GROUNDWATER CAPTURE REPORT

DFSP NORWALK

DEFENSE FUEL SUPPORT POINT NORWALK
15306 NORWALK BOULEVARD
NORWALK, CALIFORNIA

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SECTION 1
INTRODUCTION AND BACKGROUND

1.1 PURPOSE AND SCOPE

Parsons conducted a groundwater capture analysis for the Defense Fuel Support Point (DFSP) site, in Norwalk, California during February 2010. The objectives of this analysis were to: 1) delineate groundwater capture areas with the addition of new extraction well GW-16; 2) compare capture induced from the Parsons controlled extraction wells systems to the AMEC Geomatrix, Inc. (AMEC) controlled extraction wells; and 3) investigate mechanisms for early breakthrough of tert-butyl alcohol (TBA) in the Parsons controlled treatment plant. Data from previous modeling[1], various investigations, and recent water level measurements (February, 2010) were used to support the evaluation.

1.2 PROJECT BACKGROUND

The DFSP Norwalk facility is 50-acres consisting of 12 aboveground storage tanks that previously stored and distributed jet propellant (JP)-5 and JP-8. Aviation gasoline and JP-4 also were reportedly stored at the facility. Santa Fe Pacific Pipeline, L.P. (SFPP), an operating partner of Kinder Morgan Energy Partners, L.P. (KMEP), leases a 2-acre easement along the southern and eastern boundaries of DFSP for operation of its pipelines, which convey gasoline, diesel, and jet fuel. Within the southern easement lie three active pipelines, one of which is a 16-inch diameter pipeline, designated LS-1, that turns at the southeastern corner of the facility and continues northward within the eastern easement. An abandoned pipeline, likely owned or formerly operated by Golden West Pipeline, also runs along the eastern boundary of the site. The DESC has decommissioned the site, but SFPP continues to operate its pipelines. Refer to the Revised Remedial Action Plan (RAP)[2] for additional detailed background site information, which is not repeated here. The RAP includes a description of on-site environmental features;

[1] Parsons, 2009. Draft Technical Report on Pumping Test and Capture Zone Analysis, January 14.

[2] Parsons, 2006. Revised Remedial Action Plan, Defense Fuel Support Point Norwalk, September 7.

environmental settings including regional and site hydrogeology; historical site characterization data; and descriptions of past site use and operations.

Pumping tests were conducted in the groundwater extraction well GW-15 area in November 2008 to assess the hydraulic parameters in the northeast section of the site, and to determine if additional pumping wells were appropriate for use to control groundwater flow off site to the east. As a result of this study, GW-16 was installed north of GW-15 along the eastern property boundary in 2009 as an additional extraction well. After installation of GW-16, the granulated activated carbon (GAC) units became exhausted prematurely, when compared to historical carbon change rates. It was decided to conduct the following capture analysis due, in part, to the shortened longevity of the carbon, and associated costs to change out the GAC vessels.

1.3 GEOLOGY AND HYDROGEOLOGY

Previous investigations have described the geology and hydrogeology of the site. Ground surface in the area of investigation is approximately 75 feet above mean sea level[3]. Soil is comprised primarily of unconsolidated fine sand, silty fine sand, and silt, with lesser varying percentages of clay. Saturated sediments are typically encountered between 24 and 40 feet below ground surface (bgs). Previous investigations indicate that the saturated sands extend to a depth of approximately 52 feet bgs, where a confining clay layer is encountered[4].

The uppermost saturated zone (27 to 50 feet) is where most of the groundwater remediation programs are focused. Below these saturated soils lies the Bellflower Aquitard and the underlying Exposition aquifer, which is the shallowest reported aquifer beneath the site (CDWR, 1961). This Exposition aquifer is between approximately 87 and 155 feet bgs[5]. Historical interpretations of groundwater flow in the upper most unit has been generally to the northwest,

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3 USGS, 1981. United States Geological Survey (USGS), 1981 (photo revised from 1965), Whittier, California 7.5-Minute Quadrangle (1” = 2,000’).

4 Parsons, 2006.

5 Parsons. 2006.

with a hydraulic gradient of approximately 0.001 foot per foot. The estimated range of hydraulic conductivity was 11 to 25 ft/day, based on the pumping test at well GW-15 in 2008.

SECTION 2
GROUNDWATER CAPTURE ANAYSIS

2.1 GROUNDWATER EQUIPOTENTIAL MAPPING

Water levels were collected during February 2010 to help understand the influence of groundwater extraction from the northwestern (GW-2 and GW-13) and northeastern (GW-15 and GW-16) extraction wells. Water levels were collected from key wells during static and pumping conditions. Table 1 summarizes the groundwater elevations and drawdowns from groundwater extraction, with focus mainly on the northeastern and northwestern areas. Drawdown in the extraction wells of the northern areas ranged from approximate 2 to 7 feet, with the largest drawdown in GW-15. Drawdown in monitoring wells near the extraction wells was approximately 0.8 to 1.0 feet at GP-16p and MW-14, respectively. This suggests that groundwater extraction at the current rates produces a relatively profound cone of depression in the area around the extraction wells (compared to the low hydraulic gradient).

Well pumping rates were collected to assist in understanding the affects of groundwater extraction on water levels. Table 2 summarizes the pumping rates, which varied from approximately 1.7 gallons per minute (gpm) in the southeast area to 5.5 gpm in the northeast area. Extraction rates from the northeastern and northwestern areas were generally two times greater than extraction rates from the south-central and southeastern areas.

Groundwater equipotential contours were interpreted from the February 22nd to 24th water level measurements (Figure 1). Two approximate target capture areas, relative to the site boundary, are plotted on Figure 1. The equipotential contours reflect a relatively large capture area induced from groundwater extraction in the northeastern and northwestern wells. The measured capture zones incorporate areas appreciably larger than the proposed target capture areas, suggesting groundwater extraction is more than affective at current pumping rates.

2.2 GROUNDWATER MODELING

A two dimensional analytical groundwater flow model was developed to simulate groundwater capture in the northeastern and northwestern areas. The model, computed using

WinFlow v1.07[6] was based on previous work at the site and revised to simulate site-wide flow conditions. The modeling efforts included:

- calibration to static water levels,
- sensitivity analysis of hydraulic parameters
- calibration to active pumping conditions
- predictive scenario for revised pumping rates (see section 2.4)

Attached to this memo is a separate groundwater modeling report, which summarizes the hydraulic parameters and modeling process.

As noted above, the active pumping scenario was recalibrated, and the model statistically agrees with measured water levels as demonstrated by the following calibration statistics:

- Number of Targets = 83
- Residual Mean =0.0135
- Residual Standard Deviation = 0.266
- Residual Sum of Squares = 5.904
- Absolute Residual Mean (ARM) = 0.217
- Minimum Residual = -0.599
- Maximum Residual = 0.683
- Observed Range in Head = 2.790
- Resid. Std./Range in Head = 0.095
- ARM/Range in Head = 0.078

Generally, a model can be considered adequately calibrated when the ARM/Range in Head is equal to or less than 0.10[7]. Given that the ARM/Range in Head is 0.078 and the relatively difficulty in calibration of a two dimensional flow model, the model was considered fit for this purpose.

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6 Rumbaugh, J. and Rumbaugh, D. 1995. WinFlow v1.07, Environmental Simulations Inc.

Figure 2 shows the groundwater capture zones estimated using the analytical flow model. These flow paths and equipotential lines generally agree with the equipotential lines shown on Figure 1, suggesting model accuracy. As shown on Figure 2, the simulated particle paths demonstrate that groundwater capture exceeds the approximated target capture area. Additionally, it can be observed that if groundwater extraction is stopped at the southeastern, or south-central pumping wells, there is potential for compounds of concern (COCs) to migrate to the northeastern and/or northwestern extraction wells. Concentrations of TBA at GMW-39, from the 24-inch valve area, are appreciably higher than concentrations in the northeast area. Groundwater flow paths suggest that under February pumping conditions, groundwater from GMW-39 flows north and is part of the GW-15/GW-16 capture zone.

2.3 CONCENTRATIONS OF COMPOUNDS OF CONCERN

The concentrations of COCs were integrated in this capture analysis to assist in the understanding of groundwater flow, capture effectiveness, and capture efficiency. Three aspects of groundwater concentrations were analyzed for evidence of groundwater capture and treatment efficiency: 1) concentration trends in the northeast area, 2) concentration of influent to the northern treatment plant, and 3) distribution of TBA at the site. Concentrations in the northeast area were examined for trends. Downward trending concentrations in the area of groundwater extraction from this area suggest that plume capture is affective. Extraction wells were sampled for COCs to assist in determining which areas of the site contribute the highest levels of compounds being treated. Distribution of TBA concentrations in groundwater was reviewed with respect to groundwater capture zones.

2.3.1 Concentrations Trends in the Northeastern Area

Figures 3a through 3c demonstrate the concentration of COCs at wells GW-60, GW-61, and GW-62, along the eastern property boundary near extraction wells GW-15 and GW-16. Each of the graphs suggest a clear downward trend in concentrations over time. These trends are

7 Anderson and Woessner, 1992. Anderson, M.P. and W.W. Woessner, 1992. *Applied Groundwater Modeling - Simulation of Flow and Advective Transport.* Academic Press, Inc., San Diego, California.

further evidence that groundwater capture is affectively preventing ongoing migration of COCs to the east.

2.3.2 Concentrations of Influent to the Northern Treatment System

Samples were collected from the northeastern (GW- 15 and GW-16) and northwestern (GW-2 and GW-13) extraction wells. One set of samples was collected while the pumps were off, and the other set of samples were collected while the pumps were on. The samples were collected to differentiate which areas of the site, and more specifically which extraction wells, contribute the most load to the treatment plant. Samples were analyzed for volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs). SVOCs results were determined to be insignificant and therefore are omitted from the discussion.

