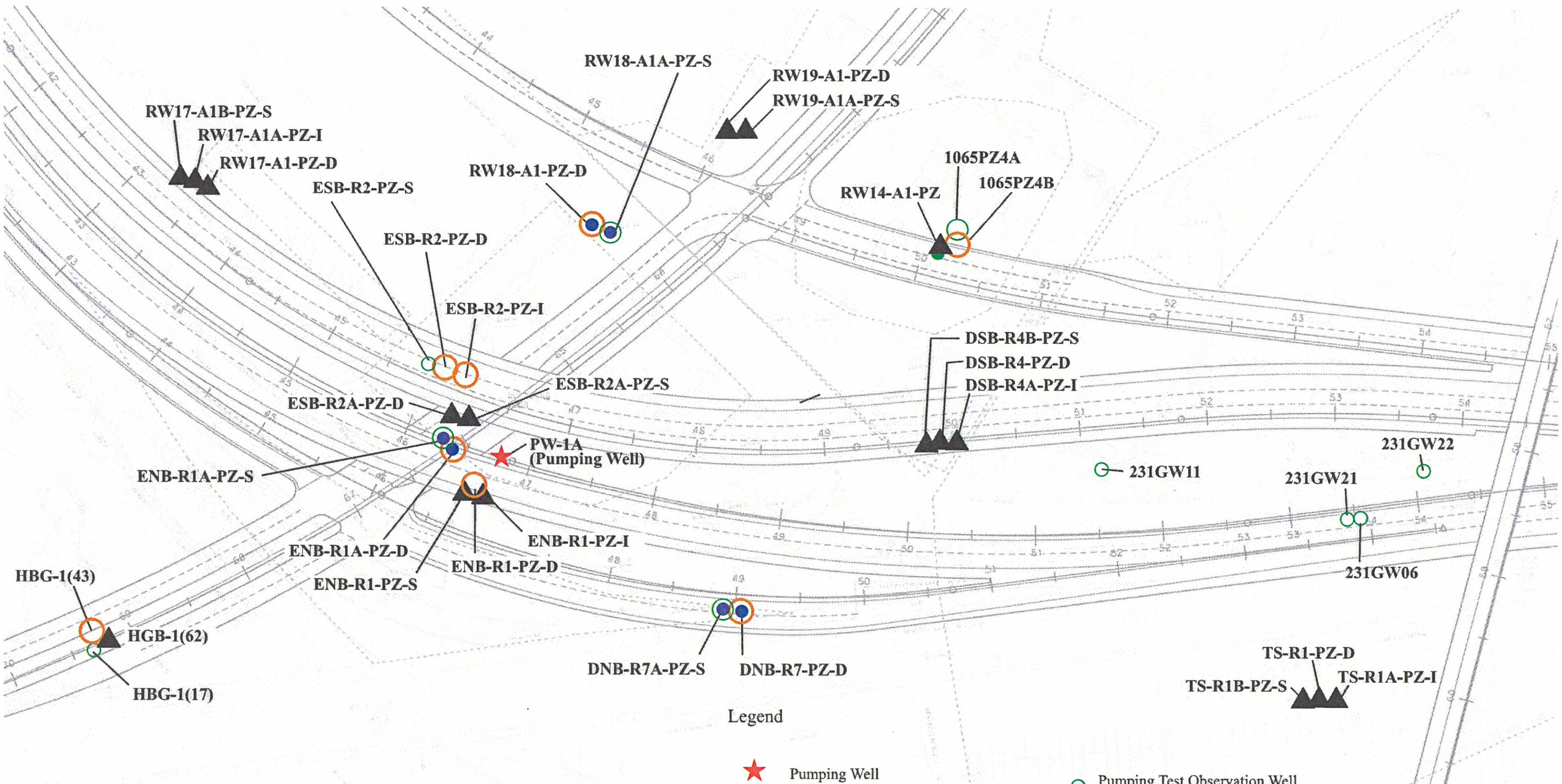
Notes:

Bold italics identify wells with pressure transducers installed for the pumping test. Water levels for other wells were collected by hand periodically during the pumping test.

Well locations are shown on Figures 1A and 1B.

AQUIFER TEST WELL LOCATIONS - EAST

Figure 1A



Legend

- Pumping Well
- Pumping Test Observation Well (Deep)
- Additional Observation Well (Manual Water Level Measurements Collected)
- Pumping Test Observation Well (Shallow and Intermediate)
- Slug Test Well Location

Note: Existing site features are shown in gray.
Proposed project roadways are shown in black.

Doyle Drive Replacement Project
San Francisco, California

Basemap: ARUP PB Joint Venture, and San Francisco Transportation Authority.

