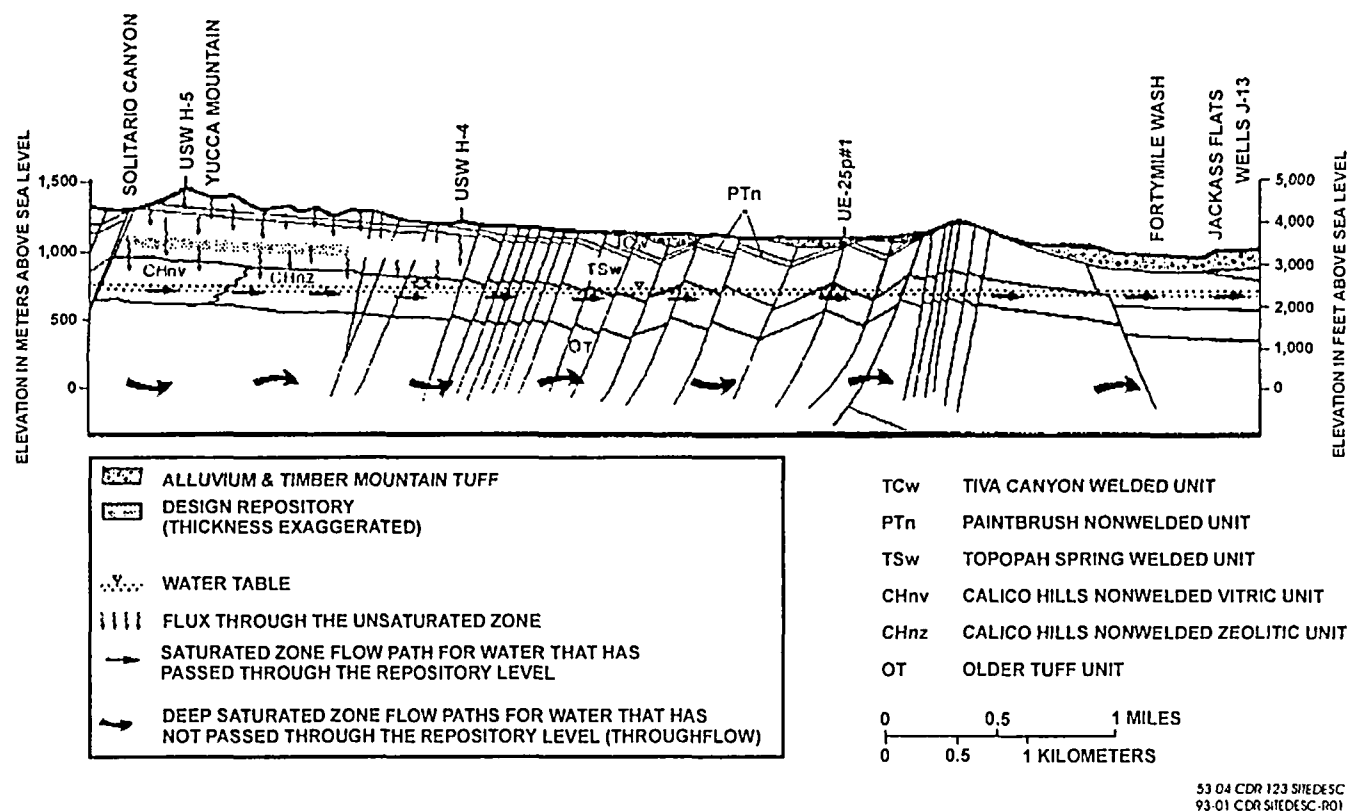
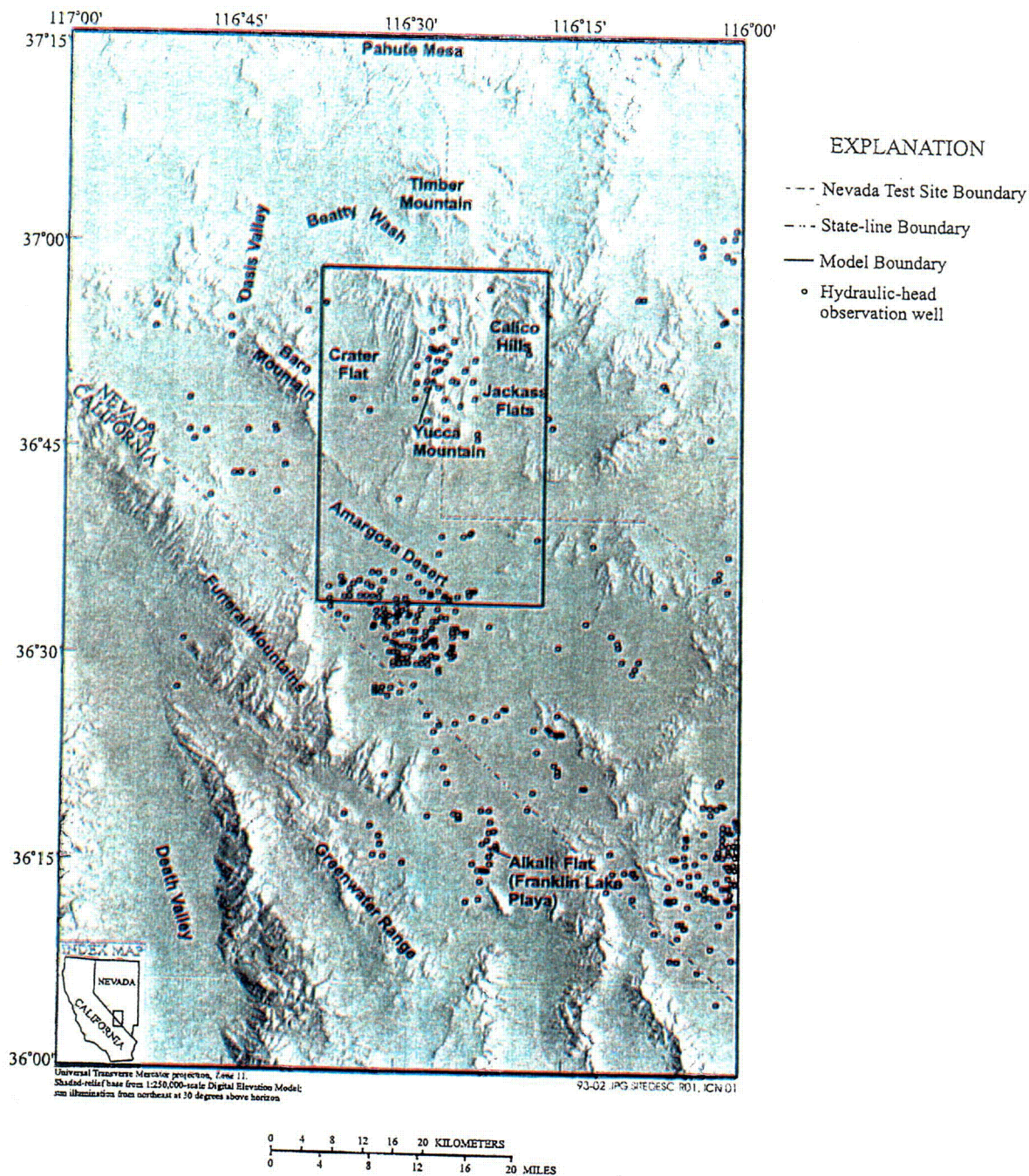




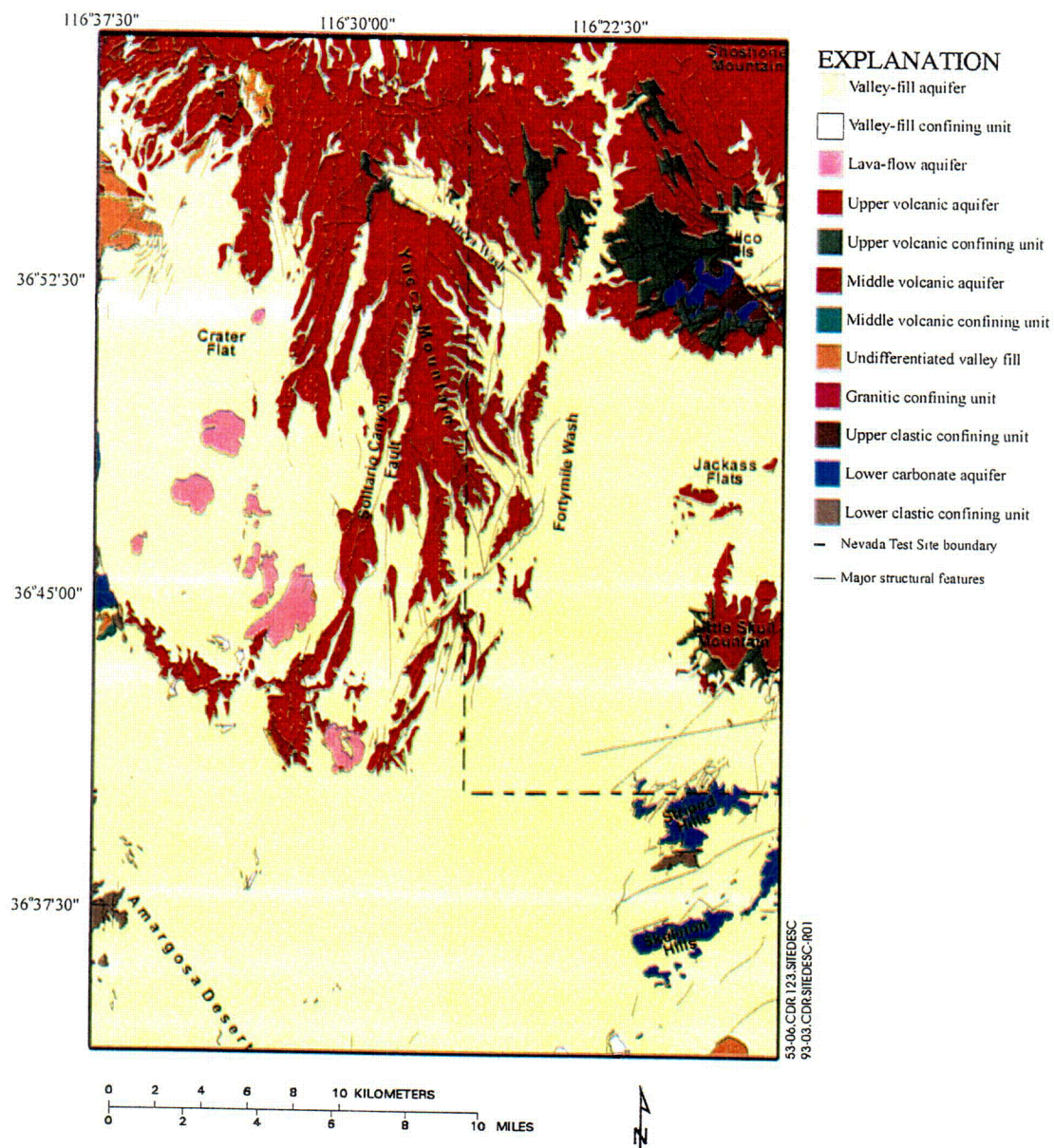
NOTE: Part of the indicated lateral flow below the water table is diverted southward before reaching the Fortymile Wash area (adapted from DOE 1988, Figure 3-46)

Figure 9.3-1. Conceptual Hydrogeologic Cross Section from Northwest to Southeast across the Site Area to Jackass Flats



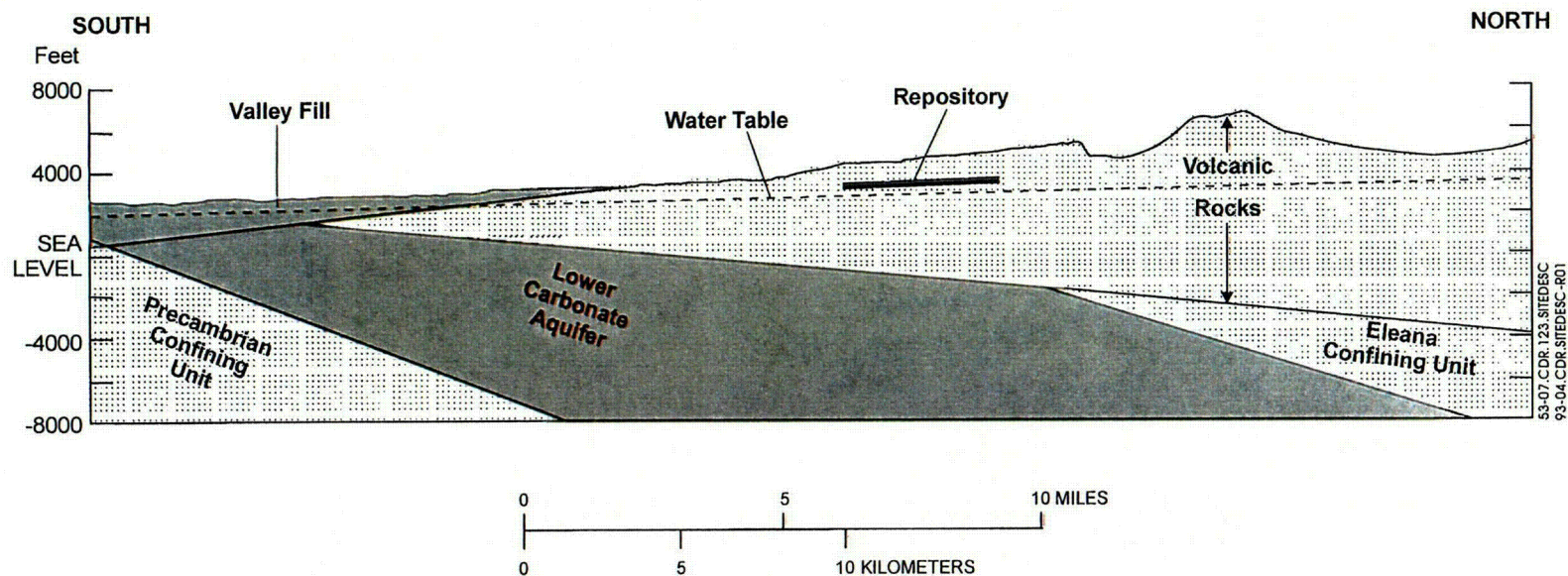
NOTE: Adapted from Czarnecki, Faunt et al. (1997, Figure 1)

Figure 9.3-2. Location of the Site Saturated Zone Study Area, Showing Associated Geographic Features and Hydraulic-Head Observation Wells



NOTE: See Table 9.3-1 for definitions of hydrogeologic and stratigraphic units. Limestone aquifer, lower volcanic aquifer, and lower volcanic confining unit do not appear at the land surface (after Czarnecki, Faunt et al. 1997).

Figure 9.3-3. Generalized Hydrogeologic Map of Site Saturated Zone Study Area with Major Faults



Source: Adapted from Robinson (1985, Figure 9)

Figure 9.3-4. Cross Section from Northern Yucca Mountain to Northern Amargosa Desert, Showing Generalized Geology and the Water Table

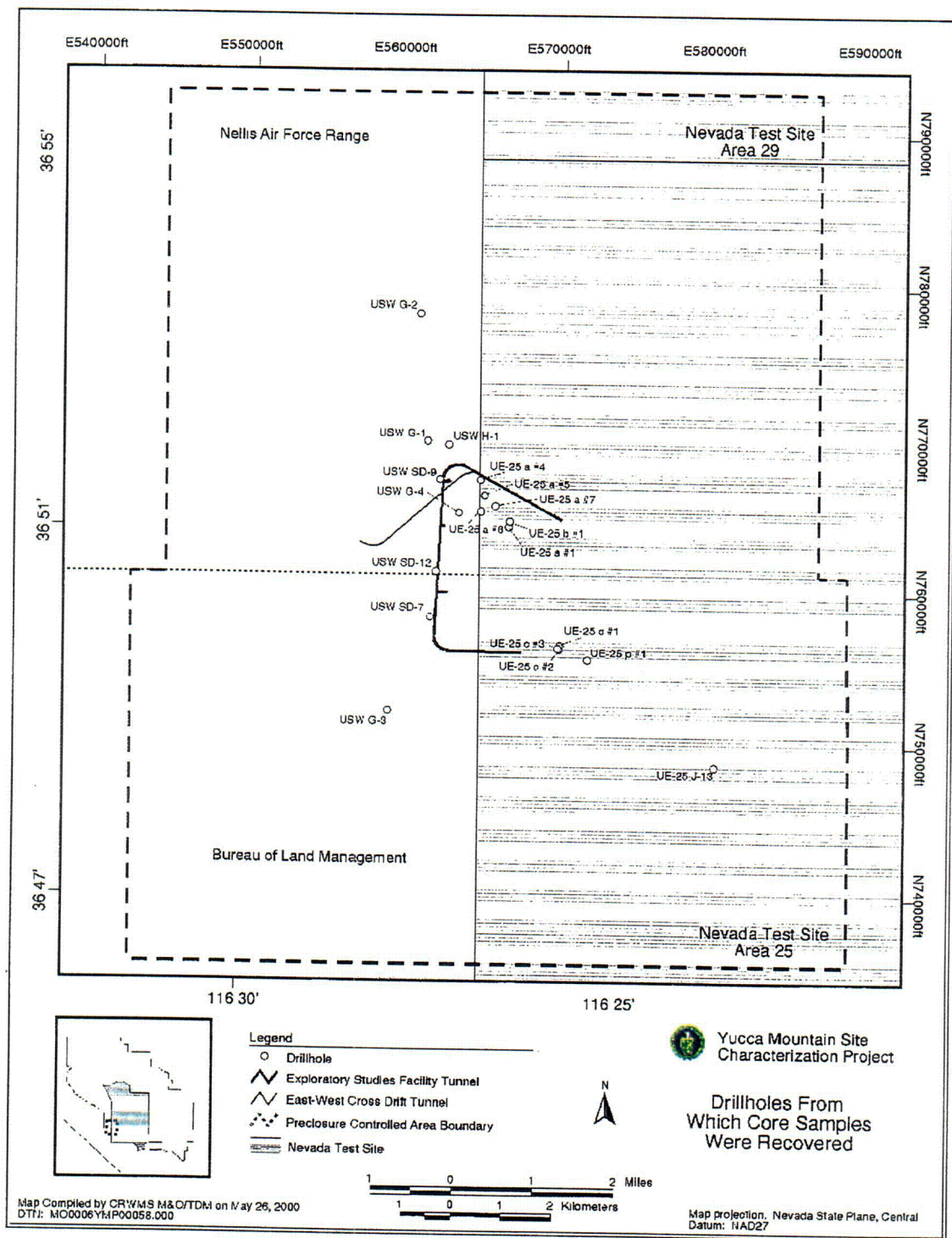
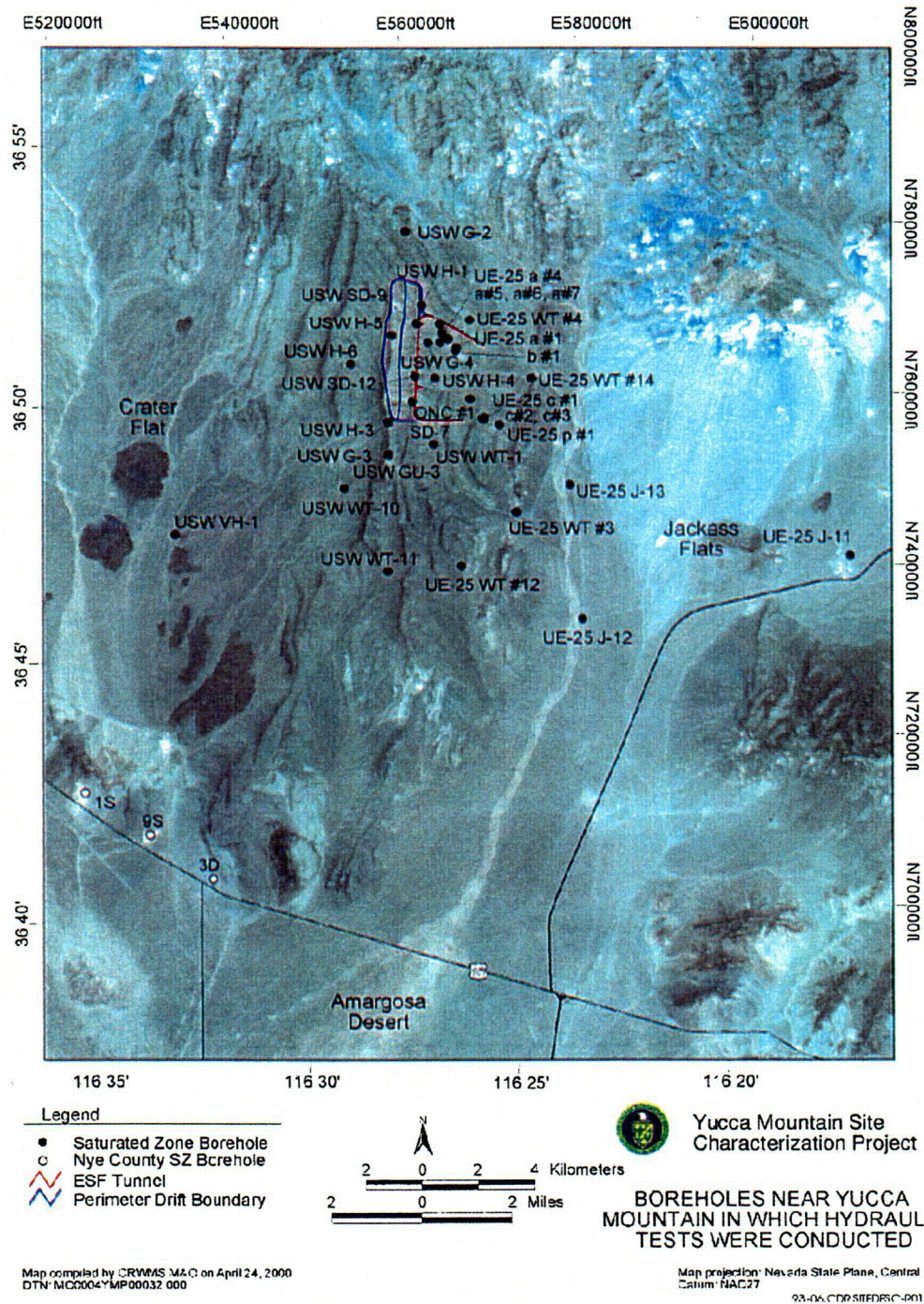
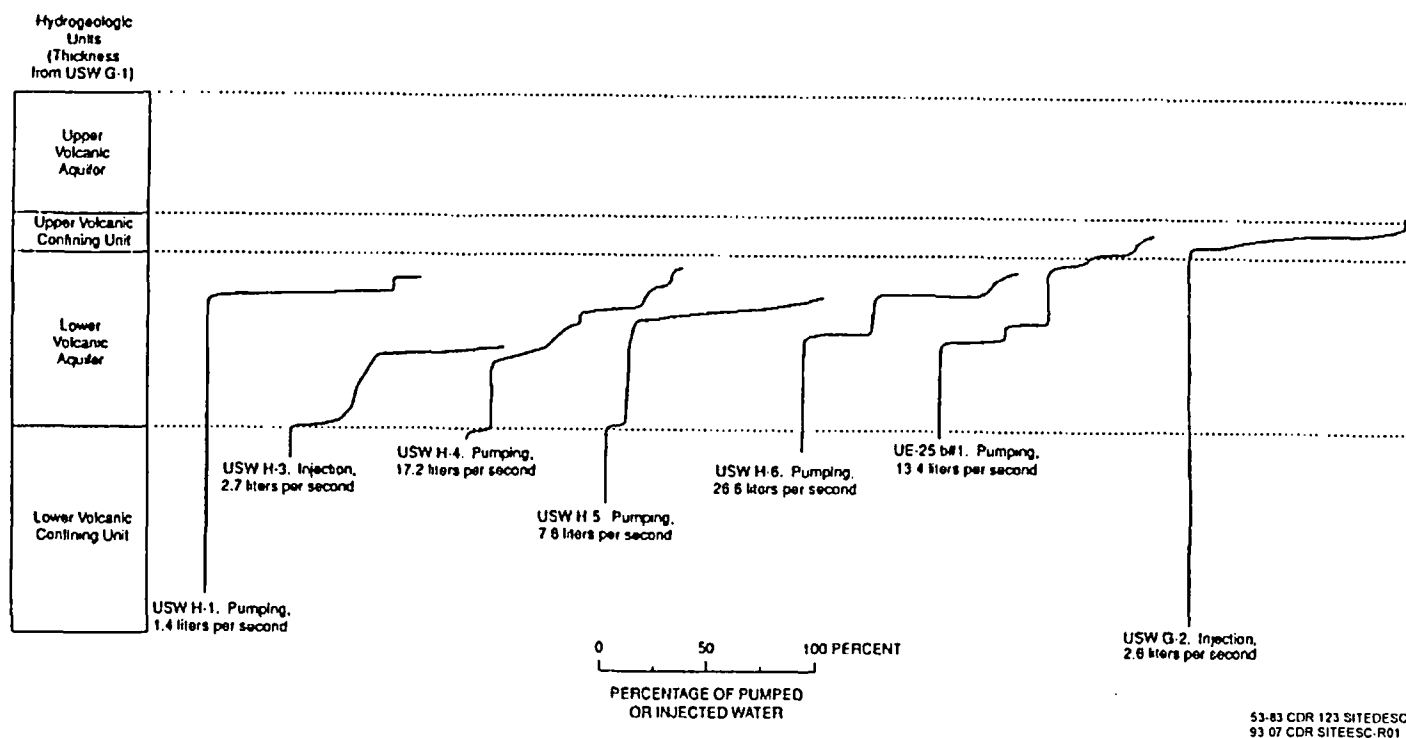


Figure 9.3-5. Drill Holes from Which Core Samples Were Recovered



Source: CRWMS M&O (2000b, Figure 3-8)

Figure 9.3-6. Boreholes near Yucca Mountain in Which Hydraulic Tests Have Been Conducted



NOTE: Flow surveys adjusted to a "standard thickness" of 524.3 m in the lower volcanic aquifer and a "standard thickness" of 121.3 m in the upper confining unit, the thickness of the units in borehole USW G-1. All flow surveys are from 0 to 100 percent of total pumping or injection.

