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APPRAISAL REPORT
CAVE BUTTES DAM
Valuation Date: July 31, 1998
Location: Maricopa County, Arizona
By: DONALD E. ROSS
For: FLOOD CONTROL DISTRICT
of MARICOPA COUNTY

A350.909

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Donald E. Ross, ASA RPG

REGISTERED PROFESSIONAL GEOLOGIST
CERTIFIED SENIOR PROFESSIONAL APPRAISER

2226 E. Sunnyside Drive
Phoenix, Arizona 85028

Phone 602-992-0758
Fax 602-482-3220

August 19, 1998

Thomas O. Johnson, P.E., R.L.S.
Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, AZ 85009-6399

Re: Appraisal Report - Cave Buttes Dam

Dear Mr. Johnson:

This report or investigation of the potential of the Cave Buttes Dam area in Maricopa County was prepared to evaluate the "Highest and Best Use" of the subject area which was determined to be sand and gravel mining. Groundwater recharge and recreation are alternative activities which are compatible with primary and multi-land use scenarios. Five areas on the property were initially identified in the field and on topographic plans as having the best potential for sand and gravel resources; these areas are as follows:

AREA	
A	The area lying between the older Cave Creek dam and the newer Cave Buttes dam.
B	The area encompassing the Apache Wash drainage.
C North	The area adjacent to the northern boundary of the property and south of the Wheeler sand and gravel quarry, extending midway to the Cave Creek dam.
C South	The area north of the Cave Creek dam.
D	The area midway between the Cave Creek dam and the entrance gate on Jomax road.

The results indicate that significant resources of sand and gravel of commercial quality are located north of the Cave Creek dam.

Area C South contains the greatest thickness and the largest tonnage of sand and gravel; it also contains significant resources of silt and clay for landfill capping. This area has other uses and would be hidden from the public view. Area C North appears to have the best quality material consisting of coarser, cleaner gravels with less fine sands and silts. The estimated resource in Area C North is somewhat smaller than Area C South. If an average thickness of commercial material of 70 feet is assumed with a density of 110 lbs/cu. feet, about 14.0 million tons of sand and gravel could

be present in Area C North adjacent to the quarry operation of Wheeler Construction. Area C South may contain 18.7 million tons using a thickness of 100 feet for a total of about 32.7 million tons for C North and C South. In the area between the dams (Area A) gravels are present but are generally poorly sorted and have a high plasticity index. Assuming an average thickness of 55 feet and a similar density, Area A may contain approximately 4.0 million tons of sand and gravel. The decision to mine in C South versus C North would depend on the demand for the soil cover material in C South and the fact that a quarry in C North is more visible. C North has the advantage in that wash gravel is exposed at the surface; C South has the advantage of thicker gravels which continue below 100 feet.

Six 100 foot deep percussion drill holes, have recently been completed using a Becker drill with an approximate 9 inch O.D. bit. Gravel depths of from 55 feet to over 100 feet were intersected. Trench sampling was naturally limited to investigation of the near surface environment. A total of twenty-two (22) back hoe pits were dug in the five areas up to a maximum depth of about 16 feet and the alluvial materials were described and sampled. The samples were sent to Law Engineering and Environmental Services for analysis. The analytical data is incorporated into the individual trench logs which are also included in the Addenda section of this report.

Area A contains a fairly small resource and the product would probably need to be washed because of the high plasticity index. Area B contains only a narrow shallow channel of washed sand and gravel material. Area D contains only minimal commercially acceptable material and the area warrants no further investigation due to its high visibility.

Based on data from the Arizona State Land Department, current royalty rates in this area vary from $0.60 to $1.65 per ton. The Flood Control District could realize an annual income for over 30 years of $800,000 per year based on an $0.80/ton royalty rate and an annual production rate of 1,000,000 tons.

Alternative uses which are not addressed in detail but could be considered include ground water recharge, a landfill, a recreational lake area, a golf course, a balloon park or a desert preserve. Some of these potential uses, such as ground water recharge and recreational lake facilities, could be developed after quarrying. The other uses, such as landfill or a golf course, can co-exist with the quarrying operation. This should be a multi use area due to the diversity of the resources on the property.

Alan Wright, geologist, provided valuable assistance in preparing this report and sampling the various areas. Thank you for the opportunity to work on this assignment and I will be happy to assist on any additional aspects of the continuing investigation.

Sincerely,

Donald E. Ross, RPG

REGISTERED GEOLOGIST
CERTIFICATE NO.
13519
DONALD E.
ROSS
ARIZONA, U.S.A.

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INTRODUCTION

This work was completed by Ross Consulting for the Flood Control District of Maricopa County. The purpose of the report is to address the "Highest and Best Use" of the Cave Buttes Dam property located approximately 19 miles north of downtown Phoenix, Arizona. Emphasis was placed on data gathering and documentation of the possible sand and gravel (aggregate) potential. Additional uses such as ground water recharge, landfill and recreation were considered.

PROPERTY LOCATION AND DESCRIPTION

The subject property is located in Maricopa County, Arizona (Figure 1) and is on the north periphery of the Phoenix metropolitan area. The community of Cave Creek lies 8 miles northeast and Interstate highway 17 is 4 miles west. The Central Arizona Project aqueduct lies immediately southwest of the property line. The Union Hills mountains traverse the southwest part of the Cave Buttes area with elevations up to 2383 feet. The valley floor at the older Cave Creek dam is at approximately 1600 feet above sea level.

Two dams are located on the property and can be accessed principally by turning west on Jomax road from Cave Creek road via a locked gate. The dams have been constructed across Cave Creek wash which is a zone of flooding during periods of heavy rain (Figure 2).

The property is located more specifically in the south half of T5N, R3E (all of section 34 and parts of sections 21, 26-29, 33 and 35) and the north half of T4N, R3E (parts of sections 1-4, 9-11, 15 and 16) of the Gila and Salt River Base and Meridian. Except for small extensions, the area is generally encompassed within the square formed by Pinnacle Peak Road and Dixileta Drive, 34th Street and 10th Street if these streets were continuous thoroughfares. The subject covers an area estimated at approximately 3000 acres. It is generally located in the floodplain of the Cave Creek wash.

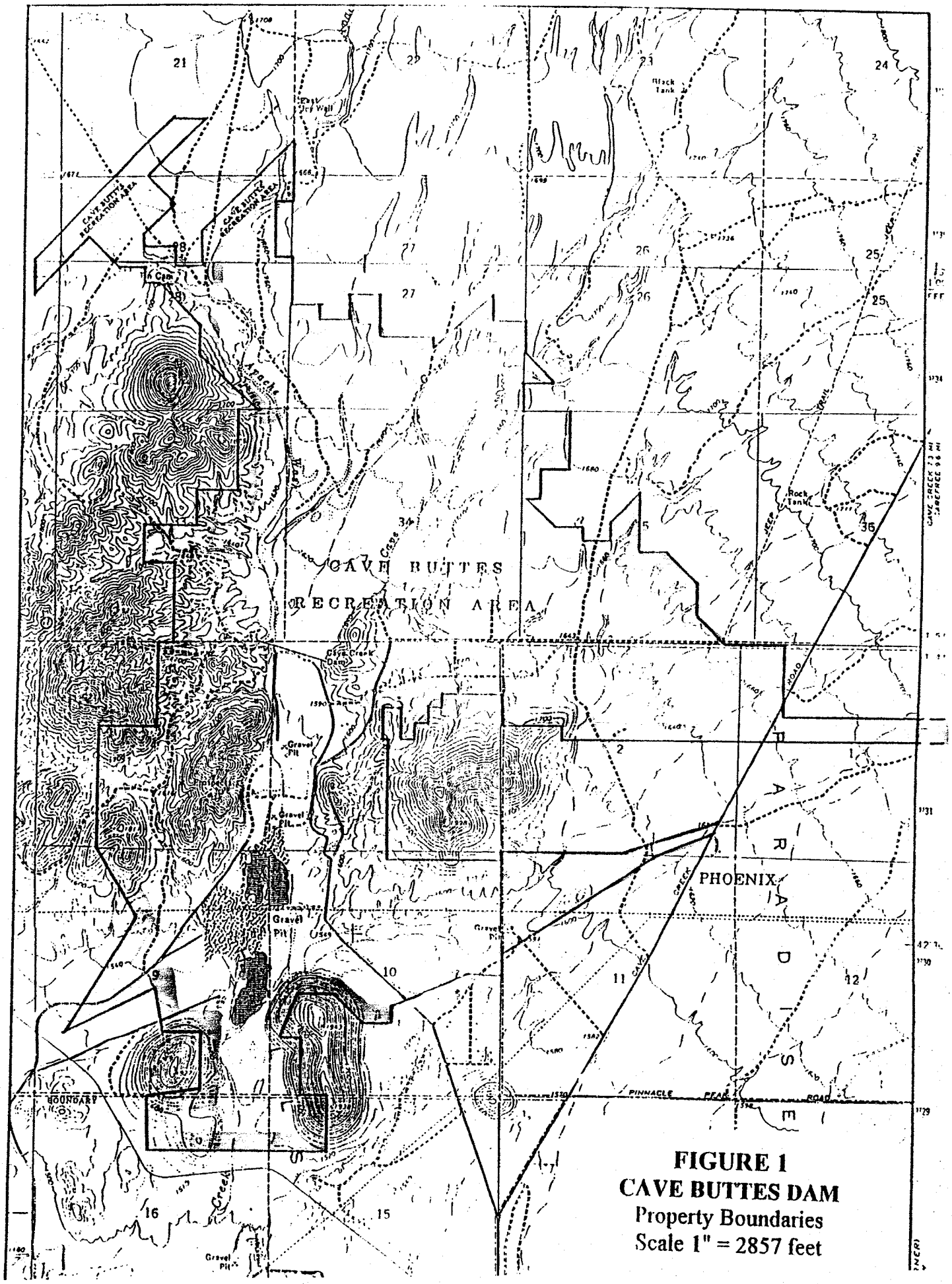

FIGURE 1
CAVE BUTTES DAM
Property Boundaries
Scale 1" = 2857 feet

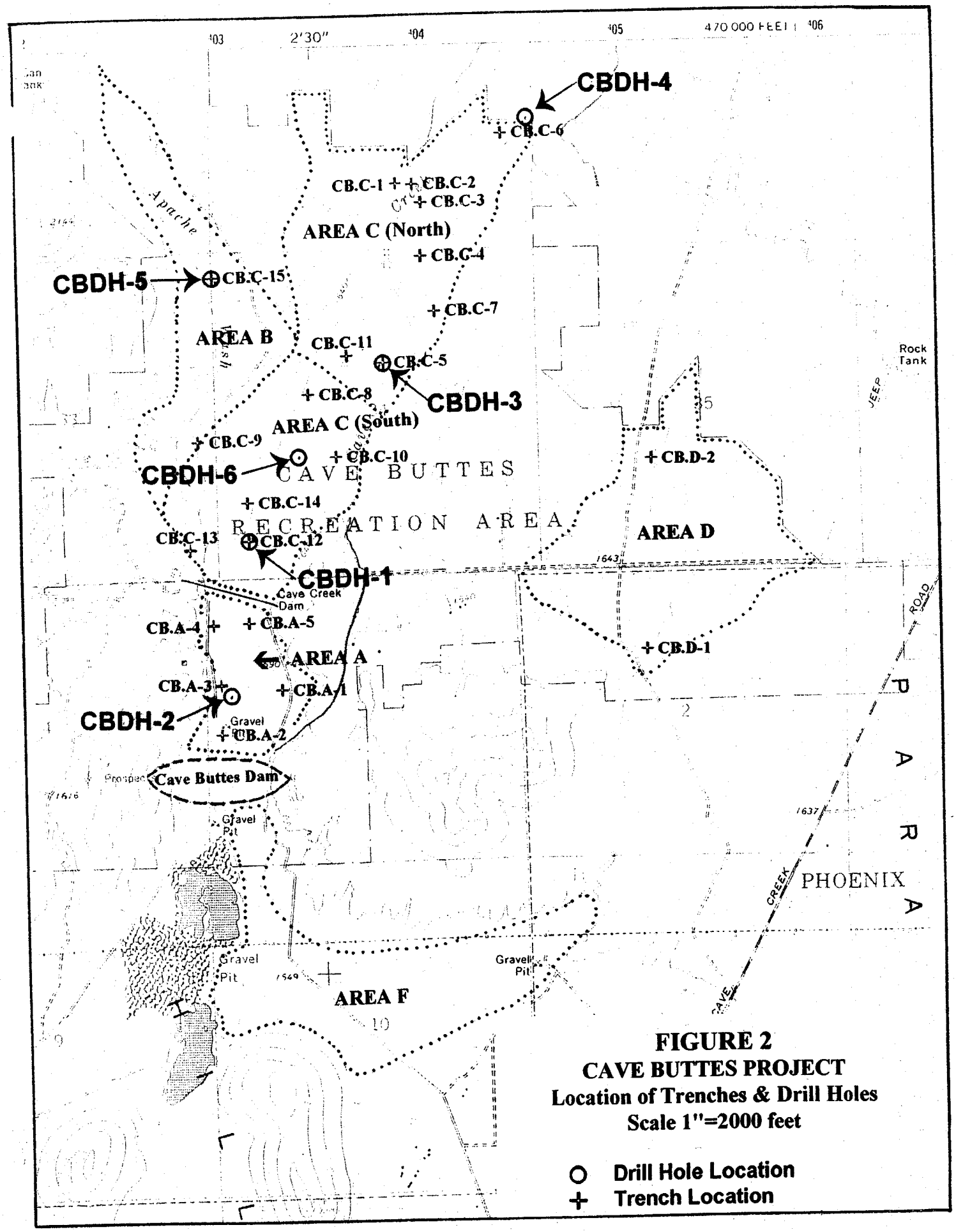

FIGURE 2
CAVE BUTTES PROJECT
Location of Trenches & Drill Holes
Scale 1"=2000 feet

○ Drill Hole Location
+ Trench Location

PROPERTY GEOLOGY

Approximately 75% of the surface of the subject property is covered by alluvial and colluvial materials of Quaternary age derived mainly from the higher ground to the northeast with some contribution locally from erosion of the Union Hills. The exposed bedrock consists of Precambrian granite and metaigneous greenschists making up 24% of the surface. Less than 1% of exposure is tuffaceous agglomerate which is probably Tertiary in age but could be Quaternary.

