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HMC

United States Department of the Interior

BUREAU OF MINES
Twin Cities Research Center
5629 Minnehaha Avenue South
Minneapolis, MN 55417-3099

August 25, 1994

Mr. Mason Coggin
AZ Dept. of Mines & Mineral Resources
1502 West Washington
Phoenix, Arizona 85007

Dear Mr. Coggin:

The U.S. Bureau of Mines has completed a draft Environmental Assessment (EA) for the Santa Cruz In Situ Copper Mining Research Project. Our records indicate that you may be interested in environmental documents associated with this project. A copy of the draft EA is enclosed for your review and comment. A two-page information sheet is also enclosed which summarizes the major features of the project.

The proposed action evaluated in the draft EA is the in situ mining of copper from a copper oxide zone using a pattern of five injection and recovery test wells, and fabrication and operation of a pilot-scale, solvent extraction-electrowinning facility to remove dissolved copper from solution. The project site is located approximately 7 miles west of the city of Casa Grande, Arizona.

A public meeting to receive comments on the draft EA is scheduled for Wednesday, September 14, 1994 at the Holiday Inn, 777 North Pinal Avenue, Casa Grande, Arizona beginning at 7 p.m. MST. The meeting room will be open at 6:30 p.m. for review of displays and informal discussion with project personnel. Any comments which you would like to offer on the adequacy of the Bureau's environmental review of this research project may be made verbally during the public meeting, or provided in writing to the above address. We would appreciate receiving any written comments by September 26, 1994. All comments received will be addressed by the Bureau in the preparation of the final EA and decision documents.

If you have any questions, please feel free to contact me at (612) 725-4588.

Sincerely,

Daniel J. Millenacker

DANIEL J. MILLENACKER
In Situ Systems

Enclosures

HMCL

INFORMATION ON THE SANTA CRUZ IN SITU COPPER MINING RESEARCH PROJECT

Proposed Action Addressed in the Draft Environmental Assessment: In situ mining of copper from an undisturbed copper oxide zone using a pattern of five injection and recovery wells, and fabrication and operation of a solvent extraction-electrowinning facility to remove copper from recovered solution.

Objectives of the Research Project: 1) Determine the technical, economic, and environmental feasibility of in situ copper mining, and 2) provide industry with the information necessary to develop commercial-scale, in situ copper mine designs.

Project Location: Seven miles west of Casa Grande, Arizona.

Project Participants: The U.S. Bureau of Mines and the Santa Cruz Joint Venture (SCJV). The SCJV is a joint venture of ASARCO Santa Cruz, Inc., a wholly-owned subsidiary of ASARCO Incorporated, and Freeport Copper Company, a wholly-owned subsidiary of Freeport-McMoRan Incorporated.

Source of Funding: Congressional appropriation to the Bureau of Mines to cover 75 pct of the cost of the research project, with the SCJV to cover the remaining 25 pct. The total cost of the project is about $22 million.

Nature of the Research Project: Dilute sulfuric acid leach solution is injected through a well into a copper oxide zone at a depth of 1,570 to 1,770 ft below land surface. Leach solution migrates through the rock, via naturally-occurring fractures, and selectively dissolves the copper minerals which it contacts. Leach solution (which now contains dissolved copper) is then drawn to adjacent recovery wells where it is pumped to a solvent-extraction electrowinning plant located on the surface. In the plant, copper is removed from the leach solution and the resulting, barren solution, is reacidified to its original strength. The reacidified leach solution is then reinjected into the ore zone to repeat the cycle. Dissolution of the copper minerals results in removal of no more than 3 pct of the total volume of the rock targeted for in situ mining.

Test Facility: Facilities to be located on the surface include wellheads, pipes, tanks to hold solvent, evaporation and storage ponds, and buildings. The injection and recovery test well field will consist of a single five-spot well pattern measuring 127 ft to a side. Recovery test wells are located at each of the four corners of the square, with the injection test well located in the center. The in situ mining process involves no excavation of land surface or underlying rock.

Ground Water Protection: Protection of ground water is a fundamental component of the engineering design. The following considerations are included in this design:

1. In situ mining solutions will be injected nearly 1,000 ft below the aquifer locally used for domestic and agricultural purposes. Tests show that the intervening 1,000 feet of granitic bedrock has low permeability and that ground water moves very slowly through these rocks.

2. The natural neutralizing capacity of the surrounding rock provides a safeguard against migration of acidic solution and harmful chemicals beyond the in situ mining zone. Laboratory tests by the U.S. Bureau of Mines demonstrate that, in the unlikely event that solution would migrate away from the in situ mining zone, the acidic solution would be neutralized and the chemical constituents that were dissolved from the rock would be precipitated from the solution and would again become part of the rock.

3. Solutions will be controlled within the in situ mining zone by pumping more solution from the recovery wells than will be injected. This causes solution to flow towards the recovery wells instead of away from them.

4. The injection and recovery wells have been constructed to prevent migration of in situ mining solutions to the overlying aquifer. The wells have two layers of casing--each cemented in place with an acid-resistant cement. Extensive tests have demonstrated the integrity of these wells.

5. Regular monitoring of ground water levels and ground water quality at the four monitor wells has shown no discernible effects in the overlying aquifer from test operations in the injection and recovery wellfield during five years of site testing.

6. The ground water monitor wells will provide a continual check on the operation of the in situ mining test.

In addition to the above, computer modeling has been used to project the maximum extent of migration of solutions. The results of this modeling confirm that acidic solutions will not migrate beyond the in situ mining zone.

Duration of the Research Project: The research plan calls for in situ mining to continue until sufficient data are collected to evaluate the mining technique. This time period is presently estimated to require 18 months to complete, but may extend for up to 4 years. Post-leach studies and facility decommissioning will require an additional period of time.

DRAFT
ENVIRONMENTAL ASSESSMENT
FOR THE
SANTA CRUZ IN SITU COPPER MINING RESEARCH PROJECT

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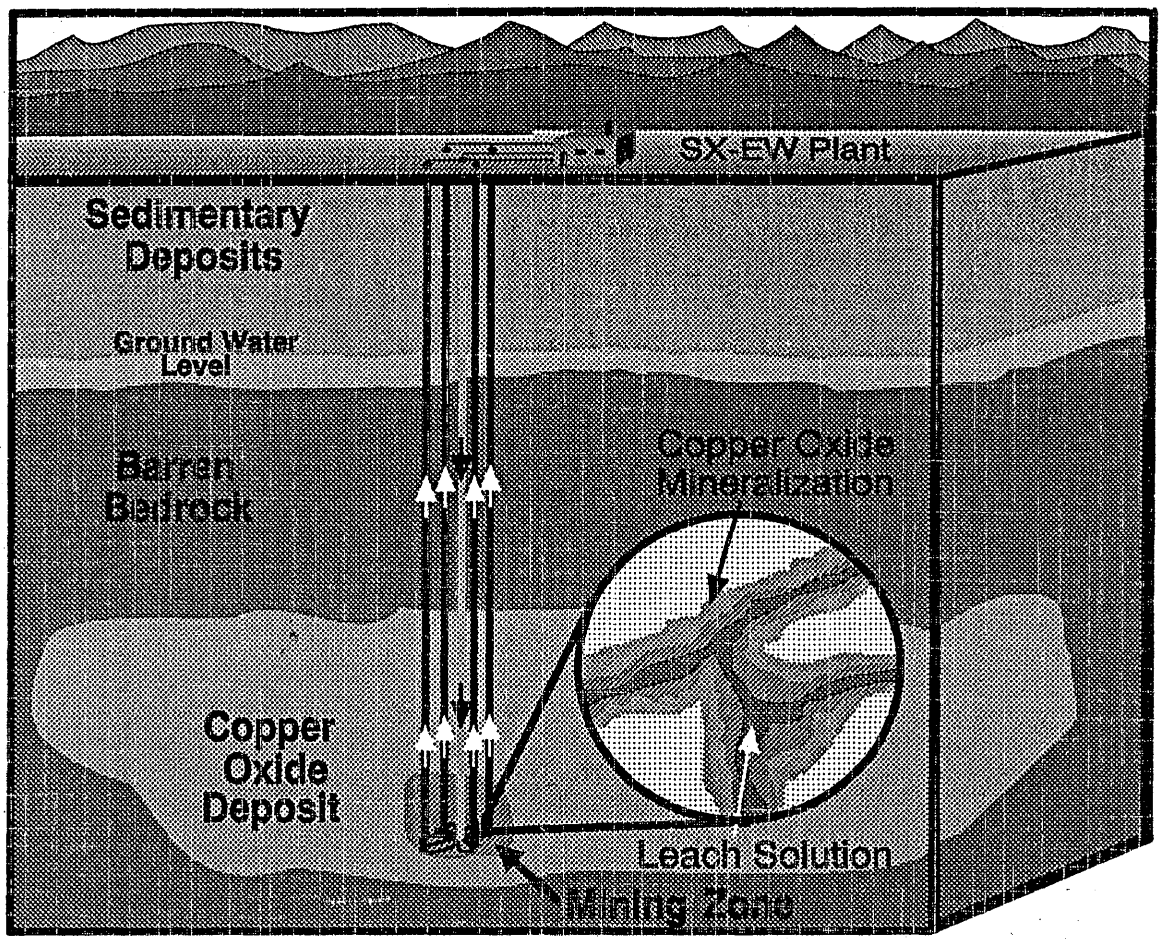

(NOT TO SCALE)

PREPARED BY

UNITED STATES BUREAU OF MINES
TWIN CITIES RESEARCH CENTER
MINNEAPOLIS, MN

AUGUST 25, 1994

CONTENTS

ILLUSTRATIONS

ACRONYMS USED IN THIS REPORT

ADEQ	Arizona Department of Environmental Quality
ADWR	Arizona Department of Water Resources
APP	Aquifer Protection Permit
AQCD	Air Quality Control District
BADCT	Best Available Demonstrated Control Technology
DIA	Discharge Impact Area
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-To-Know Act
FONSI	Finding of No Significant Impact
ID	Inside Diameter
NEPA	National Environmental Policy Act
R	Range
SCJV	Santa Cruz Joint Venture
SERC	State Emergency Response Commission
SHPO	State Historic Preservation Office
SX-EW	Solvent Extraction-Electrowinning
T	Township
TDS	Total Dissolved Solids
UIC	Underground Injection Control

DEFINITION OF TERMS

Bureau: U.S. Bureau of Mines.

Discharge Impact Area: The potential area extent of pollutant migration, as projected on the land surface, as the result of a discharge from a facility.

Mining Zone: The zone within the copper oxide deposit from which copper is extracted.

Project: Santa Cruz In Situ Copper Mining Research Project.

Santa Cruz Site: A 55-acre fenced area encompassing the test facility and adjacent land.

Study Area: A 9-square mile area which includes and surrounds the Santa Cruz site.

SX-EW Surface Facility: The SX-EW plant, associated evaporation and solution storage ponds, and ancillary facilities.

Test Facility: The well field, ground water monitor wells, an SX-EW surface facility, and associated land used for the Santa Cruz In Situ Copper Mining Research Project.

Test Site: The area encompassed by, and immediately adjacent to, the injection and recovery test well field.

Test Wells: The injection and recovery test wells.

Well Field: Injection and recovery test wells positioned in a five-spot pattern.

UNIT OF MEASURE ABBREVIATIONS

°F	degree Fahrenheit
ft	foot
ft/mi	foot per mile
gal	gallon
gal/min	gallon per minute
g/L	gram per liter
gal/d/ft	gallon per day per foot
gal/d/ft^2	gallon per day per square foot
in	inch
mD	millidarcy
mg/L	milligram per liter
pct	percent
ppm	part per million
psi	pound per square inch
st/yr	short ton per year
$\mu g/m^3$	microgram per cubic meter

1.0 CHAPTER I. INTRODUCTION

1.1 Purpose and Need for Analysis

The U.S. Bureau of Mines (Bureau), an agency within the Department of the Interior, conducts mining, minerals, and environmental-related research to ensure that the Nation has adequate mineral supplies to maintain national security, employment, and continued economic growth. One area of current Bureau research is the development of advanced mining system technologies. A research project is being conducted within the Bureau's Advanced Mining Systems program to evaluate the technical, economic, and environmental feasibility of removing copper from a copper oxide deposit without having to mine and remove large quantities of rock. The technology being investigated is an in-place mining method referred to as "in situ mining." In situ mining relies on a pattern of wells to inject and recover a solution which can selectively dissolve copper minerals from the host rock without substantially affecting or impacting the rock.

The Bureau and its cooperator, the Santa Cruz Joint Venture (SCJV), are evaluating the feasibility of in situ copper mining by conducting the "Santa Cruz In Situ Copper Mining Research Project (Project)." (The SCJV is a joint venture of ASARCO Santa Cruz, Inc., a wholly owned subsidiary of ASARCO Incorporated, and Freeport Copper Company, a wholly owned subsidiary of Freeport-McMoRan Incorporated. ASARCO Santa Cruz, Inc. is managing the Project under a cooperative agreement with the Bureau.) The Project constitutes the first in situ mining test to be conducted in the United States in an undisturbed, saturated, copper oxide-bearing crystalline rock, using wells drilled from land surface to inject and recover recycled leach solution.

The Project was initiated under direction of the U.S. Congress at a site located near Casa Grande, AZ. Congressional appropriation of funds to the Bureau supports 75 pct of the cost of the Project, while the SCJV contributes the remaining 25 pct. The SCJV, in addition to its financial contribution, is also providing the research site.

The Bureau is obligated under Section 102 (2)(C) of the National Environmental Policy Act (NEPA) to evaluate the significance of any anticipated environmental consequences which may result from conducting the Project. The evaluation was performed through this Environmental Assessment (EA) document. The purpose of the EA is to provide sufficient evidence and analysis for determining whether to prepare an Environmental Impact Statement (EIS) or a Finding of No Significant Impact (FONSI) for a Federal action. An EIS is prepared if the action is determined to have a significant impact on the human environment. A FONSI is prepared if an action will not have a significant impact on the human environment.

1.2 Description of In Situ Copper Mining

In situ mining of copper oxide minerals involves the introduction of a dilute sulfuric acid leach solution (a solution composed of between 1 and 5 pct sulfuric acid, and 99 and 95 pct water) through an injection well or wells into an ore zone which contains copper oxide minerals (fig. 1). Leach solution leaves the injection well through perforations in the well casing, migrates through fractures in the ore zone, and selectively dissolves the copper oxide minerals which it contacts. (The copper dissolution step is very similar to the physical process of water dissolving salt.) The copper combines with the sulfuric acid to form copper sulfate solution. Dissolution of the copper minerals results in removal of only a few percent of the total volume of the rock targeted for in situ mining.

The copper sulfate solution which results is drawn to recovery wells which surround the injection well. Solution moves toward the recovery wells as a result of the hydraulic gradient created by pumping of the recovery wells at a rate higher than the rate of injection. Copper-bearing solution is pumped from the recovery wells to a storage pond located on the surface and subsequently to a solvent extraction-electrowinning (SX-EW) plant. (SX-EW is a conventional copper solution processing technology which has been used by many Arizona copper producers since its first commercial application in 1968.) In the SX-EW plant, the copper sulfate solution is combined with an organic

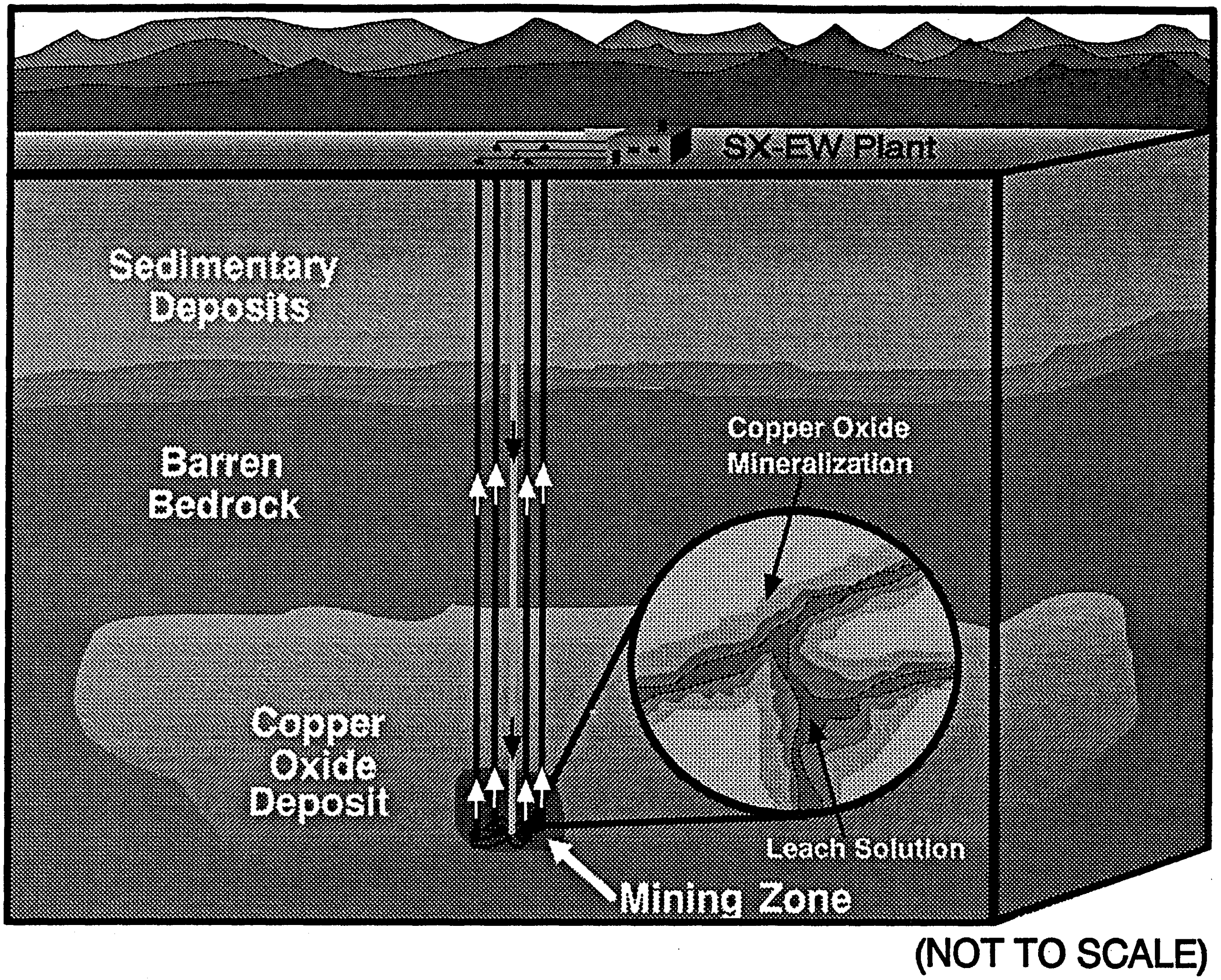

Figure 1. - In situ copper mining concept.

extractant which removes the copper from aqueous solution. The resulting copper-bearing organic solution is further processed to eventually produce sheets of pure copper. The solution which remains, now barren of copper, is reconditioned to its original acid strength and reinjected into the injection well to begin the process over again. Continuous recycling of the leach solution eliminates the need to consume large quantities of fresh water for leach solution make-up.

