Numerical Modelling for Groundwater Extraction Design and Hydrocarbon Plume Containment

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Outline

- Site history and pre-modelling investigations
- Groundwater model design and calibration
- Capture zone of existing extraction well
- Simulations of proposed extraction well configurations

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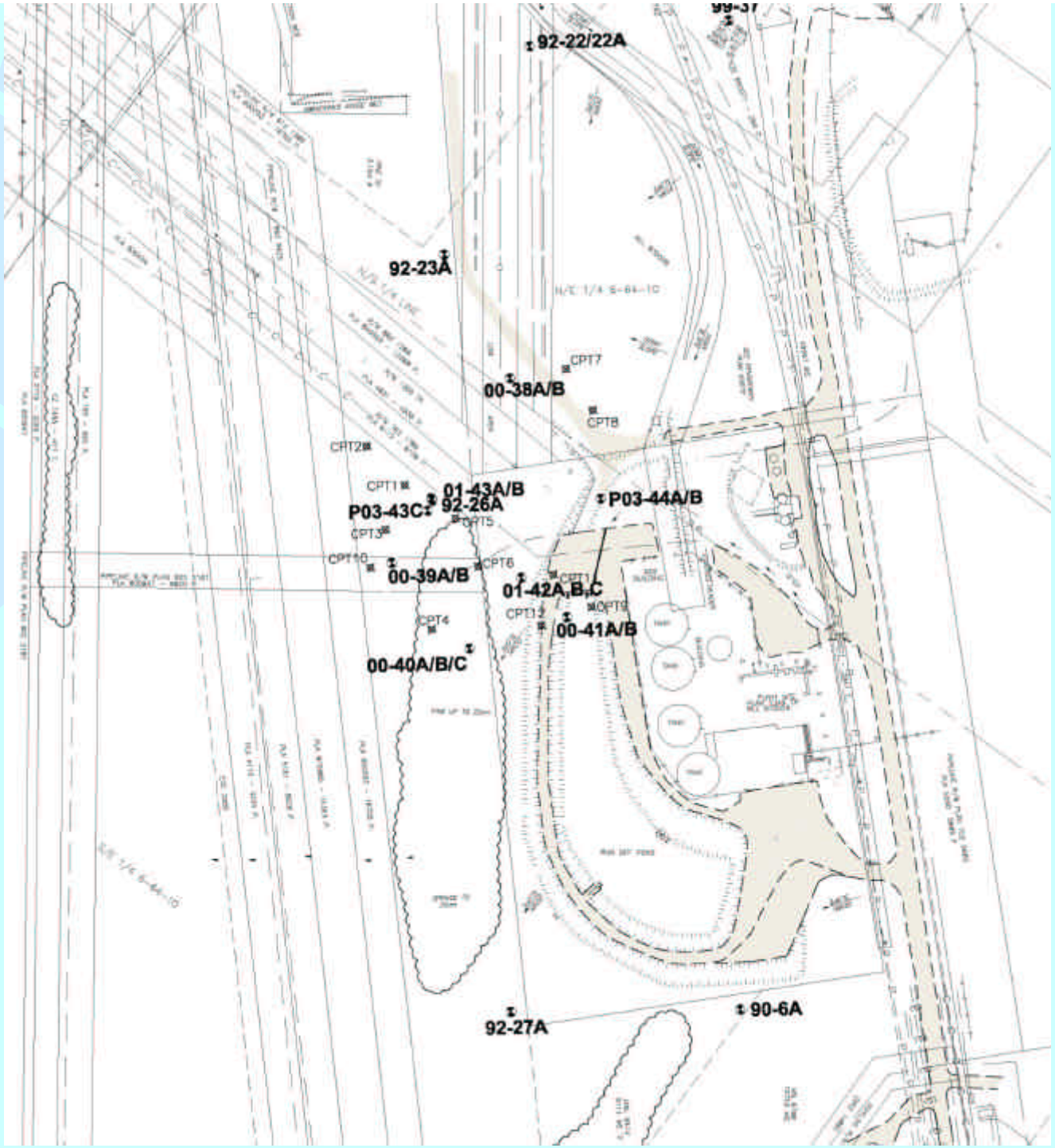
92-22/22A
92-23A
00-38A/B
CPT7
CPT8
CPT2
CPT1
01-43A/B
92-26A
P03-43C
P03-44A/B
CPT5
CPT3
CPT10
CPT6
00-39A/B
01-42A,B,C
CPT11
CPT9
00-41A/B
CPT4
00-40A/B/C
92-27A
90-6A

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Long-term (2.5 month) pumping test

- To determine aquifer storage and transmission properties, potential yield of groundwater extraction system

- Results inconclusive for shallower piezometers (A-series) installed in silty clay till
  * Seasonal decline of potentiometric surface not defined; annual fluctuations of up to 2.5 m

- Results for deeper piezometers (B-series) in weathered siltstone revealed influence of pipeline corridors

