ASA AIPG AIME AZ CA ID

DONALD E. ROSS

MINERAL EVALUATION REPORT
NEW RIVER DAM
Evaluation Date: February 1, 1999
Location: Maricopa County, Arizona
By: DONALD E. ROSS
For: FLOOD CONTROL DISTRICT
of MARICOPA COUNTY

Registered Professional Geologist
Certified Senior Professional Appraiser

ROSS CONSULTING
2226 E. Sunnyside Dr.
Phoenix, Arizona 85028
(602) 992-0758
Fax (602) 482-3220

A370.907

ASA AIPG AIME AZ CA ID

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

February 1, 1999

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

Re: Evaluation Report - New River Dam

Dear Mr. Johnson:

This report or investigation of the potential of the area upstream or north of New River Dam 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 alternate activities which are compatible with primary use and multi-land use scenarios. Seven areas on the property were identified in the field and on topographic maps as having potential for sand and gravel resources (Figures 1, 2 and 3); these areas are as follows:

AREA

A The area lying north of the New River Dam and along the New River Channel, located in the southern portion of the subject property. This area contains high quality material but it would rank on the lower end for development of sand and gravel mining relative to other areas on the subject because it is a small narrow area located near the dam.

B The area encompassing the New River drainage north of area A, located in the central or north central part of the subject. This is the best area for sand and gravel mining on the subject because it contains good quality wash and valley fill gravels over 100 feet thick and it is a large geographic area not readily visible from the Lake Pleasant Road.

C The area adjacent to the northern boundary of the property, located in the north central part of the subject. This is a relatively average area for mining. It contains good quality gravels but it is a bench gravel environment versus the higher quality wash gravel environments. It is a relatively small area.

D The area adjacent to the northern boundary and located in the central to east central portion of the subject. This is the second best area for mining because it is a large area that contains over 100 feet of sand and gravel of high quality; however, this is not in the mainstream wash area.

E The area north of the New River Dam, located in the south and southeast central portion of the subject. This is the third best area for mining because it is a large area that contains over 100 feet of sand and gravel of good quality but not as good in quality as areas B and D.

F The area located in the eastern part of the subject. This area contains bench gravels that are probably of good quality but variable in thickness. This is relatively less attractive than areas B, D, and E for mining sand and gravel.

G The area located in the western part of the subject. These are caliche cemented bench gravels. The area probably contains no commercial grade aggregate deposits.

The results of this investigation indicate that significant resources of sand and gravel of commercial quality are located north of the New River Dam.

Six 100 foot deep percussion drill holes have recently been completed using a Becker drill with an approximate 9 inch O.D. bit. Sand and gravel depths of over 100 feet were intersected. Trench sampling was naturally limited to investigation of the near surface environment. A total of 20 back hoe pits or trenches were dug in the seven areas up to a maximum depth of about 15 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 B contains the best quality of sand and gravel material. If an average thickness of commercial material of 100 feet is assumed with a density of 110 lbs/cu. ft. or 18 cu. ft./ton, about 66.5 million tons of sand and gravel could be present. Area D contains approximately 94.6 million tons using a thickness of 100 feet. A total of about 161.1 million tons is estimated for areas B and D. Assuming an average thickness of 100 feet and a similar density, area E contains approximately 88.2 million tons of sand and gravel. Area E includes the borrow pit area used for building the dam. Area C contains about 15.5 million tons assuming a 100 foot thickness. This is a relatively small area that could be mined and blended with area B material. Area A contains an estimated 8.5 million tons using an average thickness of 100 feet. Area F contains about 24.6 million tons using an average thickness of 50 feet. These are probably pediment bench gravels. Area G probably contains no saleable material; this area contains abundant caliche.

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 70 years of $1,600,000 per year based on a $0.80/ton royalty rate and an annual production rate of 2,000,000 tons. The Del Webb Anthem project of nearly 10,000 homes is slated to open in March, 1999. Three other future developments in the area are projected for 4000 acres. (The Arizona Republic, January 9, 1999)

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 and 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 a 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. 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.

TABLE OF CONTENTS

		PAGE
LETTER OF TRANSMITTAL		
TABLE OF CONTENTS		
I.	INTRODUCTION	1
II.	PROPERTY LOCATION AND DESCRIPTION	2
A.	General	
	Figure 1 - New River Dam Area - Property Boundaries Scale 1:24000	3
	Figure 2 - New River Dam Area - Location of Trenches and Drill Holes - Scale 1:24000	4
B.	Archeological and Historical	5
III.	PROPERTY GEOLOGY	7
A.	General	7
B.	Gravels	8
	Figure 3 - New River Dam Area - Resource Areas - Scale 1:24000	12
	Table 1 - Unified Soil Classification System	13
C.	Tertiary Rocks	14
D.	Precambrian Rocks	14
E.	Mineral Resources	15
IV.	WATER	16
V.	BORROW, SAND AND GRAVEL	17
A.	Current Operations and Historic Production	17
B.	Trench Sampling Program	18
	Table 2 - New River Dam - Trench Depths & Sampling Data	22
	Plate 1 - New River Dam, New River Wash & Trench # NR19	23
	Plate 2 - New River Dam Trenches NR5 & NR18	24
C.	Drilling	25
	Figure 4 - Drill Hole Summaries	26
D.	Resources Estimation	27
	1. Area A	27
	2. Area B	27
	3. Area C	27
	4. Area D	27
	5. Area E	27
	6. Area F	27
	7. Area G	27

TABLE OF CONTENTS

	PAGE
E. Production	27
1. Supply and Demand	27
2. Product Prices	31
3. Permitting	32
4. Economic Evaluation	32
VI. HIGHEST AND BEST USE	33
VII. CONCLUSIONS	35
VIII. ADDENDA	36
References	37
Trench Cut Logs	
Anthem Development - Arizona Republic, 1/9/99	
U. S. Corps of Engineers, May, 1982, Design Memorandum # 3	
U. S. Corps of Engineers, Design Memorandum #3, March, 1976, Main Report	
U. S. Corps of Engineers, March, 1976, Final EIS	
Resume	

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 New River Dam property located approximately 24 miles northwest 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.

For the purpose of the study all the available engineering and geologic data were assembled and studied and a program of trenching and drilling was conducted. The data provided information on the real extent and subsurface quality and thickness of the aggregate. The trenching program was supervised by Ross Consulting and was carried out between October 20, 1998 and January 11, 1999. The drilling program was designed by Ross Consulting and carried out by Layne Western Environmental Drilling supervised in the field by Law Engineering and Environmental Services Inc.

Additional work would be necessary before a quarrying operation could be undertaken but deposits of excellent grade aggregate material are present.

PROPERTY LOCATION AND DESCRIPTION

A. General

The subject property is located in Maricopa County, Arizona (Figure 1) and is on the northwest periphery of the Phoenix metropolitan area within the city limits of Peoria, Arizona. Peoria city center lies 14 miles south of the subject. The Central Arizona Project Canal (CAP) lies immediately north of the property line. The West Wing Mountain traverses the southwest part of the New River area with elevations of up to 1930 feet and the East Wing Mountain traverses the southeast part of the area with elevations of up to 1934 feet. The valley floor at the New River Dam is at approximately 1400 feet above sea level.

The New River Dam is located on the property and can be accessed principally by turning east on the Lake Pleasant Road south of the CAP canal. The dam has been constructed across New River wash which is a zone of flooding during periods of heavy rain (Figure 1).

The property is located more specifically in the south half of T5N, R1E comprising all of section 26 and parts of sections 22, 23, 24, 25, 27, 34 and 35 and in the north half of T4N, R1E consisting of part of section 2 (an easement) of the Gila and Salt River Base and Meridian. Except for small extensions, the area is generally encompassed within the square formed by Lake Pleasant Road and the CAP canal, the West Wing Mountain, the East Wing Mountain and Keefer Hill. The subject covers an area of approximately 2800 acres including easements. It is generally located in the floodplain of the New River wash. The location of the trenches and drill holes is shown in Figure 2. The location of the resource areas is shown in Figure 3.

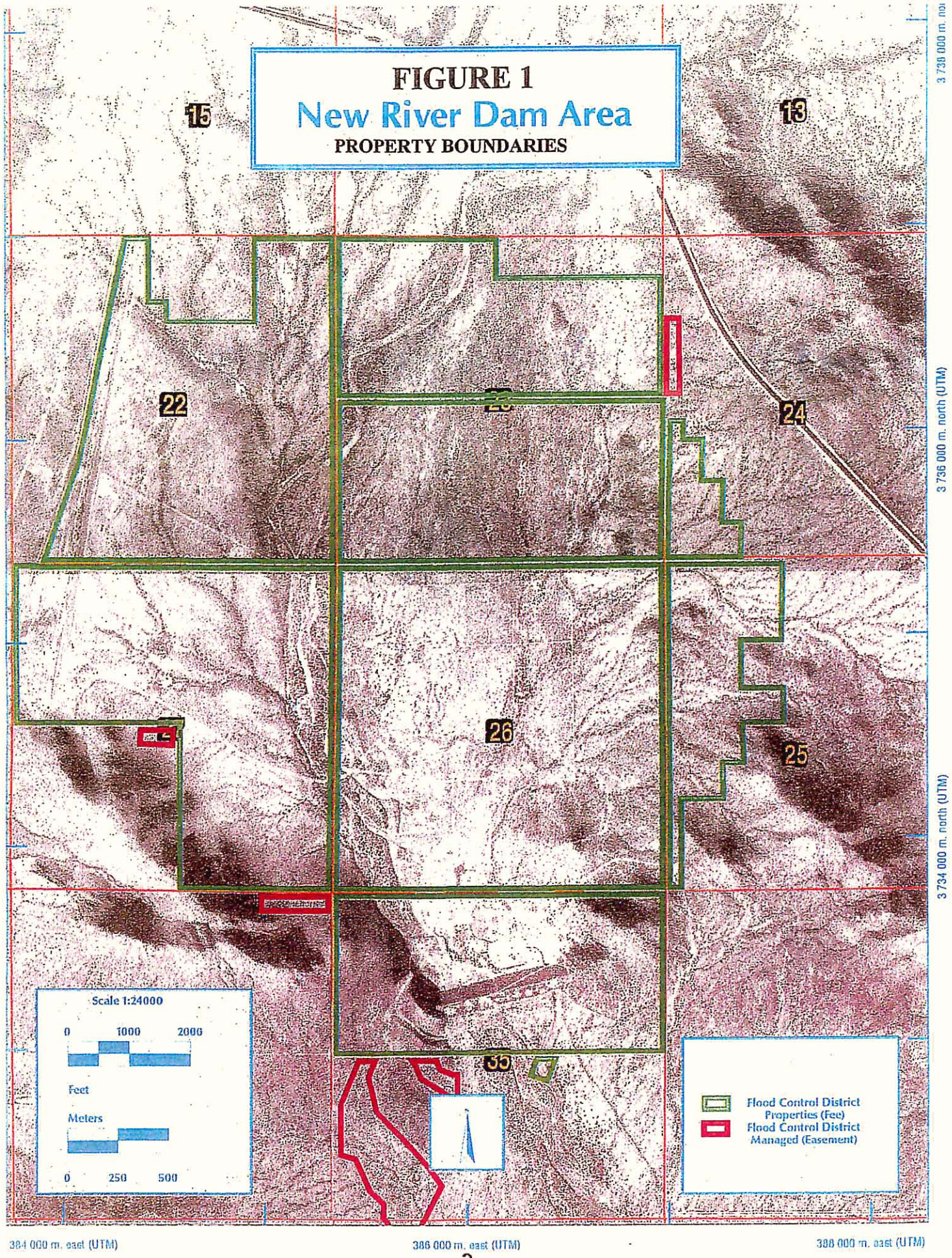


FIGURE 1
New River Dam Area
PROPERTY BOUNDARIES
15
13
22
24
26
25
35
Scale 1:24000
0
1000
2000
Feet
Meters
0
250
500
Flood Control District Properties (Fee)
Flood Control District Managed (Easement)
3 736 000 m. north (UTM)
3 734 000 m. north (UTM)
384 000 m. east (UTM)
386 000 m. east (UTM)
388 000 m. east (UTM)

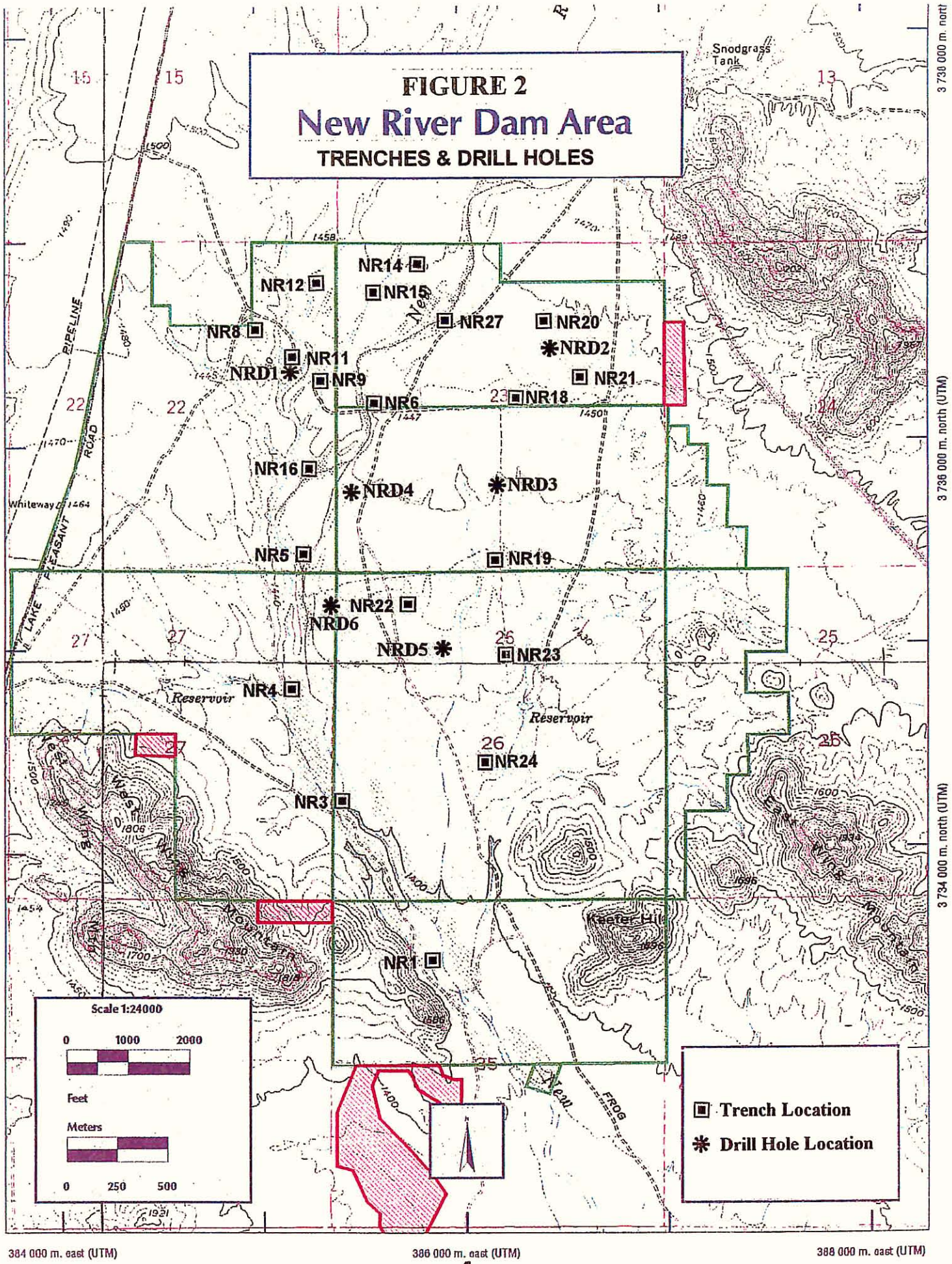


FIGURE 2
New River Dam Area
TRENCHES & DRILL HOLES
Snodgrass Tank
NR14
NR12
NR15
NR27
NR20
NR8
NRD2
NR11
NRD1
NR9
NR21
NR6
NR18
NR16
NRD4
NRD3
NR5
NR19
NR22
NRD6
NRD5
NR23
NR4
Reservoir
Reservoir
NR24
NR3
NR1
Keeler Hill
Scale 1:24000
0 1000 2000
Feet
Meters
0 250 500
Trench Location
Drill Hole Location
3 738 000 m. north
3 736 000 m. north (UTM)
3 734 000 m. north (UTM)
384 000 m. east (UTM)
386 000 m. east (UTM)
388 000 m. east (UTM)

B. Archeological and Historical

Arizona State University (ASU) investigated 43 archival sites and the Museum of Northern Arizona tested 22 archival sites which date from 300 A. D. to 1100 A. D. Many of the sites were found to be disturbed by animals, erosion and pot hunters. All of these sites were mitigated before the dam was built here. The Corps of Engineers Design Memorandum No. 3 of May, 1982, states that construction of New River Dam will destroy many of the archaeological sites and that only 2 out of the 43 ASU sites will survive. [1] [2]

Some of the archeological sites on the subject were nominated for the National Register of Historical Places. The construction of the New River Dam was considered to effectively destroy the archeological resources in the New River Archaeological District. Mitigation measures for archeological sites were therefore recommended by the U. S. Army Corps of Engineers that included mapping, excavation, pollen analysis, carbon 14 dating, archeomagnatism dating, flora/fauna identification, petrographic analysis, research, design and testing programs. The recovery of artifacts from the borrow site in section 26 was 75-100%. In the minimally or moderately affected sites recovery of artifacts was 1-4%. [3]

The archeological mitigation was sponsored entirely by the Los Angeles office of the U. S. Army Corps of Engineers. The final mitigation report of the project was officially reviewed and

---

[1] *U. S. Army Corps of Engineers, March, 1976, Final Environmental Impact Statement, New River and Phoenix Streams, Maricopa County, Arizona*

[2] *U.S. Army Corps of Engineers, May, 1982, New River Dam, Design Memorandum No. 3*

[3] *U. S. Army Corps of Engineers, March, 1976, Final Environmental Impact Statement, New River and Phoenix Streams, Maricopa County, Arizona*

accepted by the Corps, the BLM, Arizona State Land Department, SHPO and the Flood Control District. [4] [5]

---

[4] *Rodgers, James, B. October 27, 1998, An Archeological Assessment of a Proposed Sand and Gravel Testing Operation in the New River Reservoir of Northern Peoria, Arizona*

[5] *Rodger, James, B, December 11, 1998, The New River Reservoir Sand and Gravel Testing Operation of Northern Peoria, Arizona: An Adjunct Archeological Assessment*

PROPERTY GEOLOGY

A. General

Approximately 93% 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 West Wing and East Wing Mountains. The exposed bedrock consists of Precambrian granite with minor amounts of schist and gneiss capped and intruded by Tertiary felsite and andesite which is overlain by lava flows and tuffaceous agglomerates. [6]

The property is located in the Sonoran Desert section of the Basin and Range physiographic province. The province is characterized by steep mountains and broad alluvial valleys. The mountain ranges trend northwest-southeast and are composed of metamorphic and volcanic rocks. The basins are filled with alluvium and colluvium consisting of gravel, sands and clays in places over 1000 feet thick. The alluvium consists of coarse, unconsolidated, unsorted sands, gravels and cobbles. There has been a long history of erosion and deposition as evidenced by the deep weathering and dissection of the mountain ranges generating extensive alluvial fans. The soil types of the area are a reflection of the parent rocks and alluvium of the area. General soil types in this province are sandy loams, limey clay loams and limey loamy soils. Stony and rocky soils are locally present on slopes greater than 30 percent. The soils in the New River Dam area are affected by salt precipitation because rainfall is not sufficient to carry salts down to the

---

[6] *U. S. Army Corps of Engineers, May, 1982, New River Dam, p. A1-4 and Pl.15, Appendix 1*

water table. The effects are most noticeable near mountains formed of carbonate-bearing rocks where alluvial deposits are cemented by calcium carbonate forming caliche. Area G was especially strongly affected by caliche deposition using visual inspection and nearby trench samples. The rate of surface erosion from the drainage basin above the New River Dam was calculated by the Corps of Engineers. A sediment yield of 0.3 acre-foot of sediment from each square mile was estimated for the drainage area upstream for the Cave Buttes Dam, Adobe Dam and New River Dam areas. [7]

B. Gravels

USGS geologic maps and the Army Corps of Engineers generally show two unconsolidated to semi-consolidated overburden units which are Quaternary in age:

a) Recent Alluvium (Qal) - unconsolidated stream channel and tributary wash sands, gravels, silts and clays referred to as "wash" gravels. These deposits are generally relatively shallow and confined to linear and/or anastomosing channels cut into the older alluvial surface. The coarser units are often clean, well washed and ideal for construction purposes. The deposits are often stratified and individual horizons frequently pinch and swell. Area A and area B contain recent alluvium deposits.

b) Older Alluvium (Qoal) - consists of poorly- to well consolidated alluvial fan, valley fill and flood plain deposits. These deposits occur in areas C, D, E and G. Qoal also includes colluvial material mantling the lower slopes of the mountains and generally monolithic reflecting

---

[7] *U.S. Army Corps of Engineers, March, 1976, Final Environmental Impact Statement, p. I-8*

its local provenance. The colluvium of the right abutment consists principally of andesitic blocks and of the left abutment either granitic or rhyolitic material. Area F is mostly colluvial material, highly variable in width and thickness. In this area potential exists to develop a resource of granitic sand and gravel.

The older alluvium in areas C, D and E has commercial value as extensive thick deposits of good quality sand and gravel. A variable thickness of floodplain, or overbank, silts (from 0 to 9 feet) may have to be initially stripped and stockpiled or used for other purposes. The limited amount of drilling conducted in the past and the current program show sands, gravels and clayey gravels in these three areas to over 100 feet in depth. Under the floodplain silts and silty sands there are layers and lenses of older stream channel cobbles and boulders to a depth of approximately 25 feet. Underlying these are silty and clayey sands and silty and clayey gravels.

