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REPORTS

DATE:
12/07/2005

1R0277

ENSR International
27755 Diehl Road, Suite 100
Warrenville, IL 60555-3998
(630) 836-1700
FAX (630) 836-1711
www.ensr.com

December 7, 2005

ENSR Project No.: 06940-543

Mr. Glenn von Gonten
New Mexico Energy, Minerals, and Natural Resources Department
Oil Conservation Division
Environmental Bureau
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

RE: 2005 Annual Groundwater Monitoring Report
Former Unocal Unit # 9924770
South Vacuum Unit
Hobbs, New Mexico

Dear Mr. Glenn von Gonten:

ENSR Corporation, on behalf of Unocal Corporation, is submitting one copy of the 2005 Annual Groundwater Monitoring Report for the above-referenced site. Also, as per your request, attached are the groundwater modeling for the next five years for chlorides and total dissolved solids. If you have any questions or require any additional information regarding this report, please contact our office at (630) 836-1700.

Sincerely,

ENSR Corporation

Chris Kocka
Project Manager

Linda C. Yang, P.G.
Department Manager
Petroleum Services

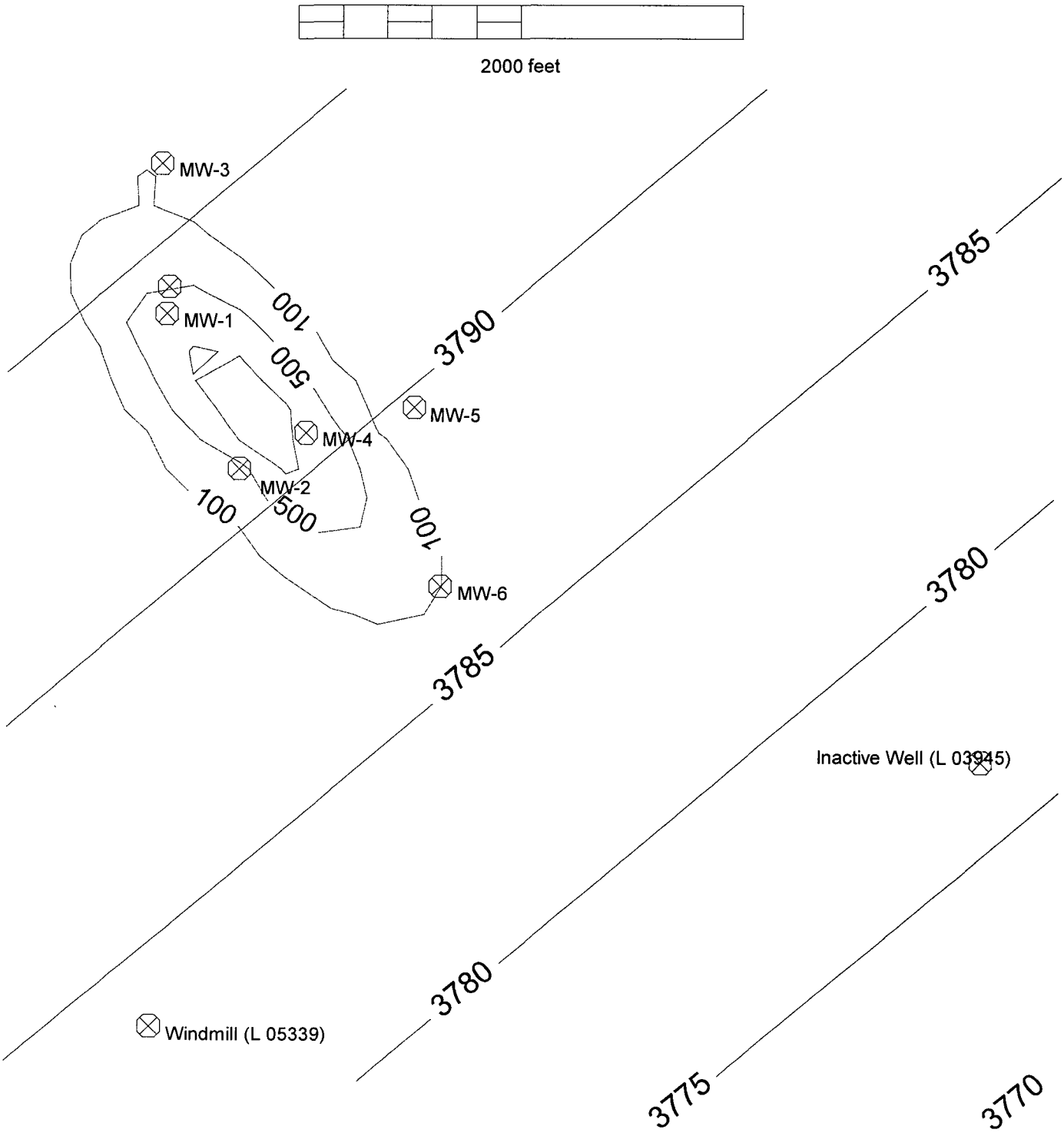
Cc: Achebe Hope, Unocal

Attachment

FORMER UNOCAL SOUTH VACUUM UNIT

WinTran Modeling Results

Chloride Plume Simulation (Year 2005)



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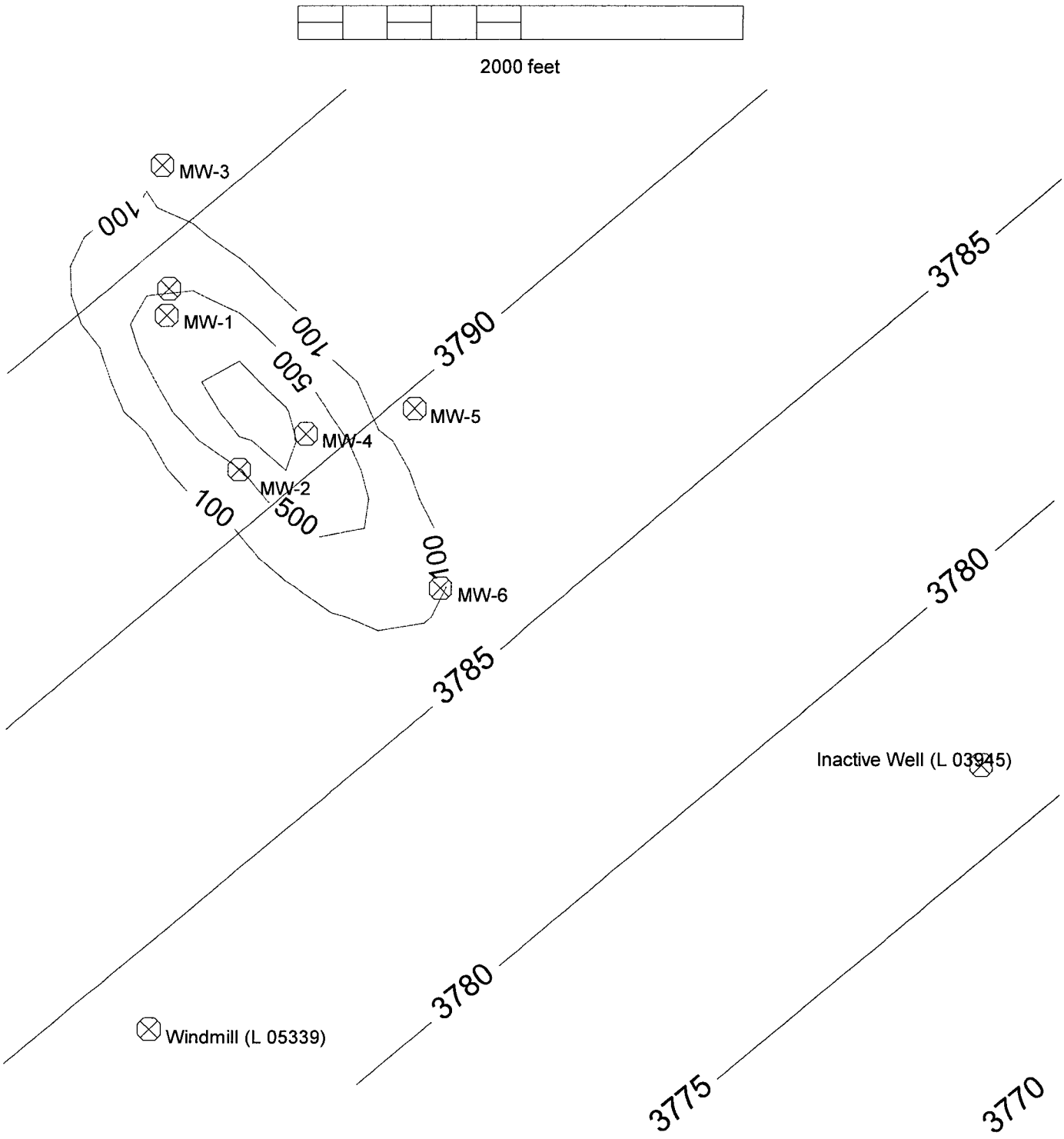
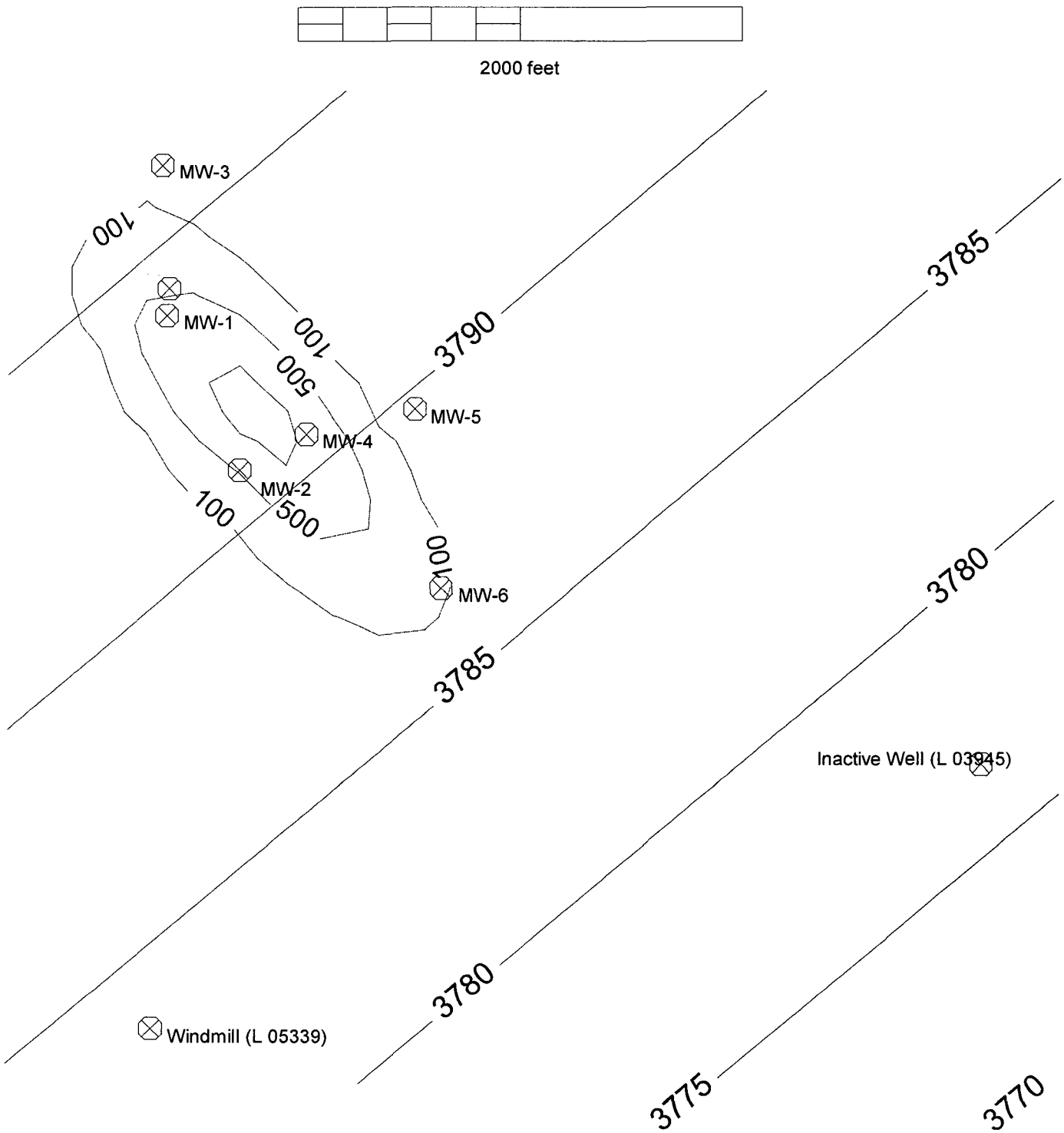


FORMER UNOCAL SOUTH VACUUM UNIT

WinTran Modeling Results

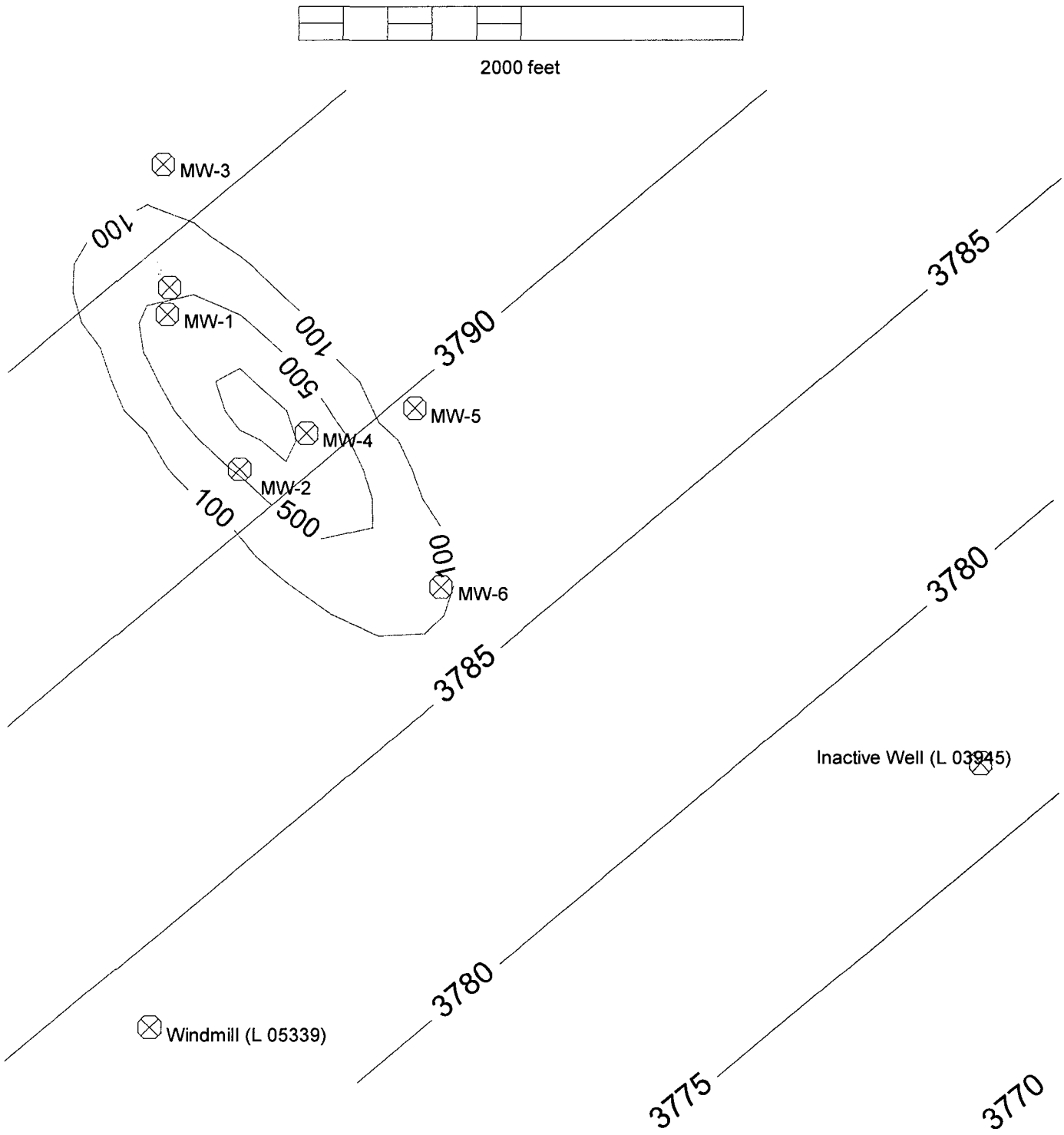
Chloride Plume Simulation (Year 2007)



FORMER UNOCAL SOUTH VACUUM UNIT

WinTran Modeling Results

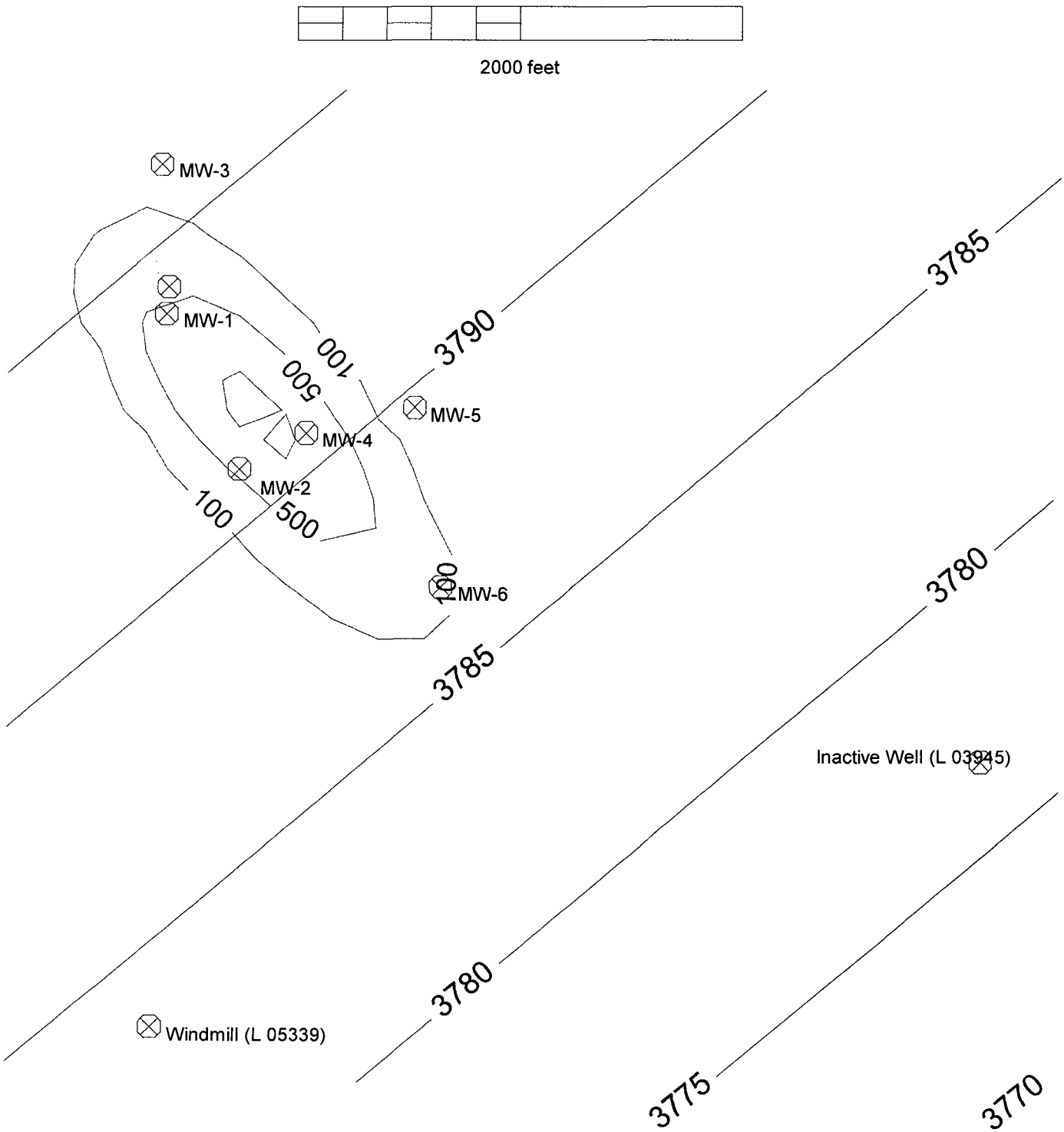
Chloride Plume Simulation (Year 2008)



FORMER UNOCAL SOUTH VACUUM UNIT

WinTran Modeling Results

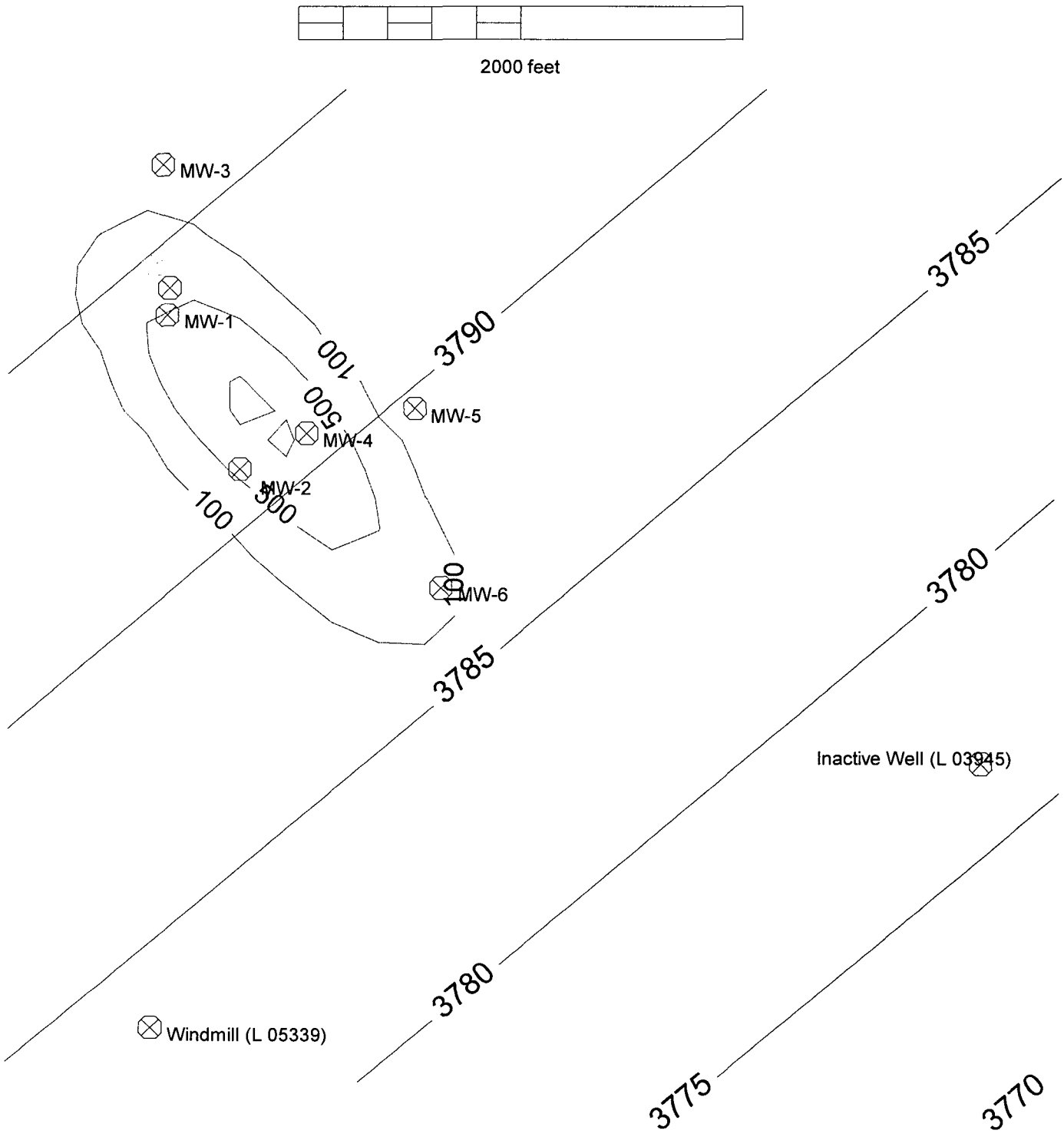
Chloride Plume Simulation (Year 2009)



