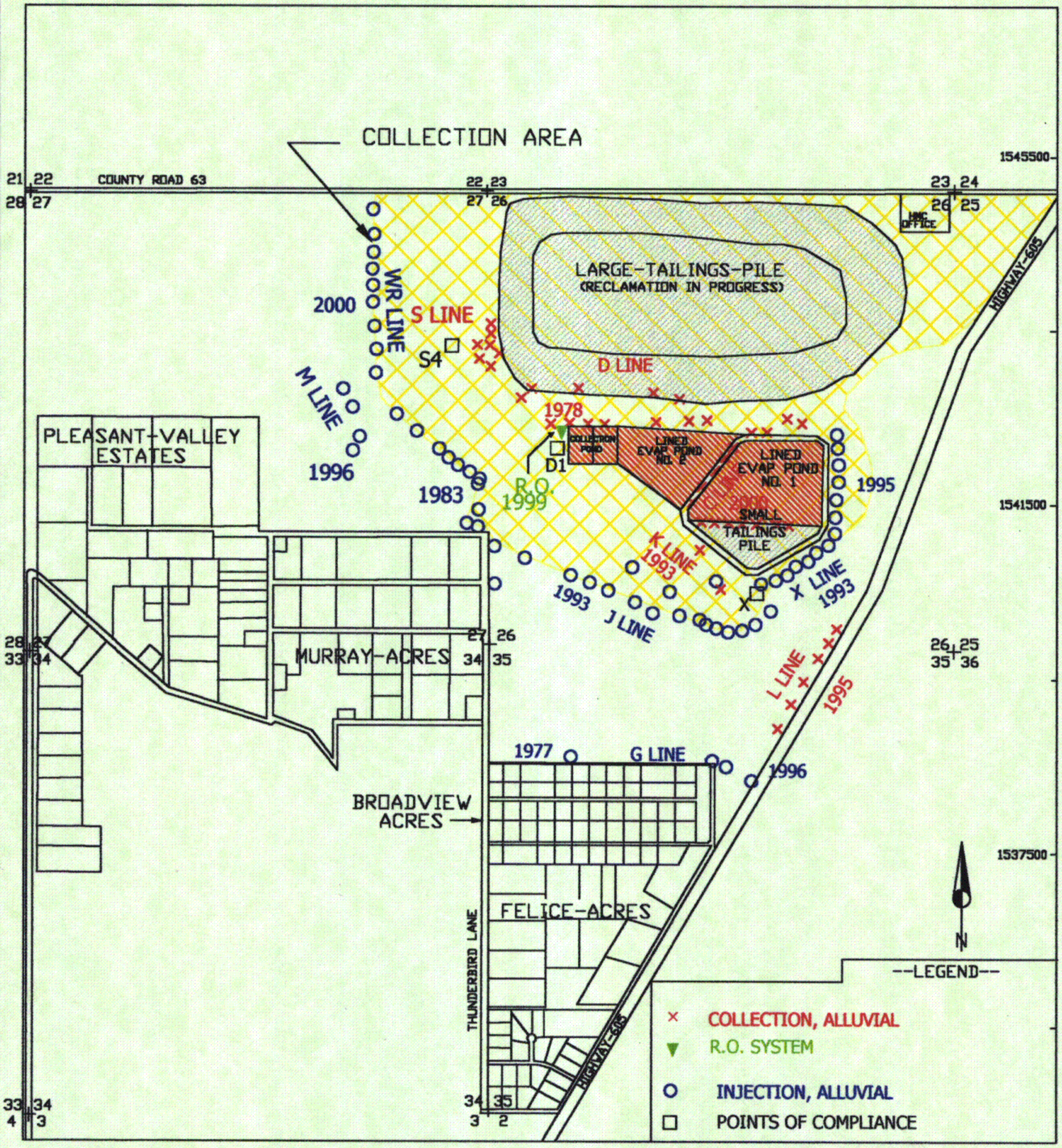

GROUND-WATER HYDROLOGY FOR SUPPORT OF BACKGROUND CONCENTRATION AT THE GRANTS RECLAMATION SITE

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GROUND-WATER HYDROLOGY
FOR SUPPORT OF BACKGROUND CONCENTRATION
AT THE GRANTS RECLAMATION SITE

FOR:

HOMESTAKE MINING COMPANY
OF CALIFORNIA

BY:

HYDRO-ENGINEERING, L.L.C.
CASPER, WYOMING

DECEMBER, 2001

GEORGE L. HOFFMAN, P.E.
HYDROLOGIST

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1.0 INTRODUCTION

This document is supporting documentation to Homestake Mining Company's (HMC) application to amend the site standards listed in license number SUA 1471, Condition 35B. The following information presents the ground-water hydrology at the Grants reclamation site relative to background water quality as revised in October of 2001.

The ground-water hydrology of the San Mateo alluvium at the Grants site was initially defined in 1976. The results of the ground-water restoration program have been defined in numerous ground-water monitoring reports for this site. The Corrective Action Program (CAP), for the Nuclear Regulatory Commission (NRC), presents the definition of the restoration program.

This information presents supporting data developed with details presented on the geologic setting and aquifer connection, aquifer properties, ground-water flow and water quality for the alluvial and Chinle aquifers. Background concentrations that are representative of this site are discussed relative to the ground-water quality in each aquifer. The figures presented in this report are numbered by the major section and located after the text of each section. The tables in this report are presented adjacent to where they are first referenced.

2.0 GEOLOGIC SETTING AND AQUIFER CONNECTIONS

Tailings at the Grants site are located on top of the alluvium and therefore the alluvial aquifer is the most important ground-water system relative to the Grants site. The surface geology and structure contours are presented on United States Geological Survey (USGS) quadrangle topographic maps. Geologic maps and other geologic information were compiled and presented by New Mexico Bureau of Mines and Mineral Resources (NMBM) and USGS reports on the area. These reports have been used in defining the geologic setting at this site but are not necessary for the background review.

The uranium ore bearing rocks that have been mined in this area outcrop in the San Mateo drainage system and contain significant natural concentrations of uranium and selenium. Therefore, the alluvial material would be expected to contain above normal concentrations of uranium and selenium that are typically present in uranium deposits. The Chinle Formation forms the base of the alluvial aquifer at the Grants site. The Chinle Formation also contains some natural uranium and selenium concentrations. Therefore, the geologic setting has significantly affected the background water quality at this site.

The hydrologic conditions in this area have been defined by New Mexico State Engineer (NMSE), USGS and NMBM reports on the area. Ground-water conditions for the Grants site have been defined in previous documents submitted to the NRC and typically referenced in the annual reports on the site. These hydrologic reports have been used in developing the hydrologic conditions presented in this report at the Grants site and are not necessary for the background review and therefore not included in this submittal. The Grants project site exists on the San Mateo alluvial system. The San Mateo alluvial system follows the San Mateo alluvium and drainage system and extends from northeast of the site to the south and west. Bedrock material exists on the surface to the northeast and southeast sides of the alluvial material. Figure 2-1 shows a typical cross section at the Grants site with saturated alluvium shown in red.

The Chinle Formation, which is a massive shale (approximately 800 feet thick) at the tailings site, exists below the alluvium. The Chinle shale is a very good aquitard and greatly restricts movement vertically from the alluvial aquifer. A few sandstones exist within the Chinle shale, which form bedrock aquifers in this area. The cross section shows the Upper Chinle sandstone in blue and shows where the Upper Chinle sandstone subcrops against the alluvial aquifer forming a direct connection between these two ground-water systems. The second major sandstone in the Chinle Formation has been named the Middle Chinle sandstone. This sandstone is shown in magenta in the cross section and also subcrops against the alluvium further south. In this cross section a third permeable zone within the Chinle shale has been defined and is called the Lower Chinle aquifer. This zone consists mainly of fractured shale and is therefore highly variable depending on secondary permeability developed in the shale. The Lower Chinle aquifer is not used very much in this area due to its depth and naturally poor water quality. A few wells are completed in the Lower Chinle aquifer due to the lack of existence of the alluvial, Upper or Middle Chinle aquifers in some areas. The San Andres aquifer exists below the Chinle Formation as is the regional aquifer in this area. The San Andres is not discussed in this report because it has not been impacted by Homestake tailings seepage.

2.1 ALLUVIAL AQUIFER

This subsection presents the geologic setting and well completions for the alluvial aquifer. The basic well data for the background alluvial wells at the Grants site are presented in Tables 2-1 and Tables 2-2. The annual reports present the basic well data for all other wells at the site. Annual reports are not presented in this submittal because they were previously submitted to the NRC and are not required for this analysis. Figures 2-2A and 2-2B show the location of the alluvial wells that have been used to define the ground-water conditions in the alluvial aquifer at the Grants site. Figure 2-2B shows the locations of the nine alluvial background wells, which are listed in Table 2-1 north of the Large Tailings. Figure 5-1 also presents the locations of the nine background wells and locations

TABLE 2-1. BASIC WELL DATA FOR GRANTS SITE BACKGROUND ALLUVIAL WELLS

WELL NAME	NORTH. COORD.	EAST. COORD.	WELL DEPTH (FT-MP)	CASING DIAM (IN)	WATER LEVEL DATE	WATER LEVEL DEPTH (FT-MP)	WATER LEVEL ELEV. (FT-MSL)	MP ABOVE LSD (FT)	MP ELEV. (FT-MSL)	DEPTH TO BASE OF ALLUVIUM (FT-LSD)	ELEV. TO BASE OF ALLUVIUM (FT-MSL)	CASING PERFOR-ATIONS (FT-LSD)	SATURATED THICKNESS
DD	1546989	488943	78.5	4.0	04/06/200	57.96	6534.63	1.9	6592.59	83	6507.7	A40-80	26.9
ND	1545927	494872	70.0	4.0	08/02/200	47.67	6545.22	1.1	6592.89	65	6526.8	A50-70	18.4
P	1546691	491058	109.1	4.0	11/28/200	53.24	6534.02	1.7	6587.26	107	6478.6	A82-112	55.5
P1	1547017	491060	105.0	6.0	11/28/200	55.75	6536.72	0.8	6592.47	105	6486.7	A60-105	50.1
P2	1546555	490912	105.0	6.0	12/04/200	61.41	6528.38	0.9	6589.79	105	6483.9	A60-105	44.5
P3	1546159	490785	95.0	5.0	03/08/200	66.91	6523.04	2.2	6589.95	85	6502.8	A55-95	20.3
P4	1546504	491899	92.0	5.0	03/08/200	85.77	6503.75	3.6	6589.52	84	6501.9	A52-92	1.8
Q	1548693	492153	98.3	4.0	03/14/200	50.11	6543.71	2.3	6593.82	100	6491.5	A72-102	52.2
R	1550372	494514	86.3	4.0	05/11/200	43.51	6560.52	0.3	6604.03	95	6508.7	A60-90	51.8

Note: A = Alluvial Aquifer
M = Middle Chinle Aquifer
T = Tailings Aquifer
* = Well Abandoned
? = Uncertain Identity

TABLE 2-2. BASIC WELL DATA FOR GRANTS SITE FAR UPGRADIENT WELLS

WELL NAME	NORTH. COORD.	EAST. COORD.	WELL DEPTH (FT-MP)	CASING DIAM (IN)	WATER LEVEL DATE	WATER LEVEL DEPTH (FT-MP)	WATER LEVEL ELEV. (FT-MSL)	MP ABOVE LSD (FT	MP ELEV. (FT-MSL)	DEPTH TO BASE OF ALLUVIUM (FT-LSD)	ELEV. TO BASE OF ALLUVIUM (FT-MSL)	CASING PERFOR-ATIONS (FT-LSD)	SATURATED THICKNESS
0914	1555500	500850	—	6.0	05/09/200	40.06	6601.94	1.4	6642.00	—	—	A-	—
0916	1552350	499600	160.0	4.0	—	—	—	0.0	6625.00	—	—	A45-70	—
0920	1555800	496900	—	7.0	—	—	—	0.7	6627.60	—	—	A-	—
0921	1555400	495800	—	5.0	05/09/200	38.60	6585.40	1.9	6624.00	—	—	A-	—
0922	1555200	492500	—	6.0	05/10/200	53.00	6568.70	1.7	6621.70	—	—	A-	—
0950	1560400	498300	81.0	5.0	07/12/200	25.70	6631.30	0.5	6657.00	—	—	A-	—

Note: A = Alluvial Aquifer
M = Middle Chinle Aquifer
T = Tailings Aquifer
* = Well Abandoned
? = Uncertain Identity

of the six far upgradient wells which are listed in Table 2-2. Figures 2-2A and 2-2B present the current operation of injection and collection wells and is subject to change with this dynamic restoration program. The limits of the alluvial aquifer are shown by delineating the area where the alluvium is not saturated by the green dotted pattern.

Homestake has drilled nearly 500 wells at the Grants site. The logs from these wells and residential wells not owned by Homestake have defined the base of the alluvium in detail. Figures 2-3A and 2-3B present the base of the alluvial contours, which show that an alluvial channel runs through the western portion of the Large Tailings and turns to the southwest near the southwest corner of the Large Tailings. The base of the alluvium contains contours of higher elevations in eastern Murray Acres, which extend back to the northeast toward the Small Tailings pile. This area tends to decrease the amount of alluvial water flowing in this area. The edge of the alluvial aquifer is defined where the base of the alluvium is equal to the water-level elevation. The green line and green dotted pattern shows where the alluvium is not saturated and is the limits of the alluvial aquifer. The San Mateo alluvium joins the Rio San Jose alluvium in the western portion of Section 28. The southern channel joins the Rio San Jose in the eastern portion of Section 4.

2.2 UPPER CHINLE AQUIFER

The Upper Chinle aquifer is important to this site because direct connection between this aquifer and the alluvium exists in the tailings area. The rate of water from the alluvium into the Upper Chinle aquifer is important in the subcrop areas. The Upper Chinle aquifer is not as important as the alluvial aquifer, but the ground-water hydrology conditions for this aquifer are important with respect to potential discharge from the tailings.

The Upper Chinle aquifer is the uppermost sandstone in the Chinle Formation and is shown in blue in Figure 2-1 on the typical cross section. The Upper Chinle Sandstone subcrops against the alluvial aquifer in some areas of the project site. Figure 2-4 shows the location of the typical cross section A – B (Figure 2-1).

The limits of the Upper Chinle aquifer are also shown on Figure 2-4. The green pattern shows where the Upper Chinle Sandstone exists between the two faults with Chinle shale above the Upper Chinle Sandstone. The Upper Chinle does not extend to the west of the West Fault but subcrops against the alluvial aquifer on its western and southern borders.

The crosshatched blue pattern shows where the Upper Chinle exists east of the East Fault with the shale above the sandstone. The red pattern shows where the Upper Chinle aquifer subcrops against the alluvium and a crosshatched red pattern shows where the alluvium is saturated over the subcropped Upper Chinle Sandstone. Figure 2-4 shows the locations of the Upper Chinle wells while basic well data for the Chinle wells is presented in annual reports.

The top of the Upper Chinle aquifer is the most important geologic feature of the Upper Chinle Sandstone because the elevation of this unit and the base of the alluvial aquifer define where these two aquifers are in direct connection. Two faults exist in the area of the Grants site and are significant in definition of the Upper Chinle structure. Numerous cross sections have been developed to correlate geophysical logs in Upper Chinle drill holes and wells. These cross sections were used in developing these structure maps. Figure 2-5 presents the elevation of the top of the Upper Chinle aquifer. This figure shows that the Upper Chinle Sandstone between the two faults generally dips to the east. The general dip is also to the east, east of the East Fault. The structure on the south side of the project area turns and dips to the northeast at a steeper gradient, which causes the sandstone to subcrop in the area of southern Felice Acres with the alluvial aquifer.

2.3 MIDDLE CHINLE AQUIFER

The Middle Chinle aquifer is important to this site because direct connection between this aquifer and the alluvium exists in the south side of Felice Acres. The Middle Chinle aquifer is not as important as the alluvial aquifer, but the ground-water hydrology conditions for this aquifer are important with respect to restoration of low concentrations in the Felice Acres area in the Middle Chinle aquifer. The rate of ground-water flow from the alluvium into the Middle Chinle is also important in the subcrop areas.

The Middle Chinle aquifer is generally the thickest of the sandstones in the Chinle Formation. Figure 2-1 shows a typical cross section of the bedrock aquifers in this area.

This figure shows Chinle shale existing between the Upper Chinle and the Middle Chinle Sandstones. The Middle Chinle Sandstone subcrops against the alluvial aquifer in some areas of the project site.

The limits of the Middle Chinle aquifer are shown on Figure 2-6. The light blue pattern shows where the Middle Chinle Sandstone exists between the two faults with Chinle shale above the Middle Chinle Sandstone. The Middle Chinle extends to the west of the West Fault in a limited area. This area is shown in dark blue. The red pattern shows where the Middle Chinle exists east of the East Fault with the shale above the sandstone. The brown pattern shows where the Middle Chinle aquifer subcrops against the alluvium and a crosshatched brown pattern shows where the alluvium is saturated over the subcropped Middle Chinle Sandstone. Figure 2-6 shows the locations of the Middle Chinle wells.

Figure 2-7 presents the structure on top of the Middle Chinle sandstone. This structure map shows the elevation of the top of the Middle Chinle sandstone on each side of the two faults in the area of the Grants tailings and the displacement of these sandstones. This structure map was developed in the same manner as the Upper Chinle sandstone structure map. The Middle Chinle sandstone also dips at a steeper rate in southern Felice Acres, which causes the Middle Chinle sandstone to subcrop against the alluvium on the south side of Felice Acres. This allows a direct connection between the Middle Chinle and alluvial aquifers. Multi-well pump tests in the Middle Chinle aquifer have shown that all three of the Middle Chinle aquifer zones in this area act as separate aquifers except for the Middle Chinle aquifer near the southern end of the East Fault where the displacement of this sandstone ceases.

The Upper and Middle Chinle limits and elevation maps show where the Upper and Middle Chinle sandstones are in direct connection with the alluvial aquifer. Additional connections have been formed by residential wells that were not properly sealed. These connections allow the alluvial aquifer and the associated Chinle aquifer to act as one

ground-water system near the areas of the subcrops. The alluvial aquifer has changed the water quality in the Chinle sandstone aquifers near the subcrop areas due to this direct connection.

2.4 LOWER CHINLE AQUIFER

The Lower Chinle aquifer is important to this site because direct connection between this aquifer and the alluvium exists to the southwest of the site in its subcrop area. The Lower Chinle aquifer is not as important as the Middle Chinle aquifer, due to less use and generally a natural poorer quality of water.