Area G has apparently had a slightly different history and is characterized by extensive surface development of caliche. The caliche can extend to more than 8 feet (Trench NR11) and is very hard digging. An examination of the contours in sections 22 and 27, T4N R1E suggests that faulting may have occurred after deposition of the older valley fill or alluvial fan material which left area G elevated in relation to areas A through E. It is unlikely that commercially acceptable gravel can be won from this area. The areas of older alluvium normally also contain patches of rudimentary soil and slope wash.

The sands and gravels intersected in the recent drilling program are illustrated in Figure 4. This data was taken from the preliminary field logs of Law Engineering and Environmental Services, Inc.

Diamond drill hole #17 (U. S. Corps of Engineers) penetrated 136 feet of alluvium in the

center of the dam site consisting of 25 feet silty sand and sandy gravel with cobbles and boulders and 111 feet of clayey sandy gravel to gravelly sandy clay (Table 1). Water was encountered at 70 feet in DDH-17. Three distinct layers of alluvium were found above the bedrock at the dam. The upper layer is 2-9 feet thick consisting of non plastic silty sand with 25-51% passing No. 200 sieve. The middle layer is 6-10 feet thick and is mainly sandy gravel non-plastic with 48-80% plus No. 4 material and 1-9% fines. The lower layer extends from 15 to 25 feet to 136 feet; it is a cemented sandy gravel with 46-83% plus No. 4 and 3-9% fines. It has a permeability of 2-8.5 fpd, a high shear strength and a PI of 10 on the coarse limit.[8]

Area B or drill hole 1 (1/18/99 - Ross Consulting) contained one foot of silty sand capping 60 feet of sandy gravel on top of 10 feet of clayey sand with gravel on top of 29 feet of sandy gravel (Figure 4). In general, drill hole No. 1 contained sandy gravel to plus 100 feet with no water. Area D or drill hole No. 2 (1/15/99 - Ross Consulting) contained 3 feet of sandy silt on top of 27 feet of cobbles on top of 39 feet of sandy gravel on top of 31 feet of silty sand with gravel. In general, drill hole 2 contained gravels and cobbles with no water encountered. Drill hole 3 (1/18/99 - Ross Consulting) was drilled in area D; it encountered 2 feet of silty sand over 8 feet of silty sand with gravel and cobbles atop 30 feet of sandy gravel atop 10 feet of gravelly sand atop 15 feet of sandy gravel atop 5 feet of gravel with clay and sand atop 10 feet of sand with clay atop 20 feet of clayey sand with gravel. In general, drill hole 3 contained gravels and sands in excess of 100 feet with no water encountered. Drill hole 4 (1/14/99 - Ross Consulting) was drilled on the west side of area D and the east side of area B; it penetrated 3 feet of silty sand atop 5 feet of sandy gravel with cobbles atop a thin layer of caliche atop 52 feet of sandy gravel with

---

[8] *U. S. Army Corps of Engineers, May, 1982, New River Dam, p. A1-36*

cobbles atop 40 feet of clayey sand with gravel. No water was encountered in drill hole No. 4. Drill hole 5 (1/14/99 - Ross Consulting) in area E penetrated 2 feet of silty sand with gravel atop 25 feet of sandy gravel with cobbles atop 3 feet of sandy clay with gravel atop 48 feet of sandy gravel with clay atop 22 feet of clayey sand with gravel. No water was encountered in drill hole 5. Drill hole 6 (1/13/99 - Ross Consulting) was drilled between area B and area E. It penetrated 2 feet of silty sand atop 38 feet of sandy gravel with boulders atop 20 feet of sand with clay and gravel atop 20 feet of sand with clay atop 20 feet of sand with cobbles and clay. Drill hole 6 did not encounter water. [9]

[9] *Law Engineering and Environmental Services Inc., January, 1999, geologic drill logs of Patrick Cook*

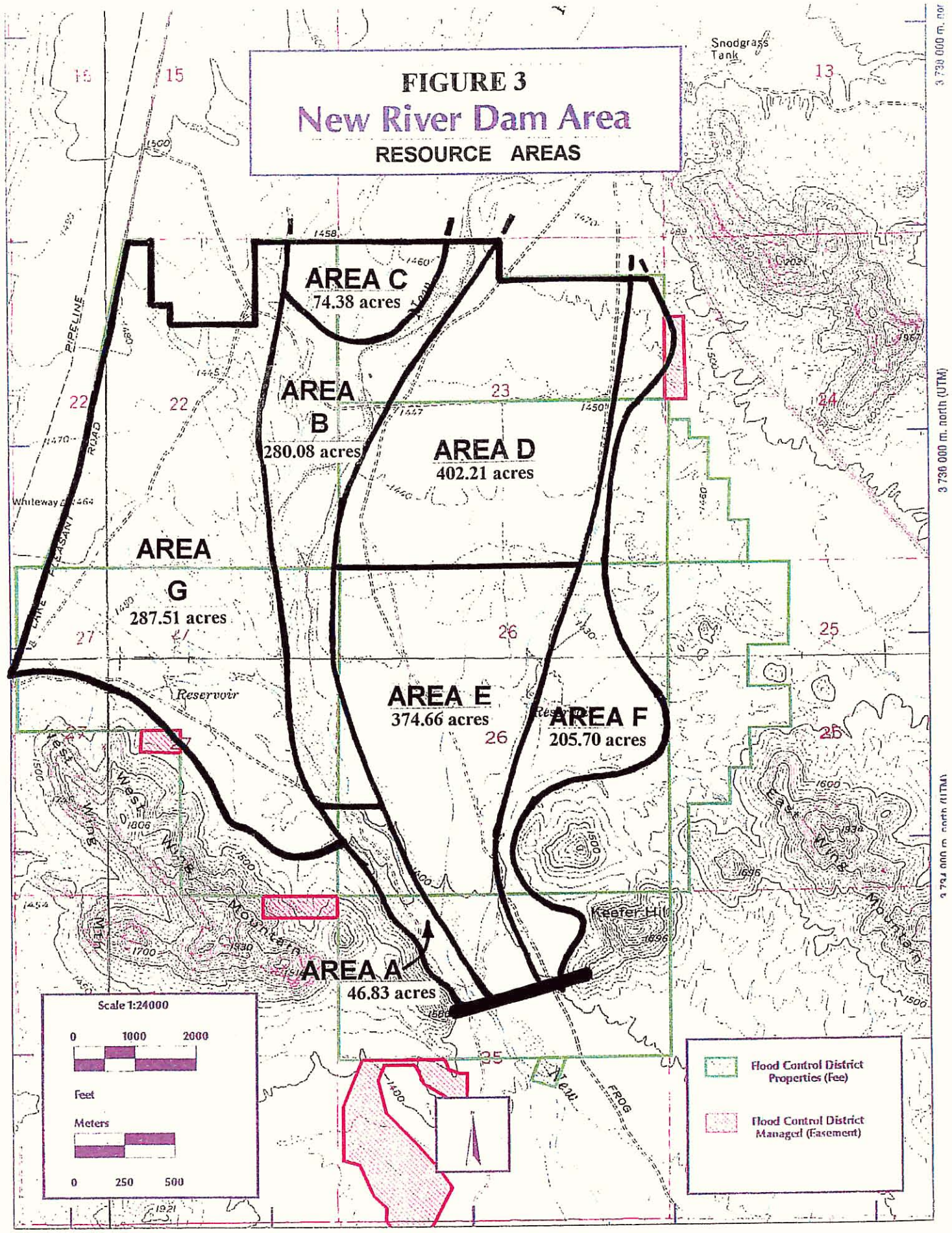


FIGURE 3
New River Dam Area
RESOURCE AREAS
AREA C
74.38 acres
AREA B
280.08 acres
AREA D
402.21 acres
AREA G
287.51 acres
AREA E
374.66 acres
AREA F
205.70 acres
AREA A
46.83 acres
Snodgrass Tank
Reservoir
Keefer Hill
Scale 1:24000
0 1000 2000
Feet
Meters
0 250 500
Flood Control District Properties (Fee)
Flood Control District Managed (Easement)
384 000 m. east (UTM)
386 000 m. east (UTM)
388 000 m. east (UTM)
3 736 000 m. north (UTM)

TABLE 1

NEW RIVER 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.

C. Tertiary/Quaternary Rocks

Tertiary to Quaternary intrusive dikes and lava flows postdate basement Precambrian crystalline rocks. The flows are composed of andesite or felsite rhyolite, vesicular basalt, tuff, flow breccia and tuffaceous agglomerate. Exposures of Tertiary intrusive igneous rocks consisting of granite and monzonite are found in the mountains to the east. Quaternary, "older alluvium" sediments are deposited as valley fill and on the slopes of most of the hills as colluvium. The most extensive Quaternary deposits are the valley fill gravel, sand silt and clay which contain varying amounts of caliche. Recent "younger" alluvium consisting of coarse sand and gravel fills the wash channels. The West Wing Mountains are made up of Tertiary volcanics. [10]

D. Precambrian Rocks

The majority of the basement complex rocks exposed on the property consist of Precambrian granite and related crystalline rocks with lesser amounts of schist and gneiss. The East Wing Mountain and Keefer Hill are primarily composed of Precambrian granite and granodiorite with minor gneiss, vein quartz and schist. Drill holes (Corps of Engineers) near the center of the dam site show white to gray, coarse grained, fractured granite overlain by 136 feet of alluvium. [11]

---

[10] *U. S. Army Corps of Engineers, May, 1982, New River Dam, p. A1-3 to A1-8 and Pl.15, Appendix I*

[11] *U.S. Army Corps of Engineers, May, 1982, New River Dam, p.A1-3 to A1-8, Appendix I*

E. Mineral Resources

The primary resources which are recognized on the property are borrow and sand and gravel. The borrow and sand and gravel resources are addressed in more detail later in the succeeding pages of this report following a description of the program of trenching and drilling. No known resources of coal, oil or metallic minerals occur on the subject. [12]

[12] *U. S. Army Corps of Engineers, May, 1982, New River Dam, p. A1-14 to A1-15, Appendix I*

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 New River Dam is an earthen structure dam and was completed to alleviate the problem of flooding in the metropolitan area as a result of the thunderstorm activity. New River Dam is 2800 feet wide and 91 feet vertically above the elevation of the original wash. Peak discharge of the New River Dam has a maximum discharge of 63,300 cfs with a detention capacity of 34,500 acre feet.[13]

The headwaters of the New River drainage are in the New River Mountains with elevations of over 5000 feet. Wet ground was not noted in the trenches but moist material was encountered in places in the drill holes completed as a part of this study. In drill hole 17 (DD-17a (17) Corps Engineers) water was reported at 70 feet at the dam site where the bedrock was under 136 feet of alluvium. [14]

---

[13] *U. S. Army Corps of Engineers, March, 1976, Final Environmental Impact Statement, p. I-3, I-7*

[14] *U. S. Army Corps of Engineers, May, 1982, New River Dam, Appendix 1, Plate 15*

BORROW, SAND AND GRAVEL

A. Current Mining Activities and Historic Production

In contrast to the Cave Buttes Dam area, no commercial production of sand and gravel for sale has been carried out from within the boundaries of the property. Borrow materials in the immediate area were excavated and used for construction of the New River Dam and related dike structures. Approximately 540,000 cu. yds of material was used for the impervious core of the dam which was derived from surficial fine clayey sands and silts from three borrow areas. The thickness of this unit varied from 0 to 6 feet in these areas. 422,000 cu. yds of sand and gravel were used for the transition zone and 1,628,000 cu. yds for the pervious shell of the embankment. An additional 264,000 cu. yds of sand and gravel were used for miscellaneous fill requirements. The sand and gravel was mined from the same three borrow areas. 125,000 tons of stone were used in the project construction and were derived from screened and/or crushed borrow material and rock from the spillway cut.

Approximately 4.5 miles north and 0.75 miles east of the New River dam there is an old quarry (Biscuit Flat, USGS 7½° Quadrangle Map). The quarry is in the SW4 of section 1, T5N R1E and is situated in the active New River Wash channel.

Approximately 9 miles north and 3.5 miles east of the New River Dam there is an active sand and gravel operation on Arizona state land leased to FNF Construction. The activities are on 320 acres located in sections 16 and 17 of T6N R2E which are also located in the New River active channel.

On the Baldy Mountain USGS 7½° Quadrangle map an old gravel pit is shown in section 8

of T5N R1E which is approximately 3 miles west and 3.5 miles north of the New River Dam. This operation was in the Agua Fria drainage. To the southwest of the property immediately west of Sun City are numerous other old gravel operations in the Agua Fria drainage.

B. Trench Sampling Program

The property was subdivided into 7 resource areas for the purpose of exploratory trenching and sampling (Figure 3). The work was conducted using a backhoe supplied by Flood Control in the period between October 20, 1998 and January 11, 1999 (Plate 1 and Plate 2). Twenty trenches were dug (Figure 2). The average depth of the trenches was approximately 12 feet and normally two samples of sand and gravel material of approximately 60 lbs. were collected from each hole. Data on the trench locations, depths and sampling is presented in Table 2. The samples were sent to Law Engineering and Environmental Services Inc. for sieve analysis and Atterberg limits testwork. Archeological or SHPO constraints affected the location of the trenches and the drill holes.

Prime target areas were areas A and B which are situated in the active New River wash channel (the site of commercial operations to the north) and areas D and E comprised of older alluvium which is extensive and thick.

Individual trench logs are appended and show the field classification and laboratory classification of the materials. These often will not correspond because most of the +3" material was removed from the sample in the field and any remaining was screened off in the laboratory.

The analytical testwork received to date shows a few higher than expected plasticity indices based on field observations but this is not expected to affect the overall positive aspect of

the aggregate.

1. Area A (46.83 acres) Area A is a relatively small, narrow and elongated area north of the New River Dam. The southwestern margin of the zone comprises the base of the slope of the West Wing Mountains. Local, poorly-sorted, clayey colluvial material from the hill slopes are mixed with the active channel gravels. One trench, NR1 was dug in this area to a depth of 14 feet and showed 8.5 feet of sand and gravel in addition to colluvial materials.

2. Area B (280.08 acres) Area B is a continuation of area A northwards. The area is bounded on the west by older alluvium of area G. This boundary is remarkably linear for about one mile and probably represents a fault zone. The eastern boundary is the limit of apparent recent river meanders on the older alluvium surface which makes up areas D and E. The northern boundary is constricted by the adjacent area C but continues as a narrower zone to the north out of the boundaries of the property. A total of 8 trenches were dug in this zone and generally displayed good quality, graded and stratified clean sands and gravels. Plate 2 shows typical material from trench NR5. Plate 1 shows the New River wash cutting down in older gravels cemented in places by calcium carbonate. Being an active channel the area contains the best growth of vegetation which would require removal prior to mining.

3. Area C (74.38 acres) Area C is relatively small and is mainly older alluvium and in places has from 2.5 to 7 feet of fine sandy silts overlying the coarser sands and gravels. The materials correlate with older alluvium of areas D and E. Three trenches were dug in this area.

4. Area D (402.21 acres) Area D is a large area with high potential. The material consists of valley fill or floodplain gravels with from 0 to 4.5 feet of fine sandy and silty cover (Plate 2, trench NR18). A monitoring well was dug in the northwest corner of this area as part of the New River Dam construction project infrastructure close to the boundary with area B. The driller's log reports sand, gravel and "rocks" down to 145 feet with "hard rock" from 145 to 155 feet which could be bedrock at the base of the well. There is an old cased well at the center of section 23 T5N, R1E. The waste material from this hole on the surface nearby looks encouraging although some of the finer material which may have been present could have been washed away. Area D also has a small basalt flow occurrence but the trenching and drilling suggest that volcanic flow materials are not present in the stratigraphic section below the surface. Plate 1 (NR19) and Plate 2 (NR18) show the quality of the material and the proximity to the surface of the aggregate. Four trenches were dug in this area.

5. Area E (374.66 acres) Area E is similar area D. Some stripping of borrow material has already taken place and the material was used for construction of the embankment. Three pits were dug in this area.

6. Area F (205.70 acres) Area F occurs in the foothills of the East Wing Mountains and the mountains northeast of the CAP canal. The deposits of sand and gravel are probably variable in thickness and the bedrock surface very irregular. Much of the bedrock in this area comprises Precambrian granite and a potential resource of sand derived from the weathering of this unit exists but was not investigated further. No trenches were dug in this zone at this time

due to SHPO constraints.

7. Area G (287.51 acres) Area G presents a flat surface with strong cementation of the gravel by caliche. Trench NR8 was dug to 8 feet and never penetrated the caliche zone. Because of this the area is considered to have little potential to develop commercial aggregate resources.

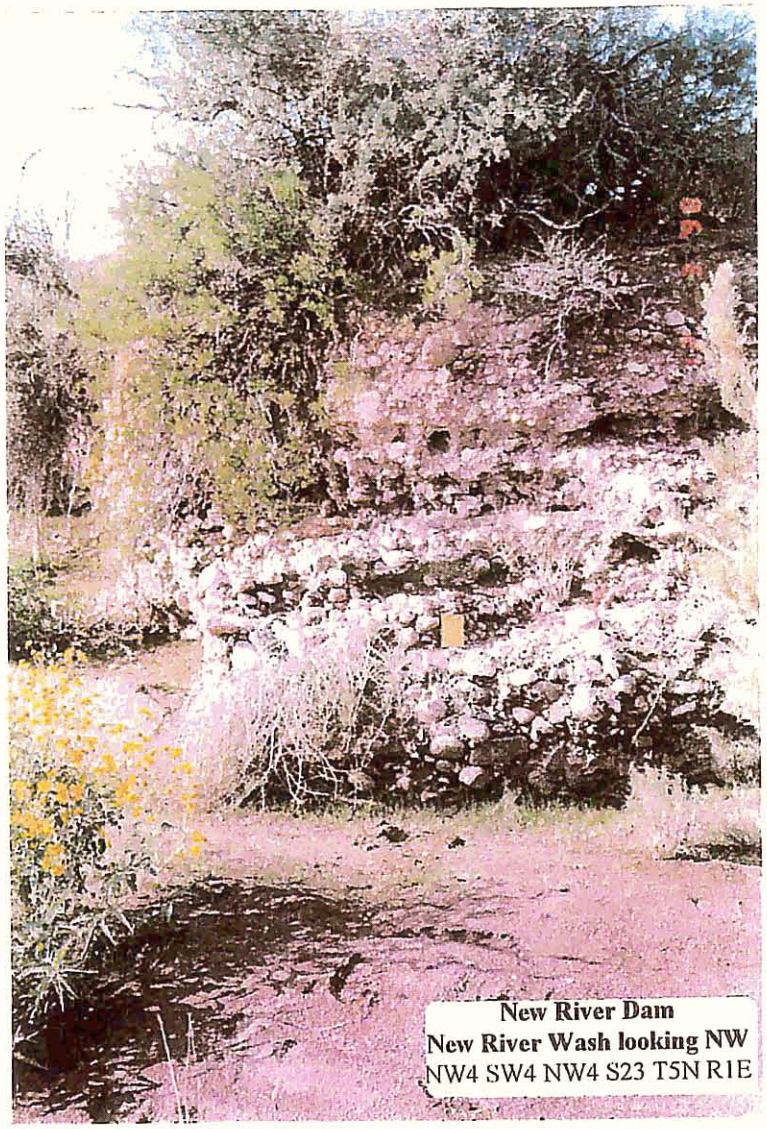
Minor caliche is present in some of the other trenches mostly in the silty fine sands overlying the gravels. Elsewhere the deposition of carbonates is rare.