BASELINE

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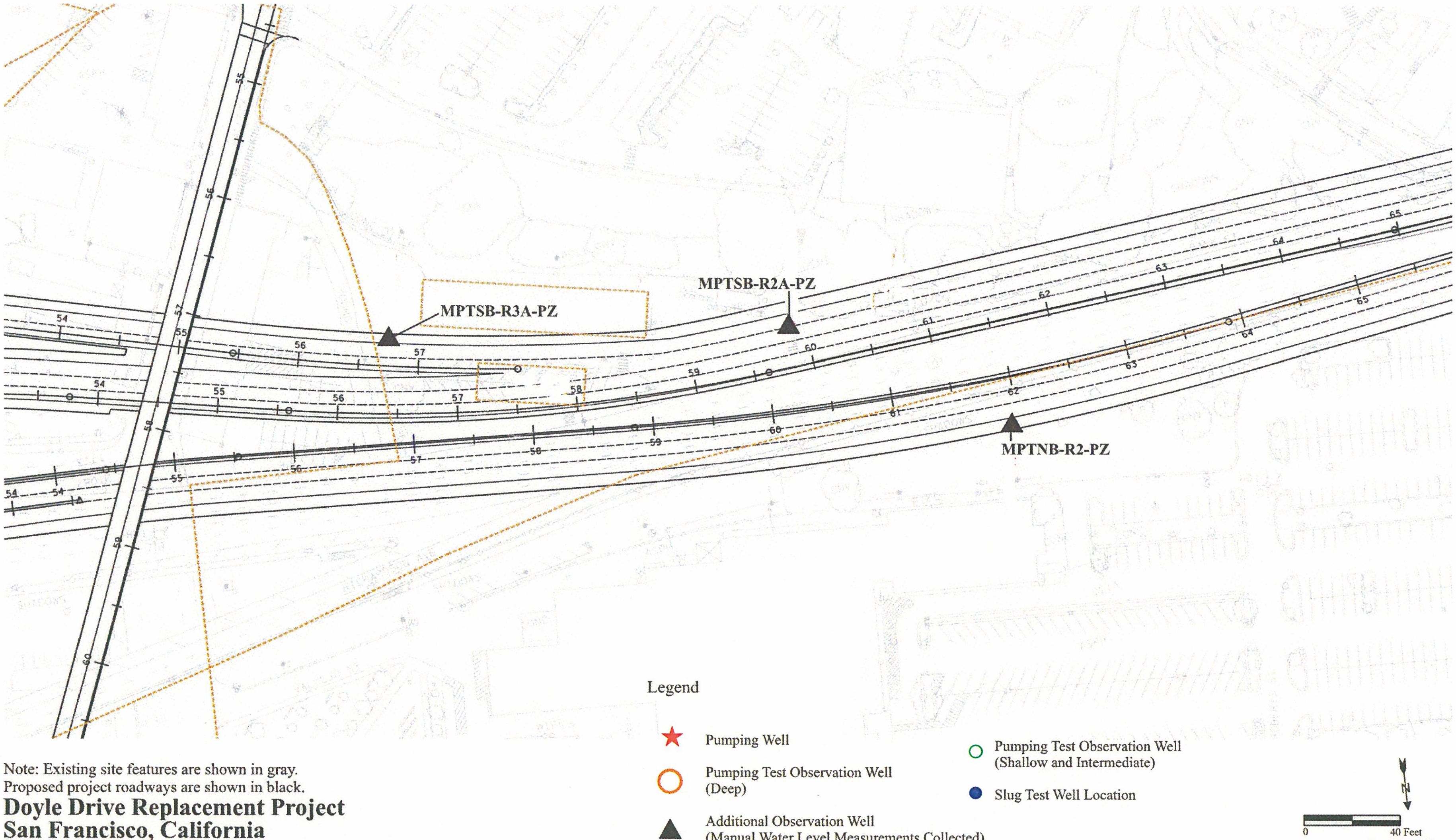
AQUIFER TEST WELL LOCATIONS - WEST

Figure 1B



Note: Existing site features are shown in gray.
Proposed project roadways are shown in black.

Doyle Drive Replacement Project
San Francisco, California

Basemap: ARUP PB Joint Venture, and San Francisco Transportation Authority.