FORMER UNOCAL SOUTH VACUUM UNIT

WinTran Modeling Results

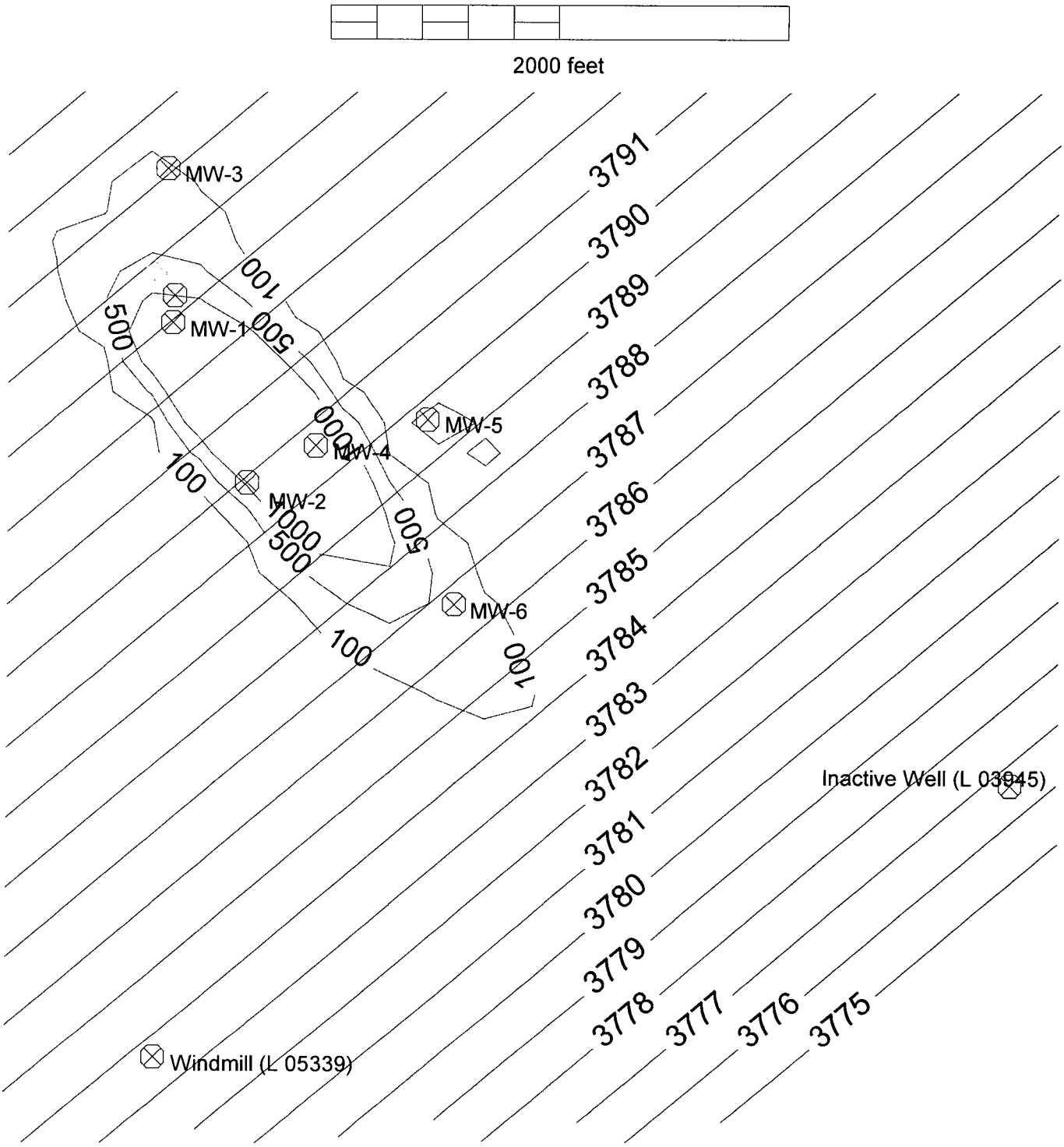
Chloride Plume Simulation (Year 2010)



FORMER UNOCAL SOUTH VACUUM UNIT

WinTran Modeling Results

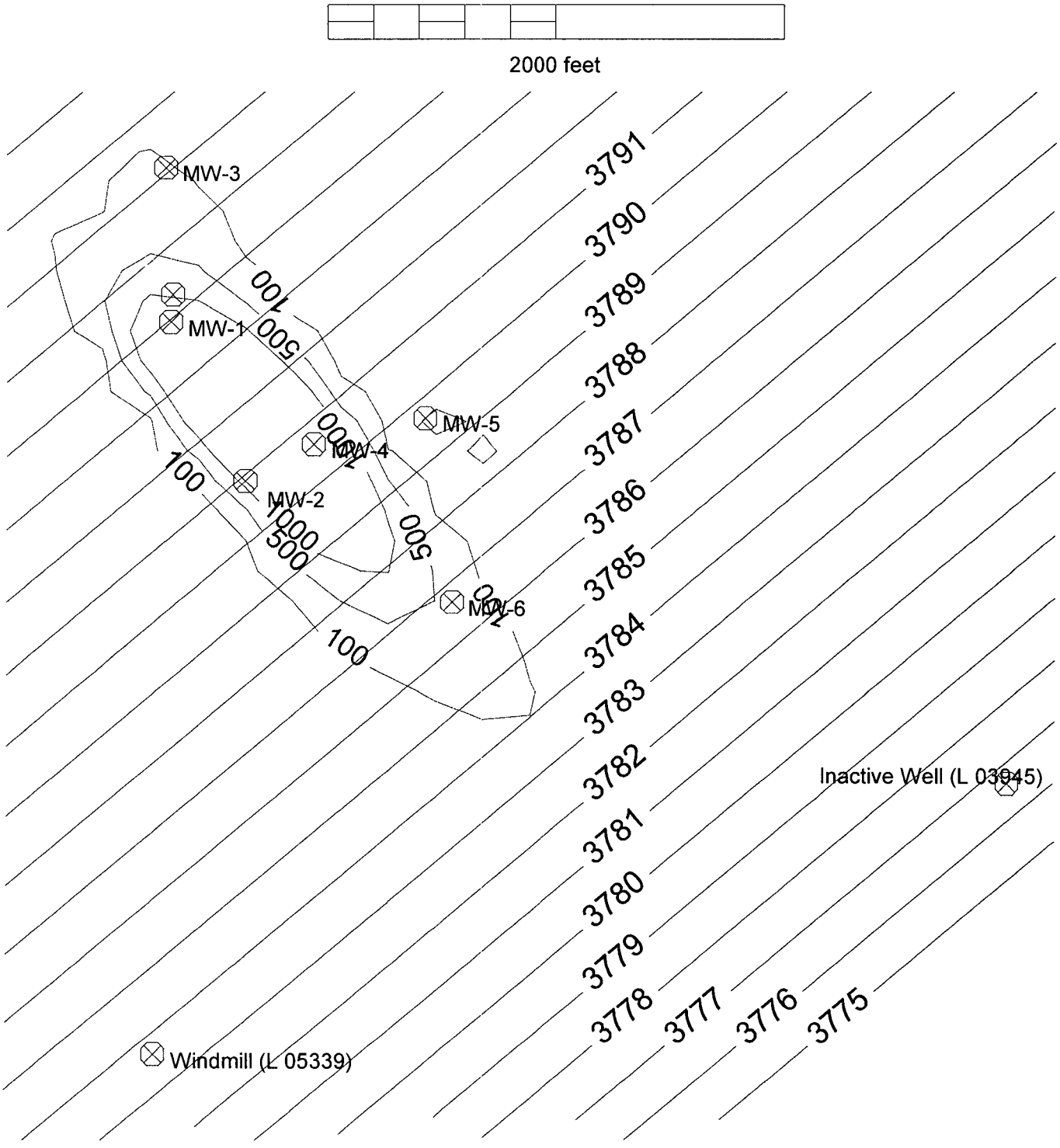
TDS Plume Simulation (Year 2005)



FORMER UNOCAL SOUTH VACUUM UNIT

WinTran Modeling Results

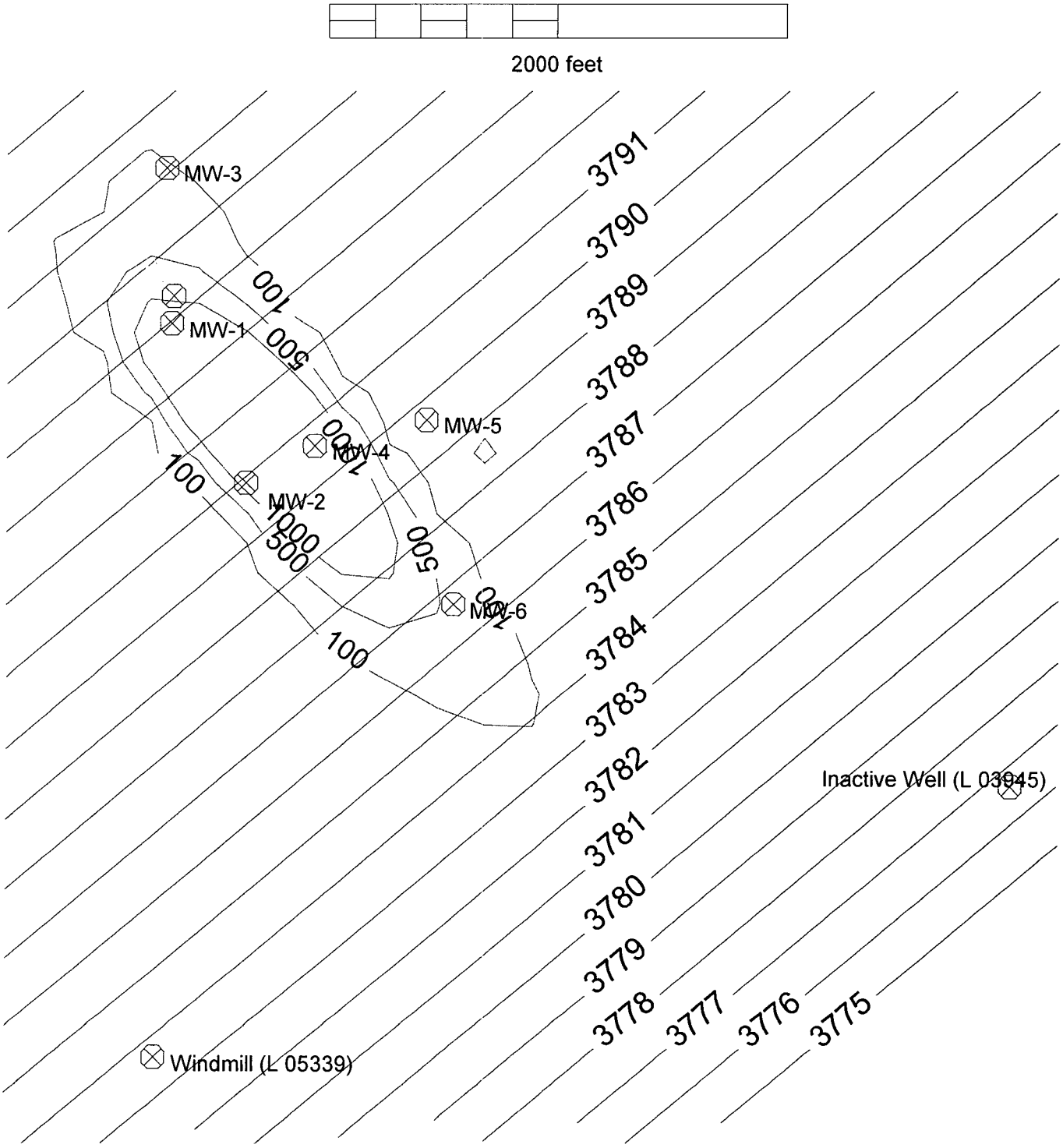
TDS Plume Simulation (Year 2006)



FORMER UNOCAL SOUTH VACUUM UNIT

WinTran Modeling Results

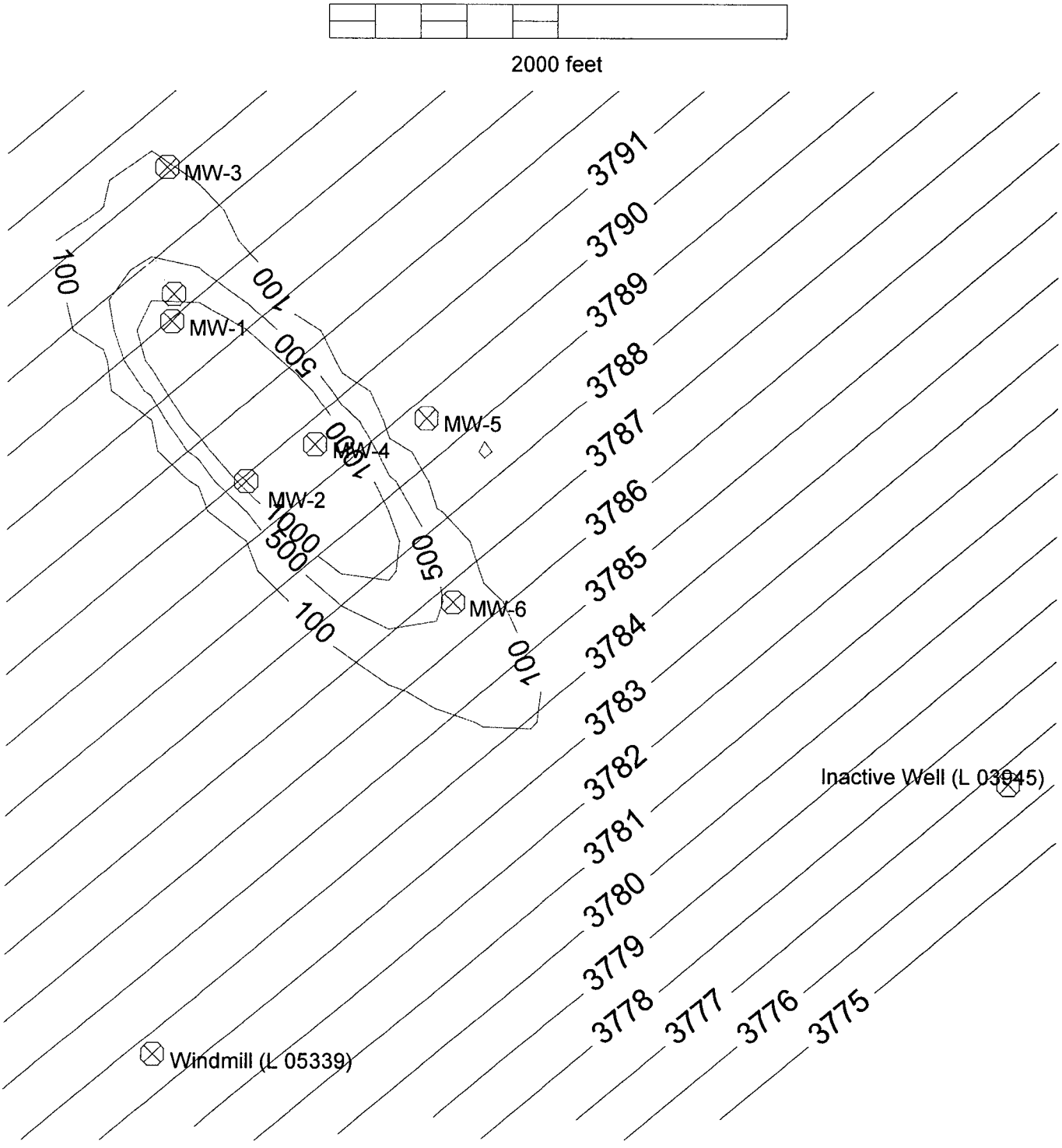
TDS Plume Simulation (Year 2007)



FORMER UNOCAL SOUTH VACUUM UNIT

WinTran Modeling Results

TDS Plume Simulation (Year 2008)

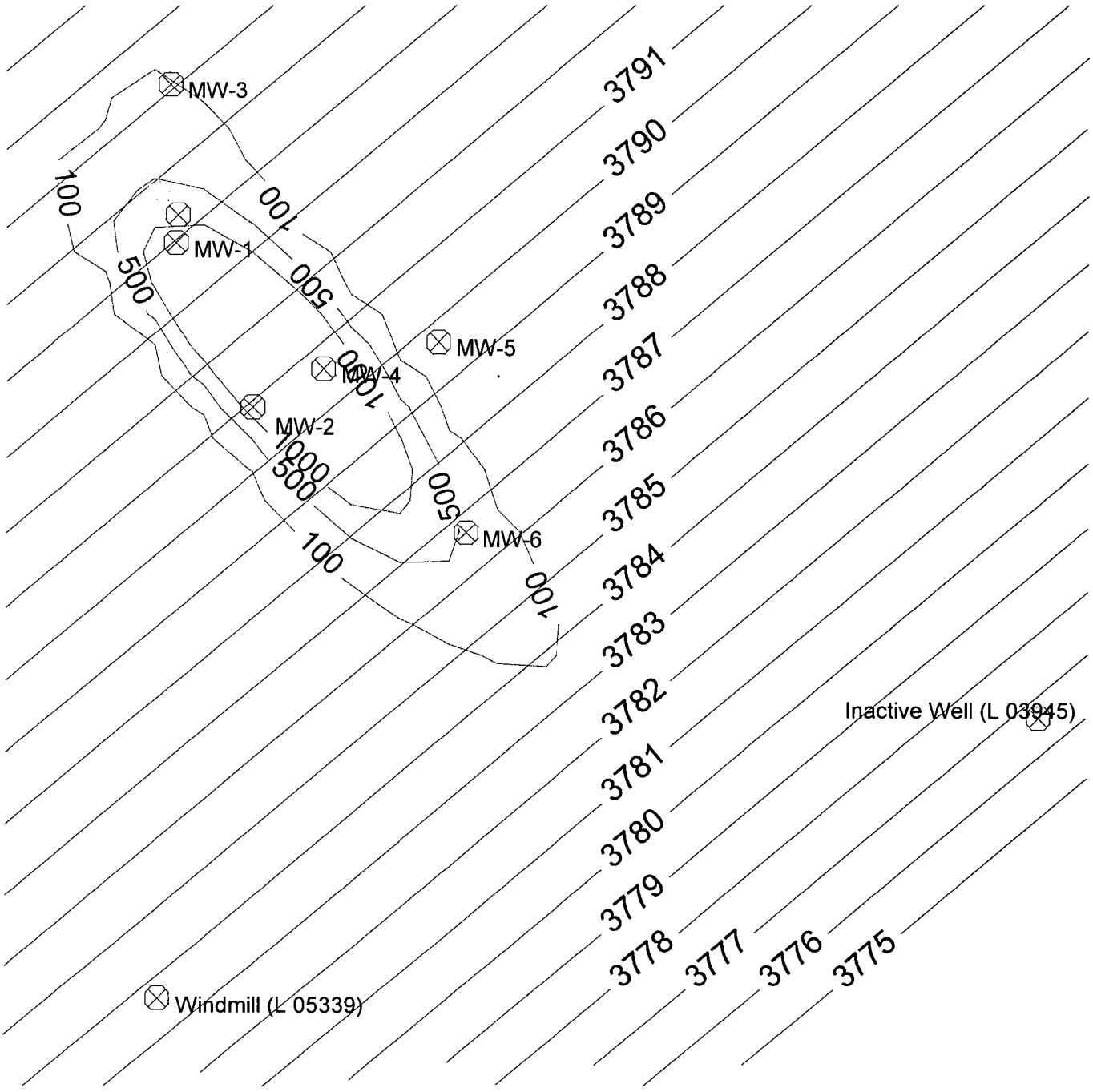


FORMER UNOCAL SOUTH VACUUM UNIT

WinTran Modeling Results

TDS Plume Simulation (Year 2009)

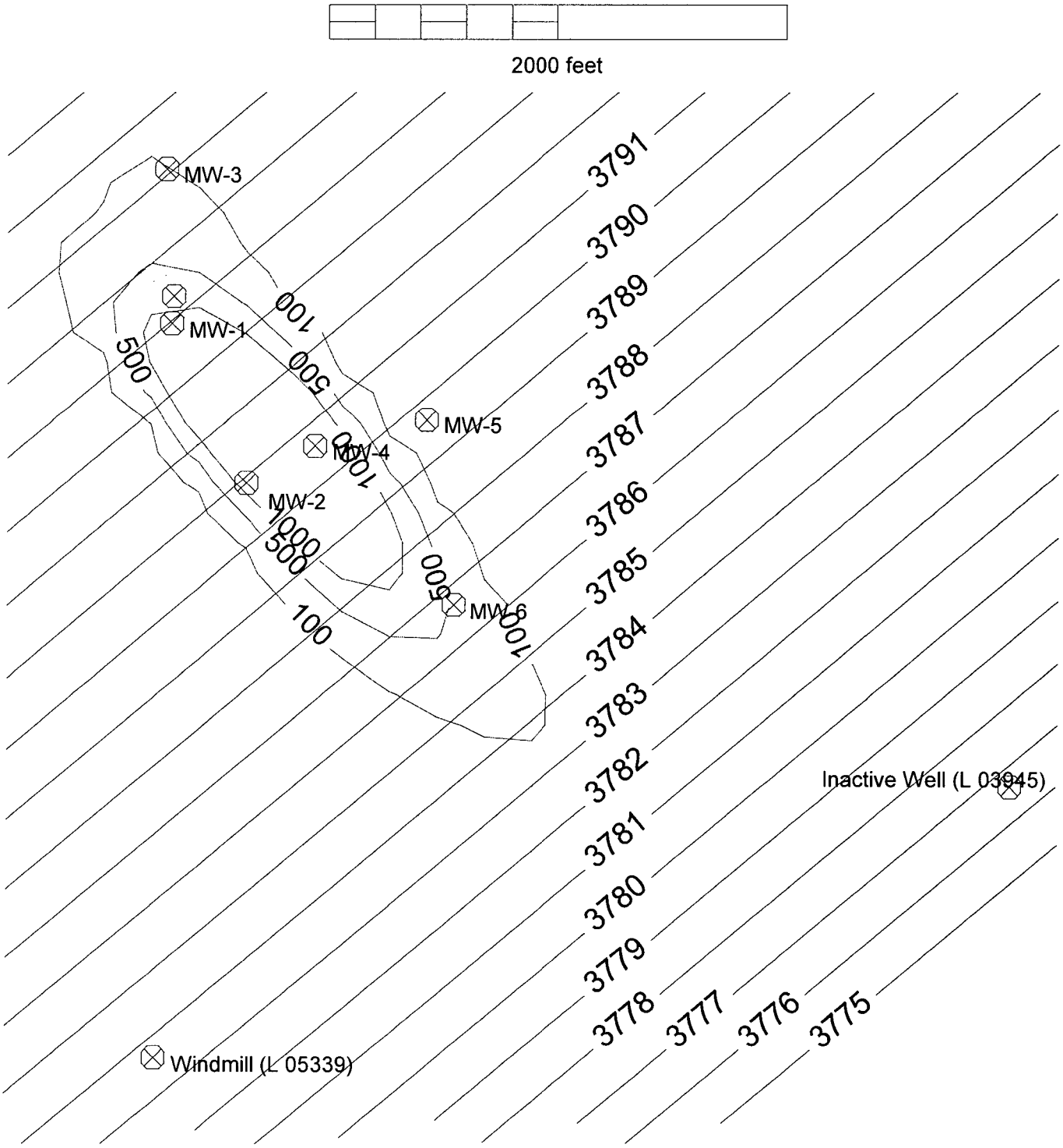
2000 feet



FORMER UNOCAL SOUTH VACUUM UNIT

WinTran Modeling Results

TDS Plume Simulation (Year 2010)



ENSR International
27755 Diehl Road, Suite 100
Warrenville, IL 60555-3998
(630) 836-1700
FAX (630) 836-1711
www.ensr.com

November 8, 2005

ENSR Project No.: 06940-543

Mr. Achebe Hope
Project Manager
Unocal Corporation
276 Tank Farm Road
San Luis Obispo, California 93406

RE: 2005 Annual Groundwater Monitoring Report
Former Unocal Unit # 9924770
South Vacuum Unit
Hobbs, New Mexico

Dear Mr. Hope:

Enclosed please find one copy of the 2004 Annual Groundwater Monitoring Report for the above-referenced site. As per your approval, the report has been submitted to the New Mexico Oil Conservation Division (NMOCD). ENSR appreciates the opportunity to provide environmental consulting services to Unocal. If you have any questions or require any additional information regarding this report, please contact our office at (630) 836-1700.