TABLE 2

NEW RIVER PROJECT

TRENCH DEPTH & SAMPLING DATA

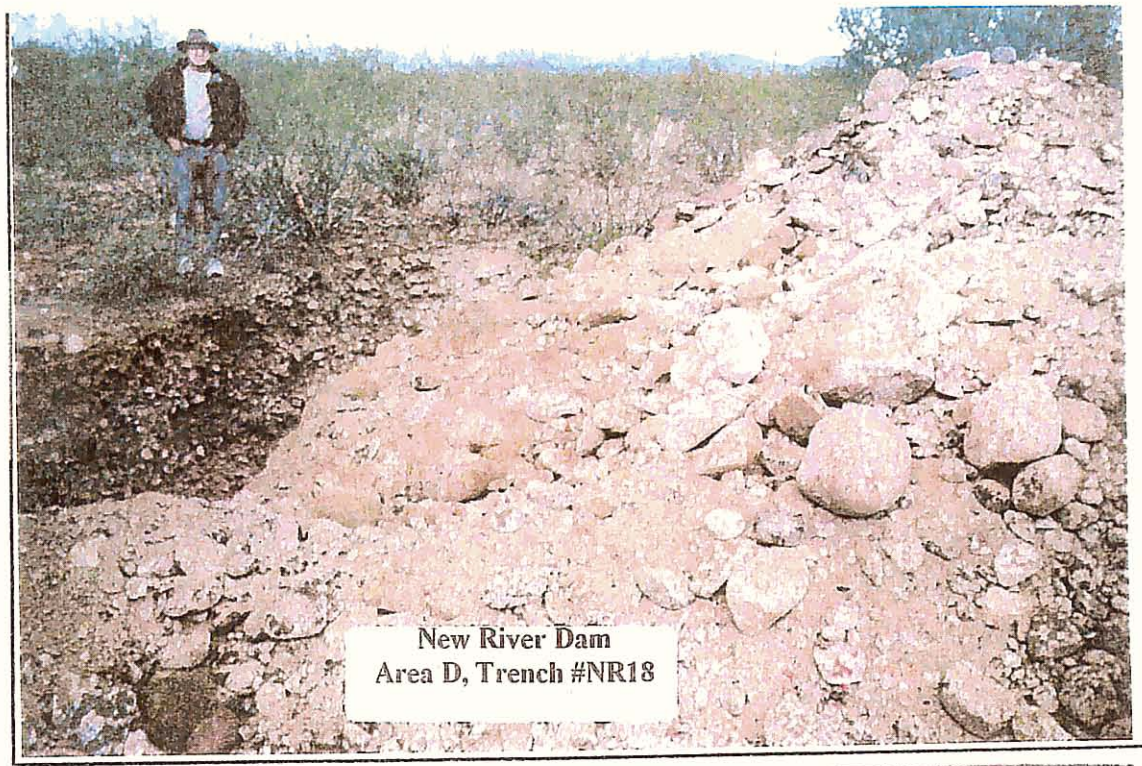
Trench # (Ross)	Area	Depth Ft	Sample #s	From (feet)	To (feet)	Soil Types Thickness in feet (see table 1 for classification)									
						GW	GP	GM	GC	SP	SM	SW	ML	CH	OH
NR-1	A	14	NR1-1	4.00	9.00				5						
			NR1-2	9.00	14.00					5					
NR-3	B	13	NR3-1	1.00	7.00		3					2	1		
			NR3-2	7.00	13.00		6								
NR-4	B	11	NR4-1	0.00	7.00		2.75					3.25	1		
			NR4-2	7.00	11.00		4								
NR-5	B	10	NR5-1	0.00	6.00		5.25								
			NR5-2	6.00	10.00		4								
NR-6	B	11	NR6-1	2.50	7.00		4.5								
			NR6-2	7.00	11.00		4								
NR-8	G	8	None Taken												
NR-9	B	14	NR9-1	3.00	8.00		5								
			NR9-2	8.00	14.00		6								
NR-11	B	13	NR11-1	0.00	4.25				4.25						
			NR11-2	5.75	13.00		7.25								
NR-12	C	14	NR12-1	3.25	6.50		1.75						1.5		
			NR12-2	6.50	12.50		6								
			NR12-3	12.50	14.00				1.5						
NR-14	C	14	NR14-1	7.00	11.00		4								
			NR14-2	11.00	14.00		3								
NR-15	C	15	NR15-1	4.00	10.00		6								
			NR15-2	10.00	15.00		5								
NR-16	B	12	NR16-1	0.00	6.00		6								
			NR16-2	6.00	12.00		6								
NR-18	D	13	NR18-1	0.00	7.00		7								
			NR18-2	7.00	13.00		6								
NR-19	D	13	NR19-1	0.00	7.00		2.5				4.5				
			NR19-2	7.00	13.00		6								
NR-20	D	13	NR20-1	1.50	6.00		4.5								
			NR20-2	6.00	13.00		7								
NR-21	D	12	NR21-1	0.00	6.00		5						1		
			NR21-2	6.00	12.00		6								
NR-22	E	12	NR22-1	1.00	6.50					5.5					
			NR22-2	6.50	12.00		2		3.5						
NR-23	E	12	NR23-1	2.50	7.00		4.5								
			NR23-2	7.00	12.00		5								
NR-24	E	10.5	NR24-1	1.00	6.00		5								
			NR24-2	6.00	10.50		4.5								
NR-27	B	10	NR27-1	2.00	6.00		4								
			NR27-2	6.00	10.00		4								



New River Dam
New River Wash looking NW
NW4 SW4 NW4 S23 T5N R1E

PLATE 1
New River Dam
New River Wash &
Trench #NR19

New River Dam
Area D, Trench #NR19



New River Dam
Area D, Trench #NR18

New River Dam
Area B, Trench #NR5

PLATE 2
New River Dam
Trenches NR5 & NR18

C. Drilling

Six drill holes (NRD1 through NRD6) were recommended and the work was performed by Layne Western Environmental Services between January 13, 1999 and January 18, 1999 under the supervision of Law Engineering and Environmental Services Inc. NRD1 was drilled in area A, NRD2 and NRD3 are in area D and NRD5 is in area E. NRD6 is on the boundary of areas B and E and NRD4 on the boundary of areas B and D. The holes were sampled and logged to a depth of 100 feet by Law; laboratory testwork will be conducted by Law as directed by Ross Consulting. Moist and, rarely, wet materials were encountered in places. These were probably perched zones, the water table being generally at depths greater than 100 feet. The observation well in area D, for example, showed standing water at 132.5 feet (September, 1985).

Summary logs of the drill hole lithologies are presented in Figure 4. The data is preliminary and derived from Law's field logs which could be modified when laboratory classifications are available. The data show that the subsurface contains significant resources of sand and gravel. Only a minor percentage of the material is classified as silt or clay.

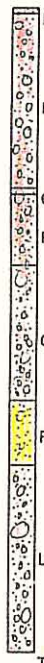
Distribution of Aggregate Types in Drill Holes

Drill Hole	%Clay/Silt	%Sand	%Gravel
NRD1	0	11	89
NRD2	3	50	47
NRD3	0	57	43
NRD4	0	43	57
NRD5	3	60	37
NRD6	0	75	25

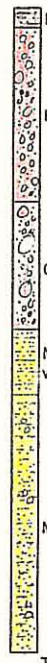
A detailed report of the drilling program with final logs of the holes and analytical results are to be presented by Law Engineering and Environmental Services..

FIGURE 4
NEW RIVER DAM
Drill Hole Summaries

NRD1



NRD2

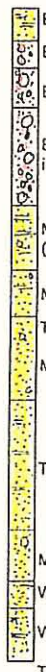


NRD3

NRD4

NRD5

NRD6



D. Resources Estimation

A very rough estimate of the resources in each of the areas illustrated in Figure 3 was made using 100 feet thickness of the aggregate materials, 2.5:1 pit slopes and a density of 110 lbs/cubic foot.

Area A. Contains approximately 8.5 million tons of aggregate resources.

Area B. Contains approximately 66.5 million tons of aggregate resources.

Area C. Contains approximately 15.5 million tons of aggregate resources.

Area D. Contains approximately 94.6 million tons of aggregate resources.

Area E. Contains approximately 88.2 million tons of aggregate resources.

Area F. Contains approximately 24.6 million tons of aggregate resources.

Area G. Contains no resources.

E. Production

1. Supply and Demand. 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 through the third quarter of 1998 was an estimated 753 million metric tons. Production for consumption of construction sand and gravel in the third quarter of 1998 was reported to be highest in California, Michigan, Texas, Ohio, and California. Their combined total was 35.6% of the U.S. total. In Arizona, estimated production through the third quarter of 1998 was 34.9 million metric

tons. [15]

The construction industry is by far the largest nationwide consumer of aggregate 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.

Arizona had the nation's second highest job growth rate over the 12 months through October, 1998, according to the U. S. Department of Labor. Arizona added 94,000 jobs over this period. [16] Maricopa County led the nation in business and employee growth from 1995 to 1996, the Census Bureau reported on December 17, 1998. The county added 3,052 businesses, 77,162 employees and 87,296 residents during the period. The county's employment rose 7.5 % to 1.11 million people. [17]

In addition to housing, one of the principle uses of construction sand and gravel is in highway construction.

The new Transportation Equity Act for the 21st Century (TEA-21) was signed into law on June 9, 1998. It brings an average 44% increase in federal highway funding for the six fiscal years 1998 to 2003. TEA-21 authorizes a $217.3 billion for highway and transit programs over six years including $175 billion for the highway program with at least $165 billion in guaranteed spending. Federal funding for highway programs will rise from about $18 billion in 1998 to more than $26 billion averaged annually through 2003. Because an average 20% share will be required of states,

---

[15] *U.S. Geological Survey, 1998 - Mineral Industry Surveys, Crushed Stone and Sand and Gravel in the Third Quarter of 1998, p. 1, 4, 5.*

[16] *The Arizona Republic, December 17, 1998, p. D1*

[17] *The Arizona Republic, December 18, 1998, p. E1*

total spending will push another quarter higher.[18]

The extra federal money will make it possible to complete the Valley's freeway network by 2007, seven years ahead of schedule according to transportation planners. The Red Mountain Freeway, scheduled to reach the Bush Highway in east Mesa by 2006, will be done sooner. The Santan Freeway, currently planned to loop around the Valley's east end by 2012 will be done years earlier. Arizona will get $658 million in federal gas-tax dollars over the next five years. [19]

The Arizona Department of Transportation is expecting a big year in 1999. Department officials are looking for a 13% budget increase in 1999, bringing it to $725.7 million, excluding right-of-way and design expenses. The aggressive road building schedule is attributed to the influx of federal money from TEA-21. Work is currently underway on I-17, worth $71 million; work on Shea Boulevard-Pima Road, worth $83 million and work on frontage roads and bridges in Tucson, worth $20 million.[20]

Another principal use of construction sand and gravel is home construction. In the metropolitan Phoenix area there were 19,895 total new home sales for the year through September, 1998. The new home market continued a strong upward trend moving from 6,895 sales in the second quarter of 1998 to 7,225 sales in the third quarter compared to 6,125 sales in the third quarter of 1997. The relatively low mortgage rates and growing economy have had a positive impact on the housing market. The market's future and that of the construction industry is determined not only by interest rates, but also international events, the potential for jobs, and consumer's confidence in their

---

[18]*Rock Products, July, 1998 p. 30*

[19]*The Arizona Republic, December 18, 1998, p. A1-A2*

[20]*Rock Products, December, 1998, p. 60*

own economic futures.[21] The economic outlook for Arizona remains optimistic with most forecast changes being upward revisions according to Tracy L. Clark, senior economist with the Bank One Economic Outlook Center.[22]

Phoenix Blue Chip consensus estimates there will be a record 31,500 single family units sold in 1998 following 1997's record of 29,124 units. The consensus estimate of approximately 27,300 units in 1999 indicates a slowdown but to a level considered high by historic standards. Even the year 2000 forecast of 24,250 units must be considered strong in historical context. The greater Phoenix area economy remains strong despite concern over the international economy. The *Greater Phoenix Blue Chip* panel is projecting slower growth for 1999 than in 1998. The year 2000 projections suggest a continuation of the slowing trend without a recession. The current expansion has been fueled by continued population growth. The panel expects growth to slip below 3.0 percent in 1999. The levels of growth forecasted for 1999 and 2000 are by no means slow, particularly considering how large the population base has become in recent years.[23]

Approximately eleven miles to the northwest, FNF Construction was the successful bidder on a 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

---

[21]*Arizona Business, December, 1998, p. 7-9*

[22]*Arizona Business, November, 1998, p. 10*

[23]*Greater Phoenix Blue Chip Consensus, October, 1998, p. 1*

material).[24]

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 U. S. producers in 1997 on average was $4.47 per metric ton ($4.05 per short ton) and $4.63 per metric ton or $4.20 per short ton for 1998 (estimated). 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).[25]

The quantity of Arizona sand and gravel increased 15% for the first quarter of 1998 versus the 1997 first quarter. The Arizona second quarter of 1998 increased 29% over the second quarter

---

[24]*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*

[25] *U. S. Geological Survey, 1998, Mineral Industry Surveys, Crushed Stone and Sand and Gravel in the Fourth Quarter of 1997, p. 2 and personal communication, W. Bolen, U.S.G.S., 2/1/99*

of 1997 and the third quarter of 1998 increased 13% over the third quarter of 1997. [26]

3. **Permitting.** One of the most critical permits required is administered by the Army Corps of Engineers (404) and is needed if activities are to take place within the "ordinary high water mark". 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 $0.75 to $1.00 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.

---

[26] *U. S. Geological Survey, December, 1998, Crushed Stone and Sand and Gravel in the Third Quarter of 1998, p. 5*

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 New River may 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 of CAP water to the water table 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 a 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.[27]

---

[27]*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 areas B, D, E and C, in that order or a combination of these prime areas. Area B is an excellent location for aggregate mining where the gravels are thick and the quarry would be down in the wash in a relatively non-visible location. Areas D and E are also prime mining areas for sand and gravel. Area C could be mined and blended with area B material. Area A is a narrow area immediately behind the dam so it probably won't be mined due to its proximity to the dam. Area F is a pediment and the gravels are generally not as thick and may have a high caliche content. Area G contains extremely heavy caliche of over 8 feet thick. The presence of caliche will probably cause this area to be unmineable. This investigation is preliminary and confined to an examination of the top 13 feet of the fluvial section using backhoe trenches and six Tubex percussion drill holes to 100 feet. The drill holes were widely spaced.

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. The effect of the dam on subsurface flow of water has not been studied. The multi-use concept is being applied elsewhere in the Salt and Verde Rivers and in the Indian Bend Wash and it could be applied in the New River Dam area.

ADDENDA

REFERENCES

Arizona Business, December, 1998, p. 7-9.

Arizona Business, November, 1998, p. 10.

The Arizona Republic, December 18, 1998, p. A1-A2.

Greater Phoenix Blue Chip Consensus, October, 1998, p. 1.

Law Engineering and Environmental Services Inc., January, 1999, Field geologic drill logs of Patrick Cook.

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.

Rascona, Steven 1998 - Hydrologist. State of Arizona, Department of Water Resources. Personal Communication.

Rodgers, James, B., October 27, 1998, An Archeological Assessment of a Proposed Sand and Gravel Testing Operation in the New River Reservoir of Northern Peoria, Arizona.

Rodgers, James, B., December 11, 1998, The New River Reservoir Sand and Gravel Testing Operation of Northern Peoria, Arizona. An Archeological Assessment.

Rock Products, December, 1998, p. 60.

Rock Products, July, 1998, p. 30.

U. S. Army Corps of Engineers, March, 1976, Final Environmental Impact Statement, New River and Phoenix City Streams, Maricopa County, Arizona

U.S. Army Corps of Engineers, March, 1976, Gila River Basin New River and Phoenix City Streams Design Memorandum No. 3, General Design Memorandum - Phase I, Plan Formulation Main Report.

U.S. Army Corps of Engineers, May, 1982, New River Dam (Including New River to Skunk Creek) Gila River Basin Phoenix Arizona & Vicinity (including) New River, Design Memorandum No. 3, General Design Memorandum - Phase II, Project Design Part 3, Draft.

U. S. Army Corps of Engineers, 1982, Hydrology Part 2 - Design Memorandum No. 2 - Gila River Basin - Phoenix Arizona & Vicinity (including New River).

U. S. Army Corps of Engineers, October, 1985, New River Dam Foundation Report.

U. S. Army Corps of Engineers, February, 1987, New River Dam Embankment Criteria and Performance Report.

U. S. Army Corps of Engineers, July, 1983, New River Dam - Contract Drawings.

U. S. Army Corps of Engineers, May, 1986, Skunk Creek and New River and Agua Fria Rivers.

U. S. Geological Survey, December, 1998, Crushed Stone and Sand and Gravel in the Third Quarter of 1998, p. 5.

U. S. Geological Survey, 1998, Mineral Industry Surveys, Crushed Stone and Sand and Gravel in the Fourth Quarter of 1997, p. 2.

PROJECT - New River Dam

Trench #: NR1

Geologist: AW **Date:** 12/2/98

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel, Cobbles and Boulders
			Rubble. Surficial, disturbed.						
		GP	Sandy Gravel. ~3% boulders, ~20% cobbles.						
5		GC	Sandy/silty Gravel. Immature, angular to subangular blocks and cobbles of locally derived bedrock (volcanics). Generally brownish in color, some clay, weakly calcareous. ~40% cobble sized material.	NR1-1	GM	NP	8.5	21.5	70
10		SP	Medium/coarse Sand. Gravel showing at base of trench. Weakly layered at top of unit. Good looking material.	NR1-2	GP	NP	4.5	44.5	51
15			TD 14 feet						
20									

PROJECT - New River Dam

Trench #: NR3

Geologist: AW **Date: 12/3/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel, Cobbles and Boulders
		ML	Silt.						
		GP	Sandy Gravel. Good quality, clean. Little or no carbonate. ~3% boulders, ~30% cobbles	NR3-1	GP-GM	NP	7.5	35.5	57
5		ML	Silt.						
		SW	Sand.						
		GP	Sandy Gravel. ~3% boulders, ~25% cobbles. Reddish in places but no clay.	NR3-2	GP-GM	NP	4	30.5	65.5
10			silty lens						
			TD 13 feet.						
15									
20									

PROJECT - New River Dam

Trench #: NR4

Geologist: AW **Date:** 12/3/98

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel, Cobbles and Boulders
		ML	Silt. Weakly calcareous.	NR4-1	SP	NP	3	57	40
1.75		GP	Sandy Gravel. ~40% cobbles						
		SW	Sand. Well washed, clean						
5									
		GP	Sandy Gravel. Weakly stratified. Not calcareous. ~5% boulders, ~30% cobbles						
				NR4-2	SP	NP	1.5	32	66.5
10									
			TD 11feet. Ravelly ground - losing trench.						
15									
20									

PROJECT - New River Dam

Trench #: NR5

Geologist: AW **Date: 12/3/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel, Cobbles and Boulders
0.75		ML	Silt. 0.00 - 0.75 feet						
		GP	Sandy Gravel.	NR5-1	GP	NP	2	14	84
			~10% boulders, ~50% cobbles.						
			Weak stratification and only very weakly calcareous.						
5									
				NR5-2	GP-GC	14	2	17.5	80.5
			8.0 - 10.0 feet weak to moderate caliche cement, hard digging.						
10									
			TD 10 feet.						
15									
20									

PROJECT - New River Dam

Trench #: NR6

Geologist: AW **Date: 12/7/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel, Cobbles and Boulders
		ML	Sandy Silt with sandy layers and vegetation roots.						
		GP	Sandy Gravel. Stratified with sandy horizons. ~2% boulders, ~30% cobbles.	NR6-1	SW-SM	NP	5	46.5	48.5
5									
				NR6-2	SP-SM	NP	4	39	57
10									
			TD 11 feet. Trench collapsing.						
15									
20									

PROJECT - New River Dam

Trench #: NR8

Geologist: AW **Date: 12/7/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel, Cobbles and Boulders
		ML	Thin brown soil cover.	NONE					
		GC	Gravel. Extremely calcareous and caliche-cemented. Very hard digging.						
5									
			TD 8 feet						
10									
15									
20									

PROJECT - New River Dam

Trench #: NR9

Geologist: AW **Date: 11/23/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel, Cobbles and Boulders
		ML	Silty Clay. Some shrub roots.						
			weak caliche						
		GP	Sandy/silty Gravel. Weak to moderately calcareous.	NR9-1	GP-GC	30	4	8	88
5			~30% boulders, ~30% cobbles.						
				NR9-2	GP-GC	24	4.5	11.5	84
10			becoming less silty.						
15			TD 14 feet						
20									

PROJECT - New River Dam

Trench #: NR11

Geologist: AW **Date: 10/20/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel, Cobbles and Boulders
		GC	Dirty Gravel. ~15-20% cobbles. Clay and silt in matrix as support. Moderately calcareous.	NR11-1	GC	12	16.5	18	65.5
~~4.25~~ 5 5.75		GM	Gravel. Strong caliche but ragged and discontinuous.						
10		GP	Sandy Gravel. ~3% boulders, ~25% cobbles. Matrix sand coarse.	NR11-2	GP	10	3.5	29	67.5
15 20			TD 13 feet						

PROJECT - New River Dam

Trench #: NR12

Geologist: AW **Date: 10/20/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel, Cobbles and Boulders
		SP	Fine Silty Sand. Varies in thickness from 1.5 to 5.0 feet across trench.						
5		GP	Sandy Gravel. Varies 0 to 3.5 feet thick. ~2% boulders, ~15% cobbles.	NR12-1	GP-GC	12	9	33	58
		ML	Silt. Weak to moderate caliche.						
10		GP	Sandy Gravel. ~5% boulders, ~15% cobbles.	NR12-2	GP-GC	19	6	36.5	57.5
		GC	Silty Gravel. ~5% boulders, ~15% cobbles.	NR12-3	SC	12	11	42.5	46.5
15			TD 14 feet.						
20									

PROJECT - New River Dam

Trench #: NR14

Geologist: AW

Date: 12/7/98

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel, Cobbles and Boulders
		ML	Sandy Silt. Moderately calcareous with some caliche nodules.						
5									
		GP	Sandy Gravel. Weakly to moderately calcareous. ~10% boulders, ~50% cobbles.	NR14-1	GP-GC	9	4.5	12	83.5
10									
				NR14-2	GP-GC	26	2.5	15.5	82
15			TD 14 feet						
20									

PROJECT - New River Dam

Trench #: NR15

Geologist: AW **Date: 10/20/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel, Cobbles and Boulders
		SM	Fine silty Sand.						
		ML	Silty Sand. Weak caliche.						
5		GP	Coarse sandy Gravel. ~5% boulders, ~25% cobbles. Good Material. Weakly calcareous.	NR15-1	GP-GC	14	7.5	28.5	64
				NR15-2	GP-GM		4	29.5	66.5
10									
				NR15-3	GP-GC	20	4	24.5	71.5
15									
			TD 15 feet						
20									

PROJECT - New River Dam

Trench #: NR16

Geologist: AW **Date: 12/7/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel, Cobbles and Boulders
		GP	Sandy Gravel. Weakly stratified. Not calcareous.	NR16-1	GP	NP	0.5	18	81.5
			~12% boulders, ~45% cobbles.						
			Sand						
5									
				NR16-2	GP	13	1.5	16	82.5
			Sand						
			Reddish coloration, some clay						
10									
			TD 12 feet						
15									
20									

PROJECT - New River Dam

Trench #: NR18

Geologist: AW **Date: 11/23,24/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel, Cobbles and Boulders
		GP	Sandy Gravel.	NR18-1	GP	NP	0.5	6.5	93
			~30% boulders, ~50% cobbles. Sharp sand.						
			Weakly calcareous near surface diminishing lower.						
			No stratification.						
5									
				NR18-2	GP	25	0.5	2.5	97
10									
			Weak carbonate on cobble and boulder surfaces.						
			Some reddish clay last 2 feet						
			TD 13 feet						
15									
20									

PROJECT - New River Dam

Trench #: NR19

Geologist: AW **Date: 12/3/98**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel, Cobbles and Boulders
		SM	Fine Sand. Occasional gravel bed. Weakly calcareous.	NR19-1	GM	NP	10	33	57
5		GP	Sandy Gravel. ~15% boulders, ~50% cobbles						
				NR19-2	GP-GM	NP	2	12	86
10			Gravel becoming reddish with some clay.						
			TD 13 feet						
15									
20									

