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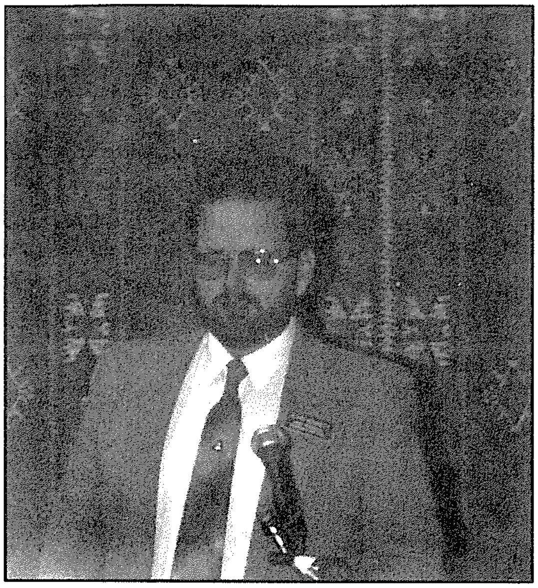


Aquifer Sensitivity Assessment for the Mesilla Valley

ABSTRACT

The potential for groundwater contamination has become an issue of great concern to the public and private sectors in recent years. One possible threat to groundwater is the nonpoint source pollution from pesticides. The pollution threat could be minimized by modeling the natural sensitivity of the groundwater basins and identifying Best Management Practices (BMPs) for agricultural source areas that could reduce potential threats. Numerous methods for modeling natural sensitivity and for identifying BMPs have been proposed and used. These methods include field-scale deterministic models, such as the Irrigation Scheduling Model (IRRSCH), that predict the rate of migration and fate of specific chemicals, and regional models that attempt to show general trends of groundwater vulnerability to contamination (Soller, 1992).

To address the regional groundwater vulnerability, a model such as DRASTIC is used in the assessment of the natural sensitivity. The DRASTIC model consists of seven factors that make the acronym "DRASTIC" (Soller 1992; USEPA 1992). The factors, their abbreviations, and data sources are: "D" for depth to water, "R" for net recharge, "A" for aquifer media, "S" for soil media, "T" for topography, "I" for impact of the vadose zone media, and "C" for hydraulic conductivity of the aquifer.

Information for depth to groundwater is obtained from the U.S. Geological Survey Groundwater Site Inventory (GWSI) Database conducted in the state of New Mexico to monitor the depth to groundwater. Information is available for all areas of the state with some areas more intensively monitored than others. The information is in digital form and easily converted into a GIS coverage of polygons representing areas of similar depths from land surface to the groundwater table.

In semiarid regions where irrigation is required for crop production the net recharge "R" in DRASTIC requires modification. This is accomplished by incorporating an estimate of the percolation below the root zone of water applied by artificial means plus the portion of precipitation that is percolated below the crop or other vegetation root zone. This requires monthly precipitation information in a spatial form as well as information to distinguish between areas irrigated and not irrigated. Land use information developed by EPA, areal photography, and other coverages are utilized to develop a coverage of irrigated and nonirrigated areas. Natural recharge is added to the artificial recharge value to arrive at total net recharge.

Information for aquifer media is developed from the descriptive information contained in geologic mapping investigations available statewide and supplemented with more intensive information when available in specific areas, such as hydrologic investigation reports and borehole reports.

The soil coverage is obtained from digital soil survey coverages being made available by the U.S. Natural Resources Conservation Service (NRCS) for various areas of the state.

For topography, the U.S. Geological Survey Digital Elevation Model (DEM) files are obtained for the area in question and processed into a polygon coverage representing areas with similar surface slope.

The impact of the vadose zone media is obtained by using the soil survey descriptive information for the soil horizon below the normal root zone. This is being made available from the NRCS for various areas of the state.

The hydraulic conductivity of the aquifer is obtained from hydrologic investigation reports, hydrology modeling efforts, and other studies available for the area in question.

Each of the DRASTIC factors, or combination thereof, can be displayed either as a paper map or in a Geographic Information System (GIS). The natural sensitivity of the area to nonpoint source pollution from nutrients and pesticides then can be modeled by combining the DRASTIC factors and the IRRSCH scaling factor into a GIS. This information then is manipulated to produce a Spatial Information Product (SIP) that displays areas that have a higher potential for contamination. The resulting GIS is then used for developing objective guidelines and management strategies for minimizing agricultural impact on groundwater pollution.

INTRODUCTION

The U.S. Environmental Protection Agency (EPA) has been concerned about groundwater contamination by pesticides in parts of the United States, mainly New York and Florida. The EPA has issued guidelines requiring states to develop strategies for management of pesticides to insure that groundwater would not be contaminated. States not adhering to the guidelines could potentially lose the use of these chemicals thereby creating a negative economic impact on agriculture. Because New Mexico is small-time in terms of pesticide use compared to many other states, pesticide companies would not likely absorb the cost of obtaining registration for restricted chemicals for use in New Mexico without a state pesticide management strategy in place.

This project began in cooperation with the New Mexico Department of Agriculture (NMDA). NMDA is the state regulatory agency for pesticides in New Mexico. NMDA's pesticide program has two goals: 1) insure that pesticide use in the state will not contaminate the groundwater; and 2) try to insure that New Mexico agriculture would not suffer because of loss of important pesticides. To meet these goals, the NMDA developed a strategy that would: 1) assess the sensitivity of New Mexico groundwater to contamination by pesticides; 2) develop a monitoring strategy; and 3) develop a response strategy should there be detections.

Initially, the project was to evaluate groundwater sensitivity assessment techniques. A number of different models were reviewed and one particular model stood out as best meeting the needs of NMDA and EPA, and one that also could utilize the best available data. The project was supported by NMDA, the New Mexico Water Resources Research Institute (WRRI), and a research grant from EPA. The Mesilla Valley (Figure 1) was chosen as the pilot study area for this project mainly because of its importance as an agricultural center in the area and its proximity to available data. The total study area is approximately 2,282 square kilometers.

GROUNDWATER AQUIFER SENSITIVITY ASSESSMENT

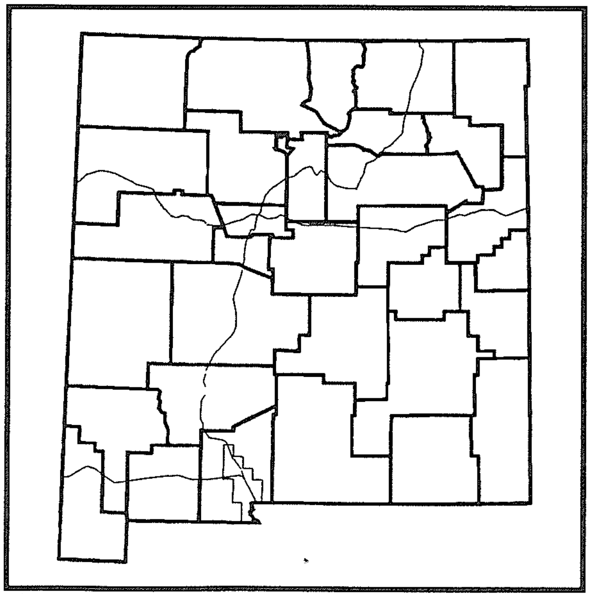


Figure 1. Pilot study area

Review of Assessment Techniques

The goal in selecting an assessment technique was to choose the most sophisticated technique (thereby allowing the incorporation of all relevant information), which could be utilized with existing and readily available data. Future maintenance and updating of data had to be considered as well as the level of expertise required to use the technique. Specifically, the model should: 1) accommodate regional areas as small as those represented by USGS 7.5 minute topological maps; 2) use readily available data; and 3) allow subsequent updates to be undertaken without high-level expertise. In September 1993, the EPA released *A Review of Methods for Assessing Aquifer Sensitivity and Groundwater Vulnerability to Pesticide Contamination* (USEPA 1993). It provides a comprehensive evaluation of numerous techniques and methods, each method reviewed in terms of information required, expertise level necessary, intended uses, and experiences of applications that had been performed. Based on this evaluation and local and state considerations of available information, technical expertise required, and need for future updating, the DRASTIC method was selected. This method was designed as a true aquifer sensitivity method and allowed for modification.