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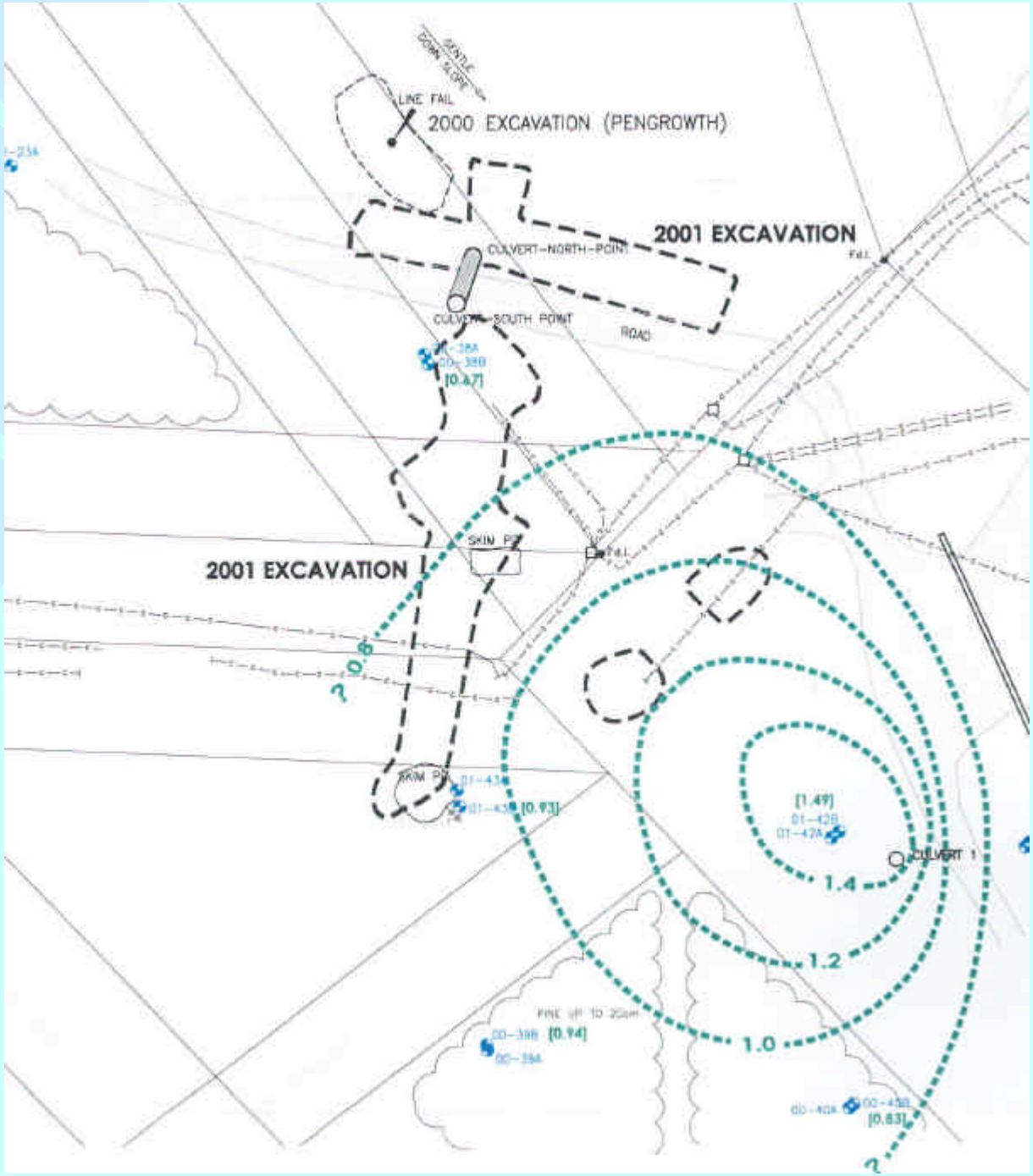
LINE FAIL
2000 EXCAVATION (PENGROWTH)
2001 EXCAVATION
CULVERT-NORTH-POINT
CULVERT-SOUTH POINT
ROAD
[0.67]
2001 EXCAVATION
SKIN PIT
[0.93]
[1.49]
1.4
1.2
1.0
CULVERT 1
FINE UP TO 20cm
[0.94]
[0.83]

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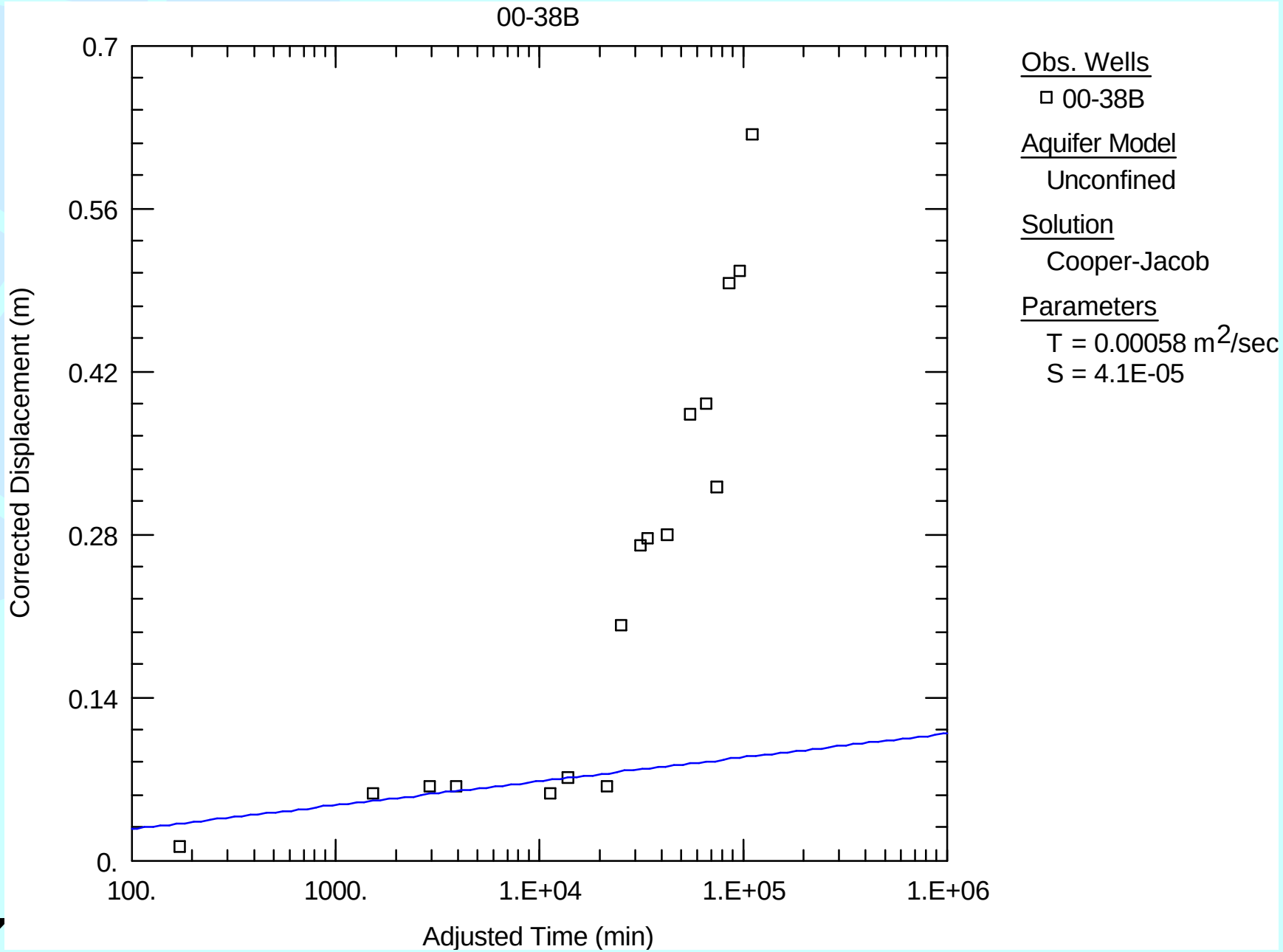
00-38B
0.7
0.56
0.42
0.28
0.14
0.
Corrected Displacement (m)
100.
1000.
1.E+04
1.E+05
1.E+06
Adjusted Time (min)
Obs. Wells
00-38B
Aquifer Model
Unconfined
Solution
Cooper-Jacob
Parameters
T = 0.00058 m2/sec
S = 4.1E-05

