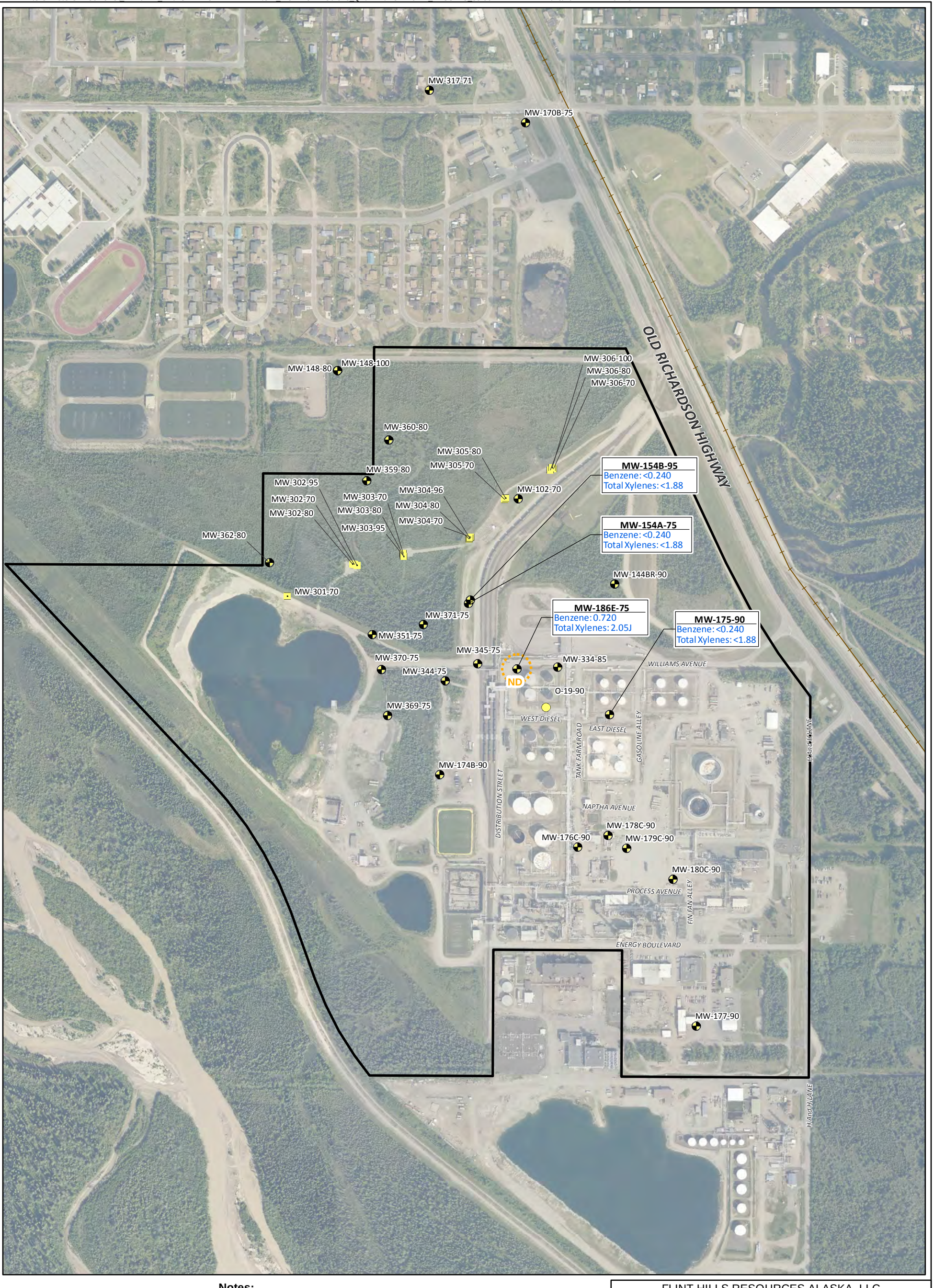
CITY: HIGHLANDS RANCH, CO DIV/GROUP: ENV/IM DB: BGRIFFITH LD: G FRANCE
PATH: W:\GISPRJ\GISPROJECTS_ENV\FHR_AK\NORTHPOLEREFINERY\GW_MONITORING\2013_Q4\MXD\FIG 4-16 BX_RESULTS_55-90FT.MXD DATE: 1/29/2014 TIME: 2:02:43 PM



Legend:

- Monitoring Well
- Vertical Profile Transect Well
- Observation Well
- Inferred benzene isopleth in micrograms per liter (µg/L)
- FHRA Property Boundary

Notes:

< Not detected; detection limit listed
J Estimated concentration, detected above the detection limit (DL) and below the limit of quantitation (LOQ)
ND Not Detected
-Results are displayed in micrograms per liter (µg/L)
-Total Xylenes calculated by SWI as the sum of o-, p- and m- xylenes
-Image provided courtesy of Pictometry International 2012

0 500 1,000
SCALE IN FEET

FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

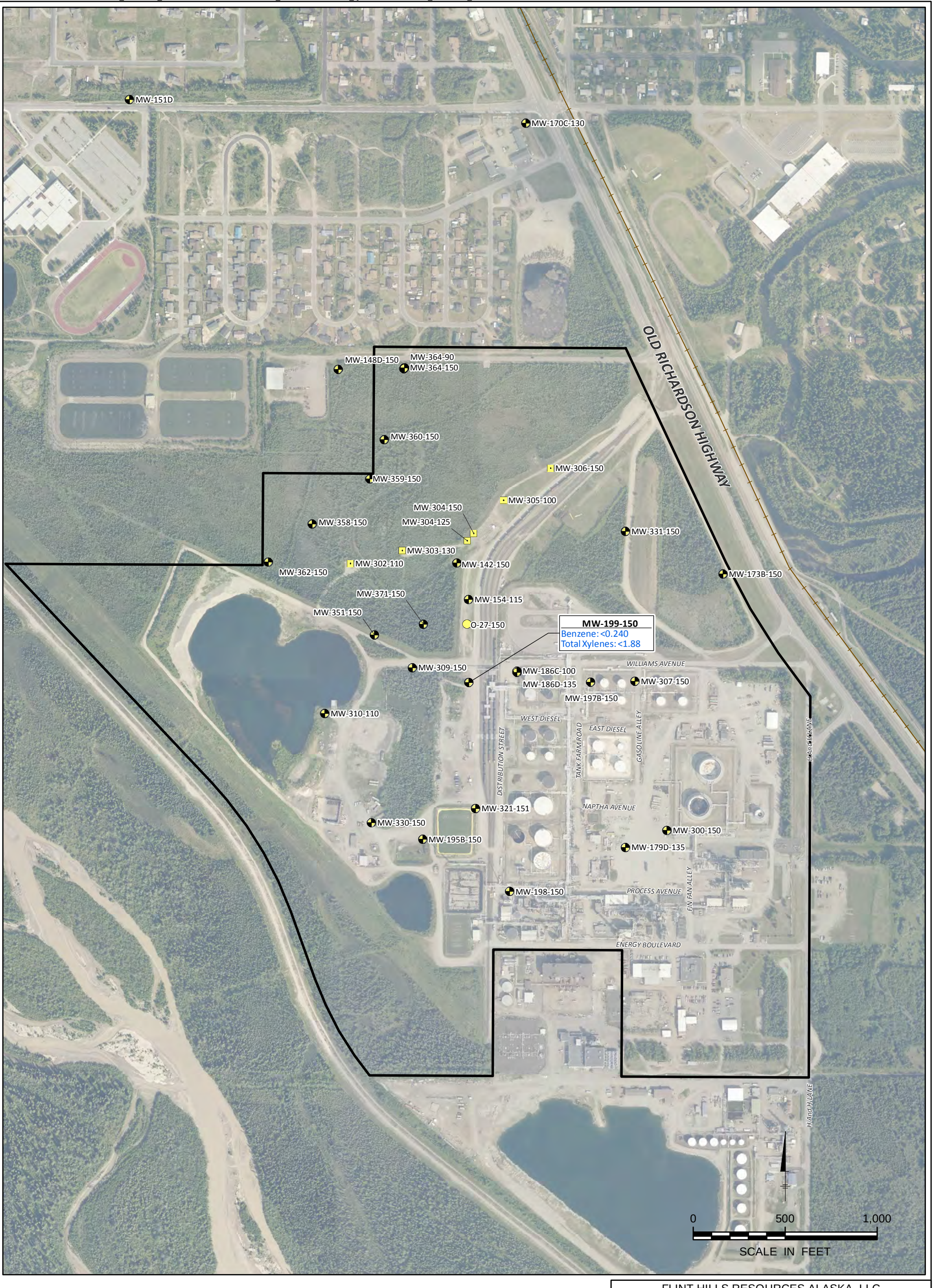
FOURTH QUARTER 2013 GROUNDWATER MONITORING REPORT

ANALYTICAL RESULTS FOR BENZENE AND TOTAL XYLENES 55 - 90 FEET BELOW WATER TABLE

ARCADIS

FIGURE
4-16

CITY: HIGHLANDS RANCH, CO DIV/GROUP: ENV/IM DB: BGRIFFITH LD: G FRANCE
PATH: W:\GISPRJ\GISPROJECTS_ENV\FHR_AK\NORTHPOLEREFINERY\GW_MONITORING\2013_Q4\MXD\FIG 4-17 BX_RESULTS_90-160FT.MXD DATE: 1/27/2014 TIME: 12:39:00 PM



Legend:

- Observation Well
- Monitoring Well
- Vertical Profile Transect Well
- FHRA Property Boundary

Notes:

< Not detected; detection limit listed
-Results are displayed in micrograms per liter (µg/L)
-Image provided courtesy of Pictometry International 2012

FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

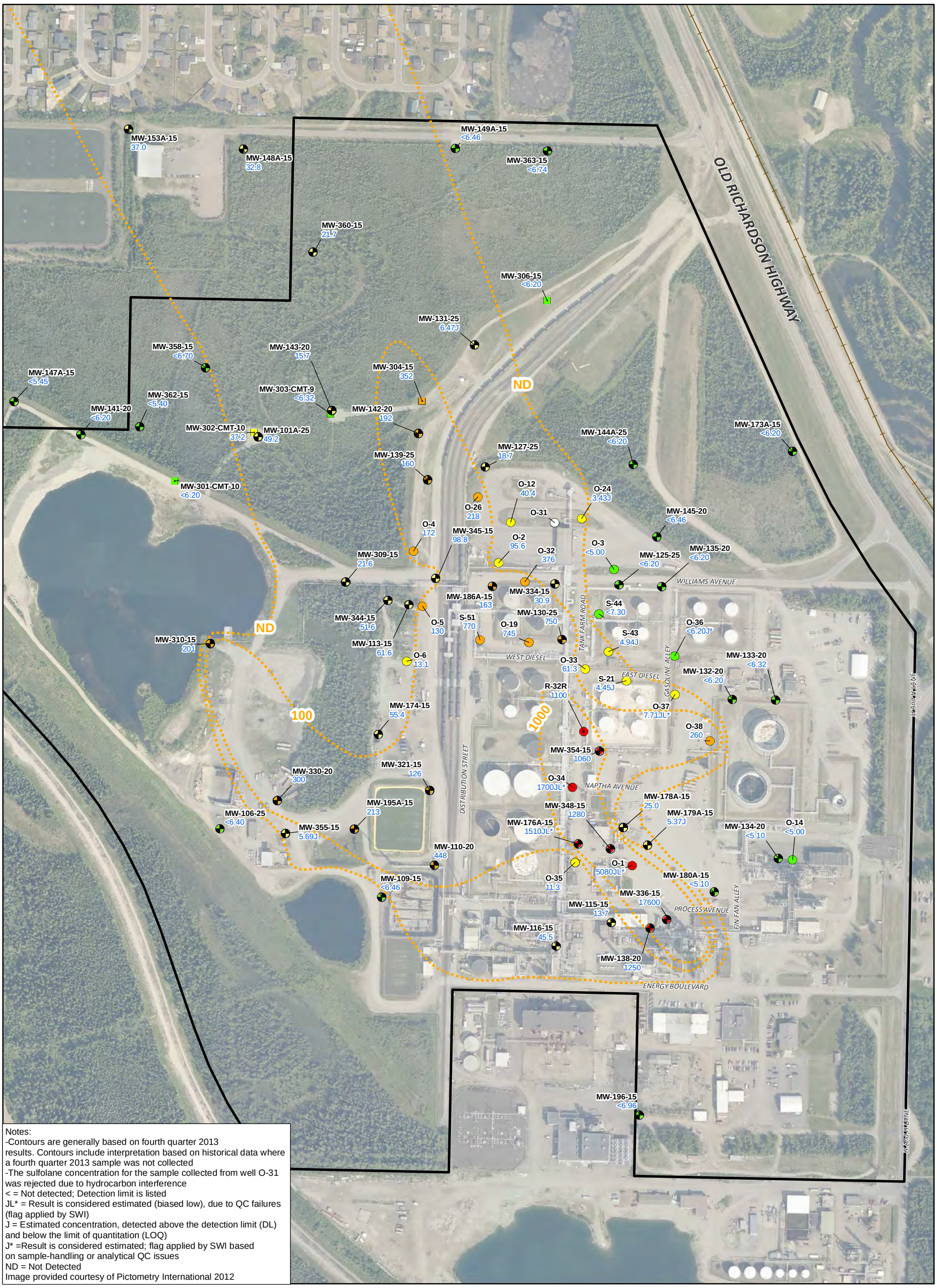
FOURTH QUARTER 2013
GROUNDWATER MONITORING REPORT

ANALYTICAL RESULTS FOR BENZENE AND TOTAL XYLENES 90 - 160 FEET BELOW WATER TABLE

ARCADIS

FIGURE
4-17

CITY: HIGHLANDS RANCH, CO DIV/GROUP: ENV/IM DB: BGRIFFITH LD: G FRANCE
PATH: W:\GISPRJ\GISPROJECTS_ENV\FHR_AK\NORTHPOLEREFINERY\GW_MONITORING\2013_Q4\MXD\FIG 4-18 ONSITEGWSULFOLANERESULTS_WT.MXD DATE: 1/30/2014 TIME: 3:10:27 PM



Notes:
-Contours are generally based on fourth quarter 2013 results. Contours include interpretation based on historical data where a fourth quarter 2013 sample was not collected
-The sulfolane concentration for the sample collected from well O-31 was rejected due to hydrocarbon interference
< = Not detected; Detection limit is listed
JL* = Result is considered estimated (biased low), due to QC failures (flag applied by SWI)
J = Estimated concentration, detected above the detection limit (DL) and below the limit of quantitation (LOQ)
J* =Result is considered estimated; flag applied by SWI based on sample-handling or analytical QC issues
ND = Not Detected
Image provided courtesy of Pictometry International 2012

Legend

- Monitoring Well
- Observation Well
- Recovery Well
- Vertical Profile Transect Well
- Approximate Sulfolane Isopleth in µg/L at Water Table
- FHRA Property Boundary

Sulfolane Results

- Not Detected
- 3.1 - 100 µg/L
- 100 - 1,000 µg/L
- >1,000 µg/L

0 350 700
SCALE IN FEET

FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

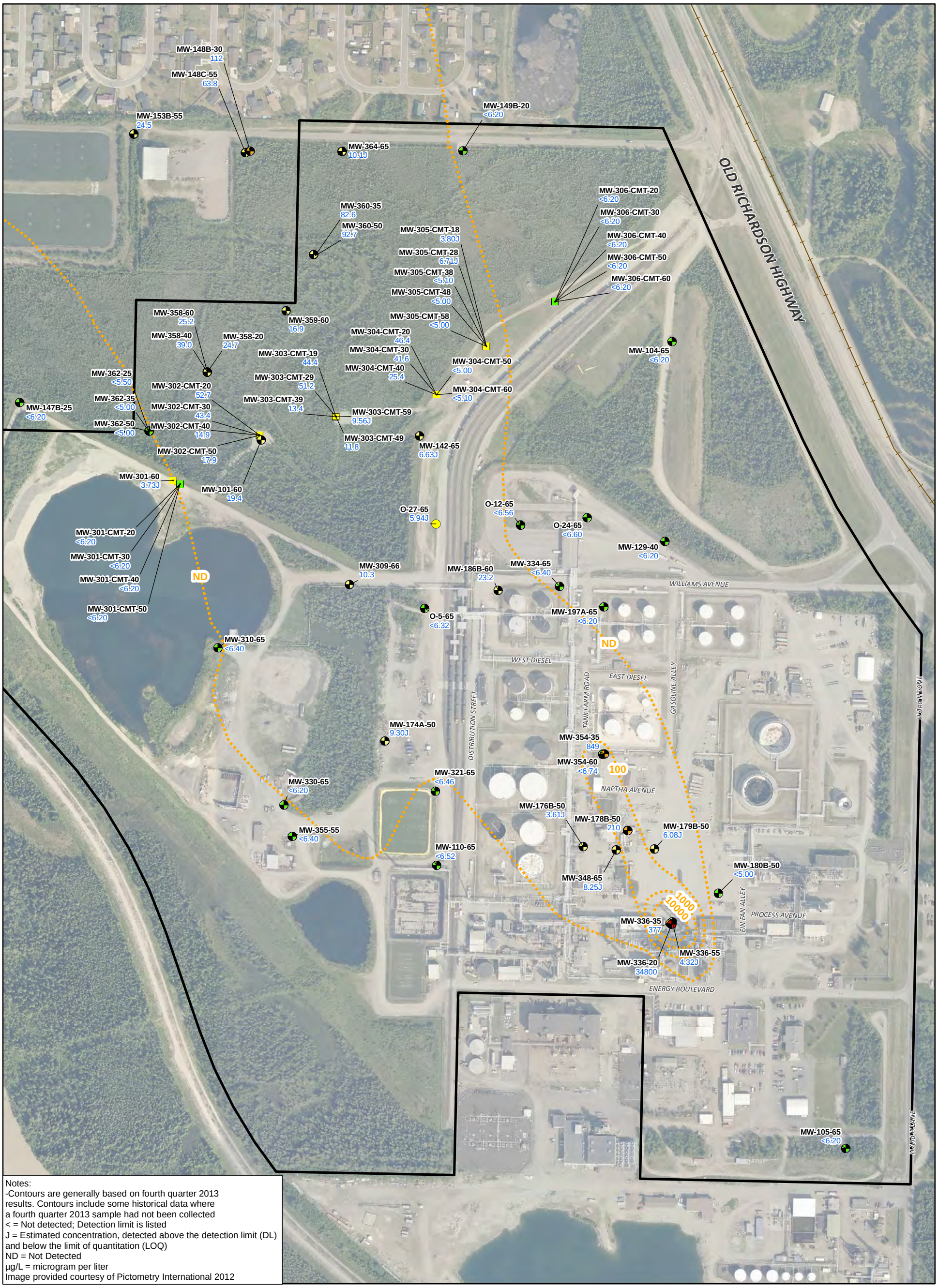
FOURTH QUARTER 2013 GROUNDWATER MONITORING REPORT

ONSITE SULFOLANE GROUNDWATER ANALYTICAL RESULTS - WATER TABLE

ARCADIS

FIGURE
4-18

CITY: HIGHLANDS RANCH, CO DIV/GROUP: ENV/IM DB: BGRIFFITH LD: G FRANCE
PATH: W:\GISPRJ\GISPROJECTS_ENV\FHR_AK\NORTHPOLEREFINERY\GW_MONITORING\2013_Q4\MXD\FIG 4-19 ONSITEGWSULFOLANERESULTS_10TO55.MXD DATE: 1/30/2014 TIME: 3:10:05 PM



Notes:
-Contours are generally based on fourth quarter 2013 results. Contours include some historical data where a fourth quarter 2013 sample had not been collected
< = Not detected; Detection limit is listed
J = Estimated concentration, detected above the detection limit (DL) and below the limit of quantitation (LOQ)
ND = Not Detected
µg/L = microgram per liter
Image provided courtesy of Pictometry International 2012

Legend

- Monitoring Well
- Observation Well
- Vertical Profile Transect Well
- Approximate Sulfolane Isopleth in µg/L
- FHRA Property Boundary

