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YARNELL PROJECT
Yavapai County, Arizona

MINING PLAN OF OPERATION

Submitted To:
U.S. DEPARTMENT OF INTERIOR
BUREAU OF LAND MANAGEMENT
Phoenix Resource Area Office
2015 West Deer Valley Road
Phoenix, Arizona 85027

Submitted By:
YARNELL MINING COMPANY, INC.
A Subsidiary of Bema Gold (U.S.) Inc.
189 South Broadway Street
Post Office Box 1182
Yarnell, Arizona 85362

December 1994

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YARNELL MINING COMPANY

June 28, 1995

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

Re: Yarnell Gold Mine - Yavapai County

Dear Mason:

Thank you again for taking the time to travel to Yarnell and discuss the benefits of mining at the Arizona Association of Mining Districts meeting last weekend. Any positive and informative discussion regarding mining is a great help to our project.

As discussed yesterday, enclosed is a copy of our Mining Plan of Operation submitted to BLM last year. I apologize for not providing you with a copy sooner.

Sincerely,
Yarnell Mining Company

Mark A. Montoya
Project Manager

Enclosure

189 S. Broadway Street, P.O. Box 1182, Yarnell, Arizona 85362 Tel: (602) 427-3353 Fax: (602) 427-6404

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The following units of measure and abbreviations are used throughout this report:

Abbreviation	Definition
$	US Dollars
Au	gold
BCY	bank cubic yards
cu yd	cubic yards
ft	feet
g	grams
in	inches
kg	kilograms
kV	kilovolts
lb	pounds
mi	mile
MPO	Mining Plan of Operation
opt	troy ounces per short ton
ozt	troy ounces
ounces	troy ounces
pa	per annum
pC	pre-Cambrian
ppm	parts per million
RC	reverse-circulation drilling
ROM	run-of-mine
t	short tons
ton	short tons
tpd	short tons per day
tpy	short tons per year
WAD	Weak acid dissociable
yd	yards
V	volts

1.1 *Report Scope*

This Mining Plan of Operation (MPO) is being submitted to the Phoenix Area Office of the U.S. Department of the Interior, Bureau of Land Management (BLM), in compliance with federal regulations regarding "Surface Management of Public Lands" under the U.S. Mining Laws stipulated by 43 CFR, Part 3800, Subpart 3809. The MPO contained herein describes the Yarnell Project proposed by Yarnell Mining Company, Inc. (YMC), a wholly-owned subsidiary of Bema Gold (U.S.) Incorporated.

1.2 *Historic Overview*

The Yarnell gold deposit is located in the Weaver Mountains of Yavapai County, Arizona, and approximately 26 miles north of the town of Wickenburg. The property is 1 1/2 miles southwest of the small community of Yarnell and some 70 miles by road from Phoenix, as shown in Figure 1.1. Average elevation of the planned mining and processing facilities is 4,800 feet above mean sea level.

Placer gold was first discovered in 1862, in the Rich Hill area, about four miles south of the Yarnell deposit. The Octave Mine, about two miles south of Rich Hill, was located a few years later and was one of the first lode discoveries in the area. It eventually produced $2 million of gold and silver between 1900 and 1930.

The Yarnell Deposit was probably first discovered in the late 1800s. By 1914, underground development had progressed to 160 feet below the surface and some 250,000 tons of ore at an average grade of 0.29 opt gold had been defined. The mine was closed in 1916.

By 1936, a 70 ton per day flotation and cyanide mill was operating on site, with head grades reported to be averaging 0.39 to 0.48 opt gold. The mill capacity was increased to 125 tons per day in 1940. The mine, using a modified shrinkage method, had difficulty feeding the mill at this greater capacity. As a result, low grade wall rock diluted the grade to 0.19 opt. Mining ceased in 1942, due to the passage of the War Measures Act.

For the next 40 years or so, there was only minor activity at the Yarnell Mine; pillar robbing and slabbing underground along with some open-cut mining of the ore body where it crops out at the top of the hill.

In 1983, Homestake Mining Company acquired the property and conducted an underground sampling and evaluation program. The results of this work apparently did not delineate a viable underground target, so Homestake Mining Company dropped the option. Norgold Resources (U.S.) Inc., (Norgold) acquired the property from the owners in December of 1988 with the intent of exploring the property for a larger, lower grade deposit which could be exploited with surface mining techniques.

In January of 1989, Asarco entered into an option agreement with Norgold to earn a 51% interest in the Yarnell Deposit by making payments, fulfilling work requirements and completing a positive feasibility study by July 1, 1991. Asarco started an intensive exploration effort early in 1990, which included geological mapping and sampling, road building, the drilling of 96 reverse-circulation drill holes totalling 24,367 feet, and four diamond drill holes totalling 1,295 feet. Asarco also completed a ground magnetometer survey, an aerial multi-sensor geophysical (Dighem) survey, surveying of old underground workings, metallurgical work, ore reserve calculations and engineering studies.

Asarco dropped the option in September of 1990, apparently because the Yarnell deposit did not meet their minimum size requirements. Bema Gold Corporation (Bema) gained control of the Yarnell deposit in April of 1991, after a successful share exchange take over bid of Norgold. Asarco was obligated under the agreement with Norgold to provide all data on the Yarnell Deposit. This was, in turn, provided to Bema. Norgold officially became YMC in June of 1994. YMC is a subsidiary of Bema Gold (U.S.) Incorporated.

Since acquiring the property, Bema has significantly advanced the permitting process by conducting baseline environmental studies, drilled three diamond drill holes for metallurgical samples, re-logged reverse-circulation drill samples, completed a new geological block model and finalized ore reserve calculations. Staff have also developed an open-pit mine design and carried out preliminary engineering and economic evaluations. Bema completed a pre-feasibility study for the Yarnell Project in November 1992, and found the metallurgical testing and mine design results favorable. All of this work is incorporated into this MPO.

1.3 *Project Operation Overview*

1.3.1 Mining

The Yarnell deposit will be mined using the conventional open-pit mining method. Benches are planned to be 20 feet high. The waste pit-slope has been designed at 53°. The ore pit-slope follows the footwall of the ore zone and is generally 30 to 50°.

Planned mining equipment includes a blast-hole drill, one front-end loader, four haul trucks, one motor grader, one water truck, one track dozer and support equipment. An additional haul truck, a further dozer and front-end loader would support crushing and pad loading activities. The mining operation is planned to operate 24 hours per day, 5 days per week. Ore would be hauled directly to the crusher area, and either dumped directly into the primary feed, or stockpiled for later feeding by the loader or dozer.

The planned open pit includes 29 benches. Ore production has been scheduled from the top of the deposit downward. Waste production includes some pre-stripping in the southern end of some lower benches. Ore production is planned for 1.2 million tons per year to meet the ore processing schedule.

The mineable reserves, with a cutoff grade of 0.010 opt, are as follows:

Ore Tons (1000's)	Average Grade (Au opt)	Contained Gold (ozt)	Waste Tons (1000's)	Strip Ratio
6,995	0.035	246,830	11,818	1.69

1.3.2 Ore Processing

Metallurgical tests show 71% gold recovery in 100 days of heap leaching when the ore is crushed to 80% minus 1 1/2 inches. Processing facilities would include a two-stage crushing plant, equipment to haul ore from the crusher to the heap leach pad, the pad, a pregnant pond, a carbon adsorption recovery plant and a barren pond. The planned recovery plant includes the adsorption circuit, along with stripping, acid washing, electrowinning and smelting facilities.

Crusher operations, together with pad loading, are planned for 24 hours per day, 5 days per week. Leaching and metal recovery activities would carry on around the clock. Based on results of column leach tests, sodium cyanide consumption is estimated to be 1 lb per ton of ore, while lime consumption is 5 lbs. per ton of ore.

1.3.3 Infrastructure

Project infrastructure includes an administrative office, mine shops, assay lab, warehouse facilities, power distribution, water supply and access roads. All facilities, except for two water supply wells and the water transport pipeline, would be at the project site. Power will be obtained from the local utility, and water is to be secured from a local ground water source.

1.3.4 Production Schedule

The production schedule calls for mining and processing 1,200,000 tons of ore per year. Annual gold production, over an approximate six year mine life, would average 30,100 troy ounces.

1.4 *Company Profile and Responsible Personnel*

Bema Gold Corporation is a Canadian company headquartered in Vancouver, British Columbia. The company conducts business in the United States through its wholly-owned U.S. subsidiary, Bema Gold (U.S.) Incorporated. Yarnell Mining Company will operate the Yarnell Project and is a wholly-owned subsidiary of Bema Gold (U.S.) Incorporated.

Bema is an experienced heap leach, gold mining company. It has successfully developed and mined the Champagne Project in Butte County, Idaho, which is currently being reclaimed and decommissioned. The Champagne Project involved mining approximately 3.5 million tons of ore and 4.0 million tons of overburden by conventional open-pit mining methods over a 5 year mine life. The ore was heap leached. Bema has just recently secured financing to construct a large scale, open pit, heap leach gold mine at the Refugio Property in Chile. Amax Gold is Bema's 50% joint venture partner in the Refugio Property.

The personnel responsible for managing the Yarnell Project and their mailing addresses are listed below.

Mr. Mark Montoya, Project Manager
Yarnell Mining Company
P.O. Box 1182
Yarnell, Arizona 85362

Mr. David LeFevre, Operations Manager
Yarnell Mining Company
P.O. Box 1182
Yarnell, Arizona 85362

1.5 *Land Status and Property Ownership*

1.5.1 Overview

The Yarnell property consists of five patented claims, 82 unpatented claims, two Arizona State Prospecting Permits and one Arizona State Mineral Lease covering in total some 1,700 acres, as shown in Figure 1.2, Property Summary Map. The Yarnell Project as described herein involves approximately 160 acres. About 50% of the total property is held by YMC. After final option payments are made, (see next section), Bema will hold the additional property subject to royalties ranging from 1/2% to 5% Net Smelter Return (NSR), along with work commitments and/or payments on the patented mining claims, and work commitments and payments on the Arizona State Prospecting Permits and Mineral Lease. Refer to Appendix 1.0 for more detail. Claim block identifications, ownership, option agreements and acreages are summarized in Table 1.1.

TABLE 1.1 Property Status

Claims	Ownership/Agreement	Map Reference	Approx. Acres
Patented Claims			
Edgar, Edmond	YMC/Subject to Royalties	1A	75
Triangle, Juniper	" "		
Mother Lode	YMC	1B	20
Unpatented Claims			
RYA 1-38 & 41-43	YMC/Subject to Royalties	2A	480
Pennsylvania #1	" "		
Alvin J.	" "		
Kathryn A	" "		
Kathryn B	" "		
Victoria 1-5	YMC/Subject to NSR	2B	156
Black Dike Ext. #5	" "		
Black Dike #1	" "		
Rim Rock #1	" "		
Thunder Hill	" "		
Black Dike #3	YMC	2C	90
Pancho Villa 1 & 2	" "		
Gold Rock 1 & 2	" "		
Crazy Horse OK	YMC(*)/Layton	2D	420
Crazy Horse Tokay	" "		
Crazy Horse 1-4	" "		
Green Rock #1	" "		
Red Rock #1	" "		
Black Rock #1	" "		
Black Dike Ext. 1-4	" "		
Grey Mare #1-#5	" "		
Sky High #1-#5	" "		
State Prospecting Permits			
No. 08-53978	YMC	3A	299
No. 08-53979	" "	3B	155
Miscellaneous			
Existing microwave site	Santa Fe	4A	1/2
Existing microwave site	Maricopa County	4B	1/4
New Microwave Site	YMC	4C	1
New Microwave Site	YMC	4D	1/2
State Mineral Lease			
Kachina Doll	State of Arizona/YMC	5A	20
No. 1 - #11-31009	" "		
TOTAL AREA			*1,718*

(*) Right of first refusal

1.5.2 Summary of Agreements

Western Building and Mining: The final option payment was made January 1, 1994 and the four patented claims and 45 unpatented claims, subject to royalty payments, are now owned by Yarnell Mining Company (YMC).

Heintzelman Agreement: The final option payment was made on June 30, 1992, and this single patented claim (mother) is now owned by YMC.

Layton Agreement: YMC signed a purchase option agreement with Priscilla Layton on September 13, 1994. This agreement granted YMC exclusive rights to explore and mine on the property and an option to purchase the 23 unpatented claims. This option is maintained by completing and filing assessment work, as well as making yearly option payments until September 13, 1997. After the final payment, YMC will own the property subject to an ongoing NSR payment.