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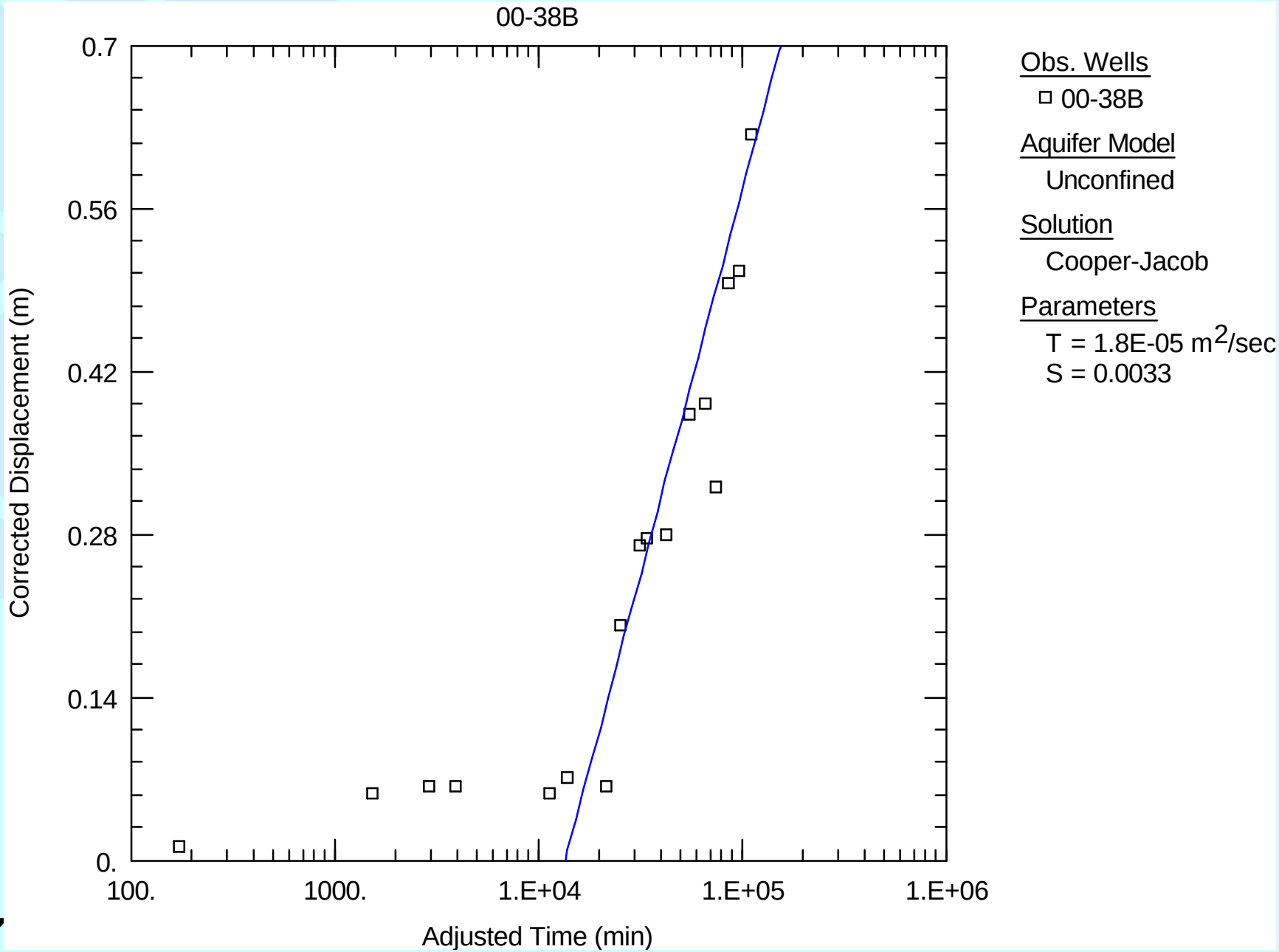
00-38B
0.7
0.56
0.42
0.28
0.14
0.
Corrected Displacement (m)
100.
1000.
1.E+04
1.E+05
1.E+06
Adjusted Time (min)
Obs. Wells
00-38B
Aquifer Model
Unconfined
Solution
Cooper-Jacob
Parameters
T = 1.8E-05 m2/sec
S = 0.0033

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Modelling objectives

- Construct a model of steady-state flow and transient drawdown during the long-term pumping test
- Evaluate the capture zone of the existing extraction well
- Use the model to help design an effective hydraulic containment system

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Hydrostratigraphic framework

- Two-layer model: till and weathered bedrock
- Topography from DEM; layer boundaries from borehole logs and cone penetrometer investigation
- Assume saturated thickness for weathered bedrock of 5 m across domain

