EVALUATION OF YEARS 2000 THROUGH 2009 IRRIGATION WITH ALLUVIAL GROUND WATER

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RIMCON

March 2010

Grants Reclamation Project
Evaluation of Years 2000 Through 2009
Irrigation with Alluvial Ground Water

For:

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Executive Summary

This report characterizes changes in uranium and selenium concentrations in four hay fields supplied with irrigation water from ground water with elevated levels of uranium and selenium. From 2000 through 2009, 270 to 394 acres were irrigated with this water. Uranium and selenium concentrations have been measured in the applied irrigation water and affected soils each year and hay crop production since 2000.

The irrigation project is being conducted by Homestake Mining Company of California (HMC) as part of the Homestake Grants Reclamation Project. The project plan established an upper limit for the uranium concentration in irrigation water at the U.S. Nuclear Regulatory Commission effluent standard of 0.44 milligrams per liter (mg/l). Selenium was set at a site-specific State of New Mexico Water Quality Control Commission standard of 0.12 mg/l.

The fields subject to irrigation are located in Sections 28, 33, and 34 in Township 12 North, Range 10 West near Grants, New Mexico. Figure 1-1 shows the locations of the four irrigations fields. Fields in Sections 28 and 33 were irrigated using a center pivot irrigation system. The field in Section 34 and an additional portion of Section 33 was irrigated by flooding. The total amount of irrigation water applied to the fields from 2000 to 2009 was 8827 acre feet (ac-ft), ranging from 695 to 1058 ac-ft annually.

The background concentrations of uranium and selenium in the soil are averages of these constituents in samples collected prior to the irrigation program and outside of the irrigated area each year. The background concentrations are compared to the concentration in each 1-foot (ft) interval of the upper five feet of soil in treated areas and each two foot interval beyond five feet starting in 2009. The difference between the treated soil and background concentration is the amount of constituent added from the irrigation. The amount of a constituent in the soil is then compared to the total amount of the constituent added over the course of irrigation.

The mean background concentrations of uranium and selenium are similar in Sections 28 and 33 (center pivot areas). The concentrations in Section 34 are generally higher than in other fields, presumably because of their association with clay soils.

Mean background concentrations of uranium, in descending 1-ft layers (0-1 ft, 1-2 ft, 2-3 ft) are:

- Section 28: 0.59, 0.53, and 0.52 milligrams per kilogram (mg/kg), then 0.12 to 0.85 for footages to 17 feet.
- Section 33: 0.79, 0.69, and 0.72 mg/kg, then 0.52 to 0.99 down to 17 feet.
- Section 34: 1.98, 1.50, and 1.16 mg/kg, then 0.31 to 1.26 down to 15 feet.

The data collected in the 24 acre flood irrigated area of Section 33 are insufficient to show trends and are not presented further in this summary, although they are presented in the report. On a mass basis, the fraction of uranium that remains in the upper 17 foot interval is equal to or exceeds 95 percent of the mass applied to the irrigated fields. This analysis excludes the flood irrigated area of Section 33.

The percentage of selenium applied to the fields, excluding the Section 33 Flood area, that remains in the upper 17 feet of the soil is equal to or exceeds 77 percent of the mass applied.

Uranium concentration in the fields and retention in the soils is discussed in the following sections.

Uranium concentrations in the treated soils of Section 28 were essentially constant and similar to background concentrations from 2003 through 2005. The most recent (2009) concentrations exceeded mean background by factors of 2.75 (0-1 ft), 2.11 (1-2 ft), and 2.38 (2-3 ft). The Section 28 soil concentrations had been steady for the previous three years, but increased in 2009. The measured concentrations indicate that all of the applied uranium is retained within the upper 17 feet of soil.

Uranium concentrations in the treated soils of Section 33 started to exceed background concentrations in 2003. The most recent (2009) concentrations exceeded the mean background by factors of 2.57 (0-1 ft), 2.67 (1-2 ft) and 2.11 (2-3 ft). Uranium has accumulated in the upper 17 feet of soil and the amount of gain in uranium soil concentrations in 2009 indicates that all applied uranium is retained within the upper 17 feet of soil.

Uranium is mainly accumulating in the upper three feet of the treated areas of Section 34 with generally less accumulation with each successive depth interval. A smaller degree of increase in uranium is observed through the five foot depth, and the data indicates that 95% of the applied uranium was retained in the upper seven feet of soil. The 2009 results exceed background by factors of 2.05 (0-1 ft at 4.06 mg/kg), 1.73 (1-2 ft at 2.59 mg/kg), and 1.57 (2-3 ft at 1.82 mg/kg).

Less than one percent of the mass of uranium and selenium applied to the fields to date has been detected in samples of hay.

Based on measured concentrations, nearly all of the uranium is being retained in the upper layers of the Section 34 flood irrigated soil while all of the uranium has been retained in the upper 17 feet of soil in the Section 28 and Section 33 center pivot irrigated areas. Uranium from the irrigation has not been detected in the alluvial ground water in the irrigation areas. In terms of risk to human health, uranium levels are currently acceptable. The dose to man by way of the ingestion of beef is negligible, as indicated by food web uptake calculations.

Potential radiation doses to the public were evaluated for:

- Residents eating beef that were fed hay grown on the irrigated areas.
- An assumed resident farmer, living on and farming the Section 34 irrigated area.
- Current residents living near the irrigated areas of Sections 28 and 33 during crop irrigation activities.

Each analysis shows that the radiological dose to existing or future occupants of the land on and near the irrigation areas is extremely small (less than one percent) compared to the average dose that the population receives from natural background and medical exposures.

Selenium uptakes in hay are below the recommended upper limit for animal feed. Selenium retention in soils had appeared to be independent of time and application, but the 2007 through 2009 data indicate retained percentages only slightly less than the corresponding uranium retention percentages. Selenium retention in the soil has been significant for the last three years when compared to chloride, which is a conservative constituent in terms of fate and transport,.

The monitoring of concentrations of uranium and selenium will continue as part of the ongoing irrigation program.

1.0 Introduction

This report characterizes changes in uranium and selenium concentrations in fields supplied with irrigation water from impacted ground-water sources near the Homestake Grants Reclamation Project. The irrigation project is being conducted by Homestake Mining Company of California (HMC).

Four fields have been irrigated with water containing elevated concentrations of uranium and selenium. Figure 1-1 shows the locations of the four irrigations fields and the locations of the associated fresh water injection used to aid ground-water restoration in the off-site areas. Ground water from wells adjacent to the Grants Reclamation Project was applied to fields situated in portions of Section 33 Pivot (150 acres) and Section 34 Flood (120 acres) during the 2000 through 2009 growing seasons and to a field in Section 28 (60 acres) during the 2002, 2003 and 2004 growing seasons. The field in Section 28 was expanded to 100 acres prior to the 2005 season and irrigated from 2005 to 2009. Fields in Sections 33 and 28 were irrigated using a center pivot irrigation system, whereas the field in Section 34 was irrigated by flooding. An additional 24 acres were flood irrigated in Section 33 in 2004, 2005, 2008 and 2009, but not in 2006 and 2007. All sections discussed in this report are located in Township 12 North, Range 10 West.

Uranium and selenium concentrations were measured in the applied irrigation water, affected soils (see Figure 1-1 for water application locations) and vegetation to determine constituent source terms and transfer to or accumulation in soils and vegetation. The measured results for the first growing season (2000) were compared to predictions made in 1999, which were based on published media transfer factors and other assumptions (ERG and HYDRO, 1999). The results from the first year of operation were reported previously (ERG and HYDRO, 2001). The report was updated for the 2001-2003 growing seasons in ERG and HYDRO, 2004 and updated again to include the 2004 through 2009 growing seasons (see ERG and HYDRO, 2005, 2006, 2007, 2008 and 2009).

The remainder of this report is organized as follows. Section 2 presents concentration data for several constituents in the irrigation water. Section 3 presents data on these same constituents in soil for background and irrigated areas, concentrations in the soil moisture, and a discussion of soil health. Section 4 presents the ground-water quality for the alluvial aquifer in the area of the irrigation fields. Section 5 addresses the constituent uptake in the vegetation. In Section 6, quantities of uranium and selenium ingested by beef-cattle and the resulting radiation dose to humans consuming this beef are calculated. This section presents additional exposure potential from the irrigation program. The report ends with conclusions and references.

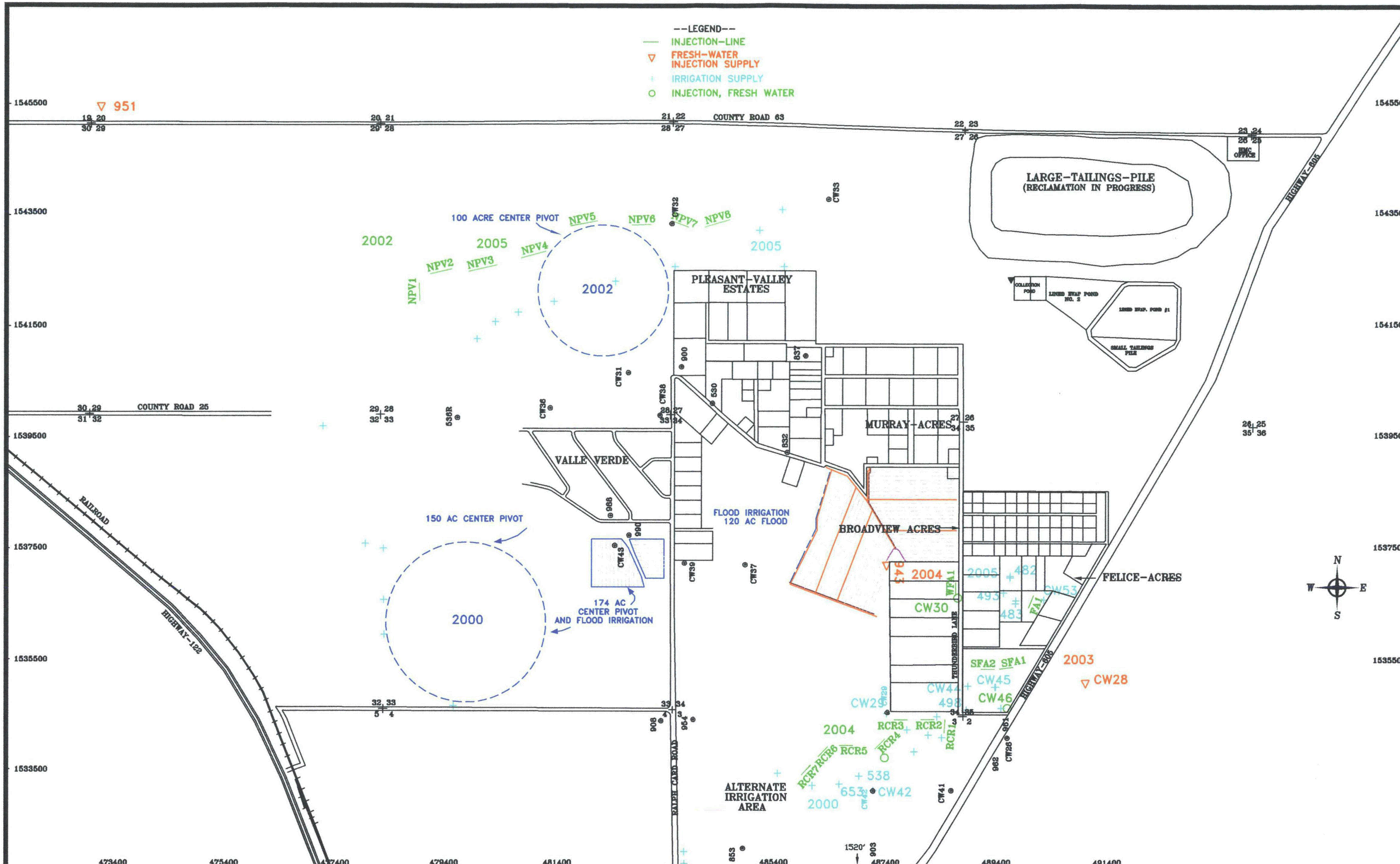

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FIGURE 1-1. LOCATION OF PRESENT INJECTION AND COLLECTION SYSTEMS IN THE IRRIGATION PROGRAM

2.0 Irrigation Water Concentrations and Usage

The project plan (ERG and HYDRO, 1999) established an upper limit for the uranium concentration in irrigation water at the NRC effluent standard of 0.44 milligrams per liter (mg/l). The maximum allowable concentration of selenium in the irrigation supply was set at a State of New Mexico Water Quality Control Commission standard of 0.12 mg/l. With five exceptions, measured uranium and selenium concentrations have been below these limits since inception of the irrigation program through 2009. As identified, adjustments were made in the irrigation supply well configuration and production rates to insure that season averages met established limits. Yearly data and averages are discussed in the following sections.

2.1 Sections 33 and 34 Irrigation

A common pipe connecting 13 wells supplied the irrigation water for Sections 33 and 34 from 2000 through 2002(see Figures 2-1 through 2-3). Three wells were added and one well was dropped in 2003 (see Figure 2-4), while five wells were added in 2004 (see Figure 2-5). Four wells were added and three dropped in 2005 (see Figure 2-6). Eight additional wells added in 2006 bringing the total active wells to 29 (see Figure 2-7). Three additional wells were added in 2007 and the use of two previous supply wells was discontinued (see Figure 2-8). In 2008 and 2009 no wells were added and the pipeline supplied water to one of the three fields at a time (see Figures 2-9 and 2-10). In the 2004 and 2005 growing seasons, irrigation of the 24 flooded acres in Section 33 occurred only in conjunction with the irrigation of the Section 34 field and at a limited rate to maintain concentrations below the limits described in Section 2.0. The Section 33 Flood field was irrigated at higher rates and application depths in 2008 and 2009, with all of the water being supplied to this field during its irrigation. Figures 2-1 through 2-10 show the Sections 33 and 34 irrigation supply well locations and supply lines for Years 2000 to 2009.

Water samples collected at the end of the pipeline at the flood outlet or center pivot are composite samples from the group of supply wells. Table 2-1 presents the concentrations of uranium, selenium, total dissolved solids (TDS), sulfate, molybdenum and chloride observed in the 2000-2009 irrigation water. Yearly averages are also presented in the table.

Average uranium and selenium concentrations were approximately 0.26 and 0.08 mg/l, respectively, over the ten growing seasons. The May 14, 2003 and the May 7, 2008 results for uranium (0.03 and 0.05 mg/l) are not included in the uranium average, because they are one order of magnitude lower than all other observations. Thus, they are assumed to be laboratory artifacts.

With one exception, the average concentrations of TDS and molybdenum were essentially constant from 2000 to 2009. The 2009 average concentrations were similar to previous averages. With the exception of the June 2006 measurement, TDS concentrations have ranged from 1390 to 1660 mg/l. Molybdenum concentrations were less than the 0.03 or 0.05 mg/l Method Detection Limits (MDLs), with the exception of four samples. Concentrations in these four samples (0.06, 0.05, 0.07 and 0.41 mg/l) exceeded MDLs. The result of 0.41 mg/l is one order of magnitude higher than all other molybdenum results and attributed to laboratory error. The sulfate concentrations ranged from 561 to 1020 mg/l. Chloride levels have been increasing slowly, and in 2009 were approximately 50 percent greater than initial measurements. Chloride concentrations have ranged from 94 to 247 mg/l in the ten years of monitoring.

Table 2-1. 2000 through 2009 Sections 33/34 Irrigation Supply Concentrations

		Parameter (mg/l)					
Year	Date	Uranium	Selenium	TDS	Sulfate	Chloride	Molybdenum
2000	8/6/2000	0.26	0.12	1530	650	105	<0.03
	8/15/2000	0.26	0.12	1550	660	106	<0.03
	8/18/2000	0.28	0.12	1570	623	115	<0.03
	8/19/2000	0.27	0.12	1550	612	109	<0.03
	8/24/2000	0.27	0.11	1530	608	106	<0.03
	8/27/2000	0.26	0.11	1530	601	103	<0.03
	8/29/2000	0.3	0.11	1580	624	109	<0.03
	9/2/2000	0.28	0.11	1550	615	104	<0.03
	Average	0.27	0.12	1549	624	107	<0.03
2001	4/20/2001	0.28	0.11	1620	693	120	<0.03
	4/27/2001	0.27	0.12	1590	688	120	<0.03
	5/6/2001	0.3	0.11	1630	597	108	0.06
	5/10/2001	0.25	0.09	1590	580	103	<0.03
	5/19/2001	0.28	0.1	1590	660	118	<0.03
	5/24/2001	0.24	0.11	1500	664	116	<0.03
	6/3/2001	0.27	0.1	1610	665	118	<0.03
	6/10/2001	0.27	0.1	1570	659	113	<0.03
	6/28/2001	0.27	0.11	1530	661	104	<0.03
	7/5/2001	0.22	0.1	1480	655	94	<0.03
	7/24/2001	0.21	0.09	1460	650	120	<0.03
	8/29/2001	0.28	0.1	1600	693	114	0.41
	9/1/2001	0.27	0.1	1610	573	128	<0.03
	9/1/2001	0.21	0.1	1570	561	121	<0.03
	9/17/2001	0.29	0.13	1600	634	100	<0.03
	Average	0.26	0.1	1570	642	113	0.04
2002	4/15/2002	0.21	0.09	1510	708	125	<0.03
	4/16/2002	0.25	0.1	1580	704	129	<0.03
	5/8/2002	0.25	0.11	1600	678	----	----
	5/8/2002	0.26	0.1	1580	737	----	----
	5/14/2002	0.25	0.09	1560	741	120	<0.03
	7/3/2002	0.23	0.1	1560	694	135	0.05
	7/31/2002	0.23	0.1	1580	678	123	<0.05
	10/2/2002	0.21	0.1	1570	703	----	----
	Average	0.23	0.1	1564	705	126	<0.03
2003	5/14/2003	*0.03	0.05	1390	663	98.5	<0.03
	9/18/2003	0.22	0.08	1600	732	----	----
	Average	0.22	0.08	1600	732	----	----

Table 2-1. 2000 through 2009 Sections 33/34 Irrigation Supply Concentrations (concluded)

		Parameter (mg/l)					
Year	Date	Uranium	Selenium	TDS	Sulfate	Chloride	Molybdenum
2004	5/4/2004	0.28	0.11	1550	703	130	<0.03
	5/27/2004	0.25	0.08	1570	690	130	<0.03
	8/18/2004	0.27	0.08	1530	693	----	----
	10/6/2004	0.23	0.08	1560	629	133	<0.03
	Average	0.26	0.09	1553	679	131	<0.03
2005	4/19/2005	0.25	0.06	1520	1020	247	<0.03
	4/20/2005	0.25	0.06	1510	996	235	<0.03
	5/25/2005	0.23	0.06	1580	603	131	<0.03
	6/1/2005	0.24	0.06	1520	661	129	<0.03
	8/8/2005	0.27	0.06	1500	621	----	----
	9/26/2005	0.3	0.07	1550	659	124	<0.03
	10/11/2005	0.29	0.07	1580	612	125	<0.03
	10/24/2005	0.35	0.08	1610	683	144	<0.03
	Average	0.27	0.06	1546	732	162	<0.03
2006	4/10/2006	0.24	0.05	1520	654	134	<0.03
	6/26/2006	0.37	0.1	2000	875	192	0.07
	8/14/2006	0.27	0.07	1580	696	----	----
	10/10/2006	0.29	0.07	1500	639	128	<0.03
	Average	0.29	0.07	1650	716	151	0.04
2007	4/12/2007	0.28	0.06	1630	668	136	<0.03
	4/30/2007	0.27	0.06	1580	670	132	<0.03
	6/4/2007	0.23	0.06	1540	654	125	<0.03
	8/21/2007	0.3	0.05	1600	678	----	----
	10/22/2007	0.31	0.06	1570	661	143	<0.03
	Average	0.28	0.06	1584	666	134	<0.03
2008	4/7/2008	*0.0521	0.073	1430	687	160	<0.03
	4/21/2008	0.262	0.042	1560	728	99	<0.03
	6/2/2008	0.254	0.048	1550	683	142	<0.03
	9/24/2008	0.213	0.049	1660	710	148	<0.03
	Average	0.24	0.05	1550	702	137	<0.03
2009	5/6/2009	0.262	0.048	1560	669	----	<0.03
	6/16/2009	0.213	0.047	1660	717	178	<0.03
	7/24/2009	0.239	0.047	1700	694	146	<0.03
	9/28/2009	0.232	0.059	1770	754	160	<0.03
	Average	0.24	0.05	1673	709	161	<0.03

2.2 Section 28 Irrigation

Section 28 was irrigated from 2002 through 2009. Figures 2-11 and 2-12 show the locations of the four wells installed to supply water to the center pivot system in the first two years. Figures 2-13, 2-14 and 2-15 show that well 886 was added in 2004 and wells M9, MO, MQ, MR, and MS were added in 2005 and 2006. Alluvial well M16 was added in 2007 and wells M9 and MQ were not used in 2007, 2008 and 2009 (see Figures 2-16, 2-17 and 2-18). Table 2-2 presents TDS, sulfate, chloride, molybdenum, uranium, and selenium concentrations obtained in the Section 28 irrigation water. One sample of irrigation water was collected during the first two irrigation seasons. Four and eight samples were collected in 2004 and 2005, respectively. Five samples were collected in both 2006 and 2007 while three samples were collected in 2008 and four samples were collected in 2009. Chloride and molybdenum were omitted as analytes in 2002 and from one sample in 2004, 2006, 2007 and 2009.

The concentrations of TDS and sulfate were essentially constant from 2002 through 2009. The TDS concentration was 2,070 mg/l in 2002 and 2003 and averaged 2115, 2109, 1986, 2122, 1917 and 2030 mg/l in 2004, 2005, 2006, 2007, 2008 and 2009, respectively. The annual average sulfate concentrations ranged from 881 to 936 mg/l. The annual average concentrations of chloride and molybdenum ranged from 133 to 185 mg/l and less than 0.03 to 0.05 mg/l, respectively.

Uranium concentrations have increased gradually in Section 28 irrigation water: 0.23 mg/l in 2002, 0.24 mg/l in 2003, and 0.27 mg/l in 2004. Uranium concentrations stabilized from 2005 through 2008 at 0.35 to 0.36 mg/l. A small increase to 0.39 mg/l occurred in 2009.

The eight-year (2002-2009) average uranium concentration of 0.32 mg/l is calculated as the average of the reported mean concentrations for the eight years, (0.23, 0.24, 0.27, 0.35, 0.35, 0.36, 0.36 and 0.39 mg/l).

Selenium concentrations were 0.08 mg/l in 2002 and less than 0.005 mg/l in 2003. The latter result is questionable because the concentration in each of the four supply wells was measured at 0.04 or 0.05 mg/l and no other water was introduced to the supply line (see HMC's 2003 Annual Report for individual well results). The average 2004 through 2009 selenium concentrations were similar to the 2002 value. Thus, the seven-year average selenium concentration of 0.08 mg/l is calculated of the average of the mean concentration reported from 2002 through 2009.

2.3 Irrigation Water Usage

Water usage, which is tabulated below, has varied from 715 acre-feet (ac-ft) in 2000 applied to the 270 acres (Sections 33 and 34) to 1034 ac-ft in 2005 applied to the 394 acres (Sections 28, 33 and 34).

YEAR	WATER USAGE (AC-FT)	IRRIGATED AREA (AC)	AREA IRRIGATED
2000	715	270	Sections 33 and 34
2001	695	270	Sections 33 and 34
2002	995	330	Sections 28, 33 and 34
2003	949	330	Sections 28, 33 and 34
2004	1028	354	Sections 28, 33 and 34
2005	1034	394	Sections 28, 33 and 34
2006	837	370	Sections 28, 33 and 34
2007	789	370	Sections 28, 33 and 34
2008	1054	394	Sections 28, 33 and 34
2009	731	394	Sections 28, 33 and 34

Table 2-2. 2002 through 2009 Section 28 Irrigation Supply Concentrations

Year	Sampling Date	Uranium	Selenium	TDS	Sulfate	Chloride	Molybdenum
		Parameter					
2002	10/2/2002	0.23	0.08	2070	881	----	----
2003	5/14/2003	0.24	<0.005	2070	936	184	<0.03
2004	5/4/2004	0.23	0.07	2120	933	190	<0.03
	5/27/2004	0.29	0.07	2110	950	170	<0.03
	8/18/2004	0.27	0.06	2140	956	----	----
	10/6/2004	0.27	0.06	2090	838	194	<0.03
	Average	0.27	0.07	2115	919	185	<0.03
2005	4/12/2005	0.48	0.11	2220	955	176	0.09
	5/6/2005	0.51	0.12	2230	1010	192	0.11
	5/20/2005	0.33	0.08	2120	916	194	<0.03
	5/27/2005	0.26	0.06	2050	907	176	<0.03
	6/3/2005	0.33	0.08	2040	926	182	<0.03
	6/10/2005	0.33	0.07	2000	943	186	<0.03
	6/17/2005	0.31	0.08	2100	899	167	<0.03
	10/11/2005	0.28	0.06	2110	863	170	<0.03
	Average	0.35	0.08	2109	927	180	0.04
2006	3/1/2006	0.35	0.08	2230	926	197	0.04
	4/10/2006	0.35	0.09	2150	985	185	0.05
	6/26/2006	0.3	0.07	1550	645	158	<0.03
	8/14/2006	0.36	0.09	1980	928	----	----
	10/2/2006	0.38	0.09	2020	925	161	0.07
	Average	0.35	0.08	1986	882	175	0.04
2007	4/1/2007	0.32	0.08	2130	904	173	<0.03
	4/30/2007	0.41	0.09	2240	980	164	0.04
	6/26/2007	0.32	0.08	2010	856	163	<0.03
	8/17/2007	0.38	0.08	2130	978	----	----
	10/10/2007	0.39	0.09	2100	885	184	0.04
	Average	0.36	0.08	2122	921	171	0.04
2008	4/1/2008	0.465	0.083	2050	1020	90	0.05
	6/2/2008	0.285	0.059	1750	893	152	<0.03
	9/24/2008	0.318	0.056	1950	867	157	<0.03
	Average	0.36	0.07	1917	927	133	0.04
2009	4/20/2009	0.388	0.065	2035	913	171	0.05
	6/2/2009	0.308	0.064	1980	871	174	0.03
	7/24/2009	0.369	0.061	2020	852	----	----
	9/28/2009	0.45	0.079	2080	940	177	0.07
	Average	0.39	0.07	2030	894	174	0.05

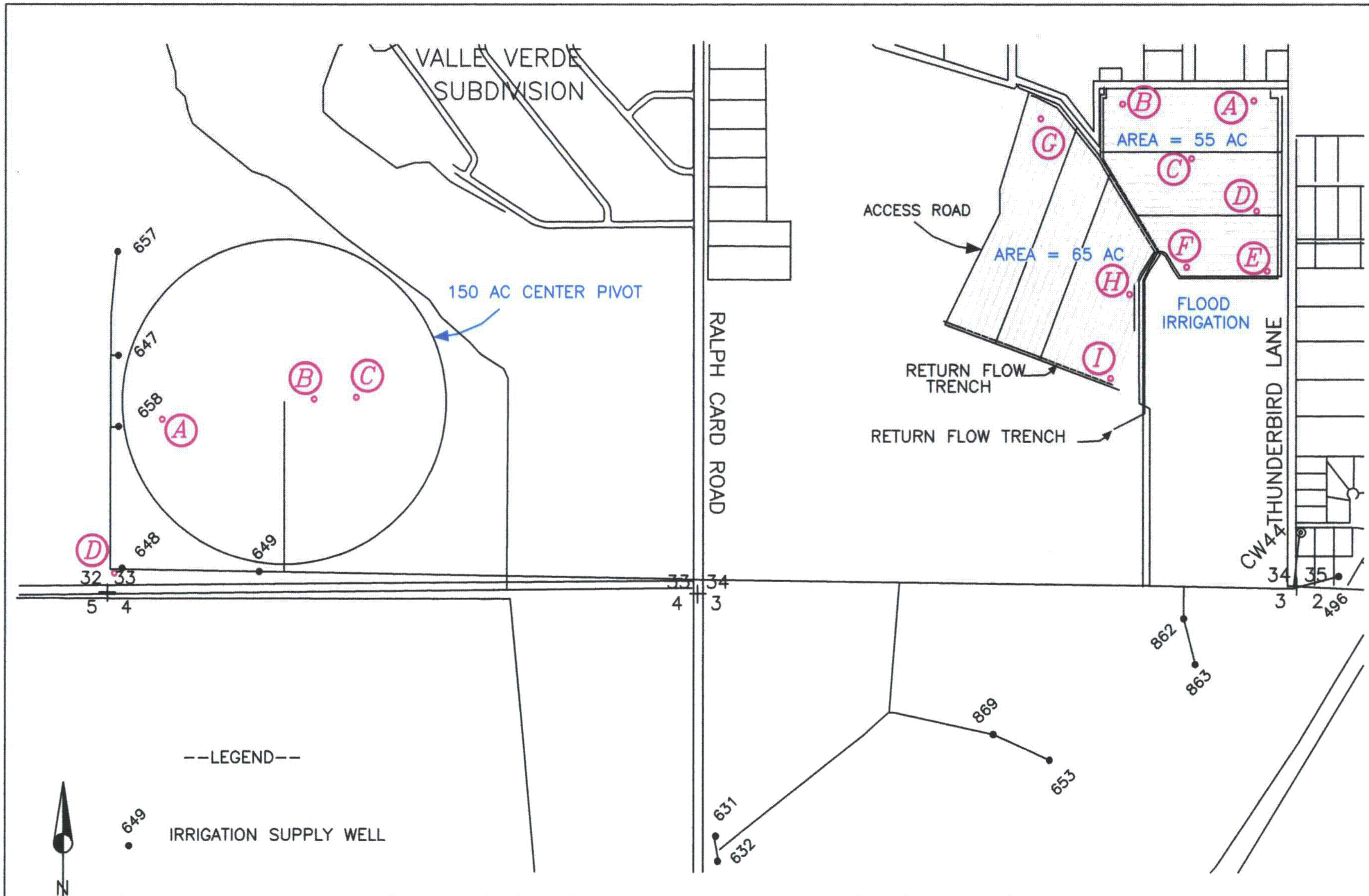

FIGURE 2–1. 1999 AND 2000 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

SCALE: 1" = 1200'

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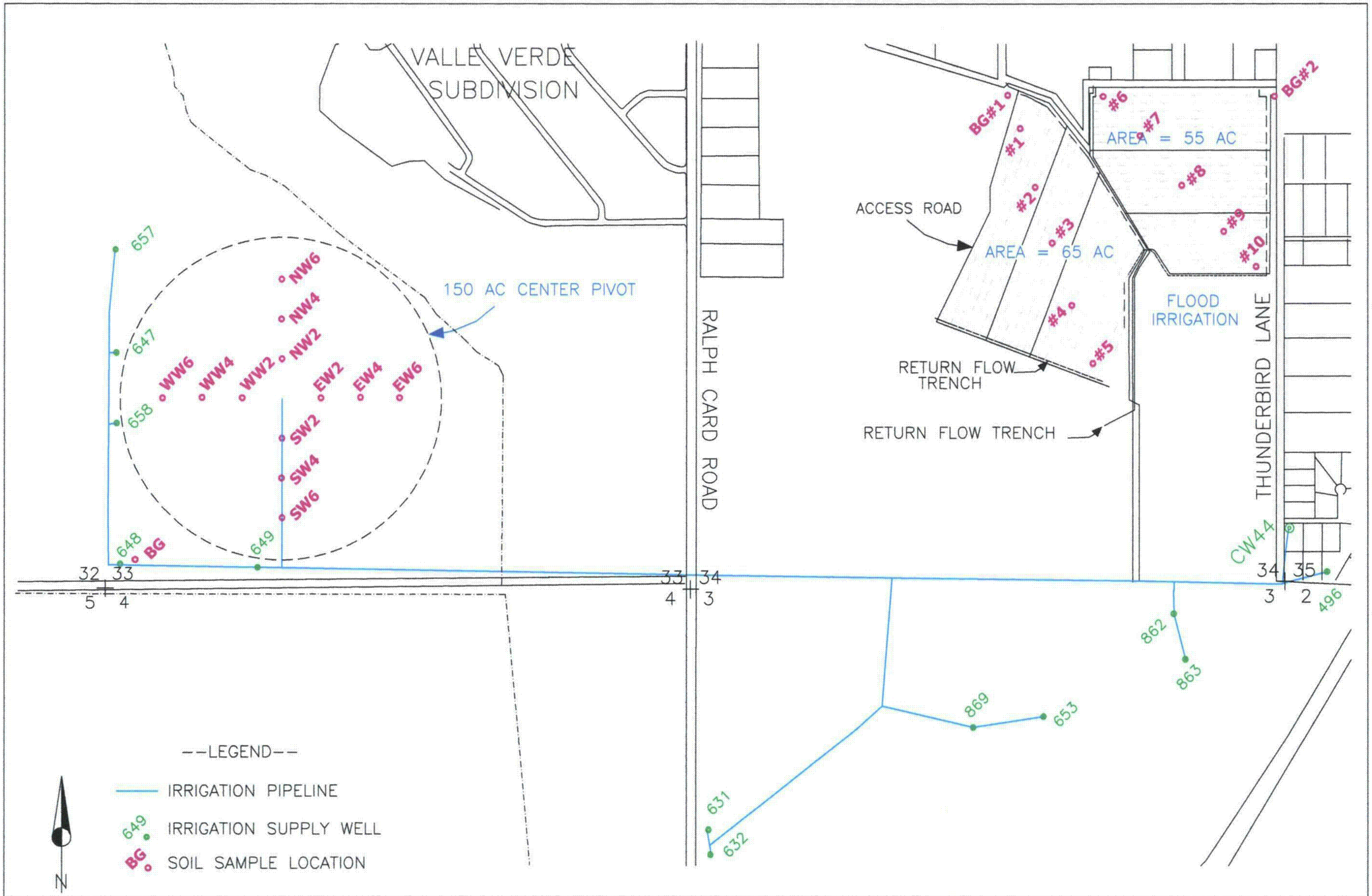

FIGURE 2-2. 2001 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

SCALE: 1" = 2400'

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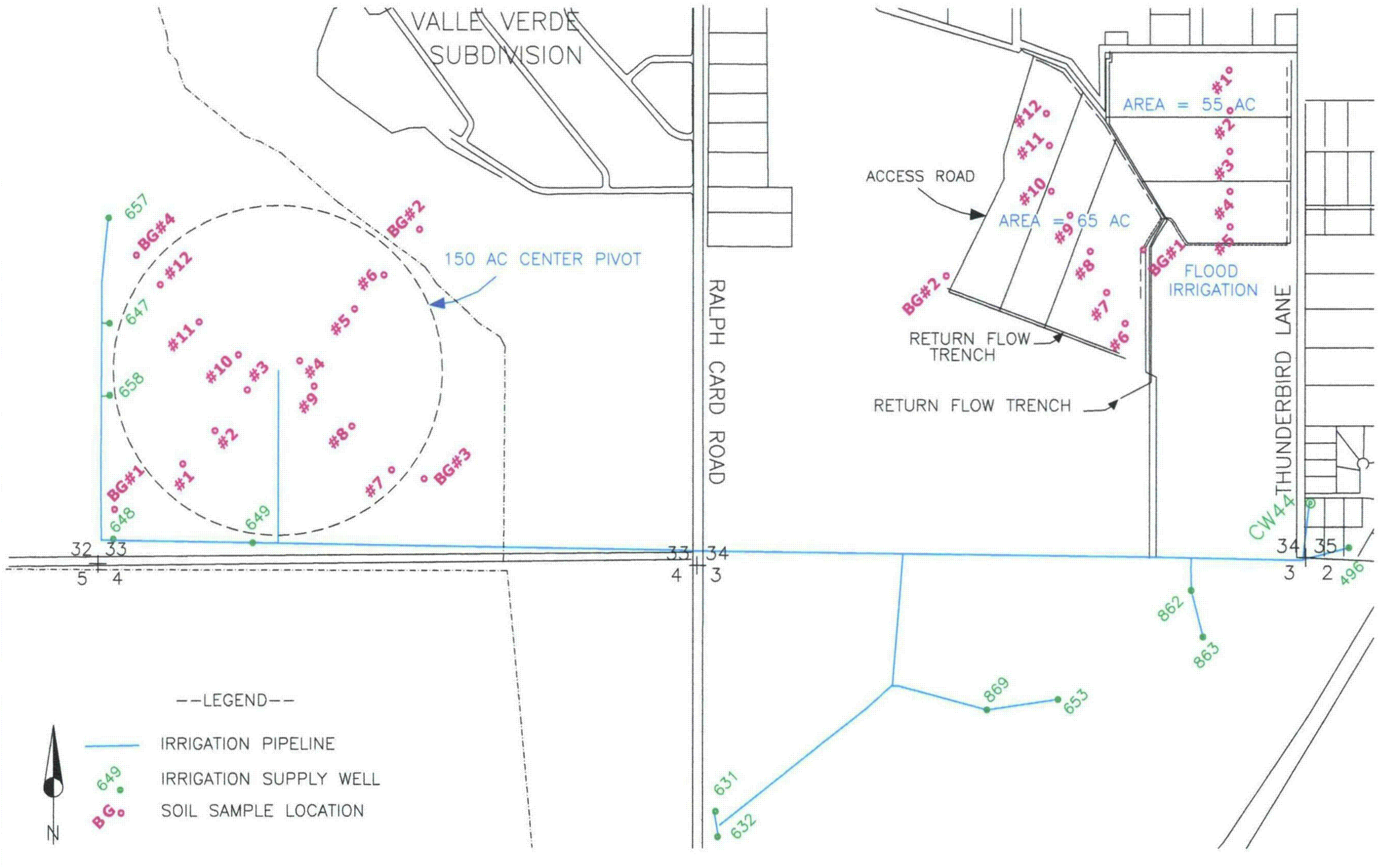

FIGURE 2-3. 2002 SECTIONS 33 AND 34 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

DATE: 02/18/10

SCALE: 1" = 1200'

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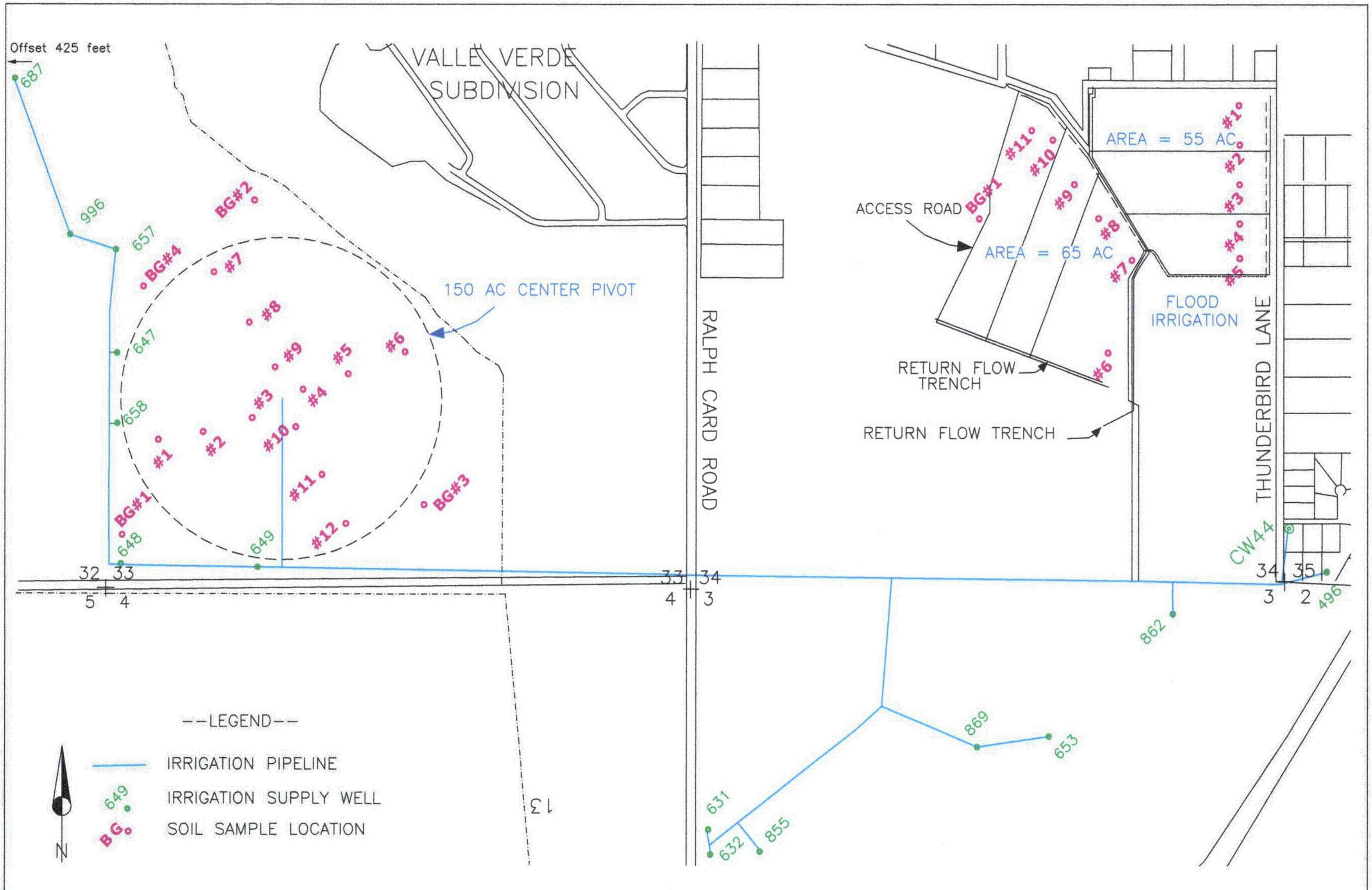

FIGURE 2-4. 2003 SECTIONS 33 AND 34 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

SCALE: 1" = 1200'

DATE: 02/18/10

C:\PROJECTS\2010-06\IRRIGATION\SOILSAMP2010.DWG

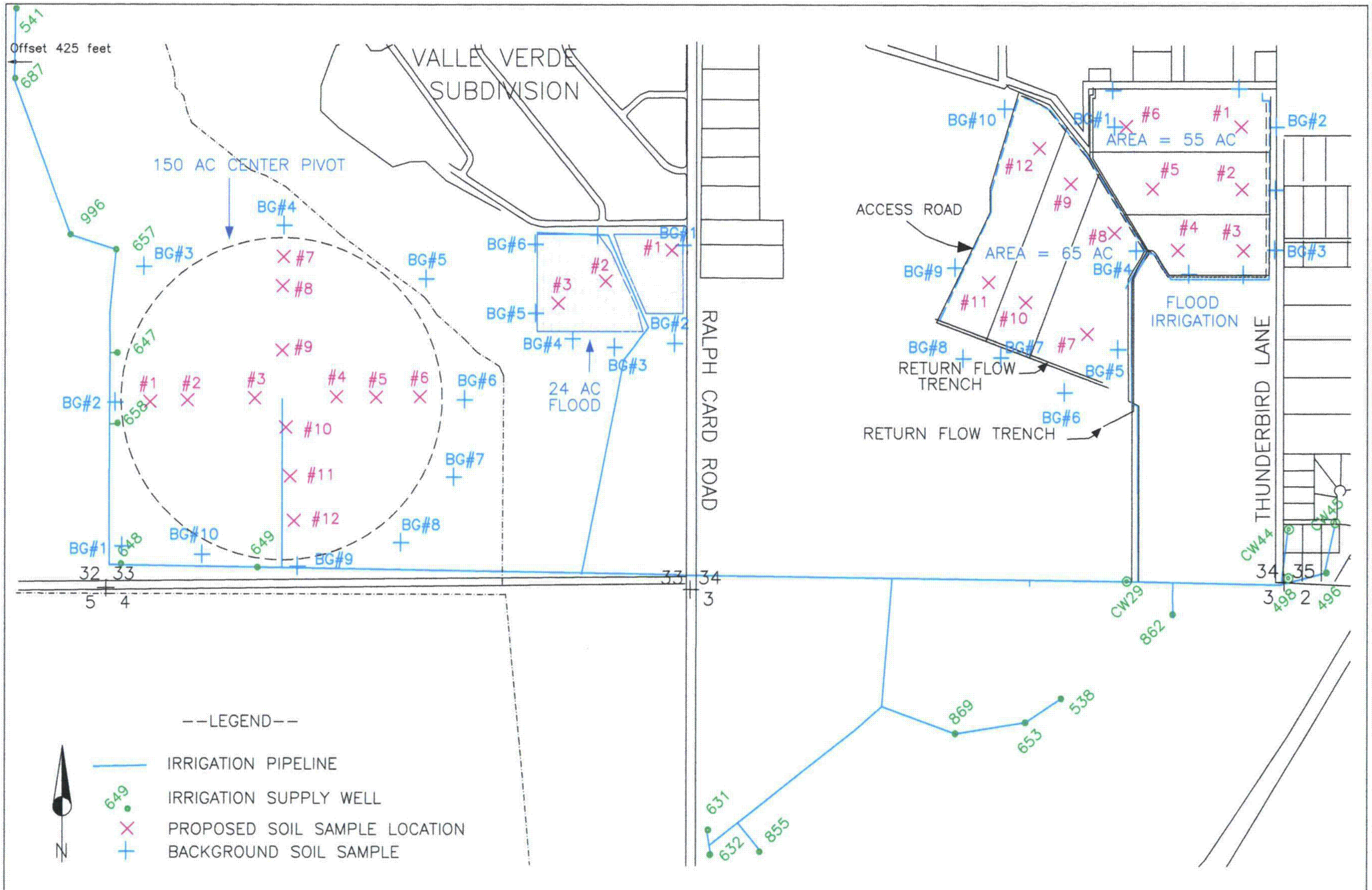

FIGURE 2-5. 2004 SECTIONS 33 AND 34 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

SCALE: 1" = 1200'

DATE: 02/18/10

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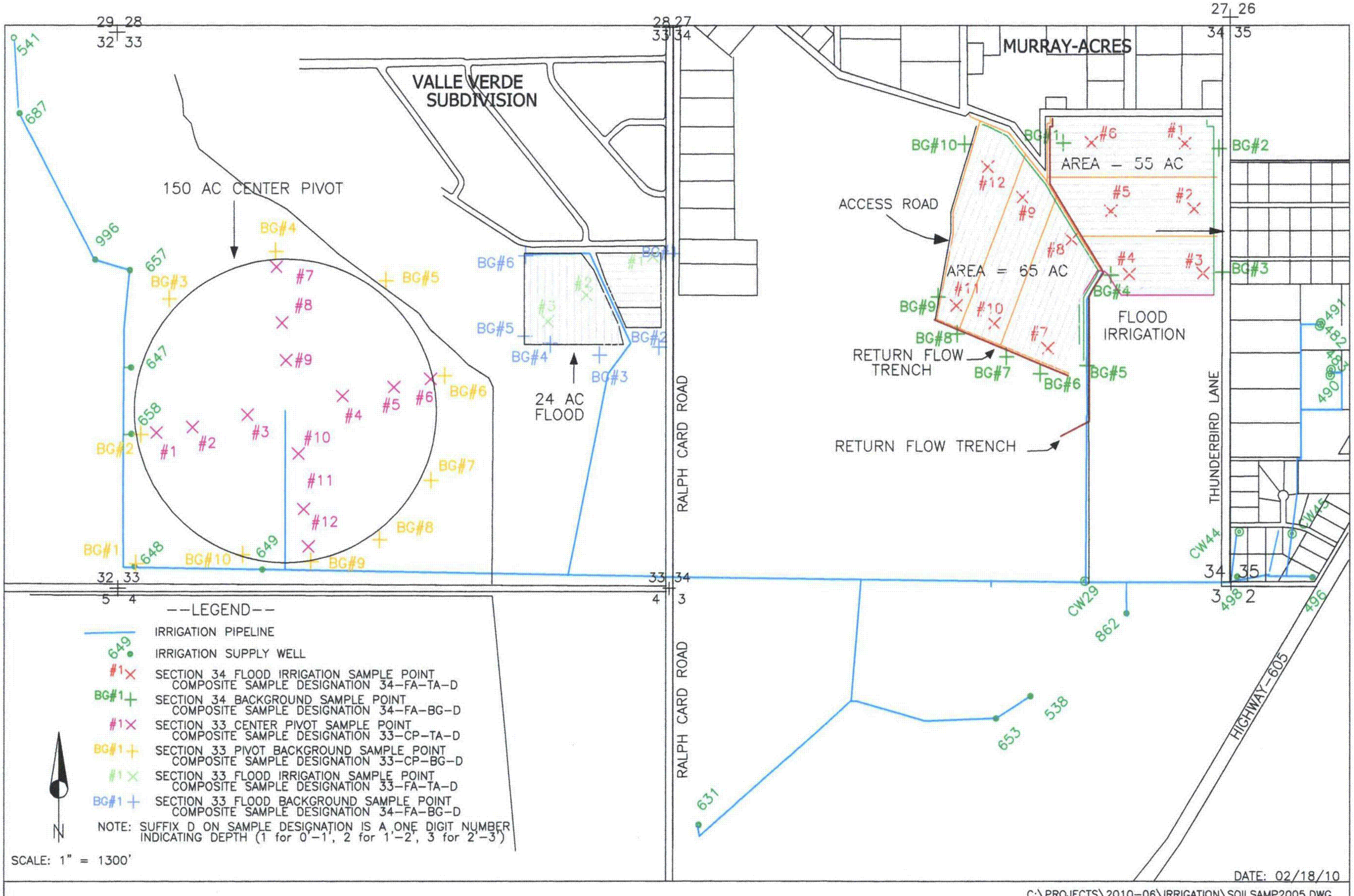

FIGURE 2-6. 2005 SECTIONS 33 AND 34 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