PROJECT - New River Dam

Trench #: NR20

Geologist: AW **Date: 1/11/99**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel, Cobbles and Boulders
		ML	Silty Sand.						
		GP	Coarse sandy Gravel. Very weakly calcareous. Looks "dirty" and has minor clay fraction from 2.75 feet. ~7% boulders, 70% cobbles.	NR20-1	GP-GM	NP	2	8	90
5									
				NR20-2	GP-GM	NP	1.5	9.5	89
10									
			TD 13 feet						
15									
20									

PROJECT - New River Dam

Trench #: NR21

Geologist: AW **Date: 1/11/99**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel, Cobbles and Boulders
		ML	Sandy Silt. Some cobbles and gravel lenses.V. weakly calcareous	NR21-1	GP	NP	0.5	3	96.5
		GP	Sandy Gravel. Very weakly calcareous. Some clay on boulders and cobbles. ~35% boulders, ~50% cobbles.						
5									
				NR21-2	GP-GC	13	1	5.5	93.5
10									
			TD 12 feet						
15									
20									

PROJECT - New River Dam

Trench #: NR22

Geologist: AW **Date: 1/11/22**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel, Cobbles and Boulders
		GP	Sandy Gravel.						
		SP	Sand. Some gravel horizons.	NR22-1	SP	NP	3	66	31
5									
		GP	Sandy Gravel.	NR22-2	GP-GM	NP	2.5	20	77.5
			~5% boulders, ~50% cobbles.						
10		GC	Clayey sandy Gravel.						
			~5% boulders, ~50% cobbles.						
			TD 12 feet						
15									
20									

PROJECT - New River Dam

Trench #: NR23

Geologist: AW **Date:** 1/11/22

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel, Cobbles and Boulders
		SM	Fine silty Sand.						
5		GP	Sandy Gravel. Very weakly calcareous. ~7% boulders, ~55% cobbles.	NR23-1	GP	NP	1.5	17.5	81
				NR23--2	SP	NP	2	21	77
10			Coarse sand wedge.						
15			TD 12 feet						
20									

PROJECT - New River Dam

Trench #: NR24

Geologist: AW **Date: 1/11/22**

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel, Cobbles and Boulders
		ML	Sandy Silt.						
		GP	Sandy Gravel. Weak calcareous cement. Dirty looking.	NR24-1	GP	NP	1	12	87
			~10% boulders, ~60% cobbles						
5									
				NR24-2	GP-GC	8	1.5	12	86.5
10			at 9 feet tough digging - some clay and weakly calcareous.						
			TD 10.5 feet						
15									
20									

PROJECT - New River Dam

Trench #: NR27

Geologist: AW **Date:** 12/7/98

Depth (feet)	Graphic Log	Field Classification	Lithology - description	Sample numbers	Laboratory Classification	P.I.	%Clay	%Sand	%Gravel, Cobbles and Boulders
		ML	Sandy Silt.						
		GP	Sandy Gravel. Good material. Weakly calcareous to 5.5 feet thereafter not calcareous.	NR27-1	GP	NP	1.5	10	88.5
5			~20% boulders, ~50% cobbles. Coarser at the top						
				NR27-2	SP	NP	0.5	15	84.5
10									
			TD 10 feet. Trench collapsing.						
15									
20									

THE ARIZONA REPUBLIC

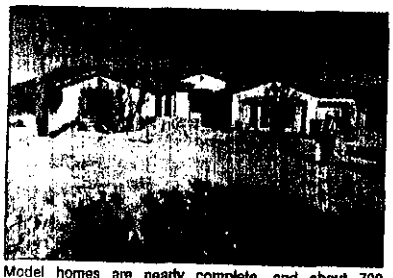
BUSINESS

E

SATURDAY
JANUARY 9, 1999

Senior Editor:
Lee Polk • 444-4813
lee.polk@pni.com

REAL ESTATE



Model homes are nearly complete, and about 700 workers are rushing to finish landscaping.

Tim Koors/The Arizona Republic

Del Webb's Anthem general manager, Tom Lucas, sits on the site of a waterfall that will empty into a lake that will be stocked with fish for residents to catch.

Anthem opening near

Leading wave of development in northwest Valley

By Catherine Reagor
The Arizona Republic

Anthem -- Del Webb Corp.'s first big multi-generational housing community in Arizona -- is less than two months away from opening for sales.

About 700 construction workers and landscapers are hustling to get the nearly 6,000 acres of desert near New River and the base of Daisy Mountain ready for Anthem's March 6 grand opening.

The development eventually will have more than 10,000 homes and 30,000 people — and is likely to transform the character of the northwest Valley.

Anthem is leading the way for housing development in the far northwest region, which actually goes past the fringes of the Valley. But it's not alone.

Following Del Webb's lead will be three other major housing developments: Tramonto near the Carefree Highway; Dynamite Mountain Ranch east of I-17 and north of Happy Valley Road; and a new Sunbelt Holding community near 19th Avenue, east of I-17.

Those developments comprise nearly 4,000 acres and will have at least twice that many homes.

Home building analysts are calling the northwest corridor running along I-17 and north of the Loop 101 the next hot spot for new houses.

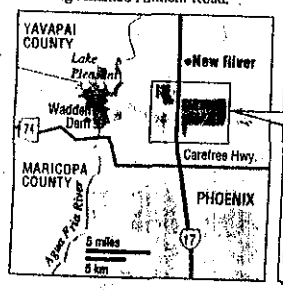
"Anthem will be the start of a wave of home building that will fill in the entire northwest corridor of the Valley," said David Thikoll, a home-building analyst with the Meyers Group of Phoenix.

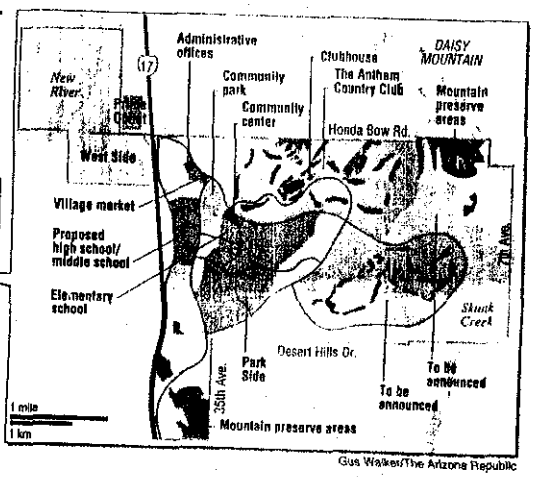
In typical Del Webb style, the company plans to have many of

Please see ANTHEM, Page E3

ANTHEM DEVELOPMENT LAND USE

Originally named The Villages at Desert Hills, Del Webb's Anthem will occupy 5,800 acres east of Interstate 17 between Desert Hills Drive and Honda Bow Road, which is being renamed Anthem Road.





Gus Walker/The Arizona Republic

AmWest contests workers' union vote

By Peter Corbett
The Arizona Republic

America West Airlines baggage handlers won a narrow victory Friday in a union-organizing election, but the Tempe-based carrier contested the vote, charging election coercion by union leaders.

Transport Workers Union organizers interfered with the secrecy of the election by collecting ballots at public meetings, which would violate the Railway Labor Act, America West said in a statement.

Union officials were unavailable late Friday afternoon to respond to America West's allegation.

The union needed about 1,000 votes from the baggage handlers and other fleet service workers and ended up with 1,063, baggage handler Pat Rezler said. America West said 1,054 workers voted for representation.

About 2,000 fleet service workers were eligible to vote.

National Mediation Board officials counted mail-in ballots on Friday in Washington.

Rezler, who has worked in fleet services in Phoenix for about 12 years, said the union will poll employees to see what issues are most important to them in negotiating a contract with America West.

Workers want better pay and a voice in workplace issues, said Rezler, who has served on the union's Phoenix organizing committee.

Workers now are paid between $6.95 and about $10 per hour, according to Rezler.

Fleet service workers for rival Southwest Airlines are paid up to $19 per hour, a Southwest spokeswoman said.

Bruce Johnson, America West vice president for human resources, said in a statement that the airline will ask the National Mediation Board to order a new election.

Fleet service workers narrowly rejected a union-organizing effort in autumn 1997 and, by law, had to wait a year before requesting a new election.

America West, which settled a contract dispute with mechanics in September, will resume negotiations with the flight attendants union Jan. 25. The flight attendants have voted to strike if an impasse is declared.

Peter Corbett can be reached at 444-4815 or at peter.corbett@pni.com via e-mail.

Bond funds '98 returns

S BROWSER

...p. on Monday will unveil Pentium III ... name for its next microprocessor, ... out this quarter. It has more ... instructions that improve ... on personal computers. ... of PCs soared about ... snapped up low-cost machines. ... sales, said Friday that retailers ... in December. Revenue rose just ... because of deep price cuts.

... fourth-quarter earnings rose ... items rose to $218.3 million, or ... million, or $1.04, a year earlier. ... billion from $3.23 billion. ... a $1.3 billion fiscal first-quarter ... practices to reflect the value of its ... cents a share to the net income ... ended Dec. 31. ... will take fourth-quarter charges of ... of firing workers and to account for ... fields and stored oil. The charges ... of about $170 million, and a ... production properties of $100 million.

... the construction of large shopping ... for five years in a bid to reduce ... ailing downtowns. ... rate rose to 10.9 percent in ... 8 percent as the number of people ... for the first time in four months. The ... of jobs-creation programs and at ... unemployment.

... today that it decided against teaming ... tions Inc. MCI WorldCom's dropping ... way for San Francisco-based AirTouch ... Vodafone Group and Bell Atlantic. ... used about 30 million of its bricks to ... Statue of Liberty and the San ... California. The 128-acre theme park ... in March. ... to sales of its new Escalade ... vehicle, Cadillac outsold Lincoln by ... for the year, narrowly keeping the ... the General Motors division has ... years. Ford Motor Co.'s Lincoln was ... sales of its luxury SUV, the ...

... Home Shopping Network, ... network reaching 70 million ... month ever in December as more ... via their TV sets. It said it rang up ... sales, including sales of 100,000 ... 000 Beanie Babies, and more than ...

...uisitions

...ions Exchange has called off ... Pacific Exchange that would have ... derivatives exchange to trade ... contracts a day. The Chicago ... the talks after learning last month ... require an extensive review of ...

... its bitter five-month takeover ... Systems Inc. on Friday, withdrawing ... the way for Quickturn to be sold to ... Systems Inc. for $271.3 million.

...rs

... announced by U.S. companies ... the year, doubling the figures ... by the outplacement firm ... Announced layoffs in December ... with 51,642 a month earlier.

... investigated by a federal grand jury ... maintenance and repair records for ... some jetliners. The Seattle ...

REAL ESTATE

Anthem preparing for grand opening

ANTHEM, from Page E1

its multimillion-dollar amenities complete before the first resident moves in.

"Before the first house is done, we will have spent $150 million on Anthem," said Thomas Lucas, general manager of the development, which is a new concept for the Sun City creator Del Webb.

"No other master-planned community in the Valley has ever offered its residents as much right when they move in," he said.

The Phoenix-based company is spending $66 million alone on the project's infrastructure. It's building a water-treatment plant for the project, funding the $12 million construction of a new freeway interchange off I-17 and donating the land and $9 million to build Anthem's first K-8 school.

All of those projects are either completed or will be this year.

"Anthem is a perfect example of a development paying for itself," Lucas said.

To give its residents places to meet and play, Del Webb is creating a 63-acre park near the heart of Anthem.

Park facilities

As soon as they move in, residents will have park with:

- A state-of-the-art 32,000-square-foot community center with a fitness center the size of a large commercial gym.
- A water park.
- A rock-climbing wall.
- A miniature railroad.
- A 4-acre lake stocked with fish for the catching.
- In-line skating areas.
- Sand volleyball courts, soccer fields and basketball courts.
- An 18-hole golf course.

Also, about one-third of the community's land will be open space.

Though Anthem is stacked with amenities and parks, and paying its own way for all infrastructure, it has its detractors.

New River emerged as a rural community, far enough away from Phoenix to escape the pollution and crowds. Many of its residents have 1-acre spreads and have fought to keep a high-dollar dense development away.

Some change minds

However, as the project has evolved, some of its original opponents have changed their minds.

"I grew up here, and when I first heard about Del Webb's plans I was a little apprehensive," said Mary Beth Baker, outgoing president of the Desert Hills Improvement Association and vice president of Desert Hills Water Co.

But it's obvious that growth is heading this way, she said, and a master-planned community like Anthem is one of the best ways for the land to be developed.

In 1985, the New River area had about 3,300 residents. Estimates now put the population at 7,300, and that figure is expected to triple by 2005, mainly because of Anthem.

Despite Del Webb's plans for top-notch amenities and high-dollar infrastructure, there are still some New River homeowners who are opposed to the development because they want nothing smaller than a project with one house per acre.

However, home-building analysts and many prospective buyers are being wowed by it.

More than 1,000 people have called Del Webb about buying a home in Anthem, which will be the city name residents use for their mail addresses.

Anne Mariucci, a senior vice president at Del Webb, said the company expects Anthem to be the top-selling master-planned community in the Valley from the day it opens.

5 housing areas

The development will likely have five housing areas when it's completed years from now. The first two are opening in March.

A family oriented neighborhood with several types of homes built by Del Webb's Coventry division will be called Anthem Parkside. Homes will run from the low $100,000s to the mid-$200,000s.

The more expensive, gated-community that will be home to the project's first golf course is called Anthem Country Club. The least expensive house there will be in the high $130,000s. With extra amenities such as a wine room, mahogany cabinets and bookcases and granite floors, homes can reach almost $400,000.

However, some of the houses in Anthem can be found in other Del Webb communities in Scottsdale costing tens of thousands of dollars more.

To avoid the cookie-cutter approach, Del Webb has more than two dozen types of homes, six distinct architectural styles — ranging from ranch to Santa Barbara — and a color pallet with yellows, mocha browns and charcoal grays to make each house different.

Convenient location

Some people who have passed the land on their way to Flagstaff or the Prime Outlet shops that are right across I-17 from the development, might wonder who will drive that far to buy a house.

Del Webb's answer to that is twofold. Lucas has clocked the time from Anthem to the I-17 and Loop 101 interchange at 15 minutes. That area called the Deer Valley corridor is evolving into a hot spot for businesses and retail.

Also the project has a large commercial and retail component that will offer jobs and shopping for Anthem residents.

A grocery store, pharmacies, hotels, gas stations, convenience stores, banks, restaurants, fast-food outlets, a movie theater and several office complexes are planned for Anthem.

More than 10 percent of the community has has been set aside for mixed-use development.

"Originally, when I heard about Anthem, I thought it was just too far of a drive to really be successful," Thikoll said.

"But now that I see what they are doing, I think people will definitely make the trade-off of being farther out for the amenities and lifestyle at Anthem."

Catherine Reagor can be reached at 444-8040 or at catherine.reagor@pni.com via e-mail.

Home buyers get FHA break in loan limits

MAIL, from Page E1

their big companies after mergers or acquisitions during the past few years and either launched their own building companies or linked with a major builder trying to get a foothold in Arizona.

FHA keeping pace

To help keep pace with rising home prices, the Federal Housing Administration is raising the limit on the mortgages it will back so that more ... can buy homes.

... home buyer in the Valley using an FHA loan can now borrow up to $... Last year, a home buyer could borrow only a maximum of $112,750 with an FHA-backed loan.

About 80 percent of home buyers that use FHA loans are first-time purchasers or minorities. The loans require smaller down payments and often have more flexible programs to qualify.

Biltmore Center sold

The Biltmore Financial Center has been purchased by the State of Florida Retirement Fund for $37 million.

The 204,880-square-foot office project at 2390 E. Camelback Road was sold by RREEF of San Francisco, said Bob Young of CB Richard Ellis. He negotiated the deal with Glenn Smigiel, Don Worthington and Jim Fijan of the same brokerage.

The investment adviser RREEF bought the building just over two years ago.

Offices combined

The accounting firm Henry & Horne has combined its two Scottsdale offices and moved into its own new building near Scottsdale Road and Shea Boulevard.

The accounting firm had offices in the Scottsdale Airpark and near Scottsdale and Camelback Roads. Its new 20,000-square-foot building will house the firm's 45 employees.

Koll names executive

Koll Development has a new head for its Phoenix division.

The Newport Beach, Calif.-based developer has named Dominic Petrucci executive vice president of its Valley office, which is developing the office projects Arrowhead Fountains in Peoria and Lincoln Towne Center in Scottsdale.

New village officers

The Camelback East Village Planning Committee, which is promoting a village core concept for the area, has elected its 1999 officers.

The group represents the area from Northern Avenue on the north to the Grand Canal on the south, 64th Street on the east to Seventh Street on the west.

Barbara Filosi is the group's chairwoman. Pam Koester of the Arizona Association of Chiropractic is vice chairwoman, and Rose Arck of Arck Corporate Services has been elected secretary.

Catherine Reagor can be reached at 444-8040 or at catherine.reagor@pni.com via e-mail.

Northwest Airlines begins new year facing snow suit

Associated Press

DETROIT — Happy New Year, Northwest Airlines — 1999 has brought a barrage of complaints and a lawsuit over delays during last ... according to the government's Air Travel Consumer Report. It improved to No. 3 in October.

Northwest also regularly placed near the bottom in handling baggage and consumer complaints.

Company officials blamed the poor showing on bad weather and labor slowdowns, including the pilots' strike last summer, which produced a third-quarter loss of $223.8 million.

New River Dam

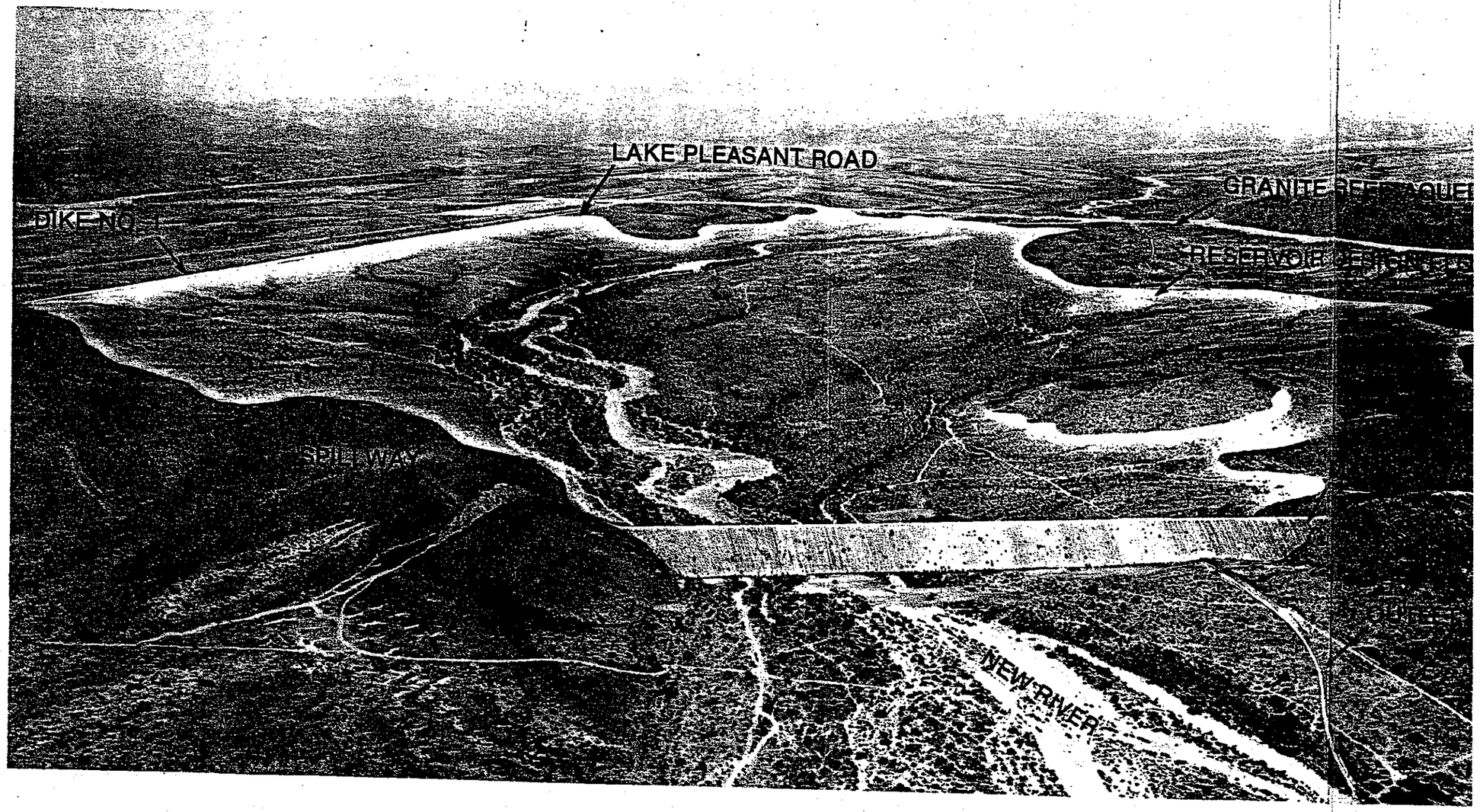
(including New River to Skunk Creek)

Draft

May 1982

Design Memorandum No. 3
General Design Memorandum Phase II
Project Design Part 3

New River Dam



PERTINENT DATA

Drainage Area	164 sq. mi.	Max. water Surface elevation	1481.0 ft., m.s.l.	Outlet Channel Base width	16.0 ft	Storage	
Type of Dam-Compacted Earth Filled							

GILA RIVER BASIN

PHOENIX, ARIZONA AND VICINITY
(INCLUDING NEW RIVER)

NEW RIVER DAM
(INCLUDING NEW RIVER TO SKUNK CREEK)

