8. Investigation Findings

8.1. HYDROGEOLOGY

Water level data show that the direction of groundwater movement is to the south-southwest, consistent with previous investigations and as expected based on regional conditions. Water table elevations range from 22 feet above msl onsite at OU-1 to 15 feet above msl at the south edge of OU-2. The horizontal groundwater gradient is 0.0018 feet/foot along this heading. Contoured water table elevation maps for shallow, intermediate, and deep wells from the first sampling event (October 6, 2008) are presented in Figure 7-1, Figure 7-2 and Figure 7-3, respectively.

Water levels measured between shallow, intermediate and deep wells in each monitoring well cluster were consistent, with differences ranging from 0.01 to 0.18 feet, indicating no significant vertical gradient under non-pumping conditions. This is important information given that vertical gradients are expected to change significantly once pumping for groundwater remediation begins.

Hydrographs constructed from Levelogger® data indicate less than an 18 inch fluctuation in water table elevation during the first monitoring quarter, even with two significant precipitation events (over 2 inches in a 24-hour period) in September (NOAA, JFK). The hydrographs also reflect the effects of moderate precipitation events through an increase in groundwater elevation that is consistent between well clusters; correlation between precipitation events and increases in water levels is inconclusive for this short time period. Hydrographs presented in Appendix G show representative trends in water table elevations during the first monitoring quarter.

Hydrographs also indicate an overall increasing trend in groundwater elevation, ranging from 0.5 to 0.9 feet above msl, from August to October 2008. Wells W-10 to W-15 (excluding W-11) are exceptional, displaying a decrease in elevation, due to their pressure transducers being installed later (September 8, 2008) in the monitoring quarter and following a significant precipitation event.

8.2. PCE PLUME

Plan-view PCE isoconcentration maps indicate variation in plume configuration with depth. Figure 7-4 indicates that shallow contamination extends from the OU-1 source area to approximately 2000 feet downgradient in the vicinity of 173rd Street, where PCE was no longer detected in shallow (~12-22 ft bgs) depths. The highest concentrations

were observed between 177th and 176th Street, where wells W-04S and W-08S indicated significant shallow groundwater contamination at 1200 ppb and1100 ppb, respectively. Several other shallow wells indicated relatively low PCE concentrations (less than 100 ppb) between OU-1 and 173rd Street. Beyond this point, PCE was not detected in the shallow monitoring wells.

Intermediate depth monitoring wells indicate that the PCE plume extends further south and west in this intermediate zone. Monitoring well W-14I, located on 169th Street, may be close to the leading edge of the plume in the intermediate zone as indicated by a PCE concentration of 680 ppb. PCE was no longer detected along 166th Street, indicating that the leading edge of the plume in the intermediate zone is located between 169th and 166th Streets.

The highest concentrations in the intermediate zone (~ 40-50 ft bgs) were observed from 177th Street to 174th Street, where several wells indicate PCE concentrations greater than 1000 ppb (see Figure 7-5). Low to 'non-detect' PCE concentrations were observed in monitoring wells near 110th Avenue to the northwest and Sayres Avenue to the southeast, indicating that the plume lies within these boundaries at intermediate depths.

Analysis of groundwater samples from deep monitoring wells indicates that contamination extends still farther to the south-southwest in the deepest interval (Figure 7-6). Although the Geoprobe® data indicated that the leading edge of the plume in the deep interval should be located between 166th and 169th Streets, PCE was detected at low concentrations (16 ppb) in W-15D which is located on 166th Street. The detection of PCE at this location indicates that the leading edge of the plume in the deep zone is located slightly further downgradient than 166th Street.

The highest PCE concentrations in deep wells were seen in wells W-06D and W-11D at 560 ppb and 620 ppb, respectively, indicating that the bulk of PCE contamination in the deep zone is located between 172nd and 175th Streets. Deep zone contamination appears to also be bounded by 110th Avenue and Sayres Avenue to the northwest and southeast, respectively.

The direction of plume movement as shown in these figures indicates that groundwater contamination follows the southeasterly regional flow direction. Groundwater samples from the monitoring wells were consistent in showing that PCE contamination extends deeper into the aquifer and becomes more widely dispersed with increasing distance from OU-1. Figure 7-7 illustrates this trend, showing a cross-section through the plume along centerline A-A' (see Figure 4-2). Water quality data obtained from monitoring wells along this centerline indicates that shallow and intermediate PCE contamination predominates to the north of 174th Street, while deeper contamination is seen extending at depth to 166th Street.

8.3. VAPOR INTRUSION

Based upon the distribution of dissolved PCE mass beneath the residential area (OU-2), and the presence of clean groundwater above the PCE plume downgradient of 172nd Street, the potential for vapor intrusion into basements of structures is expected to diminish with increasing distance from the West Side site. PCE contamination is moderate (~100 ppb) at shallow depths east of Merrick Boulevard between the 175th and 172nd Street transects and may continue to be a source of soil gas at these locations until groundwater remediation begins. Vapor intrusion is not likely to occur west of 173rd Street, where PCE was not detected at the water table and only low concentrations were detected at most locations at approximately 30 feet bgs.

8.4. PLUME MIGRATION

Shallow groundwater sample results confirm that the highest PCE contamination is in close proximity to OU-1. The presence of degradation products (trichloroethene and cis 1-2 dichloroethene) in most of the monitoring wells near OU-1 (W-01 to W-10) suggest that the PCE has been present in the vicinity of the West Side Site for a greater time, indicating proximity to the source area. Since the degradation products were not observed with similar abundance in wells further offsite (W-10 to W-15), this suggests that PCE has persisted near OU-1 longer than at the more distal locations.

