# ATTACHMENT 3

## Survey Data for Sampling Locations

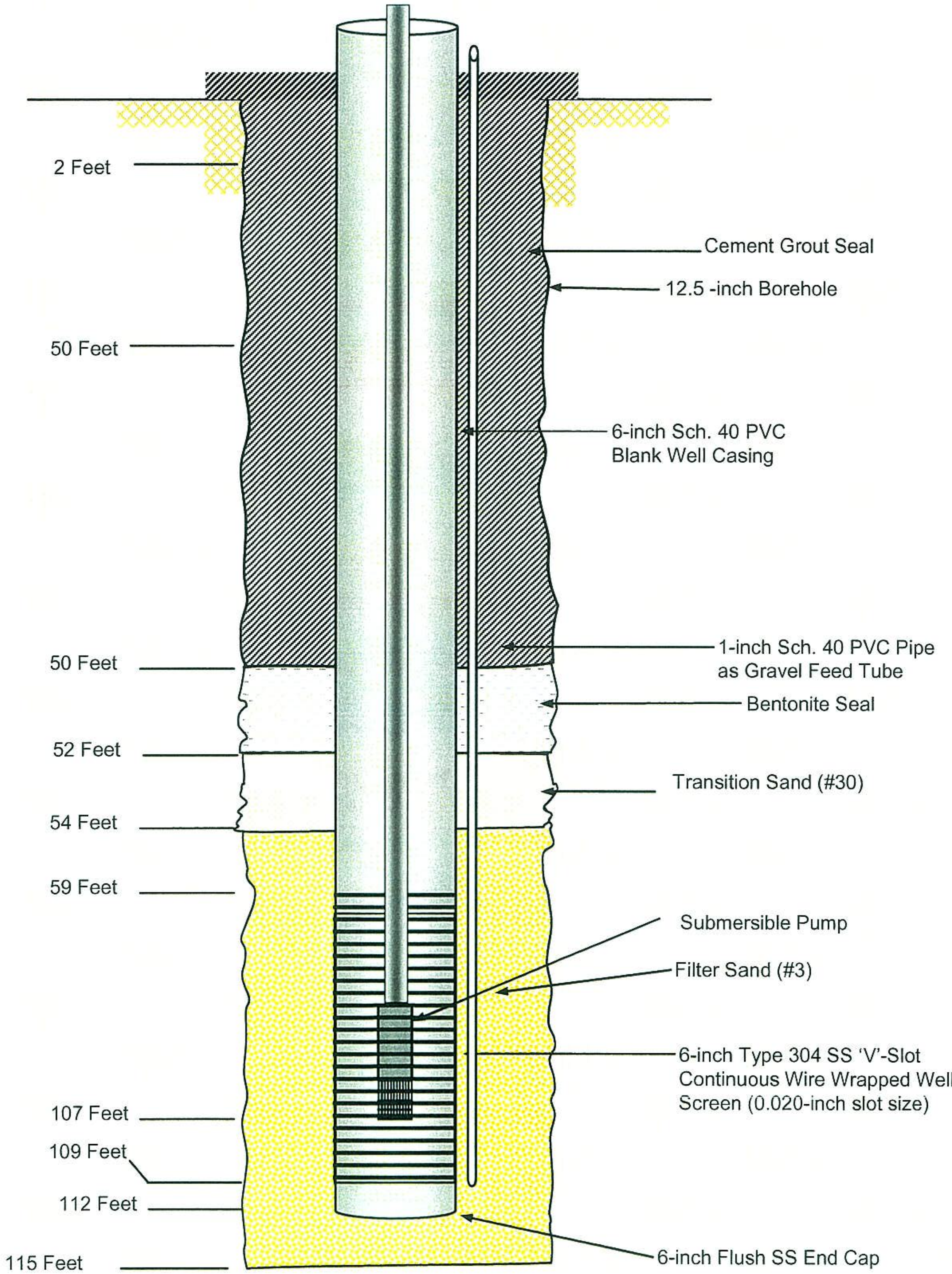


**FIGURE 2**
**EW-3 As-Built**
**Cooper Drum**

Notes: SS = stainless steel
All diameters are O.D. except the well screen, which is nominal

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## FIGURE 3
## STEP-DISCHARGE PUMPING TEST (4/29/09)
## EW-03 - COOPER DRUM

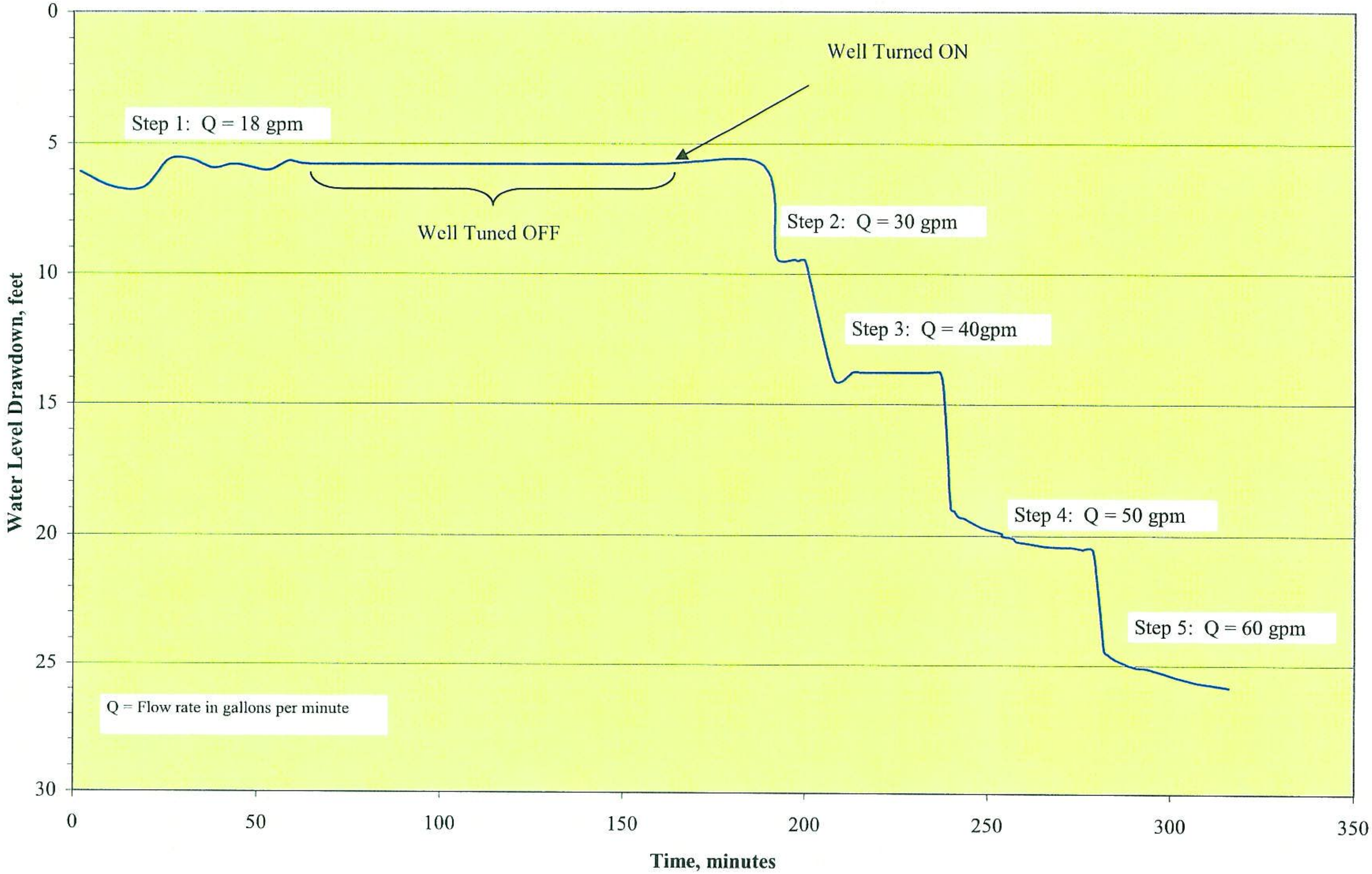
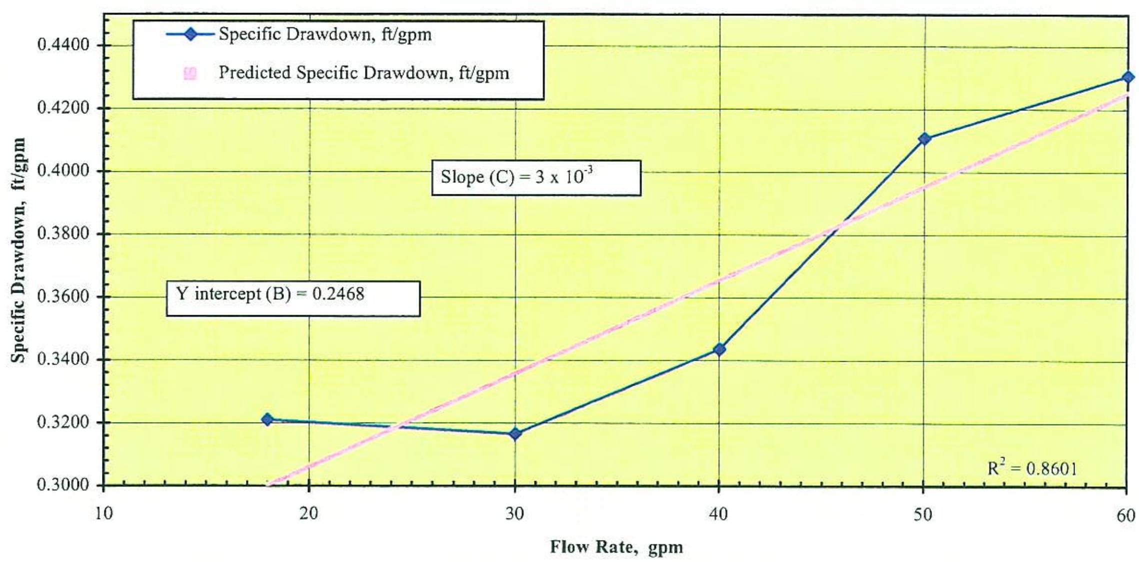


**FIGURE 4**
**ANALYSIS OF STEP-DISCHARGE PUMPING TEST**
**EW-03 - COOPER DRUM**

| Step | Time Weighted Flow Rate (Q) gpm | Drawdown (s) feet | Specific Drawdown (s/Q) feet/gpm |
|---|---|---|---|
| 1 | 18 | 5.78 | 0.3211 |
| 2 | 30 | 9.50 | 0.3167 |
| 3 | 40 | 13.75 | 0.3438 |
| 4 | 50 | 20.55 | 0.4110 |
| 5 | 60 | 25.85 | 0.4308 |

**Specific Drawdown vs. Flow Rate**




Equations:
Predicted Total Drawdown (s) = $BQ + CQ^2$
Predicted Aquifer Drawdown = BQ
Predicted Well Loss = $CQ^2$

For a flow rate of 40 gpm:
Predicted Aquifer Drawdown = (0.2468)(40) = 9.87 ft
Predicted Well Loss = $(3X10^{-3})(40)^2$ = 4.80 feet
Predicted Total Drawdown = 14.67 feet

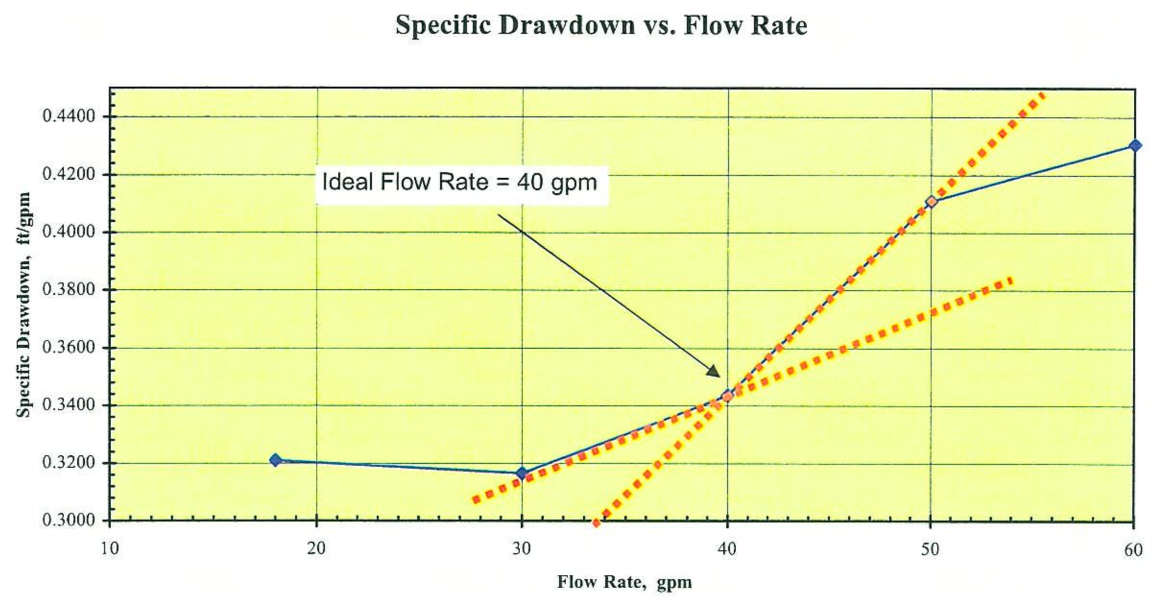
Well Efficiency at 40 gpm = 67.28%

For a flow rate of 60 gpm:
Predicted Aquifer Drawdown = (0.2468)(60) = 14.81 feet
Predicted Well Loss = $(3X10^{-3})(60)^2$ = 10.80 feet
Predicted Total Drawdown = 25.61 feet

Well Efficiency at 60 gpm =57.83%

# FIGURE 5
# CONSTANT FLOW RATE JUSTIFICATION
# EW-03 - COOPER DRUM

| Step | Time Weighted Flow Rate (Q) gpm | Drawdown (s) feet | Specific Drawdown (s/Q) feet/gpm |
|---|---|---|---|
| 1 | 18 | 5.78 | 0.3211 |
| 2 | 30 | 9.50 | 0.3167 |
| 3 | 40 | 13.75 | 0.3438 |
| 4 | 50 | 20.55 | 0.4110 |
| 5 | 60 | 25.85 | 0.4308 |



# APPENDIX I

## Well Development Log and Step-Rate Aquifer Test Field Data Sheets

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# Exhibit 7.4-1
## Monitor Well Development Data

Project: Cooper Drum

Site No: ______

Boring No: EW-3

Sample No: ______

Sampling Date: ______

Sampling Method: ______

Bar. Pres.: ______

Job No: 17326064.03020

Sampling Time: ______

Sampled By: ______

Reviewed By: ______

Elevation: ______

Weather ______

Amb. Temp. (°F) ______ °C

METHOD OF WELL DEVELOPMENT:

- [x] Pumping
- [x] Surging
- [ ] Air Lift and Surge
- [x] Bailing
- [x] Mechanical Surging development Rig
- [ ] Bailer
- [ ] Other ______

GROUND WATER ELEVATION

1) Depth Water Surface 48.55 TOC ft (from casing top as marked) — Method of Measurement: 300' Water level meter, (Keck)

2) Depth to Product (if present) ______ ft — Method of Measurement: same as above

3) Static Water Level Elevation ______ ft (casing top elevation minus 1)

4) Depth to Well Bottom 102.25 ft — pre-development (from casing top as marked) 112.10 — post-development

5) Height of Water Column (h) ______ ft (4 minus 1)

WATER SAMPLING DATA

Volume of Water in Well: (x)(h)= ______ gals (for 2" x = 0.163 gal/ft for 4" x = 0.653 gal/ft)

water column 63.55×1.5
95.325 × 10 = 953.25 gals

Amount of Water Removed from Well 1675 gals

Method of Water Removal 3" SQ pump

Was Well Pumped Dry ☐ Yes ☐ No

FIELD ANALYSIS

Water Temp ______ °C

Specific Conductance ______ micromhos — Method of Measurement U-10 Horiba

pH ______ — Method of Measurement U-10 Horiba

Physical Appearance ______

Remarks ______

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Monitor Well No: EW-3

Exhibit 7.4-1

# Monitor Well Development Data (Continued)

Project: Cooper Drum
Site No: ______
Location No: ______
Sample No: ______

Job No: 17326064.03020
Sampling Date: ______
Sampling Time: ______
Sampled By: ______
Reviewed By: ______ Date: 04-28-09

| | Time | Temp °C | Conductivity | pH | NTUs | WL | Removed | Flow Rate | Observations |
|---|---|---|---|---|---|---|---|---|---|
| pump on | 9:40 | | | | | | | | pump is @ 70' |
| | 9:41 | 18.4 | 4.22 | 5.19 | 999. | 54.15 | 33 | 17.73 | very cloudy |
| shut pump off | 9:44 | | | | | | | | |
| on | 9:56 | | | | | | | | |
| | 9:59 | 21.1 | 4.70 | 5.90 | 999 | 54.58 | 136 | 18.22 | very cloudy |
| | 10:07 | 21.2 | 4.96 | 5.91 | 999 | 54.90 | 283 | 18.10 | very cloudy |
| | 10:13 | 21.2 | 5.04 | 5.89 | 824 | 55.23 | 410 | 19.30 | very cloudy |
| | 10:16 | shut the pump on, to off load the water trailer. | | | | | | | |
| pump on | 11:30 | | | | | | | | |
| | 11:32 | 21.1 | 4.92 | 6.18 | 337 | 54.63 | 534 | 18.27 | a little cloudy |
| | 11:40 | 21.1 | 5.22 | 6.04 | 185 | 55.19 | 680 | 18.68 | a little clear |
| | 11:49 | 21.1 | 5.20 | 6.00 | 41 | 55.25 | 856 | 19.46 | clear |
| @ 11:55 drop to 80' | 11:56 | 20.8 | 5.55 | 6.06 | 6.28 | 54.16 | 1032 | 19.30 | a little cloudy |
| | 12:02 | 21.1 | 5.34 | 6.01 | 43 | 54.65 | 1136 | 18.60 | clear |
| @ 12:04 drop to 90' | 12:08 | 21.1 | 5.64 | 5.99 | 34 | 54.48 | 1233 | 18.33 | clear |
| @ 100' | 12:14 | 21.2 | 5.46 | 6.00 | 85 | 54.35 | 1440 | 17.00 | a little clear |
| | 12:23 | 21.1 | 5.32 | 6.00 | 40 | 54.56 | 1511 | 17.15 | clear |
| @ ~~12:20~~ 12:24 drop to 110' | 12:29 | 21.1 | 5.35 | 6.00 | 96 | 54.20 | 1607 | 17.51 | clear |
| | 12:34 | 21.0 | 5.34 | 6.01 | 15 | 54.33 | 1675 | 16.41 | clear |
| | 12:41 | Shut the pump off | | | | | | | |
| | 1406 | | | | | 48.60 | | | |
| | 1420 | | | | | 47.10 | | | 00291900. |
| on @ 1440 | 1443 | | | | | 57.90 | | ~30gpm | |
| | 1446 | | | | | 58.00 | | | |
| | 1447 | | | | | 58.05 | | | |
| | 1449 | | | | | 58.05 | | | |
| | 1457 | | | | | 62.60 | | | 40gpm @ 1450 |
| | 1502 | | | | | 62.30 | | | 39gpm |
| | 1504 | | | | | 62.30 | | | |
| | 1508 | | | | | 62.30 | | | 39gpm |
| off | 1509 | | | | | | | | 00292991 |

NTU = Nephelometric turbidity units
WL = Water level

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Monitor Well No: EW-3

Exhibit 7.4-1

# Monitor Well Development Data (Continued)

Project: 17326064.03020
Site No:
Location No:
Sample No:

Job No:
Sampling Date: 4/29/09
Sampling Time:
Sampled By:
Reviewed By: Date:

| | Time | Temp °C | Conductivity | pH | NTUs | WL | Removed | Flow Rate | Observations |
|---|---|---|---|---|---|---|---|---|---|
| | 1521 | | | | | 48.80 | | | 00292983 |
| on | 1523 | | | | | | | 50gpm | |
| | 1526 | | | | | 62.30 | | | |
| | 1527 | | | | | 63.0 | | 50gpm | |
| | 1529 | | | | | 67.50 | | | |
| | 1530 | | | | | 67.60 | | | |
| | 1531 | | | | | 67.80 | | 50gpm | |
| | 1533 | | | | | 67.90 | | | |
| | 1535 | | | | | 68.05 | | | |
| | 1537 | | | | | 68.20 | | | |
| | 1539 | | | | | 68.30 | | 50gpm | |
| | 1543 | | | | | 68.45 | | | 00293820 |
| | 1545 | | | | | 68.54 | | | |
| | 1548 | | | | | 68.63 | | | |
| | 1551 | | | | | 68.75 | | | |
| | 1554 | | | | | 68.83 | | | 294410 |
| | 1557 | | | | | 68.90 | | 50gpm | |
| | 1600 | | | | | 68.95 | | | |
| | 1603 | | | | | 68.97 | | | |
| | 1606 | | | | | 68.98 | | | |
| | 1609 | | | | | 69.05 | | | |
| | 1612 | | | | | 69.10 | | | |
| ↑60gpm | 1612 | | | | | | | 60gpm | |
| | 1615 | | | | | 72.96 | | | |
| | 1616 | | | | | 73.10 | | 60gpm | |
| | 1619 | | | | | 73.30 | | | |
| | 1624 | | | | | 73.60 | | | |
| | 1627 | | | | | 73.65 | | | |
| | 1630 | | | | | 73.75 | | 60gpm | 296360 |

NTU = Nephelometric turbidity units
WL = Water level

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Monitor Well No: EW-3

Exhibit 7.4-1

# Monitor Well Development Data (Continued)

Project:
Site No:
Location No:
Sample No:

Job No:
Sampling Date:
Sampling Time:
Sampled By:
Reviewed By: Date:

| Time | Temp °C | Conductivity | pH | NTUs | WL | Removed | Flow Rate | Observations |
|---|---|---|---|---|---|---|---|---|
| 1635 | | | | | 73.97 | | | |
| 1641 | | | | | 74.20 | | | |
| 1645 | | | | | 74.29 | | | |
| 1650 | | | | | 74.40 | | | 297558 |

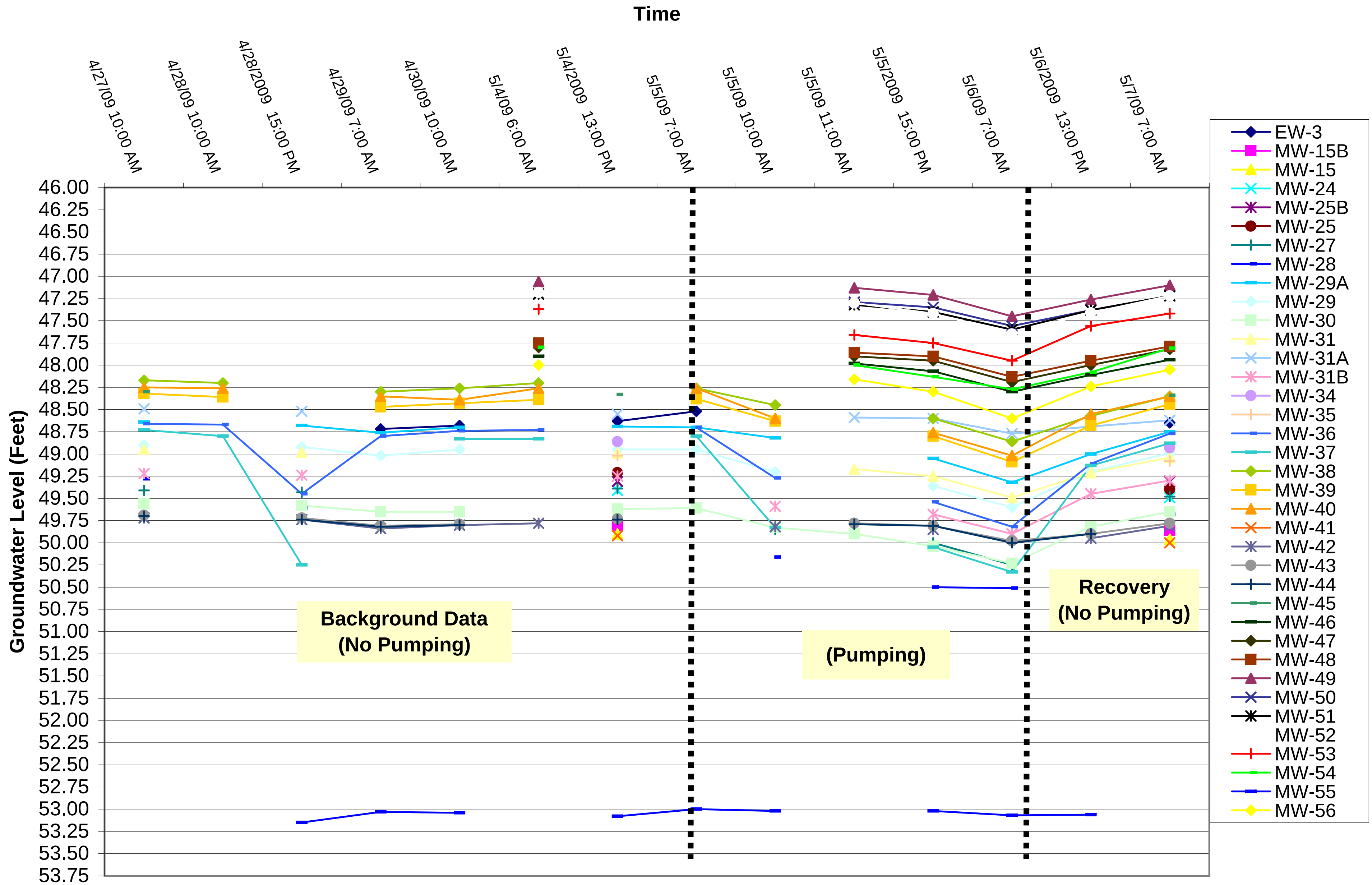
NTU = Nephelometric turbidity units
WL = Water level

7310
2483

URS #94 3/90

# APPENDIX II

## Monitoring Well Depth to Groundwater Information


Time
4/27/09 10:00 AM
4/28/09 10:00 AM
4/28/2009 15:00 PM
4/29/09 7:00 AM
4/30/09 10:00 AM
5/4/09 6:00 AM
5/4/2009 13:00 PM
5/5/09 7:00 AM
5/5/09 10:00 AM
5/5/09 11:00 AM
5/5/2009 15:00 PM
5/6/09 7:00 AM
5/6/2009 13:00 PM
5/7/09 7:00 AM
Groundwater Level (Feet)
46.00
46.25
46.50
46.75
47.00
47.25
47.50
47.75
48.00
48.25
48.50
48.75
49.00
49.25
49.50
49.75
50.00
50.25
50.50
50.75
51.00
51.25
51.50
51.75
52.00
52.25
52.50
52.75
53.00
53.25
53.50
53.75
Background Data
(No Pumping)
(Pumping)
Recovery
(No Pumping)
EW-3
MW-15B
MW-15
MW-24
MW-25B
MW-25
MW-27
MW-28
MW-29A
MW-29
MW-30
MW-31
MW-31A
MW-31B
MW-34
MW-35
MW-36
MW-37
MW-38
MW-39
MW-40
MW-41
MW-42
MW-43
MW-44
MW-45
MW-46
MW-47
MW-48
MW-49
MW-50
MW-51
MW-52
MW-53
MW-54
MW-55
MW-56

# APPENDIX III

## Constant Rate Aquifer Test Analysis Data Plots

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# AQUIFER CONSTANT-RATE TEST DATA



| | | |
|---|---|---|
| Project: COOPER DRUM | Project No.: | Static Water Level (feet bls): 48.52 |
| Well Location: | Well No.: EW-3 | Measuring Point: TOC |
| Well Diameter: 6-INCH | Measured By: E | Elevation Measuring Point (feet bls): |
| Pump Setting: ~107 | Pump On: Date 5/5/09 Time: 0820 | Available Drawdown: 14sec/10gal |
| Screen Interval(s): 59-109 | Pump Off: Date 5/6/09 Time: 0820 | Distance From Pumping Well: — |
| How Q Measured: FLOWMETER | Duration of Aquifer Test: ~24HR | Initial Totalizer Reading: 00297537 |

| Time of Measure-ment | Time Since Pumping Started (t) (minutes) | Recovery Time (t') (minutes) | t/t' | Sounder Reading (feet) | Correction (feet) | Water Level (feet) | Drawdown (feet) | Discharge (gpm) | Specific Capacity (gpm/ft) | Totalizer Reading (gallons) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0815 | | | | 48.52 | | | | | | | |
| 0820 | | | | 67.60 | | | | | | | |
| 0821 | | | | 66.25 | | | | 43 | | | |
| 0822 | | | | 65.20 | | | | | | | |
| 0824 | | | | 65.22 | | | | 44 | | | |
| 0826 | | | | 65.28 | | | | | | | |
| 0828 | | | | 65.78 | | | | 44 | | | |
| 0832 | | | | 65.52 | | | | | | | |
| 0834 | | | | 65.58 | | | 17.06 | | 2.58 | | 298210 |
| 0836 | | | | 65.60 | | | | 45 | | | |
| 0840 | | | | 65.66 | | | | | | | 298680 |
| 0844 | | | | 65.70 | | | 17.18 | 44 | 2.56 | | 15.3 psi |
| 0846 | | | | 65.75 | | | | | | | |
| 0850 | | | | 65.82 | | | | 45 | | | 299270 |
| 0855 | | | | 65.92 | | | 17.4 | | 2.59 | | Z |
| 0900 | | | | 65.94 | | | | 44 | | | 299400 |
| 0910 | | | | 66.04 | | | | 44 | | | |

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# AQUIFER CONSTANT-RATE TEST DATA


Project No. ______
Date 5/5

| Time of Measure-ment | Time Since Pumping Started (t) (minutes) | Recovery Time (t') (minutes) | t/t' | Sounder Reading (feet) | Correction (feet) | Water Level (feet) | Drawdown (feet) | Discharge (gpm) | Specific Capacity (gpm/ft) | Totalizer Reading (gallons) | SWL – 48.52 Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0925 | | | | 66.16 | | | 17.84 | 44 | 2.47 | 300590 | |
| 0958 | | | | 66.43 | | | 17.91 | 43 | 2.40 | 302060 | |
| 10.20 | | | | 66.70 | | | 18.18 | 45 | 2.48 | 303090 | pH 7.10 |
| 11:20 | | | | 66.94 | | | | 44 | | 305700 | Temp 21.0°C |
| 12.05 | | | | 67.13 | | | 18.61 | 44 | 2.36 | | |
| 13.37 | | | | 67.27 | | | 18.75 | 44 | 2.35 | ~~[illegible]~~ | 1468 psi |
| 1520 | | | | 67.65 | | | | | | 316200 | |
| 1633 | | | | 67.75 | | | | | | | |
| 1635 | | | | — | | | 19.23 | 44.00 | 2.29 | ~~[illegible]~~ | ~~300~~ 319400 |
| 1735 | | | | 67.78 | | | | 44.00 | | 321900 | |
| 1845 | | | | 67.91 | | | | 43.00 | | 325100 | |
| 1930 | | | | 67.92 | | | | 44.00 | | 328300 | |
| 2023 | | | | 68.02 | | | | 44.00 | | 329600 | |
| 2025 | | | | 68.12 | | | | 44.00 | | 332100 | |
| 2256 | | | | 68.34 | | | | 44.00 | | 336200 | |
| 2345 | | | | 68.44 | | | | 44.00 | | 338300 | |
| 5/6 145 | | | | 68.91 | | | | 44.00 | | 342100 | |
| 2.45 | | | | 68.93 | | | | 44.00 | | 348200 | |
| 5:[illegible] | | | | 68.89 | | | | 44.00 | | 353200 | |
| 812 | | | | 69.00 | | | 20.48 | 44.00 | 2.14 | | |
| 0820 | 1440 | | | 52.60 | | | | — | | | pump off |
| 0823 | 1443 | 3 | | 49.80 | | | | | | 361090 | ↓ |
| 0825 | 1445 | 5 | | 49.50 | | | | | | | |

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# AQUIFER CONSTANT-RATE TEST DATA

Page 3 of 3
Project No.
Date 5/6

| Time of Measure-ment | Time Since Pumping Started (t) (minutes) | Recovery Time (t') (minutes) | t/t' | Sounder Reading (feet) | Correction (feet) | Water Level (feet) | SWL 48.52 Drawdown (feet) | Discharge (gpm) | Specific Capacity (gpm/ft) | Totalizer Reading (gallons) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0832 | | | | 48.90 | | | | | | | |
| 0854 | | | | 49.22 | | | | — | — | — | Pump off |
| 0902 | | | | 49.20 | | | | — | — | | |
| 0920 | | | | 49.18 | | | | — | — | — | |
| 0950 | | | | 49.11 | | | | — | — | — | |
| 1201 | | | | 48.90 | | | | — | — | — | |
| 1/7 0743 | | | | 48.65 | | | | — | — | — | |
| | | | | | | | | — | — | — | 0.13 Δ |
| | | | | | | | | | | | SWL 48.52 |
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## URS CORPORATION

### HYDRODATA SHEET

Project Cooper Drum    Event ______    Sampler [illegible]

