ITT

GIS Analysis of Airborne Lidar Data for Hazardous Liquid Leak Detection

03 April 2006

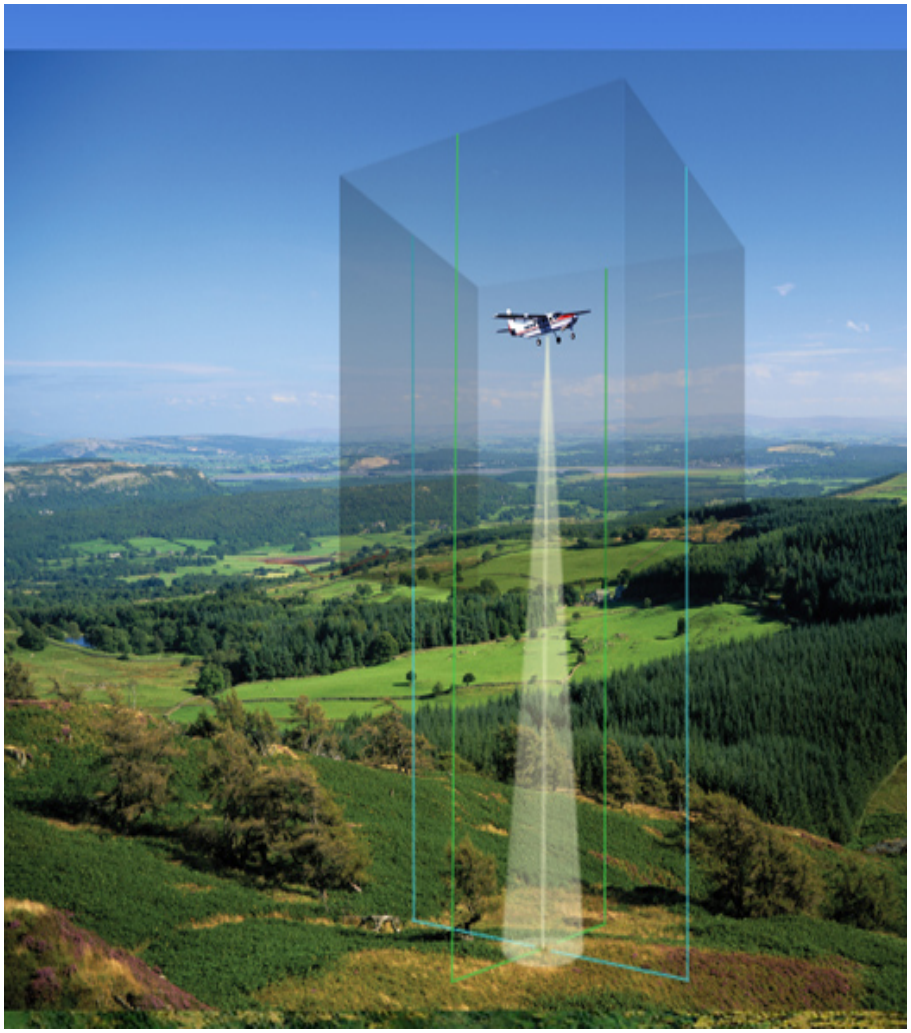
Dr. Darryl G. Murdock

Engineered for life

ITT Airborne Natural Gas Emission Lidar (ANGEL) Service Overview
Comprehensive, End-to-end, Bundled Service

The ANGEL Service is an airborne natural gas detection and reporting service which detects, quantifies, images, and maps the presence of natural gas within the atmosphere.

This service also provides high-resolution color aerial imagery and video of the pipeline corridor and surrounding areas.



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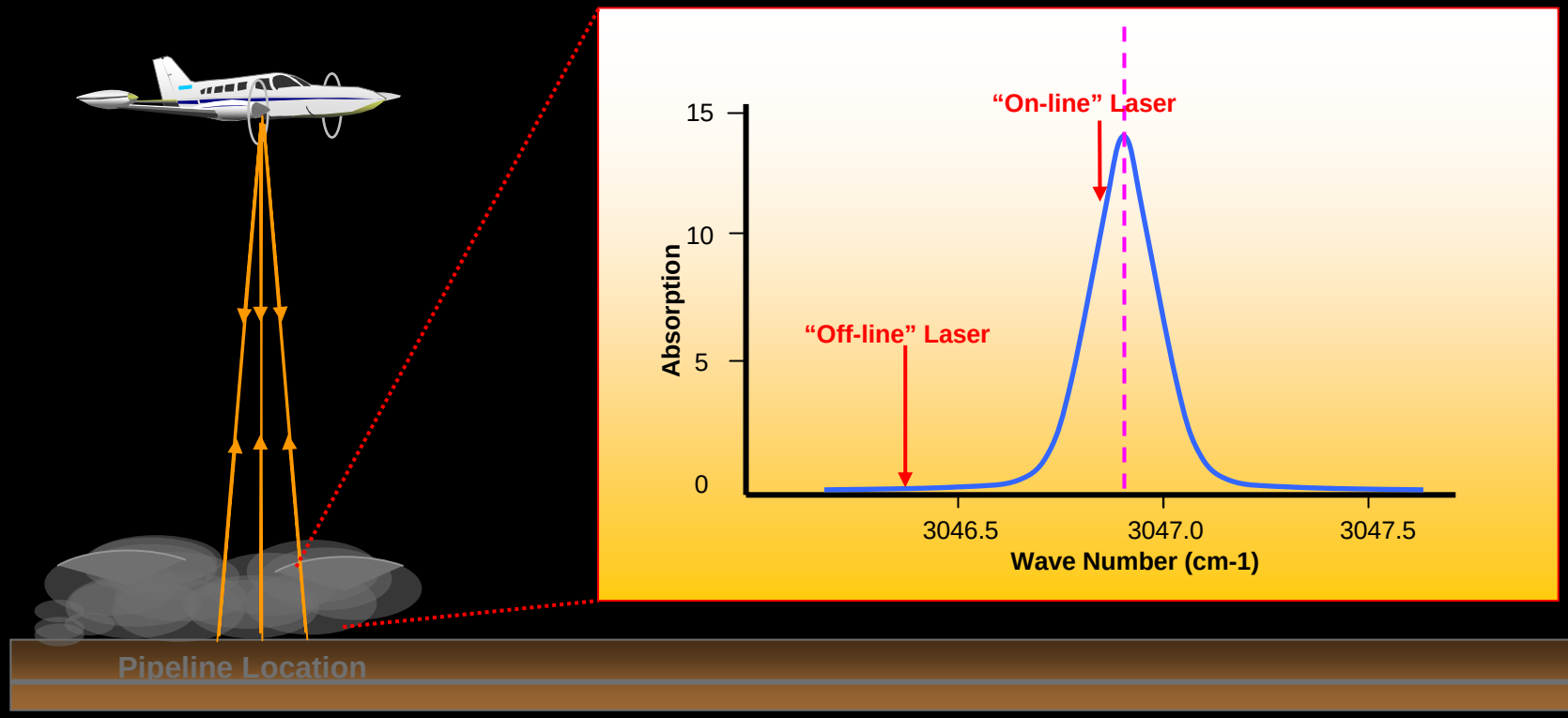
ANGEL

(Airborne Natural Gas Emissions LIDAR)

- Active Imaging Technique
- Differential Absorption Lidar (DIAL)

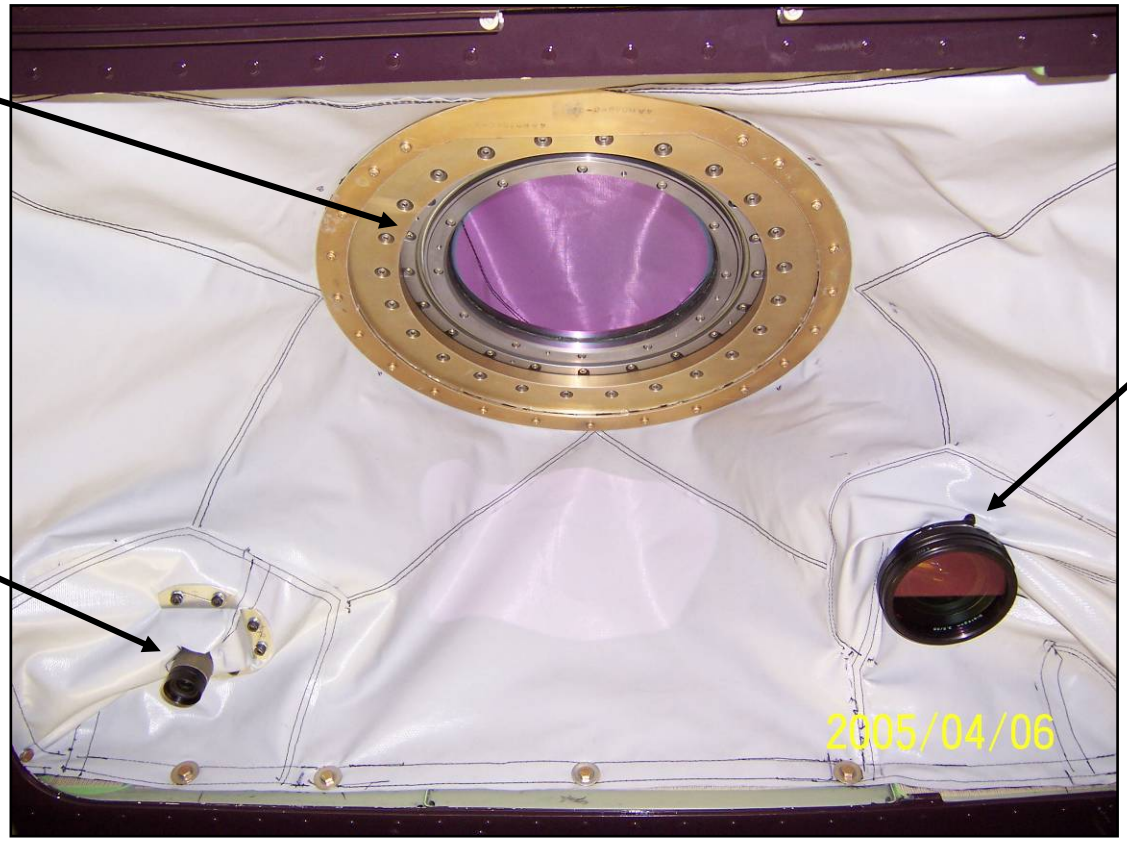


ANGEL DIAL Sensor in Cessna 208 B

ANGEL Optical Port with boot in place

DIAL Sensor

Color Video Camera



High-Resolution Digital Camera

High-Resolution Digital Color Camera

– Applanix DSS 301 camera system with 35 mm lens

– 4,000 by 4,000 pixel color imagery

– 1,041 foot wide image swath (at 1,000 foot AGL)

– GIS-ready orthorectified imagery (GeoTIFF format)