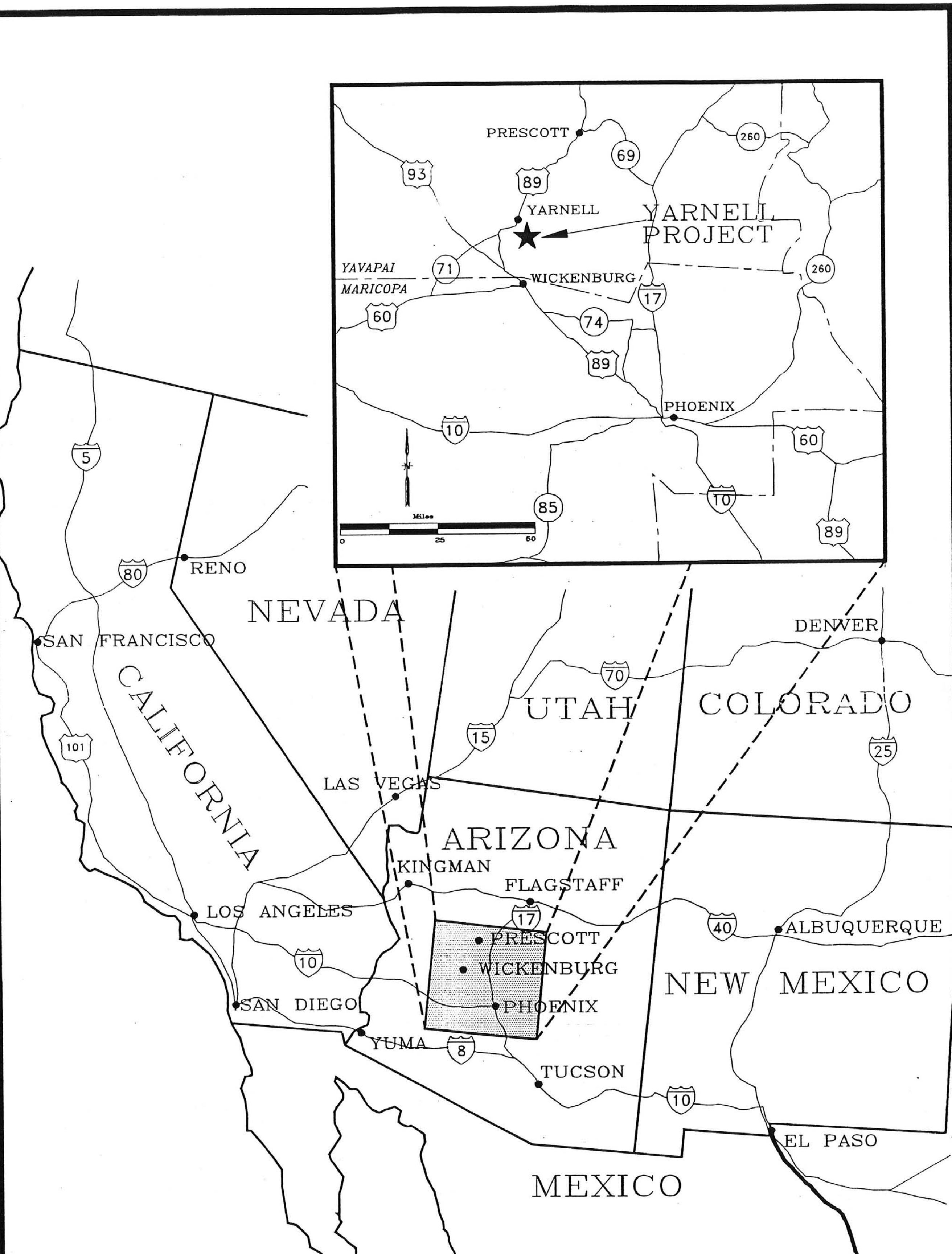
State Mineral Lease: The Arizona State Mineral Lease is a single 20-acre parcel named Kachina Doll within the Arizona Prospecting Permit No. 08-53978.

State Prospecting Permits: YMC holds two State of Arizona Prospecting Permits on a total of 454 acres. These permits were granted on June 15, 1994, for a period of five years.

Miscellaneous: Both the Santa Fe Railway Company and Maricopa County have microwave communication towers located on two small land parcels at the top of the hill overlying the Yarnell Deposit. Through Norgold, Bema has an option to purchase the Santa Fe land (1.7 acres). The ground would then be subject to a NSR to Santa Fe. In the agreement, Santa Fe has nine months in which to move their equipment to an approved alternative site.

YMC has purchased two land parcels (4C and 4D shown on Figure 1.2) about 1/2 mile to the northeast of the project site upon which the towers can be relocated. Santa Fe has approved of one of these sites. Although discussions have begun, no agreement has yet been finalized with Maricopa County. These parcels are noted as 4C and 4D on Figure 1.2.

YMC holds the property subject to the royalties discussed above. The only other commitments on the project will be work commitments and/or payments to the federal government on the unpatented mining claims and work commitments and payments on the Arizona State Prospecting Permits and the Mineral Lease. Copies of the property agreements can be found in Appendix 1.0.



YARNELL MINING COMPANY
A SUBSIDIARY OF BEMA GOLD (U.S.) INC.

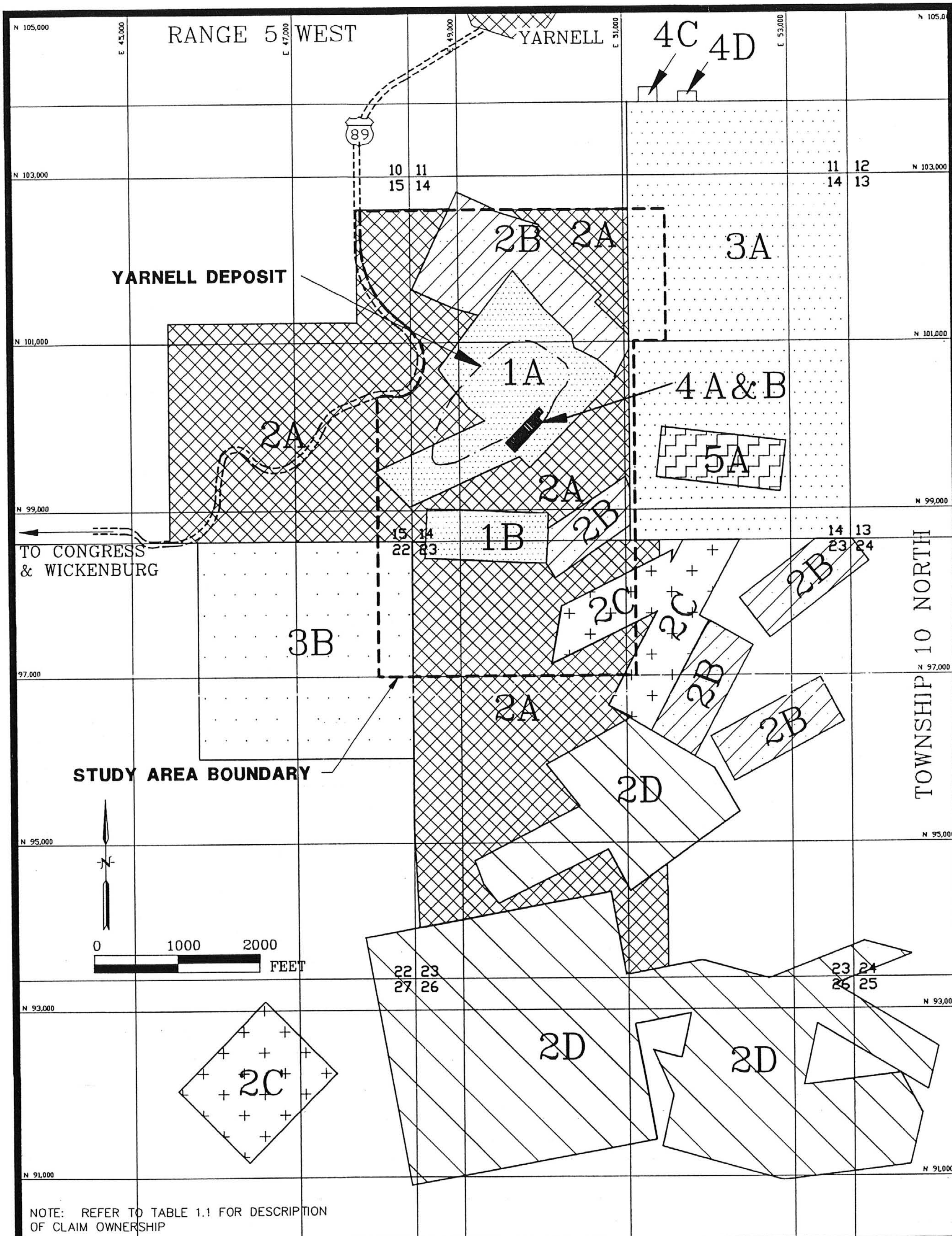
YARNELL PROJECT
YAVAPAI COUNTY, ARIZONA

TITLE

PROJECT LOCATION MAP

FIGURE

1.1



YARNELL MINING COMPANY
A SUBSIDIARY OF BEMA GOLD (U.S.) INC.

YARNELL PROJECT
YAVAPAI COUNTY, ARIZONA

TITLE

PROPERTY SUMMARY MAP

FIGURE

1.2

2.1 *Project Location and Access*

The Yarnell deposit is located in the Weaver Mountains of Yavapai County, Arizona and is approximately 26 miles north of Wickenburg and some 75 miles by road from Phoenix as shown in Figure 1.1. The property is 1.5 miles southwest of the small town of Yarnell and lies within Sections 14, 15, 22, 23, 26 and 27 of Township 10 North, Range 5 West. Average elevation of the project area is 4,800 feet above mean sea level.

Access is via 17 miles of paved U.S. Highway 89 north from Wickenburg or 35 miles south from Prescott on the same highway.

2.2 *Environmental Study Area and Project Surface Disturbance*

The Yarnell Project environmental study boundary, and the area proposed to be directly impacted by the project are shown in Figure 2.1. The study area is approximately 400 acres and reflects 155 acres to be disturbed (as summarized in Figure 2.1). In addition, the well field location near the confluence of Yarnell Creek and Antelope Creek and the water supply pipe line will result in an additional 5 acres of disturbance. Therefore, the total disturbance of the Yarnell Project is estimated at 160 acres. As shown on Table 2.1, disturbance includes approximately 91.5 acres on public land, 68 acres on private land and 0.5 acres of Rights-of-way for the water pipeline across state-owned land. The project water supply is discussed in more detail in Section 7.0.

2.3 *Project Implementation and Schedules*

Development of the Yarnell Project would begin with the completion of the permitting effort which is currently underway. Primary permit requirements consist of an approval of the MPO, via an Environmental Impact Statement (EIS) by the BLM as well as an Aquifer Protection and Air Quality Permits from the Arizona Department of Environmental Quality. It is currently estimated that approval of all permits will take 15 months from the start of the permitting effort. The tasks associated with this schedule are shown on Table 2.2 and reflect an assumption that all permit applications required for the project would be submitted during the completion of the draft EIS. In this manner, the agencies would be familiar with the Project and would be reviewing their respective permits at the same time they are required to comment on the draft EIS.

TABLE 2.1 Yarnell Project Summary of Projected Disturbance

Project Component	Projected Disturbance Area (acres)			
	Public Land (unpatented claims)	Private Land (Patented Claims)	State Leases	Total
Yarnell Pit	11.0	26.0		37.0
North Waste Rock Dump	12.5	8.5		21.0
South Waste Rock Dump	23.0	15.5		38.5
Heap Leach System/ADR Plant	36.0	5.5		41.5
Roads/Buildings/Storage	4.0	11.0		15.0
Sediment Control/Diversion	0.5	0.5		1.0
Well Field/Pipeline	4.5	--	.5	5.0
Microwave Stations Relocation	--	1.0	--	1.0
TOTAL	91.5	68.0	.5	160

In conjunction with the permitting program, detailed engineering, procurement and contractor selection activities would be performed by project staff, together with outside engineering firms, as required.

Once all permits are received, construction would immediately commence, with the owner acting as the general contractor. Individual subcontractors would be awarded for site preparation, liner and crusher installation, process plant construction and buildings.

TABLE 2.2 Yarnell Project Permitting Schedule

Task	Time	Cumulative Time
Prepare and Submit MPO		
BLM Review of Completeness	1 month	1 month
YMC Prepare Application for Other permits	2 months	2 months
Prepare and Sign MOU	1 month	2 months
Publish NOI to Prepare EIS	2 months	3 months
Public Scoping	1 month	4 months
YMC Submit Applications for Other permits	1 month	4 months
Prepare/distribute draft EIS	4 months	8 months
Public Comment Period	2 months	10 months
Prepare/Distribute Final EIS	3 months	13 months
BLM ROD	2 months	15 months
Other Permits Approval	6 months	15 months

Additionally, mining equipment would be operated by the owner as a combination pre-stripping/pad construction effort. Construction is scheduled to begin in April 1996, and is expected to take three months. Production is scheduled to begin in July 1996.

2.4 *Review of Other Permits and Approvals*

There are a number of Federal, State and local laws and regulations which will require a permit or approval for the Yarnell Project to begin construction and/or operation. Major permits and approvals are summarized below.

2.4.1 Federal Regulatory Framework

The BLM has a major Federal government role in reviewing and approving the proposed project. These BLM roles, along with other Federal agencies, are summarized below.

2.4.1.1 Mining Plan of Operation and U.S. Mining Laws

United States mining laws and the regulations by which they are enforced recognize the statutory right of a mining claim holder to develop mineral resources on Federal lands. Because the Yarnell Project includes unpatented claims located on land administered by the BLM, and will cause a surface disturbance of more than five acres, a MPO must be approved for the proposed project. BLM responsibilities for reviewing a MPO are spelled out in BLM regulations (43 CFR Part 3809; Surface Management Under the General Mining Laws).

2.4.1.2 National Environmental Policy Act

Submitting the MPO to the BLM for the project will initiate the environmental analysis process as mandated by the National Environmental Policy Act (NEPA). As a prerequisite to approving or not approving the MPO for the project, the BLM must prepare an evaluation of the environmental effects of the proposed project in accordance with NEPA. The NEPA process is the decision-making tool which will be used by BLM to determine potential impacts and mitigation measures to reduce impacts, and to identify any unavoidable impacts associated with the proposed project. For major Federal actions which could significantly affect the quality of the human environment, NEPA requires that an Environmental Impact Statement (EIS) be prepared. BLM has determined that an EIS will be required for the Yarnell Project.

2.4.1.3 Federal Land Policy and Management Act

BLM policies, plans, programs and responsibilities, based on the Federal Land Policy and Management Act (FLPMA) of 1976, recognize that public lands are an important source of the nation's mineral and energy resources. BLM is responsible for making public lands available for a wide range of uses that include the orderly and efficient development of mineral and energy resources, recreation, and wildlife/fisheries conservation. If no unnecessary or undue degradation associated with the proposed Yarnell Project is found to exist by BLM, the proposed operation would conform to FLPMA requirements.

2.4.1.4 Reclamation Plan Requirements

The Mining and Mineral Policy Act of 1970 (MMPA) states that the federal government should promote the "development of methods for the disposal, control, and reclamation of mineral waste products, and the reclamation of mined land, so as to lessen any adverse impact of mineral extraction and processing upon the physical environment that may result from mining or mineral activities." Therefore, it is a statutory mandate that BLM ensure that reclamation and closure of mineral operations be completed in an environmentally sound manner.