Table 3 lists the concentrations for each of the samples. Active flow concentrations suggest the highest concentrations are attributed to wells GW-2 and GW-15. Based on flow rates in Table 2, it is likely that the highest mass contribution to the treatment systems is from GW-15, and the second highest from GW-2. Concentrations of TBA during static conditions from GW-2, GW-13, and GW-16 were 8.8 micrograms per liter (µg/L) or less. These concentrations are low, suggesting the highest concentrations to the northern treatment plant come from GW-15.

2.3.3 Distribution of TBA

Concentrations of TBA in groundwater are approximately five orders of magnitude higher in the southeast corner of the site, near the 24-inch valve remediation system (AMEC), than in the northeast pump-and-treat area (GW-15 and GW-16). In February, the concentration of TBA from the southeastern corner was 60,000 µg/L at PZ-5 and 690 µg/L at GMW-36, whereas the highest concentration in the northeastern area was 17 µg/L at GMW-47. This distribution and potential groundwater flow paths suggest that breakthrough of TBA at the northern treatment plant could be due to transport of TBA from the southeastern area.

2.4 PREDICITNVE GROUNDWATER MODELING

The analytical groundwater model was revised to determine if reduced groundwater extraction rates could maintain a cone of depression sufficient to capture the appropriate target area. The flow rates were reduced with context to the individual concentrations of COCs at each pumping well. Reduction of flow from the wells with the highest concentrations would yield more benefit to the treatment plant than wells with lower concentrations. Simulated flow rates were reduced in the northwest and northeast area, while maintaining flow for operational wells in the south central and southeast areas. Following is a list of groundwater extraction rates used for simulation:

- GW-2 = 2 GPM
- GW-13 = 2 GPM
- GW-16 = 2 GPM
- GW-15 = 3 GPM
- GMW-36 = 2.0
- GMW-O-15 = 2.0
- MW-SF-12 = 1.7
- MW-SF-13 = 1.7
- MW-SF-16 = 1.7

Figure 4 demonstrates the groundwater flow model results from the predictive model. The capture areas demonstrated by the flow lines are smaller than those depicted in Figure 2; however, the target capture areas remain within the flow lines that end at the pumping wells. This suggests that the reduced pumping rates will remain effective at containing groundwater COCs associated with the northeastern and northwestern areas. The change represents an approximate decrease in flow of 64 percent to the northern treatment plant.

SECTION 3
CONCLUSIONS AND RECOMMENDATIONS

3.1 CONCLUSIONS

The capture analysis explored the following lines of evidence for capture effectiveness:

- water level measurements prior to and during groundwater extraction,
- estimation of drawdown induced by groundwater extraction,
- groundwater elevation contouring,
- two-dimensional analytical flow modeling,
- plotting of COC trends for the northeastern area, and
- sampling of groundwater from the groundwater extraction wells.

Based on the analysis described here-in, the following conclusions can be drawn:

- Current groundwater extraction rates (Table 2) in wells GW-2, GW-13, GW-15, and GW-16 are sufficient at achieving target capture areas and limiting the potential for further off site migration of COCs, as well as capturing existing COCs in groundwater already off site.
- Groundwater flow modeling results agree with water level contouring. The model results support the above conclusion that the extraction rates at GW-2, GW-13, GW-15, and GW-16 are more than sufficient for limiting the potential for further migration of COCs off site, as well as capturing existing COCs in groundwater already off site.
- Groundwater may potentially flow from the area of GMW-39 to the northeastern extraction wells, under February flow conditions.
- Analytical trends in the northeast area suggest a significant downward trend in COCs in groundwater, supporting the capture effectiveness.
- Analytical samples from extraction wells suggest the highest mass load to the northern treatment system is from GW-15 and GW-2.
- Predictive modeling suggests that lower extraction rates can still maintain a sufficient capture area.

3.2 RECOMMENDATIONS

The section below includes recommendations for improvement in efficiency of the northeastern and northwestern groundwater extraction systems. These recommendations are based mostly on hydrogeology and treatment operations of the site.

Based on this capture analysis, the conclusions above, and other site information, the following is recommended:

- Install flow meters, flow regulating valves, and sample ports on each extraction well (unless existing).
- Reduce long-term average groundwater extraction rates to the following:
  - *GW-2 = 2 GPM*
  - *GW-13 = 2 GPM*
  - *GW-16 = 2 GPM*
  - *GW-15 = 3 GPM*
- Interface with AMEC regarding the TBA breakthrough and the potential for TBA impacted groundwater to flow from the southeast area north to GW-15. Increasing the flow rates in the southeast area should capture groundwater near GMW-39 and reduce the potential for TBA to flow north to GW-15.
- Sample influent concentration to the treatment plant while the pumps are running prior to shut-off for each quarterly sample event.
- Collect water levels for future quarterly events synoptically (all on the same day), across the site at selected wells prior to turning the extraction wells off.
- Gauge water levels in the extraction wells during the synoptic event, but only use if necessary and if well efficiency corrections are applied.
- Continue to map the groundwater contours during each quarterly event and determine if the revised groundwater extraction rates are sufficient.

TABLES

TABLE 1

WATER LEVEL ELEVATIONS DURING FEBRUARY 2010 CAPTURE TESTING

WELL ID	STATIC WATER LEVEL ELEVATION (FT AMSL) Feb. 4, 2010	UNCORRECTED ACTIVE PUMPING WATER LEVEL ELEVATION (FT AMSL)	DRAWDOWN (FT)	CORRECTED ACTIVE PUMPING WATER LEVEL ELEVATION (FT AMSL)
GW-2	47.32	43.44	3.88	45.38
GW-13	45.72	43.39	2.33	44.56
GW-15	46.08	38.89	7.19	42.49
GW-16	46.60	43.40	3.20	45.00
GW-16p	46.82	45.99	0.83	45.99
GMW-13	47.32	47.53	-0.21	47.53
GMW-14	#N/A	#N/A	#N/A	#N/A
GMW-15	#N/A	47.15	#N/A	47.15
GMW-16	#N/A	46.99	#N/A	46.99
GMW-18	#N/A	47.60	#N/A	47.60
GMW-19	#N/A	47.23	#N/A	47.23
GMW-2	#N/A	47.56	#N/A	47.56
GMW-23	#N/A	47.37	#N/A	47.37
GMW-25	#N/A	44.85	#N/A	#N/A
GMW-26	#N/A	47.22	#N/A	47.22
GMW-27	#N/A	47.39	#N/A	47.39
GMW-28	#N/A	47.37	#N/A	47.37
GMW-29	#N/A	47.43	#N/A	47.43
GMW-3	#N/A	47.61	#N/A	47.61
GMW-30	#N/A	47.44	#N/A	47.44
GMW-31	#N/A	#N/A	#N/A	#N/A
GMW-33	47.15	47.14	0.01	47.14
GMW-37	#N/A	47.56	#N/A	47.56
GMW-39	#N/A	47.39	#N/A	47.39
GMW-41	#N/A	43.53	#N/A	#N/A
GMW-44	#N/A	47.27	#N/A	47.27
GMW-45	#N/A	46.84	#N/A	46.84
GMW-47	46.94	47.83	-0.89	47.83
GMW-48	47.96	47.85	0.11	47.85
GMW-50	47.04	46.85	0.19	46.85
GMW-51	47.07	46.93	0.14	46.93
GMW-56	#N/A	46.99	#N/A	46.99
GMW-57	46.95	46.60	0.35	46.60
GMW-58	47.76	47.33	0.43	47.33
GMW-59	48.41	48.25	0.16	48.25
GMW-6	#N/A	47.08	#N/A	47.08
GMW-60	46.97	46.39	0.58	46.39
GMW-61	47.07	46.66	0.41	46.66
GMW-62	47.14	47.04	0.10	47.04
GMW-63	#N/A	47.32	#N/A	47.32
GMW-64	#N/A	47.56	#N/A	47.56

TABLE 1
WATER LEVEL ELEVATIONS DURING FEBRUARY 2010 CAPTURE TESTING

WELL ID	STATIC WATER LEVEL ELEVATION (FT AMSL) Feb. 4, 2010	UNCORRECTED ACTIVE PUMPING WATER LEVEL ELEVATION (FT AMSL)	DRAWDOWN (FT)	CORRECTED ACTIVE PUMPING WATER LEVEL ELEVATION (FT AMSL)
GMW-65	46.95	46.98	-0.03	46.98
GMW-66	46.96	46.70	0.26	46.70
GMW-8	#N/A	47.23	#N/A	47.23
GMW-O-1	#N/A	47.62	#N/A	47.62
GMW-O-10	#N/A	47.38	#N/A	47.38
GMW-O-12	#N/A	#N/A	#N/A	#N/A
GMW-O-14	#N/A	47.61	#N/A	47.61
GMW-O-16	#N/A	47.91	#N/A	47.91
GMW-O-19	#N/A	48.24	#N/A	48.24
GMW-O-2	#N/A	47.63	#N/A	47.63
GMW-O-3	#N/A	47.56	#N/A	47.56
GMW-O-6	#N/A	48.10	#N/A	48.10
GMW-O-7	#N/A	#N/A	#N/A	#N/A
GMW-O-8	#N/A	48.12	#N/A	48.12
GMW-O-9	#N/A	47.46	#N/A	47.46
GMW-SF-7	#N/A	47.79	#N/A	47.79
GMW-SF-8	#N/A	47.98	#N/A	47.98
GW-6	46.96	46.90	0.06	46.90
GWR-1	#N/A	51.19	#N/A	#N/A
HL-2	#N/A	47.41	#N/A	47.41
HL-3	#N/A	47.44	#N/A	47.44
MW-11	#N/A	47.08	#N/A	47.08
MW-12	#N/A	47.46	#N/A	47.46
MW-13	#N/A	46.78	#N/A	46.78
MW-14	46.64	45.62	1.02	45.62
MW-16	#N/A	47.49	#N/A	47.49
MW-17	47.03	46.81	0.22	46.81
MW-24	46.69	46.49	0.20	46.49
MW-25	46.69	46.31	0.38	46.31
MW-26	46.84	46.63	0.21	46.63
MW-27	47.03	47.07	-0.04	47.07
MW-6	#N/A	47.02	#N/A	47.02
MW-7	#N/A	47.23	#N/A	47.23
MW-8	#N/A	47.63	#N/A	47.63
MW-9	#N/A	47.64	#N/A	47.64
MW-SF-1	#N/A	47.63	#N/A	47.63
MW-SF-9	#N/A	47.65	#N/A	47.65
PW-1	#N/A	47.16	#N/A	47.16
PW-3	#N/A	47.14	#N/A	47.14
PZ-10	#N/A	47.60	#N/A	47.60
PZ-5	#N/A	47.70	#N/A	47.70