A. Gravels

The major gravel or aggregate units are the wash gravels, desert bench gravels, red clay gravels, and granite sands. Silts and clays are also present as overburden and as layers or strata in the gravel units. The youngest rocks on the property are Quaternary in age and consist of poorly consolidated to unconsolidated alluvial deposits of continental, fluvial origin ranging from coarse conglomerates to fine clays (Table 1). Principle rock components within these deposits are basalt (often amygdaloidal), silicified volcanics, metasediments and metaigneous rocks (principally greenstones). The deposition of fine clay and silt materials has been facilitated by the presence of the dam structures. A pit dug north of the Cave Creek dam (CB.C-13) was located at the base of a channel cut in fine sediments and the total section of silty-clay is on the order of 25 feet (Figure 2).

The "wash gravels" are particularly well developed in Cave Creek wash which occupies a zone 1,400 to 2,200 feet wide where it crosses the property.

In the east, particularly those areas within section 2, T4N, R3E and section 35, T5N, R3E,

medium to coarse, felspar/quartz or "granitic sands", derived from subcropping granitic basement, are widespread. In some of the washes these deposits can reach 3 feet in thickness and 25-30 feet in width. The very recent deposits are mostly developed in anastomosing channels with overbank deposits of silt in places which have been cut into an older, colluvial pediment surface (desert gravels) composed of poorly sorted sediments with rudimentary soil development and strong calcification (caliche).

In many of the trenches which were cut to evaluate the sand and gravel resources a conglomerate with reddish brown, plastic clay was commonly encountered, sometimes under 5-10 feet of clean gravel. This red clay with boulders or "red clay gravel" was particularly well represented in the area between the two dams where it was often present at less than 5 feet below the surface. The washed gravels between the two dams, which may have existed originally, could well have been mined out in the past. The Army Corps of Engineers report states that, in the interval between their original site investigation and the construction of the dam, large quantities of material had been removed by commercial producers of sand and gravel.[1] In this area too, a very high proportion of large, extremely well rounded, boulders was noted in the trenches. In some of the trenches north of Cave Creek dam a distinctive dark, plastic clay was exposed in the profile.

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[1] *US Army Corps of Engineers, Los Angeles Division, 1981 - Cave Buttes Dam, Gila River Basin, New River and Phoenix City Streams, Arizona, Embankment Criteria and Performance Report, P6.*

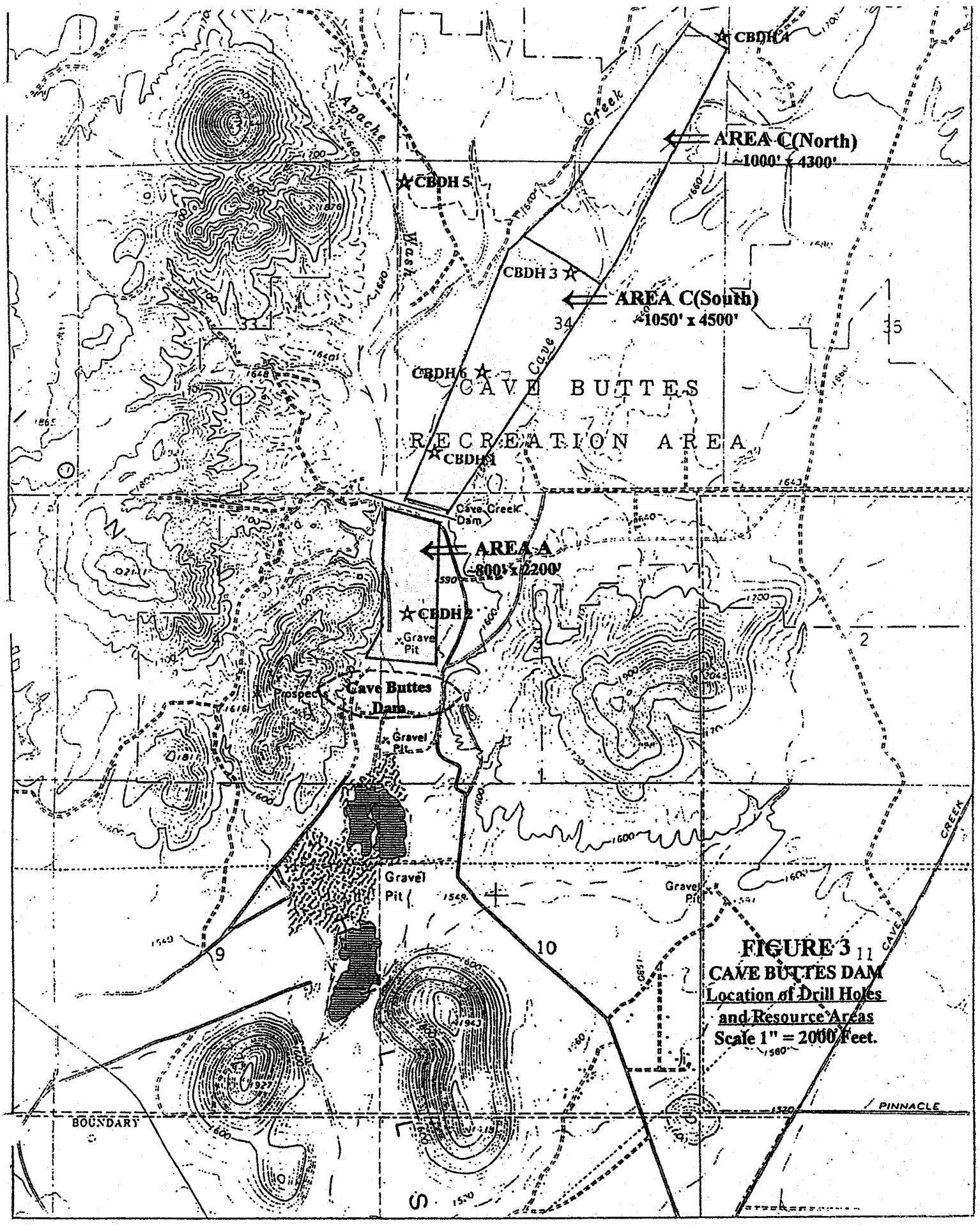

FIGURE 3
CAVE BUTTES DAM
Location of Drill Holes and Resource Areas
Scale 1" = 2000 Feet.

TABLE 1

CAVE BUTTES DAM PROJECT

UNIFIED SOIL CLASSIFICATION SYSTEM

GW	Well graded gravels, gravel/sand mixtures, little or no fines
GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
GM	Silty gravels, gravel-sand-silt mixtures
GC	Clayey gravels, gravel-sand-clay mixtures
SW	Well graded sands, gravelly sands, little or no fines
SP	Poorly graded sands, gravelly sands, little or no fines
SM	Silty sands, sand-silt mixtures
SC	Clayey sands, sand-clay mixtures
ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
OL	Organic silts and organic silty clays of low plasticity
MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
CH	Inorganic clays of high plasticity, fat clays
OH	Organic clays of medium to high plasticity, organic silts
Pt	Peat and other highly organiic soils

After U.S. Army Engineer Waterways Experiment Station (1960), "The Unified Soil Classification System." Technical Memorandum No. 3-357, Appendix A, Characteristics of Soil Groups Pertaining to Embankments and Foundations, 1953, and Appendix B, Characteristics of Soil groups Pertaining to Roads and Airfields, 1957; and A.K. Howard (1977), " Laboratory Classification of Soils - Unified Soil Classification System," Earth Science Training Manual No. 4, U.S. Bureau of Reclamation, Denver, 56 pp.

B. Tertiary Rocks

During the planning stage for the newer, Cave Buttes dam the Army Corps of Engineers examined a site approximately 7000 feet south of the current structure which was the original preferred location. Foundation studies and drilling discovered the presence of tuffaceous agglomerate under approximately 30 feet of recent alluvium consisting of layers of gravel and large nested boulders. The agglomerates extend to over 200 feet above the crystalline basement.[2] The rocks are probably a preserved remnant of Tertiary volcanic activity. A similar suite of rocks was mapped on the west side of Cave Creek in a small occurrence immediately south of the Cave Creek dam. Other occurrences are no doubt present elsewhere under the Quaternary cover.

C. PreCambrian Rocks

The majority of the basement complex rocks exposed on the property consist of metaigneous rocks (greenschists) which were probably originally basic volcanics and, in places, resemble pillow lavas. The greenschists are strongly foliated, strike north northeast for the most part and dip steeply to the east southeast on the east side of the creek and west northwest on the west side. In some places boudined quartz zones were observed which may have been chert horizons within basic tuffaceous horizons.

On the west side of the property in the northwest 1/4 of section 4 occurs a light brown to pink, medium to coarse grained granite. Much of the contact zone between this intrusive and the greenschist is covered by the older alluvium. The Precambrian rocks are cut by faults and fractures trending principally northwest (sub-parallel to the Union Hills range) but also north

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[2] *US Army Corps of Engineers, Los Angeles Division, 1981, Op. Cit. P3.*

northwest.

Hydrothermal alteration is evident in the frequent, generally narrow, quartz veins which are often ferruginous and occasionally display secondary copper minerals. There are a number of old prospect pits and adits on the property, particularly west of the creek and the dam structures. These were not sampled or examined in detail during the investigation. They were probably dug for the purpose of gold prospecting.

D. Resources

The potential resources which have been recognized on the property are borrow (soils and silts), sand and gravel, gold mineralization, copper mineralization and water. The borrow and sand and gravel resources are addressed in detail following a program of trenching and drilling, the results of which are presented in the addenda. No physical work was carried out to evaluate the gold and copper potential or the water resources of the area.

WATER

The climate of the area is classified as desert southwest receiving on average about 8 inches of rainfall per year. June and July are the hottest months with average maximum temperatures of 106.4 degrees F. Most of the precipitation occurs in the winter, frequently as severe thunderstorms. The Cave Creek dam is a interesting concrete structure, now listed on the National Register of Historic Structures, built in 1921. The Cave Buttes dam is an earthen structure dam and was completed in 1987 to alleviate the problem of flooding in the metropolitan area as a result of the thunderstorm activity. Cave Buttes dam is 2275 feet wide, 20 feet wide at the top and 109 feet vertically above the elevation of the original wash. Cave Creek dam reservoir was completely full in 1978 and 1993 after particularly heavy rainfalls.

In Cave Creek and Cave Creek wash a perched water table at surface is evidenced by stock tanks which remain full year round and by standing water in channels north of the old dam and in the old gravel pits south of the new dam. Moist ground was noted in many of the trenches and some seepage was reported by Flood Control employees near the intake works of the Cave Buttes dam. These observations relate to perched water probably resulting from the unusually wet winter of 1997/1998. Recent drilling to a depth of 100 feet did not encounter the water table which appears to be at an elevation of between 1200 feet to 1250 feet.[3] This would put the depth to the water table at 370 feet to 420 feet below the ground surface. The nearest well shows a

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[3]*Hammett, B.A. & Herther, R.L.,1995 - Maps Showing Ground Water Conditions in the Phoenix Active Management Area Maricopa, Pinal and Yavapai Counties - 1992, Department of Water Resources Hydrologic Map Series Report Number 27.*

measured depth to water of 212 feet. It is located on the boundary between the Union Hills and valley fill to the southwest which probably coincides with a fault zone. Groundwater flow is generally to the southeast. Other wells in the area show water table depths of 267 feet and 393 feet.

