0000114823

Transcript Exhibit(s)

Docket #(s): L-00000BB-01-0118-00000

Exhibit # : A1-A15, A17-A21, Bryant 1, Bryant 2, Committee 1 - Committee 4, S2, S3, S4

Application for Certificates of Environmental Compatibility

DOCKET NO. L-00000BB01-0118

RECEIVED
2001 JUL 27 P 1:32
AZ CORP COMMISSION
DOCUMENT CONTROL

Bowie Power Station Project

Prepared for:

State of Arizona Power Plant and Transmission Line Siting Committee

Submitted by:

Bowie Power Station, LLC

Date: 07-27-01
Case No. 118

EXHIBIT
Admitted
A-1

BEFORE THE
POWER PLANT AND TRANSMISSION LINE SITING COMMITTEE

In the matter of the Application of Bowie Power Station, LLC, in conformance with the requirements of Arizona Revised Statutes 40-360.03 and 40-360.06, for two Certificates of Environmental Compatibility authorizing construction of a 1,000 megawatt natural gas-fired, combined-cycle power plant, 345kV and 345kV/230kV switchyards, 345kV double-circuit transmission line and 230kV interconnection and related facilities in Cochise and Graham counties, Arizona. The proposed power station site is located in Sections 28 and 29, Township 12 South, Range 28 East, and the proposed transmission line route is located in Township 12 South, Range 28 East, Township 11 South, Range 28 East, Township 11 South, Range 27 East, and Township 11 South, Range 26 East, Gila and Salt River Base and Meridian.	Case No. 118

APPLICATION FOR CERTIFICATES OF ENVIRONMENTAL COMPATIBILITY

TABLE OF CONTENTS

Introduction 1
Figure 1 Bowie Power Station Site Map 3

Application for Certificates of Environmental Compatibility 4
Figure 2 Site Location 6
Figure 3 Typical Combined Cycle Generating System Components: One 500 MW Block 7
Figure 4 Project Site and Proposed 345kV Transmission Line Route 18

Exhibit A – Location and Land Use Maps
Exhibit A-1 20-Mile Radius
Exhibit A-2a Land Ownership and Jurisdiction (Plant Site)
Exhibit A-2b Land Ownership and Jurisdiction (Transmission Line)
Exhibit A-3 Existing and Future Land Use

Exhibit B – Environmental Reports
Exhibit B-1 Land Use Study
Exhibit B-2 Landscape Plan
Exhibit B-3 Water Supply Investigation Report (text only)
Exhibit B-4 Air Quality

Exhibit C – Areas of Biological Wealth
Exhibit C-1 Response Letters

Exhibit D – Biological Resources

Exhibit E – Scenic Areas and Visual Resources, Historic Sites and Structures and Archaeological Sites
Exhibit E-1 Scenic Areas and Visual Resources
Exhibit E-2 Historic Sites and Structures and Archaeological Sites

Exhibit F – Recreational Purposes and Aspects

Exhibit G – Concepts of Typical Facilities
Exhibit G-1 General Arrangement Concept
Exhibit G-2 Aerial View of Plant Site
Exhibit G-3 Typical 345kV Structure
Exhibit G-4 Photosimulation
Exhibit G-5 Photosimulation
Exhibit G-6 345kV/230kV Switchyard Concept

Table of Contents (continued)

Exhibit H – Existing Plans

Exhibit I – Anticipated Noise/Interference with Communication Signals

Exhibit J – Special Factors
- Exhibit J-1 Leader Packet and Newsletter
- Exhibit J-2 Media Releases, Newspaper Articles, Paid Display Advertisements
- Exhibit J-3 Public Meetings and Local Briefings
- Exhibit J-4 Interconnection Power Flow Study (Executive Summary only)

INTRODUCTION

INTRODUCTION

By means of this Application, Bowie Power Station, LLC and its assigns (Applicant) are requesting two separate Certificates of Environmental Compatibility (CEC) from the Arizona Power Plant and Transmission Line Siting Committee. The first CEC is for a nominal 1,000 megawatt (MW) combined-cycle power plant and 345 kilovolt (kV) switchyard, which will use high efficiency natural gas-fired combustion turbines. The second CEC is for a double-circuit 345kV transmission line and 345/230kV switchyard. The power plant and the transmission line/switchyard will have separate owners, with separate rights and obligations, and thus two CECs are appropriate.

The Applicant is an affiliate of Southwestern Power Group II, LLC, an independent power company engaged principally in the development of electrical power generation facilities in the western United States. Its staff has extensive experience in power plant and transmission line development and construction, facility siting, fuel procurement, and environmental engineering.

The proposed Bowie Power Station will be located in Cochise County, Arizona, approximately 2 miles north of the unincorporated community of Bowie and 80 miles east of Tucson (Figure 1). The Applicant proposes to own, construct and operate the power plant, which will be constructed in two 500 MW phases. The proposed transmission line will extend from the power plant site approximately 14.3 miles in a northwesterly direction into Graham County, Arizona, to interconnect with Tucson Electric Power Company's (TEP) existing Greenlee-Vail and Springerville-Vail 345kV transmission lines at a point located near U.S. Highway 191. In the final stage of development, a 345kV/230kV switchyard (Willow Switchyard) and a 230kV transmission interconnection with the existing Arizona Electric Power Cooperative (AEPCO) Red Tail-Dos Candados 230kV line will be installed at that location. The transmission lines and Willow Switchyard will be owned and operated by an Arizona transmission provider yet to be determined.

The proposed power plant will utilize state-of-the-art technology to attain the lowest achievable emissions and noise levels, and to generate efficient, low cost electrical power to meet Arizona needs. The power plant will also be designed as a zero-discharge facility. Final power plant and transmission line designs will be completed in conjunction with environmental studies, including air quality and water resource considerations.

The proposed power plant site was selected based upon the following considerations:

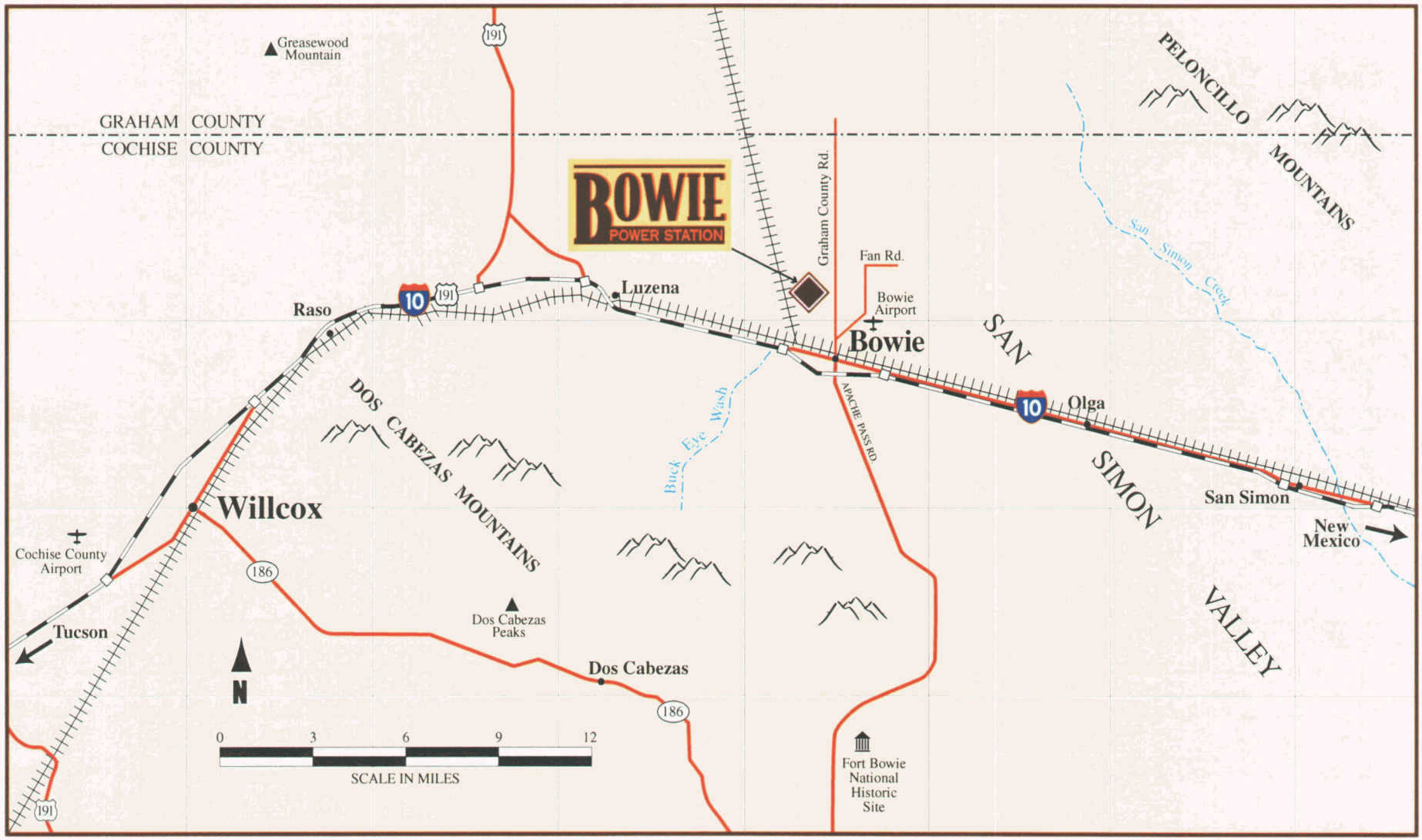
- Existing high-voltage electric transmission lines are located nearby within accessible corridors. The proposed interconnecting transmission lines and switchyard can be sited and constructed with low levels of environmental impact, and will support local and regional electrical system integrity.

- Adequate water supplies are available through on-site wells.

- An adequate natural gas supply will be available nearby.

- The proposed site is located adjacent to an existing railway line.
- The surrounding area has a low population density. The closest off-site residences are located approximately 1 mile away from the proposed generating facilities.
- Physical attributes include flat terrain, direct access and adequate acreage to achieve visual screening and buffer areas between the power plant and surrounding land uses.
- General community support for the project exists in the area.

This Application contains that information requested, and in the format prescribed by, A.A.C.R14-3-219. In addition, further information is set forth in Exhibits A through J to the Application. At the public hearing before the Committee, the Applicant will offer testimony and documentary evidence in support of this Application and the two CECs, which it is requesting.



Bowie Power Station Site Map

Figure 1

APPLICATION

APPLICATION FOR
CERTIFICATES OF ENVIRONMENTAL COMPATIBILITY

1. *Name and address of the Applicant:*

Name: Bowie Power Station, LLC
Address: 4350 E. Camelback Road, Suite B-175
Phoenix, Arizona 85018

Bowie Power Station, LLC may assign all or part of the project to other entities.

2. *Name, address, and telephone number of a representative of the Applicant who has access to technical knowledge and background information concerning this application, and who will be available to answer questions or furnish additional information:*

Name: Tom C. Wray
Project Development Manager
SouthWestern Power Group II, LLC
Address: 4350 E. Camelback Road, Suite B-175
Phoenix, Arizona 85018
Phone: (602) 808-2004
Fax: (602) 808-2099
E-mail: Twray@southwesternpower.com

3. *State each date on which Applicant has filed a ten-year plan in compliance with A.R.S. §40-360.02, and designate each such filing in which the facilities for which this application is made were described. If they have not been previously described in a ten-year plan, state the reasons therefore.*

Under the provisions of A.R.S. 40-360.02, Applicant is not required to file a 10-year plan with respect to the proposed Bowie Power Station. Applicant does not intend to construct, own, or operate the proposed transmission facilities, which are the subject of this Application. Accordingly, it is not required to file a 10-year plan with respect to those facilities. However, on June 8, 2001, Applicant made an informational filing with the Arizona Corporation Commission, which provided the same information with respect to the Bowie Power Station transmission facilities as would have been contained in a 10-year plan. Applicant subsequently revised its proposed transmission arrangements to those described in this Application; and on July 25, 2001 filed an amendment to its June 8, 2001 informational filing to reflect such revision.

4. *Description of the proposed facilities:*

4.1 *With respect to an electric generating plant:*

4.1.1 *Type of generating facilities:*

The Bowie Power Station is a natural gas-fired, combined-cycle electric generating plant. The plant will use current state-of-the-art, "F" combustion turbine technology in a highly efficient combined cycle. The plant will be designed to operate continuously in a base-loaded mode. Construction of the plant will be phased in two nominal 500 MW power blocks, with supplemental firing (also known as "duct burning") to produce a total of approximately 1,000 MW. Each power block consists of the following basic components:

- two combustion turbine generators (CTG)
- two heat recovery steam generators (HRSG)
- one steam turbine electric generator (STG)

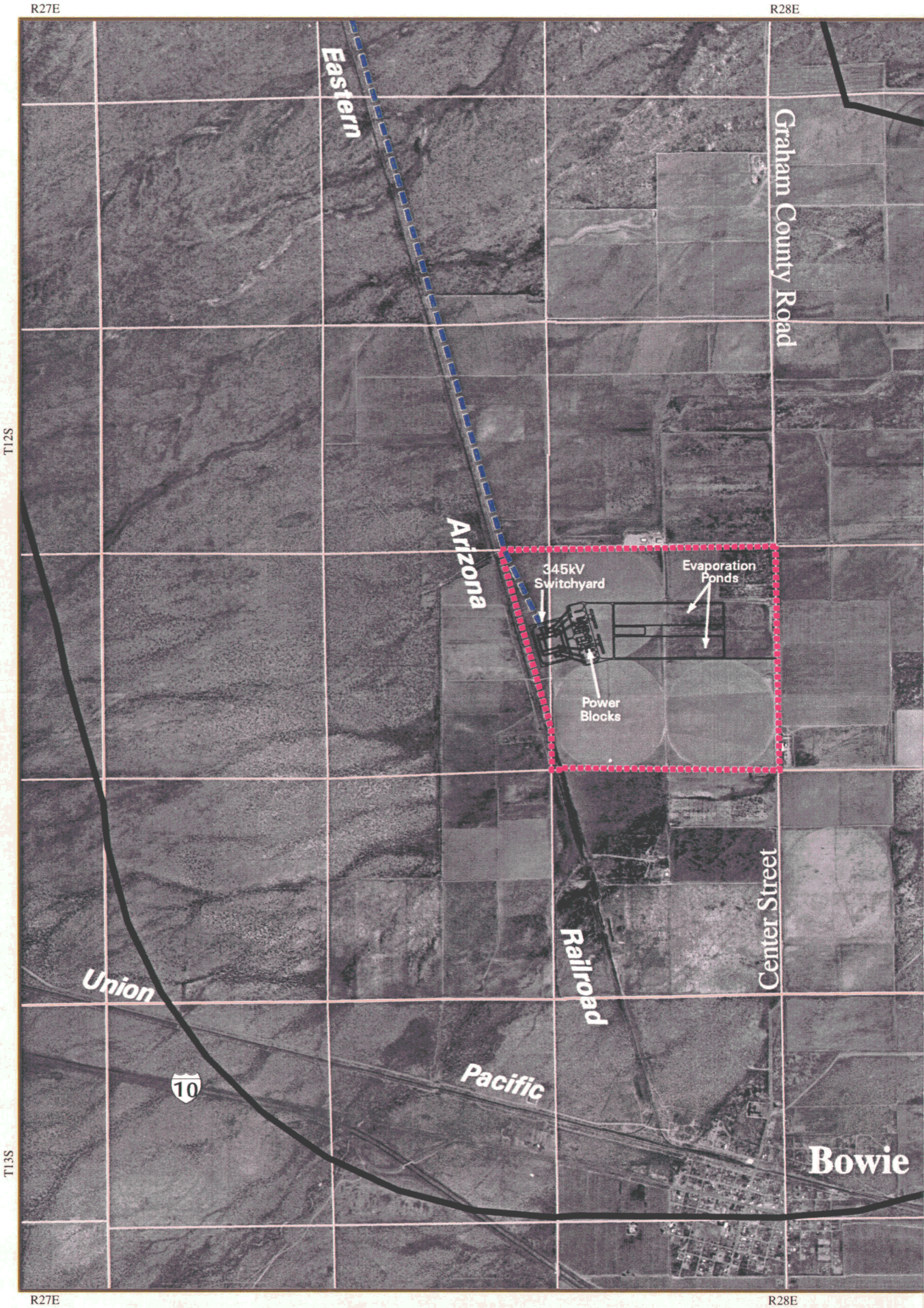
The circulating water will be cooled by a multi-cell, wet mechanical draft cooling tower. Groundwater wells will supply the makeup water. The plant will incorporate a zero discharge wastewater system. An evaporative cooling system or inlet fogging system will be used to reduce the combustion turbine air inlet temperature and increase the plant output and efficiency during warm weather.

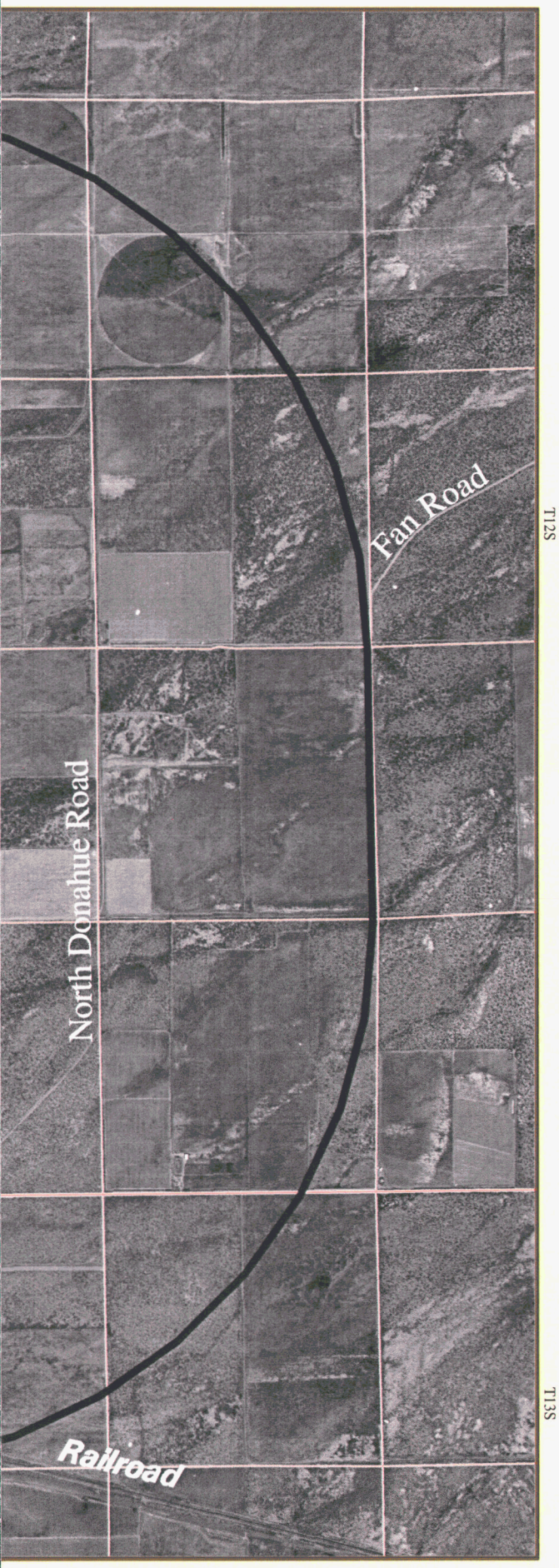
The plant will be fueled by clean natural gas. Emissions control technology will be used to ensure compliance with air quality regulations (see Exhibit B-4, Air Quality). Nitrogen oxide (NO_x) emissions will be reduced via in-situ combustion controls and a post-combustion pollution control system. The supporting infrastructure includes vehicular access, water supply system, natural gas supply lines, transmission interconnection, and a switchyard.

An aerial photograph of the proposed power plant project location and site arrangement is included as Figure 2. Figure 3 provides a graphic of typical combined-cycle project components.

4.1.2 *Number and size of proposed units:*

The power plant project includes the major components and systems described below. An illustration of the general arrangement concept is provided in Exhibit G-1.


R27E
R28E
T12S
T13S
Eastern
Arizona
Railroad
Union
Pacific
Graham County Road
Center Street
Bowie
10
345kV
Switchyard
Evaporation
Ponds
Power
Blocks



BOWIE
POWER STATION

SITE LOCATION

Figure 2

Resource Inventory

- Study Area
- Bowie Power Station Site
- Proposed Double-Circuit 345kV Transmission Line Route

General Reference Features

- Section Line
- Township and Range Boundary

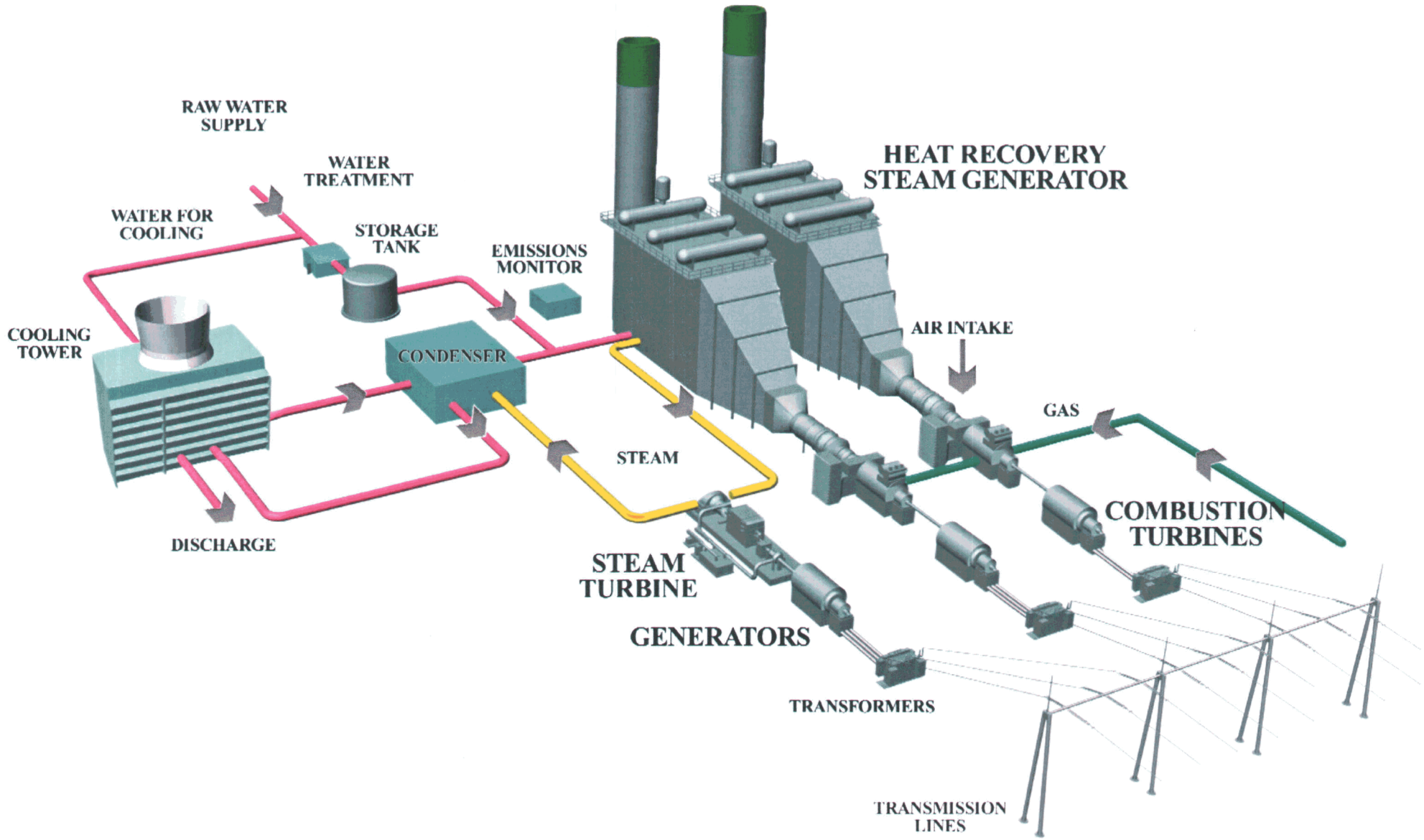
Source:
Aerial Photograph, Todd Photographic Services, 2000.

North

0 1500 3000 6000

Scale 1:36,000

m:/projects/swpg/bowiell/anls/map.aml Draft:July 26, 2001



Typical Combined-Cycle Generating System Components:
One 500 MW Block

Figure 3

4.1.2.1 *Combustion Turbine Generator*

In a CTG, air is compressed, heated through the direct combustion of fuel, and then expanded through a turbine to drive the compressor and an electric generator. The CTGs for this power station will utilize current, state-of-the-art, "F" combustion turbine technology in a highly efficient combined cycle. The CTGs will be General Electric Frame 7FA in a S207FA configuration (i.e., two Frame 7FA CTGs, two HRSGs, and one STG) and will be equipped with dry low NO_x (DLN) combustors. Each S207FA configuration generates approximately 500 MW and is referred to herein as a "power block." Two power blocks comprise the 1,000 MW power station. The CTGs will be fueled only by natural gas.

The plant will utilize an evaporative cooling system or inlet fogging system to reduce the CTG air inlet temperature and increase the plant output and efficiency during warm weather. CTG auxiliary equipment also includes self-cleaning inlet air filters, oil lubrication and cooling systems, natural gas fuel system, fire protection systems, sound attenuation equipment, and an instrumentation and control system.

4.1.2.2 *Heat Recovery Steam Generator*

The HRSG produces steam from the hot exhaust gases from the CTG. The high-pressure steam is expanded in the STG to produce more electricity and increase the overall cycle efficiency. The HRSG will be a natural circulation reheat unit with three steam pressure levels. High-pressure, superheated steam is generated in the first section of the HRSG and sent to the high pressure section of the STG. Intermediate-pressure steam from the STG is reheated in the HRSG and returned to the STG. Low-pressure steam from the HRSG is added to the low pressure section of the STG. The HRSG will be equipped with supplemental firing, which will be used to increase the output of the power station for peak output. There is one HRSG per CTG.

4.1.2.3 *Steam Turbine Generator*

As described above, the steam from the HRSG is expanded in the steam turbine, which drives an electrical generator to produce additional power. Each steam turbine generator will

be designed for additional output from the supplemental firing. There is a factory-assembled combined high-pressure/intermediate-pressure casing and a field-assembled double-flow low pressure casing. Low-pressure steam exhausts from the STG and is condensed in a condenser cooled by circulating water system. The circulation water system also cools the generator and the STG lube oil system. The STG package includes a lube oil system, gland steam condenser, automatic sealing system, and control panel.

4.1.2.4 *Air Pollution Control System*

The CTGs will be equipped with DLN combustors to reduce NO_X emissions to 9 parts per million volumetric discharge (ppmvd). Post combustion, selective catalytic reduction (SCR) systems will further reduce CTG NO_X levels to 3.0 ppmvd. The SCR catalyst is installed in the HRSG. The process reagent, aqueous ammonia, is injected into the HRSG inlet upstream of the SCR catalyst. A Continuous Emission Monitoring System (CEMS) will be located in each exhaust stack and will continuously monitor the emissions from the CTG/HRSG.

The auxiliary boiler, which will operate when a power block is not online to allow for quick starting, will be equipped with low NO_X burners. Natural gas will fuel both combustion devices. Natural gas is inherently clean and low in sulfur and will provide the lowest achievable emission rates for sulfur dioxide and particulate emissions.

4.1.2.5 *Water Handling and Treatment Facilities*

Groundwater pumped from wells on the Bowie property will supply process water. The estimate of annual average water use is 5,500 acre feet per year.

The project sponsor is considering the following preliminary concept for a makeup water treatment system:

- chemically assisted direct filtration (with coagulant, coagulant aid, and sodium hypochlorite feeds)
- cartridge filtration
- chemical dechlorination
- reverse osmosis (with proper chemical feeds for scale control or pre-softening with sodium cycle softening)

- decarbonation
- electrodeionization

The filters (preceded by chlorine addition) will also effectively remove the ferrous iron from the well water supply.

Process Wastewater Treatment

A zero-discharge wastewater system will dispose of wastewater from the cooling tower blow-down, HRSG blow-down, and makeup water treatment system effluent. The wastewater will be directed to lined evaporation ponds approximately two feet deep with a total area of approximately 60 acres. The blow-down flow rate will be 68 gallons per minute (gpm) per power block when operating. For purposes of sizing the lined evaporation ponds, an average annual flow rate of 100 gpm has been assumed.

Stormwater

Site stormwater drainage and the clean oil/water separator effluent will be directed to an unlined five-acre retention pond with a depth of three to four feet. The retained runoff will either evaporate or percolate into the ground. Site drainage is assumed as being generated from developed areas of the site including generation islands, buildings, roadways, and electrical switchyards/substations.

Potable Water

The potable water for the work force needed to construct and operate the plant will come from treated groundwater.

Sanitary Sewer

The plant's domestic wastewater treatment system will be designed for an operating work force of 37 personnel. Domestic wastewater treatment will meet or exceed Arizona Department of Environmental Quality standards and will consist of a package sewage treatment plant or an extended aeration pond system with the treated effluent routed to the site runoff detention pond. The design may also incorporate wastewater reuse for site grounds irrigation.

4.1.2.6 *Fuel System*

The purpose of the fuel system is to meter, filter, and regulate pressure of the natural gas as it moves from the transmission pipeline interconnection to the combustion turbine combustors (and the HRSG duct burner systems). Natural gas (pipeline quality, low sulfur) will be obtained from a natural gas transmission line. The gas is piped underground from the line, where it is metered, to the combustion turbine area and split to the individual combustion turbines.

The natural gas fuel system delivers and conditions natural gas from the main pipeline to each CTG and boiler. A filter separator is supplied with the CTGs to remove particulate and liquids. The pressure of the gas will be regulated from the pipeline to meet the CTG requirements.

4.1.2.7 *Instrumentation and Control System*

A microprocessor-based, distributed control system will provide remote control capability from a central control room. The distributed control system provides supervisory control to system control packages (such as those for the CTGs STGs, HRSGs, and the water treatment system) and directly monitors and controls field instruments. The control room will be equipped with an operator console, printers, engineering workstations, CEMS monitor, and fire detection panels.

4.1.2.8 *Switchyard and Electrical Interconnection*

The 345kV plant switchyard will consist of a four-bay, air-insulated substation in a breaker and one-half configuration. This design will provide connections for four CTGs, two STGs, and two positions including dead-end structures for termination of the 345kV transmission lines.

An alternate power supply provided from the existing 12kV distribution line running along Graham County Road will be used initially as construction power.

The new Willow 345/230kV Switchyard will be constructed to interconnect the 345kV transmission lines with the TEP 345kV lines and the AEPCO Red Tail-Dos Candados 230kV transmission line (see Section 4.2.1.3).

4.1.2.9 *Site Improvements*

Construction access to the power plant site will be provided via Graham County Road from the south. Permanent access will also be from Graham County Road (see Figure 2). Roads will be improved Type 1 classification surfaced to accommodate construction and normal operation and maintenance truck loading, and to eliminate dust concerns. A construction staging area for equipment and materials storage will be located west of Graham County Road in Section 28.

Paved roadways will be constructed to and around the generation islands. Roadways will be of suitable widths for truck traffic, designed for highway truck loadings, and consist of a six-inch minimum gravel or crushed stone base course followed by a two-inch asphalt binder course and a two-inch asphalt wearing course.

Certain chemicals and petroleum products required for normal operation and maintenance will be stored on site in containers approved by the U.S. Department of Transportation.

High-pressure sodium vapor-type outdoor lighting with full cutoff luminares will provide illumination in areas of normal personnel traffic such as building exteriors, equipment areas, walkways and stairs, substation areas, roadways.

Wall-mounted battery pack-type emergency lighting will be used to provide adequate levels of illumination for building egress routes. The control room will have sufficient emergency lighting levels to allow plant personnel to monitor plant activities.

4.1.3 *The source and type of fuel to be used, including a proximate analysis of fossil fuels:*

The source of natural gas supply will be the El Paso Natural Gas (EPNG) system and will likely be from Line No. 2000 located south of the power plant site (All American Pipeline). This tap is expected to be located approximately 4 miles from the facility metering point.

A chromatograph sample provided by EPNG is included in the table on the following page.

NATURAL GAS ANALYSIS		
Component	**Mole %**	**GPM**
Methane	94.28000	0.00000
Ethane	2.77000	0.74080
Propane	0.49000	0.13500
Butane	0.11000	0.03470
Iso-Butane	0.06000	0.01960
Pentane	0.03000	0.01090
Iso-Pentane	0.03000	0.01100
Neo-Pentane	0.00000	0.00000
Hexane	0.04000	0.01750
Heptane	0.00000	0.00000
Octane	0.00000	0.00000
H_2S	0.00000	0.00000
CO_2	0.34000	0.00000
Nitrogen	1.85000	0.00000
Total	100.00000	0.96950
Dry BTU:	1026	
Wet BTU:	1008	
Gravity:	0.588	
Pressure Base:	14.73	
Sample Date: December 1, 2000	Source: El Paso Natural Gas 2001	
BTU = British thermal units		

4.1.4 Amount of fuel to be utilized daily, monthly, and yearly:

Following are estimated amounts of fuel that would be used when operating continuously in a base load configuration:

- Daily –200,000 million British thermal units (MMBtu)
- Monthly – 6,000,000 MMBtu
- Annually – 80,000,000 MMBtu

4.1.5 Type of cooling to be utilized and the source of any water to be utilized:

4.1.5.1 Type of cooling:

A multi-cell, wet, mechanical draft cooling tower will be used to reduce the temperature of the circulating water. The circulating water system will operate with a minimum of 15 cycles of concentration to decrease the makeup water use and the amount of blow-down to be discharged. A side-stream softening system will be used to achieve these higher cycles of concentration.

4.1.5.2 Source of water:

Makeup water for the power plant project will be obtained from the on-site groundwater supply wells. A side-stream softening will increase the circulating water system cycles of concentration thereby reducing the amount of blow-down and wastewater. Furthermore, condensed blow-down from the boilers will be used as makeup water for the circulating water system. This will also minimize the amount of groundwater pumped for makeup water and the amount of wastewater produced.

4.1.6 Proposed height of stacks and number of stacks, if any:

There will be one exhaust stack per HRSG for the total 1,000 MW project. The four HRSG stacks are anticipated to be between 130 and 160 feet high. Each of two auxiliary boiler stacks will be 45 feet high.

4.1.7 Dates for scheduled start-up and firm operation of each unit and date construction must commence in order to meet schedules:

The scheduled start-up and commercial operation for each 500 MW unit is as follows:

Unit	Start-up	Commercial Operation Date
1	mid 2003	2nd quarter 2004
2	mid 2005	4th quarter 2005

4.1.7.1 Power Plant Project Construction

A contractor will be retained to perform the engineering, procurement, and construction for the project. In order to meet the power plant project schedule, construction must commence in 2002. The actual construction in the field for the total 1,000 MW facility should be completed in approximately 36 months. During this period, the construction work force is expected to average approximately 250 people on site, peaking at 500. An area adjacent to the plant will be used temporarily for construction parking, work trailers, storage, and lay-down areas. Water and electrical power facilities are available at the site for use during construction.

The structural elements, water retaining structures, and infrastructure facilities will be designed and constructed to accommodate future potential subsidence and operate safely.

4.1.7.2 Power Plant Project Operation

The plant will be designed for base-load operations, but will have the ability to operate at part-load. The output of the facility will be determined by market factors, such as the growth in energy demands and daily wholesale energy prices.

The power plant is designed for base-load combined-cycle operation with supplemental fired peaking capability. The combustion turbines can be fired in 10 to 15 minutes and reach full-load output in less than two hours. The power plant will be capable of producing up to 1,000 MW (nominal). An additional 100 MW of peaking capability may be available from supplemental firing, depending on the ambient temperature conditions. As ambient temperatures increase, evaporative inlet air coolers will be used to reduce the CTG inlet air temperature to near the wet bulb temperature to maximize plant output.

The power plant project will include advanced control systems to monitor and control all of the plant operation systems. Approximately 37 full-time staff will perform routine operation and maintenance functions. In addition, the plant can be remotely monitored and dispatched. Some functions, including major turbine and generator maintenance, will be outsourced to other vendors.

4.1.8 To the extent available, the estimated costs of the proposed facilities and site, stated separately:

The estimate of probable facilities cost for the power plant is in excess of $400 million. The estimate includes construction and material costs of the generation facilities and power plant switchyard. The cost of the transmission lines and the Willow 345/230kV Switchyard is provided in Section 4.2. The land cost of the power plant site will be available upon closing of the option to purchase.

4.1.9 Legal description of the proposed site:

The power plant site is located in Section 28 and a portion of Section 29, Township 12 South, Range 28 East in Cochise County, Arizona.

4.2 Description of the proposed transmission line(s):

4.2.1 General Description:

4.2.1.1 Nominal voltage for which the lines are designed

345kV alternating current (AC) – double-circuit

4.2.1.2 Description of the proposed structures:

The proposed 345kV transmission lines will be designed for a double circuit with three-phase circuits (three bundles of two conductors per phase) and static wires on single pole structures (see Exhibit G-3, typical structure diagram). The 345kV transmission structures are typically 160 feet (maximum of 175 feet) in height with span lengths of between 800 feet and 1,100 feet. The heights of structures, span length, or other characteristics could vary based on the final design or in order to accommodate site-specific conditions and mitigation measures.

4.2.1.3 Description of proposed switchyards and substations:

The new Willow Switchyard (substation) will be constructed at a site located approximately 3 miles north of the Cochise/Graham County Line on State Trust Lands in Graham County, approximately .25-mile east of U.S. Highway 191. The switchyard site is located in Section 14, Township 11 South, Range 26 East. The purpose of the switchyard is to:

a. tie the two 345kV transmission lines from the Bowie Power Station into the existing TEP Greenlee-Vail and Springerville-Vail 345kV transmission lines; and

b. provide an interconnection with the AEPCO Red Tail-Dos Candados 230kV transmission line located adjacent to the switchyard site.

In addition to the breaker and one-half and dead end structures, a 230kV autotransformer and breakers will be installed within the fenced site area. The switchyard site will require approximately 23 acres. A conceptual plan is provided in Exhibit G-6.

4.2.1.4 Purpose for constructing said transmission line:

The proposed transmission line project will connect the Bowie Power Station to the Greenlee-Vail 345kV transmission line at a minimum. Connections to the Springerville-Vail 345kV transmission line and the AEPCO Red Tail-Dos Candados 230kV line will be determined from reliability and transmission rate analyses. From these points of interconnection, power generated at the Bowie Power Station would then flow through existing transmission lines (Figure 4). The Interconnection Power Flow Study is provided in Exhibit J-5.

4.2.2 General Location:

4.2.2.1 Description of the geographic points between which the transmission line will run:

The proposed 345kV transmission lines would extend from the Bowie Power Station switchyard in the northeast quarter of Section 29, Township 12 South, Range 28 East, in Cochise County, north of Bowie, Arizona, to the proposed Willow Switchyard to be located at the intersection of the existing TEP 345kV transmission lines and the AEPCO 230kV transmission line in Section 14, Township 11 South, Range 26 East, east of U.S. Highway 191 in Graham County (see Figure 4).

4.2.2.2 Straight-line distance between such geographic points:

The straight-line distance of the proposed 345kV transmission line between the Bowie Power Station switchyard and the proposed Willow Switchyard site is approximately 13 miles.

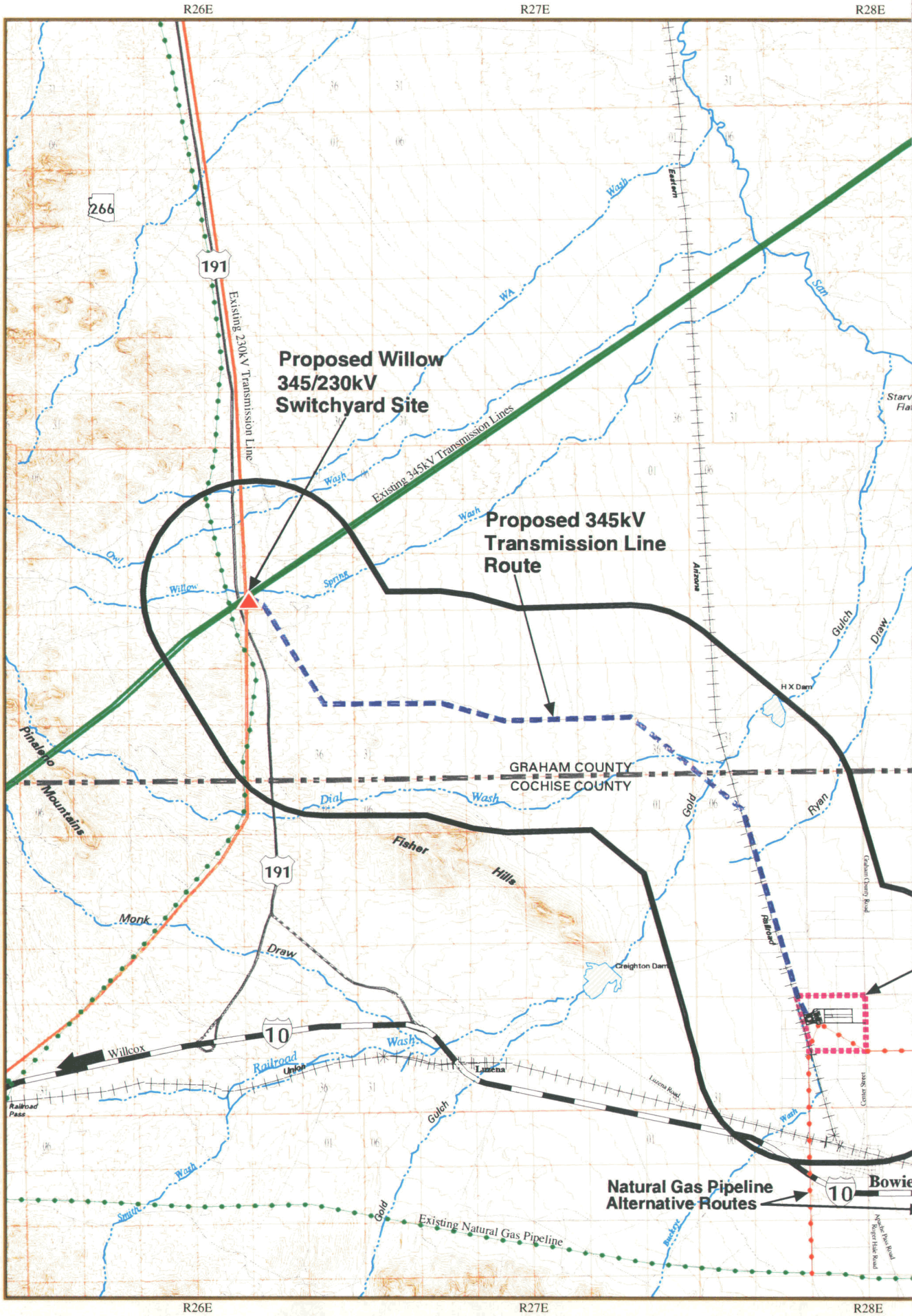
4.2.2.3 Length of the transmission line for each alternate route:

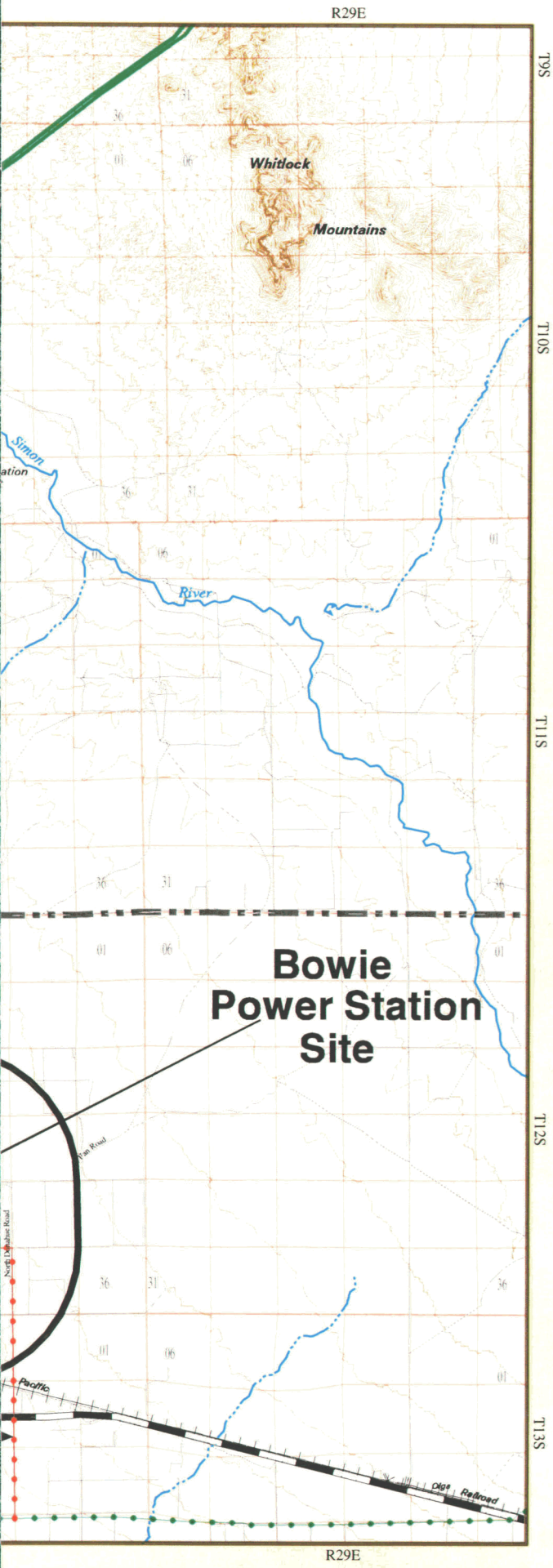
The approximate length of the proposed route is 14.3 miles. No other alternatives are proposed, but were initially considered by the Applicant.

4.2.3 Detailed Dimensions:

4.2.3.1 Nominal width of right-of-way requested

A total right-of-way width of 250 feet is anticipated for the 345kV transmission line. It is requested that the right-of-way be located


R26E
R27E
R28E
T9S
T10S
T11S
T12S
T13S
266
191
Existing 230kV Transmission Line
Proposed Willow
345/230kV
Switchyard Site
Existing 345kV Transmission Lines
Proposed 345kV
Transmission Line
Route
GRAHAM COUNTY
COCHISE COUNTY
Pinaleno
Mountains
Fisher
Hills
Monk
Draw
Willow
Spring
Wash
Dial
Gold
Ryan
Gulch
Draw
Eastern
Arizona
Railroad
H X Dam
Creighton Dam
Willcox
Railroad
Union
Luzena
Luzena Road
Railroad
Pass
Smith
Gold
Buckeye
Existing Natural Gas Pipeline
Natural Gas Pipeline
Alternative Routes
10
Bowie
Center Street
Apache Pass Road
Ranger Hale Road
Graham County Road



BOWIE POWER STATION

PROJECT SITE AND PROPOSED TRANSMISSION LINE ROUTE

Figure 4

Resource Inventory

- Study Area
- Bowie Power Station Site
- Proposed Double-Circuit 345kV Transmission Line
- Natural Gas Pipeline Alternative Routes
- Proposed Willow 345/230kV Switchyard

General Reference Features

- 345kV Transmission Line
- 230kV Transmission Line
- Natural Gas Pipeline
- County Boundary
- Interstate
- Major Road
- Road
- Railroad
- River
- Wash
- Section Line
- Township and Range Boundary
- Contour
- Reservoir

Sources:
United States Geological Survey (USGS), Willcox AZ-NM 1994, 1:100,000-scale metric topographic maps.
Contours interpolated from USGS 1:24,000-scale digital elevation models at an interval of 40 feet.

North

0 1 2 4 Miles

m:/projects/swpg/bowiet1/arnis/map.aml Draft:July 26, 2001

within a general corridor of 2,500 feet centered on the proposed route referenced in Figure 4 and Exhibit A-2b. The exact location of the alignment within the general corridor will ultimately be determined based on right-of-way considerations, site-specific design demands, and environmental requirements.

4.2.3.2 Nominal length of span:

It is anticipated that single pole structures will be used, typically requiring spans between approximately 800 feet to 1,100 feet for the 345kV line.

4.2.3.3 Maximum height of supporting structures:

Maximum of 175 feet above grade for 345kV lines; average height of tangent structures is 160 feet.

4.2.3.4 Minimum height of conductor above ground:

Estimated 25 feet for 345kV lines.

Final design of the transmission lines will ensure compliance with National Electrical Safety Code for the minimum height of conductors aboveground, and may vary due to site-specific circumstances.

4.2.4 Estimated costs of proposed transmission line and substations:

Proposed Willow 345/230kV Switchyard (substation): $8.1 million
Proposed transmission line: approximately $19 million

These estimates are based on typical costs for design and construction, and may vary based on final engineering, design, availability of materials, and potential mitigation requirements.

4.2.5 Description of the Proposed Route

Proposed Route (see Figure 4 and Exhibit A-2b): This route travels north-northwest from the Bowie Power Station Switchyard along the east side of the Eastern Arizona Railroad right-of-way for 3.8 miles. At that point the route veers northwest for 2.6 miles to a road running roughly east/west from the railroad toward U.S. Highway 191. From the intersection with this access road, the route follows the road west 5.5 miles. At this point the route turns north-northwest for 2.4 miles to intersect with the existing

345kV transmission lines and proposed Willow Switchyard site in Section 14, Township 11 South, Range 26 East in Graham County.

4.2.6 Land Ownership:

The proposed route consists of approximately 2.5 miles of private land and 11.8 miles of Arizona State Trust land for a total distance of approximately 14.3 miles. The proposed Willow Switchyard site is located on Arizona State Trust land.

5. *Jurisdictions*:

5.1 Areas of jurisdiction (as defined in A.R.S. § 40-360) affected by this route or site:

All components of the power plant will be located in an unincorporated area of Cochise County. The transmission lines will be located within unincorporated areas of Cochise and Graham counties. The proposed Willow Switchyard will be located in an unincorporated area of Graham County.

5.2 *Designation of proposed sites or routes, if any, which are contrary to the zoning ordinances or master plans of affected areas of jurisdiction:*

The proposed power station site, transmission line route, and switchyard sites are not located contrary to master plans of any affected areas of jurisdiction. A zoning change from RU-4 to HI and Special Use Permit by Cochise County will be requested for the Bowie Power Station site.

6. *Description of the environmental studies the Applicant has performed.*

The Applicant contracted with the following consultants to perform environmental studies:

Consultant	Environmental Studies
Environmental Planning Group, Inc. (EPG)	Cultural, biological and visual resources; land use; public involvement coordination; land management and site planning
URS	Water resources
Wind River Environmental Group, LLC	Air resources
Michael Theriault Acoustics, Inc.	Noise

Results of the environmental studies for the proposed project are presented in Exhibits A through I of this application.

Environmental studies of the project areas began with the collection of existing environmental data including literature, maps, aerial photographs, and other agency data. Contacts were made with appropriate agencies and organizations. In addition to secondary data investigations, pedestrian surveys were completed for cultural and biological resources. Existing conditions were measured for noise while windshield surveys were conducted to verify land use and visual resources. Visual simulations also were prepared to assist in impact assessment and mitigation planning.

Biological studies have indicated that issues related to special status species are not anticipated for this project. Historically, the majority of the Bowie property and the plant site were cultivated for agriculture. An intensive pedestrian survey for cultural resources was conducted for the plant site and transmission line route, and results are summarized in Exhibit E. Overall, no adverse impacts to cultural or biological resources are anticipated as a result of the construction and operation of the proposed project.

The location of the plant site within the Bowie property allows for buffering from the nearest residential properties (approximately 1 mile away). This distance reduces immediate visual impacts to potentially sensitive viewers and potential noise effects. Simulations of the plant show expected views of the project (see Exhibits G-4 and G-5). Additional mitigation measures include a landscape plan, subject to Cochise County regulation.

A siting evaluation was conducted by EPG to identify possible alternative routes for the proposed 345kV transmission line to interconnect the proposed Bowie Power Station with the existing Springerville-Vail and Greenlee-Vail 345kV transmission lines. Routes were evaluated using environmental criteria, based on anticipated construction requirements for the proposed double-circuit line. Two routes were initially identified that could be constructed using existing access. Following additional analysis, one route was eliminated from further consideration based primarily on potential biological impacts. Furthermore, that alternate route would not have the advantage of a termination near the intersection of the AEPCO 230kV line for the proposed Willow Switchyard site, which could be provided directly by the proposed route.

A public involvement program has been integrated with the planning process, and will continue throughout the permitting and design phases. Public meetings were held on April 25 and 26, 2001 in Willcox and Bowie, respectively, to introduce the project to the public, answer questions, and request input on the project. A newsletter describing the project was mailed out in the early stages of project development. In addition, the project team has presented project updates to local communities and organizations, and county and state representatives throughout the process. Summaries of the public involvement process are included in Exhibit J.

CONCLUSION

Applicant believes that the foregoing information and that set forth in attached Exhibit Noumbers "A" through "J" satisfy the content and format requirements of A.A.C.R14-3-219. In addition, Applicant believes that its plans for siting and designing the proposed 1,000 MW (nominal) Bowie Power Station, double-circuit 345kV transmission line and 345kV/230kV switchyard are "suitable," when judged in light of the decision-making factors set forth in A.R.S. §40-36.06. Accordingly, Applicant hereby requests that the committee render a decision or decisions granting Applicant (i) a Certificate of Environmental Compatibility for the proposed 1,000 MW (nominal) Bowie Power Station; and (ii) a Certificate of Environmental Compatibility for the double-circuit 345kV transmission line, 345/230kV switchyard and 230kV transmission interconnection, which are the subjects of this Application.

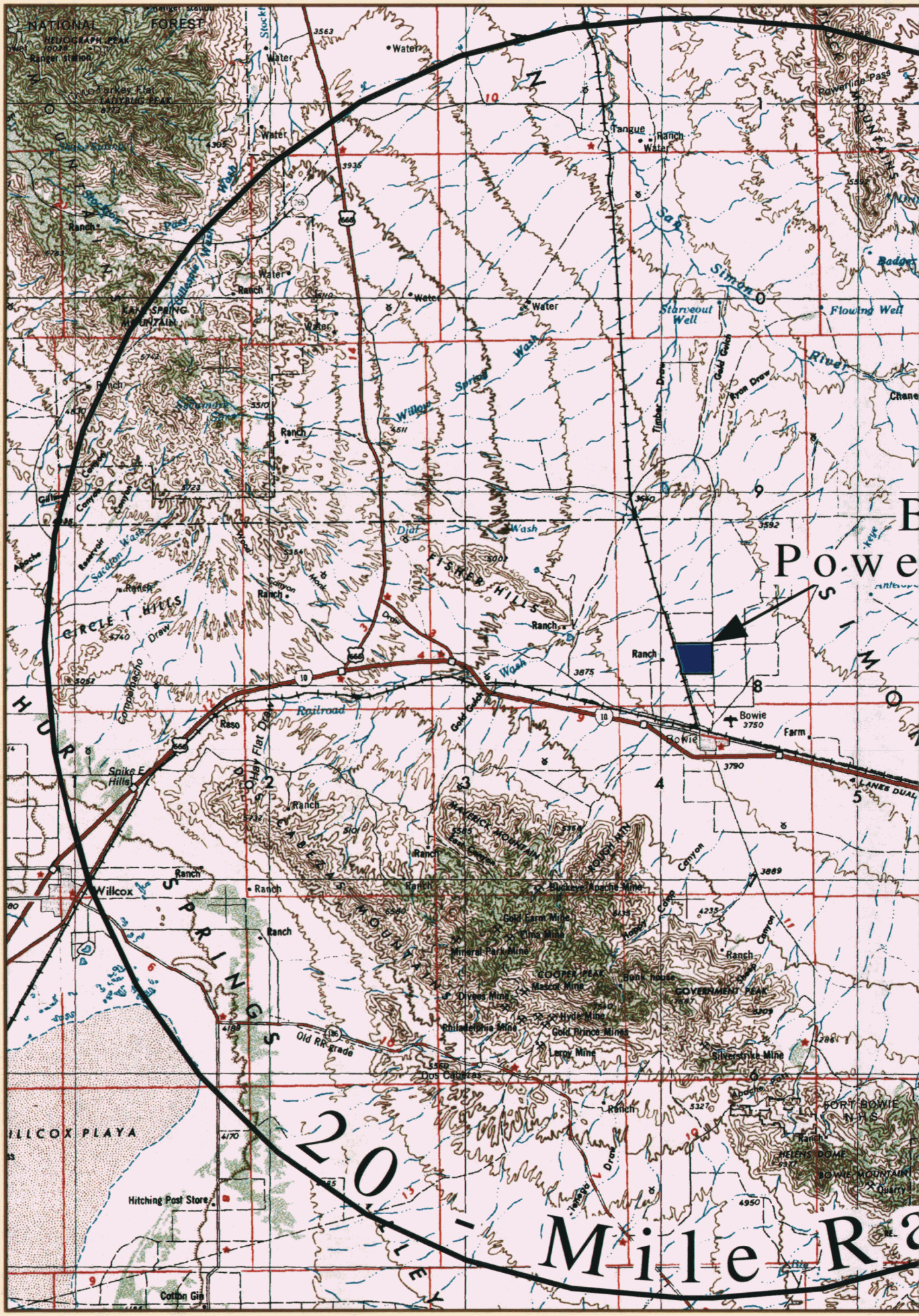
BOWIE POWER STATION, LLC

By: Tom Carlay
Authorized Officer

ORIGINAL and 25 copies of the foregoing hand delivered and filed with the Director of Utilities, Arizona Corporation Commission,

this 27th day of July, 2001.

EXHIBIT A
LOCATION AND LAND USE MAPS

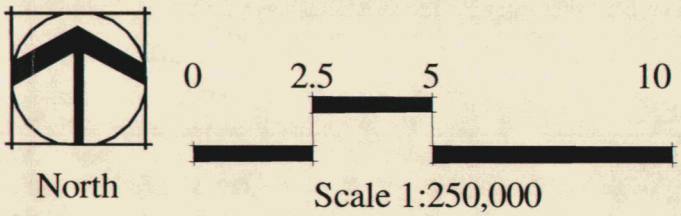

NATIONAL FOREST
Turkey Flat
Ranch
Water
Tangue
Starveout Well
Flowing Well
Willow Spring Wash
Timber Draw
Gold Gulch
Ryan Draw
Sacaton Wasp
Circle T Hills
Fisher Hills
Railroad
Bowie
Farm
Spike E Hills
Willcox
Willcox Playa
Old RR Grade
Dos Cabezas
Hitching Post Store
Cotton Gin
Fort Bowie N.M.S.
Helens Dome
Bowie Mountain
Quarry
Powerline Pass
Powe
20-Mile Ra

BOWIE POWER STATION

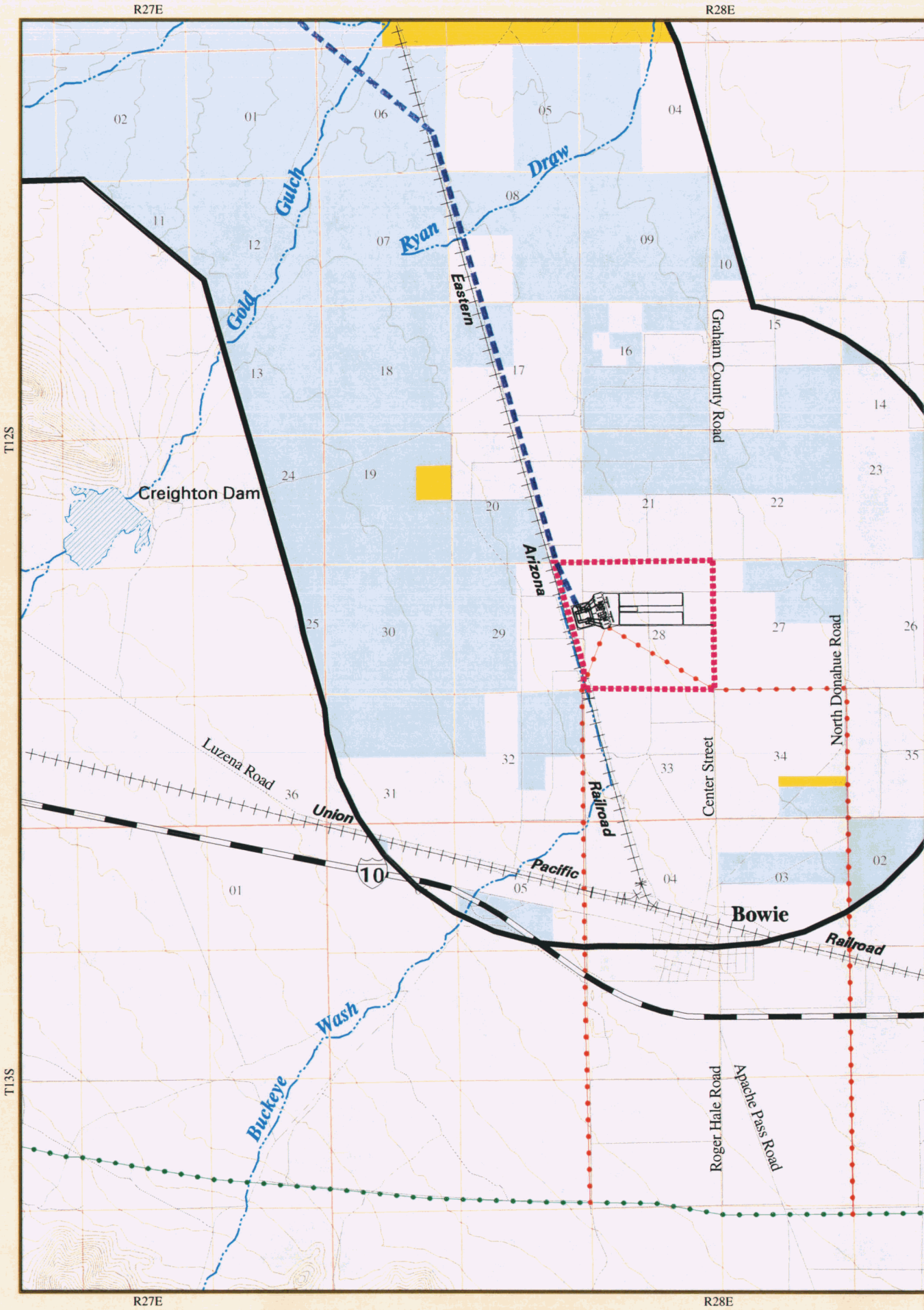
20-MILE RADIUS

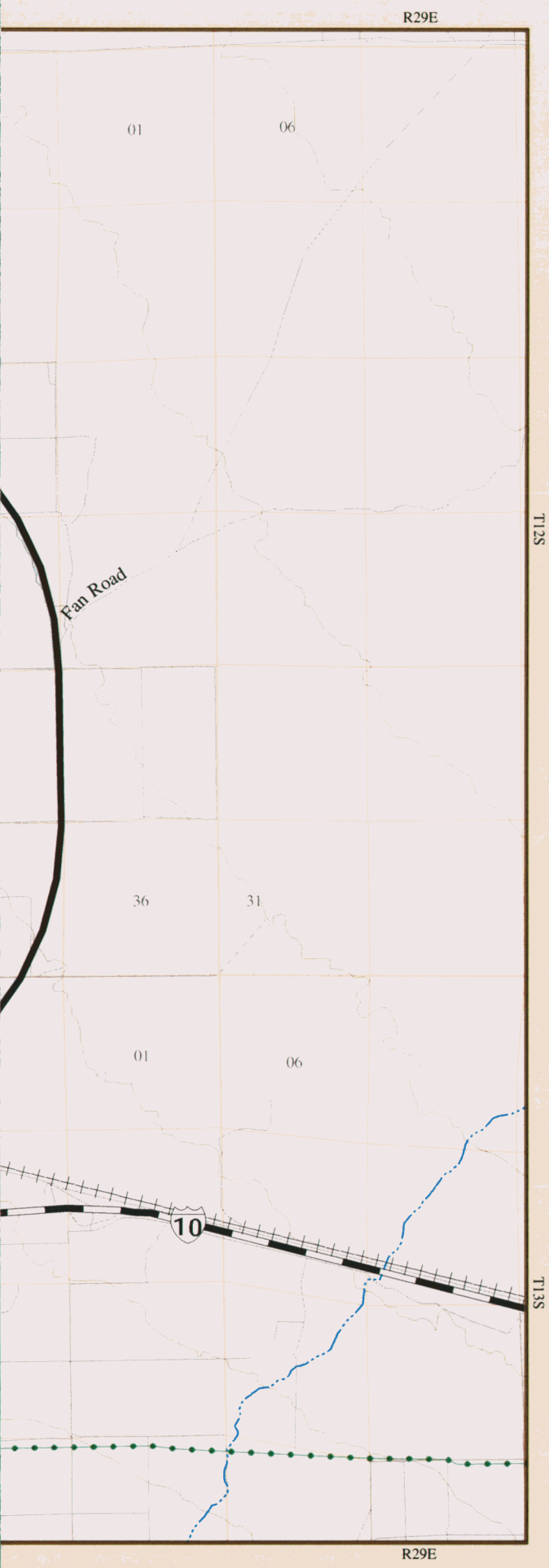
Exhibit A-1

Source:
United States Geological Survey (USGS), Silver City NM-AZ, 1970, 1:250,000-scale metric topographic map.



m:/projects/swpg/bowiet1/amls/map.aml Draft:July 26, 2001


R27E
R28E
T12S
T13S
Gold Gulch
Ryan Draw
Creighton Dam
Arizona Eastern Railroad
Graham County Road
North Donahue Road
Center Street
Luzena Road
Union Pacific Railroad
10
Bowie
Buckeye Wash
Roger Hale Road
Apache Pass Road



BOWIE POWER STATION

LAND OWNERSHIP AND JURISDICTION

Exhibit A-2a

Resource Inventory

- Study Area
- Bowie Power Station Site
- Proposed Double-Circuit 345kV Transmission Line
- Natural Gas Pipeline Alternative Routes
- Private
- State Trust
- Bureau of Land Management

General Reference Features

- Natural Gas Pipeline
- Interstate
- Road
- Railroad
- Wash
- Section Line
- Township and Range Boundary
- Contour
- Reservoir

Sources:
Arizona State Land Department, Phoenix, AZ 2001.
United States Geological Survey (USGS), Willcox AZ-NM 1994, 1:100,000-scale metric topographic maps.
Contours interpolated from USGS 1:24,000-scale digital elevation models at an interval of 40 feet.

North

0 .5 1 2

Scale 1:62,500

m:/projects/swpg/bowiet1/arcls/map.aml Draft July 26, 2001

OVERSIZED MAP

-Bowie Power Station
Land Ownership and Jurisdiction
Exhibit A-2b

TO REVIEW SEE DOCKET SUPERVISOR

DOCKET
L-00000BB-01-0118-00000

OVERSIZED MAP

-Bowie Power Station
Existing and Future Land Use
Exhibit A-3

TO REVIEW SEE DOCKET SUPERVISOR

DOCKET
L-00000BB-01-0118-00000

EXHIBIT B
ENVIRONMENTAL REPORTS

EXHIBIT B
ENVIRONMENTAL REPORTS

As stated in Arizona Corporation Commission Rules of Practice and Procedure R-14-3-219:

"Attach any environmental studies which applicant has made or obtained in connection with the proposed site(s) or route(s). If an environmental report has been prepared for any Federal agency or if a Federal agency has prepared an environmental impact statement pursuant to Section 102 of the National Environmental Policy Act, a copy shall be included as part of this exhibit."

Exhibit B-1	Land Use Study
Exhibit B-2	Landscape Plan
Exhibit B-3	Water Supply Investigation Report
Exhibit B-4	Air Quality

EXHIBIT B-1
LAND USE STUDY

EXHIBIT B-1
LAND USE STUDY

INTRODUCTION

The purpose of the land use study is to inventory existing and future land uses, and identify potential impacts that could result from the construction and operation of the proposed project. This land use report includes discussion of:

- study area and inventory methods
- inventory results
- impact assessment and mitigation

The maps that illustrate the land use components are included in Exhibit A and are described below.

STUDY AREA AND INVENTORY METHODS

The study area is illustrated within a regional context in Exhibit A-1.

The proposed Bowie Power Station would be located in Sections 28 and 29 of Township 12 South, Range 28 East. A double-circuit 345kV transmission line is proposed to connect the power station to a proposed Willow Switchyard in Section 14 of Township 11 South, Range 26 East. The transmission line would extend north from the power station following the Eastern Arizona Railway to within three-quarters mile south of the Graham County Line and then bear westward to the Willow Switchyard site near U.S. Highway 191. The transmission line would pass through Township 12 South, Range 28 East, Township 11 South, Range 27 East, and Township 11 South, Range 26 East. The study area encompasses land within a 2-mile radius of the proposed power station site and a 4-mile corridor centered on the proposed transmission line.

The methods used to gather information for the land use inventory included review and interpretation of maps, aerial photographs, planning documents, and field verification. In addition, this study is based on communication with government agencies and private individuals.

INVENTORY RESULTS

Land Ownership and Jurisdiction

Land ownership is illustrated in Exhibit A-2a, A-2b.

The power station would be located on private land in Cochise County approximately 2 miles north of the unincorporated town of Bowie. The transmission line route crosses approximately 2.5 miles of private and 11.8 miles of Arizona State Trust lands in unincorporated Cochise and Graham counties.

Existing Land Use

Existing land use is illustrated in Exhibit A-3.

Residential - Residential land uses include single-family dwelling units associated with the town of Bowie and outlying farm and ranch residences. Bowie can be characterized as primarily medium density residential. Outlying residences include the following:

- a ranch one-half mile south of the plant site
- the Diamond Z Ranch subdivision (three residences) about 2 miles east
- a mobile home about 2 miles northeast

Commercial - There are several local businesses in the town of Bowie and travel services are offered at the east and west ends of the Interstate 10 (I-10) Business Route.

Industrial - There is a salvage yard north of I-10 at Roger Hale Road.

Agricultural - The majority of the agricultural lands in the Bowie area consist of cropland, orchards, and vineyards. Fallow land and pecan and walnut orchards are common throughout the study area. Chili peppers are currently grown on the proposed power station site. A 200-acre pecan orchard lies on the eastern boundary of the site and a 90-acre orchard lies immediately to the west of the site across the Eastern Arizona Railway.

Utilities - A 69kV substation exists approximately one-quarter mile northeast of the town of Bowie. One 69kV power line traverses the study area in an east to west direction, paralleling the Union Pacific Railroad, and connecting to the 69kV substation. A tower has been constructed to support communications facilities approximately one-quarter mile southeast of the power station site. Existing 345kV and 230kV transmission lines intersect near the proposed Willow Switchyard site in Graham County. El Paso Natural Gas Line (No. 2105), an 8 5/8-inch buried pipeline, runs north-south about one-half mile west of U.S. Highway 191.

Public/Quasi-public - The Desert Rest public cemetery is located approximately 1 mile south of the project property on Center Street. Two schools are located in the central portion of Bowie along with the town library and a county government building. There are three churches in Bowie.

Transportation - I-10 is approximately one-quarter mile south of the Bowie townsite. Major arterials in the study area may be paved or improved dirt roads. Paved arterials include the I-10

Business Route and Center Street. Unpaved roads include Fan Road, North Donahue Road, and Graham County Road.

The Union Pacific Railroad roughly parallels I-10 and passes through the north end of the town of Bowie. The Arizona Eastern Railroad branches from the Union Pacific Railroad northwest of Bowie and runs north to its terminus in Globe. It abuts the western boundary of the Bowie Power Station property for approximately 1.5 miles.

Grazing/Vacant Land - Large areas of land within the study area are vacant and often used for cattle grazing. The largest areas of vacant land are west of the Arizona Eastern Railroad and in the northern portions of the study area.

As noted, the majority of the Bowie Power Station site property is currently irrigated agricultural land. The transmission lines and Willow Switchyard site would be located on open range and fallow agricultural lands.

Future Land Use

Future land use is illustrated in Exhibit A-3.

The Cochise County Comprehensive Plan Growth Areas and Land Jurisdiction Map identifies a rural growth area extending northwest and east of the town of Bowie. Rural growth areas are anticipated to have a slow to moderate rate of growth consisting primarily of low and medium density residential development and a small percentage of local commercial and industrial uses. The land north of the rural growth area, including the location of the proposed power station, is identified as a rural area. This area is defined as sparsely populated lands for rural residences and agricultural areas. It is currently zoned RU-4, Rural Zoning according to the Cochise County Zoning Regulations, which permits rural uses, single household, and manufactured homes. A zoning change to HI, Heavy Industrial, and Special Use Permit will be requested for the 700-acre project site.

The Graham County General Plan identifies land within the study area as general use. Land in this category is used mainly for grazing, mining, recreation, and hunting. The accompanying zoning according to the Graham County Land Use Regulations is Zone A, General Land Use, which permits agriculture, grazing, and low density residences.

Neither Cochise nor Graham County report any pending major subdivisions or master planned developments in the study area.

IMPACT ASSESSMENT AND MITIGATION

Impacts to land use may be identified by the loss of or restrictions to an existing land use, or site incompatibility with existing land use plans. The proposed power station site is under private ownership and currently in agricultural use. Development will remove land from agricultural use, but will not conflict with existing plans for future development.

The proposed transmission line route follows railroad right-of-way and crosses state trust land. These lands, including the Willow Switchyard site, are leased for grazing and are not expected to be impacted as a result of construction and operation of the proposed power plant and transmission line.

Several mitigation measures are proposed for the power station and transmission lines to reduce possible impacts. During the first phase of the power station construction, farming will continue on the undeveloped portion of the site. When the site is fully developed, the land will be landscaped with low water use vegetation to achieve visual mitigation objectives and restore lands previously used for agriculture. Mitigation for the transmission lines and Willow Switchyard includes repairing or replacing any fences, gates, and watering facilities including tanks, wells, and water lines that are damaged during construction to their original pre-construction condition. Temporary gates will be installed only with the permission of the landowners or land management agency and the land would be restored after construction.

In conclusion, there will be minimal impacts to existing or future land uses as a result of construction and operation of the proposed power station, transmission line, and Willow Switchyard.

EXHIBIT B-2
LANDSCAPE PLAN

EXHIBIT B-2
LANDSCAPE PLAN

INTRODUCTION

The landscape plan for the Bowie Power Station is intended to serve several functions: (1) improve the aesthetics of the site and appearance of facilities, (2) provide for the reclamation of land and maintaining vegetation cover on site, and (3) assist in the integration of the facilities into the project setting.

The landscape plan is divided into three sections: Section 1, Existing Conditions, provides a description of the character of the project site and surrounding area; Section 2, Plan Objectives, outlines the general objectives of the plan; and Section 3, Conceptual Landscape Plan, describes the layout of facilities on the site, the plan concept and specific plan components, and the implementation of the plan.

SECTION 1 - EXISTING CONDITIONS

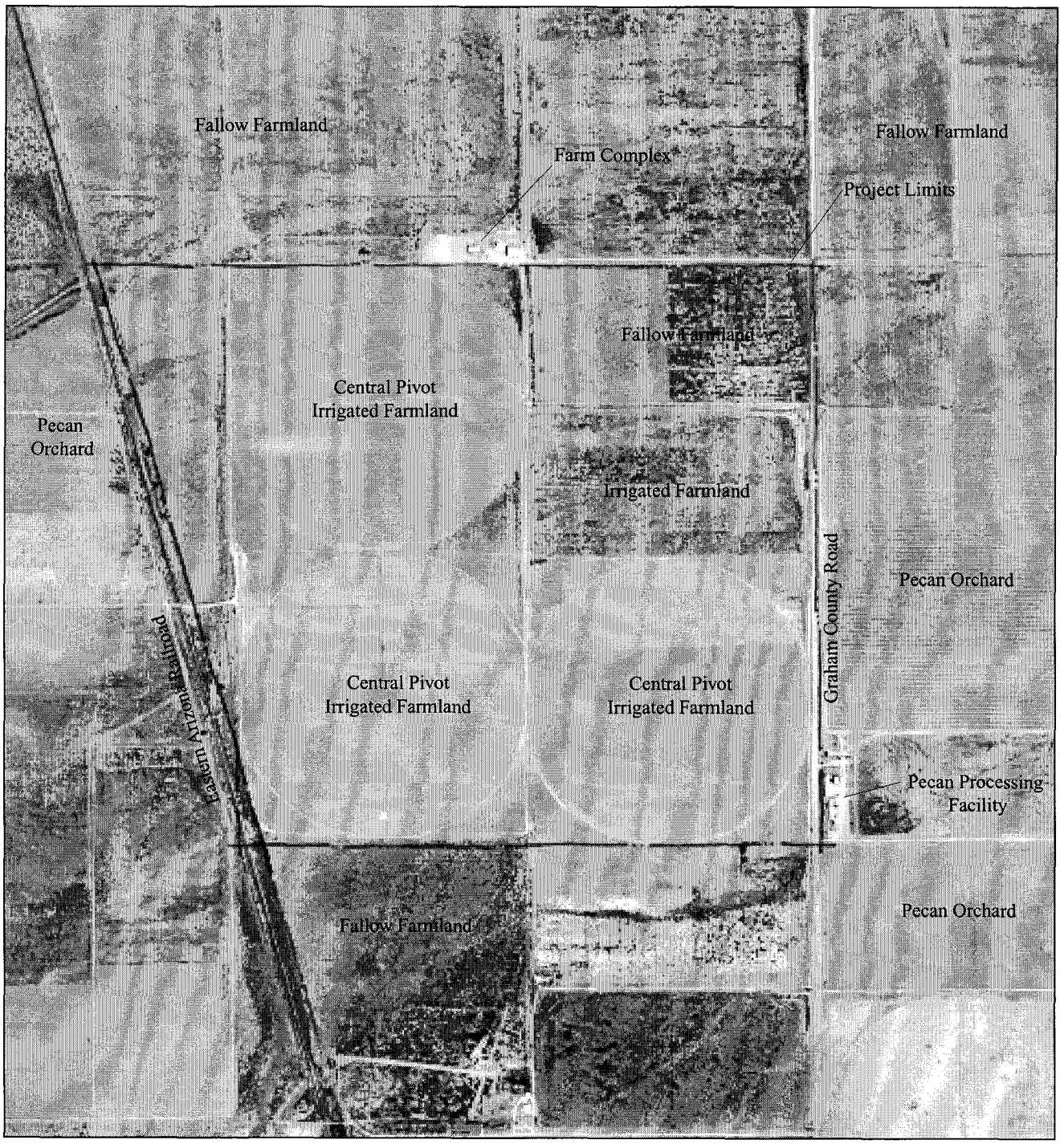
Project Site

The 700-acre project site is bordered by Graham County Road (Center Street) on the east and the Eastern Arizona Railroad on the west. The project area has been converted to agricultural use and no significant stands of native vegetation or residential uses are currently present on the site. Three agricultural irrigation pivot circles are present, one in the northwest quarter section, one in the southwest quarter section, and one in the southeast quarter section (Figure B-2.1). The northeast quarter section of the site consists of a 1/8 section of irrigated farmland and a 1/8 section of fallow farmland.

Surrounding Area

The landscape character of the overall region is primarily rural, including agricultural lands surrounded by Chihuahuan semidesert grassland and Chihuahuan desertscrub. A pecan orchard and processing facility are located immediately to the east of the property on the east side of Graham County Road. A second pecan orchard is located west of the property adjacent to the Eastern Arizona Railroad. With the exception of the orchards and a small portion of irrigated farmland to the south of the site, fallow agricultural land completely surrounds other portions of the property. This farmland extends from the property limits approximately 1½-mile to the north, 2 miles to the east, 1 mile to the south, and 1½-mile to the west. One residence is located approximately 1 mile south of the facility. A second is located 1½-mile north of the facility. A farm complex (farm out-structures) exist adjacent and immediately north of the site. The town of Bowie is located approximately 2 miles to the south.

EXISTING CONDITIONS
FIGURE B-2.1



0 1/8 1/4 1/2

Scale in Miles

North

SECTION 2 – PLAN OBJECTIVES

This section of the plan presents an overview of the plan objectives including improving the aesthetic quality of the site and appearance of the facilities, reclamation of the site and maintaining vegetative cover, and providing an overall design that is in context with the surrounding area and region.

Aesthetic Quality

Aspects contributing to the aesthetic quality of the landscape in this area include the elements of form, line, color, and texture, continuity, and scale. The aesthetic quality of the site has been addressed by (1) providing visual screening; (2) establishing landscape buffers and open space; (3) responding to the form, color, and texture of the surrounding landscape; (4) minimizing disturbance; and (5) helping to establish landscape treatments at an appropriate scale.

Site Reclamation and Vegetative Cover

The process of one plant community replacing another over time until a stable self-replicating community becomes established is called secondary succession. If a stable plant cover can be established prior to or shortly after the actual time of field retirement, the soil surface may be stabilized with an arid-adapted climax plant community. This established plant community can help prevent blowing soil and decrease tumbleweed establishment. In addition, the establishment of a stable plant community of native plant species will attract wildlife. The landscape plan for the Bowie project has taken these factors into account, and provides a reclamation and revegetation process that addresses these issues.

Area Context

Every place has characteristics that make it either unique or common. These characteristics are shaped by forms and patterns reflective of the history and the use of an area. Changes, such as the construction and operation of the Bowie facilities, will modify the characteristics of the area; however, the placement of the facilities on site, arrangement of vegetation and selection of plant material, and manipulation of grade all assist in the overall integration of facilities into the area.

SECTION 3 - CONCEPTUAL LANDSCAPE PLAN

This section describes the facility layout; plan concept and specific plan components, and implementation of the plan.

Facility Layout

The Bowie Power Station facility consists of three primary components: switchyard, power blocks and cooling towers, and evaporation ponds. As illustrated in Figure B-2.2, these components have been arranged on the site to maximize functional relationships, provide continuity and minimize visual clutter, and maximize buffer zones and open space around the facility. Following is a brief description of the layout of these components.

The switchyard is located on the western edge of the site. It will be placed 200 feet off of the property line and aligned with the Eastern Arizona Railroad and the transmission corridor. This location creates the most efficient and direct route from the generation facility to the transmission corridor reducing the length of transmission lines and establishing continuity by matching the alignment of the transmission lines with the railroad. The 200-foot buffer between the railroad and switchyard provides for screening to views from the west. The cooling towers are located and aligned to take advantage of the direction of prevailing winds and match the alignment of the switchyard.

The evaporation ponds have been rotated to align with the existing layout of the agricultural fields and provide the greatest buffer between the facility and the surrounding properties. The southern edge of the evaporation ponds has been aligned with the east/west midsection line of Section 28 facilitating continued cultivation of the southeast quarter section of the site during the first phase of the project. This location also establishes a ¼ mile buffer on the north and east sides of the facility and a ½ mile buffer on the south side of the facility.

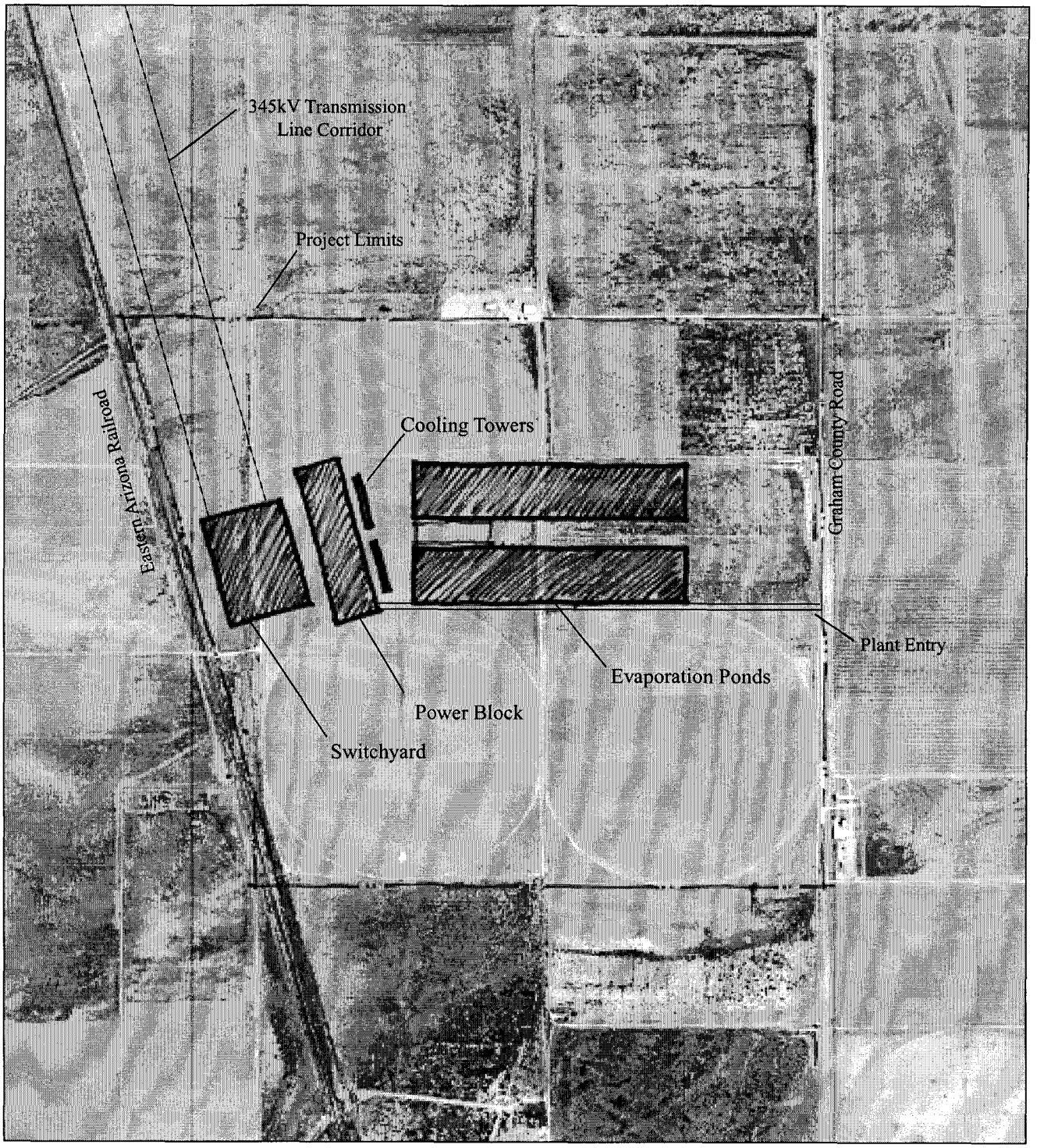
Plan Concept and Components

The project site and surrounding lands include a mixture of agricultural use that has transformed the natural desert setting of this area over time. The plan concept has considered this transition in the location of project facilities and arrangement of plan components as illustrated in Figure B-2.3.

The components of the conceptual landscape plan for the Bowie Power Station consist of three primary planting schemes (or zones) in conjunction with developed portions of the site as shown in Figures B-2.4 and B-2.5 (natural desert, agriculture/grassland, and orchard). Groves of trees arranged in rows similar to orchards, shrubs consistent with the natural desert, and grasses matching the surrounding area provide variety while helping to integrate the site into the surrounding area.

The first component, the natural desert component, is reflective of the region, primarily Chihuahuan semidesert grassland and Chihuahuan desertscrub. The plant material to be used is consistent with the plant material found in these biomes. Soaptree yucca (*Yucca elata*) will serve as the primary vertical element.

POWER FACILITY LAYOUT
FIGURE B-2.2

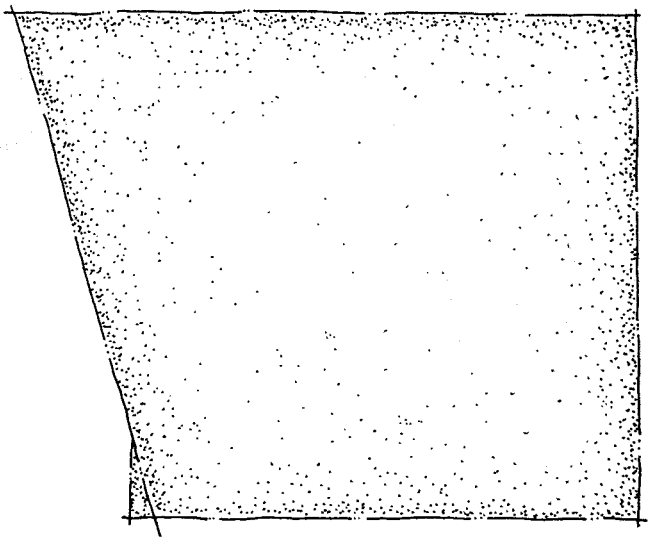


0 1/8 1/4 1/2

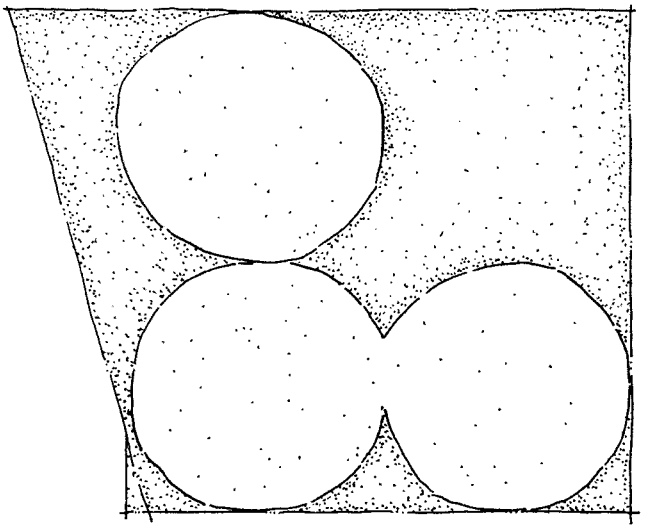
Scale in Miles

North

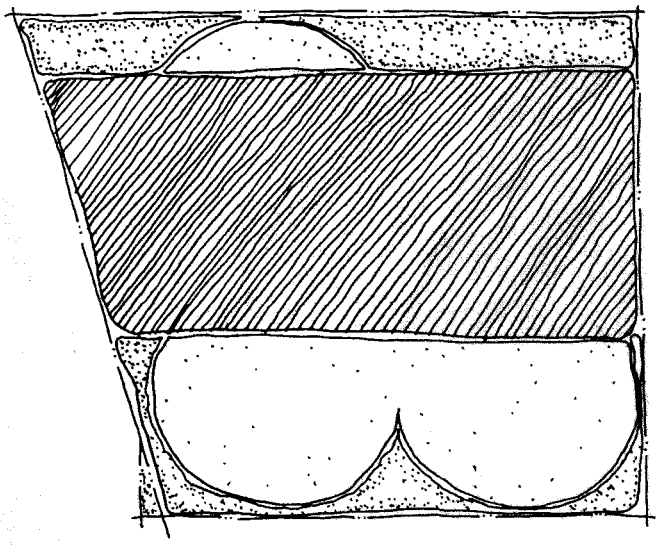
LANDSCAPE TRANSITION PROCESS
FIGURE B-2.3



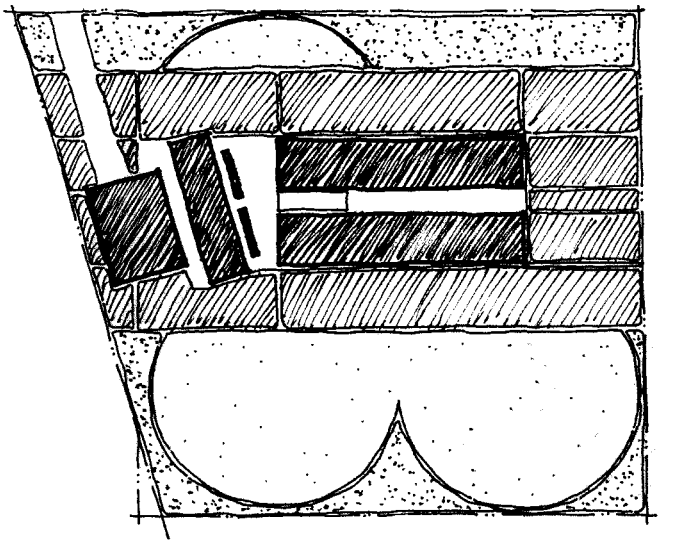
a) Natural Desert



b) Agriculture

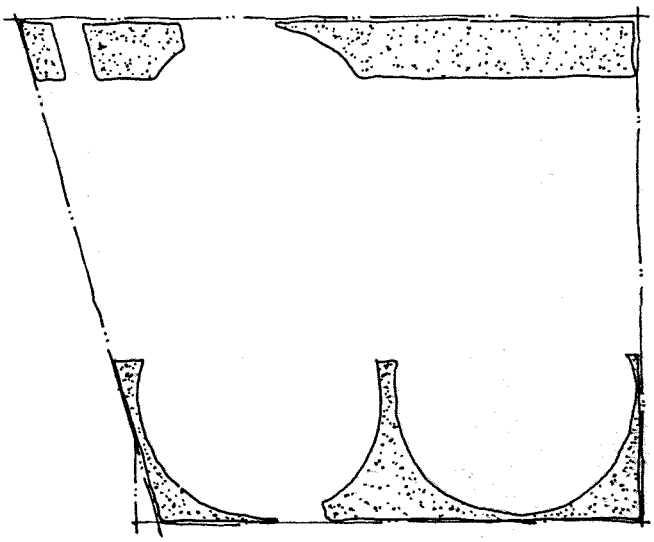


c) Orchards

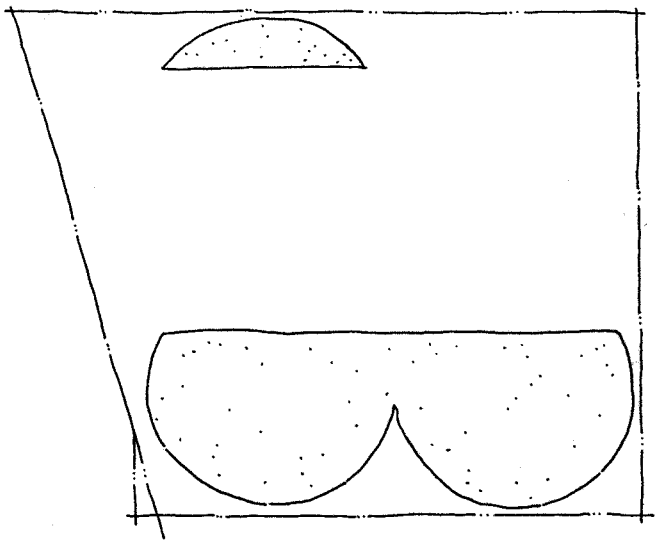


d) Industry

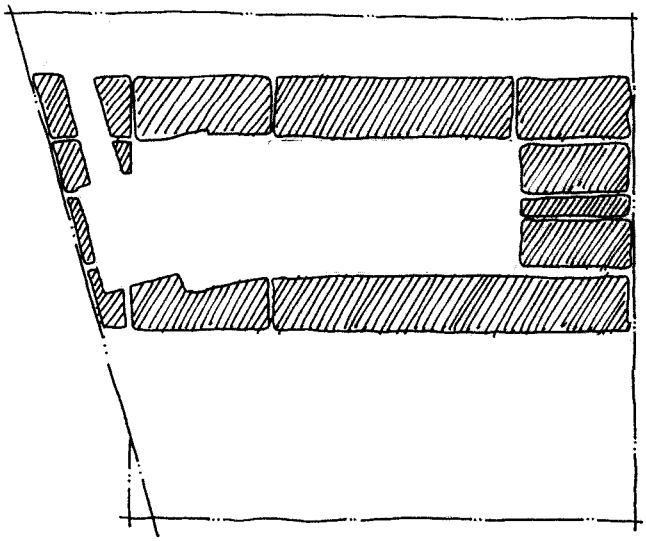
CONCEPTUAL LANDSCAPE PLAN COMPONENTS
FIGURE B-2.4



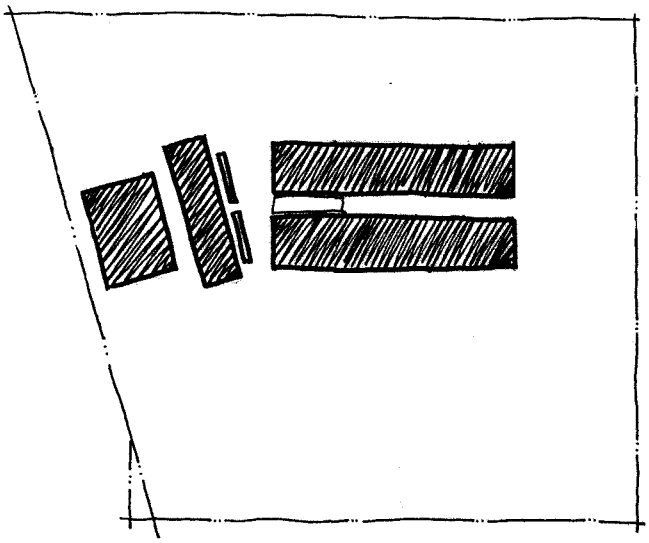
a) Natural Desert Component



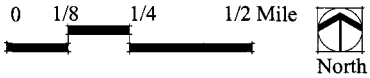
b) Agricultural/Grassland Component



c) Orchard Component



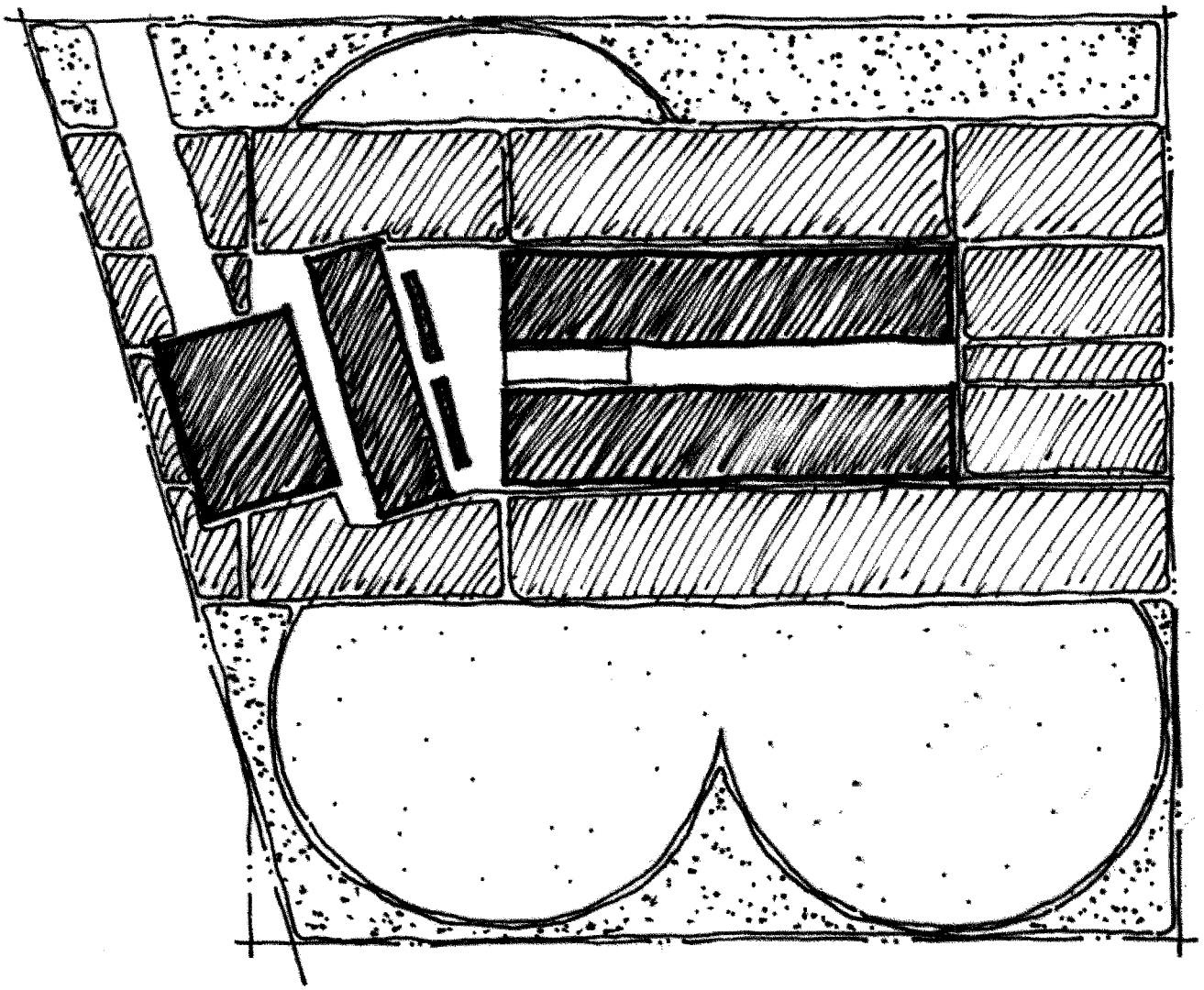
d) Plant Facilities



L e g e n d

Facilities | Orchard | Natural Desert | Grasslands

LANDSCAPE TRANSITION CONCEPT PLAN
FIGURE B-2.5



a) Landscape Transition Concept Plan

0 1/16 1/8 1/4 Mile

North

L e g e n d

Facilities Orchard Natural Desert Grasslands

The agricultural/grassland component reflects the color and texture of the farm fields in this region that are typically low growing and yellow or green in color. Rather than continuing agricultural production in these areas, in order to establish a self-sustaining low water use landscape, natural desert grasses will be planted in the circular form created by irrigation pivot sprinklers.

The orchard has been designed to assist in screening and provide continuity with lands immediately to the east of the site and consistent with the region. Mesquite trees will be planted in rows in the form of an orchard. Although not considered an orchard tree, they have low water use requirements and are adaptable to the area. The soil excavated from the evaporation pond and retention basins will be spread out over the area designated for the orchard to raise the height of the trees and increase the screening of the facility. Desert grasses will be seeded under the trees to allow for revegetation and stabilization of the soil in this area.

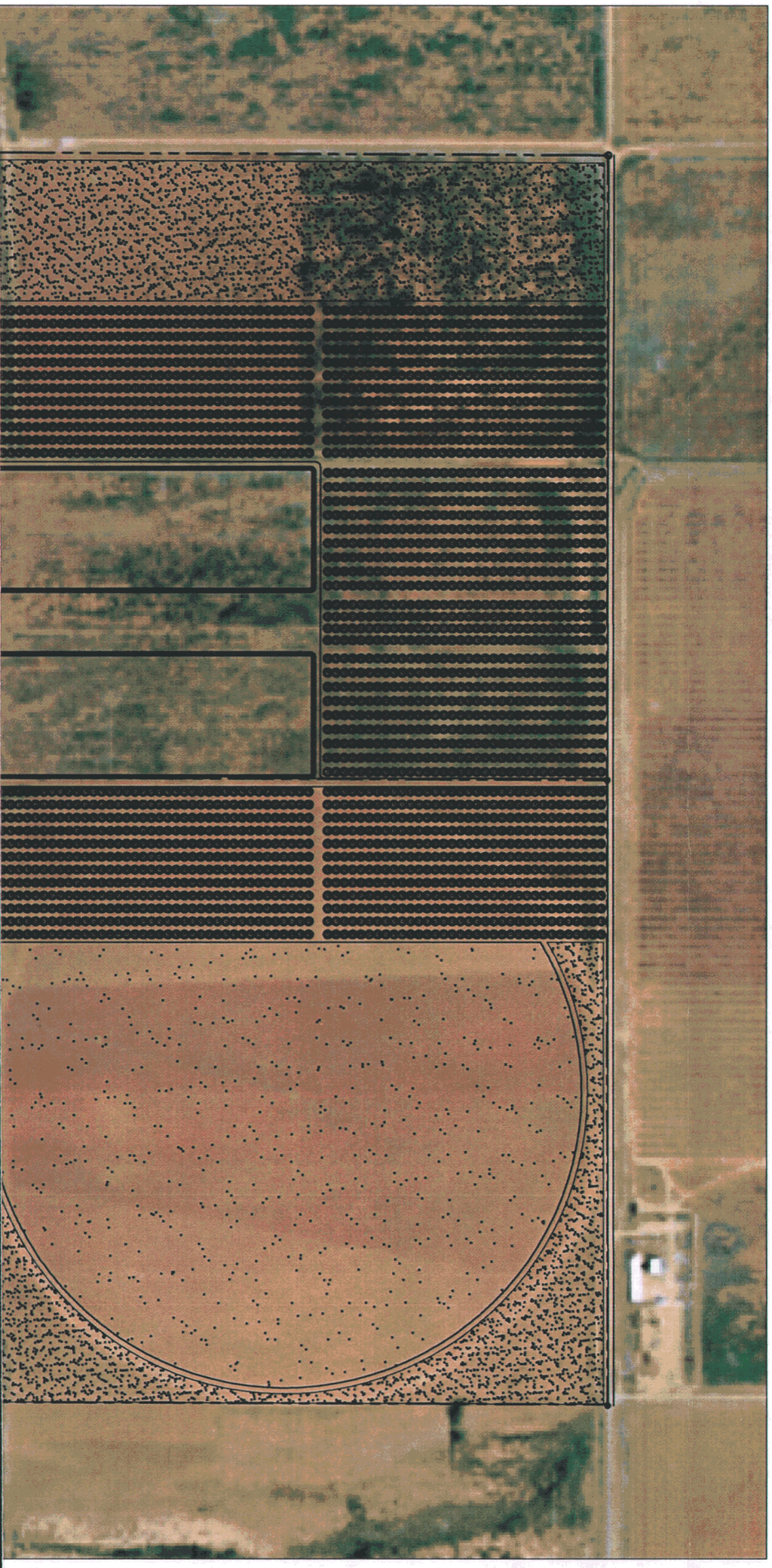
The landscape plan softens the industrial nature of the plant by placing landscape materials near project facilities. Colors of the facility will be carefully selected to assure that they compliment the landscape plan and do not detract from the surrounding area.

Implementation

The conceptual landscape plan (Figure B-2.6) illustrates how the landscape concept will be implemented and provides a list of plant material that may be selected in each of the three landscape zones previously described. Grassland/agricultural land will be seeded with native grasses in the circular form created by the existing irrigation pivots and under the orchard areas. Natural desert areas will be etablished with shrubs and grasses reflective of the Chihuahuan semidesert grassland and Chihuahuan desertscrub biomes.

Trees are to be planted in 15-gallon container size to facilitate the most effectively adaptation and success of the plant material. Accent shrubs (primarily yucca) are to be planted in 10-inch container size plants and inoculated with mycorrhiza, a microscopic fungi that has a symbiotic relationship with the plants and will increase the success rate from 10 to 20 percent to as much as 50 or 60 percent. Additional shrubs as well as groundcovers and grasses are to be established by preparing the seed bed, hydroseeding or drill seeding the appropriate seed mix, hydromulching where appropriate, and crimping with a grass hay mulch.

It is anticipated that the plantings will use supplementary irrigation from irrigation pivots and flood irrigation methods until established. Once established, the supplementary irrigation will be terminated and the species will rely on natural precipitation. Low water use and native plant material will be used exclusively.



BOWIE POWER STATION

Conceptual Landscape Plan

Figure B-2.6

Legend

Zone A - Natural Desert Theme

Zone B - Grassland / Agricultural Theme

Zone C - Orchard Theme

Plant List

Trees

Botanical Name	Common Name	Zone A	Zone B	Zone C
Cercidium floridum	*Blue Palo Verde*			○
Chilopsis linearis	*Desert Willow*			○
Prosopis alba	*Argentine Mesquite*			●
Prosopis alba 'Colorado'	*Colorado Mesquite*			●
Prosopis chilensis	*Chilean Mesquite*			○
Prosopis glandulosa	*Honey Mesquite*			○
Prosopis velutina	*Velvet Mesquite*			○

Shrubs

Botanical Name	Common Name	Zone A	Zone B	Zone C
Acacia constricta	*White Thorn Acacia*	●		
Acacia greggii	*Catclaw Acacia*	●		
Atriplex sp.	*Saltbush*	●		
Callindra eriophylla	*False Mesquite*	●		
Celtis pallida	*Desert Hackberry*	●		
Ephedra trifurca	*Mormon Tea*	●		
Larrea tridentata	*Creosote Bush*	●		
Lycium sp.	*Wolfberry*	●		
Opuntia spp.	*Prickly Pear / Cholla cacti*	●		
Parthenium incanum	*Mariola*	●		
Yucca beccata	*Banana Yucca*	●		
Yucca elata	*Soaptree Yucca*	●		

Groundcover/Grasses

Botanical Name	Common Name	Zone A	Zone B	Zone C
Agropyron smithii	*Western Wheat Grass*		●	●
Aristida sp.	*Three-on*	●	●	●
Bouteloua eriopoda	*Black Grama*	●	●	●
Bouteloua filiformis	*Slender Grama*	●	●	●
Datura meteloides	*Sacred Datura*	●		
Hilaria mutica	*Tobosa Grass*	●	●	●
Muhlenbergia porteri	*Bush Muhly*	●	●	●
Sporobolus wrightii	*Sacaton*		●	●
Tanicum obtusum	*Vine Mesquite Grass*	●	●	●
Trichachne californica	*Arizona Cottontop*	●	●	●
Tridens mudicus	*Slim Tridens*	●	●	●
Zinnia acerosa	*Desert Zinnia*	●		

Invading species

Botanical Name	Common Name	Zone A	Zone B	Zone C
Baccharis sarothroides	*Desert Broom*			
Bromus rubens	*Red Brome*			
Gutierrezia sarothrae	*Snakeweed*			
Isocoma tenuisecta	*Burroweed*			
Salsola iberica	*Russian Thistle*			
Salsola iberica	*Tumbleweed*			

Sources:
Arizona State Land Department, Phoenix, AZ 2001. United States Geological Survey (USGS), Wilcox AZ-NM 1994, Safford AZ-NM 1994, 1:100,000 scale metric topographic maps. Contours interpolated from USGS 1:24,000 scale digital elevation models at an interval of 40 feet.

Prepared for:
Bowie Power Station, L.L.C.

North

0 150 300 600

Scale: 1" = 300' - 0"

epg inc. environmental planning group

Phasing

It is anticipated that the landscape plan will be implemented over the course of a three-year period from the commencement of facility construction. In the first year the ground would be cleared and leveled, the evaporation pond and retention basins will be excavated, and the material from the basins spread over the area designated for orchards. The planting area will then be prepared including the addition of needed soil amendments. The site will be drilled or hydroseeded, and the seeded area will be covered with mulch and crimped. It is important that the seeding, mulching, and crimping be completed just prior to the monsoon season in order to take advantage of the monsoon precipitation. Once the understory planting is established (approximately two growing seasons) the trees and accent shrubs will be planted. It is anticipated that the southeast quarter-section may remain in agricultural production until the second 500 MW power block is under construction. A similar process, as outlined above, will follow at that time for the southeast quarter.

EXHIBIT B-3
WATER SUPPLY INVESTIGATION REPORT

This copy of the application includes only the report text. The tables, figures, and appendices have been omitted. A complete copy of the Water Supply Investigation Report will be furnished upon request made to the Applicant, Bowie Power Station, LLC.

WATER SUPPLY REPORT
FOR THE PROPOSED
BOWIE POWER STATION
BOWIE, ARIZONA

Prepared for

BOWIE POWER STATION, L.L.C.

URS Job No. E1-00001844.00
July 26, 2001

REGISTERED GEOLOGIST
CERTIFICATE NO.
24055
DAVID A.
CARR
DATE SIGNED 7-26-01
ARIZONA, U.S.A.

REGISTERED GEOLOGIST
CERTIFICATE NO.
24055
DAVID A.
CARR
DATE SIGNED 7-26-01
ARIZONA, U.S.A.

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 1-1
- 1.1 BACKGROUND 1-1
- 1.2 PROPERTY LOCATION 1-1
- 1.3 PURPOSE AND SCOPE 1-1

2.0 GROUNDWATER CONDITIONS 2-1
- 2.1 HYDROGEOLOGIC SETTING 2-1
- 2.2 GROUNDWATER DEVELOPMENT 2-2
- 2.3 GROUNDWATER RECHARGE AND DISCHARGE 2-3
- 2.4 DEPTH TO GROUNDWATER 2-3
- 2.5 GROUNDWATER USES 2-4
- 2.6 GROUNDWATER QUALITY 2-4

3.0 WELL INVENTORY AND GROUNDWATER PUMPAGE 3-1
- 3.1 SOURCES OF WELL DATA 3-1
- 3.2 WELL INVENTORY 3-1
- 3.3 HISTORICAL GROUNDWATER PUMPAGE 3-2
- 3.4 CURRENT AND FUTURE GROUNDWATER PUMPAGE 3-3
- 3.5 LAND SUBSIDENCE AND EARTH FISSURES 3-4

4.0 AQUIFER TESTING AND GROUNDWATER QUALITY SAMPLING 4-1
- 4.1 INTRODUCTION 4-1
- 4.2 AQUIFER TESTING FIELD PROCEDURES 4-1
- 4.3 AQUIFER TEST RESULTS 4-2
  - 4.3.1 Well (D-12-28) 28 CCC2 Aquifer Test Results 4-2
  - 4.3.2 Well (D-12-28) 28 DCC Aquifer Test Results 4-3
  - 4.3.3 Comparison with Published Values for Aquifer Parameters 4-3
- 4.4 GROUNDWATER SAMPLING RESULTS 4-4

5.0 WATER LEVEL DRAWDOWN MODELING 5-1
- 5.1 PROPOSED PRODUCTION WELLFIELD 5-1
- 5.2 ANALYTICAL METHOD 5-1
- 5.3 MODELING RESULTS 5-2

6.0 SUMMARY OF GROUNDWATER AVAILABILITY AND QUALITY 6-1

7.0 REFERENCES 7-1

LIST OF TABLES

1 Wells Located On and Adjacent To The Bowie Property
2 Historical Groundwater Quality Data in the Vicinity of the Bowie Property
3 Summary of Aquifer Test Results
4 Summary of Groundwater Quality Results for Onsite Wells

LIST OF FIGURES

1 San Simon Valley Groundwater Level Contours for 1987
2 Well Location Map
3 Historical Groundwater Levels for Bowie Property Wells and Estimated Annual Pumpage for the San Simon Valley Sub-basin
4 Historical Groundwater Levels for Nearby Wells and Estimated Annual Pumpage for the San Simon Valley Sub-basin
5 Model-Predicted Water Level Drawdown Contours

LIST OF APPENDICES

A Available Well Logs and Well Registrations for Wells Located on the Bowie Property
B Aquifer Test Data and Graphs
C Laboratory Reports for Groundwater Samples

1.0 INTRODUCTION

1.1 BACKGROUND

Bowie Power Station, L.L.C. has acquired options to purchase approximately 1,640 acres of agricultural land about 2 miles north of Bowie, Arizona, for the construction of a nominal 1,000-megawatt combined-cycle power plant. At 1,000-megawatt base load operation, the Bowie Power Station is estimated to require a continuous water supply of about 3,410 gallons per minute (gpm), or an average of 5,500 acre-feet per year (ac-ft/yr). The only available source of water for the power plant is groundwater, which is currently used for agricultural irrigation. Central Arizona Project (CAP) water and other surface water supplies are not available, and there is an insufficient supply of treated wastewater effluent. The Bowie Power Station property is not located within an Arizona Department of Water Resources (ADWR) Active Management Area (AMA) or irrigation district.

This report presents the results of a water supply investigation for the Bowie Power Station property (Bowie property). Included in this report is an overview of groundwater availability and quality in the vicinity of the property, a review of current and historic pumpage, the results of a field investigation, and the results of water level drawdown modeling to project impacts of pumping after 30 years.

1.2 PROPERTY LOCATION

The Bowie property is located in the northeast portion of Cochise County, Arizona, about 2 miles north of the town of Bowie, Arizona (see Figure 1). The property boundary and the proposed Bowie Power Station site are shown on Figure 2. Wells on and near the property are also shown on Figure 2 and are listed in Table 1. The 1,640-acre property consists of approximately 2.5 square miles of agricultural land located in all or portions of sections 20, 21, 22, 27, 28, 29, and 33 of Township 12 South, Range 28 East, of the Gila and Salt River baseline and meridian. The proposed Bowie Power Station site encompasses approximately 703 acres in all of Section 28 and a portion of Section 29.

1.3 PURPOSE AND SCOPE

A water supply investigation of the Bowie property was conducted to characterize the availability, production potential, and quality of groundwater on the property, and to assess potential water level drawdown from groundwater pumping to supply the power plant. This consisted of characterizing groundwater conditions in the vicinity of the property using available

information, completing a field investigation of the property, and analyzing the data obtained from the investigation. The scope of work included:

- compiling available information and performing an initial assessment of groundwater conditions in the area;
- compiling an inventory of existing wells on the property and selecting wells for aquifer testing and groundwater sampling;
- collecting drawdown data during irrigation events from two pumping wells and two observation wells on the property to characterize aquifer parameters and well yield;
- collecting and arranging for the analysis of groundwater samples from two irrigation wells on the property to characterize groundwater quality; and
- modeling water level drawdown to assess the incremental drawdown from pumping to supply the power plant.

2.0 GROUNDWATER CONDITIONS

2.1 HYDROGEOLOGIC SETTING

The Bowie property is located in the northwestern portion of the San Simon Valley sub-basin in southeastern Arizona (Barnes, 1991.) The area is part of the Basin and Range physiographic province, which is characterized by predominantly northwest-trending mountains separated by broad alluvial valleys. The San Simon Valley sub-basin is 6 to 25 miles wide and about 75 miles in length, covering approximately 1,930 square miles, and is bounded by the Chiricahua, Pinaleno, and Dos Cabeza Mountains on the west, and the Peloncillo Mountains on the east (Figure 1). The mountains that surround the sub-basin are composed of relatively impermeable granitic, metamorphic, and volcanic rocks that have produced the basin-fill sediments that comprise the regional aquifer.

The climate is typical of southeastern Arizona, and is characterized by low precipitation, high summer temperatures, and low humidity, which combine to cause high evaporation rates. Average annual rainfall is 8 to 10 inches.

The total thickness of the San Simon Valley sub-basin sediments may exceed 8,000 feet along the axis of the valley (Oppenheimer and Sumner, 1980). Younger alluvial fill occurs along modern stream channels, but is likely to be intermittently saturated and not hydraulically connected to the regional aquifer. The older alluvial fill of the San Simon Valley sub-basin has been subdivided into upper, middle, and lower units (Barnes, 1991). A marginal zone along the edges of the basin has been described where the middle unit is not present and the upper and lower units merge (White, 1963). The four units are described below, in descending order.

- The upper unit consists mainly of unconsolidated stream deposits of silt, sand, and gravel and forms a continuous geologic unit across the basin. The thickness of the upper unit ranges from 60 to 200 feet and driller's logs indicate that the upper unit is about 150 feet thick in the vicinity of the Bowie property. Where the upper unit is saturated in localized areas, the unit is designated as the upper aquifer.

- The middle unit (Barnes, 1991) or blue clay unit (White, 1963) underlying the upper unit consists of dense, blue clay formed by fine-grained sediments deposited during a period when a shallow lake occupied a large part of the San Simon Valley. The middle unit is about 600 feet thick along the axis of the valley, and acts as a confining layer. Near the basin margins, the middle unit pinches out and the upper and lower units merge to form

the marginal zone. In the vicinity of the Bowie property, the middle unit is believed to be about 350 feet thick, extending to a depth of about 500 feet below ground surface (bgs).

- The lower unit consists of stream and lake-bed deposits of clay, silt, sand, and gravel that overlie bedrock and in places are interbedded with volcanic debris. The unit is continuous throughout the basin and merges with the upper unit along the basin margins in the marginal zone. Groundwater occurs under confined conditions in sand and gravel units interfingered with layers of dense clay to form the lower aquifer, which supplies most of the groundwater used in the San Simon Valley sub-basin and would be the source of groundwater for the power plant. The thickness of the lower unit is generally unknown, but may be as much as 8,000 feet along the valley axis (Oppenheimer and Sumner, 1980). The thickness of the lower unit in the vicinity of the Bowie property is unknown.

- The marginal zone occurs along the margins of the basin where the middle unit pinches out and the coarser materials of the upper and lower units merge. Within the marginal zone the upper and lower aquifers have merged to form a single, unconfined aquifer.

2.2 GROUNDWATER DEVELOPMENT

Groundwater from shallow wells in the upper aquifer was pumped for domestic uses and livestock watering beginning in about 1870; however, the groundwater was too deep to be used for irrigation with the pumping methods available at that time. In 1910, a deep well was drilled into the lower aquifer for the Southern Pacific Railroad and the discovery of artesian conditions led to agricultural development. Average artesian pressure measured for eight wells in 1913 was 31 feet above land surface (Barnes, 1991). By 1915, there were 127 flowing wells in the San Simon Valley, each with an average flow rate of about 50 gallons per minute, producing an estimated 11,000 acre-feet of water per year (Barnes, 1991). Average artesian head in 1915 was 19 feet above land surface.

Depressed economic conditions following World War I led to the abandonment of many farms, and uncapped wells were allowed to flow unused, resulting in year-round flow in San Simon Creek. By the 1950s, artesian head had declined to the point that most wells required pumping at least part of the time to meet irrigation needs. In 1991, there were ten flowing wells in the San Simon Valley sub-basin (Barnes, 1991); however, these wells are completed in deeper, older sediments than those originally tapped in 1910.

As artesian head declined in lower aquifer wells, and after the advent of deep-well turbine pumps and electrical power in the 1930s, the upper aquifer began to be used for irrigation. In 1987,

water levels in the upper aquifer ranged from 30 to 80 feet and well yields were reported to range from 75 to 300 gpm (Barnes, 1991).

2.3 GROUNDWATER RECHARGE AND DISCHARGE

Both the upper and lower aquifers are recharged by infiltration of runoff along the mountain fronts. Due to high evaporation rates, recharge from infiltration of precipitation that falls on the valley floor is negligible. In addition to recharge from precipitation runoff, the upper aquifer receives as much as 15 percent of water applied for irrigation as recharge (Barnes, 1991). In the past, exchange occurred from the lower aquifer to the upper aquifer through well casings. Because the artesian pressure head has now dropped below the water level in the upper aquifer, it is likely that some exchange occurs today from the upper aquifer to the lower aquifer through wells. Irrigation pumpage is the major source of discharge from both the upper and lower aquifers in the San Simon Valley sub-basin.

2.4 DEPTH TO GROUNDWATER

Artesian pressure was measured for eight wells in 1913 and average head was about 31 feet above land surface (Barnes, 1991). Groundwater level hydrographs prepared using water level data from ADWR for wells located on and near the Bowie property are presented in Figures 3 and 4, respectively. The water level hydrographs show historic water levels from as early as 1947. Estimated decline from average artesian pressure measured in 1913 and 1915 is also shown on Figures 3 and 4. Well (D-12-28) 17 DDD is located about 1 mile north of the property, well (D-12-28) 25 DCC is about 2.5 miles east of the property, and well (D-12-28) 35 CDC2 is about 1.5 miles southeast of the property.

URS measured groundwater levels in selected wells on the site property where sounder access was available. Because an unknown thickness of lubrication oil from line-shaft pumping equipment was present in most wells, groundwater level measurements were erratic and should be considered to be approximate. Groundwater levels in lower aquifer wells on the Bowie property measured in April 2001 prior to the start of the irrigation season ranged from about 367 to 403 feet bgs. The following table summarizes groundwater level measurements collected prior to the start of the 2001 irrigation season.

Well ID	Well Use	Depth to Water (ft bgs)	Approximate Water Level Elevation (ft amsl)
(D-12-28) 28 ABC	Inactive	367	3349
(D-12-28) 28 CCC2	Active	403	3344
(D-12-28) 28 DCC	Active	388	3341
(D-12-28) 33 ABC	Inactive	394	3338

ft bgs = feet below ground surface
ft amsl = feet above mean sea level

2.5 GROUNDWATER USES

Most of the groundwater pumped in the San Simon Valley sub-basin is used for agricultural irrigation. Other uses, such as municipal and industrial, represent a relatively small percentage of total groundwater withdrawals.

2.6 GROUNDWATER QUALITY

Groundwater quality data for the northern portion of the San Simon Valley sub-basin were obtained from ADWR, the Arizona Department of Environmental Quality (ADEQ), and the United States Geological Survey (USGS). A summary of available groundwater quality data obtained from these agencies is presented in Table 2.

The results indicate that inorganic groundwater quality in the vicinity of the Bowie property is good. Review of the analytical results in Table 2 indicates only one sample with concentrations of inorganic constituents in excess of Arizona numeric Aquifer Water Quality Standards (AWQS). A 1986 groundwater sample from Well (D-13-28) 34 BBC2 had a total nitrate (nitrate plus nitrite) concentration of 11 milligrams per liter (mg/L), which exceeds the numeric AWQS of 10 mg/L. The observed nitrate exceedance is likely related to the use of nitrogen-based fertilizers and is typical for groundwater in established agricultural areas.

3.0 WELL INVENTORY AND GROUNDWATER PUMPAGE

3.1 SOURCES OF WELL DATA

Well data were obtained from the ADWR Groundwater Site Inventory (GWSI) and Well Registry databases and were used to develop a list of potential existing wells on and adjacent to the Bowie property. The ADWR well databases include information on well location, ownership, construction, water uses, production capacity, and water levels. Data for wells located on and immediately adjacent to the Bowie property are presented in Table 1. Copies of well registrations and driller's logs, if available, were obtained from ADWR for wells located on the Bowie property and are provided in Appendix A. Some records were modified based on information from recent video surveys reported by local pump contractors.

3.2 WELL INVENTORY

A search of the ADWR GWSI and Well Registry databases produced a total of 16 wells reportedly located within the Bowie property boundaries. All but three wells have ADWR registration numbers; two of the unregistered wells are capped. Table 1 lists the locations, registration numbers, water uses, construction data, and associated comments for wells located on and immediately adjacent to the Bowie property. The ADWR databases typically include well location, well registration number (if any), well construction date, well depth, screened interval (if any), casing diameter, water use, and owner information. However, records for well construction details in the Bowie area were limited.

A field inventory of the Bowie property was conducted to verify wells listed in the ADWR databases. The objective of the field inventory was to ascertain which wells were currently active and/or available for monitoring, testing or sampling. ADWR field-verifies some of the wells throughout the state on a periodic basis and updates the GWSI database with information concerning owner, water use, and well use, if known. The most recent basin-wide well inventory of the Bowie area was conducted by ADWR in 1987.

Field inspection of the Bowie property confirmed the existence of 16 wells, including:

- Two active irrigation wells with line-shaft pumps, gear drives, and natural gas powered engines: (D-12-28) 28 DCC and (D-12-28) 28 CCC2.
- Two inactive irrigation wells with line-shaft pumps, gear drives, and natural gas powered engines: (D-12-28) 33 ABC and (D-12-28) 27 BBC.

- Four wells with derelict pumping equipment.

- Two domestic wells with electric submersible pumps. Well (D-12-28) 21 CDD is active, and well (D-12-28) 22 DDC is inactive.

- Six capped wells, of which three are deep wells: (D-12-28) 21 DCC, (D-12-28) 22 CDC, and (D-12-28) 28 ABC. The other three wells are believed to be shallow. Well (D-12-28) 21 DCC was reported to produce sand, causing damage to pumping equipment.

3.3 HISTORICAL GROUNDWATER PUMPAGE

In the San Simon Valley sub-basin, no surface water supplies are available and irrigated agriculture relies entirely on groundwater. The San Simon Valley sub-basin is not within an AMA and there are no requirements for reporting groundwater pumpage. Estimated historic groundwater pumpage (Anning and Duet, 1994) is shown on figures 3 and 4. Pumpage increased dramatically after 1950 to a maximum of 139,000 acre-feet per year (ac-ft/yr) in 1980 (Anning and Duet, 1994). Subsequently, rising energy prices and agricultural market conditions resulted in decreased groundwater pumping, and by 1983 pumpage had decreased to about 42,000 ac-ft/yr. Prior to 1990, groundwater pumpage was estimated yearly from review of power consumption records. Groundwater pumpage was estimated by the USGS for 1995 using crop information and weather data, and was estimated to be about 50,000 ac-ft/yr for the San Simon Valley (personal communication S. Tadayon, USGS, June, 2001).

Prior to 1980, cotton was the principal crop but required rotation, mainly with grain crops. Rising energy costs and falling grain prices in the early 1980s resulted in allowing available land to lie fallow during alternate years rather than growing grain as a rotation crop with cotton. During the period from 1980 to present, most farms in the area typically had about 60 percent of available land in production at any one time, due to limitations of well capacity or crop rotation requirements (personal communication, R. Eastman, June 12, 2001).

In the area north of Bowie and west of Graham County Road, which includes the Bowie Power Station site, most of the available land was in production up until about 1998. Cotton was the principal crop, with smaller amounts of chiles, garlic, and alfalfa. Average consumptive use was reported to be about 6 acre-feet per acre per year (ac-ft/ac/yr) for row crops. Production resumed on about 250 acres in year 2000, growing chiles, sweet potatoes, garlic, and squash at an average rate of consumptive use of about 3.5 ac-ft/ac/yr, using pivot sprinkler systems that are more efficient than flood irrigation of row crops (personal communication, M. Cook, June 12, 2001).

In the area north of Bowie and east of Graham County Road, some land was retired from cotton in the 1960s. In the late 1970s and early 1980s about 400 acres were converted to pecan and pistachio trees using about 6 ac-ft/ac/yr. In the mid 1990s, another 320 acres of cotton were retired. In 1998, 32 acres of pecan trees were planted. In the near future, production may resume on an additional 330 acres using an average of 5 ac-ft/ac/yr (personal communication, P. Hogue, June 12, 2001).

USGS and U.S. Department of Agriculture (USDA) estimates of water requirements for various crops tend to be lower than those reported by Bowie-area farmers. The USGS estimates plant use by modeling evapotranspiration from temperature and humidity data. The USDA's estimates are also for plant use. Farmers have different criteria for determining pumpage schedules. Farmers irrigating row crops are required to pump long enough to get water to reach distant parts of the field, sometimes overwatering areas nearest the source. One well might be able to flood irrigate 20 acres of row crops in a 24-hour period. Using irrigation pivot sprinklers, the same well can irrigate 120 acres in a 24-hour period, with a uniform application (personal communication, R. Eastman, June 12, 2001). Landowners' estimates are based on approximations of unmetered pumping rates and number of irrigation days.

3.4 CURRENT AND FUTURE GROUNDWATER PUMPAGE

From the mid 1980s to the mid 1990s, estimated average annual groundwater pumpage in the San Simon Valley sub-basin was about 46,000 ac-ft/yr (Anning and Duet, 1994). The Bowie property covers an area of about 1,640 acres, of which about 703 acres will be used for the Bowie Power Station (see Figure 2). Most of the 703 acres planned for the power station is either currently in agricultural use or was in use until about 1998, and will be converted to industrial use. The remainder of the property consists of agricultural land which has been fallow for several years and will not be cultivated in the future. Assuming 60 percent of the 1,640-acre Bowie property was in production during the recent period from the mid 1980s to 2001 at an average consumptive use of 6 ac-ft/ac/yr results in a historical average consumptive use of about 3.6 ac-ft/ac/yr, or about 5,900 ac-ft/yr. The Bowie Power Station water requirement will be about 5,500 ac-ft/yr. Assuming that no current or former agricultural land will be placed into production, the average water use for the 1,640-acre property will be 3.35 ac-ft/ac/yr, resulting in a net decrease in pumpage for the Bowie Power Station compared to the reported historical average pumpage for the property.

3.5 LAND SUBSIDENCE AND EARTH FISSURES

Groundwater pumping in the San Simon Valley sub-basin has caused historic groundwater level declines and land subsidence in several areas, including Bowie. Holzer (1980) investigated subsidence in the San Simon Valley by comparing 1952 and 1974 leveling data along Interstate 10 from a point about 6 kilometers (3.7 miles) west of Bowie to a point a few kilometers east of Bowie. Holzer found subsidence along the entire interval with the maximum of 4.7 feet located at Bowie. The National Geodetic Survey (NGS) compared 1952 and 1980 leveling data for about 100 km (62 miles) along Interstate 10, near Bowie (Strange, 1983). The 1980 data indicated that subsidence had continued, with a maximum of 178 centimeters (5.9 feet) recorded near Bowie. Two survey stations showing maximum subsidence were located along the Southern Pacific Railroad about 1.5 miles south of the Bowie property. Near the town of San Simon, maximum subsidence was 39 centimeters (1.3 feet) in 1980.