Sincerely,

ENSR Corporation

Chris Kocka
Project Manager

Linda C. Yang, P.G.
Program Manager

Attachment

November 4, 2005

Mr. Daniel Sanchez
New Mexico Energy, Minerals and Natural Resources Department
Oil Conservation Division – Environmental Bureau
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

SUBJECT: TRANSMITTAL LETTER
2005 ANNUAL GROUNDWATER MONITORING REPORT
FORMER UNOCAL SOUTH VACUUM UNIT
SEC 35, T18S, R35E
LEA COUNTY, NEW MEXICO
CASE #1R0277

Dear Mr. Sanchez:

Enclosed is the 2005 Annual Groundwater Monitoring Report for the Former Unocal South Vacuum Unit site located in Lea County, New Mexico.

Please contact me at (432) 638-8740 or Achebe Hope of Unocal Corporation at (805) 547-5448 with any questions or comments.

Sincerely,

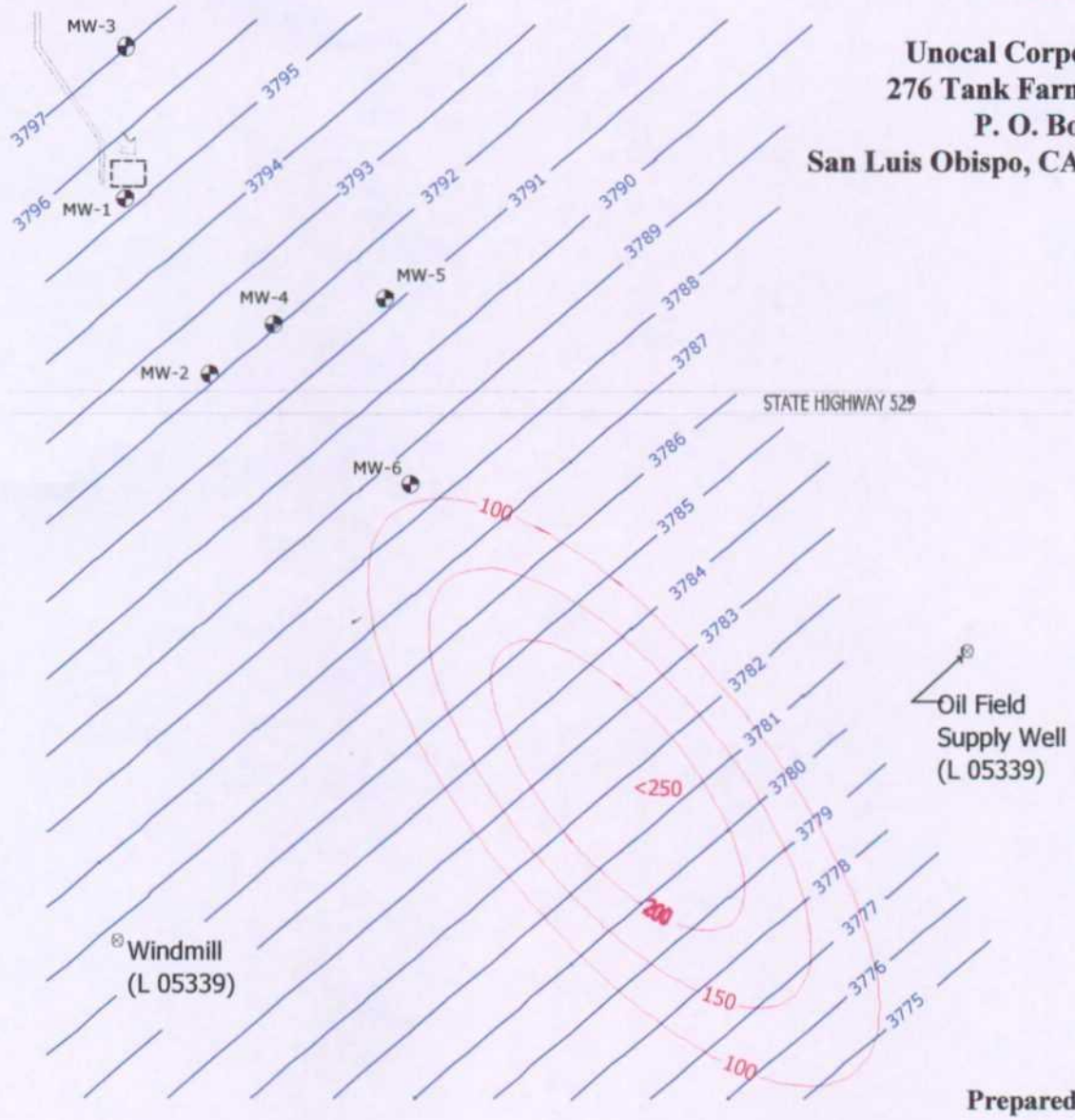
Gilbert J. Van Deventer, REM, PG, NMCS
Trident Environmental – Midland, TX

Attachments

xc: Achebe Hope, Unocal – San Luis Obispo, CA
Chris Kocka, ENSR – Warrenville, IL

2005 Annual Groundwater Monitoring Report
Former Unocal South Vacuum Unit
Section 35, Township 18 South, Range 35 East
Lea County, New Mexico

NOVEMBER 4, 2005



Prepared For:

Unocal Corporation
276 Tank Farm Road
P. O. Box 1069
San Luis Obispo, CA 93406

Prepared By:

TRIDENT ENVIRONMENTAL

P. O. Box 7624
Midland, Texas 79708

2005 Annual Groundwater Monitoring Report

Unocal Corporation

Real Estate and Remediation Services

Former Unocal South Vacuum Unit

Lea County, New Mexico

Prepared by:

Trident Environmental
P. O. Box 7624
Midland, Texas 79708
(432) 638-8740
FAX (413) 403-9968

SUBMITTED BY:

Gilbert J. Van Deventer, PG, NMCS, REM
Project Manager

DATE:

11-4-05

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FIGURES

APPENDICES

1.0 Executive Summary

Trident Environmental (Trident) was retained by ENSR Corporation (ENSR), on behalf of Unocal Corporation (Unocal), to perform the 2005 annual groundwater sampling and monitoring operations at the Former Unocal South Vacuum Unit, which is located at township 18 south, range 35 east, section 35 in Lea County, New Mexico. This report documents the 2005 annual sampling event performed by Trident at the site on August 10, 2005. This report contains the historical groundwater elevation and analytical data from monitoring wells MW-1 through MW-6. The sampling event was conducted in accordance with the November 2, 2000 Groundwater Remediation Plan submitted by Unocal and the requirements specified in the New Mexico Oil and Conservation Division (OCD) letter dated February 8, 2001.

Based on the sampling and monitoring data to date, the following conclusions relevant to groundwater conditions at the Former Unocal South Vacuum Unit are evident:

- Chloride and total dissolved solids (TDS) concentrations in MW-1, near the source area, have generally decreased since 1996. Similarly, chloride and TDS levels have decreased in the closest downgradient well, MW-4, since 1999 when that well was installed. Chloride and TDS concentrations in the remaining wells (MW-2, MW-3, MW-5, and MW-6) have remained relatively consistent with previous levels.

- The fate and transport modeling results continue to support the contention that the chloride and TDS plume is not likely to impact existing sources of water supply, the closest of which, a livestock well (Windmill L 05339) lies approximately 3,200 feet south of the source.

- According to conservative model simulations, the chloride plume will travel a maximum of 3,400 feet southeast of the source in approximately 153 years before concentrations return to levels below the New Mexico Water Quality Control Commission (WQCC) standard of 250 mg/L. The same analysis indicates that the TDS plume will travel only 2,200 feet in approximately 88 years before concentrations return to levels below the WQCC standard of 1,000 mg/L.

- Based on the modeling results and predicted natural attenuation processes (advection and dispersion), there will be no adverse impact to human health and the environment nor will the livestock well exceed WQCC standards for chlorides or TDS due to the plume originating and traveling southeast, versus south, from the former emergency overflow pit.

- Groundwater elevations had steadily decreased at a rate of approximately 0.3 feet per year since the initial sampling event of monitoring well MW-1 in January 1995; however during 2005 the groundwater table has increased to an elevation similar to the 1999 level. The recent rise may be attributed to higher than normal rainfall during 2004 and 2005.

Unocal has performed exemplary remedial actions to the source area, including plugging of the SWD well in 1971 and encapsulating the former surface impoundment area with solidification material in 1995, thus eliminating the threat of any continued release from the source. Based on the identified potential receptor and fate and transport modeling results, the chloride/TDS plume at the site presents low risk to human health and the environment; therefore Trident recommends the following actions for site closure:

- Continue the natural attenuation annual monitoring program with groundwater sampling and analysis of chloride and TDS concentrations for each of the six monitoring wells.

- Update flow and transport model to confirm the plume is naturally attenuating as described.

- Submit the 2006 annual groundwater monitoring report to OCD in January 2007 to document natural attenuation conditions.

2.0 Groundwater Sampling Procedures

Each of the six monitoring wells, MW-1 through MW-6, was gauged for depth to groundwater using a Solinst Model 101 electronic water indicator immediately prior to purging operations. A total of 36 gallons of groundwater was purged from each site monitoring well (5 to 10 gallons per well) using a decontaminated 2-inch diameter PVC bailer. After purging, groundwater samples were collected and parameters were measured using a Hanna Model 98130 pH-Conductivity-Temperature meter. Water samples for each monitoring well were transferred into 500 milliliter (ml) plastic containers for laboratory analysis of total dissolved solids (TDS) (EPA Method 160.1) and chloride (EPA Method 325.3). For each set of samples, chain of custody forms documenting sample identification numbers, collection times, and delivery times to the laboratory were completed. All water samples were placed in an ice-filled cooler immediately after collection and transported to SPL, Inc. in Houston, Texas for analysis.

3.0 Groundwater Elevations, Hydraulic Gradient and Flow Direction

Depth to groundwater varies from approximately 49.58 to 70.33 feet below top of well casing at the site. Groundwater elevations are summarized in Table 1. A groundwater gradient map indicating the direction of groundwater flow is illustrated in Figure 1. A historical groundwater elevation graph is shown in Figure 2. The groundwater gradient direction is to the southeast with a hydraulic gradient of approximately 0.004 ft/ft. According to published reports (*Ground-Water Conditions in Northern Lea County, New Mexico*, Ash, 1963 and *Geology and Ground-Water Conditions in Southern Lea County, New Mexico*, Nicholson and Clebsch, 1961) the groundwater encountered at the site is that of the Tertiary Ogallala Formation. The Ogallala Formation unconformably overlies the impermeable red-beds of the Triassic Chinle Formation at an elevation of approximately 3700 feet above mean sea level (AMSL). Based on the current groundwater elevations measured on site and published data referenced, the saturated thickness of the Ogallala Formation at the site ranges from approximately 87 to 97 feet.

4.0 Groundwater Quality Conditions

Groundwater sample analytical results are presented in Table 1. The WQCC standards are presented for comparison. Those constituents that recorded concentrations above the WQCC standards are highlighted in boldface type. The WQCC standard of 250 mg/L for chloride was exceeded in MW-1 (774 mg/L), MW-2 (355 mg/L), and MW-4 (1,050 mg/L). The WQCC standard of 1,000 mg/L for TDS was exceeded in MW-1 (1,830 mg/L) and MW-4 (2,230 mg/L). The groundwater samples obtained from upgradient monitoring well MW-3 and downgradient wells MW-5 and MW-6 had chloride and TDS concentrations below WQCC standards.

The chloride and TDS concentrations are depicted graphically in Figure 3 and 4, respectively. The concentration isocons were drawn utilizing the Surfer® (version 6.0) contour modeling program (Kriging method). Since this contouring program does not take into account the known groundwater gradient, some of the isocons were manually converged into a more southeasterly orientation. Graphs depicting historical TDS and chloride concentrations in monitoring wells MW-1 through MW-6 are shown in Figures 5 and 6.

Chloride and TDS concentrations in MW-1, near the source area, have consistently decreased since 1996, with the exception of slight fluctuations since the 2003 sampling event. Similarly, chloride and TDS levels have decreased in the closest downgradient well, MW-4, since 1999 when that well was installed. Chloride concentrations in monitoring well MW-3 have slightly increased since 2000, however TDS concentrations have continued to decline. Chloride and TDS levels in MW-2, MW-5, and MW-6 have remained relatively consistent with previous years.

5.0 Fate and Transport Modeling Results

Fate and transport modeling was performed by Trident to simulate the movement of the chloride and TDS groundwater plume over time. Simulations were conducted using the two-dimensional groundwater flow and contaminant transport model WinTran, version 1.03 (1995) designed and distributed by Environmental Simulations, Inc. (ESI) of Herndon, Virginia. WinTran is built around a steady-state analytical element flow model, linked to a finite element contaminant transport model. A more detailed discussion of the flow and transport parameters used, assumptions, model calibrations, and simulation results are described in Appendix C.

Figures 7A and 7B show the close match achieved by the chloride and TDS modeling simulations as compared to the current observed plume (Figures 3 and 4). Hydrodynamic dispersion serves to broaden the dimensions of the plume while reducing the concentrations in the middle of the plume, as depicted in Figures 8A and 8B (50 years from now). Advective flow moves the center of plume mass downgradient by a distance of approximately 1,500 feet from the former source area (SWD pit) and approximately 300 feet upgradient from well MW-6.

Continued attenuation by dilution and dispersion of the plume, after the maximum chloride and TDS concentrations decrease to levels below WQCC standards, is shown in Figures 9A (year 2158) and 9B (year 2093), respectively. The center of the chloride plume is approximately 3,400 ft away from the pit and well source in the year 2158. The center of the TDS plume is approximately 2,200 ft away from the pit and well source in the year 2093.

The portions of the chloride and TDS plumes that are above WQCC standards do not reach any of the identified potential receptors at any time during their attenuation. The updated fate and transport model is consistent with that determined in the previous annual reports, however the plumes attenuate sooner and at a reduced terminal distance as a result of inputting the most recent chloride and TDS concentrations.

6.0 Conclusions

Conclusions relevant to groundwater conditions and the remediation performance at the Former Unocal South Vacuum Unit are presented below.

- Chloride and TDS concentrations in MW-1, near the source area, have generally decreased since 1996. Similarly, chloride and TDS levels have decreased in the closest downgradient well, MW-4, since 1999 when that well was installed. Chloride and TDS concentrations in the remaining wells (MW-2, MW-3, MW-5, and MW-6) have remained relatively consistent with previous levels.
- The fate and transport modeling results continue to support the contention that the chloride and total dissolved solids (TDS) plume is not likely to impact existing sources of water supply, the closest of which, a livestock well (Windmill L 05339), lies approximately 3,200 feet south of the source.
- According to conservative model simulations, the chloride plume will travel a maximum of 3,400 feet southeast of the source in approximately 153 years before concentrations return to levels below the New Mexico Water Quality Control Commission (WQCC) standard of 250 mg/L. The same analysis indicates that the TDS plume will travel only 2,200 feet in approximately 88 years before concentrations return to levels below the WQCC standard of 1,000 mg/L.
- Based on the modeling results and predicted natural attenuation processes (dispersion and dilution), there will be no adverse impact to human health and the environment nor will the livestock well (Windmill L 05339) exceed WQCC standards for chlorides or TDS due to the plume originating and traveling southeast, versus south, from the former emergency overflow pit.
- Groundwater elevations had steadily decreased at a rate of approximately 0.3 feet per year since the initial sampling event of monitoring well MW-1 in January 1995; however during 2005 the groundwater table has increased to an elevation similar to the 1999 level. The recent rise may be attributed to higher than normal rainfall during 2004 and 2005.

7.0 Recommendations

Unocal has performed exemplary remedial actions to the source area, including plugging of the SWD well in 1971 and encapsulating the former surface impoundment area with solidification material in 1995, thus eliminating the threat of any continued release from the source. Based on the identified potential receptor and fate and transport modeling results, the chloride/TDS plume at the site presents low risk to human health and the environment; therefore Trident recommends the following actions for site closure:

- Continue the natural attenuation annual monitoring program with groundwater sampling and analysis of chloride and TDS concentrations for each of the six monitoring wells.
- Update flow and transport model to confirm the plume is naturally attenuating as described.
- Submit the 2006 annual groundwater monitoring report to OCD in January 2007 to document natural attenuation conditions.

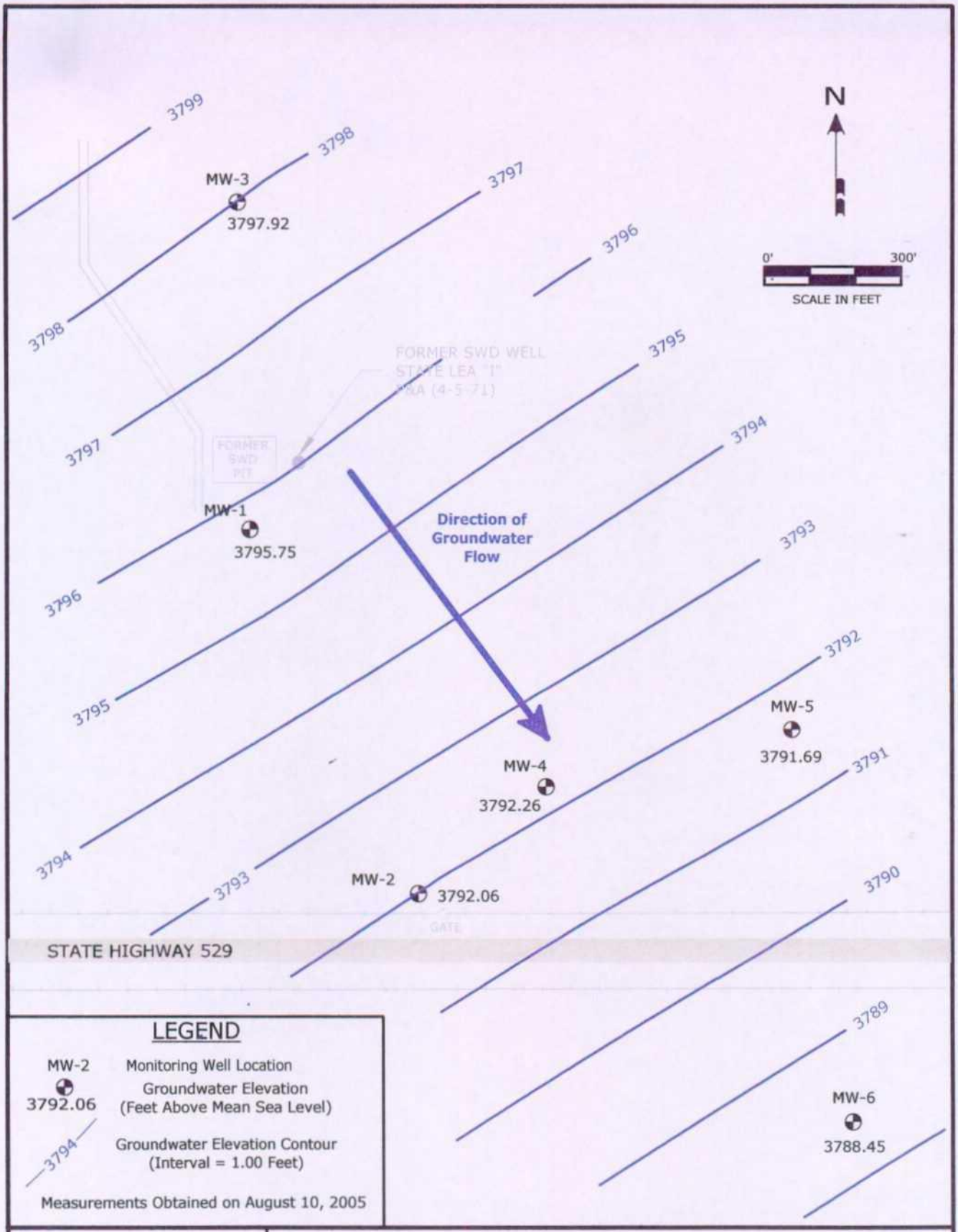
TABLES

Table 1
Summary of Groundwater Sampling Results
Former Unocal South Vacuum Unit

Monitoring Well	Sampling Date	Chloride (mg/L)	TDS (mg/L)	Depth to Groundwater (feet BTOC)	Top of Casing Elevation (feet AMSL)	Groundwater Elevation (feet AMSL)
MW-1	01/27/95	**1174**	**2250**	59.57	3858.37	3798.80
	05/18/95	**983**	**2251**	61.30	3858.37	3797.07
	08/28/96	**1420**	**2730**	61.57	3858.37	3796.80
	08/13/97	**1400**	**2800**	61.75	3858.37	3796.62
	09/30/99	**1094**	**2318**	62.51	3858.37	3795.86
	06/14/00	**927**	**2040**	62.85	3858.37	3795.52
	06/18/01	**813**	**1790**	63.07	3858.37	3795.30
	07/11/02	**784**	**1680**	63.28	3858.37	3795.09
	07/02/03	**715**	**2090**	63.66	3858.37	3794.71
	08/12/04	**628**	**2050**	63.83	3858.37	3794.54
	08/10/05	**774**	**1830**	62.62	3858.37	3795.75
MW-2	09/30/99	**298**	922	49.51	3841.64	3792.13
	06/14/00	**317**	852	49.81	3841.64	3791.83
	06/18/01	**288**	878	50.06	3841.64	3791.58
	07/11/02	**284**	808	50.29	3841.64	3791.35
	07/02/03	**268**	859	50.63	3841.64	3791.01
	08/12/04	**451**	931	50.81	3841.64	3790.83
	08/10/05	**355**	844	49.58	3841.64	3792.06
MW-3	09/30/99	73.6	427	66.74	3864.73	3797.99
	06/14/00	75.5	433	67.01	3864.73	3797.72
	06/18/01	86.4	495	67.29	3864.73	3797.44
	07/11/02	103	509	67.59	3864.73	3797.14
	07/02/03	98.3	588	67.94	3864.73	3796.79
	08/12/04	111	605	68.07	3864.73	3796.66
	08/10/05	122	533	66.81	3864.73	3797.92
MW-4	09/30/99	**1576**	**2981**	60.18	3852.51	3792.33
	06/14/00	**1500**	**2910**	60.55	3852.51	3791.96
	06/18/01	**1530**	**3180**	60.78	3852.51	3791.73
	07/11/02	**1290**	**2660**	60.98	3852.51	3791.53
	07/02/03	**1250**	**2610**	61.34	3852.51	3791.17
	08/12/04	**1130**	**2480**	61.50	3852.51	3791.01
	08/10/05	**1050**	**2230**	60.25	3852.51	3792.26
MW-5	06/14/00	13.7	274	68.57	3859.84	3791.27
	06/18/01	13.6	322	68.80	3859.84	3791.04
	07/11/02	15.5	308	68.98	3859.84	3790.86
	07/02/03	12.5	359	69.32	3859.84	3790.52
	08/12/04	15.3	375	69.46	3859.84	3790.38
	08/10/05	14.9	309	68.15	3859.84	3791.69
MW-6	06/14/00	48	382	70.79	3858.78	3787.99
	06/18/01	50.8	431	70.98	3858.78	3787.80
	07/11/02	50	422	71.26	3858.78	3787.52
	07/02/03	46.5	471	71.52	3858.78	3787.26
	08/12/04	55.1	410	71.62	3858.78	3787.16
	08/10/05	55	391	70.33	3858.78	3788.45
WQCC Standards		250	1000			

Total Dissolved Soilds (TDS) and chloride concentrations listed in milligrams per liter (mg/L)
Analyses performed by Trace Analysis Inc., Lubbock, TX (1995-1998) and SPL, Inc., Houston, TX (1999-2000).
Values in boldface type indicate concentrations exceed New Mexico Water Quality Commission (WQCC) standards.
AMSL - Above Mean Sea Level; BTOC - Below Top of Casing
Groundwater flow direction is to the southeast with a gradient of approx. 0.004 ft/ft.
Elevations and state plane coordinates surveyed by Basin Surveys, Hobbs, NM.

