EVALUATION OF POTENTIAL NITRATE AND
HEXAVALENT CHROMIUM SOURCES IN THE
VICINITY OF THE UCD LEHR FACILITY
FOR
UNIVERSITY OF CALIFORNIA, DAVIS

Dames & Moore

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1.0 INTRODUCTION

The Laboratory for Energy-Related Health Research (LEHR) has been operated by the University of California, Davis (UCD) for the U.S. Department of Energy (DOE) for 30 years to conduct studies on the long-term biological effects of low-level radiation. Laboratory animals and over 1,000 beagles, held in outdoor cages, were studied during this time. Also located beneath and adjacent to LEHR are the old campus landfill, which was closed in 1966, and a campus low-level radioactive waste disposal site, which was closed in 1974.

Due to public concern regarding the potential environmental impacts of LEHR and the landfills, water samples were collected from eight private wells in the site vicinity in October, 1989 by UCD staff. The wells which were sampled are shown on Figure 1. Chemical analyses of these samples indicated that the Maximum Contaminant Level (MCL) drinking water standard for nitrate was exceeded in four wells (Table 1). In addition, hexavalent chromium was reported at concentrations at, or in excess of, the MCL in three of these same four wells. The MCL for nitrate is 10 mg/l if reported "as nitrogen". The MCL for hexavalent chromium is 0.05 mg/l.

2.0 OBJECTIVE

The goal of this investigation was to review existing information and collect new data to evaluate whether the nitrate and hexavalent chromium detected in the nearby private wells was more likely to have originated from LEHR of from other sources. Other potential nitrate sources identified in the region include agricultural use of fertilizers, domestic septic systems, large concentrations of confined animals, and sewage treatment outfalls. Other potential sources for hexavalent chromium include geochemical mobilization from natural soil material derived from weathering of the Coast Ranges, wood preservatives, fungicides, industrial wastewater effluent, or the metallic fixtures in the well and pump installations.

3.0 SCOPE OF WORK

In order to meet the goals of this project, a phased investigation was recommended by Dames & Moore. These phases consisted of the following:

Task 1 - Verification Sampling of Domestic Wells

- Re-sampling of the domestic wells which contained nitrate levels in excess of the MCL (Miller, I. Hamel, O. Hamel, Nishi, and Roth domestic wells) in order to verify the October results;
- Collection of water samples from the UCD sewage outfall upstream of LEHR; and
- Analyses of collected samples for nitrate and hexavalent chromium.

Task 2 - Review of Existing Data

- Review of off-site domestic well chemical data;
- Review of existing data regarding groundwater gradients and regional nitrate distribution;
- Review of available private supply well construction data; and
- An assessment of other potential sources of nitrate and hexavalent chromium, such as the UCD sewage treatment plant outfall into Putah Creek, domestic septic systems, natural concentrations in soils, and residues of agricultural activities.

Task 3 - Interpretation of Data and Report Preparation

- Prepare a written report at the conclusion of Tasks 1 and 2 to present the data, summarize the findings, draw conclusions, and make recommendations for further work.

4.0 RESULTS OF VERIFICATION SAMPLING

4.1 PRIVATE WELLS

In December, 1989, five of the initial eight wells were re-sampled for the purpose of verifying the October, 1989 analytical data. The wells which were re-sampled were the Rust, I. Hamel, Roth, O. Hamel and Miller wells. The analytical results from these samples verified the earlier analytical results (Table 1). In addition, the Nishi irrigation and domestic wells were sampled in December, 1989 and January, 1990, respectively.

The location of the sampled wells and the maximum detected nitrate values are shown on Figure 2. The Roth and Miller wells, located approximately 1,500 feet south-southwest of LEHR, and the South Fork of Putah Creek, had maximum nitrate levels of 35 mg/l as N and 20.0 mg/l as N, respectively. The Nishi irrigation well, located approximately 1,000 feet east of LEHR and north of the South Fork of Putah Creek, had a maximum nitrate level of 5.2 mg/l as N. The I. Hamel and the O. Hamel wells are about 8,000 feet and 10,000 feet to the northeast, respectively and close to the North Fork of Putah Creek. These wells had maximum nitrate concentrations of 20.0 mg/l as N and 12.0 mg/l as N, respectively. The Nishi domestic well, about 6,000 feet north-northeast of LEHR, had 30 mg/l nitrate as N in the January, 1990 water sample. The Martinelli domestic and irrigation wells are located approximately 3,000 feet east of LEHR and south of Putah Creek. In October, 1989 they had nitrate levels of 5.1 mg/l as N and 1.6 mg/l as N, respectively.

4.2 UCD SEWAGE OUTFALL

In January, 1990 a sample was collected from the UCD Sewage Treatment Plant outfall to Putah Creek, just up-stream of LEHR (Figure 1). This sample contained 12.5 mg/l nitrate as N, which exceeds the MCL. Hexavalent chromium was not detected in this sample. A verification sample was collected in March, 1990 from the outfall and analyzed for nitrate only. This analysis indicated the presence of nitrate at 11.6 mg/l as N. Nitrate levels in the outfall are not normally measured, so it is uncertain how representative these values are of historical concentrations.

In January, 1990 water samples were collected and analyzed from Putah Creek downstream of the sewage outfall. Water analyzed from these samples had reported concentrations of nitrate as nitrogen between 2.1 mg/l and 4.4 mg/l. Concentrations of hexavalent chromium at levels between 0.01 mg/l and 0.02 mg/l were also reported.

5.0 REVIEW OF EXISTING DATA

5.1 GROUNDWATER LEVEL ELEVATIONS

Groundwater level elevations from wells south of the City of Davis were obtained from the California Department of Water Resources (DWR). These elevations were used to estimate the regional groundwater gradient around the LEHR facility. Both domestic and irrigation wells were used. Well depths varied from 134 to 393 feet below ground surface. The shallowest screened interval is from 100 to 120 feet below ground surface while the deepest is from 312 to 324 feet, implying that the contours represent a composite of depths and not a single discrete depth zone.

Three separate groundwater contour maps were plotted from the data collected (Figures 3 - 5). Each map shows seasonal changes in groundwater levels reflecting the beginning (Spring levels) and end (Autumn levels) of the irrigation season. Three separate years were chosen to determine possible changes in groundwater flow over time. The years plotted represent the extreme conditions of drought (1977, Figure 3) and wet (1983, Figure 4) years, and recent time (1989, Figure 5).

