should be representative of current water levels in the East Mesa and Imperial Valley. The decline in the water table in East Mesa due to the lining of the first 49 miles of the CB began in 1980 and stabilized in the early 1990s.

Groundwater contours are generally unchanged from the 1960s data in Imperial Valley, the East Salton Sea area, Mexicali Valley, and the East Mesa area adjacent to the AAC. The water table, however, has declined significantly along the first 49 mile of the CB due to its 1979 lining. This has resulted in a more northerly flow direction into East Mesa near Drop 1 of the AAC. In general, the water levels along the AAC are similar to the 1960 conditions because AAC seepage was not controlled by water level elevations near Drop 1.

3.2.3 Aquifer Definition

3.2.3.1 Physical Characteristics

The aquifer underlying the study area consists of a sequence of Cenozoic marine and terrigenous deposits up to 20,000 feet thick overlying a pre-Tertiary basement. This study is primarily concerned with the upper several hundred feet of heterogeneous deposits consisting of continental sands, silts, clays, and gravel. The hydraulic connection between the water in the deeper deposits and the water in the upper part of the groundwater reservoir is poor (Loeltz *et al.* 1975).

The near surface deposits underlying the study area generally tend to be non-continuous laterally. Figure 3-4 shows the locations of the cross sections. Cross-sections A-A' and B-B' (Figures 3-5 and 3-6), constructed from selected lithologic logs, illustrate the lateral facies changes within the central part of the basin, most likely representing cutoff meanders of ancient streambeds associated with the Colorado River. Two primary lithologic types have been identified: clays, including thick sequences of clay and predominantly clay mixtures; and sands, including clean sands, silty sands, and gravels. The oversimplification of lithologic descriptions on many of the logs precluded interpretation beyond water-bearing versus nonwater-bearing deposits. The cross sections have an approximate 100 times vertical exaggeration in order to include thinner units of the aquifer.

The cross sections illustrate a major stratigraphic relationship used in the construction of the aquifer conceptual model: a two-layer system isolated by an intermediate aquitard, ranging in thickness from approximately 0 to 250 feet, and gradually thinning towards the peripheral areas of the basin.

The geologic literature documents lateral movement along the primary faults in the region. Vertical movement is also an element of offset in such a basin having been formed by structurally down-dropped blocks along subparallel fault zones. The vertical offsets illustrated in the cross sections represent only relative sense of motion, and should not be misconstrued as representing actual vertical displacement along the San Andreas and Imperial Faults.

3.3 GEOHYDROLOGY

3.3.1 Groundwater Recharge/Discharge Areas

The primary source of groundwater recharge to the study area is underflow and importation of Colorado River water, which reaches the shallow aquifer via seepage along the unlined portions of the AAC, CB, and extensive network of conveyance channels. Subordinate sources of recharge are local runoff and underflow from tributary areas. Aquifer recharge from precipitation in the study area is considered minor (approximately 1,000 acre-feet per year) and is discussed in more detail in Section 2.1.5.2.

Groundwater discharge occurs northeast of the Salton Sea in numerous springs and seeps west of the CB running roughly parallel to the San Andreas Fault zone. The total discharge of springs and seeps, excluding the discharge due to seepage from the CB, is estimated to be only a few thousand acre-feet per year (Loeltz *et al.* 1975).

The majority of the pumping wells in the Imperial Valley are domestic, and their combined annual discharge is a few thousand acre-feet.

Most of the groundwater discharge occurring in the Imperial Valley occurs through upward flow from the deeper aquifers to the network of drains that underlie the irrigated land as well as capture of shallow groundwater by the New and Alamo Rivers near the south shore of the Salton Sea. The amount of vertical leakage averages only a few tens of thousands of acre-feet per year (Loeltz *et al.* 1975).