Figure 9.3-7. Flow Surveys for Selected Boreholes in the Yucca Mountain Area

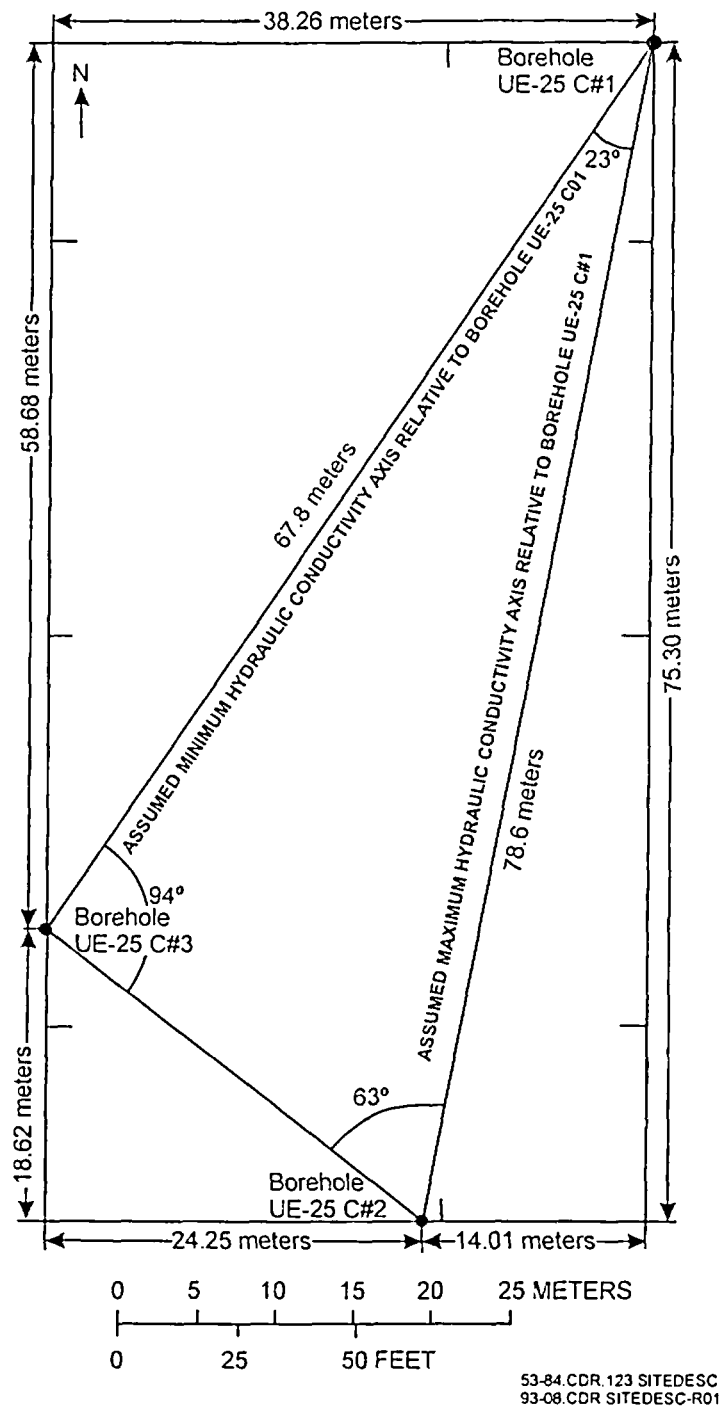
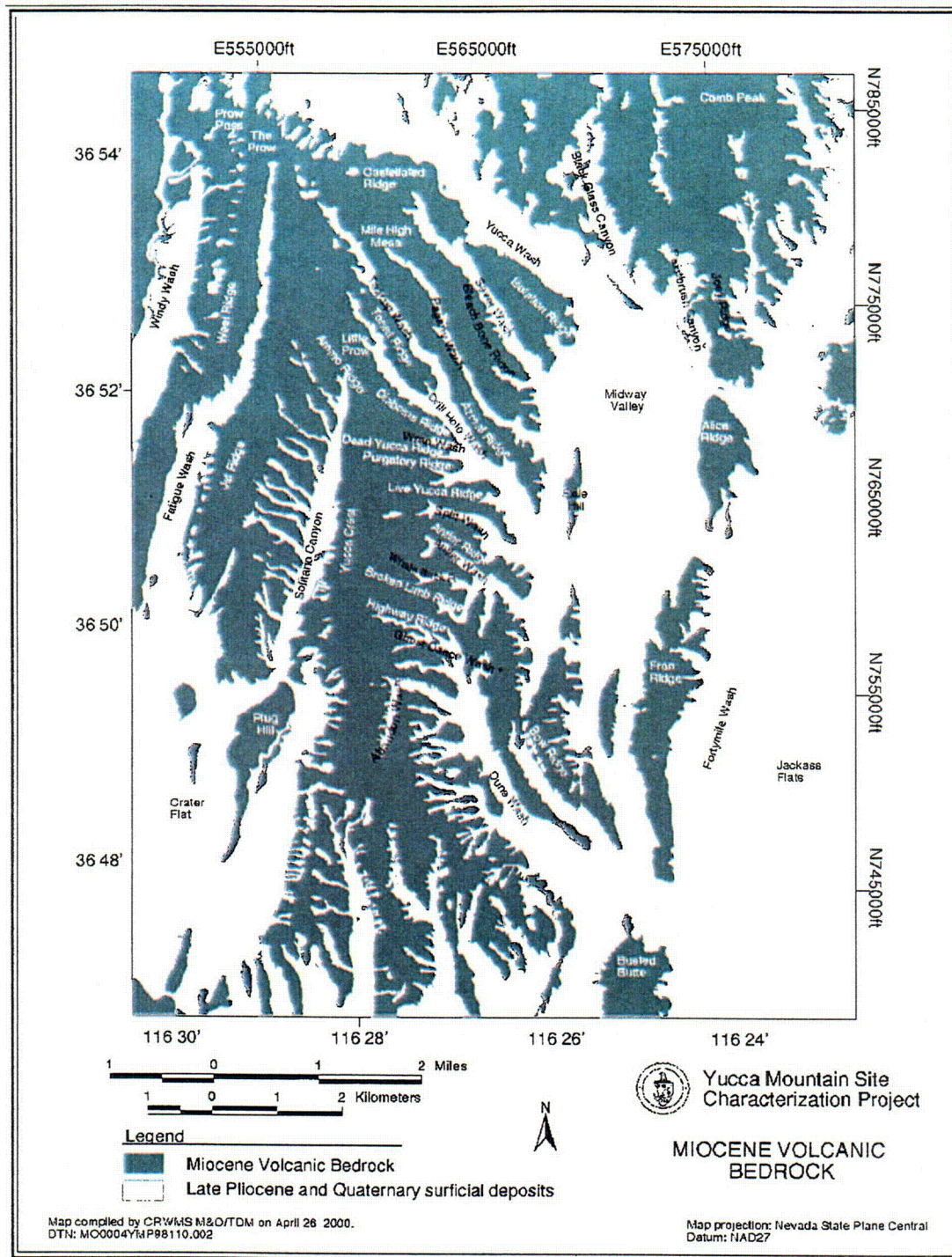
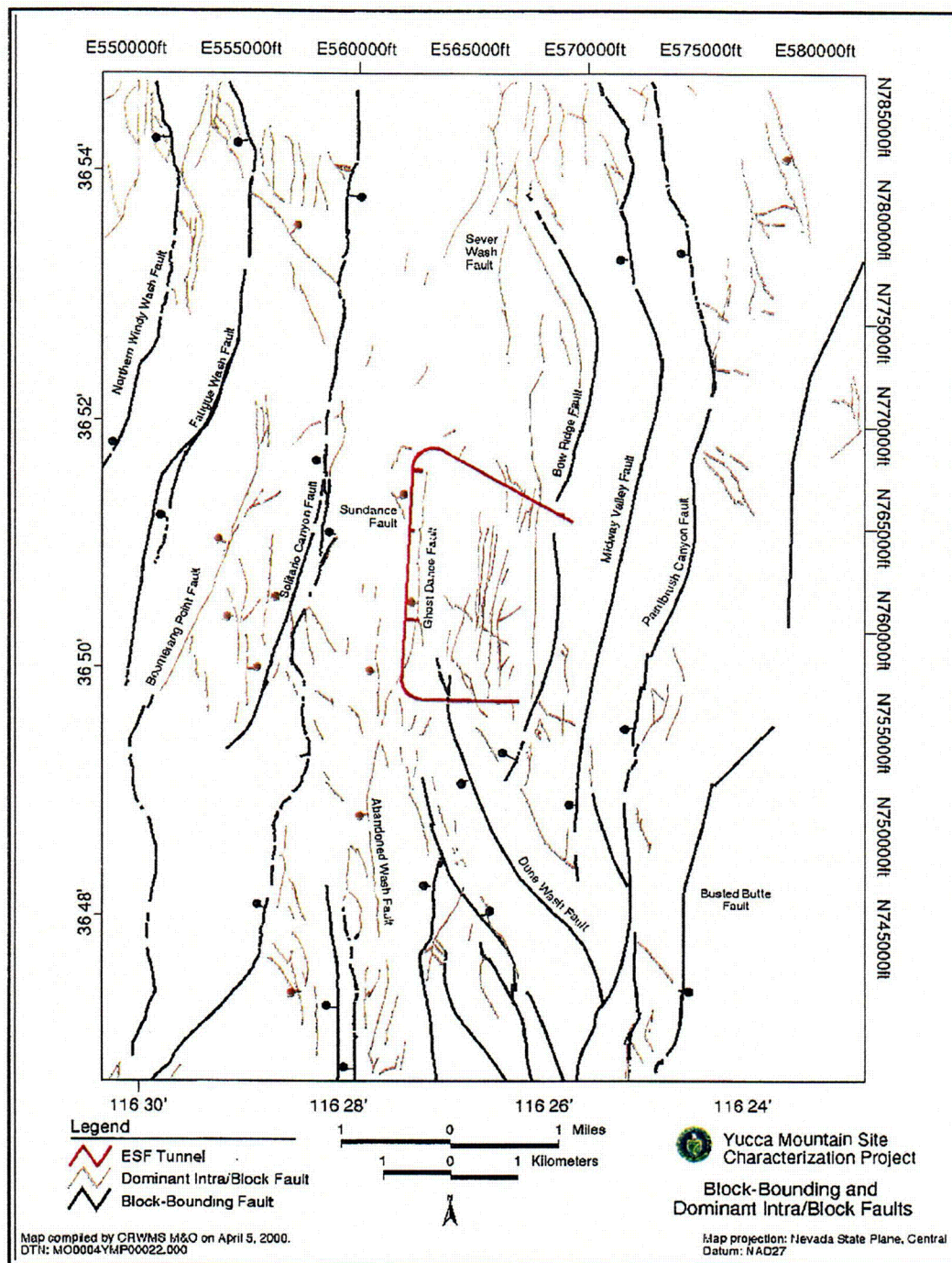


Figure 9.3-8. Location of Boreholes at the C-Hole Complex



NOTE: Upland areas where bedrock is exposed or very shallow are shaded.

Figure 9.3-9. Map Showing the Names of Principal Geographic Features in the Site Area



NOTE: Red in the site area based on the mapping of Day et al. (1998)

Figure 9.3-10. Location of Block-Bounding Faults and Important Intrablock Faults in the Yucca Mountain Area

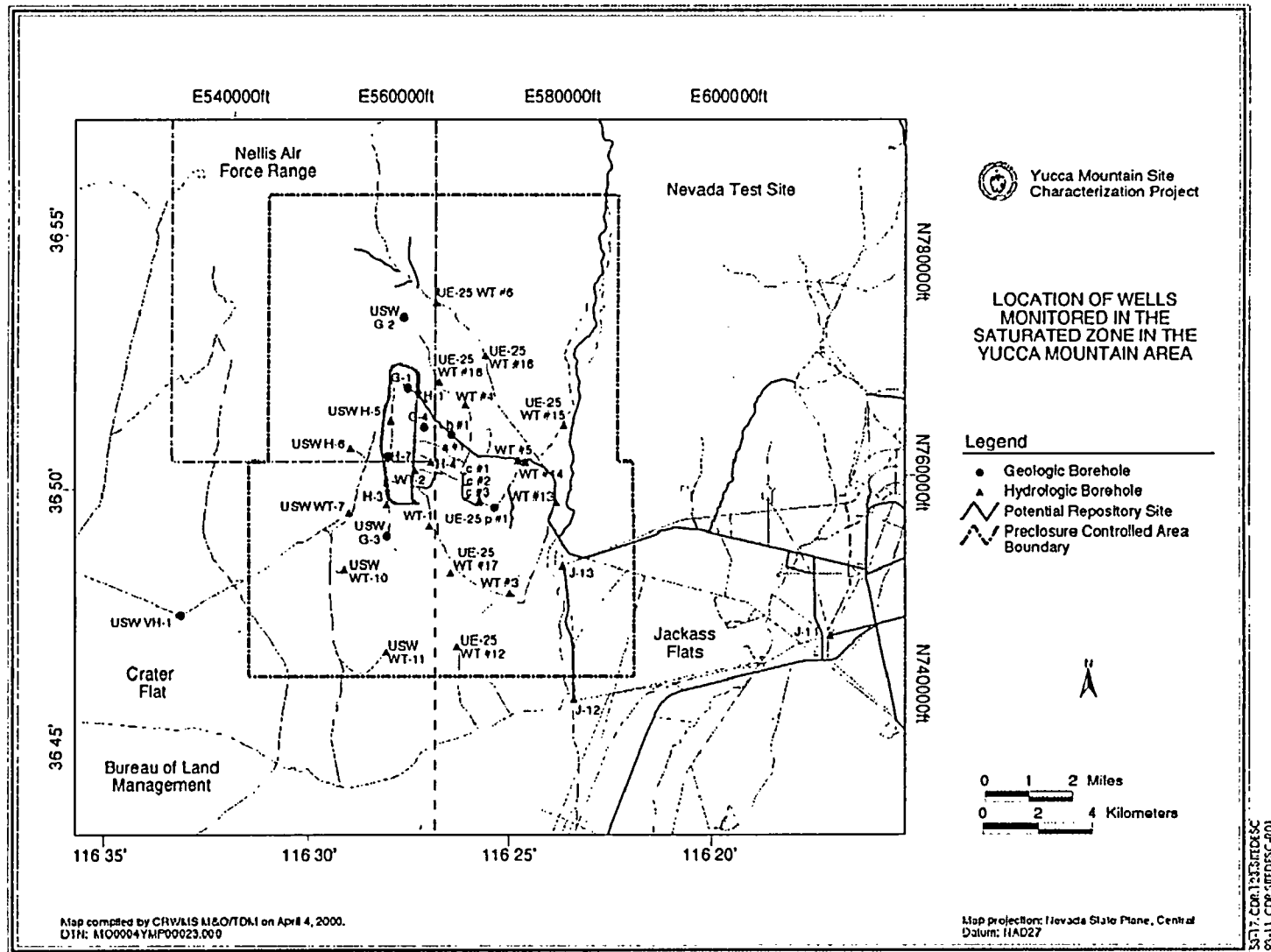
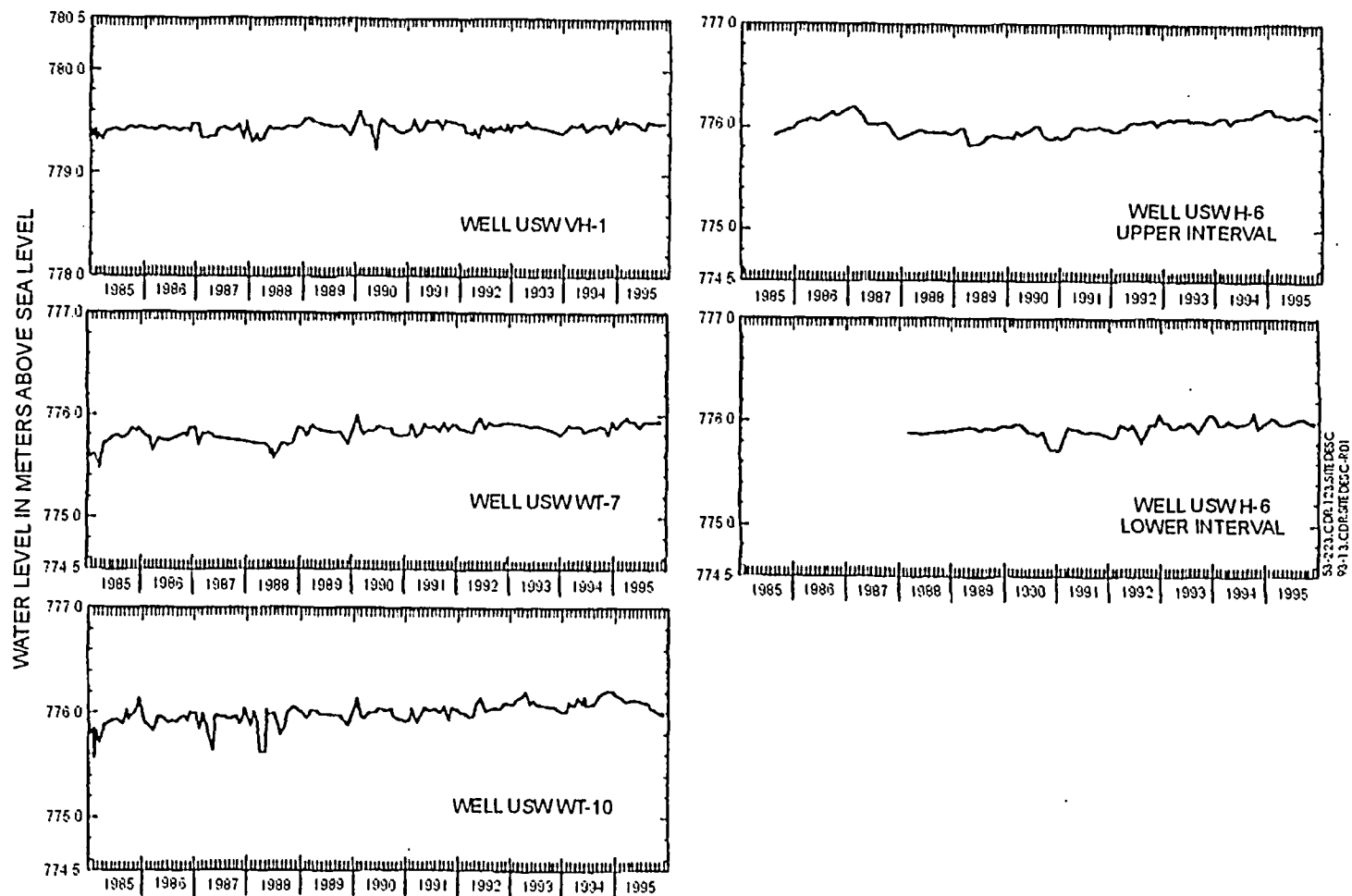


Figure 9.3-11. Location of Wells Monitored in the Saturated Zone in the Yucca Mountain Area



Source: Graves et al. (1997, Figure 42)

Figure 9.3-13. Water-Level Elevation, 1985 to 1995, for Wells Located in Crater Flat

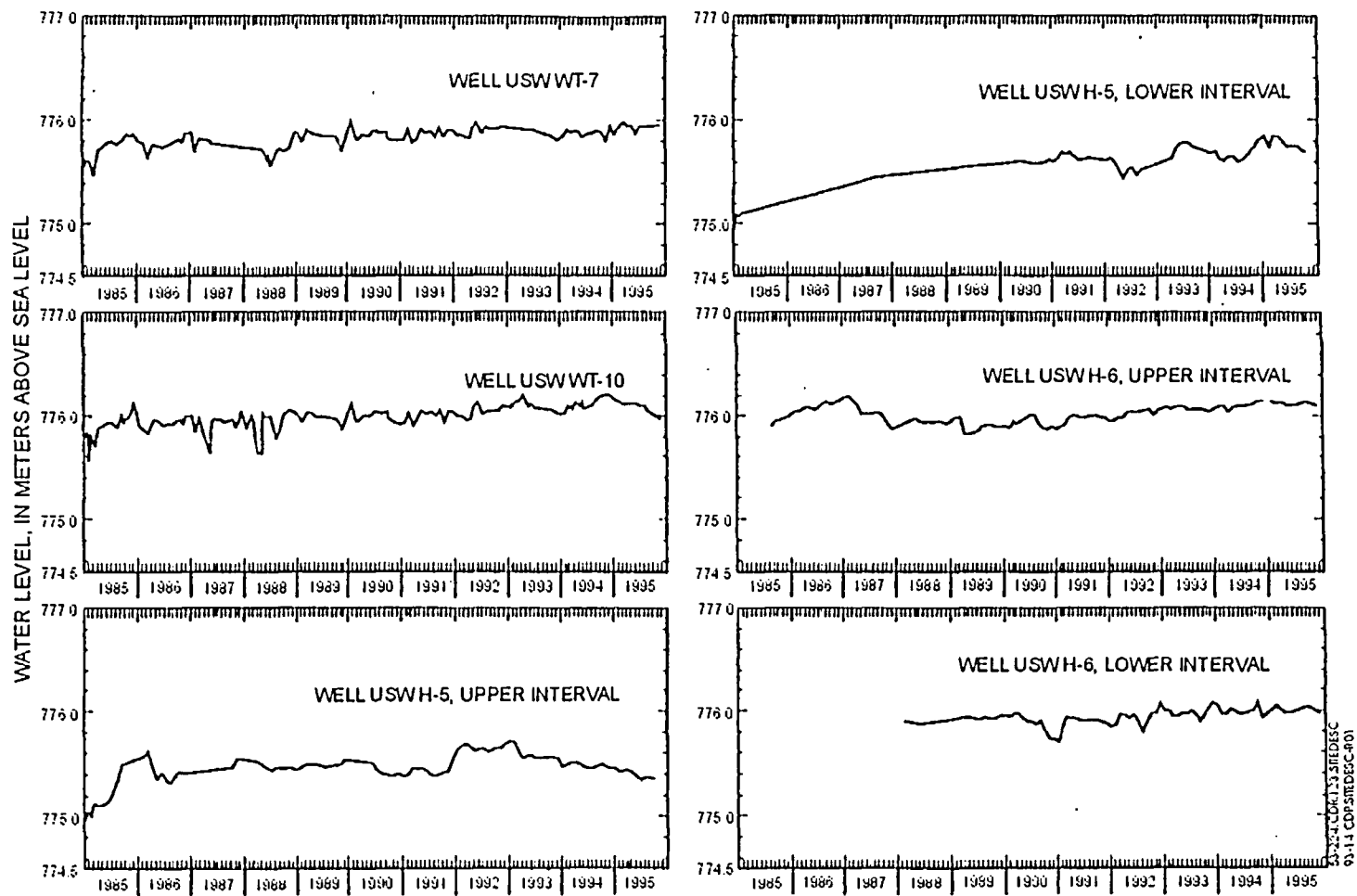
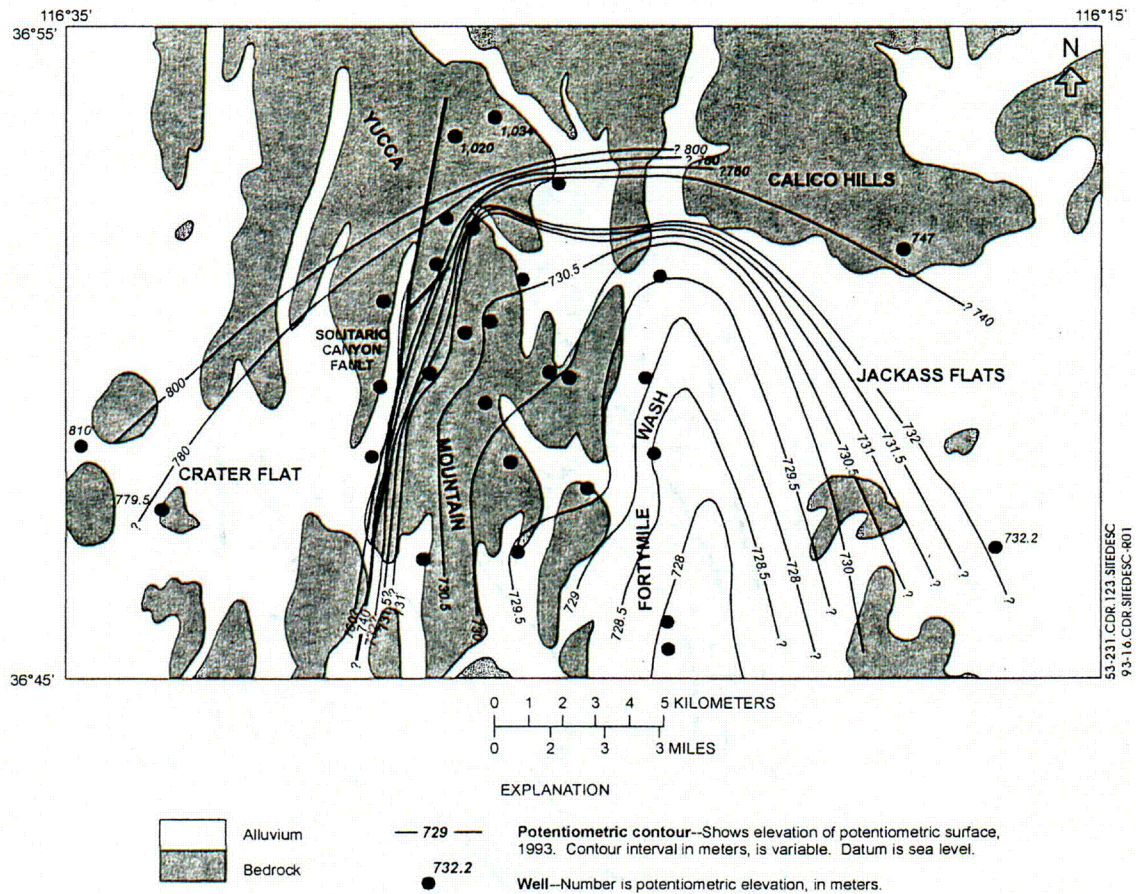
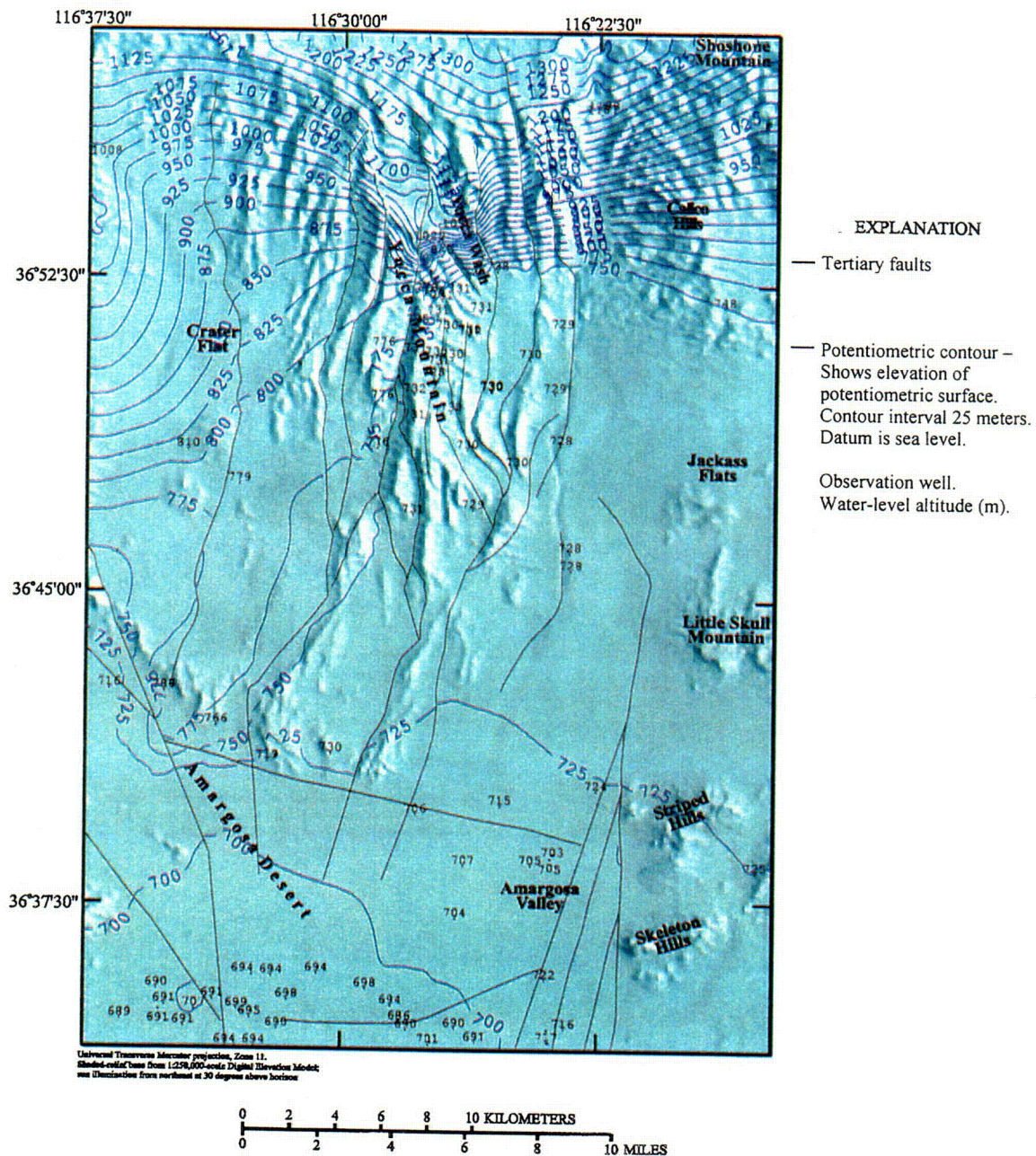


Figure 9.3-14. Water-Level Elevations, 1985 to 1995, for Wells with an Approximate Water-Level Elevation of 776 Meters



Source: Tucci and Burkhardt (1995, Figure 4)

Figure 9.3-16. Potentiometric Surface of the Yucca Mountain Area, 1993

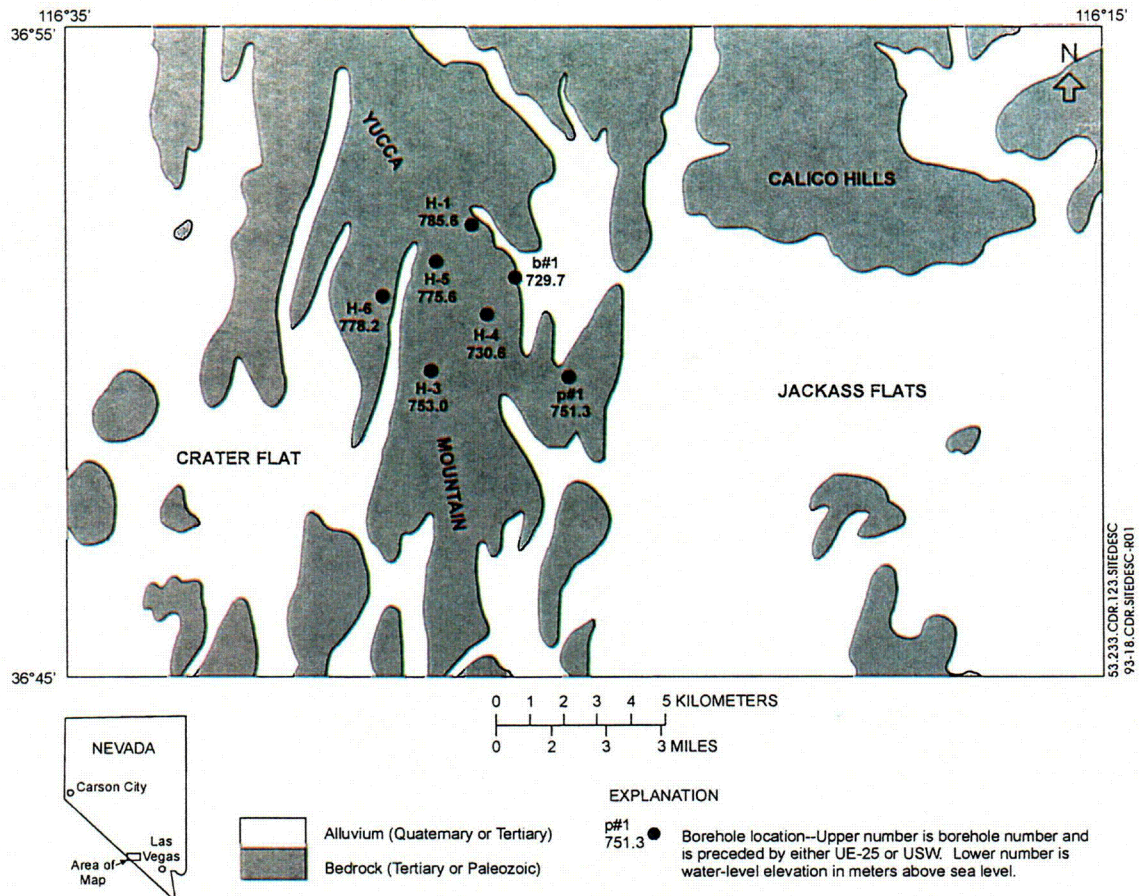


93-17.DOC.SITEDESC-R01

Source: USGS (2000a, Figure 6-1).

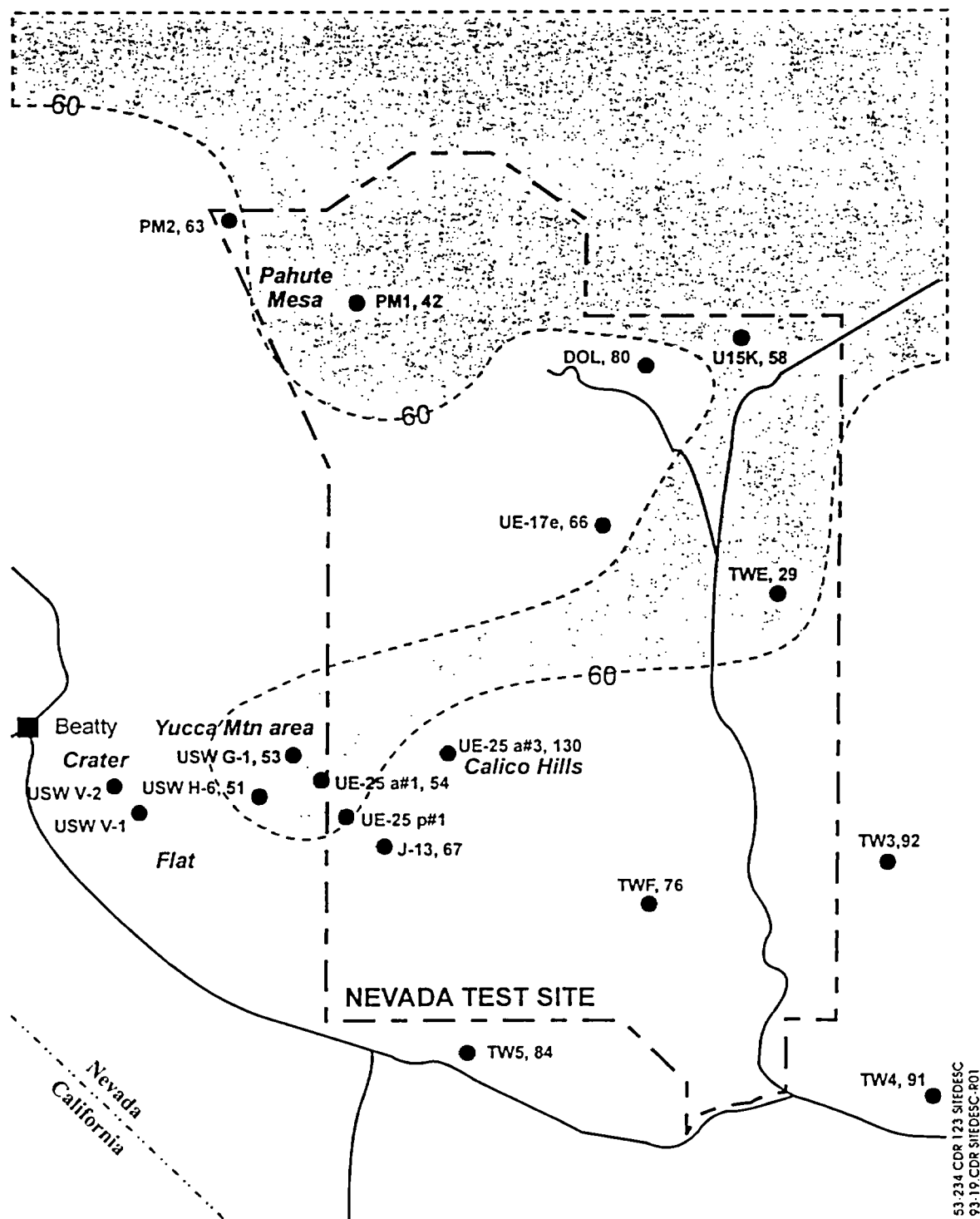
NOTE: While some contour labels are illegible, contour values can be determined from the knowledge that the contour interval is 25 m.

