Monitoring Well

Approximate Sulfolane Isopleth in µg/L

FHRA Property Boundary

118 Sulfolane Concentration (µg/L)

J Estimated value

JL Estimated value, biased low

UJ The analyte was not reported above the limit of quantitation; however, the limit of quantitationis estimated because ice was observed in the sample.

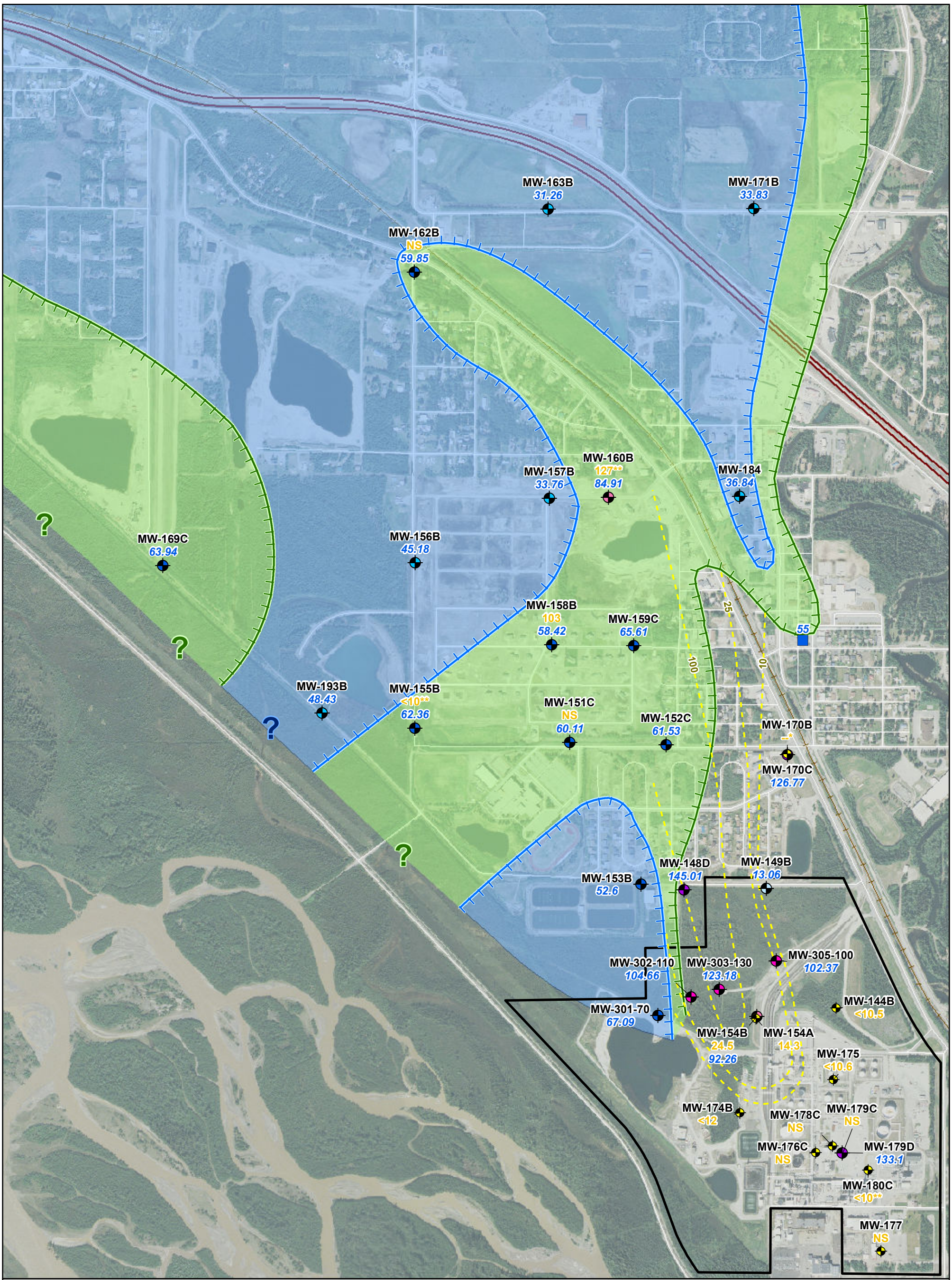
NS Not Sampled

**Sulfolane was analyzed by EPA Method 1625B with Iso-dilution

0 750 1,500 3,000

Feet

Figure 96
SULFOLANE CONCENTRATIONS
IN GROUNDWATER
10-55' BELOW THE WATER TABLE
SECOND QUARTER 2011
North Pole Refinery
Flint Hills Resources Alaska, LLC



Monitoring Well

Depth to Permafrost (BTW)

- 0 - 24.9 Ft
- 25 - 49.9 Ft
- 50 - 74.9 Ft
- 75 - 99.9 Ft
- 100 - 124.9 Ft
- 125 - 149.9 Ft

City Well

FHRA Property Boundary

Aquifer Frozen at 55' Below the Water Table

Aquifer Frozen at 90' Below the Water Table

Approximate Sulfolane Isopleth in µg/L

118 Sulfolane Concentration (µg/L)

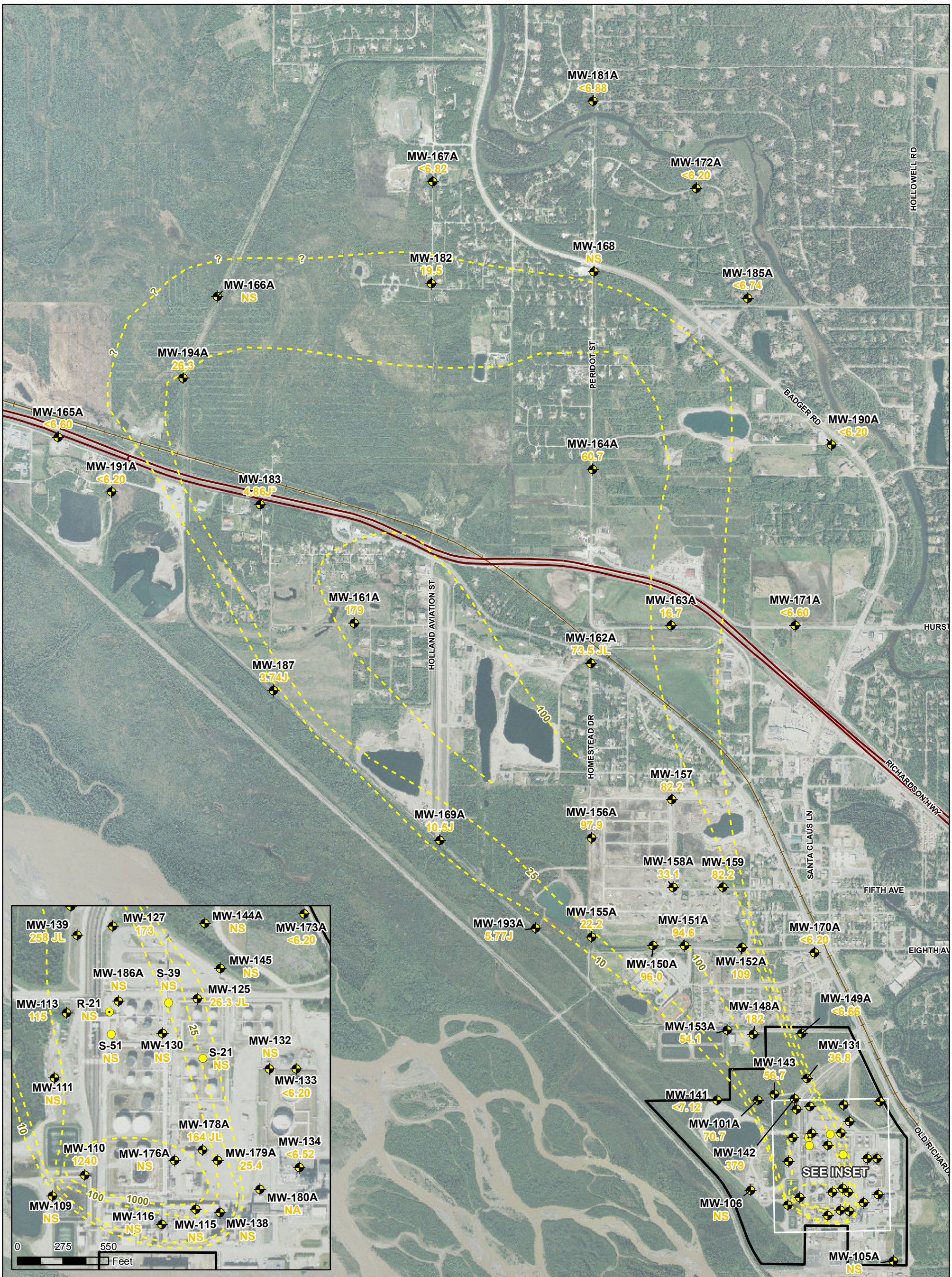
NS Not Sampled

59.0 Depth to Permafrost (feet BGS)

0 450 900 1,800

Feet

Figure 97
SULFOLANE CONCENTRATIONS
IN GROUNDWATER
55-90' BELOW THE WATER TABLE
SECOND QUARTER 2011
North Pole Refinery
Flint Hills Resources Alaska, LLC



Monitoring Well	118	Sulfolane Concentration (µg/L)	
Observation Well	J	Estimated value	
Recovery Well	JL	Result Biased Low	
Approximate Sulfolane Isopleth in µg/L	NS	Not Sampled	
FHRA Property Boundary	*	Data not used in contour	
	NA	Not Analyzed	

0 750 1,500 3,000
Feet

Notes:
Samples with duplicate data are represented by the greater of the two results.
Sulfolane was analyzed by EPA Method 1625B with Iso-dilution.
Wells were gauged for LNAPL July 14th & 15th, 2011.
Plume delineation is based on historical data.