FIGURES



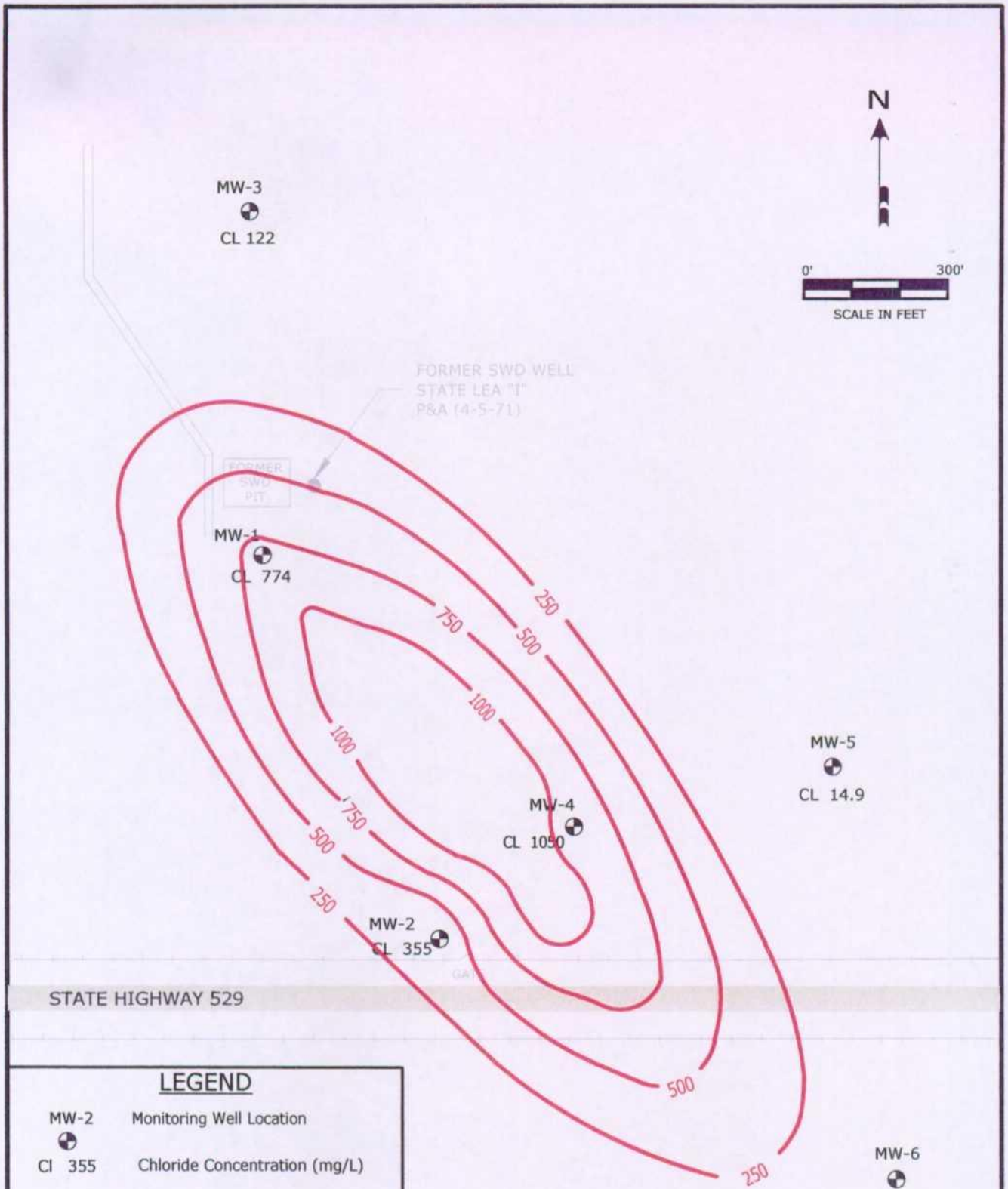
TRIDENT ENVIRONMENTAL

FIGURE 1

Former Unocal South Vacuum Unit

Groundwater Gradient Map

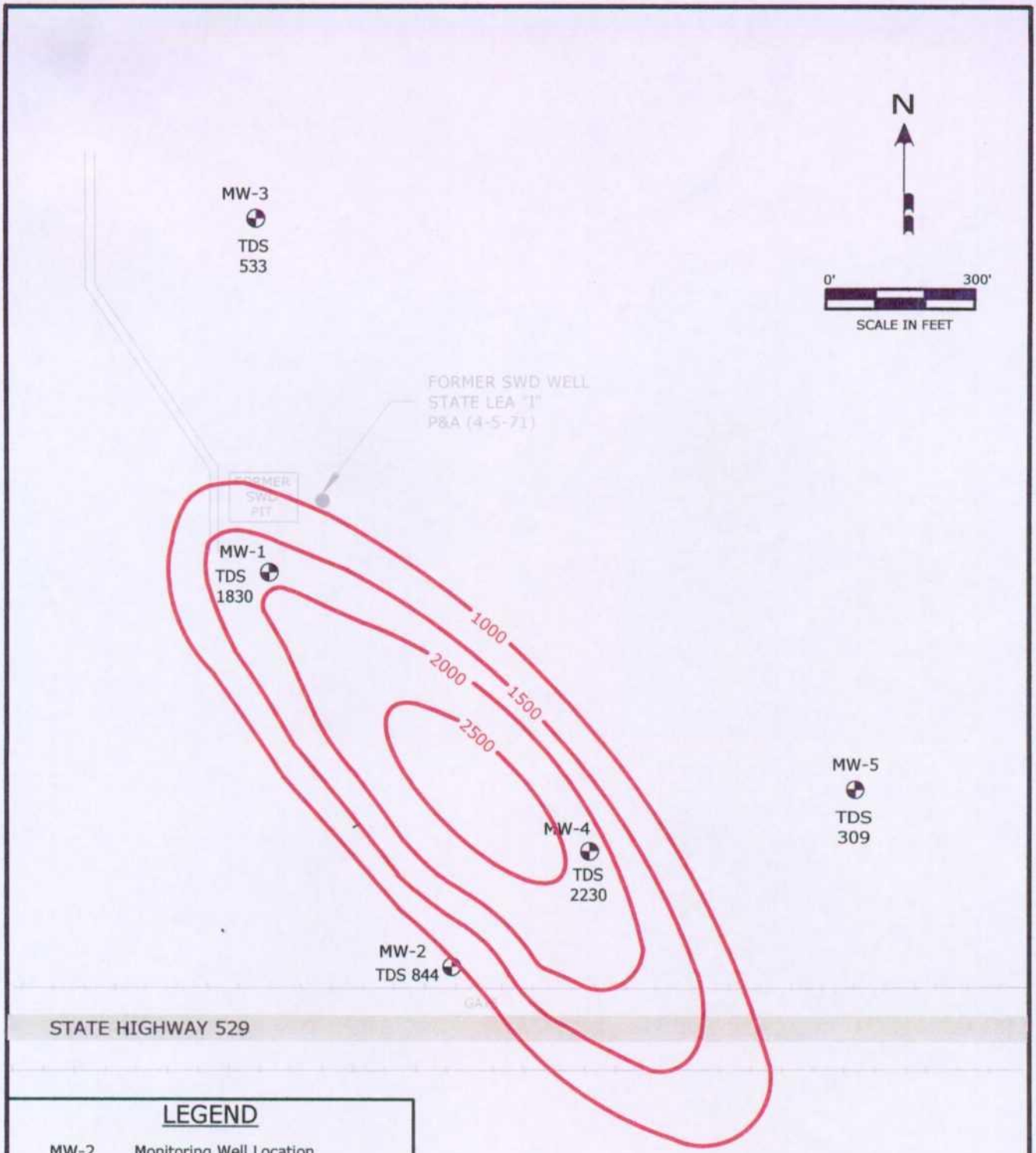
Figure 2
Historical Groundwater Elevations



TRIDENT ENVIRONMENTAL

FIGURE 3

Former Unocal South Vacuum Unit
Chloride Concentration Map
Current Conditions



TRIDENT ENVIRONMENTAL

FIGURE 4

Former Unocal South Vacuum Unit
TDS Concentration Map
Current Conditions

Figure 5
Chloride Concentrations Versus Time Graph

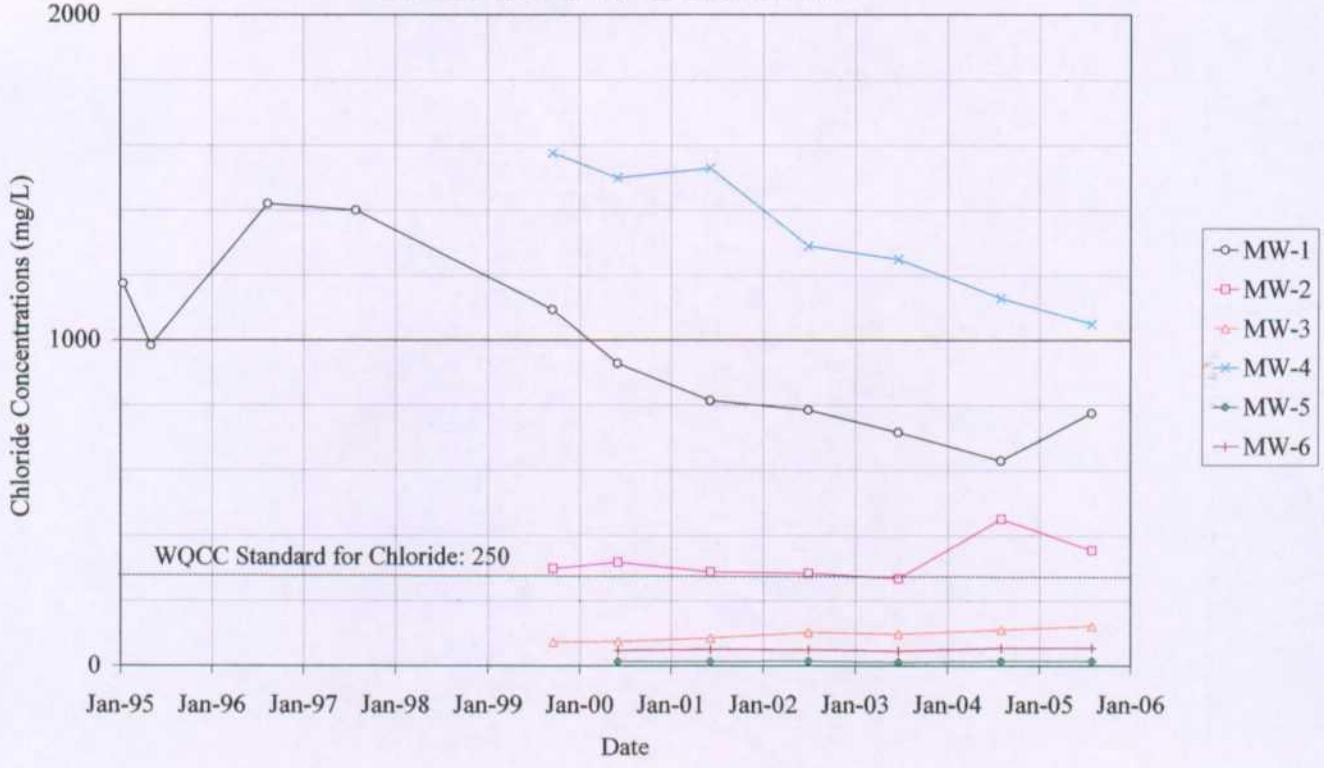
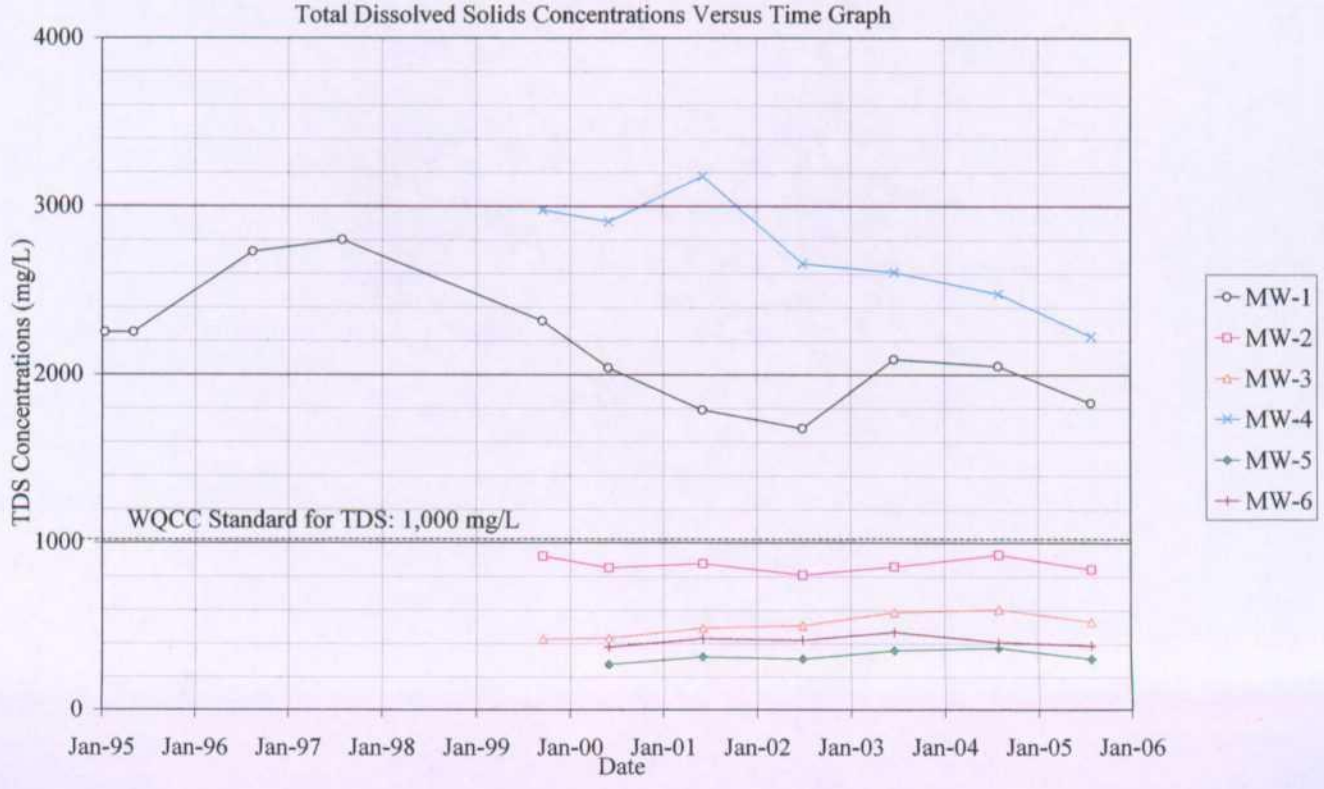
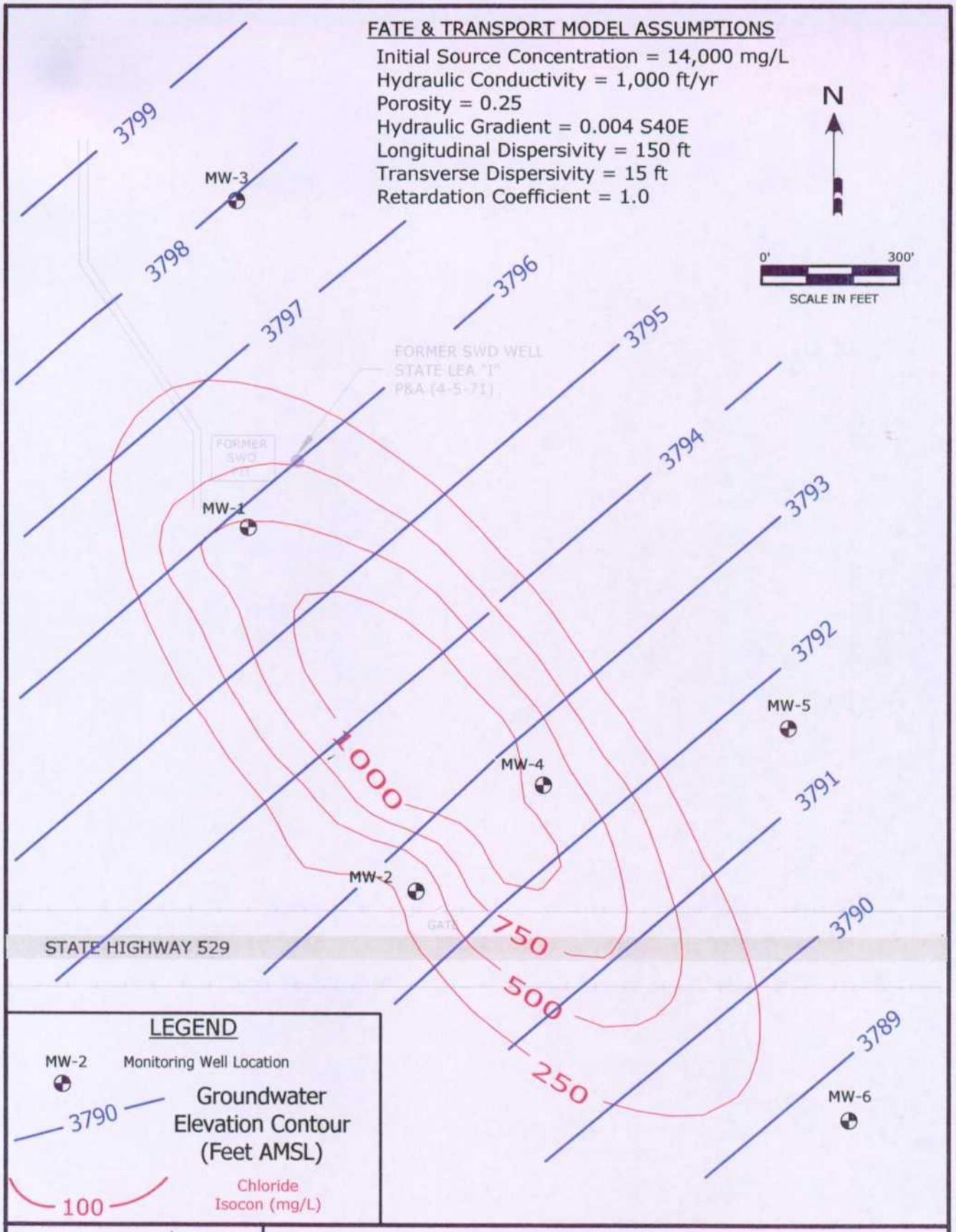


Figure 6
Total Dissolved Solids Concentrations Versus Time Graph

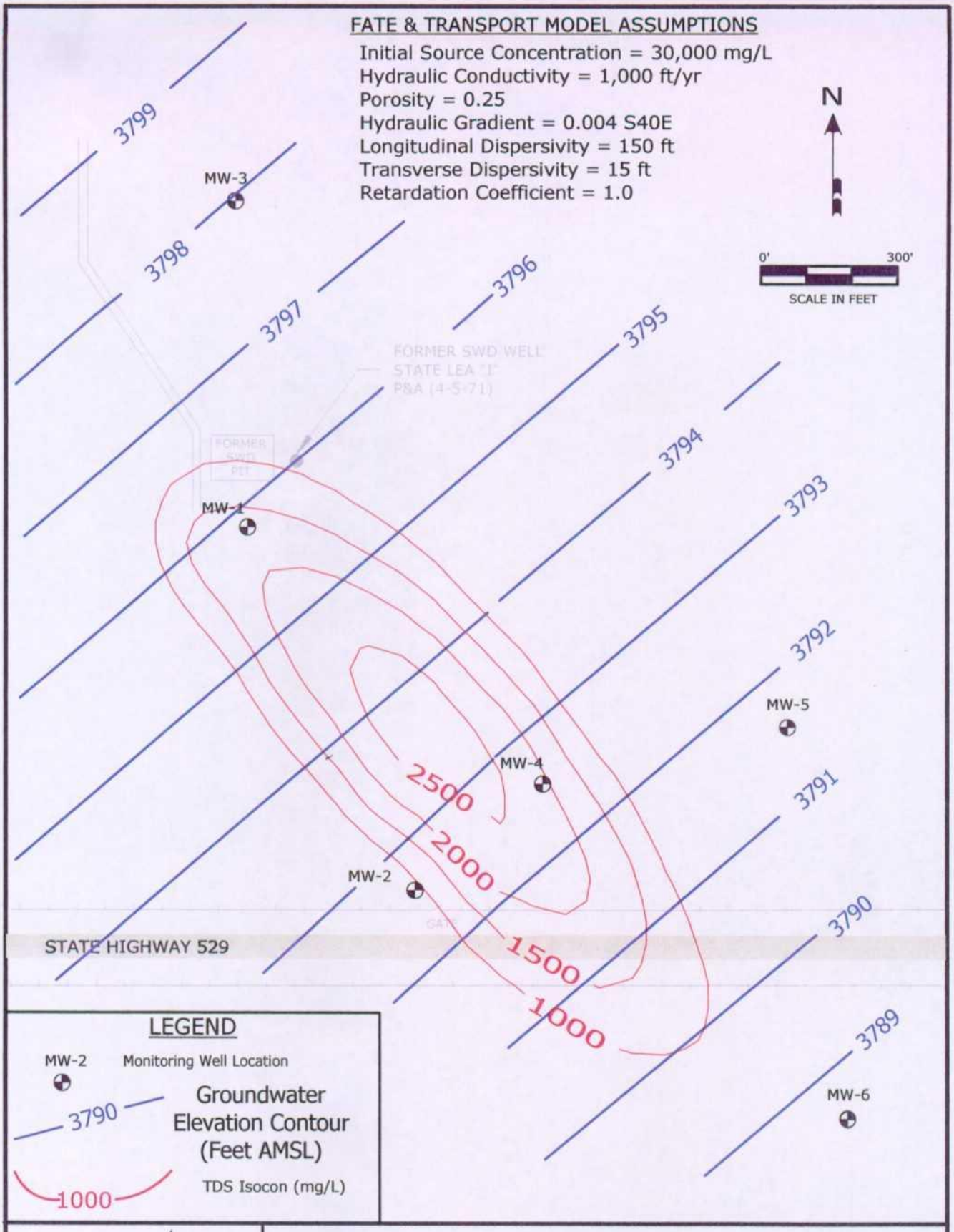




TRIDENT ENVIRONMENTAL

FIGURE 7A

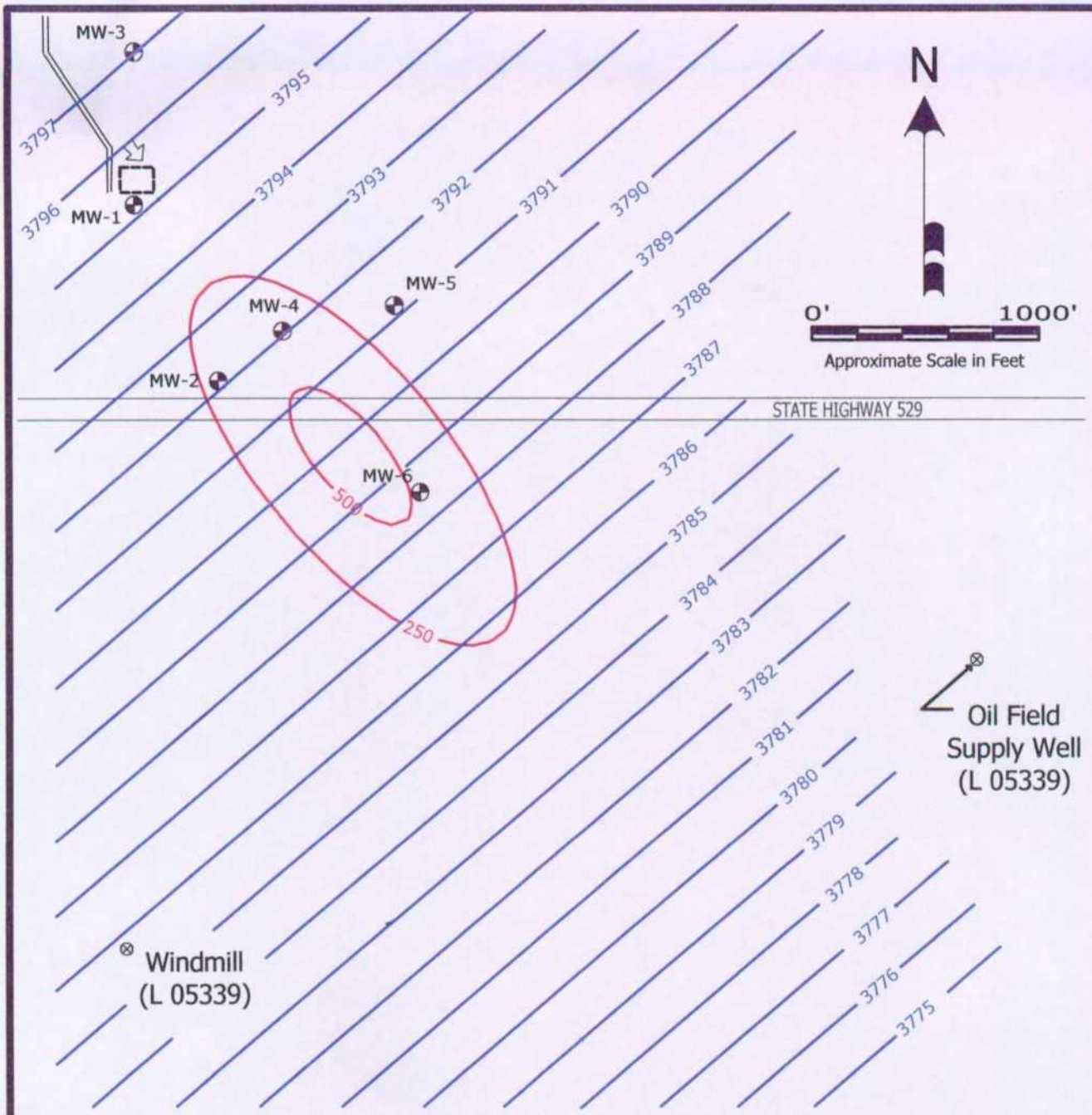
Former Unocal South Vacuum Unit
34-Year Chloride Plume Simulation (1971-2005)
Based on WinTran Modeling Results