Design Memorandum No. 3
General Design Memorandum Phase II
Project Design Part 3

Draft
May 1982

Contents

	Page
SYLLABUS	xi
REPORTS PREVIOUSLY ISSUED	xiv
REPORTS SCHEDULED FOR FUTURE ISSUANCE	xvii
FIRST COSTS (OCTOBER 1981 PRICE LEVELS)	xx
PERTINENT DATA	xxi
1. INTRODUCTION	1
General	1
Scope of report	1
Project authorization	2
Status of postauthorization studies	3
Status of postauthorization construction	5
Dreamy Draw Dam	5
Cave Buttes Dam	5
Adobe Dam	6
Dam	6
Skunk Creek channel and levees	6
2. APPROVED PLAN	7
Project features	7
Dreamy Draw Dam	7
Cave Buttes Dam	8
Adobe Dam	10
New River Dam	11
Arizona Canal diversion channel	12
Dreamy Draw	14
Cave Creek	15
Skunk Creek	17
New and Agua Fria Rivers	19
Recreation	21
Dreamy Draw Dam	22
Cave Buttes Dam	23
Adobe Dam	24
New River Dam	26
Arizona Canal diversion channel	26
Cave Creek Regional Park	28
Skunk Creek and the New and Agua Fria Rivers	29
Esthetic treatment	29
Environmental effects	32
Historical, cultural, and archeological resources	36
Social effects	40
Economics of recommended plan	42
Cost estimates	42
First costs	42
Operation and maintenance	44
Annual charges	44
Benefits	46
Justification	49
3. DIVISION OF PLAN RESPONSIBILITIES	51
Cost apportionment	51
General	51

Contents (Continued)

		Page
	Flood control	52
	Recreation	53
	Federal responsibilities	56
	Non-Federal responsibilities	56
4.	PLAN IMPLEMENTATION	58
	General	58
	Departures from previous plan	58
	Design memorandums	60
	Construction sequence	64
	Design and construction schedule	65
5.	DEPARTURE FROM PHASE I PLAN	73
	General	73
	Comparison of costs	73
	Comparison of PB-3 estimate with Phase I Design Memorandum estimate	75
	Comparison of present estimate with PB-3 estimate	75
	Comparison of benefits	80
6.	LOCAL COOPERATION	83
	Flood control features	83
	Recreational features	87
	Mitigation features	89
7.	STATEMENT OF FINDINGS	91
8.	RECOMMENDATIONS	93

Tables

1	Summary of first costs	43
2	Summary of total investment and equivalent annual charges	46
3	Equivalent annual benefits, 3-1/4 percent for 100 years	48
4	Summary of equivalent annual charges and benefits, 3-1/4 percent for 100 years	50
5	Summary of equivalent annual charges and benefits, 7-5/8 percent for 100 years	50
6	Cost apportionment (rounded) for entire project	52
7	Summary of first costs for cultural resource preservation	53
8	Summary of first costs for recreation	54
9	Cost apportionment for New River Dam	57
10	Design and construction schedule	67
11	Comparison of first costs	74
12	Comparison of benefits	81

Plates

1 Approved plan—flood control
2 Recommended plan—recreation
3 Revised design discharges for approved plan

Reports Previously Issued

No.	Title	Date	Date Approved by OCE
	Interim Report on Survey for Flood Control - Phoenix, Arizona and Vicinity (Incl. New River)	Jan 1964	May 1965
1	New River and Phoenix City Streams, Arizona, Design Memorandum No. 1, Feature Design for Dreamy Draw Dam	Jan 1972	May 1972
	Supplemental Report, Floodway Delineation for Dreamy Draw (Dreamy to Arizona Canal)	July 1979	N/A
	Final Environmental Statement, Dreamy Draw Dam, Maricopa County, Arizona	Mar 1972	May 1972 (filed with CEQ)
2	New River and Phoenix City Streams, Arizona, Design Memorandum No. 2, Hydrology, Part 1	Oct 1974	Mar 1975

Reports Previously Issued (Continued)

No.	Title	Date	Date Approved by OCE
3	New River and Phoenix City Streams, Arizona, Design Memorandum No. 3, General Design Memorandum - Phase I, Plan Formulation	Mar 1976	Jul 1977 (SPD App)
	Final Environmental Impact Statement, New River and Phoenix City Streams, Maricopa County, Arizona	Mar 1976	Sep 1976 (filed with CEQ)
3	New River and Phoenix City Streams, Arizona, Design Memorandum No. 3, General Design Memorandum - Phase II, Project Design		
	Part 1 - Cave Buttes Dam (including Cave Creek to Peoria Avenue)	Jul 1976	Jul 1977
	Part 2 - Adobe Dam (including Skunk Creek to the Arizona Canal)	April 1979	Dec 1979

Reports Previously Issued (Continued)

No.	Title	Date	Date Approved by OCE
4	New River and Phoenix City Streams, Arizona, Design Memorandum No. 4, Overall Master Plan	Sept 80	N/A
5	New River and Phoenix City Streams, Arizona, Design Memorandum No. 5, Dreamy Draw Dam, Master Plan & Feature Design	Sept 81	Jan 82

of the dam. This channelization is required to assure conveyance of the SPF to the Adobe detention basin. Two training levees, which will intercept and concentrate floodwaters at the bridges, will be about 5550 and 6590 feet in length and will vary to a maximum height of 25.5 feet near the bridges. To preclude erosion, the 1V on 3H sideslopes will be revetted where necessary. A 629-foot-long rectangular concrete channel, 241 feet wide, will convey flows under the four existing bridges. A grouted stone section, 271 feet wide, will extend 596 feet downstream from the bridge section. The channel depth will vary from 18.5 to 14.5 feet with 1V on 2H sideslopes. The next 1440 feet will have an unlined invert and grouted stone sideslopes. At this point the levees will end, but channel excavation will continue to daylight where floodflows will reenter the existing water course.

NEW RIVER DAM

2.11 New River Dam will be constructed on the New River about 8 miles upstream from the confluence with Skunk Creek. The main embankment will be a compacted-earthfill structure with a maximum height of about 104 feet above streambed. The crest of the embankment (el. 1486.7, exclusive of settlement allowance) will be 2320 feet long. An earthfill dike, about 7000 feet northwest of the right abutment of the main embankment, will be required along the west edge of the detention basin area to confine the design flood. The dike will have a crest length of 7464 feet and a maximum height of about 36 feet. An unlined spillway, 700 feet west of the right abutment of the main embankment,

maintenance shop, and fencing. All cost-shared facilities must also be on project lands, which precludes cost sharing of any facilities planned for Thunderbird Park.

NEW RIVER DAM

2.40 Development of formal recreational facilities are not recommended at the New River damsite at this time. The abundance of natural vegetation and wildlife was a factor in the decision of the recreational task force not to undertake recreational development in the area. Another factor in the decision was that, of the recommended damsites, the New River site is farthest from the urban center. While hunting and other informal recreational activities will probably continue, no formal recreational facilities will be developed until such time as the demand warrants. The resource use plan to this report (appendix 2) outlines a land use plan for the dam basin that has been carefully coordinated with involved agencies. This plan provides for recreation and other uses of the project land while preserving its wildlife habitat and cultural resource values.

2.41 An overlook structure is planned as part of the flood control project at New River Dam. The facility will consist of a small parking area, a ramada-covered plaza, and an access road. The overlook is sited on the north end of dike 1 near Lake Pleasant Road.

ARIZONA CANAL DIVERSION CHANNEL (ACDC)

2.42 The recreational plan for the diversion channel is based on the development of a safe, functional, and esthetically pleasing trail system for equestrians, hikers, joggers, and bicyclists. The paved

2.57 The temporary storage and controlled release of floodwaters from the dams will increase localized groundwater recharge along downstream channels. While this will not significantly affect the overall groundwater regime in the study area, riparian habitat along the channels will benefit from the increased duration of flows.

2.58 Sand and gravel occur in recoverable quantities along the streambeds of the project area. Aggregate materials have been excavated from numerous locations along Cave Creek, Skunk Creek, and the Agua Fria, Salt, and Gila Rivers. The major sources of supply close to the City of Phoenix along the Salt and Gila Rivers will not be affected by the project. The only potential resource that will be permanently removed is the land under the proposed embankments. The stream channels will still be available for mining. The floodways and flowage easements will restrict urban development along the stream channels, helping to preserve sources of material adjacent to urban areas. Mining will be possible in the area behind the dams before the development of recreational facilities or in areas where no facilities are planned. The dams will trap some of the sediments that normally replenish the streambeds, but this will not significantly affect the quantity of sand and gravel available downstream. No active mining operations will be disturbed by construction of the project.

2.59 The dam embankments, dikes, and levees will require approximately 75 million cubic yards of material; primarily sands, silts, and gravels. An estimated 640 acres will be excavated as borrow to supply construction materials. Over 95 percent of this acreage will be within

2.68 Construction of the Arizona Canal diversion channel will result in approximately 11.5 million cubic yards of excess materials. The Flood Control District determined that waste areas presently available within 5 miles of the proposed channel can accommodate approximately 18.4 million cubic yards. After socioeconomic projects are considered, the waste area available in 1985 could just accommodate the 11.5 million cubic yards of excess material. An environmental assessment of New River Dam is included as an attachment to the Feature Design.

Historical, Cultural, and Archeological Resources

2.69 Surveys and literature searches to identify cultural resources in the project area were conducted in the fall of 1973 by Arizona State University, Department of Anthropology, under contracts with the National Park Service and the Corps of Engineers. The surveys resulted in the discovery of 85 historic and prehistoric sites. All but three of the sites are located within or on the margins of the rights-of-way for one or more of the project alternatives.

2.70 Temporarily, the sites range in age from historic activities of the early 1900s, such as ranch house foundations and areas of past cultivation, to sites representing a yet undefined Archaic Period that predates the earliest ceramic periods of about A.D. 100 to 500. State inventory forms for the sites investigated during the survey were submitted to the State Historic Preservation Officer. Subsequently, the State Historic Preservation Officer and the Keeper of the National Register determined that one site and the Cave Creek, New River Dam, and

Skunk Creek Archeological Districts were eligible for inclusion in the National Register of Historic Places. Pursuant to Section 106 of the National Historic Preservation Act of 1966 and to Title 36 C.F.R., Part 800.4, the Corps of Engineers requested the comments of the Advisory Council on Historic Preservation and prepared a preliminary case report containing relevant information about the project, and its effect on the National Register sites, and proposed plans to avoid or mitigate the adverse effects. Onsite inspections of the sites that will be affected were held prior to the formulation of a Memorandum of Agreement. This document (refer to Adobe Dam, Design Memorandum No. 3, General Design Memorandum — Phase II Project Design - Part 2, April 1979, Exhibit A) details the actions to be taken to avoid or mitigate the adverse effects of the proposed project on National Register sites. The Advisory Council has reviewed the proposal and has determined that it is sufficient. It has been signed by the Executive Director and Chairman of the Advisory Council, the Arizona State Historic Preservation Officer, and representatives of the U.S. Bureau of Land Management, National Park Service, Flood Control District of Maricopa County, and the Corps of Engineers. An archeological testing program was carried out at New River to evaluate the effects of dam construction and to design a cultural resources mitigation program to minimize the effects. Testing involved mapping sites, examination of surface and subsurface artifacts, and test excavations of surface and subsurface features. Prehistoric and historic artifacts and nonartifactual remains were collected from all sites and analyzed. This study resulted in the formulation of recommendations for the development of a research design

1. *Introduction*

Purpose and Scope

1.01 The New River Dam Feature Design is primarily a technical document designed to provide the basis for preparation of plans and specifications. The report provides justification for general feature dimensioning, siting, selection of construction materials, and management of basin resources. It carries forth general concepts of the Phase I General Design Memorandum (GDM), which recommended construction of a dam, a dike, a spillway, and outlet works in the proximity of the West Wing Mountains on the New River and management of the flood plain between the New River damsite and the Skunk Creek confluence under flood plain management principles. The authorized Phoenix and Vicinity Flood Control Plan is shown on plate 1. The report specifically addresses a revised site selection for the dam, spillway, outlet works, and access road; the addition of another dike; and revised real estate requirements.

The Phase II Process

1.02 Major studies initiated under the Phase I GDM have been supplemented in the Phase II process to achieve feature design quality. Studies specifically included in the feature design are summarized in table 1.

Bureau of Economic Analysis - U.S. Dept of Commerce

Economic Research Service - U.S. Dept. of Agriculture

Maricopa County Association of Governments

Historical Trends

Local and Regional Development Plans

3.38 It was projected that urbanization in the direction of New River Dam would reach Union Hills by the year 2020—approximately 6 miles downstream from the proposed damsite. It was also reasoned that much of the valley watershed, composed of State of Arizona School trust lands, would not be developed because State law would prohibit its sale.

3.39 Since 1980, several factors have changed the urbanization projection pattern of Phoenix rather significantly. Much of the modified projection is attributed to an unforeseen rapid increase in commercial movement to the Phoenix area followed by a rapid population increase. Recycling of land near the urban core to multiple-unit dwellings is increasing and has resulted in sending single-family units to outlying areas where land and prices are lower. This trend has been accentuated because of the existence of large privately owned tracts of land in the outlying areas that are increasingly attractive to the planned community developer. The natural geographic setting (mountains to the south and Indian Reservation to the east) has further accentuated the urbanization trend to the north and west of Phoenix.

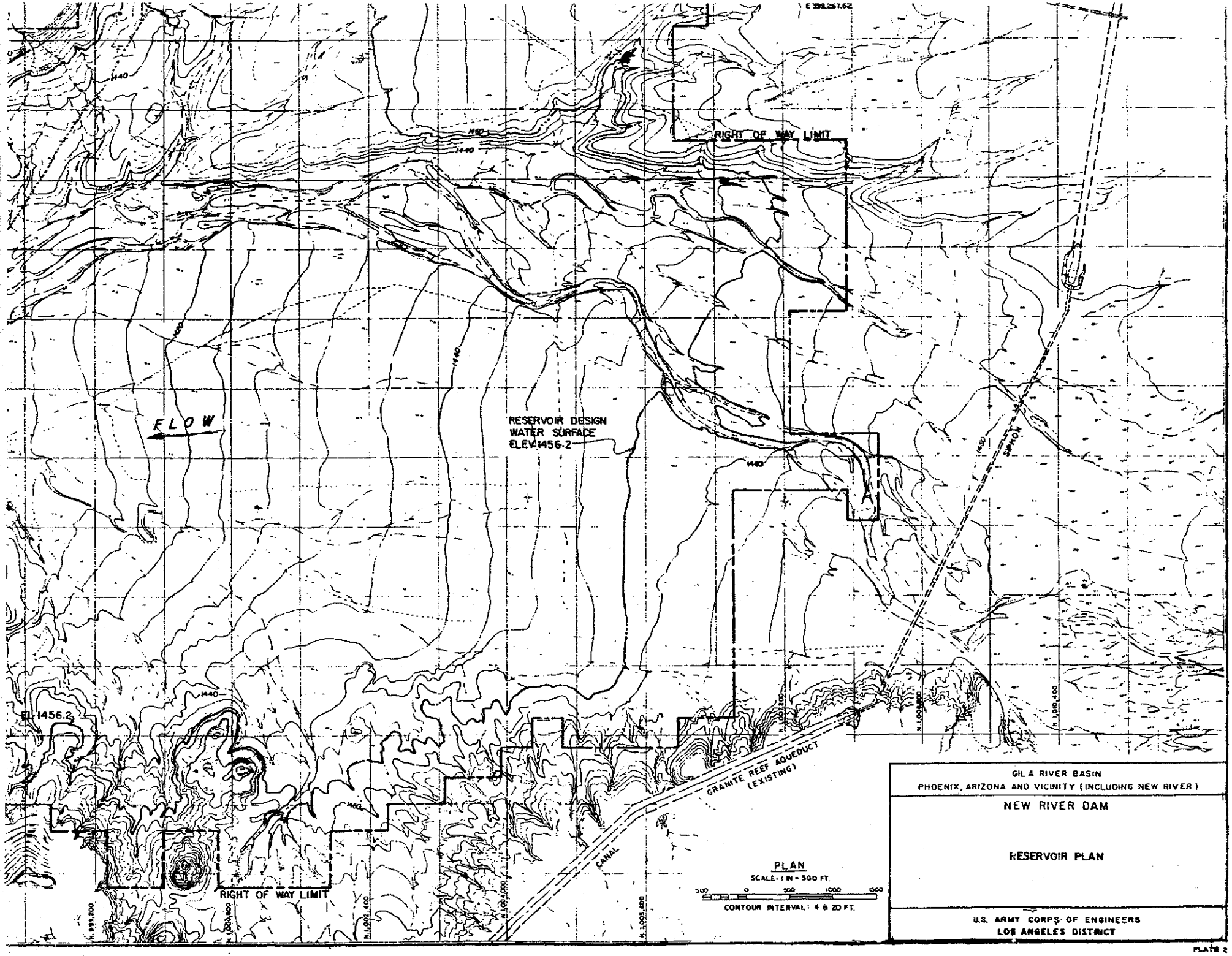
4.02 Land Use. The project area lies within an undeveloped area and provides open space for such land uses as grazing, hunting, and informal recreational use. Currently the nearest residential development is about 4 miles south of the project area. However, this is projected to change as metropolitan Phoenix continues to expand north and west. A solar community is currently being proposed for development on State lands adjacent to the project area. As urbanization continues to expand, New River Dam will become increasingly important as an area of open space. As stated in the FES, the area downstream of the proposed dam to the confluence with Skunk Creek will be subject to flood plain management.

4.03 Land Ownership. Land ownership consists of private lands purchased by the Flood Control District of Maricopa County (FCDMC, 1463 acres), State of Arizona lands currently being purchased by the FCDMC (480 acres), and Federal lands under administration of the Bureau of Land Management (BLM, 770 acres). The FCDMC currently holds a grant for BLM lands (770 acres) that permits construction and operation of flood control facilities. If the FCDMC's applications are granted for subsurface mineral rights and surface management rights on BLM lands, under the Federal Land Policy Management Act (FLPMA) and the Recreation and Public Purposes Act (R&PPA), respectively, effective management of all project lands will be assured.

4.04 Mineral Resources. The only known mineral deposits located within the project area are non-metallic resources of sand and gravel deposits. There has been no extraction of sand and gravel from within

the project area. Construction of New River Dam will not result in a shortage of sand and gravel for the areas adjacent to this project area, as the Agua Fria River, another source of sand and gravel, lies about one mile west of New River. A resource use plan, based on project resource use objectives has been developed to guide management (in three phases) of the flood control basin. Implementation of this plan will provide a more balanced use of the natural resources, as the plan identifies permitted uses for specific areas. Specific areas have been designated for preservation of sensitive biological and cultural resources. Mineral extraction will be permitted in high intensity use areas. Enforcement of such a plan becomes critical as sand and gravel supply in the Phoenix area dwindles, thus increasing the pressure to excavate within the boundaries of the project area. The Arizona State Land Department has not made any estimates of the amount of sand and gravel within the New River area or within the Phoenix area.

4.05 Air Quality. The project area lies within the Phoenix non-attainment area for carbon monoxide, ozone, and particulates. Although there is no monitoring of air quality within the project area, it is unlikely that the standard for each of these pollutants is exceeded. According to the Arizona Department of Health Services, Bureau of Air Quality, the boundary lines for the Phoenix non-attainment area are not based on measurements or models; the boundaries are the same as those used by the Maricopa Association of Governments to delineate their planning area. The lack of development within or adjacent to the project area indicates that pollutant levels are likely to be similar to those found in desert environments: low levels of carbon monoxide,



GILA RIVER BASIN
PHOENIX, ARIZONA AND VICINITY (INCLUDING NEW RIVER)

NEW RIVER DAM

RESERVOIR PLAN

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 2

Existing cultural resources

4.112 The basin area represents an important source of data on the nature of Hohokam settlement and subsistence patterns and on the relationship of these patterns to earlier Archaic settlements. Investigations conducted by the Museum of Northern Arizona have identified 41 archeological sites within the project limits that collectively represent habitation sites, agricultural fields, food gathering areas, and campsites. Three historic period sites, including a stage station, have also been identified. The New River cultural resource sites have been listed in the National Register of Historic Places as the New River Archeological District.

4.113 Geotechnical testing would have disturbed at least one site, which was recovered prior to testing. Close coordination has been maintained throughout the geotechnical testing program to assure that archeological resources are properly safeguarded. Construction limits have been established to preserve cultural resource sites while still allowing construction flexibility. All sites within the construction work limits will be recovered prior to the initiation of construction. Selected sites outside the work limits, but within the basin, will be preserved. Plate 6 of appendix 2 shows general archeological areas designated for preservation.

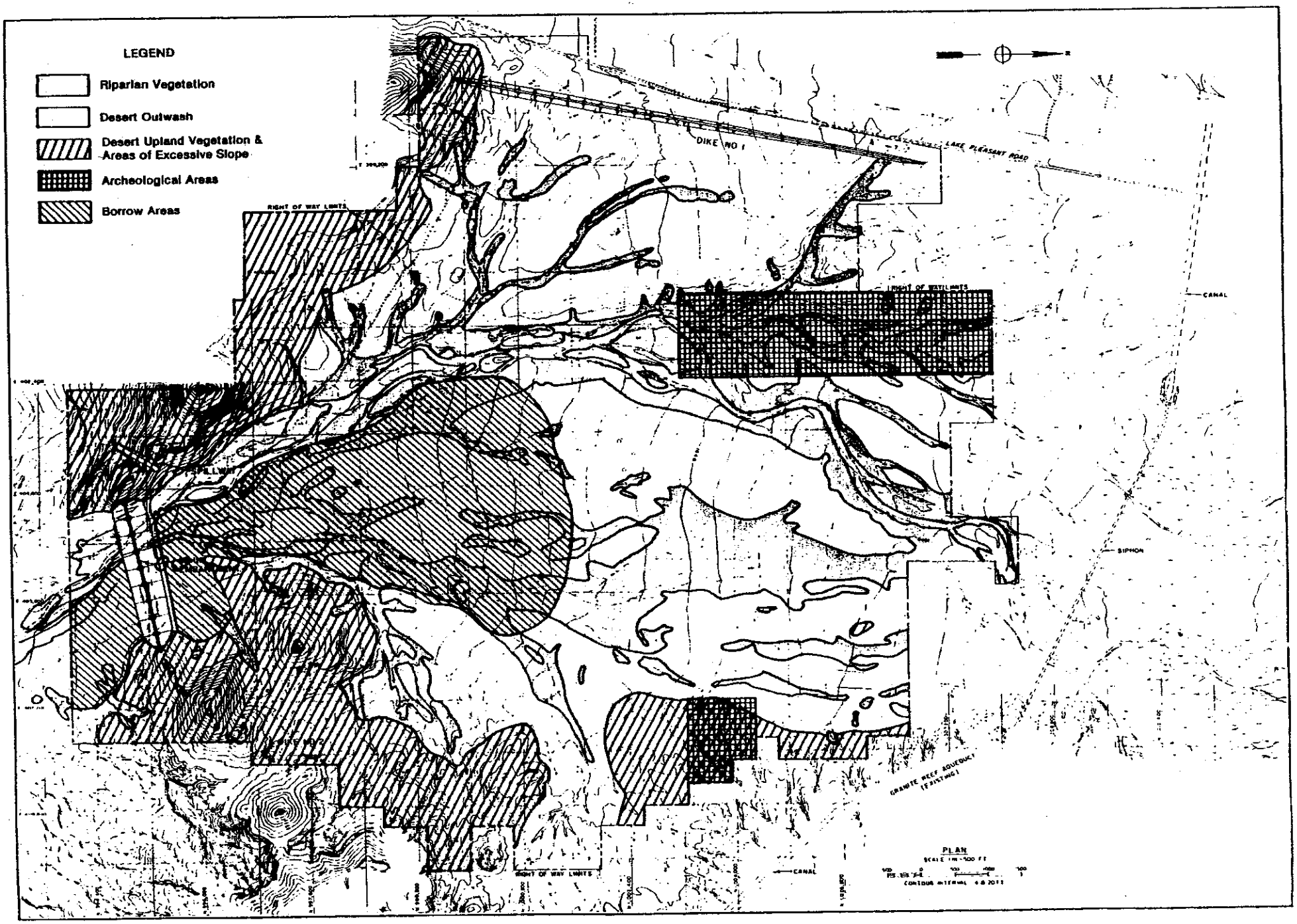


Figure 14. Significant Resources of New River Dam.

