GROUND WATER QUALITY IN THE PATTERSON-WESTLEY AREA, STANISLAUS COUNTY, CALIFORNIA

California Regional Water Quality Control Board
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Special thanks go to the well owners in the Patterson and Westley areas, without whose cooperation this study would not have been possible.

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Summary

Water samples collected from 34 wells in the Patterson-Westley area in Stanislaus County, California were analyzed for minerals and trace elements, including selenium. Twenty-eight of these wells are used for domestic purposes. Three municipal wells, two irrigation wells, and one drainage well were also sampled.

Initial sampling in August and September 1986 showed that selenium was the only constituent which exceeded a primary drinking water standard, with selenium levels ranging from 0.8 to 17 µg/L. Water from eight domestic wells showed selenium levels which exceeded the U.S. Environmental Protection Agency (EPA) drinking water standard of 10 µg/L. Seven of these wells are completed to depths ranging from 72 to 275 feet in the upper water-bearing zone. The remaining well is of unknown depth. Verification sampling in April and May 1987 for seven of these eight wells confirmed that at least six of the wells have selenium concentrations greater than 10 µg/L. Water from the remaining resampled well showed a slight decrease from 10 to 9.2 µg/L selenium.

Four of the eight wells which have water exceeding 10 µg/L selenium are approximately midway between Ingram and Del Puerto Creeks, in the Westley area. The remaining four wells with selenium concentrations exceeding the drinking water standard are approximately midway between Del Puerto and Orestimba Creeks, in the Patterson area.

The data from this study confirms both the location and extent of the high selenium concentrations identified by a USGS study conducted in 1985. The three wells shown by the USGS to have selenium concentrations exceeding 10 µg/L were sampled in this program and shown to have similar elevated levels of selenium.

Seventeen domestic wells completed in the upper water-bearing zone and one municipal well completed in the lower water-bearing zone have TDS values at or exceeding the EPA's recommended maximum secondary drinking water criterion of 1000 mg/L.

Two of the 34 wells sampled are used for irrigation purposes. Although the water quality in these two wells is acceptable for irrigation, a few domestic wells sampled have levels of salinity, chloride, boron, and sodium which would make them unsuitable as sources of irrigation water.

The Moreno and Panoche Formations in the Coast Ranges to the west of the study area are likely sources of selenium in the Patterson-Westley ground water. Oxidation of seleniferous marine sediments from these formations may result in soluble selenium being carried to the valley floor by the intermittent streams draining the Coast Ranges, or the seleniferous Coast Range sediments may themselves be transported to the valley floor.

Irrigation water derived from the San Joaquin River is probably not a significant source of selenium in the area. Water pumped from the river to supply the West Stanislaus

Irrigation District and the Patterson Water District had between <1 and 9.3 µg/L selenium in 1986 and 1987. This river water is comingled with better quality water from the DMC before use. DMC water had selenium concentrations between <1 and 3 µg/L in 1986 and 1987.

The quality of the shallow ground water in the Patterson area is represented by data on tile drainage discharges from this area. In 1986 and 1987 these discharges had between 2 and 8 µg/L selenium. Mixing with tailwater resulted in selenium levels between 0.3 and 6.5 µg/L being discharged to the San Joaquin River. Although these concentrations are slightly lower than the concentrations of supply water taken from the river, the change in selenium load to the river depends on the relative volumes of water pumped from the river and water which is returned to the river as agricultural drainage.

Recommendations

In addition to problems associated with drinking water, elevated levels of selenium in agricultural drainage waters are also of concern. Agricultural drainage waters in the Patterson and Westley areas are eventually discharged to the San Joaquin River, where selenium may have an adverse affect on the aquatic life. A water quality objective of 5 µg/L selenium has been proposed by the State Water Resources Control Board and the Central Valley Regional Water Quality Control Board for the San Joaquin River downstream of Merced River (SWRCB,1987 and CRWQCB,1988). Aquatic life criteria for selenium promulgated by the EPA is 5 µg/L (USEPA, 1987).

Although current irrigation activities in the study area have not resulted in discharges of drainage water with selenium levels greater than those now present in the river, future practices may. The installation of new subsurface tile drains in areas with drainage problems could result in discharges of excessive levels of selenium and/or salts to the river. Before new tile systems are installed it is recommended that the quality of the shallow ground water in the drainage problem area be determined, as well as the effect of discharges from any proposed tile drains on selenium loads to the river. The impact of using any ground water which is high in selenium as a potential source of irrigation water should also be considered. In addition, if new tile drainage systems are installed their discharges should be monitored.

INTRODUCTION

Background and Purpose

From February to July 1985 the United States Geological Survey (USGS) collected water samples for selenium analyses from 63 wells in the western San Joaquin Valley, California. Three of nine wells sampled in the Patterson-Westley area showed ground water with selenium levels at or slightly above the EPA drinking water standard of 10 µg/L. Dissolved selenium concentrations ranged from 1 to 13 µg/L in these nine wells (Neil, 1986).

This study was conducted to verify the location and extent of the high selenium concentrations identified by the USGS and to identify any other constituents in the ground water which may exceed levels recommended for the current beneficial uses. The objectives of the study were to determine the sources of selenium and how it moves in the ground water system. Also considered was the quality of shallow ground water and how discharges of this water, via subsurface tile drains, into the San Joaquin River may affect river water quality.

Scope of the Investigation

To verify the USGS data on the location and extent of selenium contamination in the ground water of the Patterson-Westley area, water samples were taken from 34 wells in August and September of 1986. An effort was made to sample only those wells for which data on well depths and perforation intervals was available. A few wells with either limited or no information on depths or perforation intervals were sampled at the request of some well owners. Twenty-eight of the wells sampled were determined to be perforated in the upper water-bearing zone, five in the lower water-bearing zone, and one well is of unknown depth (well logs for 28 of the 34 wells sampled are on file at the California Department of Water Resources). Five of the wells sampled were sampled by the USGS in their 1985 study of dissolved selenium in the western San Joaquin Valley. Three of these five wells were shown by the USGS to have selenium levels at or above 10 µg/L. Data for each of the wells sampled in this study is listed in Appendix A.

In order to identify constituents in the ground water which may exceed levels recommended for the current beneficial uses, the water samples were analyzed for minerals and the trace elements copper, chromium, mercury, lead, zinc, molybdenum, and nickel, as well as total selenium.

The beneficial uses identified in the Water Quality Control Plan Report (SWRCB, 1975) for the study area were compared with the currently accepted water quality objectives for the identified beneficial uses to determine if any constituents are present in excessive concentrations.

To identify sources of selenium a literature search was conducted on the geology and hydrogeology of the study area and the quality of the irrigation supply water was looked at. The movement of selenium through the ground water system in the study area was correlated to that in the Panoche Fan area to the south, where extensive studies have been conducted on selenium and its movement through ground water. The quality of the shallow ground water was determined from Regional Water Quality Control Board (RWQCB) data on subsurface tile drainage discharges.

STUDY AREA

Area Description

The study area is in Stanislaus County between Interstate 5 on the west and the San Joaquin River on the east. It extends from just northwest of Westley to just northeast of Crows Landing (see Figure 1 for the general location map and Figure 2 for a more detailed map of the study area).

The coalescing alluvial fans of Ingram, Del Puerto, and Orestimba Creeks cover the majority of the study area, extending from the eastern boundary of the Coast Ranges along Interstate 5, to the overflow lands and flood plains bordering the San Joaquin River. Land surface gradients, as steep as 130 feet per mile along some parts of the Coast Ranges, decline gradually toward the east, becoming as low as seven feet per mile in some areas.

The Patterson-Westley area has an arid to semi-arid climate. Agriculture is the predominant land use , with field crops, truck crops and orchards most common. The area is served by the West Stanislaus Irrigation District and the Patterson, Kern Canon, and Del Puerto Water Districts. The Patterson Main Canal and the West Stanislaus Irrigation District Main Canal supply the majority of the area's irrigation water from the San Joaquin River to the Patterson and Westley areas, respectively. Water from the Delta Mendota Canal (DMC) is comingled with river water in these two main canals and then distributed through a series of northwest-southeast oriented canals to the Patterson Water District and the West Stanislaus Irrigation District. In addition to river and DMC water, these two districts both obtain some water from private irrigation wells. Irrigation tailwater is either recirculated or discharged to the San Joaquin River through one of the many drains serving the area. Tile drains serving 3500 acres in the Patterson area also discharge to the San Joaquin River through one of four main drains (Figure 2). The Kern Canon and Del Puerto Water Districts, both located upslope of Lateral Number 6, use almost soley DMC water for irrigation with minor amounts of water supplied from private wells. These water districts either recirculate their tailwater or discharge back into the DMC or nearby creeks.