Project No. ______    Datum ______    Sheet ___ of ___

EW-3 Pump Test

| WELL or LOCATION | DATE | TIME | MEASUREMENT | TOTAL DEPTH | COMMENTS |
|---|---|---|---|---|---|
| MW-15B | 5/4/09 | 1357 | 49.81 | | |
| MW-15 | | 1359 | 49.90 | | |
| MW-24 | | 1404 | 49.41 | | |
| MW-34 | | 1409 | 48.86 | | |
| MW-35 | | 1412 | 49.02 | | |
| MW-41 | | 1415 | 49.92 | | |
| MW-25B | | 1420 | 49.31 | | |
| MW-25 | ↓ | 1422 | 49.21 | | |
| | | | | | |
| MW-41 | 5/7/09 | 0827 | 50.00 | | |
| MW-25 | | 0831 | 49.40 | | |
| MW-25B | | 0835 | 49.31 | | |
| MW-24 | | 0838 | 49.49 | | |
| MW-43 | | 0844 | 48.34 | | Alle |
| MW-35 | | 0849 | 49.08 | | |
| MW-34 | | 0850 | 48.93 | | |
| MW-15B | | 0857 | 49.86 | | |
| MW-15 | ↓ | 0900 | 49.96 | | |

ꝛS CORPORATION

# HYDRODATA SHEET

ect Copper Drum Event Water Level Sampler DG / BJ

ect No. ______ Datum ______ Sheet ___ of ___

EW-3 Pump Test

| WELL or LOCATION | DATE | TIME | MEASUREMENT | TOTAL DEPTH | COMMENTS |
|---|---|---|---|---|---|
| W-42 | 4/27 | 1001 | 49.72 | | |
| W 43 | 4/27 | 1003 | 49.69 | | |
| W 44 | 4/27 | 1006 | 49.70 | | |
| W 31A | " | 1015 | 48.49 | | |
| W 31B | " | 1019 | 49.22 | | |
| W31 | " | 1022 | 48.95 | | |
| W45 | " | 1027 | 48.30 | | |
| W31 | 4/28 | 0824 | 48.98 | | |
| | | | | | |
| | | | | | |
| -31A | 4/28 | 0828 | 48.52 | | |
| | | | | | |
| | | | | | |
| -31B | 4/28 | 0826 | 49.[24 or 31] | | |
| | | | | | |
| | | | | | |
| -42 | 4/28 | 0832 | 49.74 | 4/30 | 49.80 |
| | 4/29 | 0742 | 49.84 | | |
| -43 | 4/28 | 08[33 or 83] | 49.72 | 4/30 | 49.79 |
| | 4/29 | 0743 | 49.81 | | |
| -44 | 4/28 | 0834 | 49.74 | 4/30 | 49.80 |
| | 4/29 | 0745 | 49.82 | | |
| | | | | | |
| | | | | | |

URS CORPORATION

## HYDRODATA SHEET

Project Cooper Drum    Event ____    Sampler DJ/BJ

Project No. ____    Datum ____    Sheet ___ of ___

EW-3 Pump Test

| WELL or LOCATION | DATE | TIME | MEASUREMENT | TOTAL DEPTH | COMMENTS |
|---|---|---|---|---|---|
| MW-27 | 5/6 | 1334 | 49.70 | | |
| ↓ | 5/7/09 | 0730 | 49.48 | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| MW-28 | 5/6 | 1335 | 49.89 | | |
| ↓ | 5/7/09 | 0733 | 49.68 | | |
| | | | | | |
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# HYDRODATA SHEET

Project Cooper Drum Event Step Drawdown Sampler DG & BJ

Project No. ________ Datum ________ Sheet 1 of __

EW-2 pump test

| WELL or LOCATION | DATE | TIME | MEASUREMENT | TOTAL DEPTH | COMMENTS |
|---|---|---|---|---|---|
| MW29A | 4/27/09 | 0933 | 48.64 | | Background |
| ↓ | 4/28 | 0813 | 48.68 | | |
| | 4/29 | 0738 | 48.76 | | |
| | 4/30 | 1041 | 48.70 | | |
| | 5/4/09 | 1005 | 48.69 | | |
| | 5/5/09 | 0721 | 48.70 | | |
| | 5/5/09 | 0949 | 48.82 | | |
| | 5/5 | 1546 | 49.05 | | |
| | 5/6 | 0653 | 49.37 | | |
| | 5/6 | 1343 | 49.00 | | |
| ↓ | 5/7/09 | 0727 | 48.75 | | |
| | | | | | |
| MW-27 | 4/27/09 | 0948 | 49.41 | | Background |
| ↓ | 4/28 | 0808 | 49.43 | | |
| | 5/4/09 | 1439 | 49.39 | | |
| | 5/5/09 | 1045 | 49.85 | | |
| | 5/5/09 | 1543 | 50.00 | | |
| ↓ | 5/6/09 | 0649 | 50.25 | | |
| MW-28 | 4/27/09 | 0953 | 49.28 | | Background |
| ↓ | 4/28 | 0809 | 49.61 | | |
| | 5/4/09 | 1441 | 49.65 | | |
| | 5/5/09 | 1047 | 50.16 | | |
| | 5/5 | 1544 | 50.30 | | |
| ↓ | 5/6 | 0657 | 50.51 | | |

# HYDRODATA SHEET

Project Cooper Drum  Event Step Drawdown  Sampler DG / BJ

Project No. ______  Datum ______  Sheet ___ of ___

BW-3 Pump Test

| WELL or LOCATION | DATE | TIME | MEASUREMENT | TOTAL DEPTH | COMMENTS |
|---|---|---|---|---|---|
| MW29 | 4/27/09 | 0934 | 48.90 | | Background |
| ↓ | 4/28 | 0820 | 48.92 | | |
| | 4/29 | 0734 | 49.02 | | |
| | 4/30 | 1033 | 48.95 | | |
| | 5/4/09 | 1000 | 48.95 | | |
| | 5/5/09 | 0718 | 48.95 | | |
| | 5/5/09 | 0950 | 49.20 | | |
| | 5/5 | 1549 | 49.36 | | |
| | 5/6 | 0655 | 49.60 | | |
| | 5/6 | 1339 | 49.20 | | |
| Exposition | 5/7 | 0721 | 48.99 | | |
| MW-55 | 4/28/09 | 0754 | 53.15 | | Background |
| ↓ | 4/29/09 | 0722 | 53.03 | | |
| | 4/30/09 | 1011 | 53.04 | | |
| | 5/4/09 | 0844 | 53.08 | | |
| | 5/5/09 | 0655 | 53.00 | | |
| | 5/5 | 0935 | 53.02 | | |
| | 5/5 | 1535 | 53.02 | | |
| | 5/6/09 | 0727 | 53.07 | | |
| | 5/6/09 | 1233 | 53.06 | | |
| ~~BW-3~~ | ~~5/7/09~~ | ~~0743~~ | ~~48.65~~ | | ~~Given~~ |
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# HYDRODATA SHEET

Project Cooper Drum    Event Step Drawdown    Sampler DG & BT

Project No. ______    Datum ______    Sheet 1 of __

EW3 Pump Test

| WELL or LOCATION | DATE | TIME | MEASUREMENT | TOTAL DEPTH | COMMENTS |
|---|---|---|---|---|---|
| MW30 | 4/27/09 | 0935 | 49.56 | | Background |
| | 4/28 | 0816 | 49.58 | | |
| | 4/29 | 0736 | 49.65 | | |
| | 4/30 | 1037 | 49.65 | | |
| | 5/4/09 | 1004 | 49.62 | | |
| | 5/5/09 | 0720 | 49.61 | | |
| | 5/5/09 | 0949 | 49.83 | | |
| | 5/5/09 | 1049 | 49.90 | | |
| | 5/5 | 1548 | 50.04 | | |
| | 5/6 | 0654 | 50.23 | | |
| | 5/6 | 1341 | 49.82 | | |
| ↓ | 5/7/09 | 0724 | 49.65 | | |
| EW-3 | 4/29 | 0714 | 48.72 | | |
| | 4/30 | 0957 | 48.68 | | |
| | 5/4/09 | 0933 | 48.63 | | 1" |
| | 5/5 | 0652 | 48.52 | | |
| ↓ | 5/7/09 | 0743 | 48.65 | | 6" |
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URS CORPORATION

# HYDRODATA SHEET

Project Cooper Drum    Event ____    Sampler DY & EI

Project No. ____    Datum ____    Sheet ___ of ___

EW-3 Pump Test

| WELL or LOCATION | DATE | TIME | MEASUREMENT | TOTAL DEPTH | COMMENTS |
|---|---|---|---|---|---|
| MW-31A | 5/4/09 | 1044 | 48.55 | | |
| ↓ | 5/5/09 | 1051 | 48.59 | | |
| | 5/5/09 | 1552 | 48.60 | | |
| | 5/6/09 | 0643 | 48.77 | | |
| | 5/6/09 | 1358 | 48.69 | | |
| | 5/7/09 | 0718 | 48.68 | | |
| | | | | | |
| MW-31B | 5/4/09 | 1043 | 49.25 | | |
| ↓ | 5/5/09 | 1053 | 49.59 | | |
| | 5/5/09 | 1554 | 49.68 | | |
| | 5/6/09 | 0645 | 49.90 | | |
| | 5/6/09 | 1358 | 49.45 | | |
| | 5/7/09 | 0715 | 49.30 | | |
| | | | | | |
| | | | | | |
| MW-31 | 5/4/09 | 1041 | 48.99 | | |
| ↓ | 5/5/09 | 1054 | 49.17 | | |
| | 5/5/09 | 1555 | 49.25 | | |
| | 5/6/09 | 0646 | 49.49 | | |
| | 5/6/09 | 1358 | 49.21 | | |
| | 5/7/09 | 0713 | 49.04 | | |
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**URS CORPORATION**

HYDRODATA SHEET

Project Cooper Drum Event______ Sampler ~~DY~~ / EJ

Project No. ______ Datum______ Sheet ___ of ___

FW-3 pump Test

| WELL or LOCATION | DATE | TIME | MEASUREMENT | TOTAL DEPTH | COMMENTS |
|---|---|---|---|---|---|
| MW-36 | 4/27/09 | 1115 | 48.66 | | Background |
| | 4/28/09 | 0750 | 48.67 | | " |
| | | | | | |
| | 4/28 | 1640 | 49.46 | | |
| | 4/29 | 0717 | 48.80 | | |
| | 4/30 | 1007 | 48.74 | | |
| | 5/4/09 | 0912 | 48.73 | | |
| | 5/5/09 | 0700 | 48.70 | | |
| | | 0936 | 49.27 | | |
| ↓ | ↓ | 1338 | 49.54 | | |
| MW-37 | 4/27/09 | 1120 | 48.73 | | Background |
| | 4/28/09 | 0746 | 48.80 | | " |
| | | | 48.85 | | |
| | 4/29/09 | 1638 | 50.25 | | |
| | ~~4/29~~ | | | | |
| | 4/30 | 1006 | 48.83 | | |
| | 5/4/09 | 0906 | 48.83 | | |
| | 5/5/09 | 0657 | 48.80 | | |
| | 5/5 | 0934 | 49.83 | | |
| | 5/5 | 1537 | 50.05 | | |
| | 5/6 | 0722 | 50.33 | | |
| | 5/6 | 0850 | 49.35 | | |
| | 5/6 | 1217 | 49.13 | | |
| ↓ | 5/7/09 | 0737 | 48.98 | | |

~~MW-36 5/6 — 49.11~~

## URS CORPORATION

HYDRODATA SHEET

Project Cooper Drum

Event

Sampler DM/BJ

Project No.

Datum

Sheet ___ of ___

BW-2 Pump Test

| WELL or LOCATION | DATE | TIME | MEASUREMENT | TOTAL DEPTH | COMMENTS |
|---|---|---|---|---|---|
| MW-36 | 5/6 | 0724 | 49.82 | | |
| ↓ | 5/6 | 1212 | 49.11 | | |
| | 5/7/09 | 0741 | 48.77 | | |
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**URS CORPORATION**

## HYDRODATA SHEET

Project Cooper Drum　　Event ______　　Sampler DG & BT

Project No. ______　　Datum ______　　Sheet ___ of ___

BW-3 Pump Test

| WELL or LOCATION | DATE | TIME | MEASUREMENT | TOTAL DEPTH | COMMENTS |
|---|---|---|---|---|---|
| MW-37 | 5/7/09 | 0737 | 48.88 | | |
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**URS CORPORATION**

# HYDRODATA SHEET

Project Cooper Drum    Event Step Drawdown    Sampler DG

Project No. ______    Datum ______    Sheet 1 of ___

EW-3 Pum Test

| WELL or LOCATION | DATE | TIME | MEASUREMENT | TOTAL DEPTH | COMMENTS |
|---|---|---|---|---|---|
| MW-40 | 4/27 | 1040 | 48.25 | | Background |
| | 4/28 | 0802 | 48.26 | | |
| | 4/29 | 0729 | 48.36 | | |
| | 4/30 | 1024 | 48.39 | | |
| | 5/4/09 | 0805 | 48.26 | | |
| | 5/5/09 | 0702 | 48.26 | | |
| | 5/5/09 | 0944 | 48.60 | | |
| | 5/6/09 | 0739 | 49.02 | | |
| MW-39 | 4/27 | 1044 | 48.32 | | Background |
| | 4/28 | 0759 | 48.36 | | |
| | 4/29 | 0727 | 48.47 | | |
| | 4/30 | 1020 | 48.43 | | |
| | 5/4/09 | 0810 | 48.39 | | |
| | 5/5/09 | 0711 | 48.38 | | |
| | 5/5/09 | 0943 | 48.63 | | |
| MW-38 | 4/27 | 1050 | 48.17 | | Background. |
| | 4/28 | 0757 | 48.20 | | |
| | 4/29 | 0725 | 48.30 | | |
| | 4/30 | 1016 | 48.26 | | |
| | 5/4/09 | 0813 | 48.20 | | |
| | 5/5/09 | 0709 | 48.26 | | |
| | 5/5 | 0942 | 48.45 | | |
| | 5/5 | 1626 | 48.60 | | |
| | 5 | | | | |

MW-36    48.66

URS CORPORATION

# HYDRODATA SHEET

Project Cooper Drum Event______ Sampler DH & EI

Project No. ______ Datum______ Sheet ___ of ___

EW-3 Pump Test

| WELL or LOCATION | DATE | TIME | MEASUREMENT | TOTAL DEPTH | COMMENTS |
|---|---|---|---|---|---|
| MW-38 | 5/6/09 | 0744 | 48.86 | | |
| ↓ | 5/6/09 | 1306 | 48.57 | | |
| | 5/7/09 | 0749 | 48.35 | | |
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| | | | | | |
| MW-39 | 5/5 | 16.27 | 48.80 | | |
| ↓ | 5/6/09 | 0742 | 49.09 | | |
| | 5/6/09 | 1307 | 48.68 | | |
| | 5/7/09 | 0751 | 48.44 | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| MW-40 | 5/5 | 16.28 | 48.76 | | |
| ↓ | 5/6 | 0739 | 49.02 | | |
| | 5/6 | 1308 | 48.55 | | |
| | 5/7/09 | 0754 | 48.35 | | |
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# HYDRODATA SHEET

Project Coop'O Drum  Event 5/4/09  Sampler DJ [illegible]

Project No. ____  Datum ____  Sheet ___ of ___

Evt 3

| WELL or LOCATION | DATE | TIME | MEASUREMENT | TOTAL DEPTH | COMMENTS |
|---|---|---|---|---|---|
| MW42 | 5/04/09 | 1033 | ~~49.78~~ | | |
| | 5/5 | 1100 | 49.82 | | |
| | 5/5 | 1558 | 49.85 | | |
| | 5/6 | 13~~1725~~ | 50.02 | | Time 0637 |
| | 5/6 | 1404 | 49.95 | | |
| | 5/7/09 | 0705 | 49.81 | | |
| | | | | | |
| | | | | | |
| MW-43 | 5/4 | 1034 | 49.73 | | |
| | 5/5 | 1101 | 49.78 | | |
| | 5/5 | 1559 | ~~48.81~~ 49.81 | | |
| | 5/6 | 1332 ~~1724~~ | 49.98 | | 0635 |
| | 5/6 | 1405 | 49.90 | | |
| | 5/7/09 | 0707 | 49.78 | | |
| | | | | | |
| | | | | | |
| MW-44 | 5/4 | 1035 | 49.74 | | |
| | 5/5 | 1102 | 49.79 | | |
| | 5/5 | 1559 | 49.81 | | |
| | 5/6 | ~~1724~~ 0639 | 50.00 | | 0639 |
| | 5/6 | 1406 | 49.90 | | |
| | 5/7/09 | 0709 | 49.78 | | |
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URS CORPORATION

# HYDRODATA SHEET

Project Cooper Drum    Event______    Sampler DH / E T

Project No. ______    Datum______    Sheet __ of __

EW-3 Pump Test

| WELL or LOCATION | DATE | TIME | MEASUREMENT | TOTAL DEPTH | COMMENTS |
|---|---|---|---|---|---|
| MW-46 | 5/4 | 1128 | ~~47.90~~ | | |
| | 5/5/09 | 1037 | 47.98 | | |
| | 5/5 | 1604 | 48.07 | | |
| | 5/6 | 0659 | ~~48.19~~ 48.30 | | |
| | 5/6 | 13.26 | 48.11 | | |
| | 5/7/09 | 0758 | 47.94 | | |
| | | | | | |
| | | | | | |
| MW-47 | 5/4 | 1126 | 47.80 | | |
| | 5/5 | 1040 | 47.90 | | |
| | 5/5 | 1405 | 47.95 | | |
| | 5/6 | 0659 | 48.19 | | |
| | 5/6 | 13.28 | 48.00 | | |
| | 5/7/09 | 0759 | 47.82 | | |
| | | | | | |
| | | | | | |
| MW-48 | 5/4 | 1125 | ~~47.75~~ | | |
| | 5/5 | 1041 | 47.86 | | |
| | | 1406 | 47.90 | | |
| | 5/6 | 0700 | 48.13 | | |
| | 5/6 | 13.29 | 47.95 | | |
| | 5/7/09 | 0801 | 47.79 | | |

URS CORPORATION

# HYDRODATA SHEET

Project Cooper Drum Event______ Sampler DH & ET

Project No. ______ Datum______ Sheet ___ of ___

EW-3 pump test

| WELL or LOCATION | DATE | TIME | MEASUREMENT | TOTAL DEPTH | COMMENTS |
|---|---|---|---|---|---|
| MW-45 | 5/4 | 1049 | 48.33 | | |
| | | ~~1109~~ | | | |
| | | | | | |
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| | | | | | |
| | | | | | |
| MW-49 | 5/4 | 1101 | 47.06 | | |
| | 5/5/09 | 1107 | 47.13 | | |
| | 5/5/09 | 1610 | 47.21 | | |
| | 5/6 | 0705 | 47.45 | | Pen in well |
| | 5/6 | 1410 | 47.26 | | |
| | 5/7/09 | 0820 | 47.10 | | |
| MW-50 | 5/4 | 1102 | 47.20 | | |
| | 5/5/09 | 1108 | 47.29 | | |
| | 5/5/09 | 1611 | 47.35 | | |
| | 5/6 | 0706 | 47.56 | | |
| | 5/6 | 1411 | 47.38 | | |
| MW-51 | 5/4 | 1103 | 47.20 | | |
| | 5/5/09 | 1109 | 47.32 | | |
| | 5/5/09 | 1612 | 47.40 | | |
| | 5/6 | 0707 | 47.60 | | |
| | 5/6 | 1412 | 47.38 | | |
| | 5/7/09 | 0822 | 47.22 | | |

MW-50 5/7/09 0821 47.22

## URS CORPORATION

### HYDRODATA SHEET

Project ______________ Event ______________ Sampler ______________

Project No. ______________ Datum ______________ Sheet ___ of ___

| WELL or LOCATION | DATE | TIME | MEASUREMENT | TOTAL DEPTH | COMMENTS |
|---|---|---|---|---|---|
| MW-52 | 5/4 | 1109 | ~~47.18~~ | | |
| ↓ | 5/5/09 | 1113 | 47.30 | | |
| | 5/5/09 | 1615 | 47.42 | | |
| | 5/6/09 | 0710 | 47.65 | | |
| | 5/6 | 1415 | 47.41 | | |
| | 5/7/09 | 0808 | 47.22 | | |
| | | | | | |
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| | | | | | |
| | | | | | |
| MW-53 | 5/4 | 1110 | 47.37 | | |
| ↓ | 5/5/09 | 1114 | 47.66 | | |
| | 5/5/09 | 1616 | 47.75 | | |
| | 5/6/09 | 0712 | 47.95 | | |
| | 5/6 | 1416 | 47.56 | | |
| | 5/7/09 | 0809 | 47.~~89~~ 42 | | |
| | | | | | |
| MW-54 | 5/4 | 1111 | 47.80 | | |
| ↓ | 5/5/09 | 1114 | 48.00 | | |
| | 5/5/09 | 1617 | 48.13 | | |
| | 5/6/09 | 0713 | 48.27 | | |
| | 5/6 | 1417 | 48.08 | | |
| | 5/7/09 | 0810 | 47.~~92~~ 81 | | |
| | | | | | |

URS CORPORATION

# HYDRODATA SHEET

Project ____________ Event ____________ Sampler ____________

Project No. ____________ Datum ____________ Sheet ___ of ___

| WELL or LOCATION | DATE | TIME | MEASUREMENT | TOTAL DEPTH | COMMENTS |
|---|---|---|---|---|---|
| MW-56 | 5/4 | 1115 | 48.00 | | |
| ↓ | 5/5/09 | 1121 | 48.16 | | |
| | 5/5/09 | 1620 | 48.30 | | |
| | 5/6/09 | 0717 | 48.60 | | |
| | 5/6/09 | 1422 | 48.24 | | |
| | 5/7/09 | 0816 | 48.05 | | |
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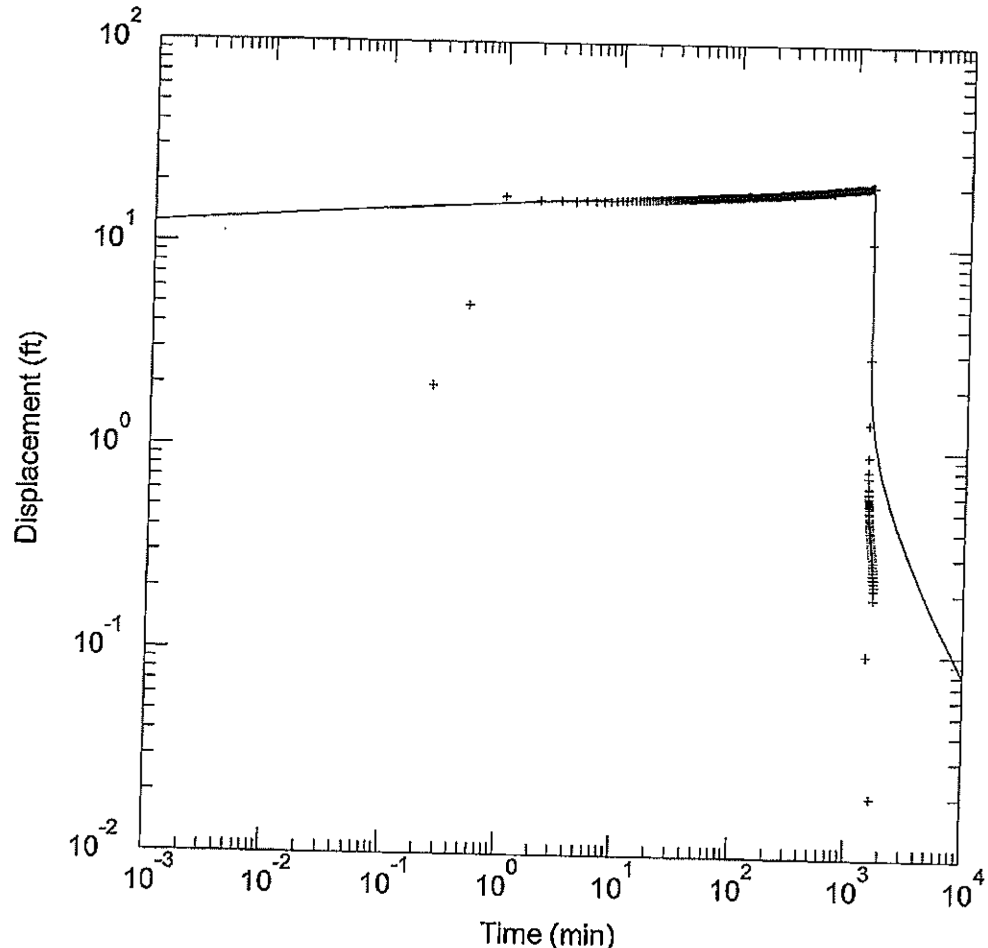
# APPENDIX IV

## Constant Rate Aquifer Test Analysis Data Analysis Curves




## WELL TEST ANALYSIS

Data Set: V:\Projects\Cooper Drum\2009\Aquifer Test_May 2009\Cooper_Drum_EW-03.aqt
Date: 01/18/10 Time: 10:52:11

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 50. ft
Aquitard Thickness (b'): 1. ft
Anisotropy Ratio (Kz/Kr): 1000.
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

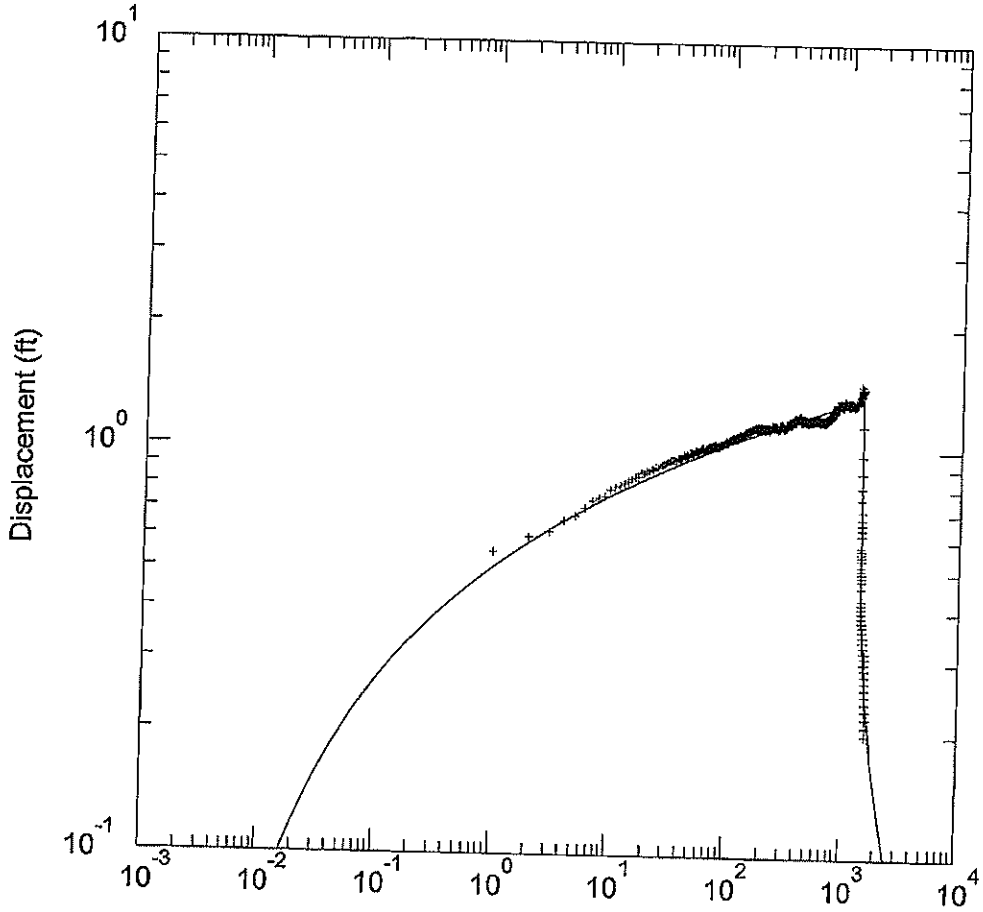
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| + PZ-1 | 0 | 1E-007 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 653.9 $ft^2$/day
S = 8.641E-10
r/B' = 1.0E-5
ß' = 0.003413
r/B" = 0
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_MW-37_Recovery.aqt
Date: 01/18/10 Time: 10:37:14

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 70. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

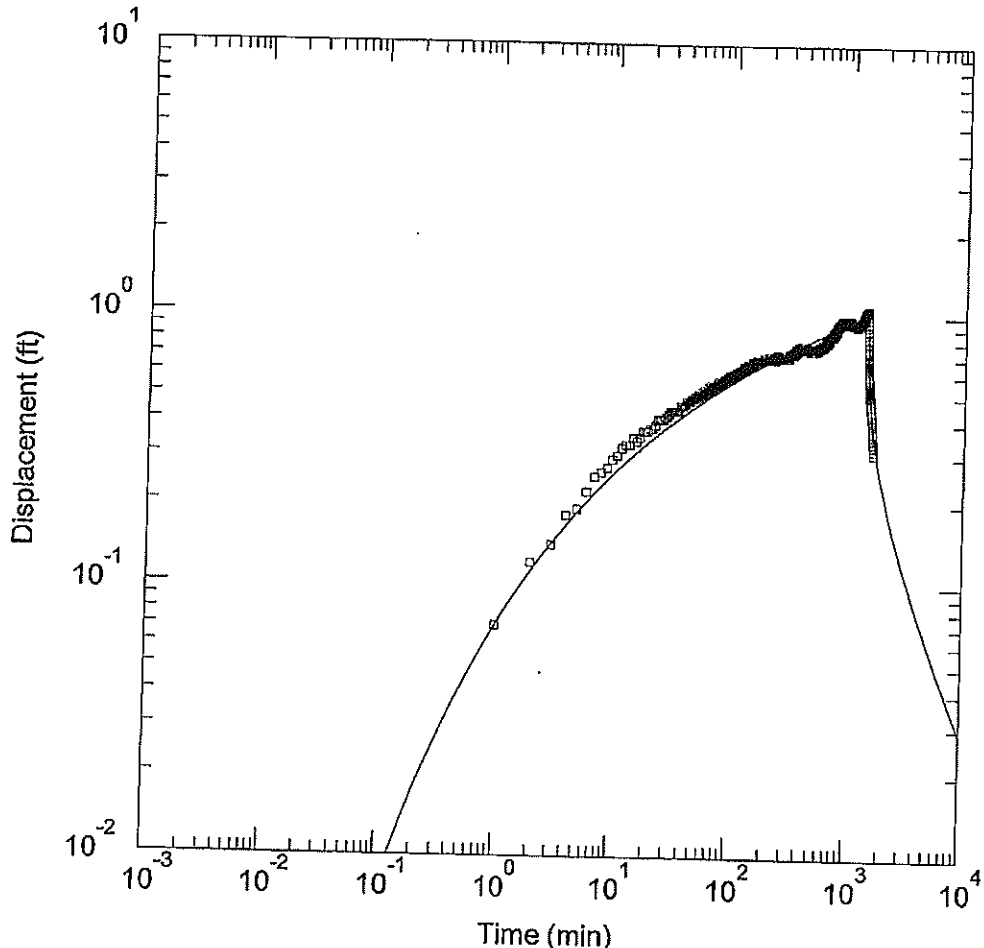
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| + MW-37 | 0 | 63 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

$T = 2848.8$ ft$^2$/day
r/B' = 1.0E-5
r/B" = 1.0E-5
S = 8.641E-6
ß' = 0.05285
ß" = 0.3668




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_MW-36.aqt
Date: 01/18/10 Time: 10:36:38

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 100. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 0.5
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

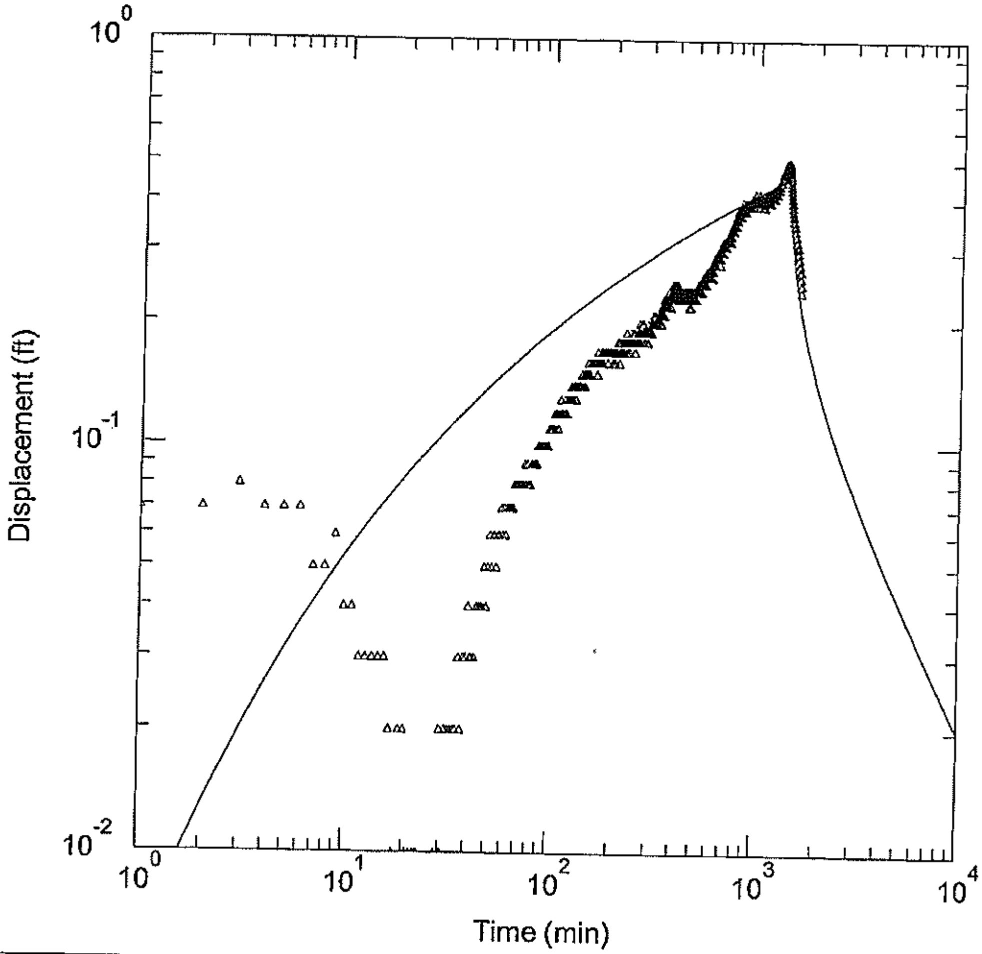
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| ▫ MW-36 | 0 | 74 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 1717.6 $ft^2$/day
S = 3.952E-6
r/B' = 1.0E-5
ß' = 10.
r/B" = 0
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_MW-38.aqt
Date: 01/18/10 Time: 10:24:03