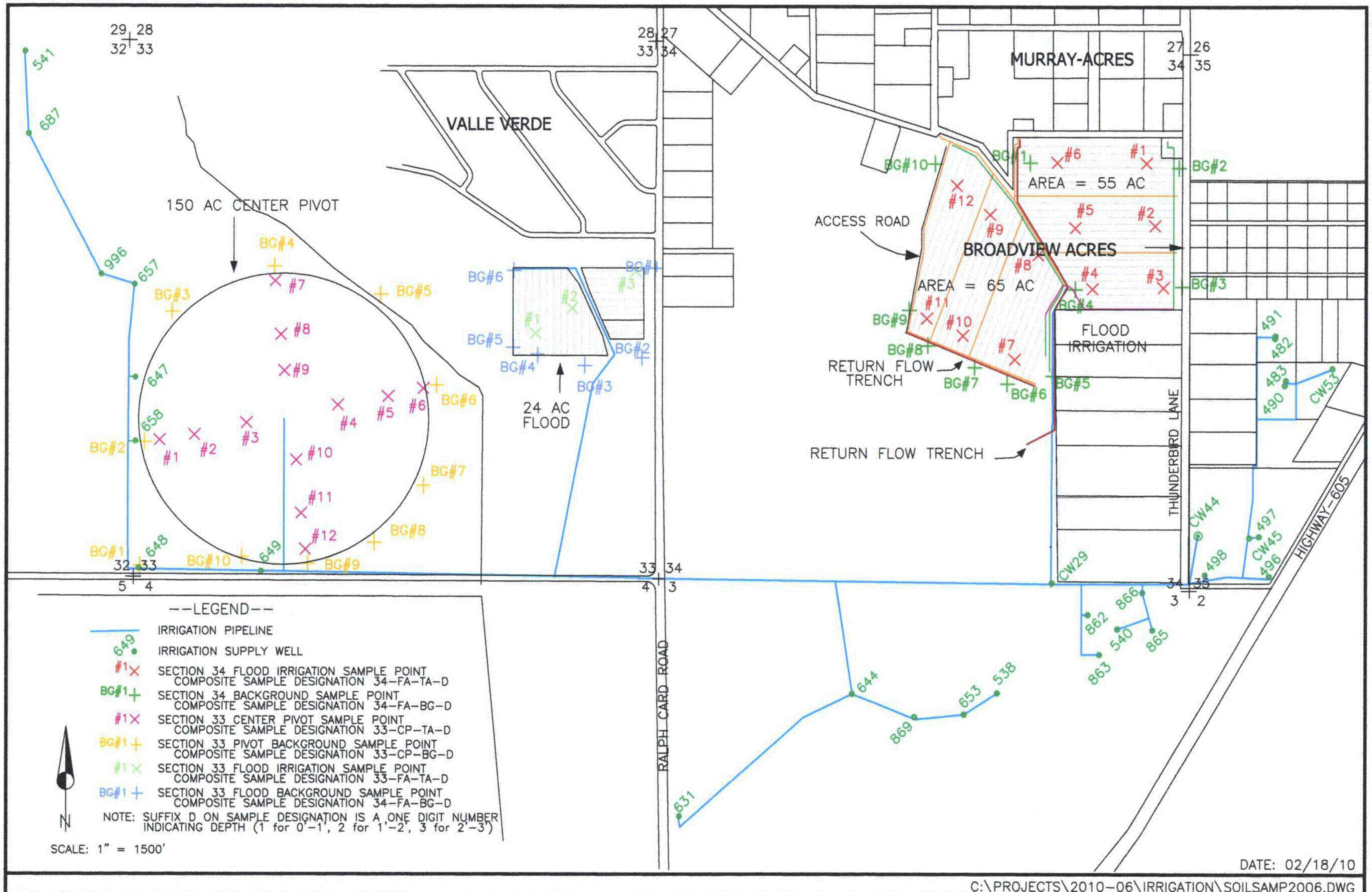

FIGURE 2-7. 2006 SECTION 33 AND 34 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

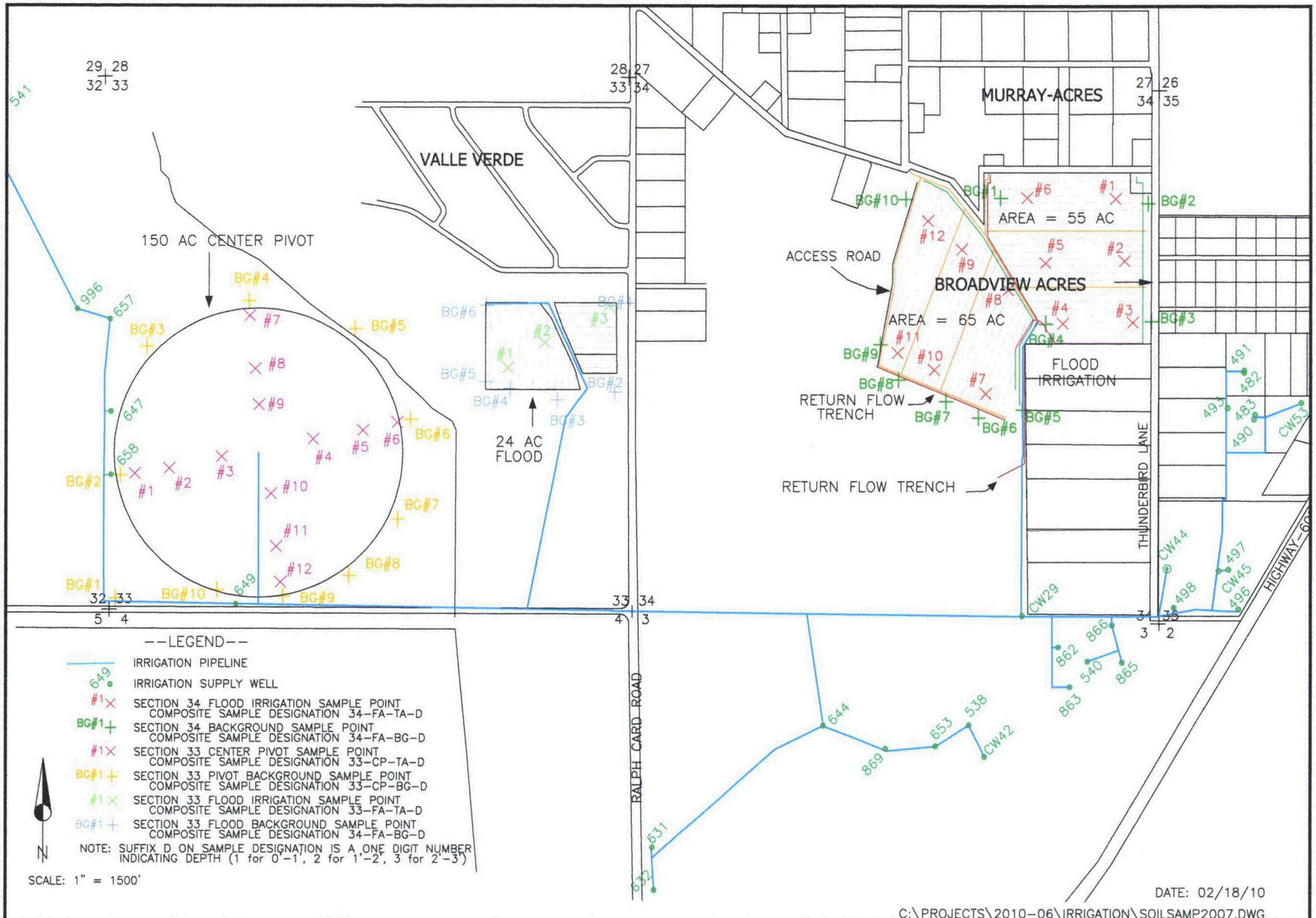

FIGURE 2-8. 2007 SECTION 33 AND 34 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

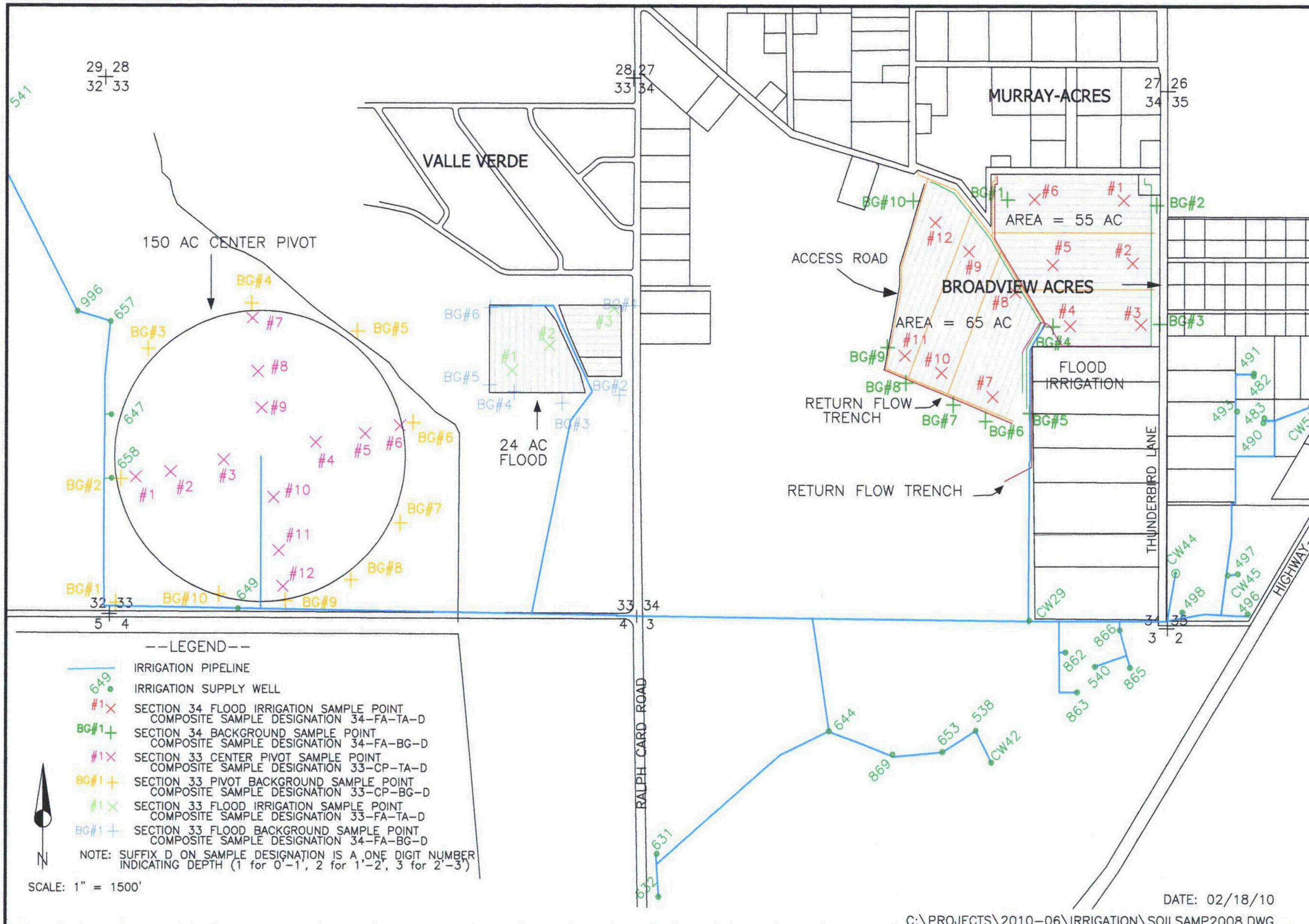

FIGURE 2-9. 2008 SECTION 33 AND 34 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

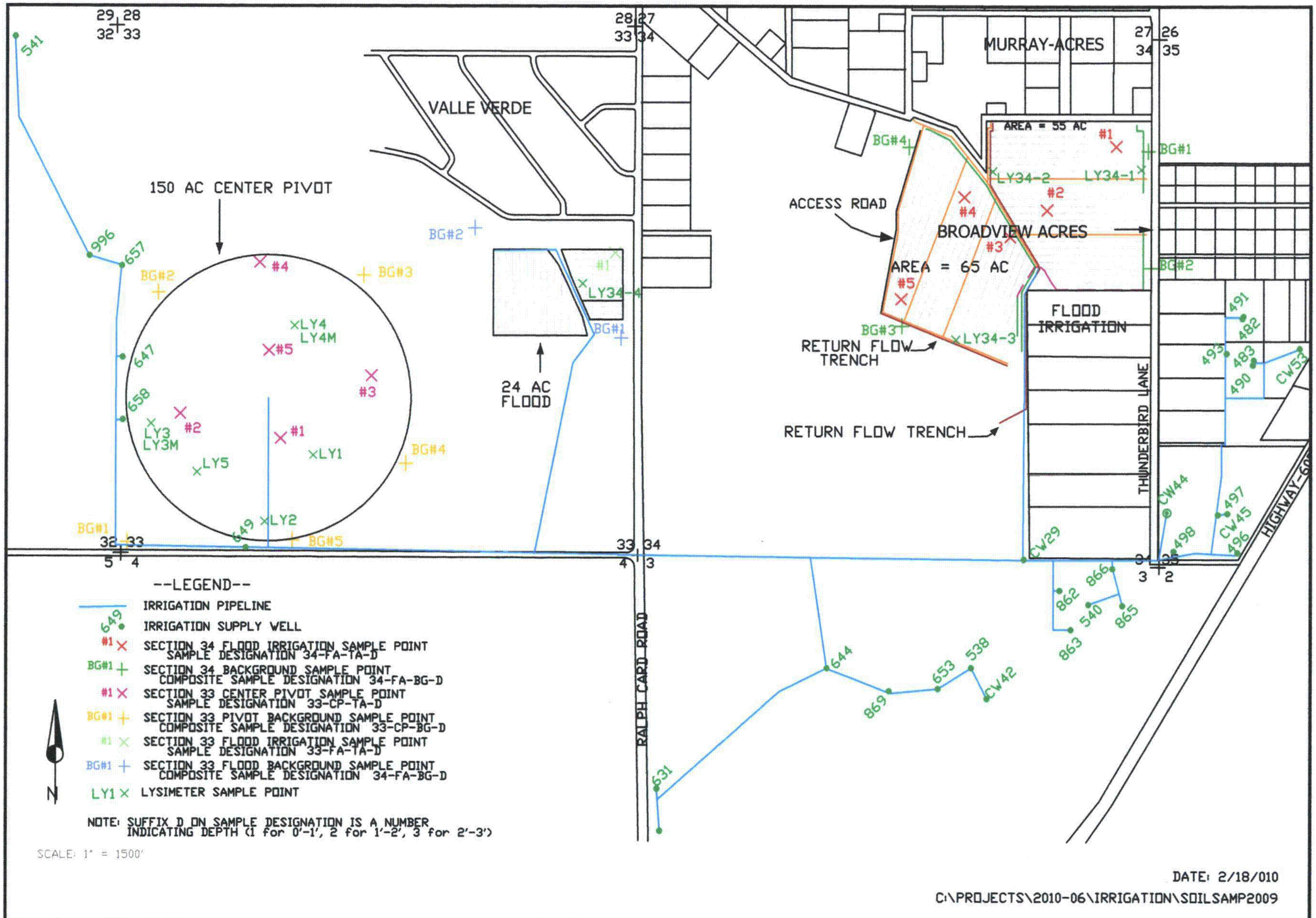

FIGURE 2-10. 2009 SECTION 33 AND 34 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

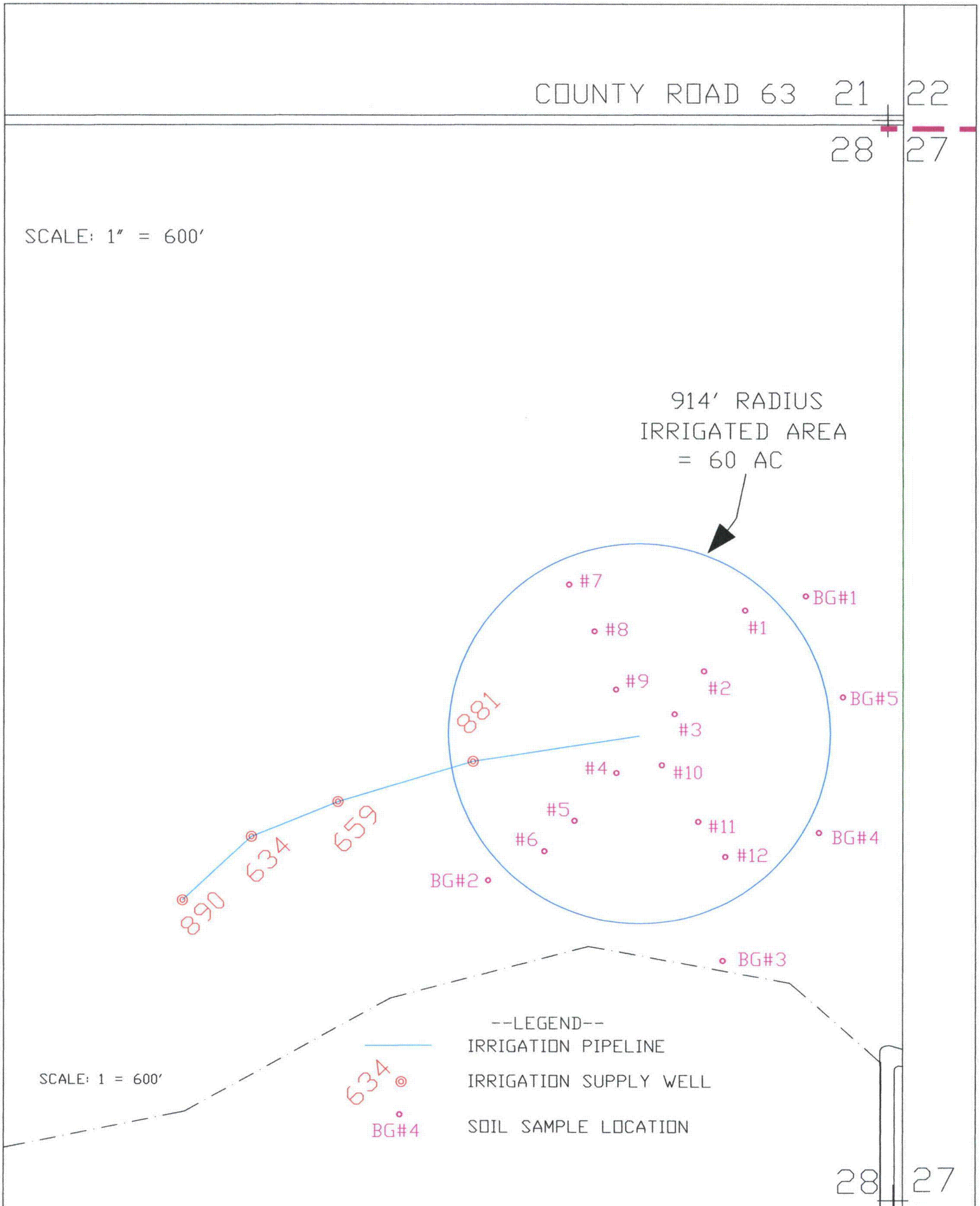

FIGURE 2-11. 2002 SECTION 28 IRRIGATION AREA WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

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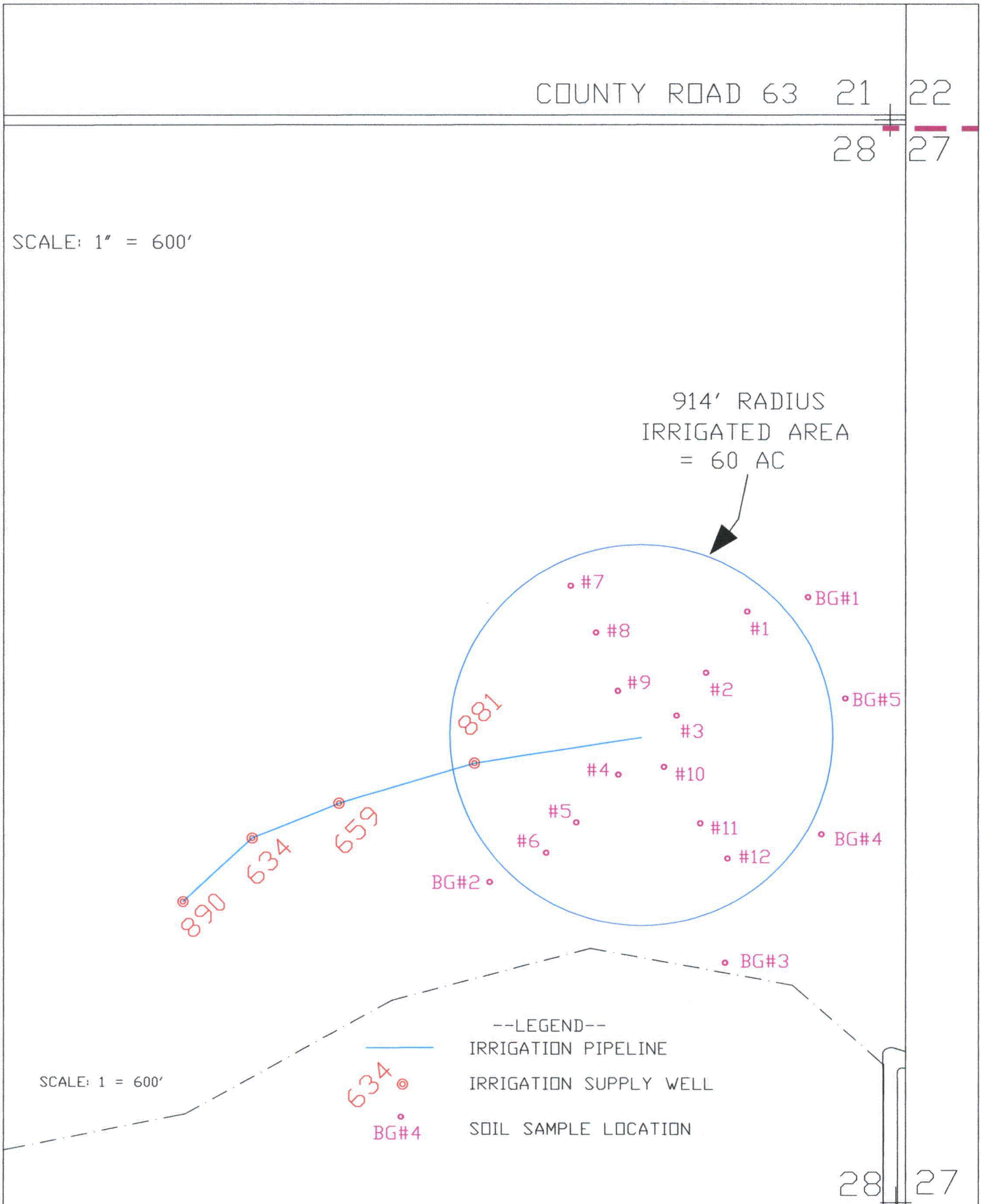

FIGURE 2-12. 2003 SECTION 28 IRRIGATION AREA WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

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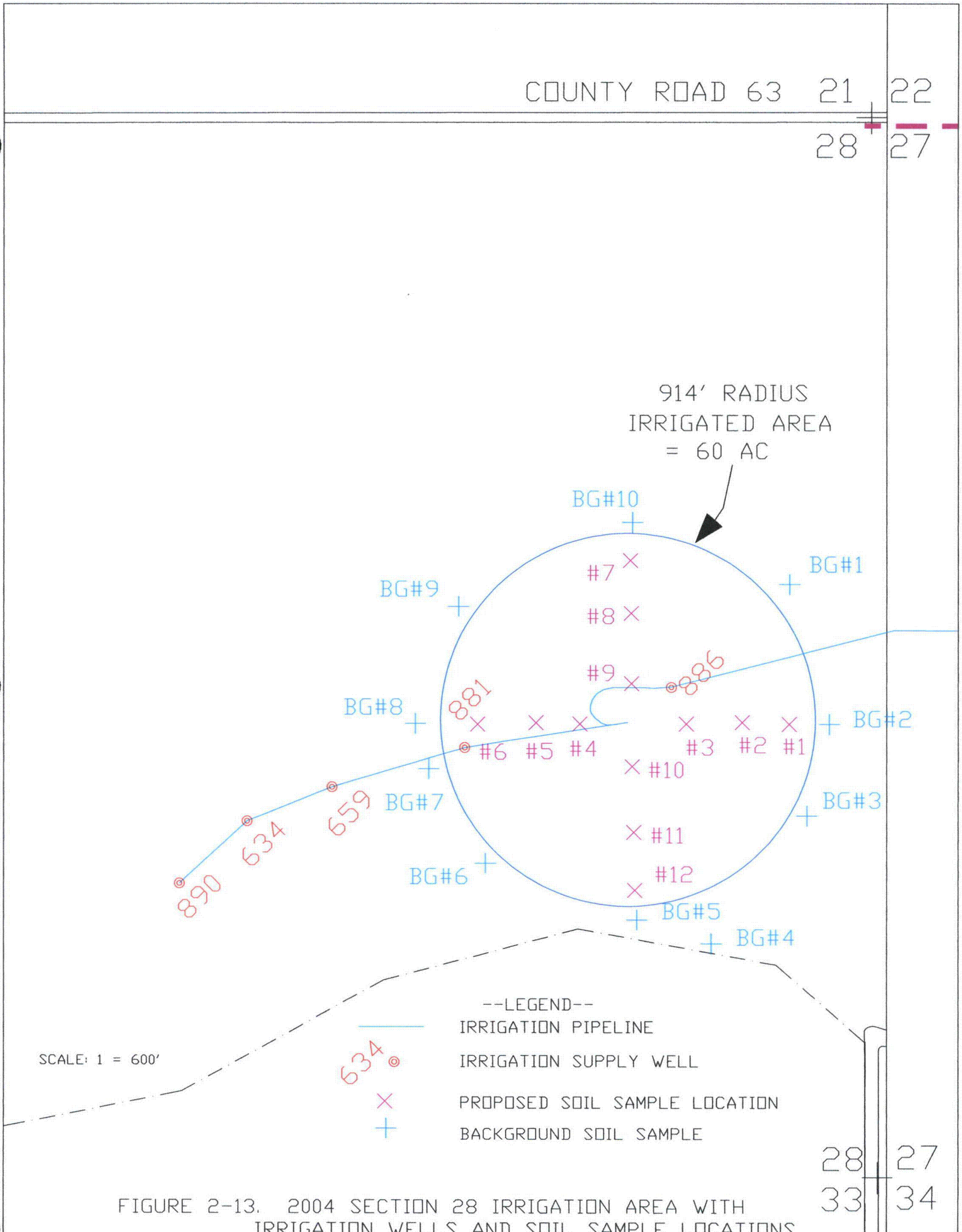


FIGURE 2-13. 2004 SECTION 28 IRRIGATION AREA WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

C:\PROJECTS\2010-06\IRRIGATION\28CP2004

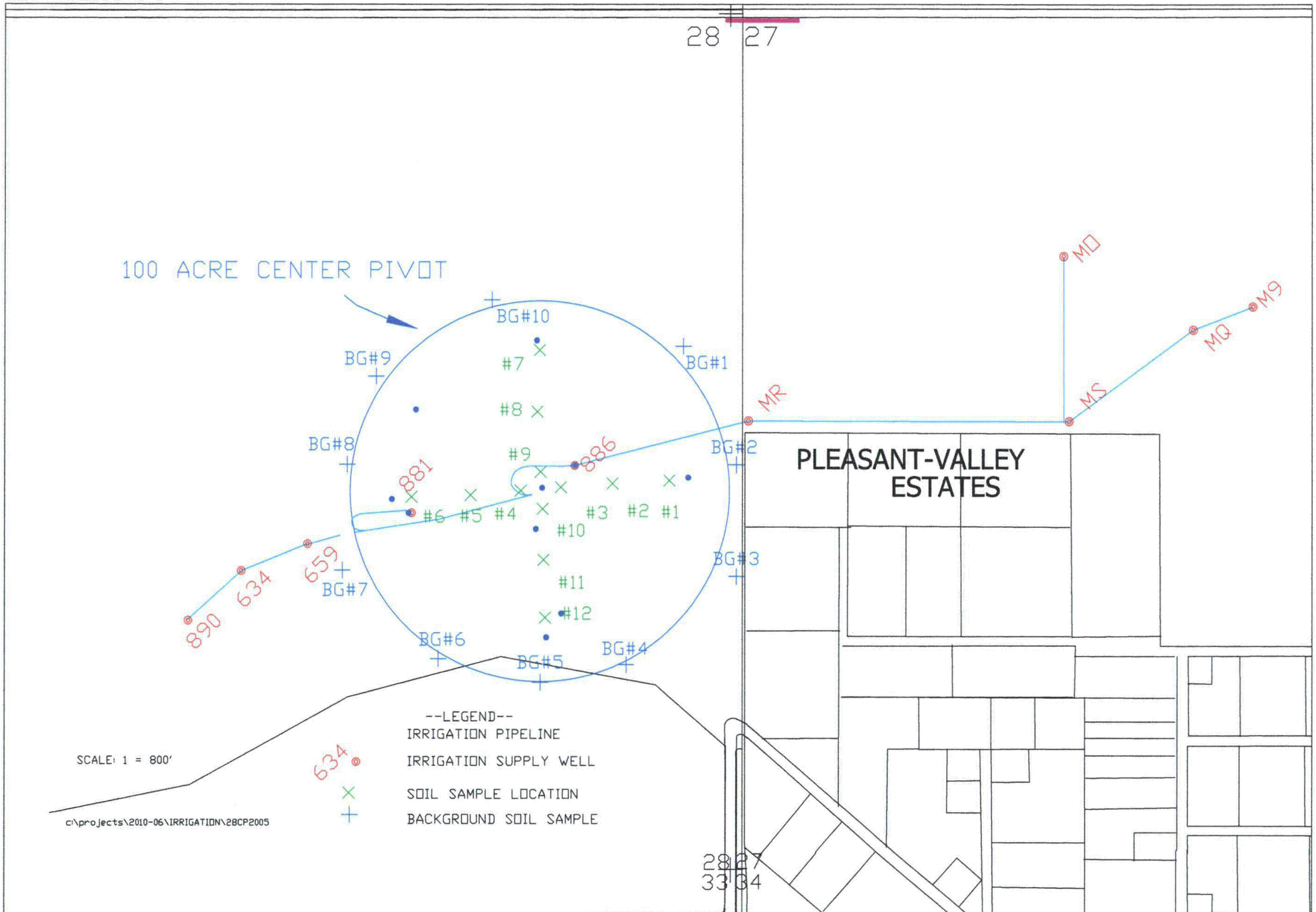


FIGURE 2-14. 2005 SECTION 28 IRRIGATION AREA WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

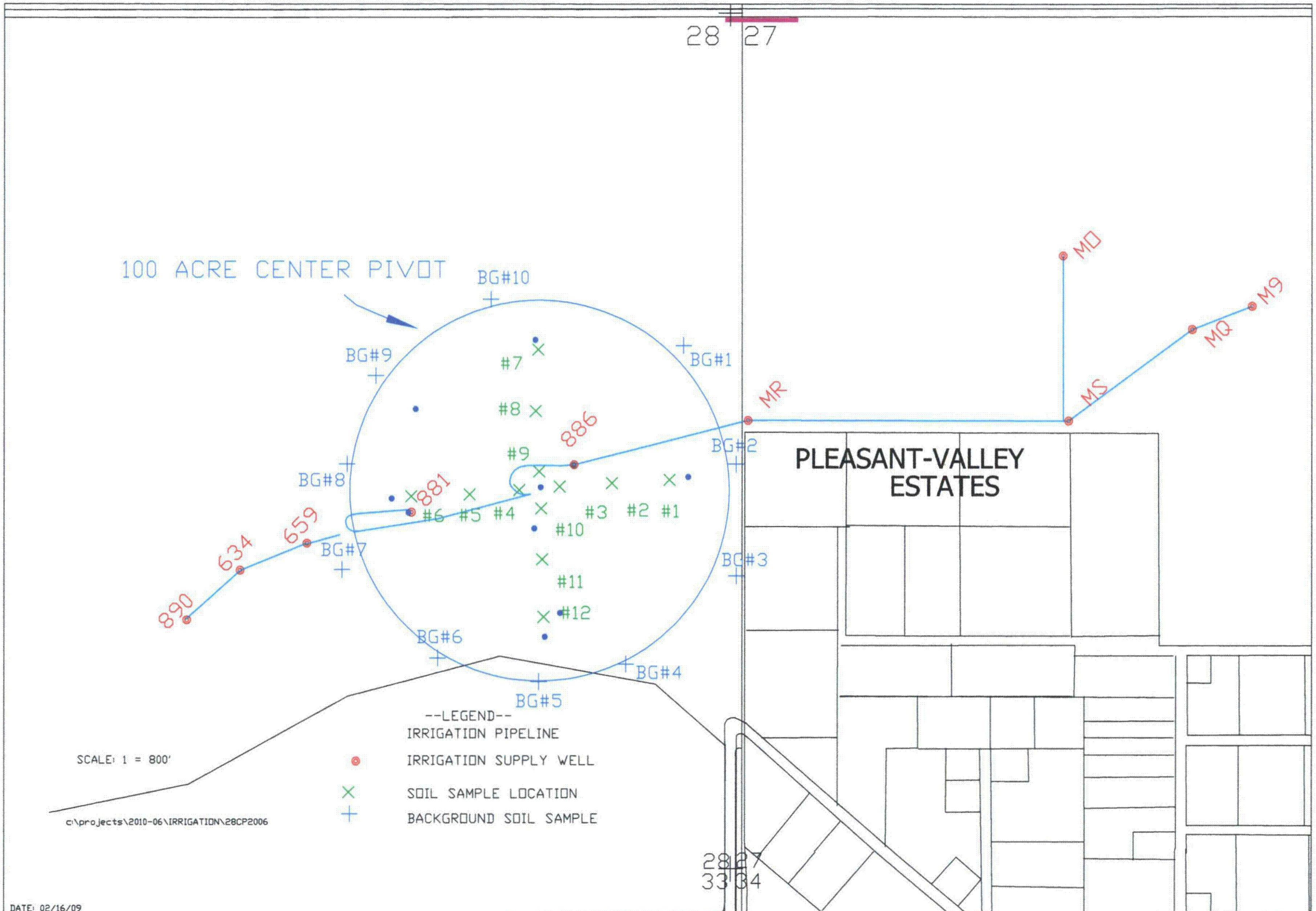


FIGURE 2-15. 2006 SECTION 28 IRRIGATION AREA WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

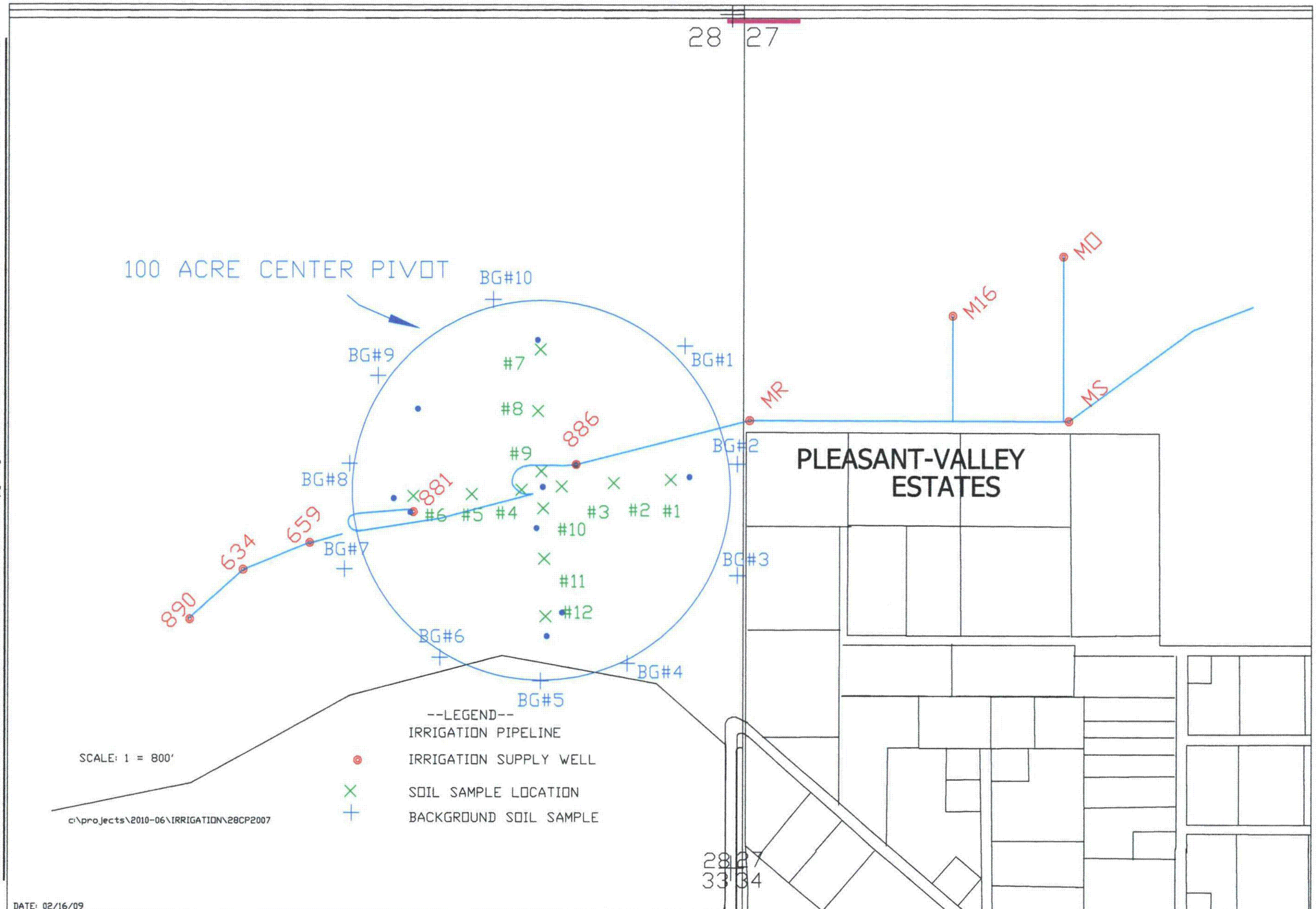


FIGURE 2-16. 2007 SECTION 28 IRRIGATION AREA WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

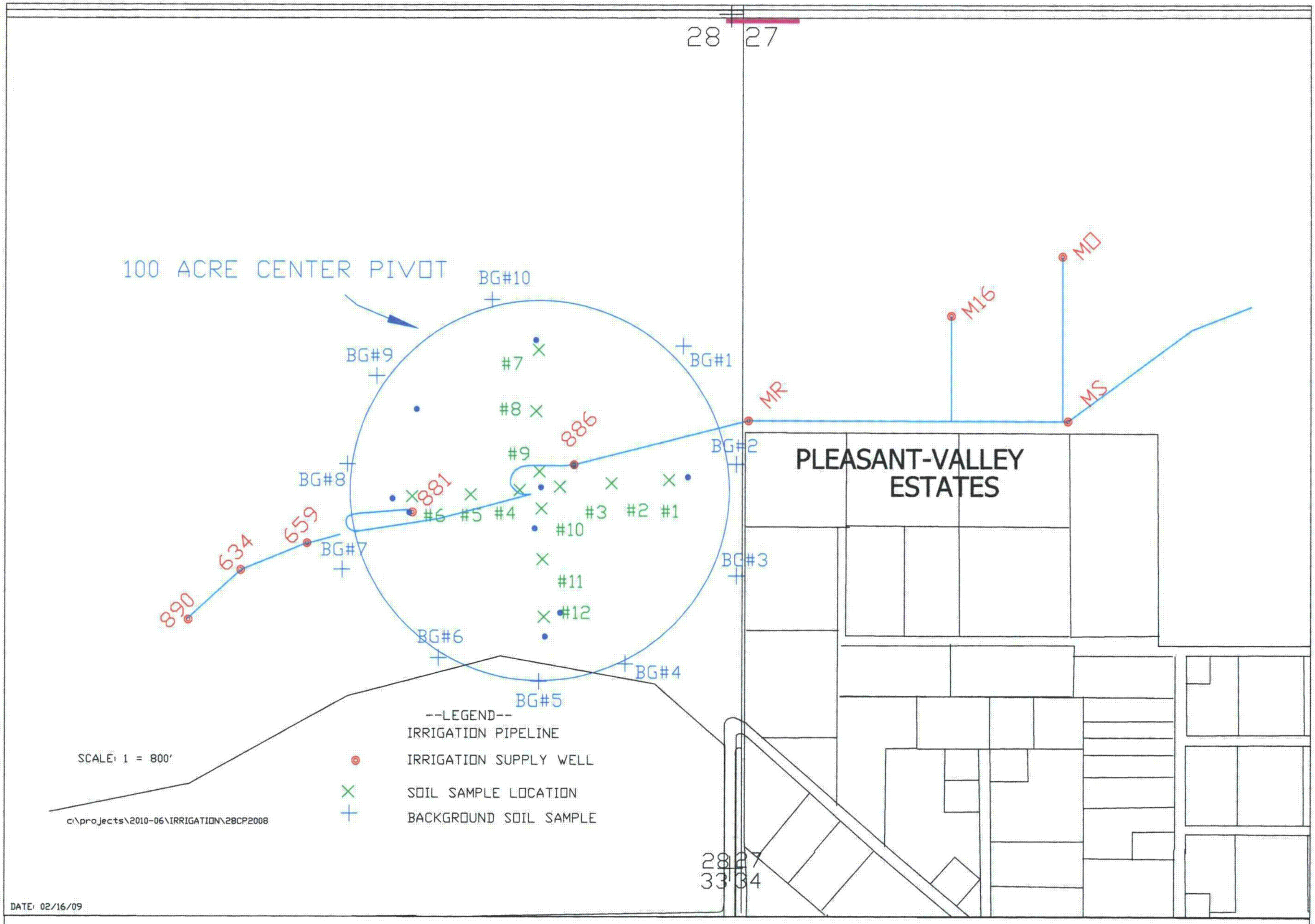


FIGURE 2-17. 2008 SECTION 28 IRRIGATION AREA WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

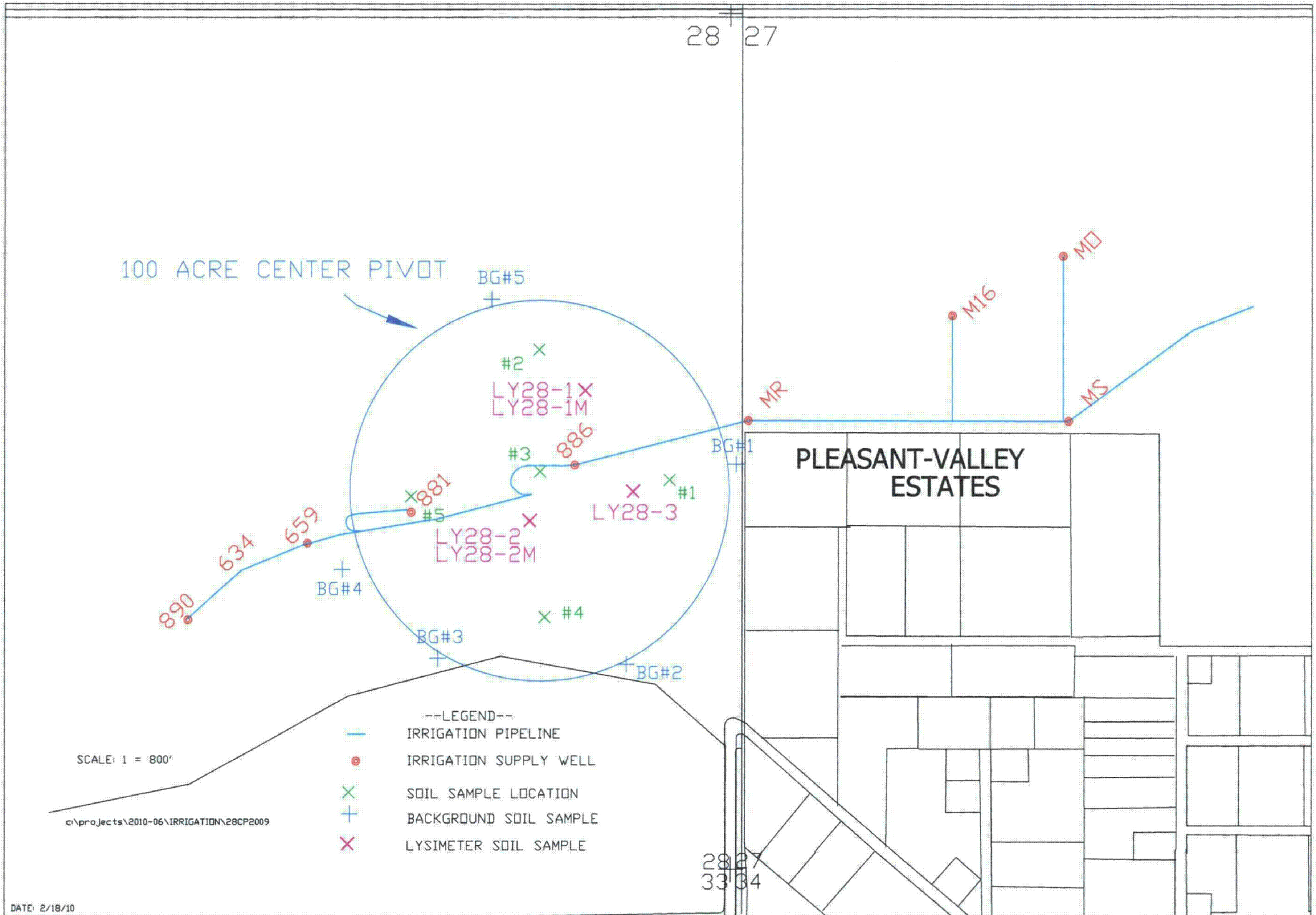


FIGURE 2-18. 2009 SECTION 28 IRRIGATION AREA WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

3.0 Soil and Soil Moisture Concentrations

Samples have been collected from irrigated and non-irrigated soils and analyzed for uranium, selenium, and chloride concentration to quantify the retention/adsorption of these constituents in the soil profile over time. The incremental quantity of uranium and selenium retained in soil was then used to calculate transfer coefficients from soil to hay. Chloride was tracked as a conservative constituent and used to verify observations of selenium retention in soil.

Investigators labeled the first samples collected from irrigated areas as pre-operations samples. Samples collected from adjacent, fallow areas were labeled as background samples. Areas slated for irrigation that were sampled prior to irrigation (pre-operations) were essentially background areas until they were irrigated with impacted ground water. Thus, to assist the reader, sampling areas are hereafter referred to as treated (irrigated areas) and untreated (non-irrigated areas) areas.

ACZ Laboratories, Inc. performed the analyses on the soil samples. When testing for chloride and sulfate, ACZ consistently returned qualifiers for those two constituents stating "analysis exceeded method hold time."

Soil moisture concentrations were initially measured in the irrigated fields in 2009. Lysimeters were installed in selected locations to collect the soil moisture water samples.

3.1 Subsurface Conditions

The subsurface conditions are defined in this section. The depth to the top of the basalt is presented in this section to show the thickness of alluvial material above the basalt. Cross-sections are used to illustrate the subsurface conditions down to the base of the alluvial aquifer.

3.1.1 Section 33

The depth of the alluvial material to the top of the basalt is presented in Figure 3-1 for the Section 33 area. This figure shows that the depth of the basalt below the land surface varies from less than 5 feet in the southwestern portion of Section 33 Center Pivot to greater than 20 feet in the southeastern portion of the pivot. The limits of the basalt are shown in the area of the eastern portion of Section 33 where the basalt is absent. It is shown by a cross-hatch pattern. Figure 3-1 shows the location of a cross-section that goes from irrigation well 657 to San Andres well 907 in Section 4. Figure 3-2 shows the cross-section indicating thickness of the alluvial material above the basalt and the thickness of the basalt. The base of the alluvial material is also shown on this cross-section and the alluvial water-level elevation is also presented to show how much of the alluvial material is saturated. The cross-section also shows the alluvial wells with their completion interval and also the depth of installation of lysimeters along this cross-section. The lysimeters results are presented later in Section 3.4.

3.1.2 Section 34

The Section 34 flood area is shown on the eastern portion of Figure 3-3. This 120 acre flood area is just south of Murray Acres and the basalt is not present under any of the Section 34 flood area. Figure 3-3 shows the location of a cross-section which runs from well CW-43 in the Section 33 Flood area through the southern portion of the Section 34 Flood area and into the western edge of Section 35. This cross-section shows the depth to the alluvial aquifer and the base of the alluvial aquifer (see Figure 3-4). On the western side of the cross-section shown in Figure 3-4, the basalt is present and the elevation of the base of the alluvium is higher than the surrounding water-level elevation in the alluvium. The cross-section shows the location of the west fault east of well CW37, and also shows that the Upper Chinle aquifer subcrops against the alluvial aquifer in the eastern edge of this cross-section.

3.1.3 Section 28

Figure 3-5 shows the depth to basalt in the Section 28 Center Pivot area. The depth to basalt in this area generally increases from the southwest side of the center pivot where the depth to the top of the basalt is approximately 10 feet to greater than 20 feet on the northeast side of the center pivot. The cross-hatch pattern shows where the basalt does not exist in the alluvial material in the far southeast corner of Section 28. Figure 3-6 presents the cross-section from irrigation well 659 through well CW-32 (see Figure 3-5 for location of this cross-section). This cross-section shows that the basalt extends down below the alluvial water level in the majority of the Section 28 Center Pivot area. Three irrigation supply wells are shown on this alluvial cross-section. The cross-section also shows the completion of two lysimeters.

3.2 Background Soil Concentrations

Naturally-occurring uranium and selenium concentrations in untreated soils were determined in two studies. In 1998, HMC characterized uranium and selenium concentrations in soils, prior to selecting fields for the irrigation study. In 1999, HMC investigated chloride concentrations in Sections 33 and 34 prior to the start of irrigation. HMC has also collected and analyzed soil samples immediately prior to and during the irrigation program.

3.2.1 1998 Investigation

The first investigation (RIMCON and Hydro-Engineering, 1998) was completed prior to the selection of treatment areas. Surface and near-surface soil samples were collected inside and outside the fields slated for irrigation. The samples were analyzed for uranium and selenium concentrations and parameters to define soil types.

At the time of sampling, surface soils in Sections 28, 33, and 34 were placed in three general categories: loamy sand, sandy loam, and sandy clay loam, respectively. The percentage of clay in these soils appeared to increase from Section 28 to 33 to 34 (RIMCON and Hydro-Engineering, 1998).

The 1998 results are listed in Tables 3-1, 3-2 and 3-3 for Section 33, 34 and 28, respectively, along with recent "untreated area" background analyses. A "1998" in the comment column in the tables indicate the sample was taken during the 1998 background investigation. Figure 3-7 shows the location of the soil samples collected in Sections 33, 34, and Section 28. Seven soil samples collected from Section 33 were analyzed for uranium and selenium. The two eastern Section 33 soil results are included with the Section 34 results in Table 3-2 because the soil in eastern Section 33 is similar to the clay soils in Section 34. This figure also shows nine samples in Section 34 and one in the northern portion of Section 3 that are considered to be representative of the area for Section 34. Figure 3-7 also shows the location of seven samples in Section 28 and one along the western edge of Section 27 that were used to define the background concentrations in Section 28 in the 1998 investigation.

3.2.2 Background Determinations during Ongoing Investigation

Additional background samples were collected in treated (pre-operational) and untreated areas, starting in 1999. HMC continued to collect samples from the treated (post-treatment) and untreated areas in subsequent years.

The background soil samples were analyzed by ACZ Laboratories, Inc. Uranium concentrations were determined using U.S. Environmental Protection Agency (EPA) Method 6020 ICP-MS, with an MDL of 0.03 mg/kg for all samples collected in 2000, 2002, 2003 and 2004; 0.01 mg/kg in 2001; 0.06 mg/kg in 2005; and 0.05 mg/kg in 1999, 2006, 2007 and 2008.