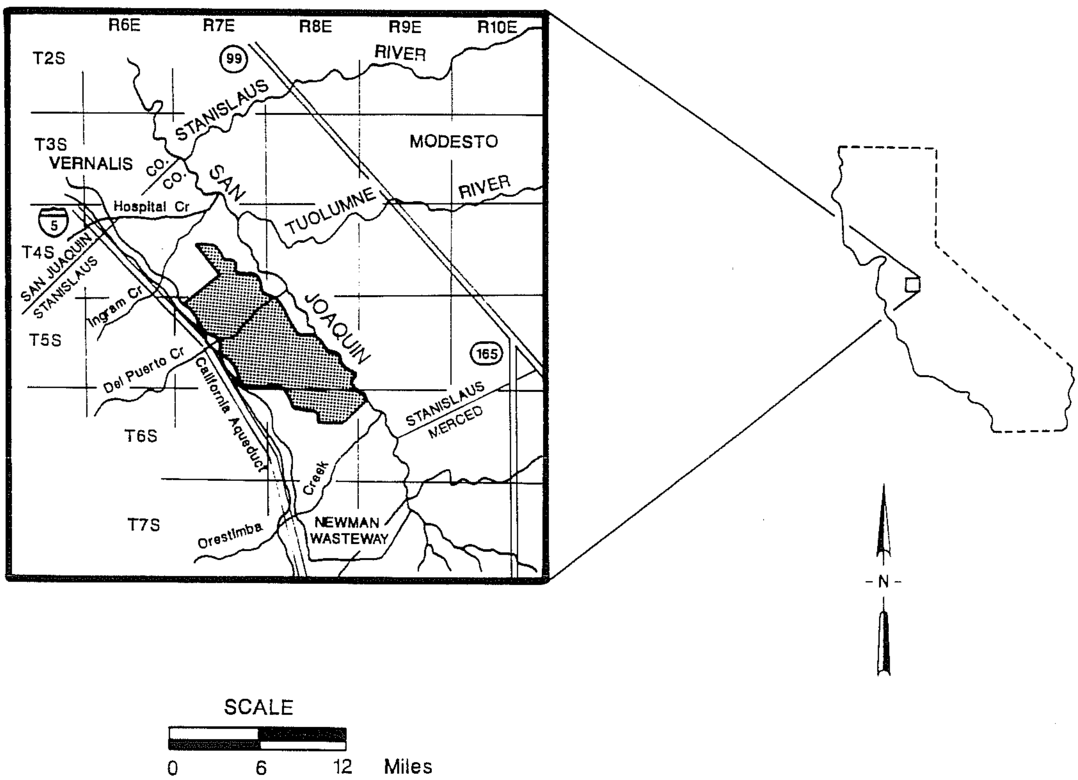
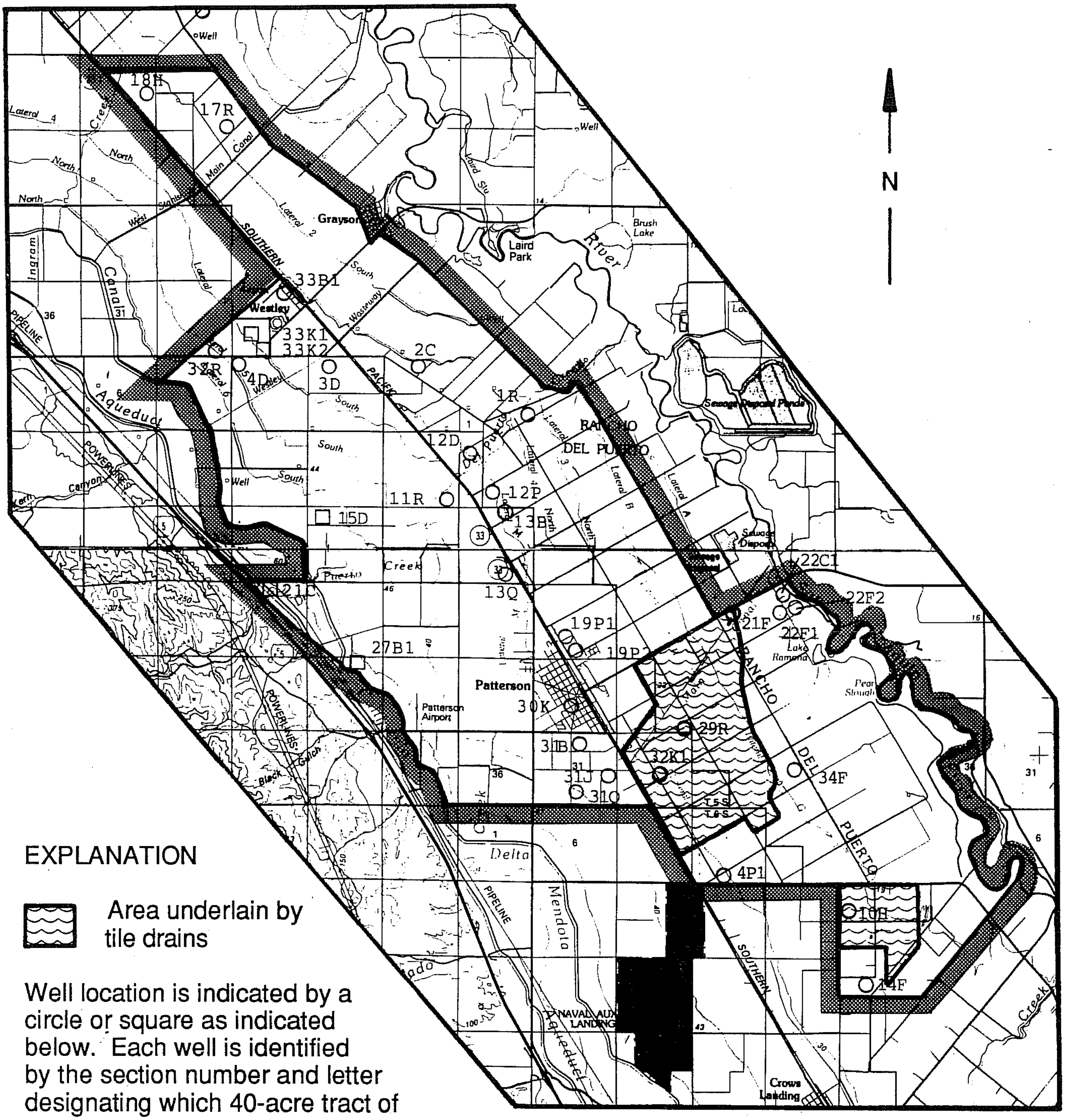


Figure 1. General Location Map



EXPLANATION

Area underlain by tile drains

Well location is indicated by a circle or square as indicated below. Each well is identified by the section number and letter designating which 40-acre tract of the section it is in.

- ○ Well completed in the upper water-bearing zone
- □ Well completed in the lower water-bearing zone

Base map from U.S. Bureau of Land Management 1:100,000 San Jose and Stockton, California 1978

SCALE

0 1 2 3 Miles

Figure 2. Study Area Map

There are six drainage basins in the Coast Ranges immediately to the west and southwest of the study area. These are, from north to south, the Ingram Creek, Kern Creek, Del Puerto Creek, Black Gulch Creek, Salado Creek, and Little Salado Creek drainage basins. All of these streams are intermittent. Del Puerto Creek is the only stream which cuts a natural channel through the study area to the San Joaquin River. Salado and Little Salado Creeks have been channeled from the east boundary of the Coast Ranges to the Olive Avenue and Spanish Grant combined drains, respectively, to take irrigation tailwater to the San Joaquin River. Ingram Creek has also been channeled to convey irrigation tailwater to the San Joaquin River. Kern and Black Gulch Creeks drain small areas, the surface flows from neither extending much farther east than Interstate 5.