Although the figures show that groundwater levels vary greatly over time, the general direction of flow from west to east is consistent in all three years. The direction of flow appears to be preserved from season to season and year to year. Only during the Fall of 1977 (Figure 3) do water levels reflect a localized change in flow direction. Contours of groundwater levels east of Davis for Fall, 1977 suggest a southerly flow direction which may be the result of low groundwater levels and heavy pumping south of that area.

Spring groundwater levels seem to show an influence from Putah Creek suggesting significant recharge of groundwater from the creek south and east of LEHR. Isolated lows seen in the spring of 1977 and 1983 may be the result of pumping effects from irrigation wells.

The west to east direction of flow is important in relation to the location of LEHR and the private wells which were sampled for nitrate and hexavalent chromium. These wells are located south, east and northeast of the facility (Figure 1). For groundwater to flow towards all of these wells from LEHR, a reversal in the groundwater gradient would be required or a groundwater mound would need to exist under the site. However, as shown on Figures 3 through 5, a west to east groundwater flow direction is predominant and reversals in regional groundwater flow are not apparent.

5.2 NITRATE DISTRIBUTION

Historic nitrate data compiled from government agencies including the Solano County Health Department, the University of California at Davis, the DWR, and the United States Geological Survey (USGS) are plotted on Figure 2. Much of the data are more than 20 years old, especially from DWR, and were collected from a variety of well depths (Table 2). However, some trends can be inferred from the data shown.

Nitrate levels seem to decrease with depth. This is seen in wells 8N/2E - 13F1, F2 and F3 with the shallowest well showing the highest levels of nitrate.

Areas of elevated concentrations of nitrate in groundwater occur throughout the area. Approximately one mile north of the Highway 113/I-80 interchange, three UCD wells show nitrate as N above 10 mg/l (Figure 2). However, well construction information for these wells was not available from DWR, so it was not possible to determine what zone these wells are screened over and, hence, what is the likely source of nitrate present in the groundwater. The area around well 8N/2E-13F1, south of I-80 and approximately one mile west of Mace Boulevard, showed a reported high value of nitrate in a shallow well (41.0 mg/l nitrate as N).

5.3 HEXAVALENT CHROMIUM DISTRIBUTION

Hexavalent chromium was detected in all private wells which were sampled (Table 1). Measured concentrations in the I. Hamel, O. Hamel, Miller, and Nishi domestic wells were at or slightly in excess of the 0.05 mg/l MCL. As discussed in Section 5.1, and shown on Figures 3, 4, and 5, these four wells are not directly down-gradient from LEHR.

Regional data on hexavalent chromium concentrations in groundwater were not available from any of the public agencies identified in this report. U.S. Geological Survey investigations of groundwater quality in Yolo and Solano Counties have detected total chromium levels between zero and 0.04 mg/l (Evenson, 1985). The highest concentration was observed in a well located just to the southwest of Davis, up-gradient of LEHR. It is possible that biogeochemical reactions in nitrate-rich subsurface environments could result in the oxidation of chromium occurring naturally in soils to hexavalent chromium.

5.4 LAND USE

The area around LEHR is predominantly agricultural. Information from the Solano County Agriculture Commissioner's office shows a variety of crops grown in this area, including tomatoes, wheat, oats, barley, corn and possibly safflower (Figure 6).

Recommended fertilizer application rates in the LEHR area range from 60 pounds of nitrogen per acre for oats to 240 pounds of nitrogen per acre for corn (Table 3). Actual rates may vary depending on the grower. Crops grown adjacent to the LEHR facility over the last four years are shown on Figure 6. According to information provided by the Solano County Department of Agriculture, 899 acres within the areas outlined on Figure 6 were actively farmed during this period. Based on the crops grown and the recommended application rates, approximately 424,000 pounds of nitrogen were applied to these fields between 1986 and 1989.

Research by the University of California, Division of Agricultural Sciences was conducted to determine the amount of nitrate that may reach groundwater from agricultural fertilizers. This research indicated that, for corn, if fertilizer is applied at a rate equal to 100% of the plant's nitrogen requirement, up to 32% of the nitrogen is lost either by conversion to nitrogen gas or by leaching of nitrate to groundwater (University of California, 1980). In addition, if over-fertilization occurs, over 50% of the fertilizer nitrogen can be lost in the same manner. Similar results were also inferred for wheat, cotton, and tomatoes. Assuming that over-fertilization did not occur and one-half of the 32% nitrogen loss reaches the groundwater in the form of nitrate, then approximately 16,960 pounds of nitrate as N per year could have reached groundwater due to normal agricultural practices from the areas outlined in Figure 6.

In order to estimate the potential nitrate release to groundwater from the beagles which were housed at LEHR, UCD small animal specialist Jim Morris, was consulted. Mr. Morris estimated that a beagle would consume 300 grams of food per day, 60 grams of which would be protein. Of the protein, about 10 grams would be nitrogen. Furthermore, nearly all of the nitrogen would be excreted, and not retained by the dog.

If it is assumed that a beagle has an average life span of 10 years, then one dog would take in 36,500 grams of nitrogen, equivalent to 80.3 pounds of nitrogen, during its life. Over 30 years, approximately 1,000 beagles were studied at LEHR, implying that 80,300 pounds of nitrogen may have been released. This is equivalent to about 2,700 pounds of nitrogen per year. It is likely that 50% to 75% of this nitrogen may be lost to the air or taken up by plants, leaving only 675 to 1,350 pounds of nitrate as N per year to potentially migrate to groundwater.

Other sources of nitrate in the area surrounding LEHR include animal pens and corrals, domestic septic systems, and the UCD sewage outfall into Putah Creek. The average nitrate concentration in the sewage effluent has been about 12 mg/l as N based on samples analyzed in January and March, 1990. The minimum average flow rate from the sewage treatment plant has been 1,000,000 gallons per day. Therefore, the outfall contributes approximately 100 pounds of nitrogen per day, or over 36,500 pounds per year.

Public agency files were checked for quantitative information on animal pens and domestic septic systems. Reliable information which could be used to assess nitrate loading from these potential sources could not be located.