Selenium concentrations in samples collected from 1999-2001 were determined using EPA Method 7742 Modified AA-Hydride, with an MDL of 0.1 mg/kg. The 2002 selenium analyses were determined using three methods. The samples were first analyzed using EPA Method 6020 ICP-MS, with an MDL of 0.8 mg/kg. The samples were then re-analyzed twice: first by way of EPA Method 7742 modified AA-Hydride, followed by EPA Method 6020 ICP-MS. The latter analysis was performed because selenium concentrations reported by way of EPA Method 7742 were below the relatively high MDL of 0.6 mg/kg. A lower MDL (0.05 mg/kg) was then obtained in subsequent years, using EPA Method 6020. The EPA M6020 ICP-MS method was used for 2003, 2004, 2005, 2006, 2007, 2008 and 2009. All selenium concentrations reported in 2002 were below the MDL of 0.60 mg/kg, limiting the usefulness of the data. The 2002 results were not considered in evaluating trends in selenium concentrations, because selenium concentrations prior to and after 2002 were lower than the lowest MDL observed in 2002 by a factor of two.

3.2.3 Mean Background Soil Concentrations

Mean background is defined as the average of the untreated, pre-irrigation-treated and background concentrations of constituents in all such samples collected to date (see Tables 3-1 through 3-3 for updated mean background values). This value is designated by section and layer(s) and is updated with new data as they are obtained. Thus, it changes annually. The importance in having this value defined in this manner is to supplement and improve the background data set. These mean background values are used to calculate uptake of a constituent in the treated areas. Figures 3-8, 3-9 and 3-10 show the data used to calculate the mean uranium background concentrations for Section 33, 34 and 28 respectively. Figures 3-11, 3-12 and 3-13 depict the mean background plots for selenium.

As of 2009, mean background uranium concentrations for the first three Section 33 intervals are 0.79 (0-1 ft), 0.69 (1-2 ft), and 0.72 mg/kg (2-3 ft). The background values for the deeper Section 33 soils from 3-4 to 15-17 feet varied from 0.52 to 0.99 mg/kg. This year is the first year to measure soil at depths greater than three feet since 1998 when select samples were taken from depths greater than three feet. The corresponding mean background concentrations for selenium and chloride are 0.14, 0.15, and 0.13 mg/kg; and 25, 36, and 36 mg/kg, respectively. Table 3-1 lists uranium, selenium, and chloride concentrations in the 1998 and 1999 background samples and those collected near the Section 33 irrigation area from 2000 through 2009. This table is broken into eleven depth intervals: 0-1 through 15-17 ft. Results from a sample are listed in the depth interval if at least 6 inches (in) of the sample is from the interval.

In Section 34, the mean background uranium concentrations were 1.98 (0-1 ft), 1.50 (1-2 ft), and 1.16 (2-3 ft) mg/kg. Table 3-2 presents the constituents in Section 34 background soils. As in Section 33, the Section 34 soils generally show a decrease in mean uranium concentrations with increasing depth, but the difference between concentrations for each depth interval is greater in Section 34. A few results appeared to be outliers and were not used to calculate concentrations. Note that the six eastern samples from Section 33 are included in the Section 34 table because the soils from these two samples are primarily clays. The Sections 33 and 34 clay soils are combined in Table 3-2 to define the background concentrations for the two flood irrigated areas.

In Section 28, the mean background uranium concentrations were 0.59 (0-1 ft), 0.53 (1-2 ft), and 0.52 (2-3 ft) mg/kg. Table 3-3 presents the results for Section 28.

The mean background concentrations of selenium are similar in Sections 28 and 33. Selenium concentrations in Section 34 are generally higher, presumably because of their association with clay soils.

Measurements for uranium, selenium, and chloride showed a high degree of variability between and within fields, with coefficients of variation (100 x standard deviation/mean) ranging between 22 and 93 percent.

Table 3-1. Pre-Operations and Background Soil Sample Results for Section 33

Interval (ft)	Location ID	Area	Depth (in)	Natural Uranium (pCi/g)	Natural Uranium mg/kg	Selenium mg/kg	Chloride (mg/kg)	Comment
0-1	S33-4	Treated	0-6	0.37	0.55	0.03	----	*1998
	S33-4	Treated	6-48	0.36	0.53	0.03	----	*1998
	S33-7	Treated	0-24	0.30	0.44	0.03	----	*1998
	S33-8	Treated	0-20	0.58	0.86	0.07	----	1998
	S33-9	Untreated	0-24	0.56	0.83	0.15	----	1998
	S33-10	Untreated	0-12	0.70	1.03	0.05	----	1998
	33A	Treated	0-6	0.24	0.36	0.10	13	1999
	33B	Treated	0-6	0.56	0.82	0.20	7	1999
	33C	Treated	0-6	0.44	0.65	0.05	35	**1999
	33D	Untreated	0-6	0.49	0.73	0.20	22	1999
	33D1	Untreated	0-6	0.77	1.14	0.20	18	2000
	BG-1	Untreated	0-12	0.66	0.98	0.10	32	2001
	BG-1	Untreated	0-12	0.58	0.85	----	2	&#2002
	BG-1	Untreated	0-12	0.53	0.78	0.12	21	2003
	BG-1	Untreated	0-12	0.60	0.88	0.27	28	2004
	BG-1	Untreated	0-12	0.53	0.78	0.18	27	2005
	BG-1	Untreated	0-12	0.60	0.88	0.18	18	2006
	BG-1	Untreated	0-12	0.60	0.89	0.39	68	2007
	BG-1	Untreated	0-12	0.49	0.72	0.21	@170	2008
	BG-1	Untreated	0-12	0.69	1.02	0.19	33	2009
			Mean	0.53	0.79	0.14	25	
			SDV	0.14	0.20	0.10	16	
			CV	25.56	25.56	66.51	65	

Interval (ft)	Location ID	Area	Depth (in)	Natural Uranium (pCi/g)	Natural Uranium mg/kg	Selenium mg/kg	Chloride (mg/kg)	Comment
1-2	S33-4	Treated	6-48	0.36	0.53	0.03	----	*1998
	S33-7	Treated	0-24	0.30	0.44	0.03	----	*1998
	S33-8	Treated	0-20	0.58	0.86	0.07	----	1998
	S33-9	Untreated	0-24	0.56	0.83	0.15	----	1998
	S33-10	Untreated	12-30	0.38	0.56	0.03	----	*1998
	BG-2	Untreated	12-24	0.51	0.76	0.20	29	2001
	BG-2	Untreated	12-24	0.40	0.59	----	8	#2002
	BG-2	Untreated	12-24	0.35	0.52	0.12	25	2003
	BG-2	Untreated	12-24	0.53	0.79	0.24	32	2004
	BG-2	Untreated	12-24	0.47	0.69	0.15	71	2005
	BG-2	Untreated	12-24	0.60	0.88	0.16	21	2006
	BG-2	Untreated	12-24	0.60	0.89	0.44	73	2007
	BG-2	Untreated	12-24	0.41	0.61	0.23	@160	2008
	BG-2	Untreated	12-24	0.49	0.73	0.15	25	2009
			Mean	0.47	0.69	0.15	36	
			SDV	0.10	0.15	0.11	24	
			CV	21.51	21.51	74.50	67	

Table 3-1. Pre-Operations and Background Soil Sample Results for Section 33 (continued)

Interval (ft)	Location ID	Area	Depth (in)	Natural Uranium (pCi/g)	Natural Uranium mg/kg	Selenium mg/kg	Chloride (mg/kg)	Comment
2-3	S33-4	Treated	6-48	0.36	0.53	0.03	----	*1998
	S33-7	Treated	24-48	0.24	0.35	0.03	----	*1998
	S33-8	Treated	20-48	0.35	0.52	0.03	----	*1998
	S33-9	Untreated	24-48	0.70	1.03	0.10	----	1998
	S33-10	Untreated	12-30	0.38	0.56	0.03	----	*1998
	S33-10	Untreated	30-60	0.40	0.59	0.03	----	*1998
	BG-3	Untreated	24-36	0.56	0.83	0.30	41	2001
	BG-3	Untreated	24-36	0.45	0.66		8	#2002
	BG-3	Untreated	24-36	0.45	0.67	0.12	22	2003
	BG-3	Untreated	24-36	0.55	0.81	0.26	31	2004
	BG-3	Untreated	24-36	0.53	0.79	0.15	@222	2005
	BG-3	Untreated	24-36	0.74	1.09	0.15	16	2006
	BG-3	Untreated	24-36	0.58	0.86	0.27	63	2007
	BG-3	Untreated	24-36	0.49	0.72	0.20	@180	2008
	BG-3	Untreated	24-36	0.56	0.82	0.13	70	2009
			Mean	0.49	0.72	0.13	36	
			SDV	0.13	0.20	0.10	24	
			CV	27.46	27.43	76.73	66	
3-4	S32-2	Untreated	24-48	0.26	0.39	<0.05	----	*1998
	S33-2	Untreated	24-48	0.27	0.4	0.09	----	*1998
	S33-4	Treated	6-48	0.36	0.53	0.03	----	*1998
	S33-7	Treated	24-48	0.24	0.35	0.03	----	*1998
	S33-8	Treated	20-48	0.35	0.52	0.03	----	*1998
	S33-9	Untreated	24-48	0.70	1.03	0.10	----	1998
	S33-10	Untreated	30-60	0.40	0.59	0.03	----	*1998
	BG-4	Untreated	36-48	0.68	1.01	0.15	60	2009
			Mean	0.41	0.60	0.06	60	
			SDV	0.18	0.27	0.05	----	
			CV	44.84	44.84	80.71	----	
4-5	S33-10	Untreated	30-60	0.40	0.59	0.03	----	*1998
	BG-5	Untreated	48-60	0.61	0.90	0.12	60	2009
			Mean	0.50	0.75	0.07	60	
			SDV	0.15	0.22	0.07	----	
			CV	29.33	29.42	92.66	----	
5-7	BG-5-7	Untreated	60-72	0.35	0.52	0.08	70	2009
7-9	BG-7-9	Untreated	72-96	0.54	0.80	0.09	30	2009
9-11	BG-9-11	Untreated	96-120	0.49	0.72	0.05	32	2009
11-13	BG-11-13	Untreated	120-144	0.51	0.76	<0.05	40	2009
13-15	BG-13-15	Untreated	144-168	0.46	0.68	0.10	70	2009
15-17	BG-15-17	Untreated	168-192	0.67	0.99	0.14	70	2009

@ = considered an outlier, did not use
* = 1998 Se Reported as less than LLD of 0.05 mg/kg, used 0.025
** = 1999 Se MDL= 0.1 Reported as less than MDL, used 0.05 mg/kg
# = 2002 Se MDL= 0.8 All data reported as < MDL, did not use
CV = coefficient of variation
SDV = standard deviation
& = 2002 Cl MDL=4, Reported as less than MDL, used 2 mg/kg

Table 3-2. Pre-Operations and Background Soil Sample Results for Section 34

Interval (ft)	Location ID	Area	Depth (in)	Natural Uranium (pCi/g)	Natural Uranium mg/kg	Selenium (mg/kg)	Chloride (mg/kg)	Comment
	CLAY SOILS							
0-1	S33-1	Untreated	0-6	0.96	1.42	0.13	----	1998
	S33-1	Untreated	6-24	1.23	1.82	0.19	----	1998
	S33-2	Untreated	0-6	1.12	1.65	0.18	----	1998
	S33-2	Untreated	6-24	1.02	1.51	0.19	----	1998
	S3-1	Untreated	0-14	0.70	1.03	0.11	----	1998
	S34-1	Untreated	3-24	@5.85	@8.77	0.10	----	1998
	S34-3	Treated	4-26	1.03	1.52	0.11	----	1998
	S34-5	Untreated	3-40	0.84	1.24	0.14	----	1998
	S34-7	Untreated	3-28	0.78	1.15	0.06	----	1998
	S34-8	Untreated	2-30	1.26	1.86	0.31	----	1998
	S34-10	Untreated	3-28	1.01	1.49	0.13	----	1998
	S34-11	Untreated	3-15	1.36	2.01	0.03	----	*1998
	S34-13	Untreated	4-18	@3.93	@5.81	0.11	----	1998
	S34-14	Treated	4-24	0.79	1.17	0.19	----	1998
	34A	Treated	0-6	1.84	2.72	0.40	36	1999
	34B	Treated	0-6	1.60	2.36	0.40	54	1999
	34C	Treated	0-6	1.18	1.75	0.30	79	1999
	34D	Treated	0-6	2.44	3.60	0.60	36	1999
	34E	Treated	0-6	1.56	2.31	0.40	25	1999
	34F	Treated	0-6	2.05	3.03	0.80	68	1999
	34G	Treated	0-6	1.25	1.85	0.30	13	1999
	34H	Treated	0-6	2.29	3.38	0.70	43	1999
	34I	Treated	0-6	0.67	0.99	0.10	42	1999
	BG-1-34	Untreated	0-12	1.67	2.47	0.30	100	2001
	BG-1-34	Untreated	0-12	0.30	0.45		7	#2002
	BG-1-34	Untreated	0-12	1.58	2.33	0.42	83	2003
	BG-1-34	Untreated	0-12	1.89	2.79	0.75	151	2004
	BG-1-34	Untreated	0-12	1.63	2.41	0.53	@400	2005
	BG-1-33F	Untreated	0-12	1.06	1.56	0.47	30	2004
	BG-1-33F	Untreated	0-12	0.76	1.12	0.25	76	2005
	BG-1-33F	Untreated	0-12	1.05	1.55	0.56	24	2006
	BG-1-34	Untreated	0-12	2.07	3.06	0.69	@253	2006
	BG-1-33F	Untreated	0-12	1.21	1.79	0.38	64	2007
	BG-1-34	Untreated	0-12	2.23	3.30	0.74	@267	2007
	BG-1-33F	Untreated	0-12	0.97	1.44	0.32	@220	2008
	BG-1-34	Untreated	0-12	1.71	2.52	0.57	@289	2008
	BG-1-33F	Untreated	0-12	0.83	1.22	0.23	50	2009
	BG-1-34	Untreated	0-12	2.27	3.35	0.59	135	2009
			Mean	1.33	1.98	0.35	59	
			SDV	0.52	0.79	0.22	36	
			CV	39.31	40.16	64.52	62	

Table 3-2. Pre-Operations and Background Soil Sample Results for Section 34 (continued)

Interval (ft)	Location ID	Area	Depth (in)	Natural Uranium (pCi/g)	Natural Uranium mg/kg	Selenium (mg/kg)	Chloride (mg/kg)	Comment
	CLAY SOILS							
	S33-1	Untreated	6-24	1.23	1.82	0.19	----	1998
	S33-2	Untreated	6-24	1.02	1.51	0.19	----	1998
	S3-1	Untreated	14-38	0.71	1.05	0.09	----	1998
	S34-1	Untreated	3-24	@5.85	@8.77	0.10	----	1998
	S34-3	Treated	4-26	1.03	1.52	0.11	----	1998
	S34-5	Untreated	3-40	0.84	1.24	0.14	----	1998
	S34-7	Untreated	3-28	0.78	1.15	0.06	----	1998
	S34-8	Untreated	2-30	1.26	1.86	0.31	----	1998
	S34-10	Untreated	3-28	1.01	1.49	0.13	----	1998
	S34-11	Untreated	15-60	0.58	0.86	0.03	----	*1998
	S34-13	Untreated	4-18	@3.93	@5.81	0.11	----	1998
	S34-13	Untreated	18-30	0.68	1.00	0.14	----	1998
	S34-14	Treated	4-24	0.79	1.17	0.19	----	1998
1-2	BG-2	Untreated	12-24	1.30	1.92	0.20	120	2001
	BG-2	Untreated	12-24	0.36	0.53		4	#2002
	BG-2	Untreated	12-24	0.99	1.46	0.35	131	2003
	BG-2-34	Untreated	12-24	1.38	2.04	0.68	----	2004
	BG-2-34	Untreated	12-24	1.65	2.44	0.69	----	2005
	BG-2-33F	Untreated	12-24	0.88	1.30	0.39	35	2004
	BG-2-33F	Untreated	12-24	0.62	0.92	0.20	103	2005
	BG-2-33F	Untreated	12-24	0.78	1.15	0.35	20	2006
	BG-2-34	Untreated	12-24	@2.66	@3.93	@0.87	@219	2006
	BG-2-33F	Untreated	12-24	0.87	1.29	0.31	57	2007
	BG-2-34	Untreated	12-24	1.87	2.67	0.78	@271	2007
	BG-2-33F	Untreated	12-24	0.80	1.18	0.31	90	2008
	BG-2-34	Untreated	12-24	1.48	2.19	0.48	@257	2008
	BG-2-33F	Untreated	12-24	1.08	1.60	0.29	70	2009
	BG-2-34	Untreated	12-24	1.46	2.15	0.39	168	2009
			Mean	1.02	1.50	0.28	80	
			SDV	0.36	0.52	0.20	52	
			CV	35.49	34.98	71.72	66	

Table 3-2. Pre-Operations and Background Soil Sample Results for Section 34 (continued)

Interval (ft)	Location ID	Area	Depth (in)	Natural Uranium (pCi/g)	Natural Uranium mg/kg	Selenium (mg/kg)	Chloride (mg/kg)	Comment
	CLAY SOILS							
2-3	S33-1	Untreated	24-48	1.32	1.95	0.23	----	1998
	S3-1	Untreated	14-38	0.71	1.05	0.09	----	1998
	S34-1	Untreated	24-36	0.43	0.64	0.13	----	1998
	S34-5	Untreated	3-40	0.84	1.24	0.14	----	1998
	S34-7	Untreated	28-40	0.43	0.64	0.41	----	1998
	S34-8	Untreated	30-60	0.69	1.02	0.34	----	1998
	S34-11	Untreated	15-60	0.58	0.86	0.03	----	*1998
	S34-13	Untreated	18-30	0.68	1.00	0.14	----	1998
	BG-3	Untreated	24-36	0.53	0.79	0.20	120	2001
	BG-3	Untreated	24-36	0.27	0.40		4	#2002
	BG-3	Untreated	24-36	1.12	1.66	0.36	141	2003
	BG-3-34	Untreated	24-36	0.93	1.38	0.40	@169	2004
	BG-3-34	Untreated	24-36	1.44	2.13	0.51	@354	2005
	BG-3-33F	Untreated	24-36	0.90	1.33	0.42	30	2004
	BG-3-33F	Untreated	24-36	0.61	0.90	0.19	81	2005
	BG-3-33F	Untreated	24-36	0.71	1.05	0.34	14	2006
	BG-3-34	Untreated	24-36	1.55	2.29	0.54	@259	2006
	BG-3-33F	Untreated	24-36	0.84	1.24	0.35	43	2007
	BG-3-34	Untreated	24-36	1.11	1.64	0.53	@246	2007
	BG-3-33F	Untreated	24-36	0.66	0.97	0.25	@170	2008
	BG-3-34	Untreated	24-36	0.85	1.26	0.27	@210	2008
	BG-3-33F	Untreated	24-36	0.41	0.61	0.10	40	2009
	BG-3-34	Untreated	24-36	0.43	0.63	0.17	159	2009
			Mean	0.78	1.16	0.28	70	
			SDV	0.34	0.50	0.15	57	
			CV	43.23	43.20	54.03	82	

Interval (ft)	Location ID	Area	Depth (in)	Natural Uranium (pCi/g)	Natural Uranium mg/kg	Selenium (mg/kg)	Chloride (mg/kg)	Comment
	CLAY SOILS							
3-4	S34-11	Untreated	15-60	0.58	0.86	<0.05	----	1998
	S34-1	Untreated	36-60	0.39	0.58	0.068	----	1998
	S34-8	Untreated	30-60	0.69	1.02	0.34	----	1998
	S33-1	Untreated	24-48	1.32	1.95	0.23	----	1998
	S33-8	Untreated	20-48	0.35	0.52	<0.05	----	1998
	S33-9	Untreated	24-48	0.70	1.03	0.10	----	1998
	S33-10	Untreated	30-60	0.40	0.59	<0.05	----	1998
	BG-3-33F	Untreated	24-36	0.59	0.87	0.12	12	2009
	BG-3-34	Untreated	24-36	0.37	0.55	0.10	135	2009
			Mean	0.60	0.89	0.16	74	
			SDV	0.30	0.49	0.12	1	
			CV	50.61	55.88	78.01	1.53	

Table 3-2. Pre-Operations and Background Soil Sample Results for Section 34 (continued)

Interval (ft)	Location ID	Area	Depth (in)	Natural Uranium (pCi/g)	Natural Uranium mg/kg	Selenium (mg/kg)	Chloride (mg/kg)	Comment
CLAY SOILS								
4-5	S34-11	Untreated	15-60	0.58	0.86	<0.05	----	1998
	S34-1	Untreated	36-60	0.39	0.58	0.068	----	1998
	S34-8	Untreated	30-60	0.69	1.02	0.34	----	1998
	S33-10	Untreated	30-60	0.40	0.59	<0.05	----	1998
	BG-5-33F	Untreated	24-36	0.59	0.87	0.12	30	2009
	BG-5-34	Untreated	24-36	0.22	0.33	0.04	55	2009
			Mean	0.48	0.71	0.14	43	
			SDV	0.17	0.25	0.14	18	
			CV	35.73	35.71	95.50	41.59	

Interval (ft)	Location ID	Area	Depth (in)	Natural Uranium (pCi/g)	Natural Uranium mg/kg	Selenium (mg/kg)	Chloride (mg/kg)	Comment
CLAY SOILS								
5-7	BG 5-7-33F	Untreated	60-72	0.28	0.42	0.05	60	2009
	BG 5-7-34	Untreated	60-72	0.21	0.31	0.04	33	2009
			Mean	0.25	0.37	0.05	47	
7-9	BG 7-9-33F	Untreated	72-96	0.24	0.35	<0.05	70	2009
	BG 7-9-34	Untreated	72-96	0.63	0.93	0.09	84	2009
			Mean	0.43	0.64	0.07	77	
9-11	BG 9-11-33F	Untreated	96-120	0.30	0.44	0.07	40	2009
	BG 9-11-34	Untreated	96-120	0.75	1.11	0.17	139	2009
			Mean	0.52	0.78	0.12	90	
11-13	BG 11-13-33F	Untreated	120-144	0.90	1.33	0.14	60	2009
	BG 11-13-34	Untreated	120-144	0.85	1.26	1.31	150	2009
			Mean	0.88	1.30	0.73	105	
13-15	BG 13-15-34	Untreated	144-168	0.65	0.96	0.53	57	2009
15-17	BG 15-17-34	Untreated	168-192	0.66	0.97	0.27	62	2009

Interval (ft)	Location ID	Area	Depth (in)	(pCi/g)	mg/kg	Selenium (mg/kg)	Chloride (mg/kg)	Comment
SANDY SOILS								
2-3	S33-2	Untreated	24-48	0.40	0.59	0.09	----	1998
	S34-14	Treated	30-90	0.20	0.30	0.03	----	*1998
			Mean	0.30	0.45	0.06	----	
			SDV	0.14	0.21	0.05	----	
			CV	47.14	46.08	79.93	----	

Interval (ft)	Location ID	Area	Depth (in)	(pCi/g)	mg/kg	Selenium (mg/kg)	Chloride (mg/kg)	Comment
SANDY SOILS								
3-4	S34-14	Treated	30-90	0.2	0.3	<0.05	----	1998
	S34-5	Untreated	40-53	0.3	0.44	0.08	----	1998
	S33-2	Untreated	24-48	0.40	0.59	0.09	----	1998
	S32-2	Treated	24-48	0.39	0.58	<0.05	----	1998
			Mean	0.32	0.48	0.07	----	
			SDV	0.09	0.14	0.01	----	
			CV	28.91	28.63	10.10	----	

Table 3-2. Pre-Operations and Background Soil Sample Results for Section 34 (continued)

	SANDY SOILS							
Interval (ft)	Location ID	Area	Depth (in)	(pCi/g)	mg/kg	Selenium (mg/kg)	Chloride (mg/kg)	Comment
4-5	S34-3	Treated	50-90	0.2	0.3	<0.05	----	1998
	S34-14	Treated	30-90	0.2	0.3	<0.05	----	1998
	S34-5	Treated	40-53	0.76	1.12	0.07	----	1998
			Mean	0.39	0.57	0.06	----	
			SDV	0.32	0.47	0.02	----	
			CV	83.62	82.57	33.33	----	

	SANDY SOILS							
Interval (ft)	Location ID	Area	Depth (in)	(pCi/g)	mg/kg	Selenium (mg/kg)	Chloride (mg/kg)	Comment
5-7	S34-5	Untreated	53-73	0.76	1.12	0.07	----	1998
	S34-11	Untreated	60-90	0.26	0.38	<0.05	----	1998
			Mean	0.51	0.75	0.06	----	
			SDV	0.35	0.52	0.03	----	
			CV	69.32	69.77	50.00	----	

	SANDY SOILS							
Interval (ft)	Location ID	Area	Depth (in)	(pCi/g)	mg/kg	Selenium (mg/kg)	Chloride (mg/kg)	Comment
7-9	S34-11	Untreated	60-90	0.26	0.38	<0.05	----	1998

@ = considered an outlier, did not use
* = 1998 Se Reported as less than LLD of 0.05 mg/kg, used 0.025
# = 2002 Se MDL= 0.8 All data reported as < MDL, did not use
CV = coefficient of variation
SDV = standard deviation

Table 3-3. Pre-Operations and Background Soil Sample Results for Section 28

Interval (ft)	Location ID	Area	Depth (in)	U-nat (pCi/g)	U-nat mg/kg	Selenium mg/kg	Chloride (mg/kg)	Comment
0-1	S28-2	Untreated	0-40	@1.06	@1.57	0.14	----	1998
	S28-3	Untreated	4-22	0.23	0.34	0.18	----	1998
	S28-9	Treated	0-40	0.33	0.49	0.06	----	1998
	NE27-1	Untreated	0-6	0.34	0.50	0.03	----	*1998
	NE28-2	Untreated	0-6	0.24	0.35	0.03	----	*1998
	NE28-4	Untreated	0-8	0.13	0.19	0.16	----	1998
	NE28-5	Untreated	0-12	0.50	0.74	0.10	----	1998
	NE28-7	Untreated	0-8	0.51	0.75	0.12	----	1998
	BG-1	Untreated	0-12	2.02	@2.99		14	#2002
	BG-1	Untreated	0-12	0.35	0.51	0.15	6	2003
	BG-1	Untreated	0-12	0.60	0.88	0.22	12	2004
	BG-1	Untreated	0-12	0.32	0.47	0.12	@283	2005
	BG-1	Untreated	0-12	0.42	0.62	0.10	19	2006
	BG-1	Untreated	0-12	0.53	0.78	0.23	32	2007
	BG-1	Untreated	0-12	0.40	0.59	0.15	@220	2008
	BG-1	Untreated	0-12	0.75	1.11	0.16	60	2009
			Mean	0.40	0.59	0.13	24	
			SDV	0.16	0.24	0.06	19.76	
			CV	40.51	40.55	47.41	83	

Interval (ft)	Location ID	Area	Depth (in)	U-nat (pCi/g)	U-nat mg/kg	Selenium mg/kg	Chloride (mg/kg)	Comment
1-2	S28-2	Untreated	0-40	@1.06	@1.57	0.14	----	1998
	S28-3	Untreated	4-22	0.23	0.34	0.18	----	1998
	S28-9	Treated	0-40	0.33	0.49	0.06	----	1998
	NE28-4	Untreated	8-28	0.23	0.34	0.03	----	*1998
	NE28-7	Untreated	8-24	0.23	0.34	0.05	----	1998
	BG-2	Untreated	12-24	@1.10	@1.62		13	#2002
	BG-2	Untreated	12-24	0.41	0.61	0.10	6	2003
	BG-2	Untreated	12-24	0.52	0.77	0.22	14	2004
	BG-2	Untreated	12-24	0.32	0.47	0.07	----	2005
	BG-2	Untreated	12-24	0.35	0.51	0.03	14	2006
	BG-2	Untreated	12-24	0.62	0.91	0.24	26	2007
	BG-2	Untreated	12-24	0.31	0.46	0.15	@240	2008
	BG-2	Untreated	12-24	0.39	0.57	0.10	50	2009
			Mean	0.36	0.53	0.11	21	
			SDV	0.12	0.18	0.07	15.82	
			CV	34.37	34.36	63.92	77	

Interval (ft)	Location ID	Area	Depth (in)	U-nat (pCi/g)	U-nat mg/kg	Selenium mg/kg	Chloride (mg/kg)	Comment
2-3	S28-2	Untreated	0-40	@1.06	@1.57	0.14	----	1998
	S28-9	Treated	0-40	0.33	0.49	0.06	----	1998
	NE27-1	Untreated	24-80	0.14	0.21	0.03	----	*1998
	NE28-4	Untreated	28-84	0.22	0.32	0.03	----	*1998
	NE28-5	Untreated	25-84	0.44	0.65	0.03	----	*1998
	NE28-7	Untreated	24-48	0.14	0.21	0.03	----	*1998
	BG-3	Untreated	24-36	@0.98	@1.45		13	#2002
	BG-3	Untreated	24-36	0.36	0.53	0.12	11	2003
	BG-3	Untreated	24-36	0.55	0.81	0.19	10	2004
	BG-3	Untreated	24-36	0.37	0.55	0.07	@290	2005
	BG-3	Untreated	24-36	0.39	0.58	0.06	16	2006
	BG-3	Untreated	24-36	0.54	0.80	0.25	30	2007
	BG-3	Untreated	24-36	0.36	0.53	0.15	@270	2008
	BG-3	Untreated	24-36	0.38	0.56	0.11	70	2009
			Mean	0.35	0.52	0.10	25	
			SDV	0.13	0.20	0.07	23.22	
			CV	37.65	37.55	74.65	93	

Table 3-3. Pre-Operations and Background Soil Sample Results for Section 28 (continued)

Interval (ft)	Location ID	Area	Depth (in)	U-nat (pCi/g)	U-nat mg/kg	Selenium mg/kg	Chloride (mg/kg)	Comment
3-4	BG-4	Untreated	36-48	0.35	0.52	0.07	60	2009
4-5	BG-5	Untreated	48-60	0.30	0.45	0.06	90	2009
5-7	BG-5-7	Untreated	60-72	0.42	0.62	0.08	100	2009
7-9	BG-7-9	Untreated	72-96	0.53	0.79	0.08	61	2009
9-11	BG-9-11	Untreated	96-120	0.35	0.52	0.09	60	2009
11-13	BG-11-13	Untreated	120-144	0.66	0.97	0.12	15	2009
13-15	BG-13-15	Untreated	144-168	0.41	0.60	0.08	70	2009
15-17	BG-15-17	Untreated	168-192	0.57	0.84	0.10	70	2009

@ = considered an outlier, did not use
* = 1998 Se Reported as less than LLD of 0.05 mg/kg, used 0.025
# = 2002 Se MDL= 0.8 All data reported as < MDL, did not use
CV = coefficient of variation
SDV = standard deviation

3.3 Constituents in Treated Soil

Uranium, selenium, molybdenum, calcium, magnesium, sodium, chloride, and sulfate levels were measured in soil samples from Sections 33 and 34 in 1999 (prior to irrigation) and after each of the 2000 through 2009 irrigation seasons. The pH, conductivity and sodium absorption ratio (SAR) were also measured or calculated for the samples.

Changes in soil chemistry between pre-irrigation samples and those collected after the first irrigation season in 2000 are described in ERG and HYDRO, 2001, 2004, 2005, 2006, 2007, 2008, 2009 and in this report.

Figures 2-1 through 2-10 show the sampling locations in Sections 33 and 34 for 2000 through 2009. Figures 2-11 through 2-18 present the soil sampling locations in Section 28 for 2002 through 2009. Figures 3-8 through 3-13 present uranium and selenium soil concentrations for each of the irrigation areas.

Composite samples were prepared from locations indicated within each irrigation area and associated background locations. In 2000, the suffixes -1, -2, or -3 on sample labels indicate samples collected from 0-6 (-1), 6-18 (-2), or 18-36 in (-3) depth intervals. The ranges of sampling depths were changed in 2001, to better assess the impacts of irrigation. In 2001 to 2009, suffixes -1, -2, and -3 indicate composites from 0-1 ft, 1-2 ft and 2-3 ft, respectively. Comparisons between data acquired in 2000 and data from subsequent years must be qualified by the change in sampling depths.

An example of compositing conducted in 2001 at Section 33 is as follows: the grab samples collected from 0-1 ft at soil sample locations EW2, EW4, EW6, WW2, WW4, WW6, NW2, NW4, NW6, SW2, SW4 and SW6 (see Figure 2-2 for sample locations) were composited into one sample labeled P-1. Grab samples from 1-2 ft at these locations were composited into one sample labeled P-2.

Table 3-4 presents the results for composite samples collected at each of the areas in 2000 through 2009. Appendix A gives the 1999, 2000 and 2009 individual sample results that were used to calculate the 2000 average values presented in Table 3-6. Individual sample analyses were measured in the treated area in 2009 to make use of the lysimeter soil results. No samples were collected from Section 28 in 2001, and irrigation in this area began in 2002. Composite samples collected at treated areas are labeled P (Section 33), F (Section 34) or N (Section 28). They are further subdivided by P-, F-, or N-1 (0-1 ft), P-, F-, or N-2, (1-2 ft) and P-, F-, or N-3 (2-3 ft). Thus, constituents in the composite samples represent an average condition in layers across the center pivot area, at 0-1 ft, 1-2 ft and 2-3 ft depth intervals.

Table 3-4. Irrigation Soil Analyses, 2000-2009

Sample Site	Date	U (mg/kg)	Se (mg/kg)	Mo (mg/kg)	pH (units)	Cond. (mmhos/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	SAR (ratio)	Cl (mg/kg)	SO4 (mg/kg)
					SECTION 33 CENTER PIVOT							
P-1	12/7/2000	0.93	0.37	<1	7.9	0.987	4.00	1.27	5.67	3.40	26	98
	6/15/2001	0.94	0.30	<1	8.0	1.230	3.77	1.48	7.48	4.84	123	500
	11/20/2002	0.98	<0.6	<1	7.8	1.610	7.71	2.80	8.10	3.53	13	300
	11/18/2003	1.36	0.28	<1	7.8	2.200	7.99	3.25	13.50	5.69	55	590
	11/9/2004	1.78	0.45	<1	7.6	3.780	19.70	8.73	21.40	5.67	101	190
	11/5/2005	1.45	0.31	<1	8.1	2.060	9.35	4.02	11.20	4.33	51	460
	10/21/2006	1.87	0.36	<1	7.8	3.560	15.80	6.36	20.40	6.13	109	1020
	11/10/2007	1.67	0.44	<1	7.7	3.280	12.40	5.91	19.10	6.31	85	600
	11/22/2008	1.41	0.41	1	8.0	2.630	10.70	5.07	17.10	6.09	80	500
	10/6/2009	2.03	0.41	2	7.8	3.472	14.63	6.95	22.75	6.71	147	1059
P-2	12/7/2000	0.81	0.45	<1	7.8	1.480	6.30	1.88	7.77	3.84	46	290
	6/15/2001	0.60	0.30	<1	7.9	1.120	4.32	1.45	6.11	3.60	109	500
	11/20/2002	0.89	<0.6	<1	7.8	2.190	10.10	3.78	13.10	4.97	14	600
	11/18/2003	1.14	0.19	<1	7.9	2.690	10.30	3.86	16.10	6.05	82	710
	11/9/2004	1.52	0.39	<1	7.6	4.300	19.40	10.80	27.50	7.07	155	200
	11/5/2005	1.15	0.21	2	8.1	3.940	15.10	7.68	27.30	8.09	94	420
	10/21/2006	1.62	0.15	<1	7.7	3.320	14.20	5.93	17.90	5.64	142	900
	11/10/2007	1.34	0.30	<1	7.7	5.300	19.60	11.00	37.00	9.46	187	900
	11/22/2008	1.37	0.35	1	8.0	3.600	13.40	6.30	25.80	8.22	114	1130
	10/6/2009	1.84	0.29	2	7.9	3.906	14.45	7.40	30.01	8.53	243	1405
P-3	12/7/2000	1.03	0.25	<1	7.6	1.720	8.35	2.29	8.33	3.71	36	210
	6/15/2001	0.54	0.10	<1	7.8	1.020	4.74	2.18	4.27	2.30	67	400
	11/20/2002	0.68	<0.6	<1	7.7	2.400	11.70	5.34	11.60	3.97	34	1000
	11/18/2003	1.00	0.18	<1	7.8	2.970	15.50	5.67	17.30	5.32	106	570
	11/9/2004	1.15	0.38	<1	7.6	3.440	15.90	9.31	19.30	5.43	137	220
	11/5/2005	1.00	0.30	1	8.0	4.500	18.70	10.50	147.00	38.50	197	580
	10/21/2006	1.05	0.14	<1	7.8	3.500	13.90	6.17	19.70	6.22	126	780
	11/10/2007	1.30	0.39	<1	7.6	4.670	20.30	10.60	26.40	6.72	174	670
	11/22/2008	1.27	0.33	3	7.9	3.600	14.80	7.10	23.10	6.98	184	1220
	10/6/2009	1.52	0.28	2	7.8	4.271	16.22	7.79	28.20	7.85	279	972
P-4	10/6/2009	1.32	0.27	2	7.8	4.113	17.19	7.87	24.92	7.17	258	911
P-5	10/6/2009	1.20	0.27	2	7.9	3.426	14.81	7.20	19.76	6.10	163	884
P-5-7	10/6/2009	0.95	0.20	2	7.9	2.799	11.03	5.33	17.07	5.78	145	696
P-7-9	10/6/2009	0.85	0.22	2	7.8	2.198	11.01	5.23	10.78	3.71	85	557
P-9-11	10/6/2009	0.93	0.19	2	7.9	2.086	13.89	6.24	6.12	1.97	86	619
P-11-13	10/6/2009	0.96	0.12	1	8.0	1.449	9.25	4.13	2.86	1.20	83	393
P-13-15	10/6/2009	0.80	0.14	1	8.0	1.435	9.42	4.24	2.72	1.11	90	329
P-15-17	10/6/2009	0.83	0.19	1	8.0	1.847	14.18	5.62	3.13	1.01	70	345
BG-1	12/7/2000	1.14	0.20	<1	7.6	1.240	9.07	2.64	0.64	0.26	18	<50
	6/20/2001	0.98	0.10	1	7.9	0.231	1.51	0.48	0.43	0.43	32	<300
	11/20/2002	0.85	<0.6	<1	7.8	0.450	3.51	0.98	0.69	0.46	<4	<100
	11/18/2003	0.78	0.12	<1	7.8	0.700	4.13	1.15	0.60	0.36	21	160
	11/8/2004	0.88	0.27	<1	7.7	0.980	6.22	1.94	1.83	0.91	28	60
	11/5/2005	0.78	0.18	<1	8.1	0.835	5.20	1.54	1.60	0.87	27	570
	10/21/2006	0.88	0.18	<1	7.9	1.060	6.04	1.69	1.87	0.95	18	160
	11/10/2007	0.89	0.39	<1	7.7	1.510	7.57	2.80	2.03	0.89	68	280
	11/22/2008	0.72	0.21	1	8.0	0.883	6.13	2.12	1.81	0.89	170	820
	10/22/2009	1.02	0.19	<1	7.5	1.08	7.32	2.21	1.78	0.81	33	230
BG-2	6/20/2001	0.76	0.20	<1	7.9	0.321	1.83	0.92	0.57	0.48	29	<300
	11/20/2002	0.59	<0.6	<1	7.7	1.250	7.58	3.04	3.56	1.54	8	<100
	11/18/2003	0.52	0.12	<1	7.7	0.670	4.27	1.28	0.70	0.42	25	90
	11/8/2004	0.79	0.24	<1	7.8	0.690	4.05	1.45	1.22	0.74	32	70
	11/5/2005	0.69	0.15	<1	8.1	0.745	4.24	1.45	1.41	0.83	71	2140
	10/21/2006	0.88	0.16	<1	8.0	0.757	3.63	1.60	1.47	0.90	21	120
	11/10/2007	0.89	0.44	<1	7.7	1.550	9.46	3.44	2.42	0.95	73	350
	11/22/2008	0.61	0.23	2	8.0	0.809	5.05	2.21	1.73	0.90	160	680
	10/22/2009	0.73	0.15	<1	7.6	1.07	7.78	2.81	1.01	0.43	25	220
BG-3	6/20/2001	0.83	0.30	<1	7.9	0.385	2.41	1.12	0.48	0.36	41	300
	11/20/2002	0.66	<0.6	<1	7.9	0.580	3.39	1.32	1.79	1.17	8	300
	11/18/2003	0.67	0.12	<1	7.7	0.620	3.77	1.39	0.70	0.43	22	70
	11/8/2004	0.81	0.26	<1	7.8	0.720	4.13	1.54	1.50	0.89	31	80
	11/5/2005	0.79	0.15	2	8.3	0.607	3.39	1.26	1.23	0.80	222	6770
	10/21/2006	1.09	0.15	<1	8.0	1.080	5.54	2.55	2.20	1.09	16	200
	11/10/2007	0.86	0.27	<1	7.7	1.740	10.60	3.73	2.81	1.05	63	300
	11/22/2008	0.72	0.20	3	8.0	0.877	5.06	2.27	2.37	1.24	180	870
	10/22/2009	0.82	0.13	1	7.7	0.600	3.48	1.36	0.87	0.55	70	370
BG-4	10/22/2009	1.01	0.15	<1	7.7	0.578	3.33	1.40	0.95	0.61	60	370
BG-5	10/22/2009	0.90	0.12	<1	7.7	0.692	4.09	1.66	1.15	0.67	60	390
BG-5-7	10/22/2009	0.52	0.08	<1	7.9	0.508	2.86	1.09	0.80	0.56	70	350
BG-7-9	10/22/2009	0.80	0.09	<1	7.6	0.442	2.57	0.87	0.65	0.49	30	240
BG-9-11	10/22/2009	0.76	0.05	<1	7.6	0.426	2.47	0.81	0.63	0.49	32	230
BG-11-13	10/22/2009	0.56	<0.05	<1	7.7	0.335	1.96	0.59	0.55	0.48	40	300
BG-13-15	10/22/2009	0.68	0.10	<1	7.6	0.318	1.69	0.50	0.57	0.54	70	540
BG-15-17	10/22/2009	0.99	0.14	1	7.7	0.387	2.06	0.68	0.87	0.74	70	530

Table 3-4. Irrigation Soil Analyses, 2000-2009 (continued)

Sample Site	Date	U (mg/kg)	Se (mg/kg)	Mo (mg/kg)	pH (units)	Cond. (mmhos/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	SAR (ratio)	Cl (mg/kg)	SO4 (mg/kg)
						SECTION 33 FLOOD						
F-1	11/5/2004	1.78	0.56	<1	7.6	2.810	19.10	7.21	11.30	3.11	114	190
	11/8/2005	1.35	0.31	1	7.8	2.690	16.80	6.23	10.20	3.01	66	1210
	10/28/2006	1.76	0.41	<1	7.8	1.480	8.25	2.91	4.79	2.03	72	1070
	11/10/2007	1.69	0.45	<1	7.8	2.000	9.35	3.60	8.85	3.48	98	450
	12/3/2008	1.70	0.43	2	8.0	1.780	7.42	2.68	11.20	4.98	89	910
	10/5/2009	1.17	0.10	<1	8.1	0.493	1.37	0.48	3.03	3.15	120	<50
F-2	11/5/2004	1.67	0.47	1	7.7	2.360	13.70	5.09	10.40	3.39	115	150
	11/8/2005	1.14	0.24	<1	7.8	2.260	13.30	4.68	9.22	3.08	57	620
	10/28/2006	1.24	0.26	<1	7.7	2.320	16.00	5.15	8.33	2.56	46	970
	11/10/2007	1.55	0.40	<1	7.8	3.070	16.90	6.58	13.00	3.79	63	390
	12/3/2008	1.53	0.39	<1	7.7	2.650	21.70	7.48	13.70	3.59	46	1670
	10/5/2009	1.17	0.09	<1	8.1	0.727	1.98	0.85	4.15	3.49	80	<50
F-3	11/5/2004	1.68	0.49	<1	7.7	2.400	18.40	6.52	11.60	3.28	115	150
	11/8/2005	1.00	0.20	<1	7.8	2.670	17.80	5.91	10.70	3.11	41	350
	10/28/2006	1.62	0.21	<1	7.7	1.840	10.90	3.38	5.93	2.22	52	970
	11/10/2007	1.51	0.40	<1	7.7	2.010	11.50	4.06	7.97	2.86	52	470
	12/3/2008	0.96	0.23	<1	7.7	2.890	19.90	6.91	12.00	3.28	50	860
	10/5/2009	0.67	0.08	3	8.2	0.705	2.13	0.98	4.10	3.29	80	500
F-4	10/5/2009	0.38	<0.05	<1	8.5	0.528	1.23	0.86	2.87	2.81	70	680
F-5	10/5/2009	0.33	<0.05	<1	8.4	0.538	1.22	1.02	2.81	2.66	50	500
F-5-7	10/5/2009	0.35	<0.05	<1	8.4	0.71	1.57	1.57	3.65	2.91	60	500
F-7-9	10/5/2009	0.27	<0.05	<1	8.6	0.44	1.01	0.86	2.19	2.26	20	170
F-9-11	10/5/2009	0.52	0.06	<1	8.5	0.534	1.13	1.00	2.78	2.69	40	230
BG-1	11/5/2004	1.56	0.47	1	7.8	0.770	3.49	1.40	2.51	1.60	30	110
	11/8/2005	1.12	0.25	<1	7.8	0.962	5.16	1.84	2.29	1.22	76	2720
	10/28/2006	1.55	0.56	<1	7.9	0.702	2.93	1.04	1.98	1.41	24	100
	11/10/2007	1.79	0.38	<1	7.8	0.800	4.30	1.55	1.96	1.15	64	140
	12/3/2008	1.44	0.32	<1	7.9	1.150	6.04	2.29	4.20	2.06	220	1200
	10/27/2009	1.22	0.23	<1	8.0	0.464	2.66	0.96	0.97	0.72	50	250
BG-2	11/5/2004	1.30	0.39	<1	7.8	0.820	4.42	1.70	2.28	1.30	35	120
	11/8/2005	0.92	0.20	<1	7.8	0.829	4.13	1.52	2.41	1.43	103	1960
	10/28/2006	1.15	0.35	<1	7.8	0.470	1.94	0.71	1.37	1.19	20	210
	11/10/2007	1.29	0.31	<1	7.8	0.810	4.24	1.65	1.79	1.04	57	160
	12/3/2008	1.18	0.32	<1	7.8	0.840	4.92	1.90	2.58	1.40	90	660
	10/27/2009	1.60	0.29	<1	8.0	0.651	2.53	1.06	2.86	2.13	70	390
BG-3	11/5/2004	1.33	0.42	<1	7.8	0.940	5.13	2.06	2.79	1.47	30	160
	11/8/2005	0.90	0.19	<1	7.8	1.110	5.74	2.20	3.55	1.78	81	3200
	10/28/2006	1.05	0.34	<1	7.9	0.677	2.88	1.05	1.84	1.31	14	190
	11/10/2007	1.24	0.35	<1	7.8	0.710	3.80	1.41	1.96	1.21	43	260
	12/3/2008	0.97	0.25	<1	7.8	0.840	4.66	1.85	3.09	1.71	170	900
	10/27/2009	0.61	0.10	1	7.9	0.93	3.66	1.94	3.68	2.20	40	400
BG-4	10/27/2009	0.87	0.12	<1	8.0	1.11	4.99	2.62	3.65	1.87	12	240
BG-5	10/27/2009	0.46	0.06	<1	7.9	0.739	3.15	1.65	2.25	1.45	30	320
BG-5-7	10/27/2009	0.42	0.05	<1	8.1	0.603	2.42	1.13	1.81	1.36	60	470
BG-7-9	10/27/2009	0.35	<0.05	<1	8.1	0.667	2.89	1.24	2.00	1.39	70	480
BG-9-11	10/27/2009	0.44	0.07	<1	8.2	0.617	2.85	1.24	1.68	1.17	40	280
BG-11-13	10/27/2009	1.33	0.14	2	8.1	0.623	2.68	1.54	1.50	1.03	60	450

Table 3-4. Irrigation Soil Analyses, 2000-2009 (continued)