The BLM's long-term reclamation goals are to shape, stabilize, revegetate, or otherwise treat disturbed areas in order to provide a self-sustaining, safe, and stable condition that provides a productive land-use plan for the area. The short-term reclamation goals are to stabilize disturbed areas and to protect both disturbed and adjacent undisturbed areas from unnecessary or undue degradation. BLM has prepared a Solid Minerals Reclamation Handbook to provide consistent reclamation guidelines for all surface-disturbing activities, including mineral activities conducted under BLM authority. BLM will review the Reclamation Plan for the Yarnell Project to ensure BLM's environmental protection responsibilities are carried out.

2.4.1.5 Reclamation Cost and Bonding

To guarantee completion of project reclamation, a bond will be required by the Yarnell Project. Bonding of reclamation procedures is required under various land management regulations, and BLM policy requires bonding for all approved mining operations on public land. If approved, the final bond amount for the proposed project would be determined by BLM based upon the final design plans for the acreage to be disturbed and the projected costs of closure and reclamation.

2.4.1.6 U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers (Corps) is responsible for evaluating the potential effects of materials placed into or removed from jurisdictional wetlands or waters of the United States. The Corps will conduct a jurisdictional delineation to determine if the proposed Yarnell Project would be affected by guidelines developed to determine compliance with Section 404 of the Clean Water Act.

2.4.1.7 *U.S. Fish and Wildlife Service*

The U.S. Fish and Wildlife Service (USFWS) administers the Endangered Species Act. If threatened or endangered species could be adversely affected by the proposed project, the BLM would prepare a Biological Assessment (BA) to comply with Section 7 of the Act. Following its submittal, the USFWS would prepare a Biological Opinion on the project impacts and any cumulative impacts from other activities occurring in the same area. The proposed project could not proceed if the USFWS decides, in its official opinion, that the project as mitigated would jeopardize the continued existence of a threatened or endangered species.

2.4.1.8 *The National Historic Preservation Act and the State Historic Preservation Office*

BLM must consult with the State Historic Preservation Office (SHPO) when potentially significant historical, archaeological, or other cultural resources could be affected by proposed development. Under Section 106 of the National Historic Preservation Act, evaluation of all potential impacts to cultural resources within the Area of Potential Effect is required for all alternatives. If necessary, a Treatment Plan would be developed to protect any cultural resources which would be eligible for the National Register of Historic Places. BLM would oversee compliance with historic preservation and monitoring plans.

2.4.1.9 *Environmental Health and Safety*

Health and safety are important considerations during all aspects of a mining operation. Regulations to protect worker health and safety are set forth by the Mine Safety and Health Administration (MSHA) and the Occupational Safety and Health Administration (OSHA) to be followed during mining activities. MSHA requires rigid employee training on the handling of reagents and process solutions and includes provisions for monitoring worker exposure levels. Other health and safety considerations which need to be evaluated during the MPO review process include the protection of surface and ground water from leaks or spills of hazardous or toxic materials, the stability of operational components such as the waste rock dump and heap leach facility, and the protection of wildlife from exposure to cyanide.

2.4.1.10 *National Pollution Discharge Elimination System*

The Environmental Protection Agency (EPA) administers the National Pollution Discharge Elimination System (NPDES) program for Arizona. This program developed as part of the Clean Water Act requires that industrial activities that discharge storm water directly into surface waters of the U.S. obtain a General Permit for storm water from the EPA's Region IX office in San Francisco. The ore processing facilities of the Yarnell Project are being designed for zero discharge. Therefore, no discharge permit is required. Storm water provisions include practices to prevent storm water pollution, monitoring and reporting. The storm water effluent limitations guidelines are described in 40 CFR Part 440 and include New Source Performance Standards. The YMC will submit a Notice of Intent (NOI) to discharge storm water from the non-ore processing facilities of the Yarnell Mine. A Storm Water Pollution Prevention Plan (SWPPP) and a Monitoring Plan will be prepared that will include provisions for the control of pollutants using Best Available Technology Economically Achievable (BAT) and Best Conventional Technology (BCT) to reduce pollutants to the level required to meet water quality standards and the EPA's industry effluent limitations.

2.4.2 Arizona Regulatory Framework

Arizona is one the few states that does not have a formal mine permitting process which includes analysis of proposed mining and reclamation operations. The state regulatory agencies which are responsible for specific issues such as air and water quality are discussed below.

2.4.2.1 Air Quality Permits

The Office of Air Quality (OAQ) within the Arizona Department of Environmental Quality (ADEQ) has jurisdiction over air quality aspects of mining projects. Air quality permits to construct and to operate the mine and processing will be required. The Air Pollution permit process includes evaluation of the type of mining and processing equipment to be used, number and size of all motor vehicles, diesel generators, engineering plans for the operation, mineralogical composition of the ore, and calculations of all sources of emissions. The permitting effort will involve an estimation of emissions and analysis of the control technology to be used at various emission points. The project will have operating conditions written into the permit that will describe allowed operations.

2.4.2.2 Aquifer Protection Permit

Water quality issues for mining developments in Arizona fall under the jurisdiction of the ADEQ. The ADEQ will be responsible for issuing an Aquifer Protection Permit to ensure that the proposed mineral processing operation is adequately designed to prevent contamination of ground water. Detailed baseline geochemical information on ground water quality, as well as the acidification potential, leachability, and chemical characteristics of the ore and waste are necessary for the Aquifer Protection Permit. ADEQ's review requires submission of detailed Geotechnical engineering reports and drawings specifying the design of the systems, the materials to be used, the construction methods to be employed, and the quality control and assurance programs to be implemented. The permit issued by the ADEQ will specify the design, operational, monitoring, and closure requirements for the project.

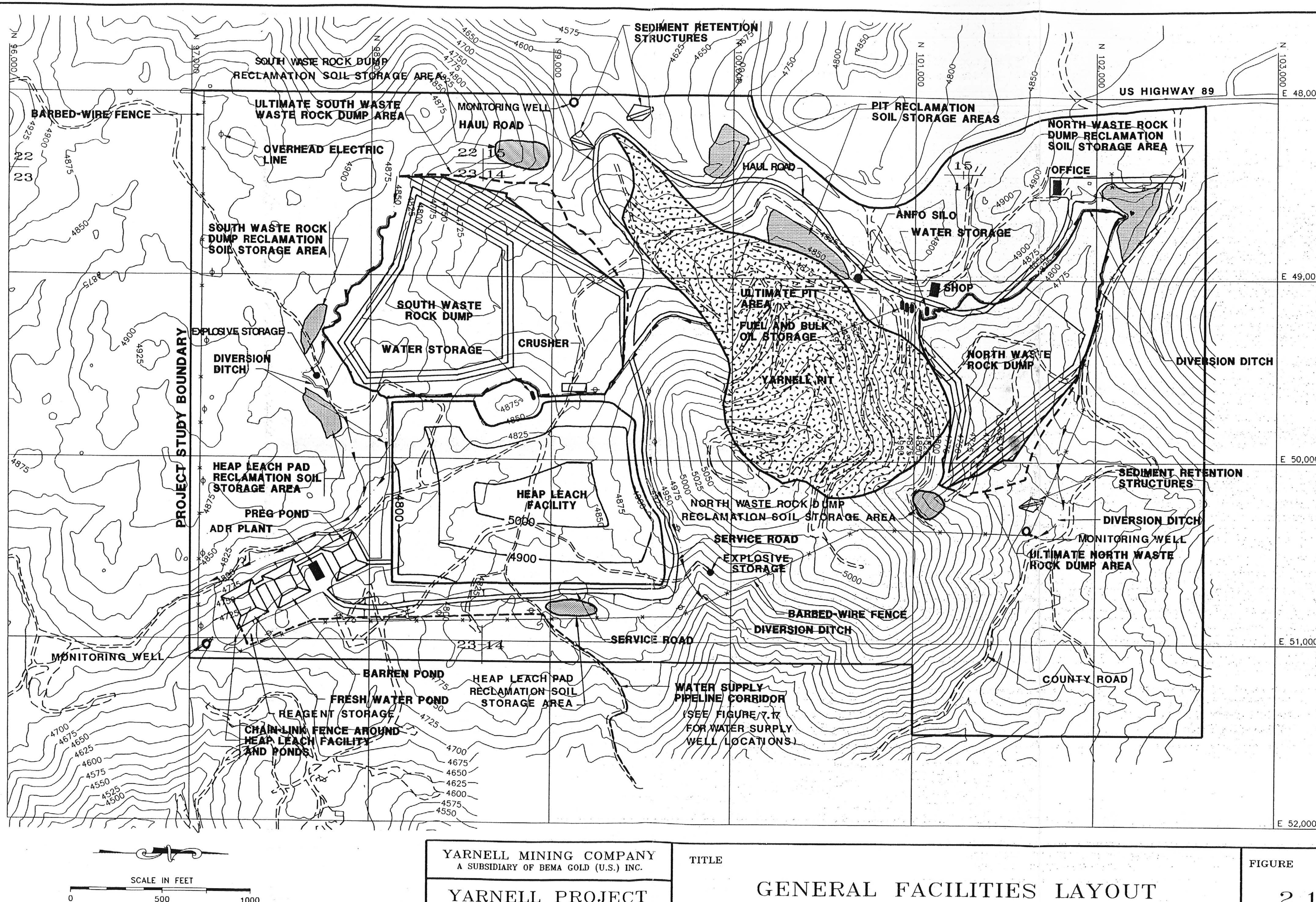
2.4.2.3 Rights of Way Easement

The proposed water supply line will follow the county road that traverses the Yarnell Creek drainage (see Section 7.0 for additional information). The pipeline will access the Yarnell Project site by following an existing exploration road that crosses the southeastern half of section 14.

YMC will be required to secure a Rights-of-Way easement agreement from the State of Arizona prior to constructing the pipeline across state land.

2.4.3 Yavapai County

Yavapai County will have review and approval authority over some aspects of Yarnell Project development and operation, including land use/zoning, engineering/construction, flood control, and solid waste management. The County Planning Department will be the responsible agency for these elements.



YARNELL MINING COMPANY A SUBSIDIARY OF BEMA GOLD (U.S.) INC.	TITLE	FIGURE
YARNELL PROJECT YAVAPAI COUNTY, ARIZONA	GENERAL FACILITIES LAYOUT	2.1

3.1 *Introduction*

The following section briefly describes the existing conditions of various resources in the vicinity of the Yarnell Project area. Data on resources have been compiled from existing studies and additional field surveys conducted by YMC on the Yarnell property. Other data collection will have to be completed as part of the impact assessment process under the requirements of the National Environmental Policy Act (NEPA).

During recent discussion held between various representatives of BLM and YMC, it has been determined that the development of the Yarnell Project could significantly affect the quality of the natural and human environment. An Environmental Impact Statement (EIS) would be required as a prerequisite to issuing an approval of the Mining Plan of Operation (MPO).

The existing environment information provided in this section of the MPO is intended to be sufficient to begin determination of significant issues which will be further defined during the EIS scoping process.

3.2 *Climatic Setting*

Meteorological data were recorded at the on-site monitoring station over the 12-month period of September 1, 1992 to August 31, 1993. A southern flow pattern in the winds, characteristic of winds in the southwestern United States, is evident at the Yarnell monitoring station. There is an overall predominance for the winds to blow from the south quadrant (southeast through southwest). There is a secondary peak from the north. The average wind speed for the year of data collection was 8.6 kt (9.9 mph). The wind speeds at the site were moderate. There were 0.1 percent calm winds (wind speeds less than 1 kt) and 68 percent of the wind speeds for the year were between 6 kt and 10 kt (6.9 mph and 11.5 mph). The highest wind speeds for the year were from the north with an average speed of 11.2 kt (12.9 mph). The winter months of November through February had the highest average wind speeds. The maximum, instantaneous wind speed recorded for the year was 47.0 kt (54.1 mph).

The average temperature at the site for the year of data collection was 15 °C (59 °F). The warmest months of the year were June through September when the monthly average temperatures were above 23 °C (73 °F). The monthly average for these four months only varied by 1.6 °C (2.9 °F). The coldest months were November through February when the monthly average temperatures were below 8 °C (46 °F). The recorded hourly maximum temperature was 38 °C (100 °F) and occurred on the afternoon of August 1,

1993. The recorded hourly minimum temperature for the year was -6.1 °C (21.0 °F) and occurred on the morning of December 20, 1992.

The site is located in the Weaver Mountains at an elevation of about 5000 feet. Based on records from nearby weather stations the estimated mean annual precipitation is approximately 20 inches. Annual lake evaporation in the site area is estimated to be on the order of 62 inches. Mean monthly precipitation and evaporation are summarized in Table 3.1.

TABLE 3.1 Mean Precipitation And Evaporation at the Yarnell Project Site

Month	Precipitation (inches)	Lake Evaporation (inches)
JAN	2.12	1.98
FEB	2.29	2.62
MAR	2.69	3.95
APR	0.85	5.63
MAY	0.50	7.61
JUNE	0.32	8.30
JUL	1.99	8.57
AUG	2.59	7.76
SEPT	1.60	6.38
OCT	1.31	4.50
NOV	1.66	2.74
DEC	2.21	1.96
ANNUAL	20.13	62.00

3.3 Air Resources

Particulate matter (PM_{10}, particulate less than 10 micrometers in aerodynamic diameter) data were collected on the Yarnell Project site from September 1, 1992 through August 31, 1993. Monitoring was performed in accordance with U.S. EPA guidelines and the Yarnell Air Monitoring Protocol (accepted by the Arizona Department of Environmental Quality (ADEQ) on November 11, 1992).