BORROW, SAND AND GRAVEL

A. Current Mining Activities and Historic Production

On the northern boundary of the property is an active sand and gravel quarry operated by Wheeler Construction. The Wheeler quarry is on state property and is subject to royalty payments to the state of Arizona.

This Wheeler quarry, situated near the Cave Buttes property, was an indicator of the likelihood of a similar deposit nearby. The pit was visited on May 11, 1998 and, at that time, problems were being encountered maintaining acceptable specifications on the aggregate caused by material at depth which contained too much red clay resulting in a high plasticity index. Additional problems which were being addressed involved inclusion of silt material which is up to 4 feet in thickness in places and overlies the sand and gravel in a part of the quarry.

South of the Cave Buttes dam is an extensive area shown on the topographic maps where sand and gravel were formerly mined.[4] The area occurs in the northwest 1/4 of the northwest 1/4 of section 10 and the northeast 1/4 and southeast 1/4 of section 9, all in T4N, R3E. Approximately 90 to 100 acres are disturbed of which about 46 acres are shown as old pits containing water. A power line runs through the center of the disturbed zone to the south and part of this area has been used as a landfill.

Two small gravel pits are shown near the middle of the area between the two dams. These pits existed when the first edition of the U.S.G.S. map was made in 1964 and mining here was

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[4] *U.S. Geological Survey - 1964 (revised 1981) Union Hills Quadrangle, Arizona - Maricopa Co.-7.5 Minute Series.*

apparently very limited in extent. The resource areas are upstream of the spillway of the Cave Buttes dam and the dam outlet can be used to control flow and prevent head cutting. The Area A zone is in an ideal situation for mining but little may be left of the original "wash gravel" aggregate resources.

Silt and soil material is present in abundance, especially immediately north of the old dam, and is currently finding a use at the county landfill at Skunk Creek.

B. Trench Sampling Program

The property was initially divided in 5 areas where the potential for developing resources of suitable aggregate was assumed to be good and these areas were prioritized and sampled using a backhoe supplied by Flood Control to dig trenches (Plate 1) at twenty two (22) sites (Figure 2). The areas were designated Area A, Area B, Area C and Area D. Area C was subsequently subdivided into C North and C South. A description of the trenches is included as Table 2.

A prime target was the area south of the active mining operation of Wheeler Construction immediately north of the northern boundary of the subject property - Area C North. In this area eight trenches were dug and the subsurface alluvial and colluvial materials sampled. A total of twenty nine samples of approximately twenty five pounds each on average were collected. Trench depths were on the order of 13-15 feet deep (near the limit of reach for the machine). Twenty-seven of the samples collected (normally three to four per trench) were sent for analysis to Law Engineering and Environmental Services Inc. Analytical data has been received for sieve passing sizes and plasticity index on all of the samples together with durability and reactivity tests on selected, composited samples.

Preliminary results have confirmed this area to be the most promising as far as quality of product is concerned.

Another prime target was the Area C South where six trenches were dug and fifteen samples collected for similar analytical work. At these sites, depths of 16 feet were achieved in two locations and 17 feet in another. This area showed good gravel intervals overlain by up to 25 feet of fine clayey silts. This area contained the greatest quantity of aggregate.

Of third priority was the area between the two dams, Area A, where five trenches were dug in a zone of approximately 800 feet by 2200 feet. Eighteen samples were collected and sent for analysis as above. There was a noticeable lack of well washed aggregate material or "wash gravel" in this area. This may have been stripped by previous operators as noted above. Most of the trenches contained the red clay gravel, in places virtually from surface in the excavations. The analytical data show high plasticity indices of up to fifty-seven (sample CB.A-3/1) for this horizon. On the east side of the valley, trench CB.A-1 showed strong development of caliche close to the surface in the desert bench soils.

Of fourth priority was the area on the east side of the property, Area D, approximately one mile west of Cave Creek road. Five samples were collected from two trenches and sent for analysis as above. This area is quite visible from the highway which may preclude mining activities in the future. It does contain limited resources of a granitic, sandy gravel which may be of commercial value. For the most part the area is underlain by desert bench soils.

In Area B (Apache Wash) one trench was dug and four samples taken. The area would be ideal for mining activities since it is remote and relatively hidden from the public view. However, there does not appear to be any extensive deposits of good quality, recently deposited, clean

aggregate material. The best materials are restricted to a narrow channel less than 50 feet wide and probably of shallow depth.

No work was carried out in the area south of Cave Buttes dam because of the power line, right of way and the existing landfill. There could be resources remaining here but the obstacles to production make this area an unlikely candidate for development.

The location coordinates and sampling data, photographic record and field classification of the alluvial materials are shown in Table 3 and the trench logs are attached. Table 1 shows the Unified Soil Classification System used in the description of the stratigraphy.

TABLE 2
CAVE BUTTES DAM
TRENCH DESCRIPTION

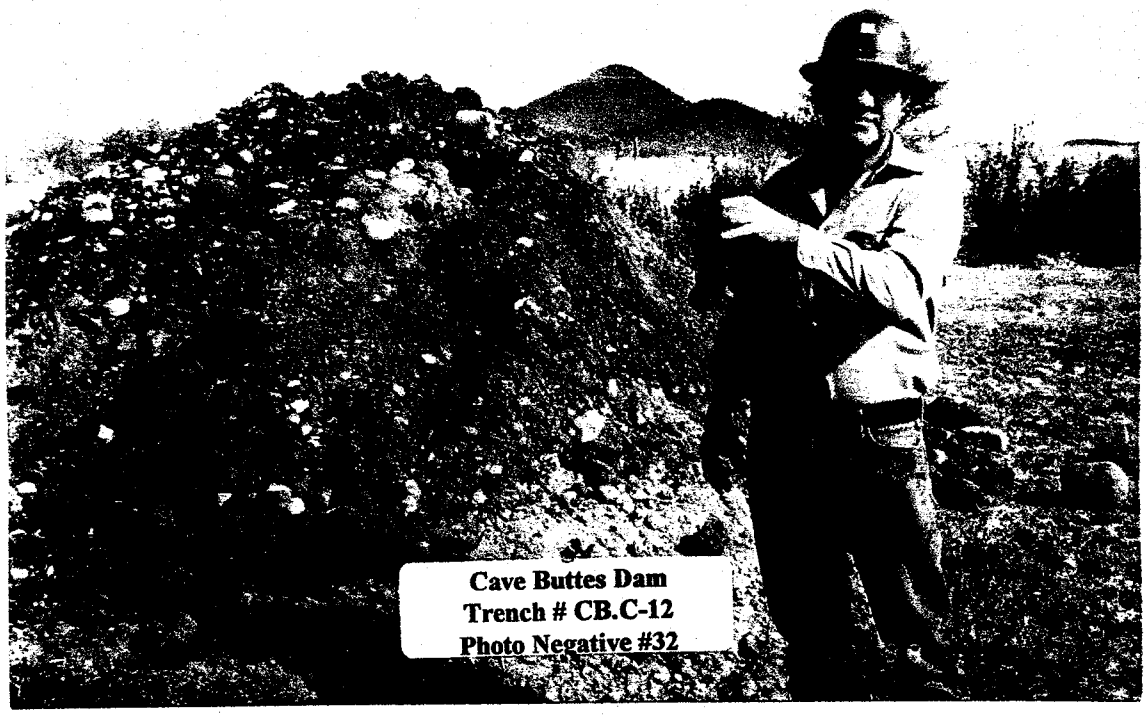
Trench #	Area	Description
CB.C-1	C(north)	Trench in Older Alluvium - abandoned at 6 feet. Red/brown clayey gravel with boulders and cobbles overlying sandy gravel. Strongly cemented with caliche at bottom. No samples. Tertiary volcanics, vesicular basalts and some quartz vein talus on surface.
CB.C-2	C(north)	Trench dug 15 feet deep approximately 300 feet from CB.C-1. Fine brown, calcareous silt at surface followed by clean, good looking gravel (also calcareous). Overbank/ terrace deposit of Cave Creek wash.
CB.C-3	C(north)	Trench dug 15 feet in active channel zone. Thin zone of sandy silt at surface with roots. Underlain by good looking gravel with moderate carbonate. 3 feet of gravel with red/brown clay at the bottom (similar to Wheeler pit to the north)
CB.C-4	C(north)	Trench dug 15 feet in active channel of Cave Creek. Thin silty gravel followed by excellent clean gravels to bottom.
CB.C-5	C(north)	Trench dug in centre of wash to 13 feet. Abandoned because of caving sands. All coarse sands and gravels from surface to 12 feet followed by gravel with clay in the last one foot.
CB.C-6	C(north)	Trench dug to 14 feet near the north boundary of the property in active channel of Cave Creek wash. All good clean sandsand gravels but with clay appearing at the bottom (similar to Wheeler pit approximately half mile to the north)
CB.C-7	C(north)	Trench dug to 14 feet. Four feet of clean well washed gravel followed by very coarse (40% boulders) gravel with clay.
CB.C-11	C(north)	Trench completed at 11 feet due to problems with large boulders. Pinkish sandy clay at surface for approx. 2 feet followed by dirty, coarse gravel with 2-5% boulders and 30% cobbles. Unstratified.
CB.C-8	C(south)	Trench dug to 13 feet. Approximately 2.5-3.0 feet of silty sand followed by coarse gravel to 11.5 feet. final 1.5 feet is boulders with clay unit
CB.C-9	C(south)	Trench dug to10 feet in channel zone represented by silty clay with strong vegetation. eight feet of silty clay followed by 2 feet of boulders with clay. Clay moist.
CB.C-10	C(south)	Trench dug to 14 feet in well stratified section with silts, sands and gravels followed by a distinctive grey clay with boulders layer from 7 to 8 feet deep. This zone underlain by medium to coarse gravel with minor clay component.
CB.C-12	C(south)	Trench dug to 16 feet. Six feet of silt followed by 2 feet of loose, medium - coarse gravel, 1.5 feet of sandy silt and 2.0 feet of green/black plastic clay. 4.5 feet of coarse gravels in bottom of section.
CB.C-13	C(south)	Trench dug to 17 feet in channel north of Cave Creek dam. Section cut 15.5 feet of clay and silty with more,sandy zones at base. Top of trench at least 10 feet below average local surface. 2 feet of grey/black clay then coarse gravel.
CB.C-14	C(south)	Trench dug to 16 feet. Ten feet of well stratified silts, sands and gravels followed by 4 feet of silty gravel with ~20% cobbles and, in the bottom, 2 feet of fine/medium sand.
CB.C-15	B	Trench dug to 13 feet in Apache Wash area. Site is on Older Alluvium near section corner. Approx. 7 feet of coarse gravels - strong caliche. 5 feet of clay/silt + boulders under. Large boulders, very hard, machine about maxed out
CB.A-1	A	Trench dug to 12 feet in Older Alluvium. Two feet of silt with caliche concretions starting at base followed by coarse gravels with boulders in places up to 3' in diameter. High carbonate content. Very hard and cemented at the base progress slow.
CB.A-2	A	Trench dug to 15 feet . Good gravel to 4.5 feet with some silt and organic material (roots) near surface. From 4.5' to bottom is red/brown, sticky clay with boulders (5-10%)
CB.A-3	A	Trench dug to 14.5 feet in disturbed zone between dams. one foot of silt underlain by greenstone ?slope wash, talus. Underlain by red/brown clay + cobbles. Cobbles very well rounded.
CB.A-4	A	Trench dug to 15 feet . Six feet of coarse gravel, medium sand and silty sand followed by red/brown clay with boulders.
CB.A-5	.	Trench dug to 12.5 feet. All in red/brown clay with boulders. Boulders up to 3 feet in diameter and 50% of the material. Abandoned.
CB.D-1	D	Trench dug to 11.5 feet - problem with caving sands. Top 3 feet is good coarse sand/gravel of granitic parentage. Followed by sandy clay (damp) grading down quickly into gray, clayey gravel with boulders which increase in size up to 2 ft.
CB.D-2	D	Trench dug to 8 feet only because of boulders and hard cemented material. Starts witjh 2 ft of dirty brown, silty gravel followed by coarse gravel with 5-10% boulders and silty. weak/mod carbonate .

