HYDROGEOCHEMISTRY OF STREAM CHANNEL RECHARGE OF SEWAGE EFFLUENT, NORTHWEST OF TUCSON, ARIZONA

by

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In the Graduate College

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ABSTRACT

This investigation has documented the water quality impacts of stream channel recharge of sewage effluent northwest of Tucson and has evaluated the hydrogeochemical mechanisms potentially responsible for observed water quality changes. The evaluation was accomplished partly through construction of twelve monitor wells and implementation of a quarterly water quality monitoring program for surface water and groundwater. Constituents monitored included major inorganic chemical constituents, trace inorganics, trace metals, priority pollutants/trace organics and microbiological contaminants. ^{15}N also proved useful in the study. The significance of a reducing zone immediately beneath the bed of the Santa Cruz River with respect to denitrification was documented.

Findings of this investigation indicate that while sewage effluent is of poor quality with respect to drinking water standards, groundwater recharged by sewage effluent is of improved quality. Other findings include:

- Nitrate in shallow groundwater near the Santa Cruz River in the Cortaro area appears to be primarily from

stream channel recharge of sewage effluent;

- Nitrate-N contents of effluent recharged groundwater averaged about 5 mg/l, well below the maximum contaminant level for drinking water of 10 mg/l, representing a 75 percent loss in total nitrogen during stream channel recharge of sewage effluent (assuming no mixing);

- Both stream channel recharge of sewage effluent and agricultural deep percolation contribute to nitrate in shallow groundwater near the Santa Cruz River in the Marana area;

- The reducing zone beneath the Santa Cruz River may be responsible for denitrification losses of up to 5 mg/l of nitrate-N. This would explain approximately 30 percent of nitrogen losses, on average, between effluent and recharged groundwater;

- The mechanisms of cation exchange and mixing with groundwater from other sources can explain the major changes in water quality between effluent and groundwater with respect to major inorganic chemical

constituents;

- Renovation of effluent with respect to coliform bacteria and enteric viruses content during recharge is not complete.

CHAPTER ONE

INTRODUCTION

Operators of wastewater treatment facilities across the country are evaluating the adequacy of current treatment and disposal technologies to meet water quality standards. An important component of such evaluation in the west, where effluent is sometimes discharged to normally dry streams, is the impact on groundwater quality.

In Arizona, the Environmental Quality Act (1986) requires assessment and control of such impacts. Enforceable drinking water standards apply to groundwater derived from stream channel recharge of sewage effluent.

The purpose of this investigation was to explain the major hydrogeochemical interactions during stream channel recharge of sewage effluent, using the environment northwest of Tucson, Arizona as a field site. Chemical quality of recharged groundwater is controlled by the quality of the source water (in this case effluent) and hydrogeochemical reactions occurring during recharge. Through the use of detailed water chemistry data and application of water chemistry fundamentals, major

reactions controlling water quality transformations are proposed.

Of particular importance to this subject is the fate of nitrogen during recharge. Enforceable drinking water standards limit nitrate-N to 10 mg/l. Total nitrogen in municipal wastewater effluent exceeds 20 mg/l. Ammonium - N, which accounted for over 60 percent of total nitrogen in effluent in this study, is toxic to aquatic life. Future environmental rules may limit the amount of ammonium in wastewater discharges.

While conversion of ammonium to nitrate (nitrification) in a treatment plant can be enhanced relatively simply, nitrate is generally regarded as mobile in groundwater and the subsurface. Removal of total nitrogen during wastewater treatment is much more difficult and costly than nitrification. For these reasons, the fate of nitrogen forms during recharge of sewage effluent was considered important. Other important topics related to inorganic chemical quality, trace organics content of water and presence of microbial pollution. Specific questions which were addressed included:

- What is the fate of nitrogen in sewage effluent during stream channel recharge?

- If nitrogen removal during stream channel recharge of sewage effluent is documented, what hydrogeochemical mechanisms are responsible?

- What are the fate and transport mechanisms of trace organics and trace metals during stream channel recharge of sewage effluent?

- What are the fate and transport mechanisms of bacteria and viruses in sewage effluent during stream channel recharge?

- What hydrogeochemical mechanisms can explain water quality transformations during the stream channel recharge of sewage effluent?

Sewage effluent has been disposed of northwest of Tucson since the early 1900's. Continuous discharge of sewage effluent to the Santa Cruz River began in 1969 and continues to this day. Much of the discharged effluent percolates through the bed of the Santa Cruz River and

recharges groundwater. Although numerous studies have been undertaken on specific aspects of groundwater quality of this area and on the water quality aspects associated with basin recharge of sewage effluent, comparatively little research has addressed the subject of stream channel recharge of sewage effluent, either in Pima County or elsewhere.

Before the initiation of this study, stream channel recharge of sewage effluent northwest of Tucson had been evaluated primarily by sampling existing large capacity irrigation wells, municipal wells and private wells, some of which were of uncertain design. This study, through the construction of systematically located and properly designed monitor wells, and systematic sampling of surface water, groundwater and the seepage zone, has allowed more conclusive results on the hydrogeochemistry of stream channel recharge of sewage effluent northwest of Tucson. Groundwater monitoring for trace organics and viral contaminants has been accomplished.

New sampling techniques for collection of water samples immediately beneath the bed of the Santa Cruz River were developed and employed to more fully characterize and

explain nitrogen transformations of percolating effluent.

Data were then used in a state-of-the-art hydrogeochemical model as a basis to identify possible hydrogeochemical mechanisms responsible for water quality changes.

The term hydrogeochemistry is used in this text to include chemical reactions in the subsurface, including those that are microbiologically mediated. Selected analytical results for bacteria and viruses are also reported and discussed.

Chapter Two describes the study area, based on existing information and research. Chapter Three summarizes research methods used in this investigation. Results and interpretation are presented in Chapter Four followed by results of hydrogeochemical modeling in Chapter Five. Significance of this research is discussed in Chapter Six.

CHAPTER TWO

DESCRIPTION OF THE STUDY AREA AND RELEVANT RESEARCH

Background on the study area and earlier investigations relevant to this research topic are necessary for a complete understanding of results. This chapter includes: a discussion of the general features of Pima County; the geologic setting of the study area; an overview of the hydrogeology of the study area; relevant information on sewage effluent disposal in Tucson; a summary of relevant information on water quality in the study area; a review of the results of selected research on sewage effluent recharge; a brief overview of trace organics in groundwater; and a summary of selected literature on virus mobility in the subsurface.

General Features

Pima County is part of the basin and range physiographic province of Fenneman (1931). The study area (Figure 1) is within the Tucson Active Management Area as defined by the Arizona Department of Water Resources. The study area includes the northern portion of the Tucson

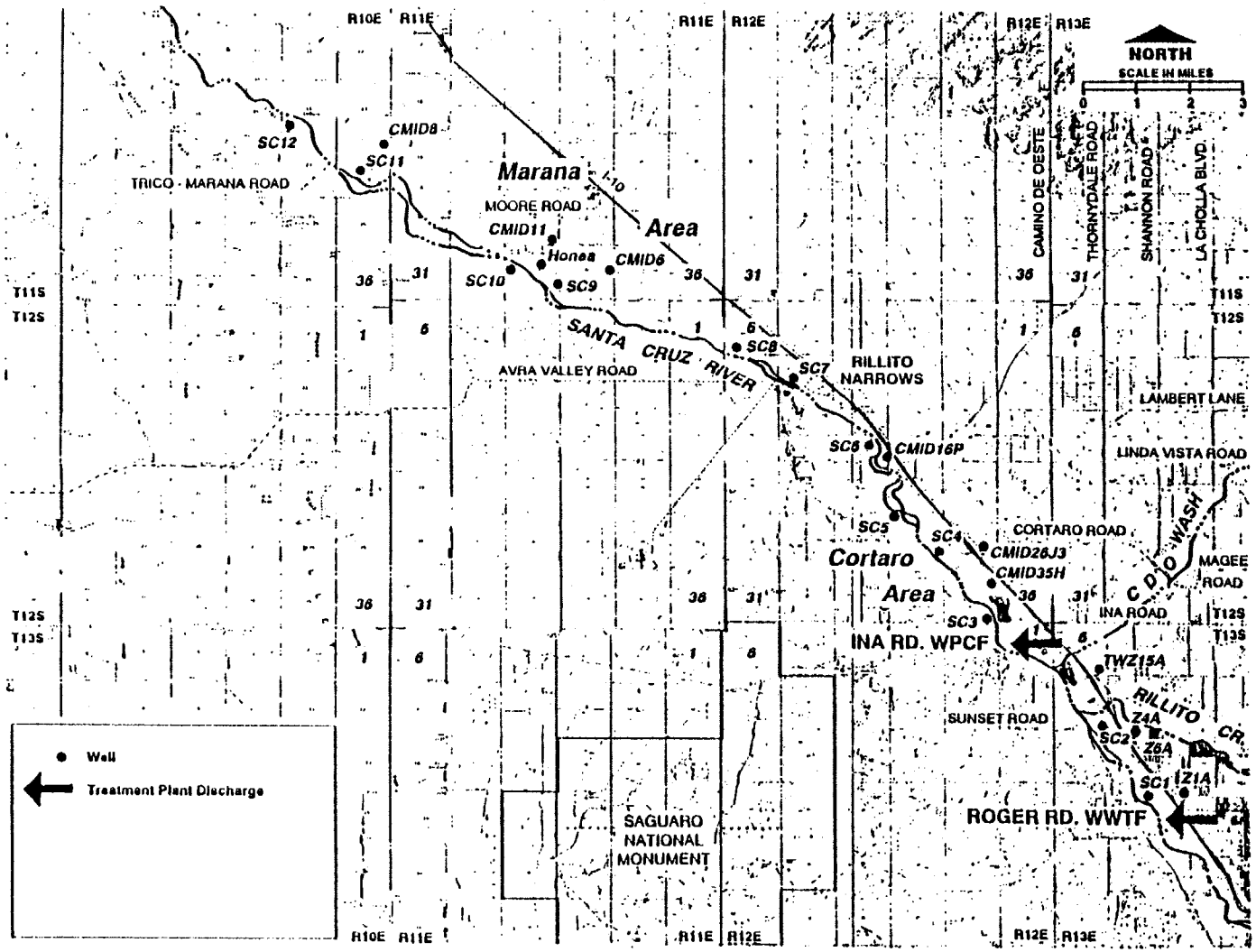


Figure 1
Map of Study Area

subbasin (referred to as the Cortaro area) and the northeastern portion of the Avra Valley subbasin (referred to as the Marana area).

The Tucson sub-basin and Avra Valley are both broad alluvial basins surrounded by mountains. The elevation in the study area ranges from about 2,200 feet above mean sea level (MSL) near the southeast corner of the study area to 1910 feet MSL at monitor well SC-12 in Marana. The climate is arid to semi-arid and average precipitation is approximately 11 inches per year (Sellers and Hill, 1974).

The population of metropolitan Pima County is approximately 650,000. Most of these people, along with associated business and industry, generate wastewater that is tributary to two wastewater treatment facilities which discharge effluent to the Santa Cruz River.

Hydrology

Surface water hydrology of the Tucson area was summarized by Condes de la Torre (1970). This work was

based on records from 15 surface monitoring sites with records extending to 60 years. Natural flow in the Santa Cruz River, between Tucson and Cortaro, is only in response to precipitation and runoff events and is absent an average of 315 days per year. Exclusive of effluent flow, the discharge rate of surface water flows, when they occur, is extremely variable. Natural discharge for the Santa Cruz River between Tucson and Cortaro exceeds 1,000 cubic feet per second (cfs) less than 1 percent of the time and exceeds 100 cfs less than 5 percent of the time.

Stream channel losses from natural flows were summarized by Burkham (1970). Average natural infiltration rates in the Santa Cruz River near the study area are approximately 480 acre feet per mile per year (Burkham, 1970).

Hydrogeology

Numerous hydrogeologic investigations have been conducted in the Tucson Basin, while fewer studies have been done in the Avra Valley. A summary of literature on both of these areas is presented, including geologic

setting, groundwater conditions, aquifer characteristics, recharge, and subsurface stratigraphy.

Geologic Setting

The geology of the study area is in large part due to Basin-and-Range faulting. The age and duration of Basin-and- Range faulting is germane to the evolution of groundwater basins in the study area. Loring (1976) defined Basin-and- Range faulting to include roughly all normal faults of late Mesozoic through Cenozoic age in Arizona. This is of somewhat greater duration than Basin-and-Range activity based on dates of post-Laramide magmatism given by Damon and Bikerman (1964). Damon and Bikerman (1964) indicated that magmatism associated with Basin-and-Range activity began in the late Eocene, peaked at the Oligocene-Miocene boundary and continued through a portion of the Pliocene. Menges and McFadden (1981) placed the end of the Basin-and-Range disturbance in two basins in southeastern Arizona at latest Miocene to Pliocene.

The Tucson Mountains are immediately west of the Santa Cruz River in the southern portion of the study area. The geology of the Tucson Mountains was first described in detail by Brown (1939) and later by Mayo (1963) and Mayo

and Davis (1976).

Subsurface Stratigraphy

Various investigators have described the subsurface stratigraphy in and around the study area. Cooper (1960) first described the Helmet Fanglomerate as a coarse conglomerate of probably early Miocene age which he believed to be made up of alluvial fan deposits. The Pantano Formation was defined by Brennan (1962) as a series of continental deposits ranging from boulder conglomerate to mudstones. Description of the Pantano Formation was further refined by Finnell (1968) and Davidson (1973). Davidson also included the most recent comprehensive review of earlier studies.

Pashley (1966) identified and described the Rillito beds. The oldest of these beds (I and II) were described as "red conglomerate and mudstone deposited during early stages of the uplift and erosion of the modern ranges." Pashley described the younger Type III Rillito beds as being deposited after the mountain ranges achieved their current configuration and consisting primarily of sand and

gravel eroded from the earlier deposited Types I and II Rillito beds. These units are overlain by what Pashley described as basin fill deposits. He suggested a middle Tertiary age for the Type I Rillito beds and a late Tertiary age for the Type III beds, while the Type II beds are assigned to an age intermediate between the two.

Davidson (1973) suggested that the Pantano Formation and the Helmet Fanglomerate are correlative. He also suggested that portions of the Type I Rillito beds of Pashley, as well as the Rillito Andesite and upper Andesite of Brown (1939) are equivalent in age to the Pantano. Davidson described the Pantano as a "silty and pebbly sandstone to moderately cemented gravel" with granitic, "sedimentary and volcanic detritus in an arkosic to clay rich, sandy matrix," containing significant amounts of mudstone and gypsiferous mudstone in certain locations.

Davidson (1973) described the Tinaja beds as a sandy gravel at the basin margins grading to gypsiferous clayey silt and mudstone in the center of the basin. He proposed that the Tinaja beds include the Type II and Type III Rillito beds of Pashley (1966). Davidson's proposed age of the Tinaja beds is probable Pliocene to late Miocene for

the upper beds, while the lower beds may be as old as late Oligocene.

Davidson (1973) named and defined the Fort Lowell Formation. This formation (called basin fill by Pashley) of Pleistocene age unconformably overlies the Tinaja beds. The formation grades from silty gravel near the basin margin to silty-sand and clay-silt in the center of the basin, and is consistently more coarse than the underlying Tinaja beds. The Fort Lowell Formation is unconformably overlain by recent alluvium.

Based on cross-sections presented by Davidson, recent alluvial deposits along the Santa Cruz River in the Cortaro area extend from land surface to a depth of 50 to 100 feet. Alluvial deposits are underlain by the Fort Lowell Formation, whose thickness is up to 50 feet. The Tinaja beds, underlying the Fort Lowell Formation, are on the order of 1,000 feet in thickness in the Cortaro area. These two formations are the primary water bearing units in the area.

Anderson (1987) did further work on the Cenozoic stratigraphy of the Tucson Basin. According to Anderson,

the Pantano Formation and lower Tinaja beds accumulated during the Oligocene until the early Miocene, before the onset of the Basin-and-Range disturbance. Middle and upper Tinaja beds accumulated from the middle Miocene and Pliocene, through the end of the Basin-and-Range disturbance. He suggested that the Fort Lowell Formation accumulated during and after the late Pliocene, after the development of through-flowing drainage conditions, as opposed to closed basin drainage conditions during which underlying formations had been deposited. Eberly and Stanley (1978) suggested that exterior-drainage systems began developing in southern and western Arizona between 10.5 and six million years ago.

Study of the Avra Valley subsurface stratigraphy is limited. Early work was done by Matlock and Morin (1976). The subsurface stratigraphy of the northern Avra Valley was studied in more detail by Allen (1981). Allen divided sediments in the Avra Valley into two units. The upper basin fill, called younger alluvium by Allen, was described as "silt and clay, interbedded with sandy gravels and gravelly sands." Allen divided the older alluvium into a fanglomerate facies consisting of sandy gravel to gravelly sands, and a mudstone facies consisting mostly of silts and

clays with evaporites locally present. The boundary between the younger and older alluvium was between 300 and 500 feet in depth, and was determined on the basis of electric log patterns, lithologic data, density log patterns and presence or absence of bedrock.

Allen (1981) inferred that the older alluvium deposited in an internally draining basin while the younger alluvium deposited in an externally draining basin. Based primarily on this distinction, Allen concluded that the younger alluvium in the Avra Valley is "tectonostratigraphically" correlated with the Fort Lowell Formation, and that the older alluvium is correlative to the upper Tinaja beds of the Tucson basin. He assigned no temporal correlations.

Whallon (1983) investigated hydrogeology of the Avra Valley. He subdivided the aquifer into two lithostratigraphic units: an upper zone of sands interbedded with gravel and silty clay (the upper 300 to 400 feet of deposits); and a lower zone composed primarily of silty clay in the northern part of the valley and consolidated sands and gravels in the southern part of the valley. Whallon documented groundwater level declines of

more than 140 feet in a central part of the valley between 1940 and 1978. Based on the differences in depositional characteristics in this lower zone, Whallon suggested that the southern portion was deposited in a fluvial environment while the northern portion of the lower zone was deposited in a playa-like environment. The data of Wrege, Schumann and Wallace (1985) and Wrege (1986) generally support Allen's and Whallon's interpretations.

Anderson (1988b) and Hanson (1989) evaluated the potential for aquifer compaction and land subsidence in the Tucson Basin. Hanson (1989) also evaluated the potential for aquifer compaction in the Avra Valley, building on the work of Anderson (1988a) and Schumann and Anderson (1988). These studies generally related the potential for aquifer compaction and land surface subsidence to factors including water-level declines and the percentage of clay and silt in the subsurface.

Groundwater

Groundwater of the Tucson basin was first studied by Smith (1910). Hydrogeologic investigations were also

undertaken by Schwalen and Shaw (1957, 1961) and Matlock and others (1965). More recent hydrogeologic studies, covering a wider geographic area, have been completed by Davidson (1973) and Babcock and others (1981 through 1990). Additional hydrogeologic information is shown in maps prepared by Osterkamp (1973a, 1973b, 1973c and 1974) and Cooley (1973).

Depth to groundwater northwest of Tucson in the early 1900's (Smith, 1910) was generally less than several tens of feet. Depth to groundwater in the 1920's reported by Schwalen and Shaw for the Cortaro portion of the study area was as shallow as 22 feet along the Santa Cruz River. In the 1950's depths to groundwater along the Santa Cruz River in the Cortaro area were about 70 to 90 feet, due to increased pumping.

Matlock, Schwalen and Shaw (1965) presented a progress report on groundwater in the Santa Cruz Valley. In the Cortaro area, they reported depths to groundwater of up to 110 feet for the period between 1960 and 1965. They reported groundwater declines in the Cortaro area between 1947 and 1965 of up to 18 feet, although they note a rise in the water table between 1961 and 1965 due to reduced

pumping, higher than average flood flows, and increased sewage effluent discharge to the river.

Matlock and Davis (1972) also reported on groundwater conditions in the Santa Cruz Valley. In 1970, depth to water along the Santa Cruz River in the Cortaro area was as shallow as 100 feet. The authors reported groundwater declines between 1965 and 1970 of up to fifteen feet in the Cortaro area. For the period 1947 to 1970, Matlock and Davis reported groundwater declines of up to 50 feet in the Cortaro area.

Matlock and Morin (1976) reported on groundwater conditions in the Avra and Altar Valleys. For 1974, they reported depth to water in the Marana portion of the study area as ranging from 223 feet near the Rillito Narrows to 330 feet along the Santa Cruz River near the alignment of Moore Road. For the period 1969 to 1974, the authors reported groundwater declines of up to 30 feet along the Santa Cruz River in the Marana area. For the period 1965 to 1974, the authors reported groundwater declines of up to 40 feet in the same area. For the period of 1952 to 1974, water level declines were as much as 100 feet. Declines were attributable primarily to agricultural pumping.

In 1988, depth to water along the Santa Cruz River ranged from 85 to 130 feet in the Cortaro area and from 300 to 390 feet in the Avra Valley (Schmidt, 1988). Maps showing the most recent available depths to groundwater and water level elevation contour maps are shown in Figures 2 and 3 respectively.

Aquifer Boundaries and Characteristics

The sedimentary units composing the aquifer in the study area are interconnected and act as a single water-bearing unit, with a hydrogeologic construction (shallow bedrock) at the Rillito Narrows. In the Cortaro area, Cooley (1973) estimated aquifer thickness at 1,200 feet to less than 400 feet. Northwest of the Rillito Narrows, aquifer thickness increases rapidly to greater than 1,200 feet.

Davidson (1973) reported transmissivity values in the Cortaro area of approximately 180,000 gallons per day per foot. These values are in good general agreement with those values reported by Schmidt (1988) for shallow monitor wells of about 130,000 to 160,000 gallons per day per foot. Schmidt (1988) reported transmissivity values of 4,000 to

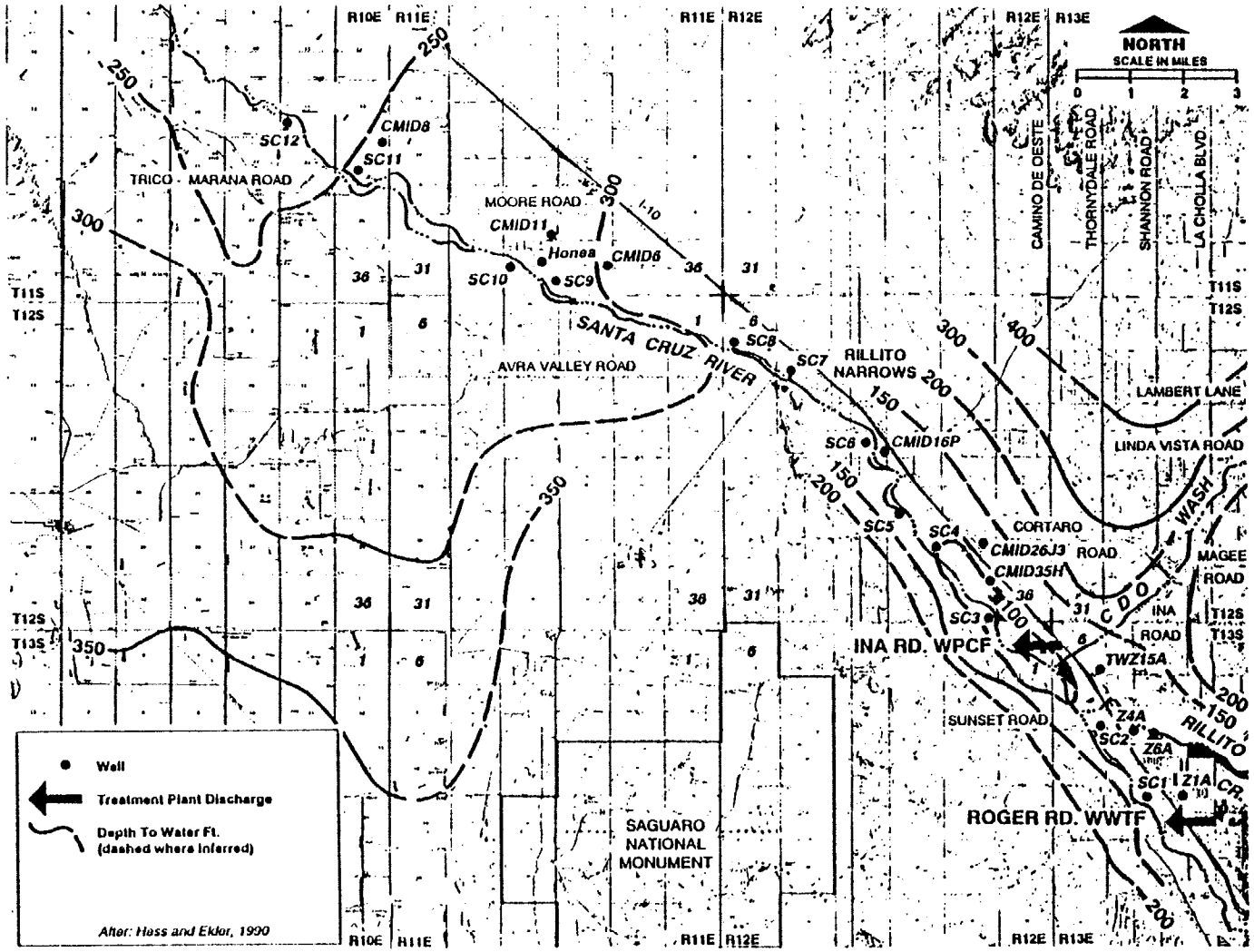


Figure 2
Depth to Groundwater in Study Area, 1989

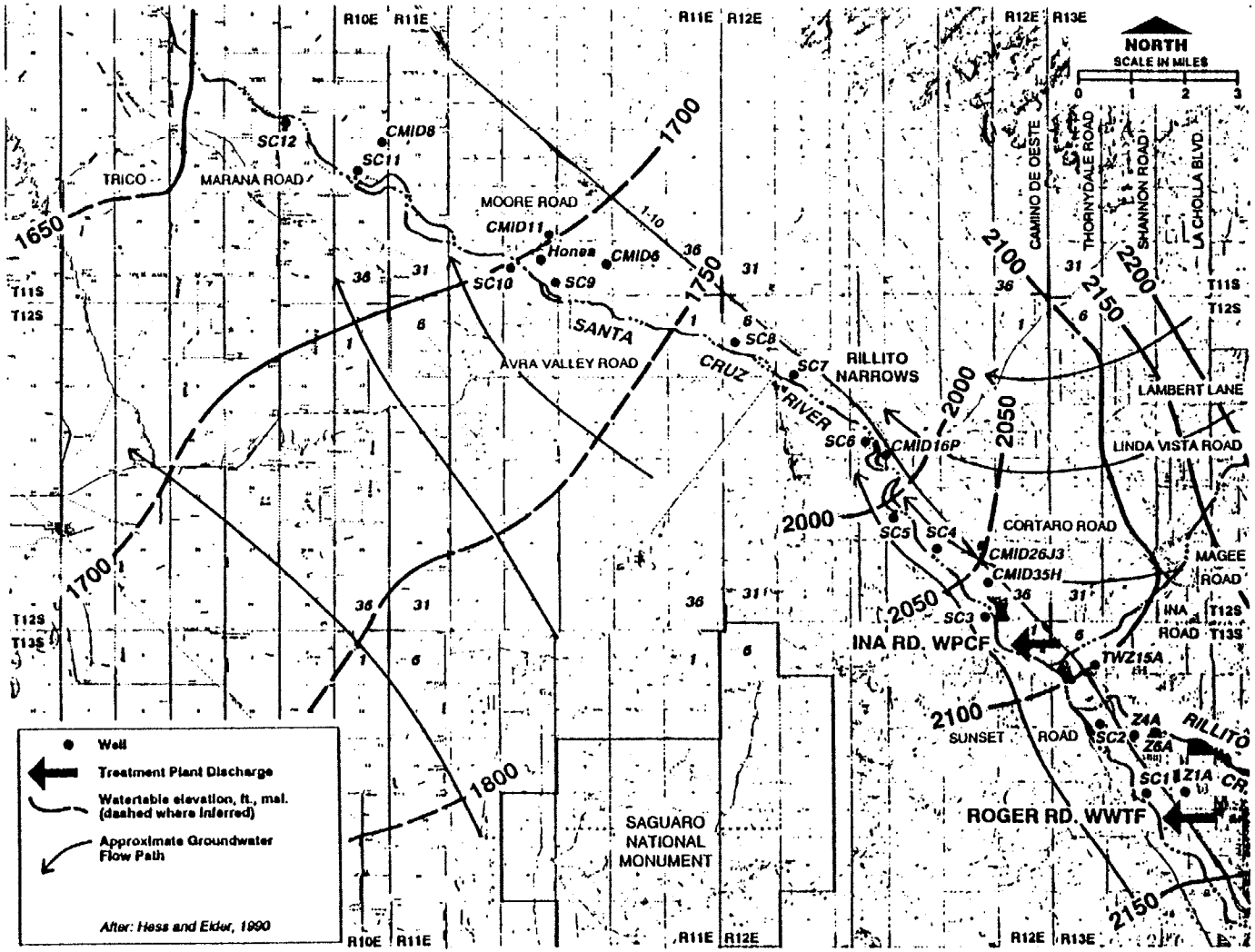


Figure 3
Water Level Elevation Contour Map, 1989

35,000 gallons per day per foot in the Avra Valley along the Santa Cruz River, based on shallow monitor wells. Davidson (1973) indicated that a specific yield value of about 15 percent is representative of the aquifers in the Tucson basin.

Various researchers have used gravity data to define basin and hydrologic boundaries in and around Tucson (Davis, 1971; Goodoff, 1975; and Oppenheimer and Sumner, 1980). Based on gravity data, Davis (1971) interpreted the east side of the Tucson Mountains as interbedded volcanics and alluvial material, with increasing alluvial deposits toward the basin. Davis interpreted the Rillito Narrows to be an extension of the fault system bounding the Catalinas, which would explain the sudden increase in depth of alluvial materials northwest of the narrows.

Goodoff's (1975) interpretation, generally consistent with that of Davis (1971), indicated that the elevation of the bedrock constriction at the Rillito Narrows is about 1,600 feet (MSL). This means that the upper 300 feet of alluvium may have been deposited under externally draining conditions. This is a slightly thicker section of alluvium than Anderson (1987) assigned to the Fort Lowell Formation

in this area, which he believed to be deposited under externally draining conditions.

Groundwater Recharge

Groundwater recharge in the Tucson basin was evaluated by Anderson (1972). More recent modeling by the Arizona Department of Water Resources (Travers and Mock, 1984) supported Anderson's results. Based on 1940 conditions, presumed to be steady state, Anderson created an analog model and used this to estimate groundwater recharge in various parts of the Tucson basin. Anderson estimated natural stream channel recharge for the Santa Cruz River between Tucson and the Rillito narrows to be 6,050 acre feet per year. This equates to about 195 acre feet per mile per year, or about 40% of the natural stream channel infiltration estimated by Condes de la Torre (1970). Increased depth to water between 1940 (recharge estimates based on 1940 conditions) and 1970 (date of infiltration estimates) may explain this difference.

Wastewater Management

Esposito and Thurnblad (1981) documented the history of wastewater collection, treatment and disposal northwest of Tucson through 1980 (see also Esposito and Davis, 1982). Sewage effluent has been disposed of northwest of Tucson since the early 1900's. The quantity of effluent has increased from several hundred acre feet in the 1900's to 6,000 acre feet per year in the 1950's, to approximately 45,000 acre feet in 1980, to nearly 60,000 acre-feet in 1993. Until the late 1960's, most of the effluent was used for irrigation of agricultural lands. More than 3,300 acres in the Cortaro area were irrigated with sewage effluent by the late 1960's. After 1969, limited Cortaro acreage was irrigated with effluent, and the bulk of the effluent was continuously discharged to the Santa Cruz River. In 1992, approximately 6,000 acre-feet of effluent were directly reused (via irrigation ditch and pipeline) for agriculture in the Marana area and 2,000 acre-feet for turf irrigation in the Tucson area.

At the present time, municipal wastewater from Metropolitan Tucson is treated by two wastewater facilities. The Roger Road Treatment Plant, located on the

alignment of Roger Road, east of the Santa Cruz River, treats approximately 35 million gallons per day. The treatment method is through biofiltration and the effluent meets EPA standards for secondary treatment. The Ina Road Water Pollution Control Facility located south of Ina Road and east of the Santa Cruz River currently treats approximately 20 million gallons per day achieving EPA secondary standards through the use of a pure oxygen-activated sludge process. Effluent from both treatment plants is chlorinated prior to discharge.

In addition to analytical results presented in this report, influent and effluent quality are monitored by the Pima County Wastewater Management Department and presented in their annual reports (Pima County Wastewater Management Department, 1983-1993).

Based on data available in 1986, Esposito and others (1986) reported on trace organics removal efficiencies of the two treatment plants. Their report showed that while these treatment facilities have the capability to treat various trace organics, several species of trace organics were in sewage effluent from the two treatment plants. This subject is discussed more fully in the results

chapter.

Nitrogen fate is of particular importance with respect to wastewater management due to enforceable groundwater standards of 10 mg/l as NO_3-N. Lance (1984) and the U.S. EPA (1975) reviewed nitrogen transformations associated with wastewater treatment. A significant portion of nitrogen in raw wastewater is in the form of organic nitrogen. Organic nitrogen undergoes ammonification during most wastewater treatment processes. An ammonification reaction specific to the transformation of organic nitrogen in urine, urea, to ammonium is:

$$H_2NCONH_2 + 2\ H_2O = (NH_4)_2CO_3$$

In this case the ammonification reaction is hydrolysis. It is enzymatically mediated by the enzyme urease and the product is ammonium carbonate. Depending on the treatment process and operations, ammonification of organic nitrogen may or may not be complete.

At near neutral pH, ammonium ion (NH_4^+) is predominant over molecular ammonia (NH_3). Ammonium is biologically

oxidized to nitrite (NO_2^-) and then to nitrate (NO_3^-) through the following nitrification reactions:

$$2NH_4^+ + 3O_2 = 2NO_2^- + 4H^+ + 2H_2O$$

$$2NO_2^- + O_2 = 2NO_3^-$$

The conversion of ammonium to nitrite is generally mediated by the bacteria genera Nitrosomonas. Nitrobacter bacteria are generally involved in the conversion of nitrite to nitrate. The nitrification of ammonia may range from minimal to complete during wastewater treatment, depending on treatment process design and operations. Nitrate, under appropriate circumstances, may be biologically reduced to nitrite and then to nitrogen gas. Simplified denitrification reactions are:

$$NO_3^- + 0.33\ CH_3OH = NO_2^- + 0.33\ CO_2 + 0.67\ H_2O$$

$$NO_2^- + 0.5\ CH_3OH = 0.5N_2 + 0.5H_2O + OH^- + 0.5\ CO_2$$

In these reactions, methanol is shown as the source of organic carbon. In addition to a carbon source, denitrification requires the absence of oxygen and the presence of denitrifying bacteria such as Pseudomonas,

Micrococcus, Achromobacter or Bacillus. Municipal wastewater treatment plants typically do not promote denitrificatioon unless specifically designed for nitrogen removal.

Other processes may also have an impact on nitrogen forms and concentrations. These processes include ammonia volatilization, uptake by plants and microbes and immobilization through clay fixation and cation exchange. Ammonia volatilization takes place through the following reaction:

$$NH^+_4 + OH^- = NH_3 + H_2O$$

However, the products of this reaction are minimal when pH is near neutrality (typical for effluent).

In land disposal, uptake of nitrogen by plants and microbes can be significant, depending on the characteristics of the disposal site. While plant uptake of nitrogen can often be estimated, incorporation of nitrogen into microbes is more difficult to quantify.

Immobilization of nitrogen, primarily in the ammonium

ion form, may take place through fixation to clays and cation-exchange. Clay fixation occurs when ammonium becomes trapped between mineral layers in clays such as montmorillonite or vermiculite. In cation exchange, positively charged ammonium ion is adsorbed by negatively charged clay and organic particles in soil or sediments. The general reaction for cation exchange is:

$$m[A^{n+}]\ \text{soil} + n\ [B^{m+}]\ \text{soln} = n\ [B^{m}+]\ \text{soil} + m\ [A^{n+}]\ \text{soln}$$

The extent of exchange is dependent on clay and organic content of the soil, as well as concentrations of ions in solution and sorbed to soil. Adsorbed ammonium may become desorbed by the same reaction process by competing ions such as Ca^{++} or Mg^{++}. Under aerobic conditions, adsorbed ammonium may oxidize to nitrate which can then leach from the exchange site and/or undergo further reactions. Nitrate is typically mobile in groundwater and soil-aquifer systems.

Water Quality

Wilson and others (1982) undertook the most comprehensive evaluation of groundwater quality in the Cortaro area portion of the study area. Earlier studies and reports included those by Matlock, Davis and Roth (1972), Laney (1972), Schmidt (1973) and Osterkamp and Laney (1974). Schmidt (1988) and Schmidt, Esposito and Eaker (1989) presented and discussed the most recent published groundwater quality data. Related studies were undertaken by Matlock (1966), Sebenik, Cluff and DeCook (1972), Sebenik (1975 a, b), Bostick (1978), Martin (1980), Thorne (1983), Koglin (1984), Randall (1983), and Stevens (1990). Applicable column studies were performed by Herbert (1976). Schwalen and Shaw (1957) first noted the significance of sewage effluent with respect to groundwater recharge. Collectively, these studies indicate that groundwater receiving sewage effluent recharge contains elevated levels of nitrate, chloride and, in places, boron.

This section presents the results of studies related to infiltration of sewage effluent in the Santa Cruz River followed by results of various investigations related to effluent water quality and groundwater quality in the

Cortaro and Marana areas. Groundwater quality investigations concentrated primarily on nitrate content of groundwater.

Matlock (1966) and Sebenik and others (1972) evaluated infiltration rates for sewage effluent discharged to the Santa Cruz River. Matlock estimated effluent infiltration rates to be three cubic feet per second per mile (cfs/mi), in a six mile reach of the Santa Cruz River below the Roger Road Treatment Plant outfall. Sebenik and others (1972) estimated losses ranging from 2.2 to 3.4 cfs/mi in a 11 mile reach downstream from the Roger outfall after flood flows in the Santa Cruz River.

Shumman and Galyean (1991) also evaluated infiltration rates of sewage effluent in the Santa Cruz River. This study consisted of construction of low flow gages in the Santa Cruz River downstream of the Ina Road wpcf discharge point. On three separate occasions of effluent flow measurement, the authors documented losses of 1.2 cfs/mi to 2.7 cfs/mi. The greatest infiltration rates were associated with a period shortly after large flood flows in the Santa Cruz River. Shumman and Galyean (1991) concluded that infiltration rates are highly variable and dependent

on such factors as time since last natural flood event, condition of the channel bottom and time of year.

Sebenik (1975b) evaluated dissolved oxygen (DO) and biochemical oxygen (BOD) demand in Roger Road treatment plant effluent releases. He found DO generally in the range of 5 to 7 mg/l and BOD in the range of 20 to 40 mg/l. Sebenik, Cluff and DeCook (1972) and Sebenik (1975a) evaluated transformations in nitrogen species in effluent as it flowed in the Santa Cruz River. Depending upon season of the year and volume of flow, they found that total nitrogen either stayed the same (winter time and low flow) or decreased (high flow during the summer). In particular, sampling during June 23, 1971, showed significant loss of ammonium-nitrogen with an increase in nitrate content in a downstream direction. Losses were attributed to solids removal (some ammonium may have been attached to soil or organic particles), nitrification and ammonia volatilization.

A number of studies have been completed on groundwater quality in the study area. In the Cortaro area, studies dating from the 1960's and 1970's showed nitrate-N concentrations in some of the groundwater in excess of the

10 mg/l primary drinking water limit (Laney, 1972; Schmidt, 1972). More recent studies showed nitrate content in most of the groundwater in this area within drinking water limits. Nitrate-N content of groundwater beneath the Santa Cruz River in certain areas of the Avra Valley exceeded 10 mg/l, based on more recent sampling results (Schmidt, 1988). In the most comprehensive of these studies, only limited analyses for priority pollutant organics were undertaken (Wilson and others, 1982; Schmidt, 1988).

Matlock, Davis and Roth (1972) investigated regional groundwater quality. This was the first study related to effluent disposal that extended into the Marana area. Analyses were completed for major inorganic chemical constituents as well as nitrogen forms. The authors concluded that high concentrations of nitrate, chloride and boron in the Cortaro area were attributable to sewage effluent recharge. No distinction was made between recharge from the stream channel as opposed to below irrigated lands where effluent was applied. Based on lower chloride and boron content of groundwater in the Marana area, the high nitrate contents in groundwater were attributed to irrigation practices as opposed to sewage effluent in that region.

Schmidt (1973), based on the results of monthly sampling of 20 large capacity agricultural supply wells during the 1971 and 1972 irrigation seasons, concluded that irrigation return flow where sewage effluent was used was the primary contributor of high nitrate contents in groundwater in the Cortaro area. Moderate nitrate contents in groundwater were found to be associated with streambed recharge of sewage effluent, and Schmidt suggested the mechanism of denitrification for sewage effluent infiltrating in the Santa Cruz River channel.

Wilson and others (1974) evaluated water quality transformations associated with sewage effluent flow and percolation and with possible interaction with landfill refuse. Results of analyses showed that nitrification of sewage effluent flowing in the Santa Cruz River had not occurred to a significant extent between the Roger Road discharge and the vicinity of Ina Road (about 5 miles). Comparing nitrogen contents of effluent in the Santa Cruz River to those in the underlying groundwater, the authors noted a loss in total nitrogen of about 80 percent (Wilson, Herbert and Ramsey, 1975). Monitoring results showed significant decrease in kjeldahl nitrogen and ammonium ion with a small increase in nitrite plus nitrate. The authors

suggested that continuous flooding of the channel promoted anaerobic denitrification of nitrogen and/or adsorption of ammonium ion. They also noted the loss of sulfate between effluent flow and underlying groundwater, which supported the presence of anaerobic conditions. Other changes in inorganic chemical composition of the waters were attributed to dissolution and precipitation of salts. They also found a significant decrease in coliform count during effluent recharge, as would be expected.

Randall (1983) evaluated halocarbon content of groundwater in the Tucson area. He concluded that groundwater in the Cortaro area is approximately 25 years old, based on the detection and content of chloroflurocarbons in groundwater samples.

Thorne (1983) evaluated the chemical and isotopic content of groundwater near the Tucson Mountains. He analyzed both inorganic chemical constituents and stable isotopes of deuterium and Oxygen 18. He suggested that nitrate content of groundwater was increasing in certain areas due to effluent discharge to the Santa Cruz River.

The isotopic composition of nitrogen compounds in

groundwater can be helpful in the determination of the source of nitrogen. Nitrogen isotopic composition is expressed by $\delta^{15}N$:

$$\delta^{15}N\ (^{o}/oo) = \frac{(^{15}N/^{14}N)spl-(^{15}N/^{14}N)std}{(^{15}N/^{14}N)std} \times 10^{3},$$

where the N_2 standard is atmospheric nitrogen (Faure, 1986). Measurement is made through mass spectrometry of nitrogen gas. Nitrogen isotope fractionation can be caused by nitrification and denitrification reactions (Hoefs, 1980).

Different sources of nitrogen may have different $\delta^{15}N$ values. Nitrogen fertilizers tend to be near 0 $^{o}/oo$ (ranging from -8 $^{o}/oo$ to +6.2 $^{o}/oo$) and animal waste is generally greater than +10 $^{o}/oo$ (ranging from +10 $^{o}/oo$ to +20 $^{o}/oo$) while natural soil nitrate lies between (Kreitler and Jones, 1975; Gormly and Spalding, 1979). Nitrogen isotopes have been used as a potential tracer of nitrogen in groundwater by several researchers including Jones (1973), Kreitler, Ragone and Katz (1978), and Spalding, Exner, Martin and Snow (1993). Spalding and others (1993) used $\delta^{15}N$ content to determine the extent of denitrification in groundwater. They found a strong inverse correlation

between nitrate content and $\delta^{15}N$ in groundwater beneath a sewage sludge disposal area.

Martin (1980) conducted an overall evaluation of groundwater quality in the Cortaro area and analyzed selected samples for $\delta^{15}N$. He found elevated nitrate and boron in portions of Cortaro area groundwater and concluded that recharge of sewage effluent caused these changes in groundwater. He observed that groundwater east of the Santa Cruz River (upgradient of where sewage effluent had been disposed) was of better quality and unchanged over time. On the basis of water chemistry and nitrogen isotope content, Martin concluded that nitrate values in groundwater were from sewage effluent either discharged to the Santa Cruz River or used for agricultural irrigation.

For the Cortaro area, Martin (1980) presented $\delta^{15}N$ data for 21 wells. Values for $\delta^{15}N$ ranged from -3 °/oo (well near irrigated field) to + 26 °/oo (well near an effluent irrigated field). For groundwater that appeared to be impacted by sewage effluent (based on inorganic chemical content), Martin found $\delta^{15}N$ values ranging from +5 °/oo to + 26 °/oo, further substantiating sewage effluent as the

source of nitrate. Martin concluded that artificial fertilizers were not an important source of nitrate in the Cortaro area.

Bostick (1978) investigated the stable isotopic content of groundwater, stream flow and sewage effluent in and along the Santa Cruz River. He concluded that ^{2}H and ^{18}O may be used as a tracer of recharge, based on different isotopic ratios between sewage effluent, background groundwater and water from wells believed to be pumping a mixture of recharged effluent and background groundwater.

Davis and others (1985) summarized the use of chloride and bromide as environmental tracers in groundwater. Koglin (1984) discussed bromide as an environmental tracer for groundwater in the Tucson Basin. Koglin suggested that chloride/bromide ratios could potentially be used to identify different sources of groundwater recharge. Stevens (1990) utilized variations in chloride/bromide ratios in groundwater in the Tucson Basin and Avra Valley to identify sources of groundwater recharge. Stevens concluded that chloride/bromide ratios can be used to identify sewage effluent which has recharged groundwater,

because the ratios are significantly different than in background groundwater.

In two column test experiments, Herbert (1976) evaluated the effect of alluvial deposits on the infiltration rates and denitrification of sewage effluent. In the first experiment, columns were packed with river sand and flooded for 28 days. In the second experiment columns were packed with gravel and were flooded for 64 days. Both experiments utilized sewage effluent as the water source for flooding. Herbert reported the development a black layer in the column shortly after the introduction of sewage effluent into the columns, and noted the inverse relationship between the build up of the black layer and infiltration rates. For the first run Herbert reported average loss in total nitrogen of 63 percent and for the second run reported a nitrogen loss of 16 percent. For Herbert's first run, most of the nitrogen losses came from loss of ammonium ion. In the first run, only one of the columns lost appreciable nitrate plus nitrite, and nitrate levels in one of the columns significantly increased. For Herbert's second set of experiments using river gravels and a longer period of continuous flooding, most nitrogen loss was as ammonium ion. However, for three

of the nine samples taken during continuous flooding and in three out of four columns, Herbert observed consistent loss of nitrate plus nitrite in the percolation of sewage effluent in the columns.

In terms of specific monitoring of shallow groundwater near the stream channel where effluent is flowing, Schmidt (1988) presented the data collected during the well drilling phases and the first groundwater sampling round included as part of this investigation. In the Cortaro area, Schmidt (1988) noted the significant apparent loss of nitrogen between effluent and receiving groundwater (where nitrate-nitrogen averaged 4 mg/l). He attributed this to atmospheric losses of nitrogen, during infiltration, as well as due to dilution with other sources of recharge such as natural stream flows. He suggested that ammonium-nitrogen concentrations in the range of .1 to .9 mg/l are due to the leaching of ammonium-nitrogen to groundwater. The data Schmidt evaluated indicated no detectable volatile halocarbons or aromatics in shallow groundwater.

In the Marana area, based primarily on chloride content of groundwater, Schmidt (1988) suggested that sewage effluent was an important source of recharge to the

shallow groundwater near the Santa Cruz River. He also noted the higher average content of nitrate in the monitor wells in the Marana area (6 mg/l) than in the Cortaro area. He attributed this to increased nitrification of effluent during downstream flow in the river to the Marana area, irrigation return flow entering the Santa Cruz River, and deep percolation of irrigation water. As in the Cortaro area, Schmidt found no detectible halocarbons or aromatics in the Marana area monitor well water.

Sewage Effluent Recharge

An excellent overview of nitrogen fate and transformations in the land application of wastewater was presented by Loehr and others (1976). An overview of the general behavior of soil nitrogen was presented by Bartholomew and Clark (1965). Documentation of denitrification of wastewaters in the subsurface has been widely reported (see for example, Smith and Duff, 1988; Rice and others, 1988; Robertson and Cherry, 1990; Degin and others, 1991; and Korom, 1992). The cation exchange capacity of clays and their ability to adsorb and retain ammonium ion has been widely researched (see for example:

Bohn, McNeal and O'Connor, 1979; Talibudeen, 1981). However, studies of nitrogen transformations associated with stream channel of sewage effluent are notably sparse in the literature.

Sewage effluent recharge has been a subject of a number of detailed field investigations. This summary is based on research in Arizona, which has primarily been on basins undergoing rapid infiltration. Many of these investigations were conducted by investigators of the U.S. Water Conservation Laboratory in Phoenix in the 70's and 80's. More recent investigations have been conducted at a site in Tucson in the southern portion of the study area of this investigation.

Flushing Meadows Project

Water quality aspects of sewage effluent recharge at the Flushing Meadows Project in Phoenix, Arizona (Bouwer,1970b) consisted of rapid infiltration basins constructed in fine, loamy sand underlain by coarse sand and gravel. The site was along the Salt River downstream of 91st Avenue. Depth to groundwater was approximately ten

feet and monitor wells were approximately 20 feet deep.

Some of the most interesting water quality results were for nitrogen forms. The nitrogen in effluent was primarily ammonium ion. For short wetting and drying cycles (two days wet, three days dry), Bouwer found that most of the ammonium ion was converted to nitrate. However, Bouwer found significant nitrogen loss with longer wetting and drying periods (two weeks wet, two weeks dry). Bouwer found a peak of nitrate in recharged groundwater immediately after the initiation of a new wetting cycle. The ammonium content of the groundwater recharged with sewage effluent was approximately five parts per million and did not change significantly with length of wetting and drying cycles. For longer wetting and drying cycles (with exclusion of the elevated nitrate concentrations at the initiation of a new wetting cycle), Bouwer found approximately 80 percent nitrogen removal. The 20 percent of nitrogen remaining consisted mostly of nitrate. Design parameters for the groundwater recharge system were discussed by Bouwer (1970a).

More detailed results of water quality investigations at the site were presented by the U.S. Water Conservation

Laboratory (1971). Nitrogen content of the secondary effluent generally ranged from 20 to 40 parts per million. Elevated nitrate content of water immediately after a new wetting cycle was attributed to nitrification of ammonium to nitrate during the drying cycle and subsequent leaching of nitrate during a new wetting cycle.

In addition, Bouwer, Rice, Escarcega and Riggs (1972) found almost complete conversion of nitrogen in the sewage effluent to nitrate in the underlying groundwater with short wetting and drying cycles. With two to three week wetting/drying cycles, 50 to 80 percent of the nitrogen was removed, excluding the elevated nitrogen content after the initiation of each new wetting cycle. The authors found greater nitrogen removal beneath vegetated basins than in non-vegetated basins.

Lance, Whisler and Bouwer (1972) evaluated oxygen utilization in soils intermittently flooded with sewage effluent in soil columns and found that drying cycles were necessary for the conversion of ammonium ion to nitrate. Ammonium that could not be nitrified due to limited available oxygen remained in the ammonium ion form that adsorbed to the soil. When the cation exchange complex

became saturated with ammonium, additional ammonium content in percolating sewage effluent passed through the columns. These results are similar to those reported by Lance and Whisler (1972) who focused on nitrogen balance in similar soil columns. Net nitrogen removal during their studies averaged 30 percent (Lance and Whisler, 1973). Nitrogen removal increased when the infiltration rate was cut in half and also when additional soluble carbon (as glucose) was added to the sewage effluent.

Denitrification during rapid infiltration of sewage effluent was further discussed by Gilbert, Robinson and Miller (1973). They concluded that denitrification during basin flooding was unlikely to occur due to the rapid leaching of nitrate. They also concluded that the top fifteen centimeters of the soil zone was the prime locale for denitrification, and that denitrification could be enhanced by management of wetting and drying cycles.

Clogging of soil during infiltration of sewage effluent was evaluated by Rice (1974). He attributed long-term clogging to entrapped gas blocking soil pores. He also suggested that biological clogging would become a factor under long-term inundation of sewage effluent.

To maximize denitrification, Bouwer (1975) suggested application of effluent at a lower infiltration rate. Bouwer suggested that no nitrogen would be removed if flooding periods were excessively long, because the resulting absence of oxygen would prevent nitrification of ammonium and cation exchange capacity of soil for ammonium would eventually be exceeded, allowing ammonium to pass through to groundwater.

Lance (1975) outlined the mechanisms of nitrogen removal during the planned application of sewage effluent. These include ammonium volatilization, incorporation into microbes, fixation by clay, adsorption by organic matter, adsorption by soil cation exchange complex and denitrification. For denitrification to occur, Lance noted that ammonium ion must be oxidized to nitrate, that oxygen must be absent and that organic carbon must be available as an energy source to denitrifying bacteria. Lance suggested that land treatment systems must be carefully engineered and managed to achieve adequate renovation or improvement in water quality. Bouwer (1976) noted that each milligram of nitrogen requires approximately one milligram of organic carbon to allow denitrification.

By the tenth year of operation of the Flushing Meadows Project, wetting and drying cycles were carefully managed to achieve consistent removal of 65 percent of total nitrogen content (Bouwer, Rice, Lance and Gilbert, 1980). Sewage effluent averaged 27.4 milligrams per liter of nitrogen, primarily in the ammonium ion form. The underlying shallow groundwater contained an average of 2.8 milligrams per liter ammonium ion, 6.25 milligrams per liter of nitrate-nitrogen and 0.58 milligrams per liter of organic nitrogen, or a total of 9.6 milligrams per liter of nitrogen. In addition to nitrogen, the researchers noted significant reduction in suspended solids, phosphate, fluoride, biochemical oxygen demand, chemical oxygen demand, total organic carbon, fecal coliform count and virus content.

Sweetwater Underground Storage and Recovery Facility

Sewage effluent recharge through infiltration basins has been studied by a number of investigators at a facility operated by Tucson Water located at the alignment of Sweetwater Drive west of the Santa Cruz River in the southern portion of the study area of this investigation.

A tracer test utilizing bromide ion was conducted by Graham (1989). He found that solute moved in a wetting front along preferential flow paths, and that unsaturated flow concentrated into fingers or channels where the water moved preferentially. Similar results were found in other test sites by Hill and Parlange (1972) Starr, Parlange and Frink (1986) and Glast, Steenhuis and Parlange (1988).

Wilson (1993) and Wilson, Powelson, Yahya, Gerba and Amy (1992) reported on water quality investigations at the Sweetwater site. The project consisted of two pilot recharge basins within a larger recharge pond at the facility. The site is underlain by large cobbles and gravel intermixed with coarse sand, silt and some clay. Depth to groundwater was approximately 120 feet below land surface. The test basins were extensively instrumented with suction lysimeters (to a depth of 20 feet), monitor wells and neutron-logging access tubes. The basins were operated via intermittent wetting and drying cycles. The researchers found that dissolved organic carbon was reduced by about 50 percent during recharge, with most of the removal occurring in the top few feet of soil. Researchers also found nitrate peaks in the subsurface with the onset of renewed wetting cycles. This was attributed to

nitrification of adsorbed ammonium and subsequent leaching with percolating effluent. Virus removal ranged from 65 to 99 percent for two different viruses which were added to the effluent.

Trace Organics

Trace organics typically found in sewage effluent include selected phthalates, volatile halocarbons and aromatics. The fate of organic pollutants introduced to the subsurface via effluent in a stream channel recharge environment is largely uninvestigated. This section reviews selected studies relevant to the mobility of trace organics in the subsurface.

The fate and transport of organic pollutants in the environment and in particular, the subsurface environment have been a study of a number of a investigations (see for example: Mabey and others, 1982; Wilson and others, 1981; McCarty, Reinhard and Rittmann, 1981). Factors associated with the fate, transport and transformation of trace organics in a reducing environment were discussed by MacCalady, Tratnyek, and Grundl (1986) and Wolfe and MacCalady (1992). Transformations of selected organic

pollutants under reducing conditions in laboratory columns were presented by Bouwer and McCarty (1983a, 1983b) and Bouwer and Wright (1988). Model parameters associated with biotransformation of trace organics were developed by Bouwer and McCarty (1984).

Barber, Thurman and Schroeder (1988) and Bouwer and others (1982) evaluated the fate of trace organic pollutants in sewage effluent recharged via rapid infiltration basins. These two field studies showed removal rates for various trace organic pollutants ranging from near zero to greater than 99 percent. The column studies suggested that additional degradation of organic pollutants is likely to take place under reducing conditions. All of the studies suggest that the fate of organic pollutants in the subsurface, even at low concentrations, is uncertain.

The interaction between organic pollutants and soils especially adsorption of organic species by clays, has been the subject of number of investigations (see for example Barber, Thurber and Runnells, 1992; Theng, 1974; Mortland, 1986).

Virus Mobility in the Subsurface

The potential for viral contamination of groundwater has been evaluated in a number of field studies. While laboratory studies have provided much of the useful information about virus behavior, the extrapolation of lab results to field conditions is not always successful (Wellings, Lewis and Mountain, 1977).

Wellings and others (1974) evaluated virus transport in the subsurface at a spray irrigation site where chlorinated effluent was applied to a very sandy soil. Initial sampling rounds showed that viruses could survive aeration, sunlight, spray irrigation and percolation through five feet of soils. Sampling after rains showed that the viruses had migrated to the 20-feet deep wells.

In further studies, Wellings and others (1975; 1977) evaluated virus mobility in the subsurface at a Florida site receiving discharge of chlorinated secondary effluent. This study documented subsurface lateral movement of at least 23 feet and virus survival for at least 28 days. Results also appeared to substantiate greater virus mobility after rainfall as well as the inadequacy of

coliform tests as a surrogate for virus tests.

Schaub and Sorber (1977) evaluated a site where unchlorinated effluent was land-applied at rapid infiltration rates through soil comprised of sand and gravel with some silt. Researchers monitored seeded coliphage f2, as well as indigenous enteroviruses at a site where depth to groundwater was 6 feet. The investigation documented that some viruses are capable of moving up to 600 feet laterally in the subsurface at some sites.

Dugan and others (1975) evaluated virus mobility at a site irrigated with chlorinated secondary effluent on silty clay soils. Soil water sampled with lysimeters at 5 feet below land surface yielded detectable viruses in 1 of 28 samples.

Gilbert and others (1976) evaluated virus mobility in the subsurface at the Flushing Meadows project near Phoenix, Arizona. They found no viruses in groundwater (which was 10 feet below infiltration basins) receiving chlorinated secondary effluent. However, one of the co-authors later questioned the virus assay methods used in this study (Gerba, 1987).

Vaughn and others (1978) evaluated virus mobility in the subsurface at three wastewater recharge operations on Long Island. All of the sediments were sand and gravel with 1-2 percent silt. Depth to groundwater ranged from 18-80 feet. Viruses were detected in 25 percent of the samples taken at sites where depth to groundwater was 18-30 feet. No viruses were detected at the recharge site where depth to groundwater was 80 feet.

Moore and others (1981) evaluated virus movement in the subsurface at an irrigation site using unchlorinated secondary effluent applied to Bermuda grass grown on loamy-clay soils over limestone bedrock. Depth to groundwater was 11-17 feet and "no viral isolates were unequivocally confirmed," although fecal coliform monitoring suggested that the wells were contaminated by the effluent irrigation practices. The authors noted problems in the methods used for virus concentration in this study.

Goyal and others (1981) evaluated virus occurrence beneath three wastewater land application sites. The sites were located in Lubbock, Texas; San Angelo, Texas; and Muskegon, Michigan, and all utilized slow-rate infiltration or irrigation with apparently unchlorinated effluent.

Soils varied from sand to clay-loam, and depth to groundwater ranged from 23 to 120 feet. Viruses were detected in some groundwater samples at all of the sites.

Vaughn and others (1983) evaluated virus occurrence in groundwater beneath a septic tank leach field on Long Island. Monitoring wells were up to 59 feet deep and as far as 220 feet away from the leach field. Viruses were detected in all down-gradient wells although virus concentrations appeared to be inversely correlated with distance.

Gerba and others (1985) presented results of viral monitoring of groundwater at 6 sites. Three of these were previously reported by Goyal and others (1981). The three additional sites were: Phoenix, Arizona - rapid infiltration of chlorinated and unchlorinated secondary effluent; Nassau County - recharge and injection of chlorinated tertiary effluent; Dan Region Project, Israel - recharge of unchlorinated post-secondary effluent. Results from the Phoenix site and the Nassau County site showed no virus isolates when the effluent was chlorinated, while results from the Dan Region project did show detectable viruses in groundwater.

Farrah and others (1981) evaluated virus occurrence in groundwater beneath a sludge holding pond and a sludge application site. Groundwater was 40-60 feet below land surface. Bi-monthly monitoring for one year showed no detectable viruses in groundwater.