Figure 98
SULFOLANE CONCENTRATIONS
IN GROUNDWATER
AT THE WATER TABLE
THIRD QUARTER 2011
North Pole Refinery
Flint Hills Resources Alaska, LLC

Monitoring Well

Approximate Sulfolane Isopleth in ug/L

FHRA Property Boundary

118 Sulfolane Concentration (µg/L)

J Estimated value

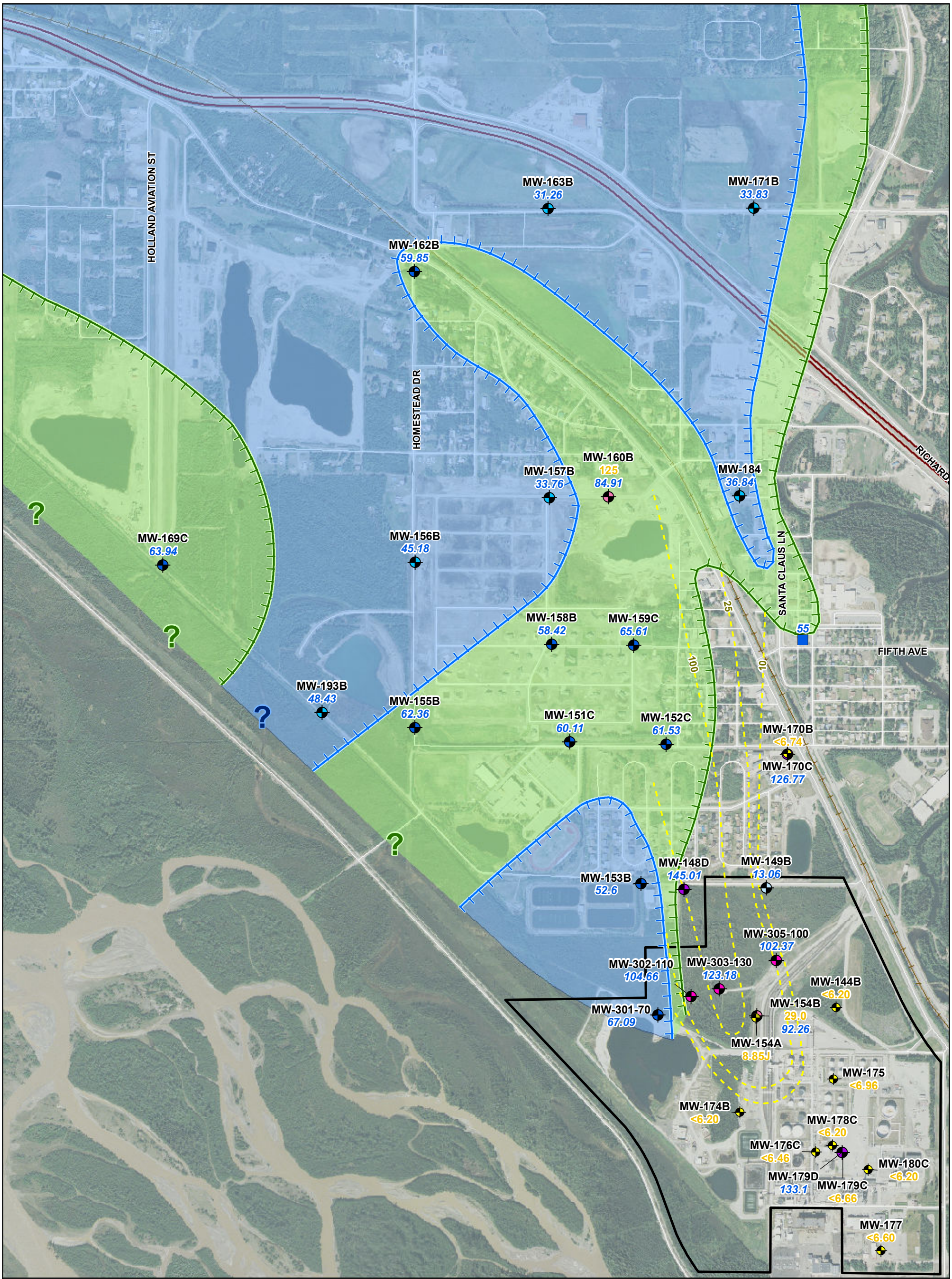
NS Not Sampled

Notes:
Samples with duplicate data are represented by the greater of the two results.
Sulfolane was analyzed by EPA Method 1625B with iso-dilution
Wells were guaged for LNAPL July 14 and 15, 2011

N

0 750 1,500 3,000
Feet

Figure 99
SULFOLANE CONCENTRATIONS
IN GROUNDWATER
10-55' BELOW THE WATER TABLE
THIRD QUARTER 2011
North Pole Refinery
Flint Hills Resources Alaska, LLC



Monitoring Well

Depth to Permafrost (BWT)

- 0 - 24.9 Ft
- 25 - 49.9 Ft
- 50 - 74.9 Ft
- 75 - 99.9 Ft
- 100 - 124.9 Ft
- 125 - 149.9 Ft
- City Well

FHRA Property Boundary

Aquifer Frozen at 55' Below the Water Table

Aquifer Frozen at 90' Below the Water Table

Approximate Sulfolane Isopleth in µg/L

118 Sulfolane Concentration (µg/L)

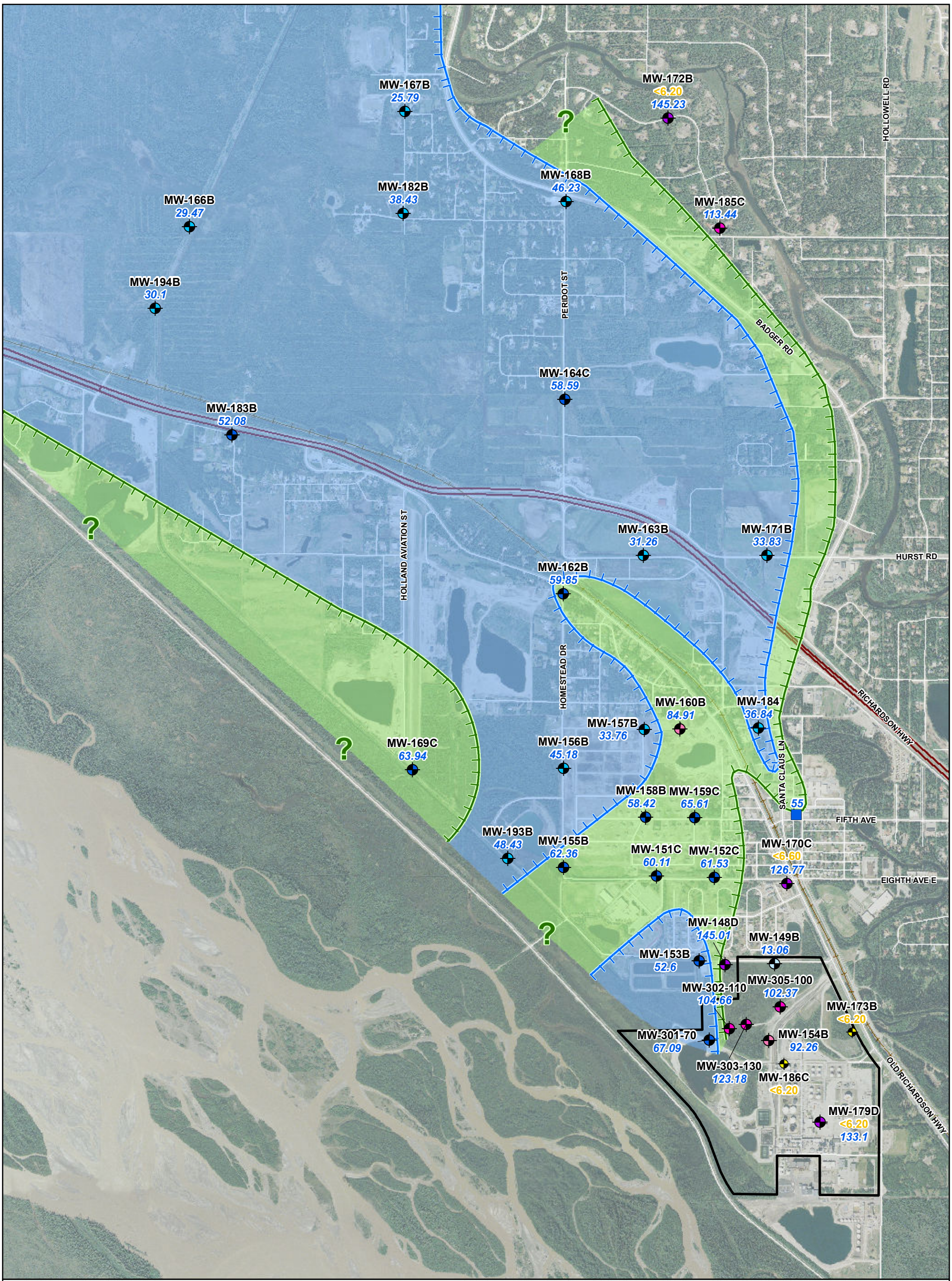
NS Not Sampled

59.0 Depth to Permafrost (feet BGS)

Notes:
Samples with duplicate data are represented by the greater of the two results.
Sulfolane was analyzed by EPA Method 1625B with iso-dilution
Wells were guaged for LNAPL July 14 and 15, 2011

0 450 900 1,800
Feet

Figure 100
SULFOLANE CONCENTRATIONS
IN GROUNDWATER
55-90' BELOW THE WATER TABLE
THIRD QUARTER 2011
North Pole Refinery
Flint Hills Resources Alaska, LLC



Monitoring Well

Depth to Permafrost (BWT)