The average rate of subsidence near Bowie for the 22-year period from 1952 to 1974 measured by Holzer (1980) was about 0.21 feet per year. For the 28-year period investigated by the NGS (Strange, 1983), the average rate of subsidence was also about 0.21 feet per year. For the 6-year period from 1974 to 1980, the average rate of subsidence was about 0.20 feet per year. Subsidence rates were last measured near the end of the period of extensive groundwater withdrawal and may have decreased in response to reductions in groundwater withdrawals. URS is currently compiling updated leveling data from the NGS, the USGS, and the Arizona Department of Transportation as part of an analysis of potential future subsidence.

Earth fissures were reported to have begun in the mid-1950s (Holzer, 1980). Holzer (1980) found a number of earth fissures near Bowie from investigation of 1978 aerial photography and field reconnaissance. The largest linear fissures intersect Interstate 10 about 6 miles east of Bowie. Another linear fissure is located about 4 miles east of Bowie and about 2 miles north of Interstate 10. Based on a review of published data, there are no known earth fissures near or on the Bowie property.

Although the Bowie Power Station will be located within an area of documented historic land subsidence, preliminary indications are that future subsidence on and in the vicinity of the property will not be of sufficient magnitude to cause concern, and that the power plant facilities and infrastructure can be engineered and constructed to accommodate future subsidence and operate safely. As indicated above, there are no known earth fissures near or on the Bowie property.

4.0 AQUIFER TESTING AND GROUNDWATER QUALITY SAMPLING

4.1 INTRODUCTION

Existing agricultural irrigation wells were selected for aquifer testing and groundwater sampling based on the results of the field inventory. Two wells were selected for testing and sampling: (D-12-28) 28 CCC2 and (D-12-28) 28 DCC. The wells are both equipped with operable, line-shaft turbine pumps. The wells are active irrigation wells and began pumping in late March 2001. Based on the driller's recollection from 1975, both wells are reported to be 1,000 feet deep and perforated from 700 to 1,000 feet bgs (personal communication from J. McBee, 2001). The GWSI database lists a total depth of 1,200 feet for well (D-12-28) 28 DCC. A third well on the property, (D-12-28) 33 ABC, with a total depth of 550 feet, is equipped and may be used later in the season for irrigation.

The irrigation wells are operated using line-shaft turbine pumps, driven by natural gas powered engines. Pump intake is reported to be about 540 feet bgs in both wells. Pumped water is currently conveyed via underground pipeline to two irrigation pivots with sprinkler nozzles designed for a flow rate of about 800 gpm at a pressure of 25 pounds per square inch (psi). The west pivot operates in a full circle, covering 120 acres; the east pivot covers 60 acres in a half circle. Either well can be piped to either pivot. Another area of less than 20 acres is sometimes planted in vegetables. Row crops of garlic are watered by decreasing engine speed and pumping to irrigation ditches. Fixed pipe sprinklers are also used for irrigating squash. Another 60 acres of pinto beans will likely be planted in July 2001.

Other wells on the property had derelict pumping equipment, reported problems, or were in unknown condition. No alternate water discharge options were available for the two active wells. Land was not available for discharge of the pumped water during a standard aquifer test.

4.2 AQUIFER TESTING FIELD PROCEDURES

The investigation was conducted by equipping two observation wells and the two active pumping wells with pressure transducers and dataloggers to record groundwater levels; a fifth pressure transducer and datalogger were used to measure changes in barometric pressure. Because testing was conducted at the start of the growing season, it was necessary to test the two wells in conjunction with agricultural irrigation activities. The wells are not equipped with flowmeters and do not have a sufficient length of straight pipe at the wellhead to install a flowmeter. Pumping rate is controlled by monitoring pressure gages and adjusting engine speed.

For periods when the wells supplied an irrigation pivot sprinkler, pumping rates were estimated using nozzle design formulas for pressure and flow rate. For periods when the wells discharged to an open irrigation ditch or fixed sprinklers, pumping rates were estimated based on drawdown in the wells, and specific capacity computed for the wells at other pumping rates. Specific capacity is defined as the ratio of the pumping rate divided by the drawdown and has units of gallons per minute per foot of drawdown (gpm/ft). Pumping rates were verified using a magnetic flowmeter temporarily installed at each irrigation pivot.

4.3 AQUIFER TEST RESULTS

Estimates of aquifer transmissivity and storativity were obtained by analyzing the relationship between time and drawdown during pumping, and between time and residual drawdown during recovery. Aquifer parameters were estimated using AQTESOLV™, a computer-based program for analyzing aquifer test data. Irrigation pumping started at well (D-12-28) 28 DCC on March 29, 2001, and at well (D-12-28) 28 CCC2 on April 2. Both wells were pumped on an irregular schedule during the month of April. Beginning on May 4, 2001, both wells were off for a period of about 6 days.

4.3.1 Well (D-12-28) 28 CCC2 Aquifer Test Results

Well (D-12-28) 28 CCC2 was pumped for a period of about 3 days beginning about 6:00 A.M. on May 10, 2001. Well (D-12-28) 28 DCC was not pumped during this period and was used as an observation well in addition to wells (D-12-28) 28 ABC and (D-12-28) 28 BCC. The pumping rate at well (D-12-28) 28 CCC2 was estimated to be about 650 gpm while watering row crops, about 850 gpm while discharging to the east pivot, and about 900 gpm while discharging to the west pivot. The average pumping rate was about 867 gpm. Well (D-12-28) 28 CCC2 was shut off at about 7:00 A.M. on May 13. Residual drawdown was measured in the pumped well and the four observation wells during the recovery period for about 1.5 days until well (D-12-28) 28 DCC was started at 6:00 P.M. on May 14.

Results for the May 10-14 aquifer test at well (D-12-28) 28 CCC2 are included in Appendix B and are summarized in Table 3. Estimates of transmissivity ranged from 34,000 to 71,000 gallons per day per foot (gpd/ft). Estimates of storage coefficient ranged from 0.0004 to 0.0007 (dimensionless). Results for recovery data from well (D-12-28) 28 BCC were not reported due to well interference from nearby well (D-12-28) 29 DBC.

4.3.2 Well (D-12-28) 28 DCC Aquifer Test Results

Well (D-12-28) 28 DCC was pumped for a period of about 6 days beginning at about 6:00 P.M. on May 14, 2001. Well (D-12-28) 28 CCC2 was not pumped during this period and was used as an observation well in addition to wells (D-12-28) 28 ABC and (D-12-28) 28 BCC. The pumping rate at well (D-12-28) 28 DCC was estimated to be about 650 gpm while watering row crops, about 850 gpm while discharging to the east pivot, and about 900 gpm while discharging to the west pivot. The average pumping rate was about 721 gpm. Well (D-12-28) 28 DCC was shut off at about 6:00 P.M. on May 18. Residual drawdown was measured in the pumped well and the four observation wells during the recovery period for about 1.5 days until well (D-12-28) 28 CCC2 was started at about 11:00 A.M. on May 20.

Results for the May 14-20 aquifer test at well (D-12-28) 28 DCC are included in Appendix B and are summarized in Table 3. Estimates of transmissivity ranged from 40,000 to 89,000 gpd/ft. Storage coefficient was estimated using data from observation well (D-12-28) 28 CCC2 to be about 0.0003 (dimensionless). Wells (D-12-28) 28 ABC and (D-12-28) 28 BCC had not recovered sufficiently prior to the May 14 test and results were not reported due to well interference effects.

4.3.3 Comparison with Published Values for Aquifer Parameters

Analysis of the aquifer test data indicates that estimates of transmissivity for the lower aquifer range from 34,000 to 89,000 gpd/ft and estimates of storage coefficient range from 0.0003 to 0.0007. For both tests, the highest values of transmissivity were estimated for well (D-12-28) 28 DCC. In addition, the specific capacity of well (D-12-28) 28 DCC was observed to be about twice as high as the specific capacity of well (D-12-28) 28 CCC2. A representative value of transmissivity for the lower aquifer in the vicinity of the Bowie Power Station is conservatively estimated to be approximately 40,000 gpd/ft. A representative value of storage coefficient for the lower aquifer is estimated to be approximately 0.0005.

No published values for aquifer parameters based on aquifer tests were located during review of hydrogeological records and documents. However, in the absence of more reliable aquifer test data, White (1965) used estimates of transmissivity for seven wells completed in the lower aquifer in the Bowie area to construct an electric analog model. Based solely on specific capacity data, estimates for transmissivity ranged from 8,000 to 34,000 gpd/ft; average estimated transmissivity was about 23,500 gpd/ft. For the seven wells reviewed by White, five were less than 660 feet deep. The deepest well was 1,040 feet and had an estimated transmissivity of 28,000 gpd/ft. Estimates of transmissivity made by White may have been influenced by

shallower well depths and poor well efficiency. Transmissivity based solely on specific capacity for wells at the Bowie property is estimated to be about 22,000 gpd/ft for well (D-12-28) 28 CCC2 and about 35,000 gpd/ft for well (D-12-28) 28 DCC.

White also estimated storage coefficient to be 0.10 based on an analysis of the volume of dewatered sediments. White (1965) indicated that the large estimate of storage coefficient might have been influenced by interaction between the upper and lower units through vertical leakage and through wells completed in both units.

4.4 GROUNDWATER SAMPLING RESULTS

Two groundwater quality samples were collected from active irrigation wells during the field investigation. Well (D-12-28) 28 DCC was sampled at 12:56 P.M., March 30, 2001, after 21 hours of pumping at about 850 gpm. Well (D-12-28) 28 CCC2 was sampled at 7:20 A.M., April 3, 2001, after 19 hours of pumping at about 900 gpm. Groundwater samples from both wells were analyzed for indicator parameters, major ions, total petroleum hydrocarbons, and metals. The analytical results are presented in Table 4. The results indicate that most inorganic parameters, including nitrate, are present at concentrations that do not exceed numeric AWQS.

Concentrations of TDS, sulfate, chloride, manganese, silver, and zinc are all below the Federal Secondary Maximum Contaminant Levels (SMCLs). SMCLs are associated with the aesthetic quality of the water, such as taste, odor, or color, and are not enforceable. TDS concentrations in the groundwater samples were 230 and 250 mg/L. Concentrations of total nitrates (nitrate plus nitrite) were 0.87 to 0.82 mg/L.

Total coliform bacteria results for both wells were positive, indicating the presence of bacteria. Agricultural irrigation wells are not usually chlorinated and do not have surface seals that meet municipal water supply standards. Therefore, the presence of bacteria is common in irrigation wells.

Petroleum hydrocarbons were detected in the sample from well (D-12-28) 28 DCC at a concentration of 2.2 mg/L total petroleum hydrocarbons (TPH). There is no AWQS for TPH. Line-shaft turbine pumps use oil to lubricate the line-shaft bearings. Columns of oil as much as several feet thick, floating on the water column, are not uncommon in irrigation wells.

5.0 WATER LEVEL DRAWDOWN MODELING

Water level drawdown from the proposed groundwater production wellfield was modeled to estimate the incremental drawdown from the proposed wellfield for the projected 30-year life of the power plant. Water level drawdown was analyzed using an analytical groundwater flow model.

5.1 PROPOSED PRODUCTION WELLFIELD

The Bowie Power Station will require a water supply of approximately 5,500 ac-ft/yr or 3,410 gpm when fully developed and operating at base load. Assuming a typical groundwater production well will be capable of yielding between 800 and 1,200 gpm, a total of six wells will be needed to supply groundwater for the power plant. This arrangement will provide sufficient operational capacity, with four wells operating simultaneously and two wells down for maintenance or repair. Six wells were simulated for a plant life of 30 years using input values of transmissivity and storage coefficient obtained from analysis of aquifer test data.

5.2 ANALYTICAL METHOD

Water level drawdown was analyzed using DREAM (Bonn and Rounds, 1990), a computer-based, analytical groundwater flow model. DREAM is capable of simulating groundwater elevation, drawdown, velocity, and streamlines for up to 30 pumping wells. The drawdown option was selected for the well impact analysis. DREAM calculates transient drawdown data for each pumping well using the Theis equation (1935), which defines unsteady, radial flow in a confined aquifer.

The assumptions inherent in the Theis equation are as follows:

- The aquifer is homogeneous, isotropic, confined, of uniform thickness, and of infinite areal extent.
- The potentiometric surface is horizontal before pumping.
- The well is pumped at a constant rate.
- The pumped well penetrates the entire thickness of the aquifer, and flow within the aquifer is horizontal.
- Flow to the well is laminar.

- The well diameter is infinitesimal so that storage within the well can be neglected.
- Water removed from storage is discharged instantaneously with decline of head.

5.3 MODELING RESULTS

The DREAM analytical model was used to simulate the incremental drawdown from the proposed production wellfield for the projected 30-year life of the power plant. For purposes of comparing annual pumpage, using the 1,640-acre property as the analytical frame of reference results in a net decrease in pumpage for the Bowie Power Station of approximately 400 ac-ft/yr.

The Bowie Power Station wellfield will be located on 703 acres. For purposes of water level drawdown analysis, using the 703 acres as the analytical frame of reference and excluding retired pumpage from the remainder of the project acreage results in a net increase in pumpage of 2,970 ac-ft/yr, or about 1,840 gpm.

The incremental drawdown was simulated by distributing the additional 1,840 gpm equally among the six groundwater production wells. The model simulated pumping the six production wells at an average pumping rate of 307 gpm for each well for 10,950 days (30 years). A transmissivity value of 40,000 gpd/ft was used, which was toward the lower end of the range of transmissivity values derived from the aquifer tests (34,000 to 89,000 gpd/ft). This yields a projected drawdown of 50 feet in the immediate vicinity of the wellfield and about 40 feet near the town of Bowie (see Figure 5). The results of the water level drawdown analysis are considered to be conservative due to the aquifer transmissivity value used in the analysis.

Because drawdown is inversely proportional to transmissivity, a higher transmissivity value will result in less drawdown. Using a transmissivity value of 80,000 gpd/ft would yield a projected drawdown of about 25 feet in the immediate vicinity of the wellfield and about 20 feet near the town of Bowie.

The results of the analysis may also be conservative due to the underlying assumptions and limitations of the DREAM analytical model. Because the DREAM model derives pumped water solely from the instantaneous release of water from aquifer storage, the model does not account for underflow, vertical leakage, or aquifer recharge and discharge. Therefore, projected drawdown using the DREAM analytical model for a given set of aquifer parameters would be considered to be larger than expected for long-term conditions.

The Theis equation used in the DREAM analytical model assumes that the aquifer has uniform properties in all directions and that the aquifer has infinite boundaries. Lithologic logs (see

Appendix A) for wells near the Bowie property indicate that the extent and thickness of the middle unit is variable and that the thickness of the unit increases to the east in the direction of the center of the basin. If the cone of depression intercepts sediments of higher permeability, areas of recharge, or unconfined aquifer conditions in the marginal zone along the basin perimeter, actual drawdown may be smaller than projected using the model. Conversely, if long-term pumping results in a cone of depression that intercepts aquifer sediments of lower permeability, impermeable rocks, or cones of depression from other pumping wells, actual drawdown may be larger than projected using the DREAM analytical model.

6.0 SUMMARY OF GROUNDWATER AVAILABILITY AND QUALITY

The results of the water supply investigation described in this report indicate that there is sufficient groundwater of suitable quality beneath the Bowie property to meet the needs of the Bowie Power Station for the planned 30-year life of the facility. The basis for this conclusion is as follows:

- Groundwater levels in the Bowie area have been stable since the early 1980s. The Bowie Power Station water requirement will be about 5,500 ac-ft/yr. Average agricultural pumpage for the 1,640-acre Bowie property since 1980 is estimated to be about 5,900 ac-ft/yr. For purposes of comparing annual pumpage, using the 1,640-acre property as the analytical frame of reference results in a net decrease in pumpage for the Bowie Power Station property of approximately 400 ac-ft/yr.

- The results of aquifer testing indicate that the transmissivity of the lower aquifer is sufficient to allow groundwater to be extracted at a rate that will meet the water supply requirements of the project. A production well completed in the lower aquifer can be expected to yield between 800 and 1,200 gpm.

- Modeling results indicate that water level drawdown after 30 years of pumping will be about 50 feet in the immediate vicinity of the wellfield and about 40 feet near the town of Bowie. The results of the water level drawdown analysis are considered to be conservative due to the 40,000 gpd/ft aquifer transmissivity value used.

- Because drawdown is inversely proportional to transmissivity, a higher transmissivity value will result in less drawdown. Projected drawdown using a transmissivity value at the upper end of the range of 80,000 gpd/ft would be about 25 feet in the immediate vicinity of the wellfield and about 20 feet near the town of Bowie.

- The results of groundwater sampling and analysis confirm that the quality of groundwater beneath the Bowie property is excellent, with TDS concentrations of about 250 mg/L, and no exceedances of numeric AWQS. These results are consistent with publicly available groundwater quality data for the Bowie area.

7.0 REFERENCES

Anning, D.W. and Duet, N.R., 1994. Summary of Groundwater Conditions in Arizona, 1987-90: U.S. Geological Survey, Open File Report 94-476.

Barnes, R.L., 1991. Maps Showing Groundwater Conditions in the San Simon Sub-basin of the Safford, Basin Graham and Cochise Counties, Arizona, Hidalgo County, New Mexico – 1987: Arizona Department of Water Resources Hydrologic Map Series Report Number 19.

Bonn, B.A., and Rounds, S.A., 1990. DREAM Analytical Ground Water Flow Programs: documentation published by Lewis Publishers, Inc., Chelsea, Michigan, 109 p.

Geraghty & Miller, 1996. AQTESOLV Aquifer Test Data Solver (Version 3.01): software and documentation developed by Glenn M. Duffield and James O. Rumbaugh, III, Geraghty & Miller Modeling Group, 155 p.

Holzer, T.L., 1980. Earth Fissures and Land Subsidence, Bowie and Willcox Areas, Arizona: U.S. Geological Survey Miscellaneous Field Studies Map MF-1156, 2 sheets, 1:24,000.

Oppenheimer, J.M., and Sumner, J.S., 1980. Depth to Bedrock Map, Basin and Range Province: Pinal Laboratory of Geophysics, University of Arizona.

Strange, W.E., 1983. Subsidence Monitoring for State of Arizona: National Geodetic Survey, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

Theis, C.V., 1935. The Relation Between the Lowering of the Pieziometric Water Surface and the Rate and Duration of Discharge of a Well Using Groundwater Storage: American Geophysical Union Transactions, p. 519-524.

White, N.D., 1963. Analysis and Evaluation of Available Hydrologic Data for San Simon Basin, Cochise and Graham Counties, Arizona: U.S. Geological Survey Water-Supply Paper 1619-DD.

White, N.D., 1965. Electric-Analog Analysis of Hydrologic Data for San Simon Basin, Cochise and Graham Counties, Arizona: U.S. Geological Survey Water-Supply Paper 1809-R.

EXHIBIT B-4
AIR QUALITY

EXHIBIT B-4
AIR QUALITY

SUMMARY

Prior to commencing construction, the Bowie Power Station Project must obtain a construction and operating permit from the Arizona Department of Environmental Quality (ADEQ). To obtain the permit, it must be demonstrated that the project will meet all applicable air quality requirements and that best available control technology (BACT) will be used to minimize emissions. An air quality impact analysis must be conducted and the results of that analysis must show that the project will not cause or contribute to an exceedance of any National Ambient Air Quality Standard (NAAQS) or Prevention of Significant Deterioration (PSD) increment. Further, the analysis must show that the project will not have an adverse impact on air quality related values such as visibility, wildlife, or vegetation in specially protected areas (Class I areas).

PROJECT EMISSIONS

The permitting requirements applicable to the Bowie Power Station are determined based on projected emissions. Such emissions will result from the combustion turbines, cooling towers, auxiliary boiler, and emergency fire pumps. Initial estimates of annual emissions from these sources have been made and are shown in Table B-4-1. These estimates include emissions expected from startups and shutdowns of the turbines, as well as from normal turbine operation.

TABLE B-4-1
ESTIMATED ANNUAL EMISSIONS

Pollutant	Estimated Annual Emissions (tons per year)
Oxides of Nitrogen	600.1
Carbon Monoxide	1,135.4
Volatile Organic Compounds	147.1
Sulfur Dioxide	104.3
Fine Particulate Matter	353.2

PERMITTING REQUIREMENTS

The project will emit more than 100 tons per year of each of the criteria pollutants shown in Table B-4-1. This makes the project a major source. Because the project will be a major source it must meet the requirements for Class I permits. The project is planned for construction in Cochise County, which is designated "attainment" or "unclassified" for all criteria pollutants. Because the area is an attainment area and the project is a major source, to obtain a permit from ADEQ, the PSD requirements must also be met.

Prior to issuing the construction and operating permit, ADEQ will verify that both the Class I and the PSD requirements have been met for the project. The application for the permit is currently being prepared and will be filed with ADEQ. The application will include a regulatory review, top-down BACT analyses, and the required air quality impact analyses. ADEQ will process the permit application and prepare a draft permit. The draft permit will be available for review by the public, the U.S. Environmental Protection Agency (EPA), the Federal Land Managers (FLMs), and the State of New Mexico.

BEST AVAILABLE CONTROL TECHNOLOGY

To obtain the necessary construction and operating permit, the permit applicant must install BACT on the emitting units that will make up the project. As indicted above, top-down BACT analyses will be included in the air quality permit application for the project. The top-down analysis method that must be used is set forth in EPA guidance. This method requires that each analysis identify all technically feasible control technologies available for use on the project. Each available control technology is then evaluated, beginning with the most effective technology, based on environmental, energy, and economic impacts. ADEQ will review the analyses presented in the application and will identify BACT for each pollutant. The combustion turbines to be installed at Bowie Power Station will be equipped with selective catalytic reduction (SCR) technology to minimize oxides of nitrogen emissions. The use of pipeline quality natural gas and good combustion practices will be used to minimize carbon monoxide, volatile organic compounds, sulfur dioxide, and fine particulate matter emissions.

AIR QUALITY IMPACTS

An air quality impact analysis is required for major sources subject to PSD review. As indicated above, the analysis will be included in the permit application submitted for the project. To qualify for the permit, the results of the analysis must show that the project will not cause or contribute to an exceedance of any NAAQS or PSD increment. The analysis must also show no adverse impact on air quality related values in Class I areas.

Prior to conducting the air quality impact analysis, a protocol detailing how the analysis will be performed will be submitted to the ADEQ for review. Typically the analysis involves two distinct phases. The objective of the first phase is to perform initial dispersion modeling to assess whether the proposed project triggers the need for pre-construction ambient monitoring, and whether predicted impacts are expected to be "significant." Predicted impacts are considered significant, with respect to PSD, if they equal or exceed the significance levels defined in the PSD regulations. If no significant ambient impacts are predicted for a particular pollutant, no further analysis for that pollutant is required. If significant ambient impacts are predicted, then a full impact analysis must be completed for that pollutant. This requires conducting a NAAQS analysis for the pollutant, in which other emission sources in the area are modeled, and

conducting a PSD increment analysis for the pollutant, which incorporates emissions from other increment-consuming sources in the area. Such an analysis will be conducted for the project.

In addition to addressing the NAAQS and PSD increments, the air quality impact analysis must address impacts to soils and vegetation and impacts to air quality related values in Class I areas. Class I areas in the vicinity of the project site include Saguaro National Park, Chiricahua National Monument, Galiuro Wilderness Area, and Gila Wilderness Area (in New Mexico). Of special interest to the FLMs with responsibility for these Class I areas are the proposed project's impacts on visibility. As part of the air permit application, an analysis will be conducted using an appropriate visibility modeling method. The FLMs will advise ADEQ if the project would adversely affect any Class I area. In processing the permit application, ADEQ must consider the opinion of the FLMs regarding visibility and other Class I area impacts.

EXHIBIT C
AREAS OF BIOLOGICAL WEALTH

EXHIBIT C
AREAS OF BIOLOGICAL WEALTH

As stated in Arizona Corporation Commission Rules of Practice and Procedure R-14-3-219:

"Describe any areas in the vicinity of the proposed site or route which are unique because of biological wealth or because they are habitats for rare and endangered species. Describe the biological wealth or species involved and state effects, if any, the proposed facilities will have thereon."

BIOLOGICAL WEALTH

Letters with a current project description were sent to Arizona Game and Fish Department (AGFD) and Arizona Department of Agriculture (ADA) to request information on special status species in the vicinity of the proposed power plant site and transmission line route (and alternate route) that make up the project area. Responses are provided in Exhibit C-1. The U.S. Fish and Wildlife Service (USFWS) web site was accessed for information on special status species that may occur in the project area, as reported in Table C-1.

Biologists traveling by vehicle and on foot assessed the project area to determine whether surveys for threatened, endangered, or otherwise sensitive species of plants and animals were warranted. Vegetation communities and geography were carefully noted to help determine the biologically preferred route for the transmission line.

Species of Concern

The USFWS lists 19 different species of plants and animals in Cochise and Graham counties as threatened or endangered species. Several other species have been designated as species of concern. Table C-1 lists the subset of this group of listed species and species of concern that are most likely to be found in habitats similar to those of the project area.

The lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*) is federally listed as an endangered species. Lesser long-nosed bats roost in caves and mine shafts and forage on the flowers and fruits of columnar cacti and the flowers of paniculate agaves. The project area may provide some limited foraging habitat in the form of paniculate agaves; however, the numerous soaptree yuccas in the project vicinity do not provide foraging substrate for this species and there are no columnar cacti in the region. Consequently, it is unlikely that robust populations of this species are present at the project site or in the general vicinity. No potential roost sites were observed at the plant site or along the alternate transmission line routes.

The cave myotis (*Myotis velifer*), a USFWS species of concern, roosts near the entrances to caves and mine tunnels in desertscrub habitat. They may also roost under bridges, and the species has been collected at old Fort Bowie as well as a number of other localities in Cochise and Graham counties. Cave myotis forage on insects and generally live near permanent water sources. It is likely that this species forages over desertscrub habitats in the project area. There are no known roost sites associated either with the plant site or the alternate transmission line routes.

The northern aplomado falcon (*Falco femoralis septentrionalis*), a federally listed endangered species, formally occurred as a fairly common summer, or possibly permanent, resident of grasslands of southeast Arizona, including Cochise County (Phillips et al. 1960). There are no records of this species in the state since 1940 and Monson and Phillips (1981) consider the species to be extinct in Arizona. Nevertheless, if the species should reinvade the state from northern Mexico, it would be in habitats similar to those in the vicinity of the project area.

The lowland leopard frog (*Rana yavapaiensis*) uses permanent water in springs, creeks, rivers, and stock tanks. This species is classified as wildlife of special concern by AGFD and as species of concern by USFWS. It may be present in the vicinity of the project area, but no suitable habitat for this frog was noted during site reconnaissance of the plant site and transmission line alternatives.

The plains leopard frog (*Rana blairi*) is classified as wildlife of special concern by AGFD. This species uses permanent and intermittent water in desert grassland and could be present in or near the project area, but no suitable habitat for this frog was noted during site reconnaissance of the plant site and transmission line alternatives.

Impacts

Potential impacts resulting from construction of the project include loss of habitat, direct mortality from construction equipment, and disturbance resulting from noise and human activity associated with construction. Operational impacts include noise from the plant site and potential direct mortality of individual animals caused by vehicles coming and going from the plant or during maintenance of the transmission line and switchyard.

In the case of sensitive species potentially occurring in the immediate project area, few or no impacts are anticipated due to a general absence of suitable habitat for the species in question. Construction of the transmission line will result in limited impact to habitat that could potentially be occupied in the future by aplomado falcons. However, since the species is not currently present in Arizona, this project will have not direct effects.

There are few, if any, paniculate agaves along the transmission line alternatives and none on the plant site. Similarly, there are no columnar (i.e., saguaro [*Cereus giganteus]*) cacti in the project area or associated region. Consequently, the possibility for impact to resources of value to lesser

long-nosed bats is remote. In addition, there will be no impact to any roosting or nursery areas for this species.

Some desertscrub habitat will likely be impacted (removed) during transmission line construction. Access roads, spur roads, pulling and tensioning sites, and equipment storage and laydown areas will all witness some impact to desertscrub habitats. As a result, some habitat that could support prey species (insects) for the cave myotis will be lost. It is doubtful, however, that the magnitude of loss of desertscrub habitat could be translated into measurable impact to cave myotis.

Neither of the two frog species that could be present in the vicinity of the project will be affected by construction of the project because no suitable habitat for either species was found in the project area.

TABLE C-1
SPECIAL STATUS SPECIES LIKELY TO OCCUR IN THE PROJECT AREA

Common Name	Scientific Name	Habitat	Federal Status	State Status
MAMMALS				
Lesser long-nosed bat	*Leptonycteris curasoae yerbabuenae*	Desertscrub with caves or mines for roosts	**E**	**WC**
Cave myotis	*Myotis velifer*	Desertscrub with caves or mine tunnels and water nearby	**SC**	**WC**
BIRDS				
Northern aplomado falcon	*Falco femoralis septentrionalis*	Semidesert grassland with *Yucca elata*	**E**	**-**
AMPHIBIANS				
Lowland leopard frog	*Rana yavapaiensis*	Permanent water in creeks, springs, rivers and stock tanks	**SC**	**WC**
Plains leopard frog	*Rana blairi*	Permanent and intermittent water in desert grasslands		**WC**

Sources: AGFD 2001; Hoffmeister 1986; National Geographic Society 1999; USFWS 2001

Key to Table:
Federal Status: E = Endangered T=Threatened
SC= Species of Concern
State Status: WC = Wildlife of Special Concern in Arizona

LITERATURE CITED

Arizona Game and Fish Department, Heritage Data Management System. 2001. Special status species by county for Arizona. Arizona Game and Fish Department, Habitat Branch, Phoenix, Arizona, May 10, 2001.

Hoffmeister, D.F. 1986. Mammals of Arizona. University of Arizona Press, Tucson, Arizona. 602 pp.

Monson, G. and A.R. Phillips. 1981. Annotated checklist of the birds of Arizona. Second Ed. University of Arizona Press, Tucson 240 pp.

National Geographic Society. 1999. Field Guide to Birds of North America. Third edition. National Geographic Society, Washington, D. C. 480 pp.

Phillips, A.R., J.T. Marshall and G. Monson. 1964. The Birds of Arizona. Univeristy of Arizona Press, Tucson. 212 pp.

U.S. Fish and Wildlife Service. 2001. Endangered species lists for Cochise and Graham Counties, Arizona. http://ifw2es.fws.gov/EndangeredSpecies/lists/ListSpecies.cfm.

EXHIBIT C-1
RESPONSE LETTERS

THE STATE OF ARIZONA
GAME AND FISH DEPARTMENT
2221 WEST GREENWAY ROAD, PHOENIX, AZ 85023-4399
(602) 942-3000 • WWW.AZGFD.COM

GOVERNOR
JANE DEE HULL
COMMISSIONERS
CHAIRMAN, DENNIS D. MANNING, ALPINE
MICHAEL M. GOLIGHTLY, FLAGSTAFF
JOE CARTER, SAFFORD
SUSAN E. CHILTON, ARIVACA
W. HAYS GILSTRAP, PHOENIX
DIRECTOR
DUANE L. SHROUFE
DEPUTY DIRECTOR
STEVE K. FERRELL

May 8, 2001

Ms. Lisa Spahr
EPG
1430 E. Ft. Lowell Blvd.
Suite 304
Tucson, AZ 85719

Re: Special Status Species Information for **Township 12 South, Range 28 East, Section 28, New Electric Generating Power Plant near Bowie, AZ.**

Dear Ms. Spahr:

The Arizona Game and Fish Department (Department) has reviewed your letter, dated April 18, 2001, regarding special status species information associated with the above-referenced project areas. The Department's Heritage Data Management System (HDMS) has been accessed and current records do not indicate the presence of any special status species in the project vicinity. In addition this project does not occur in the vicinity of any Designated or Proposed Critical Habitats.

The Department's HDMS data are not intended to include potential distribution of special status species. Arizona is large and diverse with plants, animals, and environmental conditions that are ever changing. Consequently, many areas may contain species that biologists do not know about or species previously noted in a particular area may no longer occur there. Not all of Arizona has been surveyed for special status species, and surveys that have been conducted have varied greatly in scope and intensity.

Making available this information does not substitute for the Department's review of project proposals, and should not decrease our opportunities to review and evaluate new project proposals and sites. The Department is also concerned about other resource values, such as other wildlife, including game species, and wildlife-related recreation. The Department would appreciate the opportunity to provide an evaluation of impacts to wildlife or wildlife habitats associated with project activities occurring in the subject area, when specific details become available.

If you have any questions regarding this letter, please contact me at (602) 789-3618. General status information and county distribution lists for special status species are also available on our web site at http://www.azgfd.com/frames/fishwild/hdms_site/Home.htm.

Sincerely,

Sabra S. Schwartz
Heritage Data Management System, Coordinator

SSS:ss

cc: Bob Broscheid, Project Evaluation Program Supervisor
Joan Scott, Habitat Program Manager, Region V

AGFD# 04-27-01 (07)

JANE DEE HULL
Governor

SHELDON R. JONES
Director

Arizona Department of Agriculture

1688 W. Adams Street, Phoenix, Arizona 85007
(602) 542-4373 FAX (602) 542-5420

April 24, 2001

Lisa Spahr, Environmental Scientist
Environmental Planning Group
1430 East Fort Lowell Road, Suite 304
Tucson, Arizona 85719

Re: Bowie Power Station Project

Dear Ms. Spahr:

Arizona State Law requires that the Arizona Department of Agriculture be notified in writing, with confirmation, prior to the anticipated destruction of any protected native plants during land clearing activity. On privately owned land the notification period ranges from 20 days to 60 days. The notification period on state lands is 60 days. I recommend the leaving in place, and protection of, as much of the native vegetation as is possible. The preferred alternative route would be the one having the least negative impact on protected plants and native vegetation.

The protection and salvage of protected native plants is encouraged to the greatest extent feasible. You may want to consider having the project site surveyed for protected native plants.

Plant transportation permitting and tagging are required prior to the removal of protected native plants from a property. Transportation permitting is not required when the plants are being relocated on the same property.

Native plant permit application and notification forms, and *Appendix A*, the listings of protected native plants by category; as well as, general information on the Arizona Native Plant Law, Seed Law and Noxious Weed Regulations can be obtained at: http://agriculture.state.az.us

You can correspond with me at the address listed below. You may also contact me by telephone at: 520-628-6310, by FAX at 520-628-6961, or by email at: bill.kendall@agric.state.az.us

Sincerely Yours,

Bill

William T. Kendall, Special Investigator #187
Office of Review and Investigations

Arizona Department of Agriculture
400 West Congress Street, Suite #124, Box #4
Tucson, Arizona 85701-1311

EXHIBIT D
BIOLOGICAL RESOURCES

EXHIBIT D
BIOLOGICAL RESOURCES

As stated in Arizona Corporation Commission Rules of Practice and Procedure R14-3-219:

"List the fish, wildlife, plant life, and associated forms of life in the vicinity of the proposed site or route and describe the effects, if any, other proposed facilities will have thereon."

BIOLOGICAL RESOURCES

A biological field crew surveyed the proposed 345kV transmission line route, switchyard site, and power plant site (project site) to assess plant communities and associated fauna affected by the project. Plants and animals were identified and noted along with major geographic features. Lists of potentially occurring species of animals were assembled from standard references for the state.

Most of the power plant site is located on active agricultural land, either currently under cultivation or in a fallow rotation. This land has been carefully leveled for irrigated farming and there are no areas with native vegetation except for some weedy species around the borders of the agricultural fields. There are some areas to the west and north of the plant site that may have been cleared at one time. Plant species occupying these areas include scattered honey mesquite (*Prosopis glandulosa*), desert broom (*Baccharis sarothroides*), saltbush (*Atriplex sp.*), burroweed (*Isocoma tenuisecta*), snakeweed (*Gutierrezia sarothrae*), and tumbleweed (*Salsola iberica*).

The proposed transmission line route crosses areas that include agricultural lands and native vegetation of the Chihuahuan semidesert grassland and Chihuahuan desertscrub biomes (Brown 1994). The majority of the Chihuahuan desertscrub in the project area is dominated by creosote bush (*Larrea tridentata*) and honey mesquite. Velvet mesquite (*Prosopis velutina*) is also present, particularly along major drainages. Other plants include desert zinnia (*Zinnia acerosa*) and mariola (*Parthenium incanum*). Semidesert grassland plants include soaptree yucca (*Yucca elata*) and tobosa grass (*Hilaria mutica*). Like many sites in southern Arizona, this biome has also been invaded by burroweed. Prickly pear and cholla cacti (*Opuntia* spp.) are found in both biomes.

Portions of the proposed transmission line route (and alternate route) are crossed by washes supporting xeroriparian vegetation dominated by larger shrubs and trees. Plant species in these areas include some rather large velvet and honey mesquite, wolfberry (*Lycium* sp.), catclaw (*Acacia greggii*), desert broom datura (*Datura meteloides*), desert willow (*Chilopsis linearis*), and in one area adjacent to an agricultural field, Fremont cottonwood (*Populus fremontii*).

Both the proposed transmission line route and alternate route would parallel the railroad right-of-way as it heads north from the Bowie Power Station site. Approximately 3.8 miles north of the power station site, the routes split into two possibilities for tie-in with the existing 345kV transmission lines to the north. The alternative parallels the railroad right-of-way and is the shorter of the two. However, it crosses numerous small and medium-sized washes with concentrations of native vegetation. The proposed route is approximately 1 mile longer and travels to the northwest from the point of diversion from the railroad right-of-way. This route parallels the dominant drainages in the area, rather than crossing them, and ties into the existing 345kV transmission line within 1 mile of U.S. Highway 191.

For species of mammals, birds, and reptiles and amphibians that may occur in the region where the project area is located, refer to Tables D-1, D-2, and D-3 respectively.

Impacts

Impacts associated with the proposed power plant, 345kV transmission line, and 345kV/230kV switchyard will result from construction at the plant site and construction of access and spur roads along the transmission line. There will also be disturbance at transmission tower and switchyard sites, pulling and tensioning stations, and in material lay-down and storage areas.

Potential effects of the proposed project on wildlife and plants include vegetation clearing and associated habitat loss, as well as disturbance, injury, or mortality of wildlife due to construction activities. Regional species dependent on aquatic or wetland habitats will not be affected by the project since no aquatic or wetland habitats are present on the plant site or along the transmission line alternatives. Similarly, species dependent on cliffs, woodlands, and broadleaf riparian habitats will not be affected due to absence of such habitats within the project area.

In areas where native vegetation is cleared there will be a permanent loss of potential habitat for small mammals, reptiles, and birds. Construction activities may result in temporary disturbance of wildlife due to the presence of construction equipment and human activity. Vehicles and heavy equipment could displace or cause mortality in some fossorial species. The crossing of washes and other drainages would necessitate the removal of concentrations of vegetation found in these areas and could negatively impact populations of animals dependent on them. There is also greater potential for impacts to soil integrity in these areas.

The proposed transmission line route would result in lower impacts to biological resources because it parallels rather than crosses most major drainages. The exceptions are crossings at Dial Wash and Gold Gulch north of the point at which the proposed route leaves the railroad right-of-way. These fairly major washes can be effectively spanned to avoid adverse biological impacts.

TABLE D-1 MAMMAL SPECIES THAT MAY OCCUR IN THE VICINITY OF THE PROPOSED PROJECT		
Common Name	**Scientific Name**	**Habitat**
Desert shrew	*Notiosorex crawfordi*	Any area with ample ground cover including plant debris, trash and lumber
Lesser long-nosed bat	*Leptonycteris curasoae yerbabuenae*	Areas with agave and columnar cacti for foraging and mine tunnels or deep caves for roosts
Cave myotis	*Myotis velifer*	Desertscrub with caves, mines, or bridges and water nearby
California myotis	*Myotis californicus*	Desertscrub with rock faces containing crevices, occasionally caves and mines
Western pipistrelle	*Pipistrellus hesperus*	Areas with canyon walls or cliff faces for roosting, streambeds and tanks for foraging
Big brown bat	*Eptesicus fuscus*	Wooded areas, desertscrub
Spotted bat	*Euderma maculatum*	Rocky cliffs near riparian areas
Townsend's big-eared bat	*Corynorhinus townsendii*	Areas with caves or mines, structures for night roosts
Pallid bat	*Antrozous pallidus*	Desertscrub with caves, mine, cliffs, bridges or other structures for roosts
Brazilian free-tailed bat	*Tadarida brasiliensis*	Desertscrub and foothills with mines, caves, bridges or old buildings
Pocketed free-tailed bat	*Nyctinomops femorosaccus*	Rocky cliffs and slopes, structures
Western mastiff bat	*Eumops perotis*	Rocky cliffs with crevices or shallow caves
Desert cottontail	*Sylvilagus audubonii*	Desertscrub, semi-desert grassland
Black-tailed jack rabbit	*Lepus californicus*	Desertscrub and other areas with open ground cover
Antelope jack rabbit	*Lepus alleni*	Creosote bush, mesquite, grasslands
Harris' antelope squirrel	*Ammospermophilus harrisii*	Rocky areas of creosote bush/saltbush/bursage
Rock squirrel	*Spermophilus variegatus*	Rocky areas above 1,600 feet
Round-tailed ground squirrel	*Spermophilus tereticaudus*	Creosote bush/saltbush desert with sandy or gravelly soil
Botta's pocket gopher	*Thomomys bottae*	Any area with soil suitable for digging burrows
Silky pocket mouse	*Perognathus flavus*	Mesquite, grassland
Long-tailed pocket mouse	*Perognathus formosus*	Rocky soils, often on slopes
Rock pocket mouse	*Chaetodipus intermedius*	Rocky areas of desertscrub
Desert pocket mouse	*Chaetodipus penicillatus*	Sandy areas of desertscrub with sparse vegetation
Bailey's pocket mouse	*Chaetodipus baileyi*	Flats and lower slope areas of desertscrub
Merriam's kangaroo rat	*Dipodomys merriami*	Sandy areas of desertscrub

TABLE D-1 MAMMAL SPECIES THAT MAY OCCUR IN THE VICINITY OF THE PROPOSED PROJECT		
Common Name	**Scientific Name**	**Habitat**
Ord's kangaroo rat	*Dipodomys ordii*	Areas with grass, mesquite and/or cactus
Banner-tailed kangaroo rat	*Dipodomys spectabilis*	Sparse grassy areas with mesquite, catclaw, or cactus
Plains harvest mouse	*Reithrodontomys montanus*	Desertscrub with mesquite, creosote bush, and/or grass
Western harvest mouse	*Reithrodontomys megalotis*	Desertscrub or chaparral
Cactus mouse	*Peromyscus eremicus*	Desertscrub, rocky areas, chaparral
Deer mouse	*Peromyscus maniculatus*	Creek beds, desertscrub, agricultural areas
Northern pygmy mouse	*Baiomys tailori*	Desert grasslands
Northern grasshopper mouse	*Onychomys leucogaster*	Desert grasslands
Southern grasshopper mouse	*Onychomys torridus*	Desertscrub or semi-desert grassland with compact soil
Hispid cotton rat	*Sigmodon hispidus*	Desertscrub
Arizona cotton rat	*Sigmodon arizonae*	Mesquite scrub and weedy areas along canals and washes
White-throated wood rat	*Neotoma albigula*	Desertscrub, especially with *Opuntia*
Desert wood rat	*Neotoma lepida*	Desertscrub
Muskrat	*Ondatra zibethicus*	Irrigation canals, ponds
House mouse	*Mus musculus*	Weedy areas and cultivated fields, usually near human habitation
Coyote	*Canis latrans*	Cosmopolitan, from spruce forest to low desert
Kit fox	*Vulpes velox*	Desertscrub and desert grassland with sandy or softer clay soils
Gray fox	*Urocyon cinereoargenteus*	Open desertscrub, chaparral, lower elevation woodland
Raccoon	*Procyon lotor*	Areas with permanent water
Coati	*Nasua narica*	Medium elevation woodland and shrubby grassland, may migrate or wander through desert areas
Badger	*Taxidea taxus*	Flats and drainages adjacent to mountains, grasslands
Western spotted skunk	*Spilogale gracilis*	Low and middle elevations, often in rocky areas or around human habitation
Striped skunk	*Mephitis mephitis*	From spruce/fir belt to sea level, usually near permanent water
Bobcat	*Felis rufus*	Rocky upland areas interspersed w/ open desert, grassland or woodland
Collared peccary	*Tayassu tajacu*	Desertscrub, esp. thickets along creeks and streambeds
Mule deer	*Odocoileus hemionus*	Pine forest, oak woodland, chaparral, upland desert
Source: Hoffmeister 1986; Jones et al 1992		

TABLE D-2 BIRD SPECIES THAT MAY OCCUR IN THE VICINITY OF THE PROPOSED PROJECT		
Common Name	**Scientific Name**	**Habitat**
Pied-billed grebe	*Podilymbus podiceps*	Lakes, ponds, streams, and canals
Eared grebe	*Podiceps nigricollis*	Lakes and ponds
Western grebe	*Aechmophorus occidentalis*	Lakes, ponds, and lagoons
Double-crested cormorant	*Phalacrocorax auritus*	Lakes, ponds, streams, and aqueducts
Great blue heron	*Ardea herodias*	Lakes, ponds, streams, canals, and marshes
Great egret	*Ardea alba*	Ponds, streams, and marshes
Snowy egret	*Egretta thula*	Ponds, streams, and marshes
Green heron	*Butorides virescens*	Lakes, ponds, streams, marshes, and canals
Black-crowned night heron	*Nycticorax nycticorax*	Lakes, ponds, marshes, and streams
White-faced ibis	*Plegadis chihi*	Lakes, ponds, streams, marshes, and fields
Turkey vulture	*Cathartes aura*	Open country, woodlands, farms
Canada goose	*Branta canadensis*	Lakes, ponds, and fields
Gadwall	*Anas strepera*	Lakes, ponds, and streams
American widgeon	*Anas americana*	Lakes, ponds, and streams
Mallard	*Anas platyrhynchos*	Lakes, ponds, streams, and canals
Blue-winged teal	*Anas discors*	Ponds
Cinnamon teal	*Anas cyanoptera*	Ponds, streams, and canals
Northern shoveler	*Anas clypeata*	Lakes, ponds, and streams
Northern pintail	*Anas acuta*	Lakes, ponds, and streams
Green-winged teal	*Anas crecca*	Lakes, ponds, and streams
Redhead	*Aythya americana*	Lakes and ponds
Ring-necked duck	*Aythya collaris*	Lakes and ponds
Lesser scaup	*Aythya affinis*	Lakes and ponds
Bufflehead	*Bucephala albeola*	Lakes, ponds, and streams
Ruddy duck	*Oxyura jamaicensis*	Lakes and ponds
Northern harrier	*Circus cyaneus*	Wetlands, open fields
Sharp-shinned hawk	*Accipiter striatus*	Generally distributed
Cooper's hawk	*Accipiter cooperii*	Broken woodlands or streamside groves
Harris's hawk	*Parabuteo unicinctus*	Semiarid woodland, brushland
Swainson's hawk	*Buteo swainsoni*	Fields and desert
Red-tailed hawk	*Buteo jamaicensis*	Plains, prairie groves, desert
Ferruginous hawk	*Buteo regalis*	Dry, open country
American kestrel	*Falco sparverius*	Open country, cities
Prairie falcon	*Falco mexicanus*	Dry, open country, prairies
Gambel's quail	*Callipepla gambelii*	Desertscrub and thickets
Scaled quail	*Callipepla squamata*	Desertscrub, mixed grasslands
Common moorhen	*Gallinula chloropus*	Streams, marshes, and ponds
American coot	*Fulica americana*	Lakes, ponds, streams, and marshes
Killdeer	*Charadrius vociferus*	Ponds, streams, and fields
Greater yellowlegs	*Tringa melanoleuca*	Lakes, ponds, streams, and flooded fields
Spotted sandpiper	*Actitis macularia*	Lakes, ponds, streams, and canals
Western sandpiper	*Calidris mauri*	Ponds and streams

TABLE D-2 BIRD SPECIES THAT MAY OCCUR IN THE VICINITY OF THE PROPOSED PROJECT		
Common Name	**Scientific Name**	**Habitat**
Least sandpiper	*Calidris minutilla*	Ponds and streams
Long-billed dowitcher	*Limnodromus scolopaceus*	Ponds and streams
Common snipe	*Gallinago gallinago*	Ponds, marshes, streams, and wet fields
Wilson's phalarope	*Phalaropus tricolor*	Lakes, ponds
Ring-billed gull	*Larus delawarensis*	Lakes, ponds, and streams
Rock dove	*Columba livia*	Parks, fields, urban settings
White-winged dove	*Zenaida asiatica*	Dense mesquite, mature groves, riparian woodlands
Mourning dove	*Zenaida macroura*	Wide variety of habitats
Inca dove	*Columbina inca*	Near human habitations
Common ground dove	*Columbina passerina*	Fields and hedgerows
Greater roadrunner	*Geococcyx californianus*	Scrub desert and mesquite groves
Barn owl	*Tyto alba*	Dark cavities in city and farm buildings, cliffs, trees
Western screech owl	*Otus kennicottii*	Open woodlands, streamside groves, deserts, suburban areas
Great horned owl	*Bubo virginianus*	Common in wide variety of habitats
Elf owl	*Micrathene whitneyi*	Desert lowlands, canyons, foothills
Burrowing owl	*Athene cunicularia*	Open country, golf courses, airports
Common nighthawk	*Chordeiles minor*	Woodlands, towns
Lesser nighthawk	*Chordeiles acutipennis*	Dry, open country, scrubland, desert
Common poorwill	*Phalaenoptilus nuttallii*	Sagebrush and chaparral slopes
White-throated swift	*Aeronautes saxatalis*	Mountains, canyons, and cliffs
Black-chinned hummingbird	*Archilochus alexandri*	Lowlands and low mountains
Anna's hummingbird	*Calypte anna*	Coastal lowlands, mountains, deserts
Costa's hummingbird	*Calypte costae*	Desert washes, dry chaparral
Rufous hummingbird	*Selasphorus rufus*	Suburban and riparian areas
Belted kingfisher	*Ceryle alcyon*	Streams, ponds and lakes
Gila woodpecker	*Melanerpes uropygialis*	Towns, scrub desert, cactus country, streamside woods
Ladder-backed woodpecker	*Picoides scalaris*	Dry brushlands, mesquite and cactus country, towns and rural areas
Northern flicker	*Colaptes auratus*	Open woodlands, suburban areas
Gilded flicker	*Colaptes chrysoides*	Low desert woodlands
Western wood-pewee	*Contopus sordidulus*	Riparian areas, wooded habitats, including suburban areas
Black phoebe	*Sayornis nigricans*	Woodlands, parks, suburbs, prefers to nest near water
Say's phoebe	*Sayornis saya*	Dry, open areas, canyons, cliffs
Vermilion flycatcher	*Pyrocephalus rubinus*	Streamside shrubs, bottomlands, near small wooded ponds
Ash-throated flycatcher	*Myiarchus cinerascens*	Wide variety of habitats
Brown-crested flycatcher	*Myiarchus tyrannulus*	Saguaro desert, river groves, lower mountain woodlands

TABLE D-2 BIRD SPECIES THAT MAY OCCUR IN THE VICINITY OF THE PROPOSED PROJECT		
Common Name	**Scientific Name**	**Habitat**
Cassin's kingbird	*Tyrannus vociferans*	Varied habitats
Western kingbird	*Tyrannus verticalis*	Dry, open country
Loggerhead shrike	*Lanius ludovicianus*	Hunt in open or brushy areas
Bell's vireo	*Vireo bellii*	Riparian areas, especially in mesquite trees
Plumbeous vireo	*Vireo plumbeus*	Woodland habitats
Warbling vireo	*Vireo gilvus*	Deciduous woods
Chihuahuan raven	*Corvus cryptoleucus*	Deserts, scrubby grasslands
Common raven	*Corvus corax*	Mountains, deserts, coastal areas
Horned lark	*Eremophila alpestris*	Dirt fields, gravel ridges, shores
Tree swallow	*Tachycineta bicolor*	Streams, ponds, and lakes
Violet-green swallow	*Tachycineata thalassina*	Riparian areas, streams, ponds, and lakes
Northern rough-winged swallow	*Stelgidopteryx serripennis*	Banks of streams and canals, streams, ponds, and lakes
Cliff swallow	*Petrochelidon pyrrhonota*	Lakeside, cliffs, and canals; nesting under nearby bridges, buildings, and other overhangs; streams and ponds
Barn swallow	*Hirundo rustica*	Streams, ponds, lakes, and agricultural areas
Verdin	*Auriparus flaviceps*	Southwestern desert
Cactus wren	*Campylorhynchus brunneicapillus*	Cholla cactus habitat
Rock wren	*Salpinctes obsoletus*	Arid and semiarid habitats
Canyon wren	*Catherpes mexicanus*	Canyons and cliffs, often near water
Bewick's wren	*Thryomanes bewickii*	Wooded riparian areas
House wren	*Troglodytes aedon*	Dense, brushy areas
Ruby-crowned kinglet	*Regulus calendula*	Woodlands, thickets
Black-tailed gnatcatcher	*Polioptila melanura*	Desert, especially washes
Western bluebird	*Sialia mexicana*	Woodlands, farmlands, orchards, deserts, especially in mesquite-mistletoe groves
American robin	*Turdus migratorius*	Riparian and suburban areas, desertscrub
Northern mockingbird	*Mimus polyglottos*	Variety of habitats
Bendire's thrasher	*Toxostoma bendirei*	Open farmlands, grasslands, brushy desert
Curve-billed thrasher	*Toxostoma curvirostre*	Cholla deserts and suburban areas
Crissal thrasher	*Toxostoma crissale*	Riparian areas and washes
European starling	*Sturnus vulgaris*	Generally distributed
Cedar waxwing	*Bombycilla cedrorum*	Riparian and suburban areas
American pipit	*Anthus rubescens*	Fields, ponds, pastures, riparian areas
Phainopepla	*Phainopepla nitens*	Riparian & desertscrub areas, especially in trees with mistletoe
Loggerhead shrike	*Lanius ludovicianus*	Generally distributed
Lucy's warbler	*Vermivora luciae*	Mesquites and cottonwoods along watercourses
Yellow warbler	*Dendroica petechia*	Wet habitats, open woodlands, gardens, orchards
Yellow-rumped warbler	*Dendroica coronata*	Riparian and suburban areas
Townsend's warbler	*Dendroica townsendi*	Riparian and suburban areas during migration
Common yellowthroat	*Geothlypis trichas*	Marshes and suburban areas
Yellow-breasted chat	*Icteria virens*	Dense thickets and brush

TABLE D-2 BIRD SPECIES THAT MAY OCCUR IN THE VICINITY OF THE PROPOSED PROJECT		
Common Name	**Scientific Name**	**Habitat**
Summer tanager	*Piranga rubra*	Riparian areas
Western tanager	*Piranga ludoviciana*	Transient in lowlands
Green-tailed towhee	*Pipilo chlorurus*	Brushy areas, riparian, and suburban areas
Spotted towhee	*Pipilo maculates*	Brushy areas, riparian and suburban areas
Canyon towhee	*Pipilo fuscus*	Desertscrub
Grasshopper sparrow	*Ammodramus savannarum*	Pastures, scrubby fields in winter
Chipping sparrow	*Spizella pallida*	Brushy edges and riparian areas
Brewer's sparrow	*Spizella breweri*	Deserts, field edges, and suburban areas
Black-chinned sparrow	*Spizella atrogularis*	Rocky hillsides in Desertscrub
Vesper sparrow	*Pooecetes gramineus*	Open weedy fields, roadsides, and grassy areas
Lark sparrow	*Chondestes grammacus*	Brushy, weedy areas, riparian areas, and field edges
Black-throated sparrow	*Amphispiza bilineata*	Desertscrub
Sage sparrow	*Amphispiza belli*	Saltbush desert
Lark bunting	*Calamospiza melanocorys*	Brushy desert and field edges
Savannah sparrow	*Passerculus sandwichensis*	Open fields, roadsides, and grassy areas
Song sparrow	*Melospiza melodia*	Riparian areas, marshes, and vegetated lakesides
Lincoln's sparrow	*Melospiza lincolnii*	Riparian areas, marshes, brushy fields, and hedgerows
White-crowned sparrow	*Zonotrichia leucophrys*	Suburban, riparian, and other brushy areas
Cassin's sparrow	*Aimophila cassinii*	Grassland with scattered shrubs, cactus, mesquite
Dark-eyed junco	*Junco hyemalis*	Desertscrub
Northern cardinal	*Cardinalis cardinalis*	Woodland edges, swamps, streamside thickets, suburban gardens
Pyrrhuloxia	*Cardinalis sinuatus*	Thorny brush, mesquite thickets, desert, woodland edges, ranchlands
Black-headed grosbeak	*Pheucticus melanocephalus*	Transient in lowlands
Blue grosbeak	*Guiraca caerulea*	Riparian areas
Red-winged blackbird	*Agelaius phoeniceus*	Riparian areas, irrigated fields, marshes, and feedlots
Western meadowlark	*Sturnella neglecta*	Fields and other open areas, deserts
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	Marshes, fields, feedlots
Brewer's blackbird	*Euphagus cyanocephalus*	Fields, farmyards, feedlots, ponds, and riparian areas
Great-tailed grackle	*Quiscalus mexicanus*	Riparian areas, marshes, ponds, farmyards, and suburban areas
Bronzed cowbird	*Molothrus aeneus*	Riparian and suburban areas
Brown-headed cowbird	*Molothrus ater*	Suburbs and agricultural areas
Scott's oriole	*Icterus parisorum*	Arid slopes
Hooded oriole	*Icterus cucullatus*	Riparian and suburban areas
Bullock's oriole	*Icterus bullockii*	Riparian areas
House finch	*Carpodacus mexicanus*	Riparian and suburban areas, farmland, desert
American goldfinch	*Carduelis tristis*	

TABLE D-2 BIRD SPECIES THAT MAY OCCUR IN THE VICINITY OF THE PROPOSED PROJECT		
Common Name	**Scientific Name**	**Habitat**
Lesser goldfinch	*Carduelis psaltria*	Riparian areas
House sparrow	*Passer domesticus*	Associated with human presence
Sources: AOU 1998; National Geographic Society 1999		

TABLE D-3 REPTILE AND AMPHIBIAN SPECIES THAT MAY OCCUR IN THE VICINITY OF THE PROPOSED PROJECT		
Common Name	**Scientific Name**	**Habitat**
Colorado River toad	*Bufo alvarius*	Ranges from arid mesquite-creosote bush lowlands and arid grasslands into the oak-sycamore-walnut groves in mountain canyons, often found near permanent water of springs, reservoirs, canals, and streams, but also frequents temporary pools
Great plains toad	*Bufo cognatus*	Inhabits prairies or deserts, often breeding after heavy rains in summer in shallow temporary pools or quiet water of streams, marshes, irrigation ditches, and flooded fields, frequents creosote bush desert, mesquite woodland, and sagebrush plains
Red-spotted toad	*Bufo punctatus*	Desert streams and oases, open grassland and scrubland, oak woodland, rocky canyons and arroyos, in crevices among rocks for shelter, breeds in rain pools, reservoirs, and temporary pools of intermittent streams
Southwestern woodhouse toad	*Bufo woodhousei australis*	Grassland, sagebrush flats, woods, desert streams, valleys, floodplains, farms, and city backyards, in sandy areas, breed in quiet water of streams, marshes, lakes, freshwater pools, and irrigation ditches
Canyon treefrog	*Hyla arenicolor*	Huddles in niches on sides of boulders or stream banks, favors intermittent or permanent streams with quiet pools that have a hard rocky bottom, frequents arroyos in semi-arid grassland, streams in piñon-juniper and pine-oak woodlands, and tropical scrub forest
Couch spadefoot	*Scaphiopus couchii*	Frequents shortgrass plains, mesquite savannah, creosote bush desert, thornforest, tropical deciduous forest, and other areas of low rainfall
Southern spadefoot	*Spea multiplicata*	Frequents desert grassland, shortgrass plains, creosote bush and sagebrush desert, mixed grassland and chaparral, piñon-juniper and pine-oak woodlands, and open pine forests, soil is often sandy or gravelly
Plains spadefoot	*Spea bombifrons*	Semidesert grassland with loose sandy or gravelly soil
Bullfrog	*Rana catesbeiana*	Highly aquatic, remaining in or near permanent water, frequents prairie, woodland, chaparral, forests, desert oases, and farmland, enters marshes, ponds, lakes, reservoirs, and streams – usually quiet water with thick growth of cattails or other aquatic vegetation. Introduced
Plains leopard frog	*Rana blairi*	Desert grassland, woodland, and farmlands with intermittent water
Lowland leopard frog	*Rana yavapaiensis*	Frequents desert, grassland, oak and oak-pine woodland, in permanent pools of foothill streams, overflow ponds and side channels of major rivers, permanent springs, and in drier areas – more or less permanent stock tanks
Sonoran mud turtle	*Kinosternon sonoriense*	Stream-dwelling turtle that frequents springs, creeks, ponds, and the water holes of intermittent streams, in foothill grasslands and desert

TABLE D-3 REPTILE AND AMPHIBIAN SPECIES THAT MAY OCCUR IN THE VICINITY OF THE PROPOSED PROJECT		
Common Name	**Scientific Name**	**Habitat**
Western box turtle	*Terrapene ornata*	Completely terrestrial desert species requiring firm but not hard ground for construction of burrows, frequent desert oases, riverbanks, washes, and rocky slopes
Collared lizard	*Crotaphytus collaris*	Rock-dwelling lizard that frequents canyons, rocky gullies, limestone ledges, mountain slopes, and boulder-strewn alluvial fans, usually where vegetation is sparse
Long-nosed leopard lizard	*Gambelia wislizenii wislizenii*	Arid and semiarid plains grown to bunch grass, alkali bush, sagebrush, creosote bush, or other scattered low plants, ground may be hardpan, gravel, or sand
Western banded gecko	*Coleonyx variegatus*	Variety of habitats, often associated with rocks
Gila monster	*Heloderma suspectum*	Canyon bottoms and washes in desert or desert grassland
Zebra-tailed lizard	*Callisaurus draconoides*	Frequents washes, desert pavements of small rocks, and hardpan
Lesser earless lizard	*Holbrookia maculata*	Plains and mesquite with open sandy areas
Greater earless lizard	*Cophosaurus texanus*	Sandy gravelly soil, streambeds, occasionally rocky areas
Round-tailed horned lizard	*Phrynosoma modestum*	Frequents rocky and gravelly habitats of the arid and semiarid plains, hills, and lower slopes of mountains, often with cactus, mesquite, and creosote bush
Desert spiny lizard	*Sceloporus magister*	Arid and semiarid regions on plains and lower slopes of mountains, found in creosote bush and shad-scale deserts, mesquite-yucca grassland, juniper and mesquite woodland, subtropical thornscrub, and along rivers grown to willows and cottonwoods
Plateau lizard	*Sceloporus undulatus*	Scrub, farmlands, areas with discarded lumber and other debris
Tree lizard	*Urosaurus ornatus*	Frequents mesquite, oak, pine, juniper, alder, cottonwood, and non-native trees such as tamarisk and rough-bark eucalyptus, but also may occur in treeless areas, especially attracted to river courses
Side-blotched lizard	*Uta stansburiana*	Arid or semiarid regions with sand, rock, hardpan, or loam with grass, shrubs, and scattered trees, often found along sandy washes
Great Plains skink	*Eumeces obsoletus*	Open grassland habitat with shrubs, generally near intermittent or permanent water sources
Western whiptail	*Cnemidophorus tigris*	Inhabits deserts and semiarid habitats, usually where plants are sparse, also found in woodland, streamside growth, and in the warmer, drier parts of forests
Desert grassland whiptail	*Cnemidophorus uniparens*	Desert and mesquite grassland
Gila spotted whiptail	*Cnemidophorus flagellicaudus*	Upper elevation grasslands
Banded sand snake	*Chilomeniscus cinctus*	Loose soils in low desert or upland

TABLE D-3 REPTILE AND AMPHIBIAN SPECIES THAT MAY OCCUR IN THE VICINITY OF THE PROPOSED PROJECT		
Common Name	**Scientific Name**	**Habitat**
Western glossy snake	*Arizona occidentalis*	Below 6,000 feet in sparsely vegetated woodland, chaparral, grassland or desertscrub with loose soil
Western shovel-nosed snake	*Chionactis occipitalis*	Sparsely vegetated desert areas with pockets of loose soil
Ring-necked snake	*Diadophus punctatus*	Debris along watercourses
Night snake	*Hypsiglena torquata*	Various upland and desert habitats used
Common king snake	*Lampropeltis getulus*	Deserts, marshlands, chaparral
Sonoran whipsnake	*Masticophis bilineatus*	Grassland and desertscrub
Gopher snake	*Pituophis catenifer*	Various habitats from mountain to low desert and coastal
Long-nosed snake	*Rhinocheilus lecontei*	Desertscrub, prairie, tropical woodland to 5,500 feet
Western patch-nosed snake	*Salvadora hexalepis*	Piñon–juniper woodland to low deserts on variety of soil types
Ground snake	*Sonora semiannulata*	Wide range of habitats in loose soil with some subsurface moisture
Southwestern black-headed snake	*Tantilla hobartsmithi*	In loose soil or plant litter in desert grassland and wood land habitats
Black-necked garter snake	*Thamnophis cyrtopsis*	Pine-fir forest to upland desert and chaparral, generally in the vicinity of a water source
Checkered garter snake	*Thamnophis marcianus*	Low elevation rivers, streams, ponds, and canals, and adjacent areas.
Lyre snake	*Trimorphodon biscutatus*	From oak and juniper woodland to higher elevation desert and grasslands, particularly in rocky areas.
Western coral snake	*Micruroides euryxanthus*	Wide range of arid habitats including grassland, woodland, scrub and agricultural lands, particularly upland desert in washes and river bottoms
Western blind snake	*Leptotyphlops humilis*	Desertscrub and brush covered hillsides with lose soils
Texas blind snake	*Leptotyphlops dulcis*	Sandy or rocky desert areas with shrubs
Western diamondback rattlesnake	*Crotalus atrox*	Wide range of habitats below 7,000 feet
Mojave rattlesnake	*Crotalus scutulatus*	Mostly in upland desert and lower mountain slopes
Source: Prival 1999; Stebbins 1985		

LITERATURE CITED

American Ornithologists' Union (AOU). 1998. Check-list of North American birds. 7th edition. American Ornithologists' Union, Washington, D.C.

Brown, D.E. 1994. Sonoran Desertscrub. Pages 180-222 *In* D.E. Brown, editor. The Biotic Communities-Southwestern United States and Northwestern Mexico. University of Utah Press, Salt Lake City. 342 pp.

Hoffmeister, D.F. 1986. Mammals of Arizona. University of Arizona Press, Tucson, Arizona. 602 pp.

Jones, J.K. Jr., R.S. Hoffmann, D.W. Rice, C. Jones, R.J. Baker and M.D. Engstrom. 1992. Revised checklist of North American mammals, north of Mexico. Occasional Papers, Museum Texas Tech University, 146:1-23

National Geographic Society. 1999. Field Guide to Birds of North America. Third edition. National Geographic Society, Washington, D. C. 480 pp.

Prival, David B. 1999. Revised checklist of Arizona reptiles and amphibians. Unpublished list prepared for University of Arizona Herpetology Curriculum. 5 pp.

Stebbins, R.C. 1985. Western reptiles and amphibians. Houghton Mifflin Company, New York, New York. 336 pp.

EXHIBIT E
SCENIC AREAS AND VISUAL RESOURCES, HISTORIC SITES AND STRUCTURES AND ARCHAEOLOGICAL SITES

EXHIBIT E
SCENIC AREAS AND VISUAL RESOURCES, HISTORIC SITES AND STRUCTURES AND ARCHAEOLOGICAL SITES

As stated in Arizona Corporation Commission Rules of Practice and Procedure R-14-3-219:

"Describe any existing scenic areas, historic sites and structures or archaeological sites in the vicinity of the proposed facilities and state the effects, if any, the proposed facilities will have thereon."

The following items are included as exhibits:

Exhibit E-1: Scenic Areas and Visual Resources
Exhibit E-2: Historic Sites and Structures and Archaeological Sites

EXHIBIT E-1
SCENIC AREAS AND VISUAL RESOURCES

EXHIBIT E-1
SCENIC AREAS AND VISUAL RESOURCES

The visual resource study considers the existing and planned conditions of the Bowie Power Station site (approximately 700 acres) and proposed transmission line route (approximately 14.3 miles). It identifies aesthetic impacts to the landscape's visual character, scenic quality, and sensitive viewers based on the introduction of the proposed facilities. Mitigation measures that address visual impacts resulting from new facilities are also described in this section. Specifically, the visual resource study includes a discussion of the following:

- inventory methods
- inventory results
- impact assessment
- mitigation and enhancement measures

INVENTORY METHODS

The visual inventory consisted of (1) characterizing the existing and future landscape; (2) determining landscape scenic quality; and (3) identifying sensitive viewing locations or key observation points (KOPs) from which the project would be visible. These KOPs included residences and major travel routes from which viewers may have a concern for scenic resources. The locations of these KOPs were identified through review of existing and secondary data, interpretation of aerial photography, and field review in conjunction with the land use investigations described in Exhibit A-3 and B-1. KOPs with potential distant views were also identified.

INVENTORY RESULTS

The landscape character, scenic quality of the study area, and identification of sensitive viewers are described below.

Landscape Character and Scenic Quality

Bowie Power Station and 345kV Switchyard

Existing Landscape Character - The existing character of the site is described as common or non-distinctive. Three-quarters of the project site consists of irrigated farmland using center-pivot irrigation. The remainder of the site consists of fallow farmland. Additional cultural modifications in the surrounding area include farm complexes and out-structures, pecan

processing facilities, communication towers, irrigation equipment, utilities, and the Eastern Arizona Railroad which parallels the western boundary of the site.

Future Landscape Character - The area adjacent to the plant site is currently zoned RU-4, which permits rural uses, single household, and manufactured homes. There are no new approved residential developments located adjacent to the plant site at this time.

Future plans indicate a rural growth area established by Cochise County for the town of Bowie approximately 2.5 miles south of the project site. Rural growth areas are anticipated to have a slow to moderate rate of growth and are expected to consist primarily of low and medium density residential development and local commercial or industrial uses.

345kV Transmission Line and Willow 345kV/230kV Switchyard

Existing Landscape Character - The majority of the lands crossed by the proposed transmission line and switchyard are considered common with minimal diversity or variety. The landscape consists of mostly flat terrain with vegetation that is dominated by desert scrub with a low density of mesquite. Species of cholla, prickly pear, and soaptree yucca are also common.

Along the first 3.5 miles, the project runs through fallow farmland, which has evolved into grasslands. Areas of above average scenery are present along the final 1.5 miles of the project where rolling hills and ephemeral washes provide habitat for additional species of paloverde and mesquite and create variety in the landscape.

Cultural modifications in the area include the existing Eastern Arizona Railroad, which parallels the proposed project for approximately 3.5 miles, an existing two-track road that parallels the proposed transmission line for approximately 7 miles, and U.S. Highway 191, which runs approximately one-quarter mile west of the northern terminus of the project.

Future Landscape Character - Future plans and zoning indicates that areas in the vicinity of the project will remain rural in character.

Sensitive Viewers

The inventory of sensitive viewers focused on the identification and characterization of residential and transportation views within the immediate vicinity of the plant, 345kV transmission line and 345kV/230kV switchyard. Extended views were also considered including those from the town of Bowie (2.5 miles south of the plant site) and the I-10 West Bowie interchange (2.5 miles southwest of the plant site).

Bowie Power Station and 345kV Switchyard

Residential Viewers - The nearest residence is located approximately 1 mile south of the proposed generating facilities. The next nearest residences are located 1.5 miles to the north and east respectively. Generally, views from these residences are open. However, in some cases views will be screened by existing vegetation, including the pecan orchards to the east of the project site. Extended views from the town of Bowie (approximately 2.5 miles) will be partially screened by existing structures in the town and existing vegetation.

Transportation Views - The closest major road in the area is Graham County Road. This improved gravel road lies adjacent to the plant site and connects scattered rural residences to the north and east with the town of Bowie. Other major roads in the area consist of paved roads in the town of Bowie, including Center Street and Business Route 10. The primary travel route in the area, I-10, runs 2.5 miles to the south of the project site. The views from these roads to the site are partially screened due to development in the town of Bowie, the Union Pacific Railroad, and existing vegetation.

345kV Transmission Line and Willow 345kV/230kV Switchyard

Residential Viewers - There are three residences located within 1.5 miles of the planned transmission line. Two lie to the east, and one to the south. These residences will have open views to the project. However, these views will be partially screened by existing vegetation (pecan orchards) or back dropped by distant terrain. Views from the town of Bowie will also be limited given development in the town and the general north-south orientation of the transmission line.

Transportation Views - The major transportation routes in the area are U.S. Highway 191, located one-quarter mile west of the northern terminus of the transmission line and Willow Switchyard, and Graham County Road located near the southern terminus of the project. Views from U.S. Highway 191 may be blocked or partially screened by terrain or existing vegetation. Views from Graham County Road may also be partially screened by existing vegetation or back dropped by terrain in the distance. Views from I-10 to the transmission line and Willow Switchyard will be distant and partially screened by existing vegetation and development surrounding the town of Bowie.

IMPACT ASSESSMENT

Impacts to visual resources will result from the contrast (form, line, color, and texture) created by the introduction of the proposed project. Visual impacts to the landscape's scenic quality would result from landform modifications and/or removal of vegetation that are necessary to construct the project. Visual impacts from sensitive viewers would result from the introduction of the project within their viewshed.

Bowie Power Station and 345kV Switchyard

Visual Impacts to Landscape Scenic Quality

Visual impacts to landscape scenic quality are expected to be minimal given the lack of natural amenities (varied topography, rock outcroppings, presence of water, diversity of plant life, etc.) associated with the irrigated cropland on which the power station is sited.

Visual Impacts to Sensitive Viewers

Residential and transportation viewers within close proximity to the plant will have the greatest immediate impact (see simulation, Exhibit G-4). However, these views may be partially screened by the proposed conceptual landscape plan (Exhibit B-2). Viewers at locations of greater distance (including the town of Bowie and I-10) will primarily be confined to views associated with the stacks, tops of the HRSGs, cooling tower plumes, and switchyard structures. These views will be less dominant if they are back dropped by distant terrain or screened by existing vegetation in the area. A simulation depicting the site from the west exit of I-10 can be seen in Exhibit G-5. Stack height depicted is 150 feet.

345kV Transmission Line and Willow 345kV/230kV Switchyard

Visual Impacts to Scenic Quality

Impacts to landscape scenic quality along a majority the 345kV transmission line route and Willow Switchyard location are expected to be minimal. With the exception of limited areas, the transmission line is located on lands that are primarily considered common scenery. Since the proposed route parallels existing access, minimal vegetative removal and ground disturbance will be required for construction. In areas where new access traverses above-average scenery, mitigation methods such as selective clearing and landscape restoration will be used to reduce impacts.

Visual Impacts to Sensitive Viewers

Given the remote location of the project, and dispersed nature of rural residences, impacts to sensitive viewers are expected to be minimal. Impacts to the three residences in the southern portion of the study area would be greatest. However, these views may become less dominant as they will be back dropped by distant terrain, or mitigated through the use of dulled structures and non-specular conductors.

Minimal impacts are also expected to occur along U.S. Highway 191 where views of the proposed transmission line and switchyard are partially screened by the existing 345kV and

230kV transmission lines that traverse the landscape in all directions. In addition, variations in terrain and existing vegetation limit visibility to the project.

MITIGATION AND ENHANCEMENT MEASURES

Bowie Power Station and 345kV Switchyard

To reduce the visual impacts associated with the construction and operation of the plant, mitigation measures will be implemented. These mitigation measures will include landscaping and restoration of the project site. This landscape plan (Exhibit B-2) presents specific design measures to enhance the appearance and screening of the plant. In addition, the stacks, HRSGs, and switchyard structures will be painted using colors to reduce the contrast between the proposed facilities and the surrounding landscape.

345kV Transmission Line and Willow 345kV/230kV Switchyard

To minimize impacts associated with the construction of the proposed 345kV transmission line and Willow Switchyard, mitigation measures will be implemented. These measures will include selective clearing and landscape restoration in the areas where new access is required, the use of non-specular conductors, and the use of dulled steel single-pole transmission structures.

EXHIBIT E-2
HISTORIC SITES AND STRUCTURES AND ARCHAEOLOGICAL SITES

EXHIBIT E-2
HISTORIC SITES AND STRUCTURES AND ARCHAEOLOGICAL SITES

METHODS

A cultural resource investigation in support of the Bowie Power Station was initiated to determine whether any historic sites, historic structures, or archaeological sites are located in the vicinity of the proposed power plant site, transmission line corridor, and switchyard site and how they might be affected by the construction of the project. The analysis was based on a review of records maintained at a number of agencies and research institutions, including the following:

- Arizona State Historic Preservation Office
- Arizona State Museum
- Department of Anthropology at Arizona State University
- State Office of the Bureau of Land Management

The goal of this review was to identify any prior cultural resource surveys, recorded archaeological and historical sites, and any properties listed on either the State or National Register of Historic Places located within approximately 1 mile of the project area.

In addition, an intensive field survey of approximately 1,275 acres was conducted in accordance with Arizona State Museum guidelines. The survey areas included:

- approximately 780 acres encompassing the proposed plant site and adjacent parcels of land
- approximately 472 acres encompassing the proposed double-circuit 345kVtransmission line route
- approximately 23 acres encompassing the proposed 345/230kV switchyard site

This exhibit summarizes the results of the records review and field survey, as well as providing conclusions concerning the potential for the proposed project to affect cultural resources.

FINDINGS

Proposed Power Plant Site

The records review did not identify any previously conducted cultural resource studies or previously recorded sites within the area of the proposed plant site. The intensive field survey of the proposed plant site also did not find any historic structures or archaeological sites that would be affected by construction.

Proposed 345kV Transmission Line Route and Willow 345/230kV Switchyard Site

The records review identified five previously conducted cultural resource studies that had been conducted within 1 mile of the proposed transmission line (Table E-2-1). These include studies in support of various development and research projects. Two of these studies (Gilman 1989, 1990) were conducted as part of the San Simon Archaeological Project and they identified two prehistoric archaeological sites that fall within 1 mile of the proposed transmission line. These consist of one habitation area, site AZ CC:10:64 (ASM), and one artifact scatter, site AZ CC:10:84 (ASM). None of the previously recorded sites will be crossed by the proposed transmission line alignment or affected by related construction activities.

TABLE E-2-I
PRIOR CULTURAL RESOURCE STUDIES

Project Name	ASM Number	Quadrangle Location	Total Area Surveyed	Number of Sites	Reference
AEPCO II, Dos Condados to Apache	1977-06	Monk Draw	90.1 miles	27 sites identified, none in the project area	Westfall et al. 1979
CxC, Inc. Seismological Surveys	1979-048	Luzena	15 miles	3 sites identified, none in the project area	Gregonis 1979
San Simon Archaeological Project Survey	1988-210	Fisher Hills	420 acres	25 sites identified, one within the project area: AZ CC:10:84 (ASM)	Gilman 1989
San Simon Archaeological Project Phase II	1989-201	Fisher Hills	4925 acres	33 sites identified, one within the project area; AZ CC:10:64 (ASM)	Gilman 1990
US 191 I-10 to MP 98.0	1997-11	Monk Draw	485 acres	1 site identified, none within the project area	Brown 1999

The intensive field inspection of the proposed transmission line route identified two historic structures. These include the Gila Valley, Globe & Northern Railroad (GVG&N), also known as the Arizona Eastern, and an abandoned railroad siding associated with the GVG&N, site AZ CC:10:109 (ASM). The proposed transmission line will cross a short segment of the GVG&N; however, there is good potential to avoid direct impacts to both of these features by the careful placement of new transmission line structures.

The GVG&N Railroad was completed in 1899 and connected Bowie (and the Southern Pacific Transcontinental Railroad) with Globe (Garrison et al. 1989). The railroad transported minerals out of the Globe area and provided a mean of passenger travel between Bowie and Globe. Site AZ CC:10:109 (ASM) is an abandoned railroad siding that diverges from the GVG&N Railroad and runs parallel to the existing railroad for approximately 1.5 miles, ending just before Gold Gulch. Sidings on railroads are used to allow trains to pass one another on the track. No artifacts or associated features were found during the field inspection. Although written documentation on the siding has not been found, a local resident recounts the presence of a siding near Gold Gulch (Mr. Chano Jacquez, personal communication, 2001).

The GBG&N Railroad may be regarded as locally significant and thus eligible for listing on either the National or State Registers of Historic Place. Site AZ CC:10:109 (ASM), however, is probably not eligible for listing because it lacks any of its original materials and contains no associated artifacts. Further study of the siding is unlikely to provide any additional meaningful information concerning the site's function and temporal affiliation.

The intensive field survey of the 345/230kV switchyard site did not find any historic structures or archaeological sites that would be affected by construction.

CONCLUSIONS

The cultural resource study conducted in support of the Bowie Power Station Project indicates that the proposed project facilities are located in an area with a low-to-moderate potential to contain cultural resources. No prehistoric or historic sites are present within the area sited for the proposed power station. The proposed transmission line route will cross two historic structures, however there is excellent potential to avoid any direct impacts to these structures. There were no archaeological sites or historic structures identified at the location of the proposed 345/230kV switchyard.

Additional cultural resource surveys will need to be conducted if any portion of the proposed project is relocated outside of areas previously surveyed.

There is no indication that human remains or funerary objects are present within the project area. However, if such remains were to be unexpectedly discovered on private or state lands during construction, work in that area should be halted and the finds reported to the director of the Arizona State Museum in accordance with ARS §41-844 and ARS §41-865.

REFERENCES

Brown, Gregory B.

1999 *A Cultural Resources Survey of U.S. 191 from Interstate 10 at MP 87.6 to MP 98.0, Cochise and Graham Counties, Arizona.* Logan Simpson Design, Tempe.

Garrison, James, James Woodward, Susan Wilcox, Robert Trennert, and James Ayers

1989 *Transcontinental Railroading in Arizona 1878-1940: A Context for Preserving Railroad Related Properties.* Janus Associates Inc., Phoenix.

Gilman, Patricia A. Gilman

1989 *The Archaeological Survey in the San Simon Drainage.* Office of Cultural Resource Management Report No. 73. Arizona State University, Tempe.

1990 *The Archaeological Survey in the San Simon Drainage, Phase II.* Office of Cultural Resource Management Report No. 75. Arizona State University, Tempe.

Gregonis, Linda

1979 The Archaeological Survey Report for Four CxC Inc Seismological Survey Lines in Graham and Cochise Counties, Arizona. Arizona State Museum, Tucson.

Westfall, D.A., Ken Rozen, and H.M. Davidson

1979 *The AEPCO Project, Volume II: Dos Condado to Apache Survey and Data Recovery of Archaeological Resources.* Archaeological Series No. 117. Cultural Resource Management Section, Arizona State Museum, University of Arizona, Tucson.

EXHIBIT F
RECREATIONAL PURPOSES AND ASPECTS

EXHIBIT F
RECREATIONAL PURPOSES AND ASPECTS

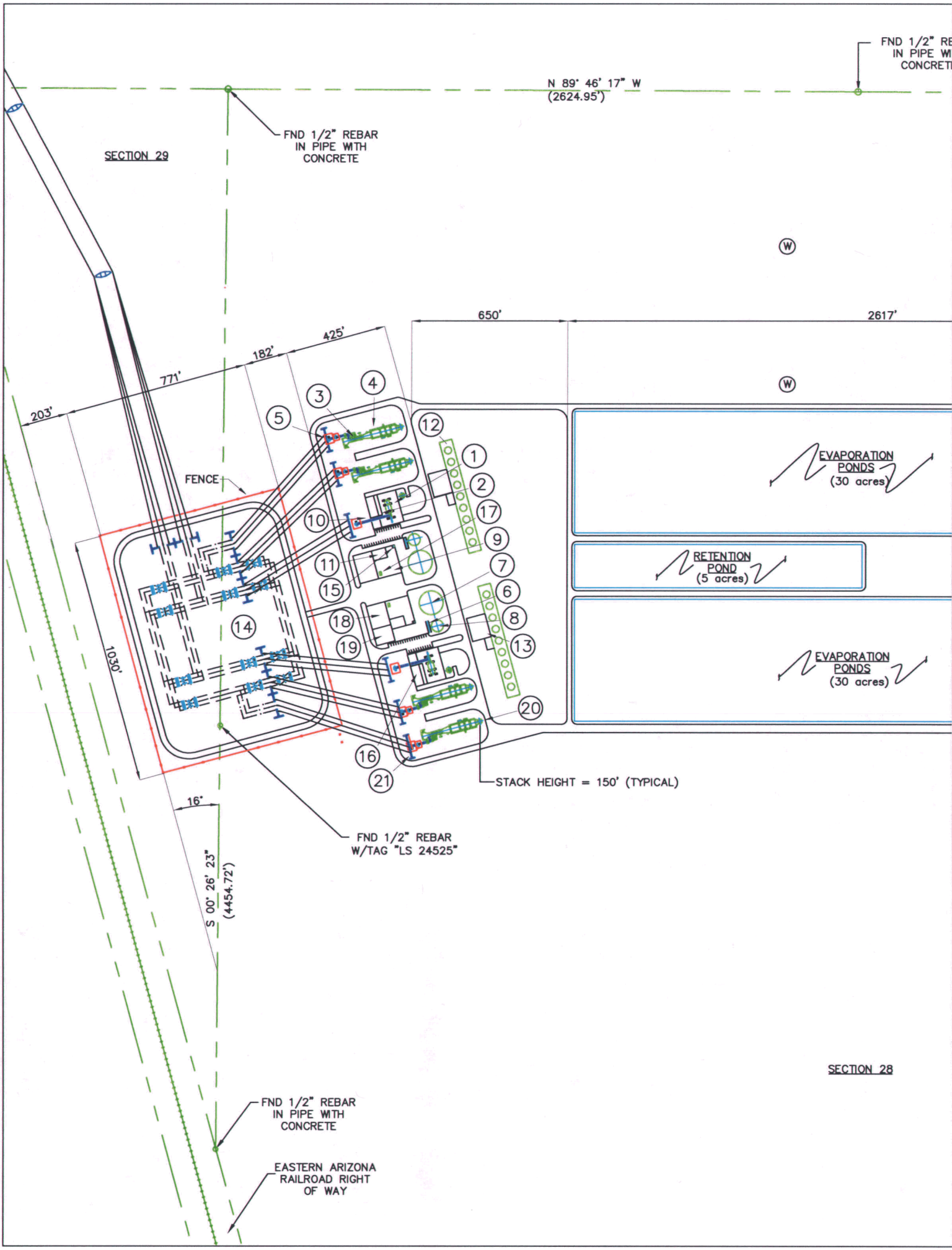
As stated in Arizona Corporation Commission Rules of Practice and Procedure R-14-3-219:

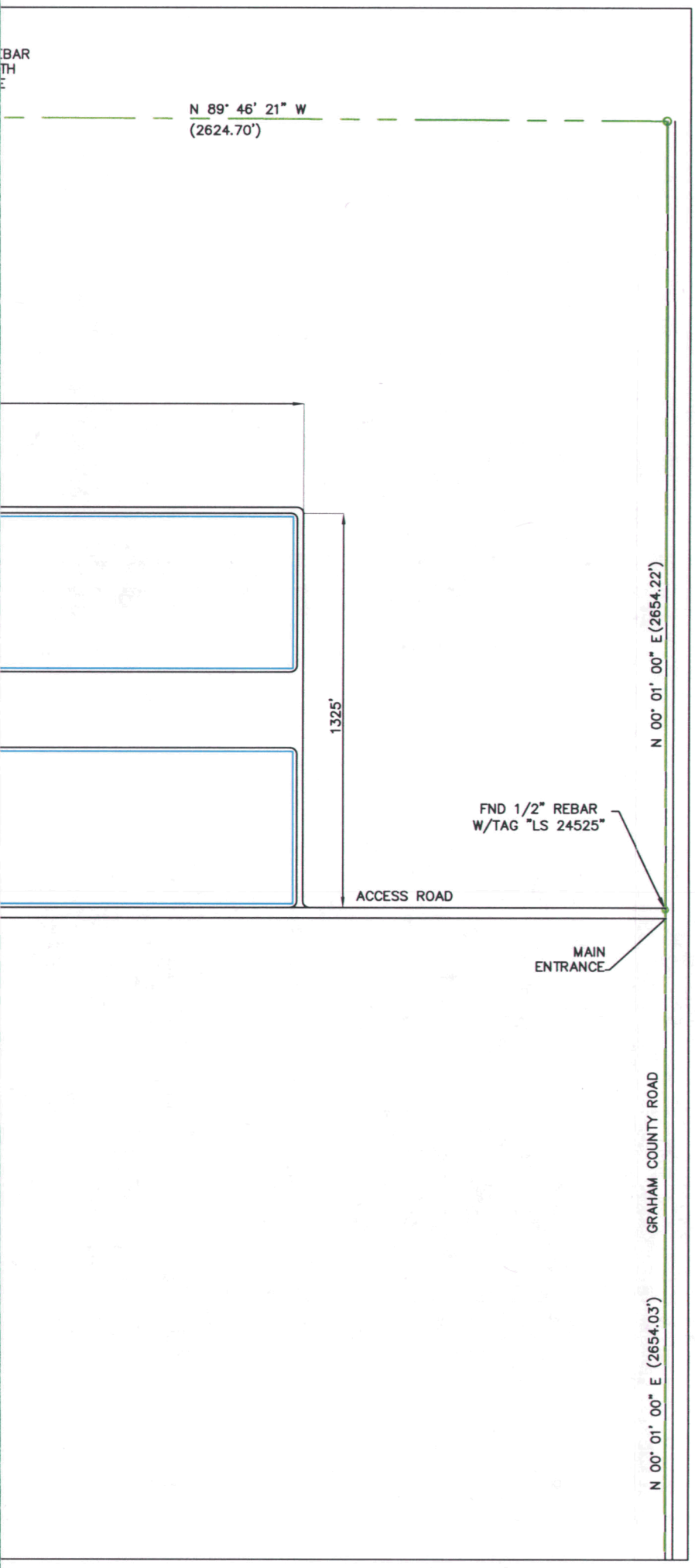
"State the extent, if any, the proposed site or route will be available to the public for recreational purposes, consistent with safety considerations and regulations and attach any plans the applicant may have concerning the development of the recreational aspects of the proposed site or route."

The power station facilities (generation units, switchyards, buildings) will be fenced and unavailable to public access.

State Trust Lands within the proposed transmission line corridor allow recreational activities such as hiking, horseback riding, and off-highway vehicle use. Operation of the transmission line would not restrict these activities. No plans currently exist to develop recreational facilities within the proposed right-of-way.

EXHIBIT G
CONCEPTS OF TYPICAL FACILITIES


FND 1/2" RE
IN PIPE WI
CONCRETI
N 89° 46' 17" W
(2624.95')
FND 1/2" REBAR
IN PIPE WITH
CONCRETE
SECTION 29
650'
2617'
425'
182'
771'
203'
FENCE
1030'
16°
S 00° 26' 23"
(4454.72')
EVAPORATION
PONDS
(30 acres)
RETENTION
POND
(5 acres)
EVAPORATION
PONDS
(30 acres)
STACK HEIGHT = 150' (TYPICAL)
FND 1/2" REBAR
W/TAG "LS 24525"
SECTION 28
FND 1/2" REBAR
IN PIPE WITH
CONCRETE
EASTERN ARIZONA
RAILROAD RIGHT
OF WAY



BOWIE POWER STATION

GENERAL ARRANGEMENT CONCEPT

Exhibit G-1

Legend

1. STEAM TURBINE GENERATOR
2. SWITCHGEAR, CONTROL, ELECTRICAL BUILDING (GROUND LEVEL)
3. GAS TURBINE GENERATOR
4. HEAT RECOVERY STEAM GENERATOR
5. STEP-UP TRANSFORMER
6. OIL-WATER SEPARATOR
7. RAW WATER STORAGE TANK
8. DEMINERALIZED WATER STORAGE TANK
9. WATER TREATMENT BUILDING
10. ISOLATED PHASE BUS
11. WATER TREATMENT, CONTROL, ELECTRICAL AREA
12. COOLING TOWER
13. CIRCULATING WATER PUMP BUILDING
14. 345KV SWITCHYARD
15. HYPOCHLORITE STORAGE TANK AND PUMPS
16. CONTROL ROOM, OFFICES (SECOND LEVEL)
17. AUXILIARY BOILER AND STACK
18. WAREHOUSE
19. ADMINISTRATION BUILDING
20. DEAD-END STRUCTURE
21. EXHAUST STACK

Notes

1. EXISTING GRADE = EL 3720'
   FINISHED GRADE = EL 3721'
   TOP OF CONCRETE = EL 3722'

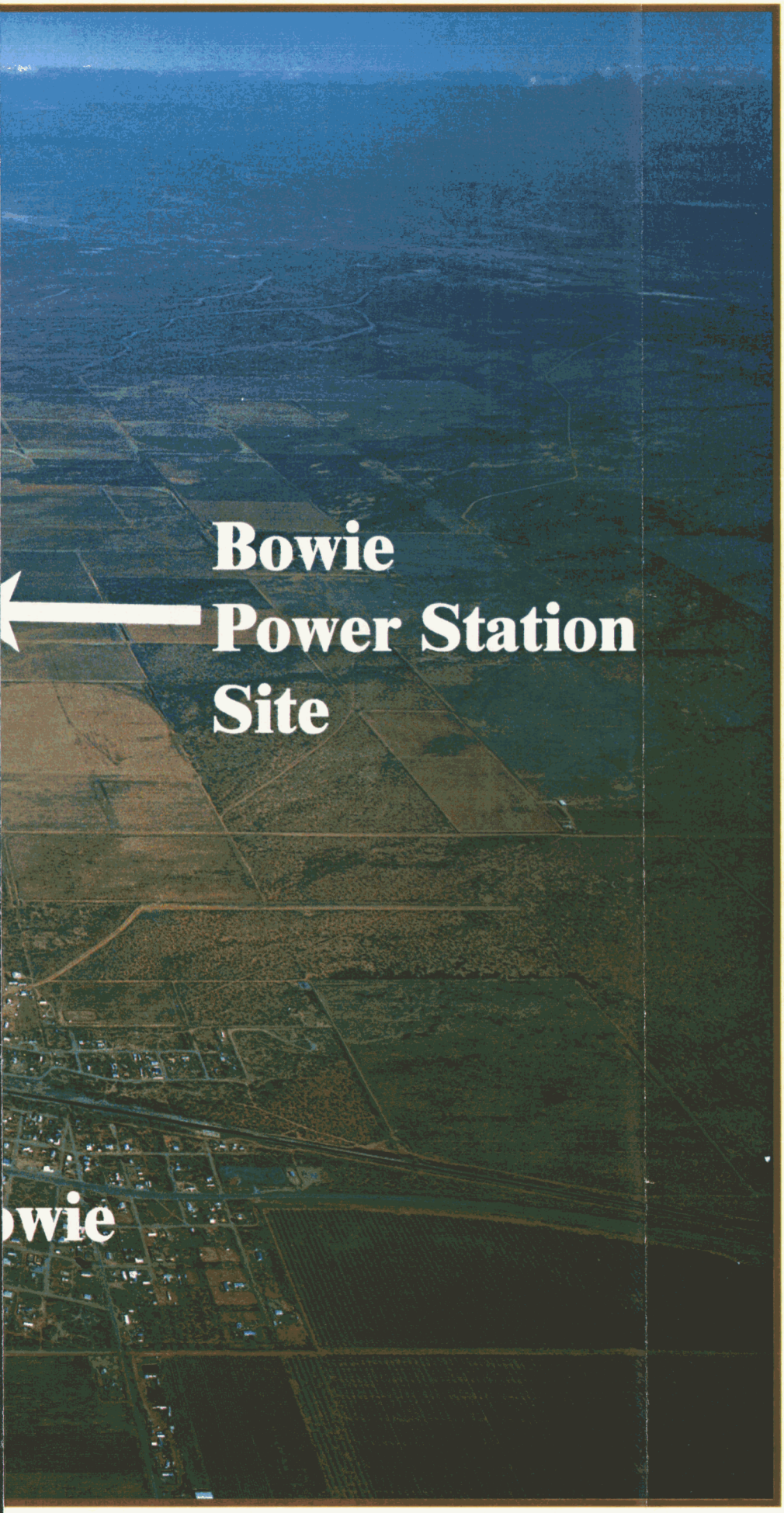
(W) = APPROXIMATE WELL LOCATION (FOR REFERENCE)

0 250 500 1000

Scale: 1" = 500' - 0"

North

I-10
Bo



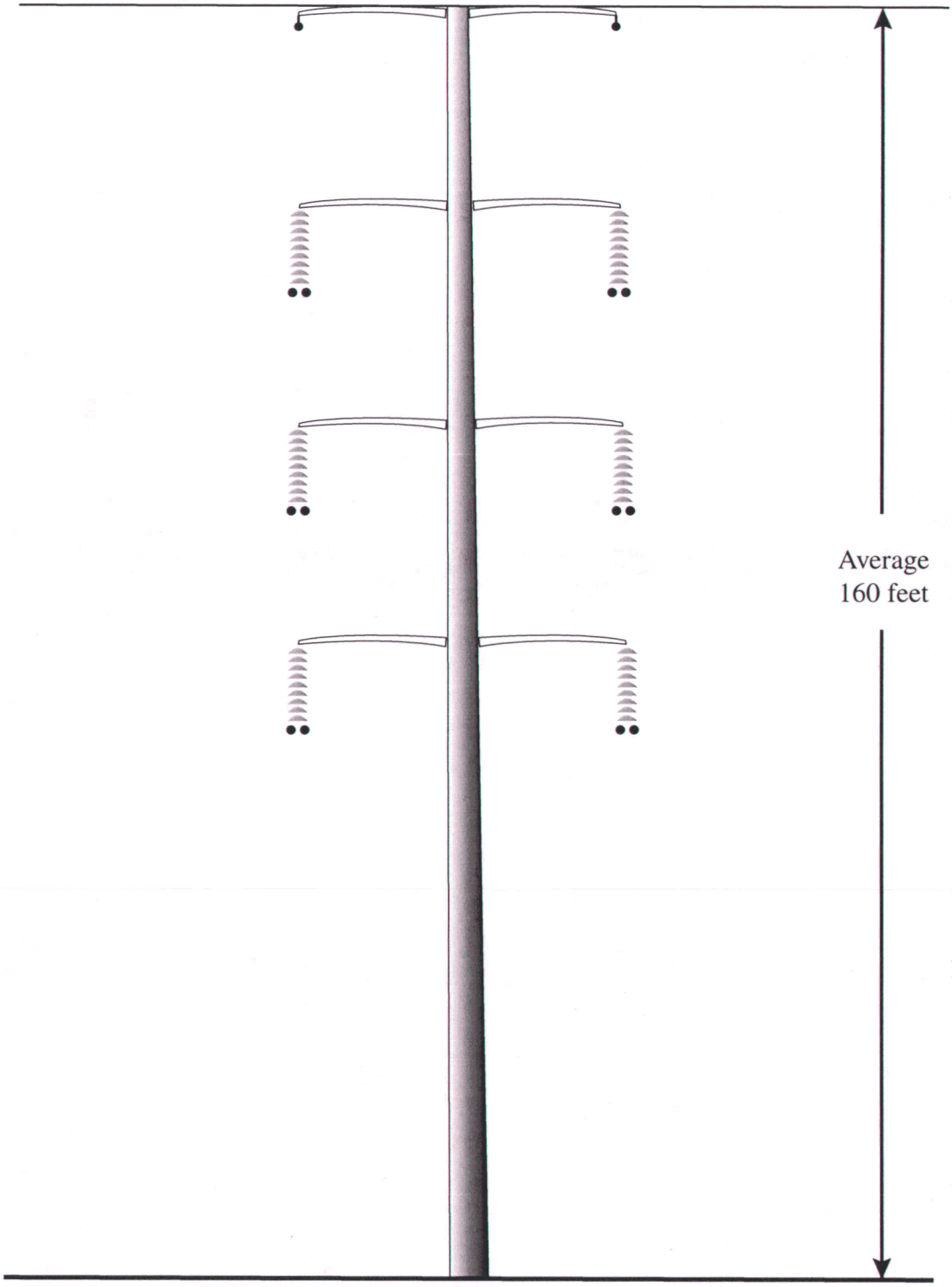
BOWIE
POWER STATION

AERIAL VIEW OF PLANT SITE

Exhibit G-2

Source:
Aerial Photograph, Todd Photographic Services, 2000.

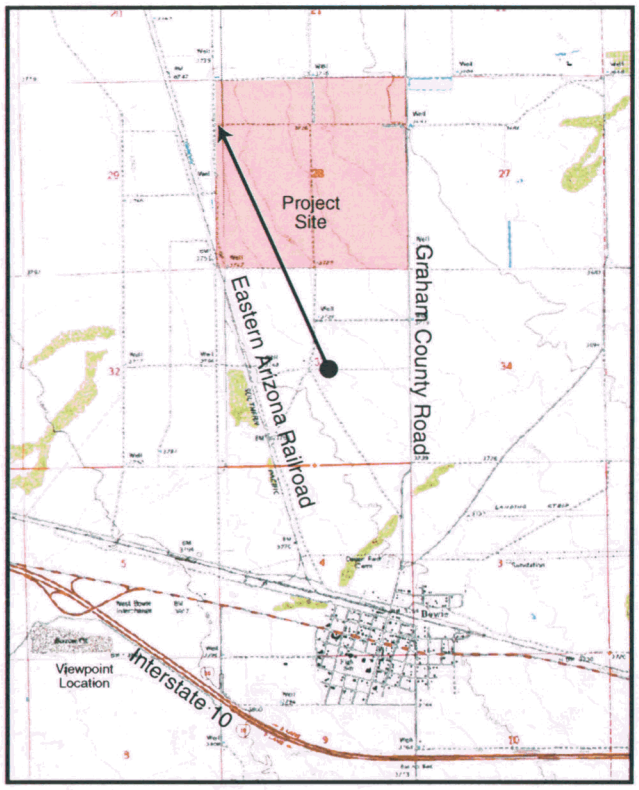
d:/projects/swpg/bowietl/oblique.ai



Typical 345kV Structure

Exhibit G-3

Simulation



Location Map

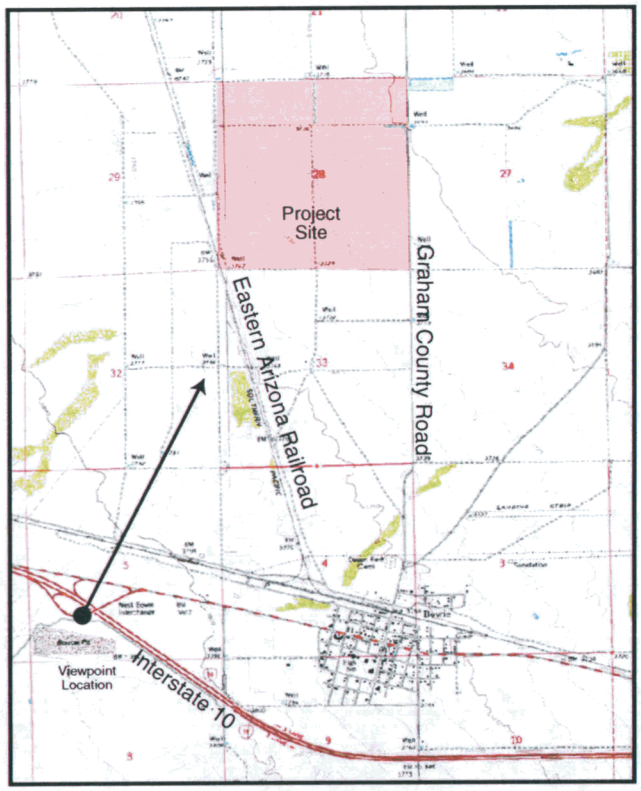
Existing Condition

Visual Simulation

View from Residence
Looking Northwest

Exhibit G-4

Simulation



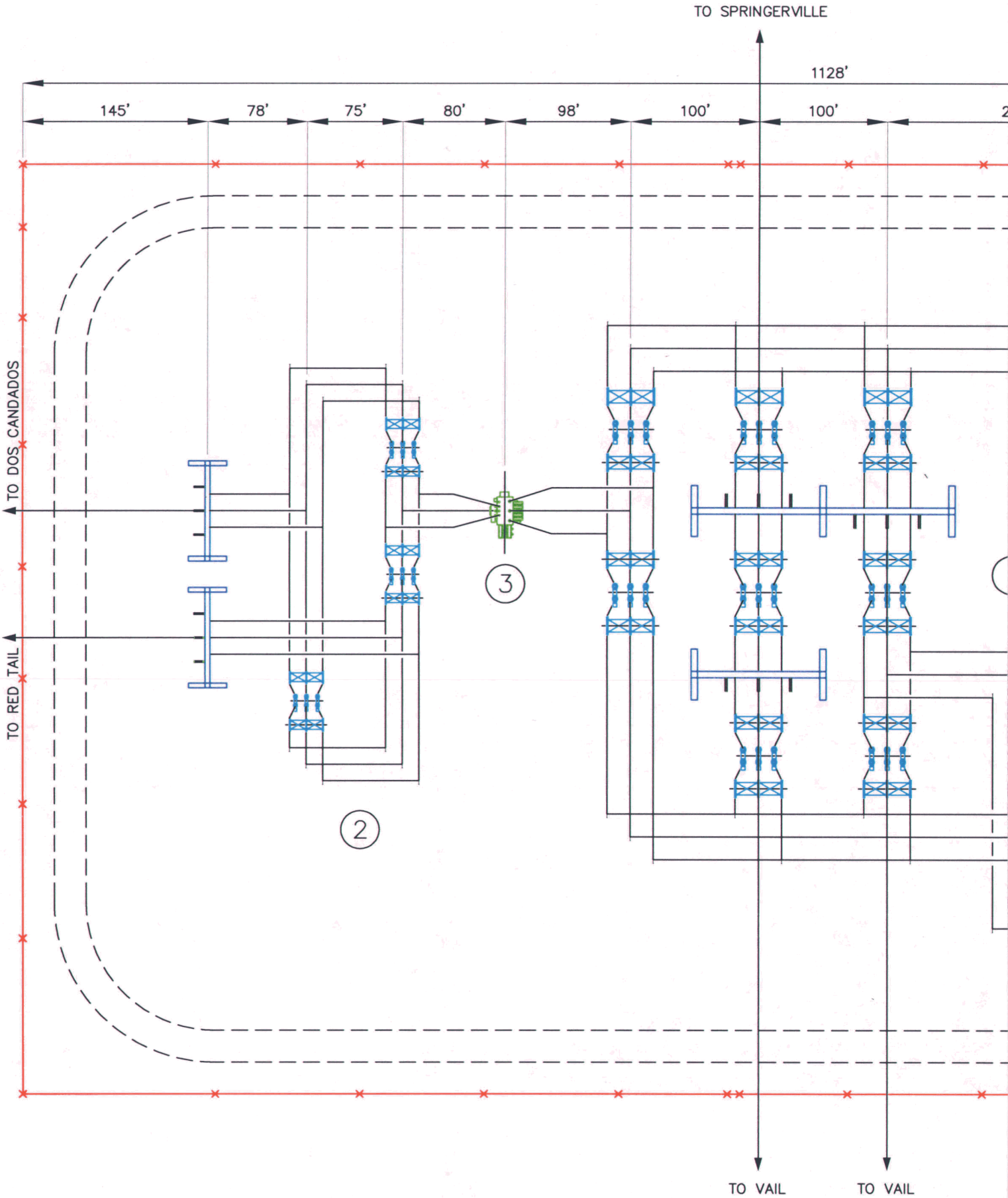
Location Map

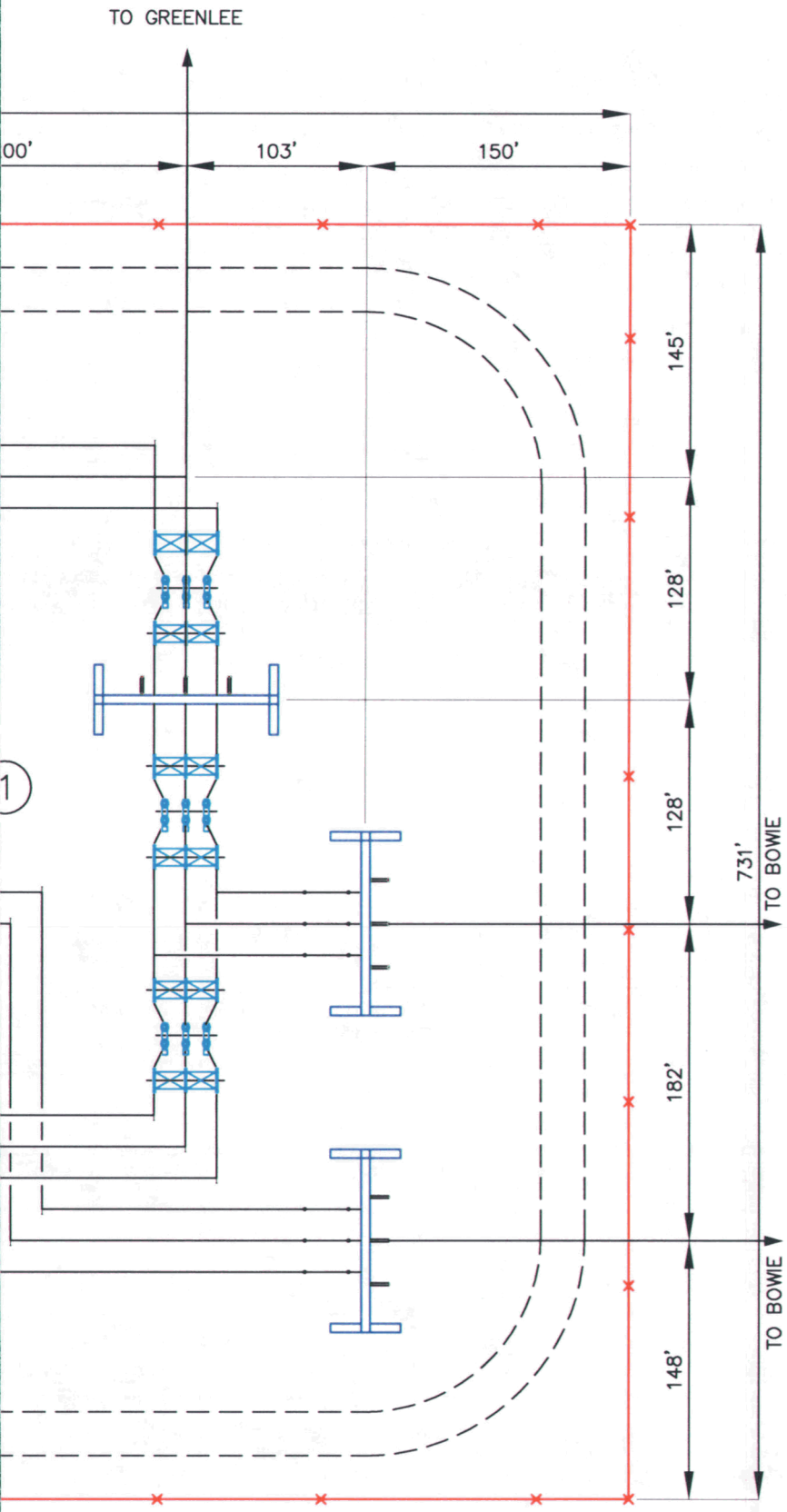
Existing Condition

Visual Simulation

View from West Exit of I-10
Looking Northeast

Exhibit G-5


TO SPRINGERVILLE
1128'
145'
78'
75'
80'
98'
100'
100'
TO DOS CANDADOS
TO RED TAIL
3
2
TO VAIL
TO VAIL



BOWIE POWER STATION

WILLOW 345kV/230kV SWITCHYARD CONCEPT

Exhibit G-6

Legend

1. *345kV SWITCHYARD*
2. *230kV SWITCHYARD*
3. *345kV/230kV TRANSFORMER*

Notes

SOURCE: R.W. BECK, INC., COPYRIGHT 2001, ALL RIGHTS RESERVED

0 50 100 200

Scale: 1" = 100' - 0"

North

EXHIBIT H
EXISTING PLANS

EXHIBIT H
EXISTING PLANS

As stated in Arizona Corporation Commission Rules of Practice and Procedure R-14-3-219:

"To the extent applicant is able to determine, state the existing plan of the state, local government, and private entities for other developments at or in the vicinity of the proposed site or route."

Existing and planned land uses are described in Exhibit B and illustrated in Exhibit A-3. Planned land uses identified for the project are identified in Cochise and Graham counties planning documents. Neither Cochise nor Graham County reported any pending major subdivisions or master planned developments in the study area.

Letters were sent to federal, state, and local government agencies to request information on proposed developments within the vicinity of the project. Table H-1 lists the recipients of these letters and whether responses were received. Copies of the contact letter and response letters are provided in Exhibit H-1. Additional contacts that were made to inform potentially affected parties of the project are summarized in Exhibit J.

TABLE H-1
LETTER RECIPIENTS

Name and Affiliation	Date Letter Sent	Date of Response	Comments
Will Wright, Graham County Planning Director	04/18/01	04/20/01	
James Vlahovich, Cochise County Planning Director	04/18/01	05/10/01	Letters received from Louisa Garbo, Planner
Linda Small, Cochise County Economic and Community Development	04/18/01	06/12/01	Letter received from Patty Lewis, Grants Administration
Dr. T.R. Ellis, Superintendent Bowie USD #14	04/18/01	04/24/01	
Lynn Setterstedt-Jarrett, Ed.D., Superintendent Wilcox USD #13	04/18/01	05/02/01	
Michael Anable, Arizona State Land Director	04/18/01	05/24/01	Telephone response from Jim Gross, Right-of-way
Cindy Lester, U.S. Army Corps of Engineers	04/18/01	04/24/01	
Linda Bailey, Graham County Parks Director	04/18/01		
Terry Cooper, Graham County Manager	04/18/01		
Michael Reed, Superintendent San Simon USD	04/18/01		
Bowie Chamber of Commerce	04/18/01		
Ken Travous, Arizona State Parks Department	04/18/01		
Mary Lynn Tischer, ADOT Transportation Director	04/18/01		
Alan Cox, Superintendent Chiricahua National Monument	04/18/01		

EXHIBIT H-1

EXAMPLE

April 18, 2001

Bowie Chamber of Commerce
P.O. Box 287
Bowie, Arizona 85605

RE: Bowie Power Station Project

Dear Sir/Madam:

The SouthWestern Power Group (SWPG) is planning a new electric generating plant approximately 2 miles north of I-10 near Bowie, Arizona. The proposed project would include construction of a combined-cycle, natural gas-fueled power plant and transmission line. Bowie Power Station, LLC, formed by SWPG to develop the power station, will contract with a transmission service provider, such as a local utility, to construct the transmission lines.

The proposed Bowie Power Station will consist of a combined-cycle, natural gas-fueled power plant including two 500-megawatt units providing a total capacity of up to 1,000 megawatts. The project will be built in phases beginning in late 2002 with the first unit in operation by early 2004. An enclosed newsletter and map provide additional information.

The transmission line will consist of a double-circuit 345kV line connecting the proposed power plant to one of the two existing 345kV lines running southwest to northeast, north of the proposed power plant site. The new transmission line would originate at the Bowie Power Station switchyard and connect with one of the existing lines, at one of two alternate points located 13 miles north or 14 miles north-northwest of the Bowie power plant site. The alternative routes are shown on the enclosed map.

Two alternative routes for a proposed pipeline to supply natural gas to the Bowie Power Station are also shown on the map. The pipeline will tap into an existing El Paso Natural Gas pipeline located south of I-10.

The purpose of this letter is to request information regarding development plans in the vicinity of the power plant site, and alternative transmission line and pipeline routes. Your response will be evaluated in preparation of the application for a certificate of environmental compatibility. Submittal of this application to the Arizona Power Plant and Transmission Line Siting

Committee of the Arizona Corporation Commission is in compliance with the Arizona Revised Statutes, Section 40-360.03.

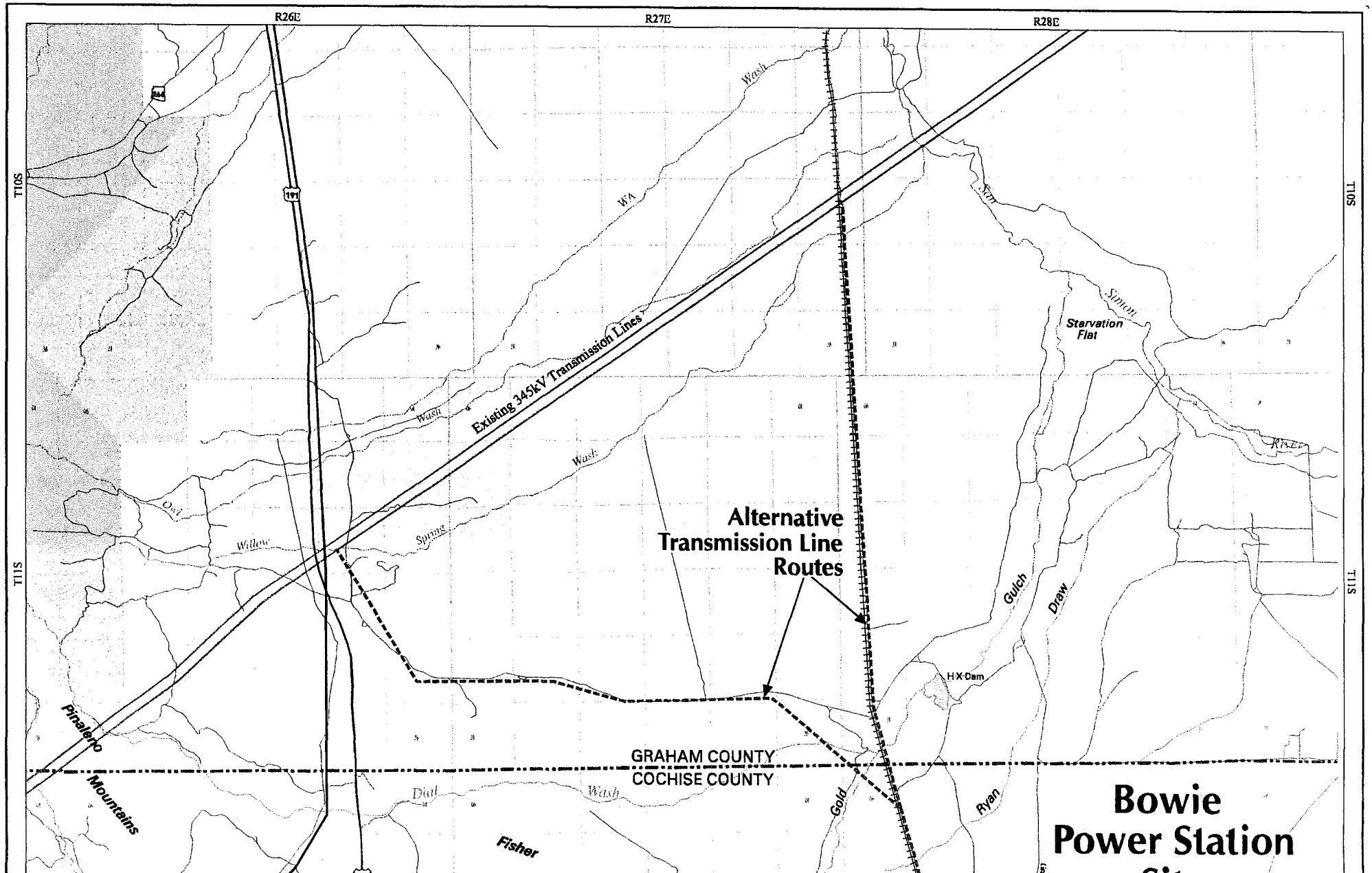
The Environmental Planning Group, Inc. (EPG) is assisting with environmental studies, siting, and permitting activities for this project. We respectfully request your response in writing as to whether you are aware of any planned developments or activities in the vicinity of the project.

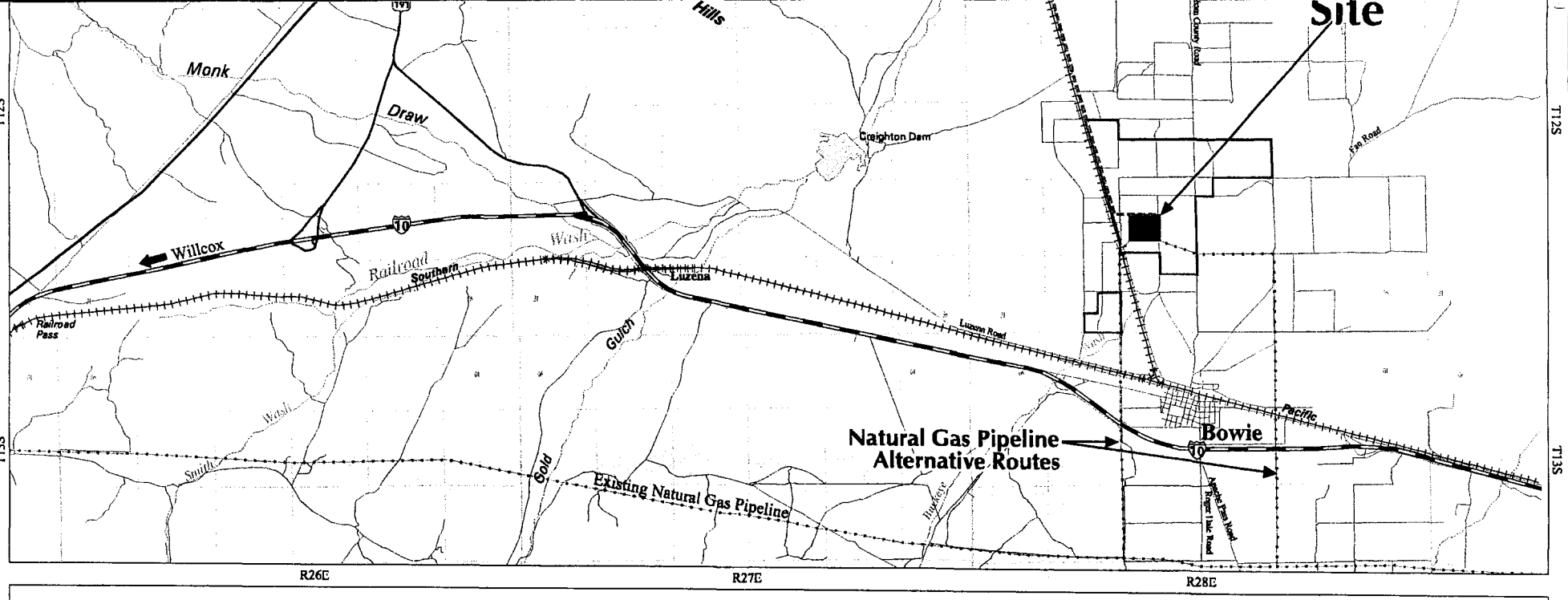
We would appreciate your response by May 15, 2001 so that we can evaluate the information prior to the submittal of the application. Please send your response to me at EPG (address on front page letterhead). Thank you in advance for your reply. Should you have any questions, please do not hesitate to call me at (602) 956-4370.

Sincerely,

Mickey Siegel
Project Manager

Enclosures


R26E
R27E
R28E
T10S
T11S
Existing 345kV Transmission Lines
Alternative
Transmission Line
Routes
Starvation
Flat
Simon
Wash
Willow
Spring
Gulch
Draw
H-X Dam
Pinaleno
Mountains
GRAHAM COUNTY
COCHISE COUNTY
Dial
Fisher
Gold
Ryan
Bowie
Power Station



General Reference Features

- 345kV Transmission Line
- 230kV Transmission Line
- Natural Gas Pipeline
- County Boundary
- Interstate
- Major Road
- Road
- Railroad
- River
- Wash
- Section Line
- Township and Range Boundary
- Contour
- Reservoir

Resource Inventory

- Bowie Project Property Boundary
- Proposed Double-Circuit 345kV Transmission Line
- Proposed Natural Gas Pipeline
- Bowie Power Station Site
- Private
- State Trust
- Bureau of Land Management
- USDA Forest Service

PROJECT LOCATION

Bowie Power Station, LLC

1 .5 0 1 2 3 MILES

Sources:
Arizona State Land Department, Phoenix, AZ 2001.
United States Geological Survey (USGS), Willcox AZ-NM 1994, Safford AZ-NM 1994, 1:100,000-scale metric topographic maps. Contours interpolated from USGS 1:24,000-scale digital elevation models at an interval of 40 feet.

BOWIE POWER STATION

Draft Revised May 03, 2001

GRAHAM COUNTY PLANNING & ZONING / COMMUNITY DEVELOPMENT

921 THATCHER BOULEVARD • SAFFORD, ARIZONA 85546
PHONE: (520) 428-0410 • FAX: (520) 428-5951

WILL WRIGHT
PLANNING DIRECTOR
COMMUNITY DEVELOPMENT COORDINATOR

April 20, 2001

MR. MICKEY SIEGEL, Project Manager
Environmental Planning Group, Inc.
4350 East Camelback Road, Suite G-200
Phoenix, AZ 85018

Dear Mr. Siegel:

This letter is written in response to your April 18, 2001 request for any knowledge that we may have of any 'planned developments or activities in the vicinity of the project', known as the (Bowie Power Station, LLC). A map was included with this letter, which I assume incorporates all the area that you want me to address in this review as to any known activities as described above in Graham County. The map of the project site includes a relatively small area in Graham County that runs in an east to west direction for about twenty (20) miles along the southern border between Graham and Cochise Counties. The map area then runs about ten (10) miles in a northerly direction into Graham County.

The area shown on the map is intersected two major highways both U.S. Highway 191 (north to south corridor) and a very small section of U.S. Highway 266. Interstate Highway 10 (east to west corridor) is also shown and lies totally in Cochise County. The map also shows a major electrical transmission line and a natural gas pipeline as well as the Southern Pacific railroad line running east to west with both the gas and railroad lines being located in Cochise County.

The land shown on this map located in Graham County is almost exclusively held by public entities, including the BLM, the State Trust and the U.S. Forest Service. Since there is a relatively small amount of private property in that part of Graham County, there is little development activity to report for that area. It should be noted, however that the area west of where the map ends in known as Bonita and that there has been significant development of hydroponic green houses for tomatoes with Eurofresh having over 100 acres under glass for their business with Mr. Johan Van den Berg at (480) 384-4621 managing that operation.

Graham County, along with Cochise County, is working with Arizona Department of Transportation (ADOT) to upgrade this section of U.S. Highway 191 to improve safety for this stretch of highway. Mr. Ron Casper the District Engineer for the Safford has been of great assistance in developing some preliminary ideas and plans for these proposed improvements and can be contacted at (520) 428-5470 in Safford.

I hope this letter adequately addresses your questions and would be happy to provide any further assistance that you may need.

RECEIVED
APR 24 2001

Sincerely,

Will Wright
Planning Director

COCHISE COUNTY PLANNING DEPARTMENT

1415 W. Melody Lane, Bisbee, Arizona 85603

(520) 432-9450
Fax 432-9429

James E. Vlahovich, Director

May 10, 2001

Mickey Siegel
Project Manager
4350 E. Camelback Road
Suite G-200
Phoenix, AZ 85018

Dear Mr. Siegel,

Thank you for your interest in Cochise County. In response to your inquiry, as per our telephone conversation yesterday, the proposed transmission and pipe lines are exempt from the Cochise County Zoning Regulations. However, as I pointed out in our conversation, it is the applicant's (South Western Power Group) responsibility to obtain any permits, or meet any additional conditions, if any, that may be applicable to the proposed activity pursuant to federal, state or any other local laws or regulations.

I also referred you to a letter previously sent to SouthWestern Power group, in which I informed that a special use permit or rezoning would be required for the power plant. For your information, the SouthWestern Power Group has not submitted any Rezoning or Special use applications to the office, therefore, whether the proposed power plant will be approved is not yet certain as a public hearing is involved. For your information, I am enclosing a handout and the criteria that we use to review special uses.

In regard to your inquiry on existing or proposed major commercial developments or subdivisions within the vicinity of the proposed site, I checked with our Department and confirmed that the only development is a communication tower, which is very near to the proposed site. If I recall correctly, you mentioned that the proposed site is in section 28 of the county's survey map. There are also two to three mobile homes near the proposed section. (Please see attached map). Aside from the tower and the existing mobile homes, we are not anticipating any major development proposals in this area in the near future.

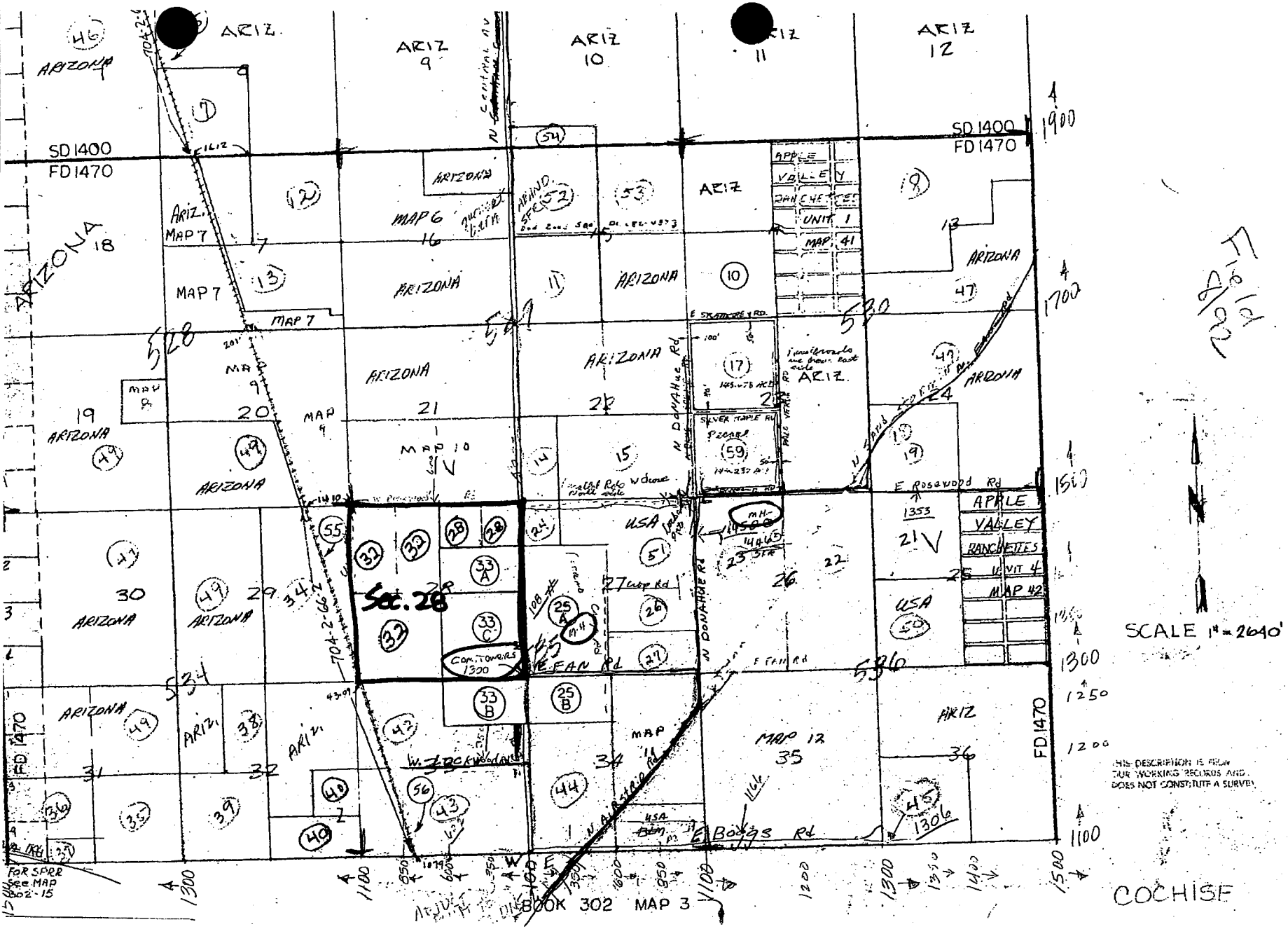
I hope this letter addresses your concerns. If you have further questions, do not hesitate to contact us.