DRASTIC Model Modification

The DRASTIC model rates relative sensitivity of land units by integrating information on vadose zone geology, soils, recharge, hydraulic conductivity, slope, aquifer media, and depth to groundwater in determining a ranking of groundwater sensitivity. It was designed to allow flexibility so that the local hydrogeological setting and its parameters could be weighted appropriately. The hydrogeological setting is defined by the spatial representation of designated mappable units. The mappable units incorporate the major hydrogeological factors which affect and often control groundwater movement. Thus, the modifications to DRASTIC were incorporated in both the selection of and weighting of these factors.

Hydrologic Parameters and Data Acquisition

The hydrogeological factors are depth to the water table (D), net recharge to the aquifer (R), aquifer media (A), soil media (S), topography (T), impact of the vadose zone (I) and hydraulic conductivity of the aquifer (C). These factors, or parameters, comprise the acronym DRASTIC. Each parameter is described as follows.

Depth-to-Water Table (D)

Depth to water refers to the depth from the land surface to the surface of the saturated zone in an unconfined aquifer or to the top of the confined aquifer. The data for the depth-to-water parameter were derived from the USGS Ground-Water Site Inventory Database (GWSI). The database is maintained by the USGS and contains information for nearly all areas of the state. These groundwater sites (wells) are selected for monitoring that provided an ability to acquire ongoing information, where the well's construction information was known, and that provided a good spatial dispersion. Well monitoring is performed by USGS staff and cooperators assuring quality information. The GWSI database includes local well identification numbers; latitude and longitude locations for each well; well construction information such as depth of well, diameter, casing, date of construction, aquifer code, and others; depth to the water table; and date of each measurement. Most sites are measured annually with selected sites measured more frequently. Elephant Butte Irrigation District (EBID) provides monthly water-level data to GWSI for 41 wells in the Mesilla Valley.

The information was extracted from the state USGS computer site with the assistance of USGS personnel by defining the area desired and the GWSI parameters to be included in the selection. The resulting file was transferred from the USGS computer to the WRRI computer. The file was imported into database file (dbf) format and was further manipulated.

For the depth-to-water table parameter, the latitude and longitude coordinates, and the depths to water for water wells in the Mesilla Valley and surrounding area including northwest El Paso County, Texas were used to create a water depth contour map. This database contained 797 observation sites with 10,204 depth-to-water table measurements. The measurements' dates spanned the period from the mid-1950s through 1994 with most sites being measured annually and selected sites measured more frequently. To develop a GIS coverage that represented the parameter, a single measurement for each site was selected. A selection was made from the database of sites having measurements within the last five-year period (January 1, 1990-December 31, 1994). This resulted in 242 sites. The most recent measurement was selected from this set. The water depth ranged from less than 5 feet to greater than 300 feet (Wilkins and Garcia 1995).

The site locations (latitude and longitude) were converted to decimal degrees. The database was then imported into ARC/INFO format and projected from the Geographic Coordinate System to the Universal Transverse Mercator coordinate system. To ensure sufficient data points throughout the study area, additional information from the Texas well database provided by the Texas Water Development Board was incorporated.

To develop the depth-to-water contour coverage, the geostatistical technique of kriging was used. Kriging is a commonly used statistical technique to estimate the regional distribution of model values based upon scattered data points or measurements (Davis 1986). The Gaussian semivariogram kriging model was utilized since it best represented the data. The next step was to create a polygon coverage (latticepoly) that represented areas of water-level depths based on attribute values. The depth-to-water table interval range, and the DRASTIC rating, weight, and resulting index are listed in Table 1.

Net Recharge (R)

The primary source of groundwater is precipitation and seepage from losing streams that infiltrate through the unsaturated zone to the water table. Net recharge indicates the amount of water per unit area of land which penetrates the ground surface and reaches the water table. The Mesilla Valley lies within an arid region where evapotranspiration exceeds regional precipitation. Therefore, the only significant potential recharge to the aquifer is through deep percolation resulting from agricultural irrigation, and infiltration from losing-water bodies such as the Rio Grande, irrigation canals and drains.

To depict this recharge parameter, it was necessary to separate agricultural areas from nonagricultural areas. This was accomplished by using two digital land use maps (El Paso and Las Cruces quads of the scale 1:250,000) for the geographic area. These digital land use maps were acquired from the USEPA over the internet. Level 1 land use codes (Anderson et al. 1976) were utilized to classify the maps (Table 2). Potential net recharge for nonirrigated land is considered to be between zero and 2 inches per unit area (Frenzel and Kaehler 1990). Potential net recharge of irrigated land and water bodies is considered to be in excess of 10 inches per unit area (Frenzel and Kaehler 1990). All agricultural land in the area receives irrigation water for successful crop production. Urban and built-up areas, rangeland, and barren land were assigned a rating of 1. Agricultural areas, water bodies, and wetlands were assigned a rating of 9. This digital map was clipped to match the project study area and to provide the coverage for the net recharge parameter.

Table 1. Depth-to-water table parameter rating (Dr), weight (Dw), and index (D)

Range[1] (feet)	Rating[1] (Dr)	Weight[2] (Dw)	Index (D)
0-5	10	5	50
5-10	9	5	45
10-20	8	5	40
20-30	7	5	35
30-50	5	5	25
50-70	3	5	15
70-100	2	5	10
100+	1	5	5

[1] Modified for local conditions from Aller et al. 1985, Table 4.
[2] From Aller et al. 1985, Table 3.

Table 2. Net recharge parameter rating (Rr), weight (Rw), and index (R)

Land Use Code[1]	Land Use[1]	Rating (Rr)[2]	Weight (Rw)[3]	Index (R)
1	Urban or Built-Up Land	1	4	4
2	Agricultural Land	9	4	36
3	Rangeland	1	4	4
4	Forest Land	1	4	4
5	Water	9	4	36
6	Wetland	9	4	36
7	Barren Land	1	4	4

[1] USGS land use and land cover classification system for use with remote sensor data (modified from Anderson et al. 1976).
[2] Modified for local conditions from Aller et al. 1985, Table 5.
[3] From Aller et al. 1985, Table 3.

Aquifer Media (A)

The shallow aquifer system in the Mesilla Valley is made up of the saturated part of the inner-valley fill, and channel sands and gravels in underlying beds of the Camp Rice Formation (Strain 1966) of the Upper Santa Fe Group (Hawley et al. 1969; Seager et al. 1971, 1976, 1982, 1987; Hawley 1975, 1978; Gile et al. 1981; Gustavson 1991) that were deposited by an ancestral Rio Grande during the mid- to late-Pliocene interval of basin filling.

The Santa Fe Group and the Rio Grande floodplain alluvium constitute the major aquifer for the valley and together are referred to as the "basin-fill deposits" in the USGS Open File Report 88-305 (Frenzel and Kaehler 1990). The stratigraphy, lithology, and geologic history of the Santa Fe Group and younger units were described by Hawley and others (1969), Seager and others (1971), Hawley (1975), Lovejoy and Hawley (1978), and Seager and others (1984). The basin-fill primarily consists of sands and gravels, with intermittent over-bank clay deposits.

To depict the aquifer media parameter, the 1:500,000 scale 1993 surface geology digital map (Dane and Bachman 1965) was clipped to match the project study area and reclassified to differentiate between the unconsolidated alluvium (Qal), basin-fill deposits (Qab), basalt flows (Qb) and cones, the Santa Fe Group (QTs), and the generally consolidated bedrock of the pre-Santa Fe Group. The alluvium is composed primarily of floodplain deposits consisting of channelized sands and gravels, with intermittent over-bank clay deposits. The basin-fill deposits consist of thin discontinuous cover of alluvial sands, gravels, and clays; eolian sands; and lucustrine deposits that overlie the Santa Fe Group. The basalt flows and cones generally postdate the Santa Fe Group and are limited in areal extent. The Santa Fe Group consists of unconsolidated to moderately consolidated sedimentary deposits, minor ash-fall volcaniclastics, and some volcanic rocks. The sedimentary deposits comprise lacustrine deposits of alternating layers of sand and clay; alluvial-fan deposits composed of sand, gravel, silt, and clay; and fluvial-facies composed of sand with lenses of gravel, silt, clay and sandy clay. The fluvial-facies are the most extensive deposits and contain most of the fresh water in the basin. These classes were assigned the DRASTIC ratings and weight listed in Table 3.

