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Modeling of Ground-Water Flow and Surface/Ground-Water Interaction for the San Pedro River Basin

Part I

Mexican Border to Fairbank, Arizona

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Chapter 1
Project Overview

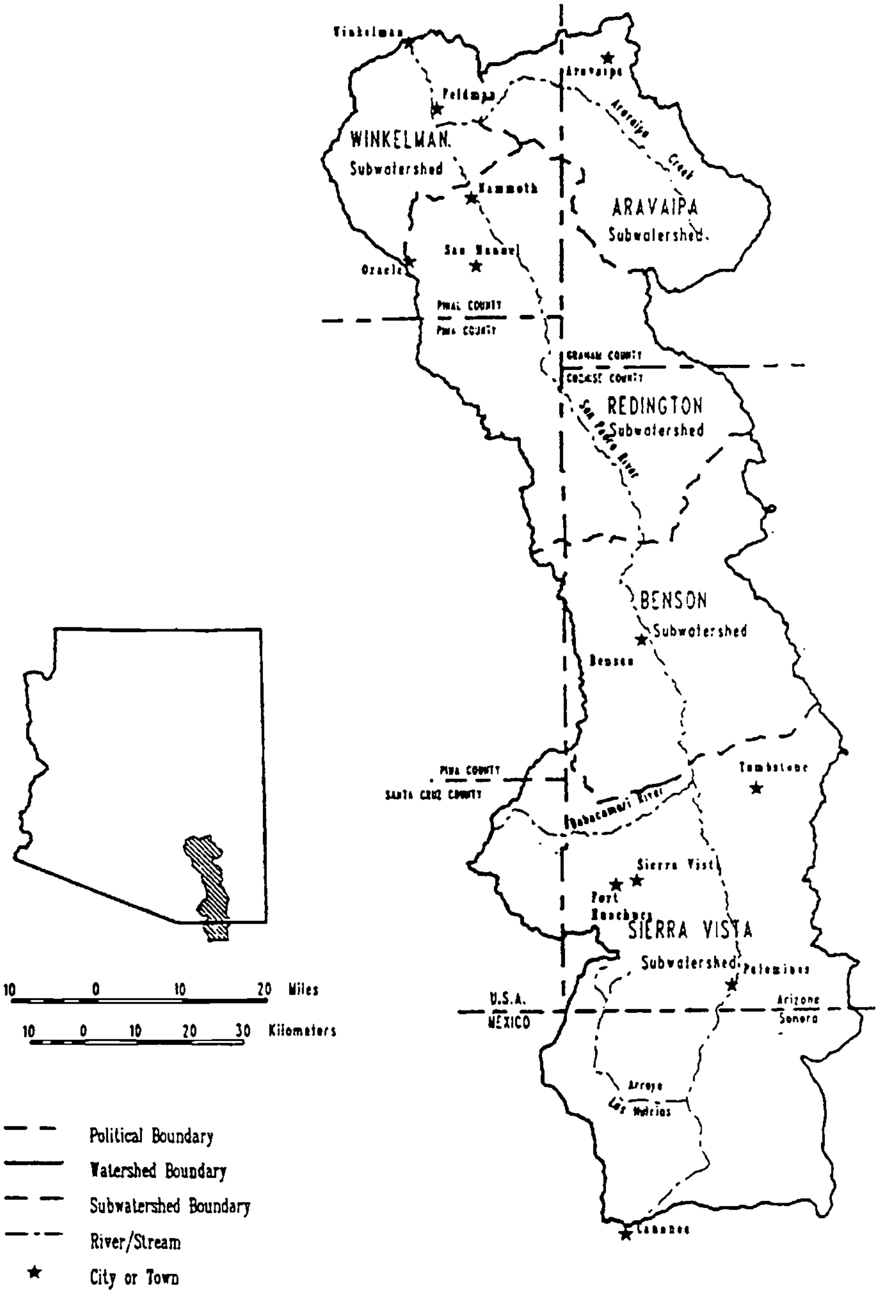
1.1 INTRODUCTION

Many hydrologic basins in the southwest have seen their perennial streamflows turn to ephemeral, their riparian communities disappear or be jeopardized, and their aquifers suffer from severe overdrafts. Under-management of ground-water exploitation and of conjunctive use of surface and ground waters are the main reasons for these events.

The San Pedro River Basin of southeastern Arizona (Figure 1-1) has only experienced limited effects from intensive ground-water withdrawals. Ground-water exploitation in that area has resulted in the formation of a cone of depression around the well fields, a portion of the mountain front recharge that otherwise would make its way to the river is being intercepted by pumping, and some portions of baseflow being captured by pumping. Some studies (e.g. Jackson *et al*, 1987; Putman *et al*, 1988) have addressed the effects that ground-water development in the Sierra Vista-Fort Huachuca area may have on baseflows. Statistical analyses of streamflows performed by Jackson *et al* (1987) and others suggest that baseflows and minimum flows along the San Pedro River have declined since the 1920s. An explanation of this trend has yet to be defined, however, and these streamflow declines are most likely due to some combination of climatic changes, ground-water withdrawals, overgrazing and surface-water diversions.

Conflicting water uses in the basin, such as instream flow maintenance on one hand and sustained water supply for growing populations on the other, make it necessary to acquire information and to develop analytical procedures to support water resources planning in the study area. Planning procedures must incorporate all relevant

San Pedro River Basin
(ADWR, 1990)
Figure 1-1



components of water resources management in order to permit the effective evaluation of the options available to decision makers. One of those components is the hydrologic aspect, which can be evaluated through the use of a mathematical simulation model of the ground-water system and its interaction with the surface-water system.

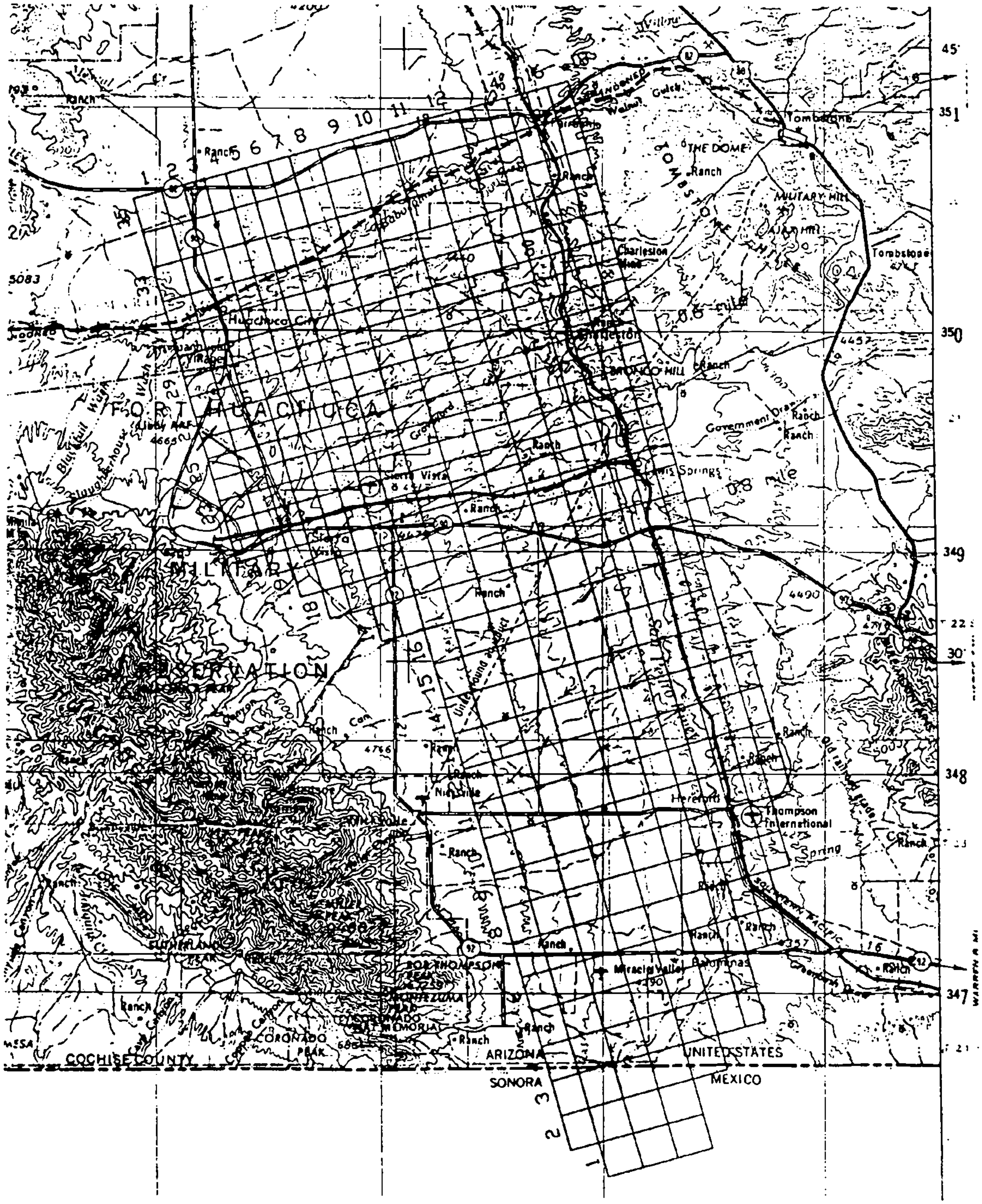
By modifying an existing numerical ground-water flow model to include a newly developed stream-aquifer interaction module (Prudic, 1989), and using recently acquired information on the surface-water and ground-water systems to augment existing information for configuration and calibration, a new model is designed. The floodplain alluvial is incorporated as part of the conceptual model and the representation of the stream-aquifer relationship is improved with respect to previous modeling.

Although duplication of historically observed water levels was incorporated into the calibration process, the ground-water model is not intended to reproduce water levels for site specific locations within the study area. Rather the goal of the study is to reproduce general ground-water flow patterns before and after development and to assess in more detail the link between the different hydrologic units of the system under pumping stress.

1.2 STUDY AREA

The study area is located in the southeastern corner of Arizona and includes a small northern portion of Sonora, Mexico. Specifically, the area extends from below the Mexico border at Cananea, Sonora to upstream at Fairbank, Arizona (Figure 1-2). The area consists of a wide valley floor filled with older alluvial deposits traversed by younger alluvial deposits along the stream channels. Flows through two stream channels, that of the San Pedro River and the Babocomari River, are included in the area.

Study Area and Grid for San Pedro River Basin
Figure 1-2



1.3 PREVIOUS GROUND-WATER MODELING INVESTIGATIONS

The first reported modeling effort in the Upper San Pedro Basin is attributed to the Arizona Water Commission (AWC, 1974). The study was part of a project aimed at analyzing the water conditions at Fort Huachuca Military Base and its surrounding areas. The modeled area extended from the Mexico border to Saint David. The model was a single layer, regular grid with cell width and length of 1 mile. The AWC conceptualized the aquifer system as being unconfined and recharged by mountain front recharge. The San Pedro river was treated as a constant head boundary.

Freethey (1982) laid the groundwork for present ground-water modeling efforts in the Upper San Pedro Basin (USPB), particularly in the Sierra Vista area. He restricted the modeled area to the portion of the basin from the Mexico border to Fairbank. Freethey developed a conceptual model for the hydrology of the area and applied a finite difference model developed by the U.S. Geological Survey (Trescott, 1975). His conceptual model, model boundaries and hydrogeologic data are the basis for all modeling efforts that came afterward. Freethey's model was designed to evaluate the definition of the system and the relative sensitivity of model changes in major factors such as evapotranspiration, aquifer parameters and river leakage. It was not intended to simulate and analyze site specific problems. The aquifer system was represented by two layers: the upper unconfined and the lower confined. River aquifer interaction took place between the stream and the upper layer. Freethey introduced a variable grid size which ranged from 0.6 mile to 1 mile, improving the resolution with respect to the previous study. Freethey's model is also known as the U.S.G.S. model.

Villnow (1986) took a different approach. He evaluated a ground-water problem in the USPB using a multi-objective ground-water management model as primary decision making tool. The model was used to generate feasible alternative management policies using the multiobjective constraint technique. The hydrology of the basin was incorporated into the management models by means of the response function method. The response function method requires a linear ground-water model, so that, although his modeled area coincided with that of Freethey, his conceptual model did not.

In 1987, the U.S. Corps of Engineers, Los Angeles District completed a ground-water flow model. Using the U.S.G.S. model as a base, the Corps analyzed the ground-water system to evaluate existing and future conditions around Fort Huachuca. Water use scenarios based on development that was likely to occur at the Fort were of special interest in the study and tested on the model. Changes in evapotranspiration and recharge rates were introduced.

In 1988, Putman *et al* used the data provided by Freethey and applied the Modular Three Dimensional Finite Difference Ground-water Flow Model (MODFLOW), developed by McDonald and Harbaugh (1984). Their purpose was to update and project future hydrologic conditions in the Sierra Vista area. Data input into the model were exactly as presented by Freethey, with the exception of pumpage, which was updated up to recent years.

One of the latest attempts to model the San Pedro Basin belongs to Rovey (1989). Her model incorporated a new representation of the stream-aquifer relationship into MODFLOW. Rovey extended the modeled area to the whole San Pedro Basin, covering an area of 4,920 square miles and running from the Mexico border to Winkelman, Arizona. The grid size ranges from 1 mile along streams to 4 miles in remote areas. Although the general characteristics of this model are reported in draft reports, the study is still in progress and final results are yet to be published.

1.4 SCOPE OF WORK

The scope of work for the modeling project includes:

1. Review of technical reports and documents that pertain to the hydrology and hydrogeology of the study area.
2. Modification of an existing Arizona Department of Water Resources (ADWR) ground-water model with new information gained from data on aquifer properties and pumpage, ground-water interpretive studies, and data on stream-aquifer interactions.
3. Incorporation of the new U.S.G.S stream-aquifer (Prudic, 1989) package into the model to provide stage calculations for river and streams.
4. Provision of an estimate of the ground-water condition in the modeled region before major development.
5. Development of a transient model that can simulate the ground-water system under alternative scenarios of development (i.e., different pumpages).
6. Use of sensitivity analysis to determine data needs for upgrading and improving modeling and management activities.

1.5 REPORT ORGANIZATION

Chapter 2 provides a description of the study area and previous hydrogeologic investigations, Chapter 3 presents a detailed description of the ground and surface-water systems. The ground-water flow model is introduced in Chapter 4, its sensitivity to parameters is discussed in Chapter 5 and the summary, conclusions and recommendations are given in Chapter 6. Chapter 7 contains the references. Chapter 8 and Chapter 9 include the model input data files and the model output files, respectively.

Chapter 2
Description of Study Area

2.1 LOCATION AND PHYSIOGRAPHY

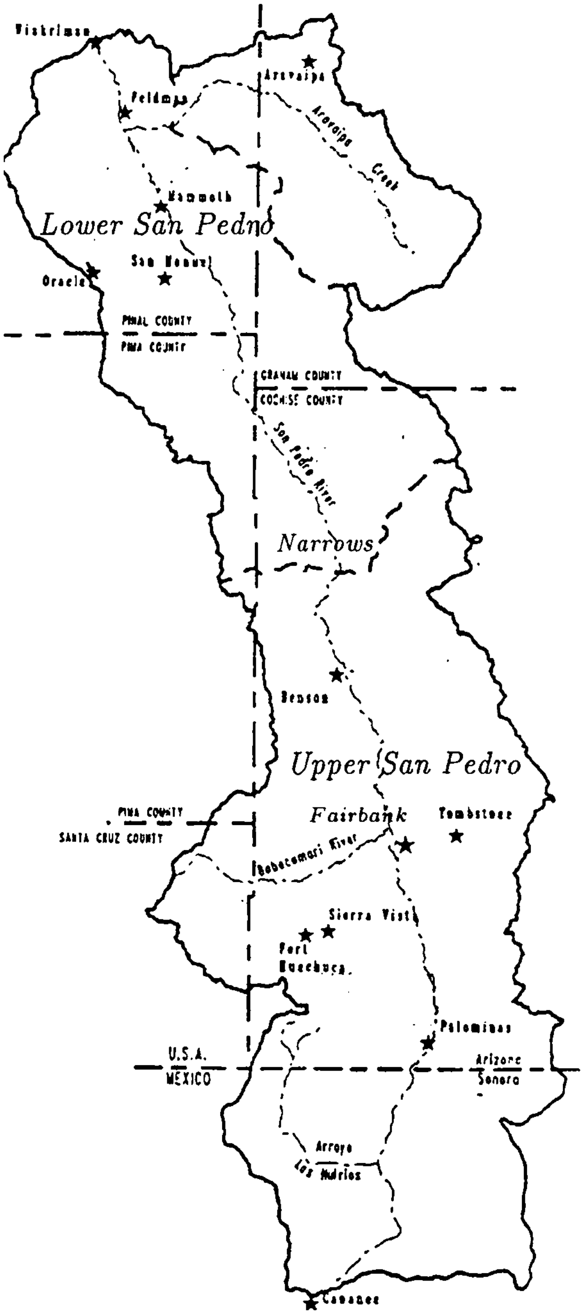
The San Pedro River valley is in southeastern Arizona and, within the United States, extends from just north of the International Border with the Republic of Mexico to Winkelman, Arizona, where it joins the Gila River (Figure 2-1). The river valley is approximately 180 miles long, with about 140 miles located within the United States, and is subdivided into two basins: the Lower and the Upper San Pedro Basins.

The boundaries of the Upper San Pedro Basin, as defined by the Arizona Department of Water Resources (ADWR), are the surface watershed from the headwaters near Cananea in the Republic of Mexico to downstream at 'The Narrows', north of Benson, Arizona (Figure 2-1). This investigation is concerned only with the portion of the upper basin which extends from several miles south of the Mexico Border to Fairbank, Arizona (north-south), and from the Huachuca Mountains to the San Pedro River (east-west) (Figure 2-2).

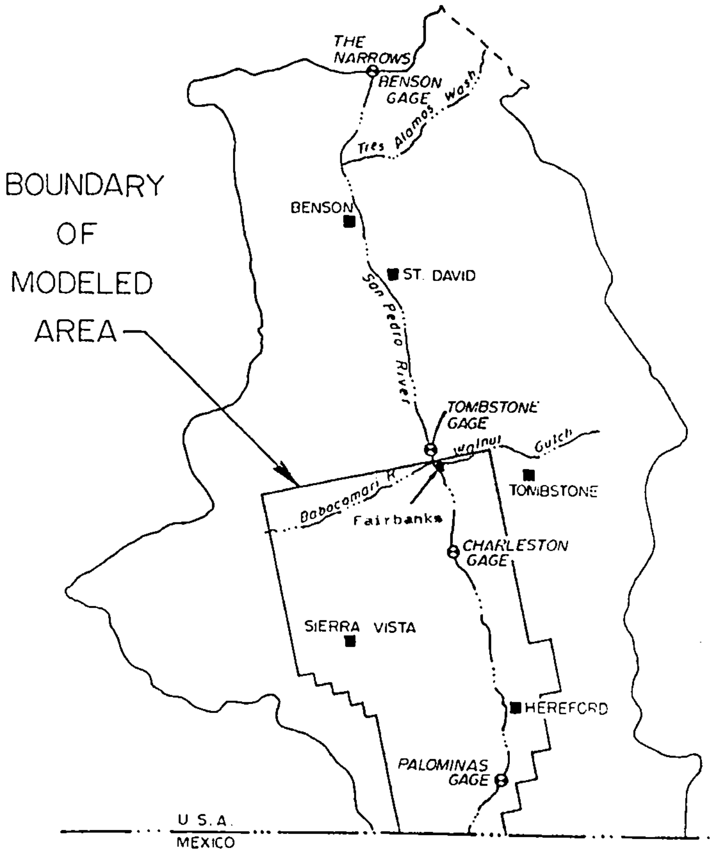
Sierra Vista, with more than 35,000 inhabitants, is the largest city in the area, followed by Huachuca City. Sierra Vista is located east of the Huachuca Mountains in the southwestern portion of the upper basin, and Huachuca City is 15 miles north of Sierra Vista. Both cities' water demands are entirely supplied by ground water. A military base, Fort Huachuca, also operates in the area, stressing the ground-water resources even more. Development outside these towns is sparse, except in the Palominas-Hereford area, where pumping for irrigation water stresses the near surface water table.

Thirty miles south of the U.S.-Mexico border lies Cananea, the closest town to the river headwaters. The San Pedro river enters the United States approximately 3

Upper and Lower San Pedro River Basins
(Modified after ADWR, 1990)
Figure 2-1



Study Area in Upper San Pedro Basin
(Putman *et al*, 1988)
Figure 2-2

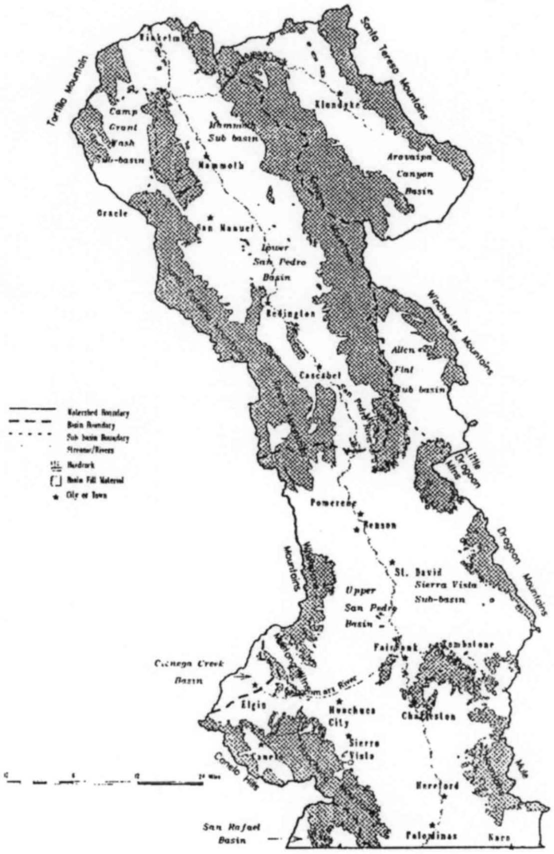


miles south of Palominas, and flows predominantly northward. Perennial and intermittent reaches alternate along its pathway. The longest perennial reach extends from just north of Hereford to just south of Fairbank and results from groundwater discharge to the stream (Putman *et al*, 1988).

The U.S. Geological Survey streamgage near Benson measures the drainage to the San Pedro River from a 2500 square mile area. Twenty-eight percent of the drainage area (696 square miles) is in Mexico, the rest is in Arizona. The river length from the head waters in Mexico to the town of Benson is 90 miles.

Within the upper basin, the main tributary is the Babocomari River, which has its headwaters west of Elgin, Arizona, and flows eastward up to its confluence with the San Pedro north of Fairbank. The Babocomari River is perennial in some reaches and intermittent in some others. The other smaller waterways that drain the basin are ephemeral.

Mountain Ranges and Sub Basins of the San Pedro River Basin
(ADWR, 1990)
Figure 2-3



The Upper San Pedro Basin is surrounded by mountain ranges. The Huachuca, Mustang, Whetstone, and Rincon Mountains to the west (Figure 2-3) constitute the drainage divide between the San Pedro and the Santa Cruz Rivers (Heindl, 1952). The

Mule, Dragoon, Little Dragoon, and Winchester Mountains border the east side of the watershed. Elevations of 5000 ft to 10000 ft are common in the bordering mountains.

In the valley, elevations range from 4200 ft above mean sea level at the International Border to about 3300 ft above mean sea level at "The Narrows". The average gradient of the overall channel is about 0.27 percent.

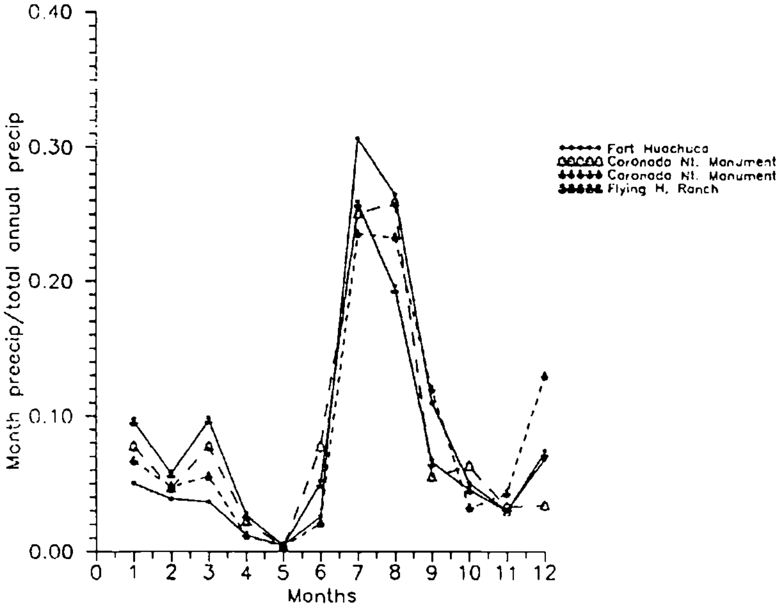
2.2 CLIMATE

The climate of the watershed is arid to semi-arid. Due to slightly higher elevations, the area does not experience the extreme desert conditions encountered in other parts of southern Arizona. Summers are moderately warm. In the higher elevations, temperatures rarely climb to 100 degrees Fahrenheit, but in the lower elevations readings above 100 degrees are frequent in the summer months. Sellers and Hills (1974) reported that winter days are characterized by warm temperatures during daytime and cool nights. The mountains surrounding the basin experience freezing temperatures at night and early morning. Putman *et al* (1988) summarized climatological information at four stations on the base of a wide compilation effort done previously by Sellers and Hills (1974). Table 2-1 provides temperature and precipitation data at selected stations.

Precipitation is highly variable from year to year. Average annual rainfall totals 11 inches (280 mm) at Benson and approximately 15 inches (380 mm) at Fort Huachuca. Annual precipitation is bimodally distributed, as evidenced in Figure 2-4. The annual rainfall distribution shows two distinct rainy seasons which differ from each other in origin and intensity. Winter storms originate mainly by Pacific fronts. When these frontal systems reach Arizona they may produce several days of gentle rain and moderate winds, and occasionally snow. The winter season extends from December to

February and accounts for about 35 % of the annual precipitation (Kafri and Ben Asher, 1978).

Monthly Precipitation Distribution over Huachuca Mountains
Figure 2-4



Summary of Annual Precipitation and Temperature Data in the
Upper San Pedro Basin (Source: Putman *et al*, 1988)
Table 2-1

			Station	
	BENSON	FAIRBANK	FORT HUACHUCA	TOMBSTONE
Elevation (ft above mean sea level)	3590	3850	4664	4610
Annual precip. (in)				
MIN	4.17	4.82	7.21	7.60
AVERAGE	11.53	11.66	15.24	13.93
MAX	19.87	19.63	25.57	23.82
Temperature (°F)				
MIN	6.0		9.0	6.0
AVERAGE	62.8		62.2	63.7
MAX	113.0		104.0	108.0

Summer rains, related to moisture penetration from the Gulf of Mexico, amount to some 60 % of the annual rainfall. These storms are orographic, convection-type thunderstorms of high intensity and short duration. Thunderstorms usually start in late afternoons and early evenings as wet and warm air masses are pushed up the southern slopes of the mountains and then cooled sufficiently. Maximum "monsoon" precipitation occurs on the southeastern (windward) side of the mountains.

In the Upper San Pedro Basin, pan evaporation has been estimated to be 60-65 inches (1,524-1,651 mm) per year (Arizona State University, 1975).

2.3 VEGETATION AND WILDLIFE

The Upper San Pedro Basin includes many vegetation types, ranging from that of the Sonoran desert to that of coniferous forests on mountains higher than 7400 ft above sea level. A riparian corridor, mainly owned by the Bureau of Land Management (BLM), supports one of the richest ecosystems in North America. Vegetation species include cottonwood (*Populus fremontii*), Gooding Willow (*Salix gooddingii*), Seep Willow (*Baccaris glutinosa*), and mesquite, as well as several grasses. These three species provide much of the habitat for the great variety of birds that nest in the area (Jackson *et al,* 1987). Many reaches have been invaded by Salt Cedar (*Tamarix chimensis*), especially in the northern part of the BLM property. The Salt Cedar is classified as a phreatophyte. Mesquites use a considerable amount of water from the saturated zone, but salt cedar and willows extract less moisture from that zone.

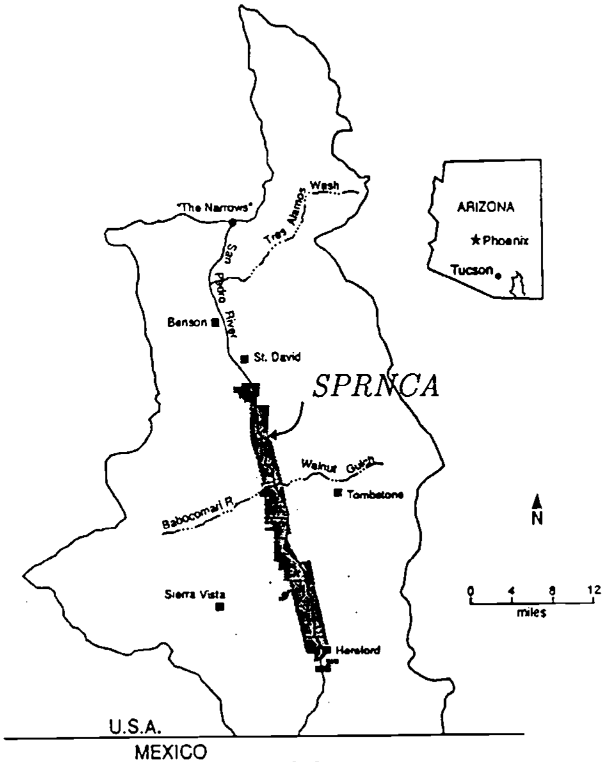
Although the Upper San Pedro Basin contains different types of environments, the riparian ecosystem along the San Pedro River corridor hosts the most abundant variety of animal species. Jackson *et al* (1987) summarize some of the wildlife features as follows:

"This desert riparian system hosts approximately 47 species of amphibians and reptiles"... "Approximately 52 species of mammals have been documented using the Chihuahuan desert riparian ecosystem, the majority of which are present along the San Pedro River."..."Well over 275 species of birds have been documented within the San Pedro Valley, of which 45 are considered riparian obligates".

2.4 THE SAN PEDRO RIPARIAN NATIONAL CONSERVATION AREA

The San Pedro Riparian National Conservation Area (SPRNCA) is a strip of 44,000 acres of riparian habitat along the San Pedro River owned by the Bureau of Land Management. As shown in Figure 2-5, only a portion of these lands falls within the study area.

San Pedro Riparian National Conservation Area (SPRNCA)
(Modified after Jackson *et al*, 1987)
Figure 2-5



All natural assets in this corridor depend on instream flows for their existence. Wildlife use the riparian zone for habitat, food and water (Jackson *et al*, 1987). Access to open water for drinking or feeding and the presence of riparian vegetation are necessary conditions for some animal species to exist. Riparian vegetation is mainly composed of cottonwood, Gooding Willow, Seep Willow, mesquite, and some grasses. In general, water consumption by these plant species is high.

Using the Braney-Criddle equation, Putman *et al* (1988) estimated seasonal consumptive use by phreatophytes:

$$U = K \cdot F \qquad (1)$$

where,

U = seasonal consumptive use (inches)
K = empirical consumptive use coefficient for growing season
F = sum of monthly consumptive use factors for the period.

Putman *et al* (1988) obtained consumptive use coefficients of different vegetation species from previous investigations conducted elsewhere and then adjusted them for their application to the San Pedro area. The 'F' factor was computed by summing the products of mean monthly temperatures and the monthly percentage of daytime hours of the year obtained from tables for any given latitude (Putman *et al*, 1988).

Table 2-2 lists 'K' values for each phreatophyte species as established by these authors. The 'F' factor was determined based on temperature readings at Tombstone. Therefore, estimates of consumptive use of water correspond to the river reach extending from the International Border at Mexico to the USGS streamgage station near Tombstone, a reach that almost coincides with the river reach modeled in the current study area. 'U' values represent the annual consumptive use per acre for each species.

Estimated Annual Consumptive Use of Water by Phreatophyte Species along the San Pedro River Reach from the International Border to the USGS Streamgage Near Tombstone, F = 64.8 (Data Source: Putman *et al*, 1988)
Table 2-2

Phreatophyte Species	K	U
Tamarisk	1.357	87.9
Seep Willow	0.886	57.4
Cottonwood	1.131	73.3
Mesquite	0.622	40.3

The same report goes further in the calculations assessing water use by phreatophytes. In addition to consumptive use, acreages of riparian habitats and their densities were interpreted from aerial photos. Field investigations helped to determine percent cover and species composition.

Dense riparian (about 75 % areal density) and light riparian (about 25 % areal density) were distinguished in this phreatophyte study. Three time periods for which adequate quality aerial imagery was available were used in the analysis. The results are summarized in Table 2-3.

Consumptive Uses and Acreage of Phreatophyte Classes for the River Reach from the International Border to the USGS Streamgage Near Tombstone (Data source: Putman *et al*, 1988)
Table 2-3

YEAR	Phreatophyte (acres)		Consumptive use (ac-ft per acre)		Consumptive use (acre-feet)		Total cons. use (acre-feet)
	dense	light	dense	light	dense	light	
1955	1,628	3,059	3.45	.99	5,617	3,028	8,645
1977	2,655	3,324	3.45	.99	9,160	3,291	12,451
1983/ 1985	368	2,667	3.45	.99	1,270	2,640	3,910

Trends observed in Table 2-3 show that by 1983/1985, phreatophyte populations had decreased even below 1955 levels. Consequences of natural events, like the October, 1983 flood, are not enough to explain such a reduction. However, Putman *et al* (1988) state that 1977 acreage figures may not be as accurate as those calculated using 1983/85 imagery, which is of finer scale and represents more closely present natural conditions.

2.5 GEOLOGIC UNITS

The San Pedro River Valley lies in a structural depression formed by northwest-trending mountain ranges. Roeske and Werrell (1973) provide a concise description of the geologic units in the San Pedro River Valley:

> *"The rocks in the San Pedro River Valley are divided into four groups based on their relative porosity and permeability. The rock units- listed in order of increasing porosity and permeability and decreasing geologic age- are the crystalline and consolidated sedimentary rocks, the consolidated and semiconsolidated sedimentary rocks, the valley-fill deposits, and the flood-plain alluvium".*

Crystalline and consolidated sedimentary rocks form the bedrock unit. Crystalline granitic (igneous) and metamorphic rocks, volcanic rocks and consolidated sedimentary rocks comprise of the geologic formations of the mountain ranges that border the basin. Because of their low permeability and porosity, water occurrence in these rocks depends on the degree of fracturing in the rocks. Wells drilled in this unit may yield a few gallons per minute, enough for domestic purposes and livestock. However, some springs from limestone beds in the Huachuca Mountains can yield as much as several hundred gallons per minute (Brown and others, 1966).

The second group of rocks makes up the Pantano formation, a Tertiary conglomerate which overlies the crystalline and sedimentary unit just described.

Geologic Formations of the Upper San Pedro Basin
Figure 2-6

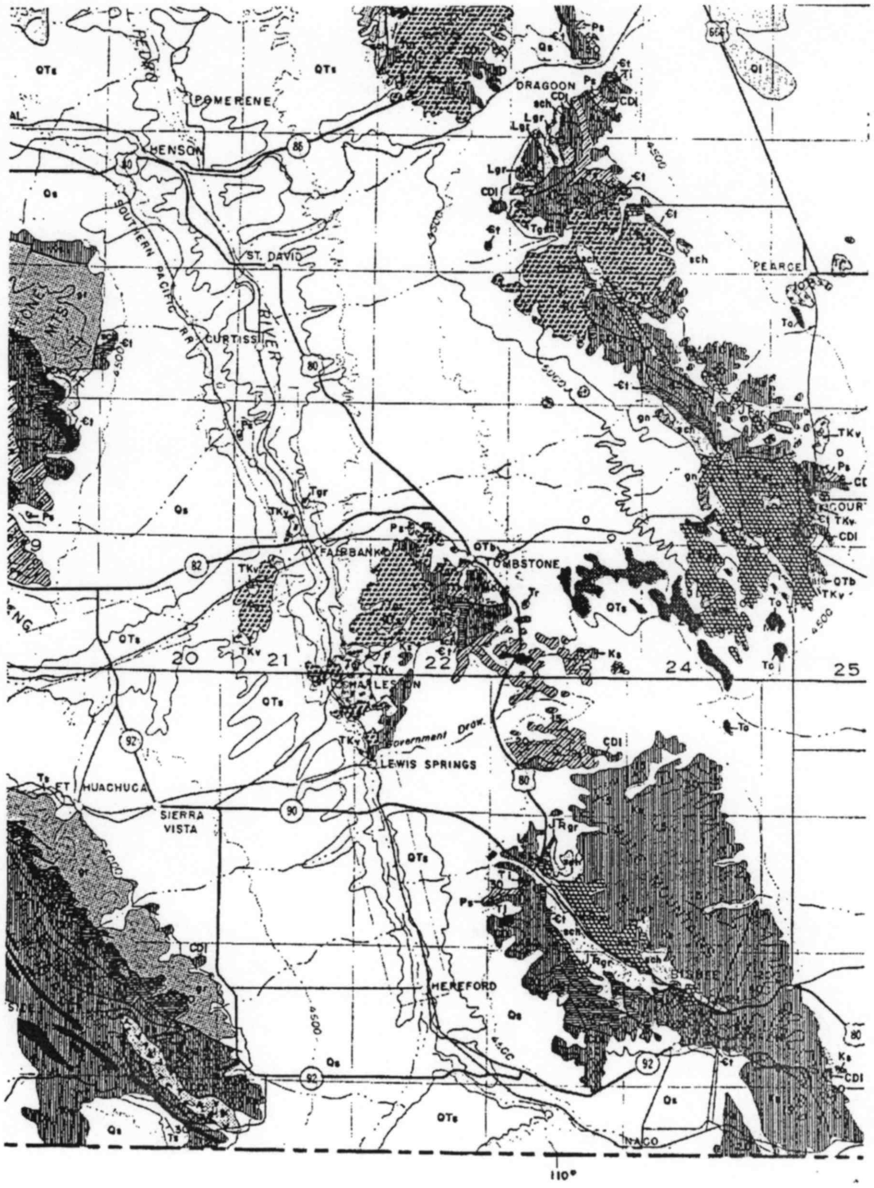


Figure 2-6 (continued)

Legend:

Sedimentary rocks:

Qs = gravel,sand and silt

Ql = lake deposits

QTs = silt, sand and gravel

Ts = sand, gravel and conglomerate

TKs = sandstone, shale and conglomerate

Ks = shale, sandstone and limestone

Ps = permian limestone, sandstone and shale

CDl = Carboniferous and Devonian limestone, shale, sandstone and quartzite

ϵ = Bolsa and Troy quartzites and Abrigo and related limestones

Igneous rocks:

Qb, QTb = basalt

Ti = diques and plugs

Ta = andesite

Tr = rhyolite

Tgr = granite and related crystalline intrusive rocks

TKv = volcanic flows and pyroclastic rocks, rhyolitic to andesitic in composition

Lgr = granite and related crystalline intrudive rocks

Ka = andesite

JTgr = granite and related crystalline intrusive rocks

Metamorphic rocks:

Lgn = gneiss

sch = schist

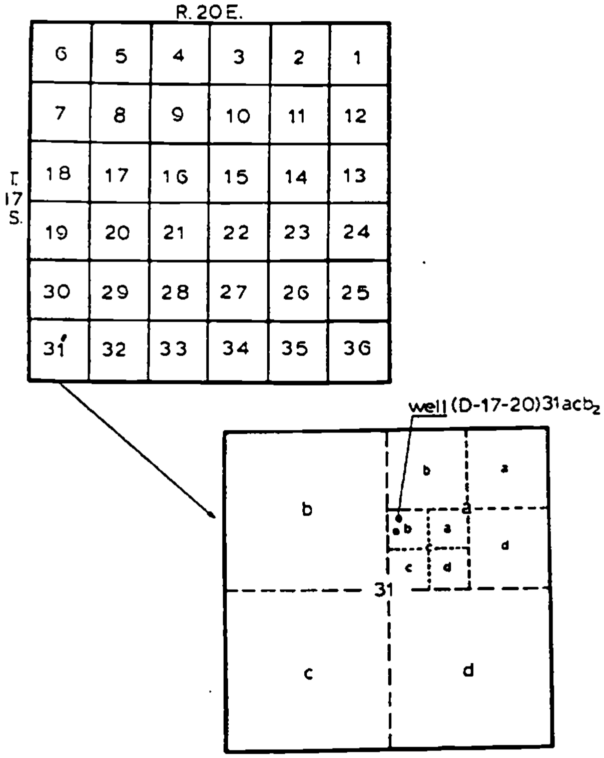
Valley fill deposits cover this unit, but the formation is exposed along the northern slopes of the Huachuca Mountains. Well cemented, this unit is characterized by low permeability and porosity and yields small to moderate amounts of water (Roeske and Werrell, 1973). In some faulted places, mainly where saturated sandstone or conglomerate is found, wells can produce several hundred gallons per minute. Putman *et al* (1988) estimated a thickness range from 500 to 1200 ft, but in places it can exceed 4000 ft (Halvorson, 1984).

