SECTION 2

Description of Study Area

2.1 General

The Study Area is located on the west side of the Valley and consists of the lands lying within the boundary of the SLU of the CVP. The SLU, as defined by the authorized service area, encompasses the entirety of Westlands, Broadview, Panoche and Pacheco Water Districts and the southern portion of San Luis Water District (Figure 2-1). These areas total approximately 713,000 acres (1,114 square miles).

The Valley is divided into two hydrologic basins: the San Joaquin River basin draining northward to the Sacramento-San Joaquin Delta, and the Tulare Lake basin to the south. The Tulare Lake basin has no outlet except during extreme flood flows, when Kings River flows reach the San Joaquin River by way of the Fresno Slough. The Study Area straddles the basin divide, with most of WWD lying in the Tulare Lake basin. The northern portion of WWD and the other four districts (referred to as the Northern SLU Districts) lie in the San Joaquin River basin.

Several ephemeral streams that originate in the Coast Range flow through the Study Area, from southwest to northeast. Flows tend to spread out because of the lack of well-defined channels and seldom reach the valley trough.

2.2 Climate

Annual rainfall in the Study Area averages 6 to 8 inches, with 90 percent of this amount falling between November and April. Summer maximum temperatures frequently exceed 100°F, with winter minimums occasionally falling below freezing. The mean annual temperature is 62°F. The area has a frost-free growing season of approximately 280 days.

2.3 Land Use

Irrigated agriculture accounts for the predominant land use in the Study Area, with only minor areas used for municipal, industrial, and other developed purposes. Table 2-1 shows specific crops grown in the Study Area.

Figure 2-1. San Luis Unit
Water District Boundaries

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TABLE 2-1
Irrigated Land Use in the San Luis Unit

	Percent of Irrigated Area, Average from 1995-1999	
Major Crop Type	**Westlands**	**Northern SLU Districts**
Forage	3%	10%
Cotton	45%	48%
Grain	6%	3%
Sugar Beets	1%	1%
Other Field	1%	2%
Tomatoes	17%	12%
Truck	19%	22%
Orchard/Vineyard	7%	2%
Total	100%	100%

Source: District crop reports, various years.

2.4 Soils and Geology

The San Joaquin Valley, a broad structural trough, is filled with thousands of feet of alluvial sediments deposited by streams flowing from the Coast Range mountains to the west and the Sierra Nevada mountains to the east. Sediments occurring in the Study Area are derived primarily from the Coast Range, which is composed predominantly of marine sandstone and shales that typically contain elevated levels of selenium and other trace elements. Soils within the Study Area consist of gently sloping, coalescing alluvial fans laid down by creeks flowing from the Coast Range.

In general, the highest positioned lands have permeable, medium-textured soils, which are Reclamation Class 1 and 2. Soils become finer textured with decreasing elevation, from west to east. These finer textured soils tend to be slowly permeable with increasing accumulations of water-soluble salts.

2.5 Water Supply

Water for irrigation is supplied primarily by the CVP pursuant to Reclamation contracts with the five water districts within the Study Area. Table 2-2 summarizes these contracts. Significant changes in the operation of the CVP have occurred over the last 10 years in response to Endangered Species listings, the Central Valley Project Improvement Act, and Delta water quality requirements. As a result, CVP deliveries are expected to fall short of contract amounts in all but the wettest years. Table 2-2 shows the latest estimates of long-term average CVP delivery to agricultural contracts in the SLU, based on recent modeling analysis using current operational rules.

TABLE 2-2
CVP Water Service Contracts and Expected Delivery[a] for the Study Area

Water District	CVP Contract (acre-feet)	Expected Average CVP Delivery[b]
Broadview	27,000	13,500
Pacheco	10,150	5,075
Panoche	94,000	47,000
San Luis	125,080	62,540
Westlands	1,150,000	575,000
Total	1,406,230	703,115

[a] Does not include municipal and industrial water service contracts.

[b] Based on Reclamation's latest unpublished CALSIM II modeling analysis, November, 2001. This estimate is subject to revision.

In addition to imported CVP water, water users, especially those in WWD, augment CVP supply by pumping groundwater from private wells and by purchasing and transferring water from other areas.