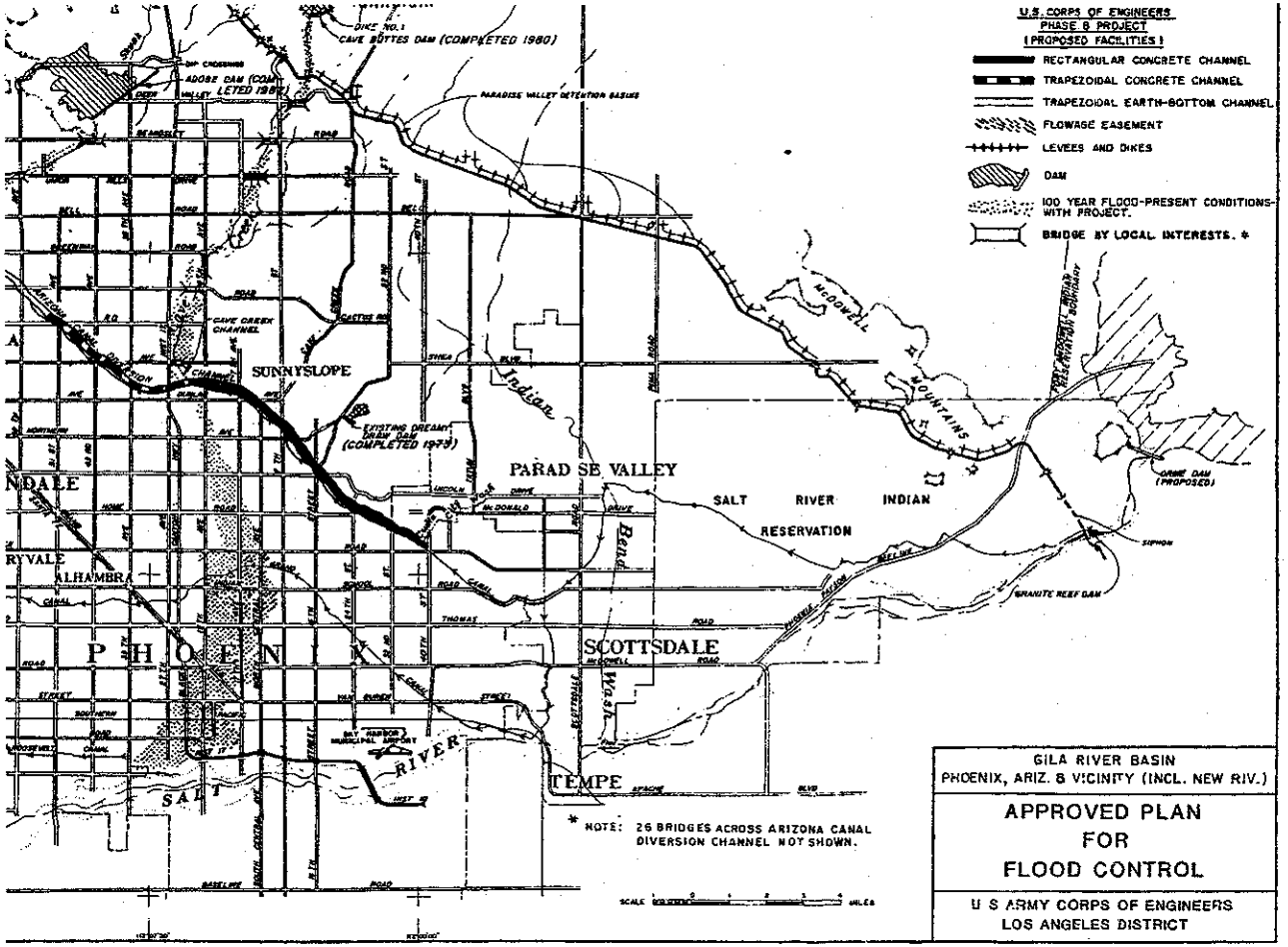
FLOOD CONTROL

7.03 The first cost of flood control features was based upon detailed quantity estimates and unit price development at October 1981 price levels. Quantity estimates were based on detailed design drawings. Large quantity items, such as borrow, excavation, dam and dike fill placement, slope protection, and spillway excavation, have been based upon a breakdown of plant, labor, and materials specific to the New River site. Other unit and lump sum costs have been developed strictly on the basis of comparable price analysis.

Borrow Areas

7.04 Borrow areas will be stripped of topsoil to a depth of 9 inches and stockpiled for later use. Stockpiled material will be spread over the borrow areas after construction and spread over the downstream slopes of the embankment and dike 1 prior to seeding. Impervious materials will be obtained generally from 1 to 6 feet in depth and will be moistened prior to excavation. Pervious shell and transition materials will be obtained from 3 to 13 feet below the ground surface and will not be moistened. Haul roads to borrow areas could use the northern exposure of the left or right abutments or an access ramp on the face of the dam. The average haul distance to the impervious borrow will be 0.2 and 1.9 miles for the dam and dike No. 1, respectively. The average distance to the pervious borrow will be 0.8 and 1.5 miles for the dam and dike No. 1, respectively.

7.05 Borrow materials will be blended at the borrow site.



GILA RIVER BASIN
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIV.)

APPROVED PLAN
FOR
FLOOD CONTROL

U S ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 1

1. *Introduction*

Purpose and Scope

1.01 Geology, soils, and materials investigations have been conducted for the following purposes (a) to determine the extent, distribution, and physical properties of the rock and soils at the site of the proposed New River Dam, dikes, and appurtenances; and (b) obtain detailed information on the foundation, construction materials, and groundwater conditions in order to provide a sound basis for the design of the proposed structures. This appendix describes the geologic and seismic setting, the geotechnical explorations, field and laboratory testing, analysis of data, foundation treatment, embankment design, construction considerations, instrumentation, and inspection plan.

Description of Project Features

1.02 The project provides for the following features:

a. A zoned earthfill dam, approximately 104 feet high (maximum) and about 2320 feet long at the crest, above the existing streambed at elevation 1486.7 feet (without settlement allowances) above mean sea level (msl).

b. A zoned earthfill dike, approximately 36.3 feet high (maximum) and approximately 7464 feet long at the crest, about 1.7 miles northwest of the right abutment of the dam at elevation 1486 feet (without settlement allowances).

2. *Topography, Geology, and Seismicity*

Regional Topography

2.01 The project area lies near the boundary of the Salt River Valley and New River-Cave Creek areas, portions of the Basin and Range physiographic province that are characterized by broad gently sloping valleys bounded by high rugged mountains. The project area is at the southern edge of a topographic and structural basin and is bounded to the southeast and southwest by the low-lying East and West Wing Mountains, respectively, and to the east by an unnamed group of peaks. The broad alluvial plain to the north and west of the project area extends up to the New River and Hieroglyphic Mountains. The damsite spans a narrow valley between the East and West Wing Mountains at the northern edge of Deer Valley, a small undissected tributary valley within the large plain of the Salt River Valley. The main drainage from the project area is through Deer Valley to the Agua Fria River and then to the Gila River. The New River begins in the New River Mountains about 40 miles north of Phoenix, is approximately 40 miles long and has a drainage area of about 350 square miles. The New River merges with Skunk Creek, approximately 8 miles below the damsite, then flows about 8 miles further downstream before merging with the Agua Fria River.

Regional Geology

2.02 The rock types existing in the mountainous areas within the project area are very similar. The basement complex consists predominantly of Precambrian granite and related crystalline rocks with

lesser amounts of schist and gneiss. These formations are extensively exposed along the eastern and southeastern margins of the project area. Elsewhere, they are covered by sediments or lava flows. Lava flows of Tertiary to Quaternary age cover a considerable area along the southwestern margin of the project area and cap a small isolated hill north of the damsite. The flows are composed of andesite (felsite), rhyolite, and vesicular basalt, and locally include tuff, flow breccia, and tuffaceous agglomerate. Exposures of Tertiary intrusive igneous rocks, consisting mainly of granite and monzonite, are found in the mountains to the east. Older Quarternary sediments are found on the slopes of most of the hills. The most extensive Quarternary deposits in the area are the poorly to well consolidated older alluvial materials that consist mainly of gravel, sand, silt, and clay and contain varying amounts of caliche. These materials form the nearly flat valley floor and extend to undetermined depths beneath the surface of valley. Recent alluvium, consisting mainly of unconsolidated coarse sand and gravel, fills the channels of the main stream courses and the tributaries associated with flood plain washes. Bedrock, similar to that of the nearby hills and mountains, underlie the alluvial deposits at great depths.

Geologic History

2.03 During the late Miocene time, subsidence, block-faulting, and erosion occurred in southwestern Arizona, which broke up the region with its existing Precambrian and younger rocks. This "gave the area a

typical basin and range structure of mountain-forming horsts separated by valleys underlain by grabens or half-grabens" (Eberly and Stanley, 1978).

2.04 Sediments were deposited in these troughs or grabens during late Cenozoic time. These sediments consisted of clastics and lesser amounts of interbedded volcanic rocks, and in some valleys, thick intervals of evaporites. All are continental deposits. Estimates of thickness of these sediments range up to 3,000 feet in the Deer Valley area, a few miles south of the proposed site for the New River Dam.

2.05 Many of the older volcanics are from the Mid-Tertiary (late Oligocene and early Miocene) orogeny, which produced great quantities of rhyolitic to andesitic tuffs, breccias, and flows. Fanglomerates and lacustrine deposits alternate with these volcanics. Overlying these volcanics and other deposits are fanglomerates (containing volcanic detritus), as well as beds of water-laid tuffs and other sediments interlayered with and overlain by basaltic lava flows. These are believed to be middle to late Miocene in age. The youngest basalts are possibly 6 million years or less, making them Pliocene in age, similar to the basalts near Gila Bend and Gillespie Dam.

Faulting

2.06 The major structural features for the State of Arizona are shown on plate 2. The greatest concentration of faults primarily coincides with the Transition Zone physiographic province and the Basin and Range Mountain Region subprovince along the Jerome-Wasatch Structural Zone.

This structural zone is a tectonic lineament roughly 60 miles wide which is characterized by long, continuous, subparallel, normal faults trending generally to the north and northwest. This zone extends from Utah south to southeast across Arizona into Mexico and is associated with numerous earthquakes and contains evidence of Quaternary faulting. The edge of this postulated zone is approximately 30 miles northeast of the project area at its closest approach.

2.07 The most significant fault in the State of Arizona is the 100-mile-long Main Street fault, which trends north-south and is about 150 miles northwest of the project area. A maximum credible earthquake of magnitude 7.5 could be generated on this fault. This could result in a bedrock acceleration of approximately 0.04g at the proposed damsite. The Verde fault system, located approximately 45 miles northeast of the project area at its southerly extent, has a total length of about 45 miles. However, this fault system consists of several splays and segments. The longest and most continuous segment is the central segment which is about 17 miles long. A maximum credible earthquake of magnitude 7.0 is possible over the total length of the Verde fault system. This could result in a maximum bedrock acceleration of approximately 0.08g at the site of the New River Dam (after Schnabel and Seed, 1973). The largest earthquake ever recorded near the Verde system was one of magnitude 5.1 in 1976, which would have produced a ground acceleration of less than 0.01g at the proposed damsite. The third largest fault system is near Globe, Arizona, approximately 95 miles east-northeast of the project area. This system is about 42 miles long

and is not considered active. The Main Street and Verde fault systems have shown signs of Quaternary movement. There have been, however, no historic or Holocene surface ruptures recorded.

2.08 The project area is located in the Basin and Range structural province whose general structural configuration is that of parallel horsts and grabens produced by block faulting. Block faulting and tilting have had an important effect upon the topographic forms in the project area. These structural movements probably reached a maximum during the Tertiary period and have affected the Quaternary lavas and sediments. Although of considerable magnitude, the faulting and tilting apparently have been gradual and the tilted blocks are not greatly broken up. The strike of the major movements conforms with the general northwest structural trend of the region; however, there are numerous northeast-trending cross faults.

Local Geology

2.09 The proposed damsite is about 23 miles northwest of Phoenix and about 7 miles west of Black Canyon Highway. The damsite spans the New River between the West Wing Mountains, which form the right abutment, and Keefer Hill, a westward projection of the East Wing Mountains, which form the left abutment. The valley is approximately 2000 feet wide at the project site. The West Wing Mountains are composed of various Tertiary volcanic rocks described as felsite, flow breccia, tuff, and tuffaceous agglomerate. The valley floor consists of poorly to well-cemented Quaternary silts, sands, and gravels that are underlain by

Tertiary volcanics near the right abutment and Precambrian granites near the left abutment. The thickness of this older alluvium at the site varies from a few feet near both abutments to an approximate depth of 136 feet near the center of the valley. The older alluvium is masked by shallow deposits of younger alluvium, consisting of loose sands, gravels, and cobbles with occasional boulders, which are generally found in the active stream channel and the smaller washes. The older alluvium includes slope wash and residual soil found on both abutments and the spillway sites. The East Wing Mountains, including Keefer Hill, are composed primarily of Precambrian granite and granodiorite with minor gneiss, vein quartz, and schist intrusives. See plate 3 for a geologic map of the damsite.

Groundwater

2.10 The New River, an ephemeral stream, flows generally south from its headwaters in the New River Mountains, through the project area on the boundary between the Salt River Valley and New River-Cave Creek groundwater areas, and emerges into Deer Valley where it meets Skunk Creek and continues south to its confluence with the Agua Fria River. In both groundwater areas, the principal aquifers are mainly alluvial deposits located in the central parts of the basins, but small water supplies can be obtained locally from the crystalline and consolidated sedimentary rocks in the mountains bounding the basins. The alluvial deposits range in thickness from a few tens of feet near the mountains to more than 1200 feet approaching the center of the basins. South of the project area, groundwater flow is in a southerly direction, toward a major cone of depression in Deer Valley.

2.11 Recharge to the groundwater basins is derived from seepage of irrigation waters, stream flows, rainfall and underflow of groundwater. There is very little recharge from stream flow and rainfall and the amount of recharge from irrigation seepage and underflow has not clearly offset the lowering of the water table due to the pumping of water for irrigation, increase in population, high evaporation and low annual precipitation.

2.12 In 1946, the highest groundwater depths in Deer Valley ranged from 161 feet in well (A-4-2) 19 bcc, approximately 4-1/2 miles southeast of the damsite to 173 feet in well (A-4-1) 10 daa, approximately 2 miles south of the right abutment of the damsite. In 1979-80, the depth to groundwater in these same general areas ranged from 449 feet in well 19 bcc to 494 feet in well (A-4-1) 10 aab, about 1/2 mile north of well 10 daa. These results show a water level decline of approximately 300 feet or an average decline of about 9 feet per year. There has been a decrease in the rate of decline of the water table since the mid-1960s, based on data from well 19 bcc and well (A-4-1) 22 bbb, approximately 4 miles southwest of the right abutment of the damsite. In well 19 bcc, the decline has been about 2-1/2 feet per year from 1963 to 1980. In well 22 bbb, the decline has been about 4 feet per year from 1963 to 1979. This decrease in the rate of decline of the water table can be attributed to the progressive change from agricultural to residential and industrial land use and a decrease in the pumpage for irrigation.

2.13 There are no water-well data available for the area in the immediate vicinity of the damsite. It is estimated that the depth to groundwater is below 70 feet (elevation, 1320 feet) based on information

from bucket auger test holes, TH 80-35 and TH 80-38, where possible groundwater was encountered at depths of 84 and 70 feet, respectively. It was not determined if groundwater was encountered in any of the diamond core holes drilled during subsurface investigations. Perched water tables were encountered in bucket auger test hole TH 80-36 at a depth of 39 feet, and test trenches TT 80-197, TT 80-198, and TT 80-200 at depths of 10 feet, 22 feet, and 15 feet, respectively. See plate 4 for the locations of the test holes and test trenches.

2.14 The only local groundwater information is provided by the following wells. In 1970, the depth to groundwater in well (A-5-1) 26 bca, about 1 mile north of the right abutment of the damsite was 126 feet (elevation, 1294 feet). In 1979, the depth to groundwater in well (A-4-1) 1 dcb, almost 2 miles southeast of the damsite, was 320 feet (approximate elevation, 1045 feet). The higher groundwater at the damsite is the result of bedrock constrictions in the narrow confines of the valley.

2.15 Groundwater information for dike no. 1 was obtained from well 26 bca, discussed in paragraph 2.14, about 1 mile east of the proposed dike, and well (A-5-1) 10 aab, less than 2 miles north of the dike. In 1969, the depth to groundwater in well 10 aab was 256 feet (elevation 1318 feet). Based on data from these two wells, it is estimated the depth to groundwater in the vicinity of the dike is greater than 150 feet.

3. *Economic Geology*

Natural Resources

3.01 The natural resources considered in this statement are those resources that have a large enough volume or value so that their exploitation would have a significant impact on the water use, land use, or economy of Maricopa County. The resources are discussed in three general groups; mineral and fossil fuels, metallic minerals, and nonmetallic minerals. All data is derived from the "Lower Colorado Region Comprehensive Framework Study," U.S. Department of Interior.

Mineral and Fossil Fuels

3.02 There are no known resources of coal or crude oil in Maricopa County. The nearest field source of coal to the project area is the Deer Creek field, a relatively minor field in eastern Pinal County, located about 100 miles southeast of downtown Phoenix. Although appreciable uranium-vanadium deposits have been located in Coconino, Navajo, and Gila Counties, none have been located in Maricopa County. The closest uranium resources to the study area lie in the Sierra Ancha Mountains in the Tonto National Forest, 75 miles east of Phoenix.

Metallic Minerals

3.03 South of the study area, in a wide belt running southeast through Pinal, Pina, and Santa Cruz Counties, lies a district in which disseminated copper and copper-molybdenum areas are being developed for

future large-scale mining. A large volume of potential iron resources occur in the Hieroglyphic Mountains (Pikes Peak district) 25 miles northwest of Phoenix. Known resources in the area total about 90 million short tons.

Nonmetallic Minerals

3.04 Halite (common salt) has been discovered underground 20 miles west of Phoenix in wells drilled about 1 mile apart. In one well, below 880 feet, more than 3000 feet of solid halite were penetrated. This resource could also be used as a raw material for the chemical industry.

3.05 Sand and gravel, a resource that is becoming more limited in the study area because of vast quantities of aggregate materials used by the construction industry, occurs in recoverable concentrations in exposed and buried stream channels, on terraces near mountain fronts, and alluvial fans. The materials near the mountain fronts contain a higher ratio of gravel to sand, where as the basin fills are mostly sand and silt. In 1970, Maricopa County produced 6,350,000 tons of sand and gravel, which represented more than a third (35.7 percent) of the production for the State. Up to the present time, there have been no sand and gravel operations within the project area. Other significant mining activities include the production of scrap mica near Buckeye in Maricopa County, and miscellaneous clay and shale for manufacturing building brick, mined at the Tolleson pit in Maricopa County.

4. *Field Investigations*

General

4.01 Two alternative damsites have been geotechnically investigated and evaluated. The first site considered was presented in the Phase I GDM and is referred to as the Phase I site. This site is on the New River approximately 7 miles north of Bell Road. The second site is approximately 2000 feet downstream (measured along the natural streambed) and is referred to as the Phase II site.

4.02 The Phase I site was explored between March 1970 and January 1972, as discussed in the Phase I GDM; the Phase II site was explored in detail between November 1979 and May 1981. Geotechnical considerations had no significant influence on the selection of the Phase II site over the Phase I site. The Phase II site was selected on the basis of economics.

Geotechnical Investigations of the Phase II Damsite

4.03 Subsurface investigations were conducted at the New River damsite for the foundation of the dam, dikes, outlet works, three alternative spillways, and potential borrow areas to determine the design and cost data for constructing an earthfill dam, two dikes, and appurtenant works. The geotechnical investigations consisted of geologic reconnaissance and mapping, shallow seismic refraction surveys, diamond core drilling, bucket-type power auger drilling, trenching, and field and laboratory testing.