The estimated time frame of PCE release into the groundwater was the late 1970's. Assuming non-pumping conditions over an approximate 30 year period and the current plume extent from OU-1 to the vicinity of 166th Street, the apparent observed rate of PCE migration is approximately 0.38 ft/day. Assuming this continued rate of movement, the PCE will continue to migrate south-southwest approximately 1/4 mile per decade. The tendency of PCE to disperse and descend within the aquifer as observed between the 172nd Street and 169th Street transects, will likely continue until groundwater remediation begins.

Given the measured groundwater gradient of 0.0018 ft/ft, an average hydraulic conductivity of 1,000 gallons-per-day per square-foot (gpd/ft2) and an average effective porosity of 30%, the rate of groundwater flow in this aquifer is estimated at 0.80 ft/day. Based on these calculated values, the retardation factor, or attenuation factor, for PCE at this location is approximately 0.5, where PCE moves through the aquifer approximately 1/2 the rate of groundwater. This is consistent with published literature on PCE movement in groundwater (USGS, 2004).

8.5. PLUME RECOVERY

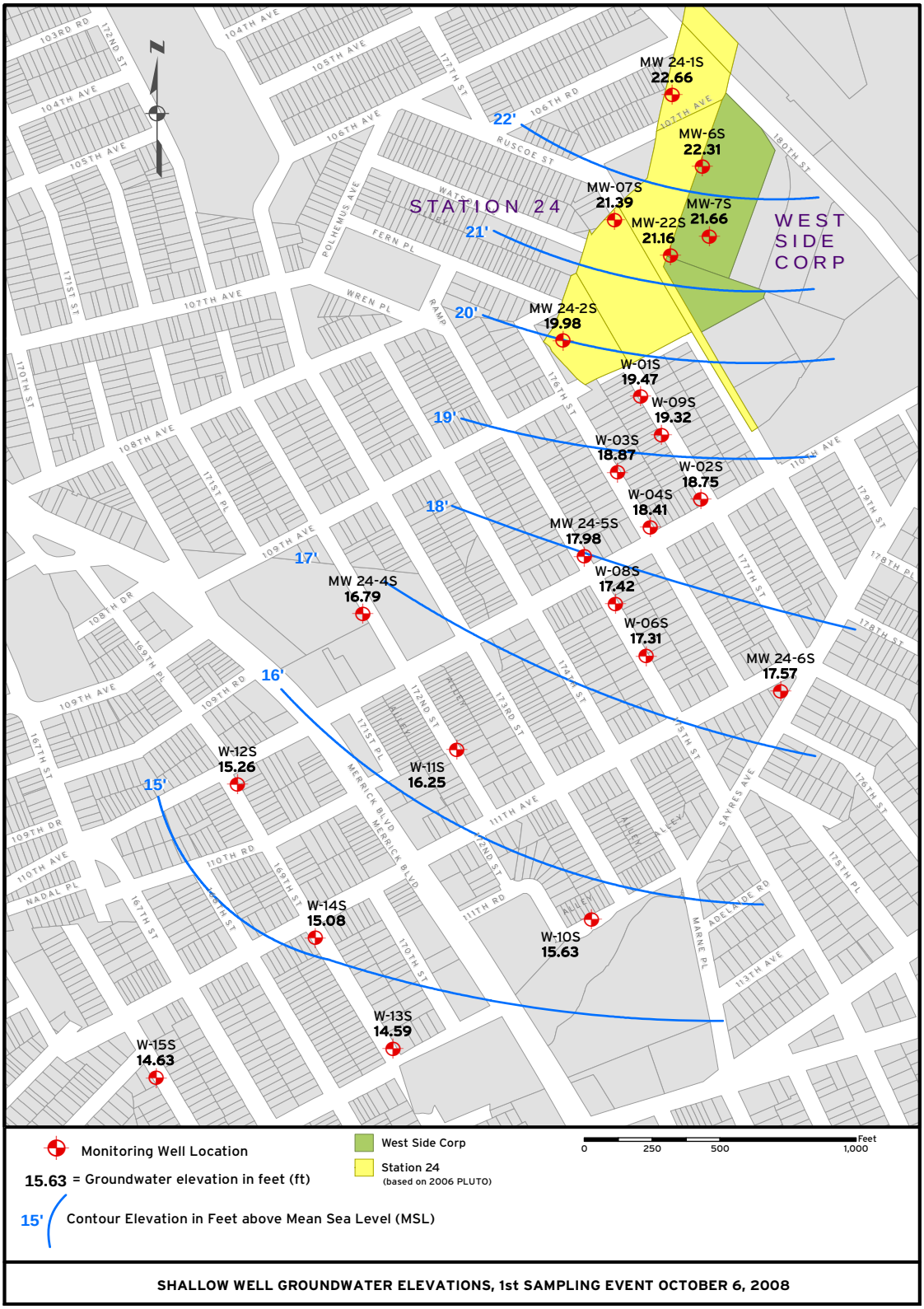
Groundwater modeling indicates that the pumping of the proposed groundwater recovery system will create 1 foot of drawdown at the leading edge of the plume and 0.5 feet drawdown well beyond this extent (Figure 7-8). Given the regional gradient, however,

resulting heads create a capture zone that reaches across Merrick Boulevard before developing a roughly east/west groundwater divide, running through the intersection of 169th Street and 111th Avenue (Figure 7-9). This anticipated capture zone should be sufficient to capture the shallow and intermediate depth portions of the PCE plume, as well as capturing the bulk of the deep plume. However, the very leading edge of the deep portion of the plume, between 169th and 166th Streets, appears to lie outside of the capture zone of the two recovery wells. While further analysis and evaluation is required to confirm the capture zone of these wells, other options for containing/capturing the leading edge of the plume's deeper portion should be explored.