Sample Site	Date	U (mg/kg)	Se (mg/kg)	Mo (mg/kg)	pH (units)	Cond. (mmhos/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	SAR (ratio)	Cl (mg/kg)	SO4 (mg/kg)
						SECTION 34 FLOOD						
F-1	12/7/2000	3.35	0.68	<1	7.7	2.594	11.95	4.66	14.58	5.03	56	767
	8/8/2001	2.72	0.50	2	7.8	5.090	10.90	3.17	13.50	5.09	182	900
	11/22/2002	0.69	<0.6	<1	7.9	1.050	4.73	1.47	5.26	2.99	18	800
	11/26/2003	3.72	0.82	1	7.8	4.570	22.50	9.62	31.60	7.89	284	2620
	11/4/2004	4.43	1.15	2	7.7	5.220	20.50	8.98	40.40	10.52	398	680
	11/19/2005	3.94	1.10	2	8.0	5.420	20.80	8.64	37.60	9.80	416	5190
	10/28/2006	4.88	0.95	<1	7.9	3.500	12.20	5.72	22.90	7.65	445	5210
	11/10/2007	5.02	1.32	2	7.8	4.910	17.50	8.05	35.00	9.79	429	4400
	12/3/2008	4.38	1.14	1	7.7	4.430	19.40	9.10	33.40	8.85	392	7700
	10/8/2009	4.06	0.97	4	7.8	4.64	19.34	8.50	30.29	8.03	279	4002
F-2	12/7/2000	2.22	0.37	<1	7.6	3.237	14.42	6.01	18.58	5.85	78	1497
	8/8/2001	1.88	0.40	2	7.6	4.970	8.20	2.25	8.57	3.75	139	1400
	11/22/2002	0.46	<0.6	<1	8.0	1.030	3.85	1.12	6.06	3.84	10	200
	11/26/2003	1.90	0.40	<1	7.8	5.020	25.20	8.01	33.60	8.25	396	2480
	11/4/2004	2.27	0.63	<1	7.6	5.370	23.80	7.90	40.50	10.17	390	370
	11/19/2005	1.41	0.38	1	7.9	4.890	20.50	5.55	32.60	9.03	352	3980
	10/28/2006	2.25	0.45	<1	7.6	3.610	12.90	4.34	23.30	7.94	478	4230
	11/10/2007	3.05	0.94	<1	7.7	5.770	21.20	8.24	40.60	10.60	560	4000
	12/3/2008	2.70	0.68	1	7.8	4.240	21.60	8.16	30.00	7.78	406	4900
	10/8/2009	2.59	0.63	3	7.8	4.62	20.06	7.64	29.49	7.85	388	4082
F-3	12/7/2000	1.62	0.03	<1	7.6	3.397	13.63	5.02	22.21	6.75	56	980
	8/8/2001	1.15	0.30	<1	7.6	5.960	10.10	3.25	9.83	3.80	170	1800
	11/22/2002	0.42	<0.6	<1	8.0	0.930	3.63	1.53	4.90	3.05	3	<100
	11/26/2003	1.08	0.19	<1	7.8	4.420	23.90	6.53	25.80	6.61	302	1550
	11/4/2004	1.40	0.37	<1	7.6	4.800	25.30	7.39	34.90	8.63	166	210
	11/19/2005	2.62	0.68	2	8.0	4.550	17.40	5.78	32.90	9.66	560	5840
	10/28/2006	1.21	0.28	<1	7.5	3.860	18.50	5.18	23.20	6.74	302	2340
	11/10/2007	1.75	0.64	<1	7.6	5.280	24.20	6.25	32.70	8.38	337	1700
	12/3/2008	1.71	0.37	<1	7.8	4.410	23.00	8.99	32.50	8.13	227	1810
	10/8/2009	1.82	0.46	3	7.7	4.66	23.09	7.41	26.51	6.83	430	3362
F-4	10/8/2009	0.95	0.21	3	7.7	3.49	19.12	5.37	17.90	5.32	268	2151
F-5	10/8/2009	0.56	0.08	2	7.8	3.11	15.88	4.81	15.79	4.91	138	861
F-5-7	10/8/2009	0.35	0.05	1	8.1	1.92	9.71	3.13	9.09	3.90	70	459
F-7-9	10/8/2009	0.36	0.05	2	8.1	1.27	4.42	1.77	6.69	4.06	76	568
F-9-11	10/8/2009	0.52	0.10	2	7.9	1.70	7.56	3.13	8.10	3.78	61	540
F-11-13	10/8/2009	1.06	0.11	2	7.9	2.32	12.66	7.85	8.29	2.85	76	1506
F-13-15	10/8/2009	0.61	0.10	2	7.9	1.51	8.60	2.41	5.93	2.53	50	490
BG-1	8/8/2001	2.47	0.30	2	7.6	4.160	5.86	1.75	2.87	1.47	100	800
	11/22/2002	0.45	<0.6	<1	7.8	0.460	3.52	0.79	0.37	0.25	7	<100
	11/26/2003	2.33	0.42	<1	7.8	1.680	5.70	2.22	9.60	4.82	83	850
	11/3/2004	2.79	0.75	<1	7.8	2.320	8.67	2.05	13.30	5.74	151	490
	11/19/2005	2.41	0.53	2	7.7	3.230	12.80	3.50	15.40	5.39	400	1360
	10/28/2006	3.06	0.69	<1	7.8	2.200	9.53	2.22	10.60	4.37	253	810
	11/10/2007	3.30	0.74	2	7.7	3.650	19.10	4.81	19.60	5.67	267	800
	12/3/2008	2.52	0.57	1	7.8	2.740	13.70	3.37	15.00	5.13	289	810
	10/30/2009	3.35	0.59	<1	7.8	1.77	7.75	1.77	8.97	4.11	135	570
BG-2	8/8/2001	1.92	0.20	2	7.5	4.730	7.94	2.60	4.53	1.97	120	300
	12/4/2002	0.53	<0.6	<1	7.8	0.410	3.03	1.06	0.32	0.22	4	<100
	11/26/2003	1.46	0.35	1	7.8	3.290	18.70	8.07	16.90	4.62	131	670
	11/3/2004	2.04	0.68	<1	7.7	4.040	19.70	4.51	26.10	7.50	220	280
	11/19/2005	2.44	0.39	2	7.9	4.460	20.80	4.99	23.90	6.66	349	1040
	10/28/2006	3.93	0.87	<1	7.7	2.400	12.30	2.59	10.90	3.99	219	810
	11/10/2007	2.67	0.78	2	7.7	4.280	21.00	5.02	25.80	7.15	271	1240
	12/3/2008	2.19	0.48	2	7.8	3.260	17.90	4.59	18.50	5.52	257	1040
	10/30/2009	2.15	0.39	1	7.7	2.98	18.50	3.41	14.00	4.23	168	830
BG-3	8/8/2001	0.79	0.20	<1	7.6	8.200	6.35	2.12	2.77	1.35	120	100
	11/22/2002	0.40	<0.6	<1	7.9	0.360	2.51	1.14	0.35	0.25	4	<100
	11/26/2003	1.66	0.36	<1	7.7	2.460	12.80	5.95	10.70	3.49	141	370
	11/3/2004	2.04	0.40	<1	7.5	4.200	25.90	5.95	24.50	6.14	169	230
	11/19/2005	2.13	0.51	2	7.9	4.160	20.50	5.74	19.00	5.25	354	1280
	10/28/2006	2.29	0.54	<1	7.8	3.000	15.00	3.17	15.40	5.11	259	1040
	11/10/2007	1.64	0.53	<1	7.6	4.420	19.80	5.26	27.60	7.80	246	950
	12/3/2008	1.26	0.27	<1	7.7	3.990	22.30	6.24	24.60	6.51	210	1480
	10/30/2009	0.63	0.17	1	7.3	3.33	20.90	4.32	13.40	3.77	159	410
BG-4	10/30/2009	0.55	0.10	<1	7.4	3.73	27.50	5.50	12.90	3.18	135	1720
BG-5	10/30/2009	0.33	0.04	<1	7.8	1.65	9.96	2.54	5.51	2.20	55	189
BG-5-7	10/30/2009	0.31	0.04	<1	7.9	1.04	4.76	1.53	4.18	2.36	33	190
BG-7-9	10/30/2009	0.93	0.09	<1	7.8	2	7.60	5.49	8.97	3.51	84	360
BG-9-11	10/30/2009	1.11	0.17	<1	7.7	3.95	18.90	12.40	17.60	4.45	139	520
BG-11-13	10/30/2009	1.26	1.31	<1	7.8	5.2	22.10	15.90	28.90	6.63	150	1610
BG-13-15	10/30/2009	0.96	0.53	<1	7.8	3.33	12.60	9.96	18.80	5.60	57	400
BG-15-17	10/30/2009	0.97	0.27	<1	7.9	4.38	21.30	14.70	23.70	5.59	62	950

Table 3-4. Irrigation Soil Analyses, 2000-2009 (concluded)

Sample Site	Date	U (mg/kg)	Se (mg/kg)	Mo (mg/kg)	pH (units)	Cond. (mmhos/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	SAR (ratio)	Cl (mg/kg)	SO4 (mg/kg)
					SECTION 28 CENTER PIVOT							
N-1	11/19/2002	2.99	<0.6	2	7.7	4.27	20.80	9.40	26.90	6.92	48	3700
	11/24/2003	0.81	0.18	<1	7.8	1.95	8.47	3.94	10.00	4.01	24	400
	11/11/2004	0.89	0.37	<1	7.6	2.67	14.60	6.38	14.00	4.32	28	70
	11/15/2005	0.68	0.17	<1	7.9	2.65	13.90	6.55	11.40	3.57	42	430
	10/21/2006	1.11	0.16	2	7.6	2.37	12.70	6.20	9.35	3.04	57	280
	11/10/2007	1.14	0.47	<1	7.7	2.50	14.00	6.18	10.90	3.43	34	490
	11/22/2008	1.17	0.39	1	7.9	2.90	16.90	8.44	13.40	3.73	48	760
	10/9/2009	1.62	0.41	2	7.8	3.69	18.18	8.96	18.14	4.87	117	895
N-2	11/19/2002	1.47	<0.6	<1	7.7	4.51	20.60	7.60	29.00	7.72	68	3400
	11/24/2003	0.70	0.16	<1	7.9	2.42	9.47	3.73	15.70	6.11	49	450
	11/11/2004	0.80	0.23	<1	7.7	2.63	11.50	4.60	16.20	5.71	61	70
	11/15/2005	0.74	0.15	<1	7.9	4.09	15.70	7.75	26.60	7.77	87	330
	10/21/2006	1.14	0.09	2	7.7	2.56	12.50	6.43	12.90	4.16	18	610
	11/10/2007	1.01	0.34	<1	7.6	3.11	17.60	8.91	15.00	4.12	37	500
	11/22/2008	1.01	0.24	1	7.8	3.27	18.40	9.17	16.40	4.42	35	870
	10/9/2009	1.12	0.19	1	7.8	3.57	20.66	10.80	15.65	3.97	65	1011
N-3	11/19/2002	0.74	<0.6	<1	7.6	4.51	22.90	7.57	26.40	6.76	39	1300
	11/24/2003	0.57	0.13	<1	7.8	2.55	13.20	5.28	13.40	4.41	74	380
	11/11/2004	0.70	0.23	<1	7.6	3.30	17.00	7.29	17.40	4.99	134	70
	11/15/2005	0.58	0.12	<1	7.9	4.29	14.90	7.44	6.00	1.80	118	420
	10/21/2006	1.06	0.08	2	7.8	3.58	15.20	8.21	26.00	7.60	37	670
	11/10/2007	0.92	0.25	<1	7.8	3.46	16.30	8.70	20.60	5.83	37	540
	11/22/2008	1.01	0.25	1	8.0	3.11	15.20	8.55	17.50	5.08	60	910
	10/9/2009	1.24	0.20	1	8.0	4.13	18.94	12.63	23.56	5.72	65	1054
N-4	10/9/2009	0.78	0.10	1	8.1	3.47	12.67	9.14	22.18	6.39	50	683
N-5	10/10/2009	0.83	0.12	3	8.2	3.77	11.46	8.43	27.17	9.22	100	783
N-5-7	10/11/2009	0.71	0.08	2	8.2	3.41	9.95	6.13	22.89	9.69	159	604
N-7-9	10/12/2009	0.76	0.10	2	8.0	3.90	14.73	10.58	23.32	6.54	140	871
N-9-11	10/13/2009	0.47	0.08	2	8.0	3.46	14.26	7.59	18.29	6.13	166	602
N-11-13	10/14/2009	0.53	0.12	1	7.9	2.68	10.01	4.34	15.14	5.88	145	747
N-13-15	10/15/2009	1.02	0.28	2	7.8	3.40	14.01	6.45	19.97	6.17	136	948
N-15-17	10/16/2009	0.41	0.20	2	7.8	3.04	14.16	6.43	16.08	4.75	92	620
BG-1	11/19/2002	2.99	<0.6	2	8.0	0.82	3.33	0.91	4.20	2.88	14	700
	11/24/2003	0.51	0.15	<1	7.9	0.33	1.94	0.61	0.30	0.26	6	60
	11/11/2004	0.88	0.22	<1	7.4	1.16	6.93	1.99	3.91	1.85	12	20
	11/15/2005	0.47	0.12	<1	7.8	1.01	6.37	2.00	2.32	1.13	283	4380
	10/21/2006	0.62	0.10	2	7.7	0.46	2.41	0.71	0.57	0.45	19	80
	11/10/2007	0.78	0.23	<1	7.7	0.71	4.19	1.35	0.95	0.57	32	118
	11/22/2008	0.59	0.15	1	7.8	0.44	2.56	0.77	0.88	0.68	220	1390
	10/15/2009	1.11	0.16	2	7.9	0.507	2.83	0.96	1.10	0.79	60	320
BG-2	11/19/2002	1.62	<0.6	<1	7.7	2.00	14.90	3.27	6.88	2.28	13	500
	11/24/2003	0.61	0.10	<1	8.0	0.35	1.69	0.81	0.60	0.53	6	120
	11/11/2004	0.77	0.22	<1	7.4	0.66	4.22	1.42	1.01	0.60	14	<10
	11/15/2005	0.47	0.07	<1	8.0	0.73	3.71	1.58	1.50	0.92	405	5350
	10/21/2006	0.51	<.05	1	7.8	0.53	2.22	0.95	0.89	0.70	14	<50
	11/10/2007	0.91	0.24	<1	7.6	0.95	5.95	2.18	1.45	0.71	26	99
	11/22/2008	0.46	0.15	1	8.0	0.40	2.11	0.89	0.88	0.71	240	1300
	10/15/2009	0.57	0.10	<1	8.0	0.658	3.20	1.31	1.82	1.21	50	300
BG-3	11/19/2002	1.45	<0.6	<1	7.8	1.51	9.24	1.95	6.29	2.66	13	500
	11/24/2003	0.53	0.12	<1	8.0	0.53	2.10	1.26	1.80	1.39	11	120
	11/11/2004	0.81	0.19	<1	7.5	0.80	4.74	2.03	1.60	0.86	10	10
	11/15/2005	0.55	0.07	<1	7.9	1.05	5.09	2.43	3.03	1.56	290	4340
	10/21/2006	0.58	0.06	1	7.9	0.44	1.33	0.68	1.25	1.25	16	70
	11/10/2007	0.80	0.25	<1	7.7	0.88	4.99	1.84	1.76	1.95	30	120
	11/22/2008	0.53	0.15	<1	8.1	0.493	1.96	0.95	1.95	1.62	270	1500
	10/15/2009	0.56	0.11	1	8.1	0.708	2.71	1.50	2.33	1.61	70	370
BG-4	10/15/2009	0.52	0.07	<1	8.3	0.603	2.22	1.55	1.56	1.14	60	360
BG-5	10/15/2009	0.45	0.06	<1	8.4	0.563	1.67	1.27	2.28	1.88	90	620
BG-5-7	10/15/2009	0.62	0.08	1	8.3	0.867	2.25	1.74	4.22	2.99	100	600
BG-7-9	10/15/2009	0.79	0.08	<1	8.1	1.51	3.73	3.01	7.83	4.27	61	370
BG-9-11	10/15/2009	0.52	0.09	<1	7.9	3.02	12.90	8.38	14.80	4.54	60	420
BG-11-13	10/15/2009	0.97	0.12	1	7.8	2.82	19.70	10.40	6.74	1.74	15	540
BG-13-15	10/15/2009	0.60	0.08	<1	7.9	0.636	2.77	1.15	1.93	1.38	70	480
BG-15-17	10/15/2009	0.84	0.10	<1	7.9	1.27	4.48	1.79	6.25	3.53	70	560

NOTE: 2000 Sample: 1 = 0 - 6 inches, 2 = 6 - 18 inches and 3 = 18 - 36 inches
2001 through 2008 Sample: 1 = 0 - 1 ft, 2 = 1 - 2 ft and 3 = 2 - 3 ft; BG samples are background.

Composite samples collected from untreated (background) areas are labeled BG-1, BG-2, or BG-3, representing the same three layers.

Table 3-5 lists concentrations of uranium and selenium in 1999 (background surface samples only), 2000 at 0-6, 6-18, and 18-36 in; and 2001 to 2009 at 0-1, 1-2 and 2-3 ft. Depths greater than three feet were first sampled in 2009.

3.3.1 Section 33 Center Pivot

Twelve locations were sampled in the treated area of Section 33 in each of the eight latter years (2001 to 2008) and at the three depths described above. Samples were collected to the top of the basalt in 2009. Samples were collected from the five lysimeter locations and were combined with five additional soil sample locations to develop the composite value for each depth interval. Appendix A presents the separate soil analysis. Fewer samples were collected in 2000. Corresponding depth intervals were sampled at each of four background locations for the three analyzed depths (BG-1, BG-2, and BG-3) in untreated areas of Section 33 for the 2002 and 2003 samples. Ten background samples were composited together for the Section 33 soils in 2004 to 2008. Five background samples were composited together for the Section 33 soils in 2009 (see Figure 2-10)

As stated in Section 3.1.3, the term "mean background" is defined as the average of all of the untreated, composite concentrations of a constituent determined from initial testing results to the most current. As defined, the mean background uranium concentration for Section 33 for the three upper layers is 0.73 mg/kg.

Generalized findings for uranium are as follows:

- Uranium concentrations in composite samples collected from the treated area in 2001 were slightly below associated background samples. The treated area results were 0.94 (0-1 ft), 0.60 (1-2 ft) and 0.54 (2-3 ft). The untreated area results were 0.98 (0-1 ft), 0.76 (1-2 ft) and 0.83 mg/kg (2-3 ft).

- Uranium concentrations in the treated area started to exceed those in background samples in 2002. The most recent (2008) concentrations observed in the treated area were 2.03 (0-1 ft), 1.84 (1-2 ft) and 1.52 (2-3 ft). This compares to the corresponding mean background values of 0.79 (0-1 ft), 0.69 (1-2 ft) and 0.72 mg/kg (2-3 ft). The concentrations of uranium in the upper three feet of treated soil exceeded the mean background by factors of 2.57 (0-1 ft), 2.67 (1-2 ft) and 2.11 (2-3 ft). Uranium accumulated in the upper two feet of soil at a relatively constant rate until 2004, when concentrations reached a fairly steady state until an increase in 2009 (see Figure 3-8).

Generalized findings for selenium are as follows:

- Selenium concentrations in composite samples collected from the treated area have generally exceeded those in associated background samples. In addition, selenium concentrations are similar at 1-2 ft and 2-3 ft in the treated areas.

- The most recent (2009) selenium concentrations observed in the treated area are 0.41 (0-1 ft), 0.29 (1-2 ft), and 0.28 (2-3 ft) mg/kg. The corresponding mean background concentrations are 0.14 (0-1 ft), 0.15 (1-2 ft) and 0.13 (2-3 ft) mg/kg.

- Selenium concentrations in 2009 for the top three feet of treated soil exceeded the mean background by factors of 2.93 (0-1 ft), 1.93 (1-2 ft) and 2.15 (2-3 ft). The 2009 selenium data from the treated area were similar to the higher treated values measured in the past while the untreated measurements were similar to the mean background values (see Figure 3-11).

Generalized findings for other parameters are as follows:

- The data in Table 3-4 show general increases in conductivity, SAR, calcium, magnesium and sodium concentrations in both treated and untreated soils in Section 33. The concentrations of sulfate and chloride have varied over time in the treated and background areas (e.g., concentrations of chloride in treated areas have generally increased, while in background areas, they have varied at generally low levels). The SAR for the treated areas has a discernable rising trend but there have been dramatic swings over the period of record.

- Increasing amounts of salts and alkalinity (inferred from increases in calcium and magnesium) in the background areas cannot be explained using the current sampling program. The increase is not likely due to movement of contaminated groundwater from the irrigated fields because uranium concentrations in all intervals in the untreated area have been similar over the course of the irrigations. The rise in salt and alkalinity levels in background samples may be due to a reduction in local precipitation.

3.3.2 Sections 33 and 34 Flood Areas

Composite soil samples were collected from three soil layers in the Section 34 flood irrigation area after the 2000 (15 samples from 3 depths at up to 9 locations), 2001 (30 samples from 3 depths at 10 locations), 2002 (36 samples from 3 depths at 12 locations), 2003 (33 samples from 3 depths at 11 locations); 2004, 2005, 2006, 2007 and 2008 (each with 36 samples from 3 depths at 12 locations) irrigation seasons. Samples were collected from three lysimeter locations and an additional five soil locations in 2009. Two background samples were combined for each of the 2001 and 2002 background soil analyses for Section 34, one background sample was collected in 2003 and ten background samples were combined in 2004, 2005, 2006, 2007 and 2008 (see

Figures 2-1 through 2-9 for sample locations). Figure 2-10 shows the five background soil sampling locations for 2009. Uranium and selenium concentrations observed in the Sections 33 and 34 flood irrigation areas are presented in Figures 3-9 and 3-12, respectively. A comparison with background was not made for Section 33 Flood, because there are insufficient data to analyze.

Generalized findings for uranium concentrations in Section 34 relative to the 2009 mean background are as follows:

- 2000: Average uranium concentrations in the treated areas are appreciably higher than those in the untreated areas when compared to those for subsequent years. However, this may reflect the difference in the sampling interval and calls this comparison into question.

- 2001: Uranium concentrations in the treated area at 0-1 ft (2.72 mg/kg) are a factor of 1.37 greater than the 2009 mean background (1.98 mg/kg). The value of treated soil at 1-2 ft (1.88 mg/kg) exceeds the mean background (1.5 mg/kg) by a factor of 1.25.

- 2002: Uranium concentrations in both treated and background areas were consistently lower than those observed in 2001, 2003, 2004, 2005, 2006, 2007 and 2008. This anomaly is likely due to a systemic analytical bias and not representative of actual concentrations.

- 2003: Uranium concentration in the treated area at 0-1 ft (3.72 mg/kg) exceeded the mean background (1.98 mg/kg) by a factor of 1.88. The uranium concentration at 1-2 ft (1.90 mg/kg) exceeded the mean background by a factor of 1.27. The 2-3 ft interval treated uranium value was essentially the same as the mean background.

- 2004: Uranium concentration in the treated area at 0-1 ft (4.43 mg/kg) exceeded the mean background through 2009 (1.98 mg/kg) by a factor of 2.24. The 1-2 ft of treated soil (2.27 mg/kg) exceeded the mean background (1.50 mg/kg) by a factor of 1.51, whereas the concentration in the bottom interval was similar to mean background.

- 2005: Uranium concentration in the treated area at 0-1 ft (3.94 mg/kg) exceeded the mean background (1.98 mg/kg) by a factor of 1.99, while the concentration of the middle interval indicated no increase and concentration in the bottom interval indicated an anomalous increase.

- 2006: Uranium concentrations in the treated area at 0-1 ft (4.88 mg/kg) exceed the mean background (1.98 mg/kg) by a factor of 2.46. The concentration from 1-2 ft (2.25) is 1.50 times the mean background of 1.50 mg/kg, indicating that less uranium has moved into the 1-2 ft interval than is retained in the upper interval. Essentially no increase was observed in the third interval, which is typical for the lower sampled interval.

- 2007: Uranium concentration in the treated area at 0-1 ft was similar to the 2006 value, indicating that uranium removal concentration has reached a maximum in the upper level. The concentration in the middle level increased to 2.03 times the mean background while the third level showed a small increase.

- 2008: Uranium concentrations gradually declined or were steady in all three layers relative to the 2007 values, indicating no additional removal of uranium. Additional removal is expected in the second and third layers.

- 2009: Uranium concentrations were steady in the upper level but gradually declined in the second foot and third foot intervals.

- From 2001 to 2009, uranium concentrations in Section 34 Flood increased in the 0-1 ft layer from 2.72 to 4.06 mg/kg. The average uranium concentration in the first 3 feet of soil increased from 1.91 to 2.80 mg/kg, or by a factor of 1.48.

- Average uranium concentrations in deeper layers of treated soils were generally lower than those in the surface samples.

A comparison of the results obtained in 2001, 2003, 2004, 2005, 2006, 2007, 2008 and 2009 indicates that uranium is accumulating in the treated areas of Section 34, primarily in the upper and middle intervals. In the 24 acre Section 33 Flood irrigation area, little accumulation of uranium has occurred due to the limited amount of irrigation on this area.

Generalized findings for selenium in Section 34 are as follows:

- 2001: The selenium concentration in the treated area at 0-1 ft (0.50 mg/kg) exceeded the mean background (0.35 mg/kg) by a factor of 1.43. The average of the first 3 feet of treated soil (0.40 mg/kg) exceeded the mean background (0.30 mg/kg) by a factor of 1.33.

- 2002: Selenium concentrations at all depths in the treated and mean background area were reported as less than 0.60 mg/kg. As stated in Section 3.1.2, the MDL was too high to be useful in determining trends.

- 2003: Selenium concentration in the treated area at 0-1 ft (0.82 mg/kg) exceeded the mean background (0.35 mg/kg) by a factor of 2.34. The average of the first 3 feet of treated soil (0.47 mg/kg) exceeded the mean background (0.30 mg/kg) by a factor of 1.56.

- 2004: Selenium concentration in the treated area at 0-1 ft (1.15 mg/kg) exceeded the mean background (0.35 mg/kg) by a factor of 3.29. The average of the first 3 feet of treated soil (0.72 mg/kg) exceeded the mean background (0.30 mg/kg) by a factor of 2.40.

- 2005: Selenium concentration in the treated area at 0-1 ft (1.10 mg/kg) exceeded the mean background (0.35 mg/kg) by a factor of 3.14. The average of the first 3 feet of soil (0.72 mg/kg) exceeded the mean background (0.30 mg/kg) by a factor of 2.40.

- 2006: Selenium concentration in the treated area of Section 34 Flood at 0-1 ft (0.95 mg/kg) exceeds the mean background (0.35 mg/kg) by a factor of 2.71. The average of the first 3 feet of soil (0.56 mg/kg) exceeds the mean background (0.30 mg/kg) by a factor of 1.87.

- 2007: Selenium concentration in the treated area of Section 34 Flood at 0-1 ft (1.32 mg/kg) exceeds the mean background (0.35 mg/kg) by a factor of 3.77 while concentration at 1-2 ft (0.94 mg/kg) exceeds the mean background (0.28 mg/kg) by a factor of 3.36. The increased selenium in 2007 should be used with caution because the background selenium values also increased.

- 2008: Selenium concentration in the treated area of Section 34 Flood at 0-1 ft (1.14 mg/kg) exceeds the mean background (0.35 mg/kg) by a factor of 3.26. A decrease in the selenium levels in each of the three intervals was observed compared to the 2007 values.

- 2009: Selenium levels decreased in the upper two intervals while concentration in the 2-3 foot interval exhibited a small increase.

A comparison of the results obtained in 2001, 2003, 2004, 2005, 2006, 2007, 2008 and 2009 indicates that selenium has accumulated in the treated areas of Section 34. The concentration of selenium peaked in the upper layer in 2004, gradually declined in 2005, rose slightly in 2006 and 2007, and decreased in 2008 and 2009. The selenium concentration at 1-2 ft was 65% of that in the upper layer in 2009. The interval (2-3 ft) shows some amount of selenium accumulation in the soil while the 3-4 ft interval only a small amount of selenium accumulation.

Generalized findings for other parameters are as follows:

- In the Section 34 Flood area, there have been increases in sodium, SAR, conductivity, magnesium and chloride to generally steady levels for the past few years, whereas levels of sulfate have generally continued to increase in the treated soils. Calcium levels have fluctuated.

3.3.3 Section 28 Center Pivot

Twelve locations were sampled in the treated area of Section 28 in 2002, 2003, 2004, 2005, 2006, 2007 and 2008 at the three, 1-ft depth intervals described above. Eight locations (3 lysimeter locations plus 5 general sample locations) were sampled in 2009 to the depth of the top of the basalt. Corresponding depths were sampled at each of the background locations in untreated areas of Section 28 (See Figure 2-11 for the five background locations that were composited for the three depths for 2002 and Figures 2-12 through 2-18 for the 2003 through 2009 locations). Graphical presentations of uranium and selenium concentrations are included in Figures 3-10 and 3-13, respectively.

Generalized findings for uranium in Section 28 are as follows:

- Uranium concentrations in composite samples collected from the treated and background areas in 2002 were, with one exception, at levels significantly above pre-operational and 2003 through 2009 treated levels. The 2002 data are likely elevated because of laboratory error and do not represent uranium concentrations in Section 28 soils. These data are not considered further.

- Uranium concentrations in the treated area slightly exceed those in the background area in 2003 to 2009. The most recent (2009) concentrations of uranium observed in the treated area were 1.62 (0-1 ft), 1.12 (1-2 ft) and 1.24 (2-3 ft); and 0.56 (0-1 ft), 0.52 (1-2 ft) and 0.52 mg/kg (2-3 ft) for the mean background. The treated intervals exceed the mean background by factors of 2.75 (0-1 ft), 2.11 (1-2 ft) and 2.38 (2-3 ft). All three interval concentrations of uranium in the treated area currently exceed background by an average factor of 2.41. Thus, uranium concentrations are more than twice that of background and had appeared to have reached a steady state until the observed 2009 increases.

Generalized findings for selenium in Section 28 are as follows:

- Selenium concentrations in composite samples collected from the treated and background areas in 2002 were all below the relatively high MDA of 0.6 mg/kg and are not useful in trend analysis.

- In 2009, selenium concentrations observed in the treated area were 0.41 (0-1 ft), 0.19 (1-2 ft) and 0.20 mg/kg (2-3 ft). Corresponding mean background concentrations were 0.13 (0-1 ft), 0.11 (1-2 ft), and 0.10 mg/kg (2-3 ft). When comparing the intervals, the three treated intervals exceeded mean background by factors of 3.15 (0-1 ft), 1.73 (1-2 ft) and 2.00 (2-3 ft). In 2009, the average concentration of selenium in the treated area exceeded the mean background by a factor of 2.29, indicating that selenium was retained in the Section 28 soils in 2009. The decline in selenium concentrations in the lower two intervals is thought to be caused by a larger quantity of water moving beyond the 3 foot soil interval.

Generalized findings for other parameters are as follows:

- As indicated in Table 3-4, there are general decreases in conductivity, SAR and calcium, magnesium, sodium and sulfate concentrations in both treated and background soils for Section 28 from 2003 to 2006 with slight increases in 2007 and 2009. The chloride and sulfate results in the untreated area are more variable.

Table 3-5. Summary of Irrigation Soil Analyses, 2000-2009

		Uranium (mg/kg)		Selenium (mg/kg)	
Section	**Yearly Data**	**Treated Area**	**Background**	**Treated Area**	**Background**
33 Center Pivot	1999 AVG:	---	0.61	----	0.12
	2000-1 AVG:	0.93	1.14	0.37	0.20
	2000-2 AVG:	0.81	----	0.45	----
	2000-3 AVG	1.03	----	0.25	----
	2001-1	0.94	0.98	0.30	0.10
	2001-2	0.60	0.76	0.30	0.20
	2001-3	0.54	0.83	0.10	0.30
	2002-1	0.98	0.85	<0.60	<0.60
	2002-2	0.89	0.59	<0.60	<0.60
	2002-3	0.68	0.66	<0.60	<0.60
	2003-1	1.36	0.78	0.28	0.12
	2003-2	1.14	0.52	0.19	0.12
	2003-3	1.00	0.67	0.18	0.12
	2004-1	1.78	0.88	0.45	0.27
	2004-2	1.52	0.79	0.39	0.24
	2004-3	1.15	0.81	0.38	0.26
	2005-1	1.45	0.78	0.31	0.18
	2005-2	1.15	0.69	0.21	0.15
	2005-3	1.00	0.79	0.30	0.15
	2006-1	1.87	0.88	0.36	0.18
	2006-2	1.62	0.88	0.15	0.16
	2006-3	1.05	1.09	0.14	0.15
	2007-1	1.67	0.89	0.44	0.39
	2007-2	1.34	0.89	0.30	0.44
	2007-3	1.30	0.86	0.39	0.27
	2008-1	1.41	0.72	0.41	0.21
	2008-2	1.37	0.61	0.35	0.23
	2008-3	1.27	0.72	0.33	0.20
	2009-1	2.03	1.02	0.41	0.19
	2009-2	1.84	0.73	0.29	0.15
	2009-3	1.52	0.82	0.28	0.13
	2009-4	1.32	1.01	0.27	0.15
	2009-5	1.20	0.9	0.27	0.12
	2009-5-7	0.95	0.52	0.20	0.08
	2009-7-9	0.85	0.8	0.22	0.09
	2009-9-11	0.93	0.76	0.19	0.05
	2009-11-13	0.96	0.56	0.12	<0.05
	2009-13-15	0.80	0.68	0.14	0.10
	2009-15-17	0.83	0.99	0.19	0.14

Table 3-5. Summary of Irrigation Soil Analyses, 2000-2009 (continued)

		Uranium (mg/kg)		Selenium (mg/kg)	
Section	**Yearly Data**	**Treated Area**	**Background**	**Treated Area**	**Background**
28 Center Pivot	2002-1	2.99	2.99	<0.60	<0.60
	2002-2	1.47	1.62	<0.60	<0.60
	2002-3	0.74	1.45	<0.60	<0.60
	2003-1	0.81	0.51	0.18	0.15
	2003-2	0.70	0.61	0.16	0.10
	2003-3	0.57	0.53	0.13	0.15
	2004-1	0.89	0.88	0.37	0.22
	2004-2	0.80	0.77	0.23	0.22
	2004-3	0.70	0.81	0.23	0.19
	2005-1	0.68	0.47	0.17	0.12
	2005-2	0.74	0.47	0.15	0.07
	2005-3	0.58	0.55	0.12	0.07
	2006-1	1.11	0.62	0.16	0.10
	2006-2	1.14	0.51	0.09	<0.05
	2006-3	1.06	0.58	0.08	0.06
	2007-1	1.14	0.78	0.47	0.23
	2007-2	1.01	0.91	0.34	0.24
	2007-3	0.92	0.80	0.25	0.25
	2008-1	1.17	0.59	0.39	0.15
	2008-2	1.01	0.46	0.24	0.15
	2008-3	1.01	0.52	0.25	0.15
	2009-1	1.62	1.11	0.41	0.16
	2009-2	1.12	0.57	0.19	0.1
	2009-3	1.24	0.56	0.20	0.11
	2009-4	0.78	0.52	0.10	0.07
	2009-5	0.83	0.45	0.12	0.06
	2009-5-7	0.71	0.62	0.08	0.08
	2009-7-9	0.76	0.79	0.10	0.08
	2009-9-11	0.47	0.52	0.08	0.09
	2009-11-13	0.53	0.97	0.12	0.12
	2009-13-15	1.02	0.6	0.28	0.08
	2009-15-17	0.41	0.84	0.20	0.1

Table 3-5. Summary of Irrigation Soil Analyses, 2000-2009 (continued)

		Uranium (mg/kg)		Selenium (mg/kg)	
Section	**Yearly Data**	**Treated Area**	**Background**	**Treated Area**	**Background**
34 Flood	1999 AVG:	----	2.44	----	0.44
	2000-1 AVG:	3.35	----	0.68	----
	2000-2 AVG:	2.22	----	0.37	----
	2000-3 AVG	1.62	----	0.30	----
	2001-1	2.72	2.47	0.50	0.30
	2001-2	1.88	1.92	0.40	0.20
	2001-3	1.15	0.79	0.30	0.20
	2002-1	0.69	0.45	<0.60	<0.60
	2002-2	0.46	0.53	<0.60	<0.60
	2002-3	0.42	0.40	<0.60	<0.60
	2003-1	3.72	2.33	0.82	0.42
	2003-2	1.90	1.46	0.40	0.35
	2003-3	1.08	1.66	0.19	0.36
	2004-1	4.43	2.79	1.15	0.75
	2004-2	2.27	2.04	0.63	0.68
	2004-3	1.40	1.38	0.37	0.40
	2005-1	3.94	2.41	1.10	0.53
	2005-2	1.41	2.44	0.38	0.69
	2005-3	2.62	2.13	0.68	0.51
	2006-1	4.88	3.06	0.95	0.69
	2006-2	2.25	3.93	0.45	0.87
	2006-3	1.21	2.29	0.28	0.54
	2007-1	5.02	3.30	1.32	0.74
	2007-2	3.05	2.67	0.44	0.78
	2007-3	1.75	1.64	0.64	0.53
	2008-1	4.38	2.52	1.14	0.57
	2008-2	2.70	2.19	0.68	0.48
	2008-3	1.71	1.26	0.37	0.27
	2009-1	4.06	3.35	0.97	0.59
	2009-2	2.59	2.15	0.63	0.39
	2009-3	1.82	0.63	0.46	0.17
	2009-4	0.95	0.55	0.21	0.1
	2009-5	0.56	0.33	0.08	0.04
	2009-5-7	0.35	0.31	0.05	0.04
	2009-7-9	0.36	0.93	0.05	0.09
	2009-9-11	0.52	1.11	0.10	0.17
	2009-11-13	1.06	1.26	0.11	1.31
	2009-13-15	0.61	0.96	0.10	0.53

Table 3-5. Summary of Irrigation Soil Analyses, 2000-2009 (continued)

	2004-1	1.78	1.56	0.56	0.47
	2004-2	1.67	1.30	0.47	0.39
	2004-3	1.68	1.33	0.49	0.42
	2005-1	1.35	1.12	0.31	0.25
	2005-2	1.14	0.92	0.24	0.20
	2005-3	1.00	0.90	0.20	0.19
	2006-1	1.76	1.62	0.41	0.21
	2006-2	1.24	1.55	0.26	0.56
	2006-3	1.62	1.05	0.21	0.35
	2007-1	1.69	1.79	0.45	0.38
	2007-2	1.55	1.29	0.40	0.31
33 Flood	2007-3	1.51	1.24	0.40	0.35
	2008-1	1.70	1.44	0.43	0.32
	2008-2	1.53	1.18	0.39	0.32
	2008-3	0.96	0.97	0.23	0.25
	2009-1	1.17	1.22	0.1	0.23
	2009-2	1.17	1.6	0.09	0.29
	2009-3	0.67	0.61	0.08	0.1
	2009-4	0.38	0.87	<0.05	0.12
	2009-5	0.33	0.46	<0.05	0.06
	2009-5-7	0.35	0.42	<0.05	0.05
	2009-7-9	0.27	0.35	<0.05	<0.05
	2009-9-11	0.52	0.44	0.06	0.07

Notes:
2000 Sample: 1 = 0 - 6 inches, 2 = 6 - 18 inches and 3 = 18 - 36 inches
2001 through 2008 Sample: 1 = 0 - 1 ft, 2 = 1 - 2 ft and 3 = 2 - 3 ft

Table 3-6 presents the treated area uranium and selenium concentrations for each year along with the mean background concentration, which was determined from all background data through that year. Table 3-6 presents the gain (difference between treated area and mean background) for 2009. The cumulative gain for 2009 is given and used in the cumulative buildup tables in the next subsection.

Figure 3-14 presents the uranium concentrations with depth for the treated and mean background concentrations. The distance between these two lines is the gain in uranium concentration. The two red lines show that uranium has been added at each depth except the bottom interval (15 to 17 feet) for Section 33 soils. The red line stops at 15 feet because no gain in uranium exists below that depth. The gain starting at a depth of 7 to 9 feet and below is small. The gain in the 4 to 13 feet intervals is small or negative for the Section 28 soils (see the green lines on Figure 3-14) but then increases in the 13 to 15 feet interval. The two blue lines show that there is a gain in the Section 34 soils to a depth of 5 feet, but there is no significant gain below this depth.

A similar plot is presented for the selenium soil concentrations in Figure 3-15. The two red lines show some gain in selenium concentration for all depths for the Section 33 soils with a gradual overall decline in the gain with depth. The gain in selenium concentration in the Section 34 soils is larger but declines quickly with increasing depth and extends only to a depth of seven feet (see blue lines on Figure 3-15). The two green lines show that a significant amount of selenium has been added only in the upper three feet and the bottom two feet in the Section 28 soils.

Table 3-6.Treated, Background and Gain in Soil Concentrations

		Uranium (mg/kg)			Selenium (mg/kg)		
Section	**Yearly Data**	**Treated Area**	**Background**	**Gain**	**Treated Area**	**Background**	**Gain**
	1999 AVG:	----	0.68		----	0.09	
	2000-1 AVG:	0.93	0.72		0.37	0.10	
	2000-2 AVG:	0.81	0.64		0.45	0.06	
	2000-3 AVG	1.03	0.60		0.25	0.04	
	2001-1	0.94	0.74		0.30	0.10	
	2001-2	0.60	0.66		0.30	0.08	
	2001-3	0.54	0.63		0.10	0.08	
	2002-1	0.98	0.75		<0.60	0.10	
	2002-2	0.89	0.65		<0.60	0.08	
	2002-3	0.68	0.63		<0.60	0.08	
	2003-1	1.36	0.75		0.28	0.10	
	2003-2	1.14	0.64		0.19	0.09	
	2003-3	1.00	0.64		0.18	0.08	
	2004-1	1.78	0.76		0.45	0.11	
	2004-2	1.52	0.65		0.39	0.11	
	2004-3	1.15	0.66		0.38	0.10	
	2005-1	1.45	0.76		0.31	0.12	
	2005-2	1.15	0.66		0.21	0.11	
	2005-3	1.00	0.67		0.30	0.11	
33 Center Pivot	2006-1	1.87	0.77		0.36	0.12	
	2006-2	1.62	0.68		0.15	0.12	
	2006-3	1.05	0.70		0.14	0.11	
	2007-1	1.67	0.78		0.44	0.14	
	2007-2	1.34	0.69		0.30	0.15	
	2007-3	1.30	0.71		0.39	0.12	
	2008-1	1.41	0.77		0.41	0.14	
	2008-2	1.37	0.69		0.35	0.15	
	2008-3	1.27	0.72		0.33	0.13	
	2009-1	2.03	0.79	1.24	0.41	0.14	0.27
	2009-2	1.84	0.69	1.15	0.29	0.15	0.14
	2009-3	1.52	0.72	0.80	0.28	0.13	0.15
	2009-4	1.32	0.60	0.71	0.27	0.06	0.20
	2009-5	1.20	0.75	0.46	0.27	0.07	0.19
	2009-5-7	0.95	0.52	0.43	0.20	0.08	0.12
	2009-7-9	0.85	0.80	0.05	0.22	0.09	0.13
	2009-9-11	0.93	0.72	0.21	0.19	0.05	0.14
	2009-11-13	0.96	0.76	0.20	0.12	<0.05	0.10
	2009-13-15	0.80	0.68	0.12	0.14	0.10	0.04
	2009-15-17	0.83	0.99	-0.16	0.19	0.14	0.05
			SUM	5.20		SUM	1.53

Table 3-6.Treated, Background and Gain in Soil Concentrations (continued)

		Uranium (mg/kg)			Selenium (mg/kg)		
Section	Yearly Data	Treated Area	Background	Gain	Treated Area	Background	Gain
28 Center Pivot	2002-1	2.99	2.99		<0.60	<0.60	
	2002-2	1.47	1.62		<0.60	<0.60	
	2002-3	0.74	1.45		<0.60	<0.60	
	2003-1	0.81	0.51		0.18	0.15	
	2003-2	0.70	0.61		0.16	0.10	
	2003-3	0.57	0.53		0.13	0.15	
	2004-1	0.89	0.88		0.37	0.22	
	2004-2	0.80	0.77		0.23	0.22	
	2004-3	0.70	0.81		0.23	0.19	
	2005-1	0.68	0.47		0.17	0.12	
	2005-2	0.74	0.47		0.15	0.07	
	2005-3	0.58	0.55		0.12	0.07	
	2006-1	1.11	0.62		0.16	0.10	
	2006-2	1.14	0.51		0.09	<0.05	
	2006-3	1.06	0.58		0.08	0.06	
	2007-1	1.14	0.78		0.47	0.23	
	2007-2	1.01	0.91		0.34	0.24	
	2007-3	0.92	0.80		0.25	0.25	
	2008-1	1.17	0.59		0.39	0.15	
	2008-2	1.01	0.46		0.24	0.15	
	2008-3	1.01	0.52		0.25	0.15	
	2009-1	1.62	0.59	1.03	0.41	0.13	0.28
	2009-2	1.12	0.53	0.59	0.19	0.11	0.08
	2009-3	1.24	0.52	0.72	0.20	0.1	0.10
	2009-4	0.78	0.81	-0.03	0.10	0.1	0.00
	2009-5	0.83	0.85	-0.02	0.12	0.09	0.03
	2009-5-7	0.71	0.58	0.13	0.08	0.07	0.01
	2009-7-9	0.76	0.66	0.10	0.10	0.1	0.00
	2009-9-11	0.47	0.41	0.06	0.08	0.07	0.01
	2009-11-13	0.53	0.39	0.14	0.12	0.1	0.02
	2009-13-15	1.02	0.12	0.90	0.28	0.57	*-0.29
	2009-15-17	0.41	0.22	0.19	0.20	0.06	0.14
			SUM	3.81		SUM	0.67

NOTE: * DID NOT USE IN SUM

Table 3-6.Treated, Background and Gain in Soil Concentrations (continued)

		Uranium (mg/kg)			Selenium (mg/kg)		
Section	Yearly Data	Treated Area	Background	Gain	Treated Area	Background	Gain
34 Flood	1999 AVG:	----	2.44		----	0.44	
	2000-1 AVG:	3.35	----		0.68	----	
	2000-2 AVG:	2.22	----		0.37	----	
	2000-3 AVG	1.62	----		0.30	----	
	2001-1	2.72	2.47		0.50	0.30	
	2001-2	1.88	1.92		0.40	0.20	
	2001-3	1.15	0.79		0.30	0.20	
	2002-1	0.69	0.45		<0.60	<0.60	
	2002-2	0.46	0.53		<0.60	<0.60	
	2002-3	0.42	0.40		<0.60	<0.60	
	2003-1	3.72	2.33		0.82	0.42	
	2003-2	1.90	1.46		0.40	0.35	
	2003-3	1.08	1.66		0.19	0.36	
	2004-1	4.43	2.79		1.15	0.75	
	2004-2	2.27	2.04		0.63	0.68	
	2004-3	1.40	1.38		0.37	0.40	
	2005-1	3.94	2.41		1.10	0.53	
	2005-2	1.41	2.44		0.38	0.69	
	2005-3	2.62	2.13		0.68	0.51	
	2006-1	4.88	3.06		0.95	0.69	
	2006-2	2.25	3.93		0.45	0.87	
	2006-3	1.21	2.29		0.28	0.54	
	2007-1	5.02	3.30		1.32	0.74	
	2007-2	3.05	2.67		0.44	0.78	
	2007-3	1.75	1.64		0.64	0.53	
	2008-1	4.38	2.52		1.14	0.57	
	2008-2	2.70	2.19		0.68	0.48	
	2008-3	1.71	1.26		0.37	0.27	
	2009-1	4.06	1.98	2.08	0.97	0.35	0.62
	2009-2	2.59	1.5	1.09	0.63	0.28	0.35
	2009-3	1.82	1.16	0.66	0.46	0.28	0.18
	2009-4	0.95	0.55	0.40	0.21	0.1	0.11
	2009-5	0.56	0.33	0.23	0.08	<0.05	0.06
	2009-5-7	0.35	0.31	0.04	0.05	<0.05	0.03
	2009-7-9	0.36	0.93	*-0.57	0.05	0.09	*-0.04
	2009-9-11	0.52	1.11	*-0.59	0.10	0.17	*-0.07
	2009-11-13	1.06	1.26	*-0.12	0.11	1.31	*-1.21
	2009-13-15	0.61	0.96	*-0.35	0.10	0.53	*-0.43
			SUM	4.50		SUM	1.35

Table 3-6.Treated, Background and Gain in Soil Concentrations (continued)

	2004-1	1.78	1.56		0.56	0.47	
	2004-2	1.67	1.30		0.47	0.39	
	2004-3	1.68	1.33		0.49	0.42	
	2005-1	1.35	1.12		0.31	0.25	
	2005-2	1.14	0.92		0.24	0.20	
	2005-3	1.00	0.90		0.20	0.19	
	2006-1	1.76	1.62		0.41	0.21	
	2006-2	1.24	1.55		0.26	0.56	
	2006-3	1.62	1.05		0.21	0.35	
	2007-1	1.69	1.79		0.45	0.38	
	2007-2	1.55	1.29		0.40	0.31	
33 Flood	2007-3	1.51	1.24		0.40	0.35	
	2008-1	1.70	1.44		0.43	0.32	
	2008-2	1.53	1.18		0.39	0.32	
	2008-3	0.96	0.97		0.23	0.25	
	2009-1	1.17	1.22	-0.05	0.10	0.23	-0.13
	2009-2	1.17	1.60	-0.43	0.09	0.29	-0.20
	2009-3	0.67	0.61	0.06	0.08	0.10	-0.02
	2009-4	0.38	0.87	-0.49	<0.05	0.12	-0.09
	2009-5	0.33	0.46	-0.13	<0.05	0.06	-0.04
	2009-5-7	0.35	0.42	-0.07	<0.05	0.05	-0.03
	2009-7-9	0.27	0.35	-0.08	<0.05	<0.05	0.00
	2009-9-11	0.52	0.44	0.08	0.06	0.07	-0.01
			SUM	-1.11		SUM	-0.52

NOTE: * DID NOT USE IN SUM

3.3.4 Comparison of Applied and Measured Soil Concentrations

3.3.4.1 Uranium

It was assumed when planning the irrigation program that all the uranium would be deposited in the upper 1-ft of soil (ERG and HYDRO, 1999). It was estimated that water containing 0.44 mg/l of uranium applied at 3 ac-ft/year would conservatively increase the concentration of uranium in the upper 1-ft of soil by 0.92 mg/kg per year. The actual average uranium concentrations in the applied water have always been lower than 0.44 mg/l. Actual irrigation application rates have range from significantly below to slightly above 3 ac-ft/yr.

The predictions of uranium accumulation in the soil have been superseded by actual measurements of uranium concentration in the irrigated areas. The measurements indicate that the applied uranium occurs beyond the upper three feet of the soil profile.

It is reasonable to adopt a cumulative mass balance approach to track the fate of the applied uranium since the beginning of the irrigation program for each area. Actual applied uranium concentrations, application rates of irrigation water, and calculated increases in soil are presented in Tables 3-7 and 3-8. The sums of measured concentrations minus background concentrations (gain) are from Table 3-6.

The calculated data in Tables 3-7 and 3-8 are determined as follows:

a = cumulative masses of uranium applied per irrigation area, mg = $\Sigma_{2000\text{-}2009}$[(average concentration in water, mg/l) (volume of water in ac-ft) (28.3 l/ft^3) (43,560 ft^2/ac)]

b = mass of soil per irrigation area, kg = (footage of soil used)(no. of acres)(90 lbs/ft^3) (454 g/lb)(43,560 ft^2/ac)(10^{-3}kg/g)

c = gain in uranium concentration, mg/kg = (sum of measured concentrations of uranium minus mean background concentrations)

d = measured mass of uranium, mg = (b)(c)/footage of soil used

e = ratio of measured to applied masses of uranium, unitless = d/a

The assumptions are consistent with those reported previously (ERG and HYDRO, 1999). For example, typical soil density is assumed to be 90 pounds per cubic foot (lb/ft^3).

The above-background concentrations (gain) of uranium in each section, in mg/kg are tabulated in Table 3-6 and are: Section 33 Center Pivot (5.20); Section 33 Flood (-1.11); Section 34 (4.50); and Section 28 (3.81). Based on this series of calculations, the ratios of measured to applied masses of uranium in the total footage of soil are: Sections 33 Pivot (1.23), 33 Flood (-0.64), 34 (0.95), and 28 (1.02).

In Section 33 Pivot and Section 28, 123 and 102 percent of the applied uranium is accounted for, respectively, indicating that all of the applied uranium is likely still in the soil profile. Gains in the upper 17 feet of soil were used in calculating these percentages. The presence of more applied uranium deeper in the soil profile in these fields may be due to the sandy loam soils, which have less adsorptive capacity than clay soils. On the other hand, most of the uranium applied to Section 34 has been retained in the upper seven feet and this is attributed to the presence of clay soils. Only the results in the upper seven feet are thought to indicate some gain in the treated soil. The measured concentrations in Section 33 Flood are less than background and therefore do not produce a reliable retention value.

Accumulating uranium concentrations for each of the upper three layers in each irrigation area are shown in Figures 3-8 (Section 33 Center Pivot), 3-9 (Sections 33 and 34 Flood), and 3-10 (Section 28 Center Pivot). Each figure is subdivided into upper, middle, and lower intervals. The horizontal line on each figure represents the mean background concentration.