5.5 PRIVATE WELL INFORMATION

The DWR keeps records for wells drilled in the State of California. Well logs normally contain well construction information including the screened interval and the presence of a sanitary seal. A well log search was conducted for the five domestic wells located near LEHR which had nitrate levels in excess of the MCL (Miller, Roth, Nishi, O. Hamel and I. Hamel). The information found is summarized in Table 4. A log was found for the Miller and Roth irrigation wells, but none were found for the domestic wells on these same properties. Two logs which seem to correspond to the Nishi domestic and irrigation wells were found and logs for wells which correspond to locations at the O. Hamel and I. Hamel properties were also found. However, it was difficult to accurately associate these wells with the proper well log. In addition, information on the logs was incomplete.

The depth of the wells sampled varies from approximately 260 to 400 feet below ground surface with screened intervals ranging from about 100 to 340 feet below ground surface (Table 4). Only the log for the Nishi domestic well, drilled in 1971, mentioned that it had no sanitary seal. The other logs had no information regarding the presence or absence of sanitary seals.

Pump rates for the wells will vary greatly depending on their use. The estimation of flow rates, depending on the use of the well, is only approximate and can vary depending on individual and local needs. For example, water use for domestic purposes can vary from 40 gallons per day per person to 127 gallons per day per person (Tchobanoglous and Schroeder, 1987) and averages about 58 gallons per day. For a family of four this is equivalent to about 0.16 gallons per minute. Driscoll (1986) reports a domestic well might supply about 150 gallons per day. The actual flow rate from the well would be sporadic, cycling off and on as required, with flows probably averaging about five gallons per minute when the pump is on.

Flow rates for irrigation wells can also be extremely variable, depending on pump size, depth to water, pump efficiency, number of wells utilized, crop needs which are dictated by crop type, soil type and time of year. In general, water requirements based on flow rates from irrigation wells are usually very high compared to rates from a domestic well. Flows from an irrigation well are possibly an order of magnitude or more than flows from a domestic well, for example 50 gallons per minute compared to 5 gallons per minute.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The private supply wells which had reported levels of nitrate and hexavalent chromium levels in excess of MCL's are located southwest, east, and northeast of LEHR. These wells are in areas which can be considered hydraulically up-gradient, side-gradient, and down-gradient of the LEHR site. In addition, the Martinelli wells and the Nishi irrigation well, which are located just down-gradient of the site (Figure 1) did not exhibit nitrate and hexavalent chromium levels in excess of the respective MCL's (Table 1).

Hexavalent chromium was detected in all of the sampled private wells and in the South Fork of Putah Creek. The variation in concentrations between these wells is much smaller than the variation in nitrate concentrations. Hexavalent chromium could be sourced naturally from sediments which have come from the Coast Ranges to the west through processes of geochemical mobilization which may be present in the nitrate-rich aquifers. Other sources of hexavalent chromium include incinerator ash and metal plating wastes. However, sufficient regional data does not exist to completely evaluate the source or sources of hexavalent chromium.

If the regionally elevated nitrate concentrations result from major distinct point sources, then the nitrate impacted groundwater should exist as distinct plumes containing high nitrate concentrations which are surrounded by areas with very low or non-detectable nitrate levels. However, the distribution of elevated nitrate concentrations in wells (Figure 2) compared to regional groundwater gradients (Figures 3, 4, and 5) does not indicate the presence of localized plumes emanating from specific sources, such as LEHR. The pattern is more suggestive of large areas which have been impacted by numerous point sources or diffuse areal (non-point) sources.

Details regarding the construction and completion of the private wells can not be well-documented because of the lack of reliable and accurate well logs, construction details, and pump rate data available from DWR. In addition, at least one of the domestic supply wells does not have a sanitary seal. These factors make it difficult to evaluate and exclude the possibility that nitrate could be channeled down the well casings from shallow surface sources such as agricultural fertilizers, animal pens, or septic leach fields near the domestic and irrigation wells.

A 1988 State Water Resources Control Board paper titled "Nitrate in Drinking Water Report to the Legislature" (1988) reviewed nitrate contamination in groundwater. This report found fertilizer use along with individual waste disposal systems and large concentrations of confined animals to be significant sources for nitrate in groundwater. All of these potential sources are found around in the vicinity of LEHR and may be contributing to elevated nitrate concentrations.

The critical factors in determining the contribution from potential nitrate sources are the source magnitude and source location. Mass loading calculations indicate that normal agricultural practices in the area could be contributing ten times the amount of nitrate to groundwater than LEHR has, on an annual basis. Furthermore, the UCD sewage outfall may be contributing twenty times the amount of nitrate than LEHR has, on an annual basis. The wells which are directly down-gradient of LEHR (Nishi irrigation, Martinelli domestic and irrigation) had some of the lowest nitrate levels measured in the private wells. The wells which had the highest nitrate levels (Nishi domestic, Miller, Roth, I. Hamel) are located in areas which are not directly down-gradient of LEHR. This is especially significant with regards to the Miller and Roth wells.

These factors imply that the LEHR site is not the likely sole source for elevated nitrate levels observed in private wells in the area and may not even be a major source. Other potential sources include domestic septic systems, the UCD sewage outfall to Putah Creek, agricultural fertilizer application, and past or current domestic animal enclosures. Overall, it appears that the elevated nitrate levels, as well as the hexavalent chromium levels, in the domestic wells are part of a regional pattern.

6.2 RECOMMENDATIONS

If further quantification of other potential sources of nitrate is required, Dames & Moore recommends that the following steps be taken:

- Regular sampling of UCD sewage outfall and analysis for nitrate, ammonia, and Total Kjeldahl Nitrogen (TKN). Monitoring of effluent volumes and comparison with creek stage at several locations at and downstream of the outfall will permit the calculation of nitrate mass loading to groundwater.

- Soil sampling and analysis for nitrate in areas adjacent to private wells to assess agriculturally related sources.

- A cement bond log and video survey of each private well to evaluate the presence and condition of sanitary and grout seals, casing, and screened section. The condition of the well and pumping equipment should be assessed first, however, to avoid possible damage to the well.

- Future water samples from the private wells should be analyzed for fecal coliform, sodium, and linear alkylbenzene sulfonate (LAS) or other chemical additives to assess any potential contribution form domestic septic systems.

In addition, in order to fully document groundwater flow directions and transport pathways, we recommend that both a shallow aquifer (70 feet) and a deep aquifer (100 - 120 feet) well be installed adjacent to LEHR and south of the South Fork of Putah Creek.

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Evenson, K.D., 1985, Chemical quality of groundwater in Yolo and Solano Counties, California, U.S. Geological Survey, Water-Resources Investigations Report 84-4244.