Beneficial Uses of Ground Water

Beneficial uses of ground water identified in the Water Quality Control Plan Report, San Joaquin River Basin (5C), for the Patterson-Westley area include municipal and domestic supply, irrigation supply, stock watering and industrial processing uses. The 34 wells sampled in this study included 28 domestic wells, three municipal wells, two irrigation wells, and one drainage well (Appendix A).

Geology

The geologic units comprising the ground water reservoirs in the Patterson-Westley area consist of consolidated and unconsolidated deposits. The consolidated deposits have limited use as a ground water reservoir and will thus be discussed only briefly below. The Tulare Formation within the unconsolidated deposits is the most important water-bearing formation in the study area and will be discussed in the greatest detail.

Consolidated deposits

Consolidated deposits of pre-Tertiary to Tertiary sedimentary and crystalline rocks contain confined, generally saline ground water. The thickness of these deposits is unknown, but is at least 10,000 feet. The formations present in these consolidated deposits are those which are exposed in the Coast Ranges to the west.

Unconsolidated deposits

Unconsolidated deposits in the western San Joaquin Valley reach a thickness of more than 1300 feet and thin to an erosional edge at the Coast Range foothills. These deposits consist of Tertiary and Quaternary age deposits of the Tulare Formation and terrace deposits, alluvium, and flood-basin deposits of Quaternary age. The Tulare Formation underlies the entire west side of the San Joaquin Valley, lying conformably over the consolidated rocks. This formation consists of beds, lenses, and tongues of clay, sand, and gravel which are derived from Jurassic to Tertiary sediments of the Coast Ranges interbedded with micaceous and arkosic sediments of the Sierra Nevada. The Corcoran Clay, a continuous, diatomaceous clay layer 35 to 100 feet thick in the study area, forms a confining layer within the Tulare Formation, separating the formation into an upper and lower zone. The lower zone consists predominantly of reduced, Coast Range derived sediments. Both oxidized and reduced sediments of

Coast Range and Sierran origin are present in the upper zone. Oxidized sediments are usually Coast Range sediments deposited on alluvial fans.

The thickness of the Tulare Formation is difficult to determine but is as thick as 1000 feet in some areas between Tracy and Dos Palos. The lower zone is approximately three times as thick as the upper zone.

Terrace deposits lie unconformably over the Tulare Formation along the valley margin. These deposits consist of silt, sand, and gravel up to 120 feet thick which are up to several hundred feet higher than present streambeds and are exposed at the mouths of streams draining the Coast Ranges.

Alluvium composed of interbedded clay, silt, sand, and gravel up to 20 feet in thickness lies conformably over the Tulare Formation in the valley, but unconformably over the Tulare along the Coast Range foothills. Terrace deposits underlie the alluvium unconformably in some areas.

Flood-basin deposits of undetermined thickness consist of clay, silt, sand, gravel, and organic materials which appear as flat-lying meander plains on the ground surface. These deposits are reworked Coast Range and Sierran sediments which form a veneer of overbank, backwater, and channel deposits.

Hydrology

The ground water in the Patterson-Westley area occurs in two water-bearing zones: an upper water-bearing zone and a lower water-bearing zone. The upper water-bearing zone contains unconfined, semi-confined, and confined water in flood basin deposits, alluvium, terrace deposits and the upper section of the Tulare Formation. This zone extends from the water table down to the top of the confining Corcoran Clay. Water levels in the study area range from approximately 70 feet above sea level near the Coast Ranges to approximately 40 feet above sea level near the San Joaquin River (Appendix B). Local, semi-confined conditions are caused by the many discontinuous clay beds in this zone. Perched ground water may also be present in localized areas due to these clay beds. The areas shown in Figure 2 which are underlain by subsurface tile drainage systems may be such areas of perched ground water. A white clay which is continuous between Vernalis and Patterson lies beneath much of the study area. This clay is 30 to 60 feet thick and lies from 100 to 200 feet below ground surface, just above the Corcoran Clay.

The upper water-bearing zone is separated from the lower water-bearing zone by the Corcoran Clay. The top of this confining clay occurs at about 125 to 150 feet below sea level in the eastern portion of the study area near the San Joaquin River. Towards the west it dips down to as low as 180 feet below sea level before rising sharply to approximately 50 feet above sea level along its westernmost extent near the Coast Ranges, just west of Patterson. Ground water above and to the east of the western boundary of the Corcoran Clay is considered to be in the upper water-bearing zone.

The lower water-bearing zone is a confined aquifer in the lower section of the Tulare Formation beneath the Corcoran Clay. It extends from the bottom of the Corcoran Clay to the base of the fresh water. In the past, water levels in the lower zone were usually lower than in the upper zone. Head differences between the two zones varied from zero to more than 100 feet where excessive pumpage occurred in the lower zone. Data more recent than 1967 is unavailable to confirm whether these conditions currently exist.

Ground water in the upper water-bearing zone generally flows to the northeast within the study area, however two ground water mounds in the upper zone affect flow directions locally (Appendix B). One mound, located to the west of the northern part of the study area results in flows to the southeast near Westley. The other mound, located between Orestimba Creek and Patterson, results in flows to the north and northwest in that part of the study area south and southwest of Patterson. Two similar mounds were present in 1952 (Davis et al., 1959) and were probably a result of the widespread distribution of imported waters from the San Joaquin River to the area and the pumping depressions which were present in the lower water-bearing zone at that time. Such pumping depressions in the lower zone may have caused the lowering of the water table on the west flank of the mound. Decreased pumping from the lower zone in the western part of the valley as a result of the availability of imported water from the DMC in 1951 and the continued application of imported water for irrigation has probably caused the mounds to change to their present levels and positions. Both mounds currently show a higher elevation than in 1952 and the mound between Orestimba Creek and Patterson has shifted to the west. As suggested by Davis and others for the 1952 water table level, these two mounds may actually be connected into one long ridge, but due to lack of control it may not be possible to determine this with any certainty.

In the lower water-bearing zone ground water flows to the east or northeast. Recent water level measurements for the lower water-bearing zone in this area are not available. Late 1967 measurements indicated mounding to the northwest of the study area. This resulted in localized flow in the lower zone to the southeast in the northwest portion of the study area. The present extent of this mound is not known.

RESULTS AND DISCUSSION

Water Quality

All water samples were analyzed for minerals and trace elements, including total selenium. The mineral quality of the ground water has been classified based on the predominant cations and anions. Sampling procedures followed are described in Appendix G.

Upper water-bearing zone

Minerals

Water in 17 of the 29 wells perforated in the upper water-bearing zone is of mixed type (the one well of unknown depth has been included with the 28 wells perforated in the upper zone because the mineral quality of the water is more typical of the upper zone). Seven wells have sulfate dominant waters, with magnesium, calcium and/or sodium the important cations. Chloride waters are present in three of the wells, with sodium and magnesium both being important cations in these waters. Two wells have water of magnesium bicarbonate type. Water quality analyses and chemical composition of ground water from the upper zone are given in Appendices C and D, respectively.

Total dissolved solids (TDS) for the 17 waters of mixed type range from 610 to 1500 mg/L, with a median of 1000 mg/L. The seven sulfate waters have TDS values ranging from 1100 to 3000 mg/L, with a median of 1860 mg/L. The three chloride waters range from 970 to 1340 mg/L TDS, with a median of 1100 mg/L. The two magnesium bicarbonate waters have 530 and 680 mg/L TDS.

Eighteen of the 29 wells perforated in the upper water-bearing zone have TDS levels at or above the EPA recommended maximum secondary drinking water criterion of 1000 mg/L. Seventeen of these wells are used for domestic purposes.

In addition to drinking water standards, guidelines have also been established for the interpretation of water quality for irrigation (Ayers and Westcot, 1985). Although the upper limits of salinity, chloride, boron, and sodium are exceeded in a few of the wells in this study, all of these wells are used for domestic purposes only. The one irrigation well perforated in the upper zone has water of acceptable quality for irrigation purposes, according to the established guidelines.