Schaub and others (1982) evaluated virus mobility in Hanover, New Hampshire, where unchlorinated primary and secondary effluent were applied to large outdoor test cells containing soil of sandy loam to silt loam, with clay content up to 5 percent. Soil percolate was sampled at depths down to 5.6 feet. Viruses were routinely detected, but typically at less than .1 percent of the concentration of the seeded coliphage f2 concentrations in the wastewater.

Vaughn and others (1981) conducted studies at a field situated test recharge basin located in Suffolk County, New York. The basin was underlain by gravelly sand with less than 1 percent silt and clay and received chlorinated tertiary effluent. Soil percolate (various depths) and groundwater at 25 feet were sampled. Although seeded viruses were found at virtually all depths, the researchers concluded that very low infiltration rates yielded the

greatest virus removal rates.

Hurst and others (1980) investigated viral contamination of soil at a test recharge basin located at the Flushing Meadows project. Soil samples from depths down to two feet below land surface were analyzed for viruses. The portion of the study related to indigenous enteroviruses showed that viruses were detectable in all soil samples. Greater virus concentrations were found at upper soil levels, and soil drying was found to increase virus inactivation.

Three studies evaluated virus content in groundwater independent of establishing the source of the viruses. Marzouk and others (1979) found viruses in 20 of 99 groundwater samples in Israel, and found no correlation between virus and bacteria occurrence. Slade (1985) found viruses in well water from a well completed in a chalk aquifer in England which has shown no evidence of bacterial contamination. Amundson and others (1988) documented coliphage contamination of water from 7 wells completed in a karst aquifer in Minnesota.

Based on these field studies, factors that appear to

be important variables in the potential for viral contamination of groundwater include: degree of wastewater treatment, disinfection practices, infiltration rate, application practices (drying cycles, for example), depth to groundwater, climate, and soils type. In general, higher degrees of treatment, disinfection, slower infiltration rates, regular drying cycles, greater depth to groundwater, lower rainfall and finer grained soils appear to decrease the potential for viral contamination of groundwater. These factors were also identified by Keswick and Gerba (1980), who noted that sunlight and temperature also impact viral survival. It is also apparent that coliform bacteria monitoring is not an adequate surrogate for virus monitoring.

Other important factors in virus monitoring include well construction methods, well sterilization and proper sampling equipment. It is commonly known that the annular space of a well can act as a conduit for downward migration of pollutants. However, in only one study reviewed, was specific mention made of sealing the annular space (Moore and others, 1981). In fact, Wellings and others (1975; 1977) noted the potential for piling construction that cut through confining layers to act as a conduit for viruses,

yet failed to recognize that the monitor wells installed for virus sampling cut through the same confining layers and could have been conduits. Contamination during or after construction can be remedied by sterilization. In the studies reviewed, well sterilization was generally not discussed. Proper sterilization and use of sampling equipment is equally important to the validity of viral investigations.

CHAPTER THREE

METHODOLOGY

This study was initiated to characterize more fully the water quality impacts of stream channel recharge of sewage effluent northwest of Tucson and to identify hydrogeochemical mechanisms responsible for water quality transformations. The following steps were taken to implement this study:

- Wells were drilled at twelve locations along the Santa Cruz River downstream of effluent discharge points;

- Groundwater quality monitoring was initiated for inorganic constituents, nitrogen species, trace metals, organics, and coliform bacteria;

- Surface water quality sampling was initiated for the same parameters;

- Specific studies were implemented to evaluate the use of specific tracers including bromide, ^{18}O, ^{2}H, ^{3}H, and ^{15}N;

- Groundwater samples were obtained and assayed for viruses; and,

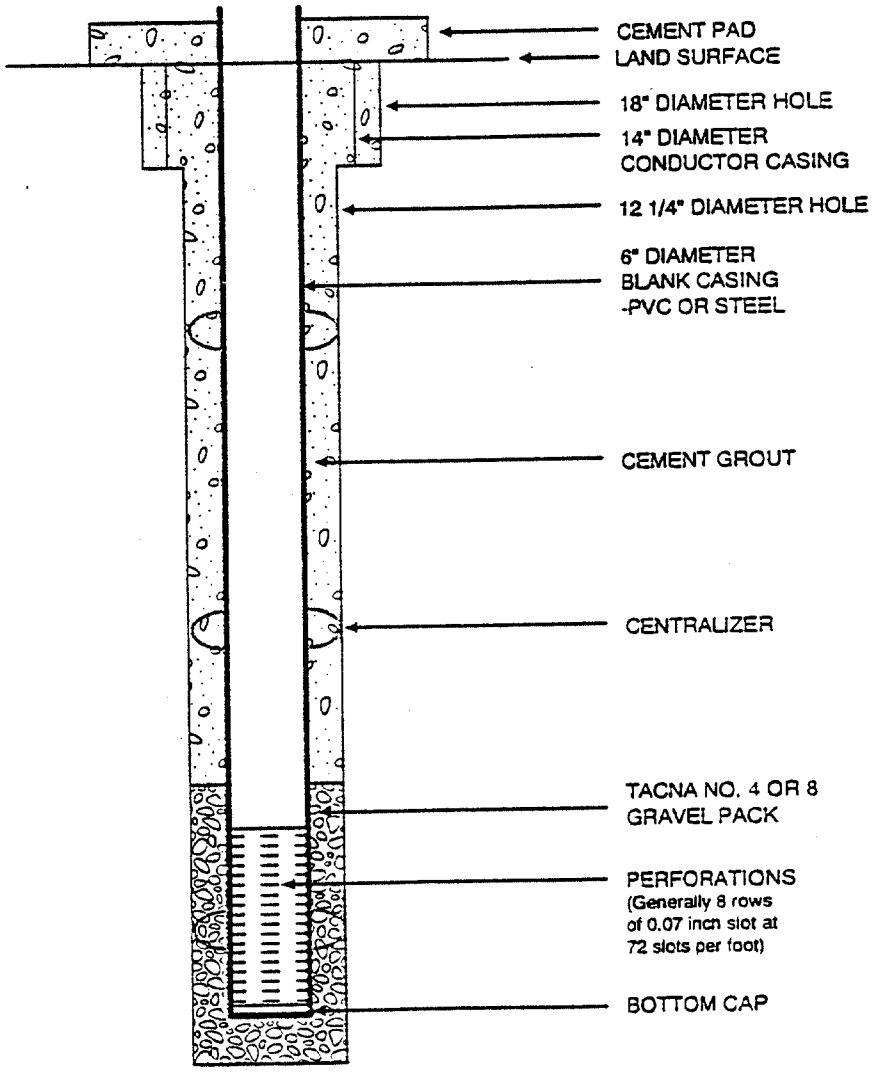
- Specific monitoring of infiltrated effluent in the seepage zone beneath the bed of the Santa Cruz River was undertaken to characterize more fully nitrogen transformations.

The wells were installed using the reverse rotary method in Spring, 1988. Depths of these wells were up to 170 feet in the Cortaro area and nearly 400 feet in the Marana area. The wells were cased with six inch diameter PVC or PVC and steel casing, perforated below the water table. The annular spaces in the wells were gravel packed to above the top of perforations and grouted to land surface. Each well was equipped with a submersible pump, powered by a portable generator. A schematic diagram of well construction details is shown in Figure 4.

Well cuttings were logged and geophysical logs were run in nearly all of the holes. Caliper logs and electric logs, including spontaneous potential, short and long normal resistivity and point resistance were run in all holes that were logged. In selected drill holes, gamma-

FIGURE 4

SCHEMATIC OF MONITOR WELL



After Schmidt, 1988

neutron logs and sonic (velocity) logs were also run. Before installation of the permanent sampling pumps, each well was developed, pumptested and water samples were collected. Grain-size analyses of well cuttings were performed, limited field mineral identification was undertaken (Whaley, personal communication, 1988) and clay mineralogy was determined for selected samples by Blair (1988) and Esposito (1989).

Quarterly groundwater monitoring was initiated after well completion in May, 1988. Water quality monitoring parameters included major inorganic chemical constituents, nitrogen species, trace metals and trace organics. Table 1 is a list of parameters and frequency of sampling/analysis. Field procedures for groundwater quality sampling were generally consistent with those guidelines of Barcelona and others (1985) and those suggested by the US Environmental Protection Agency (1982). General field protocol required that wells be pumped until field parameters of pH, temperature, and electric conductance stabilized. A minimum of three to five well volumes were always evacuated prior to collection of samples for laboratory analyses. Samples were obtained thereafter and transported to respective laboratories in

Table 1

Water Quality Monitoring Parameters and Approximate Frequency of Sampling

Approximate Parameter Group	Frequency of Sampling
Inorganic Chemical Constituents[a]	Quarterly
Metals[b]	Quarterly
Coliform[c]	Quarterly
Trace Organics[d]	Quarterly to Annually

[a] Inorganic chemical constituents include ammonium, calcium, chloride, fluoride, magnesium, nitrate, nitrite, kjeldahl nitrogen, total organic carbon, potassium, phosphate (ortho), sodium, sulfate, TDS, carbonate, bicarbonate.

[b] Trace metals include aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, strontium, zinc.

[c] Includes total and fecal coliform.

[d] Includes EPA methods 625, 608 and 601/602 or 524. See Appendix A for list of constituents.

containers filled and stored according to approved methods. Laboratory analytical procedures followed Standard Methods (Clesceri and others, 1989) and those specified by the Environmental Protection Agency (40 CFR, Part 136). Reference methods and laboratories utilized in this study are summarized in Appendix A.

As part of this investigation, monitoring of effluent flowing in the Santa Cruz River was initiated in 1988 for some sites and in 1990 for other sites. Samples were taken on a "grab" basis. Sample frequency, containers, handling, storage, transportation and analytical methods were the same as for groundwater samples.

Studies were also implemented to evaluate the use of various chemical constituents or isotopes as tracers of sewage effluent in the subsurface. Bromide in water was analyzed in samples collected during the summer of 1989 and the winter of 1990. Deuterium, oxygen-18, and tritium in water from selected wells were analyzed in samples collected in the summer of 1992. ^{15}N in water was analyzed from samples taken during April through August, 1992.

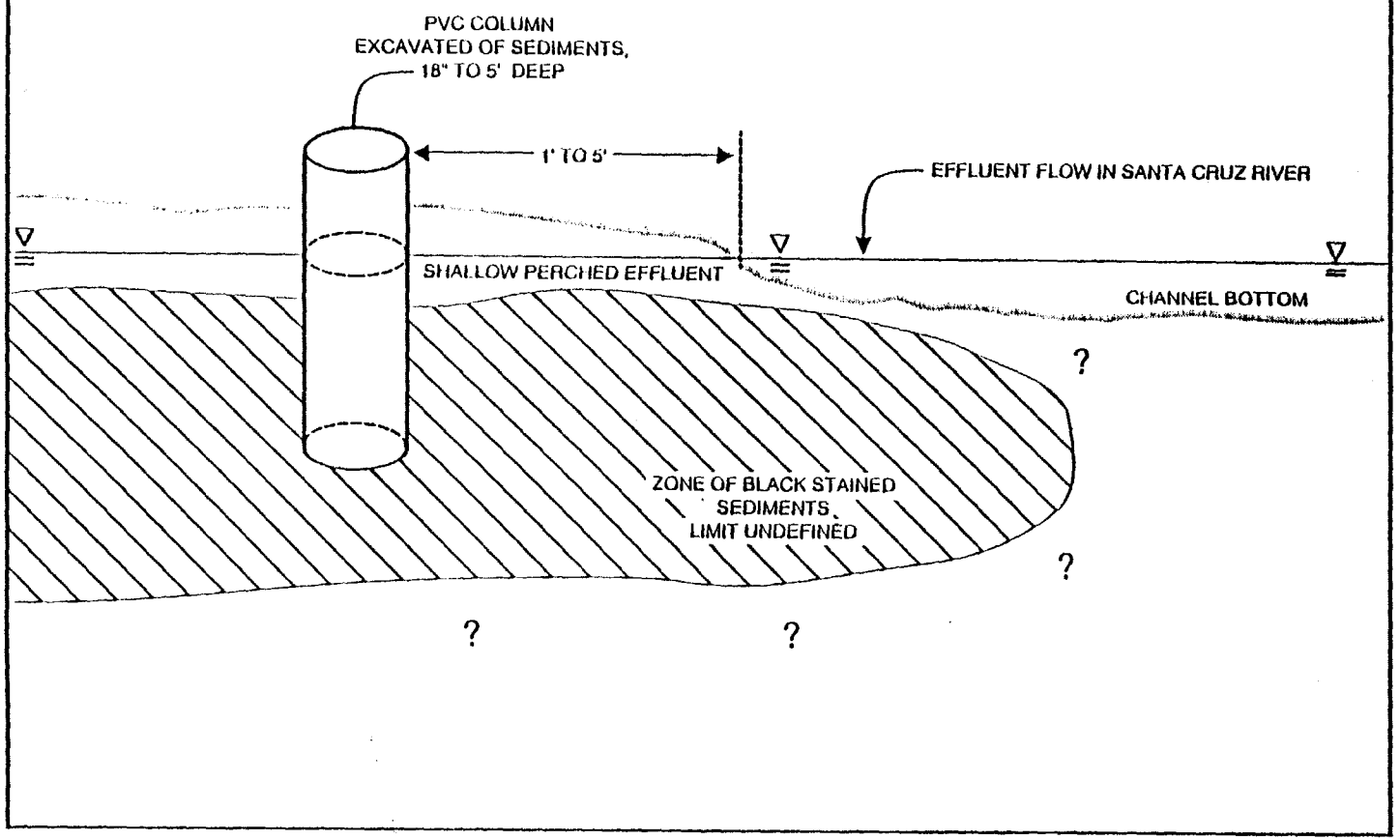
Samples of groundwater were collected on June 2, 1992,

and assayed for viruses from wells SC 1 through 4 on June 2, 1992, from wells SC 1 and 3 on February 17, 1993 (approximately one month after large flood flows on the Santa Cruz River), and on June 23, 1993, from well SC1. Samples were taken from these wells, as they represented the cases for greatest potential for virus transmission to groundwater. This was based on shallow depth to groundwater and the smallest percentage of clay in the unsaturated zone.

The quality of infiltrated effluent immediately beneath the streambed in the Santa Cruz River was also investigated. It was discovered that shallow perched water conditions existed adjacent to effluent flowing in the Santa Cruz River. The construction of temporary collection galleries, similar to shallow piezometers, allowed the sampling of water in this seepage zone. Temporary collection galleries, constructed as shown in Figure 5, allowed the sampling of this shallow perched water from depths of one foot to five feet. After construction of temporary collection galleries, water was bailed until the water cleared. Water samples were collected and analyzed for nitrogen species and organic carbon. Selected samples were also analyzed for general mineral content as well as

FIGURE 5

SCHEMATIC OF SEEPAGE ZONE SAMPLING TECHNIQUE



metals. Soil samples from the subsurface in this zone were analyzed for nitrogen species and organic carbon content. Methods of analyses for the soil samples are included in Appendix A. This portion of the study was termed seepage zone sampling.

Certain background wells were selected for chemical characterization based on their location and depth. The intent was to provide reasonable information on the background concentrations of water quality parameters. These wells were sampled during the summer of 1992. Sampling methods, preservation, and methods of analyses were as discussed as above.

CHAPTER FOUR

RESULTS AND DISCUSSION

This section presents the results of the investigation with discussion of significant results. The components of the study included monitor well installation, surface water quality monitoring, groundwater quality monitoring, evaluation of background groundwater quality, seepage zone sampling, nitrogen isotope analyses and microbiological assays. Each of these subjects is discussed including the significance of effluent recharge to groundwater quality.

Monitor Well Installation

Wells were drilled at locations shown in Figure 1 by methods described in the last chapter. Important information on the monitor wells is shown in Table 2.

Grain-size analyses and cuttings descriptions for the monitor wells in the Cortaro area show that the alluvial deposits are made up largely of sand and gravel eroded from rocks of volcanic origin, with some clay. Grain-size analyses and cuttings descriptions from the monitor wells in the Marana area show an increasing percentage of clay

Table 2
Monitor Well Information

Well	State Well Location	Elevation (ft above MSL)	Perforated Interval (ft)	Static Water Level (ft.) (Winter '92)
SC1	(D-13-13) 20 adb	2244	110-150	119.5
SC2	(D-13-13) 7 ddc	2212	95-135	96.1
SC3	(D-12-12) 35 ddd	2166	90-130	81.2
SC4	(D-12-12) 27 dac	2134	95-135	84.3
SC5	(D-12-12) 22 ccb	2114	105-165	89.5
SC6	(D-12-12) 16 ddb	2095	115-185	92.7
SC7	(D-12-12) 8 cba	2068	120-180	129.0
SC8	(D-12-12) 6 ccd	2047	230-290	211.2
SC9	(D-11-11) 34 cbc	1992	290-380	278.9
SC10	(D-11-11) 33 bcb	1978	300-370	271.6
SC11	(D-11-10) 24 cad	1931	189-329	202.5
SC12	(D-11-10) 14 cbc	1910	230-310	217.4

and silt sized material. In the Marana area, pebble-sized material in cuttings from shallow depths indicate a large percentage of sediments eroded from rocks of volcanic material, while pebbles from greater depths are primarily derived from erosion of granitic or gneissic rocks. Cuttings from the Marana area also are slightly more cemented, particularly with depth.

Evaluation of the subsurface lithologic data from this and other investigations showed the presence of a gravel unit and upper and lower clay units over much of Marana area. The gravel unit is much thicker in the southeast, thins to the northwest and pinches out to the southwest in the study area. The clay units are thickest in the southwest and northwest. To the southeast, the upper clay unit thins considerably, while the lower unit pinches out. All of these units correlate with Allen's (1981) younger alluvium. Based on correlations assigned by these investigators, the units identified in this investigation are also correlative with the Fort Lowell Formation of Davidson (1973), the basin fill of Pashley (1966), and possibly the upper Tinaja beds and Rillito III beds of the same authors, respectively. Although age-dating was not undertaken, these correlations suggest an age of late

Miocene to Holocene for these units and correlative units in the Cortaro area.

Some geophysical logs from the monitor wells can be very useful in groundwater investigations. Absent grain-size analyses or cuttings descriptions, the electric log gives reasonably good, qualitative information on the percentage of fines in the subsurface (see also Repsold, 1989; Schlumberger, 1972). The current study also indicated that integrated travel time and 3-D (sonic) velocity logs can help identify the depth to groundwater. This was also Allen's (1981) observation. Most monitor wells seek to sample the uppermost portion of the saturated aquifer. However, the location of the water table is often difficult to determine in a hole drilled by the reverse rotary method, because drilling fluid is necessary to keep the hole open. In this case, the two logs just mentioned reveal the general location of the water table, which is critical to proper well completion.

Esposito (1989) determined clay mineralogy on composite samples of well cuttings from this investigation based on methods of Moore and Reynolds (1989). For the Cortaro area, samples were composited for the shallow

portion (less than 50 feet in depth) and the deeper portion (greater than 50 feet in depth). For the Marana area, samples were composited for three layers: shallow (0-100 feet in depth), middle portion (100-200 feet in depth) and the deeper portion (deeper than 200 feet). After the cuttings samples were composited, they were suspended in distilled water and placed in an ultrasonic cell disrupter. The samples were then dispersed using sodium hexametaphosphate. Size cuts were made using a centrifuge. Samples were run on a Siemens D-500 X-Ray Diffractometer. Runs were made for both air-dried samples and the same sample saturated in ethylene glycol to achieve maximum clay expansion. Each of the samples showed three phases. Smectite was the major component and mica and kaolinite were the minor fractions in all samples. Identification of smectite as the major component of the clay fraction is consistent with information obtained from Robertson (personal communication, 1988) and from Blair (1988). Other minerals observed based on X-ray diffraction patterns included quartz, feldspar, calcite, zeolite and hematite/pyrite.

Comparisons of the x-ray diffraction patterns for the Cortaro area suggests that the upper portion of the

alluvium (0-50 feet) contains less clay than the lower portion and that a greater percentage of the clay is composed of the minor fractions, mica and kaolinite. Comparisons of the x-ray diffraction patterns for the Marana area suggest increasing clay content with depth and a decreasing proportion of minor fraction (mica and kaolinite) with depth.

Surface Water Quality Monitoring

As part of this investigation, monitoring of effluent in the Santa Cruz River was initiated in 1988. Each site was sampled five to eleven times during a four year period. Samples were analyzed for major inorganic chemical constituents, trace metals and trace organics. Sampling sites in the Santa Cruz River corresponded to the location of groundwater monitor wells. For example, river sampling site SC01RIVR was adjacent to well SC1.

Results of analyses of major inorganic chemical constituents in effluent samples from the Santa Cruz River are presented in Appendix B and summarized in Table 3. Predominant cations include sodium and calcium, while predominant anions include bicarbonate, chloride and

Table 3

Average Inorganic Chemical Constituent Content of Effluent in the Santa Cruz River

Constituent	Concentration mg/l	Concentration meq/l
Ca	51	2.55
Mg	8	0.64
Na	105	4.55
K	13	0.32
HCO_3	227	3.72
Cl	78	22.21
SO_4	86	1.80

Notes: Average based on 86 samples from effluent in Santa Cruz River, throughout wetted reach during 1988 through 1992.
Analytical results from Pima County Wastewater Management Technical Services Laboratory.
See Table 5 for nitrogen content.

sulfate.

The average inorganic chemical quality of effluent in the Santa Cruz River in the Cortaro area was compared to that in the Marana area (Table 4). Statistical evaluation of major inorganic chemical constituents in the river samples implied no significant difference among the average chemical content of the samples from the river sampling stations in the two areas. For this reason, the results of water quality monitoring of effluent in the Santa Cruz were treated as a whole, unless a specific application warranted use of a subset of the data.

Total nitrogen content of effluent in the river averaged about 22 mg/l (Table 5). Nitrate-N (5 mg/l) plus nitrite-N (<1 mg/l) averaged about 25 percent of total nitrogen content. Kjeldahl nitrogen (17 mg/l) constituted approximately 75 percent, with ammonium-N (14 mg/l) constituting the majority of kjeldahl nitrogen and organic nitrogen (3 mg/l) the remainder.

The nitrogen data were evaluated to determine if the average content of nitrogen forms at each sampling station changed systematically with distance (as found by Sebenik,

Table 4
Comparison of Average Inorganic Chemical Quality of Effluent in the Santa Cruz River - Cortaro Area and Marana Area

Constituent	Concentration (mg/l) Cortaro Area	Marana Area
Ca	48	55
Mg	7	10
Na	103	108
K	12	13
HCO_3	231	234
Cl	76	83
SO_4	84	86
NO_3	4	5

Notes: Cortaro area includes sampling stations SCO3RIVR through SCO6RIVR.
Marana area includes sampling stations SCO8RIVR, SCO9RIVR, SC10RIVR and SC12RIVR.
Number of samples = 20.
Data from 1990 through 1992.

Table 5

Average Nitrogen Content of Effluent in the Santa Cruz River

Nitrogen Form	Concentration (mg/l)	Percentage %
NO_3-N	5	23
NO_2-N	<1	<2
NH_4-N	14	64
Org-N	3	14
KjN	17	77
Total N	22	100

Note: KjN = Org N + NH_4-N;
Percentages do not total to 100 due to rounding.
Based on 85 samples.
NO_2 was not detected in 37% of samples.
Non-detectable NO_2-N averaged at detection limit (.2 mg/l).
Total N is less than the sum of components due to averaging method for NO_2-N.
Data from 1990 through 1992.

1975a). No systematic changes were apparent. However, this study was not designed to sample the "same" water sequentially as it flowed in the Santa Cruz River. Further, variability in nitrogen content and nitrogen forms in discharged effluent over time tends to overshadow small changes caused by in-stream changes, such as nitrification.

Trace organic chemicals detected in effluent samples from the Santa Cruz River are shown in Appendix C and summarized in Table 6. Commonly-found trace organics included phthalate esters, halogenated aliphatics such as methylene chloride andchloroform, and aromatics such as toluene. These are constituents that are either contributed by industrial dischargers to the municipal wastewater collection system and not fully removed or degraded during the treatment process or constituents that are created in the treatment process, such as chloroform. Some of these trace organics, (particularly methylene chloride) may also result from laboratory contamination of samples. Generally, fewer occurrences of detectable trace organics were found farther downstream from treatment plant discharge sites, suggesting degradation, volatilization, or sorption of the organic contaminants during surface flow.

Table 6. Summary of Trace Organics Detected in Effluent

Compound	Number Detected	Number of Samples Analyzed	Percent Detected	Maximum (ppb) Concentration
bis (2-ethylhexyl) phthalate	31	44	70.4%	52.5
chloroform	41	84	48.8	2.2
methylene chloride	37	84	44.0	31.3
toluene	26	73	35.6	1.6
di-n-butyl phthalate	8	44	18.2	78.4
1,4 dichlorobenzene	11	135	8.1	0.9

NOTE: Does not include compounds detected three times or less: bromodichloromethane; butylbenzylphthalate; lindane; benzoic acid; tetrachloroethane; 1,1,1 trichloroethane; 1,3 dichlorobenzene; 1,1 dichloroethene; endrin aldehyde; naphthalene; 1,2,3 trichlorobenzene.

Groundwater Quality Monitoring

Quarterly groundwater monitoring was initiated in May, 1988. This report presents approximately three years of quarterly monitoring data. Between ten and fourteen sets of samples were taken from eleven of the twelve wells. The data from Well SC11 were omitted from this report because the pump was damaged early in this study. Wells 1 and 2 are located between the Roger Road WWTF outfall and the Rillito Creek. Wells SC3 through SC6 are in the area generally referred to as the Cortaro area. Well SC7 is located in the vicinity of the Rillito Narrows. Wells 8 through 12 are located in the Marana area (see Figure 1). Water samples were analyzed for major inorganic chemical constituents, trace metals and trace organics.

Results of inorganic chemical analyses of water samples obtained from the Santa Cruz wells are presented in Appendix D. Average inorganic chemical quality data from the Santa Cruz Wells are presented in Table 7. Dominant cations in all of the wells were calcium and sodium and the dominant anions were bicarbonate, chloride and sulfate. These results are shown schematically in stiff diagrams in Figure 6 and a trilinear diagram in Figure 7.

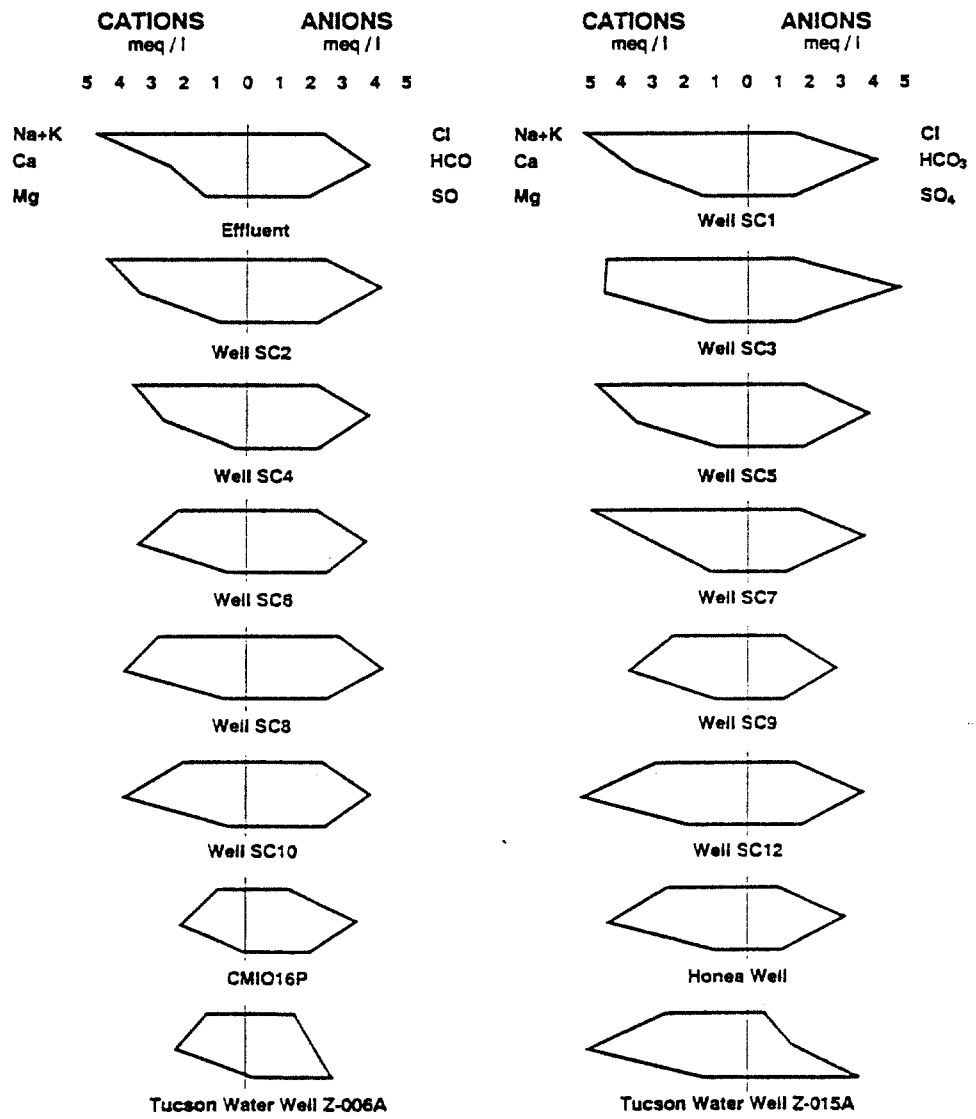
Table 7
Mean Inorganic Chemical Constituent Content of Santa Cruz Monitor Well Water
(Concentration in mg/l)

Well	Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3-N	No. of Samples
SC1	67	12	107	3	274	67	98	1	12
SC2	72	12	104	3	247	77	102	9	11
SC3	83	13	90	3	313	68	77	2	10
SC4	60	9	87	3	217	62	86	5	11
SC5	69	7	99	3	245	70	96	3	12
SC6	77	14	63	3	207	60	99	5	11
SC7	59	11	98	5	250	74	78	<1	12
SC8	86	12	75	2	231	81	98	3	13
SC9	69	10	49	2	182	50	74	5	14
SC10	87	13	59	2	204	65	88	10	13
SC12	100	16	57	2	255	61	91	9	12

Note: For standard deviation values, see Appendix G.

FIGURE 6

STIFF DIAGRAMS - GROUNDWATER AND EFFLUENT



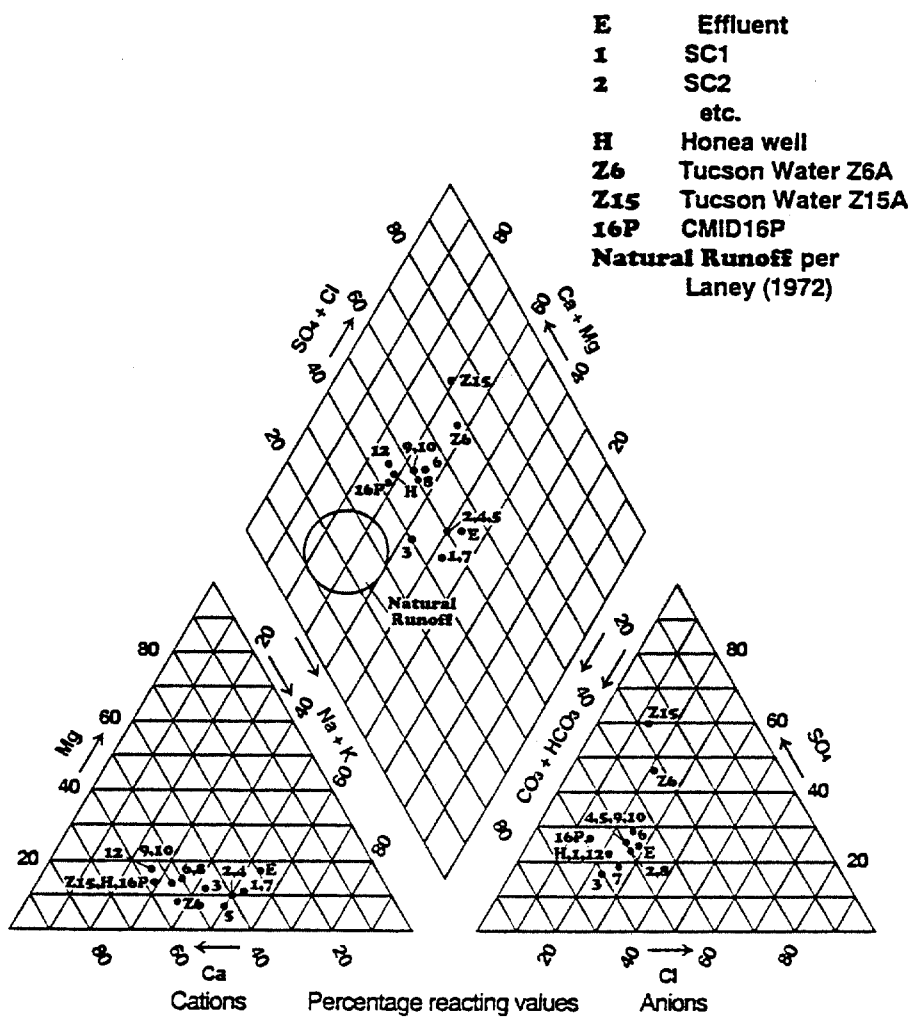


FIGURE 7

TRILINER DIAGRAM - GROUNDWATER AND EFFLUENT

Major inorganic ion data from each of the wells were evaluated to determine whether or not the chemical quality data for each constituent were normally distributed, at the 5 percent significance level. Skewness coefficient was calculated for each inorganic chemical constituent for each well and compared to those values tabulated by Harris and others (1987). This evaluation showed that the data were normally distributed in 69 of 88 cases, or 78 percent of the time. Data which are normally distributed can be evaluated through the use of parametric statistics. Data which are not normally distributed typically must be handled through the useof non-parametric statistics.

Based on hydrogeologic differences between the Cortaro area (Tucson subbasin) and the Marana area (Avra subbasin), as well as differences in the sources of groundwater recharge, it was postulated that the chemical content of groundwater would be similar among Cortaro wells, similar among Marana wells, but different between the two groups of wells.

Evaluation of the data using both parametric and non-parametric statistics for both the entire data set and data sets adjusted to achieve equal populations were undertaken.

Results of the evaluation showed significant differences in major ion chemical characteristics of water in the Cortaro area compared to water in the Marana area. Table 8 shows results of the evaluation for water quality data sets adjusted to achieve equal size populations. The parametric test showed a significant difference between the Cortaro and Marana wells for all constituents except chloride and sulfate. The non-parametric test showed similar results. Overall, the statistical evaluations suggest that groundwater quality in the Cortaro area is different than groundwater quality in the Marana area, and that both areas are impacted by recharged effluent. For purposes of data interpretation and modeling, the two areas should be treated independently.

Evaluation of nitrogen content of water from the SC monitor wells is summarized in Table 9. Nitrate content is the predominant form of nitrogen found in groundwater. Nitrite, ammonium and organic nitrogen were found infrequently at very low concentrations.

Nitrate-N content is extremely variable among the wells. Well SC7 had an average nitrate-N content of 1 mg/l while SC10 averaged 10 mg/l, or equal to the drinking water

Table 8. Comparison of Major Inorganic Chemical Constituent Content of Groundwater - Cortaro and Marana Areas

Constituent	Cortaro Wells[1]	Marana Wells[2]	t-Statistic Probability[3]	Kruskal-Wallace Probability[4]
Ca	72.1	86.0	0.000	0.000
Mg	10.7	12.8	0.000	0.003
Na	85.0	60.3	0.000	0.000
K	2.9	2.0	0.000	0.000
HCO_3	243.8	220.7	0.026	0.063
Cl	65.1	65.1	0.992	0.329
SO_4	89.8	88.9	0.769	0.900
NO_3-N	3.8	6.7	0.000	0.000

[1] Includes wells SC3, SC4, SC5, SC6.
[2] Includes wells SC8, SC9, SC10, SC12.
[3] Probability that means are equal - parametric test.
[4] Probability that means are equal - non-parametric test.

NOTE: All concentrations in mg/l.
Number of samples = 44.
Averages presented in this table will not match overall averages due to sample size adjustment necessary for statistical evaluation.

Table 9

Nitrogen Content of Water from the SC Monitor Wells

Average Concentration (mg/l)[a]		Number Detected/ Number Analyzed		
Well	NO_3-N	Organic N	NH_3-N	NO_2-N
SC1	1	5/12	0/12	0/8
SC2	9	2/11	0/11	1/7
SC3	2	6/10	2/10	0/6
SC4	5	7/11	4/11	0/7
SC5	3	7/12	4/12	0/8
SC6	6	2/11	0/11	0/7
SC7	1	3/10	7/11	0/7
SC8	3	2/11	0/13	0/8
SC9	5	3/12	0/14	2/9
SC10	10	1/13	0/13	0/9
SC12	9	2/12	0/12	0/8

NOTES: [a]Based on 10 to 13 samples per well.

standard. Of particular interest is the difference in nitrate-N content between wells SC1 and SC2 (1 and 9 mg/l, respectively), which otherwise have very similar major ion chemistry. The difference may be due to factors other than sewage effluent recharge, as discussed more fully below. Occasional detection of organic nitrogen and ammonium ion in groundwater is likely due to excess content of these nitrogen forms beyond the sorption capacity of the vadose zone.

Detectable organic contaminants found in groundwater during this study are summarized in Table 10 and detailed in Appendix E. Detectable trace organics were found in groundwater at roughly half the frequency of detections for effluent in the Santa Cruz River. Commonly found trace organics included phthalate esters and selected halogenated aliphatics such as methylene chloride. It should be noted that methylene chloride is a frequent laboratory contaminant and its detection in the sample may be the result of analytical error rather than its presence in the water sample.

Table 10. Summary of Trace Organics Detected in SC Monitor Well Water

Compound	Number Times Detected	Number Time Analyzed	Percent Time Detected	Maximum (ppb) Concentration
methylene chloride	43	134	32.1	30.3
bis(2-ethylhexyl) phthalate	16	62	25.8	32.7
1,2,3 trichlorobenzene	5	68	7.4	0.4
naphthalene	5	130	3.9	0.3
chloroform	5	134	3.7	1.3

NOTE: Does not include compounds detected three times or less: 1,1 dichloroethene; di-n-butyl phthalate; 1,2,4 trichlorobenzene; hexachlorobutadiene; tetrachloroethane; toluene; and trichlorofluoromethane.

Significance of Effluent Recharge to Groundwater Quality

One of the major questions that this investigation attempted to resolve is the significance of stream channel recharge of sewage effluent to groundwater quality in the study area. Important to this question is an evaluation of major chemical ion characteristics of effluent compared to water from the SC wells and background groundwater.

There is no "universal" quality of background groundwater in the study area. For this reason data were collected and wells were sampled in a number of places in the study area. In general, wells were selected based on proximity to SC wells and outside the influence of recharged effluent. Where more than one potential background well was available, preference was given to shallow wells and wells upgradient to particular SC wells. Characteristics of background wells are shown in Table 11 and locations are shown in Figure 1. Major ion chemical quality of background wells is shown in Table 12.

For each SC well, the extent to which groundwater is composed of recharged effluent can be evaluated in a number of ways. Approaches include the use of stiff

Table 11
Summary of Information on Background Wells

Well Name	State Well Location	Completion Depth (ft)	Perforated Interval (ft)
CMID 16P	(D-12-12) 16 ddd	231	68-225
CMID 35H	(D-12-12) 35 add	312	80-300
CMID 26J3	(D-12-12) 26 dbd	453	114-453
CMID 11	(D-11-11) 28 ddd	768	326-584
CMID 8	(D-11-10) 24 aaa	500	170-490
CMID 6	(D-11-11) 34 add	787	340-779
TWZ001A	(D-13-13) 21 bab	500	120-500
TWZ004A	(D-13-13) 17 abc	230	90-225
TWZ006A	(D-13-13) 17 aaa	506	108-506
TWZ015A	(D-13-13) 6 ddd	267	196-236
Honea Well	(D-11-11) 33 aca	500	N/A

NOTES: CMID is Cortaro Marana Irrigation District
TW is Tucson Water

Table 12 Results of Chemical Analyses of Background Wells

CONSTITUENT (mg/l)	WELL NAME AND DATE SAMPLED										
	CMID 16P	CMID 35H	CMID 26J3	CMID 8	CMID 11	HONEA WELL	CMID 6	TW Z-001A	TW Z-004A	TW Z-006	TW Z-015A
	05/12/92	05/12/92	05/12/92	05/12/92	05/12/92	05/13/92	05/12/92	09/10/90	04/13/92	04/14/92	10/02/90
Nitrate-N	3.7	1.7	0.4	8.9	0.7	6.4	2.3	2.4	6.1	2.2	3.6
TOC	ND	ND	ND	ND	ND	ND		0.13	0.32	1.1	
EC (umho/cm)(field)	513	935	928	667	647	679	527			490	715
pH (field)	7.5	7.2	7.9	7.3	7.5	7.4	7.6	7.5	7.5	7.6	7
Temperature (F)	80.3	79.1	93.2	74.3	78.2	74.9	79.8	28.5	24.9	23.1	23.1
Calcium	58	88		80	64	82		96	123	58	100
Magnesium	9	13.3		11.4	6.4	11.3		6.6	13	6.2	11
Sodium	34	102		52	68	49		63	60	45	53
Potassium	2.2	2.6		2.2	2.7	2.1		2.6	2.7	1.3	2.2
Carbonate	ND	ND		ND	ND	ND					
Bicarbonate	170	303		217	218	212		76	126	79	107
Chloride	30.2	76.4	44.2	44.2	26.4	49.2		97	90.4	29.8	30.5
Sulfate	59	130		63	106	80		144	166	91	182
Alkalinity	139	248		178	179	174		125	206	130	175
Fluoride	0.28	0.6		0.35	0.36	0.36		ND	0.29	0.32	0.11
Bromide	0.18	0.24	0.18	0.28	0.15	0.13		0.28	0.4	0.15	0.19
TDS @ 180 C	300	595		455	410	430		540	600	330	540
EC (umho/cm) (lab)	510	950		710	650	700			1000		
pH (lab)	7.6	7.5		7.4	7.7	7.6		7.5	7.4	7.1	7.1
Copper	<.01	<.01		<.01	<.01	<.01		ND	ND		ND
Iron	<.05	0.159		<.05	0.051	<.05		ND	ND		0.26
Manganese	<.01	0.016		<.01	<.01	<.01		ND			ND
Zinc	0.012	0.019		<.01	<.01	0.027		ND	0.73	ND	ND

diagrams and trilinear diagrams to graphically compare major ion chemical characteristics. These diagrams, for effluent, each SC well and selected background wells, are shown in Figures 6 and 7, respectively. In general, calcium and magnesium content are higher in groundwater than effluent, while sodium and potassium content are lower. Chloride content is generally lower in groundwater than effluent (which shows the mixing effect), while sulfate is generally somewhat higher. In particular, water from wells SC1 through SC5 appear to be a mixture of effluent and recharged natural river flow, based on the trilinear diagram in Figure 7.

Major ion chemistry of effluent and groundwater from the SC wells can be more rigorously evaluated statistically, to determine whether chemical composition is similar or significantly different. This evaluation was undertaken by comparing "average" chemical composition for groups of SC wells with average chemical composition of sewage effluent.

An initial evaluation was accomplished by grouping all of the SC wells together and comparing "average" chemical

composition to effluent. These results are shown in Table 13. Using both parametric and non-parametric tests, the evaluation showed a significant difference between means of all constituents with the exception of sulfate and nitrate, for which no significant differences were found. When nitrogen was evaluated rather than nitrate-N, a significant difference was found.

Recognizing that groundwater quality in the Cortaro area is statistically different than groundwater quality in the Marana area, a second evaluation was done using two groups - Cortaro and Marana SC well chemical results compared separately to average effluent composition. These results are shown in Tables 14 and 15, respectively. For the Cortaro area, all of the cations showed a highly significant difference ($p \leq 0.01$) between average groundwater content and average effluent content. Of the anions, only chloride showed a significant difference ($p \leq 0.05$). Results were similar for both parametric and non-parametric tests.

For the Marana area, cations showed a highly significant difference between average groundwater content and average effluent content, with the exception of the

Table 13. Comparison of Major Inorganic Chemical Constituent Content of Effluent and Groundwater

Constituent	Effluent Average [1]	Groundwater Average [2]	t-Statistic Probability [3]	Kruskal-Wallace Probability [4]
Ca	52	77	0.000	0.000
Mg	8	12	0.000	0.000
Na	107	83	0.000	0.000
K	13	3	0.000	0.000
HCO_3	227	248	0.012	0.031
Cl	80	68	0.002	0.000
SO_4	90	90	0.834	0.542
NO_3	6	5	0.125	0.240

[1] Includes all Santa Cruz River sampling stations except river at well SC11.
[2] Includes all wells except SC11.
[3] Probability that the means are equal - parametric test.
[4] Probability that the means are equal - non-parametric test.
NOTE: Concentrations in mg/l.
Number of samples = 55.
Averages presented in this table will not match overall averages due to sample size adjustment necessary for statistical evaluation.

Table 14. Comparison of Major Inorganic Chemical Constituent Content of Effluent and Groundwater in the Cortaro Area

Constituent	Effluent Average [1]	Groundwater Average [2]	t-Statistic Probability [3]	Kruskal-Wallace Probability [4]
Ca	48	78	0.000	0.000
Mg	7	12	0.000	0.000
Na	103	89	0.001	0.001
K	12	3	0.000	0.000
HCO_3	231	258	0.075	0.110
Cl	76	65	0.023	0.044
SO_4	84	92	0.399	0.066
NO_3	4	4	0.053	0.542

[1] Includes all Santa Cruz River sampling stations SC03RIVR through SC06RIVR.
[2] Includes wells SC3 through SC6.
[3] Probability that means are equal - parametric test.
[4] Probability that means are equal - non-parametric test.

NOTE: Concentrations in mg/l.
Number of samples = 20.
Averages in this table will not match overall averages due to sample size adjustment necessary for statistical evaluation.

Table 15. Comparison of Major Inorganic Chemical Constituent Content of Effluent and Groundwater in the Marana Area

Constituent	Effluent Average [1]	Groundwater Average [2]	t-Statistic Probability [3]	Kruskal-Wallace Probability [4]
Ca	55	84	0.000	0.000
Mg	10	13	0.215	0.000
Na	108	60	0.000	0.000
K	13	2	0.000	0.000
HCO_3	234	223	0.357	0.120
Cl	83	67	0.088	0.003
SO_4	86	87	0.885	0.914
NO_3	5	7	0.279	0.096

[1] Includes all Santa Cruz River sampling stations SC08RIVR, SC09RIVR, SC10RIVR, SC12RIVR.
[2] Includes wells SC8, SC9, SC10, SC12.
[3] Probability that means are equal - parametric test.
[4] Probability that means are equal - non-parametric test.

NOTE: Concentrations in mg/l.
Number of samples = 20.
Averages in this table will not match overall averages due to sample size adjustment necessary for statistical evaluation.

parametric test for magnesium, which showed no significant difference. Except for the non-parametric test for chloride, none of the anions showed a significant difference between average groundwater content and average effluent content. In general, these results indicate that shallow groundwater along the Santa Cruz River in both the Cortaro area and the Marana area is composed in large part of recharged sewage effluent, based primarily on the similarity of anion content of the waters. The trilinear diagram plot in Figure 7 clearly illustrates the chemical similarity of the water samples. Small differences in anion content of the waters are likely the result of mixing with natural stormwater recharge and background groundwater. Differences in cation content of the waters could potentially be explained by mixing and cation exchange during the percolation of effluent.

The question of effluent's contribution to groundwater quality can also be addressed through the use of chemical constituent "tracers". Based on suggestions in the literature,both boron content and chloride/bromide ratio were evaluated as tracers. Fluoride was initially thought to be a promising tracer because it is anionic and possibly conservative in the subsurface. However, evaluation of the

data showed only random differences in fluoride content among effluent, background wells and SC wells.

Chloride/bromide ratios varied systematically depending on the apparent impact of recharged sewage effluent. However, more detailed evaluation showed that this variation was due primarily to chloride content.

Boron, as suggested by earlier researchers, appears to be a good tracer for recharged sewage effluent. Boron concentration data from the SC wells, effluent, and selected background wells are shown in Table 16. One of the labs had some initial difficulty in performing boron analyses, and such results which varied by an order of magnitude or more from other analytical results from the same well were omitted from the data used to prepare Table 16. These results are far from conclusive due to the limited number of samples from background wells, but suggest that wells SC1 through SC8 yield water containing a significant amount of recharged effluent; that well SC9 yields water which is not representative of recharged effluent, and that wells SC10 and SC12 yield water which contains some recharged effluent, but less than wells SC1 through SC8. Boron content results lend to speculation

Table 16

Boron Content of Effluent and Selected Wells

Water Source	Boron Content (mg/l)	Number of Analyses
Effluent	.28	50
Well SC1	.32	11
Well SC2	.35	10
Well SC3	.23	8
Well SC4	.24	8
Well SC5	.24	8
Well SC6	.20	7
Well SC7	.25	7
Well SC8	.20	8
Well SC9	<.10	7
Well SC10	.16	9
Well SC12	.13	5
Well CMID26J3	.22	1
Well TWZ004A	<.10	1
Well TWZ006A	<.10	1
Well CMID8	.05	1

that boron isotope analyses may prove useful as a tracer of recharged sewage effluent in future studies.

Overall, data suggest that all of the wells, with the possible exception of SC9 are pumping water with a significant portion of recharged effluent. Based on the inorganic chemical constituent content, recharged effluent appears to compose a smaller fraction of water pumped from the SC monitorwells in the Marana area than in the Cortaro area.

This evaluation leaves unanswered the questions of the fate of nitrogen in effluent and the source of nitrate in wells SC2, SC10 and SC12 (average NO_3-N content of 8.5, 9.9 and 8.4 respectively). This is a particularly important question with respect to wells SC10 and SC12. Nitrate contentof water from well SC10 has exceeded the drinking water standard (10 mg/l) on six of thirteen occasions. Further, work of Sebenik and others (1972) suggested that nitrate content of effluent may increase with downstream flow in the river. Nitrate is considered mobile in the subsurface.

Nitrogen Isotope Analyses

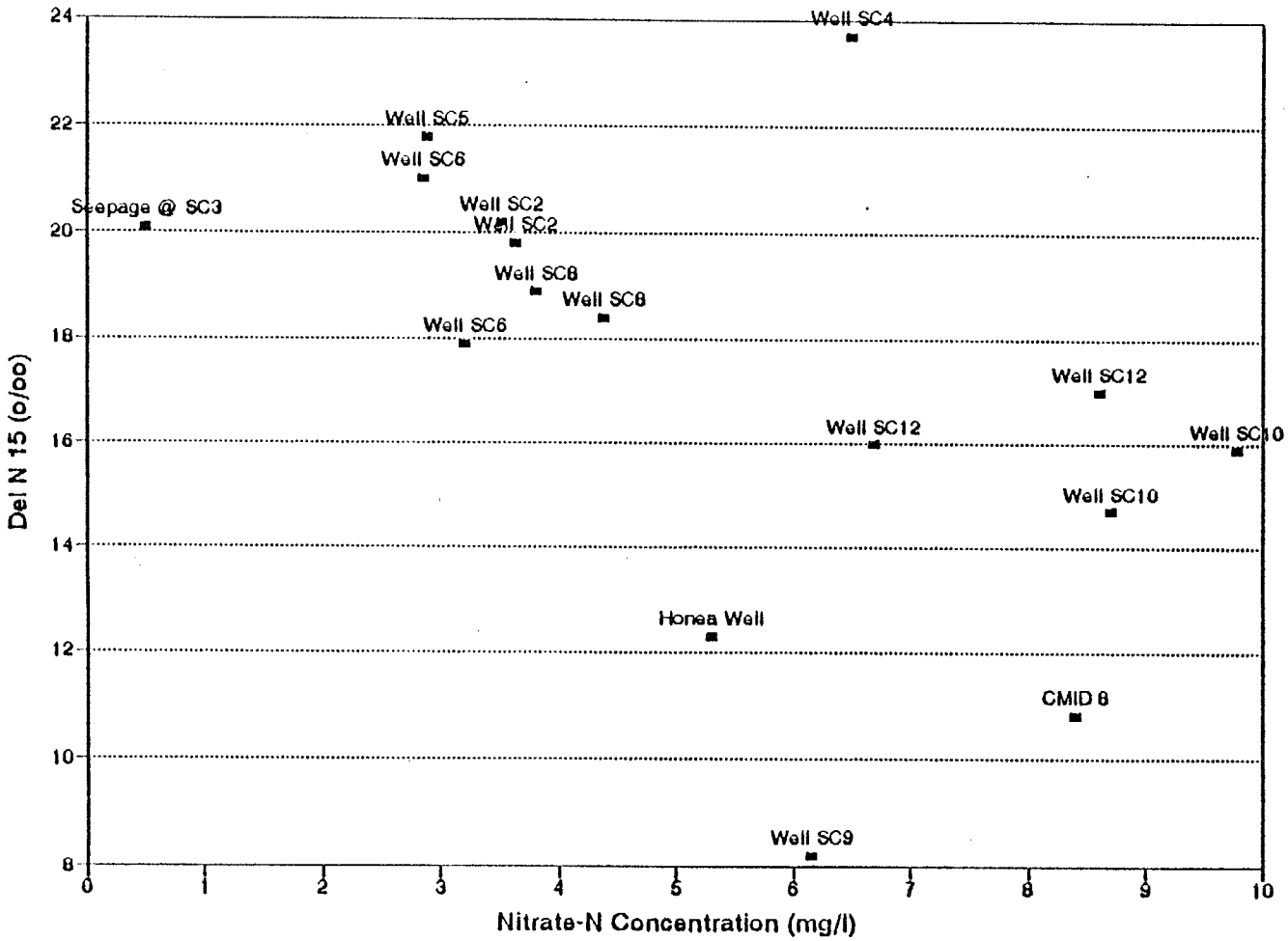
An attempt was made to use $\delta^{15}N$ as a tracer of the source of nitrate in groundwater as well as possibly to yield information on nitrogen transformations taking place. During the spring and summer of 1992 samples were taken from the SC wells, background wells, effluent and the seepage zone (see next section) for analysis of $\delta^{15}N$ content of nitrate (or ammonium in the case of effluent and seepage zone samples). Results of analyses are shown in Table 17 and Figure 8.

Nitrate in groundwater recharged primarily by sewage effluent had a $\delta^{15}N$ content of about +20 per mil while groundwater in primarily agricultural areas was closer to +10 per mil. These results are consistent with earlier research. These data suggest that the source of nitrate in wells SC2, 4, 5, 6, and 7 is recharged effluent. Well SC9 appears to be impacted primarily by agriculture, while wells SC8, 10 and 12 have nitrate derived from both effluent and agriculture. Due to very low nitrate content, samples from wells SC1 and 3 yielded uncertain nitrogen isotope data.

Table 17 Nitrogen Isotope Data

Water Source	NO3-N (mg/l)	del 15-N (per mil)	NH4-N (mg/l)	del 15-N (per mil)	Sample Date
River @ SC3			16.9	11.4	05/13/93
Seepage @ SC3			19.0	11.2	05/13/93
Seepage @ SC3	0.5	20.1	18.2	11.3	05/13/92
Well SC1	0.12	5.2			08/05/92
Well SC2	3.5	20.2			04/23/92
Well SC2	3.6	19.8			08/05/92
Well SC3	0.1	3.6			08/05/92
Well SC4	6.5	23.7			04/29/92
Well SC5	2.9	21.8			08/12/92
Well SC6	3.2	17.9			04/29/92
Well SC6	2.8	21.0			08/12/92
Well SC7	0.9	27.8			08/19/92
Well SC8	3.8	18.9			05/06/92
Well SC8	4.4	18.4			08/19/92
Well SC9	6.2	8.2			08/19/92
Well SC10	8.7	14.7			05/13/92
Well SC10	9.8	15.9			08/26/92
Well SC12	8.6	17.0			05/13/92
Well SC12	6.7	16.0			08/26/92
CMID 8	8.4	10.8			05/12/93
CMID 16P	3.7	10.0			05/12/93
CMID 26J3	0.4	9.3			05/12/92
Honea Well	5.3	12.3			05/13/93

Figure 8. Nitrogen Content Versus $\delta^{15}N$, Effluent and Seepage Zone
(low nitrogen excluded)



Seepage Zone Sampling

Based on qualitative field observations in the spring of 1992, it was surmised that significant hydrogeochemical changes may be occurring to effluent in the seepage zone immediately beneath the bed of the Santa Cruz River. In particular, the occurrence of black-stained sediments and septic-type odors suggested the absence of oxygen and presence of a reducing zone. The possibility of nitrate reduction in the subsurface has also been discussed by other researchers (Sebenik and others, 1972; Wilson and others, 1975; Schmidt, 1973, 1988).

Field experimentation yielded a method to sample water in the seepage zone. This method worked only under saturated conditions, when shallow percolation was unsaturated, such as during or after large stormwater flows, a free water sample could not be taken.

After the sampling method was worked out and preliminary field results confirmed a lack of oxygen in the seepage zone, a detailed sampling plan for the seepage zone was developed and implemented during May through August, 1992. During this period, a total of 19 water samples were

taken from the seepage zone. For each set of seepage zone samples for a particular site, a sample of effluent flowing in the Santa Cruz River was collected adjacent to the area of seepage zone sampling. A total of ten river samples were included.

The following parameters were measured in the field: temperature, electrical conductance, pH, redox potential (Eh), and dissolved oxygen. Laboratory analyses were conducted for other constituents. All samples were analyzed for nitrogen forms, total organic carbon and phosphate. Approximately one-forth of the samples were also analyzed for inorganic chemical constituents, including trace metals. Results are summarized in Table 18 and detailed in Appendix F. Statistical evaluation of the differences in chemical composition between effluent and seepage zone samples are shown in Table 19.

The results show a statistically significant loss of nitrate between the river and the seepage zone in virtually all samples. Dissolved oxygen was consistently one milligram per liter or less in the seepage zone compared one to three milligrams per liter in effluent flow.

Table 18

Comparison of Selected Parameters - Seepage Zone and Effluent

Parameter	Concentration (mg/l) Seepage Zone[1]	Effluent in Santa Cruz River[2]	Selected Effluent Samples[3]
Nitrate-N	0.2	5	2
Kjeldahl-N	17	17	18
Ammonium-N	14	13	14
Organic-N	3	4	4
Total N	17	22	20
TOC	11	16	14
DO	0.6	--	3

[1]Based on average of 19 samples, Non-detectable Nitrate-N averaged as 0.1 mg/l.

[2]Based on average of 49 samples at stations SC01RIVR through SC07RIVR.

[3]Based on average of 10 samples. Sample collection coincided with seepage zone sampling.

Note: Average of nitrate-N for seepage zone was less than detection limit.

Table 19. Comparison of Selected Constituents in Water from Seepage Zone and Selected Samples from Effluent in the Santa Cruz River

Constituent	Average Content in Seepage Water[1]	Average Content in Effluent[2]	t-Statistic Probability[3]	Kruskal-Wallace Probability[4]
NO_3-N[5]	0.4 mg/l	1.5 mg/l	0.000	0.000
NO_2-N[5]	0.1	0.2	0.008	0.026
KjN	16.3	17.9	0.401	0.064
NH_4-N	13.8	13.7	0.968	0.758
Org-N	2.5	4.4	0.002	0.003
Total N	16.7	19.5	0.127	0.011
TOC	10.5	14.1	0.266	0.006
DO	0.5	2.8	0.000	0.000

[1]Based on 19 samples.
[2]Based on 10 samples. Sample collection coincided in time and location with sampling in seepage zone.
[3]Probability that means are equal - parametric test.
[4]Probability that means are equal - non-parametric test.
[5]Average of detections; non-detectable results not included in average. To be more conservative statistically, averaging method differs from method used in Table 18 and is the reason for differences between Tables 18 and 19.

NOTE: Sample sizes are not equal.