- 0 - 24.9 Ft
- 25 - 49.9 Ft
- 50 - 74.9 Ft
- 75 - 99.9 Ft
- 100 - 124.9 Ft
- 125 - 149.9 Ft

City Well

FHRA Property Boundary

Aquifer Frozen at 55' Below the Water Table

Aquifer Frozen at 90' Below the Water Table

<10.3 Sulfolane Concentration (µg/L)

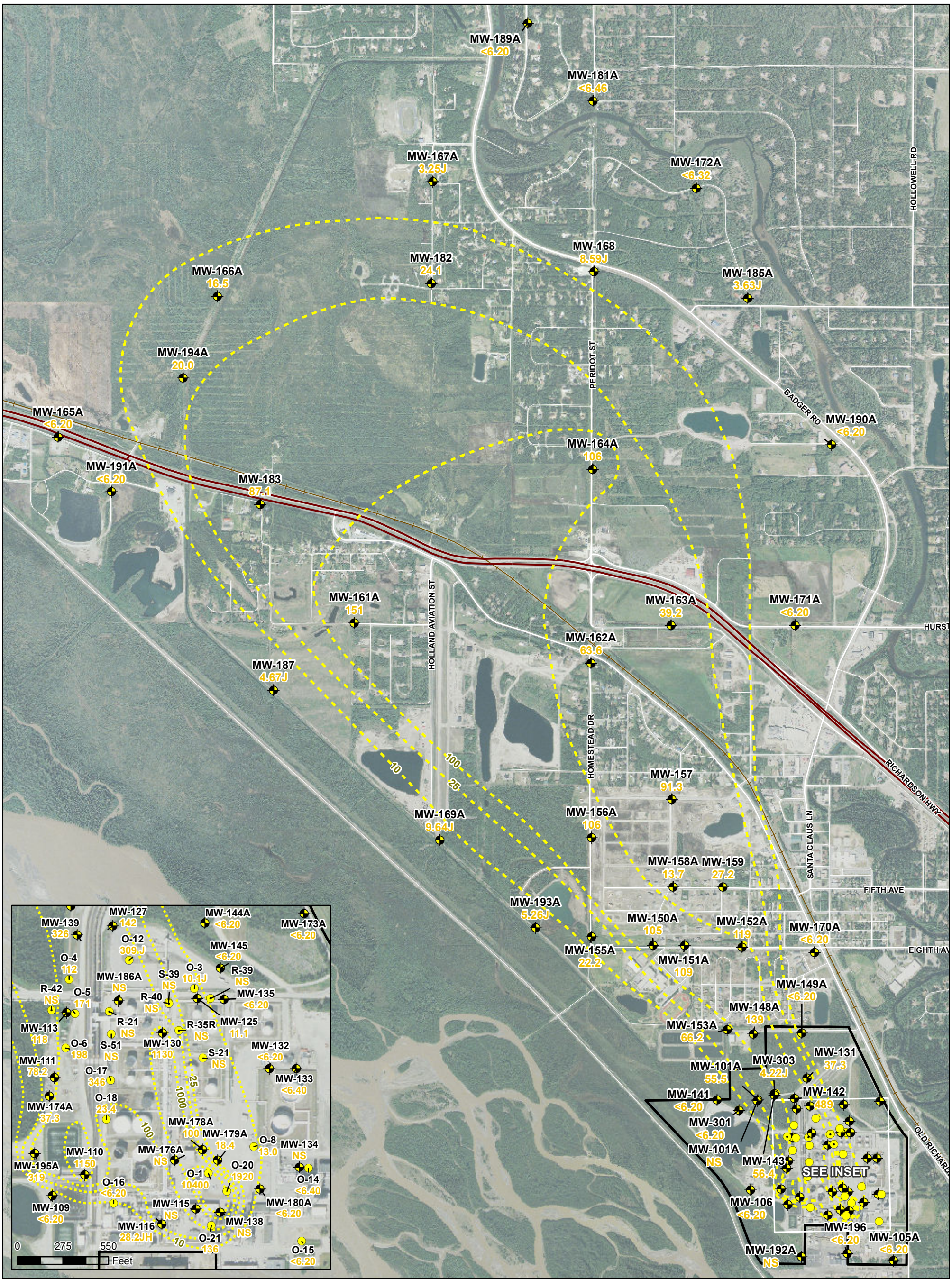
59.0 Depth to Permafrost (feet BGS)

Notes:
Samples with duplicate data are represented by the greater of the two results.
Sulfolane was analyzed by EPA Method 1625B with iso-dilution
Wells were guaged for LNAPL July 14 and 15, 2011

N

0 750 1,500 3,000
Feet

Figure 101
SULFOLANE CONCENTRATIONS
IN GROUNDWATER
90-160' BELOW THE WATER TABLE
THIRD QUARTER 2011
North Pole Refinery
Flint Hills Resources Alaska, LLC



Monitoring Well	118	Sulfolane Concentration (µg/L)	
Observation Well	J	Estimated value	
Recovery Well	NS	Not Sampled	
Approximate Sulfolane Isopleth in µg/L	JH	Estimated results biased high due to sulfolane-d8 surrogate failure	
FHRA Property Boundary			

0 750 1,500 3,000
Feet

Notes:
Samples with duplicate data are represented by the greater of the two results.
Sulfolane was analyzed by EPA Method 1625B with Iso-dilution.
Wells were gauged for LNAPL July 14th & 15th, 2011.
Plume delineation is based on historical data.

Figure 102
SULFOLANE CONCENTRATIONS
IN GROUNDWATER
AT THE WATER TABLE
FOURTH QUARTER 2011
North Pole Refinery
Flint Hills Resources Alaska, LLC

Monitoring Well

Observation Well

Recovery Well

Approximate Sulfolane Isopleth in µg/L

FHRA Property Boundary

118 Sulfolane Concentration (µg/L)

J Estimated value

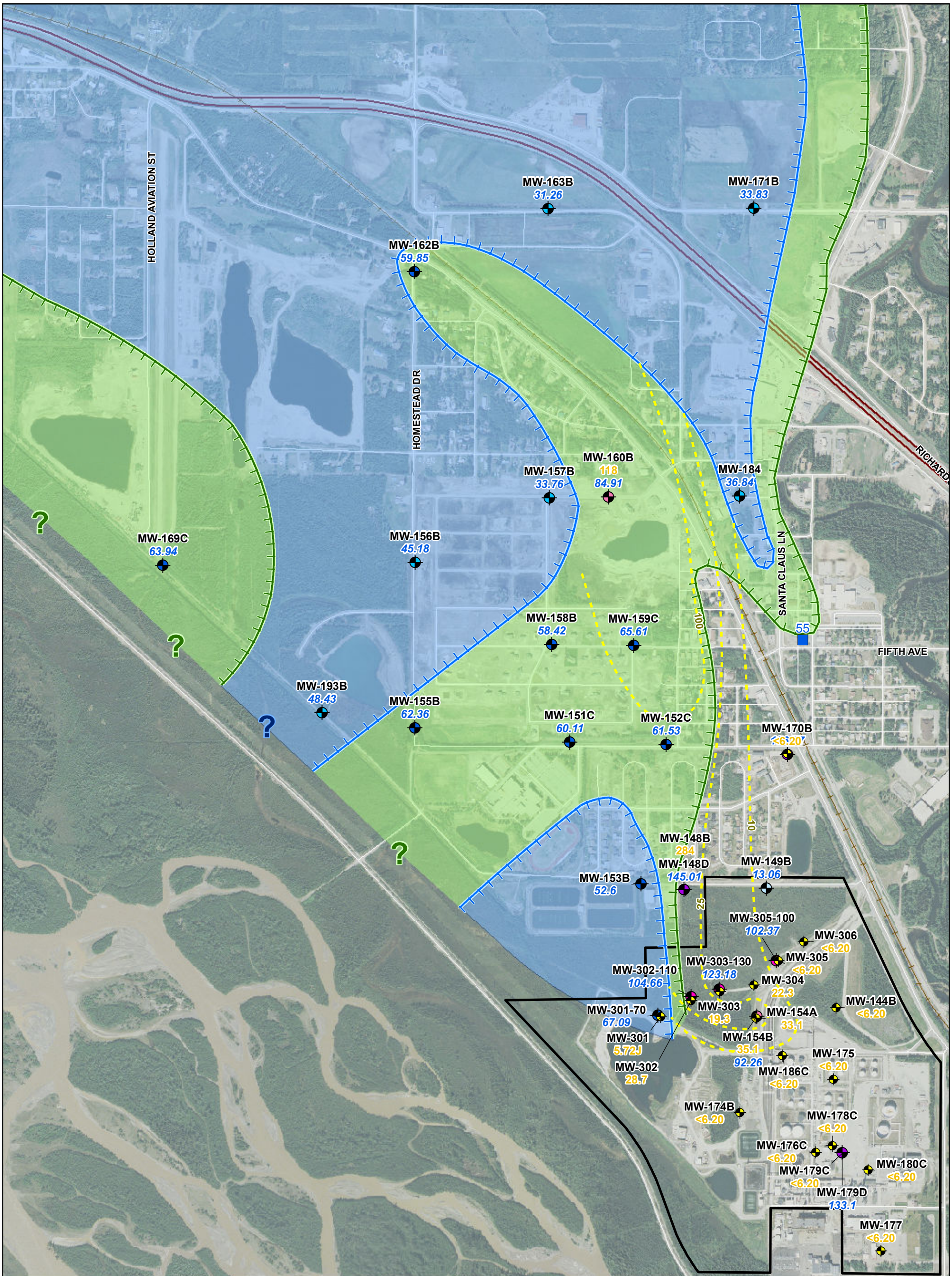
NS Not Sampled

0 750 1,500 3,000

Feet

Notes:
Samples with duplicate data are represented by the greater of the two results.
Sulfolane was analyzed by EPA Method 1625B with Iso-dilution.
Wells were gauged for LNAPL July 14th & 15th , 2011.
Plume delineation is based on historical data.