The valley-fill deposits constitute the main water bearing unit in the basin. Also called the basin fills, they are divided into an upper and a lower part. The lower unit is composed of sandstone, lenticular gravel, and siltstone beds. Its thickness increases toward the center of the valley, from a few feet at the contact with the mountains to over 1000 ft at the center (Roeske and Werrell, 1973). The upper part overlies the lower basin fill and consists of poorly cemented and compacted clay, gravel, sand and silt (Corps of Engineers, 1974). Near the mouth of the streams in the Huachuca Mountains, silty gravel is the predominant material but finer materials are found toward the central valley, characterized by well bedded silty sand and clays. According to the Corps of Engineers, this formation (upper unit) is about 620 feet thick in the Fort Huachuca well field, but reduces to a few feet thick along the San Pedro River. In the central part of the valley, where sandy and silty beds alternate, water is under artesian pressure. Groundwater occurs mainly under unconfined conditions. Figure 2-6 provides a general geologic picture of the Upper San Pedro Basin.

2.6 WELL NUMBERING SYSTEM

Figure 2-7 and the following paragraph are extracted from Roeske and Werrell (1973) and describe the well numbering scheme for Arizona.

Well Numbering System for Arizona
(Modified after Roeske and Warrell, 1973)
Figure 2-7



"The well numbers used by the Geological Survey in Arizona in accordance with the Bureau of Land Management's system of land subdivision. The land survey in Arizona is based on the Gila and Salt River meridian and base line, which divide the State into four quadrants. These quadrants are designated counterclockwise by the capital letters A, B, C, and D. All land north and east of the point of origin is in A quadrant, the north and west in B quadrant, that south and west in C quadrant, and that south and east in D quadrant. The first digit of a well number indicates the township, the second the range, and the third the section in which the well is situated. The lower case letters a, b, c, and d, after the section number indicate the well location within the section. The first letter

denotes a particular 160-acre tract, the second the 40-acre tract, and the third the 10-acre tract. These letters also are assigned in a counterclockwise direction, beginning in the northeast quarter. If the location is known within the 10-acre tract, three lowercase letters are shown in the well number. In the example shown, well number (D-17-20)31acb2 designates the well as being in the $NE\frac{1}{4}SW\frac{1}{4}SW\frac{1}{4}$ *sec. 31, T. 17 S., R. 20 E. Where more than one well is within a 10-acre tract, consecutive numbers beginning with 1 are added as suffixes."*

2.8 CONVERSION FACTORS

Although the current practice in the applied sciences is to use the SI Unit System, the U.S. English Unit System is used instead. The information contained in this work will be reported to residents of the study area. Therefore, the results of the study are given in units of common use by them. A table of conversion factors for variables encountered throughout the text is provided below:

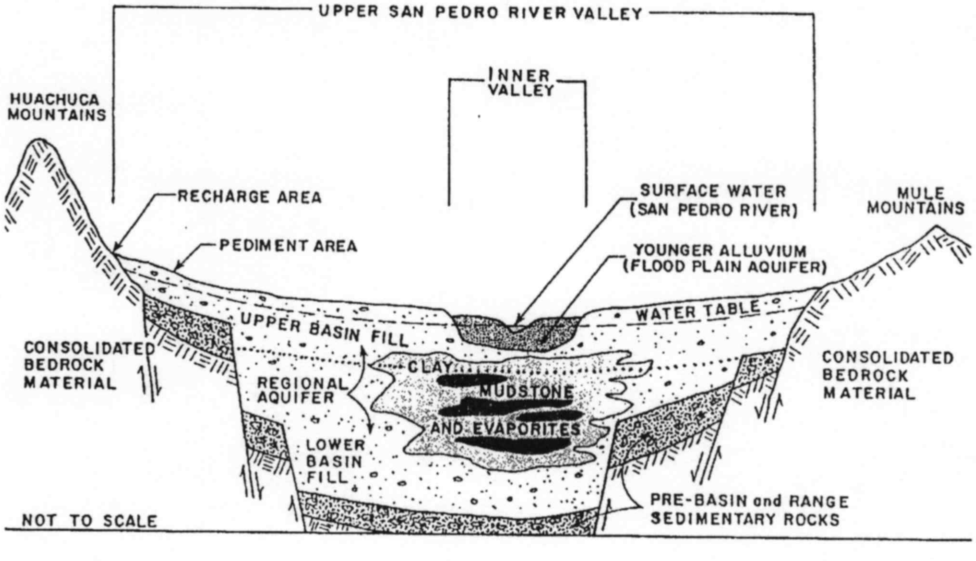
VARIABLE	MULTIPLY	BY	TO OBTAIN
Length	ft	3.048×10^{-1}	m
	mile	1.609	Km
Area	ft^2	9.290×10^{-1}	m^2
	acre	4.097×10^{3}	m^2
	mi^2	2.590	Km^2
Volume	ft^3	2.832×10^{-2}	m^3
	Acre-feet	1,233.62	m^3
Velocity	ft/sec	2.832×10^{-2}	m/sec
Discharge	ft^3/sec	2.832×10^{-2}	m^3/sec
	U.S. gal/min	6.309×10^{-5}	m^3/sec
Hydraulic Conductivity	ft/sec	3.048×10^{-1}	m/sec
Transmissivity	ft^2/sec	9.290×10^{-2}	m^2/sec

Chapter 3
Ground-water and Surface Water Systems

3.1 GROUND-WATER SYSTEM

The Upper San Pedro River watershed in Arizona represents a typical valley within the Basin and Range Lowlands Hydrogeologic Province. Its wide valley floor is filled with older alluvial deposits and with younger alluvium along stream channels. Consolidated rocks bound the valley on both sides and form the floor for the overlying deposits. Figure 3-1 represents a generalized cross section through the valley.

Geologic Cross-section of Upper San Pedro Basin
(ADWR, 1990)
Figure 3-1



Two main aquifers supply the water demand in the basin: the floodplain aquifer and the regional aquifer. Smaller aquifers, mainly in areas of fractured and saturated crystalline and consolidated rocks, provide just enough water for domestic and livestock purposes.

3.1.1 The Regional Aquifer: Occurrence and Movement of Groundwater

Unconfined over most of the Upper San Pedro Basin, the regional aquifer is the primary source of water in the area. The regional aquifer is composed of two units: an upper basin fill and a lower basin fill (Figure 3-1). The areal extent of the regional aquifer deposits in the Upper San Pedro Basin is estimated to be about 1,200 square miles. According to estimates of the Arizona Water Commission (1974), approximately 36 million acre-feet of water are held in storage in the two units, with 12 million acre-feet being stored between 700 feet and 1,200 feet below ground level. Shallow layers, less compacted and more porous, store more water per unit volume than the deeper strata that are more compacted. The Arizona Department of Water Resources (Hydrologic Survey Report [HSR], 1990) reports a storage volume of 31.9 million acre-feet in the Sierra Vista Sub-basin (from the International Border with Mexico to a point downstream of Saint David).

In saturated areas, the upper and lower basin fills are hydraulically connected with each other and, in spite of their different compositions, are considered just one hydrologic unit (Freethey, 1982).

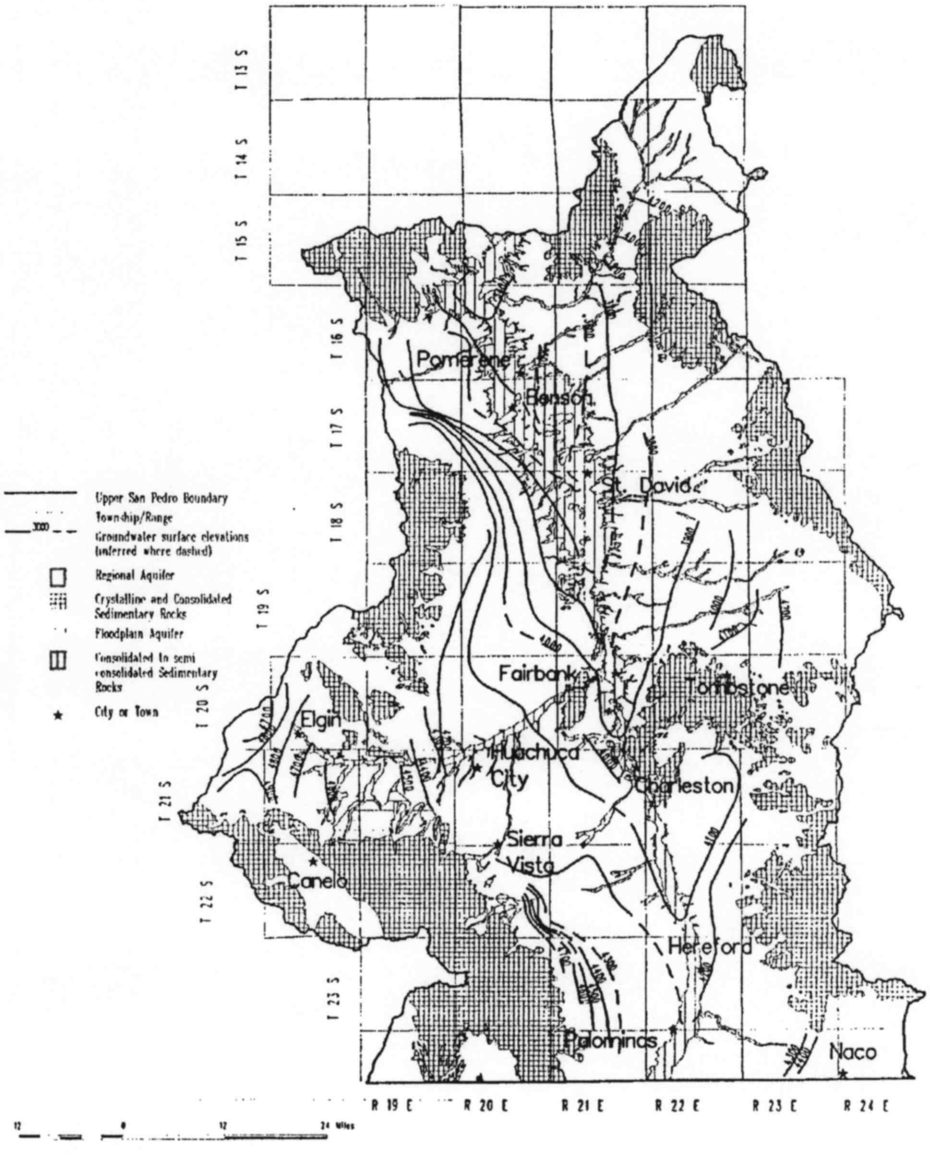
Roeske and Werrell (1973) identified two areas along the basin axis where artesian conditions occur in the regional aquifer: Palominas-Hereford and Saint David. In the Palominas-Hereford area, wells penetrating more than 200 feet encounter artesian conditions and water rises to near land surface. A head difference of less than 20 feet exists between this confined portion of the regional aquifer and the overlying alluvial aquifer. The precise magnitude of the head difference is unknown. The Saint David-Benson artesian area is more extensive, covering an area of approximately fifteen miles long by three miles wide (ADWR, 1990). Artesian pressures are encountered for wells penetrating greater than 200 feet. Artesian pressures in both areas have been declining through the years because of prolonged pumpage.

Water in the regional aquifer is replenished primarily through recharge along the mountain fronts at the east and west boundaries of the basin, as shown in Figure 3-1. A second recharge mechanism, streamflow infiltration, is small in magnitude compared to mountain front recharge. Direct infiltration from precipitation over the valley floor is another potential source of recharge, but its magnitude is considered negligible due to high evapotranspiration rates and low precipitation rates compared to the mountains' precipitation. The aquifer receives underflow across the International Border with Mexico. Freethey (1982) estimated an underflow between 700 and 3,400 acre-feet per year, while the Arizona Department of Water Resources figure for recharge to the floodplain aquifer is 900 acre-feet.

Transmissivities range from 500 ft^2/day to 15,000 ft^2/day (Harshbarger and Associates, 1974). These values are estimated on the basis of more than ten aquifer tests performed in the Sierra Vista- Fort Huachuca area. Using groundwater flow modeling, the Arizona Water Commission (1974) and Freethey (1982) also estimated transmissivities within that range. Recent aquifer tests performed by Schwartzman (1990) gave transmissivities of 27,000 ft^2/day on well (D-21-20)05abc during pumping and of 18,600 ft^2/day during recovery. Putman *et al* (1988) suggest a mean value range of 4,000 - 8,000 ft^2/day for the whole Upper San Pedro Basin. The transmissivities exhibit a high degree of variability.

Hydraulic gradients and permeability govern the rate of groundwater movement. In the regional aquifer, groundwater moves at an average rate of 20 feet per year, with a rate range from 5.8 to 102.5 feet per year (HSR, 1990). The basin flow patterns show groundwater moving from the recharge area in the bordering mountains to the inner valley (Figure 3-2). Flow occurs mainly perpendicular to the San Pedro River, altered in places by igneous bodies that create natural barriers to flow and modify an otherwise

Ground-water Flow Patterns in the Upper San Pedro Basin
(ADWR, 1990)
Figure 3-2



simple flow pattern. One such formation is the outcrop of consolidated rocks around the ghost town of Charleston that forces the groundwater up from the regional aquifer to the floodplain aquifer and ultimately to the river channel. This flow pattern alteration is partly responsible for the perennial streamflows in this reach (Putman *et al*, 1988). Near the San Pedro River, the flow direction turns parallel to the river. The fact that natural patterns have been changed by anthropogenic effects will be discussed later in this chapter.

The unconfined portions of the aquifer possess storage coefficients in the range of 0.02 to 0.15. Values estimated by the Arizona Water Commission (1974) and Harshbarger and Associates (1973) range from 0.05 to 0.10 and 0.12 to 0.15, respectively. In the confined portions of the regional aquifer values for storage properties are four orders of magnitude lower. Freethey (1982) estimated storativities of about 10^{-5}.

3.1.2 The Floodplain Aquifer: Occurrence and Movement of Groundwater

Younger deposits of unconsolidated gravel, sand and silt form the alluvial or floodplain aquifer. These alluvial deposits accumulate along the San Pedro River and its tributaries, forming a shallow aquifer whose thickness generally ranges from 40 feet to over 100 feet, but may approach 150 feet in places (Roeske and Werrell, 1974). Its width varies from a few hundred yards to several miles.

Based on aerial photography, Putman *et al* (1988) estimated a floodplain area of 35,055 acres for the whole Upper San Pedro Basin. The volume of water held in storage is approximately 525,000 acre-feet, an amount considerably smaller than the corresponding value for the regional aquifer.

Water from several sources recharges the alluvial aquifer:

- lateral flow from the regional aquifer;
- vertical leakage upward from the underlying basin fill aquifer where

confining layers result in artesian conditions;

- percolation from irrigated lands;
- movement of regional water that is forced upward by the presence of relatively impermeable (hard rock) outcrops;
- percolation of run-off water;
- underflow across the International Border.

Although information about its transmissive properties is very limited, this hydrogeologic unit is characterized by high values of hydraulic conductivity and porosity. Roeske and Werrell (1973) provide a representative range of well yields from 100 to 1,800 gpm, averaging 700 gpm. Specific capacity data from 11 wells range from 10 to 110 gpm/feet, averaging 40 gpm/feet. Putman *et al* (1988) used two different indirect methods of estimating transmissivity. In the first method, the authors transformed average specific capacity through an empirical conversion factor to yield a transmissivity value of 10,700 ft^2/day. The weakness of the method lies in the reliability of specific capacity values. The second method correlated drillers' logs with published values of hydraulic conductivity and storativity for similar sediments. Adopting an average aquifer thickness of 100 feet and a medium-fine sand as the representative sediment, transmissivities of 1,000-8,000 ft^2/day and specific yields of 0.05 - 0.15 (commonly 0.10 - 0.12) were estimated.

The importance of the alluvial aquifer is that it represents the contact between the surface and ground-water systems. Moreover, it is the major 'water supplier' for irrigation wells located along the San Pedro River and its principal tributaries, and provides the necessary water to support the abundant phreatophyte population within the riparian zone.

3.1.3 Perched Aquifers

Harshbarger and Associates (1974) reported the occurrence of a perched aquifer in the vicinity of the Fort Huachuca Military Reservation. This local aquifer extends northwestward from Carr Canyon toward the Reservation boundary and northeastward toward the San Pedro River. Head gradients of up to 300 feet per mile in the perched aquifer contrast with average gradients in the regional aquifer of about 25 feet per mile. Infiltration from the conduits that drain portions of the Huachuca Mountains is probably the source of recharge to this local storage. Leakage from this unit to the regional aquifer is believed to be small.

3.1.4 Hardrock Aquifers

Compared to other groundwater sources, these aquifers are of minor importance. They only exist in highly fractured and saturated areas of crystalline and consolidated sedimentary rocks, and their water yield is only large enough to meet domestic and stock watering needs. While their regional extent is unknown, these aquifers are believed to be small.

3.1.5 Water Use and Aquifers' Responses to Stresses

Under predevelopement conditions, discharge from the system is balanced by recharge. In the San Pedro Basin, however, the natural equilibrium has been altered by groundwater withdrawals that have resulted in some depletion of aquifer storage.

Water use within the study area is concentrated in two zones and serves two different purposes:

1) the Sierra Vista-Fort Huachuca area well-field, which supplies water mainly

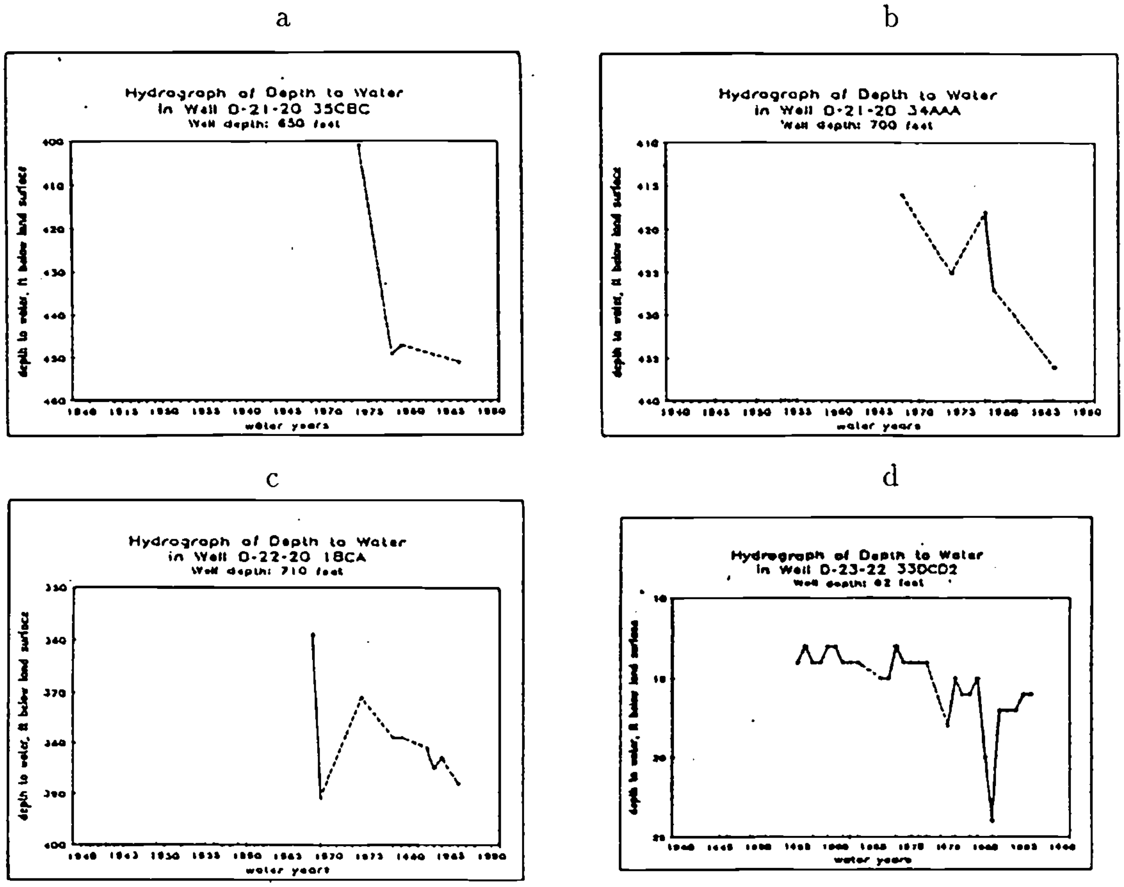
for municipal, military and industrial uses. Wells penetrate the regional aquifer up to depths of 1500 feet.

2) the Palominas-Hereford area well-field, which supplies water for agriculture. Some wells penetrate the regional aquifer, but many of them are shallow wells that penetrate only the floodplain aquifer.

Small and isolated wells outside these two areas supply enough water for domestic and livestock uses.

Before 1940, groundwater usage in the Upper San Pedro Basin was not of sufficient magnitude to cause generalized water table declines (Freethey, 1982). Between 1940 and 1966 withdrawals started to increase, reducing water levels by 0.3 - 0.5 feet per year. As early as 1974, the existence of a cone of depression was reported in the Sierra Vista-Fort Huachuca area (Harshbarger and Associates, 1974). The cone was approximately 4 miles long and 1.5 miles wide, and its length paralleled the Huachuca Mountains in a northwest-southeast direction. The cone centered around Township 21 South, Range 20 East, Section 33. Groundwater data collected by the ADWR in 1986 showed that the cone had extended one mile in width and its center had shifted eastward to Section 35. From 1974 to 1986, the well located at (D-21-20)35cbc has shown a net water level decline of 50.2 feet (Putman *et al,* 1988), i.e. approximately 3.9 ft/year (Figure 3-3-a). Within the same period, a net water level decline of 48.2 feet (approximately 3.7 ft/year) was observed at well (D-21-20)35cdd. According to the ADWR these are the only wells in the area showing such a decline rate. Two wells within the cone of depression located at (D-21-20)34aaa (Figure 3-3-b) and (D-22-20)1bca (Figure 3-3-c) have shown net water table declines for the period 1968-1986 of 20.0 ft (approximately 1.1 ft/year) and 29.2 ft (approximately 1.5 ft/year), respectively. To illustrate the increased development in the area, ADWR estimated that net decline rates around an area of 25 square miles centered at Sierra Vista (based on water level data collected after 1968) ranged from 0.4 to 3.9 feet per year for the period 1968-1986.

Hydrographs for Selected Wells in the Upper San Pedro Basin
(Putman *et al*, 1988)
Figure 3-3



Harshbarger and Associates (1974) report the existence of a second cone of depression in the vicinity of Huachuca City along the Babocomari River. Of smaller dimensions, it parallels the river in a southwest-northeast direction. Recent field data collected by Schwartzman (1990) substantiate the existence of this cone.

For the period 1966-1986, outside areas of population concentration, the water level decline rates have been about the same as the pre-1966 rates.

Wells in the Palominas-Hereford area experienced water table declines of about 8-15 feet, depending on the period and well location (Figure 3-3-d). Due to their proximity to the stream, wells in this area are greatly influenced by seasonal fluctuations in streamflows. The proximity to a renewable water supply prevents the water table from dropping even deeper in these wells.

3.2 SURFACE WATER SYSTEM

The Upper San Pedro Basin is drained by the San Pedro River and its tributaries. The area draining to "The Narrows" is about 2,500 square miles, of which 696 are in Mexico. The headwaters of the San Pedro River are north of Cananea, Sonora, Mexico, about 30 miles south of the International Border. The river enters the United States in Section 18, T24S, R22E near Palominas, Arizona, and flows northward. Within the upper basin the river runs 62 miles before leaving the basin at "The Narrows". The Babocomari River and Aravaipa Creek are the major tributaries in the upper basin. Only the Babocomari River is included in the study area. The San Pedro River is a perennial stream in several places, and is intermittent in others. Putman *et al* (1988) indicate the perennial reach as going from Hereford to just south of Fairbank, totaling 25 miles. The same source describes the Babocomari River as being perennial over two different reaches, together covering 12 miles. All minor drainageways are ephemeral, carrying flow only when precipitation events occur. Figure 2-3 in Chapter 2 depicts the drainage structure of the upper basin.

3.2.1 San Pedro River

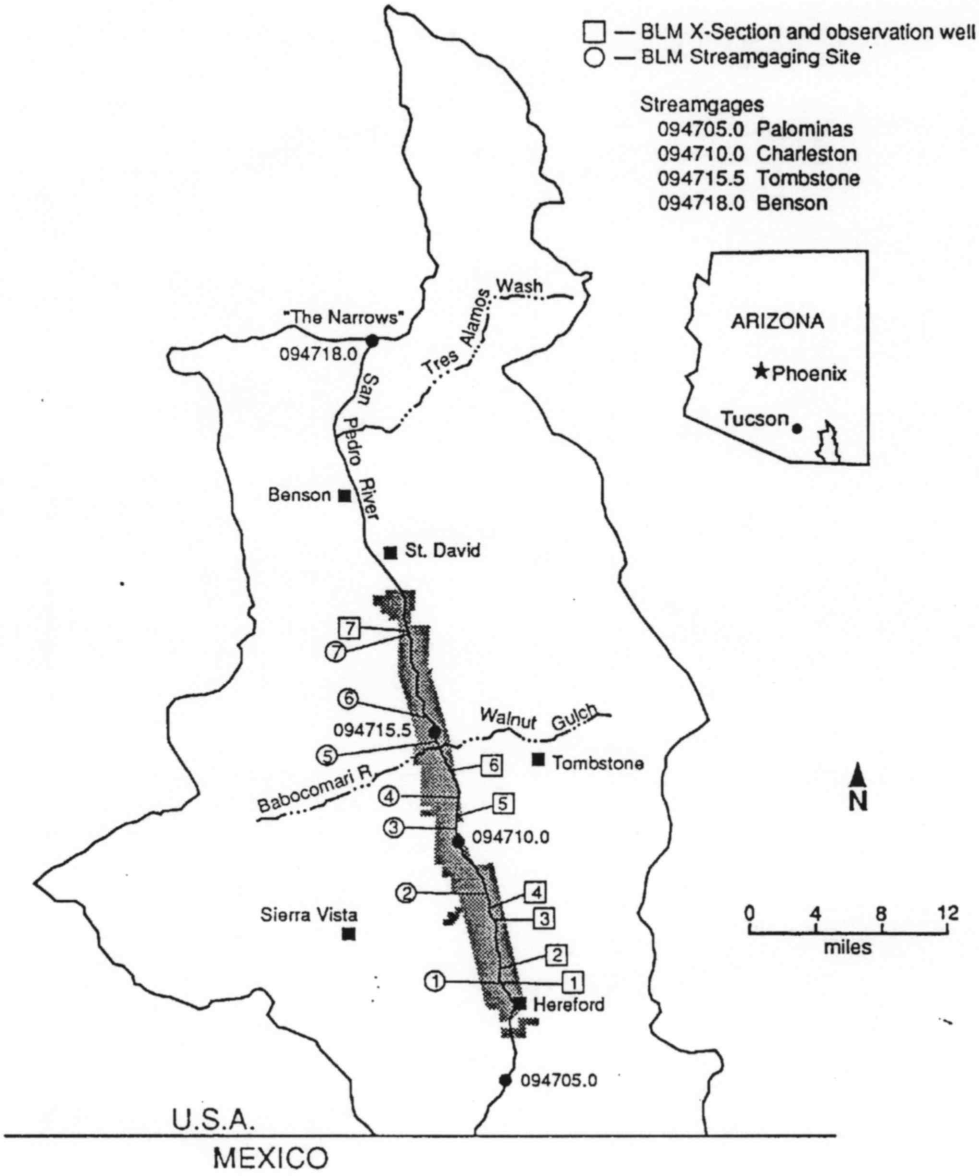
Streamflows in the San Pedro River have two components: runoff and baseflow. Runoff occurs after precipitation events or as a result of snowmelt. This component may persist for a few days until it is lost either to outflow from the basin or to storage in the river banks. The highest annual flows in the San Pedro and its tributaries occur between July and September in response to summer thunderstorms. These river flows are characterized by extremely rapid rises in river stage, high peak flow rates, and rapid declines back to baseflow conditions. A second rainfall-runoff period, less intense, occurs in winter time (November to March). Precipitation events during this season generally produce much lower peak flow rates.

Baseflows sustain streamflow in the dry season. Geologic restrictions near Charleston force the groundwater up into the alluvial aquifer, which in turn is discharged to the stream, maintaining perennial flows in the Hereford-Fairbank reach.

Except along the perennial reaches, the San Pedro River is an intermittent stream. Development, natural uses and climatic conditions influence streamflows. When phreatophyte and crop consumption use is high, groundwater discharge to the stream is intercepted by wells and plant roots, and no baseflow is maintained.

Four stream gaging stations are located along the Upper San Pedro River Basin: Palominas, Charleston, near Tombstone and near Benson (see Figure 3-4 and Table 3-1). All four stations were originally maintained by the USGS, but at the present time the USGS operates only two, Charleston and near Tombstone. The U.S. Section, International Boundary and Water Commission maintains the station at Palominas. Record length differs at each station, the only common period being from 1968 to 1976 (9 years), a short period to perform correlation analyses. Table 3-1 provides station locations, drainage area and period of record.

Streamgage Locations in the Upper San Pedro Basin
Jackson *et al*, 1987)
Figure 3-4



USGS Stream Gaging Stations
(Data Source: Putman *et al*, 1988)
Table 3-1

STATION NAME	DRAINAGE AREA (square miles)	COMBINED PERIOD OF RECORD
San Pedro River at Palominas,AZ 094705.00 (1) T23S R22E Sect.33	741 (649 in Mexico)	1936-1940 1951-1983 (2)
San Pedro River at Charleston,AZ 094710.00 (1) T21S R21E Sect.11	1,219 (696 in Mexico)	1936-1983
San Pedro River near Tombstone,AZ 094715.50 T19S R21E Sect.28	1,740 (696 in Mexico)	1968-1983
San Pedro River near Benson,AZ 094718.00 T15S R20E Sect.15	2,500 (696 in Mexico)	1968-1976

(1) within the study area
(2) since October 1, 1981 has been maintained by U.S. Section, International Boundary and Water Commission

Since 1987, when the San Pedro Riparian National Conservation Area was established, the BLM has measured streamflows at 10 locations within its property. Measurements are not taken on a daily basis, but rather on a variable number of days per month and not always the same days from month to month. At present, the period of record is too short to be used for any statistical analyses other than to indicate trends.

The new river-aquifer interaction module for MODFLOW includes a simple representation of the surface water regime. Based on streamflow data provided by the user, the package can calculate the stage in the stream (a more complete description of the module is provided in the following chapter). The need for streamflow data motivated a detailed analysis of monthly and annual streamflows at the gaging stations along the Upper San Pedro River. Annual flows were used to develop the steady state ground-water model and for the transient state ground-water model.

3.2.1.1 Annual flows

The USGS gaging station at Charleston provides one of the most complete records along the river with 69 years of continuous data collection. Several authors have used the Charleston data to analyze streamflows and correlate stations. Putman *et al* (1988) compared flows at different gaging stations with flows at Charleston, and calculated correlation coefficients and coefficients of a linear regression of the form,

$$Q_{est} = a + b \cdot Q_{Ch} \qquad (2)$$

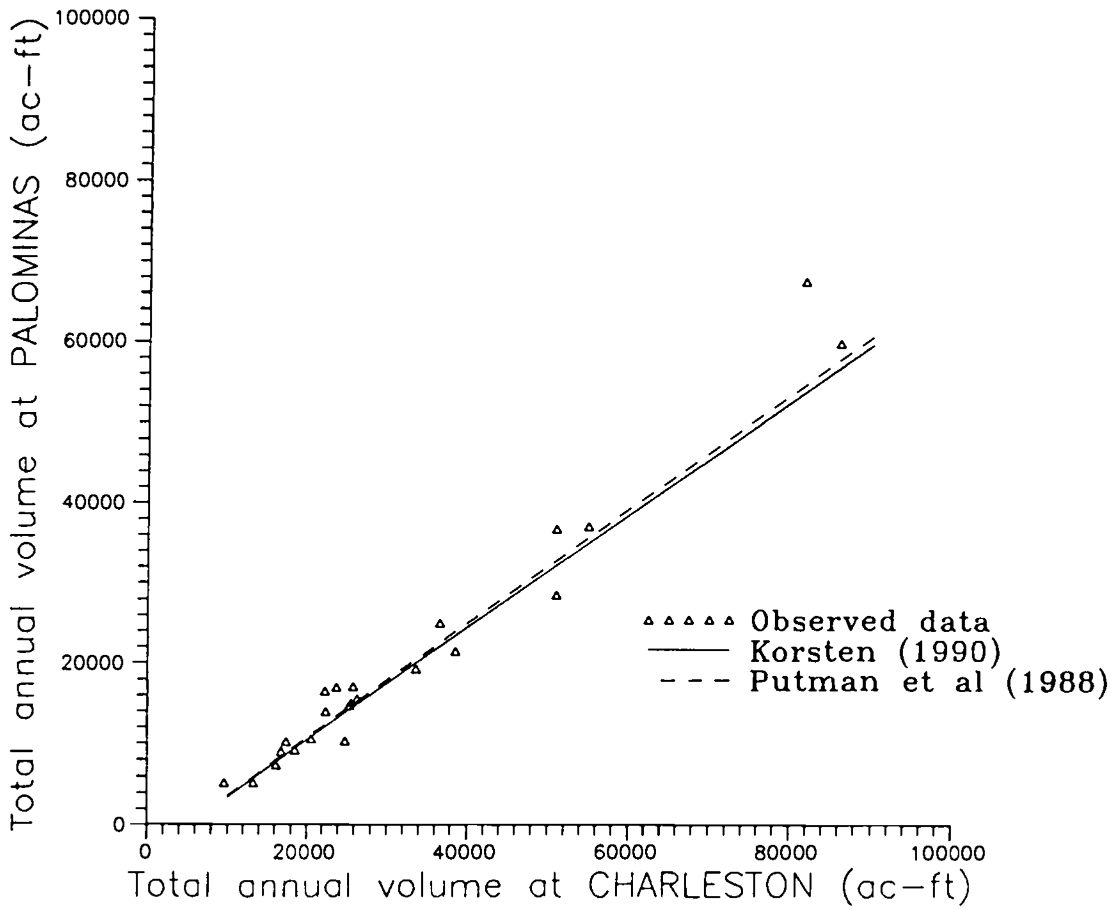
where,

Q_{est} = total annual flow at a given station (acre-feet/year)

Q_{Ch} = total annual flow at Charleston (acre-feet/year).

Korsten (1990) performed a similar regression analysis. Results from both authors are condensed in Table 3-2. Some differences between the regression equations used by Korsten (1990) and those used by Putman *et al* (1988) exist, particularly for the Tombstone station. However, at Palominas, a station within the study area, the equations are approximately the same. Observed and calculated total annual volumes of streamflows at the Palominas station are plotted in Figure 3-5.

Total Annual Volumes at Palominas Calculated Using Charleston Volumes
Figure 3-5



Jackson *et al* (1987) studied the total annual flow at Charleston with the purpose of analyzing overall trends. They concluded that:

> *"There has not been a significant trend- either up or down- in annual runoff during the period 1931-1985. However, there is a highly significant negative trend in annual runoff when the period is extended back to 1902. This is because of a number of very large flood events between 1910-1926".*

Analysis of annual runoff gives no conclusion in terms of the influence, if any, of recent pumping over streamflows. At any particular station, the annual flow varies widely from year to year, but tends to behave the same way at all stations, i.e. it rises or falls at all locations. Lower than average flows predominate, however, a succession of high annual flows followed by low annual flows is not uncommon. Mean annual flows at Charleston are tabulated in Table 3-3. Mean discharge and winter and summer peak discharge are also tabulated to show the wide range of flows.

Results of Regression Analysis for Total Annual Flow at Palominas and Tombstone as a Function of Charleston (Source: Putman *et al*, 1988; Korsten, 1990)
Table 3-2

STATION	Putman et.al.			Korsten		
	years	a	b	years	a	b
PALOMINAS	37 (*)	-3552.18	.713	36 (*)	-3612.4	.7026
Near TOMBSTONE	16	+6934.36	.860	17	+3104.9	1.012

(*) : discontinuous period of record

Korsten (1990) separated storm runoff and baseflow for data from the Palominas, Charleston and Tombstone gages, and determined regression equations at each station of the form:

$$V_B = a_B + b_B \cdot V_T \tag{3}$$

where

V_B = annual baseflow volume (acre-feet)

V_T = annual total flow volume (acre-feet)

Mean annual flow at Charleston Streamgage Station
(After Jackson *et al*, 1988)
Table 3-3

Water Year	Mean discharge (cfs)	Total Runoff Ac-ft	Peak Winter (Nov-Mar) Flow (cfs)	Peak Summer (July-Sept) Flow (cfs)
1905	62.0	44,880	669	287
1913	32.8	23,710	211	846
1914	106.0	76,540	1,120	3,000
1915	206.0	149,300	3,000	1,090
1916	47.2	34,280	400	1,760
1917	125.0	90,180	105	5,180
1918	28.0	20,290	20	920
1919	128.0	93,010	56	6,050
1920	57.2	41,760	590	860
1921	140.0	101,500	9	6,700
1922	50.4	36,500	23	1,900
1923	58.3	42,230	33	3,080
1924	34.8	25,260	562	524
1925	50.8	36,790	14	2,400
1926	170.0	122,700	38	98,000
1927	1.4	51,660	60	2,050
1928	27.7	20,070	27	350
1929	74.7	54,070	64	3,650
1930	73.9	53,500	65	3,590
1931	89.7	64,960	476	4,090
1932	63.3	45,940	717	1,720
1933	38.9	28,140	102	1,430
1934				
1935	2,000.0			
1936	61.6	44,700	630	3,400
1937	77.3	55,980	38	3,880
1938	47.8	34,610	58	2,290
1939	68.8	49,800	625	3,080
1940	80.6	58,490	163	9,100
1941	56.3	40,730	1,720	2,530
1942	32.8	23,720	164	852
1943	65.8	47,620	21	2,910
1944	33.5	24,300	43	1,240
1945	52.2	37,820	31	3,190
1946	46.3	33,490	25	3,760
1947	44.6	32,290	20	2,920
1948	45.7	33,170	24	1,530
1949	65.2	47,180	263	1,880
1950	43.4	31,430	72	1,950

Table 3-3 (continued)

Water Year	Mean discharge (cfs)	Total Runoff Ac-ft	Peak Winter (Nov-Mar) Flow (cfs)	Peak Summer (July-Sept) Flow (cfs)
1951	27.2	19,660	19	1,010
1952	26.0	26,140	16	1,840
1953	39.2	28,400	60	3,330
1954	120.0	86,730	16	5,690
1955	120.0	86,910	23	4,050
1956	28.2	20,500	25	1,330
1957	31.0	22,430	73	1,400
1958	103.0	74,740	29	3,890
1959	60.9	44,070	30	3,960
1960	33.5	24,300	1,250	470
1961	30.9	22,390	21	1,010
1962	18.3	13,280	156	457
1963	46.4	33,630	14	2,130
1964	75.6	54,910	45	5,510
1965	22.3	16,130	23	929
1966	50.5	36,590	508	1,230
1967	32.8	23,720	16	1,620
1968	35.6	25,850	2,400	404
1969	24.0	17,360	15	861
1970	36.3	26,280	20	1,780
1971	70.4	50,980	19	2,200
1972	34.1	24,780	26	2,060
1973	28.4	20,550	484	574
1974	53.2	38,530	26	3,410
1975	30.7	22,230	18	1,550
1976	35.2	25,530	67	1,400
1977	35.0	25,330	25	841
1978	119.0	86,090	263	23,700
1979	113.0	81,630	7,750	482
1980	13.2	9,590	23	287
1981	25.6	18,530	11	656
1982	23.1	16,740	12	1,830
1983	41.3	29,870	865	665
1984	122.0	88,870	524	2,930
1985	70.5	51,050	6,090	1,950

Korsten (1990) interpreted the mean errors of the regression constant, a_B, to indicate that, on the average, the equation represented actual data with errors of:

23.70 % at Palominas

30.20 % at Charleston

40.53 % at Tombstone

The computed mean annual baseflow at Palominas was 4.84 cfs (3475.5 acre-feet) and at Charleston 15.23 cfs (11,029.4 acre-feet), the flow at Charleston being 3.17 times greater than at Palominas.

Although the separation of the baseflow component from the total flow volume is extremely useful in characterizing the river-aquifer interaction process, two aspects of this analysis deserve further consideration:

a) At any station, the period of record should be long enough to indicate the cycles of dry and wet years.

b) At the three stations, the records should be of equal length and concurrent to assure that the same type of flow distribution is represented, i.e. simultaneity of low or high flows at all three.

Applying equation (3) to observed annual volumes for 33 years (water year 50/51 to water year 82/83), the following results are obtained:

Palominas

Mean annual baseflow = 4.27 cfs

Standard deviation = 2.84 cfs

Charleston

Mean annual baseflow = 14.47 cfs

Standard deviation = 3.87 cfs

A comparison with Korsten's results indicates that with a longer period of record, the mean annual baseflow at Charleston is 3.38 times greater than that at Palominas.