TABLE 3

CAVE BUTTES DAM

TRENCH LOCATION, SAMPLES AND SOIL CLASSIFICATION

Trench	Area	Latitude	Longitude	Depth Ft	Photo #s	Sample #s	"SOIL" TYPE - (see attached classification) - numbers below refer to accumulated footage of the "soil" type in the trench									
							GW	GP	GM	GC	SP	SC	SW	ML	CH	OH
CB.C-1	C(north)	33 44.637	112 02.230	6	R1; 2	C-1/1,/2			4	2						
CB.C-2	C(north)	33 44.638	112 02.186	15	R1; 3,4,5	C-2/1,/2,/3,/4		10						5		
CB.C-3	C(north)	33 44.583	112 02.158	15	R1; 6,7	C-3/1,/2,/3,/4		10.5		3				1.5		
CB.C-4	C(north)	33 44.439	112 02.168	15	R1; 8,9	C-4/1,/2,/3,/4,/5	2	11						2		
CB.C-5	C(north)	33 44.154	112 02.283	13	R1; 9,10	C-5/1,/2,/3,/4		4		1			8			
CB.C-6	C(north)	33 44.765	112 01.894	14	R1; 20,21	C-6/1,/2,/3,/4		14								
CB.C-7	C(north)	33 44.292	112 02.120	14	R1; 22,23,24	C-7/1,/2,/3	4			10						
CB.C-11	C(north)	33 44.171	112 02.398	11	R1; 30,31	C-11/1,/2,/3		1	9			1				
CB.C-8	C(south)	33 44.076	112 02.525	13	R1; 25,26	C-8/1,/2,/3			8.5	1.5				3		
CB.C-9	C(south)	33 43.950	112 02.873	10	R1; 27,28					2					8	
CB.C-10	C(south)	33 43.904	112 02.450	14	R1; 29	C-10/1,/2,/3,/4	2	5.5		1				5.5		
CB.C-12	C(south)	33 43.672	112 02.727	16	R1; 32,33,34,35	C-12/1,/2,/3,/4,/5		7						8	1	
CB.C-13	C(south)	33 43.649	112 02.913	17	R2; 2	C-13/1,/2		1						15.75		1.25
CB.C-14	C(south)	33 43.778	112 02.733	16	R2; 3	C-14/1		4					2	10		
CB.C-15	B	33 44.392	112 02.821	13		C-15/1,/2,/3,/4		7		4.5						
CB.A-1	A	33 43.254	112 02.668	12	R2; 13,14	A-1/1,/2,/3		8.25	1.75					2		
CB.A-2	A	33 43.175	112 02.840	15	R2; 11,12	A-2/1,/2,/3,/4		2.5	2	10.5						
CB.A-3	A	33 43.260	112 02.866	14.5	R2; 9,10	A-3/1,/2,/3				10.25				1		
CB.A-4	A	33 43.444	112 02.429	15	R2; 5,6	A-4/1,/2,/3,/4,/5		4.33		9	1.67					
CB.A-5	A	33 43.421	112 02.783	12.5	R2; 15,16	A-5/1,/2,/3				12.5						
CB.D-1	D	33 43.466	112 01.458	11.5	R2; 17,18	D-1/1,/2,/3				7.5			3	1		
CB.D-2	D	33 43.884	112 01.449	8	R2; 19,20	D-2/1,/2			8							
						TOTALS	8	90.08	33.25	74.75	1.67	1	13	54.75	9	1.25


Cave Buttes Dam
Trench # CB.C-12
Photo Negative #32

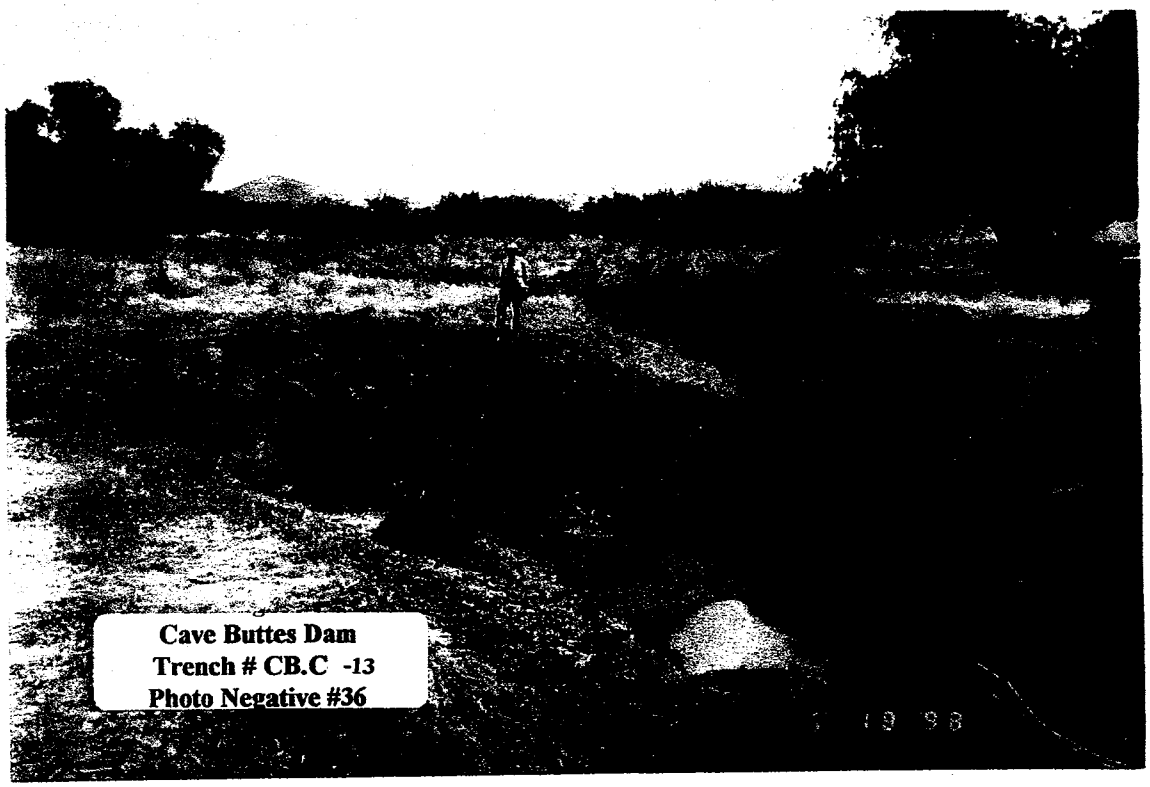

Cave Buttes Dam
Trench # CB.C -13
Photo Negative #36

PLATE 1

C. Drilling

Six drill hole sites were recommended and the work was carried out by Layne Environmental Services using a Tubex percussion system (Figure 4). Figure 4 summarizes the data from the six drill holes according to the detailed logs prepared by LAW Engineering and Environmental. The holes were sampled and logged by LAW Engineering and Environmental Services, Inc. All the holes were successfully completed to the required depth of 100 feet. Gravel intervals reported are as follows:[5]

DRILL HOLE	GRAVEL INTERVALS	GRAVEL AND SAND INTERVALS
DH1	13 -100	13 - 100
DH2	10 - 30	0 - 53
DH3	15 - 30	0 - 40; 45 - 60; 75 - 100
DH4	0 - 52; 64 - 60	0 - 68
DH 5	16 - 40	0 - 5; 16 - 40
DH 6	20 - 31	9 - 100

Details of the drilling program with logs of the holes and sample analytical results will be presented by LAW Engineering and Environmental Services, Inc. The detailed drill hole logs from LAW are in the Addenda section of this report.

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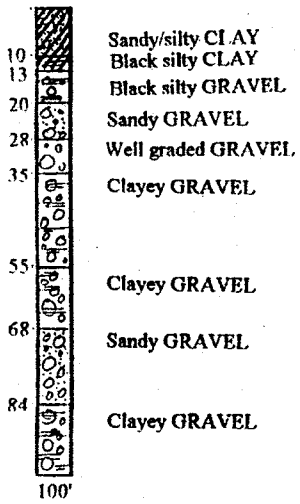
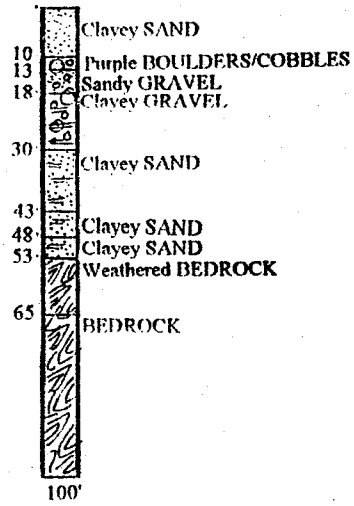
[5] *Wolle, Bruce and Cook, Patrick, 1998, Law Engineering and Environmental Services, Inc., Personal Communication.*

FIGURE 4
CAVE BUTTES PROJECT
Drill Hole Summaries
Scale 1" = 40 feet

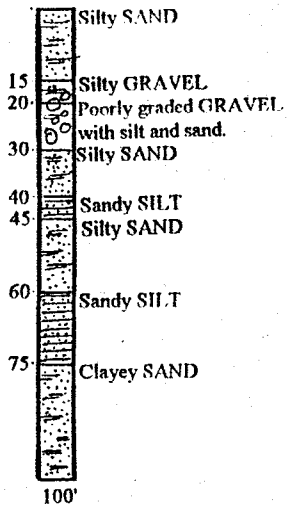
CBDH-1
Area C(South)



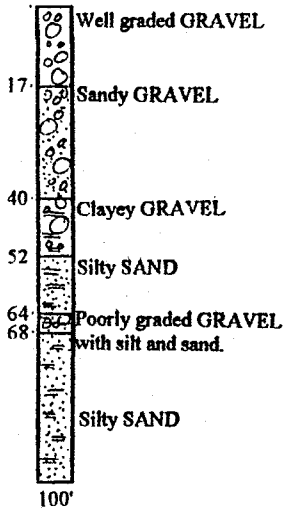
CBDH-2
Area A



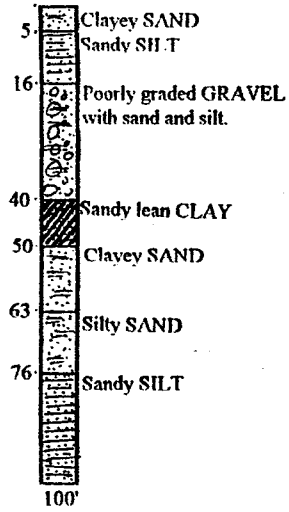
CBDH-3
Area C(North & South)



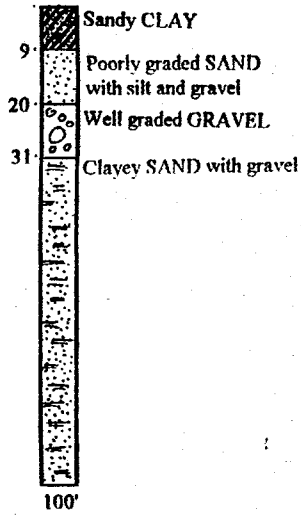
CBDH-4
Area C(North)



CBDH-5
Area B



CBDH-6
Area C(South)



Data Source: LAW Engineering and Environmental Services Inc.

D. Resources Estimation

A very rough estimate of the resources has been made for Areas A, C North & C South.

1. **Area A.** The area can be approximated by a surface rectangle 800' x 2200' (Figure 3). A depth of 55 feet has been assumed (using recent drill hole information). At 110 lbs/cu. foot and using 2.5:1 pit slopes, about 4.0 million tons are estimated. A wash plant would probably be necessary to treat the gravels because of the clay content and the resulting fairly high plasticity index. Laboratory results from trench sampling classify the gravels mostly as GW (well graded gravels, gravel/sand mixtures, little or no fines). Field classification place most of the material in the GC category (clayey gravels, gravel-sand-clay mixtures).

2. **Area C North.** The area can be approximated by a quadrilateral with a surface area of 4,300,000 sq.feet. Assuming an average thickness of 70 feet, material density of 110 lbs/cu.foot and 2.5:1 pit slopes, the area contains about 14.0 million tons of material. Most of the material from trenches was classified in the field as GP (poorly graded gravels, gravel-sand mixtures, little or no fines) and in the laboratory as GP, GW or SP (poorly graded sands, gravelly sands, little or no fines). A wash plant may be required to treat some of this material.