Table 3-7. Uranium Applied in Irrigation Water

	Uranium Concentration (mg/l)		Acreages				Volume of Irrigation Water Applied (ft)			
Year	Section 28	Sections 33/34	Section 28	Section 33 Flood	Section 33 Pivot	Section 34	Section 28 Pivot	Section 33 Flood	Section 33 Pivot	Section 34 Flood
2000	NA	0.27	NA	NA	150	120	NA	NA	2.29	3.1
2001	NA	0.26	NA	NA	150	120	NA	NA	2.11	2.85
2002	0.23	0.23	60	NA	150	120	2.2	NA	2.36	3.3
2003	0.24	0.22	60	NA	150	120	2.57	NA	2.62	3.34
2004	0.27	0.26	60	24	150	120	3.04	1.26	2.85	3.23
2005	0.35	0.27	100	24	150	120	2.38	0.84	2.67	3.13
2006	0.35	0.29	100	NA	150	120	2.33	NA	1.94	2.61
2007	0.36	0.28	100	NA	150	120	2.42	NA	2.86	0.98
2008	0.36	0.24	100	24	150	120	2.76	1.93	2.75	2.69
2009	0.39	0.24	100	24	150	120	1.85	6.13	1.43	1.53

Notes:
NA = not irrigated

Table 3-8. Cumulative Buildup of Uranium in Soils

	Section			
	28 Pivot	33 Flood	33 Pivot	34 Flood
Applied Mass of Uranium (mg), a	665,802,264	73,804,820	1,132,189,664	1,007,234,505
Sum of Measured Concentrations Minus Background (mg/kg), c	3.81	-1.11	5.20	4.50
Mass of Soil (kg), b	3,025,764,720	469,883,462	4,538,647,080	1,495,083,744
Measured Mass of Uranium (mg), d	678,127,270	-47,415,513	1,388,292,048	961,125,264
Ratio of Measured to Applied Masses, e	1.02	*	1.23	0.95

Notes: * = Background higher than treated

3.3.4.2 Selenium

The applied and measured selenium concentrations in the soil were calculated in a manner similar to that for uranium, and are presented in Tables 3-9 and 3-10.

The above-background concentrations of selenium in each section for the soil layers, in mg/kg, are: Section 33 Center Pivot (1.53); Section 33 Flood (-0.52); Section 34 (1.35); and Section 28 (0.67). Based on the same series of calculations shown above in Section 3.3.4.1, the ratios of measured to applied masses of selenium in the soil are: Sections 33 Pivot (1.18), 33 Flood (-1.32), 34 (0.89), and 28 (0.77).

In the Section 33 Pivot all the applied selenium is accounted for. The 2009 selenium results indicate that all of the applied selenium is still within the 17 foot interval of soil.

Actual selenium measurements are also shown in Figures 3-11 (Section 33 Center Pivot), 3-12 (Sections 33 and 34 Flood), and 3-13 (Section 28 Center Pivot). Each figure is subdivided into upper, middle, and lower intervals. The horizontal lines on each figure represent the mean background concentration of each layer.

There are indications that selenium, when retained, may partly be in a dissolved phase, rather than being completely absorbed in soils. A review of Figures 3-11 through 3-13 indicates that some retention of selenium appears to be occurring. Only 32, 52 and 48 percent of the chloride concentration applied was measured in the soil in 2009 for Sections 28, 33 and 34, respectively. These percentages are much less than those observed for selenium, showing that a very large percentage of the chloride added to the Section 28, 33 and 34 irrigation areas was not retained in the soil interval. The higher percentage for selenium indicates some retention of this constituent in the soil profile.

Table 3-9. Selenium Applied in Irrigation Water

	Selenium Concentration (mg/l)a		Acreages				Volume of Irrigation Water Applied (ft)			
Year	Section 28	Sections 33/34	Section 28	Section 33 Flood	Section 33 Pivot	Section 34	Section 28 Pivot	Section 33 Flood	Section 33 Pivot	Section 34 Flood
2000	NA	0.12	NA	NA	150	120	NA	NA	2.29	3.1
2001	NA	0.1	NA	NA	150	120	NA	NA	2.11	2.85
2002	0.08	0.1	60	NA	150	120	2.2	NA	2.36	3.3
2003	0.08	0.08	60	NA	150	120	2.57	NA	2.62	3.34
2004	0.07	0.09	60	24	150	120	3.04	1.26	2.85	3.23
2005	0.08	0.06	100	24	150	120	2.38	0.84	2.67	3.13
2006	0.08	0.07	100	NA	150	120	2.33	NA	1.94	2.61
2007	0.08	0.06	100	NA	150	120	2.42	NA	2.86	0.98
2008	0.07	0.05	100	24	150	120	2.76	1.93	2.75	2.69
2009	0.07	0.05	100	24	150	120	1.85	6.13	1.43	1.53

Notes: a. 2003 concentration of selenium is assumed. The value was reported as <0.005 mg/l, which is assumed to be a laboratory artifact.
NA = not irrigated

Table 3-10. Cumulative Buildup of Selenium in Soils

	Section			
	28 Pivot	33 Flood	33 Pivot	34 Flood
Applied Mass of Selenium (mg), a	154,061,449	16,769,318	344,768,797	323,256,112
Sum of Measured Concentrations Minus Background (mg/kg), c	0.67	-0.52	1.53	1.35
Mass of Soil (kg), b	3,025,764,720	469,883,462	4,538,647,080	1,495,083,744
Measured Mass of Selenium (mg), d	119,250,727	-22,212,673	408,478,237	288,337,579
Ratio of Measured to Applied Masses, e	0.77	*	1.18	0.89

Notes: * = Background higher than treated

3.3.5 Summary of Soil Concentration Comparison

The data collected to date indicate that soil attenuation of uranium is of the same order of magnitude as that predicted by the pre-operational model.

The soil properties and method of irrigation differed for the Section 33 and 28 sites and the Section 33 flood and Section 34 flood areas. The irrigation water for the Section 33 and 28 sites was applied using center pivot systems while Section 34 was flood irrigated. An additional 24 acres of flood irrigation area was added in eastern Section 33 at the beginning of the 2004 season. The small incremental changes in concentrations in uranium and selenium along with the natural variability in both the center pivot and flood irrigation areas make it difficult to accurately determine the amount of increase in concentrations in the soil from year to year. The 2001 and 2002 data indicate that the soil concentrations were not continuing to increase with time for either type of irrigation among the three irrigation sites. The 2003 and 2004 data show some increase in Sections 33 and 34 while concentrations slightly increased in 2004 in Section 28. A slight decrease was observed at all three sites in 2005. In 2006, an increase was observed in all sites except Section 28 and 33, where selenium decreased slightly in the two lower intervals. Concentrations generally increased or were fairly steady in 2007, followed by a general decrease in 2008. Uranium concentrations in 2009 increased in the Section 33 and 28 soils. Future sampling may further diminish the effects of analytical and natural variability and more clearly reveal trends in the accumulation of uranium and selenium.

The 2009 results indicate that uranium is being retained in most intervals down to the top of the basalt in Sections 28 and 33, whereas uranium is only being retained in the upper five feet interval in the Section 34 flood area. The 2009 results also indicate selenium is being retained to similar depths but these results need to be confirmed with future measurements.

In 2009, the measured uranium soil concentrations in the irrigated areas ranged from 0.27 to 4.06 mg/kg. The laboratory reported uranium MDL and PQL in 2003 and 2004 were 0.03 and 0.1 mg/kg, respectively and 0.05 and 0.3 mg/kg in 2005 to 2009. The selenium concentrations in the irrigated areas for 2009 ranged from less than 0.05 to 0.97 mg/kg. The laboratory reported selenium MDL and PQL for the soil analysis was 0.05 and 0.3 mg/kg.

The mass balance approach to tracking uranium and selenium in soil indicates that irrigation can continue without concern for excessive accumulation of these constituents.

3.4 Soil Moisture Concentrations

Lysimeters have been installed in the irrigation field areas to collect soil moisture samples and enable the measurement of the soil moisture constituent concentrations. The lysimeters were installed in augured holes at the desired depths. The porous cups were sand packed with a very fine flour sand to enhance their ability to pull moisture into the cup. A vacuum is placed on the lysimeter, which causes the soil moisture water to enter the cup. The soil moisture samples are then collected by purging the lysimeter cup. Lysimeters have been placed in each of the irrigation areas.

3.4.1 Section 33

A total of eight lysimeters have been installed in Section 33 Center Pivot irrigation area. These lysimeters have been installed at five different locations. Figure 3-1 shows the five lysimeter locations. Table 3-11 presents the completion information for the eight lysimeters in Section 33. Table 3-12 presents the lithology of the alluvium at each lysimeter. The sand pack interval is given in the fourth column of Table 3-11 while the depth to the top of the basalt is noted in the third column. A bentonite seal was placed above the sand pack that exists around the lysimeter to prevent soil moisture from readily moving down the annulus. Lysimeters were placed in the alluvial material above the basalt except at the locations LY-3 and LY-4. A hole was drilled to a depth of 31 feet at LY-3M and the lysimeter placed in the bottom of this hole with the top of the lysimeter being located 23 feet below the top of the basalt. Two lysimeters were installed in a drill hole at the LY-4M site. These lysimeters were installed ten and thirty feet below the top of the basalt at this location.

Vacuum was applied to each of the lysimeters during each sampling event. Some of the lysimeters have not produced soil moisture samples while some have produced a sample each time a vacuum has been applied. Tables 3-13 and 3-14 present the water quality analysis of the soil moisture for the lysimeters. Lysimeter LY-1 was installed in July, 2009 and monthly samples have been obtained for this lysimeter each time the vacuum has been applied. LY-2 was installed in June of 2009 and only a sample shortly after installation was obtained from this lysimeter. This inability to extract a sample with this lysimeter likely indicates adequate soil moisture is not available at this location. Lysimeters LY-3 and LY-3M were installed in June 2009 and neither of these lysimeters have ever produced a soil moisture sample. LY-4 was installed in December of 2008 and samples from this lysimeter have been obtained each time the vacuum was applied to the lysimeter. Lysimeter LY-4ML was installed in June of 2009 and monthly samples were collected from this lysimeter through December 2009. LY-4ML did not produce a sample in January or February of 2010. Lysimeter LY-4MU was installed in July of 2009 and samples from this lysimeter have been collected each month except December 2009.

Figure 3-16 presents the TDS, sulfate, chloride concentrations for lysimeter LY-4. The TDS and sulfate scales are shown on the left of the graph and the chloride scale is presented on the right. The chloride concentrations are presented with the green triangles. The first 2 to 3 samples from this lysimeter likely show some effect from the water that was used to install the fine flour sand pack around this lysimeter. Subsequent sample results indicate a very gradual increasing trend in concentrations. Figure 3-17 presents the uranium, selenium and molybdenum concentrations for LY-4 lysimeter. These three constituents show in general a fairly steady concentration with time. A typical uranium concentration of 0.06 to 0.07 is significantly less than the concentration of 0.24 mg/l that was present in irrigation water applied in 2009. The selenium concentration in the lysimeter is slightly less than the selenium concentration of the irrigation water. No measurable molybdenum concentrations at a detection limit of 0.03 mg/l.are indicated at these lysimeters. This data indicates that a similar amount of soil moisture has been moving past this lysimeter in the last year and one quarter.

The TDS, sulfate and chloride concentrations for the lysimeter that was placed ten feet below the top of the basalt (LY-4MU) is presented in Figure 3-18. The constituent concentrations in the soil moisture have been gradually declining until the most recent samples, where the concentrations became fairly steady. The first sample from this lysimeter may have been biased by water used in installation, and results should not be given any significance. This data shows a much higher TDS, sulfate and chloride concentrations existing in the soil moisture until the last part of 2009. The concentrations then declined to levels that are fairly similar to the levels in lysimeter LY-4 which is located at a shallower depth at the base of the alluvial material above the basalt. Figure 3-19 presents the uranium concentrations for LY-4MU. This data shows that a gradual declining trend in uranium concentrations was being observed in the soil moisture samples from LY-4MU during the second half of 2009. The November 2009 value from LY-4MU and LY-4ML should not be given much significance because it appears that these two samples may have been switched in November 2009. This plot indicates that the uranium concentrations are not decreasing at the same rate as the major constituents and its concentrations indicate that less soil moisture is passing LY-4MU than LY-4.

Table 3-11. Irrigation Field Lysimeter Completion Information

LYSIMETER NUMBER	LYSIMETER INTERVAL (FT-LSD)	DEPTH TO TOP OF BASALT (FT-LSD)	INTERVAL OF SAND PACK (FT-LSD)	INTERVAL OF BENTONITE SEAL (FT-LSD)
		SECTION 33		
LY1	16-17	17	15-17	0-15
LY2	15-16	16	14-16	0-14
LY3	6-7	7	5-7	0-5
LY3M	30-31	7	29-31	0-29
LY4	14-15	15	13-15	0-13
LY4MU	24-25	14	24-25	0-24
LY4ML	44-45	14	44-45	25-44
LY5	3-4	4	3-4	0-3
		SECTION 28		
LY28-1	15-16	16	14-16	0-14
LY28-1M	20-21	16	19-21	0-19
LY28-2	6-7	7	5-7	0-5
LY28-2M	20-21	14	19-21	0-19
LY28-3	9-10	10	8-10	0-8
		SECTION 34 AND 33 FLOOD		
LY34-1	8-9	DNE	7-9	0-7
LY34-2	10-11	DNE	9-11	0-9
LY34-3	10-11	DNE	9-11	0-9
LY34-4	10-11	26	8-10	0-8
NOTE: DNE= DOES NOT EXIST AT THIS LOCATION				

Table 3-12. Lithology of the Alluvium at the Lysimeters

SECTION 33 SOUTH PIVOT

LY33-1

SAMPLE DEPTH	SOIL TYPE	MOISTURE CONT.	COLOR
0-1	SAND/SILT/CLAY	WET	BROWN
1-2.5	SAND/SILT	WET	BROWN
2.5-4	SAND/CLAY	VERY MOIST	RED
4-5	SAND/CLAY	VERY MOIST	RED
5-7	SAND/CLAY	VERY MOIST	RED
7-9	SAND/CLAY	VERY MOIST	RED
9-11	SAND/CLAY	VERY MOIST	RED
11-12	SAND/CLAY	VERY MOIST	RED
12-12.8	SAND/CLAY	VERY MOIST	RED
12.8-13.8	CLAY	VERY MOIST	BROWN
13.8	BASALT		

SECTION 33 SOUTH PIVOT

LY33-2

SAMPLE DEPTH	SOIL TYPE	MOISTURE CONT.	COLOR
0-2	VERY FINE SAND/SILT/CLAY	MOIST	RED
2-4	VERY FINE SAND/SILT/CLAY	MOIST	RED
4-5.5	VERY FINE SAND	MOIST	RED
5.5-6	VERY FINE SAND	MOIST	RED
6-8	VERY FINE SAND	MOIST	RED
8.10	VERY FINE SAND	MOIST	RED
10-12	VERY FINE SAND	MOIST	RED
12-14	CLAY	MOIST	RED
14-16	CLAY	MOIST	RED
16-16.5	CLAY	MOIST	RED
16.5	BASALT		

SECTION 33 SOUTH PIVOT

LY33-3/M

SAMPLE DEPTH	SOIL TYPE	MOISTURE CONT.	COLOR
0-1	SAND/SILT	DRY	RED
1-1.5	V.F. SAND	MOIST	RED
1.5-2	V.F. SAND	MOIST	RED
2-4	V.F. SAND	MOIST	RED
4-6	V.F. SAND	MOIST	RED
6-6.6	V.F. SAND	MOIST	RED
6.6-35	BASALT		

Table 3-12. Lithology of the Alluvium at the Lysimeters (continued)

SECTION 33 SOUTH PIVOT			
LY33-4/M			
SAMPLE DEPTH	SOIL TYPE	MOISTURE CONT.	COLOR
0-2	V.F. SAND	DRY	RED
2-4	V.F. SAND	DRY	RED
4-6	V.F. SAND	DRY	RED
6-8	V.F. SAND	DRY	RED
8-10	V.F. SAND	DRY	RED
10-12	V.F. SAND	DRY	RED
12-14	V.F. SAND	DRY	RED
14-25	BASALT	MOIST	
25-50	BASALT		

SECTION 33 SOUTH PIVOT			
LY33-5			
SAMPLE DEPTH	SOIL TYPE	MOISTURE CONT.	COLOR
0-1	CLAY	DRY	RED
1-2	CLAY	DAMP	RED
2-3	CLAY	DAMP	RED
3-3.5	CLAY	DAMP	RED
3.5	BASALT		

Table 3-12. Lithology of the Alluvium at the Lysimeters (continued)

SECTION 33/34 FLOOD

LY34-1

SAMPLE DEPTH	SOIL TYPE	MOISTURE CONT.	COLOR
0-1	CLAY/SAND	DAMP	BROWN
1-2	CLAY	DAMP	BROWN
2-3	CLAY/SAND	DAMP	BROWN
3-4	SAND	DAMP	BLACK
4-5	SAND/LITTLE CLAY	MOIST	GREY
5-6	SAND	MOIST	GREY
6-7	SAND/GRAVEL	MOIST	GREY
7-8	CLAY/SAND	MOIST	TAN/GREY
8-9	CLAY/SAND	MOIST	TAN/ORANGE
9-10	SAND	MOIST	TAN/ORANGE

SECTION 33/34 FLOOD

LY34-2

SAMPLE DEPTH	SOIL TYPE	MOISTURE CONT.	COLOR
0-1	CLAY	MOIST	BROWN
1-2	CLAY	MOIST	BROWN
2-3	CLAY/LITTLE SAND	SOME MOISTURE	BROWN
3-4	CLAY/SAND	DRY	LIGHT BROWN
4-5	SAND	DRY	GREY/TAN
5-6	SAND	DRY	GREY
6-7	F. SAND/LITTLE CLAY	SOME MOISTURE	GREY/ORANGE
7-8	F. SAND/LITTLE CLAY	SOME MOISTURE	GREY/ORANGE
8-9	F. SAND/LITTLE CLAY	MOIST	BROWN/ORANGE
9-10	CLAY/FINE SAND	MOIST	BROWN/ORANGE
10-11	CLAY/FINE SAND	MOIST	BROWN
11-12	SAND/LITTLE CLAY	MOIST	BROWN/TAN

SECTION 33/34 FLOOD

LY34-3

SAMPLE DEPTH	SOIL TYPE	MOISTURE CONT.	COLOR
0-1	CLAY	DAMP	BROWN
1-2	CLAY	DAMP	BROWN
2-3	CLAY/SAND	DAMP	DARK BROWN
3-4	FINE SAND	MOIST	BROWN/BLACK
4-5	SAND	DAMP	BROWN/TAN
5-6	SAND	DAMP	TAN
6-7	SAND/CLAY	MOIST	TAN/ORANGE
7-8	CLAY/SAND	MOIST	GREY/ORANGE
8-9	CLAY/SAND	MOIST	BROWN/ORANGE
9-10	CLAY/SAND	MOIST	BROWN/RED
10-11	SAND/GRAVEL	MOIST	TAN/ORANGE

Table 3-12. Lithology of the Alluvium at the Lysimeters (continued)

SECTION 33/34 FLOOD			
LY34-4			
SAMPLE DEPTH	SOIL TYPE	MOISTURE CONT.	COLOR
0-1	CLAY	DRY	BROWN
1-2	CLAY	DRY	BROWN
2-3	CLAY	DRY	BROWN
3-4	CLAY/SAND	DRY	BROWN/GREY
4-5	SAND/CLAY	DRY	LIGHT GREY
5-6	SAND/CLAY	DRY	LIGHT GREY
6-7	SAND	DRY	LIGHT GREY
7-8	SAND	DRY	LIGHT GREY
8-9	CLAY/SAND	SOME MOISTURE	BROWN/LIGHT GREY
9-10	CLAY/SAND	MOIST	BROWN/LIGHT GREY
10-11	CLAY/SAND	MOIST	BROWN/LIGHT GREY
11-12	SAND/CLAY/COARSE	SOME MOISTURE	BROWN/LIGHT GREY
12-13	SAND/CLAY/COARSE	SOME MOISTURE	BROWN

Table 3-12. Lithology of the Alluvium at the Lysimeters (continued)

SECTION 28 NORTH PIVOT

LY28-1

SAMPLE DEPTH	SOIL TYPE	MOISTURE CONT.	COLOR
0-1	SAND	MOIST	LIGHT BROWN
1-2	SAND	MOIST	LIGHT BROWN
2-3	SAND	MOIST	LIGHT BROWN
3-4	SAND	DAMP	LIGHT BROWN
4-5	SAND	DAMP	LIGHT BROWN
5-6	SAND/LITTLE CLAY	DAMP	LIGHT BROWN /ORANGE
6-7	SAND/LITTLE CLAY	MOIST	BROWN
7-8	SAND/LITTLE CLAY	MOIST	BROWN
8-9	SAND/CLAY	MOIST	BROWN
9-10	SAND/CLAY	MOIST	TAN
10-11	CLAY/SAND	MOIST	TAN
11-12	CLAY/LITTLE SAND	DAMP	BROWN/ORANGE
12-13	CLAY/LITTLE SAND	DAMP	BROWN/RED
13-14	CLAY/LITTLE SAND	DAMP	BROWN/TAN
14-15	CLAY	DAMP	TAN
15-15.6	CLAY	DAMP	TAN
15.6	BASALT		

SECTION 28 NORTH PIVOT

LY28-2

SAMPLE DEPTH	SOIL TYPE	MOISTURE CONT.	COLOR
0-1	SAND	MOIST	BROWN
1-2	SAND/CLAY	MOIST	BROWN
2-3	SAND/CLAY	DAMP	LIGHT BROWN
3-4	SAND/CLAY	DAMP	BROWN /ORANGE
4-5	SAND	DAMP	BROWN/RED
5-6	SAND/CLAY	DAMP	BROWN/GREY
6-7	CLAY	DAMP	BROWN /ORANGE
7-7.3	CLAY	DAMP	BROWN /ORANGE
7.3	BASALT		

SECTION 28 NORTH PIVOT

LY28-3

SAMPLE DEPTH	SOIL TYPE	MOISTURE CONT.	COLOR
0-1	F. SAND	MOIST	LIGHT BROWN
1-2	SAND	MOIST	BROWN
2-3	SAND/CLAY	MOIST	BROWN
3-4	SAND/CLAY	DAMP	BROWN
4-5	SAND/CLAY	DAMP	LIGHT BROWN
5-6	SAND/CLAY	DAMP	BROWN/RED
6-7	CLAY/SAND	DAMP	BROWN/TAN
7-8	CLAY	DAMP	BROWN/TAN
8-8.6	CLAY	DAMP	BROWN
8.6	BASALT		

TABLE 3-13. WATER QUALITY ANALYSIS FOR LYSIMETER

Ca THROUGH ION_BAL

Sample Point Name	Date	Lab	Ca (mg/l)	Mg (mg/l)	K (mg/l)	Na (mg/l)	HCO3 (mg/l)	CO3 (mg/l)	Cl (mg/l)	SO4 (mg/l)	TDS (mg/l)	Cond(calc.) (µmhos/cm)	Ion_B (ratio)
LY1	7/22/2009	ENER	---	---	---	---	---	---	121	337	1240	---	---
	8/13/2009	ENER	---	---	---	---	---	---	152	543	1530	---	---
	9/23/2009	ENER	201	118	2.90	61.3	529	< 1.000	168	489	1500	* 2010	0.951
	10/16/2009	ENER	---	---	---	---	---	---	179	508	1550	* 2082	---
	11/13/2009	ENER	189	154	2.80	61.5	488	< 5.00	218	590	1560	* 2270	0.934
	12/18/2009	ENER	230	141	2.60	60.1	467	< 5.00	235	647	1640	* 2338	0.922
	12/30/2009	ENER	286	127	2.40	61.2	430	< 5.00	248	719	1770	* 2075	0.940
	1/31/2010	ENER	---	---	---	---	---	---	266	770	1940	* 2490	---
	2/22/2010	ENER	---	---	---	---	---	---	275	814	1850	* 2560	---
LY2	6/24/2009	ENER	---	---	---	---	---	---	225	654	1720	---	---
LY4	12/4/2008	ENER	---	---	---	---	---	---	269	1430	3180	---	---
	12/5/2008	ENER	---	---	---	---	---	---	310	1700	3730	---	---
	12/8/2008	ENER	---	---	---	---	---	---	317	1720	3700	---	---
	12/11/2008	ENER	---	---	---	---	---	---	336	1850	4100	---	---
	12/12/2008	ENER	---	---	---	---	---	---	337	1860	4070	---	---
	1/7/2009	ENER	---	---	---	---	---	---	330	1870	4120	---	---
	2/18/2009	ENER	702	138	5.20	412	783	< 1.000	353	2050	4150	---	0.984
	3/20/2009	ENER	---	---	---	---	---	---	326	1940	4220	---	---
	5/15/2009	ENER	---	---	---	---	---	---	328	1950	3990	---	---
	6/10/2009	ENER	---	---	---	---	---	---	336	1880	3870	---	---
	6/24/2009	ENER	---	---	---	---	---	---	324	1920	4180	---	---
	7/22/2009	ENER	---	---	---	---	---	---	315	1990	4220	---	---
	8/13/2009	ENER	---	---	---	---	---	---	354	2170	4380	---	---
	9/23/2009	ENER	728	142	3.50	392	842	< 1.000	339	2250	4530	* 4870	0.928
	10/16/2009	ENER	---	---	---	---	---	---	340	2270	4240	* 5040	---
	11/13/2009	ENER	652	147	3.80	430	634	< 5.00	338	2220	4170	* 5100	0.957
	12/18/2009	ENER	757	149	4.00	425	712	< 5.00	343	2260	4170	* 5096	1.00
	12/30/2009	ENER	699	153	4.00	468	837	< 5.00	342	2260	4250	* 3091	0.962
	1/31/2010	ENER	---	---	---	---	---	---	343	2210	4470	* 5030	---

** Signifies Specific Conductivity from HMC*

TABLE 3-13. WATER QUALITY ANALYSIS FOR LYSIMETER (cont.)

Ca THROUGH ION_BAL

Sample Point Name	Date	Lab	Ca (mg/l)	Mg (mg/l)	K (mg/l)	Na (mg/l)	HCO3 (mg/l)	CO3 (mg/l)	Cl (mg/l)	SO4 (mg/l)	TDS (mg/l)	Cond(calc.) (µmhos/cm)	Ion_B (ratio)
LY4	2/22/2010	ENER	---	---	---	---	---	---	331	2160	4140	* 5020	---
LY4ML	6/24/2009	ENER	---	---	---	---	---	---	684	5510	12000	---	---
	7/22/2009	ENER	---	---	---	---	---	---	650	5460	11600	---	---
	8/13/2009	ENER	---	---	---	---	---	---	663	5050	10400	---	---
	9/23/2009	ENER	180	29.6	6.00	2180	1140	< 1.000	629	3460	7340	* 9310	0.981
	10/16/2009	ENER	---	---	---	---	---	---	568	2570	5840	* 7904	---
	11/13/2009	ENER	166	98.2	11.0	2820	1570	72.0	591	3930	7830	* 7250	1.10
	12/18/2009	ENER	113	25.5	5.00	1520	1190	< 5.00	562	1760	4520	* 6490	1.03
LY4MU	7/22/2009	ENER	---	---	---	---	---	---	660	3240	8210	---	---
	8/13/2009	ENER	---	---	---	---	---	---	903	6990	13900	---	---
	9/23/2009	ENER	263	90.0	14.0	3510	1580	< 1.000	712	6130	11700	* 13860	1.000
	10/16/2009	ENER	---	---	---	---	---	---	592	4850	9780	* 12060	---
	11/13/2009	ENER	100.0	31.7	5.00	1790	1030	< 5.00	584	2210	5160	* 10600	1.08
	1/31/2010	ENER	---	---	---	---	---	---	600	2010	5730	* 7950	---
	2/22/2010	ENER	---	---	---	---	---	---	631	1260	4630	* 6740	---
LY28-1	10/16/2009	ENER	---	---	---	---	---	---	101	358	852	* 1286	---
	11/13/2009	ENER	187	74.2	3.80	331	232	< 5.00	174	1040	1850	* 2650	0.980
	12/18/2009	ENER	308	61.7	3.40	345	399	< 5.00	184	1240	2320	* 3130	0.942
	12/30/2009	ENER	298	61.4	3.20	354	378	< 5.00	180	1220	2460	* 3163	0.961
	1/31/2010	ENER	---	---	---	---	---	---	187	1350	2550	* 3250	---
	2/22/2010	ENER	---	---	---	---	---	---	186	1350	2450	* 3250	---
LY28-1M	10/16/2009	ENER	---	---	---	---	---	---	114	84.0	440	* 698	---
LY28-2	10/16/2009	ENER	---	---	---	---	---	---	335	218	954	* 1580	---
LY28-2M	10/16/2009	ENER	---	---	---	---	---	---	158	255	773	* 1176	---
	11/13/2009	ENER	147	60.5	7.80	106	414	6.00	128	304	937	* 1560	1.01
	12/18/2009	ENER	150	54.5	6.90	83.6	447	< 5.00	123	247	980	* 1482	0.980
	12/30/2009	ENER	143	51.5	7.30	80.2	438	< 5.00	120	202	939	* 1544	1.01
	1/31/2010	ENER	---	---	---	---	---	---	115	156	901	* 1320	---

* Signifies Specific Conductivity from HMC

TABLE 3-13. WATER QUALITY ANALYSIS FOR LYSIMETER (cont.)

Ca THROUGH ION_BAL

Sample Point Name	Date	Lab	Ca (mg/l)	Mg (mg/l)	K (mg/l)	Na (mg/l)	HCO3 (mg/l)	CO3 (mg/l)	Cl (mg/l)	SO4 (mg/l)	TDS (mg/l)	Cond(calc.) (µmhos/cm)	Ion_B (ratio)
LY28-2M	2/22/2010	ENER	---	---	---	---	---	---	113	132	756	* 1280	---
LY28-3	10/16/2009	ENER	---	---	---	---	---	---	190	781	1710	* 2476	---
	11/13/2009	ENER	306	96.9	10.00	983	421	< 5.00	290	2300	4110	* 5560	1.05
	12/18/2009	ENER	392	126	11.0	1200	399	< 5.00	318	3030	5220	* 6638	1.05
	12/30/2009	ENER	426	126	11.0	1260	394	< 5.00	339	3260	5720	* 6961	1.03
	1/31/2010	ENER	---	---	---	---	---	---	339	3380	5770	* 7250	---
	2/22/2010	ENER	---	---	---	---	---	---	344	3520	5880	* 7360	---
LY34-1	10/16/2009	ENER	---	---	---	---	---	---	124	239	1060	* 1620	---
	12/30/2009	ENER	292	77.1	2.50	543	667	< 5.00	310	1160	2630	* 3763	1.01
	2/22/2010	ENER	---	---	---	---	---	---	321	1230	2760	* 3940	---
LY34-2	10/16/2009	ENER	---	---	---	---	---	---	96.0	214	590	* 1000	---
	11/13/2009	ENER	175	69.4	12.3	354	457	< 5.00	315	676	1850	* 2950	0.985
	12/18/2009	ENER	231	84.8	10.8	387	372	< 5.00	397	868	1220	* 3413	1.00
	12/30/2009	ENER	192	85.6	11.8	436	567	< 5.00	377	799	2250	* 3339	0.977
	1/31/2010	ENER	---	---	---	---	---	---	467	1020	2500	* 3920	---
	2/22/2010	ENER	---	---	---	---	---	---	514	1190	2960	* 4160	---
LY34-3	10/16/2009	ENER	---	---	---	---	---	---	96.0	102	637	* 920	---
	11/13/2009	ENER	90.9	44.0	4.30	229	488	6.00	128	277	956	* 1660	1.04
	12/18/2009	ENER	178	78.0	3.90	338	648	< 5.00	184	766	1900	* 2760	0.943
	12/30/2009	ENER	234	105	4.70	456	680	< 5.00	211	904	2170	* 3030	1.12
	1/31/2010	ENER	---	---	---	---	---	---	231	983	2410	* 3246	---
	2/22/2010	ENER	---	---	---	---	---	---	244	1030	2370	* 3350	---
LY34-4	10/16/2009	ENER	---	---	---	---	---	---	74.0	322	854	* 1245	---
	11/13/2009	ENER	58.4	18.3	4.20	289	335	6.00	106	384	977	---	1.03
	12/18/2009	ENER	80.3	20.7	3.70	347	329	13.0	130	501	1260	* 1996	1.05
	12/30/2009	ENER	110	22.6	3.40	331	295	8.00	146	608	1470	* 2038	0.998
	1/31/2010	ENER	---	---	---	---	---	---	163	763	1630	* 2540	---

* Signifies Specific Conductivity from HMC

TABLE 3-14. WATER QUALITY ANALYSIS FOR LYSIMETER

pH THROUGH Th-230

Sample Point Name	Date	Lab	pH (std. units)	Unat (mg/l)	Mo (mg/l)	Se (mg/l)	NO3 (mg/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	V (mg/l)	Th230 (pCi/l)
LY1	7/22/2009	ENER	---	0.0420	0.0400	0.0300	1.14	---	---	---	---
	8/13/2009	ENER	---	0.0878	< 0.0300	0.0500	1.10	---	---	---	---
	9/23/2009	ENER	7.77	0.0519	0.0300	0.0350	1.90	---	---	---	---
	10/16/2009	ENER	---	0.0540	< 0.0300	0.0400	1.70	---	---	---	---
	11/13/2009	ENER	8.17	0.0487	< 0.0300	0.0390	2.80	---	---	---	---
	12/18/2009	ENER	7.81	0.0656	< 0.0300	0.0470	2.20	---	---	---	---
	12/30/2009	ENER	7.80	0.0585	< 0.0300	0.0790	1.80	---	---	---	---
	1/31/2010	ENER	---	0.0506	< 0.0300	0.0720	1.60	---	---	---	---
	2/22/2010	ENER	---	0.0506	< 0.0300	0.0820	1.50	---	---	---	---
LY2	6/24/2009	ENER	---	0.0406	0.0400	0.0140	3.31	---	---	---	---
LY4	12/4/2008	ENER	---	0.0566	< 0.0300	0.0400	1.20	---	---	---	---
	12/5/2008	ENER	---	0.0624	< 0.0300	0.0600	0.900	---	---	---	---
	12/8/2008	ENER	---	0.0715	0.0400	0.0460	0.600	---	---	---	---
	12/11/2008	ENER	---	0.0644	< 0.0300	0.0450	0.660	---	---	---	---
	12/12/2008	ENER	---	0.0641	< 0.0300	0.0440	0.650	---	---	---	---
	1/7/2009	ENER	---	0.0813	< 0.0300	0.0410	0.870	---	---	---	---
	2/18/2009	ENER	7.44	0.0655	< 0.0300	0.0410	1.40	---	---	---	---
	3/20/2009	ENER	---	0.0732	< 0.0300	0.0430	1.72	---	---	---	---
	5/15/2009	ENER	---	0.0611	< 0.0300	0.0380	1.46	---	---	---	---
	6/10/2009	ENER	---	0.0630	< 0.0300	0.0550	0.800	---	---	---	---
	6/24/2009	ENER	---	0.0621	< 0.0300	0.0500	0.560	---	---	---	---
	7/22/2009	ENER	---	0.0636	< 0.0300	0.0430	0.460	---	---	---	---
	8/13/2009	ENER	---	0.0718	< 0.0300	0.0400	0.600	---	---	---	---
	9/23/2009	ENER	7.29	0.0664	< 0.0300	0.0340	0.500	---	---	---	---
	10/16/2009	ENER	---	0.0701	< 0.0300	0.0310	0.500	---	---	---	---
	11/13/2009	ENER	7.84	0.0652	< 0.0300	0.0330	0.600	---	---	---	---
	12/18/2009	ENER	7.58	0.0651	< 0.0300	0.0310	0.500	---	---	---	---
	12/30/2009	ENER	7.60	0.0643	< 0.0300	0.0340	0.600	---	---	---	---
	1/31/2010	ENER	---	0.0702	< 0.0300	0.0380	0.500	---	---	---	---

TABLE 3-14. WATER QUALITY ANALYSIS FOR LYSIMETER (cont.)

pH THROUGH Th-230

Sample Point Name	Date	Lab	pH (std. units)	Unat (mg/l)	Mo (mg/l)	Se (mg/l)	NO3 (mg/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	V (mg/l)	Th230 (pCi/l)
LY4	2/22/2010	ENER	---	0.0732	< 0.0300	0.0350	0.500	---	---	---	---
LY4ML	6/24/2009	ENER	---	0.358	0.110	<. 0.0050	10.00	---	---	---	---
	7/22/2009	ENER	---	0.552	0.0900	0.0100	0.0200	---	---	---	---
	8/13/2009	ENER	---	0.421	0.0600	< 0.0050	< 0.100	---	---	---	---
	9/23/2009	ENER	7.76	0.268	0.0400	0.0100	< 0.100	---	---	---	---
	10/16/2009	ENER	---	0.244	0.0400	0.0060	< 0.100	---	---	---	---
	11/13/2009	ENER	8.35	0.508	0.0900	0.0110	< 0.100	---	---	---	---
	12/18/2009	ENER	7.55	0.214	< 0.0300	0.0050	< 0.100	---	---	---	---
LY4MU	7/22/2009	ENER	---	0.261	0.140	0.0100	0.0200	---	---	---	---
	8/13/2009	ENER	---	0.596	0.160	0.0060	< 0.100	---	---	---	---
	9/23/2009	ENER	7.68	0.563	0.120	0.0090	< 0.100	---	---	---	---
	10/16/2009	ENER	---	0.557	0.100	0.0090	< 0.100	---	---	---	---
	11/13/2009	ENER	8.04	0.212	0.0300	0.0090	< 0.100	---	---	---	---
	1/31/2010	ENER	---	0.504	0.0500	0.0100	< 0.100	---	---	---	---
	2/22/2010	ENER	---	0.516	0.0500	0.0100	0.800	---	---	---	---
LY28-1	10/16/2009	ENER	---	0.0224	0.0500	0.0100	2.60	---	---	---	---
	11/13/2009	ENER	8.19	0.0489	< 0.0300	0.0250	4.40	---	---	---	---
	12/18/2009	ENER	7.77	0.131	< 0.0300	0.0310	0.900	---	---	---	---
	12/30/2009	ENER	7.83	0.161	< 0.0300	0.0420	6.60	---	---	---	---
	1/31/2010	ENER	---	0.149	< 0.0300	0.0370	6.70	---	---	---	---
	2/22/2010	ENER	---	0.161	< 0.0300	0.0380	6.10	---	---	---	---
LY28-1M	10/16/2009	ENER	---	0.0009	0.160	0.0070	1.40	---	---	---	---
LY28-2	10/16/2009	ENER	---	0.0031	0.0500	0.0140	1.10	---	---	---	---
LY28-2M	10/16/2009	ENER	---	0.0044	0.160	0.0110	1.80	---	---	---	---
	11/13/2009	ENER	8.15	0.0327	0.120	< 0.0050	2.30	---	---	---	---
	12/18/2009	ENER	7.73	0.0567	0.100	< 0.0050	5.90	---	---	---	---
	12/30/2009	ENER	7.87	0.0641	0.0900	< 0.0050	6.30	---	---	---	---
	1/31/2010	ENER	---	0.0489	0.0900	< 0.0050	6.40	---	---	---	---

TABLE 3-14. WATER QUALITY ANALYSIS FOR LYSIMETER (cont.)

pH THROUGH Th-230

Sample Point Name	Date	Lab	pH (std. units)	Unat (mg/l)	Mo (mg/l)	Se (mg/l)	NO3 (mg/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	V (mg/l)	Th230 (pCi/l)
LY28-2M	2/22/2010	ENER	---	0.0558	0.0900	0.0060	7.10	---	---	---	---
LY28-3	10/16/2009	ENER	---	0.0875	0.100	0.0230	21.0	---	---	---	---
	11/13/2009	ENER	8.11	0.487	0.100	0.0500	43.5	---	---	---	---
	12/18/2009	ENER	7.87	0.553	< 0.0300	0.0420	53.7	---	---	---	---
	12/30/2009	ENER	7.90	0.628	< 0.0300	0.0480	55.3	---	---	---	---
	1/31/2010	ENER	---	0.694	< 0.0300	0.0490	60.0	---	---	---	---
	2/22/2010	ENER	---	0.758	< 0.0300	0.0520	63.7	---	---	---	---
LY34-1	10/16/2009	ENER	---	0.0837	0.0800	0.0090	2.80	---	---	---	---
	12/30/2009	ENER	7.80	0.375	< 0.0300	0.0540	10.1	---	---	---	---
	2/22/2010	ENER	---	0.368	0.0400	0.0470	11.7	---	---	---	---
LY34-2	10/16/2009	ENER	---	0.0067	0.140	0.0060	< 0.100	---	---	---	---
	11/13/2009	ENER	8.34	0.0695	0.110	0.0150	2.40	---	---	---	---
	12/18/2009	ENER	7.94	0.0871	0.0800	0.0190	7.50	---	---	---	---
	12/30/2009	ENER	7.98	0.0876	0.100	0.0210	8.30	---	---	---	---
	1/31/2010	ENER	---	0.0962	0.0800	0.0300	12.5	---	---	---	---
	2/22/2010	ENER	---	0.118	0.0900	0.0330	4.40	---	---	---	---
LY34-3	10/16/2009	ENER	---	0.0051	0.130	0.0070	1.50	---	---	---	---
	11/13/2009	ENER	8.24	0.0749	0.210	0.0250	3.60	---	---	---	---
	12/18/2009	ENER	7.91	0.239	0.0800	0.0420	7.10	---	---	---	---
	12/30/2009	ENER	7.92	0.349	0.0600	0.0740	7.60	---	---	---	---
	1/31/2010	ENER	---	0.269	0.0700	0.0600	9.20	---	---	---	---
	2/22/2010	ENER	---	0.292	0.0700	0.0630	0.500	---	---	---	---
LY34-4	10/16/2009	ENER	---	0.0261	0.280	0.0050	1.40	---	---	---	---
	11/13/2009	ENER	8.38	0.0613	0.310	0.0110	4.20	---	---	---	---
	12/18/2009	ENER	8.34	0.0714	0.280	0.0130	12.4	---	---	---	---
	12/30/2009	ENER	8.36	0.0671	0.230	0.0180	15.8	---	---	---	---
	1/31/2010	ENER	---	0.0574	0.270	0.0220	22.9	---	---	---	---

The selenium concentration in Figure 3-19 have been steady while the molybdenum concentration decreased to a low value in late 2009.

Figure 3-20 and 3-21 present the concentration plots for the lower lysimeter LY-4ML. These plots show that in general the concentrations are decreasing with time. Again, the November 2009 value should be viewed with skepticism because the samples from LY-4ML and LY-4MU are thought to have been switch based on the concentration results. The TDS, sulfate and chloride concentrations are each generally declining with time. This indicates that the rate of soil moisture water entering this area is increasing. The load (concentrations times flow rate) of major constituents is expected to be fairly constant through the soil profile. The concentrations in the soil moisture would be expected to increase when the rate of water passing through an interval decreases as a result of the crop using more water. The alfalfa that existed in this field prior to 2008 likely used more water than the present vegetation that consists primarily of grass, and therefore, the concentrations are probably declining due to a larger rate of water moving in the soil profile.

Lysimeter LY-1, which is installed 16 feet below the land surface, has been monitored monthly and has consistently produced a sample. Figure 3-22 shows the TDS, sulfate and chloride concentrations for samples from LY-1. These concentrations have generally been gradually increasing during the last half of 2009 and early 2010, possibly arising from a decrease in the rate of flow. The crops in 2009 may have been using more water in this area than they had the previous year. Figure 3-23 presents the uranium, selenium and molybdenum concentrations for LY-1, which shows an overall low concentration in each of these constituents with a small increase in selenium concentrations in the last three samples.

3.4.2 Section 34

Four lysimeters have been placed in the clay soils in Section 34 and 33 flood areas. Lysimeters LY34-1, LY34-2 and LY34-3 are in the Section 34 flood while LY34-4 is in the Section 33 flood area. Figure 3-3 shows the location of these lysimeters. Three lysimeters were installed in the Section 34 area and were completed at intervals 8-10 feet below the land surface. The completion interval for the 34-4 lysimeter was 10-11 feet (see Table 3-11 for completion details). The Section 34 lysimeters were installed in October 2009. LY-34-1 produced a sample in October and November of 2009 and February of 2010. Lysimeters LY34-2 and LY34-3 have produced samples for each month. LY34-4 produced a sample for each month until February of 2010.

Figure 3-24 presents TDS, sulfate and chloride concentrations for lysimeter LY34-2. These concentrations generally show an increasing trend with time. The uranium, selenium and molybdenum concentrations for lysimeter LY34-2 are presented in Figure 3-25 which shows and increasing trend for uranium and selenium but a decreasing trend for molybdenum. This data indicates that less soil moisture is moving past LY34-2 during the last four months. The results from lysimeters LY34-3 are fairly similar (see Figures 3-26 and 3-27). The TDS, sulfate, chloride, uranium and selenium concentrations show the increasing trend while the molybdenum concentration shows a decreasing trend. Less soil moisture is likely moving past LY34-3 during the last few months. Figures 3-28 and 3-29 present the concentration plots for lysimeter LY34-4 which is located in the Section 33 Flood Area. This data shows increasing trends for TDS, sulfate and chloride concentrations and a fairly steady concentration for uranium, selenium, and molybdenum.

3.4.3 Section 28

Lysimeters were installed at three locations in the Section 28 Center Pivot area. Table 3-11 shows that five lysimeters were installed at these three locations. In addition to the alluvial lysimeters at the LY28-1 and LY28-2 locations, there is also a basalt lysimeter. The completion details of these lysimeters are presented in Table 3-11.

Tables 3-13 and 3-14 presents the water quality results obtained from the LY28 series of lysimeters. Only one sample was obtained from the basalt lysimeter LY28-1M. Monthly samples have been obtained from lysimeter LY28-1. Only an initial sample was collected from LY28-2 which indicates that there in not adequate soil moisture at this location to consistently produce a sample. Monthly samples have been obtained from the basalt lysimeter at LY28-2M and monthly samples have also been collected from lysimeter LY28-3.

The time concentration plots for lysimeter LY28-1 are presented in Figure 3-30 and 3-31. The TDS, sulfate and chloride concentrations each are gradually increasing with time and this lysimeter indicates that a smaller rate of water is likely migrating through the soil profile in this area than has previously been the case. The uranium and selenium concentrations show a similar pattern with an increase in concentration with time. The molybdenum concentrations have been low in lysimeter LY28-1. The monitoring data for lysimeter LY28-2M is presented in Figures 3-32 and 3-33. Chloride and sulfate concentrations in this lysimeter are decreasing with time while the TDS concentration has stayed fairly steady after the first sample. The uranium concentrations generally have shown a gradual increase in concentration while the selenium concentrations have stayed very small. A general decrease has been observed in the molybdenum concentrations in this basalt lysimeter location. A small amount of uranium movement that lags other constituents may be occurring at LY28-2M.

The soil moisture sample concentrations for lysimeter LY28-3 show an increasing trend for the major constituents of TDS, sulfate and chloride (see Figure 3-34). An increasing trend is also observed for uranium in this soil moisture (see Figure 3-35). This data indicates that less soil moisture has moved past this lysimeter in the last four months.

3.5 Soil Health

Soil health as related to irrigated crop production is generally monitored as a function of the salt loading of the soils and potential adverse effects on soils due to excessive sodium in the irrigation water and in the soils. In order to understand the possible affects of these parameters on the irrigated soils, it is desirable to know other characteristics of the soil including soil particle size and texture, natural salt and sodium levels, bulk density, clay mineralogy, infiltration rates, hydraulic conductivity, and depth to bedrock. The following sections describe the soil conditions at the Grants irrigation sites and the affects of irrigation since 2000 on the soil health.

3.5.1 Irrigated Soil Physical Characteristics

Prior to establishment of the irrigated areas, a detailed assessment of the potential soils to be irrigated was conducted in 1998. Originally, SCS (now NRCS) soil mapping was used to establish baseline conditions at the site and then backhoe trenching was utilized to refine the characteristics of the irrigation areas. Following is a general description of those soils prior to irrigation.

For the Section 33 Center Pivot area, the majority of the area is comprised of the Mespun sandy loam to sandy soil series with minor acreages of Sparank sandy clay loam to clay loam and the Aparejo silty clay loam series. Following the backhoe examination, it was determined that the soils located under the pivot were comprised largely of the Mespun series and another sandy series referred to as the Glenberg, or Glenberg- variant soil series. Both soils have sandy loam to loam surface textures. The Mespun soil developed in wind blown sands and the surface sandy loam layer is shallow, generally 10 inches or less. Below 10 inches are high permeability stratified fine to medium sands. The Glenberg soils developed in fluvial deposits and the sandy loam to loam surface layer is up to 24 inches thick. Below 24 inches are highly permeable stratified fine to medium sands. The Glenberg soils generally have slopes of 1% or less and the Mespun soil slopes range from 1% to 6%.

Irrigation suitability of these soils was based on NRCS suitability ratings, field investigations including backhoe trench analyses and laboratory analyses, and double ring infiltrometer tests. These soils are generally unsuitable for flood irrigation due to their sandy nature, rolling topography, and extremely rapid infiltration rates. While these soils were considered by NRCS to be marginal for sprinkler irrigation due to their droughty nature and rapid infiltration rate, with proper irrigation application rates and pivot cycles, these soils were determined to be acceptable for the establishment of a center pivot irrigation system in Section 33.

The Section 28 Center Pivot was initially established as a 60 acre system and later expanded to cover 100 acres. The NRCS mapped this area as the Glenberg soil series with San Mateo soils occurring in swale areas. The backhoe examination confirmed the NRCS mapping and the majority of the area under the Section 28 center pivot is comprised of Glenberg sandy loam soils. This soil generally has sandy loam surface and subsurface soils ranging up to 24 inches in depth. Below 24 inches are stratified medium and fine sands. Swales are dominated by the San Mateo sandy clay loam soils consisting of loam to sandy clay loam surface and subsurface textures up to 28 inches deep. Below 28 inches are fine to medium stratified sands.

The NRCS rated the sprinkler irrigation suitability of the Glenberg soil as somewhat limited due to droughty condition and relatively low water holding capacities. However, these soils were determined to be adequate to support sprinkler irrigation in Section 28 as long as proper irrigation application rates and cycles were maintained.

The Section 34 flood irrigated soils were mapped by the NRCS with the majority of these soils described as the Sparank clay loam soils. These soils are characterized as having clay loam surface horizons with clay loam to clay subsurface horizons ranging up to 24 to 36 inches deep. Generally, stratified clay loam, sandy clay loam, and silty clay loam soils are found below these depths. Field examinations, including backhoe trenches, indicate that the northern one third of these soils in the flood irrigation area are the San Mateo soils with sandy clay loam to clay loam surface textures and clay loam sub-surface textures to 24 inch depths. Below 24 inches in these soils are stratified fine and medium sands. The remaining soils were determined to be the Sparank series as described by the NRCS. However, these soils were found to have stratified fine and medium sands located at depths of about 36 inches.