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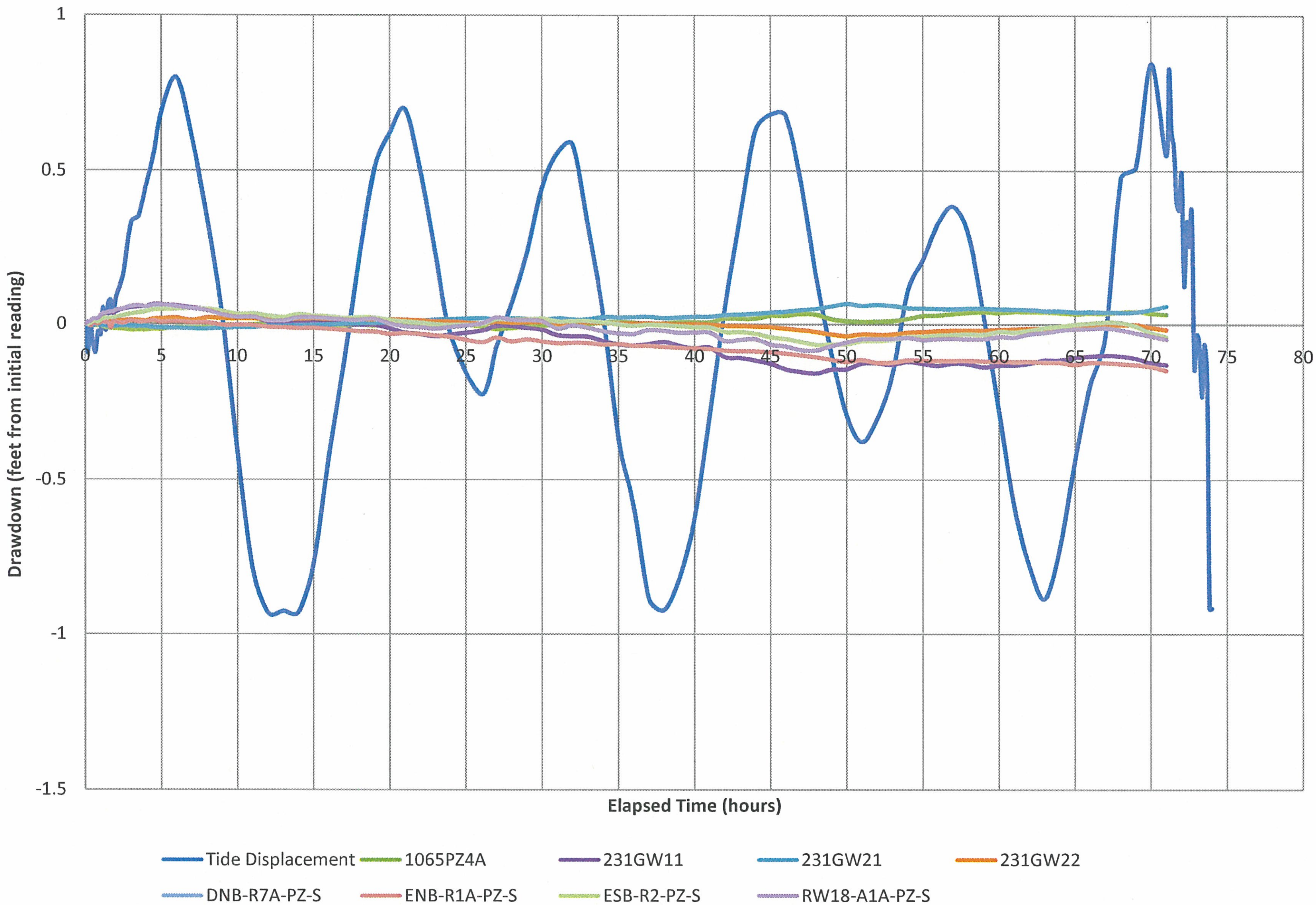