Yours truly,

Louisa Garbo, Planner

Xc: James E. Vlahovich, Director

RECEIVED
MAY 16 2001


ARIZONA
ARIZ.
ARIZ 9
ARIZ 10
ARIZ 11
ARIZ 12
SD 1400
FD 1470
MAP 6
MAP 7
MAP 9
MAP 10
MAP 11
MAP 12
MAP 41
MAP 42
APPLE VALLEY RANCHETTES UNIT 1
APPLE VALLEY RANCHETTES UNIT 4
Sec. 28
E FAIRD Rd
E Boggs Rd
E Rosewood Rd
N DONAHUE Rd
N AIRSTRIP Rd
E SYCAMORE RD
SILVER MAPLE RD
USA
SCALE 1" = 2640'
THIS DESCRIPTION IS FROM OUR WORKING RECORDS AND DOES NOT CONSTITUTE A SURVEY
COCHISE
BOOK 302 MAP 3
FOR SPRR See MAP 302-15

Board of Supervisors

Leslie E. Thompson
Chairman,
District 3

Paul Newman
District 2

Patrick Call
District 1

Jody N. Klein
County Administrator

Nadine Parkhurst
Clerk

VIA FAX
(520) 795-2025
Hard Copy to Follow

June 12, 2001

Mr. Mickey Siegel, Project Manager
Environmental Planning Group
1430 E. Ft. Lowell Blvd. Suite 304
Tucson, AZ 85719

Re: Bowie Power Station Project

Dear Mr. Siegel:

This is in response to your letters dated April 18 and May 16, 2001, which were addressed to Ms. Linda Small. The Office of Economic and Community Development has been reorganized under the Cochise County Board of Supervisors and Ms. Small left her position with the County last year.

In regards to your request for information concerning development plans in the vicinity of the power plant site, the County Planning and Zoning Department recently provided land use and property development standards for the proposed project.

The Environmental Planning Group and the SouthWestern Power Group should continue to coordinate with the Cochise County Planning and Zoning Department concerning further development of this project. If you have further questions please contact Ms. Louisa Garbo at (520) 432-9450.

Sincerely,

Patty Lewis
Grants Administrator

Cochise County • 1415 W. Melody Lane, Building B • Bisbee, Arizona 85603
(520) 432-9200 • FAX (520) 432-5016 • e-mail: board@co.cochise.az.us
http://www.co.cochise.az.us

Bowie USD #14
315 West 5th Street
Bowie, Arizona 85605

April 24, 2001

Mickey Siegel, Project Manager
Environmental Planning Group
4350 East Camelback Road, Suite G-200
Phoenix, AZ 85018

Dear Mr. Siegel:

In response to your request, Bowie School officials can think of no plans for development in the vicinity of the planned Bowie Power Station Project.

Best of luck in your efforts.

Sincerely,

Dr. T. R. Ellis, Superintendent

WILLCOX UNIFIED SCHOOL DISTRICT NO. 13
480 NORTH BISBEE AVENUE
WILLCOX, ARIZONA 85643
(520) 384-4211
e-mail: lynnsj@qwest.net
• • •
Lynn Setterstedt-Jarrett, Ed. D., Superintendent

May 2, 2001

Mickey Siegel
Project Manager
Environmental Planning Group
4350 E. Camelback Rd.
Suite G-200
Phoenix, AZ 85018

RE: Bowie Power Station Project

Dear Mickey Siegel:

I am writing in response to your inquiry as to any knowledge I might have regarding planned developments in the vicinity of the power plant site and alternative transmission line and pipeline routes. At this time I do not know of anything that would impede your project.

Sincerely,

Lynn Setterstedt-Jarrett, Ed. D.
Superintendent

RECEIVED
MAY 0 2 2001

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
ARIZONA-NEVADA AREA OFFICE
3636 NORTH CENTRAL AVENUE, SUITE 760
PHOENIX, ARIZONA 85012-1936

April 24, 2001

REPLY TO
Office of the Chief
Regulatory Branch

Mr. Mickey Siegel
Project Manager
Environmental Planning Group
4350 E Camelback Rd., Suite G-200
Phoenix, Arizona 85018

File Number: 2001-00888-SDM

Dear Mr. Siegel:

It has come to our attention that Southwestern Power Group is planning to construct a new combined-cycle natural gas-fueled electric generating station, with associated transmission lines and gas pipelines, approximately 2 miles north of Interstate-10 at (Section 28, T12S, R28E), Bowie, Cochise County, Arizona.

This activity may require a Department of the Army permit issued under Section 404 of the Clean Water Act. A Section 404 permit is required for the discharge of dredged or fill material into the "waters of the United States," including adjacent wetlands. Examples of activities requiring a permit are placing bank protection, temporary or permanent stock-piling of excavated material, grading roads, grading (including vegetative clearing operations) that involves the filling of low areas or leveling the land, constructing weirs or diversion dikes, constructing approach fills, and discharging dredged or fill material as part of any other activity.

We have searched our database and to the best of our knowledge, there are no activities or planned development in the Bowie, Arizona area.

Enclosed you will find a permit application form and a pamphlet that describes our regulatory program. If you have questions, please contact Sallie D. McGuire at (602) 640-5385 x 221. Please refer to file number 2001-00888-SDM in your reply.

Sincerely,

Cindy Lester

Cindy Lester
Chief, Arizona Section
Regulatory Branch

Enclosures

EXHIBIT I
ANTICIPATED NOISE LEVELS, AND INTERFERENCE WITH COMMUNICATION SIGNALS

EXHIBIT I
ANTICIPATED NOISE AND INTERFERENCE WITH COMMUNICATION SIGNALS

As stated in Arizona Corporation Commission Rules of Practice and Procedure R-14-3-219:

"*Describe the anticipated noise emission levels, and any interference with communication signals which will emanate from the proposed facilities.*"

A study was conducted by Michael Theriault Acoustics, Inc. to evaluate noise levels for the Bowie Power Station. The sound level evaluation results are included in this exhibit, below.

Certain effects associated with electric power facilities such as transmission lines include corona and audible noise, radio/television/electronic equipment interference, and interference with cardiac pacemakers. A summary of potential corona and audible noise, equipment and cardiac pacemaker interference, and a description of electrical and magnetic fields (EMF) is also included in this exhibit.

SOUND LEVEL EVALUATION

As part of the evaluation, an ambient noise level survey was performed in June 2001 to establish baseline (L90) levels prior to power station operation. Results showed that the average background noise level (L90) for the 26-hour monitoring period was approximately 31 decibels, A-weighted (dBA). A detailed, three-dimensional acoustical model of the facility was developed to predict noise levels at nearby receptors and site property boundaries. Results showed that noise from the plant would range from about 41 to 46 dBA at nearby homes, and would fully conform to noise level guidelines established by federal bureaus such as the Department of Housing and Urban Development (HUD) and the EPA.

An acoustical model of construction operations and equipment was also developed to predict noise levels at the nearest residences, which are about 1 mile south of the proposed facility. Surrounding land use consists of large open farming areas and low population density. Results showed that construction activities would range in level from the low-30s to mid-40s (dBA) at nearby homes.

Noise Metric Descriptions

Noise can be described using various scales, similar to Fahrenheit and Celsius scales for temperature or pound and gram scales for weight. Moreover, noise can be described using a variety of statistical metrics. The following section briefly reviews these commonly used noise descriptors. The human ear responds to a frequency range from about 20 Hertz to 20,000 Hertz. Since the ear is not equally sensitive to low and high frequencies, sound level meters are equipped with "A-Weighting" filters which approximate this irregular response. The measurements are called A-weighted levels and reported in units of decibels, dB(A).

Percentile Levels

Because community sound levels continually change over time, percentile or "exceedance" measurements are often used to quantify them. These measures take into account the amount of time an environment is at a given loudness, and allow us to separate loud, intrusive noises, from steady state or background sounds. For example:

- L10 (L-Ten) is the level exceeded 10 percent of the time, that is, only 10 percent of the measurement time are levels higher than this value. The L10 typically represents the loudest noise events occurring in the environment, such as car and truck pass-bys.

- L50 (L-Fifty) is the sound level exceeded 50 percent of the time. Levels will be above and below this value exactly one-half of the measurement time, and therefore the L50 is sometimes referred to as the "median" sound level.

- L90 (L-Ninety) is the sound level exceeded 90 percent of the time and is often called the "background" sound level. Ninety percent of the time, measured levels are higher than this value, and therefore the L90 represents the environment at its quietest periods.

Another metric used to assess community noise is called the *Day-Night Level*, or LDN. The LDN represents a 24-hour measurement of sound within a community, and is calculated by adding a 10-decibel "penalty" to noises, which occur between 10 p.m. and 7 a.m. This accounts for the potential of increased annoyance when people are resting, relaxing and sleeping. The *Day-Night Level* is the preferred metric of federal bureaus such as HUD and the EPA.

Ambient Noise Level Survey

An ambient noise level survey was conducted from June 5, 2001 through June 7, 2001 to acoustically characterize the environment near the site. Specifically, sound level measurements were collected at the nearest residences, at site property boundaries, and at off-site locations in order to establish baseline levels (L90) prior to construction and operation of the facility.

Procedures

The surrounding area was surveyed to identify potentially noise-sensitive receptors, such as residences, cemeteries, schools, hospitals, churches, etc. Measurement locations considered spatially representative of the project area were established for obtaining ambient noise readings. Numerous sound level readings were manually collected over 15 to 20 minute periods during daytime and nighttime hours, for a three-day, two-night period. Percentile (Ln) sound levels were reported, and observations of predominant noise sources and weather conditions were noted. In addition, an unattended long-term sound level monitor was deployed at Location 2 for a 26-hour period, to capture the diurnal *(day-night)* variation in sound levels.

Instrumentation

All attended short-term sound level measurements were collected with a Brüel & Kjær Model 2260 Sound Level Meter. This meter complies with Type 1 tolerance requirements of the American National Standards Institute (ANSI) and was field calibrated before and after each measurement set with a Brüel & Kjær Model 4231 Acoustic Calibrator.

All unattended long-term sound level measurements were collected with a Brüel & Kjær Model 2238 Sound Level Meter. This meter complies with Type 2 tolerance requirements of ANSI, when fitted with the Model 4198 Outdoor Microphone Probe, and was also field calibrated before and after the 26-hour deployment. A calibration laboratory qualified the equipment within the preceding 12-month period using references traceable to the National Institute of Standards and Technology.

Monitoring Results

Background sound levels were generally controlled by insect and animal noises, mechanical noise from farm equipment, and distant traffic on I-10. As shown in Table I-1, short-term background (L90) measurements typically ranged from the mid-20s to mid-50s (dBA) and average background levels ranged from the mid-20s to the low-40s (dBA). At Location 2, long-term background ambient sound levels (L90) averaged about 31.

TABLE I-1 BACKGROUND SOUND LEVELS					
Ambient Survey Location	Description	Sound Level (L_{90}, dBA)			Audible Noise Sources
		Daytime	Nighttime	Average	
1	Nearest northeastern residence	23 – 26	26 – 27	25	Insect and animal noises
2	East	27 – 53	30 – 54	43	Mechanical noise from water pump at horse stables, insect and animal noises
3	Property line	27 – 37	36 – 42	34	Insect and animal noises, distant traffic on I-10, farm equipment
4	Nearest southern residence	40 – 44	32	38	Insect noises, railway passbys, distant traffic on I-10
5	West	25 – 30	37 – 41	33	Insect noises, distant traffic on I-10, distant railway passbys

Acoustical Modeling

The power station will utilize four combined-cycle gas turbine power trains and two steam turbines to generate a nominal electrical output of 1,000 MW. For purposes of this analysis, General Electric Frame 7FAs were modeled based on a conceptual general arrangement. The three-dimensional acoustical model of the facility was developed using SoundPlan Version 5.0 to predict noise levels at offsite receptors and along property boundaries. Far-field levels for modeled equipment were estimated using octave band sound power level data from General Electric, in-house measurement data and industry-standard prediction algorithms (Edison Electric Institute 1978). (Sound power levels provide a convenient means to describe the total amount of noise generated by a piece of equipment.)

Equipment power levels were adjusted for the reduction of sound with distance *(geometrical spreading),* absorption of sound by air *(air absorption*), and absorption and reflection of sound by the ground *(ground effect).* Sound levels were further adjusted by shielding effects (i.e., via tank farms, equipment, etc.) to predict far-field levels.

Results

Plant noise levels are predicted to be about 46 dBA at the nearest southern residence, 41 dBA at the nearest northeastern residence, and 38 dBA at the Desert Rest Cemetery. Similarly, levels at the property lines of the facility are predicted to range from 45 to 61 dBA.

Operational Sound Level Assessment

The Applicant is not aware of any quantitative noise ordinances, regulations or codes limiting the amount of noise generated during operation of the facility. In the absence of such standards, it is useful to compare expected plant sound levels to guidelines established by federal bureaus such as HUD and the EPA.

HUD Guidelines

HUD considers sites where day-night sound levels do not exceed 65 dBA, to be acceptable for housing. The day-night sound level, or LDN, represents a 24-hour measurement of noise within a community. More specifically, the LDN adds a 10 decibel penalty to all noises that occur from 10 p.m. to 7 a.m., to account for the potential of increased annoyance when people are relaxing, resting, and sleeping. Since the plant is a constant sound source that will operate 24 hours a day, the LDN is calculated by adding approximately seven decibels to the predicted plant sound level. Because the highest predicted plant sound level at nearby residences is 46 dBA, the estimated LDN becomes 53 dBA, (46 dBA + 7 dBA = 53 dBA) or significantly below the recommended HUD criteria (65 dBA) for acceptable sound levels.

EPA Guidelines

The EPA indicates that exposure to sound levels at or below LDN = 55 dBA is satisfactory to *"protect the public health and welfare with an adequate margin of safety,"* since it will not produce significant speech interference either indoors or outdoors, and will lead to negligible community reaction, complaints or annoyance in average communities. Given a plant LDN of 53 dBA, Facility noise levels at the nearest homes will fully conform to EPA guidelines.

Construction Sound Level Assessment

An acoustical model of construction operations and equipment was also developed using SoundPlan and industry standard algorithms (ESEERC 1977), to predict noise levels at nearby receptors. Five construction phases were considered, namely (1) grading and excavation, (2) concrete pouring, (3) steel erection, (4) equipment installation, and (5) finishing (assumes use of blow-down silencing during plant clean out). As shown in Table I-2, levels are predicted to range from the high-20s to mid-40s (dBA) at nearby receptors.

TABLE I-2 CONSTRUCTION SOUND LEVELS AT NEAREST RESIDENCES	
Southern Residence	36 to 46 dBA
Northeastern Residence	30 to 40 dBA
Desert Rest Cemetery	28 to 38 dBA

The average individual is likely to tolerate sounds associated with construction, given their temporary nature. Moreover, the majority of construction typically takes place during daytime hours, when acceptance towards noise is higher, and the risk of sleep disturbance and interference with relaxation activities is lower.

CORONA AND AUDIBLE NOISE

Corona is the breakdown of air very near conductors and occurs when the electric field is locally intensified by irregularities on the conductor surface such as scratches or water drops. Corona, as an issue for transmission lines, is most notable during rain or fog conditions. The physical manifestations of corona include a crackling or hissing noise and very small amounts of light. Besides the nuisance aspects of corona, it results in undesirable power loss over a transmission line. Therefore the design of transmission lines incorporates conductor and equipment, which limit corona. There are no standards or regulations pertaining to corona levels on electric power facilities.

RADIO/TELEVISION/ELECTRONIC EQUIPMENT INTERFERENCE

Although corona can generate high frequency energy, which may interfere with broadcast signals or electronic equipment, this is generally not a problem for transmission lines. The Institute of Electrical and Electronic Engineers (IEEE) has published a design guide (Radio Noise Subcommittee 1971) which is used to limit conductor surface gradients so as to avoid electronic interference.

Gap discharges or arcs can also be a source of high frequency energy. Gap discharges occur when an arc forms across a gap in loose or worn line hardware. It is estimated that over 90 percent of interference problems for electric transmission lines are due to gap discharges. Line hardware is designed to be problem-free, but wind motion, corrosion and other factors can create a gap discharge condition. Gap discharges can be located and when they occur can be remedied by utilities.

There are no local, state or federal regulations with specific limits on high frequency emissions from electric power facilities. Federal Communication Commission (FCC) regulations require that transmission lines be operated so that no harmful interference is produced (FCC regulations, Section 15.25).

CARDIAC PACEMAKERS

An area of public concern related to electric fields from transmission lines has been the possibility of interference with cardiac pacemakers. There are two general types of pacemakers: asynchronous and synchronous. The asynchronous pacemaker pulses at a predetermined rate. It is practically immune to interference because it has no sensing circuitry and is not exceptionally complex. The synchronous pacemaker, however, pulses only when its sensing circuitry determines that pacing is necessary. Interference from transmission line electric field may cause a spurious signal on the pacemaker's sensing circuitry. However, when these pacemakers detect a spurious signal, such as a 60 Hertz (Hz) signal, they are programmed to revert to an asynchronous or fixed pacing mode of operation, returning to synchronous operation within a specified time after the signal is no longer detected. Cardiovascular specialists do not consider prolonged asynchronous pacing a problem. As mentioned before, some pacemakers are designed to operate that way. Periods of operation in this mode are commonly induced by cardiologists to check pacemaker performance. So, while transmission line electric fields may interfere with the normal operation of some of the older model pacemakers, the result of the interference is generally not harmful, and is of short duration (EPRI 1985 and 1979).

REFERENCES

Edison Electric Institute. 1978. Electric Power Plant Environmental Noise Guide.

Electric Power Research Institute. 1985. Evaluation of the Effects of Electric Fields on Implanted Cardiac Pacemakers, EA-3917.

_____. 1979. The Effects of 60 Hz Electric and Magnetic Fields on Implanted Cardiac Pacemakers, EA-1174.

Empire State Electric Energy Research Corporation. 1977. Power Plant Construction Noise Guide, BBN Report No. 3321.

Federal Communications Commission. Rules and Regulations, Part 15, Section 15.25.

Institute of Electrical and Electronics Engineers, Radio Noise Subcommittee. 1971. Radio Noise Design Guide for High-Voltage Transmission Lines, 70TP631-PWR.

EXHIBIT J
SPECIAL FACTORS: PUBLIC INVOLVEMENT

EXHIBIT J
SPECIAL FACTORS

PUBLIC INVOLVEMENT PROGRAM

Public involvement is a vital part of the environmental planning process, and will be integrated throughout the life of the Bowie Power Station Project. The primary objectives of the public involvement program are to establish and maintain communication, inform and educate, accurately identify and consider the issues and concerns of the community through the gathering of public comment, and ensure that public input is considered in the overall decision-making process.

A combination of informational materials, media contacts, and meeting formats was used to disseminate information and gather comment. The primary methods used are discussed below and included (1) community leader packets, (2) project newsletter and mailing list, (3) voice message telephone information line, (4) website, (5) media releases and paid display advertisements, (6) local official briefings and small group meetings, and (7) public open houses.

INFORMATIONAL MATERIALS

A variety of informational materials were developed to acquaint local community leaders and residents with the project, and to provide access to project information and team members. Materials were compiled into "leader" packets, which were distributed to local, county, state, and federal government officials and relevant agencies. A newsletter was developed for distribution to the general public, and a telephone information line and project website were established.

Leader Packet

Early in the project, a contact list of local and regional government and community leaders with a potential interest in the project was developed. Also included in this list were federal and state agencies, property owners, chambers of commerce, schools, and irrigation districts. Members of this list were identified based on their knowledge of the local community, professional position, and/or proximity to the proposed site.

The leader packet contents included a letter announcing the project, a fact sheet, site location map, as well as a listing of frequently asked questions and answers. These packets were distributed concurrently with a media release announcing the project and provided a team contact list as well. The leader packet materials and a list of recipients can be found in Exhibit J-1.

Project Newsletter and Mailing List

A newsletter was mailed in April 2001 to the residents of Bowie, Willcox, and San Simon, in addition to the members of the community leader list and an internal project mailing list. Addresses for these communities were purchased from a local mail house based on resident/occupant status and zip code. The internal mailing list was developed based on feedback from local community members who requested that they receive project information. In total, the newsletter was mailed to approximately 4,670 people.

The first newsletter introduced the project to the general public, and announced public open houses that would be held in April 2001. It provided a description of the proposed plant, as well as a concept depicting how it might appear. Environmental studies and public involvement opportunities that would occur throughout the project were also described. A comment form was included to solicit public feedback.

A second newsletter is planned for distribution in late summer or early fall 2001 to update the public on resource studies and other project developments. A copy of the first project newsletter can be found in Exhibit J-1.

Telephone Information Line

A toll free telephone information line, (877) 576-7477, regularly includes project updates and meeting dates. Callers have the opportunity to request to be added to the mailing list, express comments or questions, and/or request that a project team member return the call. The information line number has been advertised in the project newsletter and in paid advertisements. In total, nine telephone calls (as of July 24) have been received.

Website

A website, www.southwesternpower.com, was established to provide another avenue for the public to gather information. This website allows viewers to access the project newsletter, fact sheet, frequently asked questions sheet, and a graphic of a typical combined-cycle 500 MW block.

MEDIA CONTACTS

Early in the project, local, regional, and industry media contacts and publications were identified. Information was regularly provided to these contacts in an effort to keep the public informed of project activities. By distributing media releases and paid display advertisements, the project team attempted to ensure that interested citizens would have access to information and be notified about public meetings.

Media Releases

As of July 2001, two media releases have been distributed to the identified media contacts. The first was distributed in January 2001 and introduced the Applicant and the project to the public. It also summarized the project description and the local community benefits that are expected.

The second release, distributed in April 2001, announced the public open houses that would be held that month. A third release is expected at the time of the CEC application filing. Copies of the January and April releases can be found in Exhibit J-2. Related newspaper articles can also be found in this exhibit.

Paid Display Advertisements

To provide adequate time for the community to learn of and attend the April 25 and 26, 2001 public open house meetings, a paid display advertisement announcing the meetings was placed in two local papers. The ad was carried in the *Arizona Range News* and the *Eastern Arizona Courier* on April 18 and 25. The advertisement was also provided as a flyer to the Bowie Unified School District, which received 120 copies; Willcox School District, which received 500 copies; and San Simon School District, which received 130 copies. These flyers were distributed to inform student's parents of the open house meeting. A copy of the advertisement can be found in Exhibit J-2.

MEETINGS

A variety of meetings were held with elected officials, community members, agencies, and the public to relay information and gather comments. These meetings allowed the Applicant to become familiar with the community and be responsive to concerns and suggestions.

Local Official Briefings and Presentations

Early in the planning process, local elected and appointed officials were briefed on the proposed plant. These meetings offered an opportunity to identify the most effective methods of communicating with the public, additional key community members to brief, and possible issues regarding the Project. Based upon requests from local groups, additional presentations and meetings were held. A table detailing these meetings can be found in Exhibit J-3.

Public Open Houses

One set of open houses was held at two different locations to inform the public about the project and gather input. The first was held at the Willcox Community Center in Willcox on April 25,

2001. The second was held at the Bowie High School in Bowie on April 26, 2001. Both meetings were advertised through the project newsletter, telephone information line, media releases, and paid advertisements.

The open houses began with an open house format followed by a one-hour presentation and question and answer session. A total of 103 people attended and were provided with the opportunity to review informational displays and ask questions of team members. The presentation addressed topics such as project description, benefits, transmission requirements, and environmental studies. Questions from the public were recorded, and comment forms were available for attendees to provide written feedback. Through these meetings and public responses, the project team was able to identify community issues and concerns. Copies of the open house materials and displays can be found in Exhibit J-3.

ISSUE IDENTIFICATION AND PUBLIC FEEDBACK

Overall, the community has been very supportive of the project because of the economic boost and assistance it will provide towards revitalizing Bowie and neighboring communities. Questions have been received on natural gas supply reliability, water usage and source, financial backing of the project, employment opportunities, and the project's affect on utility prices. Other questions that were received or issues raised are summarized below.

- impact on the AEPCO plant
- history and ownership of SWPG and potential partnerships with other firms
- possibility of converting from natural gas to another type of fuel
- benefits the area will receive from the Project (the possibility of job opportunities, when those opportunities will be available, and if the local community will be given priority for the benefits)
- when the influx of workers will begin and where they will stay
- quantity of proposed power plants in Arizona
- affect of air quality from emissions
- what transmission corridors will be used and if any will cross BLM land
- if training will be provided to local residents to prepare for job opportunities
- where evaporative pond residue will go and if the ponds will be lined

EXHIBIT J-1
LEADER PACKET AND NEWSLETTER

LEADER PACKET

CONTACT LIST

Governor Hull's Office

Rick Collins, Chief of Staff

U.S. Senate

Senator John McCain
Senator Jon Kyl

U.S. House of Representatives

Congressman Jim Kolbe
Congressman Ed Pastor
Congressman J.D. Hayworth
Congressman Bob Stump
Congressman John Shadegg
Congressman Jeff Flake

Arizona State Senate

Senator Marsha Arzberger

Arizona House of Representatives

Representative Mark Maiorana
Representative Bobby Lugo
Representative Gail Griffin

Cochise County

Supervisor Les Thompson
Supervisor Paul Newman
Supervisor Mike Palmer
James Vlahovich, Director, Planning and Zoning
Linda Small, Director, Economic and Community Development

Graham County

Supervisor Terry Bingham
Terry Cooper, County Manager
Linda Bailey, Parks and Recreation Director
Will Wright, Planning and Zoning

City of Willcox

Mayor Marlin Easthouse

Arizona Corporation Commission

Commissioner Bill Mundell
Commissioner Jim Irvin
Commissioner Marc Spitzer
Deborah Scott, Director, Utilities Division

Chambers of Commerce

Bowie Chamber of Commerce
Eddie Browning, Executive Director, Willcox Chamber of Commerce & Agriculture

School Districts

T. Ellis, Bowie Unified School District, Superintendent
Lynn Setterstedt-Jarrett, Willcox Unified School District, Superintendent
Michael Reed, San Simon Unified School District, Superintendent

Utilities

Jack Davis, Executive Vice President, APS
Mark Bonsall, General Manager, Commercial and Customer Services, SRP
Jim Pignatelli, Chairman, President, CEO, TEP
Donald Kimball, Executive Vice President and GM, AEPCO
Steve Oldham, Sierra Pacific Resources

BOWIE POWER STATION

Facility:

- *Power plant using combined-cycle, natural gas-fueled generation technology*

Specifications:

- *Up to 1,000 megawatts total capacity, enough electricity to serve approximately 250,000 homes*
- *Two 500 megawatt units, each configured with two combustion turbines supporting one steam turbine*
- *Two exhaust stacks per unit for proper air dispersion. Four total stacks - each approximately 130 to 160 feet tall*
- *Electricity will be delivered to the transmission grid via a connection with the existing Greenlee-Vail 345 kilovolt transmission line located to the north of Bowie Power Station site*

Location:

- *Approximately 2 miles north of Bowie, Arizona, in northern Cochise County (see map on back)*

Developer:

- *SouthWestern Power Group (SWPG) develops, constructs, owns, and operates natural gas-fueled power plants in the United States. SWPG staff has extensive experience in a variety of environmental engineering, power plant siting and construction, transmission line, and fuel procurement projects.*

Cost:

- *Up to $600 million*

Project Schedule:

- *Construction planned to begin in early 2002*
- *First unit expected to be in operation in early 2004*

Employment:

- *During construction - An average of 200 jobs up to 300 at peak periods*
- *Following construction - Up to approximately 45 full-time, permanent jobs will be created*
- *Payroll projected to be approximately $2 million annually*

Property Taxes:

- *Substantial tax revenues will benefit local schools and communities*

Environmental:

- *Groundwater use will be less than existing agricultural operation*
- *Air emissions in compliance with EPA and Cochise County limits*
- *State-of-the-art plant technology with lowest achievable emissions*
- *Sound reduction methods to minimize noise*

Site Advantages:

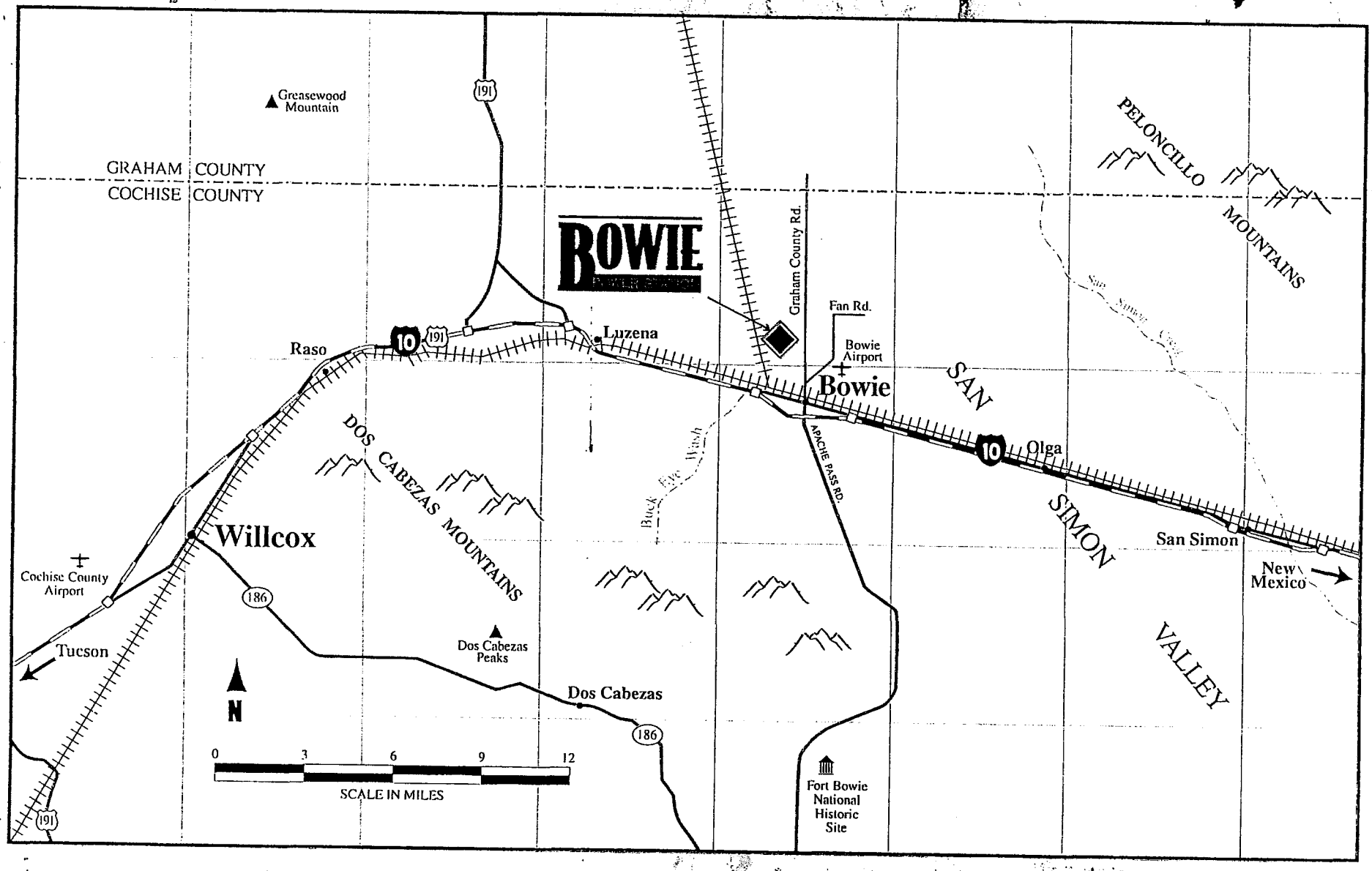
- *Proximity to natural gas pipeline*
- *Proximity to established electrical transmission*
- *Adequate water supplies on site*
- *Located on an existing railway*

More Information:

- *Contact SWPG at (602) 808-2004 or toll free at (888) 332-4599*

SOUTHWESTERN
Power Group II, LLC
An Energy Company - Alliance Builder

January 2001



BOWIE POWER STATION

Bowie Power Station

Site Map

January 2001

BOWIE POWER STATION

F.A.Q.

Frequently Asked Questions

Project Description

Q: What is the project?

A: *SouthWestern Power Group (SWPG) and Bowie Power Station, LLC have announced plans to build a combined-cycle, natural gas-fueled power generating station. The project will be constructed in phases to provide up to 1,000 megawatts (MW) total capacity.*

Q: Where would the new facility be located?

A: *In Cochise County, Arizona, approximately 2 miles north of the Bowie town center and Interstate 10, and 80 miles east of Tucson. The project site and surrounding area are primarily agricultural.*

Q: Why was that location chosen?

A: *There is a large amount of land available, providing a sufficient buffer area around the site, as well as adequate water and natural gas supplies to support the power station. Also, this location will enable SWPG to use energy generated at the Bowie facility to supply the existing electrical grid, supporting area industrial loads, Tucson power needs, or other power needs in Arizona.*

Q: What is a combined-cycle plant?

A: *Fueled by clean burning natural gas, today's combined-cycle plants generate inexpensive electricity utilizing the most innovative and efficient technology available. As the natural gas is burned, a combustion process turns a turbine connected to a primary generator. The resulting heat generates steam which turns a second turbine, essentially using the same heat energy twice (see attached diagram).*

Q: When would the plant be built?

A: *Construction is anticipated to begin in late 2002, with the first unit expected to be in operation in early 2004.*

Q: What would the plant look like?

A: *The plant will include two 500 MW power blocks. Each 500 MW block will consist of one steam turbine generator, two combustion turbine electric generators, two heat recovery steam generators, and two exhaust stacks. The project also includes plans for a switchyard, cooling towers, storage tanks, and other related facilities. Various types of site enhancements and landscape plans will be considered.*

Q: How high would the "stacks" be? How many would there be?

A: *The exhaust stacks will be up to approximately 160 feet tall. This height will be adjusted as necessary to allow for proper air dispersion. There will be two stacks for each of the two generating units, four stacks in all at the 1,000 MW level.*

Q: Are there other combined-cycle, natural gas-fueled plants like this in Arizona?

A: *Yes. Recent deregulation of the utility market has resulted in a number of proposed and approved gas-fueled power plant projects, many of which are combined-cycle.*

SOUTHWESTERN Power Group II, LLC
an Energy Company – Alliance Builder

Need

Q: Why is SWPG planning new generation?

A: *To meet the increasing electricity demands of current and forecasted growth in Arizona, new sources of power are needed. Deregulation of the utility industry has created a competitive market for the provision of that power. This is particularly the case in growing residential, commercial, and industrial loads in southern and southeastern Arizona.*

Q: Are any other new power plants planned for Cochise County?

A: *No new projects besides the Bowie Power Station have been announced in Cochise County. There is one existing power station in Cochise County southeast of Tucson. This 520 MW facility, known as the Apache Generating Station, is owned by the Arizona Electric Power Cooperative.*

Project Participants

Q: Who are SWPG and the Bowie Power Station, LLC? What experience do they have?

A: *SWPG is a developer of power plants throughout the United States and is headquartered in Phoenix, Arizona. The Bowie Power Station project is owned by Bowie Power Station, LLC; SWPG owns this entity. SWPG staff has extensive experience in a variety of environmental engineering, siting, fuel procurement, power plant construction, and transmission line projects. The firm currently has projects in development in Arizona and other states, including a 2,000 MW facility near Eloy, Arizona, known as the Toltec Power Station.*

Q: Will SWPG partner with any other energy companies on this project?

A: *Although no partner has been identified to date, other entities that can add strength to the project may be asked to join SWPG as project development progresses toward completion.*

Environmental

Q: What will be done to determine if the plant will cause environmental impacts?

A: *Extensive studies will be completed to evaluate potential impacts on air, water, visual, and noise resources. Biological and cultural resource studies will also be conducted. While minimal impacts are expected, detailed analyses will be performed to determine the best ways to further mitigate, or lessen, environmental effects.*

Air

Q: How would the plant affect local air quality? Would emissions meet air quality regulatory requirements?

A: Fueled by clean natural gas and utilizing advanced air emissions control equipment, the plant's emissions will have a minimal impact on air quality. Both the U.S. Environmental Protection Agency (EPA) and Cochise County air quality requirements will be met and the ability to accomplish that must be demonstrated prior to receiving air quality permits. Emissions will be reduced to levels well within acceptable health standards established and enforced by local and federal agencies.

Q: What components are in the air emissions?

A: The emissions will contain nitrogen oxides, carbon monoxide, and fine particulate matter. However, the presence of these substances will not exceed any of the National Ambient Air Quality Standards.

Water

Q: Does a combined-cycle plant use a significant amount of water? What would be the source for water?

A: Combined-cycle plants typically use less water than other types of generating plants. Groundwater will supply the facility. The proposed plant would use no more water than the agricultural operations the plant would replace. It is SWPG's intent to allow some agricultural activities to continue on site for the life of the Bowie Power Station Project.

Q: Will local agricultural and residential wells be affected by the groundwater drawdown?

A: Since pumping for plant operations will be less than agricultural operations, negative impacts are not expected. However, an aquifer impact study will be performed by a qualified hydrological engineering firm to examine the potential effects.

Q: What will happen to the plant wastewater?

A: Lined evaporation ponds will be used to contain all plant wastewater. The plant is designed for zero discharge off the plant site.

Visual

Q: What could be done to lessen the visual impacts of the plant?

A: Possible mitigation measures include coloring the facilities to harmonize, to the extent possible, with existing landscape. A landscape plan that will adhere to county design standards will be developed.

Noise

Q: How much noise would come from the plant?

A: Audible noise from the plant will be mitigated with noise control technology, and will meet U.S. Department of Housing and Urban Development standards at property boundaries.

Transmission Needs

Q: Will new transmission lines be needed?

A: *Yes, two alternative routes are being considered for one double-circuit 345 kilovolt (kV) line needed to connect the plant to the existing power grid. The transmission line will extend approximately 10 to 15 miles north to connect with an existing 345kV line in Graham County. These routes will be evaluated in conjunction with other studies in progress. Right-of-way needed for the transmission line will be acquired after the final route is selected.*

Financial

Q: Who would own the plant?

A: *Bowie Power Station, LLC will be the owner of the plant; SWPG owns Bowie Power Station, LLC.*

Q: How much would it cost? Who would pay for it?

A: *The proposed facility could cost up to $600 million phased in over time, and will be funded with SWPG earnings, borrowed capital, and other financial sources.*

Q: Would this project affect local electrical rates?

A: *Over time, the addition of the Bowie Power Station is expected to have the effect of reducing average retail rates due to greater generation supplies and competition.*

Community Benefits

Q: Would the community benefit from taxes paid on the plant?

A: *Yes. Substantial tax revenues would be generated each year for local schools and communities.*

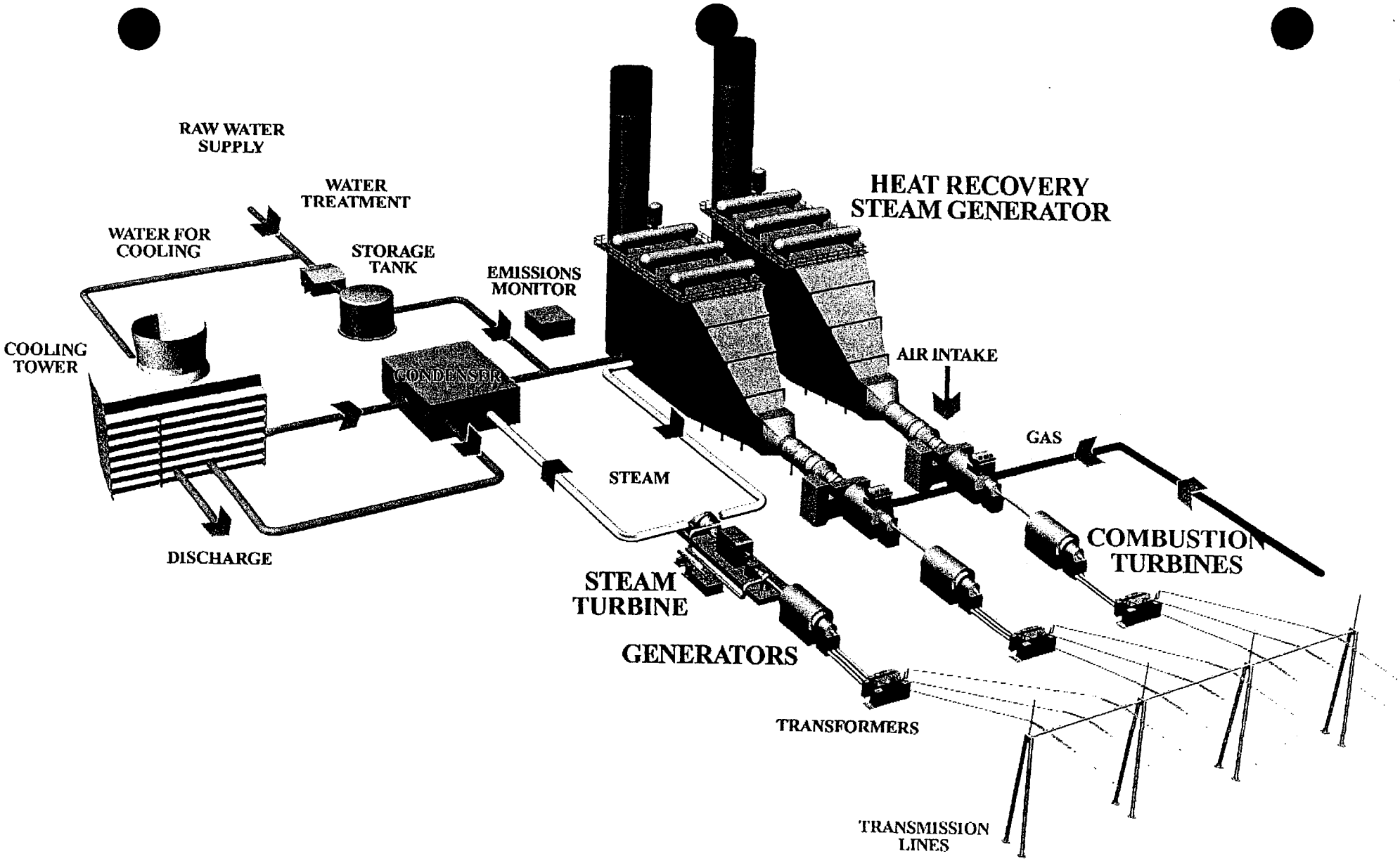
Q: How many jobs would be created for plant construction? For on-going operation?

A: *During construction an average of approximately 200 jobs, up to 300 at peak periods, will be created. Following construction approximately 45 full-time, permanent jobs will be created.*

Q: What would be the other benefits of this facility?

A:

- *It would meet the growing demand for power by using efficient, environmentally sound technology.*
- *Currently, California is experiencing critical power shortages and rolling blackouts, and Arizona came close to facing a similar situation last summer. New supplies would lessen the likelihood of similar negative impacts in Arizona.*



Typical Combined Cycle Generating System Components: One 500 MW block

BOWIE POWER STATION

NEWSLETTER

BOWIE POWER STATION

NEWSLETTER #1 • APRIL 2001

BOWIE POWER STATION

Please join us at your choice of Public Open House locations to learn more about the Bowie Power Station!

Willcox, Arizona
Wednesday
April 25, 2001
Willcox Community Center-Ballroom
112 W. Stewart

Bowie, Arizona
Thursday
April 26, 2001
Bowie
High School Gym
315 E. 5th Street

Times for both meetings:

5:30 p.m. - 6:00 p.m.
open house

6:00 p.m. - 7:00 p.m.
presentation/Q&A

7:00 p.m. - 7:30 p.m.
open house continues

New Power Generating Facility Planned Near Bowie, Arizona

SouthWestern Power Group II (SWPG) and Bowie Power Station, LLC have announced plans to develop the "Bowie Power Station," a natural gas-fueled, electric generating facility that will be located in Cochise County approximately 2 miles north of Bowie. Expected to generate 1,000 megawatts (MW) at total capacity, this plant will produce enough electricity to serve an estimated 250,000 homes. With the high rate of growth in southeastern Arizona, this new resource will significantly contribute to meeting the state's increasing energy needs. To link the power to the existing electricity grid, a new 345 kilovolt (kV) line will be built, extending 10 to15 miles north of the plant. **For more project information, see the "Quick Facts" on page 2.**

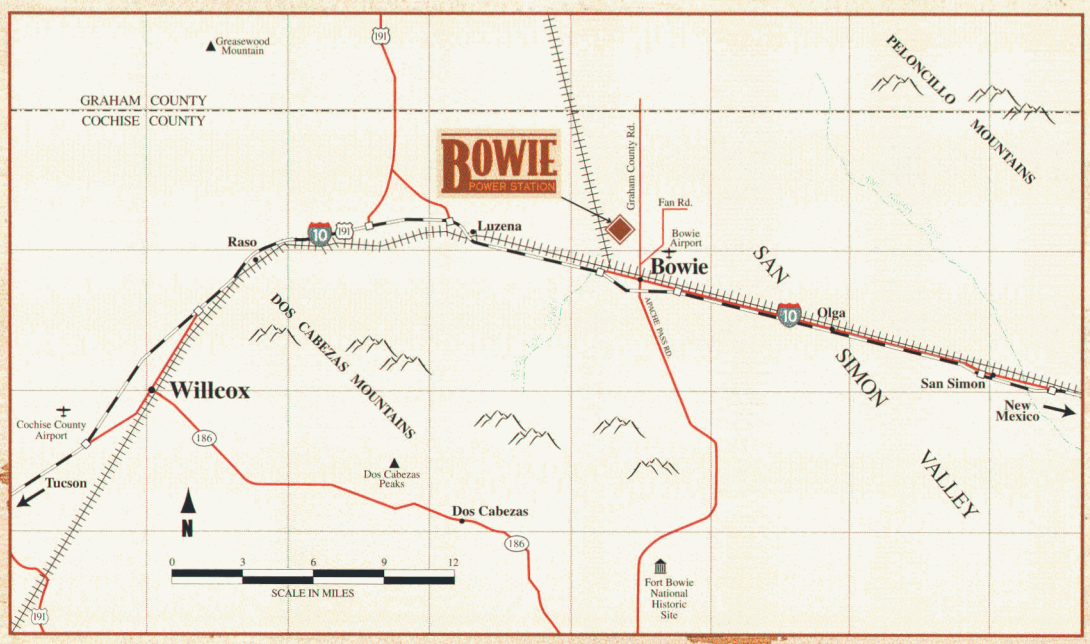
Project Offers Important Benefits for Local Community

SWPG makes every effort to establish strong relationships with local communities to ensure that they have the opportunity to share the economic benefits offered by a project like Bowie.

Because the proposed site is part of the Bowie community and lies within the Bowie Unified School District, the substantial tax revenues generated by the project each year will greatly benefit the school district and will reduce the rate of property taxes currently paid by residents.

In addition to tax revenues, regional businesses will be the recipients of an expected $2 to $4 million in purchases annually, once operation has begun. During construction of the facility, businesses will experience a growth in sales and secondary employment opportunities caused by the influx of workers, contributing to overall economic growth in the area.

In addition to the Bowie community, other neighboring communities such as San Simon, Willcox, and Safford will share in the benefits of this project, largely because of the number of employment opportunities generated by a project of this magnitude. During construction, an average of 200 jobs will be created, and about 45 permanent, full-time positions will be available during operation.



BOWIE POWER STATION

QUICK FACTS

- Two 500 megawatt blocks, each built with two combustion turbines supporting one steam turbine generator
- Up to 1,000 megawatts total capacity (phased in over time)
- Fueled by clean-burning natural gas
- Construction expected to begin in late 2002
- First unit expected to be in operation in late 2004
- Air emissions in compliance with Environmental Protection Agency (EPA) and Arizona Department of Environmental Quality (ADEQ) standards
- State-of-the-art plant technology with lowest achievable emissions
- Sound reduction methods to minimize noise
- Groundwater use will be less than existing agricultural water rights
- Average of 200 jobs created, up to 300 at peak, during construction
- 45 full-time, permanent jobs and support services created for plant operation
- Substantial tax revenues for local schools and communities
- One double-circuit 345kV transmission line extending 10 to 15 miles north of the plant will be required

Environmental Studies in Progress

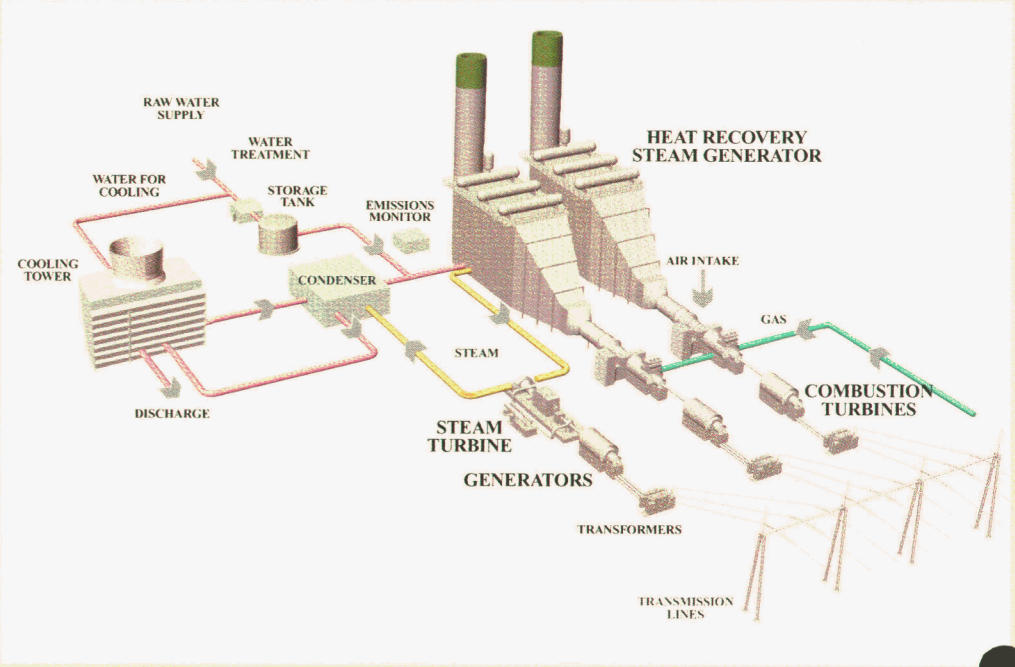
SWPG has retained environmental consultants to evaluate potential impacts on air, water, and visual resources. Biological and cultural resource studies and a noise analysis will also be conducted. Detailed analyses will be performed to determine the best ways to lessen environmental effects. Before the plant is built, several environmental permits must be granted by various agencies. These permits include air quality (ADEQ and EPA), zoning (Cochise County), and a certificate of environmental compatibility (Arizona Corporation Commission).

Opportunities for Public Involvement

Input from the community is vital to the planning process, and your participation is encouraged. A voice message information line (877-576-7477) has been established to provide project updates and offers callers the opportunity to ask questions, provide comments, or request to be added to the project mailing list.

Comments and questions may also be relayed by using the comment form inserted in this newsletter, or by attending the public open house meetings. These meetings offer a "drop-in" format for attendees to review displays and speak individually to project team members. A brief presentation and question/answer session will also be held. Please see page 1 for open house dates, locations, and times.

Typical Combined Cycle Generating System Components: One 500 MW block



BOWIE POWER STATION

APRIL 2001
COMMENT FORM

We want to hear your thoughts on the Bowie Power Station project. Your comments are important in helping us to identify ideas and issues associated with the project.

COMMENTS: _____

MAILING LIST

If you would like to be included on the project mailing list, please clearly print your name and address below. If you would like a return call to discuss any questions or concerns you may have on the project, please note your questions above and include your phone number.

Name: _____

Address: _____

City, State, Zip: _____

E-mail (optional): _____

Phone Number (optional): _____

BOWIE POWER STATION

PLACE
POSTAGE
HERE

SOUTHWESTERN POWER GROUP II, LLC
4350 E. Camelback Road
Suite B175
Phoenix, AZ 85018

Frequently Asked Questions

Who is SWPG? Who would own the plant?

Headquartered in Phoenix, SWPG is a developer of power plants throughout the United States. Currently, the firm is in the process of permitting a 2,000 MW plant near Eloy, Arizona.

The Bowie Power Station project is owned by the Bowie Power Station, LLC; SWPG owns Bowie Power Station, LLC. Visit the SWPG website at www.southwesternpower.com for more information about the company.

Why is water needed? How much water will the plant use?

Combined-cycle facilities need water for cooling and steam production. Utilizing an internal recycling and treatment system, plant discharges are minimized and water is conserved. A sufficient groundwater supply exists to meet the demands of the Bowie Power Station. In fact, the facility will use less water than the agricultural water rights allocation for lands acquired for the project.

How will this facility affect air quality?

Because this facility will use advanced air emissions control equipment and clean-burning, natural gas fuel, minimal impacts on air quality are expected. In addition, to permit the facility, emissions must meet levels established and enforced by federal and state agencies. The facility must demonstrate the ability to adhere to these standards before any air quality permits will be granted.

How much noise will be heard?

Discernible noise depends largely on the proximity of local residences and the presence of existing sound levels. An acoustics specialist will gather information about the project and the surrounding area to determine the project noise level and compliance with U.S. Housing and Urban Development guidelines.

What will the power plant look like?

The conceptual image on page 2 shows what the facility could look like. Included in this image are the stacks, which will be approximately 130 to 160 feet tall, and the heat recovery steam generators.

How do the evaporative ponds work?

After the water is cycled several times through the cooling system, it is discharged into lined ponds. The pond water has a high mineral content, but would not contain any toxic chemicals.

Will new transmission lines be needed?

Yes, two alternative routes are being considered for one double-circuit 345kV line needed to connect the plant to the existing power grid. The transmission line will extend approximately 10 to 15 miles north to connect with an existing 345kV line in Graham County. The route alternatives, which will be shown at the April public open houses, will be evaluated in conjunction with other studies in progress. Right-of-way needed for the transmission line will be acquired after the final route is selected.

Where will the natural gas come from?

A new underground natural gas pipeline will be constructed to serve the plant site. The pipeline will connect with an existing El Paso Natural Gas main line located approximately 4½ miles south of the plant site.

SOUTHWESTERN
Power Group II, LLC
An Energy Company – Alliance Builder

4350 E. Camelback Road
Suite B175
Phoenix, AZ 85018

PRESORTED
FIRST CLASS MAIL
U.S. POSTAGE
PAID
PHOENIX, AZ
PERMIT NO. 465

• Newsletter #1 •

Please join us at a Public Open House to learn more about the proposed Bowie Power Station (see page 1 for details)

IMPORTANT NEWS ABOUT THE BOWIE POWER STATION!

BOWIE
POWER STATION

EXHIBIT J-2
MEDIA RELEASES, NEWSPAPER ARTICLES, PAID DISPLAY ADVERTISEMENTS

MEDIA RELEASES

SOUTHWESTERN
Power Group II, LLC
An Energy Company – Alliance Builder

NEWS RELEASE

Date: April 18, 2001
Contact: Tom Wray, Project Manager
(602) 808-2004
toll free (888) 332-4599

COMMUNITY INVITED TO BOWIE POWER STATION PUBLIC OPEN HOUSE MEETING

(PHOENIX) April 18, 2001 – SouthWestern Power Group II (SWPG), a Phoenix-based energy resource development company, and Bowie Power Station, LLC, will hold a set of two public open house meetings regarding the proposed Bowie Power Station. Each meeting will offer the opportunity for the public to learn more about the project and provide input into the planning process.

The first open house will be held Wednesday, April 25, 2001, at the Willcox Community Center, 312 W. Stewart, in Willcox. The second is scheduled for Thursday, April 26, 2001, at the Bowie High School gymnasium, 315 E. 5th Street, in Bowie. Both meetings offer an informal, "drop in" open house format beginning at 5:30 p.m. At approximately 6:00 p.m. a brief presentation will be given, followed by a question/answer period. Following the presentation portion, the meeting will return to the open house format to offer community members time to review informational displays and speak individually with project team members.

The Bowie Power Station, a generation facility planned to be located approximately 2 miles north of the community of Bowie in Cochise County, is expected to produce 1,000 megawatts at full capacity—enough electricity to serve 250,000 homes. Using state-of-the-art combined cycle, natural gas-fueled technology, the facility is planned to be in operation in late 2004, with construction beginning in late 2002.

A toll-free voice message information line, 877-576-7477, has been established to provide brief project updates and a method for the public to request more information. The first project newsletter was recently mailed to area residents; copies may be requested by calling the phone line noted above.

###

4350 East Camelback Road · Suite B175 · Phoenix, Arizona 85018
P.O. Box 15491 · Phoenix, Arizona 85060
888.332.4599 · Tel 602.808.2004 · Fax 602.808.2099
www.southwesternpower.com

SOUTHWESTERN
Power Group II, LLC
An Energy Company - Alliance Builder

NEWS RELEASE

Date: January 31, 2001
Contact: Tom Wray, Project Manager
(602) 808-2004
toll free (888) 332-4599

SOUTHWESTERN POWER GROUP II ANNOUNCES DEVELOPMENT OF 1,000 MEGAWATT BOWIE POWER STATION

Approximately $600 Million Energy Project Planned for Cochise County --- Will Generate New Jobs, Enhance Local and School Tax Revenues

(PHOENIX) January 31, 2001 – SouthWestern Power Group II (SWPG), a Phoenix-based energy resource development company, announced plans today to develop the "Bowie Power Station," a new generation facility to be located approximately 2 miles north of Bowie, Arizona in northern Cochise County. Expected to produce 1,000 megawatts at full capacity, the power plant will utilize state-of-the-art combined cycle, natural gas-fueled technology.

With the high growth in southern Arizona, this new resource will significantly contribute to meeting increasing electricity needs. Construction is planned to begin in late 2002, with the first of two units in operation in early 2004. New jobs will be created and millions of dollars in property tax revenues will be generated, offering significant benefits to local schools and communities.

Supervisor Les Thompson of the Cochise County Board of Supervisors said, "The Bowie power plant would be a welcome addition to Cochise County. I look forward to working with SWPG and I will do what I can to help this project become a reality."

Larry Raines, Willcox City Manager, expressed a similar view. "It is extremely exciting when an economic development project of this magnitude arises. The impact to our community through assessed valuation and job creation will be well received," he said.

"SWPG looks forward to a growing and beneficial relationship with the community and to participate in and enhance the existing local business economy," said Maurice Richard, SWPG General Manager. "The planned technology and investment by SWPG will increase the asset base of the region, generate direct and indirect growth and revenue to the County, as well as provide 'state of the art' type employment opportunities during construction and throughout the expected 40-year operation of the facility."

Environmental studies have recently begun and public outreach efforts are planned to inform community members as well as encourage their participation throughout the planning process.

SWPG develops, constructs, and owns natural gas-fueled power plants in the United States. By forming alliances with customers and other service providers, SWPG is able to bring successful projects to the market. The company recently announced a similar generation project near Eloy, Arizona and has several projects under review in other states.

###

4350 East Camelback Road · Suite B175 · Phoenix, Arizona 85018
P.O. Box 15491 · Phoenix, Arizona 85060
888.332.4599 · Tel 602.808.2004 · Fax 602.808.2099
www.southwesternpower.com

NEWSPAPER ARTICLES

ARTICLES PUBLISHED ON PROJECT		
Article Title	**Publication**	**Date**
Proposed SWPG power plant to be located in Bowie	Arizona Range News	January 31, 2001
Developer plans 1,000-MW unit in Arizona	Megawatt Daily	February 1, 2001
SouthWestern Power puts spark in Cochise County with new plant	The Business Journal	February 16, 2001
Chamber meeting features Bowie Power Plant	Arizona Range News	March 28, 2001
Bowie Power Station Open House today in Willcox, Thursday in Bowie	Arizona Range News	April 25, 2001

ARIZONA
Range News
Willcox • San Simon • Sunsites • Bowie • Cochise • Dragoon
Willcox, Arizona

Download a powerful way to search (for free!) zapper click here

Proposed SWPG power plant to be located in Bowie in in

Arizona Range News
January 31, 2001

01/31/01
Ainslee S. Wittig

In the wake of a string of power shortages and rolling blackouts in California, Southeast Arizona is preparing for the future. Construction of a new power generation facility in Bowie, capable of producing 1,000 megawatts at full capacity, will begin in late 2002, said Project Manager Tom Wray of SouthWestern Power Group II, a Phoenix-based energy resource development company. The 'Bowie Power Station' is to be located about two miles north of Bowie on Graham County Road, but within Cochise County. Wray said SouthWestern Power Group (SWPG) chose the site for its optimum proximity to gas pipelines and electrical transmission lines and well as other "optimum perspectives." The plant, which will cost about $600 million, will use "state-of-the-art combined cycle, natural gas-fueled technology," instead of coal, which neighboring Arizona Electric Power Cooperative's Apache Generating Station uses, Wray said Friday. Wray said he does not think the new facility will "have any negative impact, or any impact at all" on AEPCO's plant, especially with the high demand for power. The facility, when completed, will generate enough energy (1,000 megawatts) to serve about 250,000 homes. The Apache Generating Station is a 520-megawatt facility. AEPCO's Apache Station, which has the capability of both coal and natural gas-fueled generation, has a contract with Sulphur Springs Valley Electric Cooperative (because SSVEC has partial ownership of AEPCO), and therefore the new plant will not be in direct competition with it, said Wayne Crane of SSVEC. Dennis Criswell, AEPCO assistant general manager of marketing and customer service, had just learned about the proposed project, and said, "We're looking forward to finding out more about the project." Crane, SSVEC's public relations director, said, "It won't be competition here, but the silver lining here is the economic benefit for this valley. But if it's a tight market in the next few years, and deregulation changes and makes a sudden turnaround, you never

know what can happen." Bowie, Willcox and the surrounding areas will benefit from the project through the generation of millions of dollars in property tax revenues as well as other sales-type tax revenues, such as the transaction privileges tax on natural gas purchases and taxes on other needed materials. These tax revenues will benefit the Bowie School District and the Northern Cochise Community Hospital district, Wray said. About 45 full-time permanent jobs will be created when the plant is in operation, with an annual payroll of about $2 million; and 200 to 300 jobs will be available during the year to year and a half period of construction, Wray said. Willcox City Manager Larry Rains said, "It is extremely exciting when an economic development project of this magnitude arises. The impact to our community trough assessed valuation and job creation will be well received." "We believe there will be from 45 or more good-paying jobs, that may be hired from the Willcox and Bowie communities, and these employees will be spending their money in our communities. I think the Bowie plant will have a similar impact as AEPCO has had on our community," Rains said. Rains said SWPG has been discussing the project for about nine months; and Wray said SWPG began negotiations with two Bowie landowners, Tom Cooke and Dick Eastman, about three months ago. Willcox Chamber of Commerce and Agriculture Executive Director and Economic Development Director Eddie Browning said the project must go through the permitting process with Cochise County, which will include public hearings. "There has been a lot of work going on behind the scenes up to this point; and now there will be a lot of questions that need to be answered and an open house will be helpful," Browning said. He added, "One thing this does tell me is that you never know who, where or when people are looking at our community, and we must be doing economic development all the time. They (SWPG) didn't get this farwithout seeing the positives of the area." Cochise County Supervisor Les Thompson said, "The Bowie power plant would be a welcome addition to Cochise County. I look forward to working with SWPG and I will do what I can to help this project become a reality." Wray said SWPG planned the new facility, among others in the state and nationwide, to meet increasing electricity demands and those of current and forecasted growth in Arizona. Deregulation of the utility industry has created a competitive market for the provision of this power, especially in higher growth areas such as southern and southeastern Arizona, he said. SWPG is also planning to open a 2,000-megawatt facility near Eloy, named the Toltec Power Station, for which they have two informational open houses set for Tuesday, Jan. 30 and Wednesday, Jan. 31, in the Eloy area. Wray said the company would like to have open houses in at least Willcox and Bowie sometime within the next 60 days to make presentations, answer questions and hear concerns. "We'd rather have reactions from the community sooner rather that later, before we get to far into the development process. We pride ourselves on working closely with the local communities," he said. Environmental studies to help determine the orientation of the plant have already begun at the site. Wray said meteorological towers about nine meters tall have been installed to collect data including air chemistry and weather data, which will help determine how the plant will be set up. He said SWPG's facility will have minimal impact on air quality and U.S. Environmental

Protection Agency and Cochise County air quality requirements will be met, with emissions reduced to levels well within acceptable health standards. "We don't emit sulfur dioxide as coal plants do. Our most prominent emission is nitrous oxide (NO2), and we mitigate that with the use of selective catalytic reduction until it is less than three parts per million to meet air quality standards," Wray said. He added that groundwater will supply the plant, and the proposed facility will use no more water than the agricultural operations it is replacing. The proposed combined-cycle plant will be made up of two 500-megawatt power blocks, each consisting of a steam turbine generator, two electric generators, two heat recovery steam generators and two exhaust stacks, up to 160-feet tall each. Wray said the first of the two units is expected to be in operation by early 2004. Public hearings and presentations will occur during the development process, as applications for the Air Quality Permit and Certification of Environmental Compatibility are submitted. And Wray said questions and concerns may be brought to his attention anytime by calling (602) 808-2004 or toll free, 1-888-332-4599.

©2000 MyWebPal.com. All rights reserved. Privacy Policy
All other trademarks and Registered trademarks are property of their respective owners.

Megawatt Daily
February 1, 2001

Developer plans 1,000-MW unit in Arizona

Arizona-based power developer Southwestern Power Group II said yesterday it is planning a 1,000-MW generating unit in Cochise County, Ariz., its second project in the state.

The two-unit Bowie Power Station is expected to begin commercial operation in 2004, Southwestern officials said. Construction is expected to begin late next year.

Southwestern has under development the 2,000-MW Toltec Power Station, which it announced in November. Previously, the group began initial development on an Arizona project it sold to Panda Energy. ML

The Business Journal
February 16, 2001

SouthWestern Power puts spark in Cochise County with new plant

BY RANDI WEINSTEIN
THE BUSINESS JOURNAL

SouthWestern Power Group II, a Phoenix energy resource development company, plans to build a 1,000-megawatt power plant in northern Cochise County.

The Bowie Power Station, about 200 miles southeast of the Valley, will use combined-cycle, natural-gas fueled technology.

Tom Wray, project development manager for the plant, said about 250 jobs will be created at peak construction of the facility, with 45 long-term positions.

The facility also will raise between $2 million and $4 million a year in property taxes that will go to the Cochise County school district, he said.

"The Bowie power plant would be a welcome addition to Cochise County," said Les Thompson, a member of the county board of supervisors. "I look forward to working with SWPG and I will do what I can to help this project become a reality."

In addition to the proposed Bowie plant, SouthWestern Power Group has about five other facilities in the works.

The company is wrapping up the permitting process on its proposed Toltec Power Station south of Eloy, about 70 miles south of Phoenix.

Wray said he expects to have all the necessary permits for the facility by the end of this year so the company can move ahead with construction by the first quarter of 2002.

The other plants are planned for out of state, he said.

The permitting process for the Bowie plant, however, has just begun. The company must receive numerous permits from environmental, zoning and land use agencies, as well as final approval from the Arizona Corporation Commission before that facility can move forward.

Construction is planned to begin in late 2002, with the first of two units in operation by early 2004.

FOR MORE

- **SouthWestern Power Group II:** www.southwesternpower.com

SouthWestern Power Group is a 3-year-old company with plans to enter into the wholesale power market.

California is not likely to see any of the power generated by SouthWestern Power's plants, Wray said.

"Plants around Palo Verde are in much better position to sell to California than we would be," he said. "Our power will likely stay in state."

Chamber meeting features Bowie Power Plant

Arizona Range News
March 28, 2001

CAROL BROEDER
AINSLEE S. WITTIG
Arizona Range News

Tom Wray, project development manager of the Southwestern Power Group II, LLC was the featured speaker at the Willcox Chamber of Commerce and Agriculture meeting March 6.

Wray told Chamber members that SWPG has a 1,000 megawatt (MW) facility proposed near Bowie, and a 2,000 MW facility in development near Eloy, known as the Toltec Power Station, among other power stations.

SWPG has plans to build a combined-cycle, natural gas-fueled power generating station two miles west of Bowie, with an entrance off Graham County Road.

SWPG will hold two public meetings, including short presentations about the proposed project: one at Bowie High School and one at the Willcox Community Center in late April, a couple of days apart, so that people have a chance to ask questions and air concerns. Wray said he'd like to file an application for the Bowie project with the Arizona Corporation Commission in May.

He said the project has been sited in such a way to be able to expand, and will be constructed in two phases of 500 MW each, to provide up to 1,000 MW total capacity.

The power plant will include two 500 MW, each of which will consist of one steam turbine generator, two combustion turbine electric generators, two heat recovery steam generators, and two exhaust stacks, according to Wray.

Wray said the plant will have a combined cycle configuration, which means that as the natural gas is burned, a combustion process turns a turbine connected to a primary generator. The resulting heat generates steam, which turns a second turbine, which Wray explained is a way to collect waste heat and re-use it.

The project is estimated to cost up to $600 million, he said.

Wray said the air emissions will contain nitrogen dioxide and carbon monoxide, but the presence of these substances will not exceed any of the National Ambient Air Quality Standards.

It will be very much like Apache Generation station, owned by Arizona Electric Power Cooperative (AEPCO), he added, except the SWPG power station will run only using natural gas and not by coal, as AEPCO can use.

Wray said it will take at least 14 months to get the more than 50 permits required for licensing. Permits take a long time, according to Wray, and the longest time is for the air quality permit. Wind River is their environmental consultant.

Wray said another of the permits to be obtained is the aquifer protection permit. An aquifer impact study will be performed by a hydrological engineering firm and lined cooling (evaporation) ponds will be used to contain all plant waste water, according to Wray.

The project is subject to the approval of the Arizona Corporation Commission. Wray said numerous reports go into the application, and the commission has 60 days to approve it, remand it, or reject it entirely.

Construction is scheduled to begin in late 2002, with the first unit operational in early 2004.

It should take 18 months to construct one 500 MW plant, employing 200-300 people. The plant expects to employ about 40 to 50 full-time permanent jobs following construction of both facilities, Wray said.

Wray said the firm will hire any local people they can to work at the plant, which has a $2 million projected payroll annually.

"We'd like to train local people to transition to operate the plant — it requires training, but it does wonders for acceptance to have your neighbors working in the plant," Wray said.

Property taxes will benefit the

See POWER, page 6

Bowie and San Simon school and Willcox hospital districts with about $2.5 to $3.5 million per year.

In addition, workers coming from out of town will need temporary housing. Many workers will live in recreational vehicles and put their children in local schools, Wray said.

Schools may need temporary buildings during construction, according to Wray. The effected school districts will be San Simon, Willcox and Bowie. "At Toltec, we have placed temporary portable buildings at the schools during construction to help out," he said.

La Donna Burgess, from Sulphur Springs Valley Electric Cooperative (SSVEC), asked about long-term gas supplies, which Wray replied would be natural gas from El Paso Natural Gas company.

Wray added that besides its proximity to a natural gas pipeline, other advantages to the Bowie site include a railway nearby.

Earl Moser of Willcox Real Estate asked if any of the power would go locally. Wray said the vast majority of the power could

See POWER, page 12

Power

continued from page 6

go to Tucson and Phelps Dodge in Clifton-Morenci.

Moser replied it would be local if you consider Southeastern Arizona to be local.

Wray added that the Bowie Power Station plans to join the Willcox Chamber of Commerce and work with the community.

Carol Broeder/Range News

Tom Wray of the SWPG, LLC, standing, fields questions from Chamber of Commerce and Agriculture members at their Quarterly Membership meeting March 6.

ARIZONA
Range News
Willcox, Arizona

Arizona Range News
April 25, 2001

Bowie Power Station Open House today in Willcox, Thursday in Bowie

04/25/01
Email this story to a friend

SouthWestern Power Group II (SWPG), a Phoenix-based energy resource development company, and Bowie Power Station, LLC, will hold a set of two public open house meetings regarding the proposed Bowie Power Station. Each meeting will offer the opportunity for the public to learn more about the project and provide input into the planning process.

The first open house will be held today, Wednesday, April 25, at the Willcox Community Center, 312 W. Stewart, in Willcox. The second is scheduled for Thursday, April 26, at the Bowie High School gymnasium, 315 E. 5th Street, in Bowie. Both meetings offer an informal "drop in" open house format beginning at 5:30 p.m. At about 6 p.m., a brief presentation will be given, followed by a question/answer period. Following the presentation portion, the meeting will return to the open house format to offer community members time to review informational displays and speak individually with project team members.

The Bowie Power Station, a generation facility planned to be located approximately 2 miles north of the community of Bowie in Cochise County, is expected to produce 1,000 megawatts at full capacity — enough electricity to serve 250,000 homes. Using state-of-the-art combined cycle, natural gas-fueled technology, the facility is planned to be in operation in late 2004, with construction beginning in late 2002.

A toll-free voice message information line, 1-877-576-7477, has been established to provide brief project updates and a method for the public to request more information. The first project newsletter was recently mailed to area residents; copies may be requested by calling the phone line noted above.

PAID DISPLAY ADVERTISEMENTS

PUBLIC INFORMATION OPEN HOUSE

SouthWestern Power Group (SWPG), a Phoenix-based energy development firm, and Bowie Power Station, LLC, invite the community to a public meeting regarding the Bowie Power Station, a proposed power plant to be located approximately 2 miles north of Bowie.

BOWIE POWER STATION

WILLCOX
Wednesday, April 25, 2001
Willcox Community Center - Ballroom
312 W. Stewart

BOWIE
Thursday, April 26, 2001
Bowie High School - Gym
315 E. 5th Street

The schedule for both meetings is as follows:

5:30 p.m. - 6:00 p.m. • open house
6:00 p.m. - 7:00 p.m. • presentation
7:00 p.m. - 7:30 p.m. • open house continues

The meeting will begin with an informal "drop in" open house format to offer the opportunity for community members to review project maps and displays, provide comments, and speak individually with project team members. At 6:00 p.m., a brief presentation will be held followed by a question/answer session.

For additional information, please call the project voice message information line (toll-free) at (877) 576-7477.

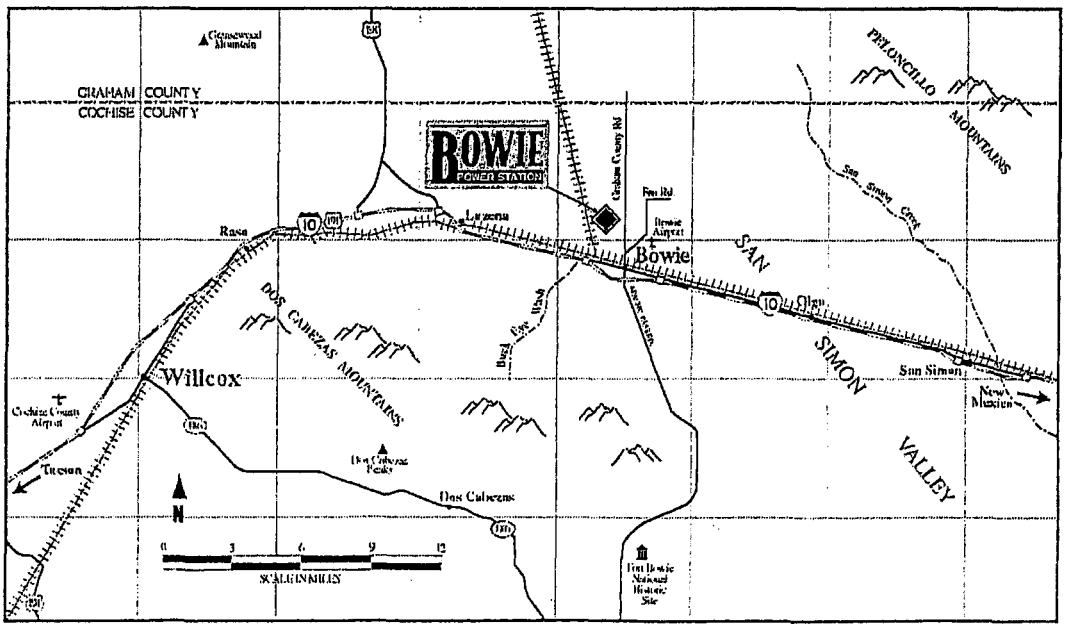


EXHIBIT J-3
LOCAL BRIEFINGS AND PUBLIC MEETINGS

LOCAL BRIEFINGS

BOWIE POWER STATION PROJECT GOVERNMENT AND COMMUNITY MEETINGS AS OF JUNE 22, 2001			
Date	**Group or Person**	**Organization/Affiliation**	**Comments/Notes**
2/20/01	Les Thompson, Chairman and Jody Klein, County Administrator	Cochise County Board of Supervisors	General project overview. County asked SWPG to keep P&Z informed. They also had general questions about employment.
2/21/01	Dick Eastman	Land owner	General project overview. SWPG asked permission to place a meteorological tower on property; it was okayed.
2/21/01	Mark Cook	Land owner	General project overview. SWPG asked permission to place a meteorological tower on property; it was okayed.
2/21/01	Calvin Allred	Attorney	General project overview.
2/21/01	Michael Bobee, Chief	Bowie Fire Department	General project overview. Mr. Bobee noted that plant may put stress on his staff during construction. He is supportive of the project.
2/21/01	Jody Johnson	Bowie Unified School District	General project overview. Discussed possibility of unifying San Simon/Willcox/Bowie school districts.
2/21/01	Mick Easthouse, Mayor; Larry Raines, City Manager	City of Willcox	General project overview. City noted they are in the running for a federal prison that would add construction jobs at about the same time that Bowie construction jobs would be needed.
2/21/01	Eddie Browning, Executive Director	Willcox Chamber of Commerce & Agriculture	General project overview.
2/21/01	Chris Cronberg, CEO	Northern Cochise Community Hospital	General project overview.
2/27/01	Lynn Setterstedt-Jarrett, Superintendent	Willcox Unified School District	Project introduction and discussion of the impact to the school district. General questions were received on classroom impact and the accommodation of new students during construction and operation.
3/6/01	Chamber members	Willcox Chamber of Commerce & Agriculture	General project overview; announced public open houses. Question asked about long-term gas supplies and where the power will go.
3/7/01	T.R. Ellis, Superintendent	Bowie Unified School District	General project overview. Discussed impact to school district.
3/8/01	Dr. Lynn Setterstedt-Jarrett, Superintendent	Willcox Unified School District	General project introduction. Questions about classroom impact and the accommodation of new students during construction and operation.
3/8/01	Michael Reed, Superintendent	San Simon Unified School District	General project introduction. Discussion of the impact to the school district. Questions were about the classroom impact and job possibilities.
06/05/01	Chamber members	Willcox Chamber of Commerce	Monthly chamber meeting, presented checks to Cowboy Hall of Fame and Economic Development fund.

PUBLIC MEETINGS

BOWIE POWER STATION

PROJECT PARTICIPANTS

Bowie Power Station, LLC (owned by SouthWestern Power Group II, LLC)

- project sponsor

Consultants and Advisors

Environmental Planning Group (EPG)

- conduct and facilitate environmental planning process and public involvement activities

RW Beck

- project design engineering and electrical system planning studies

Wind River Environmental Group

- air quality studies and permit applications

Michael Theriault Acoustics

- sound level analysis and noise control engineering

URS

- water resources studies

SOUTHWESTERN Power Group II, LLC
An Energy Company - Alliance Builder

APRIL 2001

BOWIE POWER STATION

PROJECT DESCRIPTION/ SITE ATTRIBUTES

Project Description

- up to 1,000 MW total capacity (two 500 MW blocks)
- natural gas-fueled, high efficiency, low emission technology
- combustion and steam turbines
- interconnection to existing 345 kilovolt transmission lines
- location: 2 miles north of Bowie

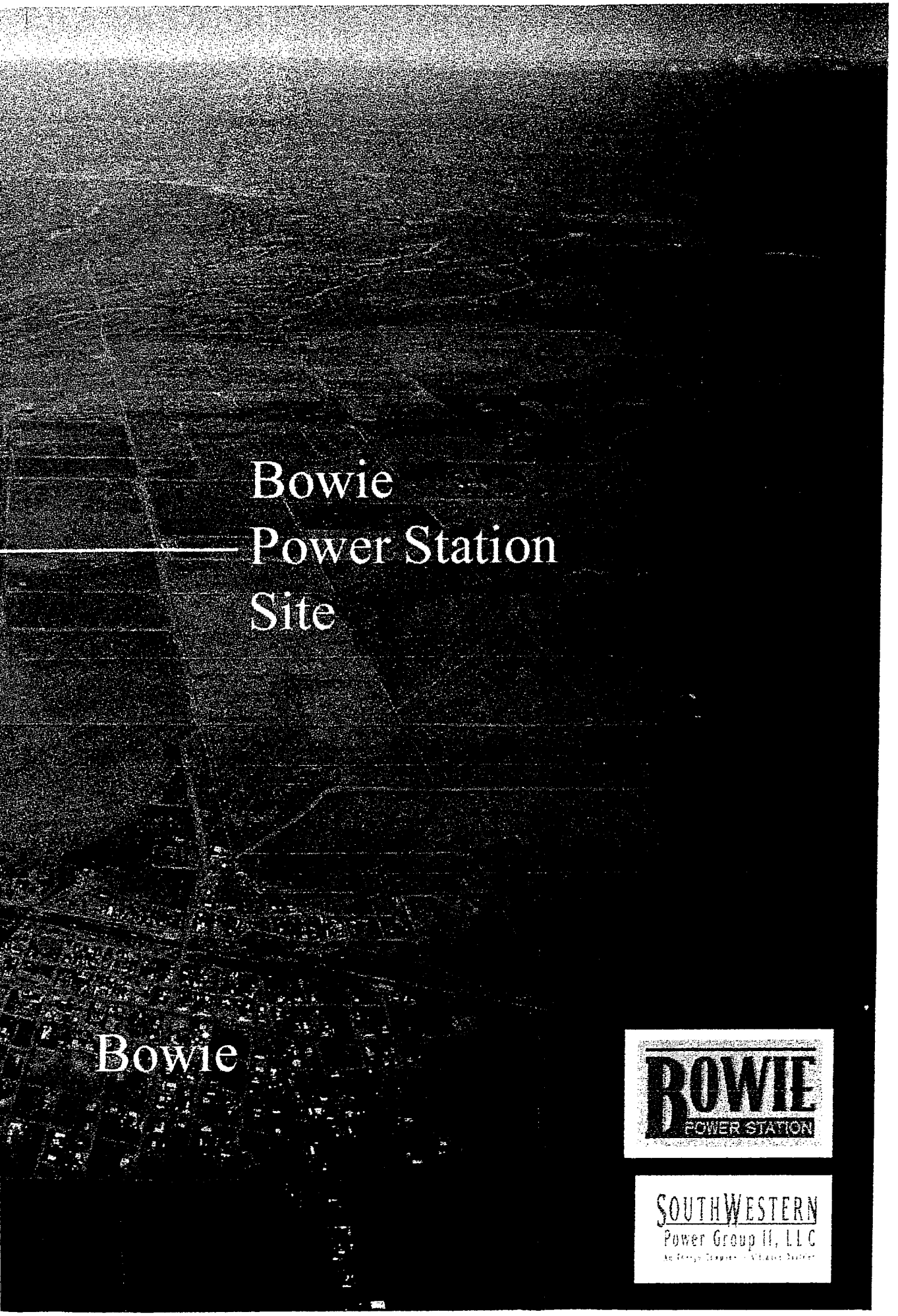
Site Attributes

- ample land and water supply
- existing land area "buffer" surrounding plant site
- near both rail and interstate highway for equipment delivery
- close to existing transmission lines

SOUTHWESTERN Power Group II, L.L.C.
An Energy Company - Alliance Builder

APRIL 2001

I-10

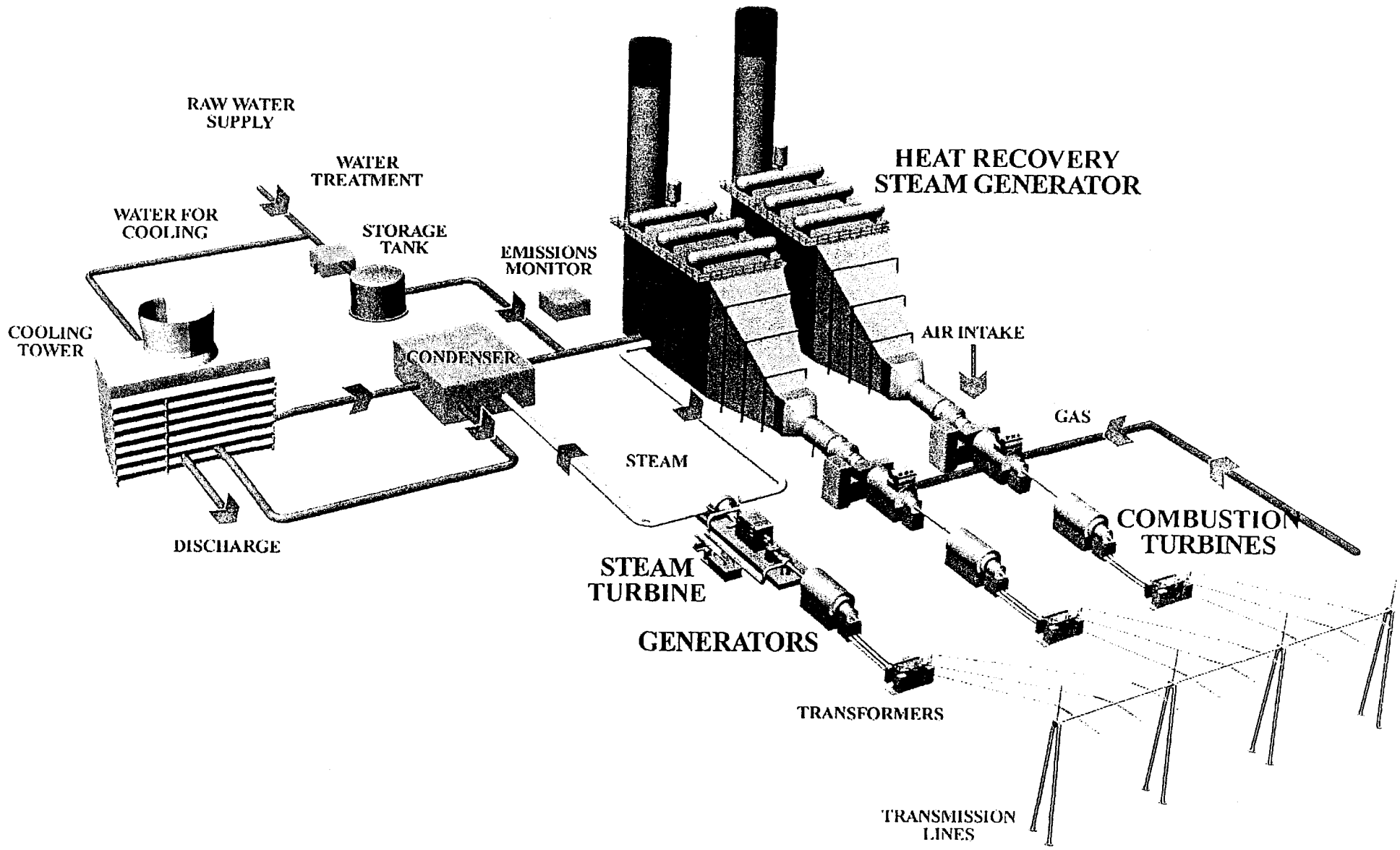


Bowie Power Station Site

Bowie

BOWIE POWER STATION

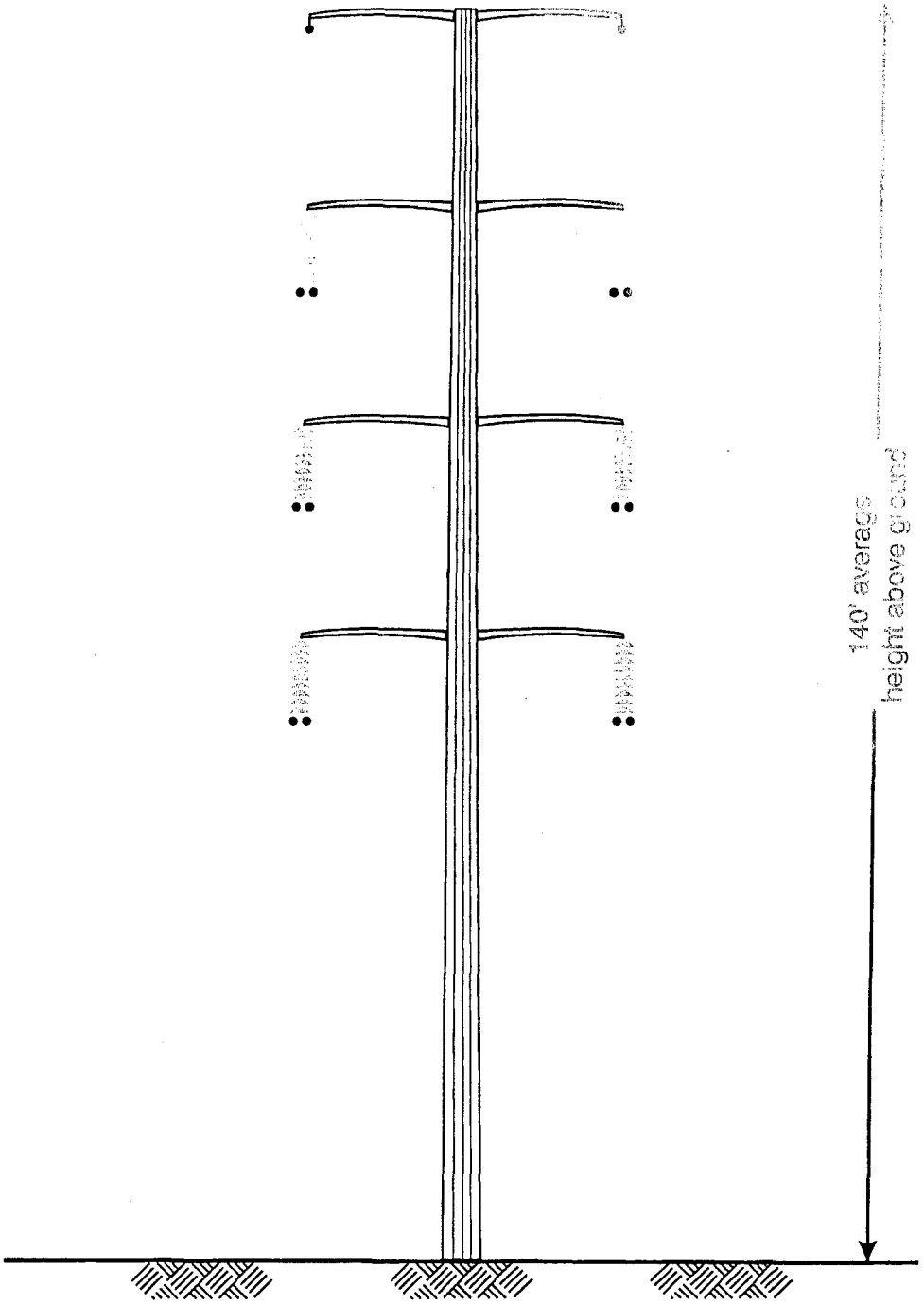
SOUTHWESTERN Power Group II, LLC



Typical Combined Cycle Generating System Components: One 500 MW block

BOWIE POWER STATION

TYPICAL STRUCTURE



Typical Single Pole 345kV Structure double-circuit

BOWIE POWER STATION

BOWIE POWER STATION

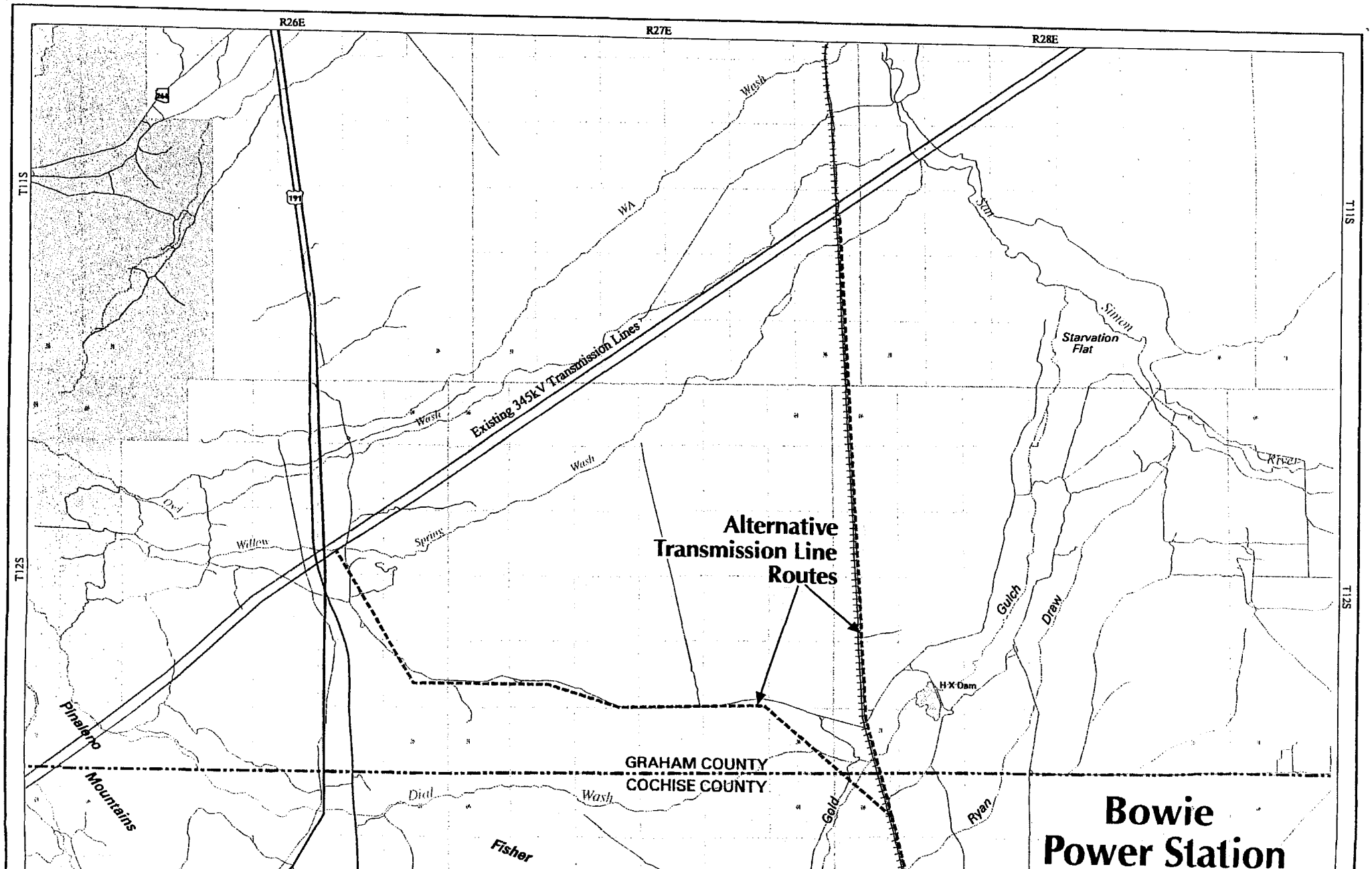
WHERE WILL THE POWER GO?

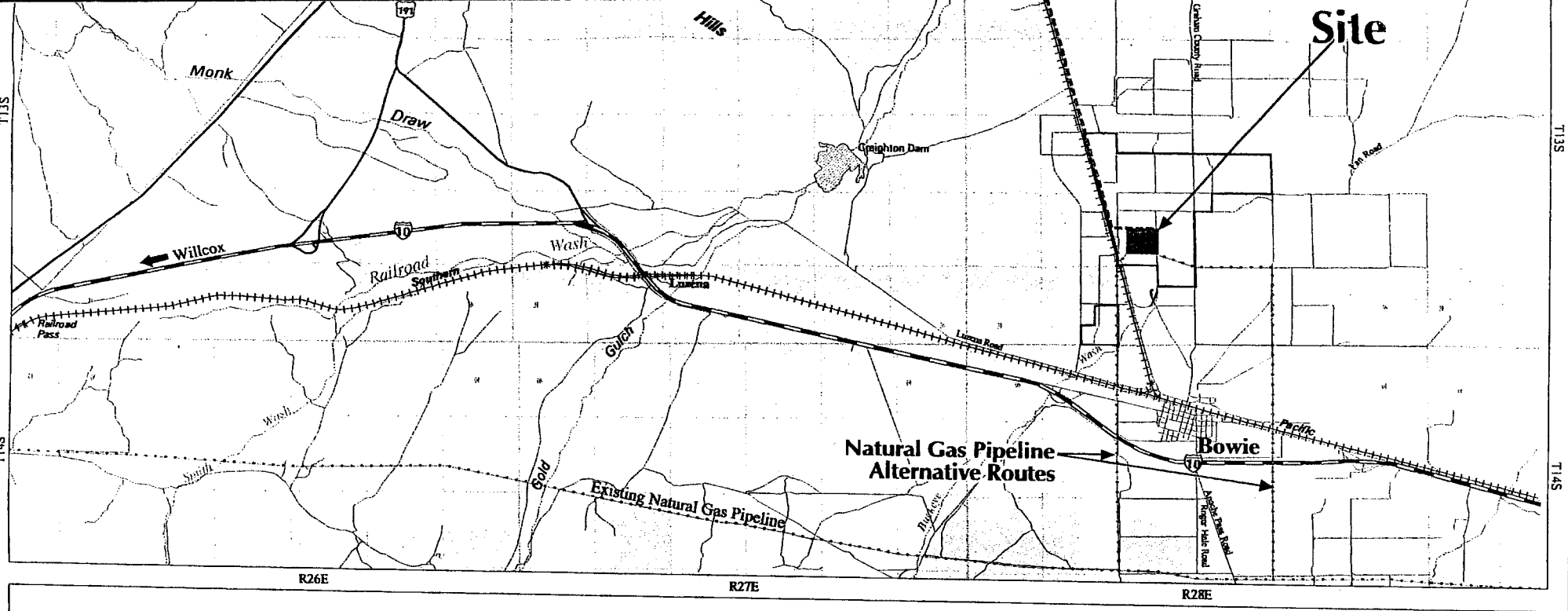
Areas to be served by Bowie Power Station:

- Local electric cooperatives
- Metropolitan Tucson
- Local mining loads
- Other areas in Arizona
- Loads in other states

SOUTHWESTERN Power Group II, LLC
An Energy Company - Alliance Builder

APRIL 2001


R26E
R27E
R28E
T11S
T12S
191
Existing 345kV Transmission Lines
Alternative
Transmission Line
Routes
Starvation
Flat
Simon
Wash
Willow
Spring
Dial
Gulch
Drew
Ryan
Gold
H-X Dam
Pinaleno
Mountains
Fisher
GRAHAM COUNTY
COCHISE COUNTY
Bowie
Power Station



General Reference Features

- 345kV Transmission Line
- 230kV Transmission Line
- Natural Gas Pipeline
- County Boundary
- Interstate
- Major Road
- Road
- Railroad
- River
- Wash
- Section Line
- Township and Range Boundary
- Contour
- Reservoir

Resource Inventory

- Bowie Project Property Boundary
- Proposed Double-Circuit 345kV Transmission Line
- Proposed Natural Gas Pipeline
- Bowie Power Station Site
- Private
- State Trust
- Bureau of Land Management
- USDA Forest Service

PROJECT LOCATION

Bowie Power Station, LLC

1 .5 0 1 2 3 MILES

Sources:
Arizona State Land Department, Phoenix, AZ 2001.
United States Geological Survey (USGS), Willcox AZ-NM 1994, Safford AZ-NM 1994, 1:100,000-scale metric topographic maps. Contours interpolated from USGS 1:24,000-scale digital elevation models at an interval of 40 feet.

BOWIE POWER STATION

Draft April 18, 2001

BOWIE POWER STATION

BOWIE PROJECT SCHEDULE

Sept. - Dec. 2000	Project Feasibility Studies and Planning • site identification • natural gas supply • electric transmission interconnection plan • water supply
Ongoing	Environmental Resource Studies and Project Design • air • water • visual • land use • vegetation and wildlife • cultural resources • acoustics
January 2001	Public announcement
Feb. - April 2001	Initial agency and community briefings
April 2001	- Project newsletter #1 - Public Open Houses
July 2001*	Application to Arizona Power Plant and Transmission Line Siting Committee for Certificate of Environmental Compatibility
September 2001*	- Project newsletter #2 - Siting Committee and Arizona Corporation Commission Hearings
Fall 2002*	Secure other permits and financing
End 2003*	Construction begins - first phase
2004*	Commercial operation

*** Projected Dates**

SOUTHWESTERN Power Group II, LLC
an Energy Company - Alliance Builder

April 2001

BOWIE POWER STATION

Project Benefits

- The Bowie Power Station would help meet the growing demand for power by using efficient, environmentally sound technology
- Economic Benefits
  - Average of 200 jobs created during construction and up to 300 at peak
  - Up to approximately 45 full-time permanent jobs created following construction
  - Payroll projected at $2 million annually
  - $2 to $4 million annually in tax revenues for local schools and communities
  - $7 to $10 million in purchases of local materials and services during construction
  - $3 to $5 million in purchases during operation
  - Approximately 150 additional secondary jobs during construction and operation

SOUTHWESTERN Power Group II, LLC
An Energy Company - Alliance Builder

APRIL 2001

BOWIE POWER STATION

ENVIRONMENTAL STUDIES

- Air quality
- Water resources
- Noise
- Land use
- Visual resources
- Cultural resources
- Biological resources

SOUTHWESTERN Power Group II, LLC
An Energy Company - Alliance Builder

APRIL 2001

BOWIE POWER STATION

AIR QUALITY

- conduct analysis using air dispersion model
- install cleanest technology available
- must meet Arizona Department of Environmental Quality and U.S. Environmental Protection Agency standards

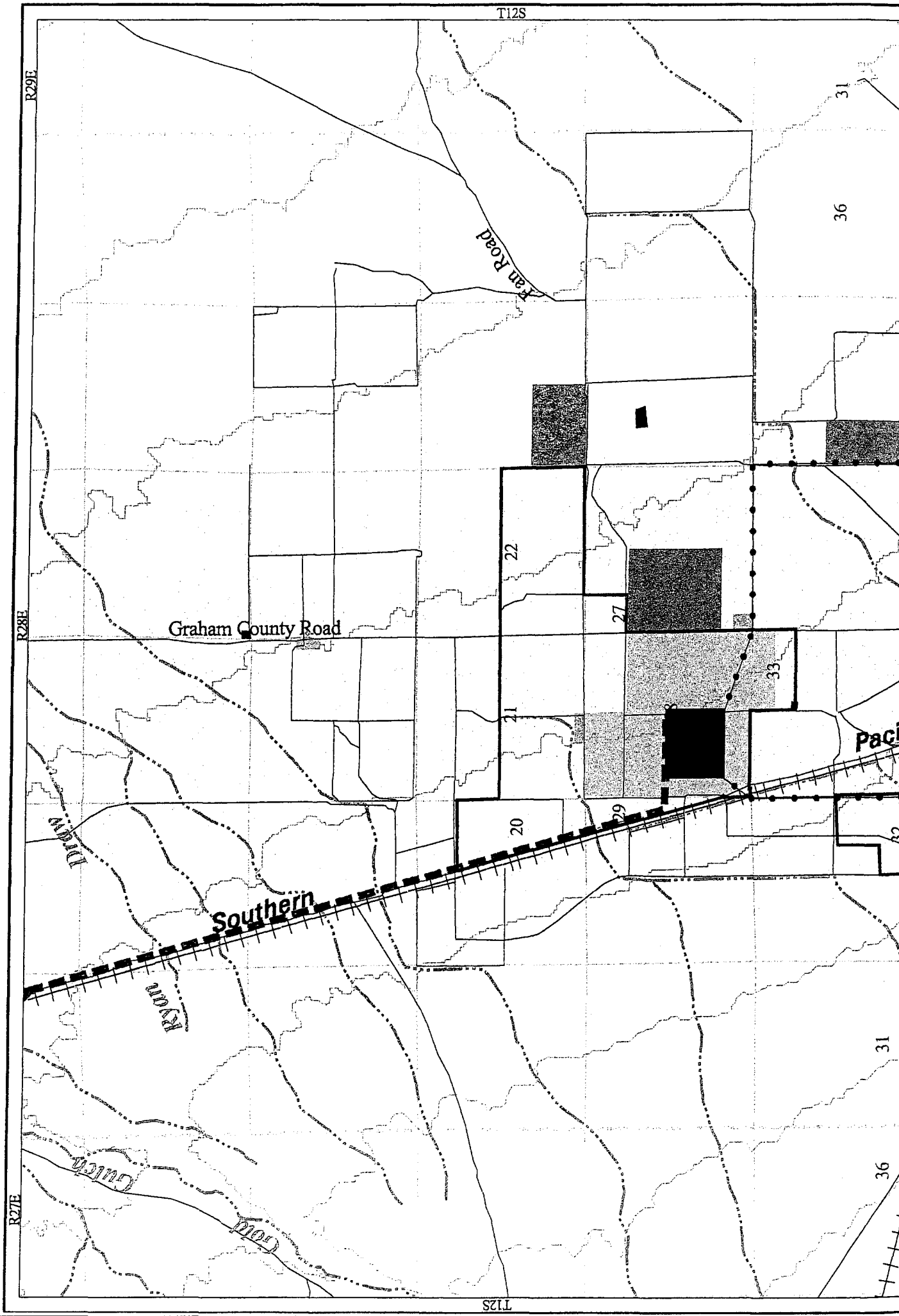
CRITERIA POLLUTANT AIR QUALITY STANDARDS APPLICABLE TO THE BOWIE POWER STATION PROJECT

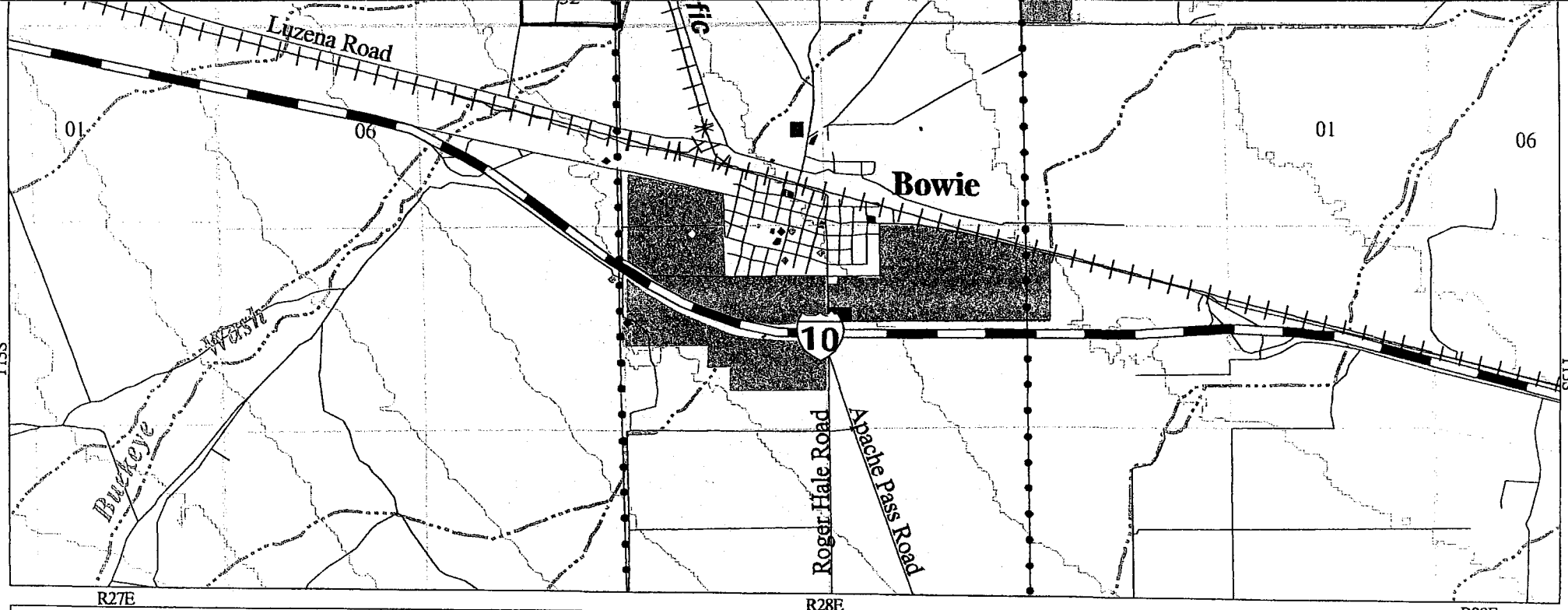
Pollutant	Prevention of Significant Deterioration Threshold Emissions (tons per year)	Averaging Period	National Ambient Air Quality Standards (micrograms per cubic meter)	Class II Increment Level (micrograms per cubic meter)
NO_2 or NO_x (Nitrogen dioxide or other N compound)	40	Annual	100	25
PM_{10} (fine particulate matter)	15	Annual	50	17
		24-hour	150	30
SO_2 (Sulfur dioxide)	40	Annual	80	20
		3-hour	1,300	512
		24-hour	365	91
CO (Carbon monoxide)	100	1-hour	40,000	NA
		8-hour	10,000	NA
Lead	—	Quarterly	1.5	NA
PM (Particulate matter)	25			
VOC (volatile organic compounds)	40			

Source: U.S. Environmental Protection Agency

SOUTHWESTERN Power Group II, LLC
An Energy Company - Alliance Builder

APRIL 2001


T12S
R29E
R28E
R27E
Graham County Road
Ham Road
Southern
Pacif
Drew
Ryan
Cuica
Gold
31
36
22
27
33
21
20
29
31
36
T12S



General Reference Features

- Interstate
- Road
- Railroad
- Wash
- Section Line
- Township and Range Boundary
- Contour

Resource Inventory

- Bowie Project Property Boundary
- Proposed Double-Circuit 345kV Transmission Line
- Proposed Natural Gas Pipeline
- Bowie Power Station Site
- Residential
- Commercial
- Light Industrial
- Public/Quasi-Public
- School/Educational Facility
- Irrigated Farmland
- Stockyard/Dairy Feedlot
- Orchard
- Farm Outstructures
- Farm Complex
- Utility/Communication Facility
- Recreation
- Vacant/Undeveloped
- Single Family Dwelling Unit
- Abandoned Residence
- Commercial
- Public/Quasi-Public
- Church
- Farm Outstructure

EXISTING LAND USE

Bowie Power Station, LLC

1 1/2 0 1 MILE

Sources:
Arizona State Land Department, Phoenix, AZ 2001.
United States Geological Survey (USGS), Willcox AZ-NM 1994, 1:100,000-scale metric topographic maps.
Contours interpolated from USGS 1:24,000-scale digital elevation models at an interval of 40 feet.

BOWIE POWER STATION

m/projects/swpg/bowie/arch/landuse.arr Draft April 25, 2001

BOWIE POWER STATION

PUBLIC INVOLVEMENT ACTIVITIES AND TOOLS

- Agency and community briefings
- Newsletters
- Public open houses
- Toll-free telephone voice message information line (877-576-7477)
- News releases
- Open house newspaper advertisements
- Frequently Asked Questions sheet
- Comment Forms
- SWPG website - www.southwesternpower.com

SOUTHWESTERN Power Group II, L.L.C
An Energy Company - Alliance Builder

APRIL 2001

April 2001

PUBLIC OPEN HOUSE
COMMENT FORM

We want to hear your views on the Bowie Power Station project. Your comments are important to help us identify ideas and issues for the project.

COMMENTS:

MAILING LIST:

If you would like to be included on the project mailing list, please print your name and address below. If you would like a return call to discuss any questions or concerns you may have on the project, please note your questions above and include your phone number.

Name:

Address:

City, state, zip:

E-Mail (optional):

Phone Number (optional):

Thank you for your input!

PLACE
POSTAGE
HERE

BOWIE
POWER STATION

SouthWestern Power Group II
4350 E. Camelback Rd - Suite B175
Phoenix, Arizona 85018

EXHIBIT J-4
INTERCONNECTION POWER FLOW STUDY

This copy of the application includes only the Executive Summary. A complete copy of the Interconnection Power Flow Study report will be furnished upon request made to the Applicant, Bowie Power Station, LLC.

Not included:
1. *Introduction and Methodology*
2. *Market Background*
3. *Case Development and Assumptions*
4. *Results*

Appendices: Contingency List, Load Flow Results Tables, Transmission Back-up

Issue Date – 07/26/01

Bowie Power Station
Interconnection Power Flow Study

Bowie Power Station, LLC

July 2001

R·W·BECK

2201 E. Camelback Road, Suite 115B Phoenix, AZ 85016-3433 Phone (602) 957-2888

BOWIE
GENERATION INTERCONNECTION
POWER FLOW STUDY

Table of Contents

EXECUTIVE SUMMARY **ES-1**

1. INTRODUCTION AND METHODOLOGY
- Introduction 1-1
- Purpose of Study 1-1
- Characteristics of AC Transmission Grid 1-2
- Project Description 1-3
- "N-1" Analysis Goals and Methodology 1-8

2. MARKET BACKGROUND
- Market Structure 2-1
  - Organizational Entities 2-1
    - FERC RTO'S 2-2
    - DESERT STAR 2-2
  - Transmission Interconnection Requirements 2-3
- Regional Background 2-4
  - Infrastructure and Constraints 2-4
  - Regional Generation 2-6
  - Proposed Regional Generation 2-6

3. CASE DEVELOPMENT AND ASSUMPTIONS
- Case Development 3-1
  - New Generation Projects in Base Case 3-2
  - Transaction Scenarios 3-3
  - Dispatch Assumptions 3-4
- Contingencies Evaluated 3-5
- Evaluation Criteria 3-5
  - WSCC Planning Criteria 3-5

4. RESULTS
- Interface and Facility Impact 4-1
- Power Flow Summary 4-2
  - Alternative 1: Project Connection to 345 kV 4-4
    - Alternative 1a: 500 MW Sale to AEPCO 4-4
    - Alternative 1b: 500 MW Sale to TEP 4-5
    - Alternative 1c: 1100 MW Sale to AEPCO/TEP 4-5

Alternative 2: Project interconnection to 345 kV and 230 kV 4-6
Alternative 2c: 1100 MW Sale to AEPCO/TEP..... 4-6
Alternative 3: Project Interconnection to Dual 345 kV Lines 4-7
Alternative 3c: 1100 MW Sale to AEPCO/TEP..... 4-7
Alternative 4: Interconnection to Dual-345kV Lines and 230kV 4-8
Alternative 4c: 1100 MW Sale to AEPCO/TEP..... 4-8

APPENDICES

A. CONTINGENCY LIST

B. LOAD FLOW RESULTS TABLES

C. TRANSMISSION BACK-UP

This report has been prepared for the use of the client for the specific purposes identified in the report. The conclusions, observations and recommendations contained herein attributed to R. W. Beck, Inc. (R. W. Beck) constitute the opinions of R. W. Beck. To the extent that statements, information and opinions provided by the client or others have been used in the preparation of this report, R. W. Beck has relied upon the same to be accurate, and for which no assurances are intended and no representations or warranties are made. R. W. Beck makes no certification and gives no assurances except as explicitly set forth in this report.

Copyright 2001, R. W. Beck, Inc.
All rights reserved.

EXECUTIVE SUMMARY

This report summarizes the results of the study to examine the potential impacts on the transmission system of interconnecting the proposed Bowie Power Station, LLC ("Client") 500/1100 MW plant ("Project") addition to the Tucson Electric Power ("TEP") and for Alternatives 2 and 4, the Arizona Electric Power Cooperative ("AEPCO"), Western Systems Coordinating Council ("WSCC") transmission grid approximately 40 miles south of the Greenlee 345 kV substation.

The Interconnection Power Flow Study was prepared by R. W. Beck at the request of Bowie Power Station, LLC to address alternative interconnection scenarios for power delivery from the proposed nominal 1,000 MW Bowie Power Station to the WSCC grid. The alternatives considered Project dispatch at both the 500 MW and 1,100 MW levels to provide interconnection at a range of potential output capacities.

Four different interconnection alternatives, corresponding to those requested in the CEC application, are evaluated herein. Where the power flow analysis identifies facilities that are loaded beyond the applicable facility ratings defined in the load flow case model, whether or not the facility requires upgrade to interconnect the Project to the system and/or to acquire transmission service from the Project will be dependent on specific utility criteria.

The study indicates that the Project can deliver its full output to the transmission grid with few to no transmission upgrades depending upon the interconnection Alternative selected.

Alternative 1 shows no loading violations based on the criteria used for either a 500 or an 1100 MW Project.

Alternative 2 has two 230 kV line violations for the loss of the Willow to Vail 345 kV line (the original Greenlee – Vail 345 kV line). Loss of this line forces the Project output down to the 230 kV system resulting in the 230 kV overloads shown in the table. However, based on the results of Alternative 1 (without the 230 kV interconnection) the violation would be alleviated by transfer tripping the 345/230 kV transformer at Willow for the loss of the identified line.

Alternatives 3 and 4 may require upgrade to the Vail 2 345/138 kV transformer unless a higher shorter term rating can be utilized. Additionally, connections to both 345 kV lines resulted in a violation of the Willow to Vail 2 345 kV (originally the Springerville to Vail 345 kV line) line rating. It is noted however, that this line has a much lower rating than the Greenlee to Vail 345 kV line. The line is identified in TEP's FERC Form 1 data as having twin bundled 954 ACSR for a portion of the line and 954 ACSR Rail for another portion. It is possible that an upgrade of this line could be required to integrate the Project into both 345 kV Vail lines.

All four Alternatives had little to no impact on the listed WSCC transmission paths. Additionally, it is noted that flow on the Springville to Vail 345 kV line is greater

than the output of Springerville Unit 2 in all cases evaluated, i.e., in line with the TEP Two County bond tax restrictions.

PROJECT DESCRIPTION

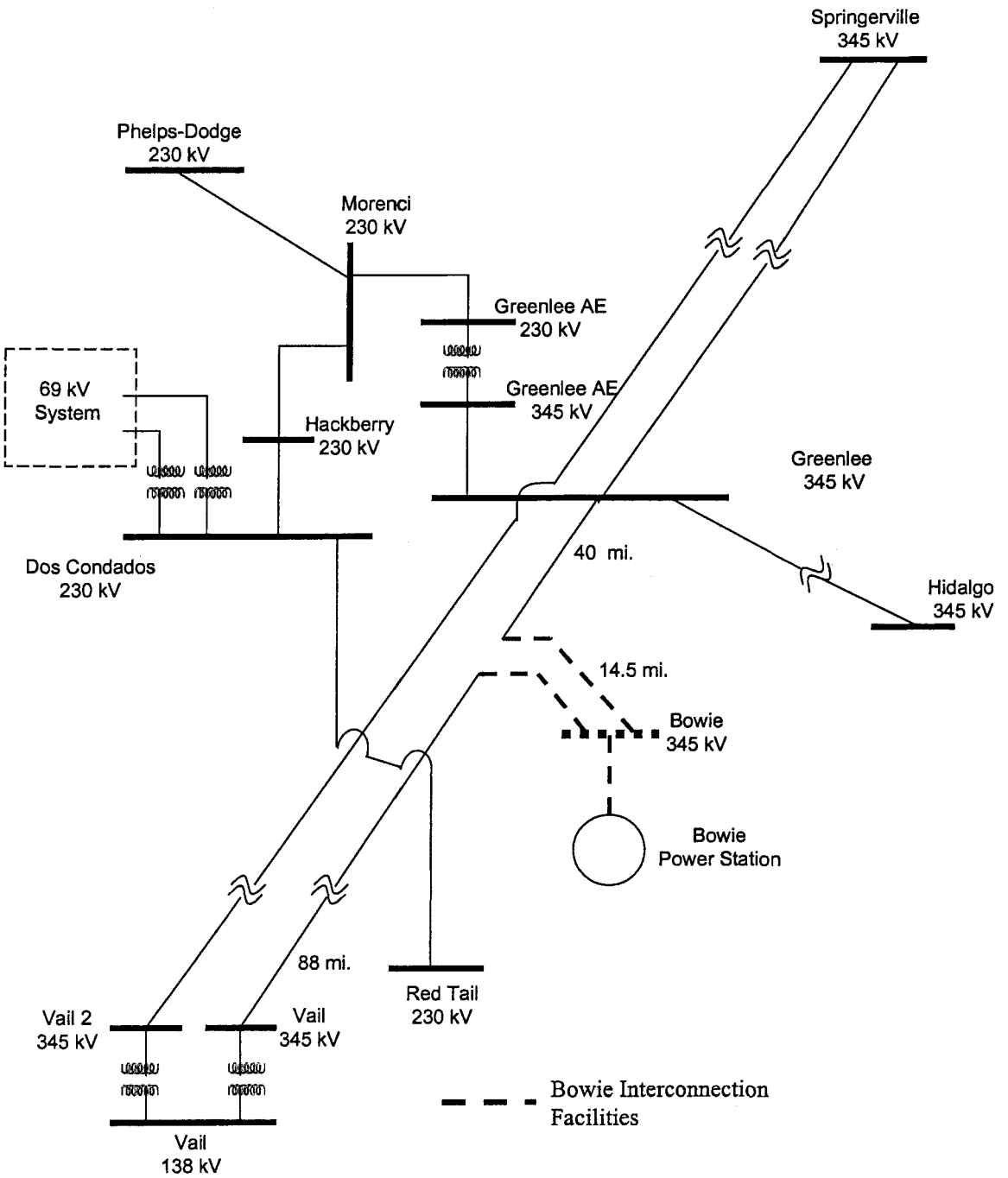
The following lists the Project assumptions used in the analyses.

Project Name:	Bowie
Maximum Summer Capability (MW):	500/1100
Interconnection Voltage:	345 kV (and 230 kV for Alts 2 and 4)
Interconnection Location:	40 miles south of Greenlee 345 kV substation
Interconnection Alternatives:	• Alt 1 – Greenlee – Vail 345 kV • Alt 2 – Greenlee – Vail 345 kV & Red Tail – Dos Condados 230 kV • Alt 3 – Greenlee – Vail 345 kV line & Springerville – Vail 345 kV • Alt 4 – Greenlee – Vail 345 kV line, Springerville – Vail 345 kV line, Red Tail – Dos Condados 230 kV
Host Transmission Utility:	TEP (and AEPCO for Alts 2 and 4)
Reliability Council/RTO:	WSCC
Plant Configuration:	One or Two 2 on 1 GE7FA/Steam Turbnie Combine Cycle with duct firing

Four separate interconnection alternatives were evaluated as shown in the following figures.

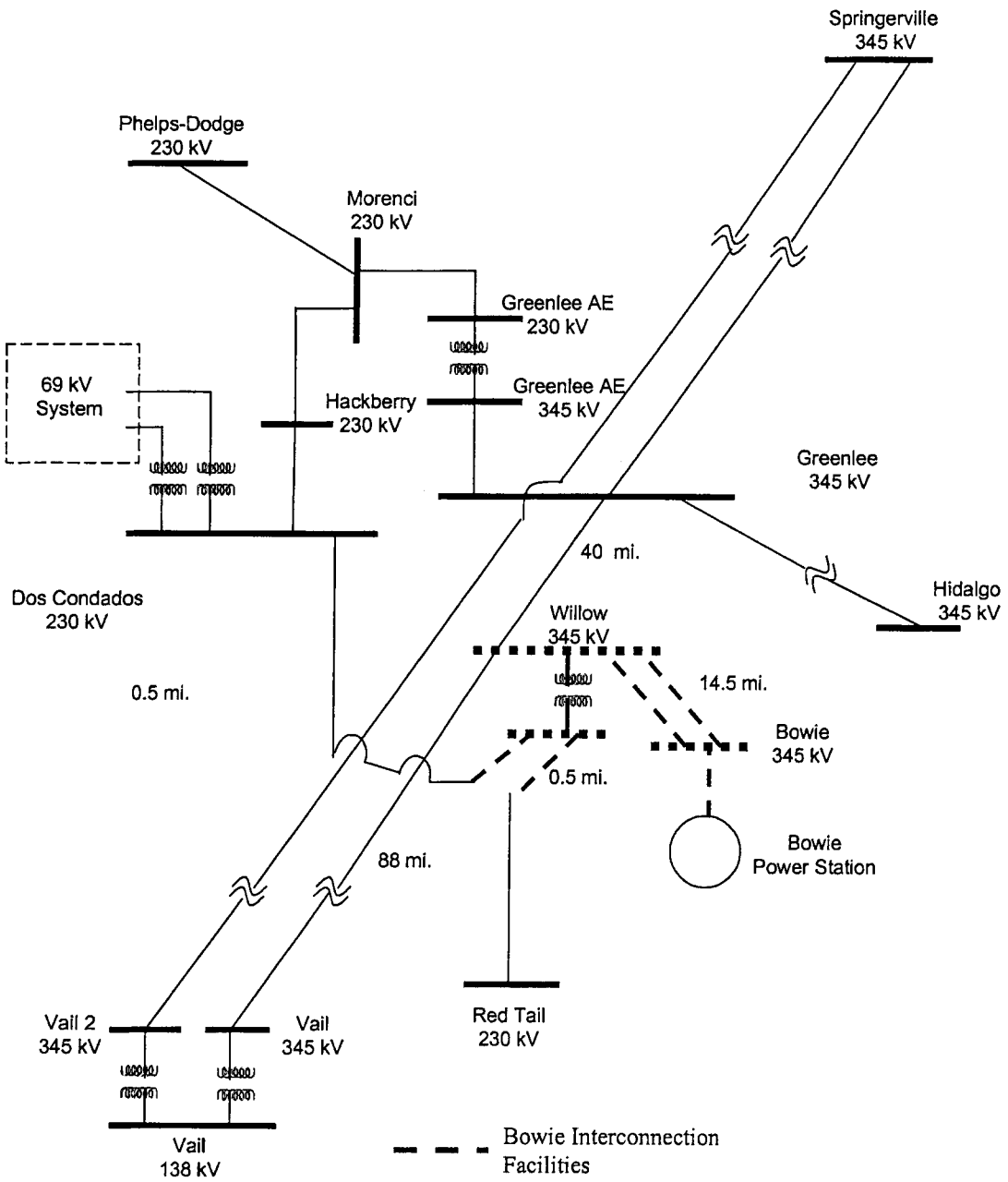
1. Alternative 1: An interconnection to the TEP system via a new 14.5 mile double circuit 345 kV loop in and out of the Greenlee – Vail transmission line approximately 40 miles south of Greenlee.

ALTERNATIVE 1 INTERCONNECTION CONFIGURATION



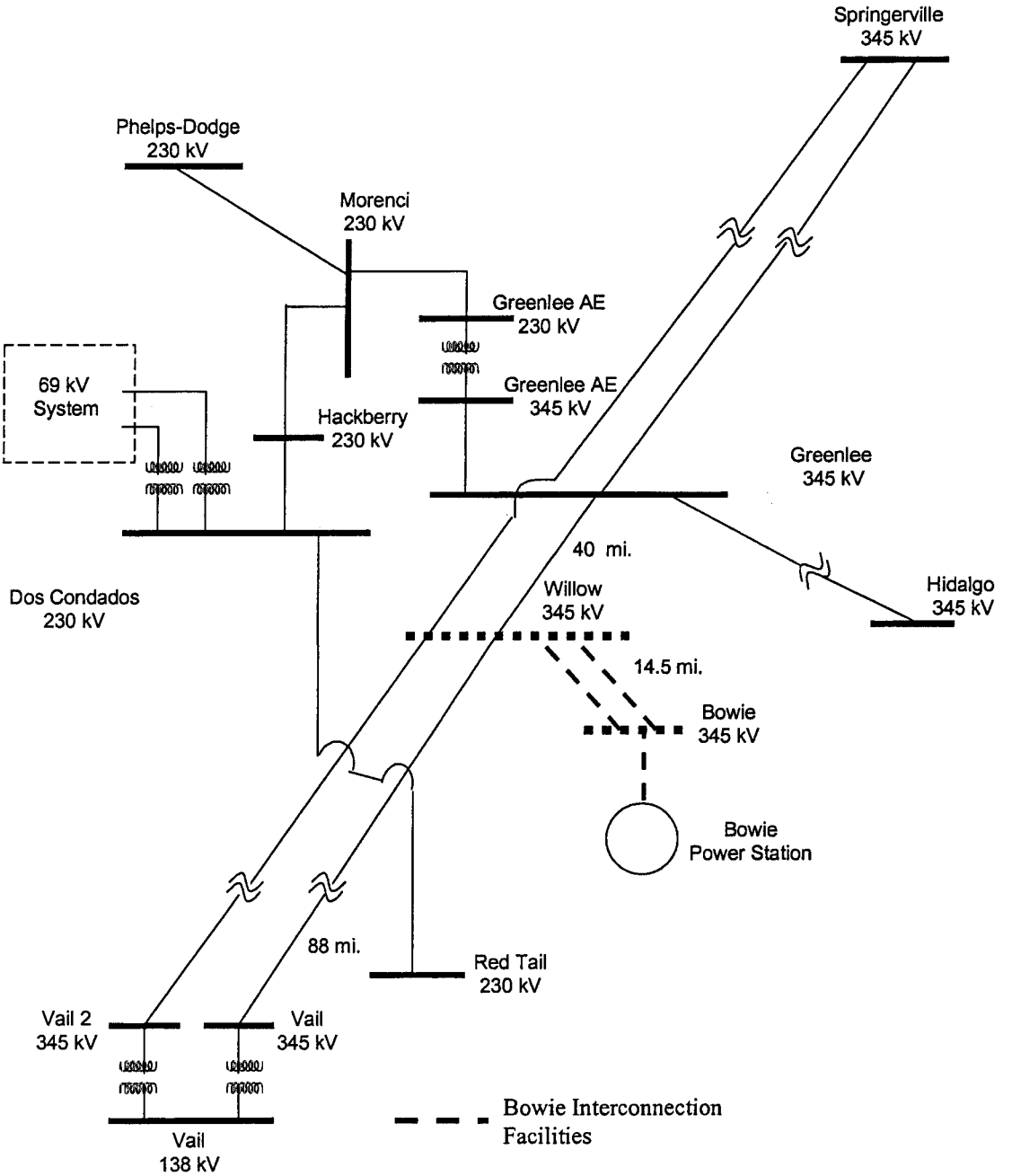
2. Alternative 2: A new substation, Willow, is constructed near the intersection of TEP's Greenlee to Vail 345 kV line and AEPCO's Dos Condados to Red Tail 230 kV line. The 14.5 mile double circuit 345 kV Bowie lines will terminate into the new breaker and a half substation. The Greenlee to Vail 345 kV line also connects to the new substation. Additionally, a 345/230 kV transformer will also be located at the substation with a 0.5 mile double circuit in and out loop of the AEPCO's Dos Condados to Red Tail 230 kV line.

ALTERNATIVE 2 INTERCONNECTION CONFIGURATION



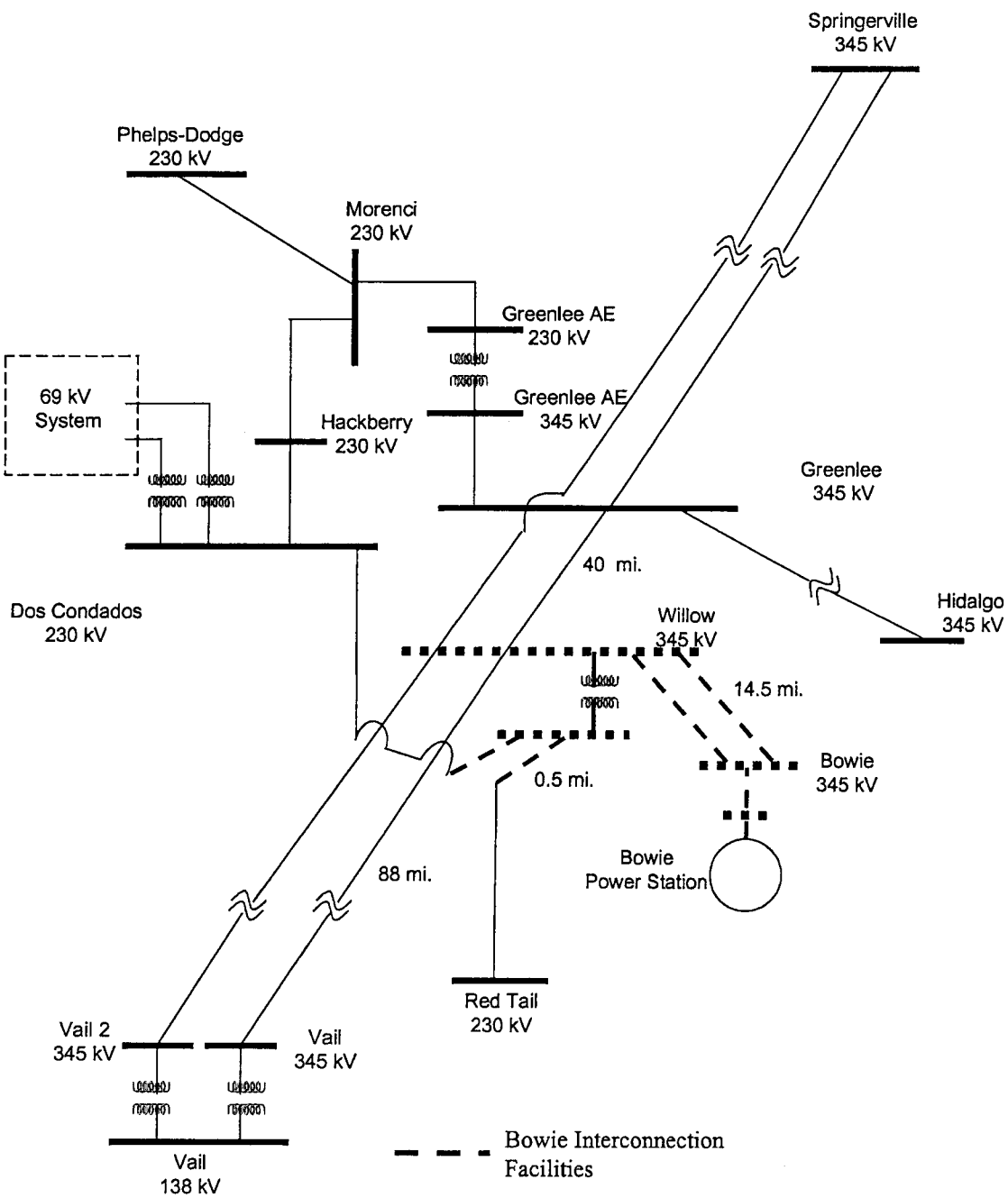
3. Alternative 3: A new substation, Willow, is constructed near the intersection of TEP's Greenlee to Vail 345 kV line and AEPCO's Dos Condados to Red Tail 230 kV line. The 14.5 mile double circuit 345 kV Bowie lines will terminate into the new breaker and a half substation. The Greenlee to Vail 345 kV and the Springerville to Vail 345 kV lines also connect to the new substation.