Trace elements and selenium

Selenium is the only measured trace element which exceeds any of the EPA primary drinking water objectives. Selenium levels ranged from 0.8 to 17 µg/L in the upper water-bearing zone (Table 1). Water from eight of the 29 wells completed in the upper zone had selenium concentrations exceeding 10 µg/L in August and September 1986. All eight of these wells are used for domestic purposes. Verification sampling was conducted in seven of these wells in April and May 1987 to confirm that selenium levels were actually above the EPA drinking water standard. It was confirmed that all but one of these seven wells have water with greater than 10 µg/L selenium. One well showed a slight decrease from 10 to 9.2 µg/L selenium.

The four wells completed in the upper water-bearing zone which were sampled by the USGS in 1985 showed similar selenium concentrations in this study. Wells 4S/7E-33B1, 5S/8E-22C1, 5S/8E-32K1, and 6S/8E-4P1 showed selenium concentrations of 10, 13, 11, and 4 µg/L, respectively, in 1985. Results from this study showed these same wells to have selenium concentrations of 11, 17, 12, and 4.4 µg/L, respectively, in 1986.

Lower water-bearing zone

Minerals

Water from two of the five wells perforated in the lower water-bearing zone are of magnesium bicarbonate type. A magnesium sodium chloride water occurs in one well and water of mixed type occurs in the remaining two wells (Appendices C and D). TDS values for the two waters of mixed type are 730 and 930 mg/L. The two waters of magnesium bicarbonate type have 460 and 580 mg/L TDS. The chloride water has a TDS of 1500 mg/L. Well number 4S/7E-33K2, a municipal well, is the only well completed in the lower zone which has a TDS value exceeding the EPA recommended maximum secondary drinking water criterion of 1000 mg/L.

Water from only one well (4S/7E-33K2) perforated in the lower zone has a constituent which exceeds the guidelines for irrigation water quality. This well is a municipal well with a chloride concentration high enough to be toxic to some plants if used for irrigation. The only irrigation well in this study which is perforated in the lower zone has water of acceptable quality for irrigation purposes.

Trace elements and selenium

None of the trace elements, including selenium are present in concentrations which exceed EPA drinking water standards. Selenium levels in the lower water-bearing zone ranged from 0.9 to 6.8 µg/L in August and September 1986 (Table 1). Well 5S/7E-27B1, sampled by the USGS in 1985, showed a selenium concentration of 5 µg/l at that time. This study showed this same well to have a concentration of 4.0 µg/L in 1986.

Table 1. Summary of Selenium Levels

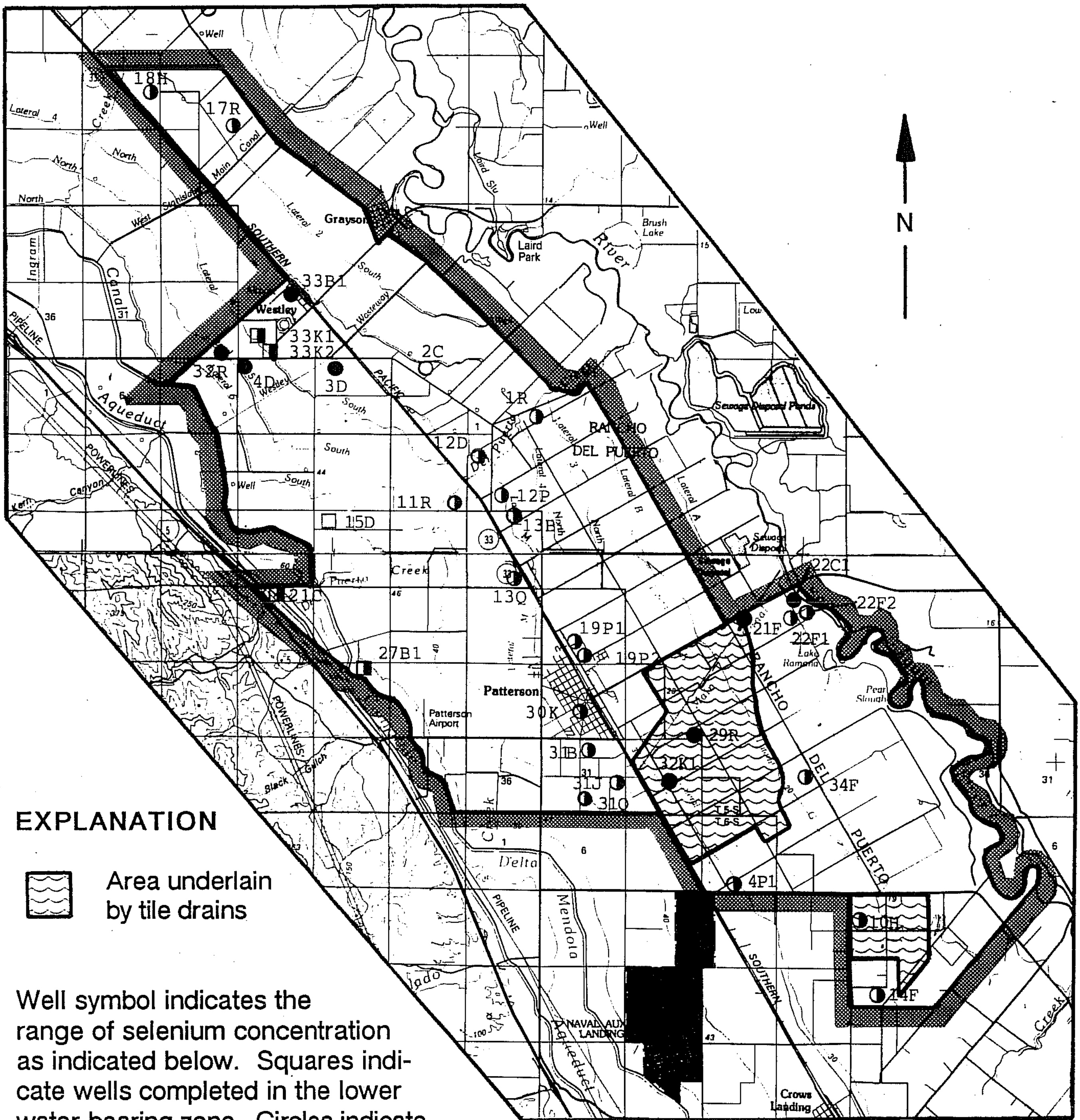
Water-bearing Zone	Number of Wells	Total Selenium (µg/L)* Minimum	Median	Maximum
Upper	29	0.8	6.5	17
Lower	5	0.9	3.8	6.8

* All selenium concentrations are from the August and September 1986 analyses, except for well 5S/8E-22F2, which was sampled in May 1987.

Occurrence of Selenium

Of the eight wells with selenium concentrations exceeding 10 µg/L, four are approximately midway between Ingram and Del Puerto Creeks in the Westley area (Figure 3). Three of these four wells range in depth from 75 to 140 feet. One well is of unknown depth. Water in all four of these wells is of mixed type with magnesium and/or sodium the predominant cation(s) and bicarbonate, sulfate, and/or chloride the predominant anions (Appendices E and F). Selenium levels ranged from 11 to 17 µg/L in August and September 1986.

The other four wells in which the water exceeds 10 µg/L selenium are approximately midway between Del Puerto and Orestimba Creeks, in the Patterson area (Figure 3). These wells range between 72 and 275 feet in depth and all have sulfate waters in which sodium and magnesium together make up 50 percent or more of the total cations (Appendices E and F). Selenium levels here ranged from 11 to 17µg/L in August and September 1986.



EXPLANATION

Area underlain by tile drains

Well symbol indicates the range of selenium concentration as indicated below. Squares indicate wells completed in the lower water-bearing zone. Circles indicate wells completed in the upper water-bearing zone.

<1 μg/L

1-10 μg/L

>10 μg/L

Base map from U.S. Bureau of Land Management 1:100,000 San Jose and Stockton, California 1978

SCALE

0 1 2 3 Miles

Figure 3. Occurrence of Selenium

SOURCES AND TRANSPORT OF SELENIUM

Selenium commonly coexists with sulfur in sulfur-bearing minerals such as pyrite and gypsum. Both pyrite and gypsum are common minerals in the marine sediments of the Coast Ranges. The Coast Ranges, being the source rock of soils making up the alluvial fans of the western San Joaquin Valley, are thus a source of selenium in the valley alluvium. The upper and lower water-bearing zones in the study area are also composed of Coast Range deposits interbedded with Sierra Nevada deposits.