The Lower Chinle aquifer is the permeable zone in the lower portion of the Chinle Formation. Secondary permeability in this portion of the Chinle shale is adequate in some locations to allow this zone to be an aquifer. Figure 2-1 shows a typical cross section of the bedrock aquifers in this area. This figure shows the Lower Chinle aquifer not being continuous due to the lack of permeability in some areas. The Lower Chinle aquifer subcrops against the alluvial aquifer in some areas to the southwest of the project site.

The limits of the Lower Chinle aquifer are shown on Figures 2-8A and 2-8B. The red pattern shows where the Lower Chinle aquifer exists east of the West Fault with Chinle shale above the Lower Chinle zone. The Lower Chinle aquifer is connected on both sides of the East Fault south of the area where this fault ceases. Therefore, in the main area of interest in the Lower Chinle, the aquifer is one unit on both sides of the East Fault. The Lower Chinle does extend to the west of the West Fault and is shown with the blue crosshatched pattern. The Lower Chinle subcrops against the alluvial aquifer in the orange pattern. The crosshatched pattern shows where the Lower Chinle aquifer subcrops against saturated alluvium. Figures 2-8A and 2-8B show the locations of the Lower Chinle wells. Homestake drilled more than half of the Lower Chinle wells (all of the CW wells and well 853), for definition of this aquifer and only a few of the 12 remaining wells are routinely used as a water supply.

The top of the Lower Chinle aquifer is the most important geologic feature of the Lower Chinle because the elevation of this unit and the base of the alluvial aquifer defines where these two aquifers are in direct connection. Two faults exist in the area of the Grants site and are significant in definition of the Lower Chinle structure. Numerous cross sections have been developed to correlate geophysical logs in Lower Chinle drill holes and wells. These cross sections were used in developing these structure maps. Figures 2-9A and 2-9B present the elevation of the top of the Lower Chinle aquifer. These figures show that the Lower Chinle between the two faults generally dips to the east near the tailings. The general dip is also to the east, west of the West Fault near the tailings. The structure on the south side of the project area turns and dips to the north-northeast at a steeper gradient, which causes the unit to subcrop in an area in Sections 3, 4, 28 and 33 with the alluvial aquifer.

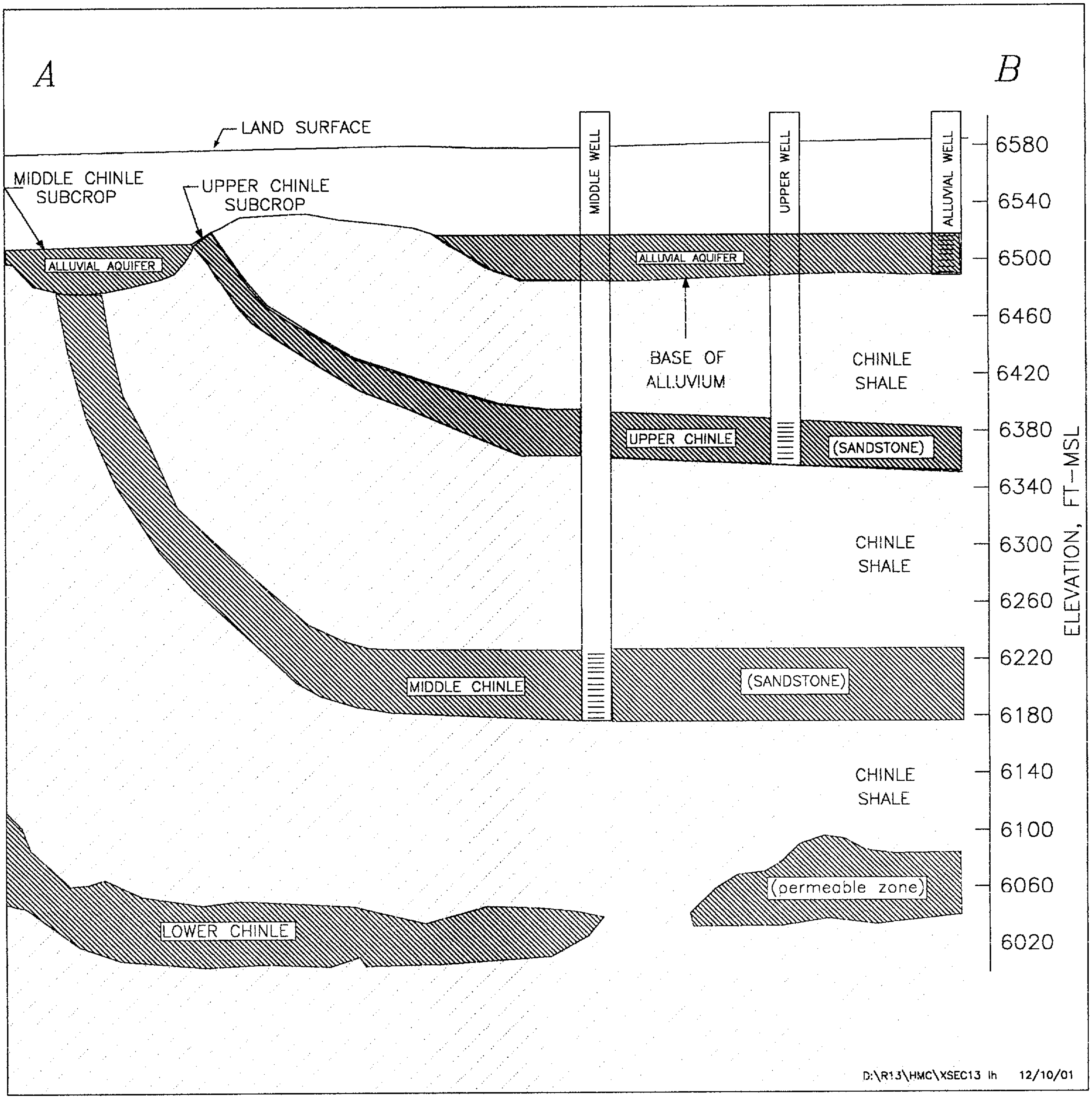
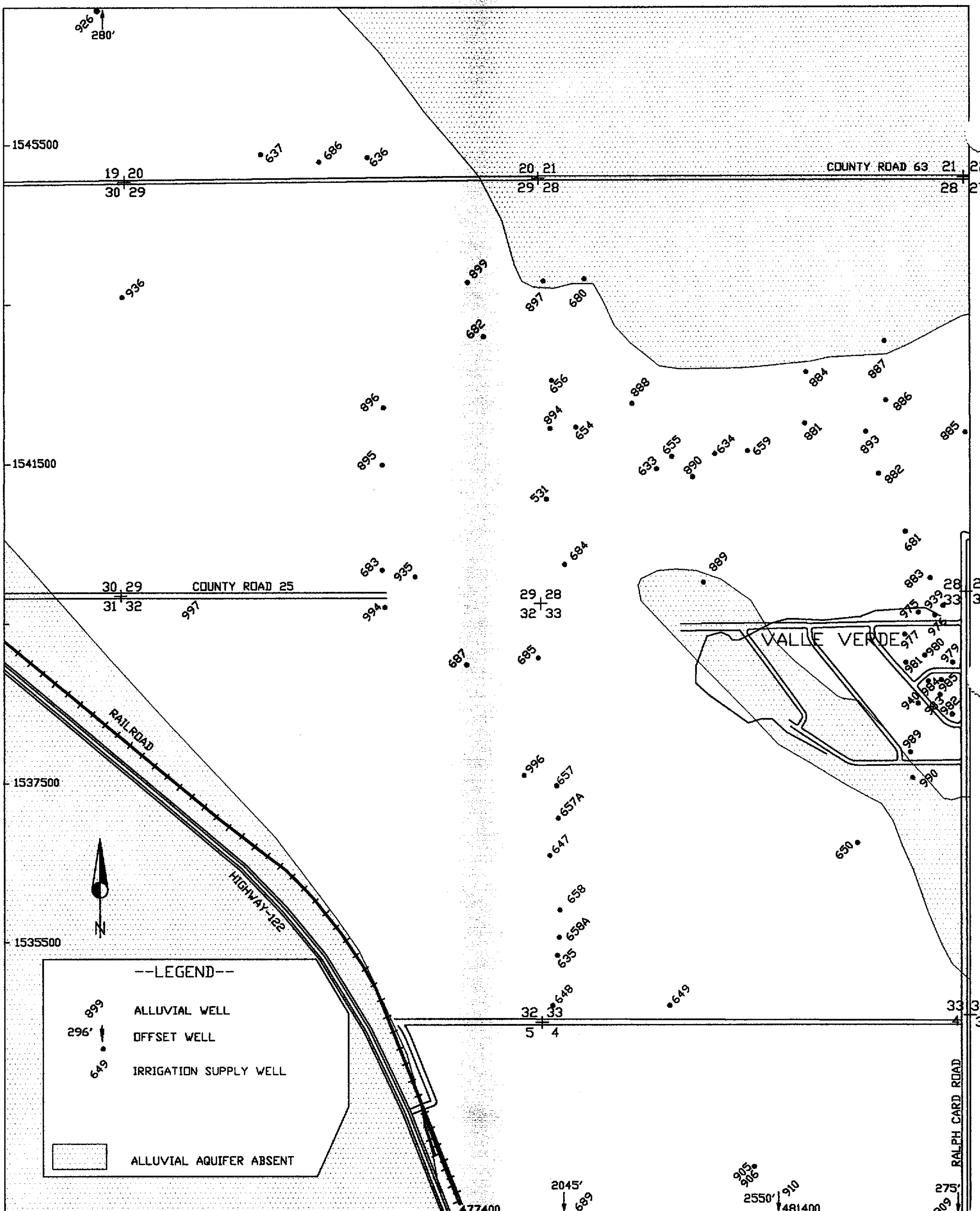


FIGURE 2-1. TYPICAL GEOLOGIC CROSS SECTION SHOWING CHINLE CONNECTION WITH THE ALLUVIAL AQUIFER



SCALE: 1"=1600'	HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W	DATE: 08/16/01

FIGURE 2-2A. ALLUVIAL WELL LOCATIONS AND SATURATED LIMITS (WEST AREA).

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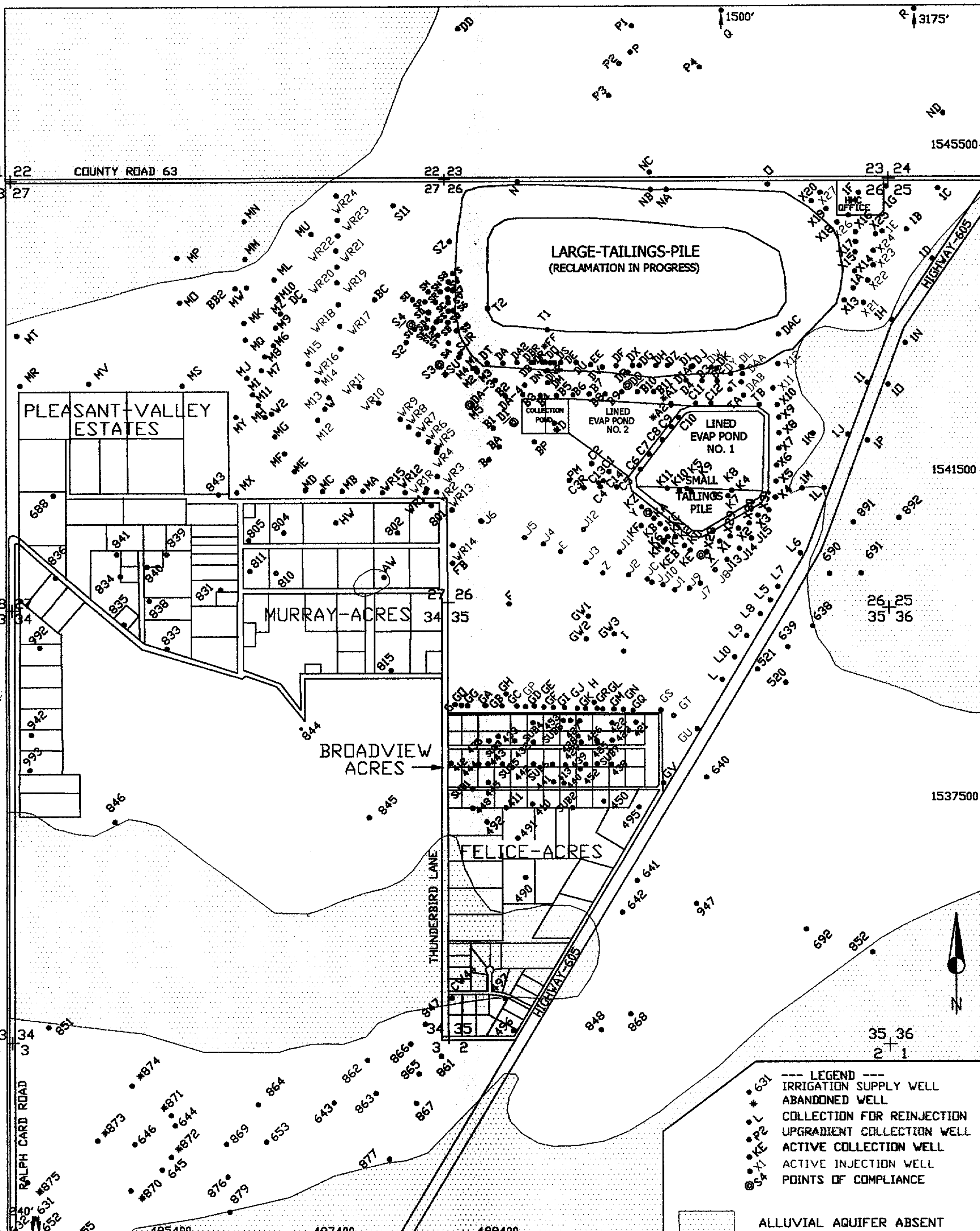

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FIGURE 2-2B. ALLUVIAL WELL LOCATIONS AND SATURATED LIMITS

PROJECTS\2001-06\DWGS\2001FIGS

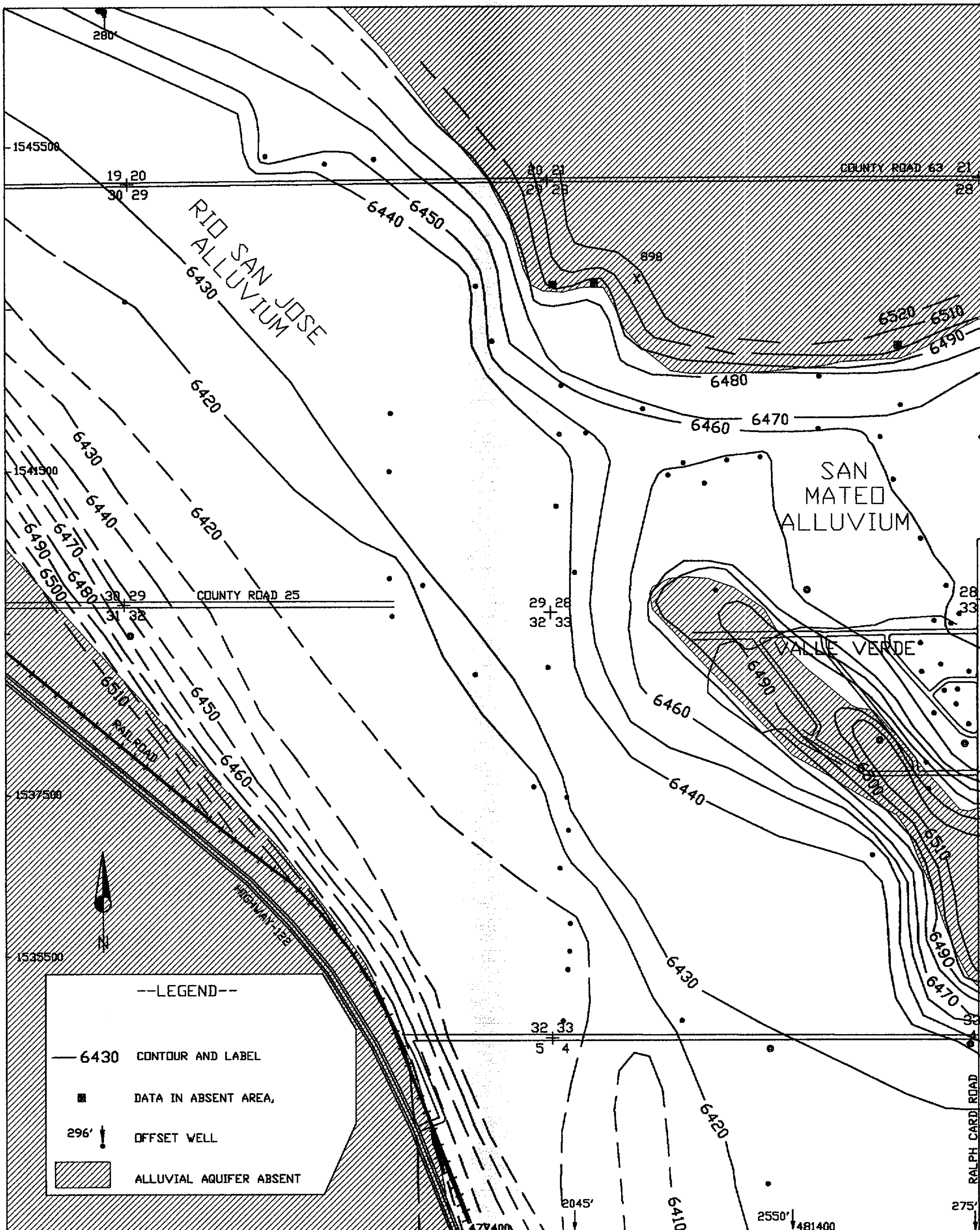

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FIGURE 2-3A. ELEVATION OF THE BASE OF THE ALLUVIUM (WEST AREA), IN FT-MSL