Sulfolane Results

- Not Detected
- 3.1 - 100 µg/L
- 100 - 1,000 µg/L
- > 1,000 µg/L

0 350 700
SCALE IN FEET

FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

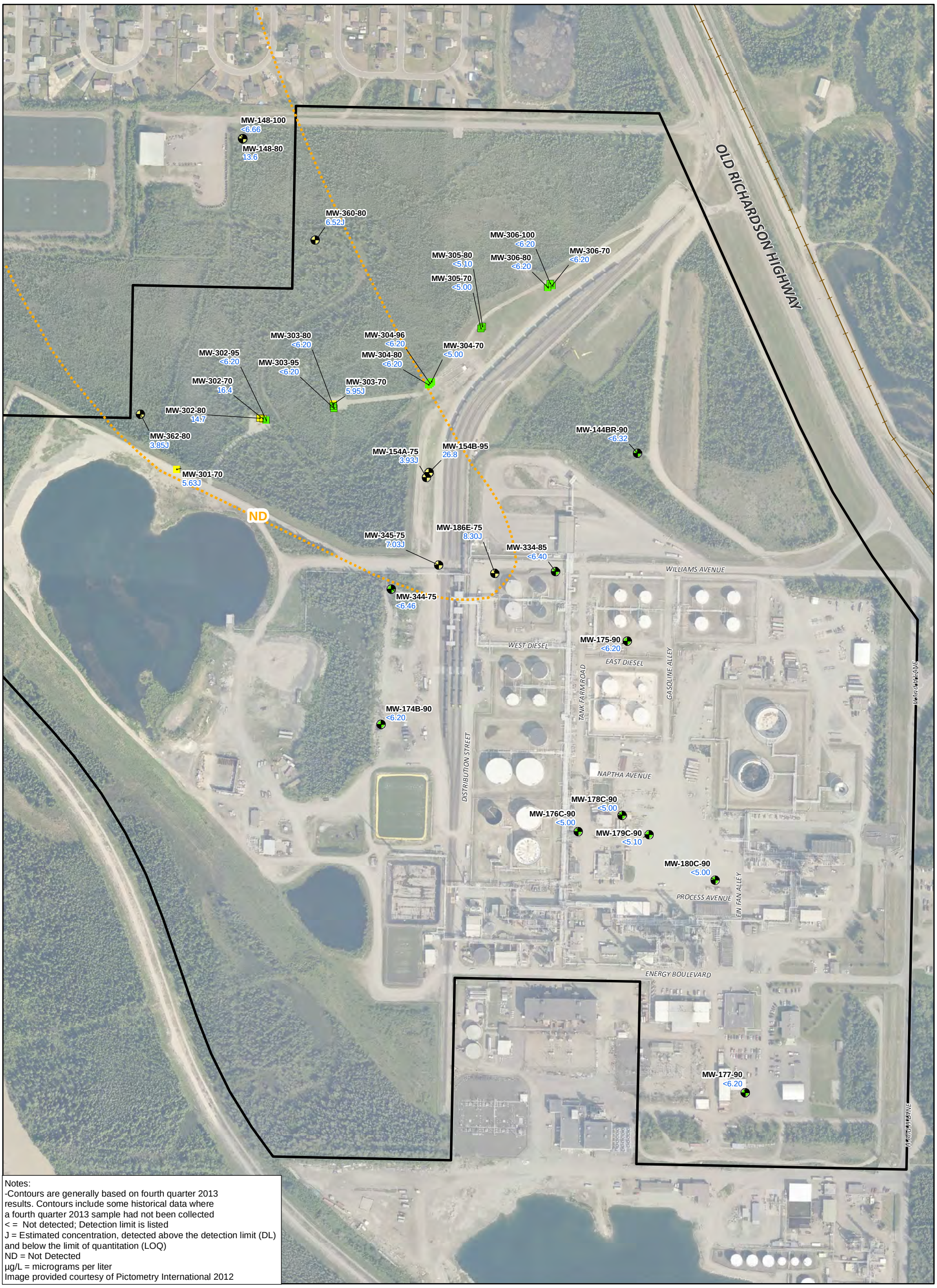
FOURTH QUARTER 2013 GROUNDWATER MONITORING REPORT

ONSITE SULFOLANE GROUNDWATER ANALYTICAL RESULTS - 10 TO 55 FEET BELOW WATER TABLE

ARCADIS

FIGURE
4-19

CITY: HIGHLANDS RANCH, CO DIV/GROUP: ENV/IM DB: BGRIFFITH LD: G FRANCE
PATH: W:\GISPRJ\GISPROJECTS_ENV\FHR_AK\NORTHPOLEREFINERY\GW_MONITORING\2013_Q4\MXD\FIG 4-20 ONSITEGWSULFOLANERESULTS_55TO90.MXD DATE: 1/30/2014 TIME: 3:11:10 PM



Notes:
-Contours are generally based on fourth quarter 2013 results. Contours include some historical data where a fourth quarter 2013 sample had not been collected
< = Not detected; Detection limit is listed
J = Estimated concentration, detected above the detection limit (DL) and below the limit of quantitation (LOQ)
ND = Not Detected
µg/L = micrograms per liter
Image provided courtesy of Pictometry International 2012

Legend

- Monitoring Well
- Vertical Profile Transect Well
- Approximate Sulfolane Isopleth in µg/L
- FHRA Property Boundary

Sulfolane Results

- Not Detected
- 3.1 - 100 µg/L
- 100 - 1,000 µg/L
- >1,000 µg/L

0 350 700
SCALE IN FEET

FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

FOURTH QUARTER 2013 GROUNDWATER MONITORING REPORT

ONSITE SULFOLANE GROUNDWATER ANALYTICAL RESULTS - 55 TO 90 FEET BELOW WATER TABLE

ARCADIS

FIGURE
4-20

CITY: HIGHLANDS RANCH, CO DIV/GROUP: ENV/IM DB: BGRIFFITH LD: G FRANCE
PATH: W:\GISPRJ\GISPROJECTS_ENV\FHR_AK\NORTHPOLEREFINERY\GW_MONITORING\2013_Q4\MXD\FIG 4-21 ONSITEGWSULFOLANERESULTS_90TO160.MXD DATE: 1/30/2014 TIME: 3:10:47 PM

Notes:
< = Not detected; detection limit is listed
µg/L = micrograms per liter
Image provided courtesy of Pictometry International 2012

Legend

- Monitoring Well
- Observation Well
- Vertical Profile Transect Well
- FHRA Property Boundary

Sulfolane Results

- Not Detected
- 3.1 - 100 µg/L
- 100 - 1,000 µg/L
- > 1,000 µg/L

0 300 600
SCALE IN FEET

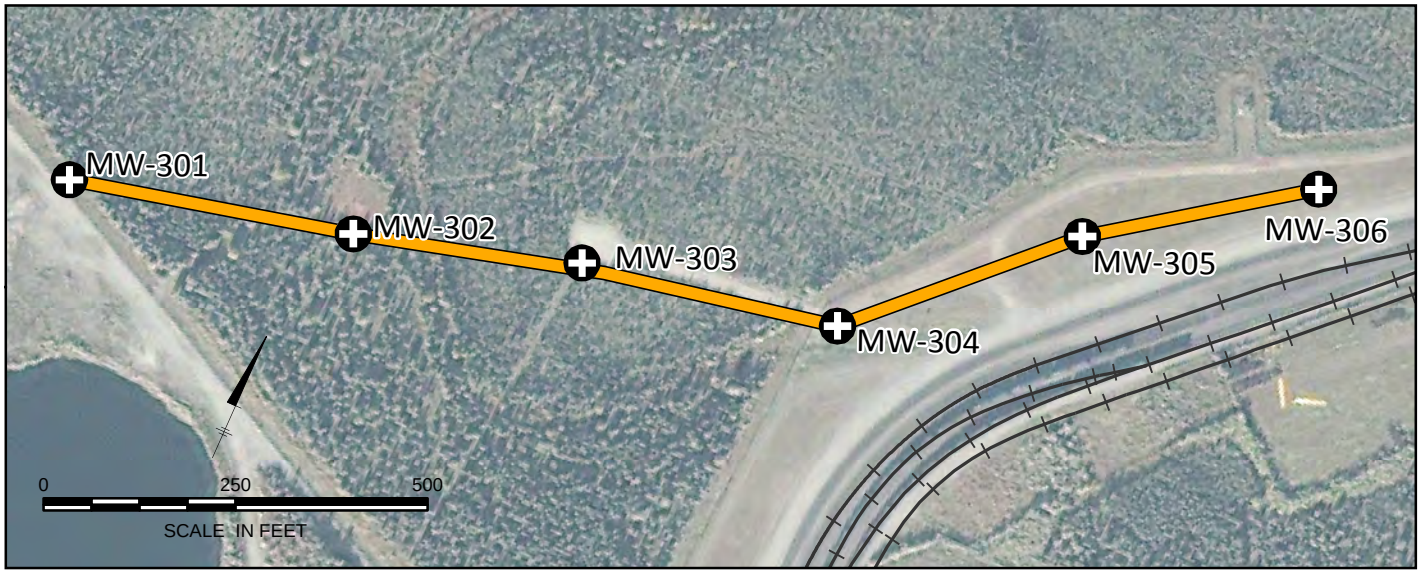
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

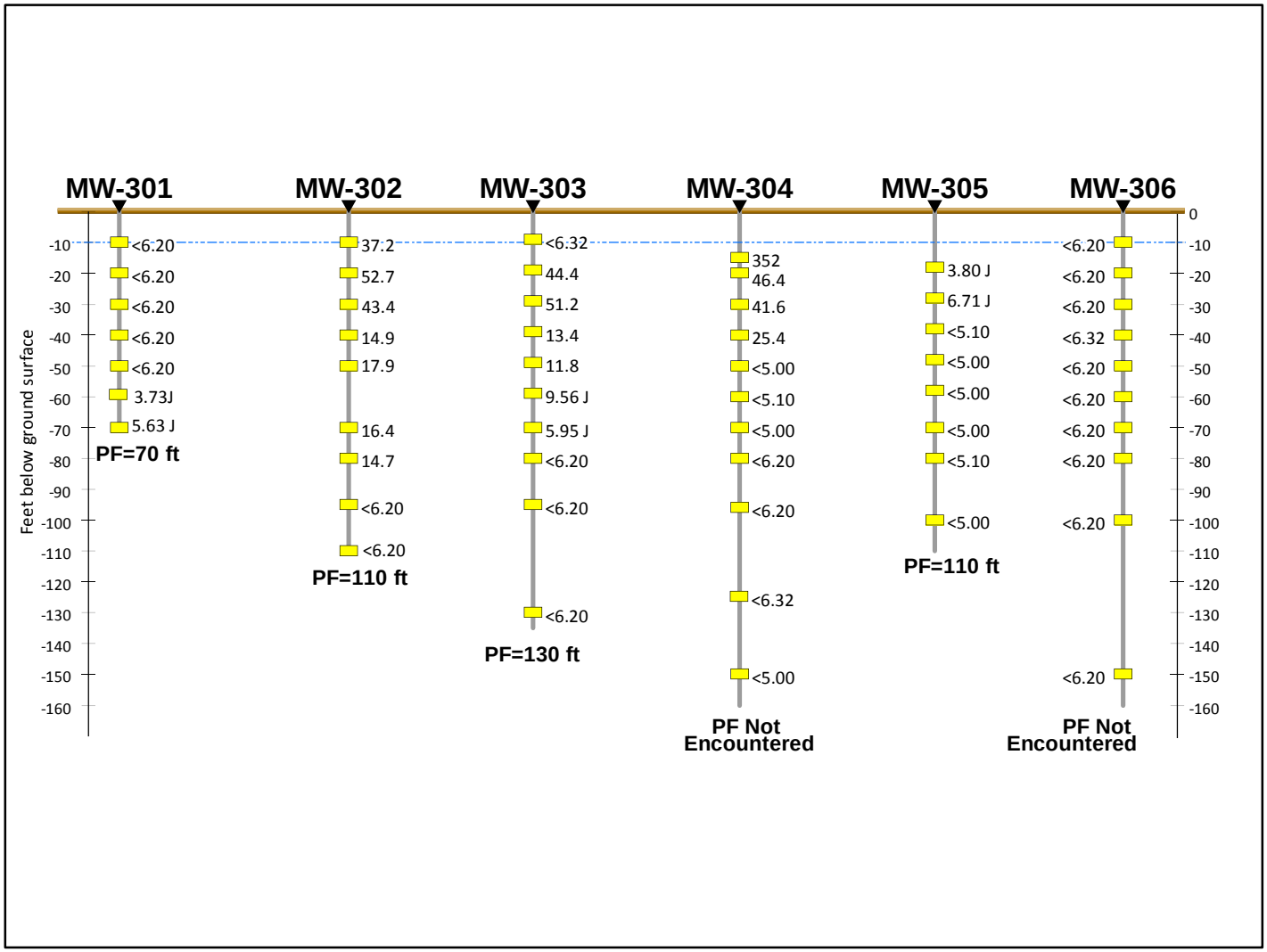
FOURTH QUARTER 2013 GROUNDWATER MONITORING REPORT

ONSITE SULFOLANE GROUNDWATER ANALYTICAL RESULTS - 90 TO 160 FEET BELOW WATER TABLE

ARCADIS

FIGURE
4-21





LEGEND:

- Sulfolane Results in microgram per liter
- Ground Surface
- Approximate Groundwater Surface
- Well Profile

NOTES:

Profile has a vertical exaggeration of 5x
< = Not detected; limit of detection (LOD) listed
J = Estimated concentration
PF= Permafrost encountered at bottom of boring.
ft = feet

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NORTH POLE REFINERY, NORTH POLE, ALASKA

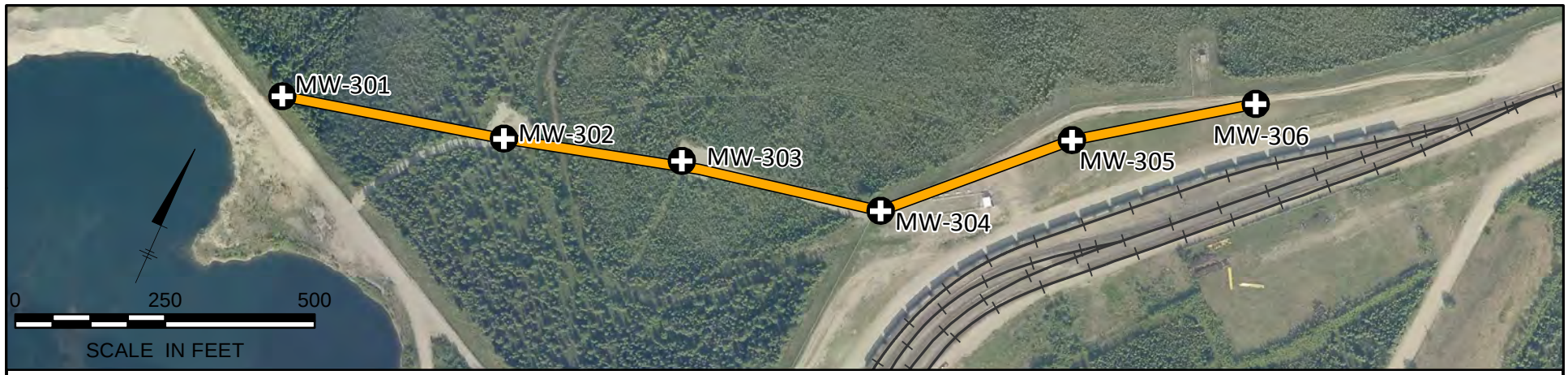
FOURTH QUARTER 2013 GROUNDWATER MONITORING REPORT

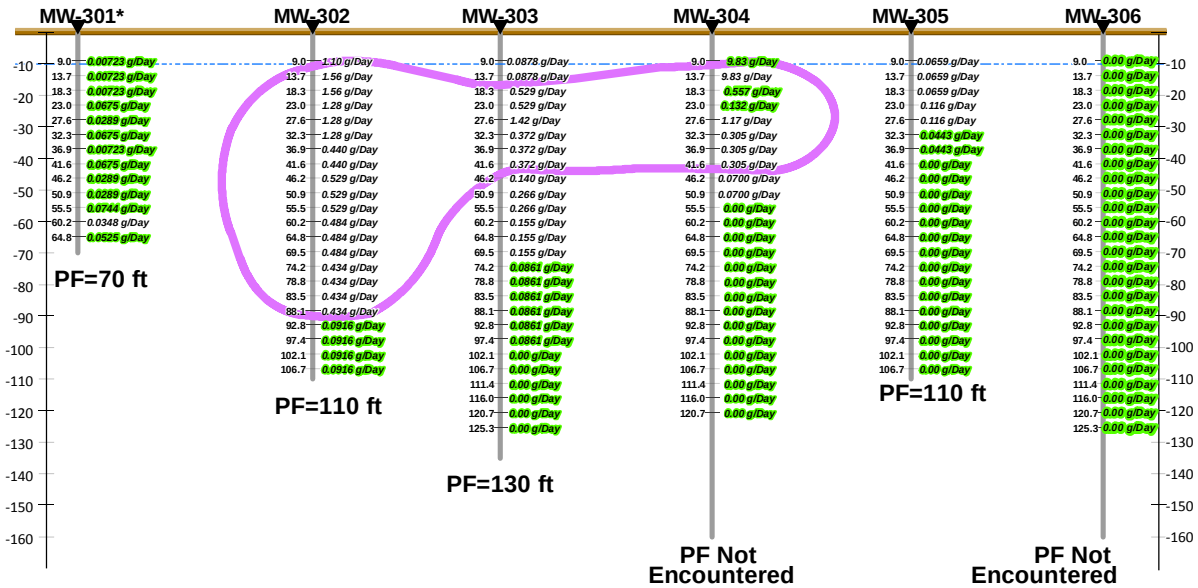
SULFOLANE AT THE VERTICAL PROFILING TRANSECT

ARCADIS

FIGURE
4-22

CITY: HIGHLANDS RANCH, CO DIV/GROUP: ENV/IM DB: BGriffith LD: G FRANCE
Path: W:\GISPrj\GISPROJECTS_ENV\FHR_AK\NorthPoleRefinery\GW_Monitoring\2013_Q4\MXD\Fig 4-22 Sulfolane_VPT_Profile.mxd Date: 1/22/2014 Time: 8:52:27 AM





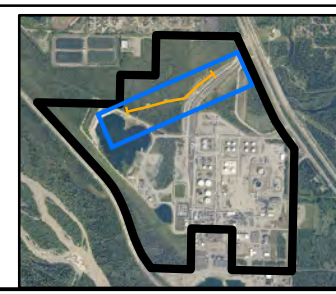
LEGEND:

- Vertical Profile Transect Well
- Ground Surface
- Approximate Groundwater Surface
- Well Profile
- Approximate extent of the 95% of total mass flux

Notes:

Mass flux values shown were calculated using the Mass Flux Toolkit (Farhat et al. 2006)
Depths associated with flux values were determined by the Toolkit.
PF = Permafrost
g/day = grams per day

Highlighted mass flux values are based on non-detect sulfolane concentrations.



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NORTH POLE REFINERY, NORTH POLE, ALASKA
FOURTH QUARTER 2013 GROUNDWATER MONITORING REPORT

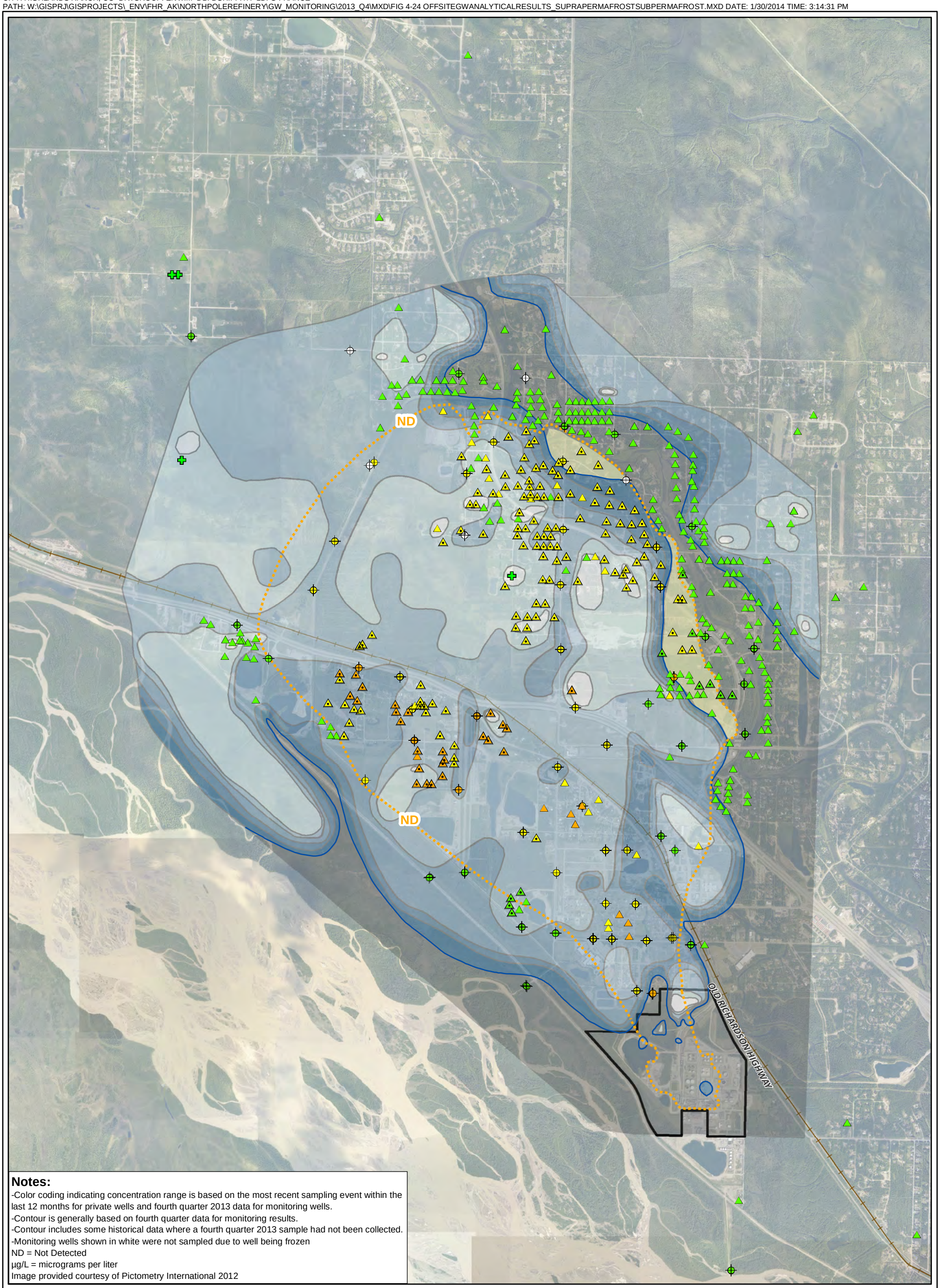
SULFOLANE MASS FLUX RATES FOURTH QUARTER 2013

ARCADIS

FIGURE
4-23

CITY: HIGHLANDS RANCH, CO DIV/GROUP: ENV/IM DB: BGriffith LD: G FRANCE
Path: W:\GISPrj\GISPROJECTS_ENV\FHR_AK\NorthPoleRefinery\GW_Monitoring\2013_Q4\MXD\Fig 4-23 Sulfolane_MassFlux_2013Q4.mxd Date: 1/30/2014 Time: 3:13:49 PM