2.6 Agricultural Drainage

2.6.1 Regional Groundwater Conditions

There are three main bodies of groundwater in the western Valley: (1) an unconfined and semi-confined zone of freshwater above the Concoran Clay member of the Tulare Formation, (2) a confined zone of freshwater beneath the Corcoran Clay, and (3) a saline body of water underlying the confined freshwater (Davis and Poland, 1957).

The deposits of the semi-confined zone are divided into three hydrogeologic units: the Coast Range alluvium, Sierran sands, and flood basin deposits. The texture of the Coast Range alluvium depends on the relative position on the alluvial fan and ranges from sand and gravel in the upper positions to silt and clay in the lower positions. The Sierran sands are highly permeable and have been tapped by wells as a source of irrigation water. The flood basin deposits, typically 5 to 35 feet thick, consist of fine-textured, moderately to densely compacted clays.

The Corcoran Clay is a lacustrine confining layer ranging from 20 to 120 feet thick, located from 400 to 900 feet beneath the ground surface in the Study Area. The lower confined zone consists of poorly consolidated flood plain, deltaic, alluvial, and lacustrine deposits of the Tulare Formation.

2.6.2 Development of Shallow Water Tables

When irrigation water is applied to land, most of the water is stored in the root zone and is used by the crop. Some water, however, percolates below the root zone. A certain amount of deep percolation is required to flush excess salts from the root zone, depending on applied water salinity, crop sensitivity to salts, target production levels, and other factors. Deep percolation beyond that required to flush excess salts is attributable mainly to non-uniform water application or over-irrigation, and may be undesirable where it contributes to a shallow water table condition.

Within the SLU, some lands have inadequate natural drainage. In these areas, the downward movement of deep percolation is impeded by low-permeability clay lenses, causing shallow water tables to form. In such drainage-affected areas, water tables have risen over time, so that they occur at shallower depths, and more and more lands are affected. As shallow water tables encroach into the crop root zone, typically agricultural productivity is adversely affected by inadequate soil aeration and salt accumulation.

Since the earliest irrigation development in the area dating back to the 1880s, salinization and shallow water table problems have limited irrigated agricultural production (SJVDP, 1990). By 1962, it was estimated that 50,000 acres along the eastern fringes of the SLU were subject to shallow water tables occurring at depths of 5 feet or less from the soil surface (Reclamation, 1962). Figure 2-2 shows areas subject to shallow water tables in depths of zero to 5 feet, 5 to 10 feet, and 10 to 20 feet, as defined by the SJVDP.