ALTERNATIVE 3 INTERCONNECTION CONFIGURATION



4. Alternative 4: A new substation, Willow, is constructed near the intersection of TEP's Greenlee to Vail 345 kV line and AEPCO's Dos Condados to Red Tail 230 kV line. The 14.5 mile double circuit 345 kV Bowie lines will terminate into the new breaker and a half substation. The Greenlee to Vail 345 kV and the Springerville to Vail 345 kV lines also connect to the new substation. Additionally, a 345/230 kV transformer will be located at the substation with a 0.5 mile double circuit in and out loop of the AEPCO's Dos Condados to Red Tail 230 kV line.

ALTERNATIVE 4 INTERCONNECTION CONFIGURATION



NEW GENERATION MODELED IN BASE CASE

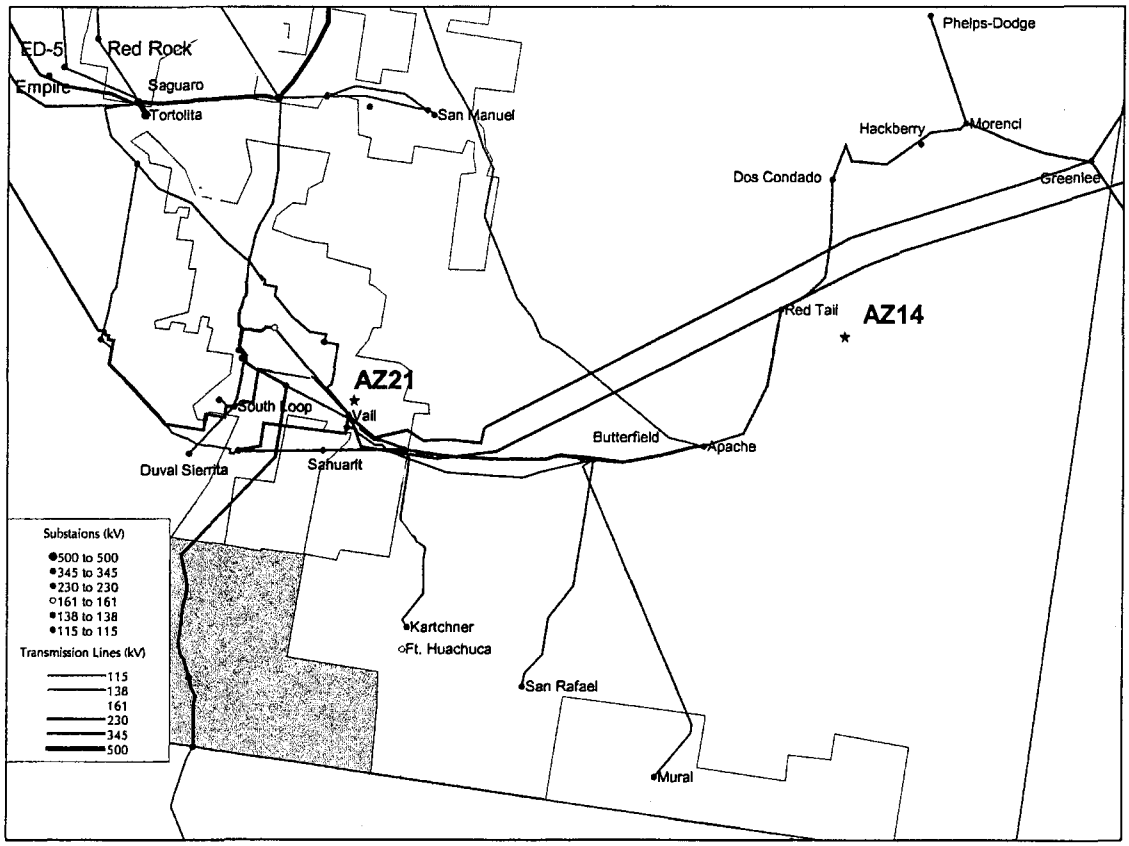
The dispatch of generation in a region impacts transmission system power flows. While it is not possible to evaluate all possible operational impacts, for planning purposes, it is necessary to assume a certain level of generation to meet the projected load. In this regard, assumptions need to be made as to which new generation projects should be included in the Base Case model used. For this analysis, plants that will be operating by 2002, additional CEC approved combined cycle plants in the Phoenix/East Valley/Tucson areas and a portion of the Palo Verde hub generation have been included in the model. Additionally, due to the proximity of the site location to New Mexico, the 500 MW Duke plant at Luna has been included in the Base Case. New projects included in the Base Case are summarized below:

1. Red Hawk 1000 MW Project (added to Base Case dispatched at 886 MW)
2. Santan 850 MW Project (already in 2001 series WSCC Case dispatched at 726 MW)
3. Desert Basin 500 MW Project (already in 2001 series WSCC Case dispatched at 460 MW)
4. Calpine West Phoenix 500 MW Project (already in 2001 series WSCC case dispatched at 300 MW)
5. Griffith Energy 650 MW Project (already in 2001 series WSCC case dispatched at 540 MW)
6. Calpine Southpoint 520 MW Project (already in 2001 series WSCC case dispatched 420 MW)
7. Panda Gila River 2080 MW Project (added to Base Case and dispatched 900 MW)
8. Other PV area new generation dispatched at 35 MW
9. Toltec Power Station 2000 MW Project (added to Base Case and dispatched at 1000 MW)
10. Duke Luna 550 MW Project in New Mexico (added to Base Case and dispatched at 500 MW)

TRANSACTION SCENARIOS

Based on the location of the Project, primary markets are located in southeast Arizona, an area shown on the following figure.

SOUTHEAST ARIZONA REGION



Proposed Generation Table in Southeastern Arizona

#	Developer	Plant Name	Location	State	MW	ISDN	Comments
AZ14	Bowie Power Station, LLC.	Bowie Power Station	Bowie	AZ	1000	2004	Planned – Announced 1/31/01
AZ21	Tucson Electric Power Co	Vail Generating Station	Rita Ranch	AZ	150	2002	Peaking Facility

The transaction schedules shown in Table 2 were simulated in the load flow case models to examine the potential impact on the transmission system of delivery to the primary markets.

Table 2
Transaction Schedules in MW

Region	"a" (Alt 1 Only) AEPCO	"b" (Alt 1 Only) TEP	"c" (All Alternatives) AEPCO/ TEP
Southeastern AZ	500	0	500
Southeastern AZ/Tucson	0	500	600

RESULTS

The following table summarizes the results for the integration Project under all four Alternatives. For lines where only one rating is identified, we have assumed that an emergency rating of 110% of continuous rating would apply based on assumptions made in the Southeast Arizona Transmission Study report as discussed under the evaluation criteria section. Loadings above the 110% of continuous rating limit have been highlighted in the table.

Tp	Overloaded Element	Rating N/E (MVA)	AC Power Flows % of E Rating						
			Base	Alt 1 Single 345 kV Connection			Alt 2 Single 345 kV & 230 kV Connection	Alt 3 Double 345 kV Connection	Alt 4 Double 345 kV & 230 kV Connection
				"a" 500	"b" 500	"c" 1100	"c" 1100	"c" 1100	"c" 1100
L	Apache To Red Tail 230kv[1]	351	29%	N.O.	N.O.	N.O.	109%	N.O.	N.O.
X	Bicknell To Bicknell 230/345kv[1]	150/193	65%	1%	100%	43%	88%	N.O.	N.O.
L	Buterfld To Pantano 230kv[1]	268	75%	23%	101%	51%	N.O.	N.O.	N.O.
L	Red Tail To Willow 230kv[1]	351	27%	-	-	-	111%	-	N.O.
L	Sag.East To Oracle 115kv[2]	120	93%	110%	90%	106%	103%	107%	104%
X	Tortolit To Tortolit 500/138k[1]	600/672	64%	66%	93%	102%	100%	91%[3]	92%
L	Vail2 To Willow 345kv[1] (originially Springerville – Vail)	666/806	42%	-	-	-	-	121%	113%
X	Vail2 To Vail 345/138kv[1]	600/720	49%	58%	73%	88%	87%	135%	126%

1. Loss of Project Bus (Alt 1) or Willow (Alts 2, 3 and 4) to Vail 345 kV line (originally Greenlee – Vail 345 kV line)
2. Loss of Saguaro West to San Manuel 115 kV line
3. Loss of Willow to Vail 345 kV line (originally Springerville – Vail 345 kV line)

Alternative 1 shows no loading violations based on the criteria used for either a 500 or an 1100 MW Project with the exception of a slight overload of the Tortolita 500/138 kV transformer which reached 102% of emergency rating. It is expected that this violation could be handled via operational means. All other facilities are within their identified emergency ratings or within 110% of their continuous ratings.

Alternative 2 has two 230 kV line violations for the loss of the Willow to Vail 345 kV line (the original Greenlee – Vail 345 kV line). Loss of this line forces the Project output down to the 230 kV system resulting in the 230 kV overloads shown in the table. However, based on the results of Alternative 1 (without the 230 kV interconnection) the violation would be alleviated by transfer tripping the 345/230 kV transformer at Willow for the loss of the identified line.

Alternatives 3 and 4 may require upgrade to the Vail 2 345/138 kV transformer unless a higher shorter term rating can be utilized. Additionally, connections to both 345 kV lines resulted in a violation of the Willow to Vail 2 345 kV (originally the Springerville to Vail 345 kV line) line rating. It is noted however, that this line has a much lower rating than the Greenlee to Vail 345 kV line. The line is identified in TEP's FERC Form 1 data as having twin bundled 954 ACSR for a portion of the line

and 954 ACSR Rail for another portion. It is possible that an upgrade of this line could be required to integrate the Project under the Alternatives 3 and 4 configuration, i.e., connected to both 345 kV Vail lines.

Interface Impact

Impact on key interface limitations are a consideration. The following tables show the contribution of the Project on the defined transmission paths.

Power Flow over Defined Paths and Regional Facilities

WSCC Path #	Path/Facility Description	Rating	Path/Facility Flows						
			Base	"1a" AEPCO 500 MW	""1b" TEP 500 MW	"1c" AEPCO/TEP 1100 MW	"2c" AEPCO/TEP 1100 MW	"3c" AEPCO/TEP 1100 MW	"4c" AEPCO/TEP 1100 MW
			MW	MW	MW	MW	MW	MW	MW
22	Southwest of Four Corners	2325 (E – W)	1751	1767	1777	1797	1790	1795	1793
47	Southern New Mexico (NM1)	925 (S) [1] 1048 (NS) [2]	589	590	589	590	590	590	590
49	East of the River (EOR)	7550 (E – W) Not rated (W – E)	5011	5009	5007	5006	5005	5005	5005
50	Cholla to Pinnacle Peak	1200 (E – W)	1096	1107	1094	1103	1101	1105	1103
NA	Springerville – Greenlee 345 kV line	745/1010	378	335	261	195	220	342	328
NA	Greenlee – Vail 345 kV line	896/1210	190	-	-	-	-	-	-
NA	Greenlee – Project Bus 345 kV line	896/1210	-	-73	20	-278	-	-	-
NA	Project Bus – Vail 345 kV line	896/1210	-	419	508	790	-	-	-
NA	Greenlee – Willow 345 kV line	896/1210	-	-	-	-	-106	-75	15
NA	Willow – Vail 345 kV line	896/1210					754	619	584
NA	Springerville – Vail 345 kV line	666/806	322	318	390	402	395	-	-
NA	Springerville – Willow 345 kV line	666/806	-	-	-	-	-	215	240
NA	Willow – Vail 345 kV line	666/806	-	-	-	-	-	586	566
NA	Greenlee 230/345 kV xfmr #1	150/193	39	-64	26	-78	-9	-69	-17
NA	Greenlee 230/345 kV xfmr #2	150/193	37	-68	28	-83	-10	-73	-18
NA	Dos Condados – Red Tail 230 kV line	350/438	-126	80	-105	108	-	90	-
NA	Dos Condados – Willow 230 kV line	350/438	-	-	-	-	-32	-	-15
NA	Willow – Red Tail 230 kV line	350/438	-	-	-	-	180	-	155

1. Simultaneous
2. Non-Simultaneous

All four Alternatives had little to no impact on the listed WSCC transmission paths. Additionally, it is noted that flow on the Springville to Vail 345 kV line is greater than the output of Springerville Unit 2 in all cases evaluated, i.e., in line with the TEP Two County bond tax restrictions.

BOWIE POWER STATION

Bowie Power Station

Application for a Certificate of Environmental Compatibility

Bowie Power Station, L.L.C.

Hearing Testimony for

State of Arizona Power Plant and Transmission Line Siting Committee

October 11, 2001

EXHIBIT
Admitted
A-7

BOWIE POWER STATION

Table of Contents

- Tom C. Wray – Tab A
- Jeffrey W. Schroeter – Tab B
- Michael S. Siegel – Tab C
- Scott Peters – Tab D

A

BOWIE POWER STATION

Witness Background

- Tom C. Wray
- General Manager, SWPG II, LLC

1

BOWIE POWER STATION

Witness Background

- Educational Background
  - Bachelors of Science, Louisiana State University
  - Masters, Electrical Engineering, University of Colorado
  - Masters, Business Administration, University of New Mexico
- Over 30 years of professional experience in electric power industry
- Developed, licensed, and permitted the Navajo Transmission Project and Panda Gila River Power Generation Facility
- Participating as Applicant's policy representative in Toltec Power Station CEC (Cases 112 and 113)

2

BOWIE POWER STATION

Scope of Testimony

- Market Analysis
- Public Involvement Activities
- Property Tax Benefits
- Conclusions

3

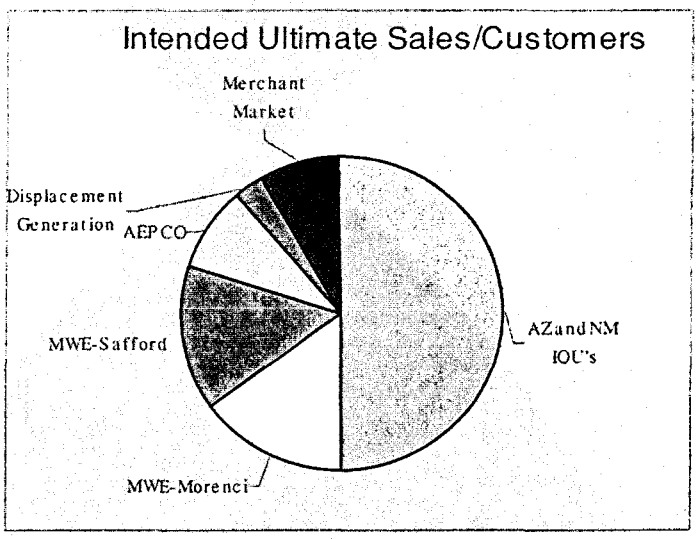
BOWIE POWER STATION

Capacity and Energy Contract Sales To:

- Tucson Electric Power Company
- Morenci Water & Electric
  - Morenci mine
  - Proposed Safford mine
- Arizona Electric Power Coop., Inc.
  - Regional electric cooperatives
- Other utilities in Arizona and New Mexico
- Displaced generation

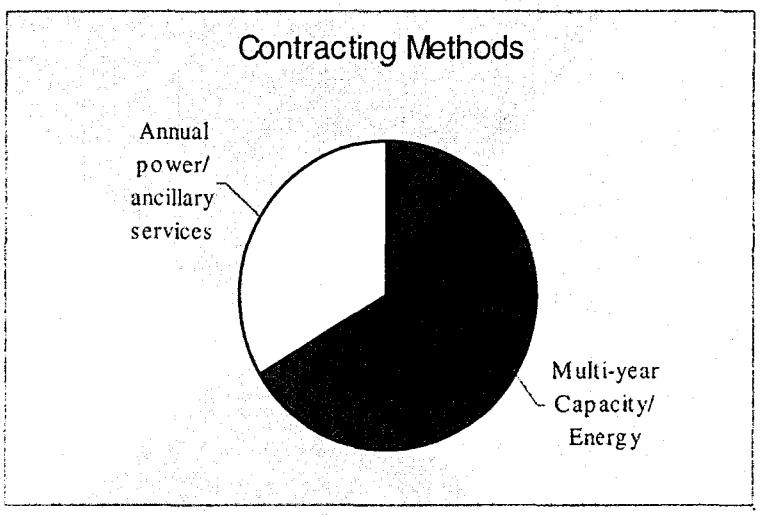
4

Bowie Project Output



5

Bowie Project Output



6

BOWIE POWER STATION

Public Involvement Activities

- Initial Press Release – January 31, 2001
- Over 35 "leader packets" to officials, agencies, and key community members
- Newsletters in April and September 2001 (approximately 4,670 recipients)
- Toll free telephone information line
- Public meetings in Willcox and Bowie in April 2001

7

BOWIE POWER STATION

Public Involvement Activities (continued)

- Media outreach efforts
  - Two news releases
  - Paid display advertisements (two local newspapers to announce public meetings)
  - Several news articles in Arizona Range News

8

BOWIE POWER STATION

Meetings and Briefings

- Cochise County
- Graham County
- Bowie Fire Department
- Bowie Unified School District
- City of Willcox
- Willcox Chamber of Commerce and Agriculture
- Willcox Unified School District
- San Simon Unified School District

9

BOWIE POWER STATION

Property Tax Benefits

- Potential to add $3 to $5 million in annual revenues per project phase
  - Bowie Unified School Districts
  - Fire District
  - Library
  - Flood Control District
  - General County

10

BOWIE POWER STATION

Conclusions

- Market Considerations and Need
  - Meets key market needs (Phoenix, Tucson)
  - Compliments ongoing planning and reliability efforts in the state (Central Arizona Transmission Study)
- Economic Considerations
  - Provides tax revenues
  - Promotes local development
  - Provides employment
- Community Support
- Environmentally Compatible
- Balances Need and Environment

11

B

Witness Background

- Jeffrey W. Schroeter, Genovation Group, Inc.
- Acting Project Manager for Bowie Power Station

1

Witness Background

- Jeffrey W. Schroeter, P.E.
- President, Genovation Group, Inc.
- Educational background
  - BS Mechanical Engineering, Texas A&M University
- Over 22 years of professional experience in all aspects of power generation project development
- Past Chair, ASME Power Division
- Developed Panda Gila River Power Generation Facility, Case No. 99

2

Scope of Testimony

- Project Facilities and Site Description
- Transmission Facilities
- Natural Gas Supply
- Water Supply
- Permits and Approvals
- Security
- Conclusions

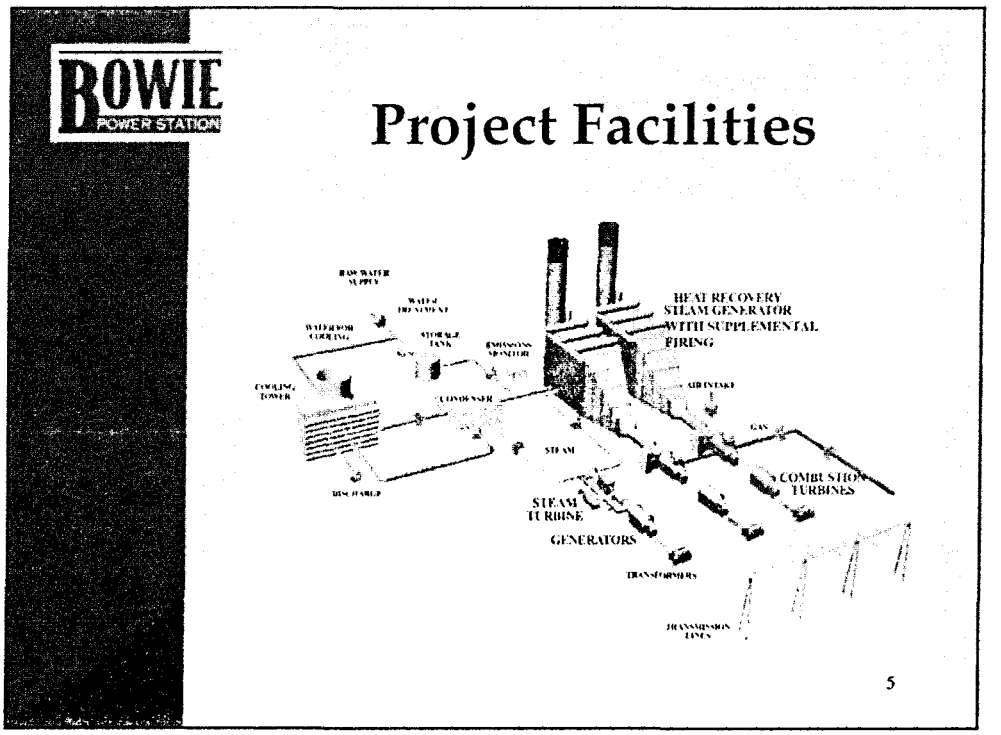
3

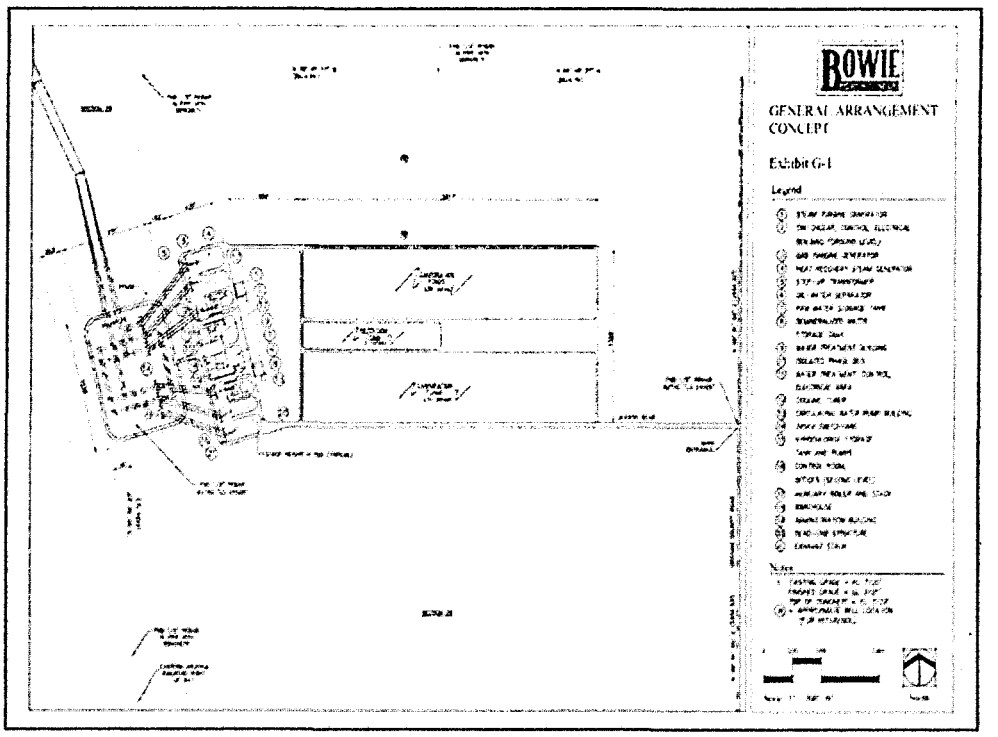
Project Facilities

Base Design

- Two 500 MW (nominal) units in a base load configuration
  - Combined cycle
- 100 MW (nominal) peaking resource
  - Duct firing capability
- Allows for phased construction

4


BOWIE
POWER STATION
Project Facilities
HEAT RECOVERY
STEAM GENERATOR
WITH SUPPLEMENTAL
FIRING
COMBUSTION
TURBINES
STEAM
TURBINE
GENERATORS
5


BOWIE
GENERAL ARRANGEMENT
CONCEPT
Exhibit G-1
Legend

Site Attributes

- Near existing high voltage transmission lines and accessible corridors
- Near existing All American and El Paso Natural Gas pipelines
- Adequate water supply
- Low population density
- Absence of critical cultural/biological issues
- Adequate land buffer
- Community support
- Property located outside of 100-year floodplain

7

Transmission Facilities

- Bowie 345kV Switchyard to proposed 345/230kV Willow Switchyard in Graham County
  - Tie the Bowie 345kV transmission lines into the existing TEP Greenlee-Vail and/or Springerville-Vail 345kV transmission lines
  - Provides an optional interconnection with the AEPCO Red Tail-Dos Candados 230kV transmission line located adjacent to the switchyard site

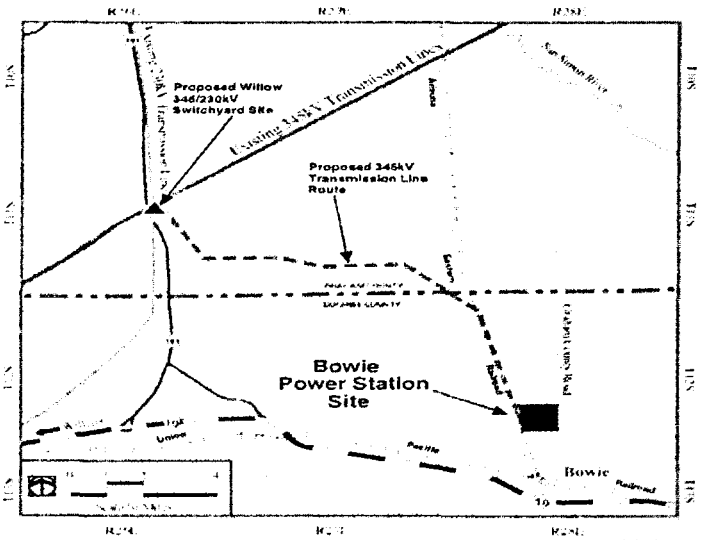
8

Transmission Route Benefits

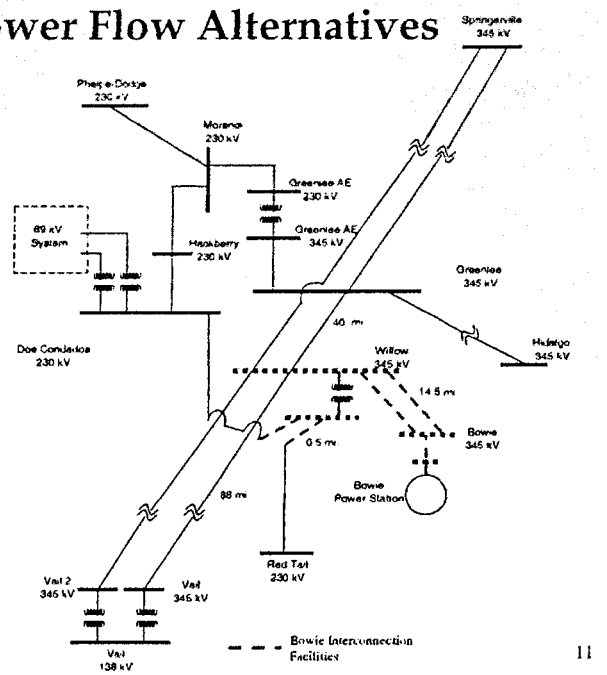
- Shortest route
- Allows for both 345/230kV connections
- Closely follows existing roads

9

Proposed Transmission Line Route



Power Flow Alternatives



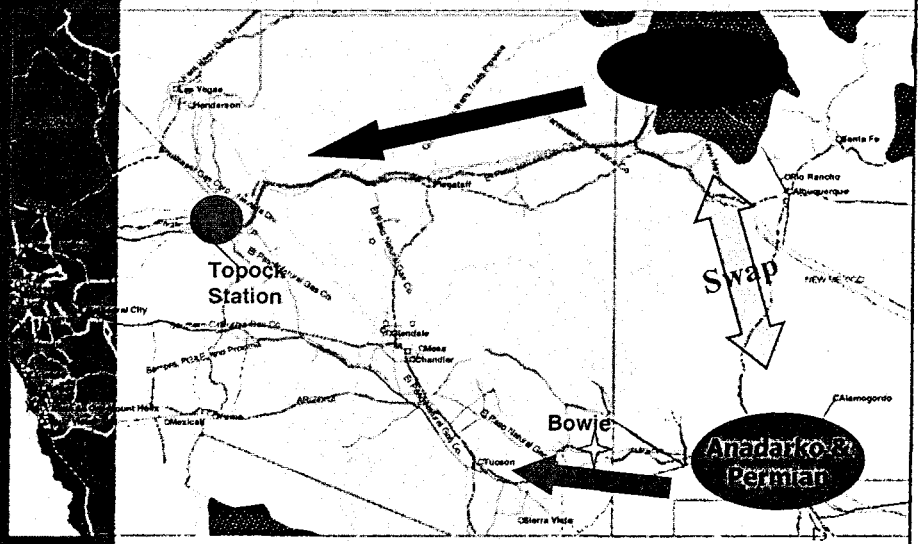
11

Natural Gas Supply and Transportation

- Bowie will consume approximately 200,000 Dth per day of natural gas at full build out
- Supply will be sourced from multiple production basins, primarily the Anadarko, Permian, and San Juan; Bowie also has access to Central Rockies production volumes
- Transportation will be sourced from the El Paso Natural Gas system
- Bowie will have adequate supply and transportation options available for its generation needs

12

Southwest Pipeline Systems



Water Supply Requirements

- Approximately 5,500 acre-feet per year, 3,410 gpm at full build out (two-unit configuration)
- Very efficient use of water supply compared to solid fuel plants
- Plant will be supplied by groundwater from on-site wells

14

BOWIE POWER STATION

Water Use

- Design average of 15 cycles of concentration in the plant's cooling towers
- Discharge blowdown water and add make-up water to cooling towers continuously
- Zero liquid discharge water handling and evaporation system preventing off-site discharge

15

BOWIE POWER STATION

Water Supply Studies

- Initial assessment of groundwater conditions using existing data
- Field inventory of existing wells on the Bowie property
- Aquifer testing of existing irrigation wells
- Groundwater sampling and analysis
- Modeling of water level drawdowns to assess potential impacts of new wells

16

Groundwater Availability Results

- Sufficient groundwater beneath the Bowie property to meet needs for the planned 30-year life of the facility
- Property is not located within a groundwater Active Management Area (AMA) or Irrigation Non-Expansion Area (INA)

17

Groundwater Quality Investigation Results

- Groundwater quality is excellent
- TDS concentration ranges about 250 milligrams per liter
- No exceedances of numeric Aquifer Water Quality Standards

18

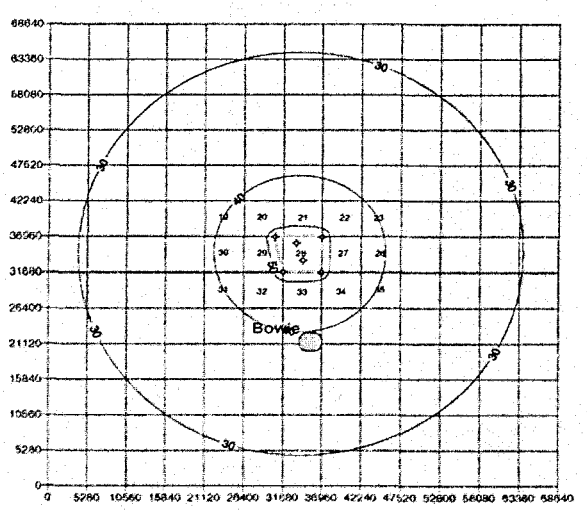
Water Level Drawdown Results

- Analysis assumptions
  - Six new wells pumping for 30 years
  - Analyzed incremental drawdown beyond current agricultural pumping
  - Total incremental pumping rate of 1,840 gpm (307 gpm per well)
- Model results
  - Predicted 40 to 50 feet of drawdown at the wellfield after 30 years

19

Model-Predicted Water Level Drawdown Contours

703 acres
Pumpage = 5,500 ac-ft/yr - (703 ac x 3.6 ac-ft/ac/yr) = 2970 ac-ft/yr = 1,840 gpm
6 wells each pumping at 307 gpm for 30 years
T = 40,000 gpd/ft
S = 0.0005



20

Subsidence and Earth Fissure Investigation

- No significant subsidence
  - Total of 5 feet of subsidence at the plant site through 2001
  - Predicted 2.2 feet residual subsidence without plant
  - An additional 2.4 feet of subsidence may occur as a result of pumping for 30 years
- The power plant facilities and infrastructure will be designed to accommodate possible subsidence

21

Subsidence and Earth Fissure Investigation

- No significant earth fissuring
  - Nearest earth fissure is 2 miles to the east of the property
  - No fissures trend toward plant site location
  - Potential for formation or growth of earth fissures is negligible

22

Permits and Approvals

- Prevention of Significant Deterioration (PSD) permit (Arizona Department of Environmental Quality and EPA)
- Well Drilling and Operations Permit (Arizona Department of Water Resources)
- Aquifer Protection Permit (Arizona Department of Environmental Quality)
- Special Use Permit (Cochise County)
- Transmission line right-of-way (Arizona State Land Department)

23

Bowie Plant Security

- Perimeter security fencing
- Security lighting
- Controlled access gates
- Redundant sources of communications to off site
  - Electric control area
  - El Paso Gas transmission
  - Law enforcement and general public
- On-site water production
- Coordination with local governmental agencies

24

BOWIE POWER STATION

Conclusions

- Site location and infrastructure
  - Optimizes transmission interconnections and existing corridors
  - Adequate natural gas supply and transportation option
  - Adequate water supply
  - Road and rail access

25

BOWIE POWER STATION

Conclusions (continued)

- Environmental Compatibility
  - Will meet or exceed air and water quality standards
  - Low population density
  - Absence of critical cultural/biological issues
  - Minimal noise and visual impact
  - Comprehensive landscape and reclamation plan

26

C

Witness Background

- Michael S. Siegel, AICP
- Principal, Senior Planner, and Project Manager for EPG
- Education
  - Masters, City and Regional Planning, Illinois Institute of Technology
  - BA, University of California, Los Angeles

1

Witness Background (continued)

- 20 years of experience in environmental planning and electrical facility siting
- EPG's lead consultant for preparation of CEC application

2

Scope of Testimony

- Overview of project site conditions
- Present environmental studies and results
- Provide opinion on environmental compatibility of the project

3

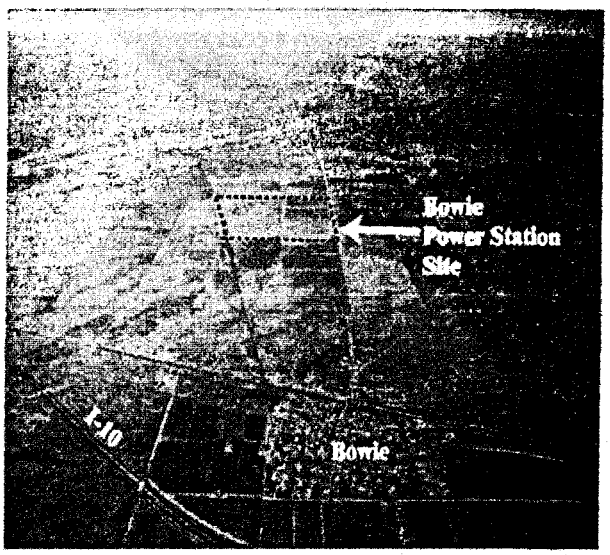
Overview of Project Site

- Plant site
- Views/existing conditions
- Transmission line route

4

BOWIE POWER STATION

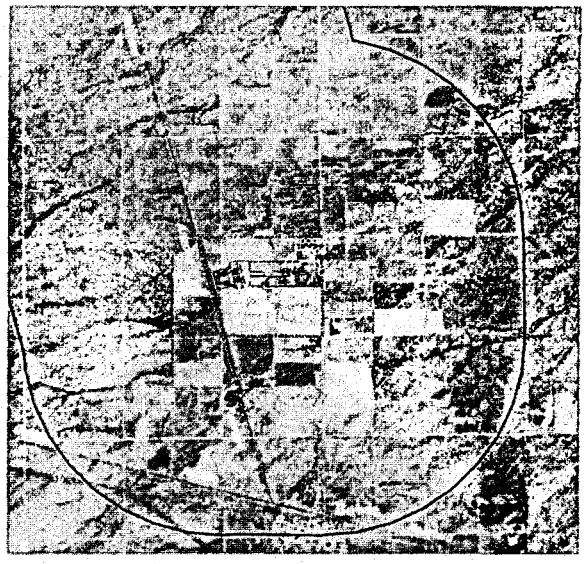
Aerial View of Plant Site



5

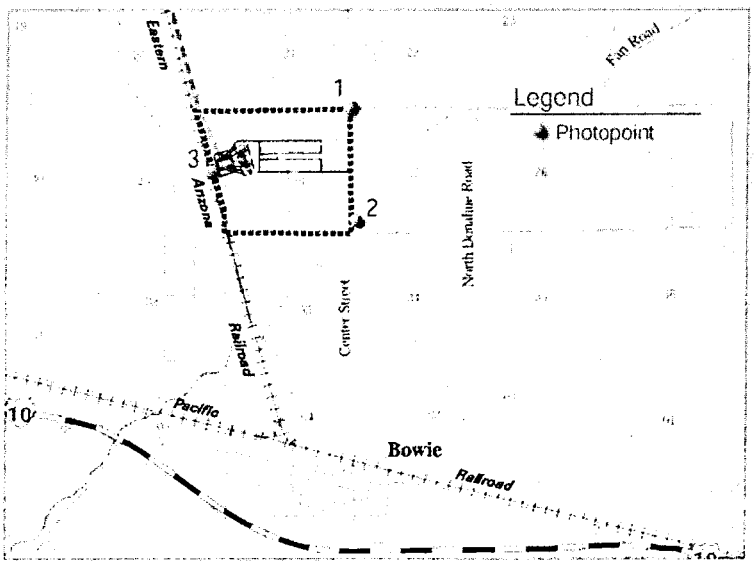
BOWIE POWER STATION

Site Location



6

Viewpoints

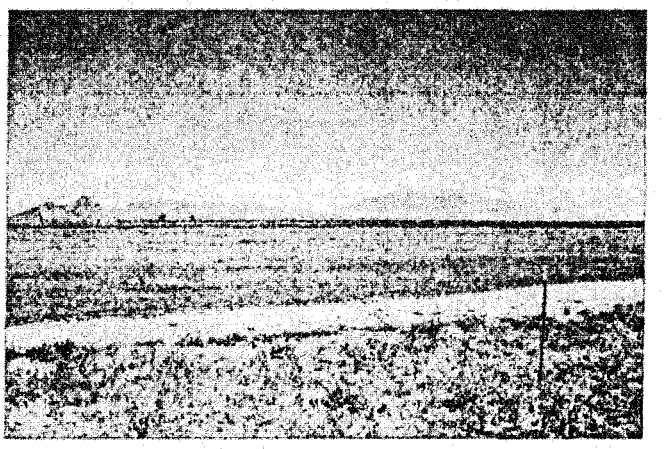


Location 1

8

BOWIE POWER STATION

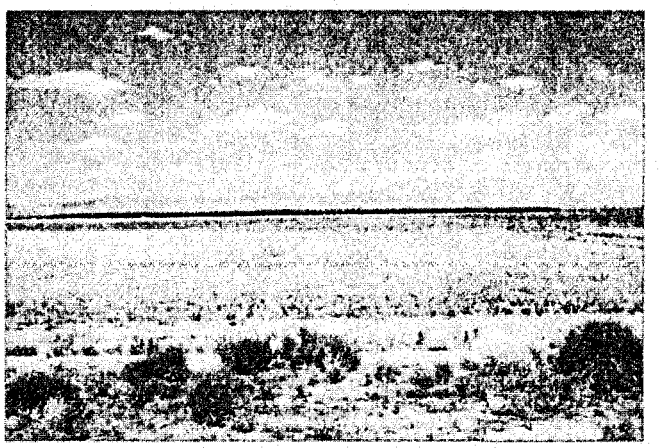
Location 2



9

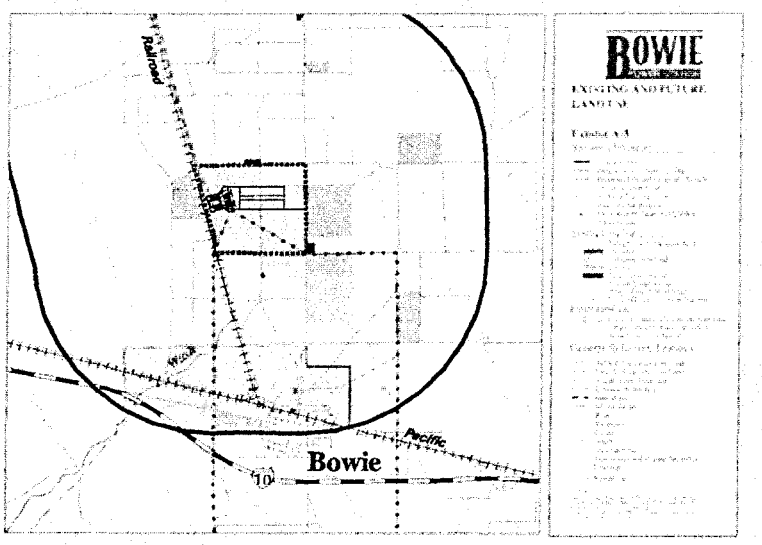
BOWIE POWER STATION

Location 3

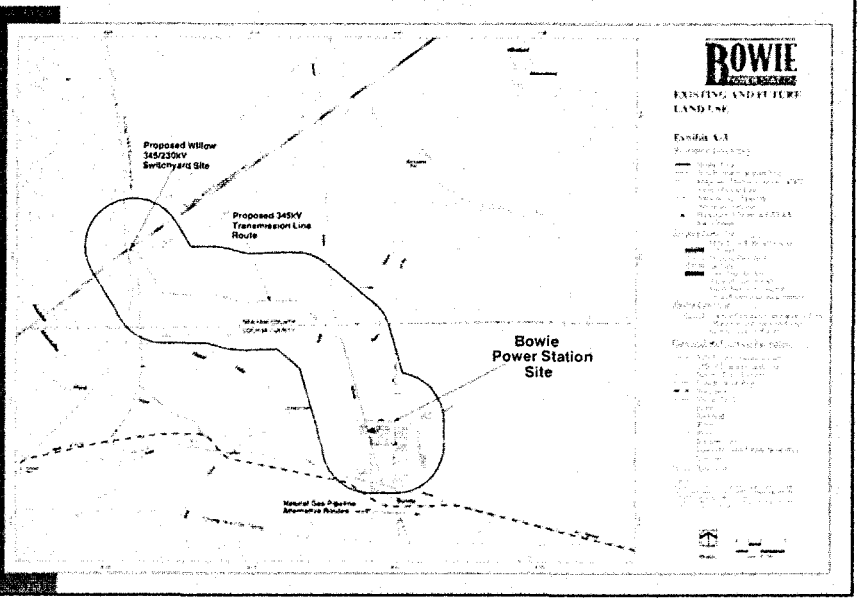


10

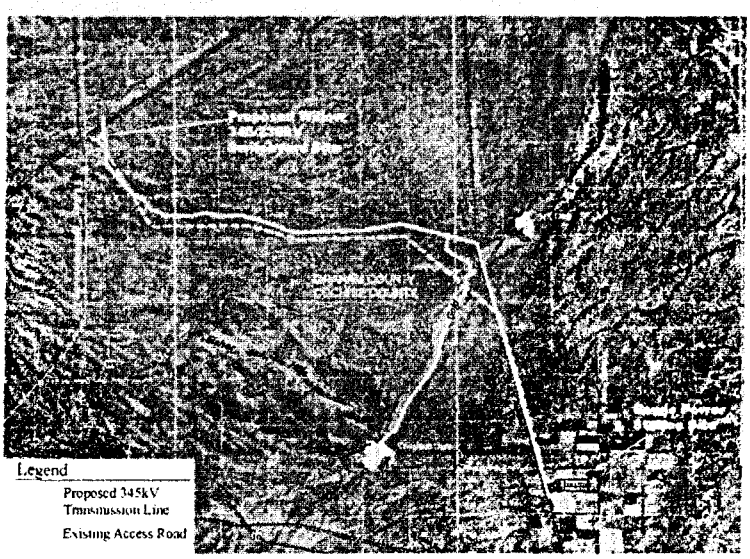
Existing and Future Land Use



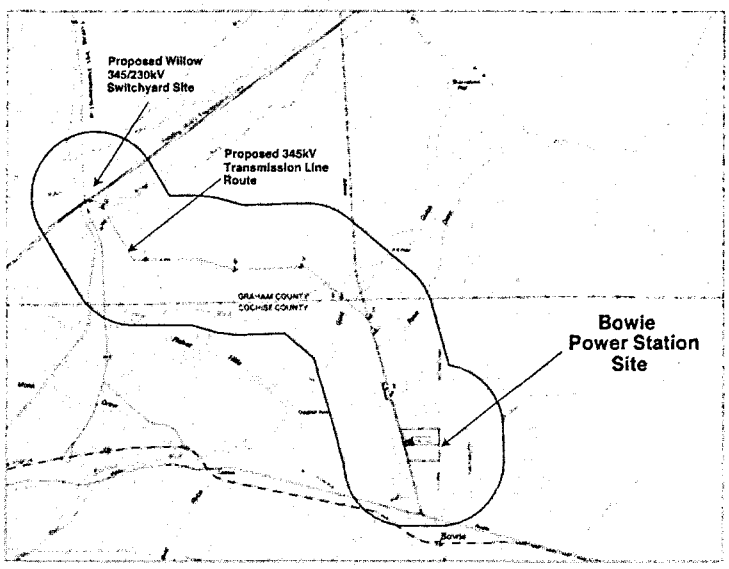
Existing and Future Land Use



Transmission Line Route



Photopoint Map



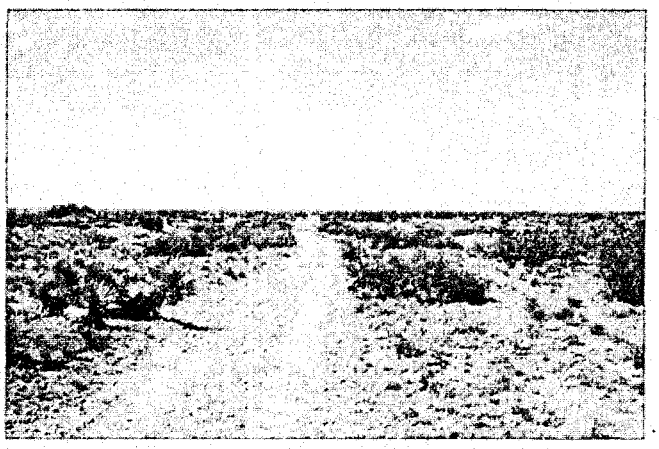
BOWIE POWER STATION

Point 1 (north)

15

BOWIE POWER STATION

Point 2 (north)



16

BOWIE POWER STATION

Point 3 (northwest)

17

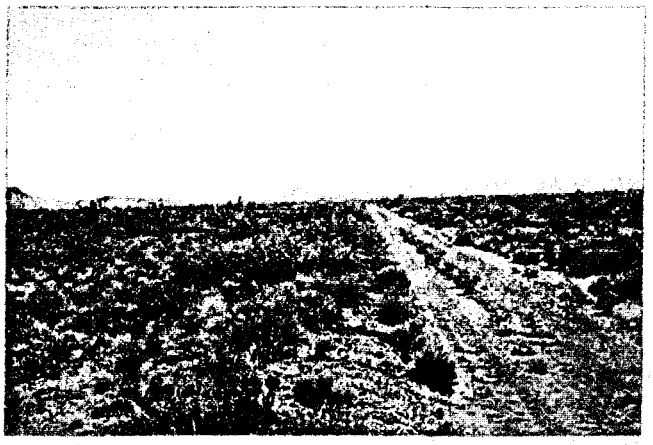
BOWIE POWER STATION

Point 4 (northwest)

18

BOWIE POWER STATION

Point 5 (west)



19

BOWIE POWER STATION

Point 6 (west)

20

BOWIE POWER STATION

Point 7 (northwest)

21

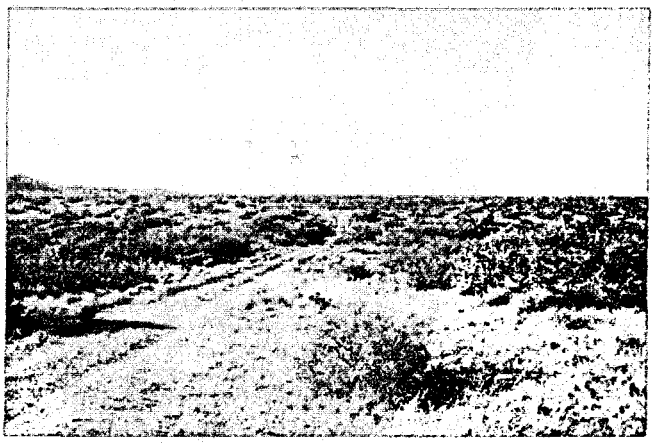
BOWIE POWER STATION

Point 8 (northwest)

22

BOWIE POWER STATION

Point 9 (northwest)



23

BOWIE POWER STATION

Environmental Studies and Results

- Existing and future land use
- Biological resources
- Historic and archaeological resources
- Scenic areas and visual resources
- Noise and interference

24

Existing Land Use

(Exhibits A, B-1)

- Power plant site is located on private land used for farming
- Transmission line route crosses vacant state and private land
- Nearest permanent residence located approximately 1 mile south of power plant and transmission line route
- No conflict with existing land uses associated with the plant site or transmission line route

25

Future Land Use

(Exhibits A, B-1)

- No pending major subdivisions or master planned developments in study area
- Project site designated as Category D - Rural Area in Cochise County Comprehensive Plan
  - Heavy industry is permitted in Category D
  - Facility will require a special use permit
- No conflicts with future land uses or development plans associated with the plant site or transmission line route

26

Biological Resources

(Exhibits C, D)

- Field reviews conducted
- Contacted state and federal agencies
  - Arizona Game and Fish Department
  - U.S. Fish and Wildlife Service
- No special status wildlife, plant species, or habitat found on plant site or transmission line route

27

Historic and Archaeological Resources

(Exhibit E-2)

- Records search and intensive Class III field survey conducted
- No adverse impacts to historic or archaeological resources associated with the plant site or transmission line route

28

Scenic Areas and Visual Resources

(Exhibits E-1, G)

- Low to average scenic quality
- Transmission line route follows existing access
- Limited viewers
  - Nearest residence 1 mile away
  - Bowie community 2 miles away
- Minimal visual impacts with mitigation

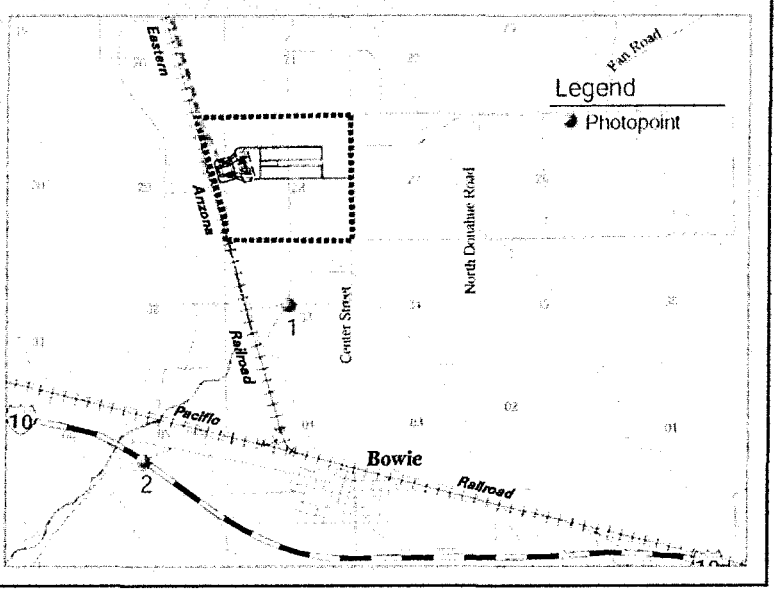
29

Visual Mitigation

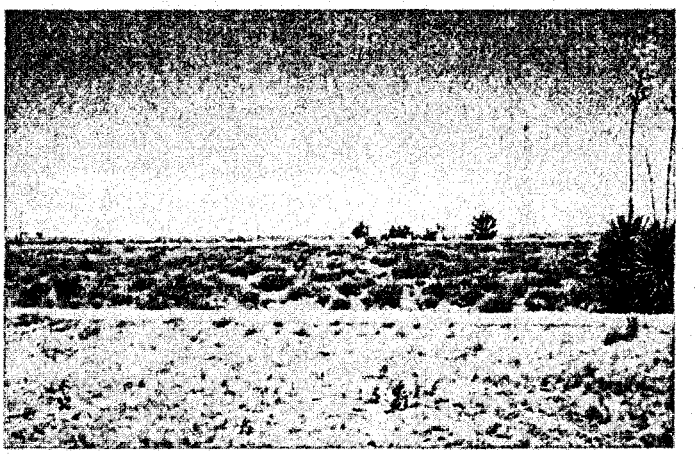
- Plant site
  - Landscape rehabilitation and enhancement
- Transmission line route
  - Utilize existing or overland access
  - Dulled steel single-pole transmission structures
  - Non-specular conductors

30

Simulation Viewpoints



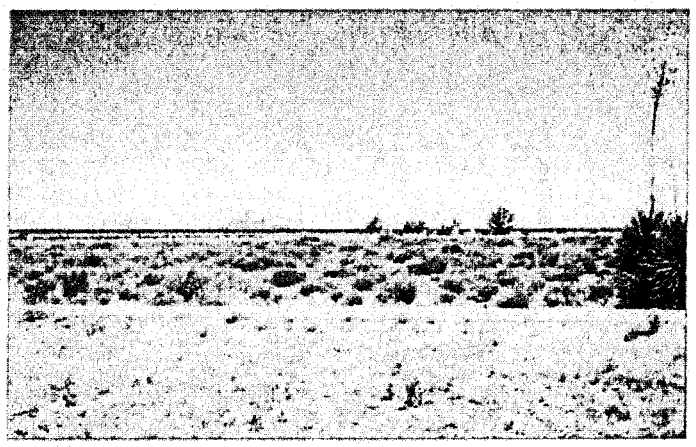
Viewpoint 1: Existing



32

BOWIE POWER STATION

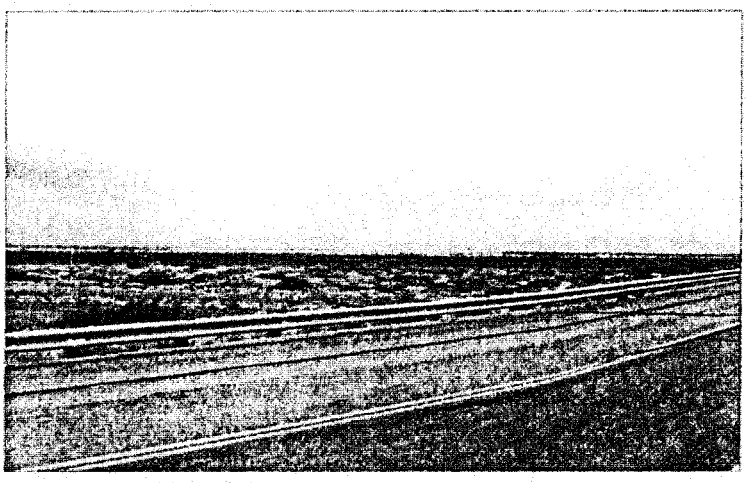
Viewpoint 1: Simulation



33

BOWIE POWER STATION

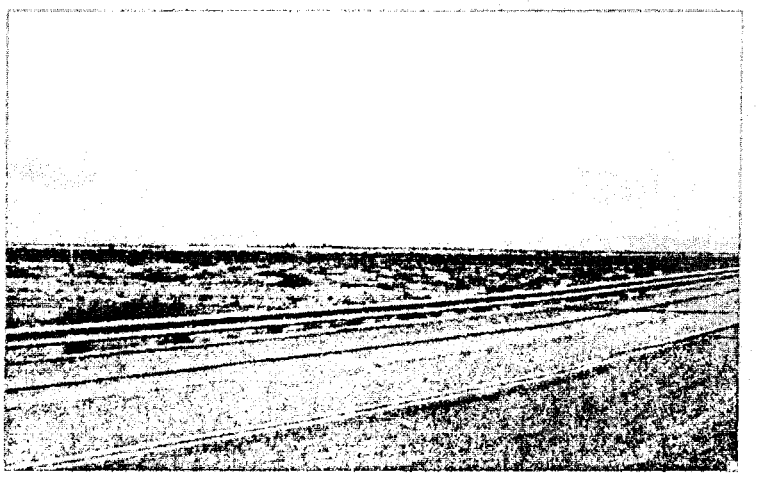
Viewpoint 2: Existing



34

BOWIE POWER STATION

Viewpoint 2: Simulation



35

BOWIE POWER STATION

Noise and Interference

(Exhibit I)

- Completed ambient noise survey
- Sound level of proposed project within established EPA and HUD guidelines
- No interference with communication signals

36

BOWIE POWER STATION

Conclusion

- Minimal impacts will be caused by construction and operation of the project facilities
- Project is environmentally compatible based on review of factors set forth in A.R.S. § 40-360.06

37

D

Witness Background

- Scott Peters, RLA, ASLA
- Director of Design Services for EPG
- BLA - Utah State University
- 6 years experience

1

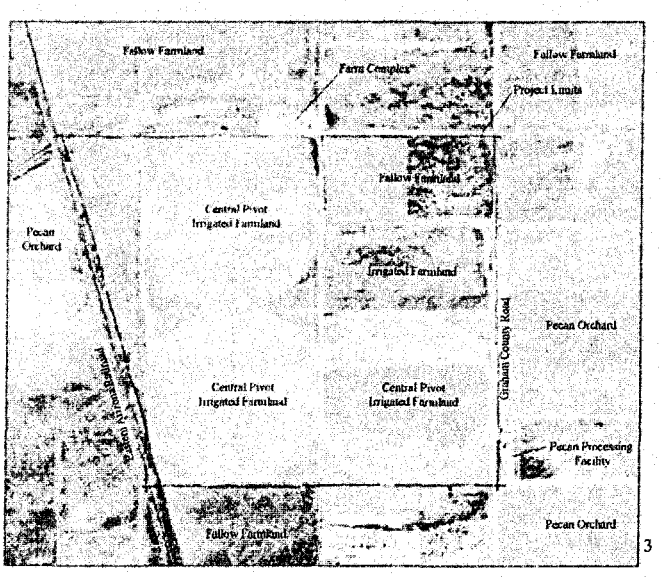
Scope of Testimony

- Site conditions
- Facility layout
- Surrounding character
- Conceptual landscape plan
- Implementation

2

BOWIE POWER STATION

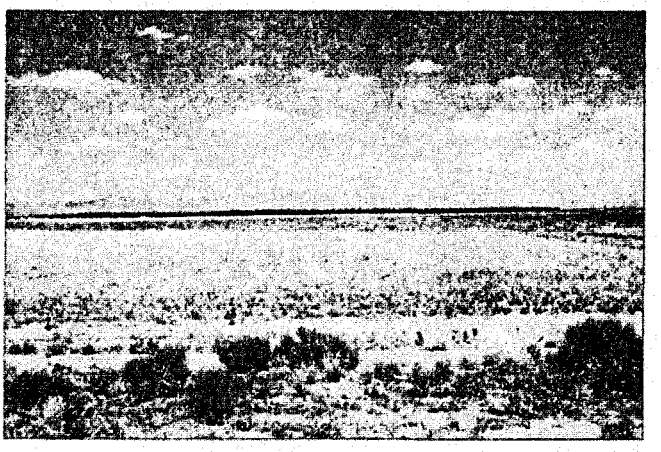
Site Conditions



3

BOWIE POWER STATION

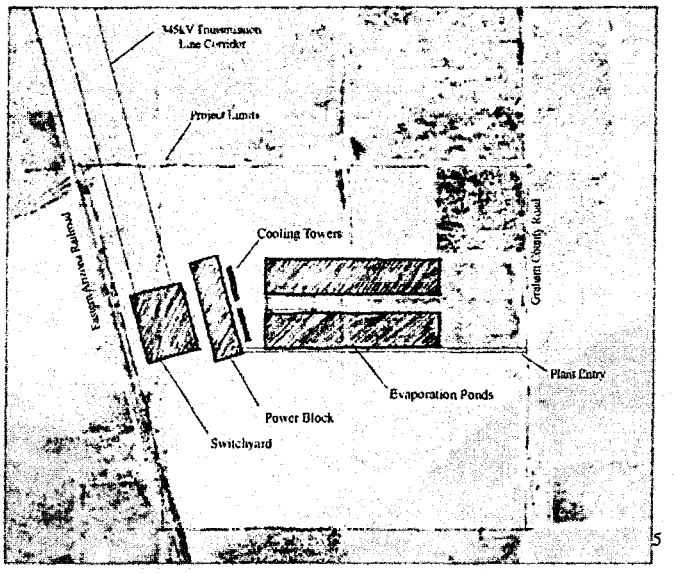
View of Site Looking East



4

BOWIE POWER STATION

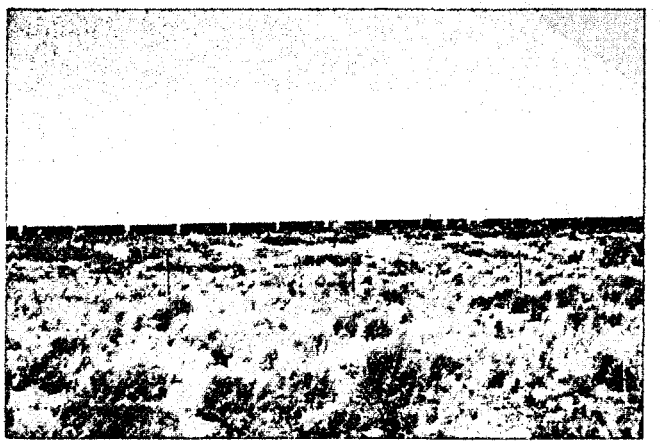
Power Facility Layout



5

BOWIE POWER STATION

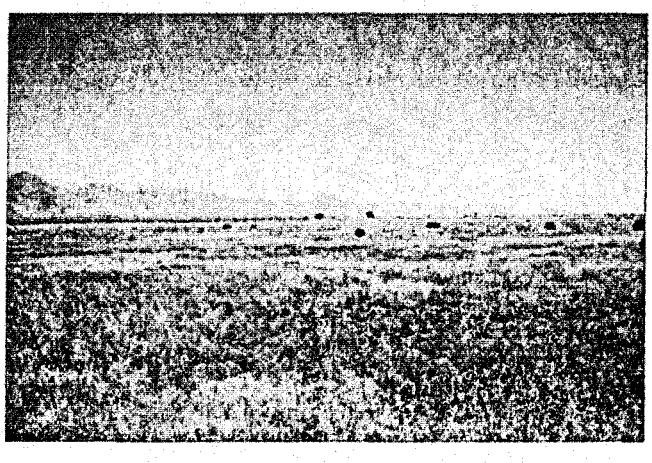
Surrounding Character: Desert Grassland



6

BOWIE POWER STATION

Surrounding Character: Farmland



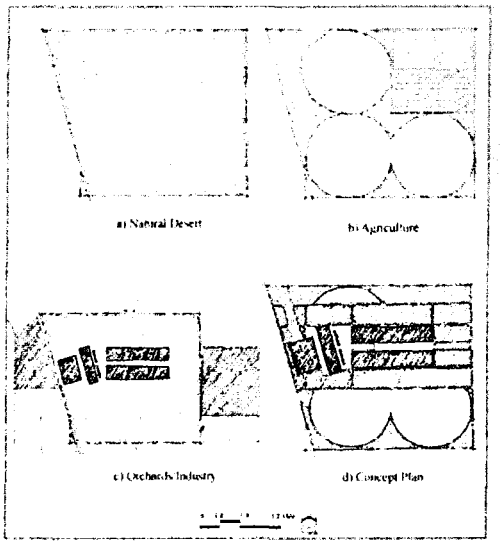
7

BOWIE POWER STATION

Surrounding Character: Orchard

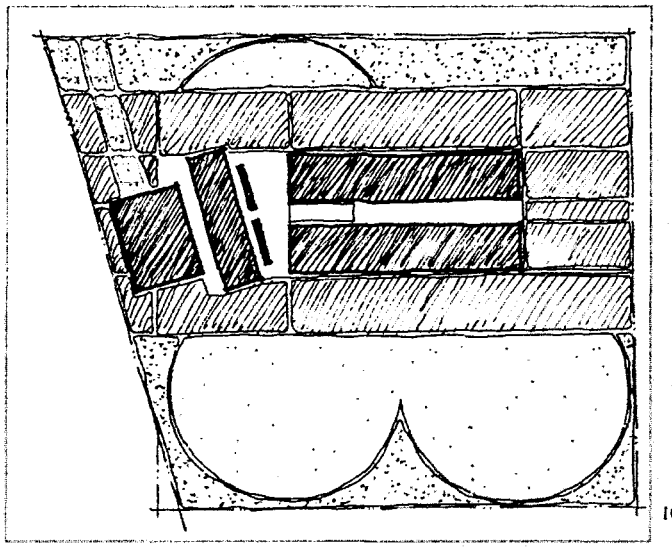
8

Conceptual Landscape Plan Elements



9

Conceptual Landscape Plan



10

BOWIE POWER STATION

Simulation

11

BOWIE POWER STATION

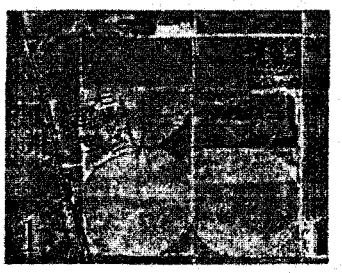
Implementation

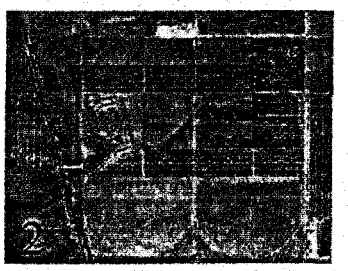
- Plant materials
- Planting/seeding methods
- Irrigation
- Project construction schedule (alternatives)
  - 2 Year Plan
  - Phased Plan

12

BOWIE POWER STATION

2-Year Plan: Years 1 and 2

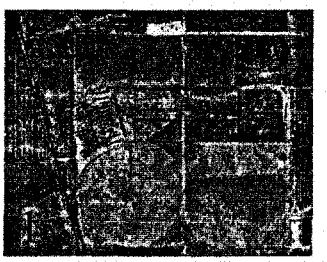


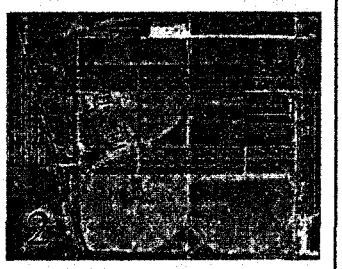


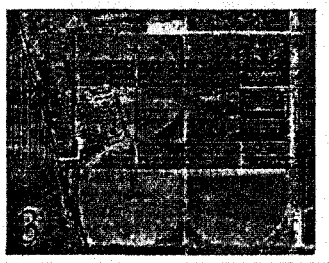
Area to be Planted Area to be Seeded Area to be Cultivated

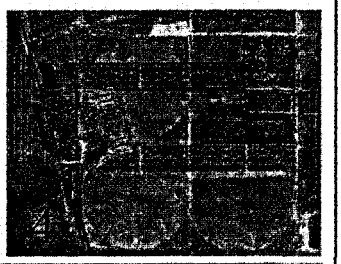
BOWIE POWER STATION

Extended Plan: Phases 1-4





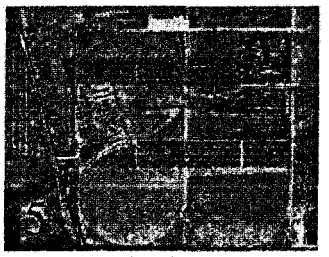


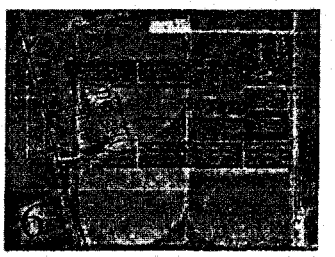


Area to be Planted Area to be Seeded Area to be Cultivated

BOWIE POWER STATION

Extended Plan: Phases 5-6





Area to be Planted | Area to be Seeded | Area to be Cultivated

BOWIE POWER STATION

Summary

- Establish landscape buffers, screening, and open space
- Reclaim land and establish vegetative cover
  - Reduce blowing soil
  - Decrease tumbleweed growth
  - Establish stable native plant species
  - Improve wildlife habitat
- Respond to character of surrounding landscape
- Coordinate with project construction schedule

16

BOWIE POWER STATION, L.L.C.

DOCKET NO. L-00000-BB01-0118

EXHIBIT # A- ____

EXHIBIT
Admitted
A-3

COPY

City of Willcox
Office of the City Manager
Larry D. Rains
101 S. Railroad Avenue, Suite B
Willcox, AZ 85643

Telephone (520) 384-4271 ext. 302
Fax (520)384-2590
email lrains@willcoxcity.org

RECEIVED
JUL 26 2001
Director of Utilities

July 24, 2001

Arizona Corporation Commission
DOCKETED
JUL 27 2001
DOCKETED BY

RECEIVED
2001 JUL 27 P 3: 45
AZ CORP COMMISSION
DOCUMENT CONTROL

Director of Utilities
Arizona Corporation Commission
1200 West Washington Street
Phoenix, AZ 85007

Re: Certificate of Environmental Compatibility for the Bowie Power Station.

DOCKET NO. L-00000BB01-0118

To Whom It May Concern:

Please accept this letter as notice that the City of Willcox is aware of the Bowie Power Station project and the impacts that this industry will have on our Community. The Southwestern Power Group II has made presentations to our local elected and appointed officials, the Chamber of Commerce members, as well as have held public forums to hear comments from the local citizens. It is our opinion that they have utilized the most practical methods of noticing our Community of the project and impacts of such activity.

Throughout this process, the City of Willcox has been supportive of said project. Although the project will not transpire within our incorporated city limits, we anticipate a positive economic impact from this organization and industry. Additionally, Southwestern Power Group II has taken a very activity role in Community citizenship. We look forward to the long-term partnerships that can evolve with the project.

The City of Willcox strongly encourages you to consider and support the Certificate of Environmental Compatibility and Bowie Power Station project.

Should you have any questions regarding this matter, please contact me at your convenience.

Respectfully,

Larry D. Rains
City Manager

cc: Southwestern Power Group II
Mayor and City Council

DOCKETED BY

L 00000 BB01-0118

RECEIVED

2001 AUG -8 P 12: 02

AZ CORP COMMISSION
DOCUMENT CONTROL

COPY

Bowie USD #14
315 W. 5th Street
Bowie, AZ 85605

Attn: Director of Utilities
Arizona Corporation
Commission
1200 West Washington
Phoenix, AZ 85007

ARIZONA CORPORATION COMMISSION
JUL 25 2001
DIRECTOR OF UTILITIES

July 24, 2001

Dear Director,

The Southwest Power Group plans to construct a new station in Bowie and we at Bowie Schools are quite excited about the project. As you probably know, Bowie is a tax-poor area and in order to finance our school district we must charge our property owners probably the highest school tax rate in Arizona at $11.50 per $100.00 A.V. The new generating plant, when constructed and in operation, will mean that tax rate can drop dramatically while at the same time provide more money to operate our schools.

The Southwest Power Group has kept us informed from the very beginning and has asked for our input along the way. We encourage you to approve their permit.

Sincerely,

Dr. T.R. Ellis, Superintendent

Arizona Corporation Commission
DOCKETED

AUG 08 2001

DOCKETED BY nac

Cc: Southwest Power Group
4350 E Camelback Rd., Suite B-175
Phoenix, AZ 85018
Attn: Jonathan Bruser

"Wings Over Willcox"

Travel the
"Magic Circle of Cochise"

Willcox Chamber of Commerce and Agriculture

WILLCOX NOW

Executive Officers:

Chris Cronberg
President

Carl Hestand
President Elect

Wayne Crane
Vice President

Jim Martin
Treasurer

Eddie Browning
Executive Director

Board of Directors:

Anne Holcomb
Gary Regnier
Phil Clifton
Kevin Stamback
Julie Hunsdon
Ron Bastian
Richard Searle
Rusty Harguess

Ex-Officio Members:

Larry Rains
Lynn Setterstedt-Jarrett
Howard Bethel

July 26, 2001

Director of Utilities
Arizona Corporation Commission
1200 West Washington Street
Phoenix, Arizona 85007

Re: CEC for Bowie Power Station Application

To Whom It May Concern:

The Willcox Chamber of Commerce and Agriculture supports Southwestern Power Group II's above mentioned application. The Chamber of Commerce has attended several local meetings in which the project was discussed in detail. The Chamber of Commerce is aware of the impacts of construction and when the plant is fully operational.

The Chamber asks the Commission to find in favor of this application. If you have any questions please do not hesitate to contact the Chamber of Commerce at your earliest convenience.

Sincerely,

Eddie Browning

Eddie Browning, Executive Director
Willcox Chamber of Commerce and Agriculture

(520) 384-2272 ◆ (800) 200-2272 ◆ (520) 384-0293 Fax
willcoxchamber@vtc.net ◆ www.willcoxchamber.com
1500 North Circle I Road
Willcox, Arizona 85643

RECEIVED
2001 AUG -8 P 3:20
AZ CORP COMMISSION
DOCUMENT CONTROL

BOWIE FIRE DIST.
P.O. BOX 241
BOWIE AZ. 85605
PHONE(520)847-2553
FAX(520)847-1129

RECEIVED
AUG - 1 2001

To whom it may concern: this is a letter of support for the proposed Power Plant in the town of Bowie . We here at the Bowie Fire Dist. feel that it will be a great asset to the town. We also feel that with out this plant the town will soon die out. It is the option of the members of the Bowie Fire Dist.& the people of this town that this Plant will help to save this town as well as help it to grow. The people from the plant have been more then forth coming about all the plains & needs they would have over the cores of the consternation and operation of the Plant. They have also been very forth coming about any and all ever mental & economic impacts it will have on the Town of Bowie and the people that live in here. They have been more then willing to meet with and answer any & all questions from all members of the community. We at the Bowie Fire Dist. Hope that you take all of this in to confederation when you make any dissection.

RECEIVED
AUG 06 2001
ARIZONA CORP. COMM.
TUCSON, AZ.

Sincerely,

Chief Michael Bovee
Bowie Fire Dist.

EXHIBIT
Admitted
A-4

BOWIE POWER STATION
NEWSLETTER #2 • SEPTEMBER 2001

BOWIE POWER STATION

The Arizona Power Plant and Transmission Line Siting Committee will hold a hearing on the Bowie Power Station Project's application for a certificate of environmental compatibility.

DATES: Thursday, October 11, and Friday, October 12

TIME: 9:00 a.m.

PLACE:
Best Western Plaza Inn
1100 W. Rex Allen Dr.
Willcox, Arizona

For updated project information, call toll free, 1-877-576-7477

This is the second in a series of newsletters designed to keep the community and interested parties informed about the progress of the proposed Bowie Power Station. Since the announcement of the project in January 2001, SouthWestern Power Group II (SWPG) and Bowie Power Station, LLC have been conducting detailed environmental and engineering studies, working on design plans for the generating facility, initiating permitting processes, narrowing alternatives for the associated transmission line, and meeting with various members of the public to gather input and feedback.

OVER 100 ATTEND PUBLIC MEETINGS

On April 25 and 26, 2001, two public open house meetings were held in Willcox and Bowie, respectively. At the beginning of the evening, attendees had the opportunity to review informational displays and speak individually with project team members. Following this portion of the meeting was a presentation and lengthy question/answer session to address the comments and questions presented by the audience. Some of the questions were about the construction schedule, air quality, sources of water and natural gas, impacts on the community during construction, and plans for the land around the plant, among many others. The "quick facts" section on page 2 and information in Newsletter #1* offer explanations of many of these subjects. Overall, community members expressed their support of the project, citing the positive economic benefits that will occur for the area.

***Newsletter #1 may be requested by calling toll free 1-877-576-7477**

Tom Wray, SWPG, responds to audience questions at the public meeting in Bowie on April 26, 2001.

BOWIE
POWER STATION

QUICK FACTS

- During construction: average of 200 jobs created, up to 300 at peak
- Substantial tax revenues for local schools and communities
- Up to 1,000 megawatts (MW) total capacity (phased in over time)
- Fueled by clean-burning natural gas
- Built with two 500 MW blocks, each with two combustion turbines supporting one steam turbine generator
- Construction expected to begin in late 2002
- First unit expected to be in operation in late 2004
- One double-circuit 345 kilovolt (kV) transmission line extending about 14 miles northwest of the plant will be required
- A 345kV switchyard will be built at the plant site; a 345/230kV switchyard will be built at the point where the new transmission line connects with existing lines in southern Graham County
- Air emissions in compliance with U.S. Environmental Protection Agency and Arizona Department of Environmental Quality standards
- State-of-the-art technology with lowest achievable emissions
- Sound reduction methods to minimize noise
- Groundwater use will be less than existing agricultural water use

TRANSMISSION LINE ROUTE SELECTED

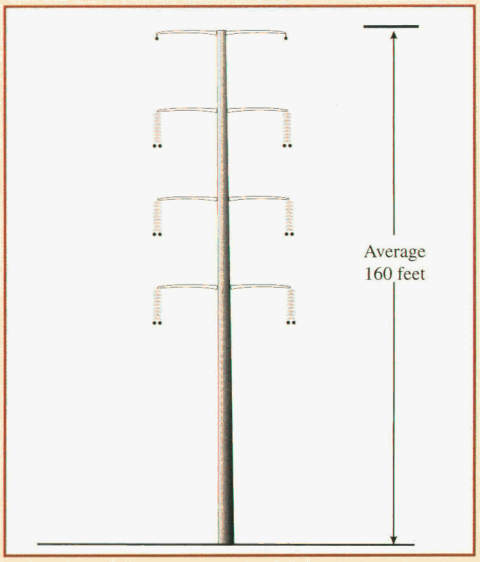
The Bowie Power Station Project involves the construction of a double-circuit 345 (kV) kilovolt transmission line, which will extend about 14.3 miles northwest from the facility to interconnect with existing transmission lines north of the Cochise/Graham County line. In the final stage of development, the 345kV/230kV "Willow" switchyard will be built at that location.

Factors such as environmental compatibility, electrical system requirements, engineering, costs, and public input were studied extensively as steps in the process of selecting a preferred route for the power line, which is shown below. The figure on page 3 illustrates a single-pole structure, typically 160 feet in height, which is expected to be used along this route.

PERMITTING PROCESS CONTINUES - First hearing on October 11-12

In July, an application for a certificate of environmental compatibility (CEC) was filed with the Arizona Corporation Commission (ACC), which is the first major step in the permitting process. In our state, all proposed power plants and certain types of transmission lines must be approved by the ACC. Prior to the application reaching the ACC, it is considered by the Arizona Power Plant and Transmission Line Siting Committee, which will hold a hearing on the Bowie project in Willcox on October 11 and 12, 2001. Beginning at 9:00 a.m., the meetings generally conclude in the late afternoon each day. Please see page 1 for location details.

The process to obtain an air quality permit from the Arizona Department of Environmental Quality and the U.S. Environmental Protection Agency is also underway and should be completed in late 2002. The project planners are working with Cochise County to obtain the necessary zoning and special use permits and identify appropriate uses for the surrounding lands. Also, an Aquifer Protection Permit will be required prior to construction of the lined evaporation ponds.



Typical double-circut 345kV structure

CULTURAL RESOURCES HIGHLIGHTS

As part of the environmental studies for the proposed generation facility, a team of archaeologists researched the history of Bowie and the surrounding areas and have learned some interesting facts. This highlight is on the past principal mode of long-distance transportation—the railroads.

The summer of 1880 was the dawn of the railroad days in Bowie. Like other parts of the United States, the area blossomed as the Southern Pacific Railroad came to town. Construction workers were needed to build not only the railroad north of town, but also other facilities such as the Bowie Depot, a hotel, a freight house, water tanks, and additional buildings to support the railroad operations.

The combination of the newly developed town services and Bowie's position on the main route for the southern transcontinental railroad meant people from all over the country could visit, fueling the area's growing economy. Also critical at the time, mail delivery was much quicker and efficient.

In 1899, the Gila Valley Globe & Northern Railroad (GVG&N) linked Bowie with the rich mining areas of central Arizona, including the city of Globe. The tons of ore mined in Globe were transported to Bowie via the GVG&N, then loaded on cars headed for the Southern Pacific Railroad. During the early 1900s, these mining operations were so successful that the tracks were heavily crowded with both passenger and freight trains. Innovative and necessary in its days, the railroads began to decline as the U.S. highway system developed.

The Southern Pacific Train Depot at Bowie, pictured below, was a key landmark in Bowie's development.

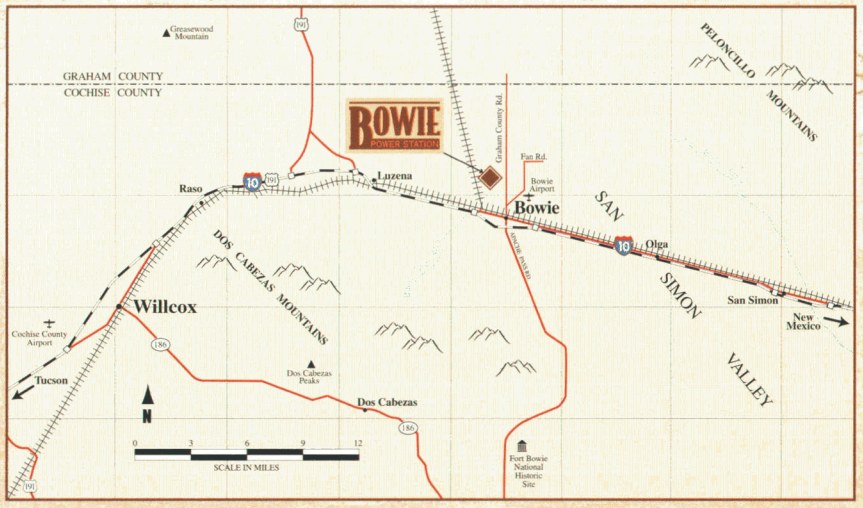
Courtesy of Margaret Gates

SOUTHWESTERN
Power Group LLC
An Energy Company – Alliance Builder
4350 E. Camelback Road
Suite B175
Phoenix, AZ 85018

PRESORTED
FIRST CLASS MAIL
U.S. POSTAGE
PAID
PHOENIX, AZ
PERMIT NO. 465

BOWIE
POWER STATION

IMPORTANT NEWS ABOUT THE BOWIE POWER STATION!



Project Area Map

[redacted]

GEOLOGICAL CONSULTANTS INC.

EXHIBIT
Admitted
A-5

GEOLOGICAL CONSULTANTS INC.

2333 West Northern Avenue, Suite 1A • Phoenix, Arizona 85021 • Telephone 602-864-1888

GEOLOGICAL CONSULTANTS INC.

Kenneth M. Euge, R.G.

GROUND SUBSIDENCE &
EARTH FISSURE EVALUATION

BOWIE POWER STATION
COCHISE COUNTY, ARIZONA

Prepared for:

Mr. Ravi Murthy, P.E.
URS Corporation
7720 North 16th Street, Suite 100
Phoenix, Arizona 85020

Prepared by:

Geological Consultants Inc.
2333 West Northern Avenue, Suite 1A
Phoenix, Arizona 85021

REGISTERED GEOLOGIST
CERTIFICATE NO.
10338
KENNETH M.
EUGE
Date Signed 10/08/01
ARIZONA U.S.A.

Project No. 2001-168

October 8, 2001

NOTICE

The geological and soils observations, findings, conclusions and recommendations presented in this report are based on (1) data from published and unpublished sources available at the time of this study and (2) photo-geological interpretation. The services provided by Geological Consultants to URS Corporation were performed in accordance with generally accepted geological principles and standard practices used by members of the geological profession in this locale at the time of this study.

It must be recognized that subsurface geologic and soils conditions may vary from place to place and from those interpreted at locations where evaluations are made by the investigator. No warranty or representation, either expressed or implied, is or should be construed regarding geological or soils conditions at locations other than those observed by the investigator.

This report was prepared in accordance with the scope of work outlined in Geological Consultants proposal for geological services dated August 17, 2001 and as authorized by URS Corporation on September 4, 2001.

TABLE OF CONTENTS

EXECUTIVE SUMMARY 1

1.0 INTRODUCTION 5

1.1 Scope of Work 6
1.2 Authorization 7

2.0 GEOGRAPHIC SETTING 8

2.1 Location 8
2.2 Physical Features 8
2.3 Climate and Vegetation 8

3.0 GEOLOGICAL EVALUATION 9

3.1 Regional Geologic Setting 9
3.2 Site Setting 10
3.2.1 Basin Stratigraphy 12

4.0 GROUND SUBSIDENCE 14

4.1 Overview 14
4.2 Groundwater 15
4.2.1 Groundwater use in San Simon Valley Sub-Basin 15
4.3 Regional Subsidence 17
4.3.1 Subsidence in the San Simon Basin & Bowie Project Area 18
4.3.2 Future Potential Ground Subsidence in Project Area 21
4.4 Earth Fissures 23
4.4.1 Known Earth Fissures Within Project Area 24
4.4.2 Potential Earth Fissure Within Project Area 24

5.0 CONCLUSIONS 26

6.0 RECOMMENDATIONS 29

7.0 BIBLIOGRAPHY 32

TABLES

Table Number	Title	
1	Cumulative Ground Subsidence Data and Subsidence Rates, 1952 Through 2001, Benchmark P324	19
2	Ground Subsidence Summary for Benchmarks in Bowie Area, I-10 Milepost 352 to 376	20

SKETCHES

1	Conceptual Geologic Cross Section, San Simon Valley-Middle Basin	11

CHARTS

Chart Number	Title	
1	Projected Subsidence Linear Trend through 2035 without Plant	37
2	Projected Subsidence Non-Linear Trend through 2035 without Plant	38
3	Actual and Projected Subsidence Non-Linear Ground Subsidence Trend 1952-2035	39

FIGURES

Figure Number	Title	
1	Site Location Map	
2	General Geologic Map	In Pocket
3	Well Location Map	
4	Well Hydrographs With Actual & Projected Subsidence	
5	Regional Ground Subsidence and Earth Fissure Map	In Pocket
6	Generalized Sequence of Earth Fissure Development	

REGISTERED GEOLOGIST
CERTIFICATE NO.
10338
KENNETH M.
EUGE
Date Signed 10/08/01
ARIZONA U.S.A.

GROUND SUBSIDENCE & EARTH FISSURE EVALUATION

EXECUTIVE SUMMARY

Introduction

This report presents the results of a ground subsidence and earth fissure evaluation for the proposed Bowie Power Station site in the San Simon Valley (also referred to as the San Simon Sub-Basin) of the Safford Basin in north-central Cochise County, Arizona (Figure 1). The scope of activities to accomplish this subsidence evaluation included several tasks: (1) an overview assessment of the entire property using available geological and hydrogeological data and geological interpretation of available aerial photography; (2) compilation of historic groundwater data; (3) compilation of previously documented ground subsidence and earth fissure data; (4) analysis and interpretation of the gathered data; (5) conducting a geological reconnaissance of the project site and nearby areas; and (6) rendering of opinions and recommendations related to power station development in a subsidence area.

Geological Evaluation

The middle portion of the San Simon Sub-Basin contains more than 6,400 feet of basin sediments deposited in a closed drainage basin. The basin fill sequence from top to bottom includes a young, upper alluvial unit, a middle blue clay unit, and a lower coarse-grained interbedded stream and lake bed unit (Sketch 1). Each of these stratigraphic units has distinctive hydrogeologic properties. The upper unit and portions of the lower unit of the basin fill commonly makes up the principal groundwater aquifer of the region.

Ground Subsidence

The major human-induced factor contributing to subsidence in the vicinity of the proposed power plant site area is the removal of groundwater from the basin aquifers due to agricultural development within the San Simon Sub-Basin. As a result of the groundwater drafting, groundwater levels in the study area have dropped about 250 feet to 350 feet through the mid-1970s. In the mid-1970s and 1980s, agricultural activity in the basin slowed due to poor economic conditions. As a result, water levels in the Bowie area of the basin began to stabilize due to substantial reductions in groundwater

use. Water levels have remained essentially static or have risen slightly through 2001. The current static condition can be attributed to a balance between water use and recharge in the basin.

The San Simon Valley area of the Safford basin and the proposed Bowie Power Station site are in an area of documented ground subsidence and related earth fissures associated with historic pumping of groundwater, primarily for agricultural purposes. Groundwater removal has caused the basin fill sediments to compress, causing the ground surface to be lowered over a very large area. Based on an analysis of historical level survey data from a benchmark about 1½ miles south of Bowie Power Station site, the maximum ground subsidence at the Bowie area totaled about 7.1 feet in 2001. Ground subsidence is estimated to be about 5 feet at the proposed power plant site through 2001. A linear projection of predicted residual ground subsidence from 2001 through 2035, without the plant, is about 2.21 feet or 0.065 feet per year.

Bowie Power Station proposes to pump about 5,500 acre-feet of groundwater per year for the 30-year operational life of the plant. The resulting water table drawdown analysis (URS, 2001) indicates that on the order of 50 feet of drawdown could occur in the immediate vicinity of the Power Station well field, and about 40 feet near the town of Bowie, over the operational life of the plant. The analysis of future potential the maximum ground subsidence that could be induced by plant water use over the 30-year plant life is expected to be about 2.15 feet or about 0.072 feet per year.

No previously reported earth fissures are located within or trend toward the proposed power plant site. Likewise, no evidence of earth fissures was observed during the geological reconnaissance of the site. Two earth fissures are within five miles of the proposed Bowie Power Station site. The closest earth fissure is about two miles east of the northeast corner of the Power Station property. This fissure trends in a north to northwest direction. The fissure also appears to be dormant because of the sediments that have accumulated in the fissure since it was first documented (Holtzer, 1980)

Conclusions

Assuming the hydrogeological conditions remain unchanged, the linear data plot analysis of subsidence against time suggests the residual subsidence at the project site from 2001 through 2035 could total about 2.21 feet or 0.065 feet per year. The nonlinear extrapolation of the same data set suggests the ground subsidence in the project area could be negligible by the year 2035.

It is anticipated that the maximum ground subsidence that could be induced by plant water use over the 30-year plant life is about 2.15 feet or about 0.072 feet per year. This subsidence rate is roughly equivalent to the residual subsidence rate calculated for the period 1980 to 2001 in the project area.

A comparison of projected residual ground subsidence from past groundwater pumping with the projected future potential active ground subsidence caused by pumping at the Bowie Power Station, shows comparable nonlinear diminishing rates of ground subsidence. The nonlinear trend line analysis relative to actual and projected ground subsidence suggests that, even with the plant in operation, ground subsidence in the project area could diminish to negligible levels by 2035.

Based on the results of the subsidence evaluation and estimates of future potential subsidence due to plant operations, it is our opinion the potential for earth fissure formation within the project property is negligible. In addition, the potential for earth fissure formation at the plant site is negligible because the plant site is located interior from the margin of the middle and lower basin fill units, the site is several miles from the bedrock pediment edge and a relatively small amount of ground subsidence is projected over the operational life of the plant. Finally, for similar reasons, the potential for new earth fissure formation and growth of existing fissures in adjacent off-site areas is negligible.

Ground subsidence and earth fissures in the project area should have a negligible impact on the construction and operation of the proposed power plant. Likewise, subsidence-related impacts to areas adjacent to the proposed facility should also be negligible.

Although the proposed Bowie Power Station is located within an area of residual ground subsidence, the power plant site facilities and related infrastructure can be engineered to account for future potential subsidence and operate safely.

Recommendations

Supplemental investigations at the Bowie Power Station site would be appropriate to verify, refine, or refute, as the case may be, the ground subsidence and earth fissure conditions identified by the

present scope of work. Such studies could be conducted as part of the geotechnical engineering analysis in connection with the design of the facility.

In addition, representative survey benchmarks should be re-surveyed for the purpose of implementing and maintaining a ground subsidence monitoring array for the site and surrounding areas. Subsidence monitoring benchmarks should also be established within the power station site and could be integrated into a subsidence monitoring program. As part of the monitoring program for known earth fissures, the earth fissures closest to the Bowie site should be periodically monitored using direct field examinations and the results documented.

GROUND SUBSIDENCE & EARTH FISSURE EVALUATION

BOWIE POWER STATION
PINAL COUNTY, ARIZONA

1.0 INTRODUCTION

This report presents the results of a ground subsidence and earth fissure evaluation for the proposed Bowie Power Station site located about one and one-half miles north of the Town of Bowie in north-central Cochise County, Arizona (Figure 1) (Bowie Power Station L.L.C., 2001). Information contained herein completes the scope of work as outlined in Geological Consultants Inc. proposal dated August 17, 2001. The objectives of this study are to compile adequate information concerning ground subsidence and earth fissures within and adjacent to the proposed power plant site to:

1) Address questions and concerns that may arise regarding the ground subsidence phenomena.

2) Define potential impacts, if any, relative to the design, construction, and operation of the proposed power plant.

3) Make recommendations to deal with the subsidence phenomena so that the proposed power plant site development can proceed.

The scope of activities to accomplish this subsidence evaluation included several tasks. The tasks were directed to an overview assessment of the entire property using available geological and hydrogeological data, geological interpretation of available aerial photography, and a geological reconnaissance of the project area. Some of the required preparatory work, such as compiling historic groundwater data, was accomplished by URS Corporation personnel. Geological Consultants Inc. used this data to supplement its data base to accomplish the project objectives.

1.1 Scope of Work

The scope of work for the ground subsidence and earth fissure evaluation included the following activities designed to satisfy the objectives of the study:

- Research of existing geological, hydrogeological, and geophysical data and the compilation of these data and existing ground subsidence/earth fissure information concerning the site region.

- Preparation of a bibliographic listing of the references reviewed and compiled.

- Assessment of future potential ground subsidence induced by groundwater withdrawal at the site and in the site vicinity using, in part, groundwater data compiled by URS personnel and historic ground subsidence data obtained from various sources for the project region (San Simon Sub-Basin).

- Use of historical groundwater and subsidence data, combined with the preliminary predictive water use data for the power plant operations, to develop future potential ground subsidence extrapolations for the site area.

- Compilation of groundwater drawdown and basin fill characteristics that may be derived from available research sources such as the U.S. Geological Survey and the Arizona Department of Water Resources (ADWR). This information can be used to roughly estimate reasonable rates of ground subsidence that can be compared with future potential ground subsidence extrapolations.

- Examination of aerial photography available from the U.S. Geological Survey over the Internet for the study area and interpretation of the photographs to identify earth fissures that may be present in the site vicinity.

- Completion of a limited ground-truth field reconnaissance (on foot) of the known and suspect earth fissures documented in the data base, and to verify, or refute the existence of the earth fissures.

- Preparation of a synopsis of possible ground subsidence/earth fissure mitigation measures that could be engineered and constructed to mitigate ground subsidence effects.

1.2 Authorization

The subsidence and earth fissure evaluation was conducted by Mr. Jason C. Williams, G.I.T., and Mr. Kenneth M. Euge, R.G., Principal Investigator. The work was performed for URS Corporation according to the authorization and the notice to proceed given September 4, 2001 and the scope of work authorized in Geological Consultants Inc. proposal to URS Corporation dated August 17, 2001.

2.0 GEOGRAPHIC SETTING

2.1 Location

The proposed Bowie Power Station site lies within north-central Cochise County about one and one-half miles north of the town of Bowie, Arizona (Figure 1). The power station property consists of approximately 2.5 square miles of agricultural land located in all or portions of sections 20, 21, 22, 27, 28, 29, and 33 of Township 12 South Range 28 East of the Gila and Salt River baseline and meridian. The Bowie Power Station power block will be located in all of Section 28 and a portion of Section 29.

2.2 Physical Features

The site is located in the central portion a large geographic basin referred to as the San Simon Valley. The basin is bounded by the Chiricahua, Dos Cabezas, Pinalenas, and Santa Teresa Mountains to the southwest, and the Pelocillo and Gila Mountains to the northeast.

The maximum relief within the property is approximately 87 feet measured from the highest point (elevation 3,748± feet) at the northwest property boundary to the northeast property boundary (elevation 3,661± feet). The original land surface has been modified by past agricultural activity. Generally, the land surface slopes to the east-northeast, at gentle grades of 3 percent or less.

2.3 Climate and Vegetation

The climate of the area is arid to semiarid. The average annual temperature ranges from about 42° Fahrenheit (F) in January with summer maximums averaging about 79° F in July. Average daily highs range from 58° F to 95° F and lows range from 24° F to 61° F (Vogt, 1980). The precipitation is confined to essentially two seasons during the year, one in the summer and the other in the winter. Average annual rainfall is about 11 inches. Snowfall averages slightly more than four inches per year. Native vegetation including desert shrubs and grasses have been removed from the land surface within the project area due to modification of the land for cultivation.

3.0 GEOLOGICAL EVALUATION

3.1 Regional Geologic Setting

The Bowie Power Station property is located within the San Simon Valley of the Safford Basin, which is a part of structural basin or trough within the Sonoran Desert region of southeast Arizona. The Safford Basin is located in the southeastern part of the Basin and Range Province and extends from the vicinity of Rodeo, New Mexico, northwest to the vicinity of Globe (Cushman, Jones and Hem, 1947). The Basin and Range Province is one of three physiographic and structural provinces in the state of Arizona: the Colorado Plateau, the Transition Zone, and the Basin and Range. The Bowie property is located entirely within the Basin and Range Province.

The Safford Basin, including the San Simon Sub-Basin, is characterized by northwest and north trending mountains that rise abruptly from broad, elongated, deep sediment-filled valleys produced by block faulting and folding that is common to the Basin and Range Province. The geology is dominated by metamorphic, granitic, and volcanic rocks of late Tertiary and older age (Figure 2) that have provided the source material for the basin fill deposits. The Mountains surrounding the Bowie property are composed of gneisses, schists, indurated sedimentary rocks, and granitic and volcanic rock types (Barnes, 1991). Rocks underlying the basin fill are probably igneous rocks including intrusive granite and extrusive volcanic rock.

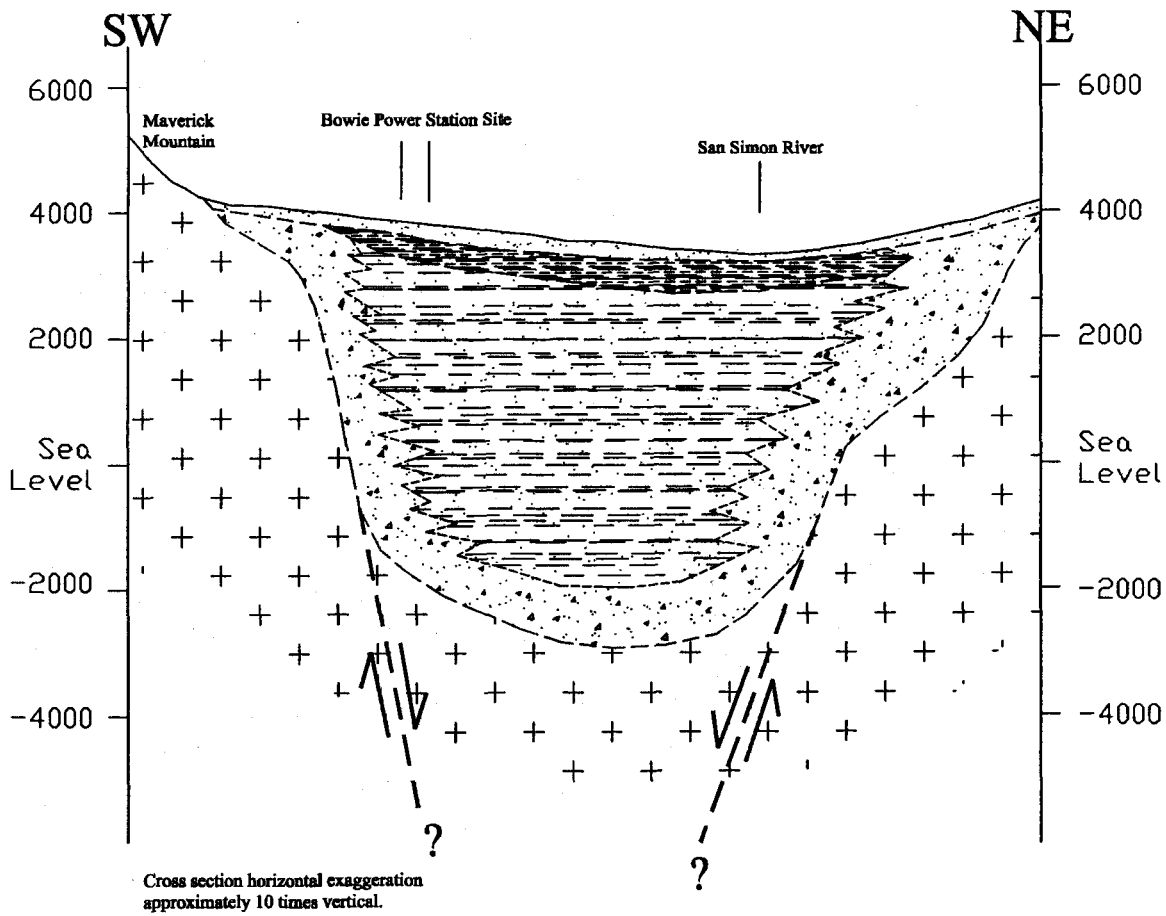
Structurally, the region has been uplifted to its present position by episodes of mountain/basin bounding fault movements (Cooley, 1977). The tectonic episodes and deformation, evident in the orientation of foliation planes and joint set discontinuities exposed in the bedrock terrain, have provided the mechanics necessary create the deep intermontane basins which were subsequently filled with sediment. The basin structure is defined by a trough that was formed by down-faulting between two nearly parallel mountain chains. The resulting structural depression is a down-thrown fault block, or graben, that is bounded by normal faults (Sketch 1). The Peloncillo Mountains, consisting of volcanic rocks and older sedimentary and granitic rocks, form the northeast side of the basin. The chain of mountains along the southwest side of the basin includes the Chiricahua, Dos Cabezas and Pinaleno Mountains composed of crystalline igneous and metamorphic rocks and older sedimentary rocks (Cushman et al, 1947).

3.2 Site Setting

The Bowie Power Station site is located in the middle portion of the San Simon Valley of the San Simon Sub-Basin. This Sub-Basin occupies a deep graben defined by northwest-trending Basin and Range faults which are concealed beneath broad alluvial fans that merge to form bajadas. The surrounding mountains are composed of gneisses and schists, indurated sedimentary rocks, granite and volcanic rocks. Around the lower slopes of the mountainous bedrock terrain, young colluvium deposits composed of erosional detritus intermingles with the young alluvium deposits of the valley floor. As the surrounding mountains eroded, the valley filled with debris (Sketch 1). The resulting alluvium has been classified as older and younger alluvial fill. The vast majority of the sediments are Pliocene and Pleistocene in age and are generally referred to as older alluvial fill (Cushman et al, 1947).

The older alluvial fill is composed of intertongued beds and lenses of clay, silt, sand, and gravel. These beds have been divided into lower, middle, and upper units. The lower unit overlies the bedrock, and consists of stream deposits interfingered with volcanic debris near the basement contact. The lower unit may exceed 7,000 feet in maximum thickness. The middle or blue-clay unit is a lacustrine deposit that was laid down at a time when a body of water, without exterior drainage, occupied a large part of the San Simon Valley. The middle unit overlies the lower unit and reaches a maximum thickness of 600 feet near San Simon. The middle unit, which acts as a confining layer and is generally encountered from 60 too 200 feet below the surface, pinches out toward the basin margins (Barnes, 1991) (Sketch 1).

The surface geology of the Bowie Power Station property is dominated by young alluvial fan deposits composed of an upper unit of mixed clay, silt, sand, and gravel. More coarse-grained soils probably occupy the former modern drainage channels that crossed the property. Some of the natural stream channels that once incised the alluvial fan surface have been removed or obscured by grading of the land surface for agricultural purposes. Coarse-grained alluvial fan deposits, although presently closest to fan apexes and the mountain fronts to the south and west, may be present locally beneath the site. Fine-grained soils, including fine sand, silt, and clay, occupy the slightly elevated terrain between the drainage channels and the fan deposits closer to the basin center.



Upper Unit: Unconsolidated stream deposits of silt, sand & gravel. 60 feet to 200 feet thick.

Middle Unit: Fine-grained blue clay lake bed deposit. 200 feet to 600 feet thick.

Lower Unit: Fine- to coarse-grained interbedded stream and lake bed deposits of clay, silt, sand, and gravel; and locally volcanic beds. 500 feet to greater than 5,500 feet thick.

Bedrock: Basement complex of crystalline igneous and metamorphic rock.

Geologic boundary contact; dashed where approximately located.

Basin bounding normal fault.

Note: Basin fill/bed rock boundary from Oppenheimer & Sumner, 1980. Stratigraphic relationships conceptualized from Cushman et al (1947), White (1963) and Barnes, 1991.

REGISTERED GEOLOGIST
CERTIFICATE NO. 10338
KENNETH M. EUGE
Date Signed 10/18/96
ARIZONA U.S.A.

Conceptural Geologic Cross Section
San Simon Valley - Middle Basin

Sketch 1
Bowie Power Station

Geological Consultants
2333 West Northern Avenue, Suite 1A Phoenix, Arizona 85021

3.2.1 Basin Stratigraphy

The San Simon Sub-Basin sediments are composed predominately of older and younger basin fill deposits. Recent alluvium deposits are found along modern stream channels. Buried stream channel deposits may be present within the site property. The three basin fill units and a mixed, marginal deposit in the project area are described below (URS, 2001):

- The upper unit consists of unconsolidated stream channel deposits of sand, silt and gravel and forms a continuous geologic unit across the basin. The thickness of the upper unit ranges from 60 to 200 feet and the driller's logs indicate that the upper unit is about 150 feet thick beneath the Bowie property. Where the upper unit is saturated in localized areas, the unit is designated as the upper aquifer.

- The middle unit (Barnes, 1991), or blue-clay unit (White, 1963), underlying the upper unit consists of dense blue clay formed by fine-grained sediments deposited during a period when a shallow lake occupied a large part of the San Simon Valley. The middle unit is about 600 feet thick along the axis of the valley, and acts as a confining layer. Near the basin margins, the middle unit pinches out and the upper and lower units merge to form the marginal zone. In the vicinity of the Bowie property, the middle unit is believed to be about 350 feet thick, extending to a depth of about 500 feet below ground surface.

- The lower unit consists of stream and lake-bed deposits of clay, silt, and gravel that overlie bedrock and in places are interbedded with volcanic debris. The unit is continuous throughout the basin and merges with the upper unit along the basin margins in the marginal zone. Groundwater occurs under confined conditions in the sand and gravel units, that interfinger with layers of dense clay, to form the lower aquifer. The lower aquifer supplies most of the groundwater used in the San Simon Valley sub-basin and would be the source of groundwater for the power plant. The thickness of the lower unit is generally unknown, but may be as much as 8,000 feet along the valley axis (Oppenheimer and Sumner, 1980). The thickness of the lower unit in the vicinity of the Bowie Property is unknown.

- The marginal zone occurs along the margins of the basin where the middle unit pinches out and the coarser materials of the upper and lower units merge. Within the marginal zone the upper and lower aquifers have merged to form a single, unconfined aquifer.

4.0 GROUND SUBSIDENCE

4.1 Overview

Ground subsidence is known to occur in alluvium-filled valleys of Arizona where agricultural activities and urban development have caused overdrafting or removal of groundwater from thick basin aquifers faster than natural recharge of the aquifer can occur. The basic cause of subsidence and lateral movement of the land surface is an increase in the intergranular pressure of the underground material. As the water table lowers, due to over-drafting, the water located in the space between the soil particles is removed. The particles will then compress under the weight of the overlying soil column. The compression of the soil is expressed as ground subsidence at the ground surface. The calculation of ground subsidence due to compression of layers in which intergranular pressure is increased is based on how the porosity, or void ratio, of the layer is reduced by an increase in intergranular pressure (Bouwer, 1978). The magnitude of subsidence is directly related to the subsurface geology, the thickness and compressibility of the alluvial sediments deposited in the valleys, and net groundwater level decline.

There are three categories of ground subsidence: (1) active subsidence; (2) residual subsidence; and (3) total subsidence. Ground subsidence induced by groundwater over-pumping is referred to as "active subsidence" and it does not immediately stop once pumping is stopped. As groundwater levels stabilize or begin to rise, the subsidence continues for some time before it gradually diminishes and stops. The ground subsidence that continues after groundwater levels stabilize or rise is referred to as "residual subsidence" and generally continues for several years. The entire ground subsidence process cannot be considered complete until residual subsidence approaches zero, whereas the cumulative drop in the land surface, known as "total subsidence" can be determined (EPA, 2001).

Although ground subsidence is a human-induced geological phenomenon that is sometimes referred to as a geologic hazard, the ground subsidence phenomenon is relatively benign when compared to other natural events such as flooding or earthquakes.

4.2 Groundwater

The major human-induced factor contributing to subsidence is the large scale removal of groundwater. Nearly all of the populated southern Arizona basins from Phoenix to Tucson have experienced at least a 100+ foot drop in groundwater level, and an area surrounding the town of Stanfield, Arizona has dropped more than 500 feet (Schumann and Genualdi, 1986). The groundwater level in the vicinity of the Bowie Power Station study area has dropped about 100 to 300 feet according to well data compiled by Schumann and Genualdi (1986), and 250 to 350 feet according to data compiled by URS (2001) (Figures 3 & 4).

Historical records indicate shallow groundwater was pumped for domestic use and livestock in the 1870s. In 1910, a deep well encountered artesian groundwater conditions that spurred agricultural development until poor economic conditions following World War I caused the abandonment of several farms. By the 1950s, artesian conditions abated to the level where pumping, probably from both the upper and lower aquifers, was required to satisfy irrigation needs. Deep well pumping from the upper aquifer began in the 1930s with the introduction of turbine pumps and electrical power. Annual water level usage, principally for agriculture, increased steadily from the early 1950s until the 1980s when rising energy costs and poor economic condition closed many of the farms. As a result, water use was reduced significantly and water levels stabilized. Records indicate the water level in the upper aquifer ranged from 30 feet to 80 feet below ground surface in 1987 (URS, 2001).

4.2.1 Groundwater Use in the San Simon Valley Sub-Basin

Two principal water-bearing zones occur in the San Simon Valley Sub-basin, and roughly correspond to the upper alluvial unit and the middle silt and clay units. These zones are referred to by the ADWR (1994) as the Upper Main Water Zone and Lower Main Water Zone, respectively. In the San Simon Valley Sub-basin, and in the Bowie Power Plant area, a third local water zone exists. This third zone is situated between the Upper Main Water Zone and the Lower Main Water Zone. This water zone designated the Significant Local Water Zone by ADWR.

Following World War II, agricultural development accelerated in the San Simon Valley sub-basin as did the water level decline in the aquifers. Annual water level usage increased steadily from the early 1950s until the 1980s, when the estimated annual pumpage in the San Simon Sub-Basin totaled 139,000 acre-feet per year. Poor economic conditions in the early 1980s resulted in cessation of most agricultural activity in the area when water use dropped to only 42,000 acre-feet per year. By the mid-1990s water use had increased slightly to about 51,400 acre-feet per year (URS, 2001). As a result of the reduction in water use in the Sub-basin, water levels began to stabilize and by 2001 the water levels had achieved essentially static conditions.

The Bowie Power Station site is located within the San Simon Valley sub-basin of the Safford basin, which is one of 14 groundwater basins located in the Southeastern Arizona Planning Area as defined by the ADWR. The agricultural lands, municipalities, and industries within the Safford Basin rely heavily on groundwater to meet their required water demands.

Agriculture in the San Simon demand center occurs primarily in the San Simon Valley along San Simon Creek. Agricultural demands in 1990 for the Safford Basin were 170,000 acre-feet. Of that amount, about 30 percent, or 51,400 acre-feet per year, are pumped from the San Simon Sub-Basin. According to ADWR (1994), long term projections are expected to be the same through year 2040.

Historical average consumptive use within the agricultural lands that will include the Bowie Power Station site is about 3.6 acre-feet per acre per year, or about 5,900 acre-feet per year. The Bowie Power Station will require about 5,500 acre-feet per year. If none of the 1,640 acres of the Power Station property are used for agricultural production, there will be a net decrease in water use by the power station as compared to the historical average pumping for the former agricultural property.

4.3 Regional Subsidence

Prior to the utilization of groundwater resources within the basins of central Arizona, the water table was higher and hydrogeologic conditions were in equilibrium. When pumping was initiated, water levels within the aquifer began to be lowered and the basin fill sediments were dewatered. In the arid southwest, the water in the aquifer is used up faster than it can be naturally replenished causing a net water table decline. As a result, the weight of the soil column is gradually increased as the buoyant effects and aquifer pressures induced by the water acting on the soil column are decreased. This condition causes increased loading stresses to consolidated portions of the thick compressible sediments, which results in the lowering (subsidence) of the land surface over a large area.

Once ground subsidence is initiated, it will continue until the causative factors, which are principally water table declines due to pumping and soil compressibility, are altered. Ground subsidence due to groundwater overdrafts is essentially irreversible. It can be arrested or stopped by reducing or halting declines in groundwater levels (combined with groundwater recharge if necessary) to prevent residual subsidence (Bouwer, 1977).

Ground subsidence was first documented in Arizona in 1934 following the releveling of first-order survey lines by the Coast and Geodetic Survey (now the National Geodetic Survey (NGS). Subsequent levels by the NGS, the U.S. Geological Survey, the U.S. Bureau of Reclamation, and the Arizona Department of Transportation has documented substantial ground surface subsidence in south central Arizona including the Salt River Valley, the Queen Creek - Apache Junction area, and the Eloy - Casa Grande - Stanfield area. As overdrafting continues, tensile stresses induced by the subsidence continue to increase until the ground breaks to form earth fissures.

The amount of ground subsidence reported through 1991 varies throughout central Arizona. Variations relate to basin shape and structure, compressibility of sediment within the basin, duration of groundwater use, volume of water pumped from the basin, natural and induced groundwater recharge, and change in water level conditions. Documented ground subsidence reported by researchers for different areas in central Arizona ranges from as little as one-half foot in the Tucson Basin to more than eighteen feet near Luke Air Force Base west of Phoenix.

Subsidence and earth fissures in urban areas can cause a variety of localized problems in central Arizona. The majority of problems have affected agricultural land. The ground subsidence has caused changes in the land surface gradient that have necessitated re-grading to reestablish proper grades for irrigation. In some localized cases, such as near Casa Grande and Queen Creek, lands have been taken out of production. Structures built across subsidence-related earth fissures may be damaged, streets crack, flow in gravity water and sewer lines can be reversed, and differential subsidence (although rare) can rupture buried utilities (Arizona Bureau of Geology and Mineral Technology, 1987).

4.3.1 Subsidence in the San Simon Sub-Basin and Bowie Project Area

Groundwater conditions in the San Simon Sub-Basin are somewhat different from other basins in Arizona affected by ground subsidence. Initial "large-scale" groundwater use in the sub-basin was provided from artesian wells. A lowering of the water table to the point where ground subsidence might be initiated lagged behind other basins that were experiencing agricultural development, such as the Picacho Basin. Ground subsidence was first documented in the Bowie area in the late 1950s.

Ground subsidence in the project area has been measured in the past by government agencies at various benchmarks along the Southern Pacific railroad alignment through the Bowie area, as well as two benchmarks along a north-trending spur of the railroad in Bowie. An early elevation vertical control survey in 1952-53 was the basis from which later ground subsidence was measured. In 1974, a second elevation survey was conducted at the same benchmarks in the area that were used in 1952-53. They discovered that at Bowie, the ground had subsided by as much as 4.7 feet over the period of 1952 to 1974 (Holtzer, 1975). A later level survey, conducted in 1979-80, recorded additional ground subsidence of about one foot for a maximum total subsidence of about 6 feet from 1952 to 1980 in the Bowie area. A GPS level survey was made of some benchmarks in the Bowie area in 2001 (A-Team/URS, 2001). The 2001 results indicate an additional 1.4 feet of ground subsidence occurred since the 1980 survey (Chart 1) or a total of 7.1 feet from 1952 to 2001. Based on the data, the land surface at benchmarks in the vicinity of the proposed Bowie Power Station site was subsiding at diminishing rates between 1952 and 2001 (Table 1).

Table 1

Cumulative Ground Subsidence and Subsidence Rates 1952 Through 2001, Benchmark P324

Year	Cumulative Subsidence (feet)	Time Period (years)	Subsidence Rate (feet per year)	Reference
1950	0	--	--	--
1974	4.70	24	0.20	Holzer, 1980
1980	5.69	6	0.165	NGS, 2001
2001	7.06	21	0.065	A-Team/URS, 2001

Interpreted subsidence contours within the Bowie Power Station site indicate that from 1952 to 1974, 2 to 3 feet of subsidence had occurred (Holtzer, 1980) (Figure 5). No recent level surveys have been conducted within the Bowie Power Station site. However, based on a comparison of recent level survey data (A-Team/URS, 2001) from a benchmark (P324) located one and one-half mile south of the site (Figure 1), with the Holtzer (1980) data, it is conceivable that the total ground subsidence from 1952 through 2001 could average about 5 feet at the plant site.

Between 1950 and 1980, active subsidence was occurring in the Bowie area due to pumping activity. Because of the leveling off of water levels in the Bowie area and the essentially static groundwater conditions within this area of the San Simon Sub-Basin, including the Bowie Power Station property, no active subsidence is occurring in the basin. However, based on the recent level survey (A-Team/URS, 2001), residual ground subsidence is likely ongoing. Table 2 includes a summary of survey leveling of benchmarks through the Bowie area along Interstate I-10 between Milepost 352 and 376 for the period 1952 through 2001.

Table 2
Ground Subsidence Summary for Benchmarks in Bowie Area, I-10 Milepost 352 to 376

	1952 to 1960		1952 to 1980		1960 to 1980		1980 to 2001	
Benchmark	Cumulative	Average Rate	Cumulative	Average Rate	Cumulative	Average Rate	Cumulative	Average Rate
EXIT 3	--	--	--	--	--	--	0.42	0.02
M324	--	0.09	2.00	0.07	1.28	0.06	--	--
N430	--	--	--	--	--	--	0.35	0.02
L324	0.67	0.67	1.24	0.04	0.57	0.57	--	--
N358	--	--	--	--	-0.60	-0.03	0.46	0.02
Q358	--	--	--	--	-0.24	-0.01	0.57	0.03
P324	--	--	5.69	0.20	--	--	1.37	0.07
X330	0.92	0.12	3.04	0.11	2.12	0.11	1.03	0.05
Y330	0.93	0.12	4.10	0.15	3.17	0.16	--	--
COTTON	--	--	--	--	1.23	0.06	1.71	0.08
COTTON RM1	--	--	--	--	1.24	0.06	--	--
108H	0.81	0.10	2.00	0.07	1.19	0.06	--	--
Z330	0.76	0.10	2.42	0.09	1.66	0.08	--	--
106H	0.66	0.08	1.71	0.06	1.05	0.05	--	--
HOLT 2 RM2	--	--	--	--	0.93	0.05	--	--
HOLT	0.64	0.08	--	--	--	--	--	--
HOLT 2 RM1	--	--	--	--	0.91	0.05	--	--
HOLT RM1	0.63	0.08	--	--	--	--	--	--
HOLT 2	--	--	--	--	0.93	0.05	0.79	0.04
Rt 86 Sta 3707	0.48	0.06	0.42	0.02	-0.06	-0.00	--	--
B331	0.48	0.06	0.18	0.01	-0.30	-0.02	--	--
C331	0.46	0.06	--	--	--	--	--	--
W330	1.37	0.17	0.96	0.03	-0.41	-0.02	--	--
V330	0.16	0.02	-0.25	-0.01	-0.41	-0.02	--	--
OLGA	--	--	--	--	-0.39	-0.02	0.01	0.0005
KARRO RM2	0.33	0.04	--	--	--	--	--	--
KARRO 2	--	--	--	--	--	--	0.07	0.003
U330	0.42	0.05	0.08	0.00	-0.34	-0.02	--	--
T330	0.44	0.06	0.18	0.01	-0.26	-0.01	--	--

4.3.2 Future Potential Ground Subsidence in Project Area

Various analytical methods may be used to predict the amount of ground subsidence and to estimate subsidence rates over time. Empirical methods can be used to extrapolate available data to deduce future subsidence trends. The amount of subsidence is available to plot against time. In this method, the amount of ground subsidence is considered a function of time, ignoring causality of the ground subsidence (Vega and others, 1984).

The reasonableness of the results using an empirical method that fits linear, quadratic, exponential, or logarithmic functions depend upon the data base used for the analysis. Fortunately, there is a reasonable amount of level survey data for the project area that can be used to calculate future potential ground subsidence trends. According to the data base, since 1952 several survey benchmarks have been resurveyed more than once (see Table 2). Although none of the survey benchmarks are within the Bowie Power Station Site, one benchmark is within one and one-half miles from the site (Benchmark P324). Data from this benchmark indicate that it documents the greatest amount of ground subsidence in the area and, therefore, would represent a conservative point of reference for calculating future potential ground subsidence at the project site.

Both a straight line trend line and a polynomial trend line have been applied to the data to develop linear and nonlinear extrapolations of ground subsidence in the project area. Assuming the hydrogeological conditions remain unchanged, the linear data plot (Chart 1) of subsidence against time suggests the residual subsidence at the project site from 2001 through 2035 could total about 2.21 feet or 0.065 feet per year. The nonlinear extrapolation of the same data set suggests the ground subsidence in the project area could be negligible by the year 2035 (Chart 2). As more survey data become available, the ground subsidence predictions may be refined.

Bowie Power Station proposes to use groundwater pumped from on-site production wells for plant operations for the projected 30-year life of the power plant. The plant operations will require approximately 5,500 acre-feet per year when fully developed and operating at base load (URS, 2001). The results of the groundwater level drawdown analysis conducted by

URS (2001) indicate drawdown will occur in the southwestern portion of the Bowie property. The calculated drawdown is about 50 feet below current static levels after 30 years.

The geological history of the San Simon Sub-Basin in terms of time of development, basin fill source material, basin fill characteristics, and the paleo-geomorphic characteristics demonstrate that it is similar to other basins in the Arizona Basin and Range Province, many of which have experienced ground subsidence. Although no detailed soil engineering data are presently available for the basin fill sediments beneath the Bowie Power Stations site, it seems reasonable to extrapolate basin fill characteristics for other basins, such as the Picacho Basin, to the San Simon Sub-Basin. Considering the similarities of the San Simon Sub-Basin and the Picacho Basin, the Bouwer (1977) method can be used to roughly estimate predicted ground subsidence. Assuming the values of ground subsidence relative to groundwater level decline for the San Simon Sub-Basin are similar to those used by Christie (1978) for the Picacho Basin (Geological Consultants, 2001), the subsidence on the order of 15 to 17 inches per 33 feet of groundwater level decline could represent a rough approximation for the San Simon Sub-Basin. Assuming these values are representative for the Bowie Power Station site, the maximum ground subsidence that could be induced by plant water use over the 30-year plant life is expected to be about 2.15 feet or about 0.072 feet per year. This subsidence rate is roughly equivalent to the residual subsidence rate calculated for the period 1980 to 2001 in the project area (Table 1).

Chart No. 3 depicts a nonlinear plot of documented ground subsidence through 2001 with the predicted additional ground subsidence for the 30-year operational life of the plant that could be induced by pumping of groundwater at the site. A comparison of projected residual ground subsidence from past groundwater pumping with the projected future potential active ground subsidence caused by pumping at the Bowie Power Station, shows comparable nonlinear diminishing rates of ground subsidence. A polynomial trend line is applied to actual ground subsidence reported for the project area and combined with the estimated projected subsidence expected from plant operation through 2035 (Chart 3). A plant start-up date of 2005 was assumed for this analysis. The trend line relative to actual projected ground subsidence suggests that, even with the plant in operation, ground subsidence in the project area could diminish to negligible levels by 2035.

4.4 Earth Fissures

Fissures occur in unconsolidated sediments, typically near the margins of alluvial valleys or near the bedrock pediment edge where groundwater levels have dropped from about 200 feet to 500 feet below ground surface (Schumann et al, 1986). The main factors relating to the development of an earth fissure are the differential consolidation of unwatered sediment over shallow bedrock irregularities coupled with groundwater withdrawal (Péwé and Larson, 1982).

Fissures are initiated underground when tensile stresses exceed the strength of the soils. The fissures then propagate upwards to intersect the ground surface. The locations of earth fissures are controlled primarily by the configuration of the buried bedrock surface, variations in the basin fill stratigraphy, and other factors. Early signs of earth fissures are small linear en echelon hairline cracks, irregularly spaced but aligned depressions, and large linear open holes (Larson and Pewe, 1982) (Figure 6). Other physical features associated with fissures are slump-related escarpments from one inch to a few inches in height, as well as a drainage pattern associated with the fissure that does not conform to the area's local drainage pattern.

Field evidence indicates the fissures are exposed after overlying sediments are eroded by surface water runoff from rainfall or irrigation (Larson and Pewe, 1982). The surface expressions of the fissures are exaggerated because the initial hairline crack is attacked by water to create wide (10 to 20 feet) and deep (more than 15 feet) erosional gullies that often have vegetation growing in them. The fissures are commonly perpendicular to natural drainage channels. The length of the fissure at the ground surface varies, usually less than one mile, but one fissure near Picacho, Arizona is more than 9 miles long. These features are easily recognizable on aerial photographs and in the field except where the land surface has been recently modified by agricultural activities or urban development.

Earth fissures cause damage to highways, railroads and canals and can require ongoing maintenance. In irrigated agricultural areas where fissures form, portions of fields are abandoned because irrigation flows are interrupted (Arizona Bureau of Geology and Mineral Technology, 1987).

4.4.1 Known Earth Fissures Within Project Area

The Bowie property is adjacent to an area of documented earth fissuring (Holzer, 1980; Harris, 1997). A review of published research documents and recent aerial photographs (Terraserver, 2001), combined with a field reconnaissance of the Bowie Power Station property and adjacent areas, indicates there are no previously mapped earth fissures located within or trending toward the proposed Bowie Power Station site. No evidence of earth fissures was observed during the geological reconnaissance of the site. Only two earth fissures are located within a five-mile radius of the Bowie Power Station. The one northwest-trending fissure is located Section 25, Township 12 South, Range 28 East, about two miles east of the northeast corner of the Bowie Power Station site. This earth fissure does not project toward the Bowie site. The fissure is about two miles long and extends to the south into Section 31, Township 12 South, Range 29 East and Section 6, Township 13 South, Range 29 East. The second fissure trends toward the northeast in the southeast corner of Section 25, Township 12 South, Range 28 East. This fissure is about one-quarter mile in length and projects away from the power station.

4.4.2 Potential Earth Fissures Within Project Area

Based on a review of available aerial photographs taken in 1996 of the Bowie area including the project area (Terraserver, 2001), no other earth fissures could be readily identified. However, the resolution of the photograph examined on the Internet was limited and may have obscured some smaller features. Likewise, agricultural activities throughout the property may also obscure the surface expression of earth fissures that may be present.

On September 10, 2001, Geological Consultants conducted a site visit to complete a ground-truth search for earth fissures within or trending toward the Bowie Property. Existing irrigation canals and roadways were carefully examined, as well as portions of the adjacent properties where native ground can be located. No evidence of earth fissures within or projecting toward the Bowie Power Station site was observed during the field reconnaissance.

A cursory assessment was also made using available geological and geophysical data to identify potential areas where earth fissures might develop near the site. Considering the proximity of the site to the buried bedrock pediment relative to a basin bounding fault to the west of the site, the assessment considered that boundary condition as a potential focus for earth fissure development. The maximum depth to bedrock in the Bowie Power Station vicinity is estimated to be more than 6,400 feet below a ground surface (Oppenheimer et al, 1980). Below the Bower Power Station, the bedrock depth could range from 5,000 feet to 5,700 feet below ground surface. About 1½ to 3 miles west of the west property boundary, a distinctive steep gradient change in the buried bedrock surface is depicted on Oppenheimer's (1980) Depth to Bedrock Map. This change is defined by a change in bedrock depths ranging from about 800 feet to 4800 feet below ground surface. This change occurs over a distance of about 1.6 miles and represents a slope gradient on the bedrock surface of about 0.47 feet per foot. The approximate gradient of the gentle sloped buried pediment surface closest to the mountain front is defined by a change in elevation of about 400 to 800 feet across a horizontal distance of about 1½ mile to 3 miles or about 0.025 to 0.13 feet per foot. The line, or break in slope, that defines the prominent change in gradient from the pediment to the deep basin could be the focus for future potential earth fissure development. The break in slope of the buried bedrock surface is located about 3 miles west and southwest from the Bowie Power Station site.

5.0 CONCLUSIONS

5.1 The San Simon Valley and the proposed Bowie power plant site are in an area of documented ground subsidence and related earth fissures. Ground subsidence resulted from groundwater over-drafting that started in the area in the 1930s and accelerated following World War II. Gradual over-drafting caused a lowering of the regional water table from about 250 feet to 350 feet through the late 1970s and early 1980s. Groundwater removal has caused the basin fill sediments to compress, causing the ground surface to be lowered over a very large area. Ground subsidence in the basin measured in the Bowie, Arizona area was about 7.1 feet as of 2001. Maximum ground subsidence at the Bowie Power Station site is estimated to be approximately 5 feet for the period 1952 through 2001.

Water levels within the basin, and at the Bowie Power Station site, began to stabilize and level off during the late 1970s and 1980s due to a reduction in groundwater use and because the reduced groundwater use is balanced with aquifer recharge. As a result of the relatively static groundwater levels in the Bowie area, ground subsidence rates have slowed from 0.20 feet per year in 1974 to 0.065 feet per year by 2001. Assuming the hydrogeological conditions remain unchanged, the linear data plot (Chart 1) of cumulative subsidence against time suggests the residual subsidence at the project site from 2001 through 2035 could total about 2.21 feet or 0.065 feet per year. The nonlinear extrapolation of the same data set suggests the ground subsidence in the project area could be negligible by the year 2035 (Chart 2).

5.2 Agricultural pumpage for the Bowie property since 1980 is estimated to average about 5,900 acre-feet per year. Bowie Power Station proposes to pump about 5,500 acre-feet of groundwater per year for the operational life of the plant or about 400 acre-feet per year less than the agricultural use estimate. The resulting water table drawdown is projected to be approximately 50 feet below the static water level at the start of plant operations over the 30-year operational life of the plant. The anticipated drawdown could induce some additional ground subsidence in the project area of approximately 0.072 feet per year, or a maximum of 2.15 feet, over the 30-year plant life.

Although not anticipated according to ADWR (1994), if renewed drafting of groundwater from other wells in the San Simon Sub-Basin causes a significant groundwater level decline regionally, the drop in the aquifer water table could cause an increase in regional subsidence that could exceed predictions.

5.3 The projected subsidence rate induced by the plant water use over 30 years is roughly equivalent to the residual subsidence rate calculated for the period from 1980 to 2001 in the project area.

5.4 Without the groundwater withdrawal caused by the plant, the residual subsidence in the project area is expected to be arrested by 2030. With the power plant in operation, subsidence rates in the project area are expected to drop to negligible levels by 2035.

5.5 Subsidence resulting from groundwater withdrawal related to operation of the proposed power plant is expected to have negligible effects on areas adjacent to the project property because the projected groundwater use for the plant operations is expected to be less than the current water use.