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 100. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

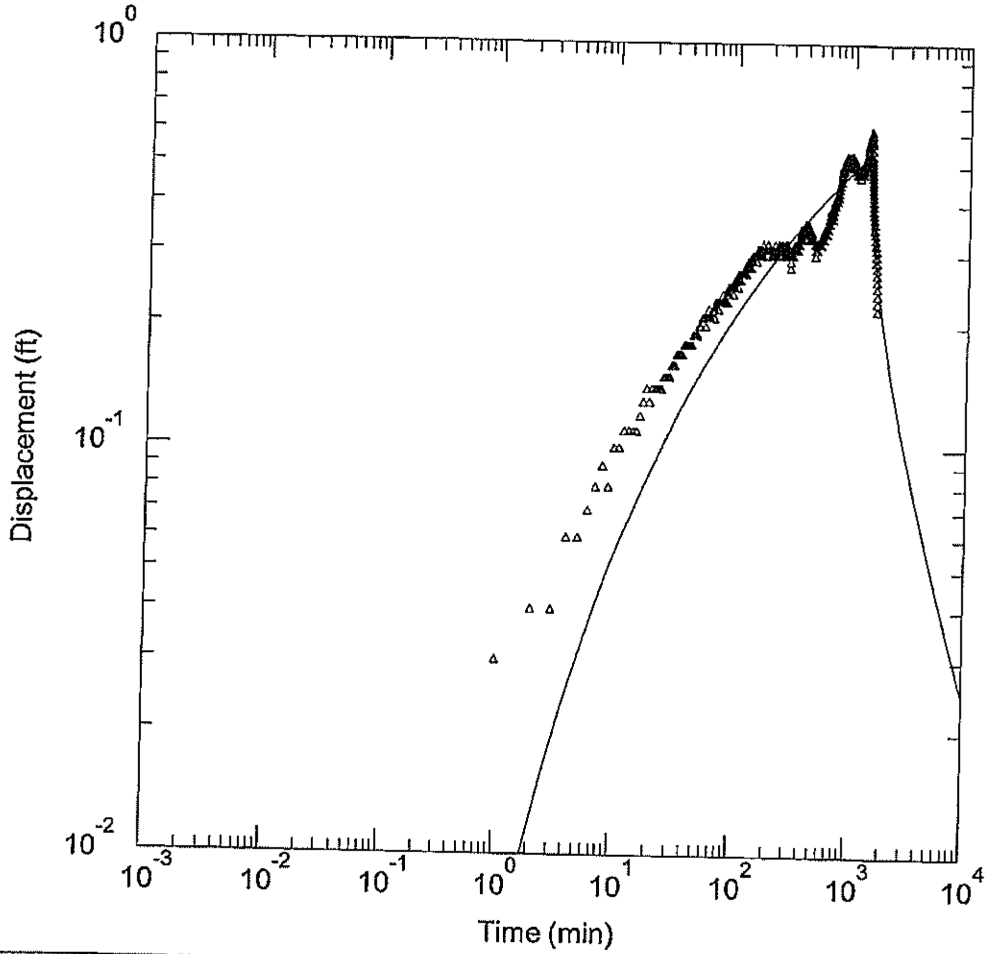
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| ▵ MW-38 | 180 | 75 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 2330.2 ft²/day
S = 7.526E-6
r/B' = 1.0E-5
ß' = 10.
r/B" = 0
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_29.aqt
Date: 01/18/10
Time: 10:33:35

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 50. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 6.536E-7
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

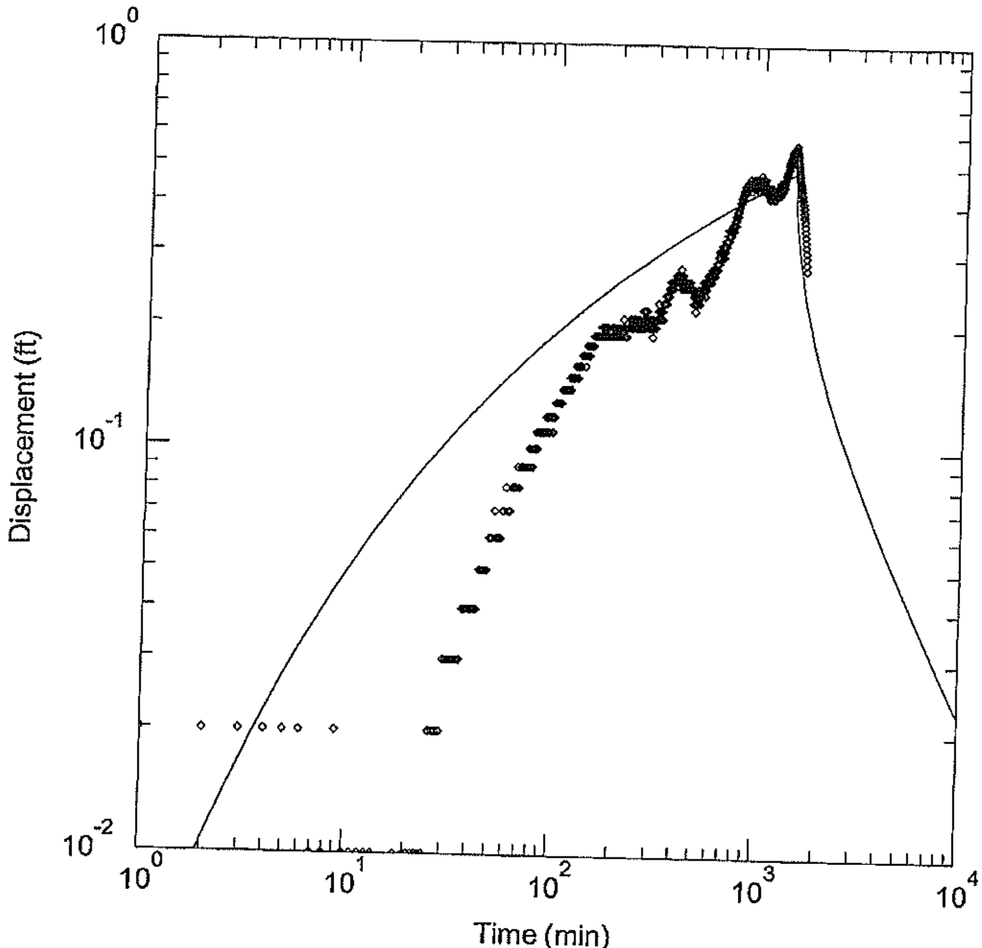
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| ▵ MW-29 | 15 | 195 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 1845.7 $ft^2$/day
S = 7.889E-6
r/B' = 9.005E-5
ß' = 10.
r/B" = 0
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_29A.aqt
Date: 01/18/10
Time: 10:31:18

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 50. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 0.006575
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

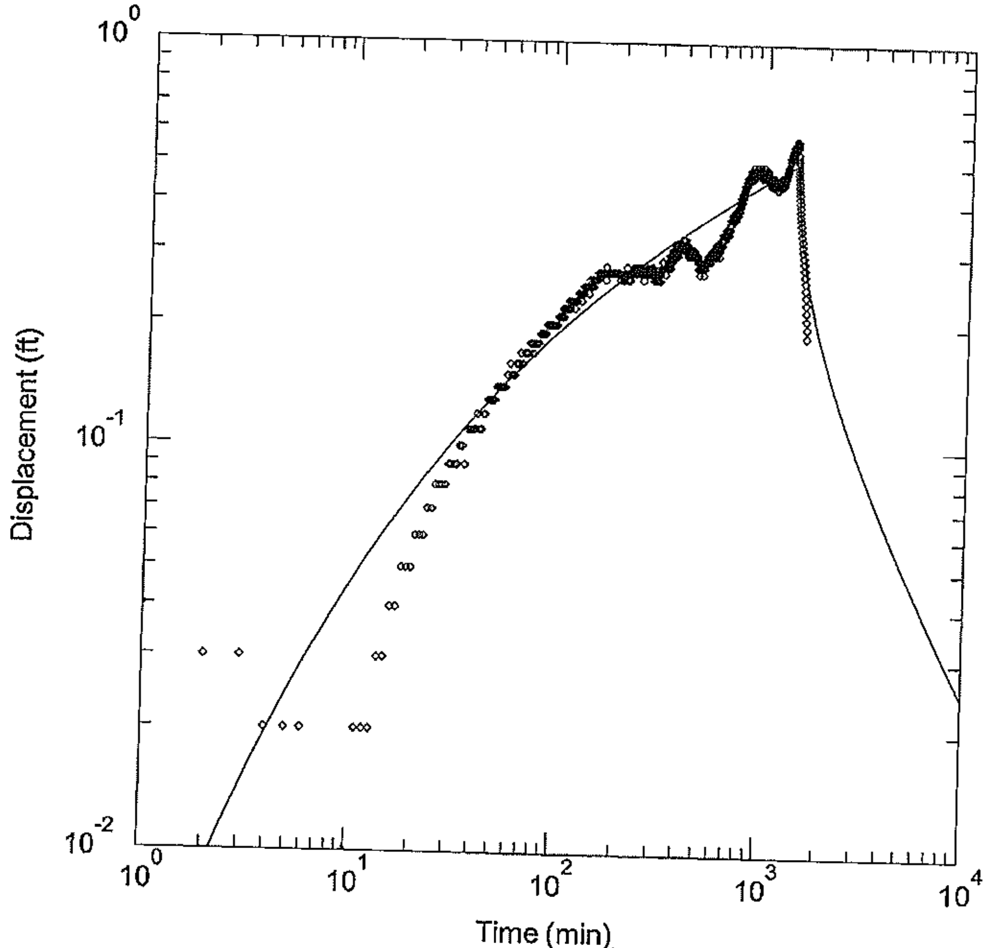
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| ◦ MW-29A | 0 | 195 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 2060.7 $ft^2$/day
r/B' = 1.0E-5
r/B" = 0
S = 8.641E-6
ß' = 10.
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_MW-39.aqt
Date: 01/18/10 Time: 10:35:28

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 100. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

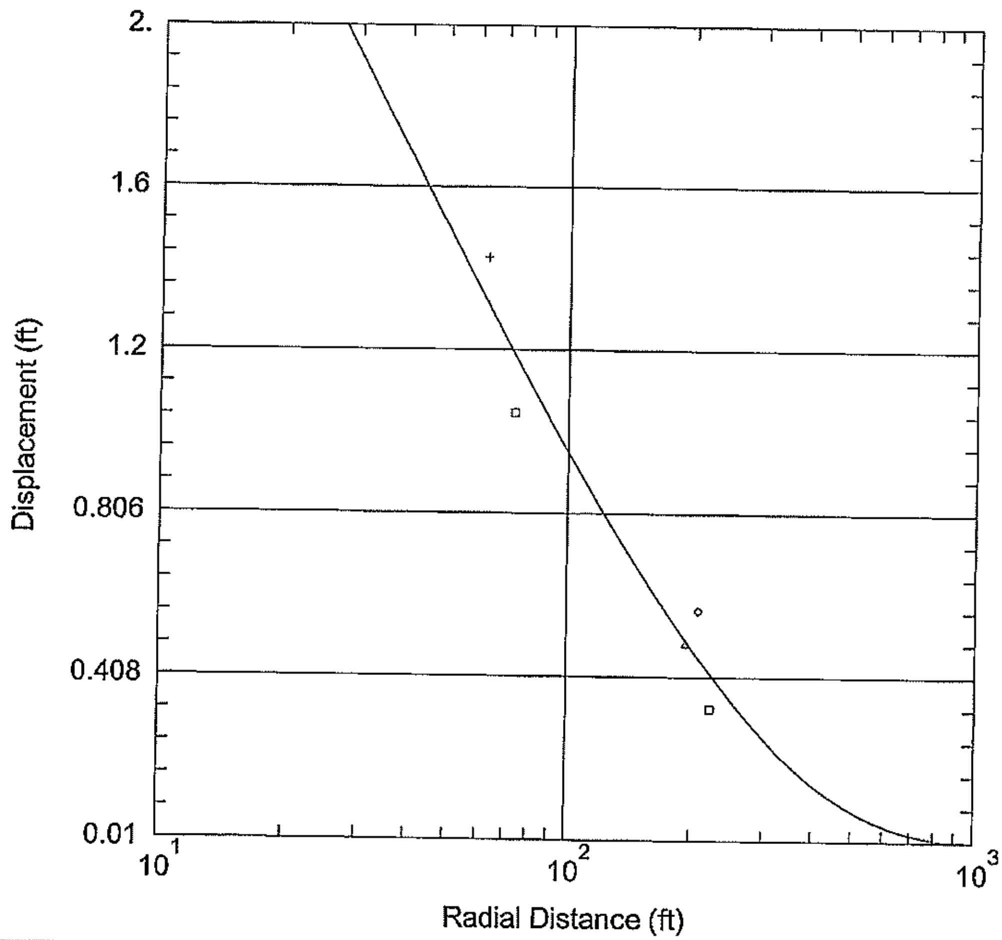
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| ◦ MW-39 | 195 | 75 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 1846. $ft^2$/day
S = 8.641E-6
r/B' = 1.0E-5
ß' = 10.
r/B" = 0
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_Distance_Drawdown.aqt
Date: 01/18/10 Time: 10:20:01

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| □ MW-36 | 0 | 74 |
| + MW-37 | 0 | 63 |
| △ MW-38 | 180 | 75 |
| ◇ MW-39 | 195 | 75 |
| □ MW-40 | 210 | 75 |

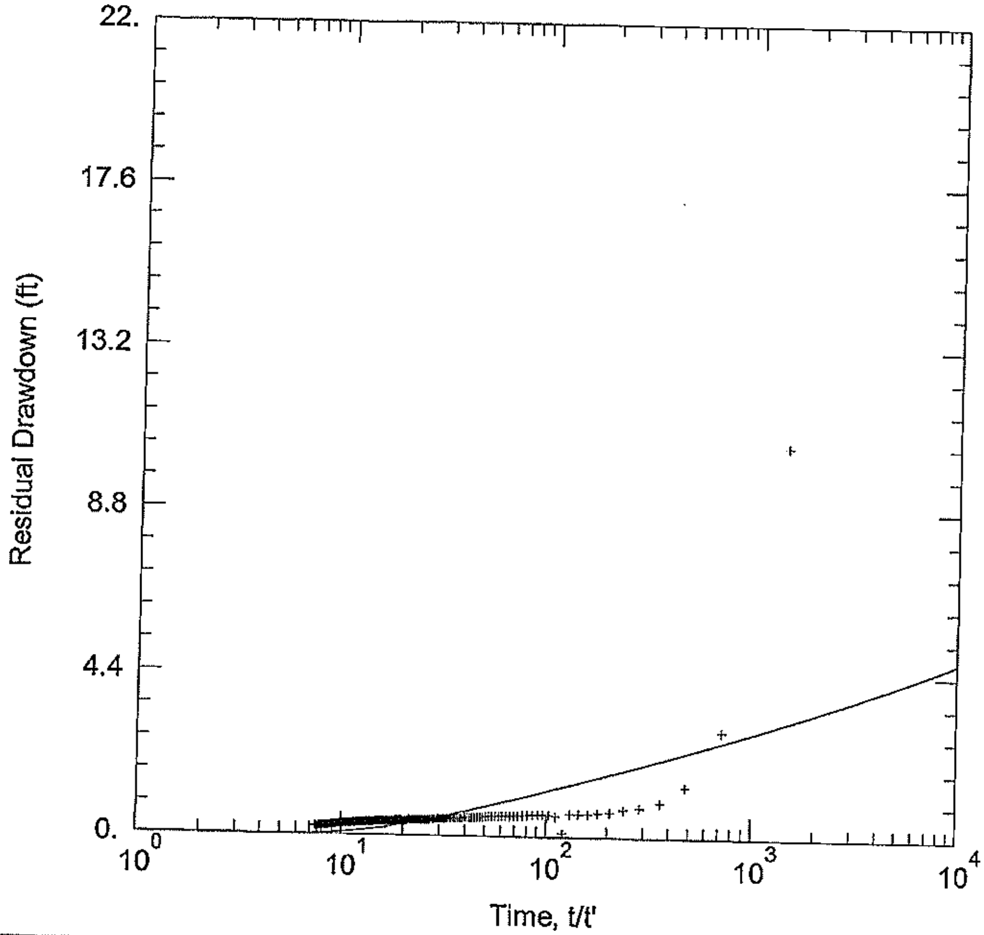
## SOLUTION

Aquifer Model: Leaky

T = 1592.4 $ft^2/day$
ß/r = 0.07674 $ft^{-1}$
b = 100. ft

Solution Method: Hantush

S = 6.853E-6
Kz/Kr = 1.




## WELL TEST ANALYSIS

Data Set: V:\Projects\Cooper Drum\2009\Aquifer Test_May 2009\Cooper_Drum_EW-03.aqt
Date: 01/18/10 Time: 10:53:35

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 50. ft
Aquitard Thickness (b'): 1. ft
Anisotropy Ratio (Kz/Kr): 1000.
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

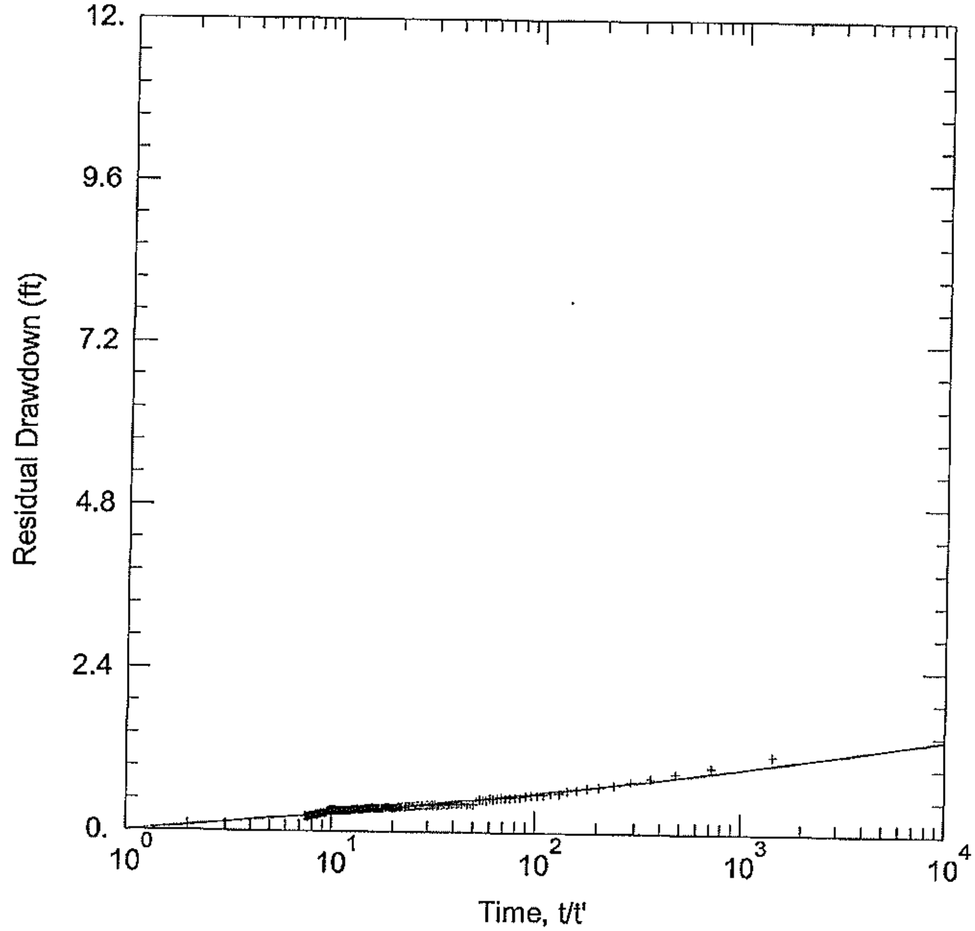
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| + PZ-1 | 0 | 1E-007 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 631. $ft^2$/day
r/B' = 1.204E-5
r/B" = 0
S = 4.161E-9
ß' = 1.0E-5
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_MW-37_Recovery.aqt
Date: 01/18/10 Time: 10:20:45

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 70. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| + MW-37 | 0 | 63 |

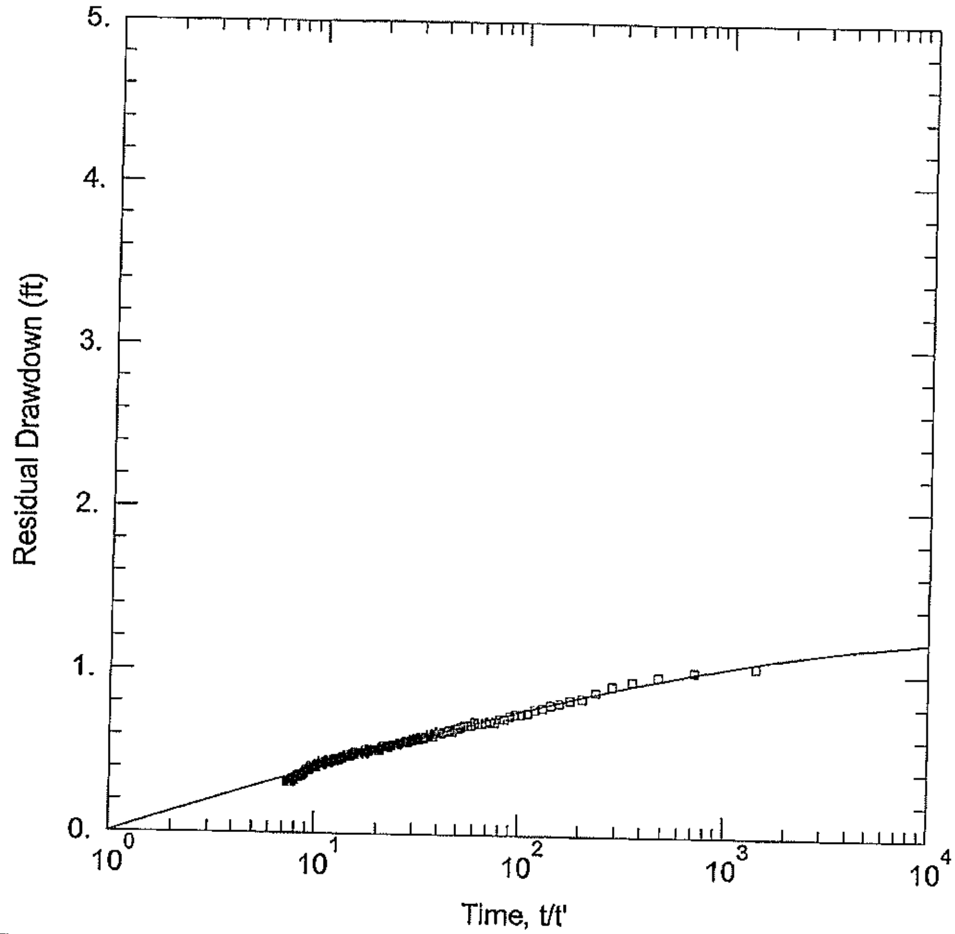
## SOLUTION

Aquifer Model: Leaky

Solution Method: Hantush

T = 3089.2 $ft^2$/day
r/B' = 1.0E-5
r/B" = 1.0E-5

S = 1.796E-8
ß' = 0.0004401
ß" = 8.801E-5




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_MW-36.aqt
Date: 01/18/10 Time: 10:21:37

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 100. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 0.5
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

Observation Wells

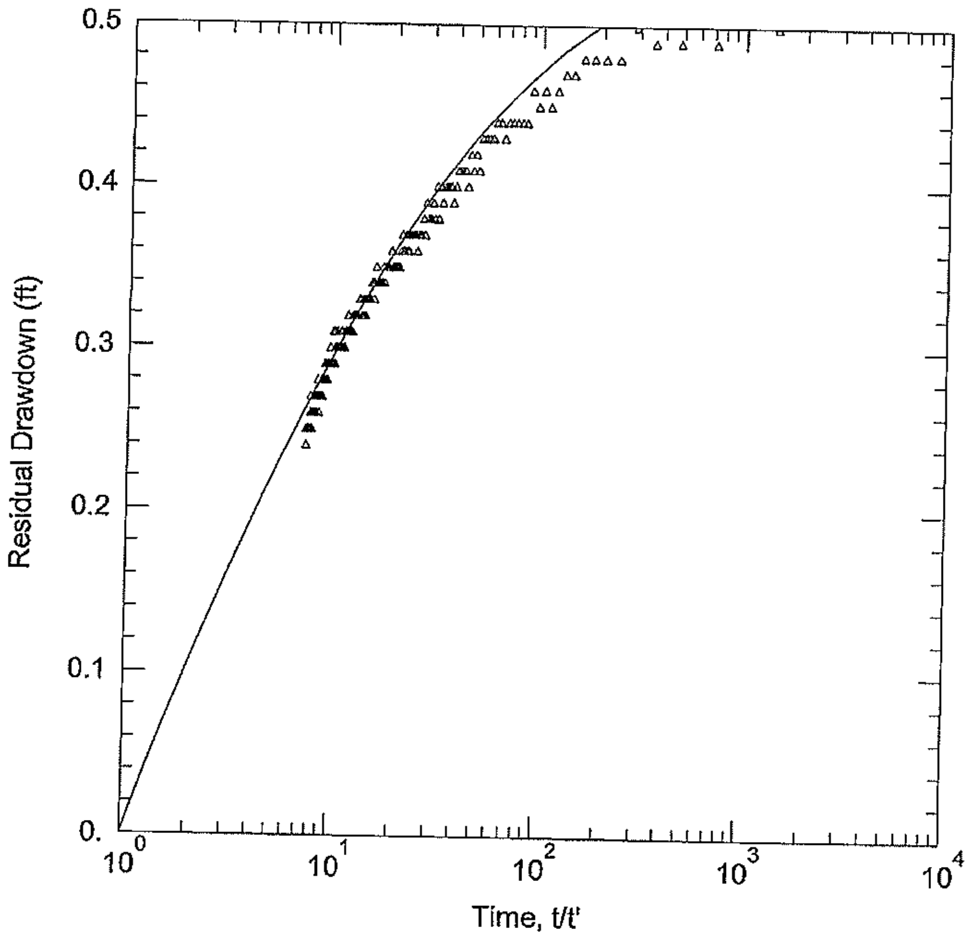
| Well Name | X (ft) | Y (ft) |
|---|---|---|
| ▫ MW-36 | 0 | 74 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 1823.5 $ft^2$/day
r/B' = 1.0E-5
r/B" = 0

S = 9.54E-7
ß' = 8.716
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_MW-38.aqt
Date: 01/18/10
Time: 10:29:19

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 100. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

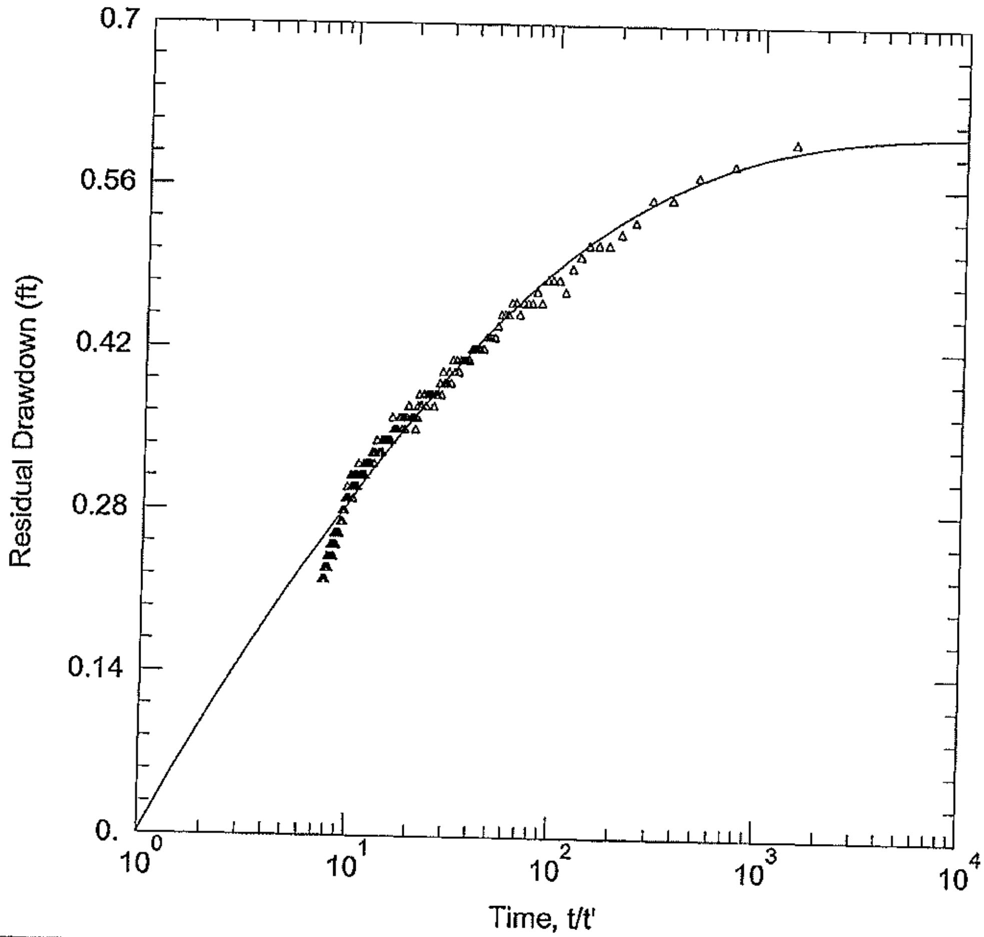
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| △ MW-38 | 180 | 75 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 1850.9 $ft^2$/day
S = 7.526E-6
r/B' = 1.0E-5
ß' = 10.
r/B" = 0
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_29.aqt
Date: 01/18/10
Time: 10:34:06

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 50. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 6.536E-7
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

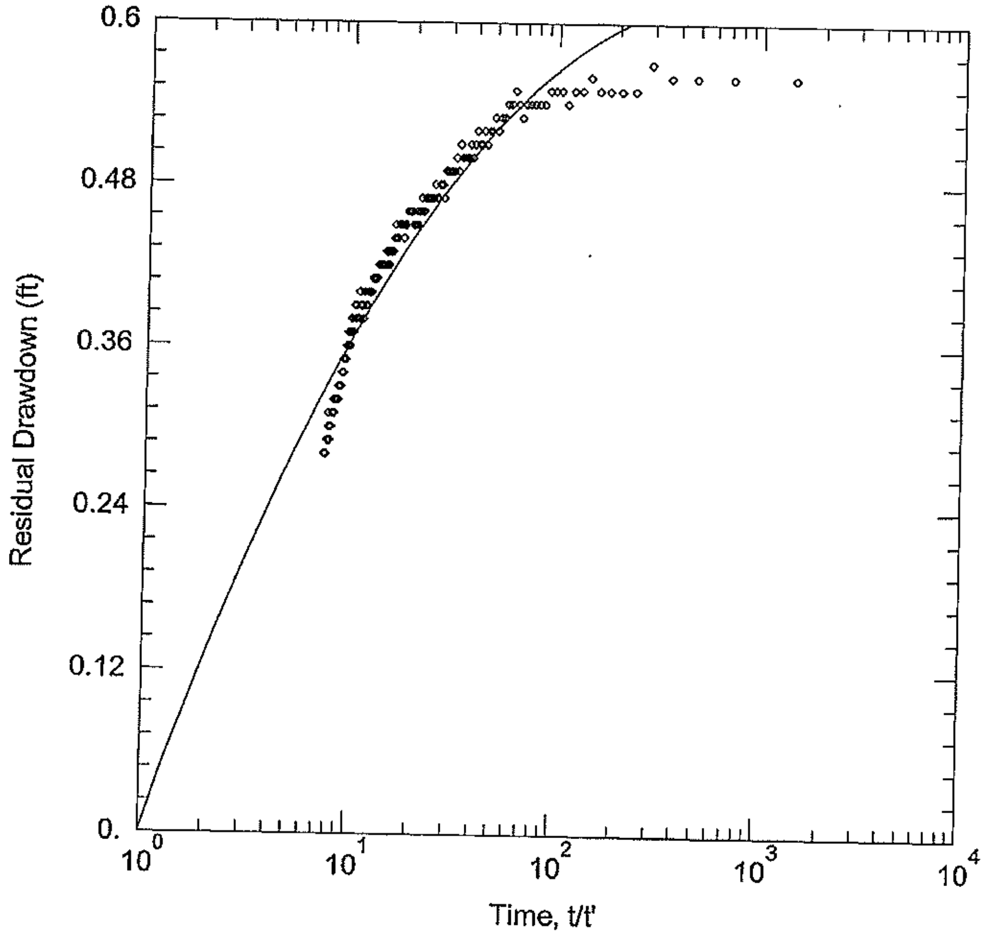
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| △ MW-29 | 15 | 195 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 2123.9 $ft^2$/day
r/B' = 9.005E-5
r/B" = 0
S = 3.972E-6
ß' = 8.86
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_29A.aqt
Date: 01/18/10 Time: 10:32:09

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 50. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 0.006575
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