The only surface evidence of in situ copper mining are the well heads and pumping equipment associated with the injection and recovery test wells, and the SX-EW surface facility (the SX-EW plant, associated evaporation and solution storage ponds, and ancillary facilities). The advantages of in situ mining over conventional surface and underground mining methods include:

- <u>Lower production costs</u> because energy needs are reduced, ore extraction and crushing are eliminated, and labor requirements are reduced.

- <u>Better use of domestic resources</u> because metal is extracted from copper deposits which are small, deep, and/or low grade and uneconomical to mine using conventional methods.

- <u>Improved worker health and safety</u> because no haulage equipment operates on site, and mine employees are not exposed to underground mining hazards.

- <u>Less environmental disruption</u> because there is no need to create open pits or dispose of overburden and waste rock.

In situ mining is a relatively new technology. It has been commercially practiced since the mid-1970's in Texas and Wyoming (<u>1</u>)[1], and more recently in Nebraska, to produce uranium from permeable sandstone deposits at depths of about 300 to 600 ft and deeper. Copper, on the other hand, has been

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[1]Numbers underlined and in parentheses refer to the list of references at the end of this publication.

commercially produced by leaching oxide ores in block-caved zones of underground mines since the 1920's (2), and in more modern times, in surface heaps and dumps. Successful extraction of uranium using in situ mining methods, coupled with the demonstrated leachability of copper oxide ores, indicated the possibility of using this mining technique to recover copper from undisturbed deposits. The principal differences between in situ mining of copper and uranium are the geologic and hydrologic environments in which the minerals are located and the chemistry of the solution used during leaching.

In situ mining of copper oxides is actually the chemical reversal of the natural geologic process which formed the copper oxide deposit. Copper was originally deposited in the host rock as sulfide minerals. Over geologic time, exposure of the upper portion of the sulfide copper deposit to air and water produced sulfuric acid and copper sulfate solution. As this acidic, copper-bearing solution was neutralized by contact with the host rock, copper oxide minerals were formed. During in situ mining, the copper oxides are again exposed to a dilute acid solution to produce copper sulfate. In this case, however, the solution is collected by wells and pumped to the surface.

1.3 Project Location

The site selected for conducting the Project is referred to as the "Santa Cruz site." The site, a 55-acre area, is located about 7 miles west of Casa Grande, AZ, and 1-3/4 miles north of Arizona State Highway 84 (fig. 2). The legal description is the NW1/4 of the NE1/4, and NE1/4 of the NW1/4, Section 13, T6S, R4E (Gila and Salt River Baseline and Meridian), Pinal County, AZ. The site was selected by the Bureau for this research because the underlying copper oxide zone met stringent criteria for the type of copper mineralization, tonnage, depth, copper grade, undisturbed condition, and ore zone saturation. (The term "saturation" refers to ground water filling the void spaces in the rock.) The surface and mineral rights are owned in fee by the SCJV. Vehicular access to the Santa Cruz site from State Highway 84 is provided by gravel-surfaced county and private roads.

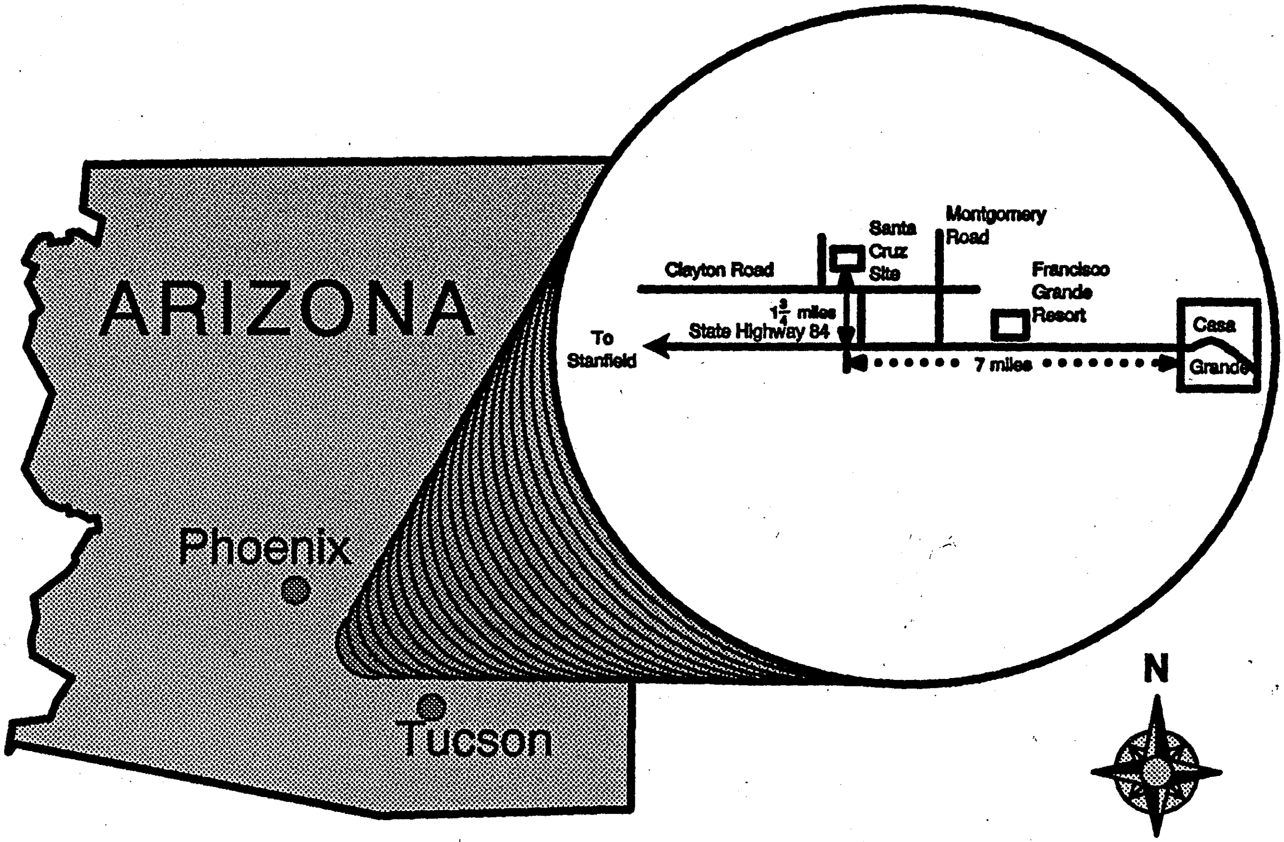

Figure 2. - Location of the Santa Cruz site.

The Santa Cruz site has not been disturbed by previous mining activity. The surface has been retired from agricultural production. The closest residential buildings are about 1 mile northeast of the site. A resort complex is located about 2-1/2 miles to the southeast.

1.4 Project Description

The Project will consist of using in situ mining methods to recover copper from a mineralized zone via test wells arranged in a single five-spot well pattern and processing the recovered copper-bearing solution on the surface in an SX-EW plant. Test wells to be used for the in situ mining test were originally installed on site in 1989 and were used for hydrological testing purposes. (See Appendix A for a complete description of hydrological testing activities performed on site.) This earlier testing was performed to evaluate the feasibility for conducting an in situ mining test. Data were obtained to define hydrogeologic conditions and site-specific geology at the Santa Cruz site. Completion of these characterization studies subsequently allowed the environmental aspects of an in situ mining test to be evaluated.

As many as four of the five test wells will be used to recover solution. These recovery wells are positioned in the shape of a square with side dimensions of 127 ft (fig. 3). The fifth well is located in the center of the square and will serve as the injection well. All test wells are completed to a depth of about 1,870 ft below land surface. The well casings are perforated in a 200-ft interval within the copper oxide zone from a depth of about 1,570 to 1,770 ft (fig. 4). Test wells are capable of delivering injection fluids to the mining zone (the zone within the copper oxide deposit from which copper is extracted) and have been extensively tested to assure well integrity. (See Appendix B for specific details on test well installation.)

During the in situ mining test, leach solution will be injected into the copper oxide zone and copper-bearing solution will be recovered through perforations in the test wells. The average leach solution injection rate will be about 25 gal/min. (Injection rates will range from 10 to 50 gal/min.)

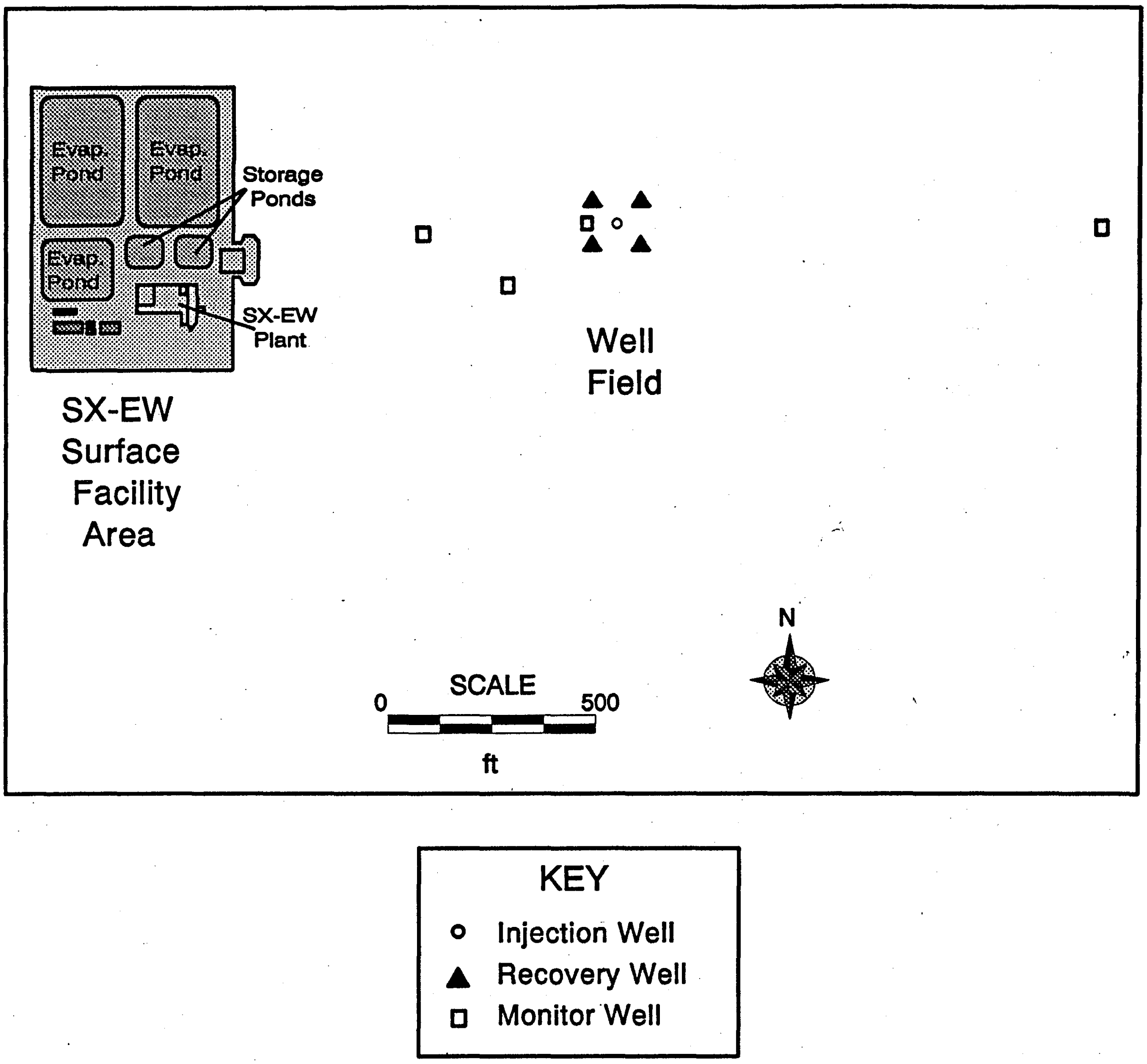

Figure 3. - Plan map of the Santa Cruz test facility.

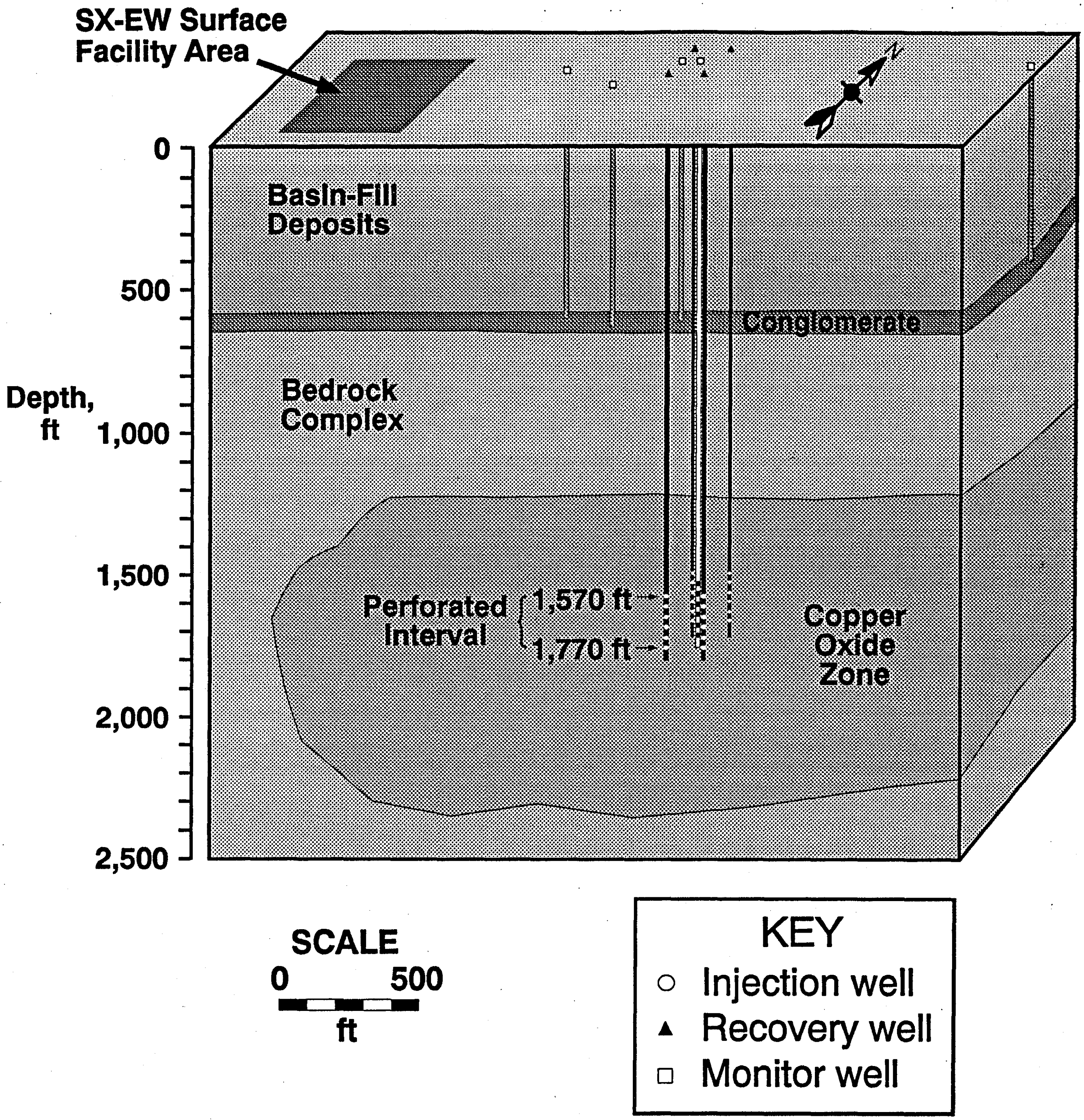

Figure 4. - Generalized well field diagram.