– USGS and NASA approved for Airborne Mapping

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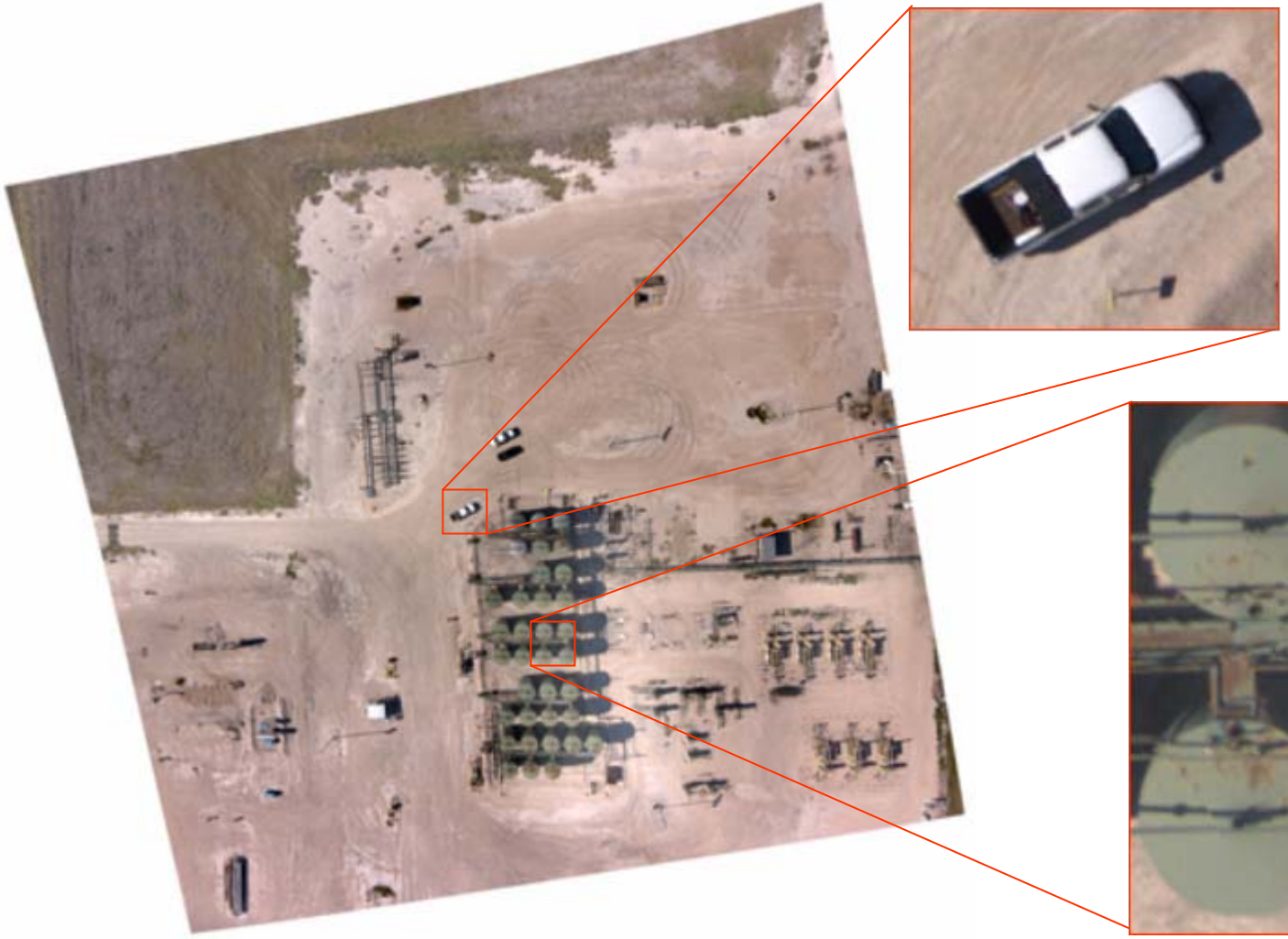
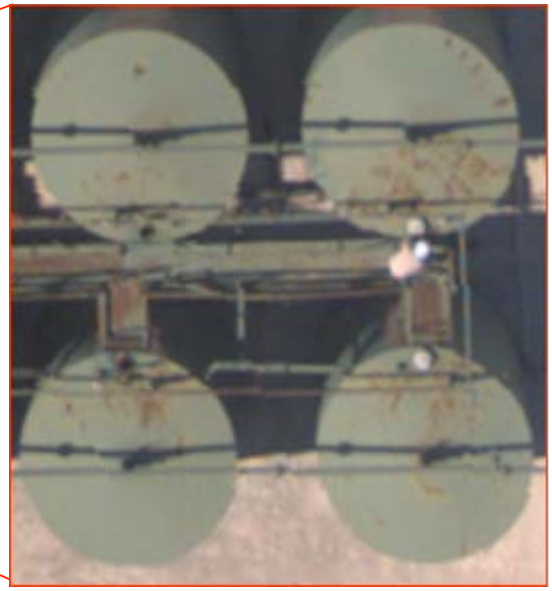
High-Resolution Digital Color Imagery



Vehicles and Equipment

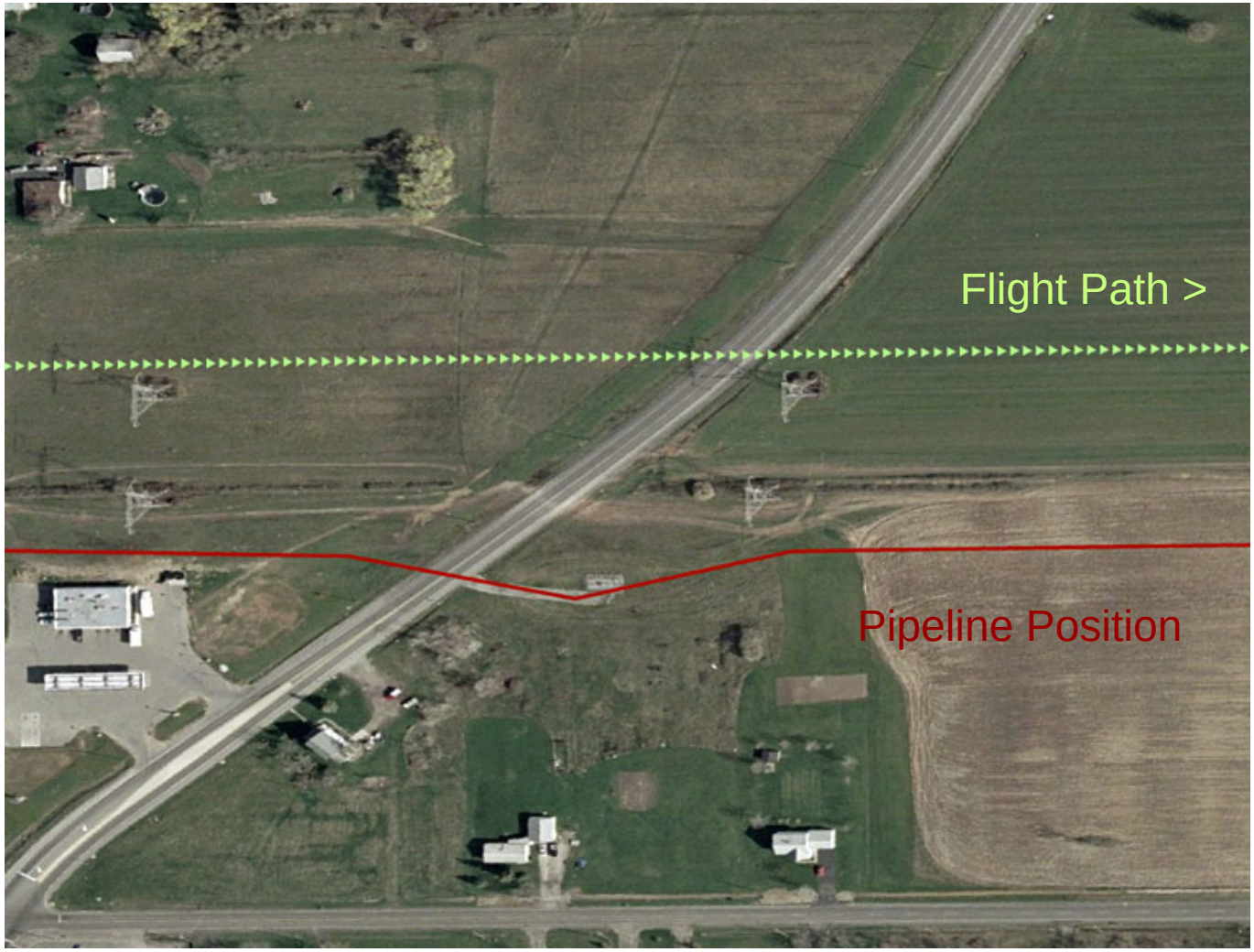


Digital Color Video System

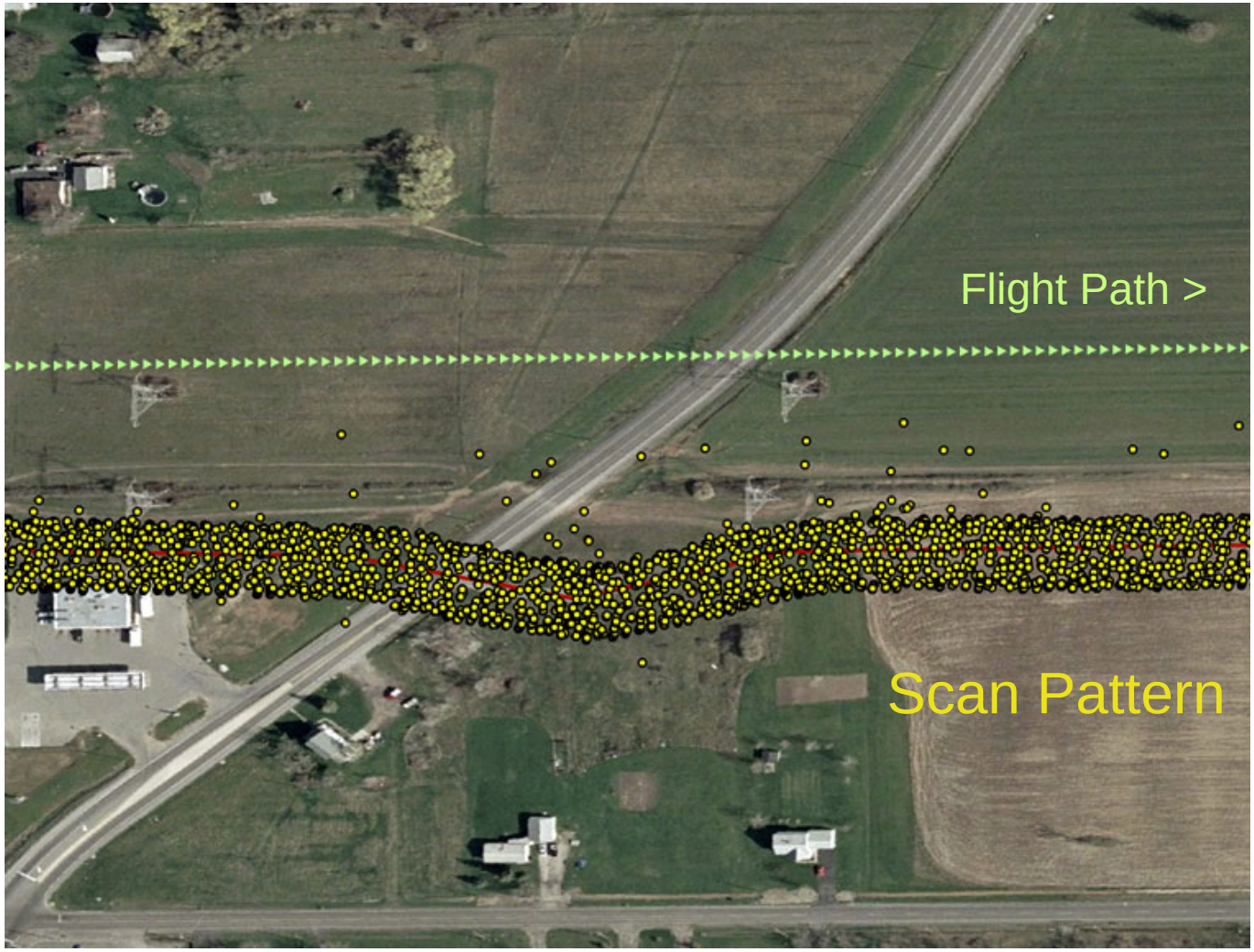
- Jai CV M91 3-chip RGB Camera
- Lateral FOV = 62 degrees
- 765 X 486 pixels
- 1080 foot swath width (1,800 feet AGL, nadir pointing)
- NTSC 30 frames/second