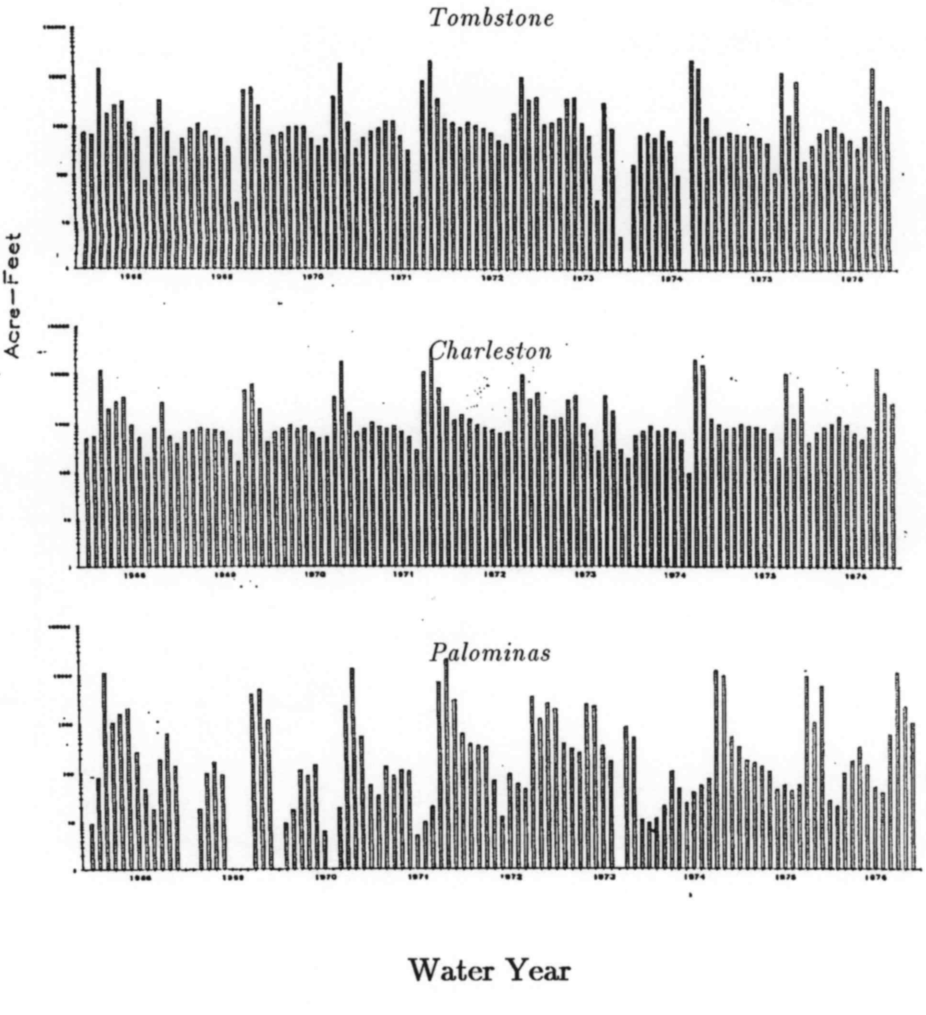
3.2.1.2 Monthly flows

Monthly flows at Palominas, Charleston and Tombstone are depicted in Figure 3-6. Table 3-4 provides monthly streamflow volumes at the three stations for the period 1968/1976. Volumes fluctuate between values close to zero and thousands of acre-feet, showing once again the high variability and seasonal characteristics of the flow regime. Minimum flows occur in the late fall and the early spring, and maximum flows in the summer and the winter.

Mean monthly discharges at the three gaging stations are summarized in Table 3-5a. Jackson *et al* (1987) state that the mean monthly discharges provide an inadequate indication of average monthly runoff volumes. They also suggest that if a representation of daily flows is desired, the median monthly flows (Table 3-5b) should be used as these flows are less variable than mean monthly flows.

According to Jackson *et al* (1987), the median daily flows average 2 cfs at Palominas, 14 cfs at Charleston, and 12 cfs at Tombstone. At Palominas, discharge is less than 1 cfs about 37 percent of the time, and greater than 100 cfs less than 5 percent of the time. At Charleston, discharge is less than 10 cfs about 30 percent of the

Monthly discharge at streamgage stations
in the Upper San Pedro Basin
(After Putman *et al*, 1988)
Figure 3-6



Monthly flows at the USGS streamgage stations in the Upper San Pedro Basin (volume in acre-feet) (after Putman *et al*, 1988)

Table 3-4

STAT	YEAR	OCT	NOV	OEC	JAN	FEB	MAR	ABR	MAY	JUN	JUL	AUG	SET
P	68	9	80	10960	1060	1060	1580	2040	258	46	18	184	608
A	69	0	0	18	96	163	91	0	1	1	3890	4800	1150
L	70	1	9	17	111	84	138	6	1	18	2180	12450	510
O	71	59	36	143	94	123	116	5	10	21	8050	24750	3330
M	72	665	410	378	358	73	13	101	63	49	3940	1340	2840
I	73	2170	415	331	277	2770	2510	373	183	1	920	555	11
N	74	9	11	20	103	45	23	39	53	74	11510	9010	514
A	75	324	173	155	133	105	45	54	42	57	3880	1020	5466
S	76	26	20	98	170	320	143	50	39	574	10410	2130	1000
C	68	486	542	11360	1960	2720	3300	902	515	199	788	2540	540
H	69	379	655	704	799	746	730	650	429	162	4470	5760	1870
A	70	406	626	758	863	722	829	607	468	499	3170	15830	1490
R	71	629	756	992	815	756	851	655	511	270	10260	29720	4770
L	72	2020	1110	1390	1150	873	776	682	595	620	3920	8770	2870
E	73	3870	1330	1090	1180	2750	3310	908	676	248	330	1630	268
S	74	181	530	649	807	664	742	631	425	89	18410	14260	1150
T	75	889	726	785	906	827	803	746	589	186	9690	1180	4890
O	76	380	614	787	906	1290	897	599	452	808	12400	3970	2420
N													
T	68	734	660	14470	1790	2680	3160	1180	586	75	888	3350	744
O	69	229	546	887	1110	755	620	550	366	26	5240	6020	2610
M	70	203	631	724	961	976	974	555	387	562	4080	18730	1220
B	71	351	601	803	942	1320	1310	651	327	35	8740	21930	3730
S	72	1420	1210	956	1240	1070	926	751	519	448	1840	10150	3520
T	73	4010	1110	1220	1530	3730	3990	1200	658	30	3110	905	5
O	74	0	167	681	757	607	849	536	101	0	22690	15700	1620
N	75	661	659	812	730	700	674	626	487	114	13120	1860	8760
E	76	204	430	783	932	1060	778	567	377	668	16430	3710	2810

Monthly discharge (cfs) at the USGS streamgage stations Period 1931-1983 (Modified after Jackson *et al*,1987)

MEAN DISCHARGE

Table 3-5a

MONTH	PALOMINAS	CHARLESTON	TOMBSTONE
Oct	25.5	36.4	99.0
Nov	5.1	14.9	14.6
Dec	22.2	31.2	50.0
Jan	22.9	33.5	52.5
Feb	11.5	25.3	41.2
Mar	8.4	21.4	36.4
Apr	2.9	12.4	13.3
May	1.3	8.3	7.3
Jun	4.1	10.5	3.9
Jul	89.8	122.4	113.0
Aug	151.0	230.0	158.0
Sep	35.7	64.0	56.4

MEDIAN DISCHARGE
Table 3-5b

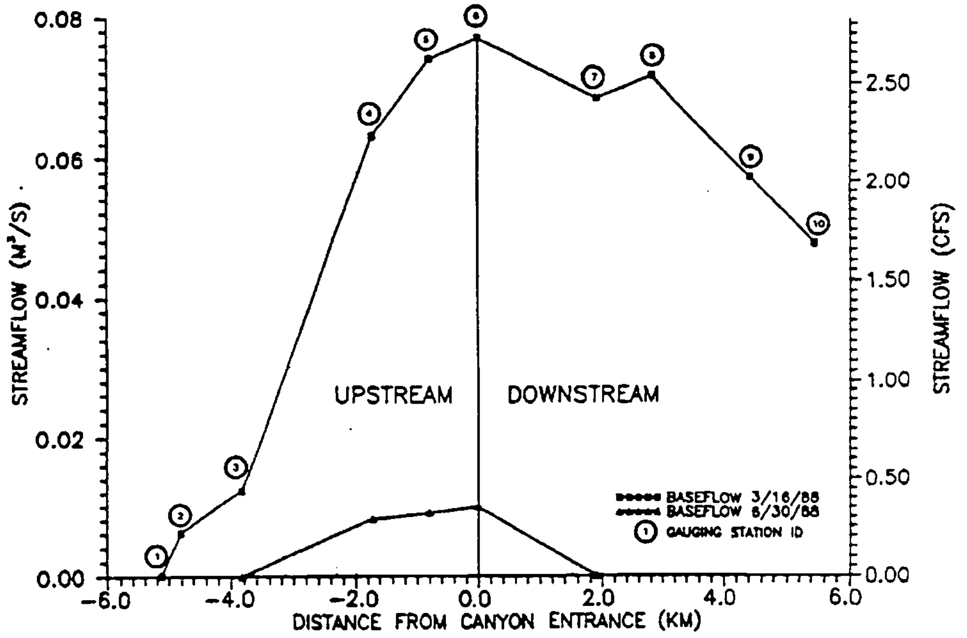
MONTH	PALOMINAS	CHARLESTON	TOMBSTONE
Oct	3.7	12.2	13.0
Nov	3.6	13.6	12.2
Dec	5.5	17.1	20.2
Jan	10.9	23.5	35.8
Feb	8.6	20.3	32.1
Mar	6.3	18.9	29.1
Apr	2.5	12.2	15.7
May	1.2	7.9	1.4
Jun	0.6	4.2	30.0
Jul	15.7	29.1	67.2
Aug	51.9	91.6	18.4
Sep	10.7	24.2	18.4

time, and greater than 100 cfs less than 10 percent of the time. Finally, at Tombstone, the discharge is less 1 cfs over 10 percent of the time, and greater than 100 cfs about 7 percent of the time. Use of flow duration curves provides the same conclusions for streamflows variabilities.

3.2.2 Tributaries

The Babocomari River is the main tributary within the study area. It is considered a predominantly ephemeral stream, however shallow water tables help to maintain streamflow over most of the year throughout some reaches. This tributary has a similar flow regime to that of the San Pedro River. Monsoon rains produce high discharges, arriving on time to restore the streamflows depleted during the hot and dry summer months. During the winter, baseflows are supported by local groundwater discharge.

Streamflows at the Babocomari River
(After Schwartzman, 1990)
Figure 3-7



The Babocomari River has not been gaged on a regular basis. Recently, the Bureau of Land Management started gaging the stream a short distance upstream of its confluence with the San Pedro River. As with the San Pedro (Section 3.2.1), these data are scattered in time, and the exact location of the gaging station is not precisely defined. Schwartzman (1990) assessed the hydrologic field data available in the area. Schwartzman surveyed approximately 12-13 miles of the stream, dividing them into five river stretches, each with a distinctive flow regime ranging from perennial reaches with very low baseflow to ephemeral reaches and scattered standing ponds and puddles. His work included the seasonal gaging of the river to determine baseflow conditions. One gaging was performed in late winter (March 1988), and the other one in early summer

(June 1988). March's flows were measurable along the whole stretch surveyed, and June's flows showed a depleted stream as a consequence of evapotranspiration losses. Figure 3-7 depicts both hydrographs.

Before this gaging, Putman *et al* (1988) had estimated annual runoff generated by precipitation events within the Babocomari watershed using the Mooseburner regional regression equation for watershed yield. Annual runoff was estimated to be about 1,477 acre-feet/year.

3.2.3 Water Use

No major surface water use is reported within the study area. Outside the study area, the Pomerene canal and the Saint David ditch supply water for irrigation in those towns. The HSR report (1990) documents irrigation diversions.

3.3 GROUND-WATER/SURFACE WATER INTERACTION

For interrelated hydrologic systems, an understanding of the individual hydrologic units is essential, but understanding the interactions between them is also crucial. Only such an understanding will allow the assessment of the extent to which changes in one part of the system will influence other parts.

The ground-water/surface water interaction manifests itself between the floodplain alluvial and the streams network. These two conduits of water form a complex system called the inner valley. The inner valley supports almost the entire phreatophyte population and a great deal of the agricultural land. The proximity of this land to a renewable source of water (the stream) has resulted in a large number of irrigation wells located in the floodplain. These wells may have an immediate effect on river flows, while wells located in the regional aquifer, away from the inner valley, can cause an effect much delayed in time.

The inner valley receives both groundwater and surface water. Groundwater enters the inner valley through the International Border. Water from the regional aquifer migrates toward the floodplain through the contact surface between both aquifers. Upward leakage from the confined portions of the regional aquifer is another mechanism by which groundwater is discharged into the floodplain aquifer. The water that finds its way to the river is the source of the stream baseflow.

Within the modeled area, the San Pedro River is mainly a gaining stream, i.e. water flows from the ground-water system to the river, sustaining streamflows during most of the year. When cultural uses and natural uses are at their maximum (hot season), the water table may fall below the stream stage. Consequently, the flow direction reverses and the stream loses water to the alluvial aquifer.

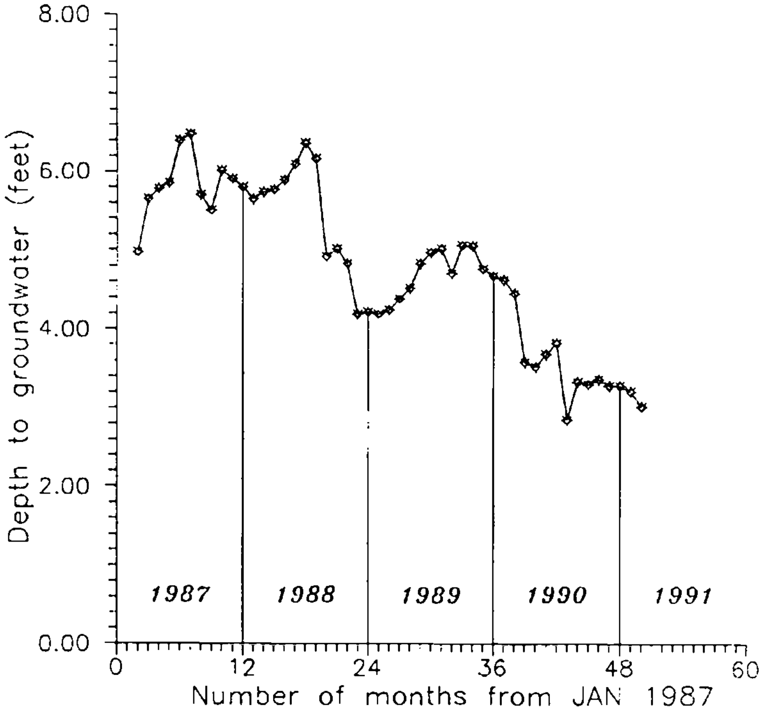
A portion of the runoff induced by rainfall or snowmelt can also recharge the floodplain alluvial when storage space is available. After the dry season, the vegetation and irrigation wells have removed enough water from the floodplain aquifer to create a significant unsaturated zone (Putman *et al*, 1988). This storage space is quickly replenished by runoff produced by flood events. When the rainy season is over the stream stage falls below the head elevation in the saturated alluvial aquifer and water starts migrating back to the river. Thus, baseflow conditions are slowly reestablished.

The water table in the floodplain aquifer is relatively shallow within the riparian corridor. Wells in the shallow water table reflect changes in river stage, giving evidence of the hydraulic connection between the surface water and the ground-water systems. Depth to groundwater varies locally. Around Hereford it averages 4 to 6 feet, reaching more than 10 feet near the Hereford Bridge. In the Palominas area the water table is found around 13-14 feet below the land surface.

Well data collected by the BLM since 1987 (tabulated in Appendix A-Table 1) were used to analyze water level fluctuations near the stream. Figure 3-8 shows the depth to the water table measured at well (D-23-22)10ada, located 128 feet away from the river. The figure illustrates a recovery trend since the beginning of the data collection. On a smaller time scale, i.e. on a monthly basis, the graph provides an indication of a seasonal cycle of depletion and recovery as a result of the combination of the evapotranspiration process and the streamflow regime.

The stream-aquifer interaction process in semi-arid environments is recognized as being a critical process in sustaining riparian communities. In spite of this fact, field and laboratory experiments studying the relationship between losing/gaining streams and their adjacent alluvial aquifers are not abundant. Matlock (1964) conducted some

Well (D-23-22)10ada Hydrograph
Figure 3-8



experiments aimed at describing the formation of a silt layer in the streambed that would control the river-aquifer interconnectedness. Years later, Kreager-Rovey (1974) proposed a mathematical description of this phenomenon. Recent field and laboratory analyses of streambed and alluvial materials performed at the Bill Williams Watershed in West Central Arizona, have proved, for that particular stream, the existence of a thin low permeability layer that reduces seepage through the streambed (Rivers West Inc., 1990).

The Southwest Watershed Research Center (USDA-ARS) in Tucson, Arizona, has done research related to this subject in the Walnut Gulch Experimental Watershed. The Walnut Gulch is an ephemeral stream discharging into the San Pedro River on its east side and draining 58 square miles. Transport processes and bed material composition were intensively studied. The presence of a well defined silty layer in the streambed has not been reported as such. No similar studies are known to exist for the San Pedro main stem. Some of the conclusions obtained in the Walnut Gulch Watershed could be extrapolated to the San Pedro River, keeping in mind the different flow regimes in the two streams (purely ephemeral versus perennial). Nevertheless, shallow clay lenses randomly located and fine bed materials with much lower permeabilities than the alluvial deposits may exist. It is not the purpose of this study to analyze transport and erosion processes and streambed materials. However, some knowledge about the composition of the latter helps to define the streambed conductance term, which in turn governs the seepage through the bottom of the streambed. A more detailed explanation of this parameter is provided in the following chapter.

Chapter 4
Hydrologic Model and Simulation

4.1 INTRODUCTION

The present chapter documents the conceptual and flow models developed for this study. For the present modeling activity, a new module (Prudic, 1989) that improves the river-aquifer interaction representation is implemented, and new data and interpretive studies on aquifer properties, pumpage and stream-aquifer interactions are incorporated. A previous study by Freethey (1982) provided a base for the present study. The Freethey study simulation period extends from 1940 to 1977. For the present study, the simulation period was increased from 1978 to 1988 using the Arizona Department of Water Resources updated pumping data.

4.2 FLOW MODEL

The governing partial differential equation for transient flow through a saturated, non-homogeneous, anisotropic porous medium of spatial domain D is,

$$\nabla \cdot [K(\hat{x}) \cdot \nabla h(\hat{x}, t)] - S_s(\hat{x}) \frac{\partial h(\hat{x}, t)}{\partial t} = W(\hat{x}, t) \tag{4}$$

and is subject to the initial conditions,

$$h(\hat{x}, 0) = H_0(\hat{x}) \tag{5}$$

within D, and boundary conditions,

$$\left[K \cdot \nabla h \cdot \hat{n} - c_b(H_b - h) - Q_b\right]\Big|_{\Gamma} = 0 \qquad (6)$$

along the boundary Γ of the domain D, and where,

$\hat{x}$ is (x, y, z), the three-dimensional coordinate directions and are assumed parallel to the principal coordinate directions of hydraulic conductivity, [L];

t is the time, [T];

K is the hydraulic conductivity tensor,[LT^{-1}];

h is the hydraulic head, [L];

W is the volumetric flux per unit volume and represents sources and/or sinks, [T^{-1}];

S_s is the specific storage of the aquifer material [L^{-1}];

$\hat{n}$ is the normal vector to the boundary Γ, [0];

c_b is the capture coefficient that controls the quantity and type of capture from the boundary Γ, [T^{-1}],

1) if $c_b = 0$, there is no capture from the boundary, the boundary is a prescribed flow boundary, and the natural recharge and discharge through the boundary are not affected by pumpage,

2) if $c_b = \infty$, there is a prescribed head condition on Γ and there is unlimited capture potential from the boundary, and

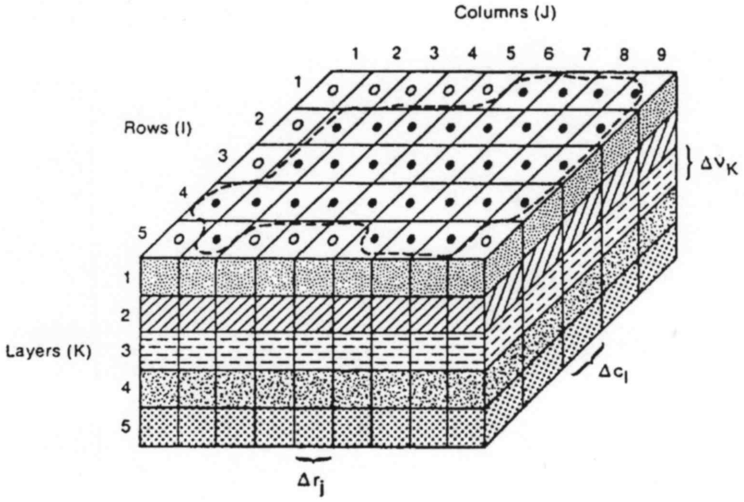
3) if c_b is otherwise, c_b is a capture coefficient for induced flow from the boundary (the boundary condition is called a head-dependent boundary);

H_b is a prescribed head, [L];

Q_b is a prescribed flow per unit surface area of the boundary Γ, [LT^{-1}].

Analytical solutions to the above partial differential equation with associated initial and boundary conditions are rarely possible except for very simple ground-water flow systems, and numerical techniques must be applied to obtain approximated solutions. The *Modular Three-Dimensional Finite-Difference Groundwater Flow Model* (MODFLOW), developed by McDonald and Harbaugh (1984), applies a finite difference scheme to Equations (4)-(6) and replaces the continuous formulation with a finite set of discrete points in time and space (Figure 4-1).

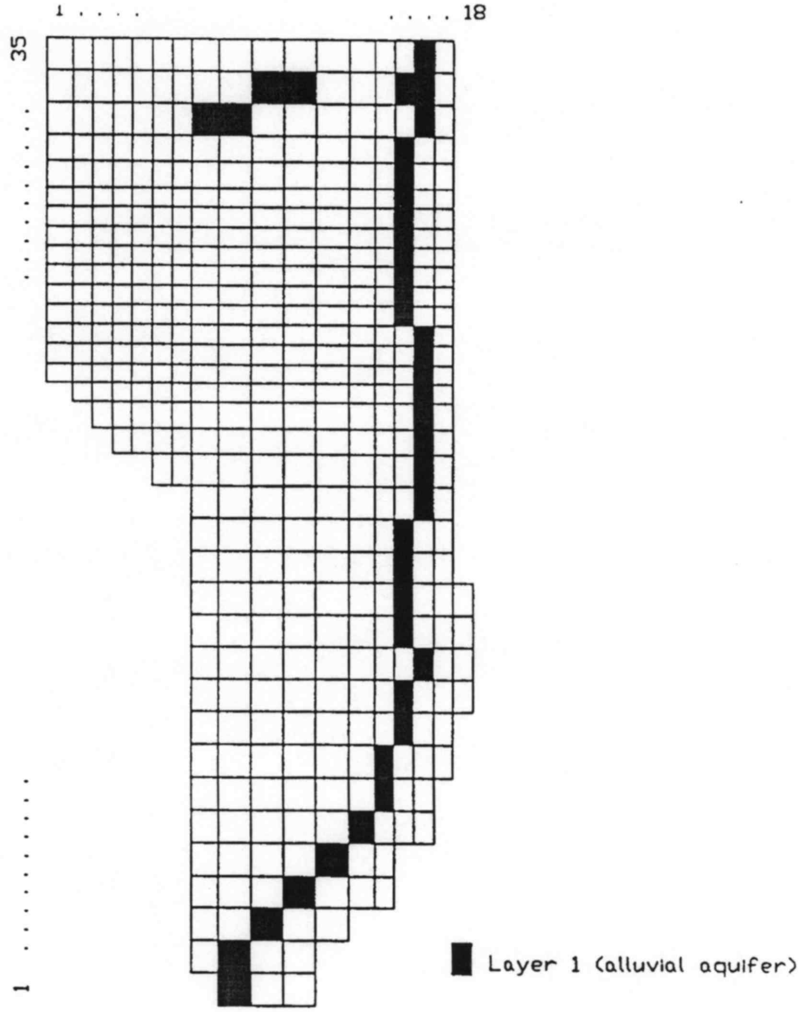
A Discretized Hypothetical Aquifer System
(McDonald and Harbaugh,1984)
Figure 4-1



The process leads to a set of simultaneous linear algebraic equations for the heads at node points. A node point is in the center of each cell within the finite difference grid.

MODFLOW has a modular structure allowing the user to incorporate a series of packages or modules to simulate different ground-water flow processes: recharge, river-aquifer interaction, evapotranspiration, drains, and well pumpage. Different solution algorithms and variable output formats are also available.

Model grid: active cells for Three Layers*
Figure 4-2



* Layer 1 is the shaded region, layers 2 and 3 include the shaded region and the rest of the active cells.

4.3 FINITE DIFFERENCE GRID

The finite difference grid applied to the modeled region is oriented in a southeastern-northwestern direction, paralleling the predominant river flow direction. Areally, the system is discretized into 18 rows and 35 columns, with high resolution where large variations in aquifer properties and large stresses occur (Figure 4-2).

Vertically, the aquifer system is represented as a three layer system. The first layer (shaded region, Figure 4-2) delineates the floodplain alluvial aquifer. This unit extents along a narrow strip encompassing the San Pedro River and the Babocomari River, having a maximum width of 1 mile. The thickness of this layer ranges between 10 feet and 60 feet. The second layer (all active cells, Figure 4-2) represents the upper basin fill. The thickness of this layer varies between a few feet at the basin boundary to 940 feet at the valley center. The third and lower most layer (all active cells, Figure 4-4) extends deeper than 1,000 feet and represents the lower basin fill. The active cell designator (IBOUND) for input to MODFLOW is given in Chapter 8 for each layer.

4.4 HYDRAULIC PROPERTIES

The hydraulic properties of the basin that are required for input to MODFLOW are the distribution of transmissivity and storage coefficients for confined aquifers, the distributions of hydraulic conductivity, aquifer bottom elevation and specific yield for unconfined aquifers, and, in addition, the aquifer top elevations if the aquifer is convertible between confined and unconfined. The model has three layers so that vertical conductance values are required for the upper two layers.

4.4.1 Floodplain Aquifer

The floodplain alluvial aquifer is assumed to behave as an unconfined aquifer (LAYCON = 1). The hydraulic conductivity of the floodplain alluvial aquifer is assumed to be isotropic and to be distributed uniformly at 1.93E-03 ft/sec. The initial water-table elevation, the aquifer bottom elevation and the vertical conductance are given for each node of the floodplain aquifer in Table 4-1. The specific yield is assumed to be constant, 0.12.

Initial Water-Table Elevation, Aquifer Bottom Elevation and
Vertical Conductance for the Floodplain Aquifer
Table 4-1

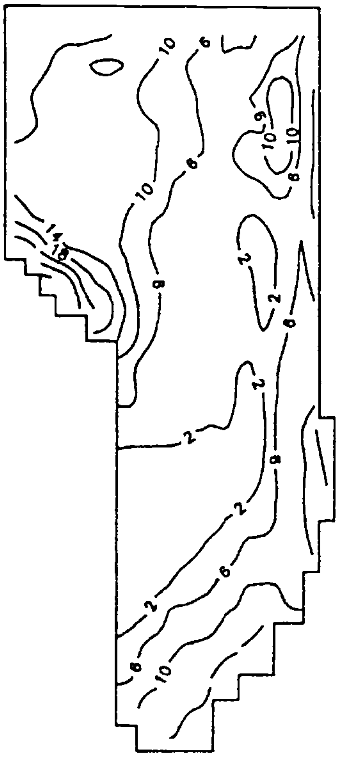
Row	Column	Bottom elevation (ft)	Initial head (ft)	Vertical conductance (E-06 ft)
9	2	4233	4285.4	0.1519
10	3	4220	4259.8	0.1509
11	4	4210	4239.9	0.1494
12	5	4196	4221.0	0.1485
13	6	4185	4206.7	0.1486
14	7	4140	4184.0	0.1270
14	8	4130	4175.7	0.1298
15	9	4120	4154.4	0.1258
15	10	4108	4143.6	0.1247
16	11	3880	4131.2	0.1283
15	12	4053	4113.1	0.1350
15	13	4040	4100.4	0.1270
15	14	4020	4085.1	0.1283
15	15	4010	4074.9	0.1283
16	16	4035	4060.0	0.1239
16	17	4021	4045.6	0.1231
16	18	4014	4037.9	0.1336
16	19	4008	4031.2	0.1242
16	20	4000	4021.9	0.3347
16	21	3990	4012.0	1.9150
16	22	3995	4002.0	2.1310
16	23	3990	3995.9	2.1310
15	24	3973	3980.9	0.2817
15	25	3952	3962.3	1.8510
15	26	3943	3952.6	1.0670
15	27	3935	3944.0	2.0910
15	28	3920	3929.8	2.1850
15	29	3910	3918.4	2.1850
15	30	3880	3908.3	1.4060
15	31	3850	3896.9	0.9192
15	32	3840	3887.4	0.7974
16	33	3800	3859.0	0.4288
16	34	3790	3854.5	0.2143
8	33	4050	4106.2	0.2409
9	33	4033	4097.7	0.1785
10	34	4004	4062.9	0.2627
11	34	4020	4048.5	1.0070
15	34	3815	3861.5	0.0680

4.4.2 Upper Basin Fill Aquifer

The upper basin fill aquifer is assumed to be convertible between confined and unconfined (LAYCON = 3). The hydraulic conductivity distribution for the upper basin fill is shown in Figure 4-3. As with the floodplain alluvial aquifer, the hydraulic conductivity is assumed to be isotropic. The specific yield for the upper basin fill aquifer is heterogeneous and is shown in Figure 4-4.

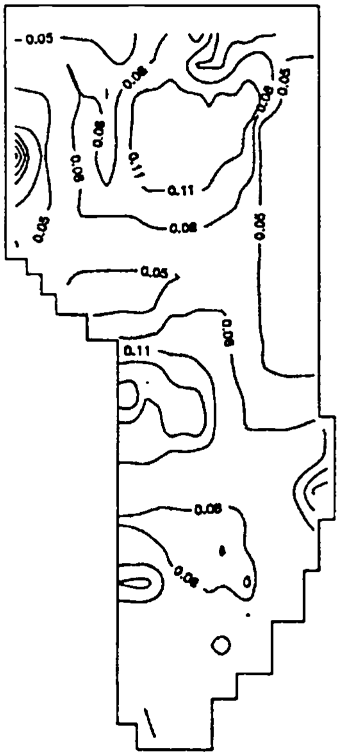
Hydraulic Conductivity Distribution
for Upper Basin Fill Aquifer
(units ft/sec × 0.604410^{-5})

Figure 4-3



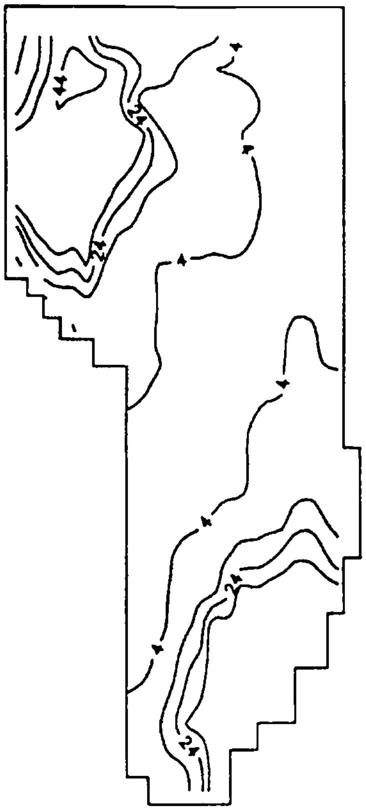
Specific Yield Distribution for
Upper Basin Fill Aquifer with
Contour Interval=0.03

Figure 4-4

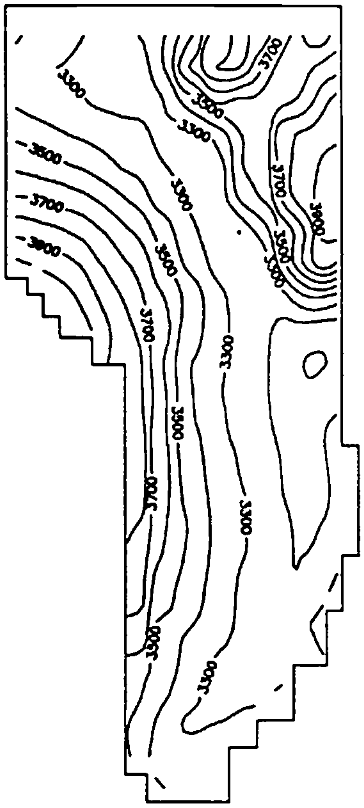


The initial water-level elevations are the steady-state water-level elevations and are shown in the steady-state modeling section of this report (see Figures 4-15). The vertical conductance distribution and the aquifer bottom elevations are shown in Figures 4-5, 4-6, respectively. The transmissivity for the upper basin fill is the product of the saturated thickness and the hydraulic conductivity. The saturated thickness is the difference between the hydraulic head in the upper basin fill and the aquifer bottom elevation for the upper basin fill, with both the hydraulic head and the bottom elevation having the same datum.

Vertical Conductances for Upper Basin Fill Aquifer; Contour Interval = 10 (units ft/sec × 10^{-7})
Figure 4-5



Bottom Elevation for Upper Basin Fill Aquifer; Contour Interval = 100 (units feet)
Figure 4-6

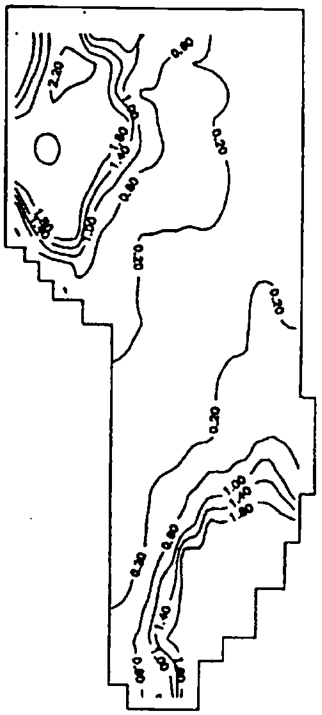


The arrays of numerical data for the hydraulic properties of the upper basin fill aquifer are found in Chapter 8.

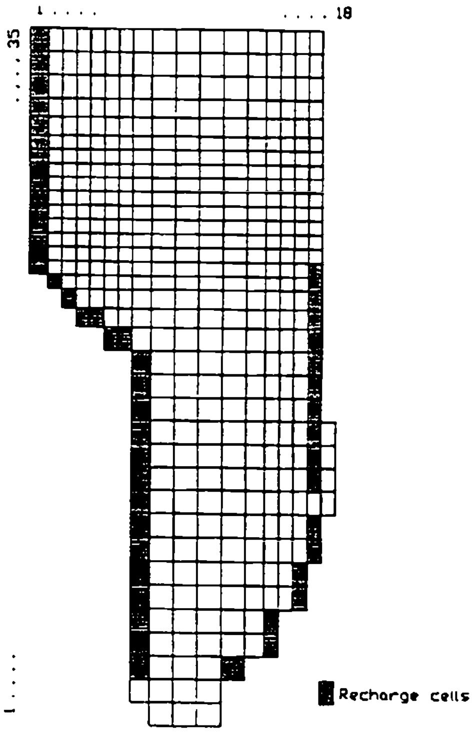
4.4.3 Lower Basin Fill Aquifer

The lower basin fill aquifer is assumed to be confined and eventually to become unconfined (LAYCON=2). The transmissivity distribution for the lower basin fill aquifer is shown in Figure 4-7 and is assumed isotropic. The storage coefficient for the lower basin fill aquifer is a constant 0.00001. Numerical values for the transmissivity array for the lower basin fill aquifer are found in Chapter 8.

Transmissivity Distribution
for Lower Basin Fill Aquifer;
Contour Interval = 0.4
(units $ft^2/sec \times 10^{-2}$)
Figure 4-7



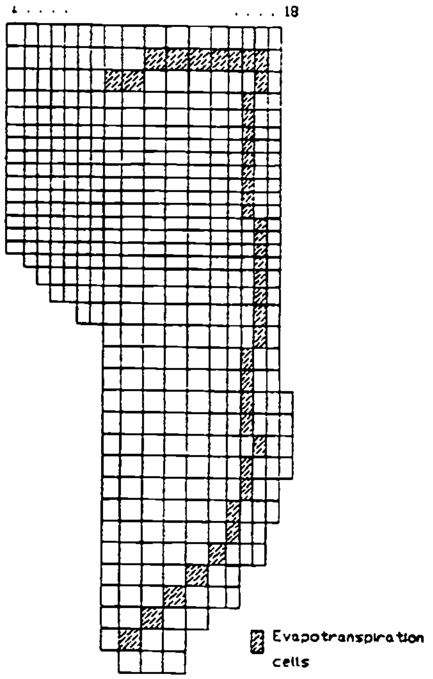
Mountainfront Recharge Cells
in Upper Basin Fill Aquifer
Figure 4-8



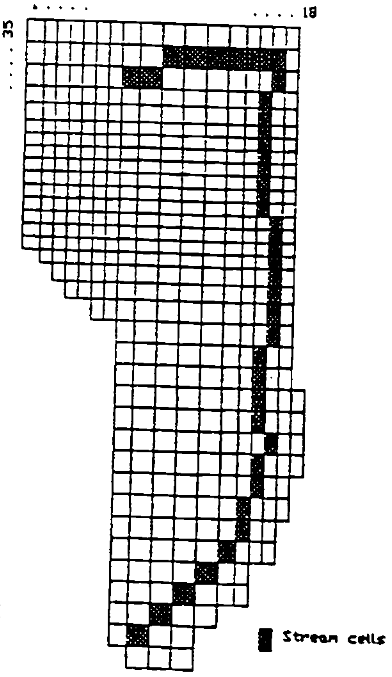
4.5 BOUNDARY CONDITIONS

Recharge is simulated along the mountain front on the west and east sides of the modeled area (Figure 4-8). Water from the recharge infiltrates into the ground-water system through the upper basin fill aquifer. Evapotranspiration occurs along streams where shallow water tables are encountered (Figure 4-9) and is aligned with cells assigned to the San Pedro River and the Babocomari River (Figure 4-10).

Evapotranspiration Cells
Figure 4-9

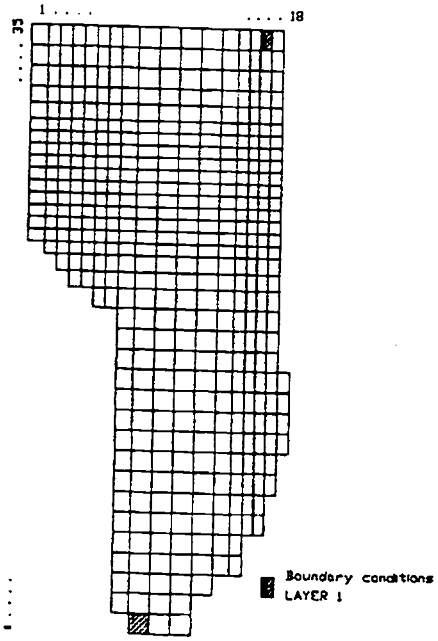


River Cells
Figure 4-10

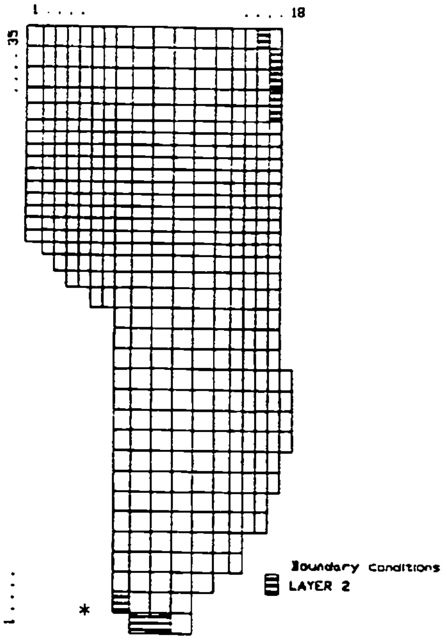


The original model included constant head boundaries at the southern and northern boundaries of the model area. The two boundary cells in the floodplain aquifer and the boundary condition cells in the upper basin fill aquifer enable simulation of ground-water flow exiting and entering across the external boundaries of the basin. In both layers, the constant head boundaries are replaced by constant flux boundaries during the steady-state simulation. In the upper basin fill aquifer, the upstream boundary is transformed into a head dependent boundary during the transient simulation.