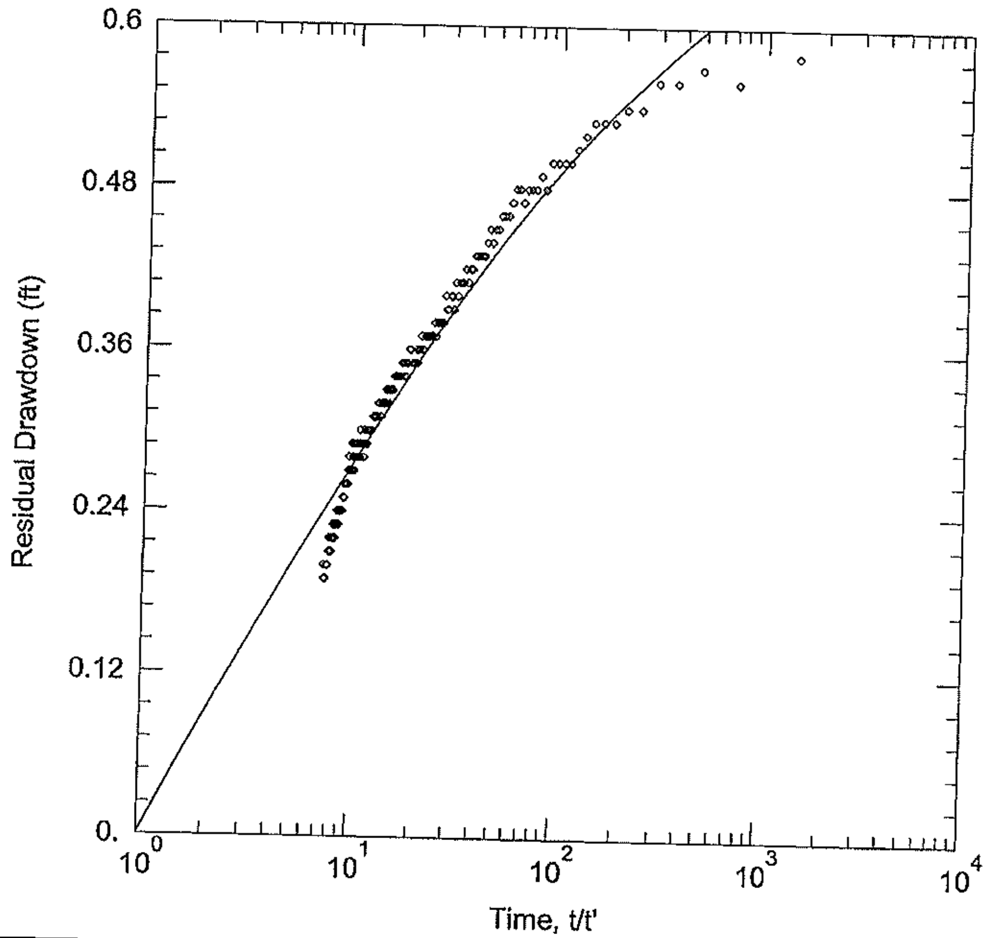
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| ◦ MW-29A | 0 | 195 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 1421.1 $ft^2$/day
r/B' = 1.0E-5
r/B" = 0
S = 8.641E-6
ß' = 10.
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_MW-39.aqt
Date: 01/18/10 Time: 10:35:55

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 100. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

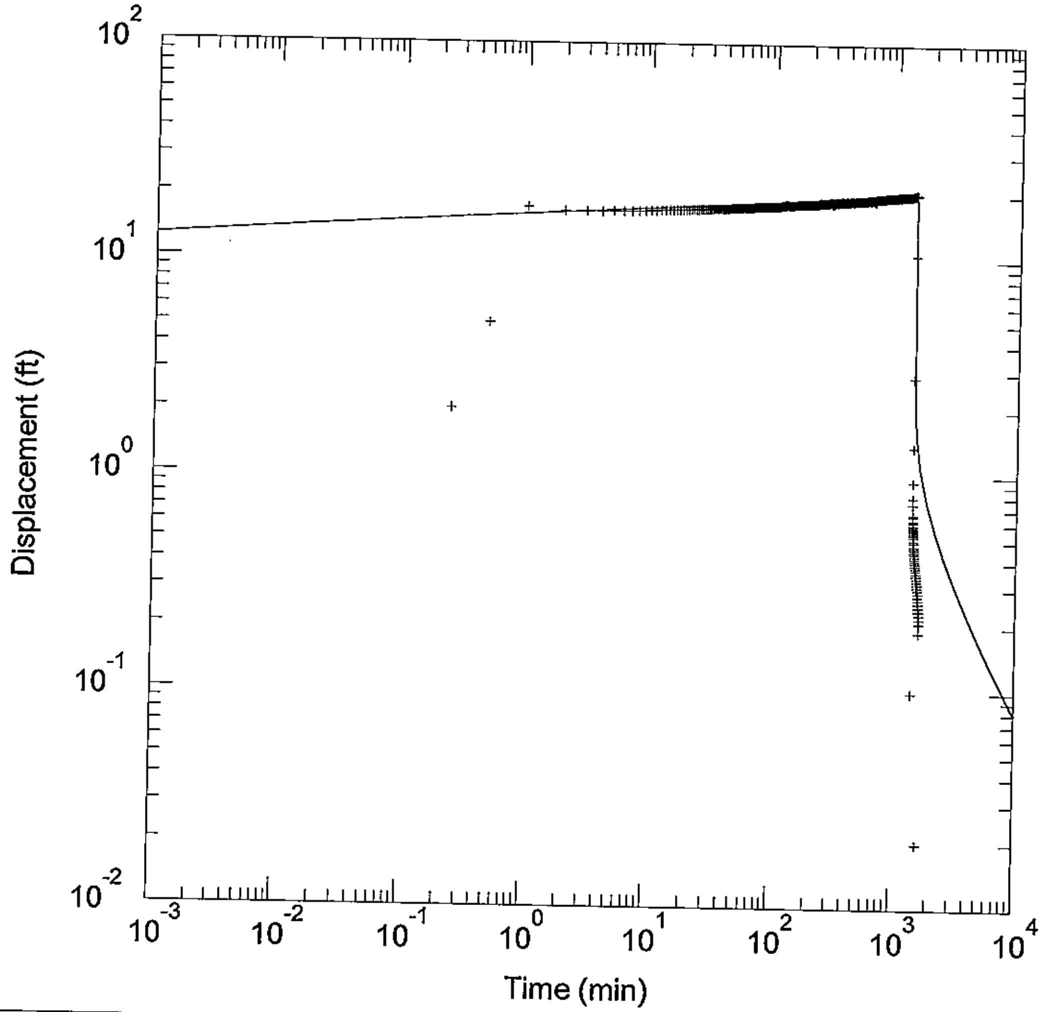
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| ◇ MW-39 | 195 | 75 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 2462. $ft^2$/day
r/B' = 1.0E-5
r/B" = 0
S = 6.57E-6
ß' = 3.544
ß" = 0




## WELL TEST ANALYSIS

Data Set: V:\Projects\Cooper Drum\2009\Aquifer Test_May 2009\Cooper_Drum_EW-03.aqt
Date: 01/18/10 Time: 10:52:11

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 50. ft
Aquitard Thickness (b'): 1. ft
Anisotropy Ratio (Kz/Kr): 1000.
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

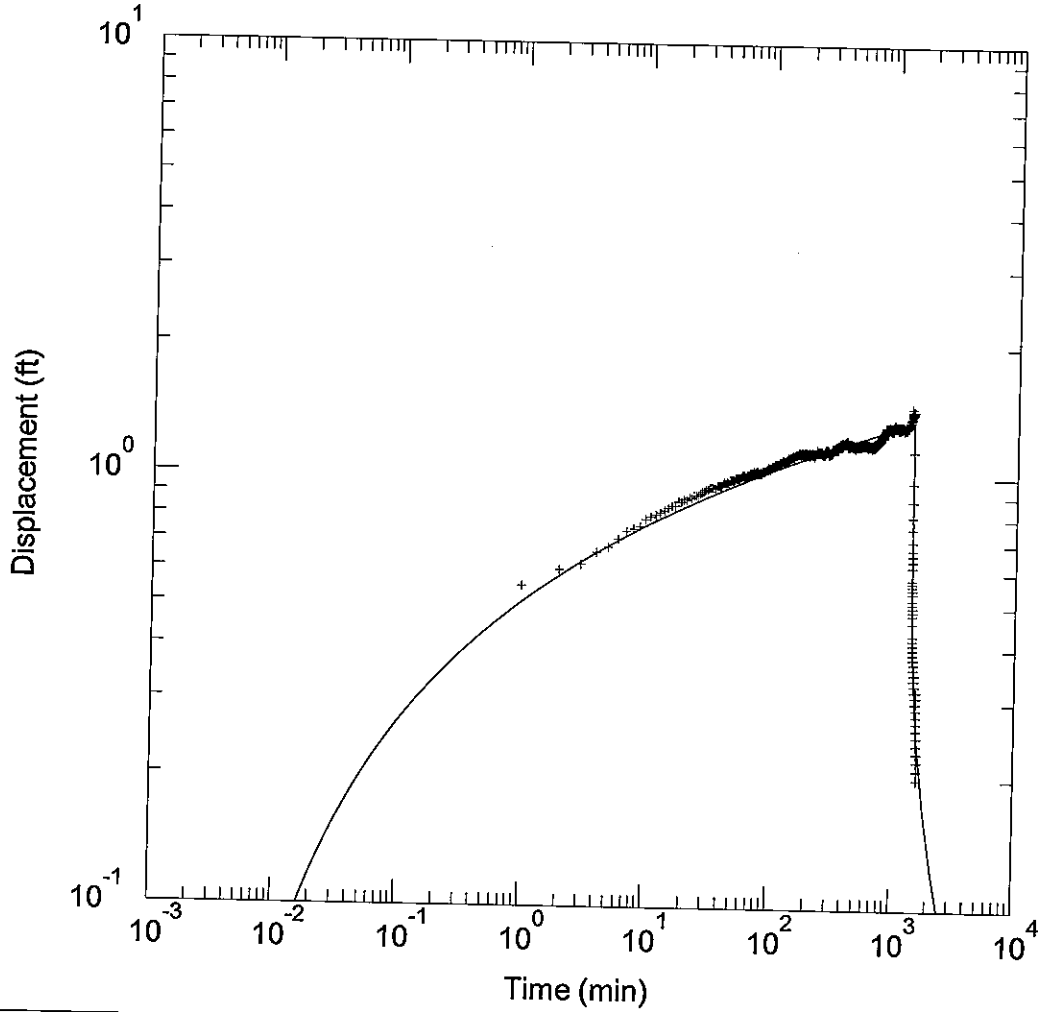
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| + PZ-1 | 0 | 1E-007 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 653.9 $ft^2$/day
r/B' = 1.0E-5
r/B" = 0
S = 8.641E-10
ß' = 0.003413
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_MW-37_Recovery.aqt
Date: 01/18/10 Time: 10:37:14

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 70. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

Observation Wells

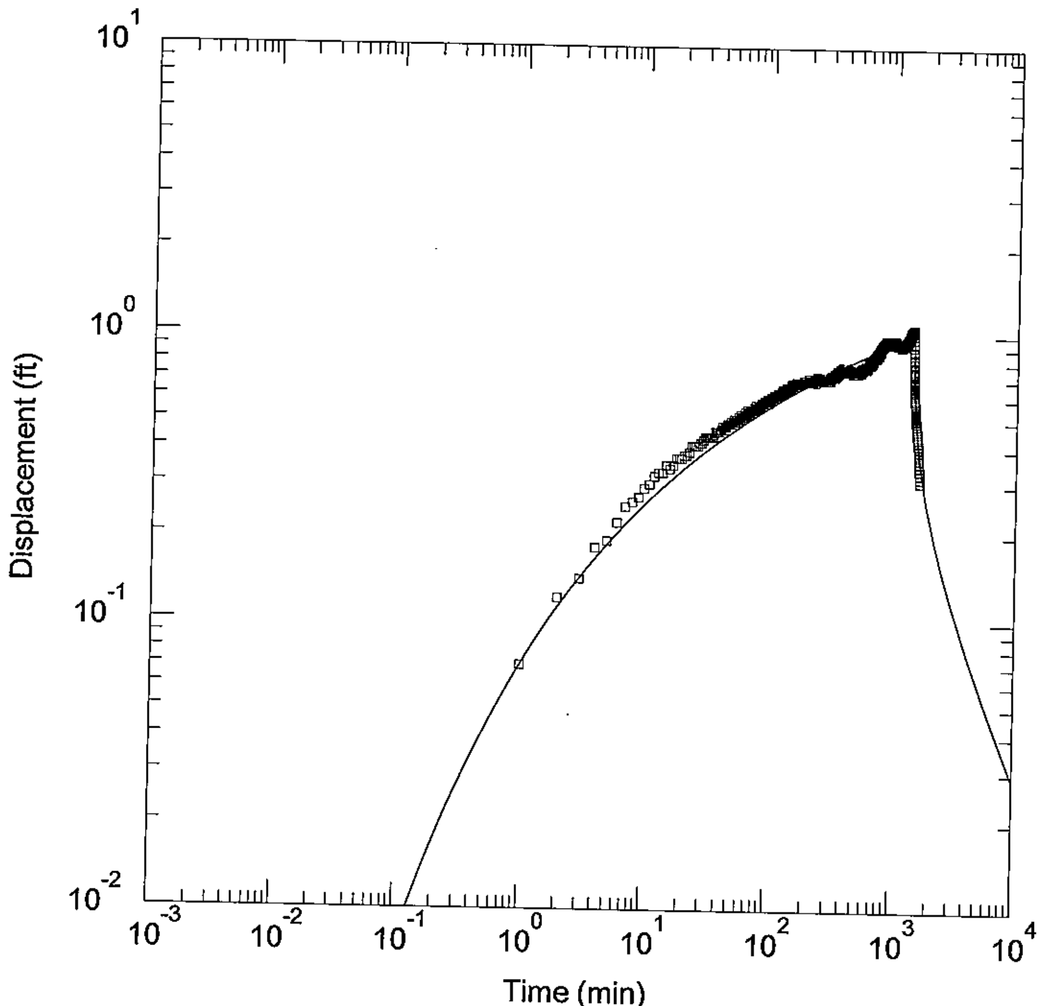
| Well Name | X (ft) | Y (ft) |
|---|---|---|
| + MW-37 | 0 | 63 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 2848.8 $ft^2$/day
r/B' = 1.0E-5
r/B" = 1.0E-5

S = 8.641E-6
ß' = 0.05285
ß" = 0.3668




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_MW-36.aqt
Date: 01/18/10
Time: 10:36:38

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 100. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 0.5
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

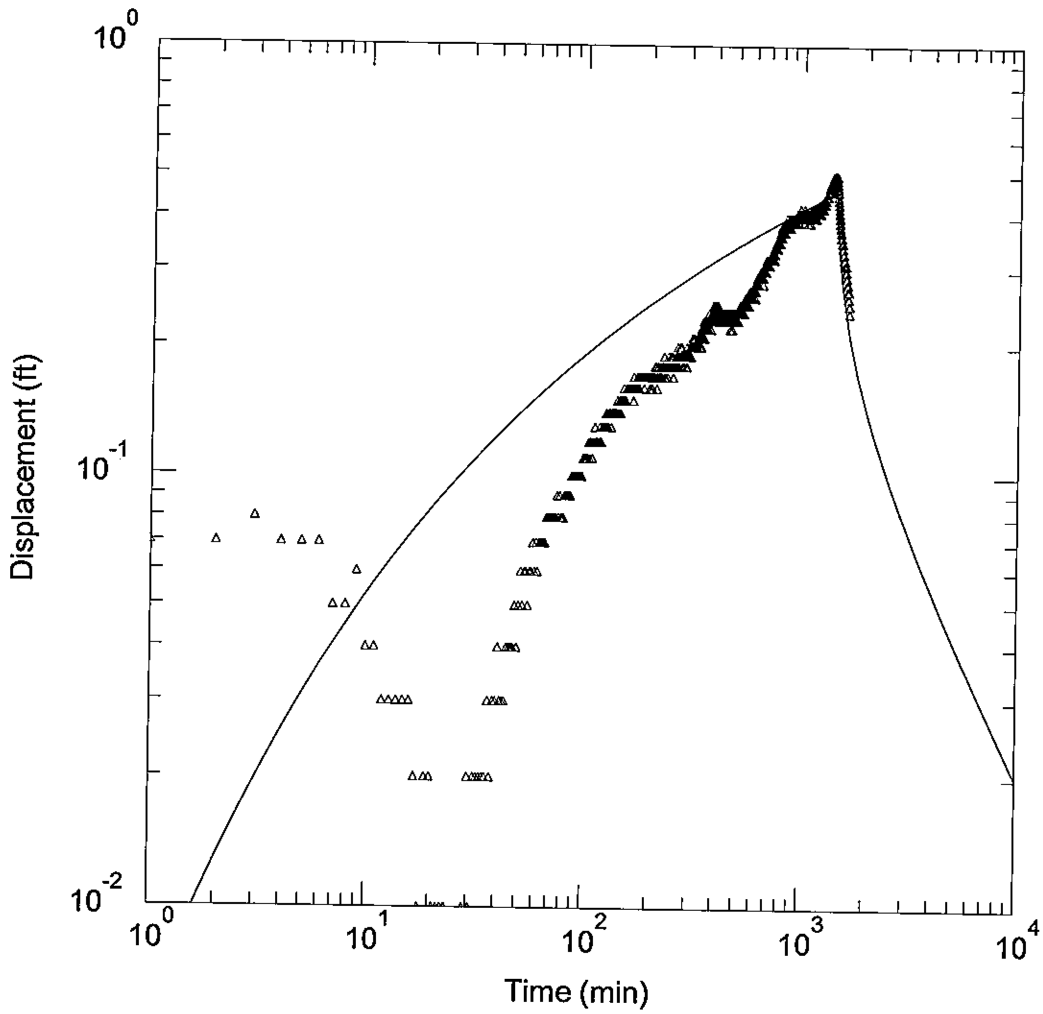
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| □ MW-36 | 0 | 74 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 1717.6 $ft^2$/day
r/B' = 1.0E-5
r/B" = 0
S = 3.952E-6
ß' = 10.
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_MW-38.aqt
Date: 01/18/10 Time: 10:24:03

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 100. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

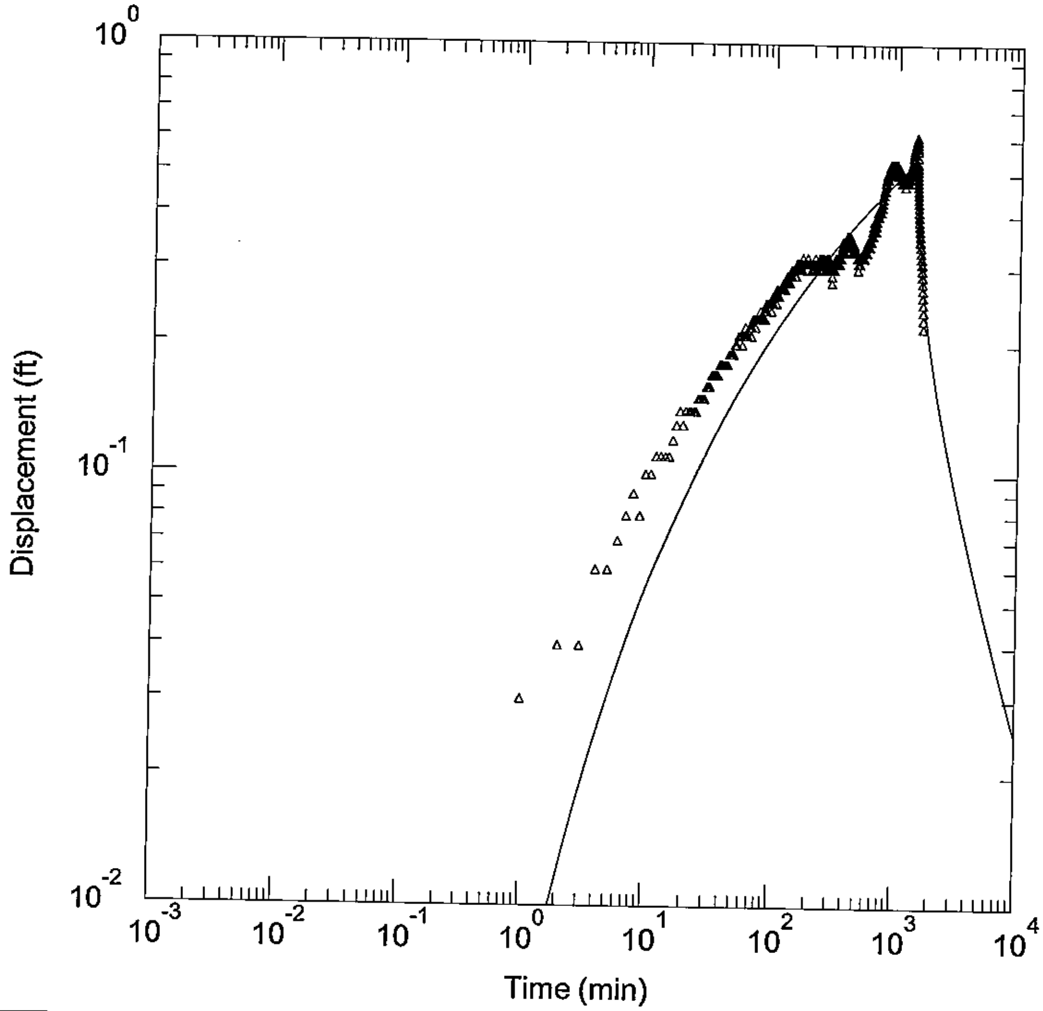
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| ▵ MW-38 | 180 | 75 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 2330.2 $ft^2$/day
r/B' = 1.0E-5
r/B" = 0
S = 7.526E-6
ß' = 10.
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_29.aqt
Date: 01/18/10 Time: 10:33:35

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 50. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 6.536E-7
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

Observation Wells

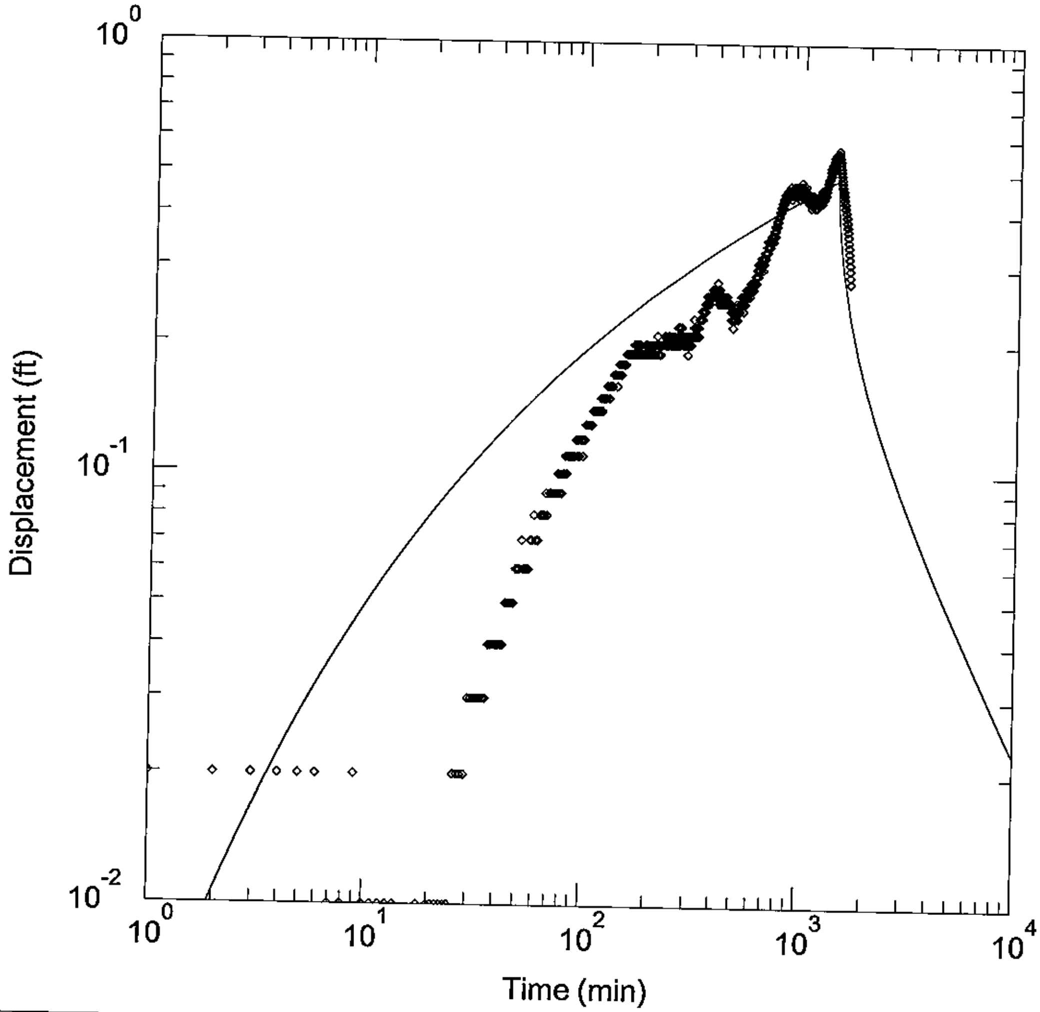
| Well Name | X (ft) | Y (ft) |
|---|---|---|
| ▵ MW-29 | 15 | 195 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 1845.7 $ft^2$/day
r/B' = 9.005E-5
r/B" = 0

S = 7.889E-6
ß' = 10.
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_29A.aqt
Date: 01/18/10 Time: 10:31:18

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 50. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 0.006575
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

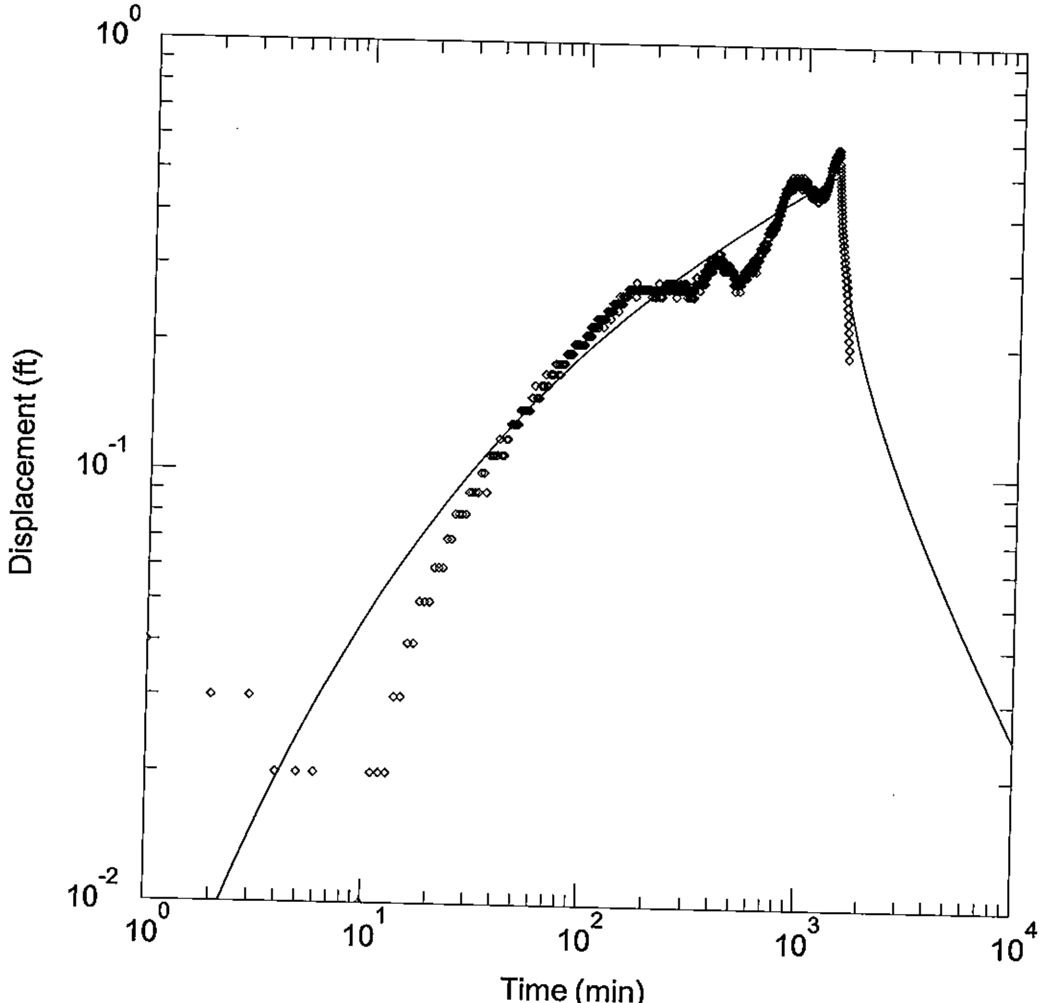
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| ◇ MW-29A | 0 | 195 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 2060.7 $ft^2$/day
S = 8.641E-6
r/B' = 1.0E-5
ß' = 10.
r/B" = 0
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_MW-39.aqt
Date: 01/18/10 Time: 10:35:28

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 100. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

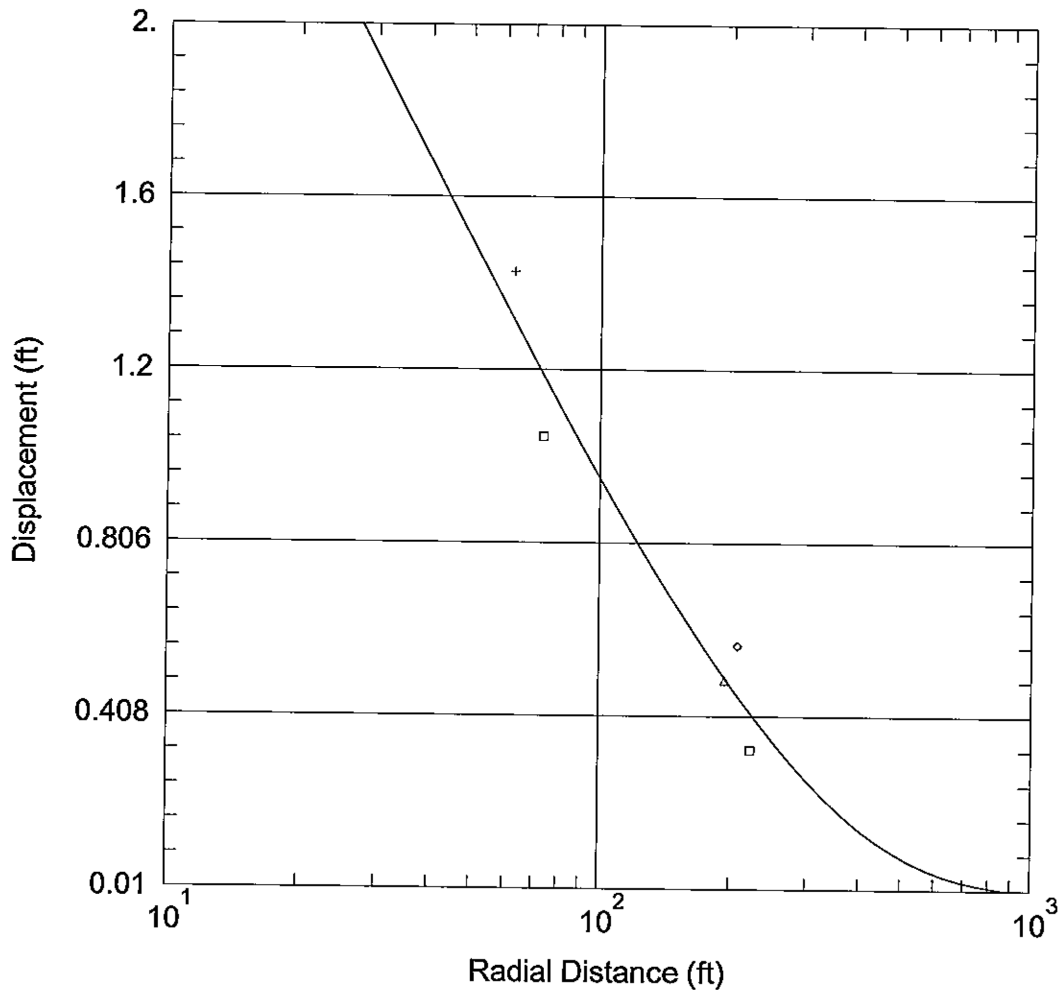
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| ◦ MW-39 | 195 | 75 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 1846. $ft^2$/day
S = 8.641E-6
r/B' = 1.0E-5
ß' = 10.
r/B" = 0
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_Distance_Drawdown.aqt
Date: 01/18/10 Time: 10:20:01

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| □ MW-36 | 0 | 74 |
| + MW-37 | 0 | 63 |
| △ MW-38 | 180 | 75 |
| ◇ MW-39 | 195 | 75 |
| □ MW-40 | 210 | 75 |

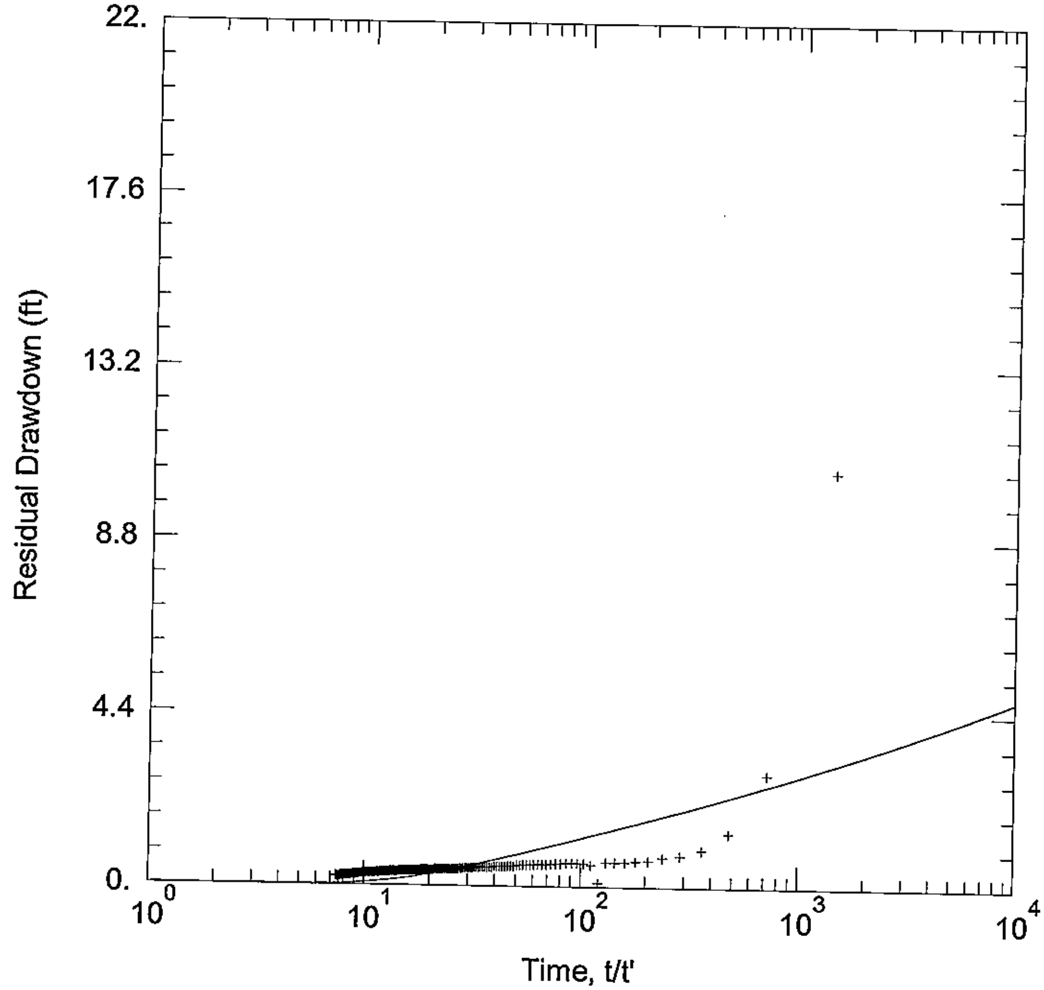
## SOLUTION

Aquifer Model: Leaky

T = 1592.4 $ft^2/day$
ß/r = 0.07674 $ft^{-1}$
b = 100. ft

Solution Method: Hantush

S = 6.853E-6
Kz/Kr = 1.