Pipeline Data from Client

Pipeline Integrated with Flight Path and Imagery



DIAL Scan Overlaid on Pipeline



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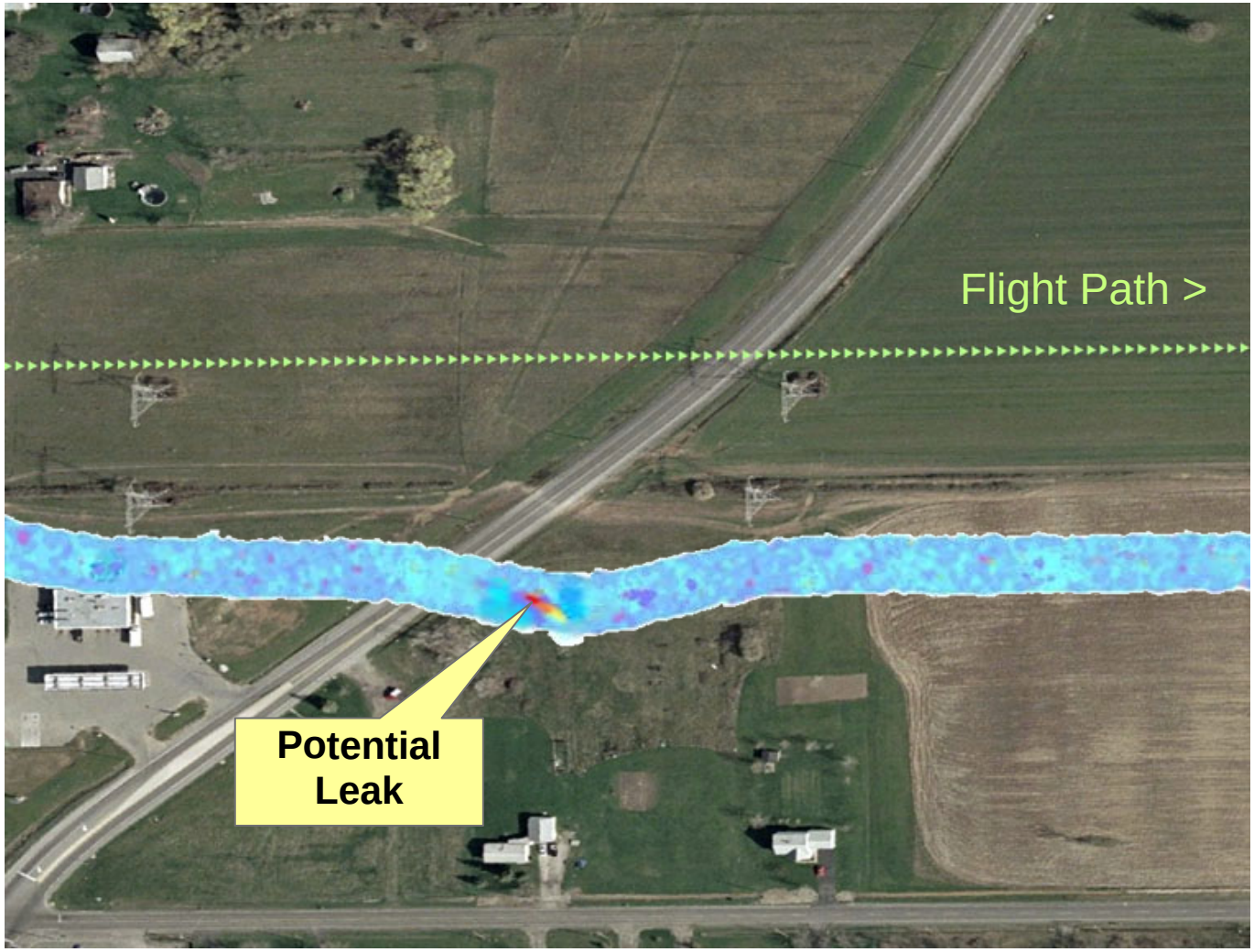
“Blue Ribbon” Analytical Layer



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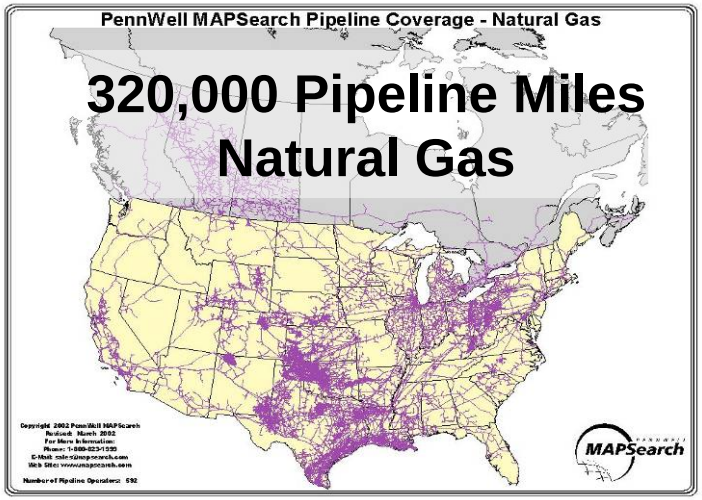
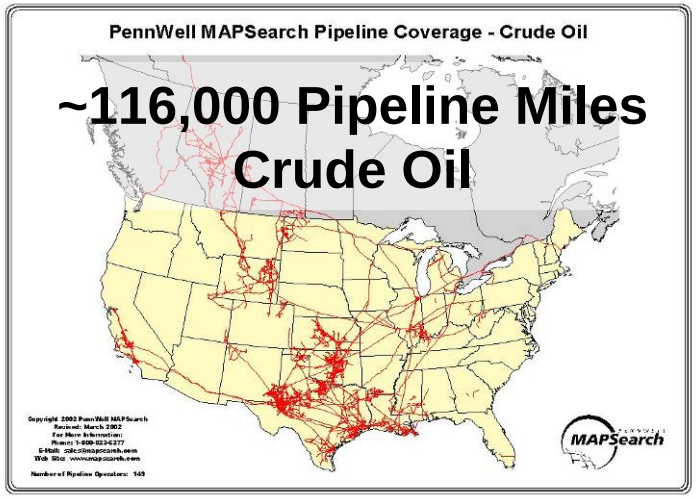
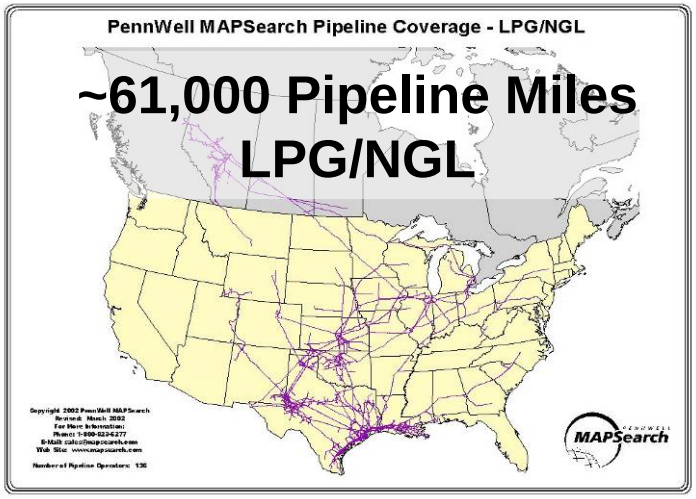
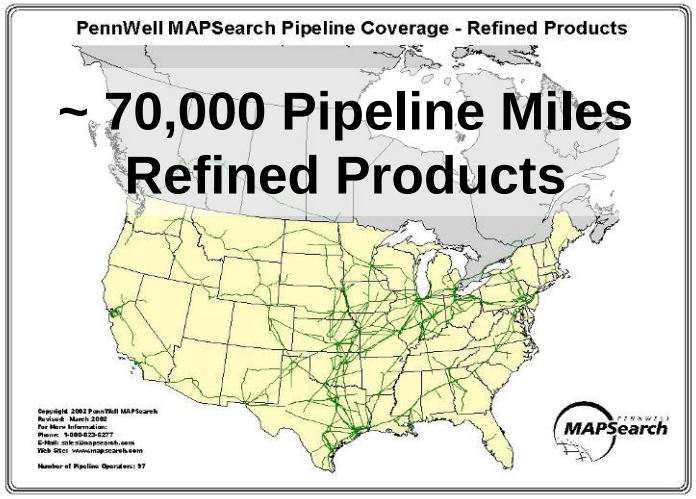
Pipeline Mileage in US and Canada









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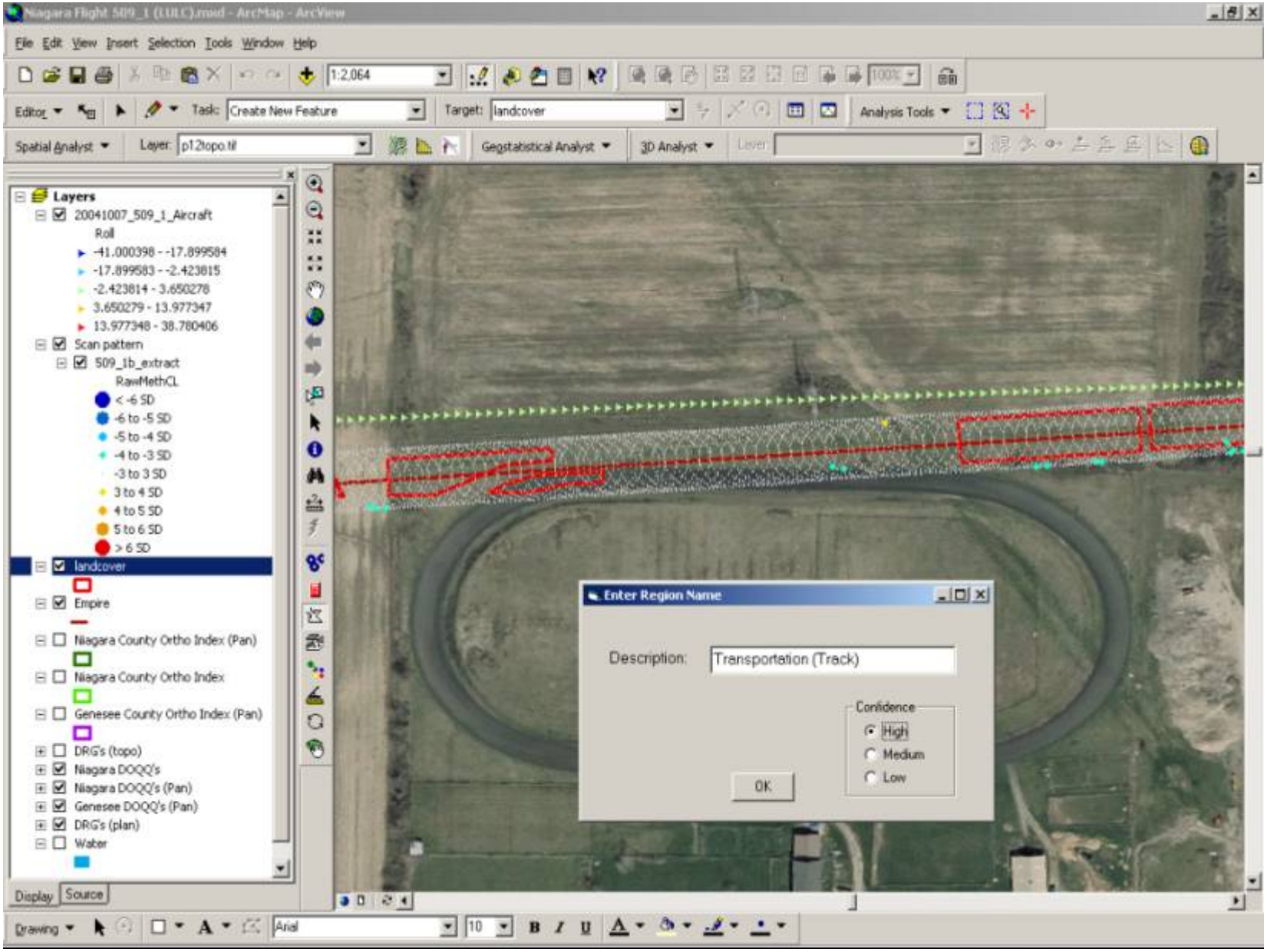
DOT/PHMSA Funded HALOS Project

Hazardous Liquids Airborne Lidar Observation Study (HALOS)

Major objectives:

- Characterize the spectral and physical properties of hazardous hydrocarbon liquid pipeline leaks.
- Demonstrate that the current ANGEL system can detect large emissions of hazardous liquids.
- Design an airborne sensor optimized to detect small leaks of natural gas and hazardous liquids.