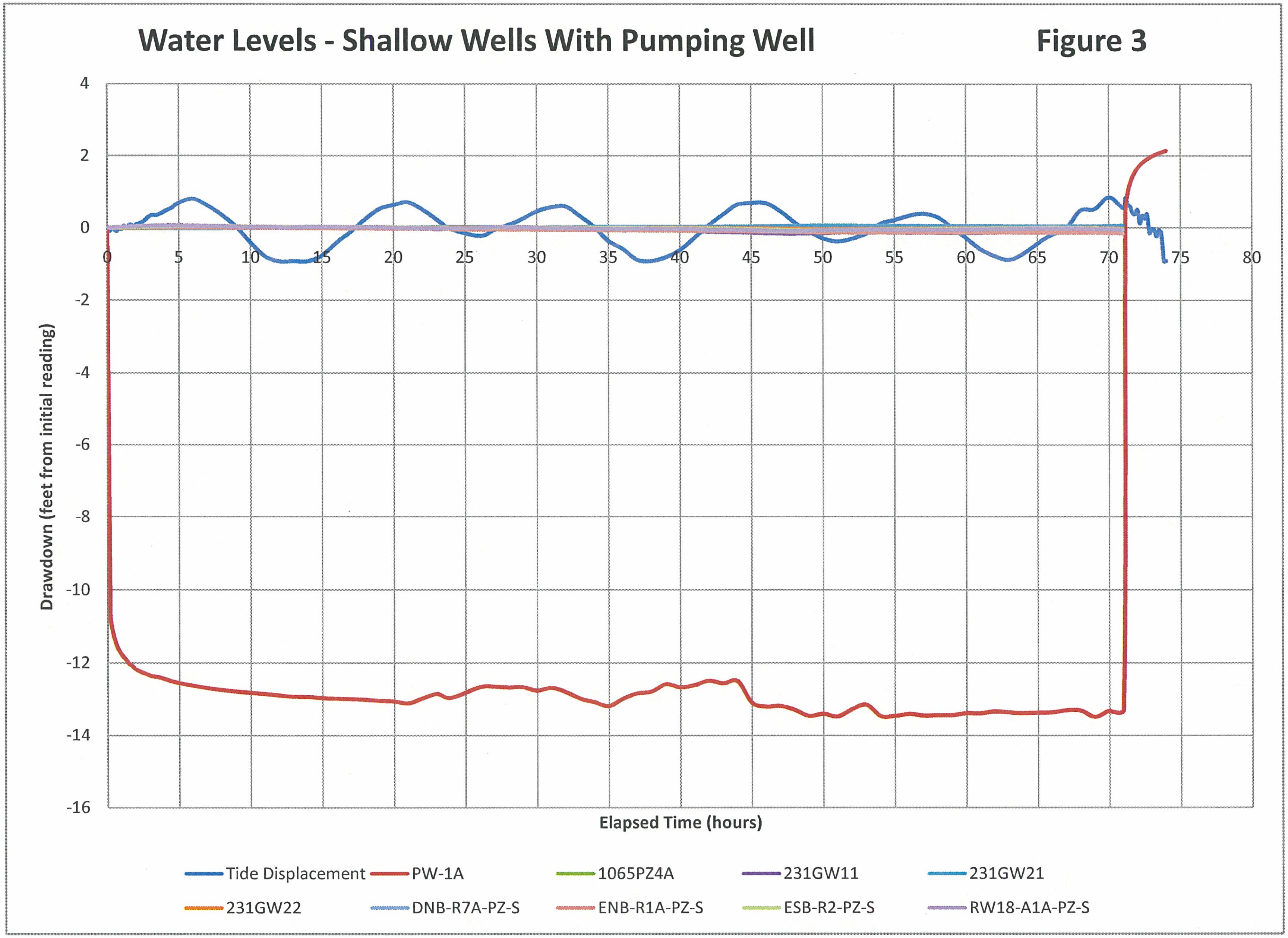
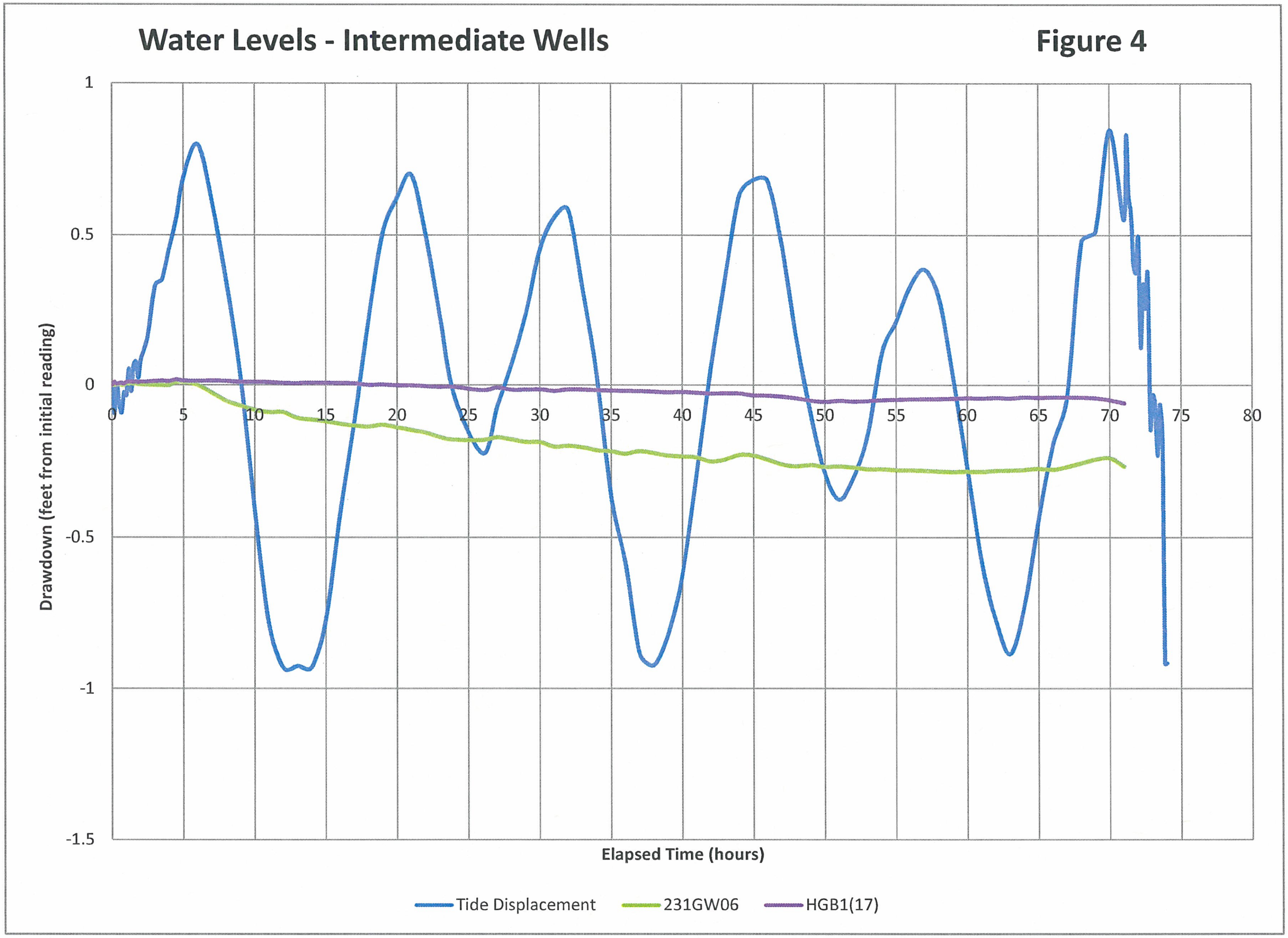
Water Levels - Shallow Wells