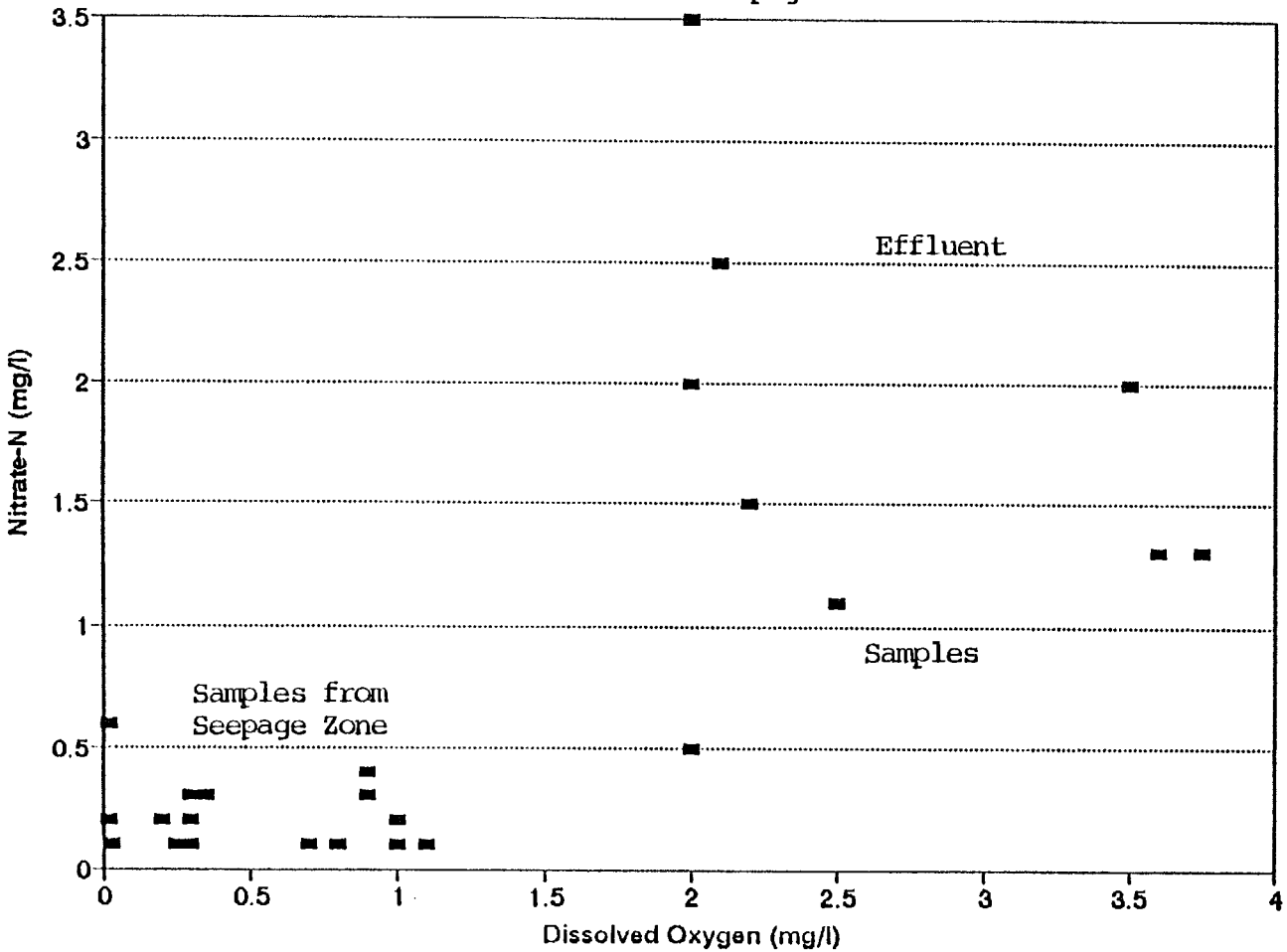
Statistical evaluation showed that the difference between effluent and seepage samples was highly significant for both nitrate content and dissolved oxygen content, based on both parametric and non-parametric tests. Differences in organic nitrogen content of the two waters was also significant. No other statistically significant differences were observed.

The significance of the water quality transformations taking place in one to two feet of percolation through the bed of the Santa Cruz River is illustrated in Figure 9. This figure shows a plot of dissolved oxygen versus nitrate for seepage zone samples and selected river samples (samplecollection coincided in time and location with seepage water sampling). All seepage zone samples are clustered in the lower left portion of the graph, while no effluent sample results plot in this area. The results suggest denitrification of nitrate taking place in the seepage zone. A general reaction believed to be occurring is:

$$2.5C\ (\text{organic}) + 2NO^-_3 + 2H = N_2(g) + 2.5\ CO_2 + H_2O.$$

This reaction needs organic carbon, nitrate and anaerobic

Figure 9. Dissolved Oxygen Versus Nitrate-N,
Effluent and Seepage Zone



conditions, all of which have been documented.

Figure 10 is a plot of dissolved oxygen versus organic nitrogen content of effluent and seepage water. In this graph, DO is used to graphically separate effluent from seepage samples, and is not intended to suggest redox reactions as a method of organic nitrogen removal from the waters. The results show less organic nitrogen content in the seepage water compared to effluent. The likely mechanism for loss of organic nitrogen is immobilization, adsorption or filtration.

Except for nitrogen forms, the inorganic chemical quality of water in the seepage zone was not significantly different from effluent. Elevated contents of total iron and manganese in turbid samples from the seepage zone in comparison to non-turbid samples suggest that the black staining may due to precipitation of iron and manganese. Further evidence for precipitation of iron and manganese is the low content of these metals in receiving groundwater compared to effluent (Table 20). Overall, data from seepage zone sampling shows that the subsurface bed of the Santa Cruz River constitutes an effective denitrification reactor. Limits to the extent of denitrification in the

Figure 10. Dissolved Oxygen Versus Organic Nitrogen,
Effluent and Seepage Zone

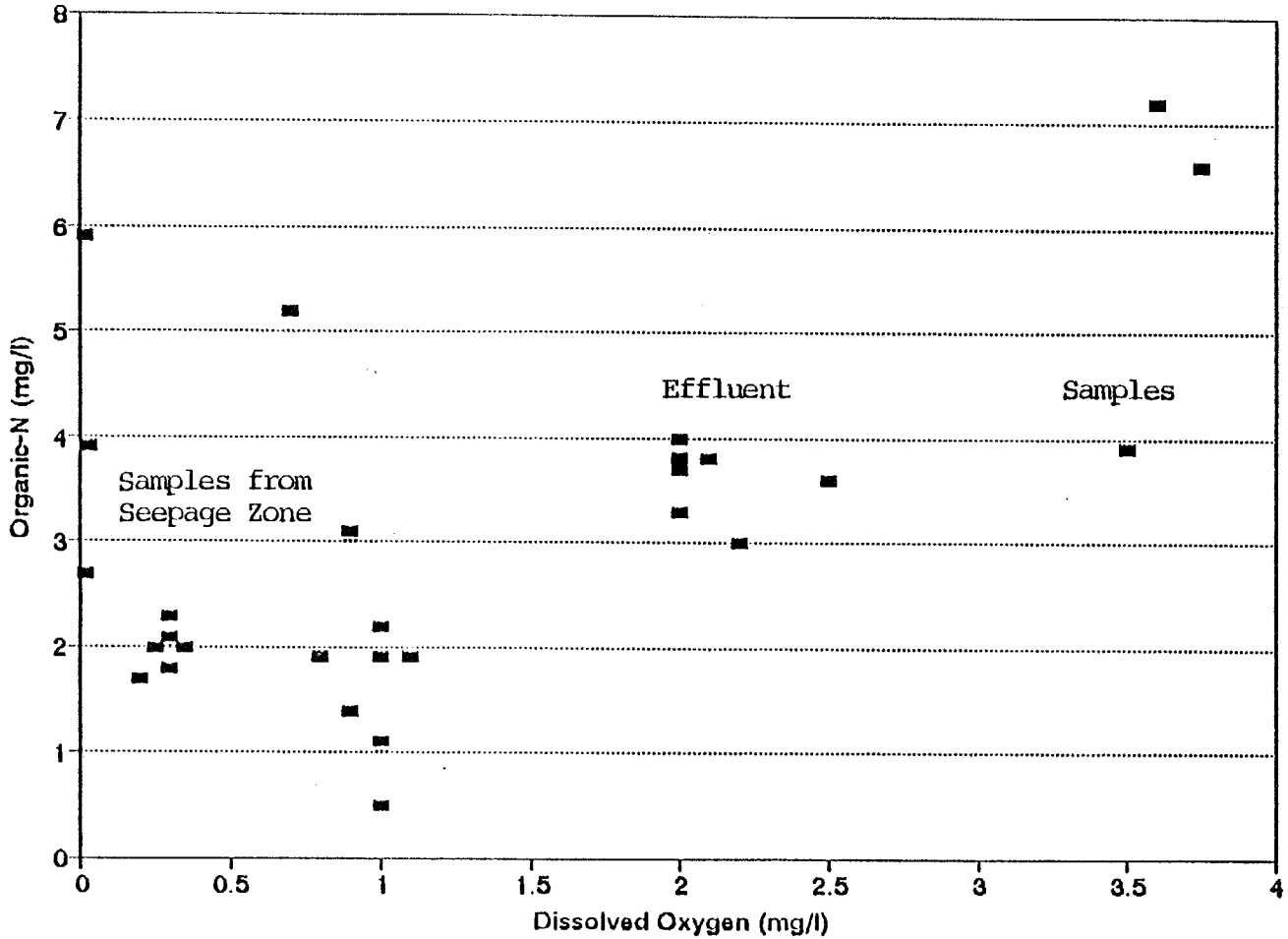


Table 20. Comparison of Concentrations of Selected Metals - Effluent and Groundwater

Effluent			Cortaro Groundwater[c]		Marana Groundwater[d]	
Metal[f]	Avg Conc (mg/l)[a]	No. Detected/ No. Analyses	Avg Conc (mg/l)[a]	No. Detected/ No. Analyzed	Avg Conc (mg/l)[a]	No.Detected/ No. Analyzed
Cu(T)	.03	78/80	.01	18/61	.01	1/43
Cu(D)	.02	7/19	.01	2/11	.01	1/14
Fe(T)	.90[b]	84/86	.25	45/81	.12[e]	39/58
Fe(D)	.06	19/19	.04	2/11	.04	6/14
Mn(T)	.11	88/89	.02	39/82	.01	4/59
Mn(D)	.02	18/19	.01	7/11	.01	0/14

[a]Non-detectable results averaged at detection limit when reported; zero otherwise.
[b]Three suspect results omitted.
[c]Includes wells SC1 through SC7.
[d]Includes wells SC8, 9, 10, 12.
[e]One suspect result omitted.
[f]T denotes total; D denotes dissolved.

seepage zone are discussed in the following chapter on hydrogeochemical modeling.

Based on the observation that organic nitrogen and ammonium appeared to be decreasing during percolation in the seepage zone, several soil samples were taken for nitrogen content analysis. Three samples were taken from the seepage zone and two from the Santa Cruz River bed above the Roger Road outfall. The samples were dried and analyzed for ammonium, nitrate and organic nitrogen content. Results are shown in Table 21. Soil samples from

Table 21

Nitrogen Content of Santa Cruz River Sediments

	Nitrogen Content, mg/kg		
Sample Description	Ammonium - N	Nitrate - N	Kjeldahl - N
Above Roger Rd Outfall	0.3	6.4	46.8
Second Sample	5.3	6.1	39.2
Near Ina Rd Bridge	34.3	<0.5	518
Second Sample	59.0	5.5	442
Third Sample	12.5	5.8	67.3

the seepage zone show significantly greater content of both ammonium and organic nitrogen, suggesting the mechanism of adsorption for removal of these constituent from percolating effluent.

Microbiological Monitoring Results

Results of monitoring showed that coliform bacteria (both total and fecal) are routinely found in sewage effluent in the Santa Cruz River. In fact, nearly every sample of effluent in the Santa Cruz contained significant numbers of both total and fecal coliform.

Results of monitoring from the SC monitor wells showed no detected fecal coliform in any well in a total of 98 samples. Total coliform were found in three wells on one occasion per well, out of 98 total samples. No wells had more than a single sample show detectable coliform, and obviously, none of the wells showed consistent coliform contamination.

Chlorinated sewage effluent from these plants is known to contain significant concentrations of enteric viruses

(Gerba, personal communication, 1992), so transmission of viruses to groundwater was a concern.

Four different SC monitor wells were sampled seven times (one well sampled twice; another three times) and assayed for enteric viruses. The first round of samples showed no detectable enteric viruses in four well water samples. The second round of sampling, conducted after large flood flows in the Santa Cruz River, showed enteric viral contamination of monitor well SC1 (MPN = 2.7/40 l). Contamination of this well could have been due to mobilization of viruses and subsurface transport due to stormwater flows. It could also have been due to poor sampling technique or contamination during water level measurements. Although sampling methods were rigorous, contamination during virus sampling cannot be ruled out. Follow up monitoring at well SC1 six months later showed no enteric viruses present. These results point to the need for expanded monitoring for viruses in the subsurface, particularly after significant storm runoff events.

Other Monitoring Results

Limited samples were obtain and analyses completed for bromide content, ^{3}H, ^{18}O, ^{2}H. Evaluation of analytical results suggested their use as indicators of sewage effluent recharge in this area was far from conclusive. Appendices B, D and G contain bromide results and Appendix G contains ^{3}H, ^{18}O, and ^{2}H results.

Considerations Relate to CAP Water

Interesting water quality changes surrounding stream channel recharge of sewage effluent may be forthcoming as the Tucson area utilizes water delivered by the Central Arizona Project (CAP) in lieu of local groundwater. Data presented in this report represent conditions when no CAP water was supplied for municipal use. As CAP begins to supply a significant percentage of municipal water needs in 1993 and beyond, changes to the inorganic chemical composition of sewage effluent are certain.

Relative to groundwater in the Tucson area, CAP water contains elevated contents of TDS, calcium, magnesium,

sodium, chloride and sulfate. The extent to which the inorganic chemical composition of sewage effluent comes to resemble CAP water is a function of CAP water utilization versus continued use of groundwater. Other parameters which may also change as a result of CAP water use include ^{3}H, ^{18}O and D, as CAP water is derived from meteoric sources.

Changes in inorganic chemical composition of sewage effluent will provide interesting information on the significance of stream channel recharge rates based on the chemical evolution of underlying groundwater. Changes in chemical composition may also result in different hydrogeochemical reactions taking place during recharge. Higher content of dissolved minerals may result in changes to cation exchange reactions as well as precipitation/ dissolution reactions.

CHAPTER FIVE

MODELING RESULTS

This chapter attempts further to explain monitoring results through the application of models. Selected results of water quality monitoring were modeled through the use of NETPATH (Plummer and others, 1991), a state-of-the-art interactive Fortran-based computer code designed to evaluate hydrogeochemical interactions. Conceptual models based on empirical field results and chemical reactions believed to be governing the fate of nitrogen are also proposed.

The basic premise that was developed and tested through geochemical modeling was that mixing and cation exchange could explain the observed differences in chemical quality between effluent and shallow groundwater pumped from the SC monitor wells. This premise was selected based on its simplicity with respect to the possible hydrogeochemical reactions. Also, the statistical evaluation generally showed significant differences among cations but not anions between effluent and groundwater, also suggesting cation exchange.

NETPATH was used to evaluate the major components of ion exchange and mixing. NETPATH results for ammonium ion adsorption were verified through an empirical model of ammonium ion adsorption, based on the results of monitoring. Finally, a conceptual model for denitrification in the seepage zone is proposed, based on likely chemical reactions, and evaluated based on consistency with monitoring results.

Two sites were selected for use in geochemical modeling using NETPATH. These selections were based primarily on the availability of background groundwater quality data. Monitor well SC6 was selected, based on the availability of background data for well CMID 16P, which is located approximately 1/2 mile upgradient of SC6 and is perforated over a similar interval. Well SC10 was selected as the second site due to the availability of background groundwater quality data at the Honea well and at well CMID 11. Although both of these wells are deeper than and neither is directly upgradient from SC10, both are within about one mile of well SC10 and represent the most proximate background groundwater quality data to any of the SC monitor wells in the Marana area.

Input data included averaged results for groundwater quality monitoring for each monitor well, results of one sample analysis of water from the background well(s), and averaged results for water quality monitoring of effluent in the Santa Cruz River. For Well SC6, results for river sampling stations 1 through 7 were included. For modeling at Well SC10, results of all river sampling were included.

NETPATH is a state-of-the-art interactive Fortran-based computer program used to evaluate net geochemical reactions in water. NETPATH revision 1.2 (2/9/92) was used for modeling. Although the models evaluated in this study consisted primarily of ion exchange reactions, NETPATH can also model precipitation, dissolution, redox, gas exchange, evaporation, dissolution and isotopic fractionation reactions. The computer code is designed to evaluate geochemical changes along a groundwater flow path, given water chemistry data and information on subsurface mineralogy. Other uses of NETPATH include evaluation of the geochemical evolution of groundwater for selected isotopic components and radiocarbon dates.

A full discussion of the assumptions and limitation of NETPATH is given by Plummer and others (1991). With

respect to the geochemical evaluation of data from this study, several specific limitations of NETPATH were important. The first limitation related to the selection of chemical constituents of the water sources used as input to NETPATH. In the terminology of Plummer, these constituents are called constraints. For each constraint, a corresponding phase (mineral phase or mineral reaction) must be included. Due to this limitation and in the options available in NETPATH for ion exchange, it was not possible to include all cations as constraints in geochemical modeling. A further limitation of NETPATH with respect to this study related to denitrification reactions. Although NETPATH can account for various nitrogen forms including degassing of nitrogen, there were no specific reactions modeling denitrification. For this reason, the interaction between effluent and the seepage zone was evaluated with a conceptual model based on the stoichiometry of the reaction believed to be occurring.

Cation exchange is a process whereby positively charged chemical species dissolved in water may become attached to negatively charged clay particles. Clay minerals such as montmorillonite with a 2:1 structure (ratio of tetrahedral to octahedral layers) tend to

participate in cation exchange to a much greater extent than the 1:1 minerals like kaolinite (Talibudeen, 1981). Adsorbed cations tend to concentrate near the external edges of the clay mineral. Because they are not an integral part of the clay structure, these cations can be displaced by or exchanged with other cations. The general order of preference for cation exchange is (Hillel, 1982):

$$Al^{3+} > Ca^{2+} > Mg^{2+} > K+ \cong NH_4^{+} > Na+ > Li+$$

Preference for cation exchange is not absolute and depends on many factors including pH, presence of organic matter, the charge of the ion, the size of the ion, the concentration of the ion in solution and in available exchange sites, and the type of clays present. Montmorillonite (smectite) has a cation-exchange capacity of about 0.95 meq/gm while kaolinite's cation exchange capacity is about 0.04 to 0.09 meq/gm (Hillel, 1982). Other clay minerals are typically between these extremes.

Relative to the water chemistry of effluent, groundwater in most of the study area was generally of similar chemical content with respect to major anions. With respect to major cations, groundwater typically

contained more calcium and magnesium and less sodium and potassium than effluent. All of the subsurface soil samples contained some clay and certain zones in the subsurface contained a significant clay component. X-ray diffraction of the clays showed the presence of: smectite, mica minerals, kaolinite, chlorite, quartz, feldspar, calcite, zeolite and hematite/pyrite. The presence of zeolite is a potential explanation for the selective loss of sodium and potassium (Talibudeen, 1981). The general reaction of cation exchange is:

$$m[A^{n+}]soil + n[B^{m+}]soln = n[B^{m+}]soil + m[A^{n+}]soln$$

This was the general equation used in NETPATH to evaluate the proposed geochemical model.

Results of modeling are shown in Appendix H and summarized in Table 22. The NETPATH computer code was able to simulate major cation chemistry changes between effluent and water from monitor wells through models which included only ion absorption and mixing with background (not influenced by effluent) groundwater. This was true for both wells SC6 and SC10.

Table 22. Summary of Cation Exchange Geochemical Models from NETPATH

	Effluent/ SC6	Effluent/ SC10
Ca/NH_4 Exchg[a]	-.368	-.233
Ca/Na Exchg[a]	-.280[e]	-.387
Mg/Na Exchg[a]	-.184	-.165
Mixing Ratio[b]	.71/.29[c]	.64/.36[d]

NOTES: [a]Units are mmols per liter. Positive values indicate the uptake of first constituent and release the second. Negative values indicate the reverse.

[b]Mixing ratio of effluent to background well.

[c]Background well is CMID16P.

[d]Background well is Honea well.

[e]In this model "Ca" consisted of 80% Ca and 20% Mg.

Results were further evaluated with respect to the potential for ammonium ion adsorption in the subsurface. Clay preference for ammonium ion is about the same as potassium, or stronger, depending on the type of clay (Talibudeen, 1981), pH of the system and concentration of constituents. An empirical model was created based on ammonium content of effluent saturated river sediments and infiltration rates measured by various researchers. This empirical model assumed that sediments were replaced or that nitrogen was leached from exchange sites on an annual basis. This assumption was based on the observation that large storm flows scour the streambed and move large volumes of sediments downstream. Such flooding may periodically remove sediments laden with sorbed nitrogen and replace them with sediments having capacity to adsorb morenitrogen. Recharge of flood water also has the potential to nitrify and/or leach ammonium sorbed to sediments.

Results of this evaluation are shown in Table 23. Using an infiltration rate of 1.2 cfs per mile of river length and an average ammonium ion loss of 9 milligrams per liter, (average effluent ammonium content less nitrate content of groundwater; or the amount of ammonium

Table 23 Evaluation of Ammonium Sorption During Effluent Recharge

Infiltration Rate			mg/l NH3-N	NH3-N Loading	NH3-N Ads.	Soil Needed for N Adsorption	
cfs/mile	l/sec/mi	l/lin ft/yr		(kg/lin ft/yr)	(mg/kg soil)	kg	cu ft
1.2	34	202977	9	1.8	35	52194	1491
1.2	34	202977	12	2.4	35	69592	1988
1.2	34	202977	17	3.5	35	98589	2817
3.4	96	575102	9	5.2	35	147883	4225
3.4	96	575102	12	6.9	35	197178	5634
3.4	96	575102	17	9.8	35	279335	7981
5	142	845738	9	7.6	35	217476	6214
5	142	845738	12	10.1	35	289967	8285
5	142	845738	17	14.4	35	410787	11737

potentially sorbing in the subsurface) yielded a nitrogen loading rate of approximately two kilograms per linear foot of channel length per year. Using an ammonium adsorption rate of 35 milligrams per kilogram, an estimated 1,500 cubic feet of sediments would be necessary to adsorb two kilograms of nitrogen. This is significantly less than the volume of sediments encountered during recharge, assuming 40 feet of width, one linear foot in the direction of stream flow, 100 feet to groundwater, and no lateral flow of effluent during recharge. Greater infiltration rates and greater concentrations of ammonium ion in effluent result in increased nitrogen loading rates. The amount of soil necessary for nitrogen adsorption increase correspondingly. However, even at infiltration rates greater than observed by other researchers, the amount of soil necessary for nitrogen adsorption appears to be realistic with respect to sediments encountered by percolating effluent. This is especially so given other loss/sorption process likely to be occurring, such as biologic uptake.

Monitoring results in the seepage zone suggest that nitrate in effluent is undergoing denitrification in the subsurface. A general, overall chemical reaction for

denitrification is (Koram, 1922):

$$5C + 4NO_3^- + 2H_2O = 2N_2 + 4HCO_3 + CO_2$$

where C could represent any number of organic carbon containing compounds. The reaction generally is microbiogically mediated through bacteria such as Pseudomonas, Micrococcus, Achromobacter and Bacillus. The reaction proceeds in the absence of oxygen and requires the presence of organic carbon. Such conditions have been verified in the seepage zone beneath the Santa Cruz River.

Based on the stoichiometry of the reaction, it appears that the extent of denitrification in the current system is limited by the availability of nitrate. Based on overall average organic carbon content of effluent (15.5 mg/l), and assuming the entire amount is available for participation in denitrification reactions, a maximum of 14.5 mg/l of nitrate could potentially be denitrified during effluent percolation.

Hydrogeochemical process related to nitrogen fate during stream channel recharge of sewage effluent are shown conceptually in Table 24 and schematically in Figure 11.

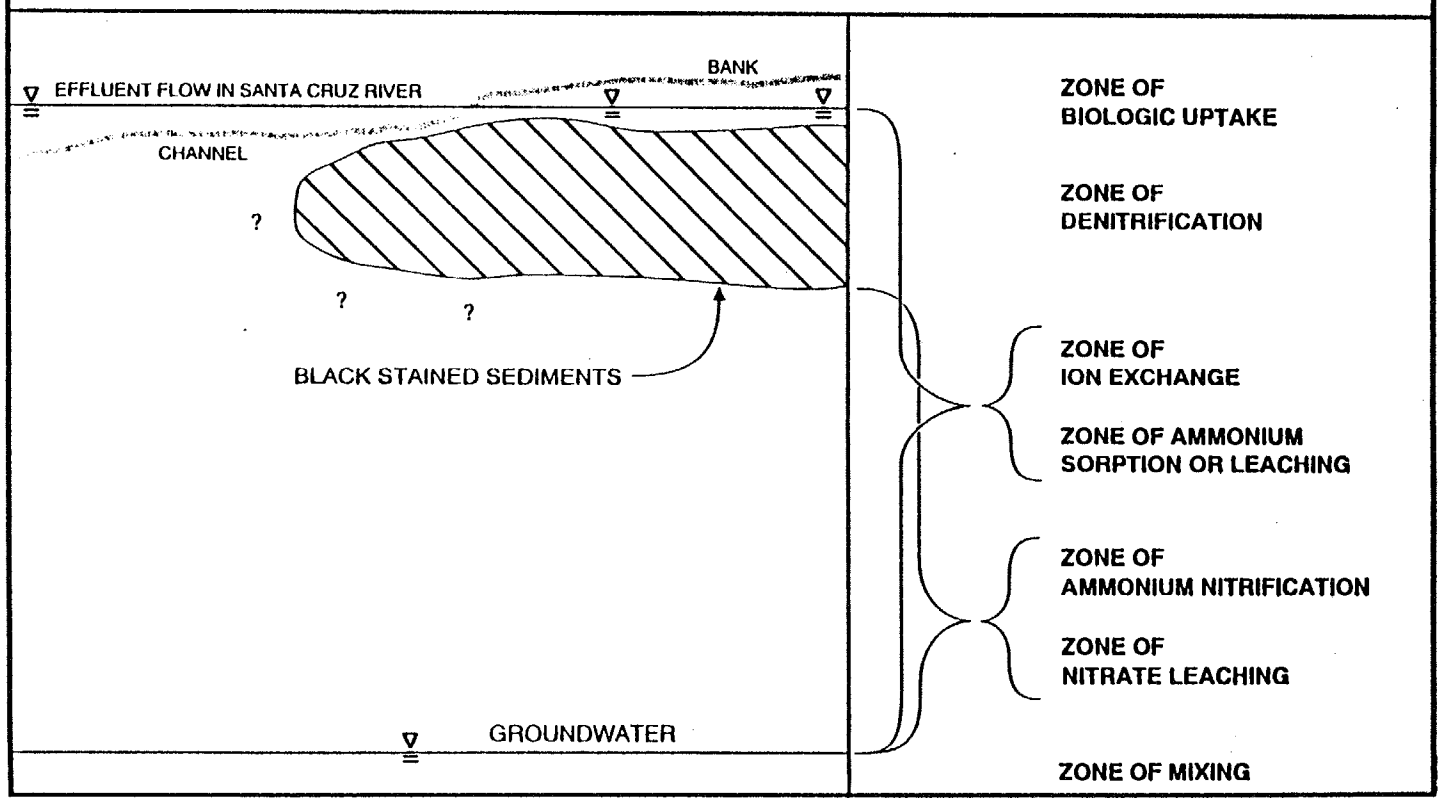
Table 24

Conceptual Model of Nitrogen Fate
During Stream Channel Recharge of Sewage Effluent

Nitrogen Form	Effluent Content (mg/l)	Dominant Chemical Process in Subsurface	Addition to Underlying Groundwater (mg/l)
NO_3-N	5	Denitrification	Trace
Org N	3	Sorption/Filtration	Trace
NH_4-N	14	Sorption/Filtration Nitrification/Leaching	Trace 5 (as NO_3-N)
Total N	22	--	5

FIGURE 11

SCHEMATIC DIAGRAM OF HYDROGEOCHEMICAL PROCESSES INVOLVING NITROGEN DURING STREAM CHANNEL RECHARGE OF SEWAGE EFFLUENT



Up to an average of 5 mg/l of nitrate in sewage effluent is believed to undergo denitrification in the seepage zone.Up to 3 mg/l of organic nitrogen and 9 mg/l of ammonium are believed to be sorbed or filtered, yielding only trace concentrations to groundwater. At least 5 mg/l of ammonium is thought to undergo nitrification in the subsurface and leach to groundwater. This is inferred by the near total loss of nitrate in the seepage zone and the average content of 5 mg/l nitrate for effluent recharged groundwater. Mixing with better quality natural recharge and upgradient groundwater likely dilute nitrate concentrations contributed by effluent so the nitrate content of recharged effluent may be greater than 5 mg/l.

Model results suggest that ion adsorption together with mixing can explain the major water quality changes between effluent in the Santa Cruz River and water from the SC monitor wells. It should be noted, however, that the solutions are not unique and that other geochemical reactions are likely contributing to water quality changes. Further, the fact that adsorption and mixing can explain major ion content changes of percolating effluent does not necessarily mean that adsorption and mixing are in fact taking place. The model represents the simplest conceptual

model that can be used to describe the evolution of water quality as effluent percolates from the bed of the Santa Cruz River to underlying groundwater. It is useful as a basis for further modeling as additional information is gathered with respect to subsurface mineralogy and other geochemical parameters.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

This study has shown that hydrogeochemical changes during the stream channel recharge of sewage effluent can be explained largely by cation exchange and mixing with background groundwater. Other mechanisms at work include denitrification of nitrate in the seepage zone beneath the Santa Cruz River and possible precipitation of some trace metals in the same region. Mechanisms responsible for microbiological renovation of effluent during recharge include filtration of bacteria by sediments and virus sorption and deactivation. Virus sorption and deactivation do not appear to be complete under all conditions. Mechanisms responsible for loss of trace organics are more uncertain, but likely include volatilizaton during stream flow, reduction, microbial/chemical degradation and partitioning. Specific findings include the following:

- Nitrate in shallow groundwater near the Santa Cruz River in the Cortaro area appears to be primarily from stream channel recharge of sewage effluent;

- Nitrate contents of effluent recharged groundwater

averaged about 5 mg/l, well below the maximum contaminant level for drinking water of 10 mg/l, representing a 75 percent loss in total nitrogen during stream channel recharge of sewage effluent;

- Both stream channel recharge of sewage effluent and agricultural deep percolation contribute to nitrate in shallow groundwater near the Santa Cruz River in the Marana area;

- The seepage (reducing) zone beneath the Santa Cruz River may be responsible for denitrification losses of up to 5 mg/l of nitrate-N. This would explain approximately 30% of nitrogen losses, on average, between effluent and recharged groundwater;

- Effective indicators of sewage effluent recharge to groundwater include chloride, boron, $\delta^{15}N$ content of nitrate, and major ion content of the water.

These results suggest that periodic flooding with scouring and flushing effect, may be important to long term continued effectiveness of the system. Results also suggest that increased amounts of nitrogen could be removed

from percolating effluent by increasing nitrification at the treatment facilities. This would be a cost effective way to meet limits on ammonium content in sewage effluent, should limits be set in the future.

Future investigations should be expanded to more fully address the fate and transport of trace organics. Viral fate and transport studies are perhaps more important. Proper implementation of such investigations will require that the wells be disinfected and that field procedures be modified to eliminate the potential for future contamination.

Groundwater quality investigations related to stream channel recharge of sewage effluent are likely to become more interesting as a result of CAP water utilization in Tucson. Elevated sulfate, bicarbonate and especially chloride content should be good indicators of sewage effluent recharge when CAP water is widely utilized. Parameters such as bromide, ^{3}H, ^{18}O and ^{2}H might also prove to be useful indicators of sewage effluent recharge in the future.

With respect to the significance of the seepage zone

to total nitrogen removal, several projects could prove useful. Evaluation of denitrification in areas with diurnal wetting and drying may be interesting. The significance of organic carbon to the reaction is of importance and could be evaluated through column studies, sampling or modeling.

APPENDIX A

Summary of Reference Methods and Laboratories for Analytical Procedures

Parameter	Analysis Method	Method Detection Limit (mg/l unless indicated)
Aluminum (ICP)	EPA 200.7	0.200
Ammonia	EPA 350.1	0.8
Antimony (ICP)	EPA 200.7	0.150
Arsenic	EPA 206.2	0.002
Barium (ICP)	EPA 200.7	0.010
Beryllium (ICP)	EPA 200.7	0.005
Bicarbonate	SM 406A	0.5
Cadmium	EPA 213.2	0.0004
Calcium (ICP)	EPA 200.7	0.030
Carbonate	SM 406A	0.5
Chloride	EPA 325.2	2.0
Chromium (ICP)	EPA 200.7	0.015
Cobalt ICP	EPA 200.7	0.030
Coliform (fecal)	SM 908C	2/100 ml
Coliform (total)	SM 908A	2/100 ml
Conductivity	SM 205	1/umio/cm
Copper (ICP)	EPA 200.7	0.015
Fluoride	EPA 340.2	0.10
Iron (ICP)	EPA 200.7	0.030
Lead	EPA 239.2	0.001
Magnesium (ICP)	EPA 200.7	0.150
Maganese (ICP)	EPA 200.7	0.010
Mercury	EPA 245.1&2	0.0002
Molybdenum ICP	EPA 200.7	0.030
Nickel (ICP)	EPA 200.7	0.100
Nitrate	EPA 353.2	0.2
Nitrite	EPA 353.2	0.2
Nitrogen (kjeldhal)	EPA 351.3	1.0
Nitrogen (total)	CALCULATED	1.0
Phosphates	EPA 365.2	0.2
Potassium (ICP)	EPA 200.7	1.0
Selenium	EPA 270.2	0.005
Silver	EPA 272.2	0.0005

Parameter	Analysis Method	Method Detection Limit (mg/l unless indicated)
Sodium (ICP)	EPA 200.7	0.5
Strontium (ICP)	EPA 200.7	0.005
Sulfate (total)	EPA 375.4	5.0
Thallium (ICP)	EPA 200.7	1.000
Titanium (ICP)	EPA 200.7	0.030
Total Dissolved Solids	EPA 160.1	20
Total Organic Carbon	SM 505B	1.0
Vanadium ICP	EPA 200.7	0.050
Zinc (ICP)	EPA 200.7	0.015

Parameters Included in EPA Method 524

Dichlorodifluoromethane	1,2-Dibromoethane
Chloromethane (Methyl Chloride)	Chlorobenzene
Vinyl chloride	1,1,1,2-Tetrachloroethane
Bromomethane (Methyl Bromide)	Ethylbenzene
Chloroethane	
Trichlorofluoromethane	M & P Xylene
1,1-Dichloroethene	O-Xylene
Methylene chloride	Styrene (ethenylbenzene)
(trans)1,2 Dichloroethene	Bromoform (Tribromomethane)
1,1-Dichloroethane	Isopropylbenzene
2,2-Dichloropropane	1,1,2,2-Tetrachloroethane
(cis)1,2-Dichloroethene	Bromobenzene
Chloroform (Trichloromethane)	1,2,3-Trichloropropane
Bromochloromethane	N-propylbenzene
1,1,1-Trichloroethane	2-Chlorotoluene
Carbon Tetrachloride	1,3,5-Trimethlybenzene
1,1-Dichloropropene	4-Chlorotoluene
(cis)1,3-Dichloropropene	Tert-butylbenzene
(trans)1,3-Dichloropropene	1,2,4-Trimethlybenzene
Benzene	Sec-butylbenzene
1,2-Dichloroethane	P-isopropyltoluene
Trichloroethene	1,3-Dichlorobenzene
1,2-Dichloropropane	1,4-Dichlorobenzene
Bromodichloromethane	N-butylbenzene
Dibromomethane	1,2-Dichlorobenzene
Toluene	1,2-Dibromo-3-chloropropane (DB)
1,1,2-Trichloroethane	1,2,4-Trichlorobenzene
Tetrachloroethene	Hexachlorobutadiene
1,3-Dichloropropane	Naphthalene
Dibromochloromethane	1,2,3-Trichlorobenzene

Detection limit for all parameters is 1.0 ug/l.

Parameters Included in EPA Method

Method 601. Purgeable Halocarbons
(cis)1,3-Dichloropropene
(trans)1,2 Dichloroethene
(trans)1,3-Dichloropropene
1,1,1-Trichloroethane
1,1,2,2-Tetrachloroethane
1,1,2-Trichloroethane
1,1-Dichloroethane
1,1-Dichloroethene
1,2-Dichlorobenzene
1,2-Dichloroethane
1,2-Dichloropropane
1,3-Dichlorobenzene
1,4-Dichlorobenzene
2-Chloroethylvinyl ether
Bromodichloromethane
Bromoform (Tribromoethane)
Bromoethane (Methyl Bromide)
Carbon tetrachloride
Chlorobenzene
Chloroethane
Chloroform (Trichloromethane)
Chloromethane (Methyl Chloride)
Dibromochloromethane
Dichlorodifluoromethane
Methylene chloride
Tetrachloroethene
Trichloroethene
Trichlorofluoromethane
Vinyl chloride

Detection limit for all parameters is 1.0 ug/l.

Parameters Included in EPA Method 602

Method 602. Purgeable Aromatics
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Benzene
Chlorobenzene
Ethylbenzene
Toluene

Detection limit for all parameters is 1.0 ug/l.

Parameters Included in EPA Method 608

Parameter	Method Detection Limit (ug/l)
4,4'-DDD (p,p TDE)	0.10
4,4"-DDE (p,p DDX)	0.10
4,4'-DDT	0.10
A-BHC (alpa)	0.05
Aldrin	0.05
B-BHC (beta)	0.05
Chlordane	0.50
D-BHC (delta)	0.05
Dieldrin	0.10
Endosulfan I	0.05
Endosulfan II	0.10
Endosulfan sulfate	0.10
Endrin	0.10
Endrin aldehyde	0.10
G-BHC (gamma)	0.05
Heptachlor	0.05
Heptachlor epoxide	0.05
PCB-1016	0.50
PCB-1221	0.50
PCB-1232	0.50
PCB-1242	0.50
PCB-1248	0.50
PCB-1254	1.00
PCB-1260	1.00
Toxaphene	1.0

Parameters Included in EPA Method 624

Chloromethane (Methyl Chloride)
Vinyl chloride
Bromomethane (Methyl Bromide)
Chloroethane
Trichlorofluoromethane
Acetone
1,1-Dichloroethene
Carbon Disulfide
Methylene chloride
(trans)1,2 Dichloroethene
1,1-Dichloroethane
Vinyl acetate (acetic acid vinyl)
2-Butanone
Chloroform (Trichloromethane)
1,1,1-Trichloroethane
Carbon tetrachloride
Benzene
1,2-Dichloroethane
Trichloroethene
1,2-Dichloropropane
Bromodichloromethane
2-Chloroethylvinyl ether
4-Methyl-2-pentanone
(cis)1,3-Dichloropropene
Toluene
(trans)1,3-Dichloropropene
1,1,2-Trichloroethane
2-Hexanone
Tetrachloroethene
Dibromochloromethane
Chlorobenzene

Ethylbenzene
O-Xylene
Styrene (ethenylbenzene)
Bromoform (Tribromomethane)
1,1,2,2-Tetrachloroethane
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2-Dichlorobenzene

Detection limit for all parameters is 1.0 ug/l.

Reference Methods for Analytical Procedures

Parameter	Reference Method
Enteric Virus	SM 9510 - G.
Bromide	EPA 300.
Boron	EPA 200.7.
^{3}H	Lindquist, 1992.
^{2}H, ^{18}O	Coleman and Others, 1982. Epstein and Mayeda, 1953.
Clay X-Ray Diffraction	Moore and Reynolds, 1989.
^{15}N	Bremner and Keeney, 1965. Bremner and Edwards, 1965. Kreitler, 1975. Gormley and Spalding, 1979.
N Content of Sediments	
Ammonia - N	EPA 350.1
Nitrate - N	EPA 300.0
TKN	EPA 351.1

Laboratories Performing Analytical Procedures

Inorganic chemical constituents; metals; coliform	BC Laboratories Bakersfield, California (through 7/89 only) Pima County Wastewater Department Technical Services Section Laboratory Tucson, Arizona
Trace Organics	California Analytical Laboratories Sacramento, California (through 7/89 only) Pima County Wastewater Department Technical Services Laboratory Tucson, Arizona
^{15}N	Hydrotrace, Inc. Raymond, Nebraska
^{3}H	University of Arizona Department of Geosciences Laboratory of Isotope Geochemistry Tucson, Arizona
$^{18}O/^{2}H$	University of Arizona Department of Geosciences Laboratory of Isotope Geochemistry Tucson, Arizona
N Content of Sediments	Turner, CAS Laboratories Tucson, Arizona
Viruses	University of Arizona Microbiology Department Tucson, Arizona
X-Ray Diffraction - Clays	USGS Clay Mineralogy Laboratory Lakewood, Colorado
Bromide	Turner, CAS Laboratories Tucson, Arizona Pima County Wastewater Department Technical Services Section Laboratory Tucson, Arizona

APPENDIX B

Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and Other Parameters

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters

Sample Station/ Constituent (mg/l)	DATE SAMPLED 03/07/90	04/03/90	05/01/90	10/03/90	01/08/92
River at SC-01					
Calcium (T)	52.0000	51.3000	57.3000	48.3000	44.9000
Magnesium (T)	6.8500	6.6300	7.7000	6.6300	6.5600
Sodium (T)	102.0000	115.0000	117.0000	103.0000	86.2000
Potassium (T)	15.1000	9.9000	10.4000	10.9000	12.8000
Carbonate	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate	192.0000	226.0000	238.0000	143.0000	193.0000
Chloride	63.4000	82.9000	73.7000	76.9000	67.5000
Sulfate (T)	90.4000	94.0000	108.0000	94.4000	87.0000
Nitrate (as N)	6.9000	4.1500	3.3000	11.4000	2.1000
Nitrogen-Organic	4.8000	2.6000	4.9000	4.1000	3.6000
Nitrogen-Total (CALC)	23.0400	20.9500	23.9000	17.6000	15.9000
Boron (T)	0.0720	0.2250 33	0.1250 33		
Fluoride (T)	0.7200	0.6000	0.6000	0.7000	0.6200
Cation/Anion Balance	9.0300 03A	5.9800 03A	7.9100 03A	3.6200 03A	3.8400 03A
Electrical Conductivity	916.0000	880.0000	880.0000	610.0000	790.0000
Field air temperature (C)				23.1000	
Field Electrical Conductivity	936.0000	0.0000	980.0000	860.0000	
Field pH	7.1500	7.7400	7.6800	7.5900	7.5000
Field water temperature (C)	23.0000	25.3000	26.0000	28.1000	
TDS @ 180 C	546.0000	556.0000	608.0000	597.0000	519.0000
TOC	21.6000	12.8000	19.2000	14.5000	12.1000
Laboratory	TSS	TSS	TSS	TSS	TSS

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 03/07/90	04/03/90	05/01/90	10/03/90	01/08/92	
River at SC-01						
Aluminum (T)	0.0910	0.0700	<0.0500		<0.2000	
Antimony (T)	<0.0625	<0.0625	<0.0625		<0.1500	
Arsenic (T)	0.0070	0.0050	0.0060	0.0080	0.0070	
Barium (T)	0.0490	0.0330	0.0390	0.0620	0.0320	
Beryllium (T)	<0.0013	<0.0013	<0.0013	0.0010	<0.0050	
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0004	
Chromium (T)	<0.0088	<0.0088	<0.0088	<0.0088	<0.0150	
Cobalt (T)					<0.0300	
Copper (T)	0.0320	0.0110	0.0230	0.0200	0.0000	
Iron (T)	0.2880	0.1810	0.1650	0.6900	0.2040	
Lead (T)	0.0020	0.0020	0.0020	0.0070	0.0010	
Manganese (T)	0.0100	0.0070	0.0080	0.0320	0.0130	
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0005	
Molybdenum (T)					<0.0300	
Nickel (T)	<0.0125	<0.0125	<0.0125		<0.1000	
Selenium (T)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	
Silver (T)	<0.0125	<0.0125	<0.0125	0.0042	0.0015	
Strontium (T)				0.4530	0.3840	67
Thallium (T)	<0.2500	<0.2500	<0.2500		<1.0000	
Tin (T)	<0.2500	<0.2500			<0.2000	67
Titanium (T)	<0.0500	<0.0500		<0.0500	<0.0300	67
Vanadium (T)					<0.0500	
Zinc (T)	0.0640	0.0390	0.0520	0.0460	0.0340	
Laboratory	TSS	TSS	TSS	TSS	TSS	

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
33 - Results suspect.
67 - Not approved EPA method

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 11/08/88	02/22/89	07/19/89	02/16/90	03/07/90	04/03/90	05/01/90	10/03/90
River at SC-02								
Calcium (T)	56.0000	60.0000	57.0000	61.1000	53.8000	52.8000	57.0000	49.3000
Magnesium (T)	7.9000	7.9000	8.0000	7.1000	7.3800	6.1000	7.6000	7.7500
Sodium (T)	120.0000	130.0000	128.0000	102.0000	107.0000	113.0000	114.0000	109.0000
Potassium (T)	14.0000	14.0000	12.0000	13.0000	15.2000	9.9000	10.1000	11.5000
Carbonate	<2.6000	<2.6000	<2.6000	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate	264.0000	169.0000	213.0000	136.0000	198.0000	230.0000	231.0000	150.0000
Chloride	87.8000	109.0000	90.6000	81.4000	66.6000	90.3000	71.6000	84.9000
Sulfate (T)	113.0000	124.0000	132.0000	87.2000	90.4000	94.4000	110.0000	94.4000
Nitrate (as N)	4.1300	19.2000	10.8200	14.6000	6.9000	4.1600	3.5000	12.0000
Nitrogen-Organic	5.4000	<0.2000	1.4000	5.0000	4.5000	4.0000	5.0000	3.4000
Nitrogen-Total (CALC)	22.7300	21.5000	14.2200	23.6000	23.5000	23.0600	23.7000	18.2000
Boron (T)	0.2300	0.2500	0.2900	0.0160	0.0670	0.2440 33	0.1830 33	
Bromide			0.3000					
Fluoride (T)	0.6700	0.6000	0.7600	0.5800	0.7000	0.6000	0.6000	0.6900
Cation/Anion Balance	2.5200 03A	0.0500	0.3100	7.4900 03A	9.8600 03A	4.2300 03A	7.7600 03A	4.2800 03A
Chloride/Bromide Ratio			302.0000					
Electrical Conductivity	940.0000	950.0000	840.0000	980.0000	922.0000	910.0000	940.0000	664.0000
Field air temperature (C)								25.3000
Field Electrical Conductivity	912.0000	876.0000	450.0000 17	827.0000	0.0000 17C	1043.0000	1040.0000	862.0000
Field pH	7.6000	7.4400	7.4800	6.7000	7.4000 33	7.8000	7.7200	7.7500
Field water temperature (C)	27.0000	23.5000	34.0000	20.0000		26.5000	25.5000	28.6000
pH	7.3000	7.5000	7.9000					
TDS @ 180 C	560.0000	620.0000	630.0000	574.0000	561.0000	550.0000	614.0000	607.0000
TOC	19.0000	14.8000	14.0000	24.0000	15.2000	10.9000	24.2000	10.1000
Laboratory	BCL	BCL	BCL	TSS	TSS	TSS	TSS	TSS

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED							
	11/08/88	02/22/89	07/19/89	02/16/90	03/07/90	04/03/90	05/01/90	10/03/90
River at SC-02								
Aluminum (T)				0.1900	0.1400	0.1350	0.4500	
Antimony (T)				<0.0625	<0.0625	<0.0625	<0.0625	<0.0625
Arsenic (T)	<0.0100	<0.0100	<0.0100	0.0070	0.0070	0.0050	0.0060	0.0100
Barium (T)	<0.1000	<0.1000	<0.1000	0.0470	0.0500	0.0350	0.0400	0.1050
Beryllium (T)				<0.0013	<0.0013	<0.0013	<0.0013	0.0020
Cadmium (T)	<0.0050	<0.0050	<0.0010	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Chromium (T)	<0.0100	<0.0100	<0.0100	<0.0088	<0.0088	<0.0088	<0.0088	<0.0088
Copper (T)			0.0160	0.0240	0.0330	0.0120	0.0240	0.0340
Iron (T)	0.1200	0.1100	0.2030	0.3900	0.3380	0.2280	0.5130	2.2400
Lead (T)	<0.0100	<0.0100	<0.0100	0.0020	0.0020	0.0040	0.0020	0.0040
Manganese (T)	0.0300	0.0100	0.0170	0.0100	0.0120	0.0110	0.0150	0.0830
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nickel (T)				<0.0125	<0.0125	<0.0125	<0.0125	
Selenium (T)	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Silver (T)	<0.0100	<0.0100	<0.0100	<0.0125	<0.0125	<0.0125	<0.0125	0.0044
Strontium (T)								0.4550
Thallium (T)				<0.0050	<0.2500	<0.2500	<0.2500	
Tin (T)				<0.2500	<0.2500	<0.2500		
Titanium (T)				<0.0500	<0.0500	<0.0500		0.2390
Zinc (T)			0.0370	0.0550	0.1750	0.0400	0.0590	0.0590
Laboratory	BCL	BCL	BCL	TSS	TSS	TSS	TSS	TSS

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 01/08/92
River at SC-02	
Calcium (T)	43.9000
Magnesium (T)	6.7300
Sodium (T)	99.8000
Potassium (T)	12.4000
Carbonate	<0.5000
Bicarbonate	190.0000
Chloride	68.0000
Sulfate (T)	79.0000
Nitrate (as N)	2.6000
Nitrogen-Organic	3.9000
Nitrogen-Total (CALC)	16.0000
Fluoride (T)	0.6300
Cation/Anion Balance	8.1600 03A
Electrical Conductivity	760.0000
Field pH	7.6000
TDS @ 180 C	513.0000
TOC	12.8000
Laboratory	TSS

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 01/08/92	
River at SC-02		
Aluminum (T)	0.2770	
Antimony (T)	<0.1500	
Arsenic (T)	0.0060	
Barium (T)	0.0410	
Beryllium (T)	<0.0050	
Cadmium (T)	<0.0004	
Chromium (T)	<0.0150	
Cobalt (T)	<0.0300	
Copper (T)	<0.0150	
Iron (T)	0.3900	
Lead (T)	0.0020	
Manganese (T)	0.0240	
Mercury (T)	<0.0005	
Molybdenum (T)	<0.0300	
Nickel (T)	<0.1000	
Selenium (T)	<0.0050	
Silver (T)	0.0017	
Strontium (T)	0.3960	67
Thallium (T)	<1.0000	
Tin (T)	<0.2000	67
Titanium (T)	<0.0300	67
Vanadium (T)	<0.0500	
Zinc (T)	0.0330	
Laboratory	TSS	

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
17C - Field EC is not temp. adjusted due to missing temp data.
17D - Field EC not determined, temp greater than 30 C.
33 - Results suspect.
67 - Not approved EPA method

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 11/08/88	02/22/89	07/18/89	02/16/90	03/07/90	04/03/90	05/01/90	10/03/90
River at SC-03								
Calcium (T)	48.0000	100.0000	48.0000	42.5000	45.5000	46.3000	48.8000	42.8000
Magnesium (T)	6.3000	15.0000	6.8000	5.9800	6.1500	4.9800	6.1000	5.7800
Sodium (T)	111.0000	102.0000	111.0000	95.8000	95.8000	104.0000	81.0000	87.0000
Potassium (T)	13.0000	13.0000	12.0000	12.9000	15.0000	9.6000	10.0000	11.4000
Carbonate	<2.6000	<2.6000	<2.6000	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate	294.0000	276.0000	276.0000	191.0000	216.0000	241.0000	249.0000	256.0000
Chloride	89.6000	104.0000	81.8000	78.1000	59.7000	74.2000	67.0000	62.6000
Sulfate (T)	89.0000	94.0000	90.0000	71.2000	76.8000	78.0000	86.4000	97.2000
Nitrate (as N)	1.8700	21.1600	6.4900	7.2000	4.0000	2.4000	1.8000	2.5000
Nitrogen-Organic	5.5000	<0.2000	1.3000	4.5000	5.1000	3.5000	3.7000	2.0000
Nitrogen-Total (CALC)	28.5700	21.1600	24.7900	25.5000	25.4000	23.1000	24.7000	22.5000
Boron (T)	0.1900	0.2600	0.2400	0.0460	0.0950	0.2500	0.2220 33	
Bromide			0.2600					
Fluoride (T)	0.4500	0.4300	0.4500	0.4600	0.5800	0.4700	0.4800	0.0450
Cation/Anion Balance	1.3200	0.2300	0.7600	4.5500 03A	8.7000 03A	5.3600 03A	0.9400	0.5500
Chloride/Bromide Ratio			314.6200					
Electrical Conductivity	940.0000	960.0000	900.0000	920.0000	906.0000	850.0000	890.0000	605.0000
Field air temperature (C)								28.9000
Field Electrical Conductivity	893.0000	906.0000	675.0000 17	837.0000	928.0000	926.0000 33	949.0000	824.0000
Field pH	7.2100	7.2300	6.9300	6.4500 33	7.0000	7.2000 33	7.2700	7.0600
Field water temperature (C)	28.0000	25.0000	35.0000	21.0000	23.5000	27.5000	28.0000	31.1000
pH	7.3000	7.3000	7.4000					
TDS @ 180 C	565.0000	555.0000	525.0000	514.0000	499.0000	490.0000	516.0000	477.0000
TOC	37.0000	17.2000	14.0000		18.0000	12.8000	14.5000	16.4000
Laboratory	BCL	BCL	BCL	TSS	TSS	TSS	TSS	TSS

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED							
	11/08/88	02/22/89	07/18/89	02/16/90	03/07/90	04/03/90	05/01/90	10/03/90
River at SC-03								
Aluminum (T)				0.3650	0.2830	0.3200	0.2090	
Antimony (T)				<0.0625	<0.0625	<0.0625	<0.0625	<0.0625
Arsenic (T)	<0.0100	<0.0100	<0.0100	0.0060	0.0030	0.0040	0.0100	0.0080
Barium (T)	<0.1000	<0.1000	<0.1000	0.0470	0.0590	0.0430	0.0420	0.0840
Beryllium (T)				<0.0013	0.0040	<0.0013	0.0020	0.0020
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Chromium (T)	<0.0100	<0.0100	<0.0100	<0.0088	<0.0088	<0.0088	<0.0088	<0.0088
Copper (T)			0.0160	0.0210	0.0270	0.0140	0.0150	0.0250
Iron (T)	<0.0500	<0.0500	0.2300	0.4330	0.4030	0.3200	0.3330	1.8000
Lead (T)	<0.0100	0.0100	<0.0100	0.0020	0.0020	0.0020	0.0030	0.0040
Manganese (T)	0.0300	<0.0100	0.0400	0.0170	0.0220	0.0250	0.0180	0.0770
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0003	<0.0002	<0.0002
Nickel (T)				<0.0125	<0.0125	<0.0125	<0.0125	
Selenium (T)	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Silver (T)	<0.0100	<0.0100	<0.0100	<0.0125	<0.0125	<0.0125	<0.0125	0.0024
Strontium (T)								0.3180
Thallium (T)				<0.2500	<0.2500	<0.2500	<0.2500	
Tin (T)				<0.2500	<0.2500	<0.2500		
Titanium (T)				<0.0500	<0.0500	<0.0500		<0.0500
Zinc (T)			0.0390	0.0510	0.0590	0.0360	0.0390	0.0440
Laboratory	BCL	BCL	BCL	TSS	TSS	TSS	TSS	TSS

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 01/08/93
River at SC-03	
Calcium (T)	38.9000
Magnesium (T)	6.4400
Sodium (T)	86.1000
Potassium (T)	13.1000
Carbonate	<0.5000
Bicarbonate	217.0000
Chloride	65.7000
Sulfate (T)	67.5000
Nitrate (as N)	1.4000
Nitrogen-Organic	3.2000
Nitrogen-Total (CALC)	21.6000
Fluoride (T)	0.4800
Cation/Anion Balance	5.9800 03A
Electrical Conductivity	795.0000
Field pH	7.2000
TDS @ 180 C	483.0000
TOC	15.0000
Laboratory	TSS

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 01/08/93
River at SC-03	
Aluminum (T)	0.7150
Antimony (T)	<0.1500
Arsenic (T)	0.0050
Barium (T)	0.0480
Beryllium (T)	<0.0050
Cadmium (T)	<0.0004
Chromium (T)	<0.0150
Cobalt (T)	<0.0300
Copper (T)	0.0000
Iron (T)	0.8610
Lead (T)	0.0030
Manganese (T)	0.0360
Mercury (T)	<0.0005
Molybdenum (T)	<0.0300
Nickel (T)	<0.1000
Selenium (T)	<0.0050
Silver (T)	0.0015
Strontium (T)	0.3260 67
Thallium (T)	<1.0000
Tin (T)	<0.2000 67
Titanium (T)	<0.0300 67
Vanadium (T)	<0.0500
Zinc (T)	0.0520
Laboratory	TSS

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
17D - Field EC not determined, temp greater than 30 C.
33 - Results suspect.
67 - Not approved EPA method

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 03/13/90	04/10/90	05/08/90	10/11/90	01/15/92	09/11/92
River at SC-04						
Calcium (T)	43.8000	46.8000	50.8000	47.5000	40.7000	45.1000
Magnesium (T)	6.1500	5.4000	6.8300	5.7000	5.6600	6.0200
Sodium (T)	101.0000	115.0000	109.0000	96.8000	91.9000	96.0000
Potassium (T)	15.2000	10.5000	10.3000	10.8000	12.9000	12.1000
Carbonate	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate	229.0000	239.0000	246.0000	204.0000	225.0000	203.0000
Chloride	71.8000	82.5000	80.2000	63.8000	72.0000	74.7000
Sulfate (T)	86.0000	88.5000	102.0000	82.6000	62.2000	75.0000
Nitrate (as N)	2.3000	2.4000	2.0000	6.1000	1.6000	2.6000
Nitrogen-Organic	4.3000	3.4000	2.4000	2.7000	3.6000	8.1000
Nitrogen-Total (CALC)	22.5000	22.1000	21.0000	21.5000	23.7000	22.2000
Boron (T)	0.2380	0.4400 33	0.3700 33			
Fluoride (T)	0.5800	0.6100	0.4800	0.5700	0.4600	0.5400
Cation/Anion Balance	5.0200 03A	5.1500 03A	3.8100 03A	5.8400 03A	6.6800 03A	5.9000 03A
Electrical Conductivity	910.0000	885.0000	980.0000	630.0000	810.0000	670.0000
Field air temperature (C)				20.2000		
Field Electrical Conductivity	855.0000	1012.0000	0.0000	835.0000		
Field pH	7.4000	7.6800	7.7900	7.5400	7.3000	7.6000
Field water temperature (C)	17.0000	24.0000	25.0000	22.2000		
TDS @ 180 C	610.0000	554.0000	542.0000	556.0000	473.0000	506.0000
TOC	20.3000	10.6000	10.4000	13.5000	13.7000	13.7000
Laboratory	TSS	TSS	TSS	TSS	TSS	TSS

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 03/13/90	04/10/90	05/08/90	10/11/90	01/15/92	09/11/92
River at SC-04						
Aluminum (T)	0.2210	0.1680	0.1670		0.3020	0.4630
Antimony (T)	<0.0625	<0.0625	<0.0625	<0.0625	<0.1500	<0.1500
Arsenic (T)	0.0030	0.0040	0.0070	0.0020	0.0040	0.0040
Barium (T)	0.0460	0.0300	0.0380	0.0750	0.0460	0.0500
Beryllium (T)	<0.0013	<0.0013	0.0020	<0.0013		<0.0050
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0004	<0.0004
Chromium (T)	<0.0088	<0.0088	<0.0088	<0.0088	<0.0150	<0.0150
Cobalt (T)					<0.0300	<0.0300
Copper (T)	0.0190	0.0140	0.0120	0.0280	0.0260	0.0160
Iron (T)	0.2730	0.2210	0.1900	0.7530	0.4390	0.3980
Lead (T)	0.0020	0.0020	0.0030	0.0060	0.0020	0.0010
Manganese (T)	0.0340	0.0360	0.0170	0.0690	0.0370	0.0340
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0005	<0.0005
Molybdenum (T)					<0.0300	<0.0300
Nickel (T)	<0.0125	<0.0125	<0.0125		<0.1000	<0.1000
Selenium (T)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Silver (T)	<0.0125	<0.0125	<0.0125	0.0028	0.0020	0.0012
Strontium (T)				0.3500	0.3340 67	0.3550 67
Thallium (T)	<0.2500	<0.2500	<0.2500			<1.0000
Tin (T)	<0.2500	<0.2500			<0.2000 67	
Titanium (T)	<0.0500	<0.0500		<0.0500	<0.0300 67	<0.0300 67
Vanadium (T)					<0.0500	0.0770
Zinc (T)	0.0790	0.0320	0.0370	0.0830	0.0470	0.0180
Laboratory	TSS	TSS	TSS	TSS	TSS	TSS

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
33 - Results suspect.
67 - Not approved EPA method

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 03/13/90	04/10/90	05/08/90	10/11/90	09/11/91	01/15/92
River at SC-05						
Aluminum (T)	0.2600	0.3280	0.1380		0.2940	0.3180
Antimony (T)	<0.0625	<0.0625	<0.0625	<0.0625	<0.1500	<0.1500
Arsenic (T)	0.0030	0.0040	0.0060	<0.0020	0.0070	0.0040
Barium (T)	0.0470	0.0390	0.0440	0.0680	0.0490	0.0480
Beryllium (T)	<0.0013	<0.0013	<0.0013	<0.0013	<0.0050	
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0004	<0.0004
Chromium (T)	<0.0088	<0.0088	<0.0088	<0.0088	<0.0150	<0.0150
Cobalt (T)					<0.0300	<0.0300
Copper (T)	0.0200	0.0120	0.0140	0.0230	0.0150	0.0290
Iron (T)	0.2880	0.2550	0.1510	0.7030	0.2170	0.4600
Lead (T)	0.0030	0.0020	0.0030	0.0050	0.0010	0.0020
Manganese (T)	0.0320	0.0220	0.0130	0.0450	0.0260	0.0380
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0005	<0.0005
Molybdenum (T)					<0.0300	<0.0300
Nickel (T)	<0.0125	0.0150	<0.0125	<0.0125	<0.1000	<0.1000
Selenium (T)	<0.0050	<0.0050	<0.0050	0.0060	<0.0050	<0.0050
Silver (T)	<0.0125	<0.0125	<0.0125	0.0026	0.0009	0.0020
Strontium (T)				0.3700	0.3820 67	0.3460 67
Thallium (T)	<0.2500	<0.2500	<0.2500		<1.0000	
Tin (T)	<0.2500	<0.2500				<0.2000 67
Titanium (T)	<0.0500	<0.0500		<0.0500	<0.0300 67	<0.0300 67
Vanadium (T)					0.0820	<0.0500
Zinc (T)	0.1080	0.0260	0.0320	0.0880	0.0370	0.0790
Laboratory	TSS	TSS	TSS	TSS	TSS	TSS