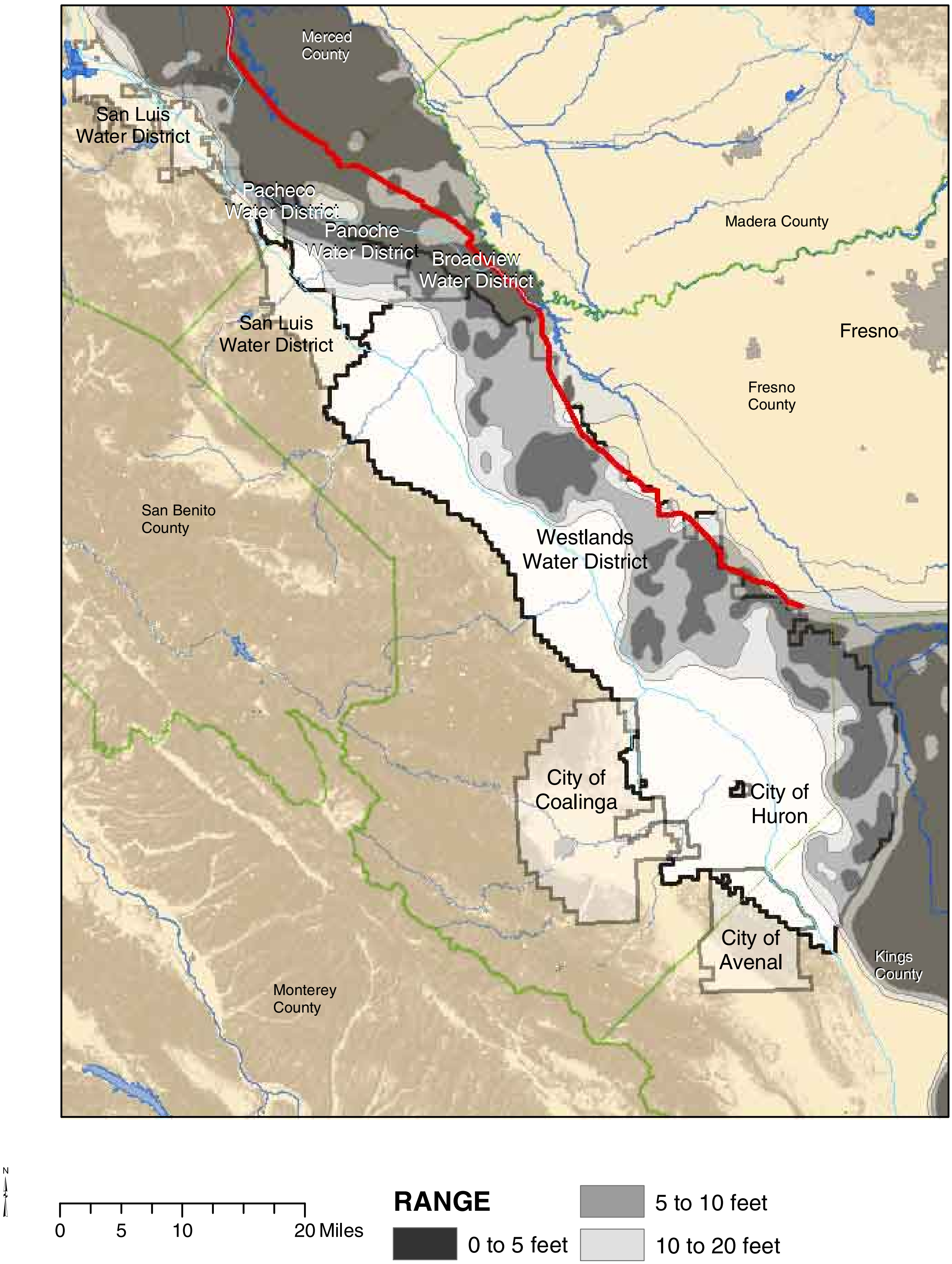
Table 2-3 shows the historical drainage-affected and non-drainage affected areas within the SLU. As of 1987, 320,000 acres, or nearly one-half of the SLU lands, had water tables within 20 feet of the ground surface.

TABLE 2-3
Irrigated Area by Depth to Water Table (1,000 acres)

Depth to Water Table	1977[a]	1982[a]	1987[a]
Westlands Water District			
< 5 feet	30	44	98
5 to 10 feet	93	116	117
10 to 20 feet	94	97	60
> 20 feet	387	347	329
Total	604	604	604
Northern SLU Districts			
< 5 feet	17.5	14.5	19.4
5 to 10 feet	13.1	16.4	18.4
10 to 20 feet	15.5	8.3	7.2
> 20 feet	33.9	40.3	34.5
Total	17.5	14.5	19.4
Combined			
< 5 feet	47.5	58.5	117.4
5 to 10 feet	106.1	132.4	135.4
10 to 20 feet	109.0	105.3	67.2
> 20 feet	420.9	387.3	363.5
Grand Totals	**683.5**	**683.5**	**683.5**

[a] SJVDP, 1990.

Figure 2-2. San Luis Unit
Shallow Groundwater Affected Areas, 1987



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2.6.3 Historical and Current Drainage Discharges

Artificial or "tile" drains have been installed on more than 35,000 acres of land in the Study Area to alleviate the effects of shallow water tables on crop production, including 5,000 acres in WWD and more than 30,000 acres in the Northern SLU Districts (Table 2-4). The drained areas are shown in Figure 2-3.

TABLE 2-4
Tile-Drained Areas and Average Annual Drainage Discharges

		Average 1986-1990		Average 1997-1998	
Water District	**Tile-Drained Area, 1990 (Acres)**	**Tilewater Discharged (Acre-Feet)**	**Total Drainwater Discharged[a] (Acre-Feet)**	**Tilewater Discharged or Recycled (Acre-Feet)**	**Total Drainwater Discharged[a] (Acre-Feet)**
Broadview	6,500	3,800	10,200	4,730	4,170
Pacheco	3,600	4,900	6,300	4,300	2,480
Panoche	22,000	12,700	28,800	13,070	18,150
San Luis	3,500	2,000	5,000	1,860	1,590
Westlands	5,000	0	0	0	0
Total	40,600	23,400	50,300	23,960	26,390

Source: Data reported from Grassland Bypass operations, and San Luis Unit Drainage Program, Plan Formulation Appendix (Reclamation, 1991).