8.6. RECOMMENDATIONS

- Conduct additional evaluation of the vertical flow field to assure capture of deep portions of the PCE plume.
- Evaluate options for recovery of the leading edge of the PCE plume. Issues that should be included in this evaluation, among others, are:
    - Available property for additional recovery well locations.
    - Delivery of recovered contaminated groundwater to a treatment location.
    - Treatment options for contaminated groundwater.
    - Sewer capacity for handling treated groundwater discharge.
    - Ultimate discharge locations and permitting (SPDES equivalent requirements and limitations).
- Consider options for alternate means of remediating the leading edge of the plume, such as chemical oxidation, reactive walls or other in-situ remediation technologies.
- Include wells 6A and 6B at Station 6 in the next sampling round to aid in the overall plume delineation.

Figure 8-1: Groundwater Elevation: Shallow Monitoring Wells



SHALLOW WELL GROUNDWATER ELEVATIONS, 1st SAMPLING EVENT OCTOBER 6, 2008

Figure 8-2: Groundwater Elevation: Intermediate Monitoring Wells

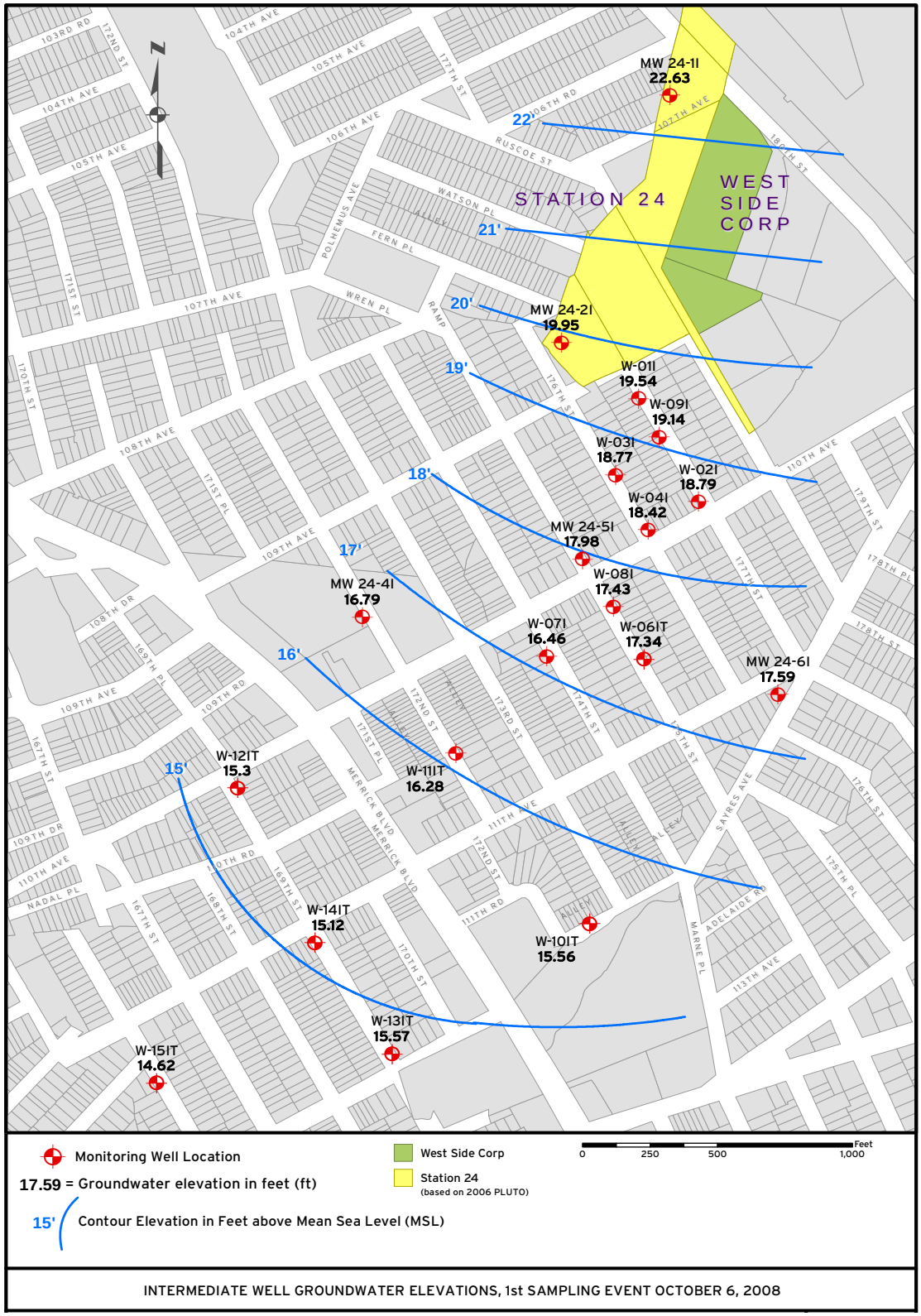


Figure 8-3: Groundwater Elevations: Deep Monitoring Wells

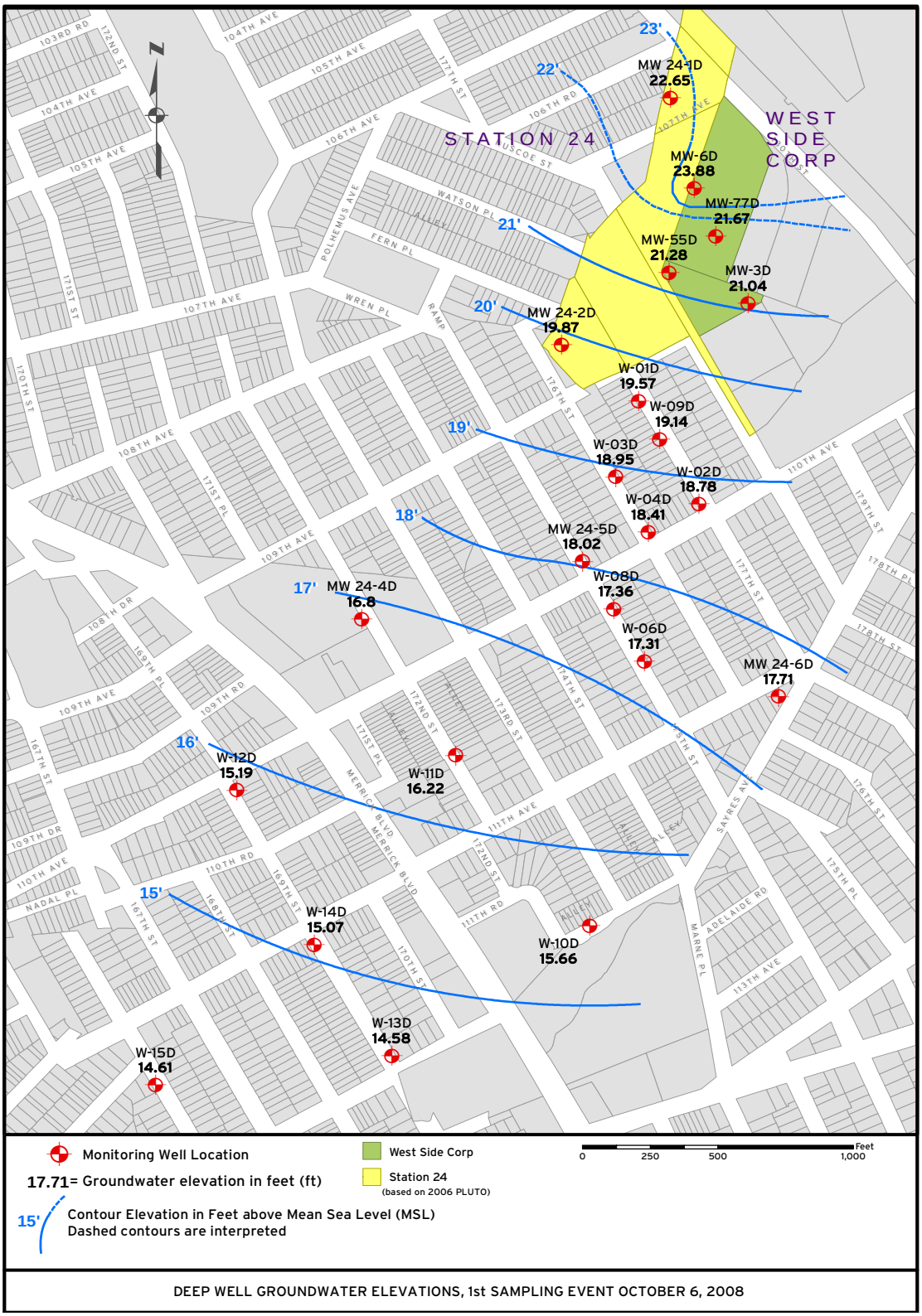
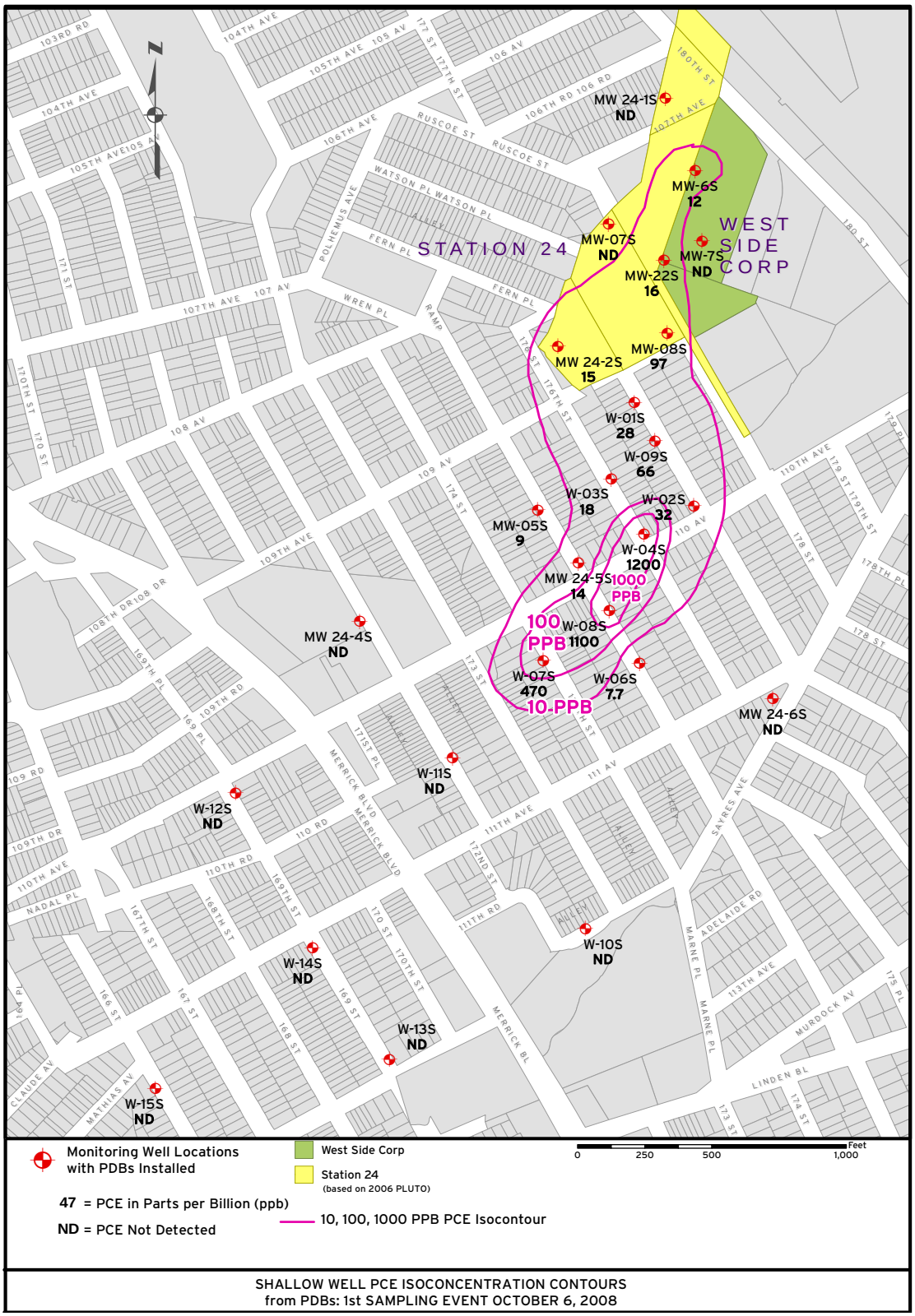