The monitoring station for the Yarnell Project was located near the west edge of Section 14, T 10 N, R 5 W of Yavapai County. This is the northwest corner of property. The elevation of the monitoring station was approximately 4,870 feet above sea level (ASL) and was located at UTM coordinates 3,786.5 km N., 338.6 km E. The terrain near the site is rugged with peaks and valleys for at least three miles in all directions. The vegetation on the property is typical desert grasses, cacti, yucca, and low bushes found in this section of Arizona. The nearest local source of dust to the air monitoring station was the access road to the site. Traffic on this road was minimal. Highway 89 was within one half mile to the west of the site.

PM_{10} data was obtained from two samplers mounted on a platform which measured PM_{10} at approximately 11 feet above the ground. One sampler collected official PM_{10} samples. The second collected data for the purpose of showing the precision of the sampling method. The official sampler operated every third day and the second sampler operated every sixth day. The sampling days coincided with the U.S. EPA six-day sampling schedule. Calibrations and audits of the equipment were performed in accordance with U.S. EPA guidelines.

The maximum 24-hour PM_{10} concentration was 28 $\mu g/m^3$ and was collected on August 2, 1993. The arithmetic average, or baseline concentration, for the year was 10.2 $\mu g/m^3$. The Arizona and federal standards for PM_{10} concentrations are 150 $\mu g/m^3$ for a 24-hour maximum and 50 $\mu g/m^3$ as the annual arithmetic mean. The quality control data collected from the second PM_{10} sampler show the precision of the data set to be very good. The average difference in concentrations was 0.2 percent or 0.05 $\mu g/m^3$. The standard deviation in the 53 paired samples was 14.3 percent for a 12-month PM_{10} average concentration of 10.2 $\mu g/m^3$. This is a standard deviation of less than 1.5 $\mu g/m^3$.

No other pollutants were measured on site. However, the project site is located in an attainment area. In other words, the area has not been designated as an area where exceedances of the National Ambient Air Quality Standards (NAAQS) have occurred. Due to the absence of industrial sources of pollution or highly populated areas proximate to the site, pollutant levels at the project site are expected to be well below the NAAQS levels and typical of "background" concentrations in rural areas of the southwestern United States.

3.4 Geology, Topography and Seismicity

The Yarnell deposit is a structurally controlled orebody, wholly contained within the Yarnell Granodiorite. Mineralization is controlled by the Yarnell Fault which strikes between 30 and 50 degrees northeast and dips to the northwest at 30 to 50 degrees. It can be traced on the property for over 3,000 feet and varies from 3 feet to more than 10 feet in thickness. The fault and the immediate hanging wall zone, consisting of broken and sheared rock, host the highest grade gold mineralization. Lower grade mineralization is seen in a weak stockwork zone up to 150 feet thick above the high-grade zone, and is locally present in the footwall of the fault.

The Yarnell Project site is located in the Weaver Mountains, a small east-west trending range northwest of Phoenix. The southern slope of the mountains drains into the Hassayampa River and into the Gila River. The northern slope of the range drains into Kirkland Creek and into the Bill Williams River. In the site area, elevations range from 5000 to 6000 feet along the crest of the Weaver Mountains to 3000 feet at the foot of the mountains approximately four miles south of the site.

The project site is within an area of low seismicity, as shown from generalized maps in ICBO (1991), U.S. Army Corps of Engineers (1982), and Algermissen et al. (1982). The seismic coefficient for the site region presented in U.S. Army Corps of Engineers (1982) is 0.025g (or 2.5 percent of gravitational acceleration). For evaluation of seismic stability of the mine structures, a seismic coefficient of 0.03g was used. A seismic coefficient (representing a horizontal acceleration) is typically used for evaluating the slope stability of materials that do not liquify or lose shear strength with seismic shaking (Seed, 1979).

3.5 Surface Water Hydrology

The project site is located at a southward bend in the Weaver Mountains on a ridge that extends to the south. Surface water drainage at the project site is entirely within the Hassayampa River drainage. The western portion of the site drains to the southwest into Fools Gulch, and the eastern portion of the site drains to the southeast into Yarnell Creek, which joins Antelope Creek.

3.6 Ground Water Hydrology

Ground water below the site and surrounding area exists within crystalline rocks having low matrix permeabilities. Ground water flow is therefore expected to be controlled by fracture permeability. Because the site is characterized by high relief, flow directions are likely to be topographically controlled. This suggests that general ground water migration will tend to be in the direction of decreasing ground surface elevation.

Based on public records, a detailed well inventory of the Yarnell area is presented in Montgomery and Associates (1989). Their description of ground water resources in the vicinity of Yarnell is summarized as follows:

- Ground water occurs in joints and fractures within the (fractured) bedrock complex. Records for 101 wells indicate that the total depth drilled ranges from 12 to 620 feet below land surface, with an average depth of about 150 feet. Depth to ground water reported for 37 wells ranges from about 6 to 520 feet below land surface, with an average depth of about 110 feet. Pumping rate reported for 74 wells ranges from about 1 to 100 gpm.

- Water quality information is available for three wells. Except for one well, estimates of total dissolved solids do not exceed secondary water quality standards. Fluoride concentrations in the three wells do not exceed primary drinking water standards.

- Available hydrogeologic data indicate that the potential ground water yield to wells is small and the potential volume of ground water in storage is limited.

The Antelope Creek Valley area is located downstream of the site. Some surface water and ground water originating at the site are expected to migrate towards this area. For the purpose of this report, the Antelope Valley area extends from south of the mining area to just beyond the front of the Weaver Mountains. Public records indicate that ground water wells have been completed in bedrock, relatively thin alluvium along the Antelope Creek Valley bottom, and thick basin-fill deposits west of the mountain front. The reported yields of these wells range from one to 100 gallons per minute depending on location. It is expected that the yield of bedrock wells are similar to wells in the Yarnell area (which are also completed in bedrock).

Water-level elevations in the fractured bedrock flow system were estimated based on the following information:

- A detailed well inventory of the site and surrounding area compiled by Montgomery & Associates (1989).

- Depth-to-water measurements obtained in mineral exploration holes within the mine area.

Although the well inventory database contained a relatively large number of records, depth-to-water measurements were given only for selected wells, and ground surface elevations were only sporadically available. Well locations in the database were generally indicated as being within a 1/4-1/4-1/4 section. Thus, the locations were accurate only to within a 660 x 660 foot square. As a consequence, most of the water-level elevations were determined by first locating the well (approximately) on a U.S.G.S topographic map, interpolating the ground surface elevation off the map, and computing the water-level elevation based on the indicated depth-to-water. Because well locations were approximate and the site area is characterized by high relief, interpolated ground surface elevations could be in error by up to 100 feet. The computed water-level elevations therefore had similar magnitudes of uncertainty.

Ground water was encountered in some of the mineral exploration holes drilled within the mining area. Water level elevations for these holes were computed based on depth-to-water measurements and surveyed ground surface elevations. Although these water levels were relatively accurate, their areal distribution covered only a small portion of the site area.

An interpreted water-level contour map (see Figure 3.1) for the site area was developed using these data points in conjunction with the following guidelines:

- Water-level contours were assumed to generally mimic the ground surface topography.
- Contours were drawn so that water-level elevations were always less than or equal to ground surface elevation.
- Where springs were identified on the U.S.G.S maps, contours were drawn so that water levels were close to ground surface.
- Contours were drawn so that the depth to water was reduced below major stream channels, consistent with limited field observations within the site area.

Although the contour map is interpretive, the resulting water table configuration is generally consistent with measured data points, and the map provides a reasonably accurate picture of the large-scale features of the ground water flow system. Shown on the map are ground water divides and zones of flow convergence, interpreted ground water flow directions, and flow paths associated with ground water presently below the mine area.

The water-level contour map indicates that the mining area is located south of a major ground water divide which is situated between the mining area and the towns of Yarnell and Glen Ilah. It is unlikely that ground water presently below the mining area will migrate toward either town. In addition, the mine is situated above a secondary ground water divide which suggests that ground water presently below the site will migrate to the east and west, toward Yarnell Creek and Fools Gulch, respectively. Both of these valleys are interpreted to be zones of ground water convergence. Thus, upon reaching the valley areas, ground water is expected to migrate in the down-valley directions and/or be discharged by evapotranspiration and springs. Ground water migrating down the YARNELL Creek valley will eventually reach the Antelope Valley area.

During exploration drilling in the mine area, ground water was encountered in 19 boreholes. Depths to water ranged from 40 to 410 feet below ground surface and the corresponding water-level elevations ranged from 4550 to 4825 feet. Since the measurements were taken during drilling, it is uncertain whether water levels had reached static conditions in the boreholes at the time of the measurements. Therefore, these water-level elevations should be considered approximate values.

An existing water supply well is located within the Yarnell Creek basin north of the mine site. This well was previously used by the town of Glen Ilah for municipal water supply, prior to being connected to the town of Yarnell water distribution system. Communications with personnel who operated the well for

Glen Ilah have indicated that during one period of operation, the well was pumped continuously at a rate of about 20 gpm for one year without dewatering (with some water level drawdown).

On November 16, 1994, Yarnell Mining Company personnel conducted a step-drawdown pumping test of the existing water-supply well to evaluate hydraulic characteristics of the fractured bedrock system. The pump test results are presented in Appendix 3.0, with pumping rates ranging from 10 to 31 gpm. The results are consistent with the historical operational pumping rate of 20 gpm. The aquifer transmissivity calculated from the pump test results is 142 ft^2/day, and the corresponding hydraulic conductivity (or permeability) is 4.4×10^{-4} cm/sec.

At the end of the November 1994 drawdown test, a ground water sample was collected and analyzed. The analysis results are presented in Appendix 2, and indicate that the ground water collected in the well has relatively high total dissolved solids (1200 mg/l), and is primarily a calcium sulfate type water. Detectable metals included cadmium, iron, manganese, and zinc. The sample exceeded EPA drinking water standards for the secondary parameters of total dissolved solids and sulfate.

From a general ground water flow standpoint, ground water beneath the project site is separated from ground water beneath the towns of Yarnell and Glen Ilah, as outlined below.

- The regional ground water contour map indicates that the site is located south of a major ground water divide which exists between the site and the towns of Yarnell and Glen Ilah.

- Interpreted ground water flow directions suggest that ground water currently below the project site is expected to flow towards to the southwest into Fools Gulch and to the southeast into Yarnell Creek, which are both considered zones of ground water convergence. Upon reaching these drainages, ground water will tend to migrate southward (in the down-valley directions).

- Ground water levels measured just north of the mine site have elevations on the order of 4550 to 4600 feet, while water levels in the vicinity of Yarnell and Glen Ilah are generally above elevation 4700 feet.

Based on these observations, it is unlikely that mining operations would reduce the quantity or impact the quality of ground water below the towns of Yarnell and Glen Ilah.

Water levels noted from exploration hole logs in the mine site area are generally from elevation 4700 feet or lower. Since the final bottom of the open pit is expected to be at elevation 4660 feet, mining is not expected to intercept significant quantities of ground water.

Since ground water below the project site is expected to migrate toward Yarnell Creek and Fools Gulch, water quality in these drainages could potentially be impacted by mining operations. Protection of ground water would be maintained by appropriate containment of solutions from processing facilities and monitoring of containment and ground water quality. Ground water protection issues would be incorporated into the Aquifer Protection Permit for the project with the Arizona Department of Environmental Quality (ADEQ).

3.7 Geochemistry

Geochemistry testing of waste rock samples was conducted to assess potential impacts of waste rock disposal on surface and ground water. Samples of exploration hole drill core were selected by YMC to represent waste rock from the hanging wall, ore zone, and footwall regions of the Yarnell deposit. Geochemical tests included assessment of acid generation potential with static acid-base accounting and assessment of constituents that may leach from the waste rock with precipitation by the EPA Method 1312 batch leach test. The test results are presented in Appendix 2, and from these results the following conclusions can be made.

- The percentage of total sulfur in the samples is low, ranging from 0.03 percent to below detection limits.

- The neutralization potential of the samples is relatively high, and the ratio of acid neutralization potential to acid generation potential (conservatively based on total sulfur) ranges from 6.7 to 84.0. BLM criteria for acceptable protection from acid generation (using this ratio) is 6.0.

- The batch test leachate had dissolved solids levels (34 to 35 mg/l), with all metals and general parameters within EPA Drinking Water Standards, except for two samples that exceeded secondary standards for iron and manganese.

Geochemical testing of the existing tailings on site (from 1936-1942, Section 1.2) was conducted to assess if special handling or treatment would be required for final disposal. Three samples were collected and tested in 1991, which included static acid-base accounting, EPA Method 1312 batch leach testing, and residual cyanide analyses. The test results are presented in Appendix 2, and from these results the following conclusions can be made.

- The percentage of total sulfur in the samples is low, ranging from 0.06 percent to below detection limits.

- The neutralization potential of the samples is not as high as that for the waste rock. The ratio of acid neutralization potential to acid generation potential (based on total sulfur) ranges from 1.3 to 6.5.

- The batch test leachate was analyzed for key metals, with all concentrations within EPA Drinking Water Standards.

Residual cyanide levels were low, with total cyanide ranging from 1.7 mg/kg to below detection limits. Free cyanide was below detection limits. The geochemical test results indicate that the waste rock is geochemically suitable for conventional disposal, and that the historic tailings could be buried in place with the waste rock.

3.8 Soil Resources

An Order I soil survey was conducted on areas proposed to be impacted by mining activities, approximately 250 acres, and a more general level Order III survey was conducted on areas not intended to be impacted, which consisted of approximately 150 acres. The total area inventoried consists of approximately 400 acres. The inventory was a refinement of the Order III soil survey of Yavapai County, Arizona, Western Part Soil Survey (USDA SCS, 1976). The field work was conducted in August and September 1994.

Typical pedons of most of the major soil types occurring in the study area were described and sampled. Typical pedons were described on a modified SCS pedon description form. Nine pedons within the study area were described and sampled in backhoe pits. The pits were excavated to bedrock. Soil pedons were described by soil horizons. Soil horizons were identified according to criteria in *Soil Taxonomy* (Soil Survey Staff, 1975, 1992) and described according to USDA standards (USDA, 1981). Soil pedons were also sampled by soil horizons. Soil samples from eight of the nine typical pedons and one sample of tailings material were analyzed to evaluate the physical and chemical parameters.