CITY: HIGHLANDS RANCH, CO DIV/GROUP: ENV/IM DB: BGRIFFITH LD: G FRANCE
PATH: W:\GISPRJ\GISPROJECTS_ENV\FHR_AK\NORTHPOLEREFINERY\GW_MONITORING\2013_Q4\MXD\FIG 4-24 OFFSITEGWANALYTICALRESULTS_SUPRAPERMAFROSTSUBPERMAFROST.MXD DATE: 1/30/2014 TIME: 3:14:31 PM



Notes:
-Color coding indicating concentration range is based on the most recent sampling event within the last 12 months for private wells and fourth quarter 2013 data for monitoring wells.
-Contour is generally based on fourth quarter data for monitoring results.
-Contour includes some historical data where a fourth quarter 2013 sample had not been collected.
-Monitoring wells shown in white were not sampled due to well being frozen
ND = Not Detected
µg/L = micrograms per liter
Image provided courtesy of Pictometry International 2012

Legend
- Monitoring Well
- Point-of-entry treatment system sample collected
- Private Well
- Approximate Sulfolane Isopleth Regardless of Depth in µg/L
- Permafrost Boring
- Suprapermafrost and Subpermafrost mixing zone
- FHRA Property Boundary

Private Well Sulfolane Results
- Not Detected
- 3.1 - 100 µg/L
- 100 - 1,000 µg/L
- > 1,000 µg/L

Monitoring Well Sulfolane Results
- Not Detected
- 3.1 - 100 µg/L
- 100 - 1,000 µg/L
- > 1,000 µg/L

Depth to Top of Permafrost in feet
- < 10
- 10 - 30
- 30 - 60
- 60 - 90
- 90 - 120
- 120 - 150
- > 150

0 2,500 5,000
SCALE IN FEET

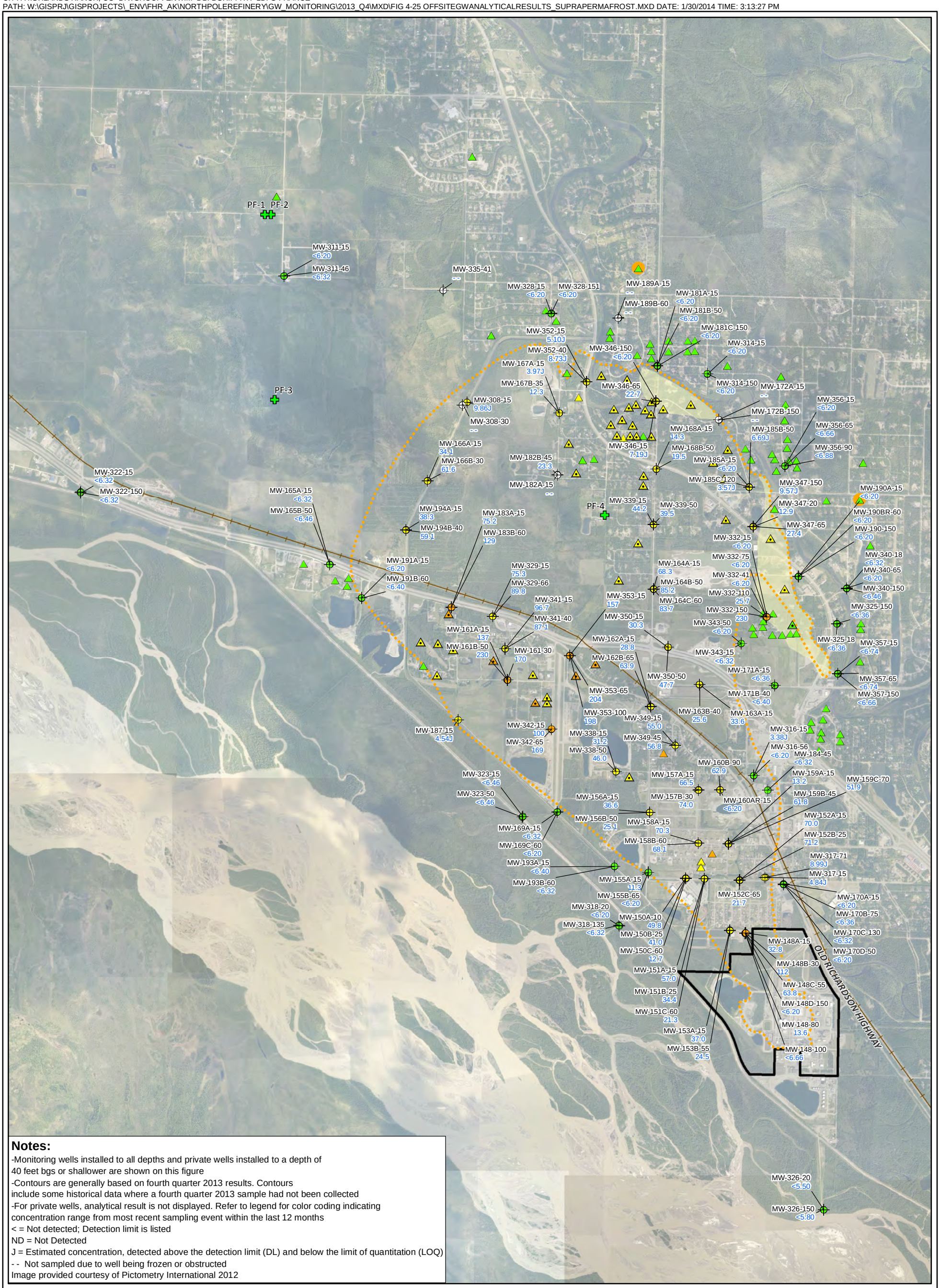
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA
FOURTH QUARTER 2013 GROUNDWATER MONITORING REPORT

APPROXIMATE EXTENT OF SULFOLANE IMPACTS IN OFFSITE MONITORING WELLS AND PRIVATE WELLS IN SUPRAPERMAFROST AND SUBPERMAFROST AQUIFERS

ARCADIS

FIGURE
4-24

CITY: HIGHLANDS RANCH, CO DIV/GROUP: ENV/IM DB: BGRIFFITH LD: G FRANCE
PATH: W:\GISPRJ\GISPROJECTS_ENV\FHR_AK\NORTHPOLEREFINERY\GW_MONITORING\2013_Q4\MXD\FIG 4-25 OFFSITEGWANALYTICALRESULTS_SUPRAPERMAFROST.MXD DATE: 1/30/2014 TIME: 3:13:27 PM



Notes:

-Monitoring wells installed to all depths and private wells installed to a depth of 40 feet bgs or shallower are shown on this figure

-Contours are generally based on fourth quarter 2013 results. Contours include some historical data where a fourth quarter 2013 sample had not been collected

-For private wells, analytical result is not displayed. Refer to legend for color coding indicating concentration range from most recent sampling event within the last 12 months

< = Not detected; Detection limit is listed

ND = Not Detected

J = Estimated concentration, detected above the detection limit (DL) and below the limit of quantitation (LOQ)

- - Not sampled due to well being frozen or obstructed

Image provided courtesy of Pictometry International 2012

Legend

- Monitoring Well
- Private Well
- Point-of-entry treatment system sample collected
- Permafrost at Surface (no shallow groundwater present)
- Initial Result from Fourth Quarter 2013
- Approximate Sulfolane Isopleth in µg/L
- Suprapermafrost and Subpermafrost mixing zone
- FHRA Property Boundary

Private Well Sulfolane Results

- Not Detected
- 3.1 - 100 µg/L
- 100 - 1,000 µg/L
- > 1,000 µg/L

Monitoring Well Sulfolane Results

- Not Detected
- 3.1 - 100 µg/L
- 100 - 1,000 µg/L
- > 1,000 µg/L

0 2,500 5,000

SCALE IN FEET

FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

FOURTH QUARTER 2013 GROUNDWATER MONITORING REPORT

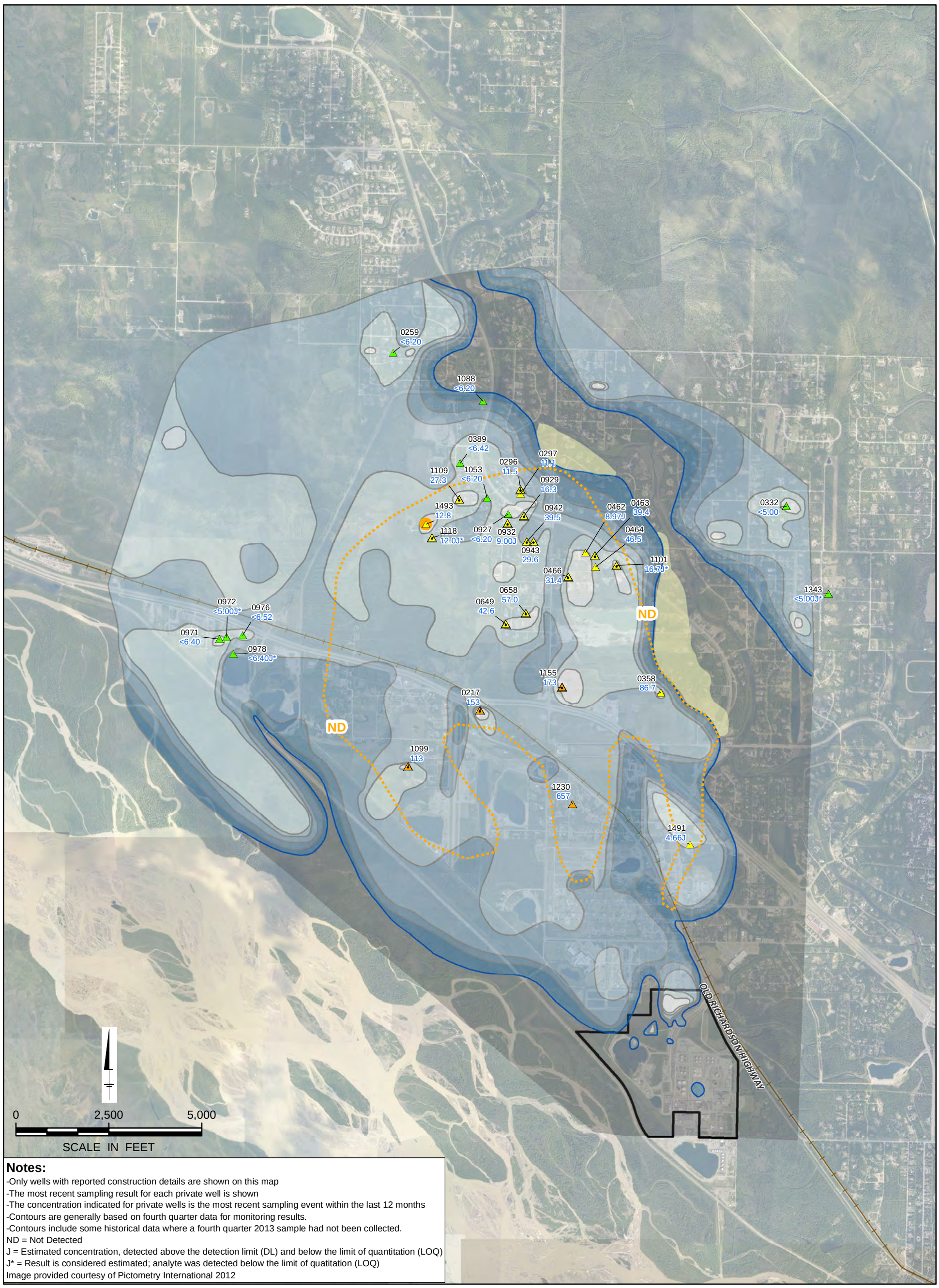
GROUNDWATER ANALYTICAL RESULTS FROM OFFSITE MONITORING WELLS AND PRIVATE WELLS SCREENED IN THE SUPRAPERMAFROST AQUIFER