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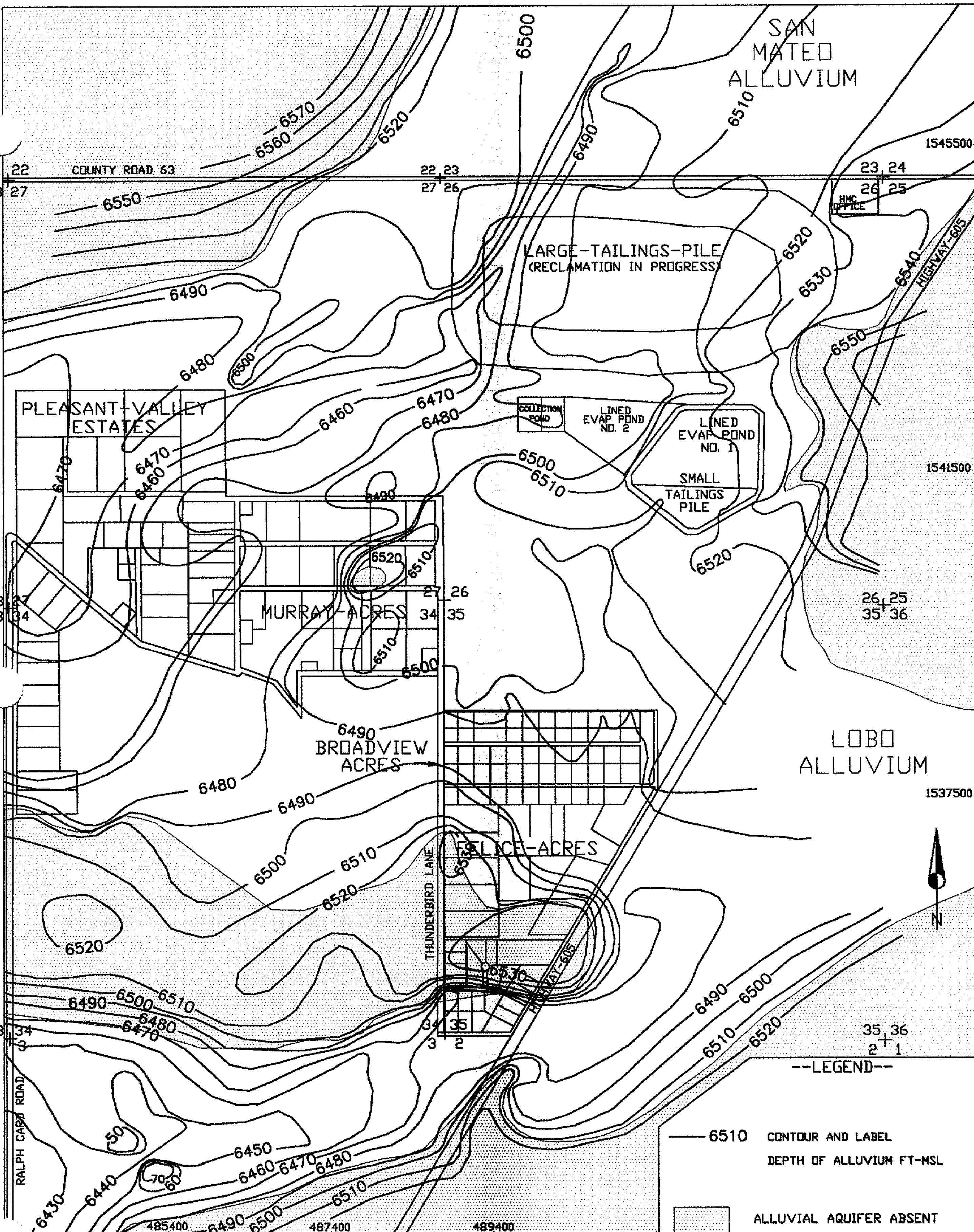

SCALE: 1"=1600' | HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W | DATE: 08/17/01 bj

FIGURE 2-3B. ELEVATION OF BASE OF THE ALLUVIUM, IN FT-MSL

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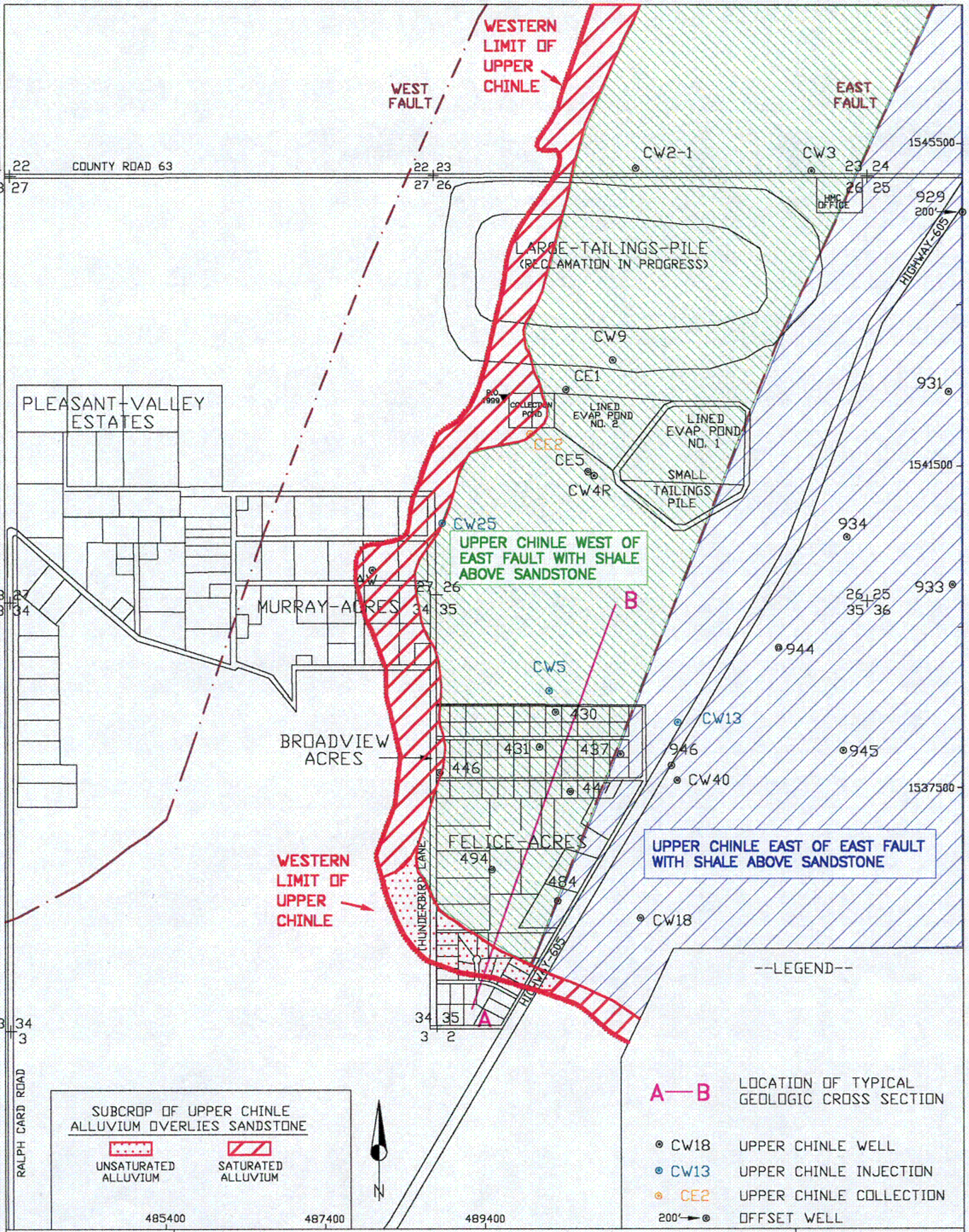

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FIGURE 2-4. LIMITS OF UPPER CHINLE AQUIFER AND WELL LOCATIONS

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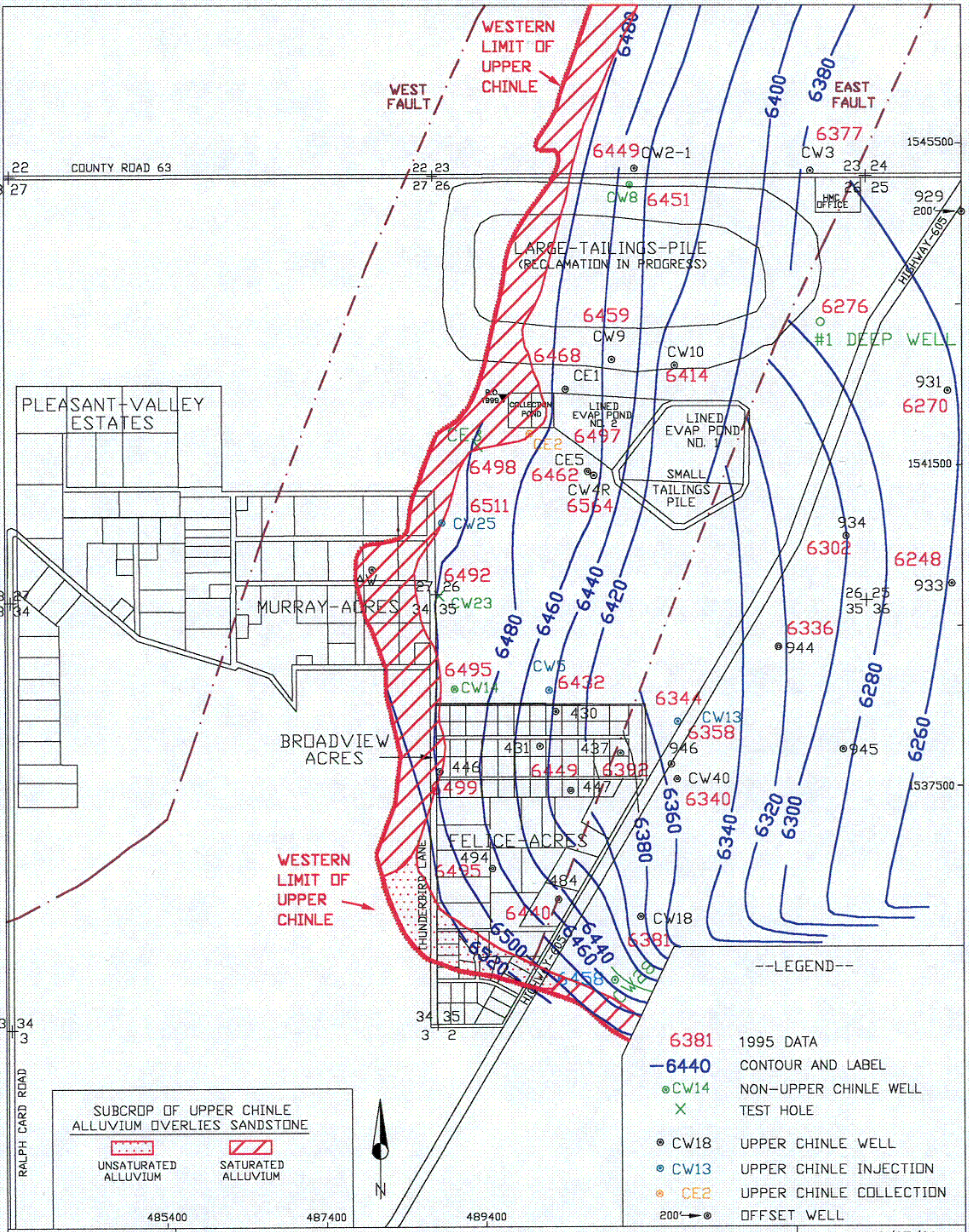

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FIGURE 2-5. ELEVATION OF THE TOP OF THE UPPER CHINLE, AQUIFER, IN FT-MSL