TABLE 1
WATER LEVEL ELEVATIONS DURING FEBRUARY 2010 CAPTURE TESTING

WELL ID	STATIC WATER LEVEL ELEVATION (FT AMSL) Feb. 4, 2010	UNCORRECTED ACTIVE PUMPING WATER LEVEL ELEVATION (FT AMSL)	DRAWDOWN (FT)	CORRECTED ACTIVE PUMPING WATER LEVEL ELEVATION (FT AMSL)
TF-16	#N/A	48.02	#N/A	48.02
WCW-12	#N/A	47.09	#N/A	47.09
WCW-13	#N/A	46.79	#N/A	46.79
WCW-14	#N/A	46.88	#N/A	46.88
WCW-2	47.07	47.08	-0.01	47.08
WCW-3	46.75	46.68	0.07	46.68
WCW-4	46.59	46.50	0.09	46.50
WCW-6	47.11	47.09	0.02	47.09
WCW-7	46.66	46.26	0.40	46.26
WCW-8	46.56	46.07	0.49	46.07
GW-3	47.33	46.55	0.78	46.55
GW-1	46.13	45.45	0.68	45.45
GW-5	46.87	46.80	0.07	46.80

NOTES: Pumping wells corrected for well efficincy (50 %), based on step tests (2008) all wells assumed to have similar efficinecy
Also removed anomallies, see fill cells below.

Several water elevations were removed from the corrected list due to annomalous readings.

#N/A: No water level measurement

Static water levels measured on Feb. 04, 2010

Pumping water levels measured Feb. 22 - 24, 2010 after approxiamtely 2 weeks of active pumping, although GW-2 and GW-13, were off for an unkown period on the weekend prior.

TABLE 2
SUMMARY OF PUMPING RATES FROM ACTIVE GROUNDWATER EXTRACTION WELLS DURING THE FEBRUARY CAPTURE TESTING

Well ID	Area	Operations Company	Flow Rate GPM (Feb. 22, 2010)[1]
GW-2	NW	Parsons	3.4
GW-13	NW	Parsons	3.4
GW-15	NE	Parsons	5.5
GW-16	NE	Parsons	2.2
GMW-36	SE	AMEC	2.0
GMW-O-15	SE	AMEC	2.0
MW-SF-12	S Central	AMEC	1.7
MW-SF-13	S Central	AMEC	1.7
MW-SF-16	S Central	AMEC	1.7

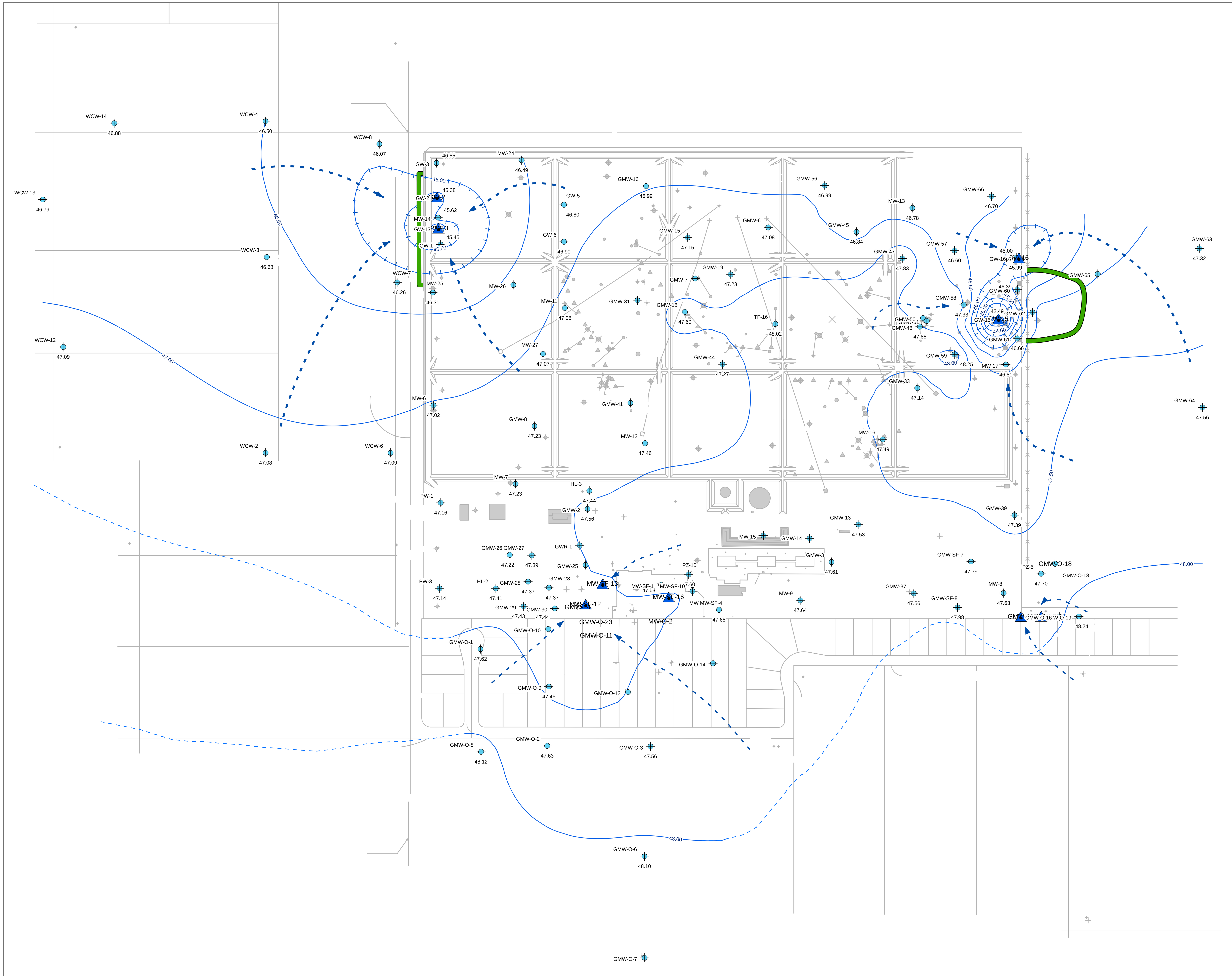
1: Flow rates (except for GW-15 and GW-16) are estimated from flow meters with combined flows

TABLE 3
SUMMARY OF ANALYTICAL RESULTS OF NORTHERN TREATMENT PLANT INFLUENT FROM WELLS GW-2, GW-3, GW-15, AND GW-16

	Static					Active Pumping		
Location	**Date**	**TPH as JP5[1]**	**Benzene**	**MTBE[2]**	**TBA[3]**	**Date**	**TPH as JP5 (µg/L)**	**TPH as Gasoline (µg/L)**
Extraction Wells								
GW-2	01/12/10	120	3.6	1.8	8.8	03/03/10	320	140
GW-13	01/12/10	< 100	< 0.50	4.8	5.2	03/04/10	< 100	< 100
GW-16	01/13/10	460 J	< 0.50	< 0.50	6.4	03/03/10	< 100	< 100
GW-15	NA[4]	NA	NA	NA	NA	03/04/10	140	220

1. TPH as JP5 = Total petroleum hydrocarbons as jet propellant 5.
2. MTBE = methyl tertiary-butyl ether
3. TBA = tert-butyl alcohol.
4. NA = not applicable, sample was not collected.

FIGURES



Legend

- ACTIVE EXTRACTION WELL (FEB. 22, 2010)
- WELL
- GROUNDWATER ELEVATION CONTOUR
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- APPROXIMATE EXTENT OF TARGET CAPTURE AREA REALTIVE TO SITE BOUNDARY - NORTHEASTERN AND NORTHWESTERN AREAS

NOTES:

1) GROUNDWATER ELEVATIONS ARE BASED ON DEPTH TO WATER MEASUREMENTS RECORDED FEBRUARY 22 - 24, 2010.

2) EXTRACTION WELLS WERE PUMPING FOR APPROXIMATELY 2 WEEKS PRIOR TO TAKING THE MEASUREMENTS, ALTHOUGH GW-2 AND GW-13 SHUT DOWN DURING THE WEEKEND PRIOR TO THE WATER LEVEL MEASUREMENTS. PUMPS WERE RESTARTED ON MONDAY, AND MEASUREMENTS IN THIS AREA WERE TAKEN ON TUESDAY.

3) WATER ELEVATIONS AT PUMPING WELLS WERE CORRECTED FOR WELL LOSS. WELL LOSS OF 50% WAS BASED ON STEP TESTING AT GW-15. FURTHERMORE, WATER LEVELS FROM THE PEIZOMETERS AND WELLS IN CLOSE PROXIMITY TO THE EXTRACTION WELLS SUPPORT THE DEPICTED CONE OF DEPRESSION.