Figure 9.3-17. Potentiometric Surface in the Yucca Mountain Site Saturated Zone Flow Model Area



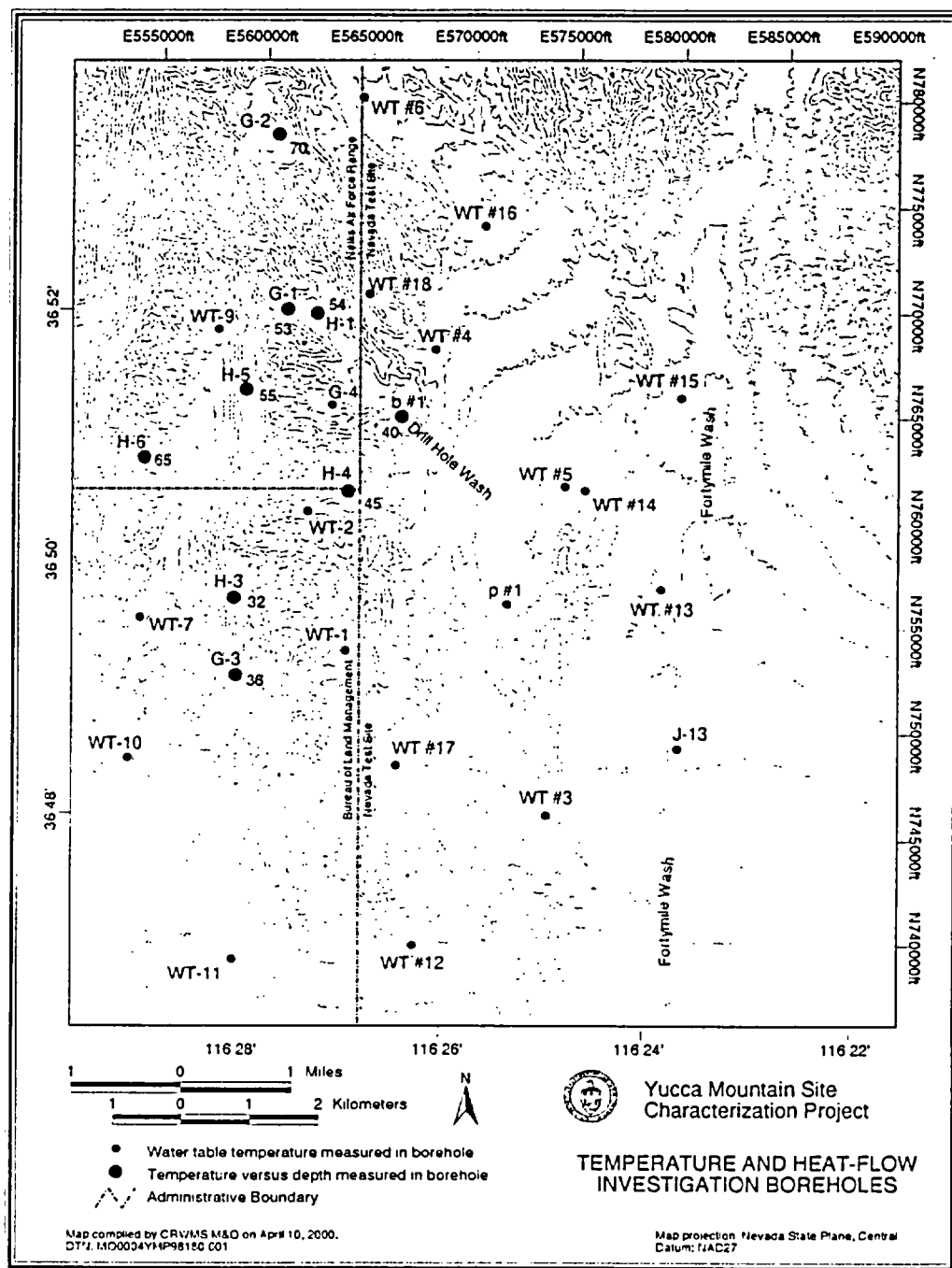
Source: Luckey et al. (1996, Figure 10)

Figure 9.3-18. Potentiometric Levels in the Lower Volcanic Confining Unit and Carbonate Aquifer



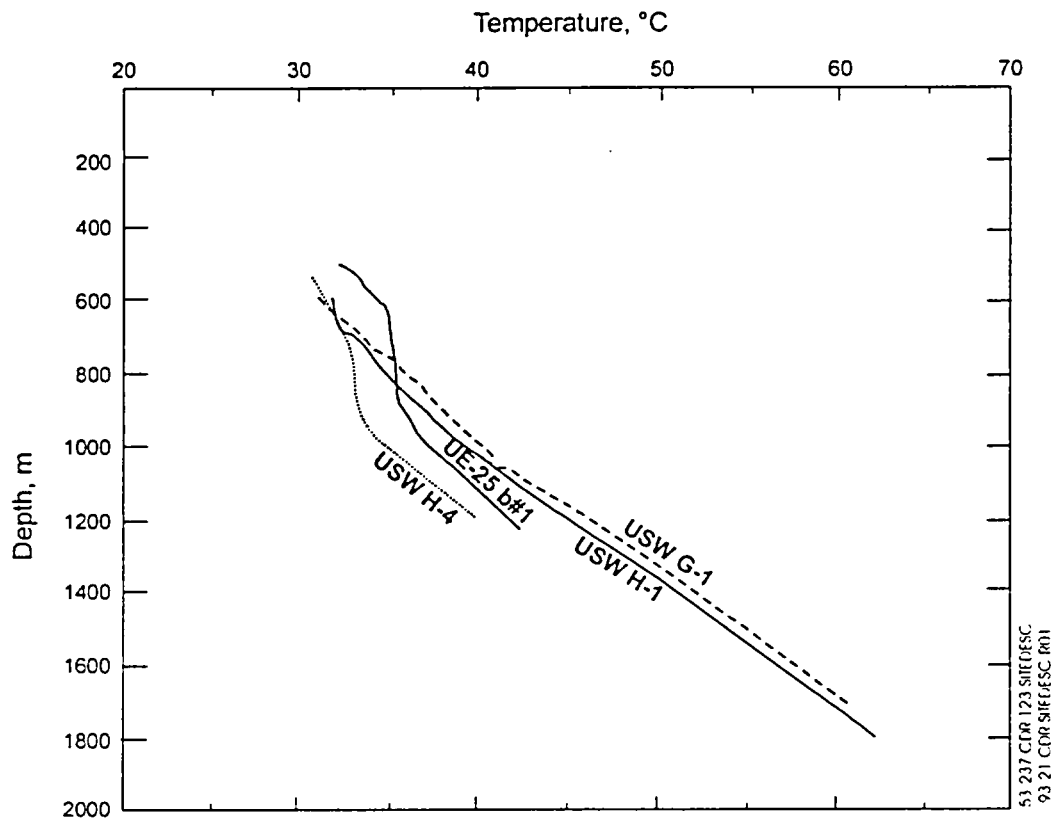
NOTE: Value following borehole number is heat flow in milliwatts per square meter (mW/m²).

Figure 9.3-19. Heat Flows Determined for Boreholes at and near the Nevada Test Site



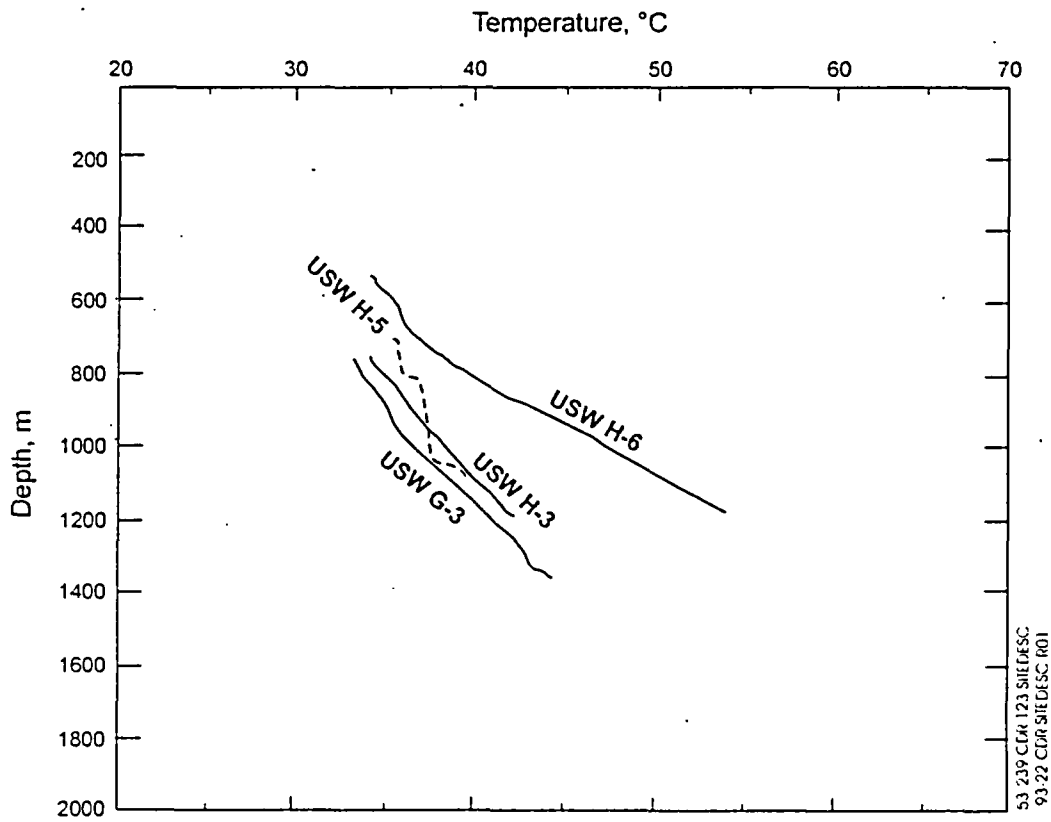
NOTE: Small symbols denote boreholes in which only water-table temperature was measured. Large symbols denote boreholes in which temperature versus depth also was measured in the saturated zone. Small numbers (e.g., 70) near borehole designators (e.g., G-2) denote heat flow in the saturated zone, in milliwatts per square meter (mW/m^2).

Figure 9.3-20. Boreholes in the Vicinity of Yucca Mountain Used for Temperature and Heat-Flow Investigations



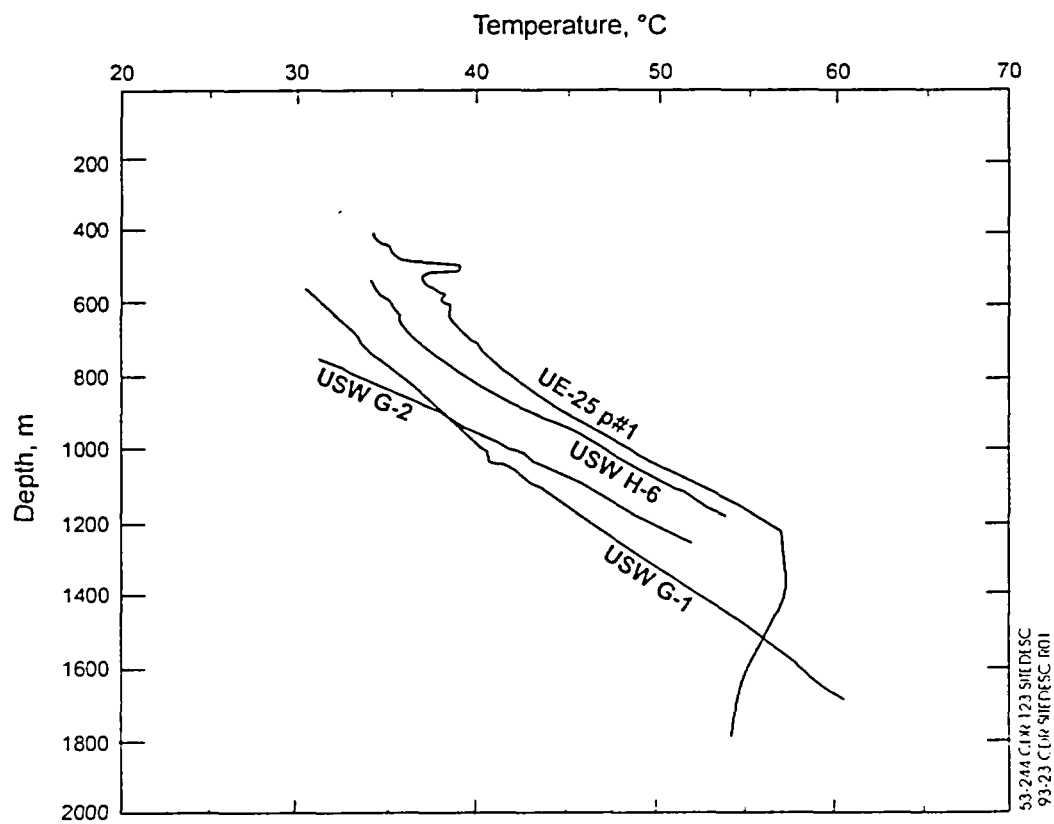
Source: Sass, Lachenbruch et al. (1988)

Figure 9.3-21. Temperature Logs for Boreholes in Upper Drill Hole Wash and along the Eastern Edge of Yucca Mountain



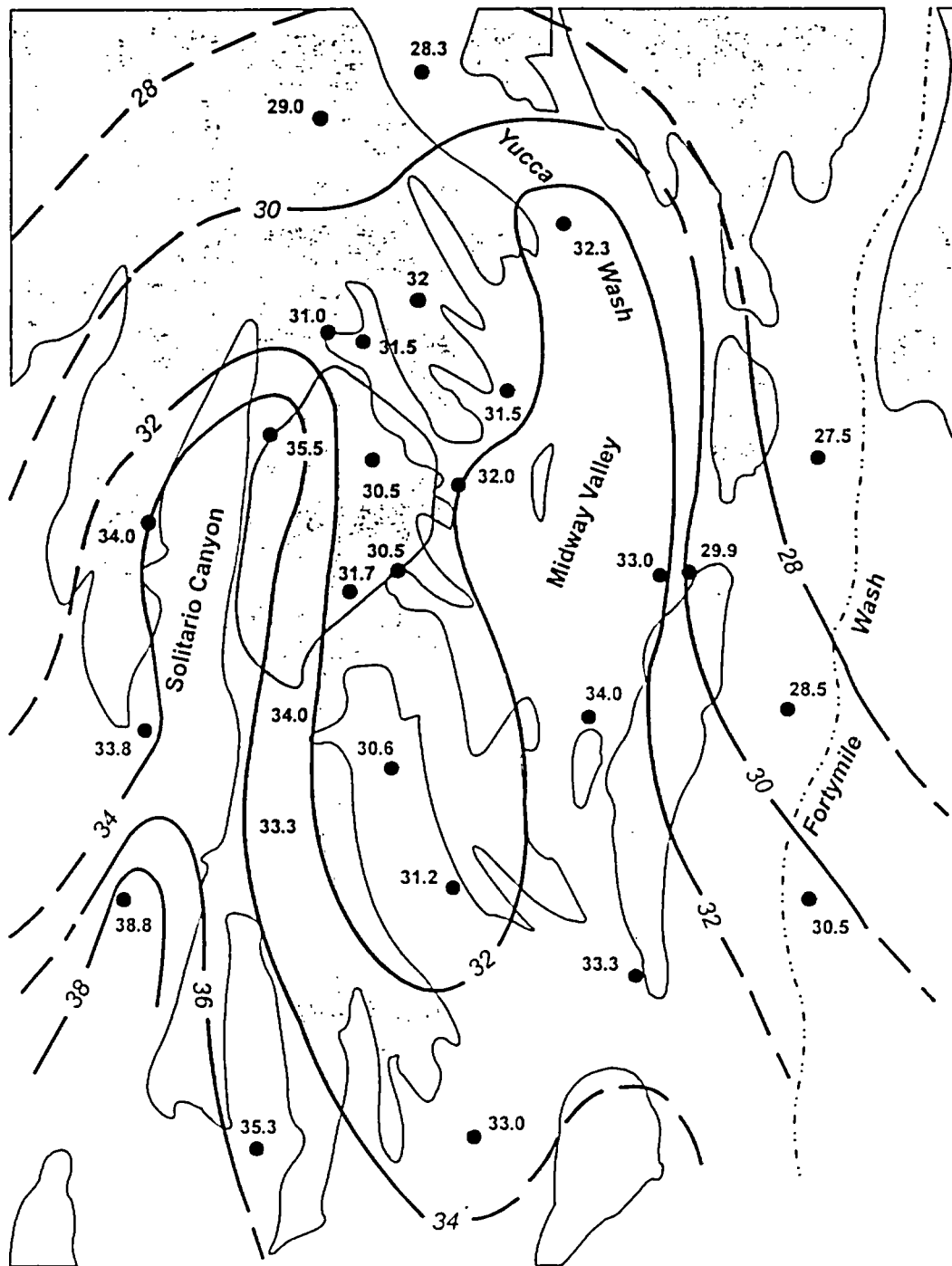
Source: Sass, Lachenbruch et al. (1988)

Figure 9.3-22. Temperature Logs for Boreholes in the Vicinity of Solitario Canyon



Source: Sass, Lachenbruch et al. (1988)

Figure 9.3-23. Saturated Zone Temperature Logs for USW G-1, USW G-2, USW H-6, and UE-25 p#1

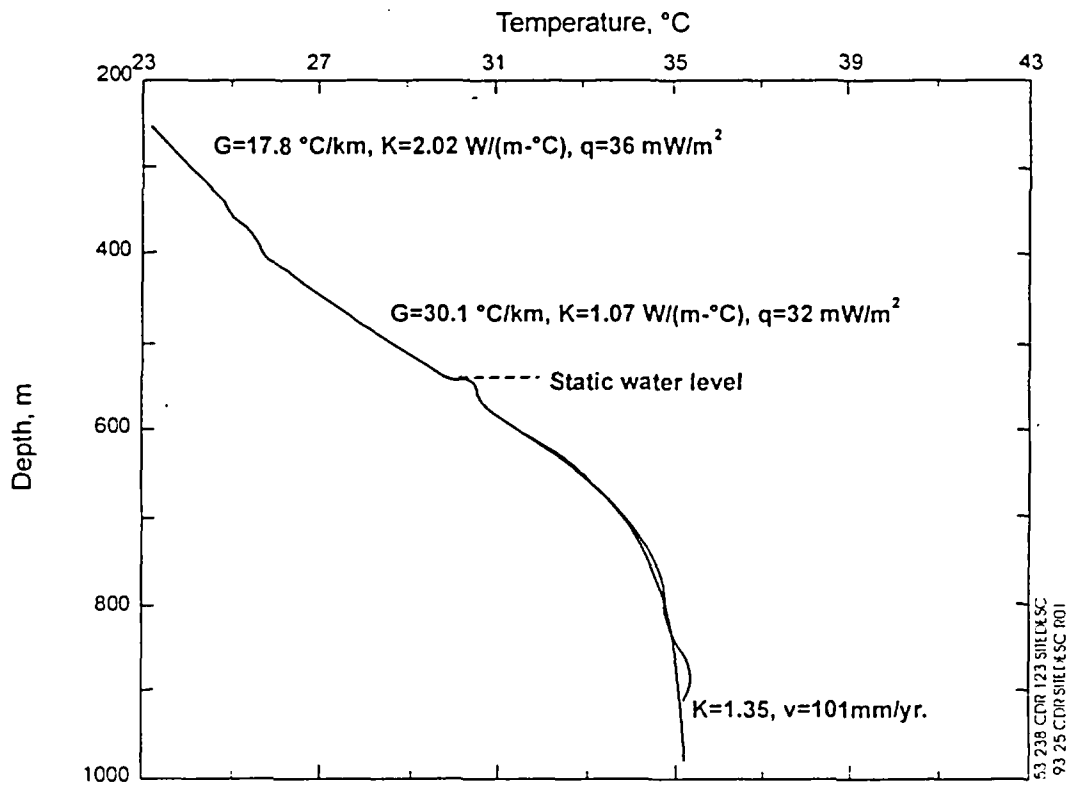


53 236 CDR 123 SIEDESC
93 24 CDR SIEDESC 001

Source: Sass, Dudley et al. (1995, Figure 8.4)

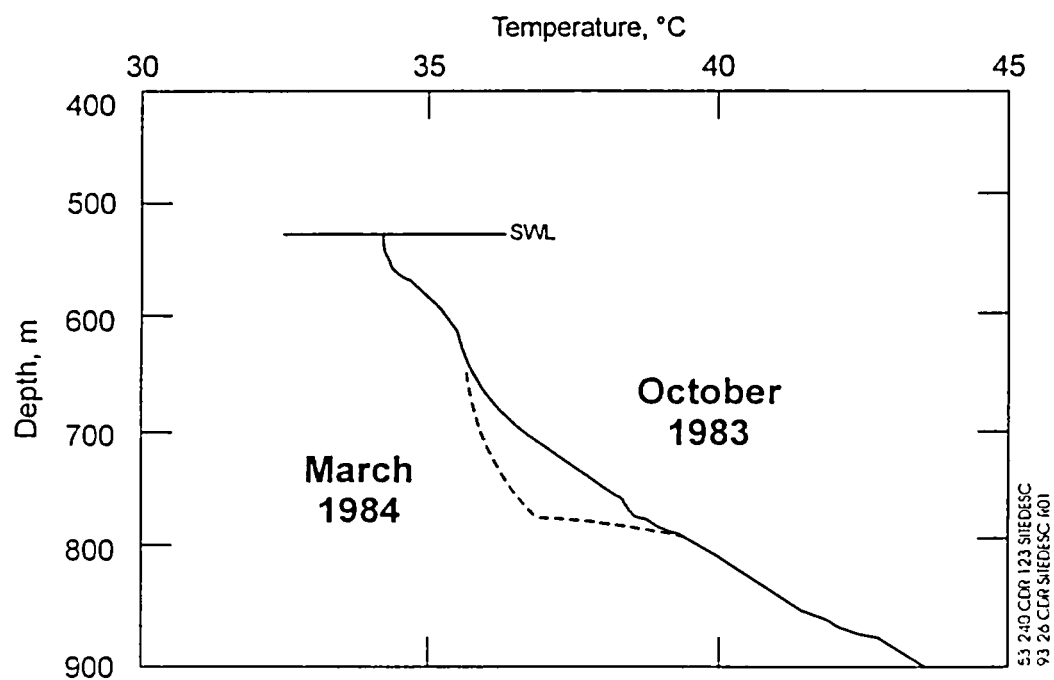
NOTE: Temperatures are given in degrees Celsius.

Figure 9.3-24. Temperatures at the Water Table in the Vicinity of Yucca Mountain



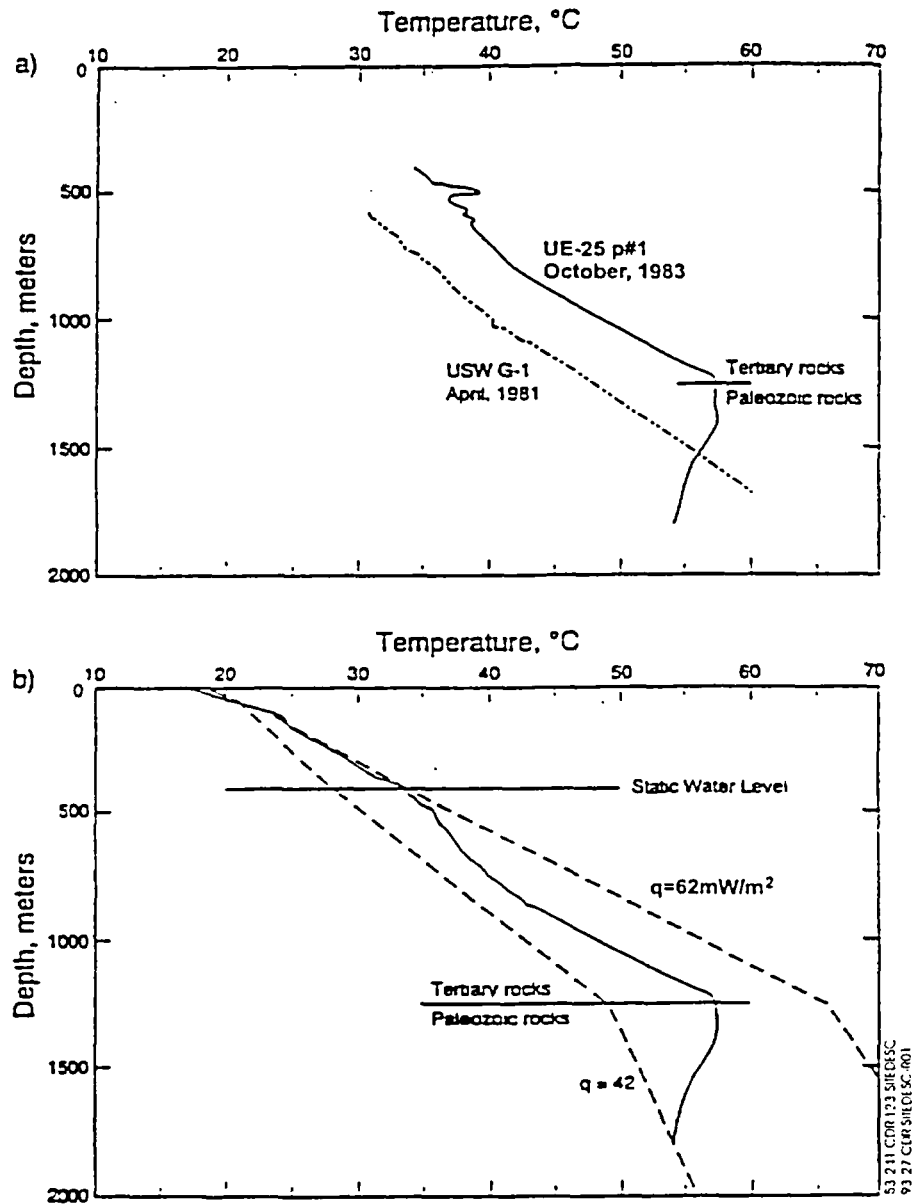
Source: Sass, Lachenbruch et al. (1988, Figure 9)

Figure 9.3-25. Temperature Log for USW G-4



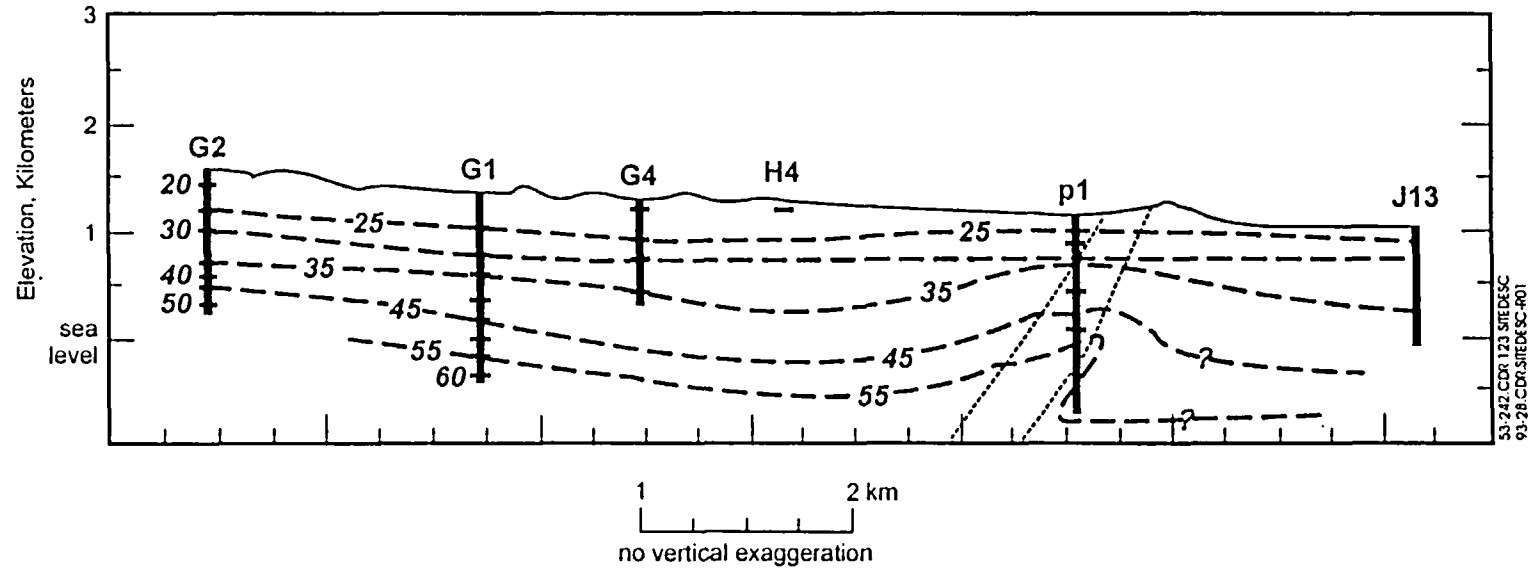
Source: Sass, Lachenbruch et al. (1988, Figure 1-17)

Figure 9.3-26. Temperature Logs for Borehole USW H-6, October 1983 and March 1984



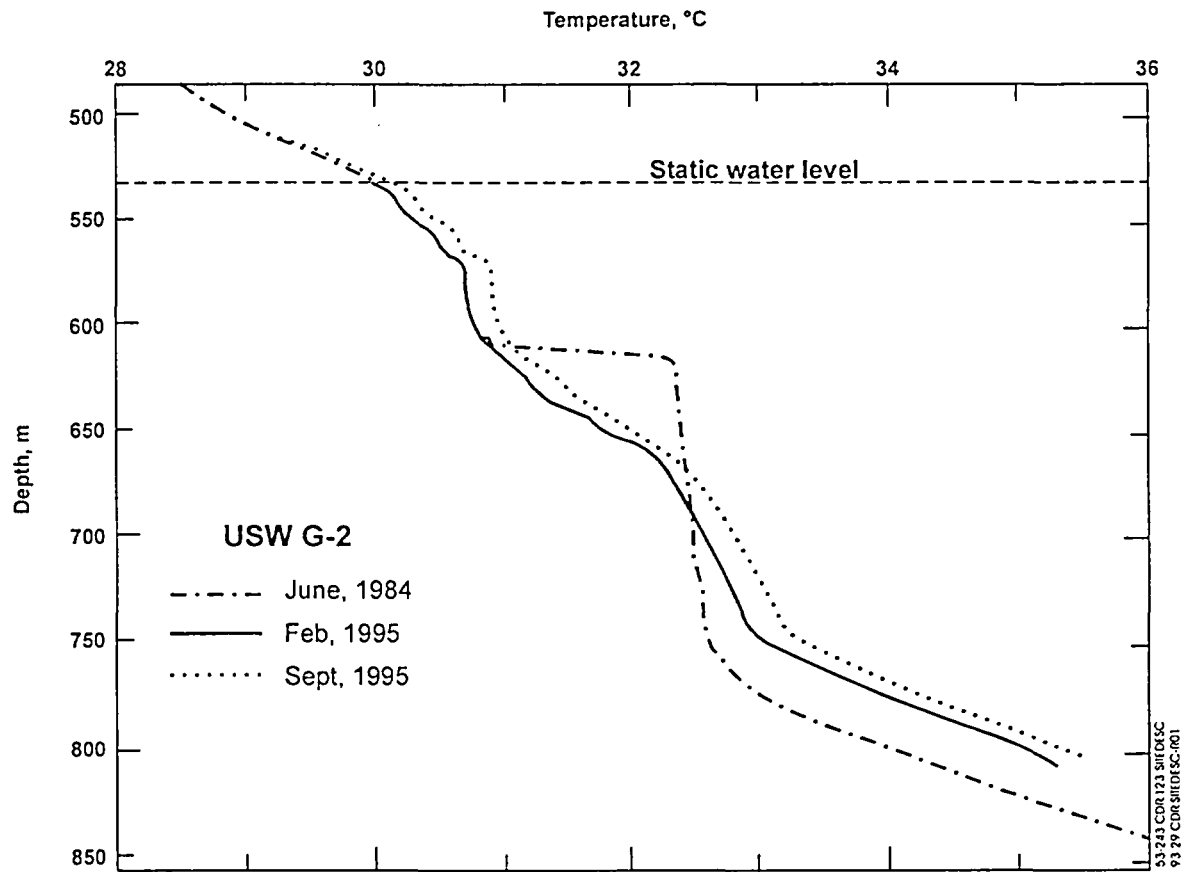
NOTE: The log of April 1981 for USW G-1 and calculated profiles for conductive heat fluxes (q) of 42 and 62 mW/m² at the UE-25 p#1 site are also shown for comparison (from Sass, Dudley et al. 1995, Figure 8.5).