Borrow Areas

4.14 The subsurface investigation of the potential borrow areas consisted of drilling 16 test holes, TH 71-2 through TH 71-4, TH 71-7, TH 71-8, TH 71-14 through TH 71-15, TH 71-19, TH 71-20, TH 71-24, through TH 71-26, TH 71-30 and TH 71-31, in 1971. The test holes were drilled with a bucket-type power auger to depths ranging from 5 to 13 feet. Sixteen test trenches, TT 71-7, through TT 71-13, TT 71-15, TT 71-16, TT 71-20, and TT 71-22 through TT-71-27 were also excavated in 1971. All these trenches except TT 71-13 were excavated with a dozer. Seventy-nine test trenches, TT 79-31, TT 80-33 through TT 80-86, TT 80-91 through TT 80-99, TT 80-101, TT 80-108 through TT 80-110, TT 80-186 through TT 80-194, and TT 80-196 were excavated in 1979 and 1980, with a backhoe. Locations of the test holes, test trenches, and borrow areas are shown on plate 13. Large representative disturbed samples were obtained at 3-foot intervals or at each change in soil type for classification tests and blending for detailed laboratory testing.

Stone Revetment

4.15 Visual inspections of potential stone sources, stockpiles of cobbles and boulders at gravel plants along the Salt, Agua Fria, and New Rivers, and Cave and Skunk Creeks were made to determine if sufficient amounts of stone revetment could be produced from these stockpiles. These sources would all be within approximately 30 miles of the damsite. A stockpile of oversize rock, excavated from the Central Arizona Project (CAP) Agua Fria tunnel outlet about 5 miles northwest of

5.03 The minus 12-inch gradations of these tests are summarized in tables 2 and 3. The fine limit, upper quartile, median, lower quartile, and coarse limit for the materials tested are shown in figures 1 and 2, respectively. Because of stratification of the foundation, the terms Stratum A, B, and C have been adopted for use in identifying the foundation strata, as explained in paragraphs 6.02, 6.05, and 6.10, respectively, of this appendix.

PERMEABILITY TESTS

5.04 Permeability tests were performed in shallow pits dug in the bottoms of the trenches excavated for TH 79-32 through TH 79-34, and TH 80-35. The purpose of these tests was to obtain large scale field data that would be used as a guide in determining a representative coefficient of permeability for the foundation materials. To perform the test, a 25-inch steel casing was placed in a pit, and a compacted backfill consisting of bentonite mixed with native soil was placed around the casing. The compacted backfill formed a seal around the casing which prevented the upward movement of water. A constant head permeability test (Test Method E-18, Bureau of Reclamation Earth Manual) was then performed. The results of the tests are shown in table 4.

5.05 The permeability test performed in test hole 79-32 at a depth of 13 feet developed leakage around the casing, which is responsible for the high permeability value obtained from this particular test on the Stratum C Material.

Table 4. Dam foundation—Field permeability.

Test hole	Depth (ft)	Field permeability (fpd)	γd (field) (lb/ft^3)	-4 (%)	-200 (%)	Materials source
79-34	10	22.7	146.5	27	4	Stratum B
80-35	8	19.4	139.7	36	9	Stratum B
79-32	13	18.5	149.9	24	4	Stratum C
79-33	9	8.5	137.5	53	6	Stratum C
79-34	18	6.2	141.	24	5	Stratum C
80-35	18	8	-	17	5	Stratum C

*From large-scale density tests.
- No value obtained.

PRESSURE TESTING

5.06 Hydraulic pressure testing, consisting of pumping water into a predetermined depth increment in a core hole and noting the quantity of water pumped at any given pressure for a specific period of time, was conducted using a single packer to seal off the section (generally a 20-foot interval) to be tested. Pressure tests were performed to locate potential zones of leakage and to determine the permeability of the rock. The results of the tests are shown on plates 15 through 20.

REFRACTIVE SEISMIC SURVEY

5.07 The geophysical explorations consisted of conducting refractive seismic surveys at the locations shown on plates 6 and 12 to determine the depth to bedrock and subsurface P-wave velocities along the dam

Dike No. 1 foundation

5.13. The results of classification and moisture content determinations are shown on soil logs on plate 28. The results of the soluble salts test are presented in attachment B.

Borrow areas

5.13 The results of classification and moisture content determinations are shown on soil logs on plates 29 through 34. The results of all detailed laboratory tests on shear strength, consolidation, permeability, dispersion, and compaction are presented in attachment B. A summary of the "Q" and "R" triaxial compression, consolidation, permeability, compaction, and the test sample gradations are presented on plates 35 and 36 for the core materials and plate 37 for the pervious shell materials.

5.15 Dispersion tests were performed on samples representative of the upper quartile, median, and lower quartile gradations of the core material. Initially pinhole dispersion tests were to be performed on the samples; however, the holes drilled in the remolded samples collapsed during the saturation phase of each test, necessitating double hydrometer tests instead (Sherard, Decher, and Ryker, 1972).

6. *Analysis of Data*

Dam Foundation

GENERAL

6.01 The foundation materials consist of layered homogeneous alluvial soils extending to a depth of 136 feet. Interpretation of the data contained on the soil logs and visual examination of the sides of the dozer trenches (pl. 38), excavated in the dam foundation indicate that there are three distinct soil layers in the dam foundation above the bedrock. The approximate geologic profile along the centerline of the dam is shown on plate 39.

STRATUM A

6.02 The first soil layer, designated Stratum A, varies in thickness from 2 to 9 feet. It consists mostly of silty sand and has been eroded away to form the banks of the active channels. The percent passing the No. 200 sieve varies from 25 to 51 percent, and the in-situ dry density varies from 98.5 to 105.8 pounds per cubic foot (lb/ft^3) with an average value 101.5 lb/ft^3 (80-percent compaction). The in-situ moisture content varies from 1.2 to 2.9 percent with an average value of 2.2 percent. Thin lenses of fine sand are found in this stratum. The results of the in-situ density tests for this stratum are presented in table 1.

6.03 The statistical analysis of the percent passing the No. 4 and No. 200 sieves and the Atterberg limits are summarized in the following tabulation.

Foundation-Stratum A

	Sieve (No.)	Coarse limit	Lower quartile	Median	Upper quartile	Fine limit
			Percent finer*			
Unblended	4	80	93	94	98	100
	200	22	33	37	40	57
Atterberg limits:						
LL		-	-	-	-	27
PI		NP	NP	NP	NP	6

*Based on minus 3 inch samples.

6.04 The in-situ densities and gradations of the materials in Stratum A indicate that they would have low shear strengths and be compressible and, therefore, are considered not suitable for the dam foundation.

STRATUM B

6.05 The second soil layer, designated Stratum B, consists mostly of sandy gravels having between 48 and 80 percent plus No. 4 material and a fine content that varies between 1 and 9 percent. The stratum varies in thickness from 6 to 10 feet and has lenses of fine sand and silty sand that vary in thickness form about 2 inches to 1 foot. The in-situ dry density of this stratum ranges from 125.2 to 146.5 lb/ft^3 with an average value of 139.8 lb/ft^3 The relative density (ASTM D 2049) of the material varies from 52 to 107 percent and the percent compaction (ASTM D 698-70) varies from 91 to 103 percent with average values of 80 to 97 percent, respectively. The in-situ moisture content varies from 2.5 to 3.8 percent with an average value of 3.2 percent. The results from TT 80-197 at 8 feet were not included in this analysis because of errors

made in the large-scale density test. The results of the in-situ density tests, relative density tests, and compaction tests are presented in table 1.

6.06 The statistical analysis of the percent passing the 3-inch, No. 4, and No. 200 sieves, and the Atterberg limits is summarized in the following tabulation.

Foundation-Stratum B

Item	Sieve (No.)	Coarse limit	Lower quartile	median	Upper quartile	Fine limit
		Percent finer*				
Unblended	3 in.	55	70	74	83	92
	No. 4	20	24	28	33	52
	No. 200	1	2	2	4	9
Atterberg limits:						
LL		-	-	-	-	-
PI		NP	NP	NP	NP	NP

*Based on minus 12-inch samples.

6.07 Based on the preceding statistical summary of the gradation data for Stratum B and the field density data, selected representative materials were remolded to approximately 85-percent relative density, 133.4 lb/ft^3 for detailed laboratory testing. The laboratory testing consisted of shear strength and permeability tests, using 12- and 18-inch-diameter cylindrical samples, respectively. The gradations of materials on which laboratory tests were conducted are shown in figure 1 along with the field gradations of representative in-situ materials for comparison purposes.

6.08 The maximum total shear strength of this material has a cohesion (c) of 1200 pounds per square foot (lb/ft^2) and friction angles (Ø) of 33 degrees. Conservative test results for the total shear strength used in design are shown in figure 3. The effective shear strength for this material has a Ø' value of = 40 degrees. The effective shear strength test results are shown in figure 4. The permeability values for the in-situ field tests were 19.5 and 22.7 feet per day (fpd) (table 4), and the laboratory tests ranged from 2 to 20 fpd.

6.09 The results of field and laboratory tests of the materials in Stratum B indicate that they would have high shear strengths and low compressibility, and therefore, are suitable for the dam foundation. Because of their high permeability, however, they are considered not suitable for foundation of the core.

STRATUM C

6.10 The third soil layer, designated Stratum C, consists mostly of cemented sandy gravels having between 46 and 83 percent plus No. 4 material and a fine content that varies between 3 and 9 percent. This stratum extends down from Stratum B to bedrock at a maximum depth of 136 feet below ground surface. The in-situ dry density of this layer varies from 123.5 to 149.9 lb/ft^3 with an average value of 140 lb/ft^3. The relative density (ASTM D 2049) of the material varies from 75 to 126 percent and the percent compaction (ASTM D 698-70) varies from 98 to 102 percent with average values of 97 and 100 percent, respectively. The in-situ moisture content varies from 1.9 to 5.2 percent with an average value of 3.7 percent. The results of the in-situ density tests, relative density tests, and compaction tests are presented in table 1.

6.11 The statistical analysis of the percent passing the 3-inch, No. 4, and No. 200 sieves and the Atterberg limits are summarized in the following tabulation and shown in figure 2.

Foundation-Stratum C

Item	Sieve (No.)	Coarse limit	Lower quartile	Median	Upper quartile	Fine limit
			Percent finer*			
Unblended	3 in.	51	65	70	80	91
	No. 4	17	24	27	33	53
	No. 200	3	4	5	6	9
Atterberg limits:						
LL	27	33	48	58	75	
PI	4	10	23	31	46	

*Based on minus 12-inch samples.

6.12 Based on the preceding statistical summary of the gradation of Stratum C and the field density data, selected representative materials were remolded to approximately 85-percent relative density 126.5 pcf, for detailed laboratory testing. The laboratory testing consisted of shear strength, consolidation, and permeability tests using 12-inch-diameter cylindrical samples for the shear strength and consolidation tests and 18-inch-diameter cylindrical samples for the permeability tests. The gradations of materials on which laboratory tests were conducted are shown in figure 4, along with the field gradations of representative in-situ materials for comparison purposes.

6.13 The total shear strength of this material has a c = 2000 lb/ft^2 and a ϕ = 14 degrees. The tests results for the total shear strength are shown in figure 5. The effective shear strength of this material

has a $\emptyset'$ = 36 degrees. The tests results for the effective shear strength are shown in figure 6. The permeability values for the in-situ field tests ranged from 6.2 to 8.5 fpd and for the laboratory tests from 2 to 4 fpd.

6.14 Two consolidation tests were performed on remolded samples of the minus 2-inch material of Stratum C. No undisturbed samples were obtained or tested because of the coarseness of the in-situ materials. The consolidation tests results are presented on plate 27. The coefficients of consolidation (Cc) of these tests were 0.059 and 0.065.

6.15 The results of field and laboratory tests of the materials in Stratum C indicate that they would have high shear strengths, low compressibility, and a relatively low permeability and, therefore, are considered suitable for the dam foundation including the core.

LIQUEFACTION

6.16 An evaluation of the data and conditions at the site indicates that the foundation materials of the dam are not susceptible to liquefaction because of the following conditions:

a. The embankment will be constructed in an area of relatively low seismic activity. The project site is located in Zone 1, seismic risk map of the United States.

b. The foundation materials will be extremely coarse and highly resistant to loss of strength from pore pressure built-up because of cyclic loading. Foundation materials beneath the embankment are moderately to highly cemented. The cemented materials are resistant to any loss of strength because of pore pressure build-up.

c. The groundwater at the site is located at least 70 feet below ground surface, but in fact may be at a depth greater than the maximum depth to bedrock at the site, which is approximately 136 feet.

d. Partial saturation of the upper foundation may occur only during flood pool storage whose maximum duration is 19 days based on the maximum probable flood pool routing.

BEDROCK

6.17 Subsurface exploration indicates that the bedrock profile is very irregular. Bedrock is exposed on both abutments, then slopes down to a known maximum depth of 136 feet in the west central part of the streambed approximately 700 feet east of the toe of the right abutment (station 24+00).

6.20 Results of investigations conducted from station 13+00 to 25+00 indicate a shallow, gently dipping, granitic bedrock surface extending from its surface contact at the left abutment to a depth of 25 feet in TH 79-34 (station 19+80), then dropping off very rapidly to its known depth of 136 feet in DD-17A (station 24+00). The upper 2 to 15 feet of the granite is generally soft to moderately hard and decomposed to highly weathered. This zone of intense weathering extends to a depth of 4 feet near the left abutment, 7 feet in DD-34, 22 feet in DD-14, and 25 feet in DD-15. The underlying more competent granite is moderately hard to hard, moderately to highly fractured, and slightly to moderately

weathered. See plate 15 for the geologic logs of core holes drilled along the proposed dam alinement and plates 5, 40, 41, and 42 for the embankment foundation and outlet works test trench logs.

6.21 Interpretation of data from the refractive seismic surveys conducted from the toe of the left abutment toward the center of the valley along the proposed dam alinement, lines 1, 2, 11, and 13, were not conclusive when compared with subsurface information obtained by drilling and trenching. Survey data indicate a generally thin, low velocity surface layer (1000-1380 ft/s) representing poorly consolidated alluvium extending to an average depth of 3 feet (with a maximum depth of 10 feet). An intermediate layer with seismic velocities ranging from 3500 to 4700 ft/s, indicative of moderately consolidated alluvium, was found to extend to various depths, ranging from about 74 feet near station 19+00 to 44 feet near DD-14 and to 57 feet in the vicinity of the outlet works. Below these depths, bedrock velocities ranging from 6700 to 10,000 ft/s were encountered. An exception to this three-layer sequence was found at line 13 where a 9- to 25-foot-thick layer with seismic velocities from 2400 to 3500 ft/s was indicated beneath the low velocity surface layer. This anomaly may be attributed to layers of caliche or cobbles and boulders that are discontinuous in length, and vary in thickness and degree of cementation.

6.22 After comparison with drill hole, test hole, and test trench data indicating granitic bedrock at much shallower depths, it appears the boundary between the intermediate and higher velocity layers may

actually reflect the contact between weathered and unweathered granite and that density contrasts between the more consolidated alluvium and weathered bedrock are too minimal to be recorded.

6.23 Refractive seismic survey line 12, which explored a possible location for the outlet works near the toe of the left abutment (near DD-16), revealed a 3-1/2-foot-thick, low velocity surface layer (1350-1550 ft/s) overlying competent granitic bedrock with an average seismic velocity of 8800 ft/s. This compared favorably with the hard, moderately to highly fractured granite encountered at a depth of 4 feet in DD-16. A comparison of line 12 with survey line 11 seems to indicate a steeply dipping unweathered bedrock surface. Core recovery in DD-14 was very poor (only 17 percent) to a depth of 44 feet where competent granite with an average seismic velocity of 7400 ft/s was encountered. This depth was remarkably close to the depth of the postulated contact between weathered and unweathered granite interpreted from refractive seismic survey line 1. Low core recovery (48 percent) in DD-15 may account for the low average seismic velocity of 4100 ft/s for the weathered granite. No faults were encountered in any of the embankment holes drilled in the granite. Joints measured in the rock cores dip primarily near vertical and 30 to 60° from the horizontal, and are slightly to moderately weathered with minor rust staining and clay.

6.24 Investigations of the bedrock from station 25+00 to station 32+00 revealed volcanic rock types. Volcanic (felsite) bedrock similar to that found on the right abutment was encountered in DD-23 and DD-18. The felsite is hard, moderately to highly fractured, and unweathered.

The bedrock surface dips steeply from its surface contact on the abutment to a depth of 11 feet approximately 20 feet from the toe of the slope. Within 125 feet of the abutment, the depth to bedrock is approximately 25 feet, dropping off to 136 feet approximately 700 feet toward the east. A possible cap of hard, massive tuffaceous agglomerate was encountered in DD-20 at a depth of 82 feet. No faults were noted in any of the embankment holes drilled in the felsite and agglomerate. Joints measured in the rock cores dip primarily 20 to 70° from the horizontal and are slightly weathered with minor clay filling. DD-44 was drilled near TH 79-33 to verify the type of material encountered in TH 79-33 at a depth of 34 feet. No bedrock was encountered to a depth of 106 feet. It was concluded, therefore, that the material encountered in TH 79-33 was not bedrock.

6.25 Interpretations of the remaining two embankment surveys corresponds closely with results from power auger and diamond core drilling. Line 14, running perpendicular to the proposed dam alinement, encountered volcanic bedrock with seismic velocities of 9300 to 10,000 ft/s at depths ranging from 25 feet at the south end of the line near DD-18 to 50 feet at the north end, indicating a possible pre-existing river channel condition. Line 15, in the New River channel, encountered apparent bedrock with an average seismic velocity of 9100 ft/s at about 68 feet. When diamond core drilling commenced at 82 feet in DD-20, slightly west of line 15, bedrock was encountered immediately, indicating that the power auger may have penetrated bedrock at a higher depth.

6.26 The permeability of the rock was determined from pressure tests conducted in each core hole drilled along the proposed dam alinement. Permeabilities in the granite ranged from 0.0 to 6.4 feet per day (fpd). Generally, the lowest permeabilities were in the moderately to highly weathered granite. Permeability values ranged from 0.0 to 0.05 fpd in DD-17A and from 0.01 to 0.02 fpd in the highly weathered zone above 44 feet in DD-14. Values for the unweathered to moderately weathered granite ranged from 0.1 to 6.4 fpd, but generally averaged 0.8 to 2.5 fpd. Higher permeabilities determined for certain zones in DD-16 and DD-34 reflect intervals where 50- to 100-percent water losses were encountered during drilling.

6.27 Permeabilities determined from pressure tests conducted in the volcanics were overall much lower than those in the granite. Values ranged from 0.0 to 0.03 fpd in the agglomerate and between 0.0 and 0.3 fpd for the felsite in DD-18. Small water losses noted during the drilling of DD-22 contributed to higher permeabilities (0.2 to 1.0 fpd) for the felsite.

Left Abutment

6.28 The materials exposed on the left abutment consist of weathered granitic bedrock and weathered residual granite boulders up to 2 to 3 feet in diameter with scattered thin patches of residual soil and slopewash varying in thickness from 0 to 5 feet. The underlying bedrock is hard, highly fractured, slightly to moderately weathered granite, with the upper 5 to 10 feet being soft to moderately hard and moderately

to highly weathered. Based on information from holes DD-19 and DD-21, the depth to good, sound rock near the toe and near the crest of the proposed embankment is approximately 10 feet. See plate 16 for the geologic logs of holes DD-19 and DD-21.

6.29 The major joint systems found in bedrock surface exposures give the granite a somewhat block-jointed appearance, the joints strike N45°E, dip near vertical and 30 to 60° to the SE, and strike N40°W, dip near vertical and 40° to the SW. Joints measured in the rock cores generally dip 20 to 70° and almost vertical from the core axis, and are slightly weathered and usually rust-stained. Fault zones were encountered in each of the core holes; between the depths of 63 and 69 feet in DD-19 and inclined 70° from the core axis, and between the depths of 16 and 35 feet in DD-21 and inclined 20° from the core axis. None, however, were found during surface geologic mapping.

6.30 The permeability of the abutment rock was determined from pressure tests conducted in each core hole. The permeability of the rock in DD-19 varied between 0.03 and 7.9 fpd. The highest permeabilities (5.4 to 7.9 fpd) occurred in the 34- to 43-foot interval where a 100-percent water loss was noted during drilling. Permeability calculations in the fault zone ranged from 0.04 to 0.1 fpd.

6.31 The permeability of the rock in DD-21 was much less, varying from 0.0 to 0.2 fpd. No water losses were noted during drilling. The permeability of the fault zone was calculated to be 0.1 fpd. The low permeabilities in the fault zones of both holes indicate areas that are relatively impermeable and should have no adverse effect on either the embankment or the left abutment foundation.

Right Abutment

6.32 The materials exposed on the right abutment consist of outcropping, steeply dipping volcanic (felsite) bedrock masked by a spotty thin cover of residual soil and slopewash. The alluvial cover ranges from a depth of 4 feet near the base of the abutment to a depth of 0 to 1 foot further up the steep slope. The exposed and underlying felsite is hard, moderately to highly fractured, and unweathered.

6.33 The depth to good, sound bedrock is about 2 to 3 feet below the existing bedrock surface based upon information from core holes DD-22 and DD-45. The drill logs indicate that the upper 2 to 3 feet of the felsite is loose and shattered. Approximately 3 feet of loose, in-place rock, however, was removed by hand and pick-axe prior to setting up to drill DD-45. See plate 16 for the geologic logs of holes DD-22 and DD-45. The felsite outcropping on the abutment in the vicinity of the proposed embankment centerline and downstream from it is platy in appearance because of the closely spaced parallel joints and exhibits flow layers trending N40-50°W, dipping 35° NE. The major joint system parallels the attitude of the layering (adversely dipping upstream and diagonally across the abutment); a secondary system strikes N30°E and dips 75° NW.

6.34 Joints measured in the rock cores dip primarily 70° to near vertical from the core axis, are parallel with intersecting joints dipping 20 to 60° from the core axis, and contain varying amounts of calcite and minor hard clay. No fault zones were encountered in either core hole nor were any faults noted during surface geologic mapping.

6.35 North of the centerline, particularly on the upper half of the abutment, the thin alluvial cover is more extensive, and the jointing in the exposed felsite is less distinct. However, the attitude of the jointing is different; the major joint system strikes N80°E and dips near vertical. A small outcrop of moderately hard to hard flow breccia is exposed at the upstream toe of the proposed embankment and occurs locally as small thin dikes in the surrounding felsite. See plate 9 for more detailed geologic mapping of the right abutment.