TRIDENT ENVIRONMENTAL

FIGURE 7B

Former Unocal South Vacuum Unit
34-Year TDS Plume Simulation (1971-2005)
Based on WinTran Modeling Results



FATE & TRANSPORT MODEL ASSUMPTIONS

Initial Source Concentration = 14,000 mg/L
Hydraulic Conductivity = 1,000 ft/yr
Porosity = 0.25
Hydraulic Gradient = 0.004 S40E
Longitudinal Dispersivity = 150 ft
Transverse Dispersivity = 15 ft
Retardation Coefficient = 1.0

LEGEND

MW-5 Monitoring Well Location

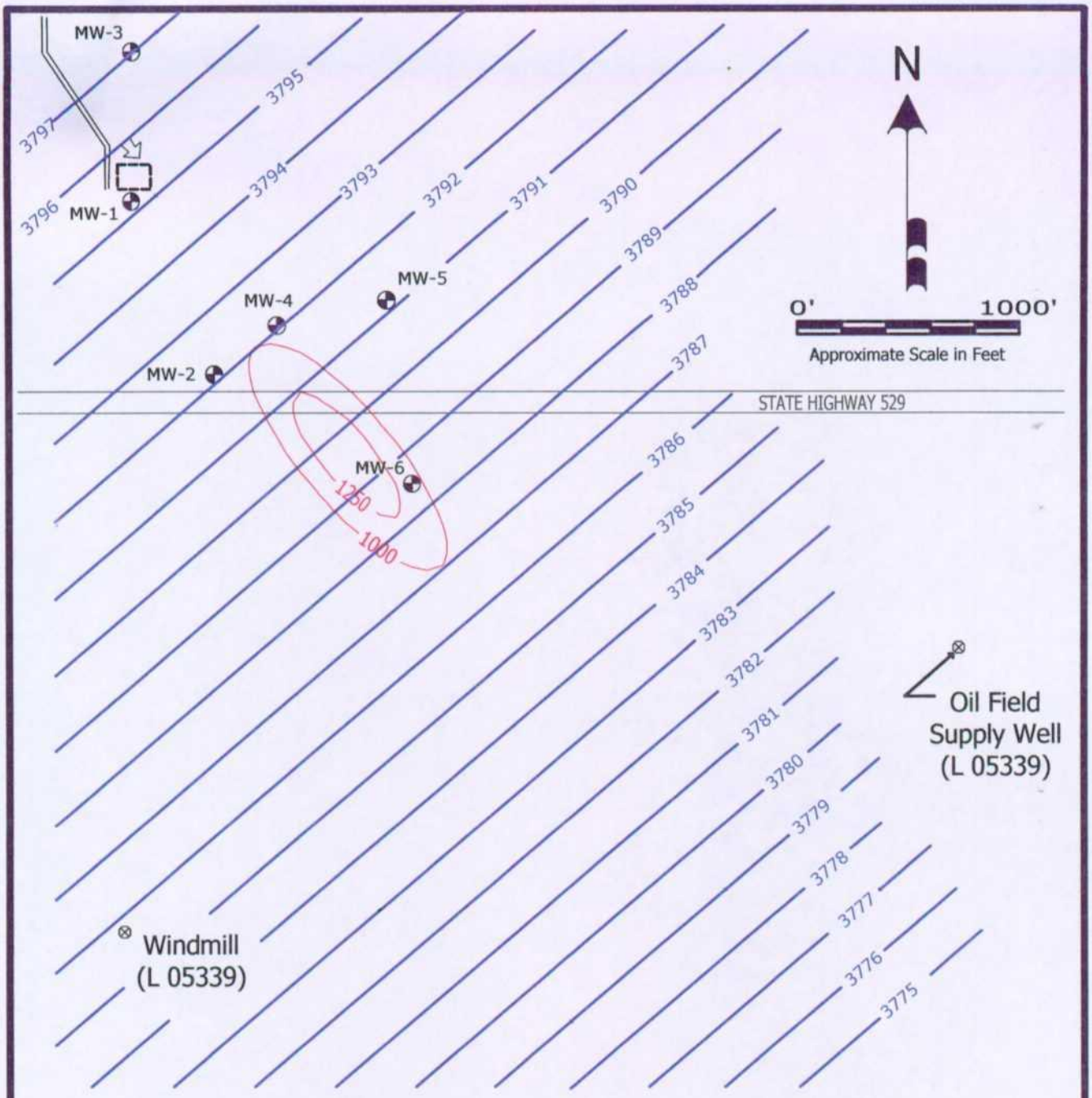
3790 Groundwater Elevation Contour

100 Chloride Isocon (mg/L)

TRIDENT ENVIRONMENTAL

FIGURE 8A

Former Unocal South Vacuum Unit
50-Year Chloride Plume Simulation (2005-2055)
Based on WinTran Modeling Results



FATE & TRANSPORT MODEL ASSUMPTIONS

Initial Source Concentration = 30000 mg/L
Hydraulic Conductivity = 1000 ft/yr
Porosity = 0.25
Hydraulic Gradient = 0.004 S40E
Longitudinal Dispersivity = 150 ft
Transverse Dispersivity = 15 ft
Retardation Coefficient = 1.0

LEGEND

MW-5 Monitoring Well Location

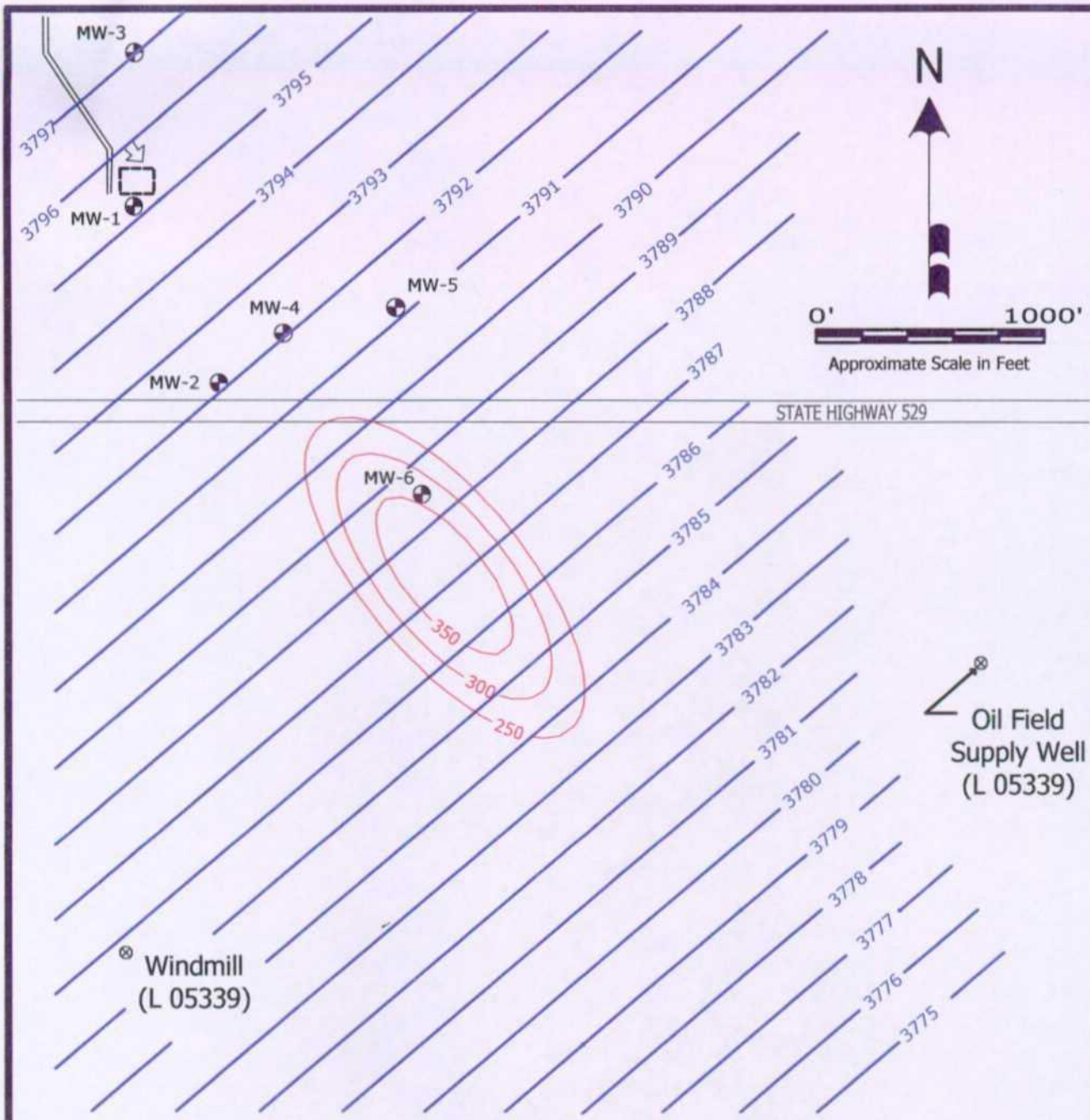
3790 Groundwater Elevation Contour

100 TDS Isocon (mg/L)

TRIDENT ENVIRONMENTAL

FIGURE 8B

Former Unocal South Vacuum Unit
50-Year TDS Plume Simulation (2005-2055)
Based on WinTran Modeling Results



FATE & TRANSPORT MODEL ASSUMPTIONS

Initial Source Concentration = 14,000 mg/L
Hydraulic Conductivity = 1,000 ft/yr
Porosity = 0.25
Hydraulic Gradient = 0.004 S40E
Longitudinal Dispersivity = 150 ft
Transverse Dispersivity = 15 ft
Retardation Coefficient = 1.0

LEGEND

MW-5 Monitoring Well Location

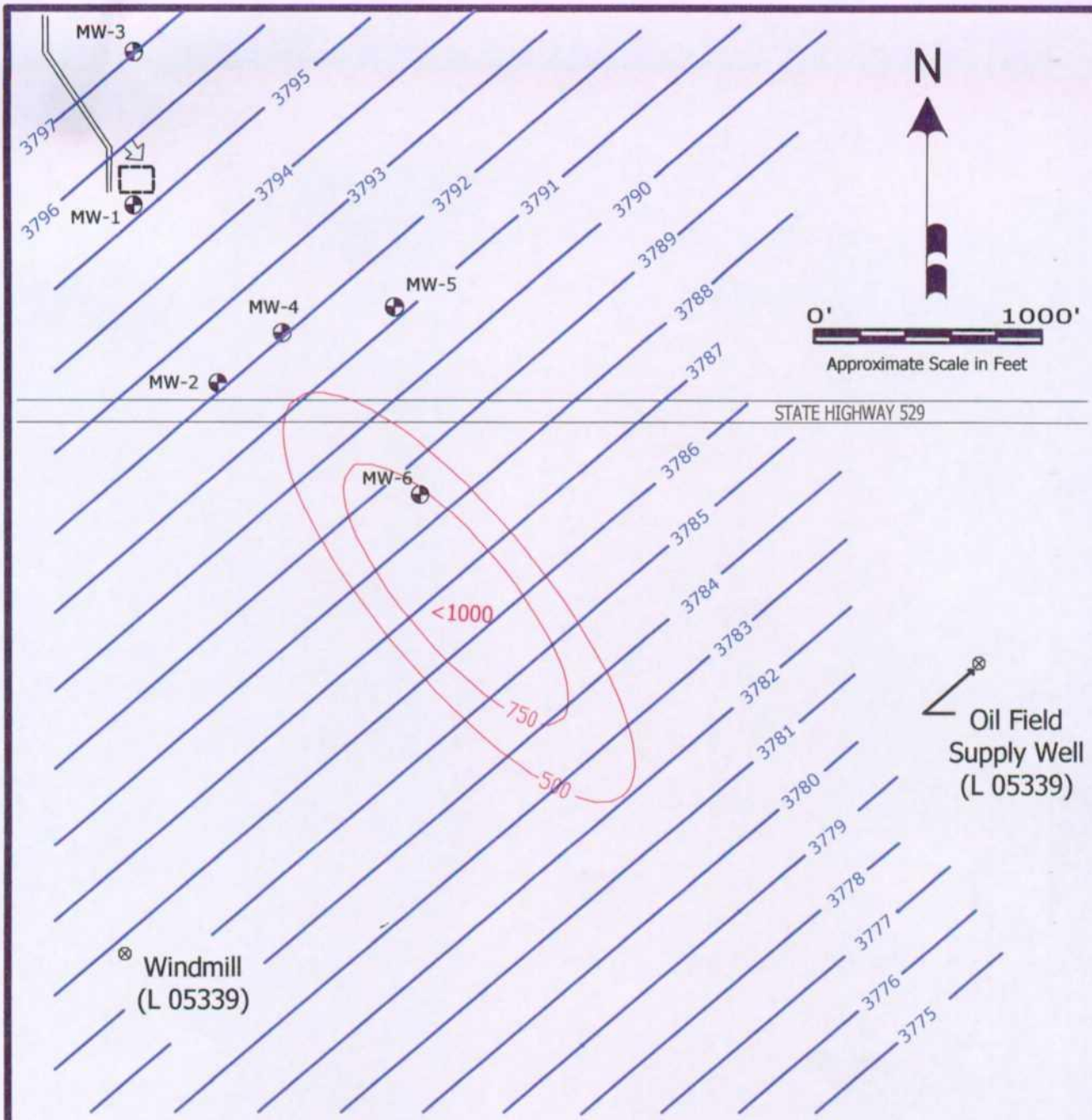
3790 Groundwater Elevation Contour

100 Chloride Isocon (mg/L)

TRIDENT ENVIRONMENTAL

FIGURE 9A

Former Unocal South Vacuum Unit
88 Year Chloride Plume Simulation (2005-2093)
Based on WinTran Modeling Results



FATE & TRANSPORT MODEL ASSUMPTIONS

Initial Source Concentration = 30000 mg/L
Hydraulic Conductivity = 1000 ft/yr
Porosity = 0.25
Hydraulic Gradient = 0.004 S40E
Longitudinal Dispersivity = 150 ft
Transverse Dispersivity = 15 ft
Retardation Coefficient = 1.0

LEGEND

MW-5 Monitoring Well Location

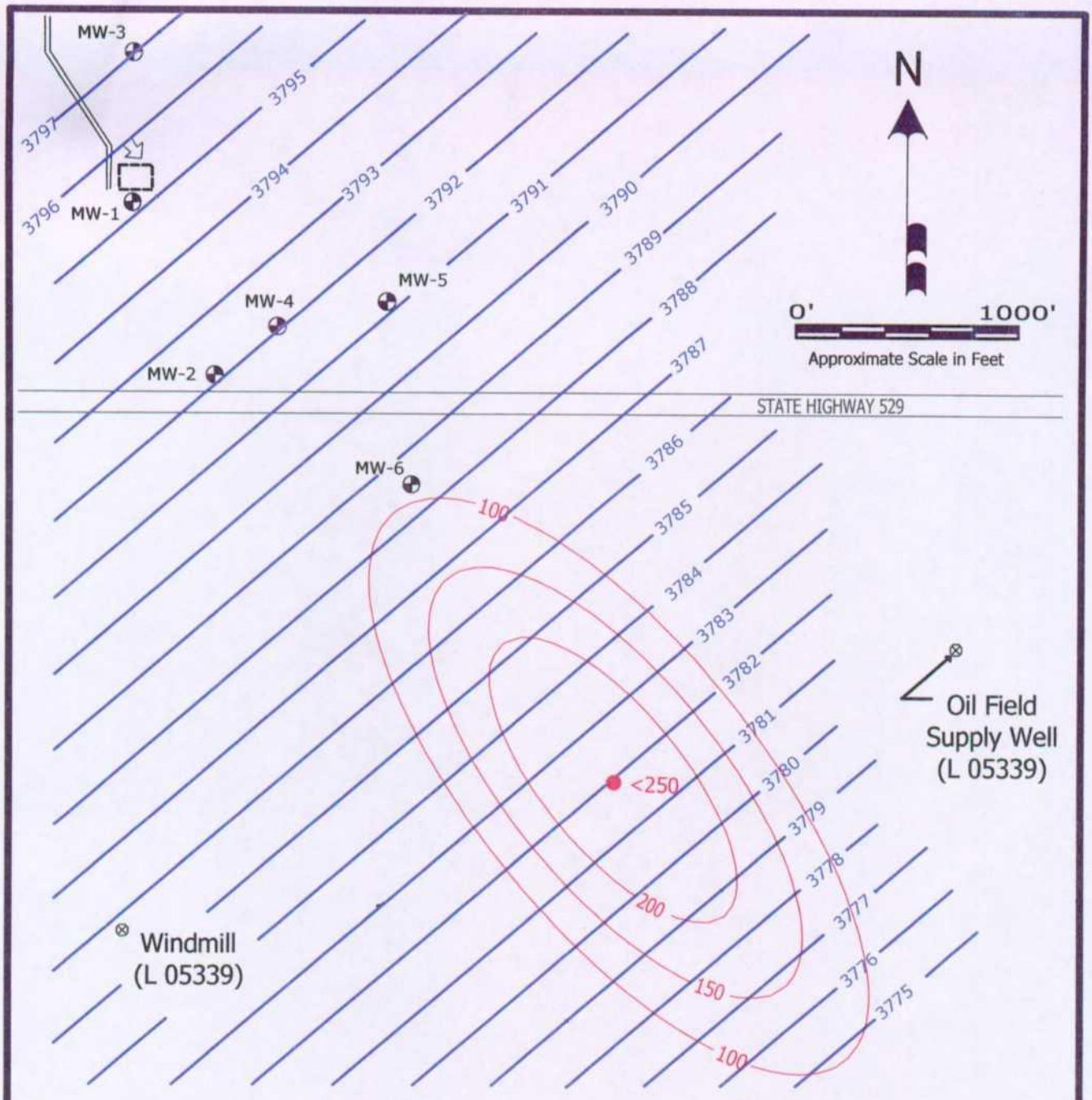
3790 Groundwater Elevation Contour

100 TDS Isocon (mg/L)

TRIDENT ENVIRONMENTAL

FIGURE 9B

Former Unocal South Vacuum Unit
88-Year TDS Plume Simulation (2005-2093)
Based on WinTran Modeling Results



FATE & TRANSPORT MODEL ASSUMPTIONS

Initial Source Concentration = 14,000 mg/L
Hydraulic Conductivity = 1,000 ft/yr
Porosity = 0.25
Hydraulic Gradient = 0.004 S40E
Longitudinal Dispersivity = 150 ft
Transverse Dispersivity = 15 ft
Retardation Coefficient = 1.0

LEGEND

MW-5 Monitoring Well Location

3790 Groundwater Elevation Contour

100 Chloride Isocon (mg/L)

TRIDENT ENVIRONMENTAL

FIGURE 10

Former Unocal South Vacuum Unit
153 Year Chloride Plume Simulation (2005-2158)
Based on WinTran Modeling Results

APPENDIX A

Laboratory Analytical Reports

And

Chain-of-Custody Documentation

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Unocal Corporation

Certificate of Analysis Number:

05080760

Report To:		Project Name:	Former Unocal South Vacuum Unit
ENSR International		Site:	Sec 35-T18S-R35E Lea County, NM
Chris Kocka		Site Address:	
27755 Diehl Road, Suite 100			
Warrenville		PO Number:	7963
IL		State:	New Mexico
60555-3998		State Cert. No.:	
ph: (630) 836-1700	fax:	Date Reported:	8/31/2005

This Report Contains A Total Of 14 Pages

Excluding This Page, Chain Of Custody

And

Any Attachments

8/31/2005

Date

Test results meet all requirements of NELAC, unless specified in the narrative.

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Case Narrative for:

Unocal Corporation

Certificate of Analysis Number:

05080760

Report To:		Project Name:	Former Unocal South Vacuum Unit
ENSR International		Site:	Sec 35-T18S-R35E Lea County, NM
Chris Kocka		Site Address:	
27755 Diehl Road, Suite 100			
Warrenville		PO Number:	7963
IL		State:	New Mexico
60555-3998		State Cert. No.:	
ph: (630) 836-1700	fax:	Date Reported:	8/31/2005

The samples in this report were received on the last day of holding time for the Total Dissoved Solids (TDS) analysis. The samples were analyzed for TDS on the day of sample receipt. Sample MW-5 (SPL ID: 05080760-05) had to be re-analyzed for TDS and the result reported is past the holding time.

Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report (" mg\kg-dry " or " ug\kg-dry ").

Matrix spike (MS) and matrix spike duplicate (MSD) samples are chosen and tested at random from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. Since the MS and MSD are chosen at random from an analytical batch, the sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The Laboratory Control Sample (LCS) and the Method Blank (MB) are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

Any other exceptions associated with this report will be footnoted in the analytical result page(s) or the quality control summary page(s).