Figure 9.3-27. Temperature Profiles for UE-25 p#1, October 1983 (a) and April 1990 (b) and USW G-1 April 1981 (a) for Comparison



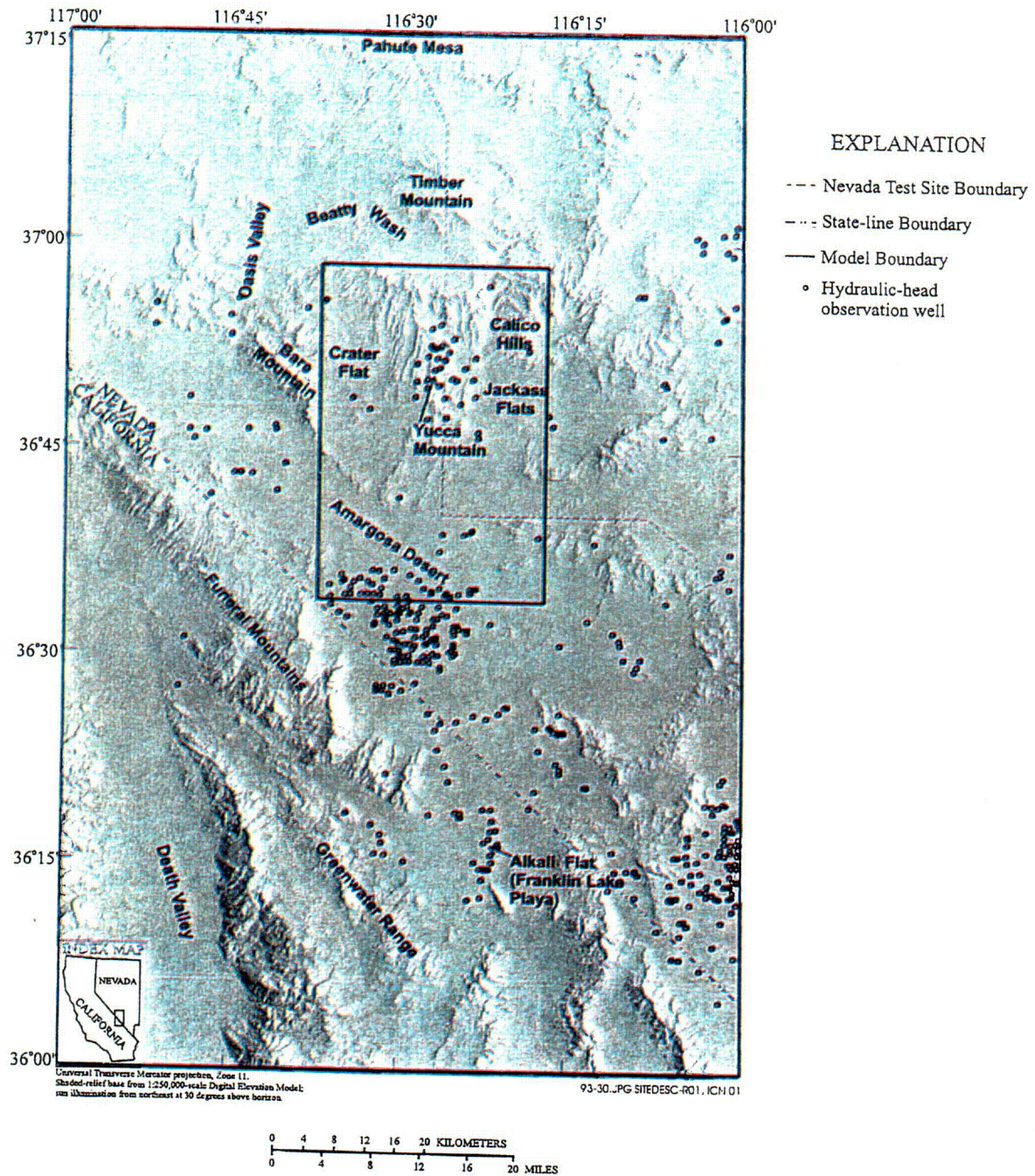
Source: Adapted from Sass, Lachenbruch et al. (1988)

Figure 9.3-28. Interpretive Thermal Cross Section between USW G-1 and Well J-13, Showing Upwelling of Isotherms along Faults Intersected in Drillhole UE-25 p#1



Source: Data are from Sass, Lachenbruch et al. (1988) and the Yucca Mountain Site Characterization Project Site and Engineering Properties Database.

Figure 9.3-29. Sequential Temperature Logs for USW G-2, 1984 and 1995



Source: Adapted from Czarnecki, Faunt et al. (1997, Figure 1)

Figure 9.3-30. Location of Site Saturated Zone Flow Model Area, Associated Geographic Features, and Hydraulic Head Observation Wells

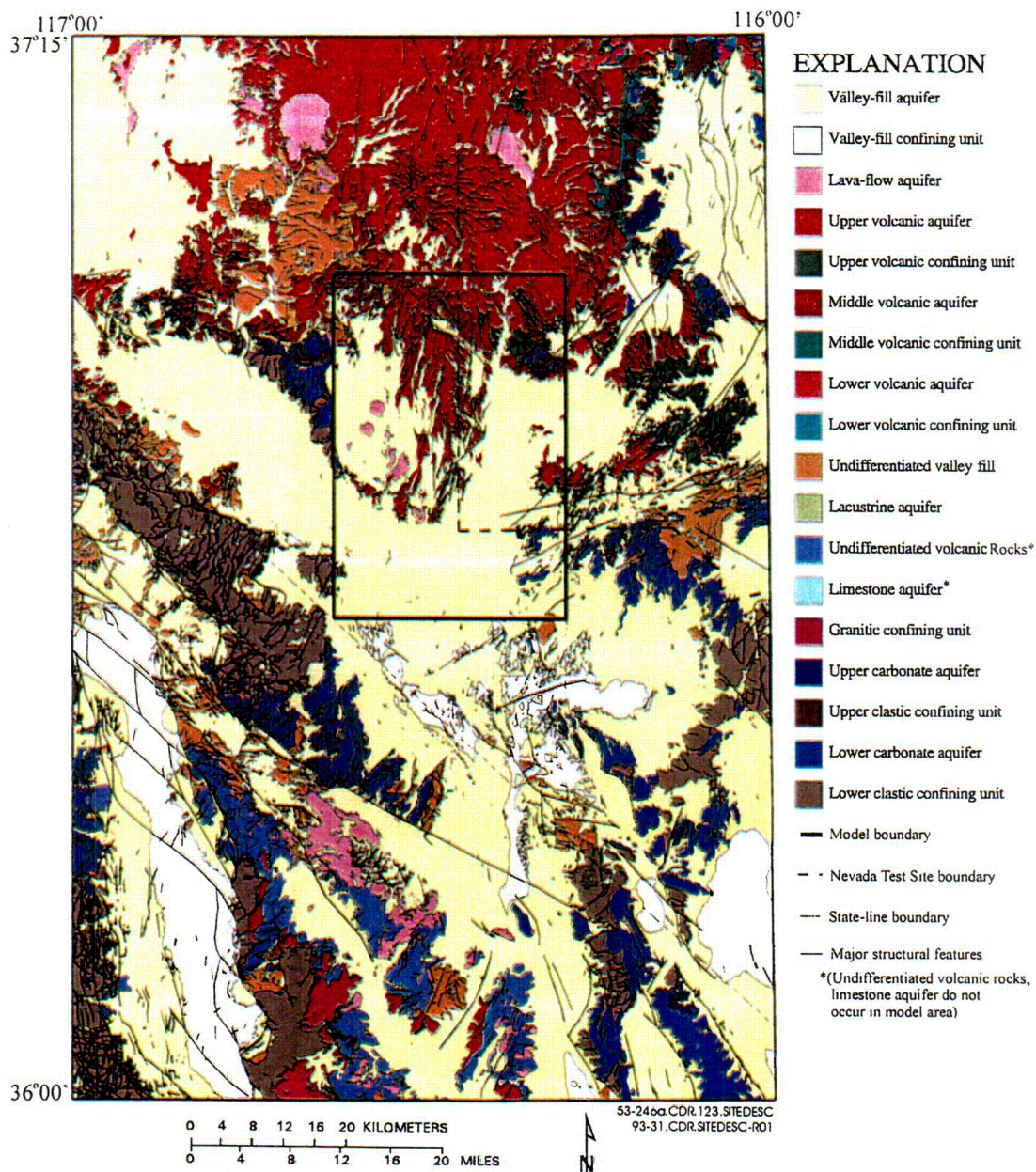


Figure 9.3-31. Generalized Hydrogeologic Units with Major Structural Features for Region Surrounding the Area of the Site Model

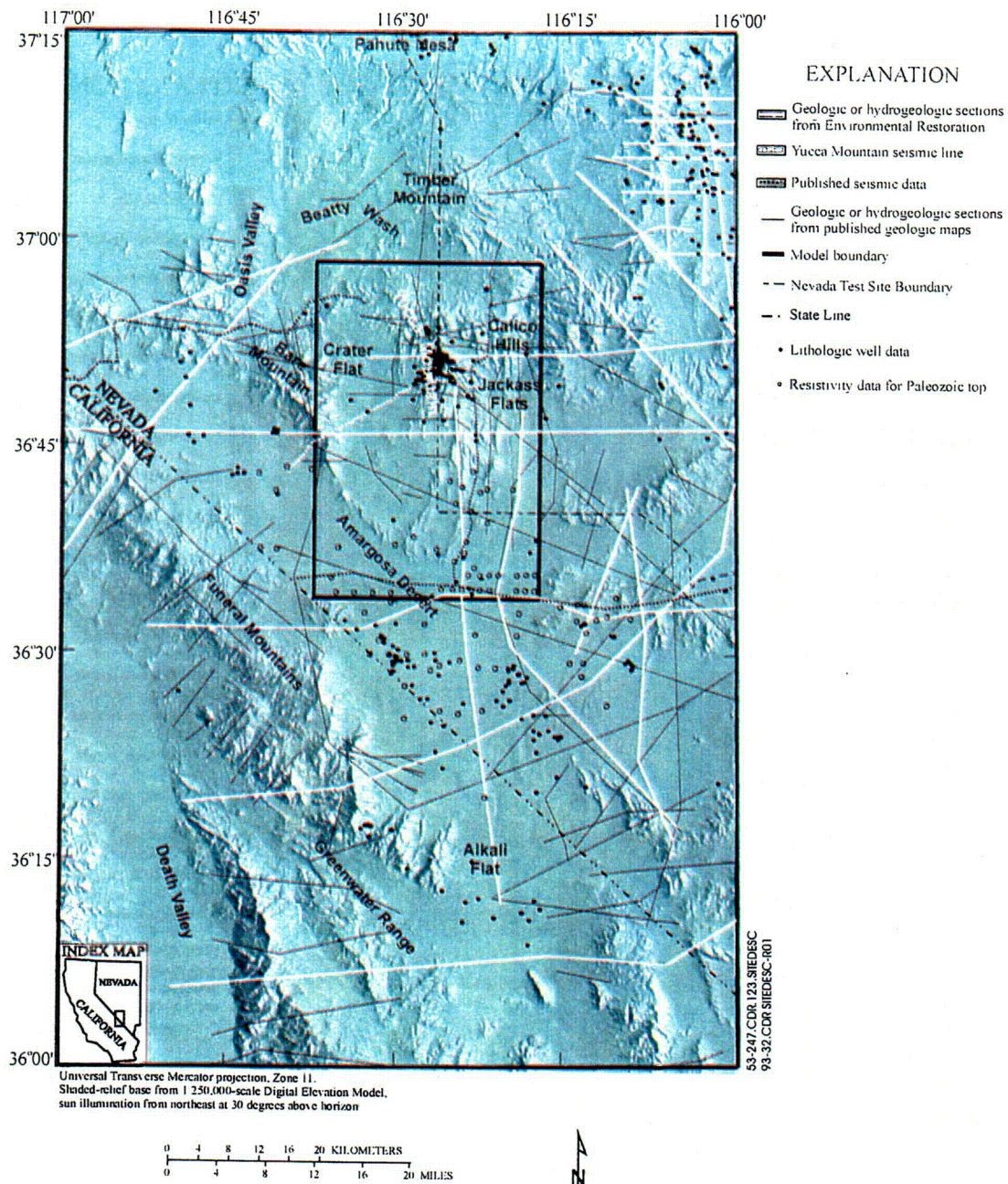
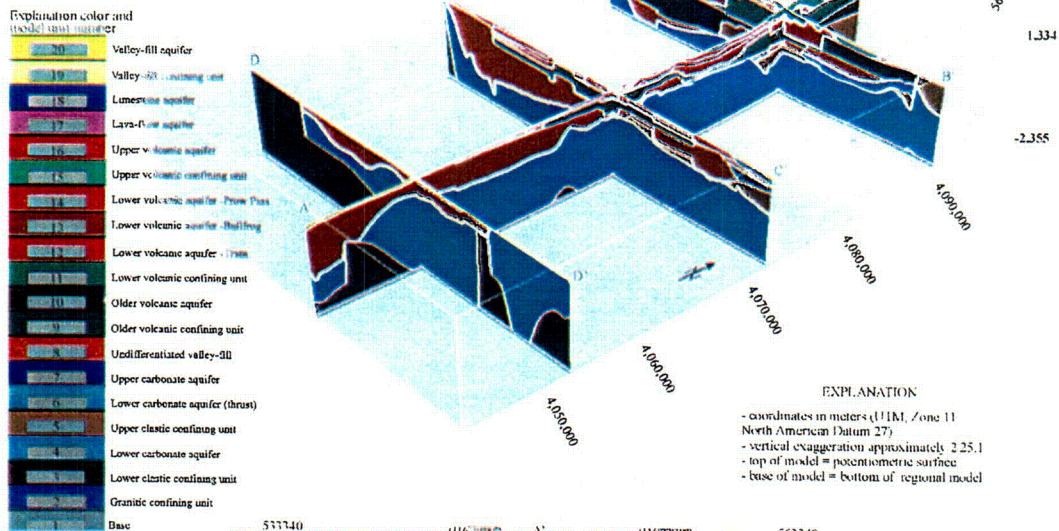
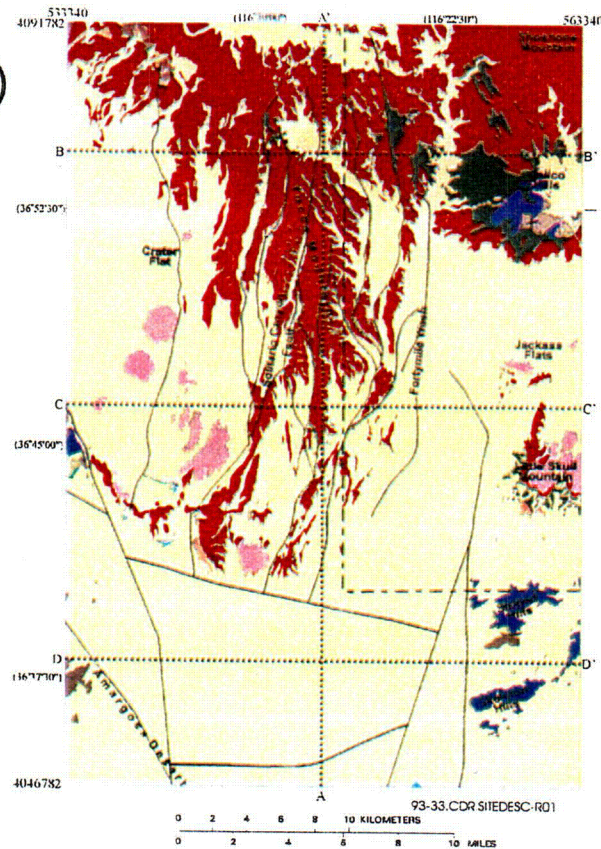


Figure 9.3-32. Geologic, Geophysical, and Well-Data Locations Used in the Construction of the Hydrogeologic Framework Model

(a)

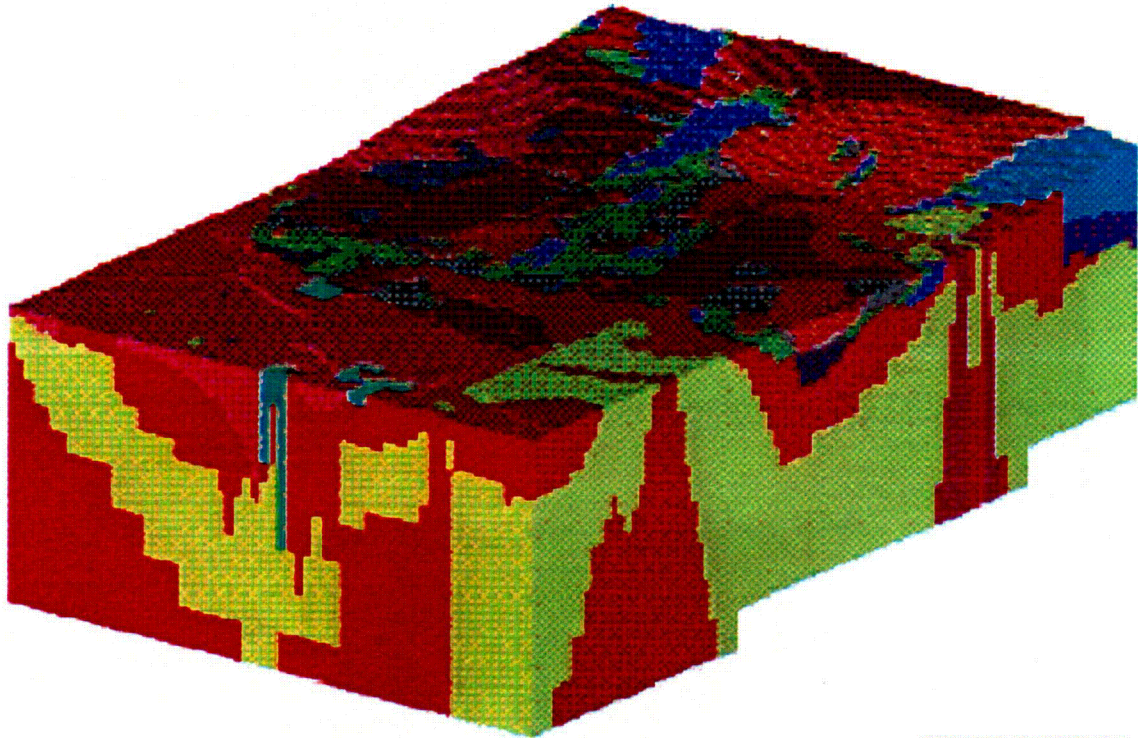


(b)



Sources: (a) USGS (2000a, Figure 6-1); (b) modified from USGS (2000a, Figure 4-2)

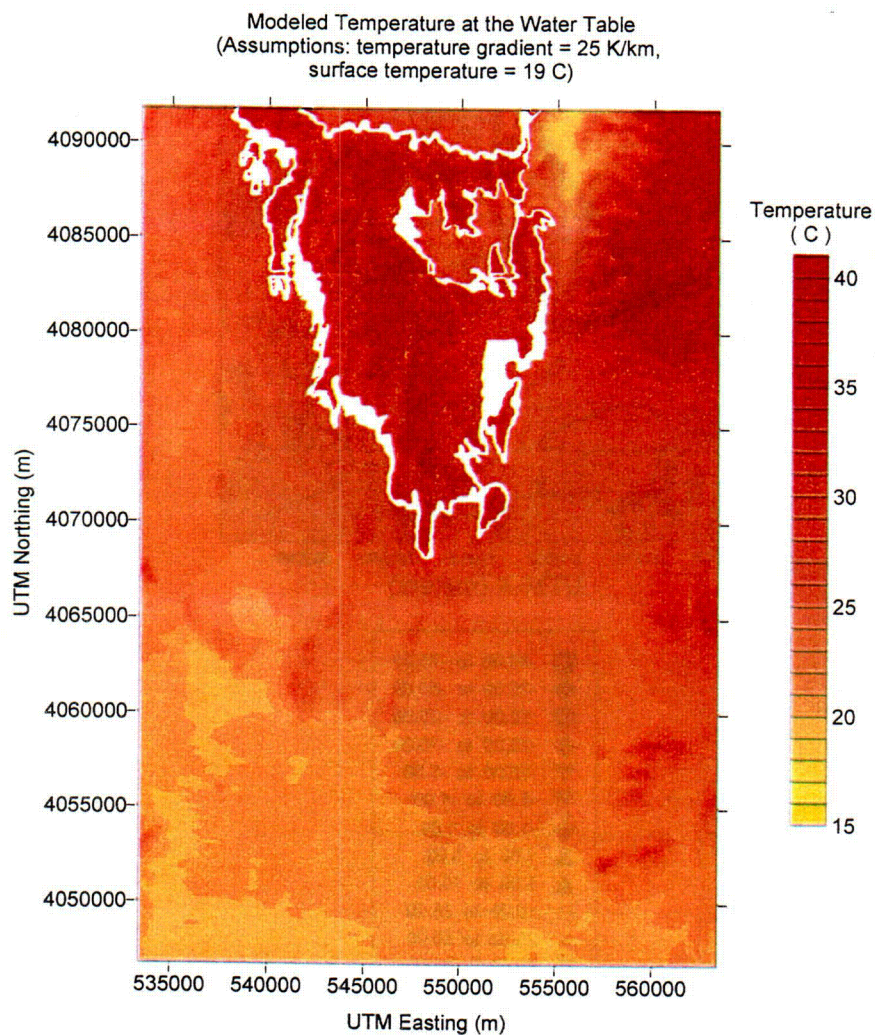
Figure 9.3-33. Fence Diagram Showing Sections through the Hydrogeologic Framework Model



93-34.DOC. SITEDESC-R01

Source: Extracted from CRWMS M&O (2000c, Figure 3)

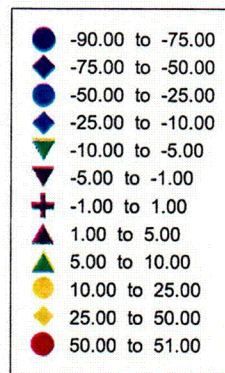
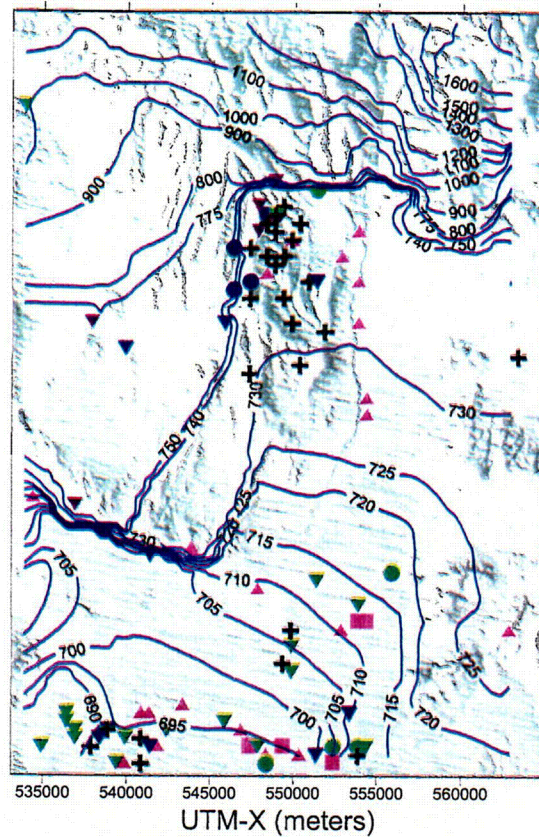
Figure 9.3-34. Three-Dimensional Representation of the Computation Grid



93-35.DOC.SITEDESC-R01

Source: CRWMS M&O (2000c, Figure 5)

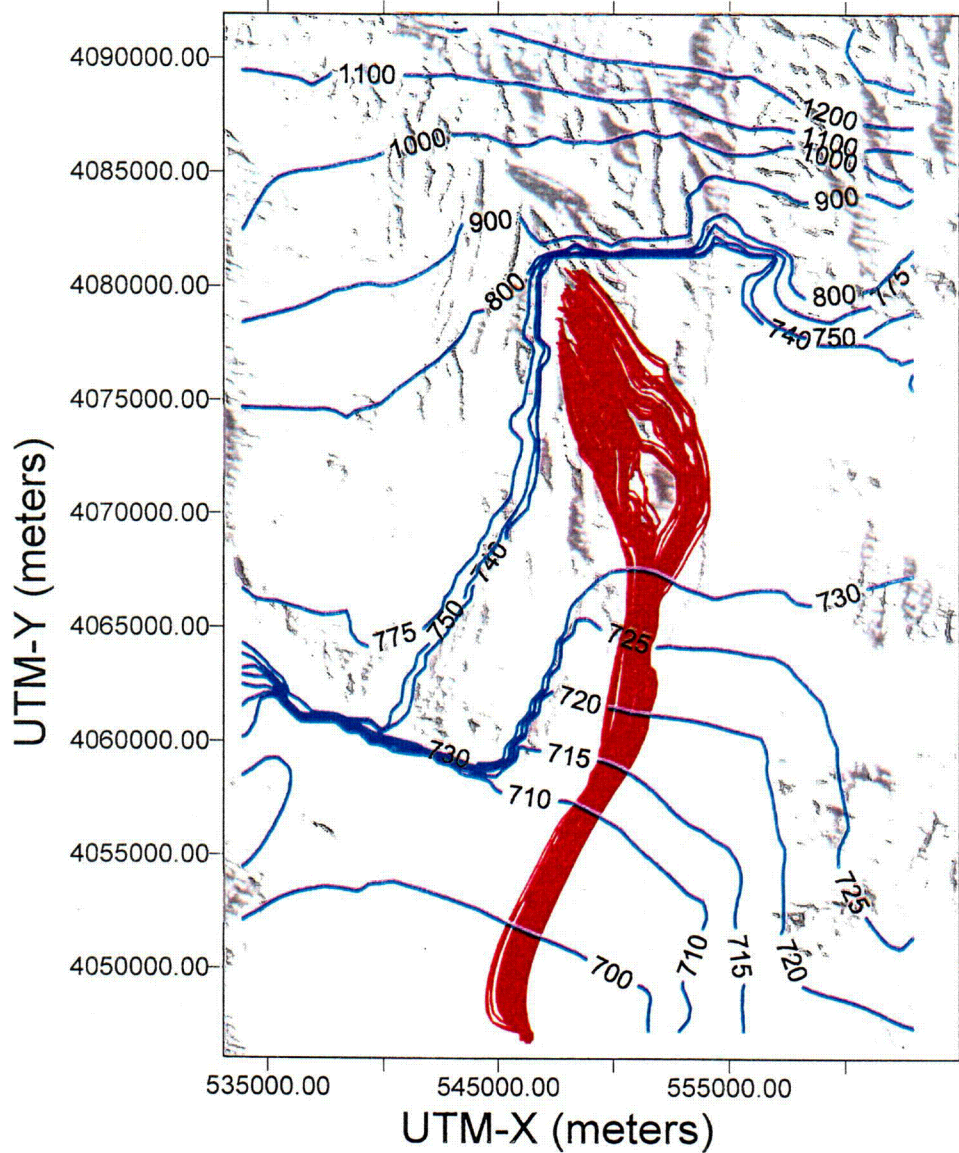
Figure 9.3-35. Map of Modeled Temperature at the Water Table for the Site-Scale Saturated Zone Flow and Transport Model Domain