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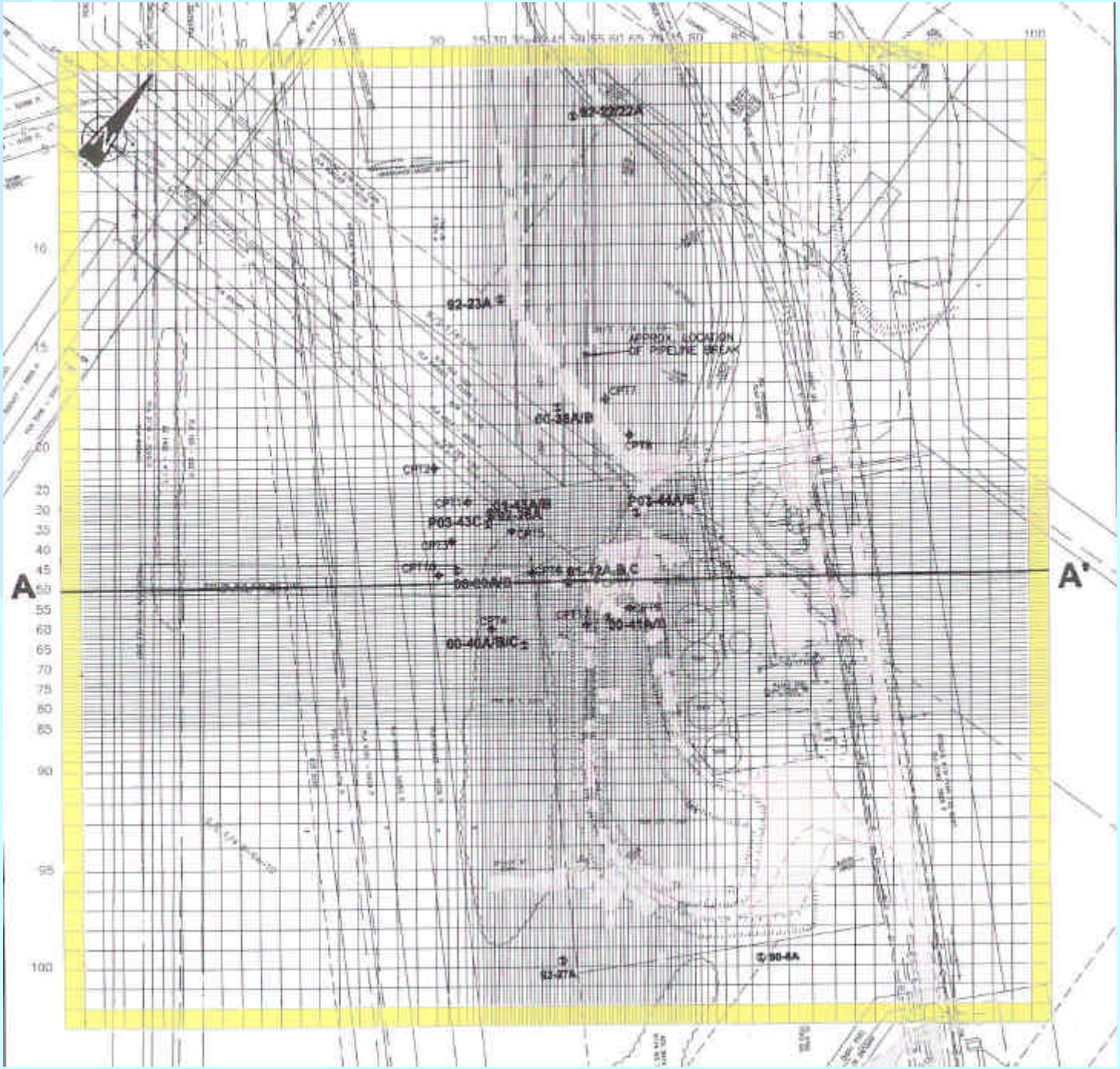
A
A'
APPROX. LOCATION OF PIPELINE BREAK
92-22/22A
92-23A
90-38A/B
P02-44A/E
P03-43C
92-42A,B,C
90-40A/B/C
90-41A/B
92-27A
90-4A

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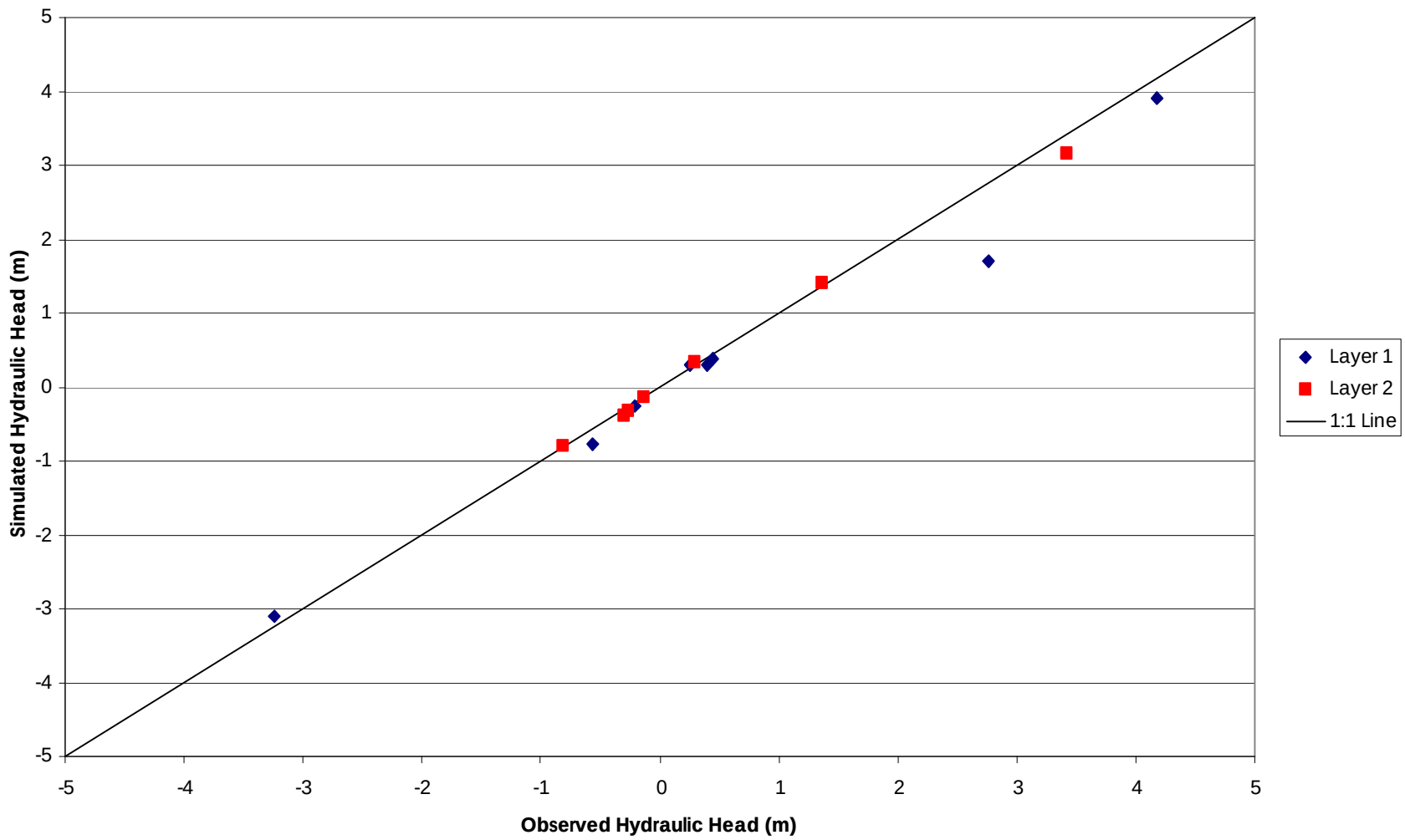
Steady-state calibration