## WELL TEST ANALYSIS

Data Set: V:\Projects\Cooper Drum\2009\Aquifer Test_May 2009\Cooper_Drum_EW-03.aqt
Date: 01/18/10 Time: 10:53:35

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 50. ft
Aquitard Thickness (b'): 1. ft
Anisotropy Ratio (Kz/Kr): 1000.
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

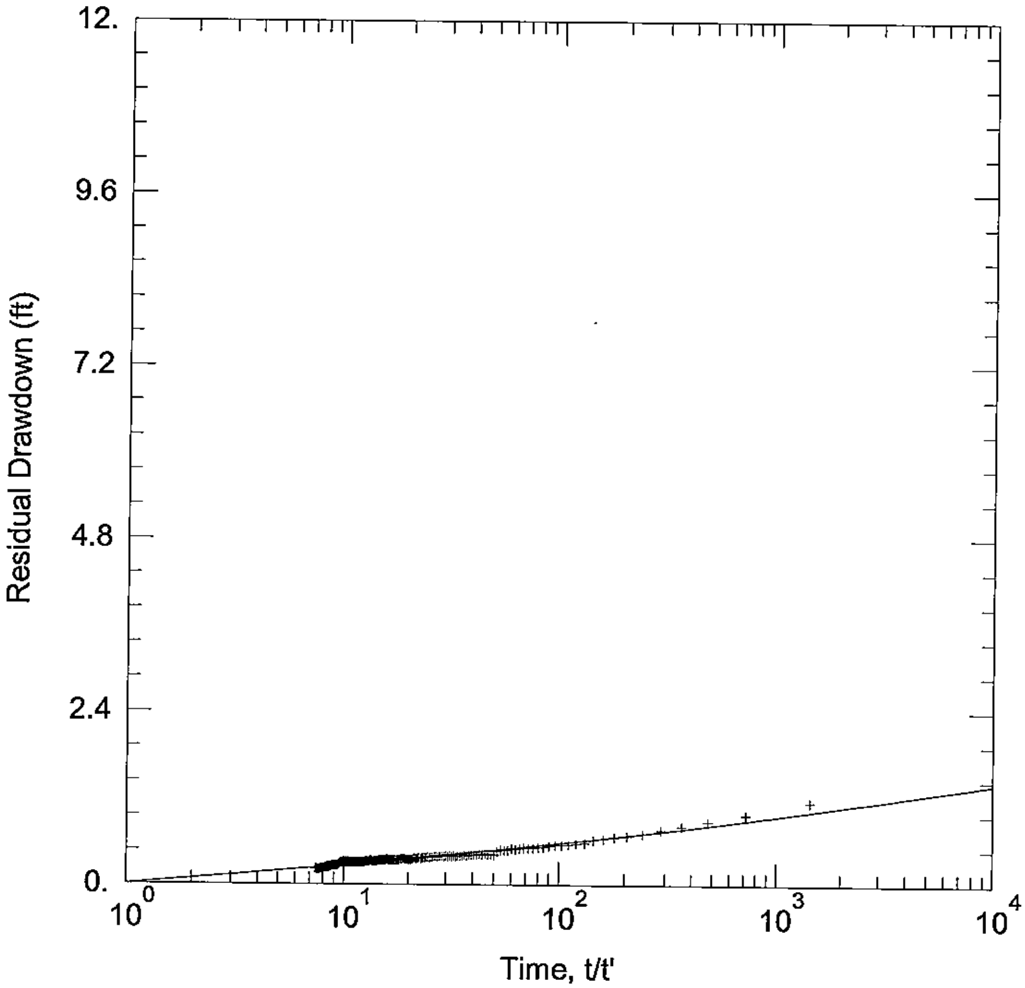
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| + PZ-1 | 0 | 1E-007 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 631. $ft^2$/day
r/B' = 1.204E-5
r/B" = 0
S = 4.161E-9
ß' = 1.0E-5
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_MW-37_Recovery.aqt
Date: 01/18/10 Time: 10:20:45

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 70. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

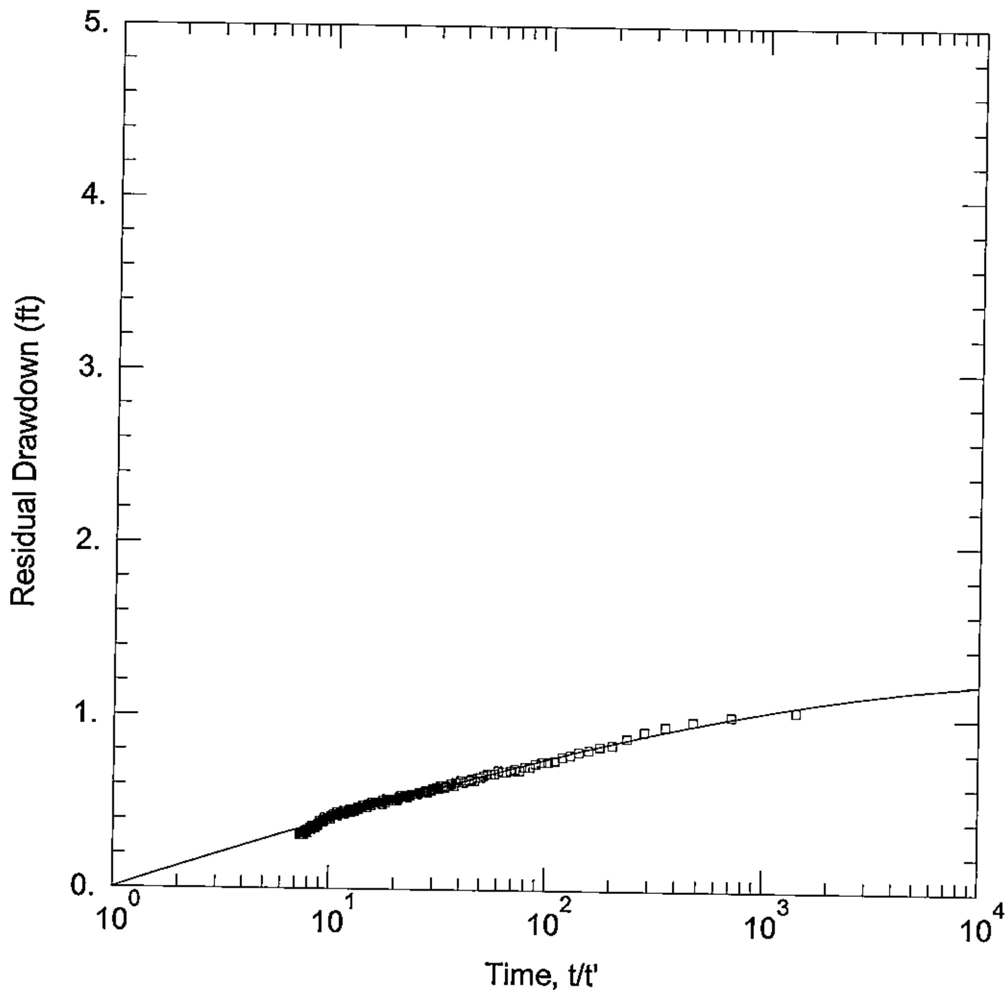
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| + MW-37 | 0 | 63 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 3089.2 $ft^2$/day
r/B' = 1.0E-5
r/B" = 1.0E-5
S = 1.796E-8
ß' = 0.0004401
ß" = 8.801E-5




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_MW-36.aqt
Date: 01/18/10
Time: 10:21:37

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 100. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 0.5
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

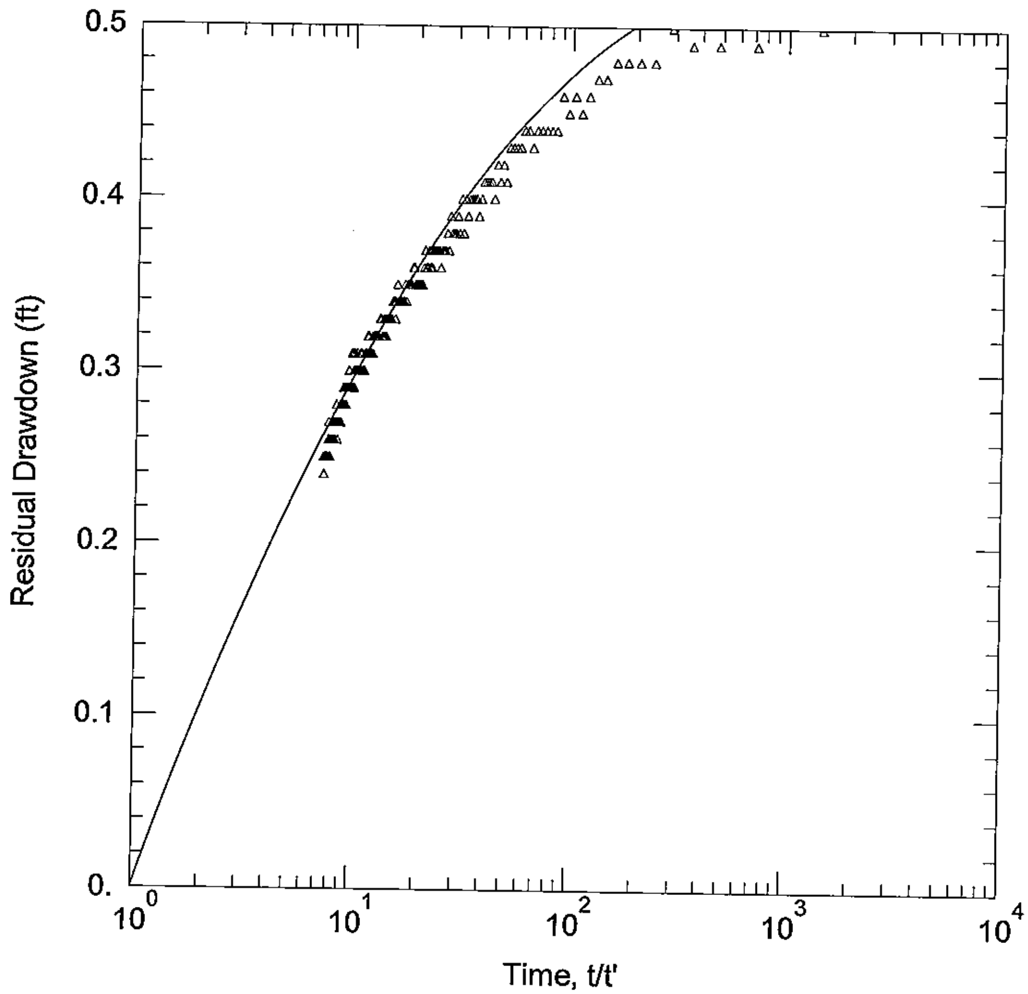
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| □ MW-36 | 0 | 74 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 1823.5 $ft^2$/day
r/B' = 1.0E-5
r/B" = 0
S = 9.54E-7
ß' = 8.716
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_MW-38.aqt
Date: 01/18/10 Time: 10:29:19

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 100. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

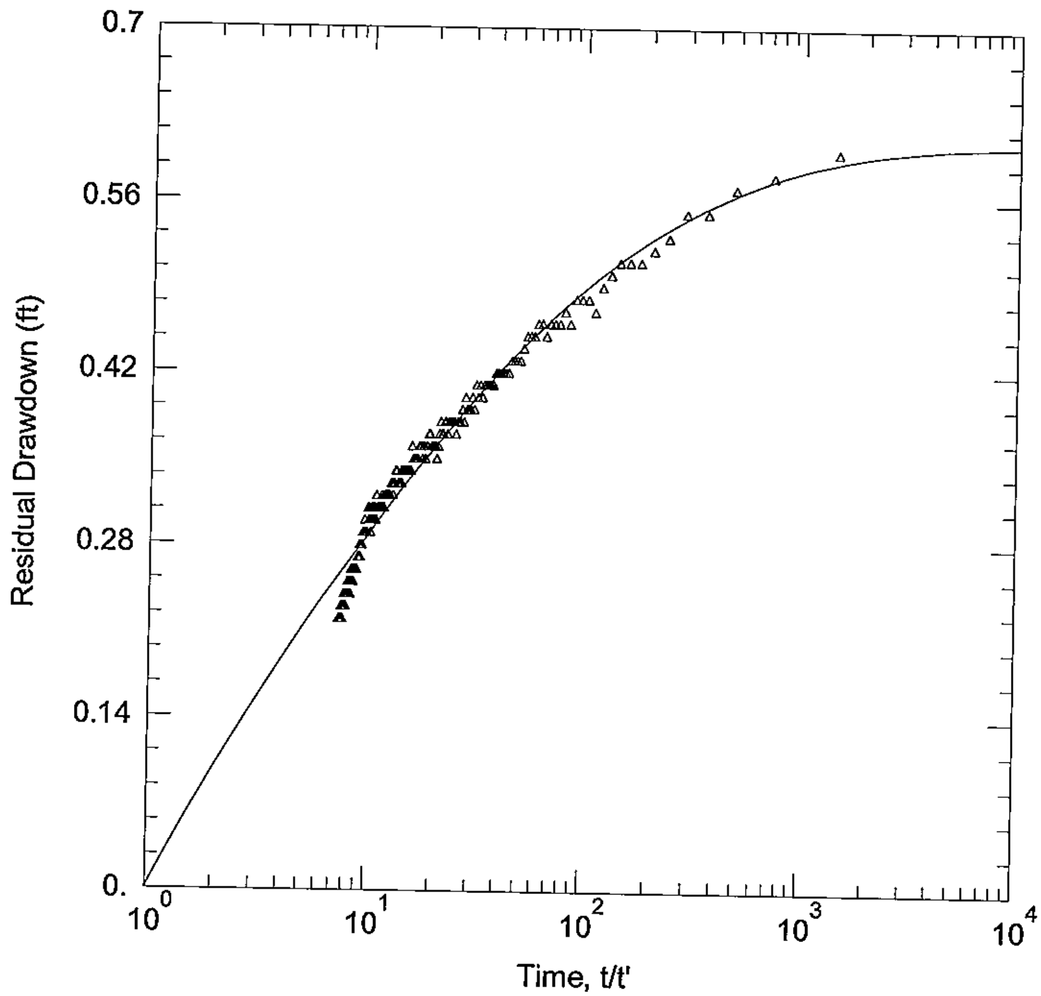
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| △ MW-38 | 180 | 75 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 1850.9 $ft^2$/day
r/B' = 1.0E-5
r/B" = 0
S = 7.526E-6
ß' = 10.
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_29.aqt
Date: 01/18/10 Time: 10:34:06

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 50. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 6.536E-7
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

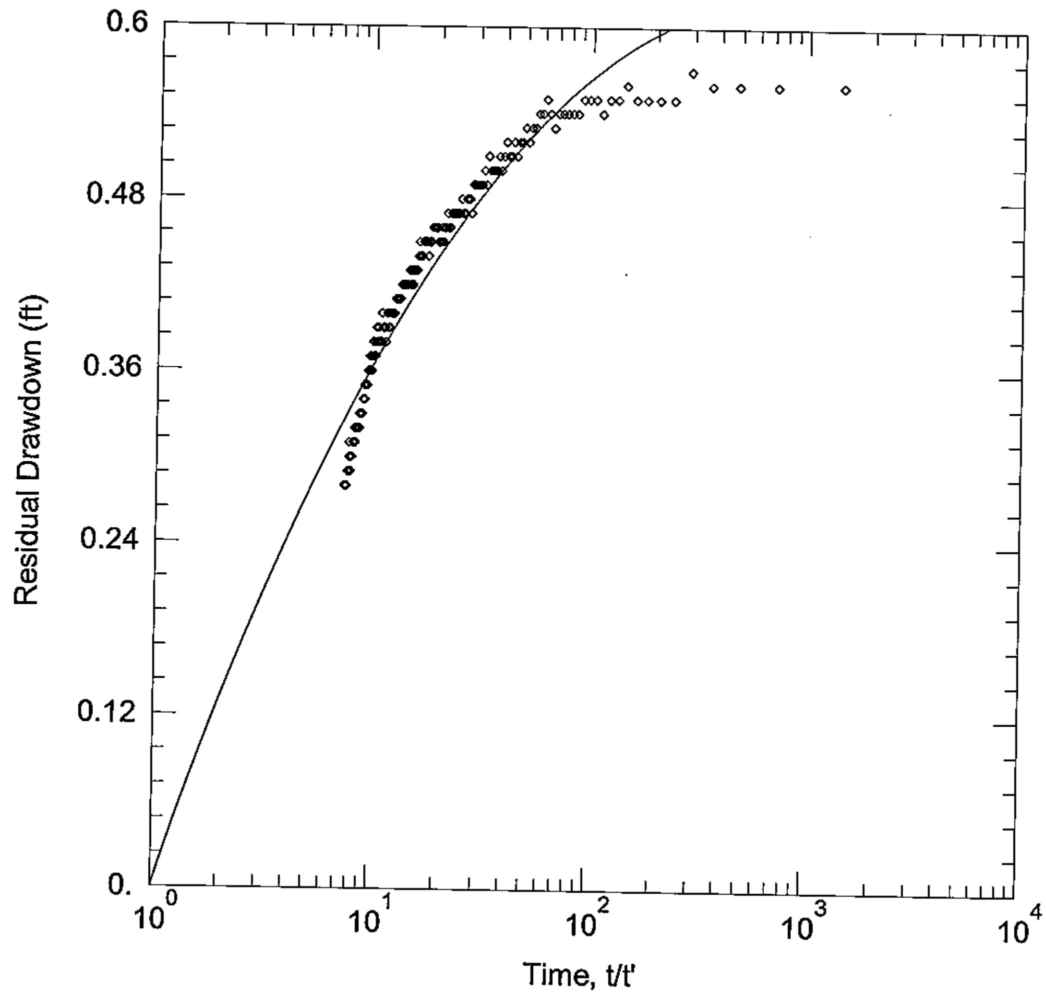
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| △ MW-29 | 15 | 195 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 2123.9 $ft^2$/day
S = 3.972E-6
r/B' = 9.005E-5
ß' = 8.86
r/B" = 0
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_29A.aqt
Date: 01/18/10 Time: 10:32:09

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 50. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 0.006575
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

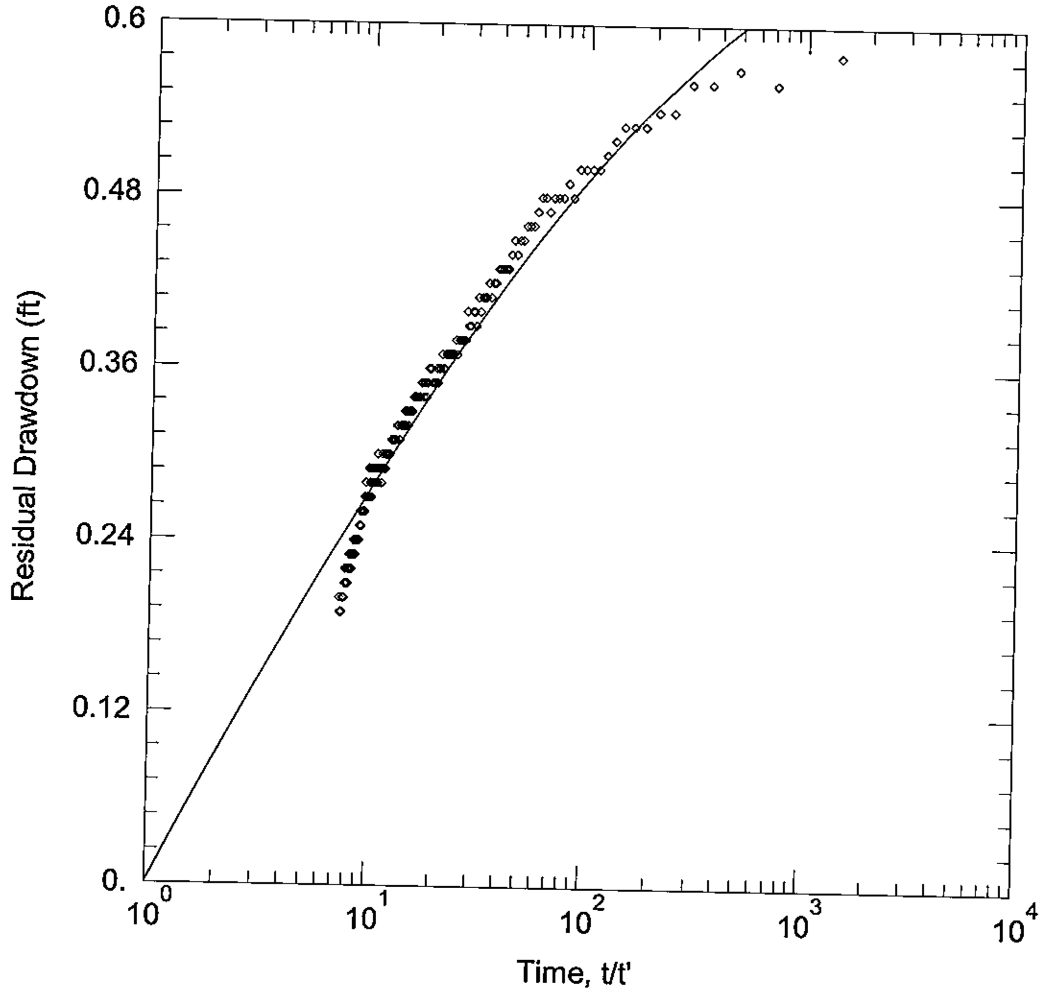
Observation Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| ◇ MW-29A | 0 | 195 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 1421.1 $ft^2$/day
r/B' = 1.0E-5
r/B" = 0
S = 8.641E-6
ß' = 10.
ß" = 0




## WELL TEST ANALYSIS

Data Set: U:\...\Cooper_Drum_MW-39.aqt
Date: 01/18/10 Time: 10:35:55

## PROJECT INFORMATION

Company: URS Corporation
Client: EPA
Location: Cooper Drum
Test Well: EW-03
Test Date: 5 May 2009

## AQUIFER DATA

Saturated Thickness: 100. ft
Aquitard Thickness (b'): 15. ft
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

## WELL DATA

Pumping Wells

| Well Name | X (ft) | Y (ft) |
|---|---|---|
| EW-03 | 0 | 0 |

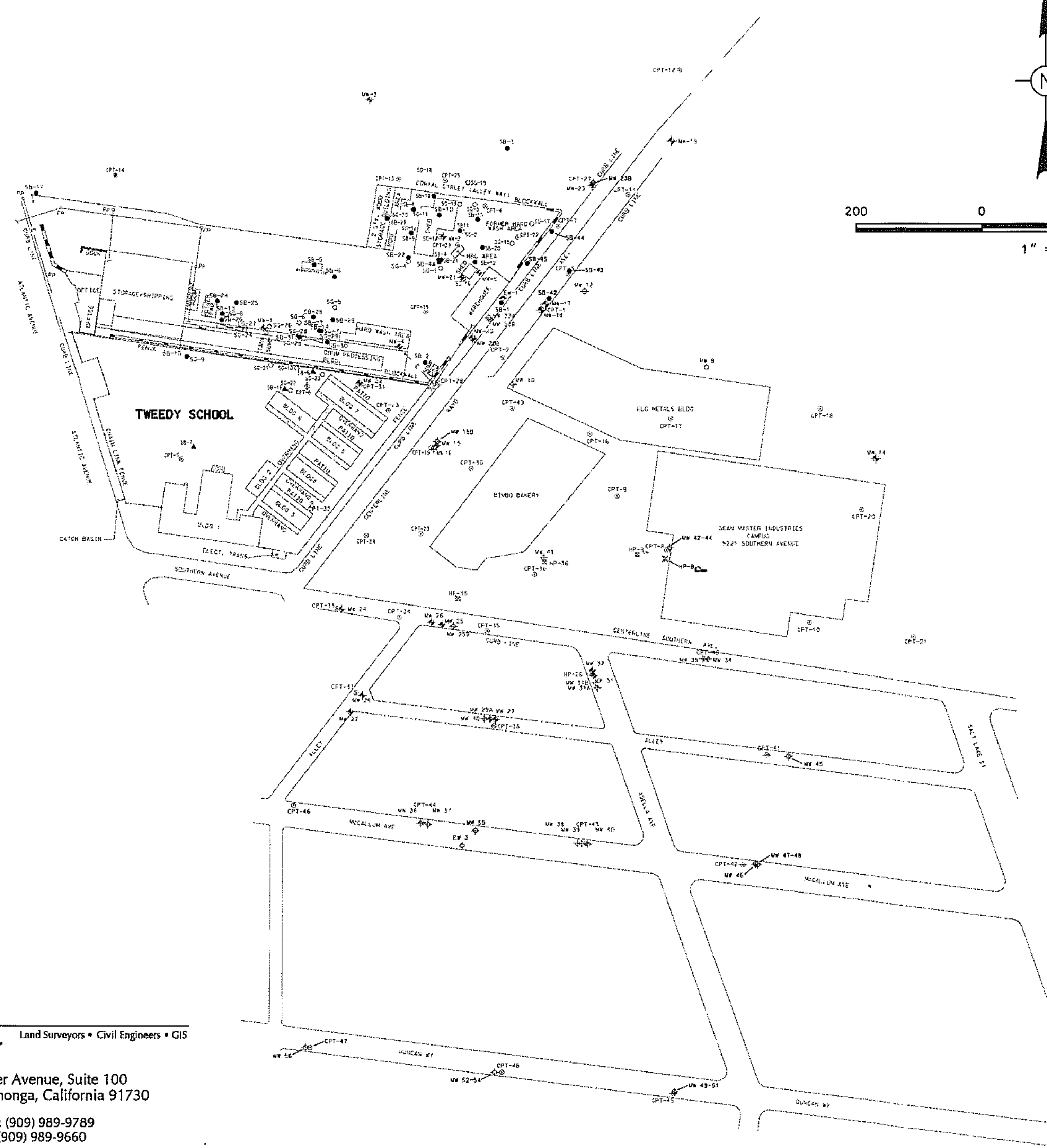
Observation Wells

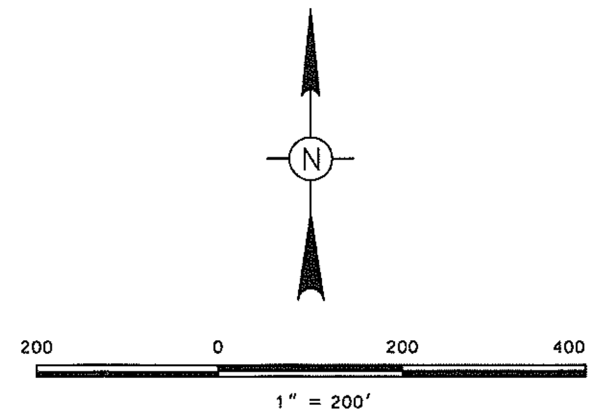
| Well Name | X (ft) | Y (ft) |
|---|---|---|
| ◇ MW-39 | 195 | 75 |

## SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 2462. $ft^2$/day
S = 6.57E-6
r/B' = 1.0E-5
ß' = 3.544
r/B" = 0
ß" = 0




## LEGEND

| | |
|---|---|
| SB-1 | SOIL BORING LOCATION AND DEPTH DISCRETE GROUNDWATER SAMPLING LOCATION (SB-18 through SB-32). |
| EW-1 | ON SITE GROUNDWATER MONITORING WELL LOCATION |
| SG-1 | SOIL-GAS SAMPLE LOCATION (SG-18 through SG-29). |
| HP-1 | HYDROPUNCH TESTING LOCATION |
| CPT-1 | CONE PENETROMETER TESTING LOCATION AND DEPTH DISCRETE GROUNDWATER SAMPLING LOCATION. |
| MW-1 | ON-SITE GROUNDWATER MONITORING WELL LOCATION |
| MW-1 | ON-SITE GROUNDWATER MONITORING WELL LOCATION |

# WELLS SURVEYED 5-28-09

**2009 WELLS SURVEYED**

| POINT NUMBER | NORTHING | EASTING | ELEVATION | DESCRIPTION |
|---|---|---|---|---|
| 3000 | 1802857.93 | 6507642.19 | N/A | hp-8a |
| 3001 | 1802875.91 | 6507649.63 | 102.75 | mw 42-44 rim |
| 3002 | 1802875.45 | 6507649.36 | 102.35 | mw42 casing |
| 3003 | 1802875.51 | 6507649.88 | 102.22 | mw43 casing |
| 3004 | 1802875.20 | 6507649.55 | 102.17 | mw44 casing |
| 3007 | 1802546.18 | 6507835.87 | 100.90 | mw45 rim |
| 3008 | 1802545.77 | 6507835.91 | 100.44 | mw-45 casing |
| 3010 | 1802376.72 | 6507783.90 | 100.08 | mw-46 rim |
| 3011 | 1802376.30 | 6507783.98 | 99.83 | mw-46 casing |
| 3012 | 1802376.56 | 6507787.35 | 100.08 | mw-47-48 rim |
| 3013 | 1802375.88 | 6507787.54 | 99.73 | mw-47 casing |
| 3014 | 1802376.07 | 6507787.18 | 99.67 | mw-48 casing |
| 3015 | 1802405.90 | 6507321.61 | 101.01 | ew-3 rim |
| 3016 | 1802405.49 | 6507321.91 | 100.52 | ew-3 6" casing |
| 3017 | 1802405.17 | 6507321.99 | 100.45 | ew-3 1" casing |
| 3018 | 1802429.73 | 6507342.88 | 100.98 | mw-55 rim |
| 3019 | 1802429.24 | 6507343.00 | 100.57 | mw-55 casing |
| 3020 | 1802468.14 | 6507057.19 | N/A | cpt-46 |
| 3021 | 1802018.93 | 6507657.76 | 98.98 | mw 49-51 rim |
| 3022 | 1802018.73 | 6507657.47 | 98.63 | mw 49 casing |
| 3023 | 1802018.40 | 6507657.87 | 98.63 | mw 50 casing |
| 3024 | 1802018.41 | 6507657.47 | 98.61 | mw 51 casing |
| 3025 | 1802049.38 | 6507385.39 | N/A | cpt-48 |
| 3026 | 1802049.70 | 6507374.04 | 99.36 | mw 52-54 rim |
| 3027 | 1802049.44 | 6507374.11 | 98.75 | mw 52 casing |
| 3028 | 1802049.48 | 6507373.70 | 98.70 | mw 53 casing |
| 3029 | 1802049.12 | 6507373.82 | 98.86 | mw 54 casing |
| 3030 | 1802087.06 | 6507084.14 | N/A | cpt-47 |
| 3031 | 1802088.19 | 6507076.95 | 100.00 | mw-56 rim |
| 3032 | 1802087.85 | 6507076.86 | 99.71 | mw-56 casing |
| 3042 | 1803043.33 | 6507282.32 | 103.03 | mw 15b rim |
| 3043 | 1803042.96 | 6507282.18 | 102.57 | mw 15b casing |
| 3044 | 1803325.01 | 6507424.10 | N/A | sb 45 |
| 3046 | 1803452.29 | 6507528.10 | 104.35 | mw 23b rim |
| | 1803452.29 | 6507528.10 | 104.03 | mw 23b casing |
| 3047 | 1803312.82 | 6507490.38 | N/A | sb 43 |
| 3048 | 1803269.60 | 6507457.98 | N/A | sb 42 |
| 3053 | 1803375.75 | 6507462.24 | N/A | sb 44 |

WestLAND Group, Inc. Land Surveyors • Civil Engineers • GIS

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Rancho Cucamonga, California 91730

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Fax: (909) 989-9660
www.westlandgroup.net

ES-1

COOPER DRUM COMPANY
SOUTH GATE, CALIFORNIA

SOIL AND GROUNDWATER SAMPLE LOCATIONS

2009 Wells Surveyed 5/28/09
By Westland Group

| Point Number | Northing | Easting | Elevation | Description |
|---|---|---|---|---|
| 3000 | 1802857.93 | 6507642.19 | N/A | hp-8a |
| 3001 | 1802875.91 | 6507649.63 | 102.75 | mw 42-44 rim |
| 3002 | 1802875.45 | 6507649.36 | 102.35 | mw42 casing |
| 3003 | 1802875.51 | 6507649.88 | 102.22 | mw43 casing |
| 3004 | 1802875.20 | 6507649.55 | 102.17 | mw44 casing |
| 3007 | 1802546.18 | 6507835.87 | 100.90 | mw45 rim |
| 3008 | 1802545.77 | 6507835.91 | 100.44 | mw-45 casing |
| 3010 | 1802376.72 | 6507783.90 | 100.08 | mw-46rim |
| 3011 | 1802376.30 | 6507783.98 | 99.83 | mw-46 casing |
| 3012 | 1802376.56 | 6507787.35 | 100.08 | mw-47-48 rim |
| 3013 | 1802375.88 | 6507787.54 | 99.73 | mw-47 casing |
| 3014 | 1802376.07 | 6507787.18 | 99.67 | mw-48 casing |
| 3015 | 1802405.90 | 6507321.61 | 101.01 | ew-3 rim |
| 3016 | 1802405.49 | 6507321.91 | 100.52 | ew-3 6" casing |
| 3017 | 1802405.17 | 6507321.99 | 100.45 | ew-3 1" casing |
| 3018 | 1802429.73 | 6507342.88 | 100.98 | mw-55 rim |
| 3019 | 1802429.24 | 6507343.00 | 100.57 | mw-55 casing |
| 3020 | 1802468.14 | 6507057.19 | N/A | cpt-46 |
| 3021 | 1802018.93 | 6507657.76 | 98.98 | mw 49-51 rim |
| 3022 | 1802018.73 | 6507657.47 | 98.63 | mw 49 casing |
| 3023 | 1802018.40 | 6507657.87 | 98.63 | mw 50 casing |
| 3024 | 1802018.41 | 6507657.47 | 98.61 | mw 51 casing |
| 3025 | 1802049.38 | 6507385.39 | N/A | cpt-48 |
| 3026 | 1802049.70 | 6507374.04 | 99.36 | mw 52-54 rim |
| 3027 | 1802049.44 | 6507374.11 | 98.75 | mw 52 casing |
| 3028 | 1802049.48 | 6507373.70 | 98.70 | mw 53 casing |
| 3029 | 1802049.12 | 6507373.82 | 98.86 | mw 54 casing |
| 3030 | 1802087.06 | 6507084.14 | N/A | cpt-47 |
| 3031 | 1802088.19 | 6507076.95 | 100.00 | mw-56 rim |
| 3032 | 1802087.85 | 6507076.86 | 99.71 | mw-56 casing |
| 3042 | 1803043.33 | 6507282.32 | 103.03 | mw 15b rim |
| 3043 | 1803042.96 | 6507282.18 | 102.57 | mw 15b casing |
| 3044 | 1803325.01 | 6507424.10 | N/A | sb 45 |
| 3046 | 1803452.29 | 6507528.10 | 104.35 | mw 23b rim |
|  | 1803452.29 | 6507528.10 | 104.03 | mw 23b casing |
| 3047 | 1803312.82 | 6507490.38 | N/A | sb 43 |
| 3048 | 1803269.60 | 6507457.98 | N/A | sb 42 |
| 3053 | 1803375.75 | 6507462.24 | N/A | sb 44 |

# ATTACHMENT 4

## Aquifer Pumping Test and Development and Results of Groundwater Flow and Fate-and-Transport Model

TECHNICAL MEMORANDUM

**TO:** Don Gruber, Project Manager, ITSI

**FROM:** Eddy Teasdale, PG

**DATE:** December 16, 2009

**SUBECT:** **Development and Results of Groundwater Flow and Fate-and-Transport Model for the Cooper Drum Superfund Site, South Gate, California**

## I. INTRODUCTION

This technical memorandum describes the numerical groundwater model developed for the Cooper Drum Superfund Project (Site) in South Gate, California The model uses particle-tracking simulations to predict capture zones of the proposed extraction system. The model also includes a fate-and-transport component that can be used to predict migration of chemicals of concern (COCs) in groundwater at the Site.