3. **Area C South.** This area can be approximated by a quadrilateral with a surface area of 4,725,000 sq.feet. Using an average thickness of the gravel of 100 feet the tonnage indicated here is about 18.7 million using the same slope and density criteria as for C North. The material from the trenches was field classified as mainly ML. Laboratory classification reports

indicate mainly GP and SM (silty sands, sand-silt mixtures) with some GW for this material. Within Area C South is a thin horizon of pure clay of unknown extent, which may have value as raw material for ceramic purposes.

The quantity of the resources of silt or borrow material have not been separately estimated but are considerable especially in Area C South. They are the result of deposition in the historic past following construction of the dams. There is, and there will continue to be, a need for this material both internally (at the landfill) and externally for fill purposes relating to the local construction activities and landscaping. The thin, interlocated clay horizon may have a variety of useful purposes.

Area B. This area contains less than 1.0 million tons which was considered insignificant for the purposes of this study.

E. Production

1. Supply and Demand. The construction industry is the largest consumer of aggregate by far nationwide and its use closely reflects the economic health of the United States. Growth in demand has also been linked directly to population increases and the trends in population growth have been used to predict future demand.

Population growth in the U.S. as a whole from 1990 to 1997 was approximately 8%; in California it was the same but in Arizona it grew by 24% to 4,555,000 persons. In addition to housing one of the principle uses is in highway construction. In November, 1997, the Senate and

House agreed to extend the Intermodal Service Transportation Efficiency Act (ISTEA) for six months which allows States to continue construction in 1998 with $9.7 billion in spending authority. As a result of the extension of the federal highway funding , many producers across the nation expect demand for aggregate to remain stable or have moderate growth in 1998. William Toal, chief economist for the Portland Cement Association and Tom Loy, senior economist for FMI management consultants both predict a 3% drop in residential construction in 1998 (Rock Products, 1998 - Jan., p.13 and Feb., p.16). This will however be more than compensated for by increases in highway spending of about 7%. The federal government also expects an increase to show up in 1997 for other construction related programs particularly the projects of the Army Corps of Engineers. For 1998 Rock Products[6] also predicts that the aggregate demand will experience a continued moderate growth of about 3%. Demand for aggregate in Arizona was approximately two and one half times the national average on a per capita basis (9 metric tons per person versus 3.6 nationwide).

Demand in general in the state will probably continue to outstrip the national average and most of this will be reflected in the statistics for the Phoenix metropolitan area since this is where virtually 50% of Arizona's population resides.

Demand for aggregate and construction materials generally in the Phoenix metro area is expected to match the demand for new homes in 1998 which is predicted to decelerate during the remainder of the year to end at slightly less than 1997 but still at more than 30,000 single family units. At the beginning of June, 1998, home construction had not slowed after five years of record growth.

Through April, 1998, home building was 16% ahead of the same time period last year and, in April itself, 27.5% more permits were issued than in the same month last year.

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[6]*Rock Products, 1997 - December. P29*

At year end the total new homes built is expected to be slightly less than 1997 which was 31,715 permits (single family homes) and building is predicted to fall off steadily year by year through 2001.[7] The current demand for housing is being fueled by the creation of new jobs in the Phoenix area and by low lending rates for 30 year home loans. Building activity in the vicinity of the subject property is at a very high level as evidenced by the large number of cement trucks, regular- and belly dump trucks and support vehicles using Cave Creek road during daylight hours.

In 1985 voters approved a half-cent sales tax to fund right-of-way purchases and construction of 231 miles of freeway loop in Phoenix which was scheduled to be mostly completed by 1995. Some sections are now not planned for completion until 2005 due to cost overruns and less revenue than expected.

Over the next five years the various local and state governments are budgeting about $2.2 billion for road construction in metropolitan Phoenix beginning with $640,000.00 in 1998. This should be followed by successive decreases of 29%, 16% and 26% in the next three years and then a 50% increase in the year 2002.

Construction sand and gravel is the only mineral commodity which is produced in common in every state. It is a major basic raw material used principally by the construction industry. Nationwide the sand and gravel sold or used by producers in 1997 was 956 million metric tons which is a 4.6% increase over the 914 million metric tons in 1996. Production for consumption of construction sand and gravel in the 4th quarter of 1997 was reported to be highest in California,

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[7]*Reagor, Catherine, 1998, The Arizona Republic, Sat. May 30.*

Michigan, Ohio, Texas and Arizona. Their combined total was 33.9% of the U.S. total.[8] In Arizona, production in 1997 was apparently slightly less, at 41 million tons in 1997, versus 41.9 million tons in 1996.

The sand and gravel resources on the subject property would be competing principally with other nearby deposits, particularly the Wheeler Construction Company, Dixileta pit production. This operation is on state of Arizona land and subject to some conflict between the state and the city of Phoenix. Apparently, Phoenix wants to maintain the area as a recreation area and charges that Wheeler is in violation of city zoning ordinances. The suit was resolved in favor of the state since they are not subject to city zoning ordinances. Wheeler now operates the quarry under a 10 year lease agreement beginning May 30, 1995 on 145 acres whereby the lessee is required to pay $0.60 per ton of product sold together with a land rent of $17,400.00 per year and a 3% administrative fee. The lessee is required to pay a minimum annual royalty of $45,000.00 (equivalent to 75,000 tons of material).

Approximately eleven miles to the northwest, FNF Construction was the successful bidder on another state sand and gravel auction of 320 acres in the New River area. The bid for this lease was $1.65 per ton, the highest in recent history. In addition the land rental is $12,800 per year with a 3% administrative fee and a minimum annual royalty of $57,750.00 (equivalent to 35,000 tons of material).[9] This bid is indicative of the extreme competition for sand and gravel resources and points

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[8] *U.S. Geological Survey, 1998, Mineral Industry Surveys, Crushed Stone and Sand and Gravel in the Fourth Quarter of 1997, P 2.*

[9] *Montandon, Wendel L., 1997, Marketability Study of Sand, Gravel and Borrow Products from Three Sites Located Above Dams in North Metropolitan Phoenix Arizona, Private Report for Maricopa Department of Transportation, Phoenix, Arizona.*

to the obvious high demand which is being experienced for construction materials. Wheeler Construction was unsuccessful in its bid for this property and has subsequently filed an application with the state to lease an adjacent 160 acres in the New River area. Two other state leases on smaller acreages exist in Maricopa County.

According to Montandon the general availability of sand and gravel deposits in the metropolitan Phoenix area and specifically the north valley can typically meet any forecast increase in demand in those areas with little difficulty.

2. **Product Prices.** The price sand and gravel sold or used by producers in the U.S. in 1997 on average was $4.38 per metric ton ($3.98 per short ton) and was unchanged from 1996. Construction sand and gravel prices are expected to increase marginally compared with the past several years. The reason for this is the increased transportation costs for materials due to production being pushed to more rural areas. Acquisition costs will escalate because of the increasing difficulties associated with permitting new operations thereby allowing resource owners with permits in hand to demand higher prices (USGS, Construction Sand and Gravel Annual Review 1996, page 4). The price of sand and gravel sold or used by producers in Arizona in 1997 was, on average $4.73 per metric ton ($4.29 per short ton) and was virtually unchanged from 1996 ($4.75 per metric ton or $4.31 per short ton).[10]

3. **Permitting.** One of the most critical permits required is administered by the

[10] *U.S. Geological Survey, 1998, Mineral Industry Surveys, Crushed Stone and Sand and Gravel in the Fourth Quarter of 1997, P 2.*

Army Corps of Engineers (404) and is needed if activities are to take place within the "ordinary high water mark" of "navigable waters". Some portion of the areas being considered are in this category. Other permit requirements have not been investigated.

4. **Economic Evaluation.** Based on royalties at the Wheeler and FNF quarries of $0.60 per ton and $1.65 per ton respectively, a royalty rate of $0.65 to $0.75 per ton would not be unreasonable for the study area. No detailed royalty income analysis or economic evaluation was completed as part of this study.

HIGHEST AND BEST USE

The "Highest and Best Use" of the property currently identified is as a source of aggregate and borrow for construction purposes. This activity would have a finite life and alternate uses can be envisaged both contemporaneously and after mining ceases. Unless required to be backfilled, an excavation will remain upon completion of mining which might be used as a groundwater recharge zone and/or recreational lake. The need for recreational facilities in the Phoenix metropolitan area will increase as the development progresses and golf courses, hot air balloon sites and public lakes can be considered. These activities are compatible with aggregate mining or quarrying as evidenced by the multi-use applications in the Salt, Gila and Agua Fria River areas. The increasing need for solid waste disposal facilities will also need to be considered in the future and Cave Buttes would be a good location.

With respect to groundwater recharge two important local considerations are applicable.

1. CAP WATER - At present there is little likelihood that additional recharge will be required since the total capacity of the aqueduct is at or approaching total use requirements.

2. EFFLUENT DISPOSAL - There will be an increasing need for recharge of effluent because of growth in the metropolitan area. The tendency, however, is to build the treatment facility and then engineer the effluent recharge nearby. Where encountered, poor permeability is addressed with increasing pond size. Only half of an equivalent credit at the "Water Bank" is applicable to

treatment plant effluent recharge. At present recharge is being used by most operators to accumulate credits with the Arizona Water Banking Authority. Currently state and city governments are conducting recharge activities to allow for flexibility of supply in the future. They will be able to use the credits to maintain or increase pumpage in areas which otherwise would be restricted because of water table maintenance regulations. Some private companies carrying out recharge activities are hoping to realize dollars by selling credits down the road. Without doubt recharge activities are recognized as an important aspect of future water management planning.[11]

[11]*Rascona, Steven 1998, Hydrologist, State of Arizona, Department of Water Resources, Personal Communication.*

CONCLUSIONS

The data acquired to date suggests that aggregate material could be mined in Area C North adjacent to the Dixileta quarry (the Wheeler Construction operation). Area C South is also an excellent location for aggregate mining where the gravels are thick and the quarry would be in a relatively non-visible location. This investigation was confined to an examination by means of trenches of the top approximately 15-16 feet of the fluvial section together with six Tubex percussion drill holes to 100 feet.

Recreational activities such as golf courses, hot air balloon sites, public lakes and groundwater recharge are compatible with aggregate mining or quarrying. The groundwater recharge will depend on the permeability analysis done by LAW Engineering and Environmental Services Inc. Law Engineering is preparing a detailed report on an analysis of drill hole data that will supplement the drilling information in this report. We have not studied the effect of two dams on subsurface flow of water. This multi-use concept is being applied in the Salt and Verde Rivers and in the Indian Bend Wash and it could be applied in the Cave Buttes dam area.

ADDENDA

TRENCH CUT LOGS

PROJECT - Cave Buttes Dam

Trench #:CB.A-1

Location: 33 43.254 N, 112 02.668 W. Elevation: ft | **Geologist:** AW | **Date: 5/20/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel and Boulders
		ML	Silt with poorly developed caliche at base						
		GP	Coarse gravel. Strong carbonate deposited on stones.	CB.A-1/1	GW	NP	4.05	28.35	67.6
5		GM	Gravel with silt. 5% cobbles						
		GP	Coarse gravel with 10-15% boulders. Sizes down to sand, little silt, some boulders up to 3ft. Moderate carbonate.	CB.A-1/2	SP-SM	NP	5.34	56.79	37.87
10				CB.A-1/3	SW-SM	NP	6.56	72.19	21.25
			T.D. Very hard, carbonate cement. Progress very slow.						
15									
20									

PROJECT - Cave Buttes Dam

Trench #:CB.A-2

Location: 33 43.175 N, 112 02.840 W. Elevation: ft | Geologist: AW | Date: 5/20/98

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel and Boulders
		GM	Gravels and silty sand. Dirty, roots and some organic debris at top.						
		GP	Good clean gravel, 5-10% boulders.	CB.A-2/1	GP	NP	1.3	39.4	59.3
5		GC	Coarse gravel with clay 25% BOULDERS.	CB.A-2/2	GP	NP	2.85	35.4	61.75
10									
				CB.A-2/3	SP-SM	NP	4.28	41.47	54.25
15									
				CB.A-2/4	SW-SC	19	3.75	26.25	70
20									

PROJECT - Cave Buttes Dam

Trench #:CB.A-3

Location: 33 43.260 N, 112 02.866 W. **Elevation:** ft | **Geologist:** AW | **Date:** 5/20/98

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel and Boulders
		ML	Silt						
			Talus of PreCambrian greenstones.						
			4'3"						
5		GC	Red clay and cobbles - boulders (very well rounded). Moist. No carbonate						
			25% BOULDERS.	CB.A-3/1	GW	57	3.6	16.65	79.75
10									
				CB.A-3/2	GW	29	3	27	70
				CB.A-3/3	SW-SC	21	4.88	37.87	57.25
			14'5"						
15									
20									