Constant Flux Boundary
Locations for Floodplain
Aquifer
Figure 4-11



Constant Flux or Head-Dependent
Boundary Locations for Upper
Basin Fill Aquifer
Figure 4-12



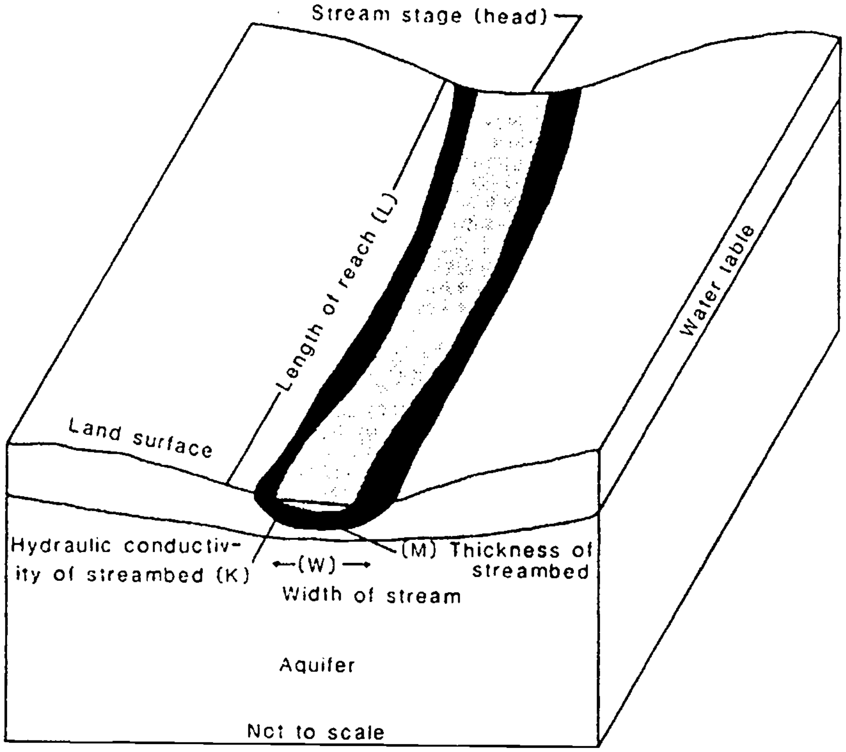
* These constant flux boundary cells
are converted to head-dependent cells

4.6 STREAM-AQUIFER INTERACTION MODULE

Prudic (1989) designed a new river package for use in MODFLOW that provides, in addition to the streambed flux calculation found in the traditional river module, a river stage calculation for stream segments in each of the cells designated as river cells. The package is called the Streamflow-Routing package and can simulate more adequately the stream-aquifer interaction process that takes place in southwestern rivers like the San Pedro.

The Streamflow-Routing package is an accounting program that tracks the streamflows that interact with the ground-water system. With this new package, portions of streams are permitted to go dry, to flow again, to be diverted and to be merged with other streams or tributaries. The accounting procedure produces a streamflow water budget that is calculated throughout the simulation, limiting the aquifer recharge to streamflow availability.

Streamed Conductance Diagram
(Prudic, 1989)
Figure 4-13



Leakage to or from the stream is calculated by the model using Darcy's law,

$$Q_1 = KWL \frac{H_s - H_a}{M} \tag{7}$$

where (Figure 4-13),

Q is the leakage to or from the aquifer through the streambed $[L^3\ T^{-1}]$;

K is the streambed hydraulic conductivity $[L\ T^{-1}]$;

W is the width of the stream [L];

L is the length of the reach [L];

H_s is the stage of the river [L];

H_a is the hydraulic head in the aquifer side of the streambed [L];

M thickness of the streambed [L].

It is customary to group the hydraulic conductivity term with the geometric parameters to define the conductance of the streambed and Equation (7) is rewritten as:

$$Q_1 = C_R\ (H_s - H_a) \tag{8}$$

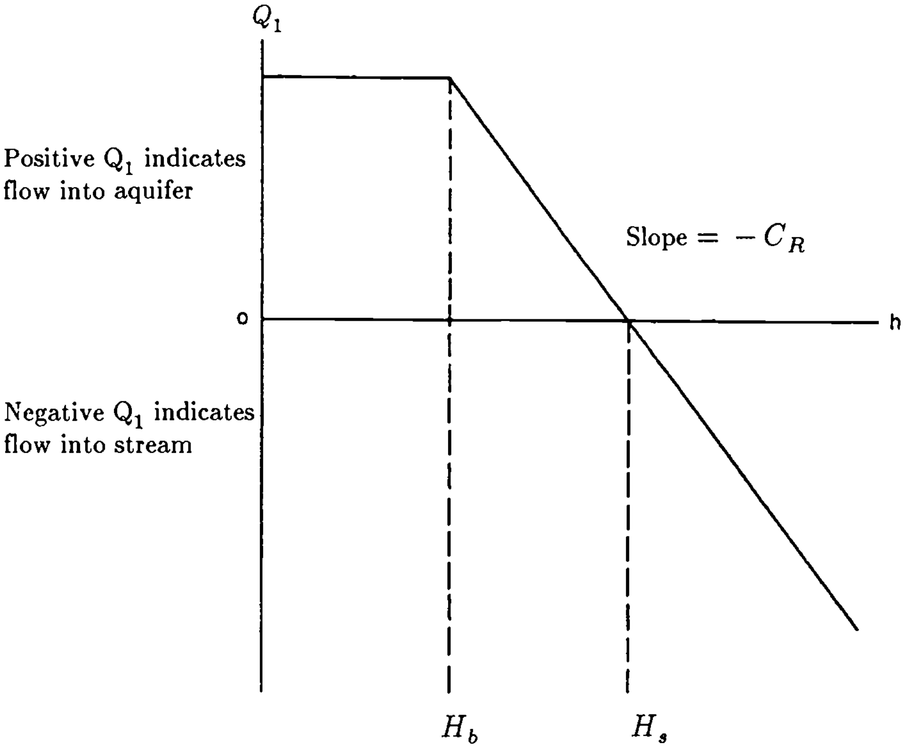
where the streambed conductance, C_R, is defined,

$$C_R = \frac{KWL}{M} \tag{9}$$

The streamflow routing package assumes constant streambed conductance for each stress period.

Under saturated conditions, the head in the aquifer adjacent to the streambed is equal to the head in the model cell beneath the streambed (Figure 4-14). The hydraulic gradient is determined by the difference between the head in the aquifer (H_a) and the stage in the stream (H_s). If unsaturated conditions dominate, the hydraulic gradient is determined by the difference between the stage in the stream (H_s) and the elevation of the bottom of the streambed (H_b).

Leakage through a Streambed as a Function of Head
(Prudic,1989)
Figure 4-14



In the model, the streamflow is specified for the first reach of each stream segment that enters the modeled area. Two or more streams can merge into one, and diversions can take place. Streamflow in a downstream reach is computed as equal to the inflow from an upstream reach plus or minus leakage to or from the aquifer. Outflow from the last reach of a tributary before confluence is added to the joining reach of the main stream. The program calculates stage in the stream by means of the Manning's equation, assuming incompressible steady flow at constant depth and a rectangular stream channel:

$$Q_s = \frac{C_f}{n} A \, R^{2/3} \, S^{1/2} \tag{10}$$

where,

Q_s is the stream discharge [L^3T^{-1}];

C_f is the conversion factor (1.0 for S.I. units);

n is the Manning's roughness coefficient [$L^{1/6}$];

S is the slope of the stream channel [0];

A is the cross-sectional area of the stream, $A = Wd$, [L^2];

d is the depth of the stream [L];

R is the hydraulic radius, $R = \frac{Wd}{W + 2d}$ [L].

It is assumed that the stream depth is much less than the stream width, giving,

$$d = \left[\frac{Q_s\, n}{C_f\, W\, S^{\frac{1}{2}}}\right]^{\frac{3}{5}} \tag{11}$$

Equation (7) is used by the model to approximate the stage in each stream reach.

Streams are represented by segments and each segment is divided into reaches. The San Pedro River and the Babocomari River contain 33 and 9 model reaches, respectively. In both cases reaches are numbered from the uppermost upstream to the lowermost downstream. The Babocomari joins the San Pedro River at its last reach. The 42 reaches in which the river system was discretized are shown in Figure 4-10. The San Pedro River width varies from 12 feet up to 27 feet and a Manning's roughness coefficient of 0.020 is adopted.

4.7 SIMULATION

Two principle simulations were performed under average annual conditions:

1. steady-state simulation for pre-development conditions, and
2. transient simulation for development conditions.

Model calibration procedures were undertaken for both simulations. The steady-state and transient simulations are presented in two separate sections. The maximum evapotranspiration rate set in the Freethey model (1982) is used. During the transient simulations, the evapotranspiration rate is constant for each stress period.

4.7.1 Steady-State Simulation

Before 1940, the pumpage in the USPB was almost negligible. Therefore, the USPB is taken to be in steady state in that year, and initial conditions for the subsequent transient simulations will use that year to provide initial conditions. The steady-state simulation model reproduces an average annual condition.

4.7.1.1 Streamflow calibration

The new stream-aquifer interaction module requires that the streamflow at the first reach of each modeled stream segment be specified. The San Pedro streamflow regime is highly variable on a seasonal, as well as on a yearly basis. Based on an evaluation of streamflows at different stations and for different time scales, the mean annual baseflow at Palominas was selected as the input variable to the model. Total streamflow, defined to be the sum of baseflow and runoff, was not used. Runoff moves rapidly through the USPB with pumpage having little effect on its discharge rates. Moreover, one of the purposes of the present modeling was to analyze the effect that pumping may have over streamflows. The use of the total streamflow would makes it difficult to determine up to what extent streamflows may be affected. Baseflow at the first model reach of the San Pedro River was set equal to 4.84 cfs (estimated value at Palominas) and to zero at the first Babocomari River model reach.

Baseflows at Charleston gaging station were used to assess and to calibrate the model results in terms of streamflows. According to Korsten (1990), the estimated mean annual baseflow at this station is 15.23 cfs. The simulated baseflow is 11.50 cfs, 24.50 % less than the estimated value.

Charleston is the only streamgaging station within the model area with a long period of records available for calibration. A geologic outcrop in the vicinity of Charleston alters the ground-water flow field, causing the flow of water to the surface. This formation is represented in the model, and therefore, the use of the streamflows at Charleston is considered appropriate for calibration purposes.

The San Pedro River is predominantly a gaining stream over most of the reach within the model area, except in an area around Palominas and in an area downstream of the Charleston Bridge. Gain-loss analyses have been reported by the ADWR (Putman *et al*, 1988) and the BLM (Jackson *et al*, 1988). For their analyses, the ADWR used annual median flows and the BLM used baseflows. Both analyses state that baseflows increase greatly between Hereford and Charleston and then decrease by Tombstone. Data provided by the BLM streamgaging stations (Section 3.2.1 and Appendix A, Table 2) were used to conduct a stream gain-loss analysis. As pointed out in Section 3.2.1, the data set can be used to indicate approximate trends. Using streamgaging readings taken between January of 1987 and July of 1989, it was determined that streamflows increase, on the average, 26 % between Hereford and Lewis Springs and, 71 % between Lewis Springs and the Charleston Bridge. A few scattered extreme values may be producing the high percentages. If these extreme values are disregarded, the streamflows between Lewis spring and the Charleston Bridge increase around 55 %. From the Charleston Bridge to a location just downstream of the Charleston Hills, streamflows decrease around 14 %, and to increase again at the Fairbank Bridge. These streamflow increases and decreases indicate the close interdependency between surface water flows and the ground-water system. Model results show baseflow gains of about 80 % between Hereford and the Charleston Bridge.

Due to the nature of the simulation in the model, no other "measurable" parameter such as depth or stream elevation can be used as calibration parameter.

4.7.1.2 Water level calibration

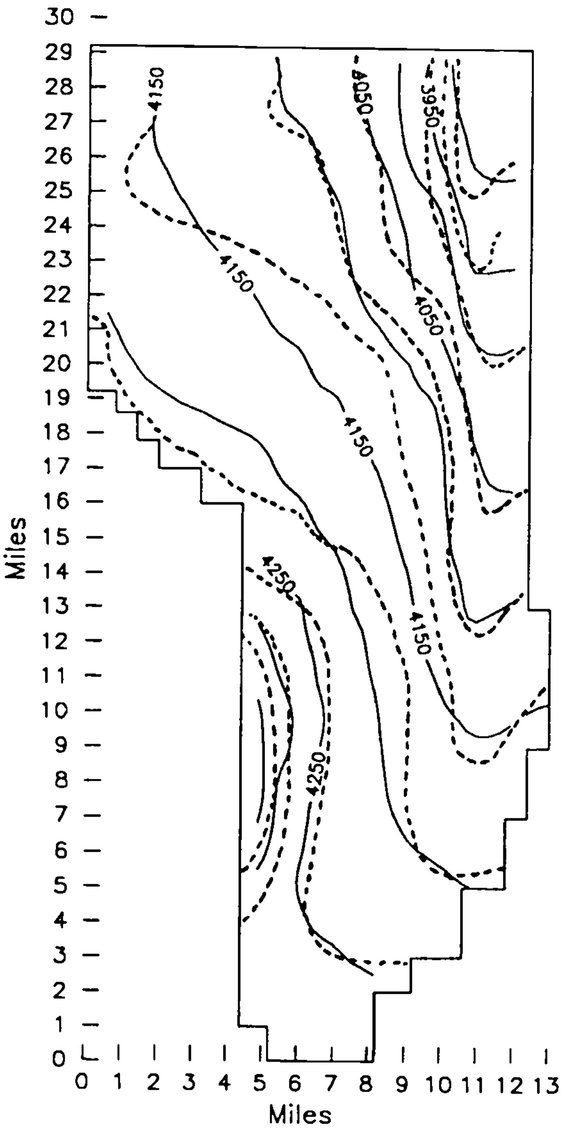
Making use of water levels observed in hydrographs and water levels reported in 1968 (Roeske and Werrell, 1974), Freethey reconstructed a water-level map for pre-development conditions. Water-level contours generated with the model along with contours constructed from field data are shown in Figures 4-15. In general there is a good agreement between the predicted contours and the field data contours, meaning that the model reproduces the steady-state ground-water flow pattern acceptably. Freethey (1982) expressed that "*the model calibration was considered acceptable when differences between model and field water levels were within +/- 25 ft because the contour interval of the water-level contour map generated from field data was 50 ft*".

Based on his conceptual model, Freethey (1982) compiled values for the discharge from and recharge to the system. Table 4-2 shows those estimates as well as model results.

The introduction of the alluvial aquifer as part of the hydrologic system produced a slight increment of the underflow estimated from Mexico with respect to previous models. The ADWR (1990) estimated an underflow rate of 4.14 cfs (3,000 acre-feet/year) of which 30 % (900 acre-feet/year) enters the United States through the floodplain alluvial and the remaining 70 % through the regional aquifer. Although the simulated total flow across the border is overestimated, the flow distribution between aquifers is correctly simulated.

The amount of water flowing from the regional aquifer to the alluvial aquifer is

Steady-State Water Levels
Figure 4-15



_____ Simulated water levels
\- - - Predicted from field data
Contour interval = 25 ft

not precisely known. The ADWR (1990) estimated that, under undepleted conditions in the Sierra Vista Sub-basin, approximately 15,900 acre-feet per year migrate from the regional aquifer to the floodplain aquifer. The simulated flow between these two aquifers is about 15,200 acre-feet per year.

Comparison between Recharge and Discharge Values from
the Conceptual Model and the Numerical Models
Steady-state (Data Source: Freethey, 1982)
Table 4-2

Recharge [+] Discharge [-] Units [cfs]

Variable	Conceptual estimates (*)		Model estimates (**)
	INPUT	OUTPUT	
Mountain front recharge	+13.3 to +15.2		+17.33
Underflow from Mexico	+ 1.0 to + 4.8		+ 5.15 (+1.26)[1] (+3.89)[2]
Stream losses SP	+ 1.1 to + 3.9		+ 1.50
Babo	0.0 to + 2.0		+ 1.14
Stream gains SP		- 2.6 to -12.8	-10.39
Babo		0.0 to - 7.0	- 3.31
Evapotranspiration		- 5.0 to -17.0	-10.91
Underflow at Fairbank		0.0	- 0.90
Underflow at NE corner		--	+ 0.39

(1) alluvial aquifer
(2) regional aquifer

(*) two layer system
(**) three layer system

4.7.1.3 Evapotranspiration calibration

Water consumed by phreatophytes is of special interest on the model mass balance. The evapotranspiration flux obtained agrees with the Freethey report estimates. The ADWR (Hydrological Survey Report, 1990) provides new estimates of water consumption by riparian vegetation before major development in the Sierra Vista Sub-basin. The new value climbs to 19,000 acre-feet/year (26.24 cfs). Model results total only 8,000 acre-feet/year.

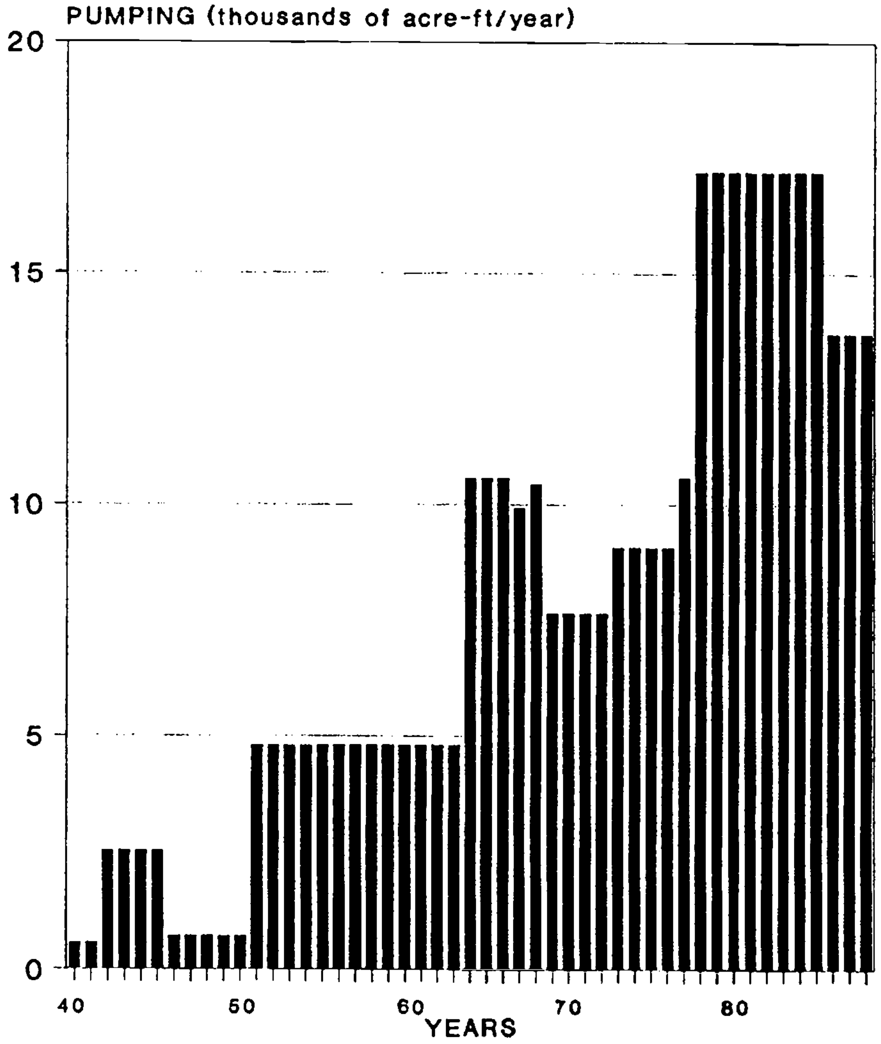
As explained before, with baseflows calibration the runoff volumes, an important component of the system mass balance, are disregarded. When disregarded, a volume of approximately 19,000 acre-feet/year, equivalent to the surface water runoff at Palominas, is not input into the model. In addition, a volume of 19,550 acre-feet/year (ADWR, 1990) from tributaries runoff enters the Sierra Vista Sub-basin, which is not considered either. Because of the rapid movement through the system, a large portion of the storms runoff continues to travel downstream leaving the model area. However, a small portion of the runoff replenishes dry season storage losses.

The sensitivity analyses performed by Freethey and this study suggest that the evapotranspiration rate greatly influences the model mass balance. Even though the model results are satisfactory, a deeper analysis of the evapotranspiration process and alternative ways to incorporate the run-off component into the model should be explored for future improvement of this model.

4.7.2 Transient-States Simulation

Man made stresses simulated for the study area for the two cases were ground-water withdrawals for irrigation, industrial and municipal uses. No direct streamflow diversions were modeled.

Simulated pumping
Figure 4-16



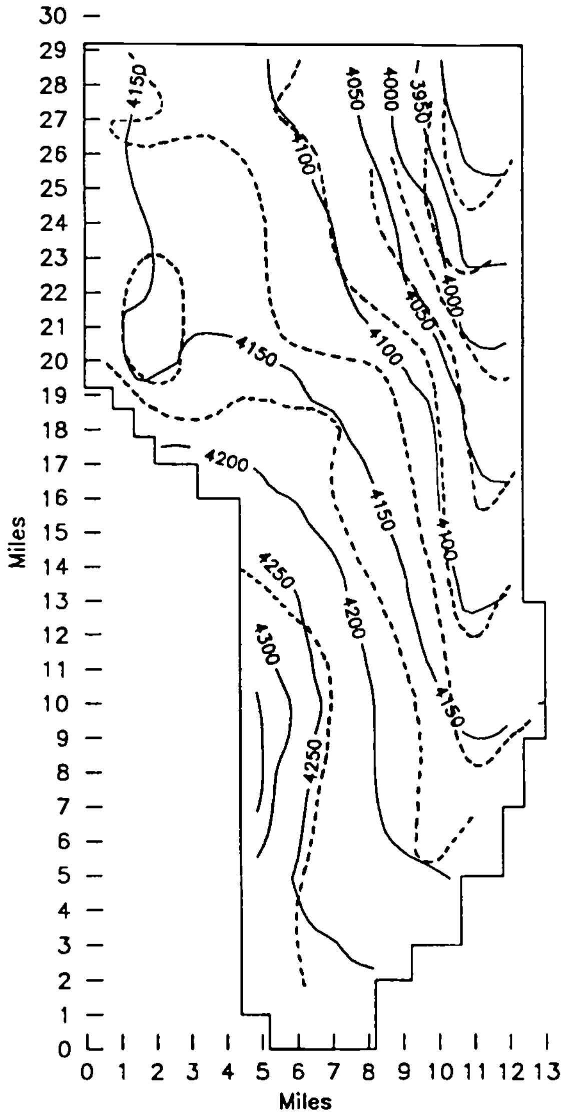
The transient simulation period covers 48 years, starting in 1940 and ending in 1988. Pumping data up to 1977 were originally compiled by Freethey (1982). The ADWR updated pumping figures up to 1988. The ADWR reviewed and relocated, when necessary, wells in the Sierra Vista-Fort Huachuca area. Irrigation wells in the Palominas-Hereford area were not subjected to close revision. The 48 year development period is divided into 12 stress periods whose lengths range from 1 to 13 years. An average pumping rate is defined for each period, with a maximum of 17,000 acre-feet reported during period 11 (1978-1985). Figure 4-16 shows pumping distribution over time. The total number of wells is variable from period to period. Spatially they are concentrated mainly in two areas: Palominas-Hereford and Fort Huachuca-Sierra Vista-Huachuca City area.

Using the same procedure followed during the steady-state analysis, models results are evaluated comparing simulated and observed values of water levels, streamflows and mass balance components.

Figure 4-17, 4-18, and 4-19 show water-level contour maps for 1968, 1977, and 1988 conditions, respectively. Water-level contours reconstructed from field data and reported in the literature are used to compare the transient response of the model. The comparison for these three periods illustrates that the regional ground-water flow pattern is reproduced. After 20 years of development, from 1968 to 1988, water levels have dropped considerably in the Sierra Vista-Fort Huachuca area. As shown in the 1988 time period, the cone of depression that already existed in 1968 has clearly expanded. The second cone of depression in the Huachuca City area, recently surveyed by Schwartzman (1990), is not reproduced by the model.

The effect of pumping over the river-aquifer interaction is evaluated by means of a losing-gaining stream reaches analysis. Period 7 (1968' conditions), period 10 (1977' conditions) and period 12 (1988' conditions) are chosen for the analysis. As Figure 4-20 illustrates, the rate at which flow takes place between the stream and the underlying alluvial aquifer has changed through the years as a consequence of increasing pumping.

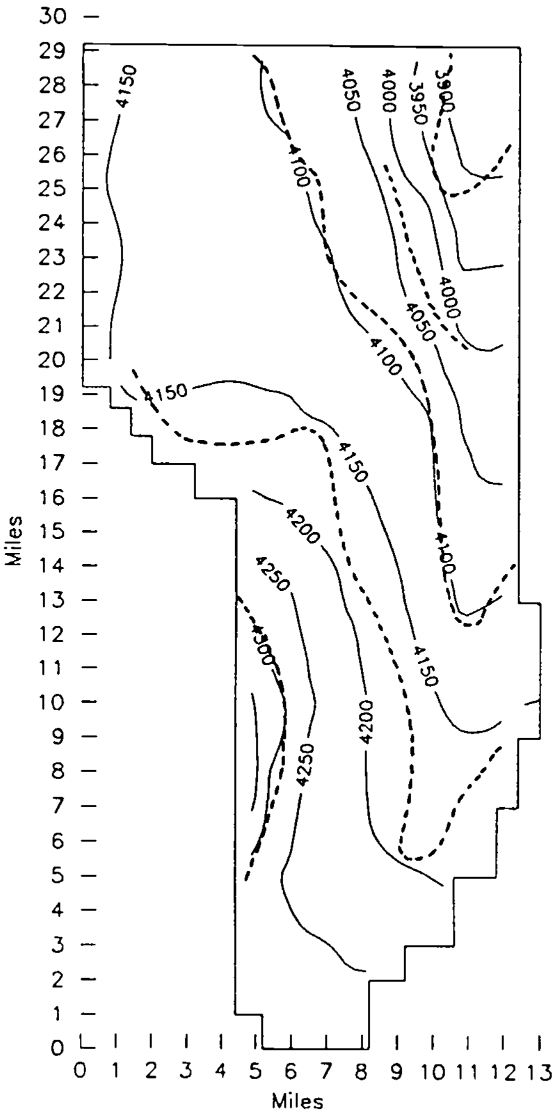
Water levels 1968 conditions
Figure 4-17



_____ Simulated (contour interval=25 ft)

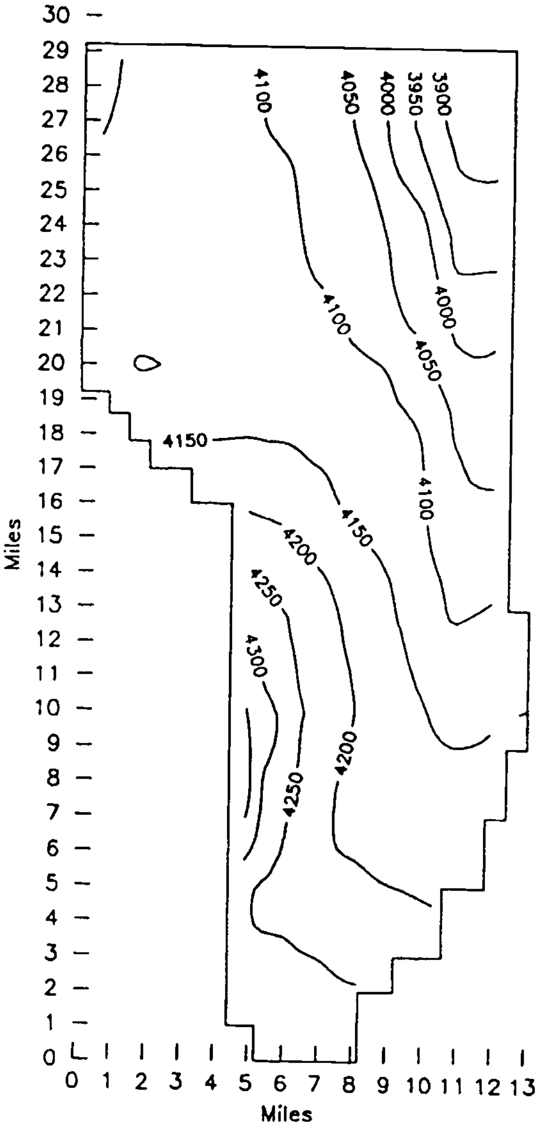
- - - Predicted from field data - Contour interval= 50 ft
(After Roeske and Werrell, 1974)

Water levels 1977 conditions
Figure 4-18



_____ Simulated (contour interval = 25 ft)
- - - Predicted from field data (After Konieczki, 1980)
Contour interval = 100 ft

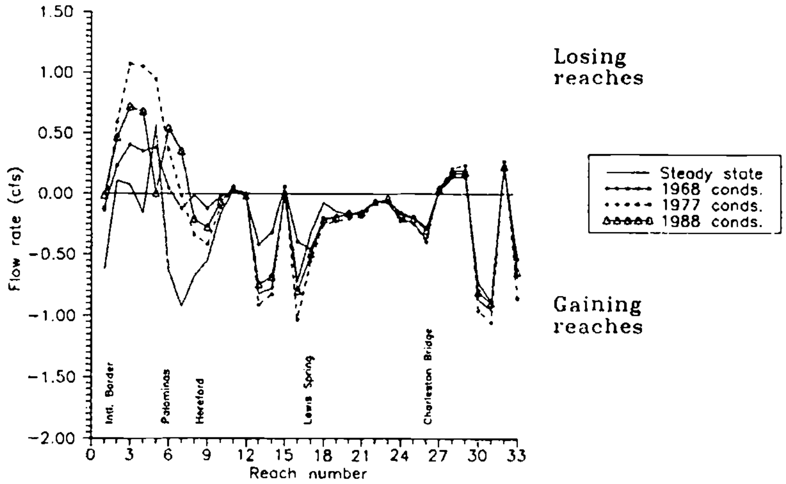
Simulated water levels 1988 conditions
Figure 4-19



_____ Simulated (contour interval = 50 ft)

Losing reaches, located around the Palominas-Hereford area and downstream of the Charleston Bridge, have lost progressively more water to the aquifer. The magnitude of this effect is greater in the Palominas-Hereford area, where a dry reach was detected (reach 5 on Figure 4-20). Not only flow rates but also the distribution of gaining-losing stream reaches have been altered. Some reaches that were gaining water from the ground-water system turned into losing ones. Gaining reaches between Lewis Spring (model reach 16) and Charleston bridge (at model reach 26) have experienced little change in the flow rate. This phenomena can be associated to the presence of a mass of low hydraulic conductivity rocks in that area which distorts the ground-water flow field.

Losing-Gaining Reaches along the San Pedro River
Figure 4-20

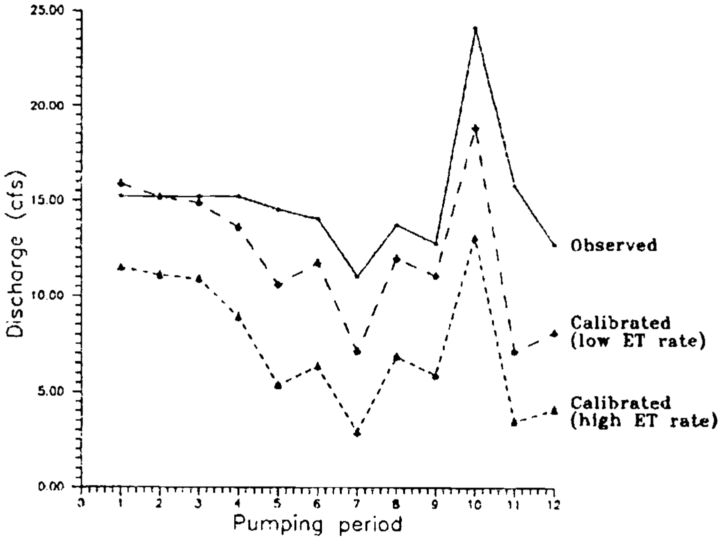


Baseflows calibration using original values of evapotranspiration rate was not totally successful. As shown in Figure 4-21, simulated baseflows lie below the estimated curve. This discrepancy between simulated and observed streamflows may be attributed to a combination of factors. First of all, the model shows a decline of the flow between the regional aquifer and the alluvial aquifer as pumping increases over time, which in turn may affect the flow of water from the alluvial system to the stream. Second, the uncertainty in the values of parameters such as the recharge rate, the maximum evapotranspiration rate and the magnitude of the mean annual baseflow, can lead to a poor match between observed and simulated streamflows. As it was pointed out in Section 3.2.1.1, the mean error in the proposed regression relationship for baseflows at Palominas (Korsten, 1990) is between 20 % and 25 %. In addition, runoff volumes are not considered in the model. Potentially, between 5,000 and 6,000 acre-feet per year of storage space in the alluvial aquifer could be replenished by runoff related waters. This is not a negligible amount when compared to the 8,000 acre-feet per year of phreatophytes consumption simulated by the model. A coarse spatial resolution along the river system, and time periods ranging from one year to thirteen years, combined with the factors described above may also contribute to a poor calibration of the streamflows.

As a very rough way to overcome the deficit of runoff volumes in the model, a run was made adjusting the maximum evapotranspiration rate. The rate was progressively reduced from a steady state value of 8×10^{-9} ft/sec up to 1×10^{-9} ft/sec for the pumping period 12. An improved match between simulated and estimated streamflows was obtained. In future updates of this model, an attempt to represent runoff volumes and to revise riparian vegetation water consumption should be made.

A model mass balance assessment for the transient state is performed. Under steady-state conditions the recharge (R) to the system equals the discharge (D) from it. Mountain front recharge migrates through the regional aquifer toward the floodplain alluvial and ultimately reaches the stream. Underflow through the model boundaries also recharges the alluvial system. The alluvial aquifer finally provides water for vegetation consumption.

CALIBRATED BASEFLOWS AT CHARLESTON STATION
Figure 4-21



When the system is stressed, *i.e.* when ground-water pumping is introduced, it responds to satisfy the water demand. Under no external sources of water, three things may happen (Bredehoeft *et al*, 1982):

1) the recharge increases;
2) the discharge decreases; or
3) the aquifer storage changes.

In mathematical terms these three possibilities can be expressed as:

$$(R+\Delta R) - (D+\Delta D) - Q = \Delta S \tag{8}$$

where,

R = natural recharge;

$\Delta D =$ recharge change induced by ground-water pumping;

D = natural discharge;

$\Delta D =$ discharge change induced by ground-water pumping;

Q = pumpage;

$\Delta S =$ change in storage.

Using the fact that $D = R$ for the steady-state condition, equation (8) can be simplified as follows:

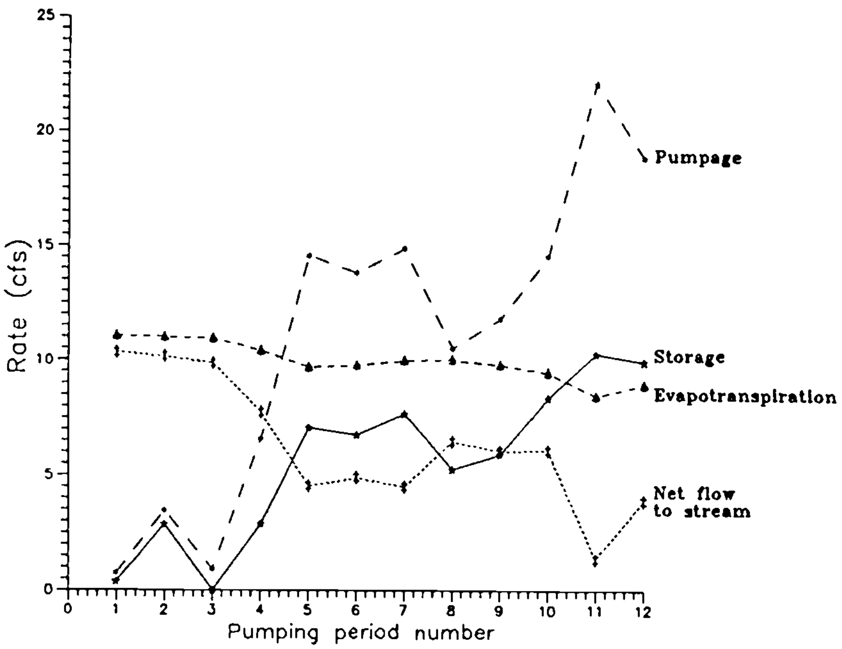
$$\Delta R + \Delta D - Q = \Delta S \tag{9}$$

The term $(\Delta R + \Delta D)$, called *capture*, represents the amount of water that can be extracted from the capture sources existing on the system as response to pumping.

In the Upper San Pedro Basin potential capture sources include evapotranspiration, streams, and underflow from Mexico. Although a potential source of capture is the underflow from the Republic of Mexico, model results indicate only a slight increase of the flow through the border with time. The magnitude of the capture increment is thus considered negligible. The Upper San Pedro Basin extents beyond the model boundary, and within the Mexican portion of the basin, there is an important well field that supply water for irrigation and mining activities. Quantitative analysis of ground-water exploitation on the Mexican side, or better yet, the addition of that portion of the basin to this model would provide a more complete picture of the stresses the system is suffering as a whole as oppose to specific locations. This would also allow the assessment of the consequences that a future well field expansion south of the border may have over the streamflows as well as underflow through the border.

Figure 4-22 shows the distribution of fluxes within the system. In absolute terms, evapotranspiration consumption has been slowly declining (in the model, evapotranspiration losses correspond mainly to riparian vegetation). It has been the lowest in coincidence with the highest pumping rate (period 11). In relative terms the amount of water captured from evapotranspiration averaged 10.17 % per pumping period, *i.e.* 10.17 % of ground-water withdrawals is made up capturing water from evapotranspiration.

Transient Simulation
Mass Balance Flux Components
Figure 4-22



The amount of water taken from aquifer storage drastically increases in direct response to pumping. During the second period, 83 % of the water demand was withdrawn from storage. However, over the whole simulation period, aquifer storage supplied, on the average, 48 % of the total ground-water withdrawals.

Water captured from the streams totals around 40 % of the ground-water withdrawals. A declining trend in the net amount of water to streams is observed since early development. This net flux reached its minimum when the simulated pumping rate was at its highest (period 11).

Chapter 5
Sensitivity Analysis

5.1 INTRODUCTION

The reliability of the calibrated steady-state ground-water flow model was evaluated by sensitivity analyses. If selected input variables are perturbed within a certain range, and if no significant changes in model results are observed, the model may be considered insensitive to those input parameters. Freethey (1982) explored the model reliability varying certain hydraulic properties within what was assumed to be a reasonable range. Riverbed leakance, effective depth of evapotranspiration, maximum rate of evapotranspiration, and vertical leakance between aquifers were the selected hydraulic parameters upon which to perform the sensitivity analysis. The model response to parameters changes was measured in terms of the standard error of the mean head change and the percent change in the net flux of the property being varied.

5.2 PREVIOUS SENSITIVITY STUDIES

Freethey analyzed the ground-water flow between the saturated sediments in the upper 1,000 feet of the basin fill and the underlying sediments. He concluded that "*the steady state model showed that the net vertical movement of groundwater is up, but the total amount is less than 2 percent of the total flux. Increasing the relative value of leakance by as much as a factor of 1,000 has little effect on head changes or the model water budget. Decreasing the relative value of leakance by a factor of 1,000 reduces the upward flow by about 10 % and affects head changes only slightly*". This behavior indicates a low sensitivity of the model water budget and heads to changes in the vertical leakance between the two basin fill layers.

The discharge by evapotranspiration makes up almost half of the total discharge from the steady state model. Freethey investigated the model sensitivity to two parameters associated with the evapotranspiration process: the maximum evapotranspiration rate and the depth below the land surface at which evapotranspiration ceases (extinction depth). His model results showed significant change in the net discharge by evapotranspiration when both parameters were modified. With a change in value of the maximum evapotranspiration rate by 10 percent, the net flux from evapotranspiration increased by as much as 144 percent. However, in terms of head changes, the model sensitivity to variation of these parameters was low.

The streambed conductance controls the net exchange of water between the river and the aquifer. When used in the sensitivity analysis, and due to the uncertainties in its determination, it can be varied within a wide range. Freethey explored the model response to this parameter and concluded that exaggerated values of the streambed conductance had little effect on the head distribution. However, the net flux between the streams and the aquifer increased but it did not exceed conceptual-model estimates. On the other hand, smaller streambed conductances produced net fluxes below conceptual-model estimates and significant head changes.

5.3 SENSITIVITY REVISITED

During the present study the sensitivity analysis was done using similar parameters. The range of multiplication factors was chosen separately for each calibrated parameter. Special attention was given to changes observed in the alluvial aquifer system as opposed to the basin fill deposits. These were the focus of Frethey's sensitivity analysis.

5.3.1 Vertical Leakance

Vertical leakance between the alluvial aquifer and the underlying basin fill deposits was increased up to a factor of 1,000 and decreased by a factor of 10. Multiplication factors of less than .01 were also attempted, but resulted in simulations with significant mass balance errors. The vertical flux across these two hydrogeologic units remained practically constant for all the factors used, and the net flux to streams was affected only just slightly.