Four soils were identified and delineated within the study area. Table 3.2 shows the soil series by name and classification.

TABLE 3.2 Classification of the Soils

Soil Name	Classification
Cellar (Taxadjunct)	loamy-skeletal, mixed, mesic, nonacidic, Lithic Torriorthens
Gaddes	loamy-skeletal, mixed, mesic, nonacidic, Ustollic Haplargids
Lynx	fine-loamy, mixed, mesic, nonacidic, Cumulic Haplustolls
Virgin peak (variant)	loamy-skeletal, mixed, mesic, nonacidic, Lithic Haplustolls

Surface soils occurring in the study area are all moderately suitable for topsoil reclamation purposes. Cellar contains about 4 inches of suitable topsoil, Cordes comprise about 25 inches, Gaddes 30 inches, and Virgin Peak contains about 6 inches. Only the surface layers of Cellar and Virgin Peak soils are suitable topsoil, but the entire soil profile of Cordes and Gaddes soils are suitable. The Cr horizon of Gaddes soils is suitable topsoil, because it generally contains more clay and less sand that the Cr horizons of Cellar and Virgin Peak soils.

Most soil horizons exhibit a moderate rating for soil reconstruction material potential due to having moderate available water holding capacity. This can be rectified by applying an organic rich mulch to the surface which not only increases water holding capacity, but also reduces the potential erosion following periods of intense precipitation.

The background soil inventory report contains maps of the study area showing soil map units and showing soil suitability for reclamation material, descriptions of soil map units and soil pedons, laboratory results of eight soil pedons, and interpretations of the soils with regard to mine reclamation and environmental impact assessment. It also contains photographs of the soil pedons.

3.9 Vegetation

A baseline vegetation survey and wetland delineation was conducted on the Yarnell Project site in October, 1991 to provide data for permitting and reclamation planning. Vegetation types were delineated and mapped, plant species collected and identified, a rare plant survey conducted, vegetation types quantatively sampled with respect to cover and woody plant density, and wetlands delineated and verified with the U.S. Army Corps of Engineers. A list of plant species in the Yarnell Project area is included in Appendix 3.0.

The project site, located in the interior chaparral scrub vegetation zone as described by Brown and Lowe (1980)*, is characterized by five shrubby vegetation types. The coarse, rocky soils of exposed ridgetops is distinguished by mountain mahogany (Cercocarpus montanus) and numerous other shrubs including turpentine bush (Haplopappus larcifolius), wait-a-minute bush (Mimosa biuncifera), live oak (Quercus turbinella), snakeweed (Gutierrezia sarothrae), bush buckwheat (Eriogonum fasciculatum), and twinberry (Menodora scoparia). Common herbaceous plants include side oats grama (Bouteloua curtipendula), black grama (Bouteloua eriopoda), red brome (Bromus rubens), and sand dropseed (Sporobolus cryptandrus). Engelmann prickly pear (Opuntia engelmannii), pancake pear (Opuntia chlorotica), and sacahuista (Notina microcarpa) are sparsely represented.

Steep south and southeast-facing slopes are dominated by a dense low shrub community distinguished by turpentine and wait-a-minute bush. Other common shrubs in the community include snakeweed and bush buckwheat. Engelmann prickly pear, pancake pear, and sacahuista are present amid a cover of side oats grama, red brome, desert needlegrass (Stipa speciosa), squirreltail (Sitanion hystrix), and sand dropseed.

Steep north-facing slopes are characterized by a very dense woody community dominated by live oak. Other shrubs present in the community include silk tassel bush (Garrya flavescens), gray oak (Quercus grisea), smooth sumac (Rhus trilobata), and desert ceanothus (Ceanothus gregii), snakeweed, turpentine bush, Fendler bush (Fendlera rupicola), and mountain mahogany. Common herbaceous species include mutton grass (Poa fendleriana), red brome, black grama, side oats grama, and squirreltail.

A live oak shrubland dominates large expanses of the dry, south, west, and east-facing slopes. Shrubs associated with live oak include snakeweed, smooth sumac, bush buckwheat, wait-a-minute bush, and twinberry. Common herbaceous species include blue grama (Bouteloua gracilis), muttongrass, side oats grama, and black grama.

Several years prior to sampling in 1991, a fire burned part of oak shrubland on the southwestern portion of the project site. This area was mapped and sampled as a separate community. The community is dominated by live oak and has a presence of snakeweed, turpentine bush, desert ceanothus, bush buckwheat, wait-a-minute bush, twinberry, and buckthorn (Rhamnus ilicifolia). The most abundant herbaceous plants include muttongrass, blue grama, needlegrass, and side oats grama.

The U.S. Fish and Wildlife Service (USFWS) identified Murphy agave (Agave murphi) as a federal Category 2 species as the only plant of interest in the project region. Field surveys were conducted for this large, conspicuous plant which is associated with historic human habitation. It was not observed on the project site.

Wetland were delineated in accordance with the U.S. Army Corps of Engineers' 1987 Wetland Delineation Manual. A vegetated wetland occur as a small linear strip along Yarnell Creek for a distance of about 1,100 linear feet. Stream courses without wetland plants, but under the jurisdiction of the Corps include an approximate 1,100 feet segment of Fool Gulch which originates on the project site and flows west, and about 1,300 linear feet of an unnamed tributary to Yarnell Creek which originates on the southeastern area of the project site.

3.10 Wildlife

A wildlife survey was conducted on the Yarnell Project site to document the baseline wildlife condition and provide data for assessment of project related impacts for the permitting process. The wildlife baseline study was conducted on an area greater than the proposed disturbance of approximately 160 acres. Intensive surveys of were conducted within these areas to characterize wildlife habitats and resources that could be directly or indirectly affected. Limited, more qualitative surveys extended beyond the project area to identify habitats and species potentially associated with areas that could be affected by mining activities.

Wildlife surveys were conducted during October, 1991 and July, 1992, focusing on assessing desert tortoise (Xerobates agassizii), bat, and other wildlife use of the project area. Mimosa shrubland, rock outcrops, and other more open, south-facing habitats on the project area were stratified and systematically surveyed for tortoises and their sign on July 8, 1992 using a variable width line transect. Bats were surveyed in the project area on October 7-10, 1991 and July 6-9, 1992 by searching most portions of all historic mine workings and by conducting dusk outflight counts of the larger mines that could not be completely searched. October surveys coincided with late summer migration and early hibernation; July surveys coincided with the use of maternity roosts.

A map of major wildlife habitat types and other important habitat features on the project area was prepared in coordination with vegetation mapping. This mapping provided the basis for stratifying wildlife surveys into appropriate habitats and evaluating the suitability of the project area for different wildlife species and groups. Habitats on the project area include mountain mahogany (Cercocarpus montanus) shrubland, north-slope oak (Quercus turbinella) shrubland, south-slope oak shrubland, burned oak shrubland, turpentine bush (Haplopappus larcifolius)/ wait-a-minute bush (Mimosa biuncifera) shrubland, disturbed areas (e.g., dirt roads, drill platforms, buildings, abandoned historic tailings), an intermittent stream, and abandoned mine tunnels, last active in 1942.

The potential presence of the 14 federal and state endangered, threatened, proposed, and candidate species (Table 3.3) on the Yarnell Project area, as identified by the U.S. Fish and Wildlife Service (USFWS) and the BLM, were evaluated based on the local distributions of vegetative communities, habitat types, species' habitat affinities, known distributions, and limited field surveys.

With the exception of the loggerhead shrike (Lanius ludovicianus), none of these species were detected on the project area and there are no records of these species from the project area. The desert tortoise has been observed just south of the project area and may occur at low densities in the marginal habitats available on-site, although no tortoise sign was located during systematic surveys of the most suitable habitat on the project area. There is potentially suitable habitat on-site for the lowland leopard frog (Rana yavapaiensis). This species is present several miles down drainage. It is unlikely that the remaining species of concern are present on-site because of unsuitable habitat or because of high elevations.

TABLE 3.3
Wildlife Species of Concern
Yarnell Project Area

Species	Common Name	Category
Accipiter gentilis	Northern goshawk	FC2, SC
Bufo microscaphus	Arizona southwestern toad	FC2[a]
Empidonax trallii extimus	Southwestern willow flycatcher	FP[h], SE
Falco peregrinus	Peregrine falcon	FE[c], SC
Glaucidium brasilianum	Ferruginous pygmy owl	FC1[f], SE[g]
Lanius ludovicianus	Loggerhead shrike	FC2
Leptonycterus sanborni	Lesser long-nosed bat	FE, SE
Macrotus californicus	California leaf-nosed bat	FC2, SC
Myotis velifer	Cave myotis	FC2
Perognathus amplus	Yavapai Arizona pocket mouse	FC2
Rana yavapaiensis	Lowland leopard frog	FC2, SC[b]
Sauromalus obesus	Chuckwalla	FC2
Strix occidentalis lucida	Mexican spotted owl	FT[d], ST[e]
Xerobates agassizii	Desert tortoise	FC2, SC

[a] FC2 = Federal Category 2 Candidate species (current data on the species insufficient to propose listing).
[b] SC = State Candidate species.
[c] FE = Federal Endangered species.
[d] FT = Federal Threatened species.
[e] ST = State Threatened species.
[f] FC1 = Federal Category 1 Candidate species (species which the USFWS has enough data to support proposing to list).
[g] SE = State Endangered species.
[h] FP = Federal Proposed species.

A variety of game species are present on-site, including Gambel's quail (Callipepla gambelii), mourning doves (Zenaida macroura), lagomorphs, javelina (Tayassu tajacu), mule deer (Odocoileus hemionus), and probably black bear (Ursus americanus) and mountain lions (Felis concolor). The site, dominated by shrubby habitats on the lower elevational edge of the chaparral vegetative community, supports a diverse reptilian, avian, and mammalian fauna. Bats, of particular concern because of moderately extensive historic mine workings, occur in low numbers. No maternity or significant winter bat roosts arepresent. No fish, amphibians, waterfowl, or wading birds were detected on-site, due to a paucity of open water. Appendix 4.0 lists the reptiles, birds, and mammals detected on the Yarnell Project area during baseline wildlife studies. With the exception of the loggerhead shrike, a federal C2 candidate species, all wildlife species detected are at least relatively common and characteristic of the habitats present on-site.

3.11 Visual Resources

The project site is located in a mountainous area, with the proposed pit at the top of a hill on the southern flank of the Weaver Mountains. Existing views from the pit site would include a panoramic view of the valley to the south with noted dropoff in elevation. Views to the north would consist of the Weaver Mountains, with primarily a shrubby-type vegetation covering. The town of Yarnell cannot be seen from the project site.

All project facilities could be seen from U.S. Highway 89 and/or a County Road north of the project site. Motorists on U.S. 89 would have a direct view of the pit highwall and the southern waste rock dump.

BLM has developed its Visual Resource Management (VRM) system to ensure that visual values are adequately considered in all management activities. The VRM system recognizes that public lands have a variety of visual values, and that these different values warrant different levels of management. VRM objectives (classes) provide the visual management standards for the design and development of new projects on public lands. The VRM classes range from Class I (most restrictive) to Class IV (least restrictive).

At the heart of the VRM system is the contrast rating process. Contrast rating is a systematic process to compare the proposed project features with the major features in the existing landscape. The basic design elements of form, line, color and texture are used to make this comparison and to describe the visual contrast created by the project. Contrast ratings are required for all major projects proposed on public lands that fall within VRM Classes I and II, and Class II areas which have high sensitivity levels. It may also be used on any project in any location at the discretion of the local BLM office. Visual impact concerns will be assessed by BLM during the impact analysis process.

3.12 Noise

Ambient sound level data was collected at the air monitoring station during the period of May through August, 1993. Data was collected continuously 24 hours per day on non-PM_{10} run days, for a total of 1903 hours of valid data. Sound levels were measured using a Quest Model 215 sound level meter, which has a dynamic range of 30 to 80 dBA and meets ANSI Type II requirements. The A-weighted signal from the sound level meter was sampled once every second by a data logger and stored in the form of hourly frequency histograms.

The histogram data was sorted into three daily time periods: daytime (7:00 a.m. to 7:00 p.m.), evening (7:00 p.m. to 10:00 p.m.), and nighttime (10:00 p.m. to 7:00 a.m.). In addition, the level exceeded 90% of the time (L90) and the day-night level (Ldn) were calculated. The L90 is representative of constantly-occurring, i.e. background, sound levels. The Ldn is often used in the assessment of noise impact. The Ldn is calculated by adding 10 dB to noise levels measured between 10:00 p.m. and 7:00 a.m. The 10 dB "penalty" accounts for increased nighttime noise sensitivity.

Table 3.4 shows the L90, Ldn, and average noise levels for each month of data. The monthly average L90 ranged from 36 to 44 dBA. In general, sound levels were highest in the evening hours, with average sound levels ranging from 45 to 52 dBA. The lowest levels occurred in the daytime hours and ranged from 42 to 45 dBA.

TABLE 3.4 Monthly Noise Levels Yarnell Project (units in dBA)

			Average Noise Levels		
Month	**L90**	**Ldn**	**Daytime**	**Evening**	**Nighttime**
May	36	52	43	45	46
June	44	56	44	52	50
July	40	52	42	48	46
August	38	52	45	50	45

3.13 Cultural Resources

A Class III cultural resources survey will be conducted on the proposed Yarnell Project site. The primary goal of the survey will be to identify cultural resources on site, including those which would be eligible or potentially eligible to be listed in the National Register of Historic Places (NRHP), as well as those already listed. Resources identified by Native Americans as having historic or contemporary significance, in accordance with the American Indian Religious Freedom Act (AIRFA) of 1978, will also be a priority.

Potential resource-specific impact types and levels will be applied to any identified prehistoric and historic sites and Native American resources based on Criteria of Effect and Criteria of Adverse Effect found at 36 CFR 800. If a recorded cultural resource property meets eligibility requirements for nomination to the NRHP, it will be necessary to determine the potential impact(s) to that resource.