## II. HYDROGEOLOGIC CONCEPTUAL MODEL

The conceptual model serves as a basis for the numerical model. The conceptual model summarized here is based on information in existing Site documents and discussions with the long-time Project Manager. Input to the numerical model included hydraulic conductivity, groundwater recharge, and chemical properties of COCs. Groundwater model boundaries are based on real world conditions. Input parameters may have been modified during model calibration, but the modifications were restricted to reasonable real world ranges.

### Site-Specific Geology

The local geology and hydrogeology is briefly described below. A more complete description of the regional and local geology and hydrogeology can be found in the *Remedial Design Technical Memorandum Field Sampling Results, and Monitoring Well Installation and Groundwater Sampling Results, Addendum Number 4* (Innovative Technical Solutions Inc. [ITSI], 2010), which is based in part on the *Geohydrology, Geochemistry, and Ground-Water Simulation-Optimization of the Central and West Coast Basin, Los Angeles, County California* (United States Geological Survey [USGS], 2003).

The Site is located in the West Coast Basin of the Los Angeles Coastal Plain and extends from Santa Monica Bay east to the Newport-Inglewood uplift, and from the Ballona Escarpment on the north to Palos Verdes and San Pedro Bay to the south. The Site is underlain by approximately 1,500 feet of fresh water-bearing strata consisting of (from youngest to oldest) the Older Dune Sands, the upper Lakewood Formation (including the semi-perched aquifer and the Bellflower aquitard), the lower Lakewood Formation (including the Gage aquifer), the San Pedro Formation (including the Silverado aquifer), and the Upper Pico Formation.

Stratigraphy is generally consistent across the Site. Interbedded silts, clays, and silty sands occur from the ground surface to approximately 60 feet below ground surface (bgs). These sediments are representative of the Bellflower aquiclude, which incorporates the perched aquifer system. The Bellflower aquiclude overlays the Gaspur aquifer, which extends to a depth of approximately 110 feet bgs. The Gaspur aquifer then overlays the Exposition aquifer. Municipal groundwater production occurs from the Exposition aquifer (part of the Lakewood Formation).

## Site-Specific Hydrogeology

Groundwater elevations beneath the Site occur at elevations of approximately 51 to 52 feet about mean seal level (msl). The semi-perched Bellflower aquiclude is underlain by silty sands of the Gaspur aquifer. The Gaspur aquifer has been furthered divided into shallow, intermediate, and lower aquifer for better representation of the volatile organic compounds (VOC) concentration.

On this basis, the groundwater beneath the Site has been separated into five zones: shallow perched, the shallow Gaspur, intermediate Gaspur, lower Gaspur, and Exposition. Groundwater within the semi-perched and Gaspur aquifers primarily flows to the south; but it also has a southwesterly component in the lower Gaspur aquifer, especially near the southern portion of Southern Avenue. A north to south flow direction is generally consistent with historical water levels measured at the Site as referenced in groundwater monitoring reports. Flow variations in this area may be or may have been influenced by several factors that include but are not limited to the natural topography, which would suggest that groundwater flow would be predominantly to the southwest, toward the ocean.

In general, VOCs and 1,4-dioxane (1,4-D) are in the shallow, intermediate, and lower intervals of the Gaspur aquifer.

## Aquifer Parameters

Aquifer parameters initially input in the model were based on results from historical pilot study injection tests and historical and 2009 aquifer tests performed at the Site. Table 1 summarizes the hydraulic conductivities calculated in these aquifer tests, and Appendix A provides details about the 2009 aquifer test. Effective porosity was estimated at 0.3 based on the lithology. Values for total organic carbon (TOC) and bulk density were derived from soil samples collected during the Cooper Drum remedial investigation feasibility study (RI/FS) (URS, 2002). Total organic carbon ranged from 0.2 to 0.03 percent, and bulk density ranged from 91.02 pounds per cubic foot (lbs/ft$^3$) to 101.92 lbs/ft$^3$ (URS, 2002).

**Table 1. Summary of Hydraulic Conductivity, Cooper Drum Site**

| Test Area | Aquifer Test Date | Hydraulic Conductivity (feet/day) |
|---|---|---|
| EW-3 (McCallum Avenue) | May 2009 | 32 to 57 |
| EW-1 (Source Area) | April 1999 | 33 to 54 |
| EW-2 (Source Area) | March 2001 | 26 to 47 |

## Groundwater Elevations, Flow Directions, and Gradients

Information on locations of wells used to collect data for interpretation of groundwater elevation, flow direction, and gradient at the Site and well specifications are included in the *Remedial Design Technical Memorandum for Field Sampling Results, and Monitoring Well Installation and Groundwater Sampling*

*Results, Addendum Number 4* (ITSI, 2010). Hydrographs of shallow zone wells show minor seasonal groundwater level fluctuations and larger multi-year fluctuations that may be related to regional pumping and recharge. Historical shallow zone groundwater elevations (from 1990 to present) range from approximately 51 to 56 feet msl. A comparison of water levels in well pairs indicates vertical gradients are generally less than a few tenths of a foot and may be either upward or downward in a given well pair. This relatively flat gradient is expected in a system with no significant layering and high permeability.

Contoured potentiometric surface maps of historical groundwater levels indicate a generally southward flow direction. The hydraulic gradient across the model area is approximately 0.001 based on May 2009 water level data (URS, 2009).

## Groundwater Recharge

Because the Site is almost entirely covered with asphalt and concrete, limited recharge was assigned to the model. Irrigation and precipitation in small areas of grass and vegetation and other areas not covered by impermeable surfaces within the model domain may provide some recharge to groundwater in this area. Recharge rates were assigned to the model based on precipitation data collected by the Los Angeles Civic Center (LLC) rain gauging station, located in the Los Angeles River Basin of the South Coast Hydrologic Area, near Los Angeles, California. (California Data Exchange Center [CDEC], 2009). Rates of 1 percent (%) of the average daily precipitation (professional judgment based on asphalt coverage) were input to the model as groundwater recharge. There are no unlined rivers or streams near the Site or model domain.

## Groundwater Pumping

No active groundwater pumping occurs on the Site; however, there are municipal supply wells completed within the Exposition aquifer. Several of these municipal wells are close to the Site. Based on recent aquifer test data (Appendix A), there does not appear to be a hydraulic connection between the Gasper and Exposition aquifers in the vicinity of the Site.

## Contaminant Distribution

Trichloroethene (TCE), cis-1,2-dichloroethane (cis-1,2-DCE) and 1,4-D are the primary COCs in groundwater at the Site. Contoured isoconcentrations for these three contaminants using May 2009 data are included in the *Remedial Design Technical Memorandum for Field Sampling Results, and Monitoring Well Installation and Groundwater Sampling Results, Addendum Number 4* (URS, 2009).

# III. GROUNDWATER FLOW AND FATE-AND-TRANSPORT MODEL DEVELOPMENT

The Site numerical model consists of two models: a groundwater flow model and a fate-and-transport model. The two are linked by an interface in the model processor. Depending on the modeling objectives, the groundwater flow model can be operated independently of the transport model; however, when transport simulation is needed, both the flow and the transport models are required.

## Model Software

The groundwater flow and fate-and-transport models were developed using the Brigham Young University Environmental Modeling Research Laboratory (EMRL) Groundwater Modeling System (GMS), Version 6.5 (EMRL, 2008). GMS is a comprehensive graphical user interface (GUI) for performing groundwater simulations. GMS provides a graphical preprocessor/postprocessor interface to several groundwater modeling codes: MODFLOW, MODPATH, MT3DMS, RT3D, FEMWATER, SEEP2D, NUFT, and UTCHEM. The EMRL of Brigham Young University, in partnership with the WES, developed the GMS interface. The GMS was used to develop the Cooper Drum Site conceptual hydrogeological model and to convert it into groundwater flow and transport models. All modeling codes and geological software tools used during this modeling effort are summarized below.

**EarthVision 7 Geological Model.** EarthVision 7 is a three-dimensional (3-D) modeling tool commonly used in oil exploration. It was used for this effort to update the 3-D geological model that has been used to support the groundwater monitoring program at the Site. Use of this sophisticated 3-D modeling tool was the most accurate, efficient, and convenient method for developing the structure of the groundwater model for this Site.

**MODFLOW Groundwater Flow Model.** The computer code selected to model groundwater flow beneath the Site was MODFLOW, a 3-D, cell-centered, finite difference, saturated flow model developed by the USGS (McDonald and Harbaugh, 1988). GMS provides an interface to the updated version, MODFLOW 2000 (Hill et al., 2000). Based on the information available, the uncertainties in site-specific information, the hydrogeologic complexity at the Site, and the modeling objectives, MODFLOW was considered an appropriate groundwater flow code.

**MODPATH Particle-Tracking Model.** Particle-tracking simulations provide a convenient means of visualizing groundwater flow paths. This is particularly useful in evaluating capture zones around a pumping well. MODPATH was selected as the particle-tracking program for this effort. MODPATH is a 3-D particle-tracking program that enables reverse and forward tracking from sinks (wells) and sources, respectively. MODPATH was developed by the USGS (Pollock, 1994). GMS has updated the interface for MODPATH to a seamless module that couples with MODFLOW 2000. MODFLOW flow modeling results (direction and rates of groundwater movement) are among the inputs for MODPATH runs.

**MT3DMS Groundwater Transport Model.** Contaminant transport simulations were conducted using the MT3DMS groundwater contaminant transport model code (Zheng and Wang, 1999). MT3DMS is an improved version of the MT3D model developed in 1990 (Zheng, 1990). It has improved numerical solvers that make the model more stable and help prevent model-induced numerical oscillations. GMS provides a module that links MODFLOW groundwater flow information to MT3DMS. MT3DMS uses this modeling output to simulate contaminant transport using the MODFLOW simulated groundwater flow field.

**Parameter Estimation System (PEST).** PEST is a model-independent parameter optimizer (Doherty, 2002). It was selected to shorten the time and improve the groundwater model calibration process. The typical calibration process for groundwater flow or transport models is iterative. The model with a specific set of parameter inputs is started; then the model results are compared to calibration targets (e.g., groundwater elevations at specific locations). After the comparison, the model is revised, and the process is repeated until the model output adequately simulates the calibration data set. GMS provides a module that links PEST with MODFLOW and MT3DMS to facilitate calibration.

## Model Construction

The flow model simulates the perched sediments, the Bellflower aquitard, the shallow, intermediate, and lower Gaspur aquifer, and the regional Exposition aquifer. The model domain was defined to incorporate an area much larger than the Site to mitigate irregularities that occur along the model edges. The model grid consists of 196 rows and 122 columns, creating model cells ranging from 10 by 10 feet to 100 by 100 feet in area (Figure 1). The model was divided into six layers: two layers represent the shallow perched zone and the Bellflower aquiclude; three layers represent the shallow, intermediate, and lower Gaspur aquifer; and the bottom layer represents the Exposition aquifer. There is no lithologic basis for these divisions, but more layers allow greater discretization of well screen intervals, greater particle tracking resolution, and better representation of VOC concentration. The top of Layer 1 is ground surface. The tops of Layers 2, 3, 4, 5, and 6 were specified as 60, 40, 25, 0, and -20 feet msl, respectively. The bottom of Layer 5 is -20 feet msl, which corresponds to the top of the Exposition aquifer. The saturated aquifer thickness is approximately 150 feet for the entire model domain and approximately 60 feet for the Gaspur aquifer.

The spatial distributions of hydraulic conductivity values for the flow model were based on several factors, including Site geology, aquifer test results, literature review, and other groundwater models in the area. The hydraulic conductivity values were categorized into zones (polygons) in the conceptual model based on interpretation of the geologic data into a solid geology model. These hydraulic conductivity values were then mapped into the numerical groundwater model and adjusted later in the flow model calibration.

A 3-D geological model was produced to support visualization of the groundwater system at the Cooper Drum Site. This 3-D geological model was developed from lithologic data within the screen intervals of Site groundwater wells. Computer modeling of the geology was performed with a 3-D modeling software tool, EarthVision 7, following an interpretation of the lithologic information by a geologist. EarthVision 7 was used to develop 3-D correlations between the boreholes. The development was accomplished by interpolating numerically coded lithology onto a 3-D grid. The 3-D grid was then filled to produce a solid geologic model and fence diagrams. This method allows for rigorous analysis of the data and the geologic system through any location within the volume. In addition, EarthVision 7 contains a database of lithologic information, cone penetrometer testing data, and water levels with depth. This method saves time because fence diagrams and 3-D models can be viewed on a monitor from several oblique angles prior to printing.

The geologic model was directly imported into GMS. The geology was discretized into two separate, independent geological grids; a course grid with dimensions of 10 feet vertically by 500 feet laterally, and a refined grid with dimensions of 10 feet vertically by 50 feet laterally. The grids were interpolated to the MODFLOW 2000 grid. The refined grid was used to enhance the geology in the general area of the Site. The 10-foot-thick lithologic data were averaged over the total thickness for each MODFLOW 2000 layer. These layer-specific lithologic interpolations were verified by comparing boring logs and cross-sections of the area.

After the lithologic data were interpolated, individual hydraulic conductivity zones were digitized based on the interpolated lithology for each layer. The conductivity zones are refined within and around the Site because of the large amount of lithologic information available from the refined geologic grid. The hydraulic conductivity zones are larger and less variable farther from the Site, because the lithologic data density decreases.

Initial conductivity values were modified and refined during iterative PEST simulations to achieve a higher degree of calibration with measured water levels. Hydraulic conductivity values in PEST simulations were allowed to vary within a range of 10 to 200 feet per day. Hydraulic conductivity distributions estimated by PEST were then modified based on historical Site information, current contaminant plume distributions, and MODPATH particle-tracking simulations. Hydraulic conductivity values range from 0.1 to 200 feet per day; hydraulic conductivity distributions for the shallow, intermediate, and lower Gaspur aquifer (Layers 3, 4, and 5) are shown on Figure 2. Vertical anisotropy ratios (Kh/Kv) ranged from 0.1 to 10 in the Gaspur aquifer. Porosity in all layers was specified as 0.30.

Groundwater flow is essentially north to south; therefore, the boundaries were specified as general head boundaries (GHBs). GHBs were determined by extrapolating the contoured potentiometric surface across the model domain and incorporating these head values into the model boundaries. GHBs were assigned high conductance values (1,000 square feet per day [$ft^2$/day]) and essentially behave as specified heads. Assigned northern GHB heads range from approximately 48 to 56 feet msl; and assigned southern GHB heads range from approximately 46 to 50 feet msl. Initial flow model steady state simulations were based on May 2009 groundwater level data.

## Flow Calibration

The flow model was calibrated to steady-state conditions and compared to the measured groundwater elevation data from May 2009. Once head errors at calibration target locations (existing monitoring wells) met predetermined criteria, the steady-state model was considered adequately calibrated.

An additional calibration technique using particle tracking was used. Simulated groundwater velocities were compared to measured velocities over time. Calibrated average model errors across the Site are listed in Table 2.

**Table 2. Groundwater Flow Calibration Results, Cooper Drum Site**

| Error Type | Error | Calibration Criterion |
|---|---|---|
| Mean Error | 0.26 feet | Not applicable |
| Mean Absolute Error | 0.36 feet | Not applicable |
| Root Mean Squared Error | 0.42 feet | ± 1 foot |
| Model Error | 6.5% | 10% |

This high degree of model calibration was probably due to the relative homogeneity and simplicity of the hydrogeologic system as well as the regularity of the potentiometric surface in this area. Simulated observed head data for the model is summarized on Figure 3.

## Transport Model Setup

Based on the Site history and the historical analytical groundwater data, the contaminants modeled were TCE, cis-1,2-DCE, and 14D. These three contaminants were selected because of their relatively large plumes.

The simulated contaminant transport processes include advection, dispersion, and adsorption (retardation). Given the lack of geochemical data available during model construction, residual source mass, biodegradation, or other chemical transformations were not simulated. Future model updates could incorporate revised parameters as additional data are collected. The modeled processes are discussed hereafter.

## Initial Transport Model Parameters

The transport model simulates the processes of advection, dispersion, and adsorption (retardation) based on the simulated groundwater flow conditions, the initial TCE, cis-1,2-DCE, and 14D concentration distributions, and the transport properties. The following subsections discuss specific parameters used in the transport model development.

### Dispersion

Dispersion refers to the process whereby a dissolved contaminant will be spatially distributed longitudinally (along the direction of groundwater flow), transversely (perpendicular to groundwater flow), and vertically (downward or upward or both) because of mechanical mixing and chemical diffusion in the aquifer. These processes contribute to the development of the plume shapes and dimensions (the spatial concentration distributions of the dissolved contaminant mass in the aquifer). Selection of values for dispersivity (the parameter used here to represent dispersion) is a difficult process given the impracticability of measuring dispersion in the field; however, simple estimation techniques based on the length of the contaminant plumes are available.

A large number of field data compiled by Gelhar, Welty, and Rehfeldt (1992), presented in *A Critical Review of Data on Field-Scale Dispersion in Aquifers*, suggest that longitudinal dispersivity is a function of the travel distance and the aquifer type. For porous media and plume length scales on the order of a few hundred feet to a few thousand feet, the longitudinal dispersivity varies between 1% and 10% of the travel distance. Transverse and vertical dispersivity are often set to be 10% and 5% of the longitudinal dispersivity, respectively (Aziz et al., 2000; Domenico and Schwartz, 1997; ASTM, 1995). For this transport model, the longitudinal dispersivity was set to be 30 feet. After verification, the transverse and vertical dispersivity were set to be 10 percent and 0.1 percent of the longitudinal dispersivity, or 3.0 and 0.03 feet, respectively. The effective molecular diffusion coefficient was set to be 0.0008 $ft^2$/day, based on the literature values of molecular diffusion in water.

### Retardation

Several geochemical reactions influencing the transport of contaminants result in the retardation of contaminant migration (dissolved contaminants moving slower than groundwater). The dominating reaction is adsorption of contaminants to the surface of soil particles. Adsorption can reduce the migration of dissolved contaminants moving through the groundwater by holding contaminant mass on the surface of soil particles. The retardation factor is the ratio of the groundwater seepage velocity to the rate that organic chemicals migrate in the groundwater. The degree of retardation depends on aquifer and constituent properties.

The retardation factor ($R_e$) is often estimated from soil properties and chemical data using the following variables: bulk density ($\rho_b$), effective porosity ($n$), organic carbon-water partition coefficient ($K_{oc}$), and fraction of organic carbon in uncontaminated soil ($f_{oc}$). The following expression was used to determine the retardation factor (Wiedemeier et al., 1999):

$$\text{Re} = 1 + \frac{K_d \rho_b}{n}$$

where:

$K_d$ = is distribution coefficient and $K_d = f_{oc} \times K_{oc}$

Organic carbon-water partition coefficients were set to literature values of 126 liters per kilogram (L/kg) for TCE, 49 L/kg for cis-1,2-DCE, and 17 L/kg for 14D (PNL, 1989).

The $\rho_b$, $n$, and $f_{oc}$ values in uncontaminated soil were determined based on Site-specific analytical data. Based on these values, the retardation factors were calculated by the MT3DMS model code using the retardation factor equation shown above.

### Degradation

The model was developed based on the assumption that TCE, cis-1,2-DCE, and 14D are not undergoing significant biodegradation or chemical transformation. This assumption is conservative because it leads to higher estimated contaminant concentrations than the assumption that biodegradation or chemical transformations act to reduce contaminant mass.

## Transport Verification

A fate-and-transport model is rarely calibrated using specific information about contaminant releases (e.g., masses of original releases, times of releases, etc.) because the factors are usually not known with adequate certainty. This information for the Site is not known. Consequently, transport model verification was conducted by simulating historical conditions and changes over time and comparing the simulated results to measured concentration data. Historical concentration data are included in the *Remedial Design Technical Memorandum for Field Sampling Results, and Monitoring Well Installation and Groundwater Sampling Results, Addendum Number 4* (URS, 2009). Transport model verifications were performed with TCE as the simulated contaminants. Although two treatability studies were completed in June 2006 that resulted in the reduction of TCE mass, this model validation approach was still considered an adequate method to use for verification.

Similar to flow calibration criteria, transport verification criteria, or the acceptable differences between model-predicted (computed) and observed concentrations (May 2009), were selected based on an empirical understanding of the potential errors in observed Site groundwater concentrations.

The simulation times for the verification runs were determined based on the availability of and the uncertainty associated with the historical groundwater concentration data. For the transport verification run, concentration data from 2004 were used as the initial concentration conditions. The verification simulation extended from 2004 through 2009. The transport for five years was simulated, and the simulated concentration plume shapes at the end of simulation period (2009) were compared to the sampled concentration data for 2009.

The observed concentrations in 2009 and the simulated concentration distributions in 2009 are provided on Figure 4. The simulated concentration distributions at the end of the simulation (2009) were compared with the concentrations observed in May 2009. The qualitative comparison indicates that, in general, the simulated concentration distributions matched the interpolated concentration distributions of sampled concentration data from 2009, verifying that contaminant transport could be simulated adequately.

## IV. CAPTURE ZONE ANALYSIS AND PARTICLE TRACKING

After the steady-state flow model calibration was successfully completed, particle tracking was performed. Particles generated using MODPATH may be calculated to travel either forward (downgradient) through the model simulation or backward (upgradient from a specific point, such as an extraction well). Forward traveling particles provide information about the predicted route of groundwater over the model run. The particle starting locations are selected to predict groundwater migration from specific locations through time. Forward traveling particles that are captured in an extraction well might not, however, predict the full capture zone for that well. They only predict the travel route from the starting location of the particle. Backward traveling particles predict where groundwater has traveled to reach a specific location. Particles traveling backward from an extraction well would predict the extent of that well's capture zone. Use of forward and backward traveling particles, therefore, depends on the particular questions being asked in the modeling effort. Particles on the figures are shown as black squares initially (year 0) and then as arrows (year 0 + n years); lines and arrows indicate particle flow paths, and the distance between arrows represents a period of five years.

For this model, particles were set to begin upgradient of the Site and were expected to travel through the area of groundwater impacted by the Site COCs (TCE, cis-1,2-DCE, and 1,4-D).

Predictive Scenarios were conducted to evaluate groundwater capture within the Cooper Drum Site model. Figure 5 illustrates the predicted flow regime or initial conditions without the influence of extraction and/or injection wells (current condition). Figures 6 through 8 show the results of predictive scenarios for the model using recently installed Extraction Well Number 3 (EW-3) pumping at 15, 20, and 30 gallons per minute (gpm). The purpose of the pumping scenarios was to see how different pumping rates would influence the particle flow paths. Starting locations for the forward traveling particles were set along the perimeters of the target area. Backward traveling particles are not used for this analysis because the forward traveling particles (and their starting locations) are most relevant for evaluating target area capture. Particles on the figures are shown as black squares initially (year 0) and then as arrows (year 0 + n years); lines and arrows indicate particle flow paths, and the distance between arrows represents a period of five years.

Figure 6 illustrates that predictive capture would occur within the Site using one extraction well with a pumping rate of 15 gpm. Predicted travel times for particles beginning at the north end of the target zone to the extraction well ranges from approximately 15 to 20 years. All of the particle flow paths to the southwest, southeast, and northeast, beginning outside of the target zone, remain outside of the area of predicted capture.

Figure 7 illustrates that predictive capture would occur within the Site using one extraction well with a pumping rate of 20 gpm. Predicted travel times for particles beginning at the north end of the target zone to the extraction well are approximately 15 years. Some of the particle flow paths to the southwest and northeast, beginning outside of the target zone, remain outside of the area of predicted capture.

Figure 8 illustrates that predictive capture would occur within the Site using one extraction well with a pumping rate of 30 gpm. Predicted travel times for particles beginning at the north end of the target zone to the extraction well are approximately 15 years. Particle flow paths to the northeast, beginning outside of the target zone, remain outside of the area of predicted capture; however, particle flow paths to the southwest and southeast are predicted to be captured. This capture zone encompasses an area larger than the Site and could influence off-site plume migration, specifically in the southeast area.

## V. FATE-AND-TRANSPORT SIMULATIONS

The model predictions were carried out based on the calibrated 3-D transport model. Eleven fate-and-transport scenarios were chosen to be simulated. A brief description of each of those scenarios is presented in Table 3.

The total model simulation time was 50 years from 2009. All estimated times to cleanup summarized in Table 3 at 50 years should be considered the minimum time to reach cleanup standards. The model was used to predict the times required for the COC plumes to reach the applicable cleanup standards of 5 μg/L for TCE, 6 μg/L for cis-1,2-DCE, and 6.1 μg/L for 14D.

**Table 3. Fate-and-Transport Model Simulations, Cooper Drum Site**

| Scenario | Description | Purpose |
|---|---|---|
| 1 | EW-3 pumping at 30 gpm | Assess time to cleanup source area using one well. |
| 2 | EW-3 (30 gpm), SEW-1 (25 gpm) | Assess time to cleanup source area using two wells. |
| 3 | EW-3 (30 gpm), SEW-1 (15 gpm) | Assess impact of reducing SEW-1 from 25 to 15 gpm. |
| 4 | EW-3 (30 gpm), EW-2 (8 gpm) and EW-4 (4 gpm). EW-2 and EW-4 screened across Shallow and Intermediate Gaspur Aquifer only. | Assess impact in source area by adding two additional wells. |
| 5 | EW-3 (30 gpm), SEW-1 (10 gpm), EW-2 (8 gpm), and EW-4 (4 gpm) | Assess impact on cleanup time by adding four wells to pumping array. |
| 6 | Same as Scenario 4, but all wells screened across entire Gaspur Aquifer. | Assess impact to cleanup time by increasing screen length. |
| 7 | Same as Scenario 5, but all wells screened across entire Gaspur Aquifer. | Assess impact to cleanup time by increasing screen length. |

**Table 3. (Continued)**

| Scenario | Description | Purpose |
|---|---|---|
| 8 | Same as Scenario 2, but added two injection (IW-1 and IW-2) wells (12.5 gpm per well) in source area. | Assess impact to cleanup time by adding two additional injection wells. |
| 9 | Same as Scenario 2, but reduced mass within treatment zone to 50 µg/L. | Assess impact of implementing ISCO mass removal (removing mass to 50 µg/L). |
| 10 | Same as Scenario 9, but reduced mass within treatment zone to applicable MCL. | Assess impact of implementing ISCO mass removal (removing mass to applicable MCL). |
| 11 | Added 350-foot bio-barrier across entire Gaspur Aquifer (down to Lower Gaspur) along Southern Avenue. Source reduced to 50 µg/L and EW3 pumping at 30 gpm. | Assess impact to cleanup times for entire plume by implementing a bio-barrier. |

gpm = gallons per minute
ISCO = in situ chemical oxidation
MCL = maximum contaminant limit
µg/L = micrograms per liter

For these simulations, it was assumed that there was no further contaminant input into the groundwater flow system as of 2009, i.e., all modeled source boundary conditions were turned off in the model. While this is unlikely based on field observations, no information is available to improve this assumption. However, it is noted that concentrations at the suspected source areas around certain wells have been dropping, suggesting that contaminant input is gradually decreasing.

Figure 9 shows the model predictions for the time required to reach the cleanup standard for each chemical within the shallow, intermediate and lower Gaspur aquifer. It is important to note that for these predictions, it was assumed that all sources are inactive and each estimated time to cleanup should be considered as a best-case scenario and non-conservative. Table 4 summarizes the results of each of the fate and transport model scenarios. Figure 10 shows the location of downgradient extraction well (EW-3), source area extraction wells (EW-2, EW-4 and SEW-1), source area injection wells (IW-1 and IW-2) and the proposed bio-barrier (Scenario 11).

**Table 4. Results of Fate-and-Transport Model Simulations, Cooper Drum Site**

| Scenario | Cleanup Times in Year<br>TCE -Shallow/Intermediate/Lower Gaspur Aquifer<br>cis-1,2-DCE - Shallow/Intermediate/Lower Gaspur Aquifer<br>14D- Shallow/Intermediate/Lower Gaspur Aquifer |
|---|---|
| 1 | TCE - 43/50/50<br>cis-1,2-DCE - 45/50/50<br>14D - 14/50/43 |
| 2 | TCE - 12/50/47<br>cis-1,2-DCE - 23/50/47<br>14D - 5/36/18 |

**Table 4. (Continued)**

| Scenario | Cleanup Times in Year<br>TCE -Shallow/Intermediate/Lower Gaspur Aquifer<br>cis-1,2-DCE - Shallow/Intermediate/Lower Gaspur Aquifer<br>14D- Shallow/Intermediate/Lower Gaspur Aquifer |
|---|---|
| 3 | TCE - 25/50/50<br>cis-1,2-DCE - 23/50/50<br>1,4-D - 7/47/24 |
| 4 | TCE - 10/44/47<br>cis-1,2-DCE - 15/50/39<br>1,4-D - 5/37/18 |
| 5 | TCE - 8/36/43<br>cis-1,2-DCE - 10/43/34<br>1,4-D - 4/22/17 |
| 6 | TCE - 12/44/49<br>cis-1,2-DCE - 12/50/39<br>1,4-D - 11/27/21 |
| 7 | TCE - 9/36/43<br>cis-1,2-DCE - 10/43/34<br>1,4-D - 4/22/17 |
| 8 | TCE - 5/25/40<br>cis-1,2-DCE - 9/28/30<br>1,4-D - 3/13/15 |
| 9 | TCE - 10/50/48<br>cis-1,2-DCE - 6/43/30<br>1,4-D - 5/32/23 |
| 10 | TCE - 6/27/25<br>cis-1,2-DCE - 5/32/23<br>1,4-D - 4/21/10 |
| 11 | TCE - 36/35/36<br>cis-1,2-DCE - 24/27/25<br>1,4-D - 15/17/12 |

cis-1,2-DCE = cis-1,2-dichloroethene
TCE = trichloroethene
1,4-D = 1,4-dioxane

## VI. SUMMARY

The six-layer transient groundwater flow and transport models, developed using available Site-specific data, were calibrated to mimic 2009 groundwater elevations to within 10 percent.