In the Panoche Fan area to the south of this study area it has been determined that the three most important geologic sources of selenium in the Coast Ranges are, in decreasing order of importance, the Kreyenhagen Shale, the Moreno Formation and the Panoche Formation (UC Salinity/Drainage Task Force, 1987). One proposed mechanism for the transport of selenium from these formations to valley alluvium is that oxidation of the seleniferous Coast Range rocks results in soluble selenium being carried to the valley floor by the intermittent streams which drain the Coast Ranges. Another mechanism may be the transport of the seleniferous sediments themselves to the valley floor.

The Moreno and Panoche Formations are present in the drainage basins to the west of the Patterson-Westley study area. Both of these formations are likely sources of selenium in this area, as they are in the Panoche Fan area. In fact, between January 1986 and December 1987 the Central Valley Regional Water Quality Control Board has detected selenium levels ranging from 8.3 to 94 µg/L in water from Black Gulch Creek. Black Gulch Creek is a small drainage basin which lies to the west of the city of Patterson and is underlain predominantly by the Moreno Formation. Ingram Creek, Kern Creek, Del Puerto Creek, and Salado Creek had selenium levels ranging from 0 to 18, 2.7 to 7.5, 0.2 to 1.2, and 2 to 5 µg/L, respectively. These four drainage basins are underlain by the Moreno and Panoche Formations, as well as other formations of the Coast Ranges. The same mechanisms which transport selenium from the Coast Ranges rocks in the Panoche Fan area to the valley alluvium also probably operate in the Patterson-Westley areas.

Water used for irrigation is also a potential source of selenium. California Department of Water Resources monthly data for the DMC near the Clifton Court Forebay shows that selenium levels for this source were between <1 and 3 µg/L from January 1986 to June 1987 (CDWR,1987). The RWQCB has conducted monthly, or twice monthly, water quality sampling at three sites along the San Joaquin River between Crows Landing and Laird Slough for the past three years. The water quality at these three locations is representative of the irrigation supply water used in the West Stanislaus Irrigation District and the Patterson Water District. The RWQCB data shows that between January 1986 and June 1987, selenium levels ranged between <1 and 9.3 µg/L at these river sites (James et al., 1988).

Shallow Ground Water Quality

In the Panoche Fan area agricultural practices have resulted in a shallow water table. Evaporation of this shallow ground water has resulted in a saline, selenium-enriched ground water. The application of less saline irrigation water and the use of subsurface tile drains has resulted in the displacement of this saline, selenium-enriched water toward the tile drains and subsequent discharge to surface waters. Studies have shown that recently installed tile systems tend to leach increasing amounts of constituents from soils, but within six to eight years leaching rates tend to level off and stabilize (CDWR, 1988).

The quality of the shallow ground water in the Patterson area is represented by RWQCB data on tile drainage discharges from this area. The data indicates that selenium concentrations ranged between 2.0 and 8.0 µg/L in 1986 and 1987 (Chilcott et al., 1988). Since these tile drains were installed between 1949 and 1970 the selenium levels from these drains have most likely stabilized already and should not vary much in the future. In addition, drainage from these tile drains is mixed with tail-water of somewhat better quality before discharge to the San Joaquin River. Two main discharge points which carry tile drainage and tailwater from the Patterson area showed between 0.3 and 6.5 µg/L selenium in 1986 and 1987. Although these levels are slightly lower than levels in the water which is pumped from the San Joaquin River to supply the West Stanislaus Irrigation District and the Patterson Water District, the change in selenium load to the river also depends on the relative volumes of water which is pumped from the river and that which is returned to the river as agricultural drainage.

Potential Problems

Discharges of agricultural drainage water with elevated levels of selenium to the San Joaquin River may have an adverse affect on the aquatic life. Although the current irrigation activities in the Patterson-Westley area have not resulted in the discharge of agricultural drainage water with selenium levels any greater than those now present in the San Joaquin River, there is a potential that they may in the future. For instance, excessive irrigation may result in a water table rise in some areas, making the installation of subsurface tile drains necessary. Potential drainage problem areas, where the ground water is within five to 20 feet of the ground surface, have already been identified in both the Patterson and Westley areas (CDWR, 1988). If ground water containing high levels of selenium is used for irrigation in these areas, or if the shallow ground water itself is high in selenium it may result in excessive levels of selenium and/or salts being discharged from proposed tiled areas to the San Joaquin River.

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APPENDIX A

Well Data

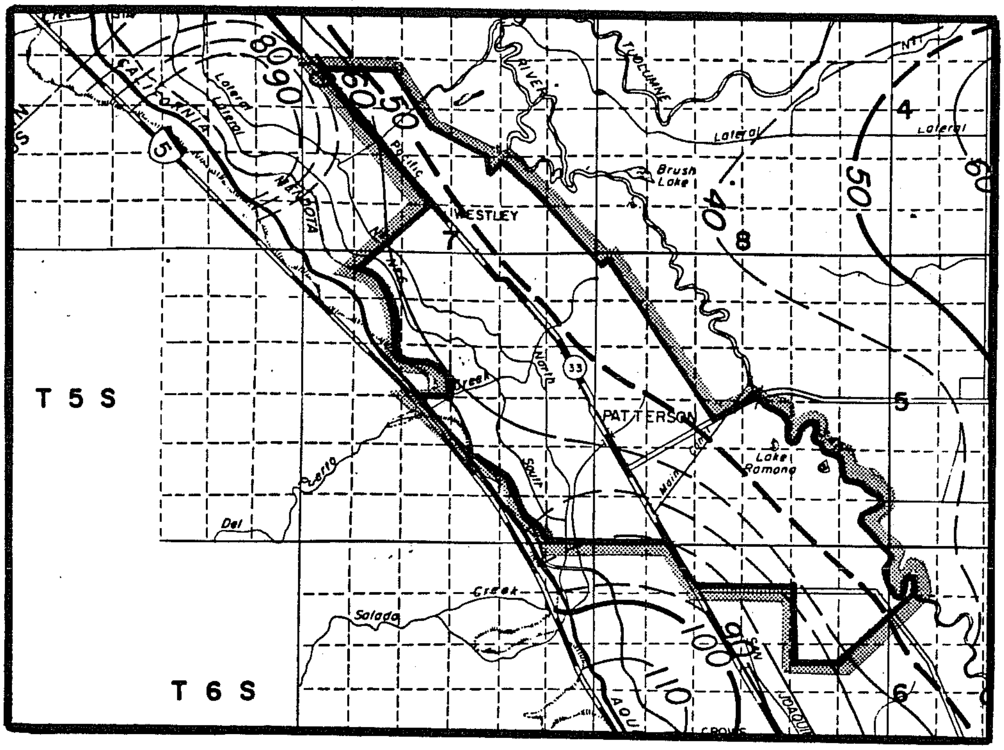
WELL NUMBER	WATER-BEARING ZONE*	WELL USE**	WELL LOG	SAMPLED BY USGS
4S 7E 17R	U	D	No	No
4S 7E 18H	U	D	Yes	No
4S 7E 32R	?	D	No	No
4S 7E 33B1	U	D	Yes	Yes
4S 7E 33K1	L	M	Yes	No
4S 7E 33K2	L	M	Yes	No
5S 7E 1R	U	I	Yes	No
5S 7E 2C	U	D	Yes	No
5S 7E 3D	U	D	Yes	No
5S 7E 4D	U	D	Yes	No
5S 7E 11R	U	D	No	No
5S 7E 12D	U	D	Yes	No
5S 7E 12P	U	D	Yes	No
5S 7E 13B	U	D	Yes	No
5S 7E 13Q	U	D	Yes	No
5S 7E 15D	L	D	Yes	No
5S 7E 21C	L	I	No	No
5S 7E 27B1	L	D	Yes	Yes
5S 8E 19P1	U	D	Yes	No
5S 8E 19P2	U	D	No	No
5S 8E 21F	U	D	Yes	No
5S 8E 22C1	U	D	Yes	Yes
5S 8E 22F1	U	D	Yes	No
5S 8E 22F2	U	D	No	No
5S 8E 29R	U	D	Yes	No
5S 8E 30K	U	M	Yes	No
5S 8E 31B	U	D	Yes	No
5S 8E 31J	U	D	Yes	No
5S 8E 31Q	U	D	Yes	No
5S 8E 32K1	U	D	Yes	Yes
5S 8E 34F	U	D	Yes	No
6S 8E 4P1	U	D	Yes	Yes
6S 8E 10H	U	R	Yes	No
6S 8E 14F	U	D	Yes	No