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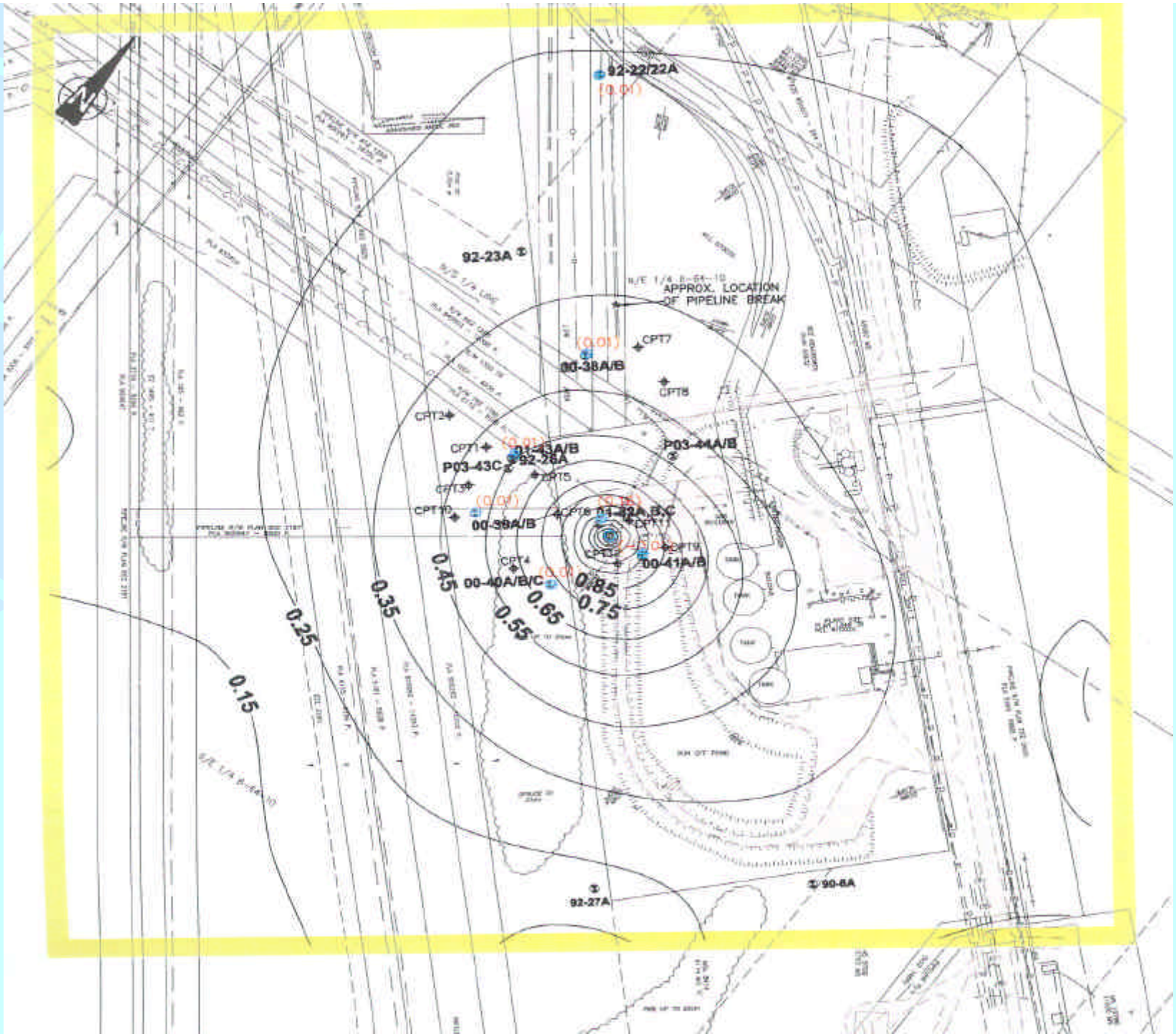
92-22/22A
(0.01)
92-23A
APPROX. LOCATION
OF PIPELINE BREAK
(0.01)
CPT7
00-38A/B
CPT8
CPT2
CPT1
01-43A/B
92-26A
P03-43C
P03-44A/B
CPT5
CPT3
CPT10
(0.01)
00-38A/B
CPT9
01-42A,B,C
CPT11
CPT12
(0.01)
CPT6
00-41A/B
CPT4
(0.01)
00-40A/B/C
0.85
0.75
0.65
0.55
0.45
0.35
0.25
0.15
92-27A
90-6A