3.14 Socioeconomics

The proposed project location is in Yavapai County, Arizona, approximately 1.5 miles southwest of the small town of Yarnell, 26 miles north of Wickenburg (in Maricopa County), and 35 miles south of Prescott. Prescott is the county seat of Yavapai County. The area has a long history of mining activity, with a major current copper mining facility located in Bagdad, about 60 miles west of Prescott. The region is still primarily rural in nature, with a population density of about 13 persons per square mile. It has a growing economy based extensively on tourism, services and light manufacturing.

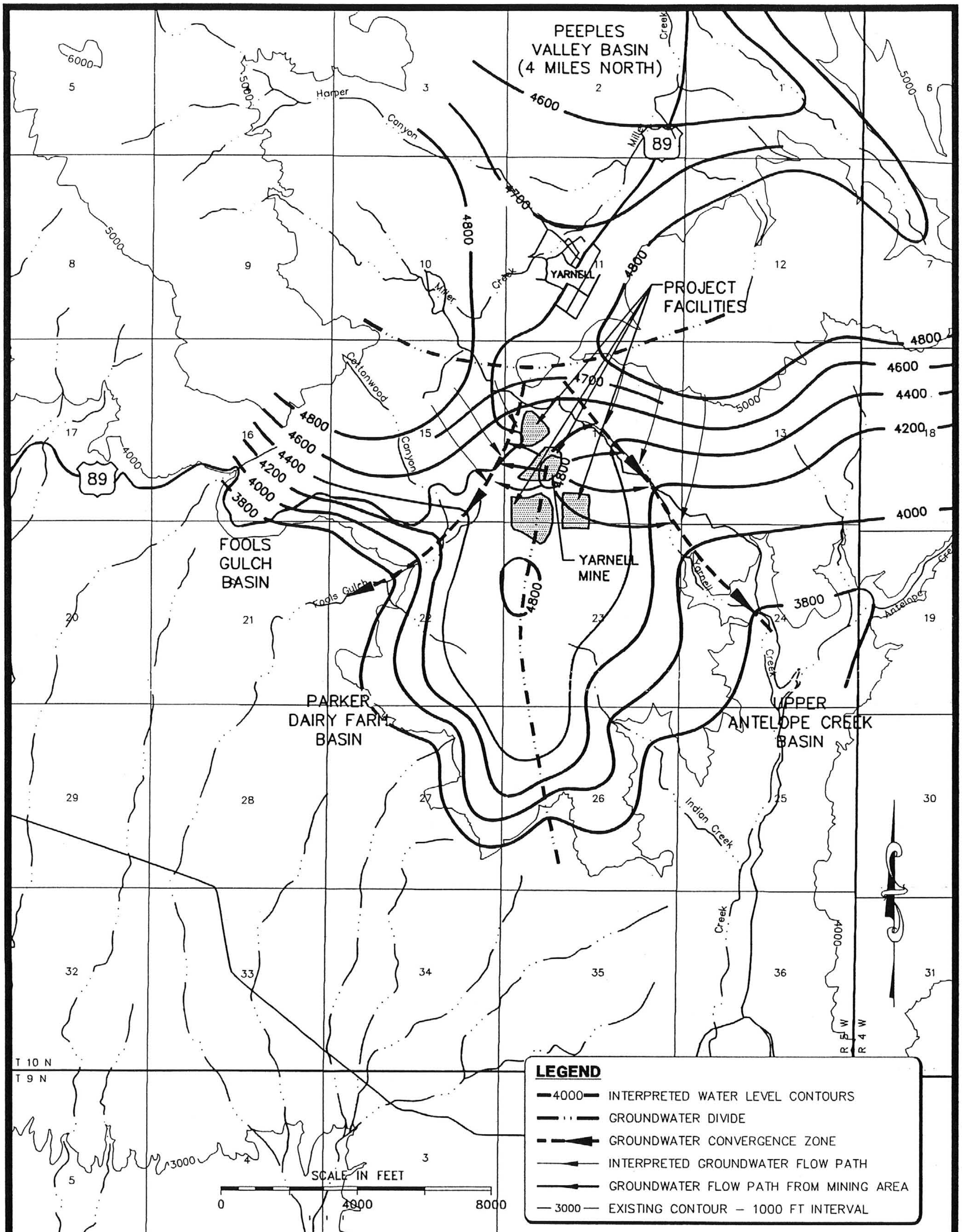
According to 1993 State of Arizona data, population figures for the area include:

- Yavapai County -- 118,400
- Prescott -- 28,405
- Wickenburg -- 4,700

The population of Yarnell has been estimated at 750 persons by the 1994 Rand McNally Road Atlas.

Employment in the County has been dominated by retail trade, services, and government in recent years. About 74 percent of 1993 total employment was within these three economic sectors. Wage and salary data also indicate the strength of these sectors, with about 64 percent of total 1992 wages and salaries within retail trade, services and government. County unemployment has ranged from 5.0 to 7.0 over the 1991-1993 period.

The operation is projected to need a peak of 100 construction workers and 89 operations workers. Based on analysis of the existing labor force in Yavapai County and Wickenburg, YMC projects that about 75-80 percent of all construction and operations workforce needs could be met by existing residents of this area. These workers could easily commute to the mine site from their existing residences. YMC is committed to a worker training program which would promote opportunities for existing residents.



YARNELL MINING COMPANY A SUBSIDIARY OF BEMA GOLD (U.S.) INC.	TITLE REGIONAL GROUNDWATER CONTOUR MAP	FIGURE 3.1
YARNELL PROJECT YAVAPAI COUNTY, ARIZONA		

4.1 *Regional Setting*

The Yarnell gold deposit is located within a granite/granodiorite intrusive body informally called the Yarnell Granite (Anderson, 1989) and more formally designated as the "Granodiorite at Yarnell" (DeWitt, 1986). The extent of the granodiorite is shown in Figure 4.1. This intrusive has invaded a sequence of metavolcanics and metasedimentary rocks of the Bradshaw Mountains Group (Anderson). Xenoliths and roof pendants of country rock are common and probably resulted from stoping and rafting during intrusion. Anderson describes the Yarnell Granodiorite as follows:

> "a foliated, coarse-grained porphyritic granodiorite to monzogranite ... [that] follows the northwest edge of the Stanton-Octave metavolcanic-metasedimentary screen to as far north as Wilhoit, where dikes of unfoliated Yarnell Granodiorite intrude foliated granodiorite of the Wilhoit batholith ... The Yarnell Granodiorite is distinctly coarse-grained and weakly foliated, with large pinkish-tan K-feldspar phenocrysts in an equigranular matrix with biotite, plagioclase, uncommon hornblende, and abundant sphene ... Chemically, the Yarnell body is metaluminous high-K, calc-alkaline, high Fe-Ti, and high total-alkali rock ..."

The Yarnell Granodiorite has not been dated, but Anderson places the age of the Yarnell pluton in the 1730 to 1710 million year range, based on lithologic similarity to other dated granites in Arizona.

The deposit is located less than a mile from the intrusive contact with pre-Cambrian mafic metavolcanic and metasedimentary rocks of the Bradshaw Mountains Group. Mid-tertiary flows of andesitic and basaltic composition unconformably overlie both the intrusive and metamorphic rock. Flow remnants cap the hills and ridges to the north and northeast of the deposit.

4.2 *Local Geology*

The Yarnell deposit is a structurally controlled orebody, wholly contained within the Yarnell Granodiorite. Figure 4.2 shows the local geology and alteration. Figure 4.3 is a typical cross-section through the deposit.

Mineralization is controlled by the Yarnell Fault which strikes between 30 to 50° northeast and dips to the northwest at 30 to 50°. It can be traced on the property for over 3,000 feet and varies from 3 feet to more than 10 feet in thickness. The fault and the immediate hanging wall zone, consisting of broken and sheared rock, host the highest grade gold mineralization, generally above

0.050 opt gold and occasionally as high as one opt. This zone is up to 60 feet in thickness. Lower grade mineralization (between 0.010 and 0.050 opt) is seen in a weak stockwork zone up to 150 feet thick above the high-grade zone, and is locally present in the footwall of the fault. The granodiorite is of uniform composition, contains porphyritic microcline as the dominant K-feldspar, has biotite as the only mafic mineral and is of generally granitic composition. A number of dikes and sills have been identified within and around the orebody; however, the total volume represented by these rocks is very small. The following lithologies have been recognized:

Aplite: Aplite is yellow-white in color, fine to very fine grained, granular texture, of quartz feldspar composition. It is present as less than four- inch wide streaks through the Yarnell pluton striking in all directions and with all degrees of dip. The aplite is probably a syn-Yarnell Granodiorite melt phase.

Andesite: Andesite is medium grey to dark grey, aphanitic with occasional biotite grains, and is commonly seen to weather the green-brown in clay developed zones. The andesite is present as 4 to 8 feet thick dikes widening from 15 to 20 feet, in elongated lenses. They strike 70 to 90° northeast and dip 25 to 40° to the northwest. The andesite dikes can be followed for 1/2 to 2/3 of a mile. They are often seen to have associated quartz veins on one or both contacts. The quartz is generally only 3 to 5 inches wide; but, can be up to 15 inches. Sericitic halos, 6 inches to 2 feet thick, generally are seen on either side of the dike with or without the associated quartz.

Felsite: The felsic dikes are yellow or orange-yellow to white, granular in texture, of quarts feldspar composition, with quartz eyes (elongated-stretched), with a sheared appearance throughout. They strike east-west to 80° northeast, are all nearly vertical in dip, average 3 to 5 feet in thickness but can be up to 20 feet thick. These dikes can be traced up to 1/2 mile along strike.

Diorite: The diorite is dark grey to black and weathers to green-brown with clay development. The main diorite dike is a prominent feature seen in aerial photographs in the west central part of Yarnell Hill. It is 10 to 20 feet thick, strikes north 10° west and dips 80 to 90° west. The dike has a sheared appearance and is magnetic.

4.3 Structure

Structural relationships within the area of the Yarnell Deposit have been identified during reconnaissance mapping of both underground and surface exposures and from logging of core. Only the most obvious and important structural elements that relate to mineralization are considered.

The most distinctive structural element within the deposit area is the Yarnell Fault which strikes 30 to 50° northeast and dips 30 to 50° to the northwest (see Figures 4.1, 4.2 and 4.3). The zone, which varies from 3 feet to more than 7 feet in thickness, consists of intensely sheared and hydrothermally altered gouge, mylonite, and micro-breccia, and commonly localized quartz veining. Within the deposit area, broken and sheared rock related to the fault may persist for more than 80 feet into the hanging wall, but locally thins to less than 10 feet both along strike and down dip of the known deposit.

Several steeply northwest dipping, northeast striking quartz veins are present in hanging wall structures and have been mapped both on the surface and where they are exposed in underground workings. These steeper veins appear to flatten and roll, may merge with the Yarnell Fault at depth, and suggest a listric configuration.

Many of the fractures within the hanging wall are oriented subparallel to and mimic the trend of the underlying Yarnell Fault. Felsic dikes, as mapped on the surface, also subparallel the Yarnell Fault in both strike and dip and show similar but much restricted alteration and mineralization.

Intensity of alteration and mineralization conform closely to areas of greatest permeability provided by structural disruption along the Yarnell Fault and within the hanging wall rocks. The Yarnell fault has been traced 2 miles to the southwest where it is covered by desert pediment, and to a point 1,500 feet to the northeast from the top of Yarnell Hill where it is concealed by alluvium and debris from hills and ridges to the north and east.

4.4 Alteration

Hypogene alteration associated with the Yarnell gold deposit varies from weak propylitic to sericitic to potassic (Figures 4.2 and 4.3). The strongest alteration is centered about the Yarnell Fault zone and decreases in intensity outward into the footwall and hanging wall.

Weak propylitic alteration is characterized by formation of minor chlorite, epidote, and calcite (as preserved in the unoxidized footwall) with weak sericitic dusting and replacement by sericitic and iron oxides along biotite edges and within plagioclase feldspars. Weak propylitic alteration commonly persists for more than 100 feet above the sericitic envelope and locally contains small quartz veinlets. In the footwall, the weak propylitic zone is thinner and is usually marked calcite gash veins. This alteration assemblage grades directly into sericitic alteration towards the deposit. Intense propylitic alteration (i.e., total replacement of biotites by chlorite, etc.,) has not been identified within rocks related to mineralization at Yarnell.

Sericitic alteration is characterized by complete replacement of biotite and plagioclase by sericitic and may contain quartz veinlets and/or stockwork. Specularite and pyrite form in conjunction with replacement of biotite by sericitic. Other specularite and pyrite that is associated with quartz veins is apparently remobilized and/or introduced by the hydrothermal fluids.

Pseudomorphs of geothite after pyrite and earthly geothite and hematite are common within the hanging wall rocks along the main Yarnell Fault zone and locally within fractures below the fault. Strong sericitic alteration extends from 30 feet to more than 100 feet into the hanging wall above the potassic zone and 10 to 45 feet into the footwall.

Potassic alteration is strongest adjacent to the Yarnell Fault where abundant quartz-adularia veins and veinlets, silica flooding, and sericitic occur with the highly crushed and tectonized rock; x-ray diffraction studies (Malusa, 1990) suggest that the clay size fraction of the fault zone is primarily fine-grained sericitic, illite, and adularia. Chalcedony, locally present as infill in fractures and vugs within the fault zone, is thought to have formed following hypogene mineralization. The potassic zone outward from the Yarnell Fault zone is defined where adularia is present as phenocrysts within selvages to quartz stockwork and quartz veinlets. It is locally accompanied by potassic replacement within pre-existing feldspars. Potassic alteration is generally found within sericitically altered and/or silica flooded rock. This zone is present as much as 50 to 80 feet into the hanging wall of the Yarnell Fault, and up to 25 feet below the fault.