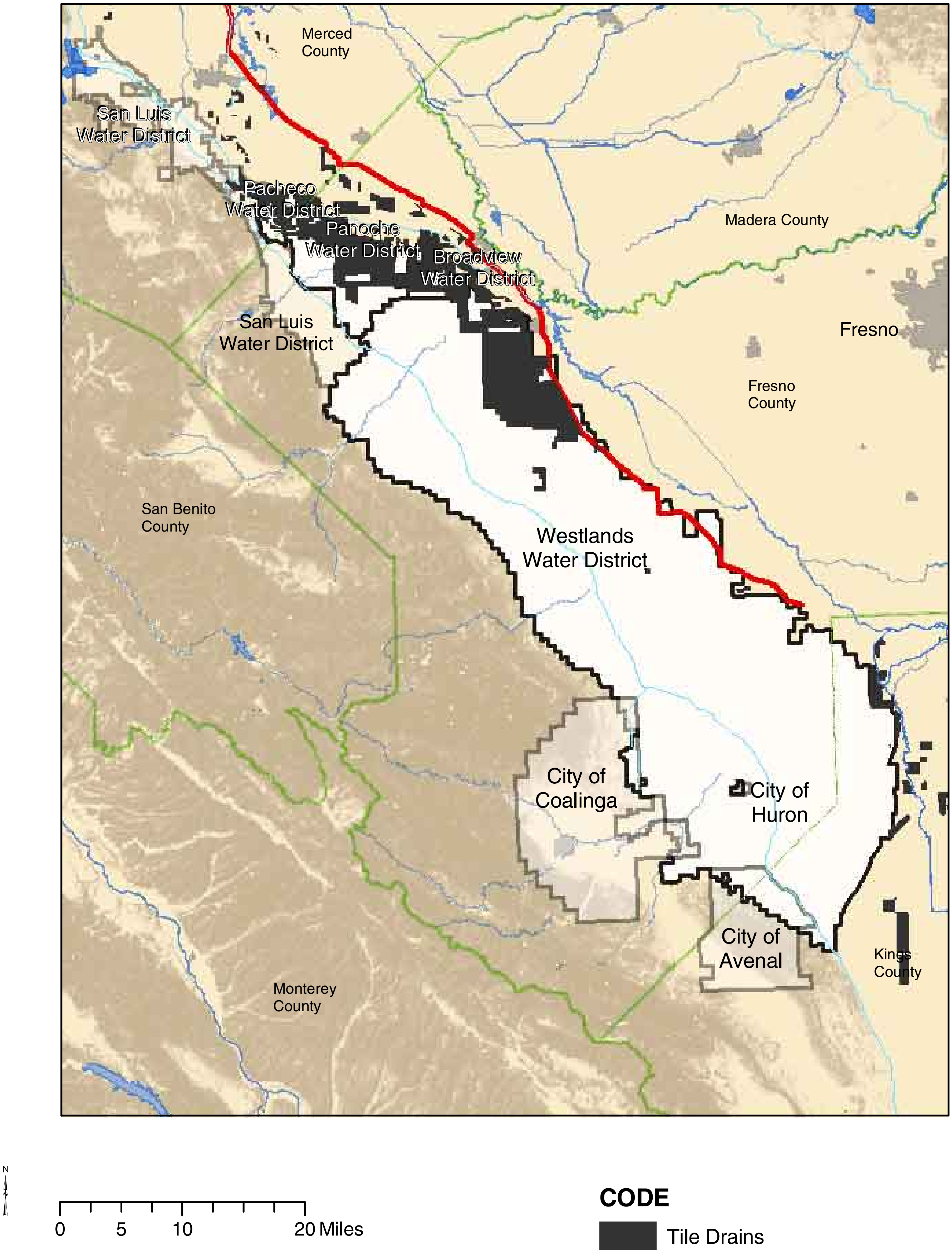
[a] Includes tilewater, tailwater and operational spills.