Figure 2



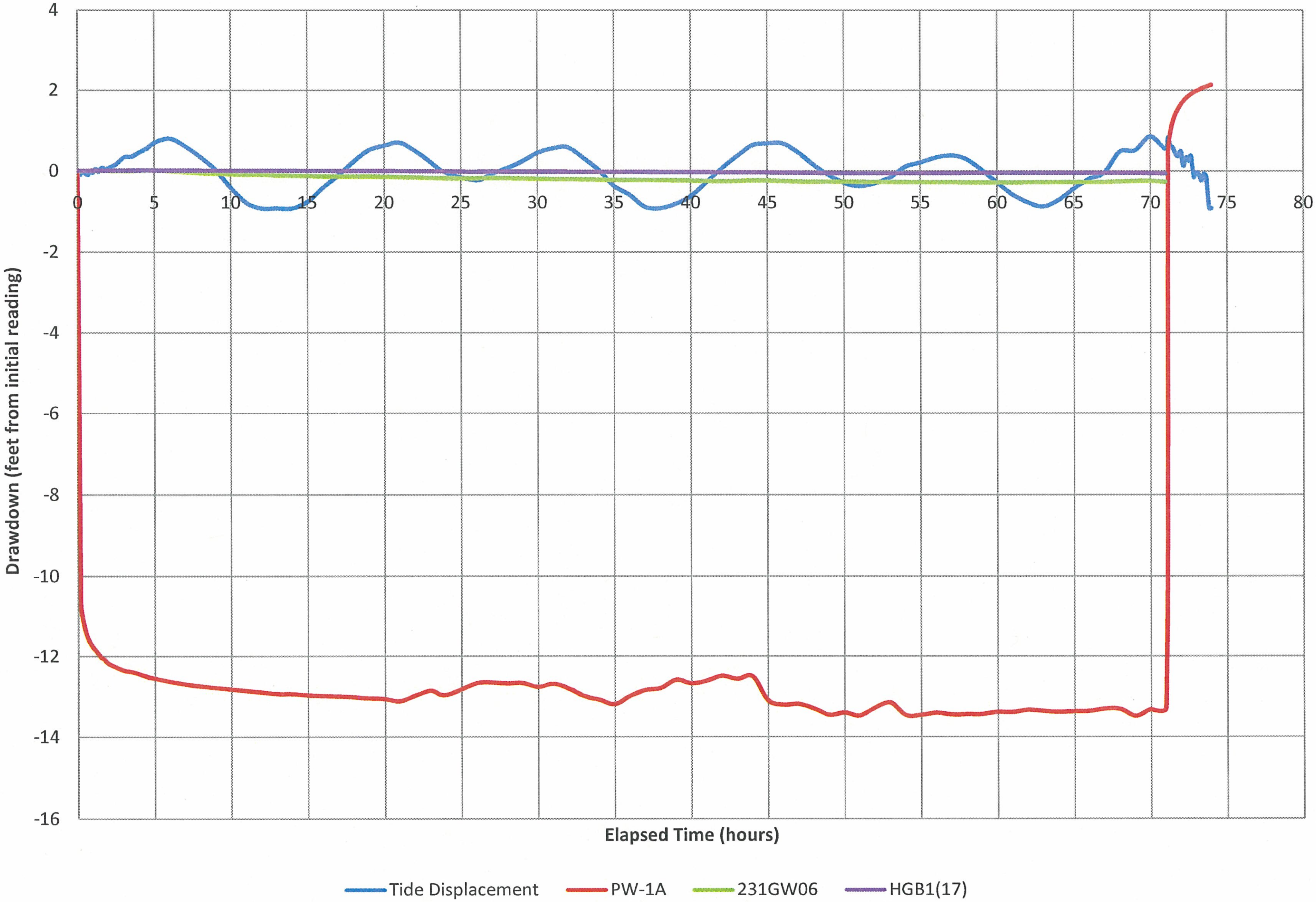

Water Levels - Shallow Wells With Pumping Well
Figure 3
Drawdown (feet from initial reading)
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Elapsed Time (hours)
Tide Displacement
PW-1A
1065PZ4A
231GW11
231GW21
231GW22
DNB-R7A-PZ-S
ENB-R1A-PZ-S
ESB-R2-PZ-S