Oxidation has affected the entire Yarnell Deposit. In the oxidation process, pyrite was altered to geothite and limonite; specular hematite was altered to geothite. Unaffected altered rocks exist below the Yarnell Fault, containing fresh pyrite and specularite, and are distinctively green-hued (due to sericitic) compared to hanging wall rocks.

4.5 *Mineralization and Paragenetic Relationship*

Gold mineralization is associated with several stages of hypogene quartz with iron sulfides (predominantly pyrite) and iron oxides (predominantly specularite). Trace amounts of base-metal sulfides and arsenopyrite have been seen in polished section and trace amounts of copper minerals including azurite and malachite are associated with quartz-hematite veinlets found within the deepest part of the underground workings. Minor amount of manganese oxide (including psilomelane) and titanium oxide (leucoxene) are also present.

Cross-cutting and textural relationships suggest that the Yarnell Fault and subsidiary structures provided the pathways for hydrothermal fluids which flooded through these structures and into the surrounding rocks. Successive movements along the Yarnell Fault are interpreted to have crushed, sheared, and possibly remobilized quartz, sericitic, and associated iron minerals. Lack of shearing and brecciation within the small amounts of banded chalcedonic quartz observed within the fault zone suggest that chalcedony deposition occurred following the latest fault movements possibly as the hydrothermal system waned. At least five generations of hypogene quartz veining have been identified through both petrographic and megascopic study of core and rock samples:

- Early grey quartz associated with specular in vugs parallel to quartz veins.

- Dark grey brecciate quartz; the dark color is probably due to fine-grained specularite.

- Lighter grey quartz with disseminated limonite pseudomorphic after pyrite commonly found along the margin of the vein.

- White quartz veins; generally coarser grained with local cockscomb texture.

The first three generations of quartz usually are found as fine-grained veinlets on the order of a 1/4 inch thick, less commonly are 1/2 inch thick and have been noted up to 3" thick in drill core. At least one generation of grey quartz with specularite and grey quartz with pyrite are associated with low to moderate contents of gold.

There are at least two stages of white quartz, both of which appear to cut across the first three generations of quartz. The white quartz veins have been measured from less than 1/2 inch to over 1 feet in drill core; one exposure in the field has an apparent thickness that approaches 20 feet. White quartz veins consistently carry a high gold content and visible gold has been identified from within some of these veins.

4.6 Gold Occurrence

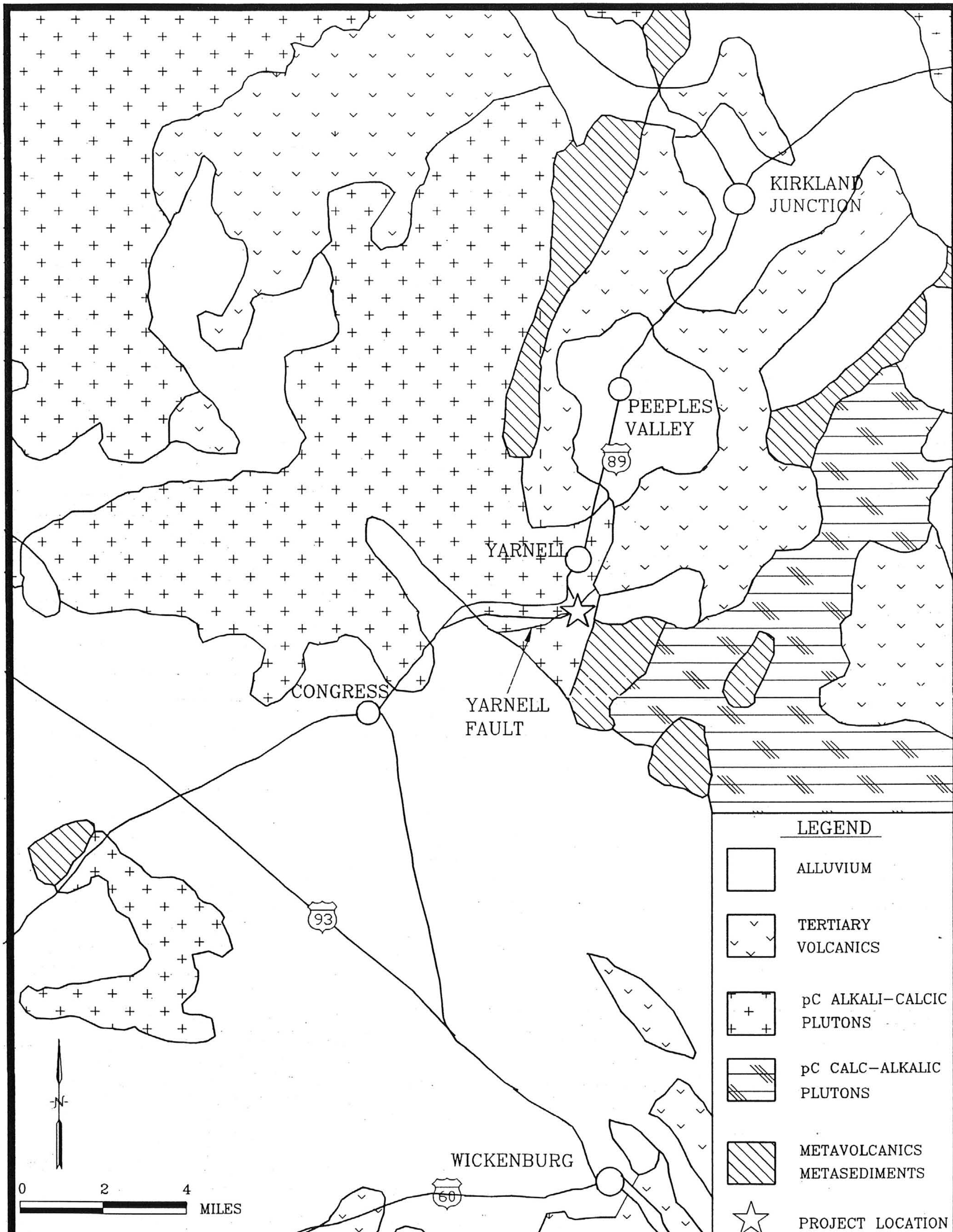
Gold is generally found associated with iron oxides (some pseudomorphic after pyrite) and/or quartz veining. Total combined iron-oxide and iron-sulfide mineral concentrations are generally low and only very locally exceed 4 to 5% beyond the immediately mineralized Yarnell Fault. Economic grades and widths of gold mineralized rock exist within both the potassic and sericitic altered zones; within weakly altered rock similar grades are only found within occasional thin quartz veinlets.

Examination of core shows that coarse visible gold is associated with quartz stockwork containing grey quartz and quartz specularite veins which are present relatively high in the hanging wall of the deposit; geochemical analysis of these rocks indicated only low to moderate gold content (less than 0.04 opt gold) and may suggest erratic distribution of gold from within this part of the deposit. Moderate to high gold content is commonly related to quartz stockwork with adularia (identified by the pink selvages and rimming along quartz veinlets) and pseudomorphs of pyrite. Highest gold content (up to 1 opt) is related to abundant red hematite and quartz which is found along the Yarnell Fault; most of the historic production came from this material.

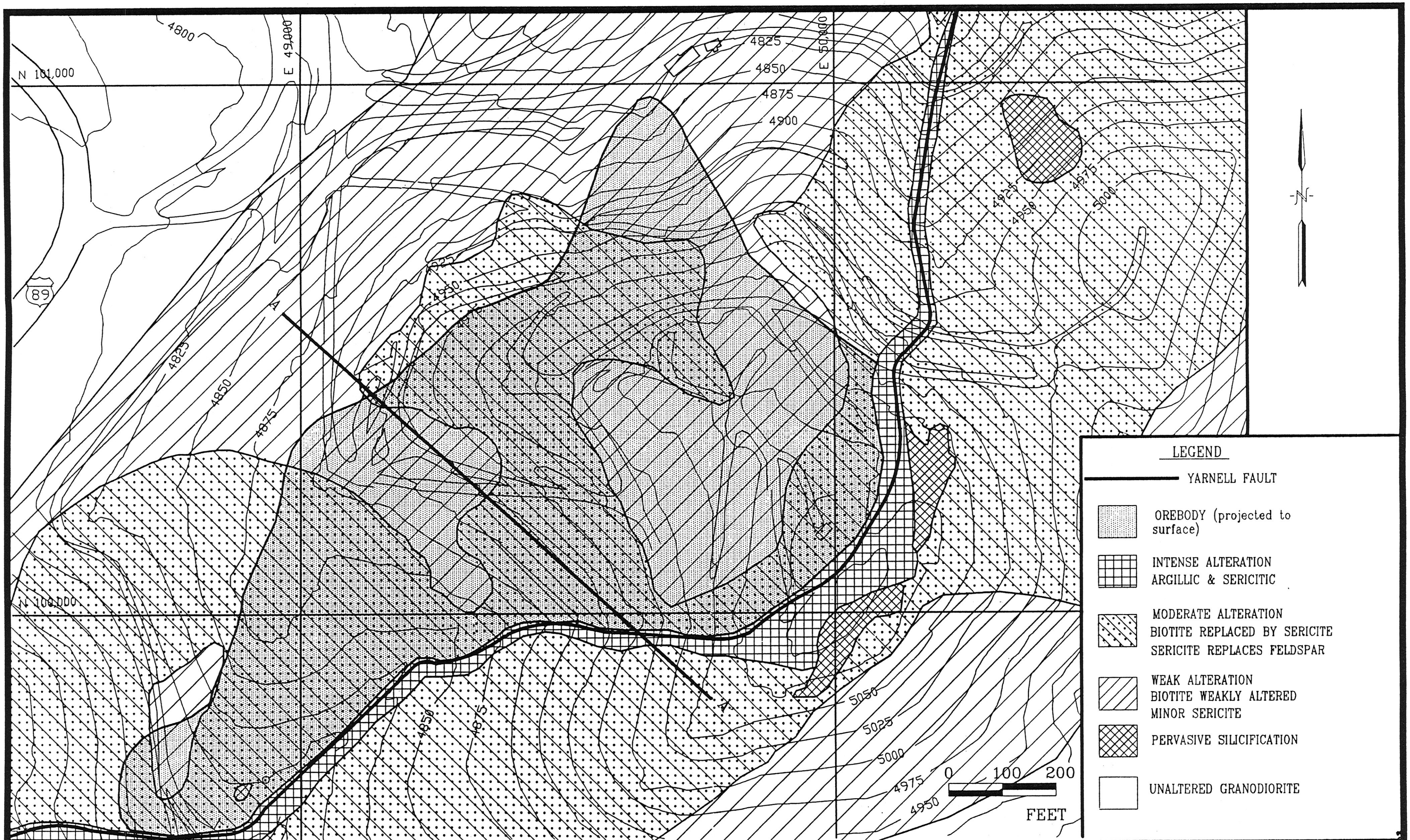
Polished section studies (Honea, 1990) were used to reveal the setting of native gold within mineralized rocks. The polished sections show native gold peripheral to and/or within geothite pseudomorphs after pyrite, and in association with grains of quartz. Native gold is also associated with geothite that is seen in fracture/vein pseudomorphs after pyrite.

4.7 *Exploration Potential*

The current mine plan for the Yarnell Project is based on the present knowledge of the site geology and the results of exploration drilling, sampling and test work completed to date. This information has been placed into geologic and mine block-models to develop an estimate of the ore and waste rock volumes to be produced. The current mine plan uses extrapolated data between drill holes and, assumes a gold price in the range of $350-375/ounce. Prior to mine development, additional exploration may be conducted that will include fill-in drilling to confirm estimates that have been made for the current open-pit mine model. The pit dimensions reflected in this MPO and the ore/waste rock volumes forecasted are based on extrapolated pit extensions to the southwest and northeast. The potential of the deposit to the southwest is limited by the Highway 89, expansion to the northeast is limited because the deposit outcrops in the Yarnell Creek drainage. It is anticipated that with minor modifications to the pit geometry that an additional 30,000 to 45,000 ounces of gold could be delineated as the mine is developed.



YARNELL MINING COMPANY A SUBSIDIARY OF BEMA GOLD (U.S.) INC.	TITLE	FIGURE
YARNELL PROJECT YAVAPAI COUNTY, ARIZONA	REGIONAL GEOLOGY MAP	4.1



YARNELL MINING COMPANY
A SUBSIDIARY OF BEMA GOLD (U.S.) INC.