Sensitivity of Model Computed Heads to Changes in Vertical Conductance
Figure 5-1

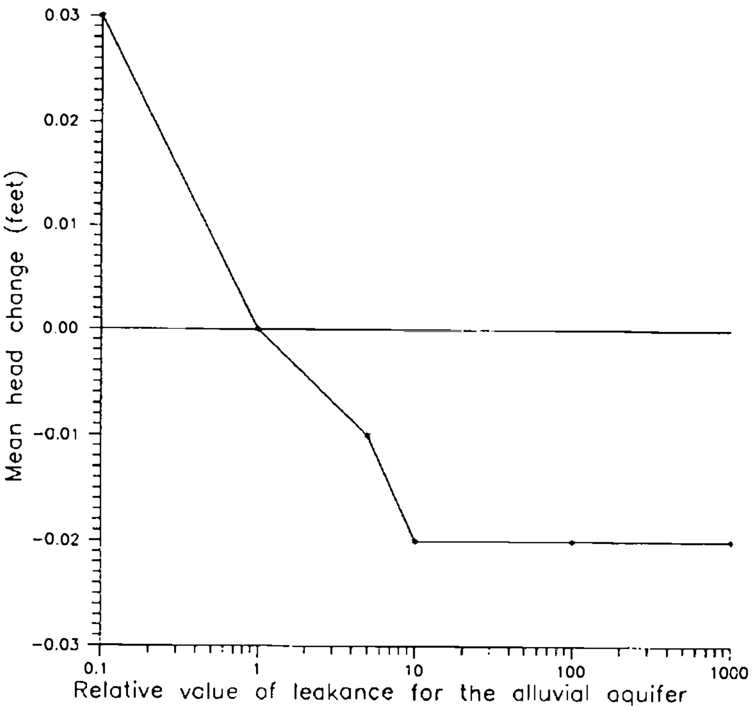
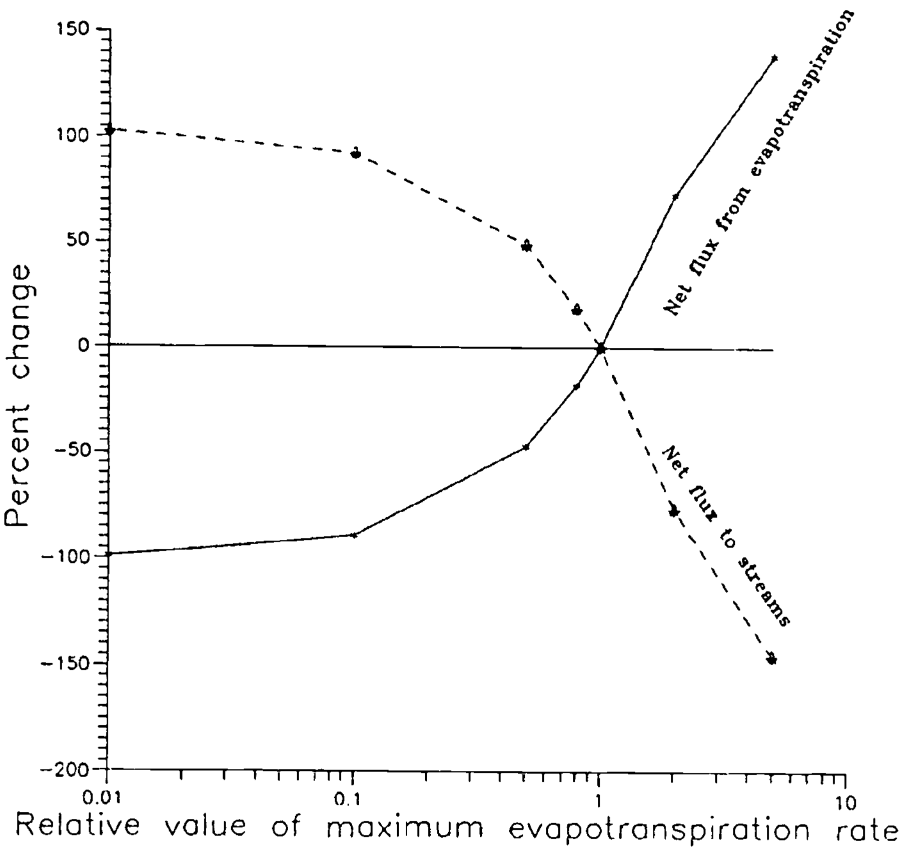


Figure 5-1 represents the mean head change (MHC) in the alluvial aquifer with respect to changes in the vertical leakance. The MHC is the deviation of simulated water levels from the calibrated values, averaged over the active flow region. In the figure, positive values of MHC indicate an increase in simulated water levels. Multiplying the parameter under analysis by as much as 1,000 produces head changes of only -.02 feet. A 10 percent decrease in the vertical conductance causes a mean head change of +0.03 feet. It can be said that the model sensitivity to this parameter is practically insignificant.

Sensitivity of Model-Computed Flux to Changes in the
Relative Maximum Evapotranspiration Rate
Figure 5-2



5.3.2 Evapotranspiration

The maximum evapotranspiration rate was varied to extraordinary limits, well beyond a reasonable range. Figure 5-2 shows the percentage changes in the model computed fluxes to streams and from evapotranspiration due to increases or decreases in the maximum evapotranspiration rate relative to the calibration value. A positive percentage change produces an increase in net evapotranspiration flux and a decrease in net flux to the stream. The curves are like a mirror image of each other, the change in the evapotranspiration is compensated for by a change in the discharge to the streams. The maximum percent change is observed when the relative maximum evapotranspiration rate exceeds .01. A ten-fold increase in the relative maximum evapotranspiration rate greatly reduces the net flux to stream, in fact, to a point where the stream may even become a losing stream.

Sensitivity of Model-Computed Baseflows to Changes in the
Relative Maximum Evapotranspiration Rate
Figure 5.3

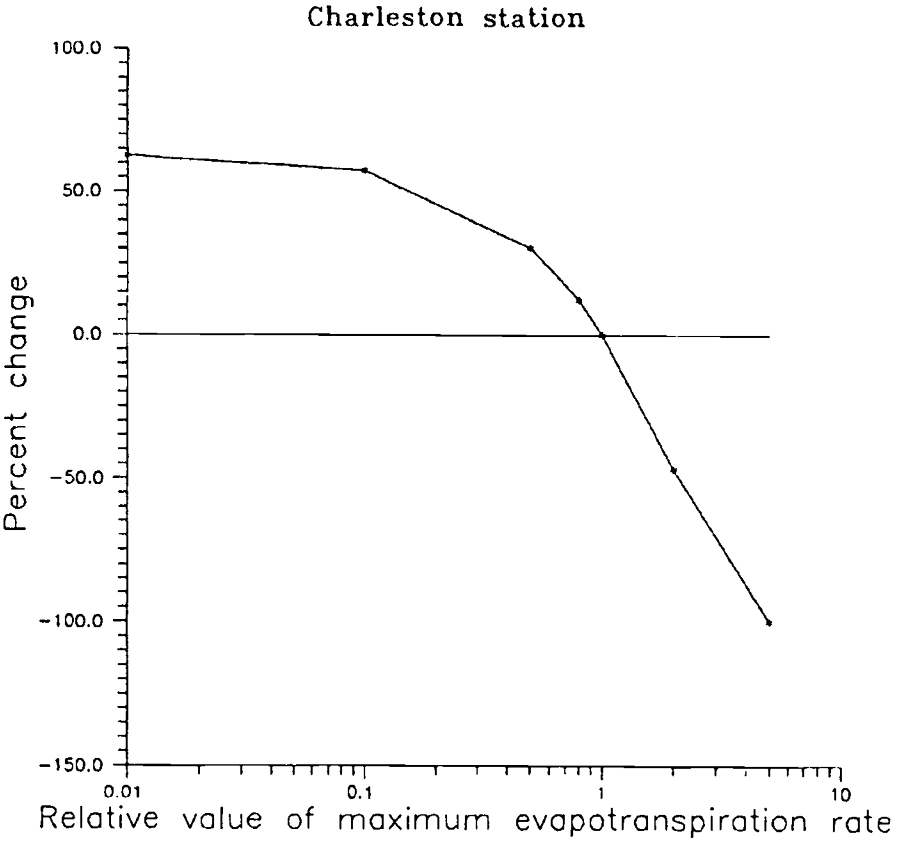
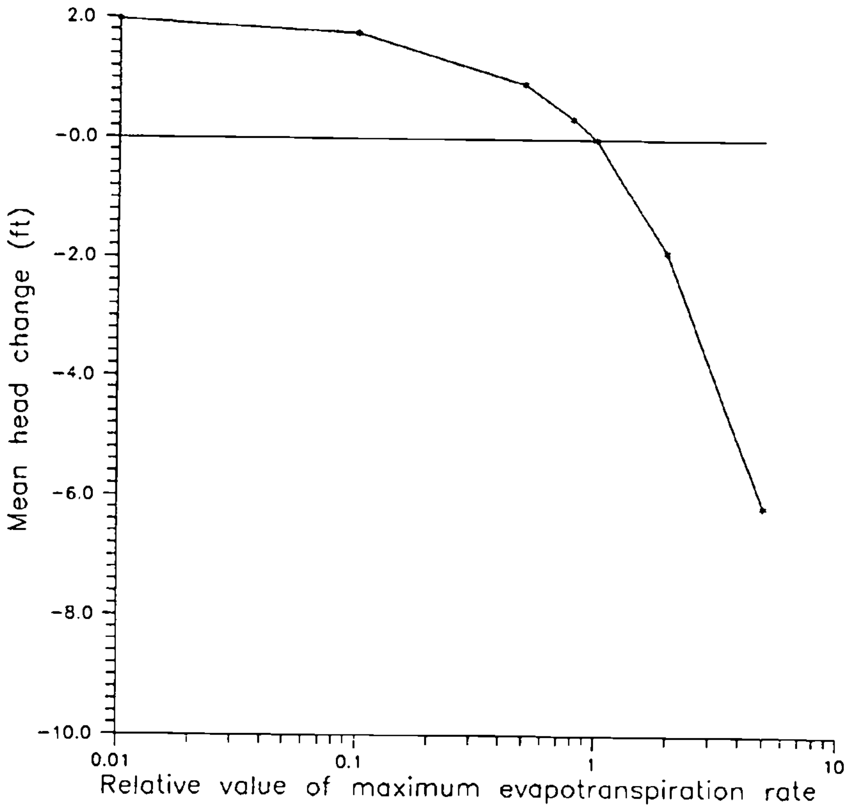


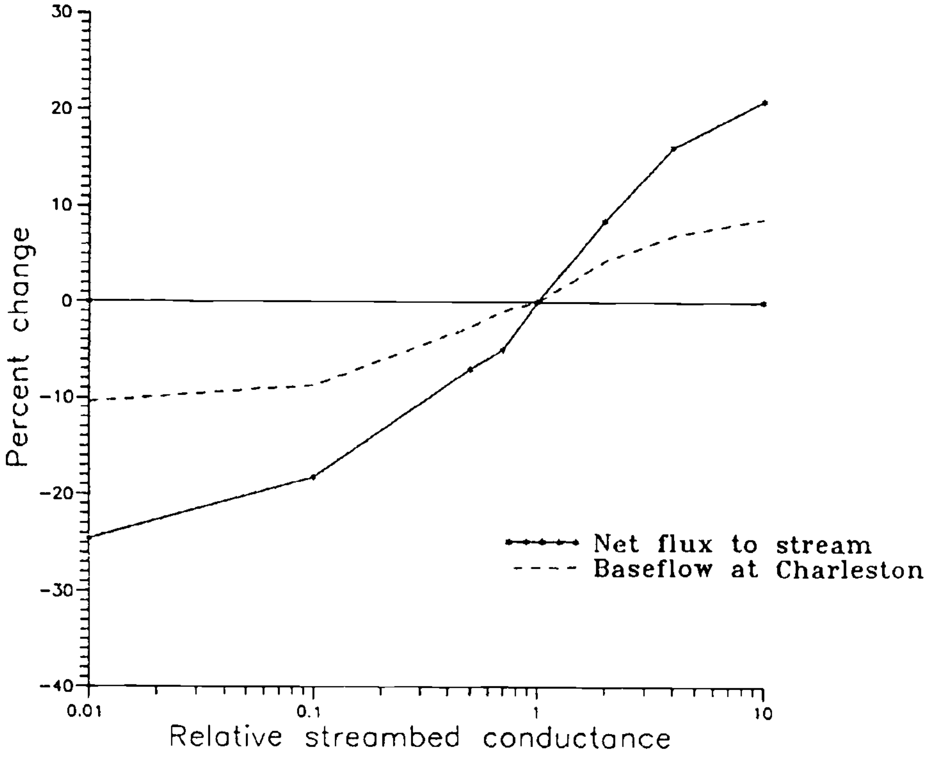
Figure 5-3 shows the sensitivity of the model computed baseflow to changes in the relative maximum evapotranspiration rate. The computed baseflows for the Charleston streamgage are plotted on the graph. The baseflows behave in an analogous manner to the behavior the net flux to streams (Figure 5-2).

Sensitivity of Model-Computed Hydraulic Head to Changes in the
Relative Maximum evapotranspiration Rate
Figure 5-4



Mean head changes (MCH) in the alluvial aquifer are depicted in Figure 5-4. For increasing values of the relative maximum evapotranspiration rate, a rapid decline in the MHC is observed, with a maximum value of -6 feet for an evapotranspiration rate five times greater than the calibrated value. With rates smaller than the calibrated one, the heads rise a maximum of 2 feet. Thus the model sensitivity to this parameter is relatively low in terms of water levels, but it is high in terms of fluxes and streamflows.

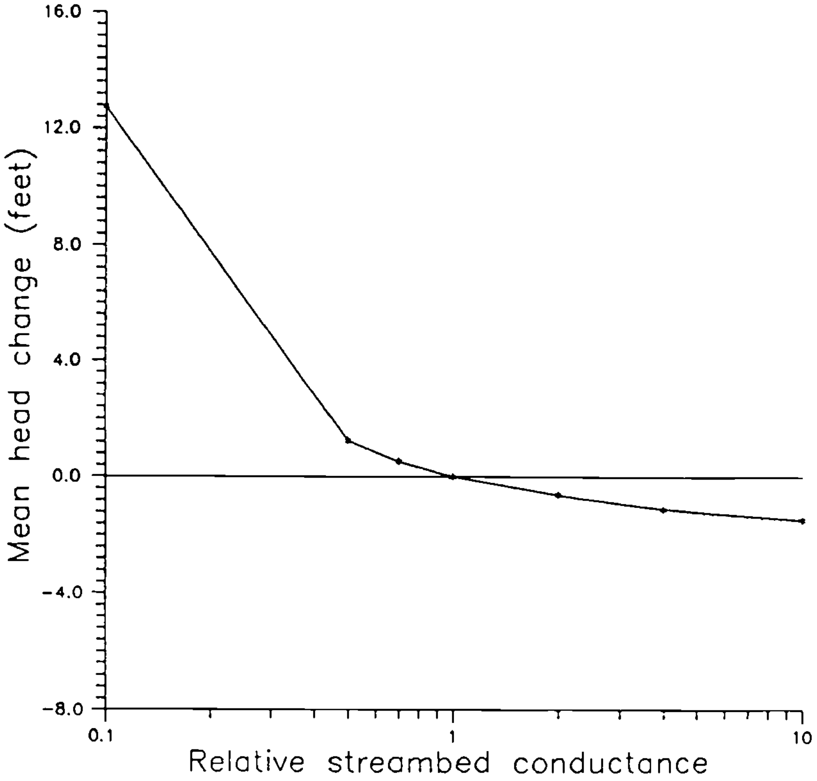
Sensitivity of Model-Computed Flux and Baseflow to Changes in Relative Streambed Conductances
Figure 5-5



5.3.3 Streambed Conductance

The third parameter analyzed was the relative value of streambed conductance to the calibration value. Multiplicative factors between 0.01 and 10 were used. For low values of the relative conductance, the net flux to streams is reduced by about 25 % (Figure 5.5). Relative streambed conductances greater than 1.0 produce an increase on the net flux. On the same figure, simulated baseflows at Charleston have been plotted. The simulated baseflows are less sensitive to changes in conductances. Even with streambed conductances 10 times greater than the calibrated values, streamflows increase just 10 %.

Sensitivity of Model-Computed Hydraulic Head to Changes in
Relative Streambed Conductance
Figure 5-6



The influence that relative streambed conductance has on heads in the alluvial aquifer is shown in Figure 5-6. Heads are moderately sensitive to conductances greater than the calibration values. The lower relative streambed conductances affect heads to a larger extent.

Chapter 6
Conclusions

6.1 SUMMARY AND CONCLUSIONS

Conflicting water uses in the Upper San Pedro Basin such as instream flow maintenance and sustained water supply for growing populations, make it necessary to develop analytical procedures to support future water resources planning in the Basin area. One principal component of the planning procedure is the hydrologic aspect, which can be evaluated, to a partial extent, through the mathematical simulation of the ground-water system and its interaction with the surface-water system.

The purpose of this study was to modify an existing ADWR ground-water model to improve simulation of ground-water and ground-water-surface-water interactions. The modifications were implemented 1) by augmenting the original MODFLOW module data sets with newly acquired information, 2) by replacing the traditional river module with the recently developed stream-aquifer module (Prudic, 1989), 3) by adding an additional layer to provide for bank storage, and 4) by recalibrating using river baseflows.

The grid used in this study is essentially that developed by Freethey (Freethey, 1982). The grid density increases in areas of intense municipal pumpage and decreases in remote areas and in the Palominas-Hereford area. Although in the past, irrigation pumpage has been concentrated in the Palominas-Hereford area, many of these irrigated lands have been retired from use.

The steady-state simulation attempted to reproduce the mean annual conditions prevalent in 1940. The resulting steady-state water levels for that year were used as initial heads for the transient simulation. The transient simulation period ran from

1940 to 1988. Pumping periods ranged from one year duration to thirteen year duration. The transient simulations reproduced average conditions over the durations of those pumping periods. Transient-states model calibration matched simulated and observed water levels and streamflows.

The match between simulated water level contour maps and field data water level contour maps was acceptable. However, a less acceptable match between MODFLOW simulated streamflows and estimated baseflows from field data was obtained. Some of the reasons for this to occur were explained in Section 4.7.2 (Transient State Simulations). The runoff component of the streamflows was not taken into account during the simulations. It is generally argued that, within the study area, runoff is exceedingly rapid, allowing little infiltration to the ground-water system. However, the runoff volumes provide some surface storage, a small quantity of local storage to the alluvial aquifer, that is usually consumed by riparian vegetation.

Prior to major development, losses to evapotranspiration and to streamflow constitute the majority of the discharge from the system for both cases. The ground-water outflow at Fairbank constituted 3.5 % of the total discharge, a small amount compared to the other two components. The total discharge was 18,460 acre-feet/year (25.5 cfs).

By the end of the transient simulation period (1988), 13,680 acre-feet/year of water were being extracted through pumping. However, the peak pumpage of 17,190 acre-feet/year (23.7 cfs) was reached during the early 1980's.

Over the 48 year simulation period, the evapotranspiration losses reduced around 20 % with respect to pre-development conditions. Streamflow gains were also reduced drastically over the 48 years. These reduction were due to the ground-water withdrawals to pumpage. Model results also indicate that 48 % of the pumpage was derived from aquifer storage (Figure 4-22).

Model results are dependent on the distribution of pumpage in time and space. The pumpage used to simulate transient conditions were provided by the ADWR. Municipal pumping has been revised by the ADWR. The ADWR is presently revising pumping figures for agriculture. This process will redefine pumping rates estimates for irrigation wells drilled mainly in the alluvial aquifer. Depending on the scope of this redefinition, model results and conclusions could be affected to different degrees, particularly if the revised wells are located near the river system.

Before any attempt to use this ground-water flow model, it is essential that the user be aware of the model capabilities and limitations. Conclusions extracted from future simulations with this model will have to be based on the model assumptions and limitations. With these caveats in mind, two principle conclusions may be drawn.

1. The geologic formation in the vicinity of the Charleston initially inhibits the effects of the Sierra Vista cone of depression on the San Pedro River. Simulation indicates that the cone will spread southward to perhaps intersect the river upstream of the formation.
2. Although a better calibration of baseflows can be achieved by reducing the maximum evapotranspiration rate to partially compensate the absence of runoff volumes, alternative ways to incorporate those volumes should be attempted in the future.

6.1 RECOMMENDATIONS FOR FUTURE INVESTIGATIONS

The grid density should be increased along the stream system and in any new areas of rapid change of hydrologic processes. Integration of Graphic Information

Systems (GIS) into the modeling process would aid in quickly reformulating grid design.

Only the southwest portion of the Upper San Pedro Basin is modeled in this study. The model area should be extended to the east of the river and downstream beyond Fairbank. It should be noted that the expansion of the modeling effort to beyond Fairbank is now being undertaken by the University of Arizona and the Arizona Department of Water Resources.

Future modeling efforts should assess and incorporate the Mexican portion of the watershed. Heavy pumping to supply water for agricultural and mining activities is taking place south of the Mexico-United States Border. This pumpage and any surface-water diversions could potentially alter the San Pedro streamflow regime as well as the underflow across the border.

As more data become available, this model should be updated in an effort to improve the model calibration. The incorporation of the new streamflow package required the use of additional data. Field determinations of the river geomorphological characteristics such as river width, Manning coefficient, slope, and hydraulic properties of the streambed will increase the present knowledge of the river-aquifer interactions and provide the data to be used in the new package (Neavile, 1991). At the present time, the BLM collects streamflow data at a number of stations within the model area. The period of records is still too short to be used for model calibration. However these data will become more useful in future model applications. In order to rely on representative statistical values, the data collection process should be done on a daily basis, and should relate streamflows to stream elevations wherever possible.

The water consumption by the riparian vegetation should be analyzed to a finer degree. The model showed sensitivity to parameters associated with the evapotranspiration process. The water consumption process by riparian vegetation needs to be refined. The determination of riparian habitat location and riparian habitat water consumption could be incorporated into future models to improve the representation of the evapotranspiration process.

The steady-state model simulates the average annual conditions prior to major development. The transient-states simulations model reflect average conditions over variable time periods (the maximum pumping period is 13 year long). With such time period, the variabilities of certain processes are masked or not taken into account. In particular, the streamflow regime and the evapotranspiration processes clearly show sharp seasonal variations. A monthly simulation would allow a more realistic assessment of all the seasonal processes. In spite of the potential improvements a smaller time scale would bring to the model, data availability, particularly in terms of pumping data, can make this option difficult to implement.

Recharge from various sources should also be analyzed to a finer extent. Percolating water from irrigated lands is modeled indirectly through a reduction of 30 % in the amount of water being pumped for agriculture. In future model improvements, the recharge process should be simulated as it actually occurs.

Chapter 7
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Chapter 8

Model Input Data

8.1 Steady State Simulation

8.1.1 BAS Data File

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8.1.2 BCF Data File

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         0 1.929E-03                                K LAYER 1
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   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   04050   0   0
42534233   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   04033   0   0
   0   04220   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   04004   0
   0   0   04210   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   04020   0
   0   0   0   04196   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   04010   0
   0   0   0   0   04185   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   03980   0
   0   0   0   0   0   041404130   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   03850   0
   0   0   0   0   0   0   0   041204108   04053404040204010   0   0   0   0
   0   0   0   0397339523943393539203910388038503840   03815   0
   0   0   0   0   0   0   0   0   0   04070   0   0   0   04035402140144008
4000399039953990   0   0   0   0   0   0   0   0   0380037903785
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
        11         1 (4(8E10.4/),3E10.4)      12  VCONT LAYER 1
 .0000E+00 .0000E+00 .0000E+00 .0000E+00 .0000E+00 .0000E+00 .0000E+00 .0000E+00
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.1851E-05 .1067E-05 .2091E-05 .2185E-05 .2185E-05 .1406E-05 .9192E-06 .7974E-06
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.1231E-06 .1336E-06 .1242E-06 .3447E-06 .1915E-05 .2131E-05 .2131E-05 .0000E+00
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.4288E-06 .2190E-06 .3703E-06
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 .0000E+00 .0000E+00 .0000E+00
        11   .6044E-5 (19F4.0,/,16F4.0)          12   k LAYER 2
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0  26  21  18  14  13  13  12  12   7   7   7   6   6   6   6
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
  33  26  22  14  12  12  12  12  12   8  10  10   6   6   6   6
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  35
  31  16  14  13  11  12  12  12  12  12  12  13  13   9   9  12
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  31  34
  23  14  13  11  11  11  11  11  12  12  12  12  14   9   9  12
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  26  24
  17  13  12  11  11  11  11  11  11  12  12  12  15  10   8  12
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  16  22  20
  14  12  12  11  11  11  11  11  11  12  12  12  14  16   8  11
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  19  21  19
  12  11  11  11  11  11  11  11  11  11  12  12  14  17   8  11
   0   9   5  .8  .4  .2  .1  .4  .5  .5   1   1   3   8   8   6  15  12  10
   9   8  10  10  10  11  11  11  11  11  11  11  11  17  11  11
  10  12  10  10   8   1   1   1   1   1   1   1   3   3   3   4   6   6   6
   7   6   4   5   7  11  11  11  11  11  11   8   8  11  11   7
  10  10  12  10  10   8   2   1   1   1   1   1   3   2   2   3   4   4   3
   5   6   5   3   8   5   5   7   7   7   8   8   8   8  11   7
   8  10  10  12  10   8   4   2   1   1   1   1   2   2   2   3   4   4   3
   3   3   5   5  .7   3   6   6   6   6   6   6  .5  .5  11   6
   0   0   8  10  12  10   8   3   2   1   2   2   2   3   3   3   4   4   3
   3   3   3  .7   5   5   5   5   5   5   5   5   5   1  .5   5
   0   0   0   8  10  12  10  10   4   2  .5  .5  .5   1   11.5   3   3   3
   2   2  .5  .5   5   5   5   8  10   6   6   6   3   3  .5   1
   0   0   0   8  10  10  10  10   1  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5
  .5  .5   1   1   4   5   5  12  .5  .5   7   8   3  .5   4   1
   0   0   0   0   0  10  10  10  10  10  10  10  10  10  10  10   2   2   2
   2   2   2   2   8   8  10  20  20  20  20  20  20   9   2  10
   0   0   0   0   0  10  10  10  10  10  10  10   7   7   7  10  10  10   8
   8   8   8   8   5   5   5   5   5   5   5   5   5   5   8  10
   0   0   0   0   0   0   0   5   2   2   2   2   2   7   7   7  10   6   5
   5   5   1   1   1  .5  .5  .5  .5  .5  .5   1   1   1   4   4
   0   0   0   0   0   0   0   0   0   1   1   1   1   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
        11          1 (19F4.0,/,16F4.0)          7  BOT LAYER 2
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0405039803900382037203680359535253485346033803340340034203460
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
4090402039503875379537203650357535103470341033503300334033803420
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  04090
4050399039403850377037003630356034703440338033203280332033603380
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  040804070
4000395038903815374536753600353034403400336033203260332033403360
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  040403990
3940389538403780371536403570350034203380334033003240328033003340
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 0391039603910
3870381037703720367036003535345034003365334032803220322032603300
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 0390038803840
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3300328032603250324032203200318032003260345036003980396038503580
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   0   0   03340328032103240324032603260326032403240322032203240322032203220
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   0   0   03320332032803190320032203220322032003200318031603160316031603170
3350344035203500355038003600375039303910372035503550345037503800
   0   0   0   0   032803300319031603140318031603090308030703080308031503300
3400370037003550363039003830382038103800371035903540347034603420
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3720394039503945394039353930393039103890384037603660366033503340
   0   0   0   0   0   0   03340330032803260324032403240320031603140312033300
3300375039553950394539453935392539153905388538553695366535553500
   0   0   0   0   0   0   0   0   03340330032803280   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
       11  1.0E-07(2(16F5.0,/),3F5.0)          12  VCONT LAYER 2
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0 1.06 1.06 1.06 1.0642.6942.6942.69 42.742.6814.9414.9410.67
10.6710.6710.67
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0 1.06 1.06 1.0642.6842.6842.6942.6942.69 42.742.6932.0332.0210.67
10.6710.6710.67
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
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42.6942.69 42.7
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53.3842.6942.69
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    010.6710.6721.3542.6742.6842.6842.6942.6942.6942.69 42.7 42.7 42.7 42.753.38
 42.742.69 42.7
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
10.6710.6710.6710.6710.6710.6721.3542.6942.6942.69 42.7 42.7 42.7 42.7 42.749.11
 42.710.6710.67
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    010.6710.67 1.49  .85  .64  .64  .85 1.49 2.13 2.13 2.13 2.13 2.13 2.1310.67
10.6710.6710.6710.6710.6710.6710.6710.6710.6721.3521.35 42.7 42.7 42.710.6710.67
32.0310.6710.67
10.6710.6710.6710.67 6.40 4.27 1.70 2.13 2.13 2.13 2.13 2.13 2.13 2.13 2.13 2.13
 2.13 2.13 2.13 2.13 2.13 2.1310.67 6.40 6.4010.6721.3510.6710.6710.6710.6710.67
21.3521.3510.67
10.6710.67 42.7 42.721.3521.3510.6710.6610.66 2.13 2.13 2.13 2.13 2.13 2.13 2.13
 2.13 2.13 2.13 2.13 2.13 6.40 6.40 6.40 6.4010.6710.6710.6710.6710.6710.6710.67
10.6721.3510.67
42.69 42.7 42.7 42.7 42.742.6942.6710.6710.6610.66 2.13 2.13 2.13 2.13 2.13 2.13
 2.13 2.13 2.13 2.13 2.13 2.13 6.40 6.4010.6710.6710.6710.6710.6710.6710.67 1.06
 1.0619.2010.67
    0    042.69 42.7 42.7 42.742.6942.6621.3314.9310.67 2.13 2.13 2.13 2.13 2.13
 2.13 2.13 2.13 2.13 2.13 6.40 6.40 6.4010.6710.6710.67 1.06 1.0610.6710.67 1.06
 1.06 1.06 6.40
    0    0    042.69 42.7 42.7 42.7 42.721.3410.6710.6510.6510.6510.66 2.13 2.13
 2.13 2.13 2.13 1.06 1.06 1.06  .85  .64 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06
 1.06 1.06 6.39
    0    0    042.69 42.7 42.7 42.7 42.742.56 6.40 6.40 6.40 6.40 6.40 2.13 2.13
 2.13 2.13 2.13 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06
 1.06 1.0610.58
    0    0    0    0    0 42.7 42.7 42.7 42.7 42.7 42.710.6710.6710.6710.6710.67
10.6710.67 1.06 1.06 1.06 1.06 1.06 1.06 1.06  1.7  1.7  1.7  1.7  1.7  1.7  1.7
 1.06 1.0610.67
    0    0    0    0    0 42.7 42.7 42.7 42.710.6710.6710.6710.6710.6710.6710.67
 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06
 1.06 1.0610.67
    0    0    0    0    0    0    042.6810.6710.6710.6710.6710.6710.6710.67 1.06
 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06  .63  .42  .21  .21  .42  .63  .85  .85
 1.06 1.0610.67
    0    0    0    0    0    0    0    0    010.6610.6610.6610.66    0    0    0
```

```
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0
      11         1 (10F8.1)              7  TOP LAYER 2
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
  4217.5  4212.9  4209.0  4204.0  4195.1  4190.0  4185.4  4181.7  4176.9  4172.2
  4168.8  4171.3  4177.8  4182.0  4184.5
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0  4212.8
  4208.1  4203.2  4196.6  4191.9  4187.2  4182.6  4178.3  4173.5  4168.7  4164.1
  4160.8  4159.9  4162.0  4163.9  4164.2
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0  4219.7  4209.4
  4200.3  4195.2  4190.4  4185.4  4180.6  4176.2  4171.1  4166.4  4162.2  4158.4
  4155.0  4152.0  4151.7  4152.3  4152.0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0  4223.7  4214.7  4205.4
  4195.7  4190.1  4184.6  4179.2  4174.1  4169.2  4164.1  4160.3  4156.4  4153.0
  4149.5  4146.2  4144.5  4144.9  4144.9
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0  4223.9  4211.1  4201.1
  4191.4  4185.3  4179.1  4173.2  4167.8  4162.9  4158.3  4154.3  4150.6  4147.3
  4143.5  4140.0  4136.6  4137.6  4137.8
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0  4223.4  4216.0  4206.4  4196.4
  4186.8  4179.7  4173.1  4167.2  4161.8  4156.7  4152.3  4148.4  4144.9  4141.4
  4137.6  4133.4  4128.6  4128.7  4129.3
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0  4222.7  4211.2  4201.8  4191.4
  4181.6  4174.0  4167.1  4160.8  4155.2  4150.4  4146.3  4142.5  4139.0  4135.7
  4131.8  4126.9  4120.7  4119.2  4120.5
      .0  4298.8  4279.6  4266.4  4270.9  4299.5  4356.2  4369.4  4380.2  4389.5
  4373.1  4347.8  4301.6  4278.8  4261.4  4236.5  4215.6  4205.1  4195.1  4183.9
  4174.6  4167.2  4160.0  4153.2  4147.3  4142.8  4138.8  4135.3  4132.1  4128.8
  4124.4  4118.1  4050.0  4108.0  4110.9
  4253.0  4233.0  4269.0  4256.6  4249.4  4248.4  4256.9  4277.1  4291.4  4301.0
  4300.7  4284.3  4263.0  4252.2  4236.0  4215.9  4201.8  4191.9  4181.9  4171.5
  4163.6  4155.7  4148.2  4141.5  4136.8  4132.6  4128.5  4124.9  4121.5  4118.2
  4113.8  4107.0  4033.0  4091.8  4094.1
  4292.8  4275.5  4220.0  4249.0  4240.3  4233.2  4230.9  4235.8  4241.9  4249.0
  4249.4  4240.8  4231.3  4221.1  4207.1  4192.4  4182.3  4173.5  4164.3  4154.9
  4148.2  4141.7  4135.2  4129.7  4123.3  4116.9  4112.9  4109.6  4106.5  4103.7
  4100.4  4096.6  4084.8  4004.0  4070.0
  4279.6  4268.6  4252.9  4210.0  4231.1  4223.8  4216.7  4213.0  4212.7  4211.5
  4210.0  4205.7  4201.5  4190.9  4180.3  4170.6  4161.9  4154.3  4146.6  4139.4
  4133.0  4127.2  4122.3  4107.9  4098.2  4095.1  4092.7  4090.0  4086.4  4081.5
  4076.6  4066.6  4055.7  4020.0  4047.2
      .0      .0  4243.3  4231.6  4196.0  4213.9  4204.9  4196.5  4192.3  4189.7
  4185.0  4180.5  4175.6  4166.5  4159.3  4151.3  4143.3  4136.7  4129.7  4123.3
  4117.3  4111.6  4094.5  4073.5  4071.2  4068.4  4064.3  4059.4  4053.5  4044.9
  4035.4  4011.4  4005.7  4010.0  4022.7
      .0      .0      .0  4224.0  4216.4  4185.0  4194.3  4184.2  4179.3  4174.4
  4164.9  4152.3  4142.9  4137.2  4133.7  4128.7  4125.3  4119.9  4113.9  4107.9
  4101.1  4082.5  4058.7  4045.8  4042.0  4033.9  4029.4  4032.1  4024.2  4001.0
  3978.5  3956.7  3944.8  3980.0  3967.3
      .0      .0      .0  4222.0  4214.5  4200.1  4140.0  4130.0  4165.9  4156.0
  4143.3  4130.2  4117.5  4105.9  4095.8  4090.4  4087.1  4081.9  4078.8  4069.7
  4058.3  4036.6  4020.3  4013.2  4009.4  3998.0  3990.9  3976.2  3962.2  3943.9
  3928.8  3914.3  3903.7  3850.0  3901.9
      .0      .0      .0      .0      .0  4194.4  4184.1  4172.1  4120.0  4108.0
  4131.7  4053.0  4040.0  4020.0  4010.0  4064.6  4054.4  4047.9  4041.8  4032.2
  4022.1  4005.8  3994.0  3973.0  3952.0  3943.0  3935.0  3920.0  3910.0  3880.0
  3850.0  3840.0  3873.8  3815.0  3860.3
      .0      .0      .0      .0      .0  4192.3  4183.9  4171.9  4158.4  4144.9
  4070.0  4119.6  4105.0  4087.6  4074.2  4035.0  4021.0  4014.0  4008.0  4000.0
  3990.0  3995.0  3990.0  3983.2  3967.4  3955.3  3943.6  3929.4  3917.3  3906.9
  3895.2  3882.6  3800.0  3790.0  3785.0
      .0      .0      .0      .0      .0      .0      .0  4173.4  4165.9  4152.3
```

```
  4141.4  4129.4  4113.9  4090.9  4077.3  4063.4  4049.5  4042.2  4035.6  4029.1
  4024.9  4008.6  3996.4  3985.3  3972.0  3958.8  3945.0  3929.5  3915.9  3906.1
  3897.8  3888.3  3876.9  3858.8  3851.8
      .0      .0      .0      .0      .0      .0      .0      .0      .0  4165.2
  4151.5  4139.5  4127.8      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0
      11   .001068 (19F4.0,/,16F4.0)           12  T LAYER 3
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0  .5  .5  .5  .5  20  20  20  20  20   7   7   5   5   5   5
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
  .5  .5  .5  20  20  20  20  20  20  20  15  15   5   5   5   5
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  .5
  .5  20  20  20  20  20  20  02  20  20  20  23  23  20  20  20
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  .5  .5
   5  20  20  20  20  20  20  20  20  20  20  20  25  20  20  20
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   5   5
  10  20  20  20  20  20  20  20  20  20  20  20  25  20  20  20
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   5   5   5
   5   5   5  10  20  20  20  20  20  20  20  20  23  20   5   5
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   5   5   5
   5   5   5   5   5  10  20  20  20  20  20  20  20  20   5   5
   0   5   5  .7  .4  .3  .3  .4  .7   1   1   1   1   1   1   5   5   5   5
   5   5   5   5   5   5  10  10  20  20  20   5   5  15   5   5
   5   5   5   5   3   2  .8   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   5   3   3   5  10   5   5   5   5   5  10  10   5
   5   5  20  20  10  10   5   5   5   1   1   1   1   1   1   1   1   1   1
   1   1   3   3   3   3   5   5   5   5   5   5   5   5  10   5
  20  20  20  20  20  20  20   5   5   5   1   1   1   1   1   1   1   1   1
   1   1   1   3   3   5   5   5   5   5   5   5  .5  .5   9   5
   0   0  20  20  20  20  20  20  10   7   5   1   1   1   1   1   1   1   1
   1   1   3   3   3   5   5   5  .5  .5   5   5  .5  .5  .5   3
   0   0   0  20  20  20  20  20  10   5   5   5   5   5   1   1   1   1   1
  .5  .5  .5  .4  .3  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5   3
   0   0   0  20  20  20  20  20  20   3   3   3   3   3   1   1   1   1   1
  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  5.
   0   0   0   0   0  20  20  20  20  20  20   5   5   5   5   5   5   5  .5
  .5  .5  .5  .5  .5  .5  .8  .8  .8  .8  .8  .8  .8  .5  .5   5
   0   0   0   0   0  20  20  20  20   5   5   5   5   5   5   5  .5  .5  .5
  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  5.
   0   0   0   0   0   0   0  20   5   5   5   5   5   5   5  .5  .5  .5  .5
  .5  .5  .5  .5  .5  .3  .2  .1  .1  .2  .3  .4  .4  .5  .5  5.
   0   0   0   0   0   0   0   0   0   5   5   5   5   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
      11         1 (19F4.0,/,16F4.0)            7  TOP LAYER 3
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0405039803900382037203680359535253485346033803340340034203460
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
4090402039503875379537203650357535103470341033503300334033803420
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  04090
4050399039403850377037003630356034703440338033203280332033603380
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  040804070
4000395038903815374536753600353034403400336033203260332033403360
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  040403990
3940389538403780371536403570350034203380334033003240328033003340
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 0391039603910
3870381037703720367036003535345034003365334032803220322032603300
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 0390038803840
3790376037203675362035503500341033703350332032703200320032403260
   0355035503550355036253715379038353880390839303930392039403900385037803750
3710368036403590355034903400336033403340332032603200320033203240
3280328033403360347034753480351535453575359536133615361736003700355036603630
3600357035403500341033603340332033003285327032403400329033603500
3340332032603280334033603410345034903500350034703450341033903390338534703500
3470340033203320332033003270325032303200331034003840367535003640
3400336033203240328033003340336033703380338033653350332033003320332033403350
3300328032603250324032203200318032003260345036003980396038503580
   0    03360330032203260328032803300331033253310329032703260327032603260324O
```

```
3230323032103170316034003550351035103510350035603940399039903660
   0   0   03340328032103240324032603260326032403240322032203240322032203220
3200319033803340340035003500355035003500355035203500380038703640
   0   0   03320332032803190320032203220322032003200318031603160316031603170
3350344035203500355038003600375039303910372035503550345037503800
   0   0   0   0   03280330031903160314031803160309030803070308030803150330 0
3400370037003550363039003830382038103800371035903540347034603420
   0   0   0   0   03300334032803240322031303120318032003140306030403110323 0
3720394039503945394039353930393039103890384037603660366033503340
   0   0   0   0   0   03340330032803260324032403240320031603140312033 00
3300375039553950394539453935392539153905388538553695366535553500
   0   0   0   0   0   0   0   0   03340330032803280   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
```

8.1.3 WEL Data File

```
        10         0
        10
         1         9         1      1.26
         1        16        35     -.330
         2         8         2      1.38
         2         9         1      .960
         2        10         1      1.55
         2        16        35     -.570
         2        17        31      .006
         2        17        32      .020
         2        17        33      .090
         2        17        34      .276
```

8.1.4 EVP Data File