PROJECT - Cave Buttes Dam

Trench #:CB.A-4

Location: 33 43.444 N, 112 02.429 W. Elevation: ft | Geologist: AW | Date: 5/18/98

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel and Boulders
		GP	Coarse gravel, boulders 5-10% cobbles 40-50%	CB.A-4/1	SM	NP	5.56	23.41	71.03
			2'4"						
		SP	Medium grained sand						
5		GP	Gravel. 1% boulders, 30% cobbles	CB.A-4/2	SP-SC	16	4.21	32.36	63.43
		GC	Clay + boulders. 20% boulders 10-15% cobbles. Red/brown color. silt and sand component. No carbonate.	CB.A-4/3	SP-SC	7	3.85	27.87	68.28
10				CB.A-4/4	GC	23	7.63	22.75	69.62
15									
			?Bedrock. Rotten, crumbly biotite granite.	CB.A-4/5	SW-SM	6	7.9	59.1	33
20									

PROJECT - Cave Buttes Dam

Trench #:CB.A-5

Location: 33 43.421 N, 112 02.783 W. Elevation: ft | **Geologist:** AW | **Date: 5/20/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel and Boulders
		GC	Very coarse red clay with boulders. Boulders (50-60%) up to 3ft., well rounded. No carbonate.	CB.A-5/1	GP	6	2.03	15.07	82.9
5									
				CB.A-5/2	GP-GC	43	2.43	13.32	84.25
10									
			T.D. Problems with large boulders.	CB.A-5/3	GP-GC	45	2.39	12.01	85.6
			12' 6"						
15									
20									

PROJECT - Cave Buttes Dam

Trench #: CB.C-1

Location: 33 44.637 N, 112 02.230 W. Elevation: ft | **Geologist:** AW | **Date: 5/14/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel and Boulders
		GM	Red/brown clay with boulders (2-5% and< 18"). 30-40% cobbles Caliche cement from 44" to 60".	CB.C-1/1					
5		GC	Red/brown sandy gravel.Caliche cement from 44" to 60"	CB.C-1/2					
10									
15									
20									

PROJECT - Cave Buttes Dam

Trench #: CB.C-2

Location: 33 44.638 N, 112 02.186 W. Elevation: ft | **Geologist:** AW **Date: 5/14/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel and Boulders
		ML	Fine brown silty sand. Moderate carbonate.	CB.C-2/1	ML	3	57.8	41.2	1
5									
		GP	Poorly graded gravel w. 5-10% boulders, 30-40% cobbles. Weak carbonate. Narrow "pea" gravel zones up to 1 foot thick	CB.C-2/2	SW-SM	NP	5.52	27.25	67.23
				CB.C-2/3	GW-G	NP	2.07	17.48	80.45
10									
				CB.C-2/4	GW	NP	2.47	21.11	76.42
15			Bottom of trench 15 feet						
20									

PROJECT - Cave Buttes Dam

Trench #: CB.C-3

Location: 33 44.583 N, 112 02.158 W. Elevation: ft | **Geologist: AW** | **Date: 5/14/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel and boulders
		ML	Sandy silt.	CB.C-3/1	GP	NP	3.3	88.7	8
		GP	Gravel with 10-12% boulders, 40% cobbles. Weak carbonate	CB.C-3/2	SP	NP	1.76	24.21	74.03
5									
				CB.C-3/3	GW	NP	1.42	23.57	75.01
10									
		GC	Poorly sorted gravel with red/brown clay. 2% boulders	CB.C-3/4	GC	16	4.41	39.69	55.9
15									
20									

PROJECT - Cave Buttes Dam

Trench #:CB.C-4

Location: 33 44.439 N, 112 02.168 W. Elevation: ft | **Geologist:** AW | **Date: 5/14/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory classification	P.I.	%Clay	%Sand	%Gravel and Boulders
		ML	Fine brown silt	CB.C-4/1	SM	NP	32.9	64.1	3
		GP	Poorly graded gravel with 3-5% boulders, 50% cobbles, 45% sand. moderate carbonate.	CB.C-4/2	GP	NP	0.78	16.24	82.98
5									
				CB.C-4/3	GP	NP	0.92	21.62	77.46
10									
		GW	"Pea" gravel. Weak carbonate. Damp.	CB.C-4/4	GW	NP	2.4	38.6	59
		GP	Coarse gravel with 1-2% boulders, 50% cobbles.						
15				CB.C-4/5	GW	NP	1.07	17.85	81.08
20									

PROJECT - Cave Buttes Dam

Trench #:CB.C-5

Location: 33 44.154 N, 112 02.283 W. Elevation: ft | **Geologist:** AW | **Date: 5/14/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel and Boulders
		GP	Very coarse gravel with 10% large boulders, 40% cobbles. Weak carbonate. Damp at 2 feet.	CB.C-5/1	SP	NP	0.75	27.75	71.5
5		SW	Coarse sand with some gravel lenses (to 5% of interval). Moderate carbonate. Good material.	CB.C-5/2	SP	NP	2.2	65.8	32
				CB.C-5/3	GP	NP	2.4	47.6	50
10									
		GC	Coarse gravel with red clay. Trench stopped - caving sands.	CB.C-5/4	GP	NP	2.3	41.7	56
15									
20									

PROJECT - Cave Buttes Dam

Trench #:CB.C-6

Location: 33 44.765 N, 112 01.894 W. Elevation: ft | **Geologist:** MW | **Date: 5/15/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel and Boulders
		GP	Very coarse gravel with 50% boulders, 30% cobbles. ?Recent deposition	BC.C-6/1	GP	NP	0.28	8.32	91.4
5			Gravel and sand with 5% cobbles	BC.C-6/2	SP	NP	1.05	48.35	50.6
10			Coarse gravel with10% boulders 40% cobbles. Weak-Mod. carbonate on stone surfaces. Some very large boulders up to 2 and 3 feet diameter.	BC.C-6/3	SW	NP	0.95	25.55	73.5
			1-2% Clay starting to occur at the base of the trench = BC.C-6/4 (~1 ft)						
15				BC.C-6/4	GP	NP	2.4	39.6	58
20									

PROJECT - Cave Buttes Dam

Trench #:CB.C-7

Location: 33 44.292 N, 112 02.120 W. Elevation: ft | Geologist: MW | Date: 5/15/98

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel and Boulders
		GW	Gravel + 10% cobbles. Clean and well washed.	CB.C-7/1	SP	NP	2.25	54.45	43.3
5		GC	Very coarse gravel with up to 40% boulders, 10-20% cobbles, 5% clay	CB.C-7/2	GP	NP	2.07	15.93	82
10				CB.C-7/3	GW-GC	9	3.02	18.14	78.84
15									
20									

PROJECT - Cave Buttes Dam

Trench #:CB.C-8

Location: 33 44.076 N, 112 02.525 W. Elevation: ft | **Geologist:** AW | **Date: 5/15/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel and Boulders
		SM	Silty sand with occasional thin (~2") gravel/cobble bands.	BC.C-8/1	SP-SM	NP	11.4	65.6	23
5		GM	Coarse gravel with 5-10% boulders, 25-30% cobbles + sand and silt Moderate to strong carbonate.	BC.C-8/2	GW	NP	1.04	16.51	82.45
10			11' 6"						
		GC	Boulders with clay and cobbles. Less clay at base. Mod/Strong carbonate.	BC.C-8/3	GP	NP	3.1	42.9	54
15									
20									

PROJECT - Cave Buttes Dam

Trench #:CB.C-9

Location: 33 43.950 N, 112 02.873 W. Elevation: ft | Geologist: AW | Date: 5/15/98

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel and Boulders
		CH	Dark clay. Moist.	NONE					
				NONE					
				NONE					
				NONE					
5				NONE					
				NONE					
				NONE					
				NONE					
		GC	Boulders with clay and cobbles	NONE					
10				NONE					
15									
20									

PROJECT - Cave Buttes Dam

Trench #:CB.C-10

Location: 33 43.904 N, 112 02.450 W. Elevation: ft | Geologist: AW | Date: 5/15/98

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel and Boulders
		SM	Silty sand with thin sand horizons GROUND SURFACE	CB.C-10/1	SM	3	37.5	55.5	7
		GW	Sandy gravel						
4.5		SC	Pink sandy clay. ?Tuffaceous component						
		GW	Coarse sand grading down to gravel						
		ML	Silt						
		SM	Distinctive grey, plastic. 2% boulders/cobbles + clay.	CB.C-10/2	SM	NP	28.32	46.18	25.5
9.5		GP	Med-coarse gravel with minor clay (<1%). Moderate carbonate.	CB.C-10/3	GP	NP	4.2	45.8	50
				CB.C-10/4	GP	NP	3.1	42.9	54
14.5									
19.5									

PROJECT - Cave Buttes Dam

Trench #:CB.C-11

Location: 33 44.171 N, 112 02.398 W. Elevation: ft | **Geologist: AW** | **Date: 5/15/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel and Boulders
		SC	Pink sandy clay/silt	CB.C-11/1	SM	NP	12.3	53.7	34
		GP	Sand and cobbles	CB.C-11/2	GW-GM	NP	4.98	24.94	70.08
		GM	Dirty, coarse gravel. 1-2% clay, 2-5% boulders, 30% cobbles. Moderate to strong carbonate. No stratification						
5									
				CB.C-11/3	GP	7	2.86	27.73	69.41
10			Weak carbonate at base.						
			Large boulders at bottom - hole stopped						
15									
20									

PROJECT - Cave Buttes Dam

Trench #:CB.C-12

Location: 33 43.672 N, 112 02.727 W. **Elevation:** ft | **Geologist:** AW | **Date:** 5/18/98

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel and Boulders
		ML	Silt	CB.C-12/4	ML	7	57.4	42.6	
5									
		GP	Loose medium/coarse sand with 2% cobbles. Moderate carbonate	CB.C-12/1	SW-SM	NP	8.04	69.38	22.58
		ML	Sandy silt						
10			9' 9"						
		CH	Green/black clay. Moderate/strong carbonate.	BC.C-12/5					
		GP	Coarse gravels, 5% boulders, 20% cobbles. Moderate/strong carbonate.	BC.C-12/2	GW	NP	1.28	26.47	72.25
15				BC.C-12/3	GW-G	NP	5.85	24.9	69.25
20									

PROJECT - Cave Buttes Dam

Trench #:CB.C-13

Location: 33 43.649 N, 112 02.913 W. Elevation: ft | Geologist: AN | Date: 5/18/98

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel and Boulders
		ML	Silt and clay. More sandy streaks at base of unit. Trench dug in channel showing at least an additional 10 feet of silts above.	CB.C-13/1	CL	14	82.9	17.1	
5(15)									
10(20)									
15(25)			15'9"						
		OH	Grey/black organic clay.						
		GP	Coarse gravel with 1-2% boulders and 40-50% cobbles	CB.C-13/2	GP	NP	1.18	23.43	75.39
20(30)									

PROJECT - Cave Buttes Dam

Trench #:CB.C-14

Location: 33 43.778 N, 112 02.733 W. Elevation: ft | Geologist: AW | Date: 5/18/98

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Labatory Classification	P.I.	%Clay	%Sand	%Gravel and Boulders
		ML	Silty sand. Section contains layers of gravel up to 1ft thick (total = 20% of the interval) and sand up to 6" (total = 10% of interval)						
5									
10									
		GP	Gravel, silty/dirty. 20% cobbles.						
15		SW	Medium/fine sand.	CB.C-14/1	SM	NP	18.9	75.1	6
20									

PROJECT - Cave Buttes Dam

Trench #:CB.C-15

Location: 33 44.392 N, 112 02.821 W. Elevation: ft | Geologist: MW | Date: 5/18/98

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel and Boulders
			SOIL						
		GP	Coarse gravel, 25% cobbles Strong carbonate. From 3-4ft high clay with strong caliche cement. From 4-8.5ft strong carbonate caliche on stone surfaces.	CB.C-15/1	GW-GC	27	8.1	27.15	64.75
5				CB.C-15/2	GP	NP	2.1	30.9	67
10		GM	Clay/silt + boulders (increasing at base of interval) + cobbles. Poorly sorted zone. cemented and strong carbonate.	CB.C-15/3	SM	NP	23.2	54.8	22
			T.D. Trench abandoned (13ft) - many large boulders. Machine maxed out. 10% Boulders.	CB.C-15/4	GW-GM	NP	9.09	33.21	57.7
15									
20									

PROJECT - Cave Buttes Dam

Trench #:CB.D-1

Location: 33 43.466 N, 112 02.458 W. Elevation: ft | Geologist: AW | Date: 5/20/98