Particle tracking, based on the flow model, was used to help predict the migration path of groundwater particles associated with contaminant plumes at the Site. Based on particle tracking capture zone analysis, EW-3 could be operated at less than 30 gpm and still provide adequate plume capture.

Eleven fate-and-transport scenarios were simulated to evaluate the impacts different remediation technologies would have on overall cleanup times. All transport model simulations assume no source mass is present at the site and that decay is not occurring at the site. The conclusions are as follows:

- Addition of source area extraction (SEW-1, EW-2 or EW-4) reduces cleanup times (Scenarios 2 through 10).
- Scenario 8 (two injection wells (IW-1 and IW-2) added near source area) appears to have a beneficial use in reducing cleanup times to 40 years.
- Scenario 10 reduced cleanup time to 25 years, but this assumed that all mass in the source area is reduced to the applicable maximum contaminant limit (MCL) by in situ chemical oxidation (ISCO), prior to groundwater extraction.
- Scenario 11 (bio-barrier) may reduce cleanup time by approximately 3-6 years.

## VII. MODEL USE, LIMITATIONS, AND UNCERTAINTY

Data for edge boundary conditions interpolated over distance are sparse, leading to unquantifiable errors along the edges of the model. This error could be mitigated with additional groundwater elevation data farther from the site. With those data, the model domain could be enlarged so that residual errors around the edges of the model would have even less relevance to the areas of interest.

Particle-tracking calibration cannot account for retardation of chlorinated solvents, so the simulated groundwater velocities may be greater than actual plume migration velocities.

This groundwater flow model is a useful predictive tool that incorporates nearly all available data within the model domain. Numerical models can be powerful tools, if used appropriately, to assist in making management decisions for the former Cooper Drum groundwater cleanup program. This model can be used to help quantify the effectiveness of current cleanup efforts at the Site. Use of this model is subject to limitations; like any computer model, it has inherent uncertainty.

Groundwater models are simplifications of the natural environment and, therefore, have recognized limitations. Hence, some uncertainty exists in the ability of this model to predict groundwater flow. Effort was expended to minimize model uncertainty by using real world values as model input whenever available. Uncertainty of the model output reflects uncertainties in the conceptual model, the input parameters, and the ability of the mathematical model to simulate real world conditions adequately.

## VIII. DISCLAIMER

The limited objective of this effort, the ongoing nature of the project, and the evolving knowledge of Site conditions and chemical effects on the environment and human health all must be considered when evaluating this memorandum because facts may become known that may make this document premature or inaccurate.

This memorandum was prepared by URS under the review of registered professionals. The conclusions and recommendations in this memorandum are based on URS' evaluation of the data. The interpretation of the data and the conclusions drawn were governed by URS' experience and professional judgment.

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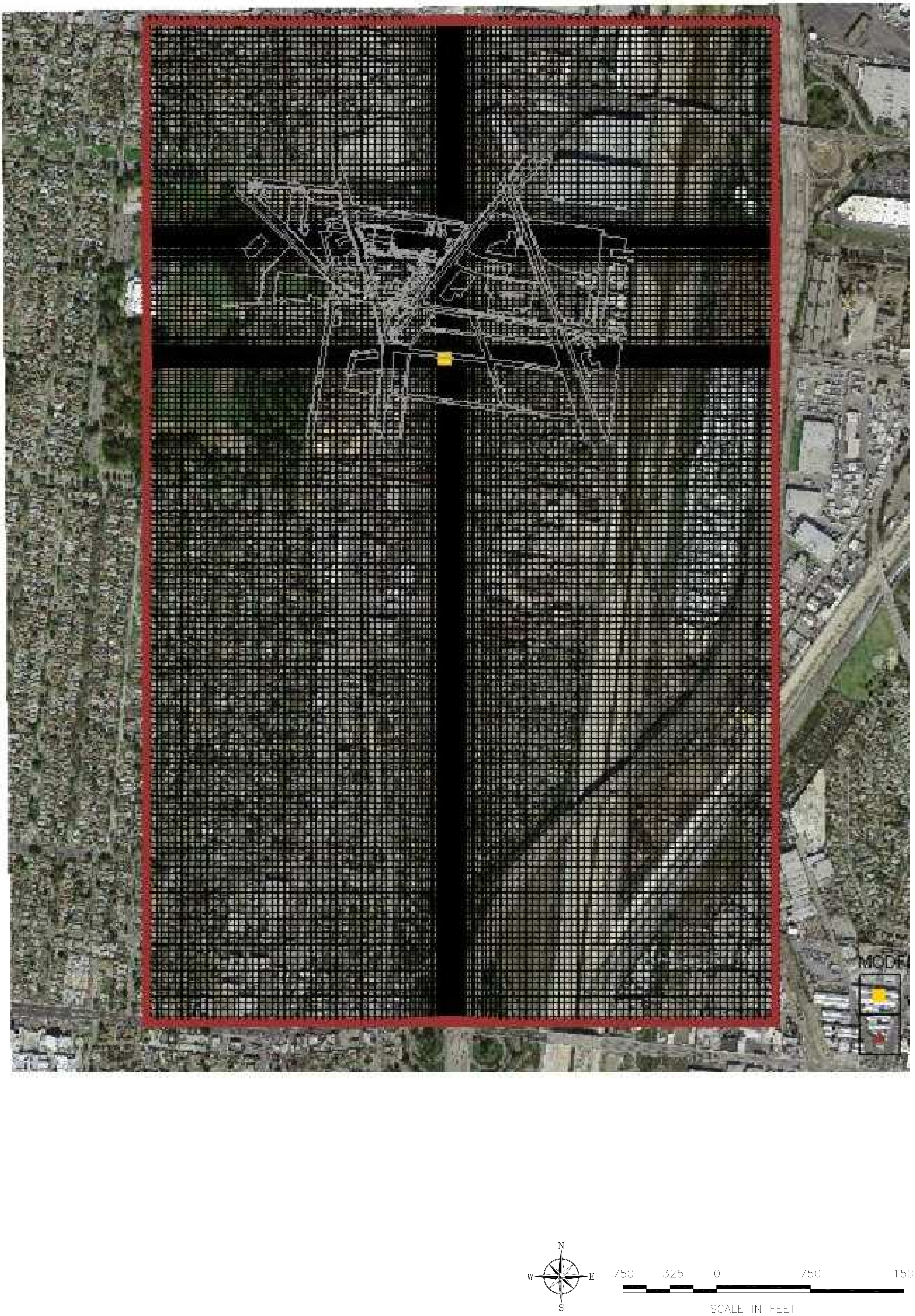
## Attachments

Figure 1 – Cooper Drum Site and MODFLOW Grid
Figure 2 - Hydraulic Conductivity Distribution, Layers 3, 4, and 5
Figure 3 – Simulated Versus Observed Heads (All Layers)
Figure 4 – Fate-and-Transport Verification (Simulated Versus Observed)
Figure 5 – Particle Tracking (No Pumping)
Figure 6 – Particle Tracking (15 gpm)
Figure 7 – Particle Tracking (20 gpm)
Figure 8 – Particle Tracking (30 gpm)
Figure 9 – Fate-and-Transport Cleanup Scenarios
Figure 10 –Location of Extraction Wells and Proposed Bio-Barrier

Appendix A – Results of May 2009 Aquifer Test

FIGURES

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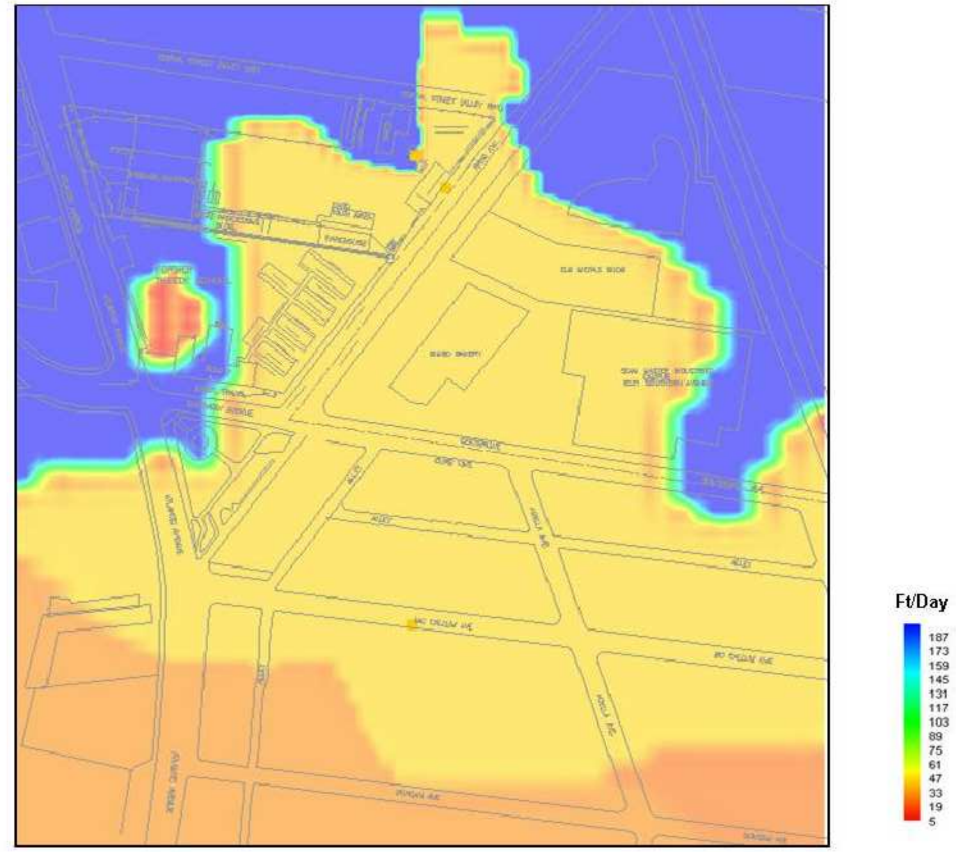
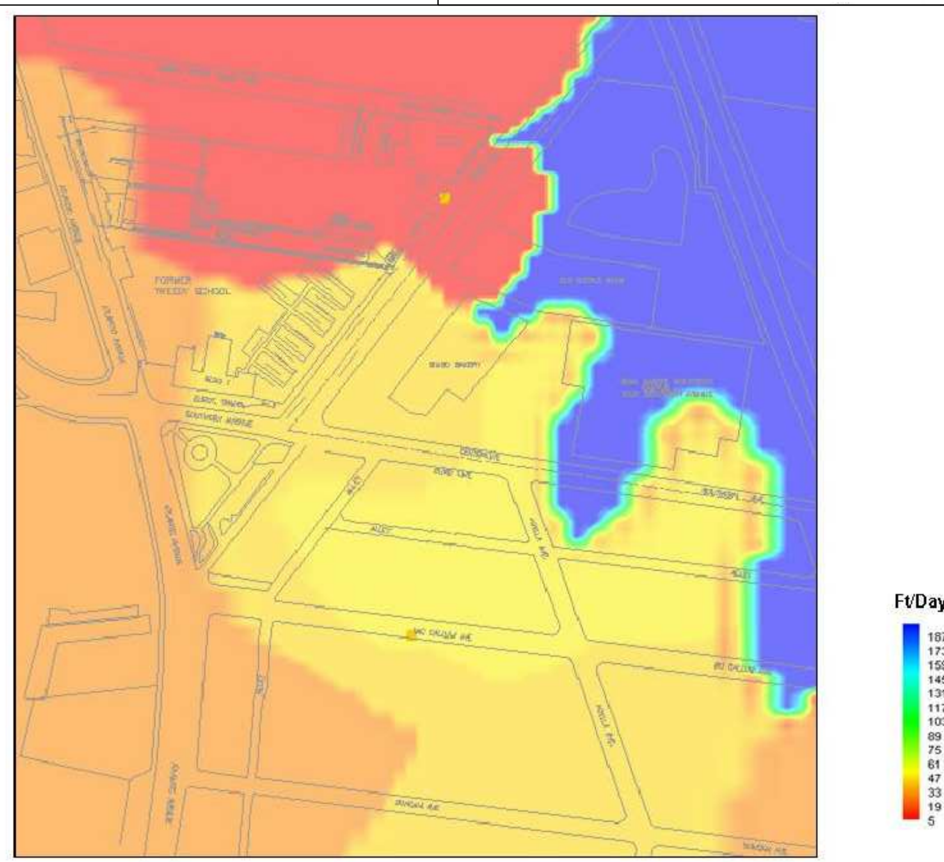
TEL: (916) 679-2000
FAX: (916) 679-2900

Cooper Drum Superfund Site
South Gate, CA

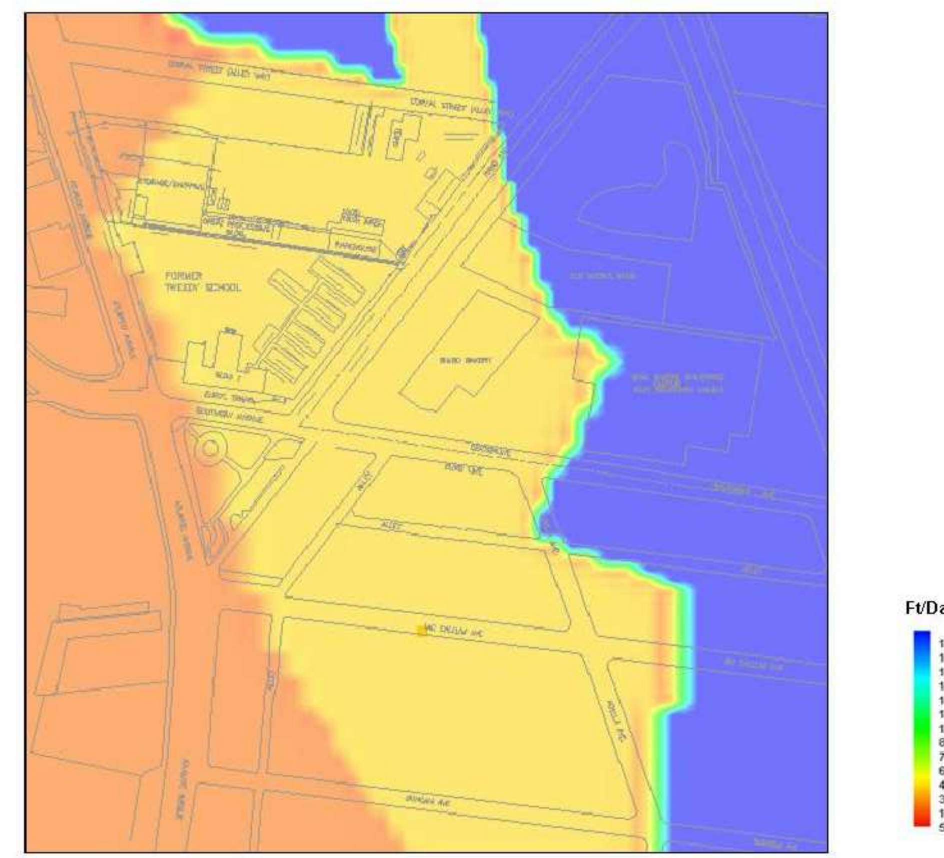
Figure 1
COOPER DRUM PROJECT SITE AND MODFLOW GRID




**Cooper Drum Hydraulic Conductivity (Shallow Gaspur)**




**Cooper Drum Hydraulic Conductivity (Intermediate Gaspur)**




**Cooper Drum Hydraulic Conductivity (Lower Gaspur)**

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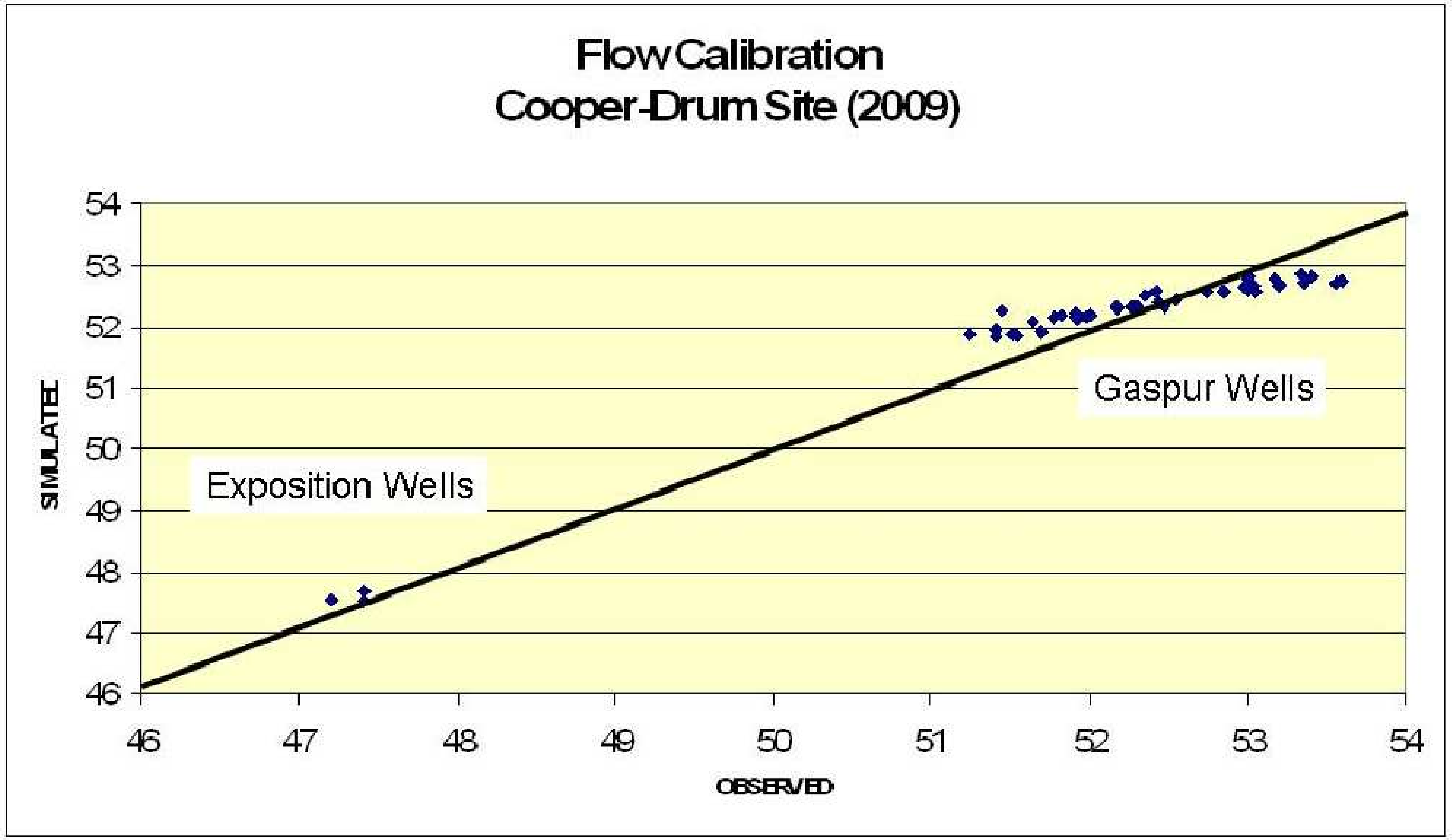
Cooper Drum Company
South Gate, California

FIGURE 2
HYDRAULIC CONDUCTIVITY DISTRIBUTION
SHALLOW, INTERMEDIATE, LOWER GASPUR




URS
2870 Gateway Oaks Dr., Ste. 150
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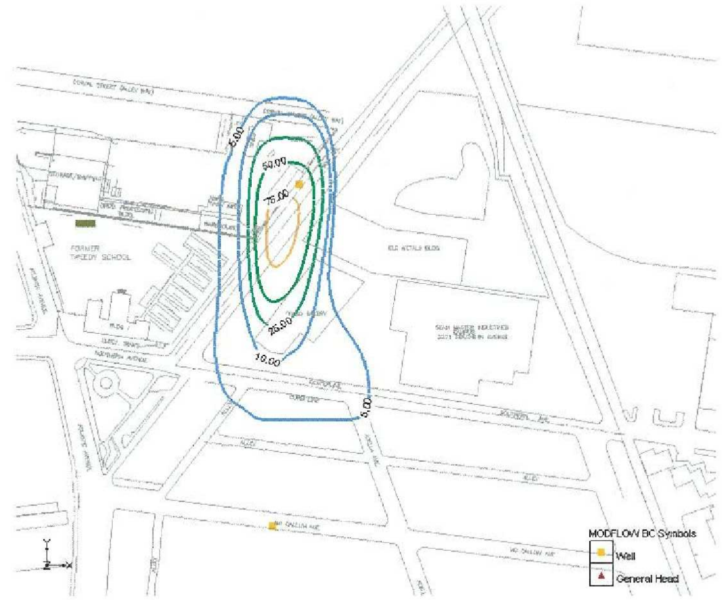
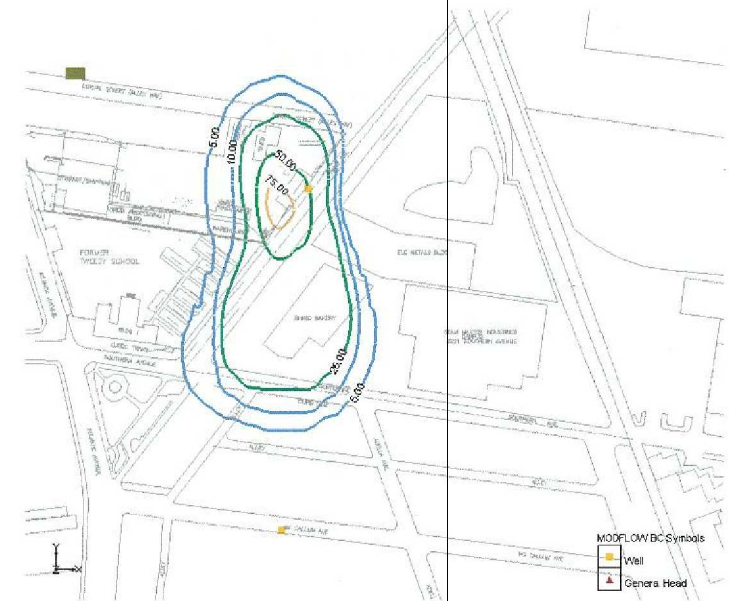
TEL: (916) 679-2000
FAX: (916) 679-2900

Cooper Drum Company
South Gate, California

FIGURE 3
FLOW CALIBRATION ALL LAYERS

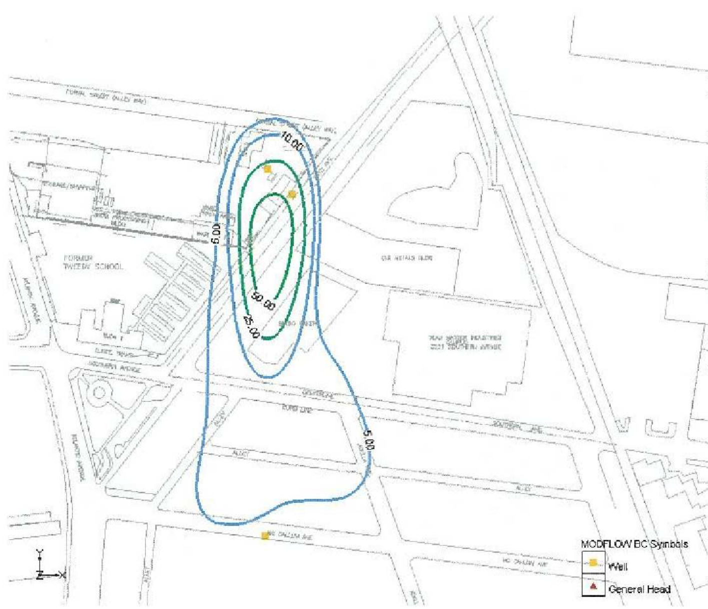


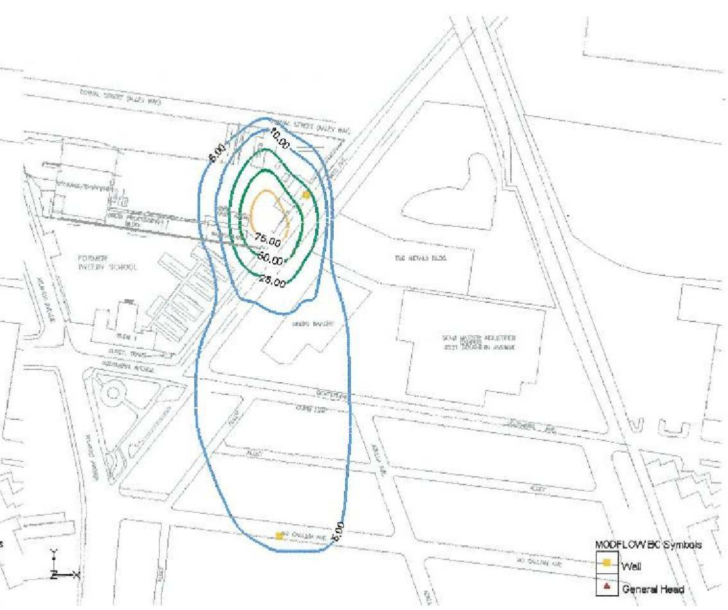


TCE 2004-2009 Simulated

TCE 2009 Observed

(CONTOURED INTERVAL 5, 10, 25, AND 75 ug/L)

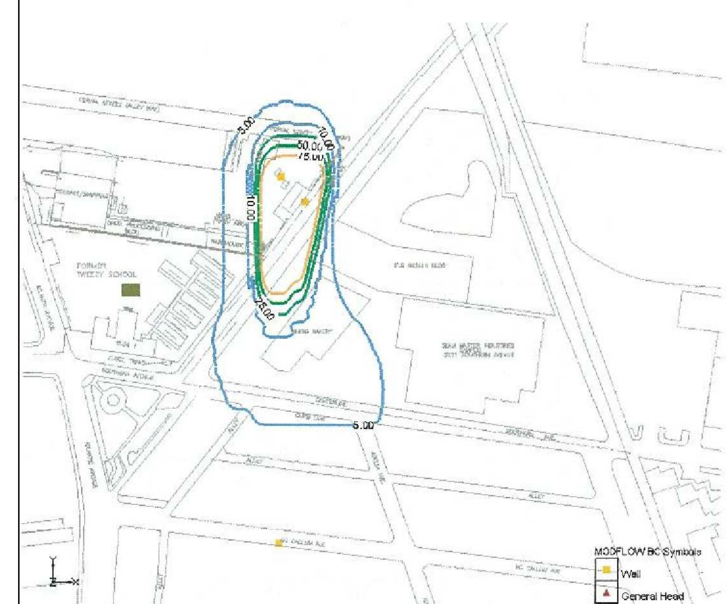


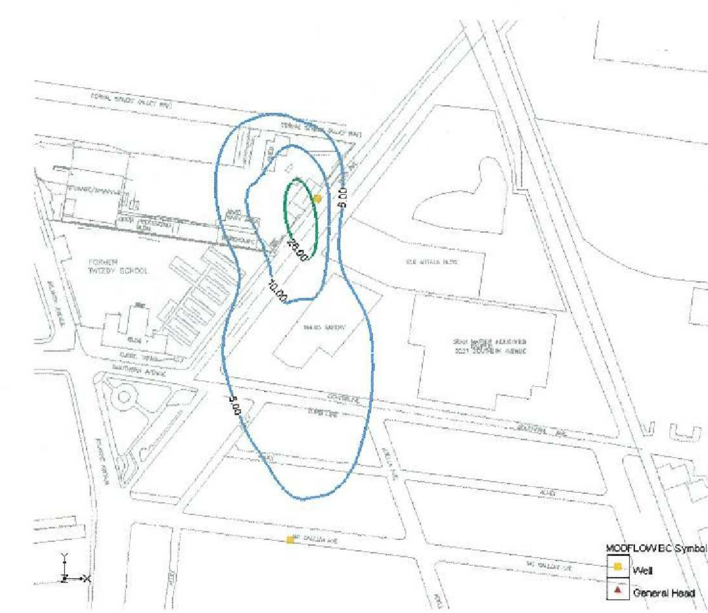


DCE 2004-2009 Simulated

DCE 2009 Observed

(CONTOURED INTERVAL 5, 10, 25, AND 75 ug/L)





1-4 Dioxane 2004-2009 Simulated

1-4 Dioxane 2009 Observed

(CONTOURED INTERVAL 5, 10, 25, AND 75 ug/L)

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FIGURE 4
TRANSPORT VERIFICATION
TCE, DCE, DIOX

PLOT BY: ROBERT_P_TAYLOR - Dec 23, 2009 - 10:03:16am
DRAWING: O:\Projects\Groundwater Modeling\Cooper Drum\2009\CooperDrum-Eddy-102209\
DRAWING: Eddy-102209-FIG-4-tce-dce-diox.dwg

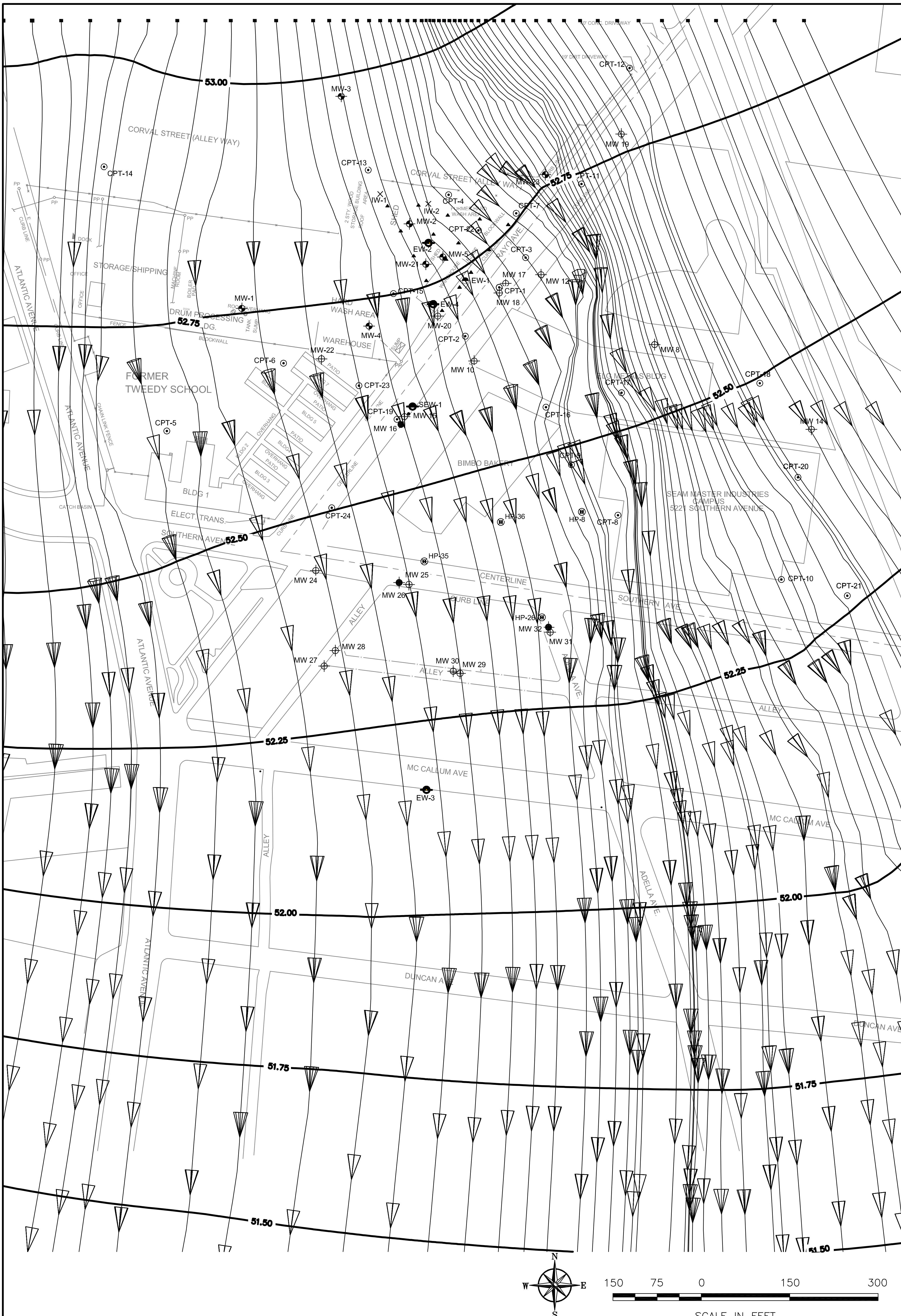


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Figure 5
PARTICLE TRACKING
(NO PUMPING)

DRAWING: Eddy-102209-FIG-6-Gen-Part-Trck(15).dwg DRAWING: O:\Projects\Groundwater Modeling\Cooper Drum\2009\CooperDrum-Eddy-102209\ PLOT BY: ROBERT_P_TAYLOR - Jan 04, 2010 - 1:23:44pm