Soil Media (S)

In general, a soil's pollution potential is affected largely by the type and amount of clay present, the shrink/swell potential (controlling the development of macropores and other secondary permeability features), and the soil's grain size. The DRASTIC index includes soils ratings appropriate for the pollution potential associated with development of secondary permeability.

The data were acquired from the NRCS state office in Digital Line Graph (DLG) format (USGS 1990). The data received included database files that contained information concerning soil characteristics and an individual DLG file for each 1:24,000 (7.5 minute) quadrangle map for Doña Ana County.

The soil coverage was developed by NRCS using the GRASS mapping system. These files were then imported into ARC/INFO and modified so that the attribute database would contain the Map Unit Symbol and Map Unit Name for each soil series. Based on the soil characteristics of the Map Unit Symbol (soil classification contained in the Soil Survey of Doña Ana County Area, New Mexico 1980), values were assigned as specified by the DRASTIC model (Aller et al. 1985, p. 8-9). The selection of a value for the parameter was based on the most restrictive soil zone that occurred in the profile. The DRASTIC values for the parameter were then attached to the database. Table 4 contains the soil media and DRASTIC rating, weight and resulting index.

Table 3. Aquifer media parameter rating (Ar), weight (Aw) and index (A)

Ptype[1]	Aquifer media[1]	Rating (Ar)[1]	Weight (Aw)[2]	Index (A)
Qab	Sand and gravel w/silt and clay	6	3	18
Qal	Sand and gravel w/silt and clay	6	3	18
Qb	Basalt	9	3	27
QTs	Sand and gravel w/silt and clay	6	3	18
pQTs	pre-Santa Fe Group rocks	4	3	12

[1] Modified for local conditions from Aller et al. 1985, Table 6.
[2] From Aller et al. 1985, Table 3.

Table 4. Soil media parameter rating (Sr), weight (Sw) and index (S)

Soil Media[1]	Rating (Sr)[1]	Weight (Sw)[2]	Index (S)
Basalt	1	5	5
Caliche	1	5	5
Carbonate Hardpan	1	5	5
Carbonate-cemented	1	5	5
Clay	1	5	5
Clay Loam	3	5	15
Dumps	1	5	5
Gravel	10	5	50
Gravel Pit	1	5	5
Lime-coated Basalt	1	5	5
Limestone Bedrock	1	5	5
Loam	5	5	25
Loamy Sand	8	5	40
Rock Outcrop	1	5	5
Sand	9	5	45
Sandy Clay	2	5	10
Sandy Clay Loam	4	5	20
Sandy Loam	7	5	35
Silt	4	5	20
Silty Clay	2	5	10
Silty Loam	5	5	25
Thin or Absent	1	5	5
Water	10	5	50
Outside of Soil Survey	1	5	5

[1] Modified for local conditions from Aller et al. 1985, Table 7.

[2] From Aller et al. 1985, Table 3.

Topography (T)

The topography coverage was derived from USGS Digital Elevation Model (DEM) files obtained over the Internet. A DEM consists of an array of elevations for ground positions that are usually at regularly spaced intervals. The 1-degree DEM provides coverage in 1- by 1-degree blocks and is available for all of the contiguous United States, Hawaii, and most of Alaska. The basic elevation model is produced by the Defense Mapping Agency (DMA) using cartographic and photographic sources.

The 1-degree DEM consists of a regular array of elevations referenced horizontally on the geographic coordinate (latitude/longitude) system of the World Geodetic System 1984 Datum. Elevation data located on the degree lines (all four sides) correspond to the same profiles on adjoining DEM blocks. Elevations are in meters relative to mean sea level. Spacing of the elevations along and between each profile is at 3 arc-seconds with 1,201 elevations per profile.

The DEMs for the 1:250,000 scale Las Cruces and El Paso quads were acquired and imported into ARC/INFO using the function "demlattice." The two lattices were then merged into one large lattice that was then clipped by a coverage of the study area. The lattice coverage was then used to derive a polygon coverage that represented the slope (or topography) for the study area. The latticepoly command used a lookup table to assign codes to the range in slope. This code was then used to attach a DRASTIC parameters database to the coverage. The topography rating, weight, and index are listed in Table 5.

Table 5. Topography parameter rating (Tr), weight (Tw), and index (T)

Range (Percent Slope)	Rating (Tr)	Weight (Tw)[1]	Index (T)
0-2	10	3	30
2-6	9	3	27
6-12	5	3	15
12-18	3	3	9
18+	1	3	3

[1] From Aller et al. 1985, Table 3.

Impact of the Vadose Zone Media (I)

The lithology of the vadose zone is made up of the unsaturated part of the inner-valley fill, and channel sands and gravels in underlying beds of the Camp Rice Formation (Strain 1966) of the Upper Santa Fe Group (Hawley et al. 1969; Seager et al. 1971, 1976, 1982, 1987; Hawley 1975, 1978; Gile et al. 1981; Gustavson 1991) that were deposited by an ancestral Rio Grande during the mid to late Pliocene interval of basin filling. The vadose zone media ratings, weights and index are listed in Table 6.

Hydraulic Conductivity of the Aquifer (C)

The hydraulic conductivity coverage was derived from work that had been conducted for the City of Las Cruces Wellhead Protection Program (Hanson et al. 1994) and from the groundwater modeling work for the Mesilla Basin (Frenzel and Kaehler 1990). A digital file that contained spatial representation of areas with similar hydraulic conductivity was imported into ARC/INFO and modified.

The first modification of the file included assigning geographic control points so that the coverage could be rotated and projected into the UTM coordinate system. The second involved modifying the "K" values originally assigned to the polygons representing hydraulic conductivity. These values were multiplied by a conversion factor that would match the requirements for the hydraulic conductivity parameter for the DRASTIC model (Aller et al. 1985, p. 8-9). The DRASTIC values for the parameter were then attached to the attribute database for analysis. The original file contained the hydraulic conductivity values in K units. Table 7 contains the transformed values and the DRASTIC rating, weight, and index.

Table 6. Vadose zone media parameter rating (Ir), weight (Iw) and index (I)

Ptype[1]	Vadose Zone Media[1]	Rating (Ir)[1]	Weight (Iw)[2]	Index (I)
Qab	Sand and gravel w/silt and clay	6	4	24
Qal	Sand and gravel w/silt and clay	6	4	24
Qb	Basalt	9	4	36
QTs	Sand and gravel w/silt and clay	6	4	24
pQTs	Pre-Santa Fe group	4	4	16

[1] Modified for local conditions from Aller et al. 1985, Table 9.
[2] From Aller et al. 1985, Table 3.

Table 7. Hydraulic conductivity of the aquifer parameter rating (Cr), weight (Cw), and index (C) (gpd/ft²) = 7.48 * K (ft/day)

Zone	Hydraulic Conductivity[1] (ft/day)	Hydraulic Conductivity (gpd/ft²)	Rating (Cr)	Weight[2] (Cw)	Index (C)
K1	140.0	1047.20	5	2	10
K2	70.0	523.60	4	2	8
K3	22.0	164.56	2	2	4
K4	18.0	136.64	2	2	4
K5	11.0	82.28	1	2	2
K6	4.5	33.66	1	2	2
K7	0.0	0.00	1	2	2

[1] From Frenzel and Kaehler 1990, Fig. 20, p. 49

[2] From Aller et al. 1985, Table 3.

Combining DRASTIC Parameter Coverages

Data tables containing the index values and parameter ranges are joined to the feature attribute table for each parameter coverage based upon the range value classification. To aid in interpreting and evaluating the natural sensitivity assessment, a GIS layer was developed for each parameter.

The seven parameter coverages were combined together by geometric intersection of the polygon coverages. All polygons from the seven coverages were split at their intersections and preserved in the output coverage. The output coverage contained the combined polygons and feature attribute tables of all seven coverages. For each polygon the feature attribute table generated contained a field for each DRASTIC parameter index value and the area of each polygon. To obtain the final (combined) DRASTIC index values, a new field was created in the feature attribute table of the natural sensitivity (NATSEN) coverage. This NATSEN index was calculated by summing the DRASTIC parameters and placing the result in the field. The weights assigned for the purpose of combining the parameters are those recommended for an agricultural application of the model (Aller et al. 1985). Table 8 lists the weights for each of the DRASTIC parameters.