D\R13\HMC\UP1600

C03

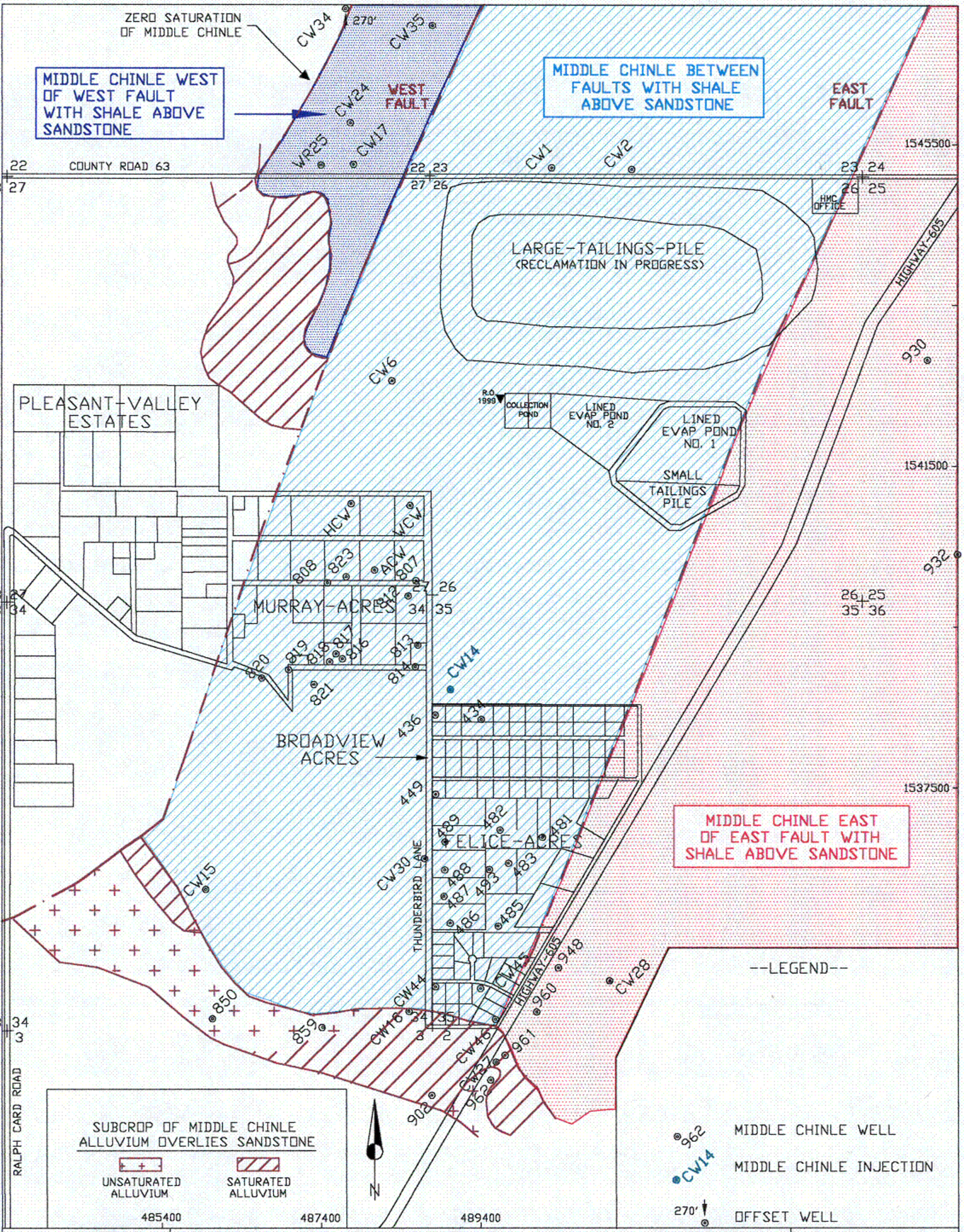

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FIGURE 2-6. LIMITS OF MIDDLE CHINLE AQUIFER AND WELL LOCATIONS

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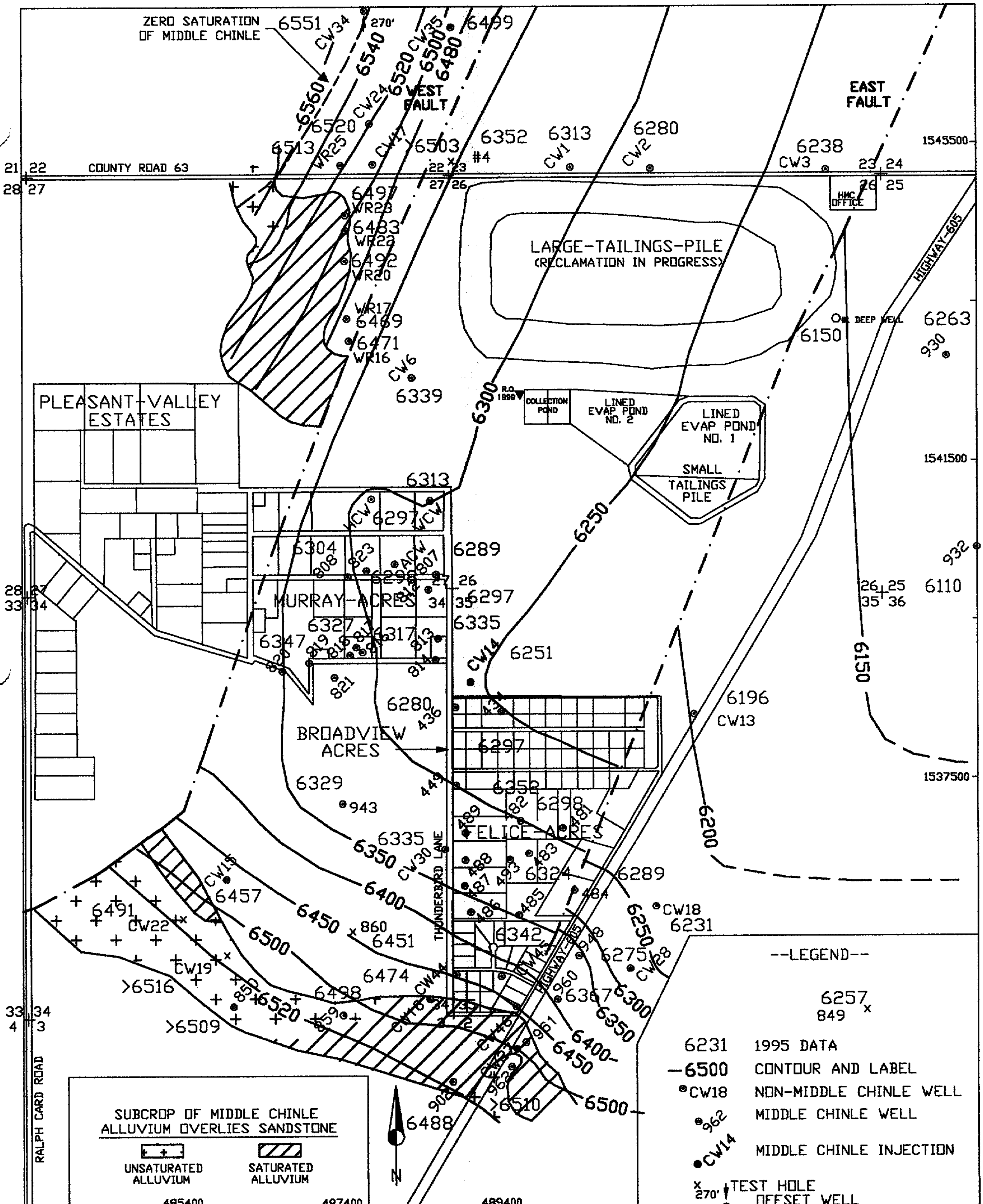
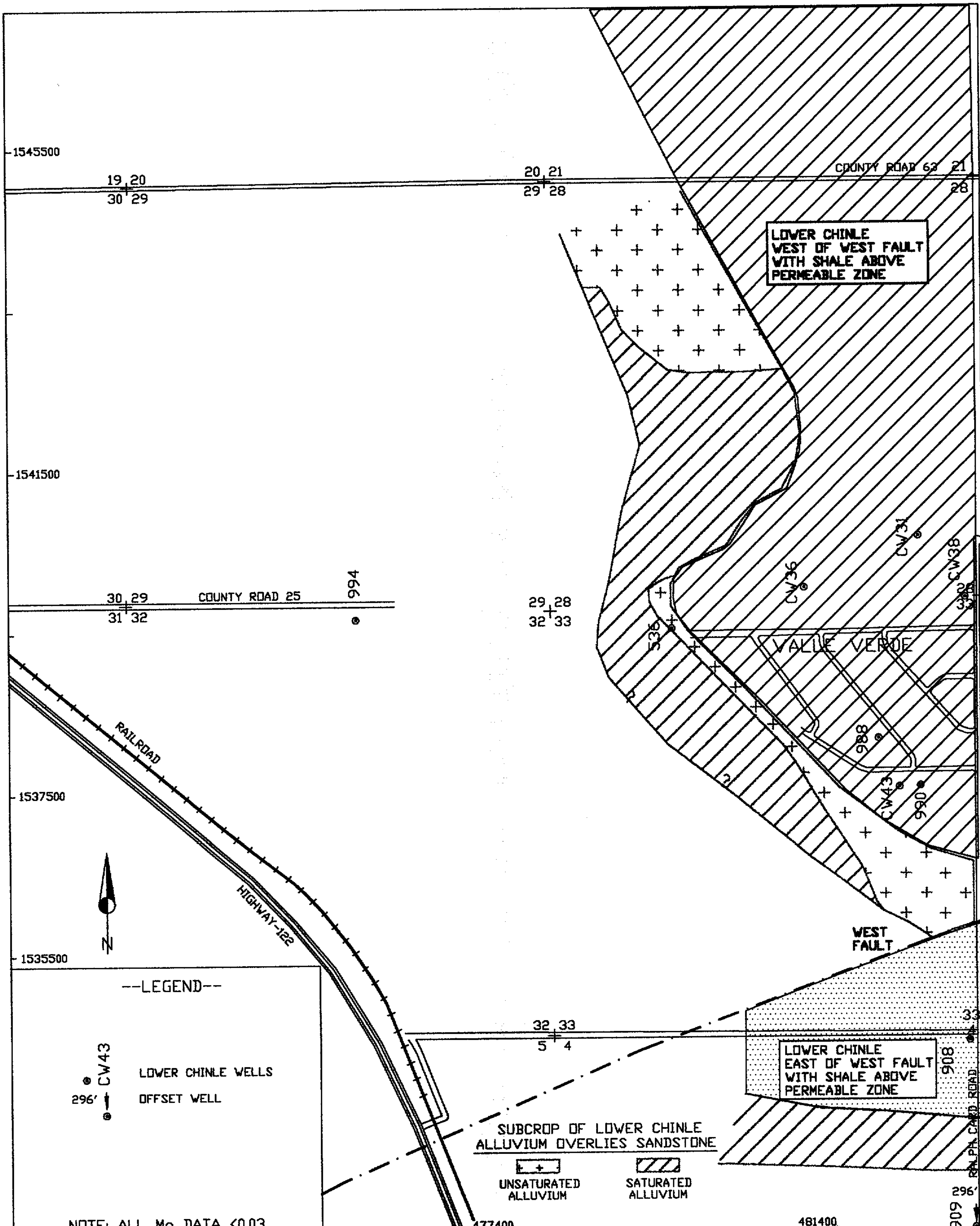


SCALE: 1"=1600'	HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W	DATE: 12/09/01

FIGURE 2-7. ELEVATION OF THE TOP OF THE MIDDLE CHINLE AQUIFER, FT-MSL

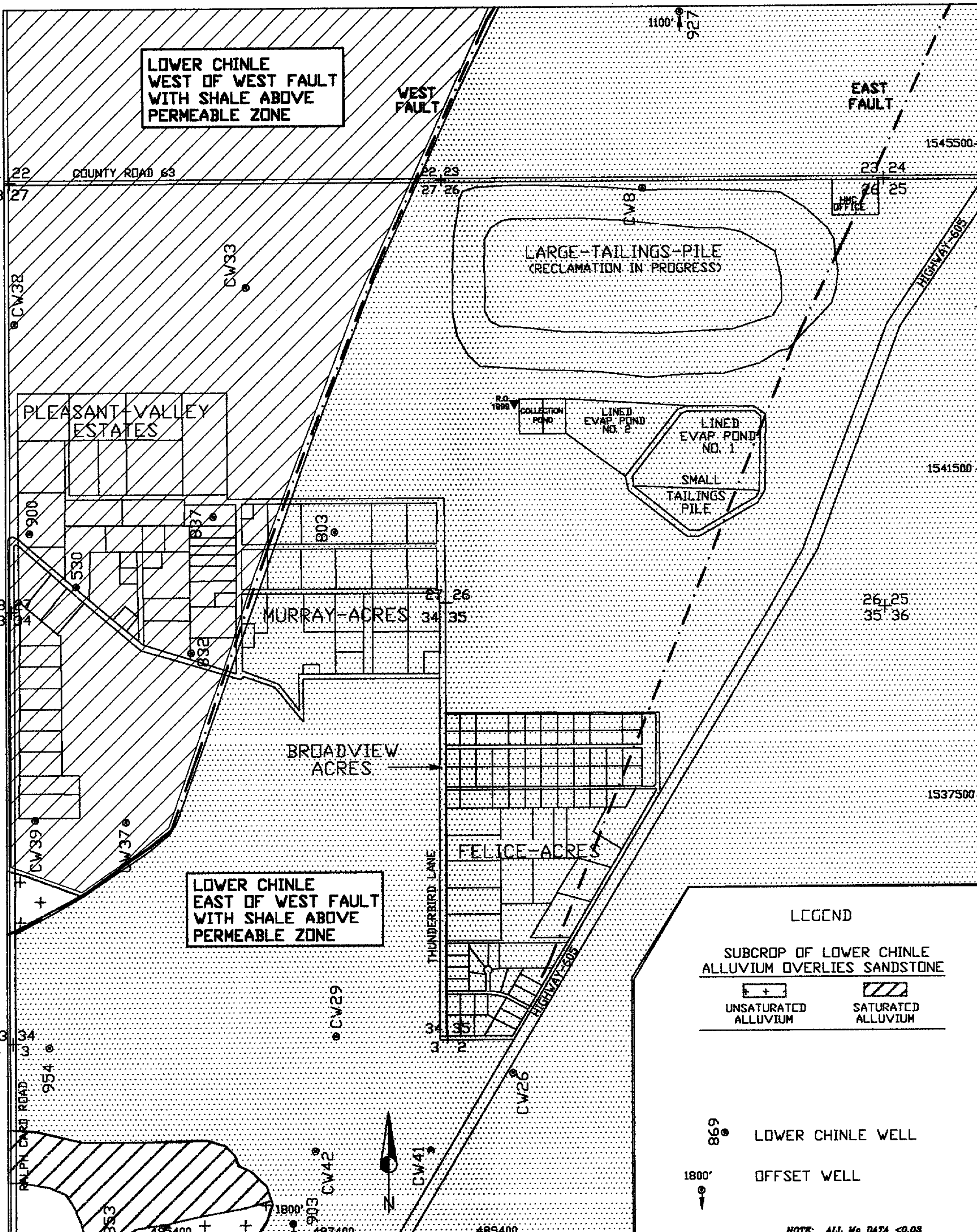
D\R13\HMC\MID1600 lh



SCALE: 1"=1600'	HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W	DATE: 12/09/01

FIGURE 2-8A. LIMITS OF LOWER CHINLE AQUIFER AND WELL LOCATIONS (WEST AREA)

D:\R13\HMC\LOW1600 lh



SCALE: 1"=1600'	HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W	DATE: 12/09/01

FIGURE 2-8B. LIMITS OF LOWER CHINLE AQUIFER AND WELL LOCATIONS

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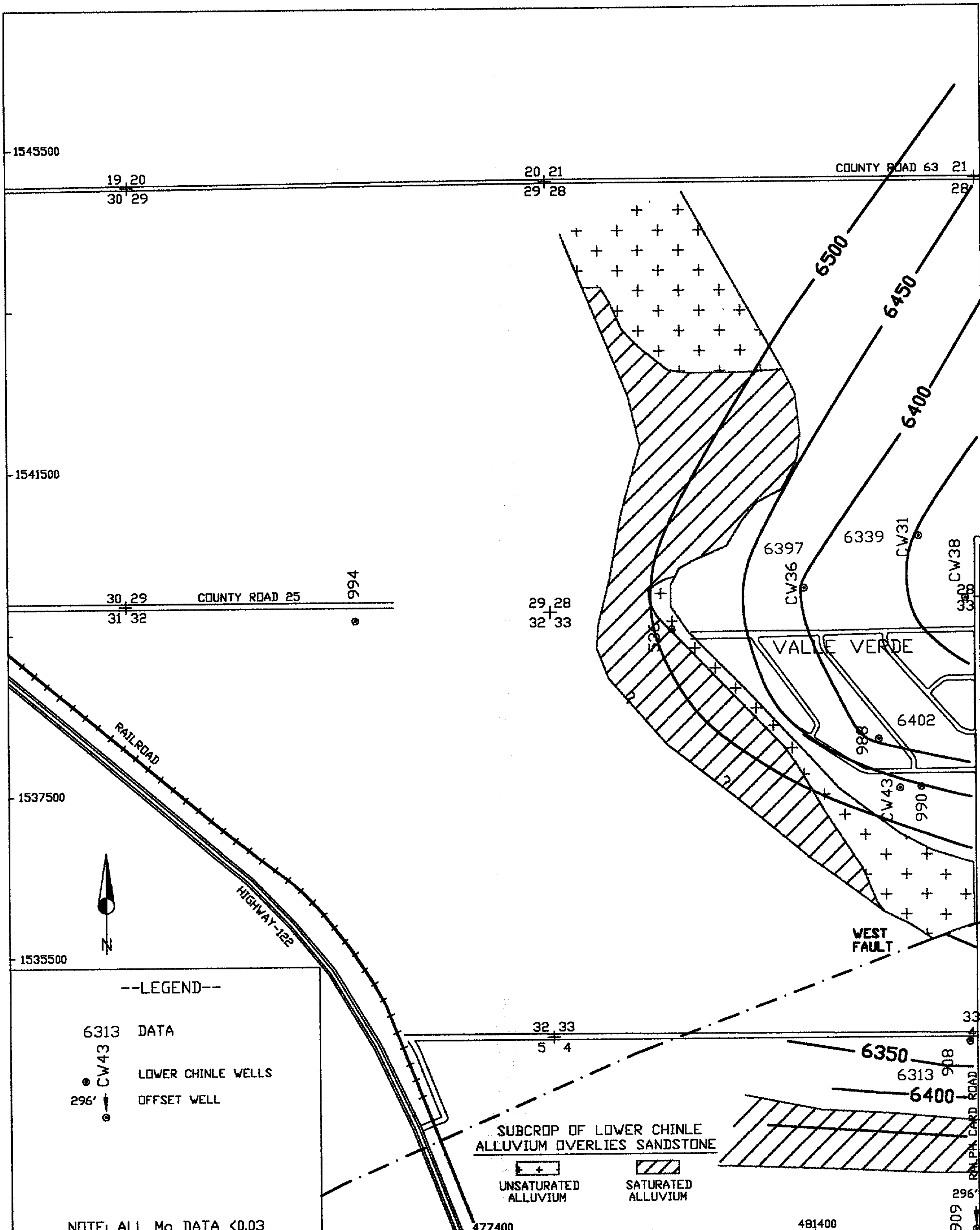
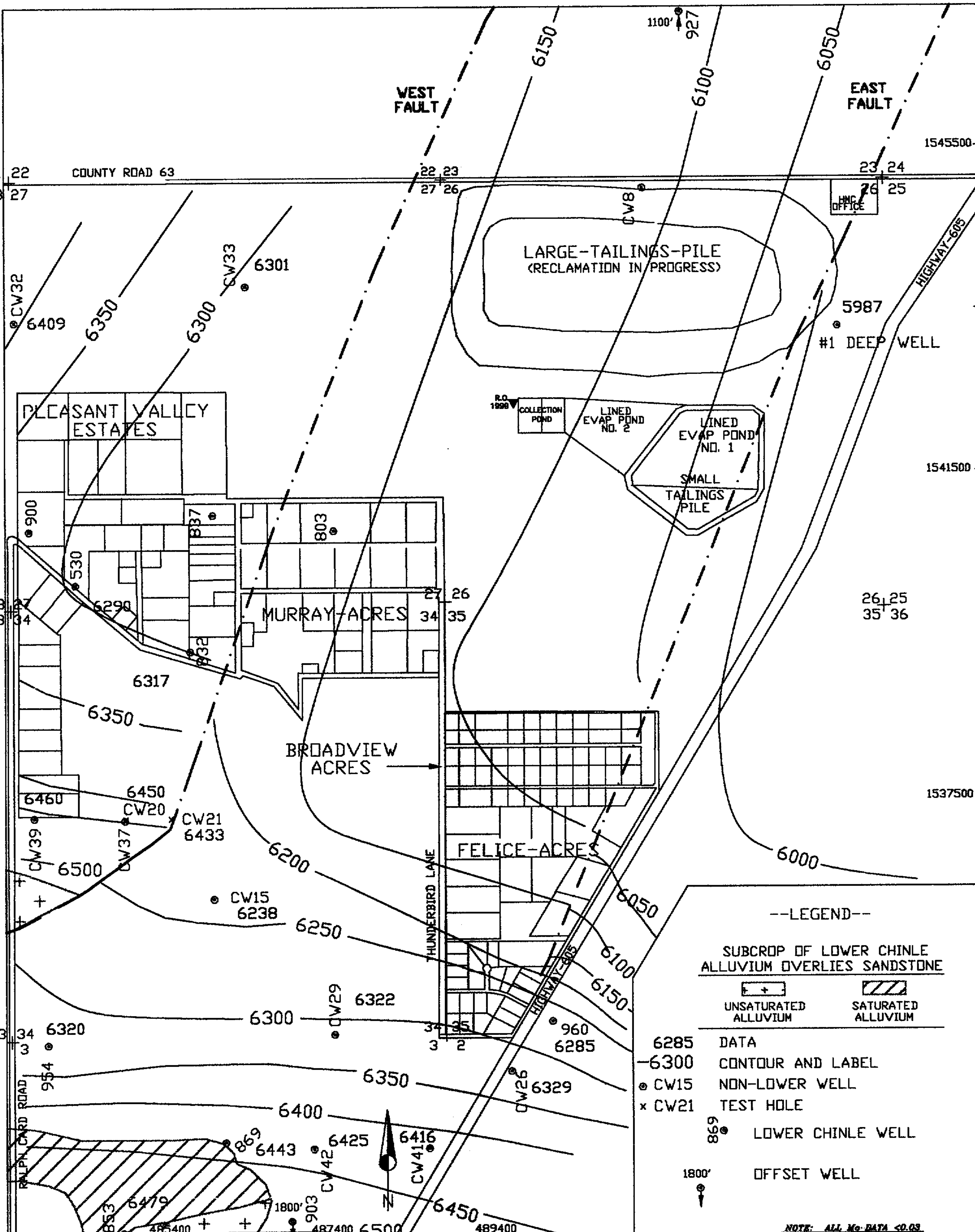


SCALE: 1"=1600'	HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W	DATE: 12/09/01
FIGURE 2-9A.	ELEVATION OF THE TOP OF THE LOWER CHINLE AQUIFER (WEST AREA), IN FT-MSL	D:\R13\HMC\LOW1600 LH
		page 2-20



SCALE: 1"=1600' | HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W | DATE: 12/09/01

FIGURE 2-9B. ELEVATION OF THE TOP OF THE LOWER CHINLE AQUIFER, FT-MSL

D:\R13\HMC\LOW1600

3.0 AQUIFER PROPERTIES

The important aquifer properties for the alluvial aquifer are the hydraulic conductivity (permeability), saturated thickness and specific yield. Hydraulic conductivity is a representation of the unit transmitting ability of the alluvial sands. Saturated thickness times hydraulic conductivity equal the transmissivity. Transmissivity is the total transmitting ability of the aquifer and the important transmitting property for the confined Chinle aquifers. The specific yield is the primary storage property for the unconfined alluvial aquifer. Storage coefficient is the important storage parameter for the confined aquifers.

3.1 SATURATED THICKNESS OF THE ALLUVIUM

The alluvial aquifer saturated thickness is defined by the difference between the water-level elevation and the base of the alluvium. The saturated thickness is presented in the basic well data tables in the annual reports. The saturated thickness contours are presented on Figures 3-1A and 3-1B and were developed by taking the difference between the water-level elevation and base of alluvium contours. This shows that the saturated thickness in the southwest corner of the Large Tailings is 60 feet in the alluvial aquifer and decreases to zero at the boundary of the alluvial aquifer. Saturated thicknesses have been increased significantly in the area of the fresh-water injection.