Approximately 4 pct more fluid than that injected will be pumped from the recovery wells in order to maintain the flow of fluid toward the recovery wells. The excess recovered solution will include water which occurs naturally in the rock. Excess recovered solution will be pumped to double-lined evaporation ponds in the SX-EW surface facility where the water will be allowed to evaporate. The evaporation ponds are designed for zero discharge.

The test well field is designed to provide the SX-EW plant with a solution feed averaging 25 gal/min. The plant has been designed to handle flowrates ranging from 10 to 55 gal/min. Concentration of copper in the leach solution is expected to range from 1 to 10 g/L. The plant is designed to produce a maximum of 1,000 st/yr of copper cathode. (For comparison purposes, a small commercial SX-EW plant at a heap leach operation may produce 20,000 st/yr or less of copper cathode, while a large commercial operation may produce over 100,000 st/yr.)

Ground water monitor wells have been installed to monitor any changes to water quality which might occur in the basin-fill deposits aquifer during the in situ mining test. Four ground water monitor wells are positioned proximal to the test wells as follows: 1) one up hydraulic gradient, 2) one within the pattern, and 3) two down hydraulic gradient. Ground water monitor wells are completed to a depth of about 640 ft.

Of the 55 acres encompassing the Santa Cruz site, the area occupied by the various components of the test facility (including well field, ground water monitor wells, and SX-EW surface facility) is 8-1/2 acres. Of the 8-1/2 acres, the well field occupies an area of only 1/3 acre.

The research plan calls for in situ mining to continue until sufficient data are collected to evaluate the mining technique. This time period is presently estimated to be 18 months, but it may extend for up to 4 years. Postleach studies (including obtaining drill core from the mining zone) and facility decommissioning will require an additional period of time.

The Project design is based upon information provided in the "Generic In Situ Copper Mine Design Manual" (3), field test designs developed under contract, and results of a comprehensive Bureau laboratory research effort. The draft manual contains a description of the specifications, designs, and environmental permitting procedures required for developing an in situ copper mine. The draft manual's generic approach allows flexibility in developing designs and costs for a wide range of deposit characteristics and operational parameters.

Initial fabrication of the SX-EW surface facility will require contract labor for short duration. Operation of the well field (the injection and recovery test wells arranged in a five-spot pattern) and SX-EW surface facility will require about 18 employees. The plant will be operated around-the-clock, 7 days/week, 365 days/year. Operating and maintenance teams will include foremen, mechanics/pipefitters, electricians/instrument technicians, solvent extraction/well field operators, and electrowinning operators. In addition, technical service contractors may be employed on site on an as-needed basis.

1.5 Project Goals

The goal of the Project is to determine the technical, economic, and environmental feasibility of in situ mining of copper oxide minerals. The Bureau believes that successful completion of this research will provide the domestic mining industry with a new, environmentally-compatible mining technology. In situ mining is not likely to replace conventional mining, but it may provide an environmentally feasible method to recover copper from copper oxide deposits which are not commercially attractive for conventional development. Specific data generated from the research will help to answer questions on such items as leaching efficiency, copper recovery, operating costs, and well pattern design and installation.

Once the Project is completed, all information will be made available to industry, academia, and the public. Results of the Project may lead to continuing research by others or an interest by industry to pursue commercial-scale in situ development of copper oxide deposits.

1.6 Environmental Permits, Authorizations, and Requirements

The SCJV is responsible for securing all environmental permits and authorizations required to conduct the Project. The SCJV will operate the Project in a manner consistent with all permit conditions assigned by the appropriate Federal, State, and local regulatory agencies. Required permits and authorizations are identified below:

1.6.1 Underground Injection Control

The U.S. Environmental Protection Agency (EPA) regulates all injection activities through the Underground Injection Control (UIC) program. Under this program, two different classifications apply to wells used for in situ mining. A Class III well designation applies to a well used in a commercial-scale in situ mining operation. A Class V well applies to a well used in experimental technologies.

The injection well to be used during the Project is considered a Class V well (subclass 5X-25). Class V experimental technology wells are defined by the EPA as "wells used in experimental or unproven technologies such as pilot-scale in situ solution mining wells in previously unmined areas." A Class V well authorization requires an operator to provide EPA with generalized inventory information for the injection well, along with any additional data that EPA may require. Required inventory information was provided to EPA on December 7 and 14, 1989. Verbal notification of the Class V well designation was made by EPA on December 21, 1989. Written confirmation was provided by EPA in correspondence dated March 1, 1993.

1.6.2 Aquifer Protection

The Arizona Revised Statutes require that an Aquifer Protection Permit (APP) be obtained by all new facilities that discharge or have the potential to discharge to an aquifer. These statutes are administered by the Arizona Department of Environmental Quality (ADEQ). Rules implementing Arizona Revised Statutes require a permit applicant to demonstrate that proposed operations will not result in violation of State aquifer water quality standards at a designated point of compliance. Statute identifies the injection well and surface impoundments as discharging facilities. The APP application must include information on facility design and operation; hydrogeologic characteristics of the site; a description of the Best Available Demonstrated Control Technology (BADCT) to be applied to eliminate or minimize discharge from the facility; and identification of proposed alert levels, discharge limitations, monitoring requirements, contingency plans, and closure and postclosure plans.

The APP application was submitted to ADEQ in May 1992. A public notice of ADEQ's preliminary decision to issue the permit was recently published in local newspapers. The purpose of ADEQ public notice is to notify the public that approval of a permit action is pending and that public comment will be accepted on the proposed action.

1.6.3 Water Use

The Santa Cruz site occurs within the Pinal Active Management Area, a ground water basin managed by the Arizona Department of Water Resources (ADWR). The ADWR regulates all well drilling, well construction and abandonment, hydrologic testing, and withdrawal of ground water occurring within this basin. Authorization to construct Project wells and boreholes and approval to conduct hydrologic testing were obtained from ADWR during earlier site work. All wells were drilled under supervision of a certified well driller. On March 14, 1989, ADWR issued a 10-year permit to construct three test wells for mineral extraction and metallurgical processing and to withdraw up to 100 acre-ft/year of ground water from these wells. The mineral extraction water use permit was granted under the condition that SCJV obtain an APP permit from ADEQ before beginning ground water withdrawal. On September 12, 1989, ADWR issued a permit to construct two additional test wells and to pump 50 acre-ft/year from each of these wells.

1.6.4 Air Quality

Regulation of air quality standards applicable to Project surface activities has been delegated to Pinal County (Arizona) Air Quality Control District (AQCD) by the State. Installation and operating permits are required. Applicable regulations cover fugitive dust generated by site activities; loss of volatile organic compounds from a gasoline storage tank and the solvent extraction process; and sulfuric acid mist from the electrowinning facility. The SCJV will obtain required air quality permits prior to construction and operation of the SX-EW surface facility.

1.6.5 Land Use

The Santa Cruz site and surrounding area are zoned general rural according to Pinal County zoning ordinances. Arizona Revised Statutes Title 11-830, which applies to mining states, "Nothing contained in any ordinance authorized by this chapter shall prevent, restrict, or otherwise regulate the use or occupation of land improvements for railroad, mining, metallurgical, grazing, or general agricultural purposes if the tract is five or more contiguous commercial acres." The Project is a mining operation and is located on a tract of land greater than five commercial acres. Therefore, the Project is exempt from county zoning ordinances. The anticipated land use for the Santa Cruz site in the future is mining of the Santa Cruz copper deposit.

1.6.6 Mine Safety

The office of the Arizona State Mine Inspector requires notification of proposed mining activities. Notice was provided to this office in 1989 during the site characterization stage of the Project.

1.6.7 Storm Water Discharge

A group application filed under the National Pollutant Discharge Elimination System covering storm water discharge from the Santa Cruz site was filed with EPA on September 30, 1991.

1.6.8 Solid Waste

Solid Waste Facility notification was filed with ADEQ on October 1, 1991.

1.6.9 Hazardous Substances

Section 302 of the Emergency Planning and Community Right-To-Know Act (EPCRA) will require notification of the State Emergency Response Commission (SERC) and the local emergency planning committee of the on-site presence of sulfuric acid and other chemical reagents considered "extremely hazardous substances." EPCRA contains specific provisions which require reporting of the existence of such hazardous chemicals, any subsequent release of those hazardous chemicals, and the preparation of an individual facility emergency response plan. Also, all vendors delivering sulfuric acid and reagents to the Santa Cruz site will be responsible for complying with requirements of the Federal Hazardous Materials Transportation and Uniform Safety Act.

1.7 Scope of the Environmental Analysis

The proposed action to be evaluated is the in situ mining of copper from a copper oxide zone, and the fabrication and operation of a pilot-scale, SX-EW facility to remove the copper from solution. The SX-EW facility to be assembled and used for solution processing will be a small-scale version of a commercial facility.

The Bureau prepared this EA to analyze probable, site-specific impacts to the human environment that could result from conducting the Project. In order to perform the analysis of impacts, certain assumptions concerning this Federal action were necessary. A complete listing of the assumptions applied to the analysis have been included in the introduction to Chapter IV. These assumptions are for the purpose of this analysis only and are not intended to apply to future mining research activities conducted by the Bureau or to any future activities which may occur at the Santa Cruz site or any other site, other than the Project being discussed in this EA.

It is beyond the scope of this EA to speculate on specific environmental effects of a future, commercial-scale in situ mining operation at the Santa Cruz site since no specific design exists and the likelihood of commercial development is highly speculative at this time. Similarly, cumulative impacts resulting from future mine development activities will not be addressed in this EA. Upon completion of the Project, the Bureau's commitment to, and involvement at, the Santa Cruz site will end. At that point, the SCJV, as surface and mineral owner, may independently decide to pursue commercial in situ copper mine development. Commercial development will not, however, be an immediate result of the Project.

1.8 Environmental Issues and Concerns

Several topics addressing potential impacts of the Project were identified during a July 25, 1990 scoping meeting attended by local residents; representatives of Federal, State, and local government agencies; and others.

(See Chapter V for a complete description of the public participation process.) The issues and concerns which were identified as a result of that meeting serve as the principal elements of the environmental consequences discussion of Chapter IV. These include:

Hydrology: Impacts to ground water quality and quantity in the basin-fill deposits aquifer as a result of in situ mining and processing of recovered leach solution in an SX-EW surface facility. (The basin-fill deposits aquifer is used for irrigation, domestic, and industrial water supply and is the main water-bearing unit which overlies the mining zone.)

Topography and Land Use: Impacts to land surface as a result of fabrication and operation of the test facility.

Wildlife: Impacts to wildlife and threatened and endangered species which may inhabit the area.

Air Quality: Impacts from potentially increased particulate levels resulting from surface development activities, vehicular traffic along gravel-surfaced roads, and emissions from the SX-EW surface facility.

Health and Safety: Impacts to human health and safety as a result of transportation and handling of hazardous materials.

Cultural Resources: Impacts to previously undiscovered historic and prehistoric sites within the Santa Cruz site.

Socioeconomics: Impacts to employment and local community resources.

2.0 CHAPTER II. ALTERNATIVES

An important component of NEPA is the analysis of possible alternatives to the proposed action. The purpose of the alternative analysis is to provide a clear basis for choice among various available options.

Alternatives considered in preparing this EA were (1) conducting the Project as proposed, (2) taking no action, (3) selecting another location for conducting the Project, (4) selecting a different mining technique and solution processing method, and (5) selecting a different leach solution. This chapter contains summary points addressing each alternative. Of these alternatives, only the first two were selected for evaluation in this EA. The analysis performed in this EA document is responsive to the environmental issues and concerns identified in Chapter I. Impacts associated with the options of conducting or not conducting the proposed action are discussed in detail in Chapter IV.

2.1 Alternatives Considered in Detail

2.1.1 Alternative No. 1 - The Proposed Action

Under this alternative, in situ mining would be used to remove copper from the Santa Cruz deposit and a SX-EW surface facility would be fabricated and operated to recover copper from solution. Approval of this alternative would allow activities proposed under the Project to proceed. Commencement of activities would be subject to approval of all required Federal, State, and local environmental authorizations and permits, and compliance with all permit conditions and stipulations.

2.1.2 Alternative No. 2 - No Action

Under this alternative, leach solution would not be injected into the deposit to remove copper and a SX-EW facility would not be built on the surface at the

Santa Cruz site. The "no action" alternative, as defined, allows comparison of the consequences associated with conducting or not conducting the Project.

2.2 Other Alternatives Considered, but Eliminated from Further Study

2.2.1 Selection of an Alternative Location

Specific Bureau site selection criteria included type of copper mineralization, tonnage, depth, copper grade, undisturbed condition, and ore zone saturation. The Santa Cruz site met all of these criteria. Further, the U.S. Congress stipulated that the Project be conducted near Casa Grande, AZ (Public Law 95-224). Selection of an alternate location for conducting this research is, therefore, not necessary.

2.2.2 Selection of an Alternative Copper Mining Technique and Processing Method

Selection of a mining method other than in situ mining to extract copper from a deposit would be contrary to the intent of the Congress. The purpose of the Project, as mandated by the Congress, is to evaluate the technical, economic, and environmental feasibility of in situ copper mining. Any deviation from in situ copper mining would not be consistent with Congressional intent.

Alternative techniques to the SX-EW process for removing copper from copper-bearing leach solution are not considered practical or necessary. SX-EW is a conventional technology which is employed at many copper mines in the southwest United States. SX-EW processing of copper-bearing solutions is an efficient, economical, and environmentally compatible processing method that has found wide acceptance by industry and regulatory agencies. The wastes requiring disposal that result from this solution processing method are minimal. Wastes which do result are disposed of in accordance with applicable environmental requirements. Selection of an alternative to the SX-EW process is not a practical option of this Project.

2.2.3 Selection of an Alternative Leach Solution

The majority of Bureau laboratory testing performed to date on copper oxide minerals has utilized a dilute sulfuric acid leaching system. Selection of dilute sulfuric acid as the leaching agent of choice is based upon a number of factors. First, sulfuric acid has been commercially proven for its ability to leach copper oxide minerals from heaps and dumps at many mining locations in the Southwest United States. Second, sulfuric acid is economical, easily available, and effective for use with the SX-EW solution processing method. Third, the chemistry of acid leaching is a well understood process.

The option of using an ammonia leach system as a potentially less corrosive leach solution has been suggested. An ammonia leach system for eventual use for in situ copper mining would require an extensive, long-term Bureau laboratory program to gather data on leaching chemistry, solution processing, and environmental considerations. The expected high cost and limited availability of ammonia would also be a prime consideration because of economic implications. This alternative is not presently available using current technology and, therefore, has been dropped from further consideration.

3.0 CHAPTER III. DESCRIPTION OF THE EXISTING ENVIRONMENT

3.1 Geology and Hydrology

(The following information on hydrology and geology was obtained primarily from the APP application (4).)

The Santa Cruz site lies within the Basin and Range physiographic province of southern Arizona. The Sacaton Mountains and Casa Grande Mountains are located 7 miles to the northeast and 12 miles to the southeast of the Santa Cruz site, respectively. The Silver Reef Mountains are located 14 miles to the south. The Santa Cruz site is located in the Casa Grande basin, west of the Casa Grande ridge. The Casa Grande ridge is a north-south trending subsurface ridge of granitic and metamorphic rocks of the bedrock complex (5). The ridge is located immediately west of the city of Casa Grande. The surface of the bedrock complex slopes generally to the west from the Casa Grande ridge to deeper parts of the basin, located several miles west of the Santa Cruz site. The bedrock complex is overlain by tilted conglomerate strata of Tertiary age, a thick sequence of basin-fill deposits of Quaternary and Tertiary age, and thin deposits of recent alluvium. Hydrogeologic conditions in western Pinal County have been described by Hardt and Cattany (5) and Wickham and Corkhill (6).

Evidence of faulting is recognized in all geologic units below the basin-fill deposits. Faulting in the area predates and postdates the Laramide hydrothermal mineralization event which formed the copper sulfide mineralization at the Santa Cruz site. Premineralization faulting is believed to be of minor importance in the understanding of hydrogeologic conditions in the area because zones of broken rock associated with this faulting often have been altered and mineralized, making these zones hydrologically more like the adjacent wall rock. Postmineralization faulting may have zones of associated clay gouge, which impede movement of ground water and leach solutions, and/or zones of brecciated and fractured rock with greater permeability than surrounding wall rock, which enhance movement of ground water and leach solutions. Postmineralization faulting also affects the configuration of bedrock surface and the attitude of bedding planes in strata older than basin-fill deposits.