4) APPROXIMATE TIME WEIGHTED AVERAGE GROUNDWATER EXTRACTION RATES (GPM) PROIR AND DURING TO THE WATER LEVEL EVENT (2/8 - 2/22) :

GW-2 AND GW-13 (COMBINED)	= 6.8
GW-15	= 5.5
GW-16	= 2.2
GMW-36 (COMBINED)	= 2.0
GMW-O-15 (COMBINED)	= 2.0
MW-SF-12 (COMBINED)	= 1.7
MW-SF-13 (COMBINED)	= 1.7
MW-SF-16 (COMBINED)	= 1.7

RATES FROM WELLS NOTED AS COMBINED ARE APPROXIAMTE AND BASED ON COMBINDED MEASUREMENTS

N W E S

0 80 160 320 480 640

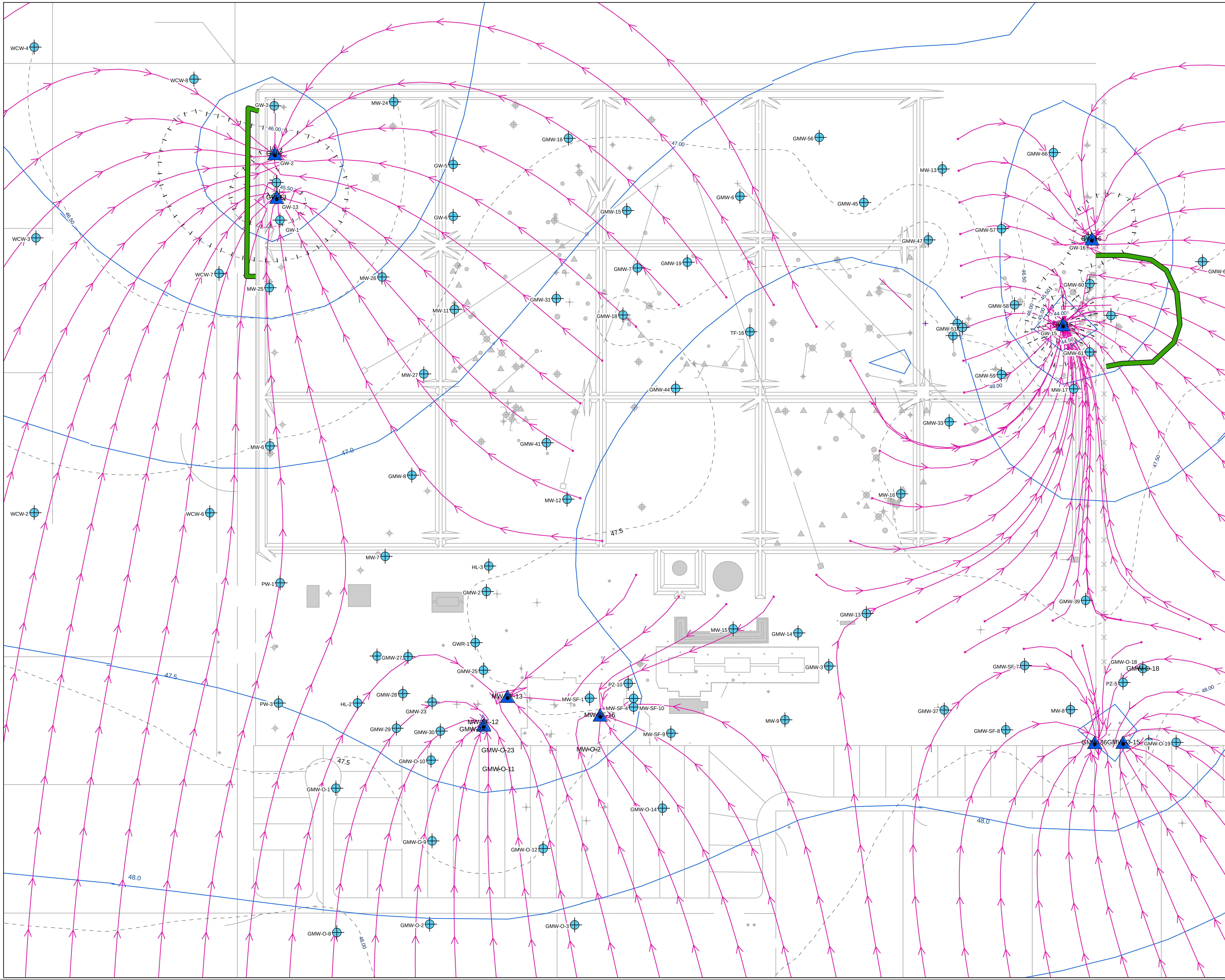
Feet

CONTOUR INTERVAL = 0.5 FEET

FIGURE 1 GROUNDWATER EQUIPOTENTIAL MAP IN THE UPPER MOST GROUNDWATER ZONE TWO WEEKS AFTER ACTIVATING PUMPS

PARSONS

FEBRUARY 22, 2010



Legend

- PUMPING WELL
- WELL
- Feb2009_GW_cont_2wkpump_dashed
- SIMULATED GROUNDWATER PARTICLE PATHS
- SIMULATED GROUNDWATER CONTOUR
- MEASURED GROUNDWATER CONTOUR
- APPROXIMATE EXTENT OF TARGET CAPTURE ZONE RELATIVE TO SITE BOUNDARY

APPROXIMATE TIME WEIGHTED AVERAGE GROUNDWATER EXTRACTION RATES (GPM) PROIR AND DURING TO THE WATER LEVEL EVENT (2/8 - 2/22) :

GW-2 AND GW-13 (COMBINED)	= 6.8
GW-15	= 5.5
GW-16	= 2.2
GMW-36 (COMBINED)	= 2.0
GMW-O-15 (COMBINED)	= 2.0
MW-SF-12 (COMBINED)	= 1.7
MW-SF-13 (COMBINED)	= 1.7
MW-SF-16 (COMBINED)	= 1.7

RATES FROM WELLS NOTED AS COMBINED ARE APPROXIAMTE AND BASED ON COMBINDED MEASUREMENTS

N
W E
S

0 60 120 240 360 480

Feet

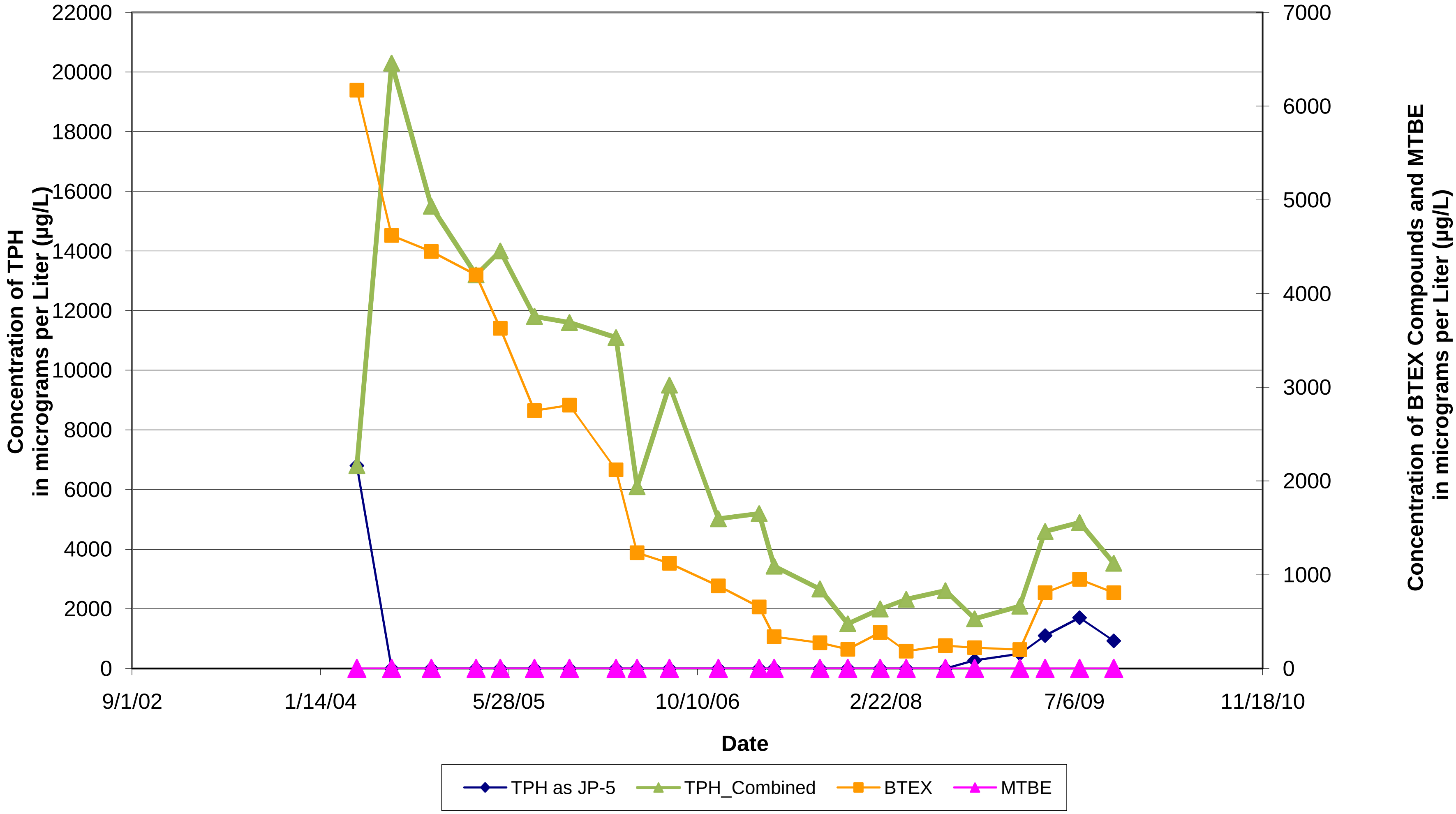
FIGURE 2
GROUNDWATER EQUIPOTENTIAL MAP AND SIMULATED FLOW MODEL RESULTS
SHORT TERM PUMPING SENARIO