Real-World Flight Testing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Target: landcover
Analysis Tools
Spatial Analyst
Layer: p12topo.tif
Geostatistical Analyst
3D Analyst
Layers
20041007_509_1_Aircraft
Roll
-41.000398 - -17.899584
-17.899583 - -2.423815
-2.423814 - 3.650278
3.650279 - 13.977347
13.977348 - 38.780406
Scan pattern
509_1b_extract
RawMethCL
< -6 SD
-6 to -5 SD
-5 to -4 SD
-4 to -3 SD
-3 to 3 SD
3 to 4 SD
4 to 5 SD
5 to 6 SD
> 6 SD
landcover
Empire
Niagara County Ortho Index (Pan)
Niagara County Ortho Index
Genesee County Ortho Index (Pan)
DRG's (topo)
Niagara DOQQ's
Niagara DOQQ's (Pan)
Genesee DOQQ's (Pan)
DRG's (plan)
Water
Display
Source
Enter Region Name
Description:
Transportation (Track)
Confidence
High
Medium
Low
OK
Drawing
Arial
10

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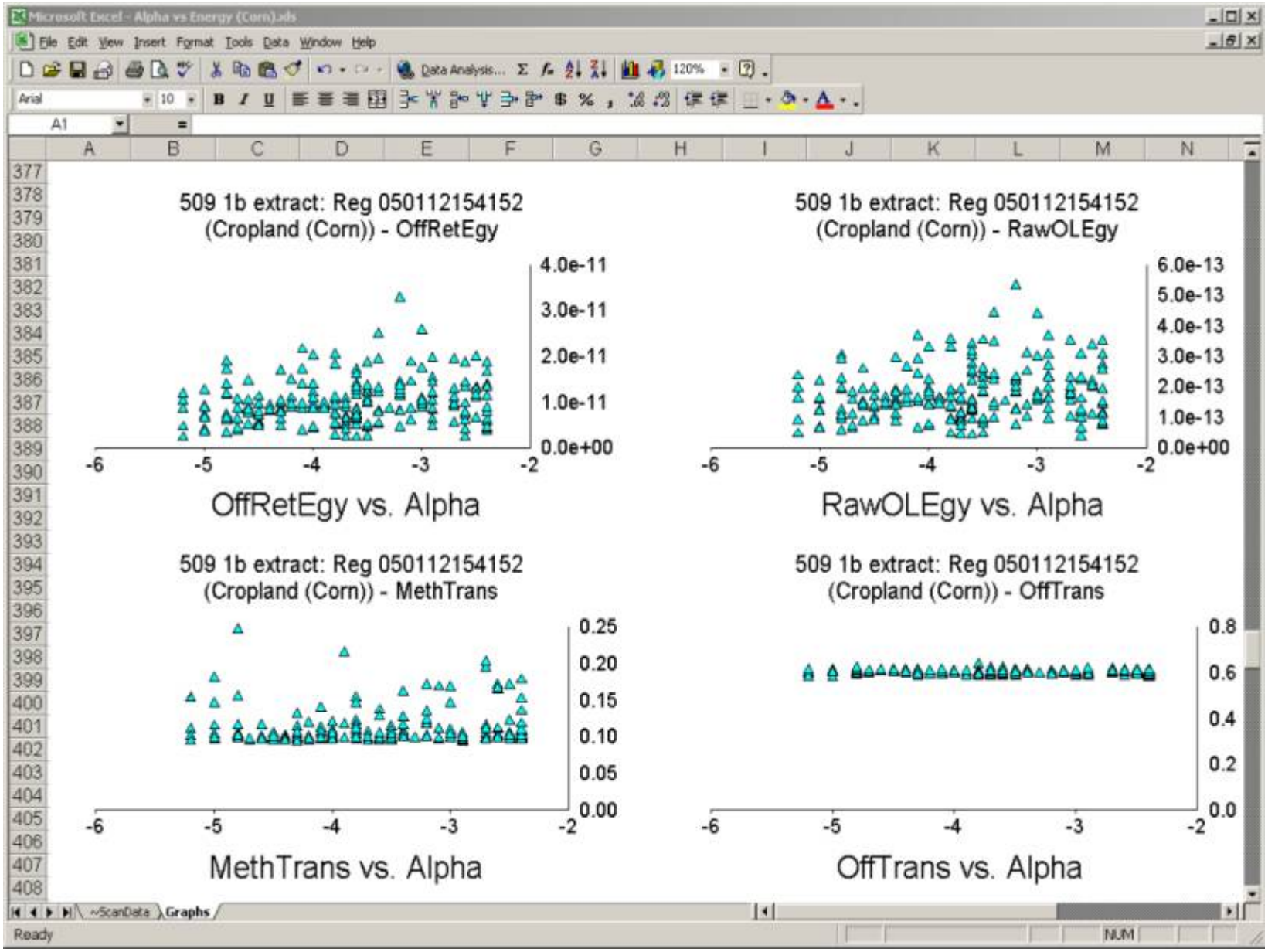
Microsoft Excel - Alpha vs Energy (Corn).xls
File Edit View Insert Format Tools Data Window Help
Data Analysis...
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=
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4.0e-11
3.0e-11
2.0e-11
1.0e-11
0.0e+00
-6 -5 -4 -3 -2
OffRetEgy vs. Alpha
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(Cropland (Corn)) - RawOLEgy
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5.0e-13
4.0e-13
3.0e-13
2.0e-13
1.0e-13
0.0e+00
-6 -5 -4 -3 -2
RawOLEgy vs. Alpha
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0.10
0.05
0.00
-6 -5 -4 -3 -2
MethTrans vs. Alpha
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0.4
0.2
0.0
-6 -5 -4 -3 -2
OffTrans vs. Alpha
~ScanData
Graphs
Ready
NUM

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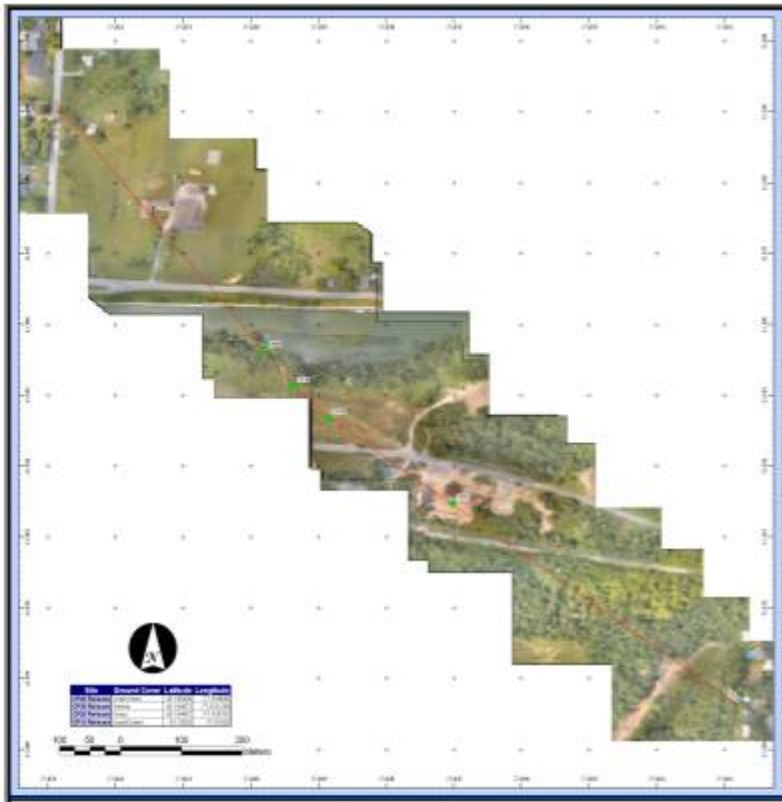

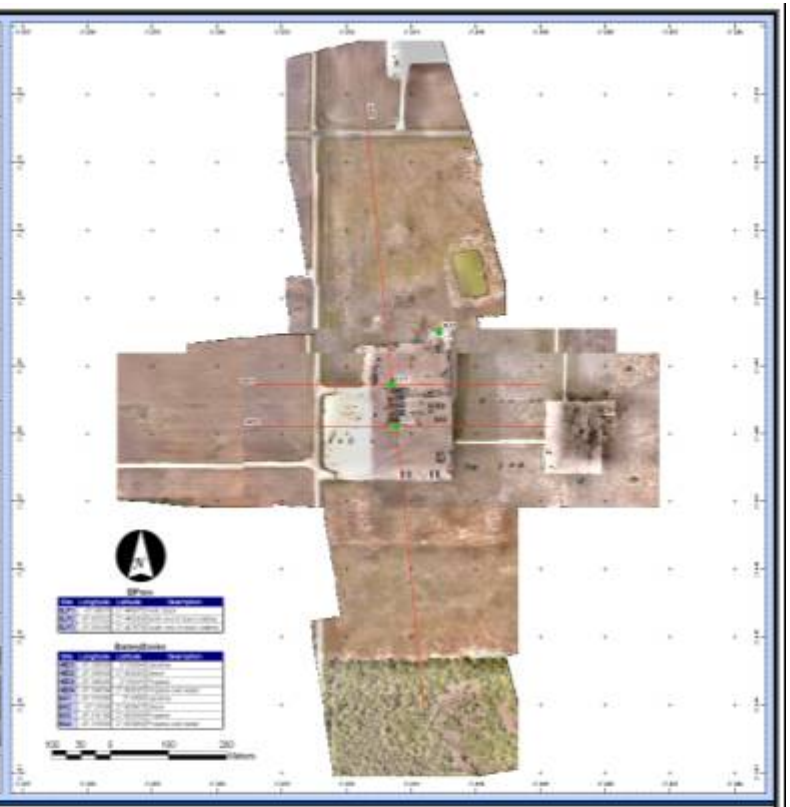

Spencerport

30-Jun-05

Route	Pass	Site	CFH	Gas
1175	3	CP11	500	Methane
		CP20	500	Methane
		CP40	987	Propane
	4	CP11	1000	Methane
		CP20	1000	Methane
		CP40	1410	Propane
	5	CP11	2000	Methane
		CP20	2000	Methane
		CP40	1410	Propane
	6	CP11	987	Propane
		CP30	500	Methane
		CP40	500	Methane
	7	CP11	1128	Propane
		CP30	1000	Methane
		CP40	1000	Methane
	8	CP11	846	Propane
		CP30	2000	Methane
		CP40	2000	Methane
	9	CP11	250	Methane
		CP20	1410	Propane
		CP40	250	Methane

17-Aug-05

Route	Pass	Site	CFH	Gas
1175	1	CP11	0	–
		CP20	0	–
	2	CP11	0	–
		CP20	0	–
	3	CP11	0	–
		CP20	0	–
	4	CP11	500	Propane
		CP20	500	Methane
	5	CP11	500	Propane
		CP20	500	Methane
	6	CP11	500	Propane
		CP20	500	Methane
	7	CP11	1000	Propane
		CP20	1000	Methane
	8	CP11	1000	Propane
		CP20	1000	Methane
	9	CP11	1000	Propane
		CP20	1000	Methane
	10	CP11	2000	Propane
		CP20	2000	Methane
	11	CP11	2000	Propane
		CP20	2000	Methane
	12	CP11	2000	Propane
		CP20	2000	Methane
1175	13	CP20	1000	Meth+Prop
	14	CP20	1000	Meth+Prop
	15	CP20	1000	Meth+Prop
	16	CP11	500	Methane
		CP20	500	Propane
	17	CP11	500	Methane
		CP20	500	Propane
	18	CP11	500	Methane
		CP20	500	Propane
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		CP20	1000	Propane
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		CP20	1000	Propane
	22	CP11	2000	Methane
		CP20	2000	Propane
	23	CP11	2000	Methane
		CP20	2000	Propane
	24	CP11	2000	Methane
		CP20	2000	Propane

Corpus Christi

17-Jun-05

Site	Route	Pass	Dir	Hatches
Kingsville	1800	1	N-S	closed
		2	N-S	open
	1801	1	W-E	closed
		2	W-E	open
	1802	1	E-W	closed
		2	E-W	open

25-Aug-05

Site	Route	Pass	Dir	Hatches
Kingsville	1800	1		closed
		2		open
	1801	1		closed
		2		open
	1802	1		closed
		2		open

Site	Route	Pass	Dir	Gas	Time
Power Plant	1806	1	–	None	–
	1806	1	SE-NW	Pro (H2O)	0608
	1805	1	SE-NW	Pro (Land)	0611
	1804	1	SE-NW	Diesel	0615
	1803	1	SE-NW	Gasoline	0621