3.1.1 Basin-Fill Deposits

The basin-fill deposits constitute the main storage reservoir for ground water in western Pinal County, AZ. Figure 5 shows the basin-fill deposits at the Santa Cruz site extending from the surface to a depth of 600 ft. The basin-fill deposits are composed of: in descending order, an upper alluvium unit, a silt and clay unit, and a lower sand and gravel unit (5). The upper alluvium unit is principally nonlithified sand and gravel with some local interbeds of silt and clay. The silt and clay unit consists of interbedded clay, silt, silty sand, and gravel strata. The lower sand and gravel unit consists of a sequence of heterogeneous deposits of weakly lithified, coarse clastic materials.

Ground water level in the basin-fill deposits presently occurs at about 490 ft below land surface in the lower sand and gravel unit. This compares with historic water levels during the 1920's, which occurred in the upper alluvium within 100 ft of the land surface. The significant decline of the ground water level is the result of many decades of irrigation pumping.
The general direction of ground water movement in the basin-fill deposits is to the west. The hydraulic gradient is about 115 ft/mi. Most of the current water production in the basin-fill deposits originates from wells which penetrate the lower sand and gravel unit. Large-capacity wells completed in this unit are capable of producing upwards of 1,000 gal/min.

Ground water samples collected from wells located at the Santa Cruz site indicate the dominant cations to be calcium and sodium. The dominant anions are sulfate and chloride. Total dissolved solids (TDS) range between approximately 1,500 and 2,000 mg/L. The concentration levels of TDS, sulfate, and chloride exceed Federal secondary drinking water standards. Nitrate levels are elevated and occasionally exceed primary drinking water standards.

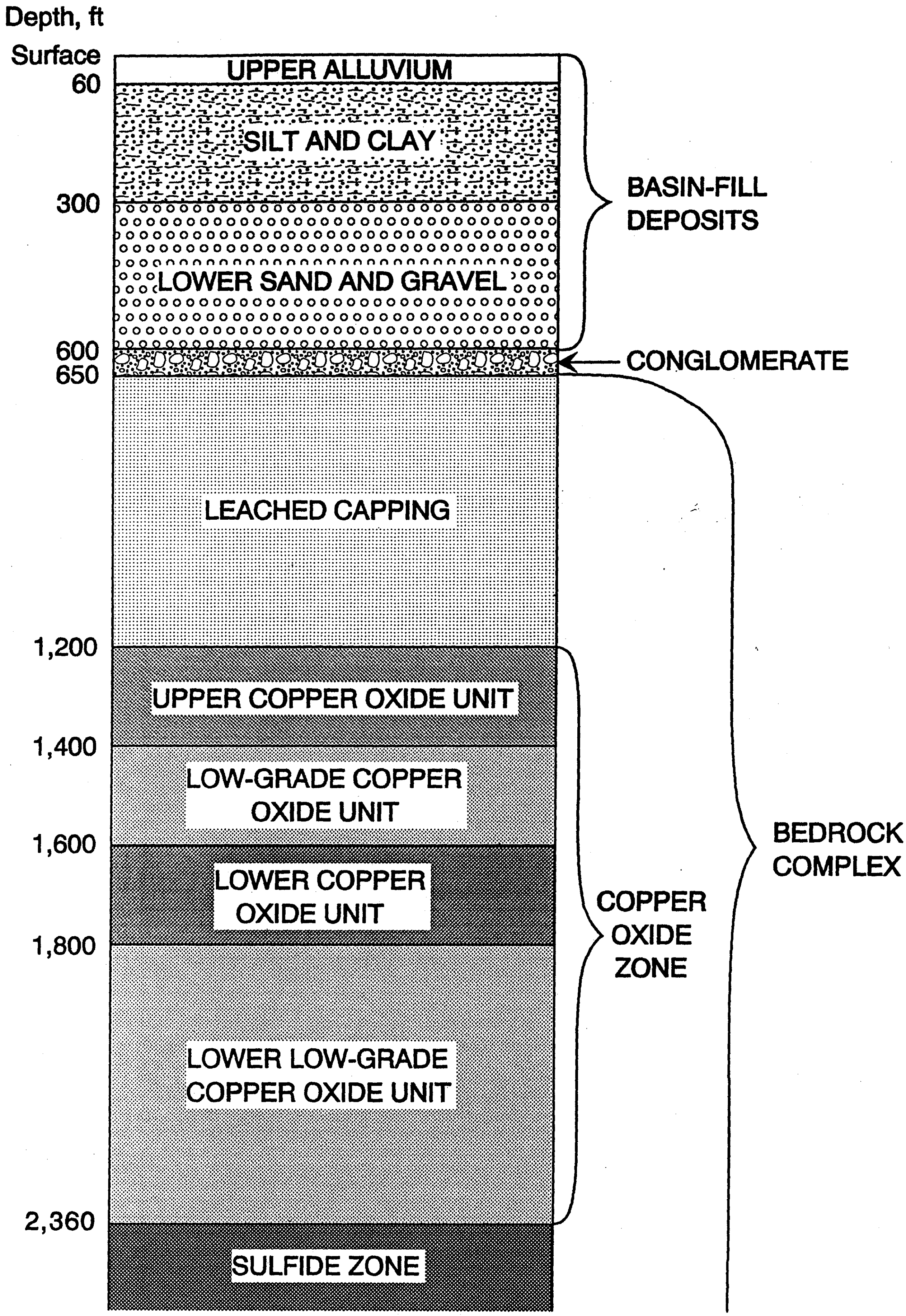

Figure 5. - Generalized stratigraphic column at the Santa Cruz site.

Transmissivity computed from pumping tests conducted at wells in the project area ranges from about 26,000 to 80,000 gal/d/ft. Based upon a saturated thickness of 83 ft, data collected from the Santa Cruz site indicate the average hydraulic conductivity of the basin-fill deposits aquifer to be about 700 gal/d/ft^2. ADWR reports a regional hydraulic conductivity ranging between 4 and 998 gal/d/ft^2 (6). The estimated specific yield for the lower sand and gravel unit at the Santa Cruz site is about 0.10.

Available well records indicate that, excluding wells completed for the Project, more than 40 active, unused, or destroyed water wells are within a 9-square-mile area around the site (hereafter referred to as the "study area"). These wells were originally constructed to provide water from the basin-fill deposits and the upper part of the conglomerate for irrigation, commercial, domestic, and industrial uses. Of these wells, six are currently being used for irrigation, three are for domestic use, two provide a commercial water supply, two are active industrial water wells, and four were used between 1977 and 1981 as industrial test wells (three of the four are currently being used for irrigation). The majority of wells (active and inactive) are on property owned by the SCJV. No active production water wells are closer than 2,000 ft from the Santa Cruz site. In addition to the water wells, there are 25 piezometers within the study area. Piezometers are used for monitoring change in ground water levels. Most of the piezometers were originally constructed as mineral exploration boreholes and were later converted to measure water levels in the basin-fill deposits.

3.1.2 Conglomerate

A moderately to well-consolidated conglomerate unit consisting of clays, sands, and gravels occurs beneath the basin-fill deposits (fig. 5). Thickness of this unit ranges from 50 ft at the Santa Cruz site to over 800 ft approximately 1/2 mile away. In general, this unit has low permeability. However, it is capable of yielding small to moderate amounts of ground water where the unit is poorly consolidated or well fractured. Results of step-discharge tests performed on an existing water well located 1/2 mile southeast of the Santa Cruz site indicate that the conglomerate is not a major water-yielding unit in this area. Water injection testing, performed in boreholes completed in conglomerate approximately 3/4 mile south of the site, indicates an average hydraulic conductivity of about 0.1 gal/d/ft^2 and permeability of about 5 mD. Potential yields from wells and permeability in the conglomerate may, however, be significantly greater in those locations where the unit is weakly consolidated or well fractured. As an example, a pumping test conducted in a water well located about 1/2 mile west of the Santa Cruz site and perforated chiefly in the upper part of the conglomerate indicated a transmissivity of approximately 55,000 gal/d/ft.

3.1.3 Bedrock Complex

Available data indicate that 147 mineral exploration core holes were completed into bedrock throughout the study area between 1964 and 1989. All but four are on land presently owned by the SCJV. The average completed depth of the core holes is about 2,750 ft.

At the Santa Cruz site, the granitic bedrock complex underlies the conglomerate and is informally classified in descending order as leached capping, copper oxide zone, and sulfide zone (fig. 5). At the Santa Cruz site, leached capping extends for about 550 ft from the base of the conglomerate to the top of the copper oxide zone (650 to 1,200 ft below the land surface). The principal rock type in this unit is Precambrian Oracle granite. Quartz monzonite porphyry, dacite porphyry, and diabase also occur in the leached capping (7). The rocks in this unit are weathered, fractured, and locally brecciated. Clay minerals and sericite often have replaced the rock-forming minerals biotite and plagioclase and some of the orthoclase via hydrothermal alteration and weathering. Clay minerals and sericite locally fill the fractures and pore spaces, significantly reducing the permeability of the rock mass. Copper minerals, which formerly occurred in the leached capping, were naturally leached out over geologic time leaving behind only trace amounts of copper in this unit. Inspection of records for water wells in the study area indicates that leached capping is rarely penetrated by water wells and is not known to yield substantial amounts of ground water (8). However, in locations where highly fractured, the unit is capable of yielding small amounts of ground water. Hydrologic testing performed at the Santa Cruz site in a hydrologic characterization well completed in the leached capping indicated a range in calculated transmissivities from about 1,100 to 1,500 gal/d/ft. Hydraulic conductivity for the tested interval is about 4.4 gal/d/ft^2. Testing also indicated that permeability of this unit decreased substantially with depth (9). Total dissolved solids content of the ground water in the leached capping ranges between 600 and 700 mg/L.

The copper oxide zone occurs beneath the leached capping and contains four separate units as shown in figure 5. At the Santa Cruz site, the copper oxide zone extends from 1,200 to 2,360 ft below the surface. The principal rock type is Precambrian Oracle granite. Minor amounts of Precambrian diabase and Laramide Quartz monzonite porphyry also occur in the zone. As with the leached capping, clay minerals and sericite have often replaced the principal rock-forming minerals, reducing the permeability of the rock. The grade and mineralization of the copper ore differs between the upper and lower copper oxide units. In the upper unit, the copper minerals chrysocolla (copper silicate) and atacamite (copper chloride) fill moderately to steeply dipping fractures, and copper grade ranges from 0.5 to 0.8 pct. In the lower unit, atacamite fills a stockwork of microfractures, with copper grade ranging between 1 and 3 pct. A review of water well records from this area does not indicate that any water wells penetrate the copper oxide zone.

Although saturated, the copper oxide zone is not known to yield substantial amounts of water. However, in locations where the rock is fractured, the zone is capable of yielding small amounts of water. Ground water samples collected from test wells at the Santa Cruz site which penetrate this zone contain total dissolved solids concentrations ranging from 800 to 1,420 mg/L. Undisturbed hydraulic gradient in the copper oxide zone is believed to be essentially flat. Ground water level measurements in the test wells have indicated a maximum hydraulic gradient of 3.7 ft/mi to the south, for the zone.

The sulfide zone underlies the copper oxide zone at a depth of 2,360 ft below the land surface. The most abundant rock type is Precambrian granite. The sulfide zone contains substantial amounts of copper and/or iron sulfide minerals. Total sulfide mineral content may be as much as 6 pct (7).

3.2 Topography and Land Use

The topography at the Santa Cruz site is essentially flat-lying with a downward gradient of about 10 ft/mi to the northwest. Land surface elevation at the test site is about 1,312 ft above mean sea level. Basin characteristics and availability of relatively shallow ground water, historically, made this region one of the most highly developed agricultural areas in the State. Over the years, declining ground water levels have caused the retirement of certain tracts of agricultural land within this area. One of the retired tracts of land includes the Santa Cruz site (fig. 6). The total area of retired agricultural land in the study area is greater than 4 square miles in size. Currently, the only evidence of past farming activities in the retired agricultural land area is the presence of (nonfunctioning) concrete irrigation canals. The closest active farming area is more than 1/4 mile west of the Santa Cruz site. The closest residential buildings are nearly 1 mile northeast of the site. A resort complex is located about 2-1/2 miles to the southeast.

The substantial withdrawal of ground water over the years from irrigation pumping has resulted in localized settling of the surface and formation of cracks within certain areas of this agricultural basin. Subsidence features resulting from ground water pumping are not evident within the Santa Cruz site or in the immediate vicinity. An irrigation well completed through the basin-fill deposits and located approximately 2,200 ft to the southeast of the test site has not exhibited any subsidence effects during the past 15 years of operation.

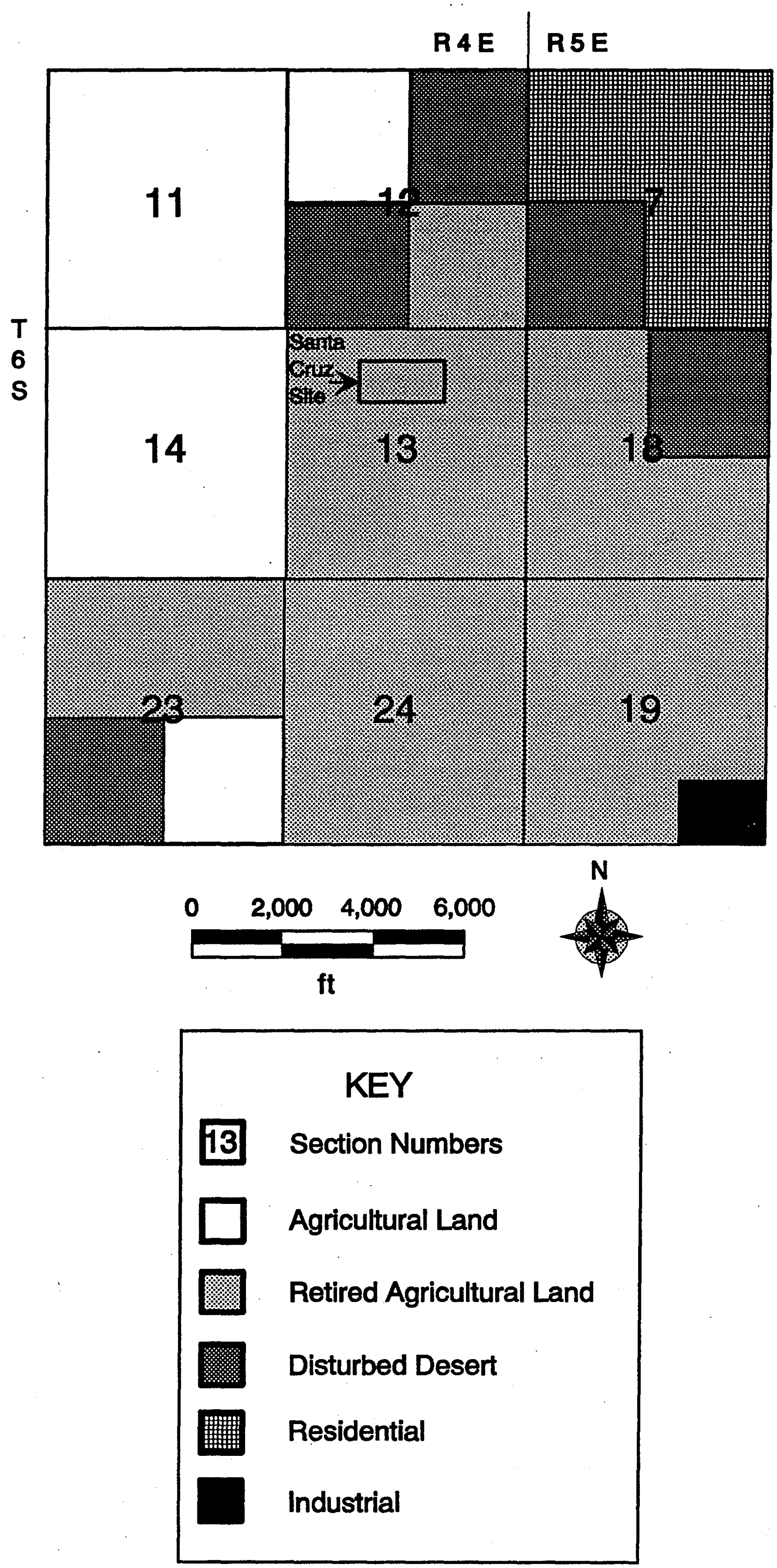

Figure 6. - Land use in the vicinity of the Santa Cruz site.

No impoundments, wetlands, streams, washes, or other surface water conveyances occur directly on the test facility. The most prominent surface water feature within the study area is the Santa Cruz Wash. The Santa Cruz Wash is located about 3/4 mile northeast of the Santa Cruz site (the area encompassed by, and immediately adjacent to, the injection and recovery test well field) and flows to the northwest. The principal tributary to the Santa Cruz Wash is the North Branch of the Santa Cruz Wash, which joins it approximately 2 miles to the north of the site. The Santa Cruz Wash trends northwest approximately 30 miles to its confluence with the Gila River. In the vicinity of the study area, the Santa Cruz Wash has been artificially channeled to contain flow. No large reservoirs have been constructed on the Santa Cruz Wash in the vicinity of the study area. The Santa Cruz Wash is an ephemeral stream channel which primarily carries runoff resulting from thunderstorms, which occur chiefly in July, August, and September.