Figure 8-4: PCE in Shallow Monitoring Wells



SHALLOW WELL PCE ISOCONCENTRATION CONTOURS
from PDBs: 1st SAMPLING EVENT OCTOBER 6, 2008

Figure 8-5: PCE in Intermediate Monitoring Wells

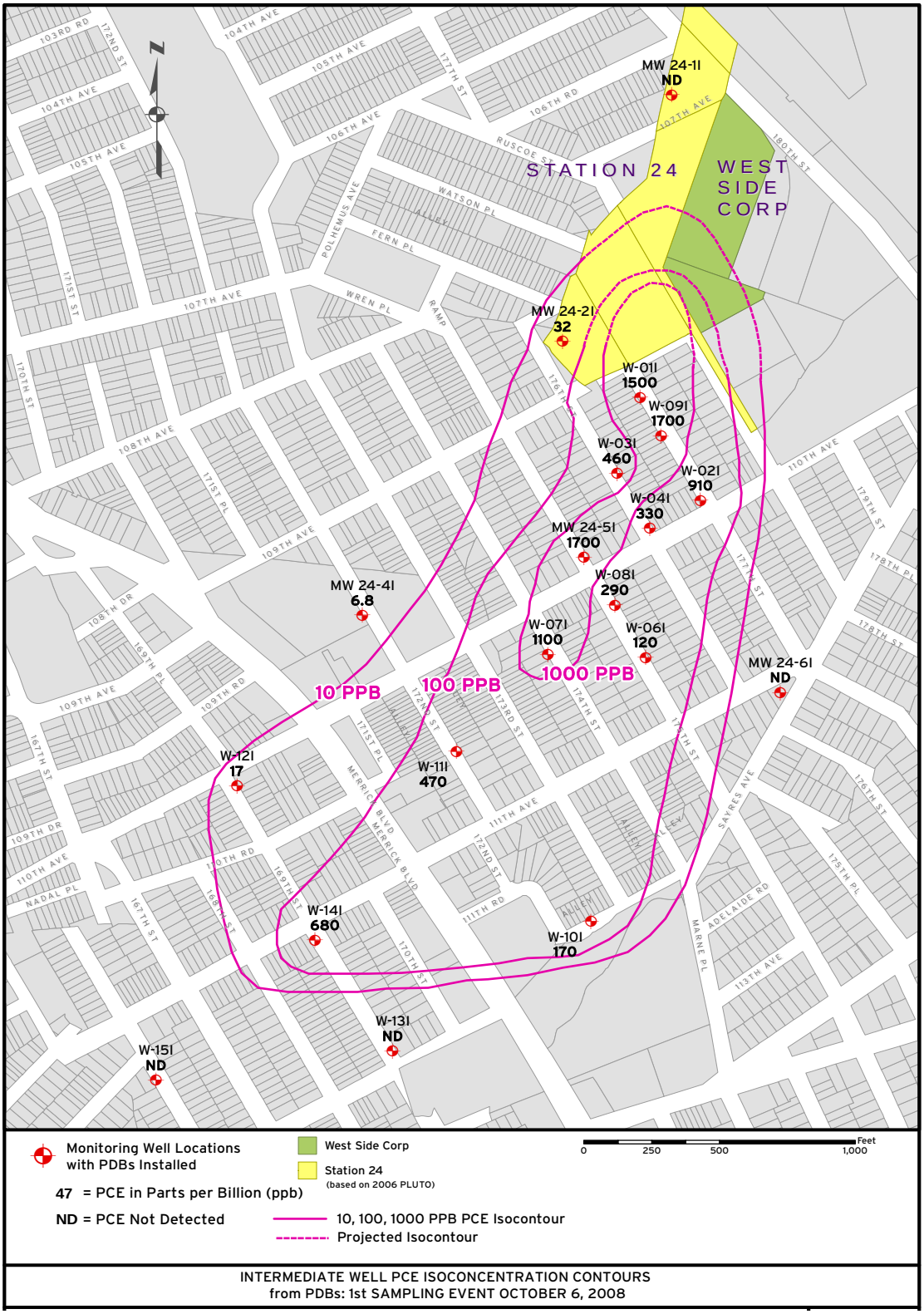
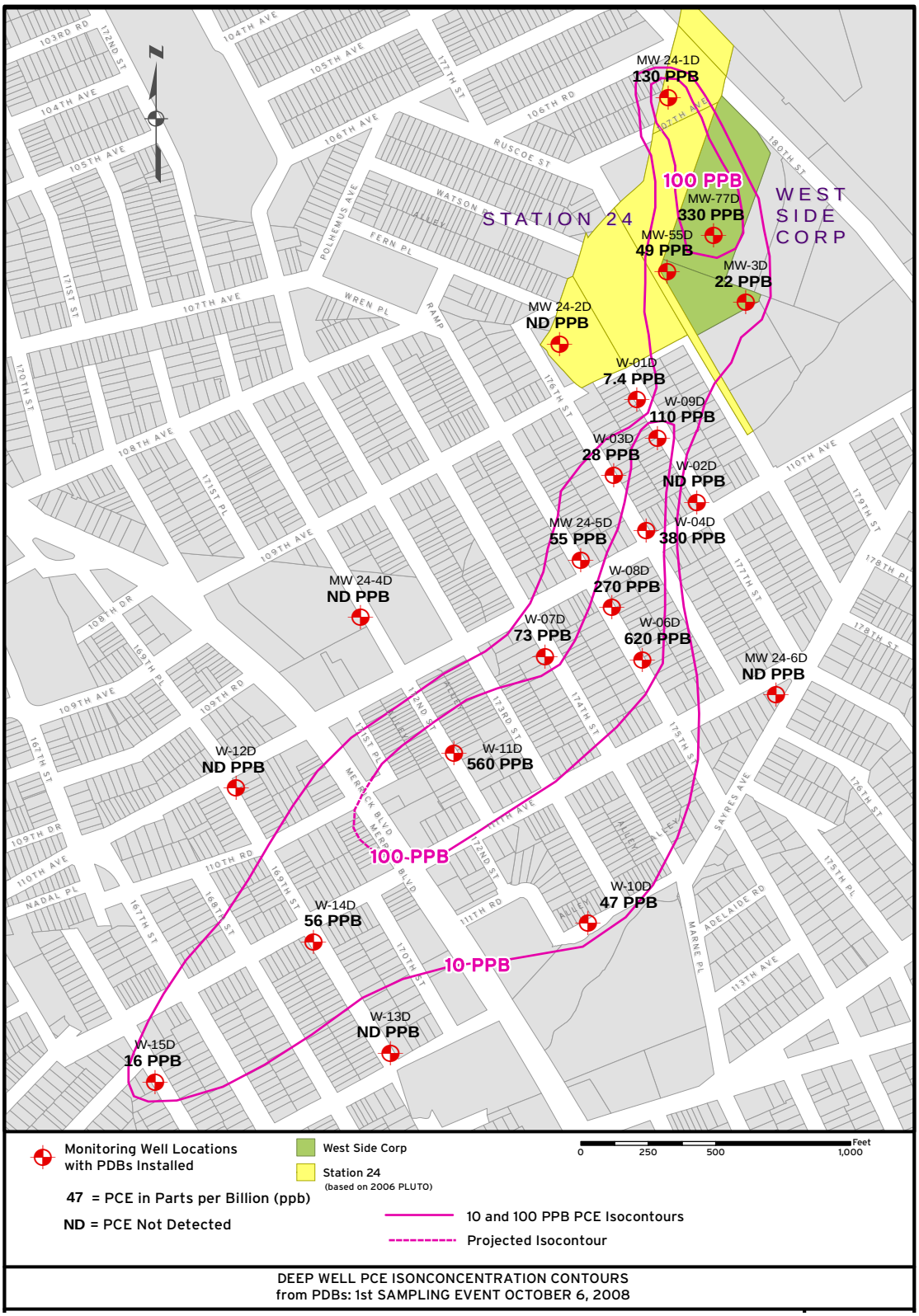
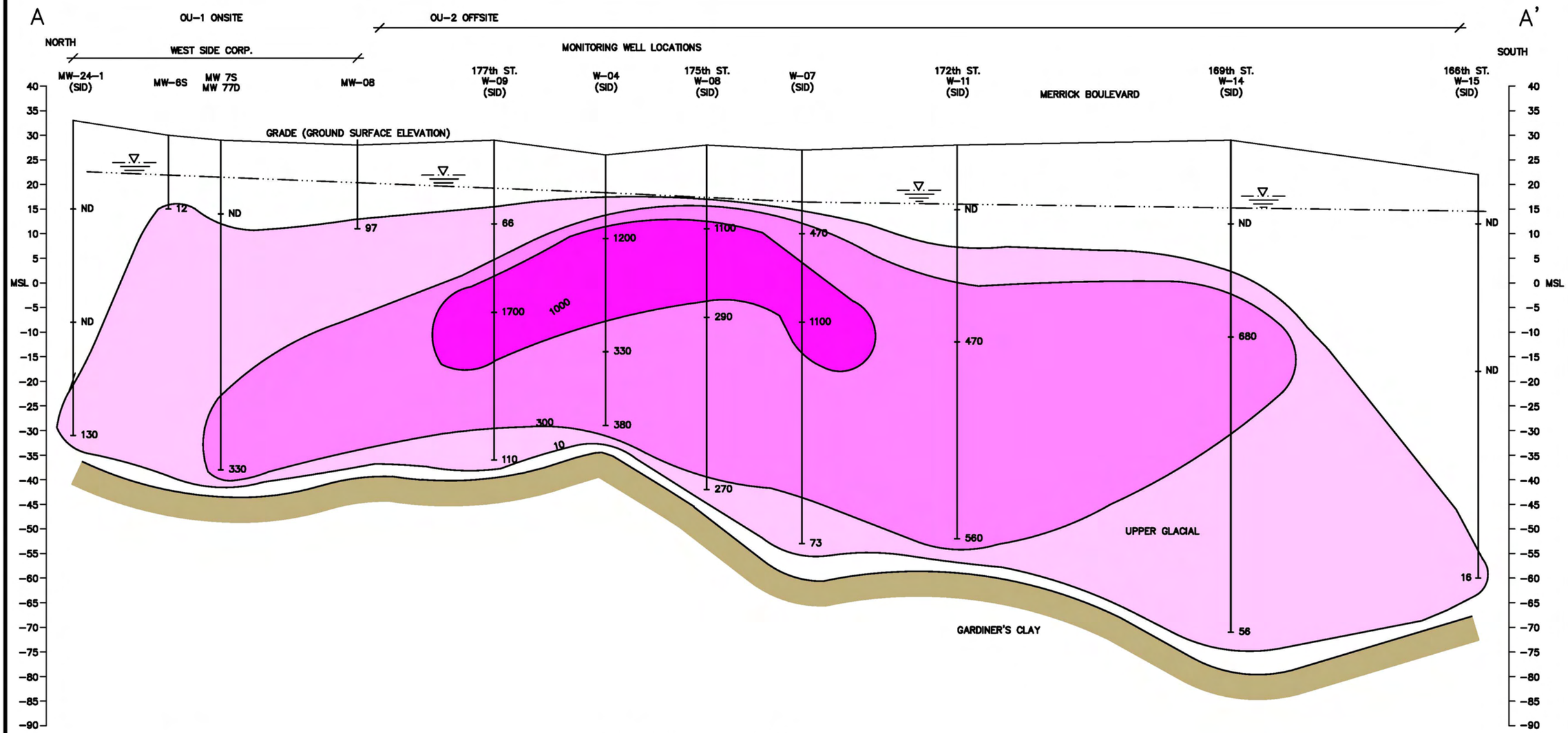