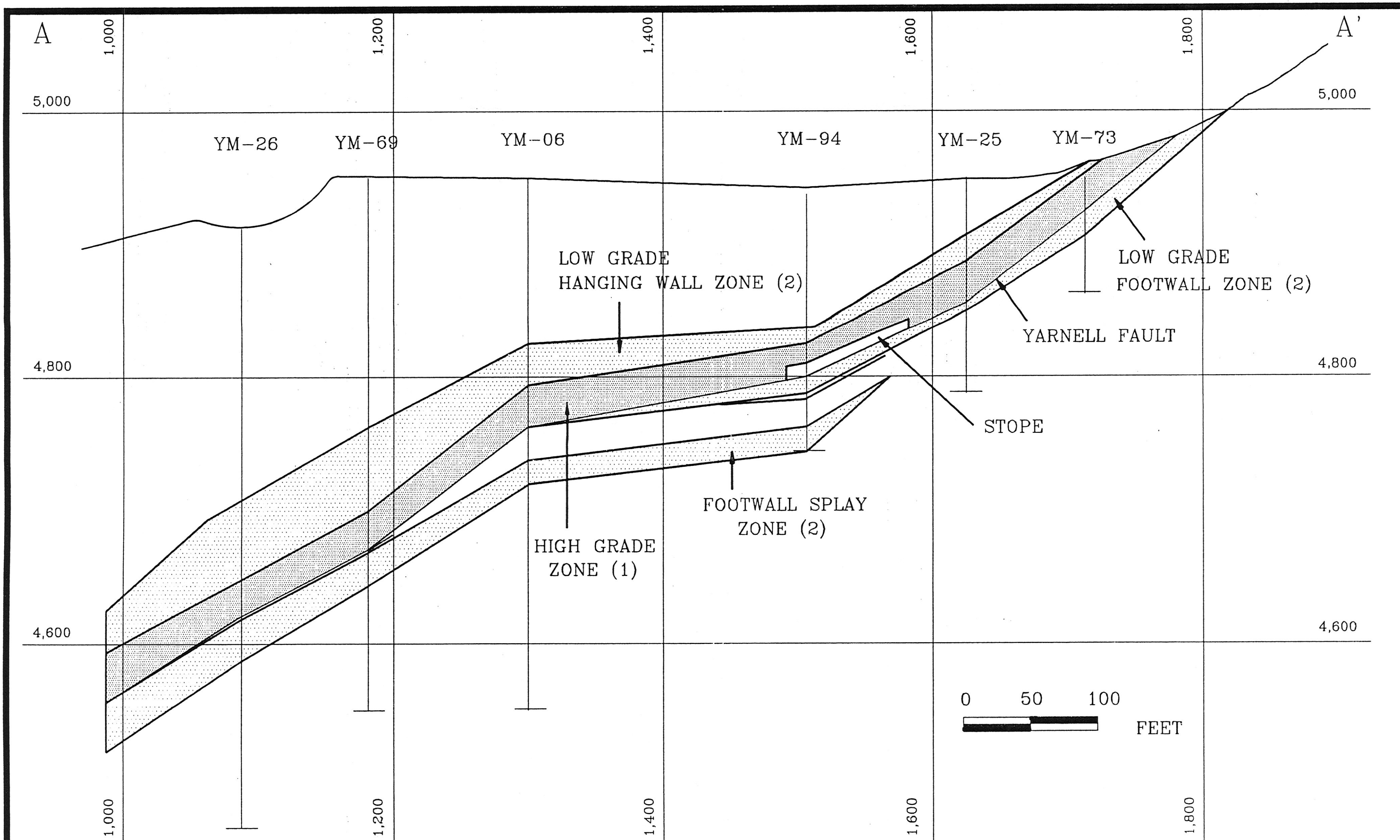
YARNELL PROJECT
YAVAPAI COUNTY, ARIZONA

TITLE

LOCAL GEOLOGY AND ALTERATION

FIGURE

4.2



YARNELL MINING COMPANY	TITLE	FIGURE
YARNELL PROJECT YAVAPAI COUNTY, ARIZONA	GEOLOGICAL CROSS-SECTION A-A' LOOKING NORTH	4.3

5.1 *Drilling*

This section describes the drilling, sampling and assaying procedures used to define the ore body. Refer to Drawing 2.1 in Appendix 5 for drill hole locations.

5.1.1 Rotary Drilling

The orebody has been defined by 96 reverse-circulation drill holes of 5 1/4 inches diameter for a total footage of 24,367 feet. The contractor used Ingersoll Rand TH-60 and TH-100 drilling equipment. A down-the-hole hammer was used on all the holes. Where drilling voids were encountered due to previous mining, the hammer was replaced by a tricone bit for the first 5 feet below the void to minimize sample loss.

5.1.2 Diamond Drilling

The contractor completed four core holes as twins to rotary holes (YM-8, YM-40, YM-63, and YM-75) using a Longyear 44 machine drilling NC-sized core. A total of 1,295 feet was drilled. One hole, YDDH-3, encountered a stope which necessitated a reduction to NX core size after passing through the workings. Three additional PQ-size holes were completed in 1991, to provide additional material for metallurgical testing. This core is still intact. The reverse-circulation (RC) holes twinned in this program were YM-79, YM-71 and YM-75.

5.2 *Sampling Procedures*

Samples were collected from the RC drilling on 5 feet intervals throughout the drill program. The drilling was momentarily stopped at the end of each 5 foot run to blow the hole clear and clean the sampling system. From the drill pipe discharge, the cuttings passed into a cyclone which rapidly dropped the cuttings into a 3-tiered Jones splitter. Cuttings from the third split were again passed through a single Jones splitter and both sides, A and B, were collected in bags with the drill hole number and footage marked on the bag. A small sample was taken from the "A" pan side, washed, and placed in plastic trays. These samples were logged along with any comments noted during the drilling of the interval. The sample trays are stored at the Yarnell site.

As remarked above, the only problem encountered during the rotary drilling was the loss of some sample after penetrating an opening. As noted, after drill hole YM-5, the drilling sequence was changed by replacing the hammer with a tricone bit for drilling below the opening. A clean sample was then secured by the time the tricone penetrated a foot below the new surface, whereas with the hammer, the sample was erratic for five to six feet before the collection ports were below the new surface. When passing through an opening, the sample return was monitored at the surface to judge if the return was from isolated blocks of mine rubble on the floor of the opening. The rubble material returned erratic volumes of material as the open spacing in the rock pile allowed sample and air to be dissipated into the rubble mass. Sampling continued below the workings until the rock became very hard and dense suggesting a non-oxidized part of the system.

The majority of the holes were drilled dry in the oxidized portion of the zone. In the deeper holes which penetrated the footwall, the bottom would often become moist and water was added to facilitate the removal of cuttings. As this moist condition was generally at or below the base of the mineralized zone, no sampling/assay problem is attributed to the collection of a wet sample within the area of the geological reserve.

Diamond drill core was split in half longitudinally using a diamond blade saw; one half of the core was sent for assay and metallurgical testing, while the remaining half was kept in storage. Sampling was integrated with the rotary footage as closely as possible. Often, the 5 foot runs were further broken down to separate obvious high-grade stringers. The assays were then recombined into the equivalent 5 foot intervals for comparison with the adjacent rotary hole values.

5.3 Assaying

The primary assay laboratory was Triad Minerals Company of Wickenburg, Arizona. Check assays were performed by Skyline Labs, Inc., in Tucson, Arizona. All assays were fire assay with gravimetric finish and results were reported as ounces per ton for gold and silver.

The following procedures were used to confirm the validity of the primary assays:

- The insertion of an Asarco standard within the sample runs, generally two per hole
- Assays of duplicate sample splits from the drill site
- Multiple assays from the same pulps
- Comparison of Triad assays with Skyline assays of same pulps
- Comparison of twinned RC and diamond drill holes

Check assay procedures confirmed that there is no bias to the assays and that the gold values used for the reserve estimate are legitimate.

5.3.1 Comparison Between Reverse-Circulation and Core Assays

There is considerable variation in assay values between the two drilling methods. The variation between individual composites is attributed to the nuggety nature of the deposit. The total amount of gold contained in the holes shows a 7% increase for the diamond drill hole assays suggesting that the RC sample assays may be undervaluing the deposit.

6.1 *Geologic Database*

Assays from 96 reverse-circulation drill holes and four diamond drill holes form the geological reserve database. Eighteen holes intersected the underground workings. These intervals were flagged in the database to construct the model of the workings and for limits of compositing. Refer to Appendix 5.0 for details.

Each hole was sampled on 5 foot intervals; however, in several of the deeper drill holes, in essentially unmineralized rock, every other sample was assayed. In these cases, an assay value equal to the average of the adjacent samples was used.

High grade assay values were cut to avoid overestimating blocks adjacent to isolated high grade portions of the orebody. Within Zone 1, assays above 0.250 opt were cut and within Zone 2 assays above 0.190 opt were cut. Cut values are the average of adjacent samples.

Asarco reassayed2 27 of the 5,134 five-foot long samples. The overall average of these reassays was 5% lower than the average of the original assays, apart from the samples which had erratically higher values in the reassays. The check assay replaced the original assay in one 5 foot interval. This interval originally assayed 0.129 opt and was replaced by the check assay of 0.031 opt. Duplicate assays, from the 40 foot interval through the 85 foot interval, in drill hole YM-50 were used in the assay database.

6.2 *Geological Model*

The geological model used to define the ore reserves is represented by the cross section shown in Figure 4.3. A narrow, well-defined, high grade zone (Zone 1) 20 to 40 feet thick (maximum 70 feet) of intensely sheared and highly altered granite, whose base approximately corresponds to the Yarnell Fault, is overlain by a stockwork zone (Zone 2) with weak to moderate sericitic alteration and more erratic low grade gold mineralization. The assay boundaries to the high grade zone are sharp and the zone shows strong continuity both down dip and along strike. Locally, the gold values extend upwards into unaltered rock and in some areas low grade mineralization is present below the fault.

The lower contact of the high grade zone approximately follows the sole of the Yarnell Fault and the upper contact of the zone is assay-defined, as are the boundaries of the low grade zone.

6.3 *Data Analysis*

Summary statistics for the high grade zone (Zone 1) and the low grade zone (Zone 2) defined by the geological model are shown in Table 6.1. Histograms and cumulative frequency curves can be seen in Appendix 5.0.

TABLE 6.1 Summary Statistics for Zone 1 and 2

High Grade Zone (Zone 1)	Raw Data	20 Foot Composites
Maximum grade (opt)	0.203	0.195
Minimum grade (opt)	0.002	0.008
Mean grade (opt)	0.069	0.070
Variance	0.00235	0.00132
Log mean grade (opt)	0.026	0.021
Low Grade Zone (Zone 2)		
Maximum grade (opt)	0.194	0.160
Minimum grade (opt)	0.000	0.002
Mean grade (opt)	0.025	0.027
Variance	0.00068	0.0034

An elementary statistical evaluation suggests that the raw assay data approximately conform to a log-normal distribution typical of most low grade gold deposits. The cumulative frequency distribution has an irregular tail above 0.110 opt indicating a small but distinct population of high grade values.

6.3.1 Bench Height Analysis

In order to evaluate the most effective composite interval, a formula was applied to sets of composites over 10, 15, 20 and 25 feet. The formula produces a value for the relative contained ounces of gold in each composite for different cut-off values. This shows that the smaller composites (10 and 15 feet) include somewhat higher contained ounces for higher cut-off grades. The cumulative frequency distributions also reflect this higher gold content in the smaller composites.

This was further studied by running preliminary reserve calculations using 15 foot and then 20 foot composite intervals. The results shows no significant difference; therefore, a 20 foot block height was chosen as this was the preferred mining bench height. Details of this analysis are included in Appendix 5.0.

6.3.2 *Variography*

Variograms were constructed based on 20 foot composites for the high grade and low grade zones and for the zones combined. Greatest variogram continuity was observed in the directions of the fault zone strike and dip. The following parameters were used for the kriging algorithm. Table 6.2 shows the parameters used for the kriging algorithm.

TABLE 6.2. Kriging Parameters

High Grade Zone - Dip and Strike	
Range - Dip direction	150 feet
Range - Strike direction	200 feet
Sill value:	0.253
Nugget value:	0.080
Low Grade Zone - Dip and Strike	
Range - Dip direction	150 feet
Range - Strike direction	100 feet
Sill value:	0.258
Nugget value:	0.110
Low Grade Zone - Vertical	
Range - Vertical	50 feet
Sill value:	0.225
Nugget value	0.050

The database for the vertical high grade composites was too small to provide a meaningful variogram, therefore, the values from the low grade vertical variogram were used in the kriging algorithm for the high grade zone. Variograms for both zones are given in Appendix 5.0.

6.4 *Block Model Construction*

Using Datamine software, the block model was constructed with geological, topographical, assay, and other relevant information. The drill hole location and assay information were entered into Datamine and this data was then rotated 45° to facilitate subsequent processing. In the rotated coordinate system, the orebody strikes due north and dips to the west.

Cross-sections were drawn on 50 foot centers perpendicular to the strike of the orebody. Drill holes were plotted on these sections with down-the-hole raw assay data. Each drill hole was 25 feet or less from the section line. Using assay values, both the high grade zone adjacent to the Yarnell Fault and the low grade zone, most often in the hanging wall, were outlined manually on each cross section. These zones were digitized into the computer model from each of the sections to constrain the various grade assignment routines.

A prototype block model was defined using an origin, in the rotated coordinate system, of North 775, East 400, and an elevation of 4,000 feet. The block size was 50 feet x 50 feet horizontally; the block height was set equal to the bench height of 20 feet.

Subcelling was used to better represent the boundaries of Zones 1 and 2. The ore zones were filled with blocks respecting the boundaries. The high grade zone was overlain upon the lower grade zone, effectively removing the overlapping blocks.

The Yarnell deposit had been previously mined by underground methods. The old workings are partially caved; therefore, access is limited. Using a plan map of the underground workings provided by Asarco and the location of drill holes which intersected the workings; a model was constructed to represent the underground workings. The model indicated that approximately 175,000 tons had been mined. This figure is similar to the tonnage estimates from past production records.

Topographic data were entered into Datamine and a topographic model was developed which closely matches the topographic data generated from aerial photography.

The individual models were overlain to produce the final geological block model. The model of the underground workings was subtracted from the zoned model to remove blocks which had been previously mined. This was then added to the topographic model in order to add the surface boundary and waste blocks outside of the mineralized zones.

6.5 *Geological Reserves*

The reserve was calculated by kriging within the two grade zones. Proven and probable reserves are considered to be those blocks within the ranges indicated by the variograms: 150 feet in the strike direction and 200 feet in the dip direction for the high grade zone and 100 feet in the strike direction and 150 feet in the dip direction for low grade zone. Three composites were also required for grade estimation.

Possible reserves were assigned to those ore blocks within a search radius of 250 feet for both the high and low grade. This reserve estimate excludes the material previously mined from underground.

Table 6.3 lists proven/probable and possible geological reserves for the Yarnell Deposit.

TABLE 6.3 Geological Reserves

Cut-off grade (Au opt)	Tons (1000's)	Average Grade (Au opt)	Contained Gold (ozt)
Proven/probable			
0.010	6,008	0.037	221,832
0.020	4,510	0.044	196,561
0.050	1,598	0.072	115,594
Possible			
0.010	1,284	0.038	48,784
0.020	884	0.047	41,796
0.050	379	0.068	25,796
Total			
0.010	7,292	0.037	270,616
0.020	5,394	0.044	238,357
0.050	1,977	0.072	141,390