The Santa Cruz Wash and adjacent areas are prone to mild flooding during heavy precipitation events. The Pinal County (Arizona) Planning and Zoning Department uses the Flood Insurance Rate Map prepared by the Federal Emergency Management Agency to evaluate potential flood impact for lands which occur in Pinal County. Community Panel Number 04007 0700D which was revised March 5, 1990, shows the Santa Cruz site is in Zone C which is defined as areas of minimal flooding or areas that are affected by a greater than a 500-year storm event (10).

Aerial photographs show that the Santa Cruz site was subject to minimal flooding during a storm event which occurred in October 1983. Because of this history, the SX-EW surface facility and the test wells will be placed on an earthen pad approximately 3 ft above the surrounding land surface. Construction of the Central Arizona Project canal system and other construction that has been completed since 1983 will divert floodwater of the Santa Cruz Wash away from the Santa Cruz site.

The U.S. Army Corps of Engineers has determined that the test facility is located outside of the ordinary high-water mark of the Santa Cruz Wash, and therefore "jurisdictional waters of the United States" regulated by Section

404 of the Clean Water Act do not occur within Section 13, T6S, R4E (11). (Section 404 of the Clean Water Act applies to wetlands protection.)

3.3 Wildlife

The Santa Cruz site contains very limited cover, food, and water for wildlife use. Vegetative cover on the surface of the retired agricultural land results from volunteer grasses, sedges, and forbs. Cover will increase during growing seasons with above-average moisture. Major soils associated with Section 13, T6S, R4E, Pinal County, are Mohall sandy loam, Denure fine sandy loam, and Gadsen clay (12). The nearest suitable wildlife habitat is bottomland area in the vicinity of the Santa Cruz Wash located approximately 3/4 mile northeast of the site. The Santa Cruz site is occasionally visited by birds and small animals.

The Bureau consulted with the U.S. Fish and Wildlife Service and Arizona Game and Fish Department concerning the potential presence of any species proposed to be listed on Federal or State lists of endangered or threatened species, or the presence of designated critical habitats which may occur within the Santa Cruz site and surrounding area. Records indicate that no listed or proposed species or designated critical habitats occur within this area.

3.4 Climate and Air Quality

The Santa Cruz site is located in the upper Sonoran Desert of central Arizona. Recent climatological data for Casa Grande, AZ, obtained from the Laboratory of Climatology at the University of Arizona, indicate average daily minimum and maximum temperatures of 34°F and 66°F in January, and 76°F and 107°F in July. The highest recorded temperature was 119°F on June 26, 1979. An average year has 108 days with maximum temperatures equal to or greater than 100°F. June, July, and August account for 72 pct of these days. An average year has 32 days with minimum temperatures less than or equal to 32°F. December and January account for 69 pct of these days.

Also from the Laboratory of Climatology study, average annual precipitation is 8.4 in. The winter months (December through March) account for 39 pct of the precipitation. July, August, and September account for 40 pct of the precipitation. During these three summer months, known as the "monsoon season," moisture of tropical origin enters the State from the south. Monsoon storms are accompanied by blowing dust, lightning, and quick, fierce downpours. Throughout most of the year, surface winds are light to moderate. The 100-year, 24-hour storm event for the Santa Cruz test facility is 4.6 in. of rainfall (13). Mean annual lake evaporation for the area encompassing the test facility is between 70 and 72 in. per year (14).

Fugitive dust affects air quality in the Casa Grande area. Agricultural practices create the potential for wind erosion and the contribution of significant amounts of dust to the air, as does natural desert. Vehicular use of graveled-surface roads is also a significant contributor of airborne dust.

3.5 Health and Safety

Human health and safety issues related to the Project are the same as those encountered in any industrial setting. Health and safety requirements of either the Mine Safety and Health Administration or the Occupational Safety and Health Administration apply.

In addition, sulfuric acid will be transported to the Santa Cruz site for use during in situ mining. The source of the acid will be one of four acid plants located in southern Arizona. Requirements of the Federal Hazardous Materials Transportation and Uniform Safety Act will apply to the transportation of acid and other reagents to the Santa Cruz site.

3.6 Cultural Resources

The Arizona State Parks, State Historic Preservation Office (SHPO) was contacted regarding the presence of known historic or cultural resources within and adjacent to the area encompassing the test facility. The SHPO has not identified any National Register-eligible Hohokam sites within the 55-acre Santa Cruz site. The Bureau has informed SHPO of limited ground disturbance activities proposed to occur at the Santa Cruz site. The SHPO has indicated that these limited activities should have no effect on any presently undiscovered National Register or eligible properties.

3.7 Socioeconomics

Casa Grande, AZ, the largest city in Pinal County, is located 7 miles east of the Santa Cruz site. The estimated population of the city in 1991 was 20,000 and 25,419 within an 11-mile radius (15). The population of Casa Grande itself is expected to grow to 22,500 by 1995. The average unemployment rate in Casa Grande is 7.0 pct, while in Pinal County the rate is 8.7 pct. The city has its own law enforcement and fire protection services, and a new 105-bed regional hospital. A local community college provides job skills training and has 2-year associate degree programs. Winter visitors contribute to the seasonal population and local economy.

Since the 1960's, the local economy has expanded from a mining and agricultural-based economy to a more balanced one including manufacturing, retail trade, government, and tourism. The community has been successful at attracting small and medium-sized manufacturing plants. A strong manufacturing base is provided by 12 principal companies. An available labor pool has made industrial opportunities and expansion attractive to manufacturers. From the 1980 census, 12.8 pct of the available workforce was employed in manufacturing; 5.5 pct in agriculture; and 7.1 pct in mining. Until 1984, ASARCO Incorporated operated the Sacaton mine, a large open-pit copper mine located 4 miles northwest of the city.

4.0 CHAPTER IV. ENVIRONMENTAL CONSEQUENCES

This chapter contains the Bureau's analysis of the probable impacts which would result to the human environment from conducting the Project. The "human environment" is defined as the natural and physical environment and the relationship of people with that environment. The natural and physical environment includes such features as plant and animal communities and the cultural significance of an area where an action is proposed to occur.

4.1 Assumptions for the Impact Analysis

In order to perform the impact analysis, certain assumptions were made concerning the Federal action. These assumptions are as follows:

4.1.1 Alternative No. 1 - The Proposed Action

- Site disturbance activities will occur with fabrication of the SX-EW surface facility.

- The Project will comply with all regulatory requirements, performance standards, permits and permit conditions required or otherwise assigned by Federal, State, and local governmental agencies.

- Existing test wells will be converted to acid injection and solution recovery wells for the purpose of conducting the in situ mining test.

- A dilute sulfuric acid solution will be injected into the mining zone and the resulting copper-bearing solution will be recovered in the recovery wells.

- All copper in situ mining and solution-processing activities will be confined to the Santa Cruz site.

- Unforeseen circumstances may require replacement of one or more of the test wells. If replacement is required, the new well would be installed within 50 ft of the well to be replaced.

- Copper recovery from the copper oxide zone will be restricted to the area of influence of a single five-spot well pattern.

- Upon completion of the Project, the test facility will be closed in accordance with a plan submitted to, and approved by, ADEQ. Upon completion of closure and postclosure activities, Bureau involvement in the Project will terminate. Upon termination of the Project, all future activities conducted at the test facility will be the sole responsibility of the SCJV, the owner of the surface and mineral rights.

- The U.S. Congress will continue to appropriate funding to the Bureau to support the Project through to completion.

- The SCJV will continue its involvement and financial commitment to the Project.

- Labor difficulties, equipment shortages, delays in contractor support or services, or other delays, will not significantly affect proposed or scheduled activities.

- Postleach evaluation of the copper oxide deposit via core hole drilling may occur following completion of in situ mining.

- Due to the research nature of the Project, a specific time period for operation, postleach evaluation, and closure can only be estimated. In situ mining is presently estimated to require 18 months to complete, but it may extend for up to 4 years. Following in situ mining, additional time will be required for subsequent postleach evaluation and other activities.

- All ponds and impoundments located on site as a component of the SX-EW surface facility are designed for zero discharge.

- All residual products which result from solution processing will be recycled or disposed of in accordance with applicable environmental requirements.

- The geographical limits of impacts to the ground water system encompass that area identified by ADEQ as the Project Discharge Impact Area (DIA). The DIA is defined as the potential area extent of pollutant migration, as projected on the land surface, as the result of discharge from a facility.

- Short-term impacts of the Project will be those that occur prior to completion of the in situ mining test. Long-term impacts will be those which occur or continue after completion of the in situ mining test.

- The Project technical approach will not be significantly different from that presented in Chapter I.

- Additional core holes may be drilled in the vicinity of the test wells during the in situ mining test to obtain rock samples for geologic study.

- Chemical conditioning of downhole pipes and equipment may periodically be required during the in situ mining test.

- Short-term "huff and puff" (solution injection and recovery from the same borehole) tests may be conducted in the test wells.

- Additional perforation of the test wells may occur. If required, perforation would be restricted to a borehole interval extending from 50 ft above, to 50 ft below the presently perforated interval.

- Short radius hydraulic fracturing may be conducted in one or more of the test wells.

- During leach solution injection a tracer may be added to the injection fluid.

- Additional evaporation ponds may be constructed to increase solution storage capacity.

- Fill material to be used for fabrication of the test facility will originate from on-site impoundment excavation areas.

4.1.2 Alternative No. 2 - No Action

- Site disturbance activities associated with fabrication of the SX-EW surface facility would not occur. Site disturbance activities would be limited to previously completed wells (used for site characterization) and an evaporation pond (installed to hold non-hazardous tracer solutions recovered during testing).

- Existing test wells will not be converted to acid injection and solution recovery wells for the purpose of conducting the in situ mining test.

- That portion of the test facility not affected by site characterization activities would remain as retired agricultural land.

- The SCJV could exercise a business decision to develop the identified mineral resource present at the Santa Cruz site at a future date using conventional mining methods or through their own research program to develop a commercial-scale in situ copper mining operation.

- If SCJV proceeds with its own future research and development program to commercially develop the mineral resource at the test facility, the U.S. Government would have no involvement.

- The cooperative research program between the Bureau and SCJV would terminate and all government rights to the test facility would also terminate.

4.2 Hydrology

The following discussion identifies impacts to ground water as a result of conducting the Project.

4.2.1 Impacts of Alternative No. 1

Ground water impacts could result from (1) injection of leach solution into the copper oxide zone during the in situ mining test, (2) pumping of ground water from the basin-fill deposits, and (3) handling of solutions in the SX-EW surface facility.

4.2.1.1 In Situ Mining Test

Dilute sulfuric acid solution will be injected through perforations (installed from 1,570 to 1,770 ft below land surface) in the injection well to dissolve copper from the copper oxide zone. The in situ mining test will target a mining zone occurring within and outside of the block bounded by the five-spot well pattern and the 200-ft-thick perforated interval (fig. 7). The chemical quality of ground water which naturally occurs within the mining zone will be affected as its composition is changed due to mineral dissolution. The Bureau has determined from laboratory leaching studies of rock core samples collected from the mining zone that major amounts of copper and chloride will be mobilized into solution, along with minor amounts of other constituents (16). Concentration of some of these chemical constituents will exceed State of Arizona aquifer water quality standards in the ground water occurring within the mining zone. The APP will allow aquifer water quality standards within the mining zone to be exceeded for in situ mining. State water quality

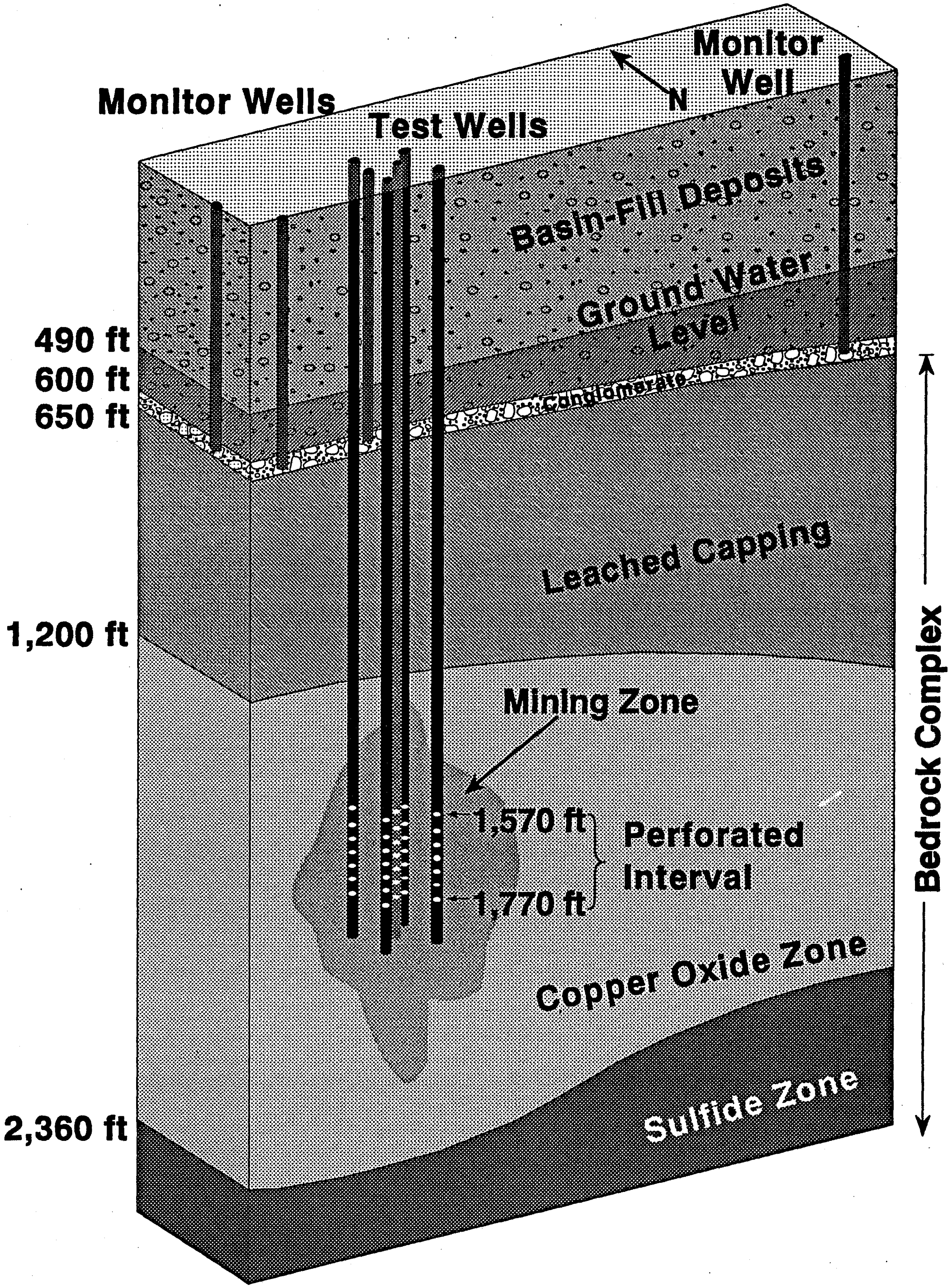

Figure 7. - Mining zone location.

standards will remain in effect at a point designated to be the hazardous substance point of compliance at a location outside of the mining zone. This point shall be located 400 ft from the western (downgradient) edge of the well field in the lower part of the basin-fill deposits and the conglomerate unit directly above the top of bedrock complex. This point corresponds to the screened interval of the western-most monitoring well shown in figure 7.

In addition to conducting laboratory core-leaching studies, the Bureau has conducted tests to determine the ability of several of the rock types present at the test site to neutralize the acidic leach solution and attenuate (remove from solution) dissolved metals (17). Results of these attenuation tests indicate that if leach solution were to migrate beyond the mining zone, its reaction with the rock and mixing with naturally-occurring ground water would change the leach solution chemistry to more closely resemble the natural composition of the ground water, but with an increased concentration of sulfate and chloride.