RW18-A1A-PZ-S



Water Levels - Intermediate Wells
Figure 4
Drawdown (feet from initial reading)
1
0.5
0
-0.5
-1
-1.5
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Elapsed Time (hours)
Tide Displacement
231GW06
HGB1(17)

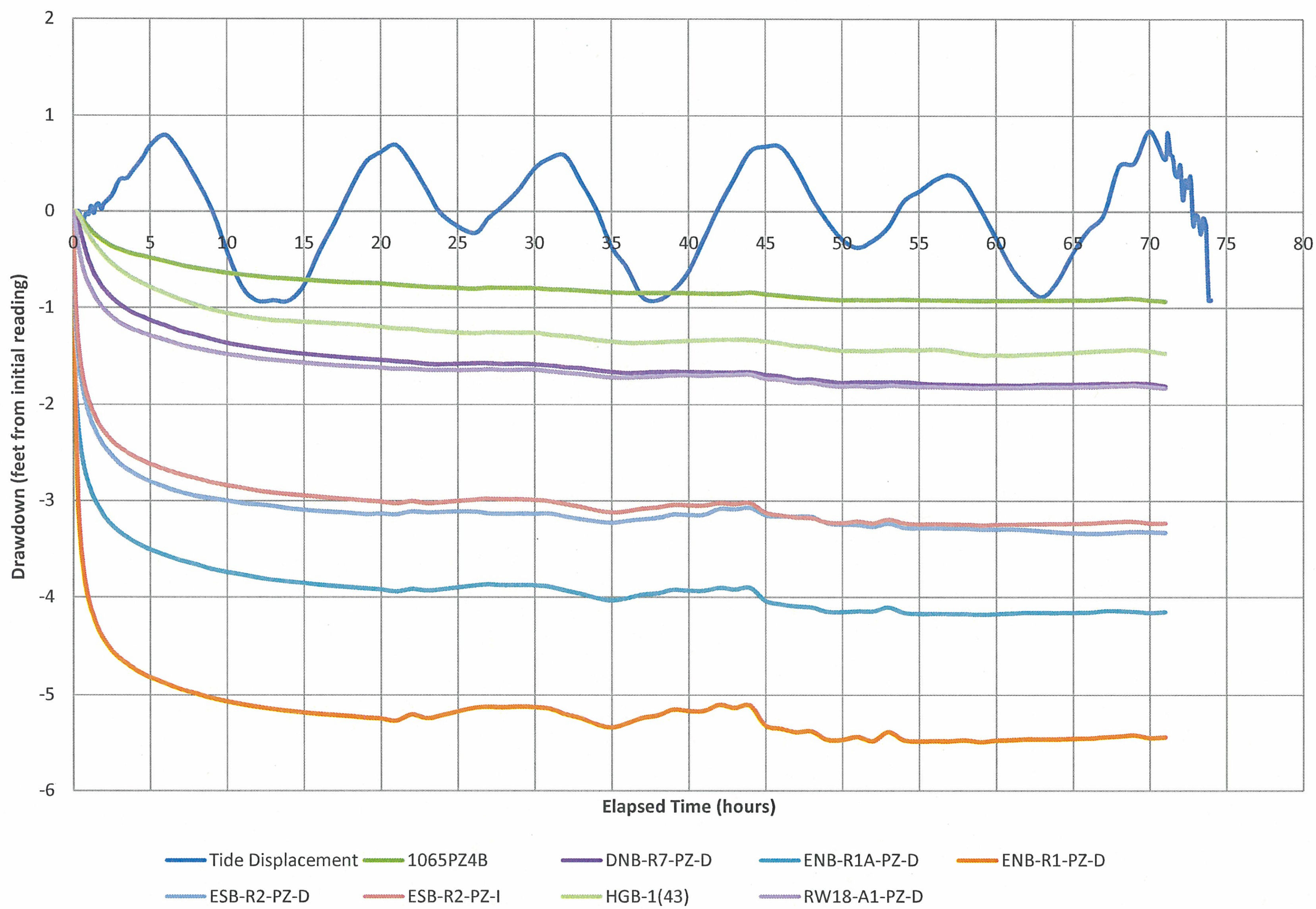
Water Levels - Intermediate Wells With Pumping Well