93-36.DOC.SITEDESC-R01

Source: Modified from CRWMS M&O (2000c, Figure 6)

Figure 9.3-36. Map of Simulated Potentiometric Surface with Calibration Residuals

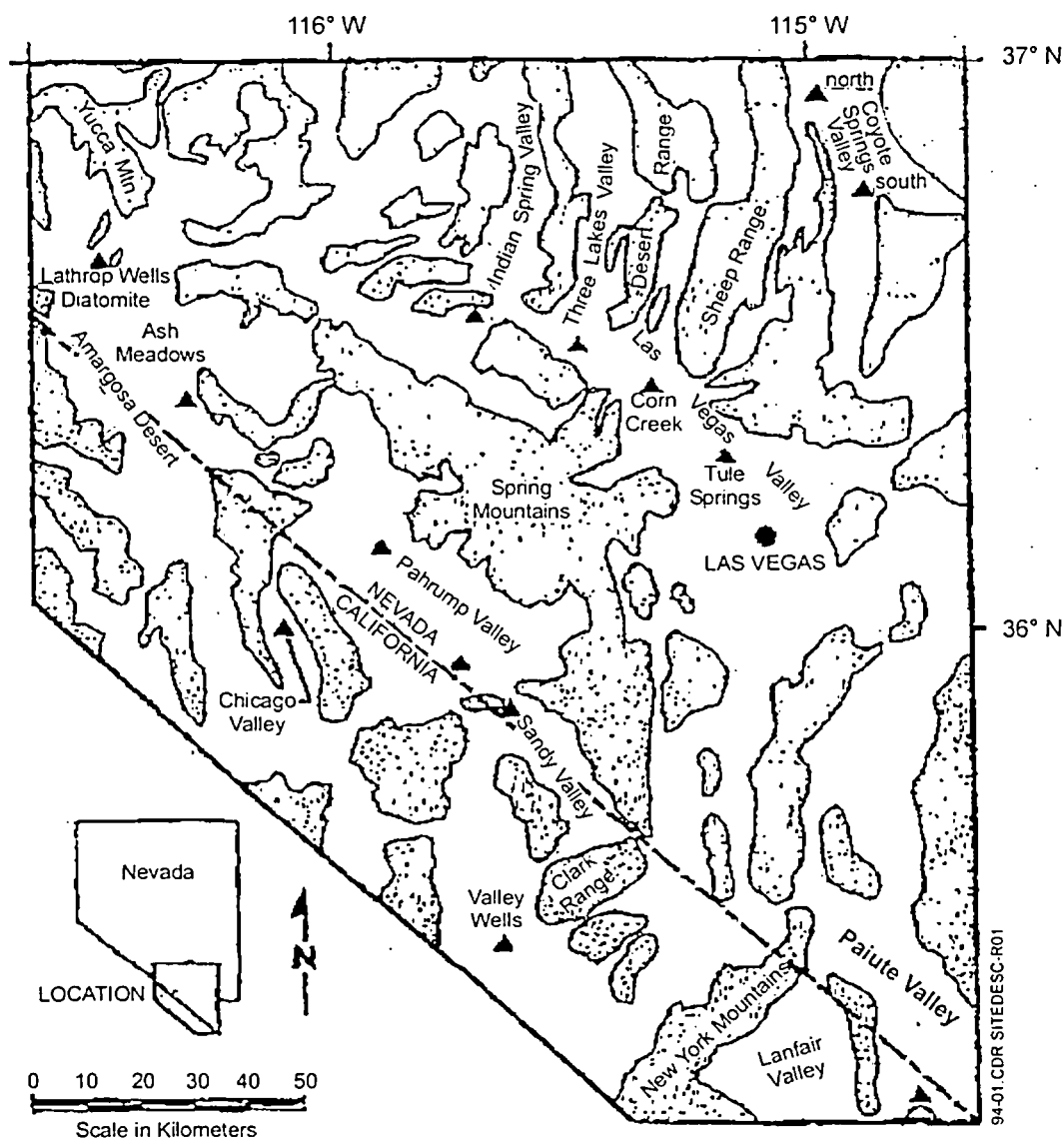


93-37.DOC.SITEDESC-R01

Source: CRWMS M&O (2000c, Figure 7)

Figure 9.3-37. Flow Paths Predicted by Site-Scale Saturated Zone Flow and Transport Model

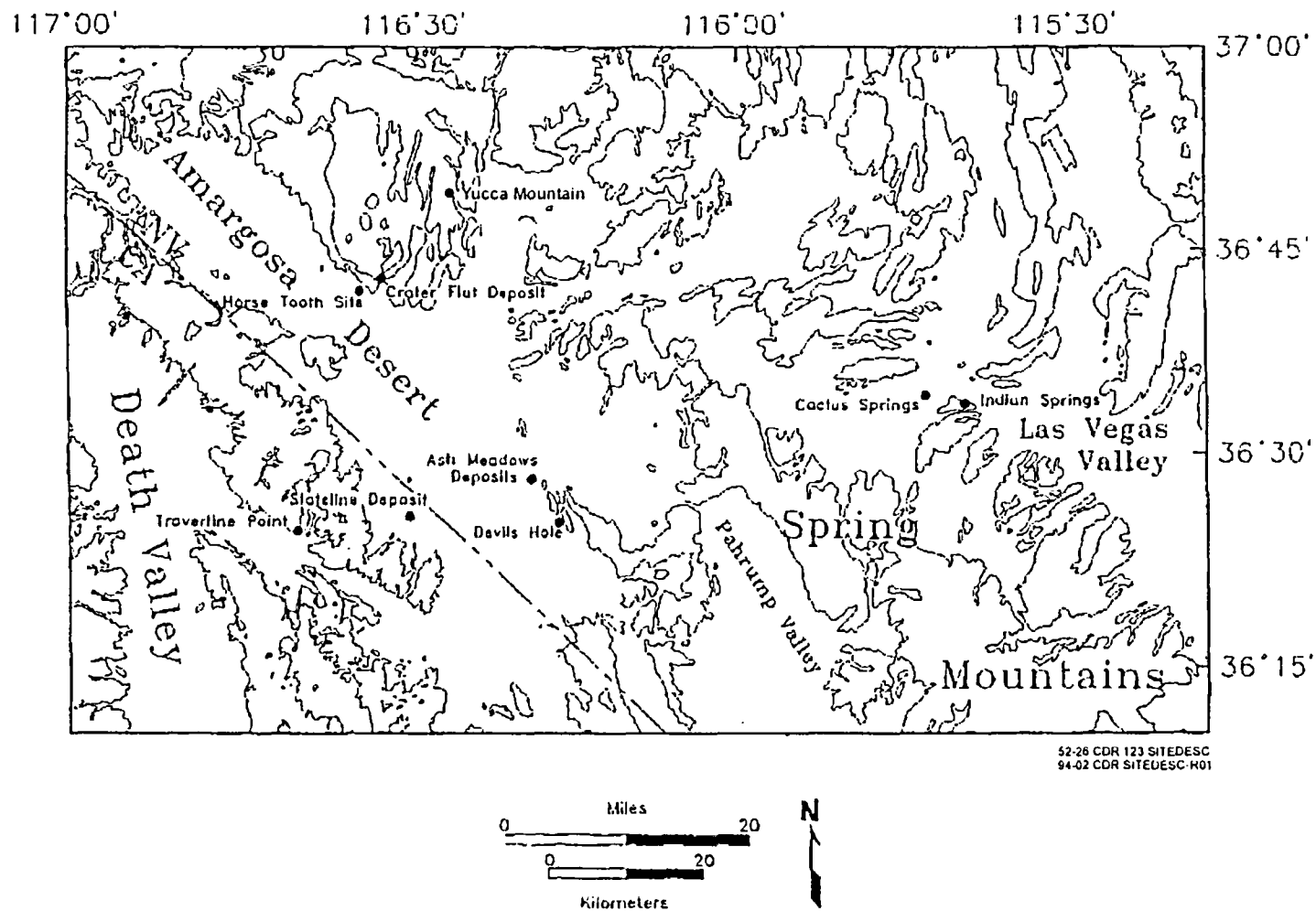
INTENTIONALLY LEFT BLANK



Source: Quade et al. (1995, Figure 1)

NOTE: Coyote Springs and Paiute Valley are tributaries to the Colorado River. Valley Wells, Ash Meadows, and Chicago Valley drain into Death Valley. Pahrump, Sandy, Indian Springs, and Three Lakes valleys are hydrographically closed. Valley deposits are shown with solid triangles.

Figure 9.4-1. General Locations of Paleo-Spring Deposits in the General Vicinity of Yucca Mountain



NOTE: The Horse Tooth site is also known as the Lathrop Wells diatomite deposit.

Figure 9.4-2. Location of Former Discharge Sites from the Regional Groundwater System

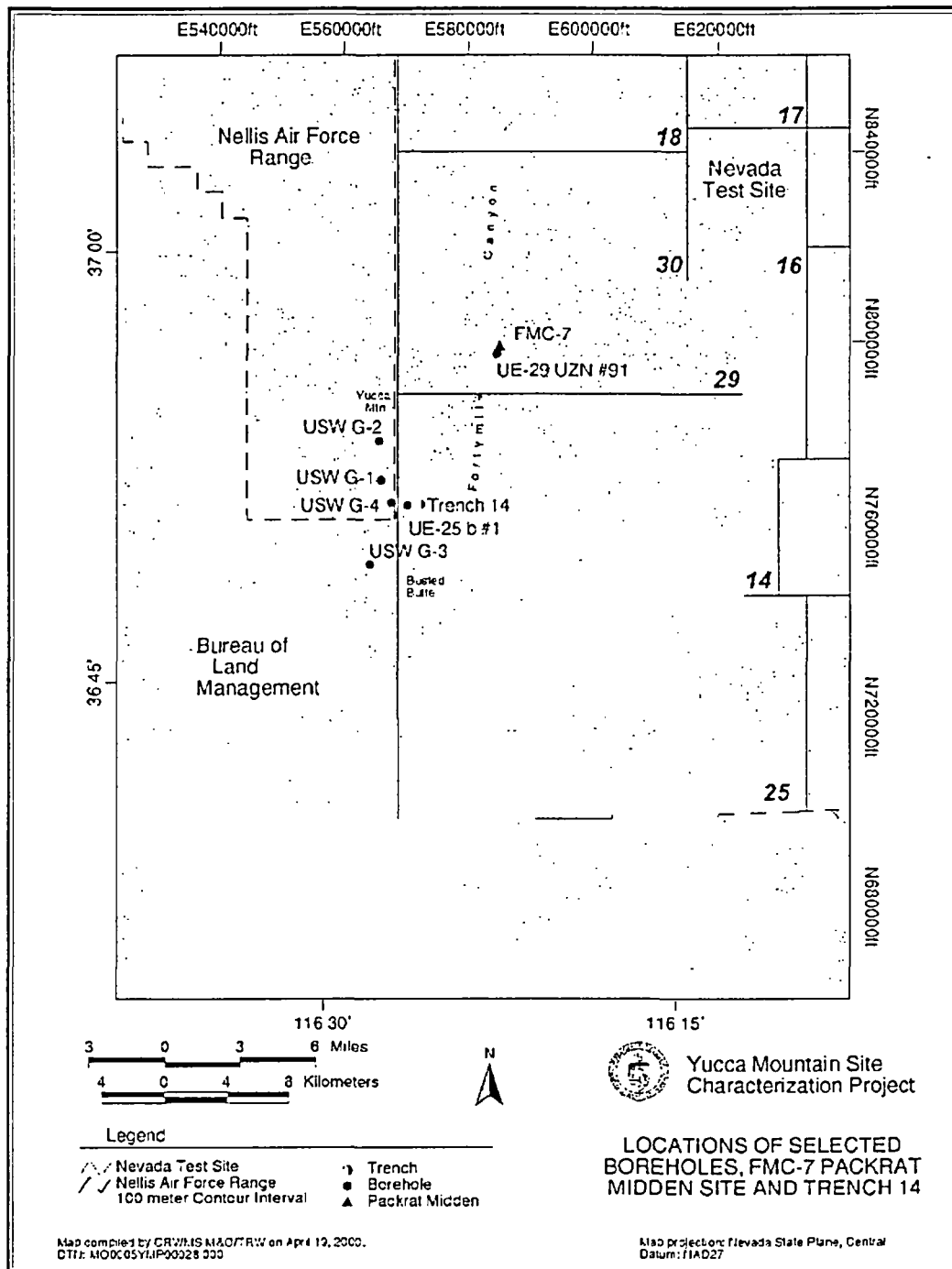
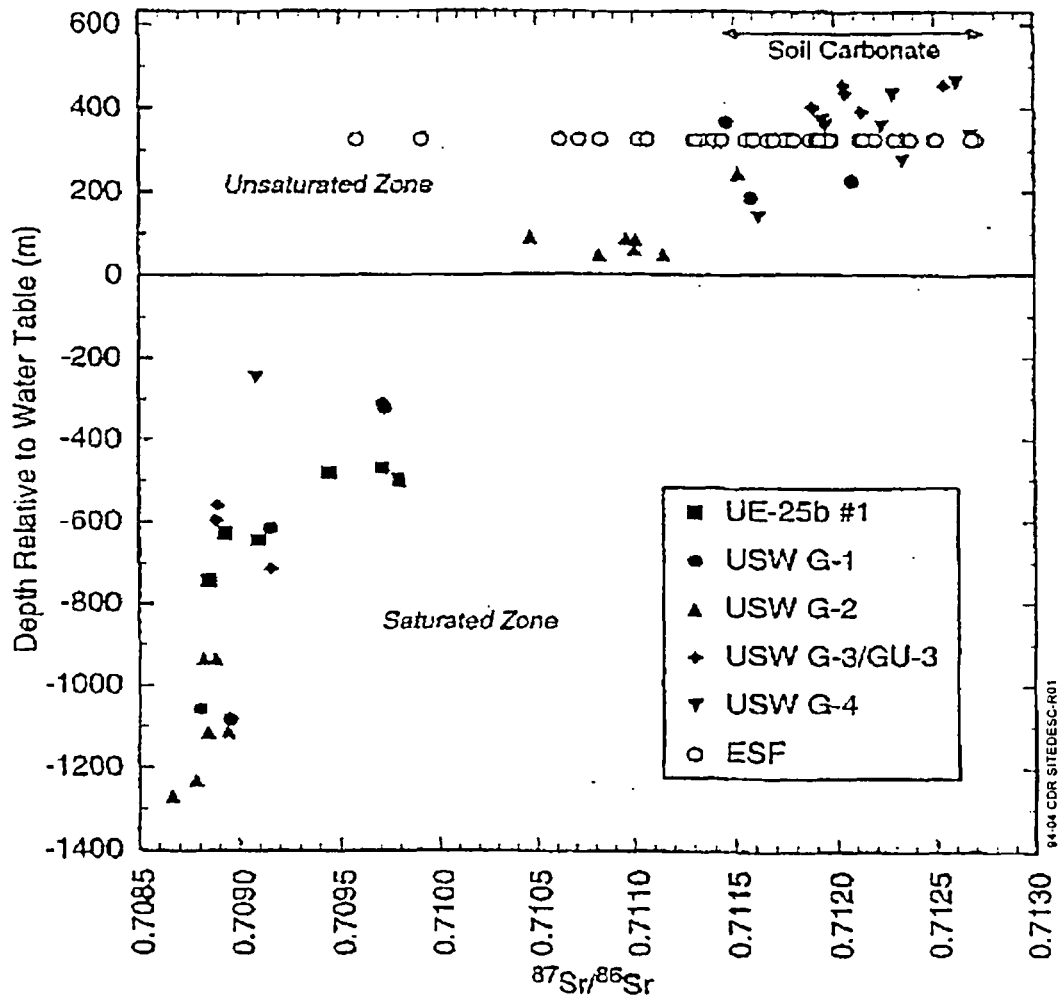
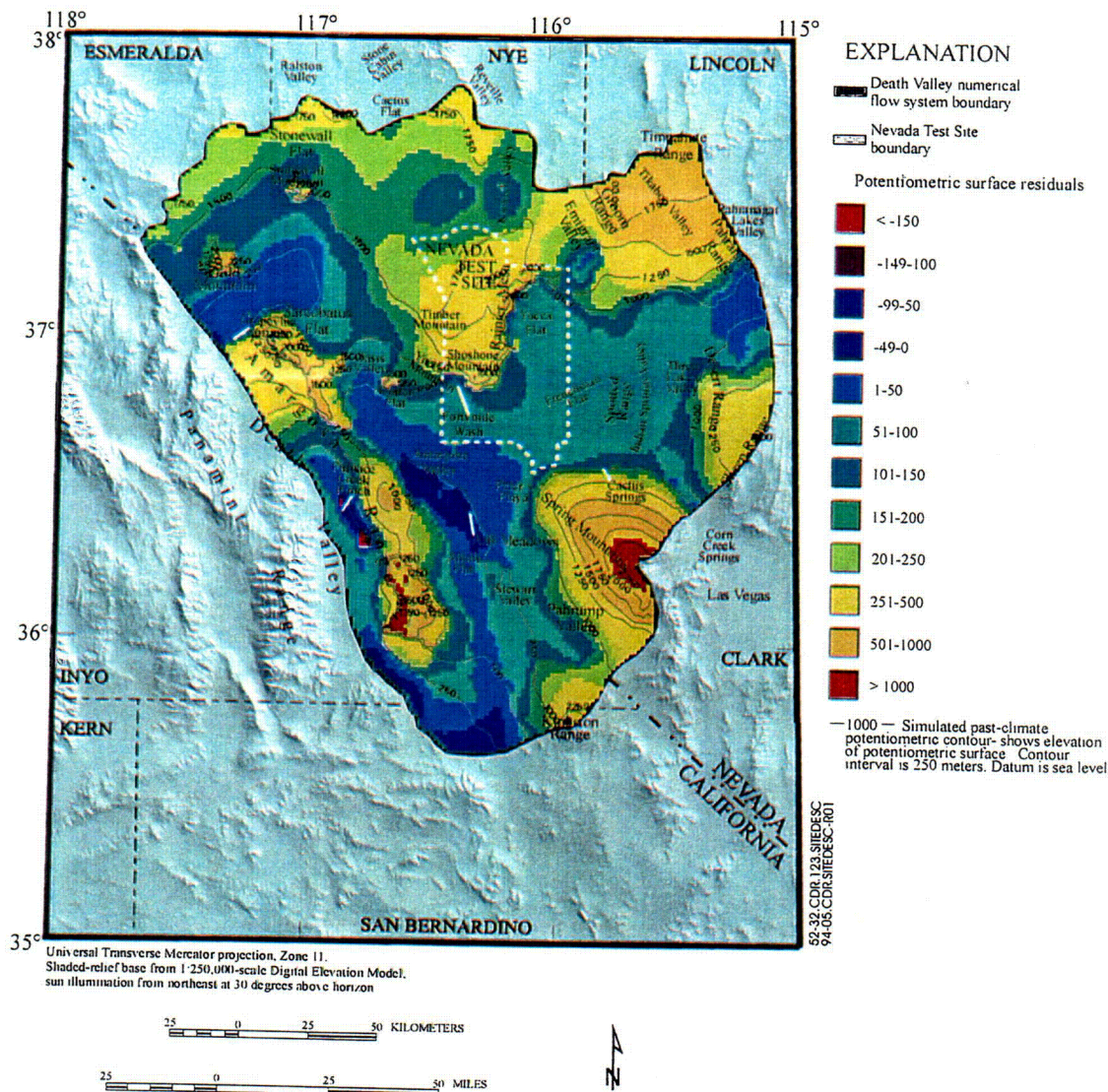


Figure 9.4-3. Locations of Selected Boreholes, FMC-7 Pack-Rat Midden Site, and Trench 14



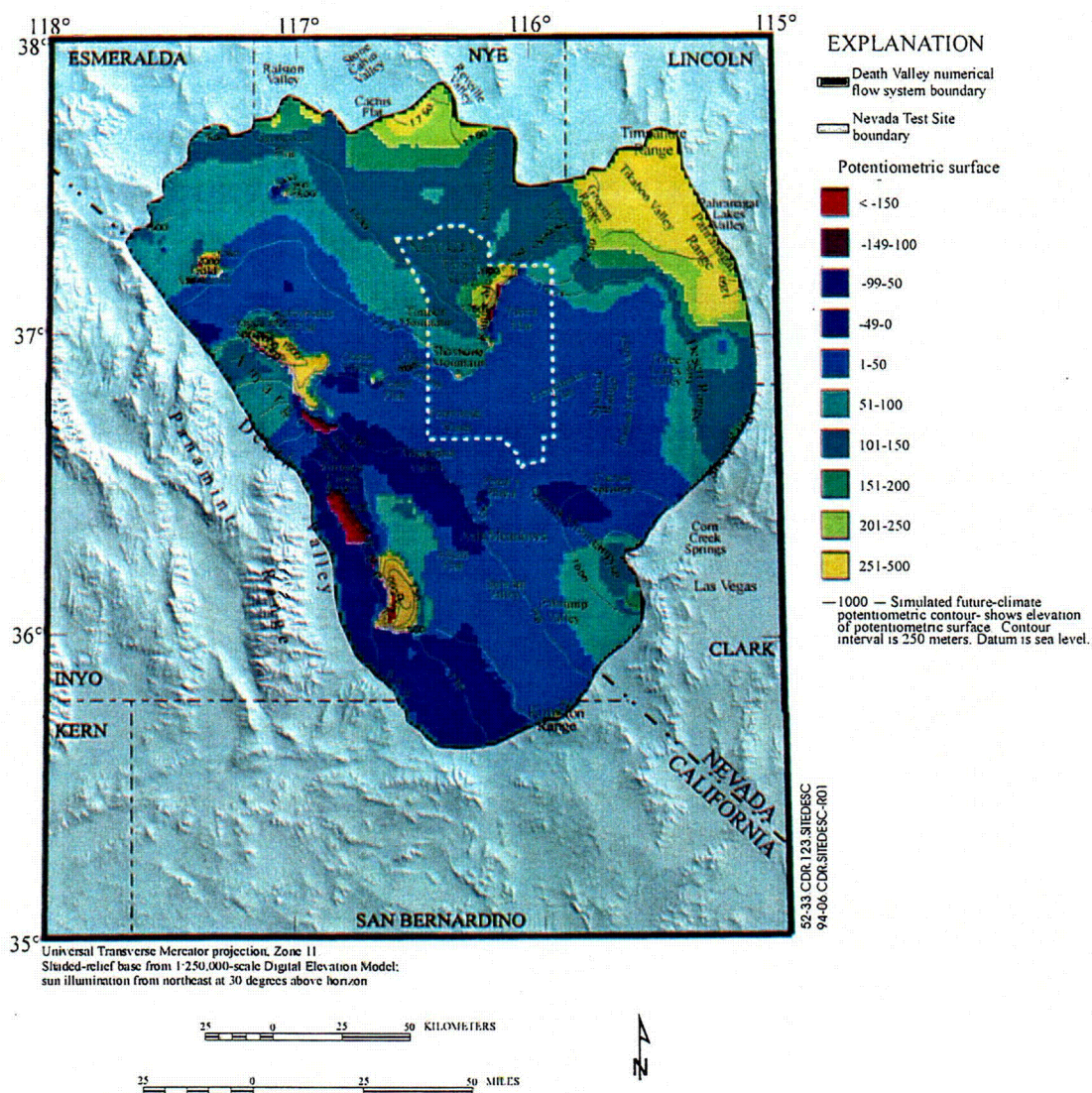
Source: Paces, Neymark et al. (1996, Figure 4.7)

Figure 9.4-4. Plot Showing Strontium Isotope Compositions of Fracture-Filling Calcites as a Function of Depth Relative to the Depth of the Water Table



NOTE: Model layer 1 represents the top layer (0-to 500-m depth) of the three layers included in the model. Illegibility of some geographic and contour labels does not affect the technical content of this figure. Contour values can be determined using the contour interval (250 m).

Figure 9.4-5. Simulated Past-Climate Potentiometric Surface for Model Layer 1 and the Difference between the Past and Present-Day Model Layer 1 Potentiometric Surface



NOTE: Model layer 1 represents the top layer (0-to 500-m depth) of the three layers included in the model. Illegibility of some geographic and contour labels does not affect the technical content of this figure. Contour values can be determined using the contour interval (250 m).

Figure 9.4-6. Simulated Future-Climate Potentiometric Surface for Model Layer 1 and the Difference between the Future and Present-Day Model Layer 1 Potentiometric Surface

C45
04/16

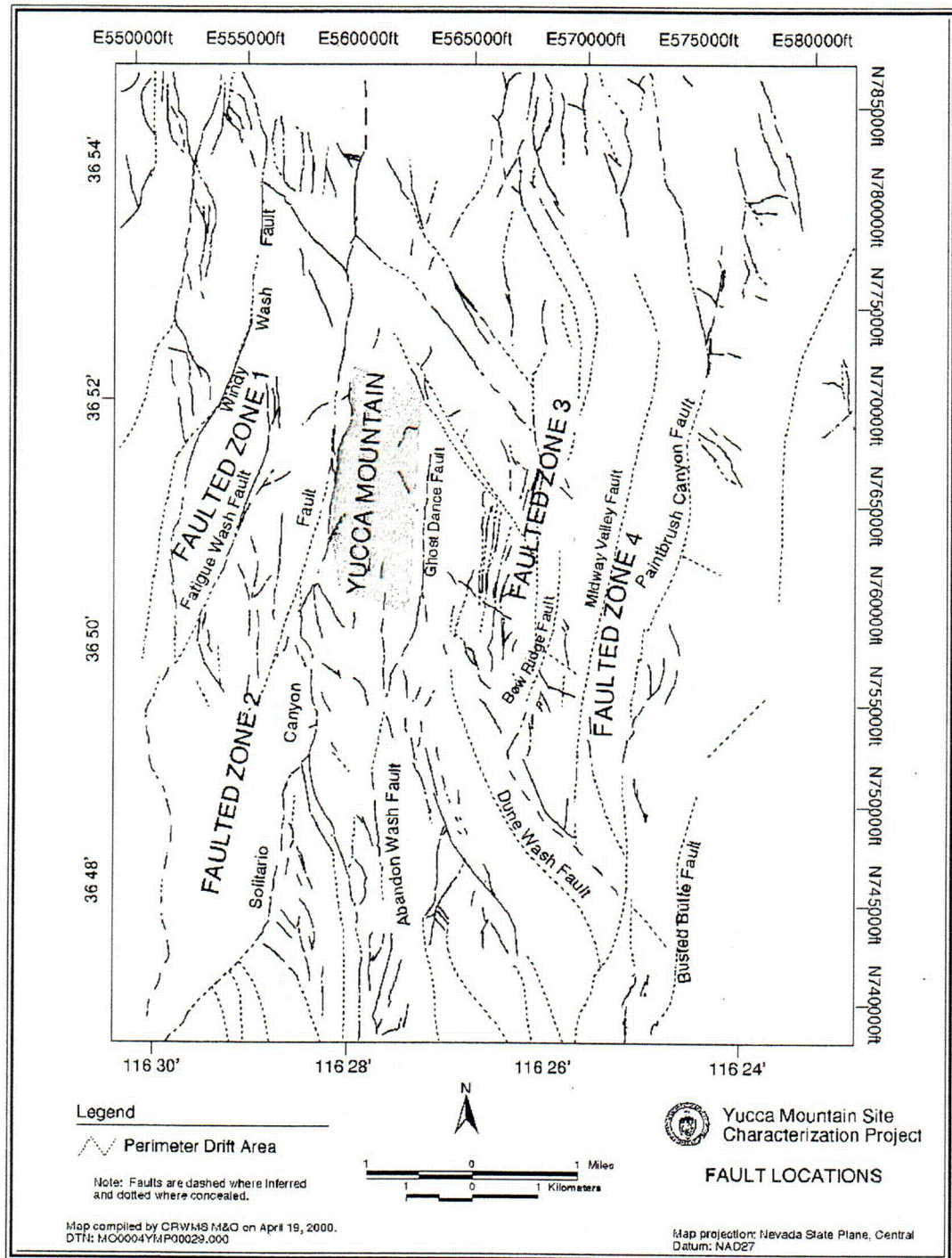
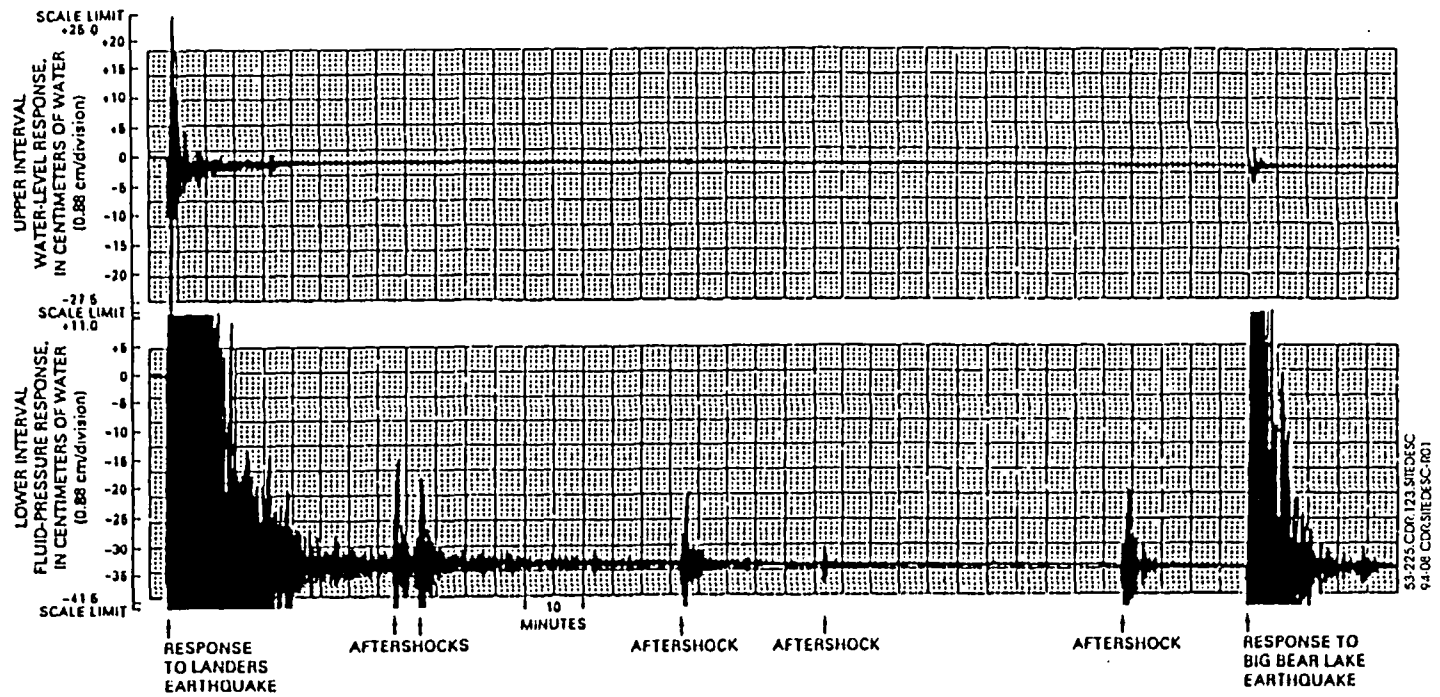