3.3.2 Direction and Rate of Groundwater Flow

The direction of groundwater flow during 1960/1965 can be determined from the water table contour map presented in Figure 3-1. The direction of groundwater flow is illustrated in Figure 3-7 using flow vectors that are drawn perpendicular to the 1960/1965 groundwater table. Flow directions are westward along the AAC between the CB and the Alamo River, then turn northwest to north between the Alamo and New

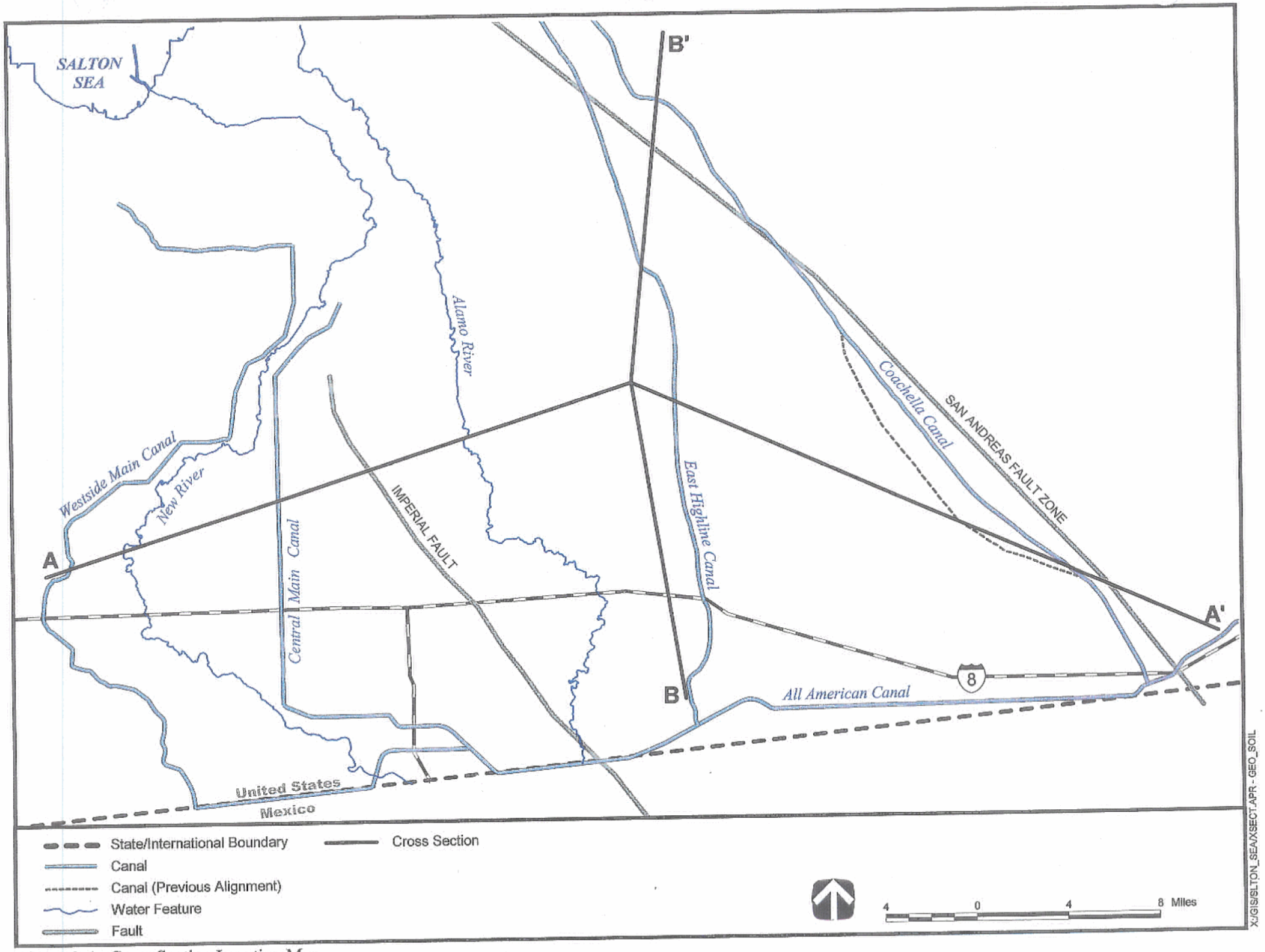

Figure 3-4 Cross Section Location Map

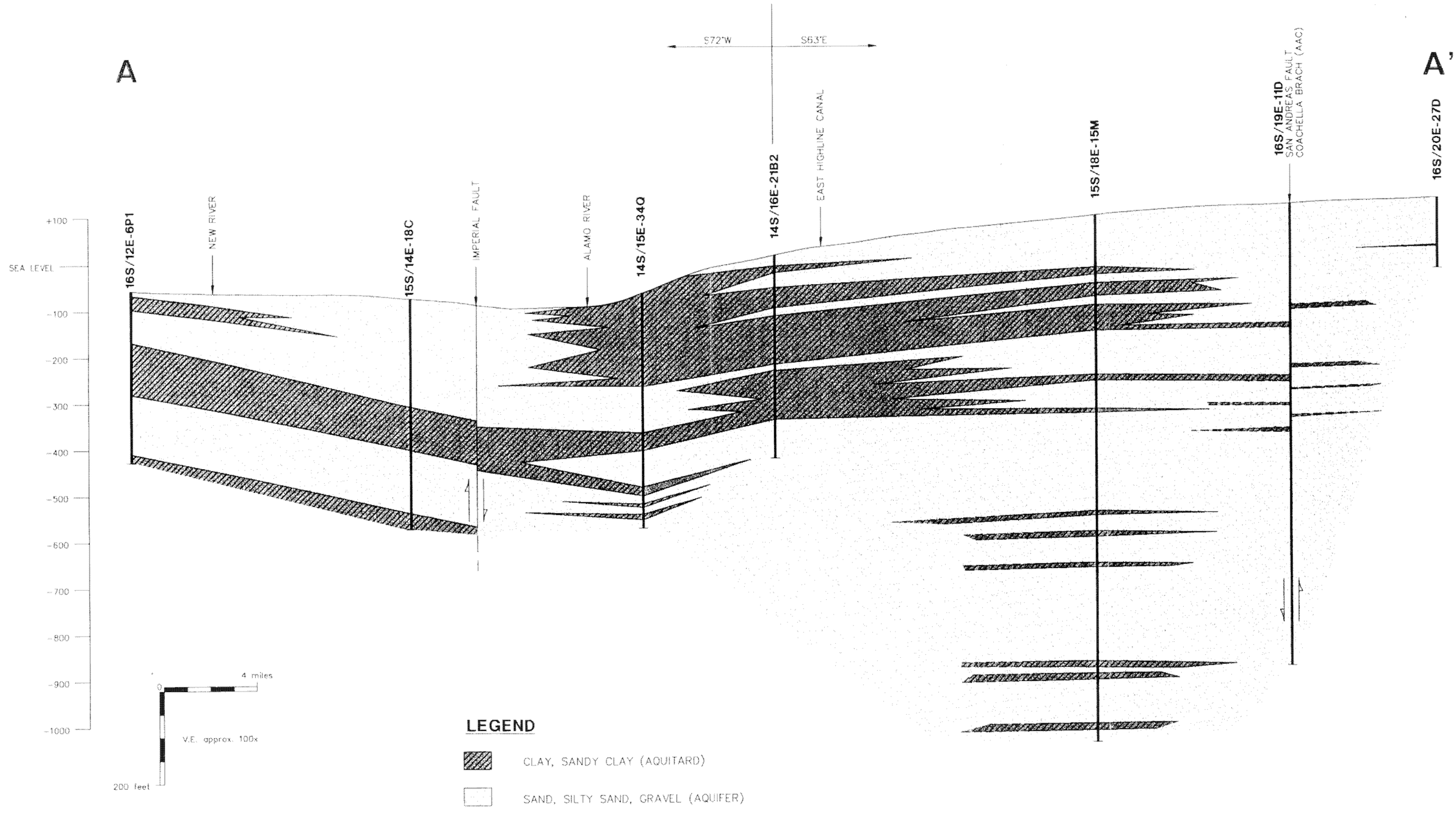

Figure 3-5

Salton Sea Authority
Geologic Cross Section A-A'