State Water Resources Control Board, 1988, Nitrate in Drinking Water Report to the Legislature, Report No. 88-11WQ, Division of Water Quality, 53 pgs.

Tchobanoglous, G. and E. D. Schroeder, 1987, Water Quality, Addison-Wesley, Reading, Massachusetts, 768 pgs.

University of California, Division of Agricultural Sciences, 1980, Nitrate losses from irrigated croplands, leaflet.

TABLE 1
UCD LEHR

NITRATE AND HEXAVALENT CHROMIUM RESULTS

	October 1989 Sampling Round		December 1989 Sampling Round		
Well	Nitrate as N(mg/l)	Cr VI (mg/l)	Nitrate as N(mg/l)	CR VI(mg/l)	Location
Rust	2.1	0.02	2.7	0.02	~1 mile NE of LEHR
I. Hamel	20.0	0.06	16.5	0.06	~1 mile NE of LEHR
Roth	35.0(18.5)(D)	0.04	18.2	0.04	South of Putah Creek, SW of LEHR
O. Hamel	12.0	0.05	11.2(10.5)(D)	0.04(0.05)(D)	~1 mile NE of LEHR
Martinelli(Dom.)	5.1	0.03	NA	NA	South of Putah Creek
Martinelli(Irr.)	1.6	0.02	NA	NA	South of Putah Creek- .9 miles East of Old Davis Road
Miller	17.0(20.0)(D)	0.05	17.6(17.6)(D)	0.05(0.05)(D)	South of Putah Creek, SW of LEHR
Nishi(Irr.)	NA	NA	5.2	0.04	Adjacent to eastern University property line, NE of UCD-10
Nishi (Dom).	NA	NA	30(A)	0.06(A)	~1 mile N of LEHR

Notes:

NA - not analyzed
(A) - sampled January 1990
(D) - duplicate analysis in parenthesis

TABLE 2A - SUMMARY OF NITRATE DATA FROM USGS AND DWR

Well	Depth (feet)	Screened Interval (feet)	Nitrate as N (Mg/l)	Date Sampled
8N/2E-13E2	120		0.2	5/53
			13.9	10/55
8N/2E-13F1	100		5.2	2/55
8N/2E-13F2	300	280-300	0.86	7/50
			0.80	6/57
			0.84	7/58
			0.98	8/59
			1.1	7/60
			0.77	7/61
			0.77	7/62
			0.86	7/65
8N/2E-13F3	57		41.0	6/56
8N/2E-13H2	148		1.9	8/69
			3.6	7/79
			5.9	8/85
8N/2E-14M3	204		3.0	9/70
			1.3	7/80
8N/2E-15B1		312-324	0.68	7/31
8N/2E-15J2	150		1.1	8/31
8N/2E-15M2	322		0.23	6/31
			0.68	7/31
			0.91	9/31
8N/2E-15P1[1]			1.2	1/85
8N/2E-16A1	352		2.0	6/50
8N/2E-16M1	137	126-137	0.68	6/31
			0.91	7/31
8N/2E-16N1	268	262-268	0.68	6/31
8N/2E-16Q1	1450		5.2	1/53
8N/2E-18C1[1]			7.4	1/85
8N/2E-18R2	494		2.5	7/50
8N/2E-19BX1	120	100-120	1.1	7/31
8N/2E-20B1[1]			5.5	1/85
8N/2E-21B2[1]			0.45	1/85
8N/2E-21G2	123		1.4	7/52
8N/2E-21K1	1400		0.20	11/71
			0.14	8/82
8N/2E-24H1	1030		4.5	11/50
8N/2E-24J3[1]			1.6	1/85
8N/2E-27Q1	144		1.8	7/52
8N/2E-29G1[1]			0.97	1/85
8N/2E-35B1[1]			ND	1/85
8N/2E-35E1	226	212-220	0.23	8/31
8N/2E-35G2	93		2.5	10/52

[1] - Data from USGS WRI 84-4244, (1985)
ND - Not Detected

TABLE 2B - SUMMARY OF NITRATE DATA FROM UNIVERSITY OF CALIFORNIA CAMPUS IRRIGATION WELLS AND SOLANO COUNTY HEALTH DEPARTMENT

Well[1]	Nitrate as N (mg/l)	Date Sampled
A1	5.9	6/27/88
BG-NORTH	3.6	6/27/88
BG-SOUTH	4.1	6/27/88
C2H	6.8	6/27/88
C2F	4.1	6/27/88
DGA	2.5	6/27/88
E2A	7.3	6/27/88
E3B	10.0	6/27/88
E3D	8.0	6/27/88
E4A	11.6	6/27/88
E5	14.8	6/27/88
E8	6.1	6/27/88
F1	5.5	6/27/88
G6	5.9	6/27/88
A[2]	9.1	1985
A[2]	2.8	1984

[1] - No well construction information available.
[2] - Data from Solano County Health Department

TABLE 3 - FERTILIZER APPLICATION RATES FOR VARIOUS CROPS IN THE VICINITY OF UCD LEHR

Crop	Lbs of N/Acre
Barley	80-100
Beans	80
Corn	240
Oats	60
Tomatoes	120
Wheat	120

NOTE:

Values reported are in pounds of nitrogen per acre independent of form of fertilizer. One pound of nitrogen is equivalent to 4.4 pounds of nitrate or one pound of nitrate "as nitrogen". One pound is equal to 453,592 mg.