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
33 - Results suspect.
67 - Not approved EPA method

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 03/13/90	04/10/90	05/08/90	10/11/90	09/11/91	01/15/92
River at SC-05						
Calcium (T)	44.8000	46.0000	47.5000	46.3000	47.0000	40.4000
Magnesium (T)	6.3000	5.9800	6.4300	5.3000	6.6100	5.5600
Sodium (T)	101.0000	120.0000	104.0000	95.3000	104.0000	88.0000
Potassium (T)	15.1000	10.8000	10.1000	11.7000	13.1000	14.0000
Carbonate	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate	229.0000	238.0000	240.0000	203.0000	172.0000	220.0000
Chloride	69.7000	80.7000	77.1000	63.7000	84.5000	70.7000
Sulfate (T)	82.0000	86.0000	102.0000	82.6000	86.3000	60.6000
Nitrate (as N)	2.1000	2.2000	2.3000	6.1000	6.0000	1.6000
Nitrogen-Organic	4.7000	2.4000	2.4000	2.3000	4.6000	2.2000
Nitrogen-Total (CALC)	22.8000	20.8000	20.7000	21.0000	18.6000	23.3000
Boron (T)	0.2500	0.2520 33	0.3480 33			
Fluoride (T)	0.5200	0.5900	0.5900	0.5600	0.7300	0.4600
Cation/Anion Balance	6.4600 03A	7.1800 03A	2.3200 03A	5.1300 03A	5.5900 03A	7.1900 03A
Electrical Conductivity	880.0000	880.0000	970.0000	570.0000	730.0000	800.0000
Field air temperature (C)				24.9000		
Field Electrical Conductivity	901.0000	974.0000	1010.0000	843.0000		
Field pH	7.3000	7.7300	7.9300	7.6100	7.6000	7.2000
Field water temperature (C)	19.0000	27.5000	28.0000	24.9000		
TDS @ 180 C	542.0000	534.0000	564.0000	510.0000	530.0000	479.0000
TOC	20.0000	10.0000	18.5000	11.2000	11.0000	20.5000
Laboratory	TSS	TSS	TSS	TSS	TSS	TSS

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 03/13/90	04/10/90	05/08/90	10/11/90	01/15/92
River at SC-06					
Calcium (T)	46.8000	46.3000	42.8000	41.3000	39.1000
Magnesium (T)	6.7300	6.1500	5.9500	5.7500	5.6400
Sodium (T)	99.8000	113.0000	103.0000	105.0000	85.9000
Potassium (T)	15.9000	11.3000	10.1000	11.5000	12.6000
Carbonate	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate	234.0000	238.0000	239.0000	198.0000	226.0000
Chloride	68.2000	84.0000	76.1000	64.4000	69.7000
Sulfate (T)	78.0000	86.0000	90.4000	86.7000	59.7000
Nitrate (as N)	1.8000	2.3000	1.8000	6.9000	1.6000
Nitrogen-Organic	3.9000	3.0000	2.4000	-7.7000	3.9000
Nitrogen-Total (CALC)	22.1000	21.4000	20.0000	11.7000	23.7000
Boron (T)	0.1480	0.3510 33	0.4030 33		
Fluoride (T)	0.5100	0.5500	0.5300	0.5900	0.4400
Cation/Anion Balance	7.7000 03A	5.3400 03A	2.4100 03A	5.6200 03A	5.2700 03A
Electrical Conductivity	885.0000	875.0000	910.0000	620.0000	760.0000
Field air temperature (C)				29.9000	
Field Electrical Conductivity	854.0000	940.0000	923.0000	840.0000	
Field pH	7.8000	7.7100	7.8900	7.6500	7.2000
Field water temperature (C)	20.0000	28.0000	30.0000	28.3000	
TDS @ 180 C	534.0000	556.0000	534.0000	526.0000	454.0000
TOC	15.7000	11.9000	12.2000	15.0000	16.1000
Laboratory	TSS	TSS	TSS	TSS	TSS

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 03/13/90	04/10/90	05/08/90	10/11/90	01/15/92	
River at SC-06						
Aluminum (T)	1.2000	0.7780	0.3230		0.9800	
Antimony (T)	<0.0625	<0.0625	<0.0625	<0.0625	<0.1500	
Arsenic (T)	0.0040	0.0060	0.0040	0.0120	0.0040	
Barium (T)	0.0600	0.0470	0.0440	0.0790	0.0550	
Beryllium (T)	0.0040	<0.0013	<0.0013	0.0010		
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0004	
Chromium (T)	<0.0088	<0.0088	<0.0088	<0.0088	<0.0150	
Cobalt (T)					<0.0300	
Copper (T)	0.0230	0.0140	0.0140	0.0300	0.0320	
Iron (T)	1.1100	0.6730	0.3050	0.6050	1.2100	
Lead (T)	0.0030	0.0030	0.0030	0.0090	0.0040	
Manganese (T)	0.0520	0.0320	0.0140	0.5900	0.0550	
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0005	
Molybdenum (T)					<0.0300	
Nickel (T)	<0.0125	0.0150	<0.0125		<0.1000	
Selenium (T)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	
Silver (T)	<0.0125	<0.0125	<0.0125	0.0021	0.0030	
Strontium (T)				0.3380	0.3370	67
Thallium (T)	<0.2500	<0.2500	<0.2500			
Tin (T)	<0.2500	<0.2500			<0.2000	67
Titanium (T)	<0.0500	<0.0500		<0.0500	0.0320	67
Vanadium (T)					<0.0500	
Zinc (T)	0.0650	0.0330	0.0230	0.0830	0.0520	
Laboratory	TSS	TSS	TSS	TSS	TSS	

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
33 - Results suspect.
67 - Not approved EPA method

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 11/08/88	02/23/89	07/18/89	02/16/90	03/20/90	04/17/90	05/15/90	10/16/90
River at SG-07								
Calcium (T)	50.0000	50.0000	51.0000	47.0000	48.5000	51.5000	47.0000	46.5000
Magnesium (T)	6.7000	6.3000	7.0000	7.6500	7.1300	7.3800	6.3000	6.2300
Sodium (T)	110.0000	120.0000	130.0000	101.0000	115.0000	122.0000	103.0000	107.0000
Potassium (T)	14.0000	14.0000	13.0000	14.7000	3.1000	10.5000	10.3000	11.4000
Carbonate	<2.6000	<2.6000	<2.6000	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate	316.0000	228.0000	238.0000	196.0000	243.0000	250.0000	256.0000	221.0000
Chloride	77.2000	88.8000	93.1000	81.5000	90.5000	90.9000	80.1000	74.3000
Sulfate (T)	92.0000	115.0000	112.0000	81.2000	91.2000	84.0000	96.0000	94.7000
Nitrate (as N)	2.1800	10.6200	11.0200	6.5000	2.8500	1.0000 33B	0.8000	7.3000
Nitrogen-Organic	7.3000	0.2000	1.0000	3.2000	4.0000	6.5000 33B	1.7000	6.0000
Nitrogen-Total (CALC)	23.0800	23.3200	21.0200	24.9000	23.4500	23.9000	21.8000	28.6000
Boron (T)	0.2600	0.2900	0.3100	0.0760	0.2500	0.1880 33	0.4780 33	
Bromide			0.4000					
Fluoride (T)	0.5000	0.6100	0.6400	0.5800	0.6600	0.5800	0.5400	0.5600
Cation/Anion Balance	1.5000	0.3700	0.4600	6.7900 03A	3.7200 03A	7.0500 03A	2.5100 03A	3.4600 03A
Chloride/Bromide Ratio			232.7500					
Electrical Conductivity	900.0000	940.0000	940.0000	910.0000	830.0000	915.0000	970.0000	680.0000
Field air temperature (C)								22.8000
Field Electrical Conductivity	913.0000	956.0000	750.0000 17	916.0000	1014.0000	1010.0000	980.0000	888.0000
Field pH	7.4000	7.9700	7.2200	7.1000	7.3000	7.6400	7.6900	7.8300
Field water temperature (C)	24.5000	25.0000	38.0000	15.0000	19.0000	23.2000	26.0000	21.7000
pH	7.6000	7.7000	7.7000					
TDS @ 180 C	550.0000	585.0000	565.0000	533.0000	584.0000	563.0000	576.0000	568.0000
TOC	23.0000	13.4000	11.0000	15.4000	16.0000	9.6000	10.7000	11.3000
Laboratory	BCL	BCL	BCL	TSS	TSS	TSS	TSS	TSS

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 11/08/88	02/23/89	07/18/89	02/16/90	03/20/90	04/17/90	05/15/90	10/16/90
River at SC-07								
Aluminum (T)				4.7000	0.7750	0.7500	0.1620	
Antimony (T)				<0.0625	<0.0625	<0.0625	<0.0625	<0.0625
Arsenic (T)	<0.0100	<0.0100	<0.0100	0.0070	0.0030	0.0070	0.0050	<0.0020
Barium (T)	<0.1000	<0.1000	<0.1000	0.0720	0.0500	0.0520	0.0440	0.0830
Beryllium (T)				<0.0013	<0.0013	<0.0013	<0.0013	<0.0013
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Chromium (T)	<0.0100	<0.0100	<0.0100	<0.0088	<0.0088	<0.0088	<0.0088	<0.0088
Copper (T)			<0.0100	0.0250	0.0160	0.0180	0.0090	0.0200
Iron (T)	0.3500	0.2200	0.1030	3.6500	0.6530	0.6380	0.3000	0.5150
Lead (T)	<0.0100	<0.0100	<0.0100	0.0080	0.0020	0.0020	0.0020	0.0040
Manganese (T)	0.1200	0.0400	0.0620	0.1120	0.0450	0.0430	0.0220	0.0470
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nickel (T)				<0.0125	<0.0125	<0.0125	<0.0125	<0.0125
Selenium (T)	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050	0.0060
Silver (T)	<0.0100	<0.0100	<0.0100	<0.0125	<0.0125	<0.0125	<0.0125	<0.0125
Strontium (T)								0.3850
Thallium (T)				<0.2500	<0.2500	<0.2500	<0.2500	
Tin (T)				<0.2500	<0.2500			
Titanium (T)				<0.0500	<0.0500			<0.0500
Zinc (T)			0.0320	0.0590	0.0670	0.0560	0.0240	0.0390
Laboratory	BCL	BCL	BCL	TSS	TSS	TSS	TSS	TSS

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 09/18/91	01/22/92
River at SC-07		
Calcium (T)	73.3000	45.0000
Magnesium (T)	22.0000	6.0700
Sodium (T)	55.7000	92.3000
Potassium (T)	18.7000	14.0000
Carbonate	<0.5000	<0.5000
Bicarbonate	209.0000 33	218.0000
Chloride	42.6000	79.5000
Sulfate (T)	43.5000	71.6000
Nitrate (as N)	2.8000	0.3000
Nitrogen-Organic		3.6000
Nitrogen-Total (CALC)	7.5000	22.8000
Fluoride (T)	0.4200	0.5400
Cation/Anion Balance	32.3900 03A	6.3900 03A
Electrical Conductivity	510.0000	840.0000
Field pH	7.6000	7.3000
TDS @ 180 C	476.0000	507.0000
TOC	25.8000	10.8000
Laboratory	TSS	TSS

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 09/18/91	01/22/92
River at SC-07		
Aluminum (T)	49.0000 33	0.4390
Antimony (T)	<0.1500	<0.1500
Arsenic (T)	0.0210	0.0040
Barium (T)	0.3460	0.0440
Beryllium (T)	<0.0050	
Cadmium (T)	0.0012	<0.0004
Chromium (T)	0.0280	<0.0150
Cobalt (T)	0.0320	<0.0300
Copper (T)	0.1640	0.0220
Iron (T)	46.9000 33	0.5480
Lead (T)	0.0620	0.0030
Manganese (T)	1.1000	0.0430
Mercury (T)	<0.0005	<0.0005
Molybdenum (T)	<0.0300	<0.0300
Nickel (T)	<0.1000	<0.1000
Selenium (T)	<0.0050	<0.0050
Silver (T)	0.0017	0.0024
Strontium (T)	0.5670 67	0.3510 67
Thallium (T)	<1.0000	
Tin (T)	<1.0000 67	<0.2000 67
Titanium (T)	0.8480 67	<0.0300 67
Vanadium (T)	0.1040	<0.0500
Zinc (T)	0.2520	0.0390
Laboratory	TSS	TSS

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
17D - Field EC not determined, temp greater than 30 C.
33 - Results suspect.
33B - Results suspect, unpreserved samples analyzed.
67 - Not approved EPA method

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 03/20/90	04/17/90	05/15/90	10/16/90	09/18/91	01/22/92
River at SC-08						
Calcium (T)	46.5000	48.8000	51.3000	47.5000	70.5000	44.5000
Magnesium (T)	6.9300	6.7800	7.2500	6.5000	21.3000	6.0400
Sodium (T)	111.0000	121.0000	135.0000	109.0000	47.7000	92.7000
Potassium (T)	3.1000	10.8000	14.5000	11.4000	18.4000	13.7000
Carbonate	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate	247.0000	246.0000	252.0000	220.0000	158.0000 33	216.0000
Chloride	89.5000	116.2000	81.6000	73.7000	34.2000	79.6000
Sulfate (T)	89.2000	94.0000	96.8000	78.1000	42.5000	71.3000
Nitrate (as N)	2.9000	1.0000 33B	1.6000	5.4000	3.5000	3.0000
Nitrogen-Organic	4.7000	5.5000	1.8000	0.9000		4.1000
Nitrogen-Total (CALC)	23.8000	23.5000	22.3000	22.2000	6.4000	23.4000
Boron (T)	0.2420	0.2410 33	0.3480 33			
Fluoride (T)	0.6500	0.5800	0.5300	0.5600	0.4300	0.5200
Cation/Anion Balance	1.9800	1.4700	11.2100 03A	7.5800 03A	37.6300 03A	5.1400 03A
Electrical Conductivity	861.0000	930.0000	950.0000	690.0000	460.0000	840.0000
Field air temperature (C)				26.6000		
Field Electrical Conductivity	1047.0000	1022.0000	1015.0000	884.0000		
Field pH	7.3800 33	7.7100	7.7900	7.9400	7.5000	7.4000
Field water temperature (C)	20.0000	24.0000	28.0000	26.1000		
TDS @ 180 C	591.0000	559.0000	564.0000	572.0000	440.0000	493.0000
TOC	18.0000	10.1000	10.7000	17.2000	24.9000	14.8000
Laboratory	TSS	TSS	TSS	TSS	TSS	TSS

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 03/20/90	04/17/90	05/15/90	10/16/90	09/18/91	01/22/92
River at SG-08						
Aluminum (T)	1.2300	0.6730	0.2730		44.0000	0.4300
Antimony (T)	<0.0625	<0.0625	<0.0625	<0.0625	<0.1500	<0.1500
Arsenic (T)	0.0070	0.0070	0.0050	<0.0020	0.0100	0.0040
Barium (T)	0.0510	0.0490	0.0520	0.0790		0.0490
Beryllium (T)	<0.0013	<0.0013	<0.0013	<0.0013	<0.0050	
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0050	0.0013	0.0005
Chromium (T)	<0.0088	<0.0088	<0.0088	<0.0088	0.0260	<0.0150
Cobalt (T)					0.0330	<0.0300
Copper (T)	0.0160	0.0120	0.0120	0.0190	0.1560	0.0210
Iron (T)	0.9130	0.6830	0.2800	0.6300	43.5000	0.5570
Lead (T)	0.0010	0.0020	0.0020	0.0040	0.0500	0.0020
Manganese (T)	0.0510	0.0400	0.0370	0.0360	1.1000	0.0460
Mercury (T)	<0.0002	0.0017	<0.0002	<0.0002	<0.0005	<0.0005
Molybdenum (T)					<0.0300	<0.0300
Nickel (T)	<0.0125	<0.0125	<0.0125	<0.0125	<0.1000	<0.1000
Selenium (T)	<0.0050	<0.0050	<0.0050	0.0070	<0.0050	<0.0050
Silver (T)	<0.0125	<0.0125	0.0019	<0.0125	0.0017	0.0014
Strontium (T)				0.3730	0.4880	0.3670 67
Thallium (T)	<0.2500	<0.2500	<0.2500		<1.0000	
Tin (T)	<0.2500	<0.2500			<0.2000 67	<0.2000 67
Titanium (T)	<0.0500	<0.0500	<0.0500	<0.0500	<0.0300 67	<0.0300 67
Vanadium (T)					<0.0500	<0.0500
Zinc (T)	0.0660	0.0260	0.0440	0.0430	0.2640	0.0650
Laboratory	TSS	TSS	TSS	TSS	TSS	TSS

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
33 - Results suspect.
33B - Results suspect, unpreserved samples analyzed.
67 - Not approved EPA method

BCL - BC Analytical Lab
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Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 03/20/90	04/17/90	05/15/90	10/16/90	09/13/91	01/22/92
River at SG-09						
Calcium (T)	49.8000	48.5000	48.8000	49.0000	129.0000	43.6000
Magnesium (T)	6.7500	7.5500	6.8000	5.9500	49.1000	6.1400
Sodium (T)	126.0000	117.0000	127.0000	104.0000	44.5000	98.9000
Potassium (T)	15.8000	11.0000	15.5000	2.2000	39.5000	12.6000
Carbonate	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate	250.0000	245.0000	251.0000	217.0000	244.0000 33	214.0000
Chloride	87.8000	175.4000	79.3000	75.6000	31.7000	78.6000
Sulfate (T)	90.8000	78.8000	95.2000	94.2000	36.7000	72.9000
Nitrate (as N)	2.9000	1.5000 33B	1.3000	6.1000	3.5000	3.5000
Nitrogen-Organic	4.6000	4.6000 33B	2.3000	5.5000		3.0000
Nitrogen-Total (CALC)	24.3000	23.3000	22.0000	27.0000	7.9000	23.0000
Boron (T)	0.3380	0.2240 33	0.4200 33			
Fluoride (T)	0.6100	0.5700	0.5200	0.5400	0.4800	0.5300
Cation/Anion Balance	7.7900 03A	5.7600 03A	9.5900 03A	2.4600 03A	54.0100 03A	6.4900 03A
Electrical Conductivity	820.0000	890.0000	940.0000	660.0000	410.0000	840.0000
Field air temperature (C)				31.1000		
Field Electrical Conductivity	1005.0000	974.0000	0.0000 17D	892.0000		
Field pH	7.3500	7.8300	7.9100	7.9200	7.2000	7.6000
Field water temperature (C)	23.5000	27.5000	32.0000	29.9000		
TDS @ 180 C	581.0000	541.0000	580.0000	572.0000	551.0000	480.0000
TOC	11.2000	12.3000	9.1000	9.8000	44.1000	56.6000 33
Laboratory	TSS	TSS	TSS	TSS	TSS	TSS

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 03/20/90	04/17/90	05/15/90	10/16/90	09/13/91	01/22/92
River at SC-09						
Aluminum (T)	0.8600	0.4130	0.2430		137.0000	0.9800
Antimony (T)	<0.0625	<0.0625	<0.0625	<0.0625	0.2490	<0.1500
Arsenic (T)	0.0060	0.0070	0.0040	<0.0020	0.0880	0.0050
Barium (T)	0.0520	0.0460	0.0510	0.0890	0.7910	0.0490
Beryllium (T)	<0.0013	<0.0013	<0.0013	<0.0013		<0.0050
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0050	0.0026	<0.0004
Chromium (T)	<0.0088	<0.0088	<0.0088	<0.0088	0.0870	<0.0150
Cobalt (T)					0.1070	<0.0300
Copper (T)	0.0080	0.0120	<0.0075	0.0210	0.3470	0.0000
Iron (T)	0.8150	0.4280	0.2500	0.7800	112.0000	0.8300
Lead (T)	0.0030	0.0020	0.0010	0.0040	0.1280	0.0030
Manganese (T)	0.0510	0.0590	0.0360	0.0230	2.6700	0.0540
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0005	<0.0005
Molybdenum (T)					<0.0300	<0.0300
Nickel (T)	<0.0125	<0.0125	<0.0125	<0.0125	<0.1000	<0.1000
Selenium (T)	<0.0050	<0.0050	<0.0050	0.0060	<0.0050	<0.0050
Silver (T)	<0.0125	<0.0125	0.0015	<0.0125	0.0014	0.0014
Strontium (T)				0.3750	0.7750 67	0.3640 67
Thallium (T)	<0.2500	<0.2500	<0.2500		<1.0000	
Tin (T)		<0.2500			0.2810 67	<0.2000 67
Titanium (T)	<0.0500	<0.0500	<0.0500	<0.0500	2.4100 67	<0.0300 67
Vanadium (T)					<0.0500	<0.0500
Zinc (T)	0.0660	0.0180	0.0400	0.0380	0.5320	0.0250
Laboratory	TSS	TSS	TSS	TSS	TSS	TSS

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
17D - Field EC not determined, temp greater than 30 C.
33 - Results suspect.
33B - Results suspect, unpreserved samples analyzed.
67 - Not approved EPA method

BCL - BC Analytical Lab
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Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 11/08/88	02/23/89	07/18/89	02/22/90	03/27/90	04/25/90	05/22/90	10/23/90
River at SC-10								
Calcium (T)	49.0000	49.0000	50.0000	43.0000	51.5000	48.8000	46.3000	55.8000
Magnesium (T)	6.7000	6.3000	6.9000	6.6800	7.4300	7.5500	6.4500	7.5800
Sodium (T)	114.0000	110.0000	119.0000	97.8000	123.0000	98.5000	121.0000	98.0000
Potassium (T)	13.0000	13.0000	12.0000	2.7000	12.1000	10.3000	11.9000	12.2000
Carbonate	<2.6000	<2.6000	<2.6000	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate	285.0000	173.0000	258.0000	199.0000	260.0000	243.0000	230.0000	241.0000
Chloride	83.5000	91.0000	83.5000	59.0000	80.8000	66.7000	77.6000	75.3000
Sulfate (T)	97.0000	115.0000	104.0000	79.8000	84.0000	84.0000	84.8000	73.5000
Nitrate (as N)	3.4400	15.7600	10.4400	6.6000	3.0000	1.2000	0.8000	4.0000
Nitrogen-Organic	3.5000	<0.2000	1.5000	2.8000	5.1000	2.8000	1.9000	8.5000
Nitrogen-Total (CALC)	19.9400	30.7600	21.9400	23.7000	25.7000	23.9000	22.0000	29.0000
Boron (T)	0.2900	0.2900	0.3400	0.0860	0.3350	0.1400 33	0.3480 33	
Bromide			0.3800					
Fluoride (T)	0.5000	0.6000	0.5500	0.6200	0.5600	0.5600	0.4600	0.5300
Cation/Anion Balance	0.4900	1.1000	1.3800	6.7800 03A	8.8200 03A	7.8700 03A	11.3000 03A	7.8500 03A
Chloride/Bromide Ratio			219.7400					
Electrical Conductivity	900.0000	940.0000	900.0000	865.0000	810.0000	880.0000	920.0000	690.0000
Field air temperature (C)								21.4000
Field Electrical Conductivity	936.0000	927.0000	675.0000 17	816.0000	1043.0000	920.0000	947.0000	887.0000
Field pH	7.5900	7.8100	7.2300	7.4000	7.7500	7.8600	7.6500	8.0300
Field water temperature (C)	23.0000	22.0000	34.0000	19.0000	21.5000	21.5000	25.0000	16.3000
pH	7.5000	7.8000	7.7000					
TDS @ 180 C	570.0000	615.0000	550.0000	513.0000	566.0000	510.0000	560.0000	534.0000
TOC	17.0000	10.3000	22.0000	15.0000	10.7000	15.2000	9.7000	9.1000
Laboratory	BCL	BCL	BCL	TSS	TSS	TSS	TSS	TSS

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 11/08/88	02/23/89	07/18/89	02/22/90	03/27/90	04/25/90	05/22/90	10/23/90
River at SC-10								
Aluminum (T)				2.5000	1.2100	1.0400	0.7030	
Antimony (T)				<0.0625	<0.0625	<0.0625	<0.0625	<0.0625
Arsenic (T)	<0.0100	<0.0100	<0.0100	0.0070	0.0050	0.0070	0.0030	0.0090
Barium (T)	<0.1000	<0.1000	<0.1000	0.0590	0.0580	0.0530	0.0460	0.1390
Beryllium (T)				<0.0013	<0.0013	<0.0013	<0.0013	<0.0013
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0060
Chromium (T)	<0.0100	<0.0100	<0.0100	<0.0088	<0.0088	<0.0088	<0.0088	<0.0088
Copper (T)			0.0100	0.0250	0.0110	0.0170	0.0100	0.0260
Iron (T)	0.1500	0.1600	0.2700	2.0600	1.2300	0.8980	0.5450	2.0300
Lead (T)	<0.0100	<0.0100	<0.0100	0.0040	0.0040	0.0050	0.0020	0.0140
Manganese (T)	0.0300	0.0300	0.0340	0.0670	0.0550	0.0590	0.0440	0.1320
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nickel (T)				<0.0125	<0.0125	<0.0125	<0.0125	<0.0125
Selenium (T)	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Silver (T)	<0.0100	<0.0100	<0.0100	<0.0125	<0.0125	<0.0125	0.0017	<0.0125
Strontium (T)								0.4080
Thallium (T)				<0.2500	<0.2500	<0.2500	<0.2500	
Tin (T)				<0.2500				
Titanium (T)				<0.0500	<0.0500		<0.0500	0.0500
Zinc (T)			0.0320	0.0760	0.0560	0.0550	0.0510	0.0860
Laboratory	BCL	BCL	BCL	TSS	TSS	TSS	TSS	TSS

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 06/19/91	09/04/91	01/29/92
River at SC-10			
Calcium (T)	56.2000	49.8000	49.2000
Magnesium (T)	6.9700	7.3900	7.3800
Sodium (T)	109.0000	96.8000	99.5000
Potassium (T)	12.2000	12.4000	13.4000
Carbonate	<0.5000	<0.5000	<0.5000
Bicarbonate	214.0000	186.0000	233.0000
Chloride	95.5000	72.3000	81.6000
Sulfate (T)	82.0000	73.2000	76.9000
Nitrate (as N)	5.9000	6.3000	2.8000
Nitrogen-Organic	2.6000	2.9000	3.1000
Nitrogen-Total (CALC)	19.2000	18.0000	25.9000
Fluoride (T)	0.5600	0.4100	0.5100
Cation/Anion Balance	4.6900 03A	8.5400 03A	7.6400 03A
Electrical Conductivity	710.0000	680.0000	880.0000
Field pH		7.6000	7.3000
TDS @ 180 C	561.0000	533.0000	529.0000
TOC	10.0000	10.0000	9.7000
Laboratory	TSS	TSS	TSS

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 06/19/91	09/04/91	01/29/92
River at SC-10			
Aluminum (T)	0.4270	2.8200	1.0900
Antimony (T)	<0.1500	<0.1500	<0.1500
Arsenic (T)	0.0100	0.0080	0.0040
Barium (T)	0.0610	0.0860	0.0610
Beryllium (T)	<0.0050	<0.0050	<0.0050
Cadmium (T)	<0.0004	0.0004	<0.0004
Chromium (T)	<0.0150	<0.0150	<0.0150
Cobalt (T)	<0.0300	<0.0300	<0.0300
Copper (T)	0.0000	0.0160	<0.0150
Iron (T)	0.5040	2.7000	1.1100
Lead (T)	0.0020	0.0060	0.0060
Manganese (T)	0.0380	0.0630	0.0670
Mercury (T)	<0.0005	<0.0005	<0.0005
Molybdenum (T)	<0.0300	<0.0300	<0.0300
Nickel (T)	<0.1000	<0.1000	<0.1000
Selenium (T)	<0.0050	<0.0050	<0.0050
Silver (T)	0.0011	0.0013	0.0014
Strontium (T)	0.4150 67	0.4090 67	0.4260 67
Thallium (T)		<1.0000	
Tin (T)	<0.2000 67		
Titanium (T)	<0.0300 67	<0.0300 67	<0.0300 67
Vanadium (T)	<0.0500	0.0740	<0.0500
Zinc (T)	0.0230	0.0210	0.0340
Laboratory	TSS	TSS	TSS

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
17D - Field EC not determined, temp greater than 30 C.
33 - Results suspect.
67 - Not approved EPA method

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 03/27/90	04/25/90	05/22/90	10/23/90	01/29/92
River at SC-11					
Calcium (T)	47.0000	49.8000	48.8000	59.3000	53.1000
Magnesium (T)	7.0000	7.0300	6.8500	9.4300	7.8600
Sodium (T)	111.0000	99.8000	118.0000	96.0000	97.2000
Potassium (T)	10.9000	10.8000	14.0000	13.8000	14.2000
Carbonate	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate	257.0000	239.0000	246.0000	234.0000	227.0000
Chloride	79.9000	68.9000	76.0000	69.7000	84.0000
Sulfate (T)	83.6000	84.4000	85.6000	74.5000	75.9000
Nitrate (as N)	4.4000	2.4000	2.3000	4.6000	4.2000
Nitrogen-Organic	3.4000	2.7000	1.3000	4.1000	2.2000
Nitrogen-Total (CALC)	26.2000	24.1000	22.0000	23.7000	24.4000
Boron (T)	0.4100 33	0.1530 33	0.3680 33		
Fluoride (T)	0.5600	0.5500	0.4500	0.5300	0.5100
Cation/Anion Balance	5.0600 03A	7.6700 03A	9.5700 03A	11.8400 03A	7.5900 03A
Electrical Conductivity	830.0000	890.0000	900.0000	720.0000	870.0000
Field air temperature (C)				25.8000	
Field Electrical Conductivity	0.0000	938.0000	941.0000	887.0000	
Field pH	7.6100	7.7500	7.5500	7.9700	7.3000
Field water temperature (C)	24.8000	23.5000	28.0000	20.0000	
TDS @ 180 C	566.0000	527.0000	558.0000	544.0000	540.0000
TOC	11.9000	7.6000	9.9000	8.8000	12.9000
Laboratory	TSS	TSS	TSS	TSS	TSS

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 03/27/90	04/25/90	05/22/90	10/23/90	01/29/92	
River at SC-11						
Aluminum (T)	2.6800	1.6700	1.1400		1.8500	
Antimony (T)	<0.0625	<0.0625	<0.0625	<0.0625	<0.1500	
Arsenic (T)	0.0080	0.0070	0.0030	0.0150	0.0040	
Barium (T)	0.0630	0.0630	0.0540		0.0720	
Beryllium (T)	<0.0013	<0.0013	<0.0013	0.0020	<0.0050	
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0004	
Chromium (T)	<0.0088	<0.0088	<0.0088	<0.0088	<0.0150	
Cobalt (T)					<0.0300	
Copper (T)	0.0160	0.0250	0.0150	0.0500	0.0000	
Iron (T)	1.9000	1.2300	0.8380	8.2800	1.7000	
Lead (T)	0.0050	0.0060	0.0030	0.0180	0.0060	
Manganese (T)	0.0710	0.0590	0.0490	0.2750	0.0570	
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0005	
Molybdenum (T)					<0.0300	
Nickel (T)	<0.0125	<0.0125	<0.0125	<0.0125	<0.1000	
Selenium (T)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	
Silver (T)	<0.0125	<0.0125	0.0015	0.0033	0.0015	
Strontium (T)				0.4630	0.4350	67
Thallium (T)	<0.2500	<0.2500	<0.2500			
Tin (T)	<0.2500			<0.2500		
Titanium (T)	0.0540		<0.0500	<0.0500	0.0440	67
Vanadium (T)					<0.0500	
Zinc (T)	0.0400	0.0620	0.0410	0.0740	0.0350	
Laboratory	TSS	TSS	TSS	TSS	TSS	

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
33 - Results suspect.
67 - Not approved EPA method

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 02/24/89	07/13/89	02/22/90	03/27/90	04/25/90	05/22/90	10/23/90	01/29/92
River at SC-12								
Calcium (T)	54.0000	58.0000	44.8000	53.5000	50.3000	49.5000	58.3000	51.4000
Magnesium (T)	6.9000	7.7000	7.1300	7.7500	7.4000	7.0000	9.4300	8.0400
Sodium (T)	116.0000	124.0000	92.0000	116.0000	99.3000	118.0000	93.3000	99.9000
Potassium (T)	14.0000	14.0000	13.8000	13.0000	11.0000	14.5000	14.1000	13.9000
Carbonate	<2.6000	<2.6000	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate	257.0000	231.0000	195.0000	257.0000	238.0000	242.0000	231.0000	218.0000
Chloride	94.9000	102.0000	72.9000 34A	77.2000	68.3000	76.0000	72.8000	84.6000
Sulfate (T)	100.0000	102.0000	76.4000	85.6000	86.8000	83.2000	74.2000	75.6000
Nitrogen-Organic	0.4000	1.5000	3.1000	4.0000	2.7000	1.8000	4.1000	2.3000
Nitrogen-Total (CALC)	24.3300	19.1900	24.7000	25.3000	24.2000	21.1000	23.2000	22.6000
pH	7.7000	7.7000						
Boron (T)	0.2300	0.2300	0.0310	0.3130	0.1250 33	0.3630 33		
Bromide		0.1600						
Fluoride (T)	0.4900	0.4700	0.5800	0.5600	0.5500	0.4500	0.5400	0.5100
Cation/Anion Balance	0.4100	0.6200	5.7300 03A	8.4800 03A	7.4100 03A	9.9800 03A	10.4200 03A	7.4000 03A
Electrical Conductivity	930.0000	920.0000	884.0000	798.0000	890.0000	890.0000	710.0000	860.0000
Field air temperature (C)							29.7000	
Field Electrical Conductivity	901.0000	650.0000 17	876.0000	980.0000	913.0000	954.0000	862.0000	
Field pH	6.7800	7.9300	7.7000	7.7500	7.8200	7.5900	7.9900	7.4000
Field water temperature (C)	19.0000	32.0000	16.0000	26.0000	24.5000	32.0000	25.2000	
TDS @ 180 C	570.0000	580.0000	510.0000	566.0000	541.0000	564.0000	544.0000	547.0000
TOC	11.6000	6.8000	13.3000	8.8000	11.2000	9.8000	9.2000	14.3000
Laboratory	BCL	BCL	TSS	TSS	TSS	TSS	TSS	TSS

Appendix B. Other Results of Analyses of Effluent Samples from the Santa Cruz River - Inorganics and other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 02/24/89	07/13/89	02/22/90	03/27/90	04/25/90	05/22/90	10/23/90	01/29/92
River at SC-12								
Aluminum (T)			3.0000	2.3300	1.8900	1.1900		2.2900
Antimony (T)			<0.0625	<0.0625	<0.0625	<0.0625	<0.0625	<0.1500
Arsenic (T)	<0.0100	<0.0100	0.0060	0.0060	0.0070	0.0030	0.0150	0.0050
Barium (T)	<0.1000	<0.1000	0.0610	0.0710	0.0640	0.0560		0.0650
Beryllium (T)			<0.0013	<0.0013	<0.0013	<0.0013	0.0010	<0.0050
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0004
Chloride/Bromide Ratio		637.5000						
Chromium (T)	<0.0100	<0.0100	<0.0088	<0.0088	<0.0088	<0.0088	<0.0088	<0.0150
Copper (T)		0.0100	0.0230	0.0150	0.0190	0.0110	0.0450	0.0000
Iron (T)	0.2600	0.2730	2.3300	2.1100	1.3500	0.8350	8.5000	2.0300
Lead (T)	<0.0100	<0.0100	0.0050	0.0050	0.0060	0.0030	0.0180	0.0070
Manganese (T)	0.0500	0.0250	0.0550	0.0700	0.0640	0.0450	0.2410	0.0530
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0005
Nickel (T)			<0.0125	<0.0125	<0.0125	<0.0125	<0.0125	<0.1000
Nitrate (as N)	10.3300	13.0900	7.6000	3.9000	2.9000	2.4000	5.0000	4.9000
Selenium (T)	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Silver (T)	<0.0100	<0.0100	<0.0125	<0.0125	<0.0125	0.0014	0.0024	<0.0005
Strontium (T)							0.4500 67	0.3900 67
Thallium (T)			<0.2500	<0.2500	<0.2500	<0.2500		
Tin (T)			<0.2500				<0.2500 67	<0.2000 67
Titanium (T)			<0.0500	<0.0500		<0.0500	0.2100 67	0.0460 67
Vanadium (T)								<0.0500
Zinc (T)		0.0260	0.0480	0.0560	0.0670	0.0410	0.0660	0.0350
Laboratory	BCL	BCL	TSS	TSS	TSS	TSS	TSS	TSS

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
17D - Field EC not determined, temp greater than 30 C.
33 - Results suspect.
34A - Sample unusally high, results used in calculations.
67 - Not approved EPA method

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

APPENDIX C

Results of Analyses of Effluent Samples from the Santa Cruz River - Detectable Trace Organics

Appendix C. Results of Analyses of Effluent Samples from the Santa Cruz River - Detectable Trace Organics

Sample Station/ Constituent (ug/l)	Sample Date	Results	Comment-Method Blank (ug/l)	Lab
River at SC-01				
bis(2-ethylhexyl) phthalate	04/03/90	7.90	(1- 2.0)	TSS
bis(2-ethylhexyl) phthalate	03/07/90	22.20	(1- 2.0)	TSS
bromodichloromethane	03/07/90	0.10		TSS
bromodichloromethane	04/03/90	0.20		TSS
butylbenzyl phthalate	03/07/90	8.40		TSS
chloroform	03/07/90	1.40		TSS
chloroform	05/01/90	2.20		TSS
chloroform	04/03/90	1.90		TSS
chloroform	10/03/90	2.10		TSS
chloroform	01/08/92	0.90		TSS
chloroform	04/22/92	1.70		TSS
1,4-dichlorobenzene	03/07/90	0.20		TSS
1,4-dichlorobenzene	04/03/90	0.20		TSS
di-n-butyl phthalate	03/07/90	2.70		TSS
methylene chloride	03/07/90	0.60		TSS
methylene chloride	04/22/92	1.80		TSS
toluene	03/07/90	0.70		TSS
toluene	04/03/90	0.70		TSS
toluene	10/03/90	1.30		TSS
toluene	04/22/92	1.60		CAL
River at SC-02				
lindane (BHC-gamma)	07/19/89	0.05		CAL
bis(2-ethylhexyl) phthalate	07/19/89	17.00	(2)	TSS
bis(2-ethylhexyl) phthalate	02/16/90	30.70	(3)	TSS
bis(2-ethylhexyl) phthalate	04/03/90	8.40	(1- 2.0)	TSS
bis(2-ethylhexyl) phthalate	03/07/90	7.60		TSS
butylbenzyl phthalate	03/07/90	3.30		CAL
chloroform	02/22/89	0.60		CAL
chloroform	07/19/89	0.70	(2)	TSS
chloroform	05/01/90	1.60		TSS
chloroform	02/16/90	1.60		TSS
chloroform	03/07/90	1.30		TSS
chloroform	04/03/90	1.40		TSS
chloroform	10/03/90	1.60		TSS
chloroform	01/08/92	0.60		TSS
1,4-dichlorobenzene	03/07/90	0.20		TSS
di-n-butyl phthalate	02/16/90	78.40		TSS
di-n-butyl phthalate	03/07/90	9.80		CAL
methylene chloride	02/16/90	0.10		TSS
methylene chloride	03/07/90	0.70		TSS

Appendix C. Results of Analyses of Effluent Samples from the Santa Cruz River - Detectable Trace Organics (Cont'd)

Sample Station/ Constituent (ug/l)	Sample Date	Results	Comment-Method Blank (ug/l)	Lab
River at SC-02 (Cont'd)				
methylene chloride	04/03/90	0.60		TSS
methylene chloride	04/22/92	1.50		TSS
toluene	02/16/90	0.30		TSS
toluene	03/07/90	0.70		TSS
toluene	04/03/90	0.70		TSS
toluene	01/08/92	0.80		TSS
benzoic acid	03/07/90	2.40		CAL
River at SC-03				
bis(2-ethylhexyl) phthalate	07/18/89	11.00	(2)	TSS
bis(2-ethylhexyl) phthalate	02/16/90	46.10	(3)	TSS
bis(2-ethylhexyl) phthalate	03/07/90	7.60		TSS
bis(2-ethylhexyl) phthalate	04/03/90	8.70		TSS
butylbenzyl phthalate	04/03/90	2.20		CAL
chloroform	02/22/89	0.80		CAL
chloroform	07/18/89	1.10		TSS
chloroform	03/07/90	1.70		TSS
chloroform	02/16/90	1.90		TSS
chloroform	04/03/90	1.50		TSS
chloroform	05/01/90	1.10		TSS
chloroform	10/03/90	2.10		TSS
chloroform	01/08/93	0.80		TSS
1,4-dichlorobenzene	03/07/90	0.70		TSS
1,4-dichlorobenzene	04/03/90	0.60		TSS
1,4-dichlorobenzene	05/01/90	0.90		TSS
di-n-butyl phthalate	03/07/90	5.70		TSS
methylene chloride	03/07/90	0.80		TSS
methylene chloride	02/16/90	0.30		TSS
methylene chloride	04/03/90	0.80		TSS
methylene chloride	05/01/90	1.70		TSS
methylene chloride	10/03/90	1.20		TSS
tetrachloroethylene (PCE)	02/16/90	0.10		TSS
tetrachloroethylene (PCE)	10/03/90	1.10		TSS
tetrachloroethylene (PCE)	01/08/93	0.50		TSS
toluene	03/07/90	0.40		TSS
toluene	02/16/90	0.40		TSS
toluene	04/03/90	0.40		TSS
toluene	05/01/90	0.30		TSS
toluene	01/08/93	0.50		TSS
1,1,1-trichloroethane	03/07/90	0.10		TSS

Appendix C. Results of Analyses of Effluent Samples from the Santa Cruz River - Detectable Trace Organics (Cont'd)

Sample Station/ Constituent (ug/l)	Sample Date	Results	Comment-Method Blank (ug/l)	Lab
River at SC-04				
bis(2-ethylhexyl) phthalate	03/13/90	13.20		TSS
chloroform	03/13/90	1.00		TSS
chloroform	04/10/90	0.90		TSS
chloroform	05/08/90	0.50		TSS
chloroform	01/15/92	1.30		TSS
1,4-dichlorobenzene	04/10/90	0.20		TSS
1,4-dichlorobenzene	05/08/90	0.20		TSS
di-n-butyl phthalate	03/13/90	14.00		TSS
methylene chloride	03/13/90	0.90		TSS
methylene chloride	04/10/90	0.40	(3)	TSS
methylene chloride	05/08/90	1.30		TSS
methylene chloride	10/11/90	1.50	(3)	TSS
methylene chloride	09/11/92	1.50		TSS
toluene	04/10/90	0.30		TSS
toluene	01/15/92	1.30		TSS
River at SC-05				
bis(2-ethylhexyl) phthalate	05/08/90	8.70	(1)	TSS
chloroform	03/13/90	1.00		TSS
chloroform	05/08/90	0.30		TSS
chloroform	01/15/92	0.80		TSS
1,3-dichlorobenzene	04/10/90	0.20		TSS
1,4-dichlorobenzene	05/08/90	0.20		TSS
1,1-dichloroethene	09/11/91	1.70		TSS
methylene chloride	03/13/90	0.70		TSS
methylene chloride	05/08/90	0.80		TSS
methylene chloride	10/11/90	2.10	(3)	TSS
toluene	03/13/90	0.20		TSS
toluene	04/10/90	0.20		TSS
toluene	01/15/92	0.80		TSS

Appendix C. Results of Analyses of Effluent Samples from the Santa Cruz River - Detectable Trace Organics (Cont'd)

Sample Station/ Constituent (ug/l)	Sample Date	Results	Comment-Method Blank (ug/l)	Lab
River at SC-06				
bis(2-ethylhexyl) phthalate	03/13/90	21.80	(1- 2.0)	TSS
chloroform	03/13/90	0.80		TSS
chloroform	04/10/90	0.70		TSS
chloroform	05/08/90	0.30		TSS
chloroform	01/15/92	0.70		TSS
1,4-dichlorobenzene	05/08/90	0.20		TSS
di-n-butyl phthalate	03/13/90	7.90		TSS
endrin aldehyde	04/10/90	0.13		TSS
methylene chloride	03/13/90	0.90		TSS
methylene chloride	10/11/90	1.10	(3)	TSS
naphthalene	03/13/90	0.10		TSS
toluene	03/13/90	0.20		TSS
toluene	04/10/90	0.10		TSS
toluene	01/15/92	0.50		CAL
River at SC-07				
bis(2-ethylhexyl) phthalate	07/18/89	12.00	(2)	TSS
bis(2-ethylhexyl) phthalate	02/16/90	21.30	(3)	TSS
bis(2-ethylhexyl) phthalate	03/20/90	12.20	(1- 2.0)	TSS
bis(2-ethylhexyl) phthalate	05/15/90	15.80	(1- 2.0)	TSS
chloroform	03/20/90	0.40		TSS
chloroform	02/16/90	0.60		TSS
chloroform	05/15/90	0.30	(3)	TSS
chloroform	09/18/91	0.10		TSS
1,4-dichlorobenzene	03/20/90	0.20		TSS
di-n-butyl phthalate	02/16/90	52.40		TSS
methylene chloride	03/20/90	0.50		TSS
methylene chloride	04/17/90	0.70	(3)	TSS
methylene chloride	02/16/90	0.20		TSS
methylene chloride	09/18/91	0.40		TSS
toluene	03/20/90	0.20		TSS
toluene	02/16/90	0.30		TSS
1,2,3-trichlorobenzene	03/20/90	0.10		TSS

Appendix C. Results of Analyses of Effluent Samples from the Santa Cruz River - Detectable Trace Organics (Cont'd)

Sample Station/ Constituent (ug/l)	Sample Date	Results	Comment-Method Blank (ug/l)	Lab
River at SC-08				
bis(2-ethylhexyl) phthalate	03/20/90	12.00	(1- 2.0)	TSS
bis(2-ethylhexyl) phthalate	05/15/90	17.80	(1- 2.0)	TSS
chloroform	04/17/90	0.30		TSS
di-n-butyl phthalate	03/20/90	17.10		TSS
methylene chloride	03/20/90	0.80	(3)	TSS
methylene chloride	04/17/90	0.70		TSS
methylene chloride	10/16/90	1.20		TSS
methylene chloride	09/18/91	0.30		TSS
River at SC-09				
bis(2-ethylhexyl) phthalate	03/20/90	23.50	(1- 2.0)	TSS
bis(2-ethylhexyl) phthalate	05/15/90	6.90	(1- 2.0)	TSS
methylene chloride	03/20/90	0.80	(3)	TSS
methylene chloride	04/17/90	0.80	(3)	TSS
methylene chloride	09/13/91	0.30		TSS
benzoic acid	03/20/90	4.40		CAL
River at SC-10				
bis(2-ethylhexyl) phthalate	07/18/89	6.00	(2)	CAL
bis(2-ethylhexyl) phthalate	02/22/90	8.80	(1)	TSS
bis(2-ethylhexyl) phthalate	03/27/90	9.60	(1- 2.0)	TSS
bis(2-ethylhexyl) phthalate	05/22/90	14.50	(1- 2.0)	TSS
chloroform	03/27/90	0.30	(3)	TSS
methylene chloride	10/23/90	1.40	(1- 0.1)	TSS
methylene chloride	09/04/91	31.30	(1- 0.1)	TSS
toluene	02/22/90	1.00		TSS
toluene	04/25/90	0.20		TSS
River at SC-11				
bis(2-ethylhexyl) phthalate	05/22/90	19.90	(1- 2.0)	TSS
bis(2-ethylhexyl) phthalate	05/22/90	52.50	(1- 2.0)	TSS
chloroform	03/27/90	0.10	(3)	TSS
methylene chloride	10/23/90	1.30	(1- 0.1)	CAL
bis(2-ethylhexyl) phthalate	03/20/90	12.00	(1- 2.0)	TSS
bis(2-ethylhexyl) phthalate	05/15/90	17.80	(1- 2.0)	TSS
chloroform	04/17/90	0.30		TSS

Appendix C. Results of Analyses of Effluent Samples from the Santa Cruz River - Detectable Trace Organics (Cont'd)

Sample Station/ Constituent (ug/l)	Sample Date	Results	Comment-Method Blank (ug/l)	Lab
River at SC-12				
bis(2-ethylhexyl) phthalate	07/13/89	26.00		TSS
bis(2-ethylhexyl) phthalate	02/22/90	12.40	(1- 2.0)	TSS
bis(2-ethylhexyl) phthalate	03/27/90	7.30	(1- 2.0)	TSS
bis(2-ethylhexyl) phthalate	05/22/90	40.50	(1- 2.0)	TSS
chloroform	03/27/90	0.10	(3)	TSS
methylene chloride	03/27/90	1.80	(3)	TSS
methylene chloride	10/23/90	5.40	(1- 0.1)	TSS
toluene	02/22/90	0.10		

Comments

1 - Method blank contained compound, results not reliable unless 5X reporting limit or 10X blank.
2 - Field blank contained compound.
3 - Trip blank contained compound.

TSS - Pima County Lab, Technical Services Section
CAL - California Analytical Lab

APPENDIX D

Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters

Sample Station/ Constituent (mg/l)	DATE SAMPLED 05/10/88	10/05/88	02/22/89	06/29/89	01/16/90	03/07/90	04/03/90	05/01/90
SC-01								
Calcium (T).....	62.0000	66.0000	70.0000	70.0000	68.3000	69.5000	66.8000	66.0000
Magnesium (T).....	11.0000	8.6000	12.8000	13.0000	12.0000	12.4000	11.5000	11.3000
Sodium (T).....	112.0000	112.0000	114.0000	114.0000	108.0000	98.8000	105.0000	102.0000
Potassium (T).....	2.9000	3.0000	2.9000	3.1000	2.6000	2.7000	2.1000	2.3000
Carbonate.....	<2.6000	<2.6000	<2.6000	<2.6000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate.....	285.0000	294.0000	321.0000	326.0000	256.0000 33	272.0000	278.0000	269.0000
Chloride.....	80.0000	79.6000	76.1000	77.9000	18.3000 33	54.4000	68.6000	64.0000
Sulfate (T).....	99.0000	93.0000	102.0000	96.0000	96.0000	96.4000	105.0000	102.0000
Nitrate (as N).....	0.2900	0.2000	0.4900	0.6900	0.6000	0.5000	0.9000	0.4000
Nitrite (as N).....					<0.1000	<0.2000	<0.2000	<0.2000
Nitrogen-Ammonia.....	0.0600	0.0400	<0.0200	<0.0200	<0.1000	<0.1000	<0.1000	<0.1000
Nitrogen-Kjeldhal.....	0.3000	<0.2000	<0.2000	<0.2000				
Nitrogen-Organic.....	0.2000	<0.2000	<0.2000	<0.2000	0.3000	0.1000	<0.1000	<0.1000
Nitrogen-Total (CALC).....	0.5500	0.2400	0.4900	0.6900	0.9000	0.6000	0.9000	0.4000
Boron (T).....	0.4300	0.2900	0.4100	0.4000	0.3780	0.1830	0.4880 31	0.1680 31
Bromide.....				0.2500	0.2300			
Fluoride (T).....	0.7600	0.7400	0.8300	0.8300	0.7300	0.9400	0.8000	0.7900
Cation/Anion Balance.....	0.5000	0.5000	0.1600	0.0500	14.8900 03A	4.6000 03A	0.7300	1.8100
Chloride/Bromide Ratio.....				311.6000	79.5700			
Electrical Conductivity.....	860.0000	850.0000	890.0000	900.0000	554.0000	891.0000	815.0000	860.0000
Field Electrical Conductivity.			767.0000	811.0000	258.0000	895.0000	897.0000	907.0000
Field pH.....			7.0000	7.9000	6.9200	6.8500	7.2000	7.1300
Field water temperature (C)...			24.0000	24.5000	23.5000	24.0000	23.5000	23.5000
pH.....	7.7000	7.6000	7.3000	7.4000				
TDS @ 180 C.....	550.0000	550.0000	545.0000	595.0000		570.0000	556.0000	582.0000
TOC.....	<5.0000	50.5000	2.6000	2.1000		1.9000	3.2000	1.6000
Laboratory.....	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 05/10/88	10/05/88	02/22/89	06/29/89	01/16/90	03/07/90	04/03/90	05/01/90
SC-01								
Aluminum (T)					0.0570	<0.0500	<0.0500	<0.0500
Antimony (T)					<0.0625	<0.0625	<0.0625	<0.0625
Arsenic (T)	<0.0100	<0.0100	<0.0100	<0.0100	0.0080	0.0080	0.0070	0.0080
Barium (T)	<0.1000	<0.1000	<0.1000	<0.1000	0.0400	0.0400	0.0350	0.0380
Beryllium (T)					<0.0013	<0.0013	<0.0013	<0.0013
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Chromium (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0088	<0.0088	<0.0088	<0.0088
Copper (T)				<0.0100	<0.0075	<0.0075	<0.0075	<0.0075
Iron (T)	<0.0500	<0.0500	<0.0500	<0.0500	0.0840	<0.0500	<0.0500	<0.0500
Lead (T)	<0.0100	<0.0100	0.0200	<0.0100	0.0050	0.0020	0.0020	<0.0010
Manganese (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0025	<0.0025	<0.0025	0.0030
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nickel (T)					<0.0125	<0.0125	<0.0125	<0.0125
Selenium (T)	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Silver (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0125	<0.0125	<0.0125	<0.0125
Thallium (T)						<0.2500	<0.2500	<0.2500
Tin (T)					<0.2500	<0.2500	<0.2500	
Titanium (T)					<0.0500	<0.0500	<0.0500	
Zinc (T)				0.1570	0.1320	0.1210	0.0900	0.1010
Laboratory	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 07/19/90	10/03/90	11/19/90	01/23/91	01/08/92
SC-01					
Calcium (T).....	69.3000	62.5000		63.5000	68.6000
Magnesium (T).....	12.6000	11.6000		11.8000	12.6000
Sodium (T).....	117.0000	100.0000		99.3000	98.8000
Potassium (T).....	2.1000	2.1000		2.4000	2.6000
Carbonate.....	<0.5000	<0.5000		<0.5000	<0.5000
Bicarbonate.....	275.0000	241.0000		240.0000	236.0000
Chloride.....	62.2000	70.2000		74.9000	77.0000
Sulfate (T).....	94.1000	97.2000		94.8000	95.6000
Nitrate (as N).....	0.2000	3.3000		1.8000	0.2000
Nitrite (as N).....	<0.2000	<0.2000		<0.2000	<0.2000
Nitrogen-Ammonia.....	<0.1000	<0.8000		<0.8000	<0.8000
Nitrogen-Organic.....	<0.1000	1.0000		0.3000	<1.0000
Nitrogen-Total (CALC).....	0.2000	4.3000		2.1000	0.2000
Boron (T).....	0.1530			0.3190	
Fluoride (T).....	0.7700	0.8900		0.7700	0.7900
Cation/Anion Balance.....	7.7500 03A	1.3700		2.0300 03A	4.7400 03A
Electrical Conductivity.....	610.0000	600.0000		660.0000	840.0000
Field Electrical Conductivity.	914.0000	871.0000	890.0000	896.0000	
Field pH.....	7.2200	7.1600	7.0800	7.1800	7.2000
Field Water temperature (C)...	24.1000	24.1000	24.0000	24.0000	
TDS @ 180 C.....	584.0000	581.0000		544.0000	571.0000
TOC.....	1.2000	1.5000		1.6000	1.0000
Laboratory.....	TSS	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 07/19/90	10/03/90	11/19/90	01/23/91	01/08/92
SC-01					
Aluminum (T)	0.0680			0.0930	<0.2000
Antimony (T)	0.0630	<0.0625		<0.0625	<0.1500
Arsenic (T)	0.0050	0.0080		0.0050	0.0060
Barium (T)	0.0410	0.0380		0.0360	0.0390
Beryllium (T)	<0.0013	<0.0013		<0.0013	<0.0050
Cadmium (T)	<0.0050	<0.0050		<0.0050	<0.0004
Chromium (T)	<0.0088	<0.0088		<0.0088	<0.0150
Cobalt (T)				0.0100	<0.0300
Copper (T)	<0.0075	<0.0075		<0.0075	0.0000
Iron (T)	0.1680	<0.0500		<0.0500	<0.0300
Lead (T)	0.0030	0.0050		<0.0010	0.0010
Manganese (T)	0.0070	0.0030		<0.0025	<0.0100
Mercury (T)	<0.0002	<0.0002		<0.0002	<0.0005
Molybdenum (T)				<0.0125	<0.0300
Nickel (T)	<0.0125			0.0130	<0.1000
Selenium (T)	<0.0050	<0.0050		<0.0050	<0.0050
Silver (T)	<0.0005	<0.0005		<0.0005	<0.0005
Strontium (T)	0.5130	0.5630		0.5480	0.5410 67
Thallium (T)	<0.0050				<1.0000
Tin (T)					<0.2000 67
Titanium (T)		<0.0500		<0.0500 67	<0.0300 67
Vanadium (T)					<0.0500
Zinc (T)	0.1630	0.0850		0.0810	0.0880
Laboratory	TSS	TSS	TSS	TSS	TSS

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
31 - Results suspect, possible contamination, used in calculations.
33 - Results suspect.
67 - Not approved EPA method