X:\35\10293-05\SECTIONS.DWG 5/14/99

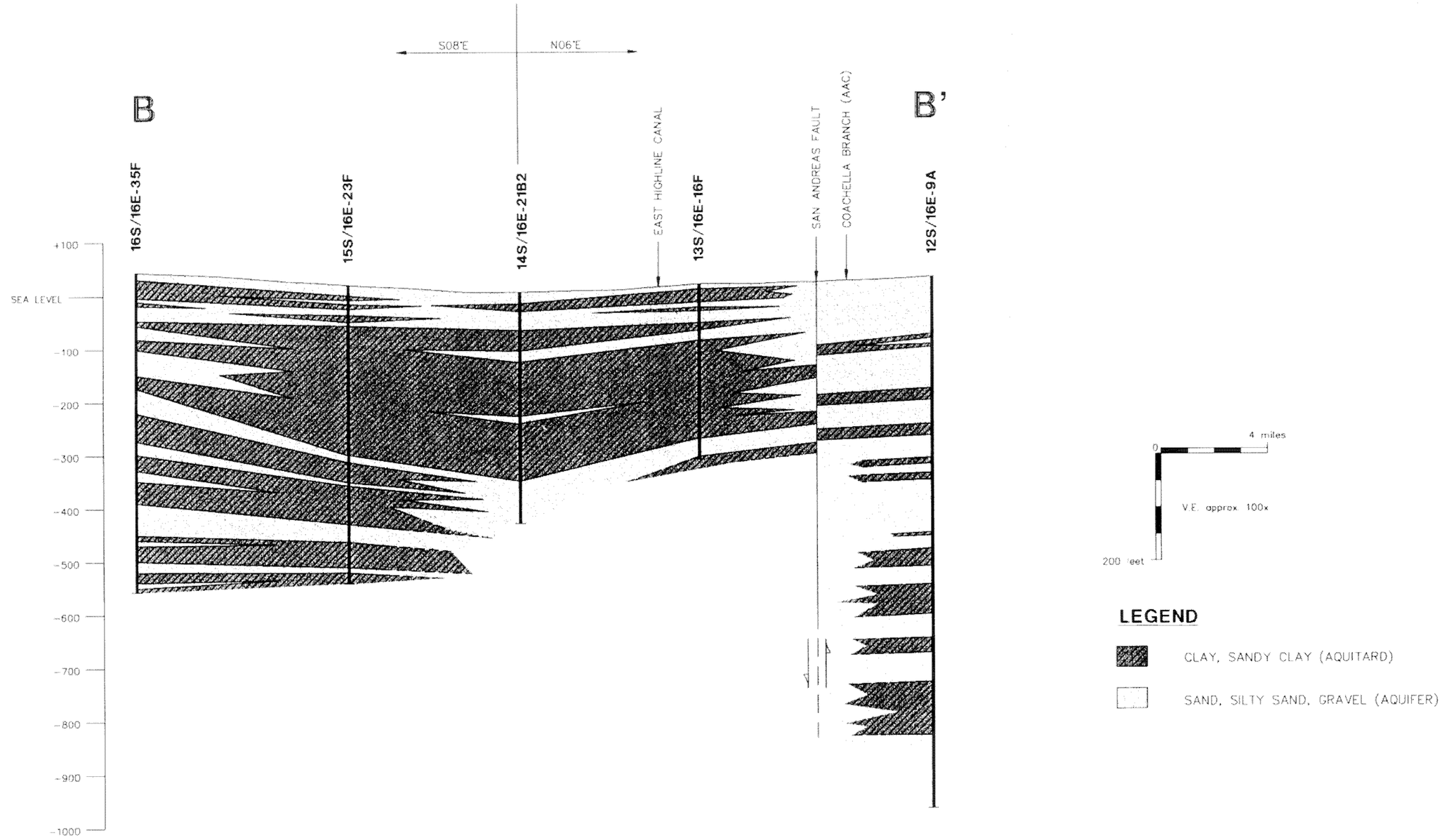

Figure 3-6

Salton Sea Authority
Geologic Cross Section B-B'