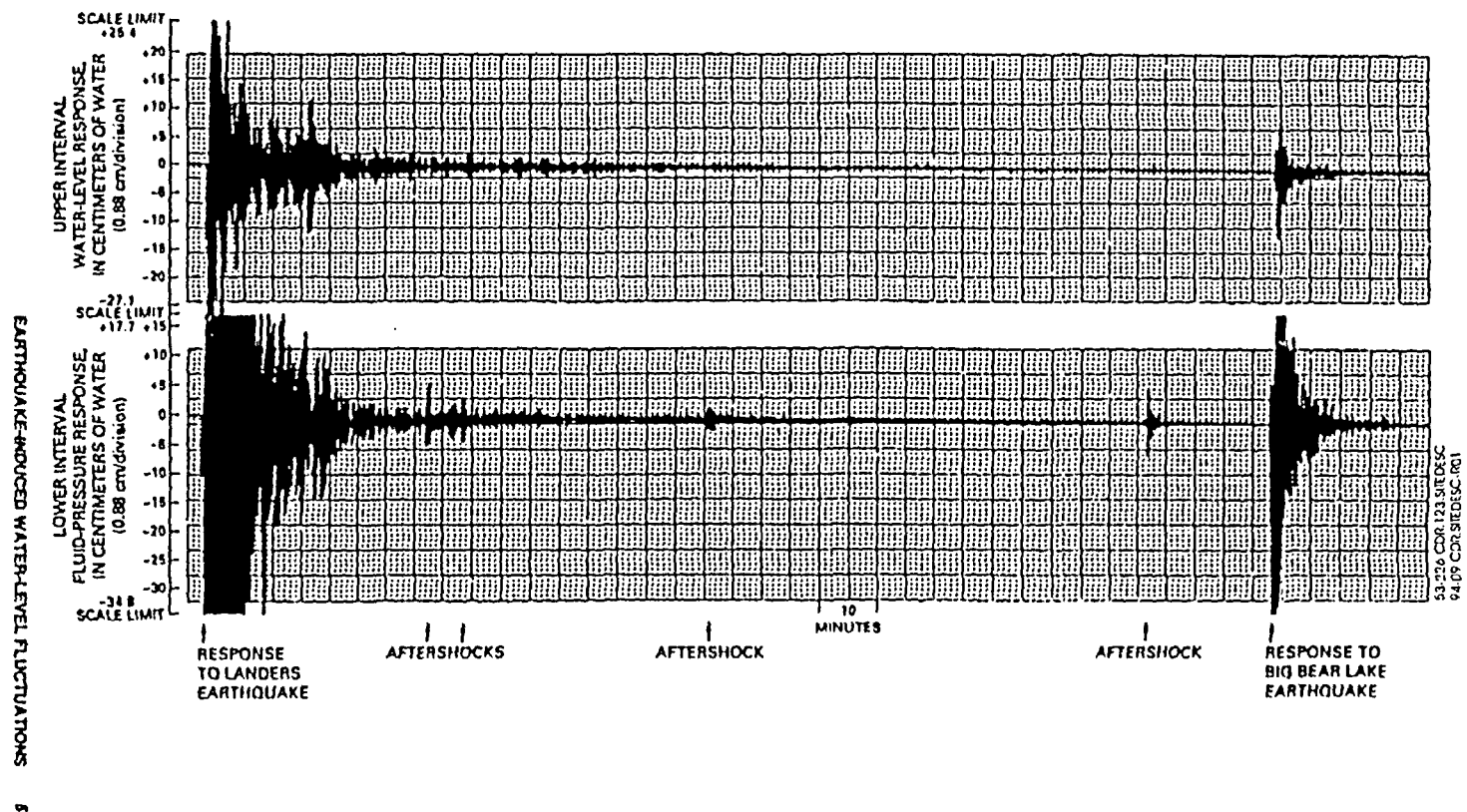
Figure 9.4-7. Locations of Faults Used in National Research Council (1992) Evaluation of Earthquake Probabilities

5 Earthquake-Induced Water-Level Fluctuations at Yucca Mountain, Nevada, June 1992



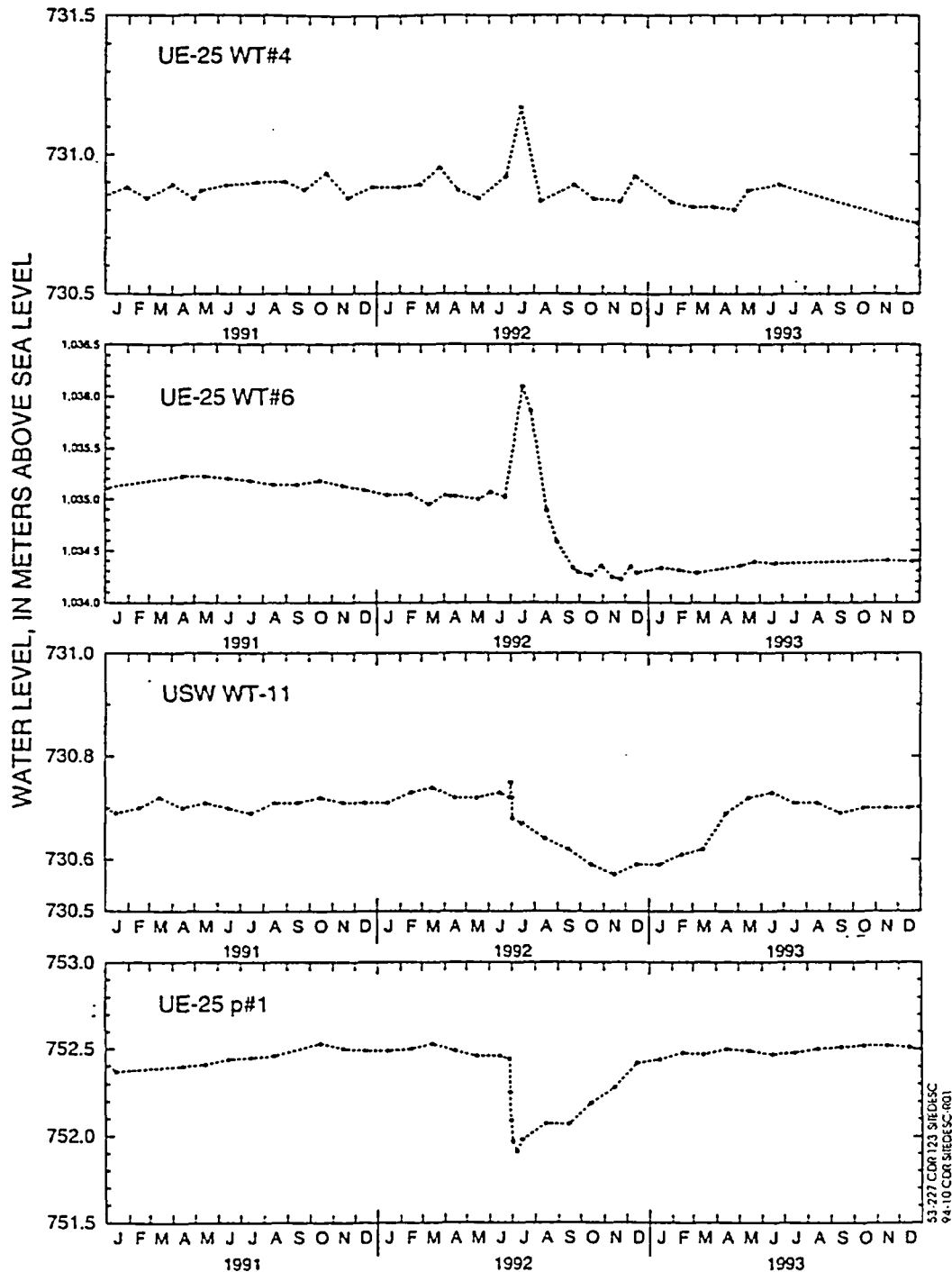
Source: O'Brien (1993, Figure 2)

Figure 9.4-8. Well USW H-5 Response to Earthquakes Near Landers (11:57:34 UTC) and Big Bear Lake (15:05:30 UTC), California, on June 28, 1992



Source: O'Brien (1993, Figure 3)

Figure 9.4-9. Well USW H-6 Response to Earthquakes Near Landers (11:57:34 UTC) and Big Bear Lake (15:05:30 UTC), California, on June 28, 1992



Source: Graves et al. (1997, Figure 39)

Figure 9.4-10. Water-Level Altitudes in Other Wells that May Have Been Affected by June 1992 Earthquakes

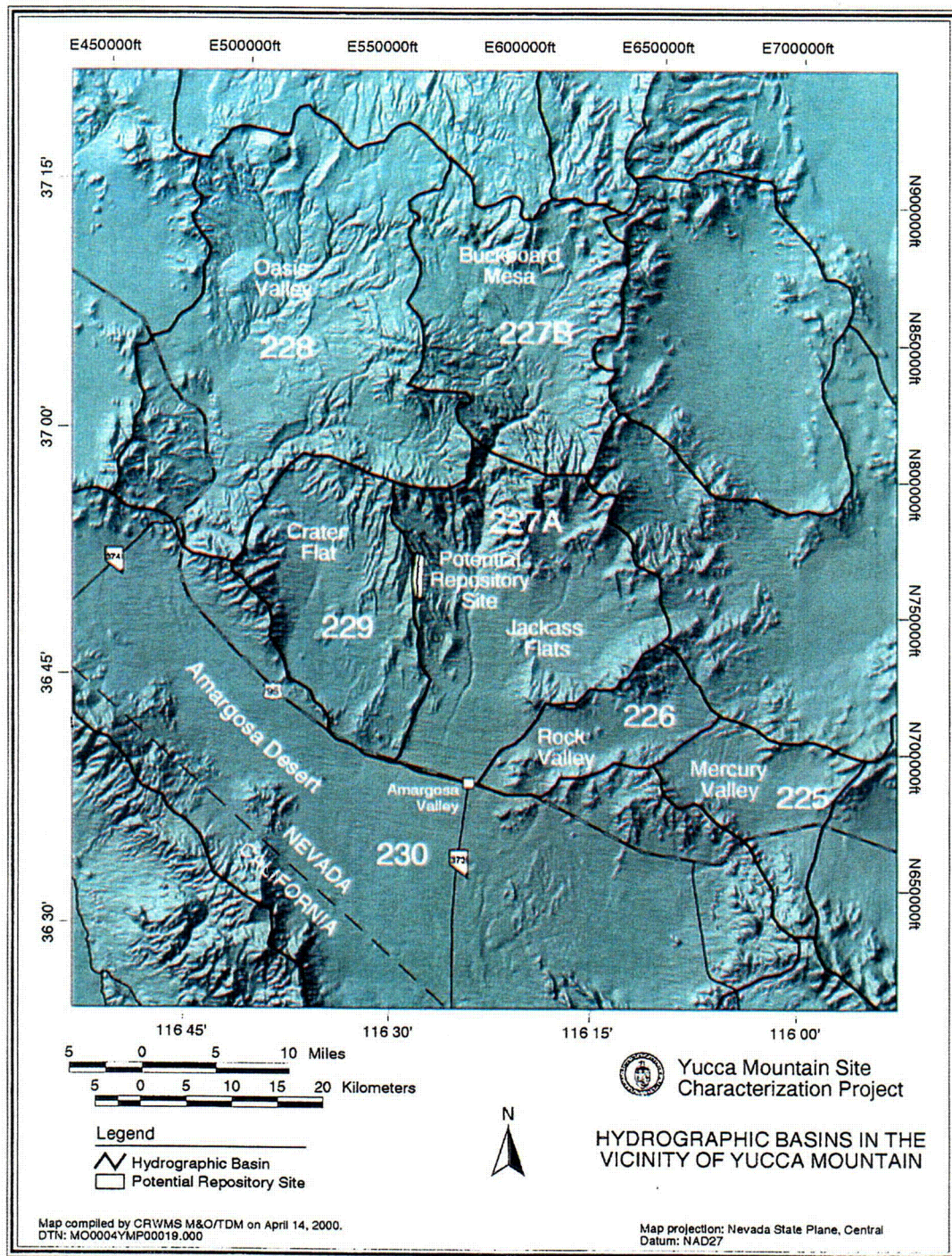


Figure 9.5-1. Hydrographic Basins in the Vicinity of Yucca Mountain

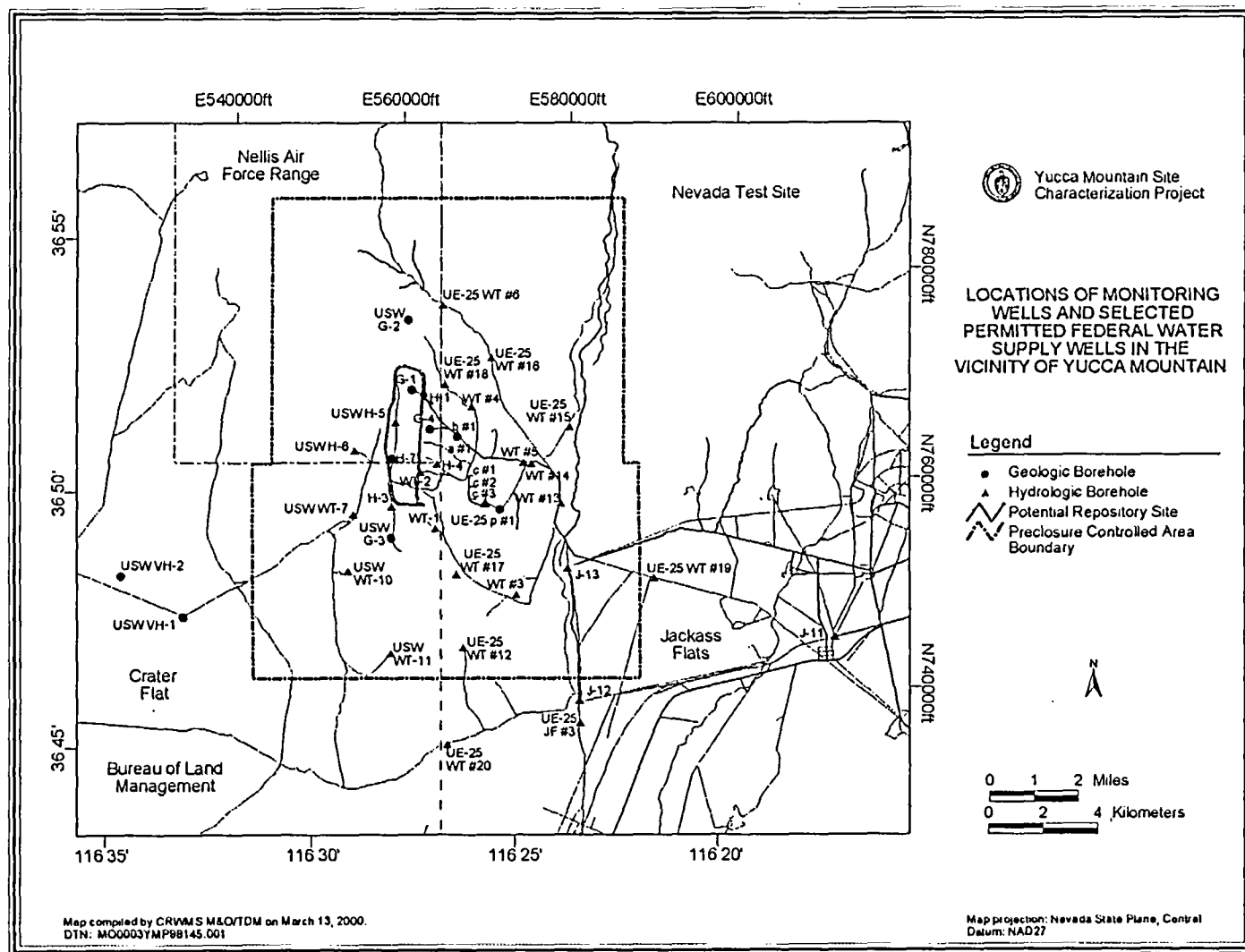


Figure 9.5-2. Location of Wells Monitored in the Saturated Zone in the Yucca Mountain Area

Table 9.2-1. Correlation of Hydrogeologic Units with Other Hydrogeologic and Lithostratigraphic Units in the Death Valley Region

Hydrogeologic Units Used in Section 9.2 (Faunt et al. 1997)	Hydrogeologic Units (Winograd and Thordarson 1975)	Major Hydrogeologic Units (Bedinger, Langer et al. 1989c)	Lithostratigraphic Units (Grose 1983; Grose and Smith 1985)
Playa deposits of Quaternary age (Qp)	Valley-fill aquifer	—	Qp
Valley-fill of Quaternary-Tertiary age (QTvf)	Valley-fill aquifer	Basin fill	Qa, QTa, QTs, Td, Ts
Volcanic rocks of Quaternary-Tertiary age (QTV)	Lava-flow aquifer	Lava flows	Qv, QTb, QTV, Tim, Ti
Volcanic rocks of Tertiary age (Tv)	Welded tuff aquifer, bedded tuff aquifer	Ash-flow tuff	Tv, Ttf, Tvr
Volcanic and volcanoclastic rocks of Tertiary age (Tvs)	Tuff aquitard, lava-flow aquitard	Undifferentiated volcanic rocks	Tvs
Granitic rocks of Tertiary-late Jurassic age (TJg)	Granitic stock minor aquitard	Crystalline rocks (upper part)	Tg, TJg
Sedimentary and metavolcanic rocks of Mesozoic age (Mvs)	—	Coarse-grained clastic rocks	TRPdc, JTRPd, Mmv, Ms, P3
Carbonate rocks of Paleozoic-Precambrian age (P2)	Upper carbonate aquifer, upper clastic aquitard, and lower carbonate aquifer	Carbonate rocks	P2, Pmd, Od, Edc
Clastic rocks of Paleozoic-Precambrian age (P1)	Lower clastic aquitard	Fine-grained clastic rocks	P1, pCd, Pcc, pEs
Igneous and metamorphic rocks of Precambrian age (pEgm)	—	Crystalline rocks (lower part)	pEm, pEg

Table 9.2-2. Generalized Stratigraphic and Hydrogeologic Units in the Death Valley Region

Stratigraphic unit ^a	Hydrogeologic Unit ^a	Major Lithology ^a	Maximum Thickness (m) ^a	Hydrogeologic Units Defined for Section 9.2 (Faunt et al. 1997)
Valley fill	Valley-fill aquifer	Alluvial fan, fluvial, fanglomerate, lakebed, and mudflow deposits	610	Playa deposits of Quaternary age (Qp) Valley-fill of Quaternary-Tertiary age (QTv)
Basalt of Kiwi Mesa	Lava-flow aquifer	Basalt flows, dense and vesicular	78	Volcanic rocks of Quaternary-Tertiary age (QTV)
Rhyolite of Shoshone Mountain		Rhyolite flows	610	
Basalt of Skull Mountain		Basalt flows	76	
Ammonia Tanks Member	Welded-tuff aquifer	Ash-flow tuff, moderately to densely welded; thin ash-fall tuff at base	76	Volcanic rocks of Tertiary age (Tv)
Rainier Mesa Member		Ash-flow tuff, nonwelded to densely welded; thin ash-fall tuff at base	183	
Tiva Canyon Member		Ash-flow tuff, nonwelded to densely welded; thin ash-fall tuff near base	107	
Topopah Spring Member		Ash-flow tuff, nonwelded to densely welded; thin ash-fall tuff near base	271	
Bedded tuff (informal unit)	Bedded-tuff aquifer	Ash-fall tuff and fluviatly reworked tuff	305	Volcanic and volcanoclastic rocks of Tertiary age (Tvs)
Wahmonie Formation	Lava-flow aquitard	Lava-flow and interflow tuff and breccia; locally hydrothermally altered	1219	
Salzer Formation	Tuff aquitard	Ash-fall tuff, tuffaceous sandstone, and tuff breccia, all interbedded; matrix commonly clayey or zeolitic	518	
		Breccia flow, lithic breccia and tuff breccia, interbedded with ash-fall tuff, sandstone, siltstone, claystone, matrix commonly clayey or calcareous	610	
		Ash-flow tuff, densely welded	61	
Grouse Canyon Member		Ash-flow tuff, nonwelded to welded	91	
Tub Spring Member		Ash-fall tuff, nonwelded to semiwelded ash-flow tuff, tuffaceous sandstone, siltstone, and claystone; all massively altered to zeolite or clay minerals; locally, minor welded tuff near base; minor rhyolite and basalt	610	
Local informal units		Rhyolite, nonwelded and welded ash flow, ash-fall tuff, tuff breccia, tuffaceous sandstone, hydrothermally altered at Calico Hills; matrix of tuff and sandstone commonly clayey or zeolitic	> 610	
Rhyolite flows and tuffaceous beds of Calico Hills		Ash-flow tuff, nonwelded to partly welded, interbedded with ash-fall tuff; matrix commonly clayey or zeolitic	91	
Tuff of Crater Flat		Tuffaceous sandstone and siltstone, claystone; freshwater limestone and conglomerate; minor gypsum; matrix commonly clayey, zeolitic, or calcareous	427	
Rocks of Pavits Spring		Freshwater limestone, conglomerate, tuff	305	
Horse Spring Formation				

Table 9.2-2. Generalized Stratigraphic and Hydrogeologic Units in the Death Valley Region (Continued)

Stratigraphic unit ^a	Hydrogeologic Unit ^a	Major Lithology ^a	Maximum Thickness (m) ^a	Hydrogeologic Units Defined for Section 9.2 (Faunt et al. 1997)
Granitic stocks	A minor aquitard	Granodiorite and quartz monzonite in stocks, dikes, and sills	Data not available	Granitic rocks of Tertiary-late Jurassic age (TJg)
Stratigraphic unit not defined	Hydrogeologic unit not defined	Not defined by Winograd and Thordarson (1975)	Data not available	Sedimentary and metavolcanic rocks of Mesozoic age (Mvs)
Tippipah Limestone	Upper carbonate aquifer	Limestone	1,097	Carbonate rocks of Paleozoic age (P2)
Eleana Formation	Upper clastic aquitard	Argillite, quartzite, conglomerate, conglomerite, limestone	2,408	
Devils Gate Limestone	Lower carbonate aquifer	Limestone, dolomite, minor quartzite	>421	
Nevada Formation		Dolomite	>465	
Undifferentiated		Dolomite	431	
Ely Springs Dolomite		Dolomite	93	
Eureka Quartzite		Quartzite, minor limestone	104	
Antelope Valley Limestone		Limestone and silty limestone	466	
Ninemile Formation		Claystone and limestone, interbedded	102	
Goodwin Limestone		Limestone	>274	
Nopah Formation Smoky Member Halfpint Member		Dolomite, limestone	326	
		Limestone, dolomite, silty limestone	218	
Dunderberg Shale Member		Shale, minor limestone	69	
Bonanza King Formation Banded Mountain Member		Limestone, dolomite, minor siltstone	744	
Papoose Lake Member	Lower clastic aquitard	Limestone, dolomite, minor siltstone	658	Clastic rocks of Paleozoic-Precambrian age (P1)
Carrara Formation		Siltstone, limestone, interbedded. Upper 320 m predominantly limestone; lower 290 m predominantly siltstone.	320 950	
Zabriskie Quartzite		Quartzite	67	
Wood Canyon Formation		Quartzite, siltstone, shale, minor dolomite	696	
Stirling Quartzite		Quartzite, siltstone	1,036	
Johnnie Formation		Quartzite, sandstone, siltstone, minor limestone and dolomite	975	
Stratigraphic unit not defined	Hydrogeologic unit not defined	Not defined by Winograd and Thordarson (1975)	Data not available	Igneous and metamorphic rocks of Precambrian age (pEgm)

Sources: Winograd and Thordarson (1975, Table 1); Faunt et al. (1997, p. 12-14)

NOTE: ^a Stratigraphic units, hydrogeologic units, major lithology, and thickness, defined by Winograd and Thordarson (1975, Table 1) for the Nevada Test Site and vicinity.

Table 9.2-3. Estimated Hydraulic Conductivity of Hydrogeologic Units

Hydrogeologic Unit	Description	Approximate Hydraulic Conductivity (m/day)
Playa deposits of Quaternary age (Qp)	Lakebed deposits of silt and clay	2×10^{-04} (all depths fractured and/or unfractured)
Valley-fill of Quaternary-Tertiary age (QTvf)	Alluvial (stream channel and fan gravels), colluvial, ash-fall, and lake deposits	1×10^{-01} (all depths fractured or unfractured)
Volcanic rocks of Quaternary-Tertiary age (QTV)	Rhyolitic, andesitic, and basaltic lava flows	4×10^{-04} (unfractured > 150 m deep) 5×10^{-01} (unfractured < 150 m deep; fractured)
Volcanic rocks of Tertiary age (Tv)	Dominantly rhyolitic ash-flow tuffs	1×10^{-00} (unfractured < 150 m deep; fractured < 3 km deep) 4×10^{-04} (unfractured > 150 m deep; fractured > 3 km deep)
Volcanic and volcanoclastic rocks of Tertiary age (Tvs)	Tuffs and tuffaceous clastic rocks	4×10^{-05} (all depths fractured or unfractured)
Granite rocks of Tertiary-late Jurassic age (TJg)	Granitic rocks	3×10^{-07} (unfractured > 300 m deep) 3×10^{-02} (weathered < 300 m deep) 5×10^{-04} (fractured < 300 m deep)
Sedimentary and metavolcanic rocks of Mesozoic age (Mvs)	Dominantly sandstones	3×10^{-02} (all depths fractured or unfractured)
Carbonate rocks of Paleozoic age (P2)	Limestones, dolomites, and calcareous shales	3×10^{-03} (unfractured > 150 m deep) 6×10^{-01} (unfractured < 150 m deep; fractured < 5 km deep)
Clastic rocks of Paleozoic-Precambrian age (P1)	Conglomerates, argillites, and quartzites	5×10^{-07} (unfractured) 1×10^{-02} 3×10^{-01} (fractured)
Igneous and metamorphic rocks of Precambrian age (pEgm)	Crystalline rocks (gneisses, schists, and migmatites)	3×10^{-07} (fractured > 300 m deep) 3×10^{-02} (weathered < 300 m deep) 5×10^{-04} (fractured < 300 m deep)

Source: Faunt et al. (1997)

Table 9.2-4. Estimated Evapotranspiration and Spring Discharge Rates by Discharge Area

Discharge Area Number	Discharge Area	Springs (m ³ /day)	Evapotranspiration (m ³ /day)	Discharge Estimated (m ³ /day)
1	Sand Springs/North Death Valley	100	Unknown	100 ^a
2	Stonewall Flat East Playa	0	300	300 ^b
3	Stonewall Flat West Playa	0	100	100 ^b
4	Lida Junction Playa	0	600	600 ^b
5	Sarcobatus Flat Main Playa	0	12,900	12,900 ^b
6	Coyote Holes Playas	0	200	200 ^b
7	Oasis Valley	3,100	14,500	16,000 ^{c,d}
8	Bonnie Claire Playa	0	400	400 ^b
9	Grapevine Canyon	3,600	2,900	5,000 ^{c,d}
10	Mesquite Flat/Stovepipe Wells	Unknown	38,100	38,100 ^b
11	Main Salt Pan	3,000	100,000	100,000 ^{b,e}
12	Saratoga Springs	700	33,200	33,200 ^{c,e}
13	Furnace Creek Ranch	11,100	Unknown	11,000 ^a
14	Salt Creek Hills	Unknown	3,800	3,800 ^b
15	Amargosa River	0	1,500	1,500 ^b
16	Peter's Playa-Amargosa Flats	0	3,400	3,400 ^b
17	Ash Meadows	57,400	64,000	64,000 ^{c,e}
18	Carson Slough	Unknown	8,100	8,100 ^c
19	Alkali Flat	Unknown	17,200	17,200 ^c
20	Indian/Cactus Springs	4,100	2,400	4,500 ^{c,d}
21	Stewart Valley Playa	0	20,800	20,800 ^b
22	Pahrump Valley	0	18,000	18,000 ^b
23	Shoshone/Tecopa	1,000	24,200	24,200 ^c
24	Chicago Valley	0	8,700	8,700 ^b
25	South Chicago Valley	1,400	4,800	4,800 ^c
26	California Valley	0	1,300	1,300 ^b
27	China Ranch	Unknown	2,500	2,500 ^c
28	Tecopa Pass	Unknown	1,800	1,800 ^c
29	Sperry Hills (Amargosa Canyon)	Unknown	6,000	6,000 ^c
30	Mesquite Lake	0	29,000	29,000 ^b

Source: From D'Agnese et al. (1997), except for rate for Ash Meadows springs (Dudley and Larson 1976) and evapotranspiration and estimated discharge rates for discharge areas 16 and 17 (Laczniak et al. 1999)

NOTES: ^a Dominantly spring

^b Dominantly evapotranspiration

^c Combined spring and evapotranspiration

^d Spring discharge is partially (50 percent) consumed as domestic water use and not recirculated.

^e Spring discharge is recirculated and consumed as evapotranspiration.

Table 9.2-5. Rainfall Recharge Area-Elevation Classes

Area-Elevation Class	Precipitation Percentage that Becomes Recharge
Greater than 2,439 m	25
2,134 - 2,439 m	15
1,829 - 2,134 m	7
1,524 - 1,829 m	3
Less than 1,524 m	0

Source: Modified by D'Agnese et al. (1997) from Maxey and Eakin (1950)

NOTE: Datum is sea level.