Additional analysis was performed to create a table that contained the combined DRASTIC values, frequency of occurrence, and the summation of the area for each value. Bar graphs of the combined DRASTIC value-frequency and DRASTIC value-area were created in order to assist in grouping the index values into ranges of sensitivities.

Table 8. Assigned weights for combining DRASTIC parameters (from Aller et al. 1985, Table 3)

DRASTIC parameter	Weight
Depth-to-water table	5
Net recharge	4
Aquifer media	3
Soil media	5
Topography	3
Impact of the vadose zone	4
Hydraulic conductivity	2

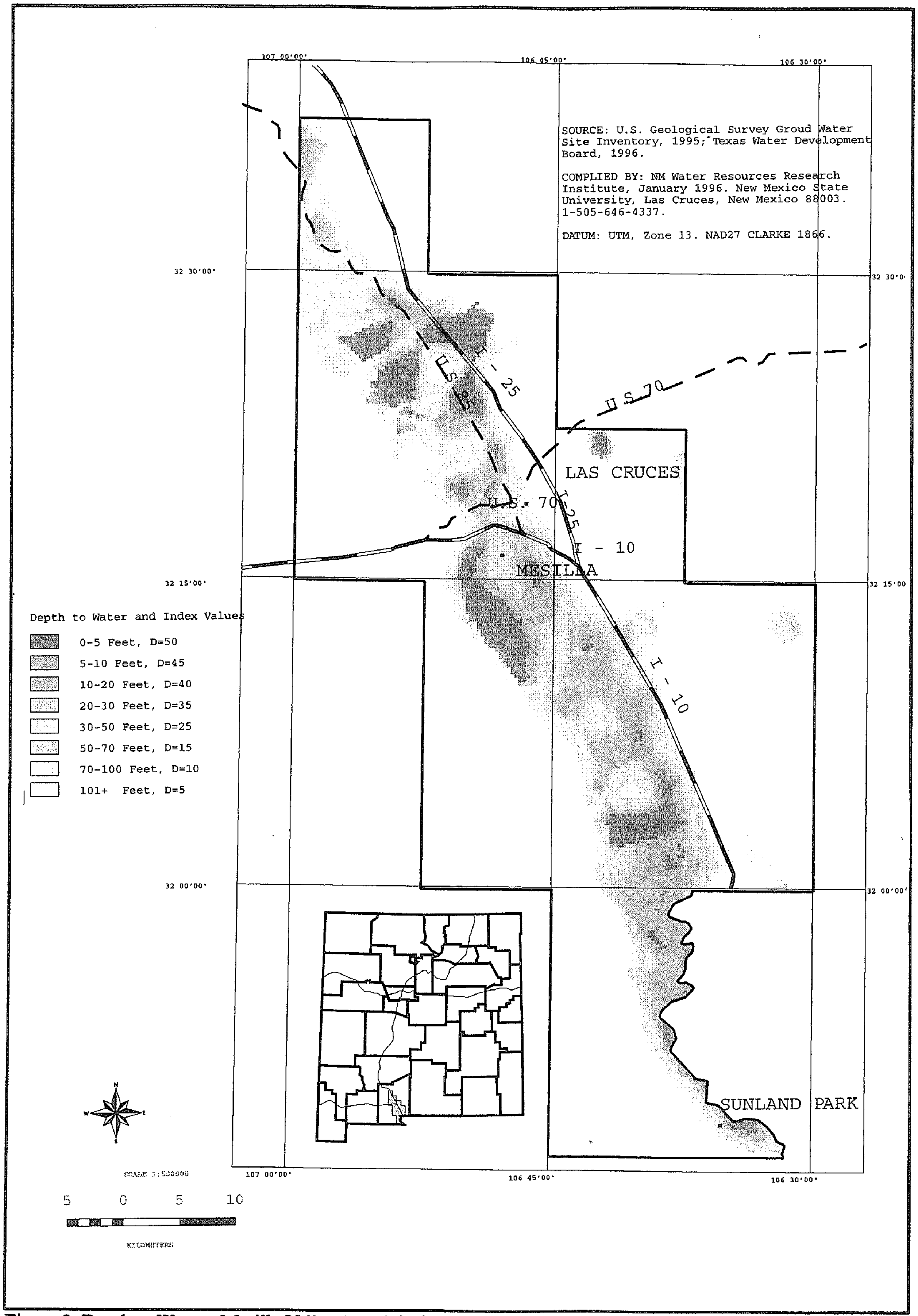
RESULTS

Groundwater Aquifer Sensitivity Assessment

The natural sensitivity assessment consisted of developing a GIS layer for each of the seven DRASTIC parameters (depth to water, net recharge, aquifer media, soil media, topography, impact of the vadose zone, and hydraulic conductivity). These layers are described below followed by the combined natural sensitivity (NATSEN) coverage.

Depth to Water

The depth to water below the land surface in the Mesilla Valley and surrounding area including northwest El Paso County, Texas is presented in Figure 2. Table 9 presents the areal extent of the selected depth-to-water table intervals. The depth-to-water table indicates that over 60 percent of the



SOURCE: U.S. Geological Survey Groud Water Site Inventory, 1995; Texas Water Development Board, 1996.

COMPLIED BY: NM Water Resources Research Institute, January 1996. New Mexico State University, Las Cruces, New Mexico 88003. 1-505-646-4337.

DATUM: UTM, Zone 13. NAD27 CLARKE 1866.

Figure 2. Depth to Water - Mesilla Valley, New Mexico

study area had a depth to water greater than 100 feet (Table 9). Areas with depth to water less than 5 feet accounted for 5.3 percent; 5-10 feet 3.1 percent; 10-20 feet 7.3 percent; 20-30 feet 5.2 percent; 30-50 feet 7.2 percent; 50-70 feet 4.8 percent; 70-100 feet 6.4 percent; and over 100 feet 60.7 percent.

Table 9. Areal extent of depth-to-water table by interval, Mesilla Valley

Depth-to-water table interval (ft)	Areal extent (km^2)	Percent
0-5	121.7	5.3
5-10	69.6	3.1
10-20	167.2	7.3
20-30	118.6	5.2
30-50	164.2	7.2
50-70	108.9	4.8
70-100	147.1	6.4
100+	1385.2	60.7
Total	2282.5	100.0

Net Recharge

The net recharge for the Mesilla Valley classified by land use ratings is presented in Figure 3. Table 10 presents the areal extent of each of the land use ratings. About 16 percent of the area was classified as agricultural and about 77 percent was classified as rangeland.

Table 10. Areal extent of net recharge areas, Mesilla Valley

Land use classification	Areal extent (km^2)	Percent
Urban or built-up land	109.0	4.8
Agricultural land	369.1	16.2
Rangeland	1769.2	77.5
Forest land	1.4	0.1
Water bodies	8.4	0.3
Wetland	0.7	< 0.1
Barren land	24.7	1.1
Total	2282.5	100.0

Aquifer Media

The aquifer media classification for the Mesilla Valley is presented in Figure 4. Table 11 presents the areal extent of each of the aquifer media classifications. About 47.8 percent of the area was classified as basin-fill, 23 percent as alluvium, and about 28.4 percent as Santa Fe or pre-Santa Fe Group.

Table 11. Areal extent of aquifer media classification, Mesilla Valley

ptype	Aquifer media	Areal extent (km^2)	Percent
Qab	Basin-fill	1092.1	47.8
Qal	Alluvium	524.9	23.0
Qb	Basalt	18.3	0.8
QTs	Santa Fe Group	414.7	18.2
pQTs	pre-Santa Fe Group	232.5	10.2
Total		2282.5	100.0

Soil Media

Table 12 presents the areal extent of the soil media classifications for the Mesilla Valley. Figure 5 presents a map of the Mesilla Valley for each of the soil media classes. Loamy sand was the dominant soil type found in the Mesilla Valley with over 46 percent of the study area classified as such. Sandy loam was next with almost 14 percent.