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 05/13/88	11/08/88	02/22/89	06/29/89	02/07/90	03/07/90	04/03/90	05/01/90
SC-02								
Calcium (T)	66.0000	68.0000	70.0000	74.0000	69.0000	75.3000	74.5000	78.8000
Magnesium (T)	10.0000	12.0000	11.6000	13.0000	11.9000	12.0000	11.1000	12.1000
Sodium (T)	111.0000	106.0000	112.0000	111.0000	102.0000	101.0000	109.0000	89.3000
Potassium (T)	3.1000	3.1000	3.1000	3.2000	2.6000	2.9000	2.4000	2.6000
Carbonate	<2.6000	<2.6000	<2.6000	<2.6000	>0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate	257.0000	268.0000	268.0000	278.0000	226.0000	230.0000	238.0000	234.0000
Chloride	69.7000	76.5000	86.4000	90.3000	74.4000	61.5000	78.4000	71.8000
Sulfate (T)	109.0000	105.0000	102.0000	100.0000	99.0000	102.0000	106.0000	106.0000
Nitrate (as N)	5.9100	6.2000	6.4900	8.8700	9.4000	9.4000	9.8700	10.5000
Nitrite (as N)					<0.2000	<0.2000	<0.2000	<0.2000
Nitrogen-Ammonia	0.0400	<0.2000	<0.0200	<0.0200	<0.1000	<0.1000	<0.1000	<0.1000
Nitrogen-Kjeldhal	<0.2000	<0.2000	<0.2000	<0.2000				
Nitrogen-Organic	<0.2000	<0.2000	<0.2000	<0.2000	0.3000	<0.1000	<0.1000	<0.0000
Nitrogen-Total (CALC)	5.9500	6.2000	6.4900	8.8700	9.7000	9.4000	9.8700	10.5000
Boron (T)	0.4200	0.4200	0.4000	0.4400	0.1530	0.1880	0.3780 31	0.4580 33
Bromide				0.3000				
Fluoride (T)	0.1800	0.1100	0.1500	0.1400	0.1700	0.2200	0.1900	0.1700
Cation/Anion Balance	0.8900	0.5500	0.0500	0.7200	2.2300 03A	5.1900 03A	2.1600 03A	0.3400
Chloride/Bromide Ratio				301.0000				
Electrical Conductivity	860.0000	860.0000	900.0000	910.0000	851.0000	944.0000	880.0000	920.0000
Field Electrical Conductivity	845.0000	910.0000	825.0000	869.0000	988.0000	884.0000	978.0000	974.0000
Field pH	7.3800	7.0100	6.9900	7.8500	6.8500	6.9500 33	7.2100	7.1100
Field water temperature (C)	23.9000	23.0000	23.5000	24.0000	23.0000	23.0000	23.0000	22.0000
pH	7.8000	7.7000	7.3000	7.4000				
TDS @ 180 C	565.0000	565.0000	575.0000	595.0000	591.0000	617.0000	540.0000	632.0000
TOC	<5.0000	2.0000	1.6000	1.8000	1.5000	1.9000	2.9000	<1.0000
Laboratory	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 05/13/88	11/08/88	02/22/89	06/29/89	02/07/90	03/07/90	04/03/90	05/01/90
SC-02								
Aluminum (T)					<0.0500	<0.0500	<0.0500	<0.0500
Antimony (T)					<0.0625	<0.0625	<0.0625	<0.0625
Arsenic (T)	<0.0100	<0.0100	<0.0100	<0.0100	0.0070	0.0050	0.0040	0.0030
Barium (T)	<0.1000	<0.1000	<0.1000	<0.1000	0.0580	0.0640	0.0580	0.0610
Beryllium (T)					<0.0013	<0.0013	<0.0013	0.0020
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Chromium (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0088	<0.0088	<0.0088	<0.0088
Copper (T)				<0.0100	<0.0075	<0.0075	<0.0075	<0.0075
Iron (T)	<0.0500	<0.0500	0.1300	<0.0500	0.0800	<0.0500	<0.0500	<0.0500
Lead (T)	<0.0100	<0.0100	0.0100	<0.0100	<0.0020	0.0010	0.0020	<0.0010
Manganese (T)	<0.0100	<0.0100	0.0100	0.0130	<0.0025	0.0070	0.0070	0.0050
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nickel (T)					<0.0125	<0.0125	<0.0125	<0.0125
Selenium (T)	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Silver (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0125	<0.0125	<0.0125	<0.0125
Thallium (T)					<0.0050	<0.2500	<0.2500	<0.2500
Tin (T)					<0.2500	<0.2500	<0.2500	
Titanium (T)					<0.0500	<0.0500	<0.0500	
Zinc (T)				0.2690	0.1610	0.0620	0.1800	0.1770
Laboratory	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 10/03/90	11/19/90	01/23/91	01/08/92
SC-02				
Calcium (T).....	73.3000		72.5000	69.9000
Magnesium (T).....	12.5000		11.8000	12.0000
Sodium (T).....	109.0000		97.5000	101.0000
Potassium (T).....	2.4000		2.7000	2.8000
Carbonate.....	<0.5000		<0.5000	<0.5000
Bicarbonate.....	240.0000		237.0000	240.0000
Chloride.....	79.8000		88.4000	74.5000
Sulfate (T).....	96.4000		102.0000	89.9000
Nitrate (as N).....	11.2000		9.6000	5.9000
Nitrite (as N).....	0.4000		<0.2000	<0.2000
Nitrogen-Ammonia.....	<0.8000		<0.8000	<0.8000
Nitrogen-Organic.....	<0.1000		0.1000	<1.0000
Nitrogen-Total (CALC).....	11.6000		9.7000	5.9000
Boron (T).....			0.3020	
Fluoride (T).....	0.2200		0.1700	0.1700
Cation/Anion Balance.....	2.7000 03A		1.6600	3.6500 03A
Electrical Conductivity.....	745.0000		730.0000	870.0000
Field Electrical Conductivity.	975.0000		1000.0000	
Field pH.....	7.1400	6.9900	7.2400	7.1000
Field water temperature (C)...	23.5000	23.4000	23.1000	
TDS @ 180 C.....	663.0000		614.0000	594.0000
TOC.....	<1.0000		<1.0000	<1.0000
Laboratory.....	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 10/03/90	01/23/91	01/08/92
SC-02			
Aluminum (T)		0.0980	<0.2000
Antimony (T)	<0.0625	<0.0625	<0.1500
Arsenic (T)	0.0060	0.0020	0.0040
Barium (T)	0.0700	0.0580	0.5400
Beryllium (T)	0.0030	<0.0013	<0.0050
Cadmium (T)	<0.0050	<0.0050	<0.0004
Chromium (T)	<0.0088	<0.0088	<0.0150
Cobalt (T)		<0.0075	<0.0300
Copper (T)	0.0100	<0.0075	0.0000
Iron (T)	<0.0500	<0.0500	<0.0300
Lead (T)	0.0070	<0.0010	0.0010
Manganese (T)	0.0180	0.0100	0.0110
Mercury (T)	<0.0002	<0.0002	<0.0005
Molybdenum (T)		<0.0125	<0.0300
Nickel (T)		<0.0125	<0.1000
Selenium (T)	<0.0050	<0.0050	<0.0050
Silver (T)	<0.0005	<0.0005	<0.0005
Strontium (T)	0.7050	0.6680 67	0.5800 67
Thallium (T)			<1.0000
Tin (T)			<0.2000 67
Titanium (T)	<0.0500	<0.0500 67	<0.0300 67
Vanadium (T)			<0.0500
Zinc (T)	0.1570	0.1130	0.1580
Laboratory	TSS	TSS	TSS

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
31 - Results suspect, possible contamination, used in calculations.
33 - Results suspect.
67 - Not approved EPA method

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 05/19/88	10/05/88	02/22/89	06/29/89	01/16/90	03/07/90	04/10/90	05/01/90
SC-03								
Calcium (T).....	82.0000	88.0000	100.0000	92.0000	87.0000	86.3000	87.3000	81.8000
Magnesium (T).....	13.0000	14.0000	15.0000	15.0000	13.2000	12.9000	11.9000	12.0000
Sodium (T).....	98.0000	102.0000	95.0000	98.0000	92.0000	85.8000	91.3000	81.3000
Potassium (T).....	3.5000	3.3000	3.1000	3.1000	2.9000	2.7000	2.4000	2.2500
Carbonate.....	<2.6000	<2.6000	<2.6000	<2.6000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate.....	326.0000	352.0000	412.0000	382.0000	286.0000	281.0000	286.0000	285.0000
Chloride.....	80.4000	82.8000	88.8000	84.6000	19.9000	59.9000	70.4000	68.2000
Sulfate (T).....	77.0000	78.0000	100.0000	68.0000	78.0000	73.0000	79.6000	77.0000
Nitrate (as N).....	2.2700	4.5300	4.5300	0.8900	1.2000	1.1000	1.6000	1.7000
Nitrite (as N).....					<0.1000	<0.2000	<0.2000	<0.2000
Nitrogen-Ammonia.....	0.0300	0.1000	21.6000	0.0500	<0.1000	<0.1000	<0.1000	<0.1000
Nitrogen-Kjeldhal.....	0.6000	<0.2000	22.0000	<0.2000				
Nitrogen-Organic.....	0.6000	<0.2000	0.4000	<0.2000	0.2000	0.1000	<0.1000	0.2000
Nitrogen-Total (CALC).....	2.9000	4.6300	26.5300	0.9400	1.4000	1.2000	1.6000	1.9000
Boron (T).....	0.2300	0.2400	0.2100	0.2700	0.2950	0.0860	0.2340 31	0.2850 33
Bromide.....				0.2300	0.2000			
Fluoride (T).....	0.6500	0.6000	0.5200	0.5000	0.5000	0.6600	0.5500	0.5300
Cation/Anion Balance.....	0.6900	0.0500	1.3100	0.1000	15.2000 03A	7.3100 03A	5.1000 03A	1.9400
Chloride/Bromide Ratio.....				367.8300	99.5000			
Electrical Conductivity.....	900.0000	910.0000	1000.0000	910.0000	585.0000	896.0000	830.0000	870.0000
Field Electrical Conductivity.	863.0000	925.0000 17	874.0000	858.0000	348.0000	900.0000	927.0000	892.0000
Field pH.....	7.4400	7.1500	7.0000	7.6000	7.0800	7.0000	7.1100	7.0800
Field water temperature (C)...	24.4000	22.0000	23.0000	21.5000	22.0000	22.0000	22.5000	
pH.....	7.6000	7.5000	7.3000	7.4000				
TDS @ 180 C.....	565.0000	585.0000	640.0000	600.0000		571.0000	566.0000	558.0000
TOC.....	27.0000	1.5000	2.8000	2.4000	2.8000	1.1000	2.4000	
Laboratory.....	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 05/19/88	10/05/88	02/22/89	06/29/89	01/16/90	03/07/90	04/10/90	05/01/90
SC-03								
Aluminum (T)					<0.0500	<0.0500	<0.0500	0.0620
Antimony (T)					<0.0625	<0.0625	<0.0625	<0.0625
Arsenic (T)	<0.0100	<0.0100	<0.0100	<0.0100	0.0090	0.0100	0.0080	0.0080
Barium (T)	<0.1000	<0.1000	<0.1000	<0.1000	0.0570	0.0550	0.0410	0.0500
Beryllium (T)					<0.0013	<0.0013	<0.0013	0.0020
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Chromium (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0088	<0.0088	<0.0088	<0.0088
Copper (T)				<0.0100	<0.0075	<0.0075	<0.0075	<0.0075
Iron (T)	<0.0500	<0.0500	0.2600	<0.0500	<0.0500	<0.0500	<0.0500	<0.0500
Lead (T)	<0.0100	<0.0100	<0.0100	<0.0100	0.0020	0.0020	0.0020	0.0040
Manganese (T)	<0.0100	<0.0100	0.0300	<0.0100	<0.0025	0.0040	<0.0025	<0.0025
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nickel (T)					<0.0125	<0.0125	<0.0125	<0.0125
Selenium (T)	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Silver (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0125	<0.0125	<0.0125	<0.0125
Thallium (T)						<0.2500	<0.2500	<0.2500
Tin (T)					<0.2500	<0.2500	<0.2500	
Titanium (T)					<0.0500	<0.0500	<0.0500	
Zinc (T)				0.3260	0.1980	0.1750	0.1140	0.1230
Laboratory	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 07/19/90	10/03/90
SC-03		
Calcium (T)	77.8000	52.0000
Magnesium (T)	12.6000	10.4000
Sodium (T)	99.8000	57.0000
Potassium (T)	2.0000	2.1000
Carbonate	<0.5000	<0.5000
Bicarbonate	289.0000	230.0000
Chloride	68.5000	59.4000
Sulfate (T)	67.4000	75.6000
Nitrate (as N)	0.2000	3.3000
Nitrite (as N)	<0.2000	<0.2000
Nitrogen-Ammonia	<0.1000	<0.8000
Nitrogen-Organic	<0.1000	0.3000
Nitrogen-Total (CALC)	0.2000	3.6000
Boron (T)	0.0200 33	
Fluoride (T)	0.6000	0.7100
Cation/Anion Balance	6.9400 03A	9.8600 03A
Electrical Conductivity	601.0000	560.0000
Field Electrical Conductivity	888.0000	750.0000
Field pH	7.1200	7.0300
Field water temperature (C)	23.3000	22.5000
TDS @ 180 C	552.0000	497.0000
TOC	1.8000	1.6000
Laboratory	TSS	TSS

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 07/19/90	10/03/90
SC-03		
Aluminum (T)	<0.0500	
Antimony (T)	<0.0625	<0.0625
Arsenic (T)	0.0070	0.0100
Barium (T)	0.0510	0.0480
Beryllium (T)	<0.0013	0.0020
Cadmium (T)	<0.0050	<0.0050
Chromium (T)	<0.0088	<0.0088
Copper (T)	<0.0075	<0.0075
Iron (T)	<0.0500	<0.0500
Lead (T)	0.0010	0.0060
Manganese (T)	0.0080	<0.0025
Mercury (T)	<0.0002	<0.0002
Nickel (T)	<0.0125	
Selenium (T)	<0.0050	<0.0050
Silver (T)	<0.0005	<0.0005
Strontium (T)	0.5380	0.5480
Thallium (T)	<0.0050	
Titanium (T)		<0.0500
Zinc (T)	0.1050	0.0930
Laboratory	TSS	TSS

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
17C - Field EC is not temp. adjusted due to missing temp data.
31 - Results suspect, possible contamination, used in calculations.
33 - Results suspect.

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 05/17/88	10/05/88	02/22/89	06/29/89	01/16/90	03/13/90	04/10/90	05/08/90
SC-04								
Calcium (T)	67.0000	72.0000	68.0000	69.0000	67.0000	69.0000	63.5000	50.5000
Magnesium (T)	10.0000	7.9000	9.5000	12.0000	10.2000	10.2000	9.0500	7.6500
Sodium (T)	97.0000	116.0000	98.0000	94.0000	92.0000	92.3000	90.3000	64.8000
Potassium (T)	3.7000	3.9000	3.4000	3.4000	3.2000	2.6000	2.5000	2.0000
Carbonate	<2.6000	<2.6000	<2.6000	<2.6000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate	226.0000	261.0000	252.0000	268.0000	212.0000	212.0000	214.0000	220.0000
Chloride	75.0000	83.9000	72.9000	76.1000	19.1000	65.3000	67.3000	65.7000
Sulfate (T)	94.0000	95.0000	93.0000	86.0000	87.0000	90.0000	95.0000	95.2000
Nitrate (as N)	7.3800	8.3800	6.3100	4.4200	4.8000	4.8000	4.3000	4.0000
Nitrite (as N)					<0.2000	<0.2000	<0.2000	<0.2000
Nitrogen-Ammonia	0.4300	0.4200	0.6000	0.3200	<0.1000	<0.1000	<0.1000	<0.1000
Nitrogen-Kjeldhal	0.7000	0.9000	0.6000	0.4000				
Nitrogen-Organic	0.3000	0.5000	<0.2000	<0.2000	0.3000	0.1000	<0.1000	0.2000
Nitrogen-Total (CALC)	8.1100	9.3000	6.9100	4.7400	5.1000	4.9000	4.3000	4.2000
Boron (T)	0.2400	0.1800	0.2600	0.2800	0.3050	0.2290	0.1750 31	0.2250
Bromide				0.2500				
Fluoride (T)	0.3700	0.3000	0.3400	0.3600	0.3600	0.3500	0.4300	0.3800
Cation/Anion Balance	1.1300	0.9600	0.0000	0.1200	14.3800 03A	5.2000 03A	1.2800	12.4800 03A
Chloride/Bromide Ratio				304.4000				
Electrical Conductivity	840.0000	880.0000	810.0000	810.0000	588.0000	810.0000	750.0000	795.0000
Field Electrical Conductivity	923.0000	900.0000 17	741.0000	494.0000	351.0000	786.0000	850.0000	826.6600
Field pH	7.2100	6.7000	6.9000	7.4000	6.9700	6.7500 33	6.9100	6.9400
Field water temperature (C)	22.2000		22.0000	23.0000	21.0000	20.8000	21.8000	22.0000
pH	7.4000	7.2000	7.2000	7.2000				
TDS @ 180 C	540.0000	570.0000	520.0000	520.0000		524.0000	516.0000	506.0000
TOC	<5.0000	2.8000	1.9000	2.4000		1.2000	2.0000	<1.0000
Laboratory	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 05/17/88	10/05/88	02/22/89	06/29/89	01/16/90	03/13/90	04/10/90	05/08/90
SC-04								
Aluminum (T).....					<0.0500	<0.0500	<0.0500	<0.0500
Antimony (T).....					<0.0625	<0.0625	<0.0625	<0.0625
Arsenic (T).....	0.0100	0.0200	0.0100	0.0160	0.0180	0.0110	0.0130	0.0180
Barium (T).....	<0.1000	<0.1000	<0.1000	<0.1000	0.0500	0.0390	0.0440	0.0510
Beryllium (T).....					<0.0013	<0.0013	<0.0013	0.0020
Cadmium (T).....	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Chromium (T).....	<0.0100	<0.0100	<0.0100	<0.0100	<0.0088	<0.0088	<0.0088	0.0220
Copper (T).....				<0.0100	<0.0075	<0.0075	<0.0075	<0.0075
Iron (T).....	<0.0500	<0.0500	0.3400	<0.0500	0.0710	0.3230	0.1270	<0.0500
Lead (T).....	<0.0100	<0.0100	0.0100	0.0100	0.0060	0.0020	0.0030	0.0040
Manganese (T).....	0.0100	<0.0100	0.0200	0.1100	<0.0025	<0.0025	0.0030	<0.0025
Mercury (T).....	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nickel (T).....					<0.0125	<0.0125	<0.0125	<0.0125
Selenium (T).....	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Silver (T).....	<0.0100	<0.0100	<0.0100	<0.0100	<0.0125	<0.0125	<0.0125	<0.0125
Thallium (T).....						<0.2500	<0.2500	<0.2500
Tin (T).....					<0.2500		<0.2500	
Titanium (T).....					<0.0500	<0.0500	<0.0500	
Zinc (T).....				0.3110	0.2190	0.1760	0.1700	0.1710
Laboratory.....	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 10/11/90	09/11/91	01/15/92
SC-04			
Calcium (T).....	38.5000	47.5000	50.7000
Magnesium (T).....	5.7000	7.5800	8.4000
Sodium (T).....	69.3000	75.8000	72.9000
Potassium (T).....	2.8000	3.4000	3.6000
Carbonate.....	<0.5000	<0.5000	<0.5000
Bicarbonate.....	142.0000	181.0000	196.0000
Chloride.....	46.3000	56.6000	54.7000
Sulfate (T).....	68.4000	72.0000	65.7000
Nitrate (as N).....	4.2000	2.2000	2.2000
Nitrite (as N).....	<0.2000	<0.2000	<0.2000
Nitrogen-Ammonia.....	<0.8000	<0.8000	<0.8000
Nitrogen-Organic.....	0.8000	6.2000	<1.0000
Nitrogen-Total (CALC).....	5.0000	8.4000	2.2000
Fluoride (T).....	0.3100	0.3600	0.4000
Cation/Anion Balance.....	0.9200	1.3500	1.6400
Electrical Conductivity.....	412.0000	540.0000	650.0000
Field Electrical Conductivity.	572.0000		
Field pH.....	6.8400	6.9000	6.9000
Field water temperature (C)...	23.5000		
TDS @ 180 C.....	378.0000	435.0000	433.0000
TOC.....	3.8000	1.5000	1.2000
Laboratory.....	TSS	TSS	TSS

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 10/11/90	09/11/91	01/15/92
SC-04			
Aluminum (T)		<0.2000	<0.2000
Antimony (T)	<0.0625	<0.1500	<0.1500
Arsenic (T)	0.0180	0.0160	0.0110
Barium (T)	0.0470	0.0530	0.0540
Beryllium (T)	<0.0013	<0.0050	
Cadmium (T)	<0.0050	<0.0004	<0.0004
Chromium (T)	<0.0088	<0.0150	<0.0150
Cobalt (T)		<0.0300	<0.0300
Copper (T)	0.0130	0.0000	0.0000
Iron (T)	0.0910	0.0340	<0.0300
Lead (T)	0.0040	0.0010	<0.0010
Manganese (T)	0.0180	0.0210	0.0190
Mercury (T)	<0.0002	<0.0005	<0.0005
Molybdenum (T)		<0.0300	<0.0300
Nickel (T)		<0.1000	<0.1000
Selenium (T)	0.0050	0.0050	<0.0050
Silver (T)	<0.0005	<0.0005	<0.0005
Strontium (T)	0.3430	0.4320 67	0.4620 67
Thallium (T)		<1.0000	
Tin (T)		<1.0000 67	<0.2000 67
Titanium (T)	<0.0500	<0.0300 67	<0.0300 67
Vanadium (T)		<0.0500	<0.0500
Zinc (T)	0.1670	0.1250	0.1390
Laboratory	TSS	TSS	TSS

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
17C - Field EC is not temp. adjusted due to missing temp data.
31 - Results suspect, possible contamination, used in calculations.
33 - Results suspect.
67 - Not approved EPA method

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 05/24/88	10/05/88	02/23/89	07/11/89	01/23/90	03/13/90	04/10/90	05/08/90
SC-05								
Calcium (T)	77.0000	68.0000	82.0000	78.0000	67.0000	71.5000	76.3000	70.0000
Magnesium (T)	8.0000	5.3000	9.2000	8.4000	7.2300	7.8900	8.2000	7.2800
Sodium (T)	117.0000	103.0000	104.0000	112.0000	97.0000	94.5000	104.0000	96.0000
Potassium (T)	4.0000	3.8000	3.9000	3.4000	3.5000	2.4000	3.1000	2.9000
Carbonate	<2.6000	<2.6000	<2.6000	<2.6000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate	277.0000	252.0000	286.0000	302.0000	232.0000	238.0000	242.0000	242.0000
Chloride	72.6000	70.4000	74.7000	79.3000	71.9000	68.9000	68.4000	68.8000
Sulfate (T)	135.0000	93.0000	114.0000	104.0000	78.0000	102.0000	111.0000	110.0000
Nitrate (as N)	4.9300	4.6200	4.7300	2.1800	1.5000	1.8000	2.2000	2.2000
Nitrite (as N)					<0.2000	<0.2000	<0.2000	<0.2000
Nitrogen-Ammonia	0.9200	0.9200	0.9000	0.7800	<0.1000	<0.1000	0.0000	<0.1000
Nitrogen-Kjeldhal	1.0000	1.0000	1.0000	0.8000				
Nitrogen-Organic	<0.2000	<0.2000	<0.2000	<0.2000	0.4500	0.8000	0.0000	0.8000
Nitrogen-Total (CALC)	5.8500	5.5400	5.6300	2.9600	1.9500	2.6000	2.2000	3.0000
Boron (T)	0.2900	3.4000	0.2500	0.2600	0.2650	0.2060	0.1650 31	0.2780
Bromide				0.2100	0.1700			
Fluoride (T)	0.1800	0.1900	0.1600	0.1900	0.2500	0.2400	0.2700	0.2400
Cation/Anion Balance	0.0500	0.5900	0.1600	0.5200	4.4700 03A	2.2300 03A	4.0600 03A	0.1800
Chloride/Bromide Ratio				377.6200	422.9400			
Electrical Conductivity	930.0000	800.0000	890.0000	900.0000	494.0000	855.0000	830.0000	860.0000
Field Electrical Conductivity	1051.0000	850.0000 17	813.0000	490.0000	338.0000	858.0000	932.0000	875.0000
Field pH	7.0900	6.8600	7.2000	6.9600	7.0600	6.8500 33	7.1200	7.1800
Field water temperature (C)	21.1000		22.5000	23.5000	23.0000	23.0000	23.9000	23.5000
pH	7.4000	7.4000	7.1000	7.4000				
TDS @ 180 C	605.0000	515.0000	565.0000	585.0000	541.0000	550.0000	556.0000	528.0000
TOC	<5.0000	3.4000	2.1000	17.0000	2.4000	2.4000	1.2000	6.4000
Laboratory	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 05/24/88	10/05/88	02/23/89	07/11/89	01/23/90	03/13/90	04/10/90	05/08/90
SC-05								
Aluminum (T)					<0.0500	<0.0500	<0.0500	<0.0500
Antimony (T)					<0.0625	<0.0625	<0.0625	<0.0625
Arsenic (T)	<0.0100	<0.0100	<0.0100	<0.0100	0.0110	0.0060	0.0080	0.0070
Barium (T)	<0.1000 <	<0.1000	<0.1000	<0.1000	0.0570	0.0750	0.0590	0.0570
Beryllium (T)					<0.0013	<0.0013	<0.0013	<0.0013
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Chromium (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0088	<0.0088	<0.0088	<0.0088
Copper (T)				<0.0100	0.0100	0.0100	<0.0075	<0.0075
Iron (T)	<0.0500	0.0800	0.1400	0.1660	0.5880	1.4100	0.0670	0.0850
Lead (T)	<0.0100	<0.0100	<0.0100	0.0100	0.0050	0.0020	0.0040	0.0020
Manganese (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0025	0.0030	<0.0025	0.0050
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nickel (T)					<0.0125	<0.0125	<0.0125	<0.0125
Selenium (T)	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Silver (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0125	<0.0125	<0.0125	<0.0125
Thallium (T)						<0.2500	<0.2500	<0.2500
Tin (T)					<0.2500	<0.2500	<0.2500	
Titanium (T)					<0.0500	<0.0500	<0.0500	
Zinc (T)				0.1700	0.1710	0.1520	0.0790	0.0910
Laboratory	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 07/19/90	10/11/90	09/11/91	01/15/92
SC-05				
Calcium (T).....	66.3000	50.4000	64.3000	62.3000
Magnesium (T).....	7.4500	5.0100	7.2800	7.4600
Sodium (T).....	106.0000	76.8000	93.3000	85.7000
Potassium (T).....	2.3000	2.3000	3.4000	3.6000
Carbonate.....	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate.....	252.0000	181.0000	213.0000	224.0000
Chloride.....	68.8000	48.6000	72.2000	71.0000
Sulfate (T).....	84.0000	66.7000	77.8000	72.7000
Nitrate (as N).....	2.4000	5.0000	1.0000	2.0000
Nitrite (as N).....	<0.2000	<0.2000	<0.2000	<0.2000
Nitrogen-Ammonia.....	<0.1000	<0.8000	<0.8000	<0.8000
Nitrogen-Organic.....	0.3000	1.0000	4.2000	1.2000
Nitrogen-Total (CALC).....	2.7000	6.0000	5.2000	3.2000
Boron (T).....	0.0880			
Fluoride (T).....	0.2700	0.3100	0.2700	0.2900
Cation/Anion Balance.....	3.7900 03A	1.9300	5.0700 03A	1.6100
Electrical Conductivity.....	599.0000	460.0000	620.0000	760.0000
Field Electrical Conductivity.	892.0000	652.0000		
Field pH.....	7.0800	7.0700	7.0000	7.0000
Field water temperature (C)...	23.5000	23.3000		
TDS @ 180 C.....	534.0000	424.0000	497.0000	506.0000
TOC.....	1.9000	2.0000	2.1000	2.5000
Laboratory.....	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 07/19/90	10/11/90	09/11/91	01/15/92
SC-05				
Aluminum (T)	0.0630		<0.2000	<0.2000
Antimony (T)	<0.0625	<0.0625	<0.1500	<0.1500
Arsenic (T)	0.0040	0.0080	0.0100	0.0100
Barium (T)	0.0580	0.2650	0.0730	0.0730
Beryllium (T)	0.0010	<0.0013	<0.0050	
Cadmium (T)	<0.0050	<0.0050	<0.0004	<0.0004
Chromium (T)	<0.0088	<0.0088	<0.0150	<0.0150
Cobalt (T)			<0.0300	<0.0300
Copper (T)	0.0120	0.0090	0.0000	0.0170
Iron (T)	0.5750	0.4180	0.1560	0.1010
Lead (T)	0.0020	0.0050	<0.0010	<0.0010
Manganese (T)	0.0030	<0.0025	0.0000	<0.0100
Mercury (T)	<0.0002	<0.0002	<0.0005	<0.0005
Molybdenum (T)			<0.0300	<0.0300
Nickel (T)	<0.0125	<0.0125	<0.1000	<0.1000
Selenium (T)	<0.0050	0.0060	0.0080	<0.0050
Silver (T)	<0.0005	<0.0005	<0.0005	<0.0005
Strontium (T)	0.4900	0.3450	0.4000 67	0.4420 67
Thallium (T)	<0.0050		<1.0000	
Tin (T)				<0.2000 67
Titanium (T)		<0.0500	<0.0300 67	<0.0300 67
Vanadium (T)			<0.0500	<0.0500
Zinc (T)	0.4800	0.1310	0.0760	0.1340
Laboratory	TSS	TSS	TSS	TSS

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
17C - Field EC is not temp. adjusted due to missing temp data.
31 - Results suspect, possible contamination, used in calculations.
33 - Results suspect.
67 - Not approved EPA method

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 05/26/88	10/05/88	02/23/89	07/11/89	01/23/90	03/13/90	04/10/90	05/08/90
SC-06								
Calcium (T)	80.0000	82.0000	69.0000	90.0000	76.8000	75.0000	75.0000	69.8000
Magnesium (T)	14.0000	14.0000	13.2000	12.0000	13.3000	14.2000	14.6000	13.5000
Sodium (T)	60.0000	61.0000	70.0000	80.0000	54.5000	59.8000	67.0000	55.0000
Potassium (T)	2.9000	3.3000	2.6000	1.8000	3.0000	2.5000	2.1000	2.4000
Carbonate	<2.6000	<2.6000	<2.6000	<2.6000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate	223.0000	231.0000	239.0000	278.0000	173.0000	184.0000	187.0000	184.0000
Chloride	55.9000	59.5000	63.0000	79.3000	44.5000	59.4000	64.0000	57.4000
Sulfate (T)	100.0000	95.0000	81.0000	104.0000	93.0000	90.8000	105.0000	114.0000
Nitrate (as N)	5.0200	7.8700	4.0400	2.1800	7.3000	4.6000	5.3000	7.3000
Nitrite (as N)					<0.2000	<0.2000	<0.2000	<0.2000
Nitrogen-Ammonia	0.0500	0.0400	0.0200	0.0400	<0.1000	<0.1000	<0.1000	<0.1000
Nitrogen-Kjeldhal	<0.2000	<0.2000	<0.2000	<0.2000				
Nitrogen-Organic	<0.2000	<0.2000	<0.2000	<0.2000	0.0000	<0.1000	<0.1000	0.2000
Nitrogen-Total (CALC)	5.0700	7.9100	4.0600	2.2200	7.3000	4.6000	5.3000	7.5000
Boron (T)	0.2000	0.1500	0.2000	0.2100	0.2460	0.0480	0.1600 31	0.2290
Bromide			<2.6000	0.1600				
Fluoride (T)	0.1300	0.1500	0.1500	0.2100	0.1900	0.1800	0.2200	0.2000
Cation/Anion Balance	0.9700	0.1900	0.0700	0.6100	6.4900 03A	4.8100 03A	3.1200 03A	3.0000 03A
Chloride/Bromide Ratio				495.6300				
Electrical Conductivity	750.0000	750.0000	740.0000	850.0000	458.0000	725.0000	720.0000	740.0000
Field Electrical Conductivity	809.0000	800.0000 17	722.0000	507.0000	325.0000	736.0000	784.0000	725.0000
Field pH	7.2200	7.0500	7.3200	6.8600	7.0600	7.2500 33	7.2300	7.3000
Field water temperature (C)	22.8000		21.5000	24.5000	22.5000	20.5000	22.0000	23.0000
pH	7.5000	7.5000	7.1000	7.3000				
TDS @ 180 C	485.0000	485.0000	455.0000	560.0000	537.0000	512.0000	500.0000	496.0000
TOC	<5.0000	1.3000	2.6000	15.0000	0.6000	<1.0000	<1.0000	5.7000
Laboratory	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 05/26/88	10/05/88	02/23/89	07/11/89	01/23/90	03/13/90	04/10/90	05/08/90
SC-06								
Aluminum (T)					<0.0500	<0.0500	<0.0500	<0.0500
Antimony (T)					<0.0625	<0.0625	<0.0625	<0.0625
Arsenic (T)	<0.0100	<0.0100	<0.0100	<0.0100	0.0050	<0.0020	0.0030	<0.0020
Barium (T)	0.1000	<0.1000	<0.1000	<0.1000	0.1080	0.1010	0.0950	0.1040
Beryllium (T)					<0.0013	<0.0013	<0.0013	<0.0013
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Chromium (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0088	<0.0088	<0.0088	<0.0088
Copper (T)				<0.0100	<0.0075	<0.0075	<0.0075	<0.0075
Iron (T)	<0.0500	0.1000	0.8100	0.0560	1.6100	0.7550	0.3950	1.0600
Lead (T)	<0.0100	<0.0100	0.0300	0.0160	0.0090	0.0070	0.0020	0.0070
Manganese (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0025	<0.0025	<0.0025	0.0040
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nickel (T)					<0.0125	<0.0125	<0.0125	<0.0125
Selenium (T)	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Silver (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0125	<0.0125	<0.0125	<0.0125
Thallium (T)						<0.2500	<0.2500	<0.2500
Tin (T)					<0.2500	<0.2500	<0.2500	
Titanium (T)					<0.0500	<0.0500	<0.0500	
Zinc (T)				0.6000	0.4600	0.3300	0.1750	0.1840
Laboratory	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 07/26/90	10/11/90	01/15/92
SC-06			
Calcium (T).....	78.3000	70.3000	77.8000
Magnesium (T).....	14.6000	13.1000	16.4000
Sodium (T).....	52.0000	55.8000	75.1000
Potassium (T).....	2.1000	2.0000	3.1000
Carbonate.....	<0.5000	<0.5000	<0.5000
Bicarbonate.....	184.0000	168.0000	224.0000
Chloride.....	51.5000	47.8000	79.2000
Sulfate (T).....	103.0000	101.0000	99.2000
Nitrate (as N).....	7.2000	6.9000	2.6000
Nitrite (as N).....	<0.2000	<0.2000	<0.2000
Nitrogen-Ammonia.....	<0.1000	<0.8000	<0.8000
Nitrogen-Organic.....	0.6000	<0.1000	<1.0000
Nitrogen-Total (CALC).....	7.8000	6.9000	2.6000
Fluoride (T).....	0.2000	0.2700	0.2300
Cation/Anion Balance.....	2.5900 03A	2.8300 03A	2.6300 03A
Electrical Conductivity.....	695.0000	490.0000	835.0000
Field Electrical Conductivity.	758.0000	692.0000	
Field pH.....	7.1600	7.1800	7.0000
Field water temperature (C)...	23.3000	22.9000	
TDS @ 180 C.....	496.0000	444.0000	554.0000
TOC.....	1.1000	1.1000	1.2000
Laboratory.....	TSS	TSS	TSS

Appendix D. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 07/26/90	10/11/90	01/15/92	
SC-06				
Aluminum (T)	<0.0500		<0.2000	
Antimony (T)	<0.0625	<0.0625	<0.1500	
Arsenic (T)	0.0040	<0.0020	0.0030	
Barium (T)	0.0940	0.1090	0.1220	
Beryllium (T)	<0.0013	0.0020		
Cadmium (T)	<0.0050	<0.0050	<0.0004	
Chromium (T)	<0.0088	<0.0088	<0.0150	
Cobalt (T)			<0.0300	
Copper (T)	<0.0075	0.0240	<0.0150	
Iron (T)	1.7100	0.1750	0.1330	
Lead (T)	0.0090	0.0060	<0.0010	
Manganese (T)	0.0030	<0.0025	<0.0100	
Mercury (T)	<0.0002	<0.0002	<0.0005	
Molybdenum (T)			<0.0300	
Nickel (T)	<0.0125		<0.1000	
Selenium (T)	<0.0050	<0.0050	<0.0050	
Silver (T)	<0.0005	<0.0005	<0.0005	
Strontium (T)	0.6850	0.4900	0.5550	67
Thallium (T)	<0.0050			
Tin (T)	<0.2500		<0.2000	67
Titanium (T)	<0.0500	<0.0500	<0.0300	67
Vanadium (T)			<0.0500	
Zinc (T)	0.2230	0.2290	0.2460	
Laboratory	TSS	TSS	TSS	

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
17C - Field EC is not temp. adjusted due to missing temp data.
31 - Results suspect, possible contamination, used in calculations.
33 - Results suspect.
67 - Not approved EPA method

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 05/31/88	10/06/88	02/23/89	07/11/89	01/23/90	03/20/90	04/17/90	05/15/90
SC-07								
Calcium (T).....	59.0000	58.0000	62.0000	63.0000	58.5000	56.5000	55.8000	61.5000
Magnesium (T).....	10.0000	11.0000	11.0000	11.0000	10.6000	10.3000	10.7000	10.5000
Sodium (T).....	95.0000	97.0000	100.0000	108.0000	103.0000	90.8000	97.5000	102.0000
Potassium (T).....	4.2000	5.0000	4.8000	5.3000	5.8000	2.8000	5.0000	6.8000
Carbonate.....	<2.6000	<2.6000	<2.6000	<2.6000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate.....	249.0000	262.0000	275.0000	299.0000	230.0000	248.0000	245.0000	241.0000
Chloride.....	80.7000	76.5000	78.2000	84.2000	71.8000	72.9000	82.1000	71.5000
Sulfate (T).....	85.0000	85.0000	83.0000	78.0000	70.0000	74.0000	70.8000	73.6000
Nitrate (as N).....	0.4000	0.4900	0.6900	0.2000	0.3000	<0.2000	0.2000 33B	<0.2000
Nitrite (as N).....					<0.2000	<0.2000	<0.2000 33B	<0.2000
Nitrogen-Ammonia.....	0.3100	0.4200	0.4500	0.5800	<0.1000	<0.1000	<0.1000 33B	1.1000
Nitrogen-Kjeldhal.....	0.4000	0.5000	0.5000	0.6000				
Nitrogen-Organic.....	<0.2000	<0.2000	<0.2000	<0.2000	<0.1000	1.1000	1.0000 33B	0.0000
Nitrogen-Total (CALC).....	0.7100	0.9100	1.1400	0.7800	0.3000		1.2000	1.1000
Boron (T).....	0.2600		0.2600	0.2200	0.2750	0.1730	0.2030 33	0.3250 33
Bromide.....				0.2100				
Fluoride (T).....	0.3800	0.3700	0.3500	0.3500	0.3600	0.4000	0.3800	0.3600
Cation/Anion Balance.....	0.8600	0.5500	0.0600	0.1100	7.3700 03A	0.2600	1.3200	7.0000 03A
Chloride/Bromide Ratio.....				400.9500				
Electrical Conductivity.....	790.0000	780.0000	800.0000	840.0000	840.0000	650.0000	750.0000	780.0000
Field Electrical Conductivity.			787.0000	486.0000	312.0000	799.0000	814.0000	822.0000
Field pH.....			7.2400	7.0100	7.1800	6.8500 33	7.1700	7.2400
Field water temperature (C)...			22.5000	24.0000	23.0000	23.5000	23.5000	23.0000
pH.....	7.4000	7.7000	7.2000	7.4000				
TDS @ 180 C.....	495.0000	480.0000	485.0000	520.0000	580.0000	504.0000	503.0000	478.0000
TOC.....	12.0000	53.1000	3.2000	24.0000	25.6000	2.7000	1.6000	1.6000
Laboratory.....	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 05/31/88	10/06/88	02/23/89	07/11/89	01/23/90	03/20/90	04/17/90	05/15/90
SC-07								
Aluminum (T)					<0.0500	<0.0500	<0.0500	<0.0500
Antimony (T)					<0.0625	<0.0625	<0.0625	<0.0625
Arsenic (T)	0.0200	0.0200	0.0200	0.0240	0.0250	0.0210	0.0260	0.0230
Barium (T)	<0.1000	<0.1000	<0.1000	<0.1000	0.0450	0.0430	0.0410	0.0480
Beryllium (T)					<0.0013	<0.0013	<0.0013	<0.0013
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Chromium (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0088	<0.0088	<0.0088	<0.0088
Copper (T)				0.0190	0.0190	0.0140	0.0140	0.0130
Iron (T)	<0.0500	<0.0500	0.2200	0.1570	0.2930	0.4450	0.2730	0.3100
Lead (T)	<0.0100	<0.0100	<0.0100	0.0140	0.0040	0.0040	<0.0010	0.0040
Manganese (T)	<0.0100	<0.0100	0.0300	0.0270	0.0460	0.0570	0.0570	0.0590
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nickel (T)					<0.0125	<0.0125	<0.0125	<0.0125
Selenium (T)	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Silver (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0125	<0.0125	<0.0125	<0.0125
Thallium (T)						<0.2500	<0.2500	<0.2500
Tin (T)					<0.2500	<0.2500	<0.2500	
Titanium (T)					<0.0500	<0.0500	<0.0500	<0.0500
Zinc (T)				0.2740	0.2230	0.2470	0.1460	0.2180
Laboratory	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 07/19/90	10/16/90	09/18/91	01/22/92
SC-07				
Calcium (T).....	55.8000	55.0000	56.4000	63.1000
Magnesium (T).....	10.3000	9.4000	10.3000	11.0000
Sodium (T).....	101.0000	102.0000	91.0000	90.9000
Potassium (T).....	4.9000	5.4000	5.4000	6.2000
Carbonate.....	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate.....	255.0000	233.0000	218.0000	240.0000
Chloride.....	70.5000	59.3000	65.7000	74.6000
Sulfate (T).....	68.0000	76.4000	85.1000	87.8000
Nitrate (as N).....	<0.2000	0.6000	0.8000	1.5000
Nitrite (as N).....	<0.2000	<0.2000	<0.2000	<0.2000
Nitrogen-Ammonia.....	1.2000	1.3000	<0.8000	<0.8000
Nitrogen-Organic.....	0.0000	0.6000		1.5000
Nitrogen-Total (CALC).....	1.2000	2.5000	0.8000	3.0000
Boron (T).....	0.0380 33			
Fluoride (T).....	0.3900	0.4000	0.3700	0.3700
Cation/Anion Balance.....	4.2800 03A	6.9100 03A	3.5300 03A	1.3600
Electrical Conductivity.....	597.0000	595.0000	740.0000	810.0000
Field Electrical Conductivity.	847.0000	759.0000		
Field pH.....	7.1100	7.3000	7.2000	7.0000
Field water temperature (C)...	22.7000	22.1000		
TDS @ 180 C.....	526.0000	506.0000	507.0000	517.0000
TOC.....	2.2000	2.0000	19.7000 31	2.7000
Laboratory.....	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 07/19/90	10/16/90	09/18/91	01/22/92
SC-07				
Aluminum (T)	<0.0500		<0.2000	<0.2000
Antimony (T)	<0.0625	<0.0625	<0.1500	<0.1500
Arsenic (T)	0.0190	0.0180	0.0210	0.0030
Barium (T)	0.0520	0.0380	0.0410	0.0510
Beryllium (T)	<0.0013	<0.0013	<0.0050	
Cadmium (T)	<0.0050	<0.0050	<0.0004	<0.0004
Chromium (T)	<0.0088	<0.0088	<0.0150	<0.0150
Cobalt (T)			<0.0300	<0.0300
Copper (T)	0.0150	0.0080	0.0000	0.0250
Iron (T)	0.7950	0.3700	0.1640	0.1230
Lead (T)	0.0020	0.0040	<0.0010	<0.0010
Manganese (T)	0.1230	0.0940	0.0280	0.0480
Mercury (T)	<0.0002	<0.0002	<0.0005	<0.0005
Molybdenum (T)			0.0300	0.0310
Nickel (T)	<0.0125	<0.0125	<0.1000	<0.1000
Selenium (T)	<0.0050	0.0060	<0.0050	<0.0050
Silver (T)	<0.0005	<0.0125	<0.0005	<0.0005
Strontium (T)	0.5550	0.4480	0.5140 67	0.5750 67
Thallium (T)	<0.0050		<1.0000	
Tin (T)			<1.0000 67	<1.0000 67
Titanium (T)		<0.0500	<0.0300 67	<0.0300 67
Vanadium (T)			<0.0500	<0.0500
Zinc (T)	0.1510	0.1390	0.2000	0.1850
Laboratory	TSS	TSS	TSS	TSS

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
31 - Results suspect, possible contamination, used in calculations.
33 - Results suspect.
33B - Results suspect, unpreserved samples analyzed.
67 - Not approved EPA method

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 06/02/88	10/06/88	02/23/89	07/11/89	01/30/90	03/20/90	04/17/90	05/15/90
SC-08								
Calcium (T)	98.0000	93.0000	93.0000	72.0000	90.5000	90.8000	78.3000	86.3000
Magnesium (T)	13.0000	13.0000	12.6000	15.0000	11.5000	11.6000	9.9500	11.4000
Sodium (T)	77.0000	77.0000	77.0000	68.0000	77.8000	78.3000	68.0000	84.0000
Potassium (T)	2.2000	2.0000	2.0000	2.3000	1.9000	1.6000	1.8000	1.5000
Carbonate	<2.6000	<2.6000	<2.6000	<2.6000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate	262.0000	264.0000	271.0000	238.0000	230.0000	230.0000	221.0000	223.0000
Chloride	83.2000	85.0000	81.1000	62.7000	76.6000	71.9000	166.3000	70.8000
Sulfate (T)	120.0000	105.0000	108.0000	86.0000	95.0000	102.0000	95.6000	101.0000
Nitrate (as N)	3.3600	3.0400	2.2700	4.5300	3.4000	3.9000	1.8000 33B	2.2000
Nitrite (as N)					<0.2000	<0.2000	<0.2000 33B	<0.2000
Nitrogen-Ammonia	0.0300	<0.0200	<0.0200	0.0600	<0.1000	<0.1000	<0.1000 33B	<0.1000
Nitrogen-Kjeldhal	<0.2000	<0.2000	<0.2000	<0.2000				
Nitrogen-Organic	<0.2000	<0.2000	<0.2000	<0.2000	<0.1000	0.2000	<0.1000 33B	<0.1000
Nitrogen-Total (CALC)	3.3900	3.0400	2.2700	4.5900	3.4000	4.1000	1.8000	2.2000
Boron (T)	0.2100		0.2200	0.2000	0.2250	0.2160	0.1750 33	0.2620 33
Bromide				0.1700				
Fluoride (T)	0.2000	0.2200	0.2000	0.1700	0.2700	0.2700	0.2600	0.2500
Cation/Anion Balance	0.0000	0.1100	0.2700	0.5100	4.3900 03A	4.1400 03A	14.7400 03A	6.1100 03A
Chloride/Bromide Ratio				368.8200				
Electrical Conductivity	900.0000	870.0000	850.0000	740.0000		728.0000	785.0000	790.0000
Field Electrical Conductivity			860.0000	416.0000	790.0000 17	837.0000	847.0000	866.0000
Field pH			7.1100	7.0000	7.1500	6.8500 33	7.1100	7.1600
Field water temperature (C)			21.2500	23.0000		22.0000	22.0000	22.5000
pH	7.4000	7.5000	7.2000	7.3000				
TDS @ 180 C	580.0000	545.0000	540.0000	490.0000	543.0000	546.0000	499.0000	488.0000
TOC	<5.0000	1.7000	<1.0000	9.2000	1.0000	<1.0000	<1.0000	3.9000
Laboratory	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 06/02/88	10/06/88	02/23/89	07/11/89	01/30/90	03/20/90	04/17/90	05/15/90
SC-08								
Aluminum (T)					<0.0500	<0.0500	<0.0500	<0.0500
Antimony (T)					<0.0625	<0.0625	<0.0625	<0.0625
Arsenic (T)	<0.0100	<0.0100	<0.0100	<0.0100	0.0050	0.0020	<0.0020	<0.0020
Barium (T)	<0.1000	<0.1000	<0.1000	0.1000	0.0650	0.0530	0.0540	0.0660
Beryllium (T)					<0.0013	<0.0013	<0.0013	<0.0013
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Chromium (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0088	<0.0088	<0.0088	<0.0088
Copper (T)				<0.0100	<0.0075	<0.0075	<0.0075	<0.0075
Iron (T)	0.1400	<0.0500	<0.0500	0.4020	0.0820	<0.0500	0.0550	0.0550
Lead (T)	<0.0100	<0.0100	0.0100	0.0230	0.0070	0.0050	0.0030	0.0020
Manganese (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0025	<0.0025	<0.0025	<0.0025
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nickel (T)					<0.0125	<0.0125	<0.0125	<0.0125
Selenium (T)	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Silver (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0125	<0.0125	<0.0125	<0.0005
Thallium (T)						<0.2500	<0.2500	<0.2500
Tin (T)					<0.2500		<0.2500	
Titanium (T)					<0.0500	<0.0500	<0.0500	<0.0500
Zinc (T)				0.3930	0.4250	0.3050	0.2380	0.2600
Laboratory	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 10/16/90	06/12/91	06/27/91	09/18/91	01/22/92
SC-08					
Calcium (T).....	87.0000	82.0000	79.8000	82.2000	81.7000
Magnesium (T).....	11.4000	11.8000	11.2000	11.5000	11.2000
Sodium (T).....	76.3000	70.5000	69.8000	71.4000	77.9000
Potassium (T).....	1.5000	1.8000	1.9000	2.2000	2.1000
Carbonate.....	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate.....	219.0000	212.0000	206.0000	211.0000	219.0000
Chloride.....	68.8000	73.7000	74.5000	68.5000	73.2000
Sulfate (T).....	101.0000	91.8000	93.0000	90.2000	90.2000
Nitrate (as N).....	2.1000	3.1000	3.9000	3.2000	3.2000
Nitrite (as N).....	<0.2000	<0.2000	<0.2000	<0.2000	<0.2000
Nitrogen-Ammonia.....	<0.8000	<0.8000	<0.8000	<0.8000	<0.8000
Nitrogen-Organic.....	0.2000	<1.0000	<1.0000		<1.0000
Nitrogen-Total (CALC).....	2.3000	3.1000	3.9000	3.2000	3.2000
Fluoride (T).....	0.3000	0.2600	0.2700	0.2600	0.2700
Cation/Anion Balance.....	5.1700 03A	3.2700 03A	1.9100	4.7000 03A	4.3700 03A
Electrical Conductivity.....	650.0000	610.0000	730.0000	760.0000	790.0000
Field Electrical Conductivity.	821.0000				
Field pH.....	7.1100	7.0000	7.0000	7.1000	7.0000
Field water temperature (C)...	22.2000				
TDS @ 180 C.....	542.0000	511.0000	532.0000	534.0000	496.0000
TOC.....	1.4000	<1.0000	<1.0000	<1.0000	<1.0000
Laboratory.....	TSS	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 10/16/90	06/12/91	06/27/91	09/18/91	01/22/92
SC-08					
Aluminum (T)		<0.2000	<0.2000	<0.2000	<0.2000
Antimony (T)	<0.0625	<0.1500	<0.1500	<0.1500	<0.1500
Arsenic (T)	<0.0020	0.0030	<0.0020	<0.0020	0.0030
Barium (T)	0.0630	0.0640	0.0610	0.0730	0.0740
Beryllium (T)	<0.0013	<0.0050	<0.0050		<0.0050
Cadmium (T)	<0.0050	<0.0004	<0.0004	0.0004	<0.0004
Chromium (T)	<0.0088	<0.0150	<0.0150	<0.0150	<0.0150
Cobalt (T)		<0.0300	<0.0300	<0.0300	<0.0300
Copper (T)	<0.0075	0.0190	0.0000	0.0000	0.0000
Iron (T)	0.0530	0.2950	0.1210	0.4470	0.3490
Lead (T)	0.0030	0.0020	0.0020	0.0010	<0.0010
Manganese (T)	<0.0025	0.0000	0.0000	0.0140	<0.0100
Mercury (T)	<0.0002	<0.0005	<0.0005	<0.0005	<0.0005
Molybdenum (T)		<0.0300	<0.0300	<0.0300	<0.0300
Nickel (T)	<0.0125	<0.1000	<0.1000	<0.1000	<0.1000
Selenium (T)	0.0060	<0.0050	<0.0050	<0.0050	<0.0050
Silver (T)	<0.0125	<0.0005	<0.0005	<0.0005	<0.0005
Strontium (T)	0.5350	0.5620 67	0.5120 67	0.5320 67	0.5850 67
Thallium (T)			<1.0000	<1.0000	
Tin (T)		<1.0000 67	<0.2000 67	<0.2000 67	<0.2000 67
Titanium (T)	<0.0500	<0.0300 67	<0.0300 67	<0.0300 67	<0.0300 67
Vanadium (T)		<0.0500	<0.0500	<0.0500	<0.0500
Zinc (T)	0.2680	0.3050	0.1870	0.2280	0.2750
Laboratory	TSS	TSS	TSS	TSS	TSS

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
17C - Field EC is not temp. adjusted due to missing temp data.
33 - Results suspect.
33B - Results suspect, unpreserved samples analyzed.
67 - Not approved EPA method

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 07/28/88	10/06/88	02/23/89	07/06/89	01/30/90	03/20/90	04/17/90	05/15/90
SC-09								
Calcium (T)	73.0000	78.0000	85.0000	58.0000	82.5000	59.0000	50.0000	62.3000
Magnesium (T)	11.0000	12.0000	12.1000	8.7000	11.4000	7.9500	7.4000	9.1000
Sodium (T)	59.0000	58.0000	58.0000	46.0000	57.5000	44.8000	42.0000	48.8000
Potassium (T)	2.4000	2.2000	2.3000	1.7000	2.1000	1.6000	1.8000	1.4000
Carbonate	<2.6000	<2.6000	<2.6000	<2.6000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate	222.0000	230.0000	248.0000	191.0000	190.0000	158.0000	142.0000	160.0000
Chloride	55.9000	57.4000	59.8000	31.9000	58.6000	27.6000	80.4000	34.6000
Sulfate (T)	87.0000	83.0000	91.0000	62.0000	84.0000	57.5000	54.4000	64.0000
Nitrate (as N)	4.2200	4.3300	4.3300	4.6200	4.2000	5.0000	4.8000 33B	5.0000
Nitrite (as N)					<0.2000	<0.2000	<0.2000 33B	<0.2000
Nitrogen-Ammonia	0.0200	<0.0200	0.0200	<0.0200	<0.1000	<0.1000	<0.1000 33B	<0.1000
Nitrogen-Kjeldhal	<0.2000	<0.2000	<0.2000	<0.2000				
Nitrogen-Organic	<0.2000	<0.2000	<0.2000	<0.2000	<0.1000	<0.1000	<0.1000 33B	<0.1000
Nitrogen-Total (CALC)	4.2400	4.3300	4.3500	4.6200	4.2000	5.0000	4.8000	5.0000
Boron (T)	<0.1000		<0.1000	<0.1000	0.1070	0.0690	0.0050 33	0.1050 33
Bromide				0.1900				
Fluoride (T)	0.2700	0.2700	0.2600	0.3100	0.2900	0.3200	0.3200	0.3000
Cation/Anion Balance	0.6900	0.2000	0.8900	0.0900	10.6600 03A	6.1600 03A	9.7500 03A	6.5300 03A
Chloride/Bromide Ratio				167.8900				
Electrical Conductivity	700.0000	710.0000	740.0000	540.0000	559.0000	458.0000	460.0000	560.0000
Field Electrical Conductivity			754.0000	352.0000	710.0000 17	567.0000	510.0000	598.0000
Field pH			7.3700		7.2000	6.8500 33	7.2600	7.2900
Field water temperature (C)			23.0000	25.0000		23.5000	23.0000	23.0000
pH	7.8000	7.6000	7.3000	7.4000				
TDS @ 180 C	455.0000	450.0000	470.0000	370.0000	466.0000	351.0000	297.0000	538.0000
TOC	<3.0000	1.4000	4.4000	17.0000	1.2000	1.6000	<1.0000	<1.0000
Laboratory	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 07/28/88	10/06/88	02/23/89	07/06/89	01/30/90	03/20/90	04/17/90	05/15/90
SC-09								
Aluminum (T)					<0.0500	<0.0500	<0.0500	0.0770
Antimony (T)					<0.0625	<0.0625	<0.0625	<0.0625
Arsenic (T)	<0.0100	<0.0100	<0.0100	<0.0100	0.0050	0.0020	0.0030	<0.0020
Barium (T)	0.1200	0.1200	0.1400	0.1060	0.1440	0.0840	0.0900	0.1140
Beryllium (T)					<0.0013	<0.0013	<0.0013	<0.0013
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Chromium (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0088	<0.0088	<0.0088	<0.0088
Copper (T)				<0.0100	<0.0075	<0.0075	<0.0075	<0.0075
Iron (T)	0.8200	<0.0500	0.0600	0.0660	15.7000	0.0980	0.1120	0.0990
Lead (T)	<0.0100	<0.0100	<0.0100	0.0110	0.0060 33	0.0050	0.0040	0.0060
Manganese (T)	0.0200	<0.0100	<0.0100	<0.0100	<0.0025	<0.0025	<0.0025	0.0030
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nickel (T)					<0.0125	<0.0125	<0.0125	<0.0125
Selenium (T)	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Silver (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0125	<0.0125	<0.0125	<0.0005
Thallium (T)						<0.2500	<0.2500	<0.2500
Tin (T)					<0.2500		<0.2500	
Titanium (T)					<0.0500	<0.0500	<0.0500	<0.0500
Zinc (T)				0.5040	0.4300	0.3180	0.2230	0.2650
Laboratory	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 07/26/90	10/16/90	06/12/91	06/27/91	09/18/91	01/22/92
SC-09						
Calcium (T).....	70.3000	82.0000	71.5000	52.9000	59.9000	81.3000
Magnesium (T).....	10.5000	11.8000	11.0000	7.7800	9.1900	11.7000
Sodium (T).....	45.0000	52.8000	44.0000	36.6000	39.7000	54.6000
Potassium (T).....	1.4000	1.7000	1.8000	1.9000	2.0000	2.1000
Carbonate.....	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate.....	172.0000	190.0000	171.0000	138.0000	150.0000	189.0000
Chloride.....	43.0000	65.7000	50.8000	27.4000	35.0000	66.2000
Sulfate (T).....	78.8000	99.4000	77.2000	55.9000	63.8000	84.7000
Nitrate (as N).....	8.0000	6.6000	4.8000	5.1000	4.6000	4.2000
Nitrite (as N).....	0.3000	0.6000	<0.2000	<0.2000	<0.2000	<0.2000
Nitrogen-Ammonia.....	<0.1000	<0.8000	<0.8000	<0.8000	<0.8000	<0.8000
Nitrogen-Organic.....	0.6000	0.1000	1.0000	1.7000		<1.0000
Nitrogen-Total (CALC).....	8.9000	7.3000	5.8000	6.8000	4.6000	4.2000
Fluoride (T).....	0.3300	0.3400	0.2900	0.3300	0.3300	0.2900
Cation/Anion Balance.....	1.0300	0.6700	2.2200 03A	4.1100 03A	4.1300 03A	3.1100 03A
Electrical Conductivity.....	570.0000	550.0000	480.0000	472.0000	480.0000	720.0000
Field Electrical Conductivity.	651.0000	735.0000				
Field pH.....	7.1300	7.0800	7.0000	7.0000	7.1000	7.3000
Field water temperature (C)...	23.7000	24.0000				
TDS @ 180 C.....	420.0000	516.0000	420.0000	333.0000		411.0000
TOC.....	2.0000	<1.0000	<1.0000	<1.0000	<1.0000	<1.0000
Laboratory.....	TSS	TSS	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 07/26/90	10/16/90	06/12/91	06/27/91	09/18/91	01/22/92
SC-09						
Aluminum (T)	<0.0500		<0.2000	<0.2000	<0.2000	<0.2000
Antimony (T)	<0.0625	<0.0625	<0.1500	<0.1500	<0.1500	<0.1500
Arsenic (T)	<0.0020	<0.0020	0.0040	<0.0020	<0.0020	<0.0020
Barium (T)	0.1160	0.1270	0.1110	0.0970	0.1120	0.1430
Beryllium (T)	<0.0013	<0.0013	<0.0050	<0.0050		<0.0050
Cadmium (T)	<0.0050	<0.0050	<0.0004	<0.0004	<0.0004	0.0009
Chromium (T)	<0.0088	<0.0088	<0.0150	<0.0150	<0.0150	<0.0150
Cobalt (T)			<0.0300	<0.0300	<0.0300	<0.0300
Copper (T)	<0.0075	<0.0075	0.0000	0.0000	<0.0150	0.0000
Iron (T)	0.1300	0.2440	0.1660	0.1310	0.1340	0.3550
Lead (T)	0.0050	0.0050	0.0040	0.0030	0.0020	0.0040
Manganese (T)	<0.0025	<0.0025	0.0000	0.0000	0.0000	<0.0100
Mercury (T)	<0.0002	<0.0002	<0.0005	<0.0005	<0.0005	<0.0005
Molybdenum (T)			<0.0300	<0.0300	<0.0300	<0.0300
Nickel (T)	<0.0125	<0.0125	<0.1000	<0.1000	<0.1000	<0.1000
Selenium (T)	<0.0050	0.0060	<0.0050	<0.0050	<0.0050	<0.0050
Silver (T)	<0.0005	<0.0125	<0.0005	<0.0005	<0.0005	<0.0005
Strontium (T)	0.4950	0.5580	0.4930 67	0.3880 67	0.4180 67	0.5700 67
Thallium (T)	<0.0050			<1.0000	<1.0000	
Tin (T)	<0.2500			<0.2000 67	<0.2000 67	<0.2000 67
Titanium (T)	<0.0500	<0.0500	<0.0300 67	<0.0300 67	<0.0300 67	<0.0300 67
Vanadium (T)			<0.0500	<0.0500	<0.0500	<0.0500
Zinc (T)	0.2600	0.2550	0.2290	0.2080	0.1700	0.1900
Laboratory	TSS	TSS	TSS	TSS	TSS	TSS

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
17C - Field EC is not temp. adjusted due to missing temp data.
33 - Results suspect.
33B - Results suspect, unpreserved samples analyzed.
67 - Not approved EPA method