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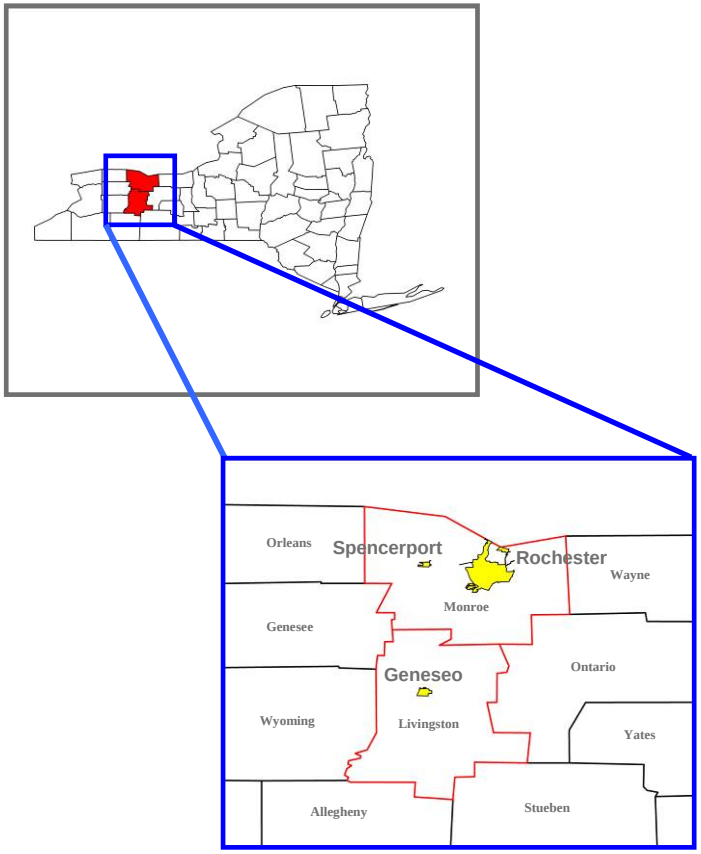
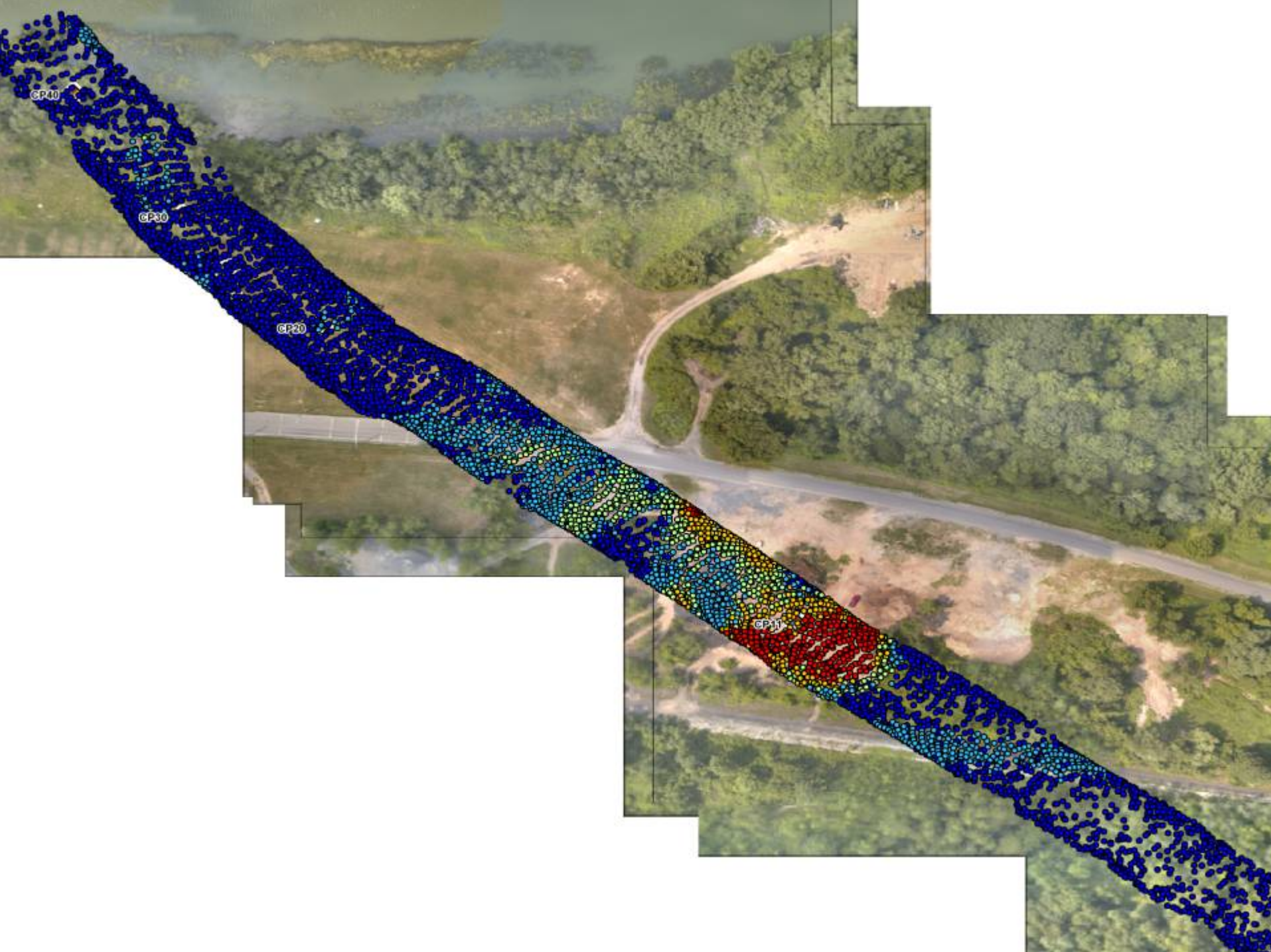
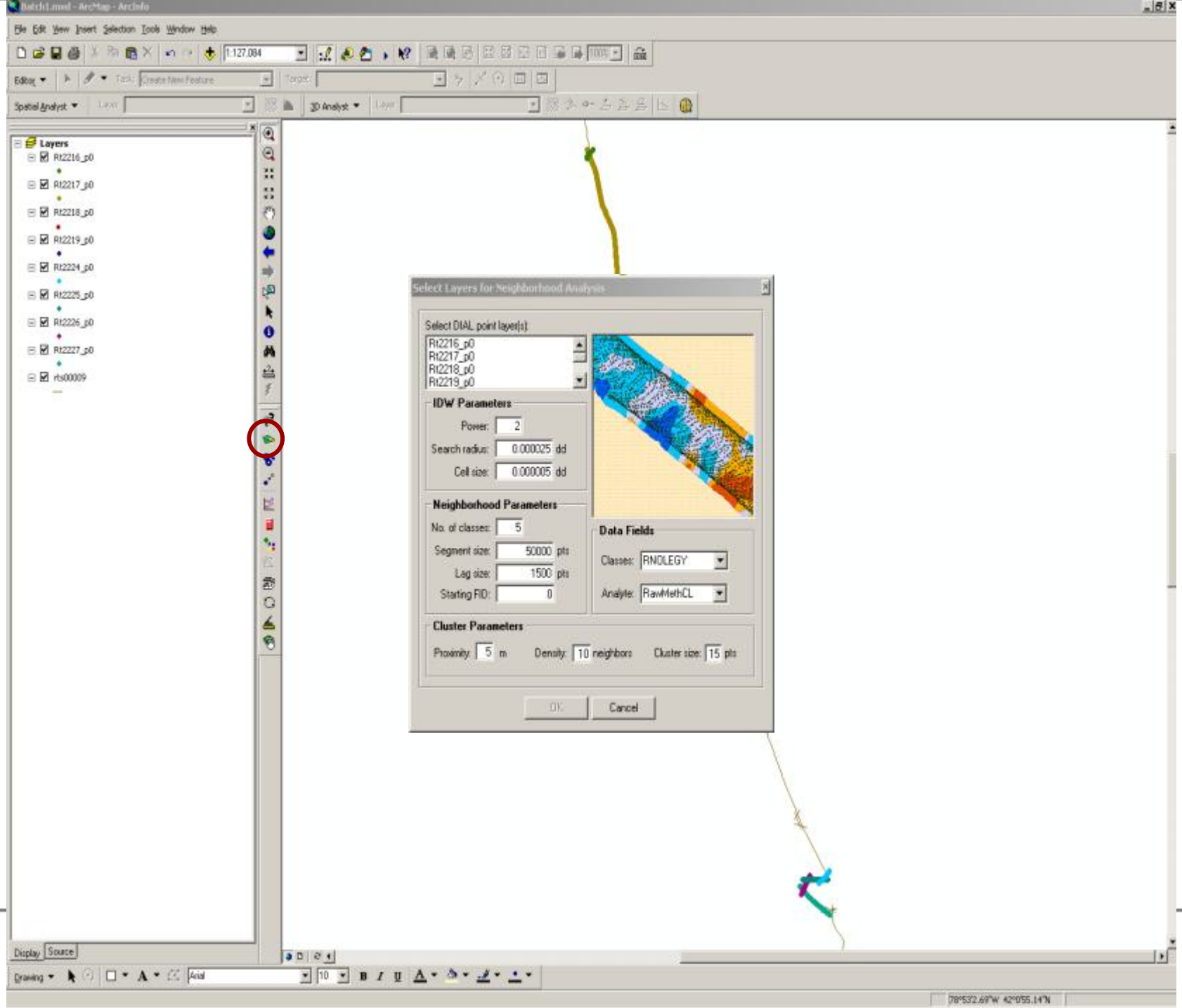
Field Collection Site: Spencerport, NY