Some of the on-farm tile drain systems in WWD were abandoned following the discovery of adverse affects of agricultural drainwater on wildlife in Kesterson Reservoir in 1984. By 1986, the drainage collector systems in WWD were plugged. As a result, discharges from the tile systems that continue to operate are contained on-farm and within the WWD by on-farm recycling.

Management of drainwater from the Northern SLU Districts has undergone major changes over the past several years. Historically, tilewater from the Northern SLU Districts and neighboring lands was commingled with variable quantities of tailwater and other water, and discharged through the Grasslands area in various natural and man-made channels. These channels conveyed the drainwater to Mud and Salt Sloughs, and thence to the San Joaquin River. From 1986 through 1990, drainwater discharge averaged about 50,000 acre-feet, including 23,000 acre-feet of tilewater, 23,000 acre-feet of tailwater, and 4,000 acre-feet of other water, primarily canal spillage (Table 2-4).

The presence of elevated concentrations of selenium in drainwater discharged through the Grasslands area posed a problem with respect to wetlands water supply, particularly beginning in 1985, when wetlands ceased to use water with selenium concentrations in excess of 2 parts per billion (ppb). To minimize this problem, water managers used a "flip-flop" system, using the Grasslands channels to convey either drainwater or freshwater in alternating patterns. This system proved to be complicated and was only partially effective in addressing water quality concerns.

Figure 2-3. San Luis Unit
Tile Drain Areas



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The Grassland Bypass Project was conceived in 1988 to help resolve water quality and water conveyance conflicts in the Grasslands area. The main feature of the proposed project used a 28-mile segment of the existing, but then inactive, San Luis Drain, and a 6-mile reach of Mud Slough to convey drainwater to the San Joaquin River, instead of using the Grasslands channels. The project's benefits included concentration of tilewater flows in a dedicated, concrete-lined conveyance facility, reducing selenium exposure in the Grasslands area, and releasing the Grasslands channels for unconstrained water delivery to wetland and wildlife refuge areas.

Negotiations between the drainers and Reclamation regarding potential use of the SLD were initiated in 1988. By November 1995, environmental documentation was completed and the Use Agreement was signed. In March 1996, a regional drainage entity called the Grassland Area Farmers was formed under the umbrella of the San Luis and Delta-Mendota Water Authority. Participants in the regional entity included Broadview Water District, Charleston Drainage District (a sub-area within San Luis Water District), Pacheco Water District, and Panoche Drainage District (which is essentially coincident with Panoche Water District). Thus, the portion of the SLU referred to in this document as the Northern SLU Districts participates in a regional drainage management program that enables them to discharge drainwater to the San Joaquin River.

The Use Agreement contains various requirements that govern how drainwater from the defined drainage service area may be conveyed and discharged to the San Joaquin River. These requirements include monthly and annual selenium load targets and non-compliance penalties that have created incentives for the drainers to reduce and manage tilewater flows. The various actions that the Northern SLU Districts have implemented in this regard are discussed in later sections.

2.7 Drainwater Quality

The quality of tilewater varies both spatially and temporally, depending on irrigation water quality, irrigation practices, soil chemistry, drainage system configuration, and many other factors. Tilewater generally contains high concentrations of dissolved salts (Figure 2-4) and may contain significant concentrations of other substances. Substances currently considered to be of concern are listed in Table 2-5. Selenium is of most concern; it was identified in 1984 as the cause of waterfowl problems at Kesterson Reservoir. Figure 2-5 shows existing concentrations of selenium in shallow groundwater. Section 3 of this Report summarizes the drainage quality assumed for preliminary planning.

Water quality is affected by a number of processes as it is applied to the land and eventually returns to the San Joaquin River. The most important of these processes are:

- *Concentration* of salts in applied irrigation water because most crops use relatively pure water and leave salts behind
- *Dissolution* of precipitated salts and trace elements as irrigation water passes through the soil
- *Interception* of poor quality groundwater by tile drainage systems

- *Dilution* of tilewater by irrigation tailwater and canal operation spillage
- *Dilution* of drainwater by natural stream flows
- *Dilution* of drainwater by blending with available CVP surface water

TABLE 2-5
Substances of Concern in Agriculture Drainwater

Primary Concern	Probable Concern[a]	Possible Concern
Selenium	Cadmium	Uranium[b]
Boron	Chromium	Vanadium[b]
Molybdenum	Copper	Nitrates[b]
Arsenic	Manganese	Tellurium
Salts	Zinc	Antimony
		Lithium
		Germanium
		Bismuth
		Strontium
		Fluoride
		Beryllium

[a] Subject to California water quality objectives in the future.
[b] Elevated concentrations have been observed in some locations.
Source: SJVDP, 1990.