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 06/14/88	10/12/88	02/23/89	07/06/89	01/30/90	03/27/90	04/25/90	05/22/90
SC-10								
Calcium (T)	74.0000	90.0000	88.0000	95.0000	87.1000	90.8000	83.3000	86.3000
Magnesium (T)	13.0000	12.0000	13.6000	14.0000	12.1000	13.4000	12.9000	13.2000
Sodium (T)	62.0000	63.0000	60.0000	63.0000	61.0000	63.8000	56.3000	64.0000
Potassium (T)	2.2000	2.3000	2.2000	2.1000	2.2000	1.9000	1.6000	1.6000
Carbonate	<2.6000	<2.6000	<2.6000	<2.6000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate	199.0000	237.0000	241.0000	240.0000	190.0000	202.0000	194.0000	193.0000
Chloride	65.5000	62.3000	62.0000	68.7000	73.1000	65.7000	60.7000	61.9000
Sulfate (T)	85.0000	95.0000	85.0000	94.0000	87.0000	86.0000	89.4000	91.6000
Nitrate (as N)	8.1800	9.8400	9.8400	10.6200	10.2000	10.3000	9.8000	10.3000
Nitrite (as N)					<0.2000	<0.2000	<0.2000	<0.2000
Nitrogen-Ammonia	<0.0200	0.0800	<0.0200	<0.0200	<0.1000	<0.1000	<0.1000	<0.1000
Nitrogen-Kjeldhal	<0.2000	<0.2000	<0.2000	<0.2000				
Nitrogen-Organic	<0.2000	<0.2000	<0.2000	<0.2000	<0.1000	<0.1000	<0.1000	0.0000
Nitrogen-Total (CALC)	8.1800	9.9200	9.8400	10.6200	10.2000	10.3000	9.8000	10.3000
Boron (T)	0.1600	0.1500	0.1600	0.1600	0.2020	0.1760	0.0070 33	0.2050
Bromide				0.2500				
Fluoride (T)	0.2500	0.2900	0.2700	0.2600	0.3000	0.3100	0.3000	0.2900
Cation/Anion Balance	0.4700	0.2400	0.0600	0.5200	2.1500 03A	4.6400 03A	1.6500	4.1800 03A
Chloride/Bromide Ratio				274.8000				
Electrical Conductivity	780.0000	780.0000	790.0000	790.0000	597.0000	699.0000	780.0000	760.0000
Field Electrical Conductivity			775.0000	468.0000	725.0000 17	756.0000	837.0000	810.0000
Field pH			7.3400		7.1500	7.1800	7.2600	7.2000
Field water temperature (C)			21.5000	23.0000		21.0000	21.0000	22.0000
pH	7.7000	7.9000	7.4000	7.6000				
TDS @ 180 C	510.0000	530.0000	495.0000	560.0000	514.0000	520.0000	493.0000	516.0000
TOC	18.0000	1.2000	<1.0000	8.5000	0.9000 33	1.0000	1.4000	<1.0000
Laboratory	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 06/14/88	10/12/88	02/23/89	07/06/89	01/30/90	03/27/90	04/25/90	05/22/90
SC-10								
Aluminum (T)					<0.0500	<0.0500	0.0500	0.0640
Antimony (T)					<0.0625	<0.0625	<0.0625	<0.0625
Arsenic (T)	<0.0100	<0.0100	<0.0100	<0.0100	0.0040	<0.0020	0.0030	<0.0020
Barium (T)	0.1500	0.1400	0.1400	0.1540	0.1490	0.1300	0.1370	0.1370
Beryllium (T)					<0.0013	<0.0013	<0.0013	<0.0013
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Chromium (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0088	<0.0088	<0.0088	<0.0088
Copper (T)				<0.0100	<0.0075	<0.0075	<0.0075	<0.0075
Iron (T)	0.2100	<0.0500	<0.0500	<0.0500	<0.2000	<0.0500	0.0870	<0.0500
Lead (T)	<0.0100	<0.0100	0.0100	0.0150	0.0130	0.0100	0.0120	0.0080
Manganese (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0025	<0.0025	<0.0025	<0.0025
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nickel (T)					<0.0125	<0.0125	<0.0125	<0.0125
Selenium (T)	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Silver (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0125	<0.0125	<0.0125	<0.0005
Thallium (T)						<0.2500	<0.2500	<0.2500
Tin (T)					<0.2500			
Titanium (T)					<0.0500	<0.0500		<0.0500
Zinc (T)				0.6320	0.5180	0.3630	0.3460	0.3580
Laboratory	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 07/26/90	10/23/90	09/04/91	01/29/92	06/19/92
SC-10					
Calcium (T).....	88.3000	86.0000	89.5000	88.0000	87.8000
Magnesium (T).....	13.2000	12.9000	14.4000	13.0000	12.2000
Sodium (T).....	53.8000	55.5000	59.3000	55.9000	55.7000
Potassium (T).....	1.5000	1.7000	2.6000	2.4000	2.0000
Carbonate.....	<0.5000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate.....	195.0000	194.0000	189.0000	188.0000	190.0000
Chloride.....	60.9000	74.0000	63.4000	65.2000	66.1000
Sulfate (T).....	92.8000	86.4000	85.8000	84.4000	86.7000
Nitrate (as N).....	9.6000	10.6000	9.6000	9.1000	10.2000
Nitrite (as N).....	<0.2000	<0.2000	<0.2000	<0.2000	<0.2000
Nitrogen-Ammonia.....	<0.1000	<0.8000	<0.8000	<0.8000	<0.8000
Nitrogen-Organic.....	<0.1000	0.8000	<1.0000	<1.0000	<1.0000
Nitrogen-Total (CALC).....	9.6000	11.4000	9.6000	9.1000	10.2000
Fluoride (T).....	0.3200	0.3100	0.3100	0.2900	0.3100
Cation/Anion Balance.....	2.1400 03A	0.1900	6.0500 03A	4.1200 03A	2.2800 03A
Electrical Conductivity.....	710.0000	615.0000	650.0000	740.0000	580.0000
Field Electrical Conductivity.	812.0000	772.0000			
Field pH.....	7.1500	7.1900	7.0000	7.0000	7.0000
Field water temperature (C)...	21.7000	21.6000			
TDS @ 180 C.....	534.0000	512.0000	544.0000	517.0000	479.0000
TOC.....	<1.0000	<1.0000	<1.0000	<1.0000	0.0000
Laboratory.....	TSS	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 07/26/90	10/23/90	09/04/91	01/29/92	06/19/92
SC-10					
Aluminum (T)	<0.0500		<0.2000	<0.2000	<0.2000
Antimony (T)	<0.0625	<0.0625	<0.1500	<0.1500	<0.1500
Arsenic (T)	<0.0020	0.0020	<0.0020	<0.0020	0.0030
Barium (T)	0.1390	0.1490	0.1330	0.1500	0.1260
Beryllium (T)	<0.0013	<0.0013	<0.0050	<0.0050	<0.0050
Cadmium (T)	<0.0050	<0.0050	<0.0004	<0.0004	<0.0004
Chromium (T)	<0.0088	<0.0088	<0.0150	<0.0150	<0.0150
Cobalt (T)			<0.0300		<0.0300
Copper (T)	<0.0075	<0.0075	0.0000	0.0000	0.0000
Iron (T)	<0.0500	0.0310	0.0430	0.0620	0.0300
Lead (T)	0.0080	0.0060	0.0020	0.0020	0.0010
Manganese (T)	<0.0025	<0.0025	0.0000	<0.0100	0.0000
Mercury (T)	<0.0002	<0.0002	<0.0005	<0.0005	<0.0005
Molybdenum (T)			<0.0300	<0.0300	<0.0300
Nickel (T)	<0.0125	<0.0125	<0.1000	<0.1000	<0.1000
Selenium (T)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Silver (T)	<0.0005	<0.0125	<0.0005	<0.0005	<0.0005
Strontium (T)	0.6560	0.5480	0.5760 67	0.6140 67	0.5280 67
Thallium (T)	<0.0050		<1.0000	<1.0000	
Tin (T)	<0.2500			<0.2000 67	<1.0000 67
Titanium (T)	<0.0500	<0.0500	<0.0300 67	<0.0300 67	<0.0300 67
Vanadium (T)			<0.0500	<0.0500	<0.0500
Zinc (T)	0.3530	0.3230	0.1460	0.2420	0.1730
Laboratory	TSS	TSS	TSS	TSS	TSS

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
17C - Field EC is not temp. adjusted due to missing temp data.
33 - Results suspect.
67 - Not approved EPA method

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 06/20/88	10/12/88	02/24/89	07/06/89
SC-11				
Calcium (T)	64.0000	79.0000	78.0000	82.0000
Magnesium (T)	11.0000	11.0000	11.0000	12.0000
Sodium (T)	57.0000	57.0000	56.0000	56.0000
Potassium (T)	2.7000	2.5000	2.5000	2.4000
Carbonate	4.3000	<2.6000	<2.6000	<2.6000
Bicarbonate	195.0000	232.0000	236.0000	233.0000
Chloride	36.5000	38.9000	36.5000	41.4000
Sulfate (T)	84.0000	85.0000	77.0000	82.0000
Nitrate (as N)	8.6700	9.3600	9.3600	11.7100
Nitrogen-Ammonia	0.0600	<0.0200	<0.0200	<0.0200
Nitrogen-Kjeldhal	0.7000	<0.2000	<0.2000	<0.2000
Nitrogen-Organic	0.6000	<0.2000	<0.2000	<0.2000
Nitrogen-Total (CALC)	9.3300	9.3600	9.3600	11.7100
Boron (T)	<0.1000	<0.1000	<0.1000	<0.1000
Bromide				0.2400
Fluoride (T)	0.2900	0.3200	0.6100	0.3000
Cation/Anion Balance	0.6700	0.2700	0.6900	0.1300
Chloride/Bromide Ratio				172.5000
Electrical Conductivity	670.0000	680.0000	700.0000	680.0000
Field Electrical Conductivity	750.0000	716.0000	715.0000	431.0000
Field pH	7.3900	7.4100	7.5100	
Field water temperature (C)	23.3000	24.0000	22.0000	24.5000
pH	8.2000	7.9000	7.5000	7.7000
TDS @ 180 C	420.0000	465.0000	415.0000	465.0000
TOC	27.0000	1.1000	1.2000	27.0000
Arsenic (T)	<0.0100	<0.0100	<0.0100	<0.0100
Barium (T)	0.1000	0.1000	0.1100	0.1200
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0500
Chromium (T)	<0.0100	<0.0100	<0.0100	<0.0100
Copper (T)				<0.0100
Iron (T)	0.1000	<0.0500	<0.0500	<0.0500
Lead (T)	<0.0100	<0.0100	<0.0100	0.0120
Manganese (T)	<0.0100	<0.0100	<0.0100	<0.0100
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002
Selenium (T)	<0.0050	<0.0050	<0.0050	<0.0500
Silver (T)	<0.0100	<0.0100	<0.0100	<0.0100
Zinc (T)				0.3340
Laboratory	BCL	BCL	BCL	BCL

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 06/21/88	10/12/88	02/24/89	07/06/89	02/06/90	03/27/90	04/25/90	05/22/90
SC-12								
Calcium (T).....	112.0000	115.0000	104.0000	104.0000	90.3000	92.8000	90.5000	98.4000
Magnesium (T).....	17.0000	17.0000	16.8000	18.0000	14.7000	14.8000	14.7000	14.7000
Sodium (T).....	59.0000	56.0000	58.0000	61.0000	53.8000	59.5000	55.0000	59.8000
Potassium (T).....	2.8000	2.7000	2.6000	2.5000	2.1000	2.1000	2.0000	2.5000
Carbonate.....		<2.6000	<2.6000	<2.6000	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate.....		313.0000	305.0000	297.0000	219.0000	231.0000	230.0000	226.0000
Chloride.....	70.2000	70.1000	64.2000	70.4000	57.5000	51.9000	54.4000	55.2000
Sulfate (T).....		84.0000	93.0000	94.0000	94.0000	90.8000	93.4000	96.4000
Nitrate (as N).....	7.7800	8.9600	8.3800	8.9600	8.4000	8.6000	7.8000	8.5000
Nitrite (as N).....					<0.2000	<0.2000	<0.2000	<0.2000
Nitrogen-Ammonia.....	0.0200	<0.0200	<0.0200	<0.0200	<0.1000	<0.1000	<0.1000	<0.1000
Nitrogen-Kjeldhal.....	0.4000	<0.2000	<0.2000	<0.2000				
Nitrogen-Organic.....	0.4000	<0.2000	<0.2000	<0.2000	<0.1000	<0.1000	<0.1000	<0.1000
Nitrogen-Total (CALC).....	8.2000	8.9600	8.3800	8.9600	8.4000	8.6000	7.8000	8.5000
Boron (T).....	0.1400	0.1300	0.1200	0.1500	<0.0050	0.1320	<0.0050	<0.0050
Bromide.....				0.2700				
Fluoride (T).....	0.1400	0.2400	0.2700	0.2500	0.3100	0.3500	0.3200	0.3000
Cation/Anion Balance.....		0.7800	1.0300	0.3200	2.1400 03A	4.4900 03A	2.1900 03A	5.4000 03A
Chloride/Bromide Ratio.....				260.7400				
Electrical Conductivity.....		880.0000	840.0000	850.0000	690.0000	683.0000	800.0000	780.0000
Field Electrical Conductivity.	970.0000	972.0000	810.0000	494.0000	810.0000 17	791.0000	829.0000	819.0000
Field pH.....	7.0300	6.9800	7.2700		7.0000	7.2000	7.2300	7.0400
Field water temperature (C)...	21.1000	21.0000	21.0000	23.0000	21.0000	21.5000	21.5000	21.5000
pH.....		7.8000	7.3000	7.5000				
TDS @ 180 C.....		585.0000	540.0000	595.0000	537.0000	542.0000	550.0000	534.0000
TOC.....	1.3000	2.1000	2.9000	25.0000	<1.0000 33	3.2000	<1.0000 19	<1.0000
Laboratory.....	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 06/21/88	10/12/88	02/24/89	07/06/89	02/06/90	03/27/90	04/25/90	05/22/90
SC-12								
Aluminum (T)					<0.0500	<0.0500	<0.0500	<0.0500
Antimony (T)					<0.0625	<0.0625	<0.0625	<0.0625
Arsenic (T)	<0.0100	<0.0100	<0.0100	<0.0100	0.0070	0.0030	0.0030	0.0020
Barium (T)	<0.1000	<0.1000	<0.1000	0.1000	0.0720	0.0640	0.0760	0.0770
Beryllium (T)					<0.0013	<0.0013	<0.0013	<0.0013
Cadmium (T)	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Chromium (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0088	<0.0088	<0.0088	<0.0088
Copper (T)				<0.0100	<0.0075	<0.0075	<0.0075	<0.0075
Iron (T)	0.1400	<0.0500	0.0600	0.1490	0.2160	0.0560	<0.0500	<0.0500
Lead (T)	<0.0100	<0.0100	<0.0100	0.0150	0.0070	0.0090	0.0090	0.0050
Manganese (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0025	<0.0025	0.0030	<0.0025
Mercury (T)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nickel (T)					<0.0125	<0.0125	<0.0125	<0.0125
Selenium (T)	<0.0050	<0.0050	<0.0050	<0.0500	<0.0050	<0.0050	<0.0050	<0.0050
Silver (T)	<0.0100	<0.0100	<0.0100	<0.0100	<0.0125	<0.0125	<0.0125	<0.0005
Thallium (T)					<0.0050	<0.2500	<0.2500	<0.2500
Tin (T)					<0.2500			
Titanium (T)					<0.0500	<0.0500		
Zinc (T)				0.6080	0.3580	0.3150	0.3080	0.2600
Laboratory	BCL	BCL	BCL	BCL	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 10/23/90	06/19/91	09/04/91	01/29/92
SC-12				
Calcium (T).....	95.0000	96.7000	97.0000	107.0000
Magnesium (T).....	14.7000	14.3000	16.3000	18.4000
Sodium (T).....	52.3000	53.0000	58.0000	62.6000
Potassium (T).....	2.0000	2.4000	2.7000	3.0000
Carbonate.....	<0.5000	<0.5000	<0.5000	<0.5000
Bicarbonate.....	232.0000	236.0000	237.0000	280.0000
Chloride.....	62.5000	62.5000	56.5000	67.1000
Sulfate (T).....	95.0000	88.9000	89.2000	85.6000
Nitrate (as N).....	9.9000	7.7000	7.8000	9.6000
Nitrite (as N).....	<0.2000	<0.2000	<0.2000	<0.2000
Nitrogen-Ammonia.....	<0.8000	<0.8000	<0.8000	<0.8000
Nitrogen-Organic.....	0.4000	<1.0000	<1.0000	<1.0000
Nitrogen-Total (CALC).....	10.3000	7.7000	7.8000	9.6000
Fluoride (T).....	0.3100	0.3300	0.3300	0.2600
Cation/Anion Balance.....	0.0600	2.1900 03A	5.3300 03A	3.8700 03A
Electrical Conductivity.....	660.0000	630.0000	680.0000	880.0000
Field Electrical Conductivity.	817.0000			
Field pH.....	7.0600	6.9000	7.0000	6.8000
Field water temperature (C)...	21.6000			
TDS @ 180 C.....	552.0000	518.0000	566.0000	611.0000
TOC.....	1.0000	<1.0000	3.8000	<1.0000
Laboratory.....	TSS	TSS	TSS	TSS

Appendix D. Results of Analyses of Ground Water Samples from the SC Monitor Wells - Inorganics and Other Parameters (Cont'd)

Sample Station/ Constituent (mg/l)	DATE SAMPLED 10/23/90	06/19/91	09/04/91	01/29/92
SC-12				
Aluminum (T)	<0.0500	<0.2000	<0.2000	<0.2000
Antimony (T)	<0.0625	<0.1500	<0.1500	<0.1500
Arsenic (T)	0.0030	0.0030	0.0020	<0.0020
Barium (T)		0.0700	0.0840	0.0750
Beryllium (T)	<0.0013	<0.0050	0.0050	<0.0050
Cadmium (T)	<0.0050	<0.0004	<0.0004	<0.0004
Chromium (T)	<0.0088	<0.0150	<0.0150	<0.0150
Cobalt (T)		<0.0300		
Copper (T)	<0.0075	0.0000	0.0000	0.0000
Iron (T)	0.0650	0.0950	0.1240	0.1120
Lead (T)	0.0040	0.0010	0.0020	0.0020
Manganese (T)	<0.0025	0.0000	0.0000	<0.0100
Mercury (T)	<0.0002	<0.0005	<0.0005	<0.0005
Molybdenum (T)		<0.0300	<0.0300	<0.0300
Nickel (T)	<0.0125	<0.1000	<0.1000	<0.1000
Selenium (T)	<0.0050	<0.0050	<0.0050	<0.0050
Silver (T)	<0.0005	<0.0005	<0.0005	<0.0005
Strontium (T)	0.8030	0.7940 67	0.8230 67	0.9020 67
Thallium (T)			<1.0000	
Tin (T)	<0.2500	<0.2000 67		<0.2000 67
Titanium (T)	<0.0500	<0.0300 67	<0.0300 67	<0.0300 67
Vanadium (T)		<0.0500	<0.0500	<0.0500
Zinc (T)	0.2500	0.1910	0.1500	0.1890
Laboratory	TSS	TSS	TSS	TSS

COMMENTS
03A - CA Balance exceeds limit set in Standard Methods (1030F), 1989.
17C - Field EC is not temp. adjusted due to missing temp data.
19 - Possible field sampling error.
33 - Results suspect.
67 - Not approved EPA method

BCL - BC Analytical Lab
TSS - Pima County Lab, Technical Services Section

APPENDIX E

Results of Analyses of Groundwater Samples from the SC Monitor Wells - Detectable Trace Organics

Appendix E. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Detectable Trace Organics

Sample Station/ Constituent (ug/l)	Sample Date	Results	Comment-Method Blank (ug/l)	Lab
SC-01				
bis(2-ethylhexyl) phthalate	06/29/89	4.00	(1- 3.4)	CAL
methylene chloride	01/16/90	0.20		TSS
methylene chloride	03/07/90	0.60		TSS
methylene chloride	07/19/90	11.10		TSS
naphthalene	04/03/90	0.10		TSS
trichlorofluoromethane	03/07/90	0.20		TSS
1,2,3-trichlorobenzene	04/03/90	0.20		TSS
SC-02				
bis(2-ethylhexyl) phthalate	06/29/89	3.80	(1- 3.4)	CAL
chloroform	05/13/88	0.60		CAL
chloroform	04/03/90	0.10		TSS
methylene chloride	04/03/90	0.70		TSS
SC-03				
bis(2-ethylhexyl) phthalate	06/29/89	3.50	(1- 3.4)	CAL
bis(2-ethylhexyl) phthalate	04/10/90	32.70		TSS
chloroform	10/03/90	1.30		TSS
methylene chloride	03/07/90	0.50		TSS
methylene chloride	07/19/90	0.70		TSS
methylene chloride	10/03/90	1.60		TSS
naphthalene	04/10/90	0.20		TSS
1,2,4-trichlorobenzene	04/10/90	0.10		TSS
1,2,3-trichlorobenzene	04/10/90	0.30		TSS
SC-04				
bis(2-ethylhexyl) phthalate	06/29/89	3.80	(1- 3.4)	CAL
bis(2-ethylhexyl) phthalate	03/13/90	27.40	(1- 2.0)	TSS
methylene chloride	03/13/90	0.90		TSS
methylene chloride	04/10/90	0.70	(3)	TSS
methylene chloride	10/11/90	1.40	(3)	TSS
methylene chloride	09/11/91	1.40		TSS
naphthalene	04/10/90	0.20		TSS
1,2,4-trichlorobenzene	04/10/90	0.20		TSS
1,2,3-trichlorobenzene	04/10/90	0.30		TSS

Appendix E. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Detectable Trace Organics (Cont'd)

Sample Station/ Constituent (ug/l)	Sample Date	Results	Comment-Method Blank (ug/l)	Lab
SC-05				
bis(2-ethylhexyl) phthalate	07/11/89	8.60	(1- 5.2)	CAL
bis(2-ethylhexyl) phthalate	03/13/90	3.10	(2- 2.0)	TSS
1,1-dichloroethene	09/11/91	1.60		TSS
di-n-butyl phthalate	03/13/90	4.60		TSS
methylene chloride	03/13/90	0.60		TSS
methylene chloride	05/08/90	1.40		TSS
tetrachloroethylene (PCE)	04/10/90	0.30		TSS
tetrachloroethylene (PCE)	07/19/90	0.20		TSS
SC-06				
bis(2-ethylhexyl) phthalate	07/11/89	9.80	(1- 5.2)	CAL
bis(2-ethylhexyl) phthalate	03/13/90	3.00	(2- 2.0)	TSS
methylene chloride	04/10/90	0.60	(3)	TSS
methylene chloride	07/26/90	0.50		TSS
methylene chloride	07/26/90	0.60		TSS
methylene chloride	10/11/90	1.20	(3)	TSS
SC-07				
bis(2-ethylhexyl) phthalate	07/11/89	4.50	(1- 5.2)	CAL
bis(2-ethylhexyl) phthalate	03/20/90	2.90	(2- 2.0)	TSS
methylene chloride	03/20/90	0.70		TSS
methylene chloride	10/16/90	1.10		TSS
methylene chloride	09/18/91	0.30		TSS
SC-08				
bis(2-ethylhexyl) phthalate	07/11/89	12.00	(1- 5.2)	CAL
chloroform	07/11/89	0.70		CAL
methylene chloride	03/20/90	0.70	(3)	TSS
methylene chloride	01/30/90	0.10		TSS
methylene chloride	04/17/90	0.80		TSS
methylene chloride	06/27/91	0.20		TSS
methylene chloride	09/18/91	0.30		TSS
methylene chloride	01/22/92	1.20		TSS
SC-09				
bis(2-ethylhexyl) phthalate	07/06/89	2.60	(1- 2.0)	CAL
bis(2-ethylhexyl) phthalate	03/20/90	9.40	(2- 2.0)	TSS
di-n-butyl phthalate	03/20/90	9.10		TSS

Appendix E. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Detectable Trace Organics (Cont'd)

Sample Station/ Constituent (ug/l)	Sample Date	Results	Comment-Method Blank (ug/l)	Lab
SC-09 (Cont'd)				
methylene chloride	03/20/90	0.70	(3)	TSS
methylene chloride	01/30/90	0.10		TSS
methylene chloride	07/26/90	0.60		TSS
methylene chloride	10/16/90	1.00		TSS
methylene chloride	06/27/91	0.20		TSS
methylene chloride	09/18/91	0.40		TSS
methylene chloride	01/22/92	0.70		TSS
SC-10				
bis(2-ethylhexyl) phthalate	07/06/89	3.10	(1- 2.0)	CAL
chloroform	03/27/90	0.10	(3)	TSS
hexachlorobutadiene	04/25/90	0.10		TSS
methylene chloride	01/30/90	0.10		TSS
methylene chloride	03/27/90	0.60	(3)	TSS
methylene chloride	07/26/90	0.60		TSS
methylene chloride	10/23/90	1.20	(3)	TSS
methylene chloride	09/04/91	30.30	(2- 0.1)	TSS
naphthalene	04/25/90	0.30		TSS
1,2,4-trichlorobenzene	04/25/90	0.20		TSS
1,2,3-trichlorobenzene	04/25/90	0.40		TSS
SC-11				
bis(2-ethylhexyl) phthalate	07/06/89	3.00	(1- 2.0)	CAL
SC-12				
bis(2-ethylhexyl) phthalate	07/06/89	5.20	(1- 0.1)	CAL
bis(2-ethylhexyl) phthalate	02/06/90	4.00	(2- 2.0)	TSS
bis(2-ethylhexyl) phthalate	03/27/90	3.30	(2- 2.0)	TSS
methylene chloride	02/06/90	0.20	(3)	TSS
methylene chloride	03/27/90	0.70	(3)	TSS
methylene chloride	10/23/90	1.20	(3)	TSS
methylene chloride	10/23/90	1.30	(3)	TSS

Appendix E. Results of Analyses of Groundwater Samples from the SC Monitor Wells - Detectable Trace Organics (Cont'd)

Sample Station/ Constituent (ug/l)	Sample Date	Results	Comment-Method Blank (ug/l)	Lab
SC-12 (Cont'd)				
methylene chloride	09/04/91	29.60	(2- 0.1)	TSS
naphthalene	03/27/90	0.10		TSS
toluene	02/06/90	0.10	(3)	TSS
1,2,3-trichlorobenzene	03/27/90	0.10		TSS

Comments

1 - Results not reliable unless 5X > Reporting Limit or 10X > blank.
2 - Method blank contained compound, results not reliable unless 5X reporting limit or 10X blank.
3 - Trip blank contained compound.
TSS - Pima County Lab, Technical Services Section
CAL - California Analytical Lab

APPENDIX F

Results of Chemical Analyses of Seepage Zone and Selected River Samples

Appendix F. Results of Chemical Analyses of Seepage Zone and Selected River Samples

Sample Station/ Constituent (mg/l)	Date Sampled Sample Location and Type				
	05/10/92	07/25/92	07/26/92	07/31/92	08/02/92
SC-03	River	River	River	River	River
Nitrate-N	1.3	2	0.5	2.5	2
Nitrite-N		ND	0.3	ND	ND
Kjeldahl-N	22	18.3	22.6	18.1	16.6
Ammonia-N	15.4	14.3	18.8	14.3	12.9
Organic N	6.6	4	3.8	3.8	3.7
Total N	23.3	20.3	23.4	20.6	18.6
Phosphate		4.8	5.7	5	5.4
TOC		10.5	15.1	10.9	15.1
EC (umho/cm)(field)	787	900	700	900	780
pH (field)	7.5	7.6	7	7.6	7.6
Eh (mV)(field)		180		30	30
DO (field)	3.75	2	2	2.1	2
Temperature (F)		82	94	80	86
Calcium		42			
Magnesium		5.34			
Sodium		96.3			
Potassium		11.8			
Carbonate					
Bicarbonate					
Chloride		72.2			
Sulfate		66.6			
Alkalinity		221			
Fluoride		0.42			
Boron		0.601			
TDS @ 180 C		494			
EC (umho/cm) (lab)		890			
Aluminum		0.481			
Antimony		ND			
Arsenic		ND			
Barium		0.054			
Beryllium		ND			
Cadmium		ND			
Chromium		ND			
Copper		0.043			
Iron		0.577			
Lead		ND			
Manganese		0.042			
Mercury		ND			
Molybdenum		ND			
Selenium		ND			
Silver		ND			
Strontium		0.363			
Titanium		ND			
Vanadium		ND			
Zinc		ND			

Appendix F. Results of Chemical Analyses of Seepage Zone and Selected River Samples (Cont'd)

Sample Station/ Constituent (mg/l)	Date Sampled Sample Location and Type						
	05/10/92	07/25/92	07/25/92	07/26/92	07/31/92	08/02/92	7/26/92
SC-03	Seep @ 1'	Seep @ 1'	Seep @ 1'	Seep @ 1'	Seep @ 1'	Seep @ 1'	Seep @ 2'
Nitrate-N	0.6	0.2	0.3	0.1	0.4	0.3	0.1
Nitrite-N		ND	ND	ND	ND	ND	ND
Kjeldahl-N	16	16.8	11.6	14.8	18.1	15.9	20.8
Ammonia-N	13.3	15	9.3	13.7	15	14.5	16.9
Organic N	2.7	1.8	2.3	1.1	3.1	1.4	3.9
Total N	16.6	17	11.9	14.8	18.5	16.2	20.8
Phosphate		7.8	3.5	7.8	3.3	3.8	6.9
TOC		7.7	8	8.6	7	7.6	39.3
EC (umho/cm)(field)	880	820	780	780	930	800	770
pH (field)	7.4	7.2	7.2	7.3	7.6	7.6	7.6
Eh (mV)(field)		-170	-160		-141	-124	
DO (field)	0.02	0.3	0.3	1	0.9	0.9	
Temperature (F)		82	83		84	83	88
Calcium			54.3	49.1			
Magnesium			6.49	6.24			
Sodium			101	98.3			
Potassium			11.7	12.2			
Carbonate							
Bicarbonate							
Chloride			75.2	70.5			
Sulfate			89.4	75.1			
Alkalinity			217	229			
Fluoride			0.57	0.57			
Boron			0.323	0.298			
TDS @ 180 C			530	501			
EC (umho/cm) (lab)			909				
Aluminum			ND	ND			
Antimony			ND	ND			
Arsenic			ND	ND			
Barium			0.078	0.058			
Beryllium			ND	ND			
Cadmium			ND	ND			
Chromium			ND	ND			
Copper			0.033	0.025			
Iron			1.32	0.659			
Lead			ND	ND			
Manganese			0.271	0.269			
Mercury			ND	ND			
Molybdenum			ND	ND			
Selenium			ND	ND			
Silver			ND	ND			
Strontium			0.444	0.374			
Titanium			ND	ND			
Vanadium			ND	ND			
Zinc			ND	ND			

Appendix F. Results of Chemical Analyses of Seepage Zone and Selected River Samples (Cont'd)

Sample Station/ Constituent (mg/l)	Date Sampled Sample Location and Type					
	7/31/92	8/2/92	8/2/92	7/25/92	7/25/92	05/10/92
SC-03	Seep @ 4'	Seep @ 4'	Seep @ 4'	Seep @ 5'	Seep @ 5'	Seep @ 5'
Nitrate-N	0.1	0.1	0.1	0.2	0.2	0.1
Nitrite-N	ND	ND	ND	ND	ND	
Kjeldahl-N	16.1	17.6	17.6	15.6	14.8	20
Ammonia-N	13.9	15.5	15.6	13.7	13.1	16.1
Organic N	2.2	2.1	2	1.9	1.7	3.9
Total N	16.1	17.6	17.6	15.8	15	20
Phosphate	4.8	4.6	5.4	4.7	2.8	
TOC	8.1	6.1	5.6	16.2	7.3	
EC (umho/cm)(field)	970	850	840	800	770	880
pH (field)	7.6	7.4	7.4	7.3	7.1	7.4
Eh (mV)(field)	-120	-194	-230			
DO (field)	1	0.3	0.25	1	0.2	0.03
Temperature (F)	82	84	83	85	86	
Calcium				52.8	52.5	
Magnesium				7.74	7.31	
Sodium				95.5	95.4	
Potassium				13.2	12.5	
Carbonate						
Bicarbonate						
Chloride				73.6	80.8	
Sulfate				68.1	83.8	
Alkalinity				235	217	
Fluoride				0.46	0.52	
Boron				0.392	0.299	
TDS @ 180 C				499	501	
EC (umho/cm) (lab)				879		
Aluminum				6.16	0.273	
Antimony				ND	ND	
Arsenic				ND	ND	
Barium				0.126	0.067	
Beryllium				ND	ND	
Cadmium				ND	ND	
Chromium				ND	ND	
Copper				0.055	0.033	
Iron				5.76	0.503	
Lead				ND.	ND	
Manganese				0.443	0.338	
Mercury				ND	ND	
Molybdenum				ND	ND	
Selenium				ND	ND	
Silver				ND	ND	
Strontium				0.446	0.408	
Titanium				0.169	ND	
Vanadium				ND	ND	
Zinc				ND	ND	

Appendix F. Results of Chemical Analyses of Seepage Zone and Selected River Samples (Cont'd)

Sample Station/ Constituent (mg/l)	Date Sampled Sample Location and Type				
SC-04	7/26/92 River	7/26/92 Seep @ 1'	SC-06	7/26/92 River	7/26/92 Seep @ 1'
Nitrate-N	1.1	0.3		1.5	0.1
Nitrite-N	0.4	ND		0.4	0.2
Kjeldahl-N	18.3	19.7		16.9	16.7
Ammonia-N	14.7	17.7		13.9	14.8
Organic N	3.6	2		3	1.9
Total N	19.8	20		18.8	16.9
Phosphate	5.4	7.4		5.4	5.9
TOC	17.3	7.9		14.6	11.1
EC (umho/cm)(field)	760	830		730	730
pH (field)	7.6	7.5		7.5	7.5
Eh (mV)(field)	76	-135			
DO (field)	2.5	0.35		2.2	1.1
Temperature (F)	82	85		92	86
Calcium	45.3	47.6			44.4
Magnesium	5.99	6.32			5.39
Sodium	99.6	100			98.8
Potassium	11	12.9			11.9
Carbonate					
Bicarbonate					
Chloride	65.4	77.4			64
Sulfate	75.1	65.4			75.4
Alkalinity	212	250			216
Fluoride	0.68	0.48			0.66
Boron	0.47	0.299			0.47
TDS @ 180 C	467	500			486
EC (umho/cm) (lab)		914			
Aluminum	0.578	0.419			0.771
Antimony	ND	ND			ND
Arsenic	ND	ND			ND
Barium	0.053	0.071			0.055
Beryllium	ND	ND			ND
Cadmium	ND	ND			ND
Chromium	ND	ND			ND
Copper	0.033	0.027			0.03
Iron	0.648	0.539			0.659
Lead	ND	ND			ND
Manganese	0.056	0.206			0.12
Mercury	ND	ND			ND
Molybdenum	ND	ND			ND
Selenium	ND	ND			ND
Silver	ND	ND			ND
Strontium	0.373	0.387			0.349
Titanium	ND	ND			ND
Vanadium	ND	ND			ND
Zinc	ND	ND			ND

Appendix F. Results of Chemical Analyses of Seepage Zone and Selected River Samples (Cont'd)

Sample Station/ Constituent (mg/l)	Date Sampled Sample Location and Type				
	7/31/92	7/31/92	7/31/92		
SC @ CDO	River	Seep @ 1'	Seep @ 1"		
Nitrate-N	3.5	0.1	0.1		
Nitrite-N	ND	ND	ND		
Kjeldahl-N	12.7	9.6	8.2		
Ammonia-N	9.4	7.7	7.7		
Organic N	3.3	1.9	0.5		
Total N	16.2	9.6	8.2		
Phosphate	4.2	6.8	7		
TOC	10.1	9	8.8		
EC (umho/cm)(field)	940	790	740		
pH (field)	7.9	7.5	7.6		
Eh (mV)(field)	20	-135	-125		
DO (field)	2	0.8	1		
Temperature (F)	83	82	82		
	05/09/92	05/09/92		05/10/92	05/10/92
SC-05	River	Seep @ 1'	SC-07	River	Seep @ 1'
Nitrate-N	1.3	0.1		2	0.2
Nitrite-N					
Kjeldahl-N	24	22		20	22
Ammonia-N	16.8	16.8		16.1	16.1
Organic N	7.2	5.2		3.9	5.9
Total N	25.3	22		22	22.2
Phosphate					
TOC					
EC (umho/cm)(field)	876	860		952	946
pH (field)	7.4	7.2		7.8	7.4
Eh (mV)(field)					
DO (field)	3.6	0.7		3.5	0.02
Temperature (F)	77.7			74.4	72

Appendix F. Results of Chemical Analyses of Seepage Zone and Selected River Samples (Cont'd)

Sample Station/ Constituent (mg/l)	Date Sampled Sample Location and Type
	8/7/92
River	Natural flow
Nitrate-N	0.9
Nitrite-N	ND
Kjeldahl-N	1.9
Ammonia-N	ND
Organic N	
Total N	2.8
Phosphate	0.8
TOC	15.3
EC (umho/cm)(field)	
pH (field)	8
Eh (mV)(field)	134
DO (field)	4
Temperature (F)	72
Calcium	50.9
Magnesium	14.3
Sodium	8.29
Potassium	10.9
Carbonate	ND
Bicarbonate	103
Chloride	ND
Sulfate	132.5
Alkalinity	103
Fluoride	0.22
Boron	ND
TDS @ 180 C	214
EC (umho/cm) (lab)	167
Aluminum	26.5
Antimony	ND
Arsenic	ND
Barium	0.495
Beryllium	ND
Cadmium	ND
Chromium	ND
Copper	0.156
Iron	27.1
Lead	ND
Manganese	0.808
Mercury	ND
Molybdenum	
Selenium	ND
Silver	ND
Strontium	0.364
Titanium	0.541
Vanadium	0.059
Zinc	0.442

APPENDIX G

Miscellaneous Monitoring Results

Selected Bromide Results

Sample Location	Sample Date	Bromide Concentration (mg/l)
SC2	04/23/92	0.24
SC4	04/29/92	0.14
SC6	04/29/92	0.22
SC8	05/06/92	0.24
CMID8	05/12/92	0.28
CMID11	05/12/92	0.15
CMID16P	05/12/92	0.18
CMID35H	05/12/92	0.24
SC10	05/13/92	0.23
SC12	05/13/92	0.22
Honea Well	05/13/92	0.13
River at SC3	05/13/92	0.25

Analyses by BC Laboratories, Inc., Bakersfield, CA.

Reference Method: EPA Methods for Chemical Analysis of Water and Wastes, EPA-600, 14-79-020. EPA Method 300.0

Results of ^{2}H and ^{18}O Analyses

Sample Location	Sample Date	$\delta^{2}H$, o/oo SMOW	δD, o/oo SMOW
River at SC3	05/13/92	-58	-8.3
SC4	04/29/92	-62	-8.9
SC6	04/29/92	-61	-8.5
SC10	05/13/92	-58	-8.1
SC12	05/13/92	-48	-8.2
CMID26J3	06/19/92	-55	-7.8

Results of Enterovirus Analyses

Sample Location	Sampling Date	MPN/40 Liters
SC1	06/02/92	0
SC2	06/02/92	0
SC3	06/02/92	0
SC4	06/02/92	0
SC1	02/17/93	2.7
SC3	02/17/93	0
SC1	06/23/93	0

Results of Tritium Analyses

Sample Location	Sample Date	Tritium Units
River at SC3	05/13/92	4.09
SC6	04/29/92	5.91
SC7	05/06/92	8.04
SC9	05/06/92	3.26
SC10	05/13/92	18.25
SC12	05/13/92	8.82
CMID16P	05/12/92	4.56
CMID25K1	05/12/92	3.91
CMID11	05/12/92	0
Honea Well	05/13/92	16.27

Standard Deviation Values Corresponding with Means Reported in Table 7

Well	Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3-N
SC1	2.9	1.2	6.9	0.4	29	17	3.7	0.9
SC2	3.7	0.8	7.0	0.3	18	8.6	5.3	2.0
SC3	13	1.4	13	0.5	55	20	9.0	1.5
SC4	11	1.7	15	0.6	36	18	11	1.9
SC5	8.5	1.2	11	0.6	33	7.3	20	1.5
SC6	6.1	1.1	9.1	0.5	34	11	8.6	1.9
SC7	3.0	0.5	5.5	1.0	22	7.1	6.9	0.4
SC8	7.2	1.2	4.8	0.3	21	26	9.2	0.8
SC9	12	1.7	7.5	0.3	33	17	15	1.1
SC10	4.8	0.7	3.6	0.3	21	4.3	3.7	0.7
SC12	8.3	1.3	3.0	0.3	36	6.8	4.0	0.7

APPENDIX H

NETPATH Modeling Results

```
Initial Well:Effluent Average                          NETPATH 1.2
Initial Well:Well CMID 16P                          February 9, 1992
Final Well  :Well SC6
```

Constraints: 4		Phases: 3	Parameters
Nitrogen	Calcium	NH4/CAEX EXCHANGE Mg/Na EX	Mixing: Yes
Magnesium	Sodium		Evaporation: No
			Rayleigh Calcs: No
			Exchange: Var. Ca/Mg
			X Calcium: .80

```
Select: <A>dd, <D>elete, <E>dit, <R>un, <S>ave, <V>iew, or <Q>uit
r
```

```
Initial Well 1 : Effluent Average
Initial Well 2 : Well CMID 16P
Final Well     : Well SC6

          Final    Initial 1   Initial 2
N         .4929      1.6288       .2643
CA       1.9148      1.2708      1.4476
MG        .5721       .3169       .3703
NA       2.7288      4.5571      1.4794
Hit <Q> to quit, or <Enter> to continue

NH4/CAEXN   2.0000CA -1.0000RS -6.0000
EXCHANGECA  -.8000NA  2.0000MG  -.2000
Mg/Na EXNA  2.0000MG -1.0000
Hit <Q> to quit, or <Enter> to continue
```

```
1 models to be tested
1 models were tested.
1 models were found which satisfied the constraints.


          MODEL   1
INIT 1    + F          .70719
INIT 2    + F          .29281
NH4/CAEX              -.36818
EXCHANGE              -.28004
Mg/Na EX              -.18350

No more models, hit <Enter> to continue
```

Effluent Average

Units: mg/l

Temp. 25.	pH 7.5	Diss. O2 2.4	Carb. Alk. 226.7	Tritium --
H2S --	Ca2+ 50.9	Eh .077	Mg2+ 7.7	Na+ 104.7
K+ 12.5	Cl- 78.4	SO42- 86.1	F- .55	SiO2 37.
Br- .31	B .28	Ba2+ --	Li+ --	Sr2+ --
Fe .47	Mn .026	NO2+NO3-N 5.6	NH4+kjd-N 17.2	PO4-P 6.1
DOC 14.8	Sp. Cond. --	Density --	13C TDIC --	14C TDIC --
34SSO4 --	34SH2S --	D --	18O --	Diss CH4 --
Sr 87/86 --	Al3+ --			

Hit <Enter> to continue

Well CMID 16P

Units: mg/l

Temp. 22.8	pH 7.5	Diss. O2 3.	Carb. Alk. 139.	Tritium --
H2S --	Ca2+ 58.	Eh Redox Ign.	Mg2+ 9.0	Na+ 34.
K+ 2.2	Cl- 30.2	SO42- 59.	F- .28	SiO2 --
Br- .18	B --	Ba2+ --	Li+ --	Sr2+ --
Fe 0.	Mn 0.	NO2+NO3-N 3.7	NH4+kjd-N 0.	PO4-P --
DOC 0.	Sp. Cond. --	Density --	13C TDIC --	14C TDIC --
34SSO4 --	34SH2S --	D --	18O --	Diss CH4 --
Sr 87/86 --	Al3+ --			

Hit <Enter> to continue

Well SC6

Units: mg/l

Temp.	pH	Diss. O2	Carb. Alk.	Tritium
20.6	7.2	3.	206.8	--
H2S	Ca2+	Eh	Mg2+	Na+
--	76.7	.8	13.9	62.7
K+	Cl-	SO42-	F-	SiO2
2.5	60.1	98.7	.19	36.
Br-	B	Ba2+	Li+	Sr2+
.22	.18	--	--	--
Fe	Mn	NO2+NO3-N	NH4+kjd-N	PO4-P
.8	.005	6.6	.3	.3
DOC	Sp. Cond.	Density	13C TDIC	14C TDIC
3.6	--	--	--	--
34SSO4	34SH2S	D	18O	Diss CH4
--	--	--	--	--
Sr 87/86	Al3+			
--	--			

Hit <Enter> to continue

```
Initial Well:Effluent Average                          NETPATH 1.2
Initial Well:Honea Well                              February 9, 1992
Final Well  :sc10
```

Constraints: 4		Phases: 3	Parameters
Calcium	Magnesium	EXCHANGE Mg/Na EX NH4/CAEX	Mixing: Yes
Sodium	Nitrogen		Evaporation: No
			Rayleigh Calcs: No
			Exchange: Ca/Na

```
Select: <A>dd, <D>elete, <E>dit, <R>un, <S>ave, <V>iew, or <Q>uit
r
```

```
Initial Well 1 : Effluent Average
Initial Well 2 : Honea Well
Final Well     : sc10
```

	Final	Initial 1	Initial 2
CA	2.1719	1.2708	2.0470
MG	.5350	.3169	.4650
NA	2.5765	4.5571	2.1325
N	.7072	1.5788	.4572

```
Hit <Q> to quit, or <Enter> to continue

EXCHANGECA -1.0000NA  2.0000MG   .0000
Mg/Na EXNA  2.0000MG -1.0000
NH4/CAEXN   2.0000CA -1.0000RS -6.0000
Hit <Q> to quit, or <Enter> to continue
```

```
1 models to be tested
1 models were tested.
1 models were found which satisfied the constraints.


          MODEL   1
INIT 1    + F          .63846
INIT 2    + F          .36154
EXCHANGE              -.38745
Mg/Na EX              -.16455
NH4/CAEX              -.23304

No more models, hit <Enter> to continue
```

Effluent Average

Units: mg/l

Temp.	pH	Diss. O2	Carb. Alk.	Tritium
25.	7.5	2.4	226.7	--
H2S	Ca2+	Eh	Mg2+	Na+
--	50.9	.077	7.7	104.7
K+	Cl-	SO42-	F-	SiO2
12.5	78.4	86.1	.55	37.
Br-	B	Ba2+	Li+	Sr2+
.31	.28	--	--	--
Fe	Mn	NO2+NO3-N	NH4+kjd-N	PO4-P
--	--	4.9	17.2	6.1
DOC	Sp. Cond.	Density	13C TDIC	14C TDIC
14.8	--	--	--	--
34SSO4	34SH2S	D	18O	Diss CH4
--	--	--	--	--
Sr 87/86	Al3+			
--	--			

Hit <Enter> to continue

Honea Well

Units: mg/l

Temp.	pH	Diss. O2	Carb. Alk.	Tritium
20.2	7.4	5.	212.	--
H2S	Ca2+	Eh	Mg2+	Na+
--	82.	.2	11.3	49.
K+	Cl-	SO42-	F-	SiO2
2.1	49.2	80.	.36	37.
Br-	B	Ba2+	Li+	Sr2+
.13	--	--	--	--
Fe	Mn	NO2+NO3-N	NH4+kjd-N	PO4-P
--	--	6.4	0.	--
DOC	Sp. Cond.	Density	13C TDIC	14C TDIC
0.	--	--	--	--
34SSO4	34SH2S	D	18O	Diss CH4
--	--	--	--	--
Sr 87/86	Al3+			
--	--			

Hit <Enter> to continue

sc10 Units: mg/l

Temp.	pH	Diss. O2	Carb. Alk.	Tritium
21.6	7.7	5.	203.9	--
H2S	Ca2+	Eh	Mg2+	Na+
--	87.0	.2	13.0	59.2
K+	Cl-	SO42-	F-	SiO2
2.0	65.4	88.4	.30	37.
Br-	B	Ba2+	Li+	Sr2+
--	.16	--	--	--
Fe	Mn	NO2+NO3-N	NH4+kjd-N	PO4-P
--	--	9.9	0.	--
DOC	Sp. Cond.	Density	13C TDIC	14C TDIC
--	--	--	--	--
34SSO4	34SH2S	D	18O	Diss CH4
--	--	--	--	--
Sr 87/86	Al3+			
--	--			

Hit <Enter> to continue

-- WATEQF OUTPUT --

Effluent Average

INITIAL SOLUTION

TEMPERATURE = 25.00 DEGREES C PH = 7.500
ANALYTICAL EPMCAT = 9.293 ANALYTICAL EPMAN = 8.743

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT

***** OXIDATION - REDUCTION *****

DISSOLVED OXYGEN = 2.400 MG/L
EH MEASURED WITH CALOMEL = 9.9000 VOLTS
MEASURED EH OF ZOBELL SOLUTION = 9.9000 VOLTS
CORRECTED EH = .0800 VOLTS
PE COMPUTED FROM CORRECTED EH = 1.352

FLAG	CORALK	PECALC	IDAVES
2	1	1	0

*** TOTAL CONCENTRATIONS OF INPUT SPECIES ***

SPECIES		TOTAL MOLALITY	LOG TOTAL MOLALITY	TOTAL MG/LITRE
CA	2	1.27077E-03	-2.8959	5.09000E+01
MG	2	3.16917E-04	-3.4991	7.70000E+00
NA	1	4.55709E-03	-2.3413	1.04700E+02
K	1	3.19880E-04	-3.4950	1.25000E+01

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT

CL	-1	2.21278E-03	-2.6551	7.84000E+01
SO4	-2	8.96869E-04	-3.0473	8.61000E+01
HCO3	-1	3.71770E-03	-2.4297	2.26700E+02
SIO2 TOT	0	6.16187E-04	-3.2103	3.70000E+01
FE	2	8.42119E-06	-5.0746	4.70000E-01
PO4-P	-3	1.97066E-04	-3.7054	6.10000E+00
F	-1	2.89682E-05	-4.5381	5.50000E-01
NH4-N	1	1.22876E-03	-2.9105	1.72000E+01
NO3-N	-1	4.00063E-04	-3.3979	5.60000E+00
B TOT	0	2.59184E-05	-4.5864	2.80000E-01
BR	-1	3.88188E-06	-5.4110	3.10000E-01
MN	2	4.73544E-07	-6.3246	2.60000E-02

*** CONVERGENCE ITERATIONS ***

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
-

ITERATION	S1-ANALCO3	S2-SO4TOT	S3-FTOT	S4-PTOT	S5-CLTOT
1	6.815E-05	1.892E-04	5.612E-07	7.612E-05	2.414E-09
2	4.172E-06	7.272E-06	3.861E-08	3.556E-06	3.700E-11
3	-1.144E-07	-2.339E-07	-8.657E-10	-1.052E-07	-4.896E-12

Effluent Average

****DESCRIPTION OF SOLUTION ****

	ANAL.	COMP.	PH	
EPMCAT	9.29	8.91	7.500	ACTIVITY H2O = .9997
EPMAN	8.74	8.15		PCO2= 6.353417E-03
				LOG PCO2 = -2.1641
			TEMPERATURE	PO2 = 1.943952E-48

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
-

EH = .0800 PE = 1.352	25.00 DEG C	PCH4 = 0.000000E+00
PE CALC S = 100.000		CO2 TOT = 3.935676E-03
PE CALC DOX= 12.964	IONIC STRENGTH	DENSITY = 1.0000
PE SATO DOX= 2.854	1.083775E-02	TDS = 634.5MG/L
TOT ALK = 4.096E+00 MEQ		CARB ALK = 3.718E+00 MEQ
ELECT = 7.630E-01 MEQ		

IN COMPUTING THE DISTRIBUTION OF SPECIES,
PE = 1.352 EQUIVALENT EH = .080VOLTS

DISTRIBUTION OF SPECIES

I	SPECIES		PPM	MOLALITY	ACTIVITY	LOG ACT	GAMMA
1	CA	2	4.4865E+01	1.1201E-03	7.4029E-04	-3.131	6.6091E-01
2	MG	2	6.8056E+00	2.8010E-04	1.8640E-04	-3.730	6.6548E-01

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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3	NA	1	1.0422E+02	4.5363E-03	4.0807E-03	-2.389	8.9957E-01
4	K	1	1.2453E+01	3.1869E-04	2.8578E-04	-3.544	8.9675E-01
64	H	1	3.4982E-05	3.4726E-08	3.1623E-08	-7.500	9.1063E-01
5	CL	-1	7.8400E+01	2.2128E-03	1.9843E-03	-2.702	8.9675E-01
6	SO4	-2	7.5016E+01	7.8141E-04	5.1381E-04	-3.289	6.5753E-01
7	HCO3	-1	2.2188E+02	3.6386E-03	3.2813E-03	-2.484	9.0180E-01
18	CO3	-2	4.4134E-01	7.3591E-06	4.8672E-06	-5.313	6.6138E-01
86	H2CO3	0	1.4421E+01	2.3265E-04	2.3326E-04	-3.632	1.0026E+00
27	OH	-1	6.1128E-03	3.5965E-07	3.2239E-07	-6.492	8.9641E-01
62	F	-1	5.3991E-01	2.8437E-05	2.5491E-05	-4.594	8.9641E-01
98	BR	-1	3.1000E-01	3.8819E-06	3.4855E-06	-5.458	8.9789E-01
19	MGOH	1	4.4837E-04	1.0858E-08	9.8231E-09	-8.008	9.0468E-01
23	MGSO4 AQ	0	1.9880E+00	1.6526E-05	1.6567E-05	-4.781	1.0025E+00
22	MGHCO3	1	6.7552E-01	7.9217E-06	7.1128E-06	-5.148	8.9789E-01
21	MGCO3 AQ	0	7.2784E-02	8.6372E-07	8.6588E-07	-6.063	1.0025E+00
20	MGF	1	1.5109E-02	3.4908E-07	3.1393E-07	-6.503	8.9932E-01
29	CAOH	1	3.7859E-04	6.6360E-09	5.9949E-09	-8.222	9.0339E-01
32	CASO4 AQ	0	1.0515E+01	7.7288E-05	7.7481E-05	-4.111	1.0025E+00
30	CAHCO3	1	3.4651E+00	3.4297E-05	3.0984E-05	-4.509	9.0339E-01
31	CACO3 AQ	0	6.0395E-01	6.0380E-06	6.0531E-06	-5.218	1.0025E+00
49	CAF+	1	1.0773E-02	1.8247E-07	1.6436E-07	-6.784	9.0072E-01
44	NASO4	-1	1.4517E+00	1.2202E-05	1.1004E-05	-4.958	9.0180E-01