Figure 103
SULFOLANE CONCENTRATIONS
IN GROUNDWATER
10-55' BELOW THE WATER TABLE
FOURTH QUARTER 2011
North Pole Refinery
Flint Hills Resources Alaska, LLC



Monitoring Well

Depth to Permafrost

- 0 - 24.9
- 25 - 49.9
- 50 - 74.9
- 75 - 99.9
- 100 - 124.9
- 125 - 149.9
- City Well

FHRA Property Boundary

Aquifer Frozen at 55' Below the Water Table

Aquifer Frozen at 90' Below the Water Table

Approximate Sulfolane Isopleth in µg/L

118 Sulfolane Concentration (µg/L)

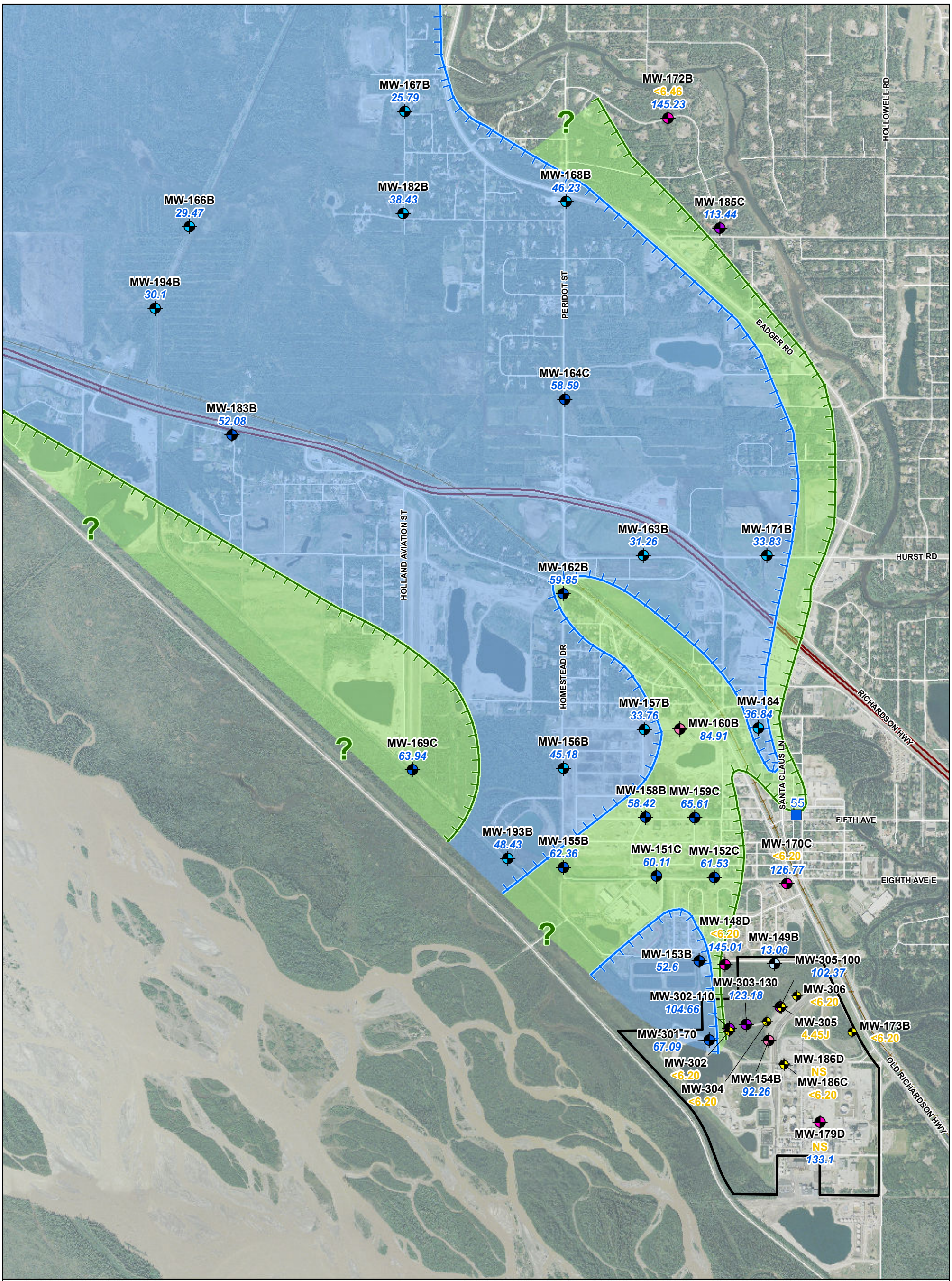
13.1 Depth to Permafrost (feet BWT)

0 450 900 1,800

Feet

Notes:
Samples with duplicate data are represented by the greater of the two results.
Sulfolane was analyzed by EPA Method 1625B with Iso-dilution.
Wells were gauged for LNAPL July 14th & 15th, 2011.
Plume delineation is based on historical data.

Figure 104
SULFOLANE CONCENTRATIONS
IN GROUNDWATER
55-90' BELOW THE WATER TABLE
FOURTH QUARTER 2011
North Pole Refinery
Flint Hills Resources Alaska, LLC



Monitoring Well

Depth to Permafrost (BWT)

- 0 - 24.9 Ft
- 25 - 49.9 Ft
- 50 - 74.9 Ft
- 75 - 99.9 Ft
- 125 - 149.9 Ft
- 100 - 124.9 Ft
- City Well