PARSONS

FEBRUARY 22, 2010

P:\DFSP Norwalk\tech\Site_gw_capture\feb2010_gw_mod_2WEEK_PATHS.mxd

FIGURE 3A
GMW-60
Historical Concentrations of TPH as JP-5, TPH Combined, BTEX, and MTBE



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Norwalk_EasternArea_Concentration graphs_UpTo4Q09.xls

PARSONS

5/15/2010

FIGURE 3B
GMW-61
Historical Concentrations of TPH as JP-5, TPH combined, BTEX, and MTBE

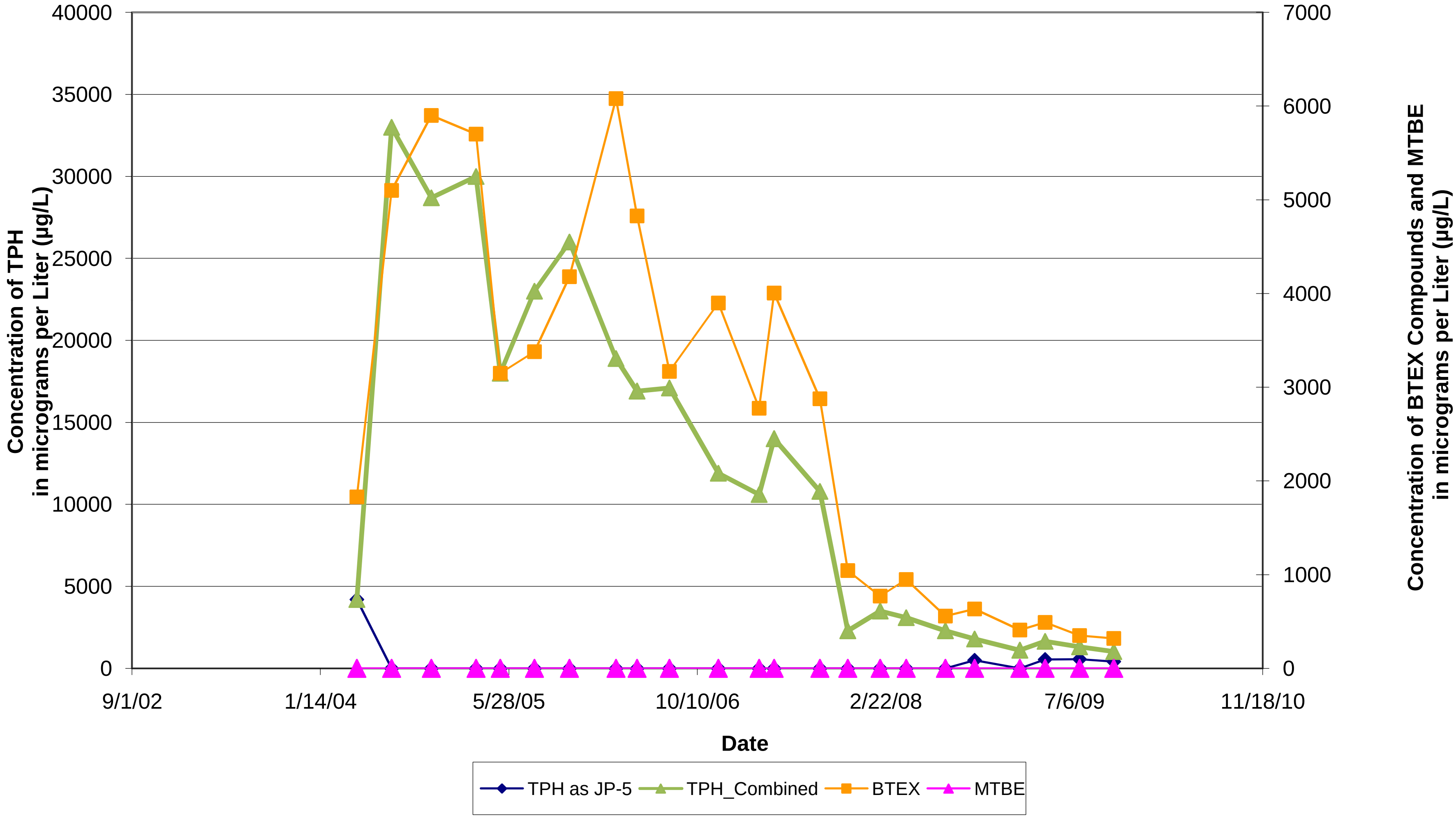
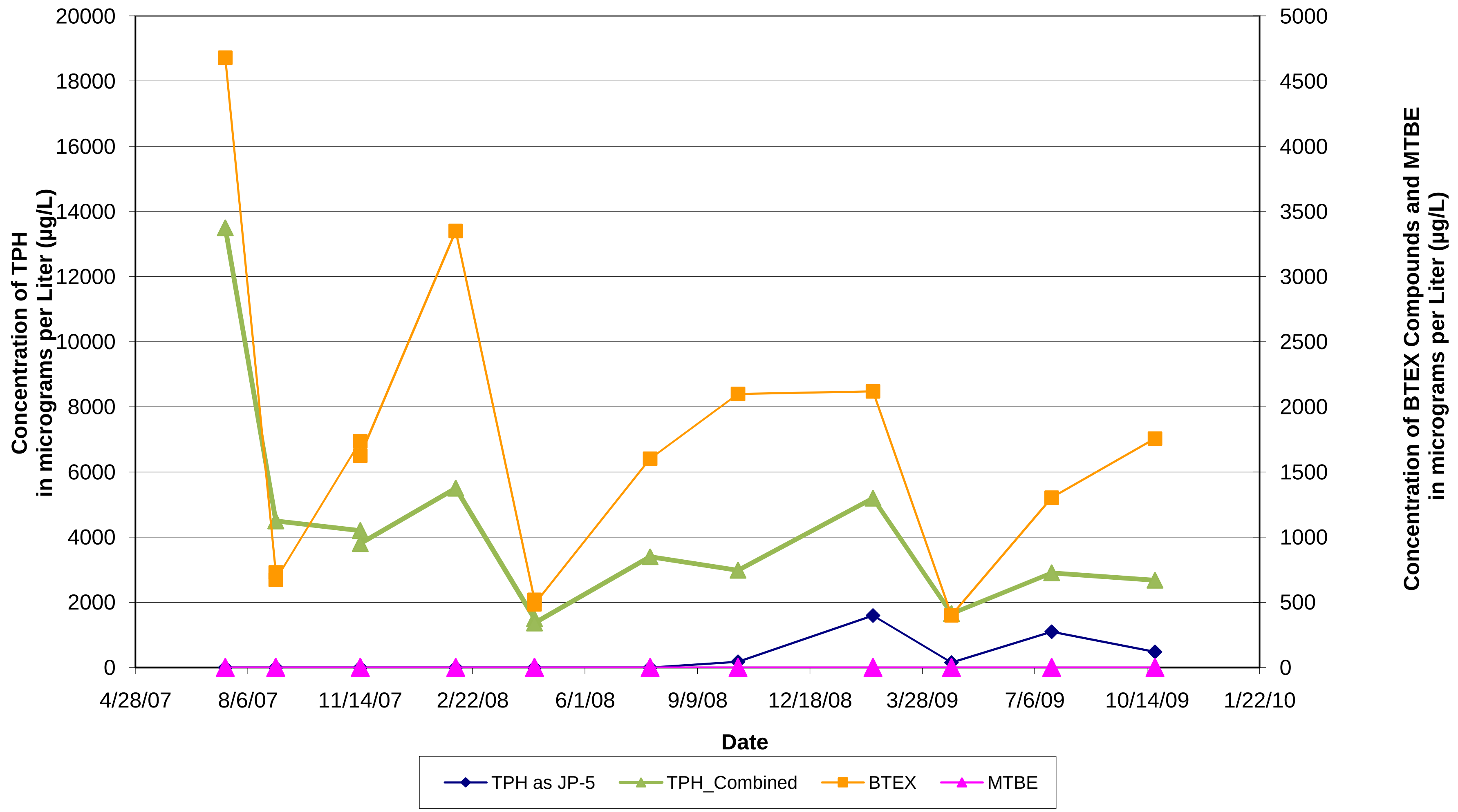
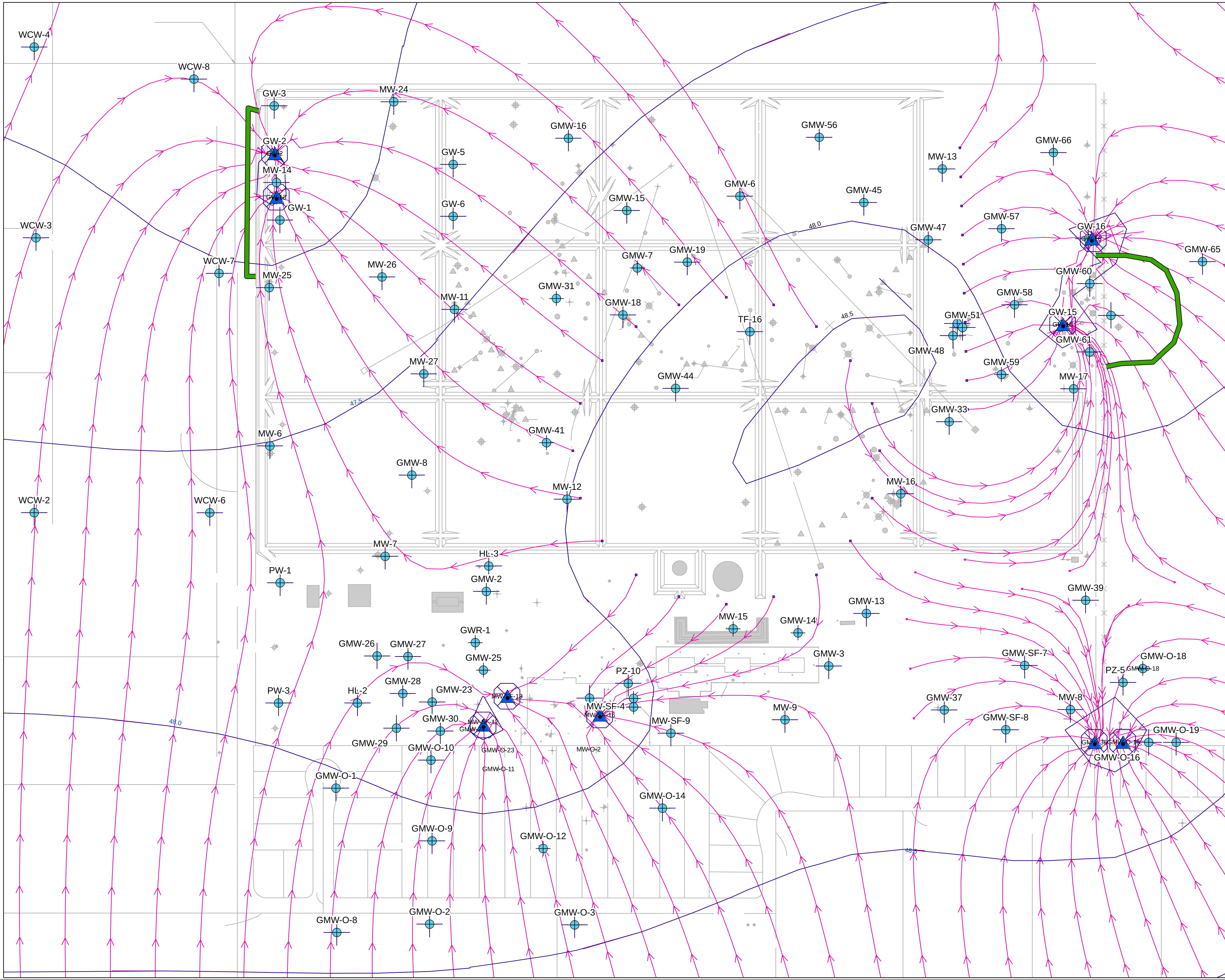