3.2 HYDRAULIC CONDUCTIVITY, TRANSMISSIVITY AND STORAGE

Figures 3-2A and 3-2B present the hydraulic conductivities measured for the alluvial aquifer at this site. The data presents the hydraulic conductivities determined from pump tests for the alluvial aquifer. These values have been contoured and are presented in Figures 3-2A and 3-2B. These figures show that hydraulic conductivities near the Large Tailings are greatest on the southwest side and generally decrease to the east. A ridge of lower hydraulic conductivities exists from the western edge of the Small Tailings to the southwest into Murray Acres. Hydraulic conductivities substantially increase to levels greater than 200 ft/day in the northern portion of Pleasant Valley and extend to the west. Hydraulic conductivities also increase in the Broadview Acres area and extend through

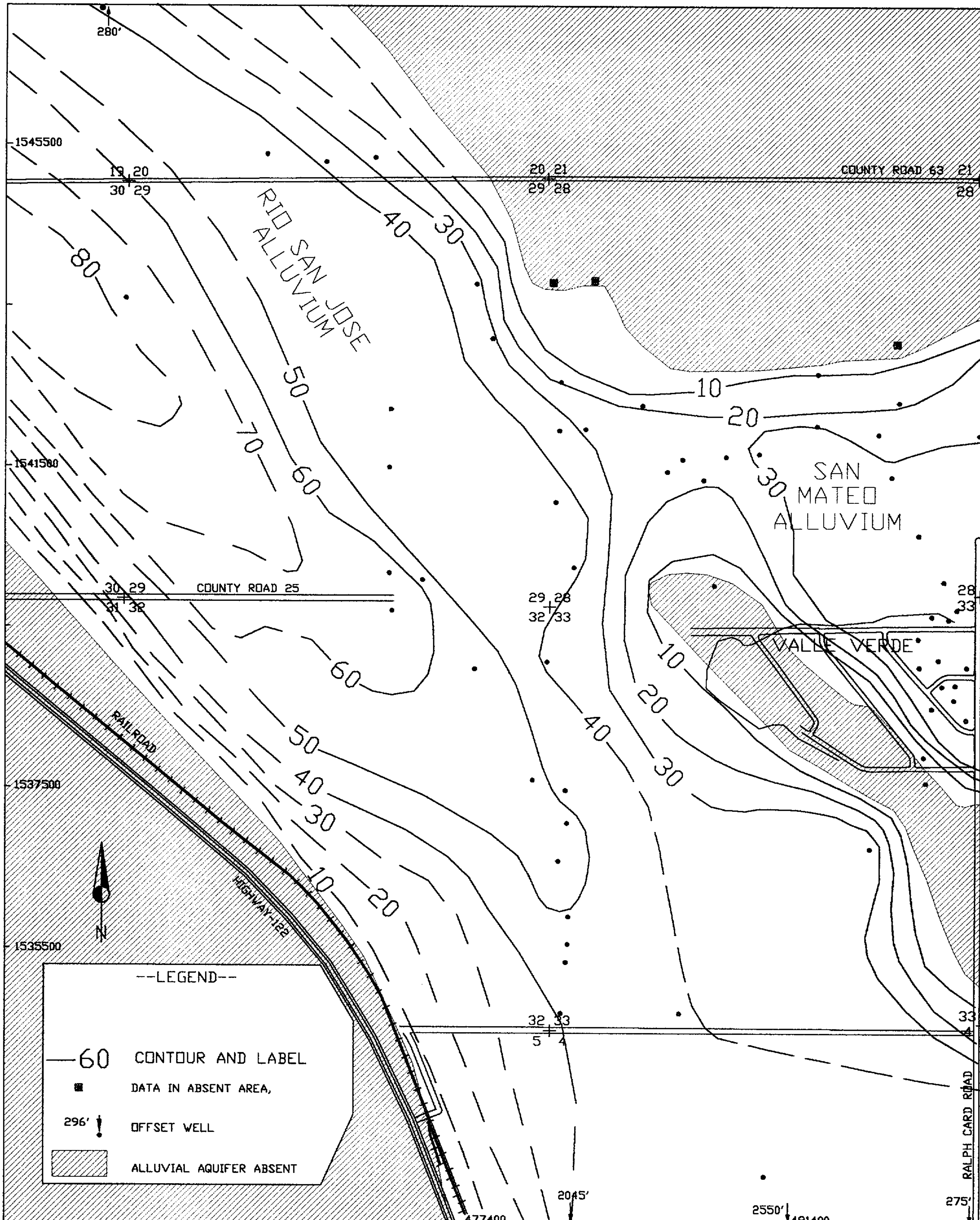
Section 3. A zone of hydraulic conductivities in Section 28 of the San Mateo alluvium and in the Rio San Jose alluvium, exceed 200 ft/day (see Figure 3-2A).

Specific yields in the alluvial aquifer for the site have varied from 0.038 to 0.28, based on pump tests. A specific yield of 0.2 is thought to best represent the alluvial aquifer at the Grants site and was selected from calibration of numerical modeling of the site. This value is considered conservative relative to the restoration of the site. The lower hydraulic conductivity area will probably have a slightly smaller specific yield, which should reduce the volume required for restoration. The two factors may offset each other, resulting in similar restoration times for varying aquifer properties.

Aquifer properties in the Upper Chinle aquifer vary significantly over the area due to the effects of secondary permeability on the sandstone. Transmissivity (hydraulic conductivity times aquifer thickness) is the important aquifer property for a confined aquifer. The transmissivity adjacent to the east side of the East Fault are approximately 2000 gal/day/ft (see Figure 3-3) and decrease to below 100 gal/day/ft to the east of this area. This affects the ground-water flow in the high transmissive zone adjacent to the East Fault. High transmissivity values also exist in the area west of the East Fault on the south side of the Small Tailings. The Upper Chinle aquifer is a confined aquifer but will, in general, have a storage coefficient of 5E-05. The specific yield of this confined aquifer is expected to be significantly less than the alluvial aquifer and is estimated at 0.1.

Aquifer properties in the Middle Chinle aquifer vary significantly over the area due to the effects of secondary permeability on the sandstone. The transmissivity adjacent to the east side of the East Fault are approximately 500 gal/day/ft (see Figure 3-4) and decrease to below 100 gal/day/ft to the east of this area. This affects the ground-water flow in the high permeability zone adjacent to the East Fault. High transmissivity values also exist in the area west of the East Fault on the south side of the Small Tailings. The Middle Chinle aquifer is a confined aquifer with a storage coefficient of 3E-5. The specific

yield of this confined aquifer is expected to be significantly less than the alluvial aquifer and is estimated at 0.1.



SCALE: 1"=1600' | HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W | DATE: 08/16/01

FIGURE 3-1A. SATURATED THICKNESS OF THE ALLUVIAL AQUIFER (WEST AREA), 2000, FEET

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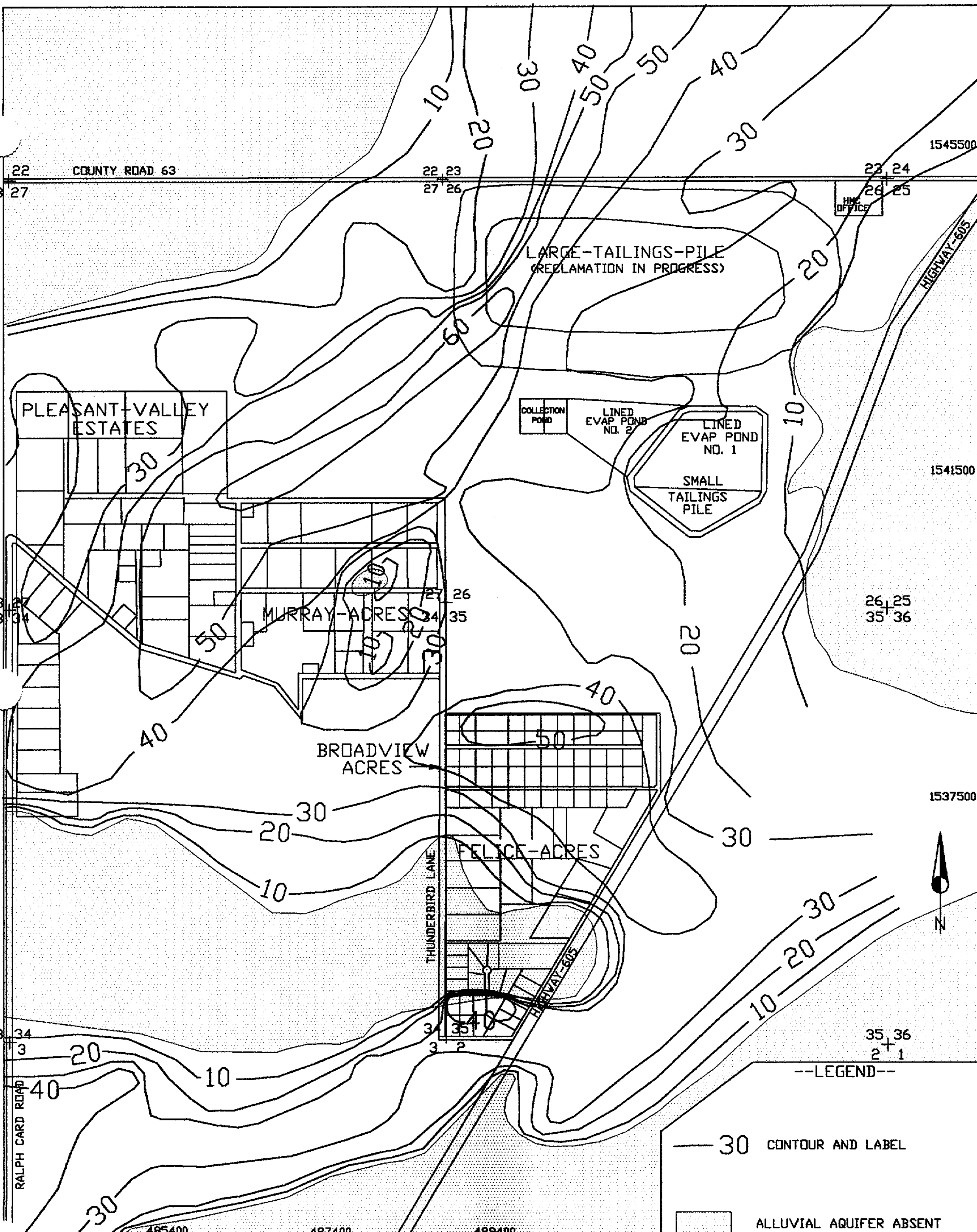

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FIGURE 3-1B. SATURATED THICKNESS OF THE ALLUVIAL AQUIFER, 2000, FEET

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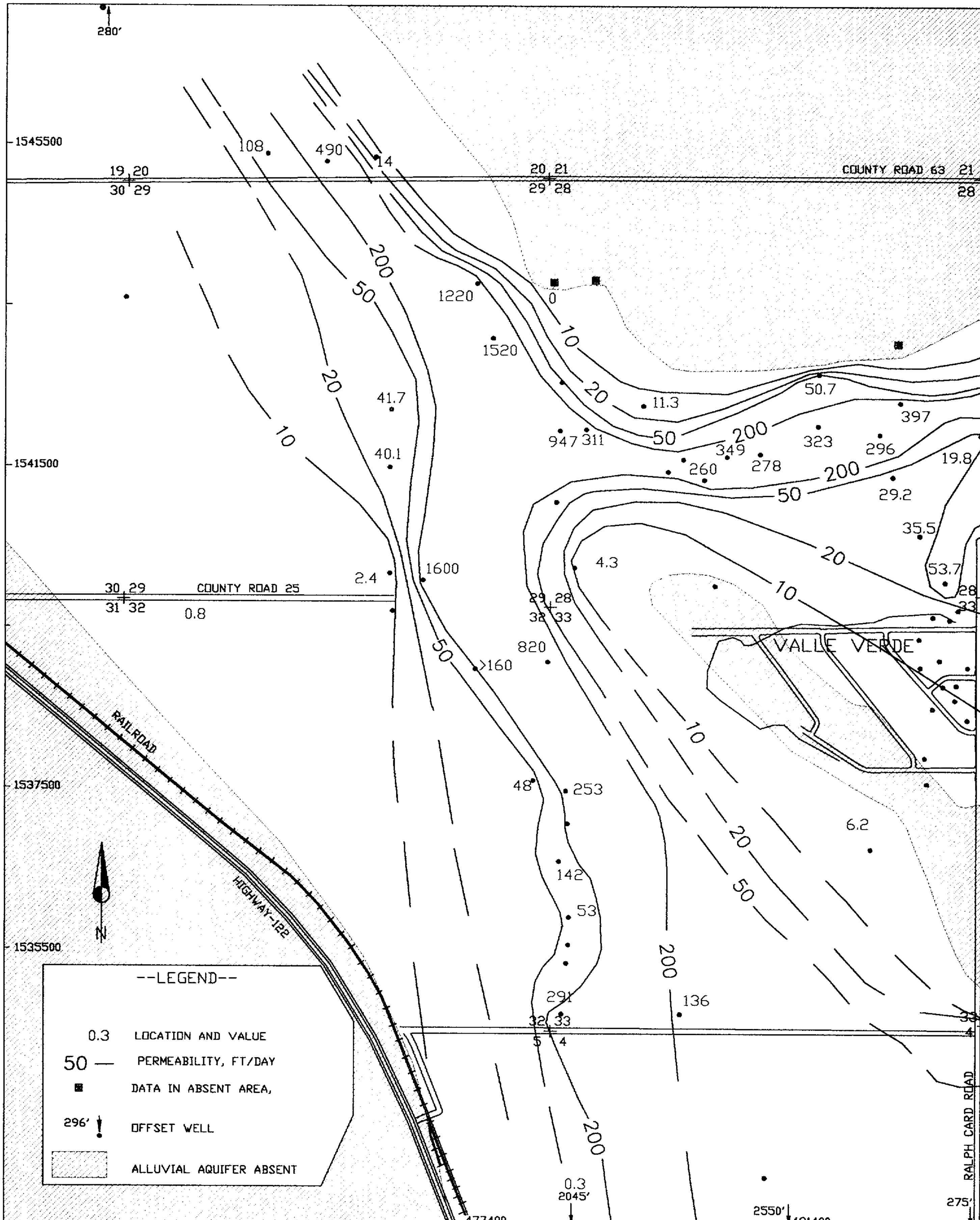

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FIGURE 3-2A. HYDRAULIC CONDUCTIVITY (PERMEABILITY) FOR THE ALLUVIAL AQUIFER (WEST AREA), FT/DAY.

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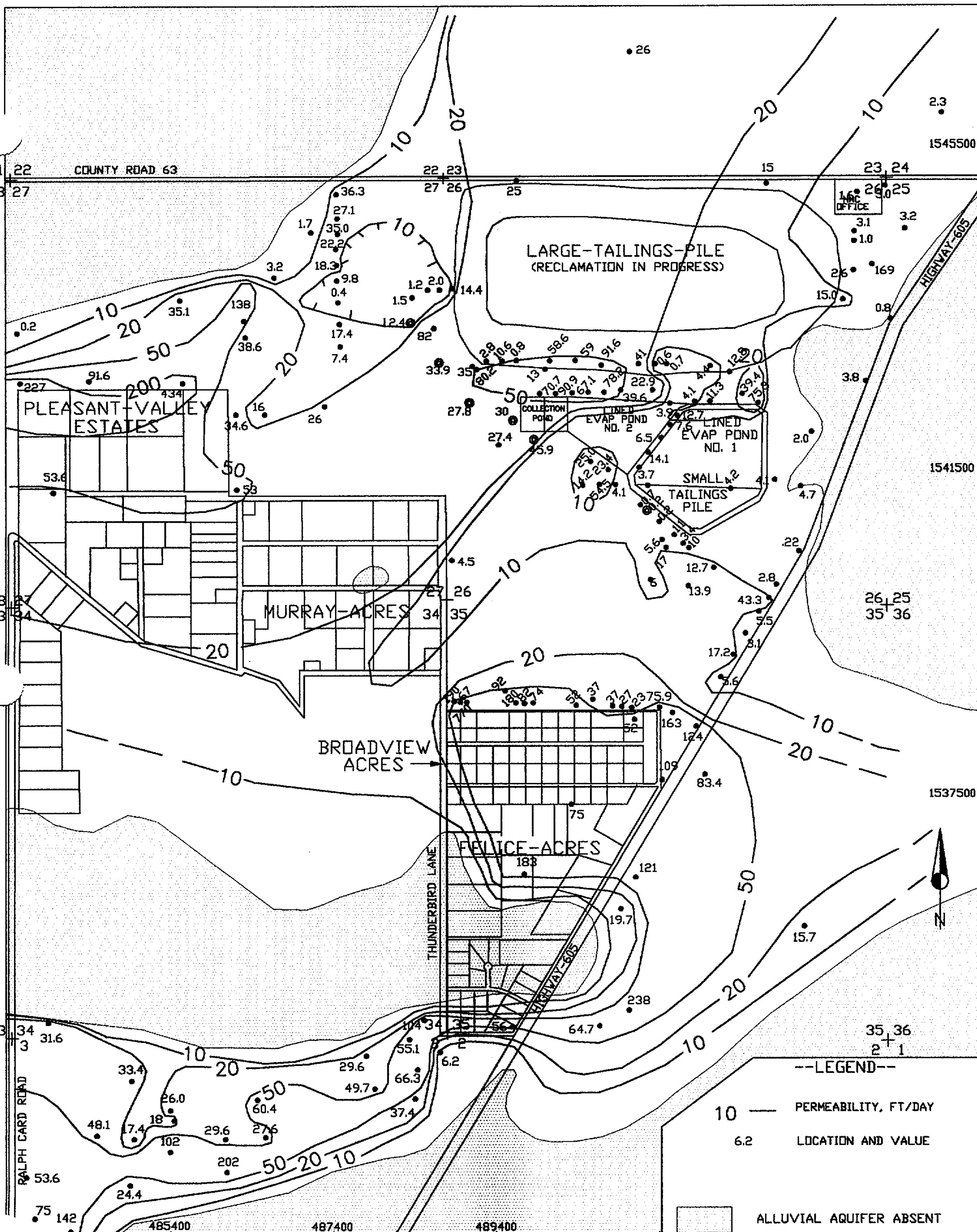

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FIGURE 3-2B. HYDRAULIC CONDUCTIVITY (PERMEABILITY) FOR THE ALLUVIAL AQUIFER, FT/DAY