FHRA Property Boundary

Aquifer Frozen at 55' Below the Water Table

Aquifer Frozen at 90' Below the Water Table

Approximate Sulfolane Isopleth in µg/L

118 Sulfolane Concentration (µg/L)

13.1 Depth to Permafrost (feet BWT)

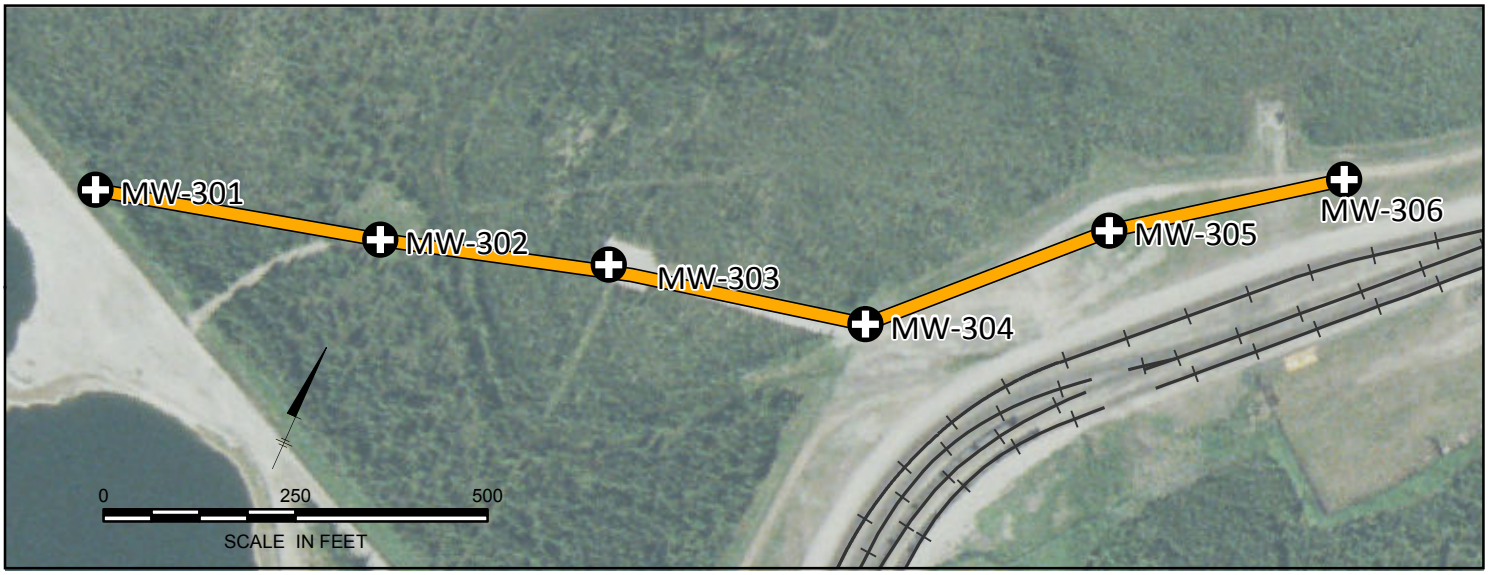
N

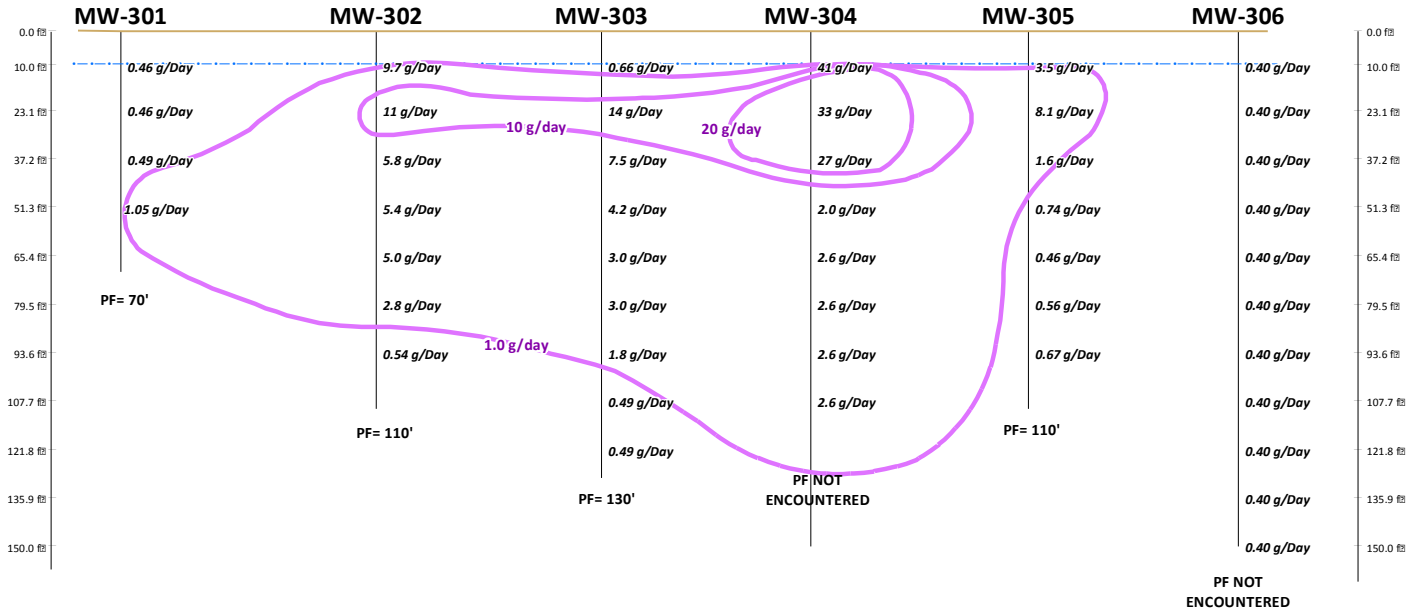
0 750 1,500 3,000

Feet

Notes:
Samples with duplicate data are represented by the greater of the two results.
Sulfolane was analyzed by EPA Method 1625B with Iso-dilution.
Wells were gauged for LNAPL July 14th & 15th, 2011.
Plume delineation is based on historical data.

Figure 105
SULFOLANE CONCENTRATIONS
IN GROUNDWATER
90-160' BELOW THE WATER TABLE
FOURTH QUARTER 2011
North Pole Refinery
Flint Hills Resources Alaska, LLC





APPROXIMATE GW

GROUND SURFACE

MASS FLUX CONTOUR

NOTES:
Mass flux values shown were calculated using the Mass Flux Toolkit. Depths associated with flux values were determined by the Toolkit.
PF= Permafrost encountered at bottom of boring.

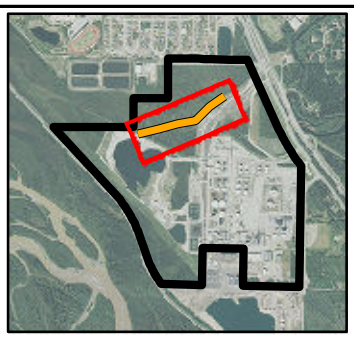
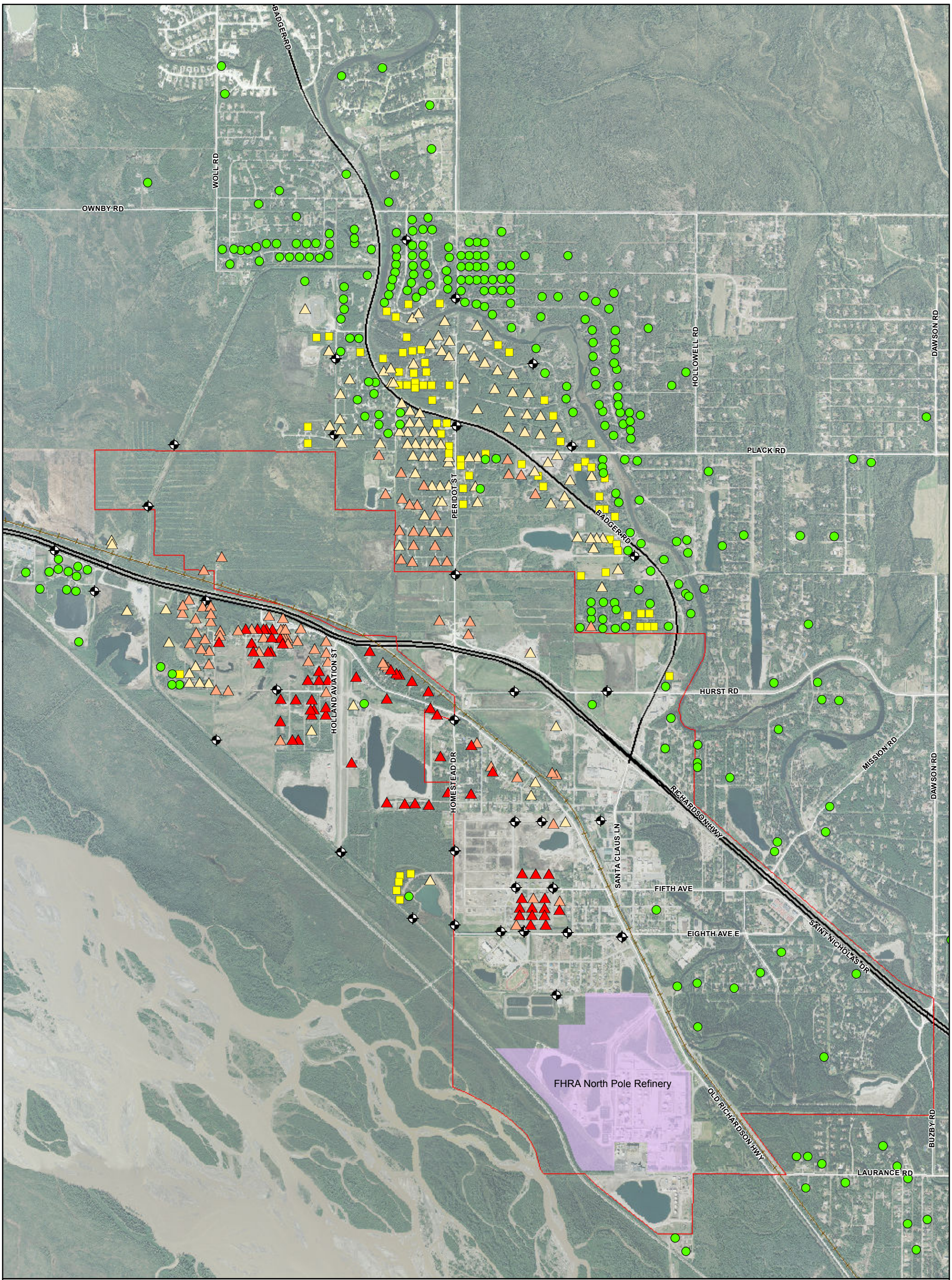


Figure 106
SULFOLANE MASS FLUX RATES
North Pole Refinery
Flint Hills Resources Alaska, LLC



ND

3.2 ppb - 10 ppb (J-flagged)

10 ppb - 25 ppb (contains J-flags)

25 ppb - 100 ppb

greater than 100 ppb

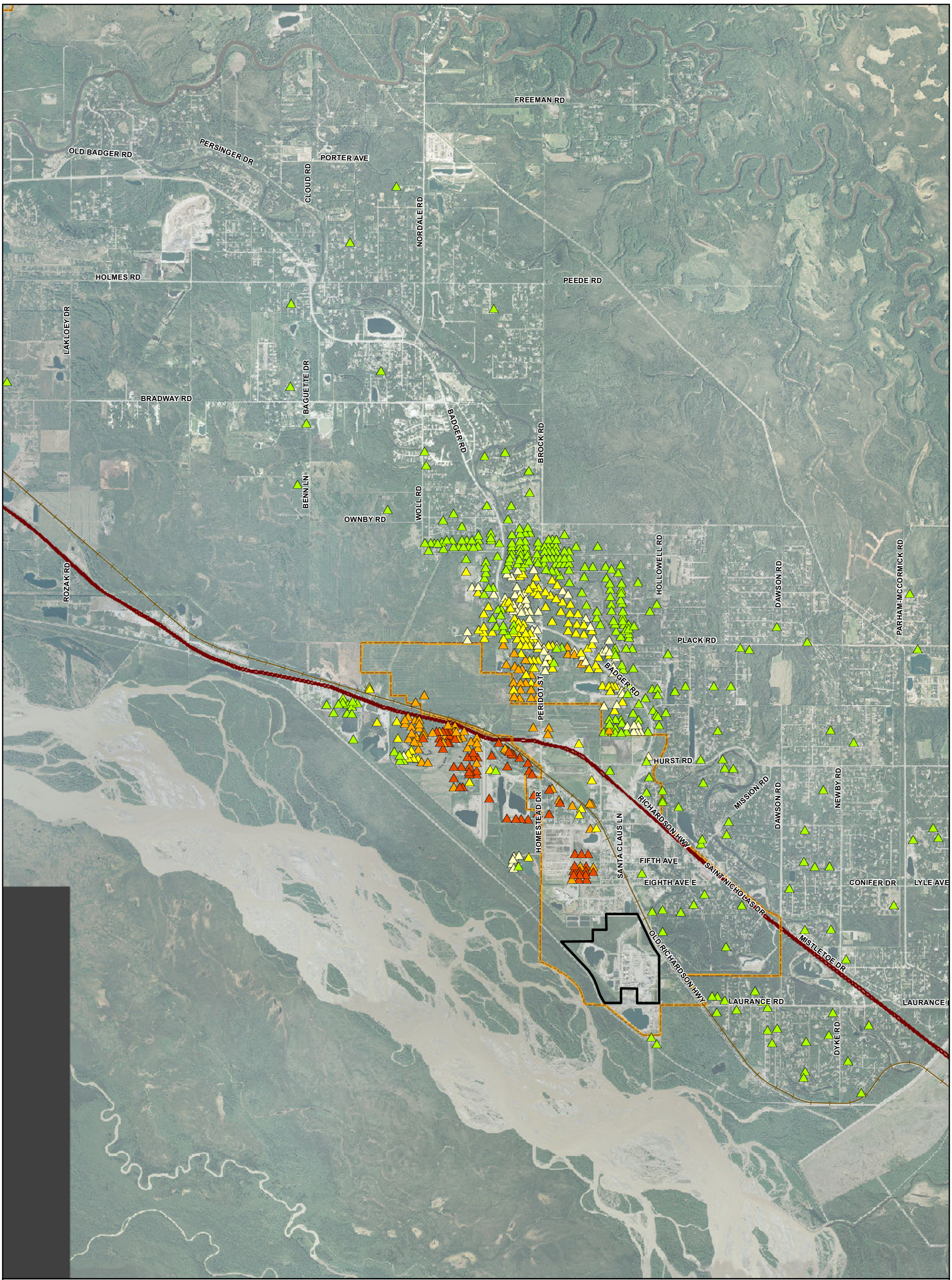
Monitoring Well

North Pole City Limits

0 1,000 2,000 4,000

Feet

Figure 107A
SULFOLANE CONCENTRATIONS
IN GROUNDWATER
FROM PRIVATE WELLS
North Pole Refinery
Flint Hills Resources Alaska, LLC