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel and Boulders
		SW	Medium/coarse felspar/quartz, granite sand. Clean,unconsolidated. Less than 1% cobbles.	CB.D-1/1	SP	NP	2.8	76.2	21
		ML	Sandy clay. Red-brown moist						
5		GC	Gravel with clay. 5-10% cobbles boulders increasing with depth (up to 2ft)						
				CB.D-1/2	SC	23	14.52	39.13	46.35
10				CB.D-1/3	GW-GC	27	6.66	19.24	74.1
			T.D. 11.5ft Problem with caving sands.						
15									
20									

PROJECT - Cave Buttes Dam

Trench #: CB.D-2

Location: 33 43.884 N, 112 01.449 W. Elevation: ft | **Geologist: AW** | **Date: 5/20/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel and Boulders
		GM	Silty gravels with rare cobbles. Dirty, brown	CB.D-2/1	GW-GC	18	8.05	26.16	65.79
		GM	Coarse gravels, 5-10% boulders, dirty with silt/sand to 5%. Weak to moderate carbonate.						
5				CB.D-2/2	GW-GC	22	8.6	28.4	62
			Very hard and cemented. Slow digging						
10									
15									
20									

DRILL HOLE LOGS

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	SAMPLES TYPE	SAMPLES Dry Density (pcf)	SAMPLES Moisture Content %
0	Dark Brown sandy silty CLAY, moist, low plasticity		1620.0				
5			1615.0	BK			5
10	Black silty CLAY with sand, wet, high plasticity		1610.0	BK			19
	Black silty GRAVEL with sand, contains 14 percent cobble, non-plastic, moist			BK			23
15			1605.0	BK			
20	Orange sandy Gravel with cobble, dry, low plasticity		1600.0				
25			1595.0				

TEST PIT CAVEBUTS.GPJ LAW_GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

HIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

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LAW
LAWGIBB Group Member

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	Dry Density (pcf)	Moisture Content %
25	Orange sandy Gravel with cobble, dry, low plasticity		1595.0	BK			3
	Orange well graded gravel with silty clay and sand, moist, low plasticity						
30			1590.0	BK			
35	Orange-brown clayey GRAVEL with sand, moist, low plasticity		1585.0	BK			
40			1580.0				
45			1575.0	BK			9
50			1570.0				

TEST PIT CAVEBUTS.(#) LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

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LAW
LAWGIBB Group Member

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	Dry Density (pcf)	Moisture Content %
50	Orange-brown clayey GRAVEL with sand, moist, low plasticity		1570.0				
55	Light brown clayey GRAVEL with sand, moist, moderate plasticity		1565.0	BK			
60			1560.0				
65			1555.0				
70	Light brown sandy GRAVEL, dry, low plasticity		1550.0	BK			
75			1545.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

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DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	SAMPLES TYPE	SAMPLES Dry Density (pcf)	SAMPLES Moisture Content %
75	Light brown sandy GRAVEL, dry, low plasticity		1545.0				
80			1540.0				
	Dark Brown clayey GRAVEL with sand, moist, moderate plasticity						
85			1535.0	BK			8
90			1530.0				
95			1525.0	BK			
100			1520.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

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DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	Dry Density (pcf)	Moisture Content %
100	FIELD ENGINEERING NOTES: Approximate ground surface elevation = 1620 feet. Soil boring terminated at approximately 1000 feet below ground surface. Groundwater not encountered. Borehole observed open to termination depth. Borehole backfilled with spoils.		1520.0				
105			1515.0				
110			1510.0				
115			1505.0				
120			1500.0				
125			1495.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 1/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

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LAW
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DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	Dry Density (pcf)	Moisture Content %
0	Dark brown clayey SAND with gravel, contains 2 percent cobbles, dry, low plasticity		1580.0				
5			1575.0	BK			
10	Purple boulders and or cobble		1570.0	BK			
	Dark brown-green sandy GRAVEL with cobble, moist, low plasticity						
15			1565.0	BK			
	Orange-brown clayey GRAVEL with sand, wet, moderate to high plasticity						
20			1560.0				
25			1555.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

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PROJECT: Cave Buttes **TEST PIT NO.:** CBDH-2
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LAW
LAWGIBB Group Member

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	Dry Density (pcf)	Moisture Content %
25			1555.0	BK			
30	Orange-brown clayey SAND with gravel, wet, moderate to high plasticity		1550.0				
35			1545.0	BK			
40			1540.0	BK			13
	Dark brown clayey SAND with gravel, moist, low plasticity						
45			1535.0				
	Gray clayey sand with gravel, moist, low plasticity						
50			1530.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

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DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	SAMPLES TYPE	SAMPLES Dry Density (pcf)	SAMPLES Moisture Content %
50	Gray clayey sand with gravel, moist, low plasticity		1530.0	BK			
	Weathered bedrock						
55			1525.0	BK			
60			1520.0				
65	BEDROCK		1515.0	BK			
70			1510.0				
75			1505.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

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DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES: IDENT	TYPE	Dry Density (pcf)	Moisture Content %
75	BEDROCK		1505.0				
80			1500.0				
85			1495.0				
90			1490.0				
95			1485.0				
100			1480.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

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LAW
LAWGIBB Group Member

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	Dry Density (pcf)	Moisture Content %
100	FIELD ENGINEERING NOTES:		1480.0				
	Approximate ground surface elevation = 1580 feet.						
	Soil boring terminated at approximately 100 feet below ground surface.						
	Groundwater not encountered.						
	Borehole observed open to termination depth.						
	Borehole backfilled with spoils.						
105			1475.0				
110			1470.0				
115			1465.0				
120			1460.0				
125			1455.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

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LAW
LAWGIBB Group Member

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	SAMPLES TYPE	SAMPLES Dry Density (pcf)	SAMPLES Moisture Content %
0	Brown silty SANDwith gravel, loose to dense, dry, non-plastic		1630.0				
5			1625.0	BK			
	Brown silty SAND, dense, dry, non-plastic						
10			1620.0				
15	Brown silty GRAVEL with sand, dry, non-plastic		1615.0	BK			
20	Brown poorly graded GRAVEL with silt and sand, contains 15 percent cobble, dry, non-plastic		1610.0				
25			1605.0				

TEST_PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

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LAW
LAWGIBB Group Member

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	Dry Density (pcf)	Moisture Content %
25	Brown poorly graded GRAVEL with silt and sand, contains 15 percent cobble, dry, non-plastic		1605.0	BK			
30	Brown silty SAND, dry, low plasticity		1600.0				
35			1595.0	BK			
40	Light brown sandy SILT with gravel, moist, low plasticity		1590.0				
45	Brown silty SAND with gravel, moist, low plasticity		1585.0	BK			
50			1580.0				

TEST PIT CAVEBUTTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

PROJECT: Cave Buttes **TEST PIT NO.:** CBDH-3
COORD N:
COORD E:
EXCAVATED: July 17, 1998
PROJ. NO.: 70241-8-0316.01 **PAGE 2 OF 5**

LAW
LAWGIBB Group Member

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	Dry Density (pcf)	Moisture Content %
50	Brown silty SAND with gravel, moist, low plasticity		1580.0				
55			1575.0	BK			
60	Brown sandy SILT with gravel, moist, moderate plasticity		1570.0				
65			1565.0	BK			17
70	Brown sandy SILT with gravel, dry, low to moderate plasticity		1560.0				
75			1555.0				

TEST PIT CAVEBUTS.GPJ LAW_GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

PROJECT: Cave Buttes TEST PIT NO.: CBDH-3
COORD N:
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LAW
LAWGIBB Group Member

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	Dry Density (pcf)	Moisture Content %
75	Brown clayey SAND with gravel, dry, moderate plasticity		1555.0	BK			
80			1550.0				
85			1545.0	BK			
90			1540.0				
95			1535.0	BK			19
100			1530.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

HIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

PROJECT: Cave Buttes **TEST PIT NO.:** CBDH-3
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LAW
LAWGIBB Group Member

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	Dry Density (pcf)	Moisture Content %
100	FIELD ENGINEERING NOTES:		1530.0				
	Approximate ground surface elevation = 1630 feet.						
	Soil boring terminated at approximately 100 feet below ground surface.						
	Groundwater not encountered.						
	Borehole observed open to termination depth.						
	Borehole backfilled with spoils.						
105			1525.0				
110			1520.0				
115			1515.0				
120			1510.0				
125			1505.0				

TEST PIT CAVEBUTS.GPJ LAW_GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

HIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

PROJECT: Cave Buttes **TEST PIT NO.:** CBDH-3
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LAW
LAWGIBB Group Member

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	Dry Density (pcf)	Moisture Content %
0	Brown well graded GRAVEL with silt and sand, dry to moist, non-plastic		1670.0				
5			1665.0	BK			
10			1660.0				
15			1655.0	BK			
	Brown sandy gravel, dry, low plasticity						
20	Brown sandy gravel, dry, low plasticity		1650.0				
25			1645.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

PROJECT: Cave Buttes **TEST PIT NO.:** CBDH-4
COORD N:
COORD E:
EXCAVATED: July 20, 1998
PROJ. NO.: 70241-8-0316.01 **PAGE 1 OF 5**

LAW
LAWGIBB Group Member

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	SAMPLES TYPE	SAMPLES Dry Density (pcf)	SAMPLES Moisture Content %
25	Brown sandy gravel, dry, low plasticity		1645.0	BK			
30			1640.0				
	Brown sandy gravel, dry, low plasticity						
35			1635.0	BK			6
40	Brown clayey GRAVEL with sand, moist, moderate plasticity		1630.0				
45			1625.0	BK			
50			1620.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

PROJECT: Cave Buttes **TEST PIT NO.:** CBDH-4
COORD N:
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LAW
LAWGIBB Group Member

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	SAMPLES TYPE	SAMPLES Dry Density (pcf)	SAMPLES Moisture Content %
50	Brown clayey GRAVEL with sand, moist, moderate plasticity		1620.0				
	Brown silty SAND with gravel, moist, moderate to high plasticity						
55			1615.0	BK			
60			1610.0				
	Brown poorly graded gravel with silt and sand, dense to hard, dry, non-plastic, contains 7 percent cobble						
65			1605.0	BK			
	Brown silty SAND with gravel, moist, low plasticity						
70			1600.0				
75			1595.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BETWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

PROJECT: Cave Buttes **TEST PIT NO.:** CBDH-4
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LAW
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DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	Dry Density (pcf)	Moisture Content %
75	Brown silty SAND with gravel, moist, low plasticity		1595.0	BK			7
80			1590.0				
85			1585.0	BK			7
90	Brown silty SAND with gravel, moist, low plasticity		1580.0				
95			1575.0	BK			19
100			1570.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

PROJECT: Cave Buttes TEST PIT NO.: CBDH-4
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LAW
LAWGIBB Group Member

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	Dry Density (pcf)	Moisture Content %
100	FIELD ENGINEERING NOTES: Approximate ground surface elevation = 1670 feet. Soil boring terminated at approximately 100 feet below ground surface. Groundwater not encountered. Borehole observed open to termination depth. Borehole backfilled with spoils.		1570.0				
105			1565.0				
110			1560.0				
115			1555.0				
120			1550.0				
125			1545.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

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LAW
LAWGIBB Group Member

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	SAMPLES TYPE	SAMPLES Dry Density (pcf)	SAMPLES Moisture Content %
0	Brown clayey SAND with gravel, dry, moderate plasticity, weak to moderate cementation		1630.0				
5	Brown sandy silt with gravel, dry, low plasticity		1625.0	BK			
10			1620.0				
15			1615.0				
	Brown silty GRAVEL with sand, dry, low to moderate plasticity						
20			1610.0				
25			1605.0				

TEST PIT CAVEBUTS.GPJ LAW_GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

PROJECT: Cave Buttes **TEST PIT NO.:** CBDH-5
COORD N:
COORD E:
EXCAVATED: July 20, 1998
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LAW
LAWGIBB Group Member

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	SAMPLES TYPE	SAMPLES Dry Density (pcf)	SAMPLES Moisture Content %
25	Brown silty GRAVEL with sand, dense to hard, dry, low to moderate plasticity		1605.0				
30	Brown-gray poorly graded GRAVEL with silt and sand, contains 17 percent cobble, dense to hard, dry, non-plastic		1600.0				
	Brown-gray poorly graded GRAVEL with silt and sand, contains 17 percent cobble, dense to hard, dry, non-plastic						
35			1595.0	BK			
40	Brown sandy lean CLAY, sample contains 26 percent cobble, moist, moderate plasticity		1590.0				
45			1585.0	BK			
50			1580.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BETWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

[redacted]