FIGURE 3C
GMW-62
Historical Concentrations of TPH as JP-5, TPH Combined, BTEX, and MTBE





Legend

- PUMPING WELL
- WELL
- SIMULATED GROUNDWATER CONTOUR
- SIMULATED PARTICLE PATH
- APPROXIMATE EXTENT OF TARGET CAPTURE ZONE RELATIVE TO SITE BOUNDARY

SIMULATED GROUNDWATER EXTRACTION RATES:

GW-2 = 2 GPM
GW-13 = 2 GPM
GW-16 = 2 GPM
GW-15 = 3 GPM

GMW-36 = 2.0
GMW-O-15 = 2.0
MW-SF-12 = 1.7
MW-SF-13 = 1.7
MW-SF-16 = 1.7

N
W E
S

0 62.5 125 250 375 500
Feet

FIGURE 4
SIMULATED FLOW MODEL RESULTS FOR REVISED PUMPING RATES

PARSONS

MAY 15, 2010

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ATTACHMENT

GROUNDWATER MODEL REPORT

DFSP NORWALK

DEFENSE FUEL SUPPORT POINT NORWALK
15306 NORWALK BOULEVARD
NORWALK, CALIFORNIA

Prepared For:

Defense Energy Support Center
8725 John J. Kingman Road
Fort Belvoir Virginia 22060-6222

Prepared By:

PARSONS

100 W. Walnut Street
Pasadena, CA 91124

JUNE 17, 2010

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LIST OF FIGURES

SECTION 1
INTRODUCTION AND BACKGROUND

1.1 PURPOSE AND SCOPE

The purpose of the following groundwater model, described herein, is to provide additional lines of evidence regarding groundwater capture analysis at the Defense Fuel Support Point (DFSP) Norwalk site (site). The modeling report is an attachment to the June 2010 capture analysis report. Some information may be omitted from this report if it is provided in the capture analysis (e.g. figures of groundwater flow paths). The reader is referred to the main groundwater capture report for additional information. Data from previous modeling[1], various investigations, and recent water level measurements (February, 2010) were used to support the evaluation.

The scope of work involved the following tasks:

- Designing and "constructing" the two-dimensional flow model
- Calibration of a static groundwater flow conditions
- Sensitivity analysis
- Calibration of the active pumping groundwater flow model using water level elevations after the extraction wells were on for a period of time (approximately 2 days – 2 weeks).
- Revision of the active pumping model to estimate if lower flow rates would sustain sufficient capture.

1.2 GEOLOGY AND HYDROGEOLOGY

Previous investigations[2] have described the geology and hydrogeology of the site. Ground surface in the area of investigation is between approximately 75 feet above mean sea

1 Parsons, 2009. Draft Technical Report on Pumping Test and Capture Zone Analysis, January 14.

2 Parsons, 2006. Eastern Boundary and Eastern Boundary Off-Site Area Soil & Groundwater Preliminary Investigation Report, Defense Fuel Support Point Norwalk. October 9.

level[3]. Soil is comprised primarily of unconsolidated fine sand, silty fine sand, and silt, with lesser varying percentages of clay. Saturated sediments are typically encountered between 24 and 40 feet below ground surface (bgs). Previous investigations[4] indicate that the saturated sands extend to a depth of approximately 52.5 feet bgs, where a confining clay layer is encountered.

The uppermost saturated zone (27 to 50 feet) is where most of the groundwater remediation programs are focused. Below these saturated soils lies the Exposition aquifer, which is the shallowest reported aquifer beneath the site[5]. This aquifer is reported between approximately 87 and 155 feet bgs, and is separated from the upper water bearing unit by clay[6]. Historical interpretations of groundwater flow in the upper most unit has been generally to the northwest, with a hydraulic gradient of approximately 0.001 foot per foot. Based on 2008 GW-15 pumping tests, the estimated range of hydraulic conductivity was estimated is 11 to 25 foot per day (ft/day).

---

[3] USGS, 1981. United States Geological Survey (USGS), 1981 (photo revised from 1965), Whittier, California 7.5-Minute Quadrangle (1” = 2,000’).

[4] Parsons, 2006.

[5] CDWR, 1961. California Department of Water Resources, *Planned Utilization of the Groundwater Basins of the Coastal Plains of Los Angeles County,* Groundwater Geology, Appendix A, Bulletin 104, 1961.

[6] Parsons, 2006.

SECTION 2
GROUNDWATER MODEL DEVELOPMENT

2.1 MODEL DESIGN

2.1.1 Conceptual Site Model

Under static conditions groundwater is believed to flow from areas of higher hydraulic head in the southeast across the site to the northwest. The gradient is shallow at approximately 0.001 (dimensionless). The upper most sand and silts formations have a moderate hydraulic conductivity and are assumed at the scale of the model to be homogenous. Active pumping wells are simulated using the analytical model and are assumed to be fully penetrating.

2.1.2 Model Specifications and Initial Parameters

The 2008 groundwater model developed for estimating location and pumping rate of GW-16 was revised for the current groundwater model. The following specifications describe the details of the initial model parameters (i.e. pre-calibration parameters).

- Code: Winflow 1.07 (1996).
- Supporting Software: Microsoft Excel® and ESRI ARCGIS
- Initial Reference Head: 45.2 feet above mean sea level (amsl) located approximately 2,100 feet north of the middle of the site. The gradient direction is N5W.
- Saturated thickness: 36 feet
- Gradient: 0.0009 dimensionless
- Recharge: 0.0 feet/day
- Porosity: 0.2 dimensionless
- Storage: 0.001 dimensionless

2.1.3 Static Model Initial Parameters

The static model was calibrated using trial and error techniques to water level observations from February 4, 2010. In order to account for the general groundwater mound in the north-central-eastern area (GMW-18 – GMW-50), a flux line sink was added to the model. After reducing the error to approximately calibrated, a sensitivity analysis was conducted.