Please do not hesitate to contact us if you have any questions or comments pertaining to this data report. Please reference the above Certificate of Analysis Number.

SPL, Inc. is pleased to be of service to you. We anticipate working with you in fulfilling all your current and future analytical needs.

8/31/2005

Elessa Sommers — Date
Senior Project Manager

Test results meet all requirements of NELAC, unless specified in the narrative.

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Unocal Corporation

Certificate of Analysis Number:

05080760

Report To: ENSR International
Chris Kocka
27755 Diehl Road, Suite 100

Warrenville
IL
60555-3998
ph: (630) 836-1700 fax: (630) 836-1711

Fax To:

Project Name: Former Unocal South Vacuum Unit
Site: Sec 35-T18S-R35E Lea County, NM
Site Address:

PO Number: 7963
State: New Mexico
State Cert. No.:
Date Reported: 8/31/2005

Client Sample ID	Lab Sample ID	Matrix	Date Collected	Date Received	COC ID	HOLD
MW-1	05080760-01	Water	8/10/2005 11:50:00 AM	8/17/2005 9:30:00 AM	227437	☐
MW-2	05080760-02	Water	8/10/2005 10:50:00 AM	8/17/2005 9:30:00 AM	227437	☐
MW-3	05080760-03	Water	8/10/2005 12:35:00 PM	8/17/2005 9:30:00 AM	227437	☐
MW-4	05080760-04	Water	8/10/2005 11:21:00 AM	8/17/2005 9:30:00 AM	227437	☐
MW-5	05080760-05	Water	8/10/2005 1:06:00 PM	8/17/2005 9:30:00 AM	227437	☐
MW-6	05080760-06	Water	8/10/2005 1:42:00 PM	8/17/2005 9:30:00 AM	227437	☐

8/31/2005

Elessa Sommers
Senior Project Manager

Date

Joel Grice
Laboratory Director

Ted Yen
Quality Assurance Officer

8/31/2005 5:42:15 PM

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID: MW-1 **Collected:** 08/10/2005 11:50 **SPL Sample ID:** 05080760-01

Site: Sec 35-T18S-R35E Lea County, NM

Analyses/Method	Result	QUAL	Rep.Limit	Dil. Factor	Date Analyzed	Analyst	Seq. #
CHLORIDE, TOTAL				**MCL**	**E325.2**	**Units: mg/L**	
Chloride	774		10	10	08/18/05 12:26	T_H	2904971
TOTAL DISSOLVED SOLIDS				**MCL**	**E160.1**	**Units: mg/L**	
Total Dissolved Solids (Residue,Filterable)	1830		10	1	08/17/05 16:00	A_E	2905335

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
* - Surrogate Recovery Outside Advisable QC Limits
J - Estimated Value between MDL and PQL
>MCL - Result Over Maximum Contamination Limit(MCL)
D - Surrogate Recovery Unreportable due to Dilution
MI - Matrix Interference

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID: MW-2 **Collected:** 08/10/2005 10:50 **SPL Sample ID:** 05080760-02

Site: Sec 35-T18S-R35E Lea County, NM

Analyses/Method	Result	QUAL	Rep.Limit	Dil. Factor	Date Analyzed	Analyst	Seq. #
CHLORIDE, TOTAL				**MCL**	**E325.2**	**Units: mg/L**	
Chloride	355		10	10	08/18/05 12:26	T_H	2904972
TOTAL DISSOLVED SOLIDS				**MCL**	**E160.1**	**Units: mg/L**	
Total Dissolved Solids (Residue,Filterable)	844		10	1	08/17/05 16:00	A_E	2905336

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
* - Surrogate Recovery Outside Advisable QC Limits
J - Estimated Value between MDL and PQL
>MCL - Result Over Maximum Contamination Limit(MCL)
D - Surrogate Recovery Unreportable due to Dilution
MI - Matrix Interference

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID: MW-3 **Collected:** 08/10/2005 12:35 **SPL Sample ID:** 05080760-03

Site: Sec 35-T18S-R35E Lea County, NM

Analyses/Method	Result	QUAL	Rep.Limit	Dil. Factor	Date Analyzed	Analyst	Seq. #
CHLORIDE, TOTAL				**MCL**	**E325.2**	**Units: mg/L**	
Chloride	122		2	2	08/18/05 12:26	T_H	2904973
TOTAL DISSOLVED SOLIDS				**MCL**	**E160.1**	**Units: mg/L**	
Total Dissolved Solids (Residue,Filterable)	533		10	1	08/17/05 16:00	A_E	2905337

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
* - Surrogate Recovery Outside Advisable QC Limits
J - Estimated Value between MDL and PQL
>MCL - Result Over Maximum Contamination Limit(MCL)
D - Surrogate Recovery Unreportable due to Dilution
MI - Matrix Interference

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID: MW-4 **Collected:** 08/10/2005 11:21 **SPL Sample ID:** 05080760-04

Site: Sec 35-T18S-R35E Lea County, NM

Analyses/Method	Result	QUAL	Rep.Limit	Dil. Factor	Date Analyzed	Analyst	Seq. #
CHLORIDE, TOTAL				**MCL**	**E325.2**	**Units: mg/L**	
Chloride	1050		20	20	08/18/05 12:40	T_H	2904975
TOTAL DISSOLVED SOLIDS				**MCL**	**E160.1**	**Units: mg/L**	
Total Dissolved Solids (Residue,Filterable)	2230		20	2	08/17/05 16:00	A_E	2905338

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
* - Surrogate Recovery Outside Advisable QC Limits
J - Estimated Value between MDL and PQL
>MCL - Result Over Maximum Contamination Limit(MCL)
D - Surrogate Recovery Unreportable due to Dilution
MI - Matrix Interference

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID: MW-5 **Collected:** 08/10/2005 13:06 **SPL Sample ID:** 05080760-05

Site: Sec 35-T18S-R35E Lea County, NM

Analyses/Method	Result	QUAL	Rep.Limit	Dil. Factor	Date Analyzed	Analyst	Seq. #
CHLORIDE, TOTAL				**MCL**	**E325.2**	**Units: mg/L**	
Chloride	14.9		1	1	08/18/05 12:04	T_H	2904968
TOTAL DISSOLVED SOLIDS				**MCL**	**E160.1**	**Units: mg/L**	
Total Dissolved Solids (Residue,Filterable)	309		10	1	08/29/05 17:30	A_E	2922005

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
* - Surrogate Recovery Outside Advisable QC Limits
J - Estimated Value between MDL and PQL
>MCL - Result Over Maximum Contamination Limit(MCL)
D - Surrogate Recovery Unreportable due to Dilution
MI - Matrix Interference

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID: MW-6 **Collected:** 08/10/2005 13:42 **SPL Sample ID:** 05080760-06

Site: Sec 35-T185-R35E Lea County, NM

Analyses/Method	Result	QUAL	Rep.Limit	Dil. Factor	Date Analyzed	Analyst	Seq. #
CHLORIDE, TOTAL			**MCL**	**E325.2**	**Units: mg/L**		
Chloride	55		1	1	08/18/05 12:04	T_H	2904969
TOTAL DISSOLVED SOLIDS			**MCL**	**E160.1**	**Units: mg/L**		
Total Dissolved Solids (Residue,Filterable)	391		10	1	08/17/05 16:00	A_E	2905340

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
* - Surrogate Recovery Outside Advisable QC Limits
J - Estimated Value between MDL and PQL
>MCL - Result Over Maximum Contamination Limit(MCL)
D - Surrogate Recovery Unreportable due to Dilution
MI - Matrix Interference

Quality Control Documentation

8/31/2005 5:42:25 PM

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Quality Control Report

Unocal Corporation

Former Unocal South Vacuum Unit

Analysis: Chloride, Total
Method: E325.2
WorkOrder: 05080760
Lab Batch ID: R148341A

Method Blank

RunID: KONELAB_050818A-29049 Units: mg/L
Analysis Date: 08/18/2005 11:04 Analyst: T_H

Analyte	Result	Rep Limit
Chloride	ND	1.0

Samples in Analytical Batch:

Lab Sample ID	Client Sample ID
05080760-01A	MW-1
05080760-02A	MW-2
05080760-03A	MW-3
05080760-04A	MW-4
05080760-05A	MW-5
05080760-06A	MW-6

Laboratory Control Sample (LCS)

RunID: KONELAB_050818A-29049 Units: mg/L
Analysis Date: 08/18/2005 11:04 Analyst: T_H

Analyte	Spike Added	Result	Percent Recovery	Lower Limit	Upper Limit
Chloride	50.00	51.33	102.7	80	120

Matrix Spike (MS) / Matrix Spike Duplicate (MSD)

Sample Spiked: 05080689-09
RunID: KONELAB_050818A-29049 Units: mg/L
Analysis Date: 08/18/2005 12:51 Analyst: T_H

Analyte	Sample Result	MS Spike Added	MS Result	MS % Recovery	MSD Spike Added	MSD Result	MSD % Recovery	RPD	RPD Limit	Low Limit	High Limit
Chloride	27.98	50	75.69	95.43	50	76.99	98.02	1.700	20	76	131

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
J - Estimated value between MDL and PQL
MI - Matrix Interference
D - Recovery Unreportable due to Dilution
* - Recovery Outside Advisable QC Limits
N/C - Not Calculated - Sample concentration is greater than 4 times the amount of spike added. Control limits do not apply.

The percent recoveries for QC samples are correct as reported. Due to significant figures and rounding, the reported RPD may differ from the displayed RPD values but is correct as reported.

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Quality Control Report

Unocal Corporation

Former Unocal South Vacuum Unit

Analysis: Total Dissolved Solids
Method: E160.1
WorkOrder: 05080760
Lab Batch ID: R148359

Method Blank

RunID: WET_050817P-2905332 Units: mg/L
Analysis Date: 08/17/2005 16:00 Analyst: A_E

Analyte	Result	Rep Limit
Total Dissolved Solids (Residue,Filterable)	ND	10

Samples in Analytical Batch:

Lab Sample ID	Client Sample ID
05080760-01A	MW-1
05080760-02A	MW-2
05080760-03A	MW-3
05080760-04A	MW-4
05080760-06A	MW-6

Laboratory Control Sample (LCS)

RunID: WET_050817P-2905334 Units: mg/L
Analysis Date: 08/17/2005 16:00 Analyst: A_E

Analyte	Spike Added	Result	Percent Recovery	Lower Limit	Upper Limit
Total Dissolved Solids (Residue,Filterabl	200.0	199.0	99.50	95	107

Sample Duplicate

Original Sample: 05080762-01
RunID: WET_050817P-2905341 Units: mg/L
Analysis Date: 08/17/2005 16:00 Analyst: A_E

Analyte	Sample Result	DUP Result	RPD	RPD Limit
Total Dissolved Solids (Residue,Filterabl	700	701	0.143	20

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
J - Estimated value between MDL and PQL
MI - Matrix Interference
D - Recovery Unreportable due to Dilution
* - Recovery Outside Advisable QC Limits
N/C - Not Calculated - Sample concentration is greater than 4 times the amount of spike added. Control limits do not apply.

The percent recoveries for QC samples are correct as reported. Due to significant figures and rounding, the reported RPD may differ from the displayed RPD values but is correct as reported.

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Quality Control Report

Unocal Corporation

Former Unocal South Vacuum Unit

Analysis: Total Dissolved Solids
Method: E160.1
WorkOrder: 05080760
Lab Batch ID: R149434

Method Blank

RunID: WET_050829S-2921999 Units: mg/L
Analysis Date: 08/29/2005 17:30 Analyst: A_E

Samples in Analytical Batch:

Lab Sample ID	Client Sample ID
05080760-05A	MW-5

Analyte	Result	Rep Limit
Total Dissolved Solids (Residue,Filterable)	ND	10

Laboratory Control Sample (LCS)

RunID: WET_050829S-2922001 Units: mg/L
Analysis Date: 08/29/2005 17:30 Analyst: A_E

Analyte	Spike Added	Result	Percent Recovery	Lower Limit	Upper Limit
Total Dissolved Solids (Residue,Filterabl	200.0	203.0	101.5	95	107

Sample Duplicate

Original Sample: 05081166-01
RunID: WET_050829S-2922002 Units: mg/L
Analysis Date: 08/29/2005 17:30 Analyst: A_E

Analyte	Sample Result	DUP Result	RPD	RPD Limit
Total Dissolved Solids (Residue,Filterabl	1010	1007	0.199	20

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
J - Estimated value between MDL and PQL
N/C - Not Calculated - Sample concentration is greater than 4 times the amount of spike added. Control limits do not apply.
MI - Matrix Interference
D - Recovery Unreportable due to Dilution
* - Recovery Outside Advisable QC Limits

The percent recoveries for QC samples are correct as reported. Due to significant figures and rounding, the reported RPD may differ from the displayed RPD values but is correct as reported.

Sample Receipt Checklist

And

Chain of Custody

8/31/2005 5:42:26 PM

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Sample Receipt Checklist

Workorder:	05080760	Received By:	NB
Date and Time Received:	8/17/2005 9:30:00 AM	Carrier name:	Fedex-Priority
Temperature:	3.0°C	Chilled by:	Water Ice

1.	Shipping container/cooler in good condition?	Yes	☑	No	☐	Not Present ☐
2.	Custody seals intact on shippping container/cooler?	Yes	☑	No	☐	Not Present ☐
3.	Custody seals intact on sample bottles?	Yes	☐	No	☐	Not Present ☑
4.	Chain of custody present?	Yes	☑	No	☐	
5.	Chain of custody signed when relinquished and received?	Yes	☑	No	☐	
6.	Chain of custody agrees with sample labels?	Yes	☑	No	☐	
7.	Samples in proper container/bottle?	Yes	☑	No	☐	
8.	Sample containers intact?	Yes	☑	No	☐	
9.	Sufficient sample volume for indicated test?	Yes	☑	No	☐	
10.	All samples received within holding time?	Yes	☑	No	☐	
11.	Container/Temp Blank temperature in compliance?	Yes	☑	No	☐	
12.	Water - VOA vials have zero headspace?	Yes	☐	No	☐	VOA Vials Not Present ☑
13.	Water - Preservation checked upon receipt (except VOA*)?	Yes	☐	No	☐	Not Applicable ☑

*VOA Preservation Checked After Sample Analysis

SPL Representative: _____ Contact Date & Time: _____

Client Name Contacted: _____

Non Conformance Issues: _____

Client Instructions: _____

SPL, Inc.

Analysis Request & Chain of Custody Record

SPL Workorder No. 05080760 | 227437 | page 1 of 1

Client Name: Trident Environmental
Address: P O Box 7624 Midland TX 79708
Phone/Fax: 432-638-8740 / 413-403-9968
Client Contact: Gil VanDeventer Email: gil@trident-environmental.com
Project Name/No.: # 9924770 & ckocka@ensr.com
Site Name: Former Unocal South Vacuum Unit
Site Location: Sec 35-T18S-R35E Lea County NM
Invoice To: Unocal - Achebe Hope Ph:

SAMPLE ID	DATE	TIME	comp	grab	matrix (W=water S=soil O=oil SL=sludge X=other)	bottle (P=plastic A=amber glass G=glass V=vial X=other)	size (1=1 liter 4=4oz 40=vial 8=8oz 16=16oz X=other)	pres. (1=HCl 2=HNO3 3=H2SO4 X=other)	Number of Containers	Chloride	TDS							
MW-1	8-10-05	1150		✓	W	P	16	Ice	1	✓	✓							
MW-2	8-10-05	1050		✓	W	P	16	Ice	1	✓	✓							
MW-3	8-10-05	1235		✓	W	P	16	Ice	1	✓	✓							
MW-4	8-10-05	1121		✓	W	P	16	Ice	1	✓	✓							
MW-5	8-10-05	1306		✓	W	P	16	Ice	1	✓	✓							
MW-6	8-10-05	1342		✓	W	P	16	Ice	1	✓	✓							

Client/Consultant Remarks: email results to ckocka@ensr.com

Laboratory remarks:

Intact? ☐ Y ☐ N
Ice? ☐ Y ☐ N
Temp: 3.0°

Requested TAT
Contract ☐ 72hr ☐
24hr ☐ Standard ☒
48hr ☐
Other ☐ ______

Special Reporting Requirements Results: Fax ☐ Email ☒ PDF ☒
Standard QC ☒ Level 3 QC ☐ Level 4 QC ☐ TX TRRP ☐ LA RECAP ☐

Special Detection Limits (specify):

PM review (initial): [initials]

1. Relinquished by Sampler: [signature]	date 8/16/05	time 3:00pm	2. Received by:
3. Relinquished by:	date	time	4. Received by:
5. Relinquished by:	date 8/17/05	time 0930	6. Received by Laboratory: [signature]

☒ 8880 Interchange Drive, Houston, TX 77054 (713) 660-0901
☐ 500 Ambassador Caffery Parkway, Scott, LA 70583 (337) 237-4775
☐ 459 Hughes Drive, Traverse City, MI 49686 (231) 947-5777

APPENDIX B

Monitoring Well Sampling Data Forms

WELL SAMPLING DATA FORM

CLIENT: Unocal Corporation
WELL ID: MW-1
SITE NAME: Former Unocal S. Vacuum Unit
DATE: 8/10/2005
PROJECT NO. V-107
SAMPLER: Van Deventer

PURGING METHOD: ☑ Hand Bailed ☐ump If Pump, Type: _____

SAMPLING METHOD: ☑ Disposable Bailer ☐rect from Discharge Hose Othe☐ _____

DESCRIBE EQUIPMENT DECONTAMINATION METHOD BEFORE SAMPLING THE WELL:

☑ Gloves ☑Alconox ☑stilled Water Rinse Othe☐ _____

DISPOSAL METHOD OF PURGE WATER: ☐ Surface Discharge ☐ums Di☑bsal Facility

TOTAL DEPTH OF WELL: 70.00 Feet
DEPTH TO WATER: 62.62 Feet
HEIGHT OF WATER COLUMN: 7.38 Feet
WELL DIAMETER: 2.0 Inch

3.6 Minimum Gallons to purge 3 well volumes

TIME	VOLUME PURGED	TEMP. °F	COND. mS/cm	pH	DO mg/L	Turb	PHYSICAL APPEARANCE AND REMARKS
11:37	0						
11:40	1	71.7	2.8	8.00			
11:43	2	68.9	2.81	7.79			
11:45	3	68.1	2.82	7.74			
11:47	4	67.7	2.78	7.87			
11:50	5	67.6	2.78	7.74			
						11:53	Collected sample
0:13	:Total Time (hr:min)		5	:Total Vol (gal)		0.38	:Average Flow Rate (gal/min)

COMMENTS: Parameters obtained using a calibrated Hanna Model 98130 pH-Temperature-Conductivity meter.

Sample placed into 500 ml plastic container, and put on ice in cooler.

Delivered sample to SPL (Houston TX) for Chloride and TDS analyses.

WELL SAMPLING DATA FORM

CLIENT: Unocal Corporation
WELL ID: MW-2
SITE NAME: Former Unocal S. Vacuum Unit
DATE: 8/10/2005
PROJECT NO. V-107
SAMPLER: Van Deventer

PURGING METHOD: ☑ Hand Bailed ☐ump If Pump, Type: _____

SAMPLING METHOD: ☑ Disposable Bailer ☐rect from Discharge Hose Othe☐ _____

DESCRIBE EQUIPMENT DECONTAMINATION METHOD BEFORE SAMPLING THE WELL:

☑ Gloves ☑Alconox ☑stilled Water Rinse Othe☐ _____

DISPOSAL METHOD OF PURGE WATER: ☐ Surface Discharge ☐ums Di☑bsal Facility

TOTAL DEPTH OF WELL: 71.00 Feet
DEPTH TO WATER: 49.58 Feet
HEIGHT OF WATER COLUMN: 21.42 Feet
WELL DIAMETER: 2.0 Inch

10.5 Minimum Gallons to purge 3 well volumes

TIME	VOLUME PURGED	TEMP. °F	COND. mS/cm	pH	DO mg/L	Turb	PHYSICAL APPEARANCE AND REMARKS
10:00	0						
10:07	2	70.6	1.10	7.36			
10:17	4	69.8	1.42	8.29			
10:24	6	68.2	1.46	8.36			
10:30	8	68.1	1.49	8.30			
10:35	10	68.1	1.56	8.33			
						10:50	Collected sample
0:35	:Total Time (hr:min)		10	:Total Vol (gal)		0.29	:Average Flow Rate (gal/min)

COMMENTS: Parameters obtained using a calibrated Hanna Model 98130 pH-Temperature-Conductivity meter.

Sample placed into 500 ml plastic container, and put on ice in cooler.

Delivered sample to SPL (Houston TX) for Chloride and TDS analyses.

WELL SAMPLING DATA FORM

CLIENT: Unocal Corporation
WELL ID: MW-3
SITE NAME: Former Unocal S. Vacuum Unit
DATE: 8/10/2005
PROJECT NO. V-107
SAMPLER: Van Deventer

PURGING METHOD: ☑ Hand Bailed ☐ump If Pump, Type: _____

SAMPLING METHOD: ☑ Disposable Bailer ☐rect from Discharge Hose Othe☐ _____

DESCRIBE EQUIPMENT DECONTAMINATION METHOD BEFORE SAMPLING THE WELL:

☑ Gloves ☑Alconox ☑stilled Water Rinse Othe☐ _____

DISPOSAL METHOD OF PURGE WATER: ☐ Surface Discharge ☐ums Di☑bsal Facility

TOTAL DEPTH OF WELL: 77.00 Feet
DEPTH TO WATER: 66.81 Feet
HEIGHT OF WATER COLUMN: 10.19 Feet
WELL DIAMETER: 2.0 Inch

5.0 Minimum Gallons to purge 3 well volumes

TIME	VOLUME PURGED	TEMP. °F	COND. mS/cm	pH	DO mg/L	Turb	PHYSICAL APPEARANCE AND REMARKS
12:15	0						
12:18	1	71.9	0.69	7.22			
12:21	2	68.9	0.74	7.19			
12:23	3	68.3	0.74	7.03			
12:30	4	67.7	0.74	7.09			
12:34	5	67.5	0.75	7.03			
						12:35	Collected sample
0:19	:Total Time (hr:min)		**5**	:Total Vol (gal)		**0.26**	:Average Flow Rate (gal/min)

COMMENTS: Parameters obtained using a calibrated Hanna Model 98130 pH-Temperature-Conductivity meter.

Sample placed into 500 ml plastic container, and put on ice in cooler.

Delivered sample to SPL (Houston TX) for Chloride and TDS analyses.

WELL SAMPLING DATA FORM

CLIENT: Unocal Corporation
WELL ID: MW-4
SITE NAME: Former Unocal S. Vacuum Unit
DATE: 8/10/2005
PROJECT NO. V-107
SAMPLER: Van Deventer

PURGING METHOD: ☑ Hand Bailed ☐ump If Pump, Type:
SAMPLING METHOD: ☑ Disposable Bailer ☐rect from Discharge Hose Othe☐
DESCRIBE EQUIPMENT DECONTAMINATION METHOD BEFORE SAMPLING THE WELL:
☑ Gloves ☑Alconox ☑stilled Water Rinse Othe☐
DISPOSAL METHOD OF PURGE WATER: ☐ Surface Discharge ☐ums Di☑bsal Facility

TOTAL DEPTH OF WELL: 71.00 Feet
DEPTH TO WATER: 60.25 Feet
HEIGHT OF WATER COLUMN: 10.75 Feet
WELL DIAMETER: 2.0 Inch
5.3 Minimum Gallons to purge 3 well volumes

TIME	VOLUME PURGED	TEMP. °F	COND. mS/cm	pH	DO mg/L	Turb	PHYSICAL APPEARANCE AND REMARKS
11:00	0						
11:07	2	71.2	4.37	7.49			
11:18	4	69.0	4.19	7.56			
11:37	6	69.1	4.03	7.28			
						11:21	Sample collected
0:37	:Total Time (hr:min)		6	:Total Vol (gal)		0.16	:Average Flow Rate (gal/min)

COMMENTS: Parameters obtained using a calibrated Hanna Model 98130 pH-Temperature-Conductivity meter.
Sample placed into 500 ml plastic container, and put on ice in cooler.
Delivered sample to SPL (Houston TX) for Chloride and TDS analyses.