The results of the attenuation tests have been combined with a flow and transport computer model (computer simulations conducted by INTERA, Inc., Austin, TX) to predict the DIA for the in situ mining test (4). The DIA is defined in Arizona Revised Statutes 49-201 as the "potential area extent of pollutant migration, as projected on the land surface, as the result of a discharge from a facility." The in situ mining test activities are expected to require 18 months to complete, but may extend for up to 4 years. The DIA has been calculated based upon the maximum 4 years of well field operation plus 16 years following termination of in situ mining operations. Figure 8 shows the projection to land surface of the DIA from the lower copper oxide unit for the 20-year period. A chloride concentration contour of 353 mg/L at the end of the 20-year period has been established as the boundary of the DIA. The 353-mg/L value represents the ambient chloride concentration of ground water in the lower copper oxide unit (1,600 to 1,800 ft below the surface) plus two standard deviations. Chloride was selected because it is not attenuated and has a large projected concentration in the leach solution. Chloride, a nonhazardous chemical, will be dispersed over a larger area than any other chemical constituent in the leach solution. Figure 9 shows a cross-

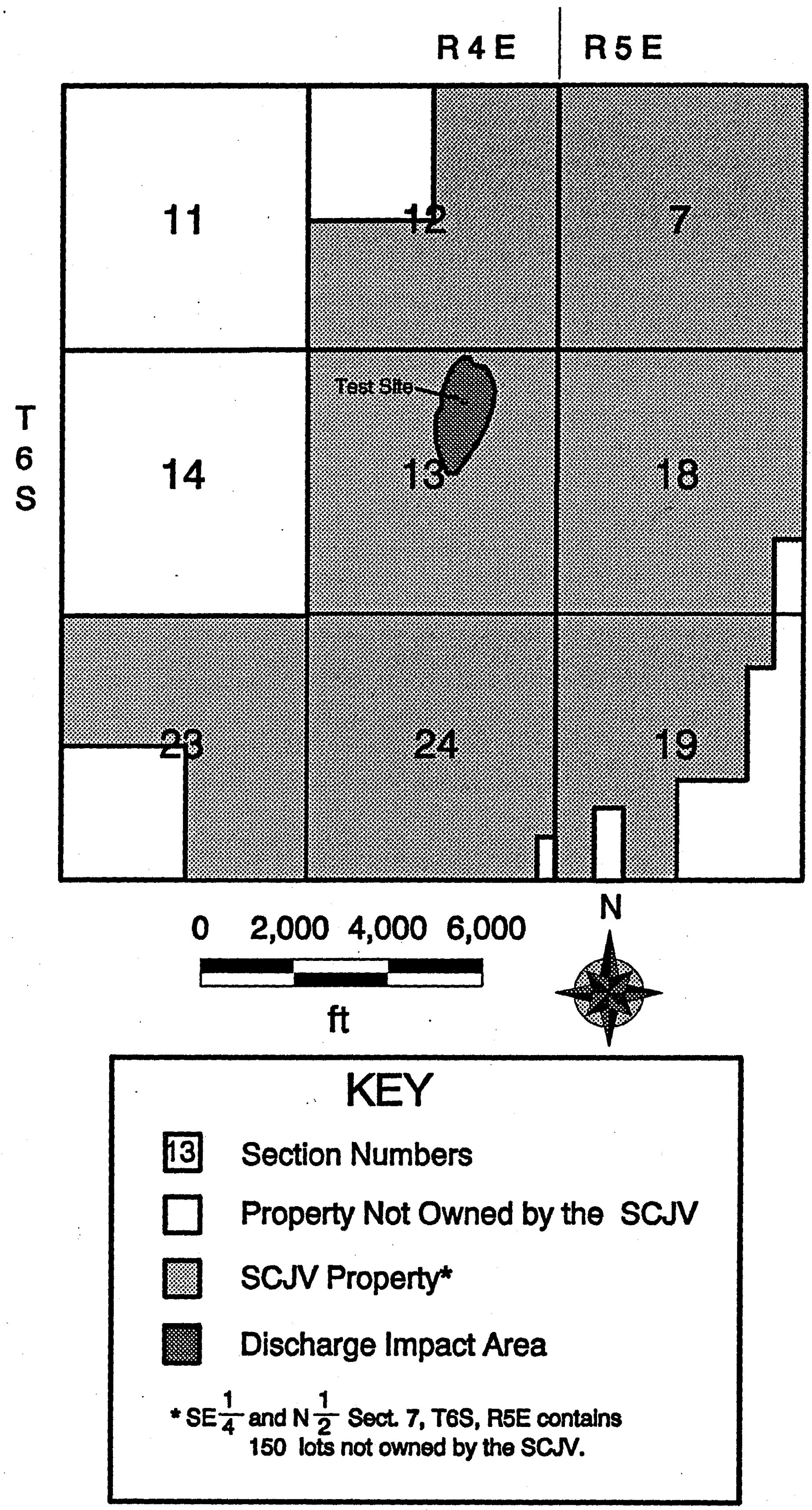

Figure 8 - Land surface projection of the discharge impact area.

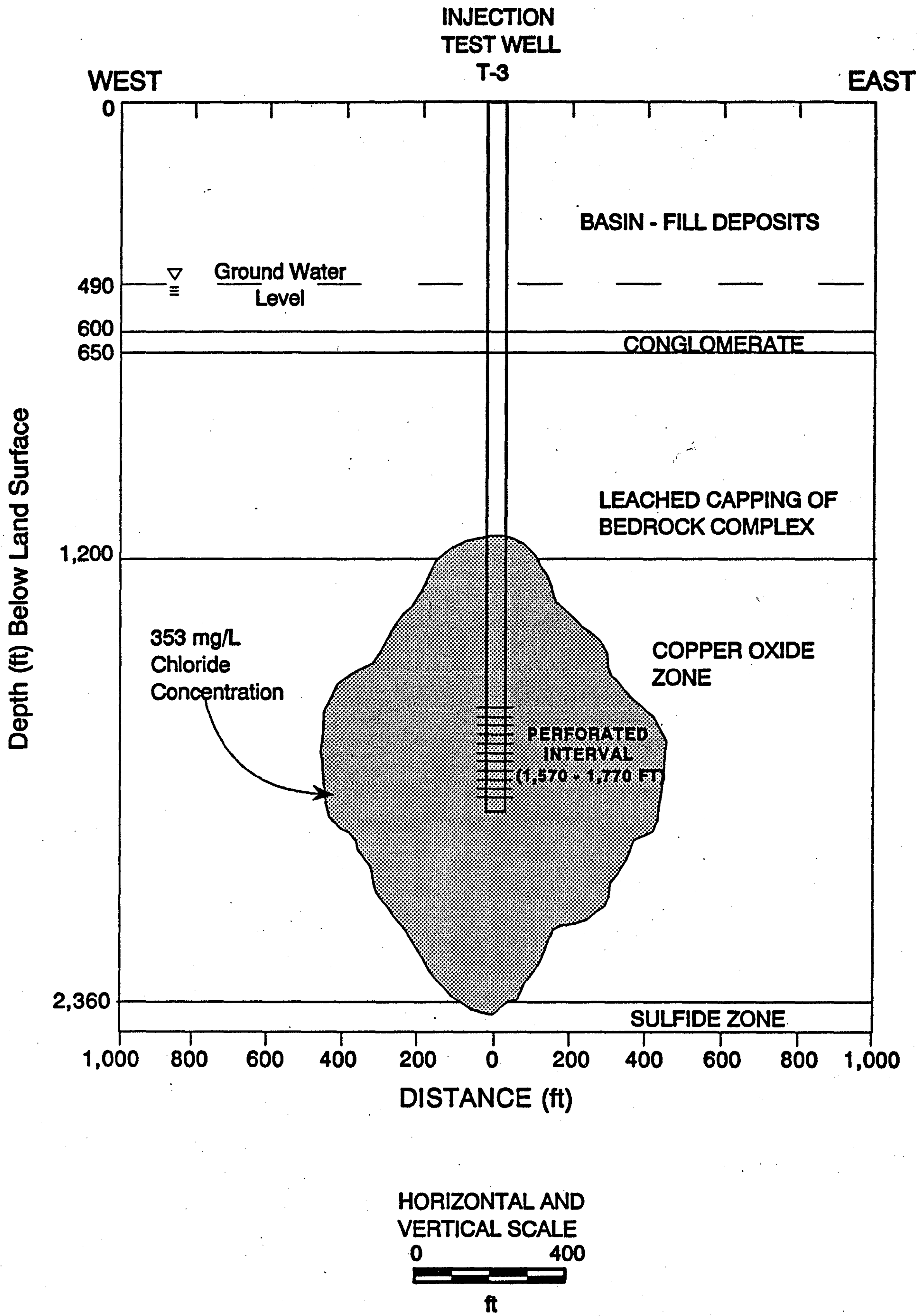

Figure 9. - Cross-section of 353 mg/L chloride concentration contour at end of 20-year period.

section of the chloride concentration contour of 353 mg/L at the end of the 20-year period. The upper boundary of the 353 mg/L chloride contour occurs about 1,050 ft below land surface.

Salt tracer (sodium chloride and sodium bromide) testing of the five-spot well pattern was permitted by ADEQ and conducted from March 14, 1991, through August 6, 1991, to evaluate horizontal and vertical movement of fluids within the mining zone. A tracer solution of known concentration was injected through the center well and pumped from the four corner wells. Salt concentration of the recovered solution was regularly monitored. This test demonstrated that fluid movement within the mining zone can be controlled and that fluid can be moved from the injection well to the recovery wells through fractures in the rock. During and after the tracer test, no pressure response or change in chloride or bromide concentrations attributable to operation of the test was observed in the basin-fill deposit monitor wells.

Regular monitoring of ground water levels and ground water quality was conducted at the test site prior to, during, and after testing activities (water injection and subsequent tracer testing beginning in July 1989 and continuing through August 1991). Results of this monitoring have shown no discernable effects to the ground water in the basin-fill deposits from testing activities in the copper oxide zone.

Impacts to ground water quality at the designated point of compliance for the test wells are not expected for the following reasons:

- The perforated interval in the test wells is separated from the basin-fill deposits by about 1,000 ft of granitic bedrock having low permeability.

- To maintain positive hydraulic control of fluids in the mining zone, more fluid will be pumped from the recovery wells than will be injected through the center injection well. Excess fluid recovery will create a negative pressure, which causes leach solution and ground water located within and outside of the mining zone to migrate toward the recovery wells instead of away from them.

- Test wells have been constructed to ensure that leach solution is injected only into the mining zone and that leach solution does not migrate from the mining zone into the basin-fill deposits through the well annulus. Important well design criteria include (1) selection and use of production well casing capable of resisting corrosion from the leach solution and withstanding high pressures, (2) sealing of the annulus between the borehole wall and the intermediate and production casing by pumping acid-resistant cement between the casings and borehole wall, and (3) pressure testing the well casings to demonstrate their mechanical integrity. All wells have been constructed to meet or exceed stringent EPA criteria for Class III injection wells, even though the wells are to be used for Class V application. Normal operating injection pressures at the well head will not exceed 600 psi for more than a 5 minute period during the in situ mining test. (See Appendix B for additional details on test well installation.)

- Laboratory data from attenuation testing together with results of computer modeling indicate that, upon completion of the Project, acid solutions which remain in the mining zone will be naturally neutralized over time and aquifer water quality standards will not be exceeded at the point of compliance.

- Mineral exploration boreholes located within 500 ft of the test wells have been abandoned in accordance with regulations of ADWR to eliminate the possibility of migration of leach solution from the bedrock through the boreholes into the basin-fill deposits.

During the Project, ground water monitoring will be conducted in the monitor wells shown on figure 7 on a regular basis to detect any changes which may occur to water quality in the basin-fill deposits. If exceedance of an aquifer water quality standard is detected during monitoring, a contingency plan specified in the APP will be implemented. The contingency plan specifies the following actions be taken: (1) notification to ADEQ of the exceedance, (2) submittal of a report proposing specific action to be taken, and (3) implementation of actions approved by ADEQ.

Abandonment of the monitor wells and test wells will occur after completion of the Project and after a determination is made that no further use will be made of the wells. Abandonment will occur in full compliance with regulations of ADWR.

4.2.1.2 Ground Water Use

Maximum economy will be made of water used during the in situ mining test. Initially, up to 10 acre-feet of water will be pumped from a ground water supply well located about 1/2 mile west of the test facility for leach solution make-up. This well is completed into the basin-fill deposits and conglomerate unit, and is located on SCJV property. After water is pumped for preparing the initial injection solution, additional process water requirements will generally be met by the excess fluid to be pumped from the recovery test wells. Pumping of the test wells will produce solution from the copper oxide zone which will be piped to, and processed in, the SX-EW plant and subsequently reinjected into the mining zone through the injection well. Recycling of leach solution pumped from the copper oxide zone will minimize the amount of ground water necessary for make-up water from the water supply well during the project life. Between 25 and 50 acre-feet/yr of additional ground water will be pumped from the water supply well for in-plant processes, plant washdown, and sanitary purposes.

The quantity of ground water to be pumped from the water supply well will reduce in the basin-fill deposits the water in storage which would otherwise be available for domestic, stock watering, or irrigation purposes. The SCJV maintains a valid right to pump up to 3,609 acre-ft/yr of ground water from the Santa Cruz site and adjacent owned lands. The maximum quantity of ground water to be pumped from the basin-fill deposits during project start-up (60 acre-ft) is approximately 1.7 pct of the total volume which the SCJV is entitled to withdraw. In comparison to irrigation pumping of basin-fill deposits in the Santa Cruz study area, 60 acre-ft represents 1.18 pct of the average annual ground water withdrawal occurring during the period 1984-1990 (4). These low percentages indicate that ground water consumption by the Project will account for only a small fraction of the water normally pumped from within the study area.

4.2.1.3 SX-EW Surface Facility

The SX-EW surface facility is to be located approximately 1,000 ft west of the test wells and will include the following components (fig. 3):

1) pilot-scale SX-EW plant,

2) one previously constructed (for site hydrologic characterization purposes) lined evaporation pond and two additional lined evaporation ponds to be installed to accommodate excess process solutions,

3) two lined solution storage reservoirs,

4) acid storage area, and

5) employee change rooms, office, laboratory, and warehouse.

The SX-EW surface facility will be confined to an area encompassing approximately 8-1/2 acres. The facility will be fabricated and operated in accordance with sound engineering practices to minimize the possibility of a release of fluids at land surface and to maintain structural integrity in the event of a flood event. (Pinal County has established the high water mark of the 1983 flood of the Santa Cruz Wash as the 100-year flood event. Structures constructed within this area will be built on pads to raise them above this flood elevation.)

All evaporation ponds and storage reservoirs will be installed with two high-density polyethylene liners. A leak detection system will be installed between the liners and monitored on a routine basis. Adequate freeboard will be maintained to eliminate the possibility of a surface spill. All ponds and solution storage reservoirs are designed for zero discharge. Because the rate of solution evaporation is uncertain, installation of additional evaporation ponds may be required during the term of the in situ mining test.

Concentrated sulfuric acid will be stored at the surface facility in a 7,000-gal tank. The tank will be set on a concrete foundation and will be surrounded by concrete walls. Chemicals other than acid will be stored in barrels or other containers in reagent storage areas. Reagent storage areas have been designed to contain and manage spills.

Although the probability of a release of a substantial quantity of fluid to land surface at the plant site is small, it is possible. Geotechnical data have been obtained for soil and sediments underlying the SX-EW surface facility to evaluate the potential impact of a spill. These data have been analyzed to estimate the volume of a spill that would be retained by these sediments, to assess the potential for a spill to cause leaching of chemical constituents from the sediments, and to assess the potential for spilled fluid to transport dissolved metals through the sediments. Results of laboratory analyses performed on soil samples collected from the site indicate that underlying soils would rapidly neutralize an acid solution spill, and metals would not be leached or transported. Any spill of leach or process solutions at land surface should not exceed a few thousand gallons, and the solution would be retained in the uppermost 20 ft of sediments below land surface (4).

A point of compliance for hazardous substances has been proposed for the SX-EW surface facility. This point is located 100 ft west from the exterior embankment at the west side of the SX-EW surface facility. If a discharge from the facility occurs, a well may be constructed to monitor ground water quality in the upper part of the basin-fill deposits at the point of compliance for hazardous substances. If exceedance of an aquifer water quality standard is detected during ground water monitoring at this point, a contingency plan specified in the APP will be implemented. The contingency plan will require the following actions to be taken: (1) notification to ADEQ of the exceedance, (2) submittal of a report proposing action to be taken, and (3) implementation of actions approved by ADEQ.

Upon completion of in situ mining, and after a decision is reached that the SX-EW surface facility is no longer needed, closure will commence. The SX-EW plant has been designed so that it can be disassembled and moved off site. Preliminary closure for the SX-EW surface facility will include the following procedures: (1) chemicals will be transported to another facility that use similar chemicals; (2) aqueous process solutions, depending upon their chemical composition, will either be pumped to an evaporation pond or be transported to another SX-EW facility; (3) the SX-EW surface facility will be flushed with water, and the wash down water collected and transferred to one of the double-lined storage ponds; and (4) solutions occurring in the storage ponds will be allowed to evaporate. Final closure may include burying of pond liners on site. More specific plans for closure will be submitted to ADEQ within 90 days following the required notice of intent to cease operations. Closure procedures are designed to ensure that no discharge will occur from the facility.

4.2.2 Alternative No. 1 - Conclusions

The Bureau concludes that impacts to ground water as a result of conducting the Project should be minor over the short term and negligible over the long term. This determination is based upon the following analyses: (1) computer flow modeling and laboratory attenuation studies indicate that Arizona aquifer water quality standards will not be exceeded at the test well point of compliance during and after the in situ mining test (verification to be provided by ground water monitoring); (2) leach solution recycling through the mining zone will minimize the quantity of ground water required to be pumped from the basin-fill deposits for leach solution make-up; (3) the quantity of water to be pumped from basin-fill deposits for in-plant needs is relatively small; and (4) the SX-EW surface facility will be designed for zero discharge.

Activities proposed to occur during the Project will result in negligible impact to current or reasonably foreseeable uses of ground water within the basin-fill deposits.

