3.0 GROUNDWATER BASIN CHARACTERIZATION

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3.1 DEFINITION OF GROUNDWATER BASINS IN THE STUDY AREA

The groundwater basin designations used in this study correspond to the designations set forth in California Department of Water Resources Bulletins 118-75 and 118-80, specifically those for basins in the Colorado Desert Hydrologic Area. Portions of seven groundwater basins make up the aerial extent of the study area, which is approximately 2,400 square miles. The basins are the Imperial Valley Basin, the Coachella Valley Basin, the Orocopia Valley Basin, the Chocolate Valley Basin, the East Salton Sea Basin, the Amos Valley Basin, and the Ogilby Valley Basin. These basins, in addition to other regional basins outside of the study area, are shown on Figure 2-7. The study area extends into the Mexicali Valley south of the international border. Hydraulic connection between this area and the southern boundaries of the Imperial Valley Basin and the Ogilby Valley Basin is assumed.

3.2 BASIN CHARACTERISTICS

A portion of the Imperial Valley Basin comprises approximately 50 percent of the study area. The entire basin, which extends beyond the westerly boundary of the study area (New River), covers an area of 1,870 square miles and drains north to the Salton Sea by the New and Alamo Rivers. The water-bearing units are made up of older and younger alluvium with a storage capacity of approximately 14 million acre-feet (Department of Water Resources 1975). Natural recharge to the basin has been estimated to be 3,300 acre-feet per year.

A portion of the south Coachella Valley Basin (approximately 13 square miles) defines the northern boundary of the study area. The basin covers an area of 690 square miles and is drained by the Whitewater River. The water-bearing units are made up of older and younger alluvium with a storage capacity of 39 million acre-feet. Natural recharge to the Coachella Valley Basin has been estimated to be 80,000 acre-feet per year.

A portion of the Orocopia Valley Basin (approximately 5 square miles) occupies the north portion of the study area. The basin covers an area of 140 square miles and is drained by the Box Canyon Wash. The water-bearing units are made up of younger and older alluvium with a storage capacity of 1.5 million acre-feet. Natural recharge to the basin has been estimated to be 500 acre-feet per year.

The western half of the Chocolate Valley Basin occupies the northeast portion of the study area. The basin covers an area of 120 square miles and is drained by Salt Creek. The water-bearing units are made up of

younger and older alluvium with a storage capacity of 1 million acre-feet. Natural recharge to the basin has been estimated to be 200 acre-feet per year.

The East Salton Sea Basin occupies the eastern boundary of the study area. The basin covers an area of 150 square miles and is drained by Iris Wash. The water-bearing units are made up of younger and older alluvium with a storage capacity of 360,000 acre-feet. Natural recharge to the basin has been estimated to be 200 acre-feet per year.

The Amos Valley Basin occupies the east-central boundary of the study area. The basin covers an area of 220 square miles. The water-bearing units are made up of younger alluvium with a storage capacity of 2.9 million acre-feet. Natural recharge to the basin has been estimated to be 250 acre-feet per year.

The Ogilby Valley Basin to the southeast covers an area of 220 square miles. The water-bearing units are made up of younger alluvium with a storage capacity of 2.9 million acre-feet. Natural recharge to the basin has been estimated to be 250 acre-feet per year.

3.2.1 Stratigraphy and Structure

The groundwater basins that make up the study area are hydraulically connected, and discussions specific to stratigraphy and structure will refer to the study area as a single groundwater system.

The study area lies within the Salton Trough, a topographic and subsurface structural depression. The trough has been filled with marine and non-marine deposits that overlie a pre-Tertiary basement complex. The trough is bounded by the San Andreas fault zone, which trends northwest-southeast approximately along the northeastern side of the study area, and the San Jacinto Fault zone to the west (outside of the study area). Southeast of the Salton Sea, the San Andreas Fault has no obvious surface expressions. Some geologists believe the fault continues southeast beneath the Algodones dune belt, but this has not yet been confirmed.

Major faults in the region generally trend northwest to southeast. The faults are marked at the surface by prominent zones of vegetation, hot springs, and scarps both in unconsolidated sediments and along range fronts and groundwater barriers. The fault planes are nearly vertical and displacements are of a right-lateral strike-slip and vertical nature. Although not conclusively demonstrated, possibly as much as 200 miles of strike-slip displacement has occurred along the San Andreas Fault in the region since the middle Eocene (Crowell and Susuki 1959). The steepness of and topographic relief along individual fault scarps, and the

great thickness of sediments within the Salton Trough indicate that rifting or other apparent vertical movements have been important in creating and maintaining the structural basin (U.S. Department of the Interior 1974).