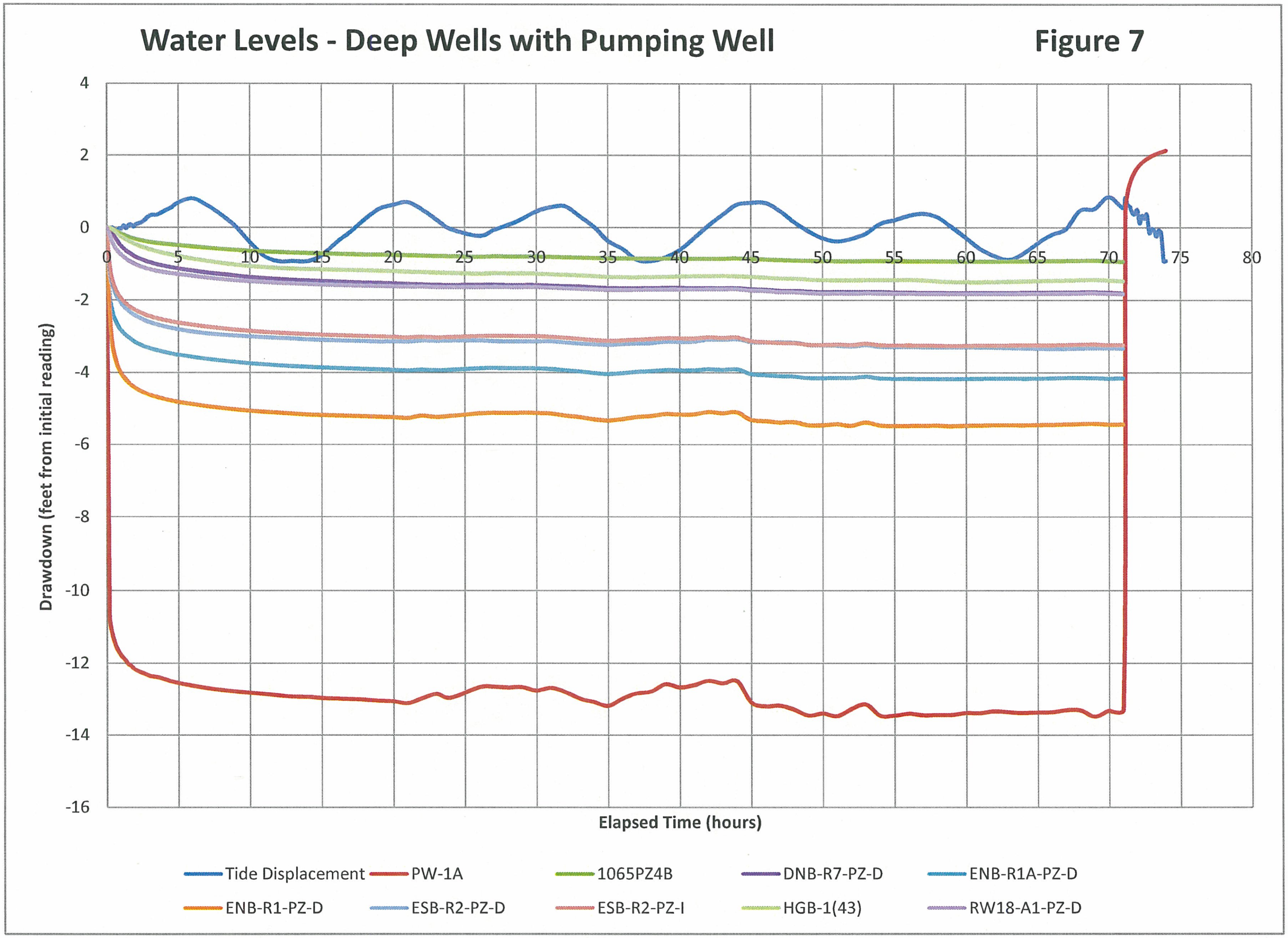
Figure 5



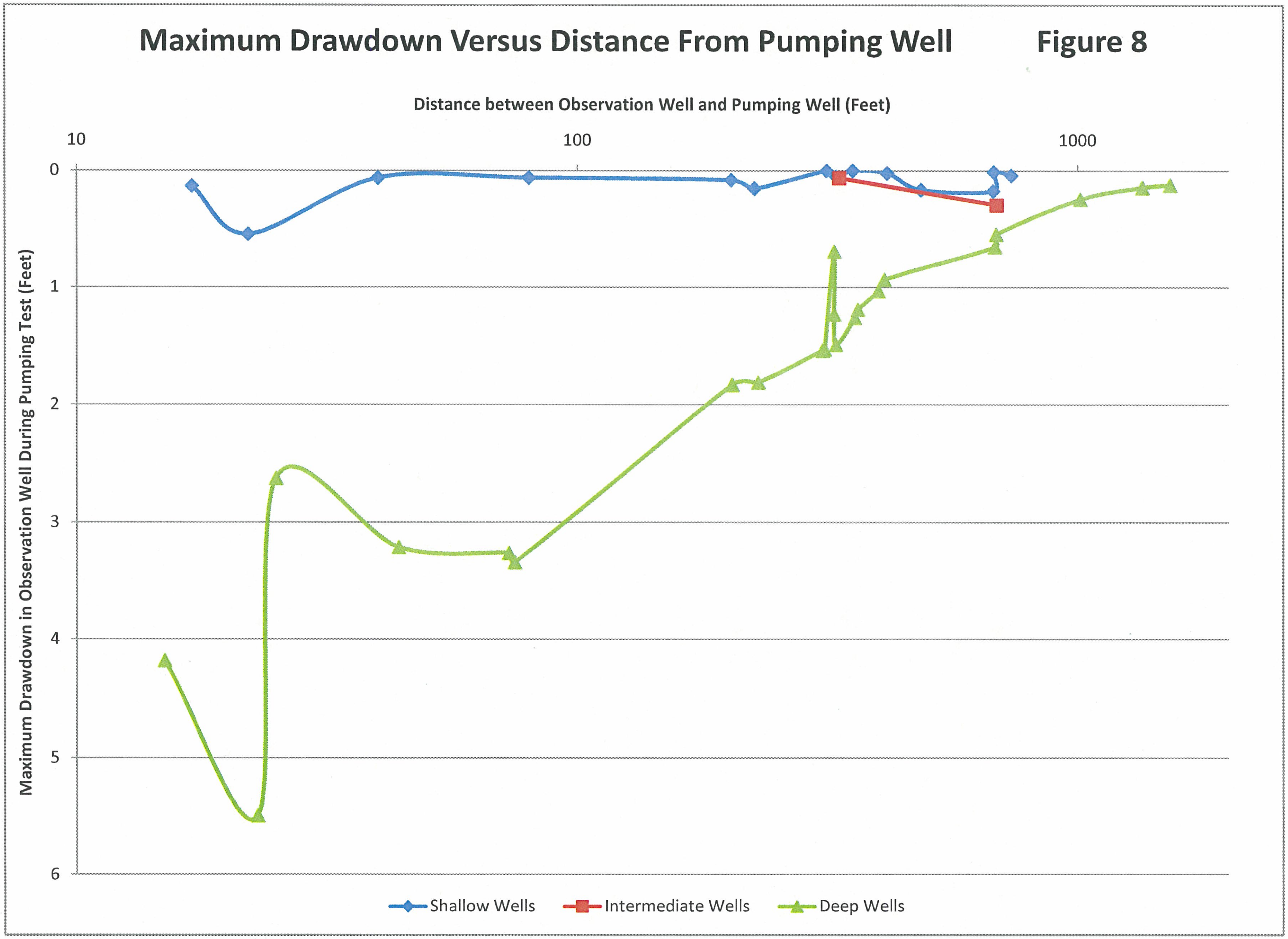
Water Levels - Deep Wells

Figure 6





Water Levels - Deep Wells with Pumping Well
Figure 7
Drawdown (feet from initial reading)
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Elapsed Time (hours)
Tide Displacement
PW-1A
1065PZ4B
DNB-R7-PZ-D
ENB-R1A-PZ-D
ENB-R1-PZ-D
ESB-R2-PZ-D
ESB-R2-PZ-I
HGB-1(43)
RW18-A1-PZ-D



Maximum Drawdown Versus Distance From Pumping Well
Figure 8
Distance between Observation Well and Pumping Well (Feet)
10
100
1000
Maximum Drawdown in Observation Well During Pumping Test (Feet)
0
1
2
3
4
5
6
Shallow Wells
Intermediate Wells
Deep Wells