Table 12. Areal extent of soil media classification, Mesilla Valley

Soil media	Areal extent (km^2)	Percent
Basalt	23.0	1.0
Caliche	0.4	< 0.1
Carbonate hardpan	19.7	0.9
Carbonate-cemented	171.4	7.5
Clay	40.7	1.8
Clay loam	148.2	6.5
Dumps & gravel pits	1.5	0.1
Limestone bedrock	108.8	4.8
Loam	95.2	4.2
Loamy sand	1067.7	46.8
Rock outcrop	115.1	5.0
Sandy clay loam	53.6	2.3
Sandy loam	317.6	13.9
Silty clay loam	22.3	1.0
Silty loam	89.5	3.9
Water	7.8	0.3
Total	2282.5	100.0

Topography

Table 13 presents the areal extent of the Mesilla Valley by topography classification. The study area is relatively level with over 60 percent classified with slopes less than 2 percent and more than 28 percent with slopes less than 6 percent. Figure 6 presents a map of the Mesilla Valley topography.

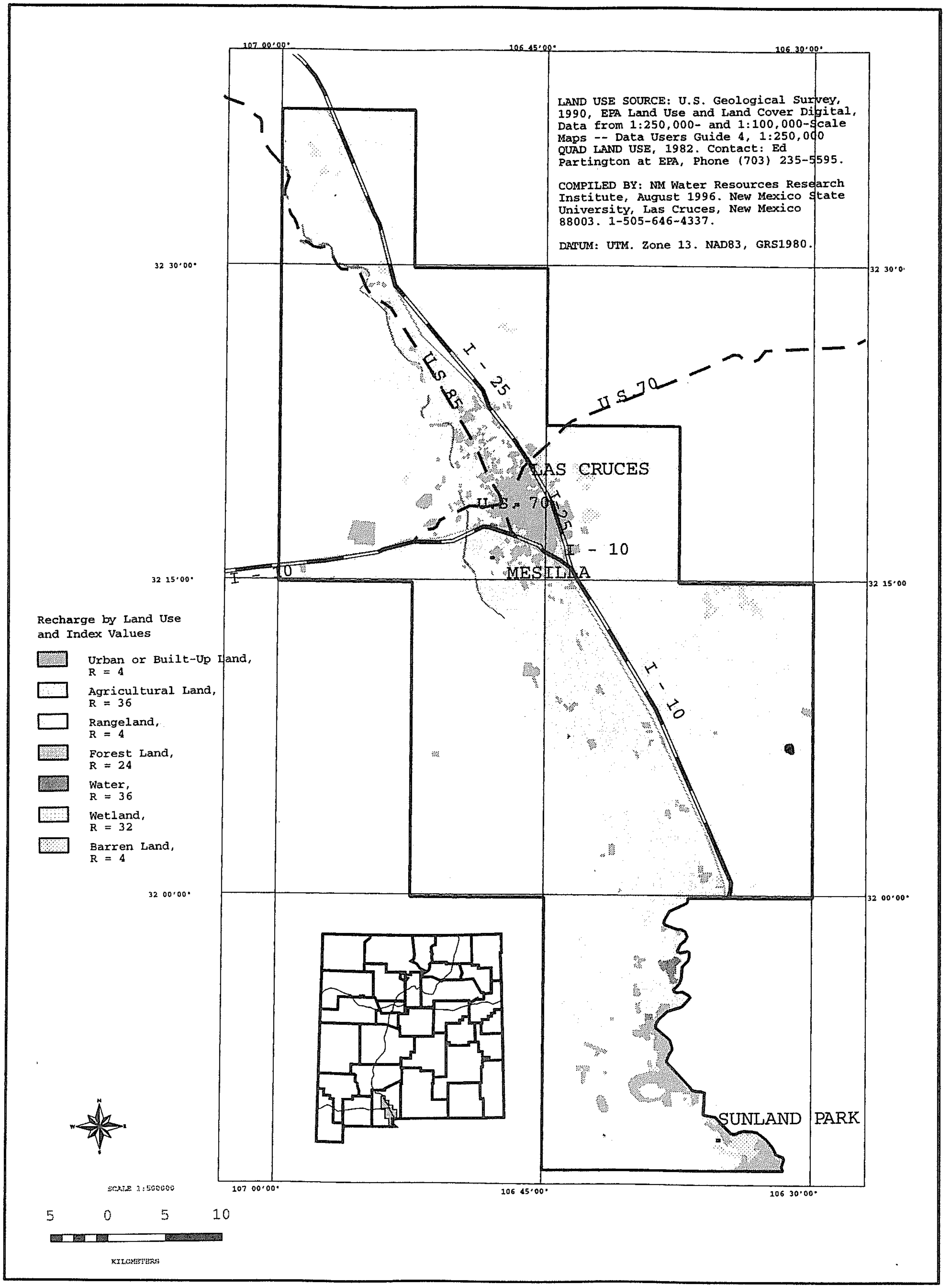
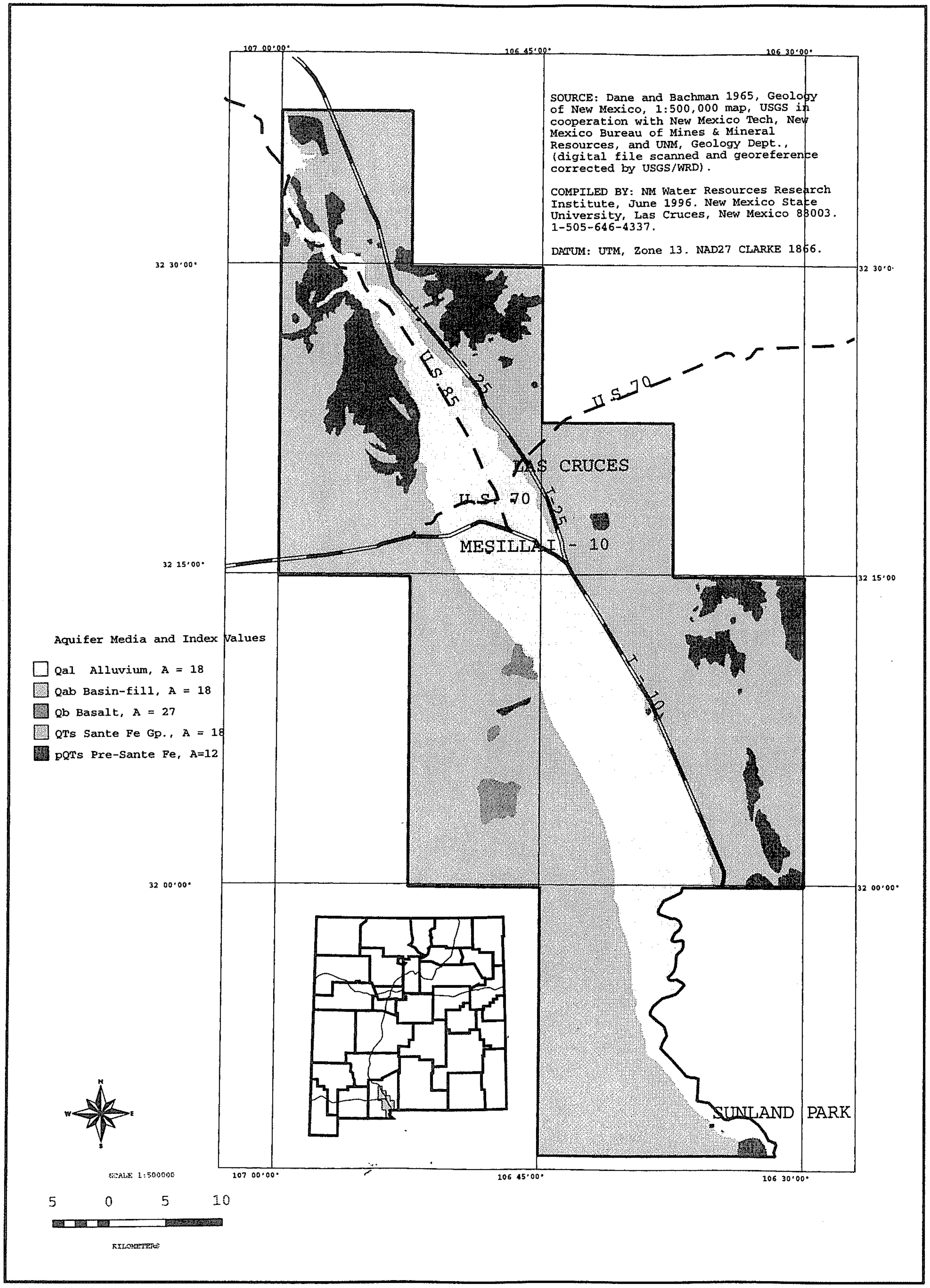


Figure 3. Net Recharge - Mesilla Valley, New Mexico



SOURCE: Dane and Bachman 1965, Geology of New Mexico, 1:500,000 map, USGS in cooperation with New Mexico Tech, New Mexico Bureau of Mines & Mineral Resources, and UNM, Geology Dept., (digital file scanned and georeference corrected by USGS/WRD).