TABLE 4 - CONSTRUCTION DETAILS OF VARIOUS WELL LOGS

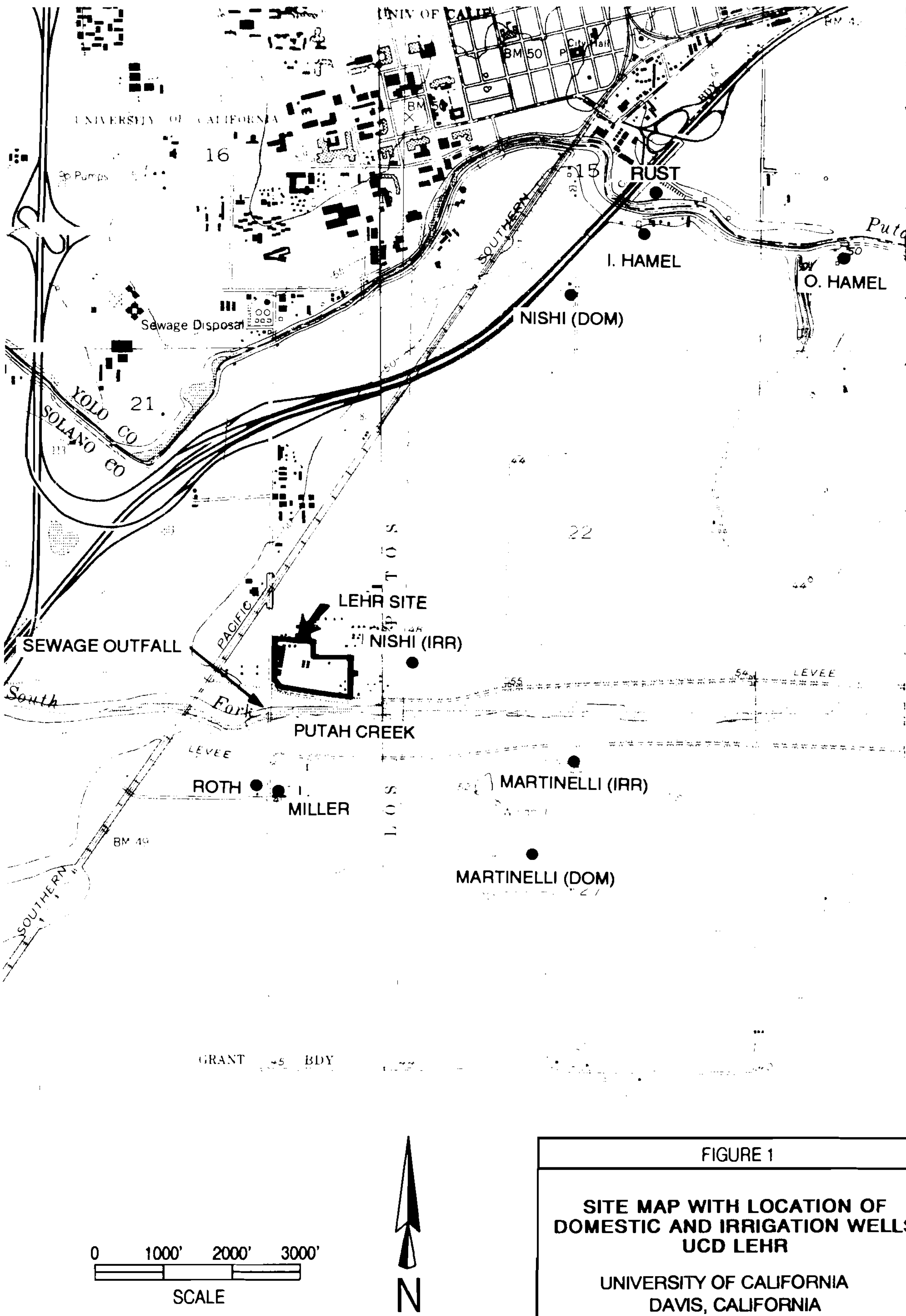
Owner	Depth (ft)	Screened Interval(ft)	Sanitary Seal	Use	Year Drilled
Roth[1]	260	100-160	-	Irr	'79
Miller[1]	265	198-265	-	Irr	'79
I. Hamel	340	105-340	-	-	'38
O. Hamel	403	-	-	-	-
Nishi (Dom)	308	184-188 264-308	NONE	Irr[2]	'71
Nishi (Irr)	281	70-286	-	-	-

NOTES:

- Not recorded on log

1 Log does not correspond with sampled well of same name.

2 Use on log does not correspond to use reported to UCD.



REFERENCE:
MERRITT & DAVIS, CALIFORNIA
7.5' QUAD. MAPS, 1952

FIGURE 1

SITE MAP WITH LOCATION OF DOMESTIC AND IRRIGATION WELLS UCD LEHR

UNIVERSITY OF CALIFORNIA
DAVIS, CALIFORNIA

Dames & Moore

90-154

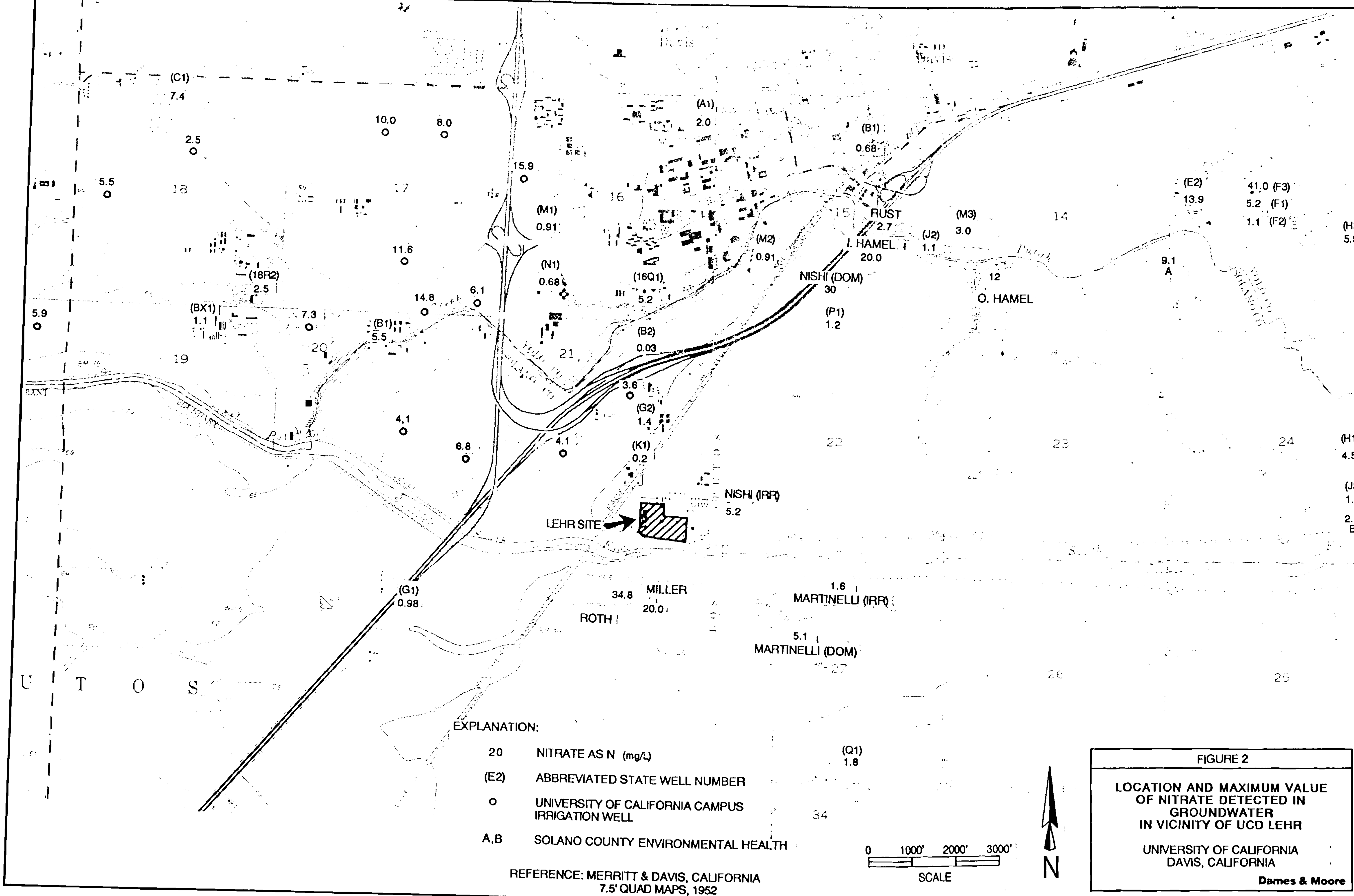
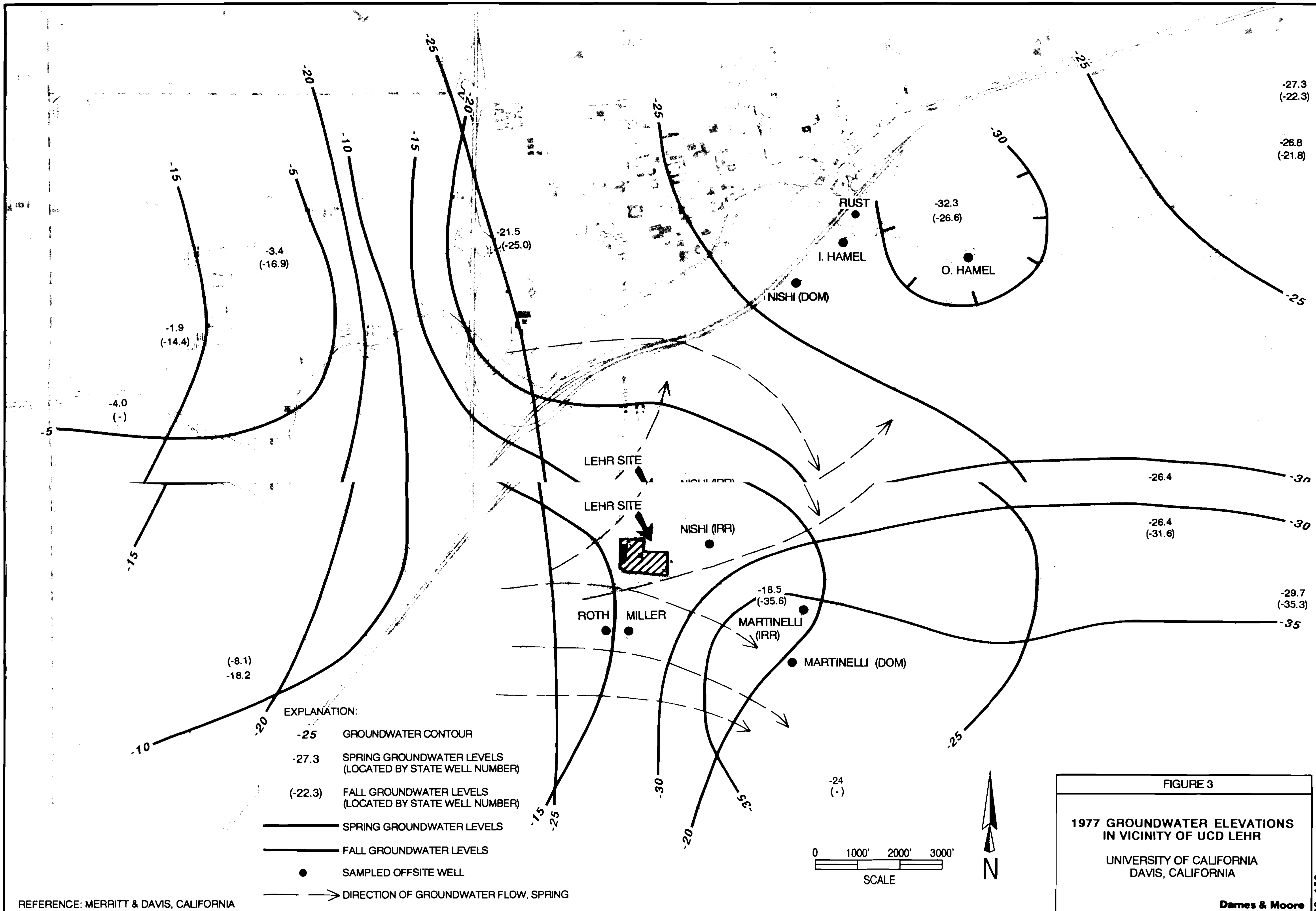


FIGURE 2

LOCATION AND MAXIMUM VALUE OF NITRATE DETECTED IN GROUNDWATER IN VICINITY OF UCD LEHR

UNIVERSITY OF CALIFORNIA
DAVIS, CALIFORNIA



-27.3
(-22.3)
-26.8
(-21.8)
RUST
-32.3
(-26.6)
I. HAMEL
O. HAMEL
NISHI (DOM)
-21.5
(-25.0)
-3.4
(-16.9)
-1.9
(-14.4)
-4.0
(-)
LEHR SITE
NISHI (IRR)
-26.4
(-31.6)
-18.5
(-35.6)
-29.7
(-35.3)
ROTH
MILLER
MARTINELLI
(IRR)
MARTINELLI (DOM)
(-8.1)
-18.2
-24
(-)
-25
-20
-15
-10
-5
-30
-35
EXPLANATION:
-25 GROUNDWATER CONTOUR
-27.3 SPRING GROUNDWATER LEVELS (LOCATED BY STATE WELL NUMBER)
(-22.3) FALL GROUNDWATER LEVELS (LOCATED BY STATE WELL NUMBER)
SPRING GROUNDWATER LEVELS
FALL GROUNDWATER LEVELS
SAMPLED OFFSITE WELL
DIRECTION OF GROUNDWATER FLOW, SPRING
DIRECTION OF GROUNDWATER FLOW, FALL
0 1000' 2000' 3000'
SCALE
N
REFERENCE: MERRITT & DAVIS, CALIFORNIA
7.5' QUAD MAPS, 1952
FIGURE 3
1977 GROUNDWATER ELEVATIONS IN VICINITY OF UCD LEHR
UNIVERSITY OF CALIFORNIA
DAVIS, CALIFORNIA
Dames & Moore
90-153