Private Wells

- Not Detected
- 3.2 µg/L - 10 µg/L (J-flagged)
- 10 µg/L - 25 µg/L
- 25 µg/L - 100 µg/L
- Greater than 100 µg/L

Data through December 19, 2011

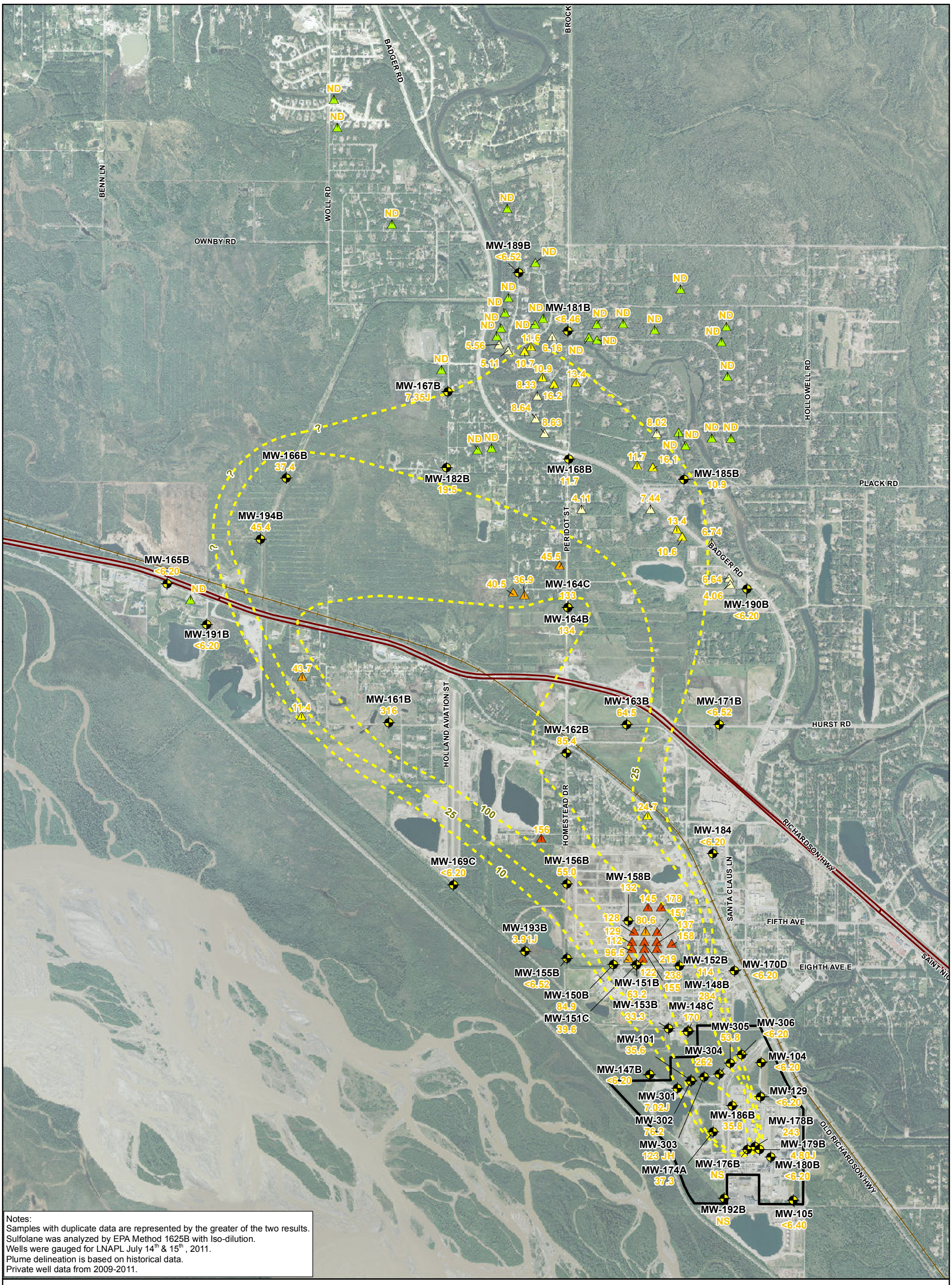
FHRA Property Boundary

North Pole City Boundary

0 2,000 4,000 8,000

Feet

Figure 107B
SULFOLANE CONCENTRATIONS
IN GROUNDWATER
FROM PRIVATE WELLS-
EXTENDED VIEW
North Pole Refinery
Flint Hills Resources Alaska, LLC



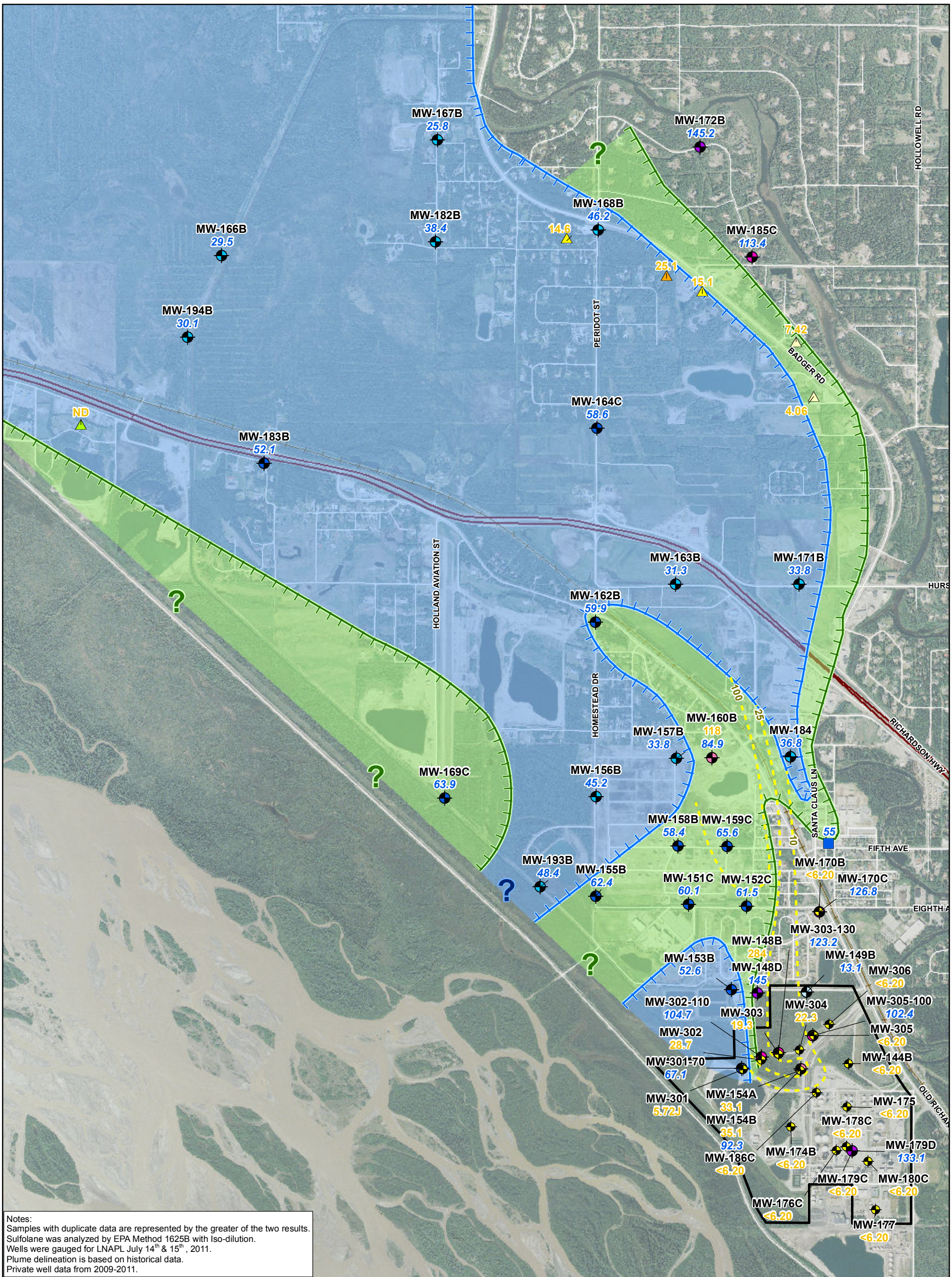
Private Wells

- Not Detected
- 3.2 µg/L - 10 µg/L (J-flagged)
- 10 µg/L - 25 µg/L
- 25 µg/L - 100 µg/L
- Greater than 100 µg/L

- Monitoring Well
- Approximate Sulfolane Isopleth in µg/L
- FHRA Property Boundary
- 118 Sulfolane Concentration (µg/L)
- J Estimated value
- NS Not Sampled

0 1,000 2,000 4,000
Feet

Figure 108
SULFOLANE CONCENTRATIONS
IN GROUNDWATER
10-55' BELOW THE WATER TABLE
FROM PRIVATE WELLS
FOURTH QUARTER 2011
North Pole Refinery
Flint Hills Resources Alaska, LLC



Notes:
Samples with duplicate data are represented by the greater of the two results.
Sulfolane was analyzed by EPA Method 1625B with Iso-dilution.
Wells were gauged for LNAPL July 14th & 15th , 2011.
Plume delineation is based on historical data.
Private well data from 2009-2011.