5.6 In areas where the basin fill consolidation has induced excessive tensile stress within the soil column, earth fissures have formed to relieve the stress. However, there are no previously mapped earth fissures located within or trending toward the proposed Bowie Power Station site. Only two earth fissures are located within a five-mile radius of the Bowie Power Station. The northwest- and northeast trending fissures are located Section 25, Township 12 North, Range 28 East, about two miles east of the northeast corner of the Bowie Power Station site.

5.7 Based on the results of the subsidence evaluation, the geological site reconnaissance, and estimates of future potential subsidence due to plant operations, it is our opinion the potential for earth fissure formation within the project property is negligible. In addition, the potential for earth fissure formation at the plant site is negligible because the plant site is located interior from the margin of the middle and lower basin fill units, the site is several miles from the bedrock pediment edge and a relatively small amount of ground subsidence is projected

over the operational life of the plant. Finally, for similar reasons, the potential for new earth fissure formation and growth of existing fissures in adjacent off-site areas is negligible.

5.8 Although the proposed Bowie Power Station is located within a documented ground subsidence area, it is our opinion the power plant site facilities and related infrastructures can be engineered to accommodate future potential subsidence and operate safely.

6.0 RECOMMENDATIONS

6.1 If required for the design, construction, and safe operation of the Bowie Power Station, the following engineering design measures could be considered to address the potential future ground subsidence at the project site:

- Structural elements such as foundations and slabs should be reinforced to respond uniformly to ground subsidence and settlement.

- Infrastructure utility systems such as water lines, drainage facilities, and sewers should be designed to compensate for future potential ground subsidence to minimize the potential for grade changes and flow reversals. For the Bowie Power Station facilities, minor adjustment to design grades should be provided to compensate for the slight change in slope gradient toward the southwest that may be induced by ground subsidence.

- Constructed facilities including flood control embankments and evaporation ponds should take into consideration the 2½ feet of ground subsidence that is predicted to occur over the operating life of the facility. For conservatism, a design ground subsidence value could include the sum of the predicted residual subsidence without the plant, which is 2.21 feet based on the linear extrapolation rate of 0.065 feet per year, plus the predicted estimated subsidence induced by pumping for plant operation, which is about estimated to be 2.2 feet, equals a total design estimated ground subsidence value of about 4.4 feet.

- Operational and emergency outlets for water retaining structures should be placed at locations to compensate for the predicted ground subsidence where feasible.

- Although we do not expect it, if, following detailed site investigations one or more earth fissures are found in the plant site area, building footprints should be located to avoid the fissure trace. If the fissure cannot be avoided, special foundation

treatments and structural design would be necessary within an earth fissure mitigation zone. Types of treatment could include, but are not limited to, overexcavation through the zone, structural barriers, soil reinforcement, erosion and piping protection, and post-tensioned slabs and footings.

6.2 Supplemental investigations can be conducted at the Bowie power plant site to verify, refine, or refute, the ground subsidence and earth fissure conditions identified by the present scope of work. The supplemental investigation may be conducted as part of the geotechnical engineering investigation for design of the facility. Possible supplemental subsidence and earth fissure investigations include the following:

- A more detailed site examination as part of the geotechnical site investigation for design of the facility.

- A micro gravity survey designed to cover the area within 5 miles of the Bowie Power Station site. The purpose of the gravity survey is to characterize and identify buried bedrock highs, boundaries of the blue clay unit and the lake bed deposit in the lower unit, and other geologic structures that could potentially be a focus for earth fissure development.

6.3 We recommend existing survey benchmarks be re-surveyed for the purpose of implementing and maintaining a ground subsidence monitoring array for the site and surrounding areas. Some of the survey benchmarks that have been used by other researchers to measure ground subsidence (Holtzer, 1980; Strange; 1983) should be included in the monitoring program as primary survey monuments. The off-site benchmarks could be integrated with new survey benchmarks located within the Bowie property. Secondary monuments within a five-mile radius of the property could also be incorporated into the program. A list of primary ground subsidence benchmarks, and other secondary benchmarks, will be included in the ground subsidence monitoring program.

Subject to the approval by the appropriate state agency, such as the Arizona Department of Water Resources or the Arizona Geological Survey, following the initial baseline survey, the

primary subsidence monitoring stations should be surveyed at one-year intervals for the initial five years of plant operation when groundwater drafting rates are greatest. The frequency of subsequent monitoring should be established based on the results of the first five years of monitoring. Secondary monuments may be surveyed at less frequent intervals depending upon the amount of ground subsidence measured at the primary stations. Surveying of the subsidence monitoring array should be conducted using currently accepted methods and standards of practice. Survey accuracy standards should be 0.05 feet (or about 2 centimeters). Data collected should be compiled in an easy-to-use format such as Microsoft Excel. Reporting should be done at least annually with reports distributed to other interested parties including the ADWR, which currently maintains a statewide clearinghouse for subsidence monitoring data.

Implementation of a subsidence and earth fissure monitoring program should provide an adequate "early warning" system to allow the owner to evaluate these ongoing geological phenomena and assess and respond to potential hazards that might result. Additionally, other agencies may use the information gathered to develop appropriate mitigation measures to deal with potentially adverse effects that might impact other areas within the San Simon Sub-Basin.

7.0 BIBLIOGRAPHY

A-Team/URS; 2001; Survey of Benchmarks Surrounding Bowie, Arizona; prepared for URS Corporation; September 2001.

Arizona Bureau of Geology and Mineral Technology; 1987; Subsidence areas and earth-fissure zones: Fieldnotes [Arizona Bureau of Geology and Mineral Technology]; v.17; no.1; p. 6-9.

Arizona Bureau of Geology and Mineral Technology; 1973; Index of Mining Properties in Cochise County, Arizona; prepared by Stanton B. Keith, Geologist; Bulletin 187, 1973, reprinted 1985; 98 p.

Arizona Department of Transportation; 1967; Arizona Materials Inventory, Aggregate Sources and Geology, Cochise County, Arizona; prepared by Material Division; 49 p.

Arizona Department of Transportation; 1967; Arizona Materials Inventory, Aggregate Sources and Geology, Graham County, Arizona; prepared by Material Division; 30 p.

Arizona Department of Water Resources (ADWR); 1994; Arizona Water Resource Assessment, Volume I, Inventory and Analysis; pp. 109-123.

Arizona Department of Water Resources (ADWR); 1994; Arizona Water Resource Assessment, Volume II, Hydrologic Summary; pp. 188-192.

Barnes, R.L.; 1991; Maps showing groundwater conditions in the San Simon sub-basin of the Safford basin, Graham and Cochise Counties, Arizona, Hidalgo County, New Mexico - 1987; Arizona Department of Water Resources Hydrologic Map Series Report Number 19.

Bouwer, H.; 1977; Land subsidence and cracking due to ground water depletion: Groundwater (Journal of Association of Ground Water Scientists and Engineers); v. 15; no. 5; p. 358 - 364.

Bowie Power Station L.L.C.; 2001; Application for Certificates of Environmental Compatibility, Bowie Power Station Project; prepared for State of Arizona Power Plant and Transmission Line Siting Committee, Case No. 118, July 27, 2001.

Cooley, M.E.; 1977; Map of Arizona showing selected alluvial structures and geomorphic features.; U.S. Geological Survey; Open File Report 77-343; 29 p.

Christie, F.J.; 1978; Analysis of gravity data from the Picacho basin, Pinal County, Arizona: Tucson, University of Arizona M.S. thesis, 105 p.

Cushman, R.L, Jones, R.S. and Hem, J.D.; 1947; Geology and Ground-Water Resources of the San Simon Basin, Cochise and Graham Counties, Arizona; U. S. Geological Survey Open-File Report (unnumbered); preparerd in cooperation with the Arizona State Land Department, O.C. Williams, Commissioner; 27 p.

Environmental Protection Agency; 2001; Proposed Countermeasures for Environmental Harm Due to Maricultural Breeding; Marine Resource Conservation in Chinese Taipai, APEC MRC Working; Group; **http://www.epa.gov.tw/**

Geological Consultants Inc.; 2001; Ground Subsidence and Earth Fissure Evaluation, Toltec Power Station, Pinal County, Arizona; prepared for URS Corporation; GCI Project No. 2001-141, July 6, 2001; 34 p.

Harris, R.C.; 1997; Earth Fissures in the Bowie-San Simon Area, Cochise County, Arizona; Arizona Geological Survey Open-File Report 97-19; November 1997; 10 p.

Holzer, T.L.; 1980; Reconnaissance Maps of Earth Fissures and Land Subsidence, Bowie and Wilcox Areas, Arizona; U.S. Geological Survey Miscellaneous Field Investigation Series Map MF-1156; 2 plates.

National Geodetic Survey; 2001; **http://www.ngs.noaa.gov/datasheets.html** ; Listing of survey benchmarks within Eloy NW, Eloy South, Friendly Corners, and Greene Reservoir U.S.G.S. 7.5' quadrangles.

Oppenheimer, J.M. and Sumner, J.S.; 1980; Depth to bedrock map, Tucson 2-degree Sheet; University of Arizona, Department of Geophysics, Tucson, Arizona.

Pewe, T.L., and Larson, M.K., 1982, Origin of land subsidence and earth fissures in northeast Phoenix, Arizona: City of Phoenix; 98 p.

Poland, J.F.; 1984; Guidebook to studies of land subsidence due to ground-water withdrawal: International Hydrological Programme, Working Group 8.4; Studies and reports in hydrology; 40; New York; UNESCO; 305 p.

Schumann, H.H., and Genualdi, R.B.; 1986; Land subsidence, earth fissures, and water-level changes in southern Arizona; Arizona Bureau of Geology and Mineral Technology; Map 23.

Strange, W.E.; 1983; Subsidence monitoring for the State of Arizona: National Oceanic and Atmospheric Administration, National Geodetic Survey, 74 p.

Terraserver; 2001; **http://terraserver.homeadvisor.msn.com**; Aerial photographs of Friendly Corners, Arizona area enlarged to 1m.

URS; 2001; Consultants report entitled "Water Supply Investigation Report for the Proposed Bowie Power Station, Bowie, Arizona"; URS Job No. E1-00001844.00; prepared for Bowie Power Station, L.L.C.; July 26, 2001

U.S. Geological Survey; 1987; Vanar NW, Arizona Quadrangle, Provisional Edition; Scale: 1:24,000.

U.S. Geological Survey; 1979; Fisher Hills, Arizona Quadrangle; Scale: 1:24,000.

U.S. Geological Survey; 1979; Luzena, Arizona Quadrangle; Scale: 1:24,000.

U.S. Geological Survey; 1974; Bowie, Arizona Quadrangle; Scale: 1:24,000.

U.S. Geological Survey; 1974; Ryan Draw, Arizona Quadrangle; Scale: 1:24,000.

Vega, G.F., Yamamoto, S., and Working Group; 1984; Techniques for prediction of subsidence: *in* Poland, J.F.; 1984; Guidebook to studies of land subsidence due to ground-water withdrawal: International Hydrological Programme, Working Group 8.4; Studies and reports in hydrology; 40; New York; UNESCO; 305 p.

Vogt, K.D.; 1980; Soil Survey of San Simon Area, Arizona, Parts of Cochise, Graham, and Greenlee Counties, Arizona; U.S. Department of Agriculture, Soil Conservation Service (now National Resource Conservation Service in cooperation with the Arizona Agricultural Experiment Station; September 1980; 148 p.

White, N.D.; 1963; Analysis and Evaluation of Available Hydrologic Data for San Simon Basin, Cochise and Graham Counties, Arizona; U.S. Geological Survey Water Supply Paper 1619-DD.

Charts

CHART 1

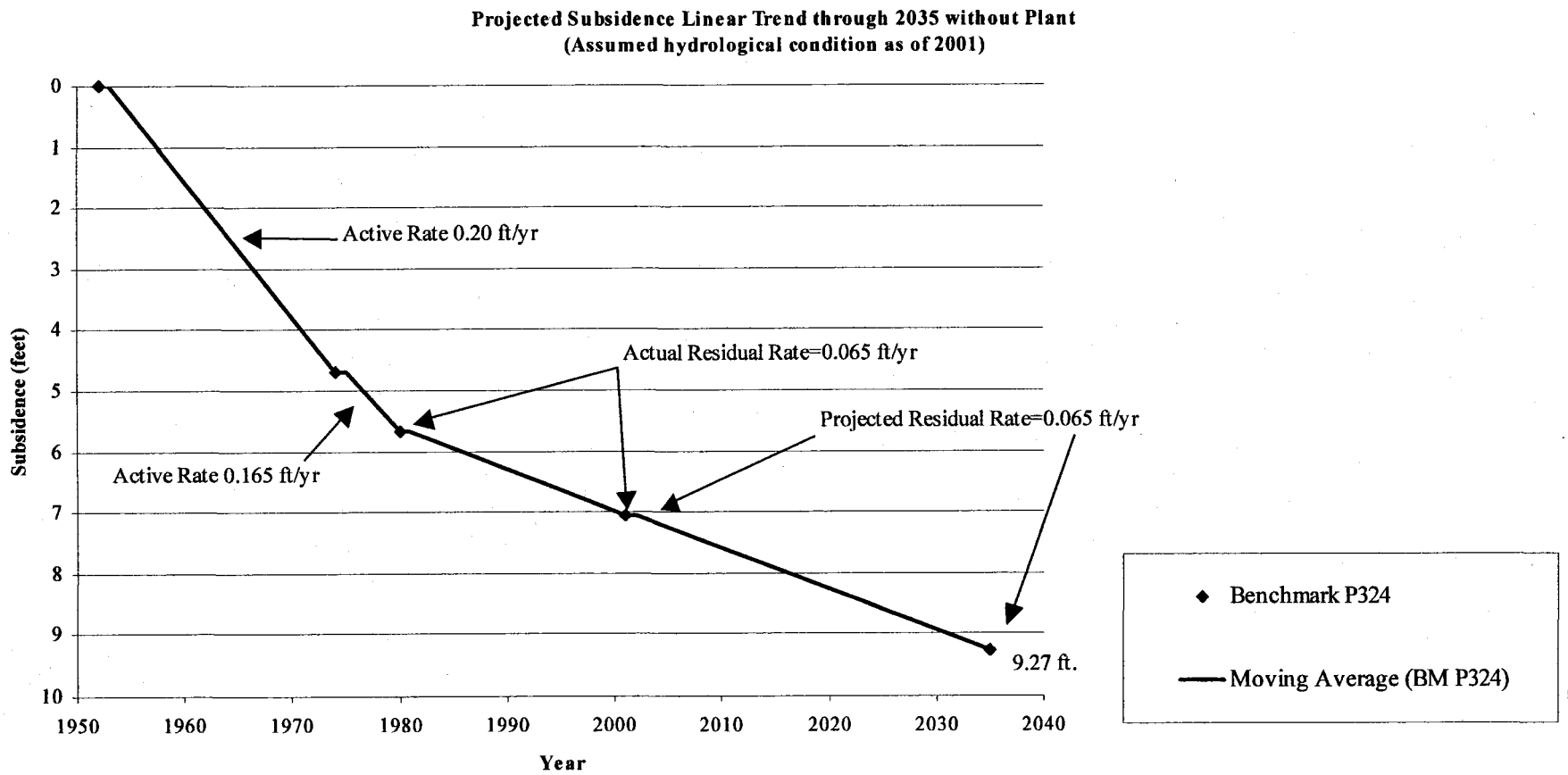

Projected Subsidence Linear Trend through 2035 without Plant
(Assumed hydrological condition as of 2001)
Subsidence (feet)
0
1
2
3
4
5
6
7
8
9
10
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
Year
Active Rate 0.20 ft/yr
Actual Residual Rate=0.065 ft/yr
Projected Residual Rate=0.065 ft/yr
Active Rate 0.165 ft/yr
9.27 ft.
Benchmark P324
Moving Average (BM P324)

CHART 2

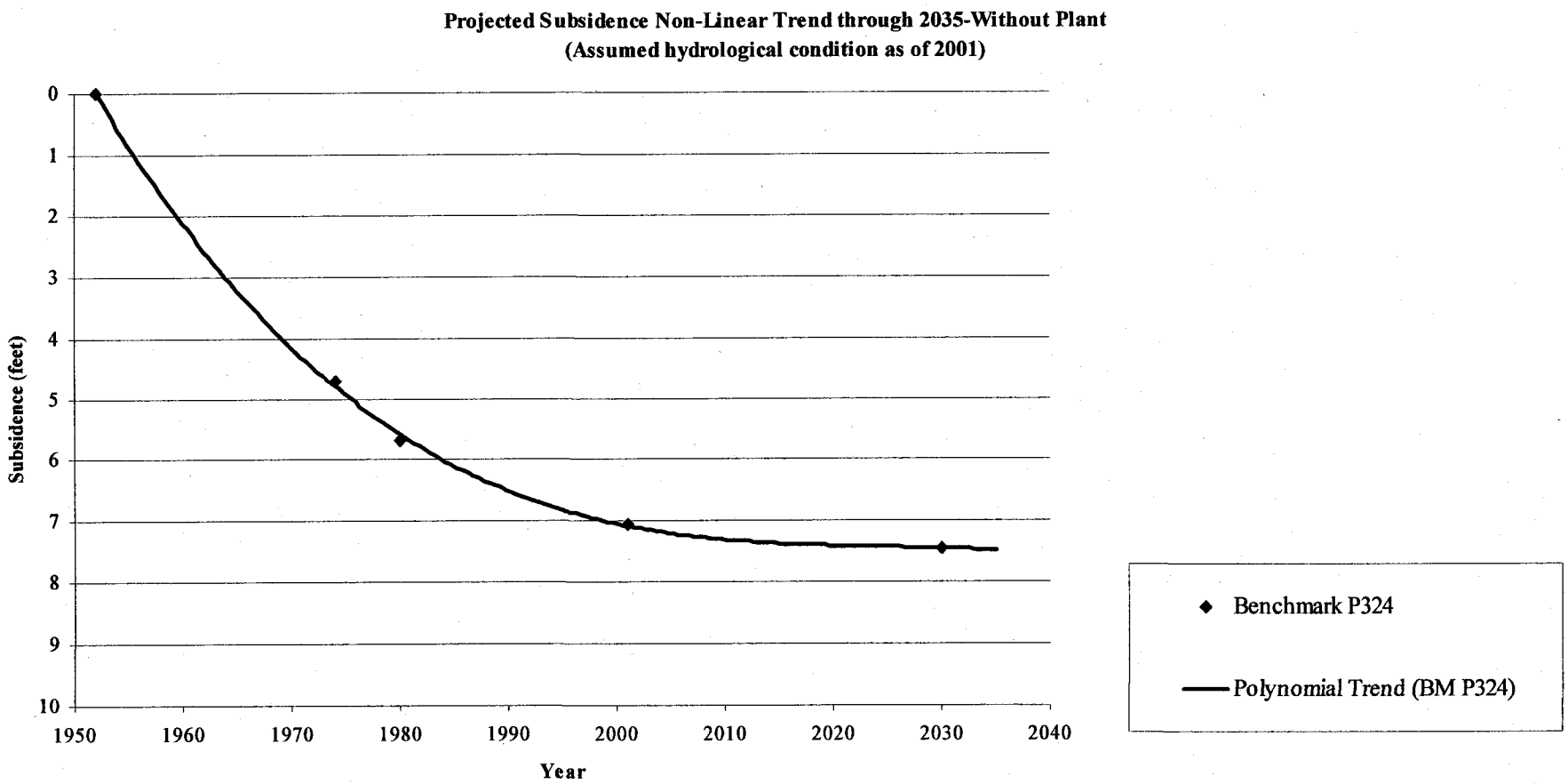
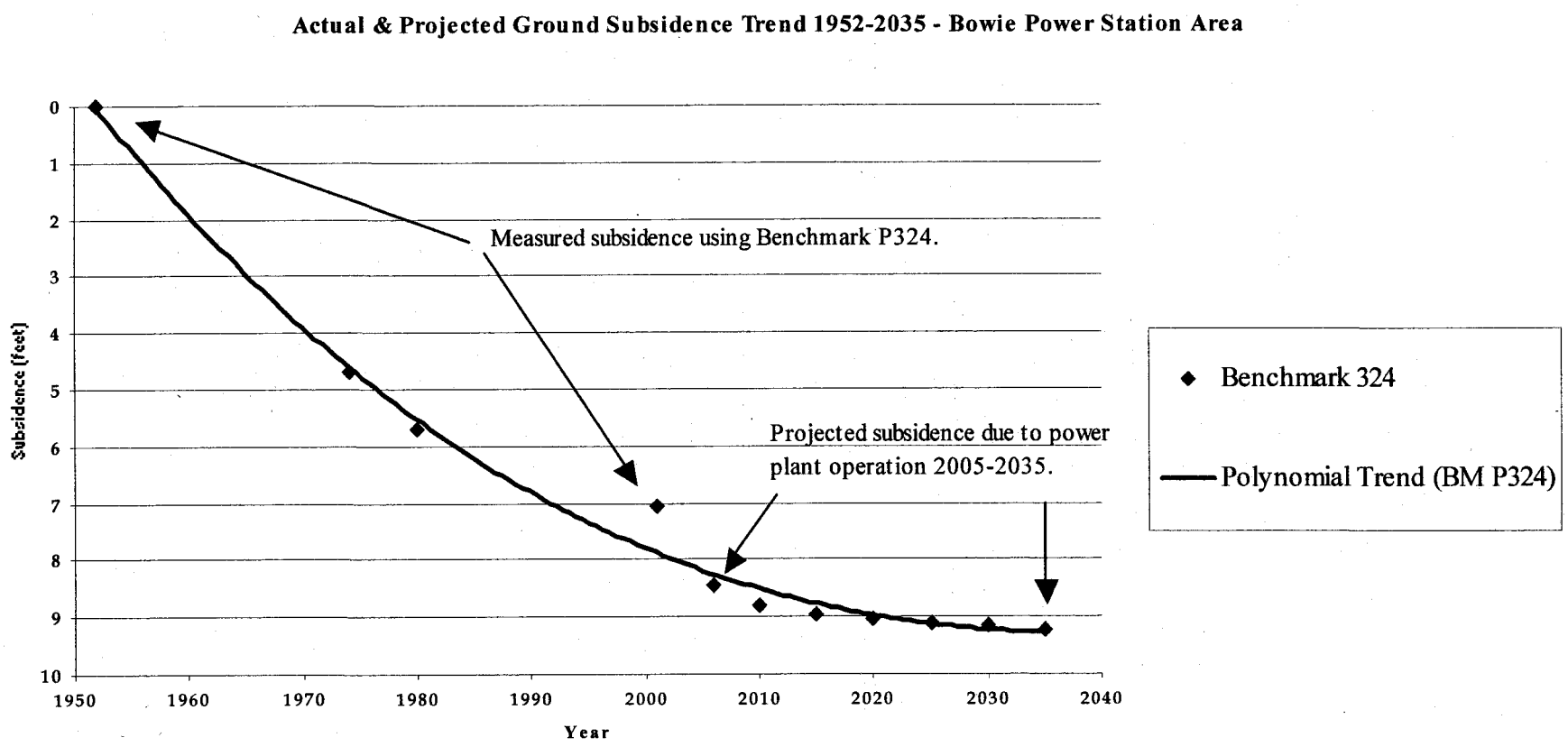
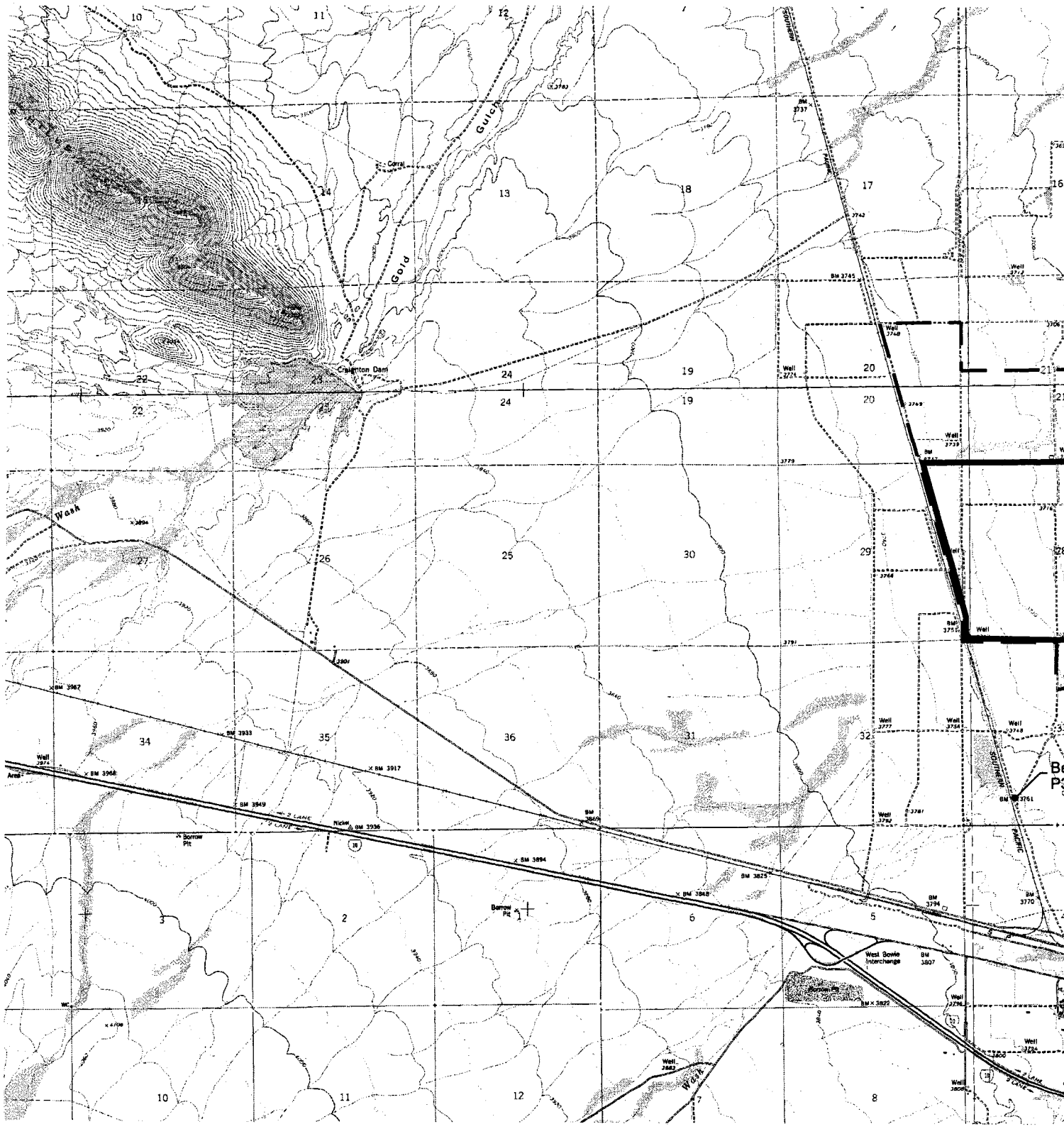

Projected Subsidence Non-Linear Trend through 2035-Without Plant
(Assumed hydrological condition as of 2001)
Subsidence (feet)
0
1
2
3
4
5
6
7
8
9
10
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
Year
Benchmark P324
Polynomial Trend (BM P324)

CHART 3


Actual & Projected Ground Subsidence Trend 1952-2035 - Bowie Power Station Area
Subsidence (Feet)
0
1
2
3
4
5
6
7
8
9
10
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
Year
Measured subsidence using Benchmark P324.
Projected subsidence due to power plant operation 2005-2035.
Benchmark 324
Polynomial Trend (BM P324)

Figures



Reference: USGS Topographic Quad
Fisher Hills, Az 1979
Ryan Draw, Az 1974
Bowie, Az 1974
Luzena, Az 1979

LEGEND:

SITE BOUNDARY

PROPERTY BOUNDARY

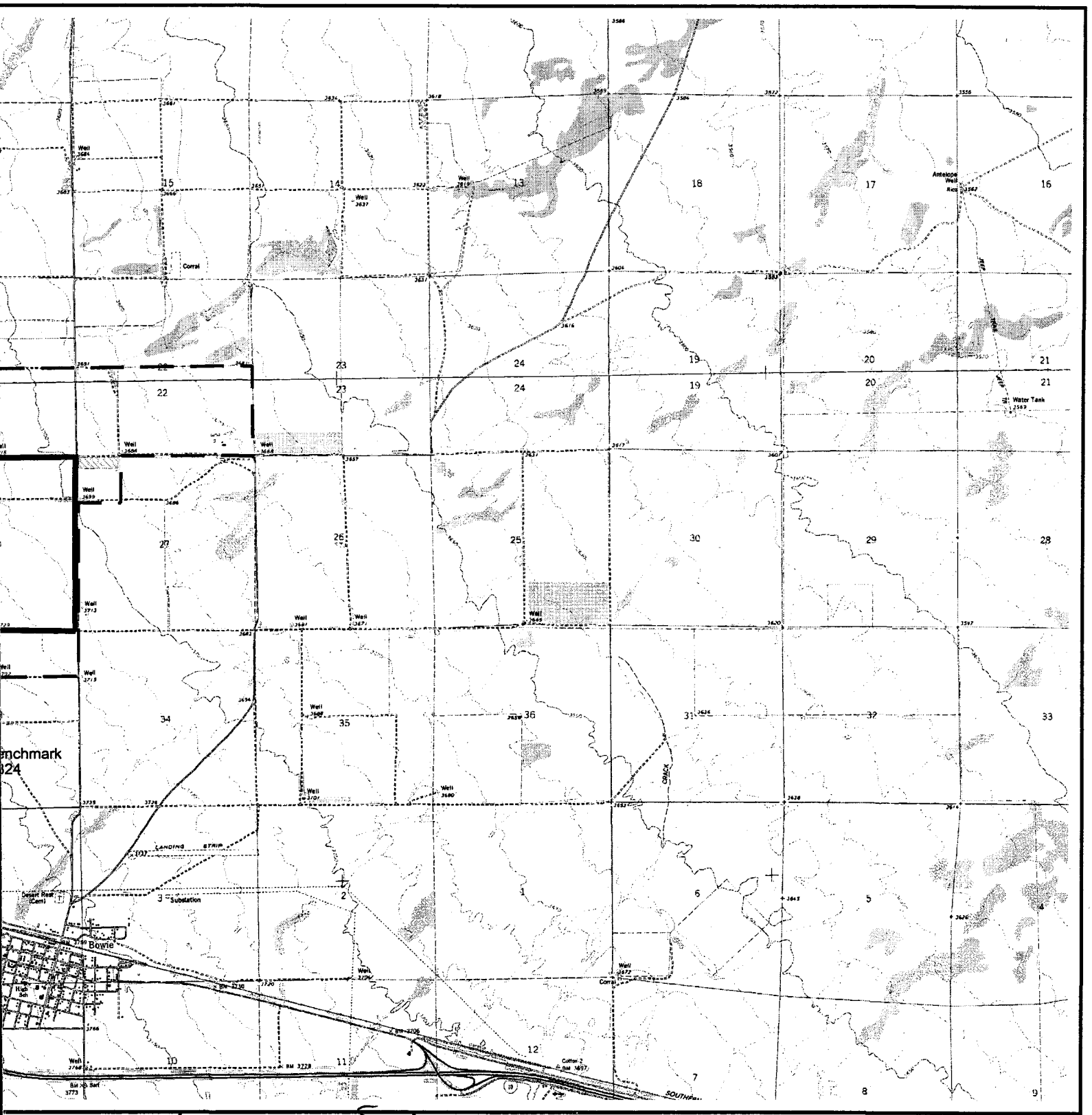
N

0 1

Scale in Miles

E1-47034002.00

A15050.DWG 10-8-01 XREF:46866001QUADS.DWG IMAGES:32109C5, 32109C4, 32109D4, 32109D5



2

REGISTERED GEOLOGIST
CERTIFICATE NO.
10338
KENNETH M.
EUGE
Date Signed 10/8/01
ARIZONA U.S.A.

Site Location Map

Figure 1
Bowie Power Station

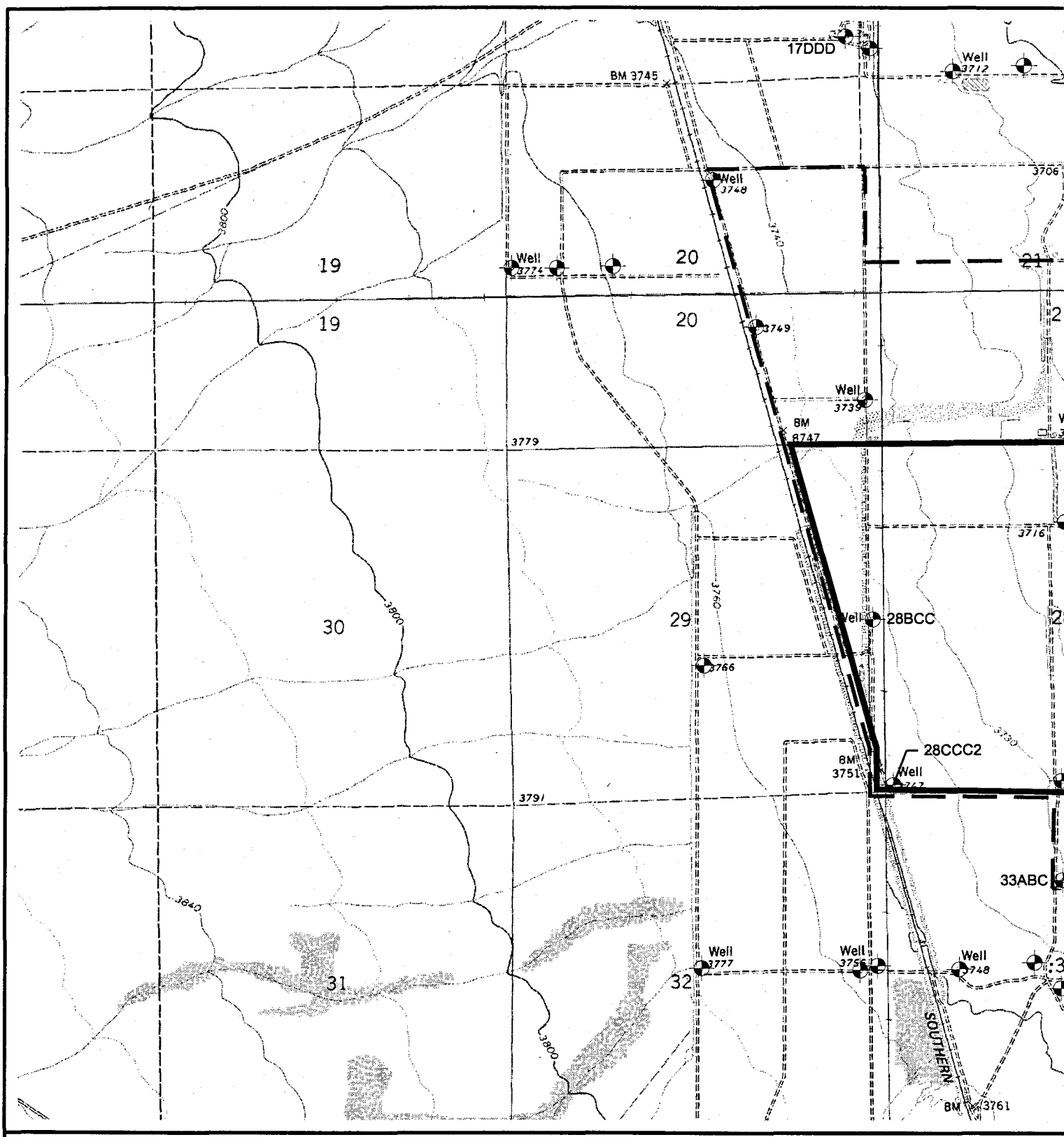
Geological Consultants Inc.
2333 West Northern Avenue, Suite 1A Phoenix, AZ 85021

OVERSIZED MAP

-Bowie Power Station
General Geologic Map
Figure 2

TO REVIEW SEE DOCKET SUPERVISOR

DOCKET
L-00000BB-01-0118-00000



Reference: USGS Topographic Quad
Fisher Hills, Az 1979
Ryan Draw, Az 1974
Bowie, Az 1974
Luzena, Az 1979

LEGEND:

EXISTING WELL

SITE BOUNDARY

PROPERTY BOUNDARY

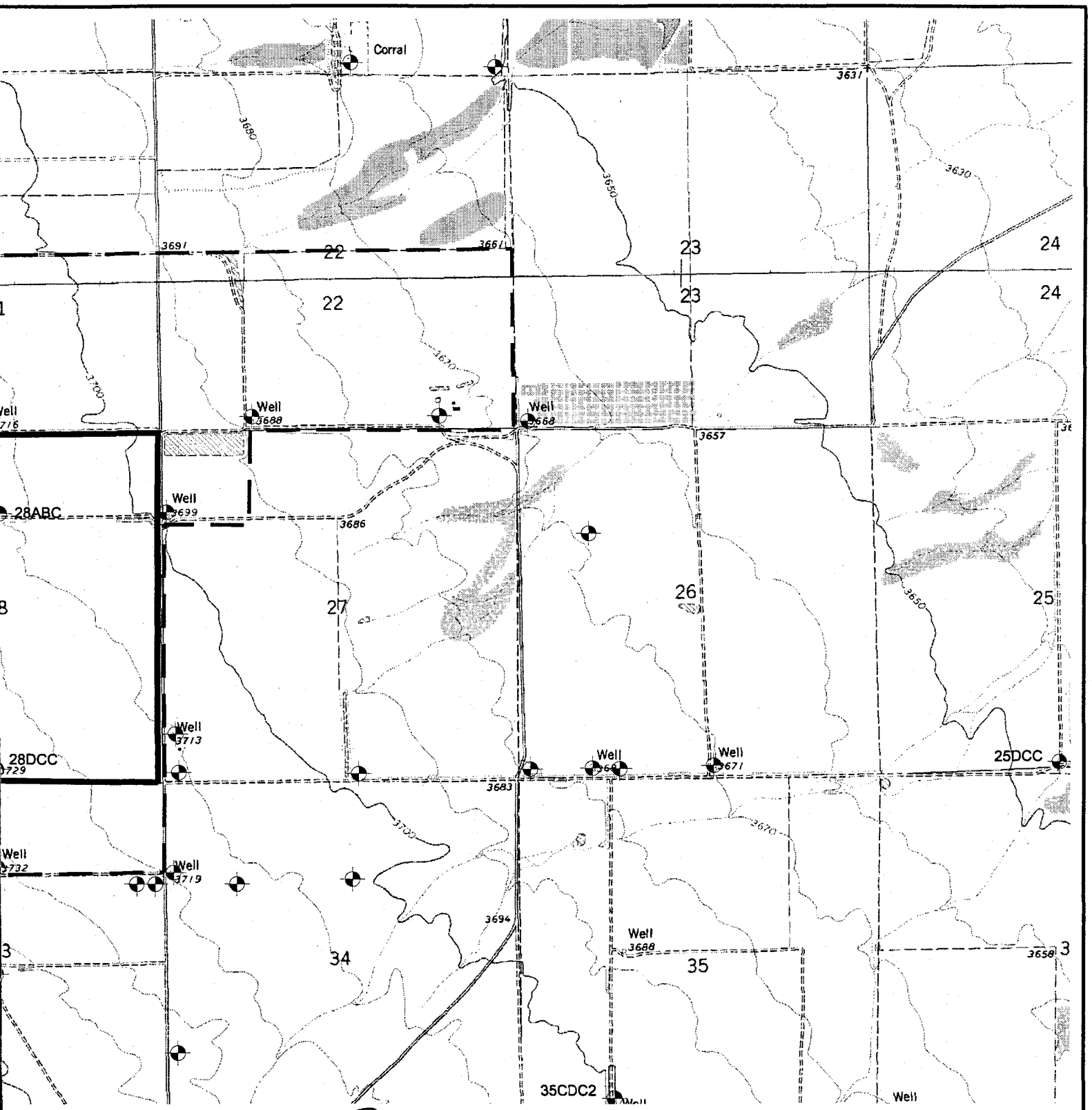
N

0 1/2

Scale in Miles

A15053.DWG 9-19-01 XREF:46866\001QUADS.DWG IMAGES:32109C5, 32109C4, 32109D4, 32109D5

E1-47034002.00



1

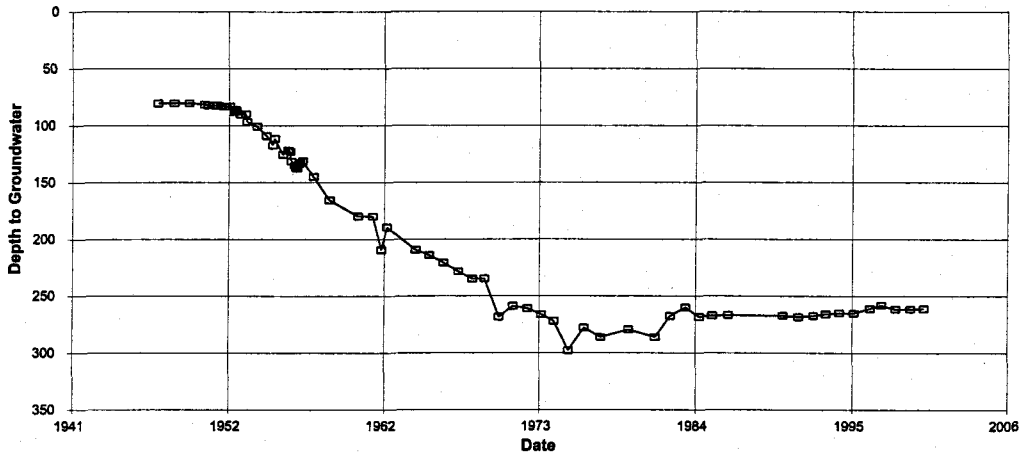
REGISTERED GEOLOGIST
CERTIFICATE NO.
10338
KENNETH M.
EUGE
Date Signed 10/08/01
ARIZONA U.S.A.

Well Location Map

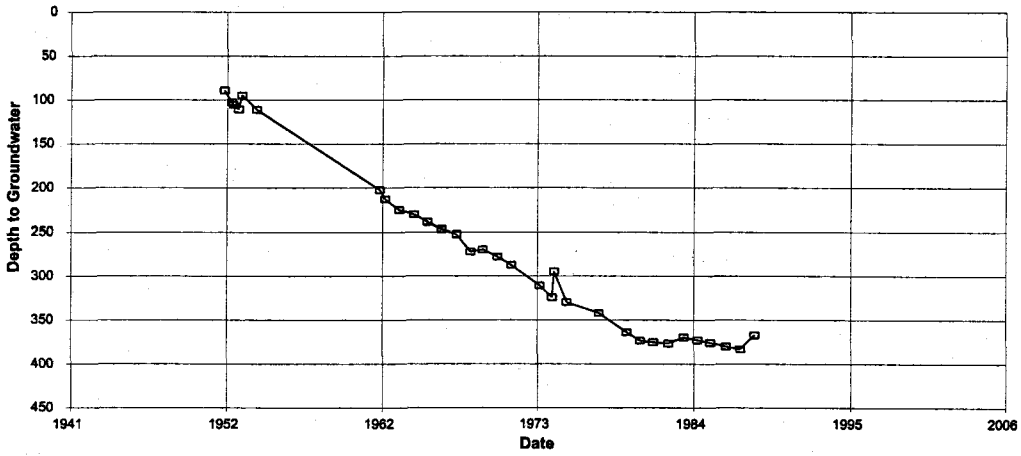
Figure 3
Bowie Power Station

Geological Consultants Inc.

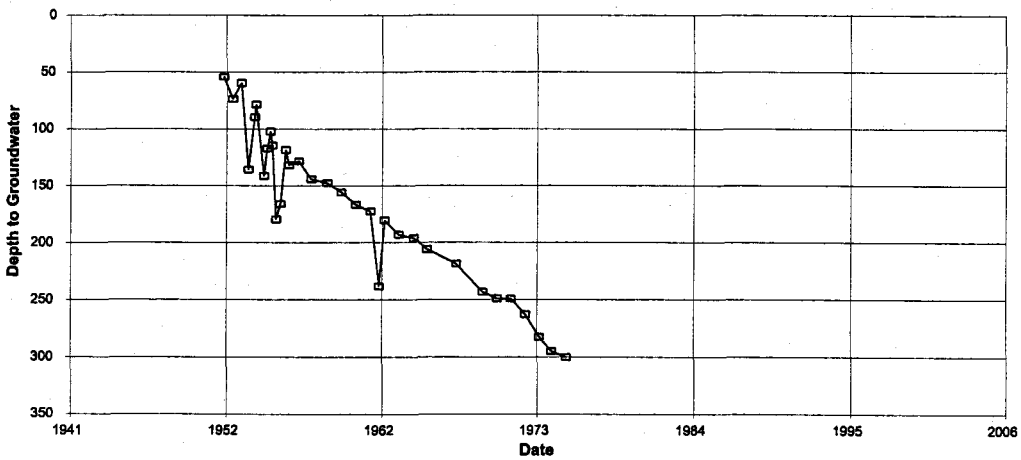
2333 West Northern Avenue, Suite 1A Phoenix, AZ 85021



Well No. 17DDD



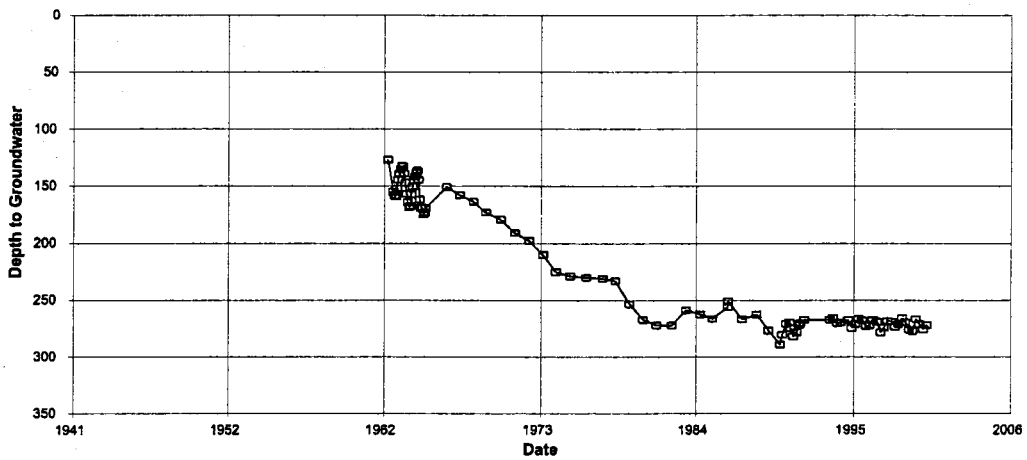
Well No. 33ABC1



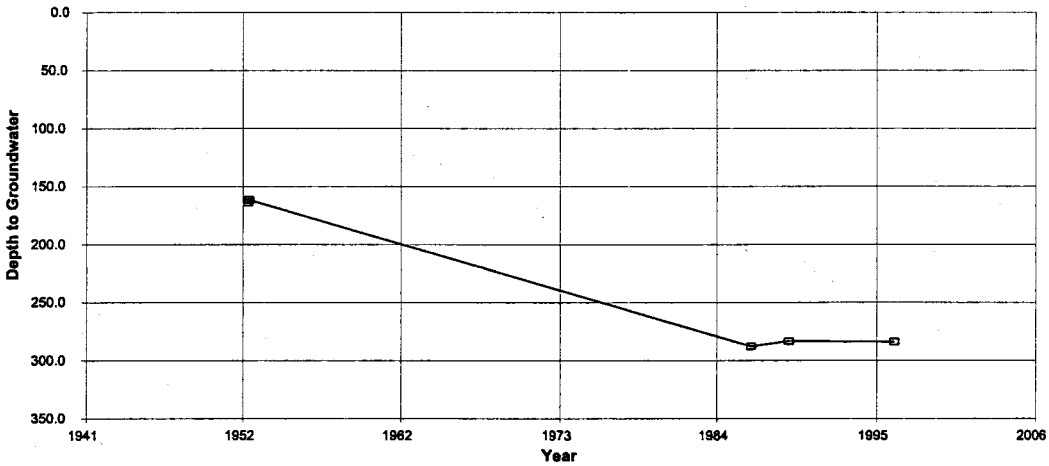
Well No. 35CDC2

A15066.DWG 10-3-01

E1-47034002.00



Well No. 25DCC



Well No. 04CCC1

REGISTERED GEOLOGIST
CERTIFICATE NO.
10338
KENNETH M.
EUGE
Date Signed 10/29/01
ARIZONA U.S.A.

Well Hydrographs

Figure 4
Bowie Power Station

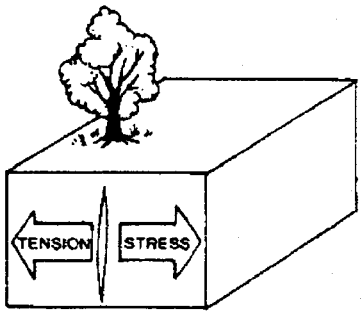
Geological Consultants Inc.
2333 West Northern Avenue, Suite 1A Phoenix, AZ 85021

OVERSIZED MAP

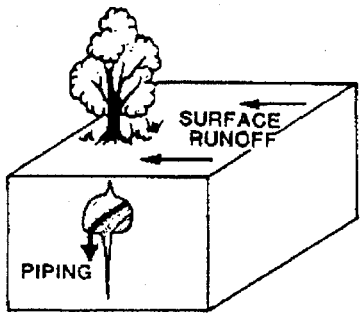
-Bowie Power Station Regional Ground Subsidence and Earth Fissure Map Figure 5

TO REVIEW SEE DOCKET SUPERVISOR

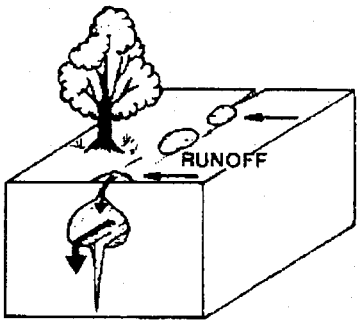
DOCKET L-00000BB-01-0118-00000



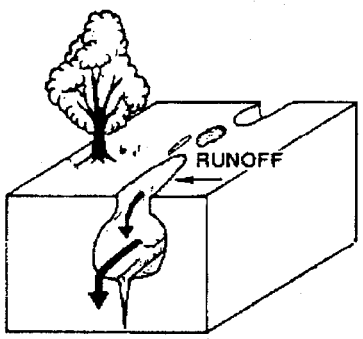
1. Lateral stresses induce tension cracking



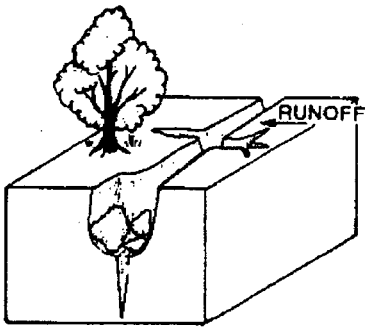
2. Surface runoff and infiltration enlarge crack through subsurface piping



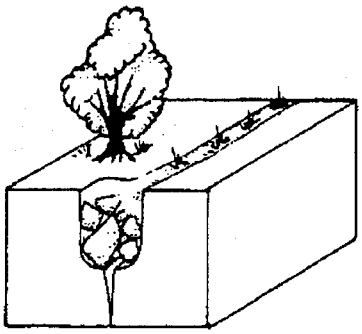
3. As piping continues, fissure begins to appear at surface as series of potholes and small cracks



4. As infiltration and erosion continue, fissure enlarges and completely opens to surface as tunnel roof collapses



5. The entire fissure is opened to the surface and enlargement continues as fissure walls are widened, extensive slumping and side-stream gullying occur



6. Fissure becomes filled with slump and runoff debris and is marked by vegetation lineament and slight surface depression, it may become reactivated upon renewal of tensile stress

(From Pewe, 1982)

REGISTERED GEOLOGIST
CERTIFICATE NO.
10338
KENNETH M.
EUGE
Date Signed 10/08/01
ARIZONA U.S.A.

Generalized Sequence of Earth Fissure Development

Figure 6
Bowie Power Station

Geological Consultants Inc.
2333 West Northern Avenue, Suite 1A Phoenix, AZ 85021

A15051.DWG 10-5-01

MEMORANDUM

Ryley Carlock & Applewhite
A PROFESSIONAL ASSOCIATION

Date: October 5, 2001

To: Tom Wray, General Manager, SouthWestern Power Group II, L.L.C.

From: Sheryl Sweeney, Esq. SAS

Subject: Bowie Project Water Overview

I. BACKGROUND

You have indicated that at a special open meeting of the Arizona Corporation Commission on October 3, 2001, Commissioner Spitzer inquired as to the nature of Arizona law governing groundwater withdrawals in non-active management areas ("AMA"). The purpose of this memo is to provide an overview of Arizona law which is both responsive to Commissioner Spritzer's inquiry and specific to the proposed Bowie Power Station Project (the "Project").

As further background to our analysis, it is our understanding that the proposed plant will be supplied with water pumped from wells located on the Project site.

II. DISCUSSION

A. REASONABLE AND BENEFICIAL USE

Outside of an AMA,[1] the owner of land overlying groundwater has the right to capture the groundwater percolating beneath the land and put the land to reasonable use (often referred to as the doctrine of reasonable use). *Town of Chino Valley vs. City of Prescott*, 131 Ariz. 78, 638 P.2d 1324 (1981); *Cherry v. Steiner*, 543 F.Supp 1270 (D.Ariz. 1982); *Bristor v. Cheatham*, 75 Ariz. 227, 225 P.2d 173 (1953). This legal principle has been codified in A.R.S. § 45-453.1, which states that "in areas outside of active management areas, a person may withdraw and use groundwater for reasonable and beneficial use . . .", subject to statutory limitations on the transportation of water away from the land. While there appear to be no reported Arizona cases addressing the use of groundwater for power generation, the use of water for power generation clearly is recognized as a beneficial use. For example, A.R.S. § 45-464.E., authorizes the creation of Type 2 water rights (within an AMA) for electrical generating facilities. The annual amount of such a right would be the amount determined to be reasonable to meet the operational requirements of the facility for a full year.

---

[1] We have confirmed that the Project is not located within an AMA.

EXHIBIT
Admitted
A-6

In that regard, the Third Management Plan ("TMP") for the Phoenix AMA imposes the following conservation requirements on large scale (more than 25 MW) power plants constructed after 1984:

1. An annual average of 15 or more cycles of concentration shall be achieved at fully operational cooling towers during periods when the power plant is generating electricity.

2. Blowdown water shall be discharged on a continuous basis, and make-up water shall be provided on a continuous basis.

3. The maximum amount of wastewater feasible excluding blowdown water and sanitary wastewater, shall be diverted to the cooling process.

TMP § 6-503. While these requirements are not applicable to the Project, because it is not located within an AMA, they provide a guide to what could be considered the most restrictive measure of "reasonableness." Thus, if the Project can meet these standards, it appears that the reasonable use requirements clearly would be satisfied.

B. TRANSPORTATION

Groundwater withdrawn can be put to use on the land from which it is withdrawn and can be transported within a subbasin of a groundwater basin (or within a groundwater basin if there are no subbasins) without payment of damages to surrounding water users. A. R. S. § 45-544.A.1(a). The water can be transported between subbasins, subject to the payment of damages, but cannot be transported away from a groundwater basin. A. R. S. § 45-544.A.1(b) and A.2. The Project is located entirely within the San Simon Valley subbasin of the Safford Basin. Therefore, the withdrawal of water from the Project site for use on the Project site will not give rise to a statutory claim for damages.

C. CONVERSION

In non-AMA areas, a groundwater use can be converted from an irrigation to an industrial use at will, subject only to the doctrine of reasonable use and any applicable limitations on the transportation of water away from the land from which it is withdrawn. There are no applications or permits required for the conversion.

D. WELLS

When an existing well is conveyed, a notice of change of ownership must be filed with the Arizona Department of Water Resources ("ADWR"). A. R. S. § 45-593.C. In addition, if the type of use changes (e.g., from irrigation to industrial), the owner of the well should file a notice of change of well information with ADWR, to ensure that the new use is of record.

In order to drill a new well outside of an AMA, a notice of intention to drill must be filed with the Arizona Department of Water Resources ("ADWR"), describing the location and characteristics of the proposed well, and the name and license number of the well driller. A.R.S. § 45-596.C. Assuming that the information in the notice of intent is complete, ADWR will notify the applicant that it may proceed to drill the new well. A.R.S. § 45-596.D.

III. CONCLUSION

In light of the foregoing, and with specific reference to the Project, it would appear that the Project's proposed use of groundwater is in accordance with all applicable Arizona law.

Gas Displacement - Example

Bowie Purchase | $2.80 + $0.30 + $0.05 = $3.15

Displaced Purchase | $3.10 + $0.45 - $0.05 = $3.50

Bowie Savings | $0.35 per MMBtu

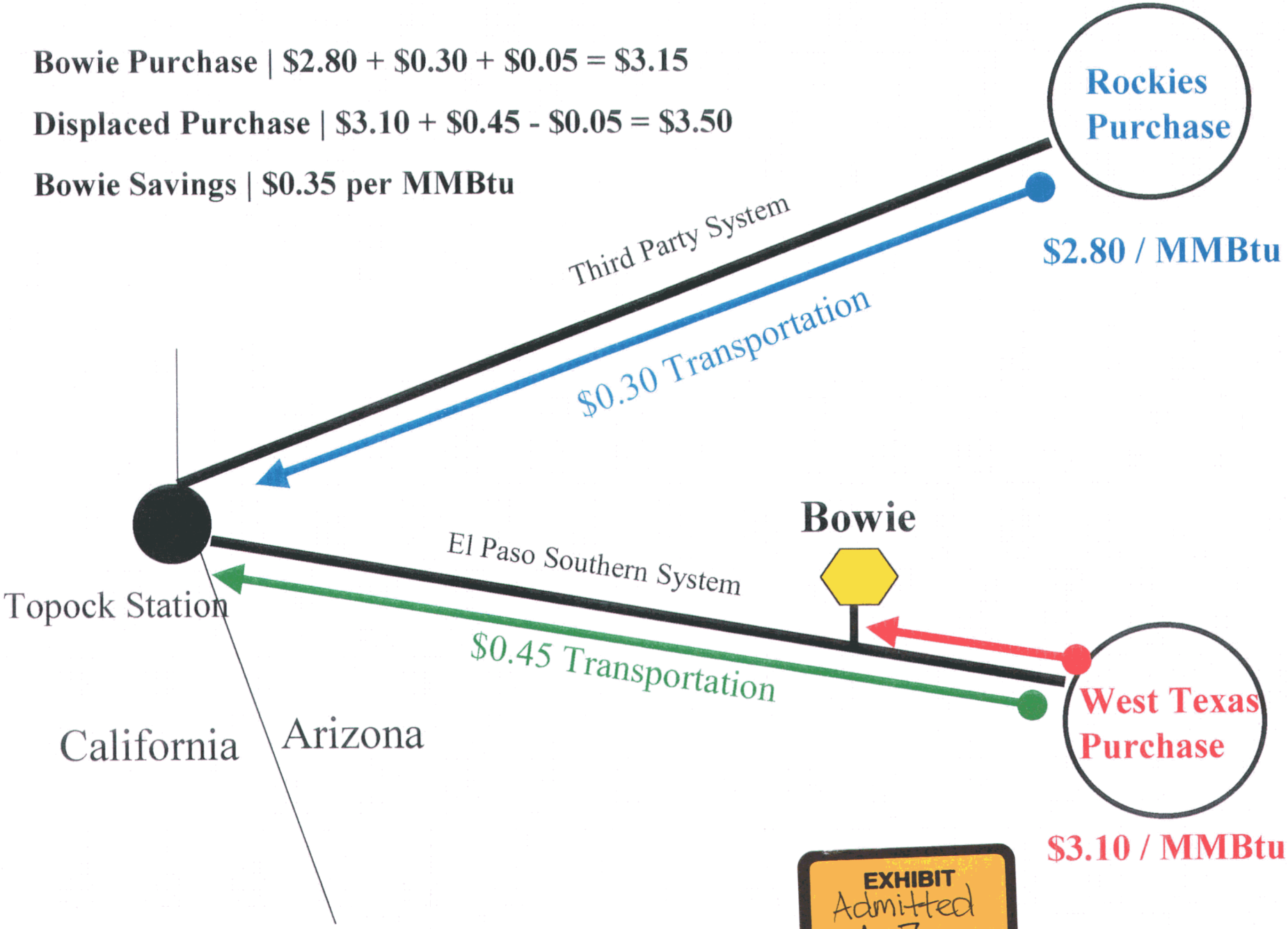


EXHIBIT
Admitted
A-7

BOWIE POWER STATION

Economic Comparison
Wet vs. Dry Cooling

Assumptions

Output (MW)	1,000	950
Heat Rate (Btu/kWh)	7,000	7,200
Capacity Factor	80%	75%
Capital Cost	Base	$10M
O&M Cost	Base	$0.50

EXHIBIT
Admitted
A-8

BOWIE POWER STATION

Economic Comparison Wet vs. Dry Cooling

Results

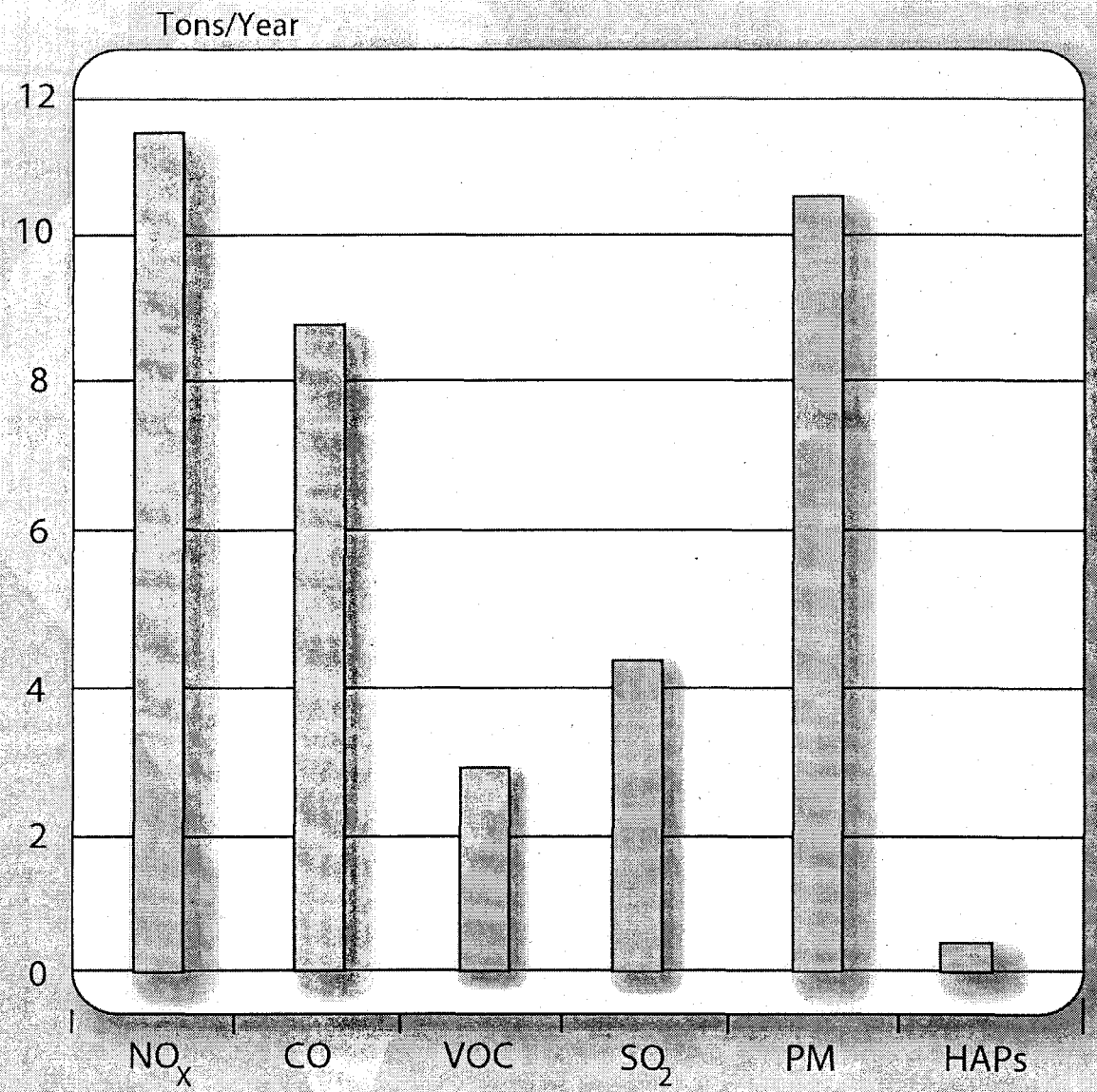
Net Generation (MWH) With heat rate effect	7,008,000	6,068,125
30-year Economic Premium paid	—	$447,414,897
Equivalent Value Per acre-feet of water	—	$2,983

BOWIE POWER STATION

Advantages of Wet Cooling System

- Less of a visual impact (50 ft. vs. 120 ft.)
- Less air pollution
- Lower noise impact (5 dBA)

Net Increase of Air Pollutants for Dry Cooling System



Pollutant	Tons/Year
NO_X	11.3
CO	8.9
VOC	3.0
SO_2	4.4
PM	10.6
HAPs	0.3

Average annual output
1,000 MW

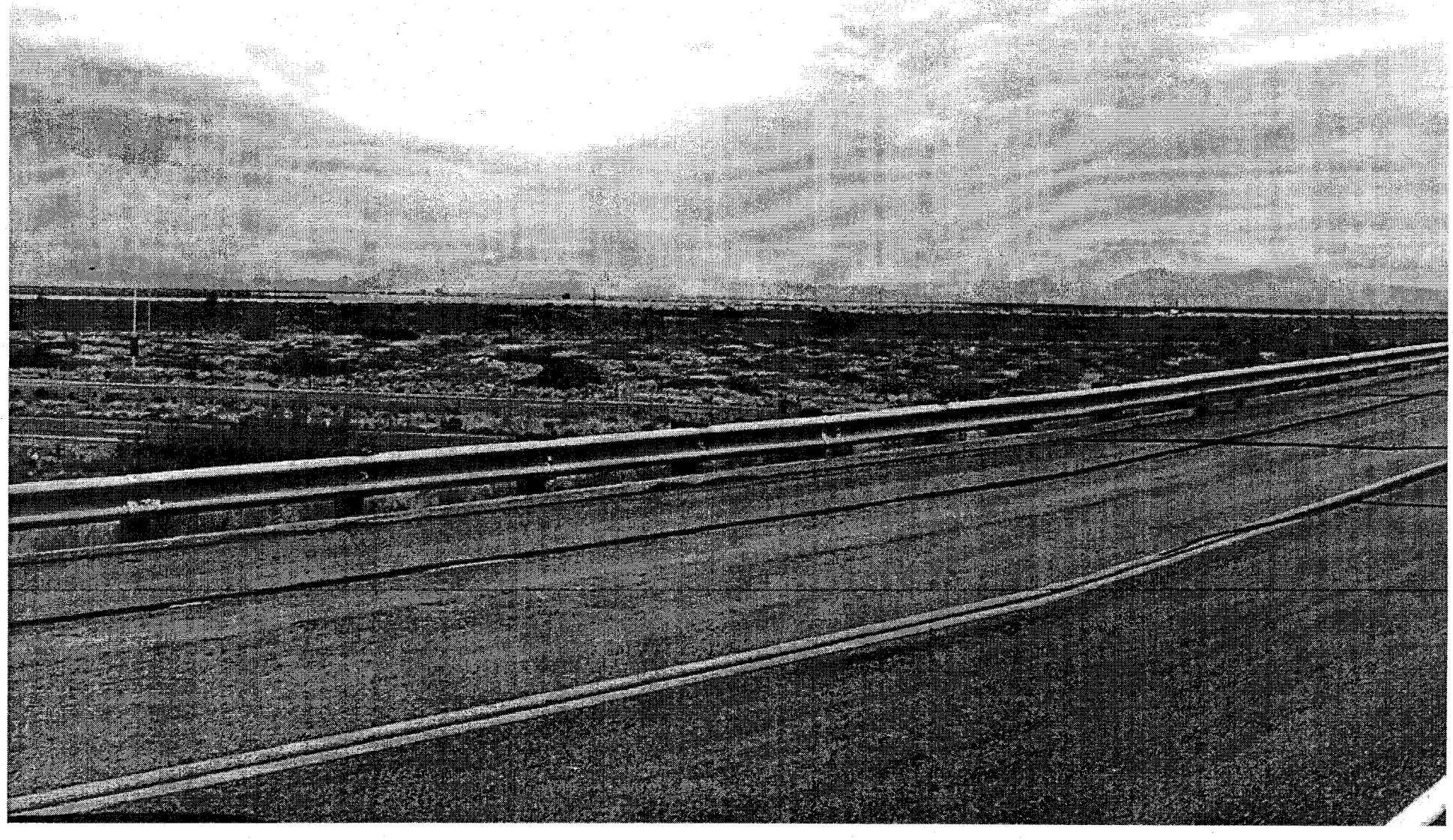
BOWIE POWER STATION

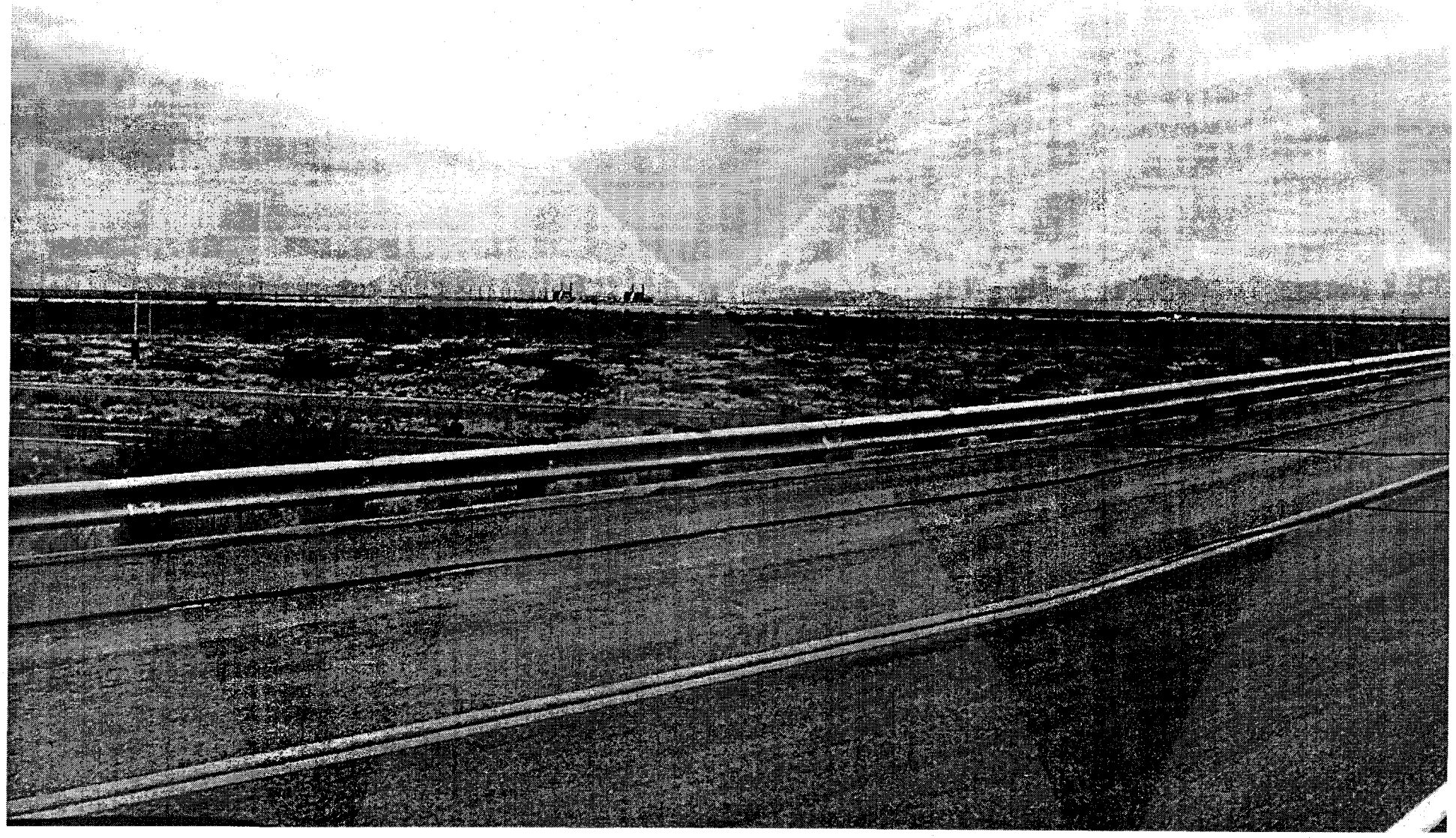
Increase of Noise Impact for Dry Cooling System

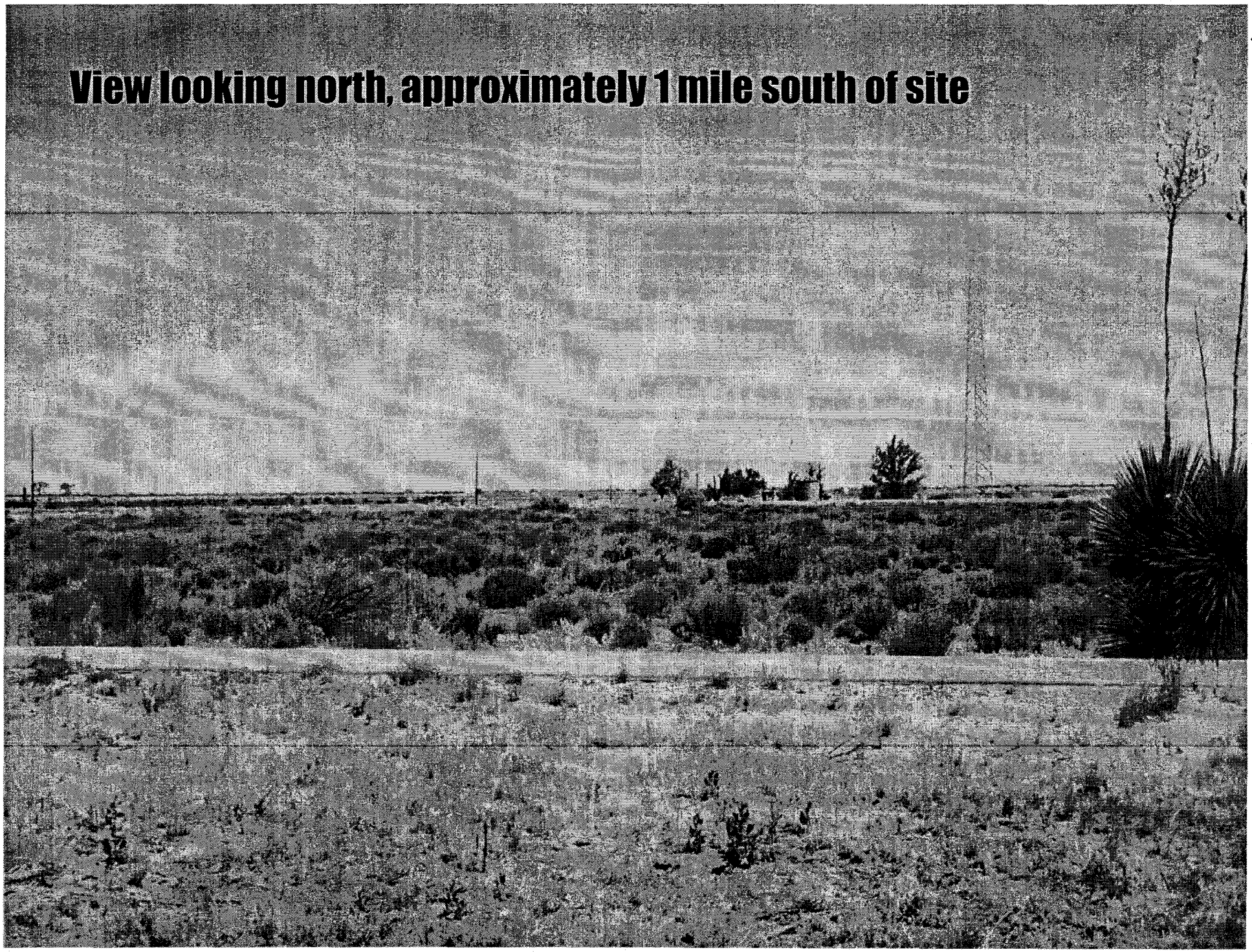
Impact: 5 dBA louder

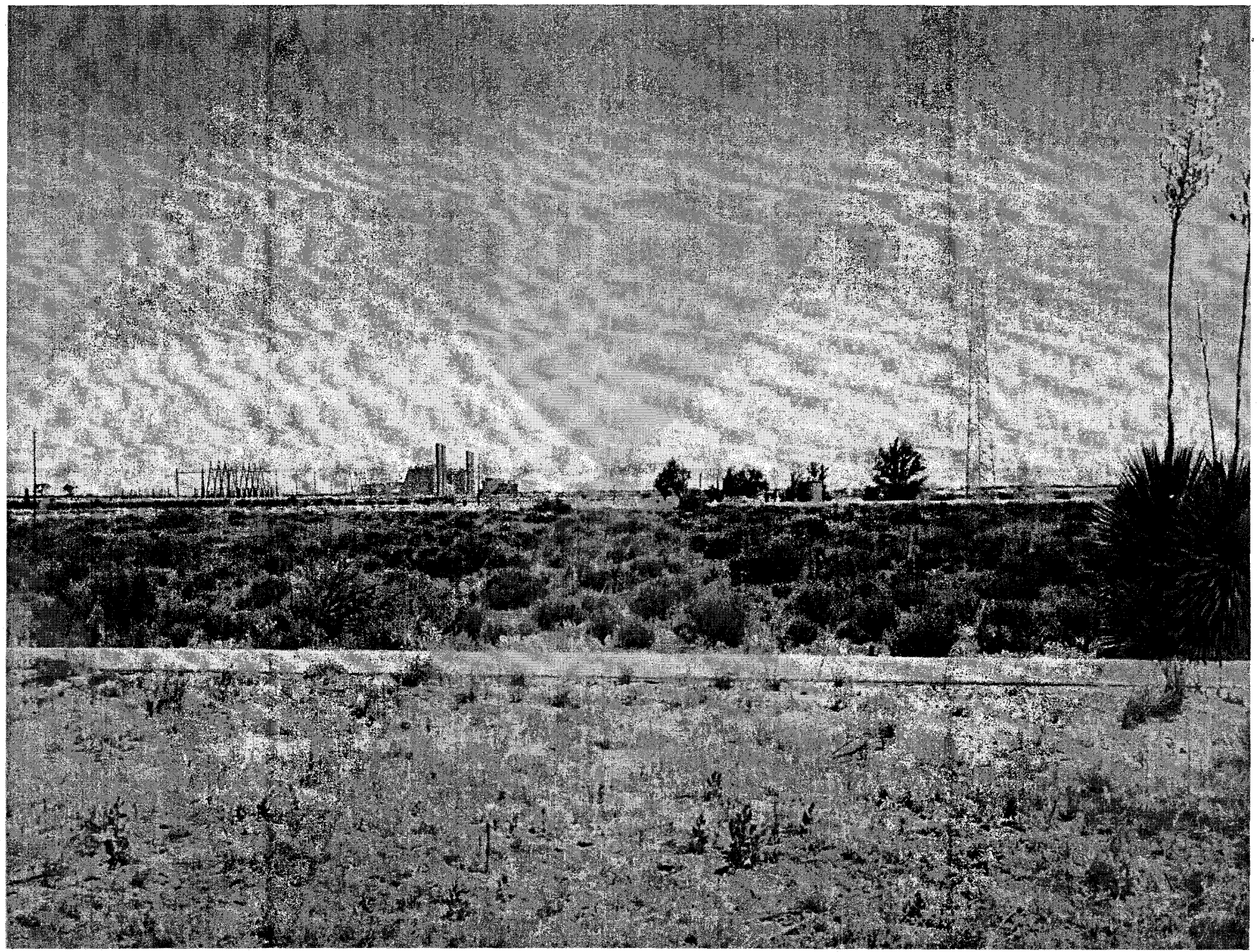
ISO of the United Nations	
Change (dBA)	Description
0	No observed reaction
5	Sporadic complaint
10	Widespread complaints
15	Threaten community action
20	Vigorous community action

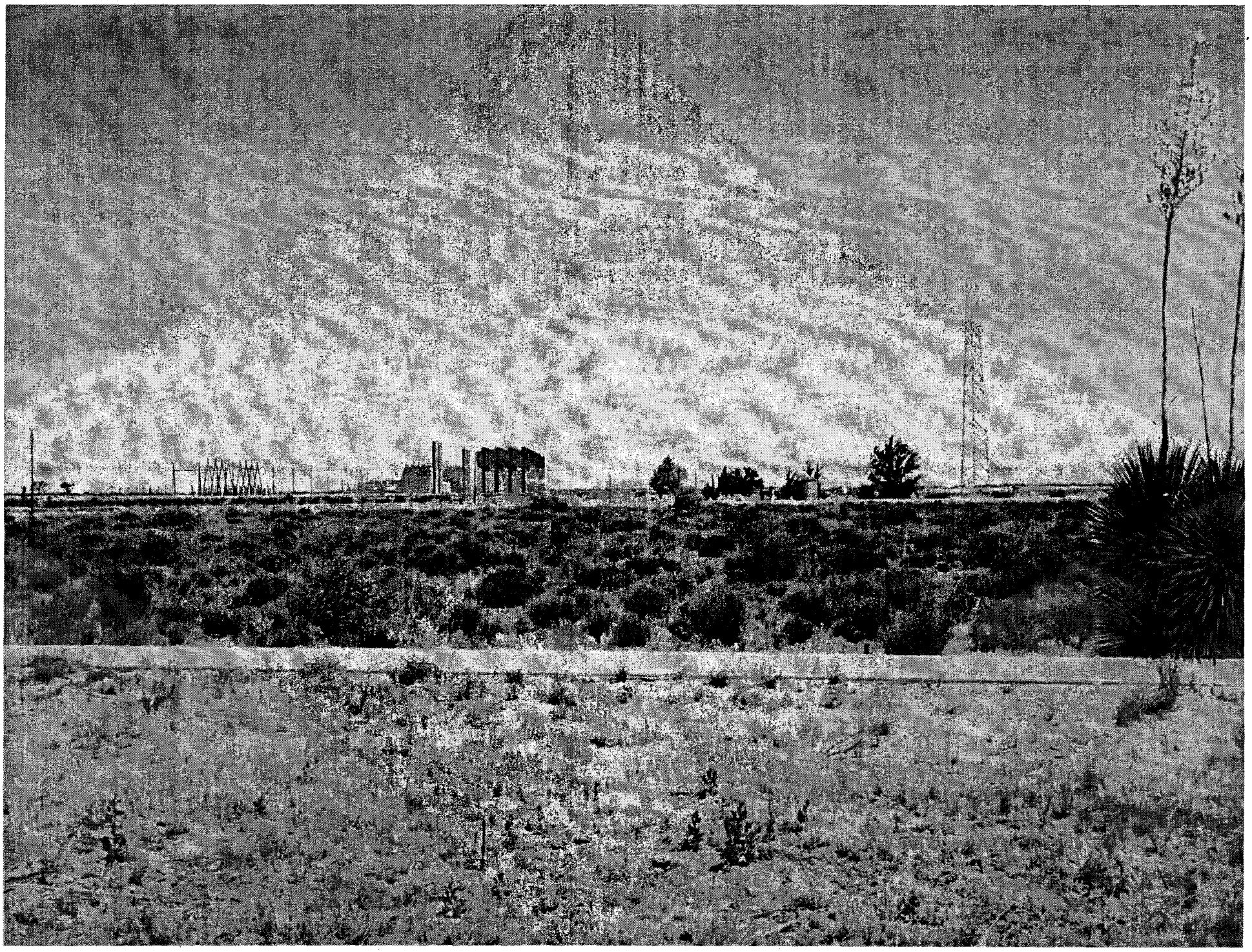
View looking northeast from I-10, approximately 2 ½ miles from site

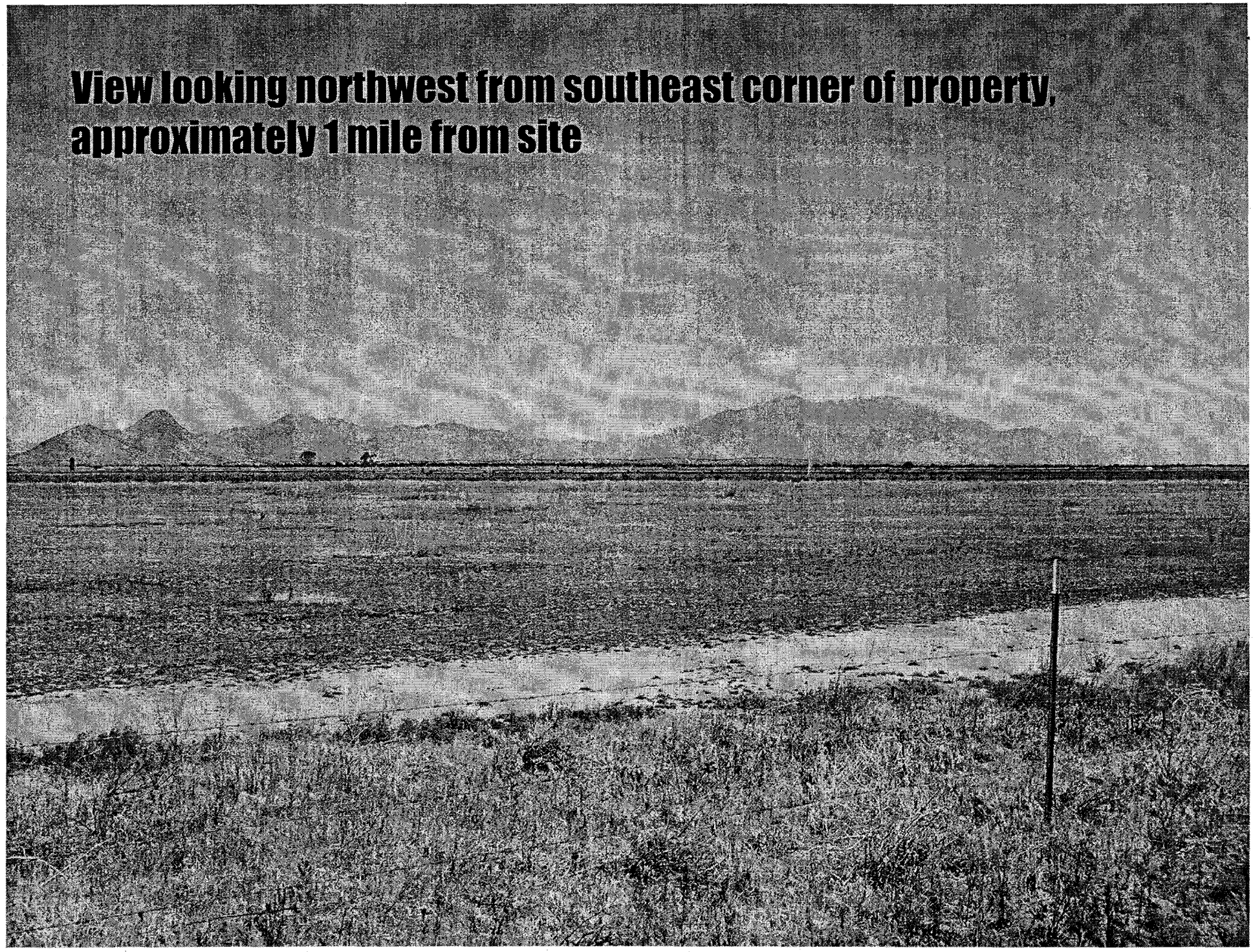


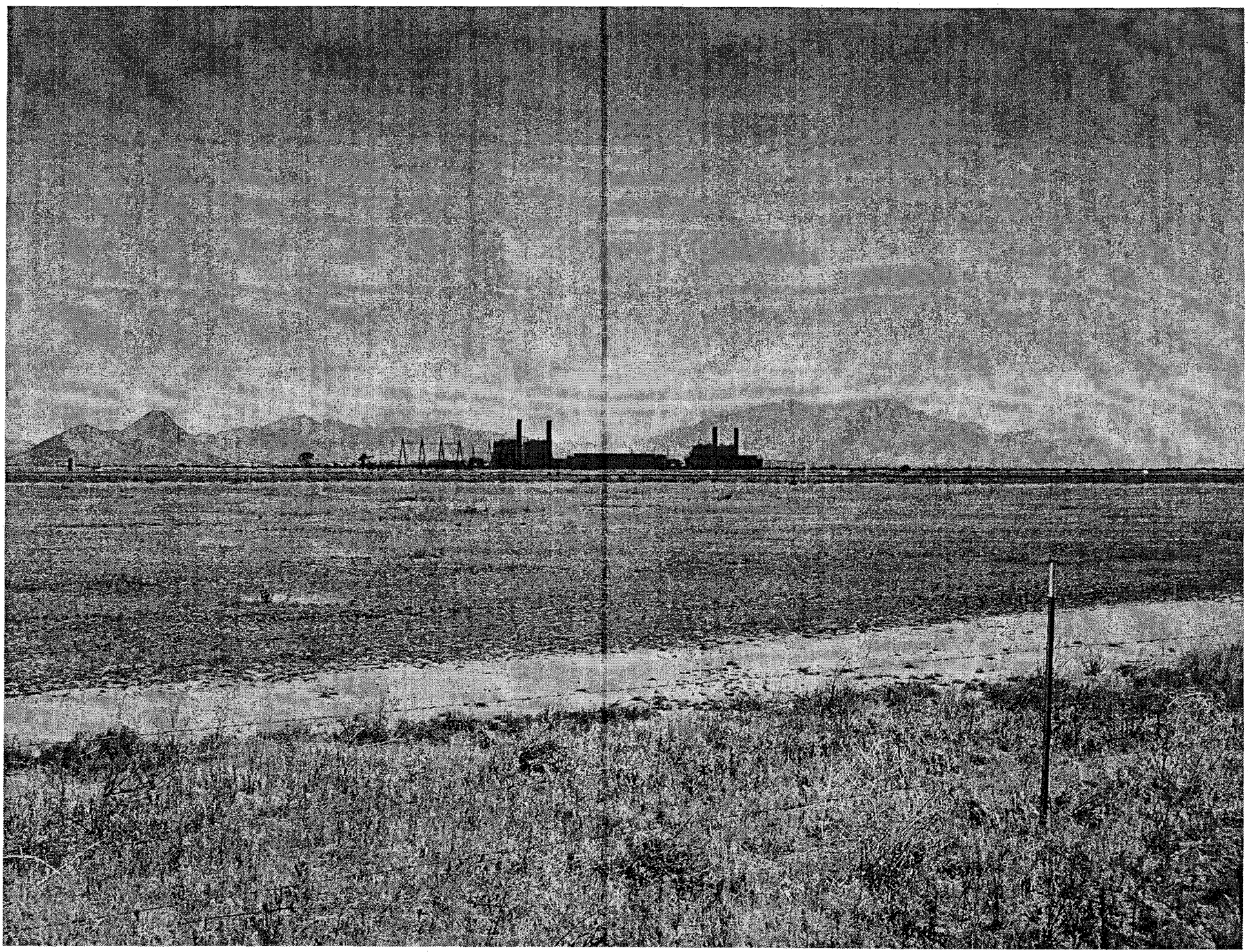



View looking north, approximately 1 mile south of site






View looking northwest from southeast corner of property,
approximately 1 mile from site



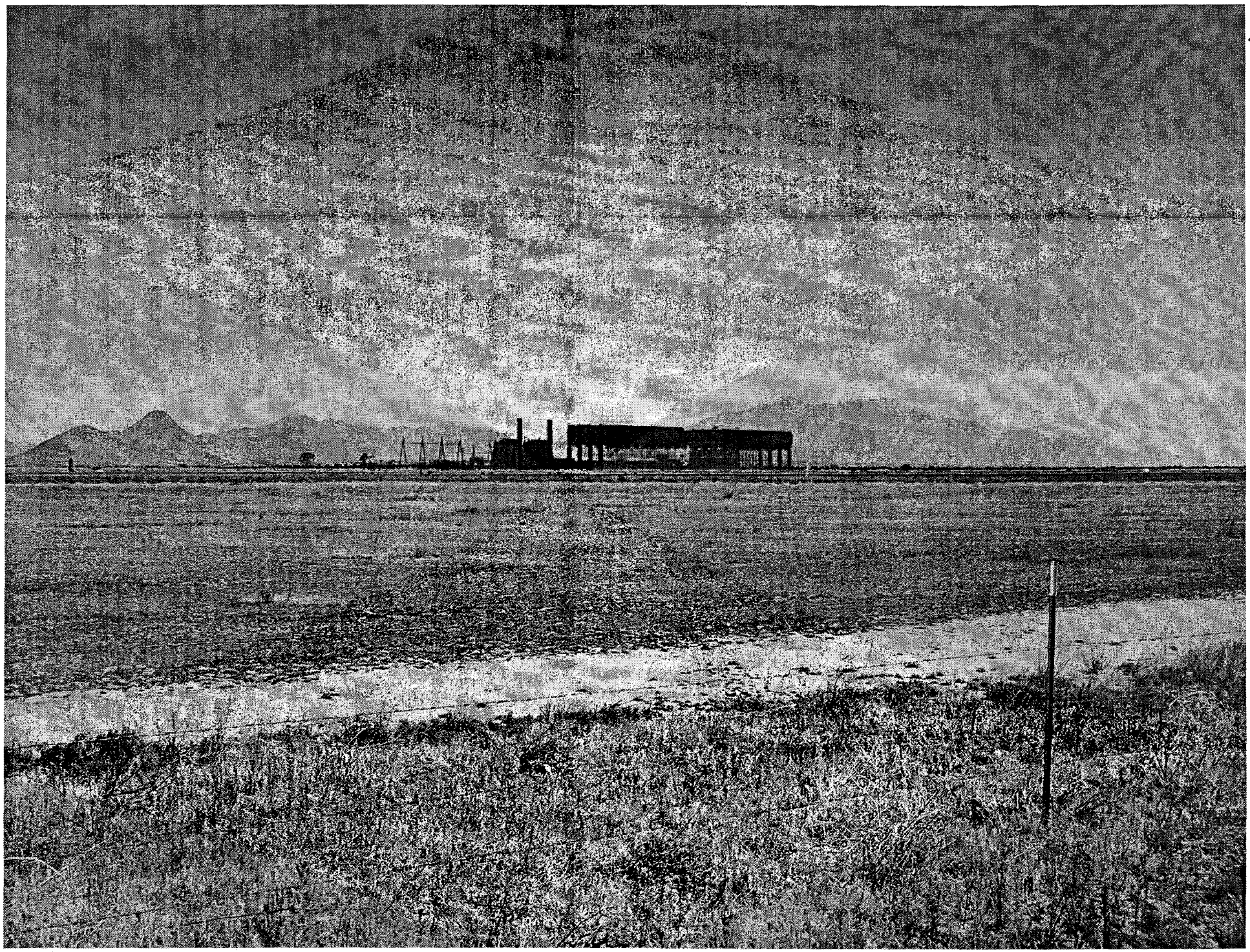


EXHIBIT
Admitted
A-9

environmental planning group

October 23, 2001

Mr. John Kennedy
Habitat Branch Chief
Arizona Game and Fish Department
2221 West Greenway Road
Phoenix, Arizona 85023-4399

SUBJECT: AGFD NO. 04-27-01(7)
Transmittal of the Application for Certificates of Environmental Compatibility
Bowie Power Station – Case No. 118
Bowie, Arizona

Dear Mr. Kennedy:

As we discussed in our telephone call last Friday, I am forwarding you a copy of the Application for Certificates of Environmental Compatibility for the Bowie Power Station and 345kV Transmission Line and Switchyard on behalf of the applicant, Bowie Power Station, LLC. The application contains more detailed plans than were available when the initial inquiry letter regarding special status species was sent in April. The response letter from AGFD dated May 8, 2001 is located in Exhibit C, along with the survey of areas of biological wealth.

If you have any questions, please do not hesitate to call me at 520-795-2001 or Mickey Siegel at 602-956-4370.

Sincerely,

E. Linwood Smith, PhD
Biological Services Manager

Enclosure (1)

cc w/o enclosure: Laurie A. Woodall, Chairman of the APPTLSC
Tom C. Wray, SouthWestern Power Group II
Lawrence V. Robertson, Jr., Munger-Chadwick
Mickey Siegel, EPG

4350 E. Camelback Rd. • Suite G-200 • Phoenix, Arizona 85018
602-956-4370 • 602-956-4374 fax • www.epgaz.com

Bowie Power Station Permitting Schedule

Permit	Month/Year
CEC – ACC	
Filed	07/01
Hearings (start)	10/01
Siting Committee decision*	12/01
ACC decision*	02/02
Air Permit – ADEQ	
Filed	12/01
Public hearing*	06/02
Permit issued*	08/02
Aquifer Protection Permit – ADEQ	
Filed	12/01
Administratively complete*	02/02
Permit issued(reviewed by EPA Region 9)*	08/02
Well Permit – ADWR	
Filed*	02/02
Administratively complete*	03/02
Permit to drill issued by ADWR*	04/02
Local Zone Approval/Industrial Use Permit	
Filed*	02/02
Hearing (Cochise County Planning Commission)*	03/02
Hearing (Cochise County Board of Supervisors)*	04/02

Note: * - Anticipated date

EXHIBIT
Admitted
A-10

Rev. 12/10/01

[redacted]

GEOLOGICAL CONSULTANTS INC.

EXHIBIT
Admitted
A-11

GEOLOGICAL CONSULTANTS INC.

Kenneth M. Euge, R.G.

GROUND SUBSIDENCE & EARTH FISSURE MONITORING PROGRAM

BOWIE POWER STATION
COCHISE COUNTY, ARIZONA

Prepared for:

Mr. Ravi Murthy, P.E.
URS Corporation
7720 North 16th Street, Suite 100
Phoenix, AZ 85020

Prepared by:

Geological Consultants Inc.
2333 West Northern Avenue, Suite 1A
Phoenix, Arizona 85021

REGISTERED GEOLOGIST
CERTIFICATE NO. 10338
KENNETH M. EUGE
Date Signed 12/06/01
ARIZONA U.S.A.

Project No. 2001-168

December 6, 2001

TABLE OF CONTENTS

EXECUTIVE SUMMARY 1

1.0 INTRODUCTION 4

1.1 Monitoring Programs in Other Areas 4

1.2 Monitoring Program Elements 6

2.0 GROUND SUBSIDENCE AND EARTH FISSURE MONITORING PROGRAM 8

2.1 Groundwater Level Monitoring 8

2.2 Ground Subsidence Monitoring 9

2.2.1 Ground Subsidence Monitoring Benchmarks 9
2.2.2 Re-survey Ground Subsidence Benchmarks 11
2.2.3 Operational Ground Subsidence Monitoring 12
2.2.4 Subsidence Monitoring Network Survey Methods 13

2.3 Earth Fissure Monitoring 13

2.4 Reporting 14

2.5 Alert Conditions and Contingencies 15

3.0 BIBLIOGRAPHY 17

TABLES

Table Number Title

1 Groundwater Level Monitoring Wells 18
2 Primary Ground Subsidence Monitoring Benchmarks 19
3 Primary Ground Subsidence Monitoring Benchmarks: Proposed New Survey Benchmarks in Plant Vicinity 19
4 Summary of Reported Earth Fissures within 5-mile Radius of Bowie Power Station Site 20

FIGURES

Figure Number	Title
1	Representative Wells for Groundwater Level Monitoring
2	Ground Subsidence Monitoring Benchmarks Location Map

APPENDICES

Appendix Number	Title
A	NGS Geodetic Benchmarks Construction Guidelines and Construction Details
B	Primary Ground Subsidence Monitoring NGS Benchmarks: NGS Benchmark Data Sheets

EXECUTIVE SUMMARY

This report presents a recommended ground subsidence and earth fissure monitoring program for the proposed Bowie Power Station site in the San Simon Valley of the Safford Basin north of Bowie, Cochise County, Arizona. The scope of the monitoring program, which will be implemented by the Owner/Operator, includes the following activities:

- Identify representative groundwater wells, within and near the Bowie Power Station to be used for on- and off-site groundwater level monitoring, that have a history of groundwater level monitoring by the Arizona Department of Water Resources (ADWR).
- Identify and select five existing National Geodetic Survey (NGS) benchmarks for ground subsidence level surveying both on- and off-site.
- Install six new benchmarks, including two within the Bowie Power Station property, to supplement the existing NGS benchmark network.
- Establish procedures and guidelines for conducting benchmark level surveys.
- Identify known earth fissures for monitoring and procedures to document observations.
- Define an annual monitoring schedule for the initial five years of plant operation that may be adjusted depending upon the groundwater level, subsidence, and earth fissure monitoring results
- Compile and analyze groundwater level and ground subsidence measurement.
- Define alert and action items to deal with anomalous or unforeseen groundwater level, ground subsidence, or earth fissure conditions.
- Prepare ground subsidence and earth fissure monitoring reports.

Groundwater Level Monitoring

Nine groundwater wells, that have a history of monitoring by the ADWR, are located within five miles of the Bowie Power Station property. Historic groundwater level information on some of these wells is available to the public through the ADWR Groundwater Site Inventory (GWSI). Bowie will obtain and compile the groundwater level information, including those collected by ADWR, for inclusion in the monitoring reports.

Ground Subsidence Monitoring

Five existing NGS benchmarks within five miles of the Bowie Power Station property will be used for ground subsidence level surveying. Three of these benchmarks have a history of being used for ground subsidence monitoring measurements. Additionally, six new benchmarks, including two within the Bowie Power Station property, will be installed to supplement the existing NGS benchmark network. An initial monitoring Baseline Data Set (BDS) survey will be conducted prior to commencement of plant operation. Subsequent monitoring surveys will be conducted annually for the first five years of plant operation. The monitoring frequency will be adjusted based on the results of the initial five years of monitoring. The benchmark surveys will be conducted using conventional traverse level surveys or Global Positioning System (GPS) methods. The survey control will be tied to an existing NGS survey control benchmark founded in bedrock about 3½ miles west-northwest of the Bowie Power Station.

Earth Fissure Monitoring

Geologists, at a frequency consistent with the ground subsidence monitoring program, will monitor four known earth fissures within a five-mile radius of the Bowie Power Station using direct field observation. A focused geological reconnaissance will be conducted within the entire Bowie property to investigate for the presence of any new earth fissures that may develop during the monitoring period. The earth fissure monitoring will include documentation of surface expression and any visual indications of renewed earth fissure activity.

Analysis and Report

Data from the ground subsidence and earth fissure monitoring program will be prepared and submitted in a report following evaluation and analysis of the data gathered during each monitoring period. Groundwater level data, ground subsidence data, and earth fissure observations will be compiled in an easily used format. Although not anticipated based on the results of the Ground Subsidence and Earth Fissure Evaluation (Geological Consultants, 2001), if the results of the monitoring program indicate possible anomalous or unforeseen conditions that (1) exceed predicted ground subsidence rates (about 0.072 feet per year) or (2) indicate renewed earth fissure activity, additional action items would be evaluated. These action items could include development of an

investigative program to evaluate the alert condition, notification of appropriate jurisdictions regarding the alert condition and proposed program to evaluate the alert condition, conduct of the investigative program, and if necessary, preparation of appropriate work plans and alternatives to mitigate the alert condition.

As used herein, the phrase "alert condition" means: (1) Ground subsidence rates substantially exceed the predicted average rate of 0.072 feet per year at the ground subsidence benchmarks' BOWIE1and BOWIE2 at the Bowie Power Station and/or (2) field evidence of new earth fissure activity or renewed activity along an existing earth fissure within a 5-mile radius of the plant site. As used herein, the phrase "action item" means a task or series of tasks to thoroughly evaluate the identified alert condition and, if required as a result of evaluation of the "alert condition," to prepare appropriate work plans and alternatives to mitigate the identified "alert condition."

A qualitative assessment of trends observed within the ground subsidence data gathered during the monitoring program will be used to determine "alert condition"for off-site areas.

Ground subsidence and earth fissure monitoring reports will be distributed to ADWR, Arizona Geological Survey, Arizona Corporation Commission, Central Arizona Project, U.S. Geological Survey (USGS), Water Resources Branch (Tucson).

Ground Subsidence and Earth Fissure Monitoring Program

Bowie Power Station
Cochise County, Arizona

1.0 INTRODUCTION

This report presents a recommended ground subsidence and earth fissure monitoring program for the proposed Bowie Power Station site in the San Simon Valley of the Safford Basin north of Bowie, Cochise County, Arizona. Assessments of documented and future potential ground subsidence and earth fissures and their potential impact on the design, construction, and safe operation of the Bowie Power Station have been previously conducted. The scope and results of the ground subsidence and earth fissure assessment are presented in a report entitled "Ground Subsidence and Earth Fissure Evaluation, Bowie Power Station, Cochise County, Arizona" dated October 8, 2001, prepared by Geological Consultants Inc. of Phoenix, Arizona on behalf URS Corporation and Bowie Power Station L.L.C. (Geological Consultants, 2001a).

This document comprises a proposed program for monitoring ground subsidence and earth fissures in the southwest portion of San Simon Valley section of the Safford Basin in conjunction with operation of the Bowie Power Station. The ground subsidence and earth fissure monitoring program will be implemented by the Owner/Operator as a condition of the Certificate of Environmental Compatibility (CEC) for the power station.

1.1 Monitoring Programs in Other Areas

A ground subsidence and earth fissure monitoring program was developed to address CEC conditions for Toltec Power Station (Geological Consultants, 2001b). The Toltec Power Station monitoring program, which was reviewed and approved by the ADWR, is used as the model for the Bowie Power Station ground subsidence and earth fissure monitoring program.

No other ground subsidence monitoring programs associated with power plant withdrawal of groundwater were identified. However, monitoring programs that deal with shallow settlement caused by structural loading of near-surface soils, during and shortly after construction, are commonly implemented:

- A settlement monitoring program was designed and implemented for the Palo Verde Nuclear Generating Station west of Phoenix, Arizona in response to Nuclear Regulatory Commission criteria for siting a nuclear power facility. The program was designed specifically to monitor for construction-related heave and settlement associated with site excavations and structural loading, respectively. The program includes installation of specially designed benchmarks that were integrated into the site survey network. Additionally, special extensometers anchored in bedrock were installed beneath each power block unit. The survey benchmarks and extensometers were monitored on a monthly interval during the construction period and at fewer frequent intervals following construction. The purpose of the monitoring program was to verify the predictive heave and settlement models for the plant design.

Research of various federal, state, and local jurisdictional agency documents indicates several monitoring programs have been developed specifically for the purpose of monitoring ground subsidence caused by groundwater withdrawal:

- A program has been implemented by the Harris-Galveston Subsidence District (HGSD) to assess ground subsidence in the Houston-Galveston, Texas metropolitan area where more than 13 feet of subsidence has occurred since 1943 (HGSD, 1998). The primary District program includes a series of NGS benchmarks that have been re-surveyed periodically since 1975 throughout the metropolitan area using conventional survey methods and the GPS. The benchmark network is used to define absolute and differential ground elevations. These data are also used to define historic and current ground subsidence and to calibrate predictive subsidence models. The HGSD network is now the survey basis used by all governmental agencies in the region.

- An aquifer compaction and land subsidence monitoring program has been implemented in the El Paso, Texas-Juarez, Chihuahua area (Heywood, 1994). Through the 1980s, extensive ground water use in the metropolitan area has induced ground subsidence. Population growth and associated increases in groundwater use is expected to continue. In 1992, the USGS, in cooperation with the NGS and the U.S. Section of the International Boundary and Water Commission, began a subsidence monitoring program to quantify the mechanical response of the aquifer

to subsidence-induced stresses. The initial program included conventional leveling of NGS benchmarks to first-order accuracy. GPS is used to periodically monitor elevation changes affecting the network benchmarks.

- A ground subsidence and earth fissure monitoring program has been developed for the Flood Control District of Maricopa County (FCDMC) related to the safety evaluation of the District's flood control structures and other related facilities (Kimley-Horn & Associates Inc., 2000). When implemented, this program will include the survey of benchmarks throughout Maricopa County that will be used to monitor ground surface elevation changes at regular intervals ranging from one year to five years, depending upon the rate of subsidence near each structure. Earth fissure monitoring will also be conducted for fissures located within a five-mile radius of a structure. Earth fissure monitoring will be conducted at the same intervals as the subsidence monitoring.

1.2 Monitoring Program Elements

Because of the anticipated groundwater use in the Bowie Power Station area and the potential for related ground subsidence, a subsidence monitoring program will be implemented. Groundwater conditions, groundwater pumpage history, aquifer test results, and water level drawdown modeling for the Bowie Power Station site and surrounding area are discussed in detail in the Water Supply Report for the Proposed Bowie Power Station, Bowie, Arizona, prepared by URS Corporation (URS, 2001). The proposed monitoring program includes the elements necessary to assess groundwater level conditions, ground subsidence and earth fissures during the operational life of the Bowie Power Station. The key elements include monitoring ground water levels, land surface elevation changes, and conditions in the vicinity of documented earth fissures. The following description of the monitoring program is based on a combination of the author's experience with the subsidence monitoring program developed by the FCDMC, the experience of the United States Bureau of Reclamation (BOR) in connection with the Central Arizona Project canal, the National Resource Conservation Service (NCRS) in connection with flood control structures in Graham County and Cochise County, and project experience of other qualified consultants dealing with ground subsidence and earth fissures.

The initial activity of the subsidence monitoring program consists of an evaluation of known subsidence within the Bowie Power Station area. As stated previously, this evaluation has been conducted. The results of the ground subsidence evaluation help to establish the general parameters of the monitoring program and the specific details for monitoring at the Bowie Power Station site. If significant subsidence and earth fissure conditions are identified during the monitoring program that might compromise the facility's geotechnical and engineering design criteria and possibly affect the safe operation of the power plant or off-site areas, the monitoring program results will be used in connection with the development of mitigation measures to reduce potential ground subsidence impacts to the power plant facilities and off-site areas.

Implementation of the subsidence and earth fissure monitoring program will provide an adequate "early warning" system to allow the Owner/Operator to evaluate these ongoing geological phenomena and assess and appropriately respond to the observed conditions, if necessary. Additionally, other agencies may use the information gathered to supplement their own ground subsidence assessment programs within the San Simon Valley of the Safford Basin or other nearby areas.

The scope of the ground subsidence and earth fissure monitoring program is tailored to Bowie Power Station. The monitoring program is designed to incorporate trigger mechanisms that will become activated if and when unanticipated subsidence, or earth fissure emergency conditions, are identified.

2.0 Subsidence and Earth Fissure Monitoring Program

Elements of the proposed ground subsidence and earth fissure monitoring program include the selection of (1) representative groundwater wells within and near the Bowie Power Station site that are used for groundwater level monitoring, (2) existing benchmarks for land surface level surveying, (3) new benchmarks within the Bowie property, (4) earth fissures in the plant site vicinity, and (5) reporting of the observed ground subsidence and earth fissure conditions. ADWR will be granted access to well sites and subsidence monitoring benchmarks within the properties controlled by the Bowie Power Station for the purposes of conducting independent ADWR groundwater level and subsidence monitoring.

2.1 Groundwater Level Monitoring

2.1.1 ADWR's GWSI data base contains well and groundwater level information from hundreds of wells throughout the state. Some of these wells are monitored by ADWR annually for static water levels and are designated as "index wells." Many of the wells in the GWSI data base, as well as Index wells, have several years of historic water level data that provide information on water level trends through time (Table 1).

Nine representative groundwater wells have been identified for monitoring groundwater levels within a 5-mile radius of the Bowie property. Three of the wells are located within the Bowie property and six are located off-site. Of the six off-site wells, three of the wells are ADWR Index Wells. Figure 1 shows the location of the nine groundwater level monitoring wells for the purpose of evaluating static groundwater levels in the area and any implications to ground subsidence. Table 1 lists the location, well depth, most recent depth to water, and years of available data for each of the nine wells.

2.1.2 Bowie Power Station will obtain and compile the groundwater level information from the six non-Index wells on an annual basis. Additionally, Bowie will obtain and compile groundwater level information collected by ADWR from the three index wells on an annual basis. The combined groundwater level data base will be included in the monitoring reports. If available, groundwater pumping rates should

be compiled. The ability to use the three ADWR index wells data will provide historic water level data for comparison, improves consistency of water level measuring equipment, measuring practices, and well altitude measurements, and provide ADWR and the public a high level of confidence in the accuracy of the data should any anomalous measurements or trends arise.

2.1.3 Bowie will select at least one inactive groundwater well within the Project property and install pressure transducers of continuous water level monitoring. The annual report will include quarterly water levels from the transducer recordings.

2.2 Ground Subsidence Monitoring

2.2.1 Ground Subsidence Monitoring Benchmarks

2.2.1.1 Selected existing representative NGS benchmarks within the project area will be included in the subsidence monitoring program. Although such NGS benchmarks are within five miles of the Bowie Power Station property boundary, the majority of the benchmarks are south of the power station site along the railroad and interstate highway alignment. Benchmarks summarized in Table 2 include the primary benchmarks for the monitoring program. Proposed benchmark locations are depicted in Figure 2. Other NGS benchmark in the project area may be used as alternate benchmarks to replace primary benchmarks that become unuseable.

2.2.1.1.1 Survey benchmarks that have been used by other researchers to measure ground subsidence (Holzer, 1980; Strange, 1983; NGS, 2001, URS, 2001) are included in the monitoring program as primary survey benchmarks. Three NGS benchmarks that were previously used for ground subsidence measurement are reported by the NGS to be monumented and in good condition. Primary benchmarks with a past history of subsidence monitoring are included in Table 2.

2.2.1.1.2 Other existing NGS benchmarks are included as primary benchmarks for the monitoring program. The additional benchmarks are also within five miles of the Bowie property boundary and were selected to provide adequate monitoring of off-site areas. These primary benchmarks are included in Table 2.

2.2.1.2 Bowie proposes to examine, witness and document each existing NGS benchmark as the first task of the monitoring program. A brief technical memorandum presenting the results of this first task will be prepared and submitted to ADWR for review and comment. Benchmarks considered unsatisfactory for inclusion in the monitoring program, will be replaced by an adjacent NGS benchmark.

2.2.1.3 Six new locations are proposed for the installation of additional primary benchmarks to supplement the existing NGS benchmarks. Two of the proposed benchmarks will be located within the Bowie Power Station property boundary and four about one to two miles outside the property boundary. The new benchmark locations on the Bowie Power Station property will be identified by the Owner/Operator and established at locations that will not be disturbed by construction. They will be installed sometime near the end of construction but prior to plant operation. The approximate locations of the new benchmarks are depicted on Figure 2 and summarized in Table 3.

As dictated by the location/condition of a new benchmark, Bowie will attempt to locate the benchmarks within public easements or rights-of-way or within easements obtained from private property owners and protected as appropriate for the location to secure their integrity. New benchmarks within the Bowie Power Station property will be installed at locations away from plant construction or operations activity to minimize the potential for damage. The new benchmarks will be constructed according to current NGS standards. Construction guidelines and a benchmark detail are provided in Appendix A.

2.2.1.4 A non-NGS type secondary benchmark will be installed in the well pad of any new proposed groundwater supply wells. The survey monument pin and cap will be placed in the concrete pad during the construction of the pad. Off-well head monitoring points will be installed 50 feet from the well head. The monument will consist of a ½-inch diameter stainless steel rod driven 10 feet into the ground. At the ground surface a pin head and ID cap will be protected with a concrete pedestal with its top flush or slightly above the ground surface.

Similar well pad and off well pad survey monuments will be installed a four other on site wells at locations that will provide site-wide coverage. The survey monuments will be placed at locations suitable for GPS survey observations.

2.2.2 Re-survey Subsidence Benchmarks

2.2.2.1 The four selected primary ground subsidence monitoring benchmarks will be re-surveyed for the purpose of implementing and maintaining a ground subsidence monitoring array for the power plant site and surrounding areas. NGS Data Sheets for the primary benchmark survey control points are included in Appendix B.

2.2.2.1.1 Prior to plant operations, a Baseline Data Set (BDS) must be obtained for position and elevation of each primary monitoring benchmark. The primary BDS will be used to measure the relative amount of subsidence that may be occurring in the project area. A baseline ground subsidence contour map should be constructed that combines previous ground subsidence data from other researchers and the BDS.

Previous surveys used to obtained ground subsidence data utilized survey control tied to the North American Datum (NAD) 27 or National Geodetic Vertical Datum (NGVD) 29

datums. Prior to compiling the BDS, the previously obtained survey data will be adjusted to the NAD 83 and North American Vertical Datum (NAVD) 88 survey datums established for the subsidence monitoring program.

2.2.2.1.2 A survey control benchmark, used to tie the subsidence monitoring array together, will be located in a bedrock area that is not susceptible to ground subsidence. One existing NGS benchmark (PID CY1170) is founded in bedrock at the east end of the Fisher Hills about 3½ miles west-northwest of the Bowie Power Station. This bedrock benchmark will be used for the Bowie Power Station monitoring program. No other bedrock rock benchmarks were identified within a reasonable proximity to Bowie Power Station.

2.2.2.1.3 Bedrock benchmarks and the ground subsidence monitoring survey network benchmarks will be thoroughly documented and witnessed.

2.2.3 Operational Ground Subsidence Monitoring

2.2.3.1 Following the initial baseline survey, the primary subsidence monitoring stations will be surveyed at one-year intervals for the initial five years of plant operation when groundwater drawdown rates are greatest. The frequency of subsequent monitoring will be established based on the results of the first five years of monitoring.

2.2.3.2 Selected secondary benchmarks will be surveyed if a primary monitoring program benchmark becomes unusable or damaged. Other secondary benchmarks may be surveyed from time to time to supplement the primary benchmark network, depending upon the amount of ground subsidence measured at primary benchmarks. Secondary benchmarks used for supplemental monitoring will be identified in the ground subsidence and earth fissure monitoring report.

2.2.4 Subsidence Monitoring Network Survey Methods

2.2.4.1 Surveying of the primary subsidence monitoring array will be conducted using currently accepted methods and standards of practice.

2.2.4.2 Survey accuracy standards should be 0.05 feet (or about 2 centimeters). The subsidence monitoring program survey will use the NAD 83 and NAVD 88 survey datums as appropriate.

2.2.4.3 Conventional level line traverse survey and appropriate GPS survey methods will be used. Prior to initiating the Baseline Data Survey, benchmark horizontal and vertical survey control from previous surveys that used survey control tied to the NAD 27 or NGVD 29 datums will be adjusted to the NAD 83 and NAVD 88 survey datums. The traverse or GPS survey will be closed on an established bedrock benchmark to assure the survey accuracy standards are achieved.

New technologies are being developed to perform land surface elevation monitoring, such as Interferometric Synthetic Aperture Radar (INSAR) and Light Detection and Ranging System (LIDAR). The Bowie Power Station will evaluate the application of new technologies and possible modifications to the ground subsidence and earth fissure monitoring program.

2.3 Earth Fissure Monitoring

2.3.1 Documented earth fissures, closest to the Bowie site, will be periodically monitored using direct field examinations (Figure 2; Table 4). These features will be examined at the same times the subsidence monitoring surveys are conducted.

A focused geological reconnaissance will be conducted within the entire Bowie property to investigate for the presence of any new earth fissures that may develop during the monitoring period.

2.3.2 Earth fissure monitoring will be conducted using direct examination on the ground by geologists or geotechnical engineers. The earth fissure survey will include measurement of surface expression (length, width, depth, orientation, differential displacement, evidence of activity or inactivity), photo documentation, and documentation of precipitation events that have occurred during the monitoring period.

2.3.3 If there are visual indications of renewed earth fissure activity, stress field monitoring may be required depending upon the actual rate of subsidence in the fissure area and the rate of fissure growth. Deformation across and near earth fissures is complex and requires varied and extensive instrumentation to determine depth, type of active fissure movement, and stress field components. Methods of measurement can include differential GPS, electronic distance measurement, and tape or wire extensometers (Carpenter, 1994) (See section 4.4).

2.4 Reporting

Detailed ground subsidence, earth fissure, and groundwater level data will be provided in the monitoring reports. Section 2.4.2 describes the technical information that will be defined, deduced, and interpreted from the monitoring data base. In addition to the data obtained from the subsidence monitoring program benchmarks and index wells, data obtained from additional well elevation monuments installed on or near groundwater production wells within the property will be included in the monitoring program.

2.4.1 Data collected will be compiled in an easy-to-use format such as Microsoft Excel. The data from each monitoring period should be presented. Groundwater level measurements for each selected well will be summarized. Cumulative subsidence and rates of subsidence will be calculated for each benchmark. Earth fissure monitoring observations will be documented.

2.4.2 A ground subsidence and earth fissure monitoring report will be prepared and submitted within 60 days of the completion of the ground subsidence monitoring and receipt of ADWR index well groundwater level data. The report will include the following:

- A groundwater level contour map and groundwater level hydrographs will be constructed detailing the groundwater level information obtained from the nine representative groundwater monitoring wells.
- Descriptions of ground subsidence trends, ground subsidence measurements, subsidence rate calculations, and subsidence contour maps.
- Earth fissure monitoring observation field reports, and photographs and maps as appropriate.
- A summary of the observations made, analysis and interpretation of the data gathered, and conclusions and recommendations pertaining to the subsequent monitoring period and, if necessary, action items to assess anomalous or unforeseen conditions.

Reports will be distributed to the following organizations:

- Cochise County Planning and Zoning Department
- Arizona Department of Water Resources
- Arizona Geological Survey
- Arizona Corporation Commission
- U.S. Geological Survey, Water Resources Branch (Tucson)

A summary of the ground subsidence monitoring report will be published and provided to the general public through the Bowie Power Station internet web site.

2.5 Alert Conditions and Contingencies

Any anomalous conditions will be reported along with an assessment of the anomalous condition relative to the safe operation of the plant, and recommendations to fully evaluate the conditions identified. Proposed alert levels for ground subsidence and earth fissures will include:

- Ground subsidence rates that substantially exceed the predicted average rate of 0.072 feet per year at ground subsidence benchmarks' BOWIE1 and BOWIE2 at the Bowie Power Station.
- Field evidence of renewed activity along an existing earth fissure within a 5-mile radius of the plant site or evidence of new earth fissure activity.

- In lieu of a numerical alert level for off-site benchmarks, a qualitative assessment of ground subsidence data gathered and anomalous ground subsidence trends observed within the subsidence data that deviate significantly from predicted values will be used to define an off-site alert condition. Bowie, in cooperation with ADWR, will review the hydrologic and subsidence data in detail, and will attempt to identify the cause of the off-site anomaly. Further actions by Bowie would depend on the cause and magnitude of the anomaly.

Action items in response to an identified anomalus condition will include the following:

- Develop an investigative program to evaluate the condition.
- Notify appropriate jurisdictions regarding the anomalous condition and proposed program to investigate the condition.
- Initiate the investigative program
- Based on the results of the investigation, prepare appropriate work plans and alternatives to mitigate the anomalous condition, which may include but not be limited to an increase in monitoring frequency and submittal of interim summary reports to ADWR, an evaluation and possible modification of well field operations, special inspections of sensitive power plant components, and design engineering evaluations.

If it is determined that an "alert condition" is caused (or probably caused) by the operation of Bowie Power Station, the following are examples of mitigation measures that might be considered to address the situation:

- Acquire or import water from other sources within the basin to mitigate groundwater drawdown in the project area.
- Acquisition of additional properties surrounding the Bowie property to reduce groundwater drawdown in the project area.
- Modify the operation of the power station well field.
- Modify the operation of the plant to reduce groundwater consumption.
- Other mitigation measures that may be identified.

The mitigation measure(s) selected will depend on the specific circumstances surrounding the observed "alert condition."

3.0 BIBLIOGRAPHY

Carpenter, M.C.; 1994; Deformation Across and Near Earth Fissures: Measurement Techniques and Results; U.S. Geological Survey Open-File Report 94-532; pp. 55-58.

Geological Consultants Inc.; 2001a; consultants report entitled "Ground Subsidence & Earth Fissure Evaluation, Bowie Power Station, Cochise County, Arizona"; prepared for URS Corporation Inc.; Geological Consultants Project No. 2001-168; October 8, 2001; 39 p.

Geological Consultants Inc.; 2001b; consultants report entitled "Ground Subsidence & Earth Fissure Monitoring Program, Toltec Power Station, Pinal County, Arizona"; prepared for URS Corporation Inc.; Geological Consultants Project No. 2001-141; October 26, 2001; 18 p.; and Addendum No 1, prepared by Geological Consultants Inc.; November 6, 2001; 5p.

Harris-Galveston Subsidence District (HGSD); 1998; Groundwater Management Plan; pp. 35-45.

Haywood; C.E.; 1994; Monitoring Aquifer Compaction and Land Subsidence Due to Ground-Water Withdrawal in the El Paso, Texas-Juarez, Chihuahua, Area; U.S. Geological Survey Open-File Report 94-532; pp.14-17.

Holzer, T.L.; 1980; Reconnaissance Maps of Earth Fissures and Land Subsidence, Bowie and Wilcox Areas, Arizona; U.S. Geological Survey Miscellaneous Field Investigation Series Map MF-1156; 2 plates.

Kimley-Horn & Associates, Inc.; 2000; Program and Policy: Structures Assessment Program-Phase I; prepared for Flood Control District of Maricopa County, FCD No. 98-41/PCN PLAN.01.00; January 2000.

National Geodetic Survey; 2001; http://www.ngs.noaa.gov/datasheets.html; listing of survey benchmarks within Bowie, Ryan Draw, Fisher Hills, and Luzena U.S.G.S. 7.5-minute topographic quadrangles.

URS Corporation; 2001;Water Supply Report for the Proposed Bowie Power Station, Bowie, Arizona; URS Job No. E1-00001844.00; prepared for Bowie Power Station L.L.C.; July 26, 2001

Table 1
Summary of Representative Wells for Groundwater Level Monitoring
Bowie Subsidence & Earth Fissure Monitoring Program

	Cadastral Location	Well Altitude (ft MSL)	Well Depth (ft)	Most Recent Depth to Water (ft)	Water Level Elevation (ft MSL)	Years of Record	Comments
1	(D-12-28)15BCB	3684	1000	1/27/93	3370	1954-1993	ADWR Index Well
2	(D-12-28)17DDD	3724	567	10/31/00	3463	1947-2000	ADWR Index Well
3	(D-12-28)20DBD1	3749	800	1/21/97	3618	1963-1997	On Bowie Property
4	(D-12-28)22CDC	3688	660	1/22/97	3609	1951-1997	On Bowie Property
5	(D-12-28)25DCC	3645	1700	11/14/00	3373	1963-2000	ADWR Index Well
6	(D-12-28)32DCC1	3792	600	1/14/97	3357	1963-1997	ADWR Non-Index Well
7	(D-12-28)33ABC1	3732	550	2/8/89	3365	1951-1989	On Bowie Property
8	(D-13-28)04CCC1	3796	462	1/14/97	3512	1952-1997	ADWR Non-Index Well
9	(D-13-28)11DBC	3722	500	2/3/97	3354	1954-1997	ADWR Non-Index Well

Table 2
Primary Ground Subsidence Monitoring Benchmarks:
Existing NGS Benchmarks in Bowie Power Station Vicinity

Distance from Property Center (miles)	Permanent Identifier (PID)	Vertical Source	Latitude	Longitude	Designation
1.9	CY0355*	88/ADJUSTED	N322003	W1092939	P 324
2.8	CY0530*	88/ADJUSTED	N322004	W1093138	Q 358
3.1	CY0328	29/ADJ UNCH	N321900	W1092901	BART RM 1
3.7	CY0283*	88/ADJUSTED	N321914	W1092710	Y 330
4.5	CY1170**	29/VERT ANG	N322253	W1093353	FISHER

Note: * Existing NGS Survey Benchmarks With Past History of Subsidence Monitoring.
** Existing NGS Survey Benchmark in Bedrock.

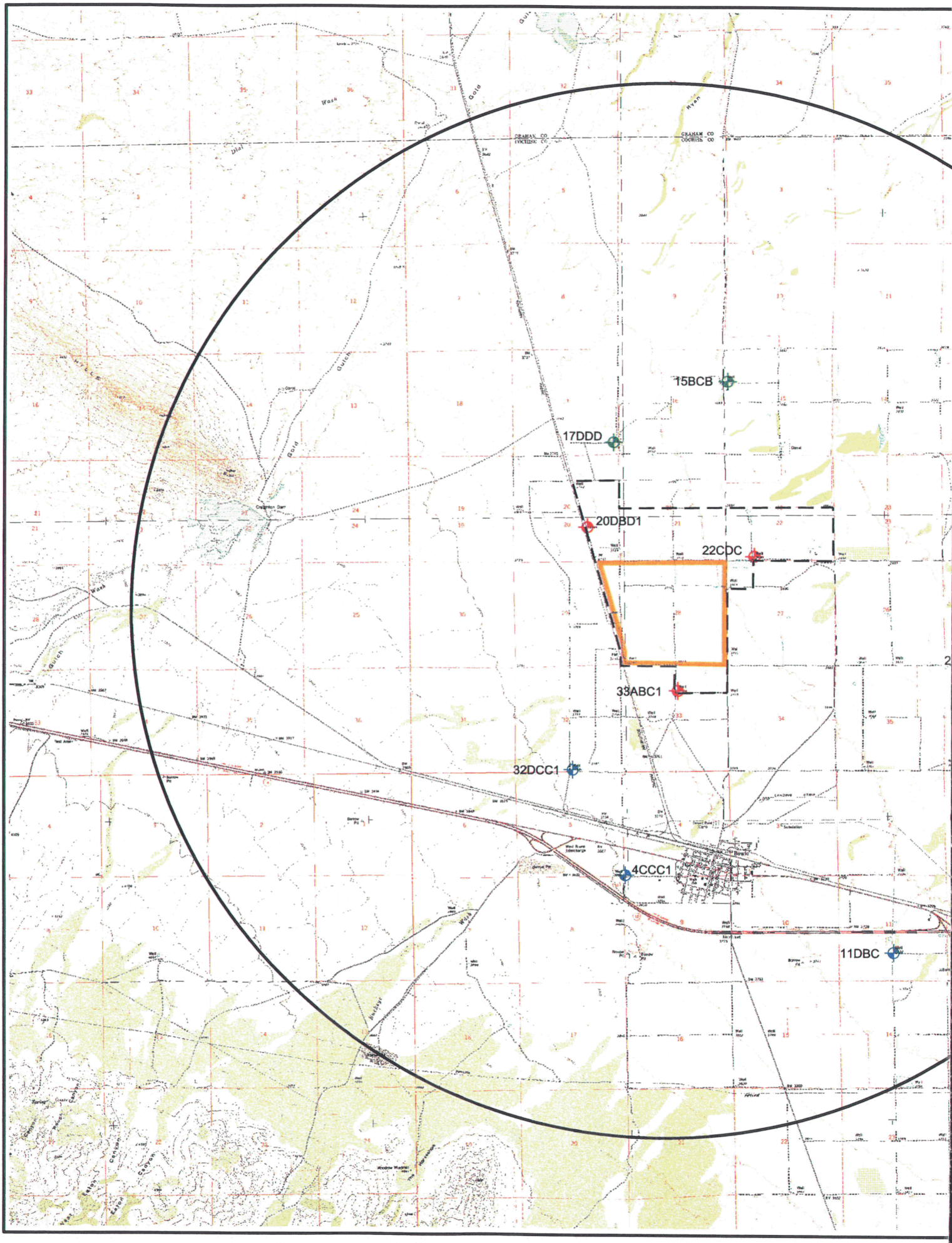
Table 3
Primary Ground Subsidence Monitoring Benchmarks:
Proposed New Survey Benchmarks in Bowie Power Station Vicinity

Distance from Plant Site (miles)	Temporary Identification	Proposed Vertical Source	Latitude (approx.)	Longitude (approx.)
On-Site	BOWIE1	NAVD 88	N322207	W1092902
On-Site	BOWIE2	NAVD 88	N322119	W1092959
2 E	BOWIE3	NAVD 88	N322116	W1092656
2 W	BOWIE4	NAVD 88	N322117	W1093206
0.75 NW	BOWIE5	NAVD 88	N322209	W1093106
1.0 N	BOWIE6	NAVD 88	N322302	W1093004

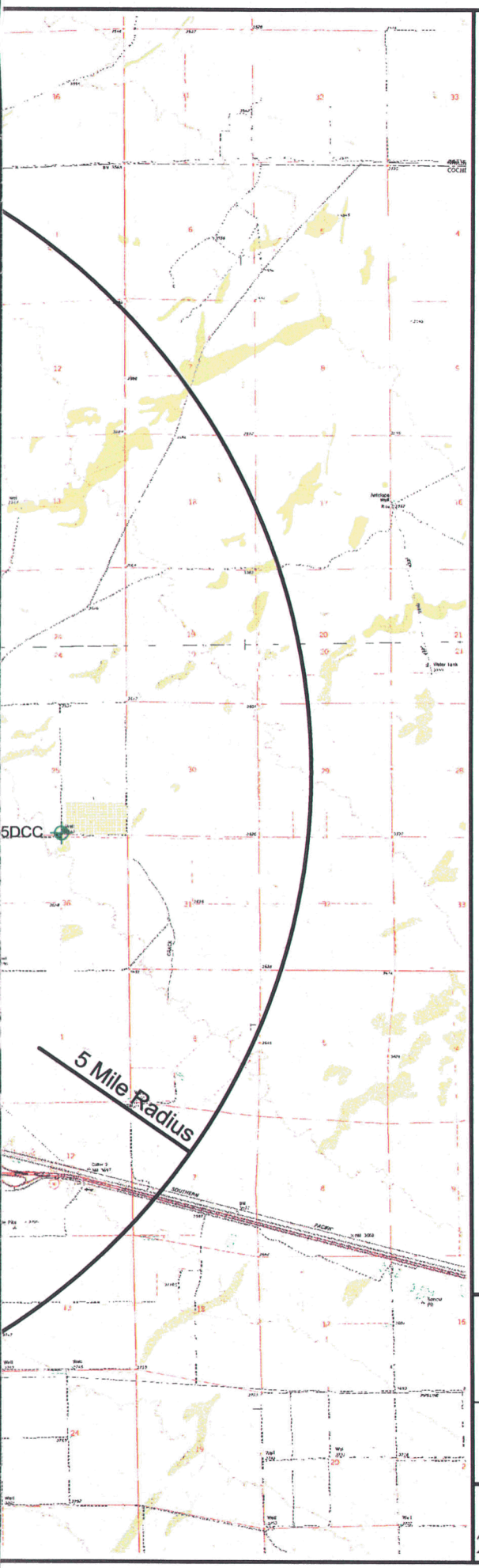
Table 4
Summary of Reported Earth Fissures within
5-mile Radius of Bowie Power Station Site

	Fissure Length (miles)	Location	Trend	Note
1	2	Section 25 & NE ¼ Section 36, T12S, R28E; W½ Section 31, T12S, R29E	NW to S	2 to 3 miles East of East boundary of Power Station site
2	¼	SE¼ Section 25, T12S, R28E	NE-SW	2 ¾ miles East of East boundary of Power Station site

From Geological Consultants Inc. (2001)



GV22\E1100001844\A15162.DWG 12-5-01 XREF:46886\001QUADS.DWG IMAGES:32109C5, 32109C4, 32109D4, 32109D5



LEGEND:

- Site boundary
- Property boundary
- ADWR Index wells
- Wells located on Bowie property
- Other wells with historic groundwater level data

NOTES:

Base Map from USGS Topographic Quadrangles: Bowie, AZ 1974; Ryan Draw, AZ 1974; Fisher Hills, AZ 1979; and Luzena, AZ 1979.