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DATUM: UTM, Zone 13. NAD27 CLARKE 1866.

Figure 4. Aquifer Media - Mesilla Valley, New Mexico

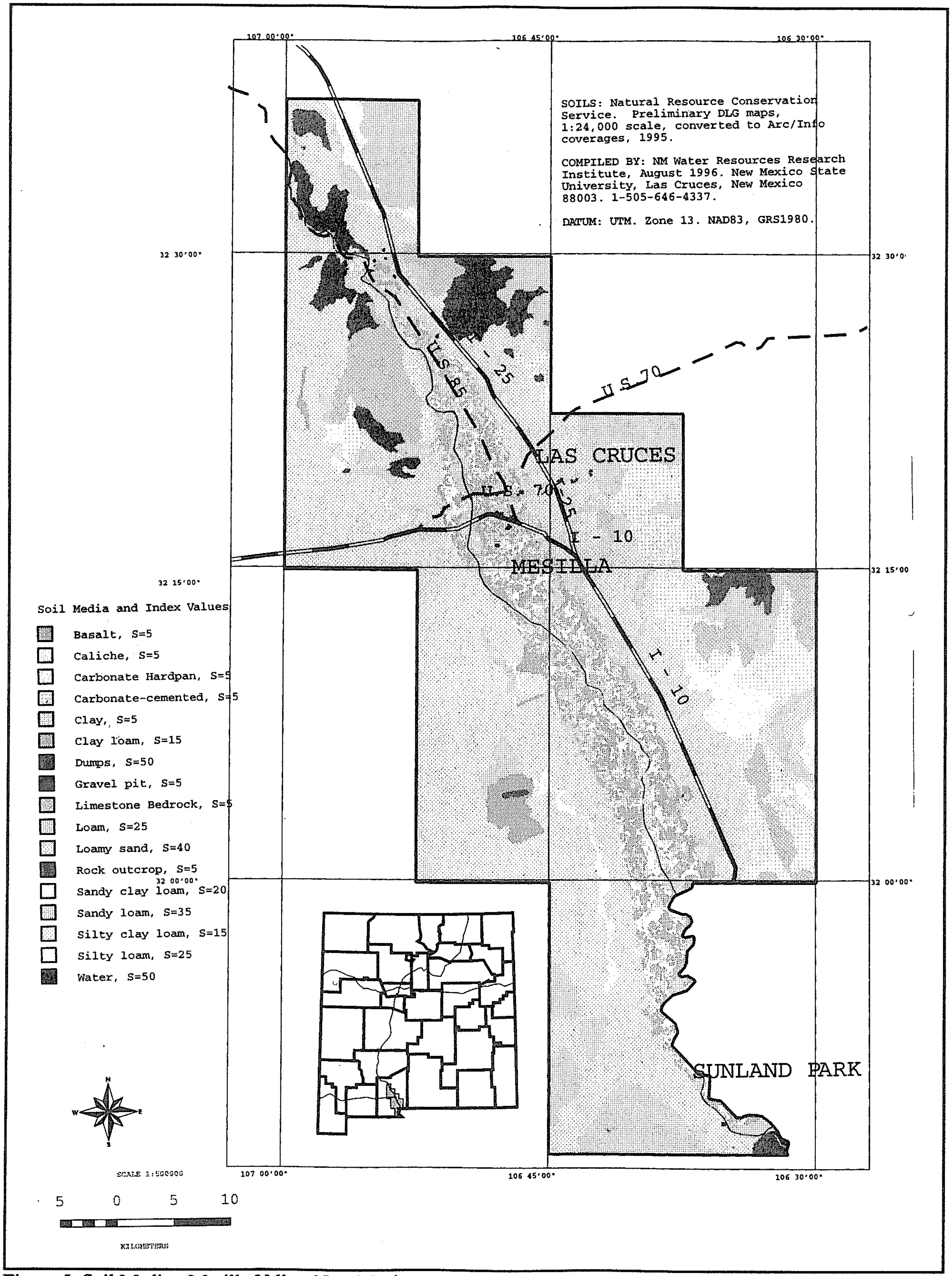
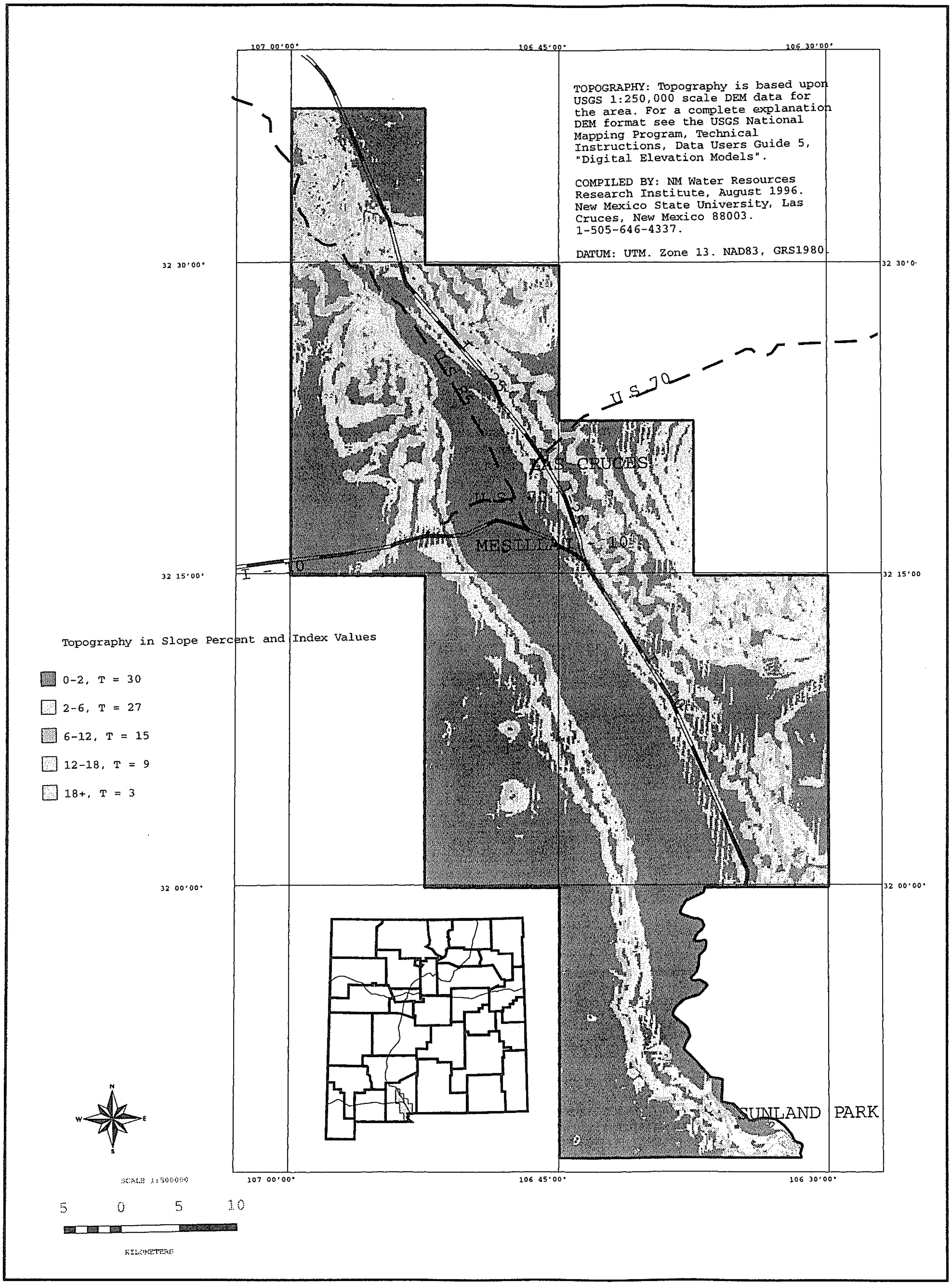


Figure 5. Soil Media - Mesilla Valley, New Mexico



TOPOGRAPHY: Topography is based upon USGS 1:250,000 scale DEM data for the area. For a complete explanation DEM format see the USGS National Mapping Program, Technical Instructions, Data Users Guide 5, "Digital Elevation Models".