X:\GIS\10243-05\SECTIONS.DWG 5/14/99

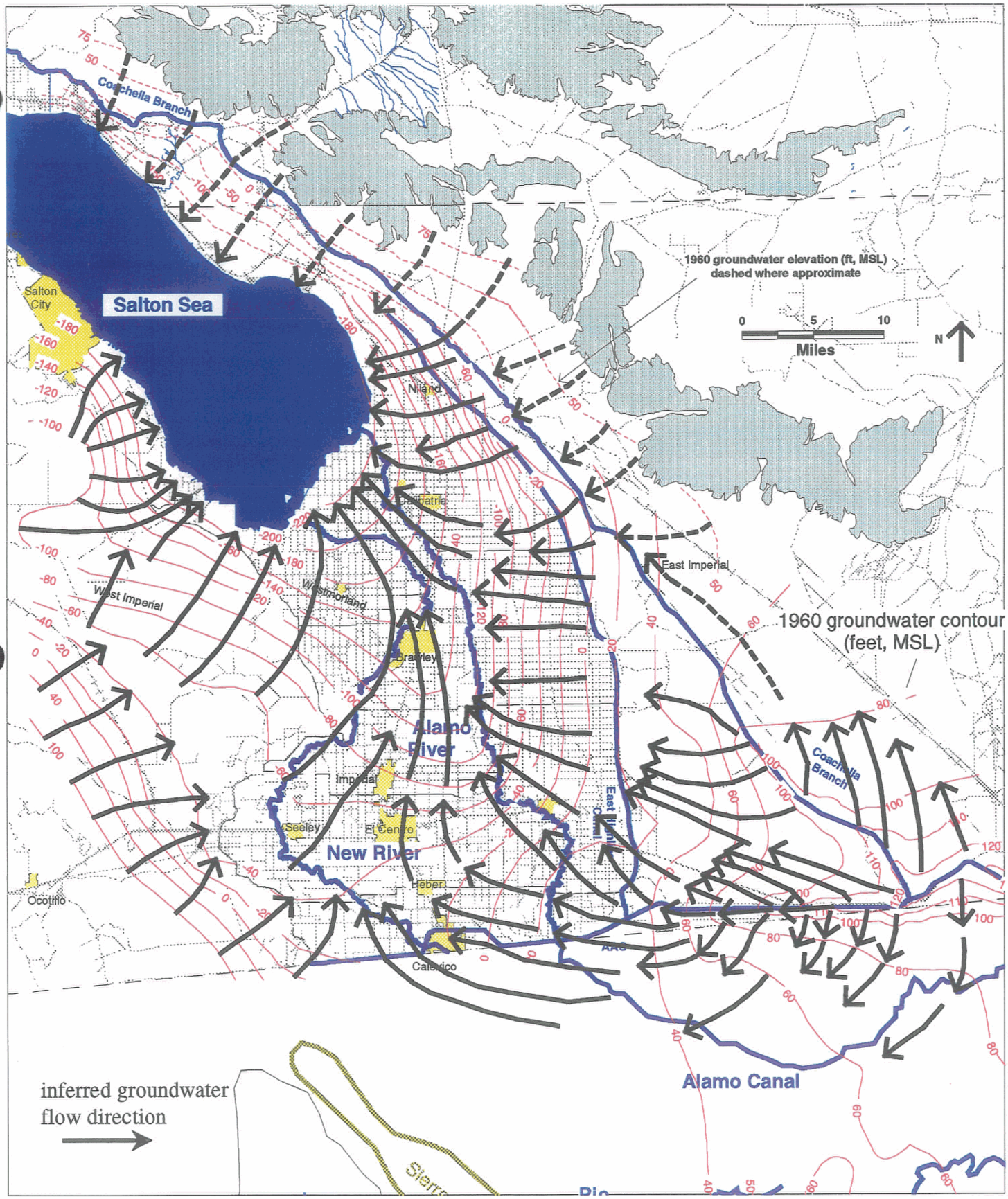

Figure 3-7 Composite Groundwater Flow Directions 1960/1965

River. Flow direction below the AAC is to the south into Mexico east of the CB, but then turns southwest between the CB and the East Highline Canal. Apparent flow direction is to the northwest in western Imperial Valley and to the southwest east of the Salton Sea, as flow from both these areas converges towards the Salton Sea. Flow direction in East Mesa is west to northwest, although it is also locally influenced by the groundwater mound under the Coachella Branch.