The NRCS rated these soils as somewhat limited for flood irrigation due to very slow percolation or infiltration rates. However, these soils had been flood irrigated historically since the 1950's. The biggest factor in flood irrigation of these soils was excessive cracking if they were allowed to dry. Extensive laser leveling was conducted on the Section 34 flood area prior to irrigation in 2000 and the site was seeded for alfalfa forage production. Irrigation was accomplished through gated pipe delivery for flood irrigation.

The Section 33 flood irrigated soils were mapped by the NRCS as the Sparank soils. These soils are characterized as having clay loam surface horizons and clay loam to clay subsurface horizons to depths of 72 inches. Field investigations for these soils showed that the southwest portion of the Section 33 flood irrigated soils were comprised of the Aparejo clay loam soil series, sandy substratum phase. The remainder of the soil was the Sparank clay loam soils as mapped by NRCS. Like some of the Section 34 flood irrigated soils, these soils had fine to medium sands at depths of 24 to 36 inches. As with the Section 34 flood irrigated area, these soils were historically flood irrigated in the 1950's and 1960's. These soils were seeded to alfalfa and irrigated in 2004, 2005 and 2008. A portion of the area was tilled and seeded to triticale in the fall of 2008.

3.5.2 Soil Salt and Sodium Relationships with Irrigation Water Quality

Measurement of soil chemistry, particularly sodium levels and salt (Electrical Conductivity - EC) levels provides an understanding of the amount of soluble constituents that remain in the soil after an irrigation season. In the case of soil salinity, it is desirable to leach salts through the root zone to prevent crop toxicity from occurring. The concentration of sodium and salt in the site irrigation water has been examined to assess their affect on the irrigated soils.

Sodium affects soil physical properties by causing soil clays to expand and disperse. The expansion of clay results in a significant decrease in soil permeability which in turn reduces the fraction of irrigation or meteoric water that can move through the soil profile. Because potential adverse affects of sodium on soils are related to the amount of exchangeable sodium that can adsorb on the soil cation exchange complex, measurement of the exchangeable sodium and cation exchange capacity provides a valuable tool for predicting and monitoring potential adverse affects on soil health due to sodium in the irrigation water.

Since soil clays are directly affected by sodium, it stands to reason that sandy center pivot soils with only a very small clay fraction are not generally affected by the presence of high sodium levels. Conversely, heavy clay irrigated soils have a higher risk for being adversely affected by higher sodium levels. In addition, the salinity concentrations in the soil and irrigation water will alter how significant the effect of sodium is on the soil clays. Salts tend to flocculate clays, reducing the amount of expansion. When salts are significant, soil permeability may not be affected by higher concentrations of the sodium.

Historically, since ESP and CEC are more difficult and expensive to analyze, scientists developed an empirical relationship comparing soluble sodium to exchangeable sodium (U.S.D.A. Handbook 60) assuming the soils are in chemical equilibrium. The sodium adsorption ratio (SAR) compares soluble sodium concentrations to the concentration of soluble calcium and magnesium in the soil. In soils that were in chemical equilibrium, a SAR of 12 was comparable to an ESP of 15. For irrigated soils like those at the Grants irrigation sites, the soil may not be in chemical equilibrium and the historical comparison of SAR to ESP may not be as accurate. However, SAR is still a useful parameter to examine for potential sodium risks to soil health. Irrigation wells have been analyzed for sodium and salinity concentrations. This data is useful in assessing the current and potential adverse risk to the soil associated with the irrigation water. The mean SAR of irrigation water from these wells was 5.2 and the SAR range was 4.2 to 6.1. The mean electrical conductivity (EC) of water from these wells was 2690 umhos/cm and the range was 2205 to 3440 umhos/cm.

As described previously, the concentration of salts in irrigation water can be useful to counteract the possible adverse effects of sodium on expanding soil clays. Table B-1 in Appendix B shows the level of exchangeable sodium, at varying clay contents, which would cause a 25% reduction in soil hydraulic conductivity at three concentrations of salt in the irrigation water. Without considering all other factors that ameliorate the effects of sodium on soils, an ESP of 15% (SAR 12) was historically considered risky for successful irrigation of all soils.

For the Section 33 and 28 center pivot soils, the average clay content is approximately 15%. Referring to Table B-1, the estimated critical ESP of these soils would be 25%, 30%, and 40% for irrigation water with salt concentrations of 1000 umhos/cm, 2000 umhos/cm, and 4000 umhos/cm, respectively. Essentially, this data confirms that, because of low clay content, little risk exists for irrigation of these soils in relation to adverse affects due to sodium.

For the Section 33 and 34 flood irrigated areas, the average clay content is 35 to 40%. Referring to Table B-1, the critical ESP for these soils would be 15%, 21%, and 28% for the 1000 umhos/cm, 2000 umhos/cm, and 4000 umhos/cm salt levels, respectively. In relation to the average site irrigation water electrical conductivity of 2690 umhos/cm, adverse soil problems associated with sodium would not likely occur as long as the ESP of the soils stayed below about 25% (SAR < 20).

Table B-2 in Appendix B shows the soil health risk when the sodium level (SAR) of the irrigation water is included with the salinity concentration effects. The table summarizes the associated risk for all soil textural families ranging from sandy (center pivot irrigation) soils to fine loamy to fine clay (flood irrigation) soils. The average SAR of the irrigation water is 5.2 and, when coupled with the 2690 umhos/cm salinity levels, the resulting irrigation water quality class is a C4S1. For the sandy center pivot irrigated soils, the soil health risk associated with irrigation of the C4S1 water will be very low to low in relation to possible reductions in permeability and hydraulic conductivity. For the fine loamy to clayey flood irrigated soils, the soil health risk is low.

While sodium effects are primarily a physical problem in soils, high salinity levels could cause problems related to salt concentration crop toxicity.. In the absence of information for salt tolerance for a specific crop, a soil salinity level in excess of 2200 umhos/cm may be considered a level of concern for toxicity to plants. However, individual crops respond differently to salinity levels. The primary crops grown at the site are alfalfa and grass. Both of these crops are adapted to the growing conditions for the Grants area and are moderately to strongly salt tolerant. Soil salt levels around 4500 umhos/cm may prevent some germination of these crops. However, once germinated they are strongly salt tolerant and can withstand salt concentrations in excess of 4500 umhos/cm. Regardless of the individual crop salt tolerance, it is important for all crops and overall soil health to leach a portion of the salts below the root zone to prevent the buildup of salts over time.

3.5.3 Effects of Current Irrigation Practices on Soil Health

ESP is not generally available in the HMC irrigated soil database; therefore, any discussions in this report on possible sodium soil changes will focus on the use of SAR. Table 3-4 provides a summary of the soluble sodium, calcium, magnesium, SAR, and EC annual monitoring data for both background and irrigated soils for the life of the irrigation project.

For the Section 33 center pivot area, the SAR for background soil samples before irrigation was approximately 1.0. After the 2009 irrigation season, the reported SAR under the center pivot for the 1 foot, 2 foot, and 3 foot sampling depths was 6.71, 8.53, and 7.85, respectively. While these values appear to have increased significantly over the past ten years, these SAR values more appropriately reflect the migration of the soluble constituents in the irrigation water. And, as stated before, sodium at these levels will have limited adverse affects on the sandy center pivot soils.

The background electrical conductivity levels for Section 33 ranged from 200 to 1740 umhos/cm. After the 2009 season, the average EC for the three sampling depths for all years was 3742, 3906, and 4271 umhos/cm. Keep in mind that the EC of the irrigation water can range up to 3400 umhos/cm and while the EC has increased over time, the salinity levels are reflective of the migration of the irrigation water constituents and are lower than levels that will create concern over potential toxicity for the crops that have been grown.

For Section 28, the average background SAR in the soil for all depths is 1.21. After the 2009 irrigation season, the average SAR in the 3 foot sampling depth was 4.85 and the SAR for the 1 foot depth, 2 foot depth, and 3 foot depth was 4.87, 3.97, and 5.72, respectively. Again, the apparent increase in SAR is indicative of the movement of the irrigation water through the soil profile. Evidence of this process is that the SAR increased immediately after the first irrigation season. Again, the sodium has little effect on the permeability of sandy soils.

The average EC of the 3 foot soil profile for Section 28 is 624 umhos/cm and the individual 1 foot depth, 2 foot depth, and 3 foot depth averages for all years was 704, 802, and 814 umhos/cm, respectively. In 2009 the average EC was 3796 umhos/cm and the 1 foot, 2 foot, and 3 foot depths were 3690, 3570, and 4130 umhos/cm, respectively. Again, these increases occurred immediately after the first irrigation and are reflective of the irrigation water quality and mass water balance. All EC levels are lower than levels expected to cause salt toxicity problems in the site crops.

For the Section 34 flood area the average background SAR for the 3 foot root zone is 4.04 and the average for all years of the individual 1 foot, 2 foot, and 3 foot sampling depths was 4.11, 4.23, and 3.77, respectively. Following the 2009 irrigation season, the average SAR level for all depths was 7.57 and the 1 foot, 2 foot, and 3 foot depths were 8.03, 7.85, and 6.83, respectively. Review of the yearly data shows that the SAR, reflective of the soluble sodium, is variable from year to year. That is, depending on the amount of leaching through the soil profile, the SAR goes up or down on a yearly basis. Based on SAR numbers and irrigation infiltration observations, these soils are not showing any significant reduction in soil permeability or hydraulic conductivity. These findings are consistent with the predictions described in Appendix B-2 for the C4S1 water quality class.

The average background EC of the 3 foot sampling depth for Section 34 is 2696 umhos/cm and for the 1 foot, 2 foot, and 3 foot depths the EC was 1777, 2980, and 3330 umhos/cm, respectively. After the 2009 irrigation season, the average EC for the 3 foot sampling depth was 4640 umhos/cm and for the 1 foot, 2 foot, and 3 foot depths, the ECs were 4640, 4620, and 4660 umhos/cm, respectively. This area was irrigated before the HMC program began, and the background salt levels are indicative of that previous irrigation. However, review of the yearly EC data as shown in Table 7 shows that the salts concentrations can vary up or down on a yearly basis and are directly related to the amount of yearly leaching of the salts through the root zone. While these EC levels may be marginal for some crops, particularly some row crops, they are suitable for the hay and grass crops grown on the site.

For the Section 33 flood irrigated soils, the average background SAR was 1.68 and the average for all years of the individual 1 foot, 2 foot, and 3 foot sampling depths was 0.72, 2.13, and 2.20, respectively. At the end of the 2009 irrigation season, the average SAR for all depths was 3.31 and the 1 foot, 2 foot, and 3 foot SAR values were 3.15, 3.49, and 3.29, respectively. As with the other irrigated areas, the increase in SAR was immediately reflected in the first year and the values move up or down annual depending in leaching. The SAR value after five years of irrigation is still well below levels of concern for reducing hydraulic conductivities and permeability.

The average background EC for the 3 foot sample depth for Section 33 is 681 umhos/cm and the background EC for the 1 foot, 2 foot, and 3 foot individual sample depths is 464, 651, and 930 umhos/cm, respectively. At the end of the 2009 irrigation season, the average 3 foot EC was 641 umhos and the individual 1 foot, 2 foot, and 3 foot depth EC was 493, 727, and 705 umhos/cm, respectively. Significant leaching of salts occurred on the newly seeded area that had little evapotranspiration for the season. These EC levels are well within the acceptable toxicity range for the crops grown at the site. As noted earlier, it is important to leach salts from the root zone to prevent buildup of salts to the level that they affect crop production. The combined irrigation well water is routinely analyzed for chloride, a major component of soil salts. By measuring the applied irrigation water chloride and comparing that data to the mass soil chloride concentrations, the net chloride passing through the root zone over time can be determined on a mass balance basis. This measurement is directly related to salt concentrations and allows for a direct assessment of the yearly and cumulative leaching of salts through the root zone.

Detailed tabular data on chloride leaching for all sites is provided in Table 3-4. For Section 33 center pivot soils, a net 84 percent of all applied chloride for all the years of irrigation has been leached through the soils. Evaluation of the data shows that actual leaching may be variable and in one year, no leaching occurred. Routine irrigation practices are sufficient to allow for leaching of salts from the sandy soils.

For the Section 28 center pivot site, 87 percent of the applied chloride has passed through the root zone for all of the years of irrigation. As with the Section 33 irrigation, salts are easily leached below the root zone.

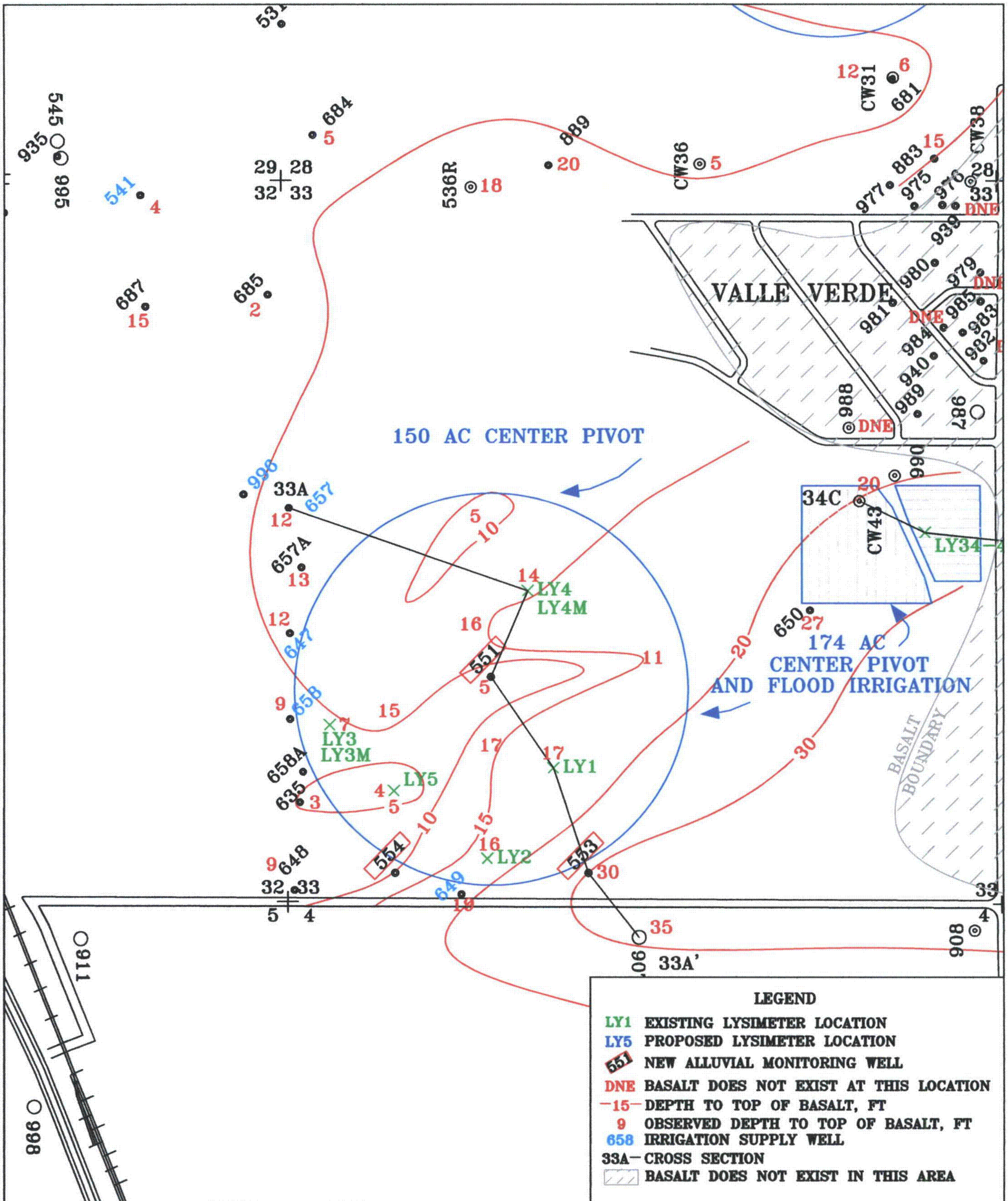
For the Section 34 flood irrigated soils, the mass balance of applied chloride versus stored soil chloride indicates that 70 percent of the chloride has been leached through the root zone or did not enter the soil. Since this is a mass balance calculation using total applied chloride, the percent leaching is likely distorted because the calculation has not been corrected for chloride not entering the soil profile due to tail water losses. If one assumes that tail water accounts for 25 percent of the applied water only 52 percent of the chloride was leached. This data is reflected in the annual residual concentration of salts (EC) in the Section 34 flood irrigated soils. The very heavy clay soils make it more difficult to maintain salt leaching and prevent salt toxicities over time. However, review of the soil EC data on a yearly basis shows that sufficient salts are leached over time to avoid diminished soil health due to salt toxicity.

While EC levels are lower in the Section 33 flood irrigation area than in the Section 34 area, the relationship is very similar. Note that the differences are related primarily to the lower background EC levels at the start of irrigation. When accounting for chloride lost due to tail water, the net leaching level of the chloride in Section 33 flooded soils is 48%. As in Section 34, the leaching has been sufficient so far to prevent the occurrence of noticeable salt toxicity.

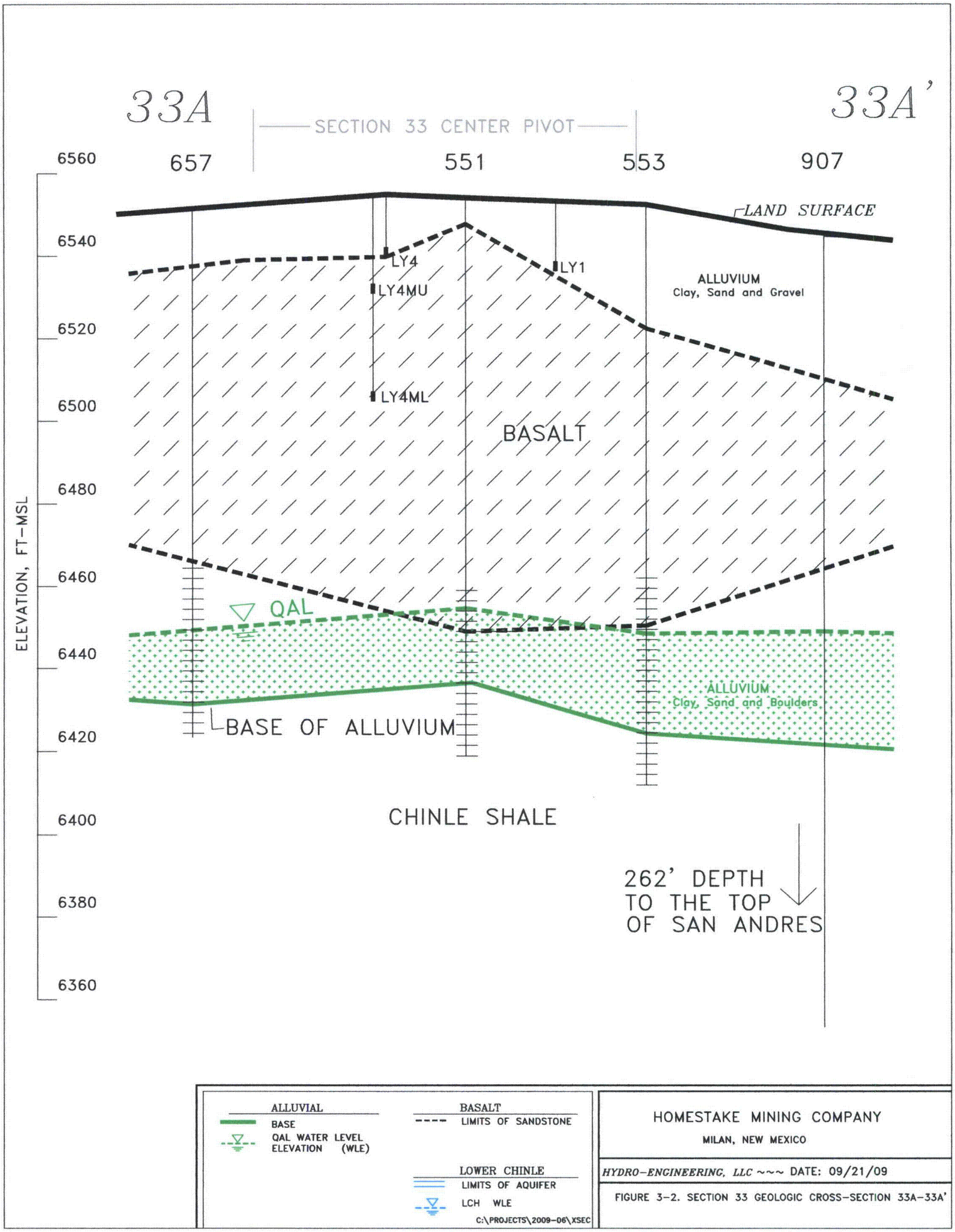
3.5.4 Conclusions

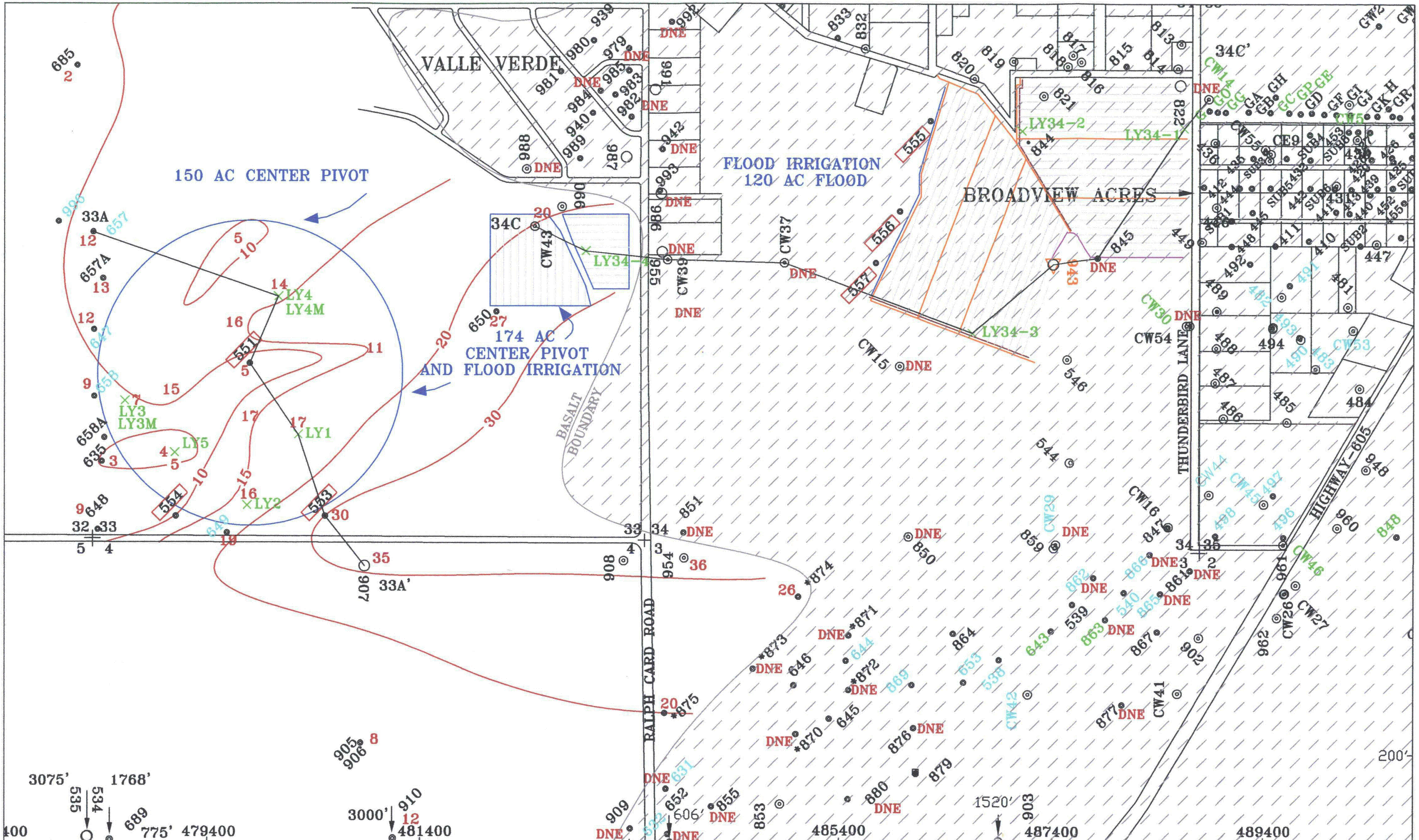
Soil Health associated with irrigation programs is generally centered around the affects of excess sodium on soil physical properties and on salt buildup to potentially toxic levels for vegetation or crops. The potential risk that these elements pose is much different for sandy soils than for heavier clay or clay loam soils. The low clay content of sandy soils allows for much higher sodium concentrations because sodium has no adverse affect on sand particles. The irrigation water quality for the site wells can be classified as C4S1 water with SAR levels less than 10 and EC levels greater than 2250 umhos/cm. The average SAR for the site water is 5.2 and the average EC is 2690 umhos/cm. This water quality is rated as very low to low sodium risk on sandy soils and low sodium risk on fine loamy soils, due to the flocculation effects that salts have on soil clays.

While salt concentrations are important to counteract the affect of higher sodium levels on soil clays, the salts may have a toxic affect on vegetation. For the alfalfa and grasses grown at the site, the soil salt toxicity level of concern is in excess of 4500 umhos/cm. Leaching of salts at all sprinkler and flood irrigated sites has prevented the buildup of salts to toxic levels. Review of the annual data indicates that the soil health, as related to salts and sodium, has not been adversely affected over the years.



SCALE: 1" = 900'	FIGURE 3-1. SECTION 33 DEPTH TO TOP OF BASALT, LOCATION OF PROPOSED LYSIMETERS, ADDITIONAL ALLUVIAL MONITORING WELLS AND CROSS SECTION.	HOMESTAKE MINING COMPANY GRANTS, NEW MEXICO
C:\PROJECTS\2009-06\BASALT		
DATE: 10/23/09		

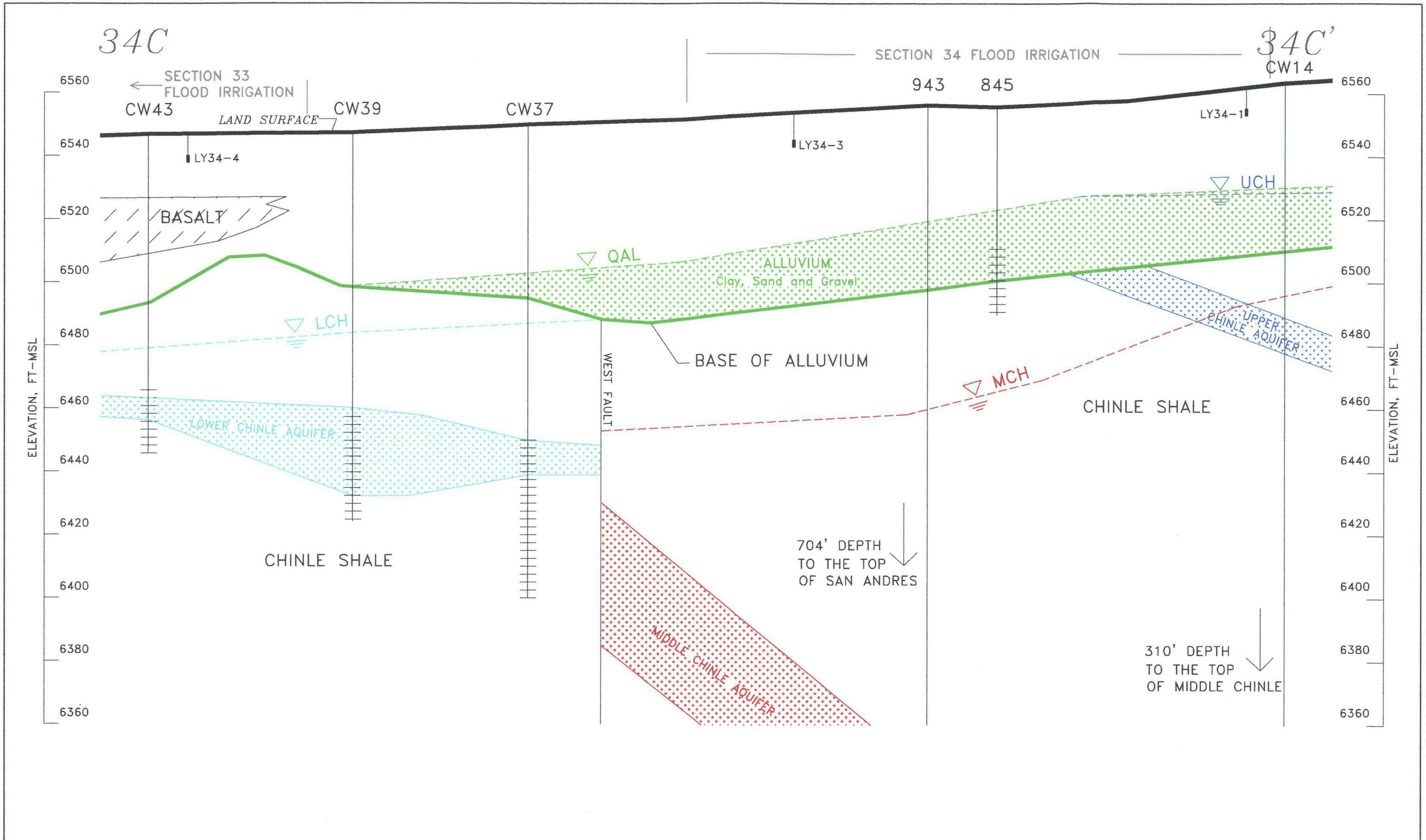

33A
33A'
SECTION 33 CENTER PIVOT
657
551
553
907
6560
6540
6520
6500
6480
6460
6440
6420
6400
6380
6360
ELEVATION, FT-MSL
LAND SURFACE
LY4
LY4MU
LY4ML
LY1
ALLUVIUM
Clay, Sand and Gravel
BASALT
QAL
ALLUVIUM
Clay, Sand and Boulders
BASE OF ALLUVIUM
CHINLE SHALE
262' DEPTH TO THE TOP OF SAN ANDRES
ALLUVIAL
BASE
QAL WATER LEVEL ELEVATION (WLE)
BASALT
LIMITS OF SANDSTONE
LOWER CHINLE
LIMITS OF AQUIFER
LCH WLE
C:\PROJECTS\2009-06\XSEC
HOMESTAKE MINING COMPANY
MILAN, NEW MEXICO
HYDRO-ENGINEERING, LLC ~~~ DATE: 09/21/09
FIGURE 3-2. SECTION 33 GEOLOGIC CROSS-SECTION 33A-33A'



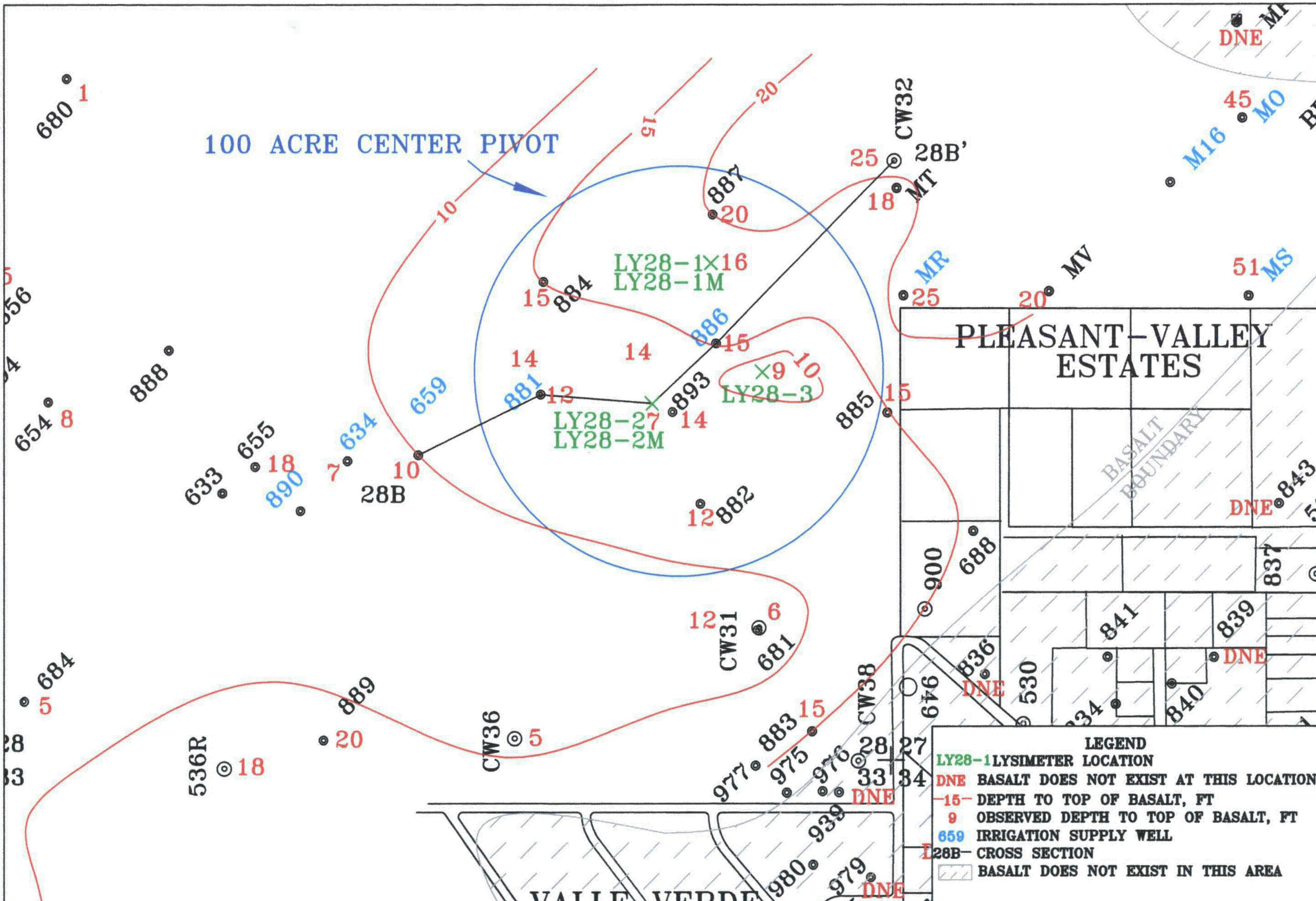
SCALE: 1" = 800'	LEGEND	
C:\PROJECTS\2009-06\BASALT	LY34-1 LYSIMETER LOCATION	DNE BASALT DOES NOT EXIST AT THIS LOCATION
DATE: 10/23/09	658 IRRIGATION SUPPLY WELL	-15- DEPTH TO TOP OF BASALT, FT
	559 PROPOSED ALLUVIAL MONITORING WELL	9 OBSERVED DEPTH TO TOP OF BASALT, FT
	*657 ABANDONED WELL	34C- CROSS SECTION
		BASALT DOES NOT EXIST IN THIS AREA

FIGURE 3-3. SECTION 34 DEPTH TO TOP OF BASALT, LOCATION OF PROPOSED LYSIMETERS, ADDITIONAL ALLUVIUM MONITORING WELLS AND CROSS SECTION

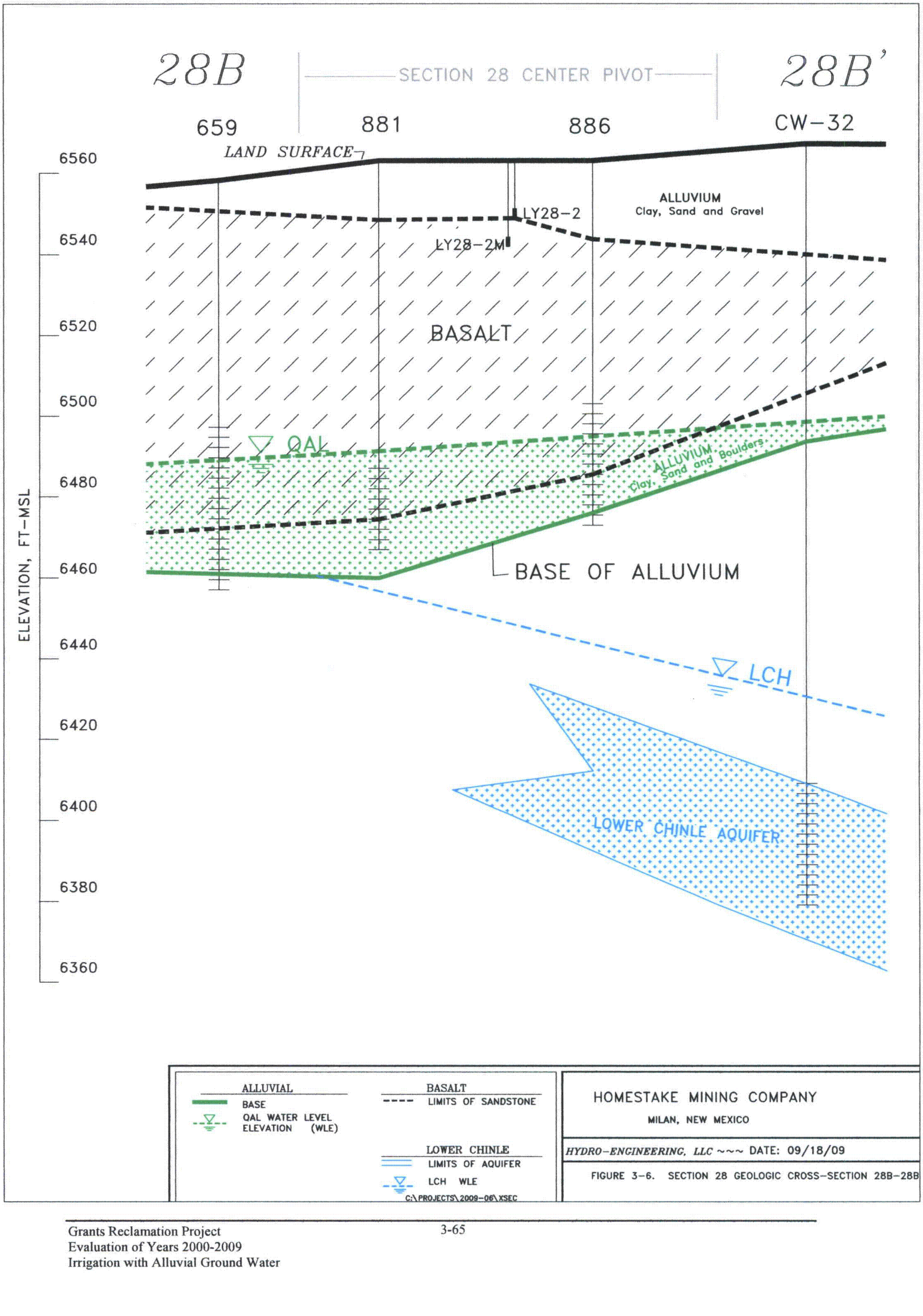
HOMESTAKE MINING COMPANY
GRANTS, NEW MEXICO



SCALE: 1" = 550' C:\PROJECTS\2009-06\Xsec DATE: 9/17/09	LEGEND BASALT — LIMITS OF SANDSTONE ALLUVIAL — BASE; QAL WATER LEVEL ELEVATION (WLE) UPPLE CHINLE — LIMITS OF SANDSTONE; UCH WLE MIDDLE CHINLE — LIMITS OF SANDSTONE; MCH WLE LOWER CHINLE — LIMITS OF AQUIFER; LCH WLE C:\PROJECTS\2009-06\XSEC	FIGURE 3-4. SECTION 34 GEOLOGIC CROSS-SECTION 34C-34C'	HOMESTAKE MINING COMPANY GRANTS, NEW MEXICO PAGE: 3-63



SCALE: 1" = 500'	FIGURE 3-5. SECTION 28 DEPTH TO TOP OF BABSALT, LOCATION OF PROPOSED LYSIMITERS, ADDITIONAL ALLUVIUM MONITORING WELLS AND CROSS SECTION	HOMESTAKE MINING COMPANY GRANTS, NEW MEXICO
C:\PROJECTS\2009-06\BASALT		
DATE: 10/23/09		


28B
SECTION 28 CENTER PIVOT
28B'
659
881
886
CW-32
LAND SURFACE
6560
6540
6520
6500
6480
6460
6440
6420
6400
6380
6360
ELEVATION, FT-MSL
ALLUVIUM
Clay, Sand and Gravel
LY28-2
LY28-2M
BASALT
QAL
ALLUVIUM
Clay, Sand and Boulders
BASE OF ALLUVIUM
LCH
LOWER CHINLE AQUIFER
ALLUVIAL
BASE
QAL WATER LEVEL ELEVATION (WLE)
BASALT
LIMITS OF SANDSTONE
LOWER CHINLE
LIMITS OF AQUIFER
LCH WLE
C:\PROJECTS\2009-06\XSEC
HOMESTAKE MINING COMPANY
MILAN, NEW MEXICO
HYDRO-ENGINEERING, LLC ~~~ DATE: 09/18/09
FIGURE 3-6. SECTION 28 GEOLOGIC CROSS-SECTION 28B-28B