N

0 6000 12000

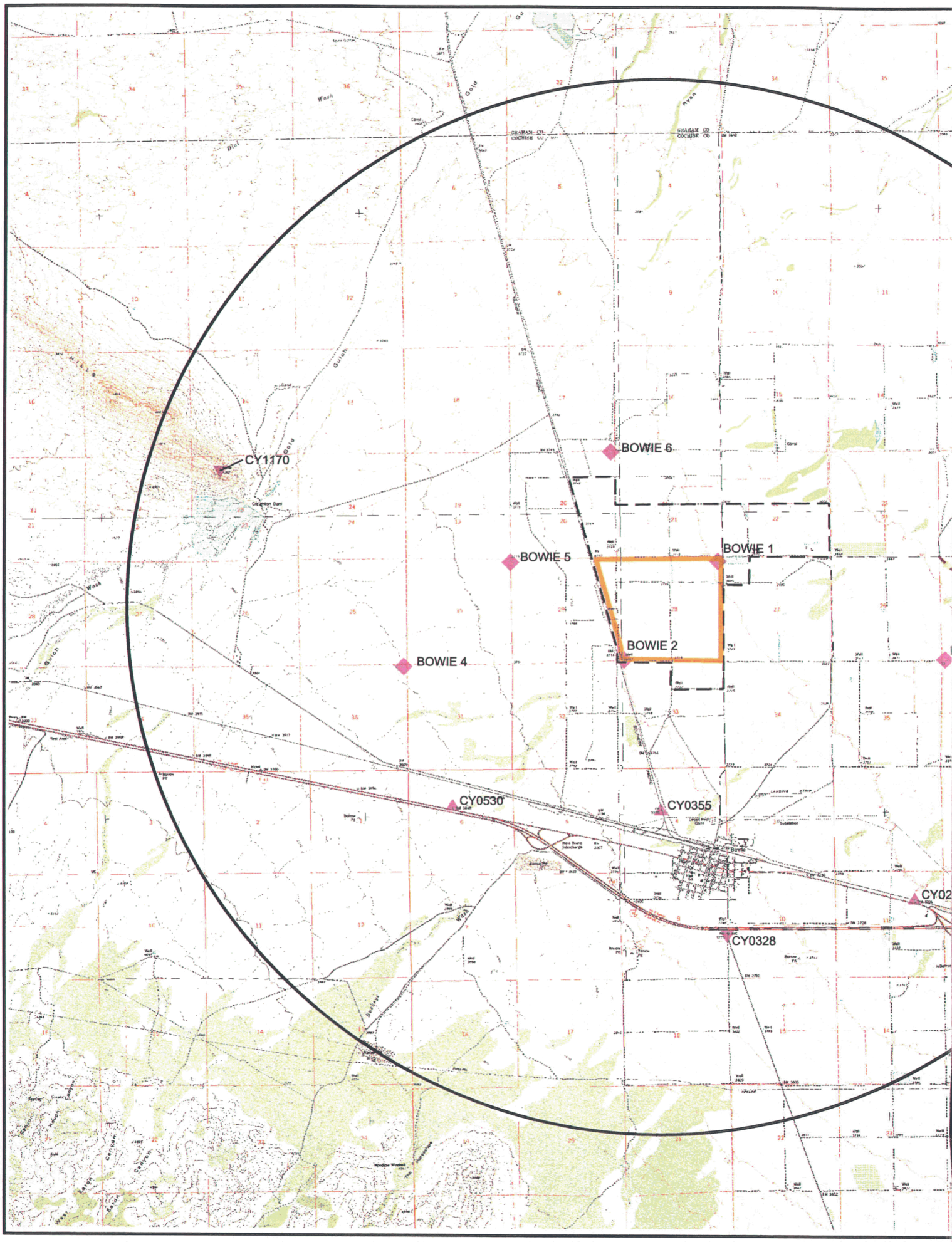
Scale in Feet

REGISTERED GEOLOGIST
CERTIFICATE NO. 10338
KENNETH M. EUGE
Date Signed 12/19/16
ARIZONA U.S.A.

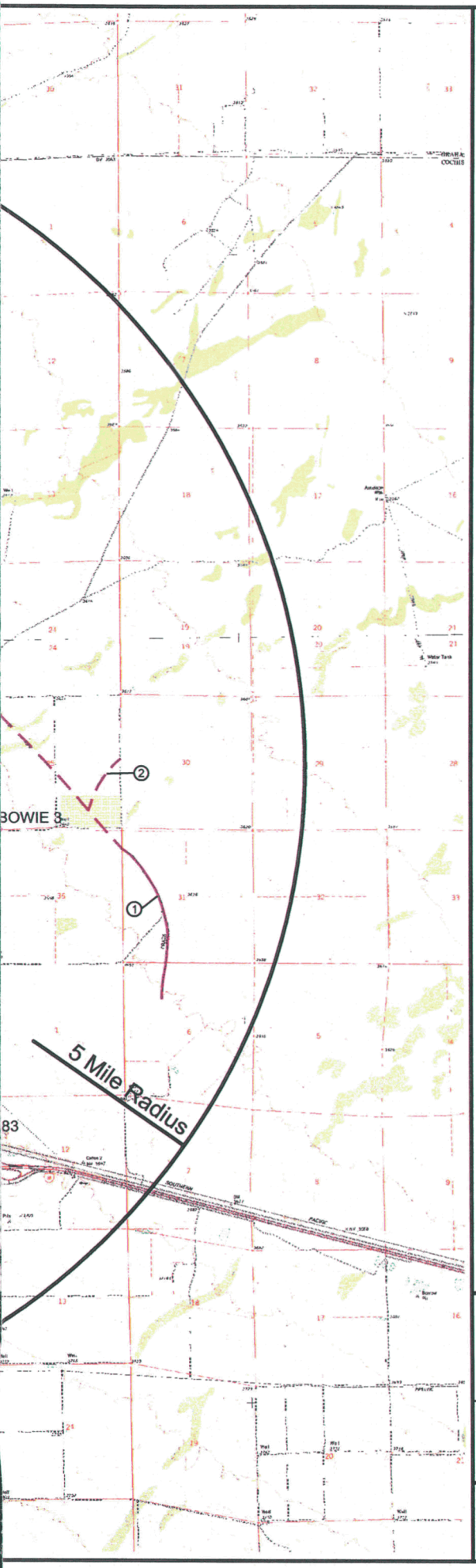
Representative Wells for Groundwater Level Monitoring

Figure 1
Bowie Power Station

Geological Consultants Inc.
2333 West Northern Avenue, Suite 1A Phoenix, AZ 85021



G:\22\E1\00001844\A15161.DWG 12-5-01 XREF:46886\001QUADS.DWG IMAGES:32109C5, 32109C4, 32109D4, 32109D5



LEGEND:

- Site boundary
- Property boundary
- Earth Fissure Location (Laney, 1978; Holzer, 1980; Harris, 1997; Groundwater Consultants, 2001)
- ①,② Earth Fissures Within 5-Mile Radius of Plant Site. See Report Table 4
- Existing NGS Benchmarks Used Previously for Subsidence Measurements
- Existing NGS Benchmarks Not Previously Used for Subsidence Measurements
- Proposed New Benchmarks for Subsidence Measurements

NOTES:

Base Map from USGS Topographic Quadrangles: Bowie, AZ 1974; Ryan Draw, AZ 1974; Fisher Hills, AZ 1979; and Luzena, AZ 1979.

N

0 6000 12000

Scale in Feet

REGISTERED GEOLOGIST
CERTIFICATE NO. 10338
KENNETH M. EUGE
Date Signed 12/9/05
ARIZONA U.S.A.

Ground Subsidence Monitoring Benchmark Location Map

Figure 2
Bowie Power Station

Geological Consultants Inc.

2333 West Northern Avenue, Suite 1A Phoenix, AZ 85021

APPENDIX A

NGS Geodetic Benchmarks
Construction Guidelines and Construction Details

NOAA Manual NOS NGS 1

Geodetic Bench Marks

Lt. Richard P. Floyd
NOAA Corps
National Geodetic Survey
Rockville, Md.
September 1978

U.S. DEPARTMENT OF COMMERCE
Juanita M. Kreps, Secretary

National Oceanic and Atmospheric Administration
Richard A. Frank, Administrator

National Ocean Survey
Allen L. Powell, Director

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

Stock Number 003-017-00442-2

FOREWORD

Bench marks are long lasting points for which elevations have been determined, used to control other surveys and to monitor movement of and within the Earth's crust. They constitute the visual evidence of vertical control established by the National Geodetic Survey (NGS), an office of the National Ocean Survey, National Oceanic and Atmospheric Administration. Bench mark design and setting procedures are important to the leveling program. In the past, however, availability of materials and ease of setting were often the primary considerations rather than soil mechanics, geology, properties of materials, and the like.

Advancing technology brought both the ability to determine elevations more precisely and a greater need for bench marks to hold these elevations. The releveling program for the new adjustment of the National Vertical Control Network provided an ideal opportunity to upgrade the quality of NGS bench marks to meet future geodetic requirements.

This manual was written for two main groups of users. One includes managers and field personnel, both publicly and privately employed, who are involved with setting bench marks that will meet NGS specifications. The guidance given here must be adhered to strictly to obtain the quality required by the National Geodetic Survey. The other group consists of the users of NGS vertical control data. Supplementing other vertical control data, the information in this manual makes it possible to judge the reliability of an NGS bench mark elevation.

Because of a limited number of bench mark types, it is not possible to set the optimal monument in every case. For some installations, geologists or other specialists might be consulted. The manual includes enough detail to enable judicious modification in design when the occasion arises.

Dimensions have been given only in metric units wherever feasible. Commercial products are normally specified in English units, and consequently, English units are given in parenthesis when applicable. A conversion table from metric to English units is given in appendix A.

CONTENTS

Chapter	Page
Foreword	iii
Abstract	1
1. Introduction	1
2. Sources of vertical instability	2
Origins in the subsurface	2
On or near-surface origins	3
Motion intrinsic to the monument	5
Intended stability of NGS bench marks	5
3. Considerations in selecting a site	5
Security	5
Utility	6
Stability	6
Corrosive environment	10
Safety	12
4. Installation	12
Maintaining good public relations	12
Special considerations at line intersections	13
Disk set in bedrock or structure	13
Class A rod mark	14
Class B rod mark	25
Miscellaneous marks	26
5. Descriptions	35
Appendix A. Approximate conversion table: metric to English units	36
Appendix B. The use of geopotential heights for Great Lakes Vertical Datum	37
Appendix C. Soils	41
Appendix D. Existing monumentation in the vertical network	43
Appendix E. Examples for determining bench mark depths	45
Bibliography	48
Index	49

TABLES

1. Summary of measures taken to set high-quality bench marks 11
2. Sleeve depth for class A rod mark set within the continental United States 27
3. Minimum depth for class B rod mark 27

FIGURES

1. Referencing of bench marks 7
2. Intersection of lines-of-position 8
3. NGS bench mark disk stamped with designation and year 14
4. Sleeved class A rod mark 16
5. Class A rod mark showing logo flange and hinged access cover 17

6. Setting a sleeved class A rod mark 20
7. Distribution of potentially expansive materials, Northeastern States 28
8. Distribution of potentially expansive materials, Southeastern States 29
9. Distribution of potentially expansive materials, North-Central States 30
10. Distribution of potentially expansive materials, South-Central States 31
11. Distribution of potentially expansive materials, Western States 32
12. Climate factor 33
13. Extreme depth of frost penetration 34
14. Mississippi River flows uphill 38
15. Elevation 38
16. Geodetic reference ellipsoid 39
17. The geoid 39

Mention of a commercial company or product does not constitute an endorsement by the NOAA National Ocean Survey. Use for publicity or advertising purposes of information from this publication concerning proprietary products or the tests of such products is not authorized.

GEODETIC BENCH MARKS

Lt. Richard P. Floyd
National Geodetic Survey
National Ocean Survey, NOAA
Rockville, Md. 20852

ABSTRACT.—Geodetic survey control points must be remarkably stable due to the very intent of establishing geodetic control. All monuments are subject to the effects of geologic and soil activity. Vertical control points are particularly vulnerable because this activity results in vertical movements much more so than horizontal motion. In addition to natural disturbances, damage inflicted by mankind is a critical problem in monumentation. This manual explains how and where to set bench marks for maximum stability and calls attention to the factors that affect vertical instability.

1. INTRODUCTION

To function as good references for elevations, bench marks must be relatively stable points. Accordingly, it is necessary to define what is meant by stability before an understanding of high quality monumentation can be gained. "Stability" refers to the ability to maintain a fixed position. It is characterized by its degree and duration.

To the local surveyor running a topographic survey on a small construction site, a stable point could be defined as the top of a prominent boulder or a spike driven into a gravel road surface. These objects are subject to movements of a few centimeters to a decimeter or more in a year's time, but they are adequate for the surveyor's needs. It would be uneconomical to spend the time and money necessary to set higher quality bench marks.

Another surveyor might be concerned with laying out a major highway that could take years to complete. Therefore, the control must be more stable in its position and longer lasting. To this surveyor, a stable point could be represented by a concrete post extending to a depth of a meter or so, or a spike in the side of a large utility pole. These bench marks might hold their elevations within a few centimeters while the project is being carried out. It follows that the bench mark stability required depends on the precision of the survey being carried out and the duration of the project for which the elevations are needed.

The National Geodetic Survey (NGS) of the National Ocean Survey is responsible for establishing and maintaining the National Networks of Geodetic Control. The survey markers comprising these networks serve as basic reference points for numerous surveying, engineering, mapping, land use planning, and scientific projects. If the networks are to adequately serve these purposes, they must be established to a high degree of accuracy and monumented in a manner that best preserves their original geodetic positions.

Stability requirements for the National Vertical Network control points have increased significantly in recent years due to continually advancing technology. Both the ability to determine elevations more precisely and the need to know elevations more accurately have resulted from this technological boom. Uses have increased from basic control for boundary surveys and mapping to large scale planning and construction of transportation systems such as interstate highways and transcontinental pipelines. More recently, increased emphasis on crustal motion studies and control for missiles, satellites, and spacecraft has brought about a need for more accurately known positions and, consequently, more stable control points.

Elevations are referenced to a level surface, or geoid, which is approximately equivalent to mean

sea level.[1] Not even the Earth's crust, which averages 35 kilometers in thickness, is stable relative to the geoid. Young mountains are uplifting while areas of the ocean floor subside. Ideally, a bench mark used strictly for control should remain motionless with respect to the geoid. Since the geoid is intangible, the only basis we have for appraising bench mark stability is the Earth's crust, even though it is in constant motion. A monument can be considered as stable as possible if it is motionless with respect to the crust.

To clarify this, a distinction must be made between crustal motion and motion within the crust. Crustal motion is movement of the crust as a whole. It is caused by phenomena such as isostasy (the concept of the crust floating on the mantle) and tectonic plate movement. Motion within the crust originates above the base of the crust.

It is motion originating above the base of the crust that we would usually like to prevent from being transmitted to our bench marks. Prevention being impossible, the next best thing is to reduce the motion's effects. This can be done by (1) minimizing surface effects and (2) with the aid of geological information, avoiding or accounting for movements of deeper origins.

The following chapters deal with identification of the various factors that can cause changes in bench mark elevations, and steps that must be taken to set high-quality bench marks. These marks include disks set in bedrock or structures, sleeved rod type bench marks, rod marks with disks, and some miscellaneous types.

2. SOURCES OF VERTICAL INSTABILITY

The subject of bench mark instability can be more easily understood if it is separated into two categories characterized by the depths at which movement originates. Those with their roots within about 15 meters of the surface will be called "near-surface sources of instability," while those that originate below about 15 meters will be called "subsurface sources of instability." If the effects of near-surface sources of instability cannot be avoided by prudent selection of the bench mark site, they can be counteracted so that they are not reflected in the bench mark elevation. Subsurface effects usually cannot be economically counteracted by a suitable bench mark design so they must be avoided or accounted for.

Bench mark movement can be likened to that of a float bobbing up and down on the surface of the ocean. The total vertical movement of the float is the result of accumulated movements caused by sea (locally generated choppy waves), swell (long, rolling waves from a distant origin), and tide. At times, these individual effects act together, amplifying the total movement. For example, the float might be lifted by a sea which is on the crest of a swell at high tide. Other times, one effect will tend to cancel another, as when the float is on the crest of a wave which is in the trough of a swell. At any rate, the float is in motion with respect to a reference surface, which in this case is the ocean floor.

To correlate this to bench mark movements, the respective counterparts of sea, swell, tide, and the ocean floor are near-surface movements, movements within the crust, motion of the entire crust, and the geoid.[2] It would be ideal if we could fix the bench mark to the geoid as we can anchor a piling to the ocean floor to eliminate tidal motion. However, there is no analogous way to counteract the effect of crustal motion on a bench mark.

In the ocean, the effect of swell could be avoided in some areas by making use of an existing breakwater, harbor, or bay. Similarly, with proper bench mark site selection, many movements within the crust can be avoided, but choice of a location is not as obvious. Considerable geological information is needed to determine which areas exhibit no subsurface instability.

Finally, the effects of sea in many situations can be avoided. Where this is not possible, they can be economically counteracted by building a small floating barrier. Essentially, this is what can be done for vertical control points. The sleeved class A rod mark (see fig. 4, page 16) consists of a steel rod that is isolated from near-surface motion by the sleeve.

Origins in the Subsurface

Crustal Motion

First among the subsurface causes of vertical movement is crustal motion. Even if it were possible to prevent this movement, it would be undesirable in many cases. Crustal motion studies are an important application of leveling data. The movement of one area of the crust in relation to another serves as the basis for these studies. To determine this, knowledge of crustal motion with respect to the geoid is not essential. What is necessary is to know which bench marks reflect *only* crustal motion. Referring to the parallel drawn with the sea surface, if a float is to be used to monitor tides, it must be known that the effects of seas and swell have been eliminated.

[1] A concise, easily understood description of the geoid is given in appendix B.

[2] The gravitational effects of the sun and moon exert an influence on land masses just as they do on the oceans, causing a phenomenon known as "Earth tides." No analogy for Earth tides is made in this parallel.

Caverns and Mines

Caverns and underground excavations contribute to vertical movements on the surface of the Earth. Sometimes the motion is abrupt as is the case with sink holes, and other times their effects result only in gradual subsidence. When crustal uplift is occurring simultaneously with subsidence caused by a gradual caving in of an underground mine, the wrong conclusion can be drawn about the stability of an area. In general, the National Geodetic Survey is not concerned with monitoring subsidence caused by underground excavations and caverns. Since it is too costly to anchor bench marks below the depth of disturbance and isolate monuments against such movement, these areas must be avoided wherever possible.

Pumping

Subsidence is also caused by pumping of oil or water. When fluid is removed from the ground, the resulting decrease in pressure allows gravity to pull down the overlying soils. Associated with this is piping, or the removal of fines from a soil stratum, which aggravates the situation. Again, in carrying out its basic mission of developing and maintaining a network of geodetic control, NGS is not primarily concerned with monitoring this type of motion. Except where subsidence is the subject of special study, such as in the Houston, Tex., area and Santa Clara Valley, Calif., these areas too should be avoided wherever possible.

On or Near-Surface Origins

Impact

The reliability of a bench mark elevation is largely dependent upon its exposure to impact. The results of impact can range from an infinitesimal change in elevation as a result of being stepped on to total destruction caused by earth-moving equipment, which is perhaps the most common cause of bench mark loss. NGS bench marks have been designed to minimize the chances of vandalism, tampering by souvenir hunters, and impact which is relatively small in magnitude.

For class A rod marks, this is accomplished by three precautionary measures: first, the datum point is set slightly below ground level; second, a protective pipe is placed around the datum point; and third, the bench mark component which is imprinted with the NGS logo, and might be considered a worthy souvenir, is not an integral part of the datum point.

By their inherent nature, other types of NGS bench marks are not vulnerable to relatively slight impact. Heavy impact, such as that caused by construction equipment, cannot be counteracted by economical design so it must be avoided by judicious placement.

Frost Heave

Besides disturbances caused by human intervention, there are a great many resulting from natural phenomena. Of these, frost heave is one of the most severe. The occurrence of frost action depends on three factors: freezing temperatures; available water; and certain soil characteristics, most notably soil particle size. The absence of any one of the essential conditions precludes the occurrence of frost heave.

For example, it is the influx of additional water into a soil's freezing zone after the freezing has already begun that results in excessive frost heave. The freezing of water initially present does not cause a significant problem. When the water table is near the surface, additional water is available to be drawn up into the freezing zone causing the frost heave problem. A water table within 2 meters of the ground surface indicates a potential hazard and it is normally further from the surface on hills than in low-lying areas. Consequently, less severe frost heave can be expected to be found on hills.

Even though water is available, significant frost heave will not occur unless the soil can draw it up and hold it in the freezing zone. Soils which are capable of this are called "frost susceptible." The main factor in determining frost susceptibility of a soil is particle size distribution. Coarse-grained soils contain spaces that are too large to draw up and hold water. At the other extremity, many clays are impervious to water. (Clays, however, are detrimental for reasons other than frost heave as explained in other sections of the manual.) The soils most susceptible to frost action, and therefore to be avoided where freezing occurs, are silts and silty sands with soil particle sizes less than 0.02 millimeter (U.S. Army Corps of Engineers 1967).

Shrinking and Swelling of Soil and Rock

Another phenomenon that can cause bench mark instability is shrinking and swelling of soil due to changes in moisture content. The magnitude of soil volume change depends upon two factors. One is the character of the soil, including particle size and distribution, degree of cementation, and, most importantly, mineralogy (Patrick and Snethen 1976). Fine-grained soils containing certain clay minerals, particularly montmorillonite,[3] are highly expansive.

The other factor governing the shrinking or swelling of a soil is the measure of its variation in moisture content. Seasonal climate variability provides a good indication of the degree and depth

[3] Montmorillonite is a clay mineral made up of layered, plate-like particles separated by water. The addition of more water causes the particles to separate even more until they finally disperse.

to which volume change will occur.* An expansive soil subject to either a consistently moist or dry climate year around will not exhibit a change in volume, but if the climate is wet during one season and dry during another, a volume change will occur. Figure 12 (page 33) separates the United States into areas of differing climate variability. The higher the value of the climate factor, the more variable the moisture content of the soil.

This expansive character is not limited to soils. Sedimentary rocks are those which were formed by the consolidation of sediments. If the parent materials were of an expansive nature, the rock itself will likely have this characteristic to a surprisingly high degree. Substantial pavement damage has occurred on some highways founded on sedimentary bedrock when the water content has been altered.

Soil Expansion and Contraction

The terms "expansion" and "contraction" indicate changes in volume resulting from a change in temperature rather than a change in moisture content. Like other materials, soil expands when its temperature rises and contracts when its temperature is lowered. It differs from most other materials in that the range of temperature variation is not constant throughout its depth. At the surface, the temperature variation is near that of the air. At some depth, the temperature is nearly constant throughout the year. In unfrozen soils, expansion and contraction due to temperature change is negligible, but in frozen soils they are factors to consider. In permafrost, temperature change can have a significant effect on a bench mark down to a depth of about 10 meters (Bozozuk *et al.* 1962).

Slope Instability

Slope instability covers a wide range of movements ranging from rockslides and mudflows to the nearly imperceptible movement known as creep. Rockslides and mudflows are obvious and would probably result in the total destruction of a bench mark. Creep presents a greater problem to monumentation because it could result in only a slight change in the bench mark elevation which could lead to erroneous conclusions. Evidence of creep can sometimes be witnessed in leaning utility poles where the upper layer of soil slides in relation to that beneath it.

Gravity is the main force that produces creep, but gravity can be aided by a number of other factors, among which the presence of moisture is probably the most dominant. In some instances, a small amount of water can increase cohesion and retard the flow of soil downhill. More often, water decreases friction between soil particles, allowing them to flow more rapidly. When moisture is confined to the upper layers of a slope by an impermeable substratum, the likelihood for creep is quite high.

Sometimes a slope can be stable until a cut is taken from it which upsets the equilibrium and starts a slide. If the cut was taken from an area providing substantial support to a slope, the slide will occur rapidly. When the slope is less steep or provides more of its own support through cohesion of the soil, a cut will have no effect or result only in creep. Highways are notorious for producing slides in some parts of the country.

Soil Consolidation

When a soil mass is subject to loading, the soil particle orientation undergoes a change resulting in a condition of closer packing and smaller voids. The longer the load remains, the more stable the particle reorientation becomes, until a condition of equilibrium is finally reached. If a load is removed, rebound occurs.

Many kinds of loads can cause a soil mass to consolidate significantly. Large structures can cause soil consolidation resulting in settlement of the structure. They are often constructed in such a manner that they do not exceed a specified settlement, or at least a certain settlement rate. The total allowable settlement is usually a few centimeters. The rate occurs rapidly at first and decreases with time. Some structures continue settling for many years after construction has been completed. Besides compressing the soil directly beneath it, a new building causes the surrounding soil to be drawn down.

Water reservoirs exert tremendous stresses on soil deposits. As a reservoir is filled or drained, the soil mass below it compresses and rebounds accordingly. As with structures, the surrounding soil is also affected by the loading and unloading. Large rivers also exhibit this trait to some extent with the seasonal change in water level.

A special case of consolidation due to loading can be seen in manmade deposits or fill. Not only do these deposits exert a pressure onto what may be a compressible soil below, but they themselves are subject to consolidation. When the purpose of fill is other than to improve the subgrade of a construction site, it is usually deposited loosely, and will compact under its own weight. Fills are usually deposited in small or narrow areas. Examples include levees, landscape improvements, and disposal sites for undesirable materials such as trash, overburden, and dredge deposits. However, sometimes the areas can be very extensive, as in the case of reclaimed strip mines.

* Soil mechanics being a complex science, the maximum depth at which soil is affected by this phenomenon is not universally agreed upon. Here, it is assumed to be 15 meters.

Erosion

Impairment of some bench marks can be attributed to erosion. Soils in or on which a monument is set are subject to removal by the action of wind and water. This can result in the monument being obviously displaced, or only a subtle disturbance rendering it unsuspectingly unfit for use as a geodetic control point. Undercutting can occur along the outsides of curves in rivers and embankments near large bodies of water where storms are likely to occur. It is conceivable that wind erosion could also present a problem in some locations, but it would probably result in the loss by burying a bench mark rather than changing its elevation.

Motion Intrinsic to the Monument

Choice of materials for a bench mark monument is critical for two important reasons. First, ultimate deterioration of materials results in the loss of a bench mark's reliability. The outmoded copper clad rod mark (page 44) has been known to corrode to such an extent that sections of the rod have separated entirely. Failure of a bench mark from this cause would not be abrupt. In fact, it could be difficult to detect. For this reason, when a monument is recovered for releveling, it should be tested to ascertain its condition. For rod type bench marks this can be accomplished by grasping the rod and pulling it to make sure its integrity has been retained.

Secondly, a bench mark's elevation can change with the expansion and contraction of the monument due to temperature change. Theoretically, this can amount to changes on the order of a millimeter or more between hot and cold seasons. In choosing bench mark materials, the thermal coefficient of linear expansion must be considered. If modifications involving changes in materials are made to the prescribed designs for rod marks, materials having a direct bearing on the bench mark elevation should be limited to those having a coefficient less than 20×10^{-6} cm/cm per °C.

Intended Stability of NGS Bench Marks

From the information in this chapter, it is evident that the causes of instability vary widely in both depth of origin and geographical extent. To counteract deep subsurface activity would be economically unfeasible, so bench mark specifications for the National Vertical Control Network have been developed to resist movements at or near the surface. Among such movements are those caused by impact, frost heave, shrinking and swelling of soils, soil expansion and contraction, and in some cases where the effect is not too deep, consolidation. Except for consolidation, bench marks set as described herein can always be expected to resist movements from these causes.

To accomplish this objective, most bench marks must be anchored *below* the depths at which these movements originate. Mere massiveness does not insure stability. This point is extremely important to bear in mind. Even a very large building is subject to vertical displacements beyond those tolerable if it rests on a shallow foundation in expansive clay.

3. CONSIDERATIONS IN SELECTING A SITE

The most effective precaution that can be taken to assure a bench mark's stability and survival is to choose a good location for setting it. Because there is such a wide variety of situations that can be encountered when setting the monuments, it is impossible to cover them all in a manual. The ultimate selection of a site is necessarily left to the discretion of the mark setter and it is imperative that good judgment be exercised. There are many things to consider. Table 1 (page 11) will help keep them in perspective.

Security

Foremost on the list of considerations is the bench mark's susceptibility to damage or destruction, which is probably the major cause of bench mark disturbance. In view of the great expense of leveling, foresight spent to preserve a monument is well worthwhile. Anticipate construction that might occur at the location. Is the site in the path of a future highway, waterway, ditch, or pipeline? Will an adjacent shopping center or parking lot be expanded in the foreseeable future? Is the prospective bench mark site near a potentially active mine or quarry? Highway maintenance often involves the widening of its surface and the straightening of curves. Setting the marks near the edge of the right-of-way and on the outsides of curves increases their chances for survival.

Conversely, the outside of a bend in a river should be avoided because erosion eventually undercuts the bank. Undercutting can also occur on shoreline scarps where stormy waters slowly but surely wear away the embankment. Do not set bench marks at these locations. Flood plains should be avoided when otherwise comparable sites can be used because marks may be buried in sediment or washed out.

Often, sites can be located which provide natural protection for the monuments. Locations near the edge of the right-of-way, well away from a highway surface, provides protection from mowers and other maintenance vehicles. Property fence lines and utility poles usually remain in place for years and afford good protection for marks. Structures which are of themselves not suitable for bench

mark settings prevent vehicles and equipment from damaging monuments that are set adjacent to them. And finally, private property and public areas such as parks and cemeteries provide excellent sites from a standpoint of survival.

Utility

Availability to users is another important consideration in choosing a bench mark site. The major use of NGS bench marks is to provide vertical control for other surveys. If the bench mark cannot be found or conveniently leveled to, its worth is questionable. Many users first inadvertently find a survey mark, then request information about it. Others use vertical descriptive information to locate control points near a proposed engineering project; so locate bench marks where they can be accurately described.

Again, foresight must be used when selecting the exact location. A bench mark set flush with the ground is easily concealed with debris. Are there nearby objects that can be used to reference the monument? Are these objects fairly permanent? Will the measurements define a precise point where the hidden bench mark can be found?

To enable the mark setter to situate a monument where its position can be accurately described, a familiarity with referencing techniques is required. Bench marks are usually located in the following manner: First, directions are given to the general area in which the bench mark is located. Normally, this puts the individual within 100 meters or so of the monument. Then the bench mark is found by following distances and directions from prominent reference objects. These distances and directions establish lines-of-position (LOPs). The prominent objects are referred to here as "origins."

For example, a bench mark can be referenced by stating a distance and direction from the corner of a house as follows: "The monument is 35.8 meters northeast of the east corner of the house." (See fig. 1a.) In this case, there is one origin and two LOPs. The origin is the east corner of the house. One LOP is referred to as "35.8 meters [from]... the east corner of the house." It defines a circle with a radius of 35.8 meters and its center at the east corner of the house. The other LOP is given as "northeast of the east corner of the house." It defines a line beginning at the east corner of the house running at an azimuth of 45° east of north.

At least two LOPs are required to define a point. If the description read only "35.8 meters from the east corner of the house," the bench mark could be anywhere on the circle with a radius of 35.8 meters and a center at the east corner of the house. Or, if the description read only "northeast of the east corner of the house," the mark could be anywhere on the line beginning at the east corner of the house and running at an azimuth of 45° east of north. In either case, it would be difficult to find.

Sometimes more than two LOPs are required to define a point. "The bench mark is located 26.7 meters south of the centerline of the highway and 10.2 meters from a 40-centimeter oak tree." Two LOPs are given by this statement, but they define more than one point as can be seen in figure 1b. An additional LOP, such as a direction from the water tank or tree, is required for the unique point to be located.

The important concept to be concluded is that the more nearly perpendicular the angle at which lines-of-position intersect, the more accurately a position can be determined and the easier it will be to locate. (See figs. 2a and 2b.) To apply this concept to bench mark setting, consideration should be given to the ease with which future recovery can be made from the reference measurements. Other considerations in bench mark placement rarely restrict the site to such a limited area that this cannot be done. Leeway of just a few meters is usually enough to make the difference between a mark that can be accurately referenced and one that cannot.

Stability

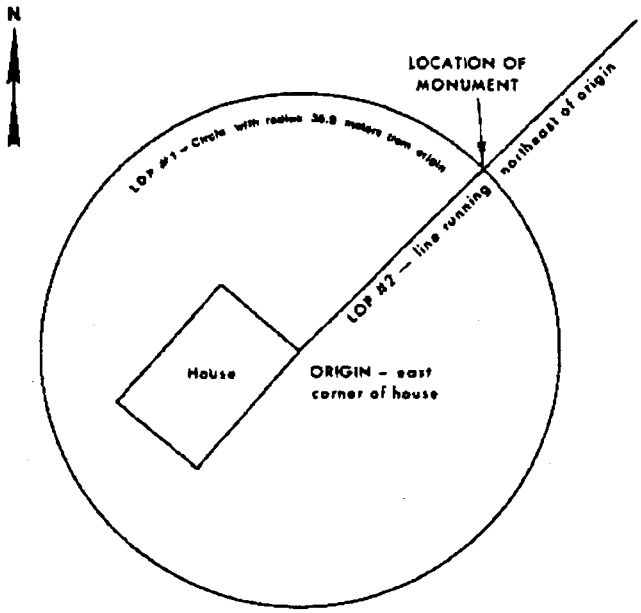
Advantageous Topographic Features

Crests of hills are good places to set bench marks for three reasons. First, the problem of slope instability is eliminated. Even though the neighboring hillside might be sliding, the summit will remain stable. Second, frost heave is less likely with the increased separation from the water table. And third, the consistency of the soil will tend to be more firm.

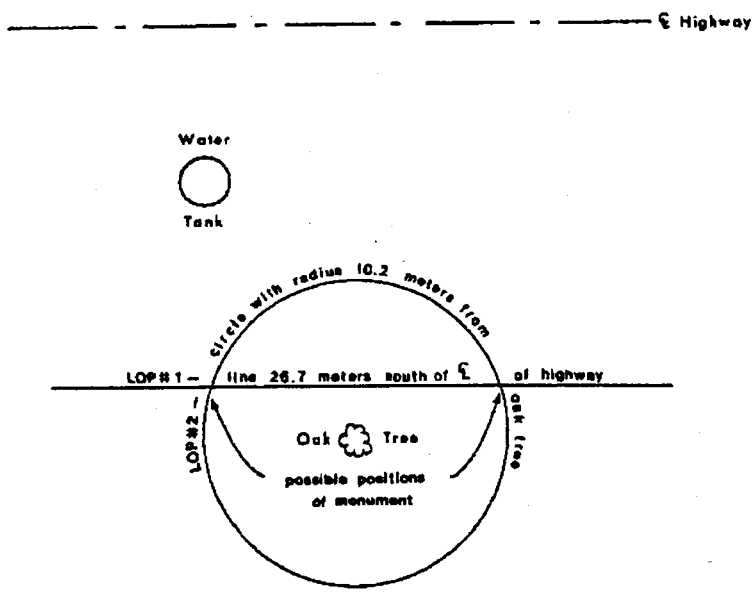
Effect of Soil Grain Size

Whenever soil types can be ascertained, it is preferable to choose a site with coarse-grained soils over one with fine-grained soils. Most of the problems associated with soil movements are attributable to the fine particles it contains. The fraction of grain sizes less than 0.02 millimeter governs whether or not a soil is frost susceptible. Soils susceptible to high volume change due to variation in moisture content are normally clays, which are fine-grained. Also, poorly drained clays provide environments conducive to corrosion. Avoid sites with fine-grained soils whenever an alternative is available.

One way to determine the type of soil in the locality is to examine that which has been exposed by digging, especially where a bank has been left

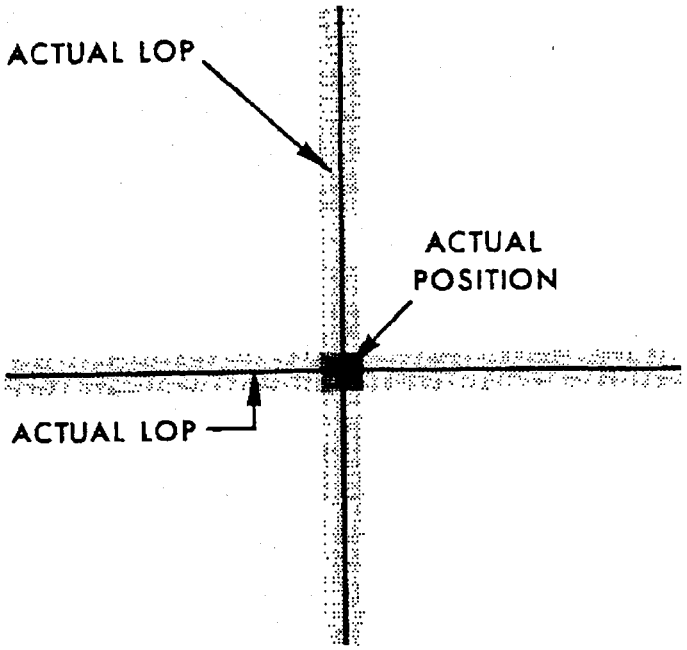


(a) Bench mark referenced to house corner.

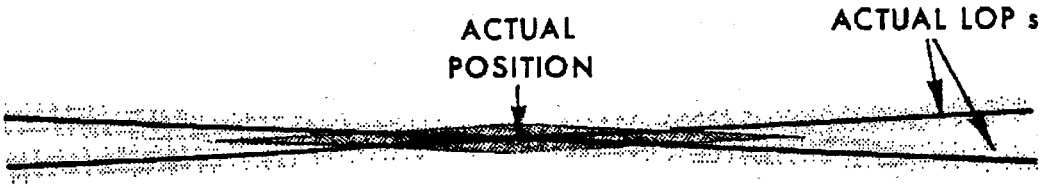


(b) Bench mark referenced to tree and road centerline.

Figure 1.—Referencing of bench marks.



(a) LOPs cross at right angles.



(b) LOPs cross at shallow angle.

Figure 2.—Intersection of lines-of-position. Light shade indicates range of measurement errors. Dark shade indicates area in which monument could be found.

exposed. Look at soil grain size in nearby highway cuts and excavations. Good drainage is usually inherent in coarse-grained soils and therefore can also be used as an indication. It can be recognized by uniform coloration with depth.

Effects of Vegetation

The presence of vegetation, particularly trees, has marked influence on the stability of the upper layers of a soil mass. Trees, underbrush, grass, and moss act as insulation, reducing the depth of the active frost zone and thus reducing frost heave. However, the problem of expansive soils is aggravated by vegetation. In seasons of abundant rainfall, vegetation exerts very little influence on soil volume change. When the weather is dry and only a little free water is available in the soil, trees and other plants draw even more out than normally is lost through evaporation and lowering of the water table. This results in even greater shrinkage. With trees, this effect occurs within a distance from the trees roughly equal to their heights (Bozozuk and Burn 1960).

Areas covered with thick vegetation should be avoided even where expansive soils do not exist because vegetation will conceal a bench mark, making it of much less value than one that is open to view. Do not place bench marks near lone trees because this will subject them to disturbances from growing roots.

Geological Considerations

It will not be feasible to determine the nature and extent of subsurface geological activity in many instances. Nevertheless, it is an important consideration that should never be overlooked when the means are available. A generally stable area may have pockets of unstable ground within it, and detailed geological data are required to determine this. Caverns and underground mines, and water and oil bearing strata subject to pumping are especially prone to cause significant subsidence. Bench marks established strictly for geodetic control should not be set in these areas.

Geological information is available through Federal, State, and even private organizations. General overviews of karsts (subterranean cavities), slope instability, and the like are available from the U.S. Geological Survey. For more specific information on larger scale maps, the individual State Geological Surveys, State Departments of Natural Resources, universities, and public utilities commissions must be contacted. These agencies can provide pertinent geological data including maps of underground mines, cavernous areas, slope movements, and areas subject to subsidence from the pumping of oil, gas, or water. Liaison with these organizations is a necessity.

Whenever possible, sound bedrock should be used for a bench mark setting. However, it is often difficult to determine whether or not an outcrop is indeed sound bedrock, the decision being based mainly on visual evidence of only the exposed portion of the formation. Where a large portion of the outcrop is exposed, try to ensure that the part in which the disk will be set is essentially intact with the rest of the outcrop. Large outcrops with widely spaced fractures and crevices can be considered bedrock for mark setting purposes. Where only a small portion of the outcrop is visible, use a pry bar to make certain the intended setting is not a separate boulder.

Examine the surface of the bedrock. Make sure it is solid, and not in a state of deterioration. The margin of weathered rock can be surprisingly thick. If its surface has begun to crumble or has deep fissures in close proximity, the outcrop is unsound and should not be used. Another type of bench mark will be more stable.

Some sedimentary rock contains detrimental clay minerals, such as montmorillonite, but it is difficult to determine this. When geological maps or expert advice indicates that sedimentary outcrops are expansive, they shall not be used for bench mark settings. A site must be located in a structure or another rock outcrop, or a rod type mark must be used. Expansive bedrock will not be a problem is if lies beneath sufficient overburden because it will not be subject to variations in moisture content.

Structural considerations

Structures are subject to movements from any of the sources pointed out in chapter 2. Fixing a bench mark disk on a structure by no means assures that it will be a good geodetic control point. Before setting the disk, determine whether or not the structure will be at least as stable as a class A rod mark (page 14). If not, use the class A or B rod mark instead.

Relating the stability of a large structure to that of a class A rod mark can be accomplished by (1) comparing the depth of the structure's foundation to the required depth for the sleeve (table 2, page 27), and (2) assuring that the structure is a multistory concrete, masonry, or steel unit. The class A rod mark sleeve is set to a depth below that affected by expansive soils and frost heave. For comparable stability, a massive structure's foundation need not be as deep as the sleeve because the weight of the structure can resist some of the force exerted by the ground which tends to move it. Also, the structure itself will have a shielding effect on the soil below, making conditions such as temperature and moisture content less variable. If its foundation is at least a quarter as deep as a class A

rod mark's specified sleeve depth, a massive structure will be considered stable. Small structures, such as semaphores, concrete culverts, platforms, retaining walls, bridges, etc., must never be used. Very large bridges can be used only if it is positively determined that the structural member in which the disk will be placed rests directly on bedrock.

Since most structures are expected to settle both during and some time after construction, those less than 5 years old must not be used as settings for bench marks unless the foundations are on bedrock. Choose a structure that has a long life expectancy. Modern buildings will probably remain undisturbed a long time, but make sure that they have not been too newly constructed. Older buildings may last a long time if they have historical significance.

Caution must be taken to assure that the disk is placed in a spot that is an integral part of the structure's foundation or fixed rigidly to it. Placing a disk on an appendage, such as steps entering a building, is unacceptable unless the appendage has its own foundation of sufficient depth. Avoid places which might be damaged or covered during construction of an addition to the structure. Building entrances are especially susceptible to reconstruction.

Miscellaneous Areas To Avoid

As explained in the chapter on sources of instability, sites near water reservoirs and large rivers, where the water level is variable, can rise and fall due to rebound and compression of the soil. This movement might be thought by the layman to be minor, but in terms of precise geodetic measurements, it is not. Where possible, bench marks should be established a few hundred meters from the confines of these sources of ground activity.

Permafrost has a stabilizing effect on bench marks anchored to a sufficient depth within it, but significant expansion and contraction of frozen ground due to temperature variation can occur to a depth of about 10 meters. A bench mark anchored below this depth can be expected to be quite stable. In regions where permafrost normally exists near the surface, thawing influences can keep the ground in an unfrozen condition to a depth greater than that which is prevalent. Any body of water, such as a pond, lake, or river, will have this effect. Other influential effects include buildings, roads, pipelines, and, in short, any mark of civilization.

Corrosive Environment

The rate at which a material will corrode or deteriorate is affected by its environment. Two conditions are required before corrosion can occur. (1) The metal being corroded *must* be in contact with an electrolyte, or liquid capable of conducting electric current. This makes it possible for certain chemical reactions to occur. Electrolytes vary widely, ranging from a minute amount of nearly pure water formed by condensation, to sea water. (2) There must be a dissimilarity in two areas of the surface being corroded. This could result from the presence of strains or inclusions in an alloy, the contact of dissimilar metals, or a multitude of possibilities between these extremes.

Environmental factors governing the corrosive character of a soil are principally the degree of aeration and the presence of water-soluble salts. Aeration is important because many metals need oxygen to form a dense, tough layer of metallic oxide on their surfaces, which prevents further corrosion by isolating the remaining metal from the electrolyte. Aluminum and steel protect themselves in this manner. In addition, when one area of a metal is in an environment with a good supply of oxygen while another area lacks oxygen, a condition of dissimilarity is set up in which corrosion is accelerated. An example of this can be seen in a partially submerged piece of iron. That portion above water is supplied with more oxygen than the portion below water. At the waterline these dissimilarities are close to one another, resulting in intensified corrosion.

Water-soluble salts have an effect on corrosion in two ways. First, the ions that form when salts dissolve improve the capability of the electrolyte to carry current. The greater the ability of the electrolyte to carry current, the faster corrosion will occur. In both atmospheric and underground corrosion, water is normally the electrolytic medium. Water with dissolved salts is a better electrolyte than pure water. The salts most often found in highly corrosive soils are sodium chloride ($NaCl$), commonly known as table salt, sodium sulfate (Na_2SO_4), calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$), potassium sulfate (K_2SO_4), and calcium bicarbonate ($Ca(HCO_3)_2$) (Romanoff 1957).

The second effect of water-soluble salts is the influence they have on the formation of the dense, tough protective layer which forms on the surface of certain metals. Sometimes this layer cannot form in the presence of various ions. For example, aluminum is normally quite noncorrosive because aluminum oxide quickly forms on its surface. However, in the presence of dissolved salts, the oxide layer does not form densely enough to prevent infiltration of the electrolyte, so corrosion continues at a high rate.

Of the types of monuments which may be used in the National Vertical Control Network, only the

Table 1.—Summary of measures taken to set high-quality bench marks

COUNTERMEASURES (Discussed on page no. shown in parentheses)	UNDESIRABLE CONDITIONS: Damage/destruction (3)	Frost heave (3)	Expansive soils/rock (3)	Compression of soils (4)	Slope instability (4)	Subsidence from pumping (3)	Caverns/underground mines (2)	Depression of permafrost (10)	Settling of structures (10)	Concealment (6)	Corrosion (10)	Erosion (5)
Use disk set in bedrock (13)	X	X	X	X	X	X	X					X
Seek coarse-grained soils (6)		X	X									
Seek well-drained soils (9)		X									X	
Seek well-aerated soils (10)											X	
Set on crests of hills (6)		X			X							
Seek soils with high resistivity (12)											X	
Natural/readymade protection[a] (5)	X											
Anticipate future construction[b] (5)	X											
Set near edge of right-of-way (5,12)	X										X	
Bench mark design (3,12,14)	X	X	X	X							X	
Anchor sleeved rod below level of disturbance (14)		X	X	X								
Set disk in massive, deep structure (9)		X	X	X	X							
Historically significant structure (10)	X											
Modern buildings (10)	X											
Remain distant from thawing effects[c] (10)								X				
Ensure good referencing (6)										X		
Avoid heavy vegetation (9)			X							X		
Avoid river banks (5)												X
Avoid flood plains (5)										X		X
Avoid shoreline scarps (5)												X
Avoid salt water shorelines (12)											X	
Avoid areas as determined by geological data[d] (9)			X		X	X	X					
Avoid expansive bedrock (9)			X									
Avoid new structures (less than 5 years old) (10)									X			

[a]Includes fence lines, utility poles, structures, and private and public grounds.

[b]Includes highways, parking lots, buildings, pipelines, and waterways.

[c]Includes lakes, rivers, buildings, and pipelines.

[d]Overviews of karsts, slope instability, shale outcrops, oil and gas bearing formations, etc., from the U.S. Geological Survey, States' Geological Surveys, States' Departments of Natural Resources, and public utilities commissions.

class A and B rod marks (pages 14 and 25) are particularly vulnerable to corrosion. The rods for these marks will unavoidably be placed in corrosive soils. As a protective measure, the rod is made of type 316 stainless steel, which is more resistant to corrosion in nearly all environments than other affordable alloys. Even so, steps can be taken to increase its life. It is most susceptible to corrosion in poorly aerated environments and those in which there are chlorides.

Iron compounds are commonly contained in soils. Well-aerated soils are generally recognized by their red, yellow, or brown colors resulting from the oxidation of these compounds. Sites with these soils should be sought for bench mark setting. Poorly aerated soils are usually gray in color due to the lack of sufficient oxygen to oxidize the iron compounds. They may also be identified by their poor drainage characteristics.

Avoid areas where there is a high concentration of chlorides. When setting marks along highways, keep them at least 10 meters from the road surface where heavy salting might be done in winter; setting along the edge of the right-of-way is generally a good practice. Although it will sometimes be impossible due to project requirements, try to avoid salt water shore lines. When the purpose of a project is to provide shore line control, stay off the beach if project instructions will allow.

Finally, if the means are available to measure soil resistivity, a good indication of the corrosive character of a soil can be obtained. The more resistant a soil, the poorer the electrolyte, and consequently, the less corrosive it will be.

Safety

If a monument extends below ground level, there is a chance of encountering underground cables or pipes when installing it. This is especially true when drilling a hole for the sleeved class A rod mark (page 18), and the situation is more critical in urban areas than in rural areas. Evidence of underground utility lines often can be observed at the surface. Waterlines are marked by valve boxes at most street intersections. Avoiding the line between valve boxes will decrease the chances of hitting a pipe. Also, fire hydrants indicate where a water main lies. Hydrants usually are placed within a meter of the line and to the side away from the street centerline. Most water and sewer lines lie under the road surface, but some are placed adjacent to it. Avoid the area between the street and sidewalk.

Telephone and electrical cables are normally laid from 1/2 to 1 meter below the surface. Housing developments built in the 1960's and later are much more apt to have underground cables than those built before that time. The absence of telephone and power poles is conclusive evidence that there are underground cables in the area, but the presence of poles does not necessarily dictate otherwise. Buried telephone lines usually run directly between junction box pedestals or between telephone poles. Electrical cables may be run adjacent to telephone lines. Where an electric appliance such as an air conditioning unit or flood light is located apart from other structures, an underground cable to it would probably run directly from a metering device. Stay clear of that path.

Gas lines are harder to detect. Meters and valves are helpful if they are not too far apart. As with telephone cable pedestals, do not drill on a direct line between them.

If circumstances permit, the best way to avoid problems is to contact the local metropolitan utilities commissions. Underground pipe and cable information can often be had by calling one centralized office which maintains liaison with all the various utility companies. When it is possible to do reconnaissance a few days in advance of the actual mark setting, this alternative will be efficient. If this is not possible, it is advisable to use a pipe and cable locator for detecting conductive materials underground. However, these devices are not infallible. Plastic, unreinforced concrete, and clay tile pipe will not register on them. Get into the habit of looking for "Buried Cable" signs. And finally, set marks near utility poles, but not on line between them when other considerations in site selection will allow. Utility poles cannot be set over water and sewage pipes.

4. INSTALLATION

Maintaining Good Public Relations

The purpose of the Federal Government is to serve the public. Pertaining to the establishment and maintenance of geodetic control, this principle has at least two applications. One is to gain the understanding and good will of the public. Another is to project the credibility of the National Ocean Survey/National Geodetic Survey through the visible evidence of its mission—survey control markers.

These objectives can be accomplished with only a little extra effort. Always obtain permission from the landowner when setting bench marks on private property. Responsible officials must be consulted when a prospective site is located on public or corporate land. If approached in a polite and tactful manner, a hesitant individual often can be persuaded to permit installation at the desired site. Most citizens can be convinced to take personal interest in having a bench mark carrying NGS's distinction on their property. Appeal to the indi-

vidual's public spirit. Explain what bench marks are used for, the need for their stability and durability, and the expense involved with replacing them. The setting of bench marks provides an excellent opportunity to make the public aware of NOS/NGS activities. Under no circumstances shall a bench mark be installed on an unwilling property owner's land, thereby provoking hostility toward the Federal Government.

The importance of a clean, neat installation cannot be overemphasized. Not only does it help maintain friendly relations with the local citizens, but it also upholds the esteem of the Federal Government. Sloppy bench mark installations by a few mark setters could understandably lead users to believe that the whole leveling program is run in a haphazard manner. Do not allow this to happen.

Special Considerations at Line Intersections

Level line intersections are of prime importance when it comes to mathematical adjustment of a vertical control network or portion of it. Junction points are used for the initial adjustment of the system. Intermediate elevations are not taken into account until after this initial phase of the adjustment. As a result, no elevations can be better than those at the junctions; therefore, only the highest quality bench marks should be used there.

Sound bedrock should be used for these points if at all possible. Relocating the point of intersection as much as 10 kilometers to take advantage of an outcrop would not be unreasonable. When outcrops of sound bedrock are not available, choose the next best location following the guidelines enumerated in chapter 3. Other than bedrock marks, only disks in structures and class A rod marks as explained in succeeding sections are permissible for first-order junction bench marks.

Once the location is found, steps must be taken to preserve the junction by placing supplemental monuments nearby which can also serve as junction points. In the event the primary monument is destroyed, the integrity of the network will remain. At intersections of two first-order lines, a minimum of three monuments shall be placed not less than 0.5 kilometer apart. At intersections of first- and second- or two second-order lines, a minimum of two monuments shall be placed not less than 0.5 kilometer apart. Junctions with third-order lines need no special considerations. In all cases, try to select sites that will not all be destroyed by one common cause such as the widening of a highway.

Disk Set in Bedrock or Structure

Sound bedrock is the most desirable setting for a bench mark. Besides the ease with which a disk can be installed in bedrock, it provides the most stable setting that can be used in terms of both underground activity and disturbances inflicted by people. Always use bedrock when a suitable outcrop exists. As a rule of thumb, the bedrock is good if the distance between joints and fissures is greater than 1 meter.

The National Geodetic Survey bench mark disk (see fig. 3) is made of brass or bronze. It is about 9 centimeters in diameter and has a spherical surface to support the foot of the leveling rod. Information is imprinted on this surface to identify the monument and to aid the user in obtaining data on it. This logo is recessed so that it does not interfere with placement of the leveling rod. A deformed shank, about 7-1/2 centimeters long, is silver-soldered to the bottom surface of the disk to help prevent the disk from being dislodged. Disks with tubular shanks can also be used.

The step-by-step procedure for setting the disk in bedrock is as follows:

1. Stamp the designation and year on the top surface using 4.75-millimeter (3/16-inch) steel dies.
2. Pick a fairly level and accessible spot on the outcrop that is intact with the bulk of the rock.
3. Drill a 2-1/2-centimeter hole about 10 centimeters into the bedrock and recess the area around the top of the hole to a diameter slightly larger than that of the disk. When the installation is completed, the top surface of the disk should set level and flush with the surrounding rock. *Caution*: Safety goggles should be worn when drilling into bedrock or masonry.
4. Remove the rock powder from the hole and recessed area and fill the hole with *clean* water; then pour cement into it. Mixing of the ingredients is done right in the hole. By adding more water and cement, make enough mortar so that an extra amount is available to place on the underside of the disk and, if applicable, inside the shank. When the mortar is completely mixed, it should be thick but still workable.
5. Fill the depression on the underside of the disk with mortar. For disks having tubular shanks, also fill the shank with mortar. This is very important because it will prevent the existence of highly undesirable voids under the disk once it is in place.
6. Place the shank of the disk into the drilled hole and press the mark firmly into place. Work the excess mortar around the outer edge of the disk, making sure that it is smooth and flush with the top surface. An exposed edge of the disk would provide an area which could be used by someone to dislodge it. Fresh mortar

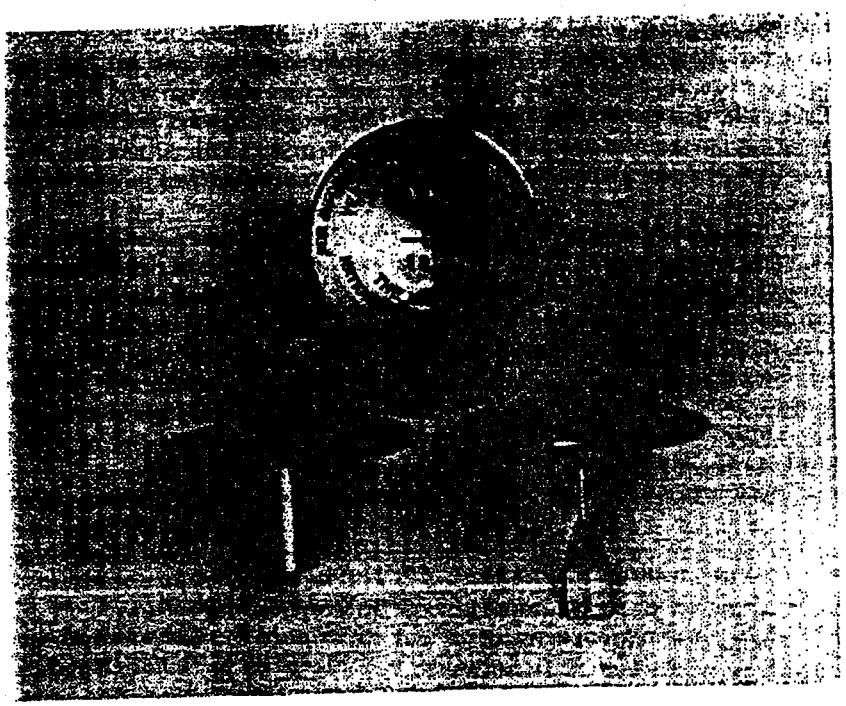


Figure 3.—NGS bench mark disk stamped with designation and year.

on the upper surface of the disk can easily be cleaned off.

7. Sprinkle some dry cement on the exposed surface of the disk; then rub it with a clean rag using circular strokes. This will clean the disk very nicely, removing all excess mortar from its surface and recessed letters. Rubbing the wet mortar around the edge of the disk in the same manner will do no harm. On the contrary, this is often done intentionally to finish its surface and prevent cracking. Brush away loose cement and make sure that the finished product has a very neat appearance.
8. If there is a nearby crevice or spot of ground in which a witness post can be conveniently set, this should be done.
9. While the mortar is still wet, it must be covered to prevent heavy rains from ruining its surface and to conceal the disk from people who might tamper with it. A piece of wood, cardboard, heavy paper, or similar biodegradable item will suffice.
10. The installation is not complete until all accumulated trash has been picked up. Leave the place in good order.

In setting a disk in a massive concrete or masonry structure, first make sure the structure is stable. Its foundation must extend to a depth that equals or exceeds 25 percent of the specified depth of the sleeve for the class A rod mark, as indicated in table 2 (page 27). Furthermore, the foundation must be at least as deep as the maximum depth of frost penetration indicated on the map in figure 13 (page 34).

The disk can be mounted vertically in the wall of a structure, but should always be set horizontally if possible. The procedure for setting a disk horizontally in a structure is identical to that for setting one in bedrock. Make sure safety goggles are worn when drilling into masonry or concrete. Since for a vertical setting the hole for the disk's shank must be drilled horizontally, the mortar must be mixed separately. When drilling into brick or other soft material, a hammer and star drill should be used, rather than heavy power equipment, to prevent extensive damage to the exterior. The hole should be wetted before mortar is put into it. After placing the shank of the disk into the mortar filled hole, work it to the bottom edge of the hole so that it will not settle askew while the mortar is curing.

Class A Rod Mark

The class A rod mark is to be used whenever possible where sound bedrock and substantially stable structures are not available. The top of a steel rod serves as the datum point. The rod itself anchors the datum point to a stable stratum of soil. In most areas a sleeve is required to isolate the rod from soil movements occurring above the

stable stratum.[5] (See fig. 4.) This sleeve is omitted where no soil movements are expected. At the surface an encasement around the datum point provides protection from impact and information to the user. (See fig. 5.)

The rod is assembled from sections of 1.43-centimeter (9/16-inch) type 316 stainless steel[6] coupled with threaded studs of the same material. The sleeve is made from 2.54-centimeter (1-inch) schedule 40 polyvinyl chloride (PVC) pipe with fittings to couple the sections. The annular space between the rod and sleeve must be filled to prevent water from infiltrating it. If water is allowed to seep into this space, two problems will arise: corrosion will occur; and when the water freezes, stresses between the sleeve and soil will be transmitted to the rod. The substance used as the filler should be a grease or grease-like product with a consistency that will remain soft at cold temperatures. It must be insoluble in water, noncorrosive to the rod and sleeve, and must have an extremely long life expectancy.

The casement consists of a 12.7-centimeter (5-inch) PVC pipe, 1/2-meter long, fitted with an aluminum flange around its top edge. The flange is imprinted with the standard information that accompanies all bench mark monuments and is stamped with the station's designation and year. Its inside edge is recessed to accommodate a hinged aluminum cover. This arrangement is placed around the top of the rod, slightly below ground level. Approximately 20 liters (2/3 cubic foot) of concrete is then poured around it to hold it firmly in place and to aid in recovery of the monument if it becomes buried.

This type of monument has been designed to prevent near-surface soil movements from changing the bench mark elevation. The two major kinds of movements it can counteract are frost heave, and shrinking and swelling of expansive soils. Averting these movements is accomplished by extending the sleeve to the maximum depth to which these soil movements are expected to occur. Then the rod assembly, after being placed inside the sleeve, is driven or pressed into the soil so that it is anchored below the sleeve, and consequently, below the layer of disturbance.

When frost heave can occur, the sleeve is placed to a depth three times as great as the maximum frost penetration indicated in figure 13 (page 34). When any type of upright, such as a post, pile, or pipe, is subject to frost action, the upward motion caused by frost heave is normally greater than the subsequent settlement after the ground has thawed. Unless there is an opposing force, the object will eventually be ejected from the ground. A sleeve placed to three times the depth of frost will have, in nearly all instances, enough friction between it and the soil below the frozen layer to resist the upward force of frost heave. In any case, the jacking effect of frost action will be retarded.

Consolidation of a soil mass can be counteracted with this bench mark when it is placed to a sufficient depth. As long as the sleeve isolates the rod from the soil where consolidation (or rebound) can have an effect, movement from this cause will not change the bench mark's elevation. To be used effectively in this manner, a geologist or soils expert must determine where these movements occur.

It is suggested that one of two methods be used to place the 2.54-centimeter (1-inch) PVC sleeve, though other methods might also prove effective. (1) Where the soil is self-supporting, the cleanest and quickest method is to use a small diameter, conventional flight auger. Briefly, a hole is drilled to the specified depth of the sleeve, the string of augers used in drilling the hole is retracted, and the sleeve is lowered into the hole. (2) Where the soil is subject to caving, as in a loose dry sand, or in working below the water table, a hollow-stem auger can be used. The auger is drilled to the specified depth, the bench mark sleeve is lowered into place through the auger, and the auger is retracted, leaving the sleeve in place.

When it is unknown whether or not a hole will support itself, use the conventional flight auger. If the hole caves before the bench mark sleeve can be lowered into it, start over using a hollow stem auger. Once some experience is gained in a particular region, the mark setter will intuitively know whether a conventional auger will likely suffice or if efficiency would be lost in this trial-and-error method.

A suggested routine using the conventional flight auger is given next. Some of the steps need not necessarily be taken in the prescribed order. Experience will dictate the most efficient manner for a particular crew. One crew's method is pictorially illustrated in figure 6 (pages 20-24).

WARNING: Precautions must be taken before drilling into the ground. Underground pipes and cables can be damaged and can also cause damage to drilling equipment. Conceivably, injury or death could result from drilling into an electrical cable or gas line. (See "Safety," page 12.)

[5] Although it is somewhat detrimental from a corrosion standpoint, the sleeve is normally essential for stability.

[6] This alloy has the optimum combination of iron, nickel, and chromium to combat corrosion in both weight loss and pit depth, and yet remains economical.

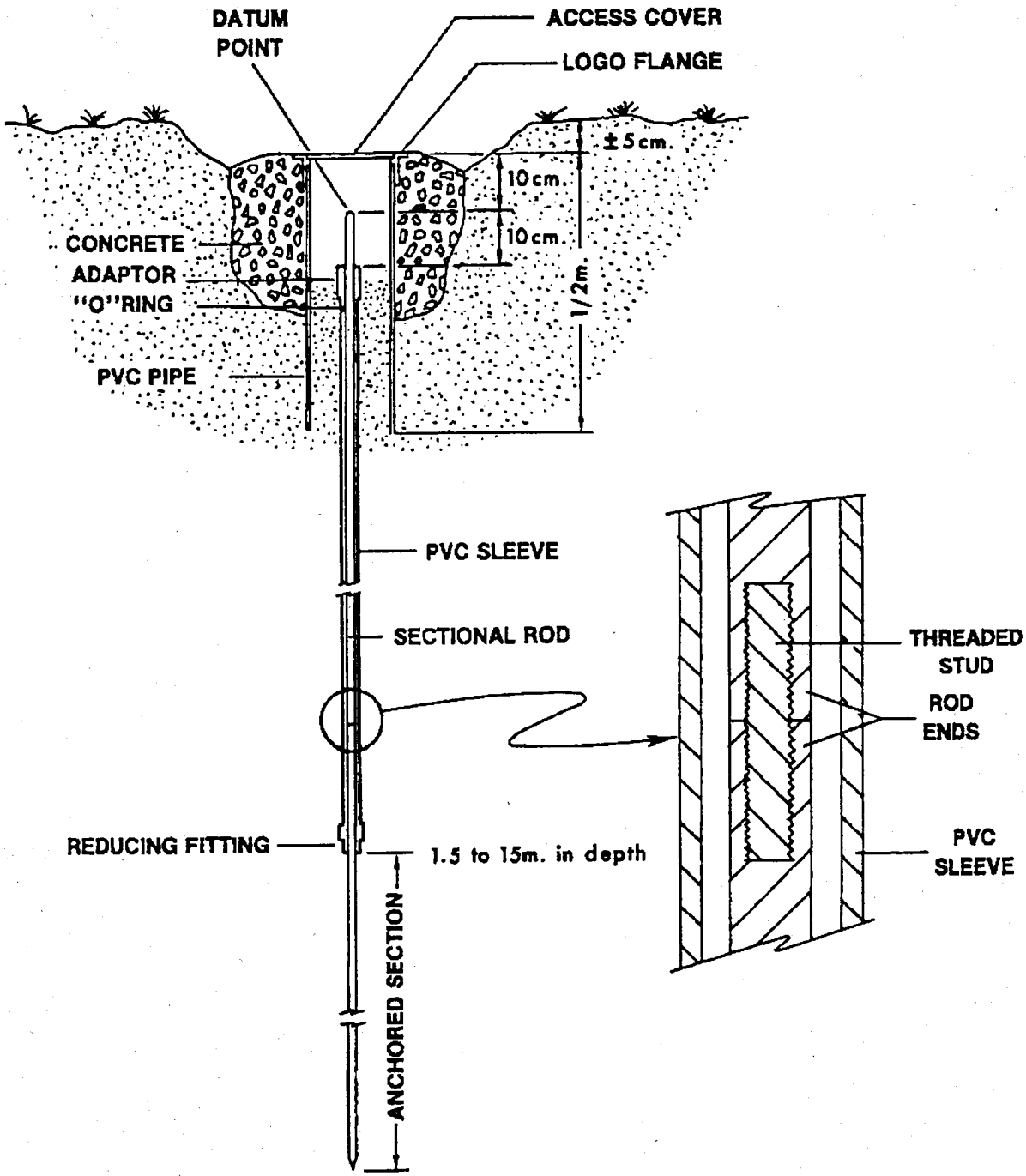


Figure 4.—Sleeved class A rod mark.

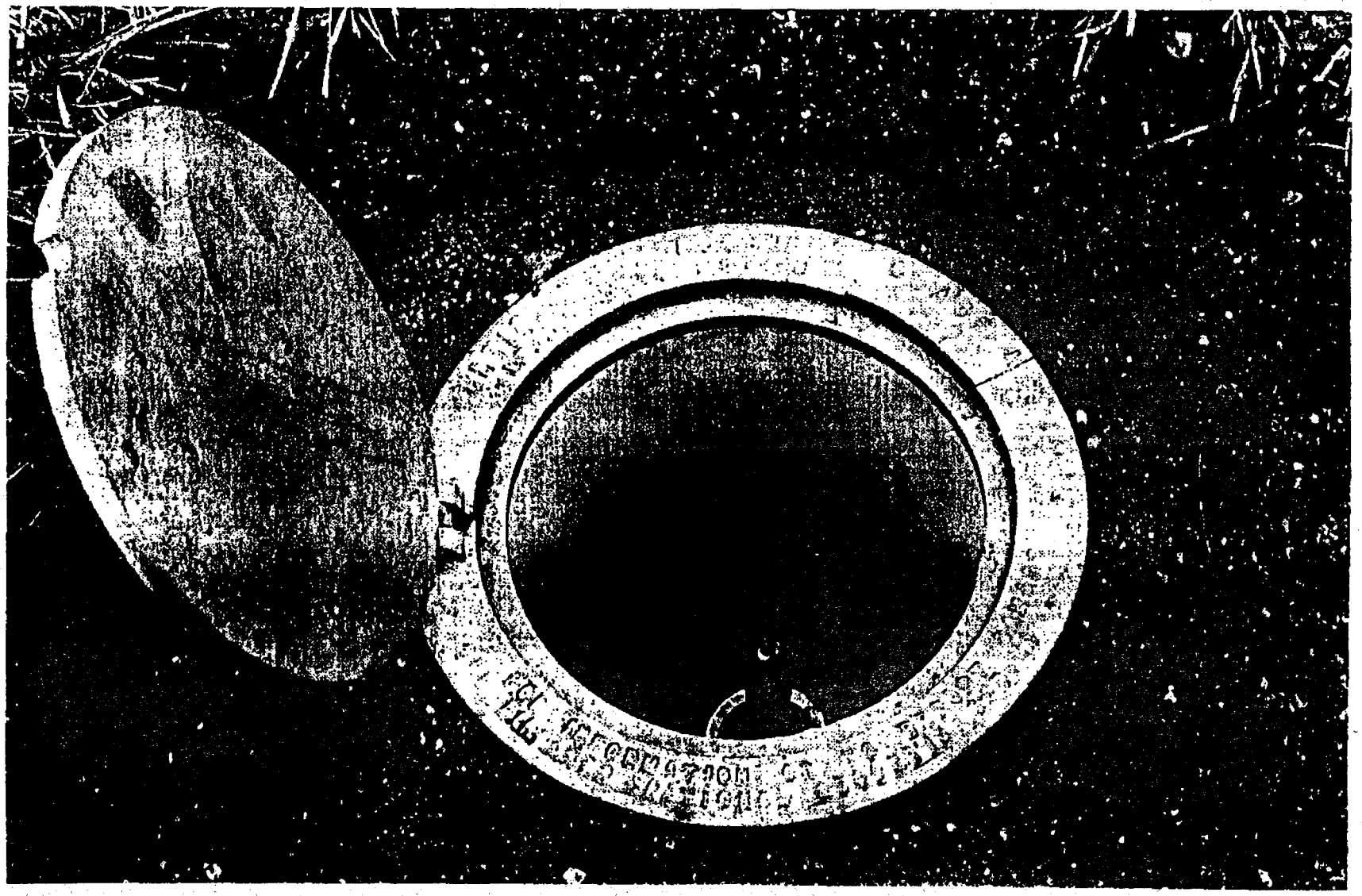


Figure 5.—Class A rod mark showing logo flange and hinged access cover.

1. Maneuver the drill into position with the rotary head situated over the spot where the monument is to be placed. When the site is on an incline, the vehicle should be facing uphill.
2. Level the vehicle with the stabilizing jacks. A carpenter's level can be placed vertically against the drill head mast to make sure it is plumb both transversely and longitudinally.
3. Where neat landscaping must be preserved, place a 2-meter square tarpaulin on the ground and drill through a 1/2-meter hole cut in its center.
4. Bore a hole 30 centimeters in diameter to a depth slightly more than 1/2 meter for the protective flanged encasement. This hole will be filled with soil during subsequent operations, but the objective is to loosen the soil in preparation for setting the encasement.
5. Connect an appropriate bit to the first section of a small diameter conventional flight auger and begin drilling a hole to the required sleeve depth. Depths for sleeves set within the continental United States are specified in table 2 (page 27). Use figures 7 through 13 in conjunction with this table to determine the depth. Use the deepest depth indicated when a variety of conditions exists. In regions outside the conterminous States, the sleeve shall be placed to a depth of 10 meters. Examples for determining the depths are given in appendix E.
6. When the required depth is reached, pull the augers straight up with no rotation to keep the hole clean. Before removing the last section of auger, clean the loose soil out and away from the hole bored in step 4. After all the flights have been retrieved, move the rotary drill head off the axis of the hole to provide clearance for the next steps.
7. Attach appropriate fittings to one end of a 2.54-centimeter (1-inch) PVC pipe to reduce the inside diameter to 1.59 or 1.90 centimeters (5/8 or 3/4 inch). Lower the pipe into the hole with the reduced end down, then connect and lower more sections of pipe as required. The last section to be assembled must be cut to length so that when the bottom of the hole is reached, the top of the sleeve will be about 25 centimeters below the surface of the ground. Finally, glue a female slip-to-thread adaptor to the top of the sleeve. This will be used to make connections to a grease pump for filling the annular space with lubricant.
8. Assemble the 1.43-centimeter (9/16-inch) stainless steel rod and lower it into the sleeve. If a long, unwieldy length is required, the rod may be coupled while it is being lowered into the sleeve. To obtain tight joints, finger tighten them and then apply one-quarter turn more.
9. When the rod assembly rests in the bottom of the hole, it must be pressed or driven into the soil beneath the sleeve. Alternately couple and drive more sections of rod until it resists a downward static force of 250 kilograms,[7] but make sure at least 1 meter of rod extends below the sleeve. In clay, driving may be terminated if the 250 kilograms of resistance are not met after 10 meters of rod have been driven.

   Care must be taken not to deform the end of the rod being driven, or coupling of the next section will be difficult. In the event refusal is met before the minimum of 1 meter is driven, the rod and sleeve must be pulled up, and the hole must be drilled to the depth at which the rod will ultimately be placed (1 meter below the sleeve). New soil, soil mixed with cement, or concrete must then be compacted in the bottom of the hole to provide a good anchoring material for the rod. In cases where soil mixed with cement or concrete is used, extreme care must be taken to prevent the sleeve from becoming embedded in the anchoring material, or movement of the sleeve will be transmitted to the rod. One way to do this would be to dump a layer of the original soil over the anchoring material to provide a buffer between it and the bottom of the sleeve. If a large obstruction makes it impossible to drill to the required depth, the anchoring material must be compacted in the bottom of the hole to a depth 1 meter above the obstruction. Adjust the sleeve length accordingly and take precautions to isolate it from the anchoring material.
10. Provide the top of the rod with a suitable high point on which a leveling rod can be supported. This may be done in one of three ways. (1) When the depth to which the rod will be driven is known in advance, use a prerounded top section for the last length of rod to be coupled. (2) Cut off the rod when the proper depth is reached and round the top with a file. Or (3) crimp a type 316 stainless steel cap with a hemispherical end onto the top of it.
11. Pump the filler into the annular space between the rod and sleeve, making sure no voids are

[7] The 250-kilogram resistive force can be determined indirectly by relating dynamic resistance to driving rate. Ignoring energy losses, the work done in driving the rod equals the energy output of the driving equipment. For a drop hammer, the *Resistance* offered by the soil times the *set* (penetration per blow) equals the *W*eight of the hammer times the *H*eight from which it was dropped (Rs = WH). For a gasoline powered impact hammer, the *Resistance* times the *set* equals the effective *E*nergy output of the impact hammer (Rs = E). Since the ultimate bearing capacity under static load is usually many times the driving resistance, this relationship will yield conservative results if R is set to 250 kilograms.

left. Approximately 1/3 liter (0.1 gallon) of filler is needed for each meter of sleeve. During this operation, the sleeve may have to be lifted slightly to allow air to escape from its bottom. When the entire space is filled, place a 1.43-centimeter (9/16-inch) ID (inside diameter) × 2.54-centimeter (1 inch) OD (outside diameter) "O" ring or rubber bushing around the rod inside the top of the sleeve just below the adaptor. This will serve to steady the rod for the process of differential leveling. It will also stabilize the rod horizontally in the event the mark is someday used also for horizontal control.

12. Backfill the hole around the bench mark sleeve with soil. Much of the soil brought to the surface during the drilling of the hole can be disposed of in this manner. Make sure the sleeve gets firmly impacted in the hole in case the monument is eventually used also for horizontal control. In areas subject to frost heave, it is desirable to use a clean sand in the upper end of the hole to the depth of maximum frost penetration.
13. Clean the soil out of the 30-centimeter hole around the bench mark sleeve to a depth of about 30 centimeters. Place a 1/2-meter length of 12.7-centimeter (5-inch) PVC pipe around the rod and sleeve so that they are centrally located within it. Press or drive the pipe down until its top edge is about 5 centimeters below the surface of the ground and 10 centimeters above the top of the rod. Fill the protective pipe around the sleeve with soil until about 2 to 4 centimeters of the sleeve and 10 centimeters of the rod are exposed.
14. Stamp the bench mark designation and year in the area provided on the aluminum flange supplied for the top of the protective PVC pipe. Then fit the flange and cover over the pipe.
15. Mix about 20 liters of concrete, the approximate amount produced by the commercially available 36-kilogram (80-pound) bag of premixed concrete. Pour the concrete around the pipe and flange and tamp it into place. Finish the surface of the concrete so that it is flush with the top surface of the flange and it slopes gently away from it. This is important because no exposed edges will be left to facilitate removal of the flange, and water will drain away from the access cover rather than into it. Remove excess concrete from the flange and be sure the imprinted information is not defiled with concrete.
16. Set a witness post when appropriate.
17. Before leaving the area, clean it up. Scatter or otherwise dispose of any leftover soil from the drilled holes. Pick up trash which has accumulated during the installation. Finally, set a temporary covering over the wet concrete to shelter it until it cures.

The procedure for placing a sleeved bench mark using hollow-stem augers is nearly the same, with the following exceptions:

1. After boring the 30-centimeter hole for the encasement, attach an appropriate cutterhead to the first section of a small diameter, hollow-stem auger. At the time of this writing, the smallest known available size has a 5.7-centimeter (2-1/4-inch) ID and a 12.7-centimeter (5-inch) OD. Fit the cutterhead with a disposable knockout plug. Plastic is preferred to a wood plug which could swell when used in a wet environment, making its removal difficult. Never use a metal plug unless it is type 316 stainless steel. Contact of dissimilar metals in the completed installation must be avoided.
2. Drill to the required sleeve depth in such a manner as to bring as little soil to the surface as possible. This is accomplished by combining proper speeds of rotation and feed to obtain a screwing effect rather than a boring effect, and by halting rotation immediately after the drill head has reached the bottom of the feed stroke.
3. Retract the string of augers about 1/4 meter and secure them with an auger fork. Disconnect the augers from the rotary drill head and move the head off the axis of the hole to provide clearance for lowering the sleeve.
4. Assemble and lower the 2.54-centimeter (1-inch) PVC sleeve into the hollow stem of the auger string. To knock out the disposable plug in the cutterhead, lift the assembled sleeve about 2 or 3 meters and let it drop. When working below the water table, cohesionless soils at the bottom of the hole can sometimes be washed up inside the hollow stem by pressure of water outside the augers. To prevent this, fill the inside of the auger with water to at least the height of the water table before the plug is knocked out.
5. Retract the string of augers by reversing the rotation of the drill head and lifting it with the pullout mechanism. With the appropriate combination of rotation and pullout speeds, excess soil that was brought to the surface can sometimes be returned and compacted around the bench mark sleeve.
6. Assemble and lower the stainless steel rod as before and complete the remaining steps as listed in the procedure for using the conventional flight auger.

In some situations, unexposed bedrock will be encountered before the required bench mark sleeve

1 Drill rig maneuvered into position and leveled.

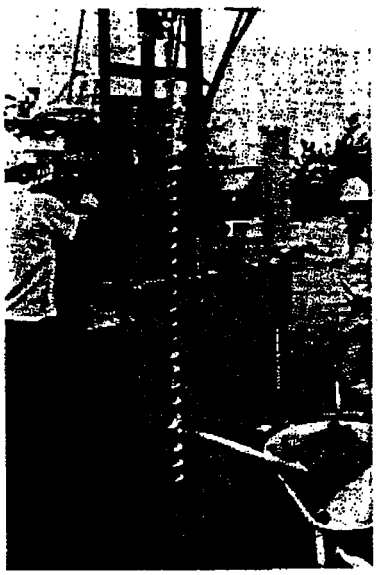
2 Digging through the sod.

3 Preparing to attach a large auger.

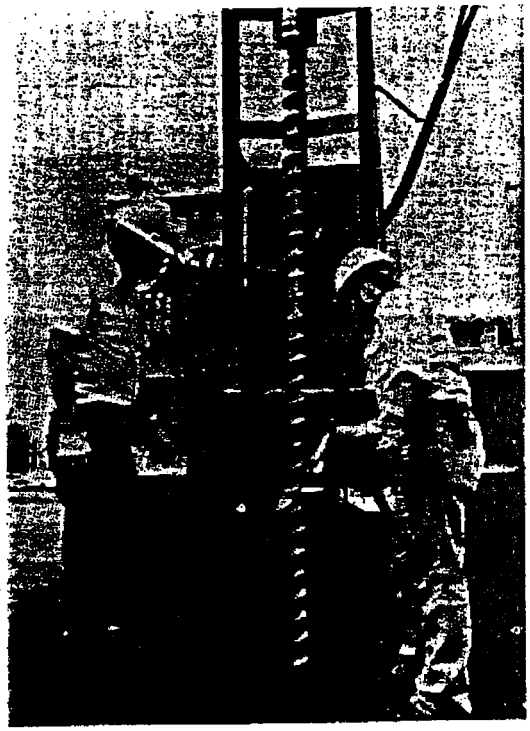
4 Boring a hole for the protective casement.

Figure 6.—Setting a sleeved class A rod mark.

5 Attaching a length of conventional flight auger.



6 Drilling a hole for the sleeve.



7 Retracting the flight augers.

8 Retracting the lower sections of flight auger.

Figure 6.—Continued.

9 Pumping filler into the sleeve.

10 Sleeve lowered into the hole.

11 Lowering the rod into the sleeve.

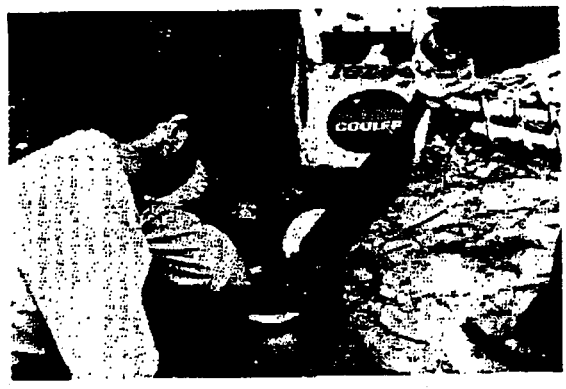
12 Driving the rod into soil beneath the sleeve.

Figure 6.—Continued.

(13) Filling soil in hole around the sleeve. (Sleeve temporarily extended to keep dirt out.)

(14) Sleeve and rod in place.

(15) Driving the protective pipe into place.

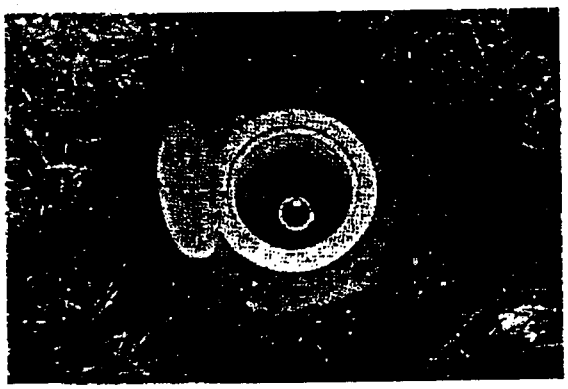


(16) Filling soil inside the protective pipe.

Figure 6.—Continued.

(17) Preparing the hole for concrete.

(18) Working concrete around the protective pipe and logo flange.



(19) The completed bench mark.

(20) Writing the description.

Figure 6.—Continued.

depth is reached. If drilling is halted by an underground obstruction, note the depth of the obstacle, move the equipment a few meters, and try drilling again with a conventional flight auger. If the obstruction is once again encountered at roughly the same depth, it is likely to be bedrock. The class A rod mark can be set to a depth less than normally required if one of the holes is 4 meters or more in depth. If both holes are less than 4 meters, another try must be made or another site located.

Once it has been established that there is probable bedrock at a depth of 4 meters or more, a rod type bench mark can be set. Where the soil is self-supporting and the desired hole stays open, backfill it with concrete or soil for 1 meter above the bedrock. If the hole has caved, redrill it with a hollow-stem auger to a depth 1 meter above the bedrock. Place the sleeve into the hole as usual making sure it does not become fixed to the concrete in the bottom, if used. *Before* placing the rod, cut its bottom section off so that when pressed or driven to the bedrock, its upper end will be about 15 centimeters below ground level. The remaining steps are identical to those for placing the usual sleeved rod mark. (See pages 18-19.)

To anchor the rod into the underground bedrock would be desirable but not absolutely necessary. Total vertical motion at any particular depth results from the accumulation of incremental changes below it. Accumulation begins at the level where movement is nonexistent and the surface of bedrock delineates the level where *no* soil movement occurs. Since the rod will be exposed to the soil for only 1 meter above that depth, only the activity accumulated over a 1-meter depth starting from zero movement will be transmitted to the rod. This amount is negligible.

Where the soil is nonexpansive and the maximum depth of frost penetration is less than 1/2 meter as determined in figures 7 through 13, no sleeve is required for the class A rod mark. The setting procedure is simple.

1. Maneuver the drill rig into position and level it.
2. Bore a hole 30 centimeters in diameter to a depth slightly greater than 1/2 meter to accommodate the protective flanged encasement.
3. Press or drive the rod to its required 4-meter depth. In areas where this is made difficult due to the existence of hard clay, scattered stones or cobbles, or frost, a hole can be drilled to a depth of 3 meters, *maximum*. The rod can be placed in the hole and pressed or driven another meter so its top is about 15 centimeters below ground level. Then the hole is backfilled.
4. Fabricate the protective encasement, set a witness post, and clean up as with installing the sleeved class A bench mark.

This mark can also be set with an ordinary post hole digger and gasoline powered hammer. First, the 30-centimeter hole is dug. Then the sectional rod is driven and connected, one length at a time. And finally, the protective casement is constructed and the remaining steps taken as indicated.

Class B Rod Mark

To perpetuate the National Vertical Control Network with monuments of only the most stable nature would be ideal, but other factors make this impossible. Situations will be encountered where bedrock or other stable settings are not at hand, and where the soil is unstable but the equipment required to set the sleeved rod mark is unavailable. Among others, mark maintenance personnel, who relocate monuments which are destined for destruction, and those who set tidal bench marks for the Office of Marine Surveys and Maps, National Ocean Survey, need an alternative to the sleeved class A rod mark.

The class B mark consists of a stainless steel rod assembly driven to a depth based on soil and weather conditions, and capped with the standard bench mark disk. It has no sleeve. A casement at the surface protects the monument from damage by impact. This casement differs from the flanged encasement for the class A rod mark in that a PVC clean-out plug is used in place of the logo flange and access cover. The bench mark disk carries the logo and designation. Except where soil movements are nonexistent, these marks cannot be expected to hold their elevations as well as the class A rod marks. The procedure for setting a class B rod mark is as follows:

1. Dig a 30-centimeter hole to a depth slightly greater than 1/2-meter for the protective casement.
2. Taking care not to deform its end, drive the first section of 1.43-centimeter (9/16-inch) stainless steel rod down to just above ground level. Make sure it remains plumb while driving. Couple another section of rod tightly to the first and drive the assembly down as before. To obtain tight joints, finger tighten them and then apply one-quarter turn more. Repeat this procedure until the required depth is reached as indicated in table 3 (page 27). When a variety of conditions occur, use the deepest depth specified. In clay, however, the depth may be limited to 10 meters. Drive the last section down to about 10 centimeters below ground level. Every effort must be made to reach the minimum depth specified. If firm resistance is met before the required rod depth is nearly approached, discontinue driving before the rod becomes tightly embedded in the resistant layer. Using a pipe wrench to rotate the rod

clockwise while simultaneously pulling up on it, try to pull it out so the installation can be attempted in another spot. When firm resistance is met at nearly the required rod depth, continued driving will probably result in reaching that depth. Drive with determination; as long as the rod keeps going down, no matter how slowly, keep at it. If the required depth is not reached after exhaustive efforts, cut the rod off about 10 centimeters below ground level and use as is.

3. Stamp the designation and year on the bench mark disk and crimp the hollow shank on the disk onto the top of the rod.
4. Place a 10.2- or 12.7-centimeter (4- or 5-inch) PVC pipe 1/2 meter in length around the disk and rod. Press or drive the pipe down until its top edge is about 5 centimeters below ground and 5 centimeters above the disk. Fit the top of the pipe with the proper size slip plug or threaded plug with appropriate female adaptor.
5. Mix about 20 liters of concrete to place around the top of the protective pipe. Twenty liters is the approximate amount produced by the commercially available 36-kilogram (80-pound) bag of premixed concrete. Pour concrete around the pipe and tamp it into place. Finish the top surface of the concrete so that it slopes gently downward and away from the top of the pipe. This is important because it will help drain water away from the protective pipe rather than into it.
6. Set a witness post when appropriate.
7. Before leaving the area, clean up any trash that accumulated during the installation. Finally, set a temporary covering over the whole arrangement to protect it until the concrete cures.

Miscellaneous Marks

Occasionally, a natural or readymade bench mark setting will exist that would be more stable than a rod mark but which cannot accommodate a brass disk. An example is a deep well casing. It would resist not only near-surface movements, but also, to a degree, movements originating in the subsurface such as subsidence from pumping. A good illustration of this can be seen in Santa Clara Valley, Calif., where well casings project prominently because of ground subsidence. These settings should not be passed by simply because disks cannot be mounted on them. They can furnish excellent references for elevations, *provided* they extend at least three times as deep as the required sleeve depth for a class A rod mark in that area.

It is important to select a good point of reference for the elevation of this type of bench mark. A prominent protrusion can be used if it is definite and has a good high point on which to rest the leveling rod. Alternatively, a cross can be etched with deep fine lines on a spot accessible to a leveling rod or tape. If possible, stamp or etch the bench mark designation and year nearby.

Table 2.—Sleeve depth for class A rod mark set within the continental United States

Condition	Extent of occurrence	Depth
Soil volume change[a]	nonexpansive	no sleeve required[b]
	low expansive character	6 meters × CF[c]
	medium or high expansive character	10 meters × CF[c]
Active frost penetration[d]	maximum 0.5 meter or less	no sleeve required[b]
	maximum greater than 0.5 meter	3 × max frost penetration
Permafrost[e]	any extent	10 meters

[a] Categories of expansiveness are shown on the maps in figures 7 through 11. Inability to accurately delineate category boundaries necessitates assumption of the greater expansive character when working near a boundary. A consolidated map of these figures, at a larger scale, in color, is available by writing to the USAE Waterways Experiment Station, P.O. Box 631, Attn: GEO, Vicksburg, MS 39180. It is entitled Occurrence and Distribution of Potentially Expansive Materials in the United States.

[b] Where no sleeve is required, the rod assembly shall be set to the depth at which a static load of 250 kilograms causes no movement (see footnote 7, page 18) but at least 4 meters.

[c] The Climate Factor (CF) is indicated on the map in figure 12. Use the larger value when there is doubt as to what value applies to a particular site.

[d] Depth of maximum frost penetration is indicated on the map in figure 13. Use the upper limit for each area delineated.

[e] For an excellent overview of permafrost areas, consult Ferrains (1965).

Table 3.—Minimum depth for class B rod mark[a]

Condition	Depth
Nonexpansive soils	4 meters
Soils of low expansive character	5 meters × CF
Medium or highly expansive soils	6 meters × CF
Low penetration resistance[b]	To substantial resistance[c]
Seasonal frost penetration	4 × maximum frost penetration[d]
Permafrost	2.5 × maximum depth of active frost layer

[a] Footnotes a, c, d, and e from table 2 also apply here.

[b] A static load of 250 kilograms will move the rod.

[c] Substantial resistance is indicated when a static load of 250 kilograms will not move the rod (see footnote 7, page 18).

[d] The minimum depth shall be 4 meters.

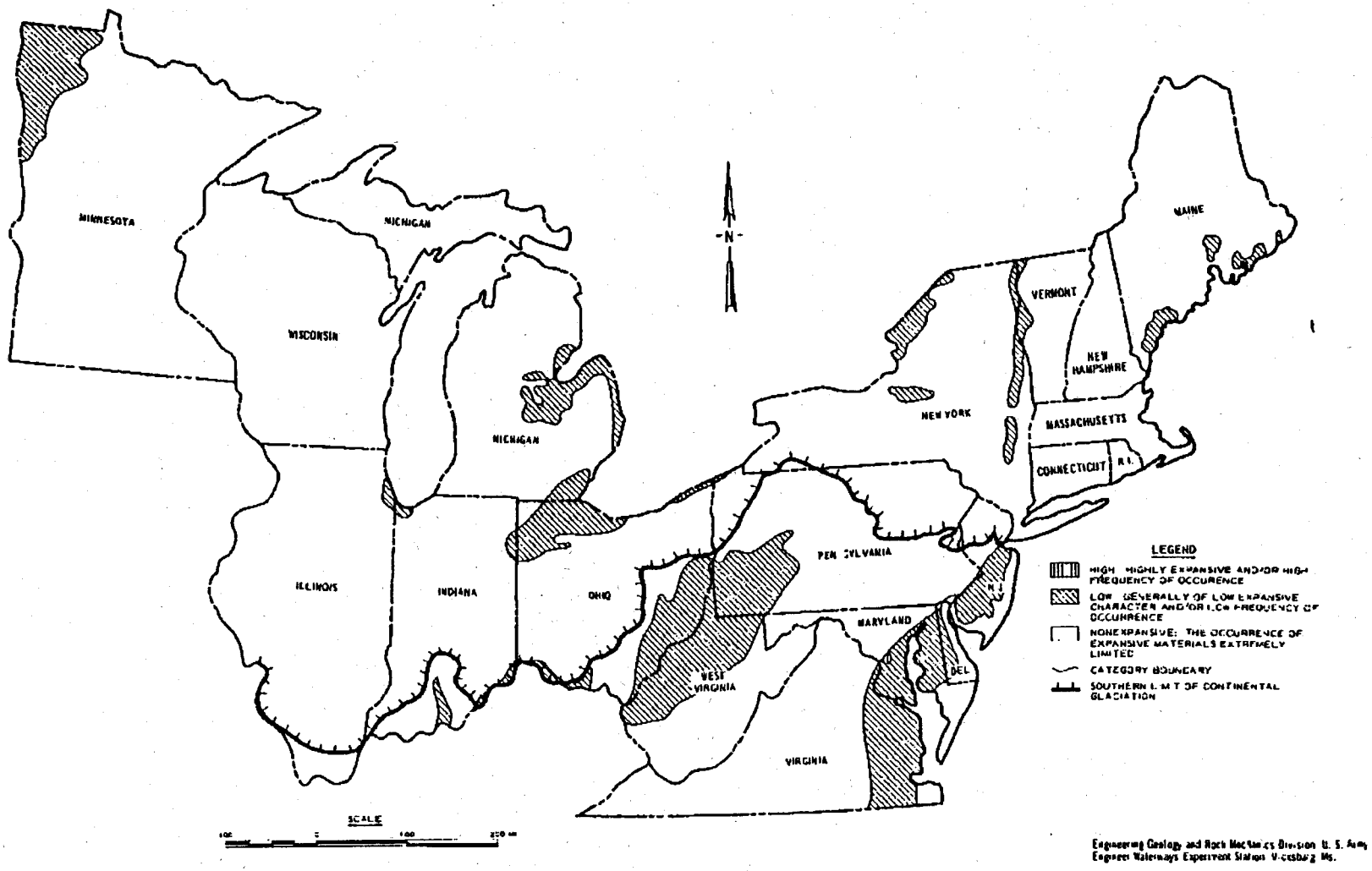


Figure 7.—Distribution of potentially expansive materials, Northeastern States.

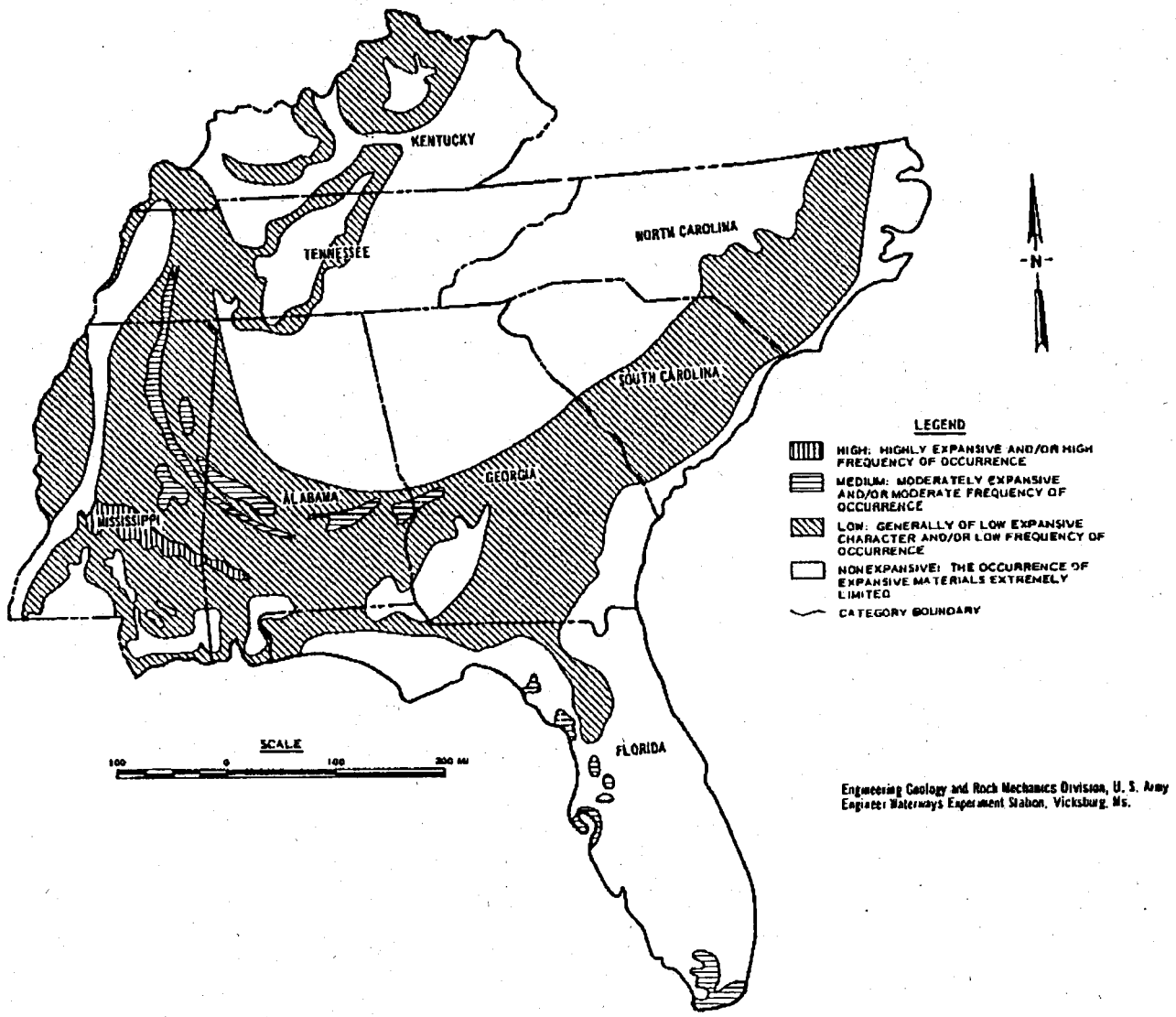


Figure 8.—Distribution of potentially expansive materials, Southeastern States.

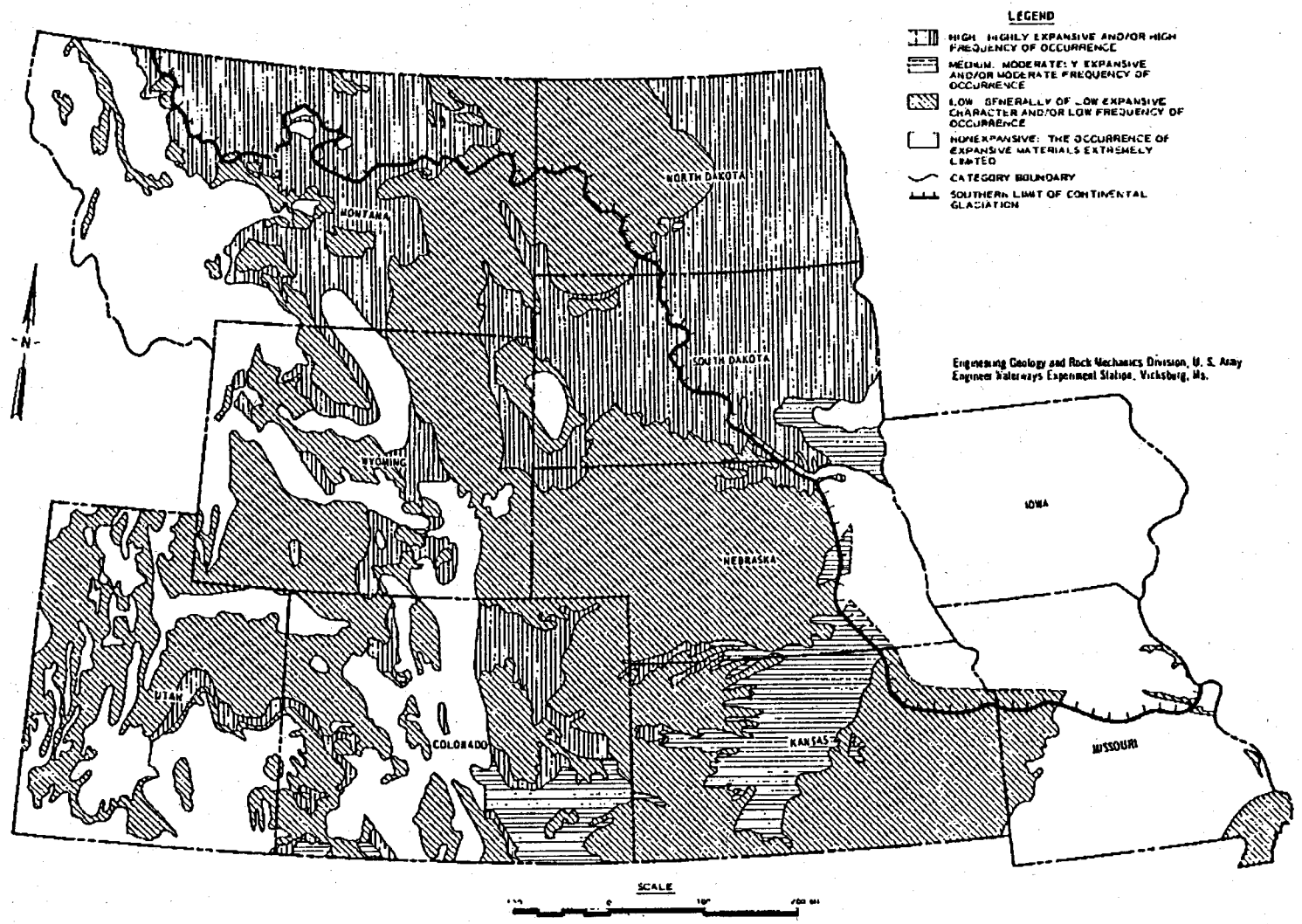


Figure 9.—Distribution of potentially expansive materials, North-Central States.

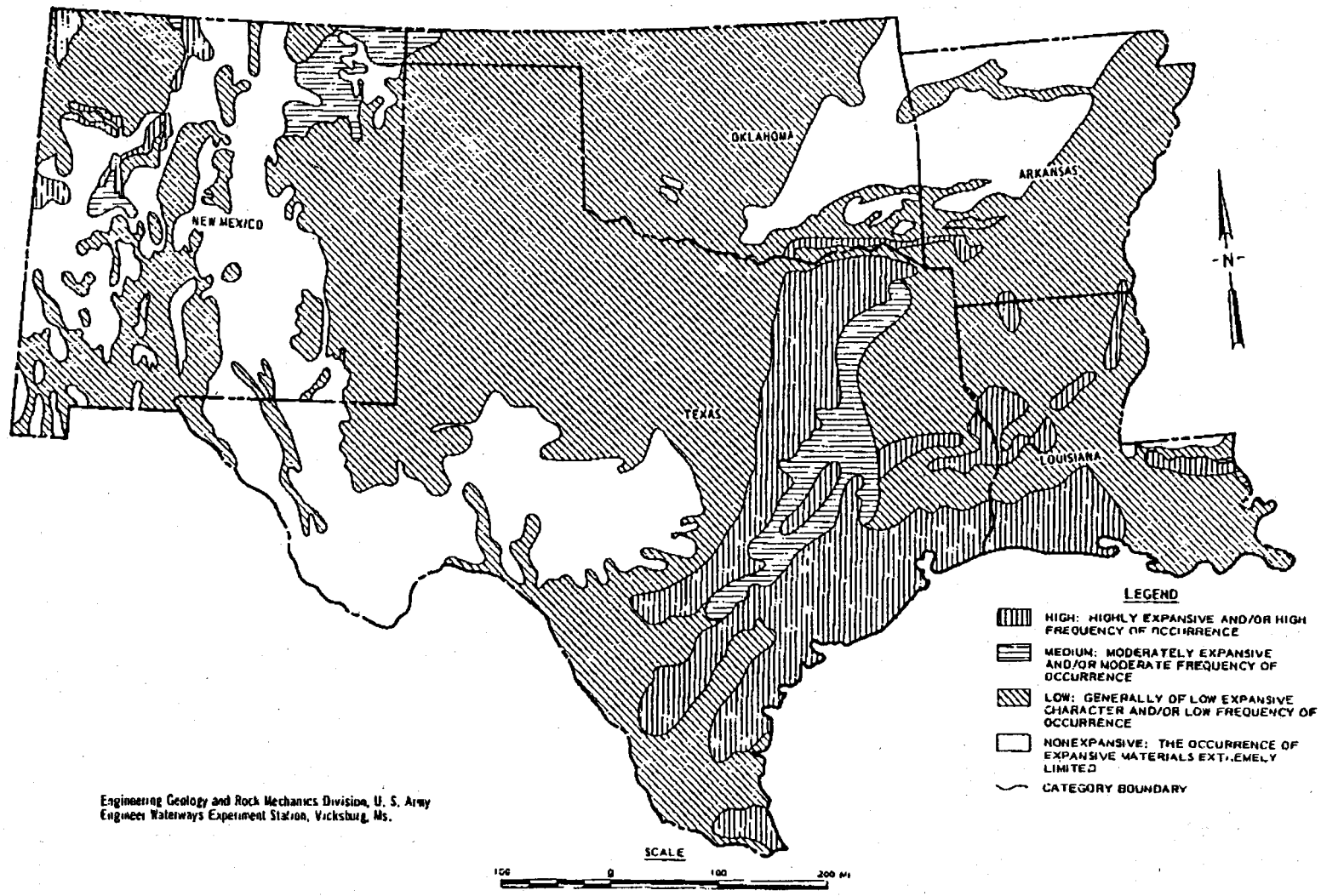
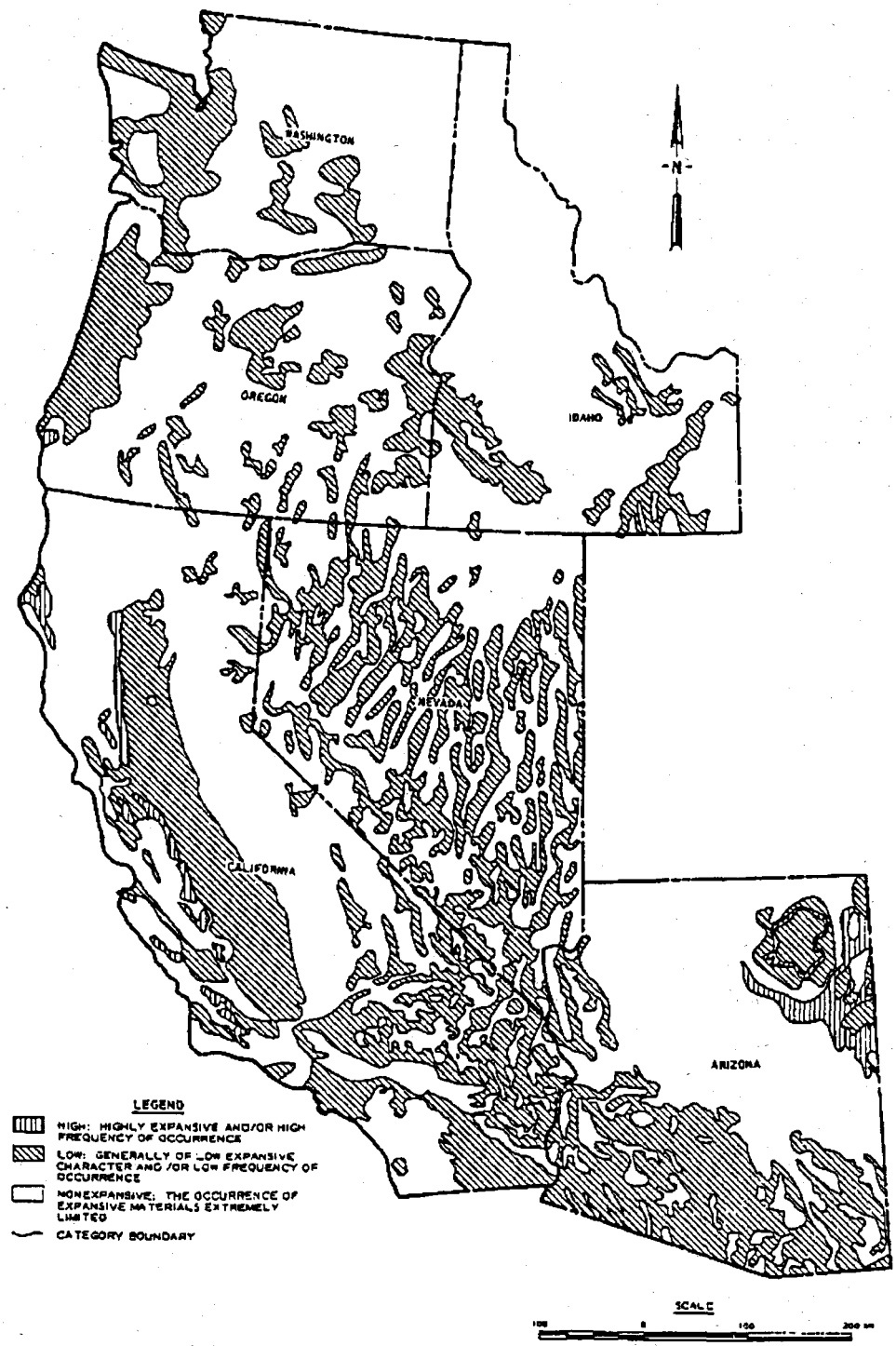


Figure 10.--Distribution of potentially expansive materials, South-Central States.



Engineering Geology and Rock Mechanics Division, U. S. Army
Engineer Waterways Experiment Station, Vicksburg, Ms.

Figure 11.—Distribution of potentially expansive materials, Western States.

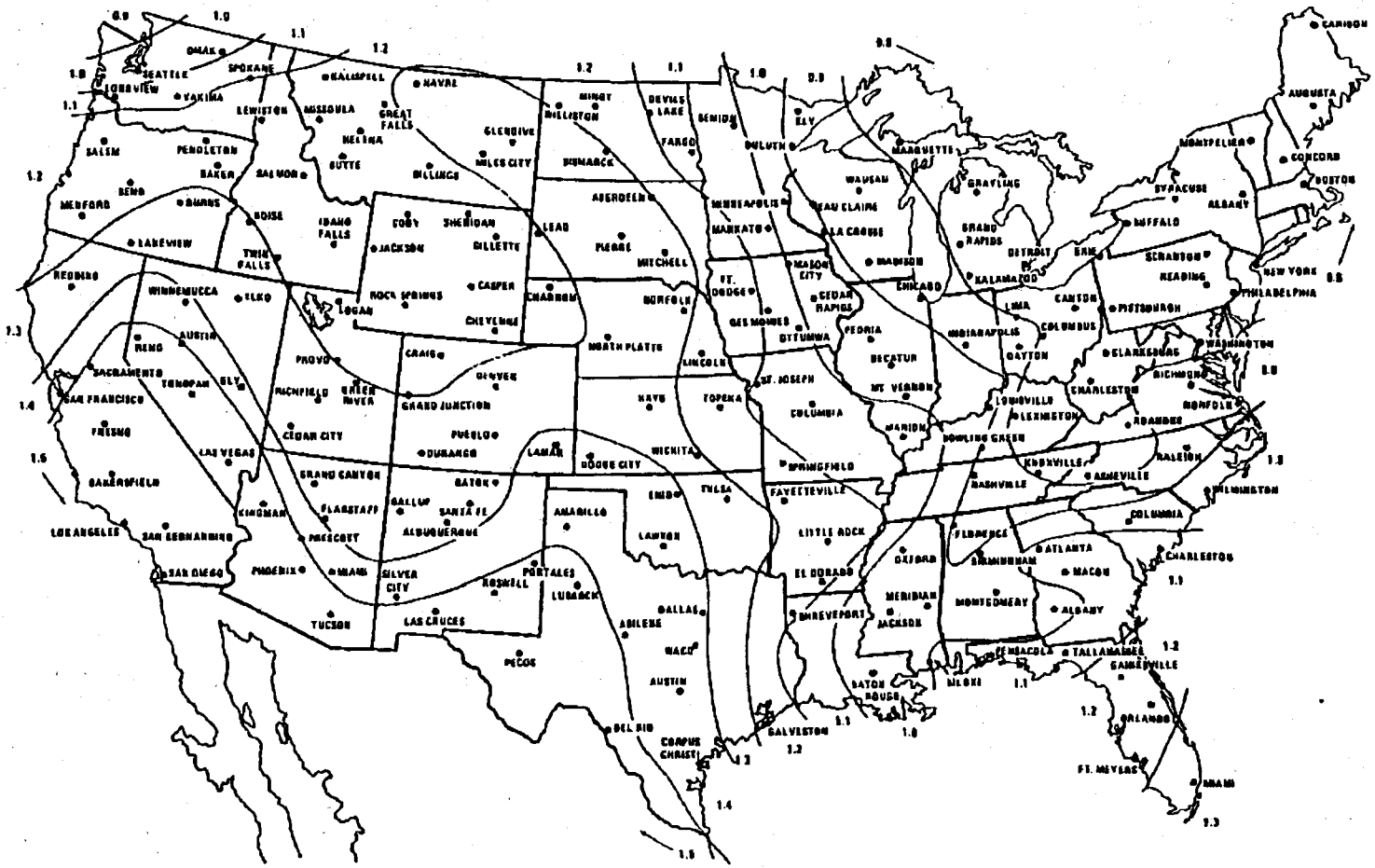


Figure 12.—Climate Factor (CF), adapted from Building Research Advisory Board (National Academy of Sciences 1968).

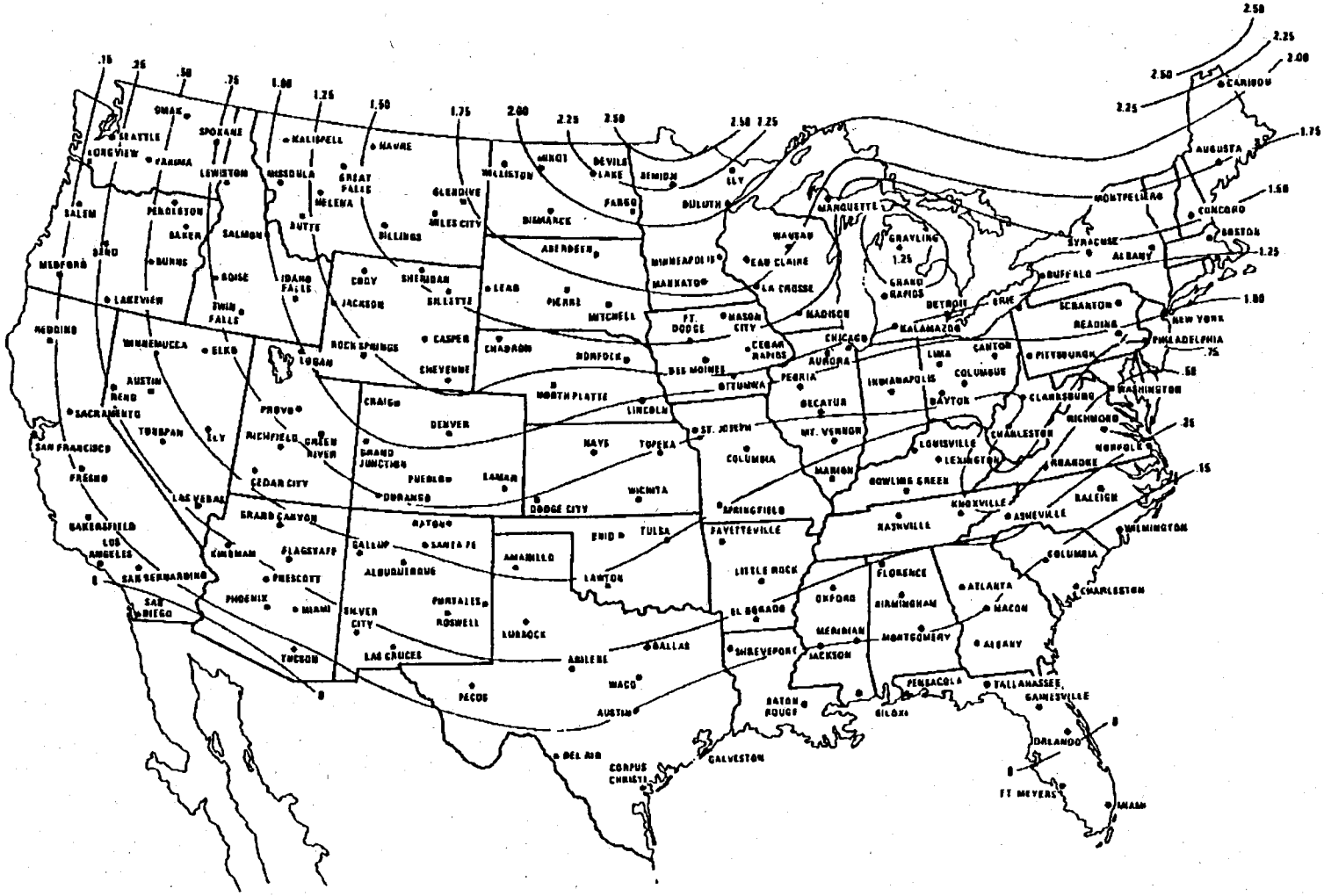


Figure 13.—Extreme depth of frost penetration (in meters).

5. DESCRIPTIONS

Descriptions are an important product of geodetic leveling because the utility of the vertical control network depends largely on how effectively they facilitate bench mark recovery. Consult the *NOAA Manual*, Geodetic leveling (Berry 1978), in preparation at the time of this writing, for detailed instructions on how to write descriptions. If this is not available, *Special Publication* No. 239, Manual of geodetic leveling (Rappleye 1948), also contains some valid information. General guidance for describing a monument is given here. In NGS, geodetic data, including descriptions, are stored, manipulated, retrieved, and sometimes disseminated by computer. Consequently, descriptions must be submitted in proper computer-readable form for inclusion with NGS vertical control data. Consult chapter 7 of *Input Formats and Specifications for the NGS Data Base* (NOAA 1977) for acceptable format.

The text of the description provides information needed to locate a bench mark. It must be clear and concise, first leading the reader to the general vicinity of the monument, then to the exact spot. Directions should start from a highway intersection or prominent landmark in the nearest city shown on an official state highway map.

Unless the bench mark is very near the starting point, distances are first given to the nearest tenth of a mile (or kilometer). The nearer the monument is approached, the more refined the measurements become, going from miles and tenths, to tenths of a mile, to feet and tenths (or kilometers and tenths, to tenths of a kilometer, to meters and tenths). As a rule, give distances in order of decreasing magnitude, but the final reference measurements should be made in the order which lends most conveniently to recovery. For example, if a monument is located 2.6 meters from the corner of a building and 5.4 meters from a fence, it should be stated in that order because the building would be spotted first. Distances must usually be accompanied by directions to 8 points of the compass (i.e., north, northeast, east...). Where confusion could result with only 8 points, 16 points of the compass may be used (i.e., east, east-southeast, southeast...).

Do not record numeric data with more significant digits than those with which they were obtained. The number 2.90 does not imply the same meaning as the number 2.9. The former refers to a value between 2.895 and 2.905, which is accurate to the nearest hundredth of a unit. The latter refers to a value between 2.85 and 2.95, accurate only to the nearest tenth.

All bench marks to be included in the national network must be referenced with consistent techniques, or misinterpretation of some descriptions will result. Distances between reference objects and monuments should nearly always be measured horizontally or mathematically reduced to a horizontal distance. In special circumstances where great convenience results, a sloped distance may be recorded in the description, but it *must* be labeled as such. Distances not labeled as "sloped" are always assumed to be horizontal. For an angle of 30°, the difference between a horizontal distance of 10 meters and its sloped counterpart is more than a meter. A discrepancy of this magnitude can result in considerable loss of time when searching for a buried monument, expecially if the lines-of-position intersect at a shallow angle as shown in figure 2 (page 8). Furthermore, a distance measured from a line, such as a fenceline or centerline, should always be measured perpendicularly to that line.

The origins of measurements must be clearly defined in all cases except the following two, where by convention they are inferred. (1) At the junction of two or more roads, the origin will be assumed to be the intersection of the centers of the roads unless specifically defined otherwise. "The intersection of U.S. Highway 29 and State Road 120" means the intersection of their centers. (2) Measurements are assumed to be from the center of objects such as utility poles. Where another position is desired for the starting point, it should be noted (e.g., "4.5 meters southeast of the southeast edge of telephone pole number 258").

Good descriptions are very important. Some bench marks are not recovered and used for many years after they are set. During this time heavy vegetation can grow up around the monument, making recovery difficult and time consuming. Objects used as reference points can be moved or destroyed. Good judgment and foresight are needed in referencing the mark and writing the description.

APPENDIX A.—APPROXIMATE CONVERSION TABLE: METRIC TO ENGLISH UNITS

1 millimeter	=	0.039 inch
1 centimeter	=	0.39 inch
1 decimeter	=	3.9 inches
1 meter	=	3.3 feet
1 kilometer	=	0.62 mile
1 liter	=	0.26 gallon
1 liter	=	0.035 cubic foot

APPENDIX B.—EXCERPT FROM U.S. LAKE SURVEY *MISCELLANEOUS PAPER* 68-6, THE USE OF GEOPOTENTIAL HEIGHTS FOR GREAT LAKES VERTICAL DATUM, BY CARL B. FELDSCHER AND RALPH MOORE BERRY, LAKE SURVEY DISTRICT, DEPARTMENT OF THE ARMY, U.S. CORPS OF ENGINEERS[a]

This discussion deals in general with a subject that the average civil engineer, without any geodetic orientation, would think of as "levels." This average engineer, having been exposed to the subject through a course in "basic surveying," is inescapably inclined to think of "levels" as the process of determining "elevations," in the context of a summation of vertical "height differences" above some arbitrary "horizontal" plane assumed as a datum.

If the purpose of "levels" is merely to provide reference for setting of pavement forms, or any other type of construction of moderately limited extent, this first intuitive concept is adequate; witness the fact that the average sewer undeniably manages to flow "down hill." But if the purpose of "levels" is to provide vertical control over a relatively large area, or of higher accuracy than that required in ordinary construction, additional considerations must be introduced.

The first additional consideration to be introduced is the well-known fact that the earth is not, in fact, a plane surface. Even the engineer with only a basic course in surveying is willing to concede this point. However, the nature of this surface involves some moderately subtle concepts that are not immediately apparent.

For example, many people are willing to accept a sphere as being a suitable geometrical figure of the earth. This, however, can lead to some patent absurdities if carelessly applied to the principles of levels. There is the case of the flow of the Mississippi River. Considering the 1535 kilometer section from the mouth of the Ohio River (Cairo, Illinois) to Head of Passes, Louisiana, engineer's levels indicate that the mid-stage elevation of the water surface drops approximately 91 meters. (See fig. 14, this manual.) This agrees with common sense but, to the unwary, is a bit difficult to reconcile with the fact that Head of Passes is 2643 meters farther from the *center of the earth* than the Mississippi River is at Cairo, Illinois. This could lead to the conclusion that the river is running *uphill* at a rate of 1.7 meters per kilometer, instead of downhill at a rate of 6 centimeters per kilometer. (The explanation of this absurdity lies in the fact that the meridional section of the earth is approximately elliptical.)

This can, of course, be countered by the engineer with the statement that he never meant for his levels to define the distance of a point from the center of the earth. When pressed for another definition, he will mutter something about height above "Mean Sea Level." This can, however, be an elusive concept unless carefully defined. There is not much difficulty with the definition at any single point on an unobstructed ocean shoreline. Here, we are told, mean sea level will be revealed as the average height of the water over the 19-year period that is required for the earth and moon to go through their entire cycle of combinations that produce the tides. This concept is simple in principle even though a bit difficult to implement. Even the generalization that Mean Sea Level must be the surface defined by a number of such points is not difficult until faced with the theoretical proposition of just what is meant by Mean Sea Level when it is used as a reference to define the "elevation" of a point far inland and high above the level of the ocean. (See fig. 15, this manual.) The usual explanation for this is that Mean Sea Level is the surface that would be generated if all the continents were criss-crossed with a number of narrow canals extending from ocean to ocean, admitting ocean water without causing any currents and without diminishing the quantity of water in the oceans.

Accepting this concept, the question immediately arises as to just what is the actual shape of this Mean Sea Level surface, and this leads back to the questions originally brought out. Isaac Newton in his *Principia*, first published in 1687, made substantial contributions to the theory of the attraction of gravity and concluded that the figure of the earth is that of an *ellipsoid* of revolution.

[a] Presented at Army Science Conference, U.S. Military Academy, West Point, New York, June 1968. The U.S. Lake Survey was abolished in 1976. Some functions were transferred to the National Ocean Survey, NOAA.

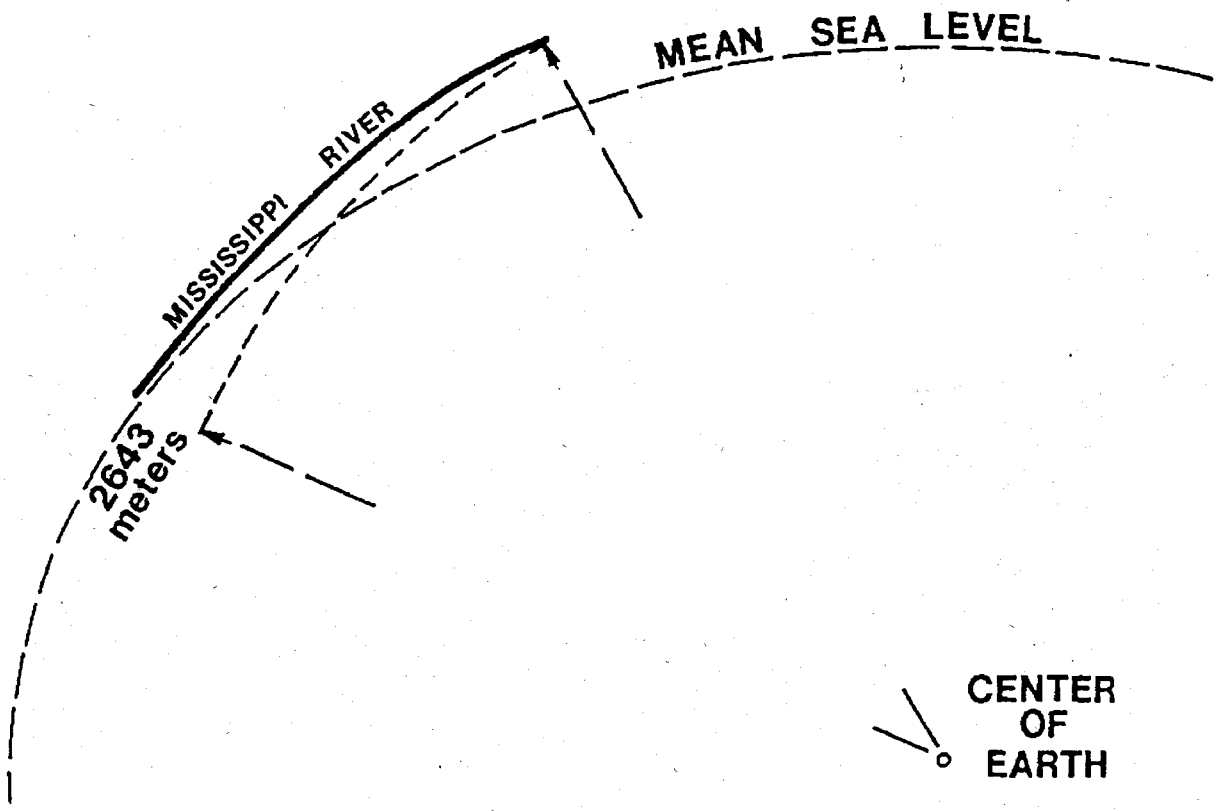


Figure 14.—Mississippi River flows uphill.