Approximate groundwater flow rates can be calculated based on the slope of the water table, the aquifer hydraulic conductivity, and the aquifer effective porosity. Groundwater velocity in the permeable East Mesa sands and gravels is estimated to be 450 feet per year using a gradient of 0.001 foot per foot (ft/ft), a hydraulic conductivity of 250 feet per day (Bureau of Reclamation 1987), and an effective porosity of 20 percent. In contrast, groundwater velocity in the semi-permeable Imperial Valley lake sediments is estimated to be only 10 feet per year using a gradient of 0.004 ft/ft, a hydraulic conductivity of 0.5 foot per day (Bureau of Reclamation 1987), and an effective porosity of 8 percent. In addition to the major differences in groundwater flow rates between the East Mesa and central Imperial Valley, there are also smaller groundwater flow rate variations due to variability in the gradient and hydraulic conductivity within each area.

3.3.3 Groundwater Pumpage

There is very little permanent groundwater pumping in the central Imperial Valley, the East Mesa, and the East Salton Sea area. The most significant groundwater extraction is the artesian discharge of groundwater east of the Salton Sea, which is estimated to be 2,000 acre-feet per year in the Dos Palmas area (Bureau of Reclamation 1993) and 4,000 acre-feet in the Hot Mineral Spa area (Hunter 1990s). Groundwater pumping is not a major resource in central Imperial Valley because the water is not suitable for domestic or agricultural uses. Although there is discharge and recharge of geothermal water in Imperial Valley, this occurs in much deeper aquifers that are not in hydraulic communication with the shallow regional aquifer system.

Groundwater pumping occurs at two locations in the East Mesa, the American Girl and Mesquite Mines (see Figure 3-3). Each well pumps an average of 9,000 acre-feet per year.

There is a very large amount of pumping in Mexcali, which is currently estimated to be at a rate of 750,000 acre-feet per year. However, the pumping all occurs south of the La Mesa Drain, which is the southern

boundary of this canal seepage study. Thus, pumping rates in Mexico will not be explicitly incorporated into the seepage study groundwater model.

3.4 REGIONAL GROUNDWATER CONCEPTUAL MODEL

Groundwater in the study area occurs in water-bearing formations within and adjacent to the Salton Trough, including the Chocolate Valley, East Salton Sea, Amos Valley, Ogilby Valley, Imperial Valley, and Mexicali Valley groundwater basins. The aquifer area is bordered by the Salton Sea on the northwest, the Chocolate Mountains on the northeast, the Cargo Muchacho Mountains and Pilot Knob on the southeast, and the San Jacinto fault on the west. The isometric block diagram presented in Figure 3-8 illustrates the key stratigraphic, hydrologic, and hydraulic characteristics of the aquifer conceptual model.

3.4.1 Stratigraphic Conceptual Model

Groundwater is found within a shallow unconfined alluvial aquifer that is bounded at depth by an aquitard, and a deeper semi-confined alluvial aquifer that is bounded above by the aquitard and at depth by low permeability non-marine sediments. The thickness and elevation of the aquifers varies in relation to the ground surface topography as depicted in the cross-sections presented in Section 3.2.1. Using these cross-sections, ground surface elevations from USGS DEM data, and structure data given in the Imperial County Groundwater Model (Montgomery Watson 1995), the topography of the aquifers, the aquitard, and non-marine sedimentary units was estimated, as depicted in Appendix G. The ground surface varies from roughly 1,000 feet mean sea level (MSL) in the eastern boundaries to -235 feet MSL at the Salton Sea. Elevations of the base of the deeper aquifer varies from -800 feet MSL in the center of the Salton Trough to -200 feet MSL in the northeast. Total sediment thickness averages 1,000 feet. The upper aquifer averages 250 feet in thickness, and the deeper aquifer averages 550 feet in thickness. The aquifers are separated by an aquitard that varies from 0 to 260 feet in thickness. The aquitard pinches out in the southeast of East Mesa such that only one aquifer is present in this area, and thickens towards the north and center of the basin under the Salton Sea.

3.4.2 Conceptual Model of Recharge/Discharge Features

Major sources of groundwater recharge include seepage from the unlined portions of the All American and Coachella Branch Canals, percolation in the agricultural fields and the extensive canal network in central Imperial County, mountain front recharge where streams discharge to the valley floor, and recharge during high-flow years in the Colorado River in Mexico. Major sources of groundwater discharge include drainage