Figure 2-4. San Luis Unit
Salinity in Shallow Groundwater, about 1990

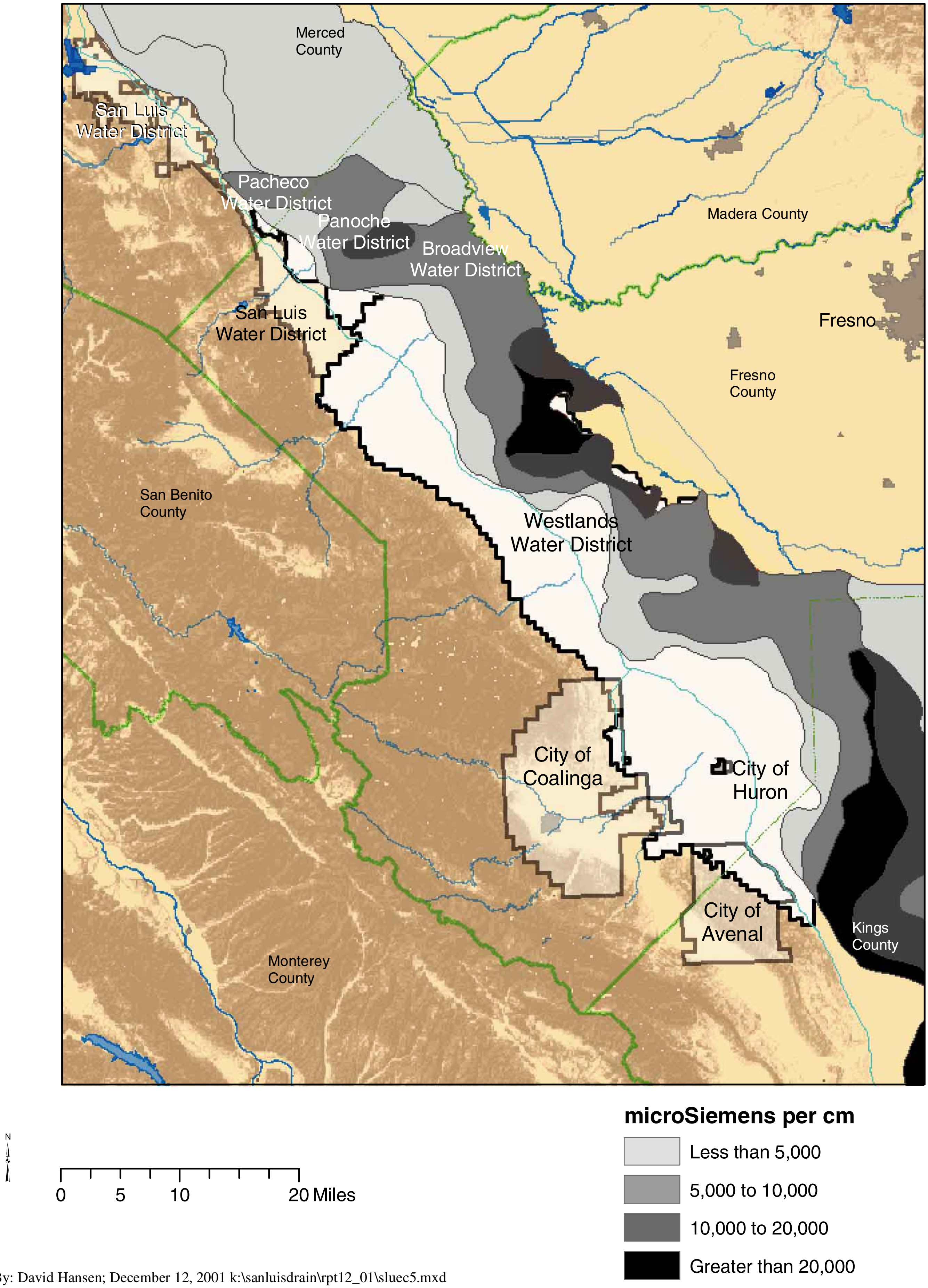

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