ARCADIS

FIGURE

4-25

CITY: HIGHLANDS RANCH, CO DIV/GROUP: ENV/IM DB: BGRIFFITH LD: G FRANCE
PATH: W:\GISPRJ\GISPROJECTS_ENV\FHR_AK\NORTHPOLEREFINERY\GW_MONITORING\2013_Q4\MXD\FIG 4-26 OFFSITEGWANALYTICALRESULTS_SUBPERMAFROST.MXD DATE: 1/29/2014 TIME: 2:48:51 PM



Notes:
-Only wells with reported construction details are shown on this map
-The most recent sampling result for each private well is shown
-The concentration indicated for private wells is the most recent sampling event within the last 12 months
-Contours are generally based on fourth quarter data for monitoring results.
-Contours include some historical data where a fourth quarter 2013 sample had not been collected.
ND = Not Detected
J = Estimated concentration, detected above the detection limit (DL) and below the limit of quantitation (LOQ)
J* = Result is considered estimated; analyte was detected below the limit of quatitation (LOQ)
Image provided courtesy of Pictometry International 2012

Legend
- Point-of-entry treatment system sample collected
- Private Well
- Initial Result from Fourth Quarter 2013
- Approximate Sulfolane Isopleth in µg/L
- Suprapermafrost and Subpermafrost mixing zone
- FHRA Property Boundary

Private Well Sulfolane Results
- Not Detected
- 3.1 - 100 µg/L
- 100 - 1,000 µg/L
- > 1,000 µg/L

Depth to Top of Permafrost in feet
- < 10
- 10 - 30
- 30 - 60
- 60 - 90
- 90 - 120
- 120 - 150
- > 150

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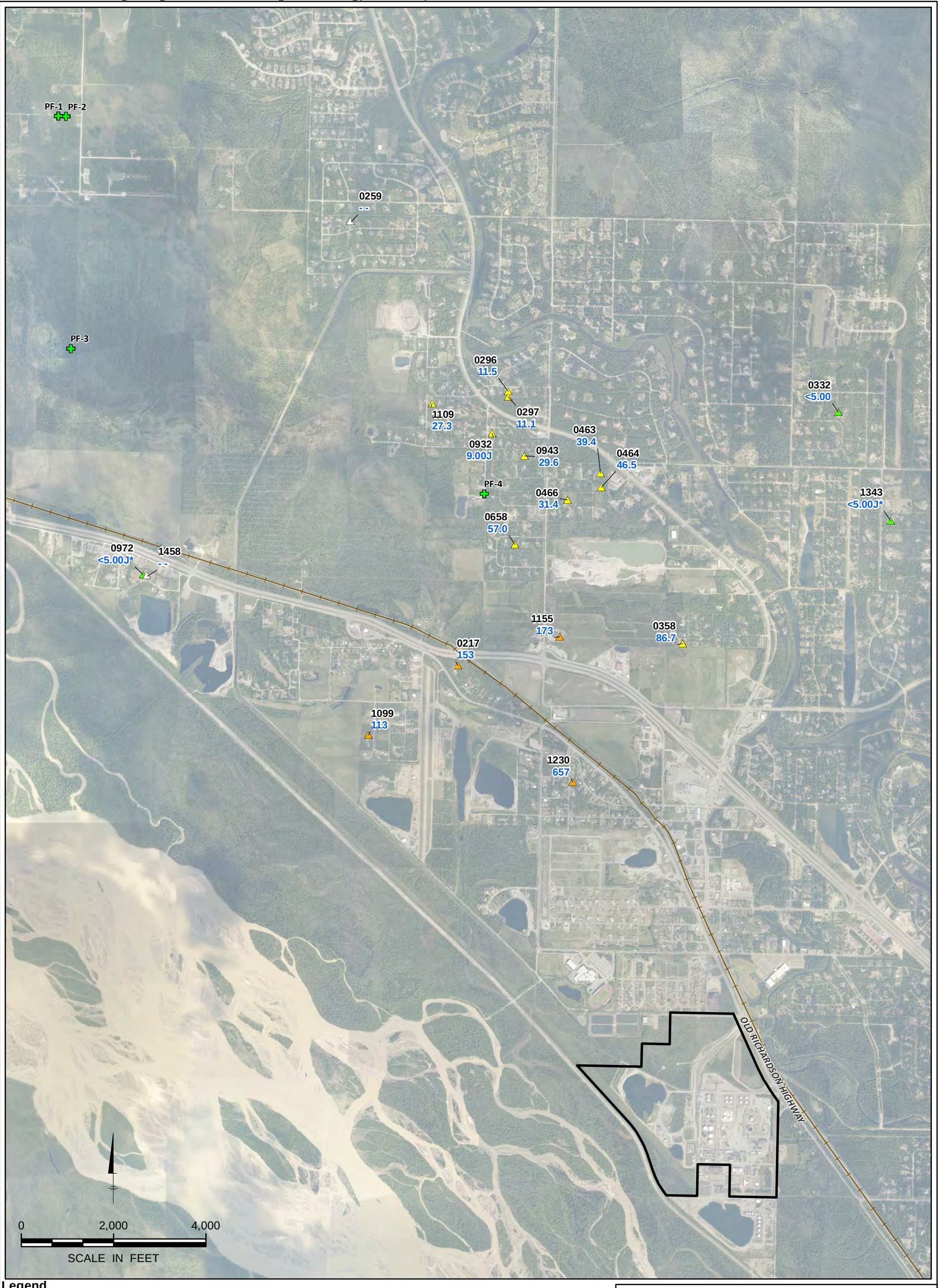
NORTH POLE REFINERY, NORTH POLE, ALASKA
FOURTH QUARTER 2013
GROUNDWATER MONITORING REPORT

GROUNDWATER ANALYTICAL RESULTS FROM PRIVATE WELLS IN SUBPERMAFROST AQUIFER

ARCADIS

FIGURE
4-26

CITY: HIGHLANDS RANCH, CO DIV/GROUP: ENV/IM DB: BGRIFFITH LD: G FRANCE
PATH: W:\GISPRJ\GISPROJECTS_ENV\FHR_AK\NORTHPOLEREFINERY\GW_MONITORING\2013_Q4\MXD\FIG 4-27 Q4DEEPRESIDENTIAL.MXD DATE: 1/31/2014 TIME: 9:54:58 AM



Legend

- Private Wells

Private Well Sulfolane Results

- Not Detected
- 3.1 - 100 µg/L
- 100 - 1,000 µg/L
- >1,000 µg/L
- Permafrost Boring
- FHRA Property Boundary

25 Sulfolane Concentration (µg/L)
J Estimated concentration, detected above the detection limit (DL) and below the limit of quantitation (LOQ)
J* Result is considered estimated; flag applied by SWI based on sample-handling or analytical QC issues
< Not detected: detection limit listed
- - Well was frozen during fourth quarter 2013 and could not be sampled
1458 Private Well Location ID

Notes:
Sulfolane was analyzed by EPA Method 1625B with iso-dilution
Image provided courtesy of Pictometry International 2012

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NORTH POLE REFINERY, NORTH POLE, ALASKA
FOURTH QUARTER 2013
GROUNDWATER MONITORING REPORT

DEEP RESIDENTIAL SULFOLANE RESULTS - FOURTH QUARTER 2013

ARCADIS

FIGURE
4-27

CITY: SF DIV/GROUP: ENV/IM DB: BGRIFFITH LD: PIC: PM: TM: TR:
PROJECT: (PROJECT #)
PATH: W:\GISPrj\GISPROJECTS_ENV\FHR_AK\NorthPoleRefinery\GW_Monitoring\2013_Q4\MXD\Fig 4-28 AirSparge_PilotTest_Layout.mxd 1/13/2014 11:07:51 AM

Legend

- Monitoring Well
- Air Sparge
- Sparge Monitoring Point
- Air Distribution Piping

0 20 40
SCALE IN FEET

Notes:

Image provided courtesy of Pictometry International 2012

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NORTH POLE REFINERY, NORTH POLE, ALASKA