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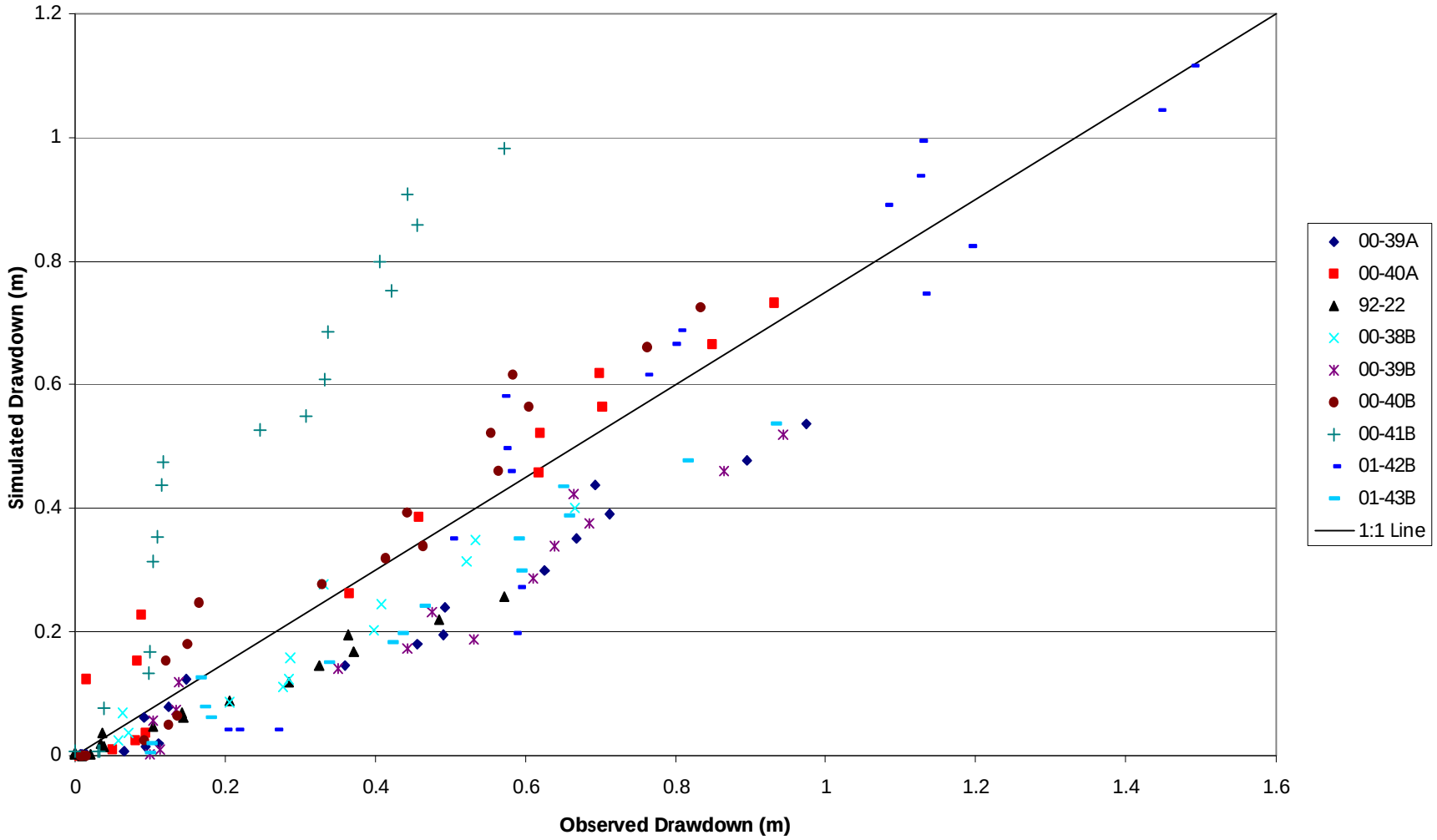
Transient calibration



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Simulation #1: Capture zone

- The portion of an aquifer contributing flow to a recovery well
- Reverse particle tracking from the existing extraction well location
- How does the introduction of high K pipeline corridors influence the capture zone of the extraction well?

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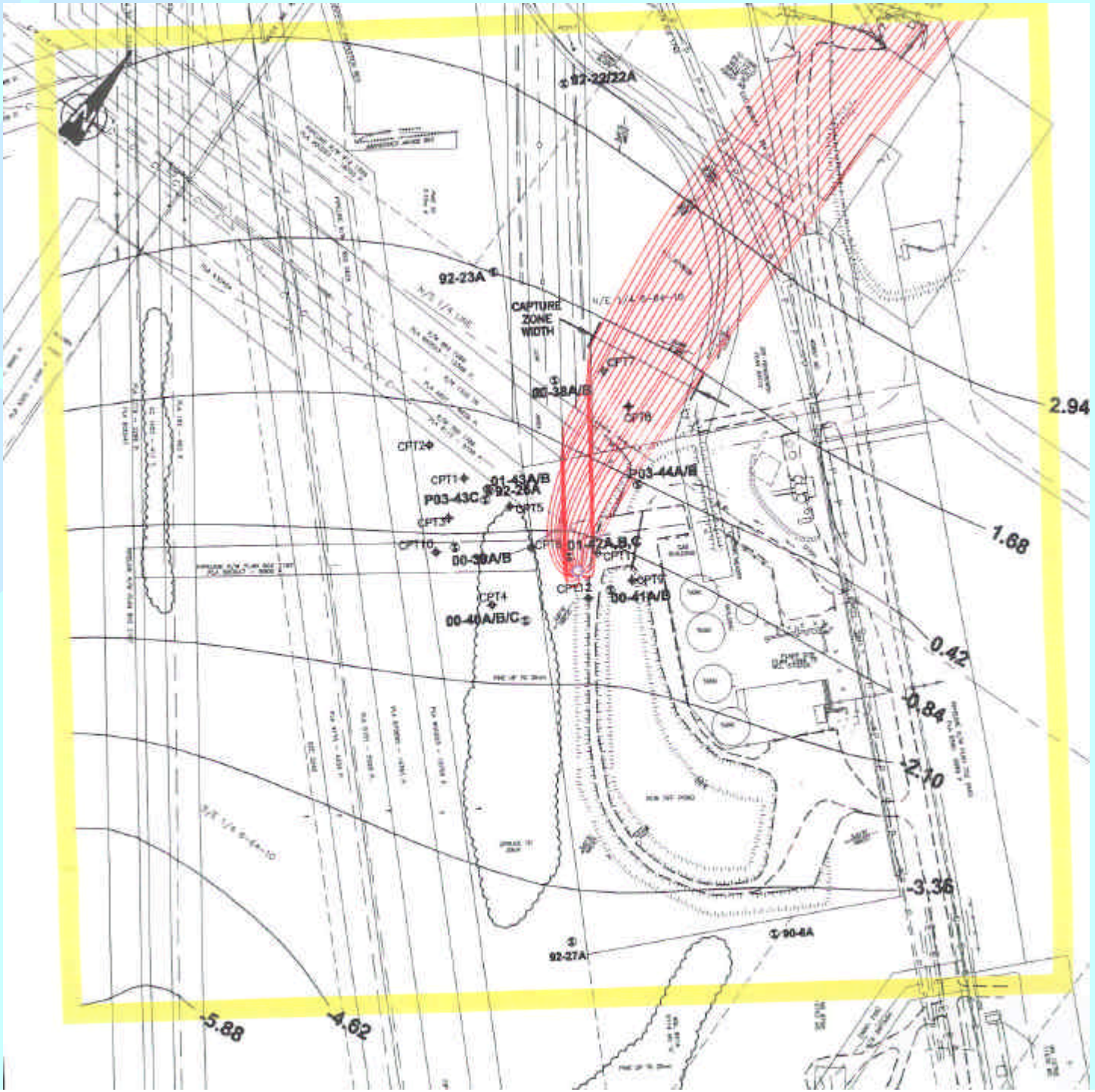
92-22/22A
92-23A
CAPTURE ZONE WIDTH
CPT7
00-38A/B
CPT6
CPT2
CPT1
01-43A/B
92-25A
P03-43C
P03-44A/B
CPT5
CPT3
CPT10
00-39A/B
01-42A,B,C
CPT11
CPT9
CPT12
00-41A/B
CPT4
00-40A/B/C
2.94
1.68
0.42
-0.84
-2.10
-3.36
90-6A
92-27A
-5.88
-4.62