Monitoring Well

Depth to Permafrost

- 0 - 24.9
- 25 - 49.9
- 50 - 74.9
- 75 - 99.9
- 100 - 124.9
- 125 - 149.9

FHRA Property Boundary

Private Wells

- Not Detected
- 3.2 µg/L - 10 µg/L (J-flagged)
- 10 µg/L - 25 µg/L
- 25 µg/L - 100 µg/L
- Greater than 100 µg/L

Aquifer Frozen at 55' Below the Water Table

Aquifer Frozen at 90' Below the Water Table

City Well

Approximate Sulfolane Isopleth in µg/L

118 Sulfolane Concentration (µg/L)

13.1 Depth to Permafrost (feet BWT)

N

0 750 1,500 3,000

Feet

Figure 109
SULFOLANE CONCENTRATIONS
IN GROUNDWATER
55-90' BELOW THE WATER TABLE
FROM PRIVATE WELLS
North Pole Refinery
Flint Hills Resources Alaska, LLC

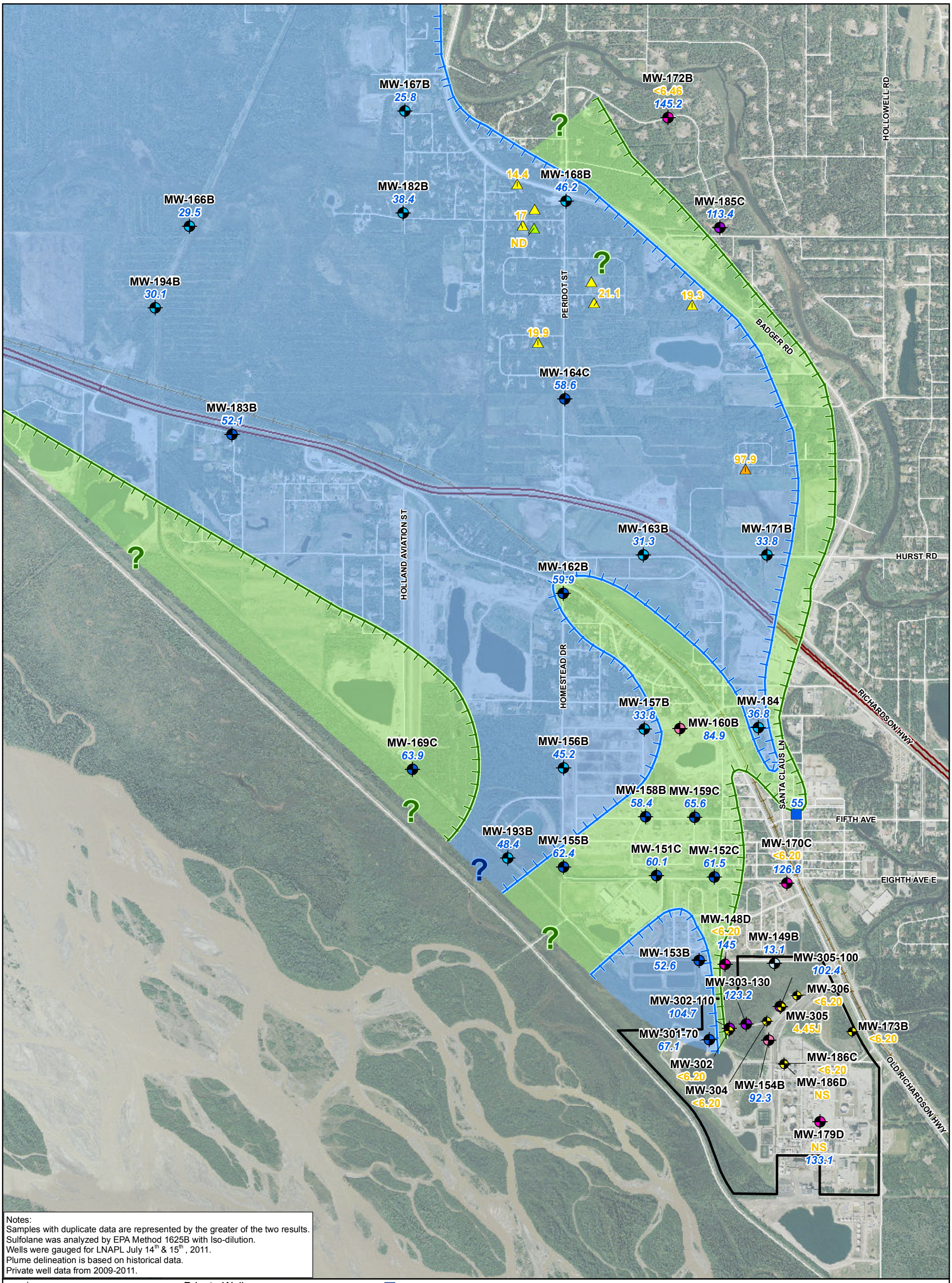


Figure 110
SULFOLANE CONCENTRATIONS
IN GROUNDWATER
90-160' BELOW THE WATER TABLE
FROM PRIVATE WELLS
North Pole Refinery
Flint Hills Resources Alaska, LLC

Private Wells

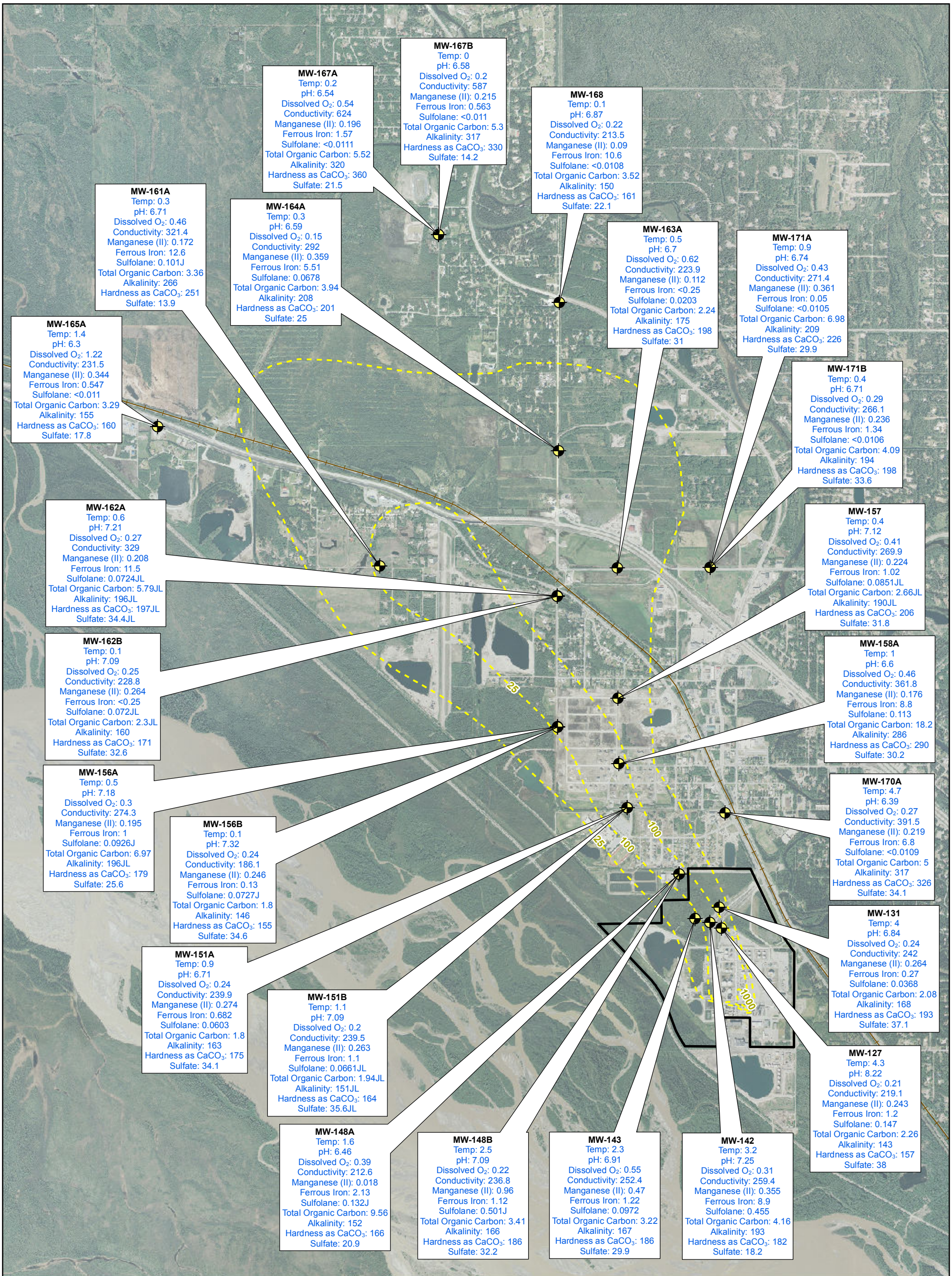
- Not Detected
- 3.2 µg/L - 10 µg/L (J-flagged)
- 10 µg/L - 25 µg/L
- 25 µg/L - 100 µg/L
- Greater than 100 µg/L
- <10.3 Sulfolane Concentration (µg/L)

FHRA Property Boundary

0 1,000 2,000 4,000
Feet

Figure 111
SULFOLANE CONCENTRATIONS
IN GROUNDWATER
>160' BELOW THE WATER TABLE
FROM PRIVATE WELLS
North Pole Refinery
Flint Hills Resources Alaska, LLC

Private well data from 2009-2011.