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DATUM: UTM. Zone 13. NAD83, GRS1980.

Topography in Slope Percent and Index Values

- ▨ 0-2, T = 30
- ▨ 2-6, T = 27
- ▨ 6-12, T = 15
- ▨ 12-18, T = 9
- ▨ 18+, T = 3

Figure 6. Topography - Mesilla Valley, New Mexico

Table 13. Areal extent of the topography for the Mesilla Valley

Topography (percent slope)	Areal extent (km^2)	Percent
0-2	1383.8	60.6
2-6	643.5	28.2
6-12	146.6	6.4
12-18	39.4	1.7
18+	69.2	3.1
Total	2282.5	100.0

Impact of Vadose Zone Media

Table 14 lists the areal extent of the area classified for impact of the vadose zone. Over 47 percent of the area was classified as basin-fill and 23 percent as alluvium. Over 28 percent was classified as Santa Fe or pre-Santa Fe Group. A map of the area with the impact of the vadose zone parameter is presented in Figure 7.

Table 14. Areal extent of the vadose zone media, Mesilla Valley

ptype	Impact of vadose zone	Areal extent (km^2)	Percent
Qab	Basin-fill	1092.0	47.8
Qal	Alluvium	524.9	23.0
Qb	Basalt	18.3	0.8
QTs	Santa Fe Group	414.7	18.2
pQTs	pre-Santa Fe Group	232.6	10.2
Total		2282.5	100.0

Hydraulic Conductivity of the Aquifer

Table 15 presents the areal extent of the hydraulic conductivity classes for the aquifer in the Mesilla Valley. Over 36 percent of the groundwater aquifer was classified as K7 and over 32 percent as K3. Figure 8 presents a map of the hydraulic conductivity classes for the Mesilla Valley.

Table 15. Areal extent of the hydraulic conductivity classes in the Mesilla Valley

Hydraulic conductivity class[1]	Areal extent (km^2)	Percent
K1	70.2	3.1
K2	336.5	14.7
K3	737.2	32.3
K4	132.6	5.8
K5	78.5	3.4
K6	97.1	4.3
K7	830.4	36.4
Total	2282.5	100.0

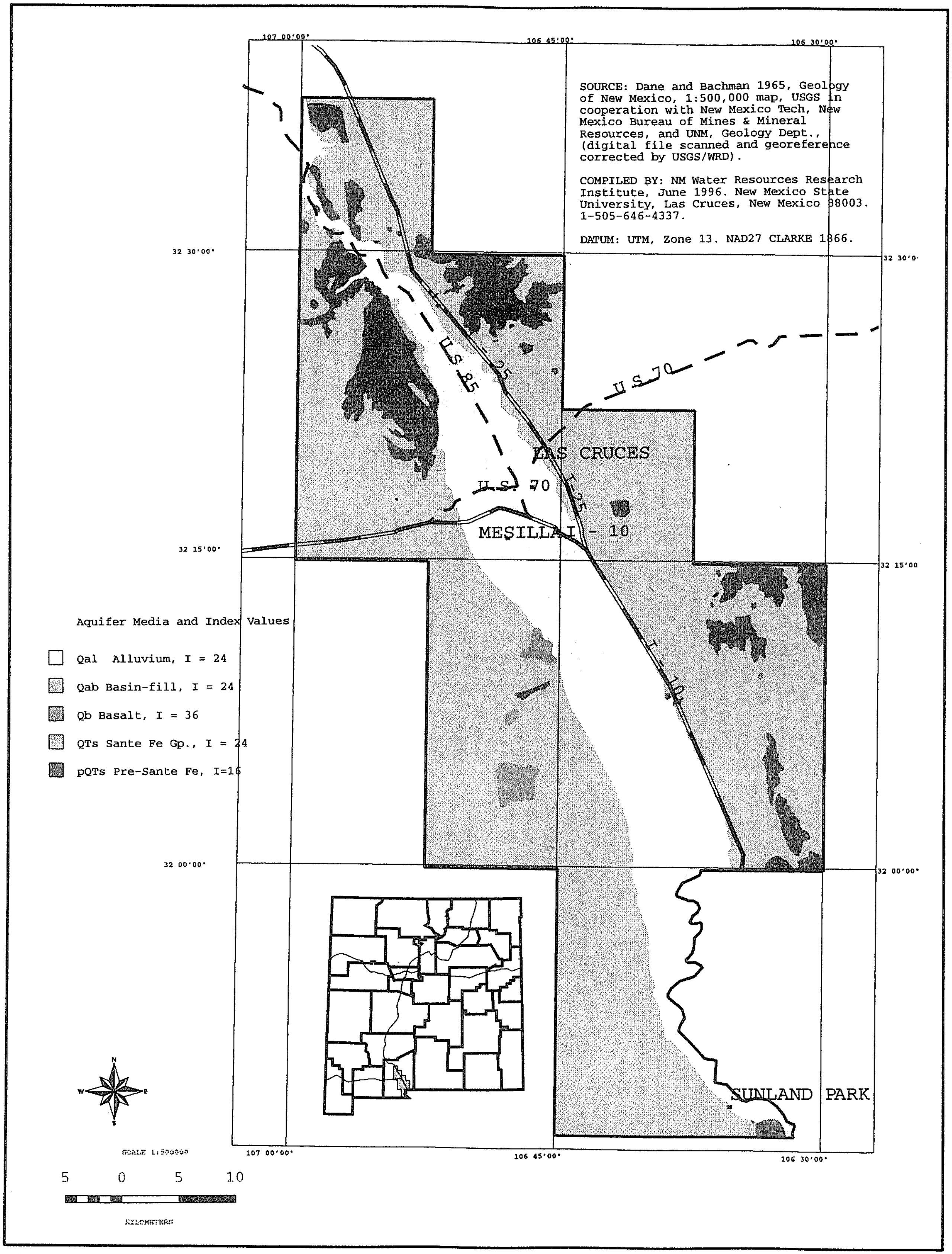
[1] See Table 7, pg 91.

Natural Sensitivity Assessment

By combining the seven DRASTIC parameters, a natural sensitivity index was developed. These values were grouped into six categories: *very slight* - indicating the groundwater aquifer is very well protected and contamination risk from nonpoint sources is very low; *slight* - indicating the groundwater aquifer is reasonably well protected, but because one or more of the hydrologic parameters are conducive to contamination, there is a higher level of risk of nonpoint source pollution; *low* - the groundwater aquifer is somewhat protected, but more than one of the parameters are conducive to contamination; *moderate* - the groundwater aquifer is susceptible to contamination because there are few natural protections; *severe* - the groundwater aquifer is much more susceptible to contamination due to a number of hydrologic conditions; and *extreme* - all hydrologic parameters are conducive to the rapid transport of contamination to the groundwater aquifers. Results indicated that of the 2,282 km^2 included in the study area, a very small area (less than one percent) was classified as *extreme*. However, this area as well as the *severe* class deserve special attention, as natural conditions are such that any contaminant is likely to reach the water table quite rapidly. Table 16 presents the areal extent of each of the six natural sensitivity categories. Figure 9 presents the NATSEN coverage in map form.

Table 16. Areal extent of the natural sensitivity classes in the Mesilla Valley

Natural Sensitivity Class	Areal extent (km^2)	Percent
Very Slight	262.0	11.5
Slight	313.8	13.7
Low	1159.3	50.8
Moderate	351.0	15.4
Severe	183.5	8.0
Extreme	12.9	0.6
Total	2282.5	100.0



SOURCE: Dane and Bachman 1965, Geology of New Mexico, 1:500,000 map, USGS in cooperation with New Mexico Tech, New Mexico Bureau of Mines & Mineral Resources, and UNM, Geology Dept., (digital file scanned and georeference corrected by USGS/WRD).