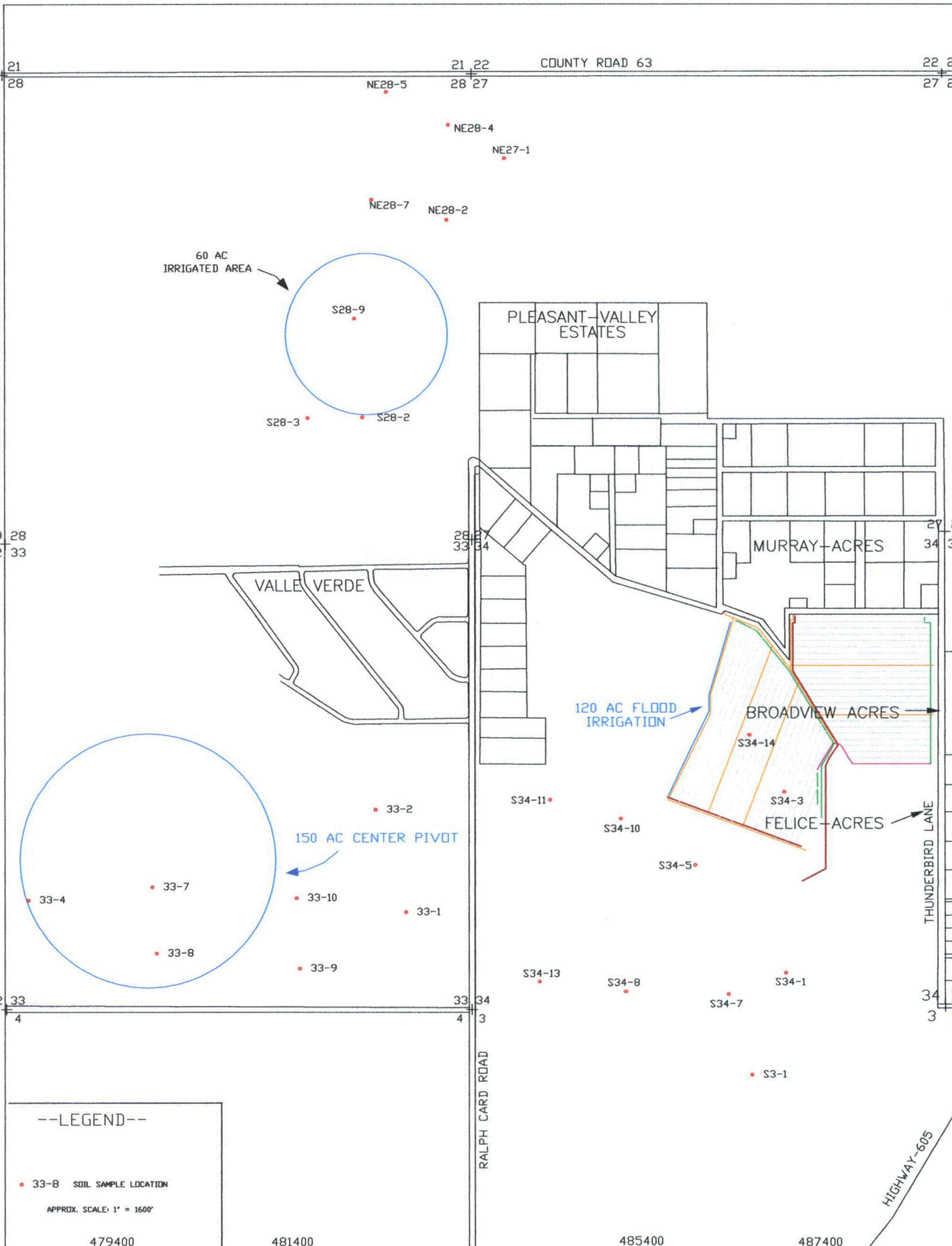


FIGURE 3-7. LOCATION OF IRRIGATION AREAS WITH SOIL SAMPLE LOCATIONS FROM THE 1998 INVESTIGATION

DATE: 02/13/09
(hmg) C:\PROJECTS\2009-06\IRRIGATION\98IRRI

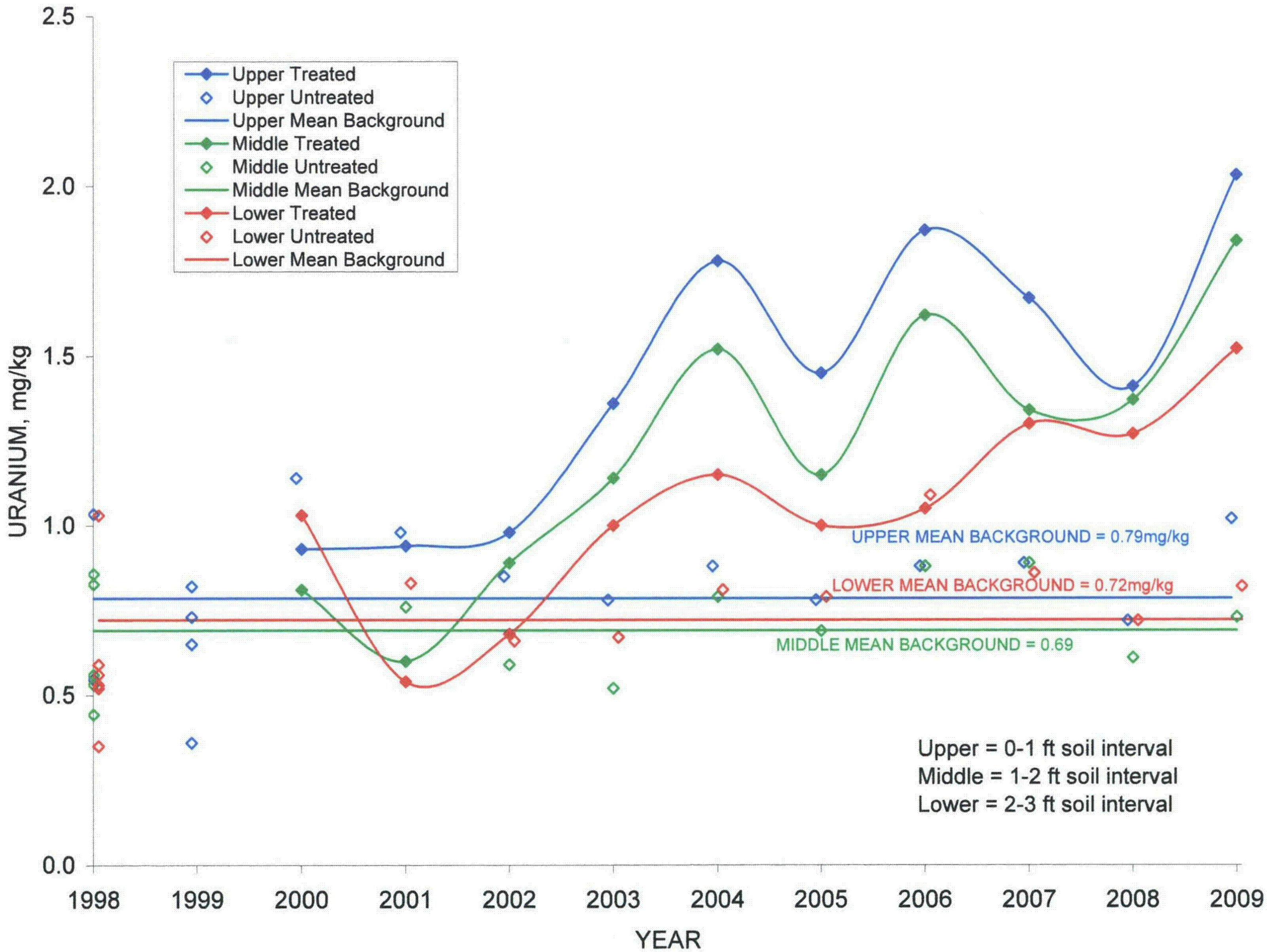


FIGURE 3-8. URANIUM CONCENTRATIONS VERSUS TIME FOR SECTION 33 CENTER PIVOT SOIL SAMPLES

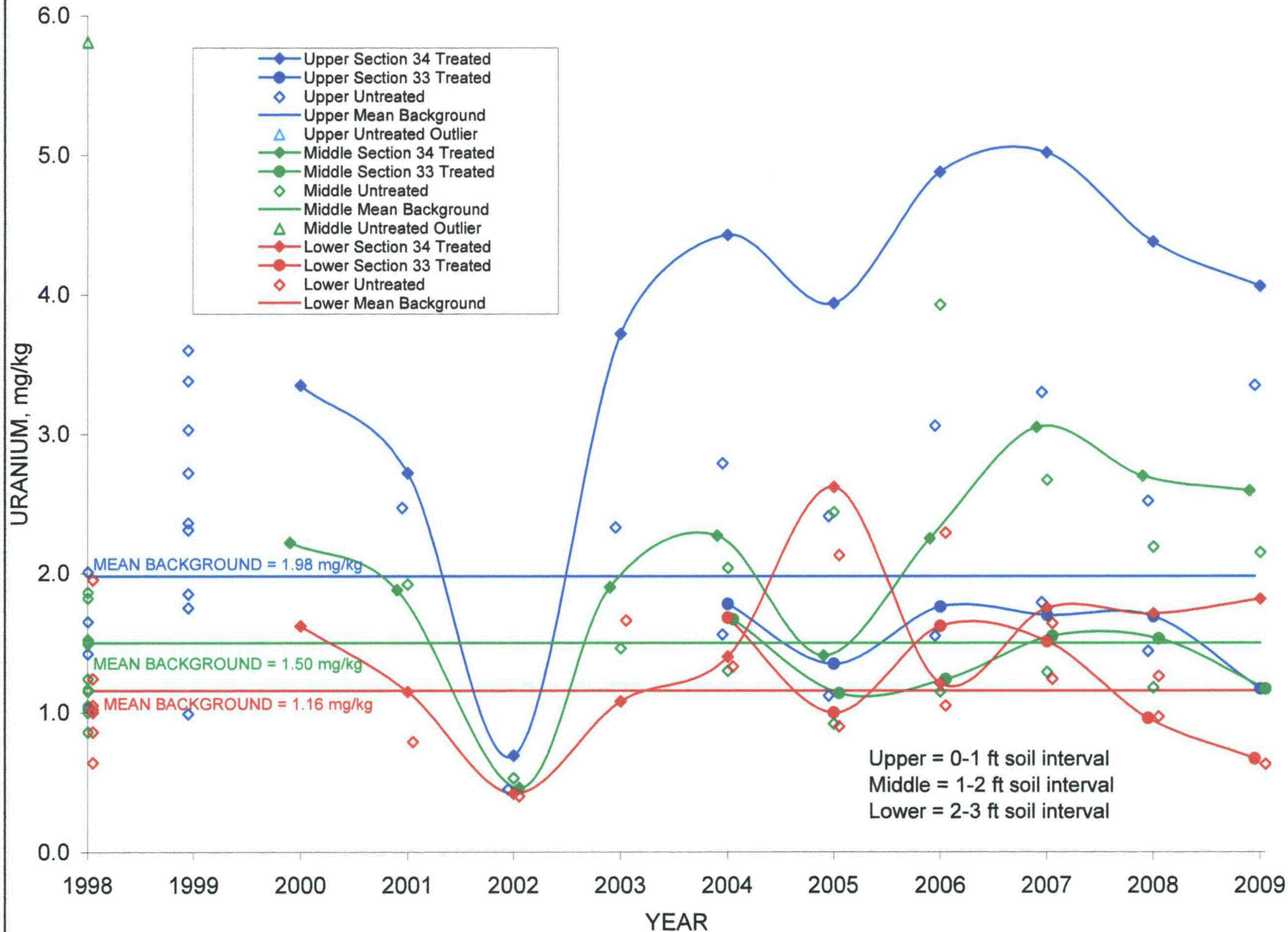


FIGURE 3-9. URANIUM CONCENTRATIONS VERSUS TIME FOR SECTIONS 33 AND 34 FLOOD SOIL SAMPLES

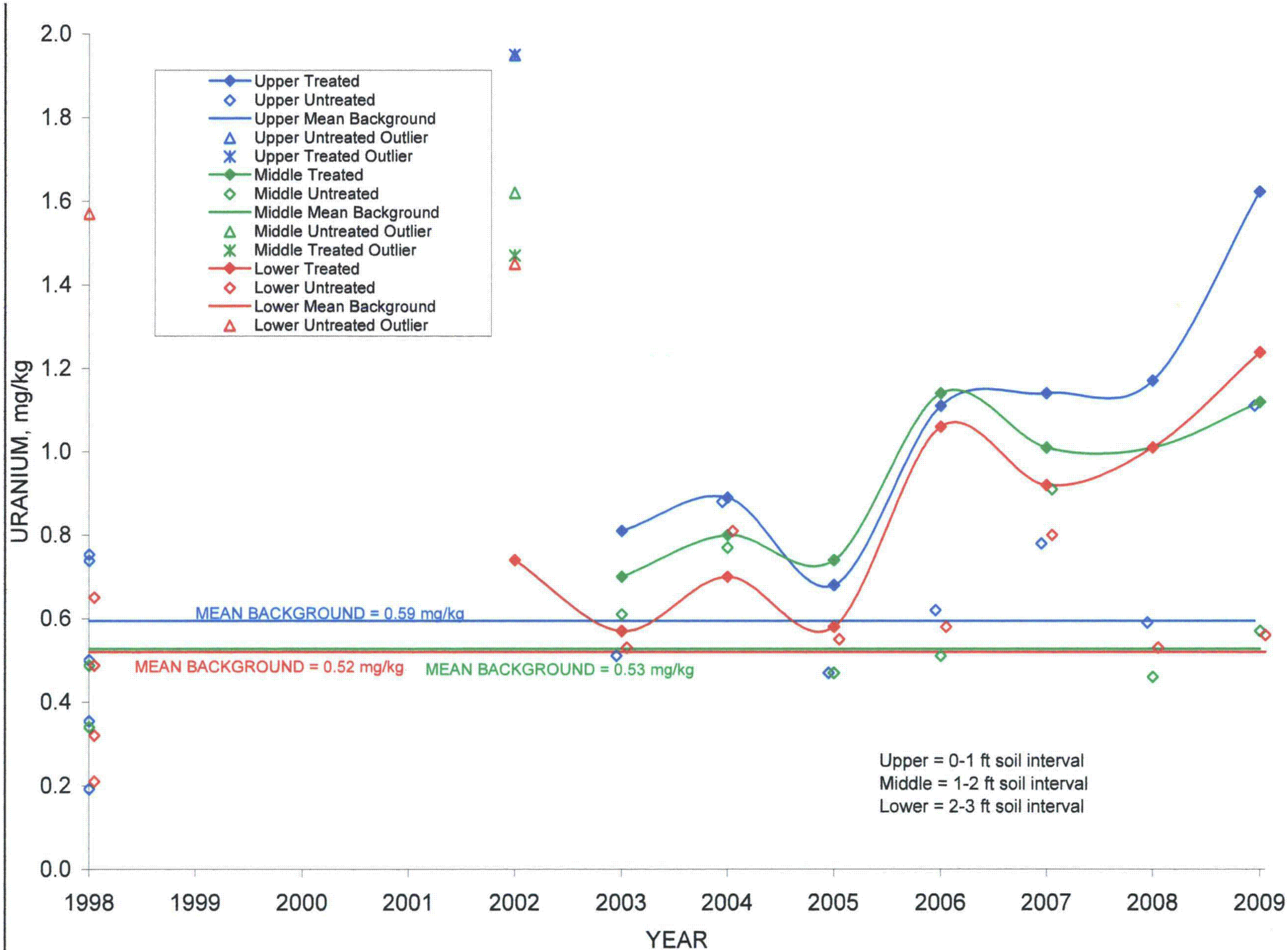


FIGURE 3-10. URANIUM CONCENTRATIONS VERSUS TIME FOR SECTION 28 CENTER PIVOT SOIL SAMPLES

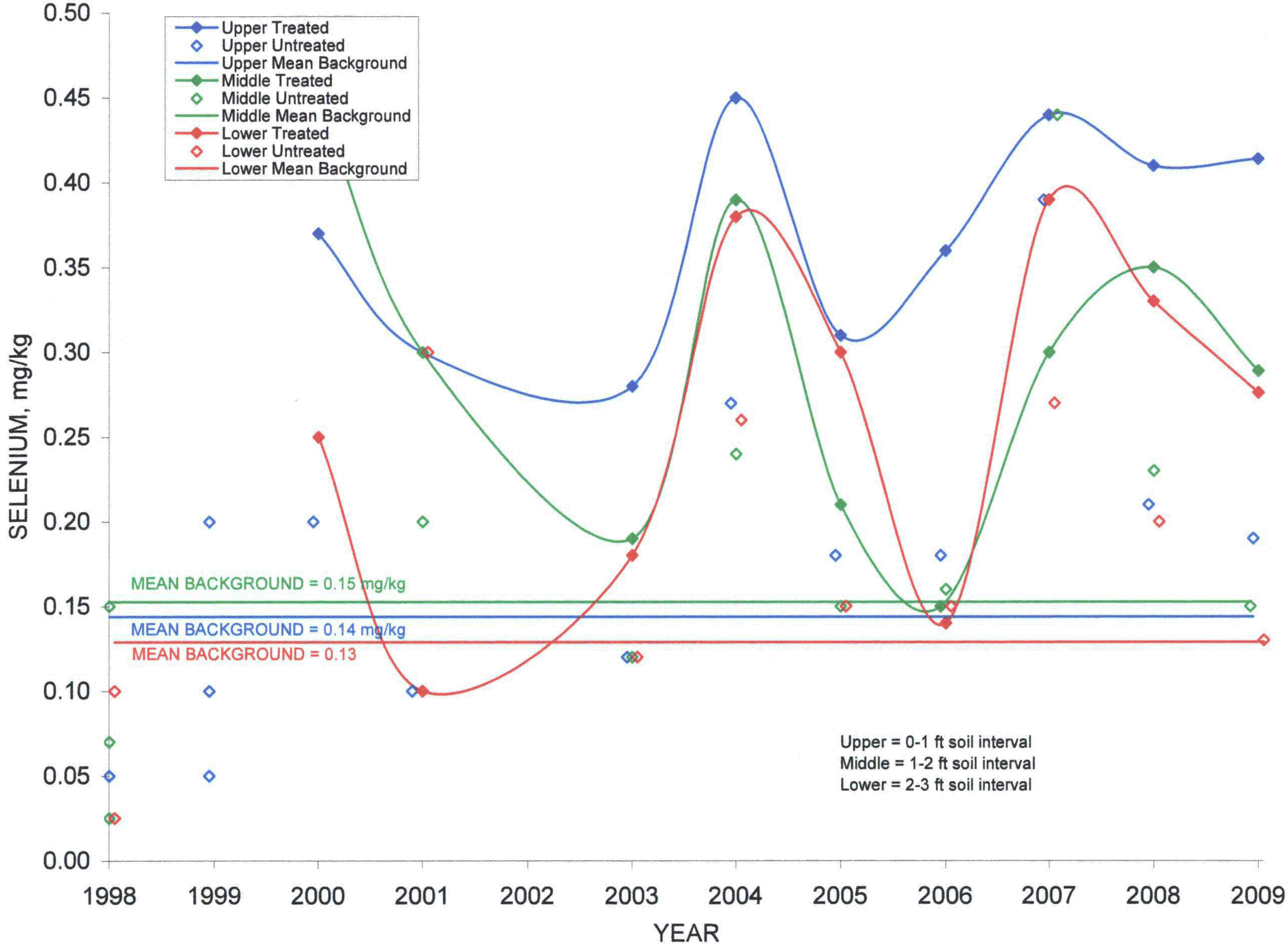


FIGURE 3-11. SELENIUM CONCENTRATIONS VERSUS TIME FOR SECTION 33 CENTER PIVOT SOIL SAMPLES

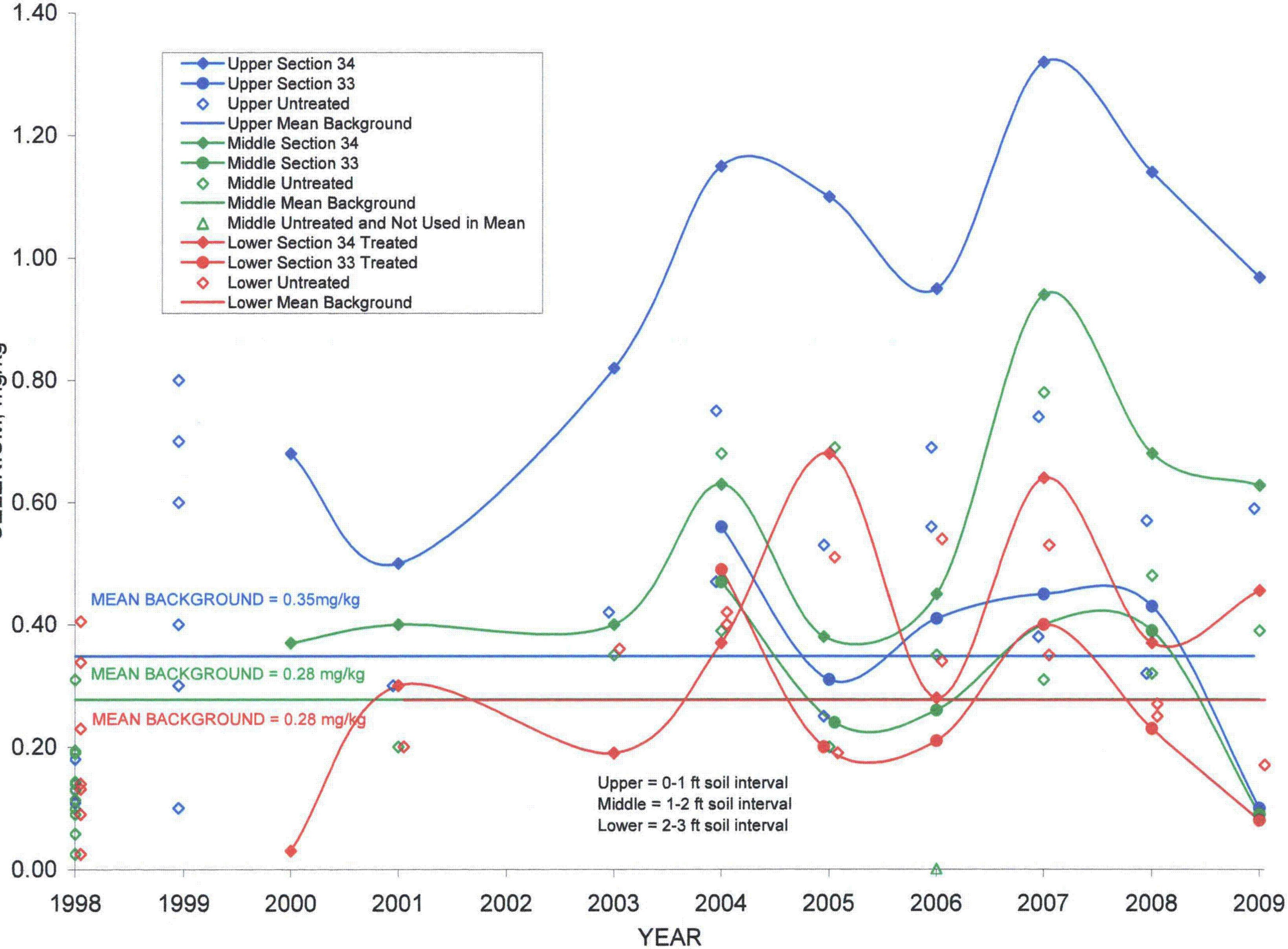


FIGURE 3-12. SELENIUM CONCENTRATIONS VERSUS TIME FOR SECTIONS 33 AND 34 FLOOD SOIL SAMPLES

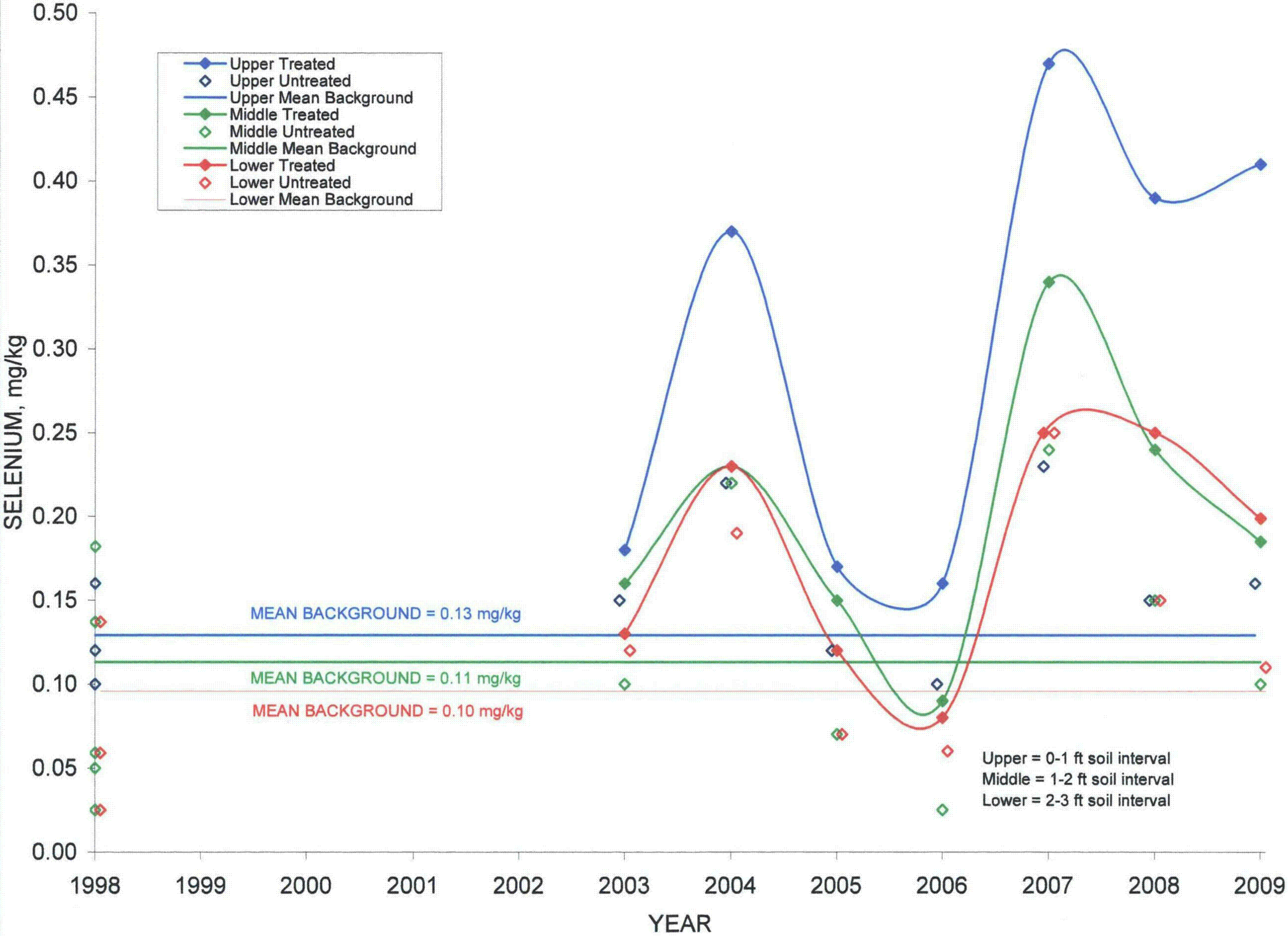


FIGURE 3-13. SELENIUM CONCENTRATIONS VERSUS TIME FOR SECTION 28 CENTER PIVOT SOIL SAMPLES

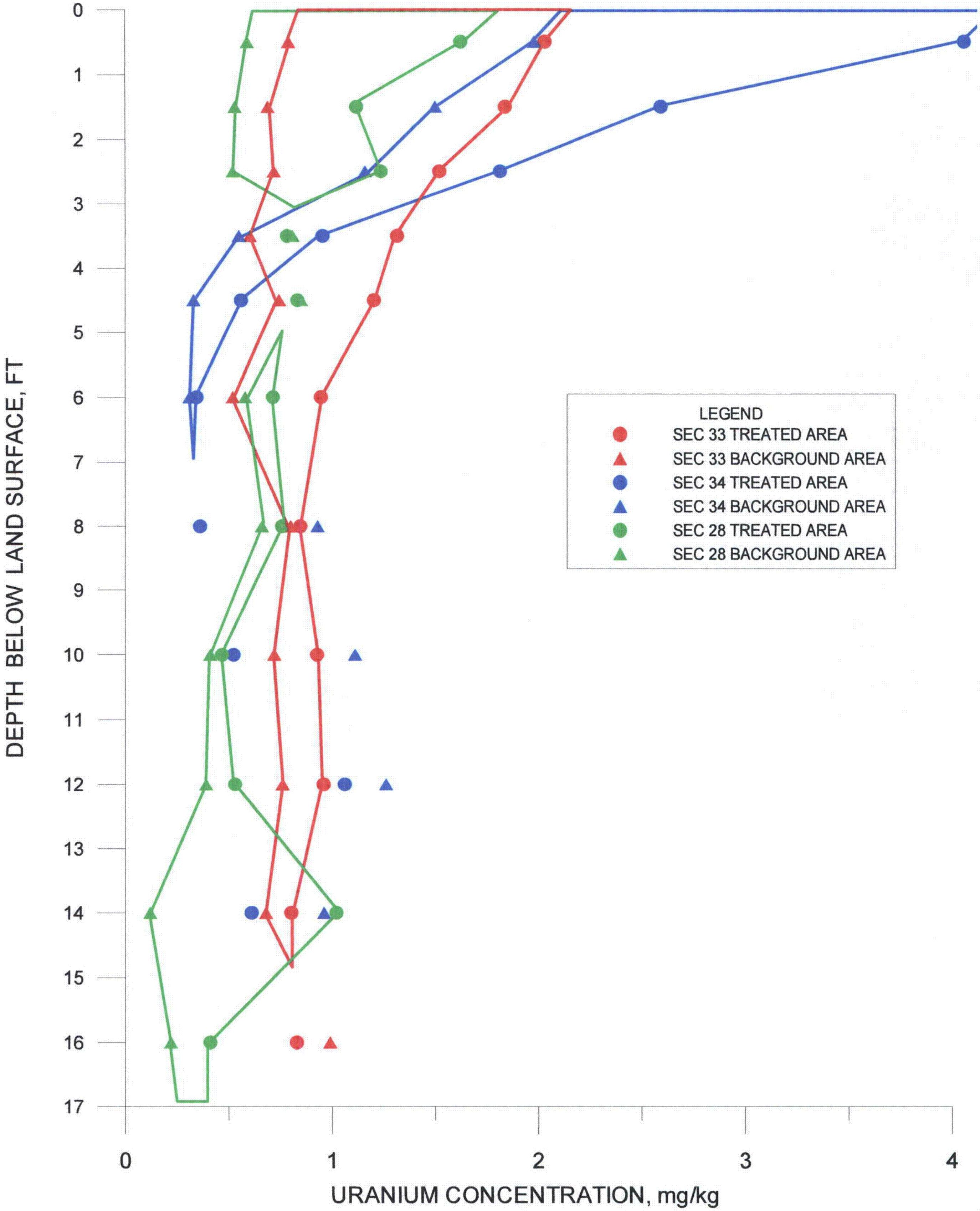


FIGURE 3-14. URANIUM CONCENTRATION IN THE SOILS WITH DEPTH IN SECTIONS 33, 34 AND 28 IRRIGATION AREAS

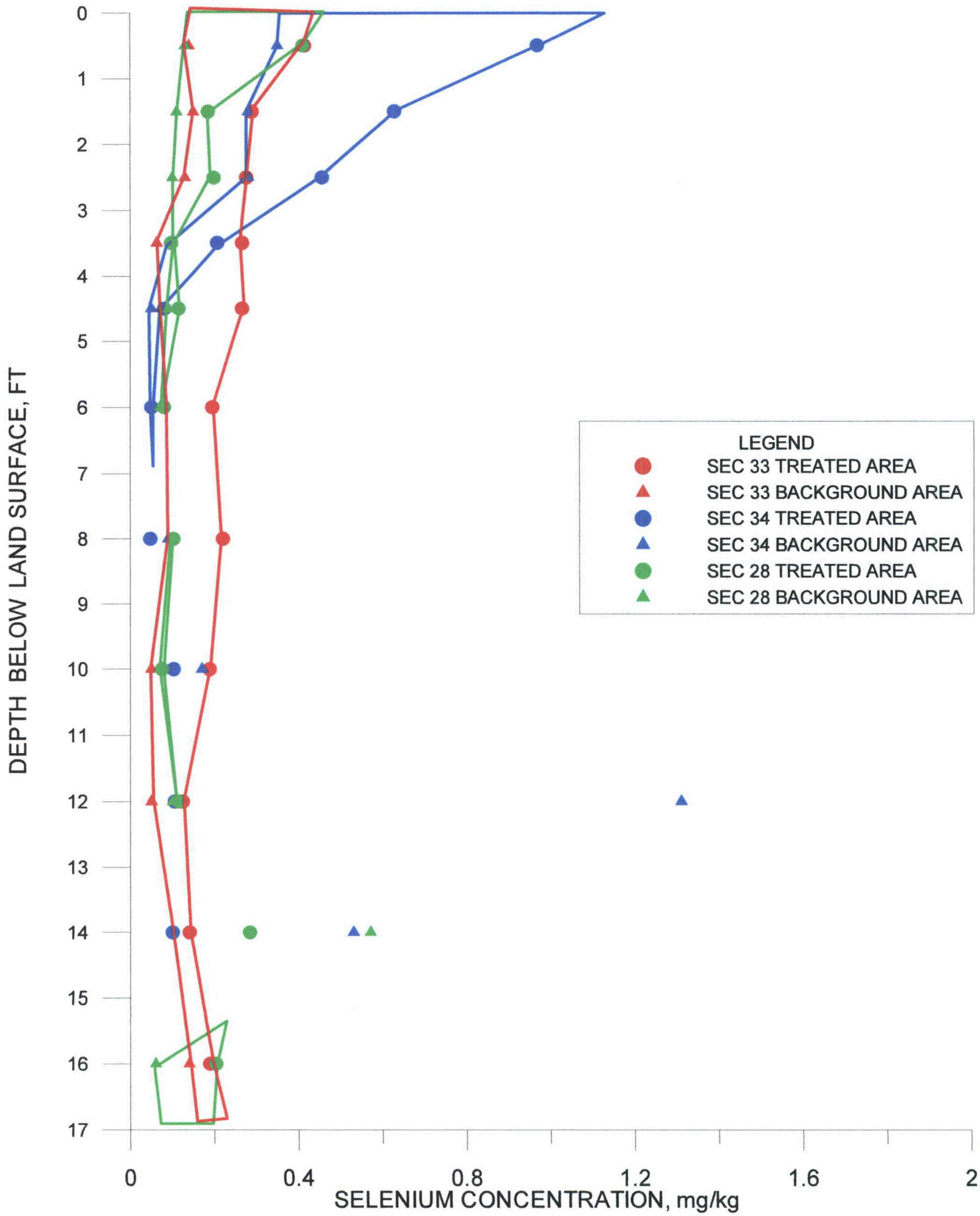


FIGURE 3-15. SELENIUM CONCENTRATION IN THE SOILS WITH DEPTH IN SECTIONS 33, 34 AND 28 IRRIGATION AREAS

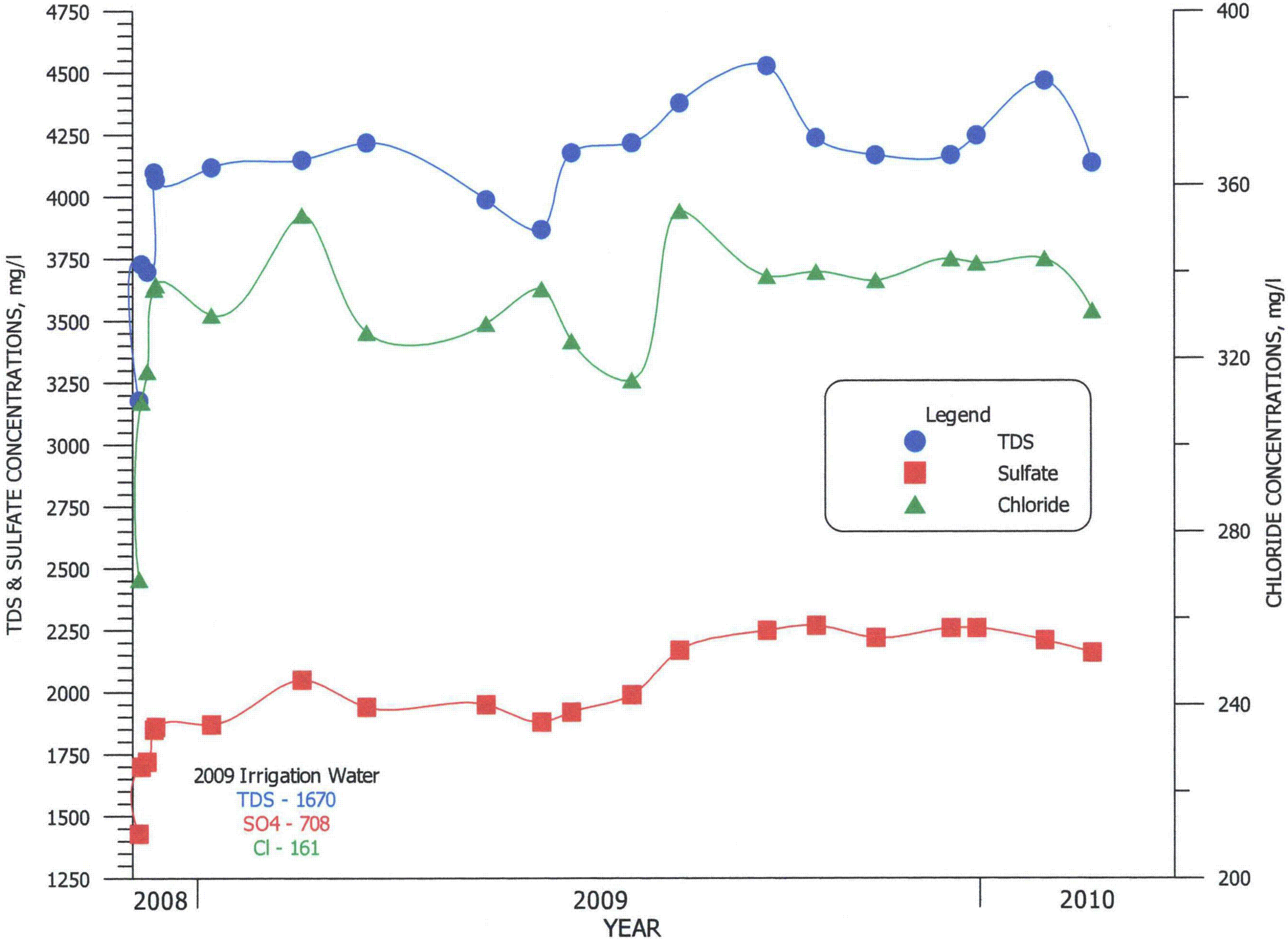


FIGURE 3-16. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY4.

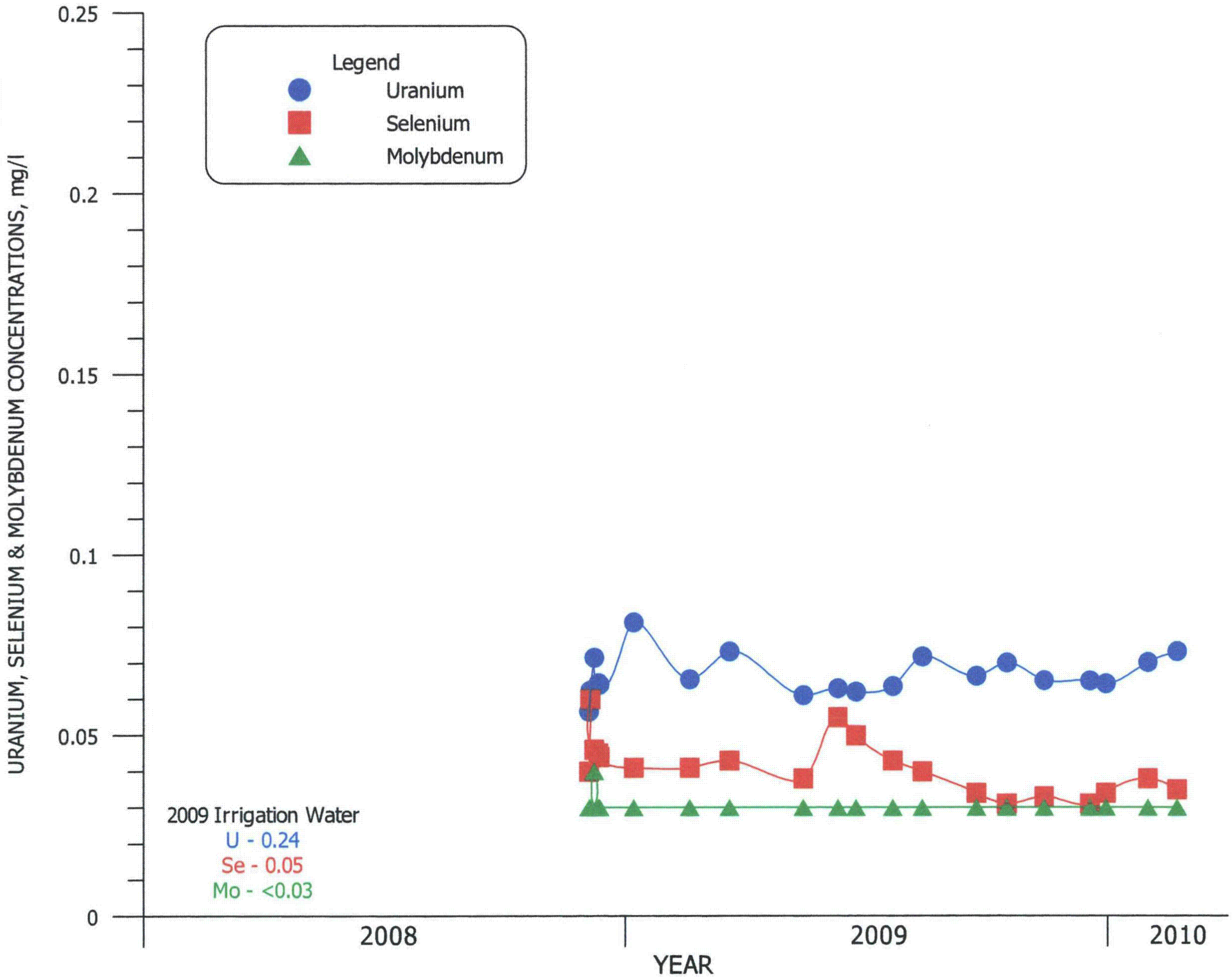


FIGURE 3-17. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY4.

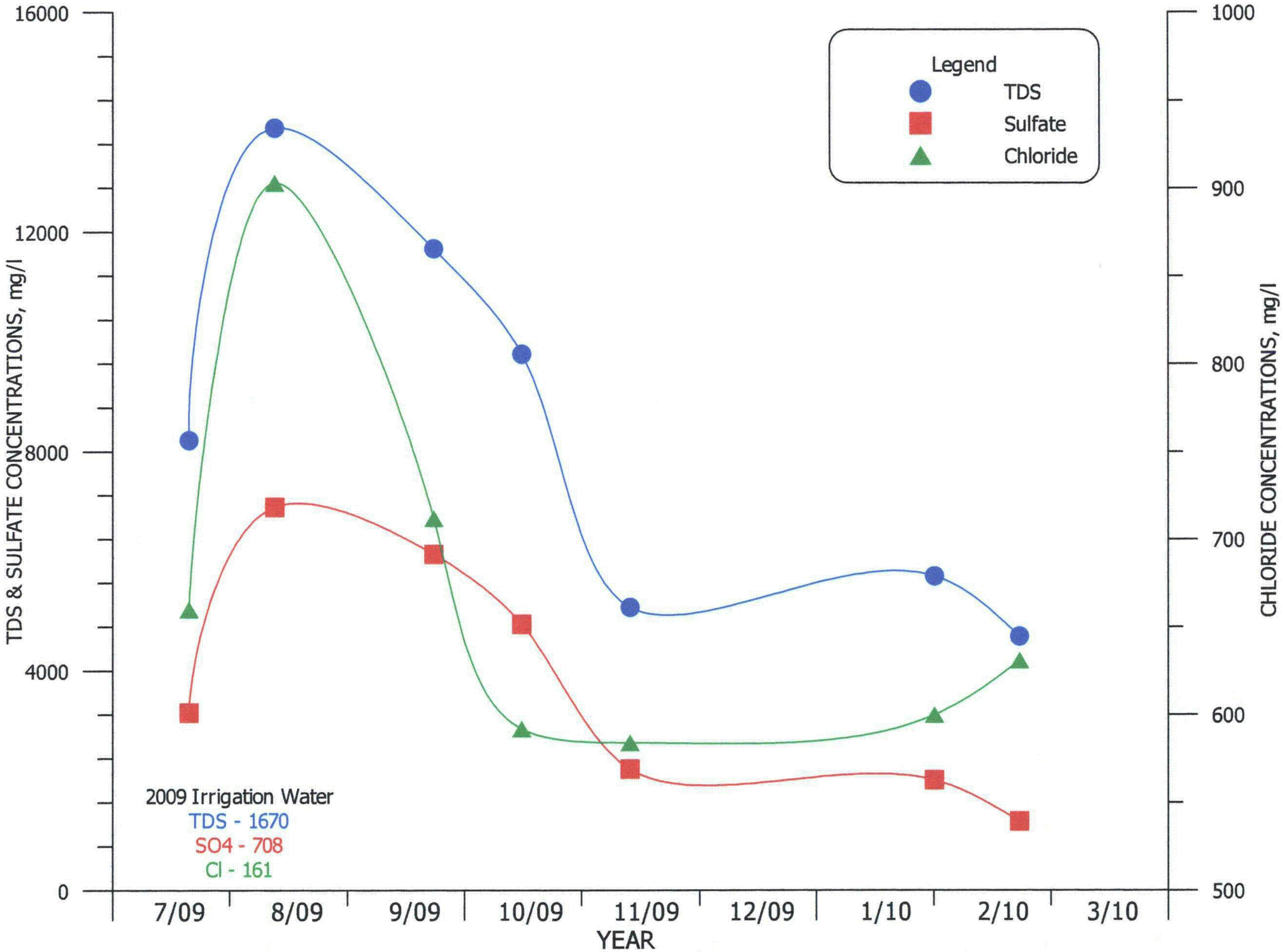


FIGURE 3-18. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY4MU.

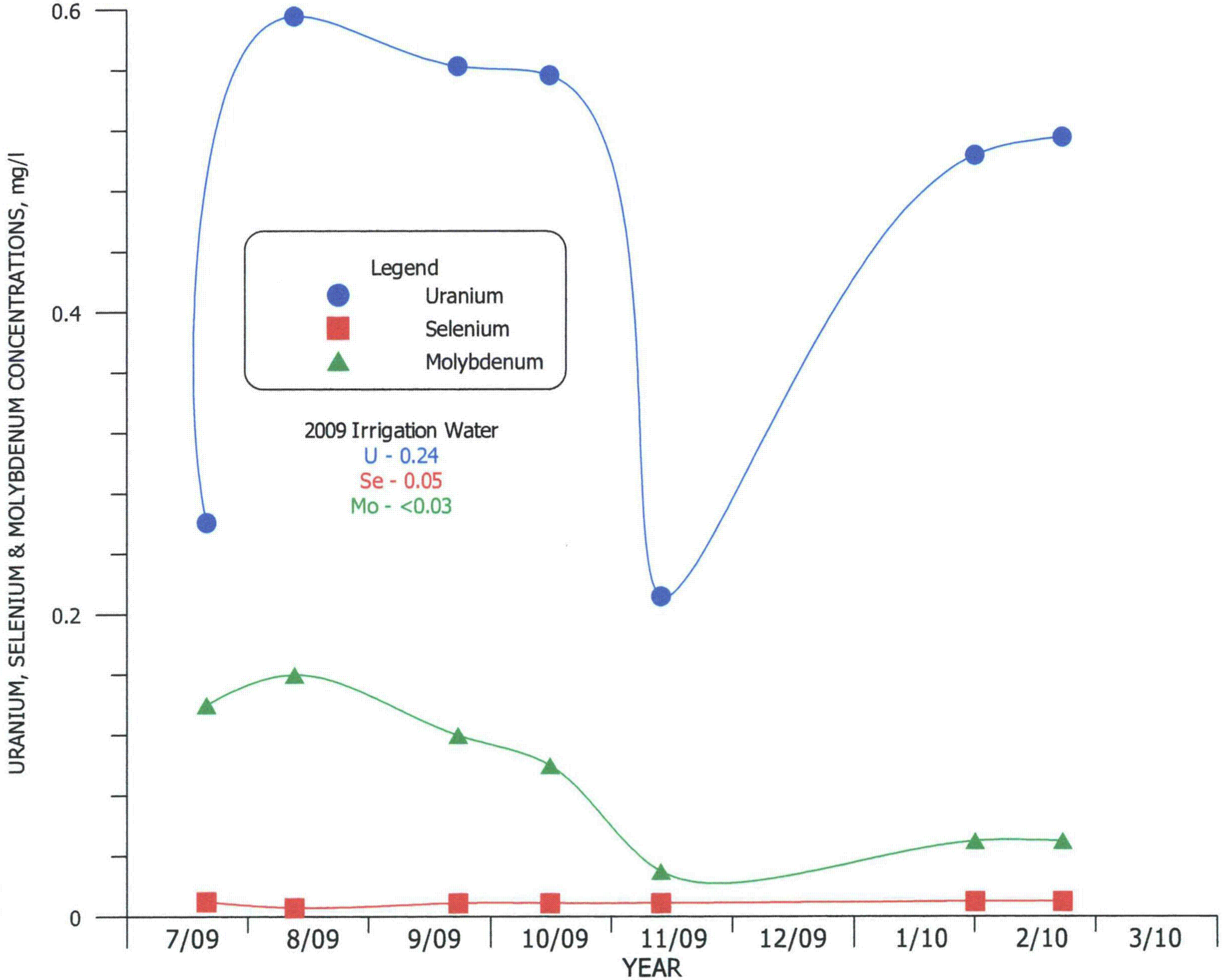


FIGURE 3-19. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY4MU.

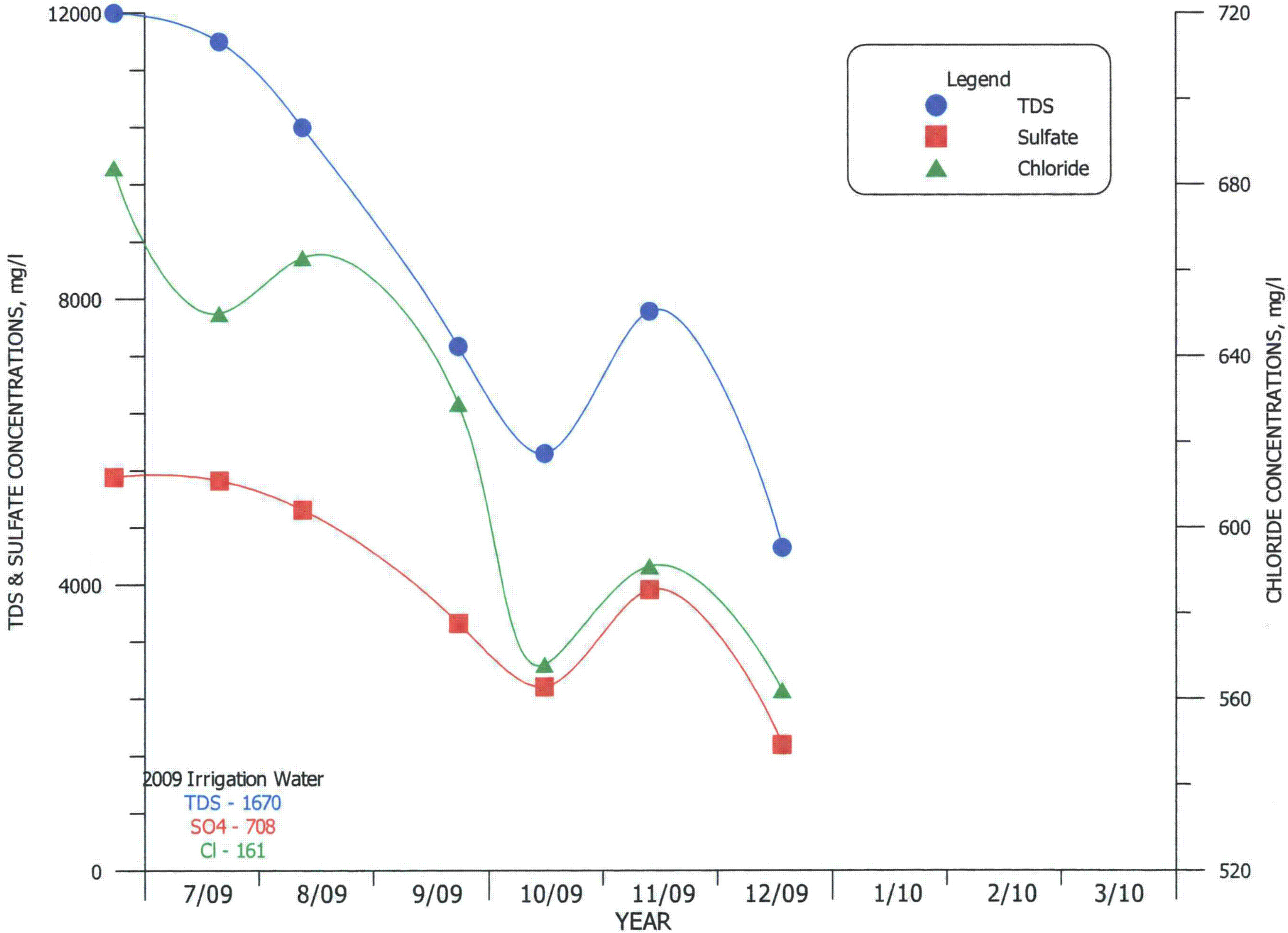


FIGURE 3-20. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY4ML.

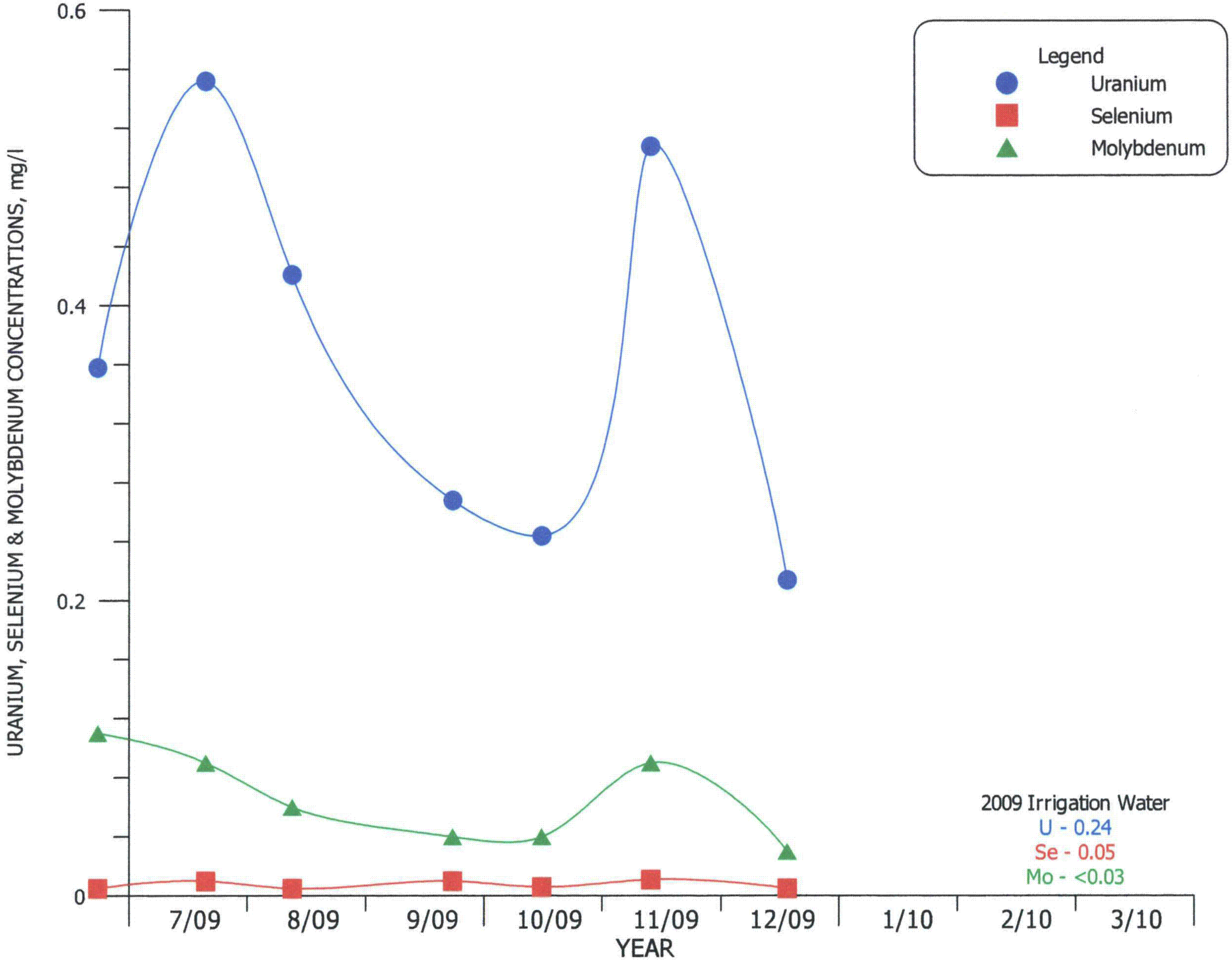


FIGURE 3-21. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY4ML.

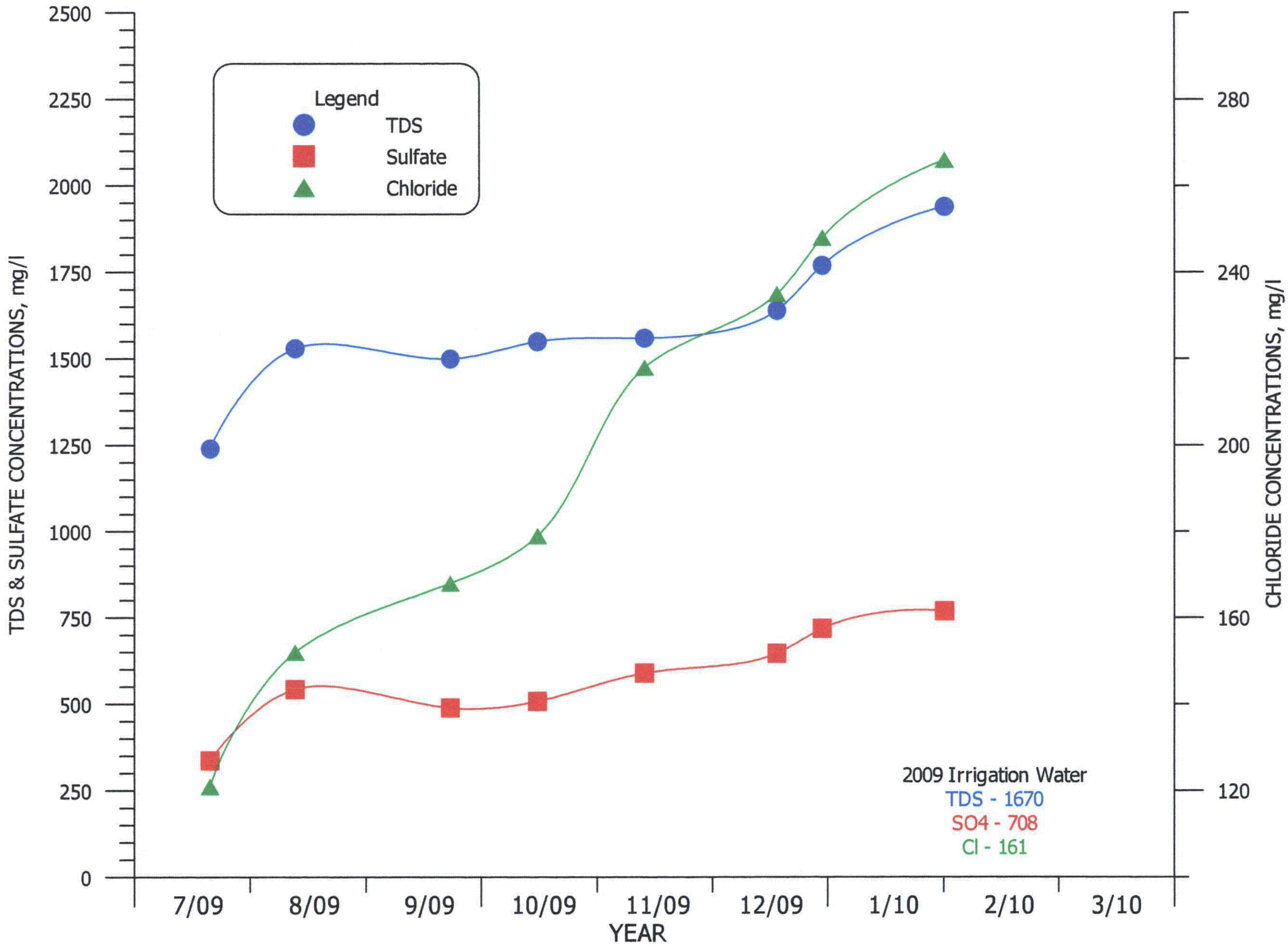


FIGURE 3-22. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY1.