Monitoring Well

Approximate Sulfolane Isopleth in µg/L

FHRA Property Boundary

0 1,000 2,000 4,000

Feet

Figure 112
MONITORED NATURAL ATTENUATION PARAMETERS
FIRST QUARTER 2011
North Pole Refinery
Flint Hills Resources Alaska, LLC

Monitoring Well

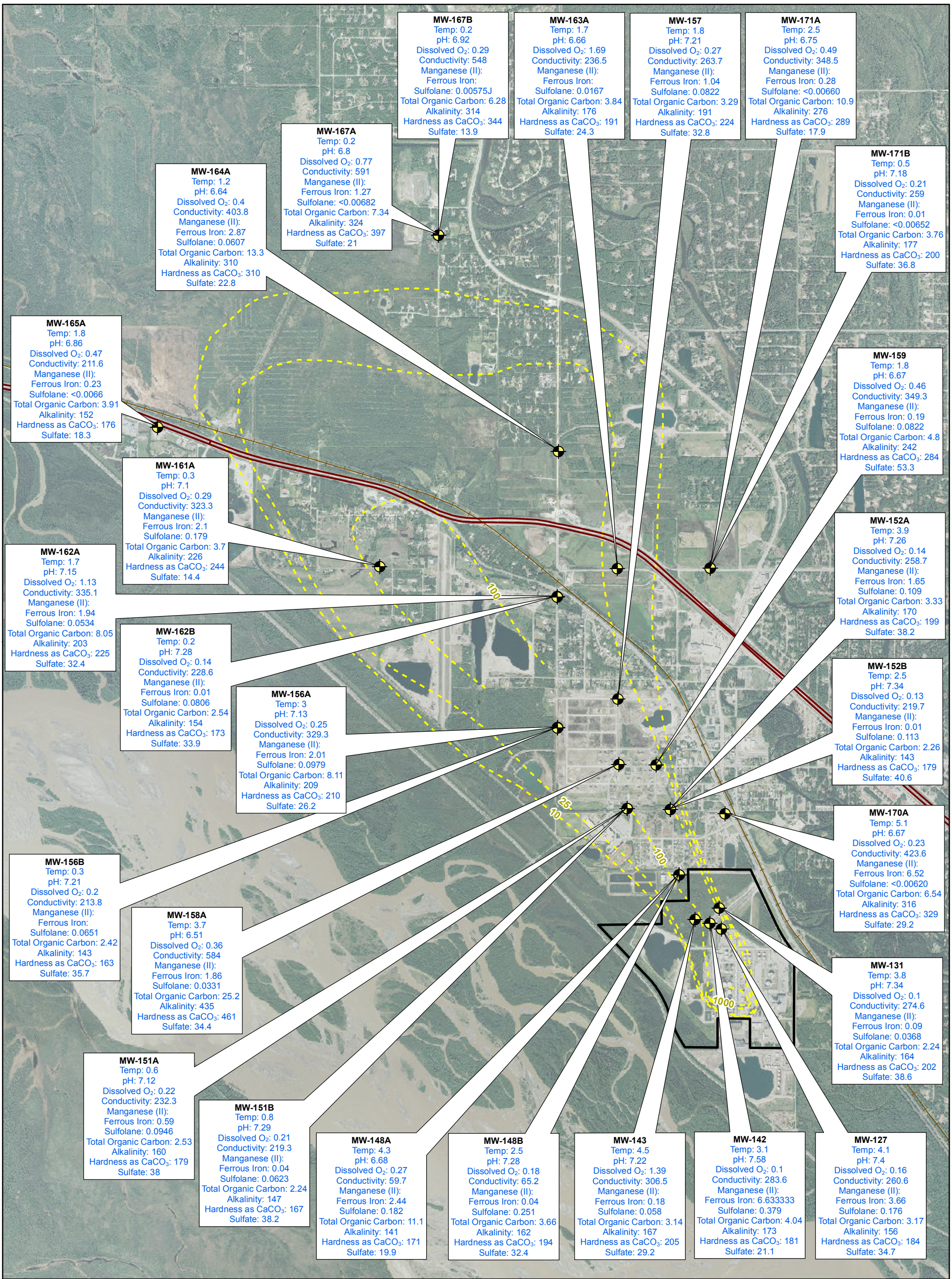
Sulfolane Isopleth in µg/L
(Dashed where approximate)

FHRA Property Boundary

N

0 1,000 2,000 4,000
Feet

Figure 113
MONITORED NATURAL
ATTENUATION PARAMETERS
SECOND QUARTER 2011
North Pole Refinery
Flint Hills Resources Alaska, LLC



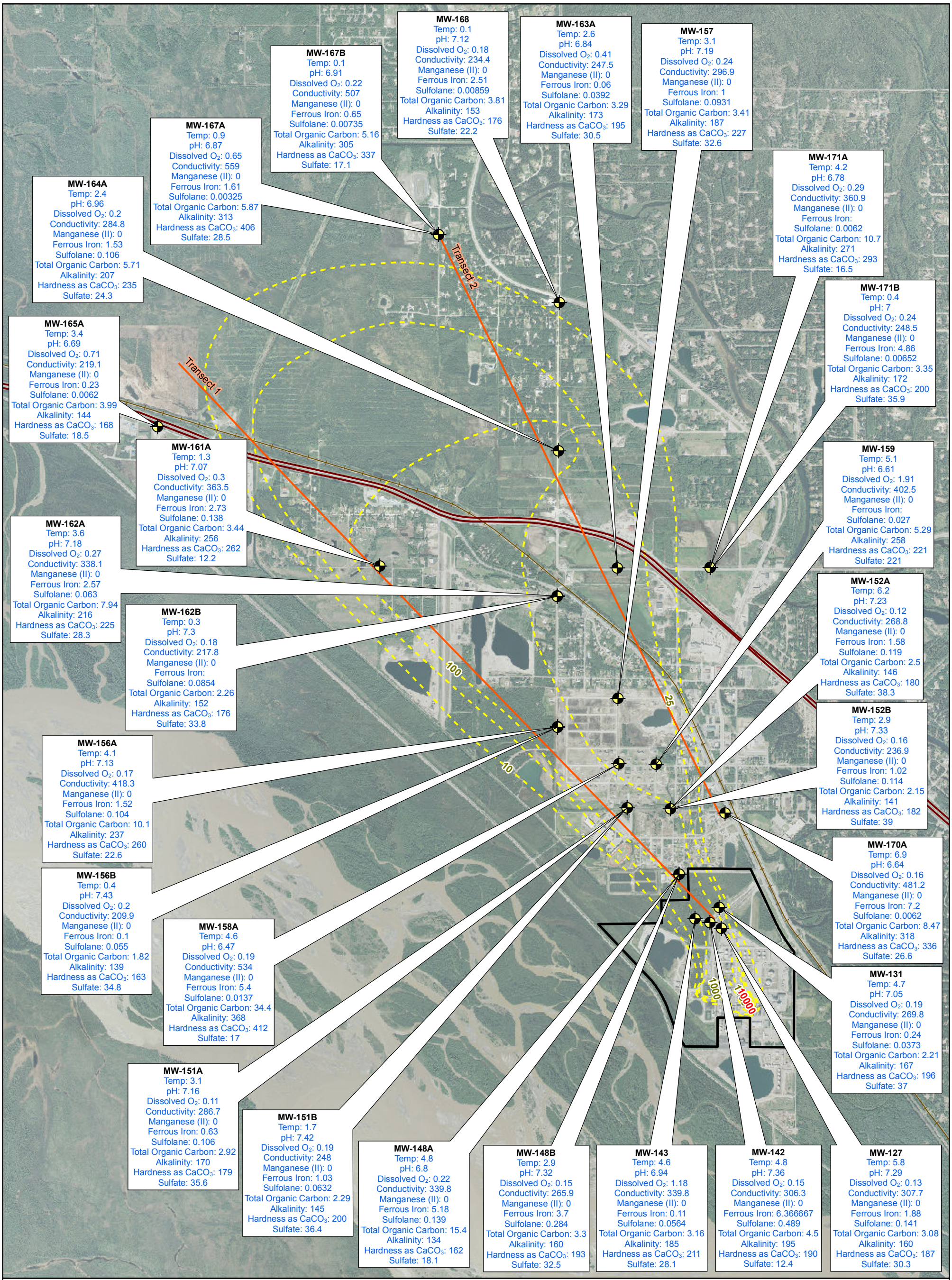
Monitoring Well

Sulfolane Isopleth in µg/L
(Dashed where approximate)

FHRA Property Boundary

0 1,000 2,000 4,000
Feet

Figure 114
MONITORED NATURAL
ATTENUATION PARAMETERS
THIRD QUARTER 2011
North Pole Refinery
Flint Hills Resources Alaska, LLC



Monitoring Well

FHRA Property Boundary

Sulfolane Isopleth in µg/L
(Dashed where approximate)

0 1,000 2,000 4,000
Feet

Figure 115
MONITORED NATURAL
ATTENUATION PARAMETERS
FOURTH QUARTER 2011
North Pole Refinery
Flint Hills Resources Alaska, LLC