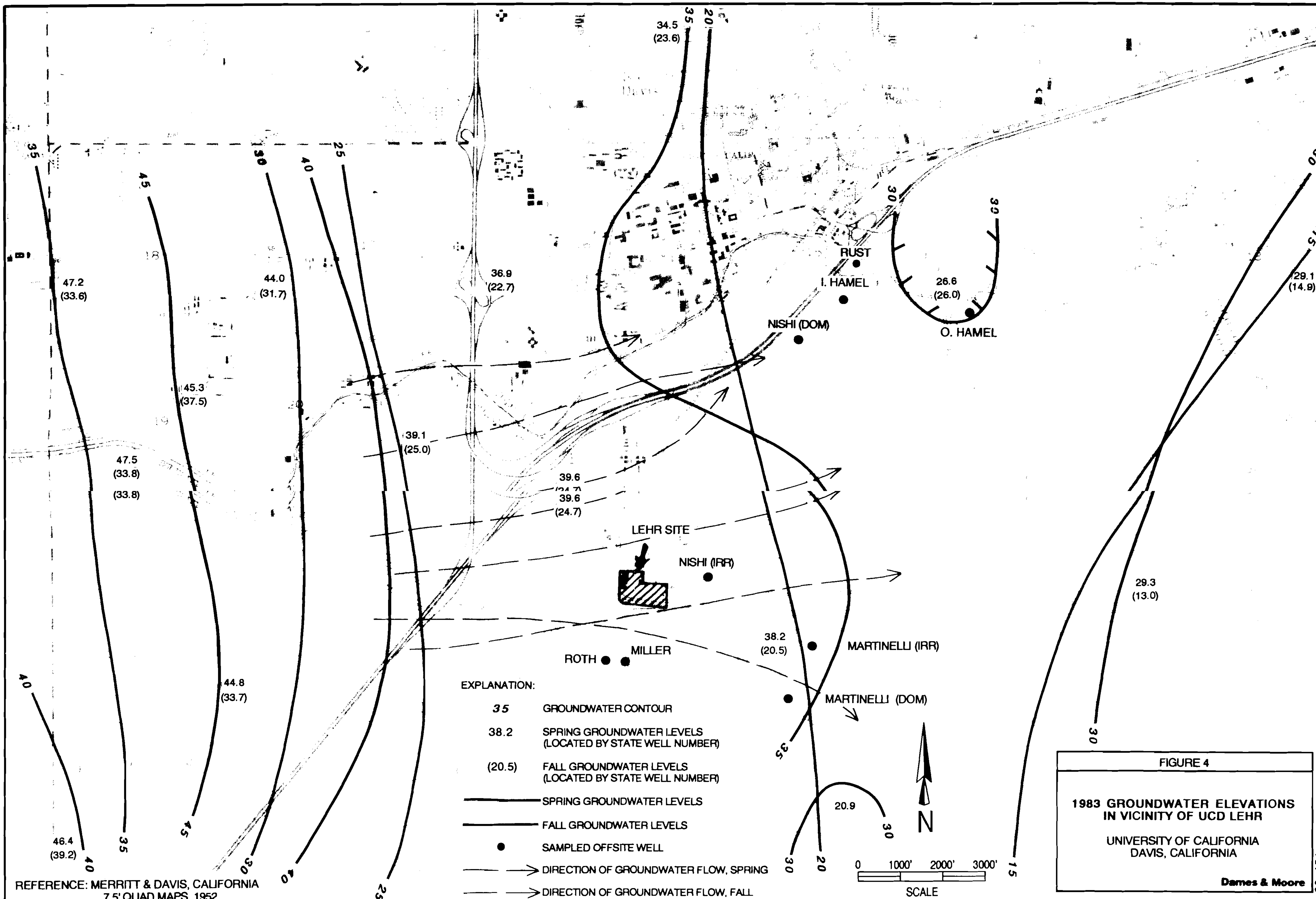
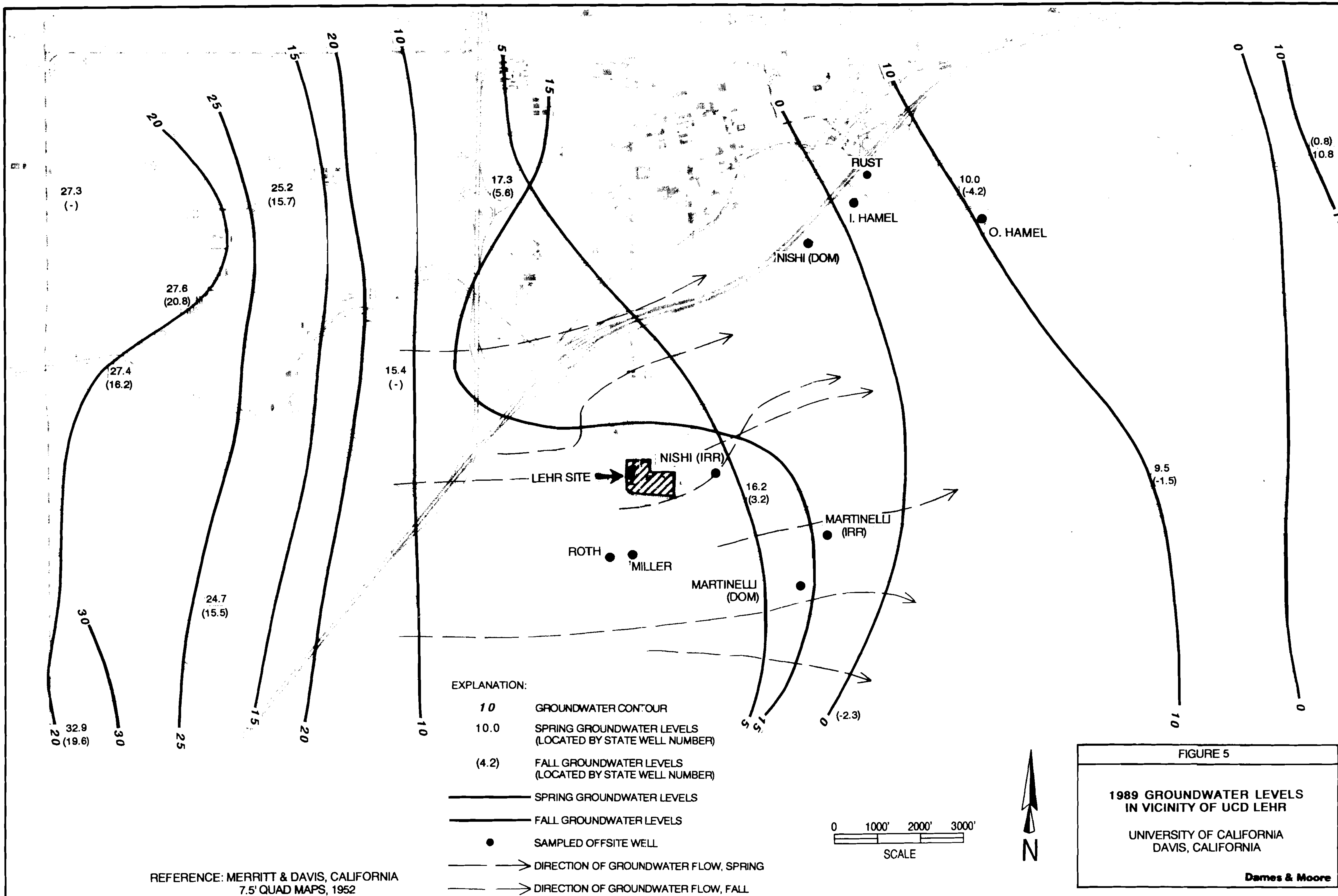