```
         1         0
         0         0         0
        15         1 (19F4.0,/,16F4.0)           7  LANO SURFACE ELEVATION
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   04110   0   0
   04284   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   04093   0   0
   0   04260   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   04064   0
   0   0   04240   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   04041   0
   0   0   0   04221   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   04030   0
   0   0   0   0   04210   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   04000   0
   0   0   0   0   0   041854175   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   03910   0
   0   0   0   0   0   0   0   041554143   04120410240844072   0   0   0   0
   0   0   0   0398339623953394539303920391138983891   03880   0
   0   0   0   0   0   0   0   0   0   04132   0   0   0   04060404640394033
4022401040104005   0   0   0   0   0   0   0   0   038603850   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
        15     2.E-8 (19F4.0,/,16F4.0)          12 MAX ET RATE
```

```
                                                        1
       1
                                                        1
           1
                                                            1
               1
                                                            1
                   1
                                                            1
                       1
                                                            1
                           1   1
                                                            1
```

```
                       1
                                                           1
                           1   1
                                                           1
                                   1   1       1   1   1   1
                   1   1   1   1   1   1   1   1   1       1
                                           1                   1   1   1   1
   1   1   1   1                                       1   1


        15        10 (19F4.0,/,16F4.0)           8 EXTINCTION DEPTH






                                                       1
       1
                                                       1
           1
                                                           1
               1
                                                           1
                   1
                                                           1
                       1
                                                           1
                           1   1
                                                           1
                                   1   1       1   1   1   1
                   1   1   1   1   1   1   1   1   1       1
                                           1                   1   1   1   1
   1   1   1   1                                       1   1
```

8.1.5 RCH Data File

```
         3         0
         0
        18  1.00E-09 (2(16F5.0/),3F5.0)        12  AREAL RECH RATE FT/S
                    29.7019.3329.0040.0627.6226.9325.5539.3618.6415.8811.0520.03
38.6740.75 44.2

               21.41


          33.15


     13.81


     55.25


13.81


41.44

            .34  .34 3.79 5.18 7.5913.1215.1917.9517.9517.9520.0321.4120.7217.95











           4.97





                8.28 8.28





                          6.21 7.59


                                    14.520.72     11.7412.4311.7416.5712.4311.05
 7.59  6.9 6.21 4.83 4.83

                                             20.7211.7412.4312.43
```

8.1.6 STR Data File

```
      42         2         1       0       1   1.486      -1       0
      42         0         0
   1    9    2    1    1        4.84    4283    .279    4278    4283
   1   10    3    1    2                4260    .279    4255    4260
   1   11    4    1    3                4240    .279    4235    4240
   1   12    5    1    4                4220    .223    4215    4220
   1   13    6    1    5                4210    .167    4205    4210
   1   14    7    1    6                4180    .167    4175    4180
   1   14    8    1    7                4170    .167    4165    4170
   1   15    9    1    8                4150    .167    4145    4150
   1   15   10    1    9                4140    .167    4135    4140
   1   16   11    1   10                4130    .167    4125    4130
   1   15   12    1   11                4113    .167    4108    4113
   1   15   13    1   12                4100    .167    4095    4100
   1   15   14    1   13                4080    .167    4075    4080
   1   15   15    1   14                4070    .167    4065    4070
   1   16   16    1   15                4060    .167    4055    4060
   1   16   17    1   16                4040    .134    4035    4040
   1   16   18    1   17                4035    .134    4030    4035
   1   16   19    1   18                4030    .100    4025    4030
   1   16   20    1   19                4020    .100    4015    4020
   1   16   21    1   20                4010    .100    4005    4010
   1   16   22    1   21                4000    .100    3995    4000
   1   16   23    1   22                3995    .100    3990    3995
   1   15   24    1   23                3980    .100    3975    3980
   1   15   25    1   24                3960    .100    3955    3960
   1   15   26    1   25                3950    .100    3945    3950
   1   15   27    1   26                3940    .100    3935    3940
   1   15   28    1   27                3930    .100    3925    3930
   1   15   29    1   28                3920    .100    3915    3920
   1   15   30    1   29                3910    .100    3905    3910
   1   15   31    1   30                3890    .134    3885    3890
   1   15   32    1   31                3880    .134    3875    3880
   1   16   33    1   32                3860    .167    3855    3860
   1   16   34    1   33                3850    .167    3845    3850
   1    8   33    2    1        .000    4100    .106    4090    4100
   1    9   33    2    2                4090    .132    4080    4090
   1   10   34    2    3                4060    .132    4050    4060
   1   11   34    2    4                4040    .106    4030    4040
   1   12   34    2    5                4020    .106    4010    4020
   1   13   34    2    6                3970    .106    3960    4000
   1   14   34    2    7                3900    .132    3890    3900
   1   15   34    2    8                3875    .111    3865    3875
   1   16   34    2    9                3850    .111    3840    3850
      22     .0031      .022
      22     .0027      .022
      22     .0027      .022
      22     .0013      .022
      22     .0052      .022
      22     .0019      .022
      21     .0038      .022
      20     .0024      .022
      22     .0019      .022
      24     .0020      .022
      23     .0023      .022
      23     .0034      .022
      25     .0038      .022
      27     .0019      .022
      27     .0019      .022
      24     .0038      .022
      12     .0011      .022
      13     .0012      .022
      14     .0027      .022
      17     .0032      .022
      20     .0016      .022
```

```
      23      .0042       .022
      25      .0063       .022
      27      .0032       .022
      27      .0032       .022
      27      .0032       .022
      27      .0032       .022
      25      .0032       .022
      23      .0027       .022
      20      .0010       .022
      18      .0042       .022
      17      .0030       .022
      17      .0046       .022
       3      .0021       .020
       3      .0040       .020
       3      .0038       .020
       3      .0038       .020
       3      .0042       .020
       3      .0189       .020
       3      .0080       .020
       3      .0060       .020
       3      .0046       .020
2
0
```

8.1.7 PCG Data File

```
100       5         1
.01      .001       1.        2         1
```

8.1.8 OPC Data File

```
3         8         0         0
0         1         0         1
1         0         1         0
```

8.2 Transient State Simulation

8.2.1 BAS Data File

```
Upper San Pedro River Model
 --transient STATE-- THREE LAYERS
         3        18        35        12         1
11 12 00 00 15 00 17 18  0 20 00 22 23
         0         1
        35         1(1914,/,1614)               5
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   1   0   0
   1   1   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   1   0   0
   0   0   1   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   0
   0   0   0   1   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   0
   0   0   0   0   1   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   1   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   1   1   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   1   1   0   1   1   1   1   0   0   0   0
   0   0   0   0   1   1   1   1   1   1   1   1   1   0   1   0
   0   0   0   0   0   0   0   0   0   0   1   0   0   0   0   1   1   1   1
   1   1   1   1   0   0   0   0   0   0   0   0   0   1   1   1
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
        35         1(1914,/,1614)               5
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   0   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
```

```
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   0   0   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   0   0   0   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   0   0   0   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   0   0   0   0   0   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   0   0   0   0   0   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   0   0   0   0   0   0   0   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   0   0   0   0   0   0   0   0   0   2   2   2   2   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
    35         1(19I4,/,16I4)             5
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   3   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   3   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   0   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   0   0   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   0   0   0   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   0   0   0   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   0   0   0   0   0   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   0   0   0   0   0   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   0   0   0   0   0   0   0   3   3   3   3   3   3   3   3   3   3   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   0   0   0   0   0   0   0   0   0   3   3   3   3   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
    0.0
    35         1 (10F8.1)                 7 INITIAL HEAD (UPPER)
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
```

```
      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0  4106.2      .0      .0
  4297.5  4285.4      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0  4097.7      .0      .0
      .0      .0  4259.8      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0  4062.9      .0
      .0      .0      .0  4239.9      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0  4048.5      .0
      .0      .0      .0      .0  4221.0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0  4206.7      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0  4184.0  4175.7      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0  4154.3  4143.6
      .0  4113.1  4100.4  4085.1  4074.9      .0      .0      .0      .0      .0
      .0      .0      .0  3980.9  3962.3  3952.6  3944.0  3929.8  3918.4  3908.3
  3896.9  3887.4      .0  3861.5      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
  4131.2      .0      .0      .0      .0  4060.0  4045.6  4037.9  4031.2  4021.9
  4012.0  4002.0  3995.9      .0      .0      .0      .0      .0      .0      .0
      .0      .0  3859.0  3854.5  3850.1
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0
      35         1 (10f8.1)              7 INITIAL HEAD (INTERMEDIATE)
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
  4217.2  4212.7  4208.8  4203.9  4194.9  4189.8  4185.1  4181.4  4176.5  4171.7
  4168.3  4170.6  4177.0  4181.1  4183.6
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0  4211.9
```

```
  4207.7  4203.0  4196.6  4191.8  4187.0  4182.3  4178.0  4173.2  4168.3  4163.6
  4160.2  4159.2  4161.2  4163.0  4163.3
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0  4217.9  4208.2
  4200.2  4195.2  4190.4  4185.4  4180.5  4176.0  4170.9  4166.0  4161.7  4157.9
  4154.4  4151.2  4150.8  4151.4  4151.1
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0  4221.8  4212.6  4203.4
  4196.0  4190.3  4184.7  4179.2  4174.0  4169.1  4163.9  4159.9  4156.0  4152.5
  4148.8  4145.5  4143.5  4144.0  4143.9
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0  4222.0  4208.7  4199.5
  4192.2  4185.7  4179.3  4173.3  4167.8  4162.8  4158.1  4154.1  4150.3  4146.8
  4142.9  4139.2  4135.6  4136.6  4136.8
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0  4221.9  4214.2  4204.2  4195.4
  4187.5  4180.1  4173.4  4167.4  4161.8  4156.7  4152.2  4148.2  4144.5  4141.0
  4136.9  4132.5  4127.5  4127.6  4128.2
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0  4221.3  4209.6  4199.9  4190.7
  4182.4  4174.5  4167.4  4161.0  4155.3  4150.4  4146.2  4142.3  4138.7  4135.3
  4131.2  4126.0  4119.3  4118.1  4119.4
      .0  4298.9  4280.2  4267.0  4271.3  4299.9  4356.5  4369.8  4380.5  4389.8
  4373.3  4347.9  4301.6  4278.6  4261.1  4235.8  4214.4  4203.7  4193.5  4183.7
  4175.5  4167.8  4160.4  4153.5  4147.5  4142.8  4138.8  4135.3  4131.9  4128.6
  4123.9  4117.3  4106.6  4106.8  4109.8
  4297.5  4285.4  4270.0  4257.2  4249.8  4248.7  4257.2  4277.5  4291.7  4301.3
  4300.9  4284.4  4263.0  4252.2  4235.8  4215.4  4201.0  4191.0  4181.0  4171.5
  4164.2  4156.3  4148.6  4141.9  4137.1  4132.8  4128.6  4125.0  4121.5  4118.3
  4114.0  4107.7  4097.7  4091.5  4093.3
  4293.3  4276.5  4259.9  4249.3  4240.6  4233.5  4231.2  4236.2  4242.3  4249.3
  4249.6  4241.0  4231.5  4221.2  4207.1  4192.2  4182.0  4173.1  4164.0  4155.2
  4148.9  4142.4  4135.8  4130.2  4123.7  4117.3  4113.1  4109.8  4106.7  4103.9
  4100.7  4096.9  4084.9  4063.2  4068.9
  4280.2  4269.2  4253.3  4240.0  4231.3  4224.0  4216.9  4213.4  4213.2  4211.9
  4210.3  4206.0  4201.8  4191.2  4180.6  4170.8  4162.1  4154.5  4146.7  4140.0
  4134.0  4128.2  4123.2  4108.7  4098.8  4095.7  4093.2  4090.4  4086.7  4081.8
  4076.9  4067.2  4057.7  4048.6  4048.4
      .0      .0  4243.5  4231.8  4221.2  4214.0  4205.2  4197.0  4192.9  4190.2
  4185.3  4180.7  4175.9  4167.1  4159.9  4151.8  4143.8  4137.3  4130.3  4124.4
  4118.8  4113.0  4095.7  4074.6  4072.1  4069.2  4065.1  4060.1  4054.1  4045.4
  4035.9  4011.4  4002.0  4010.2  4021.2
      .0      .0      .0  4224.1  4216.5  4206.7  4194.4  4185.1  4179.9  4175.0
  4165.2  4152.0  4143.1  4138.3  4134.8  4129.5  4126.1  4120.7  4114.8  4109.3
  4103.4  4085.5  4061.0  4047.0  4043.3  4035.1  4030.4  4032.9  4024.9  4001.6
  3979.2  3956.7  3936.8  3938.2  3960.1
      .0      .0      .0  4222.2  4214.6  4200.2  4184.7  4176.1  4166.2  4156.9
  4143.5  4128.9  4117.5  4108.2  4098.0  4091.5  4088.8  4083.4  4080.2  4073.0
  4064.6  4044.1  4024.8  4014.2  4011.3  3999.6  3992.2  3976.8  3962.4  3944.3
  3930.2  3916.1  3900.9  3881.0  3897.0
      .0      .0      .0      .0      .0  4194.5  4184.2  4173.2  4155.0  4143.8
  4132.0  4113.5  4100.6  4085.5  4075.1  4065.5  4057.1  4050.1  4043.7  4037.4
  4032.5  4019.9  4001.4  3981.1  3962.3  3952.7  3944.0  3929.8  3918.4  3908.4
  3897.0  3887.5  3877.4  3861.6  3858.3
      .0      .0      .0      .0      .0  4192.4  4184.2  4173.0  4158.7  4145.9
  4131.5  4118.2  4104.6  4088.9  4075.7  4060.3  4046.1  4038.2  4031.5  4022.0
  4012.0  4002.0  3995.9  3982.9  3967.7  3955.5  3943.4  3929.3  3916.7  3905.9
  3895.8  3885.1  3859.1  3854.6  3850.1
      .0      .0      .0      .0      .0      .0      .0  4174.4  4166.4  4153.0
  4141.5  4128.5  4113.8  4092.0  4078.3  4062.6  4049.0  4041.3  4034.5  4029.0
  4026.5  4009.9  3997.2  3985.5  3972.2  3958.9  3945.0  3929.3  3915.5  3905.6
  3898.3  3889.3  3878.7  3866.3  3852.5
      .0      .0      .0      .0      .0      .0      .0      .0      .0  4165.8
  4151.5  4139.0  4127.5      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0
        35         1 (10f8.1)                    7 INITIAL HEAD (LOWER)
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
```

```
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
  4217.2  4212.7  4208.8  4203.9  4194.9  4189.8  4185.1  4181.4  4176.5  4171.7
  4168.2  4170.6  4177.0  4181.1  4183.6
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0  4211.9
  4207.7  4203.0  4196.5  4191.8  4187.0  4182.3  4178.0  4173.2  4168.3  4163.6
  4160.2  4159.2  4161.2  4163.0  4163.3
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0  4217.9  4208.2
  4200.2  4195.2  4190.4  4185.4  4180.5  4176.0  4170.9  4166.0  4161.7  4157.9
  4154.4  4151.2  4150.8  4151.4  4151.1
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0  4221.7  4212.6  4203.4
  4196.0  4190.3  4184.7  4179.2  4174.0  4169.1  4163.9  4159.9  4156.0  4152.5
  4148.8  4145.5  4143.5  4144.0  4143.9
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0  4222.0  4208.7  4199.5
  4192.2  4185.7  4179.3  4173.3  4167.8  4162.8  4158.1  4154.1  4150.3  4146.8
  4142.9  4139.2  4135.6  4136.6  4136.8
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0  4221.9  4214.2  4204.2  4195.4
  4187.5  4180.1  4173.4  4167.4  4161.8  4156.7  4152.2  4148.2  4144.5  4141.0
  4136.9  4132.5  4127.5  4127.6  4128.2
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0  4221.3  4209.6  4199.9  4190.7
  4182.4  4174.5  4167.4  4161.0  4155.3  4150.4  4146.2  4142.3  4138.7  4135.3
  4131.2  4126.0  4119.3  4118.1  4119.4
      .0  4298.9  4280.2  4267.0  4271.3  4299.9  4356.5  4369.8  4380.5  4389.7
  4373.3  4347.9  4301.6  4278.6  4261.0  4235.8  4214.5  4203.7  4193.5  4183.7
  4175.5  4167.8  4160.4  4153.5  4147.5  4142.9  4138.8  4135.3  4131.9  4128.6
  4123.9  4117.3  4106.6  4106.8  4109.8
  4297.5  4285.4  4270.0  4257.2  4249.8  4248.7  4257.2  4277.5  4291.7  4301.3
  4300.9  4284.4  4263.0  4252.2  4235.8  4215.4  4201.0  4191.0  4181.0  4171.5
  4164.2  4156.3  4148.6  4141.9  4137.1  4132.8  4128.7  4125.0  4121.5  4118.3
  4114.0  4107.7  4097.7  4091.5  4093.3
  4293.3  4276.5  4259.9  4249.3  4240.6  4233.5  4231.2  4236.2  4242.3  4249.3
  4249.6  4241.0  4231.5  4221.2  4207.1  4192.2  4182.0  4173.1  4164.0  4155.2
  4148.9  4142.4  4135.8  4130.2  4123.7  4117.3  4113.1  4109.8  4106.7  4103.9
  4100.7  4096.9  4084.9  4063.2  4068.9
  4280.2  4269.2  4253.3  4240.0  4231.3  4224.0  4216.9  4213.4  4213.2  4211.9
  4210.3  4206.0  4201.8  4191.2  4180.6  4170.8  4162.1  4154.5  4146.7  4140.0
  4134.0  4128.2  4123.2  4108.7  4098.8  4095.7  4093.2  4090.4  4086.7  4081.8
  4076.9  4067.2  4057.7  4048.6  4048.4
      .0      .0  4243.5  4231.8  4221.2  4214.0  4205.2  4197.0  4192.9  4190.2
  4185.3  4180.7  4175.9  4167.1  4159.9  4151.8  4143.8  4137.3  4130.3  4124.4
  4118.8  4113.0  4095.7  4074.6  4072.1  4069.2  4065.1  4060.1  4054.1  4045.4
  4035.9  4011.4  4002.0  4010.2  4021.2
      .0      .0      .0  4224.1  4216.5  4206.7  4194.4  4185.1  4179.9  4175.0
  4165.2  4152.0  4143.1  4138.3  4134.8  4129.5  4126.1  4120.7  4114.8  4109.3
  4103.4  4085.5  4061.0  4047.0  4043.3  4035.1  4030.4  4032.8  4024.9  4001.6
  3979.2  3956.7  3936.9  3938.2  3960.1
      .0      .0      .0  4222.2  4214.6  4200.2  4184.7  4176.1  4166.2  4156.9
  4143.5  4128.9  4117.5  4108.2  4098.0  4091.5  4088.8  4083.4  4080.2  4073.0
  4064.6  4044.1  4024.8  4014.2  4011.3  3999.6  3992.2  3976.8  3962.4  3944.3
  3930.2  3916.1  3900.9  3881.0  3897.0
      .0      .0      .0      .0      .0  4194.5  4184.2  4173.2  4155.0  4143.8
  4132.0  4113.5  4100.6  4085.5  4075.1  4065.5  4057.1  4050.1  4043.7  4037.4
  4032.5  4019.9  4001.4  3981.1  3962.3  3952.7  3944.1  3929.8  3918.4  3908.4
  3897.0  3887.5  3877.4  3861.6  3858.3
      .0      .0      .0      .0      .0  4192.4  4184.2  4173.0  4158.7  4145.9
  4131.5  4118.2  4104.7  4088.9  4075.7  4060.3  4046.1  4038.3  4031.5  4022.0
  4012.0  4002.1  3995.9  3982.9  3967.7  3955.5  3943.4  3929.3  3916.7  3905.9
  3895.8  3885.1  3859.1  3854.6  3850.1
      .0      .0      .0      .0      .0      .0      .0  4174.4  4166.4  4153.0
  4141.5  4128.5  4113.8  4092.0  4078.3  4062.6  4049.0  4041.3  4034.5  4029.0
  4026.4  4009.9  3997.2  3985.5  3972.2  3958.9  3945.0  3929.3  3915.5  3905.6
  3898.3  3889.3  3878.7  3866.2  3852.5
      .0      .0      .0      .0      .0      .0      .0      .0      .0  4165.8
```

```
  4151.5  4139.0  4127.5      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0
  63072000         1         1
 126144000         2         1
 157680000         2         1
 409968000         2         1
  94608000         1         1
  31536000         1         1
  31536000         2         1
 126144000         1         1
 126144000         1         1
  31536000         2         1
 252288000         4         1
  94608000         2         1
```

8.2.2 BCF Data File

```
         0        -1
 1 3 2
        11         1(3F10.0)                     7  HORZ.ANISOTROPY
        1.        1.        1.
        11         1(4(8F10.0/),3F10.0)          7  DELR
      5280      5280      5280      5280      5280      5280      5280      5280
      5280      5280      5280      5280      5280      5280      5280      5280
      5280      4224      4224      3168      3168      3168      3168      3168
      3168      3168      3168      3168      3168      3168      4224      4224
      5280      5280      5280
        11         1(2(8F10.0/),2F10.0)          7  DELC
      4224      3168      3168      3168      3168      3168      3168      4224
      5280      5280      5280      5280      4224      3168      3168      3168
      3168      3168
         0       .12                                SPECIFIC STORAGE LAYER 1
         0  1.929-03                                K LAYER 1
        11         1(19F4.0,/,16F4.0)            7  BOT LAYER 1
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   04050   0   0
42534233   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   04033   0   0
   0   04220   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   04004   0
   0   0   04210   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   04020   0
   0   0   0   04196   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   04185   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   041404130   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   041204108   04053404040204010   0   0   0   0
   0   0   0   0397339523943393539203910388038503840   03815   0
   0   0   0   0   0   0   0   0   0   04070   0   0   0   04035402140144008
4000399039953990   0   0   0   0   0   0   0   0   0380037903785
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
        11         1 (4(8E10.4/),3E10.4)        12   VCONT LAYER 1
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.1851E-05 .1067E-05 .2091E-05 .2185E-05 .2185E-05 .1406E-05 .9192E-06 .7974E-06
.0000E+00 .6803E-07 .0000E+00
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.1231E-06 .1336E-06 .1242E-06 .3447E-06 .1915E-05 .2131E-05 .2131E-05 .0000E+00
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        0    .00001                               STORAGE COEF. LAYER 2
       11  .6044E-5 (19F4.0,/,16F4.0)       12    K LAYER 2
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0  26  21  18  14  13  13  12  12   7   7   7   6   6   6   6
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
  33  26  22  14  12  12  12  12  12   8  10  10   6   6   6   6
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  35
  31  16  14  13  11  12  12  12  12  12  12  13  13   9   9  12
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  31  34
  23  14  13  11  11  11  11  11  12  12  12  12  14   9   9  12
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  26  24
  17  13  12  11  11  11  11  11  11  12  12  12  15  10   8  12
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  16  22  20
  14  12  12  11  11  11  11  11  11  12  12  12  14  16   8  11
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  19  21  19
  12  11  11  11  11  11  11  11  11  11  12  12  14  17   8  11
   0   9   5  .8  .4  .2  .1  .4  .5  .5   1   1   3   8   8   6  15  12  10
   9   8  10  10  10  11  11  11  11  11  11  11  11  17  11  11
  10  12  10  10   8   1   1   1   1   1   1   1   3   3   3   4   6   6   6
   7   6   4   5   7  11  11  11  11  11  11   8   8  11  11   7
  10  10  12  10  10   8   2   1   1   1   1   1   3   2   2   3   4   4   3
   5   6   5   3   8   5   5   7   7   7   8   8   8   8  11   7
   8  10  10  12  10   8   4   2   1   1   1   1   2   2   2   3   4   4   3
   3   3   5   5  .7   3   6   6   6   6   6   6  .5  .5  11   6
   0   0   8  10  12  10   8   3   2   1   2   2   2   3   3   3   4   4   3
   3   3   3  .7   5   5   5   5   5   5   5   5   5   1  .5   5
   0   0   0   8  10  12  10  10   4   2  .5  .5  .5   1   1 1.5   3   3   3
   2   2  .5  .5   5   5   5   8  10   6   6   6   3   3  .5   1
   0   0   0   8  10  10  10  10   1  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5
  .5  .5   1   1   4   5   5  12  .5  .5   7   8   3  .5   4   1
   0   0   0   0   0  10  10  10  10  10  10  10  10  10  10  10   2   2   2
   2   2   2   2   8   8  10  20  20  20  20  20  20   9   2  10
   0   0   0   0   0  10  10  10  10  10  10  10   7   7   7  10  10  10   8
   8   8   8   8   5   5   5   5   5   5   5   5   5   5   8  10
   0   0   0   0   0   0   0   5   2   2   2   2   2   7   7   7  10   6   5
   5   5   1   1   1  .5  .5  .5  .5  .5  .5   1   1   1   4   4
   0   0   0   0   0   0   0   0   0   1   1   1   1   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
       11         1 (19F4.0,/,16F4.0)        7  BOT LAYER 2
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0405039803900382037203680359535253485346033803340340034203460
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
4090402039503875379537203650357535103470341033503300334033803420
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   04090
4050399039403850377037003630356034703440338033203280332033603380
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   040804070
4000395038903815374536753600353034403400336033203260332033403360
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   040403990
3940389538403780371536403570350034203380334033003240328033003340
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0391039603910
3870381037703720367036003535345034003365334032803220322032603300
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0390038803840
3790376037203675362035503500341033703350332032703200320032403260
   0355035503550355036253715379038353880390839303930392039403900385037803750
3710368036403590355034903400336033403340332032603200320033203240
3280328033403360347034753480351535453575359536133615361736003700355036603630
3600357035403500341033603340332033003285327032403400329033603500
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3340332032603280334033603410345034903500350034703450341033903390338534703500
347034003320332033203300327032503230320033103400384036753500364 0
34003360332032403280330033403360337033803380336533503320330033203320334033 50
33003280326032503240322032003180320032603450360039803960385035 80
    0    0336033003220326032803280330033103325331032903270326032703260326032 40
32303230321031703160340035503510351035103500356039403990399036 60
    0    0    033403280321032403240326032603260324032403220322032403220322032 20
32003190338033403400350035003550350035003550352035003800387036 40
    0    0    033203320328031903200322032203220320032003180316031603160316031 70
33503440352035003550380036003750393039103720355035503450375038 00
    0    0    0    0    032803300319031603140318031603090308030703080308031503 300
34003700370035503630390038303820381038003710359035403470346034 20
    0    0    0    0    033003340328032403220313031203180320031403060304031103 230
37203940395039453940393539303930391038903840376036603660335033 40
    0    0    0    0    0    0    033403300328032603240324032403200316031403120 3300
33003750395539503945394539353925391539053885385536953665355535 00
    0    0    0    0    0    0    0    0    03340330032803280    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
       11   1.0E-07(2(16F5.0,/),3F5.0)           12  VCONT LAYER 2
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0 1.06 1.06 1.06 1.0642.6942.6942.69 42.742.6814.9414.9410.67
10.6710.6710.67
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0 1.06 1.06 1.0642.6842.6842.6942.6942.69 42.742.6932.0332.0210.67
10.6710.6710.67
   .0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0 1.06 1.0642.6742.6742.6842.6842.6942.69 42.7 42.7 42.7 42.7 49.149.11
42.6942.69 42.7
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
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53.3842.6942.69
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    010.6710.6721.3542.6742.6842.6842.6942.6942.6942.69 42.7 42.7 42.7 42.753.38
 42.742.69 42.7
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
10.6710.6710.6710.6710.6710.6721.3542.6942.6942.69 42.7 42.7 42.7 42.7 42.749.11
 42.710.6710.67
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
10.6710.6710.6710.6710.6710.6710.6710.6721.3542.69 42.7 42.7 42.7 42.7 42.7 42.7
42.7110.6710.67
    010.6710.67 1.49  .85  .64  .64  .85 1.49 2.13 2.13 2.13 2.13 2.13 2.1310.67
10.6710.6710.6710.6710.6710.6710.6710.6710.6721.3521.35 42.7 42.7 42.710.6710.67
32.0310.6710.67
10.6710.6710.6710.67 6.40 4.27 1.70 2.13 2.13 2.13 2.13 2.13 2.13 2.13 2.13 2.13
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21.3521.3510.67
10.6710.67 42.7 42.721.3521.3510.6710.6610.66 2.13 2.13 2.13 2.13 2.13 2.13 2.13
 2.13 2.13 2.13 2.13 2.13 6.40 6.40 6.40 6.4010.6710.6710.6710.6710.6710.6710.67
10.6721.3510.67
42.69 42.7 42.7 42.7 42.742.6942.6710.6710.6610.66 2.13 2.13 2.13 2.13 2.13 2.13
 2.13 2.13 2.13 2.13 2.13 2.13 6.40 6.4010.6710.6710.6710.6710.6710.6710.67 1.06
 1.0619.2010.67
    0    042.69 42.7 42.7 42.742.6942.6621.3314.9310.67 2.13 2.13 2.13 2.13 2.13
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 1.06 1.06 6.40
    0    0    042.69 42.7 42.7 42.7 42.721.3410.6710.6510.6510.6510.66 2.13 2.13
 2.13 2.13 2.13 1.06 1.06 1.06  .85  .64 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06
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    0    0    042.69 42.7 42.7 42.7 42.742.56 6.40 6.40 6.40 6.40 6.40 2.13 2.13
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 1.06 1.0610.58
    0    0    0    0    0 42.7 42.7 42.7 42.7 42.7 42.710.6710.6710.6710.6710.67
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 1.06 1.0610.67
    0    0    0    0    0 42.7 42.7 42.7 42.710.6710.6710.6710.6710.6710.6710.67
 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06
 1.06 1.0610.67
    0    0    0    0    0    0    042.6810.6710.6710.6710.6710.6710.6710.67 1.06
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1.06 1.06 1.06 1.06 1.06 1.06 1.06 1.06  .63  .42  .21  .21  .42  .63  .85  .85
1.06 1.0610.67
   0    0    0    0    0    0    0    0    010.6610.6610.6610.66    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0
        11         .01(19F4.0,/,16F4.0)               10  SPECIFIC YIELD LAYER 2
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   4   4   4   4   4  21  21  21   4   4   4   8   8   4   4
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   4   4   4   4   4   4   4   4   4   4   4   4   8   8   4   4
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   4
   8   8   8   4   4   4   4   4   4   4   4   4   8   8   4   4
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   4   4
   8   8   8   8   8   8   8   8   8   8   8   8   8   8   4   4
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   4   4
   4   8   8   8   8   8   8   8   8   8   8   8   8   8   4   4
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   8   4   4
   4   8   8   8   8   8   8   8  12  12  12   8   8   8   4   4
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   8   4   4
   4   8   8   8   8   8   8   4   4   4   4   4   4   4   4   4
   0   8   8   8   8   8  16   8   8   8   8  12  12  21  21   8   8   4   4
   4   8   8   8   8   8  12  12  12  12  12  12   4   4   4   4
  12  12   8   8   8   8  16   8   8   8   8  12  12  12  21   8   8   4   4
   4   8   8   8   8  12  12  12  12  12  12  12  12   4   8   4
   8   8  12   8   8   8   8   8   4   8  12   8  16  16  12  12   8   8   4
   4   8   8   8   8  12  12  12  12  12  12  12  12  12   8   8
   8   8   8  16   8   8   8   8   4  12  12   8  16  16  12  12   8   8   8
   4   8   8   8   8  12  12  12  12  12  12  12   2   2  16   8
   0   0   8   8  16   8   8   4   4   8  12   8   8   8   8   8   8   8   8
   4   8   8   8   8   8  12  12  12  12  12  12   4   2   2   8
   0   0   0   8   8  12   4   8   8   8   8   8   8   8   8   8   8   8   8
   4   8   8   8   8   8   8  12  12  12  12  12  12  12   2   4
   0   0   0   8   8   8  12  12  12   8   8   8   8   8   4   4   4   4   4
   4   4   4   4   4   4   4   4   2   2   4  12  12  12   4   4
   0   0   0   0   0   8   8   8   8   8   8   8   8   8   4   4   4   4   4
   4   4   4   4   4   4   4   4   4   4   4   4   4   4   4   8
   0   0   0   0   0   8   8   8   8   8   8   8   8   8   4   4   4   4   4
   4   4   4   4   4   4   2   2   2   2   4   4   4   4   8   8
   0   0   0   0   0   0   0   8   8  21  21   8   8   8   4   4   4   4   4
   4   4   2   2   2   2   2   2   2   2   2   2   4   4   8   8
   0   0   0   0   0   0   0   0   0  21  21  12  12   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
        11           1  (10F8.1)                     7  TOP LAYER 2
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
  4217.2  4212.7  4208.8  4203.9  4194.9  4189.8  4185.1  4181.4  4176.5  4171.7
  4168.3  4170.6  4177.0  4181.1  4183.6
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0  4211.9
  4207.7  4203.0  4196.6  4191.8  4187.0  4182.3  4178.0  4173.2  4168.3  4163.6
  4160.2  4159.2  4161.2  4163.0  4163.3
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0  4217.9  4208.2
  4200.2  4195.2  4190.4  4185.4  4180.5  4176.0  4170.9  4166.0  4161.7  4157.9
  4154.4  4151.2  4150.8  4151.4  4151.1
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0  4221.8  4212.6  4203.4
  4196.0  4190.3  4184.7  4179.2  4174.0  4169.1  4163.9  4159.9  4156.0  4152.5
  4148.8  4145.5  4143.5  4144.0  4143.9
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0  4222.0  4208.7  4199.5
  4192.2  4185.7  4179.3  4173.3  4167.8  4162.8  4158.1  4154.1  4150.3  4146.8
  4142.9  4139.2  4135.6  4136.6  4136.8
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0  4221.9  4214.2  4204.2  4195.4
  4187.5  4180.1  4173.4  4167.4  4161.8  4156.7  4152.2  4148.2  4144.5  4141.0
  4136.9  4132.5  4127.5  4127.6  4128.2
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
```

```
      .0      .0      .0      .0      .0      .0  4221.3  4209.6  4199.9  4190.7
  4182.4  4174.5  4167.4  4161.0  4155.3  4150.4  4146.2  4142.3  4138.7  4135.3
  4131.2  4126.0  4119.3  4118.1  4119.4
      .0  4298.9  4280.2  4267.0  4271.3  4299.9  4356.5  4369.8  4380.5  4389.8
  4373.3  4347.9  4301.6  4278.6  4261.1  4235.8  4214.4  4203.7  4193.5  4183.7
  4175.5  4167.8  4160.4  4153.5  4147.5  4142.8  4138.8  4135.3  4131.9  4128.6
  4123.9  4117.3  4050.0  4106.8  4109.8
  4253.0  4233.0  4270.0  4257.2  4249.8  4248.7  4257.2  4277.5  4291.7  4301.3
  4300.9  4284.4  4263.0  4252.2  4235.8  4215.4  4201.0  4191.0  4181.0  4171.5
  4164.2  4156.3  4148.6  4141.9  4137.1  4132.8  4128.6  4125.0  4121.5  4118.3
  4114.0  4107.7  4033.0  4091.5  4093.3
  4293.3  4276.5  4220.0  4249.3  4240.6  4233.5  4231.2  4236.2  4242.3  4249.3
  4249.6  4241.0  4231.5  4221.2  4207.1  4192.2  4182.0  4173.1  4164.0  4155.2
  4148.9  4142.4  4135.8  4130.2  4123.7  4117.3  4113.1  4109.8  4106.7  4103.9
  4100.7  4096.9  4084.9  4004.0  4068.9
  4280.2  4269.2  4253.3  4210.0  4231.3  4224.0  4216.9  4213.4  4213.2  4211.9
  4210.3  4206.0  4201.8  4191.2  4180.6  4170.8  4162.1  4154.5  4146.7  4140.0
  4134.0  4128.2  4123.2  4108.7  4098.8  4095.7  4093.2  4090.4  4086.7  4081.8
  4076.9  4067.2  4057.7  4020.0  4048.4
      .0      .0  4243.5  4231.8  4196.0  4214.0  4205.2  4197.0  4192.9  4190.2
  4185.3  4180.7  4175.9  4167.1  4159.9  4151.8  4143.8  4137.3  4130.3  4124.4
  4118.8  4113.0  4095.7  4074.6  4072.1  4069.2  4065.1  4060.1  4054.1  4045.4
  4035.9  4011.4  4002.0  4010.2  4021.2
      .0      .0      .0  4224.1  4216.5  4185.0  4194.4  4185.1  4179.9  4175.0
  4165.2  4152.0  4143.1  4138.3  4134.8  4129.5  4126.1  4120.7  4114.8  4109.3
  4103.4  4085.5  4061.0  4047.0  4043.3  4035.1  4030.4  4032.9  4024.9  4001.6
  3979.2  3956.7  3936.8  3938.2  3960.1
      .0      .0      .0  4222.2  4214.6  4200.2  4140.0  4130.0  4166.2  4156.9
  4143.5  4128.9  4117.5  4108.2  4098.0  4091.5  4088.8  4083.4  4080.2  4073.0
  4064.6  4044.1  4024.8  4014.2  4011.3  3999.6  3992.2  3976.8  3962.4  3944.3
  3930.2  3916.1  3900.9  3881.0  3897.0
      .0      .0      .0      .0      .0  4194.5  4184.2  4173.2  4120.0  4108.0
  4132.0  4053.0  4040.0  4020.0  4010.0  4065.5  4057.1  4050.1  4043.7  4037.4
  4032.5  4019.9  4001.4  3973.0  3952.0  3943.0  3935.0  3920.0  3910.0  3880.0
  3850.0  3840.0  3877.4  3815.0  3858.3
      .0      .0      .0      .0      .0  4192.4  4184.2  4173.0  4158.7  4145.9
  4070.0  4118.2  4104.6  4088.9  4075.7  4035.0  4021.0  4014.0  4008.0  4000.0
  3990.0  3995.0  3990.0  3982.9  3967.7  3955.5  3943.4  3929.3  3916.7  3905.9
  3895.8  3885.1  3800.0  3790.0  3785.0
      .0      .0      .0      .0      .0      .0      .0  4174.4  4166.4  4153.0
  4141.5  4128.5  4113.8  4092.0  4078.3  4062.6  4049.0  4041.3  4034.5  4029.0
  4026.5  4009.9  3997.2  3985.5  3972.2  3958.9  3945.0  3929.3  3915.5  3905.6
  3898.3  3889.3  3878.7  3866.3  3852.5
      .0      .0      .0      .0      .0      .0      .0      .0      .0  4165.8
  4151.5  4139.0  4127.5      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
      .0      .0      .0      .0      .0
         0   .00001                                    STORAGE COEF. LAYER 3
        11   .001068 (19F4.0,/,16F4.0)          12  T LAYER 3
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0  .5  .5  .5  .5  20  20  20  20  20   7   7   5   5   5   5
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
  .5  .5  .5  20  20  20  20  20  20  20  15  15   5   5   5   5
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  .5
  .5  20  20  20  20  20  20  02  20  20  20  23  23  20  20  20
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  .5  .5
   5  20  20  20  20  20  20  20  20  20  20  20  25  20  20  20
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   5   5
  10  20  20  20  20  20  20  20  20  20  20  20  25  20  20  20
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   5   5   5
   5   5   5  10  20  20  20  20  20  20  20  20  23  20   5   5
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   5   5   5
   5   5   5   5   5  10  20  20  20  20  20  20  20  20   5   5
   0   5   5  .7  .4  .3  .3  .4  .7   1   1   1   1   1   1   5   5   5   5
   5   5   5   5   5   5  10  10  20  20  20   5   5  15   5   5
   5   5   5   5   3   2  .8   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   5   3   3   5  10   5   5   5   5   5  10  10   5
   5   5  20  20  10  10   5   5   5   1   1   1   1   1   1   1   1   1   1
```