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Simulation #1: Learnings

- Estimate of capture zone better constrained than previous estimates with analytical model
- Capture zone increased by up to 50% because of high K pipeline corridor
- For appropriately placed extraction wells, pipeline corridors could be advantageous to hydraulic containment

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Simulation #2: Potential extraction well configurations

- Two- and three-well configurations investigated
- "Ideal" and "non-ideal" extraction conditions
- Forward particle tracking from areas of known hydrocarbon impacts

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92-22/22A
92-23A
4.20
2.94
1.68
0.42
-0.84
-2.10
-3.36
-4.62
-5.88
CPT7
CPT8
CPT2
CPT1
CPT3
CPT10
CPT4
CPT5
CPT6
CPT11
CPT12
CPT9
00-38A/B
01-43A/B
92-20A
P03-43C
P03-44A/B
01-42A,B,C
00-41A/B
00-40A/B/C
92-27A
90-6A

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92-22/22A
92-23A
APPROX. LOCATION
OF PIPELINE BREAK
CPT7
00-38A/B
CPT8
CPT2
CPT1
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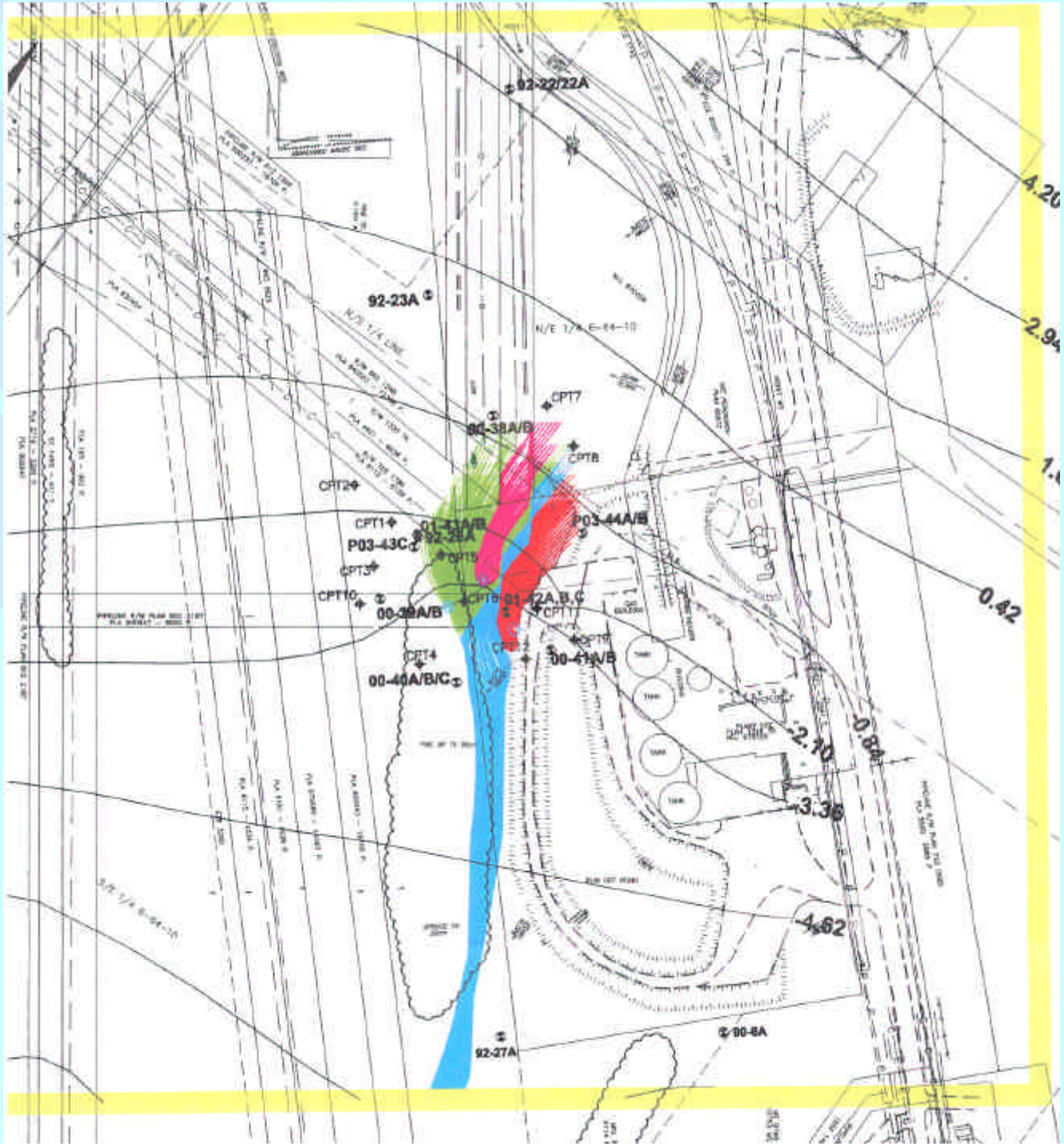
92-28A
P03-43C
P03-44A/B
CPT5
CPT3
CPT10
00-39A/B
CPT6
01-42A,B,C
CPT11
CPT12
CPT9
00-41A/B
CPT4
00-40A/B/C
4.20
2.94
1.68
0.42
-0.84
-2.10
-3.36
92-27A
90-6A