* Water-bearing Zone
U = Upper water-bearing zone
L = Lower water-bearing zone

** Well Use
D = Domestic
M = Municipal
I = Irrigation
R = Drain

APPENDIX B

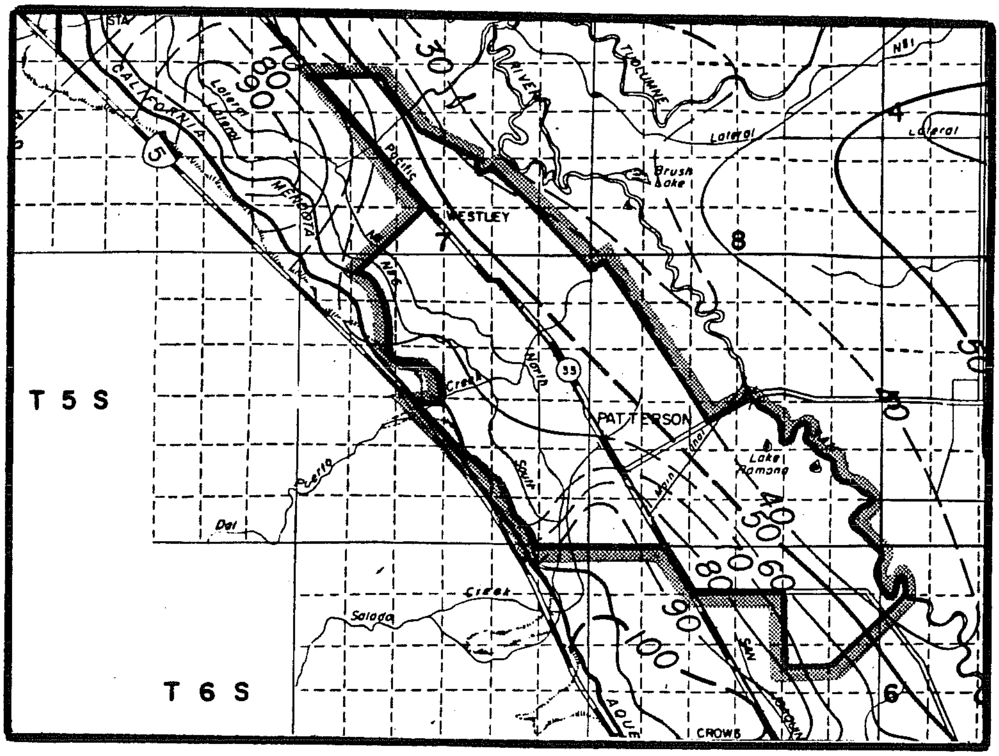
Ground Water Elevation Contours for the Upper Water-bearing Zone in the Patterson-Westley Area, 1986



SPRING 1986

N

FALL 1986



EXPLANATION

250

Lines of equal elevation of water in the upper water-bearing zone, contours dashed where inferred, contour interval 10 feet.

APPENDIX C

Ground Water Quality in the Upper and Lower Water-bearing Zones

Upper Water-bearing Zone

WELL NUMBER	SAMPLE DATE	EC umhos cm	TDS mg/L	pH	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO4 mg/L	Carb Alk mg/L	Bicar Alk mg/L	Total Alk mg/L	Total Hard-ness mg/L	B mg/L	Cu ug/L	Cr ug/L	Hg ug/L	Pb ug/L	Zn ug/L	Mo ug/L	Ni ug/L	Se ug/L
4S 7E 17R	28 AUG 86	1800	1100	8.0	85	64	150	1.4	320	220	0	170	170	540	1.9	<1	44	<0.5	<5	14	<5	<5	4.2
4S 7E 18H	3 SEP 86	2200		7.8	110	75	170	1.7	360	270			220	680	2.0	<1	18	<0.5	1	39	<5	<5	1.0
4S 7E 32R**	10 SEP 86	2200	1500	7.8	100	110	190	3.4	190	540			630	630	1.3	1	19	<0.5	<5	220	<5	<5	14
	17 APR 87																						15
4S 7E 33B1	27 AUG 86	2400	1500	7.9	90	120	160	1.7	310	340	0	230	230	750	0.83	3	22	<0.5	<5	2	<5	<5	11
	15 MAY 87																						10
5S 7E 1R	4 SEP 86	1800	1000	7.8	23	120	97	2.4	260	190			300	620	0.50	<1	25	<0.5	<5	33	<5	<5	6.6
5S 7E 2C	28 AUG 86	1700	940	8.1	41	120	110	2.7	220	130	0	310	310	600	0.40	2	16	<0.5	<5	35	<5	<5	0.8
5S 7E 3D	10 SEP 86	1600	1000	7.8	68	120	90	3.1	230	280			590	590	0.49	<1	13	<0.5	<5	70	<5	<5	17
	17 APR 87																						17
5S 7E 4D	10 SEP 86	2000	1200	7.8	83	120	170	3.3	220	450			620	620	1.5	<1	7	<0.5	<5	17	<5	<5	12
	10 SEP 86*	2000	1300	7.8	82	120	170	3.3	230	470			600	600	1.5	<1	7	<0.5	<5	19	<5	<5	12
	17 APR 87																						12
5S 7E 11R	27 AUG 86	1000	530	8.0	25	72	72	1.9	94	100	0	260	260	370	0.74	3	8	<0.5	<5	23	<5	<5	2.3
5S 7E 12D	10 SEP 86	1100	680	8.1	11	97	66	2.5	100	120			380	380	0.60	3	2	<0.5	<5	36	<5	<5	1.5
5S 7E 12P	24 SEP 86	1800	1000	8.0	53	100	110	2.6	200	180	0	310	310	580	0.61	11	20	<0.5	<5	26	<5	<5	2.6
5S 7E 13B	27 AUG 86	1600	970	8.2	53	75	160	2.4	250	170	0	190	190	440	0.52	7	18	<0.5	9	57	<5	<5	4.7
5S 7E 13Q	4 SEP 86	1600	1000	8.0	68	85	67	4.4	200	200			250	500	0.31	<1	20	<0.5	<5	17	<5	<5	2.2
5S 8E 19P1	27 AUG 86	1500	1000	8.1	60	66	130	1.3	160	280	0	220	220	460	0.61	<1	27	<0.5	<5	12	<5	<5	5.2
5S 8E 19P2	28 AUG 86	2100	1400	7.8	86	100	170	1.7	230	420	0	270	270	710	0.65	1	41	<0.5	<5	20	<5	<5	8.7
5S 8E 21F	3 SEP 86	2600		8.0	110	130	240	3.3	250	690			320	920	1.4	47	1	<0.5	4	53	7	<5	14
	17 APR 87																						17
	17 APR 87*																						17
5S 8E 22C1	27 AUG 86	3400	2300	8.0	160	140	280	3.9	260	1200	0	280	0	1000	2.1	<1	<1	<0.5	<5	70	8	<5	17
	15 MAY 87																						16
5S 8E 22F1	28 AUG 86	2000	1300	8.0	51	64	250	2.4	220	340	0	340	340	480	1.1	2	2	<0.5	<5	8	10	<5	7.5
5S 8E 22F2	15 MAY 87	3350	2432	7.8	170	120	330	5.7	280	1250	0	310	310	920	2.4	<1	<1		<5	9	8	<5	9.1
	15 MAY 87*	3350	2308	7.8	170	120	330	5.9	270	1250	0	310	310	920	2.4	<1	<1		<5	11	7	<5	
5S 8E 29R	27 AUG 86	2300	1600	7.8	120	84	230	1.0	240	560	0	220	220	700	1.1	1	24	<0.5	<5	58	<5	<5	11
	15 MAY 87																						9.2
	15 MAY 87*																						9.4