```
   1   1   3   3   3   3   5   5   5   5   5   5   5   5  10   5
  20  20  20  20  20  20  20   5   5   5   1   1   1   1   1   1   1   1   1
   1   1   1   3   3   5   5   5   5   5   5   5  .5  .5   9   5
   0   0  20  20  20  20  20  20  10   7   5   1   1   1   1   1   1   1   1
   1   1   3   3   3   5   5   5  .5  .5   5   5  .5  .5  .5   3
   0   0   0  20  20  20  20  20  10   5   5   5   5   5   1   1   1   1   1
  .5  .5  .5  .4  .3  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5   3
   0   0   0  20  20  20  20  20  20   3   3   3   3   3   1   1   1   1   1
  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  5.
   0   0   0   0   0  20  20  20  20  20  20   5   5   5   5   5   5   5  .5
  .5  .5  .5  .5  .5  .5  .8  .8  .8  .8  .8  .8  .8  .5  .5   5
   0   0   0   0   0  20  20  20  20   5   5   5   5   5   5   5  .5  .5  .5
  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  .5  5.
   0   0   0   0   0   0   0  20   5   5   5   5   5   5   5  .5  .5  .5  .5
  .5  .5  .5  .5  .5  .3  .2  .1  .1  .2  .3  .4  .4  .5  .5  5.
   0   0   0   0   0   0   0   0   0   5   5   5   5   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
        11      .01(19F4.0,/,16F4.0)          10  SPECIFIC YIELD LAYER 3
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   4   4   4   4   4  21  21  21   4   4   4   8   8   4   4
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   4   4   4   4   4   4   4   4   4   4   4   4   8   8   4   4
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   4
   8   8   8   4   4   4   4   4   4   4   4   4   8   8   4   4
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   4   4
   8   8   8   8   8   8   8   8   8   8   8   8   8   8   4   4
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   4   4
   4   8   8   8   8   8   8   8   8   8   8   8   8   8   4   4
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   8   4   4
   4   8   8   8   8   8   8   8  12  12  12   8   8   8   4   4
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   8   4   4
   4   8   8   8   8   8   8   4   4   4   4   4   4   4   4   4
   0   8   8   8   8   8  16   8   8   8   8  12  12  21  21   8   8   4   4
   4   8   8   8   8   8  12  12  12  12  12  12   4   4   4   4
  12  12   8   8   8   8  16   8   8   8   8  12  12  12  21   8   8   4   4
   4   8   8   8   8  12  12  12  12  12  12  12  12   4   8   4
   8   8  12   8   8   8   8   8   4   8  12   8  16  16  12  12   8   8   4
   4   8   8   8   8  12  12  12  12  12  12  12  12  12   8   8
   8   8   8  16   8   8   8   8   4  12  12   8  16  16  12  12   8   8   8
   4   8   8   8   8  12  12  12  12  12  12  12   2   2  16   8
   0   0   8   8  16   8   8   4   4   8  12   8   8   8   8   8   8   8   8
   4   8   8   8   8   8  12  12  12  12  12  12   4   2   2   8
   0   0   0   8   8  12   4   8   8   8   8   8   8   8   8   8   8   8   8
   4   8   8   8   8   8   8  12  12  12  12  12  12  12   2   4
   0   0   0   8   8   8  12  12  12   8   8   8   8   8   4   4   4   4   4
   4   4   4   4   4   4   4   4   2   2   4  12  12  12   4   4
   0   0   0   0   0   8   8   8   8   8   8   8   8   8   4   4   4   4   4
   4   4   4   4   4   4   4   4   4   4   4   4   4   4   4   8
   0   0   0   0   0   8   8   8   8   8   8   8   8   8   4   4   4   4   4
   4   4   4   4   4   4   2   2   2   2   4   4   4   4   8   8
   0   0   0   0   0   0   0   8   8  21  21   8   8   8   4   4   4   4   4
   4   4   2   2   2   2   2   2   2   2   2   2   4   4   8   8
   0   0   0   0   0   0   0   0   0  21  21  12  12   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
        11        1 (19F4.0,/,16F4.0)          7  TOP LAYER 3
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0405039803900382037203680359535253485346033803340340034203460
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
4090402039503875379537203650357535103470341033503300334033803420
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   04090
4050399039403850377037003630356034703440338033203280332033603380
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   040804070
4000395038903815374536753600353034403400336033203260332033403360
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   040403990
3940389538403780371536403570350034203380334033003240328033003340
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  0391039603910
3870381037703720367036003535345034003365334032803220322032603300
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  0390038803840
```

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   0   0   03340328032103240324032603260326032403240322032203240322032203220
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   0   0   03320332032803190320032203220322032003200318031603160316031603170
3350344035203500355038003600375039303910372035503550345037503800
   0   0   0   0   032803300319031603140318031603090308030703080308031503300
3400370037003550363039003830382038103800371035903540347034603420
   0   0   0   0   033003340328032403220313031203180320031403060304031103230
3720394039503945394039353930393039103890384037603660366033503340
   0   0   0   0   0   0   0334033003280326032403240324032003160314031203300
3300375039553950394539453935392539153905388538553695366535553500
   0   0   0   0   0   0   0   0   03340330032803280   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
```

8.2.3 WEL Data File

```
68         0
12
 1        16        35    -0.330
 2        16        35    -0.600
 2        17        31    +0.006
 2        17        32    +0.020
 2        17        33    +0.090
 2        17        34    +0.280
 2        13         8       -.14
 1        14         7       -.10
 2        15         8       -.10
 2         3        22       -.15
 2         2        23       -.15
 2         4        26       -.15
15
 1        16        35    -0.330
 2        16        35    -0.600
 2        17        31    +0.006
 2        17        32    +0.020
 2        17        33    +0.090
 2        17        34    +0.280
 2        12         6       -.07
 1        13         6       -.10
 2        14         6       -.08
 1        14         7       -.10
 2        13         8       -.14
 2        15         8       -.10
 2         2        23       -.97
 2         3        22       -.97
 2         4        26       -.97
17
 1        16        35    -0.330
 2        16        35    -0.600
 2        17        31    +0.006
 2        17        32    +0.020
 2        17        33    +0.090
 2        17        34    +0.280
 1        11         4       -.05
 2        11         5       -.03
 1        12         5       -.07
 2        12         6       -.15
 1        13         6       -.21
 2        14         6       -.10
 1        14         7       -.10
 2        13         8       -.15
 2        15         8       -.10
 2         2        32       -.01
 2         2        31       -.01
32
 1        16        35    -0.330
 2        16        35    -0.600
 2        17        31    +0.006
 2        17        32    +0.020
 2        17        33    +0.090
 2        17        34    +0.280
 2        11         3       -.10
 1        11         4       -.22
 2        11         5       -.12
 1        12         5       -.22
 2        12         6       -.28
 1        13         6       -.41
 2        14         6       -.22
 2        10         6       -.16
 2        11         7       -.02
```

```
    1        14        7       -.22
    2        13        8       -.28
    1        14        8       -.20
    2        15        8       -.22
    2        16        9       -.44
    2        16       10       -.46
    2         2       32       -.05
    2         2       31       -.05
    2         4       22       -.07
    2         5       21       -.03
    2         8       20       -.08
    2         4       21       -.07
    2         3       21       -.07
    2         2       24       -.15
    2         3       22      -1.85
    2         2       23       -.41
    2         4       26       -.22
   40
    1        16       35     -0.330
    2        16       35     -0.600
    2        17       31     +0.006
    2        17       32     +0.020
    2        17       33     +0.090
    2        17       34     +0.280
    2        11        3       -.18
    1        11        4       -.36
    2        11        5       -.18
    1        12        5       -.36
    2        12        6       -.50
    1        13        6       -.71
    2        14        6       -.36
    2        15        6       -.18
    2        11        7       -.07
    2        12        7       -.13
    2        13        7       -.27
    1        14        7       -.36
    2        12        8       -.13
    2        13        8       -.50
    2        14        8       -.36
    2        15        8       -.18
    2        13        9       -.13
    1        15        9      -1.03
    2        16        9       -.78
    2        16       10       -.78
    1        15       15       -.66
    2        15       16       -.66
    2        15       17       -.66
    2         2       32       -.09
    2         2       31       -.09
    2         4       22       -.28
    2         3       21       -.28
    2         5       21       -.12
    2         8       20       -.32
    2         4       21       -.28
    2         2       24       -.65
    2         3       22      -2.12
    2         2       23       -.57
    2         4       26       -.29
   43
    1        16       35     -0.330
    2        16       35     -0.600
    2        17       31     +0.006
    2        17       32     +0.020
    2        17       33     +0.090
    2        17       34     +0.280
    2        11        3       -.21
    1        11        4       -.31
    2         8        5       -.10
```

```
  2          11           5       -.10
  1          12           5       -.31
  2          12           6       -.42
  1          13           6       -.52
  2          14           6       -.21
  2          15           6       -.10
  2          11           7       -.10
  2          12           7       -.21
  2          13           7       -.21
  1          14           7       -.21
  2          12           8       -.10
  2          13           8       -.31
  1          14           8       -.21
  2          15           8       -.10
  2          13           9       -.10
  1          15           9       -.96
  2          16           9       -.10
  2          16          10       -.43
  2           9          12       -.43
  1          15          15       -.43
  2          11          16       -.85
  2          15          16       -.43
  2          15          17       -.43
  2           2          32       -.12
  2           2          31       -.10
  2           4          22       -.05
  2           3          21       -.20
  2           5          21       -.07
  2           8          20       -.15
  2           4          21      -1.04
  2           2          24       -.76
  2           3          22      -2.47
  2           2          23       -.67
  2           4          26       -.34
 44
  1          16          35     -0.330
  2          16          35     -0.600
  2          17          31     +0.006
  2          17          32     +0.020
  2          17          33     +0.090
  2          17          34     +0.280
  2          11           3       -.32
  1          11           4       -.48
  2           8           5       -.16
  2          11           5       -.16
  1          12           5       -.48
  2          12           6       -.64
  1          13           6       -.80
  2          14           6       -.32
  2          15           6       -.16
  2          11           7       -.16
  2          12           7       -.32
  2          13           7       -.32
  1          14           7       -.32
  2          12           8       -.16
  2          13           8       -.48
  1          14           8       -.32
  2          15           8       -.16
  2          13           9       -.16
  1          15           9       -.69
  2          16           9       -.26
  2          16          10       -.26
  2           9          12       -.26
  1          15          15       -.26
  2          11          16       -.52
  2          15          16       -.26
  2          15          17       -.26
  2           2          32       -.13
```

```
 2        2       31      -.11
 2        4       22      -.23
 2        3       21      -.23
 2        5       21      -.08
 2        3       20      -.23
 2        8       20      -.21
 2        4       21      -.63
 2        2       24      -.79
 2        3       22     -2.57
 2        2       23      -.70
 2        4       26      -.35
43
 1       16       35    -0.330
 2       16       35    -0.600
 2       17       31    +0.006
 2       17       32    +0.020
 2       17       33    +0.090
 2       17       34    +0.280
 2       11        3      -.23
 1       11        4      -.34
 2        8        5      -.11
 2       11        5      -.11
 1       12        5      -.34
 2       12        6      -.46
 1       13        6      -.57
 2       14        6      -.23
 2       15        6      -.11
 2       11        7      -.11
 2       12        7      -.23
 2       13        7      -.23
 1       14        7      -.23
 2       12        8      -.11
 2       13        8      -.34
 1       14        8      -.23
 2       15        8      -.11
 2       13        9      -.11
 1       15        9      -.11
 2        2       32      -.16
 2        2       31      -.13
 2        4       22      -.17
 2        3       21      -.17
 2        5       21      -.08
 2        5       22      -.16
 2        3       20      -.17
 2        4       23      -.17
 2        8       20      -.05
 2        4       21      -.31
 2        7       19      -.32
 2        8       21      -.11
 2        2       24      -.70
 2        3       22     -2.56
 2        2       23      -.62
 2        4       26      -.18
 2        4       27      -.18
 2        8       15      -.00
43
 1       16       35    -0.330
 2       16       35    -0.600
 2       17       31    +0.006
 2       17       32    +0.020
 2       17       33    +0.090
 2       17       34    +0.280
 2       11        3      -.34
 1       11        4      -.51
 2        8        5      -.17
 2       11        5      -.17
 2       12        5      -.51
 1       12        6      -.67
```

```
 2        13        6      -.85
 2        14        6      -.34
 2        15        6      -.17
 2        11        7      -.17
 2        12        7      -.34
 2        13        7      -.34
 1        14        7      -.34
 2        12        8      -.17
 2        13        8      -.51
 1        14        8      -.34
 2        15        8      -.17
 2        13        9      -.17
 1        15        9      -.17
 2         2       32      -.20
 2         2       31      -.17
 2         4       22      -.20
 2         3       21      -.20
 2         5       21      -.20
 2         5       22      -.33
 2         3       20      -.20
 2         4       23      -.18
 2         8       20      -.08
 2         4       21      -.38
 2         7       19      -.50
 2         8       21      -.12
 2         2       24      -.40
 2         3       22     -2.28
 2         2       23      -.31
 2         4       26      -.16
 2         4       27      -.16
 2         8       15      -.00
45
 1        16       35    -0.330
 2        16       35    -0.600
 2        17       31    +0.006
 2        17       32    +0.020
 2        17       33    +0.090
 2        17       34    +0.280
 2        11        3      -.45
 1        11        4      -.68
 2         8        5      -.22
 2        11        5      -.22
 1        12        5      -.68
 2        12        6      -.97
 1        13        6     -1.13
 2        14        6      -.45
 2        15        6      -.22
 2        11        7      -.22
 2        12        7      -.45
 2        13        7      -.45
 1        14        7      -.45
 2        12        8      -.22
 2        13        8      -.68
 1        14        8      -.45
 2        15        8      -.22
 2        13        9      -.22
 1        15        9      -.22
 2         2       32      -.10
 2         2       31      -.10
 2         3       32      -.10
 2         2       30      -.09
 2         4       22      -.20
 2         3       21      -.20
 2         5       21      -.23
 2         5       22      -.52
 2         3       20      -.20
 2         4       23      -.20
 2         8       20      -.13
```

```
 2       4      21     -.50
 2       7      19     -.50
 2       8      21     -.12
 2       2      24     -.34
 2       3      22    -1.92
 2       2      23     -.31
 2       4      26     -.13
 2       4      27     -.13
 2       8      15     -.00
67
 1      16      35   -0.330
 2      16      35   -0.600
 2      17      31   +0.006
 2      17      32   +0.020
 2      17      33   +0.090
 2      17      34   +0.280
 2      11       3     -.61
 1      11       4     -.91
 2       8       5     -.30
 2      11       5     -.30
 1      12       5     -.92
 2      10       6     -.26
 2      12       6    -1.31
 1      13       6    -1.53
 2      14       6     -.60
 2      15       6     -.30
 2      11       7     -.30
 2      12       7     -.61
 2      13       7     -.61
 1      14       7     -.60
 2      12       8     -.30
 2      13       8     -.92
 1      14       8     -.60
 2      15       8     -.30
 2      13       9     -.30
 1      15       9     -.30
 2      16       9     -.14
 2      16      10     -.58
 2       9      12     -.41
 1      15      15     -.35
 2      11      16     -.70
 2      15      16     -.35
 2      15      17     -.35
 2       6      21     -.06
 2       7      22     -.06
 2       2      27     -.06
 2       7      17     -.00
 2       6      19     -.10
 2       4      19     -.10
 2      10      19     -.10
 2       6      20     -.41
 2       8      19     -.03
 2      10      20     -.21
 2       5      21     -.31
 2       8      20     -.31
 2       8      21     -.16
 2       4      22     -.09
 2       3      21     -.09
 2       3      20     -.09
 2       7      19     -.63
 2       4      23     -.09
 2       5      22     -.41
 2       4      21     -.42
 2       4      20     -.82
 2       8      15     -.00
 2       6      17     -.00
 2       2      23    -1.36
 2       3      22    -1.79
```

```
 2      2     24    -.68
 2      4     26    -.13
 2      4     27    -.13
 2      2     32    -.07
 2      2     31    -.07
 2      3     32    -.07
 2      2     30    -.07
 2      1     35    -.01
 2      4     35    -.05
68
 1     16     35  -0.330
 2     16     35  -0.600
 2     17     31  +0.006
 2     17     32  +0.020
 2     17     33  +0.090
 2     17     34  +0.280
 2     11      3    -.00
 1     11      4    -.00
 2      8      5    -.55
 2     11      5    -.55
 1     12      5    -.00
 2     10      6    -.48
 2     12      6    -.00
 1     13      6    -.00
 2     14      6    -.00
 2     15      6    -.00
 2     11      7    -.55
 2     12      7   -1.12
 2     13      7   -1.12
 1     14      7    -.00
 2     12      8    -.55
 2     13      8   -1.68
 1     14      8    -.00
 2     15      8    -.00
 2     13      9    -.55
 1     15      9    -.00
 2     16      9    -.00
 2     16     10    -.00
 2      9     12    -.75
 1     15     15    -.00
 2     11     16   -1.28
 2     15     16    -.00
 2     15     17    -.00
 2      7     17    -.00
 2      6     21    -.06
 2      7     22    -.06
 2      2     27    -.06
 2      4     19    -.13
 2     10     19    -.13
 2      6     20    -.50
 2      6     19    -.13
 2      8     19    -.06
 2     10     20    -.26
 2      8     15    -.00
 2      6     17    -.00
 2      3     32    -.07
 2      3     31    -.07
 2      2     30    -.07
 2      5     21    -.21
 2      8     20    -.25
 2      8     21    -.15
 2      4     22    -.51
 2      3     21    -.25
 2      3     20    -.25
 2      7     19    -.51
 2      4     23    -.25
 2      5     22    -.51
 2      4     21    -.71
```

2	4	20	-.45
2	2	23	-2.15
2	3	22	-.95
2	2	24	-.19
2	4	26	-.28
2	4	27	-.28
2	2	32	-.07
2	2	31	-.07
2	1	35	-.01
2	4	35	-.06

8.2.4 GHB Data File

```
         4         -1
         4
         1          9          1  4370.4     .01721
         2          9          1  4383.7     .01176
         2          8          2  4397.5     .00694
         2         10          1  4428.7     .01152
        -1
        -1
        -1
        -1
        -1
        -1
        -1
        -1
        -1
        -1
        -1
        -1
        -1
```

8.2.5 EVP Data File

```
         1         0
         0         0         0
        15         1 (19F4.0,/,16F4.0)          7  LAND SURFACE ELEVATION
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   04110   0   0
   04284   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0.  0   0   0   0   0   0   0   0   04093   0   0
   0   04260   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   04064   0
   0   0   04240   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   04041   0
   0   0   0   04221   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   04030   0
   0   0   0   0   04210   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   04000   0
   0   0   0   0   0   041854175   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   03910   0
   0   0   0   0   0   0   0   041554143   04120410240844072   0   0   0   0
   0   0   0   0398339623953394539303920391138983891   03880   0
   0   0   0   0   0   0   0   0   0   04132   0   0   0   04060414641394133
4022401040104005   0   0   0   0   0   0   0   0   038603850   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
        15 .00000002 (19F4.0,/,16F4.0)         12 MAX ET RATE
```

```
                                                      1
      1
                                                      1
          1
                                                          1
              1
                                                          1
                  1
                                                          1
```

```
                       1
                                                           1
                           1   1
                                                           1
                                   1   1       1   1   1   1
                   1   1   1   1   1   1   1   1   1       1
                                           1                   1   1   1   1
   1   1   1   1                                       1   1


        15        10 (19F4.0,/,16F4.0)           8 EXTINCTION DEPTH






                                                       1
       1
                                                       1
           1
                                                           1
               1
                                                           1
                   1
                                                           1
                       1
                                                           1
                           1   1
                                                           1
                                   1   1       1   1   1   1
                   1   1   1   1   1   1   1   1   1       1
                                           1                   1   1   1   1
   1   1   1   1                                       1   1


        -1        -1        -1
        -1        -1        -1
        -1        -1        -1
        -1        -1        -1
        -1        -1        -1
        -1        -1        -1
        -1        -1        -1
        -1        -1        -1
        -1        -1        -1
        -1        -1        -1
        -1        -1        -1
```

8.2.6 RCH Data File

```
         3         0
         0
        18.000000001 (2(16F5.0/),3F5.0)         12  AREAL RECH RATE FT/S

                    29.7019.3329.0040.0627.6226.9325.5539.3618.6415.8811.0520.03
38.6740.75 44.2

               21.41


          33.15


     13.81


     55.25


13.81


41.44

            .34  .34 3.79 5.18 7.5913.1215.1917.9517.9517.9520.0321.4120.7217.95











           4.97





                8.28 8.28





                          6.21 7.59


                                    14.520.72     11.7412.4311.7416.5712.4311.05
 7.59  6.9 6.21 4.83 4.83

                                             20.7211.7412.4312.43


        -1
        -1
        -1
        -1
        -1
        -1
        -1
        -1
        -1
```

```
-1
-1
-1
-1
-1
-1
```

8.2.7 STR Data File

```
         42           2           1         0         1     1.486        -1         0
         42           0           0
    1     9     2     1     1              4.84      4283      .279      4278      4283
    1    10     3     1     2                        4260      .279      4255      4260
    1    11     4     1     3                        4240      .279      4235      4240
    1    12     5     1     4                        4220      .223      4215      4220
    1    13     6     1     5                        4210      .167      4205      4210
    1    14     7     1     6                        4180      .167      4175      4180
    1    14     8     1     7                        4170      .167      4165      4170
    1    15     9     1     8                        4150      .167      4145      4150
    1    15 .  10     1     9                        4140      .167      4135      4140
    1    16    11     1    10                        4130      .167      4125      4130
    1    15    12     1    11                        4113      .167      4108      4113
    1    15    13     1    12                        4100      .167      4095      4100
    1    15    14     1    13                        4080      .167      4075      4080
    1    15    15     1    14                        4070      .167      4065      4070
    1    16    16     1    15                        4060      .167      4055      4060
    1    16    17     1    16                        4040      .134      4035      4040
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    16    .0038      .022
    18    .0024      .022
    18    .0019      .022
    19    .0020      .022
    18    .0023      .022
    18    .0034      .022
    21    .0038      .022
    21    .0019      .022
    22    .0019      .022
    19    .0038      .022
```

```
        10      .0011       .022
        11      .0012       .022
        12      .0027       .022
        12      .0032       .022
        14      .0016       .022
        16      .0042       .022
        18      .0063       .022
        19      .0032       .022
        19      .0032       .022
        19      .0032       .022
        19      .0032       .022
        19      .0032       .022
        18      .0027       .022
        18      .0010       .022
        16      .0042       .022
        16      .0030       .022
        16      .0046       .022
         3      .0021       .020
         3      .0040       .020
         3      .0038       .020
         3      .0038       .020
         3      .0042       .020
         3      .0189       .020
         3      .0080       .020
         5      .0060       .020
         5      .0046       .020
2
0
```

8.2.8 PCG Data File

```
100         5          1
.01      .001         1.          2          1
```

8.2.9 OPC Data File

```
  3    8    0    0
 10    1    1    0
 -1    1    1    1
 -1    1    1    1
 -1    1    1    1
 -1    1    1    1
 -1    1    1    1
 -1    1    1    1
 -1    1    1    1
 -1    1    1    1
 -1    1    1    1
 -1    1    1    1
 -1    1    1    1
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 -1    1    1    1
 -1    1    1    1
 -1    1    1    1
 -1    1    1    1
 -1    1    1    1
 -1    1    1    1
```

APPENDIX A

Table 1

Water levels measured at BLM wells

(Data provided by BLM)

```
  DATE       DIVERSION DAM     SUMMER'S WELL      CONTENTION    BOQUILLAS #3     BOQUILLAS #2    BOQUILLAS #1    COTTONWOOD #1     LEWIS SPRINGS
   HEREFORD #2       HEREFORD #1     HEREFORD BRIDGE      MOSON SPRING     PALOMINAS WELL #4      PALOMINAS WELL #5      PALOMINAS WELL #10
PALOMINAS BRIDGE WELL
================================================================================================================================================
================================================================================================================================================
============================
 02-05-87         5.82                --               --             8.22             9.18             9.04               --               --
            --                --                                                      --                     --                      --

 02-06-87           --                --               --               --               --               --            13.52               --
          3.80                --                 --               --                  --                     --                      --

 02-19-87         5.75                --               --             8.29             9.15             9.43            13.43               --
            --                --              10.17               --                  --                     --                      --

 02-20-87           --                --               --               --               --               --               --               --
          3.83                --                 --               --                  --                     --                      --

 02-21-87           --                --               --               --               --               --               --               --
            --              4.36                 --               --                  --                     --                      --

 02-26-87           --                --               --               --               --               --            13.32               --
          3.72              5.58              10.07               --                  --                     --                      --

 02-27-87         5.75                --               --               --               --               --               --               --
            --                --                 --               --                  --                     --                      --

 02-28-87           --                --               --             8.03             9.11             9.35               --               --
            --                --                 --               --                  --                     --                      --


 03-05-87           --                --               --               --               --               --            13.40               --
            --                --                 --               --                  --                     --                      --

 03-06-87           --              5.71               --               --               --               --               --               --
            --                --                 --               --                  --                     --                      --

 03-09-87         5.70              5.69             6.32             8.12             9.14             9.38            12.75             4.95
          3.81              5.60              10.15               --                  --                     --                      --

 03-16-87         5.71              5.64             6.29             8.04             9.17             9.41            13.37             4.91
          3.81              5.63              10.13               --                  --                     --                      --

 03-24-87         5.69              5.68             6.31             8.07             9.20             9.43            13.30             4.93
          3.28              5.65              10.16               --                  --                     --                      --

 03-30-87         5.70              5.70             6.42                8             9.24             9.43            13.26             4.97
          3.93              5.71              10.17               --                  --                     --                      --
```

04-07-87	3.97	5.69	5.76	5.72	10.29	6.27	--	8.14	--	9.26	9.47	--	13.38	--	4.98
04-13-87	3.95	5.72	5.79	5.76	10.23	6.28	--	8.27	--	9.29	9.49	--	13.40	--	5.05
04-20-87	--	5.70	--	5.81		6.24		8.31	--	9.33	9.53	--	--	--	--
04-22-87	3.95	--	5.83	--	10.26	--	--	--	--	--	--	--	13.41	--	5
04-27-87	4.01	--	5.87	--	10.30	--	--	--	--	--	--	--	13.45	--	5.16
04-28-87	--	--		5.24		6.07		7.80	--	8.87	9.16	--	--	--	--
04-29-87	3.77	--	5.63	5.40	10.16	5.99	--	7.96	--	9	--	--	13.24	--	4.78
05-05-87	3.98	5.48	5.84	5.68	10.32	6.21	--	8.21	--	9.26	9.53	--	13.42	--	5.20
05-15-87	4.02	5.61	5.85	5.76	10.36	6.33	--	8.22	--	9.27	9.58	--	13.45	--	5.36
05-21-87	4.03	5.62	5.95	5.79	10.37	6.40	--	8.17	--	9.22	9.59	--	13.51	--	5.35
05-27-87	4.12	5.79	--	5.96	10.48	6.57	--	8.29	--	9.34	9.70	--	13.65	--	5.52
06-02-87	4.20	5.91	6.31	6.05	10.52	7.21	--	8.36	--	9.43	9.76	--	13.75	--	5.65
06-10-87	4.19	6.04	6.37	6.13	10.53	7.69	--	8.40	--	9.48	9.76	--	13.89	--	5.65
06-21-87	4.32	6.99	6.50	6.18	10.65	9.60	--	--	--	9.58	9.99	--	14.05	--	5.87

07-01-87	4.37	7.47	6.54	6.29	10.68	10.28	--	8.57	--	9.67	10.02	--	14.18	--	5.91
07-08-87	4.39	7.59	6.46	6.37	10.70	10.59	--	8.60	--	9.92	10.01	--	14.33	--	5.98
07-14-87	4.32	7.62	6.39	6.37	10.65	11.30	--	8.87	--	10.16	10.05	--	14.38	--	5.98
07-23-87	4.42	7.75	6.53	6.62	--	12.56	--	8.79	--	10.27	10.11	--	14.39	--	6
08-03-87	4.43	7.52	6.30	6.01	10.67	12.56	--	9.20	--	9.45	9.86	--	14.32	--	5.77
08-07-87	3.89	*	5.75	5.55	10.20	*	--	8.38	--	9.24	8.52	--	*	--	4.90
08-12-87	3.47	*	5.28	4.88	9.76	*	--	8.24	--	--	--	--	*	--	4.32
08-18-87	4.06	5.76	5.87	5.74	10.38	7.29	--	8.37	--	9.38	9.58	--	13.82	--	5.20
08-25-87	--	5.57	--	5.32	10.12	6.95	--	8.19	--	9.20	9.46	--	13.73	--	4.89
08-26-87	3.61	--	5.57	--	--	--	--	--	--			--	--	--	--
08-28-87	3.65	5.24	5.42	5.23	9.95	6.64	--	7.98	--	8.98	9.29	--	13.52	--	4.23
09-02-87	--	5.78	--	5.81	--	--	--	8.35	--	9.37	9.62	--	--	--	--
09-14-87	4.17	6.06	6.12	5.95	10.48	7.59	--	8.37	--	9.41	9.79	--	14.11	--	5.48
09-23-87	--	6.19	--	5.64	--	--	--	--	--	--	--	--	--	--	--
09-25-87	3	5.31	5.27	--	9.35	7.56	--	--	--	--	--	--	--	--	4.41

09-27-87	--	--	--	--	--	--	--	7.79	--	8.99	9.30	--	13.11	--	--
09-30-87	--	5.62	--	--	--	--	--	--	--	--	--	--	--	--	--
10-01-87	--	--	--	5.61	--	7.05	--	8.27	--	9.32	9.57	--	--	--	--
10-02-87	4.08	--	5.83	--	10.40	--	--	--	--	--	--	--	--	--	5.21
10-09-87	4.15	5.88	6.09	5.78	10.47	7.55	--	8.41	--	9.46	9.78	--	14.28	--	5.47
10-15-87	--	5.73	--	5.73	--	9.44	--	8.40	--	9.44	9.78	--	--	--	--
10-16-87	4.13	--	6.05	--	10.47	--	--	--	--	--	--	--	14.31	--	5.43
10-23-87	4.09	5.97	6.12	5.75	10.46	9.10	--	8.37	--	9.40	9.75	--	14.28	--	5.44
10-29-87	4.10	6	6.03	5.78	10.45	9.10	--	8.39	--	9.41	9.77	--	14.29	--	5.44
11-03-87	4.10	5.84	5.95	5.63	10.45	--	--	8.31	--	9.33	9.70	--	14.20	--	5.30
11-10-87	4.04	5.83	5.95	5.64	10.41	7.81	--	8.30	--	9.32	9.70	--	14.18	--	5.27
11-19-87	3.87	--	5.88	--	10.35		--		--			--	14.15	--	5.19
11-20-87	--	5.77	--	5.70	--	7.50	--	8.27	--	9.29	9.68	--	--	--	--
11-25-87	--	--	--	5.76	--	--	--	--	--	--	--	--	--	--	--
11-27-87	4.05	--	5.87	--	10.40	--	--	--	--	--	--	--	14.29	--	5.19
11-28-87		5.75		--		7.46		8.31		9.33	9.72		--		--

	--		--		--		--		--			--		--	
12-03-87	3.98	--	5.80	--	10.36	--	--	--	--	--	--	--	14.19	--	5.14
12-04-87	--	5.71	--	5.70	--	7.36	--	8.26	--	9.27	9.65	--	--	--	--
12-10-87	3.94	--	5.82	--	--	--	--	--	--	--	--	--	14.12	--	5.12
12-11-87	--	5.66	--	5.68	--	7.29	--	8.25	--	9.27	9.67	--	--	--	--
12-16-87	3.90	5.63	5.78	5.56	10.28	7.23	--	8.24	--	9.26	9.63	--	14	--	5.06
12-28-87	3.80	--	--	5.64	9.96	6.97	--	8.14	--	9.15	9.48	--	13.87	--	5.21
01-06-88	3.84	5.53	5.72	5.55	9.94	6.88	--	8.18	--	9.16	9.66	--	13.73	--	4.99
01-21-88	3.80	5.48	5.70	5.58	10.17	6.78	--	8.18	--	9.21	9.64	--	13.71	--	5.06
01-26-88	--	5.52	--	5.57	--	6.78	--	8.21	--	9.24	9.65	--	--	--	--
01-28-88	3.82	--	5.52	--	10.21	--	--	--	--	--	--	--	13.78	--	5.05
02-02-88	3.83	--	5.73	--	10.21	--	--	--	--	--	--	--	13.70	--	4.92
02-03-88	--	5.50	--	5.57	--	6.71	--	8.23	--	9.25	9.65	--	--	--	--
02-08-88	3.80	--	5.73	--	10.20	--	--	--	--	--	--	--	13.79	--	4.95
02-09-88	--	5.50	--	5.57	--	6.68	--	8.23	--	9.26	9.65	--	--	--	--

02-17-88	3.82	5.47	5.75	5.57	10.28	6.66	--	8.24	--	9.27	9.66	--	13.73	--	5.02
02-23-88	3.82	--	5.75	--	10.22	6.65	--	8.25	--	9.28	9.68	--	13.78	--	4.94
02-25-88	--	5.47	--	5.58	--	--	--	--	--	--	--	--	--	--	--
02-29-88	3.85	--	5.76	--	10.25	--	--	--	--	--	--	--	13.72	--	4.95
03-01-88	--	5.46	--	5.57	--	6.14	--	8.26	--	9.28	9.68	--	--	--	--
03-10-88	--	--	--	--	--	--	--	--	15.52	--	--	16.44	--	18.65	--
03-11-88	3.85	5.45	5.77	5.58	10.25	6.06	--	8.26	--	9.30	9.69	--	13.67	--	4.93
03-17-88	--	5.45	--	5.59	--	6.08	--	8.26	--	9.29	9.68	--	13.70	--	4.94
03-18-88	--	--	--	--	--	--	--	--	16.51	--	--	16.73	--	18.83	--
03-31-88	3.83	--	5.77	--	10.25	--	--	--	15.87	--	--	16.72	13.62	19.01	4.95
							--		--			--		--	
04-01-88	--	5.45	--	5.59	--	6	--	8.26	--	9.31	9.69	--	--	--	--
04-07-88	--	5.42	--	5.64	--	5.96	--	8.25	--	9.30	9.69	--	--	--	--
04-09-88	3.88	--	5.80	--	10.28	--	--	--	--	--	--	--	13.62	--	4.96
04-14-88	--	5.44	--	5.59	--	5.95	--	8.28	--	9.33	9.69	--	--	--	--
04-15-88	3.90	--	5.82	--	10.16	--	--	--	--	--	--	16.99	13.64	19.15	5

04-21-88	3.93	--	5.86	--	10.19	--	--	--	--	--	--	16.94	13.64	20.25	5.08
04-22-88	--	5.46	--	5.64	--	5.96	--	8.33	--	9.39	9.74	--	--	--	--
04-28-88	3.97	--	6.07	--	10.28	--	--	--	16.03	--	--	16.91	13.69	19.24	5.15
04-29-88	--	5.47	--	5.74	--	5.99	--	8.32	--	9.38	9.76	--	--	--	--
05-05-88	4	5.55	6.03	5.81	10.22	6.04	--	8.44	15.82	9.51	9.83	16.79	13.81	18.99	5.25
05-12-88	4	--	6.03	--	10.21	--	--	--	15.77	--	--	16.82	13.72	18.95	5.34
05-13-88	--	5.57	--	5.91	--	6.11	--	8.48	--	9.56	9.81	--	--	--	--
05-19-88	--	--	--	--	--	--	--	--	15.86	--	--	16.83	--	18.97	--
05-20-88	4.07	5.68	6.12	6.04	10.32	6.26	8.68	8.48	--	9.56	9.81	--	13.84	--	5.46
05-27-88	--	--	--	--	--	--	--	--	16.10	--	--	16.95	--	19.03	--
05-28-88	4.12	5.74	6.23	6.04	10.37	7.06	8.90	8.64	--	9.71	10.01	--	13.97	--	5.61
									--			--		--	
06-03-88	4.13	6.08	6.21	6.04	10.41	8.36	8.70	8.65	16.33	9.72	10.03	17.02	14.04	19.11	5.65
06-09-88	--	--	--	--	--	--	--	--	16.69	--	--	17.22	--	19.16	--
06-10-88	4.25	--	6.40	--	10.53	--	8.78	--	--	--	--	--	14.16	--	5.73
06-11-88	--	6.80		6.29		9.31		8.76	--	9.82	10.15	--	--	--	--
06-14-88		--		--		9.76		8.72		9.78	9.78		14.21		5.79

	4.25		6.40		10.52		8.82		16.85			17.33		19.19	
06-30-88	4.27	7.75	6.48	6.26	10.51	12.64	8.85	8.74	17.27	9.83	10.20	17.63	14.36	19.32	5.83
07-07-88	4.19	7.75	6.40	--	10.51	12.64	8.82	8.56	--	9.67	10.09	--	14.45	--	5.70
07-13-88	4.11	6.32	6.35	5.91	10.60	10.53	8.48	8.39	--	9.49	9.93	--	14.38	--	5.61
07-14-88	--	--	--	--	--	--	--	--	16.50	--	--	17.39	--	19.25	--
07-21-88	4	6.53	6.04	5.97	10.25	9.96	8.49	7.73	16.10	8.82	9.43	17.29	*	19.11	5.11
07-27-88	3.54	6.14	5.87	5.54	9.87	8.91	8.22	7.78	--	8.87	9.47	--	*	--	5.08
07-28-88	--	--	--	--	--	--	--	--	15.68	--	--	17.01	--	18.97	--
08-11-88	3.13	5.87	4.94	4.99	9.50	6.41	7.59	7.48	*	8.52	9.03	*	*	*	4.06
08-19-88	3.14	5.27	5.35	5.26	9.53	6.48	8.12	7.95	--	9.01	9.61	--	*	--	4.82
08-20-88	--	--	--	--	--	--	--	--	*	--	--	*	--	*	--
08-26-88	2.37	*	4.47	4.27	8.86	5.51	7.52	6.77	*	7.83	*	*	*	*	3.53
09-01-88	3.03	*	4.69	4.69	--	5.46	7.50	7.65	*	8.67	9.06	*	*	*	4.12
09-08-88	3.41	*	5.19	4.99	--	5.96	8.02	7.95	*	9.18	9.53	*	*	*	4.95
09-16-88	3.08	*	4.68	4.91	9.43	5.45	7.43	7.70	*	8.72	9.10	*	*	*	4.10

09-23-88	--	*	5.15	5.28	9.67	5.87	7.63	7.97	--	8.98	9.46	--	*	--	4.78
09-29-88	3.52	--	5.35	--	9.84	--	7.78	--	*	--	--	*	13.82	*	5.15
09-30-88	--	*	--	5.54	--	6.08	--	8.19	--	9.21	9.75	--	--	--	--
10-06-88	--	*	--	5.68	--	--	--	--	--	--	--	--	--	--	--
10-11-88	3.58	5.62	5.45	5.65	9.87	6.33	7.79	8.18	*	9.22	9.83	*	*	*	5.29
10-21-88	--	--	--	3.43	--	5.55	7.40	6.91	*	7.94	--	*	*	*	--
10-27-88	--	5.37	--	5.02	--	5.94	--	7.92	--	8.94	9.29	--	--	--	--
10-28-88	3.98	--	4.20	--	9.46	--	8	--	--	--	--	--	*	--	4.67
10-30-88	--	--	--	--	--	--	--	--	*	--	--	*	--	*	--
11-07-88	4.15	--	4.17	--	9.63	--	8.15	--	--	--	--	--	13.70	--	4.94
11-08-88	--	5.57	--	5.29	--	6.33	--	8.02	--	9.06	9.54	--	--	--	--
11-17-88	4.18	--	4.21	--	9.65	--	8.20	--	--	--	--	--	*	--	4.98
11-18-88	--	5.42	--	5.34	--	6.52	--	8.04	--	9.06	9.56	--	--	--	--
11-30-88	4.17	5.41	4.21	5.24	9.63	6.56	8.16	8.06	*	9.10	9.66	*	*	*	4.94

12-08-88	--	5.39	--	5.35	--	6.61	--	8.08	*	9.12	9.70	*	--	*	--
12-09-88	4.05	--	4.21	--	9.63	--	8.14	--	--	--	--	--	*	--	4.94
12-15-88	--	--	--	--	--	--	8.11	--	--	--	--	--	*	--	4.92
12-19-88	--	5.43	--	5.42	--	6.59	--	8.12	--	9.12	9.68	--	--	--	--
12-28-88	4.18	--	4.21	--	9.65	--	8.15	--	--	--	--	--	*	--	5.01
12-29-88	--	5.42	--	5.24	--	6.60	--	8.19	--	9.20	9.68	--	--	--	--
12-30-88	--	--	--	--	--	--	--	--	*	--	--	*	--	*	--
01-06-89	--	5.32	--	5.39	--	--	8.07	--	--	--	--	--	--	--	4.73
01-07-89		--		--		--		--	*	--	--	*	--	*	--
01-10-89	4.17	--	4.17	--	9.65	6.53	--	8.14	--	9.17	9.60	--	--	--	--
01-18-89	--	5.37	--	5.26	--	6.57	--	8.17	--	9.23	9.65	--	--	--	--
01-20-89	--	--	--	--	--	--	--	--	*	--	--	*	--	*	--
01-27-89	4.21	5.35	4.21	5.29	9.80	6.62	7.90	8.15	*	9.21	9.62	*	*	*	4.88
	--		--		--		--		--			--	--	--	--
02-03-89	4.22	5.36	4.23	5.28	9.72	6.60	8.04	8.17	--	9.20	9.63	--	*	--	4.88
02-07-89	4.22	--	4.24	--	9.72	--	8.07	--	*	--	--	*	*	*	4.91
02-08-89		5.37		5.30		6.62		8.17		9.22	9.69		--		--