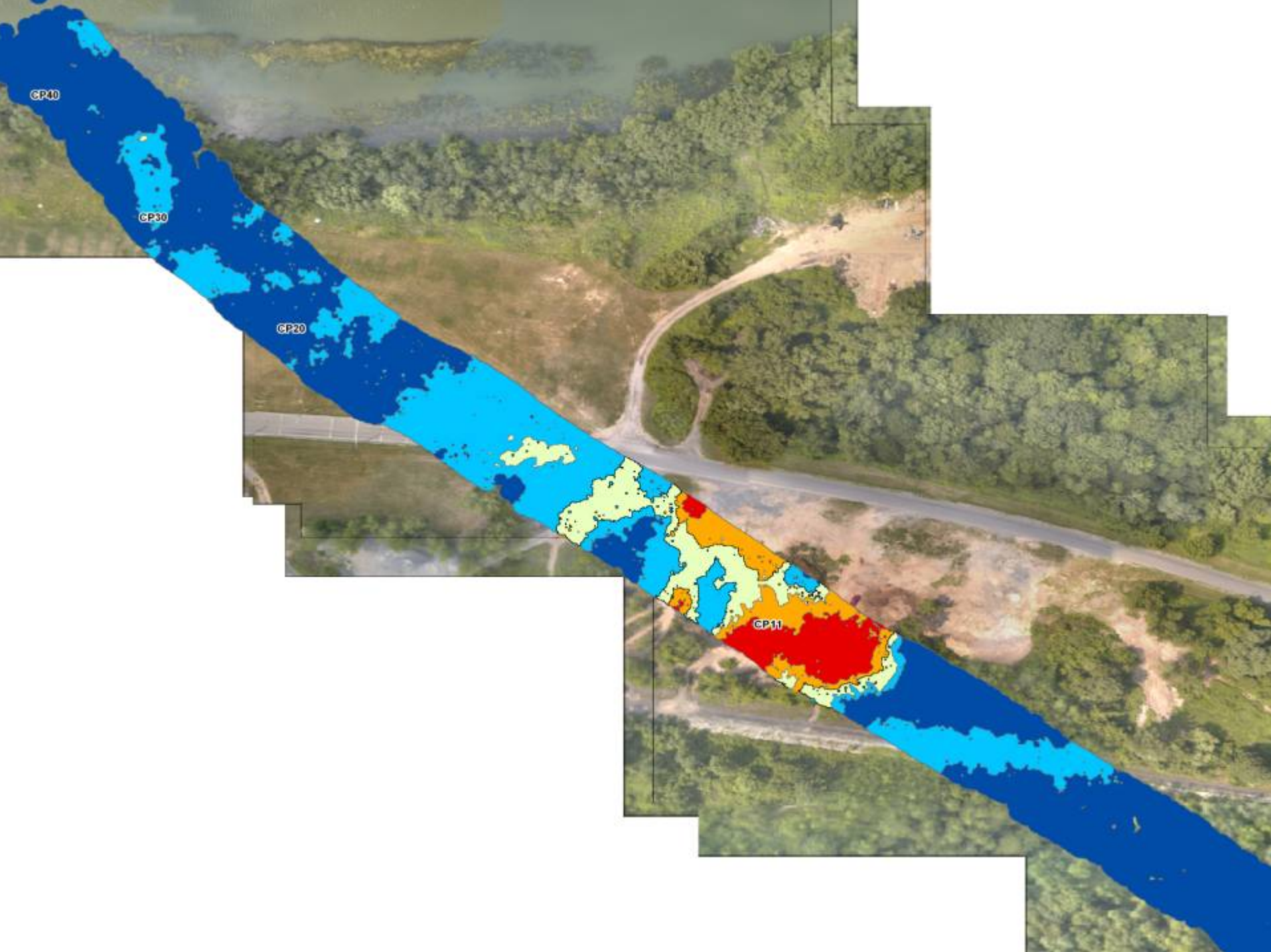


Sandpit Release Site

CP40
CP30
CP20
CP11

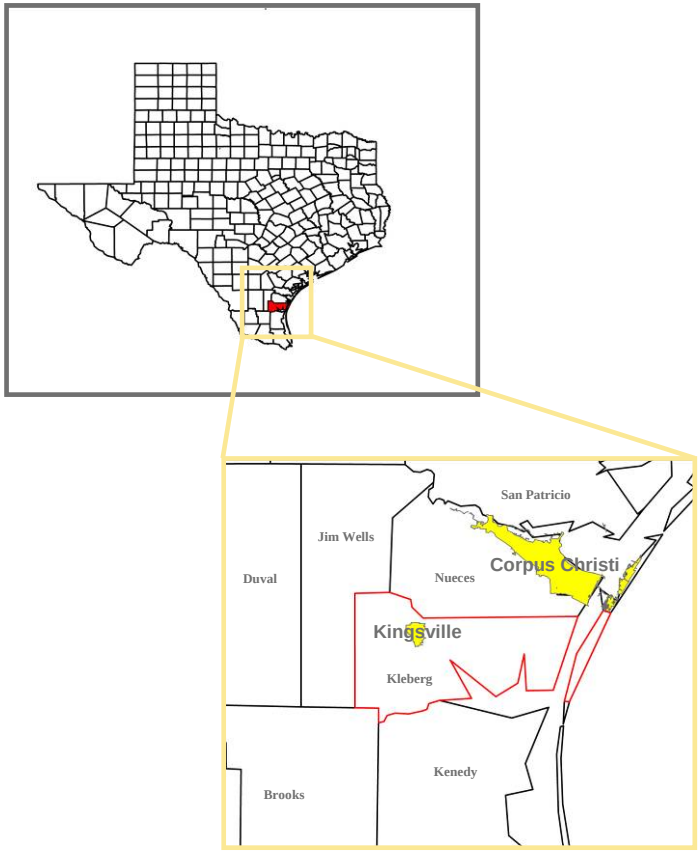

CP40
CP30
CP20
CP11


Batch1.mxd - ArcMap - ArcInfo
File Edit View Insert Selection Tools Window Help
Editor
Spatial Analyst
3D Analyst
Layers
Rt2216_p0
Rt2217_p0
Rt2218_p0
Rt2219_p0
Rt2224_p0
Rt2225_p0
Rt2226_p0
Rt2227_p0
rts00009
Display
Source
Drawing
Select Layers for Neighborhood Analysis
Select DIAL point layer(s):
Rt2216_p0
Rt2217_p0
Rt2218_p0
Rt2219_p0
IDW Parameters
Power: 2
Search radius: 0.000025 dd
Cell size: 0.000005 dd
Neighborhood Parameters
No. of classes: 5
Segment size: 50000 pts
Lag size: 1500 pts
Starting FID: 0
Data Fields
Classes: RNDLEGY
Analyte: RawMethCL
Cluster Parameters
Proximity: 5 m
Density: 10 neighbors
Cluster size: 15 pts
OK
Cancel


CP40
CP30
CP20
CP11

CP40
CP30
CP20
CP11

Field Collection Site: Kingsville, TX



El Paso Production Tank Battery

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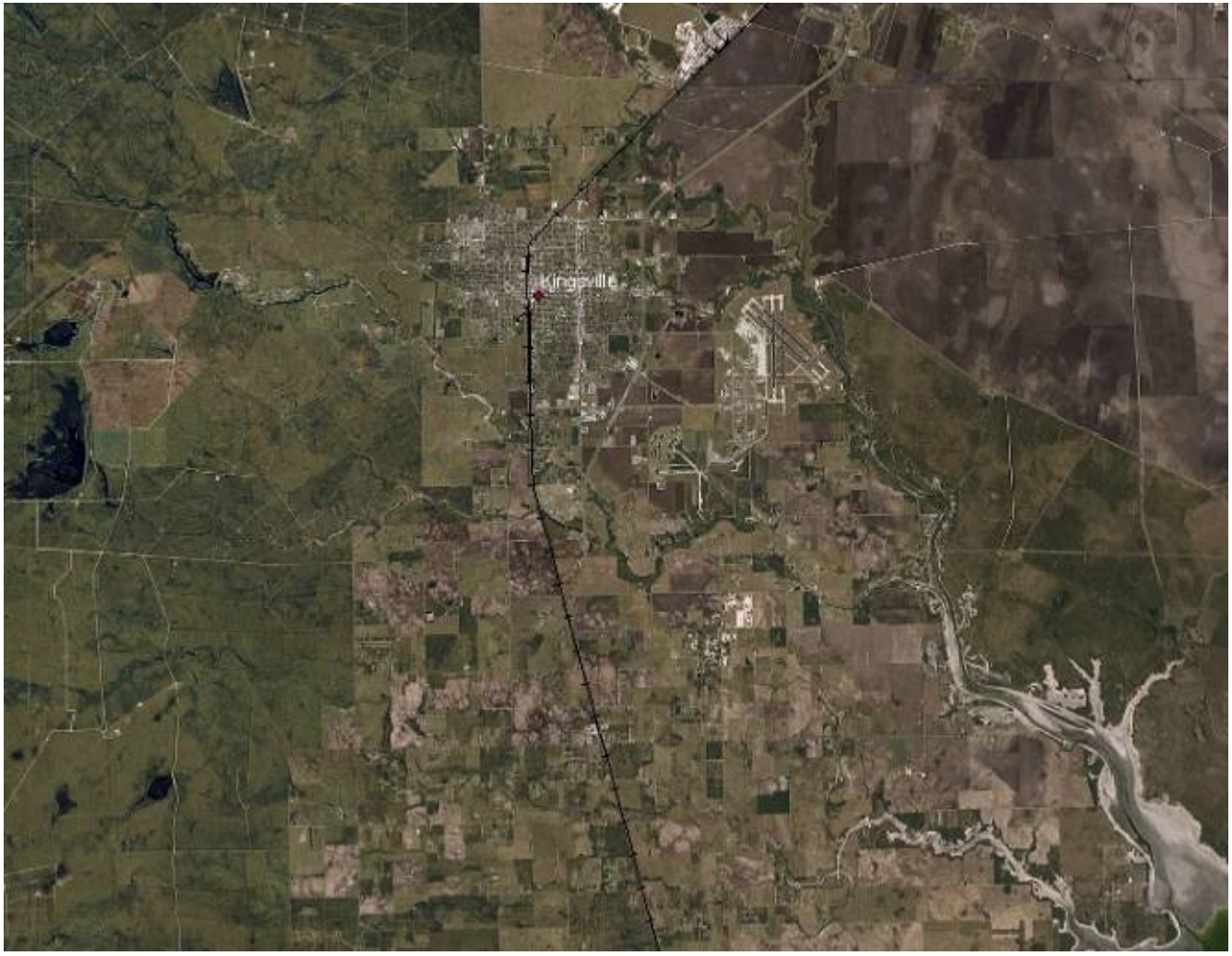
Mission Planning: DOQQs (1:150,00 scale)



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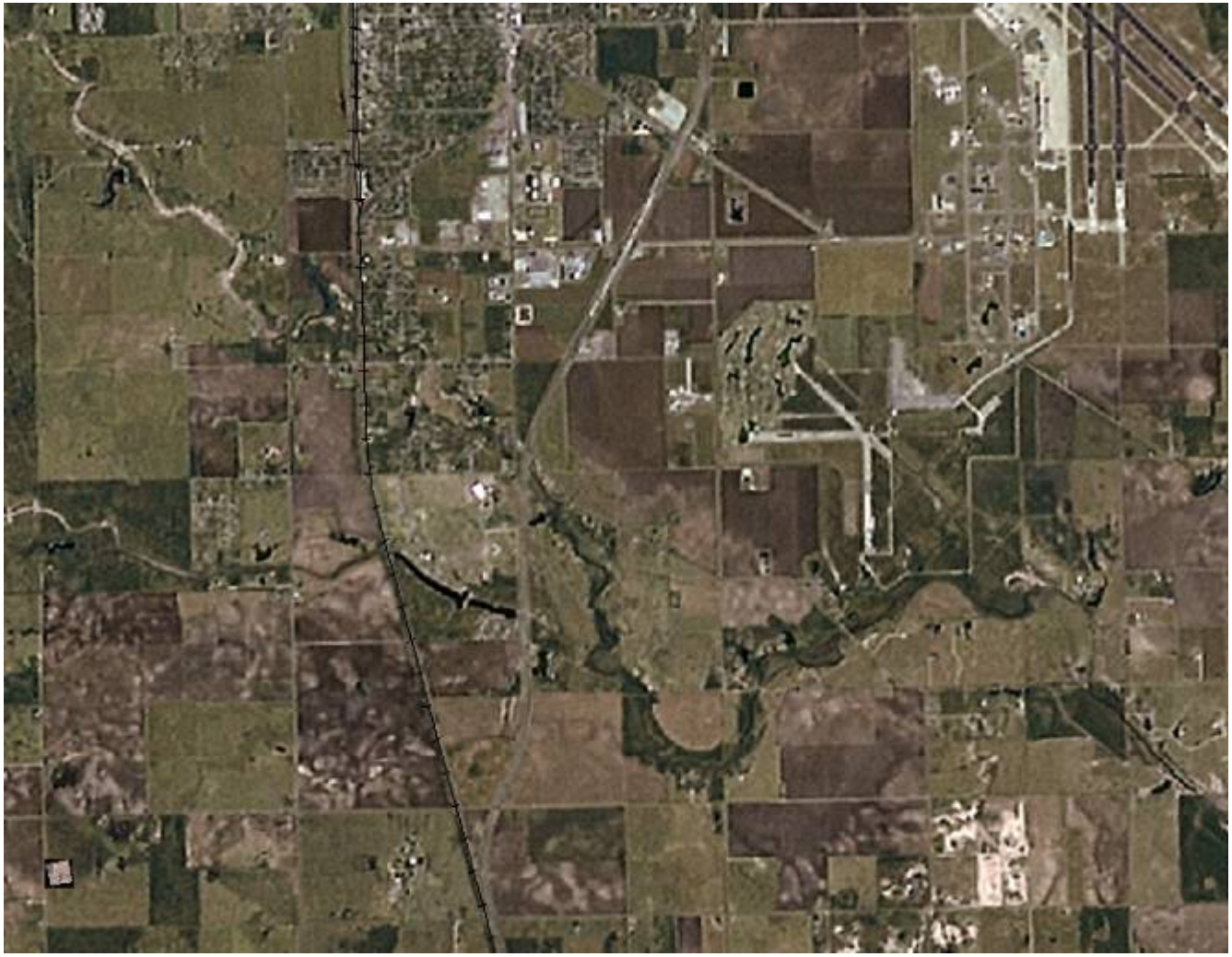
Mission Planning: DOQQs (1:50,000 scale)



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Mission Planning: DOQQs (1:24,000 scale)

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Mission Planning: 3 GPS Points