Figures 1 and 2 demonstrated the sensitivity analysis. Using the information obtained in the sensitivity analysis, the “final” calibrated model was selected (see Figures 1 and Figures 2). The following information summaries the calibrated static groundwater model:

```
File: STWD2.WFL
============================================================================
Number of Linesinks Defined by Infiltration Rate = 1

     Line Sink #1
        x1: 21478.560547   y1: 9565.980469
        x2: 21565.279297   y2: 9488.969727
        Discharge per length = -5.700000
        Head in Center of Linesink    = 47.552776
        Total Linesink Discharge      = -661.074646 [L3/T]
Number of Linesinks Defined by Head = 0
Number of Ponds = 0
Number of Wells = 0
Reference Head = 44.600000    Defined at -- x: 20898.820313   y: 11208.410156
============================================================================
                                Calibration Targets
  Target       Computed        Residual       Well Name
   Head          Head
  47.32        47.50          -0.1830          GMW-13
  47.06        47.33          -0.2748          GMW-33
  46.87        47.05          -0.1839          GMW-47
  47.74        47.29          0.4473          GMW-48
  46.94        47.29          -0.3457          GMW-50
  46.98        47.31          -0.3289          GMW-51
  46.86        47.10          -0.2400          GMW-57
  47.58        47.55          0.0346          GMW-58
  48.19        47.37          0.8155          GMW-59
  46.89        47.21          -0.3245          GMW-60
  47.01        47.32          -0.3102          GMW-61
  47.12        47.24          -0.1214          GMW-62
  46.91        47.05          -0.1355          GMW-65
  46.88        46.86          0.0177          GMW-66
  46.96        46.66          0.2955          GW-6
  46.61        46.53          0.0762          MW-14
  46.98        47.36          -0.3760          MW-17
  46.67        46.43          0.2361          MW-24
  46.66        46.72          -0.0567          MW-25
  46.79        46.72          0.0689          MW-26
  47.01        46.93          0.0823          MW-27
  47.03        47.00          0.0257          WCW-2
  46.78        46.53          0.2515          WCW-3
  46.62        46.18          0.4404          WCW-4
  47.09        47.09          0.0001          WCW-6
  46.65        46.65          -0.0023          WCW-7
  46.56        46.29          0.2717          WCW-8
  47.27        46.40          0.8744          GW-3
```

```
  46.09        46.61          -0.5212           GW-1
  46.82        46.57          0.2491          GW-5
  46.99        46.84          0.1451          GMW-7
  46.80        47.09          -0.2939           GW-16p

   Number of Targets           = 32
   Residual Mean               = 0.019809
   Residual Standard Deviation = 0.323998
   Residual Sum of Squares     = 3.371744
   Absolute Residual Mean      = 0.250940
   Minimum Residual            = -0.521202
   Maximum Residual            = 0.874359
   Observed Range in Head      = 2.099998
   Resid. Std./Range in Head   = 0.154285
   ARM/Range in Head = 0.11
=====================================================================
                                 Aquifer Properties
     .... Transient Flow Model ....
     Permeability...............= 18.000000 [L/T]
     Porosity...................= 0.200000
     Storage....................= 0.001000
     Leakage factor.............= 0.000000
     Elevation of Aquifer Top....= 46.000000
     Elevation of Aquifer Bottom.= 10.000000
     Uniform Regional Gradient...= 0.000900
     Angle of Uniform Gradient...= 95.000000

     Model Results Computed at Time = 10000.000000
=========================================================================
```

2.1.4 Calibrated active pumping model

The static model was revised to include the pumping wells listed in the capture report. These wells were known to be active during water level measurements from February 22nd through Feb 24th. The model was re-calibrated to the February 22 to 24 water level elevations. Two link sinks used to simulate the central mounding were expanded. The following information summarizes the calibrated static groundwater model:

```
=========================================================================
Number of Linesinks Defined by Infiltration Rate = 2

     Line Sink #1
        x1: 21269.119141   y1: 9472.849609
        x2: 21355.839844   y2: 9395.839844
        Discharge per length = -5.700000
        Head in Center of Linesink    = 48.125332
        Total Linesink Discharge      = -661.074646 [L3/T]
```

```
      Line Sink #2
         x1: 21284.339844   y1: 9551.929688
         x2: 20733.099609   y2: 8974.639648
         Discharge per length = -1.400000
         Head in Center of Linesink    = 47.965256
         Total Linesink Discharge      = -1117.485352 [L3/T]


Number of Linesinks Defined by Head = 0


Number of Ponds = 0
Number of Wells = 9

      Well #1
         Center of Well --  x: 20076.820313   y: 9825.059570
         Radius = 1.000000
         Pumping Rate = 657.000000
         Head at Well Radius           = 44.742641
      Well #2
         Center of Well --  x: 20080.199219   y: 9740.089844
         Radius = 1.000000
         Pumping Rate = 657.000000
         Head at Well Radius           = 44.794762
      Well #3
         Center of Well --  x: 21608.789063   y: 9492.809570
         Radius = 1.000000
         Pumping Rate = 1066.000000
         Head at Well Radius           = 45.152714
      Well #4
         Center of Well --  x: 21668.310547   y: 9659.370117
         Radius = 1.000000
         Pumping Rate = 420.000000
         Head at Well Radius           = 46.130901
      Well #5
         Center of Well --  x: 21670.199219   y: 8680.650391
         Radius = 1.000000
         Pumping Rate = 385.000000
         Head at Well Radius           = 46.953720
      Well #6
         Center of Well --  x: 21725.400391   y: 8680.969727
         Radius = 1.000000
         Pumping Rate = 385.000000
         Head at Well Radius           = 46.980392
      Well #7
         Center of Well --  x: 20482.250000   y: 8714.360352
         Radius = 1.000000
         Pumping Rate = 327.000000
         Head at Well Radius           = 46.702011
      Well #8
         Center of Well --  x: 20528.720703   y: 8770.179688
         Radius = 1.000000
         Pumping Rate = 327.000000
         Head at Well Radius           = 46.660744
```

Well #9
Center of Well -- x: 20708.820313 y: 8733.879883
Radius = 1.000000
Pumping Rate = 327.000000
Head at Well Radius = 46.910118

Reference Head = 47.000000 Defined at -- x: 20898.820313 y: 11208.410156
===
===

Calibration Targets

Target Head	Computed Head	Residual	Well Name
45.99	46.42	-0.4337	GW-16p
47.53	47.79	-0.2588	GMW-13
47.15	47.04	0.1104	GMW-15
46.99	46.79	0.1990	GMW-16
47.60	47.26	0.3403	GMW-18
47.23	47.28	-0.0508	GMW-19
47.56	47.28	0.2836	GMW-2
47.37	47.26	0.1059	GMW-23
47.22	47.32	-0.1003	GMW-26
47.39	47.28	0.1063	GMW-27
47.37	47.33	0.0410	GMW-28
47.43	47.41	0.0231	GMW-29
47.61	47.81	-0.2045	GMW-3
47.44	47.29	0.1512	GMW-30
47.14	47.66	-0.5195	GMW-33
47.56	47.81	-0.2517	GMW-37
47.39	47.63	-0.2356	GMW-39
47.27	47.58	-0.3073	GMW-44
46.84	47.29	-0.4456	GMW-45
47.83	47.29	0.5368	GMW-47
47.85	47.54	0.3113	GMW-48
46.85	47.45	-0.5991	GMW-50
46.93	47.42	-0.4908	GMW-51
46.99	47.13	-0.1368	GMW-56
46.60	47.00	-0.3958	GMW-57
47.33	46.89	0.4360	GMW-58
47.08	47.20	-0.1222	GMW-6
46.39	46.61	-0.2182	GMW-60
46.66	46.75	-0.0867	GMW-61
47.04	46.73	0.3141	GMW-62
47.32	47.48	-0.1603	GMW-63
47.56	47.79	-0.2311	GMW-64
46.98	47.12	-0.1391	GMW-65
46.70	46.95	-0.2535	GMW-66
47.23	47.11	0.1229	GMW-8
47.62	47.65	-0.0290	GMW-O-1
47.38	47.42	-0.0422	GMW-O-10
47.61	47.80	-0.1867	GMW-O-14
47.91	47.60	0.3104	GMW-O-16
48.24	47.78	0.4579	GMW-O-19

47.63	48.02	-0.3891	GMW-O-2
47.56	48.06	-0.5049	GMW-O-3
48.10	48.52	-0.4213	GMW-O-6
48.12	48.06	0.0597	GMW-O-8
47.46	47.73	-0.2744	GMW-O-9
47.79	47.67	0.1170	GMW-SF-7
47.98	47.75	0.2281	GMW-SF-8
46.90	46.61	0.2934	GW-6
47.41	47.42	-0.0095	HL-2
47.44	47.29	0.1524	HL-3
47.08	46.82	0.2572	MW-11
47.46	47.44	0.0170	MW-12
46.78	47.12	-0.3357	MW-13
45.62	45.41	0.2122	MW-14
47.49	47.76	-0.2697	MW-16
46.81	47.04	-0.2329	MW-17
46.49	46.28	0.2068	MW-24
46.31	46.34	-0.0348	MW-25
46.63	46.53	0.0992	MW-26
47.07	46.91	0.1570	MW-27
47.02	46.94	0.0786	MW-6
47.23	47.20	0.0252	MW-7
47.63	47.55	0.0768	MW-8
47.64	47.83	-0.1924	MW-9
47.63	47.26	0.3725	MW-SF-1
47.65	47.64	0.0093	MW-SF-9
47.16	47.25	-0.0928	PW-1
47.14	47.50	-0.3558	PW-3
47.60	47.46	0.1449	PZ-10
47.70	47.60	0.1026	PZ-5
48.02	47.62	0.3958	TF-16
47.09	47.06	0.0301	WCW-12
46.79	46.75	0.0444	WCW-13
46.88	46.55	0.3277	WCW-14
47.08	47.19	-0.1119	WCW-2
46.68	46.59	0.0925	WCW-3
46.50	46.37	0.1270	WCW-4
47.09	47.11	-0.0237	WCW-6
46.26	46.31	-0.0547	WCW-7
46.07	46.11	-0.0371	WCW-8
46.55	45.87	0.6827	GW-3
45.45	45.77	-0.3190	GW-1
46.80	46.52	0.2771	GW-5

```
Number of Targets             = 83
Residual Mean                 = -0.013510
Residual Standard Deviation = 0.266357
Residual Sum of Squares       = 5.903689
Absolute Residual Mean        = 0.216823
Minimum Residual              = -0.599072
Maximum Residual              = 0.682747
Observed Range in Head        = 2.790001
Resid. Std./Range in Head     = 0.095469
=============================================================================
```

Aquifer Properties

```
.... Transient Flow Model ....

 Permeability................= 12.000000 [L/T]
 Porosity....................= 0.200000
 Storage.....................= 0.001000
 Leakage factor..............= 0.000000
 Elevation of Aquifer Top....= 46.000000
 Elevation of Aquifer Bottom.= 10.000000
 Uniform Regional Gradient...= 0.000880
 Angle of Uniform Gradient...= 110.000000

 Model Results Computed at Time = 14.000000
```

2.1.5 Predictive model

The predictive model was based on the active pumping model. All parameters remained the same, except well pumping rates. Pumping rates at the northeastern and northwestern wells were reduced to:

- GW-2 = 2 GPM
- GW-13 = 2 GPM
- GW-16 = 2 GPM
- GW-15 = 3 GPM

Using the above rates the model suggests capture zone will remain larger than the target areas. Field verification is necessary to validate the model.