	--		--		--		--		--			--		--	
02-17-89	4.23	5.34	4.26	5.32	9.73	6.54	8.06	8.21	*	9.29	9.74	*	*	*	4.88
03-08-89	4.25	5.36	4.26	5.35	9.75	6.57	8.02	8.22	*	9.28	9.72	*	*	*	4.91
03-20-89	4.32	--	4.31	--	9.79	--	--	--	--	--	--	--	*	--	5
03-22-89	--	5.35	--	5.41	--	6.57	--	8.27	*	9.32	9.75	*	--	*	--
04-06-89	--	5.41	--	5.52	--	6.59	--	8.34	--	9.42	9.44	--	--	--	--
04-07-89	4.45	--	4.44	--	9.88	--	--	--	*	--	--	*	*	*	5.24
04-14-89	4.53	5.47	4.51	5.64	9.93	6.64	8.25	8.45	*	9.53	9.89	*	*	*	5.35
04-19-89	4.49	--	4.52	--	9.90	--	8.40	--	*	--	--	*	*	*	5.44
04-20-89	--	5.51	--	5.65	--	6.71	--	8.45	--	9.54	9.91	--	--	--	--
04-27-89	--	5.57	--	5.71	--	6.80	--	8.50	--	9.62	9.94	--	--	--	--
04-28-89	4.50	--	4.54	--	9.20	--	8.44	--	*	--	--	*	*	*	5.41
05-03-89	4.60	--	4.76	--	9.99	--	8.50	--	*	--	--	*	*	*	5.55
05-04-89	--	5.62	--	5.79	--	6.86	--	8.54	--	9.71	9.97	--	--	--	--
05-12-89	4.62	5.74	4.78	5.81	10	7.60	8.57	8.54	*	9.64	10.03	*	*	*	5.67

05-17-88	--	--	--	--	--	--	--	--	*	--	--	*	--	*	--
05-19-89	--	5.73	--	5.83	--	7.54	--	8.50	--	9.60	9.99	--	--	--	--
05-25-89	4.66	--	4.87	--	10.04	--	8.71	--	16.31	--	--	18.14	14.04	17.69	5.77
05-26-89	--	6.22	--	5.86	--	8.52	--	8.57	--	9.65	10.03	--	--	--	--
05-31-89	4.70	--	4.90	--	10.08	--	—	--	--	--	--	--	14.14	--	5.80
06-01-89	--	6.68	--	5.95	--	9.37	--	8.62	--	9.72	10.14	--	--	--	--
06-02-89	--	--	--	--	--	--	--	--	16.58	--	--	18.33	--	17.74	--
06-08-89	4.73	7.15	4.93	6.09	10.10	10.31	8.78	8.67	16.83	9.74	10.18	18.47	14.17	18.83	5.93
06-13-89	--	--	--	--	10.17	--	--	--	--	--	--	--	--	--	5.94
06-14-89	--	--	--	--	--	--	--	8.62	--	9.87	10.22	--	--	--	--
06-15-89	--	7.38	--	6.13	--	10.74	--	--	--	--	--	--	--	--	--
06-29-89	4.82	--	5.02	--	10.19	--	8.99	8.97	--	10.06	10.36	--	--	--	6
06-30-89	--	7.73	--	6.26	--	12.06	--	--	17.49	--	--	18.97	14.51	18.27	--
07-06-89	4.95	--	5.10	--	10.28	--	--	--	--	--	--	--	14.58	--	6.06
07-07-89	--	7.73	--	6.59	--	12.06	32 DAY RECORDER	9.35	--	10.39	10.45	--	--	--	--

07-12-89	4.82	--	4.90	--	10.16	--	--	--	--	--	--	--	--	--	5.94
07-14-89	--	7.73	--	6.65	--	12.06	--	9.32	--	10.34	10.41	--	14.49	--	--
07-19-89	4.77	--	5.02	--	10.14	--	--	--	17.80	--	--	19.22	--	18.48	5.98
07-20-89	--	7.73	--	5.80	--	12.06	--	8.25	--	9.37	9.39	--	--	--	--
07-24-89	--	--	--	--	--	--	--	--	--	--	--	--	14.56	--	--
07-26-89	--	--	--	--	--	--	--	--	17.30	--	--	19.20	--	18.41	--
07-27-89	--	--	--	--	--	--	8.72	--	--	--	--	--	14.51	--	5.82
07-28-89	--	7.73	--	*	--	12.06	--	8.50	--	9.60	--	--	--	--	--
	--		--		--		--		--			--	--	--	--
08-02-89	4.77	--	4.90	--	10.12	--	--	--	--	--	--	--	EQUIP. FAILURE	--	5.81
08-10-89	--	5.98	--	5.88	--	10.16	--	--	--	--	--	--	EQUIP. FAILURE	--	--
08-11-89	4.43	--	4.54	--	EQUIP. FAILURE	--	—	8.47	--	9.50	9.91	EQUIP. FAILURE	--	EQUIP. FAILURE	5.25
08-16-89	4.34	--	4.81	--	EQUIP. FAILURE	--	—	--	--	--	--	--	--	--	5.10
08-17-89	--	--	--	--		--		--	15.45	--	--	17.96	13.66	17.54	--
08-18-89	--	5.63	--	5.44	--	*	--	--	--	--	--	--	--	--	--
08-21-89	--	--	--	--	--	8.06	--	--	--	--	--	--	--	--	--
08-24-89	4.63	--	4.55	--	10.12	--	8.47	--	--	--	--	--	--	--	5.19
08-25-89		--		--		8.06		--		--	--		13.87		--

	--		--		--		--		15.67			17.96		17.59	
09-01-89	--	--	--	--	--	9	--	--	--	--	--	--	--	--	--
09-06-89	4.65	--	4.88	--	10.18	--	--	--	15.80	--	--	18.04	14.02	17.66	5.45
09-07-89	--	6.46	--	5.94	--	9	--	--	--	--	--	--	--	--	--
09-08-89	--	--	--	--	--	--	--	8.52	--	9.62	10.26	--	--	--	--
09-13-89	--	*	--	6.06	--	10.28	--	8.67	--	9.75	10.45	--	--	--	--
09-14-89	4.75	--	5.03	--	10.30	--	--	--	16.25	--	--	18.21	14.42	17.76	5.74
09-20-89	4.80	--	5.14	--	10.36	--	--	--	16.59	--	--	18.34	14.51	17.82	5.85
09-21-89	--	7.73	--	6.19	--	11.25	--	8.77	--	9.86	10.52	--	--	--	--
09-28-89	--	7.73	--	6.42	--	*	--	--	--	--	--	--	--	--	--
09-29-89	4.88	--	5.17	--	10.42	--	9.15	--	17.02	--	--	18.63	--	17.96	5.90
10-04-89	4.76	*	5.08	*	10.29	*	--	*	*	*	*	*	*	*	5.60
10-16-89	--	7.73	--	6.18	--	12.06		--	17.20	--	--	18.69	--	17.95	--
10-17-89	4.75	--	5.03	--	10.31	--	--	9.12	--	9.68	10.29	--	14.54	--	5.71
10-25-89	4.77	--	5.03	--	10.32	--	--	--	--	--	--	--	--	--	5.69
10-26-89	--	--	--	--	--	--	--	--	--	--	--	--	14.56	--	--

10-27-89	--	7.73	--	6.13	--	12.06	8.10	--	--	--	--	--	--	--	--
10-30-89	--	--	--	--	--	--	--	8.48	--	9.55	10.19	--	--	--	--
11-14-89	--	7.73	--	5.96	--	12.06	--	--	--	--	--	--	--	--	--
11-15-89	--	--	--	--	--	--	--	8.41	--	9.48	10.11	--	--	--	--
11-16-89	EQUIP. FAILURE	--	EQUIP. FAILURE	--	EQUIP. FAILURE	--	--	--	EQUIP. FAILURE	--	--	EQUIP. FAILURE	14.11	EQUIP. FAILURE	5.29
11-21-89	4.59	--	4.76	--	10.14	--	--	--	--	--	--	--	14.06	--	5.29
11-22-89	--	7.73	--	6.03	--	--	--	--	--	--	--	--	--	--	--
11-30-89	--	7.73	--	5.95	--	--	7.91	8.36	--	9.43	10.02	--	--	--	--
12-01-89	4.52	--	4.65	--	10.11	--	--	--	15.96	--	--	18.09	14.01	17.68	5.21
12-05-90	--	--	--	--	--	11.14	--	--	--	--	--	--	--	--	--
12-07-89	4.53	--	4.62	5.80	10.12	--	--	--	15.89	--	--	18.03	13.99	17.68	5.19
12-08-89	--	6.66	--	--	--	--	--	--	--	--	--	--	--	--	--
12-13-89	--	6.43	--	5.88	--	--	--	--	--	--	--	--	--	--	--
12-14-89	--	--	--	--	--	10.05	--	8.36	--	9.43	9.98	--	--	--	--
12-15-89	4.51	--	4.72	--	10.10	--	--	--	15.87	--	--	17.97	13.96	17.63	5.15

12-21-89	--	6.59	--	5.76	--	--	--	--	--	--	--	--	--	--	--
01-08-90	--	6.03	--	5.62	--	8.93	--	8.33	--	9.39	9.93	--	--	--	--
01-09-90	4.46	--	4.62	--	10.06	--	--	--	15.79	--	--	17.87	13.90	17.59	5.05
01-18-90	--	--	--	--	--	--	--	--	15.76	--	--	17.81	--	17.57	5.03
01-23-90	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
01-24-90	--	5.87	--	5.45	--	--	--	--	--	--	--	--	--	--	--
03-20-90	--	5.63	--	5.47	--	--	--	--	--	--	--	--	--	--	--
03-22-90	--	--	--	--	--	--	--	7.71	--	9.32	9.78	--	--	--	--
03-23-90	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5
03-26-90	4.60	--	3.69	--	10.10	--	--	--	15.54	--	--	16.60	13.79	NO ACCESS; PLATE COVERED	--
03-27-90	--	5.60	--	5.49	--	--	--	--	--	--	--	--	--	NO ACCESS; PLATE COVERED	--
03-28-90	--	--	--	--	--	--	--	7.72	--	9.32	9.78	--	--	--	--
03-29-90	--	--	--	--	--	--	--	--	--	--	--	--	13.77	--	5.01
03-30-90	--	--	3.46	--	--	--	--	--	15.76	--	--	16.54	--	NO ACCESS; PLATE COVERED	--
04-02-90	--	5.61	--	5.55	--	--	--	--	--	--	--	--	--	--	--
04-03-90		--		--		6.80		--		--	--		--		--

	--		--		--		--		--			--		--	
04-04-90	--	--	--	--	--	--	--	8.30	--	9.34	9.78	--	13.78	--	--
04-05-90	4.64	--	3.49	--	10.05	--	--	--	15.76	--	--	16.54	--	--	5.01
04-09-90	--	--	--	--	--	--	7.74	--	--	--	--	--	13.80	--	5.12
04-10-90	--	5.63	--	5.57	--	7.83	--	--	--	--	--	--	--	--	--
04-11-90	--	--	3.47	--	--	--	--	--	15.82	--	--	16.58	--	--	--
04-12-90	--	--	--	--	--	--	--	8.29	--	9.43	9.86	--	--	--	--
04-13-90	--	--	--	--	--	--	--	--	--	--	--	--	--	19.79	--
04-17-90	--	5.73	--	5.77	--	6.74	--	--	--	--	--	--	--	--	--
04-18-90	--	--	--	--	--	--	--	8.33	--	9.41	9.95	--	--	--	--
04-19-90	5.79	--	3.57	--	10.10	--	--	--	15.88	--	--	16.67	13.94	19.77	5.29
04-23-90	--	5.83	--	5.74	--	6.74	--	--	--	--	--	--	--	--	--
04-24-90	--	--	--	--	--	--	7.87	8.35	--	9.52	9.94	--	13.92	--	5.37
04-26-90	5.81	--	3.55	--	--	--	--	--	15.87	--	--	16.73	--	19.87	--
									DISCONTINUED						
05-02-90	5.82	--	3.60	--	10.15	--	--	--	--	--	--	16.83	--	19.88	--
05-03-90	--	6.03	--	5.83	--	--	--	--	--	--	--	--	13.94	--	5.39

```
05-04-90          --                 --               --            8.33             9.54           10.05             --               --
          --               --                --                --                  --                   --                      --

05-07-90          --                 --               --            --               --             --                --               --
          5.82             3.69              10.24             --                  --                Equip.failure          Equip.failure

05-08-90         6.08             5.99                --            --               --             --                --               --
          --               --                --                --                  --                   --                      --

05-09-90          --                 --               --            8.45             8.34           9.98              13.80            4.85
          --               --                --               7.98                 --                   --                      --

05-10-90          --                 --               --            --               --             --                --               --
          --               --                --                --                  --                   16.92                   18.83

05-14-90          --                 --               --            --               --             --                14.14            5.62
          --               --                --                --                  --                   --                      --

05-15-90          --              6.09                --            8.41             8.20           9.98              --               --
          --               --                --                --                  --                   --                      --

05-16-90          --                 --               --            --               --             --                --               --
          5.82             3.62              10.25             --                  --                   17.05                   18.92

05-17-90         6.31                --               --            --               --             --                --               --
          --               --                --                --                  --                   --                      --

05-21-90          --                 --               --            --               --             --                14.17            5.52
          --               --                --                --                  --                   --                      --

05-22-90          --                 --               --            8.50             8.63           9.88              --               --
          5.82             3.73              10.18             --                  --                   17.17                   18.93

05-23-90          --              6.09                --            --               --             --                --               --
          --               --                --                --                  --                   --                      --

05-29-90          --                 --               --            --               --             --                14.41            5.79
          5.82             3.75              10.32             --                  --                   17.43                   19.06
      START:19.01
05-30-90         6.31             5.66                --            8.64             8.24           10.23             --               --
          --               --                --                --                  --                   --                      --
         --


06-04-90         6.31             6.29                --            --               --             --                --               --
          --               --                --                --                  --                   --                      --
         --
06-05-90          --                 --               --            8.64             9.85           10.04             --               --
          5.82             3.75              10.32             --                  --                   --                      --
         --
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06-06-90	--	22.23	--	--	--	--	--	--	--	--	--	--	17.68	13.30	19.26	5.98
06-07-90	--	--	--	--	--	--	--	8.44	--	--	--	--	--	--	--	--
06-11-90	--	--	--	--	--	--	--	--	8.73	--	9.86	10.12	--	14.97	--	5.85
06-13-90	--	--	6.31	--	6.35	--	--	--	--	--	--	--	--	--	--	--
06-14-90	5.82	21.09	--	3.83	--	10.39	--	--	--	--	--	--	17.81	--	19.09	--
06-19-90	--	--	--	--	--	--	--	--	8.76	--	10.31	10.47	--	14.74	--	5.99
06-22-90	5.82	20.68	6.31	3.81	6.65	10.37	--	--	--	--	--	--	17.98	--	19.62	--
06-26-90	--	--	6.31	--	6.82	--	--	--	--	--	--	--	--	--	--	--
06-27-90	--	--	--	--	--	--	--	--	9.55	--	10.63	10.51	--	14.90	--	6.10
06-28-90	5.82	20.65	--	3.89	--	10.44	--	--	--	--	--	--	18.09	--	19.73	--
07-02-90	5.82	18.69	--	3.83	--	10.41	--	--	--	--	--	--	18.15	14.94	19.82	5.92
07-03-90	--	--	6.31	--	--	--	--	--	9.67	--	10.71	10.52	--	--	--	--
07-05-90	--	--	--	--	6.66	--	--	--	--	--	--	--	--	--	--	--
07-09-90	--	--	--	--	--	--	--	8.37	8.15	--	8.09	10.35	--	13.16	--	5.75
07-10-90	--	--	6.31	--	6.06	--	--	--	--	--	--	--	--	--	--	--
07-11-90	5.82	17.19	--	3.77	--	10.33	--	--	--	--	--	--	18.19	--	19.68	--
07-17-90	--	16.59	--	2.02	--	8.68	--	--	--	--	--	--	--	12.81	--	3.61
07-20-90			No Access		5.48		--		7.86		7.59	No Access		--		--

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        No Access              --                   --                  --                   --                   No Access                 No Access
           --
07-23-90            --                   --                 --               --                 --               --                  --                  --
           4.62               2.77                 9.23                 --                   --                       --                         --
          16.36
07-24-90            --                  5.37                --               --                 --               --                  --                  --
           --                  --                   --                  --                   --                       --                         --
           --
07-25-90            --                   --                 --              7.94               7.64              --                13.51               4.45
           --                  --                   --                  --                   --                       --                         --
           --
07-27-90        No Access                --                 --               --                 --            No Access              --                  --
           --                  --                   --                  --                   --                   No Access                 No Access
           --


08-01-90            --                  6.04                --              8.53               7.64             10.12                --                  --
           --                  --                   --                  --                   --                       --                         --
           --
08-02-90            --                   --                 --               --                 --               --                  --                  --
           --                  --                   --                  --                   --                     16.63                      18.67
          19.91
08-03-90        No Access                --                 --               --                 --               --                13.24               4.81
        No Access            3.06                 9.40                  --                   --                       --                         --
           --
08-08-90            --                  5.54                --               --                 --               --                  --                  --
           --                  --                   --                8.13                   --                       --                         --
           --
08-09-90            --                   --                 --              8.37               8.14             10.02              13.93               5.13
           --                  --                   --                  --                   --                       --                         --
           --
08-10-90        No Access                --                 --               --                 --               --                  --                  --
           5.47              3.45                 9.80                  --                   --                     16.74                      18.65
          16.58
08-14-90            --                   --                 --               --                 --               --                  --                4.98
           --                  --                   --                  --                   --                       --                         --
           --
08-15-90            --                  5.02                --               --                 --               --                  --                  --
           --                  --                   --                  --                   --                       --                         --
           --
08-16-90            --                   --                 --               --                 --               --                  --                  --
           --                  --                 8.93                  --                   --                       --                         --
          16.37
08-17-90        No Access                --                 --           No Access          No Access         No Access         No Access                --
        No Access          No Access                --                  --                   --                   No Access                 No Access
           --
08-21-90            --                  5.22                --               --                 --               --                  --                  --
           --                  --                   --                  --                   --                       --                         --
           --
08-22-90            --                   --                 --              8.17               7.91             9.60               13.37               4.89
           --                  --                   --                  --                   --                       --                         --
```

	--														
08-24-90	5.16 16.22	No Access	3.41	--	9.30	--	--	--	--	--	--	No Access	--	No Access	--
08-28-90	-- --	5.64	--	5.55	--	--	--	--	--	--	--	--	--	--	--
08-29-90	-- --	--	--	--	--	--	--	8.46	--	8.23	9.84	--	--	--	--
08-30-90	5.30 21.83	--	3.38	--	9.33	--	--	--	--	--	--	--	13.23	--	5.24
09-06-90	4.25 18.89	--	3.29	--	9.21	--	--	--	--	--	--	--	14.04	--	4.34
09-07-90	-- --	No Access	--	No Access	--	--	--	No Access	--	No Access	No Access	No Access	--	No Access	--
09-11-90	-- --	--	--	--	--	--	--	8.40	--	8.16	9.85	--	14.25	--	5.41
09-12-90	5.18 22.22	--	3.40	--	9.90	--	--	--	--	--	--	--	--	--	--
09-13-90	-- --	5.68	--	5.31	--	--	--	--	--	--	--	--	--	--	--
09-19-90	4.73 18.09	--	3.00	--	9.36	--	--	--	--	--	--	16.32	13.78	18.64	4.53
09-20-90	-- --	No Access	--	4.99	--	--	--	7.96	--	8.98	No Access	--	--	--	--
09-24-90	-- --	5.35	--	5.15	--	--	--	--	--	--	--	--	--	--	--
09-26-90	-- --	--	--	--	--	--	--	8.28	--	9.30	9.68	--	14.26	--	5.18
09-27-90	5.17 21.17	--	3.41	--	9.80	--	--	--	--	--	--	16.55	--	18.36	--
10-04-90	-- --	--	--	5.03	--	--	--	8.05	--	9.11	--	--	13.92	--	4.95
10-06-90	5.07 16.42	No Access	3.27	--	9.65	--	--	--	--	--	No Access	16.44	--	18.39	--
10-09-90	-- --	--	--	--	--	--	--	8.31	--	9.43	9.74	--	14.20	--	5.32

10-11-90	5.35 16.16	--	3.34	--	9.79	--	--	--	--	--	--	16.58	--	18.61	--
10-12-90	-- --	5.42	--	5.39	--	--	--	--	--	--	--	--	--	--	--
10-15-90	-- --	--	--	--	--	--	--	8.39	--	9.41	9.80	--	14.26	--	5.39
10-16-90	-- --	5.53	--	5.46	--	--	--	--	--	--	--	--	--	--	--
10-17-90	5.30 16.18	--	3.36	--	9.80	--	--	--	--	--	--	16.58	--	18.47	--
10-22-90	-- --	5.47	--	5.38	--	--	--	--	--	--	--	--	--	--	--
10-23-90	-- --	--	--	--	--	--	--	8.32	--	9.45	--	--	14.24	--	5.33
10-24-90	5.33 16.40	--	3.43	--	9.79	--	--	--	--	--	--	16.63	--	18.48	--
10-26-90	-- --	--	--	--	--	--	--	--	--	--	9.85	--	--	--	--
10-29-90	-- --	5.47	--	5.47	--	--	--	--	--	--	--	--	--	--	--
10-30-90	-- --	--	--	--	--	--	--	8.38	--	9.47	9.86	--	14.28	--	5.33
10-31-90	5.22 16.95	--	3.38	--	9.76	--	--	--	--	--	--	16.63	--	18.51	--
11-05-90	-- --	--	--	--	--	--	--	--	--	--	--	--	13.25	--	5.24
11-07-90	-- --	5.49	--	--	--	--	--	--	--	--	--	--	--	--	--
11-08-90	-- --	--	--	5.51	--	--	--	8.30	--	9.37	9.77	--	--	--	--
11-09-90	5.29 16.58	--	3.25	--	9.69	--	--	--	--	--	--	16.50	--	18.48	--
11-13-90	-- --	5.45	--	5.21	--	--	--	--	--	--	--	--	--	--	--
11-14-90		--		--		--		8.32		9.34	9.77		--		5.17

	--	--		--		--		--		--			--		--	
11-15-90	5.22	16.24	--	3.31	--	9.73	--	--	--	--	--	--	16.52	14.19	18.39	--
11-19-90	--	--	5.43	--	5.31	--	--	--	--	--	--	--	--	--	--	--
11-20-90	--	--	--	--	--	--	--	--	8.34	--	9.40	9.77	--	--	--	--
11-21-90	5.25	16.61	--	3.30	--	9.75	--	--	--	--	--	--	16.58	14.12	18.54	5.18
11-30-90	--	--	--	--	--	--	--	--	--	--	--	--	16.47	14.12	18.41	5.11
12-03-90	--	--	--	--	--	--	--	--	8.34	--	9.39	9.69	--	--	--	--
12-04-90	5.20	--	--	3.28	--	9.67	--	--	--	--	--	--	--	14.09	--	5.17
12-05-90	--	--	5.36	--	5.26	--	--	--	--	--	--	--	--	--	--	--
12-06-90	--	15.85	--	--	--	--	--	--	--	--	--	--	16.48	--	18.41	--
12-10-90	--	--	--	--	--	--	--	--	--	--	--	--	--	14.01	--	5.03
12-12-90	--	--	5.38	--	5.26	--	--	--	--	--	--	--	--	--	--	--
12-13-90	--	--	--	--	--	--	--	--	8.32	--	9.38	9.70	--	--	--	--
12-14-90	5.17	15.79	--	3.27	--	9.68	--	--	--	--	--	--	16.48	--	18.47	--
12-17-90	--	--	--	--	--	--	--	--	8.38	--	9.44	Inoperative	--	--	--	--
12-18-90	--	--	5.32	--	5.31	--	--	--	--	--	--	--	--	--	--	--
12-19-90	5.22	15.79	--	3.29	--	9.70	--	--	--	--	--	--	16.49	14.07	18.37	5.13
12-24-90	--		--	--	--	--	--	--	--	--	--	--	--	14.15	--	--

		--														
12-26-90	--	--	5.40	--	5.37	--	--	--	--	--	--	--	--	--	--	5.10
12-31-90	--	--	--	--	--	--	--	--	8.39	--	9.45	9.75	--	--	--	--
01-02-91	5.19	15.62	--	3.27	--	9.63	--	--	--	--	--	--	16.49	--	18.39	--
01-03-91	--	--	--	--	5.26	--	--	--	--	--	--	--	--	--	--	--
01-04-91	--	--	5.28	--	--	--	--	--	--	--	--	--	--	14.03	--	5.06
01-08-91	--	--	5.23	--	5.22	--	--	--	--	--	--	--	--	--	--	--
01-09-91	5.17	15.57	--	3.27	--	9.62	--	--	--	--	--	--	16.43	13.99	18.37	--
01-10-91	--	--	--	--	--	--	--	--	8.39	--	9.47	9.74	--	--	--	5.07
01-14-91	--	--	5.27	--	5.24	--	--	--	--	--	--	--	--	--	--	--
01-15-91	--	--	--	--	--	--	--	--	8.38	--	9.11	9.72	--	--	--	5.04
01-16-91	4.77	15.51	--	3.25	--	9.59	--	--	--	--	--	--	16.44	14.00	18.36	--
01-23-91	--	--	5.19	--	5.17	--	--	--	--	--	--	--	--	--	--	--
01-24-91	--	--	--	--	--	--	--	--	8.32	--	9.38	9.65	--	13.94	--	4.96
01-25-91	5.09	15.46	--	3.08	--	9.49	--	--	--	--	--	--	16.37	--	18.28	--
01-28-91	--	--	5.16	--	5.18	--	--	--	--	--	--	--	--	--	--	--
01-29-91	--	--	--	--	--	--	--	--	8.37	--	9.42	9.67	--	--	--	--

01-30-91	--	--	--	--	--	--	--	--	--	--	--	--	--	13.96	--	4.99
01-31-91	5.18	15.46	--	3.17	--	9.56	--	--	--	--	--	--	16.41	--	18.32	--
02-04-91	--	--	5.18	--	5.22	--	--	--	--	--	--	--	--	--	--	--
02-05-91	--	--	--	--	--	--	--	--	8.40	--	9.45	9.68	--	14.00	--	5.02
02-06-91	5.19	15.58	--	3.22	--	9.57	--	--	--	--	--	--	16.42	--	18.37	--
02-11-91	--	--	5.17	--	5.26	--	--	--	--	--	--	--	--	--	--	--
02-12-91	--	--	--	--	--	--	--	--	8.21	--	9.29	No Access	--	13.75	--	4.85
02-15-91	4.88	15.41	--	2.82	--	9.17	--	--	--	--	--	--	16.29	--	18.22	--
02-19-91	--	--	No Access	--	5.11	--	--	--	--	--	--	--	--	--	--	--

Table 2

Streamflow data at BLM streamgage stations within the riparian corridor

(Data provided by BLM)

DATE	HEREFORD BRIDGE	LEWIS SPRINGS	CHARLESTON BRIDGE	CHARLESTON HILLS	FAIRBANK BRIDGE	TOMBSTONE GAGE	SUMMERS	BABOCOMARI	INTERNATIONALBORDER	PALOMINAS	REMARKS
01-06-87	13.60	17.70	19.40	21	--	12.40	--				
01-21-87	12.40	16.70	25.30	22.10	26.30	23.70	--				
02-06-87	11	12.70	20.80	18.20	19.60	21	--				
03-03-87	17.40	19.40	28.30	25.40	28.40	31.10	--				
03-20-87	11	13.50	20.20	19.90	20.60	24	22.30				
03-31-87	8.90	11.20	18.30	18.90	19.70	20.40	17.80				
04-16-87	8.20	10.10	15.80	15.90	15.20	17	14				
04-29-87	9.30	15.10	15.70	16.10	15	16.90	17.60				
06-11-87	1.70	--	--	3.10	1.50	0	.80				
06-24-87	1.10	1.30	2.60	1.50	0	0	--				
07-02-87	--	--	--	--	--	--	.20				
07-09-87	1	1.20	.60	0	0	0	.20				
09-01-87	--	8.60	--	--	--	--	--				
09-14-87	2.70	3.60	5.50	5.10	3.20	1.80	.80				
10-01-87	5.10	6.30	9.90	8.90	11.60	9.90	6.90				
10-15-87	2.40	3.30	7.40	6	4.60	3.70	1.20				
11-05-87	2.90	4.10	8.60	8.80	6.80	5.90	2.20				
11-17-87	4.30	6.20	10.10	11	9.60	8.40	5.30				
12-15-87	5.30	8.90	13.70	13.40	13.80	13.50	8.10				
01-29-88	8.60	12.30	16.40	17.10	17	20.50	17.60				
02-18-88	7.80	11.60	15.10	17.30	19.10	19.40	17.60				
03-15-88	9.10	10.80	17.10	17.60	16.30	17.90	15.40				

04-05-88	7.60	10.70	15.80	16.50	16.10	15.90	13.10
04-19-88	5.10	8.80	13.10	13.80	13.70	13.70	11.50
05-03-88	3.70	6.30	10.70	10.50	8.70	11.10	7.10
05-31-88	2.40	1.70	4.40	3.60	1.30	.40	.90
06-13-88	1	1	2.30	--	0	0	--
06-30-88	.70	.70	1.30	.80	0	0	.10
07-14-88	1.20	1.20	3.70	2.40	.02	0	.60

NO MEASUREMENTS FROM 7/15 TO 10/3 DUE TO HIGH FLOW.

10-14-88	6.60	9.10	13.20	11.50	10.20	9.50	5.90
11-04-88	16.70	22.30	28.50	--	21.30	28.10	24.80
11-22-88	10.80	14.10	10.90	21.20	20.70	21.20	19.60
12-19-88	11.80	16.80	19.10	22.30	23.10	21.30	21
12-30-88	12	15.60	23.40	20.20	24	23.10	20.50
01-18-89	12.90	18.30	25.40	24.50	25.80	27.50	28
02-08-89	11.80	16.80	21.30	21.70	23.80	23.10	16.30
02-28-89	10.70	14.30	18.80	21.40	22.10	21.40	20.70
03-22-89	7.50	10.70	16.50	17.60	16.90	18	15.50
04-06-89	4.30	7.10	11.10	11.20	12.10	11.80	10.50
04-20-89	4.20	4.80	7.60	7.70	6.60	7.60	5
05-04-89	2.40	3.20	7.60	6.40	5.40	4.70	2
05-19-89	4.40	4.10	6.40	3.40	5.10	4.70	1.10
06-01-89	1.50	1.20	2.50	1.50	.10	0	.50

06-14-89	.90	.80	3.60	1.30	0	--	.10
06-29-89	.80	.60	1.30	0	0	0	0
07-12-89	.70	.80	1.60	0	0	0	0
07-27-89	17.80	3.30	8.40	--	--	--	--
07-28-89	--	--	--	--	--	0	.30
07-31-89	--	--	--	4.20	2.50	--	--
08-02-89	2.50	1.40	--	--	--	--	--
08-04-89	--	--	--	--	--	0	.30
08-11-89	11.50	23.40	29.90	--	10	13.30	7.10
08-16-89	--	27.90	--	--	19.20	--	--
08-18-89	--	--	33.10	--	--	--	47
08-21-89	--	--	--	90.20	--	91.90	--
09-07-89	4.50	6.20	6.50	6.60	3.90	2.90	2.70
09-21-89	1.70	1.30	3.30	2.30	0	0	.40
10-02-89	1.40	1.10	2.40	2	0	0	0
10-17-89	2.20	1.40	3.40	--	.80	0	.50
10-25-89	2.10	1.50	--	--	--	--	--
10-26-89	--	--	4.50	3.90	--	--	.40
10-30-89	--	--	--	--	3.50	0	--
11-14-89	--	--	6.03	--	--	2.32	0.34
11-15-89	--	--	--	--	6.17	--	--
11-16-89	EQUIP. FAILURE	EQUIP. FAILURE	--	8.48	--	--	
01-08-90	--	--	--	--	--	8.44	10.28
01-09-90	4.28	7.67	--	--	--	--	--

01-11-90	--	--	11.77	12.70	11.65	--	--		
03-15-90	5.21	8.66	6.54	11.46	13.01	--	10.97	1.41	1.95
1.53	ADWR DATA								
03-20-90	--	--	--	--	--	--	10.67		
		(IB+PAL)							
03-22-90	--	--	--	12.30	10.43	12.47	--	1.20	
03-23-90	--	8.83	11.75	--	--	--	--	--	
03-26-90	4.13	--	--	--	--	--	--	--	
03-27-90	--	--	--	--	--	--	8.47	--	
03-28-90	--	--	--	11.59	12.17	12.52	--	1.14	
03-29-90	--	7.80	10.51	--	--	--	--	--	
03-30-90	4.17	--	--	--	--	--	--	--	
04-02-90	--	--	--	--	--	--	9.56	--	
04-03-90	--	--	--	--	10.86	12.02	--	0.92	
04-04-90	--	--	11.11	12.15	--	--	--	--	
04-05-90	4.01	8.22	--	--	--	--	--	--	
04-10-90	--	--	--	--	--	10.85	6.22	--	
04-11-90	5.17	6.43	9.48	--	--	--	--	--	
04-12-90	--	--	--	9.90	--	--	--	--	
04-13-90	--	--	--	--	9.27	--	--	0.71	
04-17-90	--	--	--	--	--	--	4.55	--	
04-18-90	--	--	8.35	8.15	--	--	--	--	
04-19-90	3.50	4.43	--	--	--	7.69	--	--	
04-20-90	--	--	--	--	6.97	--	--	0.65	
04-23-90	--	--	--	--	--	6.41	3.27	--	
04-24-90	--	4.25	6.98	7.02	--	--	--	--	
04-25-90	--	--	--	--	--	--	--	.61	
04-26-90	2.75	--	--	--	6.75	--	--	--	

05-02-90	--	--	--	--	--	4.32	--	--
05-03-90	--	3.56	6.70	--	--	--	2.16	--
05-04-90	--	--	--	6.62	5.43	--	--	.40
05-07-90	2.03	--	--	--	--	--	--	--
05-08-90	--	--	--	--	--	3.26	.97	--
05-09-90	--	2.23	5.17	4.58	--	--	--	--
05-11-90	--	--	--	--	3.45	--	--	.10
05-14-90	--	1.62	4.50	--	--	--	--	--
05-15-90	--	--	--	3.37	--	1.17	.60	--
05-16-90	2.90	--	--	--	--	--	--	--
05-17-90	--	--	--	--	1.65	--	--	0
05-21-90	--	1.22	3.32	--	--	0	--	--
05-22-90	1.87	--	--	2.62	--	--	--	--
05-23-90	--	--	--	--	--	--	.44	--
05-25-90	--	--	--	--	.24	--	--	0
05-29-90	1.67	.90	--	--	--	0	--	--
05-30-90	--	--	2.75	1.69	0	--	.24	0
06-04-90	--	--	--	--	0	0	.12	0
06-05-90	1.78	--	1.82	.91	--	--	--	--
06-06-90	--	.64	--	--	--	--	--	--
06-11-90	--	.26	1.25	.50	--	--	--	--
06-12-90	--	--	--	--	0	0	--	0
06-13-90	--	--	--	--	--	--	0	--
06-14-90	.39	--	--	--	--	--	--	--
06-19-90	--	.10	.20	0	--	--	--	--
06-20-90	--	--	--	--	0	0	--	0

06-22-90	0	--	--	--	--	--	0	--
06-26-90	--	--	--	--	0	0	0	0
06-27-90	--	Equip.failure	Equip.failure	0	--	--	--	--
06-28-90	Equip.failure	--	--	--	--	--	--	--
07-02-90	.62	.42	.31	--	--	0	--	--
07-03-90	--	--	--	0	--	--	--	--
07-05-90	--	--	--	--	0	--	0	0
07-09-90	--	.86	3.42	1.77	--	--	--	--
07-10-90	--	--	--	--	0	0	0	0
07-11-90	1.33	--	--	--	--	--	--	--
07-20-90	No Access	No Access	No Access	No Access	No Access	No Access	No Access	No Access
07-23-90	24.54	No Access	No Access	No Access	No Access	--	--	No Access
07-24-90	--	--	--	--	--	41.73	35.58	--
07-30-90	--	--	--	--	9.99	--	--	No Flow
08-01-90	--	--	--	--	--	4.68	0.59	--
08-03-90	No Access	No Access	No Access	No Access	No Access	No Access	No Access	No Access
08-07-90	--	--	--	--	--	17.69	--	--
08-08-90	--	--	13.91	--	--	--	9.80	0
08-09-90	--	7.76	--	11.07	--	--	--	--
08-10-90	3.32	--	--	--	No Access	--	--	No Access
08-17-90	No Access	No Access	No Access	No Access	No Access	No Access	No Access	No Access
08-21-90	--	--	--	--	--	23.05	22.26	--
08-22-90	--	11.66	18.99	18.30	--	--	--	--
08-23-90	--	--	--	--	15.25	--	--	No Flow
08-24-90	4.85	--	--	--	--	--	--	--
08-28-90	--	--	--	--	--	--	6.74	--

08-29-90	--	--	17.46	--	5.63	4.74	--	No Flow	
08-31-90	3.30	5.28	--	8.78	--	--	--	--	
09-05-90	--	--	--	--	--	13.86	--	--	
09-06-90	10.70	13.04	23.43	--	--	--	--	--	
09-10-90	--	5.02	9.35	--	6.01	--	--	No Flow	
09-11-90	--	--	--	7.85	--	--	--	--	
09-12-90	2.53	--	--	--	--	1.33	--	--	
09-13-90	--	--	--	--	--	--	1.27	--	
09-21-90	No Access	No Access	No Access	--	--	--	No Access	--	
09-24-90	--	--	--	--	--	--	11.86	--	
09-25-90	--	--	--	--	--	11.61	--	--	
09-26-90	--	7.23	11.81	12.40	--	--	--	--	
09-27-90	3.33	--	--	--	--	--	--	--	
09-28-90	--	--	--	--	6.34	--	--	No Flow	
10-02-90	--	--	--	--	28.26	25.51	--	0.94	
10-05-90	12.21	17.37	24.86	26.32	--	--	25.16	--	
10-09-90	--	6.15	11.08	10.76	--	--	--	--	
10-11-90	3.23	--	--	--	--	6.35	--	--	
10-12-90	--	--	--	--	--	--	3.68	--	
10-15-90	--	4.17	8.93	8.32	6.43	--	--	No Flow	
10-16-90	--	--	--	--	--	4.83	2.63	--	
10-17-90	2.74	--	--	--	--	--	--	--	6.28
10-22-90	--	--	--	--	--	4.71	2.56	--	--
10-23-90	--	4.96	8.88	8.53	--	--	--	--	--
10-24-90	2.81	--	--	--	--	--	--	--	--
10-29-90	--	--	--	--	6.09	4.76	2.45	0.11	--

10-30-90	--	4.79	8.59	8.21	--	--	--	--	--
10-31-90	2.58	--	--	--	--	--	--	--	--
11-05-90	--	5.72	--	--	8.71	7.16	--	0.31	--
11-07-90	--	--	--	--	--	--	6.23	--	--
11-08-90	--	--	10.20	10.77	--	--	--	--	--
11-09-90	3.75	--	--	--	--	--	--	--	2.12
11-13-90	--	--	--	--	--	--	6.84	--	--
11-14-90	--	7.16	12.20	11.50	--	9.40	--	--	--
11-15-90	3.94	--	--	--	--	--	--	--	--
11-19-90	--	--	--	--	11.12	9.94	7.49	0.51	--
11-20-90	--	--	10.98	11.71	--	--	--	--	--
11-21-90	3.98	7.38	--	--	--	--	--	--	--
12-04-90	5.41	8.65	13.04	--	--	--	--	--	--
12-05-90	--	--	--	--	--	12.68	10.14	--	--
12-06-90	--	--	--	--	--	--	--	--	2.72
12-07-90	--	--	--	13.94	13.63	--	--	0.75	--
12-10-90	--	8.92	13.65	--	--	--	--	--	--
12-12-90	--	--	--	--	--	13.97	11.49	--	--
12-13-90	--	--	--	13.49	--	--	--	--	--
12-14-90	5.93	--	--	--	--	--	--	--	--
12-17-90	--	--	14.27	16.21	16.48	--	--	0.88	--
12-18-90	--	--	--	--	--	17.15	13.67	--	--
12-19-90	6.74	10.69	--	--	--	--	--	--	--
12-26-90	--	10.13	14.69	--	--	--	12.69	--	--
12-27-90	--	--	--	--	--	14.91	--	--	--
12.31-90	--	--	--	16.18	16.89	--	--	0.96	--

01-03-91	--	--	--	--	--	16.12	14.01	--	--
01-04-91	7.33	11.13	No Access	--	--	17.77	15.39	--	--
01-09-91	7.77	--	No Access	--	--	--	--	--	4.10
01-10-91	--	11.71	--	16.50	--	--	--	--	--
01-14-91	--	--	--	--	17.51	--	15.27	0.94	--
01-15-91	--	12.51	--	16.62	--	17.80	--	--	--
01-16-91	8.37	--	No Access	--	--	--	--	--	--
01-23-91	--	--	--	--	--	23.08	20.91	--	--
01-24-91	--	17.70	No Access	23.56	--	--	--	--	--
01-25-91	12.19	--	--	--	21.49	--	--	0.97	--
01-29-91	--	--	--	19.68	--	20.34	--	--	--
01-30-91	--	12.75	No Access	--	17.84	--	19.05	1.03	--
01-31-91	9.19	--	--	--	--	--	--	--	--
02-04-91	--	--	--	--	--	16.86	15.44	--	--
02-05-91	--	12.00	No Access	18.34	--	--	--	--	--
02-06-91	8.21	--	--	--	--	--	--	--	4.55
02-08-91	--	--	--	--	17.86	--	--	0.98	--
02-11-91	--	--	--	--	--	--	14.76	--	--
02-13-91	58.58	No Access	--	--	--	--	--	--	--
02-14-91	--	--	No Access	No Access	No Access	No Access	--	No Access	--