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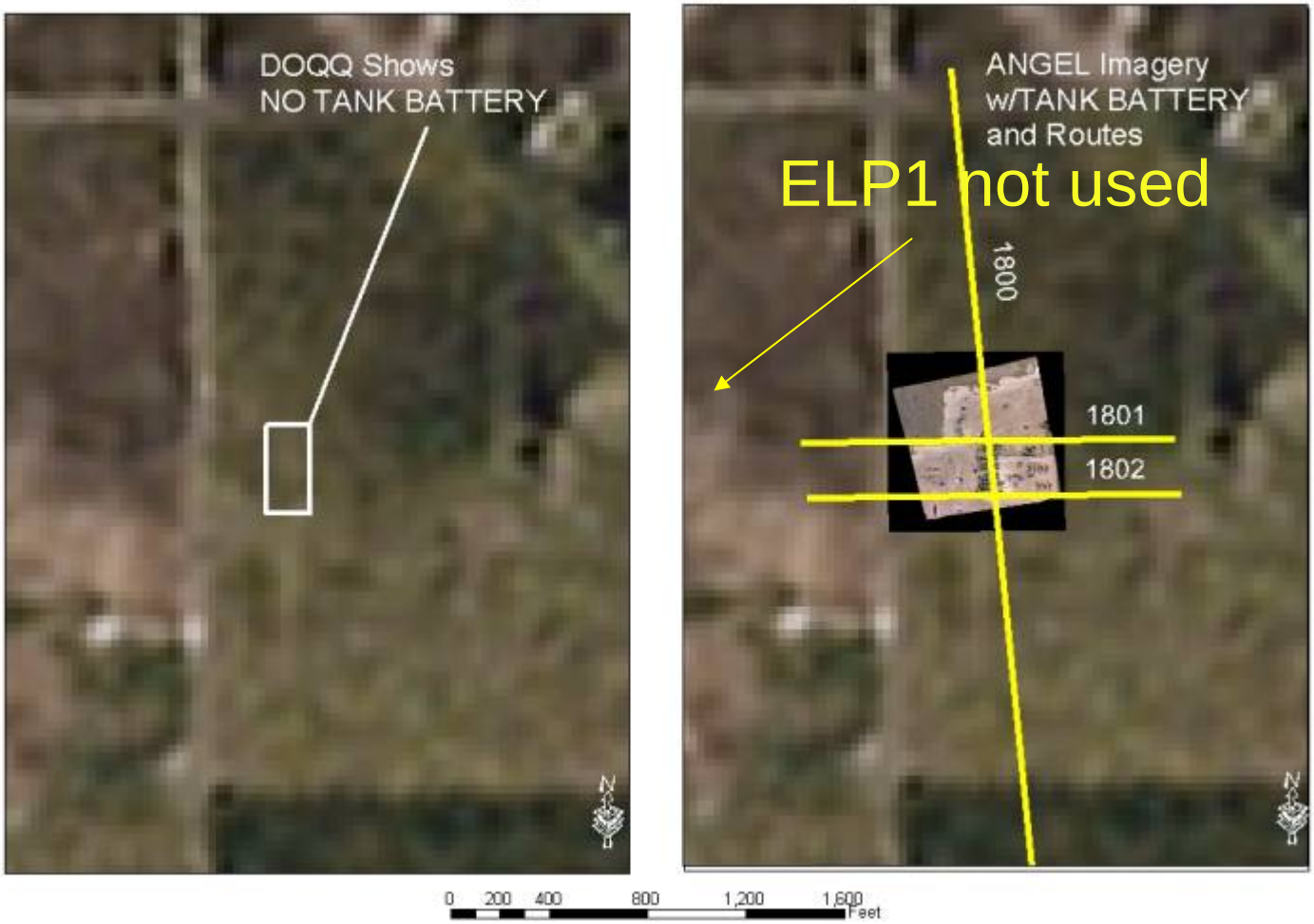
Mission Planning: 2 GPS Points = 3 Planned Routes

Mission Planning: DOQQs

Kingsville, TX Flight Planning



Condensate Tank Battery

Meteorology Station at Kingsville – 17 June 2005

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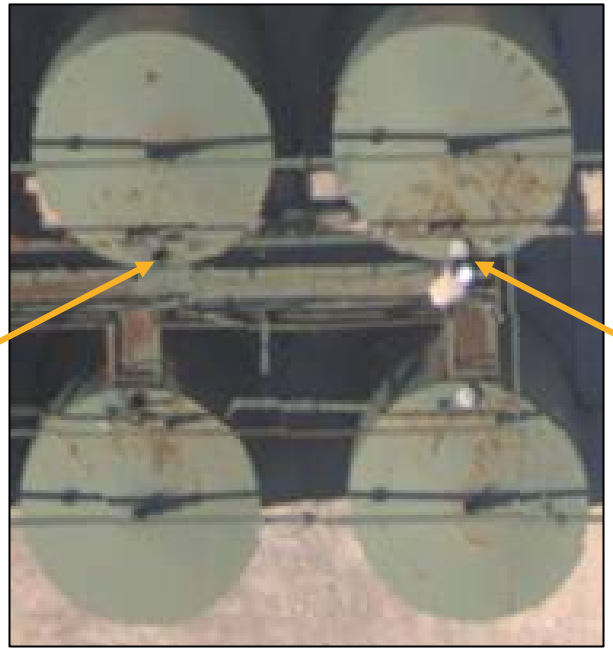
Thief Hatches



Thief Hatch Opened

Thief Hatch Closed

Collection Summary – 17 June 2005

Thief Hatches Closed (VRU on)		
Route Flown	**Collection Time**	**Direction of Travel**
1800	7:38	North to south
1801	7:44	East to West
1802	7:50	West to East
Thief Hatches Opened (VRU off)		
Pass	**Collection Time**	**Direction of Travel**
1800	7:55	North to South
1801	7:59	East to West
1802	8:01	West to East
	0:23	**minutes**

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Ground Team for ANGEL Service Overflight

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1800_pass1 Traditional Approach (Thief Hatches Closed) Laser Samples

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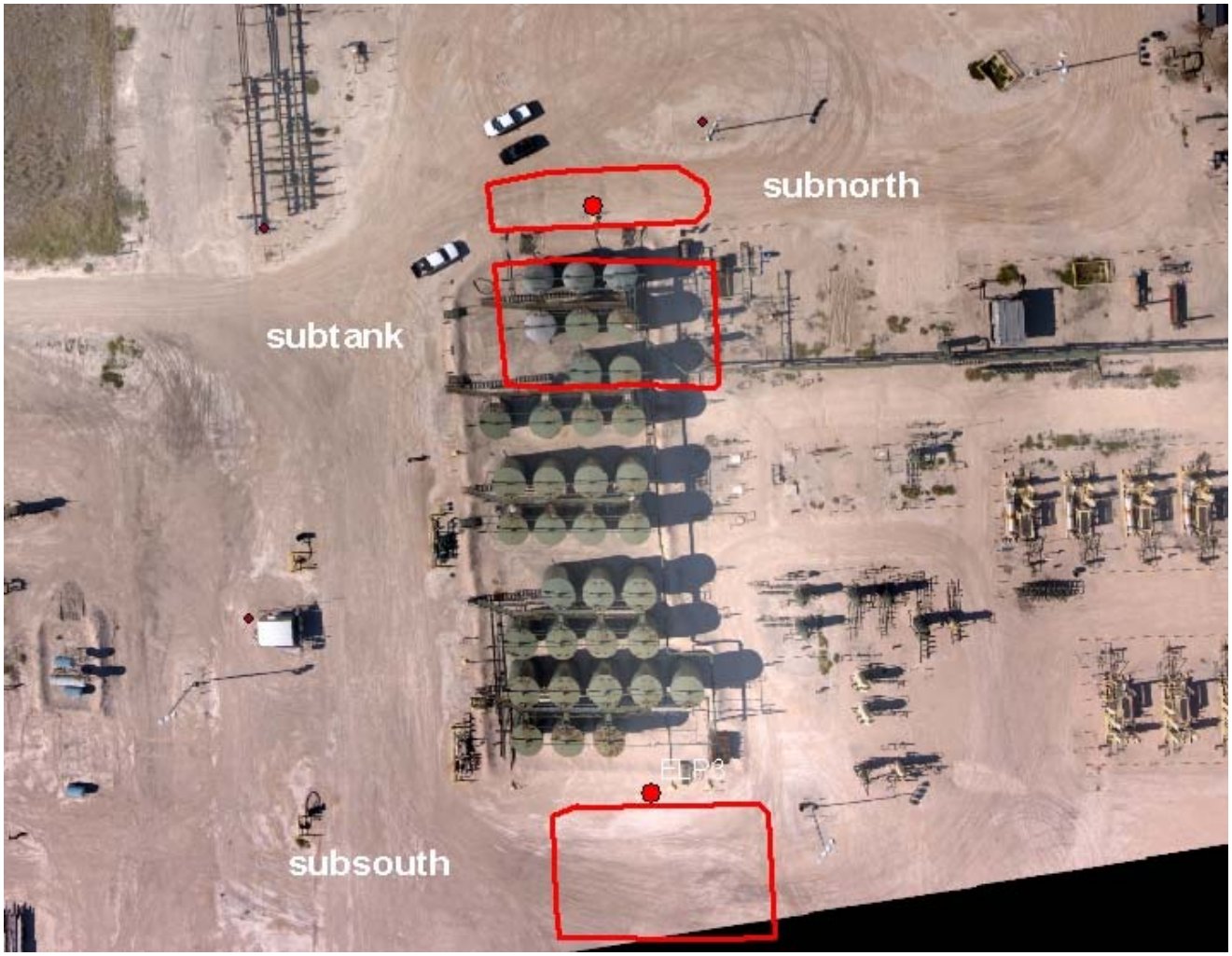
Methods – Data Subsetting



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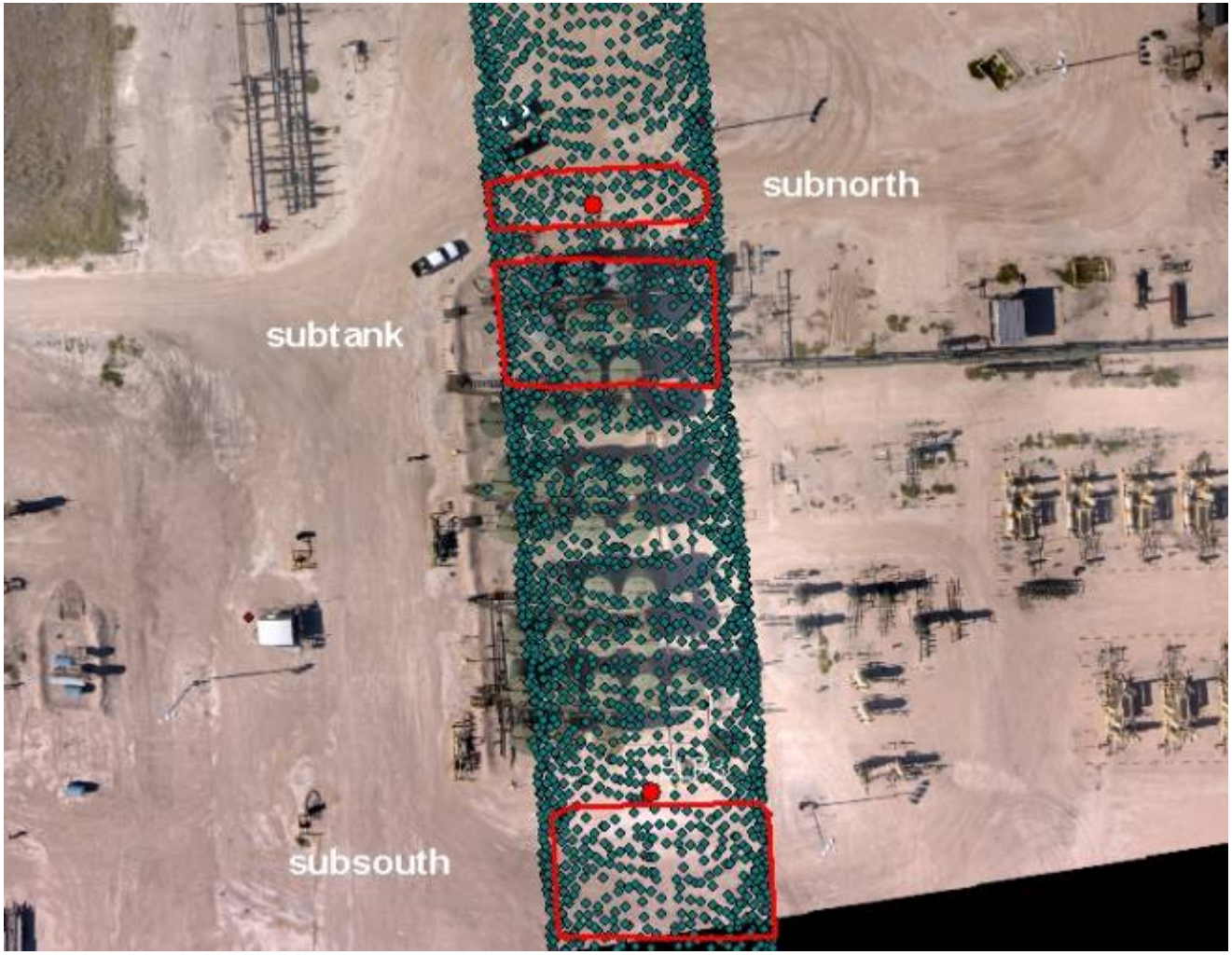
Methods – Route 1800_pass1