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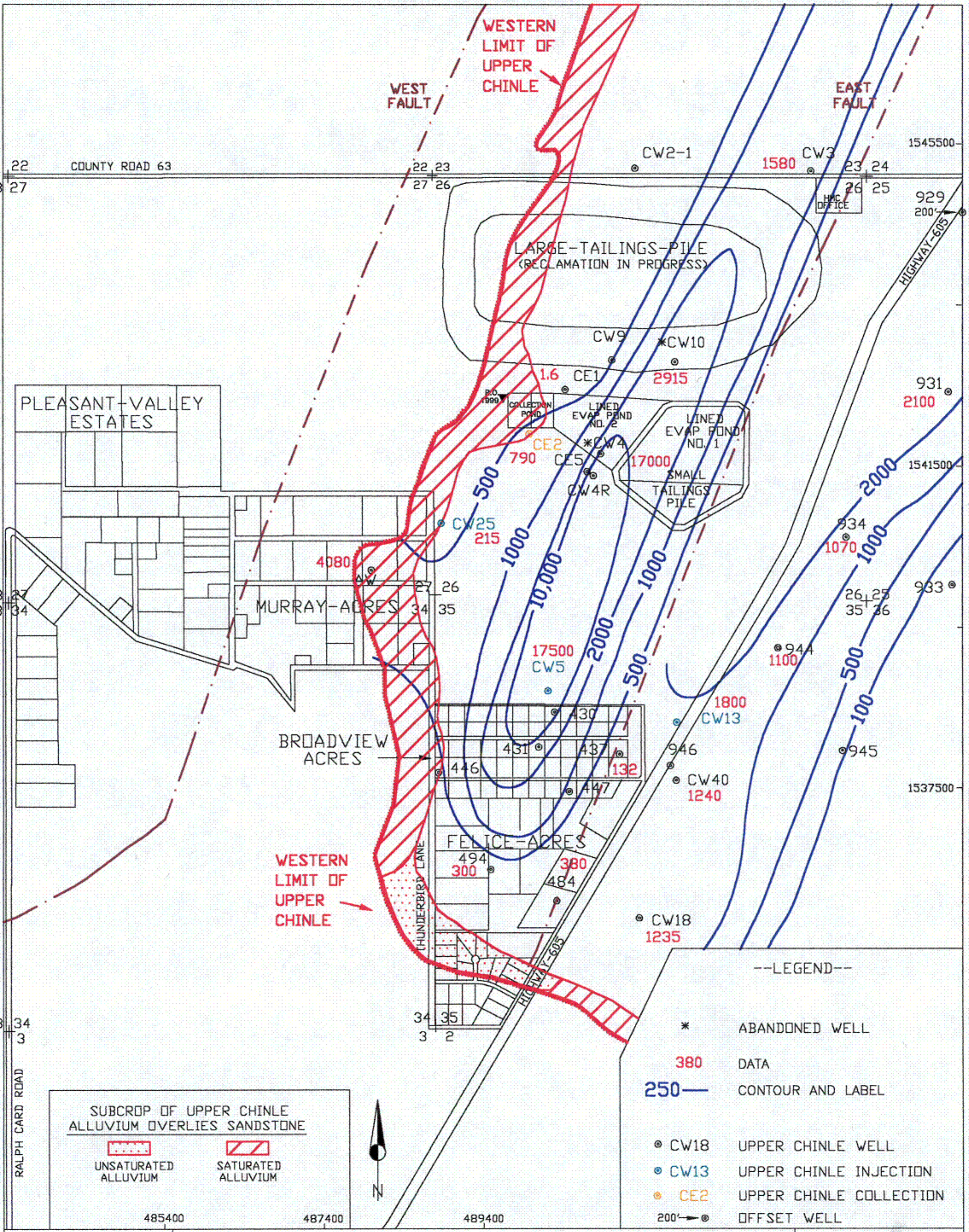

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FIGURE 3-3. TRANSMISSIVITY FOR THE UPPER CHINLE AQUIFER, GAL/DAY/FT

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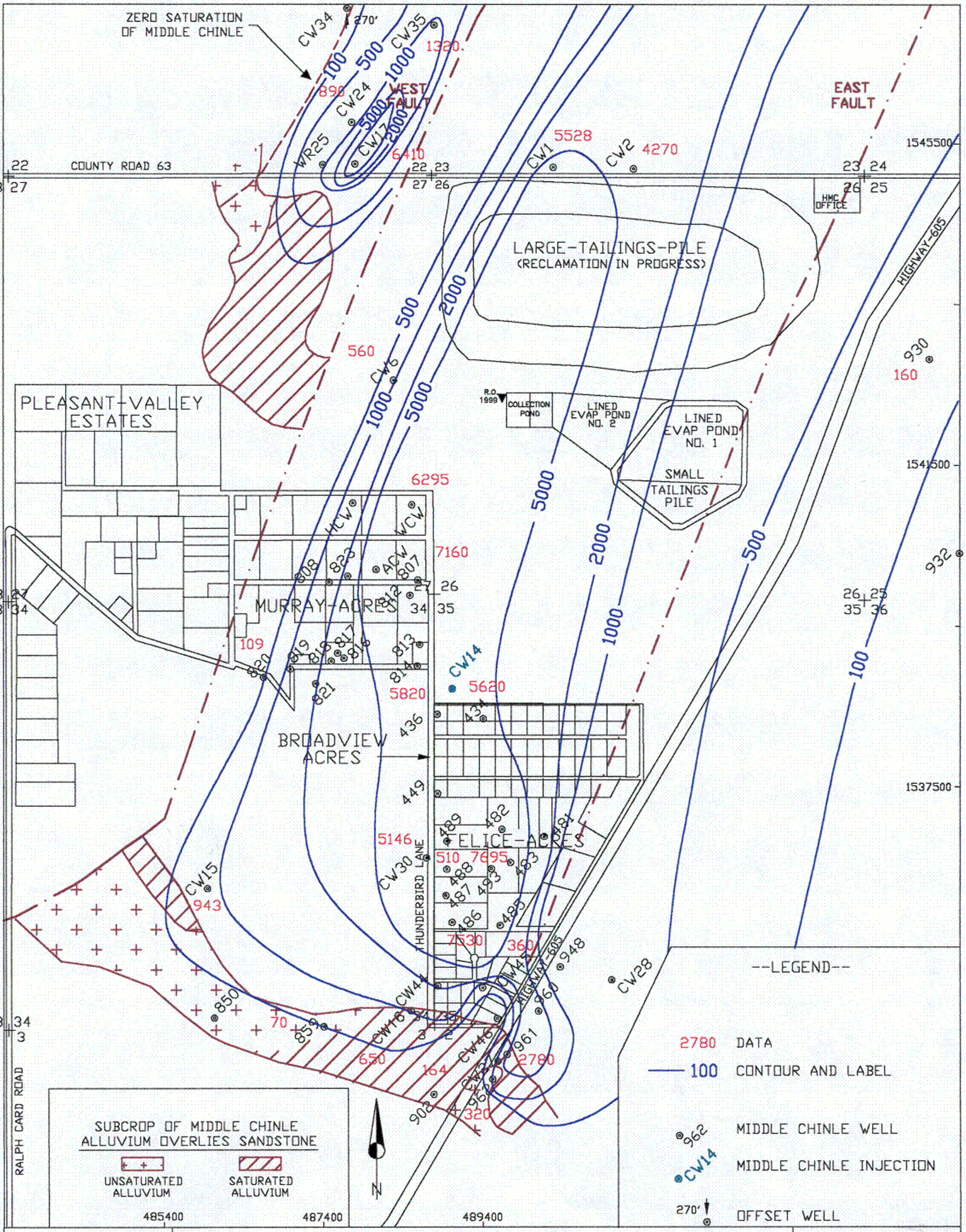
C05



SCALE: 1"=1600' | HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W | DATE: 12/09/01

FIGURE 3-4. TRANSMISSIVITY FOR THE MIDDLE CHINLE AQUIFER, GAL/DAY/FT

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C06

4.0 GROUND-WATER FLOW

This section presents the water-level information for the Grants site aquifers. The direction of ground-water flow is defined by the water-level elevation maps and is helpful in defining connections between the aquifers.

4.1 ALLUVIAL

The depths of the water level for the alluvial wells are presented in the basic well data tables and the water-level appendix in the annual reports. Figures 4-1A, 4-1B, 4-1C and 4-1D present the water-level elevations for the alluvial aquifer for 2000. Figures 4-1A and 4-1B present the water-level contours for use in this subsection while Figures 4-1C and 4-1D are overlays of Figures 4-1A and 4-1B for use with the Chinle ground-water flow subsections. Water-level elevation data, along with the water-level contours, for the Grants site are presented on Figures 4-1A and 41-B. Figure 4-1B shows that the ground water is flowing into the tailings area from the north and converges to the collection wells. Red arrows are shown to indicate the direction of ground-water flow. The fresh-water injection downgradient of the site, used in conjunction with the collection wells, forces ground water to converge from all directions to the collection points. Water-level elevations vary from 6,540 ft above mean sea level (ft-msl) on the east side of the tailings to a low of 6,500 ft-msl on the western edge of Pleasant Valley.

Figure 4.1-1A shows the direction of alluvial ground-water flow in the area immediately west of the Grants Project area with red flow arrows. Flow in the San Mateo alluvium is forced to flow through the western portion of Section 28 due to the zero saturation limits to the north and south of this area. The San Mateo alluvial water then mixes with the Rio San Jose alluvial water, which continues to flow to the south. Alluvial ground water that flows through the northern portion of Section 3 (see Figure 4.1-1B) joins the Rio San Jose ground-water system in the eastern portion of Section 4.

4.2 UPPER CHINLE

The depth to water levels and elevations are presented in the basic well data table and water level appendix in the annual reports. The water-level elevations were used to show flow direction for the Upper Chinle aquifer.

The water-level depths vary over the area but, in general, are less than 100 feet to the water level in Upper Chinle wells. Water-level elevations are presented in Figure 4-2 for 2000 for the Upper Chinle in blue contours. The blue arrows show the direction of ground-water flow in the Upper Chinle aquifer. This figure shows that ground water in the Upper Chinle between the two faults is flowing into the Large Tailings area from the north. The fresh-water injection into Upper Chinle well CW5 forces flow back toward the collection well, south of the collection ponds from the Broadview Acres area. Flow in the Upper Chinle in Broadview and Felice Acres is to the south and discharges to the alluvial aquifer in the subcrop area. Flow east of the East Fault is parallel to the fault to the northeast of injection well CW13, close to the fault due to the high permeability zone adjacent to the fault. South of injection well CW13 the flow is parallel to the fault back toward the subcrop area. The flow in the majority of the area east of the East Fault is to the east-southeast into the lower permeability material away from the fault.

The water-level elevations for the alluvial aquifers are presented in Figure 4-1D on an overlay to be placed on top of Figure 4-2 to show where the heads in the two aquifers are close. The alluvial contours are in black while the alluvial flow directions are presented by green arrows. Similarities in water-level elevations in the two aquifers indicate some connection in the area. The head in the alluvial aquifer upgradient of the site is higher than the head in the Upper Chinle. Therefore, ground water in this area is likely to be flowing from the alluvial aquifer into the Upper Chinle in the subcrop area. The heads in the two aquifers are very similar on the west side of the Large Tailings in the subcrop area and to the south in the collection pond area. The amount of transmitting ability the Upper Chinle aquifer has in the subcrop area also controls the rate of alluvial water moving into the Upper Chinle aquifer. This transmitting ability is low

enough in some areas to greatly restrict movement into the Upper Chinle due to the sandstone transitioning into a shale.

Ground water likely flows between these two aquifers depending on the head conditions at different times. Water-level elevations in the Broadview acres are very similar in these two aquifers indicating potential connection in this area. Several wells in Broadview Acres are completed in both the Upper Chinle and alluvial aquifers, which results in connection in this area. The Upper Chinle water discharges in southern Felice Acres to the alluvium where the head is significantly larger in the Upper Chinle than in the alluvial aquifer. The Upper Chinle water is also discharging to the alluvium from the east side of the East Fault due to the much higher head in the Upper Chinle in this area than in the alluvial aquifer.

The travel time for seepage into the Upper Chinle aquifer near the Large Tailings to the Broadview Acres area was approximately 20 years. This indicates that an average ground-water velocity of approximately 1 ft/day existed for the ground water moving in the Upper Chinle from the Large Tailings to the Broadview Acres area. Alluvial water naturally moved through the Upper Chinle in this portion of the aquifer prior to the tailings due to the subcrop conditions. Therefore, this portion of the Upper Chinle aquifer contained alluvial type water prior to the tailings. The travel time to the subcrop area east of the East Fault in the Upper Chinle is estimated to be approximately 30 years due to alluvial ground water having to flow to this area. Recharge from alluvial to the Upper Chinle east of the East Fault then moved back to the northeast. A ground-water velocity estimate of approximately 1 ft/day is appropriate for this portion of the Upper Chinle aquifer.

4.3 MIDDLE CHINLE

Water levels in Homestake's Upper, Middle and Lower Chinle wells are presented in the annual reports. Fall of 2000 water-level elevations for the Middle Chinle aquifer are presented on Figure 4-3. The gradient in the Middle Chinle aquifer is steeper in its

subcrop area in the southern portion of Felice Acres near wells CW44, CW45 and CW46. This increase in gradient is due to an influx of water in this area to the Middle Chinle aquifer from the alluvial aquifer. The blue arrows show the direction of ground-water flow in the Middle Chinle aquifer. Flow on the east side of the East Fault is mainly to the north near the East Fault, but due to a decrease in the transmissivity in the aquifer to the east, flow moves easterly away from the East Fault.

Ground-water flow west of the West Fault is to the southwest, discharging into the alluvial aquifer. This prevents the alluvial aquifer water from entering the Middle Chinle aquifer in the subcrop area on the west side of the West Fault. This Middle Chinle water flows from upgradient of the site into the area west of the Large Tailings. The remainder of the Middle Chinle aquifer is recharged by the alluvial aquifer south of Felice Acres.

A mound of water around well CW14 has been created by the injection of fresh water into this well. This causes the ground-water flow to be to the north and south of well CW14. Flow between the two faults in the Middle Chinle aquifer, north of CW14, continues downgradient of the tailings area. The head in the Middle Chinle aquifer on each side of the two faults is significantly different than the head between the two faults, which shows that the ground water is not readily connected on each side of these faults.

The alluvial water-level elevations on the overlay in Figure 4-1D should also be used over Figure 4-3 for comparison with the Middle Chinle piezometric surface. Green arrows are used to show the direction of flow in the alluvial aquifer. The water-level elevation in the Middle Chinle between the two faults is significantly lower than the alluvial aquifer in the tailings area indicating no high conductance connection zone in this area. The head in the Middle Chinle aquifer west of the West Fault to the west of the Large Tailings is similar to the water-level elevation in the alluvial aquifer indicating that some potential connection could exist in this area. Water-level elevations east of the East Fault in the Middle Chinle are also significantly below the water-level elevations in the alluvial aquifer. The water-level elevations in the Middle Chinle on the south side of Felice Acres are

slightly less than the alluvial water-level elevations and the existence of the subcrop in this area allows ground water to flow from the alluvial aquifer to the Middle Chinle. Water quality changes also indicate connection in this area.

The time for contaminated alluvial flow to reach the subcrop area in the Middle Chinle on the south side of Felice Acres was roughly 30 years. Alluvial ground water has moved back to the north from the subcrop area in the Middle Chinle aquifer into the Felice and Broadview Acres area. The ground-water velocity rate is slightly less than 1 ft/day for this movement in the Middle Chinle aquifer. The natural direction of ground-water flow in the Middle Chinle aquifer between the two faults is to the north. Therefore, this area of the Middle Chinle aquifer contained alluvial type water prior to seepage concentrations flowing into this area. Alluvial water also moves from the Middle Chinle subcrop area into the Middle Chinle on the east side of the East Fault. Movement velocity in this area based on water-quality changes has to be significantly less than 1 ft/day.

4.4 LOWER CHINLE

Water-level elevations for the Lower Chinle wells are presented with the remainder of the Chinle wells in the annual reports. Figures 4-4A and 4-4B present the 2000 water-level elevations for the Lower Chinle aquifer. The West and East Faults are shown on these figures. Flow west of the West Fault in the Lower Chinle is mainly to the northeast. Flow between the two faults is to the northwest, indicating that the Lower Chinle water moves across the West Fault. The approximate subcrop areas for the Lower Chinle aquifer are also shown on these two figures.

The overlays in Figures 4-1C and 4-1D present the water-level elevations for the alluvial aquifer in black and should be used over Figures 4-4A and 4-4B respectively to compare the heads in the two aquifers. The comparison between the alluvial and the Lower Chinle aquifers shows that generally water-level elevations in the alluvial aquifer are significantly greater than the water-level elevations in the Lower Chinle. Water-level elevations between these two aquifers is very similar in the west-central portion of Section 3 where

the Lower Chinle subcrops against the alluvial aquifer and direct connection occurs. Water-level elevations would be expected to be very similar in the two aquifers in the subcrop area. Water-level elevation west of the West Fault in the alluvial aquifer is significantly greater than the water-level elevations in the Lower Chinle except for the area near the Lower Chinle subcrop. These two water-level elevation figures indicate the only connection between the alluvial and Lower Chinle aquifers is in the subcrop areas.

The travel time from the tailings to the Lower Chinle subcrops in Section 3 is roughly 30 years. Water movement in the weathered Lower Chinle would be less than 1 ft/day. These movement rates would greatly decrease where adequate secondary permeability in the Chinle shale has not developed.

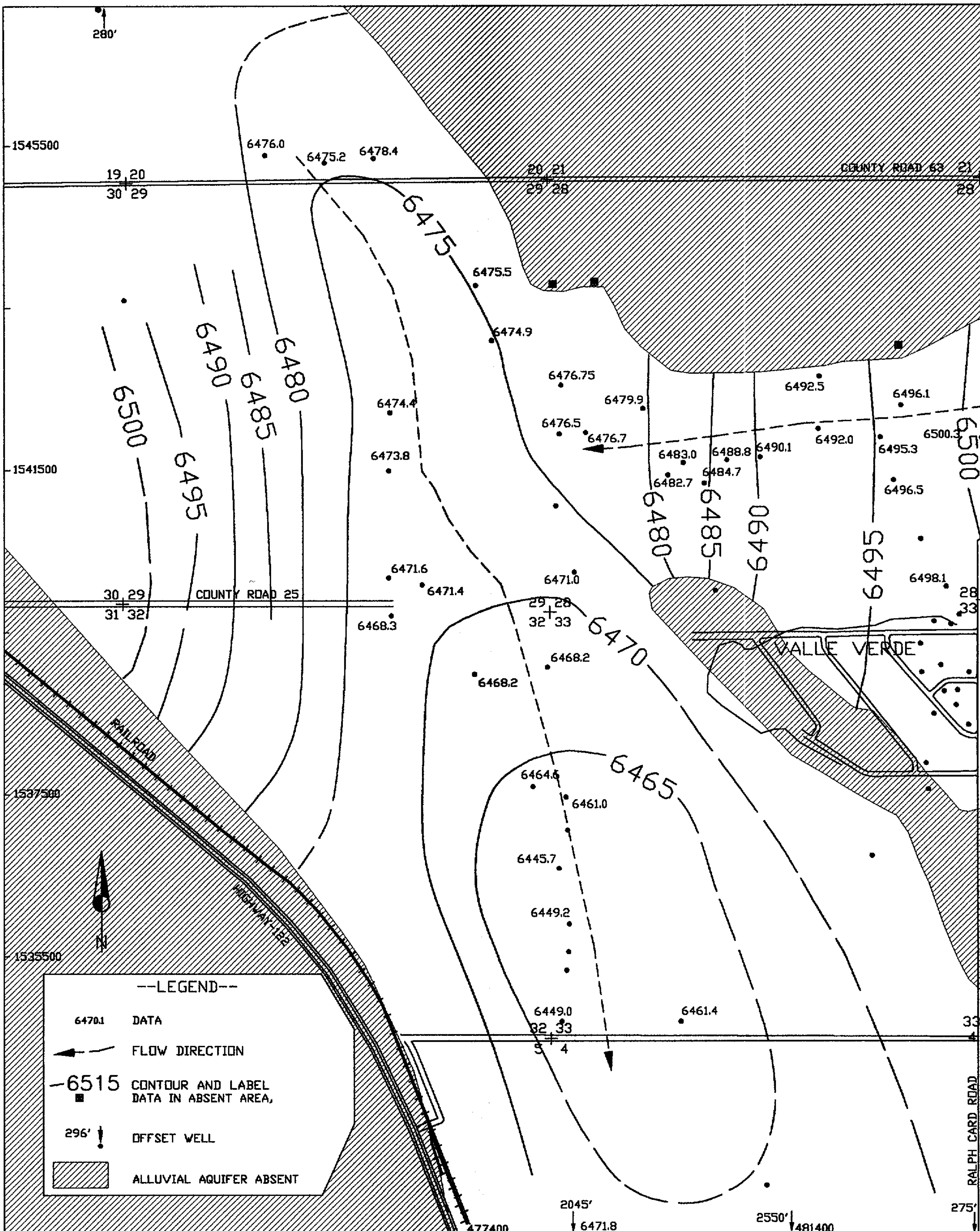

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FIGURE 4-1A. WATER-LEVEL ELEVATION FOR THE ALLUVIAL AQUIFER, (WEST AREA), 2000, FT-MSL.