The Imperial Fault runs through the west-central portion of the study area. The fault was concealed beneath the Imperial Valley alluvium until 1940, when the Imperial Valley and surrounding regions were shaken by a strong earthquake of Richter magnitude 7.1. The resulting surface expression of the fault extended from near Brawley south across the international boundary. Low scarps were produced, and as much as 15 feet of right-lateral separation occurred near the international border. The Imperial Fault parallels other major faults in the basin (Norris and Webb 1976).

The oldest rocks exposed in the study area are Precambrian gneisses, anorthosites, and schists of the Orocopia, Chocolate, and Cargo Muchacho Mountains as well as Pilot Knob to the south. If these Precambrian rock sequences underlie the central portion of the Salton basin, they are at depths of approximately 20,000 feet or more.

An erosional surface developed on the older rocks early in the Tertiary. The scarcity of lower Tertiary sedimentary rocks suggests that the area was emergent and above sea level for at least part of that time. Beginning probably in the Miocene, the Salton Trough was depressed, possibly in response to an opening in the continental rift. As depression of the land surface continued, the sea entered and marine sediments were deposited in late Miocene and early Pliocene time. By mid-Pliocene, deposition was of a continental nature (U.S. Department of the Interior 1974). Most of the strata overlying the basement complex is nonmarine, but the Mio-Pliocene Imperial Formation is a widespread marine unit sometimes nearly 4,000 feet thick. The Imperial Formation represents the final large-scale marine incursion into the basin (Norris and Webb 1976).

Overlying the marine Imperial Formation is a thick heterogeneous sequence of predominantly nonmarine deposits. Most of the deposits in the central part of the valley were brought in by the Colorado River and are several thousand feet thick. The deposits of the Colorado River are generally finer-grained silts, sand, and clay, in contrast to locally derived deposits of coarse sand and gravel. The deposits of Lake Cahuilla form the uppermost lacustrine silt, sand, and clay units in the central part of the valley within the shoreline of ancient Lake Cahuilla (Loeltz *et al.* 1975). These sediments range from a few feet to 300 feet in thickness.

3.2.2 Groundwater Levels

The direction of groundwater movement is controlled primarily by contours of groundwater level elevation; the rate of groundwater movement is proportional to the gradient or slope of the groundwater table. The shape of groundwater level contours also can be used to infer the location of aquifer recharge features, discharge features, faults, and underflow boundaries. The following section presents groundwater levels for the entire study area, including central Imperial Valley, the East Mesa, Mexicali Valley, and the East Salton Sea area. Prior studies have addressed all these areas except the East Salton Sea, where the water table elevation is not well understood due to the limited number of locations where groundwater level measurements have been taken. Water level contour maps have not been previously published for the East Salton Sea area.

3.2.2.1 Groundwater Levels for 1960

Published water level contours are available for 1965 for Imperial Valley (Loeltz *et al.* 1975) and 1960 for the East Mesa (Olmsted *et al.* 1973; Bureau of Reclamation 1991) and Mexicali Valley (Olmsted *et al.* 1973). Given that well hydrographs displayed little variation during this period, the aquifer was in approximate steady state during the 1960 to 1965 period. Therefore, these published water level contours were merged to define a composite 1960/1965 water level contour map for the study area (Figure 3-1). The water level contours are dashed east of the Salton Sea area to reflect the limited data in this area; only five measured water levels are available in this 250-square-mile area.

The water table shows a broad groundwater mound in the East Mesa area extending westward from Pilot Knob to the East Highline Canal that is associated with seepage recharge from the AAC. The mound also extends northwest along the Coachella Branch due to seepage recharge along the first 49 miles of the CB prior to its lining. Between the canals, the direction of movement is west-northwestward, but south of the AAC the flow direction is into Mexico. East of the CB, the flow direction is northward for the first 20 miles, but gradually swings to the west further north. Prior to construction of the AAC and CB, groundwater contours in the region were influenced by the Alamo Canal and exhibited a generally westward gradient (see Figure 4-3). A more thorough discussion of the changes in groundwater levels associated with the AAC and its CB is given in Section 4.