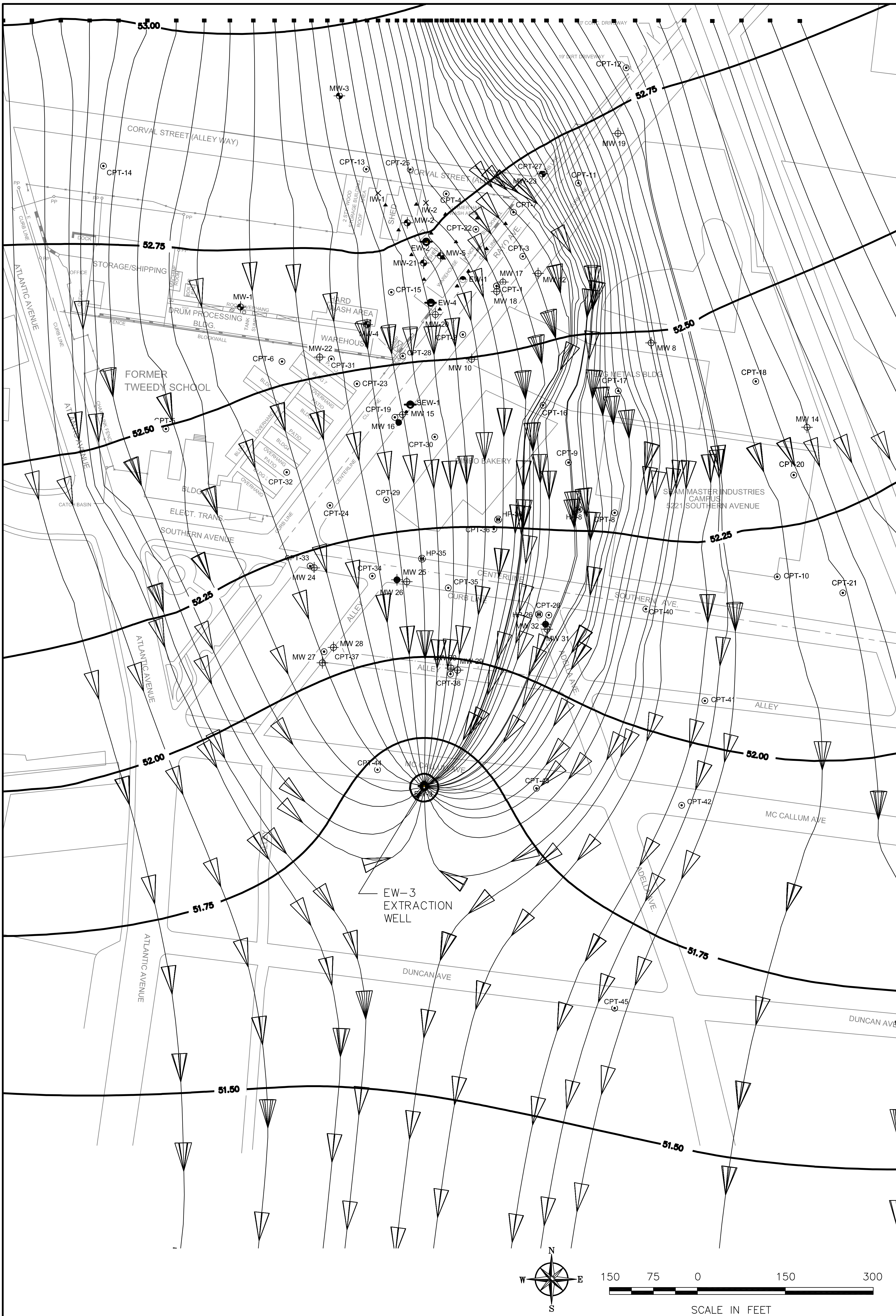


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Figure 6
PARTICLE TRACKING
(15 gpm)

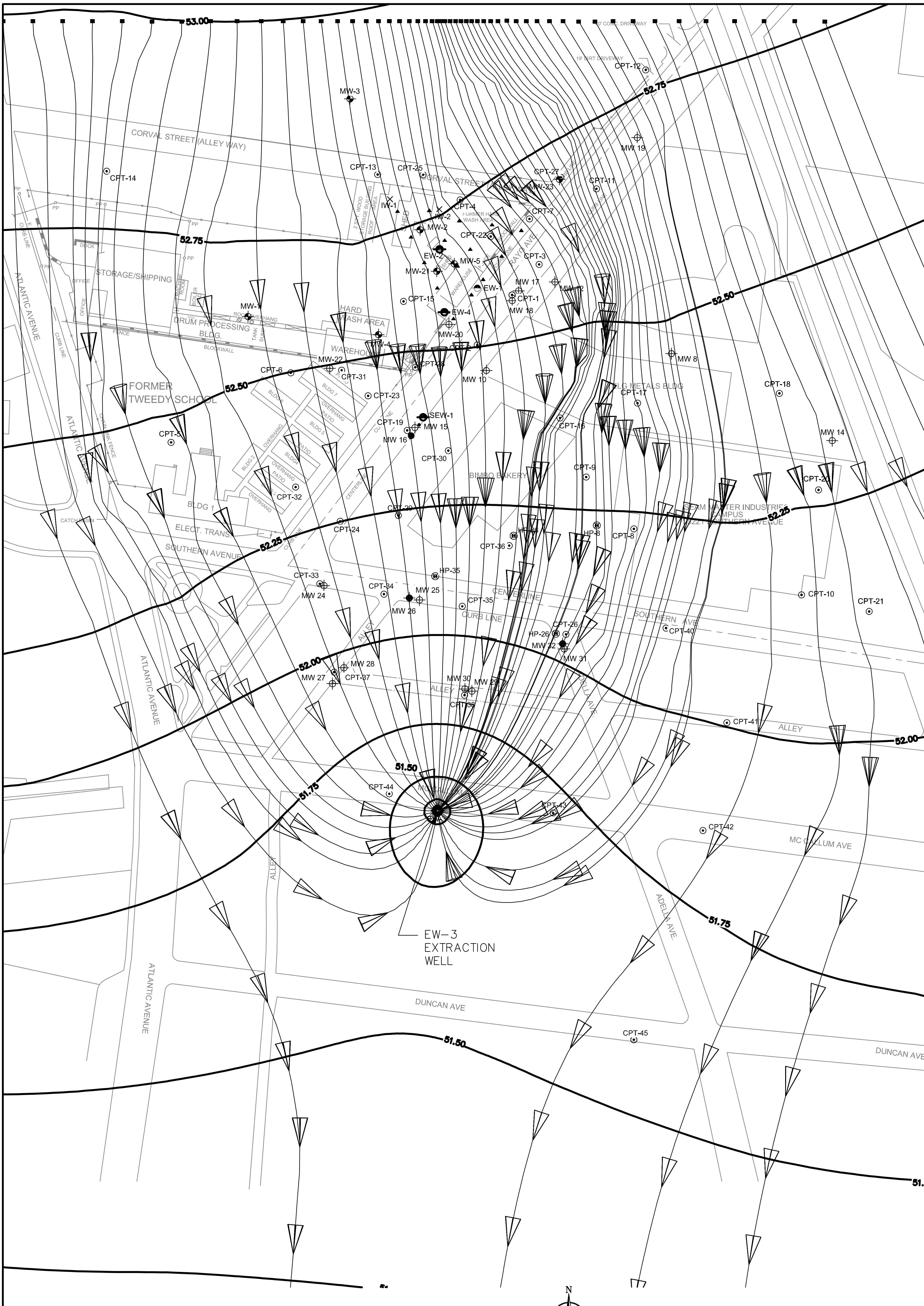


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Figure 7
PARTICLE TRACKING
(20 GPM)

DRAWING: Eddy-102209-FIG-8-Gen-Part-Trck(30).dwg DRAWING: O:\Projects\Groundwater Modeling\Cooper Drum\2009\CooperDrum-Eddy-102209\ PLOT BY: ROBERT_P_TAYLOR - Jan 04, 2010 - 1:20:24pm

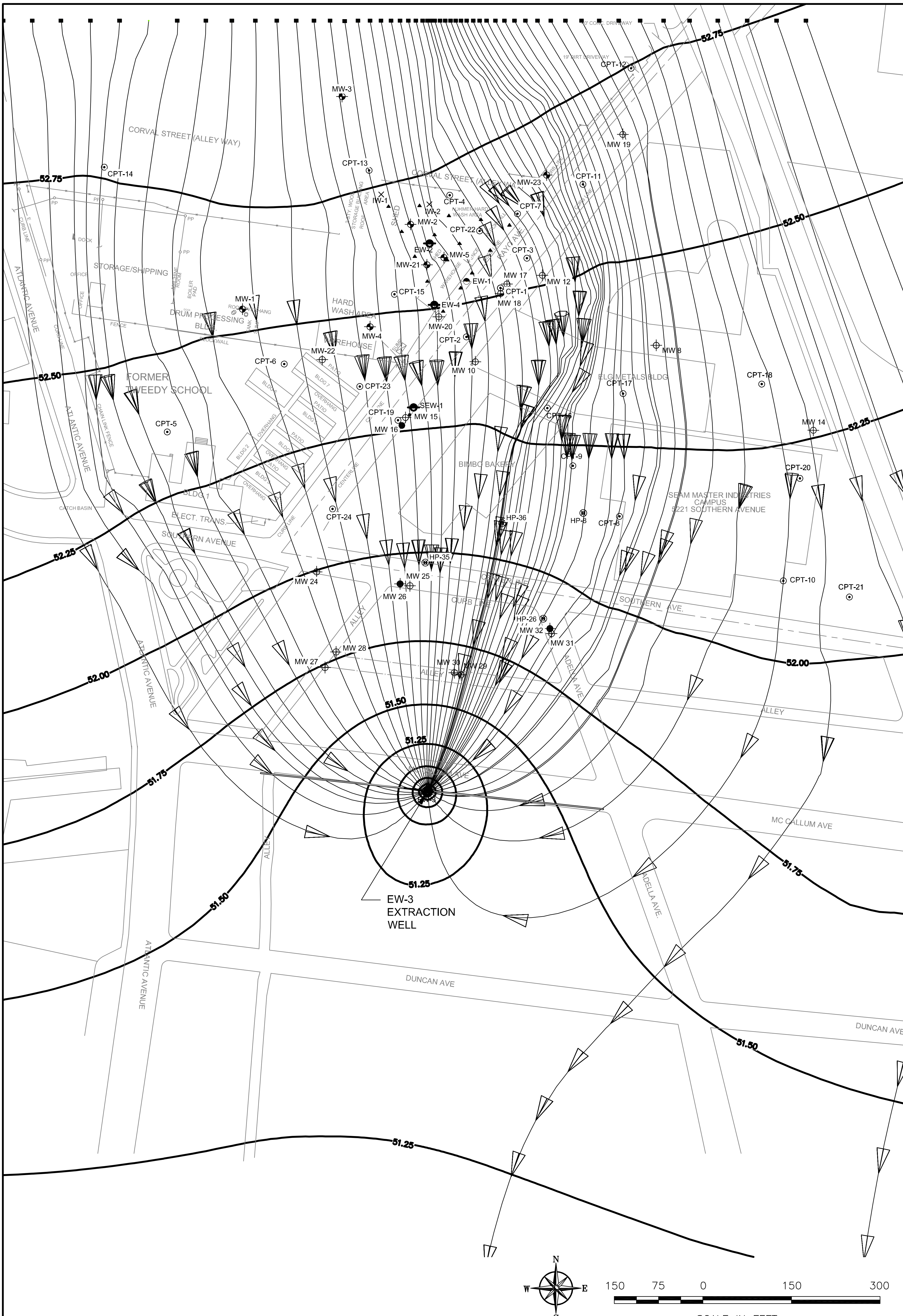


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Figure 8
PARTICLE TRACKING
(30 GPM)

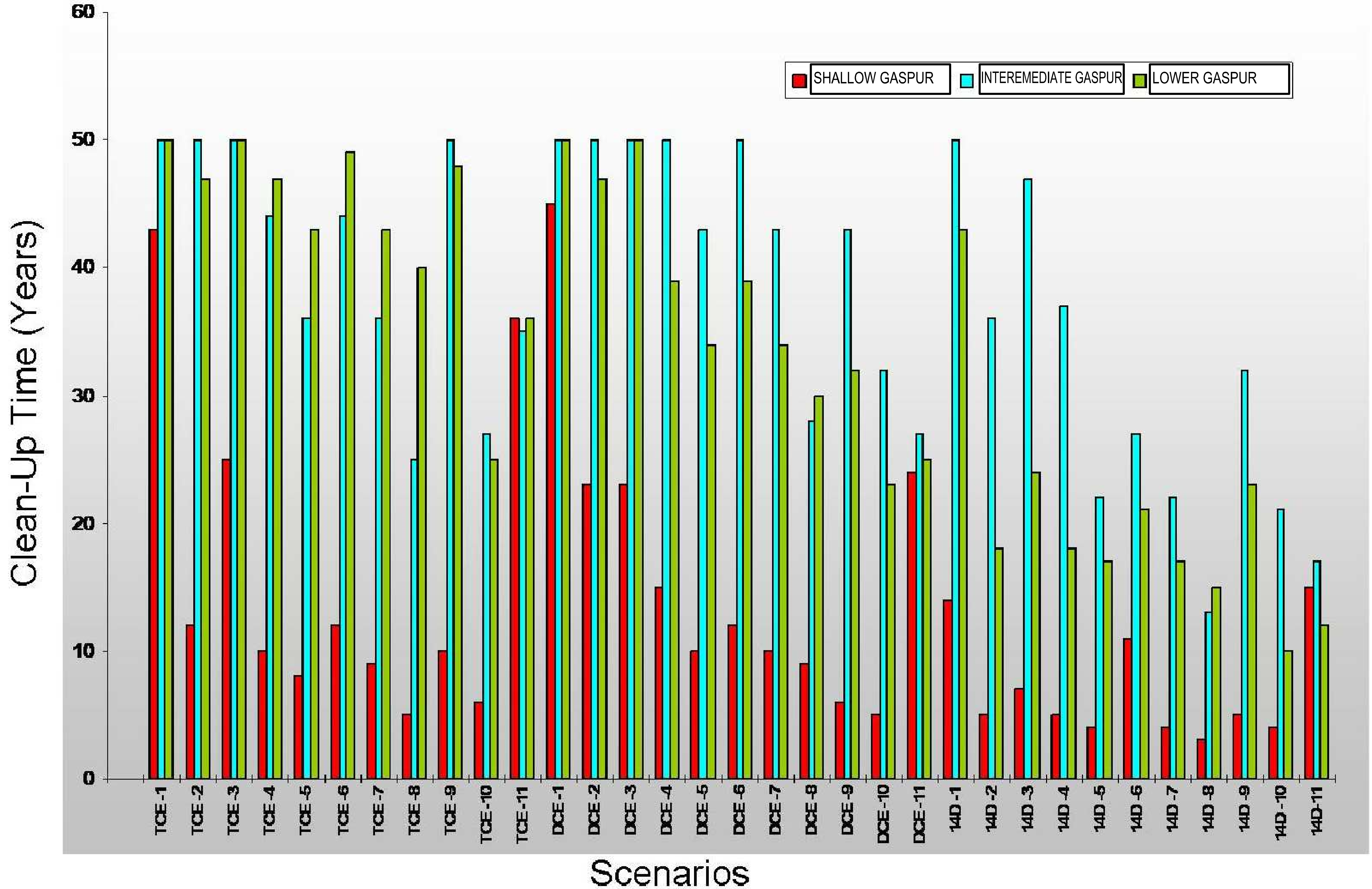



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FIGURE 9
FATE AND TRANSPORT
CLEAN-UP SCENARIOS


DRAWING: Eddy-102209-FIG-9-FATE-CLN-SCENO.dwg
DRAWING: O:\Projects\Groundwater Modeling\Cooper Drum\2009\CooperDrum-Eddy-102209\
PLOT BY: ROBERT_P_TAYLOR - Jan 04, 2010 - 10:48:05am

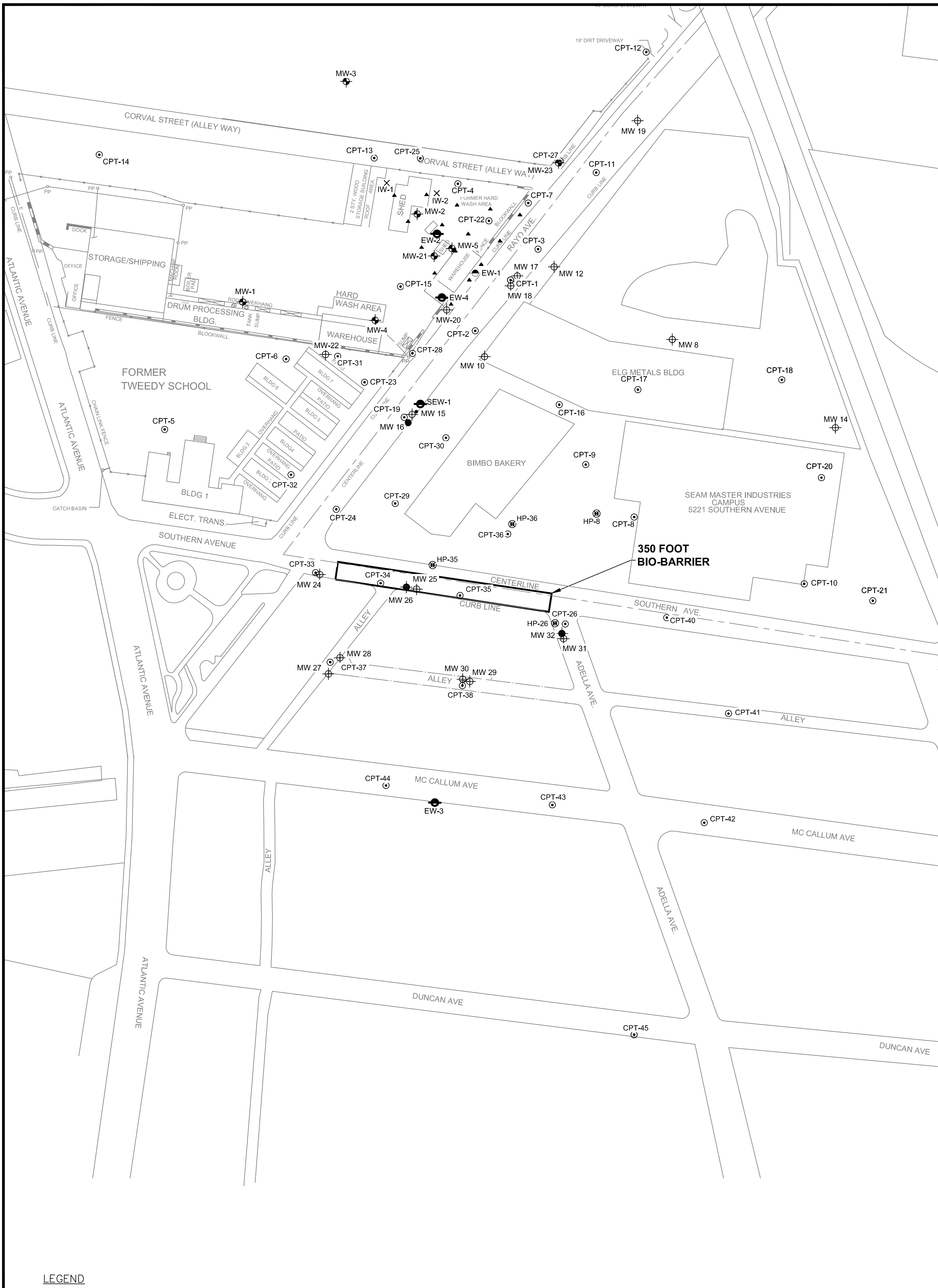


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Figure 10
APPROXIMATE LOCATION OF PROPOSED BIO-BARRIER LOCATION

URS

# TECHNICAL MEMORANDUM

**TO:** Don Gruber (Project Manager), ITSI

**FROM:** Eddy Teasdale, PG

**DATE:** December 18, 2009

**SUBJECT:** **Aquifer Testing Results for Extraction Well EW-3, Cooper Drum Superfund Site, South Gate, California**

---

## INTRODUCTION

This technical memorandum summarizes the activities associated with aquifer testing of extraction well EW-3 at the Cooper Drum Superfund Site (Site) in South Gate, California. A detailed description of the preliminary efforts associated with this project is presented in the *Cooper Drum Company Remedial Design Sampling and Analysis Plan* (URS Group, Inc. [URS], 2008). EW-3 was installed in April 2009 to address the downgradient extent of the Cooper Drum groundwater contaminant plume. EW-3 is located within the public right-of-way on McCallum Avenue (Figure 1).

## WELL CONSTRUCTION

EW-3 was constructed in a borehole 12.5 inches in diameter drilled with a mud-rotary rig to approximately 115 feet below ground surface (bgs). Figure 2 depicts an as-built drawing of EW-3, which consists of 6-inch-inside diameter (ID) Schedule 40 polyvinyl chloride (PVC) well casing from approximately 1 foot bgs (street level) to 59 feet bgs; 6-inch-ID stainless steel, v-slot well screen (0.02-inch slot size) from 59 to 109 feet bgs; and, 6-inch-ID stainless steel well casing (sump) from 109 to 112 feet bgs. EW-3 also includes a 1-inch-ID PVC sounding tube from approximately 3 to 112 feet bgs.

Filter pack material composed of siliceous sand was placed in the annular space between the well screen and the borehole from 54 to 115 feet bgs using a tremie pipe. A 2-foot-thick bridge of fine-grained sand was placed on top of the filter pack material from 52 to 54 feet bgs through the tremie pipe, and a 2-foot bentonite seal was placed above the bridge sand from 50 to 52 feet bgs to protect the filter pack during grouting. A cement grout sanitary seal was pumped under pressure into the annular space above the bentonite seal from approximately 5 to 50 feet bgs through the tremie pipe. The cement grout used for the sanitary seal consisted of Type II Portland cement with 3 pounds of powdered nonbeneficiated bentonite, and 7 gallons of water per 94-pound sack of cement.

The wellhead for EW-3 was completed approximately 3 feet below street level with a 12-inch flush-mounted traffic vault box. The surface surrounding the vault box was covered with asphalt to match the existing street grade.

## WELL DEVELOPMENT

EW-3 was developed by simultaneous swabbing, airlifting, and pumping with a 10-foot-long perforated flanged swabbing tool. The well screen interval was initially developed with the swab tool, then a temporary submersible pump was installed. The submersible test pump was used to further develop EW-3. The well was alternately pumped and surged at progressively increasing pumping rates from 17 to

60 gallons per minute (gpm). Throughout this phase, the discharge water was predominantly clear, with periods of brief turbidity, and had trace levels of sand in the discharge after approximately 8 hours of pump-and-surge development.

## STEP-RATE AQUIFER PUMPING TEST

A 6-hour step-rate aquifer pumping test was conducted in EW-3 on April 29, 2009, to evaluate the well's production capability and efficiency (specific capacity). The flow rate was monitored using a flowmeter with a totalizer installed in the discharge pipe. EW-3 was pumped for approximately one-hour intervals at average rates of approximately 18, 30, 40, 50, and 60 gpm. Higher discharge rates were not attained due to the amount of drawdown. The static water level within EW-3 was measured at 48.55 feet bgs prior to the start of the pumping test. The water level drawdowns in the well at the end of pumping steps 1 through 5 were approximately 54, 58, 62, 69, and 74 feet, respectively (Figure 3). Aquifer test data sheets for EW-3 are presented in Appendix I.

The step-rate aquifer test was evaluated using the methodology outlined by Lewis-Clark utilizing the 1964 Hantush and Bierschenk method (1977). A regression analysis of the groundwater production rate versus the specific drawdown was used to obtain well-specific coefficients that provide an accurate prediction of water level drawdown. The water level drawdown values are then used to calculate the percentage of the total head loss that is attributable to laminar flow and the specific capacities at various pumping rates. The specific capacity of a well is the ratio of the pumping rate (gpm) and the water level drawdown (feet). Specific capacity values, which are reported in units of gallons per minute per foot of drawdown (gpm/ft), provide a relative indication of the well efficiency at a particular pumping rate and time.

## STEP-RATE AQUIFER PUMPING TEST RESULTS

Using the average pumping rates and observed drawdown values from the EW-3 step-discharge aquifer test, the resultant specific capacity values at the end of each step were calculated to be 3.11; 3.16; 2.91; 2.43, and 2.32 gpm/ft for steps 1 through 5, respectively.

Analysis of the step-rate pumping data, assuming a pumping rate of 40 gpm, indicates the following (Figure 4):

- The predicted total drawdown is approximately 14.67 feet (corresponding to a pumping water level of about 63.2 feet bgs).
- The well efficiency is predicted to be about 67 percent.
- The specific drawdown is predicted to be approximately 0.34 feet/gpm.

At 60 gpm, the following results were obtained (Figure 4):

- The predicted total drawdown is approximately 25.61 feet (corresponding to a pumping water level of 74.16 feet bgs).
- The well efficiency is predicted to be about 57 percent.

- The specific drawdown is predicted to be approximately 0.41 feet/gpm.

The critical discharge or point of discharge is defined as the rate where rapid changes in slopes are noted. As shown on Figure 5, the critical discharge for EW-3 is estimated to be approximately 40 to 45 gpm.

## EW-3 SPECIFICATIONS AND OPERATIONAL INFORMATION

Based on the data and analyses developed from the step-rate aquifer test, a Grunfos 85550-3 submersible pump with a standard operating capacity of 45 gpm (maximum capacity of 80 gpm) was installed in EW-3 on April 28, 2009. The pump assembly intake was set at 107 feet bgs, which is within the well screen. This pump intake setting will prevent drawdown below the annular seal within EW-3. In order to provide an adequate net positive suction head to avoid damage to the pump impellers, the pumping water level was not be allowed to drop below approximately 10 feet above the pump intake setting.

## CONSTANT RATE AQUIFER TESTING

Prior to conducting the constant rate aquifer test, groundwater level measurements were collected on 36 monitoring wells. The data from these wells are included in Appendix II. The constant rate pumping test was conducted in EW-3 from 8:15 a.m. May 5, 2009, to approximately 08:12 a.m. May 6, 2009 (approximately 24 hours).

EW-3 was pumped at approximately 44 gpm for the entire test period. The flow rate of the well was monitored using an in-line flowmeter with a totalizer installed in the discharge pipe. The water was discharged through a bag filter and then to the sanitary sewer under an industrial wastewater permit. The static water level measured in the well prior to the start of the test was 48.52 feet bgs. The water-level drawdown in the well at the end of the constant rate test was approximately 69 feet bgs and corresponds to pumping water level of 32.01 feet mean sea level. Water level drawdown recovery data were collected after the test period from EW-3 for approximately 24 hours.

Eight monitoring wells in the proximity of EW-3 were used as observation points during the constant rate test (MW-29, MW-29A, MW-30, MW-36, MW-37, MW-38, MW-39, and MW-40) (Figure 1). Groundwater levels were measured in each monitoring well using pressure transducers. Constant rate test observation data were analyzed to determine localized aquifer characteristics. Ground water level data from each of the observation wells were analyzed using the Hantush Method (1960), Theis Distance Drawdown and Hantush Recovery. Groundwater elevation data collected during the aquifer test is summarized in Appendix II, and depth to water measurements at EW-3 are included in Appendix III.

## CONSTANT RATE PUMPING TEST RESULTS

The drawdown data collected during the aquifer test from each observation well was analyzed using AQTESOLV (Duffield, 2007), a software package designed to match type-curves from various analytical solutions to estimate aquifer transmissivity (T), hydraulic conductivity (k), and storativity (S). The previously cited Hantush and Jacob leaky aquifer solution method was used to analyze the data sets from the observation wells. Note that the calculations do not provide unique solutions, and parameter results are likely to be within a range of values. Constant rate aquifer test analysis plots are presented in Appendix IV.

Based on curve matching, transmissivity, hydraulic conductivity, and storage coefficients, values for the extraction well and observation wells were calculated. Transmissivity values ranged from 1,206 to 3,089 square feet per day ($ft^2$/day), hydraulic conductivity values ranged from 24.1 to 61.8 feet per day (feet/day); and storage coefficients ranged from $4.02 \times 10^{-6}$ to $8.64 \times 10^{-6}$. The values are summarized in Table 1.

Results are assumed to be representative of aquifer characteristics associated with the classification of Cooper Drum hydrogeologic characteristics.

Based on the results of the constant rate aquifer test and analysis of data collected from EW-3 and surrounding monitoring wells, the following conclusions are made:

- Aquifer transmissivity values range from 1,206 to 3,089 $ft^2$/day and correspond to hydraulic conductivity values ranging 24.1 to 61.8 feet/day (assuming an aquifer thickness of 50 feet). Storativity values range from 0.00000402 to 0.00000864.
- There does not appear to be a significant hydraulic influence from pumping EW-3 (completed in the Gaspur aquifer) on the Exposition aquifer (noted in MW-55).
- During the pump test (other than the pumping well), similar drawdown was noted from all depths (shallow, intermediate and lower) of the Gaspur Aquifer. This similarity in hydrogeologic response suggests that limited stratification occurs throughout the Gaspur aquifer in proximity to EW-3.
- EW-3 operates at an efficiency of approximately 67% when pumped at roughly 44 gpm. The calculated specific yield of the well for this test was 2.15 gpm/foot.
- Based on particle tracking analysis, EW-3 could operate at 20 to 30gpm and maintain capture.

## RECOMMENDATIONS

Based on the step-rate and constant rate aquifer testing and analysis, EW-3 should not be operated at a flow rate greater than 30 gpm to avoid creating a larger-than-needed capture zone and possibly influencing off-Site plume migration.

## REFERENCES

Duffield, Glenn M., 2007. AQTESOLV for Windows. Version 4.02. HydroSOLVE, Inc. Distributed by Geraghty & Miller Modeling Group, Reston, VA.

Lewis, Clark, 1977. *The analysis and planning of step drawdown tests.* Quarterly Journal of Engineering Geology, Volume 10. pp 125-143.

Hantush, M.S. and C.E. Jacob, 1955. *Non-steady radial flow in an infinite leaky aquifer.* American Geophysical Union Trans., vol. 36, pp. 95-100.

URS, 2008. *Cooper Drum Company Remedial Design Sampling and Analysis Plan.* October.

**ATTACHMENTS:**

Table 1 – May 2009 Aquifer Test Analysis Results

Figure 1 – EW-3 Location
Figure 2 – EW-3 As-Built
Figure 3 – Step-Rate Discharge Pumping Test Water Level Drawdown Curve
Figure 4 – Step-Discharge Pumping Test Analysis
Figure 5 – Critical Discharge Analysis of Step-Discharge Test

Appendix I – Well Development Log and Step-Rate Aquifer Test Field Data Sheets
Appendix II – Monitoring Well Depth to Groundwater Information
Appendix III – Constant Rate Aquifer Test Field Sheets
Appendix IV – Constant Rate Aquifer Test Analysis Data Analysis Curves

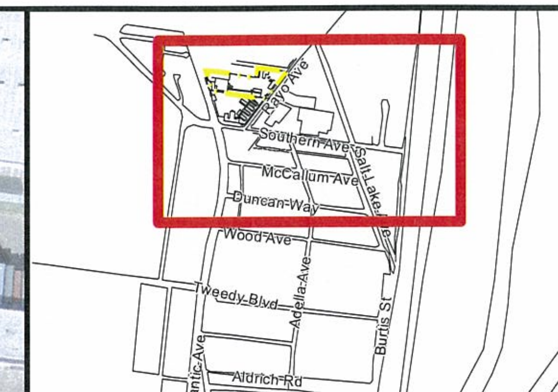
## TABLES

**Table 1**

**Summary of Transmissivity, Storativity and Hydraulic Conductivity Values**
**For Well EW-3 Aquifer Test**
**Cooper Drum Site**

| Well Number | Screened Interval (ft BGS) | Gasper (Intermediate/Lower) | Distance From Pumping Well (ft) | Maximum Drawdown (ft) | Drawdown | | | | | | Recovery | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Hantush's Method (1960) | | | Distance Drawdown | | | Hantush Method (Recovery) | |
| | | | | | Transmissivity ($ft^2$/day) | Storage Coefficient | Hydraulic Conductivity (ft/day) | Transmissivity ($ft^2$/day) | Storage Coefficient | Hydraulic Conductivity (ft/day) | Transmissivity ($ft^2$/day) | Hydraulic Conductivity (ft/day) |
| EW-3 | 59-109 | Intermediate/Lower | 0 | 20.44 | -- | -- | -- | 1592 | $6.85 \times 10^{-6}$ | 31.8 | -- | -- |
| MW-37 | 99.5-109.5 | Lower | 63 | 1.45 | 2849 | $8.64 \times 10^{-6}$ | 57.0 | -- | -- | -- | 3089 | 61.8 |
| MW-36 | 77-87 | Intermediate | 74 | 1.06 | 1718 | $4.02 \times 10^{-6}$ | 34.4 | -- | -- | -- | 1824 | 36.5 |
| MW-38 | 56.5-66.5 | Shallow | 180 | 0.50 | 2330 | $8.64 \times 10^{-6}$ | 46.6 | -- | -- | -- | 1851 | 37.0 |
| MW-29 | 75-90 | Intermediate | 195 | 0.61 | 1846 | $8.64 \times 10^{-6}$ | 36.9 | -- | -- | -- | 2124 | 42.5 |
| MW-29A | 56-66 | Shallow | 195 | 0.57 | 2060 | $7.88 \times 10^{-6}$ | 41.2 | -- | -- | -- | 1421 | 28.4 |
| MW-30 | 104-114 | Lower | 195 | 0.28 | -- | -- | -- | -- | -- | -- | -- | -- |
| MW-39 | 78-88 | Intermediate | 195 | 0.58 | 1846 | $7.88 \times 10^{-6}$ | 36.9 | -- | -- | -- | 2462 | 49.2 |
| MW-40 | 100-110 | Lower | 210 | 0.38 | -- | -- | -- | -- | -- | -- | -- | -- |

**FIGURES**


**Legend**

- 2008 Cone Penetrometer Test Boring
- 2009 Monitoring Well
- 2009 Extraction Well
- 2008 Hydropunch Boring
- Previous CPT Boring
- Previous Monitoring Well
- Previous Extraction Well
- Previous Hydropunch Boring
- Roads
- Property Boundary
- A - A' Cross Section Line

N

0 100 200

Scale in Feet

**Figure 1**
**Site Map and 2009 Aquifer Test Well Locations**
**Cooper Drum Company**
**South Gate, California**

L:\GIS\Projects\CooperDrum\ArcMaps\CPT_well_locs 10.05.09 Chico