C:/FORMS/SAMPLING DATA FORM

WELL SAMPLING DATA FORM

CLIENT: Unocal Corporation
WELL ID: MW-5
SITE NAME: Former Unocal S. Vacuum Unit
DATE: 8/10/2005
PROJECT NO. V-107
SAMPLER: Van Deventer

PURGING METHOD: ☑ Hand Bailed ☐ump If Pump, Type: _____

SAMPLING METHOD: ☑ Disposable Bailer ☐rect from Discharge Hose Othe☐ _____

DESCRIBE EQUIPMENT DECONTAMINATION METHOD BEFORE SAMPLING THE WELL:

☑ Gloves ☑Alconox ☑stilled Water Rinse Othe☐ _____

DISPOSAL METHOD OF PURGE WATER: ☐ Surface Discharge ☐ums Di☑bsal Facility

TOTAL DEPTH OF WELL: 75.00 Feet
DEPTH TO WATER: 68.15 Feet
HEIGHT OF WATER COLUMN: 6.85 Feet — 3.4 Minimum Gallons to purge 3 well volumes
WELL DIAMETER: 2.0 Inch

TIME	VOLUME PURGED	TEMP. °F	COND. mS/cm	pH	DO mg/L	Turb	PHYSICAL APPEARANCE AND REMARKS
12:52	0						
12:54	1	70.7	0.45	7.35			
12:56	2	68.8	0.44	7.26			
12:59	3	68.3	0.44	7.26			
13:01	4	68.3	0.45	7.25			
13:04	5	68.5	0.43	7.29			
						13:07	Sample collected
0:12	:Total Time (hr:min)		5	:Total Vol (gal)		0.42	:Average Flow Rate (gal/min)

COMMENTS: Parameters obtained using a calibrated Hanna Model 98130 pH-Temperature-Conductivity meter.
Sample placed into 500 ml plastic container, and put on ice in cooler.
Delivered sample to SPL (Houston TX) for Chloride and TDS analyses.

C:/FORMS/SAMPLING DATA FORM

WELL SAMPLING DATA FORM

CLIENT: Unocal Corporation
WELL ID: MW-6
SITE NAME: Former Unocal S. Vacuum Unit
DATE: 8/10/2005
PROJECT NO. V-107
SAMPLER: Van Deventer

PURGING METHOD: ☑ Hand Bailed ☐ump If Pump, Type: _____

SAMPLING METHOD: ☑ Disposable Bailer ☐irect from Discharge Hose Othe☐ _____

DESCRIBE EQUIPMENT DECONTAMINATION METHOD BEFORE SAMPLING THE WELL:

☑ Gloves ☑Alconox ☑stilled Water Rinse Othe☐ _____

DISPOSAL METHOD OF PURGE WATER: ☐ Surface Discharge ☐ums Dis☑bsal Facility

TOTAL DEPTH OF WELL: 76.00 Feet
DEPTH TO WATER: 70.33 Feet
HEIGHT OF WATER COLUMN: 5.67 Feet
WELL DIAMETER: 2.0 Inch

2.8 Minimum Gallons to purge 3 well volumes

TIME	VOLUME PURGED	TEMP. °F	COND. mS/cm	pH	DO mg/L	Turb	PHYSICAL APPEARANCE AND REMARKS
13:25	0						
13:28	1	72.0	0.59	7.30			
13:31	2	69.4	0.59	7.30			
13:35	3	68.1	0.59	7.25			
13:37	4	68.3	0.59	7.29			
13:39	5	68.0	0.59	7.23			
						13:43	Sample collected
0:14	:Total Time (hr:min)		5	:Total Vol (gal)		0.36	:Average Flow Rate (gal/min)

COMMENTS: Parameters obtained using a calibrated Hanna Model 98130 pH-Temperature-Conductivity meter.

Sample placed into 500 ml plastic container, and put on ice in cooler.

Delivered sample to SPL (Houston TX) for Chloride and TDS analyses.

APPENDIX C

Description of Fate and Transport Modeling

Description of Fate and Transport Modeling

Conceptual Model

Produced water containing high concentrations of chloride, and resultant high levels of total dissolved solids (TDS), was reportedly discharged into a surface pit and adjoining injection well for a period of about 10 years, until the well was plugged and abandoned in1971. The chloride and TDS plume continued to migrate southeastwards for the next approximately 30 years after the source input was stopped, producing the configuration and constituent concentration distribution observed currently. Extrapolating from current conditions for decades into the future, taking account of both advective flow and attenuation by hydrodynamic dispersion, enables prediction of the probable distance that the residual plume will travel as well as the gradually declining concentrations in the plume.

Basic Site Data

Information about site conditions was obtained from data in a TRW Inc. "Report of Additional Groundwater Investigation, Former Unocal South Vacuum Unit, Lea County, New Mexico" (July 18, 2000). This included lithologic records from well installations, water level data, and water quality analytical results.

Simulation Model

Simulations were conducted with the two-dimensional groundwater flow and contaminant transport model WinTran, version 1.03 (1995) designed and distributed by Environmental Simulations, Inc. (ESI) of Herndon, Virginia. WinTran is built around a steady-state analytical element flow model, linked to a finite element contaminant transport model. The Windows interface allows for rapid data input, processing, parameter manipulation and optimization, and output in multiple formats. The fundamental mathematics of the model solutions, model verification (benchmarked against MODFLOW), and use of WinTran is documented in the "Guide to Using WinTran" published by ESI.

Base Map

A simplified site base map, edited with TurboCAD (Version 7), was exported to a universal drawing exchange file (DXF) file format. The DXF base map was imported into WinTran, which preserves the original units of measurement.

Flow Parameters

Input requirements for the steady-state groundwater flow simulation include: hydraulic gradient and direction of flow, hydraulic conductivity, aquifer top and bottom elevations, and reference head. The values used were based on the following sources:

- Hydraulic gradient – measured gradient of 0.004 feet/foot from August 10, 2005 site measurements reported by Trident.

- Direction of flow – measured direction of approximately S 40° E from August 10, 2005 site measurements reported by Trident.

- Hydraulic conductivity – no site measurements were available; therefore, a literature value based on the saturated zone lithology was selected. Typical lithology is described as silty sand and very fine sand. Fetter (1988, Table 4.5, p. 80) cites an average range of 10^{-5} to 10^{-3} cm/sec for hydraulic conductivity of silty sands and fine sands. A conservative upper limit was selected, and converted from S.I. unit to 2.8 ft/day, or approximately 1000 ft/yr.

- Aquifer top and bottom elevations – bottom elevation of Ogallala Formation at 3700 feet reported by Trident. The top elevation for an unconfined aquifer must be greater than the reference head. An elevation of 4000 feet was assumed.

- Reference head – measured unconfined head of 3795.5 feet adjacent to the former pit and upgradient well MW-1 from August 2005 measurements reported by Trident.

Transport Parameters

Input requirements for the contaminant transport numerical simulation include: longitudinal and transverse dispersivity, porosity, diffusion coefficient, contaminant half-life, and retardation coefficient. The values used were based on the following sources:

- Longitudinal and transverse dispersivity – no site measurements were available; therefore, a literature value based on the plume length was selected. Fetter (1993, Section 2.11, pp. 71-77) notes the apparent scale-dependency of longitudinal dispersivity, which typically may be about 0.1 times the flow length. For the current site scale and plume length of approximately 1500 feet, a value of 150 feet was selected for longitudinal dispersivity. According to the WinTran user's guide (ESI, 1995, p.11), longitudinal dispersivity is usually 5 to 10 times higher than transverse dispersivity; therefore, a value of 30 feet (i.e., one-fifth of the longitudinal value) was selected for transverse dispersivity.

- Porosity – no site measurements were available; therefore a literature value based on saturated zone lithology was selected. Typical lithology is described as silty sand and very fine sand. A range of 0.25 to 0.50 is typically given for unconsolidated "sand" (e.g., Freeze & Cherry, 1979, Table 2.4, p. 37); however, the Ogallala Formation is predominantly very fine grained, compacted and partly cemented, and may also fit within the range of 0.05 to 0.30 for sandstone. Fetter (1988, Table 4.3 and Figure 4.10, pp. 74-75) cites an average value of 0.20 for the specific yield of very fine sands. Specific retention of silty fine sand is approximately 0.05, for a total porosity of 0.25, which is the value selected for the transport modeling. WinTran uses the porosity term to estimate groundwater velocity, and actually requires an effective porosity value. Fetter (1988, Section 4.4, pp. 84-85) notes that pores of most sediments down to clay size are interconnected and that the effective porosity is virtually equal to the total porosity.

- Diffusion coefficient – this parameter is normally only relevant for very slow fluid movement, and is commonly assumed to be zero for advective-dominated transport, as in the present case.

- Contaminant half-life – this parameter accounts for chemical decay (e.g., radioisotopes, biological transformation of organic molecules); however, the species of interest in the present case are inorganic ions and are not expected to decay to any appreciable extent. A conservative value of 1000 years was used, which produces a negligible decay coefficient of less than 0.001 yr^{-1}.

- Retardation coefficient – this parameter accounts for sorption processes that slow the movement of contaminants relative to the groundwater velocity. Inorganic ions such as chloride are commonly taken as conservative tracers in groundwater and are not considered to be retarded; therefore, a value of 1.0 was selected for the retardation coefficient.

Flow Model Calibration

The vicinity of the site where water level measurements were recorded in August 10, 2005 is simulated closely by the flow model. It is known that groundwater levels in the Ogallala Formation are decreasing slowly (less than 0.5 ft/yr), but this effect cannot be reproduced in the steady-state flow model. Water levels were probably somewhat higher than the present day during the period of brine disposal and initial transport. Even if the declining trend continues into the future, it does not affect the transport model solution for long extrapolation times, since sufficient saturated thickness remains (i.e., above the assumed aquifer base elevation of 3700 feet) for a valid flow and transport solution.

The average groundwater velocity may be estimated using the darcy expression: $v = (k \cdot i) / n$ where k is the hydraulic conductivity (ft/yr), i is the hydraulic gradient (ft/foot), and n is the effective porosity (unitless). The resultant average velocity is 16 ft/yr.

Transport Model Calibration

The objective of the transport modeling was to first obtain a plume configuration with concentration values that closely match current observed values. This was done by simulating an initial contaminant release to groundwater for a period of 11 years (c. 1960 to 1971) with a constant source concentration located at the pit and injection well, then simulating a 28-year transport period (c. 1971 to 1999) with no further contaminant input but restarting the model from the end of Year 11 by retaining the mass of contaminant from the initial plume. An iterative approach was needed to optimize the initial source concentration so that the plume at Year 39 resembled the actual plume conditions in 1999. An initial value of 14,000 mg/L for chloride and 30,000 mg/L for TDS were found to produce the best match. The initial chloride value was also chosen because it is typical of chloride concentrations within the producing formation (Devonian) in the South Vacuum Oil Field according to chemists at Martin Water Laboratories (verbal communication, 12-05-01). Actual disposal concentrations during the 1960s are unknown, and may have been higher than these values, but it is presumed that some attenuation and dilution may have occurred in the vadose zone, which is currently 48 to 68 feet thick. WinTran does not account for vadose zone transport, and the source input is treated as an injection well with instantaneous transfer of contaminant mass to groundwater.

After calibrating the model such it corresponded to actual 1999 conditions, the model was again run for 6 years (1999 to 2005) at one-year increments after entering in the known concentrations at each monitoring well. Figures 7A and 7B show the close match achieved by the chloride and TDS simulations compared to the current observed plume.

Simulation of Fate and Transport

Estimation of chloride and TDS fate and transport was achieved by restarting the transport model from the end of Year 45 (2005) by retaining the distribution of contaminant mass and projecting for a further 50 years into the future. As depicted in Figures 8A and 8B, dispersion serves to broaden the dimensions of the plume while reducing the concentrations in the middle of the plume. Advective flow moves the center of plume mass downgradient by a distance of approximately 1,500 feet from the former source area (SWD pit) and approximately 300 feet upgradient from well MW-6.

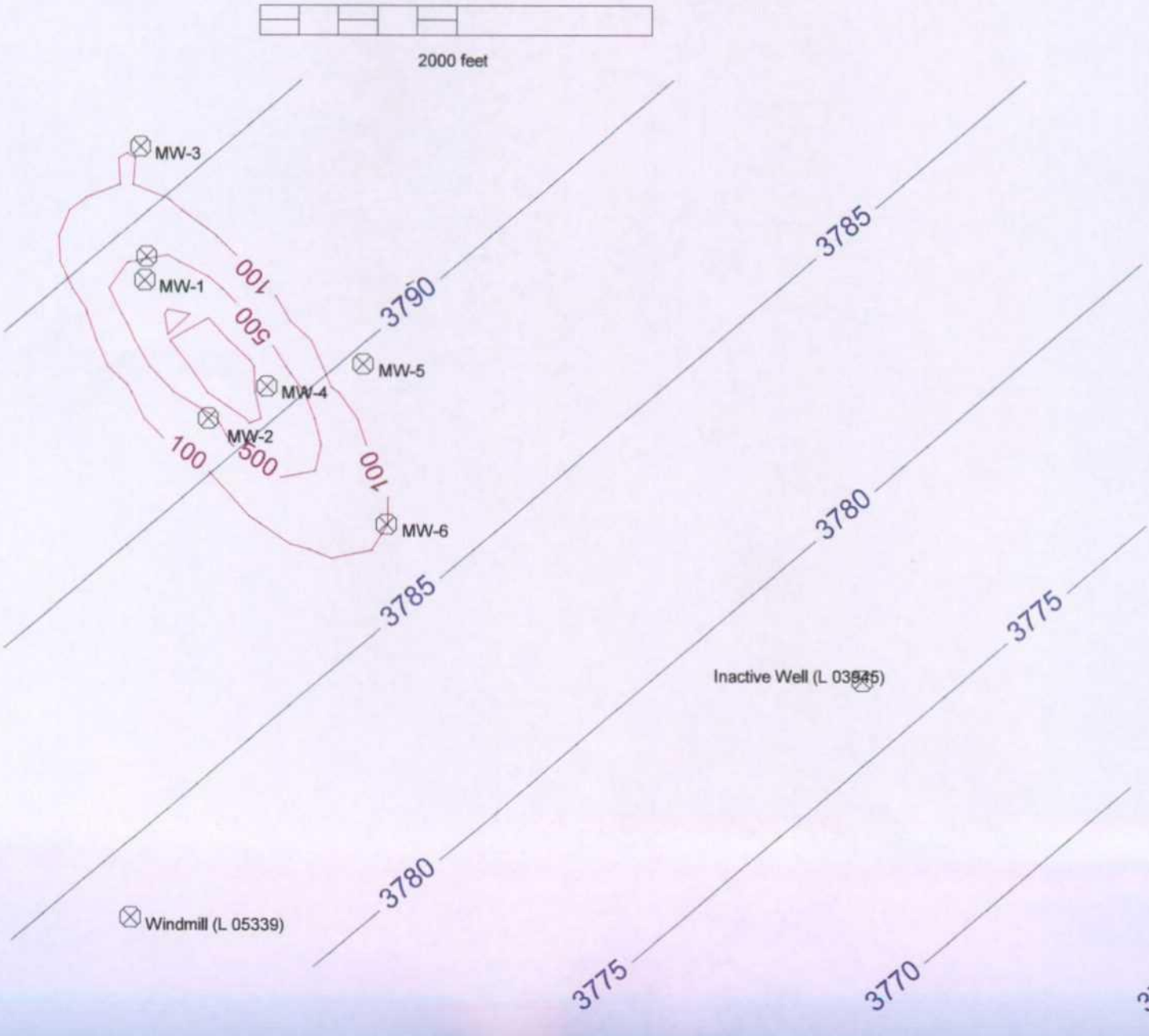
Running the model for 153 years in the future (Year 2158) produces a chloride plume center concentration of 249 mg/L (below the WQCC standard of 250 mg/L) as shown in Figure 9A. The center of the chloride plume is approximately 3,400 ft away from the former pit and well source at that time.

Running the model for 88 years in the future (Year 2093) produces a TDS plume center concentration of 995 mg/L (below the WQCC standard of 1,000 mg/L) as shown in Figure 9B. The center of the TDS plume is approximately 2,200 ft away from the pit and well source at that time.

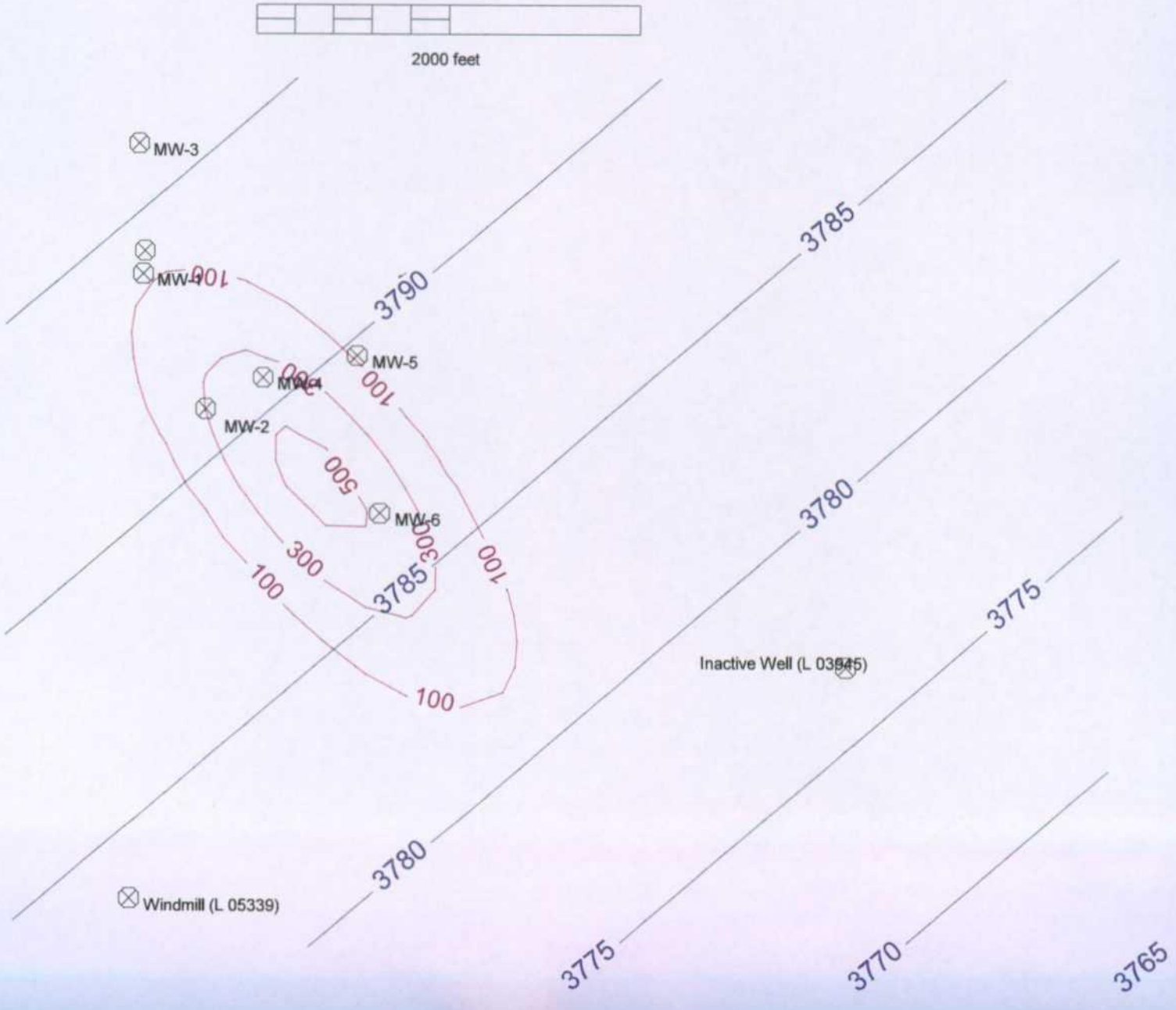
These results support the contention that the chloride and TDS plume is not likely to impact any existing sources of water supply, the closest of which is a windmill (NM File No. L05339) located approximately 3,000 feet south of the source.

The trend of decreasing concentration is not linear (exponential e^{-kt} function). Interestingly, the center of the plume moves at a greater rate (22 feet/year) over successive time intervals than would be assumed from the groundwater velocity alone (16 feet/year), due to the added effect of dispersion.