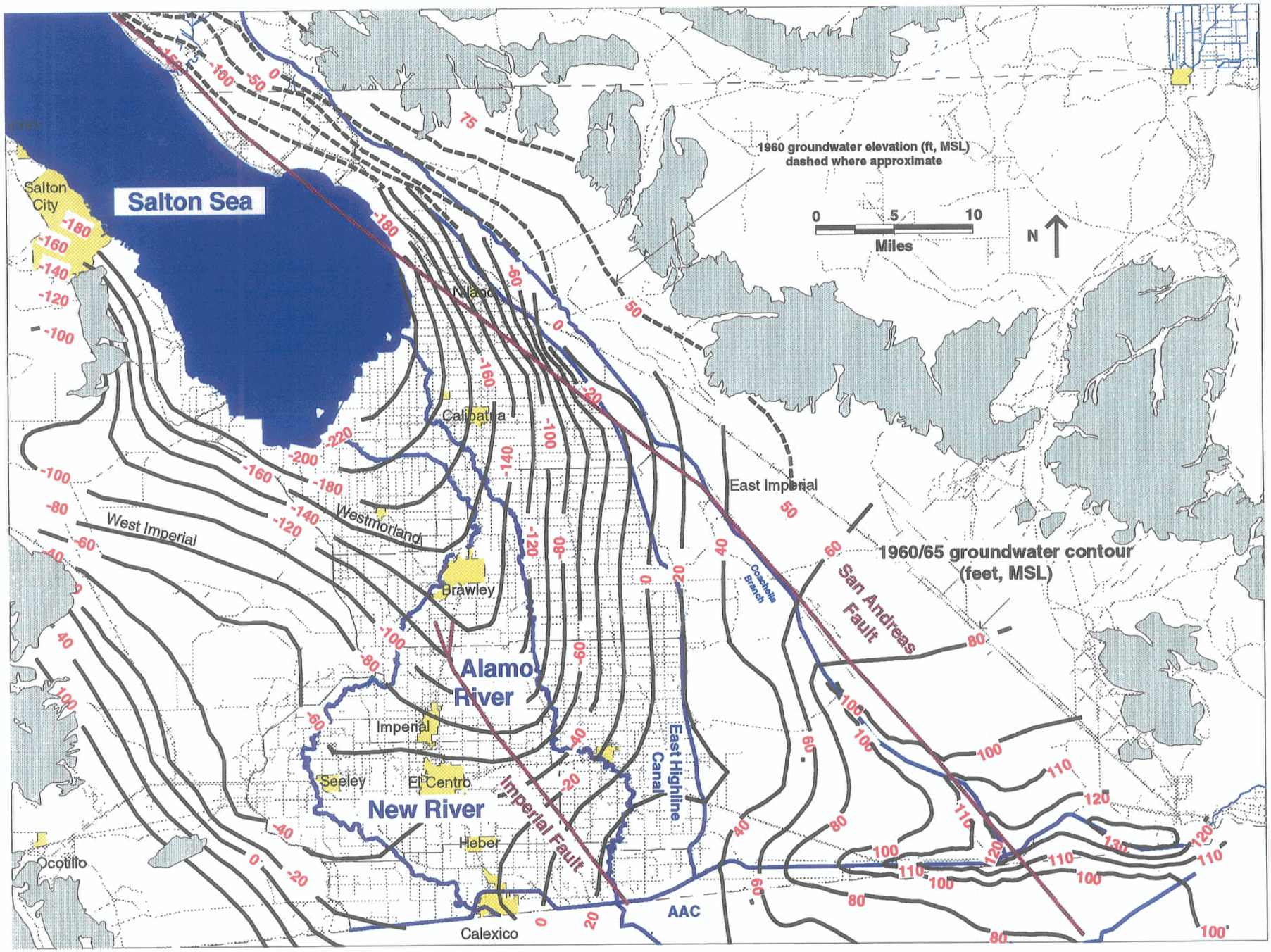

Figure 3-1. Composite Groundwater Level Contour Map for 1960/65

Groundwater in central Imperial Valley moves towards the axis of the valley and converges upon the New River and the Alamo River, which are the principal areas of discharge. Artesian groundwater conditions have historically been quite common between the East Highline Canal and the Alamo River, but the artesian conditions do not extend west of the Alamo River. This suggests that the Alamo River may be a more significant source of discharge than the New River. Groundwater east of the Salton Sea flows westward toward the Salton Sea, although a considerable amount of groundwater discharges under artesian conditions in wetlands several miles east of the Salton Sea. Section 5.0 gives a more detailed discussion of the wetlands and local groundwater conditions between the Salton Sea and the CB.