KOMEX


92-22/22A
92-23A
CPT7
00-38A/B
CPT8
CPT2
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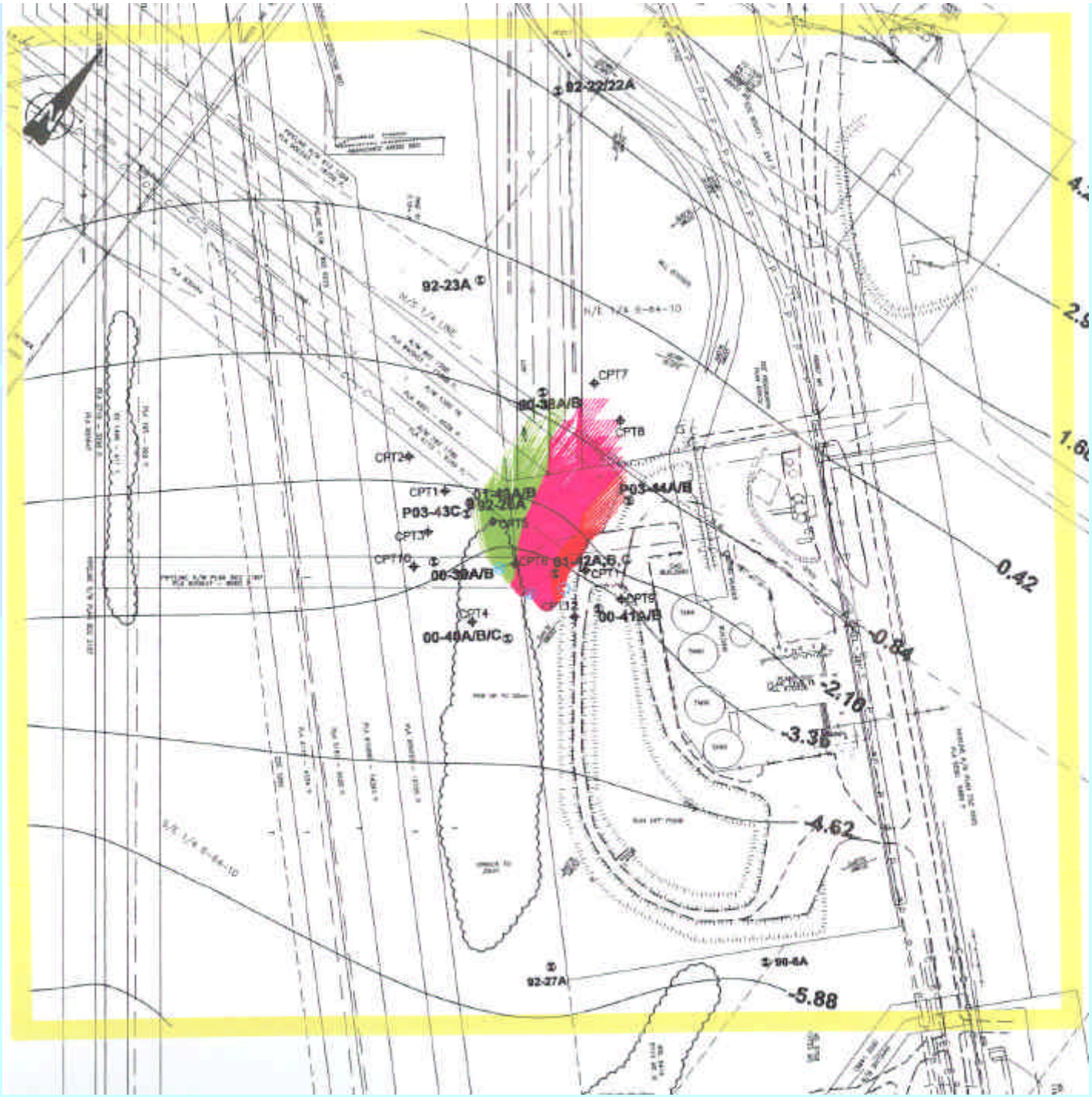
92-28A
P03-44A/B
P03-43C
CPT5
CPT3
CPT6
01-42A,B,C
CPT10
00-39A/B
CPT11
CPT9
CPT4
00-40A/B/C
00-41A/B
92-27A
00-8A
4.20
2.94
0.42
2.10
0.86
3.36
4.62

KOMEX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92-23A
CPT7
00-38A/B
CPT8
CPT2
CPT1
01-43A/B
92-21A
P03-44A/B
P03-43C
CPT5
CPT3
CPT6
00-38A/B
01-42A,B,C
CPT11
CPT12
CPT9
00-41A/B
CPT4
00-40A/B/C
0.42
-0.84
-2.10
-3.35
-4.62
92-27A
90-6A
-5.88

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Design features of remediation system

- Three wells
- Some offset of wells preferred to avoid hydrocarbon escape through stagnation points and down high K corridors
- Near the leading edge of the plume is preferred to downgradient
- Extraction wells near corridors to increase the capture zones of each well

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Acknowledgements

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- Brent Mooder (co-author)

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