2.2 MODEL LIMITATIONS

The model was designed with sufficient complexity to broadly identify groundwater flow paths. The water-level contours calculated by the model in areas outside of the monitoring well network should be considered less accurate than the water-level contours in the area bounded by the monitoring well network.

A basic assumption of the model was that the water bearing unit could be considered heterogeneous and isotropic. It is known that the groundwater system is heterogeneous; however, at the scale of the model, most of the aquifer variability is believed to "average out" so that the assumption is valid for the scale of the model.

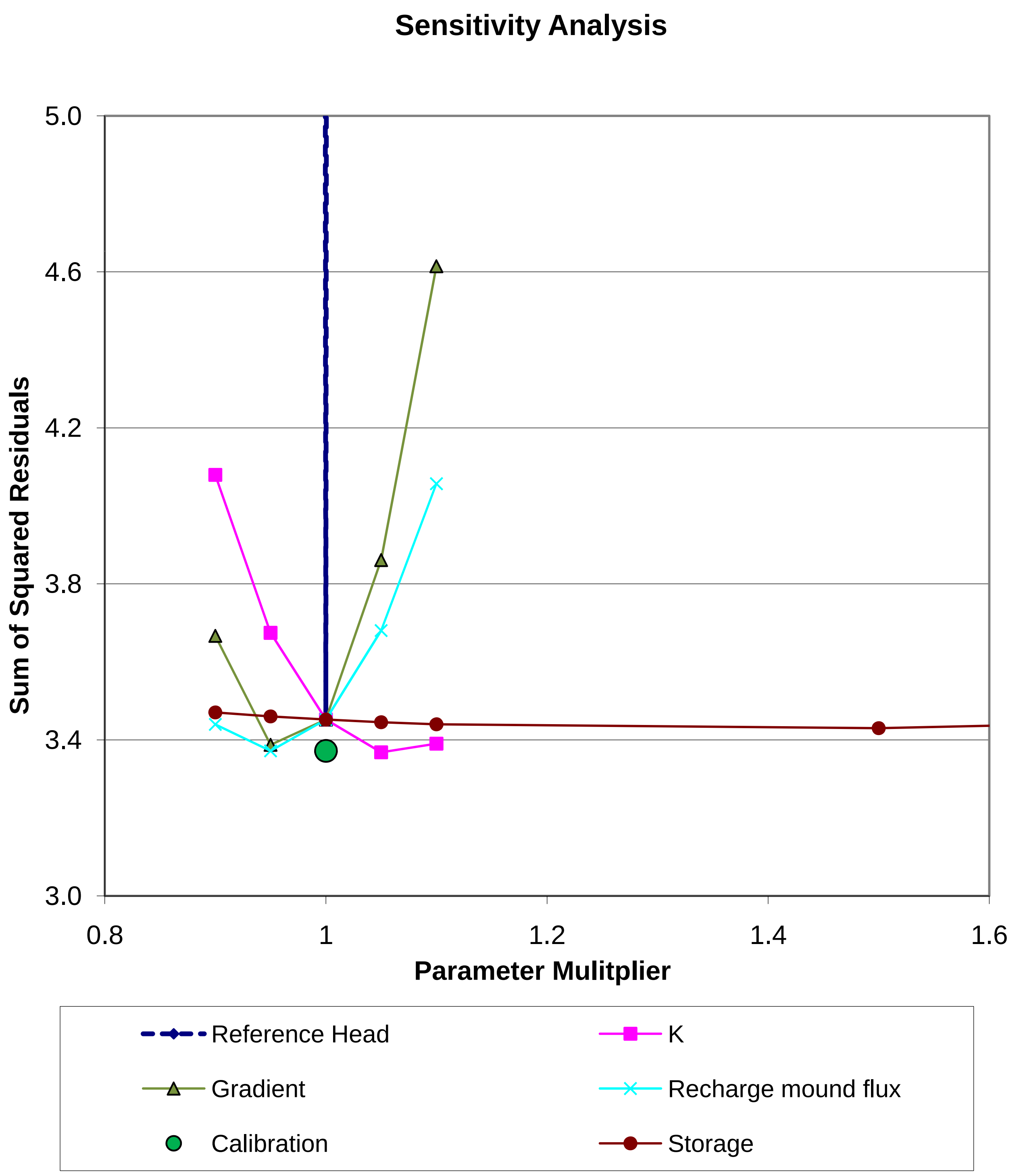
SECTION 3
CONCLUSIONS

Parsons constructed a two-dimensional analytical groundwater flow model for the DFSP site in Norwalk, California. The objectives of the model were to identify groundwater flow paths across the facility. Example particle tracking was conducted to simulate regional groundwater flow. Based on these simulations, the following conclusions were reached:

- The model is a useful tool for identifying flow paths from specific locations at the facility.
- Refinements to the 2008 model included the addition of field data (water level data from new monitoring wells), which improved the model calibration statistics, thus increasing confidence in the results of the modeled area.
- Groundwater capture under existing conditions creates a relativity large capture area, similar to that indentified in water elevation contour plots.
- Sufficient capture may be sustained using lower pumping rates at GW-2, GW-13, GW-15 and GW-16.

The flow model was used for capture analysis of the northeast and northwest areas of the site. Further information regarding the capture analysis can be found in the capture report.

FIGURES



PARSONS
40 La Riviere Dr., Suite 350 Buffalo, NY 14202

FIGURE A1
SENSITIVITY ANALYSES

ERROR AS SUM OF SQUARED RESIDUALS

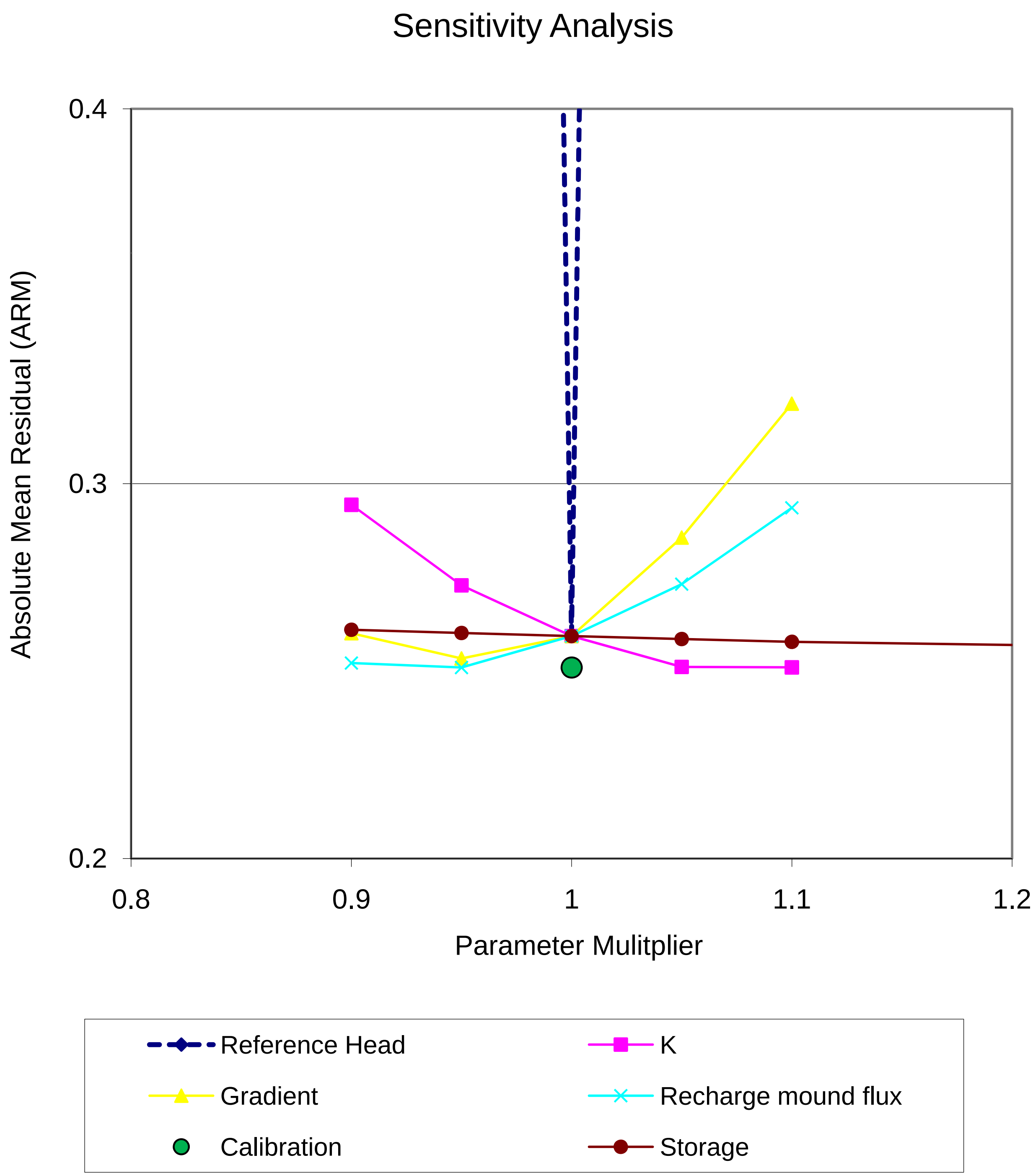


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FIGURE A2
SENSITIVITY ANALYSES

ERROR AS ABSOLUTE MEAN RESIDUAL (ARM)