Table 9.2-6. Potential Recharge Classifications for Elevation Zones

Altitude Zone	Recharge Rating
Greater than 2,743 m	5
2,438 to 2,743 m	4
2,134 to 2,438 m	3
1,829 to 2,134 m	2
1,524 to 1,829 m	1
Less than 1,524 m	0

Source: D'Agnese et al. (1997)

Table 9.2-7. Potential Recharge Classifications for Vegetation Zones

Vegetation Zone	Recharge Rating
Coniferous forests	5
Pinyon-juniper	3
Mixed shrub	1
All others	0

Source: D'Agnese et al. (1997)

Table 9.2-8. Potential Recharge Classifications for Slope-Aspect Zones

Slope-Aspect Zone	Recharge Rating
Northeast	5
Northwest	4
Flat	3
Southeast	2
Southwest	1

Source: D'Agnese et al. (1997)

Table 9.2-9. Potential Recharge Classifications for Parent Material Types

Hydrogeologic Unit (see Figure 9.2-3)	Recharge Rating
QTvf	5
TJg, Mvs, pEgm	4
P2	3
Qp, QTv, Tv, P1	2
Tvs	1

Source: D'Agnese et al. (1997)

Table 9.2-10. Final Recharge Potential Zones and Relative Recharge Percentages

Class Number	Recharge Potential	Estimated Average Rate (Percentage of Precipitation)
5	High	30
4	High-moderate	25
3	Moderate	15
2	Moderate-low	7
1	Low	3
0	No recharge	0

Source: D'Agnese et al. (1997, Table 10)

Table 9.2-11. Recharge Estimated with the Refined Maxey-Eakin Method Compared with Previously Determined Maxey-Eakin Estimates

Hydrographic Area Number	Hydrographic Area	Recharge Estimate	
		Maxey-Eakin (m ³ /day)	Refined Maxey-Eakin (m ³ /day)
144	Lida Valley	1,600	6,600
145	Stonewall Flat	300	2,800
146	Sarcobatus Flat	4,100	5,000
147	Gold Flat	12,800	22,400
148	Cactus Flat	2,000	10,400
157	Kawich Valley	11,800	25,500
158	Emigrant Valley	10,800	43,900
159	Yucca Flat	2,400	6,300
160	Frenchman Flat	300	3,300
161	Indian Springs Valley	33,800	27,600
162	Pahrump Valley	74,300	68,400
163	Mesquite Valley	9,800	7,300
168	N. Three Lakes Valley	6,800	4,000
169	Tikaboo Valley	20,300	33,200
211	S. Three Lakes Valley	20,300	24,800
225/226	Mercury/Rock Valleys	1,000	1,300
227	Fortymile Canyon	7,800	2,300
228	Oasis Valley	3,400	10,300
229	Crater Flat	700	400
230	Amargosa Valley	5,100	1,400
241	California/Chicago Valleys	1,000	1,600
242	Lower Amargosa Valley	300	100
243	Death Valley	32,400	32,400

Source: D'Agnese et al. (1997)

Table 9.2-12. Median and Interquartile Range Values for Selected Major Ions and Deuterium in Groundwater by Major Subdivision of the Death Valley Regional Groundwater Flow System

Selected Major Ions										
Constituent (mg/L)	Pahute Mesa (N = 18) ^a		Oasis Valley (N = 29) ^b		Yucca Mountain-Fortymile Wash Area (N = 18) ^c		West-Central Amargosa Desert (N = 52) ^c		Ash Meadows Springs (N = 11) ^c	
	Md	IQ	Md	IQ	Md	IQ	Md	IQ	Md	IQ
Calcium (Ca)	8.4	23	22	15	10	13	28	26	47	8.5
Sodium (Na)	78	77	150	278	56	39	76	77	69	11
Bicarbonate (HCO ₃)	124	86	268	364	145	102	171	228	304	16
Sulfate (SO ₄)	105	87	96	74	22	11	77	128	81	19
Chloride (Cl)	9.5	25	45	32	7.4	3	18	23	22	4.5
Silica (SiO ₂)	44	10	57	14	52	8	70	22	23	3.7
Dissolved Solids	246	279	522	307	229	71	320	255	432	63
Hydrogen Ion										
Constituent (mg/L)	Pahute Mesa (N = 4) ^d		Oasis Valley (N = 16) ^e		Yucca Mountain-Fortymile Wash Area (N = 21) ^f		West-Central Amargosa Desert (N = 21) ^g		Ash Meadows Springs (N = 7) ^d	
	Md	IQ	Md	IQ	Md	IQ	Md	IQ	Md	IQ
Deuterium (‰)	-112	6.1	-108	6.1	-102	4	-102	2.5	-103	1

Sources: ^a McKinley et al. (1991, Table 5)

^b McKinley et al. (1991, Table 2)

^c McKinley et al. (1991, Table 1)

^d Thomas et al. (1996, Appendix A)

^e White and Chuma (1987, Table 1)

^f Benson and Klieforth (1989, Table 1a)

^g Claassen (1985, Table 6)

NOTES: N = number of samples; Md = median value; IQ = interquartile range, the difference between the 25th percentile and 75th percentile value

Table 9.2-13. Divisions of the Death Valley Regional Groundwater Flow System

Subregion	Groundwater Basin	Groundwater Section
Northern Death Valley	None	a. Lida-Stonewall b. Sarcobatus Flat c. Grapevine Canyon d. Oriental Wash
Central Death Valley	Pahute Mesa-Oasis Valley	a. Kawich Valley b. Oasis Valley
	Ash Meadows	a. Pahrnagat Valley b. Tikaboo Valley c. Indian Springs Valley d. Emigrant Valley e. Yucca-Frenchman Flats f. Specter Range
	Alkali Flat-Furnace Creek	a. Fortymile Canyon b. Amargosa River c. Crater Flat d. Funeral Mountains
Southern Death Valley	None	a. Pahrump Valley b. Shoshone-Tecopa c. California Valley d. Ibex Hills

Source: D'Agnese et al. (1997, Table 12)

Table 9.2-14. Water Budget for the Death Valley Regional Groundwater Flow System

Inflow or Outflow	Type of Flux	Cubic Meters Per Day
Inflow	Flux In: Recharge (infiltration)	312,300
	Flux In: Pahrnagat Valley	20,000
	Flux In: Sand Spring Valley	1,700
	Flux In: Railroad Valley	3,400
	Flux In: Stone Cabin Valley	3,400
	Flux In: Ralston Valley	3,400
	Total	344,200
Outflow	Discharge: Evapotranspiration	148,600
	Discharge: Springs	125,400
	Flux Out: Death Valley/Saratoga Springs	100,000
	Total	374,000
Change In Storage	From pumpage	29,800

NOTE: Table is adapted from D'Agnese et al. (1997, Table 13). The "change in storage" value was calculated using Equation 9.2-1, assuming steady-state conditions.

Table 9.2-15. Comparison of Simulated and Estimated Regional Water-Budget Components

Flux	Water Budget Component	Simulated (m ³ /day)	Estimated (m ³ /day)
In	Constant head (north and east boundaries)	69,000	31,900
	Recharge	338,000	312,300
Out	Wells	88,000	89,400
	Evapotranspiration	173,000	148,600
	Springs (regional)	51,700	125,400
	Constant head	98,000	100,000

Source: D'Agnese et al. (1997, Table 17)

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Table 9.3-1. Correlation of Generalized Stratigraphy with Unsaturated and Saturated Hydrogeologic Units in the Vicinity of Yucca Mountain

System and Series	Stratigraphic Unit	Hydrogeologic Units		Saturated Hydrogeologic Units ^b	Comments
		Unsaturated	Saturated		
QUATERNARY and TERTIARY	Alluvium, colluvium, eolian deposits, spring deposits, basalt lavas, lacustrine deposits, playa deposits	QAL Alluvium	QTa Valley-fill aquifer QTc Valley-fill confining unit		QAL restricted to stream channels on Yucca Mountain, QTa occurs mainly in Amargosa Desert; major water-supply source
TERTIARY Miocene	TIMBER MOUNTAIN GROUP Rainier Mesa Tuff	—	—		Minor erosional remnants at Yucca Mountain
	PAINTBRUSH GROUP Tiva Canyon Tuff	TCw Tiva canyon welded unit	—	Upper Volcanic Aquifer	Mainly densely welded; caprock on Yucca Mountain. Not known in SZ at or near Yucca Mountain
	(bedded Tuff) Yucca Mountain Tuff Pah Canyon Tuff Topopah Spring Tuff (Vitrophyre and nonwelded tuffs at base)	PTn Paintbrush nonwelded unit	—		PTn includes bedded and nonwelded tuffs between basal part of Tiva Canyon Tuff and upper part of Topopah Spring Tuff
		TSw Topopah Spring welded unit	uva Upper volcanic aquifer		About 300 m of densely welded tuff in UZ. Host rock for repository. In SZ where downfaulted to east, south, and west of site
	Calico Hills Formation	CHn Calico Hills nonwelded unit	uvc Upper volcanic confining unit	Upper Volcanic Confining Unit	Mainly nonwelded tuff, with thin rhyolite lavas in northern site area. Varies from vitric in southwest site area to zeolitic where near or below water table
	CRATER FLAT GROUP Prow Pass Tuff Bullfrog Tuff Tram Tuff	CFu Crater Flat undifferentiated unit	mva ^a Middle volcanic aquifer	Lower Volcanic Aquifer	Small occurrence in UZ. Widespread in SZ. Variably welded ash-flow tuffs and rhyolite lavas. Commonly zeolitized. Most permeable zones are fracture-controlled

Table 9.3-1. Correlation of Generalized Stratigraphy with Unsaturated and Saturated Hydrogeologic Units in the Vicinity of Yucca Mountain (Continued)

System and Series	Stratigraphic Unit	Hydrogeologic Units		Saturated Hydrogeologic Units ^b	Comments
		Unsaturated	Saturated		
TERTIARY Miocene (Continued)	Unnamed flow breccia Lithic Ridge Tuff	—	mvc Middle volcanic confining unit	Lower Volcanic Confining Unit	Nonwelded tuff, pervasively zeolitized
	Volcanics of Big Dome	—	Iva ^a Lower volcanic aquifer	???	Lava flows and welded tuff not known at Yucca Mountain
	(Lower Tertiary?) Older volcanics	—	Ivc Lower volcanic confining unit		Nonwelded tuff, pervasively zeolitized. Tuffaceous sediments in lower part
PERMIAN PENNSYLVANIAN	Bird Spring Fm Tippipah Limestone	—	uca Upper carbonate aquifer	???	Limited distribution in SZ north and east of Yucca Mountain
MISSISSIPPIAN- DEVONIAN	Eleana Formation (Chainman Shale)	—	ecu Eleana confining unit	Upper Clastic Confining Unit	Argillite (mudstone) and siltstone. Occurrence inferred beneath volcanics of northern Yucca Mountain
DEVONIAN SILURIAN ORDOVICIAN CAMBRIAN	Devils Gate Ls, Nevada Fm, Ely Springs Dol, Eureka Qtzt., Pogonip Gp, Nopah Fm, Dunderberg Sh, Bonanza King Fm, Upper Carrara Fm	—	Ica Lower carbonate aquifer	Lower Carbonate Aquifer	Mainly limestone and dolomite with relatively thin shales and quartzites. Major regional aquifer, >5 km thick
	Lower Carrara Fm	—	qcu Precambrian confining unit	Proterozoic Confining Unit	Dolomite, shale
PROTEROZOIC (Upper Precambrian)	Proterozoic rocks				Quartzite, slate, marble. Fractures commonly healed by mineralization

Sources: Adapted from Czarnecki, Faunt et al. (1997); Luckey et al. (1996); Montazer and Wilson (1984)

NOTES: SZ = saturated zone; UZ = unsaturated zone

^aThe middle volcanic aquifer in this table correlates to the lower aquifer of Luckey et al. (1996). The lower aquifer in this table correlates with volcanics of Big Dome, which is not addressed by Luckey et al. (1996) because it is not recognized at Yucca Mountain.^bLuckey et al. (1996, Figure 7)

Table 9.3-2. Principal Sources of Hydrologic Data and Interpretations Related to Drilling at Yucca Mountain

Borehole	Hydrologic Test Data	Geohydrology
UE-25 b#1	Lobmeyer et al. 1983	Lahoud et al. 1984
UE-25 c#1, 2, 3	—	Geldon 1993, 1996; Geldon et al. 1997, 1998; Fahy 1997
UE-25 p#1	Craig and Johnson 1984; Anderson 1991 (Core)	Craig and Robison 1984; Carr, M.D. et al. 1986 (Geology)
UE-29 a#1, #2	Waddell et al. 1984	—
USW G-2	—	O'Brien 1998
USW G-3, GU-3	Anderson 1994 (Core)	—
USW G-4	Bentley 1984; Anderson 1994 (Core)	Lobmeyer 1986
USW H-1	Rush et al. 1983	Rush et al. 1984
USW H-3	Thordarson et al. 1984	Thordarson et al. 1985
USW H-4	Whitfield et al. 1984	Whitfield et al. 1985; Erickson and Waddell 1985
USW H-5	Bentley et al. 1983	Robison and Craig 1991
USW H-6	Craig et al. 1983	Craig and Reed 1991
USW SD-7	—	O'Brien 1997
USW VH-1	Thordarson and Howells 1987	Thordarson and Howells 1987
USW WT-10 USW WT-12	—	O'Brien 1997
UE-25 J-13	Thordarson 1983	Thordarson 1983

Table 9.3-3. Types of Single-Well and Multiple-Well Tests and Methods of Analysis Used at Yucca Mountain

Type of Test	Method of Analysis	Analysis Reference
Single-well, constant-rate discharge ("pumping") or injection	Specific capacity, steady-state drawdown	Brown 1963; Ahrens et al. 1981; ASTM D 5472-93
	Straight-line fit to drawdown, buildup, or recovery in uniform, isotropic aquifer	Cooper and Jacob 1946; Jacob 1946; Ferris et al. 1962; Lohman 1979; Raghavan and Hadinoto 1978
	Straight-line fit to drawdown in dual-porosity aquifer	Cooper and Jacob 1946; Moench 1984
	Type curve: nonequilibrium drawdown, buildup, or recovery in uniform, isotropic, confined aquifer	Theis 1935; Ferris et al. 1962; Lohman 1979
	Type curve: drawdown in well of large diameter	Papadopoulos and Cooper 1967
	Type curve: drawdown in anisotropic, unconfined aquifer	Stallman 1965
	Type curve: drawdown or recovery in anisotropic, unconfined aquifer, with delayed yield from storage	Neuman 1975
	Computer-generated curve match; drawdown, buildup, or recovery with variable aquifer properties and boundaries	Barr 1985; Barr 1991
Single-well, variable-rate discharge	Cyclic-rate drawdown and recovery (Brown's method)	Ferris et al. 1962
	Multiple-swabbing drawdown recovery; analyzed as recovery from constant-flux withdrawal by straight-line or type-curve methods	Cooper and Jacob 1946; Jacob 1946; Ferris et al. 1962; Lohman 1972; Raghavan and Hadinoto 1978; Theis 1935
Single-well, instantaneous slug-injection or withdrawal, with change or storage in well (also approximated by single-swab withdrawal)	Type curve: falling-head or rising-head recovery from instant head change	Cooper et al. 1967; Papadopoulos et al. 1973
	Harmonic analysis of underdamped, oscillatory response to sudden head change	Van Der Kamp 1976
Single-well, pressure-pulse injection, without change of storage in well	Type curve: pressure decay, multiple shut-in cycles	Bredehoeft and Papadopoulos 1980; Neuzil 1982

Table 9.3-3. Types of Single-Well and Multiple-Well Tests and Methods of Analysis Used at Yucca Mountain (Continued)

Type of Test	Method of Analysis	Analysis Reference
Multiple-well, constant-rate discharge ("pumping") or injection, with response in observation well(s)	Straight-line fit to head change as function of time at specified distance	Cooper and Jacob 1946
	Straight-line fit to head change as function of distance at specified time or steady-state	Cooper and Jacob 1946
	Type curve: nonequilibrium head change at specified distance in uniform, isotropic, confined aquifer	Theis 1935; Ferris et al. 1962; Lohman 1972
	Type curve: drawdown in leaky, confined aquifer without confining-bed storage	Cooper 1963
	Type curve: drawdown in fissure-block (dual-porosity) aquifer	Streltsova-Adams 1978
	Type curve: drawdown or recovery in anisotropic, unconfined aquifer with delayed yield from storage	Neuman 1975
	Analytical solution for estimating transmissivity tensor components from computed drawdown distribution around discharging well: drawdown from an infinite anisotropic aquifer.	Papadopoulos 1967

Table 9.3-4. Estimated Transmissivity Values Obtained from Single-Borehole Aquifer Tests in the Vicinity of Yucca Mountain

Borehole	Transmissivity (m ² /day)					Reference
	Upper Volcanic Aquifer	Upper Volcanic Confining Unit	Middle ^h Volcanic Aquifer	Middle ^h Volcanic Confining Unit	Carbonate Aquifer	
USW H-1	–	–	152	5.0×10^{-3}	–	Rush et al. (1984)
USW H-3	–	–	<1.1	$<4.1 \times 10^{-1}$	–	Thordarson et al. (1985)
USW H-4	–	–	178	23	–	Whitfield et al. (1985)
USW H-5	–	–	35	–	–	Robison and Craig (1991)
USW H-6	–	–	229	6.3×10^{-2}	–	Craig, R.W. and Reed (1991)
USW G-2	–	9 ^a	–	–	–	O'Brien (1998)
USW G-4	–	–	589 ^b	–	–	Lobmeyer (1986)
UE-25 b#1	–	26	297	$<3.0 \times 10^{-3}$	–	Lahoud et al. (1984); Moench (1984)
C-holes Complex	–	2.0	21 1,600 - 3,200? ^c	–	–	Geldon (1996); Geldon et al. (1998)
UE-25 p#1	–	–	15	2.0	118	Craig, R.W. and Robison (1984)
USW WT-10	1,600 ^d	–	–	–	–	O'Brien (1997)
UE-25 WT#12	7? ^e	7? ^e	–	–	–	O'Brien (1997)
UE-25 J-13	120	3.7 ^f	1.4	6.3×10^{-1} ^g	–	Thordarson (1983)

Source: Adapted from Luckey et al. (1996, Table 5)

NOTE: – = no data; < = less than

^a Though the top 3 m of the water column in borehole USW G-2 were in the upper volcanic aquifer, the upper volcanic confining unit (saturated interval of 256 m) is considered to be the interval tested.

^b Average determined from four tests

^c It is assumed that this range of transmissivity is for the lower volcanic aquifer. However, pumping and monitoring wells were completed in saturated intervals of both the lower volcanic aquifer and lower volcanic confining unit.

^d Average determined from three tests

^e Of the saturated interval tested in borehole UE-25 WT#12, 41 m were completed in the upper volcanic aquifer and 12 m were completed in the upper volcanic confining unit. The low transmissivity could indicate the lowest limit of transmissivity values for the upper volcanic aquifer, or that the degree of fracturing in the interval tested of the upper volcanic aquifer was very low and the transmissivity is more representative of the upper volcanic confining unit (O'Brien 1997, pp. 22 to 23).

^f Average determined from two tests

^g Includes part of the lower volcanic aquifer

^h Middle aquifer and confining unit nomenclature on this table is analogous to the lower unit nomenclature used in Luckey et al. (1996)

Table 9.3-5. Estimated Apparent Hydraulic Conductivity Values Obtained from Single-Borehole Tests in the Vicinity of Yucca Mountain

Borehole	Apparent Hydraulic Conductivity (m/day)					Reference
	Upper Volcanic Aquifer	Upper Volcanic Confining Unit	Middle ⁹ Volcanic Aquifer	Middle ⁹ Volcanic Confining Unit	Carbonate Aquifer	
USW H-1	—	—	4.3×10^{-1}	5.5×10^{-6}	—	Rush et al. (1984)
USW H-3	—	—	$<3.7 \times 10^{-3}$	$<3.2 \times 10^{-3}$	—	Thordarson et al. (1985)
USW H-4	—	—	4.3×10^{-1}	1.1×10^{-1}	—	Whitfield et al. (1985)
USW H-5	—	—	6.0×10^{-1}	—	—	Robison and Craig (1991)
USW H-6	—	—	8.0×10^{-1}	1.8×10^{-4}	—	Craig, R.W. and Reed (1991)
USW G-2	—	3.5×10^{-2} ^a	—	—	—	O'Brien (1998)
USW G-4	—	—	1.4	—	—	Lobmeyer (1986)
UE-25 b#1	—	2.6×10^{-1}	4.9×10^{-1}	$<1.0 \times 10^{-4}$	—	Lahoud et al. (1984); Moench (1984)
C-holes Complex	—	2.0×10^{-2}	7.0×10^{-2} $6.5 - 13$? ^b	—	—	Geldon (1996); Geldon et al. (1998)
UE-25 p#1	—	—	3.3×10^{-2}	5.8×10^{-3}	1.9×10^{-1}	Craig, R.W. and Robison (1984)
USW WT-10	19 ^c	—	—	—	—	O'Brien (1997)
UE-25 WT#12	1.3×10^{-1} ? ^d	1.3×10^{-1} ? ^d	—	—	—	O'Brien (1997)
UE-25 J-13	1.0	1.2×10^{-1} ^e	7.6×10^{-3}	2.6×10^{-3} ^f	—	Thordarson (1983)

Source: Adapted from Luckey et al. (1996, Table 5)

NOTE: — = no data; < = less than

^a Though the top 3 m of the water column in borehole USW G-2 were in the upper volcanic aquifer, the upper volcanic confining unit (saturated interval of 256 m) is considered to be the interval tested.

^b It is assumed that this range of hydraulic conductivity is for the lower volcanic aquifer. However, pumping and monitoring wells were completed in saturated intervals of both the lower volcanic aquifer and lower volcanic confining unit.

^c Average determined from three tests

^d Of the saturated interval tested in borehole UE-25 WT#12, 41 m were completed in the upper volcanic aquifer and 12 m were completed in the upper volcanic confining unit. The low hydraulic conductivity could indicate the lowest limit of hydraulic conductivity for the upper volcanic aquifer, or that the degree of fracturing in the interval tested of the upper volcanic aquifer was very low and the hydraulic conductivity is more representative of the upper volcanic confining unit (O'Brien 1997, pp. 22 to 23).

^e Average determined from two tests

^f Includes part of the lower volcanic aquifer

⁹ Middle aquifer and confining unit nomenclature on this table is analogous to the lower unit nomenclature used in Luckey et al. (1996)

Table 9.3-6. Drill Depth and Date Completed of Wells Monitored in the Saturated Zone in the Yucca Mountain Area

Well	Drilled Depth (m)	Date Completed (month-year)
USW WT-1	515	5-83
USW WT-2	628	7-83
UE-25 WT#3	348	5-83
UE-25 WT#4	482	6-83
UE-25 WT#6	383	6-83
USW WT-7	491	7-83
USW WT-10	431	8-83
USW WT-11	441	8-83
UE-25 WT#12	399	8-83
UE-25 WT#13	354	7-83
UE-25 WT#14	399	9-83
UE-25 WT#15	415	11-83
UE-25 WT#16	521	11-83
UE-25 WT#17	443	10-83
UE-25 WT#18	623	5-84
USW G-2	1,831	10-81
USW G-3	1,533	3-82
USW G-4	915	11-82
USW H-1 (well monitors four depth intervals)	1,829	1-81
USW H-3 (well monitors two depth intervals)	1,219	3-82
USW H-4 (well monitors two depth intervals)	1,219	6-82
USW H-5 (well monitors two depth intervals)	1,219	8-82
USW H-6 (well monitors two depth intervals)	1,220	10-82
USW VH-1	762	2-81
UE-25 a#1	762	9-78
UE-25 b#1 (well monitors two depth intervals)	1,220	9-81
UE-25 c#1	914	10-83
UE-25 c#2	914	3-84
UE-25 c#3	914	6-84
UE-25 p#1	1,805	5-83
UE-25 J-11	405	7-57
UE-25 J-12	3,472	8-68
UE-25 J-13	1,063	1-63

Table 9.3-7. Statistical Information from 1985 to 1995 for Wells and Well Intervals Monitored in the Yucca Mountain Area

Well	Minimum Water-Level Elevation (m)	Maximum Water-Level Elevation (m)	Range (m)	Mean Water-Level Elevation (m)	Median Water-Level Elevation (m)	Standard Deviation (m)	Number of Data Points Used
USW WT-1	729.98	730.50	0.52	730.35	730.35	0.092	128
USW WT-2	730.14	730.81	0.67	730.65	730.70	0.128	106
UE-25 WT#3	729.41	729.85	0.44	729.64	729.70	0.126	119
UE-25 WT#4	730.28	731.17	0.89	730.78	730.81	0.118	131
UE-25 WT#6	1,033.29	1,036.09	2.80	1,034.60	1,034.52	0.553	117
USW WT-7	775.47	775.99	0.52	775.83	775.85	0.096	113
USW WT-10	775.56	776.21	0.65	776.00	776.00	0.114	132
USW WT-11	730.21	730.81	0.60	730.66	730.69	0.099	119
UE-25 WT#12	729.11	729.58	0.47	729.47	729.48	0.074	123
UE-25 WT#13	728.53	729.43	0.90	729.11	729.14	0.119	118
UE-25 WT#14	729.29	729.98	0.69	729.68	729.69	0.073	135
UE-25 WT#15	728.98	729.42	0.44	729.22	729.22	0.070	124
UE-25 WT#16	737.82	738.57	0.75	738.27	738.29	0.147	123
UE-25 WT#17	729.45	729.84	0.39	729.70	729.72	0.083	117
UE-25 WT#18	730.52	730.92	0.40	730.75	730.76	0.095	38
UE-25 b#1							
upper interval	730.48	730.79	0.31	730.65	730.63	0.065	99
lower interval	728.52	730.25	1.73	729.67	729.77	0.425	67
UE-25 p#1	751.92	752.69	0.77	752.44	752.49	0.161	120
USW VH-1	779.30	779.60	0.30	779.44	779.45	0.048	147
USW G-2	1,019.58	1,020.56 ^a	0.98	1,020.17	1,020.12	0.241	28
USW G-3	729.96	730.83	0.87	730.50	730.51	0.169	113
UE-25 J-11	732.09	732.40	0.31	732.21	732.20	0.055	71
UE-25 J-12	727.81	728.15	0.34	727.93	727.94	0.053	100
UE-25 J-13	728.30	728.69	0.39	728.44	728.44	0.065	121
USW H-1							
tube 1	785.00	786.05	1.05	785.49	785.49	0.272	101
tube 2	735.67	736.28	0.61	735.97	735.95	0.161	75
tube 3	730.35	730.81	0.46	730.60	730.62	0.098	108
tube 4	730.51	731.04	0.53	730.85	730.90	0.126	124
USW H-3							
upper interval	731.07	731.93	0.86	731.52	731.41	0.287	128
lower interval	747.39	759.61	12.22	755.91	756.80	3.098	59
USW H-4							
upper interval	730.20	730.52	0.32	730.40	730.40	0.061	128
lower interval	730.18	730.83	0.65	730.51	730.52	0.108	101
USW H-5							
upper interval	774.96	775.72	0.76	775.46	775.47	0.139	106
lower interval	774.95	775.86	0.91	775.62	775.64	0.186	54
USW H-6							
upper interval	775.83	776.20	0.37	776.02	776.03	0.087	118
lower interval	775.71	776.08	0.37	775.94	775.95	0.070	79

Source: Adapted from Graves et al. (1997, Table 2)

NOTE: ^aThe water level in well USW G-2 has been declining since the well was completed on 10-24-81. Elevation of water level on 11-10-81 was 1,031.82 m (U.S. Geological Survey historical records). Elevation of water level on 09-17-82 was 1,028.84 m (Robison et al. 1988). Range of water-level change since 11-01-81 is 12.24 m.

Table 9.3-8. Potentiometric Levels at Varying Depth Intervals in Boreholes at Yucca Mountain

Borehole	Depth Interval (m)	Primary Hydrogeologic Unit	Potentiometric Level Elevation (m)	Remarks
UE-25 b#1	488 - 1,199	Lower volcanic aquifer	730.71	1991 mean level
	1,199 - 1,220	Lower volcanic confining unit	729.69	1991 mean level
UE-25 c#3	692 - 753	Lower volcanic aquifer	730.22	1990 mean level
	753 - 914	Lower volcanic aquifer	730.64	1990 mean level
UE-25 p#1	384 - 500	Lower volcanic aquifer	729.90	Craig, R.W. and Robison (1984)
	1,297 - 1,805	Carbonate aquifer	751.26	Average value; Craig, R.W. and Robison (1984)
USW G-4	615 - 747	Lower volcanic aquifer	730.3	Average value; Bentley (1984)
	747 - 915	Lower volcanic aquifer	729.8	Average value; Bentley (1984)
USW H-1	573 - 673	Lower volcanic aquifer	730.94	1991 mean level
	716 - 765	Lower volcanic aquifer	730.75	1991 mean level
	1,097 - 1,123	Lower volcanic aquifer	736.06	1991 mean level
	1,783 - 1,814	Lower volcanic confining unit	785.58	1991 mean level
USW H-3	762 - 1,114	Lower volcanic aquifer	731.35	1991 mean level
	1,114 - 1,219	Lower volcanic confining unit	753.05	Mean for 12/91 ^a
USW H-4	525 - 1,188	Lower volcanic aquifer	730.41	1991 mean level
	1,188 - 1,219	Lower volcanic confining unit	730.56	1991 mean level
USW H-5	708 - 1,091	Lower volcanic aquifer	775.43	1991 mean level
	1,091 - 1,219	Lower volcanic confining unit	775.65	1991 mean level
USW H-6	533 - 752	Lower volcanic aquifer	775.99	1991 mean level
	752 - 1,220	Lower volcanic aquifer	775.91	1991 mean level
	533 - 1,193	Lower volcanic aquifer	776.09	Jan. - May 1984 mean level
	1,193 - 1,220	Lower volcanic confining unit	778.18	Jan. - May 1984 mean level
UE-25 J-13	282 - 451	Upper volcanic aquifer	728.8	Thordarson (1983)
	471 - 502	Upper volcanic confining unit	728.9	Thordarson (1983)
	585 - 646	Lower volcanic aquifer	728.9	Thordarson (1983)
	820 - 1,063	Lower volcanic aquifer	728.0	Thordarson (1983)

Source: Adapted from Luckey et al. (1996, Table 3)

NOTE: ^aPotentiometric levels rising throughout 1991 in response to reconfiguration of the packer that isolates the lower interval.

Table 9.3-9. Elevations of Hydrogeologic Units in Deep Boreholes at Yucca Mountain

Borehole	Elevation of Water Level	Elevation of Bottom of Borehole	Elevation of Base of Hydrogeologic Unit			
			Upper Volcanic Aquifer	Upper Volcanic Confining Unit	Middle ^a Volcanic Aquifer	Middle ^a Volcanic Confining Unit
USW G-2	1,020	-277	1,056	730	361	>TD
USW G-3	730	-53	1,119	1,005	307	>TD
USW G-4	731	355	875	733	>TD	>TD
USW H-1	731	-526	871	736	200	>TD
USW H-3	731	264	1,119	1,030	387	>TD
USW H-4	730	30	888	753	94	>TD
USW H-5	776	259	996	886	439	>TD
USW H-6	776	82	931	843	427	>TD
UE-25 b#1	731	-19	806	631	12	>TD
UE-25 c#1	730	216	758	615	>TD	>TD
UE-25 p#1	752	-691	780	678	241	-130
UE-25 J-13	728	-52	612	481	36	>TD

Source: Adapted from Luckey et al. (1996, Table 2)

NOTE: All elevations are in meters above sea level; water level is for uppermost interval monitored; base of hydrogeologic unit is shown even if it is above the saturated zone; >TD indicates that at the total depth, borehole was still in or had not reached this hydrogeologic unit.