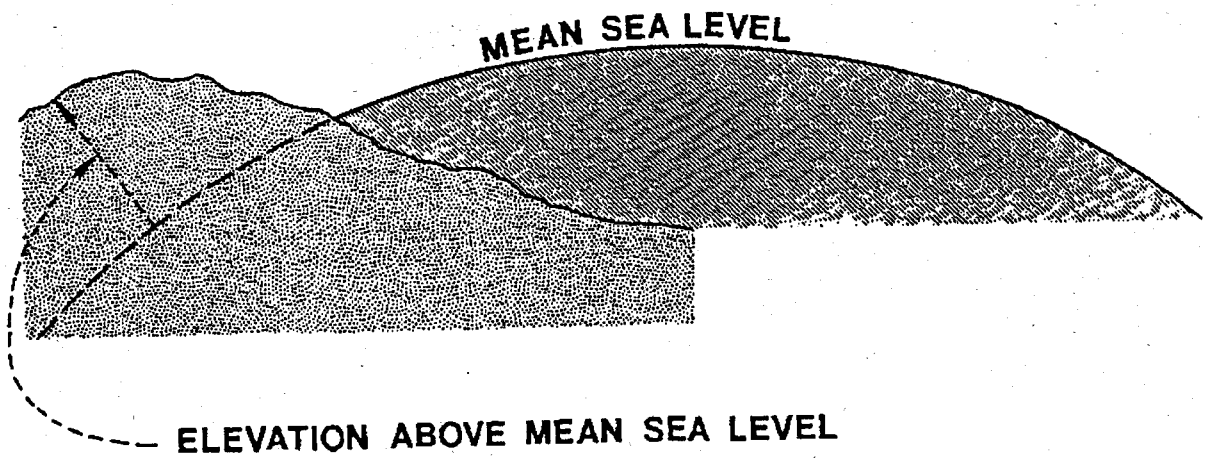


Figure 15.—Elevation.

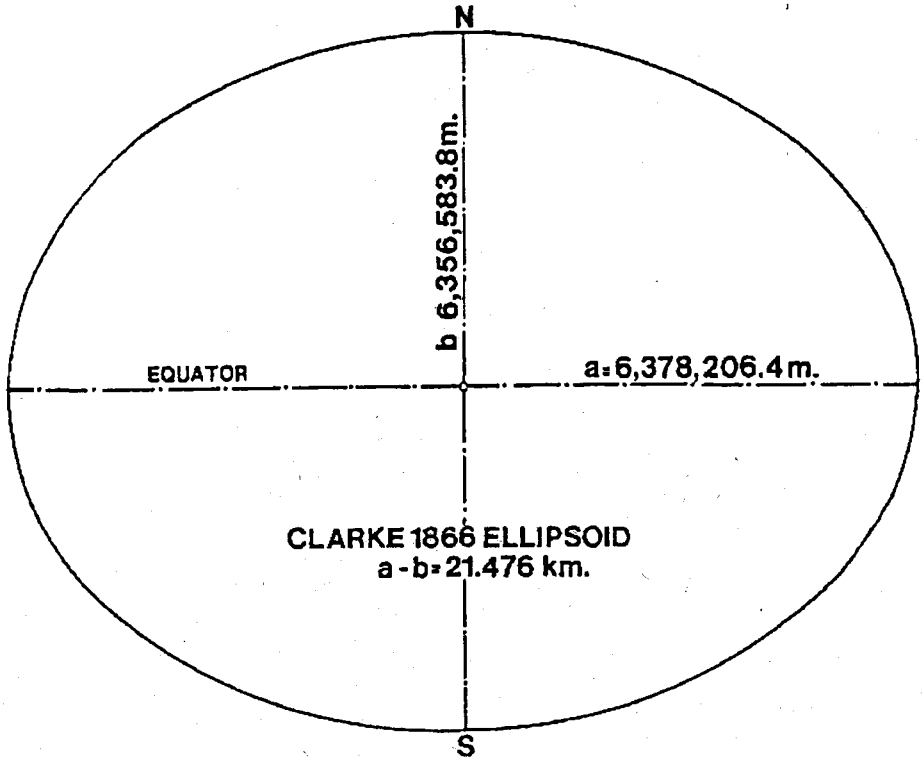


Figure 16.—Geodetic reference ellipsoid.

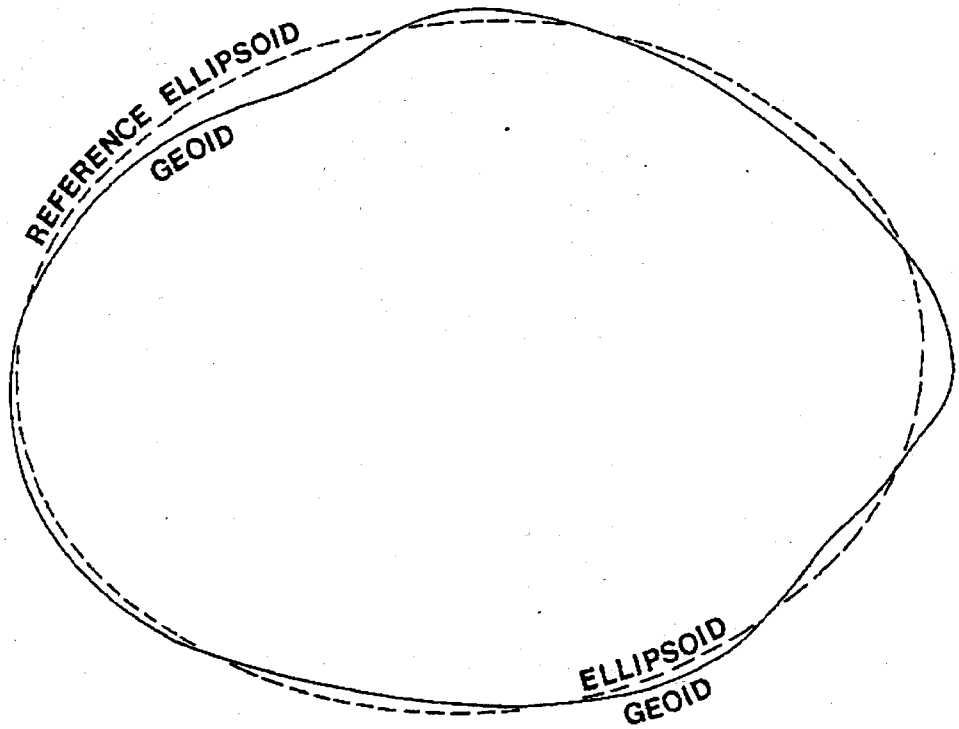


Figure 17.—The geoid.

This was based strictly on a mathematical derivation, with certain assumptions made about homogeneity. This was subsequently substantiated by the measurements made by the French mathematicians Picard, Clairaut, Bouguer, Maupertuis, Cassini *et al.* (Todhunter 1873) considered to be the beginning of modern metrical geodesy, in the interval 1669-1735-1743.

The figure generated by rotating an ellipse about its minor axis is generally adopted by geodesists today as an acceptable approximation to the shape of the sea-level surface but it must be understood that this is actually only a mathematical model on which the calculations of geodetic positions can be carried out with sufficient accuracy for most work. The adoption of this geometrical shape is actually a compromise with expediency, because of the use of other more complicated shapes would enormously increase the complexity of calculations. The dimensions of the reference ellipsoid in actual use vary throughout the world, with, as might be expected, different figures being used in North America, Europe, Russia, etc. (See fig. 16, this manual.)

The actual shape of the Mean Sea Level surface, however, is not readily amenable to description by a simple mathematical expression. If the waves, tides, currents, etc., be "averaged out" and the sea level surface considered to be the quiet, undisturbed, smooth surface of the sea, a liquid in equilibrium, it will be immediately obvious that this surface will be everywhere normal to the direction of gravity. This is indeed the definition of the Mean Sea Level surface even when it is extended underneath the surface of the continents. Further consideration will reveal that this is an *equipotential* surface. Whatever its shape, the technical name assigned to the particular equipotential surface that is defined by mean sea level (where available) is the *geoid*. If the earth were a homogeneous body, or if density varied systematically with distance from the center of the earth, the geoid would be a smooth surface of revolution, closely approaching an ellipsoid. Since, as is well known, the mass distribution within the earth is not systematic, the surface of the geoid does approach an ellipsoid as the simplest "best fit" figure, but it is actually an undulating surface, sometimes above and sometimes below the mathematical figure. (See fig. 17, this manual.) Since the level bubble in a surveying instrument indicates a perpendicular to the local direction of gravity, the surface of reference in leveling is actually the geoid and not the geodetic ellipsoid.

APPENDIX C.—SOILS

Elementary knowledge of soil classifications and terms is necessary to understand the information presented in this manual. Terms used by the layman and expert alike carry many connotations and can cause considerable confusion. Technical classifications can even be confusing in that a variety of classification systems have been devised, each for a different use. A synopsis of soil classification and explanation of some of the more common soils terms are set forth below.

To the engineer the term *soil* generally refers to an unconsolidated mixture of discrete particles interspersed with gasses and liquids, which lies above bedrock. No fine line can be drawn between *soil* and *bedrock* without arbitrarily defining bedrock in terms of physical properties such as compressive strength or degree of consolidation. There are an infinite number of phases between the hardest rock and the loosest soil. For the purpose of this manual, it will suffice to call bedrock any extensive, hard, earthen material which cannot be penetrated without a diamond or tungsten carbide tipped drill bit. Soil includes the materials formed by mechanical disintegration and chemical decomposition of bedrock.

Soils are divided into two groups called *organic* and *inorganic*. Organic soils are those which contain an appreciable amount of decayed plant or animal matter. They can be identified by their dark color and distinctive odor resulting from the decomposition of the organic matter. Large deposits of these soils form peat bogs, muskeg, and swamps, but they also overlie other soils in an often thin layer of humus. The main disadvantage of organic soils from an engineering standpoint is their high compressibility. A load placed on this type of soil is subject to excessive settling.

Inorganic soils are distinguished from one another by a number of criteria, the most important being texture. Texture is mainly a reflection of grain size, but it is also influenced by particle shape. Soils may be grouped on this basis into four classes—*clay, silt, sand* and *gravel*. The size limits for these particles are as follows: *

clay	less than 0.005 mm
silt	0.005 to 0.05 mm
sand	0.05 to 2.0 mm
gravel	greater than 2.0 mm

Sands and gravels are often referred to as *coarse-grained* or *granular* soils. They are *cohesionless* and the individual particles can be distinguished with the unaided eye. Accordingly, visual inspection of a soil sample to determine whether or not it is coarse-grained is the first step in field identification. For the purpose of mark setting, it is not necessary to distinguish between sand and gravel. Both are very good soils in which to set monuments.

Clays and silts are *fine-grained* materials. Their individual particles cannot be differentiated with the unaided eye. Normally, particles of this size are flat and plate-like rather than rounded, and due to this the soils are usually *cohesive*. The degree of this characteristic gives an indication of grain size and can therefore be used to determine whether a soil contains mostly clay or mostly silt.

By varying its water content, a clay can be made into a consistency where it can be deformed rapidly without cracking or crumbling, exhibiting a property called *plasticity*. A clay can be rolled into long thin threads without breaking, and upon air drying it will have considerable strength. Silts can also be rolled into threads but when held by its end, a silt thread which is more than about 10 centimeters long will break. Unlike clay, a small amount of air-dried silt can easily be crushed with the fingers. If enough water is added to a pat of silt to make its consistency like that of a thick paste, and this pat is shaken in the palm of the hand, it will appear wet and shiny. If the pat is then squeezed, the surface moisture will disappear and the pat will eventually crack. Clay, on the other hand, will remain unchanged when handled in such a manner.

A soil mass consisting mainly of a limited range of particle sizes is said to be *uniform*. More often, soils contain appreciable amounts of many different particle sizes, frequently including all four of the major classes (i.e., clay, silt, sand, and

* Some systems use 0.002 and 0.074 mm to distinguish between clay and silt, and silt and sand respectively.

gravel). These are called *mixed* soils. They are described by naming the two most predominant constituents, the one of lesser abundance qualifying the greater. For example, a silty sand might contain 60 percent sand-sized particles and 30 percent silt-sized particles. The remainder would be clay or gravel or both.

Another way to qualitatively describe a coarse-grained soil is with the term *clean*. A clean sand or gravel does not contain an appreciable amount of fines (particles less than about 0.1 millimeter). Locations with these types of soils provide excellent sites for setting bench marks.

A description of soil is not complete until some indication is given as to its natural condition. Granular soils may be *loose* or *dense*. Fine-grained soils are described by their *consistency*, which can be *soft*, *medium*, *firm*, *stiff*, or *hard*. A simple test can be employed to determine the consistency by pressing the fist, thumb, or fingernail into the soil and gauging the resulting penetration. In addition, one of the most significant conditions of a soil mass is described by its drainage characteristics. Good drainage is indicated with a sloping topography to facilitate the removal of surface water, granular soil particles which allow water to percolate through, and a water table not too near the surface. It is desirable to locate bench marks in soils with good drainage.

APPENDIX D.—EXISTING MONUMENTATION IN THE VERTICAL NETWORK

Since the beginnings of precise geodetic leveling in the United States in 1877, and the subsequent formation of the Coast and Geodetic Survey in 1878, a variety of different types of bench marks have been established in our National Vertical Control Network. For the most part, they were appropriate for their times, but according to today's high standards, they have various shortcomings and are no longer to be set. Many of the monuments, to be sure, were set in such a manner as to have maintained their positions very well. In any event, they do comprise the major portion of the network.

The first bench marks were placed at intervals of from 5 to 15 kilometers. They were established on structural members of buildings, dams, aqueducts, bridges, locks, piers, culverts, arches, and pedestals; on granite, marble, or cedar posts; and in bedrock and boulders. Some of them had no physical markings for the exact elevation reference point, but were defined descriptively by phrases such as "centre of the sill," "top of a post," and "northwest corner of the top surface." Others were marked with chiseled square or circular cavities, centers of triangles, crosses, lines, bolts, and rectangular metal plates.

Early in this century, precast concrete posts, 1 to 2 meters in length and, in a few instances, 1-meter lengths of pipe began supplementing the stone posts. Along with this development, bronze tablets came into use. The disks were a major improvement over the chiseled squares and other markings in that they provided a more definite high point to support the leveling rod and were more clearly visible to a person searching for the bench mark.

Cast in place concrete monuments were introduced in the latter half of the 1930's. The procedure for setting them started with digging a hole about 30 to 35 centimeters in diameter to a depth of about 1 meter or below the frost line. The better monuments were cast in tapered holes with a smaller diameter at the top. The bottom of the hole was then extended and enlarged to provide greater resistance to heaving and settling. A form was set in place for the top of the mark and sometimes for the entire length of it to make its sides smooth, thereby lessening the effect of frost heave. Casting posts in place eliminated the work required to manhandle the heavy precast posts, which consequently were phased out completely in the 1940s.

In 1954, the Coast and Geodetic Survey began experimenting with the copperclad steel rod mark. Until this time, bench mark settings had been limited to two basic types: structures and posts (or pipes). Bench marks in structures have generally held their elevations well. When foundations are investigated to the extent directed in this manual, they will be even more reliable. Concrete or stone posts, however, are excessively vulnerable to the forces of nature. Frost heave jacks them up, expansive soils cause them to "float," and their own weight makes them settle. If they are located in well-drained, coarse-grained soils, they make very good bench marks, but anything resistant to impact and corrosion will suffice in these areas.

Disks have had relatively few changes through the years. Most of them have been made of brass or bronze. The tops have been about 8 to 10 centimeters in diameter and spherically shaped. Irregularly shaped shanks have served as anchors to secure the tablets in drill holes. The earlier tablets were cast in one solid piece. Later the shank was fabricated separately and silver soldered to a disk which was cut and pressed from sheet stock. Legends have varied little. They indicated the organization which established the mark (i.e., Coast and Geodetic Survey, National Ocean Survey, or National Geodetic Survey), the type of mark (i.e., bench mark, tidal bench mark, or vertical control mark), whom to write for information (i.e., The Director and organization, Washington, D.C.) and a phrase warning against vandalism.

Changes occurred to the disks during the following time periods: (1) From 1934 until 1956, the adjusted elevation was stamped on the disk as a matter of standard procedure. This was a very poor practice because both movements of the monument and readjustments of the network caused many of the stamped elevations to be erroneous. (2) For a short time during and immediately after World War II, cast iron was used because brass and bronze were in short supply. A considerable number of these disks corroded to such an extent that the precise datum point was

worn down and the logo became illegible. Brass or bronze disks make good bench marks when set in substantial structures of concrete or masonry. An improvement could be made, however, by providing the upper surface with a protuberance to define a more precise datum point. Flat disks should never be used for bench marks.

In 1955, the Coast and Geodetic Survey began installing rod type bench marks. They consisted of 5/8-inch copper-clad steel rods in 5-, 8-, and 10-foot sections driven to refusal or some maximum depth. The required rod depth was attained by joining threaded ends of rod sections with brass couplings. Some of these marks have been driven to depths well in excess of 30 meters. A brass bench mark disk with a tubular stem was either crimped or soldered over the top of the rod.

The major problem encountered with this mark was one of corrosion. Copper and steel are quite incompatible in many environments. A galvanic cell is set up where the copper coat is protected at the expense of the corroding steel core. This situation is aggravated at the rod ends because the area of exposed steel is small in relation to the area of exposed copper. Rod marks have been known to fail completely at the first joint below the surface, the results of which are obvious.

Another problem with this type of bench mark stems from the fact that even though it may be driven deeply into the soil, the stable substratum in some cases does not grip the rod as tightly as the unstable soil near the surface. Consequently, it will move with disturbances in the upper layers. Reaching refusal at shallow depth makes this an even more serious problem.

In the early 1970s, a modofication to the rod mark was made by attaching a base plate to a 4-foot section of rod. Use of the rod mark continued, but at a less frequent interval. The purpose of the modified rod with base plate, sometimes called the "pre-fab," was to replace the cast-in-place concrete post which was subsequently phased out. The advantages of the prefab over the concrete post were that it was easier to install and, because it was quite lightweight, it was not prone to settlement. The disadvantages of vulnerability to frost heave and expansive soils remained.

The problem of galvanic corrosion in the copper clad rod mark and prefab mark was identified in 1976. Galvanized steel was temporarily substituted for copper-clad steel until the entire bench mark program could be studied in detail and revamped. This manual is a result of that study.

Bench marks established in bedrock have been recognized for many years as a most desirable elevation reference and have been used throughout our leveling history. The only drawbacks in using a bedrock reference (which are minor in comparison to the shortcomings of some of the other marks) are (1) it is sometimes difficult to distinguish between bedrock and large boulders, and (2) bedrock can sometimes exhibit volume change with variation of moisture content. The guidelines in this manual will reduce these problems.

APPENDIX E.—EXAMPLES FOR DETERMINING BENCH MARK DEPTHS

The following examples illustrate how to compute class A and B rod mark depths for four different geographical areas. Part A of each example gives four basic steps for determining the sleeve depth of a class A rod mark. Determining the rod depth for this mark is usually straightforward, as explained in steps 8 and 9 (page 18) of the routine for setting the mark. Part B of each example shows how to determine the rod depth for a class B rod mark. In addition to the four steps needed for class A rod marks, one extra step is required.

Step 1

A depth is determined to prevent expansive soils from changing the elevation of the mark.

Step 2

A depth is determined to prevent frost heave from affecting the mark.

Step 3

A determination is made as to whether or not permafrost is present.

Step 4

In regions without permafrost, the deeper depth determined in steps 1 and 2 is taken as the depth for the sleeve or minimum depth for the rod (class A or B, as appropriate). In regions where permafrost occurs, the depth specified for permafrost regions is used.

Step 5

Rod depth is further determined by the resistance of the ground at the time the rod is driven into position. The penetration rate indicates whether or not the rod must be driven to a greater depth than that determined above. With the "Cobra" used by NGS mark setters, the rate must not exceed 4 centimeters per second. (It must take at least 25 seconds to drive 1 meter of rod.)

Example 1

Location: Battle Mountain, Nevada

Part A. Sleeve depth for class A rod mark.

Step 1

a. Find Battle Mountain on a road atlas and estimate its location in figure 11. At this particular location it is difficult to determine whether the soil is nonexpansive or of low expansive character. Therefore, consider the worse condition—a soil of low expansive character.

b. Using figure 12, determine the climate factor. Battle Mountain is located on or very near the line delineating 1.3 from 1.4. Again, use the worse case—1.4.

c. From table 2, determine the sleeve depth required to prevent changes in soil volume from altering the elevation of the rod. In this instance, it is 6 meters × 1.4, or 8.4 meters.

Step 2

a. Check figure 13 to determine the extreme depth of frost penetration. For Battle Mtn, frost depth is between 0.50 and 0.75 meter.

b. Return to table 2. Footnote d states, "Use the upper limit for each area delineated." So use 0.75 meter. The sleeve depth required to counteract the effect of frost heave is 3 × 0.75 meter, or 2.25 meters.

Step 3

Permafrost is not a consideration here. The only locations where permafrost occurs in the conterminous United States are Mount Washington in New Hampshire and the Front Range of the Colorado Rocky Mountains.

Step 4

In this illustration, eliminating the effect of expansive soils would require an 8.4-meter sleeve, while eliminating frost heave would require only a 2.25-meter sleeve. The greater of the two, an 8.4-meter sleeve, must be set.

Part B. Rod depth for class B rod mark.

Part A must be studied to understand how the expansive character of the soil, climate factor, and extreme depth of frost penetration were determined. The particulars are not repeated here.

Step 1

a. The soil is of low expansive character.

b. Climate factor is 1.4.

c. From table 3, compute the minimum rod depth for expansiveness of soil—5 meters × 1.4, or 7.0 meters.

Step 2

a. Extreme depth of frost penetration is between 0.50 and 0.75 meter. Use 0.75 meter.

b. From table 3, the minimum rod depth required to counteract the effect of frost heave is 4 × 0.75 meter, or 3.0 meters.

Step 3

As in part A, permafrost is not a consideration.

Step 4

Expansive soil requires a 7.0-meter rod, and frost heave requires a 3.0-meter rod. Minimum rod depth is the greater of the two—7.0 meters.

Step 5

When a depth of 7.0 meters is reached, if the rod can be driven faster than the allowable rate, continue driving the rod until the rate decreases to the maximum rate allowed.

Example 2

Location: Thief River Falls, Minnesota

Part A. Sleeve depth for class A rod mark.

Step 1

a. From figure 7, the soil is of low expansive character.
b. From figure 12, the climate factor is 1.1.
c. From table 2, the sleeve depth required to prevent changes in soil volume from changing the elevation of the rod is 6 meters × 1.1, or 6.6 meters.

Step 2

a. From figure 13, the extreme depth of frost penetration is between 2.25 and 2.50 meters. Use 2.50 meters.
b. From table 2, the sleeve depth required to counteract the effect of frost heave is 3 × 2.50 meters, or 7.5 meters.

Step 3

Permafrost is not a consideration here.

Step 4

In this case, elimination of the effect of expansive soils requires a 6.6-meter sleeve, while elimination of frost heave requires a 7.5-meter sleeve. The greater of the two, a 7.5-meter sleeve, must be set.

Part B. Rod depth for class B rod mark.

Step 1

a. The soil is of low expansive character.
b. The climate factor is 1.1.
c. From table 3, the minimum rod depth when considering expansiveness of soils is 5 meters × 1.1, or 5.5 meters.

Step 2

a. The extreme depth of frost penetration is between 2.25 and 2.50 meters. Use 2.50 meters.
b. From table 2, the minimum rod depth required to counteract frost heave is 4 × 2.50 meters, or 10.0 meters.

Step 3

Permafrost is not a consideration here.

Step 4

Expansive soils require a 5.5-meter rod, and frost heave requires a 10.0-meter rod. The minimum rod depth is the greater of the two—10.0 meters.

Step 5

When a depth of 10.0 meters is reached, if the rod can be driven faster than the allowable rate, continue driving until the rate decreases to the maximum rate allowed.

Example 3

Location: Alpine, Texas

Part A. Sleeve depth for class A rod mark.

Step 1

a. From figure 10, the soil is nonexpansive.
b. From table 2, no sleeve is required to prevent changes in soil volume from changing the elevation of the rod.

Step 2

a. From figure 13, the extreme depth of frost penetration is less than 0.5 meter.
b. From table 2, no sleeve is required to prevent frost heave from changing the elevation of the rod.

Step 3

Permafrost is not a consideration here.

Step 4

No sleeve is required to eliminate the effects of either expansive soil or frost heave. This is an example of a class A rod mark with no sleeve. According to note b in table 2, the rod is driven to 4 meters or until its driving rate decreases to the maximum rate allowed, whichever is the greater depth.

Part B. Rod depth for class B rod mark.

Rod depths for class B rod marks in areas of nonexpansive soils, extreme depth of frost penetration less than 0.5 meter, and no permafrost (all three conditions satisfied) are the same as rod depths for class A rod marks. The only difference between the marks in these areas is that the class A mark has no disk, but an aluminum logo cap is built into the surface casement. The class B mark is topped with a disk and has a PVC plug in the surface casement. Since the type of surface casement can be used to distinguish visually between class A rod marks (which are more reliable) and class B rod marks (less reliable), all rod marks in these areas set to specifications should be provided with an aluminum logo cap, but no disk. Where no sleeve is required for the class A rod mark, class B rod marks are not easier to set and, therefore, should not be used.

Example 4

Location: Sourdough, Alaska (Between Paxton and Gulkana)

Part A. Sleeve depth for class A rod mark.

Step 1

The presence of permafrost overrides this step.

Step 2

The presence of permafrost overrides this step.

Step 3

Consult Map I-445, Permafrost Map of Alaska (Ferrains 1965). The area around Sourdough is generally underlain by thick to thin permafrost. Local knowledge of conditions, available from utilities companies and local citizens, should also be considered.

Step 4

From table 2, the sleeve depth is 10 meters.

Part B. Rod depth for class B rod mark.

Steps 1 and 2

The presence of permafrost overrides these steps.

Step 3

From Map I-445, the area is generally underlain by permafrost.

Step 4

a. From local knowledge, the ground has never been known to thaw below 1.2 meters.
b. From table 3, the minimum rod depth is 2.5 × 1.2 meters, or 3.0 meters.

Step 5

If the driving rate is not exceedingly slow, the site is not underlain by permafrost and a new rod depth will have to be determined accordingly.

Note: In areas of Alaska that are not underlain by permafrost, information on expansiveness of soils (such as that found in figures 7 through 11 of this manual) must be obtained locally if possible. When no information is available, step 1 is omitted. Extreme depth of frost penetration, used in step 2, must also be obtained locally.

BIBLIOGRAPHY

Ballantine, William, 1976: Choosing corrosion-resistant fasteners for marine application. *Sea Technology*. Compass Publications, Inc., Arlington, Va., February, pp. 8-10.

Baracos, A. and Bozozuk, M., 1957: Seasonal movements in some Canadian clays. *Proceedings of the Fourth International Conference on Soil Mechanics and Foundation Engineering*, London, England, August 12-24. Butterworths Scientific Publications, London, pp. 264-268.

Berry, Ralph Moore, 1978: NOAA Manual, Geodetic leveling (in preparation).

Bozozuk, M. and Burn, K. N. 1960: Vertical ground movements near elm trees. *Geotechnique* 10(1), pp. 19-32.

Bozozuk, M., Johnston, G. H., and Hamilton, J. J., 1962: Deep bench marks in clay and permafrost areas. *Special Technical Publication* No. 322, Symposium on Field Testing of Soils, American Society for Testing and Materials, 266 pp.

Construction Research Center, University of Texas, 1976: Interim report of experimental foundation designs on expansive clay soils. Department of Housing and Urban Development, Washington, D.C., May, 67 pp.

Feldscher, Carl B. and Berry, Ralph Moore, 1968: The use of geopotential heights for Great Lakes Vertical Datum, *Miscellaneous Paper* 68-6, Lake Survey District, Corps of Engineers, Detroit, Mich., August, 20 pp.

Ferrains, Jr., Oscar J., 1965: Permafrost map of Alaska. Map I-445, U.S. Geological Survey, Washington, D.C.

International Nickel Company, Inc., 1970: *Corrosion in Action*. International Nickel Co., New York, N.Y., June, 47 pp.

Kjellman, W., Kallstenius, T., and Liljedahl, Y., 1955: Accurate measurements of settlements. *Royal Swedish Geotechnical Institute Proceedings*, No. 10, Stockholm, Sweden, pp. 7-33.

Leonards, G. A. (editor), 1962: *Foundation Engineering*. Civil Engineering Series, McGraw Hill, New York, N.Y., 1136 pp.

Maltby, Calvin S. and Doskins, Eriks, 1968: Bench mark monumentation. *Surveying and Mapping* XXVIII (1), 45-51.

National Academy of Sciences, 1968: Criteria for selection and design of residential slabs-on-ground. *Publication 1571*, Building Research Advisory Board, National Academy of Sciences, Washington, D.C., p. 38.

National Oceanic and Atmospheric Administration, 1977: Input Formats and Specifications for the NGS Data Base. Available in preprint form from NGS, Code Clx4, National Ocean Survey, NOAA, Rockville, MD 20852.

Patrick, D. M. and Snethen, D. R., 1976: An occurrence and distribution survey of expansive materials in the United States by physiographic areas. Interim Report under Federal Highway Administration contract, Rept. No. FHWA-RD-76-82. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. Available from National Technical Information Service, Springfield, VA 22161 (NTIS document no. PB 265230).

Rappleye, Howard S., 1948: Manual of geodetic leveling, *Special Publication* No. 239, Coast and Geodetic Survey (now National Ocean Survey) 94 pp. Available from National Technical Information Service, Springfield, VA 22161. (NTIS document no. COM-72-50049.)

Romanoff, Melvin, 1957: Underground Corrosion. National Bureau of Standards *Circular* 579, U.S. Government Printing Office, Washington, D.C., 227 pp.

Snethen, Donald R. and Johnson, Lawrence D., 1977: Characterization of expansive soil subgrades using soil suction data. Presented at conference on Moisture Influence on Pavement Materials, 56th Annual Meeting of Transportation Research Board, Washington, D.C., January 24-28, 32 pp.

Todhunter, I., 1873: *A History of the Mathematical Theories of Attraction and the Figure of the Earth*. Vol. 1, Macmillan, London. Reprinted by Dover Publications, 1962: New York, N.Y., vols. 1 and 2 in one book.

U.S. Army Corps of Engineers, 1967: Frost and permafrost problems with soil and rock. Cold Regions Research and Engineering Laboratory, Hanover, N.H., December 2-3.

U.S. Department of Agriculture, 1941: *Yearbook of Agriculture*. U.S. Government Printing Office, Washington, D.C., pp. 270-274.

U.S. Geological Survey, 1966: *Topographic Instructions of the United States Geological Survey, Book 2*. U.S. Government Printing Office, Washington, D.C., pp. 37-45.

INDEX

Augers 15
Bedrock 4, 9, 11, 13, 25, 41, 43, 44
Bench mark ..... iii, 1, 5, 43
  Class A rod mark 2, 9, 10-12, 14-17
    Casement 15, 19
    Installation of 18-25
    Sleeve 2, 14-15, 18, 19, 25, 27, 45-46
  Class B rod mark 25-26, 27, 45-46
  Destruction of 1, 3, 4, 5, 13
  Disk 13-14, 43-44
    Horizontally set 13-14
    Vertically set 14
    Miscellaneous types 26
    Outmoded types 43-44
Bridges 10
Buildings (see structures)
Caves 2-3, 9
Chiselled markings 43
Clay 3, 25
  Corrosive nature 6
  Expansiveness 3
  Identification of 41
Climate
  Climate Factor (CF) 3-4, 27, 33, 45-46
  Effect on expansive soils 3-4
Coast and Geodetic Survey 43, 44
Concrete post 43
Consolidation 4, 5, 15
Copper clad rod 5, 44
Corrosion 5, 10-11, 43-44
Creep 4
Crustal Motion ..... iii, 1, 2
Descriptions 6, 35
Designation 13, 19, 26
Dissimilar metals 10
Drilling 11, 15, 18, 19, 20-21, 25
Earth moving equipment 3
Electrical cables 12, 15
Electrolyte 10, 11
Erosion 5, 11
Expansive soils 3-4, 5, 9, 11, 15, 28-32, 43, 44, 45-46
Fence lines 5, 35
Fill 4
Frost heave 3, 5, 6, 9, 11, 15, 34, 43, 44, 45-46
Gas lines 12, 15
Geoid 1-2, 37-40
Geological information 9, 11
Ground water (see also water table) 3

Highways 4, 5, 10, 11, 12, 13
Hills 6, 11
Impact 3, 5-6
Installation
  Of class A rod 25-26
  Of class B rod 14-25
  Of disk 13-14
Junctions 13
Landowner 12-13
Line-of-position (LOP) 6, 35
Metric units ..... iii, 36
Mines 2-3, 9
Montmorillonite 3, 9
Mortar 13, 14
National Geodetic Survey (NGS) ..... iii, 1, 43
National Ocean Survey (NOS) ..... iii, 25, 43
National Vertical Control Network ..... iii, 1, 25, 43
Numeric data 35
Permafrost 10, 27, 45-46
Polyvinyl chloride (PVC) pipe 15, 18, 19, 26
Private property 6, 12
Referencing 6, 11, 35
Rivers 4, 5, 10, 11
Roads 4, 5, 10, 11, 12, 13
Safety 12, 13, 15
Sedimentary rock 4, 9
Settlement 4, 10, 43
Sloped distances 35
Slope movement 4, 6, 9, 11
Soil
  Aeration 10, 12
  Classification 41-42
  Grain size 3, 6, 8, 11, 41
  Inorganic 41
  Organic 41
  Resistivity 12
Stability 1-2, 6, 9-10, 13, 15, 25
Streets 4, 5, 10, 11, 12
Structures 4, 5, 9-10, 11, 14, 43
Subsidence 3, 9
Telephone cables 12
Thermal coefficient of expansion 5
Tidal bench mark 25, 43
Trash 14, 19, 26
Underground pipes 12, 15
Utility poles 1, 4, 5, 11, 12, 35
Vandalism 3
Vegetation 9, 11
Water reservoirs 4, 10
Water soluble salts 10
Water table 3, 6
Weathering 9
Well casings 26

APPENDIX B

Primary Ground Subsidence Monitoring NGS Benchmarks
NGS Benchmark Data Sheets

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
DATABASE = Sybase ,PROGRAM = datasheet, VERSION = 6.56
1        National Geodetic Survey,   Retrieval Date = DECEMBER  6, 2001
 CY0355 ***********************************************************************
 CY0355  DESIGNATION -  P 324
 CY0355  PID         -  CY0355
 CY0355  STATE/COUNTY-  AZ/COCHISE
 CY0355  USGS QUAD   -  BOWIE (1974)
 CY0355
 CY0355                          *CURRENT SURVEY CONTROL
 CY0355
 CY0355* NAD 83(1986)-  32 20 03.     (N)    109 29 41.     (W)     SCALED
 CY0355* NAVD 88     -      1149.341  (meters)    3770.80   (feet)  ADJUSTED
 CY0355
 CY0355  GEOID HEIGHT-         -26.80  (meters)                     GEOID99
 CY0355  DYNAMIC HT  -        1147.649 (meters)    3765.25   (feet)  COMP
 CY0355  MODELED GRAV-     979,127.4   (mgal)                       NAVD 88
 CY0355
 CY0355  VERT ORDER  -  FIRST     CLASS II
 CY0355
 CY0355.The horizontal coordinates were scaled from a topographic map and have
 CY0355.an estimated accuracy of +/- 6 seconds.
 CY0355
 CY0355.The orthometric height was determined by differential leveling
 CY0355.and adjusted by the National Geodetic Survey in June 1991.
 CY0355
 CY0355.The geoid height was determined by GEOID99.
 CY0355
 CY0355.The dynamic height is computed by dividing the NAVD 88
 CY0355.geopotential number by the normal gravity value computed on the
 CY0355.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
 CY0355.degrees latitude (g = 980.6199 gals.).
 CY0355
 CY0355.The modeled gravity was interpolated from observed gravity values.
 CY0355
 CY0355;                     North         East    Units  Estimated Accuracy
 CY0355;SPC AZ E     -    148,120.      276,620.      MT  (+/- 180 meters Scaled)
 CY0355
 CY0355                          SUPERSEDED SURVEY CONTROL
 CY0355
 CY0355  NGVD 29     -      1150.375  (m)          3774.19   (f) ADJ UNCH    1 2
 CY0355
 CY0355.Superseded values are not recommended for survey control.
 CY0355.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
 CY0355.See file dsdata.txt to determine how the superseded data were derived.
 CY0355
 CY0355_MARKER: DB = BENCH MARK DISK
 CY0355_SETTING: 36 = FOUNDATION
 CY0355_STAMPING: P 324 1952
 CY0355_STABILITY: B = PROBABLY HOLD POSITION/ELEVATION WELL
 CY0355
 CY0355  HISTORY     - Date     Condition        Report By
 CY0355  HISTORY     - 1952     MONUMENTED       CGS
 CY0355  HISTORY     - 1953     GOOD             NGS
 CY0355  HISTORY     - 1979     GOOD             NGS
 CY0355
```

```
CY0355                          STATION DESCRIPTION
CY0355
CY0355'DESCRIBED BY COAST AND GEODETIC SURVEY 1952
CY0355'0.6 MI NW FROM BOWIE.
CY0355'0.6 MILE NORTHWEST ALONG THE SOUTHERN PACIFIC COMPANY RAILROAD FROM
CY0355'THE STATION AT BOWIE, IN THE TOP OF THE NORTHEAST FOUNDATION OF A
CY0355'WATER TANK LEG, 47.1 FEET WEST OF THE WEST RAIL OF THE MAIN TRACK, 40
CY0355'1/2 FEET NORTHWEST OF THE NORTHEAST FENCE CORNER AROUND THE SECTION
CY0355'HOUSE, 1.2 FEET EAST OF THE WEST EDGE, 0.3 FOOT SOUTH OF THE NORTH
CY0355'EDGE, AND ABOUT LEVEL WITH THE TRACK.
CY0355
CY0355                          STATION RECOVERY (1953)
CY0355
CY0355'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 1953
CY0355'RECOVERED IN GOOD CONDITION.
CY0355
CY0355                          STATION RECOVERY (1979)
CY0355
CY0355'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 1979
CY0355'1.0 KILOMETER (0.6 MILE) NORTHWEST ALONG THE SOUTHERN PACIFIC RAILROAD
CY0355'FROM THE STATION AT BOWIE, 0.3 KILOMETER (0.2 MILE) NORTH OF A DIRT
CY0355'ROAD CROSSING, IN TOP OF THE NORTH SIDE OF A 0.6 BY 0.7-METER
CY0355'CONCRETE POST (FORMER WATER TANK LEG FOUNDATION) PROJECTING 14
CY0355'CENTIMETERS, 65.2 METERS (215.0 FEET) NORTH OF A SWITCH STAND
CY0355'FOR THE NORTH LEG OF A RAILROAD RAIL TRIANGLE,
CY0355'14.3 METERS (37 FEET) WEST OF THE WEST RAIL.
CY0355'THE MARK IS 0.4 METERS  S FROM A WITNESS POST.
CY0355'THE MARK IS ABOVE LEVEL WITH THE RAILS.

*** retrieval complete.
Elapsed Time = 00:00:01
```

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
DATABASE = Sybase ,PROGRAM = datasheet, VERSION = 6.56
1        National Geodetic Survey,   Retrieval Date = DECEMBER  6, 2001
 CY0530 ***********************************************************************
 CY0530  DESIGNATION -  Q 358
 CY0530  PID         -  CY0530
 CY0530  STATE/COUNTY-  AZ/COCHISE
 CY0530  USGS QUAD   -  LUZENA (1979)
 CY0530
 CY0530                          *CURRENT SURVEY CONTROL
 CY0530
 CY0530* NAD 83(1986)-  32 20 04.     (N)    109 31 40.     (W)     SCALED
 CY0530* NAVD 88     -      1173.581  (meters)    3850.32   (feet)  ADJUSTED
 CY0530
 CY0530  GEOID HEIGHT-         -26.77  (meters)                     GEOID99
 CY0530  DYNAMIC HT  -        1171.855 (meters)    3844.66  (feet)  COMP
 CY0530  MODELED GRAV-     979,128.3   (mgal)                       NAVD 88
 CY0530
 CY0530  VERT ORDER  -  FIRST     CLASS II
 CY0530
 CY0530.The horizontal coordinates were scaled from a topographic map and have
 CY0530.an estimated accuracy of +/- 6 seconds.
 CY0530
 CY0530.The orthometric height was determined by differential leveling
 CY0530.and adjusted by the National Geodetic Survey in June 1991.
 CY0530
 CY0530.The geoid height was determined by GEOID99.
 CY0530
 CY0530.The dynamic height is computed by dividing the NAVD 88
 CY0530.geopotential number by the normal gravity value computed on the
 CY0530.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
 CY0530.degrees latitude (g = 980.6199 gals.).
 CY0530
 CY0530.The modeled gravity was interpolated from observed gravity values.
 CY0530
 CY0530;                    North         East    Units  Estimated Accuracy
 CY0530;SPC AZ E     -   148,130.      273,510.      MT  (+/- 180 meters Scaled)
 CY0530
 CY0530                          SUPERSEDED SURVEY CONTROL
 CY0530
 CY0530  NGVD 29     -      1172.896  (m)         3848.08   (f) ADJ UNCH    1 2
 CY0530
 CY0530.Superseded values are not recommended for survey control.
 CY0530.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
 CY0530.See file dsdata.txt to determine how the superseded data were derived.
 CY0530
 CY0530_MARKER: DB = BENCH MARK DISK
 CY0530_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
 CY0530_STAMPING: Q 358 1960
 CY0530_PROJECTION: PROJECTING 14 CENTIMETERS
 CY0530_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO
 CY0530+STABILITY: SURFACE MOTION
 CY0530
 CY0530  HISTORY     - Date     Condition        Report By
 CY0530  HISTORY     - 1960     MONUMENTED       CGS
 CY0530  HISTORY     - 1979     GOOD             NGS
```

```
CY0530
CY0530                          STATION DESCRIPTION
CY0530
CY0530'DESCRIBED BY COAST AND GEODETIC SURVEY 1960
CY0530'2.4 MI W FROM BOWIE.
CY0530'2.4 MILES WEST OF INTERSECTION LIGHT AT BOWIE, ARIZONA, ON STATE
CY0530'HIGHWAY 86, 0.2 MILE WEST OF MILEPOST 350, 97 FEET NORTH OF CENTERLINE
CY0530'OF HIGHWAY, 2 FEET SOUTHEAST OF WITNESS POST, SET IN THE TOP OF A
CY0530'10-INCH SQUARE CONCRETE POST PROJECTING 4 INCHES.
CY0530
CY0530                          STATION RECOVERY (1979)
CY0530
CY0530'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 1979
CY0530'4.7 KILOMETERS (2.9 MILES) WEST ALONG INTERSTATE HIGHWAY 10 FROM THE
CY0530'RICHARDS AVENUE UNDERPASS AT BOWIE, 0.2 KILOMETER (0.1 MILE) WEST OF
CY0530'MILE POST 362, 31.1 METERS (102 FEET) NORTH OF THE CENTERLINE OF THE
CY0530'WESTBOUND TRAFFIC LANES, 42.0 METERS (138 FEET) NORTHWEST OF THE
CY0530'WEST END OF THE NORTH HEADWALL OF A 3-CHANNEL BOX CULVERT, 27.0
CY0530'METERS (88 FEET) WEST OF A FENCE CORNER POST AND 0.5 METER (1.8 FEET)
CY0530'SOUTH OF THE NORTH RIGHT-OF-WAY FENCE.
CY0530'THE MARK IS 0.7 METERS  SE FROM A WITNESS POST.
CY0530'THE MARK IS 1.5 M BELOW THE HIGHWAY.

*** retrieval complete.
Elapsed Time = 00:00:03
```

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
DATABASE = Sybase ,PROGRAM = datasheet, VERSION = 6.56
1         National Geodetic Survey,   Retrieval Date = DECEMBER  6, 2001
 CY0328 ***********************************************************************
 CY0328  DESIGNATION -  BART RM 1
 CY0328  PID         -  CY0328
 CY0328  STATE/COUNTY-  AZ/COCHISE
 CY0328  USGS QUAD   -  BOWIE (1974)
 CY0328
 CY0328                         *CURRENT SURVEY CONTROL
 CY0328
 CY0328* NAD 83(1986)-  32 19 00.     (N)    109 29 03.     (W)     SCALED
 CY0328* NAVD 88     -      1151.10   (+/-2cm)    3776.6    (feet)  VERTCON
 CY0328
 CY0328  GEOID HEIGHT-          -26.77  (meters)                    GEOID99
 CY0328
 CY0328  VERT ORDER  -  SECOND    CLASS 0 (See Below)
 CY0328
 CY0328.The horizontal coordinates were scaled from a topographic map and have
 CY0328.an estimated accuracy of +/- 6 seconds.
 CY0328
 CY0328.The NAVD 88 height was computed by applying the VERTCON shift value to
 CY0328.the NGVD 29 height (displayed under SUPERSEDED SURVEY CONTROL.)
 CY0328.The vertical order pertains to the superseded datum.
 CY0328
 CY0328.The geoid height was determined by GEOID99.
 CY0328
 CY0328;                     North         East    Units  Estimated Accuracy
 CY0328;SPC AZ E     -   146,180.      277,620.     MT  (+/- 180 meters Scaled)
 CY0328
 CY0328                         SUPERSEDED SURVEY CONTROL
 CY0328
 CY0328  NGVD 29     -      1150.398  (m)          3774.26    (f) ADJ UNCH    2 0
 CY0328
 CY0328.Superseded values are not recommended for survey control.
 CY0328.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
 CY0328.See file dsdata.txt to determine how the superseded data were derived.
 CY0328
 CY0328_MARKER: DB = BENCH MARK DISK
 CY0328_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
 CY0328_STAMPING: BART NO 1 1960
 CY0328_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO
 CY0328+STABILITY: SURFACE MOTION
 CY0328
 CY0328  HISTORY     - Date     Condition        Report By
 CY0328  HISTORY     - 1960     MONUMENTED       CGS
 CY0328  HISTORY     - 1970     GOOD             NGS
 CY0328
 CY0328                          STATION DESCRIPTION
 CY0328
 CY0328'DESCRIBED BY NATIONAL GEODETIC SURVEY 1970
 CY0328'0.5 MI S FROM BOWIE.
 CY0328'0.3 MILE EAST FROM THE POST OFFICE IN BOWIE ALONG INTERSTATE HIGHWAY
 CY0328'BUSINESS ROUTE TO A PAVED SIDE ROAD THENCE SOUTH 0.6 MILE TO
 CY0328'OVERPASSES THENCE SOUTH 0.05 MILE, 63 FEET SOUTH OF A METAL WITNESS
 CY0328'POST WITH SIGN, 36 FEET EAST OF THE CENTER OF THE PAVED ROAD, 1 FOOT
```

```
CY0328'WEST OF A FENCE, SET IN THE TOP OF A 12-INCH SQUARE CONCRETE MONUMENT
CY0328'SET FLUSH WITH THE SURFACE OF THE GROUND.  SEC 10, T 13 S, R 28 E.

*** retrieval complete.
Elapsed Time = 00:00:01
```

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
DATABASE = Sybase ,PROGRAM = datasheet, VERSION = 6.56
1        National Geodetic Survey,   Retrieval Date = DECEMBER  6, 2001
 CY0283 ***********************************************************************
 CY0283  DESIGNATION -  Y 330
 CY0283  PID         -  CY0283
 CY0283  STATE/COUNTY-  AZ/COCHISE
 CY0283  USGS QUAD   -  BOWIE (1974)
 CY0283
 CY0283                          *CURRENT SURVEY CONTROL
 CY0283
 CY0283* NAD 83(1986)-  32 19 14.     (N)    109 27 12.     (W)     SCALED
 CY0283* NAVD 88     -      1129.781  (meters)    3706.62   (feet)  ADJUSTED
 CY0283
 CY0283  GEOID HEIGHT-         -26.79  (meters)                     GEOID99
 CY0283  DYNAMIC HT  -        1128.115 (meters)    3701.16   (feet)  COMP
 CY0283  MODELED GRAV-     979,126.0   (mgal)                       NAVD 88
 CY0283
 CY0283  VERT ORDER  -  FIRST     CLASS II
 CY0283
 CY0283.The horizontal coordinates were scaled from a topographic map and have
 CY0283.an estimated accuracy of +/- 6 seconds.
 CY0283
 CY0283.The orthometric height was determined by differential leveling
 CY0283.and adjusted by the National Geodetic Survey in June 1991.
 CY0283
 CY0283.The geoid height was determined by GEOID99.
 CY0283
 CY0283.The dynamic height is computed by dividing the NAVD 88
 CY0283.geopotential number by the normal gravity value computed on the
 CY0283.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
 CY0283.degrees latitude (g = 980.6199 gals.).
 CY0283
 CY0283.The modeled gravity was interpolated from observed gravity values.
 CY0283
 CY0283;                    North         East     Units  Estimated Accuracy
 CY0283;SPC AZ E     -   146,630.      280,520.      MT  (+/- 180 meters Scaled)
 CY0283
 CY0283                          SUPERSEDED SURVEY CONTROL
 CY0283
 CY0283  NGVD 29     -      1130.143  (m)          3707.81   (f) ADJ UNCH    1 2
 CY0283
 CY0283.Superseded values are not recommended for survey control.
 CY0283.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
 CY0283.See file dsdata.txt to determine how the superseded data were derived.
 CY0283
 CY0283_MARKER: DB = BENCH MARK DISK
 CY0283_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
 CY0283_STAMPING: Y 330 1953
 CY0283_PROJECTION: PROJECTING 25 CENTIMETERS
 CY0283_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO
 CY0283+STABILITY: SURFACE MOTION
 CY0283
 CY0283  HISTORY     - Date     Condition        Report By
 CY0283  HISTORY     - 1953     MONUMENTED       CGS
 CY0283  HISTORY     - 1960     GOOD             NGS
```

```
CY0283  HISTORY     - 1979     GOOD             NGS
CY0283
CY0283                          STATION DESCRIPTION
CY0283
CY0283'DESCRIBED BY COAST AND GEODETIC SURVEY 1953
CY0283'2.0 MI E FROM BOWIE.
CY0283'2.0 MILES EAST ALONG THE SOUTHERN PACIFIC RAILROAD FROM THE STATION AT
CY0283'BOWIE, 100 FEET SOUTH OF THE SOUTH RAIL, 99 FEET NORTH OF THE CENTER
CY0283'LINE OF STATE HIGHWAY 86, 6 FEET SOUTH OF A VERTICAL RAIL.  3 FEET
CY0283'EAST OF A WITNESS POST.  3 FEET BELOW THE TOP OF THE RAILS, SET IN THE
CY0283'TOP OF A CONCRETE POST WHICH PROJECTS 0.9 FOOT ABOVE THE GROUND.
CY0283
CY0283                          STATION RECOVERY (1960)
CY0283
CY0283'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 1960
CY0283'RECOVERED IN GOOD CONDITION.
CY0283
CY0283                          STATION RECOVERY (1979)
CY0283
CY0283'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 1979
CY0283'3.2 KILOMETERS (2.0 MILES) EAST ALONG THE SOUTHERN PACIFIC RAILROAD
CY0283'FROM THE STATION AT BOWIE, 0.2 KILOMETER (0.1 MILE) WEST OF THE
CY0283'JUNCTION OF BUSINESS LOOP INTERSTATE 10 AND A FRONTAGE ROAD LEADING
CY0283'EAST, 31.8 METERS (104 FEET) SOUTH OF THE SOUTH RAIL, 28.4 METERS
CY0283'(93 FEET) NORTH OF THE CENTERLINE OF THE INTERSTATE 10 BUSINESS LOOP
CY0283'HIGHWAY AND 40.2 METERS (132 FEET) SOUTHEAST OF THE SECOND UTILITY
CY0283'POLE EAST OF RAILROAD BRIDGE 1100.31.
CY0283'THE MARK IS 0.5 METERS  W FROM A WITNESS POST.
CY0283'THE MARK IS 1.5 M BELOW THE RAILS.

*** retrieval complete.
Elapsed Time = 00:00:01
```

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
DATABASE = Sybase ,PROGRAM = datasheet, VERSION = 6.56
1         National Geodetic Survey,   Retrieval Date = DECEMBER  6, 2001
 CY1170 ***********************************************************************
 CY1170  DESIGNATION -  FISHER
 CY1170  PID         -  CY1170
 CY1170  STATE/COUNTY-  AZ/COCHISE
 CY1170  USGS QUAD   -  FISHER HILLS (1979)
 CY1170
 CY1170                          *CURRENT SURVEY CONTROL
 CY1170
 CY1170* NAD 83(1992)-  32 22 53.71930(N)     109 33 53.35902(W)     ADJUSTED
 CY1170* NAVD 88     -      1312.2    (meters)    4305.     (feet)  VERTCON
 CY1170
 CY1170  LAPLACE CORR-          -1.73  (seconds)                     DEFLEC99
 CY1170  GEOID HEIGHT-         -26.81  (meters)                      GEOID99
 CY1170
 CY1170  HORZ ORDER  -  FIRST
 CY1170
 CY1170.The horizontal coordinates were established by classical geodetic methods
 CY1170.and adjusted by the National Geodetic Survey in August 1993.
 CY1170
 CY1170.The NAVD 88 height was computed by applying the VERTCON shift value to
 CY1170.the NGVD 29 height (displayed under SUPERSEDED SURVEY CONTROL.)
 CY1170
 CY1170.The Laplace correction was computed from DEFLEC99 derived deflections.
 CY1170
 CY1170.The geoid height was determined by GEOID99.
 CY1170
 CY1170;                    North         East     Units   Scale      Converg.
 CY1170;SPC AZ E     -   153,336.508   269,988.191   MT  0.99993953 +0 19 20.4
 CY1170;UTM  12      - 3,583,638.832   635,001.871   MT  0.99982475 +0 46 07.4
 CY1170
 CY1170:                Primary Azimuth Mark                     Grid Az
 CY1170:SPC AZ E     -  FISHER AZ MK                             229 56 41.4
 CY1170:UTM  12      -  FISHER AZ MK                             229 29 54.4
 CY1170
 CY1170|-----------------------------------------------------------------------|
 CY1170| PID    Reference Object                     Distance       Geod. Az  |
 CY1170|                                                            dddmmss.s |
 CY1170| CY1164 BOWIE LOADING CHUTE                APPROX. 9.8 KM 1273114.8  |
 CY1170| CY1163 BOWIE WATER TANK                   APPROX. 9.6 KM 1274407.1  |
 CY1170| CY1169 GILMAN CAIRN                        18.593 METERS 13028      |
 CY1170|        FISHER RM 1                          6.217 METERS 14801      |
 CY1170|        FISHER AZ MK                                      2301601.8 |
 CY1170|        FISHER RM 2                          9.244 METERS 26255      |
 CY1170|-----------------------------------------------------------------------|
 CY1170
 CY1170                          SUPERSEDED SURVEY CONTROL
 CY1170
 CY1170  NAD 83(1986)-  32 22 53.71449(N)     109 33 53.35624(W) AD(       ) 1
 CY1170  NAD 27      -  32 22 53.45600(N)     109 33 51.11100(W) AD(       ) 1
 CY1170  NGVD 29     -      1311.4    (m)          4302.     (f) VERT ANG
 CY1170
 CY1170.Superseded values are not recommended for survey control.
 CY1170.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
```

```
CY1170.See file dsdata.txt to determine how the superseded data were derived.
CY1170
CY1170 MARKER: DS = TRIANGULATION STATION DISK
CY1170 SETTING: 66 = SET IN ROCK OUTCROP
CY1170 STABILITY: A = MOST RELIABLE AND EXPECTED TO HOLD
CY1170+STABILITY: POSITION/ELEVATION WELL
CY1170
CY1170  HISTORY     - Date     Condition        Report By
CY1170  HISTORY     - 1945     MONUMENTED       CGS
CY1170  HISTORY     - 1956     GOOD             USE
CY1170  HISTORY     - 1960     GOOD             CGS
CY1170  HISTORY     - 1983     GOOD             AZDT
CY1170
CY1170                          STATION DESCRIPTION
CY1170
CY1170'DESCRIBED BY COAST AND GEODETIC SURVEY 1945 (RAM)
CY1170'STATION IS ON THE HIGHEST PART OF THE LOWEST AND MOST SE
CY1170'HILL IN THE GROUP OF HILLS SHOWN ON THE U.S. GEOLOGICAL
CY1170'SURVEY CHARTS AS FISHER HILLS.  AND IS LOCATED BY APPROXIMATE
CY1170'AIR LINE DISTANCES, 6 MILES NW OF BOWIE, 4 MILES ENE OF THE
CY1170'JUNCTION OF U.S. HIGHWAY 666 AND STATE HIGHWAY 86, 3 MILES
CY1170'S OF THE COCHISE-GRAHAM COUNTY LINE, AND 1/4 MILE NNW OF
CY1170'THE UX RANCH.
CY1170'
CY1170'TO REACH THE STATION FROM THE POST OFFICE IN BOWIE, GO N
CY1170'0.1 MILE ACROSS THE RAILROAD TRACKS, TAKE THE FIRST LEFT
CY1170'TURN AND FOLLOW THE MAIN GRADED ROAD W 0.4 MILE TO A FORK.
CY1170'TAKE THE LEFT FORK FOR 0.15 MILE, THENCE LEFT FORK AGAIN
CY1170'AND CONTINUE ALONG THE N SIDE OF THE SOUTHERN PACIFIC CO.
CY1170'RAILROAD TRACKS ON THE MAIN GRAVEL ROAD FOR 4.4 MILES TO
CY1170'A ROAD RIGHT JUST BEFORE REACHING A GATE IN A FENCE LINE.
CY1170'(NOTE--TO REACH THE AZIMUTH MARK FROM HERE, GO THROUGH THE
CY1170'GATE AND CONTINUE W FOR 1.6 MILES TO WHERE A BRIDGE HAS BEEN
CY1170'WASHED OUT.  THE AZIMUTH MARK IS SET IN THE NW CONCRETE
CY1170'ABUTMENT.) TURN RIGHT AND FOLLOW THE MAIN ROAD ALONG THE
CY1170'E SIDE OF THE FENCE LINE 1.8 MILES TO A TRACK ROAD FORKING
CY1170'BACK TO THE RIGHT JUST AFTER CROSSING A LARGE WASH, AND
CY1170'1/4 MILE BEFORE REACHING THE UX RANCH.  TURN BACK TO THE
CY1170'RIGHT ON THE TRACK ROAD FOR 0.2 MILE, THENCE LEFT FORK
CY1170'FOR 0.35 MILE.  HERE TURN LEFT ACROSS COUNTRY FOR 1/4
CY1170'MILE TO THE END OF TRUCK TRAVEL AT THE BASE OF THE
CY1170'HILL.  PACK SSW FOR ABOUT 1/4 HOUR TO THE TOP AND THE
CY1170'STATION.
CY1170'
CY1170'STATION MARK IS A BRONZE STATION DISK SET IN A DRILL HOLE
CY1170'IN OUTCROPPING BEDROCK WHICH PROJECTS ABOUT 3 INCHES ABOVE
CY1170'THE GROUND AND IS STAMPED FISHER 1945.  IT IS 61 FEET NW
CY1170'OF STATION GILMAN (U.S.G.S. 1940) (NOT OCCUPIED.  A ROCK
CY1170'CAIRN ABOUT 5 FEET IN DIAMETER AND 4 FEET HIGH IS THE ONLY
CY1170'STATION MARK.) AND 34-1/2 FEET NE OF AN OLD FENCE LINE.
CY1170'
CY1170'REFERENCE MARK 1 IS A BRONZE REFERENCE DISK SET IN A DRILL
CY1170'HOLE IN OUTCROPPING BEDROCK WHICH PROJECTS ABOUT 1 FOOT ABOVE
CY1170'THE GROUND AND IS STAMPED FISHER NO 1 1945.  IT IS SSE OF THE
CY1170'STATION AND ABOUT 6 INCHES LOWER.
CY1170'
CY1170'REFERENCE MARK 2 IS A BRONZE REFERENCE DISK SET IN A DRILL
CY1170'HOLE IN OUTCROPPING BEDROCK WHICH PROJECTS ABOUT 6 INCHES
CY1170'ABOVE THE GROUND AND IS STAMPED FISHER NO 2 1945.  IT IS W
CY1170'OF THE STATION AND ABOUT 1-1/2 FEET LOWER.
CY1170'
CY1170'AZIMUTH MARK IS A BRONZE AZIMUTH DISK SET IN A DRILL HOLE
CY1170'IN THE NE END OF THE NW CONCRETE ABUTMENT OF A WASHED OUT
```

```
CY1170'BRIDGE.  IT IS SW OF THE STATION, 20.8 FEET S OF THE NEAREST
CY1170'WOOD TELEPHONE POLE, 8.0 FEET SE OF A 4- BY 4-INCH WHITE
CY1170'WITNESS POST, AND IS STAMPED FISHER 1945.
CY1170
CY1170                          STATION RECOVERY (1956)
CY1170
CY1170'RECOVERY NOTE BY US ENGINEERS 1956
CY1170'STATION RECOVERED AS DESCRIBED.
CY1170'
CY1170'AZIMUTH MARK NOT SEARCHED FOR.
CY1170
CY1170                          STATION RECOVERY (1960)
CY1170
CY1170'RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1960 (NES)
CY1170'THE STATION WAS RECOVERED AS DESCRIBED.  ALL MARKS WERE FOUND
CY1170'IN VERY GOOD CONDITION.  THE HORIZONTAL ANGLE TO THE AZIMUTH
CY1170'MARK WAS NOT MEASURED.
CY1170
CY1170                          STATION RECOVERY (1983)
CY1170
CY1170'RECOVERY NOTE BY ARIZONA DEPARTMENT OF TRANSPORTATION 1983 (GH)
CY1170'THE STATION MARK, REFERENCE MARKS AND AZIMUTH MARK WERE RECOVERED AS
CY1170'DESCRIBED IN 1945.
CY1170'
CY1170'TO REACH THE STATION FROM THE POST OFFICE IN SAFFORD TRAVEL EAST ALONG
CY1170'U.S. HIGHWAY 70 FOR 0.3 MILE TO THE JUNCTION WITH U.S. HIGHWAY 666.
CY1170'TURN RIGHT AND TRAVEL SOUTH ALONG U.S. 666 FOR 16.8 MILES TO THE
CY1170'JUNCTION WITH STATE ROUTE 266, CONTINUE SOUTH ALONG U.S. 666 FOR 14.4
CY1170'MILES TO A PAVED ROAD LEFT.  TURN LEFT AND TRAVEL SOUTHEAST FOR 3.2
CY1170'MILES TO A GRADED ROAD LEFT NEAR A CATTLE GUARD.  TURN LEFT AND TRAVEL
CY1170'EAST FOR 2.15 MILES TO THE AZIMUTH MARK ON THE RIGHT, CONTINUE EAST
CY1170'FOR 3.65 MILES TO A CATTLE GUARD.  CROSS THE CATTLE GUARD FOR 75 FEET
CY1170'TO A TRACK ROAD LEFT.  TURN LEFT AND TRAVEL NORTH ALONG THE EAST SIDE
CY1170'OF A FENCELINE FOR 1.5 MILES TO A FENCE CORNER.  TURN LEFT AND TRAVEL
CY1170'NORTH ALONG A FENCELINE FOR 1.6 MILES TO A FENCE CORNER.  TURN RIGHT
CY1170'AND TRAVEL NORTH FOR 0.85 MILE TO A FORK.  TAKE THE LEFT FORK WEST AND
CY1170'NORTH TO A FENCE CORNER ON A DAM.  TURN LEFT CROSSING ON TOP OF DAM
CY1170'FOR 0.3 MILE TO A ROAD LEADING RIGHT IN SPILLWAY.  TRAVEL NORTH FOR
CY1170'0.55 MILE TO A EAST-WEST FENCELINE.  TURN LEFT ALONG A FENCELINE FOR
CY1170'0.25 MILE TO END OF TRUCK TRAVEL.  PACK SOUTHWEST TO THE HIGH POINT AT
CY1170'THE EAST END OF THE HILL AND THE STATION.