The gradient or slope of the groundwater table in the East Mesa, especially prior to canal construction (see Figure 4-3), is relatively flat at a slope of only 4 feet per mile, reflecting the very high aquifer transmissivity in this area. In contrast, the gradient or slope of the groundwater table in the central Imperial Valley is relatively steep at a slope of 20 feet per mile, reflecting the very low aquifer transmissivity in this area. Despite the presence of the San Andreas and Algodones Faults in the East Mesa area, the groundwater contours do not necessarily appear to create a barrier effect. Mounding effects may also be attributable to canal seepage or a combination of the two. The Algodones Fault is an unmarked dotted line northeast of the San Andreas Fault on Figure 2-2a.

3.2.2.2 Historical Variation in Groundwater Levels

Groundwater levels adjacent to the canal in the East Mesa area have varied significantly over time, primarily in response to seepage of imported Colorado River water. Sections 4.0 and 5.0 give a detailed discussion of the rise in groundwater levels associated with both the AAC and its CB, and the decline in water levels associated with the lining of the first 49 miles of the CB in 1979. These canals have had the most significant impact on water levels in the study area.

Hydrographs for selected monitoring wells in Imperial Valley, annual precipitation, and the cumulative departure from precipitation are given in Figures 3-2a and 3-2b. The cumulative departure from precipitation shows a prolonged wet period from 1940 to 1955, a dry period during the 1970s, and a return to average conditions in the early 1990s. Hydrographs for the three wells located nearest central Imperial Valley (15S14E18C, 5614.4, and 7611.08) show very little long-term trends, which is attributed to groundwater levels being controlled by the tile drains in IID. Wells in the East Mesa (5816.5 and 11S15E23M) show a declining trend from 1980 to the mid-1990s, which is attributed to the lining of the

first 49 miles of the Coachella Branch. Well 6925 located in the East Mesa at the CB turnout of the AAC shows a smaller influence from the CB lining and recovers in the 1990s to pre-lining levels; this is attributed to the small impact of the CB lining on the water levels and seepage rates of the AAC. Well 16S21E33E near Pilot Knob shows a rising trend in the 1990s that is also reflected in other wells in this area; this is attributed to heavy rainfalls in the 1990s producing the wet conditions observed in the cumulative precipitation departure data.

There are also seasonal trends in the water levels of many East Mesa wells, with highest water levels in March and the lowest water levels in September. The seasonal trends appear strongest near the AAC below Drop 1, although they can also be observed in East Mesa. These seasonal trends are thought to be associated with variations in canal leakage, which dominates the overall water budget in this area. Water levels in summer months may be falling because the net canal seepage is reduced due to evapotranspiration from the shallow groundwater between Drop 2 and the East Highline Canal. Additional well hydrographs and summaries of the entire project water level database are given in Appendix F.

In general, the water table in the central Imperial Valley has not changed significantly in the last 50 years because the water table is controlled by the elevations of the New and Alamo Rivers, which act as drains regulating the water table, and the Salton Sea, which acts as a sink for the entire Imperial and Coachella Valleys. The large IID system of canals, drains, and sub-surface drains also acts to regulate the water table in Imperial Valley.

The southern study area in Mexicali Valley experiences a larger variation in groundwater levels than Imperial Valley due to variations in both pumping rates and flows in the Colorado River in Mexico. Water level maps for Mexicali given in Appendix F for 1985, 1989, and 1992 and the 1965 data in Figure 3-1 show fluctuations over time, as well as large sinks associated with the 750,000 acre-feet per year of groundwater extraction. The water levels in Mexicali fluctuate, rising periodically due to excess Colorado River flows into Mexico and falling periodically due to pumping. However, there is no apparent long-term rising or falling trend in the water levels in Mexicali.

3.2.2.3 Current Groundwater Levels

Groundwater levels for the study area based on 1993 data are given in Figure 3-3. The 1993 period was chosen because it is the most recent period with data in Mexicali Valley, and it also is a time period which