Figure 8-6: PCE in Deep Monitoring Wells





LEGEND

B-41 BOREHOLE

256 PCE IN ug/L (ppb)

DASHED LINE INDICATES PROJECTED ISOCONTOUR

10 ISOCONCENTRATION CONTOUR

NOTE: DEPTHS OF PDBs AND (PCE) ARE AT WELL SCREEN MIDPOINT.

COLOR KEY

≥10 ug/L

≥300 ug/L

≥1000 ug/L

HORIZONTAL SCALE: 1" = 320'

MALCOLM PIRNIE

NYSDEC
WESTSIDE CORP. OU-2, JAMAICA, QUEENS
PASSIVE DIFFUSION BAG SAMPLING DATE 10.06.08
PERCHLOROETHENE (PCE) IN GROUNDWATER
CROSS SECTION LOOKING EAST INTO PLUME FROM CENTERLINE A-A'

MALCOLM PIRNIE, INC.

FIGURE 8-7

User:mckenna Spec:PIRNIE STANDARD File:I:\0266375\SECTION A-A-2.DWG Scale:1:1 Date:02/26/2009 Time:10:25 Layout:Layout1
XREFS: IMAGES:J:\0266375\plume3.cal K:\Symbols2000\Pirnie Standard\Gen\MPI Title Blocks\MPLOGOBK_NoBleed.jpg

Figure 8-8: Station 24 Proposed Recovery Well Drawdown Following 1-year of Pumping