4.2.3 Alternative No. 2 - Conclusions

If the Project is not conducted, injection of leach solution to dissolve copper from a copper oxide deposit would not occur; ground water would not be pumped from the basin-fill deposits aquifer for leach solution makeup and plant use; and a SX-EW surface facility would not be built. No in situ mining related impacts would occur to ground water from a decision not to conduct the Project.

4.3 Topography and Land Use

The following discussion identifies impacts to the land surface as a result of fabrication and operation of the test facility.

4.3.1 Impacts of Alternative No. 1.

Fabrication of the SX-EW surface facility will require disturbance of up to 8-1/2 acres of the ground surface at the Santa Cruz site. A final closure plan (as required by regulation) will be submitted to ADEQ within 90 days of the decision to cease operations. Final closure may include dismantling of the facility and burial of pond liners on site, followed by site grading. No open pits or mine rock waste dumps will occur on the land surface as a result of the Project.

Subsidence of the ground surface is not expected to occur from in situ mining activities at the Santa Cruz site. Dissolution of copper from the mining zone will result in the removal of only a few percent of the volume of rock occurring within, and somewhat beyond, the block bounded by the four recovery test wells and perforated interval (127 X 127 X 200 ft) (fig. 4). The Bureau has conducted laboratory tests of rock core obtained from the Santa Cruz site to calculate the amount of surface subsidence that might be expected to occur as a result of copper dissolution from this block (18). Triaxial compression tests were performed on unleached and leached laboratory core samples to provide axial stress and displacement data for comparison of relative rock strengths. From these data, the maximum subsidence calculated to occur at land surface (based upon the block dimensions at a depth of 1,570 to 1,770 ft below land surface) is less than 1/1000 of an inch.

Subsidence of the surface from withdrawal of ground water from a water supply well located about 1/2 mile west of the test facility (completed in basin-fill deposits and conglomerate) is not expected to occur given the relatively small quantity of water to be pumped from this well for initial leach solution make-up and in-plant processes (60 acre-ft/yr, maximum). For comparison purposes, the average amount ground water pumped from non-exempt wells in the Santa Cruz study area for the period 1984 through 1990 was 5,095 acre-ft (4).

To confirm negligible surface subsidence resulting from the Project six surface elevation monuments have been constructed at and around the Santa Cruz site. These monuments will be surveyed before and after the in situ mining test to verify the prediction that only negligible surface subsidence will occur.

4.3.2 Alternative No. 1 - Conclusions

Based upon the results of a laboratory investigation, the Bureau concludes that surface subsidence resulting from dissolution of copper from the mining zone will be negligible over both the short and long term. Pumping of water from the supply well completed into the basin-fill deposits and conglomerate unit will similarly result in negligible surface subsidence.

Land use will not be changed or affected during the Project. The anticipated use of the Santa Cruz site in the future is for mining of the Santa Cruz copper deposit.

4.3.3 Alternative No. 2 - Conclusions

If the in situ mining test is not conducted, the SX-EW surface facility would not be built, dissolution of copper from the mining zone would not occur, and water would not be recovered from a water supply well for use in leach solution make-up or for in-plant processes. No impacts would occur to land surface from a decision not to conduct the Project.

4.4 Wildlife

The following discussion identifies impacts to wildlife from surface activities occurring on the Santa Cruz site.

4.4.1 Impacts of Alternative No. 1.

Potential impacts to wildlife are related to use and ingestion of pond water by birds and animals. A total of five uncovered ponds are to be located on site as a component of the SX-EW surface facility. Ponds will be used for storage of leach solution and for evaporation of excess recovered solution. Total surface area of the five ponds will be 3.6 acres. Animal access to the test facility will be restricted by a 5-ft-high fence installed around the perimeter. An additional fence will be installed to enclose the SX-EW surface facility. Small birds and animals may be attracted to these open impoundments.

No documented evidence exists to indicate that any bird has been injured or harmed as a result of ingesting fluids from open ponds associated with SX-EW plants in Arizona. Statewide, between 6 and 12 uncovered ponds occur at each of 7 commercial heap, dump, and block cave leaching operations using the SX-EW process. At a minimum, 42 uncovered ponds occur at the various mines. Each of these ponds has an average surface area of about 1 acre. Solutions contained in SX-EW ponds generally have a smell, taste, and appearance which makes the fluids unattractive and unpalatable to animals and birds. Arizona has no requirements for covering SX-EW ponds. Ponds associated with the SX-EW plant at the Santa Cruz site will serve the same purpose as those used commercially, but may be smaller in number and size. Santa Cruz ponds will not be covered. Availability of water from irrigation canals and irrigated fields, together with the Santa Cruz Wash located 3/4 miles northeast of the site, provide wildlife with an available alternative source of water.

4.4.2 Alternative No. 1 - Conclusions

The Bureau concludes that impacts to wildlife from conducting the Project should be minor over the short term and negligible over the long term. Ingestion of pond water by animals and birds should occur infrequently, if at all. Other alternative sources of good-quality water for wildlife are located nearby.

4.4.3 Alternative No. 2 - Conclusions

SX-EW ponds would not be constructed under this alternative. Wildlife would be allowed to freely roam and utilize the surface of the retired agricultural land. The Bureau concludes that no impacts would occur to wildlife in the area from a decision not to proceed with the Project.

4.5 Air Quality

The following discussion addresses fugitive dust, sulfuric acid mist, and volatile organic compound air emissions which may result from the Project.

4.5.1 Impacts of Alternative No. 1

During SX-EW surface facility fabrication and conduct of the in situ mining test, the potential exists for fugitive dust to be generated as a result of earthwork activities and from vehicular traffic occurring at and around the site. During site preparation and earthwork, a considerable amount of moisture will be added to graded soils to meet minimum compaction requirements. The added moisture will minimize fugitive dust generation during this activity. Fugitive dust generation due to vehicular traffic will be controlled by imposing speed limits, watering of the roads, use of dust suppressants, or other appropriate methods. Fugitive dust will be controlled in accordance with REG. 4-2-040 of the Pinal County Air Quality Control District Code of Regulations. The SCJV will obtain all necessary air quality permits prior to the start of SX-EW surface facility fabrication. Emission sources to be regulated include all storage and processing tanks which contain, and have the potential to release, sulfuric acid mist and volatile organic compounds.

4.5.2 Alternative No. 1 - Conclusions

The Bureau concludes that impacts to air quality as a result of increased fugitive dust generation from SX-EW surface facility fabrication and road use, as well as release of sulfuric acid mist and volatile organic compounds from process and storage tanks, should be minor over the short term and nonexistent over the long term.

4.5.3 Alternative No. 2 - Conclusions

Vehicle-induced dust emissions would be non-existent since no traffic would access the Santa Cruz site. Earthwork would not occur on site. Sulfuric acid mist and volatile organic compounds would not be released to the atmosphere since process and storage tanks would not be located on site. Offsite agricultural practices would continue to make the area susceptible to wind erosion and fugitive dust generation. The Bureau concludes that no Project-related impacts would occur to air quality from a decision not to proceed.

4.6 Health and Safety Considerations

The following discussion identifies considerations to be given to human health and safety from SX-EW plant operations and transport/use of sulfuric acid.

4.6.1 Alternative No. 1 - Conclusions

Standard industrial safety practices will be followed during fabrication and operation of the SX-EW surface facility. Safety requirements of applicable Federal and State government agencies will be observed. All vendors delivering hazardous materials to the Santa Cruz site will comply with provisions of the Hazardous Materials Transportation and Uniform Safety Act. State and local government agencies will be informed of the on-site presence of hazardous materials. An emergency response plan will be developed for handling a hazardous materials spill.

The Bureau concludes that impacts to human health and safety as a result of conducting the Project should be minor over the short term and nonexistent over the long term.

4.6.2 Alternative No. 2 - Conclusions

Under this alternative, no SX-EW surface facility would be fabricated or operated, and sulfuric acid would not be transported to the Santa Cruz site. The Bureau concludes that no impacts will occur to human health and safety from a decision not to proceed with the Project.

4.7 Cultural Resources

The following discussion identifies impacts to cultural resources from site activities associated with the Project.

4.7.1 Impacts of Alternative No. 1

The Bureau has initiated discussions with SHPO informing that office of ground disturbance activities proposed to occur at the Santa Cruz site. SHPO has indicated that proposed disturbance activities should have no effect on any National Register or eligible properties. The SHPO has specified, however, that should archaeological resources be unearthed during ground-disturbing activities, the stipulations found under 36 CFR 800.11 be followed. To ensure compliance with this stipulation, the Bureau will require the SCJV to include language in all site preparation and/or earthwork contracts specifying that in the event archaeological resources are discovered or unearthed on site, subcontractors shall cease activities and immediately notify SCJV. The SCJV would then be required to immediately notify the Bureau of the discovery. The SCJV or the Bureau would further communicate the discovery to SHPO to obtain assistance in determining the cultural significance of the site and/or to determine the need for mitigation.

4.7.2 Alternative No. 1 - Conclusions

The Bureau concludes that impacts to cultural resources from earthwork and surface facility fabrication should be minor over the short term and negligible over the long term. If archaeological resources are discovered during site disturbance activities, procedures are in place to ensure prompt notification of the SHPO and compliance with the stipulations included under 36 CFR 800.11.

4.7.3 Alternative No. 2 - Conclusions

Under this alternative, no site disturbance activities associated with construction of a SX-EW surface facility would occur and no potentially occurring cultural resources would be unearthed. The Bureau concludes that no impacts would result to unearthed cultural resources from a decision not to proceed with the Project. Cultural resources may continue to remain undiscovered with a decision not to proceed.

4.8 Socioeconomics

The following discussion identifies impacts to employment, local economy, aesthetics, and community resources associated with the Project.

4.8.1 Impacts of Alternative No. 1:

Efforts will be made to employ local contractors and labor, to the degree possible, for SX-EW surface facility fabrication and operation. Wages for projected short-term employment will be paid at the prevailing Casa Grande area wage rate. Increased local spending will result from the employees hired by the Project. The Project will be beneficial to the local economy, but the impact will not be readily discernable given the strong economy in this community.

Use of local labor will not strain available housing or community resources since the majority of the workforce will be available from the existing community. Contractor personnel who are hired to work on the Project (on an intermittent basis) from outside of the community will most likely use commercial establishments in Casa Grande for food and lodging. Efforts will be made to obtain materials and supplies locally, subject to government procurement regulations.

Aesthetics of the local area will not be affected since the test facility is not visible from any heavily traveled road. Site fabrication activities will result in only limited surface disturbance consistent with preparing building foundations and shallow excavations for impoundments. The only surface features visible will be buildings which contain processing tanks and electrowinning cells, shop, laboratory, change house, office, and storage tanks. The appearance of the site will be similar to that of many of the small industrial plants located in the Casa Grande area. The Santa Cruz site is privately owned and not open to public access.

4.8.2 Alternative No. 1 - Conclusions

The Bureau concludes that positive economic benefits will accrue to the Casa Grande community over the short term, but will be negligible over the long term. The relatively few, short-term employment opportunities will have a relatively minor influence on the local economy. Local equipment distributors and service contractors may see a slight expansion of their business receipts associated with the Project's need for contractor services. Social conditions and aesthetics of the area should be minimally affected.

4.8.3 Alternative No. 2 - Conclusions

Without the short-term economic benefits of the Project, changes in employment and personal income would be limited to those provided by the existing manufacturing, mining, retail, and agricultural activities in the Casa Grande area. The Bureau concludes that minimal impacts will occur to employment, personal income, and local community resources from a decision not to proceed with the Project.

5.0 CHAPTER V. CONSULTATION AND COORDINATION

5.1 Consultation with Other Agencies

In the course of preparing this draft EA, the Bureau contacted a number of government agencies to obtain information on environmental resources present in the vicinity of the Santa Cruz site. Information was also collected on operating practices of copper mines in southern Arizona. A listing of agencies contacted and specific information requested is provided in the following:

Arizona State Parks, State Historic Preservation Office was contacted regarding the existence of known historic or cultural resources which occur within the area.

U.S. Fish and Wildlife Service was consulted regarding the existence of species listed or proposed to be listed as threatened or endangered.

Arizona Game and Fish Department was contacted regarding the presence of special-status species in the area and wildlife use of uncovered ponds associated with the test facility.

Office of State (Arizona) Mine Inspector was contacted regarding the number of copper mining operations in Arizona employing SX-EW processing techniques and the approximate number of uncovered ponds associated with these facilities.

5.2 Public Involvement

A public scoping meeting was held in Casa Grande, AZ, on July 25, 1990, to solicit comments and questions from local residents and government agencies regarding the Bureau's proposal to conduct the Project.

A variety of media methods were used to provide publicity for the meeting and encourage maximum public participation. These publicity methods included (1) publication of a meeting announcement in the Federal Register on June 25, 1990, (2) paid meeting announcements which appeared in local Casa Grande, AZ, newspapers on July 11, 13, and 24, 1990, (3) a press release to local newspapers and radio stations, the Associated Press, and Phoenix and Tucson daily newspapers, and (4) meeting announcement letters sent to U.S. Senators and Congressmen from Arizona, local-area State Legislators, and various Federal, State, and local government agencies.

Newspaper articles about the Project appeared in advance of the public meeting in the following newspapers: Pinal Pioneer and Casa Grande Dispatch (Casa Grande, AZ) and the Arizona Daily Star (Tucson). After the meeting date, follow up newspaper articles appeared in the Casa Grande Dispatch and Tucson Citizen discussing the proposed Project and public reaction.

A total of 62 individuals attended the public meeting. Those attending included Congressional staff members; a representative of a national environmental group; representatives of various Federal, State, and local government agencies; and local residents. Nine separate verbal or written comments addressing 38 items were received from individuals and government agencies. These items have been consolidated according to subject matter and are addressed in this EA.

5.3 Review of Draft EA

A copy of the draft EA has been provided to key staff members of the following U.S. Senators and Representatives, and Arizona Legislators:

<u>Federal Legislators:</u>

Honorable Sam Coppersmith, U.S. Representative
Honorable Dennis DeConcini, U.S. Senator
Honorable Pete Domenici, U.S. Senator
Honorable Karan English, U.S. Representative

Honorable Jim Kolbe, U.S. Representative
Honorable Jon Kyl, U.S. Representative
Honorable John McCain, U.S. Senator
Honorable Ed Pastor, U.S. Representative
Honorable Bob Stump, U.S. Representative

Arizona Legislators:

Honorable Bob Chastain, AZ Representative
Honorable Harry Clark, AZ Representative
Honorable Pete Rios, AZ Senate

A copy of the draft EA has additionally been sent to all attendees of the July 25, 1990, public meeting who expressed an interest in receiving copies of environmental documents prepared by the Bureau. Copies were additionally provided to Federal and State government agencies which provided verbal or written comment, city and county officials, and Project members. Those officials or individuals receiving a copy of the draft EA include:

Federal Agencies:

Anna-Marie Cook, EPA, Region IX, San Francisco, CA
Kathryn Devenport, U.S. Forest Service, Tucson, AZ
Lester Kaufman, EPA, Region IX, San Francisco, CA
Walt Keyes, U.S. Forest Service, Tucson, AZ
Gilbert D. Metz, U.S. Fish and Wildlife Service, Phoenix, AZ
Clarence Tenley, EPA, Region IX, San Francisco, CA
Jaqueline Wyland, EPA, Region IX, San Francisco, CA

State Agencies:

Mason Coggin, AZ Dept. Mines and Minerals Resources, Phoenix, AZ
Timothy Davis, AZ Dept. Environmental Quality, Phoenix, AZ
James F. Dubois, AZ Dept. Environmental Quality, Tucson, AZ
Charles Graf, AZ Dept. Environmental Quality, Phoenix, AZ
Dennis Kimberlin, AZ Dept. Water Resources, Casa Grande, AZ
State Historic Preservation Officer, AZ State Parks, Phoenix, AZ
Duane L. Shroufe, AZ Game and Fish, Phoenix, AZ

Dennis Turner, AZ Dept. Environmental Quality, Phoenix, AZ
Greg Wallace, AZ Dept. Water Resources, Phoenix, AZ

Local Government Agencies:

Jeffrey Fairman, Economic Development Foundation, Casa Grande, AZ
Phil Hogue, Pinal County Dept. Planning, Florence, AZ
Jimmie Kerr, Pinal County Board of Supervisors, Casa Grande, AZ
Maxine Leather, Central AZ Association of Governments
Bob Mitchell, Mayor, Casa Grande, AZ
Kent Myers, City Manager, Casa Grande, AZ
Helen Neuharth, Casa Grande Chamber of Commerce, Casa Grande, AZ
Dave Snider, Director, Casa Grande Public Library,
Casa Grande, AZ

Individuals:

Fareed Abouhaidar, Mesa, AZ
S.A. Anzalone, Tucson, AZ
Kermit Behnke, Casa Grande, AZ
Richard E. Bernard, Casa Grande, AZ
Joni Bosh, Phoenix, AZ
Roy Bowyer, Casa Grande, AZ
Michael Brady, Scottsdale, AZ
Marjori and Ron Brattain, Casa Grande, AZ
Leo and Jeanne Butterfield, Arizona City, AZ
A. Thomas Cole, Casa Grande, AZ
Julie Curtiss, Phoenix, AZ
Marian DiMino, Casa Grande, AZ
Kim Frair, Casa Grande, AZ
Jim Garvey, Casa Grande, AZ
Michael Gregory, Bisbee, AZ
John Gutierrez, Tempe, AZ
Paula Hamby, Casa Grande, AZ
Steven B. Hildebrand, Tucson, AZ
Stephen M. Hufnagel, Casa Grande, AZ
Mario R. Lluria, Phoenix, AZ
F.A. Mattias, Casa Grande, AZ

Daniel McDonald, Casa Grande, AZ
P.K. Rana Medhi, Casa Grande, AZ
Loren Mitchell, Casa Grande, AZ
Maurice Mordka, Tucson, AZ
George H. Myers, Tucson, AZ
Butch Opsahl, Casa Grande, AZ
Mike Sarita, Casa Grande, AZ
Robin Strathy, Phoenix, AZ
Mr. and Mrs. James Sullivan, Scottsdale, AZ
George Tapia, Casa Grande, AZ
Mike Tapia, Casa Grande, AZ
Bill Wahl, Tucson, AZ
Brad Wilde, Phoenix, AZ
Fred Wilson, Casa Grande, AZ

Santa Cruz Joint Venture and Project Consultants:

Charles Barter, E.L. Montgomery & Assoc., Tucson, AZ
Dale Dixon, ASARCO Incorporated, Tucson, AZ
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Frederick T. Graybeal, ASARCO Incorporated, New York, NY
Albert Raihl, ASARCO Incorporated, Tucson, AZ
Priscilla Robinson, Consultant, Tucson, AZ
Robert L. Russell, Freeport-McMoRan Inc., New Orleans, LA

6.0 CHAPTER VI. LIST OF PREPARERS

An interdisciplinary team of Bureau professional staff was formed to prepare this EA. The interdisciplinary team approach was used to comply with Section 102(2)(A) of NEPA, which requires agencies within the Federal Government to "utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and decision making which may have an impact on the human environment."