APPENDIX C

Ground Water Quality in the Upper and Lower Water-bearing Zones

Upper Water-bearing Zone

WELL NUMBER	SAMPLE DATE	EC umhos cm	TDS mg/L	pH	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO4 mg/L	Carb Alk mg/L	Bicar Alk mg/L	Total Alk mg/L	Total Hard-ness mg/L	B mg/L	Cu ug/L	Cr ug/L	Hg ug/L	Pb ug/L	Zn ug/L	Mo ug/L	Ni ug/L	Se ug/L
5S 8E 30K	3 SEP 86	1400		8.0	64	58	120	1.5	140	270			150	400	0.53	2	22	<0.5	11	3	<5	<5	6.0
5S 8E 31B	28 AUG 86	1400	860	8.0	75	51	140	1.2	160	230	0	160	160	380	0.62	1	21	<0.5	<5	90	<5	<5	6.5
5S 8E 31J	24 SEP 86	1300	820	7.7	84	39	140	0.8	130	160	0	290	290	340	0.81	2	13	<0.5	<5	90	<5	<5	1.5
5S 8E 31Q	28 AUG 86	1600	1000	7.8	53	58	140	0.9	170	210	0	280	280	480	0.68	100	17	0.8	7	9	<5	<5	3.8
5S 8E 32K1	28 AUG 86	1500	1100	7.7	80	60	150	1.5	64	450	0	160	160	480	0.64	7	28	<0.5	<5	16	<5	<5	12
	28 AUG 86*	1500	1100	8.0	86	61	150	1.5	60	470	0	170	170	470	0.63	7	28	<0.5	<5	15	<5	<5	13
5S 8E 34F	27 AUG 86	3900	3000	7.5	300	160	330	3.0	520	1100	0	300	300	1500	2.0	1	<1	<0.5	<5	13	<5	<5	8.5
6S 8E 4P1	24 SEP 86	2000	1400	7.8	110	64	190	1.0	120	480	0	280	280	530	0.43	4	14	<0.5	<5	7	<5	<5	4.4
6S 8E 10H	28 AUG 86	870	620	8.0	56	35	64	1.9	37	210	0	190	190	300	0.32	<1	1	<0.5	<5	17	<5	<5	3.2
	28 AUG 86*	880	610	8.3	55	34	63	1.9	34	200	0	170	170	300	0.30	<1	1	<0.5	<5	16	<5	<5	3.4
6S 8E 14F	4 SEP 86	1300	770	8.0	53	48	94	2.2	93	260			180	360	0.64	<1	7	<0.5	<5	18	7	<5	9.5

* A duplicate of the above sample

** Depth of this well is unknown

BLANKS INDICATE THAT THE LAB DID NOT ANALYZE FOR THE CONSTITUENT

CONSTITUENTS:

EC = electrical conductivity
TDS = total dissolved solids
Ca = calcium
Mg = magnesium
Na = sodium
K = potassium
Cl = chloride
SO4 = sulfate
Carb alk = carbonate alkalinity
Bicar = bicarbonate alkalinity
Total alk = total alkalinity
B = boron
Cu = copper
Cr = chromium
Hg = mercury
Pb = lead
Zn = zinc
Mo = molybdenum
Ni = nickel
Se = selenium

APPENDIX C

Ground Water Quality in the Upper and Lower Water-bearing Zones

Lower Water-bearing Zone

WELL NUMBER	SAMPLE DATE	EC umhos/cm	TDS mg/L	pH	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO4 mg/L	Carb Alk mg/L	Bicarb Alk mg/L	Total Alk mg/L	Total Hard-ness mg/L	B mg/L	Cu ug/L	Cr ug/L	Hg ug/L	Pb ug/L	Zn mg/L	Mo ug/L	Ni ug/L	Se ug/L
4S 7E 33K1	27 AUG 86	1600	990	8.0	56	89	130	2.4	280	310	0	120	120	500	0.53	<1	3	<0.5	<5	4	<5	<5	6.7
	27 AUG 86*	1600	990	8.0	58	89	130	2.4	260	260	0	130	130	500	0.47	<1	3	<0.5	<5	5	<5	<5	6.9
4S 7E 33K2	27 AUG 86	2400	1500	7.9	78	120	210	3.0	430	330	0	140	140	670	0.62	1	2	<0.5	<5	4	<5	<5	6.5
5S 7E 15D	28 AUG 86	820	460	8.1	28	50	63	1.7	65	69	0	230	230	280	0.67	1	8	<0.5	<5	49	<5	<5	0.9
5S 7E 21C	28 AUG 86	1000	580	8.0	36	70	69	2.0	45	150	0	300	300	380	0.81	<1	6	<0.5	<5	4	<5	<5	1.4
5S 7E 27B1	3 SEP 86	1300		8.1	39	45	170	2.6	120	150			220	250	1.1	2	16	<0.5	1	80	<5	<5	3.8
	3 SEP 86*	1300		8.1	39	45	170	2.6	120	150			220	250	1.2	32	16	<0.5	1	100	<5	<5	4.1

*A duplicate of the above sample

BLANKS INDICATE THAT THE LAB DID NOT ANALYZE FOR THE CONSTITUENT

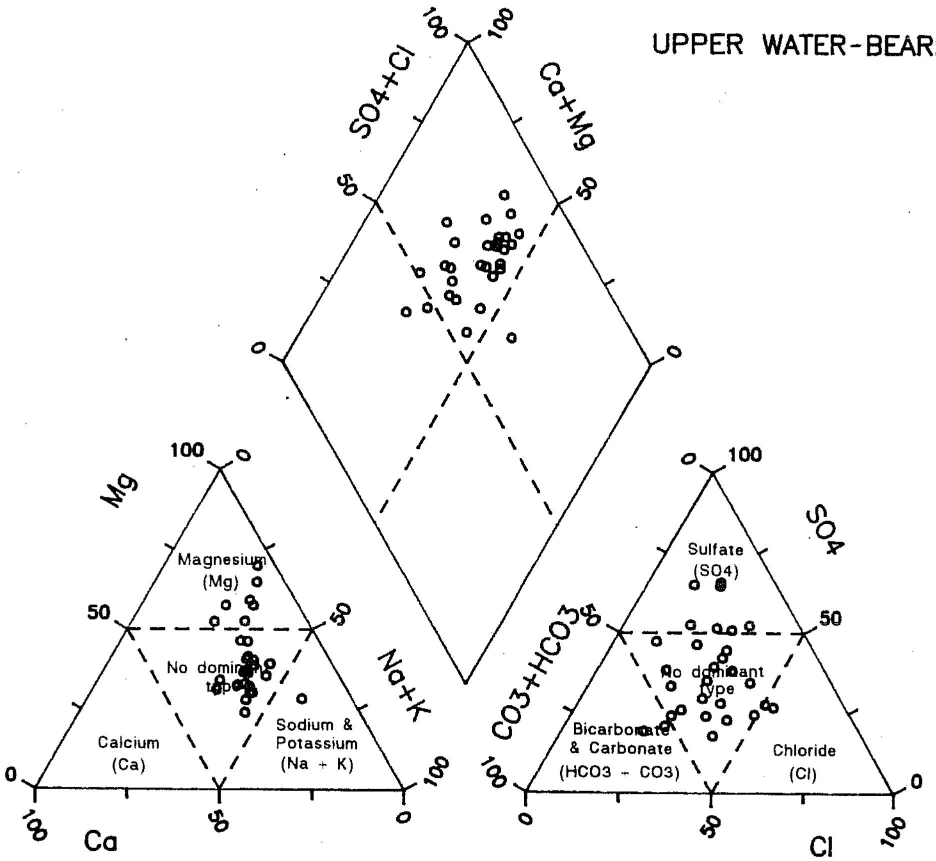
CONSTITUENTS

EC = electrical conductivity
TDS = total dissolved solids
Ca = calcium
Mg = magnesium
Na = sodium
K = potassium
Cl = chloride
SO4 = sulfate
Carb alk = carbonate alkalinity
Bicarb = bicarbonate alkalinity
Total alk = total alkalinity
B = boron
Cu = copper
Cr = chromium
Hg = mercury
Pb = lead
Zn = zinc
Mo = molybdenum
Ni = nickel
Se = selenium