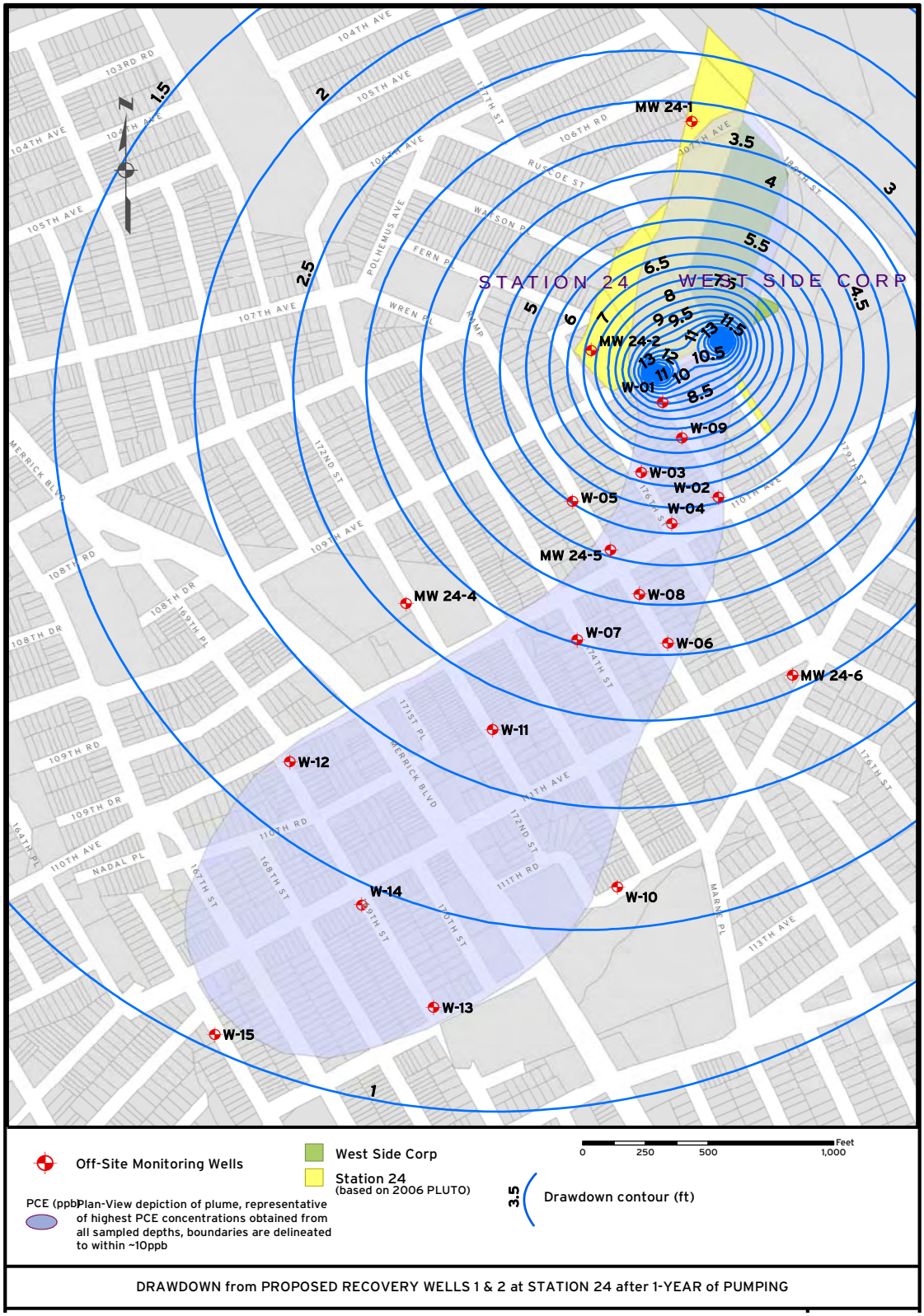
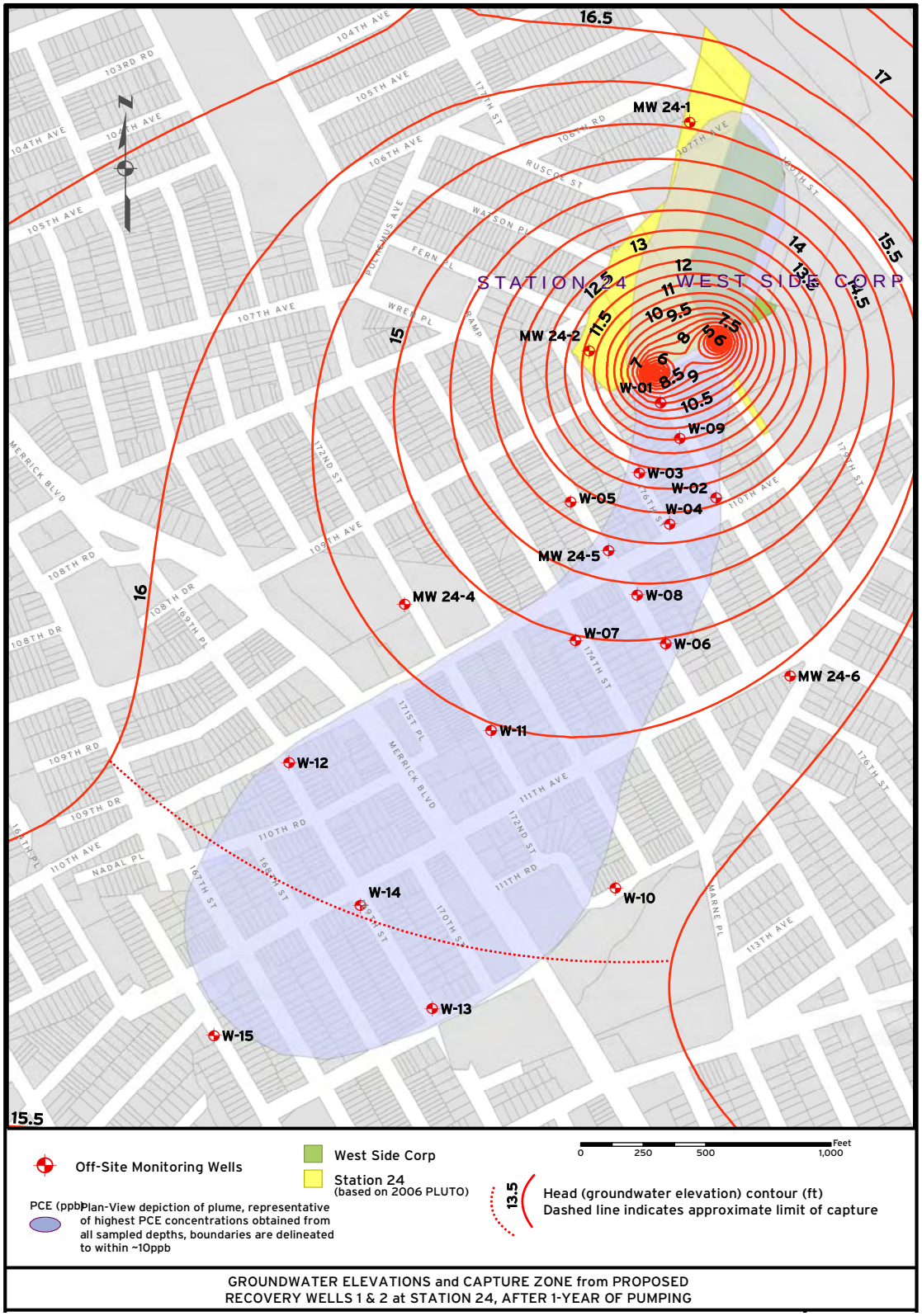


Figure 8-9: OU-1 and OU-2 Groundwater Elevation Following 1-year of Pumping



GROUNDWATER ELEVATIONS and CAPTURE ZONE from PROPOSED RECOVERY WELLS 1 & 2 at STATION 24, AFTER 1-YEAR OF PUMPING