^aThe middle volcanic aquifer and confining unit in this table are equivalent to the lower units listed in Luckey et al. (1996, Table 2).

Table 9.3-10. Chemistry of Waters from Boreholes J-13 and UE-25 p#1 and the Unsaturated Zone at Yucca Mountain

Analytes and UE-25 Measurements	J-13 (mg/L)	Unsaturated Zone (mg/L)	UE-25 p#1 (mg/L)
Sodium	45	26-70	171
Bicarbonate	143	-	698
Calcium	11.5	27-127	87.8
Potassium	5.3	5-16	13.4
Magnesium	1.8	5-21	31.9
Sulfate	18.1	39-174	129
Nitrate	10.1	-	<0.01
Chloride	6.4	34-106	37.0
Fluoride	2.1	-	3.5
Silicon	30.0	72-100	30.0
pH	6.9	6.5-7.5	6.7
Eh (mV)	340	-	360

Source: Triay et al. 1997

NOTE: -- = not measured

Table 9.3-11. Site Saturated Zone Hydrogeologic Units, Equivalent Units, and Associated Lithologies in the Vicinity of Yucca Mountain

Hydrogeologic Unit (Age) ^a	Model Unit Number (Parameter Name)	Equivalent Unit			Lithology	Data-Availability Rating ^b
		Winograd and Thordarson (1975)	Laczniak et al. (1996)	Luckey et al. (1996)		
Valley-fill aquifer (Q, T)	20 (qal)	Valley Fill (Valley-fill aquifer)	Alluvial deposits (Valley-fill aquifer)	Alluvium	Alluvial fan, fluvial, fanglomerate, lakebed, eolian and mudflow deposits	9.0
Valley-fill confining unit (Q, T)	19 (tpla)	Valley Fill (Valley-fill aquifer)	Alluvial deposits (Valley-fill aquifer)	Alluvium	Playa deposits	5.0
Limestone aquifer (T)	18 (tlim)	—	—	—	Lacustrine limestones, calcareous spring deposits	0.9
Lava-flow aquifer (Q, T)	17 (B)	Basalt of Kiwi Mesa Basalt of Skull Mountain (Lava-flow aquifer)	Basalt	—	Basalt flows, dikes and cinder cones, latite dikes	1.0
Upper volcanic aquifer (T)	16 (uva)	Timber Mountain Tuff Paintbrush Tuff (Welded-tuff aquifer)	Thirsty Canyon Group Timber Mountain Group Paintbrush Group (Welded-tuff and lava-flow aquifers)	Paintbrush Group (Upper volcanic aquifer)	Variably welded ash-flow tuffs and rhyolite lavas (nonwelded tuffs)	6.0
Upper volcanic confining unit (T)	15 (uvcu)	Wahmonie Formation Salyer Formation Rhyolite flows and tuffaceous beds of Calico Hills (Lava-flow aquitard - Tuff aquitard)	Volcanics of Area 20 Wahmonie Formation (Lava-flow aquifers)	Calico Hills Formation (Upper Volcanic Confining unit)	Rhyolite lavas, volcanic breccias, nonwelded to welded tuffs, commonly argillaceous or zeolitic	1.0

Table 9.3-11. Site Saturated Zone Hydrogeologic Units, Equivalent Units, and Associated Lithologies in the Vicinity of Yucca Mountain (Continued)

Hydrogeologic Unit (Age) ^a	Model Unit Number (Parameter Name)	Equivalent Unit			Lithology	Data-Availability Rating ^b
		Winograd and Thordarson (1975)	Laczniak et al. (1996)	Luckey et al. (1996)		
Middle volcanic aquifer (T)–Prow Pass, Bullfrog, Tram Tuff units	13, 14, 12 (mva)	Grouse Canyon Member Tuff of Crater Flat (Tuff aquitard)	Crater Flat Group Belled Range Group (Welded-tuff and lava-flow aquifers)	Crater Flat Group (Lower Volcanic Aquifer)	Variably welded ash-flow tuffs and rhyolite lavas	0.8, 0.8, 0.8
Middle volcanic confining unit (T) ^c	11 (mvcu)	Local informal units of Indian Trail Formation (Tuff aquitard)	Tunnel Formation (Tuff confining unit)	Flow Breccia Lithic Ridge Tuff (Lower Volcanic Confining Unit)	Nonwelded tuff, commonly zeolitized	0.8
Older volcanic aquifer (T)	10 (lva)	Tub Spring Member (Tuff aquitard)	Volcanics of Big Dome (Lava-flow and welded-tuff aquifer)	–	Variably welded ash-flow tuffs, rhyolite lavas	0.1
Older volcanic confining unit (T)	9 (lvcu)	?(Tuff aquitard)	Older Volcanics (Tuff confining unit)	–	Nonwelded tuff, commonly zeolitized	0.1
Undifferentiated valley fill (T)	8 (lcv)	Rocks of Pavits Spring Horse Spring Formation (Tuff aquitard)	Pavits Spring Formation Horse Spring Formation Paleocolluvium	–	Tuffaceous sandstone, tuff breccia, siltstone, claystone, conglomerate, lacustrine limestone, commonly argillaceous or calcareous. Sedimentary breccia.	5.0
Upper carbonate aquifer (Pz)	7 (uca)	Tippipah Limestone (Upper carbonate aquifer)	Bird Spring Formation (Upper carbonate aquifer)	–	Limestone	0.3
Upper clastic confining unit (Pz)	5 (ecu)	Eleana Formation (Upper clastic aquitard)	Eleana Formation (Eleana confining unit)	–	Siliceous siltstone, sandstone, quartzite, conglomerate, limestone	0.5

Table 9.3-11. Site Saturated Zone Hydrogeologic Units, Equivalent Units, and Associated Lithologies in the Vicinity of Yucca Mountain (Continued)

Hydrogeologic Unit (Age) ^a	Model Unit Number (Parameter Name)	Equivalent Unit			Lithology	Data-Availability Rating ^b
		Winograd and Thordarson (1975)	Laczniak et al. (1996)	Luckey et al. (1996)		
Lower carbonate aquifer (Pz)	4, 6 (thrust) (lca)	Devils Gate Limestone Nevada Formation Ely Springs Dolomite Eureka Quartzite Pogonip Group Nopah Formation Dunderberg Shale Bonanza King Upper Carrara Formation (Lower carbonate aquifer)	Guilmette Formation Simonson Dolomite Sevy, Laketown, and Lone Mountain Dolomite Roberts Mountain Formation Dolomite of the Spotted Range Ely Springs Dolomite Eureka Quartzite Pogonip Group Nopah Formation Bonanza King Formation Upper Carrara Formation (Lower carbonate aquifer)	Lone Mt. Dolomite Roberts Mt. Dolomite (Carbonate Aquifer)	Dolomite and limestone, locally cherty and silty	0.5
Lower clastic confining unit (Pz, pC)	3 (qcu)	Lower Carrara Formation Zabriskie Quartzite Wood Canyon Formation Stirling Quartzite Johnnie Formation (Lower clastic aquitard)	Lower Carrara Formation Zabriskie Quartzite Wood Canyon Formation Stirling Quartzite Johnnie Formation Noonday (?) Dolomite (Quartzite confining unit)	—	Quartzite, siltstone, shale, dolomite	0.8

Table 9.3-11. Site Saturated Zone Hydrogeologic Units, Equivalent Units, and Associated Lithologies in the Vicinity of Yucca Mountain (Continued)

Hydrogeologic Unit (Age) ^a	Model Unit Number (Parameter Name)	Equivalent Unit			Lithology	Data-Availability Rating ^b
		Winograd and Thordarson (1975)	Laczniak et al. (1996)	Luckey et al. (1996)		
Granitic confining unit (T)	2 (gran)	Granitic Stocks (A minor aquitard)	Granite	—	Granodiorite and quartz monzonite in stocks, dikes and sills	0.1

Source: CRWMS M&O (2000b, Table 6-1)b

NOTE: — = no units identified; hydrologic names listed in parentheses;

^aQ = Quaternary; T = Tertiary; Pz = Paleozoic; pC = Precambrian;

^bData-availability rating: 0.1 = poor; 10.0 = excellent

Table 9.3-12. Correlation of Reference Information Base and Integrated Site Model Version 3.1 to Hydrogeologic Units

Site Saturated Zone Hydrogeologic Unit	Geologic/Lithologic Stratigraphy (Reference Information Base Item 1.1.2.1)						ISM3.1
	Definition/Buesch, Spengler et al. (1996)	Group	Formation	Member	Zone	Subzone	
Valley-Fill Aquifer							Alluvium
Valley-Fill Confining Unit							
Limestone Aquifer							
Lava-Flow Aquifer							
Upper Volcanic Aquifer	Timber Mountain Group	tm	Tmr				44tpk
Upper Volcanic Aquifer	Rainier Mesa Tuff	Tp					
Upper Volcanic Aquifer	Paintbrush Group						
Upper Volcanic Aquifer	Post-tuff unit "x" bedded tuff			Tpbt6			
Upper Volcanic Aquifer	Tuff unit "x"			Tpki (informal)			44tpk
Upper Volcanic Aquifer	Pre-tuff unit "x" bedded tuff			Tpbt5			44tpc
Upper Volcanic Aquifer	Tiva Canyon Tuff		Tpc				Tiva and post-Tiva
Upper Volcanic Aquifer	Crystal Rich Member			Tpcr			
Upper Volcanic Aquifer	Vitric zone				Tpcrv		
Upper Volcanic Aquifer	Nonwelded subzone					Tpcrv3	
Upper Volcanic Aquifer	Moderately welded subzone					Tpcrv2	
Upper Volcanic Aquifer	Densely welded subzone					Tpcrv1	
Upper Volcanic Aquifer	Nonlithophysal zone				Tpcm		
Upper Volcanic Aquifer	Subvitrophyre transition subzone					Tpcrn4	
Upper Volcanic Aquifer	Pumice poor subzone					Tpcrn3	
Upper Volcanic Aquifer	Mixed pumice subzone					Tpcm2	
Upper Volcanic Aquifer	Crystal transition subzone (not always present)					Tpcm1	
Upper Volcanic Aquifer	Lithophysal zone				Tpcr1		
Upper Volcanic Aquifer	Crystal transition subzone (not always present)					Tpcr1	
Upper Volcanic Aquifer	Crystal-poor Member			Tpcp			
Upper Volcanic Aquifer	Upper lithophysal zone				Tpcpul		
Upper Volcanic Aquifer	Spherulite-rich subzone					Tpcpul1	
Upper Volcanic Aquifer	Middle nonlithophysal zone				Tpcpm		Tpcp
Upper Volcanic Aquifer	Upper subzone						Tpcpmn3
Upper Volcanic Aquifer	Lithophysal subzone						Tpcplnn2
Upper Volcanic Aquifer	Lower subzone						Tpcpmn1
Upper Volcanic Aquifer	Lower lithophysal zone				Tpcpl1		

Table 9.3-12. Correlation of Reference Information Base and Integrated Site Model Version 3.1 to Hydrogeologic Units (Continued)

Site Saturated Zone Hydrogeologic Unit	Geologic/Lithologic Stratigraphy (Reference Information Base Item 1.1.2.1)						ISM3.1		
	Definition/Buesch, Spengler et al. (1996)	Group	Formation	Member	Zone	Subzone			
Upper Volcanic Aquifer	Hackly-fractured subzone				Tpcpln	Tpcpllh			
Upper Volcanic Aquifer	Lower nonlithophysal zone								
Upper Volcanic Aquifer	Hackly subzone					Tpcplnh			
Upper Volcanic Aquifer	Columnar subzone					Tpcplnc			
Upper Volcanic Aquifer	Vitric zone				Tpcpv				
Upper Volcanic Aquifer	Densely welded subzone					Tpcpv3	Tpcpv3		
Upper Volcanic Aquifer	Moderately welded subzone					Tpcpv2	Tpcpv2		
Upper Volcanic Aquifer	Nonwelded subzone					Tpcpv1	Tpcpv1		
Upper Volcanic Aquifer	Pre-Tiva Canyon bedded tuff			Tpbt4			Tpbt4		
Upper Volcanic Aquifer	Yucca Mountain Tuff		Tpy				Tpy		
Upper Volcanic Aquifer	Pre-Yucca Mountain bedded tuff			Tpbt3			Tpbt3		
Upper Volcanic Aquifer	Pah Canyon Tuff	Tpp		Tpbt2			Tpp Tpbt2		
Upper Volcanic Aquifer	Pre-Pah Canyon bedded tuff								
Upper Volcanic Aquifer	Topopah Spring Tuff	Tpt		Tptr	Tptrv				
Upper Volcanic Aquifer	Crystal-Rich Member								
Upper Volcanic Aquifer	Vitric zone								
Upper Volcanic Aquifer	Nonwelded subzone					Tptrv3	44tptprv23		
Upper Volcanic Aquifer	Moderately welded subzone					Tptrv2	44tptprv23		
Upper Volcanic Aquifer	Densely welded subzone				Tptrn	Tptrv1	44tptprv1		
Upper Volcanic Aquifer	Nonlithophysal zone								
Upper Volcanic Aquifer	Dense subzone					Tptm3			
Upper Volcanic Aquifer	Vapor-phase corroded subzone					Tptrn2			
Upper Volcanic Aquifer	Crystal transition subzone (not always present)					Tptrn1			
Upper Volcanic Aquifer	Lithophysal zone				Tptrl				
Upper Volcanic Aquifer	Crystal transition subzone (not always present)					Tptrl1		44tptr1	
Upper Volcanic Aquifer	Crystal-Poor Member								
Upper Volcanic Aquifer	Lithic-rich zone								
Upper Volcanic Aquifer	Upper lithophysal zone				Tptp Tptpf or Tptrf		Tptpul Tptpmn		44tptpul 44tptpmn
Upper Volcanic Aquifer	Middle nonlithophysal zone								
Upper Volcanic Aquifer	Nonlithophysal subzone								
Upper Volcanic Aquifer									
Upper Volcanic Aquifer								Tptpmn3	

Table 9.3-12. Correlation of Reference Information Base and Integrated Site Model Version 3.1 to Hydrogeologic Units (Continued)

Site Saturated Zone Hydrogeologic Unit	Geologic/Lithologic Stratigraphy (Reference Information Base Item 1.1.2.1)						ISM3.1
	Definition/Buesch, Spengler et al. (1996)	Group	Formation	Member	Zone	Subzone	
Middle Volcanic Aquifer	Lava and flow breccia (informal)			T113			
Middle Volcanic Aquifer	Bedded tuff			T113bt			
Middle Volcanic Aquifer	Older tuffs (informal)			Tt			
Middle Volcanic Aquifer	Unit a (informal)			Tta			
Middle Volcanic Aquifer	Unit b (informal)			Ttb			
Middle Volcanic Aquifer	Unit c (informal)			Ttc			
Middle Volcanic Aquifer	Sedimentary rocks and calcified tuff (informal)			Tca			
Middle Volcanic Aquifer	Tuff of Yucca Flat (informal)			Tyf			
Middle Volcanic Confining Unit							
Lower Volcanic Aquifer							
Lower Volcanic Confining Unit							
Undifferentiated Valley Fill							
Upper Carbonate Aquifer							
Upper Clastic Confining Unit							
Lower Carbonate Aquifer	Lone Mountain Dolomite		Sim				paleozoic Grav (not used)
Lower Carbonate Aquifer	Roberts Mountain Formation		Sim				paleozoic Grav (not used)
Lower Clastic Confining Unit							
Granitic Confining Unit							

Table 9.3-13. Calibration Parameters Used in Saturated Zone Site-Scale Model

Parameter Name	Geologic Unit or Feature	Calibrated Value	Parameter Type	Minimum Value	Maximum Value
gran	Granites	1.96×10^{-16}	Permeability	1.00×10^{-17}	1.00×10^{-14}
lcla	Lower Clastic Confining Unit	1.00×10^{-16}	Permeability	1.00×10^{-16}	1.00×10^{-14}
lca2	Lower Carbonate Aquifer	5.00×10^{-14}	Permeability	5.00×10^{-14}	1.00×10^{-12}
ucla	Upper Clastic Confining Unit	1.00×10^{-16}	Permeability	1.00×10^{-16}	1.00×10^{-14}
lca1	Lower Carbonate Aquifer Thrust	1.00×10^{-14}	Permeability	1.00×10^{-14}	1.00×10^{-12}
ucar	Upper Carbonate Aquifer	4.08×10^{-14}	Permeability (fixed)	4.08×10^{-14}	4.08×10^{-14}
udif	Undifferentiated Valley Fill	5.00×10^{-15}	Permeability	5.00×10^{-15}	1.00×10^{-12}
ovoc	Older Volcanic Confining Unit	2.00×10^{-16}	Permeability	2.00×10^{-16}	1.00×10^{-11}
ovoa	Older Volcanic Aquifer	5.00×10^{-16}	Permeability	3.00×10^{-16}	1.00×10^{-12}
lvoc	Lower Volcanic Confining Unit	2.00×10^{-15}	Permeability	1.00×10^{-15}	1.00×10^{-11}
tram	Crater Flat-Tram	2.36×10^{-13}	Permeability	1.00×10^{-13}	1.00×10^{-11}
bull	Crater Flat-Bullfrog	1.54×10^{-11}	Permeability	1.00×10^{-13}	8.00×10^{-11}
prow	Crater Flat-Prow Pass	8.00×10^{-12}	Permeability	1.00×10^{-13}	5.00×10^{-11}
uvoc	Upper Volcanic Confining Unit	5.00×10^{-14}	Permeability	4.00×10^{-14}	1.00×10^{-12}
uvoa	Upper Volcanic Aquifer	8.00×10^{-14}	Permeability	8.00×10^{-14}	1.00×10^{-11}
lava	Lava Flow Aquifer	1.00×10^{-12}	Permeability	1.00×10^{-16}	2.00×10^{-12}
lime	Limestone Aquifer	1.00×10^{-12}	Permeability	1.00×10^{-15}	1.00×10^{-11}
vala	Valley Fill Aquifer	5.00×10^{-12}	Permeability	1.00×10^{-13}	8.00×10^{-12}
ewba	East-West Barrier	1.05×10^{-18}	Permeability	1.00×10^{-18}	1.00×10^{-15}
nsba	Solitario Canyon Fault	1.00×10^{-18}	Permeability	1.00×10^{-18}	1.00×10^{-15}
fpb1	Fortymile Wash Fault	10	multiplier	2	100
fpb2	Spotted Range-Mine Mountain Zone	11.7789	Multiplier	1	70
fpb3	Northern Low Perm Zone	7.11×10^{-2}	Multiplier	1.00×10^{-5}	0.5
fpb4	Imbricate Fault Zone	1	Multiplier	1	100
cffz	Crater Flat Fault	5.00×10^{-14}	Permeability	1.00×10^{-15}	5.00×10^{-13}
allu	Alluvial Uncertainty Zone	3.20×10^{-12}	Permeability	1.00×10^{-13}	1.00×10^{-11}
wash	Lower Fortymile Wash Zone	5.00×10^{-12}	Permeability	1.00×10^{-14}	8.00×10^{-12}

Source: CRWMS M&O (2000c, Table 8)

Table 9.4-1. Summary of Previous Water Table Rises Estimated by Various Investigators Based on Available Field Evidence

Investigator	Information Source	Estimated Water Table Rise
Bish and Vaniman 1985	Vitric material within nonwelded tuffs	< 100 m (330 ft)
Levy 1991	Zeolitization depths in Yucca Mountain boreholes	< 60 m (200 ft)
Paces et al. 1993	Lathrop Wells Diatomites	80 to 115 m (262 to 312 ft)
Marshall et al. 1993	Strontium isotopic evidence from calcites in unsaturated zone volcanics	< 85 m (280 ft)
Szabo et al. 1994	Petrographic and morphological differences between calcite deposits in Browns Room, Devils Hole	Up to 9 m (30 ft)
Spaulding 1994; Spaulding 1997	Presence of ancient pack-rat middens (FMC-7) in northern Fortymile Canyon	30 to 80 m (98 to 262 ft)
Quade 1994; Quade et al. 1995	Analysis of $^{234}\text{U}/^{238}\text{U}$ activity ratios for samples from Lathrop Wells Diatomites	< 115 m (377 ft)
Forester et al. 1996	Isotopic evidence from fracture and cavity-filling paleospring deposits in volcanic rocks in Yucca Mountain area and southern Nevada	Up to 100 to 120 m (330 to 394 ft) during last two glacial cycles

Table 9.4-2. Amounts of Water Table Rise Predicted by Groundwater Modeling Simulations

Investigator	Model Description	Estimated Water Table Rise
Czarnecki 1984	Yucca Mountain regional finite-element groundwater flow model: Simulated effect of doubling precipitation (15-fold increase in recharge) over Yucca Mountain region	< 130 m (426 ft)
Ahola and Sagar 1992	Yucca Mountain (uncalibrated) regional finite-element groundwater flow model: Simulated effect of a 10-fold increase in recharge in Yucca Mountain area and in Fortymile Wash)	75 to 100 m (246 to 330 ft)
D'Agnese et al. 1999	Death Valley regional steady-state groundwater flow model: Evaluated past, full-glacial climate (21,000 ka) condition	60 to 150 m (197 to 492 ft)
D'Agnese et al. 1999	Death Valley regional steady-state groundwater flow model: Evaluated future, global-warming climate condition	< 50 m (164 ft)

Table 9.4-3. Amounts of Water Table Rise Predicted by Hydrotectonic Modeling Simulations

Investigator	Model Description	Estimated Water Table Rise
Carrigan et al. 1991	Fault-patch strain concentration model: Magnitude 6.5 earthquake Magnitude 8 earthquake	< 8 m (26 ft) < 17 m (56 ft)
Cook and Kemeny 1991	Regional stress change model: 7 percent unsaturated zone porosity assumed	< 10 m (33 ft)
National Research Council 1992	Regional stress change model (poro- elastic response model): 1 percent unsaturated zone porosity assumed	< 20 m (66 ft)
Bredehoeft 1992	Dislocation strain model: magnitude 6 earthquake	1 m (3 ft)
Davies and Archambeau 1997	Analytical model simulations/inferred crustal stress and permeability differences north and south of large hydraulic gradient: Magnitude 5.5 to 6 earthquake on Bow Ridge fault Magnitude ≥ 6 earthquake along a 15-km segment of the Bow Ridge fault	150 m (492 ft) 250 m (820 ft)

Table 9.5-1. Annual Groundwater Discharges from Wells UE-25 J-12 and UE-25 J-13 (1983 to 1997)

Well	Year	Annual Discharge (m ³)	Annual Discharge (a.-ft)
Well UE-25 J-12	1983	93,075	75.39
	1984	93,440	75.69
	1985	98,915	80.12
	1986	108,040	87.51
	1987	77,015	62.38
	1988	77,380	62.68
	1989	127,020	102.89
	1990	117,895	95.49
	1991	131,035	106.14
	1992	47,450	38.43
	1993	94,535	76.57
	1994	181,405	146.94
	1995	135,050	109.39
	1996	162,790	131.86
	1997	63,510	51.44
Well UE-25 J-13	1983	174,105	141.03
	1984	155,125	125.65
	1985	104,025	84.26
	1986	66,065	53.51
	1987	123,370	99.93
	1988	96,360	78.05
	1989	64,240	52.03
	1990	77,380	62.68
	1991	62,415	50.56
	1992	99,645	80.71
	1993	158,410	128.31
	1994	159,870	129.49
	1995	184,325	149.30
	1996	104,390	84.55
	1997	123,005	99.63

Source: Adapted from Tucci and Faunt (1999, Table 1)

Table 9.5-2. Annual Groundwater Withdrawals from Basin 227A (1961 to 1992)

Year	Annual Withdrawal (m ³)	Annual Withdrawal (a.-ft)
1961	113,580	92
1962	230,865	187
1963	691,359 ^a	560 ^a
1964	691,359 ^a	560 ^a
1965	691,359 ^a	560 ^a
1966	691,359 ^a	560 ^a
1967	691,359 ^a	560 ^a
1968	N/A	N/A
1969	N/A	N/A
1970	N/A	N/A
1971	N/A	N/A
1972	N/A	N/A
1973	N/A	N/A
1974	N/A	N/A
1975	N/A	N/A
1976	N/A	N/A
1977	N/A	N/A
1978	N/A	N/A
1979	N/A	N/A
1980	N/A	N/A
1981	140,741	114
1982	70,370	57
1983	267,902	217
1984	249,383	202
1985	202,469	164
1986	174,074	141
1987	200,000	162
1988	174,074	141
1989	191,358	155
1990	196,297	159
1991	193,827	157
1992	146,914	119

Source: Adapted from CRWMS M&O (2000e, Table 4.10)

NOTES: ^a Data represent annual average values, as reported by Young (1972).

N/A = not available

Table 9.5-3. Basin 227A (Including Jackass Flats) Pumping Summary (1993 to 1997)

Year	Wells (UE-25 J-12 + UE-25 J-13) m ³ /yr. (a.-ft/yr.)	C-hole Wells m ³ /yr. (a.-ft/yr.)	Total (UE-25 J-12 + UE-25 J-13 + C-hole Wells) m ³ /yr. (a.-ft/yr.)	YMP Pumpage m ³ /yr. (a.-ft/yr.)	Other Pumpage ^{a, b} m ³ /yr. (a.-ft/yr.)
1993	253,087 (205)	0	253,087 (205)	98,766 (80)	154,321 (125)
1994	341,976 (277)	0	341,976 (277)	93,827 (76 ^c)	249,383 (202)
1995	319,754 (259)	23,457 (19)	343,210 (278)	139,506 (113)	203,704 (165)
1996 ^d	306,173 (248)	227,161 (184)	533,334 (432)	309,877 (251)	223,457 (181)
1997	186,420 (151)	238,272 (193)	424,692 (344)	316,050 (256)	108,642 (88)
Average	281,482 (228)	97,450 (79)	379,013 (307)	191,358 (155)	187,655 (152)

Source: Adapted from CRWMS M&O (2000e, Table 4.11)

NOTES: ^a Other pumpage = (Total pumpage of wells UE-25 J-12 + UE-25 J-13 + C-hole Wells) – (Yucca Mountain Project pumpage)

^b Other pumpage is diverted for use on the Nevada Test Site.

^c Value includes 0.63 a.-ft pumpage from well USW VH-1 in Crater Flat.

^d The 1996 values in this table differ somewhat from the 1996 values presented in Table 9.5-1 because there are differences in values reported in their respective sources. However, this difference does not impact the conclusions presented in this section.

Table 9.5-4. Summary of U.S. Department of Energy Yucca Mountain Project Water Rights (Basins 227A and 229) (As of January 1999)

Permit Number	Source (Well Number)	Permitted Diversion m ³ /s (ft ³ /s)	Duty m ³ /yr. (a.-ft/yr.)	Proof of Completion (Filing Date)	Expiration Date	Use Category
57373	UE-25 J-12	0.000 (0.000)	0.00 (0.00)	Filed 12/7/92	4/9/2002	IND ^a
57374	UE-25 J-13	0.023 (0.800)	531,100 (430.19) ^b	Filed 12/7/92	4/9/2002	IND
57375	USW VH-1 ^c	0.028 (1.000)	75,778 (61.38)	Filed 12/7/92	4/9/1998	IND
57376	UE-25 J-13	0.005 (0.200)	117,074 (94.83)	Filed 12/7/92	4/9/2002	IND
58827	UE-25 #1	0.0255 (0.900)	531,100 (430.19) ^b	EOT ^d Filed 1/20/99	12/31/2000	IND
58828	UE-25 #3	0.0255 (0.900)	531,100 (430.19) ^b	Filed 3/8/96	12/31/2000	IND
58829	UE-25 #2	0.0255 (0.900)	531,100 (430.19) ^b	Filed 3/13/98	12/31/2000	IND

Source: Adapted from CRWMS M&O (2000e, Table 4.7)

NOTES: ^a IND = industrial

^b Total combined duty under all these permits shall not exceed 531,100 m³/yr (430.19 a.-ft/yr.).

^c USW VH-1 is located in Basin 229 (Crater Flat); all other wells are located in Basin 227A.

^d EOT = extension of time

Table 9.5-5. Summary of Existing Nonfederal Water Rights in Basin 227A

Application Number	Certificated (A) m ³ /yr. (a.-ft/yr.)	Duty Permit (B) m ³ /yr. (a.-ft/yr.)	Total (A+B) m ³ /yr. (a.-ft/yr.)	Use Category	Location	Owner or Responsible Entity
18528	30,839 (24.98)	0.00 (0.00)	30,839 (24.98)	COM ^a	N/A	N/A
60705	0.00 (0.00)	16,901 (13.69)	16,901 (13.69)	COM ^a	N/A	N/A
21593	19,926 (16.14)	0.00 (0.00)	19,926 (16.14)	DOM ^b	SW ¼ SW ¼ Sec 18, T15S, R50E	NDOT ^c
11141	6,975 (5.65)	0.00 (0.00)	6,975 (5.65)	Stock Water	N/A	N/A
12729	14,284 (11.57)	0.00 (0.00)	14,284 (11.57)	Stock Water	N/A	N/A
Total	72,025 (58.34)	16,901 (13.69)	88,926 (72.03)	DOM ^b	N/A	N/A

Source: Adapted from Thiel Engineering Consultants (1999, pp. 21, 22)

NOTES: ^aCOM = commercial

^bDOM = domestic

^cNDOT = Nevada Department of Transportation (Underground)

N/A = not available or not applicable

Table 9.5-6. Summary of Recent U.S. Department of Energy Water Rights Applications

Recent Application Number	Source (Well Number)	Previous Application Number	Requested Diversion Rate m ³ /s (ft ³ /s)	Requested Duty m ³ /yr. (a.-ft/yr.)
63263	UE-25 J-13	57374	0.028 (1.0) ^a	530,865 (430) ^b
	UE-25 J-13	57376		
63264	UE-25 J-12	57373	0.028 (1.0) ^a	530,865 (430) ^b
63265	UE-25#1	58827	0.0255 (0.9) ^a	530,865 (430) ^b
63266	UE-25#2	58829	0.0255 (0.9) ^a	530,865 (430) ^b
63267	UE-25#3	58828	0.0255 (0.9) ^a	530,865 (430) ^b

Source: Adapted from CRWMS M&O (2000e, Table 4.8)

NOTE: ^aThe total requested duty for each well shall not exceed 530,865 m³/yr. (430 a.-ft/yr.).

^bThe total annual duty requested for all five wells combined, including the duty for well USW VH-1, is 530,865 m³/yr. (430 a.-ft/yr.).