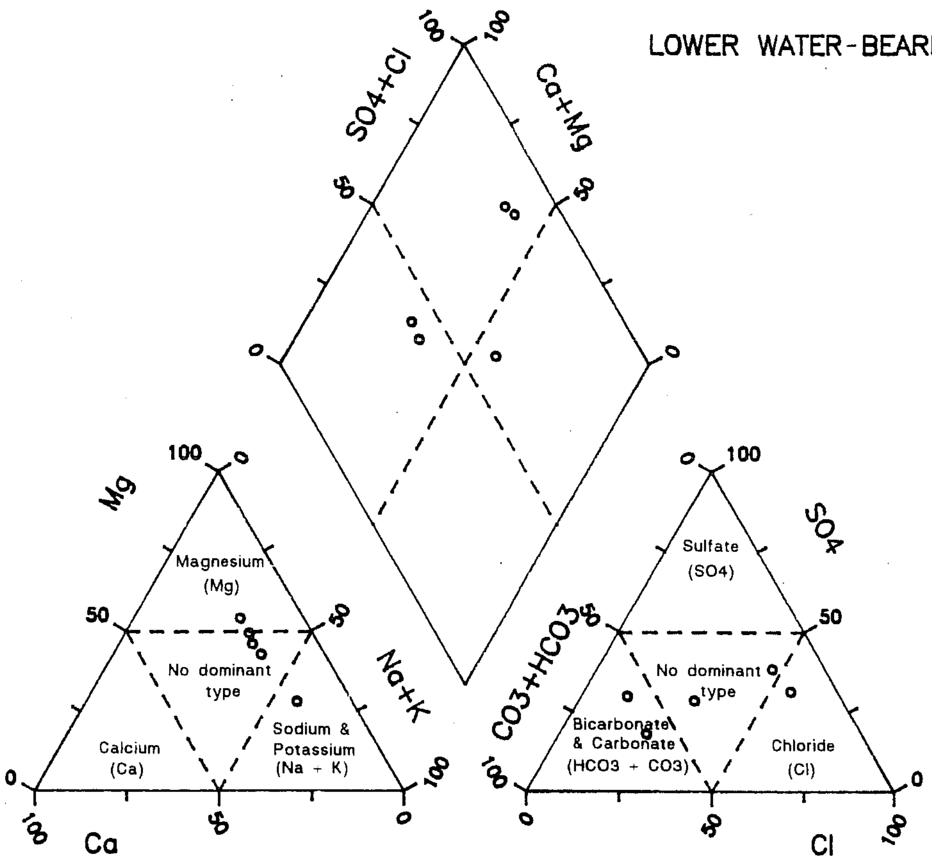
APPENDIX D

Chemical Composition of Ground Water in the Patterson-Westley Area

UPPER WATER-BEARING ZONE



LOWER WATER-BEARING ZONE



APPENDIX E

Selenium Concentrations for Various Ground Water Types in the Patterson-Westley Area

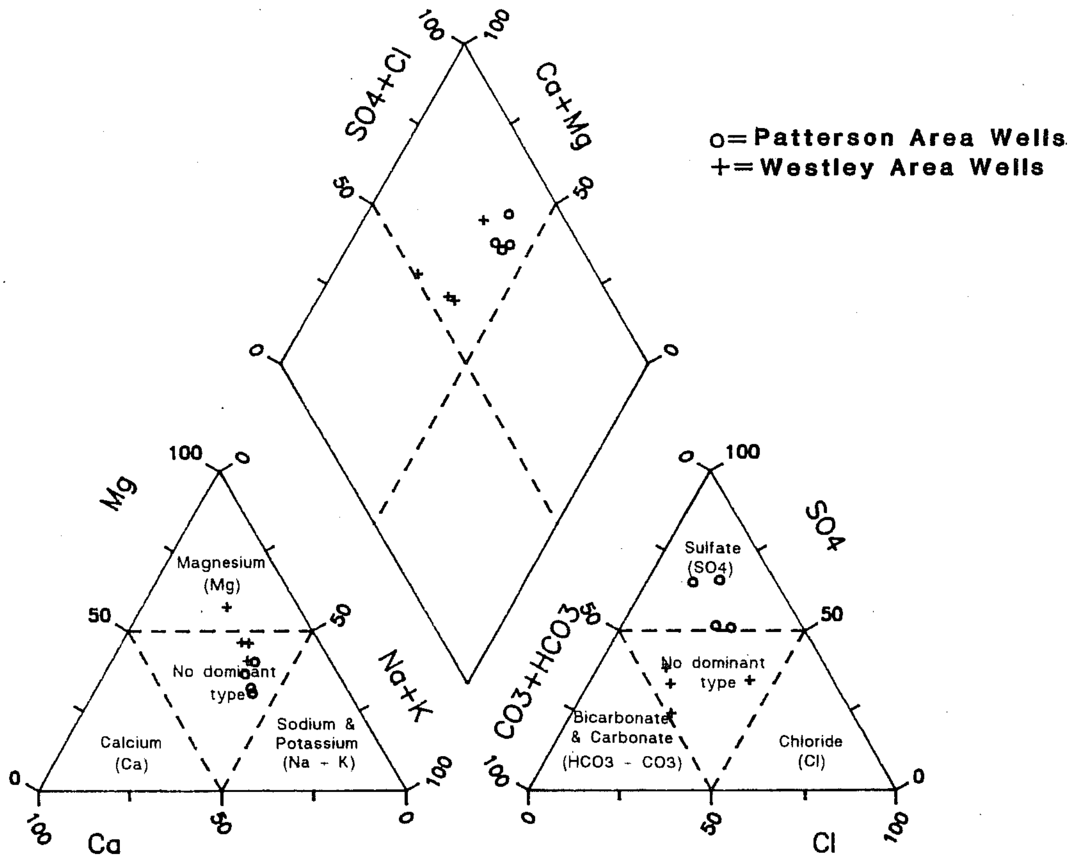
WELL NUMBER	WATER-BEARING ZONE*	SELENIUM** (µg/L)
BICARBONATE TYPE		
5S/7E-11R	U	2.3
5S/7E-12D	U	1.5
5S/7E-15D	L	0.9
5S/7E-21C	L	1.4
CHLORIDE TYPE		
4S/7E-17R	U	4.2
4S/7E-18H	U	1
4S/7E-33K2	L	6.5
5S/7E-13B	U	4.7
SULFATE TYPE		
5S/8E-21F	U	14
5S/8E-22C1	U	17
5S/8E-22F2	U	9.1
5S/8E-29R	U	11
5S/8E-32K1	U	12
5S/8E-34F	U	8.5
6S/8E-4P1	U	4.4
MIXED TYPE		
4S/7E-32R	U	14
4S/7E-33B1	U	11
4S/7E-33K1	L	6.7
5S/7E-1R	U	6.6
5S/7E-2C	U	0.8
5S/7E-3D	U	17
5S/7E-4D	U	12
5S/7E-12P	U	2.6
5S/7E-13Q	U	2.2
5S/7E-27B1	L	3.8
5S/8E-19P1	U	5.2
5S/8E-19P2	U	8.7
5S/8E-22F1	U	7.5
5S/8E-30K	U	6
5S/8E-31B	U	6.5
5S/8E-31J	U	1.5
5S/8E-31Q	U	3.8
6S/8E-10H	U	3.2
6S/8E-14F	U	9.5

*U=Upper water-bearing zone L=Lower water-bearing zone

** Selenium concentrations are those measured in August and September

APPENDIX F

Chemical Composition of Ground Water with >10 µg/L Selenium



APPENDIX G

Sampling Procedures

Water to be analyzed for selenium was collected in 1 pint plastic bottles pre-rinsed in nitric acid. Samples to be analyzed for minerals were collected in 1/2 gallon plastic containers pre-rinsed in hydrochloric acid. All samples were collected after three casing volumes of water had been purged from the well and the EC and temperature had stabilized. Sample containers were rinsed three times with the water to be analyzed before sample collection. Ice was used to preserve all water samples to be analyzed for minerals from the time of collection until delivery to the laboratory. Samples to be analyzed for minerals were delivered to the laboratory for analyses within 24 hours of collection. Samples to be analyzed for trace elements and selenium were stored on ice immediately after collection and then preserved with ultra-pure nitric acid to a pH of less than 2 before transport to the laboratory. Duplicate samples were collected on 10 percent of the samples for quality assurance. The results of these duplicate samples are included in Appendix C.