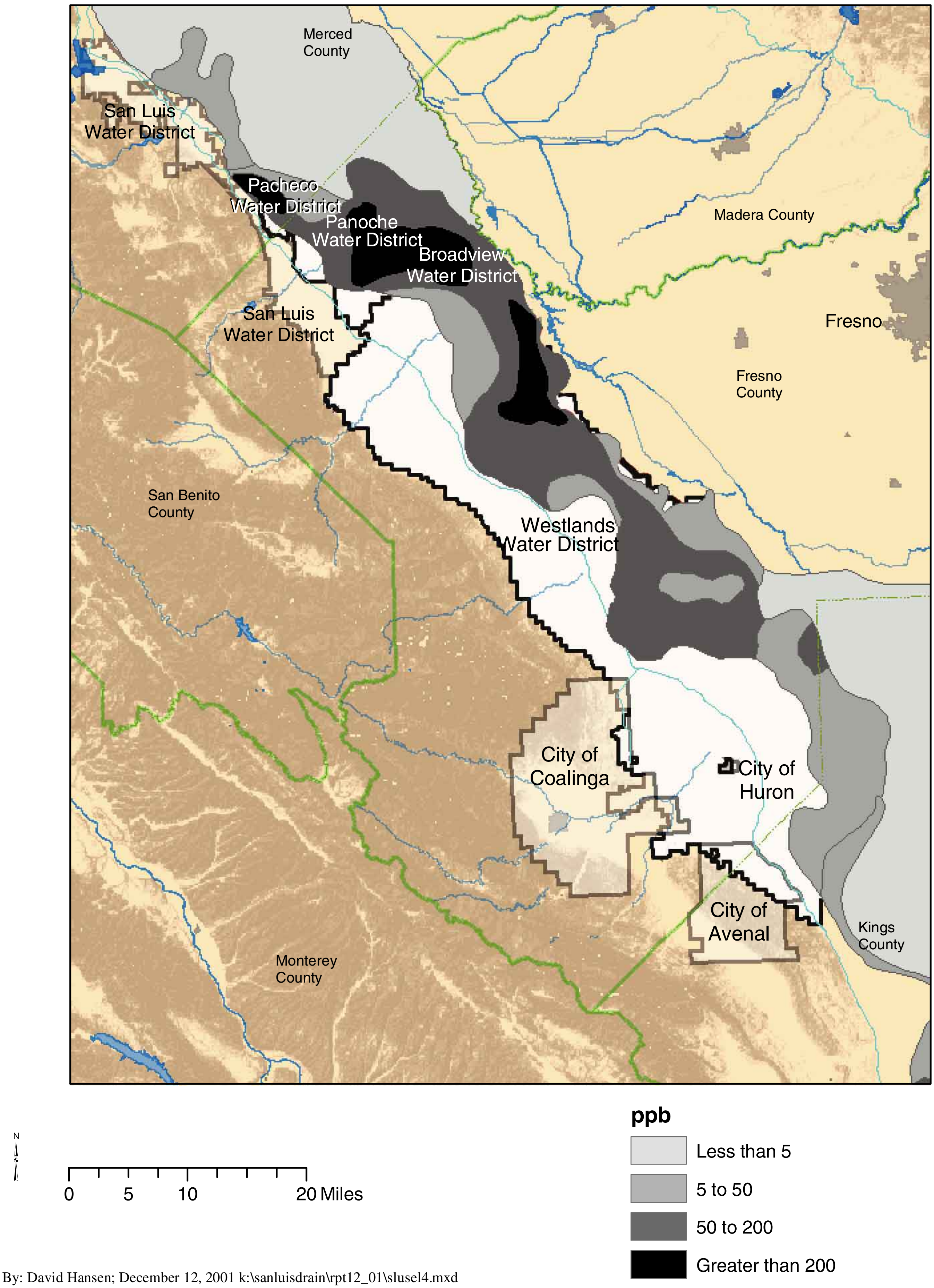
Figure 2-5. San Luis Unit
Selenium Concentrations in Shallow Groundwater, 1990



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