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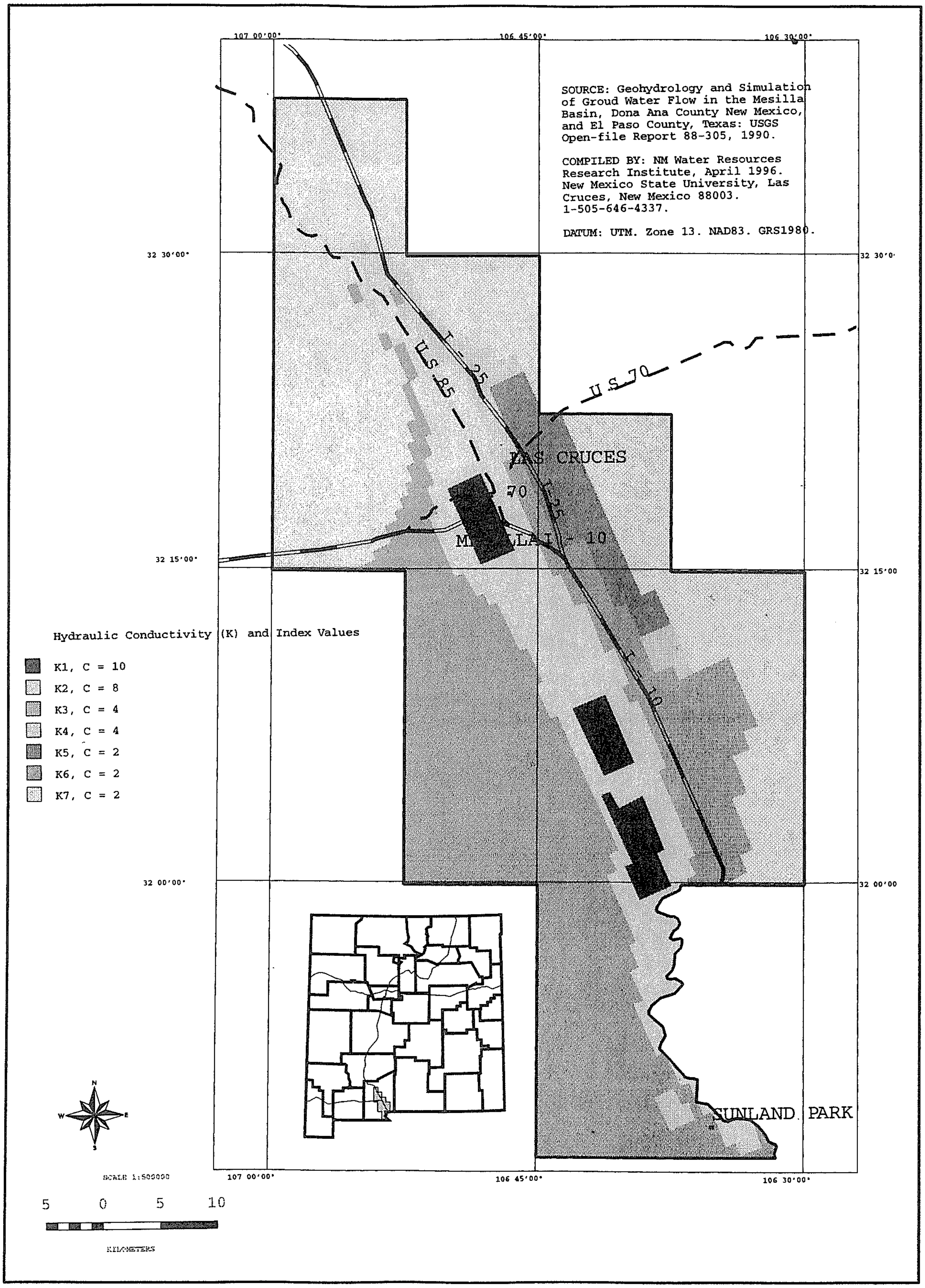
DATUM: UTM, Zone 13. NAD27 CLARKE 1866.

Figure 7. Impact of Vadose Zone Media - Mesilla Valley, New Mexico



SOURCE: Geohydrology and Simulation of Groud Water Flow in the Mesilla Basin, Dona Ana County New Mexico, and El Paso County, Texas: USGS Open-file Report 88-305, 1990.

COMPILED BY: NM Water Resources Research Institute, April 1996. New Mexico State University, Las Cruces, New Mexico 88003. 1-505-646-4337.

DATUM: UTM. Zone 13. NAD83. GRS1980.

Figure 8. Hydraulic Conductivity - Mesilla Valley, New Mexico

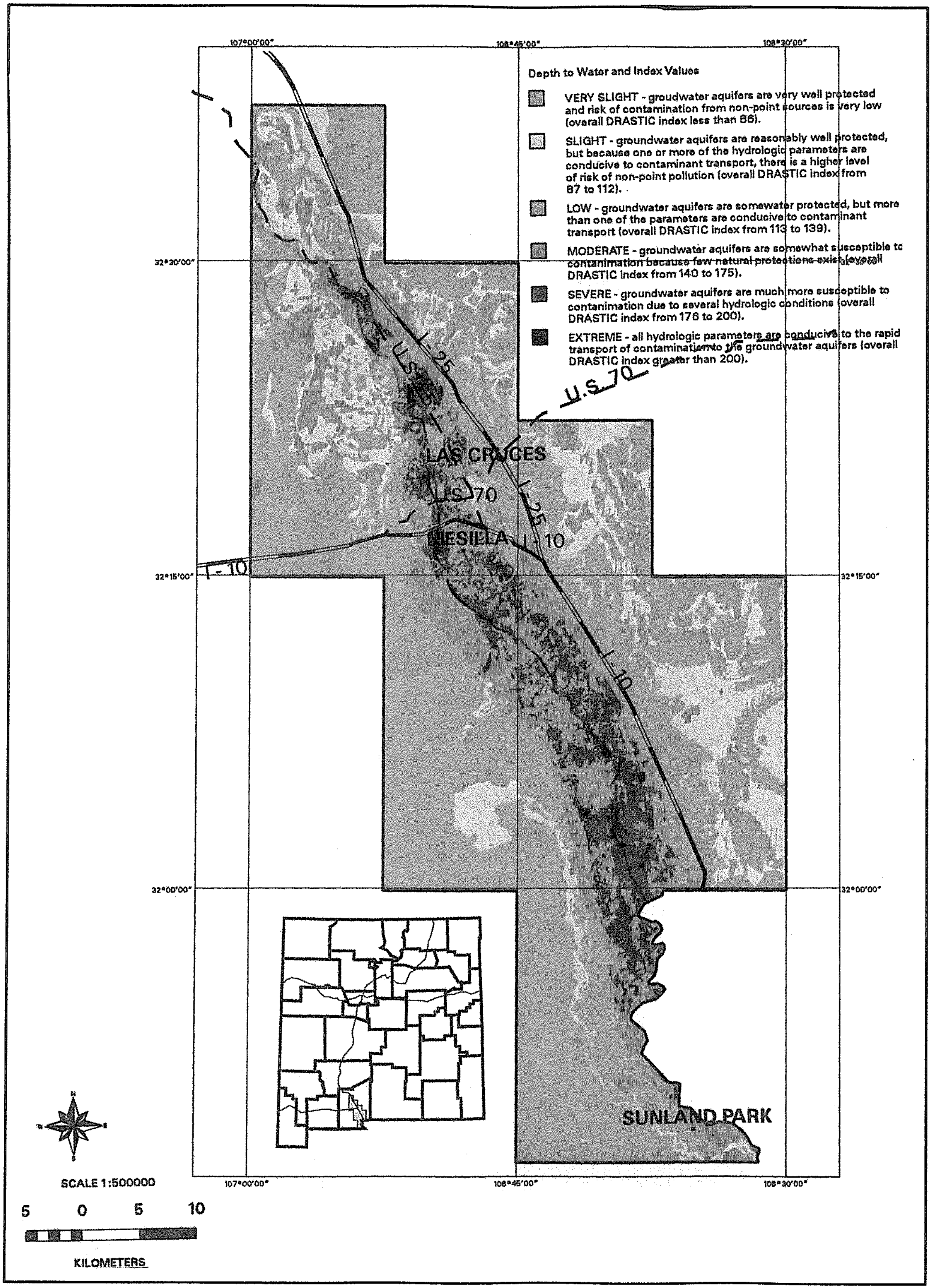


Figure 9. Natural Sensitivity of Groundwater Aquifers - Mesilla Valley, New Mexico

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