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 43 NAHCO3     0  6.3045E-01  7.5110E-06  7.5297E-06  -5.123  1.0025E+00
 42 NACO3     -1  3.3861E-02  4.0822E-07  3.6814E-07  -6.434  9.0180E-01
 94 NACL       0  4.7175E-31  8.0772E-36  8.0973E-36 -35.092  1.0025E+00
 46 KSO4      -1  1.5457E-01  1.1443E-06  1.0319E-06  -5.986  9.0180E-01
 95 KCL        0  4.2146E-32  5.6566E-37  5.6708E-37 -36.246  1.0025E+00
 63 HSO4      -1  1.7012E-04  1.7537E-09  1.5771E-09  -8.802  8.9932E-01
 24 H4SIO4AQ   0  5.8942E+01  6.1363E-04  6.1517E-04  -3.211  1.0025E+00
 25 H3SIO4    -1  2.4262E-01  2.5526E-06  2.2920E-06  -5.640  8.9789E-01
 26 H2SIO4    -2  2.1147E-05  2.2487E-10  1.4872E-10  -9.828  6.6138E-01
  8 FE         2  3.6750E-01  6.5846E-06  4.3857E-06  -5.358  6.6605E-01
  9 FE         3  1.1720E-12  2.1000E-17  9.0421E-18 -17.044  4.3058E-01
 10 FEOH       2  2.0416E-07  2.8041E-12  1.8457E-12 -11.734  6.5819E-01
 11 FEOH       1  3.5442E-03  4.8678E-08  4.3845E-08  -7.358  9.0072E-01
 12 FE(OH)3   -1  1.6431E-09  1.5385E-14  1.3858E-14 -13.858  9.0072E-01
 77 FE(OH)2    1  1.9241E-03  2.1425E-08  1.9321E-08  -7.714  9.0180E-01
 78 FE(OH)3    0  7.6456E-04  7.1587E-09  7.1766E-09  -8.144  1.0025E+00
 79 FE(OH)4   -1  3.1146E-04  2.5159E-09  2.2688E-09  -8.644  9.0180E-01
 80 FE(OH)2    0  1.0569E-06  1.1769E-11  1.1798E-11 -10.928  1.0025E+00
 13 FEHPO4     1  2.9389E-11  1.9370E-16  1.7468E-16 -15.758  9.0180E-01
100 FEHPO4     0  1.9186E-01  1.2645E-06  1.2677E-06  -5.897  1.0025E+00
 65 FEH2PO4    1  1.3767E-02  9.0136E-08  8.1285E-08  -7.090  9.0180E-01
 99 FEH2PO4    2  2.2016E-11  1.4414E-16  9.5332E-17 -16.021  6.6138E-01
- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO     QUIT, OR A PAGE INCREMENT
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 15 FESO4      1  6.5131E-12  4.2902E-17  3.8643E-17 -16.413  9.0072E-01
 16 FECL       2  6.8190E-14  7.4735E-19  4.9190E-19 -18.308  6.5819E-01
 28 FECL2      1  6.5903E-16  5.2026E-21  4.6861E-21 -20.329  9.0072E-01
 33 FECL3      0  1.4840E-19  9.1550E-25  9.1778E-25 -24.037  1.0025E+00
 34 FESO4      0  6.0682E-02  3.9972E-07  4.0072E-07  -6.397  1.0025E+00
101 MN         2  2.2602E-02  4.1166E-07  2.7419E-07  -6.562  6.6605E-01
102 MN         3  2.4481E-26  4.4588E-31  1.9199E-31 -30.717  4.3058E-01
106 MNOH       1  1.9799E-05  2.7575E-10  2.4837E-10  -9.605  9.0072E-01
107 MN(OH)3   -1  6.5239E-14  6.1606E-19  5.5490E-19 -18.256  9.0072E-01
111 MNHCO3     1  6.0191E-03  5.1940E-08  4.6783E-08  -7.330  9.0072E-01
109 MNSO4      0  1.0826E-03  7.1740E-09  7.1919E-09  -8.143  1.0025E+00
110 MN(NO3)2   0  7.1817E-09  4.0157E-14  4.0257E-14 -13.395  1.0025E+00
103 MNCL       1  2.2077E-04  2.4438E-09  2.2012E-09  -8.657  9.0072E-01
104 MNCL2      0  1.4897E-07  1.1844E-12  1.1874E-12 -11.925  1.0025E+00
105 MNCL3     -1  1.9025E-10  1.1801E-15  1.0630E-15 -14.973  9.0072E-01
108 MNF        1  4.0593E-06  5.4934E-11  4.9480E-11 -10.306  9.0072E-01
115 HMNO2     -1  3.0703E-14  3.4932E-19  3.1464E-19 -18.502  9.0072E-01
 45 PO4-P     -3  8.2110E-05  2.6526E-09  1.0351E-09  -8.985  3.9020E-01
 47 HPO4      -2  1.0581E+01  1.1031E-04  7.2606E-05  -4.139  6.5819E-01
 48 H2PO4     -1  3.9746E+00  4.1007E-05  3.6980E-05  -4.432  9.0180E-01
 40 MGPO4     -1  9.8996E-02  8.3045E-07  7.4890E-07  -6.126  9.0180E-01
 73 MGHPO4     0  1.2031E+00  1.0008E-05  1.0033E-05  -4.999  1.0025E+00
- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO     QUIT, OR A PAGE INCREMENT
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 41 MGH2PO4    1  3.0192E-02  2.4906E-07  2.2461E-07  -6.649  9.0180E-01
 75 CAPO4     -1  3.2998E-01  2.4449E-06  2.2048E-06  -5.657  9.0180E-01
 74 CAHPO4     0  3.9970E+00  2.9396E-05  2.9469E-05  -4.531  1.0025E+00
 76 CAH2PO4    1  1.0639E-01  7.7671E-07  7.0044E-07  -6.155  9.0180E-01
 61 KHPO4     -1  6.0564E-03  4.4864E-08  4.0458E-08  -7.393  9.0180E-01
 50 NAHPO4    -1  7.6164E-02  6.4061E-07  5.7770E-07  -6.238  9.0180E-01
 36 H3BO3 AQ   0  1.5692E+00  2.5394E-05  2.5457E-05  -4.594  1.0025E+00
```

37	H2BO3	-1	3.1879E-02	5.2445E-07	4.6850E-07	-6.329	8.9333E-01
85	NO3-N	-1	5.6000E+00	4.0006E-04	3.5801E-04	-3.446	8.9489E-01
38	NH3 AQ	0	3.2863E-01	1.9309E-05	1.9357E-05	-4.713	1.0025E+00
39	NH4-N	1	1.6819E+01	1.2015E-03	1.0734E-03	-2.969	8.9333E-01
92	NH4SO4	-1	8.9944E-01	7.8879E-06	7.1048E-06	-5.148	9.0072E-01

MOLE RATIOS FROM ANALYTICAL MOLALITY		MOLE RATIOS FROM COMPUTED MOLALITY		LOG ACTIVITY RATIOS	
CL/CA	= 1.7413E+00	CL/CA	= 1.9755E+00	LOG CA/H2 =	11.8694
CL/MG	= 6.9822E+00	CL/MG	= 7.8998E+00	LOG MG/H2 =	11.2705

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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CL/NA	= 4.8557E-01	CL/NA	= 4.8779E-01	LOG NA/H1 =	5.1107
CL/K	= 6.9175E+00	CL/K	= 6.9434E+00	LOG K/H1 =	3.9560
CL/AL	= 2.2128E+27	CL/AL	= 2.2128E+27	LOG AL/H3 =	22.5000
CL/FE	= 2.6276E+02	CL/FE	= 3.3605E+02	LOG FE/H2 =	9.6420
CL/SO4	= 2.4672E+00	CL/SO4	= 2.8318E+00	LOG CA/MG =	.5989
CL/HCO3	= 5.9520E-01	CL/HCO3	= 6.0814E-01	LOG NA/K =	1.1547
CA/MG	= 4.0098E+00	CA/MG	= 3.9989E+00		
NA/K	= 1.4246E+01	NA/K	= 1.4234E+01		

Effluent Average

	PHASE	IAP	KT	LOG IAP	LOG KT	IAP/KT	LOG IAP/KT
18	ANHYDRIT	3.804E-07	4.130E-05	-6.420	-4.384	9.209E-03	-2.036
22	ARAGONIT	3.603E-09	4.612E-09	-8.443	-8.336	7.813E-01	-.107
151	ARTIN	2.770E-25	3.981E-19	-24.558	-18.400	6.958E-07	-6.158
20	BRUCITE	1.937E-17	3.890E-12	-16.713	-11.410	4.980E-06	-5.303
13	CALCITE	3.603E-09	3.312E-09	-8.443	-8.480	1.088E+00	.037

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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98	CHALC	6.155E-04	2.999E-04	-3.211	-3.523	2.052E+00	.312
21	CHRYSOTL			-56.560	-51.800		-4.760
30	CLENSTIT	1.193E-20	1.349E-17	-19.923	-16.870	8.842E-04	-3.053
100	SILGEL	6.155E-04	1.995E-03	-3.211	-2.700	3.085E-01	-.511
29	DIOPSIDE			-39.248	-36.220		-3.028
12	DOLOMITE	3.269E-18	8.128E-18	-17.486	-17.090	4.022E-01	-.396
113	FEOH3A	2.857E+05	7.674E+04	5.456	4.885	3.723E+00	.571
97	FLUAPT			-52.138	-66.790		14.652
63	FLUOR	4.810E-13	1.096E-11	-12.318	-10.960	4.387E-02	-1.358
28	FORSTRIT	2.312E-37	7.762E-29	-36.636	-28.110	2.978E-09	-8.526
111	GOETH			-36.518	-44.197		7.679
112	GREENA			-61.445	-63.190		1.745
19	GYPSUM	3.802E-07	2.498E-05	-6.420	-4.602	1.522E-02	-1.818
65	HALITE	8.097E-06	3.819E+01	-5.092	1.582	2.120E-07	-6.674
109	HEMATI	8.169E+10	9.840E-05	10.912	-4.007	8.302E+14	14.919

118	HUNTITE	2.691E-36	3.090E-31	-35.570	-30.510	8.707E-06	-5.060
39	HYDMAG			-52.882	-37.820		-15.062
96	HYXAPT			-54.036	-59.350		5.314
99	MAGADI	3.020E-19	5.012E-15	-18.520	-14.300	6.026E-05	-4.220
110	MAGHEM	8.169E+10	2.344E+06	10.912	6.370	3.485E+04	4.542
11	MAGNESIT	9.073E-10	5.754E-09	-9.042	-8.240	1.577E-01	-.802
108	MAGNET	3.282E+07	2.723E-10	7.516	-9.565	1.205E+17	17.081

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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67	MIRABI	8.533E-09	7.709E-02	-8.069	-1.113	1.107E-07	-6.956
59	NAHCOL	1.339E-05	2.831E-01	-4.873	-.548	4.729E-05	-4.325
61	NATRON	8.083E-11	4.887E-02	-10.092	-1.311	1.654E-09	-8.781
150	NESQUE	9.065E-10	6.152E-06	-9.043	-5.211	1.474E-04	-3.832
102	QUARTZ	6.155E-04	9.886E-05	-3.211	-4.005	6.226E+00	.794
37	SEPIOLIT			-43.058	-40.100		-2.958
10	SIDERITE	2.135E-11	2.692E-11	-10.671	-10.570	7.931E-01	-.101
101	SILGLAS	6.155E-04	9.616E-04	-3.211	-3.017	6.401E-01	-.194
147	STRENGIT	9.354E-27	3.981E-27	-26.029	-26.400	2.350E+00	.371
38	TALC			-62.981	-62.290		-.691
66	THENAR	8.556E-09	6.622E-01	-8.068	-.179	1.292E-08	-7.889
62	THRNAT	8.103E-11	1.334E+00	-10.091	.125	6.076E-11	-10.216
32	TREMOLIT			-141.477	-140.300		-1.177
60	TRONA	1.085E-15	1.603E-01	-14.965	-.795	6.765E-15	-14.170
107	VIVIAN	9.018E-35	1.000E-36	-34.045	-36.000	9.018E+01	1.955
154	SEP PT			-43.058	-37.212		-5.846
172	MANGANO	2.741E+08	8.670E+17	8.438	17.938	3.162E-10	-9.500
173	PYROLUST	4.318E+00	7.261E+15	.635	15.861	5.947E-16	-15.226
174	BIRNSITE	4.318E+00	1.233E+18	.635	18.091	3.502E-18	-17.456
175	NUSTITE	4.318E+00	3.192E+17	.635	17.504	1.353E-17	-16.869
176	BIXBYITE	3.683E-17	2.449E-01	-16.434	-.611	1.504E-16	-15.823
177	HAUSMITE			43.018	61.540		-18.522

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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178	MNOH2	2.850E-20	1.225E-13	-19.545	-12.912	2.327E-07	-6.633
179	MNOH3			-50.192	-35.644		-14.548
180	MANGANIT	6.068E-09	5.781E-01	-8.217	-.238	1.050E-08	-7.979
181	RHODOCHR	1.335E-12	2.891E-11	-11.875	-10.539	4.617E-02	-1.336
183	MNCL2	1.080E-12	5.754E+08	-11.967	8.760	1.876E-21	-20.727
184	MNCL2,1W	1.079E-12	3.327E+05	-11.967	5.522	3.244E-18	-17.489
185	MNCL2,2W	1.079E-12	9.419E+03	-11.967	3.974	1.146E-16	-15.941
186	MNCL2,4W	1.078E-12	5.129E+02	-11.967	2.710	2.103E-15	-14.677
187	TEPHRITE	4.625E+13	1.324E+23	13.665	23.122	3.492E-10	-9.457
188	RHODONIT	4.626E-02	3.327E+09	-1.335	9.522	1.391E-11	-10.857
190	MNSO4	1.409E-10	4.667E+02	-9.851	2.669	3.019E-13	-12.520
191	MN2SO4,3			-71.301	-5.711		-65.590
192	MN3PO4,2	2.208E-38	1.489E-24	-37.656	-23.827	1.483E-14	-13.829
193	MNHPO4	1.991E-11	1.130E-13	-10.701	-12.947	1.762E+02	2.246

Well SC5

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT

INITIAL SOLUTION

TEMPERATURE = 20.60 DEGREES C PH = 7.200
ANALYTICAL EPMCAT = 7.812 ANALYTICAL EPMAN = 7.652

***** OXIDATION - REDUCTION *****

DISSOLVED OXYGEN = 3.000 MG/L
EH MEASURED WITH CALOMEL = 9.9000 VOLTS
MEASURED EH OF ZOBELL SOLUTION = 9.9000 VOLTS
CORRECTED EH = .8000 VOLTS
PE COMPUTED FROM CORRECTED EH = 13.725

FLAG	CORALK	PECALC	IDAVES
2	1	1	0

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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*** TOTAL CONCENTRATIONS OF INPUT SPECIES ***

SPECIES		TOTAL MOLALITY	LOG TOTAL MOLALITY	TOTAL MG/LITRE
CA	2	1.91476E-03	-2.7179	7.67000E+01
MG	2	5.72058E-04	-3.2426	1.39000E+01
NA	1	2.72884E-03	-2.5640	6.27000E+01
K	1	6.39716E-05	-4.1940	2.50000E+00
CL	-1	1.69616E-03	-2.7705	6.01000E+01
SO4	-2	1.02805E-03	-2.9880	9.87000E+01
HCO3	-1	3.39112E-03	-2.4697	2.06800E+02
SIO2 TOT	0	5.99493E-04	-3.2222	3.60000E+01
FE	2	1.43330E-05	-4.8437	8.00000E-01
PO4-P	-3	9.69109E-06	-5.0136	3.00000E-01
F	-1	1.00065E-05	-4.9997	1.90000E-01
NH4-N	1	2.14305E-05	-4.6690	3.00000E-01
NO3-N	-1	4.71470E-04	-3.3265	6.60000E+00
B TOT	0	1.66607E-05	-4.7783	1.80000E-01
BR	-1	2.75469E-06	-5.5599	2.20000E-01

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MN	2	9.10599E-08	-7.0407	5.00000E-03

*** CONVERGENCE ITERATIONS ***

ITERATION	S1-ANALCO3	S2-SO4TOT	S3-FTOT	S4-PTOT	S5-CLTOT
1	7.618E-05	2.850E-04	3.125E-07	4.018E-06	3.615E-10
2	4.281E-06	1.078E-05	1.674E-08	1.626E-07	6.930E-12
3	-1.869E-07	-5.654E-07	-7.242E-10	-8.389E-09	-9.628E-13

Well SC6

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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****DESCRIPTION OF SOLUTION ****

	ANAL.	COMP.	PH	ACTIVITY H2O = .9998
EPMCAT	7.81	7.39	7.200	PCO2= 1.171757E-02
EPMAN	7.65	7.24		LOG PCO2 = -1.9312
			TEMPERATURE	PO2 = 1.199906E-01
EH = .8000	PE = 13.725		20.60 DEG C	PCH4 = 0.000000E+00
PE CALC S =	100.000			CO2 TOT = 3.833651E-03
PE CALC DOX=	13.655		IONIC STRENGTH	DENSITY = 1.0000
PE SATO DOX=	3.178		1.044272E-02	TDS = 566.0MG/L
TOT ALK =	3.440E+00 MEQ			CARB ALK = 3.391E+00 MEQ
ELECT =	1.536E-01 MEQ			

IN COMPUTING THE DISTRIBUTION OF SPECIES,
PE = 13.725 EQUIVALENT EH = .800VOLTS

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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DISTRIBUTION OF SPECIES

I	SPECIES		PPM	MOLALITY	ACTIVITY	LOG ACT	GAMMA
1	CA	2	6.9477E+01	1.7344E-03	1.1570E-03	-2.937	6.6708E-01
2	MG	2	1.2784E+01	5.2612E-04	3.5330E-04	-3.452	6.7151E-01
3	NA	1	6.2421E+01	2.7167E-03	2.4498E-03	-2.611	9.0175E-01
4	K	1	2.4908E+00	6.3735E-05	5.7300E-05	-4.242	8.9903E-01

64	H	1	6.9667E-05	6.9154E-08	6.3096E-08	-7.200	9.1240E-01
5	CL	-1	6.0100E+01	1.6962E-03	1.5249E-03	-2.817	8.9903E-01
6	SO4	-2	8.2530E+01	8.5962E-04	5.7061E-04	-3.244	6.6380E-01
7	HCO3	-1	2.0207E+02	3.3136E-03	2.9951E-03	-2.524	9.0389E-01
18	CO3	-2	1.8212E-01	3.0367E-06	2.0270E-06	-5.693	6.6753E-01
86	H2CO3	0	2.7890E+01	4.4991E-04	4.5108E-04	-3.346	1.0026E+00
27	OH	-1	2.1745E-03	1.2793E-07	1.1497E-07	-6.939	8.9870E-01
62	F	-1	1.8452E-01	9.7177E-06	8.7334E-06	-5.059	8.9870E-01
98	BR	-1	2.2000E-01	2.7547E-06	2.4796E-06	-5.606	9.0012E-01

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19	MGOH	1	2.8709E-04	6.9521E-09	6.3032E-09	-8.200	9.0666E-01
23	MGSO4 AQ	0	3.7258E+00	3.0970E-05	3.1044E-05	-4.508	1.0024E+00
22	MGHCO3	1	1.1362E+00	1.3322E-05	1.1992E-05	-4.921	9.0012E-01
21	MGCO3 AQ	0	5.3707E-02	6.3729E-07	6.3883E-07	-6.195	1.0024E+00
20	MGF	1	8.6973E-03	2.0093E-07	1.8114E-07	-6.742	9.0150E-01
29	CAOH	1	2.0431E-04	3.5810E-09	3.2423E-09	-8.489	9.0542E-01
32	CASO4 AQ	0	1.7576E+01	1.2917E-04	1.2948E-04	-3.888	1.0024E+00
30	CAHCO3	1	4.5821E+00	4.5349E-05	4.1060E-05	-4.387	9.0542E-01
31	CACO3 AQ	0	3.6253E-01	3.6241E-06	3.6328E-06	-5.440	1.0024E+00
49	CAF+	1	5.1862E-03	8.7835E-08	7.9302E-08	-7.101	9.0284E-01
44	NASO4	-1	9.3874E-01	7.8897E-06	7.1314E-06	-5.147	9.0389E-01
43	NAHCO3	0	3.4553E-01	4.1162E-06	4.1261E-06	-5.384	1.0024E+00
42	NACO3	-1	6.7433E-03	8.1291E-08	7.3479E-08	-7.134	9.0389E-01
94	NACL	0	2.1768E-31	3.7267E-36	3.7357E-36	-35.428	1.0024E+00
46	KSO4	-1	3.1766E-02	2.3515E-07	2.1255E-07	-6.673	9.0389E-01
95	KCL	0	6.4950E-33	8.7167E-38	8.7376E-38	-37.059	1.0024E+00
63	HSO4	-1	3.3309E-04	3.4334E-09	3.0953E-09	-8.509	9.0150E-01
24	H4SIO4AQ	0	5.7493E+01	5.9850E-04	5.9994E-04	-3.222	1.0024E+00
25	H3SIO4	-1	9.4150E-02	9.9049E-07	8.9156E-07	-6.050	9.0012E-01
26	H2SIO4	-2	2.3977E-06	2.5494E-11	1.7018E-11	-10.769	6.6753E-01
8	FE	2	3.4424E-10	6.1675E-15	4.1449E-15	-14.382	6.7206E-01
9	FE	3	2.0089E-09	3.5991E-14	1.5771E-14	-13.802	4.3819E-01

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10	FEOH	2	1.3589E-04	1.8663E-09	1.2400E-09	-8.907	6.6444E-01
11	FEOH	1	1.1992E-12	1.6470E-17	1.4870E-17	-16.828	9.0284E-01
12	FE(OH)3	-1	9.0692E-20	8.4911E-25	7.6662E-25	-24.115	9.0284E-01
77	FE(OH)2	1	1.0749E+00	1.1969E-05	1.0819E-05	-4.966	9.0389E-01
78	FE(OH)3	0	2.1460E-01	2.0092E-06	2.0141E-06	-5.696	1.0024E+00
79	FE(OH)4	-1	4.3712E-02	3.5307E-07	3.1914E-07	-6.496	9.0389E-01
80	FE(OH)2	0	1.2190E-16	1.3573E-21	1.3606E-21	-20.866	1.0024E+00
13	FEHPO4	1	2.4499E-09	1.6146E-14	1.4595E-14	-13.836	9.0389E-01
100	FEHPO4	0	6.7982E-12	4.4803E-17	4.4911E-17	-16.348	1.0024E+00
65	FEH2PO4	1	9.9559E-13	6.5179E-18	5.8915E-18	-17.230	9.0389E-01
99	FEH2PO4	2	3.7288E-09	2.4411E-14	1.6295E-14	-13.788	6.6753E-01
15	FESO4	1	1.1403E-08	7.5104E-14	6.7807E-14	-13.169	9.0284E-01
16	FECL	2	7.3127E-11	8.0141E-16	5.3249E-16	-15.274	6.6444E-01
28	FECL2	1	8.6567E-13	6.8334E-18	6.1695E-18	-17.210	9.0284E-01
33	FECL3	0	1.5021E-16	9.2654E-22	9.2877E-22	-21.032	1.0024E+00
34	FESO4	0	5.8707E-11	3.8668E-16	3.3761E-16	-15.412	1.0024E+00
101	MN	2	4.3906E-03	7.9962E-08	5.3739E-08	-7.270	6.7206E-01
102	MN	3	5.7982E-15	1.0560E-19	4.6272E-20	-19.335	4.3819E-01
106	MNOH	1	1.3804E-06	1.9224E-11	1.7356E-11	-10.761	9.0284E-01
107	MN(OH)3	-1	5.7819E-16	5.4596E-21	4.9292E-21	-20.307	9.0284E-01
111	MNHCO3	1	1.0744E-03	9.2702E-09	8.3696E-09	-8.077	9.0284E-01

109	MNSO4	0	2.1464E-04	1.4222E-09	1.4256E-09	-8.846	1.0024E+00

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110	MN(NO3)2	0	1.9853E-09	1.1100E-14	1.1127E-14	-13.954	1.0024E+00
103	MNCL	1	3.3176E-05	3.6721E-10	3.3154E-10	-9.479	9.0284E-01
104	MNCL2	0	1.7249E-08	1.3713E-13	1.3746E-13	-12.862	1.0024E+00
105	MNCL3	-1	1.6891E-11	1.0477E-16	9.4590E-17	-16.024	9.0284E-01
108	MNF	1	2.7195E-07	3.6801E-12	3.3226E-12	-11.479	9.0284E-01
112	MNO4	-1	2.0568E-06	1.7303E-11	1.5525E-11	-10.809	8.9724E-01
113	MNO4	-2	2.4823E-10	2.0882E-15	1.3875E-15	-14.858	6.6444E-01
115	HMNO2	-1	7.5591E-16	8.5998E-21	7.7643E-21	-20.110	9.0284E-01
45	PO4-P	-3	1.3814E-06	4.4623E-11	1.7786E-11	-10.750	3.9858E-01
47	HPO4	-2	3.9293E-01	4.0962E-06	2.7217E-06	-5.565	6.6444E-01
48	H2PO4	-1	3.0413E-01	3.1375E-06	2.8360E-06	-5.547	9.0389E-01
40	MGPO4	-1	2.9744E-03	2.4950E-08	2.2552E-08	-7.647	9.0389E-01
73	MGHPO4	0	7.8648E-02	6.5418E-07	6.5576E-07	-6.183	1.0024E+00
41	MGH2PO4	1	4.0180E-03	3.3143E-08	2.9958E-08	-7.523	9.0389E-01
75	CAPO4	-1	8.1755E-03	6.0571E-08	5.4749E-08	-7.262	9.0389E-01
74	CAHPO4	0	2.1547E-01	1.5845E-06	1.5883E-06	-5.799	1.0024E+00
76	CAH2PO4	1	1.1676E-02	8.5230E-08	7.7039E-08	-7.113	9.0389E-01
61	KHPO4	-1	4.5417E-05	3.3641E-10	3.0408E-10	-9.517	9.0389E-01
50	NAHPO4	-1	1.7102E-03	1.4383E-08	1.3001E-08	-7.886	9.0389E-01
36	H3BO3 AQ	0	1.0199E+00	1.6504E-05	1.6543E-05	-4.781	1.0024E+00
37	H2BO3	-1	9.5498E-03	1.5709E-07	1.4071E-07	-6.852	8.9574E-01
85	NO3-N	-1	6.6000E+00	4.7147E-04	4.2302E-04	-3.374	8.9724E-01

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38	NH3 AQ	0	2.1207E-03	1.2459E-07	1.2489E-07	-6.903	1.0024E+00
39	NH4-N	1	2.9609E-01	2.1151E-05	1.8946E-05	-4.722	8.9574E-01
92	NH4SO4	-1	1.7591E-02	1.5426E-07	1.3927E-07	-6.856	9.0284E-01

MOLE RATIOS FROM ANALYTICAL MOLALITY		MOLE RATIOS FROM COMPUTED MOLALITY		LOG ACTIVITY RATIOS	
CL/CA	= 8.8584E-01	CL/CA	= 9.7793E-01	LOG CA/H2	= 11.4633
CL/MG	= 2.9650E+00	CL/MG	= 3.2239E+00	LOG MG/H2	= 10.9481
CL/NA	= 6.2157E-01	CL/NA	= 6.2434E-01	LOG NA/H1	= 4.5891
CL/K	= 2.6514E+01	CL/K	= 2.6613E+01	LOG K/H1	= 2.9582
CL/AL	= 1.6962E+27	CL/AL	= 1.6962E+27	LOG AL/H3	= 21.6000
CL/FE	= 1.1834E+02	CL/FE	= 2.7501E+11	LOG FE/H2	= .0175
CL/SO4	= 1.6499E+00	CL/SO4	= 1.9731E+00	LOG CA/MG	= .5152
CL/HCO3	= 5.0018E-01	CL/HCO3	= 5.1188E-01	LOG NA/K	= 1.6310
CA/MG	= 3.3471E+00	CA/MG	= 3.2966E+00		
NA/K	= 4.2657E+01	NA/K	= 4.2625E+01		

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	PHASE	IAP	KT	LOG IAP	LOG KT	IAP/KT	LOG IAP/KT
18	ANHYDRIT	6.602E-07	4.605E-05	-6.180	-4.337	1.434E-02	-1.844
22	ARAGONIT	2.345E-09	4.905E-09	-8.630	-8.309	4.782E-01	-.320
151	ARTIN	3.584E-26	4.171E-19	-25.446	-18.380	8.594E-08	-7.066
20	BRUCITE	4.670E-18	3.808E-12	-17.331	-11.419	1.226E-06	-5.911
13	CALCITE	2.345E-09	3.497E-09	-8.630	-8.456	6.707E-01	-.173
98	CHALC	6.002E-04	2.669E-04	-3.222	-3.574	2.249E+00	.352
21	CHRYSOTL			-58.435	-52.103		-6.333
30	CLENSTIT	2.803E-21	1.140E-17	-20.552	-16.943	2.460E-04	-3.609
100	SILGEL	6.002E-04	1.736E-03	-3.222	-2.760	3.457E-01	-.461
29	DIOPSIDE			-40.589	-36.452		-4.138
12	DOLOMITE	1.680E-18	1.032E-17	-17.775	-16.986	1.628E-01	-.788
113	FEOH3A	6.274E+07	7.674E+04	7.798	4.885	8.177E+02	2.913
97	FLUAPT			-57.256	-67.006		9.751
63	FLUOR	8.825E-14	9.734E-12	-13.054	-11.012	9.066E-03	-2.043

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28	FORSTRIT	1.309E-38	6.863E-29	-37.883	-28.163	1.908E-10	-9.719
111	GOETH			-34.620	-44.478		9.857
112	GREENA			-91.227	-63.190		-28.037
19	GYPSUM	6.599E-07	2.492E-05	-6.181	-4.603	2.648E-02	-1.577
65	HALITE	3.736E-06	3.732E+01	-5.428	1.572	1.001E-07	-7.000
109	HEMATI	3.939E+15	2.146E-04	15.595	-3.668	1.836E+19	19.264
118	HUNTITE	8.614E-37	5.927E-31	-36.065	-30.227	1.453E-06	-5.838
39	HYDMAG			-53.911	-37.540		-16.371
96	HYXAPT			-59.136	-59.539		.403
99	MAGADI	2.545E-20	5.012E-15	-19.594	-14.300	5.079E-06	-5.294
110	MAGHEM	3.939E+15	2.344E+06	15.595	6.370	1.681E+09	9.225
11	MAGNESIT	7.161E-10	6.726E-09	-9.145	-8.172	1.065E-01	-.973
108	MAGNET	2.940E+02	7.610E-10	2.468	-9.119	3.863E+11	11.587
67	MIRABI	3.417E-09	4.770E-02	-8.466	-1.321	7.163E-08	-7.145
59	NAHCOL	7.337E-06	2.577E-01	-5.134	-.589	2.847E-05	-4.546
61	NATRON	1.214E-11	3.282E-02	-10.916	-1.484	3.699E-10	-9.432
150	NESQUE	7.157E-10	7.121E-06	-9.145	-5.147	1.005E-04	-3.998
102	QUARTZ	6.002E-04	8.447E-05	-3.222	-4.073	7.105E+00	.852
37	SEPIOLIT			-44.327	-40.391		-3.935
10	SIDERITE	8.402E-21	3.143E-11	-20.076	-10.503	2.673E-10	-9.573
101	SILGLAS	6.002E-04	8.595E-04	-3.222	-3.066	6.983E-01	-.156
147	STRENGIT	2.804E-25	4.191E-27	-24.552	-26.378	6.691E+01	1.825

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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38	TALC			-64.879	-62.785		-2.094
66	THENAR	3.425E-09	6.719E-01	-8.465	-.173	5.097E-09	-8.293
62	THRNAT	1.216E-11	1.431E+00	-10.915	.156	8.497E-12	-11.071
32	TREMOLIT			-146.058	-141.290		-4.767
60	TRONA	8.922E-17	2.527E-01	-16.050	-.597	3.531E-16	-15.452
107	VIVIAN			-54.648	-36.000		-28.648
154	SEP PT			-44.327	-37.212		-7.115
172	MANGANO	1.350E+07	1.591E+18	7.130	18.202	8.481E-12	-11.072
173	PYROLUST	1.549E+23	1.518E+16	23.190	16.181	1.020E+07	7.009
174	BIRNSITE	1.549E+23	1.233E+18	23.190	18.091	1.256E+05	5.099
175	NUSTITE	1.549E+23	3.192E+17	23.190	17.504	4.852E+05	5.686

176	BIXBYITE	3.391E+04	3.601E-01	4.530	-.444	9.418E+04	4.974
177	HAUSMITE			63.240	62.420		.820
178	MNOH2	7.103E-22	1.104E-13	-21.149	-12.957	6.434E-09	-8.192
179	MNOH3			-40.153	-35.863		-4.288
180	MANGANIT	1.841E+02	5.781E-01	2.265	-.238	3.185E+02	2.503
181	RHODOCHR	1.089E-13	3.047E-11	-12.963	-10.516	3.575E-03	-2.447
183	MNCL2	1.250E-13	8.984E+08	-12.903	8.953	1.391E-22	-21.857
184	MNCL2,1W	1.249E-13	3.988E+05	-12.903	5.601	3.133E-19	-18.504
185	MNCL2,2W	1.249E-13	9.020E+03	-12.903	3.955	1.385E-17	-16.859
186	MNCL2,4W	1.249E-13	3.305E+02	-12.904	2.519	3.778E-16	-15.423
187	TEPHRITE	1.093E+11	3.646E+23	11.039	23.562	2.998E-13	-12.523

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188	RHODONIT	4.353E-04	5.785E+09	-3.361	9.762	7.525E-14	-13.123
190	MNSO4	3.066E-11	6.902E+02	-10.513	2.839	4.443E-14	-13.352
191	MN2SO4,3			-48.400	-5.282		-43.118
192	MN3PO4,2			-43.309	-23.850		-19.459
193	MNHPO4	1.463E-13	1.130E-13	-12.835	-12.947	1.295E+00	.112

Effluent @ SC6

INITIAL SOLUTION

TEMPERATURE = 27.00 DEGREES C PH = 7.700
ANALYTICAL EPMCAT = 8.572 ANALYTICAL EPMAN = 8.346

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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***** OXIDATION - REDUCTION *****

DISSOLVED OXYGEN = 2.400 MG/L
EH MEASURED WITH CALOMEL = 9.9000 VOLTS
MEASURED EH OF ZOBELL SOLUTION = 9.9000 VOLTS
CORRECTED EH = .0800 VOLTS
PE COMPUTED FROM CORRECTED EH = 1.343

FLAG	CORALK	PECALC	IDAVES
2	1	1	0

*** TOTAL CONCENTRATIONS OF INPUT SPECIES ***

SPECIES	TOTAL MOLALITY	LOG TOTAL MOLALITY	TOTAL MG/LITRE

CA	2	1.08096E-03	-2.9662	4.33000E+01
MG	2	2.46933E-04	-3.6074	6.00000E+00

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NA	1	4.40882E-03	-2.3557	1.01300E+02
K	1	3.14742E-04	-3.5020	1.23000E+01
CL	-1	2.04331E-03	-2.6897	7.24000E+01
SO4	-2	8.35358E-04	-3.0781	8.02000E+01
HCO3	-1	3.72238E-03	-2.4292	2.27000E+02
FE	2	1.39747E-05	-4.8547	7.80000E-01
PO4-P	-3	2.00283E-04	-3.6984	6.20000E+00
F	-1	2.73864E-05	-4.5625	5.20000E-01
NH4-N	1	1.16439E-03	-2.9339	1.63000E+01
NO3-N	-1	2.85741E-04	-3.5440	4.00000E+00
B TOT	0	2.77679E-05	-4.5565	3.00000E-01
MN	2	2.73181E-06	-5.5635	1.50000E-01

*** CONVERGENCE ITERATIONS ***

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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ITERATION	S1-ANALCO3	S2-SO4TOT	S3-FTOT	S4-PTOT	S5-CLTOT
1	6.884E-05	1.552E-04	4.455E-07	8.117E-05	1.299E-08
2	4.347E-06	6.202E-06	3.262E-08	3.925E-06	1.921E-10
3	-1.041E-07	-1.681E-07	-5.873E-10	-9.212E-08	-2.377E-11

Effluent @ SC5

****DESCRIPTION OF SOLUTION ****

	ANAL.	COMP.	PH	
EPMCAT	8.57	8.20	7.700	ACTIVITY H2O = .9998
EPMAN	8.35	7.79		PCO2= 4.461056E-03
				LOG PCO2 = -2.3506
			TEMPERATURE	PO2 = 5.247522E-47

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EH = .0800 PE = 1.343 27.00 DEG C PCH4 = 0.000000E+00

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PE CALC S =  100.000                                CO2 TOT =  3.843268E-03
PE CALC DOX= 12.600          IONIC STRENGTH         DENSITY =   1.0000
PE SATO DOX=  2.654           1.004518E-02          TDS =      570.7MG/L
TOT ALK =  4.134E+00 MEQ                            CARB ALK =  3.722E+00 MEQ
ELECT   =  4.159E-01 MEQ

IN COMPUTING THE DISTRIBUTION OF SPECIES,
PE =   1.343      EQUIVALENT EH =   .080VOLTS
```

DISTRIBUTION OF SPECIES

I	SPECIES		PPM	MOLALITY	ACTIVITY	LOG ACT	GAMMA
1	CA	2	3.7798E+01	9.4361E-04	6.3102E-04	-3.200	6.6873E-01
2	MG	2	5.2410E+00	2.1569E-04	1.4518E-04	-3.838	6.7307E-01

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3	NA	1	1.0084E+02	4.3886E-03	3.9600E-03	-2.402	9.0233E-01
4	K	1	1.2254E+01	3.1357E-04	2.8212E-04	-3.550	8.9969E-01
64	H	1	2.2021E-05	2.1858E-08	1.9953E-08	-7.700	9.1282E-01
5	CL	-1	7.2400E+01	2.0433E-03	1.8383E-03	-2.736	8.9969E-01
6	SO4	-2	7.0857E+01	7.3804E-04	4.9121E-04	-3.309	6.6557E-01
7	HCO3	-1	2.2155E+02	3.6330E-03	3.2859E-03	-2.483	9.0447E-01
18	CO3	-2	7.2003E-01	1.2005E-05	8.0342E-06	-5.095	6.6922E-01
86	H2CO3	0	8.9027E+00	1.4362E-04	1.4396E-04	-3.842	1.0024E+00
27	OH	-1	1.1213E-02	6.5969E-07	5.9331E-07	-6.227	8.9938E-01
62	F	-1	5.1190E-01	2.6960E-05	2.4247E-05	-4.615	8.9938E-01
19	MGOH	1	6.5624E-04	1.5891E-08	1.4416E-08	-7.841	9.0718E-01
23	MGSO4 AQ	0	1.5593E+00	1.2961E-05	1.2991E-05	-4.886	1.0023E+00
22	MGHCO3	1	5.3177E-01	6.2356E-06	5.6168E-06	-5.251	9.0077E-01
21	MGCO3 AQ	0	9.6516E-02	1.1453E-06	1.1479E-06	-5.940	1.0023E+00
20	MGF	1	1.1762E-02	2.7172E-07	2.4513E-07	-6.611	9.0212E-01
29	CAOH	1	6.0023E-04	1.0520E-08	9.5309E-09	-8.021	9.0597E-01
32	CASO4 AQ	0	8.7172E+00	6.4067E-05	6.4215E-05	-4.192	1.0023E+00
30	CAHCO3	1	3.0370E+00	3.0058E-05	2.7231E-05	-4.565	9.0597E-01
31	CACO3 AQ	0	8.8606E-01	8.8578E-06	8.8783E-06	-5.052	1.0023E+00
49	CAF+	1	9.1224E-03	1.5450E-07	1.3958E-07	-6.855	9.0344E-01
44	NASO4	-1	1.3600E+00	1.1430E-05	1.0338E-05	-4.986	9.0447E-01
43	NAHCO3	0	6.1283E-01	7.3005E-06	7.3174E-06	-5.136	1.0023E+00

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42	NACO3	-1	5.9786E-02	7.2073E-07	6.5187E-07	-6.186	9.0447E-01
94	NACL	0	4.2423E-31	7.2630E-36	7.2798E-36	-35.138	1.0023E+00
46	KSO4	-1	1.5059E-01	1.1147E-06	1.0082E-06	-5.996	9.0447E-01
95	KCL	0	3.8555E-32	5.1743E-37	5.1863E-37	-36.285	1.0023E+00
63	HSO4	-1	1.0818E-04	1.1151E-09	1.0059E-09	-8.997	9.0212E-01
8	FE	2	5.9099E-01	1.0588E-05	7.1331E-06	-5.147	6.7367E-01
9	FE	3	2.0379E-12	3.6511E-17	1.6065E-17	-16.794	4.4000E-01
10	FEOH	2	6.3863E-07	8.7709E-12	5.8430E-12	-11.233	6.6618E-01
11	FEOH	1	1.0569E-02	1.4516E-07	1.3114E-07	-6.882	9.0344E-01

12	FE(OH)3	-1	1.4916E-08	1.3965E-13	1.2617E-13	-12.899	9.0344E-01
77	FE(OH)2	1	7.6776E-03	8.5486E-08	7.7319E-08	-7.112	9.0447E-01
78	FE(OH)3	0	4.8504E-03	4.5413E-08	4.5513E-08	-7.342	1.0023E+00
79	FE(OH)4	-1	3.1219E-03	2.5217E-08	2.2807E-08	-7.642	9.0447E-01
80	FE(OH)2	0	5.9553E-06	6.6309E-11	6.6463E-11	-10.177	1.0023E+00
13	FEHPO4	1	5.2938E-11	3.4889E-16	3.1556E-16	-15.501	9.0447E-01
100	FEHPO4	0	3.5394E-01	2.3327E-06	2.3381E-06	-5.631	1.0023E+00
65	FEH2PO4	1	1.5798E-02	1.0343E-07	9.3546E-08	-7.029	9.0447E-01
99	FEH2PO4	2	2.4527E-11	1.6057E-16	1.0746E-16	-15.969	6.6922E-01
15	FESO4	1	1.1526E-11	7.5918E-17	6.8587E-17	-16.164	9.0344E-01
16	FECL	2	1.2196E-13	1.3365E-18	8.9038E-19	-18.050	6.6618E-01
28	FECL2	1	8.9837E-16	7.0916E-21	6.4068E-21	-20.193	9.0344E-01
33	FECL3	0	1.8801E-19	1.1597E-24	1.1624E-24	-23.935	1.0023E+00

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34	FESO4	0	9.7871E-02	6.4464E-07	6.4614E-07	-6.190	1.0023E+00
101	MN	2	1.3022E-01	2.3716E-06	1.5977E-06	-5.797	6.7367E-01
102	MN	3	1.8269E-25	3.3271E-30	1.4639E-30	-29.834	4.4000E-01
106	MNOH	1	2.1171E-04	2.9483E-09	2.6636E-09	-8.575	9.0344E-01
107	MN(OH)3	-1	2.3629E-12	2.2312E-17	2.0158E-17	-16.696	9.0344E-01
111	MNHCO3	1	3.5019E-02	3.0217E-07	2.7299E-07	-6.564	9.0344E-01
109	MNSO4	0	6.2888E-03	4.1670E-08	4.1767E-08	-7.379	1.0023E+00
110	MN(NO3)2	0	2.1404E-08	1.1967E-13	1.1995E-13	-12.921	1.0023E+00
103	MNCL	1	1.1883E-03	1.3153E-08	1.1883E-08	-7.925	9.0344E-01
104	MNCL2	0	7.4515E-07	5.9242E-12	5.9379E-12	-11.226	1.0023E+00
105	MNCL3	-1	8.7876E-10	5.4507E-15	4.9244E-15	-14.308	9.0344E-01
108	MNF	1	2.2433E-05	3.0356E-10	2.7425E-10	-9.562	9.0344E-01
115	HMNO2	-1	7.1016E-13	8.0794E-18	7.2992E-18	-17.137	9.0344E-01
45	PO4-P	-3	1.4945E-04	4.8276E-09	1.9356E-09	-8.713	4.0094E-01
47	HPO4	-2	1.1855E+01	1.2359E-04	8.2334E-05	-4.084	6.6618E-01
48	H2PO4	-1	2.8043E+00	2.8930E-05	2.6166E-05	-4.582	9.0447E-01
40	MGPO4	-1	1.4887E-01	1.2487E-06	1.1294E-06	-5.947	9.0447E-01
73	MGHPO4	0	1.1030E+00	9.1747E-06	9.1960E-06	-5.036	1.0023E+00
41	MGH2PO4	1	1.7237E-02	1.4219E-07	1.2860E-07	-6.891	9.0447E-01
75	CAPO4	-1	5.4308E-01	4.0236E-06	3.6392E-06	-5.439	9.0447E-01
74	CAHPO4	0	4.0107E+00	2.9494E-05	2.9562E-05	-4.529	1.0023E+00
76	CAH2PO4	1	6.6479E-02	4.8529E-07	4.3893E-07	-6.358	9.0447E-01

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61	KHPO4	-1	6.7603E-03	5.0075E-08	4.5291E-08	-7.344	9.0447E-01
50	NAHPO4	-1	8.3574E-02	7.0288E-07	6.3573E-07	-6.197	9.0447E-01
36	H3BO3 AQ	0	1.6599E+00	2.6860E-05	2.6922E-05	-4.570	1.0023E+00
37	H2BO3	-1	5.5215E-02	9.0828E-07	8.1425E-07	-6.089	8.9648E-01
85	NO3-N	-1	4.0000E+00	2.8574E-04	2.5658E-04	-3.591	8.9795E-01
38	NH3 AQ	0	5.6285E-01	3.3068E-05	3.3145E-05	-4.480	1.0023E+00
39	NH4-N	1	1.5738E+01	1.1243E-03	1.0079E-03	-2.997	8.9648E-01
92	NH4SO4	-1	8.0503E-01	7.0595E-06	6.3778E-06	-5.195	9.0344E-01

MOLE RATIOS FROM ANALYTICAL MOLALITY	MOLE RATIOS FROM COMPUTED MOLALITY	LOG ACTIVITY RATIOS
CL/CA = 1.8903E+00	CL/CA = 2.1654E+00	LOG CA/H2 = 12.2000

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CL/MG   =  8.2748E+00     CL/MG   =  9.4731E+00     LOG MG/H2 =   11.5619
CL/NA   =  4.6346E-01     CL/NA   =  4.6559E-01     LOG NA/H1 =    5.2977
CL/K    =  6.4920E+00     CL/K    =  6.5161E+00     LOG K/H1  =    4.1504
CL/AL   =  2.0433E+27     CL/AL   =  2.0433E+27     LOG AL/H3 =   23.1000
CL/FE   =  1.4621E+02     CL/FE   =  1.9297E+02     LOG FE/H2 =   10.2533
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CL/SO4  =  2.4460E+00     CL/SO4  =  2.7685E+00     LOG CA/MG =     .6381
CL/HCO3 =  5.4892E-01     CL/HCO3 =  5.6242E-01     LOG NA/K  =    1.1473
CA/MG   =  4.3775E+00     CA/MG   =  4.3748E+00
NA/K    =  1.4008E+01     NA/K    =  1.3996E+01
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Effluent @ SC6

	PHASE	IAP	KT	LOG IAP	LOG KT	IAP/KT	LOG IAP/KT
18	ANHYDRIT	3.100E-07	3.935E-05	-6.509	-4.405	7.876E-03	-2.104
22	ARAGONIT	5.070E-09	4.476E-09	-8.295	-8.349	1.133E+00	.054
151	ARTIN	1.125E-24	3.899E-19	-23.949	-18.409	2.886E-06	-5.540
20	BRUCITE	5.110E-17	3.928E-12	-16.292	-11.406	1.301E-05	-4.886
13	CALCITE	5.070E-09	3.225E-09	-8.295	-8.491	1.572E+00	.196
12	DOLOMITE	5.913E-18	7.310E-18	-17.228	-17.136	8.089E-01	-.092
113	FEOH3A	2.021E+06	7.674E+04	6.306	4.885	2.634E+01	1.421
97	FLUAPT			-51.548	-66.694		15.146
63	FLUOR	3.710E-13	1.156E-11	-12.431	-10.937	3.209E-02	-1.494

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111	GOETH			-35.474	-44.072		8.598
19	GYPSUM	3.098E-07	2.496E-05	-6.509	-4.603	1.241E-02	-1.906
65	HALITE	7.280E-06	3.859E+01	-5.138	1.586	1.886E-07	-6.724
109	HEMATI	4.087E+12	6.956E-05	12.611	-4.158	5.876E+16	16.769
118	HUNTITE	8.045E-36	2.313E-31	-35.094	-30.636	3.478E-05	-4.459
39	HYDMAG			-52.025	-37.945		-14.080
96	HYXAPT			-53.160	-59.266		6.106
110	MAGHEM	4.087E+12	2.344E+06	12.611	6.370	1.744E+06	6.241
11	MAGNESIT	1.166E-09	5.369E-09	-8.933	-8.270	2.173E-01	-.663
108	MAGNET	7.481E+09	1.724E-10	9.874	-9.764	4.341E+19	19.638
67	MIRABI	7.684E-09	9.544E-02	-8.114	-1.020	8.051E-08	-7.094
59	NAHCOL	1.301E-05	2.952E-01	-4.886	-.530	4.407E-05	-4.356
61	NATRON	1.257E-10	5.833E-02	-9.901	-1.234	2.155E-09	-8.667
150	NESQUE	1.166E-09	5.764E-06	-8.933	-5.239	2.022E-04	-3.694
10	SIDERITE	5.731E-11	2.512E-11	-10.242	-10.600	2.281E+00	.358
147	STRENGIT	3.108E-26	3.891E-27	-25.508	-26.410	7.987E+00	.902
66	THENAR	7.703E-09	6.580E-01	-8.113	-.182	1.171E-08	-7.932
62	THRNAT	1.260E-10	1.292E+00	-9.900	.111	9.748E-11	-10.011
60	TRONA	1.639E-15	1.309E-01	-14.786	-.883	1.251E-14	-13.903
107	VIVIAN	1.357E-33	1.000E-36	-32.867	-36.000	1.357E+03	3.133
172	MANGANO	4.012E+09	6.617E+17	9.603	17.821	6.063E-09	-8.217
173	PYROLUST	2.035E+02	5.230E+15	2.309	15.718	3.891E-14	-13.410

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- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO     QUIT, OR A PAGE INCREMENT
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174	BIRNSITE	2.035E+02	1.233E+18	2.309	18.091	1.650E-16	-15.782
175	NUSTITE	2.035E+02	3.192E+17	2.309	17.504	6.376E-16	-15.195
176	BIXBYITE	3.394E-14	2.063E-01	-13.469	-.685	1.645E-13	-12.784
177	HAUSMITE			46.396	61.149		-14.252
178	MNOH2	5.624E-19	1.282E-13	-18.250	-12.892	4.386E-06	-5.358
179	MNOH3			-48.515	-35.546		-12.969
180	MANGANIT	1.842E-07	5.781E-01	-6.735	-.238	3.186E-07	-6.497
181	RHODOCHR	1.284E-11	2.824E-11	-10.892	-10.549	4.546E-01	-.342
183	MNCL2	5.399E-12	4.720E+08	-11.268	8.674	1.144E-20	-19.942
184	MNCL2,1W	5.398E-12	3.069E+05	-11.268	5.487	1.759E-17	-16.755
185	MNCL2,2W	5.397E-12	9.602E+03	-11.268	3.982	5.620E-16	-15.250
186	MNCL2,4W	5.394E-12	6.236E+02	-11.268	2.795	8.650E-15	-14.063
190	MNSO4	7.848E-10	3.921E+02	-9.105	2.593	2.002E-12	-11.699
191	MN2SO4,3			-69.595	-5.902		-63.693
192	MN3PO4,2	1.528E-35	1.525E-24	-34.816	-23.817	1.002E-11	-10.999
193	MNHPO4	1.315E-10	1.130E-13	-9.881	-12.947	1.164E+03	3.066

Well CMID 16P

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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INITIAL SOLUTION

TEMPERATURE = 22.80 DEGREES C PH = 7.500
ANALYTICAL EPMCAT = 5.170 ANALYTICAL EPMAN = 4.639

***** OXIDATION - REDUCTION *****

DISSOLVED OXYGEN = 3.000 MG/L
EH MEASURED WITH CALOMEL = 9.9000 VOLTS FLAG CORALK PECALC IDAVES
MEASURED EH OF ZOBELL SOLUTION = 9.9000 VOLTS 2 1 1 0
CORRECTED EH = .0000 VOLTS
PE COMPUTED FROM CORRECTED EH = .000

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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*** TOTAL CONCENTRATIONS OF INPUT SPECIES ***

SPECIES	TOTAL MOLALITY	LOG TOTAL MOLALITY	TOTAL MG/LITRE

CA	2	1.44759E-03	-2.8394	5.80000E+01
MG	2	3.70312E-04	-3.4314	9.00000E+00
NA	1	1.47941E-03	-2.8299	3.40000E+01
K	1	5.62820E-05	-4.2496	2.20000E+00
CL	-1	8.52118E-04	-3.0695	3.02000E+01
SO4	-2	6.14395E-04	-3.2116	5.90000E+01
HCO3	-1	2.27881E-03	-2.6423	1.39000E+02
F	-1	1.47430E-05	-4.8314	2.80000E-01
NO3-N	-1	2.64248E-04	-3.5780	3.70000E+00
BR	-1	2.25332E-06	-5.6472	1.80000E-01

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT

*** CONVERGENCE ITERATIONS ***

ITERATION	S1-ANALCO3	S2-SO4TOT	S3-FTOT	S4-PTOT	S5-CLTOT
1	4.765E-05	1.415E-04	3.631E-07	0.000E+00	0.000E+00
2	1.729E-06	3.656E-06	1.238E-08	0.000E+00	0.000E+00
3	-7.869E-08	-1.931E-07	-5.475E-10	0.000E+00	0.000E+00

Well CMID 16P

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT

****DESCRIPTION OF SOLUTION ****

	ANAL.	COMP.	PH	ACTIVITY H2O = .9999
EPMCAT	5.17	4.95	7.500	PCO2= 4.136669E-03
EPMAN	4.64	4.42		LOG PCO2 = -2.3833
			TEMPERATURE	PO2 = 1.366026E-54
EH = .0000	PE =	.000	22.80 DEG C	PCH4 = 0.000000E+00
PE CALC S = 100.000				CO2 TOT = 2.418865E-03
PE CALC DOX= 13.170			IONIC STRENGTH	DENSITY = 1.0000
PE SATO DOX= 2.878			6.908128E-03	TDS = 335.6MG/L
TOT ALK = 2.279E+00 MEQ				CARB ALK = 2.279E+00 MEQ
ELECT = 5.300E-01 MEQ				

IN COMPUTING THE DISTRIBUTION OF SPECIES,

PE = .000 EQUIVALENT EH = .000VOLTS

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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DISTRIBUTION OF SPECIES

I	SPECIES		PPM	MOLALITY	ACTIVITY	LOG ACT	GAMMA
1	CA	2	5.3909E+01	1.3455E-03	9.5746E-04	-3.019	7.1161E-01
2	MG	2	8.4556E+00	3.4791E-04	2.4872E-04	-3.604	7.1491E-01
3	NA	1	3.3897E+01	1.4749E-03	1.3526E-03	-2.869	9.1702E-01
4	K	1	2.1945E+00	5.6141E-05	5.1377E-05	-4.289	9.1514E-01
64	H	1	3.4457E-05	3.4195E-08	3.1623E-08	-7.500	9.2478E-01
5	CL	-1	3.0200E+01	8.5212E-04	7.7981E-04	-3.108	9.1514E-01
6	SO4	-2	5.0428E+01	5.2513E-04	3.7247E-04	-3.429	7.0929E-01
7	HCO3	-1	1.3579E+02	2.2261E-03	2.0449E-03	-2.689	9.1861E-01
18	CO3	-2	2.4415E-01	4.0698E-06	2.8980E-06	-5.538	7.1206E-01
86	H2CO3	0	9.2587E+00	1.4932E-04	1.4958E-04	-3.825	1.0017E+00
27	OH	-1	5.0644E-03	2.9788E-07	2.7254E-07	-6.565	9.1492E-01
62	F	-1	2.7361E-01	1.4407E-05	1.3181E-05	-4.880	9.1492E-01
98	BR	-1	1.8000E-01	2.2533E-06	2.0639E-06	-5.685	9.1592E-01
19	MGOH	1	4.8440E-04	1.1727E-08	1.0796E-08	-7.967	9.2060E-01
23	MGSO4 AQ	0	1.8174E+00	1.5103E-05	1.5127E-05	-4.820	1.0016E+00
22	MGHCO3	1	5.4365E-01	6.3733E-06	5.8374E-06	-5.234	9.1592E-01
21	MGCO3 AQ	0	5.5971E-02	6.6401E-07	6.6507E-07	-6.177	1.0016E+00

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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20	MGF	1	9.6453E-03	2.2278E-07	2.0426E-07	-6.690	9.1690E-01
29	CAOH	1	4.0069E-04	7.0212E-09	6.4575E-09	-8.190	9.1970E-01
32	CASO4 AQ	0	9.6872E+00	7.1179E-05	7.1292E-05	-4.147	1.0016E+00
30	CAHCO3	1	2.6496E+00	2.6217E-05	2.4112E-05	-4.618	9.1970E-01
31	CACO3 AQ	0	4.4631E-01	4.4606E-06	4.4677E-06	-5.350	1.0016E+00
49	CAF+	1	6.7162E-03	1.1372E-07	1.0438E-07	-6.981	9.1786E-01
44	NASO4	-1	3.3776E-01	2.8380E-06	2.6070E-06	-5.584	9.1861E-01
43	NAHCO3	0	1.3039E-01	1.5529E-06	1.5554E-06	-5.808	1.0016E+00
42	NACO3	-1	5.8681E-03	7.0724E-08	6.4967E-08	-7.187	9.1861E-01
94	NACL	0	6.1523E-32	1.0531E-36	1.0547E-36	-35.977	1.0016E+00
46	KSO4	-1	1.9031E-02	1.4085E-07	1.2938E-07	-6.888	9.1861E-01
95	KCL	0	2.9812E-33	4.0000E-38	4.0064E-38	-37.397	1.0016E+00
63	HSO4	-1	1.1384E-04	1.1732E-09	1.0757E-09	-8.968	9.1690E-01
85	NO3-N	-1	3.7000E+00	2.6425E-04	2.4150E-04	-3.617	9.1390E-01

MOLE RATIOS FROM ANALYTICAL MOLALITY	MOLE RATIOS FROM COMPUTED MOLALITY	LOG ACTIVITY RATIOS

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT

CL/CA	=	5.8863E-01	CL/CA	=	6.3331E-01	LOG CA/H2	=	11.9811
CL/MG	=	2.3011E+00	CL/MG	=	2.4492E+00	LOG MG/H2	=	11.3957
CL/NA	=	5.7598E-01	CL/NA	=	5.7773E-01	LOG NA/H1	=	4.6312
CL/K	=	1.5140E+01	CL/K	=	1.5178E+01	LOG K/H1	=	3.2108
CL/AL	=	8.5212E+26	CL/AL	=	8.5212E+26	LOG AL/H3	=	22.5000
CL/FE	=	8.5212E+26	CL/FE	=	8.5212E+26	LOG FE/H2	=	9.8533
CL/SO4	=	1.3869E+00	CL/SO4	=	1.6227E+00	LOG CA/MG	=	.5854
CL/HCO3	=	3.7393E-01	CL/HCO3	=	3.8278E-01	LOG NA/K	=	1.4204
CA/MG	=	3.9091E+00	CA/MG	=	3.8673E+00			
NA/K	=	2.6286E+01	NA/K	=	2.6272E+01			

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	PHASE	IAP	KT	LOG IAP	LOG KT	IAP/KT	LOG IAP/KT
18	ANHYDRIT	3.566E-07	4.359E-05	-6.448	-4.361	8.181E-03	-2.087
22	ARAGONIT	2.775E-09	4.760E-09	-8.557	-8.322	5.830E-01	-.234
151	ARTIN	1.973E-25	4.074E-19	-24.705	-18.390	4.842E-07	-6.315

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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20	BRUCITE	1.847E-17	3.849E-12	-16.733	-11.415	4.799E-06	-5.319
13	CALCITE	2.775E-09	3.406E-09	-8.557	-8.468	8.147E-01	-.089
12	DOLOMITE	2.000E-18	9.150E-18	-17.699	-17.039	2.186E-01	-.660
63	FLUOR	1.663E-13	1.034E-11	-12.779	-10.986	1.609E-02	-1.793
19	GYPSUM	3.565E-07	2.497E-05	-6.448	-4.603	1.428E-02	-1.845
65	HALITE	1.055E-06	3.776E+01	-5.977	1.577	2.793E-08	-7.554
118	HUNTITE	1.039E-36	4.269E-31	-35.983	-30.370	2.434E-06	-5.614
39	HYDMAG			-53.302	-37.681		-15.621
11	MAGNESIT	7.208E-10	6.217E-09	-9.142	-8.206	1.159E-01	-.936
67	MIRABI	6.805E-10	6.075E-02	-9.167	-1.216	1.120E-08	-7.951
59	NAHCOL	2.766E-06	2.702E-01	-5.558	-.568	1.024E-05	-4.990
61	NATRON	5.295E-12	4.011E-02	-11.276	-1.397	1.320E-10	-9.879
150	NESQUE	7.205E-10	6.615E-06	-9.142	-5.179	1.089E-04	-3.963
66	THENAR	6.814E-10	6.670E-01	-9.167	-.176	1.022E-09	-8.991
62	THRNAT	5.301E-12	1.381E+00	-11.276	.140	3.838E-12	-11.416
60	TRONA	1.466E-17	2.009E-01	-16.834	-.697	7.295E-17	-16.137

Seepage Zone

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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INITIAL SOLUTION

TEMPERATURE = 24.10 DEGREES C PH = 7.400
ANALYTICAL EPMCAT = 8.876 ANALYTICAL EPMAN = 7.842

***** OXIDATION - REDUCTION *****

DISSOLVED OXYGEN = .600 MG/L
EH MEASURED WITH CALOMEL = 9.9000 VOLTS FLAG CORALK PECALC IDAVES
MEASURED EH OF ZOBELL SOLUTION = 9.9000 VOLTS 2 1 1 0
CORRECTED EH = -.1500 VOLTS
PE COMPUTED FROM CORRECTED EH = -2.543

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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*** TOTAL CONCENTRATIONS OF INPUT SPECIES ***

SPECIES		TOTAL MOLALITY	LOG TOTAL MOLALITY	TOTAL MG/LITRE
CA	2	1.25071E-03	-2.9028	5.01000E+01
MG	2	2.71625E-04	-3.5660	6.60000E+00
NA	1	4.27389E-03	-2.3692	9.82000E+01
K	1	3.17300E-04	-3.4985	1.24000E+01
CL	-1	2.07717E-03	-2.6825	7.36000E+01
SO4	-2	7.93692E-04	-3.1003	7.62000E+01
HCO3	-1	3.72237E-03	-2.4292	2.27000E+02
FE	2	2.81285E-05	-4.5509	1.57000E+00
PO4-P	-3	1.38906E-04	-3.8573	4.30000E+00
F	-1	2.84396E-05	-4.5461	5.40000E-01
NH4-N	1	1.17868E-03	-2.9286	1.65000E+01
NO3-N	-1	1.42870E-05	-4.8451	2.00000E-01
B TOT	0	3.23958E-05	-4.4895	3.50000E-01

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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MN	2	4.91724E-06	-5.3083	2.70000E-01

*** CONVERGENCE ITERATIONS ***

ITERATION S1-ANALCO3 S2-SO4TOT S3-FTOT S4-PTOT S5-CLTOT

1	6.412E-05	1.663E-04	5.056E-07	5.139E-05	2.386E-08
2	3.218E-06	5.428E-06	2.816E-08	2.155E-06	3.276E-10
3	-9.797E-08	-1.898E-07	-7.369E-10	-6.477E-08	-4.279E-11

Seepage Zone

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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****DESCRIPTION OF SOLUTION ****

	ANAL.	COMP.	PH	
EPMCAT	8.88	8.55	7.400	
EPMAN	7.84	7.36		
			TEMPERATURE	
EH = -.1500	PE = -2.543		24.10 DEG C	
PE CALC S =	100.000			
PE CALC DOX=	12.988		IONIC STRENGTH	
PE SATO DOX=	2.803		1.012407E-02	
TOT ALK =	3.981E+00 MEQ			
ELECT =	1.192E+00 MEQ			

ACTIVITY H2O = .9998
PCO2= 8.569853E-03
LOG PCO2 = -2.0670
PO2 = 1.009608E-64
PCH4 = 1.357406E-18
CO2 TOT = 4.009250E-03
DENSITY = 1.0000
TDS = 567.8MG/L
CARB ALK = 3.722E+00 MEQ

IN COMPUTING THE DISTRIBUTION OF SPECIES,
PE = -2.543 EQUIVALENT EH = -.150VOLTS

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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DISTRIBUTION OF SPECIES

I	SPECIES		PPM	MOLALITY	ACTIVITY	LOG ACT	GAMMA
1	CA	2	4.4871E+01	1.1202E-03	7.4951E-04	-3.125	6.6911E-01
2	MG	2	5.9423E+00	2.4456E-04	1.6470E-04	-3.783	6.7346E-01
3	NA	1	9.7786E+01	4.2559E-03	3.8408E-03	-2.416	9.0246E-01
4	K	1	1.2360E+01	3.1627E-04	2.8458E-04	-3.546	8.9981E-01
64	H	1	4.3931E-05	4.3607E-08	3.9811E-08	-7.400	9.1294E-01
5	CL	-1	7.3599E+01	2.0771E-03	1.8690E-03	-2.728	8.9981E-01
6	SO4	-2	6.6426E+01	6.9189E-04	4.6074E-04	-3.337	6.6592E-01
7	HCO3	-1	2.2263E+02	3.6508E-03	3.3024E-03	-2.481	9.0459E-01
18	CO3	-2	3.4219E-01	5.7055E-06	3.8203E-06	-5.418	6.6958E-01
86	H2CO3	0	1.8484E+01	2.9818E-04	2.9892E-04	-3.524	1.0025E+00
27	OH	-1	4.5199E-03	2.6591E-07	2.3918E-07	-6.621	8.9950E-01
62	F	-1	5.3099E-01	2.7965E-05	2.5154E-05	-4.599	8.9950E-01