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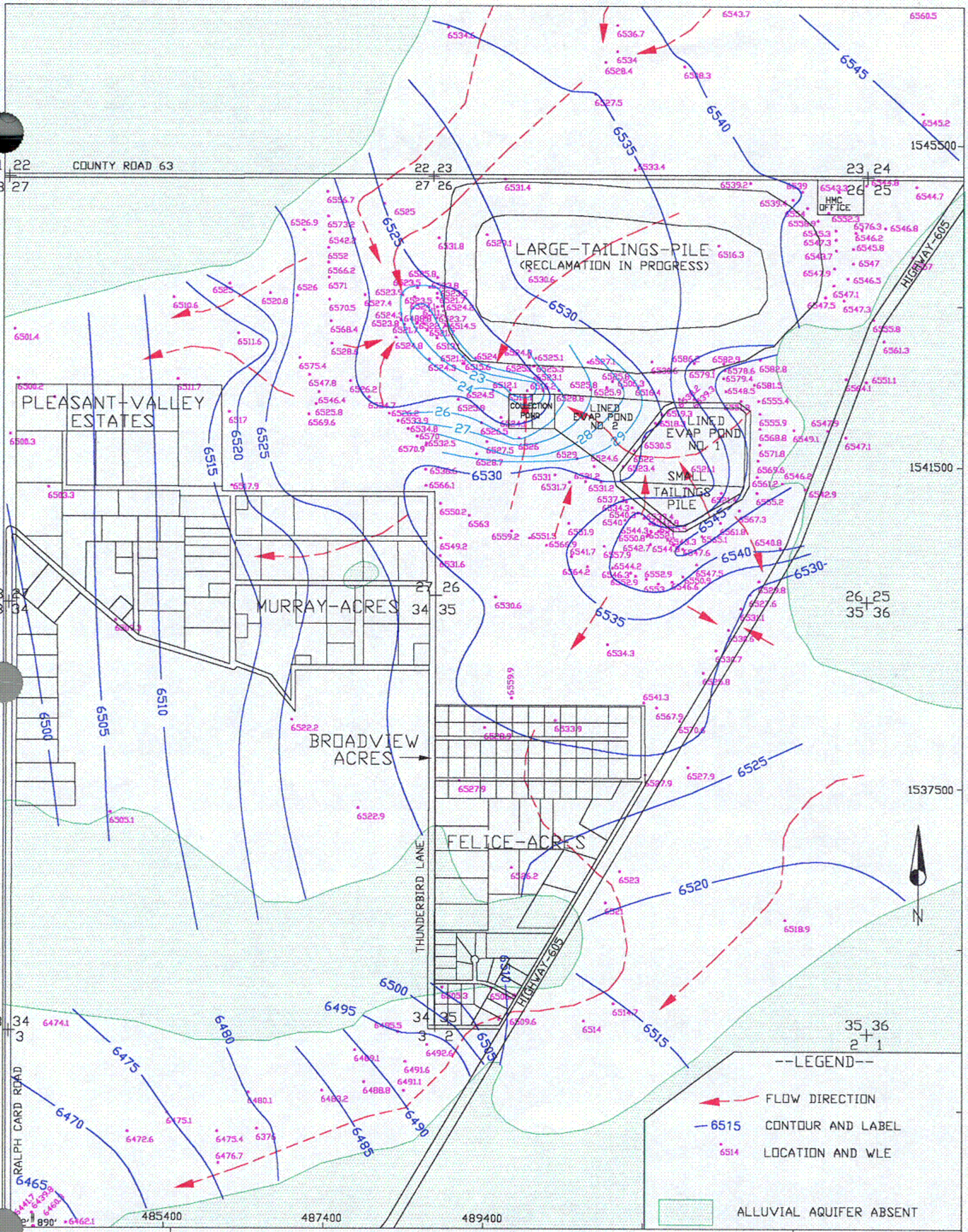

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FIGURE 4-1B. WATER-LEVEL ELEVATION FOR THE ALLUVIAL AQUIFER, 2000, FT-MSL

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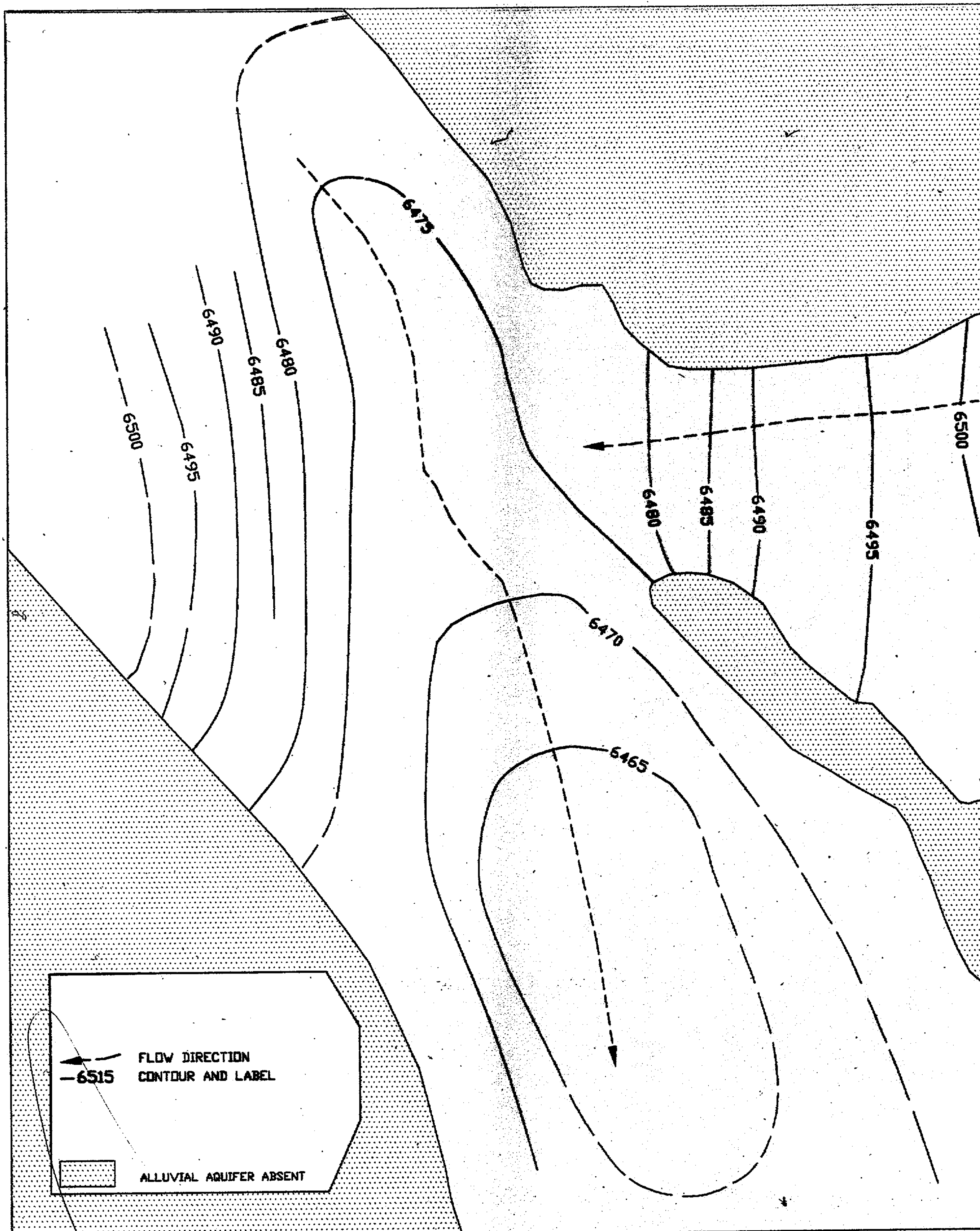

FIGURE 4-1C. WATER-LEVEL ELEVATIONS FOR THE ALLUVIAL AQUIFER, (WEST AREA), 2000, FT-MSL, OVERLAY

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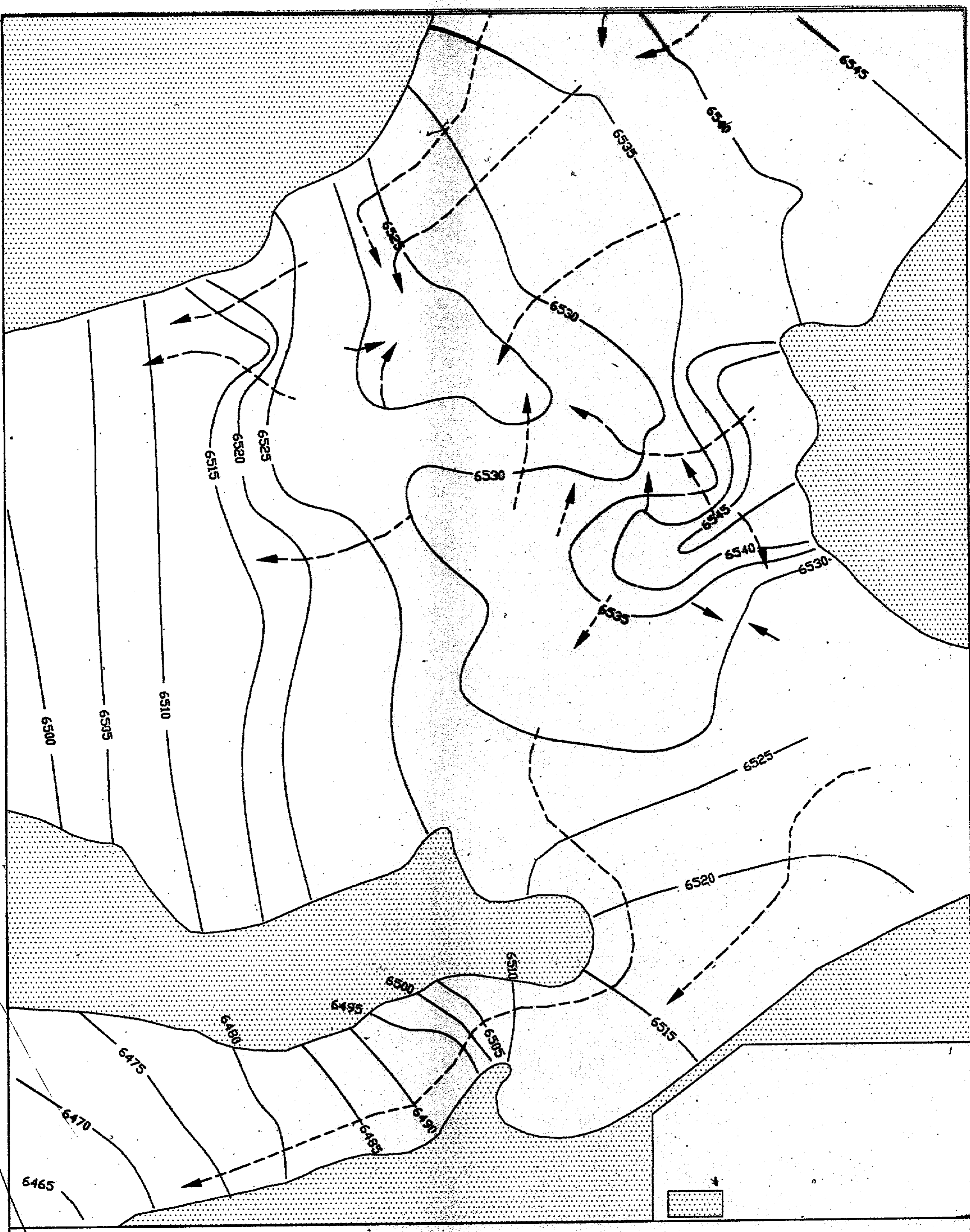

FIGURE 4-1D. WATER-LEVEL ELEVATIONS FOR THE ALLUVIAL AQUIFER, 2000, FT-MSL, OVERLAY

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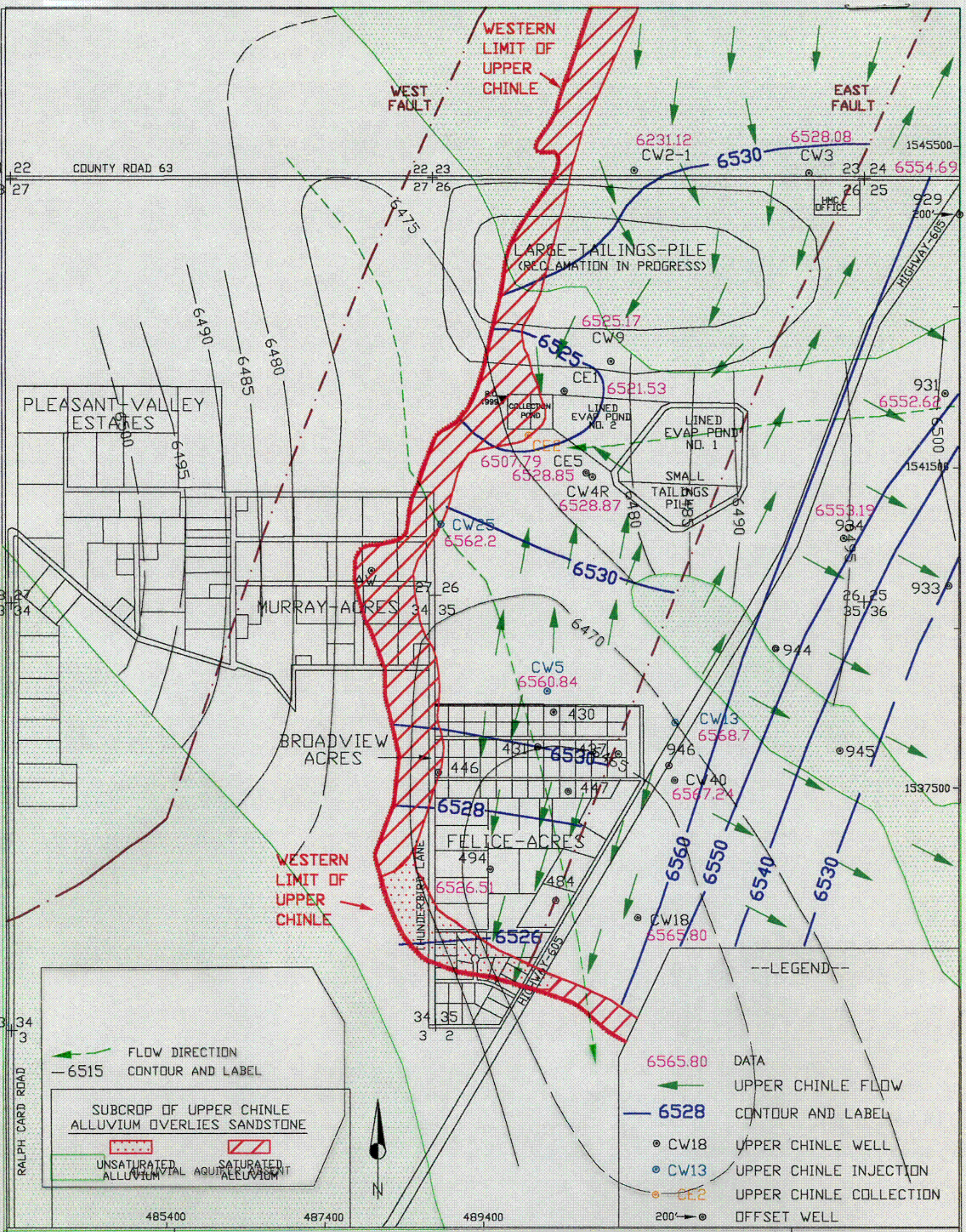

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FIGURE 4-1C. WATER-LEVEL ELEVATIONS FOR THE ALLUVIAL AQUIFER, (WEST AREA), 2000, FT-MSL, OVERLAY