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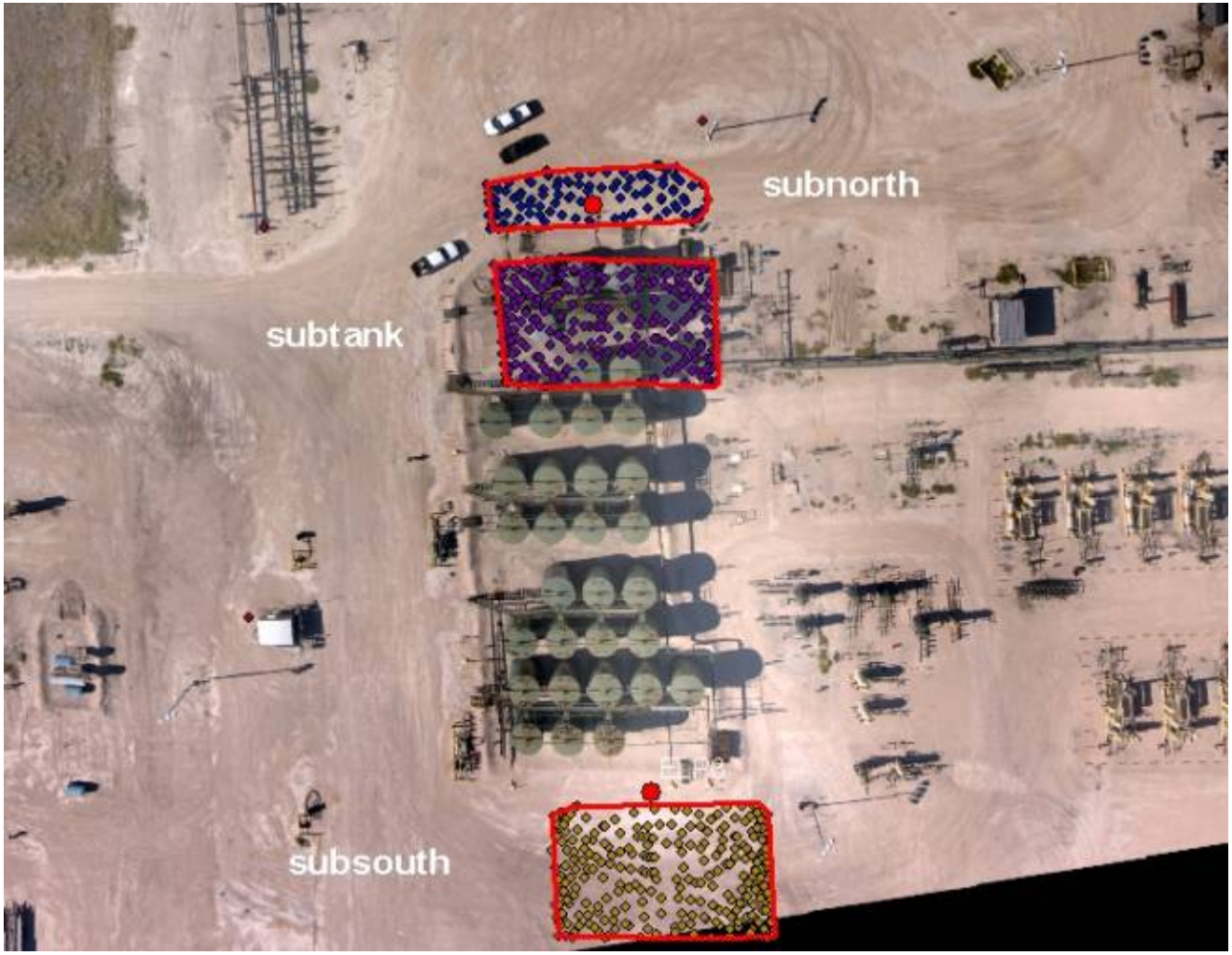
Methods – Route 1800_pass1
Subnorth & Subtank & Subsouth



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Results: north_1800_pass1
Thief Hatches Closed

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Results: north_tank_1800_pass2
Thief Hatches Open

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1801 Pass 1 (Thief Hatches closed)

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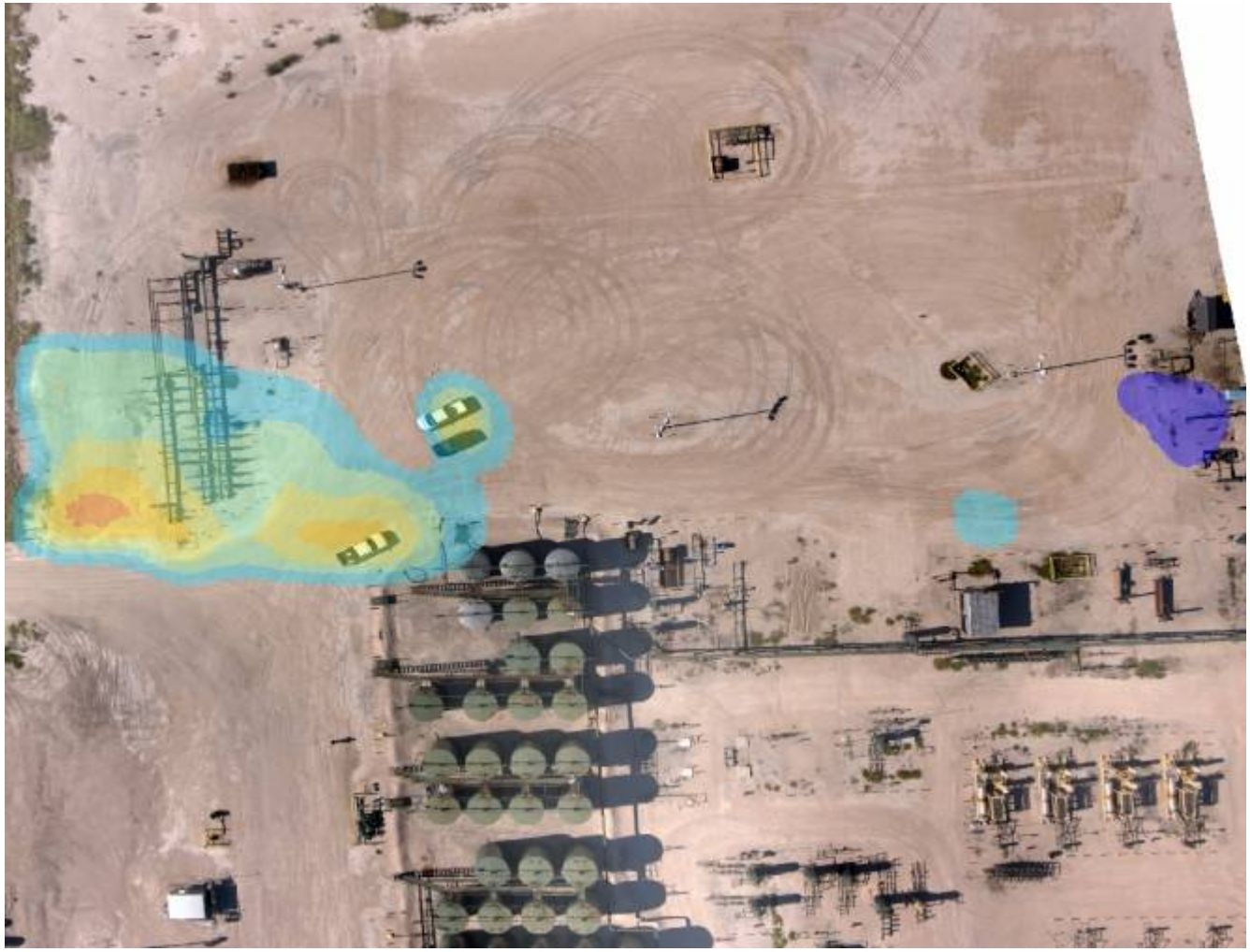
1801 Pass 2 (Thief Hatches Open, Wind From East)



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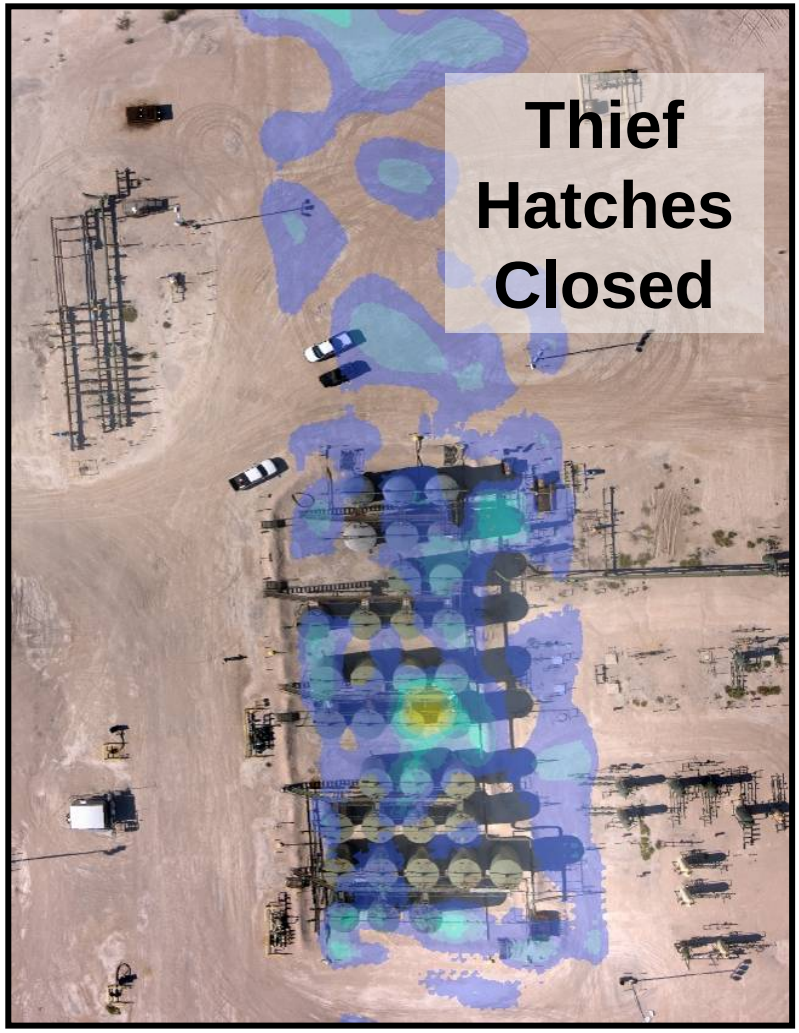
Kingsville Route 1800 Pass 1 and Pass 2 – 17 June 2005 Longer Run Results



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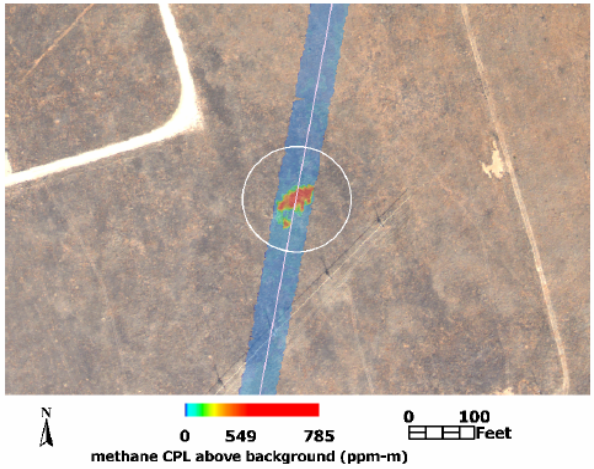
Airborne Natural Gas Emission Lidar (ANGEL) Service
ANGEL Service Anomaly Report ID# R2613.1_011-0002

Engineering Field Test Results - [redacted]

THE FOLLOWING ANOMALY REPORT HAS BEEN GENERATED:



Wind speed/dir: Calm at closest reporting FAA station = KGNC

Distance to KGNC = 6.3mi. Local wind conditions may differ from those at reporting station.

Summary Table

Significance Index: 6

1=low, 6=high

Pipeline:
179M835B

Anomaly Location:
N (WGS84): 32.577136°
W (WGS84): -102.670049°

Anomaly location includes DIAL measurements within 25 meters.

DIAL Collection:
Date: 01-25-2006
Time: 15:06 UTC

Imagery Collection:
Date: 01-24-2006
Time: 17:51 UTC

Crew: 11,14,15
Analysts: 8,21,27,28
Analysis Processes: 10

FIELD VERIFICATION:

DIRECT QUESTIONS OR CONCERNS TO:

Customer Support Center
ITT - ANGEL Service
800 Lee Road, Rochester, NY 14606-0488
(585) 269-5121 (office), (585) 269-5603 (fax)
Email: ais@itt.com

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