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 19 MGOH       1  2.8998E-04  7.0221E-09  6.3712E-09  -8.196  9.0731E-01
- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO     QUIT, OR A PAGE INCREMENT
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 23 MGSO4 AQ   0  1.5389E+00  1.2792E-05  1.2822E-05  -4.892  1.0023E+00
 22 MGHCO3     1  5.9550E-01  6.9828E-06  6.2907E-06  -5.201  9.0089E-01
 21 MGCO3 AQ   0  4.9796E-02  5.9088E-07  5.9226E-07  -6.227  1.0023E+00
 20 MGF        1  1.2822E-02  2.9622E-07  2.6726E-07  -6.573  9.0224E-01
 29 CAOH       1  2.8183E-04  4.9397E-09  4.4758E-09  -8.349  9.0609E-01
 32 CASO4 AQ   0  9.4763E+00  6.9646E-05  6.9808E-05  -4.156  1.0023E+00
 30 CAHCO3     1  3.4718E+00  3.4361E-05  3.1134E-05  -4.507  9.0609E-01
 31 CACO3 AQ   0  4.7160E-01  4.7145E-06  4.7255E-06  -5.326  1.0023E+00
 49 CAF+       1  1.0507E-02  1.7795E-07  1.6079E-07  -6.794  9.0356E-01
 44 NASO4     -1  1.2146E+00  1.0208E-05  9.2339E-06  -5.035  9.0459E-01
 43 NAHCO3     0  5.9734E-01  7.1160E-06  7.1326E-06  -5.147  1.0023E+00
 42 NACO3     -1  2.3829E-02  2.8727E-07  2.5986E-07  -6.585  9.0459E-01
 94 NACL       0  4.1832E-31  7.1618E-36  7.1785E-36 -35.144  1.0023E+00
 46 KSO4      -1  1.3545E-01  1.0027E-06  9.0704E-07  -6.042  9.0459E-01
 95 KCL        0  3.9540E-32  5.3065E-37  5.3189E-37 -36.274  1.0023E+00
 63 HSO4      -1  1.8672E-04  1.9246E-09  1.7365E-09  -8.760  9.0224E-01
  8 FE         2  1.3067E+00  2.3411E-05  1.5780E-05  -4.802  6.7404E-01
  9 FE         3  4.9915E-16  8.9429E-21  3.9398E-21 -20.405  4.4056E-01
 10 FEOH       2  6.6167E-11  9.0873E-16  6.0570E-16 -15.218  6.6654E-01
 11 FEOH       1  9.4391E-03  1.2963E-07  1.1713E-07  -6.931  9.0356E-01
 12 FE(OH)3   -1  2.5305E-09  2.3692E-14  2.1407E-14 -13.669  9.0356E-01
 77 FE(OH)2    1  5.5421E-07  6.1708E-12  5.5821E-12 -11.253  9.0459E-01
- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO     QUIT, OR A PAGE INCREMENT
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 78 FE(OH)3    0  1.7550E-07  1.6431E-12  1.6470E-12 -11.783  1.0023E+00
 79 FE(OH)4   -1  5.6608E-08  4.5723E-13  4.1360E-13 -12.383  9.0459E-01
 80 FE(OH)2    0  2.0741E-06  2.3094E-11  2.3148E-11 -10.635  1.0023E+00
 13 FEHPO4     1  8.9620E-15  5.9064E-20  5.3428E-20 -19.272  9.0459E-01
100 FEHPO4     0  4.6126E-01  3.0399E-06  3.0470E-06  -5.516  1.0023E+00
 65 FEH2PO4    1  4.1744E-02  2.7329E-07  2.4722E-07  -6.607  9.0459E-01
 99 FEH2PO4    2  8.4167E-15  5.5102E-20  3.6895E-20 -19.433  6.6958E-01
 15 FESO4      1  2.4868E-15  1.6379E-20  1.4800E-20 -19.830  9.0356E-01
 16 FECL       2  2.6469E-17  2.9008E-22  1.9335E-22 -21.714  6.6654E-01
 28 FECL2      1  2.6686E-19  2.1065E-24  1.9034E-24 -23.720  9.0356E-01
 33 FECL3      0  5.6784E-23  3.5027E-28  3.5109E-28 -27.455  1.0023E+00
 34 FESO4      0  1.9263E-01  1.2688E-06  1.2717E-06  -5.896  1.0023E+00
101 MN         2  2.3480E-01  4.2763E-06  2.8824E-06  -5.540  6.7404E-01
102 MN         3  2.8062E-29  5.1106E-34  2.2515E-34 -33.648  4.4056E-01
106 MNOH       1  1.5396E-04  2.1441E-09  1.9373E-09  -8.713  9.0356E-01
107 MN(OH)3   -1  2.7929E-13  2.6372E-18  2.3829E-18 -17.623  9.0356E-01
111 MNHCO3     1  6.3487E-02  5.4781E-07  4.9498E-07  -6.305  9.0356E-01
109 MNSO4      0  1.0017E-02  6.6372E-08  6.5527E-08  -7.177  1.0023E+00
110 MN(NO3)2   0  9.7188E-11  5.4339E-16  5.4466E-16 -15.264  1.0023E+00
103 MNCL       1  2.1793E-03  2.4122E-08  2.1796E-08  -7.662  9.0356E-01
104 MNCL2      0  1.3896E-06  1.1047E-11  1.1073E-11 -10.956  1.0023E+00
105 MNCL3     -1  1.6658E-09  1.0333E-14  9.3361E-15 -14.030  9.0356E-01
- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO     QUIT, OR A PAGE INCREMENT
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108 MNF        1  4.1980E-05  5.6808E-10  5.1329E-10  -9.290  9.0356E-01
115 HMNO2     -1  1.6127E-13  1.8348E-18  1.6578E-18 -17.780  9.0356E-01
 45 PO4-P     -3  4.1598E-05  1.3438E-09  5.3943E-10  -9.268  4.0143E-01
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47	HPO4	-2	6.9803E+00	7.2768E-05	4.8503E-05	-4.314	6.6654E-01
48	H2PO4	-1	3.3495E+00	3.4555E-05	3.1258E-05	-4.505	9.0459E-01
40	MGPO4	-1	4.4733E-02	3.7523E-07	3.3943E-07	-6.469	9.0459E-01
73	MGHPO4	0	6.9841E-01	5.8093E-06	5.8228E-06	-5.235	1.0023E+00
41	MGH2PO4	1	2.2094E-02	1.8225E-07	1.6486E-07	-6.783	9.0459E-01
75	CAPO4	-1	1.7086E-01	1.2658E-06	1.1451E-06	-5.941	9.0459E-01
74	CAHPO4	0	2.6588E+00	1.9553E-05	1.9598E-05	-4.708	1.0023E+00
76	CAH2PO4	1	8.9214E-02	6.5125E-07	5.8911E-07	-6.230	9.0459E-01
61	KHPO4	-1	4.0167E-03	2.9752E-08	2.6913E-08	-7.570	9.0459E-01
50	NAHPO4	-1	4.7744E-02	4.0154E-07	3.6323E-07	-6.440	9.0459E-01
36	H3BO3 AQ	0	1.9703E+00	3.1883E-05	3.1958E-05	-4.495	1.0023E+00
37	H2BO3	-1	3.1159E-02	5.1256E-07	4.5955E-07	-6.338	8.9659E-01
85	NO3-N	-1	2.0000E-01	1.4287E-05	1.2831E-05	-4.892	8.9806E-01
38	NH3 AQ	0	2.3694E-01	1.3921E-05	1.3953E-05	-4.855	1.0023E+00
39	NH4-N	1	1.6209E+01	1.1579E-03	1.0382E-03	-2.984	8.9659E-01
92	NH4SO4	-1	7.7770E-01	6.8198E-06	6.1621E-06	-5.210	9.0356E-01

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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MOLE RATIOS FROM ANALYTICAL MOLALITY			MOLE RATIOS FROM COMPUTED MOLALITY			LOG ACTIVITY RATIOS		
CL/CA	=	1.6608E+00	CL/CA	=	1.8543E+00	LOG CA/H2	=	11.6748
CL/MG	=	7.6472E+00	CL/MG	=	8.4935E+00	LOG MG/H2	=	11.0167
CL/NA	=	4.8601E-01	CL/NA	=	4.8807E-01	LOG NA/H1	=	4.9844
CL/K	=	6.5464E+00	CL/K	=	6.5677E+00	LOG K/H1	=	3.8542
CL/AL	=	2.0772E+27	CL/AL	=	2.0771E+27	LOG AL/H3	=	22.2000
CL/FE	=	7.3846E+01	CL/FE	=	8.8724E+01	LOG FE/H2	=	9.9981
CL/SO4	=	2.6171E+00	CL/SO4	=	3.0021E+00	LOG CA/MG	=	.6581
CL/HCO3	=	5.5802E-01	CL/HCO3	=	5.6896E-01	LOG NA/K	=	1.1302
CA/MG	=	4.6045E+00	CA/MG	=	4.5804E+00			
NA/K	=	1.3470E+01	NA/K	=	1.3457E+01			

Seepage Zone

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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	PHASE	IAP	KT	LOG IAP	LOG KT	IAP/KT	LOG IAP/KT
18	ANHYDRIT	3.453E-07	4.222E-05	-6.462	-4.374	8.179E-03	-2.087
22	ARAGONIT	2.863E-09	4.673E-09	-8.543	-8.330	6.128E-01	-.213
151	ARTIN	1.227E-25	4.019E-19	-24.911	-18.396	3.053E-07	-6.515
20	BRUCITE	9.422E-18	3.874E-12	-17.026	-11.412	2.432E-06	-5.614
13	CALCITE	2.863E-09	3.351E-09	-8.543	-8.475	8.545E-01	-.068
12	DOLOMITE	1.802E-18	8.530E-18	-17.744	-17.069	2.112E-01	-.675
113	FEOH3A	6.240E+01	7.674E+04	1.795	4.885	8.131E-04	-3.090
97	FLUAPT			-53.032	-66.834		13.802
63	FLUOR	4.742E-13	1.070E-11	-12.324	-10.970	4.431E-02	-1.354

111	GOETH			-40.268	-44.254		3.985
19	GYPSUM	3.452E-07	2.498E-05	-6.462	-4.602	1.381E-02	-1.860
65	HALITE	7.179E-06	3.802E+01	-5.144	1.580	1.888E-07	-6.724
109	HEMATI	3.896E+03	1.152E-04	3.591	-3.939	3.382E+07	7.529
118	HUNTITE	7.132E-37	3.525E-31	-36.147	-30.453	2.023E-06	-5.694
39	HYDMAG			-53.831	-37.763		-16.068
96	HYXAPT			-55.054	-59.388		4.335
110	MAGHEM	3.896E+03	2.344E+06	3.591	6.370	1.662E-03	-2.779
11	MAGNESIT	6.292E-10	5.939E-09	-9.201	-8.226	1.059E-01	-.975
108	MAGNET	3.382E+00	3.351E-10	.529	-9.475	1.009E+10	10.004
67	MIRABI	6.780E-09	6.996E-02	-8.169	-1.155	9.691E-08	-7.014

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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59	NAHCOL	1.268E-05	2.778E-01	-4.897	-.556	4.566E-05	-4.340
61	NATRON	5.622E-11	4.509E-02	-10.250	-1.346	1.247E-09	-8.904
150	NESQUE	6.287E-10	6.336E-06	-9.202	-5.198	9.923E-05	-4.003
10	SIDERITE	6.028E-11	2.777E-11	-10.220	-10.556	2.171E+00	.337
147	STRENGIT	2.124E-30	4.023E-27	-29.673	-26.395	5.281E-04	-3.277
66	THENAR	6.797E-09	6.642E-01	-8.168	-.178	1.023E-08	-7.990
62	THRNAT	5.634E-11	1.353E+00	-10.249	.131	4.165E-11	-10.380
60	TRONA	7.144E-16	1.758E-01	-15.146	-.755	4.065E-15	-14.391
107	VIVIAN	1.141E-33	1.000E-36	-32.943	-36.000	1.141E+03	3.057
172	MANGANO	1.818E+09	9.802E+17	9.260	17.991	1.855E-09	-8.732
173	PYROLUST	2.565E-07	8.429E+15	-6.591	15.926	3.044E-23	-22.517
174	BIRNSITE	2.565E-07	1.233E+18	-6.591	18.091	2.080E-25	-24.682
175	NUSTITE	2.565E-07	3.192E+17	-6.591	17.504	8.038E-25	-24.095
176	BIXBYITE	1.272E-23	2.647E-01	-22.895	-.577	4.806E-23	-22.318
177	HAUSMITE			37.493	61.718		-24.225
178	MNOH2	1.649E-19	1.199E-13	-18.783	-12.921	1.375E-06	-5.862
179	MNOH3			-53.511	-35.689		-17.823
180	MANGANIT	3.567E-12	5.781E-01	-11.448	-.238	6.170E-12	-11.210
181	RHODOCHR	1.101E-11	2.922E-11	-10.958	-10.534	3.769E-01	-.424
183	MNCL2	1.007E-11	6.297E+08	-10.997	8.799	1.599E-20	-19.796
184	MNCL2,1W	1.007E-11	3.451E+05	-10.997	5.538	2.917E-17	-16.535
185	MNCL2,2W	1.006E-11	9.337E+03	-10.997	3.970	1.078E-15	-14.967

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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186	MNCL2,4W	1.006E-11	4.693E+02	-10.997	2.671	2.144E-14	-13.669
190	MNSO4	1.328E-09	5.051E+02	-8.877	2.703	2.629E-12	-11.580
191	MN2SO4,3			-77.305	-5.624		-71.680
192	MN3PO4,2	6.968E-36	1.473E-24	-35.157	-23.832	4.730E-12	-11.325
193	MNHPO4	1.398E-10	1.130E-13	-9.854	-12.947	1.237E+03	3.093

-- EOF -- (HIT ENTER TO QUIT, T TO GO TO THE TOP, OR A NEGATIVE PAGE INCREMENT)

-- WATEQF OUTPUT --

Effluent Average

INITIAL SOLUTION

TEMPERATURE = 25.00 DEGREES C PH = 7.500
ANALYTICAL EPMCAT = 9.275 ANALYTICAL EPMAN = 8.693

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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***** OXIDATION - REDUCTION *****

DISSOLVED OXYGEN = 2.400 MG/L
EH MEASURED WITH CALOMEL = 9.9000 VOLTS
MEASURED EH OF ZOBELL SOLUTION = 9.9000 VOLTS
CORRECTED EH = .0800 VOLTS
PE COMPUTED FROM CORRECTED EH = 1.352

FLAG	CORALK	PECALC	IDAVES
2	1	1	0

*** TOTAL CONCENTRATIONS OF INPUT SPECIES ***

SPECIES		TOTAL MOLALITY	LOG TOTAL MOLALITY	TOTAL MG/LITRE
CA	2	1.27076E-03	-2.8959	5.09000E+01
MG	2	3.16917E-04	-3.4991	7.70000E+00
NA	1	4.55708E-03	-2.3413	1.04700E+02
K	1	3.19879E-04	-3.4950	1.25000E+01

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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CL	-1	2.21278E-03	-2.6551	7.84000E+01
SO4	-2	8.96868E-04	-3.0473	8.61000E+01
HCO3	-1	3.71769E-03	-2.4297	2.26700E+02
SIO2 TOT	0	6.16187E-04	-3.2103	3.70000E+01
PO4-P	-3	1.97065E-04	-3.7054	6.10000E+00

F	-1	2.89682E-05	-4.5381	5.50000E-01
NH4-N	1	1.22876E-03	-2.9105	1.72000E+01
NO3-N	-1	3.50054E-04	-3.4559	4.90000E+00
B TOT	0	2.59184E-05	-4.5864	2.80000E-01
BR	-1	3.88187E-06	-5.4110	3.10000E-01

*** CONVERGENCE ITERATIONS ***

ITERATION	S1-ANALCO3	S2-SO4TOT	S3-FTOT	S4-PTOT	S5-CLTOT

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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1	6.813E-05	1.887E-04	5.613E-07	7.408E-05	0.000E+00
2	4.159E-06	7.198E-06	3.848E-08	3.365E-06	0.000E+00
3	-1.146E-07	-2.340E-07	-8.725E-10	-1.051E-07	0.000E+00

Effluent Average

****DESCRIPTION OF SOLUTION ****

	ANAL.	COMP.	PH	
EPMCAT	9.28	8.89	7.500	
EPMAN	8.69	8.10		

ACTIVITY H2O = .9997
PCO2= 6.854522E-03
LOG PCO2 = -2.1640
PO2 = 1.943956E-48
PCH4 = 0.000000E+00
CO2 TOT = 3.935712E-03

TEMPERATURE
25.00 DEG C

EH = .0800 PE = 1.352
PE CALC S = 100.000

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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PE CALC DOX= 12.964
PE SATO DOX= 2.854
TOT ALK = 4.096E+00 MEQ
ELECT = 7.955E-01 MEQ

IONIC STRENGTH
1.080000E-02

DENSITY = 1.0000
TDS = 633.3MG/L
CARB ALK = 3.718E+00 MEQ

IN COMPUTING THE DISTRIBUTION OF SPECIES,
PE = 1.352 EQUIVALENT EH = .080VOLTS

DISTRIBUTION OF SPECIES

I	SPECIES		PPM	MOLALITY	ACTIVITY	LOG ACT	GAMMA
1	CA	2	4.4851E+01	1.1197E-03	7.4050E-04	-3.130	6.6131E-01
2	MG	2	6.8030E+00	2.8000E-04	1.8644E-04	-3.729	6.6587E-01
3	NA	1	1.0422E+02	4.5363E-03	4.0813E-03	-2.389	8.9971E-01
4	K	1	1.2453E+01	3.1869E-04	2.8583E-04	-3.544	8.9690E-01

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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64	H	1	3.4978E-05	3.4722E-08	3.1623E-08	-7.500	9.1074E-01
5	CL	-1	7.8400E+01	2.2128E-03	1.9846E-03	-2.702	8.9690E-01
6	SO4	-2	7.5042E+01	7.8168E-04	5.1430E-04	-3.289	6.5795E-01
7	HCO3	-1	2.2188E+02	3.6386E-03	3.2818E-03	-2.484	9.0194E-01
18	CO3	-2	4.4114E-01	7.3558E-06	4.8680E-06	-5.313	6.6178E-01
86	H2CO3	0	1.4423E+01	2.3269E-04	2.3330E-04	-3.632	1.0026E+00
27	OH	-1	6.1117E-03	3.5959E-07	3.2239E-07	-6.492	8.9656E-01
62	F	-1	5.3991E-01	2.8436E-05	2.5495E-05	-4.594	8.9656E-01
98	BR	-1	3.1000E-01	3.8819E-06	3.4861E-06	-5.458	8.9803E-01
19	MGOH	1	4.4840E-04	1.0859E-08	9.8252E-09	-8.008	9.0481E-01
23	MGSO4 AQ	0	1.9904E+00	1.6546E-05	1.6587E-05	-4.780	1.0025E+00
22	MGHCO3	1	6.7566E-01	7.9233E-06	7.1154E-06	-5.148	8.9803E-01
21	MGCO3 AQ	0	7.2812E-02	8.6405E-07	8.6621E-07	-6.062	1.0025E+00
20	MGF	1	1.5112E-02	3.4916E-07	3.1405E-07	-6.503	8.9947E-01
29	CAOH	1	3.7865E-04	6.6369E-09	5.9966E-09	-8.222	9.0353E-01
32	CASO4 AQ	0	1.0529E+01	7.7386E-05	7.7579E-05	-4.110	1.0025E+00
30	CAHCO3	1	3.4662E+00	3.4307E-05	3.0998E-05	-4.509	9.0353E-01
31	CACO3 AQ	0	6.0423E-01	6.0408E-06	6.0558E-06	-5.218	1.0025E+00
49	CAF+	1	1.0777E-02	1.8253E-07	1.6443E-07	-6.784	9.0086E-01
44	NASO4	-1	1.4531E+00	1.2214E-05	1.1016E-05	-4.958	9.0194E-01
43	NAHCO3	0	6.3066E-01	7.5134E-06	7.5321E-06	-5.123	1.0025E+00
42	NACO3	-1	3.3866E-02	4.0829E-07	3.6825E-07	-6.434	9.0194E-01

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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94	NACL	0	4.7191E-31	8.0798E-36	8.1000E-36	-35.092	1.0025E+00
46	KSO4	-1	1.5472E-01	1.1454E-06	1.0331E-06	-5.986	9.0194E-01
95	KCL	0	4.2161E-32	5.6586E-37	5.6727E-37	-36.246	1.0025E+00
63	HSO4	-1	1.7026E-04	1.7551E-09	1.5786E-09	-8.802	8.9947E-01
24	H4SIO4AQ	0	5.8942E+01	6.1363E-04	6.1516E-04	-3.211	1.0025E+00
25	H3SIO4	-1	2.4258E-01	2.5522E-06	2.2920E-06	-5.640	8.9803E-01
26	H2SIO4	-2	2.1134E-05	2.2473E-10	1.4872E-10	-9.828	6.6178E-01
45	PO4-P	-3	8.2590E-05	2.6681E-09	1.0426E-09	-8.982	3.9075E-01
47	HPO4	-2	1.0651E+01	1.1104E-04	7.3132E-05	-4.136	6.5860E-01
48	H2PO4	-1	4.0028E+00	4.1298E-05	3.7248E-05	-4.429	9.0194E-01
40	MGPO4	-1	9.9720E-02	8.3652E-07	7.5449E-07	-6.122	9.0194E-01
73	MGHPO4	0	1.2121E+00	1.0083E-05	1.0108E-05	-4.995	1.0025E+00
41	MGH2PO4	1	3.0413E-02	2.5089E-07	2.2628E-07	-6.645	9.0194E-01
75	CAPO4	-1	3.3241E-01	2.4629E-06	2.2214E-06	-5.653	9.0194E-01
74	CAHPO4	0	4.0272E+00	2.9618E-05	2.9691E-05	-4.527	1.0025E+00
76	CAH2PO4	1	1.0718E-01	7.8244E-07	7.0572E-07	-6.151	9.0194E-01
61	KHPO4	-1	6.1003E-03	4.5189E-08	4.0758E-08	-7.390	9.0194E-01
50	NAHPO4	-1	7.6717E-02	6.4525E-07	5.8198E-07	-6.235	9.0194E-01
36	H3BO3 AQ	0	1.5692E+00	2.5394E-05	2.5457E-05	-4.594	1.0025E+00
37	H2BO3	-1	3.1874E-02	5.2435E-07	4.6850E-07	-6.329	8.9349E-01
85	NO3-N	-1	4.9000E+00	3.5005E-04	3.1332E-04	-3.504	8.9505E-01

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 38 NH3    AQ  0  3.2869E-01  1.9312E-05  1.9360E-05  -4.713  1.0025E+00
- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO     QUIT, OR A PAGE INCREMENT
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 39 NH4-N      1  1.6819E+01  1.2015E-03  1.0736E-03  -2.969  8.9349E-01
 92 NH4SO4    -1  9.0033E-01  7.8957E-06  7.1129E-06  -5.148  9.0086E-01
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MOLE RATIOS FROM ANALYTICAL MOLALITY			MOLE RATIOS FROM COMPUTED MOLALITY			LOG ACTIVITY RATIOS		
CL/CA	=	1.7413E+00	CL/CA	=	1.9761E+00	LOG CA/H2	=	11.8695
CL/MG	=	6.9822E+00	CL/MG	=	7.9028E+00	LOG MG/H2	=	11.2705
CL/NA	=	4.8557E-01	CL/NA	=	4.8780E-01	LOG NA/H1	=	5.1108
CL/K	=	6.9175E+00	CL/K	=	6.9434E+00	LOG K/H1	=	3.9561
CL/AL	=	2.2128E+27	CL/AL	=	2.2128E+27	LOG AL/H3	=	22.5000
CL/FE	=	2.2128E+27	CL/FE	=	2.2128E+27	LOG FE/H2	=	15.0000
CL/SO4	=	2.4672E+00	CL/SO4	=	2.8308E+00	LOG CA/MG	=	.5990
CL/HCO3	=	5.9520E-01	CL/HCO3	=	6.0814E-01	LOG NA/K	=	1.1547
CA/MG	=	4.0098E+00	CA/MG	=	3.9991E+00			
NA/K	=	1.4246E+01	NA/K	=	1.4234E+01			

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Effluent Average
- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO     QUIT, OR A PAGE INCREMENT
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	PHASE	IAP	KT	LOG IAP	LOG KT	IAP/KT	LOG IAP/KT
18	ANHYDRIT	3.808E-07	4.130E-05	-6.419	-4.384	9.220E-03	-2.035
22	ARAGONIT	3.605E-09	4.612E-09	-8.443	-8.336	7.816E-01	-.107
151	ARTIN	2.772E-25	3.981E-19	-24.557	-18.400	6.963E-07	-6.157
20	BRUCITE	1.938E-17	3.890E-12	-16.713	-11.410	4.981E-06	-5.303
13	CALCITE	3.605E-09	3.312E-09	-8.443	-8.480	1.088E+00	.037
98	CHALC	6.155E-04	2.999E-04	-3.211	-3.523	2.052E+00	.312
21	CHRYSOTL			-56.560	-51.800		-4.760
30	CLENSTIT	1.193E-20	1.349E-17	-19.923	-16.870	8.844E-04	-3.053
100	SILGEL	6.155E-04	1.995E-03	-3.211	-2.700	3.085E-01	-.511
29	DIOPSIDE			-39.248	-36.220		-3.028
12	DOLOMITE	3.272E-18	8.128E-18	-17.485	-17.090	4.025E-01	-.395
97	FLUAPT			-52.128	-66.790		14.662
63	FLUOR	4.813E-13	1.096E-11	-12.318	-10.960	4.390E-02	-1.358
28	FORSTRIT	2.312E-37	7.762E-29	-36.636	-28.110	2.979E-09	-8.526
19	GYPSUM	3.806E-07	2.498E-05	-6.419	-4.602	1.523E-02	-1.817

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- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO     QUIT, OR A PAGE INCREMENT
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65	HALITE	8.100E-06	3.819E+01	-5.092	1.582	2.121E-07	-6.674
118	HUNTITE	2.695E-36	3.090E-31	-35.569	-30.510	8.721E-06	-5.059
39	HYDMAG			-52.882	-37.820		-15.062

96	HYXAPT			-54.026	-59.350		5.324
99	MAGADI	3.021E-19	5.012E-15	-18.520	-14.300	6.027E-05	-4.220
11	MAGNESIT	9.076E-10	5.754E-09	-9.042	-8.240	1.577E-01	-.802
67	MIRABI	8.544E-09	7.709E-02	-8.068	-1.113	1.108E-07	-6.955
59	NAHCOL	1.339E-05	2.831E-01	-4.873	-.548	4.731E-05	-4.325
61	NATRON	8.087E-11	4.887E-02	-10.092	-1.311	1.655E-09	-8.781
150	NESQUE	9.069E-10	6.152E-06	-9.042	-5.211	1.474E-04	-3.831
102	QUARTZ	6.155E-04	9.886E-05	-3.211	-4.005	6.226E+00	.794
37	SEPIOLIT			-43.058	-40.100		-2.958
101	SILGLAS	6.155E-04	9.616E-04	-3.211	-3.017	6.401E-01	-.194
38	TALC			-62.981	-62.290		-.691
66	THENAR	8.567E-09	6.622E-01	-8.067	-.179	1.294E-08	-7.888
62	THRNAT	8.107E-11	1.334E+00	-10.091	.125	6.079E-11	-10.216
32	TREMOLIT			-141.476	-140.300		-1.176
60	TRONA	1.086E-15	1.603E-01	-14.964	-.795	6.771E-15	-14.169
154	SEP PT			-43.058	-37.212		-5.846

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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sc10

INITIAL SOLUTION

TEMPERATURE = 21.60 DEGREES C PH = 7.700
ANALYTICAL EPMCAT = 8.037 ANALYTICAL EPMAN = 7.749

***** OXIDATION - REDUCTION *****

DISSOLVED OXYGEN = 5.000 MG/L
EH MEASURED WITH CALOMEL = 9.9000 VOLTS FLAG CORALK PECALC IDAVES
MEASURED EH OF ZOBELL SOLUTION = 9.9000 VOLTS 2 1 1 0
- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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CORRECTED EH = .2000 VOLTS
PE COMPUTED FROM CORRECTED EH = 3.420

*** TOTAL CONCENTRATIONS OF INPUT SPECIES ***

SPECIES	TOTAL MOLALITY	LOG TOTAL MOLALITY	TOTAL MG/LITRE

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      CA          2    2.17189E-03          -2.6632          8.70000E+01
      MG          2    5.35018E-04          -3.2715          1.30000E+01
      NA          1    2.57651E-03          -2.5890          5.92000E+01
      K           1    5.11773E-05          -4.2909          2.00000E+00
      CL         -1    1.84574E-03          -2.7338          6.54000E+01
      SO4        -2    9.20764E-04          -3.0359          8.84000E+01
      HCO3       -1    3.34357E-03          -2.4758          2.03900E+02
      SIO2 TOT    0    6.16145E-04          -3.2103          3.70000E+01
      F          -1    1.57998E-05          -4.8013          3.00000E-01
      NO3-N      -1    7.07205E-04          -3.1505          9.90000E+00
- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO     QUIT, OR A PAGE INCREMENT
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      B TOT       0    1.48095E-05          -4.8295          1.60000E-01
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                    *** CONVERGENCE ITERATIONS ***

ITERATION  S1-ANALCO3   S2-SO4TOT    S3-FTOT     S4-PTOT     S5-CLTOT

     1      1.053E-04   2.815E-04   5.062E-07   0.000E+00   0.000E+00
     2      5.740E-06   9.999E-06   2.581E-08   0.000E+00   0.000E+00
     3     -2.754E-07  -5.532E-07  -1.171E-09   0.000E+00   0.000E+00

sc10


- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO     QUIT, OR A PAGE INCREMENT
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                    ****DESCRIPTION OF SOLUTION ****

          ANAL.      COMP.          PH            ACTIVITY H2O =    .9998
EPMCAT     8.04       7.62        7.700            PCO2=  3.654805E-03
EPMAN      7.75       7.34                         LOG PCO2 =  -2.4371
                                TEMPERATURE        PO2 =  1.595579E-40
EH =  .2000  PE =   3.420        21.60 DEG C       PCH4 =  0.000000E+00
PE CALC S =  100.000                               CO2 TOT =  3.455010E-03
PE CALC DOX= 13.126            IONIC STRENGTH      DENSITY =   1.0000
PE SATO DOX=  2.734             1.072087E-02       TDS =      566.3MG/L
TOT ALK =  3.348E+00 MEQ                           CARB ALK =  3.344E+00 MEQ
ELECT   =  2.825E-01 MEQ

IN COMPUTING THE DISTRIBUTION OF SPECIES,
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PE = 3.420 EQUIVALENT EH = .200VOLTS

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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****DESCRIPTION OF SOLUTION ****

	ANAL.	COMP.	PH
EPMCAT	8.04	7.62	7.700
EPMAN	7.75	7.34	

EH = .2000 PE = 3.420
PE CALC S = 100.000
PE CALC DOX= 13.126
PE SATO DOX= 2.734
TOT ALK = 3.348E+00 MEQ
ELECT = 2.825E-01 MEQ

TEMPERATURE
21.60 DEG C

IONIC STRENGTH
1.072087E-02

ACTIVITY H2O = .9998
PCO2= 3.654805E-03
LOG PCO2 = -2.4371
PO2 = 1.595579E-40
PCH4 = 0.000000E+00
CO2 TOT = 3.455010E-03
DENSITY = 1.0000
TDS = 566.3MG/L
CARB ALK = 3.344E+00 MEQ

IN COMPUTING THE DISTRIBUTION OF SPECIES,
PE = 3.420 EQUIVALENT EH = .200VOLTS

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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DISTRIBUTION OF SPECIES

I	SPECIES		PPM	MOLALITY	ACTIVITY	LOG ACT	GAMMA
1	CA	2	7.9214E+01	1.9775E-03	1.3124E-03	-2.882	6.6364E-01
2	MG	2	1.2013E+01	4.9442E-04	3.3035E-04	-3.481	6.6816E-01
3	NA	1	5.8956E+01	2.5659E-03	2.3107E-03	-2.636	9.0053E-01
4	K	1	1.9934E+00	5.1009E-05	4.5793E-05	-4.339	8.9775E-01
64	H	1	2.2054E-05	2.1892E-08	1.9953E-08	-7.700	9.1142E-01
5	CL	-1	6.5400E+01	1.8457E-03	1.6570E-03	-2.781	8.9775E-01
6	SO4	-2	7.2797E+01	7.5825E-04	5.0066E-04	-3.300	6.6029E-01
7	HCO3	-1	1.9678E+02	3.2268E-03	2.9129E-03	-2.536	9.0273E-01
18	CO3	-2	5.7570E-01	9.5989E-06	6.3746E-06	-5.196	6.6409E-01
86	H2CO3	0	8.4522E+00	1.3635E-04	1.3671E-04	-3.864	1.0027E+00
27	OH	-1	7.4509E-03	4.3834E-07	3.9338E-07	-6.405	8.9742E-01
62	F	-1	2.9116E-01	1.5334E-05	1.3761E-05	-4.861	8.9742E-01
19	MGOH	1	9.3056E-04	2.2534E-08	2.0406E-08	-7.690	9.0556E-01

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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23	MGSO4 AQ	0	3.1394E+00	2.6095E-05	2.6160E-05	-4.582	1.0025E+00

22	MGHCO3	1	1.0405E+00	1.2201E-05	1.0967E-05	-4.960	8.9887E-01
21	MGCO3 AQ	0	1.6036E-01	1.9028E-06	1.9075E-06	-5.720	1.0025E+00
20	MGF	1	1.3185E-02	3.0460E-07	2.7423E-07	-6.562	9.0028E-01
29	CAOH	1	7.9944E-04	1.4012E-08	1.2671E-08	-7.897	9.0429E-01
32	CASO4 AQ	0	1.7644E+01	1.2967E-04	1.2999E-04	-3.886	1.0025E+00
30	CAHCO3	1	5.1529E+00	5.0998E-05	4.6118E-05	-4.336	9.0429E-01
31	CACO3 AQ	0	1.3154E+00	1.3150E-05	1.3182E-05	-4.880	1.0025E+00
49	CAF+	1	9.5064E-03	1.6100E-07	1.4517E-07	-6.838	9.0166E-01
44	NASO4	-1	7.8297E-01	6.5805E-06	5.9404E-06	-5.226	9.0273E-01
43	NAHCO3	0	3.1694E-01	3.7757E-06	3.7850E-06	-5.422	1.0025E+00
42	NACO3	-1	2.1092E-02	2.5427E-07	2.2953E-07	-6.639	9.0273E-01
94	NACL	0	2.2309E-31	3.8194E-36	3.8288E-36	-35.417	1.0025E+00
46	KSO4	-1	2.2707E-02	1.6809E-07	1.5174E-07	-6.819	9.0273E-01
95	KCL	0	5.6400E-33	7.5692E-38	7.5879E-38	-37.120	1.0025E+00
63	HSO4	-1	9.5118E-05	9.8045E-10	8.8269E-10	-9.054	9.0028E-01
24	H4SIO4AQ	0	5.8862E+01	6.1276E-04	6.1427E-04	-3.212	1.0025E+00
25	H3SIO4	-1	3.2186E-01	3.3861E-06	3.0436E-06	-5.517	8.9887E-01
26	H2SIO4	-2	2.9447E-05	3.1311E-10	2.0793E-10	-9.682	6.6409E-01
36	H3BO3 AQ	0	8.8793E-01	1.4368E-05	1.4404E-05	-4.842	1.0025E+00
37	H2BO3	-1	2.6827E-02	4.4130E-07	3.9469E-07	-6.404	8.9438E-01
85	NO3-N	-1	9.9000E+00	7.0721E-04	6.3360E-04	-3.198	8.9592E-01

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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MOLE RATIOS FROM ANALYTICAL MOLALITY			MOLE RATIOS FROM COMPUTED MOLALITY			LOG ACTIVITY RATIOS		
CL/CA	=	8.4983E-01	CL/CA	=	9.3336E-01	LOG CA/H2	=	12.5181
CL/MG	=	3.4499E+00	CL/MG	=	3.7332E+00	LOG MG/H2	=	11.9190
CL/NA	=	7.1637E-01	CL/NA	=	7.1934E-01	LOG NA/H1	=	5.0637
CL/K	=	3.6066E+01	CL/K	=	3.6185E+01	LOG K/H1	=	3.3608
CL/AL	=	1.8457E+27	CL/AL	=	1.8457E+27	LOG AL/H3	=	23.1000
CL/FE	=	1.8457E+27	CL/FE	=	1.8457E+27	LOG FE/H2	=	15.4000
CL/SO4	=	2.0046E+00	CL/SO4	=	2.4342E+00	LOG CA/MG	=	.5991
CL/HCO3	=	5.5203E-01	CL/HCO3	=	5.7201E-01	LOG NA/K	=	1.7029
CA/MG	=	4.0595E+00	CA/MG	=	3.9997E+00			
NA/K	=	5.0345E+01	NA/K	=	5.0303E+01			

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- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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	PHASE	IAP	KT	LOG IAP	LOG KT	IAP/KT	LOG IAP/KT
18	ANHYDRIT	6.571E-07	4.491E-05	-6.182	-4.348	1.463E-02	-1.835
22	ARAGONIT	8.366E-09	4.839E-09	-8.077	-8.315	1.729E+00	.238
151	ARTIN	1.698E-24	4.126E-19	-23.770	-18.384	4.115E-06	-5.386
20	BRUCITE	5.112E-17	3.827E-12	-16.291	-11.417	1.336E-05	-4.874

13	CALCITE	8.366E-09	3.456E-09	-8.077	-8.461	2.421E+00	.384
98	CHALC	6.145E-04	2.741E-04	-3.211	-3.562	2.242E+00	.351
21	CHRYSOTL			-55.297	-52.033		-3.264
30	CLENSTIT	3.142E-20	1.185E-17	-19.503	-16.926	2.653E-03	-2.576
100	SILGEL	6.145E-04	1.793E-03	-3.211	-2.747	3.428E-01	-.465
29	DIOPSIDE			-38.406	-36.398		-2.008
12	DOLOMITE	1.762E-17	9.767E-18	-16.754	-17.010	1.804E+00	.256
63	FLUOR	2.485E-13	1.000E-11	-12.605	-11.000	2.484E-02	-1.605
28	FORSTRIT	1.607E-36	7.060E-29	-35.794	-28.151	2.276E-08	-7.643
19	GYPSUM	6.568E-07	2.495E-05	-6.183	-4.603	2.632E-02	-1.580
65	HALITE	3.829E-06	3.752E+01	-5.417	1.574	1.021E-07	-6.991
118	HUNTITE	7.812E-35	5.103E-31	-34.107	-30.292	1.531E-04	-3.815
39	HYDMAG			-50.998	-37.604		-13.394

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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99	MAGADI	7.589E-20	5.012E-15	-19.120	-14.300	1.514E-05	-4.820
11	MAGNESIT	2.106E-09	6.489E-09	-8.677	-8.188	3.245E-01	-.489
67	MIRABI	2.667E-09	5.327E-02	-8.574	-1.274	5.007E-08	-7.300
59	NAHCOL	6.731E-06	2.634E-01	-5.172	-.579	2.556E-05	-4.592
61	NATRON	3.396E-11	3.596E-02	-10.469	-1.444	9.443E-10	-9.025
150	NESQUE	2.104E-09	6.886E-06	-8.677	-5.162	3.056E-04	-3.515
102	QUARTZ	6.145E-04	8.758E-05	-3.211	-4.058	7.017E+00	.846
37	SEPIOLIT			-42.217	-40.324		-1.893
101	SILGLAS	6.145E-04	8.820E-04	-3.211	-3.055	6.968E-01	-.157
38	TALC			-61.720	-62.671		.951
66	THENAR	2.673E-09	6.696E-01	-8.573	-.174	3.992E-09	-8.399
62	THRNAT	3.403E-11	1.408E+00	-10.468	.149	2.416E-11	-10.617
32	TREMOLIT			-138.533	-141.063		2.530
60	TRONA	2.290E-16	2.276E-01	-15.640	-.643	1.006E-15	-14.997
154	SEP PT			-42.217	-37.212		-5.005

Honea Well

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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INITIAL SOLUTION

TEMPERATURE = 20.20 DEGREES C PH = 7.400
ANALYTICAL EPMCAT = 7.206 ANALYTICAL EPMAN = 7.005

***** OXIDATION - REDUCTION *****

DISSOLVED OXYGEN = 5.000 MG/L
EH MEASURED WITH CALOMEL = 9.9000 VOLTS FLAG CORALK PECALC IDAVES

62	THRNAT	3.403E-11	1.408E+00	-10.468	.149	2.416E-11	-10.617
32	TREMOLIT			-138.533	-141.063		2.530
60	TRONA	2.290E-16	2.276E-01	-15.640	-.643	1.006E-15	-14.997
154	SEP PT			-42.217	-37.212		-5.005

Honea Well

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
-

INITIAL SOLUTION

TEMPERATURE = 20.20 DEGREES C PH = 7.400
ANALYTICAL EPMCAT = 7.206 ANALYTICAL EPMAN = 7.005

***** OXIDATION - REDUCTION *****

DISSOLVED OXYGEN = 5.000 MG/L
EH MEASURED WITH CALOMEL = 9.9000 VOLTS FLAG CORALK PECALC IDAVES
MEASURED EH OF ZOBELL SOLUTION = 9.9000 VOLTS 2 1 1 0
CORRECTED EH = .2000 VOLTS
PE COMPUTED FROM CORRECTED EH = 3.436

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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*** TOTAL CONCENTRATIONS OF INPUT SPECIES ***

SPECIES		TOTAL MOLALITY	LOG TOTAL MOLALITY	TOTAL MG/LITRE
CA	2	2.04699E-03	-2.6889	8.20000E+01
MG	2	4.65037E-04	-3.3325	1.13000E+01
NA	1	2.13251E-03	-2.6711	4.90000E+01
K	1	5.37341E-05	-4.2697	2.10000E+00
CL	-1	1.38849E-03	-2.8575	4.92000E+01
SO4	-2	8.33240E-04	-3.0792	8.00000E+01
HCO3	-1	3.47627E-03	-2.4589	2.12000E+02
SIO2 TOT	0	6.16123E-04	-3.2103	3.70000E+01
F	-1	1.89590E-05	-4.7222	3.60000E-01
NO3-N	-1	4.57166E-04	-3.3399	6.40000E+00
BR	-1	1.62771E-06	-5.7884	1.30000E-01

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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*** CONVERGENCE ITERATIONS ***

ITERATION	S1-ANALCO3	S2-SO4TOT	S3-FTOT	S4-PTOT	S5-CLTOT
1	8.534E-05	2.388E-04	5.364E-07	0.000E+00	0.000E+00
2	4.142E-06	7.797E-06	2.441E-08	0.000E+00	0.000E+00
3	-1.947E-07	-4.337E-07	-1.129E-09	0.000E+00	0.000E+00

Honea Well

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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****DESCRIPTION OF SOLUTION ****

	ANAL.	COMP.	PH
EPMCAT	7.21	6.85	7.400
EPMAN	7.01	6.65	

EH = .2000 PE = 3.436
PE CALC S = 100.000
PE CALC DOX= 13.545
PE SATO DOX= 3.033
TOT ALK = 3.478E+00 MEQ
ELECT = 1.989E-01 MEQ

TEMPERATURE
20.20 DEG C

IONIC STRENGTH
9.756721E-03

ACTIVITY H2O = .9998
PCO2= 7.537381E-03
LOG PCO2 = -2.1228
PO2 = 3.843888E-42
PCH4 = 0.000000E+00
CO2 TOT = 3.756981E-03
DENSITY = 1.0000
TDS = 529.5MG/L
CARB ALK = 3.476E+00 MEQ

IN COMPUTING THE DISTRIBUTION OF SPECIES,
PE = 3.436 EQUIVALENT EH = .200VOLTS

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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DISTRIBUTION OF SPECIES

I	SPECIES		PPM	MOLALITY	ACTIVITY	LOG ACT	GAMMA
1	CA	2	7.5111E+01	1.8750E-03	1.2656E-03	-2.898	6.7495E-01
2	MG	2	1.0492E+01	4.3180E-04	2.9327E-04	-3.533	6.7918E-01
3	NA	1	4.8806E+01	2.1241E-03	1.9212E-03	-2.716	9.0451E-01
4	K	1	2.0937E+00	5.3574E-05	4.8321E-05	-4.316	9.0195E-01
64	H	1	4.3852E-05	4.3527E-08	3.9811E-08	-7.400	9.1461E-01
5	CL	-1	4.9200E+01	1.3885E-03	1.2523E-03	-2.902	9.0195E-01
6	SO4	-2	6.6483E+01	6.9250E-04	4.6526E-04	-3.332	6.7185E-01
7	HCO3	-1	2.0656E+02	3.3871E-03	3.0706E-03	-2.513	9.0655E-01
18	CO3	-2	2.8984E-01	4.8325E-06	3.2639E-06	-5.486	6.7541E-01
86	H2CO3	0	1.8154E+01	2.9284E-04	2.9355E-04	-3.532	1.0024E+00
27	OH	-1	3.3279E-03	1.9577E-07	1.7652E-07	-6.753	9.0165E-01
62	F	-1	3.5061E-01	1.8465E-05	1.6649E-05	-4.779	9.0165E-01
98	BR	-1	1.3000E-01	1.6277E-06	1.4698E-06	-5.833	9.0299E-01
19	MGOH	1	3.6318E-04	8.7943E-09	7.9955E-09	-8.097	9.0917E-01
23	MGSO4 AQ	0	2.4953E+00	2.0740E-05	2.0787E-05	-4.682	1.0022E+00
22	MGHCO3	1	9.6168E-01	1.1276E-05	1.0182E-05	-4.992	9.0299E-01
21	MGCO3 AQ	0	7.1358E-02	8.4671E-07	8.4861E-07	-6.071	1.0022E+00

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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20	MGF	1	1.3572E-02	3.1353E-07	2.8352E-07	-6.547	9.0429E-01
29	CAOH	1	3.4121E-04	5.9802E-09	5.4300E-09	-8.265	9.0800E-01
32	CASO4 AQ	0	1.5623E+01	1.1482E-04	1.1508E-04	-3.939	1.0022E+00
30	CAHCO3	1	5.0861E+00	5.0336E-05	4.5705E-05	-4.340	9.0800E-01
31	CACO3 AQ	0	6.3440E-01	6.3417E-06	6.3560E-06	-5.197	1.0022E+00
49	CAF+	1	1.0679E-02	1.8085E-07	1.6377E-07	-6.786	9.0556E-01
44	NASO4	-1	5.9698E-01	5.0171E-06	4.5482E-06	-5.342	9.0655E-01
43	NAHCO3	0	2.7786E-01	3.3100E-06	3.3174E-06	-5.479	1.0022E+00
42	NACO3	-1	8.3156E-03	1.0024E-07	9.0875E-08	-7.042	9.0655E-01
94	NACL	0	1.4023E-31	2.4007E-36	2.4061E-36	-35.619	1.0022E+00
46	KSO4	-1	2.1623E-02	1.6006E-07	1.4510E-07	-6.838	9.0655E-01
95	KCL	0	4.4991E-33	6.0379E-38	6.0514E-38	-37.218	1.0022E+00
63	HSO4	-1	1.6898E-04	1.7418E-09	1.5751E-09	-8.803	9.0429E-01
24	H4SIO4AQ	0	5.9036E+01	6.1455E-04	6.1593E-04	-3.210	1.0022E+00
25	H3SIO4	-1	1.4949E-01	1.5726E-06	1.4200E-06	-5.848	9.0299E-01
26	H2SIO4	-2	5.6905E-06	6.0506E-11	4.0866E-11	-10.389	6.7541E-01
85	NO3-N	-1	6.4000E+00	4.5717E-04	4.1157E-04	-3.386	9.0027E-01

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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MOLE RATIOS FROM ANALYTICAL MOLALITY			MOLE RATIOS FROM COMPUTED MOLALITY			LOG ACTIVITY RATIOS		
CL/CA	=	6.7831E-01	CL/CA	=	7.4052E-01	LOG CA/H2	=	11.9023
CL/MG	=	2.9858E+00	CL/MG	=	3.2156E+00	LOG MG/H2	=	11.2673
CL/NA	=	6.5111E-01	CL/NA	=	6.5369E-01	LOG NA/H1	=	4.6836
CL/K	=	2.5840E+01	CL/K	=	2.5917E+01	LOG K/H1	=	3.0841
CL/AL	=	1.3885E+27	CL/AL	=	1.3885E+27	LOG AL/H3	=	22.2000
CL/FE	=	1.3885E+27	CL/FE	=	1.3885E+27	LOG FE/H2	=	14.8000

CL/SO4	=	1.6664E+00	CL/SO4	=	2.0050E+00	LOG CA/MG	=	.6350
CL/HCO3	=	3.9942E-01	CL/HCO3	=	4.0993E-01	LOG NA/K	=	1.5994
CA/MG	=	4.4018E+00	CA/MG	=	4.3424E+00			
NA/K	=	3.9686E+01	NA/K	=	3.9648E+01			

Honea Well

	PHASE	IAP	KT	LOG IAP	LOG KT	IAP/KT	LOG IAP/KT
- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT							
-							
18	ANHYDRIT	5.888E-07	4.651E-05	-6.230	-4.332	1.266E-02	-1.898
22	ARAGONIT	4.131E-09	4.931E-09	-8.384	-8.307	8.377E-01	-.077
151	ARTIN	1.628E-25	4.189E-19	-24.788	-18.378	3.886E-07	-6.410
20	BRUCITE	9.138E-18	3.800E-12	-17.039	-11.420	2.405E-06	-5.619
13	CALCITE	4.131E-09	3.513E-09	-8.384	-8.454	1.176E+00	.070
98	CHALC	6.162E-04	2.640E-04	-3.210	-3.578	2.334E+00	.368
21	CHRYSOTL			-57.538	-52.131		-5.407
30	CLENSTIT	5.632E-21	1.122E-17	-20.249	-16.950	5.020E-04	-3.299
100	SILGEL	6.162E-04	1.714E-03	-3.210	-2.766	3.595E-01	-.444
29	DIOPSIDE			-39.864	-36.473		-3.391
12	DOLOMITE	3.954E-18	1.055E-17	-17.403	-16.977	3.748E-01	-.426
63	FLUOR	3.508E-13	9.627E-12	-12.455	-11.016	3.644E-02	-1.438
28	FORSTRIT	5.147E-38	6.786E-29	-37.288	-28.168	7.585E-10	-9.120
19	GYPSUM	5.886E-07	2.491E-05	-6.230	-4.604	2.363E-02	-1.627
65	HALITE	2.406E-06	3.724E+01	-5.619	1.571	6.461E-08	-7.190
118	HUNTITE	3.622E-36	6.294E-31	-35.441	-30.201	5.755E-06	-5.240
39	HYDMAG			-53.115	-37.514		-15.602
99	MAGADI	4.089E-20	5.012E-15	-19.388	-14.300	8.159E-06	-5.088
11	MAGNESIT	9.572E-10	6.823E-09	-9.019	-8.166	1.403E-01	-.853
67	MIRABI	1.714E-09	4.563E-02	-8.766	-1.341	3.756E-08	-7.425
59	NAHCOL	5.899E-06	2.555E-01	-5.229	-.593	2.309E-05	-4.637
61	NATRON	1.202E-11	3.163E-02	-10.920	-1.500	3.801E-10	-9.420
- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT							
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150	NESQUE	9.566E-10	7.218E-06	-9.019	-5.142	1.325E-04	-3.878
102	QUARTZ	6.162E-04	8.325E-05	-3.210	-4.080	7.401E+00	.869
37	SEPIOLIT			-43.709	-40.418		-3.291
101	SILGLAS	6.162E-04	8.506E-04	-3.210	-3.070	7.244E-01	-.140
38	TALC			-63.958	-62.830		-1.128
66	THENAR	1.717E-09	6.728E-01	-8.765	-.172	2.553E-09	-8.593
62	THRNAT	1.205E-11	1.441E+00	-10.919	.159	8.360E-12	-11.078
32	TREMOLIT			-143.686	-141.382		-2.304
60	TRONA	7.104E-17	2.636E-01	-16.148	-.579	2.696E-16	-15.569
154	SEP PT			-43.709	-37.212		-6.497

CMID 11

INITIAL SOLUTION

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT

TEMPERATURE = 21.80 DEGREES C PH = 7.500
ANALYTICAL EPMCAT = 6.747 ANALYTICAL EPMAN = 6.595

***** OXIDATION - REDUCTION *****

DISSOLVED OXYGEN = 5.000 MG/L
EH MEASURED WITH CALOMEL = 9.9000 VOLTS
MEASURED EH OF ZOBELL SOLUTION = 9.9000 VOLTS
CORRECTED EH = .2000 VOLTS
PE COMPUTED FROM CORRECTED EH = 3.417

FLAG	CORALK	PECALC	IDAVES
2	1	1	0

*** TOTAL CONCENTRATIONS OF INPUT SPECIES ***

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT

SPECIES		TOTAL MOLALITY	LOG TOTAL MOLALITY	TOTAL MG/LITRE
CA	2	1.59765E-03	-2.7965	6.40000E+01
MG	2	2.63384E-04	-3.5794	6.40000E+00
NA	1	2.95940E-03	-2.5288	6.80000E+01
K	1	6.90868E-05	-4.1606	2.70000E+00
CL	-1	7.45043E-04	-3.1278	2.64000E+01
SO4	-2	1.10404E-03	-2.9570	1.06000E+02
HCO3	-1	3.57465E-03	-2.4468	2.18000E+02
SIO2 TOT	0	6.16123E-04	-3.2103	3.70000E+01
F	-1	1.89590E-05	-4.7222	3.60000E-01
NO3-N	-1	5.00026E-05	-4.3010	7.00000E-01
BR	-1	1.87813E-06	-5.7263	1.50000E-01

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT

*** CONVERGENCE ITERATIONS ***

ITERATION	S1-ANALCO3	S2-SO4TOT	S3-FTOT	S4-PTOT	S5-CLTOT
1	7.164E-05	2.432E-04	3.513E-07	0.000E+00	0.000E+00
2	4.058E-06	9.562E-06	1.962E-08	0.000E+00	0.000E+00
3	-1.608E-07	-4.374E-07	-7.441E-10	0.000E+00	0.000E+00

CMID 11

****DESCRIPTION OF SOLUTION ****

	ANAL.	COMP.	PH	
EPMCAT	6.75	6.38	7.500	

ACTIVITY H2O = .9998
PCO2= 6.337988E-03

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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EPMAN 6.60 6.24

LOG PCO2 = -2.1980
PO2 = 2.899723E-41
PCH4 = 0.000000E+00
CO2 TOT = 3.795783E-03
DENSITY = 1.0000
TDS = 529.7MG/L
CARB ALK = 3.575E+00 MEQ

EH = .2000 PE = 3.417
PE CALC S = 100.000
PE CALC DOX= 13.310
PE SATO DOX= 2.933
TOT ALK = 3.577E+00 MEQ
ELECT = 1.488E-01 MEQ

TEMPERATURE
21.80 DEG C

IONIC STRENGTH
8.934416E-03

IN COMPUTING THE DISTRIBUTION OF SPECIES,
PE = 3.417 EQUIVALENT EH = .200VOLTS

DISTRIBUTION OF SPECIES

I	SPECIES		PPM	MOLALITY	ACTIVITY	LOG ACT	GAMMA
1	CA	2	5.7055E+01	1.4243E-03	9.7441E-04	-3.011	6.8415E-01
2	MG	2	5.8072E+00	2.3899E-04	1.6445E-04	-3.784	6.8812E-01
3	NA	1	6.7660E+01	2.9446E-03	2.6728E-03	-2.573	9.0770E-01
4	K	1	2.6884E+00	6.8791E-05	6.2279E-05	-4.206	9.0533E-01
64	H	1	3.4736E-05	3.4479E-08	3.1623E-08	-7.500	9.1717E-01
5	CL	-1	2.6400E+01	7.4504E-04	6.7451E-04	-3.171	9.0533E-01
6	SO4	-2	9.1405E+01	9.5203E-04	6.4859E-04	-3.188	6.8127E-01

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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7	HCO3	-1	2.1308E+02	3.4940E-03	3.1782E-03	-2.498	9.0962E-01
18	CO3	-2	3.8615E-01	6.4383E-06	4.4077E-06	-5.356	6.8461E-01
86	H2CO3	0	1.4581E+01	2.3521E-04	2.3573E-04	-3.628	1.0022E+00
27	OH	-1	4.7354E-03	2.7858E-07	2.5213E-07	-6.598	9.0505E-01
62	F	-1	3.5371E-01	1.8628E-05	1.6859E-05	-4.773	9.0505E-01
98	BR	-1	1.5000E-01	1.8781E-06	1.7021E-06	-5.769	9.0630E-01
19	MGOH	1	2.9550E-04	7.1553E-09	6.5262E-09	-8.185	9.1207E-01
23	MGSO4 AQ	0	2.0363E+00	1.6925E-05	1.6960E-05	-4.771	1.0021E+00
22	MGHCO3	1	5.6120E-01	6.5804E-06	5.9638E-06	-5.224	9.0630E-01
21	MGCO3 AQ	0	5.5392E-02	6.5727E-07	6.5862E-07	-6.181	1.0021E+00
20	MGF	1	8.0207E-03	1.8529E-07	1.6815E-07	-6.774	9.0751E-01
29	CAOH	1	3.7818E-04	6.6282E-09	6.0381E-09	-8.219	9.1097E-01
32	CASO4 AQ	0	1.7008E+01	1.2499E-04	1.2525E-04	-3.902	1.0021E+00
30	CAHCO3	1	4.1585E+00	4.1155E-05	3.7491E-05	-4.426	9.1097E-01
31	CACO3 AQ	0	6.7801E-01	6.7776E-06	6.7916E-06	-5.168	1.0021E+00

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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49	CAF+	1	8.6217E-03	1.4601E-07	1.3268E-07	-6.877	9.0870E-01
44	NASO4	-1	1.1659E-00	9.7987E-06	8.9131E-06	-5.050	9.0962E-01
43	NAHCO3	0	4.0018E-01	4.7671E-06	4.7770E-06	-5.321	1.0021E+00
42	NACO3	-1	1.6916E-02	2.0392E-07	1.8549E-07	-6.732	9.0962E-01
94	NACL	0	1.0509E-31	1.7991E-36	1.8028E-36	-35.744	1.0021E+00
46	KSO4	-1	3.9845E-02	2.9495E-07	2.6829E-07	-6.571	9.0962E-01
95	KCL	0	3.1238E-33	4.1921E-38	4.2008E-38	-37.377	1.0021E+00
63	HSO4	-1	1.9481E-04	2.0080E-09	1.8223E-09	-8.739	9.0751E-01
24	H4SIO4AQ	0	5.8982E+01	6.1398E-04	6.1524E-04	-3.211	1.0021E+00
25	H3SIO4	-1	2.0387E-01	2.1447E-06	1.9438E-06	-5.711	9.0630E-01
26	H2SIO4	-2	1.1797E-05	1.2543E-10	8.5871E-11	-10.066	6.8461E-01
85	NO3-N	-1	7.0000E-01	5.0003E-05	4.5191E-05	-4.345	9.0377E-01

MOLE RATIOS FROM ANALYTICAL MOLALITY	MOLE RATIOS FROM COMPUTED MOLALITY	LOG ACTIVITY RATIOS
CL/CA = 4.6634E-01	CL/CA = 5.2310E-01	LOG CA/H2 = 11.9887
CL/MG = 2.8287E+00	CL/MG = 3.1175E+00	LOG MG/H2 = 11.2160

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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CL/NA = 2.5175E-01	CL/NA = 2.5302E-01	LOG NA/H1 = 4.9270
CL/K = 1.0784E+01	CL/K = 1.0830E+01	LOG K/H1 = 3.2943
CL/AL = 7.4504E+26	CL/AL = 7.4504E+26	LOG AL/H3 = 22.5000
CL/FE = 7.4504E+26	CL/FE = 7.4504E+26	LOG FE/H2 = 15.0000
CL/SO4 = 6.7483E-01	CL/SO4 = 7.8258E-01	LOG CA/MG = .7727
CL/HCO3 = 2.0842E-01	CL/HCO3 = 2.1324E-01	LOG NA/K = 1.6326
CA/MG = 6.0659E+00	CA/MG = 5.9596E+00	
NA/K = 4.2836E+01	NA/K = 4.2805E+01	

CMID 11

	PHASE	IAP	KT	LOG IAP	LOG KT	IAP/KT	LOG IAP/KT
18	ANHYDRIT	6.320E-07	4.469E-05	-6.199	-4.350	1.414E-02	-1.849
22	ARAGONIT	4.295E-09	4.826E-09	-8.367	-8.316	8.899E-01	-.051
151	ARTIN	2.659E-25	4.118E-19	-24.575	-18.385	6.457E-07	-6.190
20	BRUCITE	1.045E-17	3.830E-12	-16.981	-11.417	2.729E-06	-5.564
13	CALCITE	4.295E-09	3.447E-09	-8.367	-8.462	1.246E+00	.095

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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98	CHALC	6.155E-04	2.756E-04	-3.211	-3.560	2.233E+00	.349
21	CHRYSOTL			-57.364	-52.019		-5.344
30	CLENSTIT	6.435E-21	1.194E-17	-20.191	-16.923	5.391E-04	-3.268
100	SILGEL	6.155E-04	1.804E-03	-3.211	-2.744	3.411E-01	-.467
29	DIOPSIDE			-39.610	-36.388		-3.222
12	DOLOMITE	3.113E-18	9.661E-18	-17.507	-17.015	3.222E-01	-.492
63	FLUOR	2.770E-13	1.006E-11	-12.558	-10.997	2.753E-02	-1.560
28	FORSTRIT	6.729E-38	7.100E-29	-37.172	-28.149	9.477E-10	-9.023
19	GYPSUM	6.318E-07	2.495E-05	-6.199	-4.603	2.532E-02	-1.597
65	HALITE	1.803E-06	3.756E+01	-5.744	1.575	4.800E-08	-7.319
118	HUNTITE	1.636E-36	4.953E-31	-35.786	-30.305	3.303E-06	-5.481
39	HYDMAG			-53.540	-37.617		-15.923
99	MAGADI	6.583E-20	5.012E-15	-19.182	-14.300	1.313E-05	-4.882
11	MAGNESIT	7.249E-10	6.443E-09	-9.140	-8.191	1.125E-01	-.949
67	MIRABI	4.625E-09	5.445E-02	-8.335	-1.264	8.493E-08	-7.071
59	NAHCOL	8.495E-06	2.645E-01	-5.071	-.578	3.212E-05	-4.493
61	NATRON	3.143E-11	3.663E-02	-10.503	-1.436	8.581E-10	-9.066
150	NESQUE	7.244E-10	6.840E-06	-9.140	-5.165	1.059E-04	-3.975
102	QUARTZ	6.155E-04	8.821E-05	-3.211	-4.054	6.977E+00	.844
37	SEPIOLIT			-43.594	-40.311		-3.283
101	SILGLAS	6.155E-04	8.865E-04	-3.211	-3.052	6.943E-01	-.158
38	TALC			-63.785	-62.648		-1.137

- HIT ENTER TO CONTINUE, T TO GO TO THE TOP, Q TO QUIT, OR A PAGE INCREMENT
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66	THENAR	4.633E-09	6.692E-01	-8.334	-.174	6.924E-09	-8.160
62	THRNAT	3.148E-11	1.404E+00	-10.502	.147	2.243E-11	-10.649
32	TREMOLIT			-143.005	-141.017		-1.988
60	TRONA	2.674E-16	2.229E-01	-15.573	-.652	1.199E-15	-14.921
154	SEP PT			-43.594	-37.212		-6.382

-- EOF -- (HIT ENTER TO QUIT, T TO GO TO THE TOP, OR A NEGATIVE PAGE INCREMENT)

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