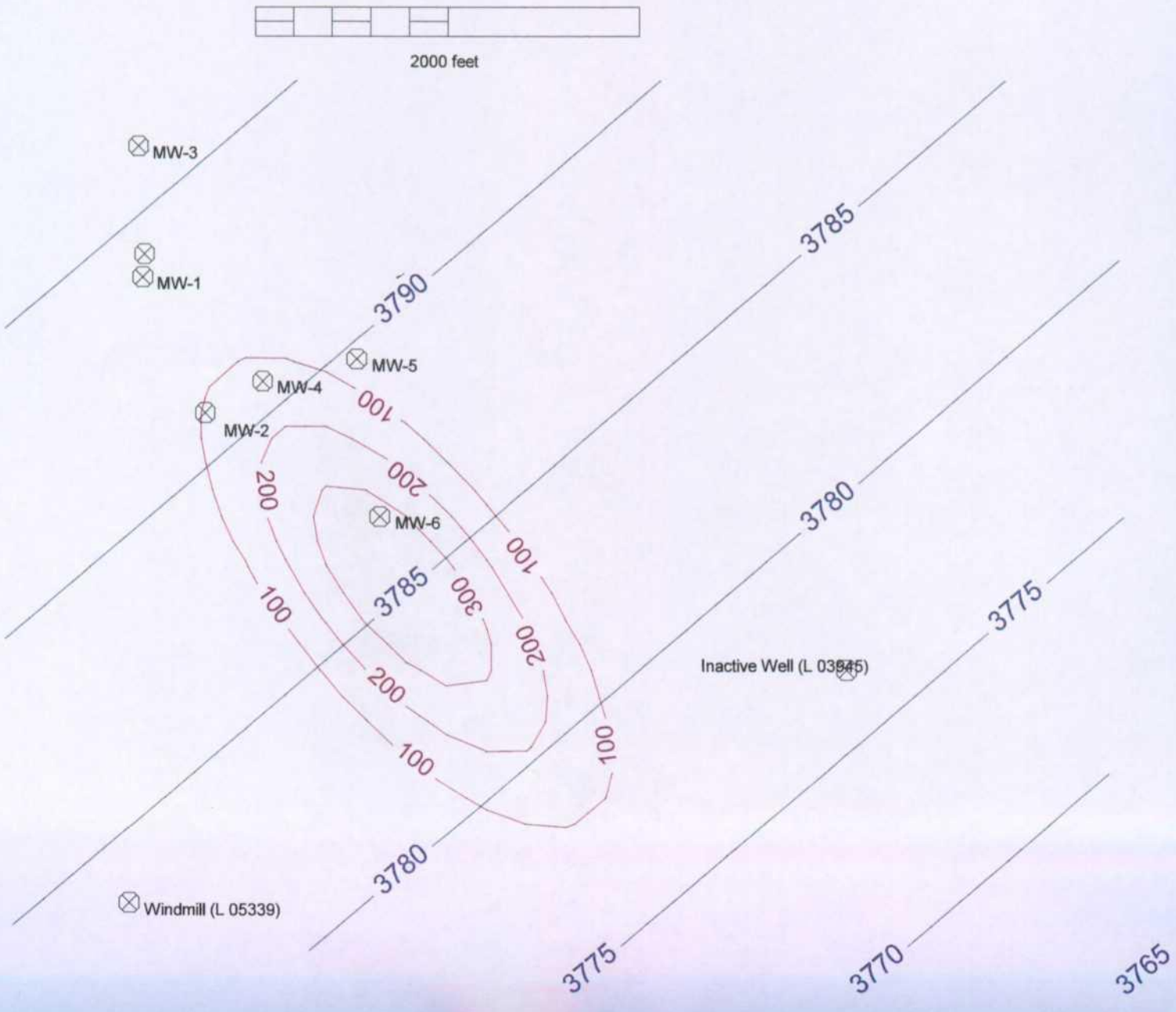
Chloride Plume Simulation (Year 2005)



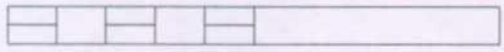
Chloride Plume Simulation (Year 2055)



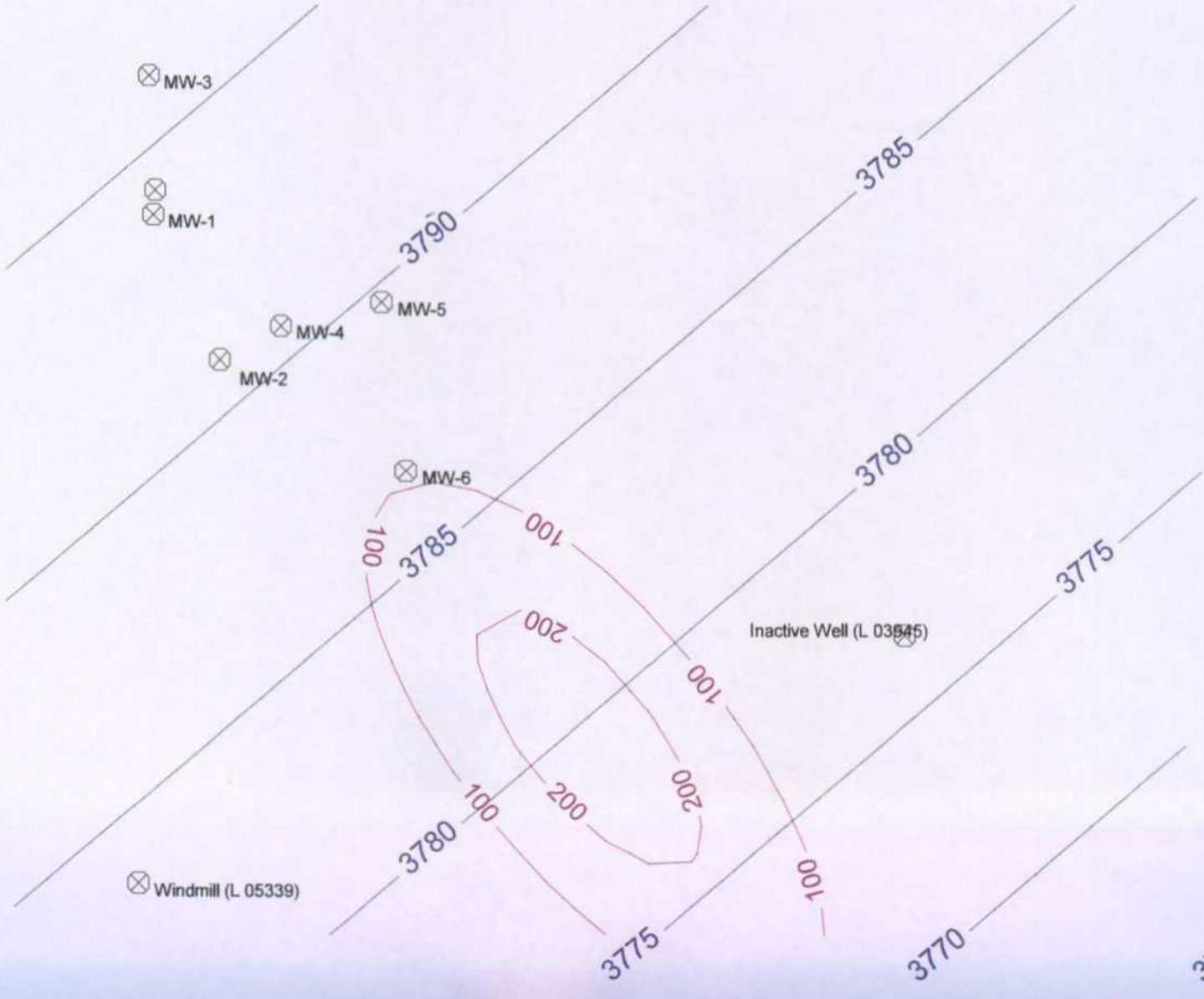
Chloride Plume Simulation (Year 2093)

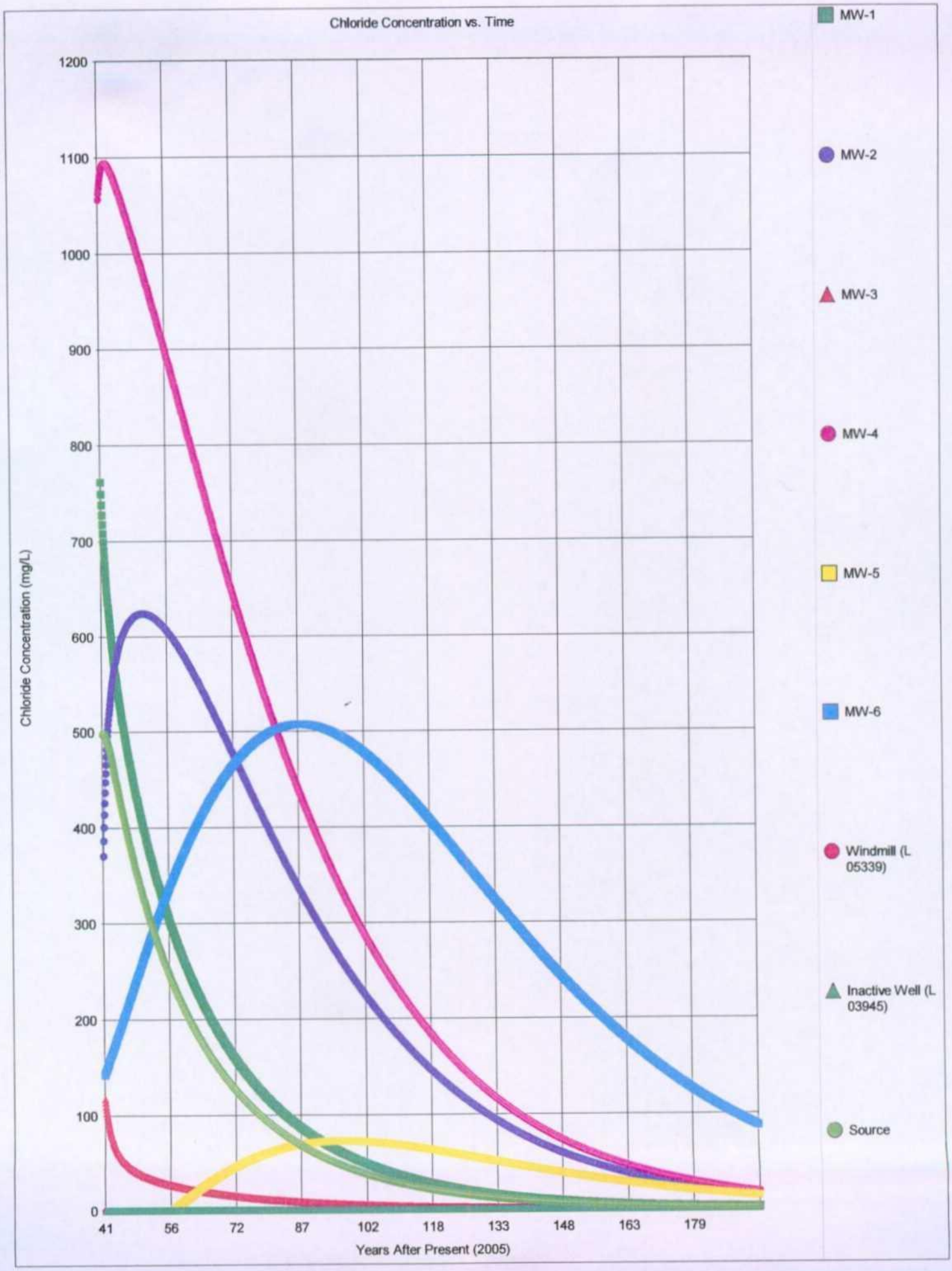


Chloride Plume Simulation (Year 2158)

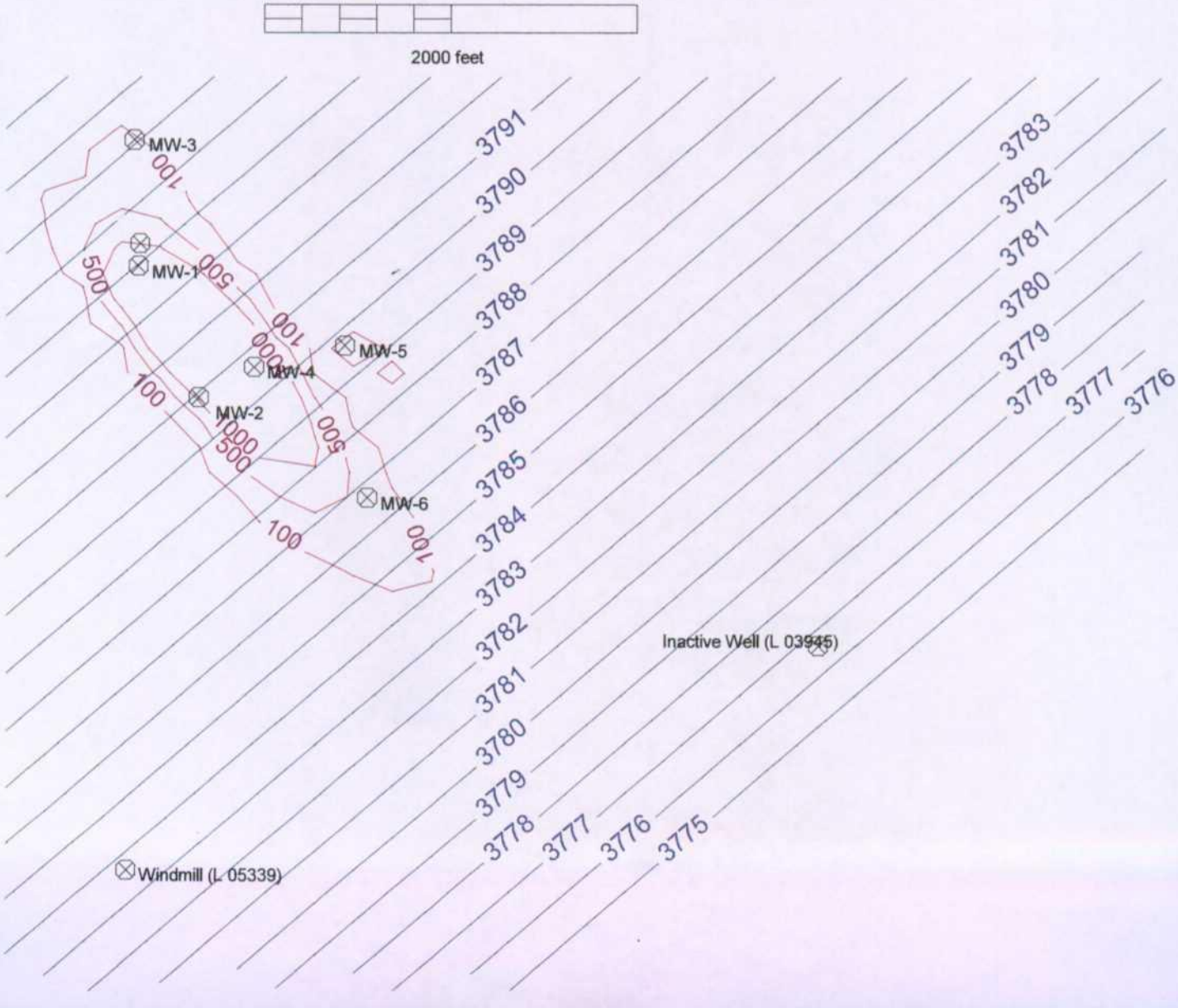


2000 feet

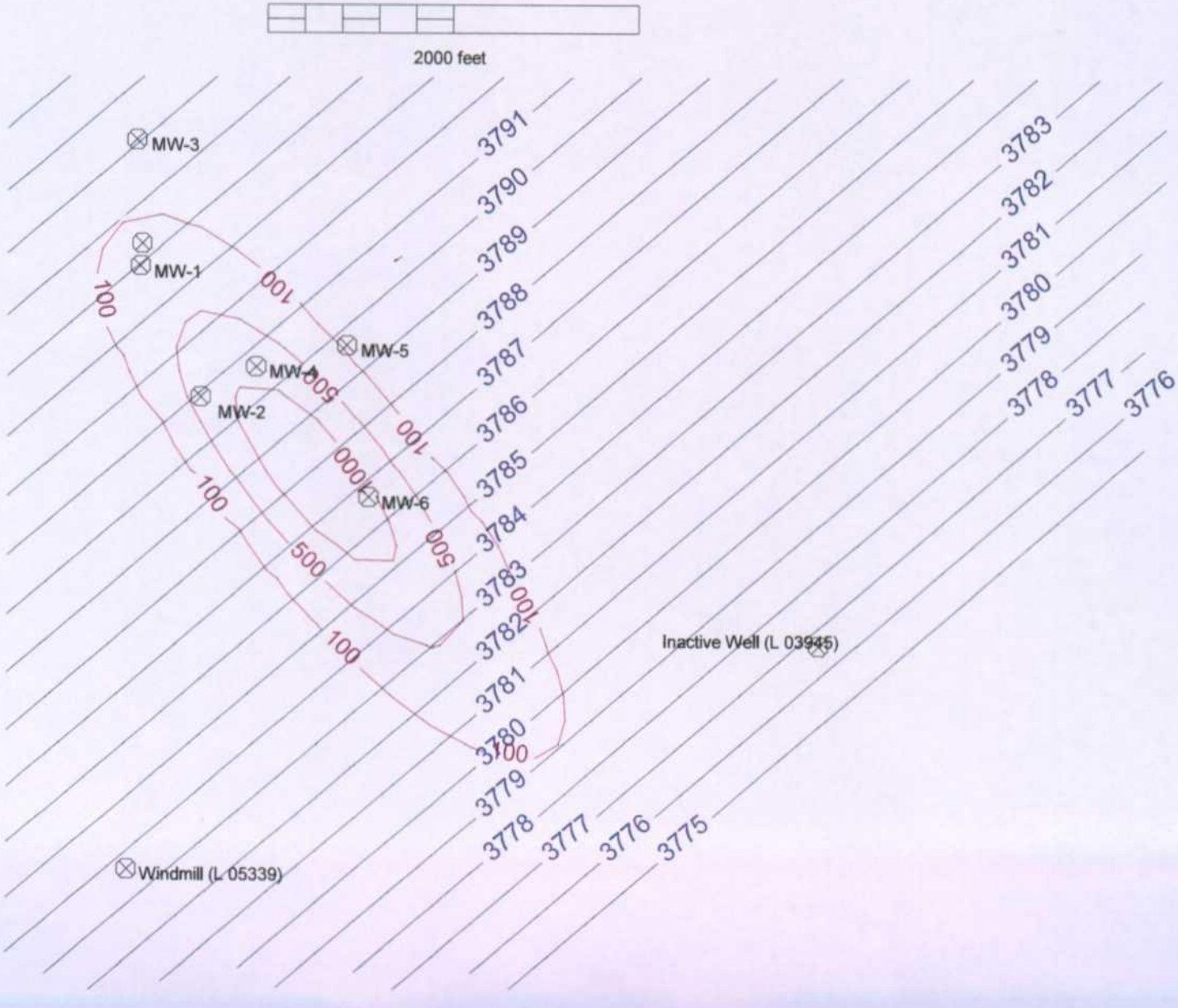



Chloride Concentration vs. Time
Chloride Concentration (mg/L)
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
41
56
72
87
102
118
133
148
163
179
Years After Present (2005)
MW-1
MW-2
MW-3
MW-4
MW-5
MW-6
Windmill (L 05339)
Inactive Well (L 03945)
Source

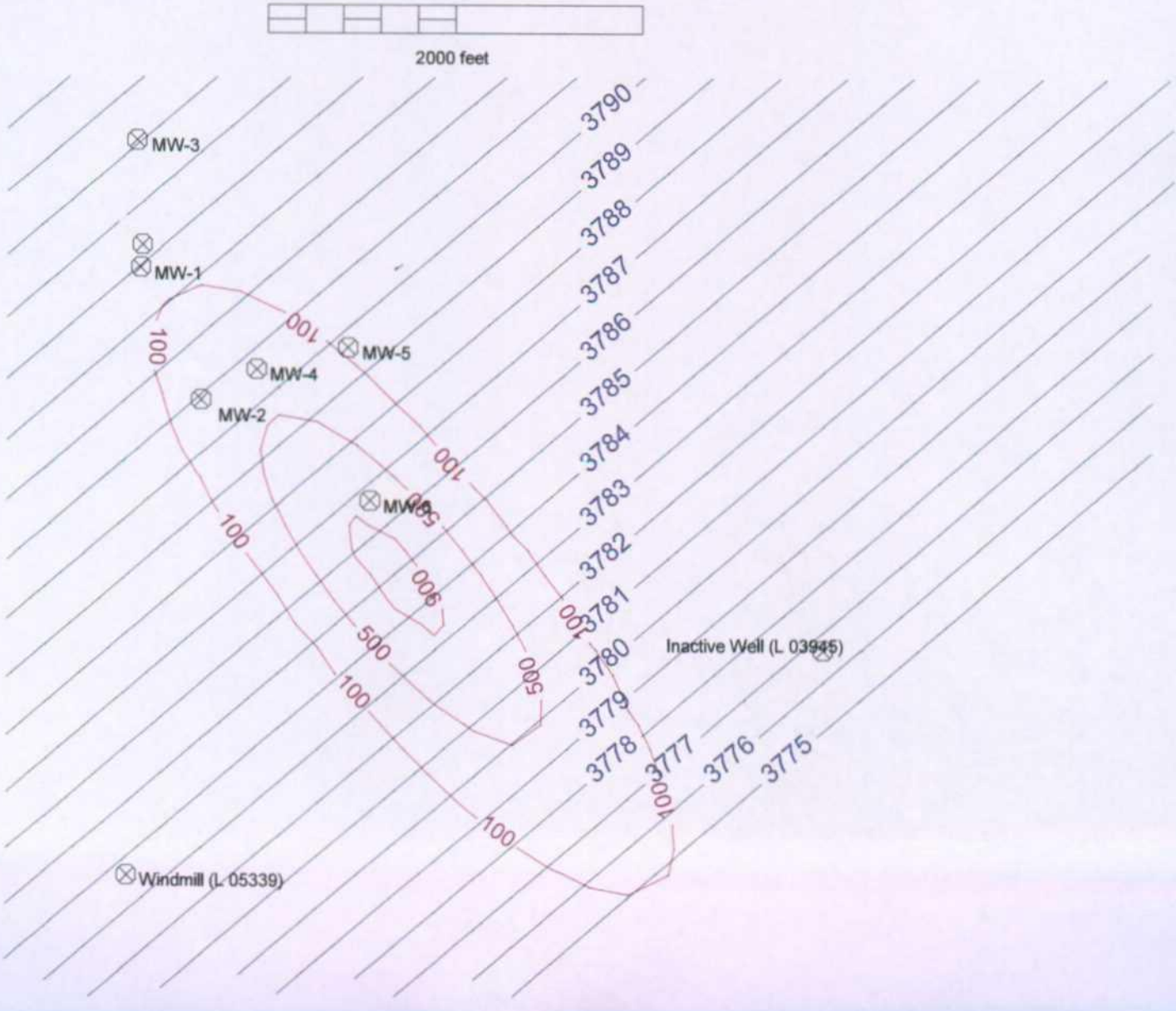
TDS Plume Simulation (Year 2005)

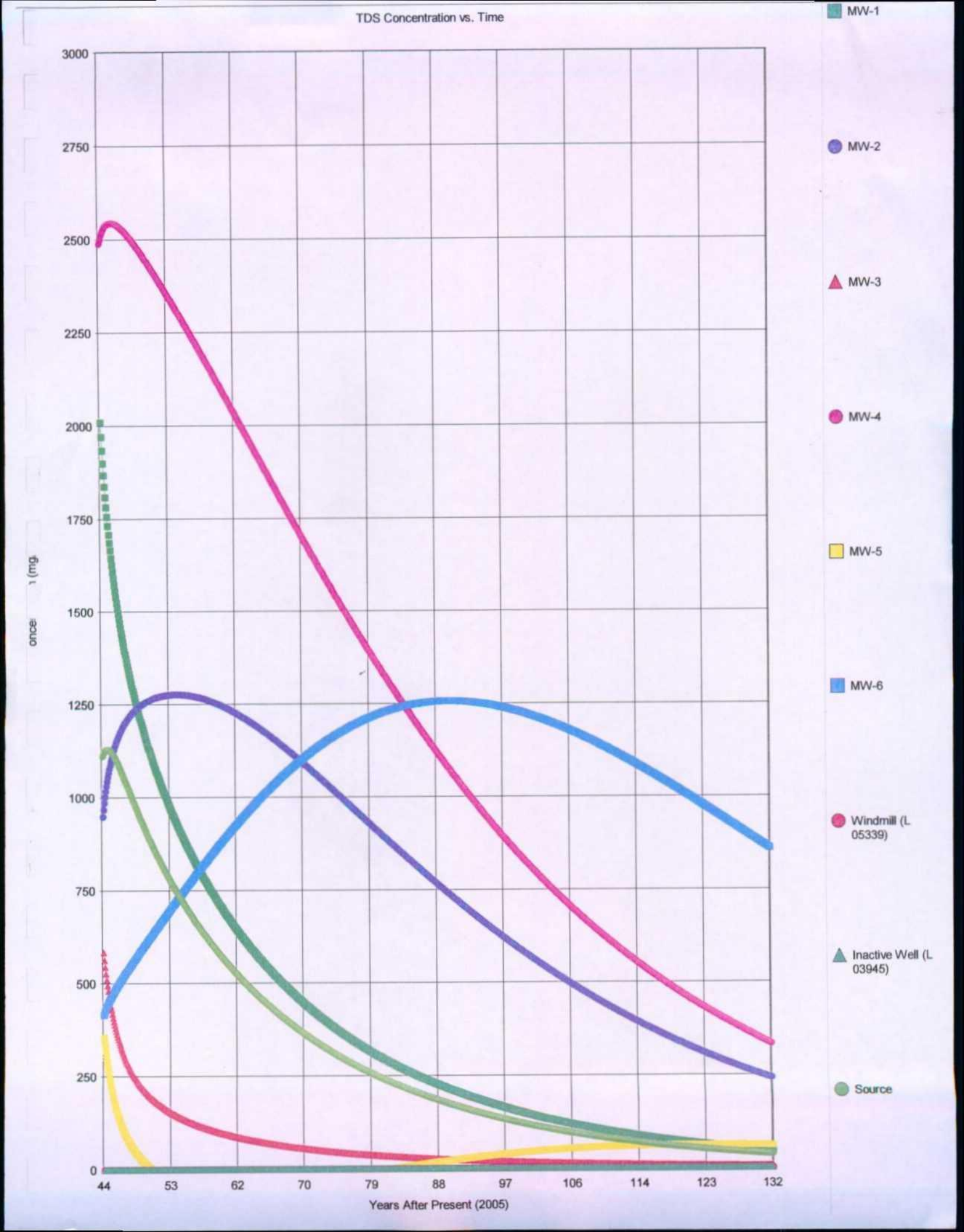


TDS Plume Simulation (Year 2055)



TDS Plume Simulation (Year 2093)




TDS Concentration vs. Time
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
44
53
62
70
79
88
97
106
114
123
132
Years After Present (2005)
MW-1
MW-2
MW-3
MW-4
MW-5
MW-6
Windmill (L 05339)
Inactive Well (L 03945)
Source