FIGURE 4

1983 GROUNDWATER ELEVATIONS IN VICINITY OF UCD LEHR

UNIVERSITY OF CALIFORNIA
DAVIS, CALIFORNIA

Dames & Moore



REFERENCE: MERRITT & DAVIS, CALIFORNIA
7.5' QUAD MAPS, 1952

FIGURE 5

1989 GROUNDWATER LEVELS IN VICINITY OF UCD LEHR

UNIVERSITY OF CALIFORNIA
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90-152

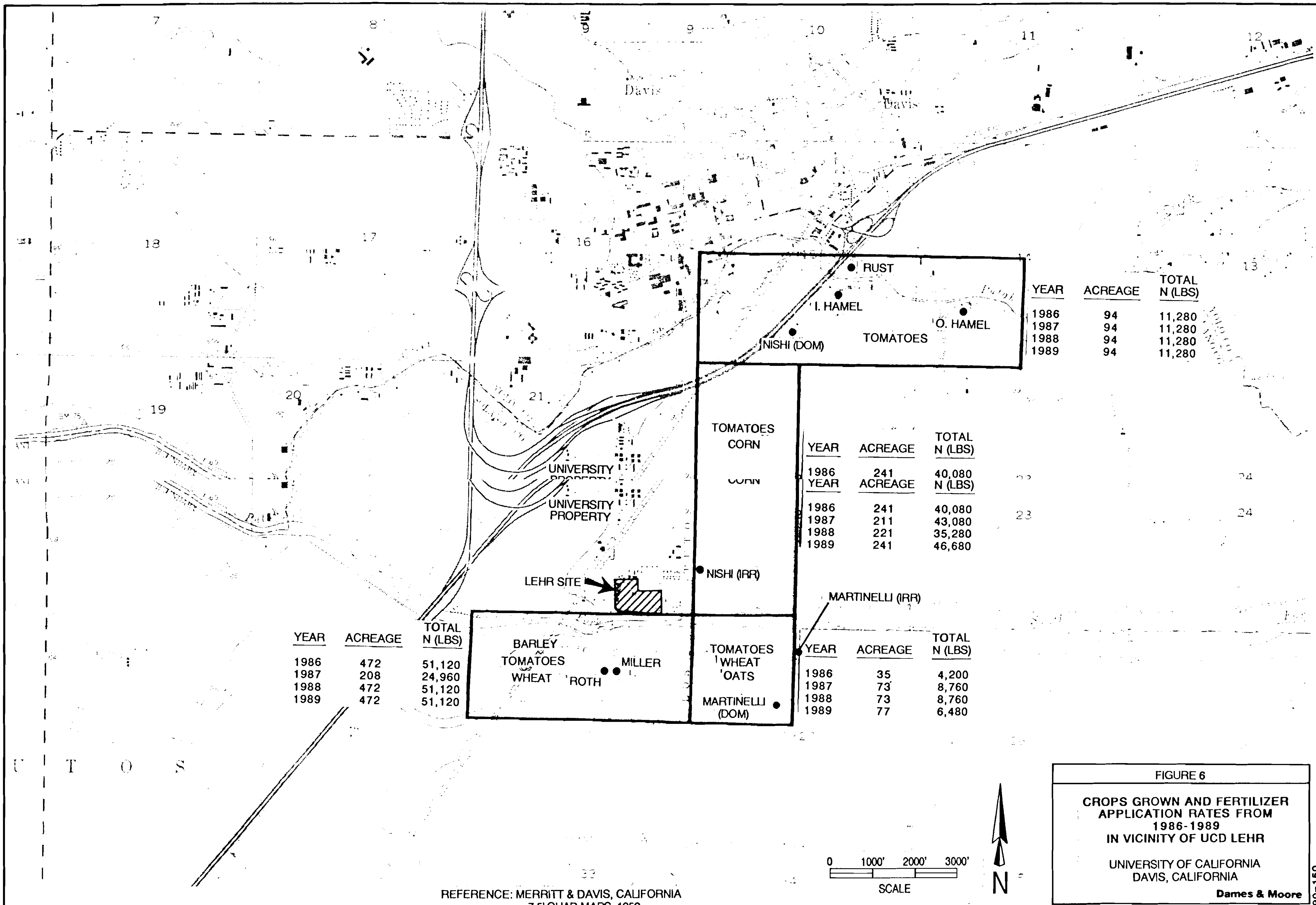

FIGURE 6

CROPS GROWN AND FERTILIZER APPLICATION RATES FROM 1986-1989 IN VICINITY OF UCD LEHR

UNIVERSITY OF CALIFORNIA
DAVIS, CALIFORNIA