PROJECT: Cave Buttes **TEST PIT NO.:** CBDH-5
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LAW
LAWGIBB Group Member

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	SAMPLES TYPE	SAMPLES Dry Density (pcf)	SAMPLES Moisture Content %
50	Brown clayey SAND, dry to moist, low plasticity		1580.0				
55			1575.0	BK			26
60			1570.0				
	Brown silty SAND, dense, dry, low plasticity						
65			1565.0				
70			1560.0				
75			1555.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

PROJECT: Cave Buttes **TEST PIT NO.:** CBDH-5
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LAW
LAWGIBB Group Member

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	SAMPLES TYPE	SAMPLES Dry Density (pcf)	SAMPLES Moisture Content %
75	Brown silty SAND, dense, dry, low plasticity		1555.0	BK			13
	Brown sandy SILT, dry, low to moderate plasticity						
80	Brown sandy SILT, dense to hard, dry, low to moderate plasticity		1550.0				
85			1545.0	BK			18
90	Brown sandy SILT with trace gravel, dense, dry, low to moderate plasticity		1540.0				
95			1535.0	BK			4
100			1530.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/19/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

HIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

PROJECT: Cave Buttes **TEST PIT NO.:** CBDH-5
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LAW
LAWGIBB Group Member

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	Dry Density (pcf)	Moisture Content %
100	FIELD ENGINEERING NOTES:		1530.0				
	Approximate ground surface elevation = 1630 feet.						
	Soil boring terminated at approximately 100 feet below ground surface.						
	Groundwater not encountered.						
	Borehole observed open to termination depth.						
	Borehole backfilled with spoils.						
105			1525.0				
110			1520.0				
115			1515.0				
120			1510.0				
125			1505.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

PROJECT: Cave Buttes **TEST PIT NO.:** CBDH-5
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DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	SAMPLES TYPE	SAMPLES Dry Density (pcf)	SAMPLES Moisture Content %
0	Brown sandy clay, weak to moderate cementation, dry, low plasticity		1620.0				
5			1615.0	BK			4
	Brown poorly graded SAND with silt and gravel, dry, non-plastic						
10			1610.0				
15			1605.0	BK			
	Brown poorly graded SAND with silt and gravel, moist, non-plastic						
20	Brown well graded GRAVEL with clay and sand, moist, low to moderate plasticity		1600.0				
25			1595.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

PROJECT: Cave Buttes TEST PIT NO.: CBDH-6
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COORD E:
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LAW
LAWGIBB Group Member

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	SAMPLES TYPE	SAMPLES Dry Density (pcf)	SAMPLES Moisture Content %
25	Brown well graded GRAVEL with clay and sand, moist, low to moderate plasticity		1595.0	BK			
30			1590.0				
	Orange-Brown clayey SAND with gravel, moist, moderate plasticity						
35			1585.0	BK			
40			1580.0				
	Orange-Brown clayey SAND with gravel, moist, moderate plasticity						
45			1575.0	BK			
50			1570.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

PROJECT: Cave Buttes **TEST PIT NO.:** CBDH-6
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LAW
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DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	Dry Density (pcf)	Moisture Content %
50	Orange-Brown clayey SAND with gravel, moist, moderate plasticity		1570.0				
55			1565.0	BK			
60	Light brown clayey SAND with gravel, moist, moderate plasticity		1560.0				
65			1555.0	BK			
70			1550.0				
75			1545.0				

TEST PIT CAVEBUTS.GPJ LAW_GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

PROJECT: Cave Buttes **TEST PIT NO.:** CBDH-6
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LAW
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DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	SAMPLES TYPE	SAMPLES Dry Density (pcf)	SAMPLES Moisture Content %
75	Light brown clayey SAND with gravel, moist, moderate plasticity		1545.0	BK			
80			1540.0				
	Tan-Brown clayey SAND with gravel, dry, moderate plasticity						
85			1535.0	BK			
90			1530.0				
95	Tan-broen clayey SAND with gravel and cobble, dry, low plasticity		1525.0	BK			
100			1520.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

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DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES: IDENT	TYPE	Dry Density (pcf)	Moisture Content %
100	FIELD ENGINEERING NOTES:		1520.0				
	Approximate ground surface elevation = 1620 feet.						
	Soil boring terminated at approximately 100 feet below ground surface.						
	Groundwater not encountered.						
	Borehole observed open to termination depth.						
	Borehole backfilled with spoils.						
105			1515.0				
110			1510.0				
115			1505.0				
120			1500.0				
125			1495.0				

TEST PIT CAVEBUTS.GPJ LAW GIBB.GDT 8/18/98

DRILLER: Layne Environmental Services
EQUIPMENT: AP-1000/Becker
HOLE DIM.: 9
REMARKS: Dual Wall Down-Hole Percussion Hammer with Tubex Attachment

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PROJECT: Cave Buttes **TEST PIT NO.:** CBDH-6
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LAW
LAWGIBB Group Member

RESUME

DONALD E. ROSS

Registered Professional Geologist
Certified Senior Property Appraiser

2226 E. Sunnyside Drive
Phoenix, AZ 85028

Telephone (602) 992-0758
Fax (602) 482-3220

GENERAL EXPERIENCE: Consultant and owner of Ross Consulting - specializing in: mine valuation, expert testimony, property tax consultation and sand and gravel appraisal. (Since 1973)

Natural Resource Appraisal Supervisor for the State of Arizona - appraisal and cash flow analysis of mining and petroleum properties. (1974-88)

Senior Geologist for Inspiration Consolidated Copper Co. - mineral exploration/development and hydrologic studies. (1967-1973)

PROFESSIONAL GEOLOGIST REGISTRATION: American Institute of Professional Geologists, Number 3223
Arizona State Board of Technical Registration, Geologist, Reg .13519
Idaho State Board of Registration of Professional Geologists, Reg. 279
California State Board of Registration for Geologists, Reg. 4513

APPRAISER CERTIFICATION: Certified Appraiser, State of Arizona, Number 30142
Certified Appraiser, State of Utah, Number CG00047299
Accredited Senior Appraiser, American Society of Appraisers, Number 003142

MEMBERSHIP: American Institute of Mining Engineering (AIME), member since 1967

EDUCATION: B. S. Degree - Arizona State University, Major: Geology
Colorado School of Mines, Short Courses
The Lincoln Institute of Land Policy, "Appraisal of Mining Property"
Society of Mining, Metallurgy and Exploration, Short Course
State of Arizona and International Association of Assessing Officers, 9 appraisal courses

EXPERIENCE: **Consultant/Appraiser, Ross Consulting, 1973 to present**

Mine valuation, expert testimony, property tax consultation, ore body appraisal, geologic evaluation, ore reserve determination, sand and gravel appraisal, implementation of mine appraisal systems, environmental studies and royalty rate determination.

Natural Resource Unit Supervisor, State of Arizona, 1974 to 1988

Expert witness testimony to defend mine appraisals; economic evaluation and appraisal of each producing mine in Arizona including analysis of costs, revenues and production data; development of capitalization rates and discounted cash flow analysis; investigation of hydrologic and environmental factors, analysis of successful and unsuccessful mining investment; evaluation of metal price trends and technological advances.

DONALD E. ROSS

EXPERIENCE: **Inspiration Consolidated Copper Co., Inspiration, AZ, 1967 to 1973**

Chief Geologist, Sanchez Project, AZ - Supervise geology division; prepare hydrology and environmental reports; prepare geological interpretation for the district; estimate ore reserves; coordinate property acquisition; conduct pit planning and feasibility studies.

Project Geologist, Leslie Denn Project, Winthrop, WA - Supervise exploration program, drilling and geological mapping; correlate geochemical and geophysical results; study hydrology; study environmental impact; estimate ore reserves; prepare final geological report.

Resident Mine Geologist, Inspiration, AZ - Estimate ore reserves; log drill core; stake mining claims; develop water supply; study environmental impact; prepare geological and property maps.

COURT EXPERIENCE: Expert witness in court cases regarding appraisal and mine valuation:
American Smelting and Refining Co. v. Pima County, AZ, 1974.
Ranchers Exploration and Development v. Gila County, AZ, 1975.
Cyprus-Pima Mining Co. v. Pima County, AZ, 1976.
Duval Corporation/Mineral Park Mine v. Mohave County, AZ, 1976.
Cyprus-Bagdad Mining Co. v. Yavapai County, AZ, 1977.
Inspiration Consolidated Copper Co. v. Gila County, AZ, 1980.
Inspiration Consolidated Copper Co. v. Gila County, AZ, 1981.
Maricopa County Flood Control District v. R. C. Jones, AZ, 1993.
Wharf Resources v. Lead-Deadwood School District, SD, 1993.
ASARCO - Ray Mine v. Gila County, AZ, 1996.
City of Phoenix v. R. Peters, 1997.

EXPERT WITNESS EXPERIENCE: Arizona Board of Tax Appeals, AZ, expert witness in ninety-three mine valuation cases.
Homestake - McLaughlin Mine v. Lake County, CA.
Sonora Mining Co. - Jamestown Mine v. Toulumne County, CA.
Cyprus-Bagdad Mining Co. v. Yavapai Co., AZ.

PUBLICATIONS: Assessment of Sand and Gravel Resources and Economic Mining Potential:
Fort McDowell Mohave - Apache Indian Community, AZ;
NADSAT project #19; U. S. Department of Commerce

Appraisal Manual for Mines and Natural Resources:
Arizona Department of Revenue, published from 1979 to 1988.

Appraisal Manual for Mines and Quarries:
South Dakota, Lawrence County, published 1989 & 1990.

INSTRUCTOR: Mines and Quarry Valuation, International Association of Assessing Officers Workshop, 1993-1997.

CONSULTING PROJECTS

Project: Carlin Trend, NV
Objective: Appraisal and Property Tax Analysis
Client: Newmont Gold Company

Project: Mission and Ray Mines, AZ
Objective: Appraisal and Property Tax Analysis
Client: ASARCO

Project: Bagdad and Miami Mines, AZ
Objective: Appraisal and Expert Witness
Client: Cyprus Minerals Company

Project: Valley gravel quarry, CA
Objective: Appraisal
Client: Tokai Bank

Project: Jamestown Mine, CA
Objective: Appraisal and Expert Witness
Client: Sonora Mining Corporation

Project: Alaska Mines
Objective: Appraisal
Client: City/Borough Juneau, AK

Project: San Manuel Mine, AZ
Objective: Appraisal of gold and copper mines
Client: Magma Copper Company

Project: Sanchez Mine, AZ
Objective: Geologic and ore reserve analysis
Client: AZCO Mining

Project: South Dakota Gold Mines
Objective: Appraise gold mines/write appraisal manual
Client: Lawrence County, SD

Project: Rocky Canyon BLM, CA
Objective: Appraise granite quarry
Client: Union Asphalt, Inc., CA

Project: Appraisal Manual, AZ
Objective: Write appraisal manual
Client: Arizona Department of Revenue

Project: Russian gold mines
Objective: Evaluate potential

Project: Poulsbo Clay Mine, WA
Objective: Appraisal
Client: Pope Res. & Ash Grove Cement

Project: Morenci Mine, AZ
Objective: Appraisal and Expert Witness
Client: Phelps Dodge Corporation

Project: McLaughlin Mine, CA
Objective: Economic Evaluation and Expert Witness
Client: Homestake Mining Company

Project: Tuscon Houghton and Marana Quarries, AZ
Objective: Appraisal sand/gravel
Client: The CalMat Companies

Project: Utah Gypsum Mine
Objective: Appraisal
Client: Key Bank, UT

Project: Sand/gravel deposits, AZ
Objective: Appraisal
Client: Flood Control District - Maricopa Co. ,AZ

Project: Coal Mines, AZ & NM
Objective: Appraisal
Client: Navajo Nation

Project: La Posta & Pala Indian Reservations, CA
Objective: Appraisal & royalty rate - gravel quarry
Client: Bureau of Indian Affairs

Project: Fort McDowell Indian Reservation, AZ
Objective: Financial analysis for sand/gravel
Client: Fort McDowell Indian Tribe

Project: McDowell Mountains, AZ
Objective: Prepare geological map and analysis report
Client: Andover Corporation Markland Properties, Inc.

Project: Mississippi River Limestone Quarry, MO
Objective: Discounted cash flow
Client: Mercantile Bank, St. Louis, MO

Project: Gila River Waterfowl Preserve, AZ
Objective: Appraisal sand and gravel deposit
Client: Sam Kelsall

Project: Wellington, UT
Objective: Appraisal coal mine
Client: Coastal Corp.

Project: Henderson Moly Mine, CO
Objective: Appraisal
Client: Grand County, CO