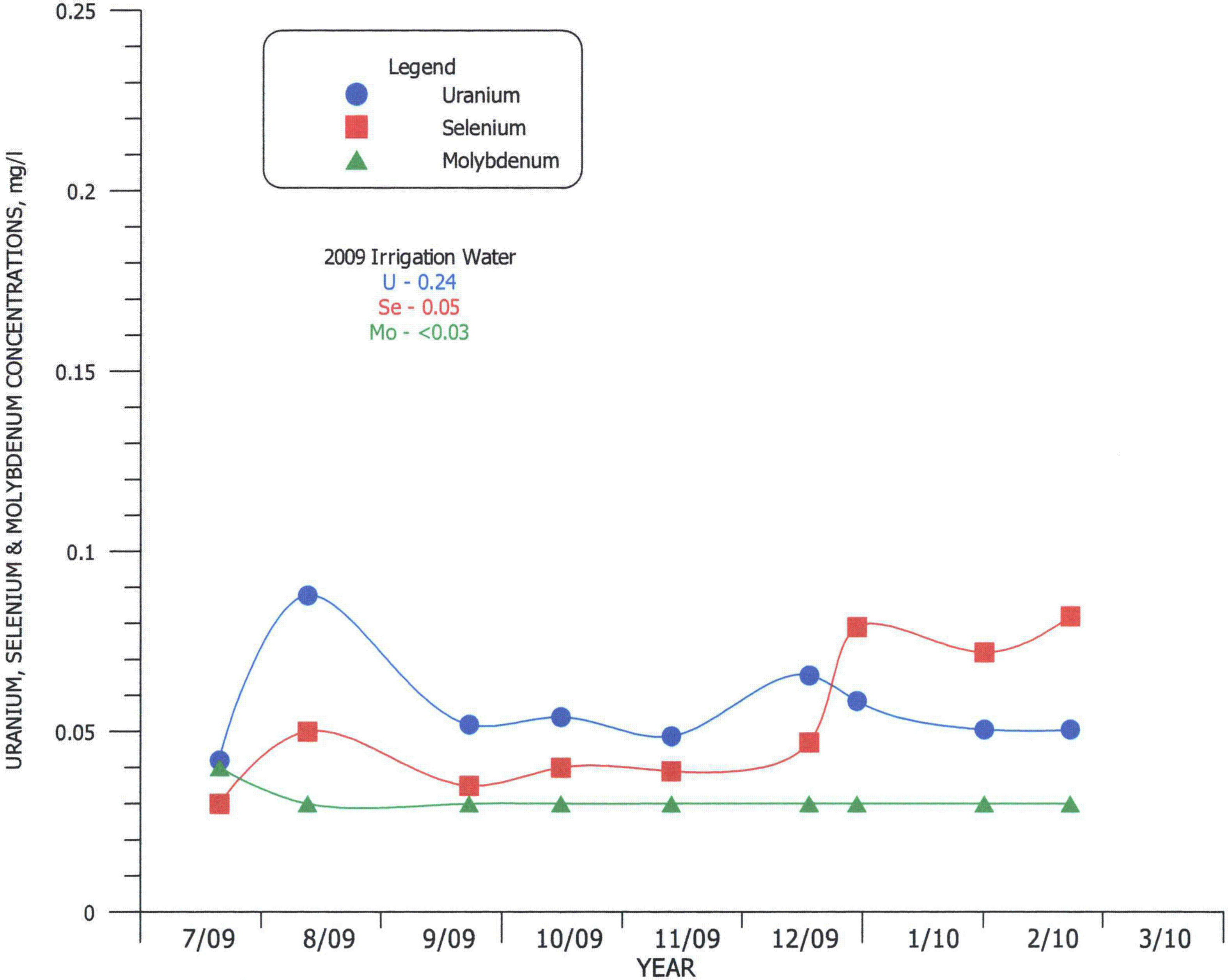


FIGURE 3-23. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY1.

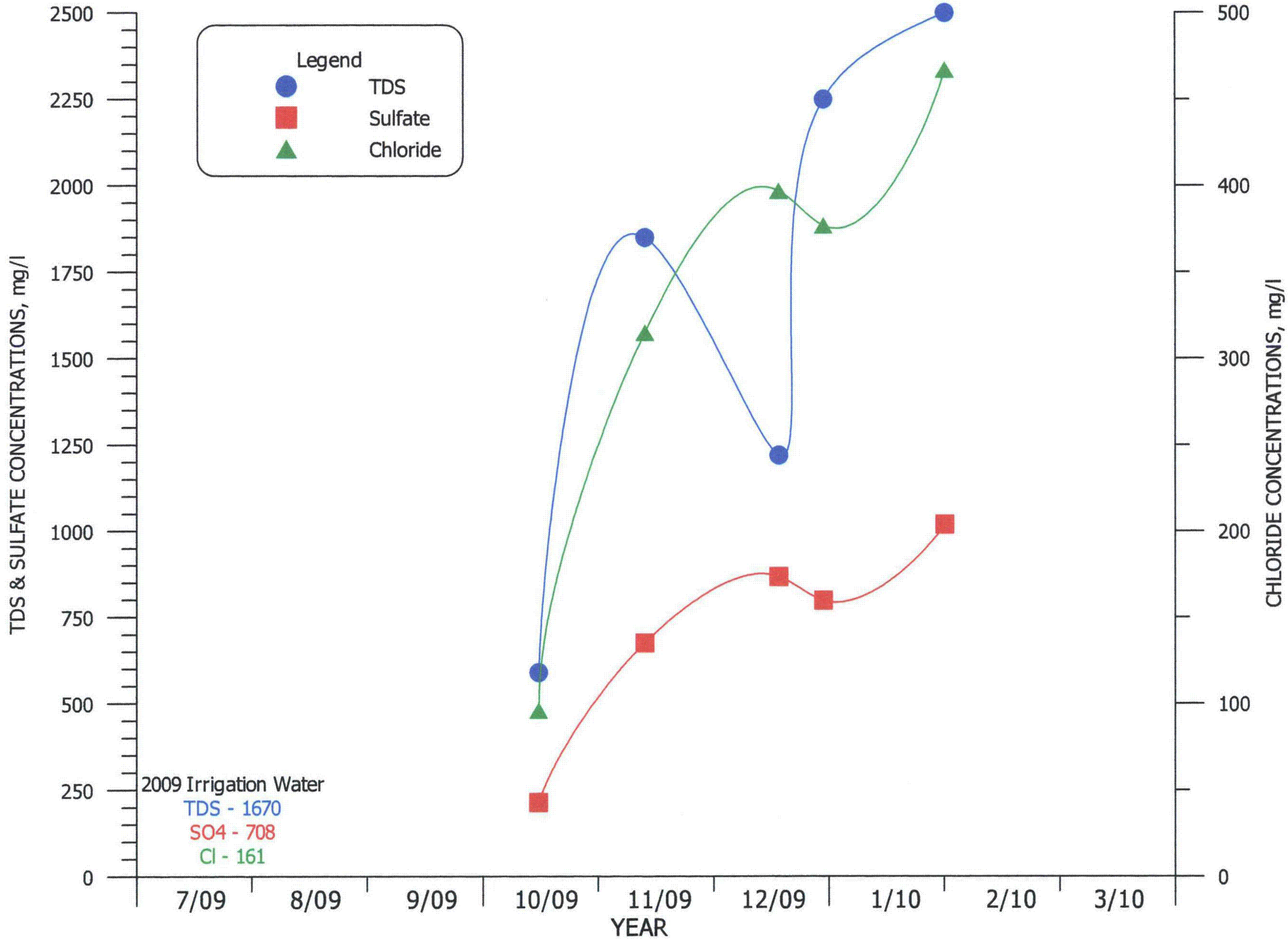


FIGURE 3-24. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY34-2.

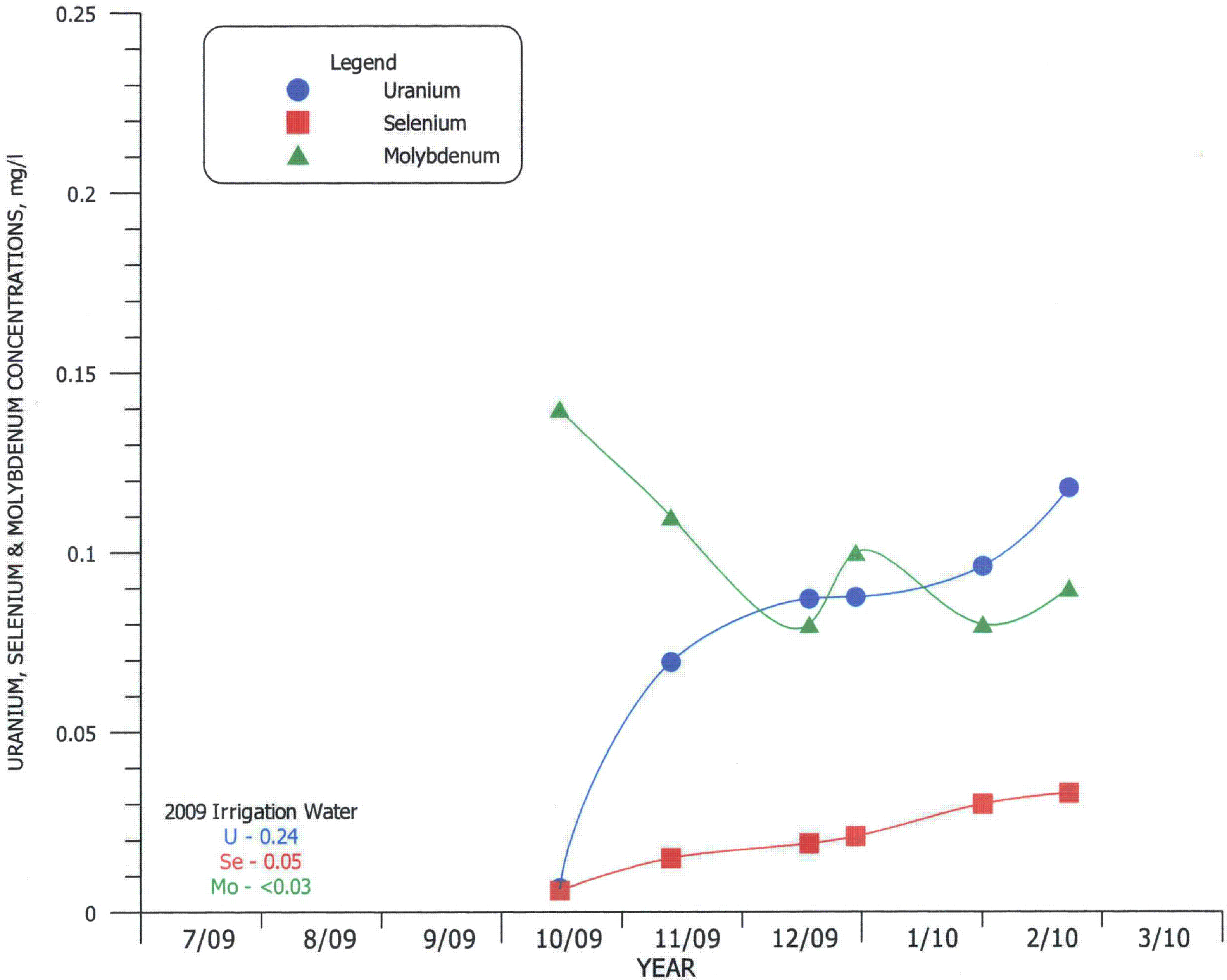


FIGURE 3-25. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY34-2.

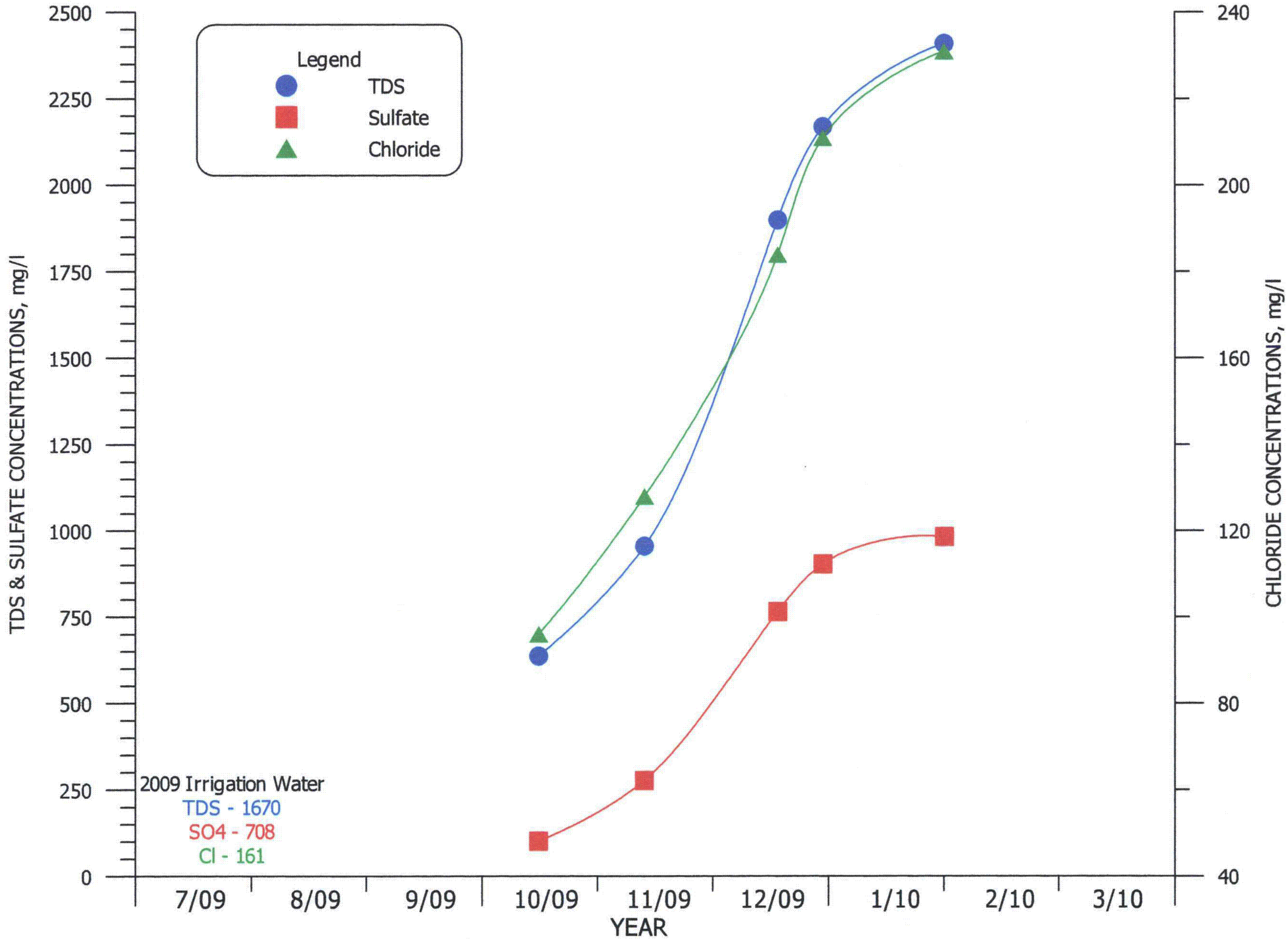


FIGURE 3-26. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY34-3.

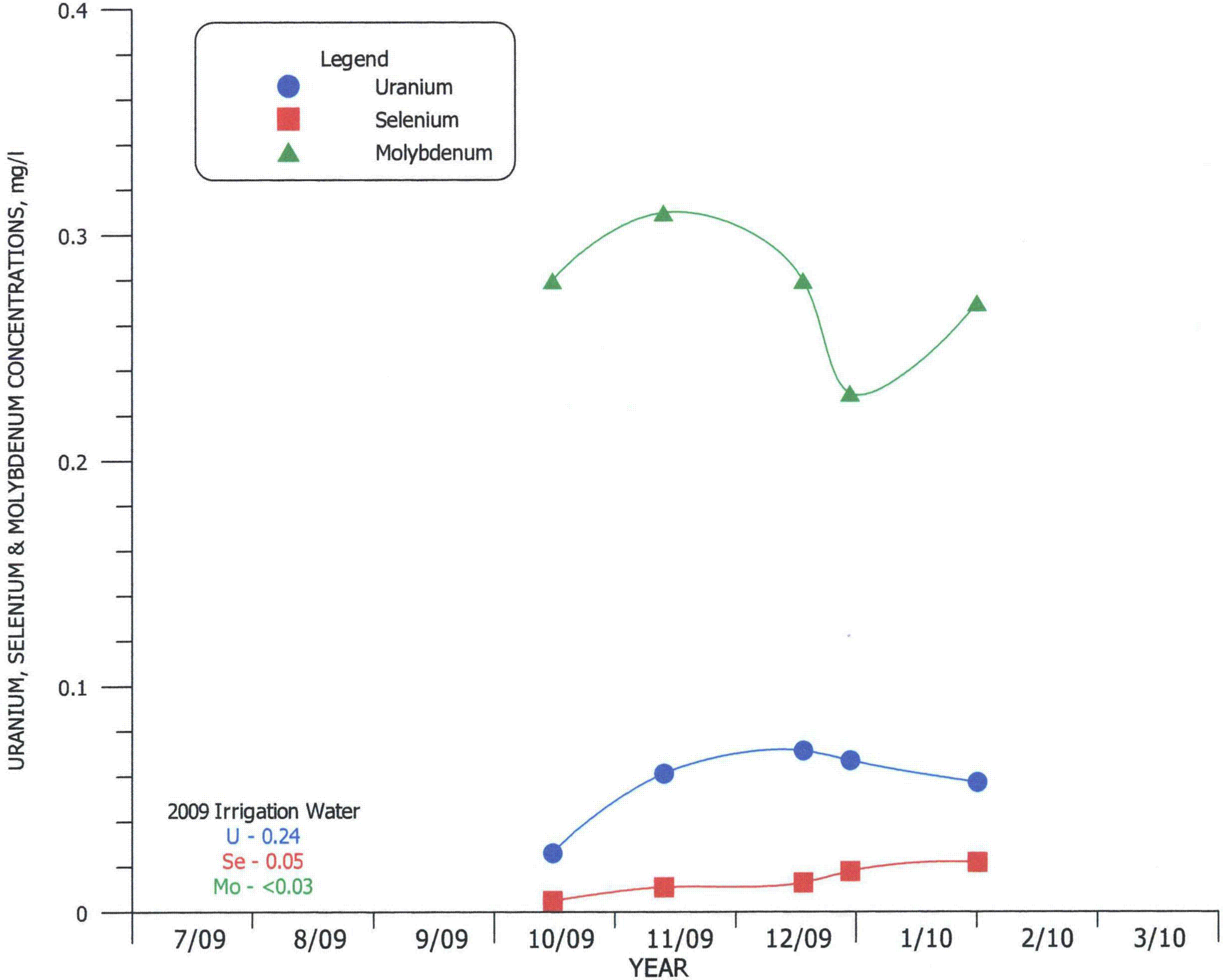


FIGURE 3-27. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY34-3.

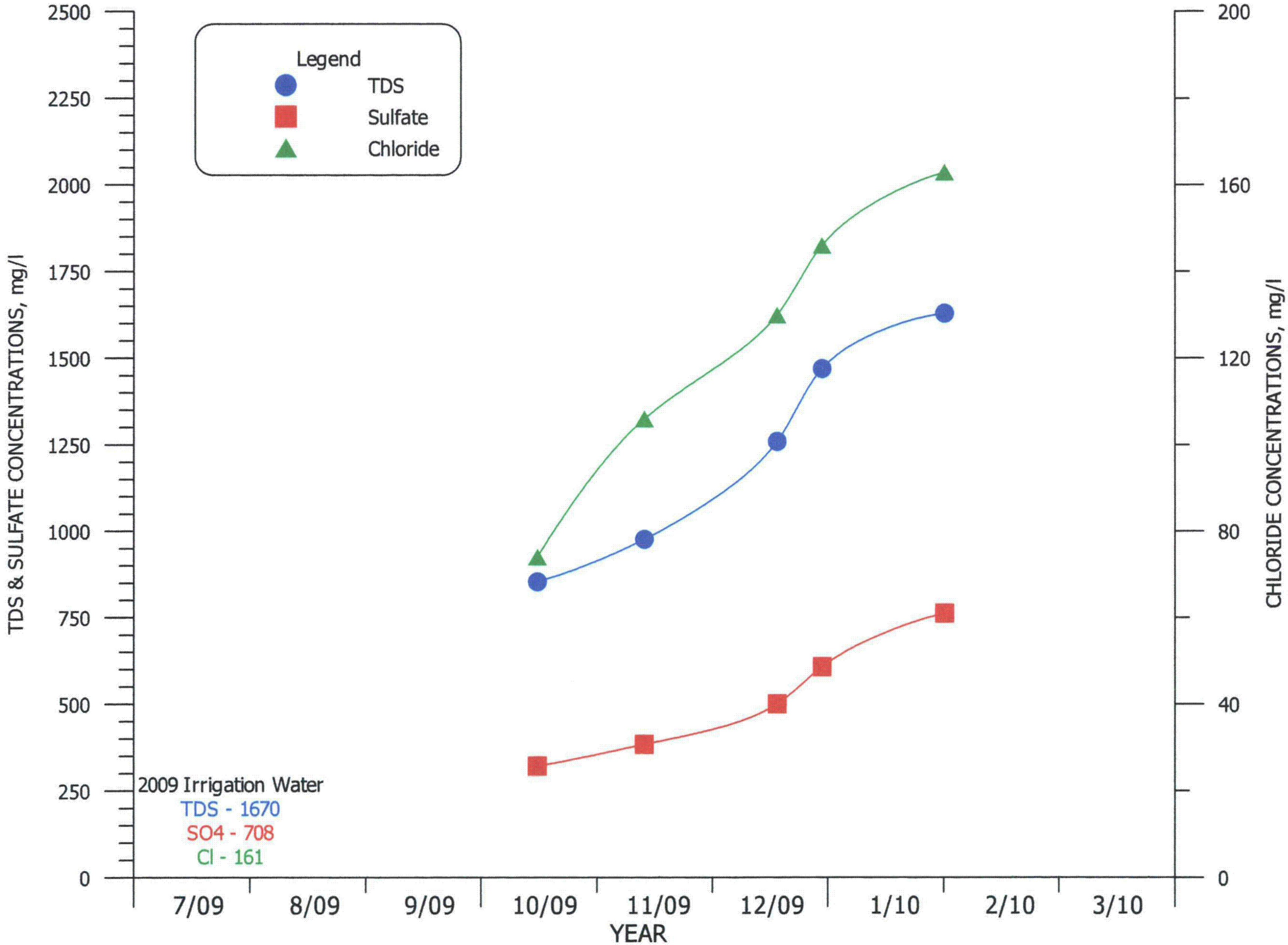


FIGURE 3-28. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY34-4.

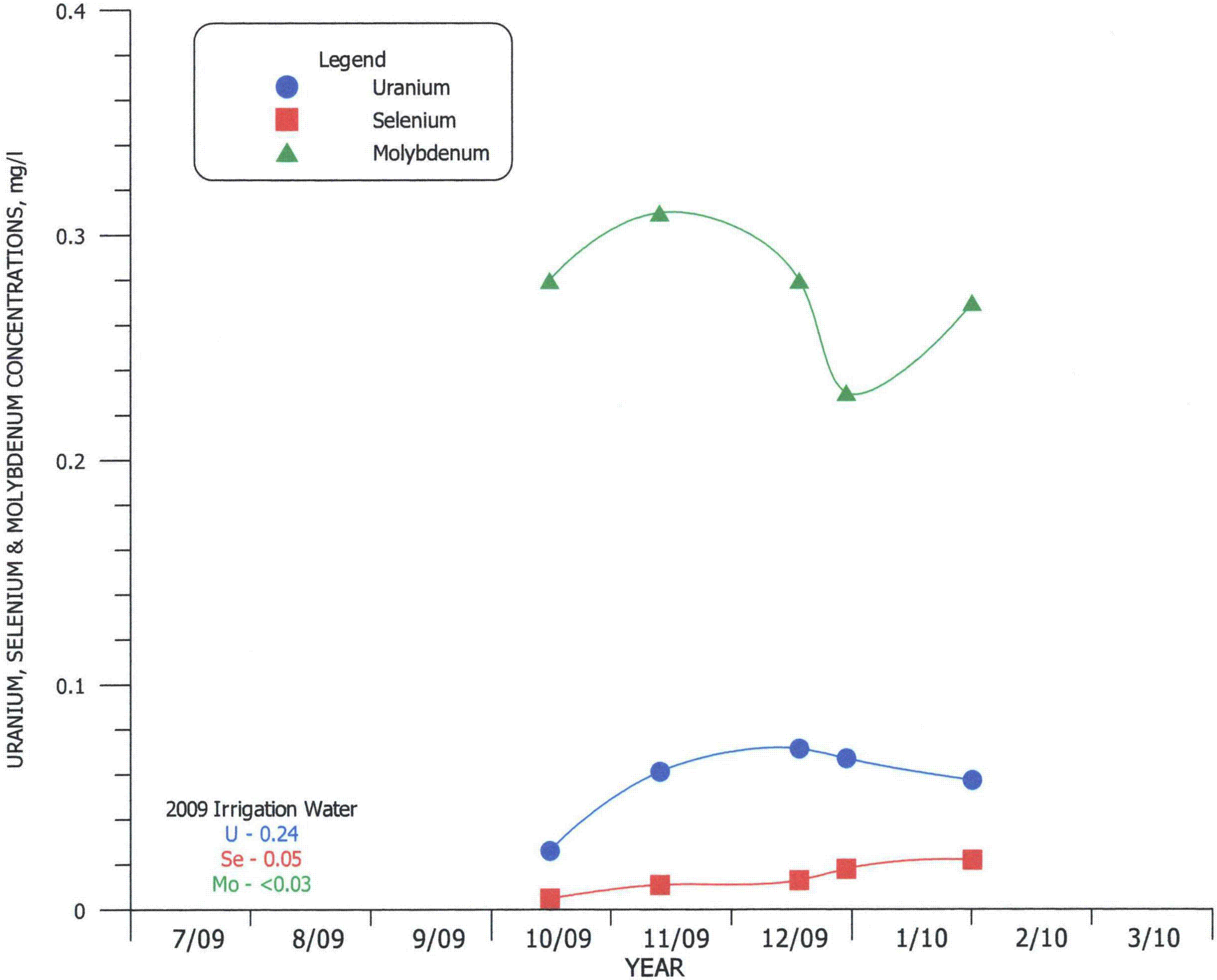


FIGURE 3-29. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY34-4.

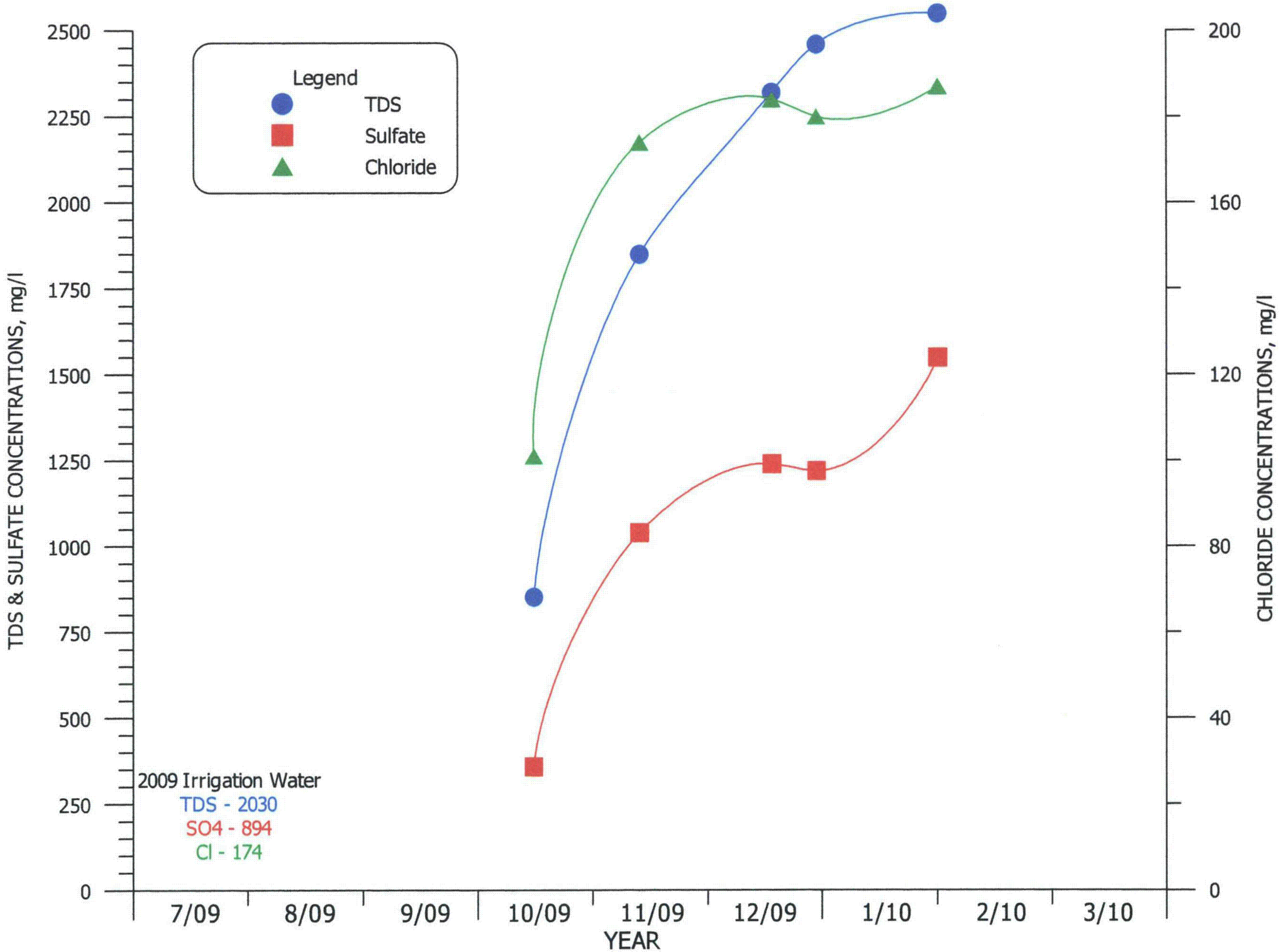


FIGURE 3-30. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY28-1.

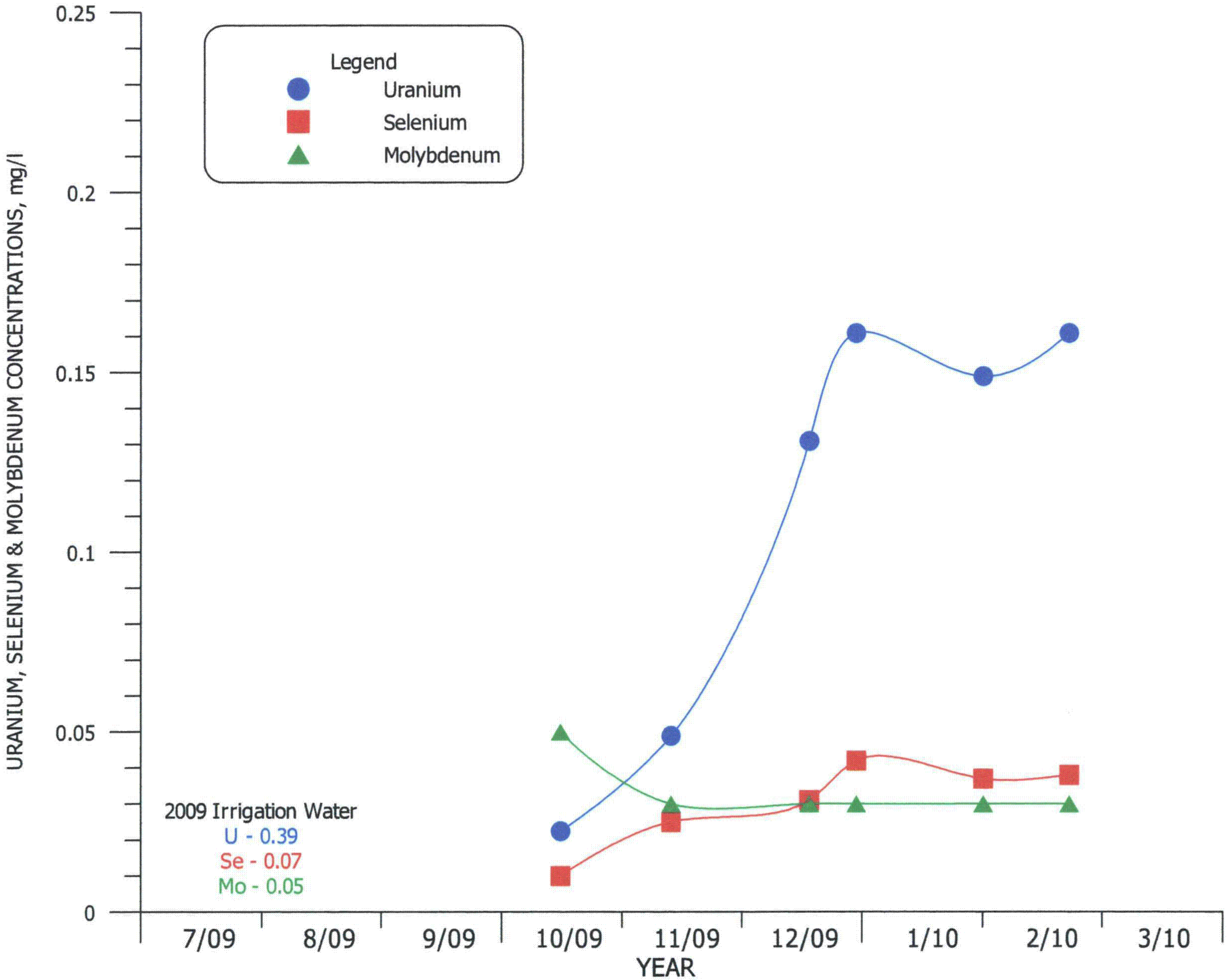


FIGURE 3-31. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY28-1.

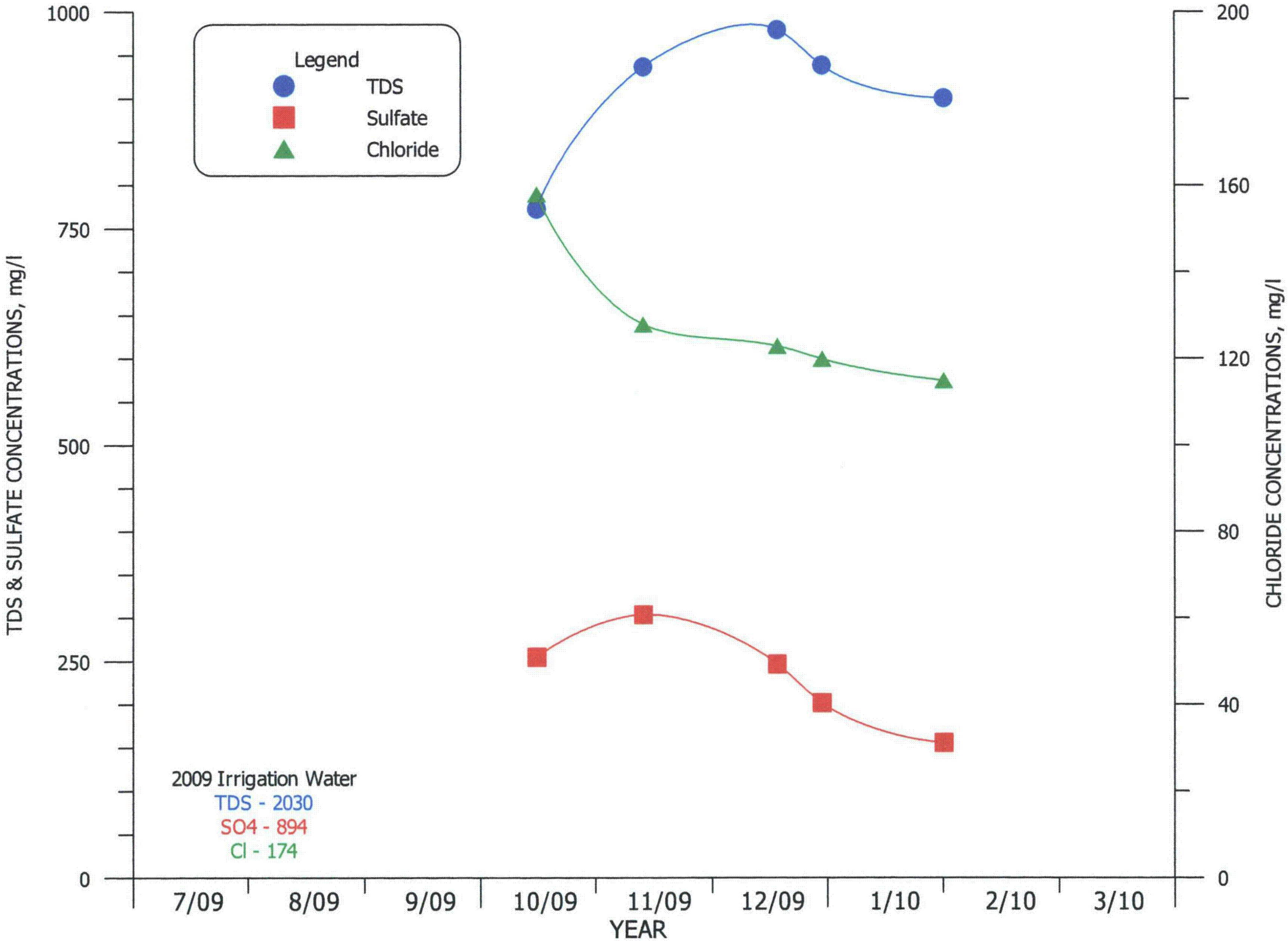


FIGURE 3-32. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY28-2M.

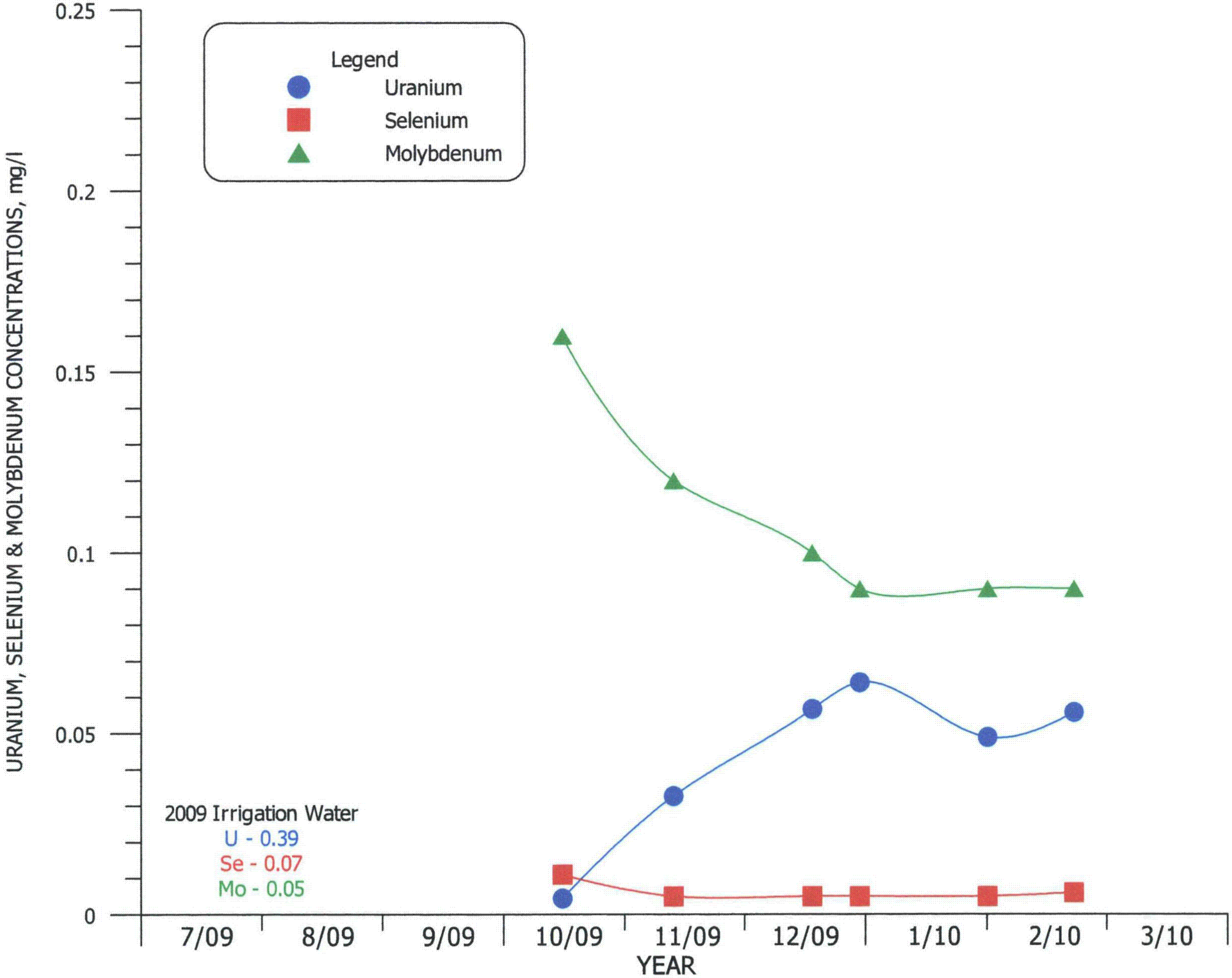


FIGURE 3-33. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY28-2M.

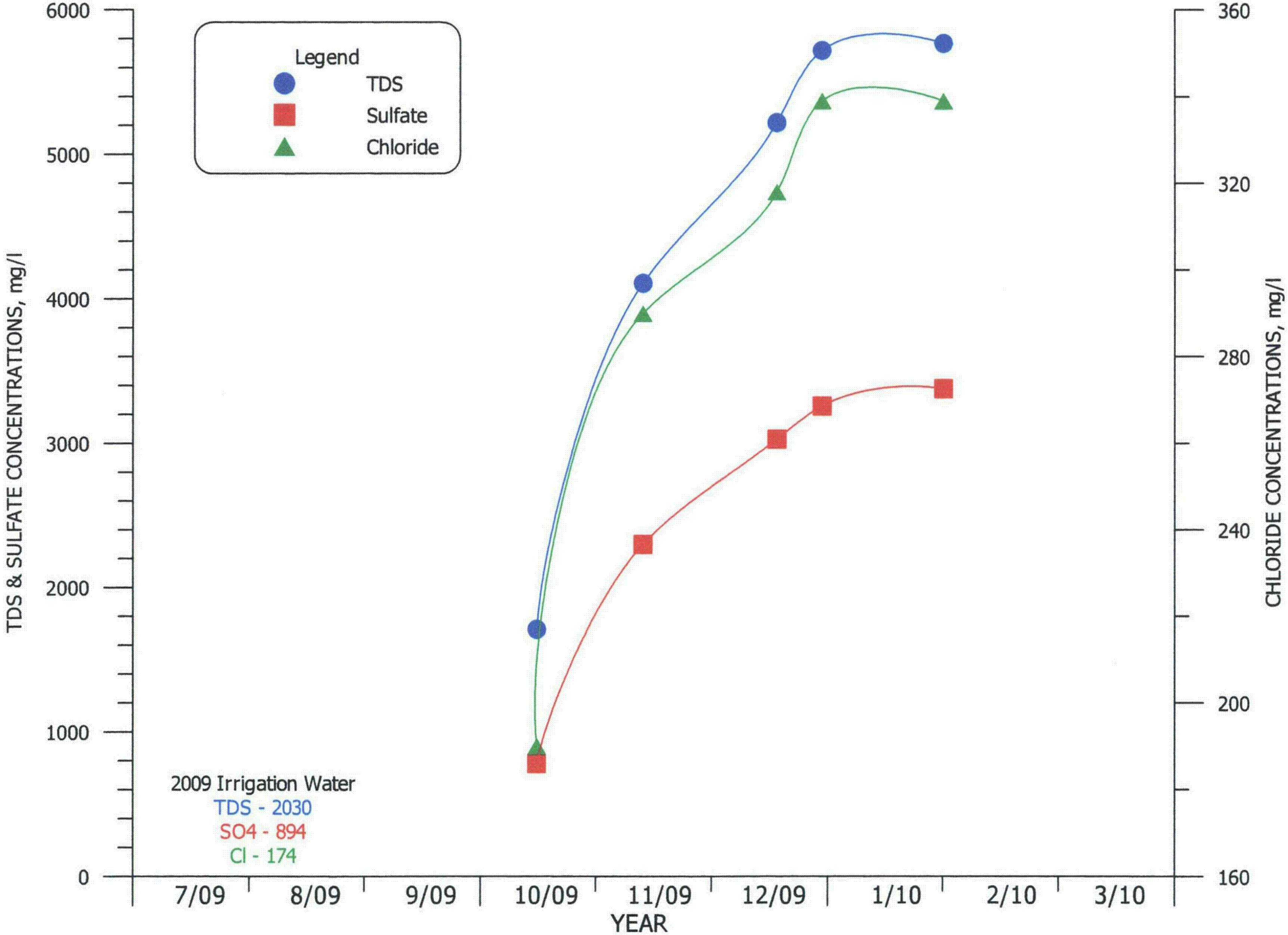


FIGURE 3-34. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY28-3.

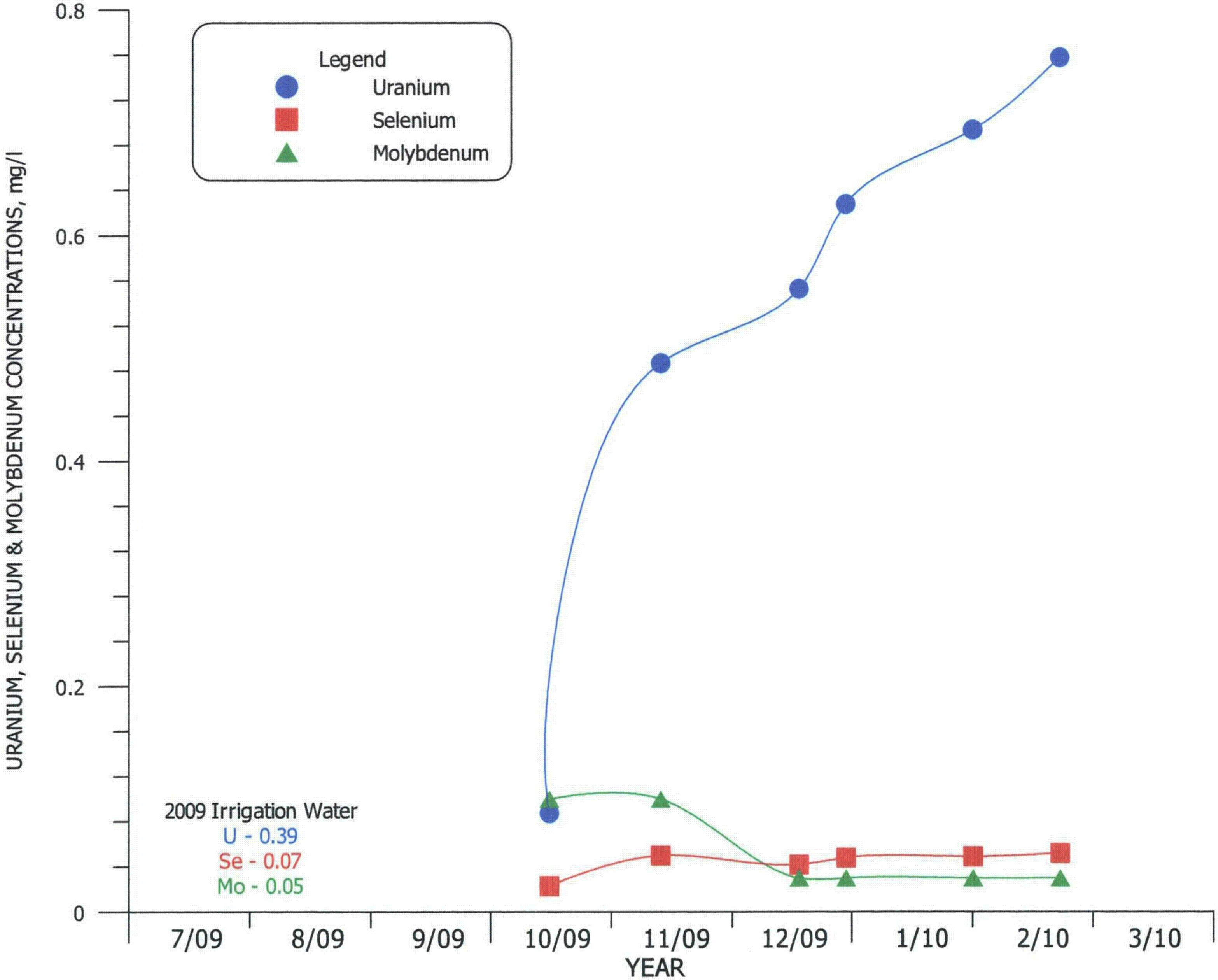


FIGURE 3-35. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY28-3.