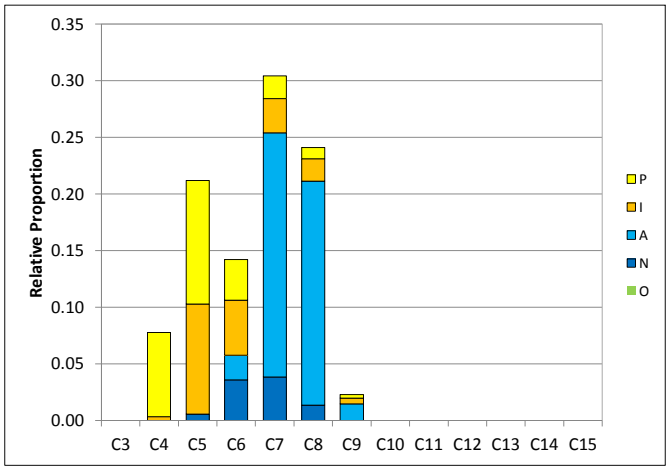
FOURTH QUARTER 2013 GROUNDWATER MONITORING REPORT

AIR SPARGE PILOT TEST SITE LAYOUT

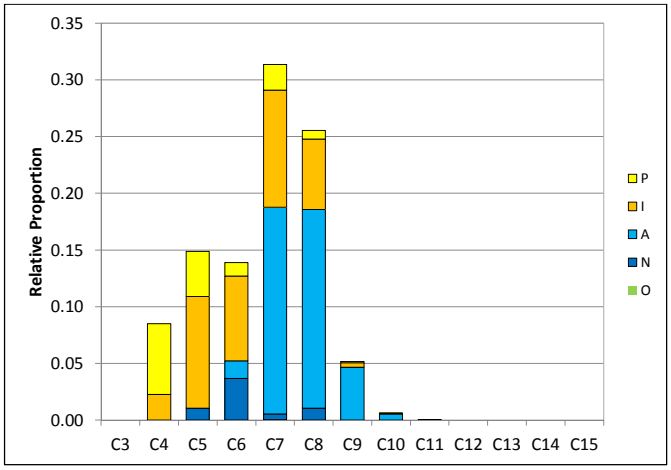
ARCADIS

FIGURE
4-28

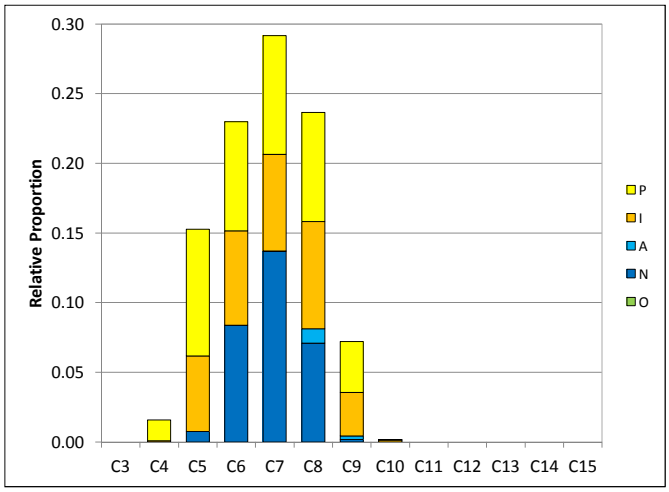
Gasoline 87 Regular



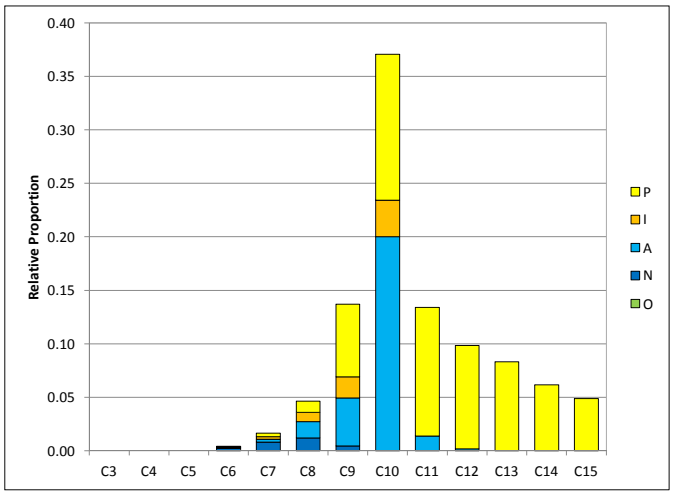
Gasoline Premium



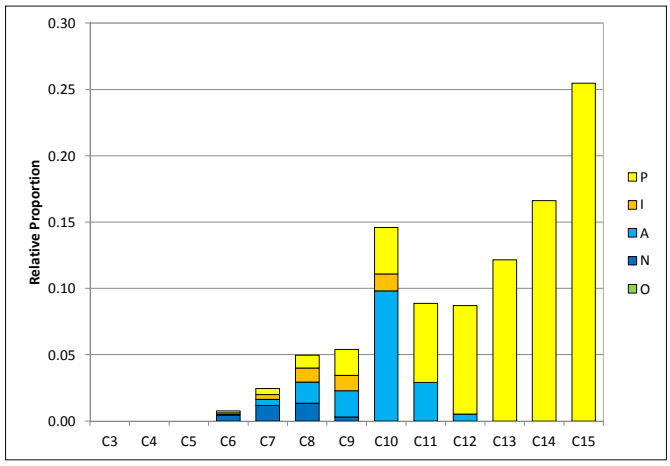
Naptha



Jet-A



Diesel #2



Legend

LNAPL = light nonaqueous phase liquid
C = carbon
P = paraffin
I = isoparaffins
A = aromatics
N = napthalenes
O = olefins

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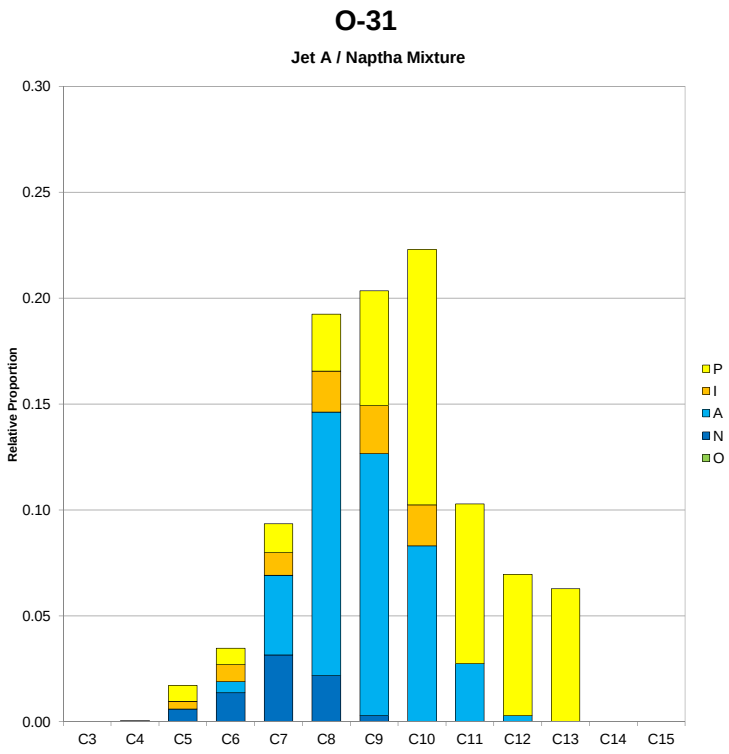
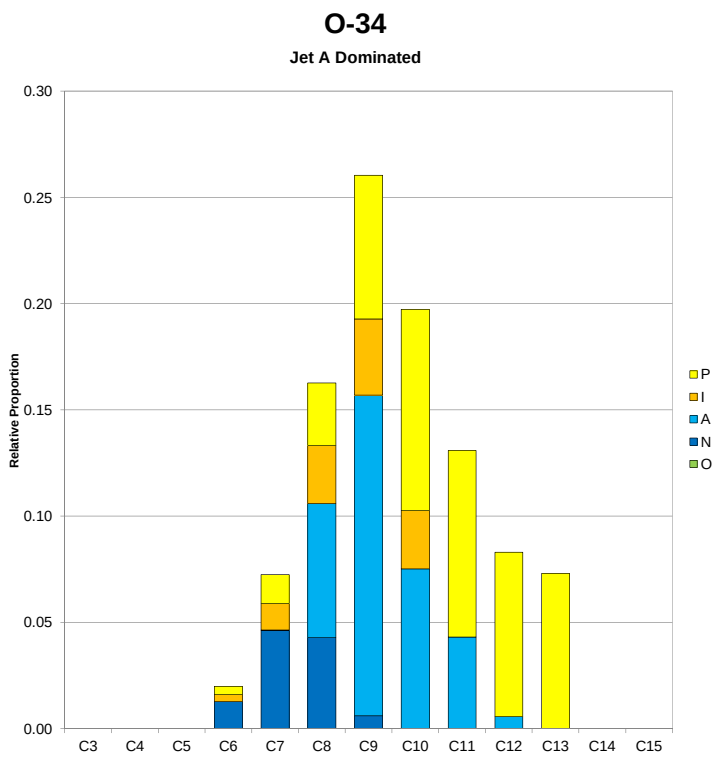
FOURTH QUARTER 2013 GROUNDWATER MONITORING REPORT

REFINED PRODUCT PIANO ANALYSIS

ARCADIS

FIGURE
4-29





Legend

LNAPL = light nonaqueous phase liquid
C = carbon
P = paraffin
I = isoparaffins
A = aromatics
N = napthalenes
O = olefins

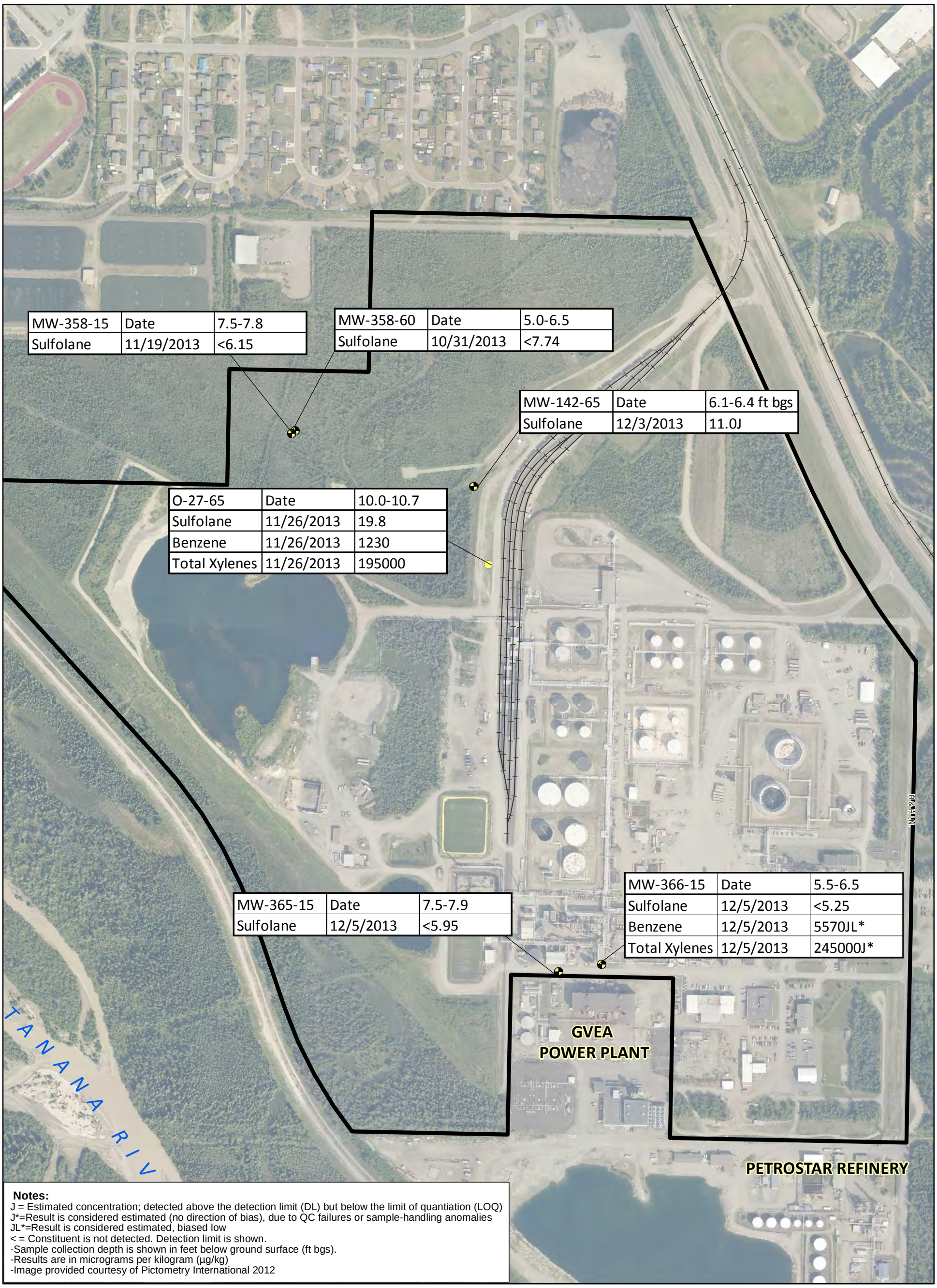
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA
FOURTH QUARTER 2013 GROUNDWATER MONITORING REPORT