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C08-A

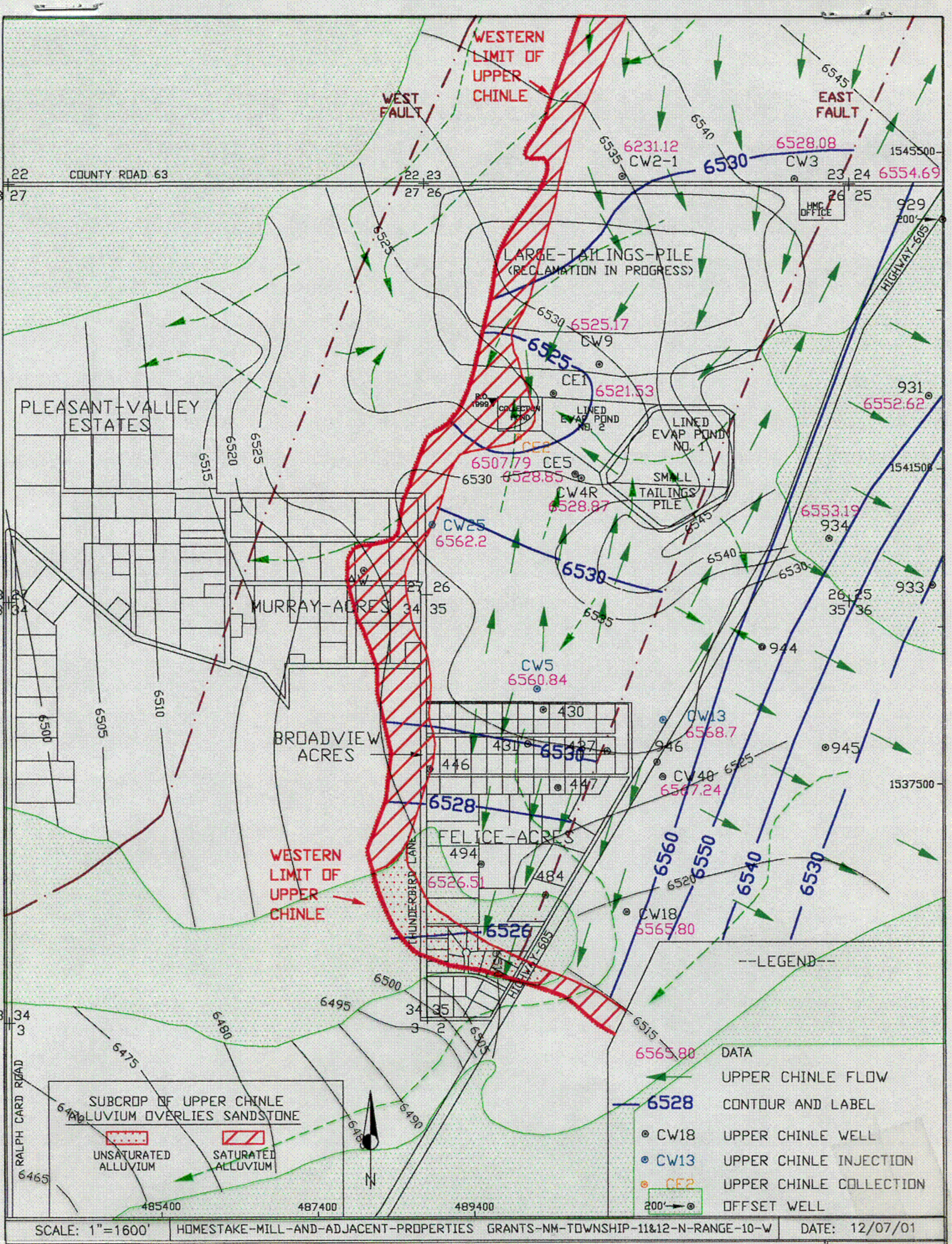

FIGURE 4-1D. WATER-LEVEL ELEVATIONS FOR THE ALLUVIAL AQUIFER, 2000, FT-MSL, OVERLAY

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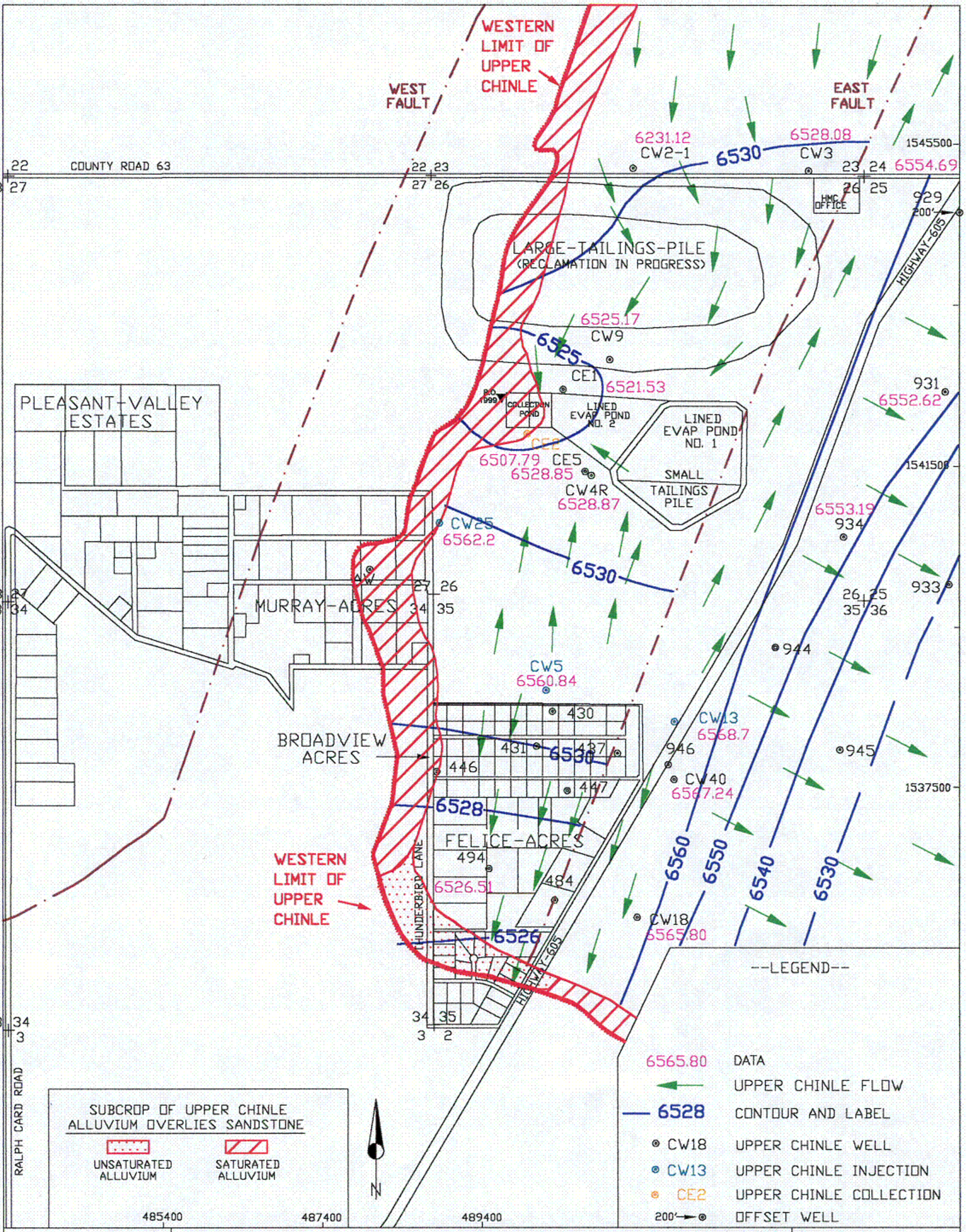

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FIGURE 4-2. WATER-LEVEL ELEVATIONS FOR THE UPPER CHINLE AQUIFER, 2000, FT-MSL

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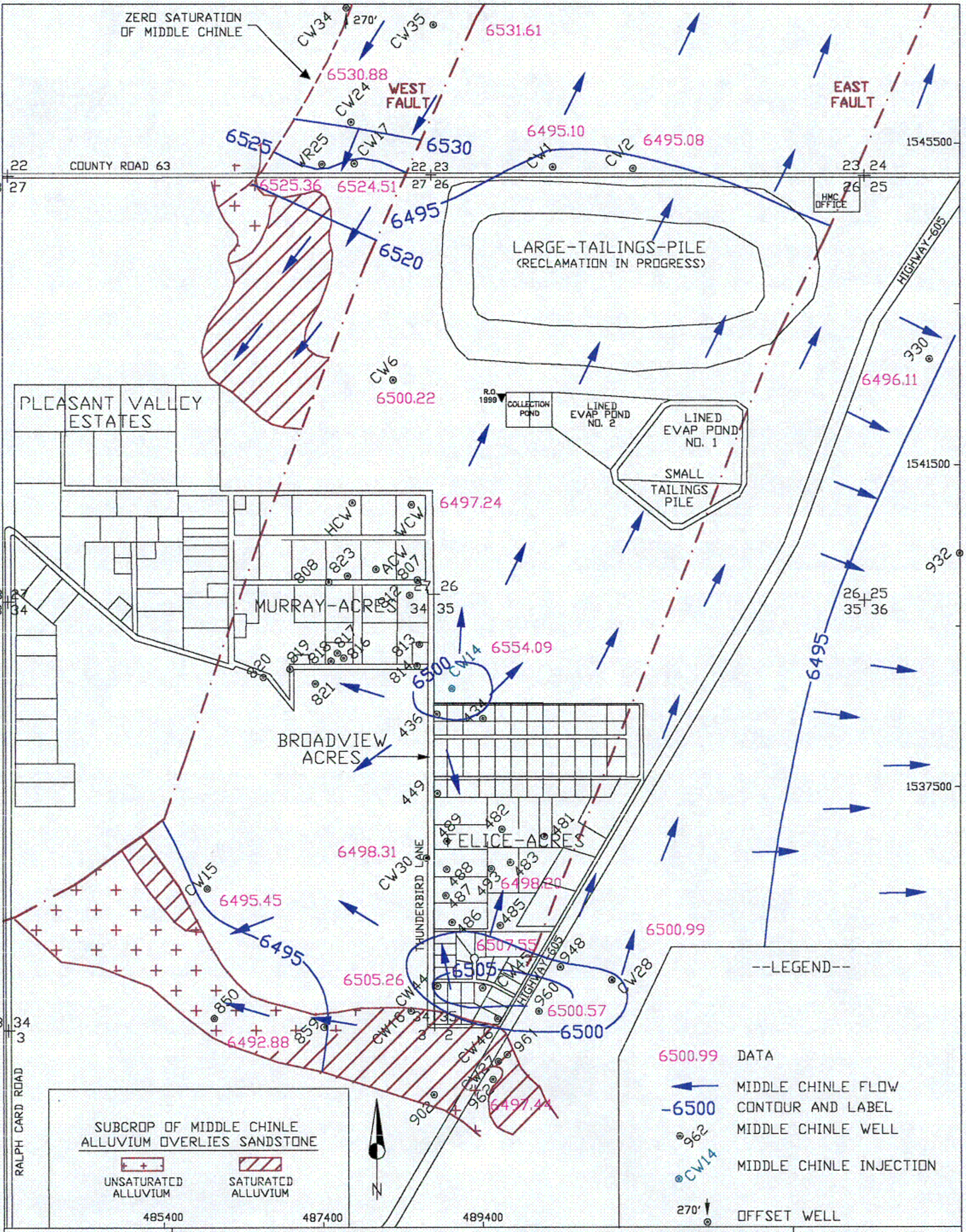

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FIGURE 4-3. WATER-LEVEL ELEVATIONS FOR THE MIDDLE CHINLE AQUIFER, 2000, FT-MSL

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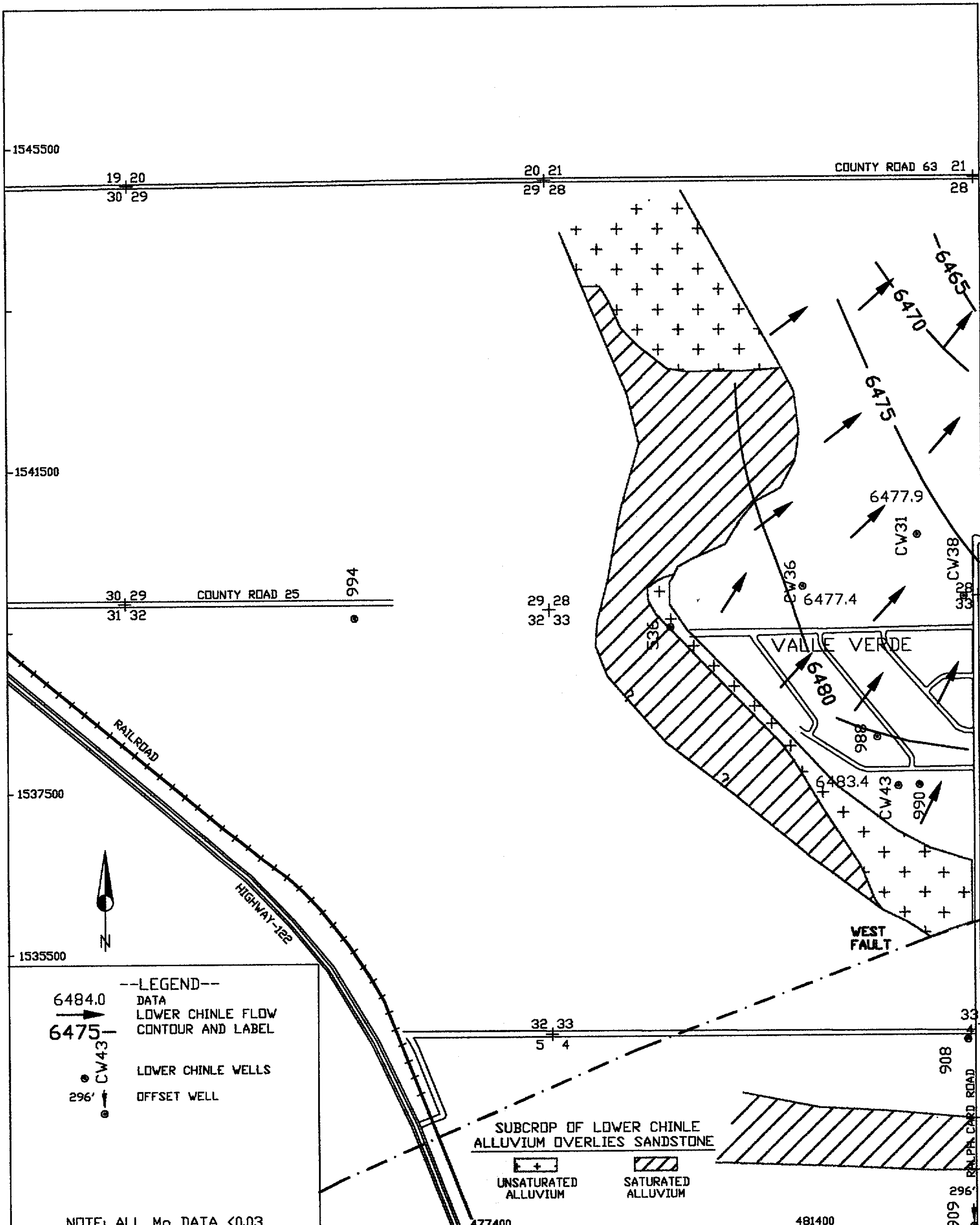

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FIGURE 4-4A. WATER-LEVEL ELEVATIONS FOR THE LOWER CHINLE AQUIFER (WEST AREA), 2000, FT/MSL		D:\R13\HMC\LOW1600 lh
		page 4-13

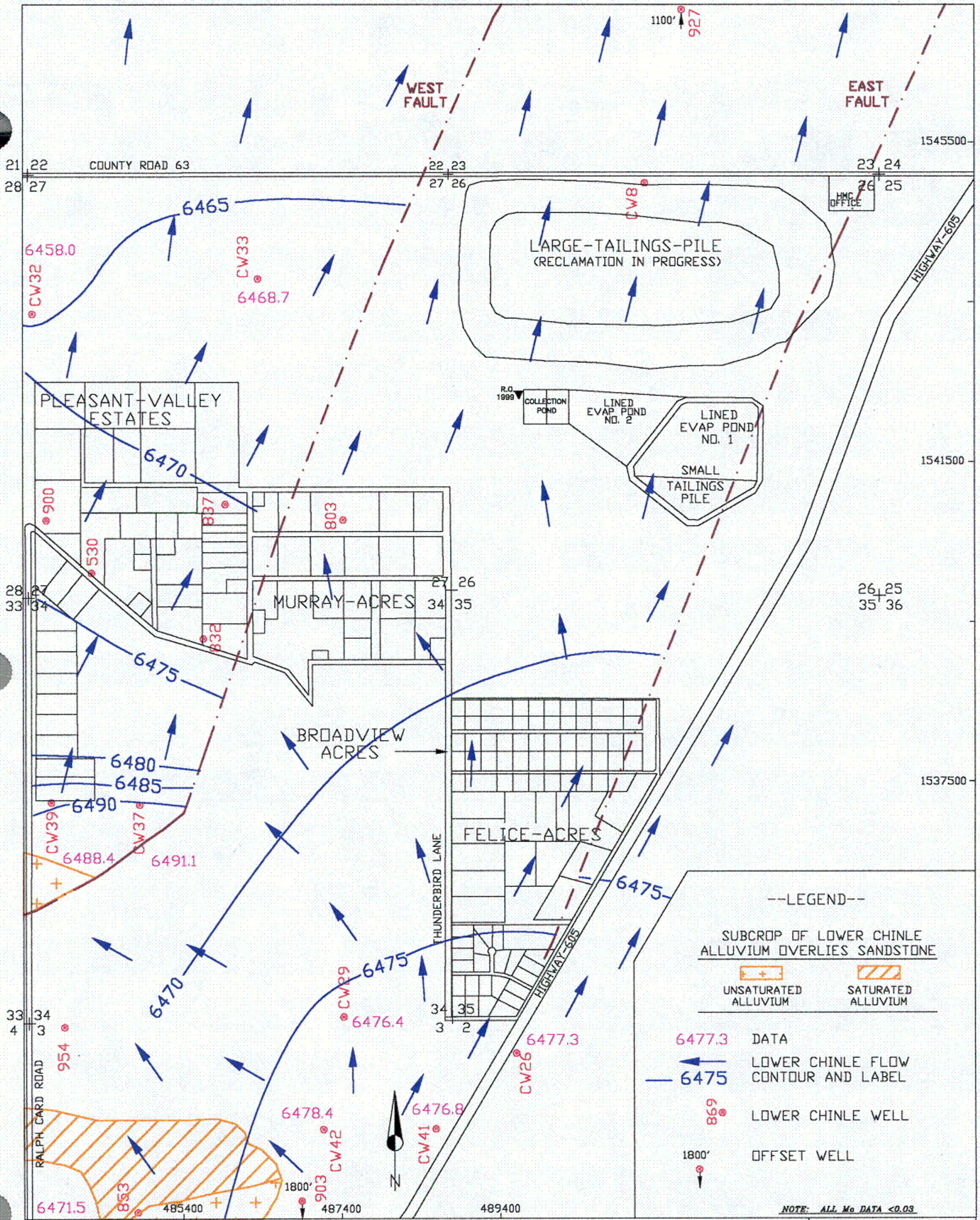

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FIGURE 4-4B. WATER-LEVEL ELEVATIONS FOR THE LOWER CHINLE AQUIFER, 2000, FT-MSL

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