*** retrieval complete.
Elapsed Time = 00:00:09
```

EXHIBIT
Admitted
A-12

Lawrence V. Robertson, Jr. (001709)
MUNGER CHADWICK, P.L.C.
National Bank Plaza
333 N. Wilmot, Suite 300
Tucson, Arizona 85711
(520) 721-1900; Facsimile (520) 747-1550
E-Mail: lvrobertson@mungerchadwick.com
Attorneys for: Bowie Power Station, L.L.C.

BEFORE THE ARIZONA POWER PLANT AND

TRANSMISSION LINE SITING COMMITTEE

IN THE MATTER OF THE APPLICATION OF BOWIE POWER STATION, LLC, IN CONFORMANCE WITH THE REQUIREMENTS OF ARIZONA REVISED STATUTES 40-360.03 AND 40-360.06, FOR TWO CERTIFICATES OF ENVIRONMENTAL COMPATIBILITY AUTHORIZING CONSTRUCTION OF A NOMINAL 1,000 MEGAWATT NATURAL GAS-FIRED, COMBINED-CYCLE POWER PLANT, 345KV and 345KV/230KV SWITCHYARDS, 345KV DOUBLE-CIRCUIT TRANSMISSION LINE AND 230KV INTERCONNECTION AND RELATED FACILITIES IN COCHISE AND GRAHAM COUNTIES, ARIZONA. THE PROPOSED POWER STATION SITE IS LOCATED IN SECTIONS 28 AND 29, TOWNSHIP 12 SOUTH, RANGE 28 EAST, AND THE PROPOSED TRANSMISSION LINE ROUTE IS LOCATED IN TOWNSHIP 12 SOUTH, RANGE 28 EAST, TOWNSHIP 11 SOUTH, RANGE 28 EAST, TOWNSHIP 11 SOUTH, RANGE 27 EAST, AND TOWNSHIP 11 SOUTH, RANGE 26 EAST, GILA AND SALT RIVER BASE AND MERIDIAN.	CASE NO. L00000BB-01-0118 (Case No. 118) DECISION NO. _____ (POWER PLANT)

DECISION OF THE ARIZONA POWER PLANT AND TRANSMISSION LINE SITING COMMITTEE AND CERTIFICATE OF ENVIRONMENTAL COMPATIBILITY

Pursuant to notice given, as provided by law, the Arizona Power Plant and Transmission Line Siting Committee ("Committee") held public hearings at the Best Western Plaza, 1100 Rex Allen Drive, Willcox, Arizona on October 11-12, 2001, and at the Embassy Suites, 1515 North 44th Street,

Phoenix, Arizona on December 10-11, 2001, in conformance with the requirements of Arizona Revised Statutes §40-360 et. seq., for the purpose of receiving evidence and deliberating upon the Application, of Bowie Power Station, L.L.C. and its assigns ("Applicant") for a Certificate of Environmental Compatibility ("Certificate") in the above-captioned case.

The following members and designees of members of the Committee were present for the evidentiary presentation during all or portions of the aforesaid hearings and/or deliberation and vote on the Application:

Laurie A. Woodall	Chair, and Designee for Arizona Attorney General
Ray Williamson	Designee for Chairman of Arizona Corporation Commission
Mark McWhirter	Designee for Director of Energy Office of Arizona Department of Commerce
Richard Tobin	Designee for Director of Arizona Department of Environmental Quality
Jeff McGuire	Appointed Member
Mike Palmer	Appointed Member
A. Wayne Smith	Appointed Member
Sandie Smith	Appointed Member
Margaret Trujillo	Appointed Member
Mike Whalen	Appointed Member

The Applicant was represented by Lawrence V. Robertson, Jr. The Arizona Corporation Commission ("Commission") staff was represented by Jason D. Gellman. Wayne Bryant appeared on his own behalf as an individual intervenor.

At the conclusion of the public hearings, after consideration of (i) the Application and the evidence presented during the public hearings, (ii) the closing arguments of the parties, and (iii) the legal requirements of Arizona Revised Statutes §40-360 through §40-360.13 and A.A.C. R14-3-213, upon motion duly made and seconded, by a ____ vote the Committee voted to grant the Applicant the following Certificate.

Applicant is hereby granted a Certificate to site and construct the following facilities ("Project"):

> A natural gas fired, combined cycle electric generating plant with an operating capability not to exceed a nominal site rating of 1000 megawatts (MW). The facilities shall consist of up to two (2) power blocks, each rated up to 500 MW nominal. Each power block shall consist of (i) two combustion turbine generators (CTG), (ii) two heat recovery steam generators (HRSG) and (iii) one steam turbine electric generator. The plant design may also incorporate supplementary or duct-firing of the HRSG for a given power block. The duct-firing design would be incorporated in the HRSG's. The power plant and supporting infrastructure shall be located in Section 28 and a portion of Section 29, Township 12 South, Range 28 East, G&SRB&M.

The supporting power plant infrastructure shall include (i) an air pollution control system, (ii) water handling and treatment facilities, (iii) fuel system, (iv) instrumentation and control system, (v) switchyard and electrical interconnection(s), (vi) chemical and petroleum product storage facilities, (vii) vehicular access facilities, (viii) evaporation ponds, and (ix) other site improvements. Each of these infrastructure components is described in some detail in the Application.

In connection with the design and construction of Project facilities, Applicant shall use low profile structures, moderate stacks, neutral colors, compatible landscaping and low intensity directed lighting for the power plant. The transmission facilities shall include the use of non-reflective conductors and towers. In addition, Applicant shall use a zero discharge system for cooling water, subject to existing regulatory requirements. Further, Applicant shall operate the evaporation ponds so that any salt residue(s) contained therein shall not cause damage to crops grown on fields adjacent to the Project site.

This Certificate is further granted upon the following conditions.

1. Applicant shall comply with all existing applicable air and water pollution control standards and regulations, and with all existing applicable ordinances, master plans and regulations of the State of Arizona, Cochise County and Graham County, the United States of America, and any other governmental entities having jurisdiction, including but not limited to the following:

   A. all applicable zoning stipulations and conditions, including but not limited to landscaping and dust control requirements and/or approvals;

   B. all applicable air quality control standards, approvals, permit conditions and requirements of the Arizona Department of Environmental Quality ("ADEQ") and/or other State of Arizona or Federal agencies having jurisdiction, and Applicant shall install and operate selective catalytic reduction at the level determined by ADEQ.

   C. all applicable water use and conservation requirements of the Arizona Department of Water Resources ("ADWR").

D. all applicable water use and discharge requirements of ADEQ.

E. all applicable noise control standards, and during normal operations the project shall not exceed applicable (i) HUD or EPA residential noise guidelines or (ii) OSHA worker safety noise standards; and

F. all applicable regulations and permits governing storage and handling of chemical and petroleum products;

In connection with approvals of or permits for Project facilities to be issued by Cochise County or Graham County, Applicant shall attach a copy of this Decision and Certificate to any applications or requests it submits to such counties. A courtesy copy will also be provided to the community of Bowie and the City of Wilcox.

2. In connection with the engineering, design, construction, operation and maintenance of the Project facilities, Applicant and its consultants and contractors shall apply recognized and accepted geotechnical engineering and civil engineering standards and practices. In addition, Applicant shall implement the Ground Subsidence and Earth Fissure Monitoring Program agreed to between Applicant and the Arizona Department of Water Resources, which was received into evidence as Exhibit No. _____.

A. In the event of the occurrence of an "alert condition," as defined in the Monitoring Program, Applicant, ADWR, Cochise County and the United States Geological Survey ("USGS") shall confer as to the investigative and/or mitigation program(s), if any, to be undertaken in response to such "alert condition." In the event Applicant, ADWR, Cochise County and USGS are unable to agree as to the program(s) or course(es) of action to be undertaken,

Applicant shall refer the matter to the Commission for a hearing and decision to determine the investigative and/or mitigation programs, if any, to be undertaken in response to such "alert condition."

B. Commencing with the fifth year of commercial operation of the initial power block of the Project, Applicant shall annually contribute One Hundred Thousand Dollars ($100,000) to a Subsidence Mitigation Fund ("Fund") to be established and maintained by Applicant at a national or state-chartered bank. Such contribution obligation shall be suspended whenever the balance in the Fund reaches the principal amount of Five Hundred Thousand Dollars ($500,000). Interest earned on the Fund shall belong to Applicant.

C. Persons claiming property damage as a result of ground subsidence allegedly directly attributable to Project operation may submit a claim for mitigation payment to Applicant. Applicant shall investigate the circumstances surrounding the claim and make a determination, if possible, as to the cause of the claimant's alleged property damage. If it is determined that the damage in question has been caused by Project operations, funds shall be disbursed from the Fund to compensate claimant for the amount of damage determined to be directly attributable to the Project. If the cause or amount of the alleged damage is in dispute, Applicant agrees to submit the matter to binding arbitration with the American Arbitration Association, if the person claiming damage agrees.

D. The Subsidence Mitigation Fund account shall be maintained for three (3) years after the end of the Project's economic life, as determined by Applicant. Once the three (3) year period has passed, the account shall be closed, and any remaining funds shall be disbursed back to Applicant.

3. Applicant shall prepare a plan for shutdown, decommissioning and cleanup of the plant site which shall be filed with the Commission's Docket Control section within one year of beginning construction. In that regard, the Committee recommends that Applicant work with Cochise County and/or any other local governing body with jurisdiction over the plant site to ensure that such plan is reasonable, and is followed or amended as needed.

4. Applicant's plant interconnection must satisfy the Western Systems Coordinating Council's ("WSCC") single contingency outage criteria (N-1) and all applicable local utility planning criteria without reliance on remedial action such as reducing generator output, generator unit tripping or load shedding.

5. Prior to construction of any facilities, Applicant must provide the Commission with technical study evidence that sufficient transmission capacity exists to accommodate the full output of the plant and that the full output of the plant shall not compromise the reliable operation of the interconnected transmission system. The technical studies shall include a power flow and stability analysis report showing the effect of the plant on the existing Arizona electric transmission system. The technical study report(s) shall document both physical flow capability as well as contractual schedule capability to deliver full plant output to its intended market. In addition, Applicant must provide the Commission with updates to the information required in this condition not more than one year and not less than three months prior to commercial operation of the plant. Prior to

commencing operation of a given power block, transmission facilities improvements necessary to deliver the output of that power block to intended markets, as identified in the aforesaid technical studies, shall have been completed.

6. Applicant shall become and remain a member of the WSCC, or its successor, and file an executed copy of its WSCC Reliability Management System ("RMS") Generator Agreement with the Commission. Membership by an affiliate of Applicant satisfies this condition only if Applicant is bound by the affiliate's WSCC membership.

7. Applicant shall apply to become, and if accepted, thereafter remain a member of the Southwest Reserve Sharing Group or its successor, thereby making its units available for reserve sharing purposes, subject to competitive pricing.

8. Applicant shall continue to participate in good faith in state and regional transmission study forums to identify and encourage expedient implementation of transmission enhancements, including transmission cost participation as appropriate, to reliably deliver power from the Project throughout the WSCC grid in a reliable manner.

9. Applicant shall first offer wholesale power purchase opportunities to credit-worthy Arizona load-serving entities and to credit-worthy marketers providing service to those Arizona load-serving entities.

10. Applicant shall offer for Ancillary Services, in order to comply with WSCC RMS requirements, a total of up to 10% of its total plant capacity to (A) the local Control Area with which it is interconnected and (B) Arizona's regional ancillary service market, (i) once a Regional Transmission Organization (RTO) is declared operational by FERC order, and (ii) until such time that an RTO is so declared, to a regional reserve sharing pool.

11. Pursuant to applicable Federal Energy Regulatory Commission ("FERC"), regulations, Applicant shall not knowingly withhold its capacity from the market for reasons other than a forced outage or pre-announced planned outage.

12. Within 30 days of the Commission decision authorizing construction of the Project, Applicant shall erect and maintain at the site a sign of not less than 4 feet by 8 feet dimensions, advising:

A. that the site has been approved for the construction of a 1000 megawatt (nominal) generating facility;

B. the expected date of completion of the Project; and

C. phone number for public information regarding the Project.

In the event that Applicant requests an extension of the term of the Certificate prior to completion of the construction, Applicant shall use reasonable means to directly notify all landowners and residents within one-mile radius of the Project of the time and place of the proceeding in which the Commission shall consider such request for extension. Applicant shall also provide notice of such extension to Cochise County, Graham County, the community of Bowie and the City of Wilcox.

13. Applicant shall pursue all necessary steps to ensure a reliable supply and delivery of natural gas for the generating facility.

14. In connection with the construction of the Project, Applicant shall use commercially reasonable efforts, where feasible, to give due consideration to use of qualified Arizona contractors. In addition, Applicant shall encourage the hiring of qualified local employees in connection with construction and operation of the Project facilities.

15. Applicant shall participate in workshops to commence during the year 2002 which shall address both long term and short term gas transportation reliability and capacity issues within the State of Arizona. Applicant shall work with other participants on an ongoing basis to develop alternative solutions to these gas pipeline issues.

16. Within five days of Commission approval of this CEC, Applicant shall request in writing that El Paso Natural Gas Company ("El Paso") provide Applicant with a written report describing the operational integrity of El Paso's Southern System facilities through the Bowie and San Simon areas. Such request shall include:

A. a request for information regarding inspection, replacement and/or repairs performed on this segment of El Paso's pipeline facilities since 1996 and those planned through 2006; and

B. an assessment of subsidence impacts on the integrity of this segment of pipeline over its full cycle, together with any mitigation steps taken to date or planned in the future.

Applicant shall file El Paso's response under this docket with the Commission's Docket Control. Should El Paso not respond within thirty (30) days, Applicant shall docket a copy of Applicant's request with an advisory of El Paso's failure to respond. In either event, Applicant's responsibility hereunder shall terminate once it has filed El Paso's response or Applicant's advisory of El Paso's failure to respond.

17. In conjunction with its construction of the Project facilities, Applicant shall implement the Landscape Plan set forth at Exhibit B-2 to the Application [Ex. #A-1].

18. This authorization to site and construct the Project facilities shall expire five (5) years from the date the Certificate is approved by the Commission unless construction is completed and the plant is in operation. If construction on a power block has not begun before expiration of the five-year limit, Applicant shall no longer be authorized to begin construction on such power block. However, before such expiration Applicant may request that the Commission extend this time limitation.

GRANTED this _____ day of _____, 2001.

Arizona Power Plant and Transmission Line
Siting Committee

By: _____
Laurie A. Woodall, Chair

Copy of the foregoing e-mailed
this ____day of December, 2001, to:

Laurie Woodall, Chair
Arizona Power Plant and
Transmission Line Siting Committee
1275 W. Washington
Phoenix, Arizona 85007

Jason D. Gellman, Attorney
Arizona Corporation Commission
1200 W. Washington Street
Phoenix, AZ 85007

Wayne Bryant
2475 East Water Street
Tucson AZ 85719-3455

_____

EXHIBIT
Admitted
A-13

Lawrence V. Robertson, Jr. (001709)
MUNGER CHADWICK, P.L.C.
National Bank Plaza
333 N. Wilmot, Suite 300
Tucson, Arizona 85711
(520) 721-1900; Facsimile (520) 747-1550
E-Mail: lvrobertson@mungerchadwick.com
Attorneys for: Bowie Power Station, L.L.C.

BEFORE THE ARIZONA POWER PLANT AND

TRANSMISSION LINE SITING COMMITTEE

IN THE MATTER OF THE APPLICATION OF BOWIE POWER STATION, LLC, IN CONFORMANCE WITH THE REQUIREMENTS OF ARIZONA REVISED STATUTES 40-360.03 AND 40-360.06, FOR TWO CERTIFICATES OF ENVIRONMENTAL COMPATIBILITY AUTHORIZING CONSTRUCTION OF A NOMINAL 1,000 MEGAWATT NATURAL GAS-FIRED, COMBINED-CYCLE POWER PLANT, 345KV and 345KV/230KV SWITCHYARDS, 345KV DOUBLE-CIRCUIT TRANSMISSION LINE AND 230KV INTERCONNECTION AND RELATED FACILITIES IN COCHISE AND GRAHAM COUNTIES, ARIZONA. THE PROPOSED POWER STATION SITE IS LOCATED IN SECTIONS 28 AND 29, TOWNSHIP 12 SOUTH, RANGE 28 EAST, AND THE PROPOSED TRANSMISSION LINE ROUTE IS LOCATED IN TOWNSHIP 12 SOUTH, RANGE 28 EAST, TOWNSHIP 11 SOUTH, RANGE 28 EAST, TOWNSHIP 11 SOUTH, RANGE 27 EAST, AND TOWNSHIP 11 SOUTH, RANGE 26 EAST, GILA AND SALT RIVER BASE AND MERIDIAN.	CASE NO. L00000BB-01-0118 (Case No. 118) DECISION NO: _____ (TRANSMISSION LINE)

DECISION OF THE ARIZONA POWER PLANT AND TRANSMISSION LINE SITING COMMITTEE AND CERTIFICATE OF ENVIRONMENTAL COMPATIBILITY

Pursuant to notice given, as provided by law, the Arizona Power Plant and Transmission Line Siting Committee ("Committee") held public hearings at the Best Western Plaza, 1100 West Rex Allen Drive, Willcox, Arizona on October 11-12, 2001, and at the Embassy Suites, 1515 North 44th

Street, Phoenix, Arizona on December 10-11, 2001, in conformance with the requirements of Arizona Revised Statutes §40-360 et. seq., for the purpose of receiving evidence and deliberating upon the Application of Bowie Power Station, L.L.C. and its assigns ("Applicant") for a Certificate of Environmental Compatibility ("Certificate") in the above-captioned case.

The following members and designees of members of the Committee were present for all or portions of the evidentiary presentation during the aforesaid hearings and deliberations and vote on the Application:

Laurie A. Woodall	Chair, and Designee for Arizona Attorney General
Ray Williamson	Designee for Chairman of Arizona Corporation Commission
Mark McWhirter	Designee for Director of Energy Office of Arizona Department of Commerce
Richard Tobin	Designee for Director of Arizona Department of Environmental Quality
Jeff McGuire	Appointed Member
Mike Palmer	Appointed Member
A. Wayne Smith	Appointed Member
Sandie Smith	Appointed Member
Margaret Trujillo	Appointed Member
Mike Whalen	Appointed Member

The Applicant was represented by Lawrence V. Robertson, Jr. The Arizona Corporation Commission ("Commission") staff was represented by Jason B. Gellman. Wayne Bryant appeared on his own behalf as an individual intervenor.

At the conclusion of the public hearings, after consideration of (i) the Application and the evidence presented during the public hearings, (ii) the closing arguments of the parties, and (iii) the legal requirements of Arizona Revised Statutes §40-360 through §40-360.13 and A.A.C. R14-3-213, upon motion duly made and seconded, by a ____ vote the Committee voted to grant the Applicant the following Certificate.

Applicant is hereby granted a Certificate to site and construct the following facilities, as requested in the Application: (i) a double-circuit 345 kV transmission line, which shall interconnect Applicant's Bowie Power Station facilities with the Western Systems Coordinating Council ("WSCC") transmission grid at Tucson Electric Power Company's ("TEP") 345 kV Greenlee-Vail transmission line and Arizona Electric Power Company's ("AEPCO") 230 kV Red Tail-Dos Condados Transmission Line; and (ii) the new Willow 345/230 kV switchyard [Sec.14, T11S, R26E, G&SRB&M], through which the aforesaid interconnections will be accomplished. As testified to by the Applicant during the public hearings, electric power and energy produced at the Bowie Power Station are intended primarily to serve Southeastern Arizona markets.

The double-circuit 345 kV transmission line hereby authorized shall originate at Applicant's Bowie Power Station and follow the route proposed by Applicant in its Application for a distance of approximately 14.3 miles to the point of interconnection with the proposed Willow switchyard. In that regard, Applicant is further authorized to use a 2500' wide corridor within which it will

ultimately acquire up to a 250' wide right-of-way for purposes of siting and construction of the line. Exhibit "A" to this Decision and Certificate sets forth a generalized narrative legal description of the routing hereby approved for the double-circuit 345 kV transmission line. Exhibit "B", as attached hereto, consists of a map depicting the aforementioned 345 kV transmission line corridor.

The authorized double- circuit 345 kV transmission line shall be designed and constructed on single-pole or monopole structures. The monopole structures shall consist of dulled galvanized steel. The conductors shall be non-specular. The spans between the transmission structures shall vary in distance from 800' to 1100' depending upon conductor size, terrain and environmental mitigation conditions at a given location.

The details of the aforementioned interconnections shall be the subject of contractual arrangements to be entered into between the Applicant and TEP, and the Applicant and AEPCO, respectively.

This Certificate is further granted upon the following conditions.

1. Applicant shall comply with all existing applicable air and water pollution control standards and regulations, and with all existing applicable ordinances, master plans and regulations of the State of Arizona, Cochise County and Graham County, the United States of America, and any other governmental entities having jurisdiction.

2. A) Applicant shall make every reasonable effort to identify and correct, on a case-specific basis, all complaints of interference with radio or television signals from operation of the lines and related facilities. In addition to any transmission repairs, and depending upon the circumstances, the relevant

corrective actions may include, adjusting or modifying receivers, adjusting or repairing, replacing or adding antennas, antenna signal amplifiers, filters, lead-in cables, or other corrective actions.

B) Applicant shall maintain written records for a period of 5 years of all complaints of radio or television interference attributable to operation of the lines, together with the corrective action taken in response to each complaint. All complaints shall be recorded to include notations on the corrective action taken. Complaints not leading to a specific action or for which there was no resolution should be noted and explained. The record shall be signed by the Project owner and also the complainant, if possible, to indicate concurrence with the corrective action or agreement with the justification for a lack of action.

C) Applicant shall advise interested persons how they may express concerns or submit complaints to Applicant or the Commission when they believe the transmission line and related facilities herein authorized are creating noise in excess of applicable HUD standards or causing interference with communications signals in excess of applicable FCC standards. Such complaints as may be filed with the Commission shall be processed pursuant to those provisions of A.A.C. R14-2-212 (A) and (C) applicable to service disputes.

3. Within 45 days of securing complete easements or rights-of-way, for the entire alignment of the transmission lines hereby authorized, Applicant shall erect and thereafter maintain signs providing public notice that such easements and rights-of-way are the site of future transmission lines. Such signs shall be (i) no smaller than a standard highway information sign, and (ii) prominently placed at reasonable locations in close proximity to the proposed centerline of the transmission alignments which are accessible to the public. Further, such signs shall advise:

A) that the site has been approved for the construction of Project facilities, including a 345 kV transmission line, as applicable to the individual site;

B) the expected date of completion of the Project facilities; and

C) a phone number for public information regarding the Project.

In the event that the Project requires an extension of the term of this Certificate prior to completion of construction, Applicant shall use reasonable means to directly notify all landowners and residents within a one mile radius of the Project facilities of the time and place of the proceeding in which the Commission shall consider such request for extension.

4. A) Applicant shall continue to consult with the Arizona State Historic Preservation Office ("SHPO") and the Arizona State Land Department concerning the identification and treatment of those cultural resources, if any, situated within the area of potential effect from the transmission lines. Applicant shall comply with existing state laws concerning the treatment of cultural resources on private and state land, including A.R.S. 41-841 to 41-846, A.R.S. 41-861 to 41-864, and A.R.S. 41-865.

B) In addition, Applicant's construction contract(s) for the transmission lines shall include a provision that (i) Applicant shall cooperate with SHPO to develop and implement a mitigation plan, and (ii) an archaeologist permitted by the Arizona State Museum shall conduct on-site monitoring during construction. Further, to the extent applicable, Applicant shall adhere to and implement the mitigation measures suggested in SHPO's August 14, 2001, letter to the Chairman of the Siting Committee, which was received into evidence as Exhibit No. C-3.

C) After construction, Applicant shall allow Arizona Site Stewards, a volunteer-staffed SHPO program, to periodically inspect any archaeological or cultural resource sites then existing within transmission corridors controlled by Applicant for vandalism or damage.

5. A) In connection with the final design, routing and construction of the transmission lines, Applicant shall, wherever feasible utilize the following general criteria: use existing or overland access; minimize vegetation clearing and ground disturbance; revegetate or restore areas of construction disturbance; use dulled, monopole transmission structures; and, if necessary, complete Native Plant Inventory and develop plant salvage program prior to construction.

B) In addition, before construction of the transmission facilities may commence, Applicant shall file a construction mitigation and restoration plan with the

Commission's Docket Control section. The goals of the plan shall be to avoid environmental impacts where practicable; and where impacts are unavoidable, to minimize such impacts and focus on-site preparation to facilitate the natural process of revegetation. Other key elements of the plan shall include the following:

(1) emphasize final site preparation to encourage natural revegetation;

(2) avoid (i.e. preserve), where practicable, mature native trees;

(3) stipulating maximum construction corridor width, preserve topsoil and plant materials from the right-of-way before grading, and respread over the right-of-way after construction is complete;

(4) imprint the restored right-of-way, and provide indentations to catch seed and water;

(5) implement best management practices to protect the soil;

(6) apply restoration methods that have been shown to work in the desert environment;

(7) prevent the spread of noxious weeds or other undesirable species; and

(8) implement measures to discourage unauthorized off-highway vehicle use of right-of-way.

Within one year of completion of the Project, Applicant shall rehabilitate to its original state any area disturbed by construction of the Project, except for any road that may be necessary to access the transmission lines for maintenance and repair.

(C) The edge of each transmission line structure shall be offset at least 100' from the edge of any natural gas pipeline(s) rights-of-way, if any, which the transmission line(s) may parallel.

6. Applicant shall be responsible for arranging that all field personnel involved in the Project receive training as to proper ingress, egress and on-site working protocol for environmentally sensitive areas and activities. Contractors employing such field personnel shall maintain records documenting that the personnel have received such training.

7. Prior to construction of any Project transmission facilities, Applicant shall provide the Commission with copies of any Agreement(s) it enters into with the entity or entities it selects to own and operate the 345 kV transmission facilities. Such Agreement(s) shall be filed with the Commission within 30 days of execution of such Agreement(s).

8. Prior to construction of any Project transmission facilities, Applicant shall provide the Commission with copies of the transmission interconnection agreement(s) it ultimately enters into with any transmission provider(s) with whom it is interconnecting within 30 days of execution of such agreement(s).

9. Applicant shall continue to participate in good faith in State and regional transmission study forums, including the Central Arizona Transmission Study, to identify and encourage expedient implementation of transmission enhancements to reliably deliver power from the Project through the WSCC transmission grid.

10. This authorization to construct the aforementioned facilities shall expire five (5) years from the date this Certificate is approved by the Commission, unless construction is completed to the point that the 345 kV transmission line is capable of operating by that time; provided, however,

that prior to such expiration Applicant may request that the Commission extend this time limitation; and, provided further that, in any event, Applicant shall complete construction of the aforementioned facilities prior to the date the Bowie Power Station is ready for operation.

GRANTED this _____ day of _____, 2001.

Arizona Power Plant and Transmission Line
Siting Committee

By: _____
Laurie A. Woodall, Chair

Decision No. _____

Copy of the foregoing sent via
electronic mail this ____day of
December, 2001, to:

Laurie Woodall, Chair
Arizona Power Plant and
Transmission Line Siting Committee
1275 W. Washington
Phoenix, Arizona 85007

Jason D. Gellman, Attorney
Arizona Corporation Commission
1200 W. Washington Street
Phoenix, AZ 85007

Wayne Bryant
2475 East Water Street
Tucson AZ 85719-3455

_____

EXHIBIT
Admitted
A-14

In anticipation of the impact of the Project upon the demand for local public services, and prior to the commencement of construction, Applicant shall do the following:

A. Donate sufficient funds to the Bowie Fire District ("Fire District") as a capital outlay to enable it to acquire, through purchase or lease, an additional emergency services vehicle, with the manner of acquisition to be determined by the District. In addition, funds will be provided to assist the District to train its personnel and/or volunteers in emergency response and the handling of hazardous materials.

B. Donate to the Bowie School District ("District") such additional classrooms and portable classrooms, together with related utility hook-ups, in the event the Superintendent of the District concludes that formally adopted student-teacher ratios will be exceeded by reason of construction of Project facilities.

C. Make arrangements with high schools in the Bowie and Willcox area to support science and vocational academic and training programs.

D. Make arrangements that state and local employment agencies be consulted in connection with the hiring of employees for the construction and operation of Project facilities.

E. Make arrangements with Cochise County to address and resolve traffic control problems and concerns, including consideration of paving roads, adding traffic lights and/or staggering Project work shift changes.

THE STATE OF ARIZONA
GAME AND FISH DEPARTMENT
2221 WEST GREENWAY ROAD, PHOENIX, AZ 85023-4399
(602) 942-3000 • WWW.AZGFD.COM

GOVERNOR
JANE DEE HULL
COMMISSIONERS
CHAIRMAN, DENNIS D. MANNING, ALPINE
MICHAEL M. GOLIGHTLY, FLAGSTAFF
JOE CARTER, SAFFORD
SUSAN E. CHILTON, ARIVACA
W. HAYS GILSTRAP, PHOENIX
DIRECTOR
DUANE L. SHROUFE
DEPUTY DIRECTOR
STEVE K. FERRELL

December 5, 2001

Ms. Laurie Woodall, Chairman
Power Plant and Transmission Line Siting Committee
Office of the Attorney General
1275 West Washington
Phoenix, Arizona 85007

Re: Bowie Power Station Project

Dear Ms. Woodall

The Arizona Game and Fish Department (Department) has reviewed the application for two Certificates of Environmental Compatibility (CEC) for the Bowie Power Station project. One CEC is requested for the construction of a 1,000-megawatt combined-cycle power plant. The other CEC is for a double-circuit 345kv transmission line and switchyard. The Department provides the following comments for the Power Plant and Transmission Line Siting Committee's consideration.

The Department understands that the proposed power plant will include a zero-discharge system to dispose of cooling tower blow-down wastewater. The wastewater will be directed to two 30-acre evaporation ponds in proximity to the generating facility. Based on the location of this facility (southeastern Arizona), the design of evaporation ponds, and the potential quality of the wastewater, the Department is concerned about negative impacts to migratory birds, such as waterfowl and sandhill cranes, which may be attracted to the ponds.

Location of Power Plant

The Sulphur Springs Valley supports an annual population of 21,000 wintering sandhill cranes, as well as other populations of migratory waterfowl. Based on Department surveys, sandhill cranes have been documented at the Willcox Playa, Crane Lake, Whitewater Draw Wildlife Area, the Safford Valley-Duncan area, and the Bonita area (attached). Southeastern Arizona provides valuable habitats for migratory birds and wintering populations of sandhill cranes due to the presence of agriculture, along with the availability of suitable roosting habitat. This facility, if constructed in Southeastern Arizona, would likely attract migratory birds.

Evaporation Ponds

As proposed, the evaporation ponds will be constructed two feet deep over an area of approximately 60 acres. In Arizona's dry climate, evaporation ponds and any other open water sources generally attract wildlife. The depth of the evaporation ponds will provide a shallow foraging area and encourage use by waterfowl, shorebirds and other migratory birds that use shallow water to feed and/or roost.

EXHIBIT
Admitted
A-15

Ms. Laurie Woodall
December 5, 2001
2

Quality of Wastewater in Evaporation Ponds

As a result of the cooling and evaporation process, wastewater from power plants are typically saline, and contain various elements and chemical compounds. Elements, such as Selenium, typically occur in evaporation ponds and have been found to negatively affect survival of young birds.

The Department recommends that the applicant consider incorporating the following measures into the project design to minimize potential negative impacts to migratory birds:

1. Locate the ponds close to the power plant and associated facilities to deter use by migratory birds. Also, design the ponds to limit or restrict use by migratory birds, such as constructing deeper ponds (minimum 4 feet) with steeper sides to prevent vegetation from becoming established and restricting use by wading birds. The Department can assist in the design and placement of the ponds.

2. If monitoring indicates use by migratory birds at the evaporation ponds, we recommend developing alternate (off-site) wetland habitats to provide foraging and loafing areas for migratory birds.

The Department can work with the applicant to develop appropriate mitigation to minimize adverse impacts to wildlife resources. We appreciate the opportunity to review this CEC application. Please contact Bob Broscheid, Project Evaluation Program Supervisor, at (602) 789-3605 if you have any questions regarding this letter.

Sincerely,

John Kennedy
Habitat Branch Chief

cc: Gerry Perry, Regional Supervisor, Region V, Tucson
Bob Broscheid Project Evaluation Program Supervisor ✓
Sam Lawry, Migratory Bird Supervisor, Game Branch
E. Linwood Smith, Biological Services Manager, Environmental Planning Group

EXHIBIT A

Legal Description: Proposed Route of Bowie 345kV Transmission Line

As shown on General Corridor Map (Exhibit B), a strip of land 2,500 feet in width and being located in Cochise and Graham Counties, Arizona, the centerline of said strip of land being described as follows:

Beginning at the Northwest boundary of the Bowie Power Station's 345kV switchyard, located in the SE ¼ of the NE ¼ of Section 29, Township 12 South, Range 28 East, Gila and Salt River Base and Meridian, Cochise County Arizona, said point being located at Latitude 32°21'54"N, Longitude 109°30'8"W;

Thence Northwesterly 959 feet to a point located in the NE ¼ of the NE ¼ of Section 29, T12S, R28E at Latitude 32°22'2"N, Longitude 109°30'13"W;

Thence North-northwesterly paralleling the Arizona Eastern Railroad 18,965 feet to a point located in the NE ¼ of the SE ¼ of Section 6, T12S, R28E, Graham County, Arizona, at Latitude 32°25'3"N, Longitude 109°31'11"W;

Thence Northwesterly crossing the Arizona Eastern Railroad 13,653 feet to a point located in the SE ¼ of the SE ¼ of Section 26, T11S, R27E at Latitude 32°26'31"N, Longitude 109°33'12"W;

Thence Westerly 11,901 feet to a point located in the SW ¼ of the SE ¼ of Section 28, T11S, R27E at Latitude 32°26'29"N, Longitude 109°35'31"W;

Thence West-northwesterly 6,079 feet to a point located in the NW ¼ of the SE ¼ of Section 29, T11S, R27E at Latitude 32°26'46"N, Longitude 109°36'39"W;

Thence Westerly 11,000 feet to a point in the NE ¼ of the SW ¼ of Section 25, T11S, R26E at Latitude 32°26'47"N, Longitude 109°38'47"W;

Thence Northwesterly 10,938 feet to a point in the SE ¼ of the SW ¼ of Section 14, T11S, R26E at Latitude 32°28'20"N, Longitude 109°39'52"W;

Thence West-northwesterly to a point in the SW ¼ of Section 14, T11S, R26E; said point being the point of terminus at the proposed interconnection of the Bowie 345kV transmission line with either or both the 345kV Springerville-Vail and 345kV Greenlee-Vail transmission lines at or near the proposed Willow Switchyard (substation) site.

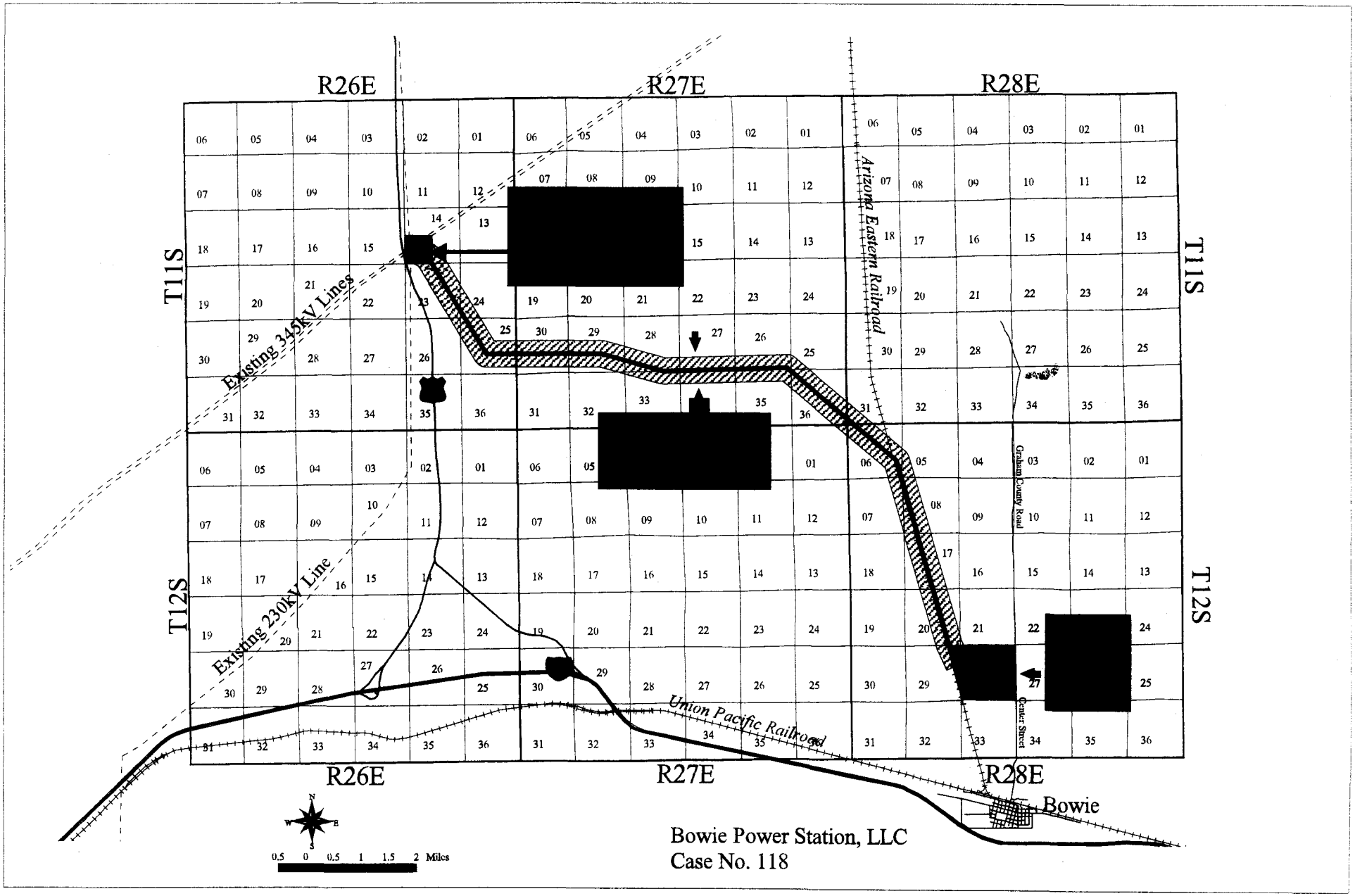
Proposed Willow Switchyard (substation)

The proposed Willow Switchyard will be located on a parcel of land of approximately 23 acres within the SW ¼ of Section 14, Township 11 South, Range 26 East, Gila and Salt River Base and Meridian, Graham County, Arizona.

EXHIBIT
Admitted
A-17

EXHIBIT B

Bowie 345kV Transmission Line
General Corridor Map



Lawrence V. Robertson, Jr. (001709)
MUNGER CHADWICK, P.L.C.
National Bank Plaza
333 N. Wilmot, Suite 300
Tucson, Arizona 85711
(520) 721-1900; Facsimile (520) 747-1550
E-Mail: lvrobertson@mungerchadwick.com
Attorneys for: Bowie Power Station, L.L.C.

BEFORE THE ARIZONA POWER PLANT AND

TRANSMISSION LINE SITING COMMITTEE

IN THE MATTER OF THE APPLICATION OF BOWIE POWER STATION, LLC, IN CONFORMANCE WITH THE REQUIREMENTS OF ARIZONA REVISED STATUTES 40-360.03 AND 40-360.06, FOR TWO CERTIFICATES OF ENVIRONMENTAL COMPATIBILITY AUTHORIZING CONSTRUCTION OF A NOMINAL 1,000 MEGAWATT NATURAL GAS-FIRED, COMBINED-CYCLE POWER PLANT, 345KV and 345KV/230KV SWITCHYARDS, 345KV DOUBLE-CIRCUIT TRANSMISSION LINE AND 230KV INTERCONNECTION AND RELATED FACILITIES IN COCHISE AND GRAHAM COUNTIES, ARIZONA. THE PROPOSED POWER STATION SITE IS LOCATED IN SECTIONS 28 AND 29, TOWNSHIP 12 SOUTH, RANGE 28 EAST, AND THE PROPOSED TRANSMISSION LINE ROUTE IS LOCATED IN TOWNSHIP 12 SOUTH, RANGE 28 EAST, TOWNSHIP 11 SOUTH, RANGE 28 EAST, TOWNSHIP 11 SOUTH, RANGE 27 EAST, AND TOWNSHIP 11 SOUTH, RANGE 26 EAST, GILA AND SALT RIVER BASE AND MERIDIAN.	CASE NO. L00000BB-01-0118 (Case No. 118) DECISION NO. _____ (POWER PLANT)

December 10, 2001

EXHIBIT
Admitted
A-18

DECISION OF THE ARIZONA POWER PLANT AND TRANSMISSION LINE SITING COMMITTEE AND CERTIFICATE OF ENVIRONMENTAL COMPATIBILITY

Pursuant to notice given, as provided by law, the Arizona Power Plant and Transmission Line Siting Committee ("Committee") held public hearings at the Best Western Plaza, 1100 Rex Allen Drive, Willcox, Arizona on October 11-12, 2001, and at the Embassy Suites, 1515 North 44th Street, Phoenix, Arizona on December 10-11, 2001, in conformance with the requirements of Arizona Revised Statutes §40-360 et. seq., for the purpose of receiving evidence and deliberating upon the Application, of Bowie Power Station, L.L.C. and its assigns ("Applicant") for a Certificate of Environmental Compatibility ("Certificate") in the above-captioned case.

The following members and designees of members of the Committee were present for the evidentiary presentation during all or portions of the aforesaid hearings and/or deliberation and vote on the Application:

Laurie A. Woodall	Chair, and Designee for Arizona Attorney General
Ray Williamson	Designee for Chairman of Arizona Corporation Commission
Mark McWhirter	Designee for Director of Energy Office of Arizona Department of Commerce
Patrick Schiffer	Designee for Director of Arizona Department of Water Resources
Richard Tobin	Designee for Director of Arizona Department of Environmental Quality
Jeff McGuire	Appointed Member
Mike Palmer	Appointed Member
A. Wayne Smith	Appointed Member
Sandie Smith	Appointed Member
Margaret Trujillo	Appointed Member
Mike Whalen	Appointed Member

The Applicant was represented by Lawrence V. Robertson, Junior. The Arizona Corporation Commission ("Commission") staff was represented by Jason D. Gellman. Wayne Bryant appeared on his own behalf as an individual intervenor.

At the conclusion of the public hearings, after consideration of (i) the Application and the evidence presented during the public hearings, (ii) the closing arguments of the parties, and (iii) the legal requirements of Arizona Revised Statutes §40-360 through §40-360.13 and A.A.C. R14-3-213, upon motion duly made and seconded, by a ____ vote the Committee voted to grant the Applicant the following Certificate.

Applicant is hereby granted a Certificate to site and construct the following facilities ("Project"):

> A natural gas fired, combined cycle electric generating plant with an operating capability not to exceed a nominal site rating of 1000 megawatts (MW). The facilities shall consist of up to two (2) power blocks, each rated up to 500 MW nominal. Each power block shall consist of (i) two combustion turbine generators (CTG), (ii) two heat recovery steam generators (HRSG) and (iii) one steam turbine electric generator. The plant design may also incorporate supplementary or duct-firing of the HRSG for a given power block. The duct-firing design would be incorporated in the HRSG's. The power plant and supporting infrastructure shall be located in Section 28 and a portion of Section 29, Township 12 South, Range 28 East, G&SRB&M.

The supporting power plant infrastructure shall include (i) an air pollution control system, (ii) water handling and treatment facilities, (iii) fuel system, (iv) instrumentation and control system, (v) switchyard and electrical interconnection(s), (vi) chemical and petroleum product storage facilities, (vii) vehicular access facilities, (viii) evaporation ponds, and (ix) other site improvements. Each of these infrastructure components is described in some detail in the Application.

In connection with the design and construction of Project facilities, Applicant shall use low profile structures, moderate stacks, neutral colors, compatible landscaping and low intensity directed lighting for the power plant. The transmission facilities shall include the use of non-reflective conductors and towers. In addition, Applicant shall use a zero discharge system for cooling water, subject to existing regulatory requirements. Further, Applicant shall operate the evaporation ponds so that any salt residue(s) contained therein shall not cause damage to crops

grown on fields adjacent to the Project site.

This Certificate is further granted upon the following conditions.

1. Applicant shall comply with all existing applicable air and water pollution control standards and regulations, and with all existing applicable ordinances, master plans and regulations of the State of Arizona, Cochise County and Graham County, the United States of America, and any other governmental entities having jurisdiction, including but not limited to the following:

A. all applicable zoning stipulations and conditions, including but not limited to landscaping and dust control requirements and/or approvals;

B. all applicable air quality control standards, approvals, permit conditions and requirements of the Arizona Department of Environmental Quality ("ADEQ") and/or other State of Arizona or Federal agencies having jurisdiction, and Applicant shall install and operate selective catalytic reduction at the level determined by ADEQ.

C. all applicable water use and conservation requirements of the Arizona Department of Water Resources ("ADWR").

D. all applicable water use and discharge requirements of ADEQ.

E. all applicable noise control standards, and during normal operations the project shall not exceed applicable (i) HUD or EPA residential noise guidelines or (ii) OSHA worker safety noise standards; and

F. all applicable regulations and permits governing storage and handling of chemical and petroleum products;

In connection with approvals of or permits for Project facilities to be issued by Cochise County or Graham County, Applicant shall attach a copy of this Decision and Certificate to any applications or requests it submits to such counties. A courtesy copy will also be provided to the community of Bowie and the City of Wilcox.

2. In anticipation of the impact of the Project upon the demand for local services, and prior to the commencement of construction, Applicant shall do the following:

A. Donate to the Bowie Fire District ("Fire District") as a capital outlay to enable it to acquire, through purchase or lease, an additional emergency services vehicle, with the manner of acquisition to be determined by the

Fire District to train its personnel and/or volunteers in emergency response and the handling of hazardous materials.

B. Donate to the Bowie School District ("School District") such additional classrooms and portable classrooms, together with related utility hook-ups, in the event the Superintendent of the School District concludes that formally adopted student-teacher ratios will be exceeded by reason of the construction of Project facilities.

C. Make arrangements with high schools in the Bowie and Willcox area to support science and vocational academic and training programs.

D. Make arrangements that state and local employment agencies be consulted in connection with the hiring of employees for the construction and operation of Project facilities.

E. Make arrangements with Cochise County to address and resolve traffic control problems and concerns, including consideration of paving roads, adding traffic lights and/or staggering Project construction work shift changes.

3. In connection with the engineering, design, construction, operation and maintenance of the Project facilities, Applicant and its consultants and contractors shall apply recognized and accepted geotechnical engineering and civil engineering standards and practices. In addition, Applicant shall implement the Ground Subsidence and Earth Fissure Monitoring Program agreed to between Applicant and the Arizona Department of Water Resources, which was received into evidence as Exhibit No. A-11.

A. In the event of the occurrence of an "alert condition," as defined in the Monitoring Program, Applicant, ADWR, Cochise County and the United States Geological Survey ("USGS") shall confer as to the investigative and/or mitigation program(s), if any, to be undertaken in response to such "alert condition." In the event Applicant, ADWR, Cochise County and USGS are unable to agree as to the program(s) or course(s) of action to be undertaken, Applicant shall refer the matter to the Commission for a hearing and decision to determine the investigative and/or mitigation programs, if any, to be undertaken in response to such "alert condition."

B. Commencing with the fifth year of commercial operation of the initial power block of the Project, Applicant shall annually contribute One Hundred Thousand Dollars ($100,000) to a Subsidence Mitigation Fund ("Fund") to be established and maintained by Applicant at a national or state-chartered bank. Such contribution obligation shall be suspended whenever the balance in the Fund reaches the principal amount of Five Hundred Thousand Dollars ($500,000). Interest earned on the Fund shall belong to Applicant.

C. Persons claiming property damage as a result of ground subsidence allegedly directly attributable to Project operation may submit a claim for mitigation payment to Applicant. Applicant shall investigate the circumstances surrounding the claim and make a determination, if possible, as to the cause of the claimant's alleged property damage. If it is determined that the damage in question has been caused by Project operations, funds shall be disbursed from the Fund to compensate claimant for the amount of damage determined to be directly attributable to the Project. If the cause or amount of the alleged damage is in dispute, Applicant agrees to submit the matter to binding arbitration with the American Arbitration Association, if the person claiming damage agrees

D. The Subsidence Mitigation Fund account shall be maintained for three (3) years after the end of the Project's economic life, as determined by Applicant. Once the three (3) year period has passed, the account shall be closed, and any remaining funds shall be disbursed back to Applicant.

4. Applicant shall prepare a plan for shutdown, decommissioning and cleanup of the plant site that shall be filed with the Commission's Docket Control section within one year of beginning construction. Such plan shall provide for a return of the power plant site to original pre-construction grade elevation. In that regard, the Committee recommends that Applicant work with Cochise County and/or any other local governing body with jurisdiction over the plant site to ensure that such plan is reasonable, and is followed or amended as needed.

5. Applicant, its affiliates, successors and assignees may withdraw groundwater for electrical generation and related uses, to include but not limited to landscape maintenance, in an

amount not to exceed 55,000 acre-feet per ten-year period as determined by using a ten-year rolling average commencing on the date the Bowie Power Station first begins withdrawing groundwater in connection with the Project.

6. Applicant's plant interconnection must satisfy the Western Systems Coordinating Council's ("WSCC") single contingency outage criteria (N-1) and all applicable local utility planning criteria without reliance on remedial action such as reducing generator output, generator unit tripping or load shedding.

7. Prior to construction of any facilities, Applicant must provide the Commission with technical study evidence that sufficient transmission capacity exists to accommodate the full output of the plant and that the full output of the plant shall not compromise the reliable operation of the interconnected transmission system. The technical studies shall include a power flow and stability analysis report showing the effect of the plant on the existing Arizona electric transmission system. The technical study report(s) shall document both physical flow capability as well as contractual schedule capability to deliver full plant output to its intended market. In addition, Applicant must provide the Commission with updates to the information required in this condition not more than one year and not less than three months prior to commercial operation of the plant. Prior to commencing operation of a given power block, transmission facilities improvements necessary to deliver the output of that power block to intended markets, as identified in the aforesaid technical studies, shall have been completed.

8. Applicant shall become and remain a member of the WSCC, or its successor, and file an executed copy of its WSCC Reliability Management System ("RMS") Generator Agreement with the Commission. Membership by an affiliate of Applicant satisfies this condition only if Applicant is bound by the affiliate's WSCC membership.

9. Applicant shall apply to become, and if accepted, thereafter remain a member of the Southwest Reserve Sharing Group or its successor, thereby making its units available for reserve sharing purposes, subject to competitive pricing.

10. Applicant shall continue to participate in good faith in state and regional transmission study forums to identify and encourage expedient implementation of transmission enhancements, including transmission cost participation as appropriate, to reliably deliver power from the Project throughout the WSCC grid in a reliable manner.

11. Applicant shall first offer wholesale power purchase opportunities to credit-

worthy Arizona load-serving entities and to credit-worthy marketers providing service to those Arizona load-serving entities.

12. Applicant shall offer for Ancillary Services, in order to comply with WSCC RMS requirements, a total of up to 10% of its total plant capacity to (A) the local Control Area with which it is interconnected and (B) Arizona's regional ancillary service market, (i) once a Regional Transmission Organization (RTO) is declared operational by FERC order, and (ii) until such time that an RTO is so declared, to a regional reserve sharing pool.

13. Pursuant to applicable Federal Energy Regulatory Commission ("FERC"), regulations, Applicant shall not knowingly withhold its capacity from the market for reasons other than a forced outage or pre-announced planned outage.

14. Within 30 days of the Commission decision authorizing construction of the Project, Applicant shall erect and maintain at the site a sign of not less than 4 feet by 8 feet dimensions, advising:

A. that the site has been approved for the construction of a 1000 megawatt (nominal) generating facility;

B. the expected date of completion of the Project; and

C. phone number for public information regarding the Project.

In the event that Applicant requests an extension of the term of the Certificate prior to completion of the construction, Applicant shall use reasonable means to directly notify all landowners and residents within one-mile radius of the Project of the time and place of the proceeding in which the Commission shall consider such request for extension. Applicant shall also provide notice of such extension to Cochise County, Graham County, the community of Bowie and the City of Wilcox.

15. Applicant shall pursue all necessary steps to ensure a reliable supply and delivery of natural gas for the generating facility.

16. In connection with the construction of the Project, Applicant shall use commercially reasonable efforts, where feasible, to give due consideration to use of qualified Arizona contractors. In addition, Applicant shall encourage the hiring of qualified local employees in connection with construction and operation of the Project facilities.

17. Applicant shall participate in workshops to commence during the year 2002 which shall address both long term and short-term gas transportation reliability and capacity

issues within the State of Arizona. Applicant shall work with other participants on an ongoing basis to develop alternative solutions to these gas pipeline issues.

18. Within five days of Commission approval of this CEC, Applicant shall request in writing that El Paso Natural Gas Company ("El Paso") provide Applicant with a written report describing the operational integrity of El Paso's Southern System facilities through the Bowie and San Simon areas. Such request shall include:

A. a request for information regarding inspection, replacement and/or repairs performed on this segment of El Paso's pipeline facilities since 1996 and those planned through 2006; and

B. an assessment of subsidence impacts on the integrity of this segment of pipeline over its full cycle, together with any mitigation steps taken to date or planned in the future.

Applicant shall file El Paso's response under this docket with the Commission's Docket Control. Should El Paso not respond within thirty (30) days, Applicant shall docket a copy of Applicant's request with an advisory of El Paso's failure to respond. In either event, Applicant's responsibility hereunder shall terminate once it has filed El Paso's response or Applicant's advisory of El Paso's failure to respond.

19. In conjunction with its construction of the Project facilities, Applicant shall implement the Landscape Plan set forth at Exhibit B-2 to the Application [Ex. #A-1].

20. Applicant shall work with the United States Fish and Wildlife Service and the Arizona Game and Fish Department to develop screening or other methods to protect wildlife from harm at the Project's evaporation ponds.

21. This authorization to site and construct the Project facilities shall expire five (5) years from the date the Certificate is approved by the Commission unless construction is completed and the plant is in operation. If construction on a power block has not begun before expiration of the five-year limit, Applicant shall no longer be authorized to begin construction on such power block. However, before such expiration Applicant may request that the Commission extend this time limitation.

GRANTED this _____ day of _____, 2001.

Arizona Power Plant and Transmission Line
Siting Committee

By: _____
Laurie A. Woodall, Chair

Copy of the foregoing e-mailed
this ____day of December, 2001, to:

Laurie Woodall, Chair
Arizona Power Plant and
Transmission Line Siting Committee
1275 W. Washington
Phoenix, Arizona 85007

Jason D. Gellman, Attorney
Arizona Corporation Commission
1200 W. Washington Street
Phoenix, AZ 85007

Wayne Bryant
2475 East Water Street
Tucson AZ 85719-3455

_____

Lawrence V. Robertson, Jr. (001709)
MUNGER CHADWICK, P.L.C.
National Bank Plaza
333 N. Wilmot, Suite 300
Tucson, Arizona 85711
(520) 721-1900; Facsimile (520) 747-1550
E-Mail: lvrobertson@mungerchadwick.com
Attorneys for: Bowie Power Station, L.L.C.

BEFORE THE ARIZONA POWER PLANT AND

TRANSMISSION LINE SITING COMMITTEE

IN THE MATTER OF THE APPLICATION OF BOWIE POWER STATION, LLC, IN CONFORMANCE WITH THE REQUIREMENTS OF ARIZONA REVISED STATUTES 40-360.03 AND 40-360.06, FOR TWO CERTIFICATES OF ENVIRONMENTAL COMPATIBILITY AUTHORIZING CONSTRUCTION OF A NOMINAL 1,000 MEGAWATT NATURAL GAS-FIRED, COMBINED-CYCLE POWER PLANT, 345KV and 345KV/230KV SWITCHYARDS, 345KV DOUBLE-CIRCUIT TRANSMISSION LINE AND 230KV INTERCONNECTION AND RELATED FACILITIES IN COCHISE AND GRAHAM COUNTIES, ARIZONA. THE PROPOSED POWER STATION SITE IS LOCATED IN SECTIONS 28 AND 29, TOWNSHIP 12 SOUTH, RANGE 28 EAST, AND THE PROPOSED TRANSMISSION LINE ROUTE IS LOCATED IN TOWNSHIP 12 SOUTH, RANGE 28 EAST, TOWNSHIP 11 SOUTH, RANGE 28 EAST, TOWNSHIP 11 SOUTH, RANGE 27 EAST, AND TOWNSHIP 11 SOUTH, RANGE 26 EAST, GILA AND SALT RIVER BASE AND MERIDIAN.	CASE NO. L00000BB-01-0118 (Case No. 118) DECISION NO. _____ (TRANSMISSION LINE)

December 10, 2001

EXHIBIT
Admitted
A-19

DECISION OF THE ARIZONA POWER PLANT AND TRANSMISSION LINE SITING COMMITTEE AND CERTIFICATE OF ENVIRONMENTAL COMPATIBILITY

Pursuant to notice given, as provided by law, the Arizona Power Plant and Transmission Line Siting Committee ("Committee") held public hearings at the Best Western Plaza, 1100 West Rex Allen Drive, Willcox, Arizona on October 11-12, 2001, and at the Embassy Suites, 1515 North 44th Street, Phoenix, Arizona on December 10-11, 2001, in conformance with the requirements of Arizona Revised Statutes §40-360 et. seq., for the purpose of receiving evidence and deliberating upon the Application of Bowie Power Station, L.L.C. and its assigns ("Applicant") for a Certificate of Environmental Compatibility ("Certificate") in the above-captioned case.

The following members and designees of members of the Committee were present for all or portions of the evidentiary presentation during the aforesaid hearings and deliberations and vote on the Application:

Laurie A. Woodall	Chair, and Designee for Arizona Attorney General
Ray Williamson	Designee for Chairman of Arizona Corporation Commission
Mark McWhirter	Designee for Director of Energy Office of Arizona Department of Commerce
Patrick Schiffer	Designee for Director of Arizona Department of Water Resources
Richard Tobin	Designee for Director of Arizona Department of Environmental Quality
Jeff McGuire	Appointed Member
Mike Palmer	Appointed Member
A. Wayne Smith	Appointed Member
Sandie Smith	Appointed Member
Margaret Trujillo	Appointed Member
Mike Whalen	Appointed Member

The Applicant was represented by Lawrence V. Robertson, Jr. The Arizona Corporation Commission ("Commission") staff was represented by Jason B. Gellman. Wayne Bryant appeared on his own behalf as an individual intervenor.

At the conclusion of the public hearings, after consideration of (i) the Application and the evidence presented during the public hearings, (ii) the closing arguments of the parties, and (iii) the legal requirements of Arizona Revised Statutes §40-360 through §40-360.13 and A.A.C. R14-3-213, upon motion duly made and seconded, by a ____ vote the Committee voted to grant the Applicant the following Certificate.

Applicant is hereby granted a Certificate to site and construct the following facilities, as requested in the Application: (i) a double-circuit 345 kV transmission line, which shall interconnect Applicant's Bowie Power Station facilities with the Western Systems Coordinating Council ("WSCC") transmission grid at Tucson Electric Power Company's ("TEP") 345 kV Greenlee-Vail transmission line and Arizona Electric Power Company's ("AEPCO") 230 kV Red Tail-Dos Condados Transmission Line; and (ii) the new Willow 345/230 kV switchyard [Sec.14, T11S, R26E, G&SRB&M], through which the aforesaid interconnections will be accomplished. As testified to by the Applicant during the public hearings, electric power and energy produced at the Bowie Power Station are intended primarily to serve Southeastern Arizona markets.

The double-circuit 345 kV transmission line hereby authorized shall originate at Applicant's Bowie Power Station and follow the route proposed by Applicant in its Application for a distance of approximately 14.3 miles to the point of interconnection with the proposed Willow switchyard. In that regard, Applicant is further authorized to use a 2500' wide corridor within which it will ultimately acquire up to a 250' wide right-of-way for purposes of siting and

construction of the line. Exhibit "A" to this Decision and Certificate sets forth a generalized narrative legal description of the routing hereby approved for the double-circuit 345 kV transmission line. Exhibit "B", as attached hereto, consists of a map depicting the aforementioned 345 kV transmission line corridor.

The authorized double- circuit 345 kV transmission line shall be designed and constructed on single-pole or monopole structures. The monopole structures shall consist of dulled galvanized steel. The conductors shall be non-specular. The spans between the transmission structures shall vary in distance from 800' to 1100' depending upon conductor size, terrain and environmental mitigation conditions at a given location.

The details of the aforementioned interconnections shall be the subject of contractual arrangements to be entered into between the Applicant and TEP, and the Applicant and AEPCO, respectively.

This Certificate is further granted upon the following conditions.

1. Applicant shall comply with all existing applicable air and water pollution control standards and regulations, and with all existing applicable ordinances, master plans and regulations of the State of Arizona, Cochise County and Graham County, the United States of America, and any other governmental entities having jurisdiction.

2. A) Applicant shall make every reasonable effort to identify and correct, on a case-specific basis, all complaints of interference with radio or television signals from operation of the lines and related facilities. In addition to any transmission repairs, and depending upon the circumstances, the relevant corrective actions may include, adjusting or modifying receivers, adjusting or repairing, replacing or adding antennas, antenna signal amplifiers,

filters, lead-in cables, or other corrective actions.

B) Applicant shall maintain written records for a period of 5 years of all complaints of radio or television interference attributable to operation of the lines, together with the corrective action taken in response to each complaint. All complaints shall be recorded to include notations on the corrective action taken. Complaints not leading to a specific action or for which there was no resolution should be noted and explained. The record shall be signed by the Project owner and also the complainant, if possible, to indicate concurrence with the corrective action or agreement with the justification for a lack of action.

C) Applicant shall advise interested persons how they may express concerns or submit complaints to Applicant or the Commission when they believe the transmission line and related facilities herein authorized are creating noise in excess of applicable HUD standards or causing interference with communications signals in excess of applicable FCC standards. Such complaints as may be filed with the Commission shall be processed pursuant to those provisions of A.A.C. R14-2-212 (A) and (C) applicable to service disputes.

3. Within 45 days of securing complete easements or rights-of-way, for the entire alignment of the transmission lines hereby authorized, Applicant shall erect and thereafter maintain signs providing public notice that such easements and rights-of-way are the site of future transmission lines. Such signs shall be (i) no smaller than a standard highway information sign, and (ii) prominently placed at reasonable locations in close proximity to

the proposed centerline of the transmission alignments which are accessible to the public. Further, such signs shall advise:

A) that the site has been approved for the construction of Project facilities, including a 345 kV transmission line, as applicable to the individual site;

B) the expected date of completion of the Project facilities; and

C) a phone number for public information regarding the Project.

In the event that the Project requires an extension of the term of this Certificate prior to completion of construction, Applicant shall use reasonable means to directly notify all landowners and residents within a one mile radius of the Project facilities of the time and place of the proceeding in which the Commission shall consider such request for extension.

4. A) Applicant shall continue to consult with the Arizona State Historic Preservation Office ("SHPO") and the Arizona State Land Department concerning the identification and treatment of those cultural resources, if any, situated within the area of potential effect from the transmission lines. Applicant shall comply with existing state laws concerning the treatment of cultural resources on private and state land, including A.R.S. 41-841 to 41-846, A.R.S. 41-861 to 41-864, and A.R.S. 41-865.

B) In addition, Applicant's construction contract(s) for the transmission lines shall include a provision that (i) Applicant shall cooperate with SHPO to develop and implement a mitigation plan, and (ii) an archaeologist permitted by the Arizona State Museum shall conduct on-site monitoring during construction. Further, to the extent applicable, Applicant shall

adhere to and implement the mitigation measures suggested in SHPO's August 14, 2001, letter to the Chairman of the Siting Committee, which was received into evidence as Exhibit No. C-3.

C) After construction, Applicant shall allow Arizona Site Stewards, a volunteer-staffed SHPO program, to periodically inspect any archaeological or cultural resource sites then existing within transmission corridors controlled by Applicant for vandalism or damage.

5. A) In connection with the final design, routing and construction of the transmission lines, Applicant shall, wherever feasible utilize the following general criteria: use existing or overland access; minimize vegetation clearing and ground disturbance; revegetate or restore areas of construction disturbance; use dulled, monopole transmission structures; and, if necessary, complete Native Plant Inventory and develop plant salvage program prior to construction.

B) In addition, before construction of the transmission facilities may commence, Applicant shall file a construction mitigation and restoration plan with the Commission's Docket Control section. The goals of the plan shall be to avoid environmental impacts where practicable; and where impacts are unavoidable, to minimize such impacts and focus on-site preparation to facilitate the natural process of revegetation. Other key elements of the plan shall include the following:

(1) emphasize final site preparation to encourage natural revegetation;

(2) avoid (i.e. preserve), where practicable, mature native trees;

(3) stipulating maximum construction corridor width, preserve topsoil and plant materials from the right-of-way before grading, and respread over the right-of-way after construction is complete;

(4) imprint the restored right-of-way, and provide indentations to catch seed and water;

(5) implement best management practices to protect the soil;

(6) apply restoration methods that have been shown to work in the desert environment;

(7) prevent the spread of noxious weeds or other undesirable species; and

(8) implement measures to discourage unauthorized off-highway vehicle use of right-of-way.

Within one year of completion of the Project, Applicant shall rehabilitate to its original state any area disturbed by construction of the Project, except for any road that may be necessary to access the transmission lines for maintenance and repair.

(C) The edge of each transmission line structure shall be offset at least 100' from the edge of any natural gas pipeline(s) rights-of-way, if any, which the transmission line(s) may parallel.

6. Applicant shall be responsible for arranging that all field personnel involved in the Project receive training as to proper ingress, egress and on-site working protocol for environmentally sensitive areas and activities. Contractors employing such field personnel shall maintain records documenting that the personnel have received such training.

7. Prior to construction of any Project transmission facilities, Applicant shall provide the Commission with copies of any Agreement(s) it enters into with the entity or entities it selects to own and operate the 345 kV transmission facilities. Such Agreement(s) shall be filed with the Commission within 30 days of execution of such Agreement(s).

8. Prior to construction of any Project transmission facilities, Applicant shall provide the Commission with copies of the transmission interconnection agreement(s) it ultimately enters into with any transmission provider(s) with whom it is interconnecting within 30 days of execution of such agreement(s).

9. Applicant shall continue to participate in good faith in State and regional transmission study forums, including the Central Arizona Transmission Study, to identify and encourage expedient implementation of transmission enhancements to reliably deliver power from the Project through the WSCC transmission grid.

10. This authorization to construct the aforementioned facilities shall expire five (5) years from the date this Certificate is approved by the Commission, unless construction is completed to the point that the 345 kV transmission line is capable of operating by that time; provided, however, that prior to such expiration Applicant may request that the Commission extend this time limitation; and, provided further that, in any event, Applicant shall complete construction of the aforementioned facilities prior to the date the Bowie Power Station is ready for operation.

GRANTED this _____ day of _____, 2001.

Arizona Power Plant and Transmission Line
Siting Committee

December 10, 2001

By: _____
Laurie A. Woodall, Chair

Decision No. _____

Copy of the foregoing sent via
electronic mail this ____day of
December, 2001, to:

Laurie Woodall, Chair
Arizona Power Plant and
Transmission Line Siting Committee
1275 W. Washington
Phoenix, Arizona 85007

Jason D. Gellman, Attorney
Arizona Corporation Commission
1200 W. Washington Street
Phoenix, AZ 85007

Wayne Bryant
2475 East Water Street
Tucson AZ 85719-3455

_____

December 10, 2001

- A groundwater level contour map and groundwater level hydrographs will be constructed detailing the groundwater level information obtained from the nine representative groundwater monitoring wells.
- Descriptions of ground subsidence trends, ground subsidence measurements, subsidence rate calculations, and subsidence contour maps.
- Earth fissure monitoring observation field reports, and photographs and maps as appropriate.
- A summary of the observations made, analysis and interpretation of the data gathered, and conclusions and recommendations pertaining to the subsequent monitoring period and, if necessary, action items to assess anomalous or unforeseen conditions.

Reports will be distributed to the following organizations:

- Cochise County Planning and Zoning Department
- Arizona Department of Water Resources
- Arizona Geological Survey
- Arizona Corporation Commission
- U.S. Geological Survey, Water Resources Branch (Tucson)

A summary of the ground subsidence monitoring report will be published and provided to the general public through the Bowie Power Station internet web site.

2.5 Alert Conditions and Contingencies

Any anomalous conditions will be reported along with an assessment of the anomalous condition relative to the safe operation of the plant, and recommendations to fully evaluate the conditions identified. Proposed alert levels for ground subsidence and earth fissures will include:

- Ground subsidence rates that substantially exceed (i) the predicted average rate of 0.072 feet per year at ground subsidence benchmarks' BOWIE1 and BOWIE2 at the Bowie Power Station, or (ii) the predicted average rate of 0.072 feet per year plus 10 percent or more, at one or more of the off-site benchmarks listed in Tables 2 and 3.

EXHIBIT
Admitted
A-20

- Field evidence of renewed activity along an existing earth fissure within a 5-mile radius of the plant site or evidence of new earth fissure activity.

The existence of an "alert condition" may be declared by Bowie Power Station, ADWR, Cochise County and/or USGS, based upon reported data prepared and provided pursuant to Section 2.4 above.

Action items in response to an identified anomalus condition will include the following:

- Develop an investigative program to evaluate the condition.
- Notify appropriate jurisdictions regarding the anomalous condition and proposed program to investigate the condition.
- Initiate the investigative program
- Based on the results of the investigation, prepare appropriate work plans and alternatives to mitigate the anomalous condition, which may include but not be limited to an increase in monitoring frequency and submittal of interim summary reports to ADWR, an evaluation and possible modification of well field operations, special inspections of sensitive power plant components, and design engineering evaluations.

If it is determined that an "alert condition" is caused (or probably caused) by the operation of Bowie Power Station, the following are examples of mitigation measures that might be considered to address the situation:

- Acquire or import water from other sources within the basin to mitigate groundwater drawdown in the project area.
- Acquisition of additional properties surrounding the Bowie property to reduce groundwater drawdown in the project area.
- Modify the operation of the power station well field.
- Modify the operation of the plant to reduce groundwater consumption.
- Other mitigation measures that may be identified.

The mitigation measure(s) selected will depend on the specific circumstances surrounding the observed "alert condition."

Applicant shall utilize in the design, construction and operation of the second 500 MW power block, solar technology for inlet cooling of both combustion turbines. Applicant shall select such technology based on, but not limited to, Applicant's evaluation of initial installed cost, operating cost, and proven performance of the technology itself. Applicant shall be released from any responsibility to revegetate land associated with installation and operation of the solar application contemplated by this condition.

EXHIBIT
Admitted
A-21

RECEIVED
NOV 1 2001
U.A. PLUMBERS & STEAMFITTERS LOCAL 141

a. Approval or extension of eligibility;
b. Discontinuance of eligibility if the county eligibility staff receives verification that the applicant:
   i. Is an inmate in a public institution or in a public mental hospital,
   ii. Does not reside in Arizona,
   iii. Is eligible for Title XIX coverage in another state or territory, or
   iv. Is deceased; and
c. Discontinuance of eligibility if the head-of-household or an adult household member submits a written request for discontinuance.

2. The county eligibility staff shall communicate a discontinuance of eligibility for any other reasons on the 16th day following the date of determination.
3. The county eligibility staff shall communicate demographic changes that do not affect eligibility on the day that the county eligibility staff verifies the change.

Historical Note
New Section adopted by final rulemaking at 5 A.A.R. 294, effective January 8, 1999 (Supp. 99-1).

R9-22-1619. Rights Following Receipt of a Notice of Denial or Discontinuance of Coverage
A member or head-of-household may take the following actions in response to an adverse action by the county eligibility staff:
1. Apply again for eligibility under this Article;
2. Appeal the denial or discontinuance under R9-22-802; or
3. Stop a proposed discontinuance by providing proof of eligibility to the county eligibility staff within 15 days after the date of the Notice of Action.

Historical Note
New Section adopted by final rulemaking at 5 A.A.R. 294, effective January 8, 1999 (Supp. 99-1).

R9-22-1620. Retroactive Coverage for MI/MN, ELIC, and SESP
The Administration or contractors shall be responsible for covered emergency medical services as defined by R9-22-102 which are provided to a MI/MN, ELIC, or SESP eligible person during the 2 days before the date that a county eligibility staff determines a person eligible and the county communicates the eligibility determination to the Administration as specified in R9-22-1618. The Administration shall not be responsible for the costs of emergency medical services that are deducted from the household's annual income under R9-22-1626.

Historical Note
New Section adopted by final rulemaking at 5 A.A.R. 294, effective January 8, 1999 (Supp. 99-1).

R9-22-1621. Reserved

R9-22-1622. Verification of Information for MI/MN Eligibility
A. Verification. The applicant shall provide the county eligibility staff with verification of all information necessary to complete the determination of eligibility in the initial application process or at the time of a redetermination or interim change.
   1. The county eligibility staff shall not approve an applicant's eligibility until all required verification is received.
   2. The county eligibility staff shall offer to assist the applicant in obtaining verification and shall provide assistance if authorized by the applicant.
B. Procedure for obtaining verification. Except where otherwise indicated in this Article, the county eligibility staff shall adhere to the following procedure for requesting and obtaining verification:
   1. The county eligibility staff shall 1st request documented verification that is available at the time of the interview. Documented verification is evidence in written form provided on an official document from an applicant qualified to have knowledge of the information provided. Documented verification shall be secured from the applicant or from a 3rd-party.
   2. If documented information is not immediately available at the time of the interview, the county eligibility staff shall accept collateral verification. Collateral verification is information presented other than on an official document and obtained from a person who has knowledge of the information. The applicant shall identify potential sources of collateral verification for each item of information.
   3. If sources of collateral verification are not available, the county eligibility staff shall request that the applicant obtain documented information that is not immediately available at the time of the interview.
   4. If the county eligibility staff and the applicant exhaust all potential sources of collateral and documented verification and determine that documented and collateral verification are not available, the county eligibility staff shall accept a written declaration as verification. The written declaration shall be signed and dated by the head-of-household.
      a. Verification is not available if:
         i. A record does not exist for the information that needs to be verified, or
         ii. A record exists but the person or entity able to provide the information refuses to provide it to both the county eligibility staff and the applicant.
      b. Verification that is available only upon payment of a fee is not considered unavailable.
C. Reverification waiver. The county eligibility staff shall not reverify information for determinations or redeterminations of eligibility if information that is not subject to change is contained in case records and verified under this Article.
D. Resolution of inconsistencies required. The county eligibility staff shall reconcile any inconsistencies between the verified information and the case file before approving eligibility unless the inconsistencies have no effect on the eligibility determination.

Historical Note
New Section adopted by final rulemaking at 5 A.A.R. 294, effective January 8, 1999 (Supp. 99-1).

R9-22-1623. Residence Requirements for MI/MN Eligibility
A. General Requirements. To be eligible for MI/MN coverage, an applicant shall be a resident of Arizona. An MI/MN applicant may establish Arizona residency on behalf of all members of the household by:
   1. Signing an affidavit attesting to:
      a. Current residence in Arizona and intent to remain indefinitely, and
      b. Abandonment of residency outside of Arizona; and
   2. Meeting the Arizona residency requirements under A.R.S. § 36-2903.01.
B. Residency of household groups. If the head-of-household meets the requirements of subsection (A), the county eligibility staff will consider the residency requirements met for all household members unless the county eligibility staff has evidence that:
   1. A dependent child household member may not meet the requirements of subsection (A). The head-of-household

EXHIBIT
Admitted
Bryant 1

D. The director shall adopt rules for use by the counties in determining whether an applicant is a resident of this state and of the county and is either a United States citizen, a qualified alien as prescribed in § 36–2903.03 or eligible for state assisted emergency care under § 36–2905.05. The rules shall require that state residency is not established unless the requirements of paragraphs 1 and 2 of this subsection are met or unless residency is proved pursuant to paragraph 3 of this subsection:

1. The applicant produces one of the following:

(a) A recent Arizona rent or mortgage receipt or utility bill.

(b) A current Arizona motor vehicle driver license.

(c) A current Arizona motor vehicle registration.

(d) A document showing that the applicant is employed in this state.

(e) A document showing that the applicant has registered with a public or private employment service in this state.

(f) Evidence that the applicant has enrolled the applicant's children in a school in this state.

(g) Evidence that the applicant is receiving public assistance in this state.

(h) Evidence of registration to vote in this state.

2. The applicant signs an affidavit attesting that all of the following apply to the applicant:

(a) The applicant does not own or lease a residence outside this state.

(b) The applicant does not own or lease a motor vehicle registered outside this state.

(c) The applicant is not receiving public assistance outside this state. As used in this subdivision, "public assistance" does not include unemployment insurance benefits.

(d) The applicant is actively seeking employment in this state if he is able to work and is not employed.

3. An applicant who does not meet the requirements of paragraph 1 or 2 of this subsection may apply to have residency determined by a special eligibility officer who shall be appointed by the county board of supervisors. The special eligibility officer shall receive any proof of residency offered by the applicant and may inquire into any facts relevant to the question of residency. A determination of residency shall not be granted unless a preponderance of the credible evidence supports the applicant's intent to remain indefinitely in this state. A denial of a determination of residency may be appealed in the same manner as any other denial of eligibility for the system.

4. An applicant who has relocated to this state from another state or foreign country within six months before the date of application for the purpose of obtaining state assisted medical care pursuant to this article shall have the applicant's residency determined by a special eligibility officer appointed pursuant to paragraph 3 of this subsection. The special eligibility officer shall require, at a minimum, compliance with paragraphs 1 and 2 of this subsection. The special eligibility officer shall also receive any additional proof of residency offered by the applicant and may inquire into any facts relevant to the question of residency. A determination of residency shall not be made unless a preponderance of the credible evidence supports the applicant's intent to remain indefinitely in this state. A denial of the determination of residency may be appealed in the same manner as any other denial of eligibility for the system.

E. In accordance with constitutional standards and pursuant to subsection D of this section, the director of the department of economic security shall establish and maintain residency standards for those public benefit programs related to eligibility in the system which are equivalent to those residency standards established for the purposes of this article.

F. The director may adopt rules to do the following:

1. Authorize advance payments based on estimated liability to a provider or a nonprovider after the provider or nonprovider has submitted a claim for services and before the claim is ultimately resolved. The rules shall specify that any advance payment shall be conditioned on the execution prior to payment of a contract with the provider or nonprovider which requires the administration to retain a specified percentage, which shall be at least twenty per cent, of

RECEIVED
NOV 19 2001
UA PLUMBERS AND
STEAMFITTERS LOCAL #74

Bryant #2

RESOLUTION NO. 2000.73

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF TEMPE, ARIZONA, REQUIRING THE PROVISION OF HEALTH INSURANCE BENEFITS FOR ALL PUBLIC WORKS CONTRACTS THAT REQUIRE CITY COUNCIL APPROVAL

WHEREAS, the need for health insurance is essential to an individual's quality of life; and

WHEREAS, countless Americans are without health insurance; and

WHEREAS, as a society we should ensure equal access to health care for all, and not neglect those who may not have coverage due to economic circumstances or due to employer who may not provide coverage for their employees.

NOW, THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF TEMPE, ARIZONA, AS FOLLOWS:

1. That all public works construction and consultant contracts that require City Council approval will require that the consultant, general contractor, and all major subcontractors, as determined at the start of each project, provide health insurance to their employees and dependents of their employees as verified by affidavit.

2. Health insurance will be required for all employees, except for those employees who work less than one hundred and twenty (120) days in any calendar year.

3. The health insurance requirements will apply to all applicable contracts that are advertised for bid and entered into after January 1, 2001. Contracts that have already been advertised for bid, have currently been entered into, or current contracts that may have amendments or addendums after January 1, 2001 will not be subject to this resolution.

4. The procedures for implementation of this Resolution will be identified in guidelines established by the Public Works Manager.

5. Staff is directed to provided a preliminary report to Council regarding the implementation of this program within six months from the date of this Resolution and a full report within one year.

EXHIBIT
Admitted
Bryant 2

PASSED AND ADOPTED BY THE CITY COUNCIL OF THE CITY OF TEMPE, ARIZONA, this 14th day of December, 2000.

Neil G. Giuliano
MAYOR

ATTEST:

Kathy L. West
City Clerk

APPROVED AS TO FORM:

C. Brad Woodford
City Attorney

Guidelines for Implementation of Resolution No. 2000.73

These Guidelines are provided for purposes of implementing Resolution No. 2000.73 which requires that health insurance be provided by all consultants, general contractors and major subcontractors, as determined at the start of each project, for employees and dependents of employees. Questions regarding this procedure should be addressed to Howard Hargis, Public Works Manger for the City of Tempe, (480-350-8373).

1. All consultants and general contractors, who bid on projects or enter into public works contracts in excess of $30,000 with the City of Tempe, after January 1, 2001, are required to sign an affidavit in the form attached hereto. The general contractor shall be responsible for ensuring that the subcontractors comply with the health insurance requirements.

2. Health insurance is required for all employees, except for those employees who work less than one hundred and twenty (120) days in any calendar year. A "work day" consists of any time within a twenty-four hour period, regardless of number of hours, that the individual is paid.

3. The level of health insurance provided shall be determined by each employer, but should be no less than that provided by the Arizona Cost Containment Health System.

4. All complaints concerning violations of the health insurance requirements shall be filed, in writing, with the Public Work's Department, within five (5) days from discovery of the violation. An administrative hearing will be held before the Public Work's Manager, and a written decision of findings will be provided to the parties to the hearing within ten (10) days thereafter. Appeal from the decision of the Public Work's Manager may be made within ten (10) days of the date of the decision by filing a notice of appeal in writing with the Public Work's Department. If an appeal is timely filed, an administrative hearing will be held before an administrative hearing officer appointed by the City Manager. The decision of the administrative hearing officer shall be final.

5. In the event of a finding of violation of the insurance provisions, the company in violation of the provision shall be barred from bidding on, or entering into, any public works contract with the City for a period of three (3) years.

6. All consultants and contractors subject to the health insurance requirements shall post, in English and Spanish, notice of the health insurance requirements at the job site. Signs for posting will be provided by the City.

Dated this 14th day of December, 2000.

Howard Hargis, Public Works Manager

Tempe Councilman Dennis J. Cahill
Phone: 602-968-1959 FAX: 602-968-6564

Ensure to Insure

We have all seen the headlines lately: **Arizona 41st in the Country in Health Coverage for Kids...200,000 Arizona Children Without Medical Insurance...Unemployment in Arizona the Lowest in 25 Years...** How can we explain this contradiction? How can we stand by and watch children suffer? How can we stand by and watch tax payers suffer? The latter of the three headlines that I mentioned is the key to solving the dilemma of the first two headlines.

I have a way to cut down the number of uninsured children in Arizona. I call it ***Ensure to Insure.*** With the reform of welfare, America is changing it's social contract with her citizens. Likewise, many businesses are changing the social contract that they have with their employees by eliminating or reducing insurance coverage. The intent of welfare reform is to transition people from government dependency to self-sufficiency through employment. But if the private sector does not uphold its' end of the social contract by providing benefits for those entering the job market, large segments of the population will not be protected from debilitating circumstances that such insurance was designed to cover. The social and economic costs of those suffering uninsured calamities will ultimately be paid by the taxpayer, who will find themselves caring for those employees businesses no longer protect. This will ultimately increase the costs Americans pay to uphold the general welfare.

For example, families without adequate medical insurance or daycare will find acute illnesses becoming chronic, and uncared for children becoming problem adults. Likewise, wage earners without adequate provisions for sick or emergency leave will find themselves unable to hold on to jobs when emergencies arise and will potentially become homeless. As government reforms welfare with the expectations that those who can work should work, it must ensure that those who do work receive adequate coverage from their employers. If not, the taxpayer will find him or herself subsidizing a cost that should be carried by those who buy the goods or services the employees produce. In other words, when possible, the true cost of a good or service should be reflected in its price, and this price should include the cost of providing adequate health care and other basic benefits.

Government can and should play an important role in ensuring that businesses shoulder their responsibility and not opt out of the social contract. Here is where government can use the carrot and not the stick. **Government can require that those with whom government does business provide adequate benefits to their employees.**

The current system most governments employ for awarding contracts to businesses is structured so that the incentive is for businesses **not to provide benefits**. Most contracts are awarded to those willing to provide the required service or good at the lowest cost. One of the easiest ways for a business to reduce costs is not to provide benefits to employees and /or pay employees the lowest wages possible. This can be accomplished by either minimizing compensation for full time employees or hiring only part time employees. A company that gives its employees adequate

benefits actually puts itself at a competitive disadvantage when it bids against companies that cut costs by reducing employee benefits.

I propose that all social service providers, such as government, churches, and others use my carrot approach to ensure that the taxpayers' burden will not grow as a result of welfare reform. This program -- ***Ensure to Insure*** -- will create a level playing field for all those who bid for contracts with these organizations. It will ensure that employees who work for a company, that wins the contract, will not be an added burden to the taxpayer.

Such a program has similarities to programs for the use of alternative fueled vehicles and recycling. Both of these programs place the user in a leadership role in promoting a societal good and improving the environment. It should also be noted that both these programs cost more than the traditional methods of vehicle fueling and waste removal, but only in the short term. In the long term they save money. Governments now have programs that improve the physical environment. It is time to have programs that improve the human environment. It is the responsibility of both the public and private sectors to join in a partnership to uphold the social contract with the American people. Let us ***Ensure to Insure*** the worker of Arizona who deserves a decent compensation for a decent day's work. Let's end the era of taxpayers subsidizing companies that cut corners with employees' benefits.

ARIZONA DEPARTMENT OF WATER RESOURCES
HYDROLOGY DIVISION

MEMORANDUM

TO: Power Plant and Transmission Line Siting Committee

THROUGH: Greg Wallace, Chief Hydrologist
Arizona Department of Water Resources

Pat Schiffer, Siting Committee Member

FROM: Dale Mason, Supervisor
Groundwater Modeling Section
Hydrology Division

DATE: October 10, 2001

RE: Hydrologic Review of Bowie Power Station Application for a Certificate of Environmental Compatibility, A.C.C. Docket No. L-00000BB01-0118

This review consists of two sections; the first is an analysis of recent water level and pumpage records for the area around the proposed plant site. The second section is a review of the applicant's hydrologic analysis of potential water level impacts near the plant site.

General Background

The proposed plant site is located in Sections 28 and 29 of Township 12 South, Range 28 East located in the San Simon sub-basin of the Safford groundwater basin. The plant will be a combined-cycle base load plant with a proposed generating capacity of 1,000-megawatt. Water use by the plant is estimated to average about 5,500 acre-feet per year. The only source of water available for the plant is groundwater to be pumped from existing wells on the plant site. CAP surface water or effluent is not available for plant cooling.

The proposed plant site is in an active agricultural area that has a long history of large-scale agricultural activities. Some of the irrigation wells have water level records dating back to the early 1950's, and two wells located on or near the plant site are ADWR index wells. The U.S. Geological Survey measured water levels in the San Simon sub-basin area to support geohydrologic investigations that were undertaken by that agency prior to the creation of the ADWR. The ADWR conducted water level sweeps of the San Simon sub-basin in 1987 and 1997 as part of an ongoing water level data collection program.

EXHIBIT
Admitted
Committee 1

Geohydrology

The San Simon sub-basin is a north to northwest trending valley about 75 miles long and 6 to 25 miles wide (Barnes, 1991). Bowie and the proposed plant site are located near the northwestern end of the sub-basin. There are three geologic units that make up the regional aquifer system in the San Simon sub-basin. They are an upper unit, which consists of sand, silt, and gravel, a middle confining unit consisting of silts and clays, and a lower unit under artesian pressure, which is a series of interfingered sands, silts, and gravels.

Agricultural Development

Agricultural development in the San Simon sub-basin area began in 1910 with the discovery of the lower artesian aquifer. The early deep wells completed in the lower aquifer flowed at the surface and led to extensive agricultural development near the towns of Bowie, Olga, and San Simon (Barnes, 1991). By the 1940's there were about 140 artesian wells in use in the San Simon sub-basin. However, loss of pressure due to overdrafting of the lower aquifer caused most wells to be pumped to produce water. By 1991 there were only 10 flowing wells left, and these were very deep wells, 1,500 feet deep or greater. Most irrigation wells in the Bowie area are completed in the lower confined unit. Some shallow irrigation and domestic wells are completed in the upper aquifer. The wells for the proposed plant will withdraw water from the lower confined aquifer unit.

Groundwater pumpage for agricultural development in the San Simon sub-basin began in the early 1900's and by the mid-1940's there were over 140 irrigation wells in operation. Irrigation withdrawals were generally less than 10,000 acre-feet per year until the early 1950's. Groundwater withdrawals peaked in the 1970's, with pumpage estimated to have exceeded 100,000 acre-feet per year through most of the 1970's (see attached estimated pumpage graph). Groundwater withdrawals have declined in the 1980's and 1990's to generally less than 50,000 acre-feet per year, and by the late 1990's had declined to less than 5,000 acre-feet (USGS, 2000). Since 1995 the U. S. Geological Survey has not reported estimated pumpage for the San Simon sub-basin of the Safford groundwater basin.

Water Levels

The results of the large-scale groundwater pumpage from the 1950's to the 1980's were water level declines in the lower aquifer of as much as 300 feet in some areas of the San Simon sub-basin. Hydrographs from wells with historic water level data in the vicinity of the proposed Bowie plant show large water declines starting in the 1950's (see attached well hydrographs). A number of the wells near or on the Bowie plant site have recorded water level declines in excess of 200 feet, with one well having a total recorded decline of 293 feet. During the peak pumpage years of 1955 to 1980, annual water level declines in many of these wells ranged from 6 to 10 feet per year.

In the early-1980's as agricultural pumpage decreased, the water levels declines began to slow and water levels began to stabilize in the Bowie area. Currently, water levels in the lower aquifer

and water levels began to stabilize in the Bowie area. Currently, water levels in the lower aquifer in the vicinity of Bowie are generally stable. However, from 1987 to the present, several wells on the proposed plant site are showing long-term declines of between 0.5 foot to about 1.0 foot per year. The most recently available water levels from the lower aquifer near the proposed plant range from about 280 feet below land surface to about 400 feet below land surface.

Water Level Impact Analysis

The analytic method used to predict the water level impact of plant pumpage used reasonable hydrologic parameters derived from aquifer tests conducted by the URS Corporation for the plant proponent. The analytic model used a standard Theis solution to predict drawdowns of approximately 50 feet over 30 years on or near the plant property. The model analysis indicates that annual drawdown due to plant withdrawals may approach about 2 feet per year over the 30 years of the plant. The hydrologic parameters used in the analysis are conservative and the resulting drawdowns represent a higher value than what may actually occur due to plant withdrawals.

However, the Theis solution does not take into consideration the current regional water level declines of about 1 feet per year that has been observed in the area; nor does it take into account other future groundwater withdrawals in the area. Future groundwater use by agriculture may not reach the significant levels of the past, but the cumulative impact of increased future agricultural pumpage and pumpage for the proposed plant may increase water level declines in Bowie area beyond those predicted by the analytic model.

Land Subsidence

Past agricultural pumpage has resulted in land subsidence and earth fissure formation in the San Simon sub-basin. By 1980, 6 feet of land subsidence had been measured near Bowie and a little over 1 foot near San Simon. According to the applicant's hydrologic report, historic subsidence rates in the Bowie area were calculated to be about 0.2 feet per year during the period of greatest groundwater pumpage. URS Corp. has requested historic water level data from the Department for use in preparing a more detailed subsidence report. However, to date the Department has not received this report.

Conclusions:

The impact on local water levels by Bowie power plant will be controlled by the amount of groundwater pumped for cooling, and by groundwater use in the surrounding agricultural areas. Using the best case scenario of continued low agricultural pumpage, there would be only a slight increase in the current rate of water level decline in the Bowie area. Under this scenario the currently observed water level declines will continue or increase slightly.

Under a worst case scenario of increased future groundwater use by agricultural, water level declines can be expected to increase as the volume of agricultural pumpage increases. In fact, the

applicant's hydrology report indicates that agricultural production on a number of acres near the plant site is expected to resume in the near future.

Land subsidence in the Bowie area needs to be reported on more fully. The applicant's hydrologic report has not yet been supplemented with the most current subsidence data. The latest data available is from the 1980's. In the applicant's slide presentation, received by the Department on October 3, 2001, predicted subsidence rates were referenced. The data supporting these values needs to be reviewed by our staff and by the committee in order to properly evaluate subsidence issues.

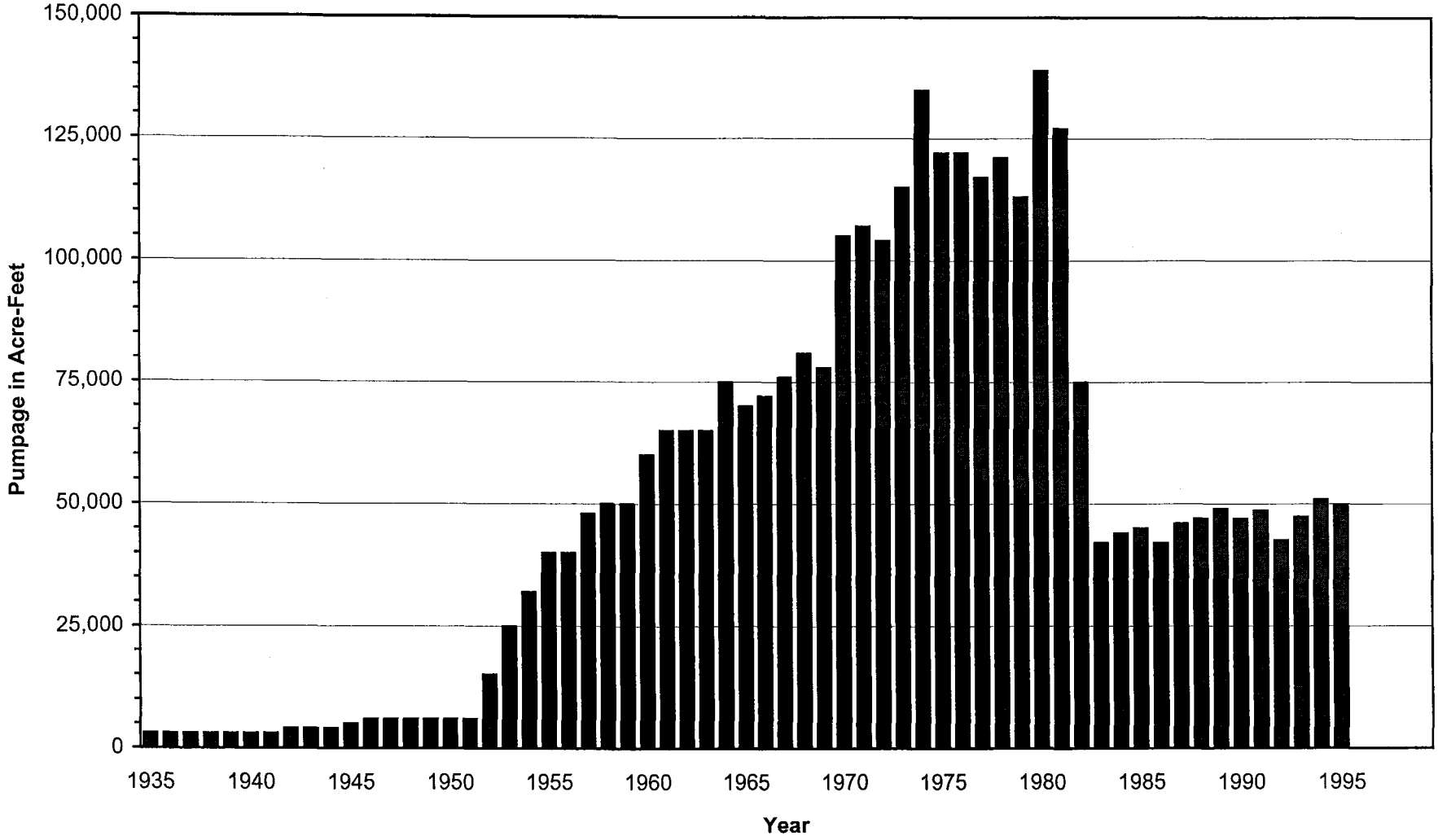
References:

Barnes, R.L., 1991. Maps Showing Groundwater Conditions in the Sam Simon sub-basin of the Safford Basin, Graham and Cochise Counties, Arizona Hildalgo County, New Mexico – 1987; Arizona Department of Water Resources, Hydrologic Maps Series Report No. 19.

United States Geologic Survey, Annual Water Year Data, Various Reports

San Simon Sub-Basin Estimated Pumpage

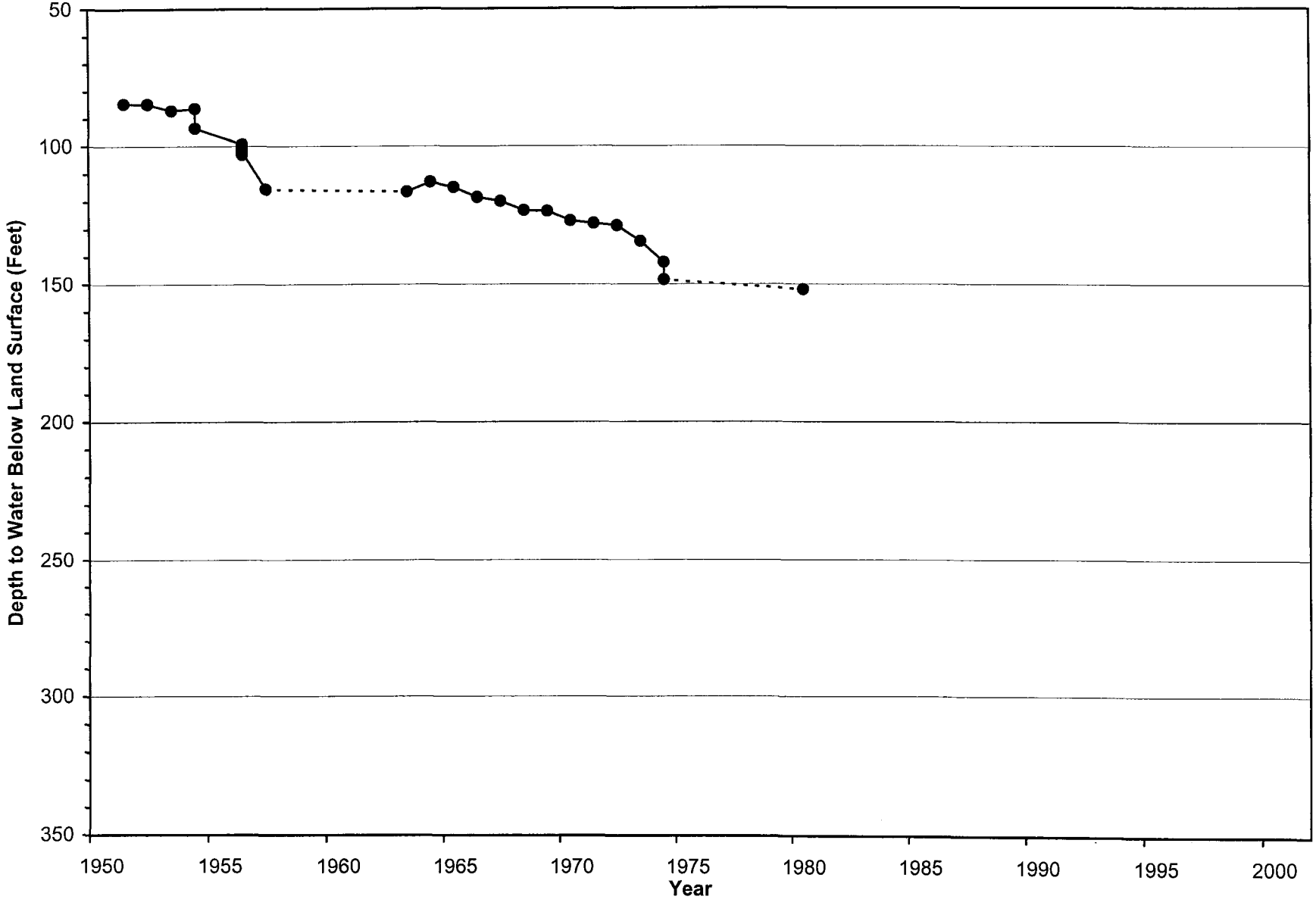
Source: U.S. Geological Survey

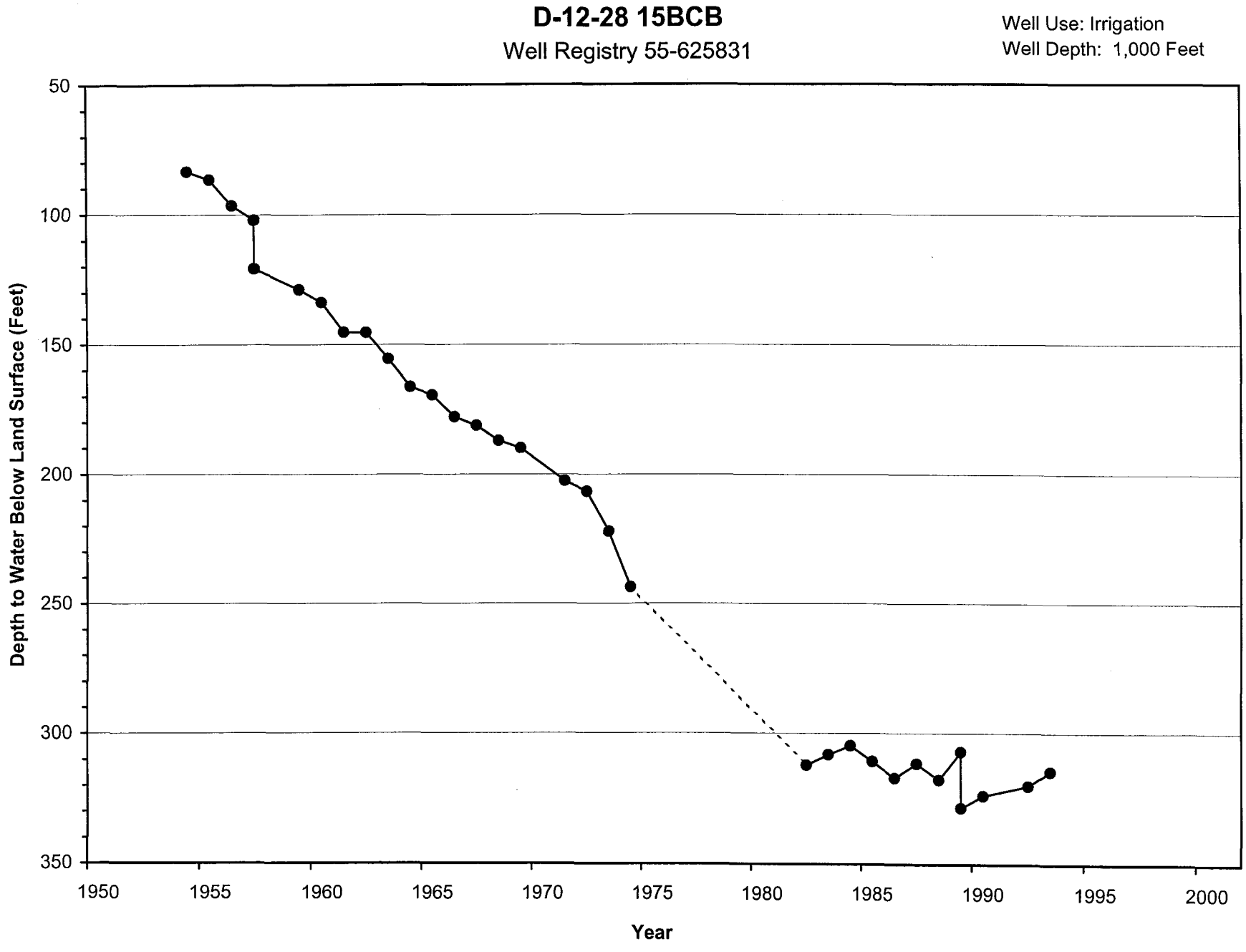


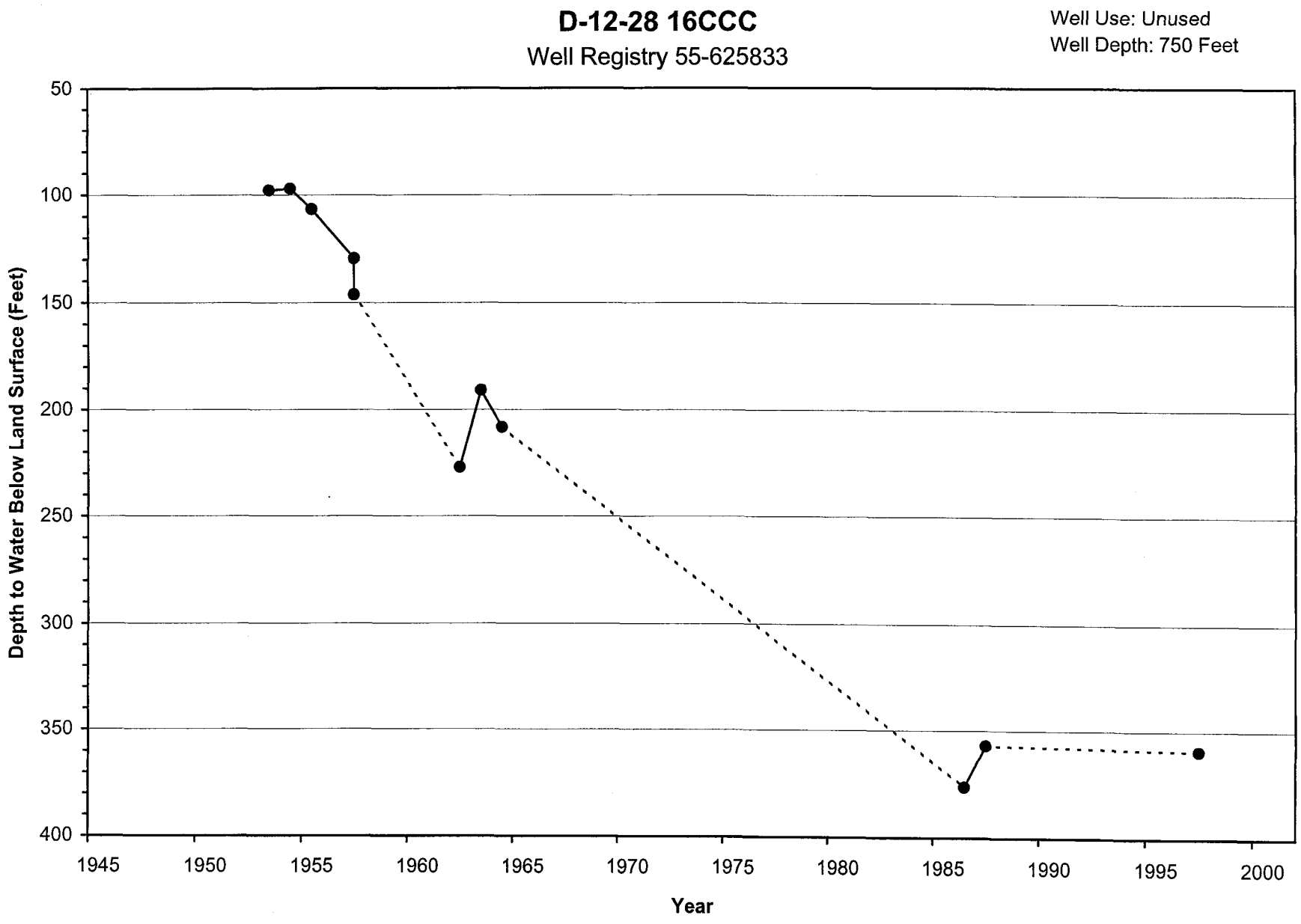
D-12-28 13BCD

Well Registry 55-625871

Well Use: Domestic
Well Depth: 770 Feet



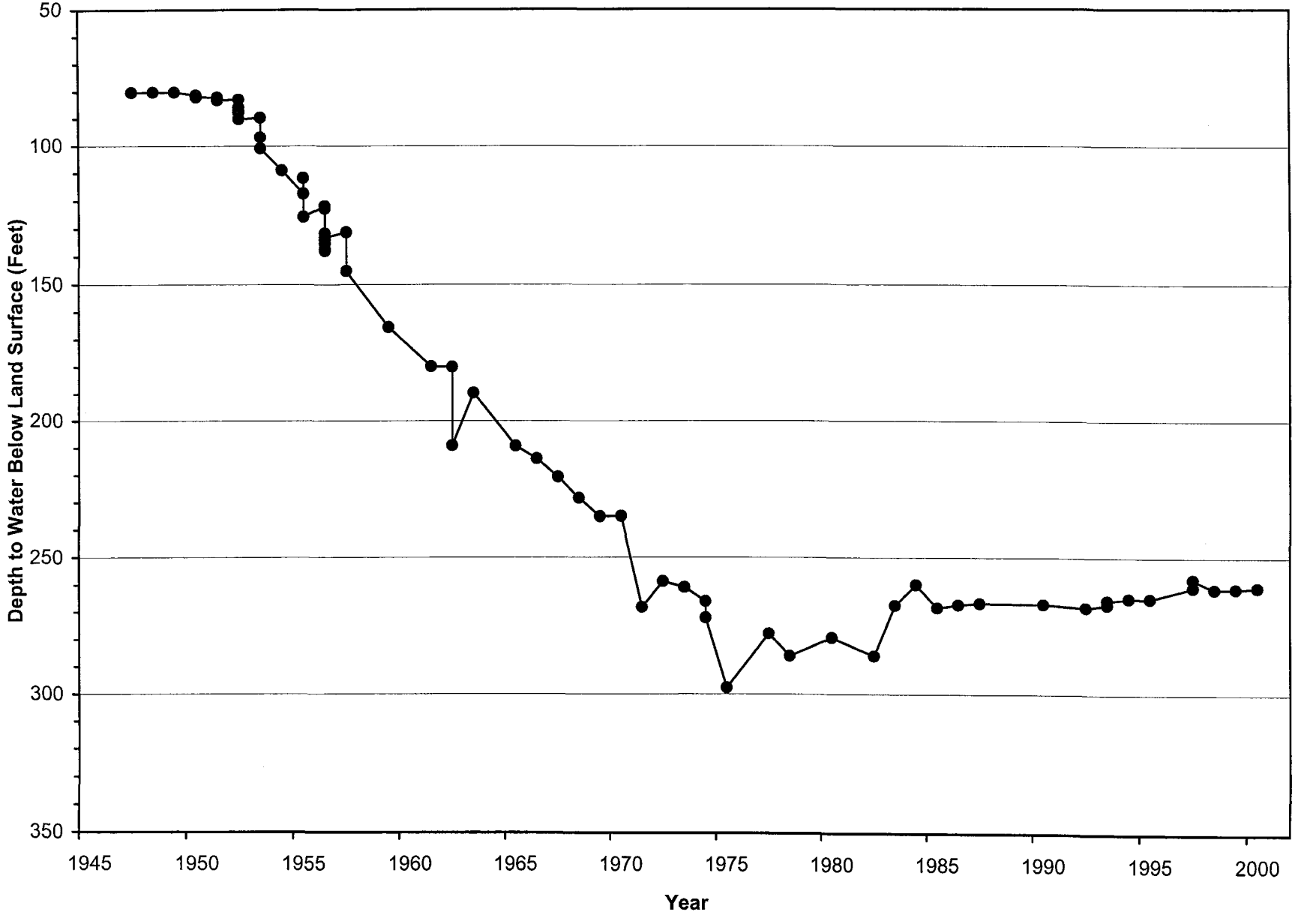

D-12-28 15BCB
Well Registry 55-625831
Well Use: Irrigation
Well Depth: 1,000 Feet
Depth to Water Below Land Surface (Feet)
50
100
150
200
250
300
350
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year

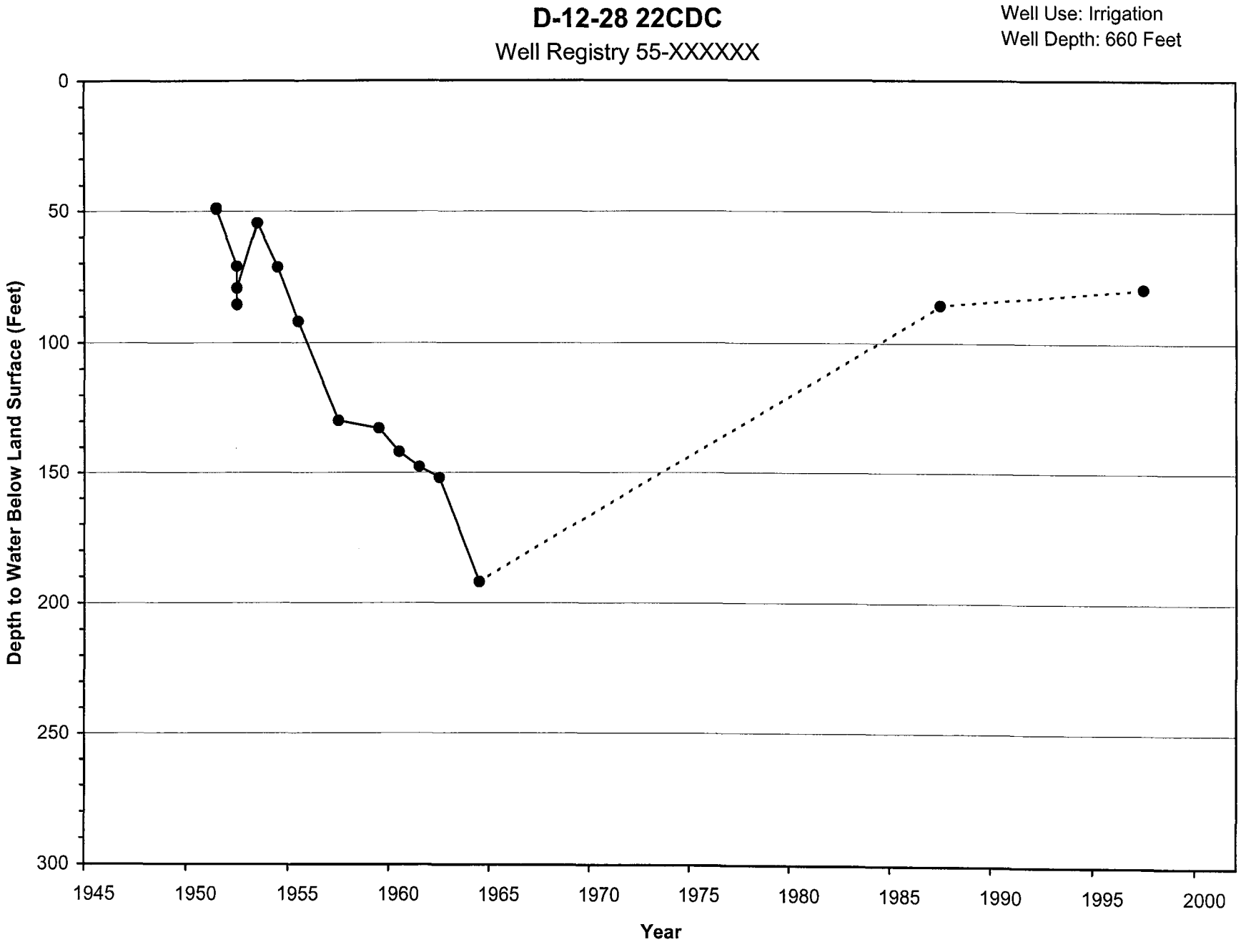

D-12-28 16CCC
Well Registry 55-625833
Well Use: Unused
Well Depth: 750 Feet
Depth to Water Below Land Surface (Feet)
50
100
150
200
250
300
350
400
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year

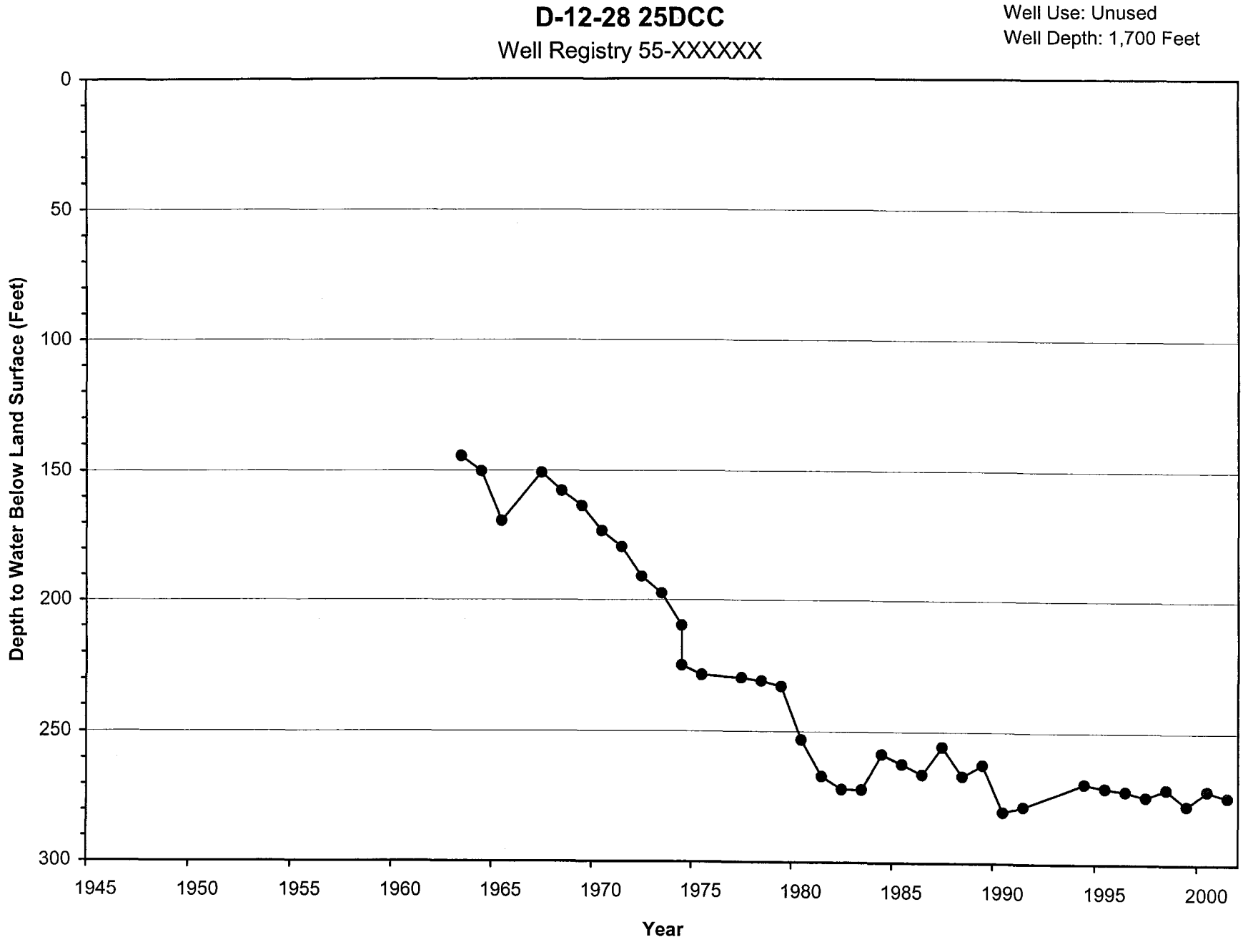
D-12-28 17DDD

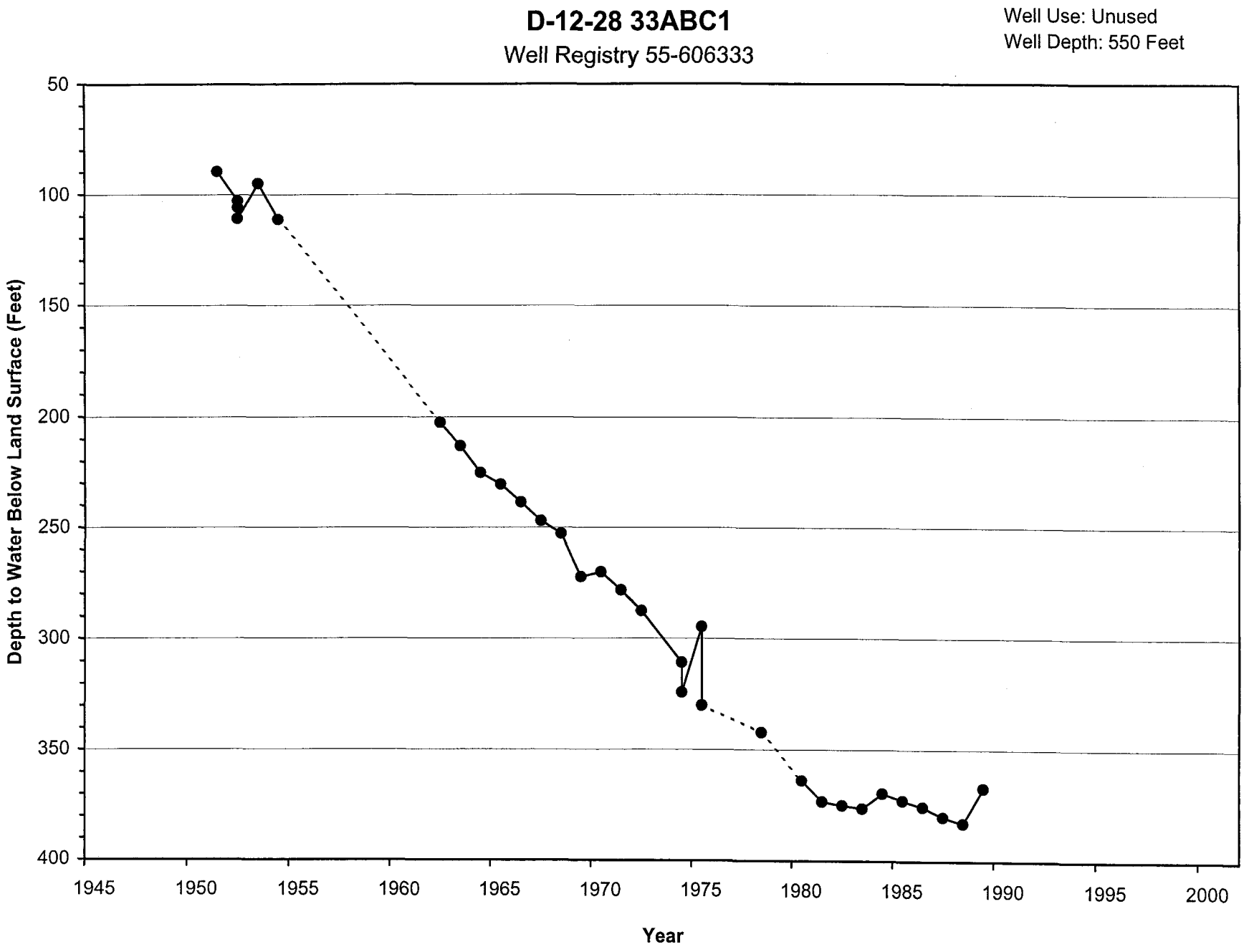
Well Registry 55-609816

Well Use: Unused
Well Depth: 567 Feet




D-12-28 22CDC
Well Registry 55-XXXXXX
Well Use: Irrigation
Well Depth: 660 Feet
Depth to Water Below Land Surface (Feet)
0
50
100
150
200
250
300
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year


D-12-28 25DCC
Well Registry 55-XXXXXX
Well Use: Unused
Well Depth: 1,700 Feet
Depth to Water Below Land Surface (Feet)
0
50
100
150
200
250
300
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year


D-12-28 33ABC1
Well Registry 55-606333
Well Use: Unused
Well Depth: 550 Feet
Depth to Water Below Land Surface (Feet)
50
100
150
200
250
300
350
400
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year

Historic Drawdown Calculations
Bowie Power Plant Area

Cadastral	Reg No.	Well Depth	Drawdown Calculations
D-12-28 13BCD	55-625871	770	-67.4 Total Decline 1951-1980
			-2.3 Annual Avg.
			-63.9 Decline 1951-1975
			-2.7 Annual Avg.
D-12-28 15BCB	55-625831	1,000	-245.1 Total Decline 1954-1992
			-6.5 Annual Avg.
			-160.3 Decline 1954-1975
			-7.6 Annual Avg. 1954-1975
			-228.8 Decline 1954-1982
			-8.2 Annual Avg. 1954-1982
D-12-28 16ACB	55-625832	830	-111.1 Total Decline 1962-1997
			-3.2 Annual Avg.
			-47.9 Decline 1962-1974
			-4.0 Annual Avg.
			-100.1 Decline 1962-1987
			-4.0 Annual Avg.
D-12-28 16CCC	55-625833	750	-261.4 Total Decline 1953-1997
			-5.9 Annual Avg.
			-110.3 Decline 1953-1964
			-10.0 Annual Avg.
			-259.0 Decline 1953-1987
			-7.6 Annual Avg.
D-12-28 17DDD	55-609816	567	-180.5 Total Decline 1947-2000
			-3.4 Annual Avg.
			-126.1 Decline 1951-1965
			-9.0 Annual Avg. 1951-1965
			-215.6 Decline 1951-1975
			-9.0 Annual Avg. 1951-1975
			36.9 Decline 1975-2000
			1.5 Annual Avg. 1975-2000
D-12-28 22CDC		660	-30.6 Total Decline 1951-1997
			-2.4 Annual Avg.
			-143.3 Decline 1951-1964
			-11.0 Annual Avg.

Historic Drawdown Calculations
Bowie Power Plant Area

Cadastral	Reg No.	Well Depth	Drawdown Calculations
D-12-28 25DCC		1,700	-147.7 Total Decline 1963-2001
			-3.9 Annual Avg. 1963-1990
			-102.0 Decline 1963-1975
			-8.5 Annual Avg.
			-60.7 Decline 1975-1990
			-4.0 Annual Avg.
			15.0 Decline 1990-2001
			1.4 Annual Avg.
D-12-28 26DCC		687	-40.2 Total Decline 1953-1964
			-3.7 Annual Avg.
D-12-28 28CCC1		500	-273.0 Total Decline 1954-1987
			-8.3 Annual Avg.
D-12-28 32ACC	55-615877	600	-170.0 Total Decline 1963-1987
			-7.1 Annual Avg.
D-12-28 32DAA			
D-12-28 32DCC1	55-606341	600	-159.7 Total Decline 1963-1987
			-6.7 Annual Avg.
D-12-28 33ABC1	55-606333	550	-277.8 Total Decline 1951-1989
			-7.5 Annual Avg.
			-135.7 Decline 1951-1964
			-10.4 Annual Avg. 1951-1964
			-240.4 Decline 1951-1975
			-10.0 Annual Avg. 1951-1975
			-37.4 Decline 1975-1989
			-2.7 Annual Avg. 1975-1989
D-12-28 35CDC2		620	-245.6 Total Decline 1951-1975
			-10.2 Annual Avg. 1951-1975
			-138.5 Decline 1951-1964
			-10.7 Annual Avg.

THE STATE OF ARIZONA
GAME AND FISH DEPARTMENT
2221 WEST GREENWAY ROAD, PHOENIX, AZ 85023-4399
(602) 942-3000 • WWW.AZGFD.COM

GOVERNOR
JANE DEE HULL
COMMISSIONERS
CHAIRMAN, DENNIS D. MANNING, ALPINE
MICHAEL M. GOLIGHTLY, FLAGSTAFF
JOE CARTER, SAFFORD
SUSAN E. CHILTON, ARIVACA
W. HAYS GILSTRAP, PHOENIX
DIRECTOR
DUANE L. SHROUFE
DEPUTY DIRECTOR
STEVE K. FERRELL

EXHIBIT
Admitted
Committee 2

October 10, 2001

Ms. Laurie A. Woodall, Chairman
Power Plant & Transmission Line Siting Committee
Office of the Attorney General
1275 West Washington
Phoenix, Arizona 85007

Re: *Power Plant and Transmission Line Projects*

Dear Ms. Woodall:

Thank you for taking the time to meet with the Arizona Game and Fish Department to discuss issues associated with addressing impacts to wildlife resources during the review of proposed power plant and transmission line projects. The Department is very interested in participating in the review of proposed projects and providing information regarding potential impacts to wildlife resources early in the planning stages and consistent with the Committee's authority and the Department's mission. As we discussed, the Department focuses on several wildlife resource issues when reviewing initial power plant and transmission line project proposals. Addressing these issues early in the process would help to ensure that potential impacts to wildlife resources are considered and addressed to the greatest extent possible.

The Department understands that the Committee has responsibility in evaluating an application to consider the impact of a proposed project on fish and wildlife and its habitat, and in doing so, the Committee must give special consideration to the protection of unique areas that have "biological wealth" or are habitats for rare and endangered species. To assist the Committee in this responsibility, the Department recommends that an applicant provide the following information as part of the Department's review of the application for the committee:

1. To provide meaningful comments early in the process, we need an accurate description of the project area, including exact location, land use and ownership of the project area and adjacent lands, overall condition of the project area (e.g., has the area been previously disturbed; is the project area surrounded by development or undisturbed habitat), topography, including drainages within or in proximity to the project area and depth to groundwater.

2. Presence of Threatened and/or Endangered Species and Critical Habitat(s), and other special status species, located within or in proximity to proposed project area. The project proponent should contact the U.S. Fish and Wildlife Service and AGFD early on in the planning process to obtain special status species information pertinent to the project area.

3. Presence of riparian or other high-quality wildlife habitats (e.g., native vegetation, wetlands, previously undisturbed habitats, bighorn sheep lambing habitat, etc.) that may be directly or

indirectly impacted as a result of the project. This analysis should include consideration of potential impacts to Waters of the U.S., as regulated by the U.S. Army Corps of Engineers (Clean Water Act).

4. Whether groundwater pumping could adversely impact surface and sub-surface water flows, and high-value wildlife habitats that these flows may support within or in proximity to the project area.

5. Presence of big game (e.g., deer, desert bighorn sheep) and small game (e.g., quail) within or in proximity to the project area (i.e., general wildlife resources description).

6. Size and location of evaporation ponds (if applicable), as well as the anticipated quality of the water in the ponds.

7. Type, location, and timing associated with construction of pipelines/power lines. Will power lines include features to eliminate or minimize electrocution to raptors; will the location of power lines permanently impact wildlife through actual habitat loss and fragmentation; and will construction activities displace wildlife during critical months/seasons (nesting and lambing/fawning periods).

8. Whether proposed project area maintain opportunities for wildlife-related recreation.

9. Whether the proposed project area is within an important wildlife movement corridor.

We understand that much, if not all, of this information should be contained within the application, as specified by A.A.C.R. 14-3-219. We understand we can review applications at the Corporation Commission. We believe, however, that receipt of a copy of the application and conferences with the applicant can expedite the process. The Department can provide more detailed comments regarding potential impacts to wildlife resources, and potential alternatives and mitigation measures to avoid or minimize these impacts, when actual proposals are developed. Please coordinate with John Kennedy, at (602) 789-3602. Thank you again for interest in wildlife related issues.

Sincerely,

Duane L. Shroufe
Director

DLS:mk

cc: John Kennedy, Habitat Branch Chief, Arizona Game and Fish Department
Jim Odenkirk, Assistant Attorney General

216929

"Managing and conserving natural, cultural, and recreational resources"

Arizona ®
State Parks

Jane Dee Hull
Governor

State Parks
Board Members

Chair
Walter D. Armer, Jr.
Benson

Vice-Chair
Suzanne Pfister
Phoenix

Joseph H. Holmwood
Mesa

John U. Hays
Yarnell

Elizabeth J. Stewart
Tempe

Vernon Roudebush
Safford

Michael E. Anable
State Land
Commissioner

Kenneth E. Travous
Executive Director

Arizona State Parks
1300 W. Washington
Phoenix, AZ 85007

TTY: 602.542.4174
www.pr.state.az.us

800.285.3703
from (520) area code

General Fax:
602.542.4180

Director's Office Fax:
602.542.4188

EXHIBIT
Admitted
Committee 3

In reply, please refer to
SHPO-2001-1129 (7511)
no adverse effect

RECEIVED
SEP 17 2001

August 14, 2001

Laurie A. Woodall, Chairperson, Power Plant and Transmission Line Siting Committee
Assistant Attorney General, Environmental Enforcement Section
Office of the Attorney General
1275 West Washington
Phoenix, Arizona 85007

RE: Certificate of Environmental Compatibility: The Proposed Bowie Power Station and Transmission Line, Graham and Cochise Counties, Arizona

Dear Ms. Woodall:

Thank you for having the committee's applicant (i.e., Bowie Power Station LLC) initiate consultation with this office regarding the above-mentioned state plan and associated certificate of environmental compatibility. The proposed construction plan includes a generation station, a transmission line, and a switchyard facility on private land and portions of Arizona State Land Department land. Historian Bill Collins and I have reviewed the documents submitted and offer the following comments pursuant to the State Historic Preservation Act (i.e., A.R.S. § 41-861 to 41-864) and the committee's factors to be considered (i.e., A.R.S. § 40-360.06.A.5).

According to the cultural resources survey report, a historic-period linear site (AZ CC:10:109 ASM), a historic-period and currently in-use railroad track (Arizona Eastern Railroad), and 12 isolated artifact and/or feature occurrences were identified within the geographic area affected by the plan. The report was professionally prepared and well written.

The eligibility status of AZ CC:10:109 (ASM) and the railroad is unclear at this time. We suggest treating them as if they were eligible for inclusion in the State Register of Historic Places rather than conduct additional studies to positively determine their eligibility status. We agree that the isolated artifact and/or feature occurrences are not eligible for inclusion under any criterion.

Both AZ CC:10:109 (ASM) and the railroad are situated within the proposed transmission line corridor, and can be easily avoided by ground-disturbing activities. The transmission lines will visually impact both properties, but this impact will likely be small. No preservation treatment of the isolated artifact and/or feature occurrences is necessary.

Based on the above, this office conditionally concurs with a finding of no impacts (i.e., no adverse effect) for this plan provided that ground-disturbing activities avoid AZ CC:10:109 (ASM) and the railroad and that the visual impacts to these properties be minimized to the extent possible. Please also taken into account any comments from Arizona State Land Department regarding historic properties.

If a federal permit is required for any developments on the subject parcel (e.g., a Section 404 permit from the Army Corps of Engineers, or a National Pollutant Discharge Elimination System [NPDES] permit from the U.S. Environmental Protection Agency), the project proponents should be aware that the undertaking will need to be reviewed by the

appropriate federal agency and this office pursuant to Section 106 of the National Historic Preservation Act as implemented by 36 C.F.R. 800. If federal assistance or permitting is anticipated, we strongly urge the applicant to contact the agency as soon as possible to obtain information on the consultation process. Federal involvement entails compliance and review considerations different from the State Historic Preservation Act.

We offer the following conditions for the committee's consideration:

1) The applicant will avoid conducting ground-disturbing activities within the boundaries of AZ CC:10:109 (ASM) and the in-use railroad grade other than the use of established vehicular crossings.

2) The applicant will minimize visual impacts to the existing railroad to the extent possible. This could be accomplished by using the largest feasible spacing between transmission line towers, and thus minimizing the number of towers situate adjacent to the railroad.

3) If a federal agency determines that all or part of this state plan represents a federal undertaking subject to review under the National Historic Preservation Act, the applicant will participate as a consulting party, on committee's behalf, in the federal compliance process (i.e., 36 C.F.R. 800) to reach a finding of effect and to resolve adverse effects, if any.

4) Should cultural features and/or deposits be encountered during ground-disturbing activities related to the proposed plan, the applicant will comply with A.R.S. § 41-844, which requires that work cease in the immediate area of the discovery and that the Director of the Arizona State Museum be notified promptly.

We appreciate the committee's cooperation with this office in considering the effects of state plans on cultural resources situated in Arizona. If you have any questions, please contact me at (602) 542-7137 or electronically via mbilsbarrow@pr.state.az.us.

Sincerely,

Matthew H. Bilsbarrow, RPA
Compliance Specialist/ Archaeologist
State Historic Preservation Office

cc.
Kris Dobschuetz, Environmental Planning Group, 4350 E Camelback Rd, Suite G-200, Phoenix, AZ 85018
Steve Ross, Arizona State Land Department, 1616 W Adams St, Phoenix, AZ 85007
Bill Collins, SHPO

EXHIBIT
Admitted
Committee 4

ARIZONA DEPARTMENT OF WATER RESOURCES
HYDROLOGY DIVISION

MEMORANDUM

TO: Power Plant and Transmission Line Siting Committee

THROUGH: Greg Wallace, Chief Hydrologist
Arizona Department of Water Resources

Pat Schiffer, Siting Committee Member

FROM: Dale Mason, Supervisor
Groundwater Modeling Section
Hydrology Division

DATE: December 7, 2001

RE: Preliminary Hydrologic Review of Bowie Power Station Application,
Certificate of Environmental Compatibility,
A.C.C. Docket No. L-00000BB01-0118

This hydrologic review consists of two sections; the first is an analysis of recent water level and pumpage records for the area around the proposed plant site. The second section is a review of the applicant's hydrologic analysis of potential water level and land subsidence impacts near the proposed plant site.

General Background

The proposed Bowie Power Station is located in Sections 28 and 29 of Township 12 South, Range 28 East located in the San Simon sub-basin of the Safford groundwater basin. The station will be a combined-cycle base load plant with a proposed generating capacity of 1,000-megawatt. Water use by the plant is estimated to average about 5,500 acre-feet per year. The only source of water available for the plant is groundwater to be pumped from existing wells on the plant site. CAP surface water or effluent is not available for plant cooling.

The proposed site is in an active agricultural area that has a long history of large-scale irrigation withdrawals. Some of the irrigation wells have water level records dating back to the early 1950's, and two wells located on or near the plant site are ADWR index wells. The U.S. Geological Survey measured water levels in the San Simon sub-basin area to support geohydrologic investigations undertaken by that agency prior to the creation of the ADWR. The ADWR conducted water level sweeps of the San Simon sub-basin in 1987 and 1997 as part of an ongoing water level data collection program.

Geohydrology

The San Simon sub-basin is a north to northwest trending valley about 75 miles long and 6 to 25 miles wide (Barnes, 1991). Bowie and the proposed plant site are located near the northwestern end of the sub-basin. There are three geologic units that make up the regional aquifer system in the San Simon sub-basin. They are an upper unit, which consists of sand, silt, and gravel; a middle confining unit consisting of silts and clays; and a lower unit under artesian pressure, which is a series of interfingered sands, silts, and gravels.

Agricultural Development

Agricultural development in the San Simon sub-basin area began in 1910 with the discovery of the lower artesian aquifer. The early deep wells completed in the lower aquifer flowed at the surface and led to extensive agricultural development near the towns of Bowie, Olga, and San Simon (Barnes, 1991). By the 1940's, there were about 140 artesian wells were in use in the San Simon sub-basin. However, most wells required pumps to produce water due to loss of pressure caused by overdrafting of the lower aquifer caused. By 1991, there were only 10 flowing wells left, and these were very deep wells, 1,500 feet deep or greater. Most irrigation wells in the Bowie area are completed in the lower confined unit. A number of shallow irrigation and most domestic wells are completed in the upper aquifer. The wells for the proposed plant will withdraw water from the lower confined aquifer.

Irrigation withdrawals in the San Simon sub-basin were generally less than 10,000 acre-feet per year until the early 1950's. Ground-water withdrawals peaked in the 1970's, with pumpage estimated to have exceeded 100,000 acre-feet per year through most of the 1970's (see attached estimated pumpage graph). Groundwater withdrawals have declined since 1980 to generally less than 50,000 acre-feet per year, and by the late 1990's had declined to less than 5,000 acre-feet per year (USGS, 2000). Since 1995 the U. S. Geological Survey has not separately reported estimated pumpage for the San Simon sub-basin of the Safford groundwater basin.

Water Levels

The results of the large-scale groundwater pumpage from the 1950's to the 1980's were water level declines in the lower aquifer of as much as 300 feet in some areas of the San Simon sub-basin. Hydrographs from wells with historic water level data in the vicinity of the proposed Bowie plant show large water declines starting in the 1950's (see attached well hydrographs). A number of the wells near or on the Bowie plant site have recorded water level declines in excess of 200 feet, with one well having a total recorded decline of 293 feet. During the peak pumpage years of 1955 to 1980, annual water level declines in many of these wells ranged from 6 to 10 feet per year.

In the early-1980's as agricultural pumpage decreased, the water levels declines began to slow and water levels began to stabilize in the Bowie area. Currently, water levels in the lower aquifer in the vicinity of Bowie are generally stable. However, from 1987 to the present, several wells on the proposed plant site show long-term declines of between 0.5 foot and 1.0 feet per year.

The most recently available water levels near the proposed plant range from about 280 feet below land surface to about 400 feet below land surface.

Water Level Impact Analysis

The analytic method used to predict the water level impact of plant pumpage used reasonable hydrologic parameters derived from aquifer tests conducted by the URS Corporation for the plant proponent. The analytic model used a standard Theis solution to predict drawdowns of approximately 50 feet over 30 years on or near the plant property. The model analysis indicates that annual drawdown due to plant withdrawals may approach about 2 feet per year over the 30 years of the plant. The hydrologic parameters used in the analysis are conservative and the resulting drawdowns represent a higher value than what may actually occur due to plant withdrawals.

However, the Theis solution does not take into consideration the current regional water level declines of about 1 foot per year that has been observed in the area; nor does it take into account other future groundwater withdrawals in the area. Future groundwater use by agriculture may not reach the significant levels of the past, but the cumulative impact of increased future agricultural pumpage and pumpage for the proposed plant may increase water level declines in Bowie area beyond those predicted by the analytic model.

Land Subsidence

Past agricultural pumpage has resulted in land subsidence and earth fissure formation in the San Simon sub-basin. Measured land subsidence near Bowie between 1952 and 1980 was about 6 feet (Geological Consultants, 2001). The project proponent undertook a land subsidence investigation in September and October of 2001. This investigation measured an additional 1.4 feet of subsidence between 1980 and 2001 in the Bowie area (Geological Consultants, 2001). The total measured land subsidence in the Bowie area from 1952 to present is about 7.4 feet. Land subsidence on the plant site itself has been estimated at about 5 feet based the site's position relative to survey stations with measured subsidence (Geological Consultants, 2001).

The rate of land subsidence in the Bowie area has declined from the 1950's to the present, probably reflecting the decrease in agricultural pumping with time. From the 1952 to 1974, which includes the period of greatest groundwater pumpage, the subsidence rate in the Bowie area was about 0.2 feet per year. The subsidence rate between 1974 and 1980 declined to about 0.16 feet per year, and recent data presented in the subsidence report suggests that subsidence from 1980 to the present has declined to about 0.065 feet per year (Geological Consultants, 2001).

It is difficult to predict future subsidence rates; however, the subsidence report submitted by the proponent suggests that there could be an additional 2.2 feet of residual land subsidence in the Bowie area by 2030, even if the proposed plant is not built. If the plant is built the rate of subsidence through 2030 is predicted to be similar to the current rate because groundwater withdrawals by the plant are expected to be similar to present withdrawals for agricultural lands

on the plant site.

Conclusions:

Major areas of concern to ADWR staff are future water level declines and potential subsidence rates. The impact on local water levels and land subsidence rates by the proposed Bowie power plant will be controlled by the amount of groundwater pumped for cooling, and by groundwater use in the surrounding agricultural areas. Using the best case scenario of continued low agricultural pumpage, there would be only a slight increase in the current rate of water level decline in the Bowie area. Under this scenario the currently observed water level declines will continue or increase slightly. Land subsidence rates may also remain at or near the current rate of 0.065 feet per year.

Under a worst case scenario of increased future groundwater use by agriculture, water level declines can be expected to increase as the volume of agricultural pumpage in the surrounding area increases. In fact, the applicant's hydrology report indicates that agricultural production on a number of acres near the plant site is expected to resume in the near future.

If total water use in the area surrounding the proposed plant increases it is likely that subsidence rates may also increase. Therefore, ADWR staff recommended to the proponent that land subsidence and water levels near the proposed plant site be monitored. The proponent developed and submitted to ADWR a land subsidence and water level monitoring plan that ADWR staff has reviewed. The plan contains sufficient monitoring and mitigation provisions, including reporting of data from the monitoring activities to ADWR staff, Arizona Corporation Commission staff, and other interested agencies for independent review. ADWR staff recommends that the Committee incorporate the monitoring plan into a stipulation to be attached to the Certificate of Environmental Compatibility.

References:

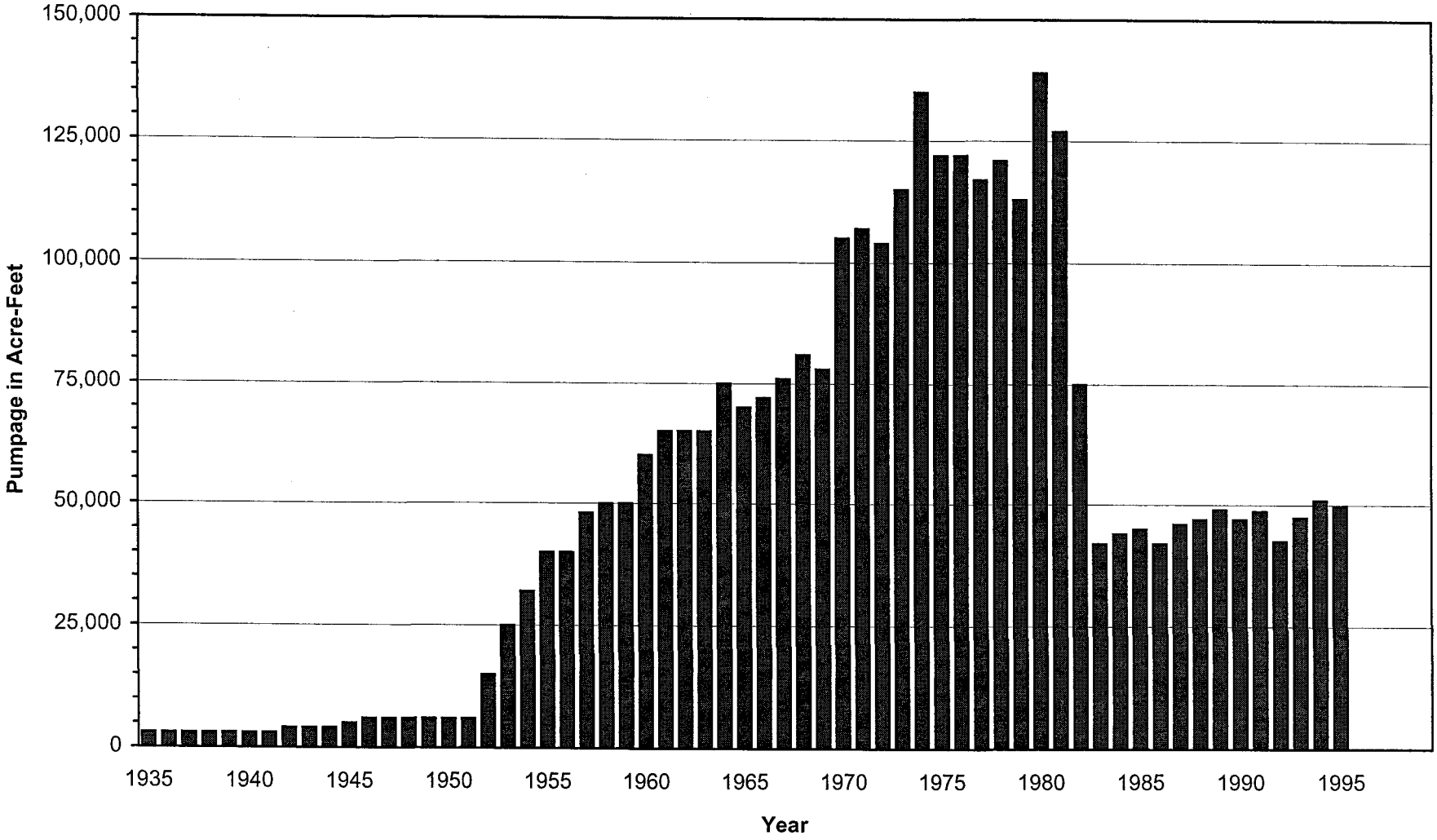
Barnes, R.L., 1991. Maps Showing Groundwater Conditions in the Sam Simon sub-basin of the Safford Basin, Graham and Cochise Counties, Arizona Hildalgo County, New Mexico – 1987; Arizona Department of Water Resources, Hydrologic Maps Series Report No. 19.

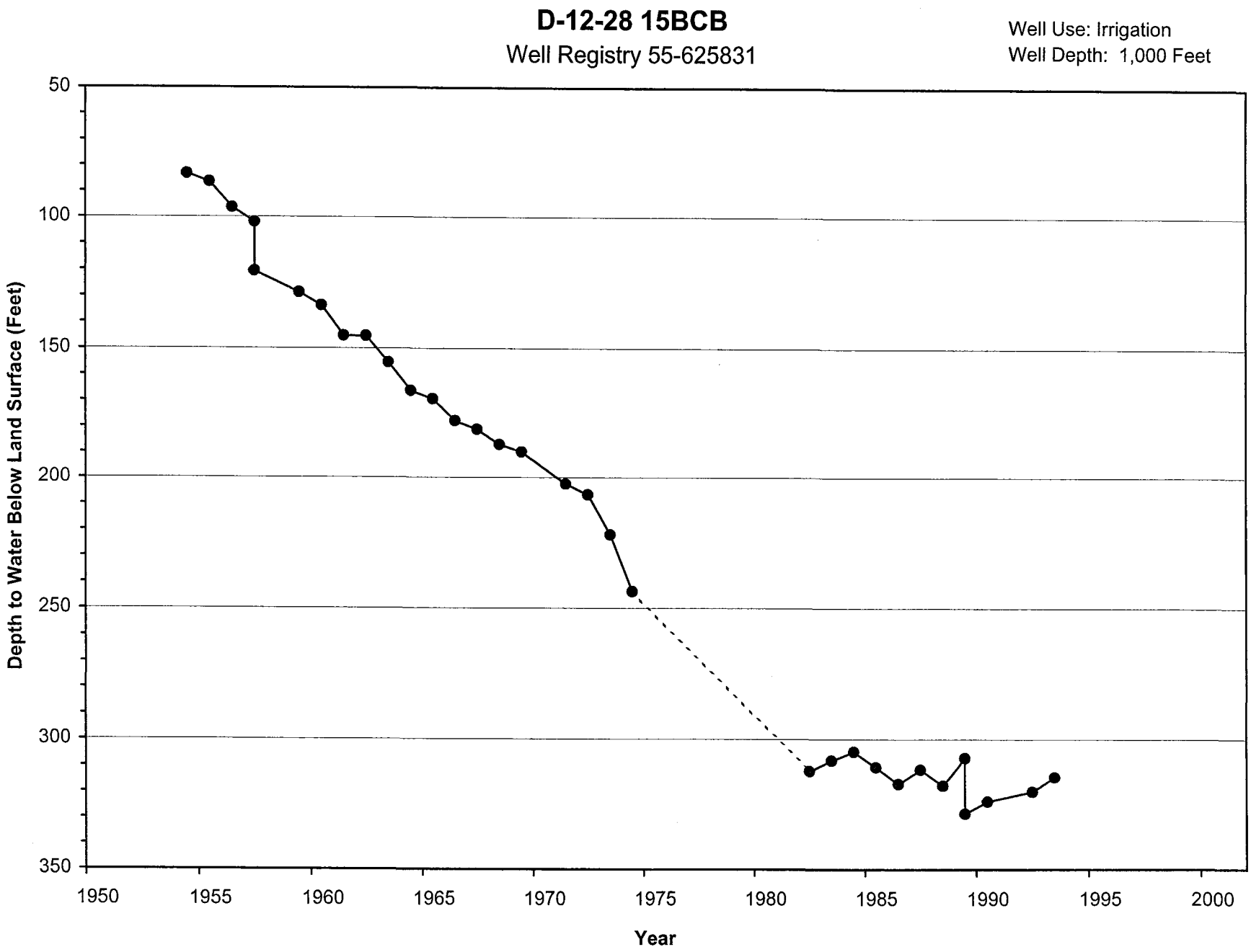
United States Geologic Survey, Annual Water Year Data, Various Reports

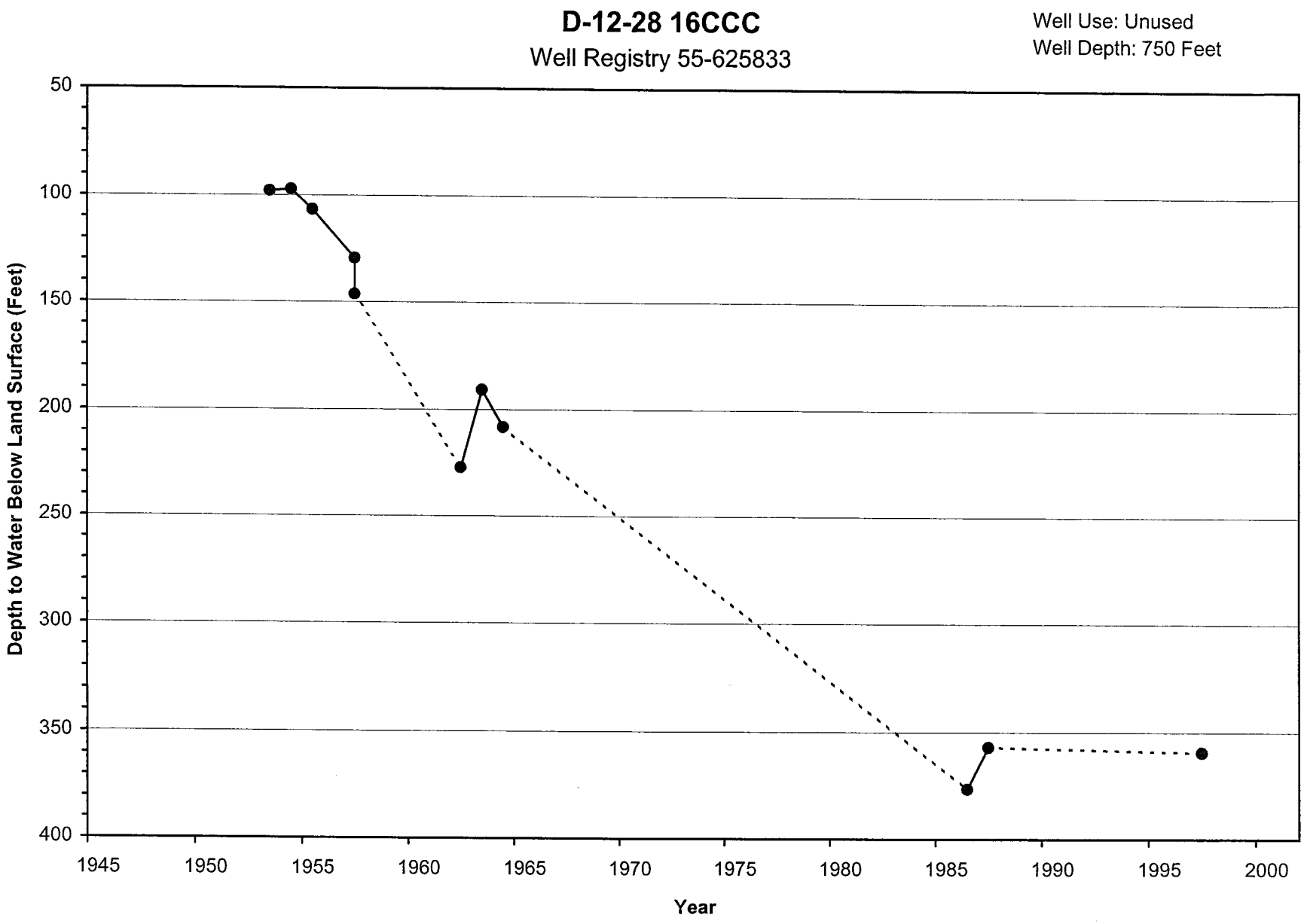
Geological Consultants Inc., 2001, Ground subsidence and earth fissure evaluation, Bowie Power Station Cochise County, Arizona, 39 p.

Estimated Pumpage San Simon Sub-Basin

Source: U.S. Geological Survey



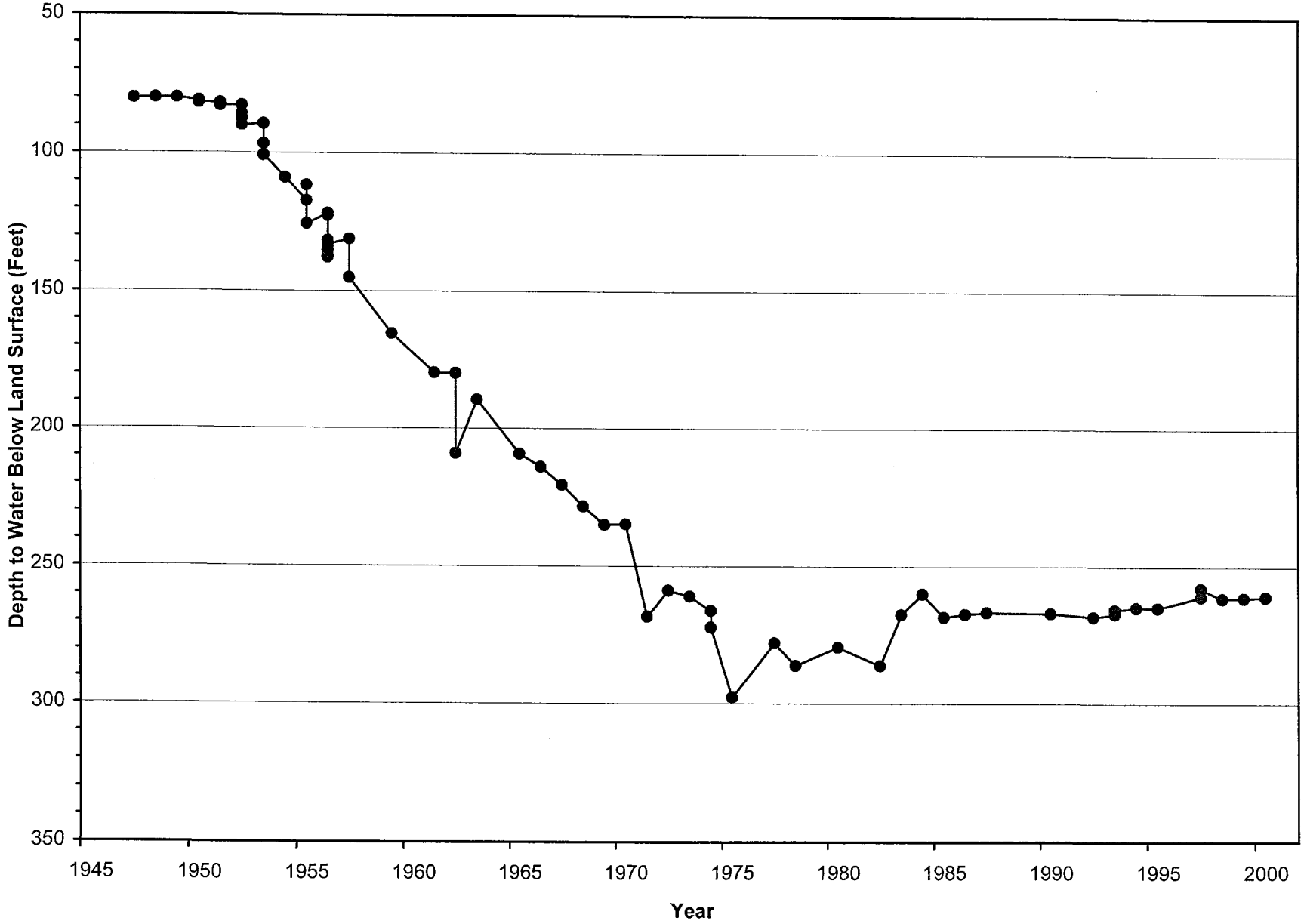

D-12-28 15BCB
Well Registry 55-625831
Well Use: Irrigation
Well Depth: 1,000 Feet
Depth to Water Below Land Surface (Feet)
50
100
150
200
250
300
350
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year

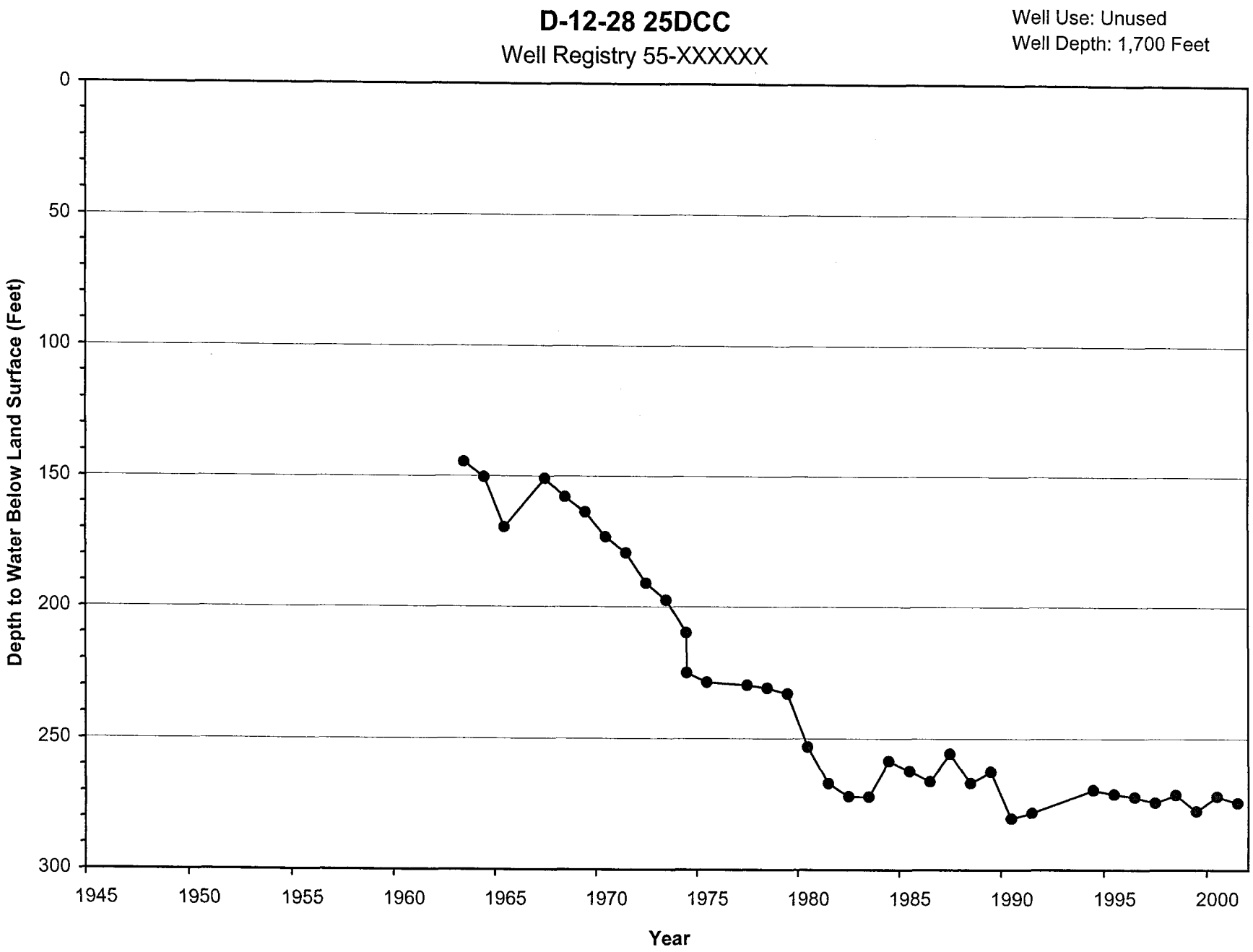

D-12-28 16CCC
Well Registry 55-625833
Well Use: Unused
Well Depth: 750 Feet
Depth to Water Below Land Surface (Feet)
50
100
150
200
250
300
350
400
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year

D-12-28 17DDD

Well Registry 55-609816

Well Use: Unused
Well Depth: 567 Feet




D-12-28 25DCC
Well Registry 55-XXXXXX
Well Use: Unused
Well Depth: 1,700 Feet
Depth to Water Below Land Surface (Feet)
0
50
100
150
200
250
300
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year

Arizona Corporation Commission

Power Plant Issues

ACC Staff Presentation

November 1, 2001

EXHIBIT
Admitted
5-2

Agenda

- Context of Need Determination
- Proposed Plants in Arizona
- Forecasted Water/Gas Usage
- Arizona EHV Transmission
- Comparison of Proposed Generation & Transmission
- When is Enough ENOUGH?
- Questions

Context of Need Determination

- Existing Loads with Reserve Margins
- Projected Loads with Reserve Margins
- Replace Older, Less Efficient Plants
- Competitive Margin
- Ancillary Services

Proposed Plants in Arizona

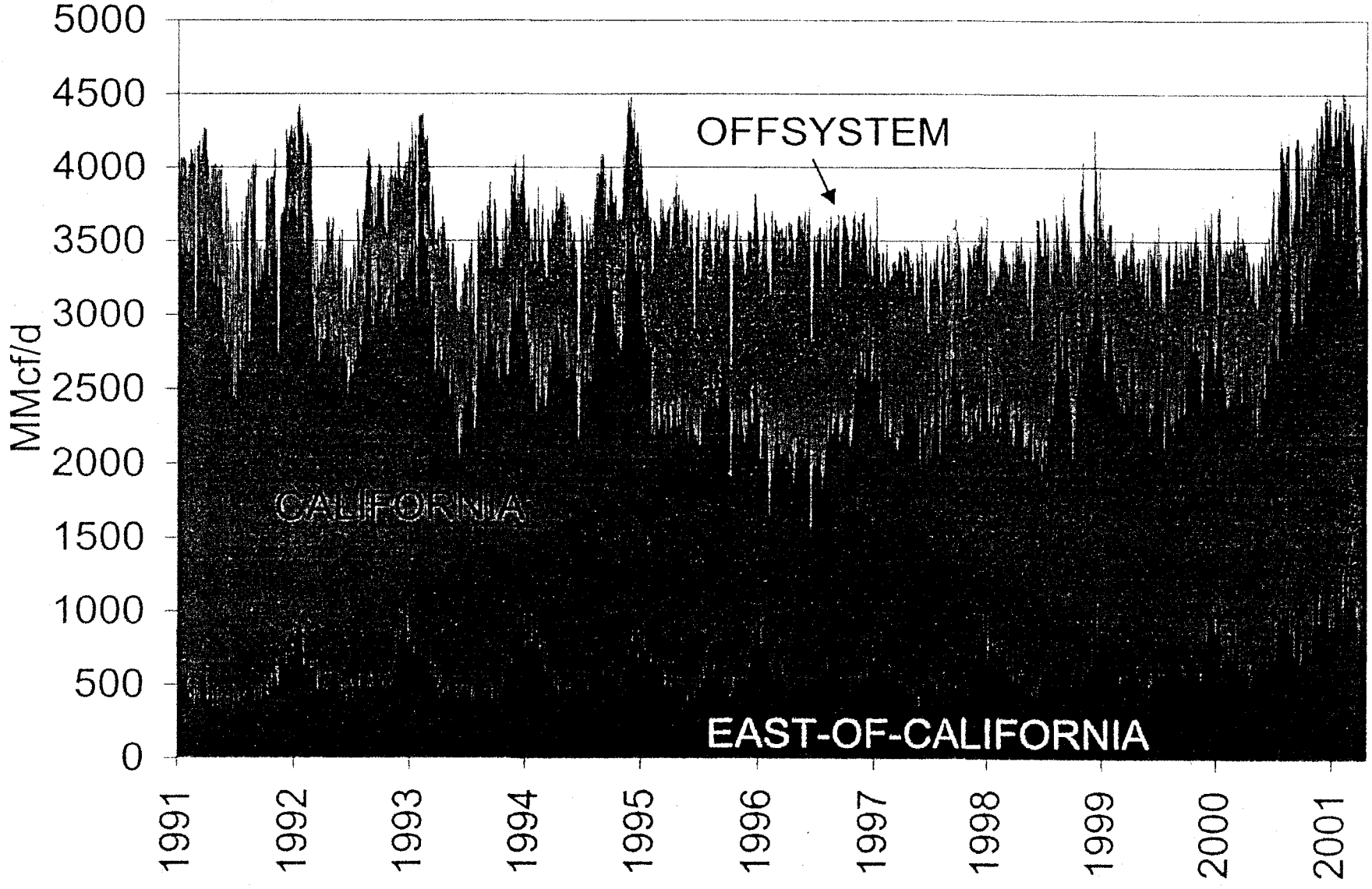
Status	Year							
	2001	2002	2003	2004	2005	2006	2007	
Commercial Operation	1,830	-	-	-	-	-		1,830
Under Construction	-	2,370	3,365		-	-		5,735
Regulatory Approval Received	-	450	1,040	1,605	825	620	530	5,070
Application Under Review	-	500	2,340	540	1,540			4,920
Application Filed	-	-	-	500	500	-		1,000
Announced	-	-	520	580	-	-	2,720	3,820
Total MW	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Forecasted Water/ Gas Usage

Year	No. Power Plants Units	Output (MW)	Water Usage (Acre-ft/Yr)	Gas Usage (B Btu/Yr)
2001	4	1,830	12,843	110,986
2002	6	3,320	24,102	195,554
2003	5	6,745	39,773	408,223
2004	4	2,645	26,000	130,887
2005	1	2,865	17,500	189,437
2006	0*	620	3,465	37,230
2007	0*	530	3,325	33,830
	20	18,555	127,008	1,106,147

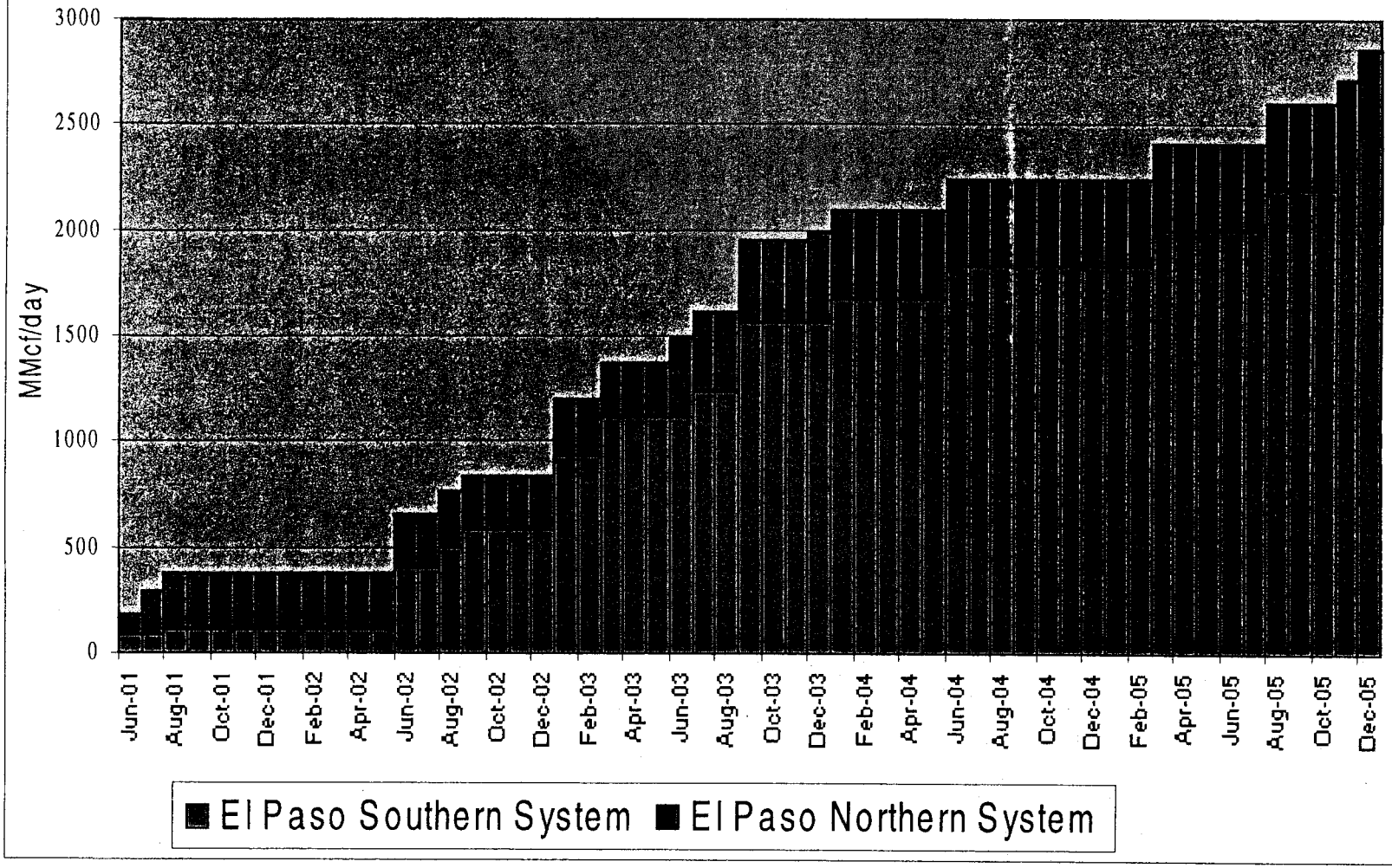
* Additional generating units are being added to existing plant site.

System Utilization

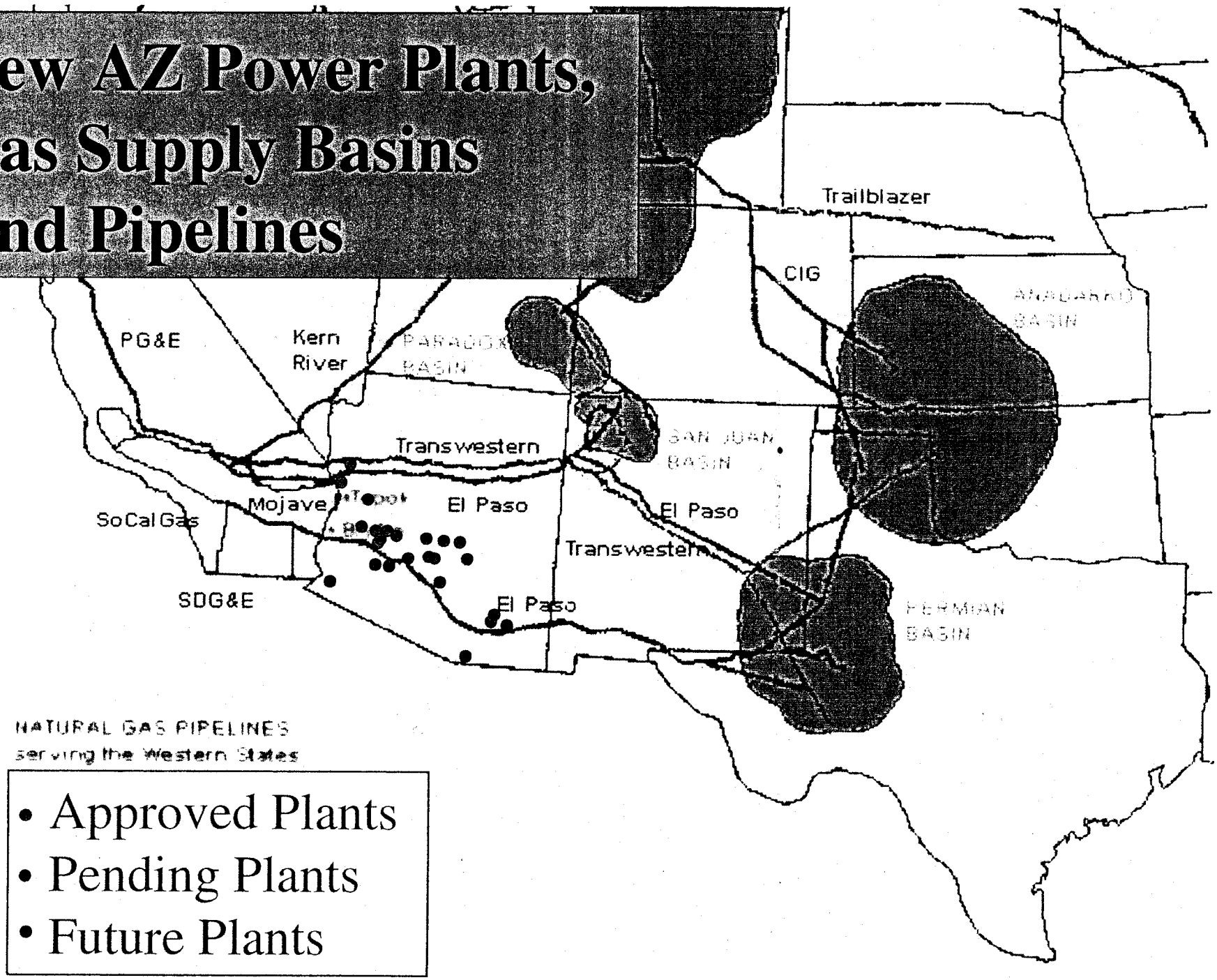


Source: Presentation to East of California parties by El Paso Natural Gas Company on April 26, 2001

Projected Gas Consumption of New Electric Generation in Arizona

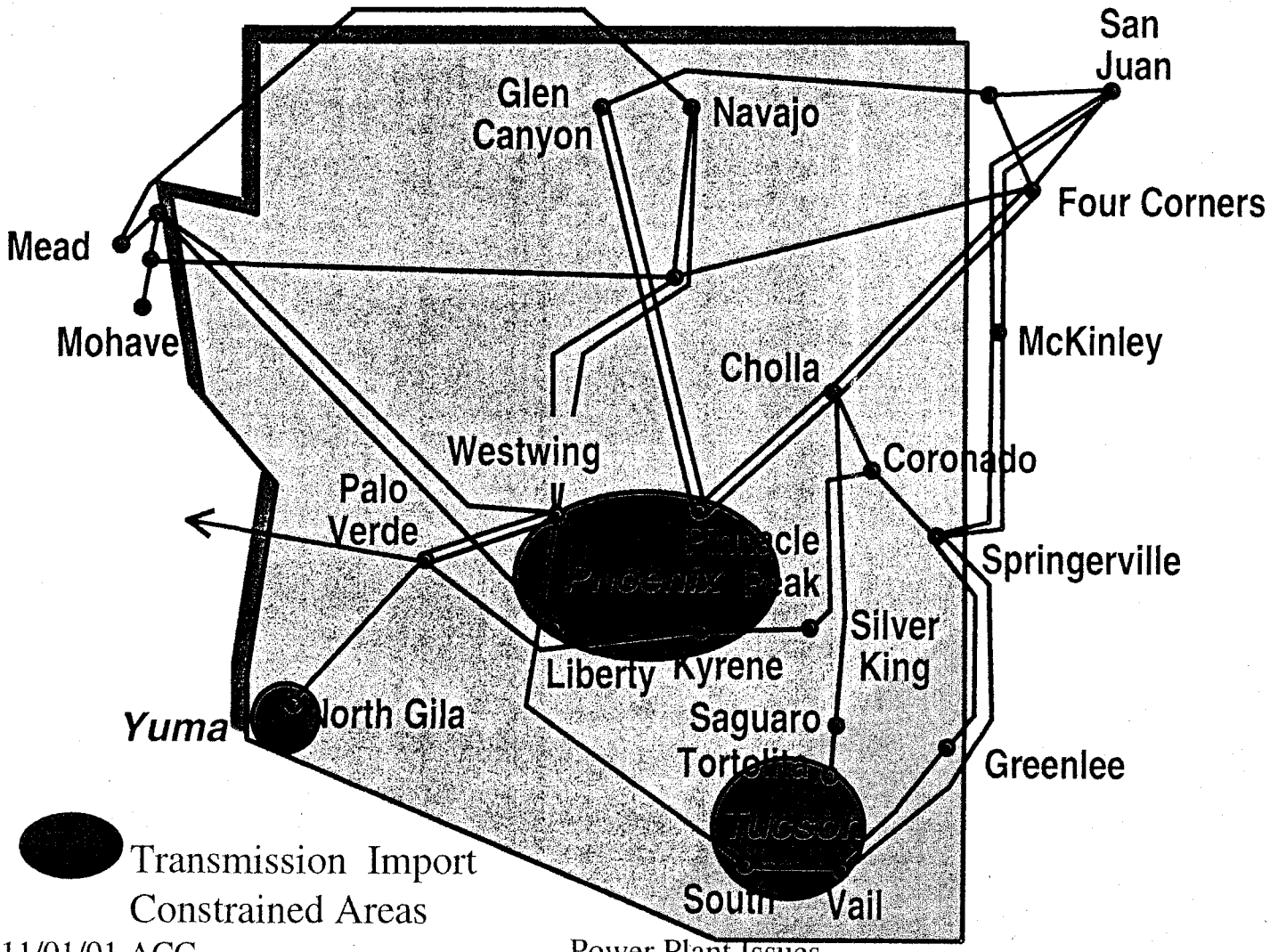


New AZ Power Plants, Gas Supply Basins And Pipelines



- Approved Plants
- Pending Plants
- Future Plants

Arizona EHV Transmission



Comparison of Proposed Generation & Transmission

Status	Generation MWs	Transmission MWs	
Commercial Operation	1,830	-	1,830
Under Construction	5,735	-	5,735
Regulatory Approval Received	5,070	-	5,070
Application Under Review (1)	4,920	1,950	2,970
Application Filed	1,000		1,000
Announced (2)	3,820	2,850	970
Total MWs	22,375	4,800	

(1) Palo Verde to Southwest Valley & South Sub to Nogal
(2) PNM's Palo Verde to Mexico, NRG's Palo Verde to Yuma West & SRP's Palo Verde to Southeast Valley

When is Enough ENOUGH?

- Water Resources Over Utilized
- Gas Supply or Delivery Capability Exceeded
- Transmission System Deliverability Exceeded
- Market Saturated

Questions ?

TRANSMISSION SYSTEM LIMITATIONS IN THE STATE OF ARIZONA AS IT AFFECTS THE SOUTHWEST TRANSMISSION SYSTEM AND FUTURE RESOURCES OF AEPCO

INTRODUCTION

This document has been prepared to provide the Rural Utilities Services (RUS) information on the transmission system limitations that exist in the State of Arizona as it affects the ability of Southwest Transmission Cooperative, Inc. (Southwest) to import power on behalf of AEPCO to its Class A Member load centers from new generation sources that are being sited in the state.

Information in this document will add further detail to the presentation on transmission system limitations that was briefly discussed with the RUS at a meeting held at the RUS's offices on August 9, 2001. Based on the discussions at the meeting on August 9th, Southwest understands that the information contained in this document will help the RUS in its review of AEPCO's proposed construction of a new 38 MW aero-derivative combustion turbine at Apache Generation Station.

GENERAL DISCUSSION OF POWER PLANTS PROPOSED OR UNDER CONSTRUCTION

As of the date of this document, approximately 22 power plants are proposed or under construction in the state of Arizona. The cumulative output of these 22 plants is approximately 19,235 MW. The majority of these plants are classified as "merchant plants," meaning that the developers of the plants have secured funding to construct these plants based upon a reasonable assumption that they will be able to sell their power into the "market." Indeed, recent experience with the shortage of power in California has spawned a growing awareness throughout the Southwest, for the need to add generating capacity to the existing transmission system grid. The developers of these merchant plants within the state of Arizona have become very active because of the California situation, and are confidant that because of less restrictive regulatory practices in the state, they will be able to quickly site their plants, sell their generation to entities within the state and outside of the state, specifically to markets in California. Some of these developers teamed up with the transmission owning entities in the state for their planned generation needs. AEPCO also has a need for additional generation, as do many entities throughout the Southwest, and these have been sufficiently delineated in the document entitled "Study Documents to Support the Current Resource Choice," which was provided to the RUS on August 9th.

While it is true that there is a recognized need for additional generation throughout the Southwest, it is interesting to note that within the state of Arizona, there has not been any announced transmission system expansion projects, to accommodate access to major hubs or common entity-owned buses from the proposed 19,235 MW of proposed generation system additions. The developers of these merchant projects, with their desires to get their generation to the marketplace, have merely proposed interconnections to the existing bulk transmission system, without looking at any major infrastructure changes to the bulk system.

EXHIBIT
Admitted
5-3

The Arizona Corporation Commission (ACC), which has siting approval for the construction of generation and transmission projects within the state of Arizona, has approved several of the generation projects, even though these plants simply interconnect with the existing Extra High Voltage (EHV) system. However, in performing the recent assessment of the EHV transmission system within Arizona, the ACC staff pointed out that "the State of Arizona does not have adequate existing or planned transmission facilities to deliver the energy needs of the state in a reliable manner." (*Biennial Transmission Assessment 2000-2009*, February 2001, p. iii) The ACC staff is concerned that without additional transmission lines to accommodate the full output of these proposed plants, "curtailment and scheduling restriction procedures will have to be developed." (Ibid)

In a similar vein, the Western Governor's Association issued a report on transmission expansion in the West, and concluded that even with the generation and transmission facilities that are planned through 2004, "It should be noted that without these expansion projects, the existing transmission system may not be adequate to meet peak load, integrate new planned generation and maintain sufficient levels of reliability." (*Conceptual Plans for Electricity Transmission in the West*, Report to the Western Governor's Association, August 2001, p. 5)

TRANSMISSION IMPORT CONSTRAINED ZONES WITHIN ARIZONA

Historically, Arizona's EHV system was developed to interconnect large generating resources to the major load centers. With the growth that has occurred in the state over the last several years, these lines, which also provided strong ties to neighboring states such as New Mexico, Colorado and Utah, have become constrained in their ability to serve the metropolitan areas of Phoenix and Tucson. The electric utilities within these constrained areas have long relied upon their own internal generation to cover their loads under peak periods. It is now generally recognized that within the state of Arizona, there are three major transmission import constrained zones: The Phoenix metropolitan area, Tucson and Yuma. As pointed out above, most of these proposed power plants are seeking interconnection to the existing EHV system, which has become constrained. Several of the proposed plants are located south of Phoenix in the Casa Grande, Coolidge, Gila Bend area, where there is not sufficient transmission capability on the existing transmission system to get the generation to the marketplace. The relationship of these proposed plants to the Southwest system will be discussed below from a current and future perspective.

In addition to the proposed plants which are sited near the Phoenix area and between Phoenix and Tucson, several are also proposed for Northwest Arizona, which has a bearing on the ability of AEPCO to serve its customers in Northwest Arizona.

LIMITATIONS INTO THE SWTRANSCO TRANSMISSION SYSTEM

Because the Southwest transmission system ties either directly or indirectly to various buses in the transmission import constrained zones enumerated above, it will be instructive to list these. Southwest ties indirectly to most of those buses through its contracts with the Western Area Power Administration (Western). The listing is as follows:

Import Constrained Zone	Bus	Southwest connection
Phoenix metropolitan area	Westwing	Direct tie
	Liberty	Indirect tie through Western
	Kyrene	Indirect tie through Western
	Pinnacle Peak	Indirect tie through Western
Tucson area	Saguaro/Tortolita	Indirect tie through Western
	Vail/South	Direct tie
Yuma area	North Gila	No ties
Northwest Arizona	Davis	Indirect tie through Western
	Mead	Indirect tie through Western
	Topock	Direct tie to South Pointe

As the Yuma area has no direct bearing on the Southwest transmission system, it will be not discussed further in this document. At the present time, there is little available transmission system capacity to the above-mentioned buses. The 345 kV line from Vail/South to Westwing that is the mainstay of Southwest's ability to export and import power on behalf of AEPCO and the Class A Members in Northwest and Southeast Arizona, is fully subscribed. Southwest owns 24% of this line, with Tucson Electric Power Company (TEP) owning the remaining 76%. The ability to deliver to Northwest Arizona through Western's Parker Davis and Intertie Transmission systems is also constrained, as these transmission systems are also fully subscribed.

CURRENT EXPERIENCE GETTING AEPCO POWER DELIVERED

This section will discuss the experience of Southwest/AEPCO in getting power delivered over the existing bulk transmission system from newly constructed power plants that are located away from the Palo Verde area. Prior to it efforts to secure the purchase of GT4, AEPCO unsuccessfully explored PPA possibilities with the developer's of these plants that were the closest to being on line to meet AEPCO's needs in 2002 and 2003, for which existing transmission capability may be available.

Plant	Location	Size	Status
Griffith Energy Project	Northwest Arizona	530 MW	In testing
South Pointe Project	Northwest Arizona	500 MW	Operational
Sundance Energy	Coolidge Area	450 MW	Not yet permitted
UniSource Energy (TEP)	Springerville Area	760 MW	Not yet permitted

With respect to the Griffith and South Pointe projects, Southwest might have been able to arrange with Western to deliver this power into Mohave's area, but not to its other Class A Members in Southeast Arizona as Western no longer has any available transmission capability on its Parker-Davis or Intertie transmission systems. Indeed, Western has recently discussed with Southwest ways in which to make procedural changes to Southwest's existing contract

paths into Northwest Arizona due to operational difficulties now being encountered as a result of the addition of the Griffith Project to Western's Intertie system.

AEPCO discussed with the developers of Sundance Energy purchasing supplemental capacity and energy both for the short term needs (2002) and for longer term needs, possibly to the year 2020. AEPCO proposed a PPA for 15 to 25 MW for the summer of 2002, which would be served over Western's existing transmission system to Class A loads at Oracle Junction and Marana. At an initial amount of 13 MW, Sundance could displace the current transmission service arrangement with Western, but any amounts beyond that would need additional capability to that area from Southwest's rights from Westwing. While Western was initially favorable to amending the contracts with Southwest for both the short and long term needs of AEPCO, Sundance Project was unwilling to offer such a small PPA.

In late 2000, TEP's parent UniSource Energy contacted AEPCO about the potential development of units 3&4 at the Springerville generating station. At the time of construction of the Springerville plant, only two of the original four units were constructed. The last two units are to be placed in service in 2004 and 2005. TEP constructed two 345 kV transmission lines on separate structures from the Springerville generating station into the Tucson area, with one of the structures being constructed to handle an additional circuit. AEPCO has been in discussion with TEP about being an off-taker of 50 MW of the output of the new units, as well as participating in the construction costs of the additional 345 kV circuit, at a proportionate share of the project costs of $59M, with Southwest's share being approximately $8 M. This Springerville resource is continuing to be evaluated by AEPCO/Southwest.

EFFORTS TO SECURE FUTURE TRANSMISSION CAPABILITY

This section will discuss the efforts of Southwest to secure future new transmission capability for AEPCO power deliveries to the Class A Members.

Early in 2001, Southwest was invited to participate with utilities and other market entrants from across the state in the development of the Central Arizona Transmission System (CATS) study. Because many of the proposed power plants are sited between Phoenix and Tucson, CATS was developed to study future EHV transmission ties between these two import-constrained zones. The CATS group has recognized that when the transmission system for the Palo Verde Generating Station was originally planned, consideration was given for a 500 kV line to be constructed from Palo Verde to the Tucson area (Saguaro Switchyard). However, the final Palo Verde transmission system resulted in the construction of the second Palo Verde to Westwing 500 kV line instead. Based on input received from CATS members, there is significant interest to support the construction of a 500 kV line from Palo Verde to the Tucson area, along with additional lines that will provide the market entrants with transmission alternatives for delivery of their generation to existing and future markets.

Many of the new power plants are to be sited at or near the Palo Verde Switchyard. Palo Verde is recognized as a major trading hub in the Southwest U.S. And, while Southwest's transmission system does not tie directly to the Palo Verde Switchyard, the study of future additions to the bulk transmission system at Palo Verde, extending to Central Arizona, could make it possible for

Southwest to deliver to and from Palo Verde. However the proposed transmission facilities being studied at CATS will not be available until at least 2004. Southwest is hopeful that through the addition of new transmission enhancements to the EHV system that will be proposed through CATS, it will be able to secure future transmission capability to meet AEPCO's needs for resources.

The following is a listing of the proposed power plants that are sited at other than Palo Verde:

Plant	Location	Size	Status
Big Sandy Project	Northwest Arizona	720 MW	Not yet permitted
Desert Basin	Casa Grande Area	500 MW	Operational/sold to SRP
Toltec Power Station	Casa Grande Area	2,000 MW	Not yet permitted
Bowie Power Station	Tucson Area	1,000 MW	Not yet permitted

As of this writing, Western is still determining the impact of the Big Sandy Project to its Intertie system. Western believes it can provide for deliveries of power into the Northwest Arizona and Phoenix areas. Future deliveries from these areas to AEPCO's customers could then be realized in conjunction with the transmission elements under consideration in the CATS study.

The Toltec plant proposes to interconnect to Southwest's and TEP's Vail/South to Westwing 345 kV line, but as discussed earlier, this line is fully subscribed for both Southwest and TEP. In order to provide for the output of this plant, one possibility is to construct a second Vail/South to Westwing 345 kV line. The cost to construct this 178 mile line is approximately $90M. Toltec has not yet initiated any service request.

The Southwestern Power Group II LLC, the developers for the Toltec Power Station, are also the developers for the recently announced Bowie Power Station. The Bowie plant material suggests interconnecting with Southwest's Apache to Redtail 230 kV line and with TEP's Vail to Greenlee 345 kV line. However, Bowie has not yet contacted TEP or Southwest to develop a System Impact Study as required by the Open Access Transmission Tariffs (OATT) of both entities. Our preliminary assessment is that transmission capability is not available to deliver Bowie power to Tucson or other markets without additional transmission line construction.

In conclusion, Southwest is currently unable to provide and/or procure transmission for the delivery of power from any of the merchant plants that are in operation, currently under construction, or planned for construction in Arizona. Southwest is participating in studies by transmitting utilities to determine improvements necessary to facilitate the deliveries of such power. The transmission projects under study will not be in service until 2004 and possibly even later.

C:\WINNT\Profiles\brucee\Personal\TransSysLimitationsinArizonaforRUS.doc

Arizona Proposed Power Plants - Technical Summary

Status / Facility	Estimated Online Date	Output (MW)	# of Units	Technology	Fuel Type	Gas Use (MMBtu/Yr)	Water Use (Acre-Ft/Yr)	Water Source(s)
0								
West Phoenix (Phase 1)	08/01/2001	120	1-1-1	Combined	Gas	6,619,200	1,083	Groundwater - Existing Wells
Desert Basin	06/01/2001	520	1-2-1	Combined	Gas	33,100,000	4,200	50% CAP and 50% Casa Grande Effluent
Griffith Energy Project	07/01/2001	650	1-2-1	Combined	Gas	36,266,400	3,060	Mohave County Groundwater Rights
South Point	06/01/2001	540	1-2-1	Combined	Gas	35,000,000	4,500	Groundwater
	Yearly Subtotal	**1,830**				**110,985,600**	**12,843**	
	Status Total	**1,830**				**110,985,600**	**12,843**	
1								
Kyrene	06/01/2002	250	1-2-1	Combined	Gas	17,885,000	1,600	SRP Surface Water or Tempe Effluent
West Phoenix (Phase 2)	09/01/2002	500	1-2-1	Combined	Gas	29,234,800	4,516	Ground Water - Existing wells
Gila River 2	08/01/2002	520	1-2-1	Combined	Gas	32,169,750	3,333	Groundwater
Gila River 1	06/01/2002	520	1-2-1	Combined	Gas	32,169,750	3,333	Groundwater
Arlington Valley 1	08/01/2002	580	1-2-1	Combined	Gas	37,740,000	6,800	Groundwater
Sundance Energy Project #1	06/01/2002	450	10	Comb Turb	Gas	22,000,000	720	CAP
	Yearly Subtotal	**2,820**				**171,199,300**	**20,302**	
Redhawk 2	01/01/2003	530	1-2-1	Combined	Gas	32,830,250	3,325	For Site - 3,300 Groundwater, 10,000 Effluent
Mesquite Power Plant	03/01/2003	1,265		Combined	Gas	64,000,000	7,490	Groundwater
Redhawk 1	01/01/2003	530	1-2-1	Combined	Gas	32,830,250	3,325	For Site - 3300 Ground Water, 10,000 Effluent
Harquahala	09/01/2003	1,040	4-1-1	Combined	Gas	60,882,000	6,000	CAP Surface Water w/ Groundwater Backup
	Yearly Subtotal	**3,365**				**190,542,500**	**20,140**	
	Status Total	**6,185**				**361,741,800**	**40,442**	
2								
Gila River 4	01/01/2003	520	1-2-1	Combined	Gas	32,169,750	3,333	Groundwater
Gila River 3	01/01/2003	520	1-2-1	Combined	Gas	32,169,750	3,333	Groundwater
	Yearly Subtotal	**1,040**				**64,339,500**	**6,666**	
Springerville Units #3	06/01/2004	380	1	Fossil	Coal	0	5,000	Existing wells and water rights
Gila Bend	06/01/2004	845	3-2-1	Combined	Gas	56,355,000	10,000	Groundwater
Springerville Unit 4	06/01/2004	380	1	Fossil	Coal	0	5,000	Existing wells and water rights

EXHIBIT
Admitted
5-4

Status	Facility	Estimated Online Date	Output (MW)	# of Units	Technology	Fuel Type	Gas Use (MMBtu/Yr)	Water Use (Acre-Ft/Yr)	Water Source(s)
		Yearly Subtotal	**1,605**				**56,355,000**	**20,000**	
	Santan	12/01/2005	825	3-3-1	Combined	Gas	53,655,000	6,500	SRP, CAP or Gilbert Surface Water
		Yearly Subtotal	**825**				**53,655,000**	**6,500**	
	Redhawk 3	06/01/2006	530	1-2-1	Combined	Gas	32,830,250	3,325	For Site - 3,300 Groundwater, 10,000 Effluent
	Sundance Energy Project #2	06/12/2006	90	2	Comb Turb	Gas	4,400,000	140	CAP with Groundwater backup
		Yearly Subtotal	**620**				**37,230,250**	**3,465**	
	Redhawk 4	12/01/2007	530	1-2-1	Combined	Gas	33,830,250	3,325	For Site - 3,300 Groundwater, 10,000 Effluent
		Yearly Subtotal	**530**				**33,830,250**	**3,325**	
		Status Total	**4,620**				**245,410,000**	**39,956**	
3									
	Toltec 1	09/30/2003	1,000	2-2-1	Combined	Gas	61,250,000	5,000	Groundwater
	Arlington Valley 2	06/30/2003	600	1-2-1	Combined	Gas	37,000,000	1,000	Groundwater
	Welton-Mohawk	06/01/2003	520	1-2-1	Combined	Gas	44,375,000	5,500	Colorado River Water Allocation
		Yearly Subtotal	**2,120**				**142,625,000**	**11,500**	
	Bowie 1	06/30/2004	500	1-2-1	Combined	Gas	40,000,000	2,750	Groundwater
	La Paz 1	10/30/2004	540	1-2-1	Combined	Gas	34,531,920	3,250	Groundwater
		Yearly Subtotal	**1,040**				**74,531,920**	**6,000**	
	Bowie 2	12/31/2005	500	1-2-1	Combined	Gas	40,000,000	2,750	Groundwater
	La Paz 2	03/30/2005	540	1-2-1	Combined	Gas	34,531,920	3,250	Groundwater
	Toltec 2	03/31/2005	1,000	2-2-1	Combined	Gas	61,250,000	5,000	Groundwater
		Yearly Subtotal	**2,040**				**135,781,920**	**11,000**	
		Status Total	**5,200**				**352,938,840**	**28,500**	
5									
	Littlefield (Beaver Dam)	06/01/2003	520	1-2-1	Combined	Gas			
		Yearly Subtotal	**520**						
	Signal Peak (Desert Basin 2)	06/01/2004	580		Combined	Gas	0	250	Casa Grande Effluent and CAP
		Yearly Subtotal	**580**				**0**	**250**	
	Maestros Group Nogales Project	01/01/2007	500			Gas	0	0	Treated Effluent
	Safford	01/01/2007	220			Gas	0	0	
	Winchester	06/01/2007	750	1-2-1	Combined	Gas			

Status	Facility	Estimated Online Date	Output (MW)	# of Units	Technology	Fuel Type	Gas Use (MMBtu/Yr)	Water Use (Acre-Ft/Yr)	Water Source(s)
	White Tank Mountain	01/01/2007	1,250	5	Pump Storage	Hydro			
		Yearly Subtotal	**2,720**				**0**	**0**	
		Status Total	**3,820**				**0**	**250**	
6									
	Big Sandy (Phase I)	08/01/2002	500	1-2-1	Combined	Gas	24,354,870	3,800	Groundwater
		Yearly Subtotal	**500**				**24,354,870**	**3,800**	
	Big Sandy (Phase II)	12/01/2003	220	1-1-1	Combined	Gas	10,716,143	1,467	Ground
		Yearly Subtotal	**220**				**10,716,143**	**1,467**	
	Montezuma (520 MW)	01/01/2007	0		Combined	Gas		0	
		Yearly Subtotal	**0**					**0**	
		Status Total	**720**				**35,071,013**	**5,267**	
Total for Arizona Proposed Power Plants			**22,375**				**1,106,147,253**	**127,258**	

Status Key:
- **0 - Commercial Operation**
- **1 - Under Construction**
- **2 - Regulatory Approval Received**
- **3 - Application Under Review**
- **4 - Application Filed**
- **5 - Announced**
- **6 - Suspended or Denied Approval**

Emissions and Pollutants Information Not Available in Database