2013 LNAPL PIANO ANALYSIS O-31 and O-34

ARCADIS

FIGURE
4-30

CITY: HIGHLANDS RANCH, CO DIV/GROUP: ENV/IM DB: BGRIFFITH LD: G FRANCE
PATH: W:\GISPRJ\GISPROJECTS_ENV\FHR_AK\NORTHPOLEREFINERY\GW_MONITORING\2013_Q4\MXD\FIG 4-31 SOILANALYTICALRESULTS.MXD DATE: 1/30/2014 TIME: 3:17:12 PM



Notes:
J = Estimated concentration; detected above the detection limit (DL) but below the limit of quantiation (LOQ)
J*=Result is considered estimated (no direction of bias), due to QC failures or sample-handling anomalies
JL*=Result is considered estimated, biased low
< = Constituent is not detected. Detection limit is shown.
-Sample collection depth is shown in feet below ground surface (ft bgs).
-Results are in micrograms per kilogram (µg/kg)
-Image provided courtesy of Pictometry International 2012

Legend
- Monitoring Well
- Observation Well
- FHRA Property Boundary

0 400 800
SCALE IN FEET

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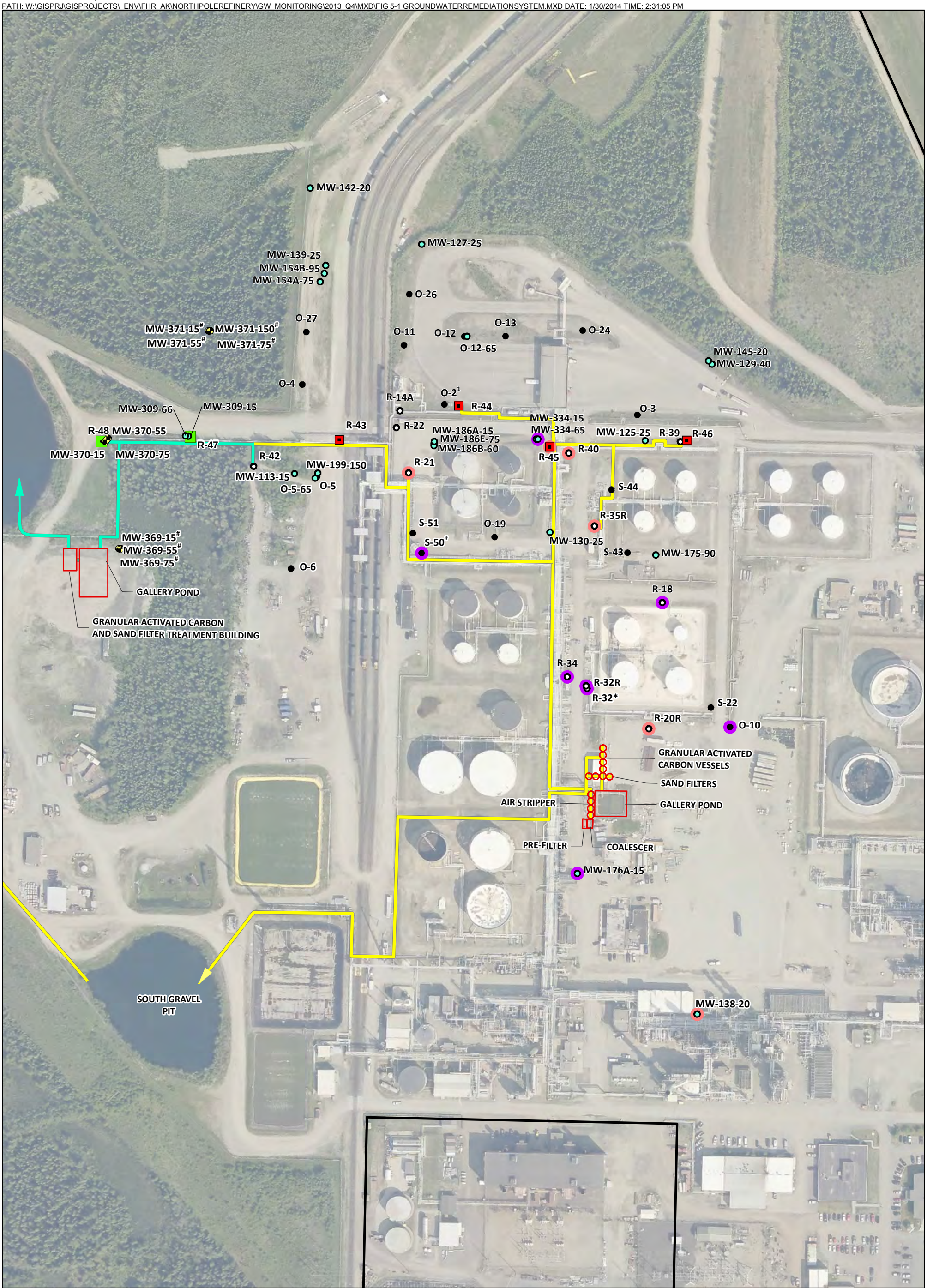
FOURTH QUARTER 2013
GROUNDWATER MONITORING REPORT

SOIL ANALYTICAL RESULTS

ARCADIS

FIGURE
4-31

CITY: HIGHLANDS RANCH, CO DIV/GROUP: ENV/IM DB: BGRIFFITH LD: G FRANCE
PATH: W:\GISPRJ\GISPROJECTS\ ENV\FHR AK\NORTHPOLEREFINERY\GW MONITORING\2013 Q4\MXD\FIG 5-1 GROUNDWATERREMEDIATIONSYSTEM.MXD DATE: 1/30/2014 TIME: 2:31:05 PM



Legend

- Monitoring Well
- Observation Well
- Recovery Well
- New Recovery Wells Installed in 2013
- Proposed Recovery Wells
- Proposed Remediation System Piping
- Remediation System Piping
- Installed Product Recovery System
- Manual Product Recovery
- FHRA Property Boundary

0 200 400
SCALE IN FEET

Notes:

*Product recovery systems installed in wells R-32 are under evaluation.
Manual product recovery is completed with a vacuum truck or portable product pump.
† Product recovery at S-50 was by manual recovery and an installed product recovery system during third quarter 2013
#Proposed Monitoring Wells
[1]Manual product recovery. An installed product recovery system was previously used.
Image provided courtesy of Pictometry International 2012

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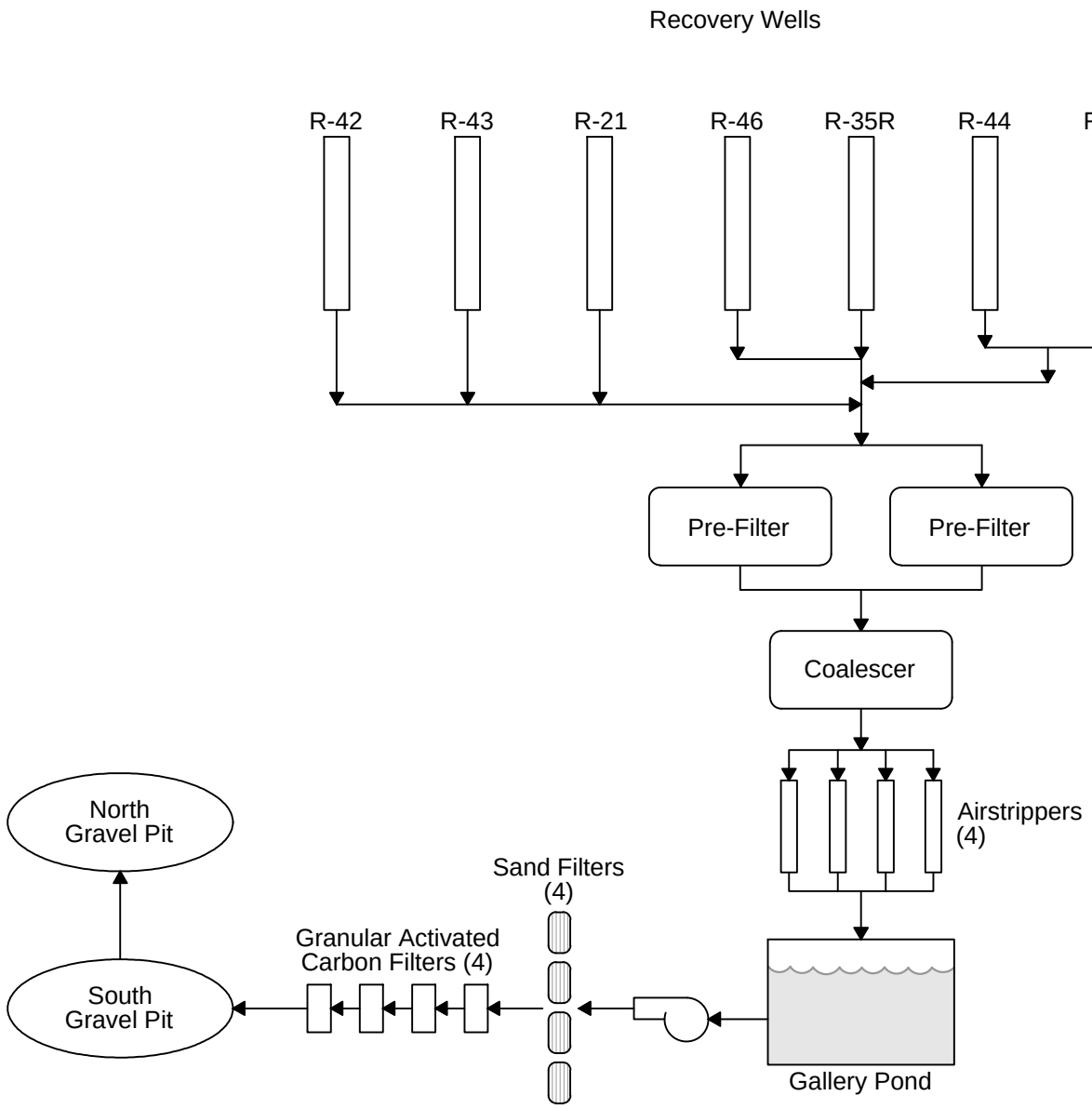
FOURTH QUARTER 2013 GROUNDWATER MONITORING REPORT

GROUNDWATER RECOVERY AND TREATMENT SYSTEM

ARCADIS

FIGURE
5-1



NORTH POLE REFINERY
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FOURTH QUARTER 2013
GROUNDWATER MONITORING REPORT

CURRENT PROCESS FLOW DIAGRAM-GROUNDWATER CAPTURE AND TREATMENT SYSTEM

ARCADIS

FIGURE
5-2

CITY: SAN RAFAEL, CA (PETALUMA) GROUP: ENVCAD DB: (P. WISTED), J. HARRIS
\\arcadis-us.com\officedata\SanRafael-CA\ENVCAD\Petaluma\ACTIB0081981\00040\00001\4Q13\DWG\81981T02.dwg LAYOUT: 5-2 SAVED: 1/20/2014 7:40 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: SETUP1 PLOTSTYLETABLE: ARCADIS.CTB PLOTTED: 1/31/2014 8:04 AM BY: HARRIS, JESSICA
XREFS: IMAGES: PROJECTNAME: ----