The following individuals are responsible for preparation of this EA:

Name	Title	Contribution
Jon K. Ahlness	Supv. Mng. Eng.	Topography, Subsidence
Linda J. Dahl	Geologist	Geology
Dianne C. Marozas	Geologist	Leaching Chemistry
Daniel J. Millenacker	Hydrologist	EA Team Leader, Hydrology, Geology, Wildlife, Cultural Resources, Socioeconomics
Steven E. Paulson	Geochemist	Leaching Chemistry
Joseph M. Pugliese	Mining Engineer	Air Quality, Hydrology, Well Construction
Theodore L. Triplett	Mining Engineer	Topography, Subsidence
Pamela J. Watson	Mining Engineer	Health and Safety

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APPENDIX A

CHARACTERIZATION STUDIES TO EVALUATE THE SUITABILITY OF THE SANTA CRUZ SITE AS A LOCATION FOR CONDUCTING AN IN SITU COPPER MINING TEST

A comprehensive testing program has been conducted to evaluate hydrologic and geologic conditions present at the Santa Cruz site. Studies were conducted to provide information on the geologic structure and geologic and hydrologic conditions within the copper oxide zone, leached capping of bedrock complex, conglomerate unit, and basin-fill deposits. Data collection and analyses were critical for evaluating the suitability of the Santa Cruz site for conducting the Project.

Preliminary characterization studies at the site were initiated in 1987 by reentering and wedging off from a preexisting exploration core hole (SC-19) (see figure A-1 for all core hole and well locations) to obtain a core sample from the copper oxide zone. Assay and inspection of the core indicated that copper content and host rock type adequately met project criteria. Water injection testing in the core hole determined the granitic host rock to be sufficiently permeable to allow fluids to migrate through the rock mass.

Based upon the favorable results of the SC-19 drilling and testing effort, two new core holes (C-1 and C-2) were completed within 150 ft of SC-19. The additional core holes verified the existence of two separate mineralized units at this specific location. Mineralized zones consisted of an upper copper oxide unit located between 1,200 and 1,400 ft below land surface and a lower copper oxide unit from about 1,600 to 1,800 ft.

Core specimens collected from the drilling programs were used in laboratory studies to assess and evaluate the distribution and chemical composition of the copper and other minerals in the bedrock. Laboratory leaching tests using dilute sulfuric acid solution were performed on core samples to determine such factors as copper loading in solution, fractional copper removal versus time, and reagent consumption per unit of copper produced.

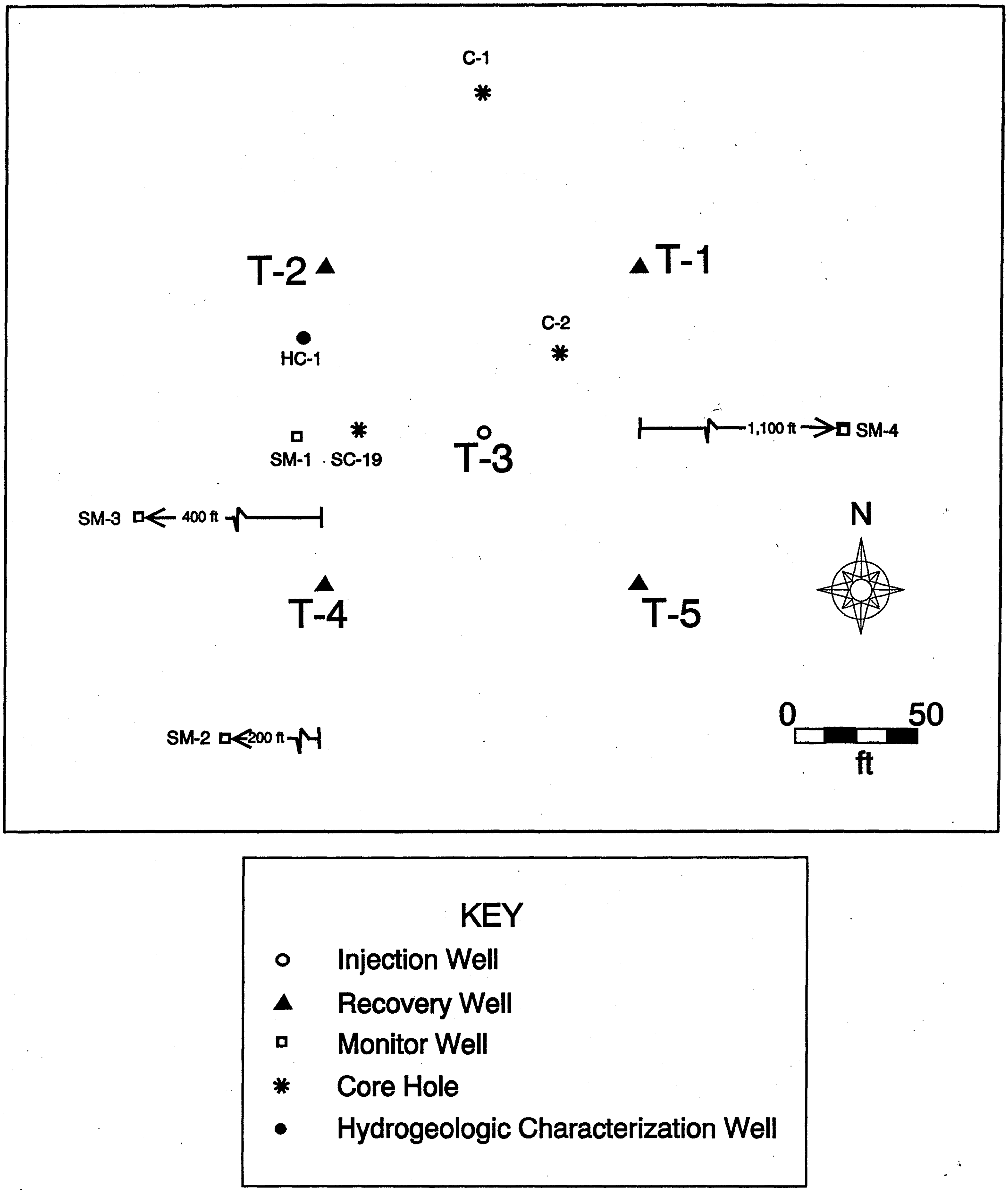

Figure A-1. - Plan map of well and core hole locations.

Following core hole drilling, hydrogeologic characterization well HC-1 was installed to allow for measurement of hydraulic parameters in the leached capping of bedrock complex, which extends from about 650 to 1,200 ft below land surface. Leached capping occurs between the conglomerate and the copper oxide zone. Results of pumping tests indicated permeability in the leached capping is small and the upper part of the leached capping is more permeable than the lower part. Data from these pumping tests provided an indication that potential fluid communication between the in situ mining zone and basin-fill deposits would be restricted by the intervening leached capping. Determination of the degree of potential fluid communication between the mining zone and the basin-fill deposits, an overlying source of potable water, was useful for evaluating the environmental feasibility of an in situ mining activity.

Upon completion of well and core hole drilling and testing, holes HC-1, SC-19, C-1, and C-2 were abandoned in accordance with State regulatory criteria. In addition, other exploration core holes which were located within 500 ft of the test wells were also abandoned. Abandonment was necessary to eliminate the potential for vertical migration of fluids during well testing activities through open boreholes or wells extending between the bedrock and basin-fill deposits.

As the next step in the site characterization process, five test wells were completed in 1989 in the immediate vicinity of C-2 to a total depth of about 1,900 ft. These wells were arranged in a five-spot pattern with the corner-to-corner spacing of 127 ft and were designed and constructed using criteria developed during the first stage of the research. The wells were designed to function as hydrologic test wells and, later, as leach solution injection and recovery wells. The latter use would occur only if results of site characterization studies were deemed favorable and if a decision were reached to proceed to the in situ mining test.

A variety of tests were conducted at the wells to evaluate the geology and hydrology of the bedrock complex and also to assess the integrity of the completed wells. Tests were performed in both the open boreholes (immediately after drilling and before installation of well casing) and/or in the cased wells perforated between 1,570 and 1,770 ft. Geophysical logging, water injection tests, pressure communication tests, pumping tests, and chloride/bromide tracer tests were included in the suite of activities performed in these wells.

Geophysical logging was conducted to provide information on rock properties, hole size, hole deviation, and cement bonding. Water injection tests were performed in both the open and cased holes to measure the injection capacity of the tested interval(s), formation permeability, and vertical distribution of flow of injected water to the bedrock complex. Pressure communication tests were performed in the perforated interval of the lower copper oxide unit. Testing was accomplished by injecting water into one of the five test wells and measuring the fluid rise in the others. This test was repeated four times, using different wells for injection. Results indicated pressure communication among all the test wells.

The tracer test consisted of injecting a tracer solution composed of water, sodium chloride (3,000 mg/L chloride), and sodium bromide (200 mg/L bromide) through the injection well (T-3) for a 4-1/2-month period at an average rate of about 23 gal/min and measuring the recovered tracer concentration in the four recovery wells (T-1, T-2, T-4, and T-5) while maintaining a combined average pumping rate of about 25 gal/min. This test was designed to provide information on fluid flow from the injection well to the recovery wells. A series of monitor wells (SM-1, SM-2, and SM-3) completed in the lower portion of the basin-fill deposits, showed no chemical or pressure response from the tracer test. The lack of response in the ground water of the basin-fill deposits indicates that tracer solutions did not migrate from the mining zone into this aquifer.

Results of the tracer test, attenuation testing results, and other collected field data were used to prepare a three-dimensional computer model to analyze solution movement within the mining zone. (The computer model used, SWIFT II, is widely accepted in ground water modeling applications.) The model was used to assist with defining the potential areal extent of leach solution migration. Results of all characterization studies and computer modeling indicated that the test site would serve as a suitable location for conducting an in situ copper mining test.

APPENDIX B
TEST WELL INSTALLATION

The test wells have been installed and completed to control the injection and recovery of dilute acid solution and to eliminate the possibility of migration of solutions along the well bore to the basin-fill deposits aquifer.

All test wells were installed approximately as shown in figure B-1. A 19-in-diameter borehole was drilled from land surface to a depth of 20 ft. A blank steel surface casing with a 15-3/8-in inside diameter (ID) was installed in the borehole. The space (annulus) between the borehole and the casing was filled with cement.

Following installation of the surface casing, a 14-3/4-in-diameter borehole was drilled to a depth of about 1,220 ft. Blank steel casing (10-3/16-in ID) was installed from land surface to a depth of about 1,200 ft. This casing was positioned in the center of the borehole by centralizers spaced at 80-ft intervals. The well annulus was pressure grouted with acid-resistant cement from the base of the casing to land surface.

Next, a 9-7/8-in borehole was drilled from 1,200 ft (the bottom of the cased 14-3/4-in diameter borehole) to a depth of about 1,870 ft. A 6-in-ID, fiberglass-reinforced plastic pipe was then installed in the borehole from land surface to the 1,870 ft depth. Centralizers were placed on the casing at approximately 60-ft intervals. The well annulus was pressure grouted with acid-resistant cement from the base of casing to land surface. A pressure test was conducted in the casing to document its mechanical integrity.

After casing integrity testing, approximately 200 ft of casing in the lower copper oxide unit near the bottom of the well was perforated, using shaped explosive charges, to allow injection and recovery of fluids. Perforations were spaced approximately one per vertical foot.

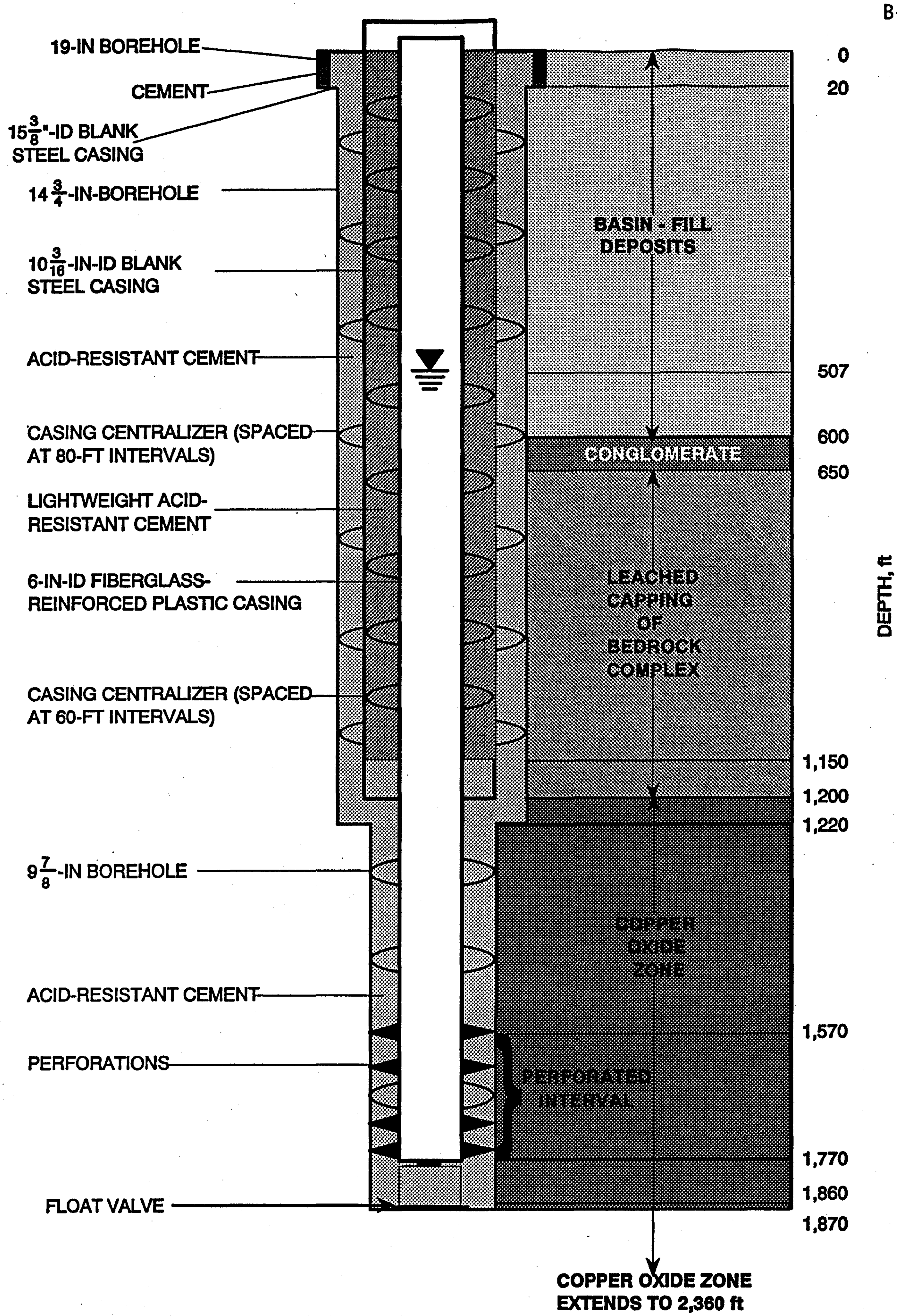

Figure B-1. - Schematic diagram of injection and recovery wells.