6.36 The permeability of the abutment rock was determined from pressure tests conducted in each core hole. The permeability of the rock in DD-22 varied between 0.2 and 4.3 fpd. The lowest permeability (0.2 fpd) occurred below the 56-foot depth where no water losses were encountered during drilling. The permeability of the rock in the drill hole above 56 feet varied from 1.6 to 4.3 fpd where 100-percent water losses were encountered several times during drilling. The permeability of the rock in DD-45 was similar, ranging from 0.1 to 3.1 fpd. The lowest permeabilities (0.1 to 0.9 fpd) occurred below the 45-foot depth. Permeability values above 45 feet varied between 1.9 and 3.1 fpd, reflecting heavy water losses encountered during drilling.

Spillway

6.37 Plate 43 shows a geologic profile along the centerline of the proposed spillway and cross sections. The profile and cross sections show both the generalized geologic sections and the foundation

excavation line and cut slopes. The geologic sections were developed from surface geologic mapping, dozer trenching, and diamond core drilling.

6.38 The spillway site consists of a layered volcanic sequence, together with an underlying sandstone unit that dips 30° to the northeast. The bedrock is overlain by thin scattered patches of alluvium (0 to 2 feet thick) with a 3- to 5-foot thick cover from station 12+60 to station 11+90 west of the centerline. The alluvium consists of residual soil and slopewash, which would be readily rippable.

6.39 The underlying bedrock, as encountered in the majority of the diamond core holes with the exception of DD-37 and DD-50, is a hard, moderately to highly fractured, unweathered felsite. See plates 17 and 18 for the geologic logs of the core holes drilled in the spillway. Interpretation of data from the refractive seismic surveys conducted near the crest of the saddle that forms the spillway, lines 9 and 10, indicate a thin low velocity surface layer (1400 ft/s) of approximately 2-foot thickness representing poorly consolidated alluvial material. An intermediate layer, with seismic velocities ranging from 2700 to 4250 ft/s extends to a maximum depth of 6 feet and is composed of less competent, highly fractured felsite bedrock with residual soil-filled joints. This layer, together with the surface layer, would be easily rippable. Below the 6-foot depth, seismic velocities ranged from 7800 to 11,500 ft/s, indicating competent felsite bedrock, the upper few feet of which could be ripped. Generally, P-wave velocities greater than

8000 ft/s for extrusive and intrusive igneous rocks are considered to represent competent bedrock, marginally rippable, and suitable for an unlined spillway.

6.40 Production trench TT-93, excavated with a D9G dozer to verify interpretations of the seismic data, encountered nonrippable felsite bedrock at a maximum depth of 8 feet. TT-94 was excavated to determine the rippability of the bedrock on the downstream side of the spillway because of a lack of seismic information. Excavation extended down to a depth of 14 feet, but no bedrock refusal was encountered. See plate 7 for trench logs of TT-93 and TT-94.

6.41 Spillway excavation from station 19+25 to 23+00 would be in felsite. From station 13+00 to station 11+90, excavation would be in the dipping layered volcanics, consisting of felsite, a 6-foot-thick layer of flow breccia, and a 30-foot-thick layer of tuff. Core hole DD-37, drilled at station 13+30, encountered these three diffrent rock units; the flow breccia and tuff, however, were below the spillway invert. A 3-1/2-foot-thick zone of altered felsite was found above its contact with the moderately hard to hard massive flow breccia. The underlying tuff unit is moderately hard to hard and moderately to highly fractured. A moderately soft sandstone, the upper 7 feet of which is tuffaceous in nature and underlies the tuff unit, was encountered in DD-50, drilled at station 12+30.

6.42 Felsite outcrops on the spillway, particularly on the crest of the saddle, exhibit flow layers trending N35^{o}W, dipping 25-30°NE, similar to that of the felsite on the right abutment. Bedrock exposures in TT-93

show a moderately hard to hard, platy to blocky, highly fractured felsite with the same layering characteristics. The major joint systems strike N35°W, dip 25°NE (the same as the attitude of the layering) and strike N60°E, dip 80° NW.

6.43 No definite layering of the felsite was found in TT-94. The felsite was hard, blocky, moderately fractured with pockets of highly fractured rock. Five prominent joint systems were measured: striking N45°E, dipping adversely 45°W, striking N25°W, dipping 20°SW, striking N60°W, dipping 40°NE, striking N20°E, dipping 80°NW, and striking E/W dipping 60°N. The greater depth of excavation accomplished in this trench could be due to the greater variety and more random orientation of fracture patterns and the nature of the fracturing.

6.44 The flow breccia exposed on the surface tends to be highly fractured and moderately soft to moderately hard. The tuff forms a prominent ridge with columnar-type jointing east of the spillway centerline near the downstream end. The primary joint systems strike N 35°W, dip 30°NE, and strike N50°E, dip near vertical. The same dip patterns were noted in the core samples of tuff in DD-37. The joints measured in the felsite cores tend to dip 20-40° from the horizontal, with occasional intersecting joints dipping 50° from the horizontal to near vertical, and contain varying amounts of calcite and minor hard red clay.

6.45 The permeability of the spillway rock was determined from pressure tests conducted in each core hole. Permeability values at the invert elevation varied between 0.0 and 1.8 fpd. The rock near the invert of

the crest and vicinity showed overall lower permeability values, between 0.0 and 0.7 fpd. This indicates less fractured rock.

6.46 At the location and elevation of the sill, the rock would be adequate to resist scour during spillways flows. Experience with the different types of materials in the spillway indicates that excavation in this rock would be stable at slopes of 2V on 1H and 4V on 3H and excavation in the alluvium would be stable at slope of 1V on 2H. The alluvial materials at the downstream end of the spillway, varying in thickness from 3 to 5 feet near DD-50 and 0.5 to 1.5 feet in the vicinity of test trenches 58 through 80, would be easily eroded during a spillway flow. The underlying sandstone bedrock would also be subject to some erosion during a spillway flow. See plate 8 for the logs of the these test trenches.

Outlet Works

6.47 Results of the investigation conducted near the right abutment for a possible outlet works location indicated that the depth to bedrock along an alinement close to the toe of the abutment would be deeper than the invert elevation of the outlet works in most areas. This would result in differential settlement unless the outlet conduit was notched into the abutment to found the structure entirely on rock. The steep and adverse dip of the bedrock on the abutment, however, would cause slope stability problems and excessive removal of rock from the abutment during excavation. This adverse condition was the basis for locating the outlet works near the left abutment. The logs of the trenches excavated along the right abutment are shown on plates 9, 10, and 11.

6.48 A geologic profile along the centerline of the proposed outlet works near the left abutment is shown on plate 5. This profile shows both a generalized geologic section and the foundation excavation line for the outlet works. The geologic section was developed f om surface geologic mapping, backhoe trenching, and diamond core drilling. The materials from station 21+00 to station 23+00 (upstream from the inlet portal) consist of alluvium underlain by granitic bedrock. The materials along the alinement from station 21+00 to station 13+00 consist of alluvium underlain by granitic bedrock. Downstream from station 13+00, the bedrock surface drops off gradually and is below the invert elevation of the outlet channel.

6.49 The alluvium from station 23+00 to station 21+00 consists of silty sand to gravelly silty sand and decreases in thickness from 6 to 3 feet. The inlet channel will be founded along most of its length in soft to moderately hard granite except in the vicinity of core borrow area No. 2. From station 21+00 to station 13+00, the alluvium is composed of silty sand to gravelly, silty sand and varies in thickness from 2 to 4 feet. The underlying granitic bedrock is moderately hard to hard, slightly to moderately weathered, and highly fractured, the upper 3 feet of which is soft to moderately hard, decomposed to highly weathered with numerous thin breccia, clay gouge, and caliche zones. Joints measured in the rock cores generally dip near vertical, and 20 to 60° from the horizontal, and are rust stained with occasional clay filling. The prominent joint system in the trench exposures strikes N65°E, and dips 70° to near vertical to the SE, similar to joint attitudes on the left abutment. See plate 19 for the geologic logs of

core holes drilled near the alinement of the proposed outlet works' and plates 40, 41, and 42 for the outlet works test trench logs. The outlet conduit, dissipator, and a small portion of the outlet channel will be founded on moderately hard to hard granite that will provide a sound foundation for the structures.

6.50 Two fault zones were encountered in the area of the outlet works in core holes DD-32 and DD-33; between the depths of 17.5 and 20 feet in DD-32; and inclined 60° from the horizontal and between 19 and 28 feet in DD-33 with an undetermined dip. No fault zones were found in DD-34 drilled near the dam centerline or in DD-35, drilled downstream from the centerline.

6.51 The permeability of the rock was determined from pressure tests conducted in each core hole and varied between 0.0 and 5.5 fpd, showing increased permeabilities downstream from DD-33, where 100 percent water losses were encountered during drilling in the less weathered granite of DD-34 and DD-35. The low permeabilities of the fault zones in DD-32 and DD-33 (0.0 to 0.2 fpd) are indications of relatively impermeable zones that should have no adverse effect on either the embankment or the outlet works foundation.

6.52 Below station 13+00, the outlet channel will be founded in poorly to well cemented alluvial streambed deposits, overlain by a variable thickness (ranging from 3 to 7 feet) of silty sand and gravelly-silty sand.

Dike No. 1 Foundation

6.53 A generalized profile along the centerline of the proposed dike is shown on plate 44. The foundation materials of Dike No. 1 consist of nonhomogeneous alluvial soils. Examination of the soil logs indicates three distinct layers in the upper 25 feet of the foundation. The first layer is a sandy clay that varies between 1 and 4 feet in thickness. The second layer is caliche and varies between 10 and 18 inches in thickness. The total dissolved solids (TDS) of the caliche layer ranged from 520 to 1900 parts per million (ppm) at a pH of 8 and from 4100 to 6900 ppm at a pH of 5.5. These values indicate that the caliche in the foundation of dike No. 1 is not water soluble. The third layer, which extends down to at least 25 feet below ground surface, is a cemented sandy gravel. There are thin lenses of caliche within the cemented sandy gravel.

6.54 An approximate velocity profile along the original alinement of the proposed dike is shown on plate 23. This profile was developed from interpretation of data from the refractive seismic surveys. Results indicated that the velocities of the materials north of line 35, from the surface to a depth of 5 feet, varied from 1250 to 2700 ft/s. The velocity of the underlying materials, from 5 to 30 feet below ground surface (with a maximum of 47 feet at line 35), varied from 3100 to 5300 ft/s. This intermediate velocity layer appeared to pinch out at line 29. Below these depths, velocities of the bottom layer ranged from 6600 to 15,000 ft/s. Some of the differences noted in the seismic velocities shown on plate 23, can be attributed to layers of caliche.

Dike No. 2 Foundation

6.55 A generalized geologic profile along the centerline of the proposed dike is shown on plate 19. The profile was developed from surface geologic mapping and diamond core drilling. The materials along the dike alinement consist of a 0- to 6-foot layer of alluvium composed of silty sandy gravel overlying hard, highly fractured, slightly weathered granitic bedrock, the upper 2 to 13 feet of which is soft to moderately hard and moderately to highly weathered, according to information from core holes DD-9 through DD-11. See plate 19 for the geologic logs of the core holes. Interpretation of data from refractive seismic surveys conducted near the proposed dike alinement, lines 6 through 8, indicate that the zone of weathered, less competent granite, represented by seismic velocities ranging from 5300 to 6800 ft/s, may extend from depths of 16 to 19 feet near the upstream end of the dike to depths of 25 to 29 feet near the downstream end. The harder slightly weathered granite is represented by seismic velocities ranging from 8500 to 12,000 ft/s.

6.56 Fault zones were noted in DD-11 between the depths of 13.5 and 15 feet and 35.5 and 36 feet, inclined 40-60° and 70-80° from the horizontal, respectively. Joints measured in the rock cores dip primarily near vertical and 30 to 50° from the horizontal, and are usually rust stained with occasional clay filling.

6.57 The permeability of the rock was determined from pressure tests conducted in holes DD-9 and DD-11. The permeability of the rock in DD-9 varied between 0.2 and 0.8 fpd and in DD-11 from 0.0 to 0.2 fpd. Little

or no water takes were observed while pressure-testing the intervals containing the two faults in DD-11, indicating that these zones are relatively impermeable and should have no adverse effect on the dike foundation.

Embankment Materials

CORE BORROW

6.58 Core materials, classified as a low to nonplastic, sandy silts, silty sands, and gravelly silty sands, will be obtained by excavating and blending the upper soil layer in core borrow areas No. 1, No. 2, and No. 3, which extend to shallow depths of 4, 6, and 3 feet, respectively. Suitable core materials excavated from Stratum A of the main embankment foundation may also be used. Profiles of core borrow areas No. 1 and No. 2, are shown on plate 45 and of borrow area No. 3 on plate 46. The statistical analysis of the blended materials of the upper soil layers presented in figures 7, 8 and 9, respectively, indicate that a sufficient quantity of fines, at least 22 percent passing the No. 200 sieve, is present in the soils to provide a relatively impervious core.

6.59 The statistical analysis of the percent passing No. 4 and No. 200 sieves before and after blending and the Atterberg limits is summarized as follows.

Borrow area No. 1, core material, 0 to 4 feet

Item	Sieve Size	Coarse limit	Lower quartile	Median	Upper quartile	Fine limit
		Percent finer*				
Blended	No. 4	66	90	92	94	99
	No. 200	25	29	34	37	53
Unblended	No. 4	51	92	95	97	100
	No. 200	21	28	33	41	65
Atterberg limits:						
LL		-	-	-	-	-
PI		NP	NP	NP	NP	NP

* Based on minus 3-inch samples.

Borrow area No. 2, core material, 0 to 6 feet

Item	Sieve size	Coarse limit	Lower quartile	Median	Upper quartile	Fine limit
		Percent finer*				
Blended	No. 4	69	87	91	95	97
	No. 200	24	30	35	43	54
Unblended	No. 4	55	85	92	95	100
	No. 200	21	27	34	46	73
Atterberg limits:		-	-	-	-	26
LL		-	-	-	-	-
PI		NP	NP	NP	NP	6

* Based on minus 3-inch samples.

Borrow area No. 3, core material, 0 to 3 feet

	Sieve size	Coarse limit	Lower quartile	Median	Upper quartile	Fine limit
		Percent finer*				
Blended	No. 4	72	88	96	98	99
	No. 200	22	31	36	42	61
Unblended	No. 4	72	88	96	98	100
	No. 200	22	31	37	43	63
Atterberg limits:						
LL		-	-	-	-	-
PI		NP	NP	NP	NP	18

* Based on minus 3 inch samples.

6.60 Examination of the soil logs indicate that, while 98 percent of the material is smaller than 2 inches, there are zones of cobbles and boulders, or caliche cemented materials in the core materials of the three borrow areas. It is estimated that the maximum sizes of the cobbles in core borrow areas No. 1 and No. 2 is less than 9 inches (3/4 the placement lift thickness) while the core borrow materials from borrow area No. 3 will contain some cobbles larger than 9 inches. The percentage of plus 9-inch cobbles in the core borrow material from borrow area No. 3 is so minute that the material can be processed on grade during placement. Nine inches will be the maximum material size allowed in the core. The caliche cemented material, which is located beneath the designated core borrow depth in areas No. 1 and No. 2 and in the lower portions of Stratum A from station 13+00 to station 21+00 in the dam foundation, will be wasted and not permitted in the core zone.

6.61 The approximate percentage of the total embankment yardage of core material available from each source is 28 percent from core borrow area No. 1, 31 percent from core borrow area No. 2, 164 percent from borrow area No. 3, and 27 percent from the dam foundation excavation. This indicates that approximately twice the required amount of material is available.

6.62 The selection of core material samples for laboratory tests was based upon statistical gradational analysis of the core borrow areas. The samples for the "$\bar{R}$" triaxial compression tests were selected to represent the upper quartile, median, and lower quartile gradations of the blended core materials. The test gradations are shown in figure 9. Since the core materials will be placed at about 95-percent maximum density (ASTM D 698-70) with a moisture content at about optimum, the samples were remolded to 95-percent maximum density (ASTM D 698-70) at optimum, optimum plus 2-percent, and optimum minus 2-percent moisture. The results of the tests are summarized on plate 36 and in figure 10. The test results and pertinent back-up information are presented in attachment B. A summary of maximum p-q values from laboratory tests, and the design total shear strength envalope is presented in figure 10. The total shear strength parameters ranged from C = 2000 lb/ft^2 and Ø = 4 degrees to c = 500 lb/ft^2 and Ø = 19 degrees.

6.63 The design effective shear strength envelope was developed from the "$\bar{R}$" triaxial compression tests and the meaured pore pressure. The results of the tests are summarized on plate 36 and in figure 11. The effective shear strength parameter ranged from Ø' = 31 degrees to Ø' = 39 degrees.

6.64 Excess pore pressure during construction is not anticipated because the core materials will not be placed in a saturated condition and consolidation of the core materials will occur gradually during construction. Only two Q triaxial tests, therefore, were performed. The samples selected for the Q test represent the upper quartile and median of the blended core borrow gradations. A summary of maximum p-q values, from laboratory tests, and the design Q shear strength are presented on plate 35 and in figure 12.

6.65 Permeability tests were performed on samples representative of the median and lower quartile core gradations. Each sample was compacted to 90-, 95-, and 100-percent maximum density (ASTM D 698-70) at optimum moisture content. Chamber pressures of 25 and 50 pounds per square inch were used in the tests. The results of these tests are summarized in table 5 and presented on plate 35.

Table 5. Core material, laboratory permeability

Gradation	Maximum density (%)	Permeability (fpd)
Median	90	0.5
Median	95	.1
Median	100	.02
Lower quartile	90	.8
Lower quartile	95	.3
Lower quartile	100	.05

6.66 Consolidation tests were performed on samples representative of the upper quartile, median, and lower quartile gradations. Each sample was compacted to 95 percent maximum density (ASTM D 698-70) at optimum,

optimum plus 2-percent, and optimum minus 2-percent moisture content. The results of these tests, which were very similar, are summarized in table 6 and presented on plate 35.

Table 6. Core material, consolidation tests.

Gradation	Moisture content (%)	Pressure saturated at (tsf)	Initial void ratio	Overburden pressure (tsf)	Cc
Lower quartile	opt +2	3.28	0.39	7.2	0.092
Lower quartile	opt +2	6.55	.389	7	.093
Lower quartile	opt	3.28	.386	6.2	.104
Lower quartile	opt	6.55	.388	8.2	.10
Lower quartile	opt-2	3.28	.390	6.8	.089
Lower quartile	opt-2	6.55	.392	8.0	.115
Median	opt +2	3.28	.413	8.0	.097
Median	opt +2	6.55	.414	8.9	.081
Median	opt.	3.28	.415	8.2	.111
Median	opt.	6.55	.416	10.5	.087
Median	opt-2	3.28	.415	10.8	.097
Median	opt-2	6.55	.416	10.8	.10
Upper quartile	opt-2	3.28	.398	-	-
Upper quartile	opt+2	6.55	.466	10.5	.1
Upper quartile	opt	3.28	.466	9.1	.104
Upper quartile	opt	6.55	.468	10.1	.115
Upper quartile	opt-2	3.28	.476	11.7	.146
Upper quartile	opt-2	6.55	.476	8.3	.131

6.67 The consolidation test results, placement densities, gradations, and Atterberg limits of the core material indicate that: (a) collapse of the soil will not occur during saturation of the core under embankment loading; and (b) very little settlement should occur because of consolidation.

6.68 Dispersion tests were performed on samples representative of the upper quartile, median, and lower quartile gradations. These tests indicate that the core materials are nondisperive (Sherard, Decker, and Ryker, 1972).

PERVIOUS SHELL

6.69 Pervious material, classified as coarse-grained, silty sandy gravels, and sandy gravels, will be obtained by excavating and blending the soils between 3 and 13 feet below original ground surface in borrow area No. 3, (pl. 46) and from suitable materials excavated from the Stratum B of the dam embankment foundation and spillway excavation. Profiles of borrow area No. 3 are shown in plate 46. A statistical analysis of the blended gradations of this material, shown in figure 13, indicates that 75 percent of the materials will have less than 8 percent fines by weight, and therefore, will provide a relatively pervious shell.

6.70 The statistical analysis of the percent passing the 3 inch, No. 4, and No. 200 sieves before and after blending and the Atterberg limits are summarized in the following tabulation.

Borrow Area No. 3, pervious shell materials, 3 to 13 feet.

	Sieve (No.)	Coarse limit	Lower quartile	Median	Upper quartile	Fine limit
		Percent finer*				
Blended	3 in.	60	76	85	91	100
	No. 4	20	32	39	44	64
	No. 200	1	4	5	6	15
Unblended	3 in.	52	76	85	94	100
	No. 4	13	32	37	47	94
	No. 200	1	3	6	7	20
Atterberg limits:						
LL		-	-	-	-	-
PI		NP	NP	NP	NP	NP

*Based on minus 6-inch sample.

6.71 The pervious shell materials, when excavated and blended for the full depth of excavation, will have high shear strengths, and relatively high permeability, and will form a nonshrinking dense shell. Examination of the data contained in the soil logs indicates that there are materials larger than 18 inches (3/4 of the placement lift thickness). Visual estimates indicate that 6 percent of potential pervious shell materials contain boulders larger than 18 inches. This percentage is based upon the footage of the zones containing oversize materials below 3 feet, divided by the exploration footage below 3 feet of the test trenches and holes in the pervious shell borrow area.

6.72 The selection of samples tested in the laboratory was based on the statistical gradation analysis of the blended pervious shell borrow areas. "R" type triaxial shear tests and permeability were performed on samples selected to represent the upper quartile, median, and lower quartile blended pervious shell gradation using 12- and 18-inch-diameter cylindrical samples, respectively. The upper quartile, median, and lower quartile blended gradations and the corresponding gradations of materials on which laboratory tests were conducted are shown in figures 14, 15, and 16, respectively. The pervious shell materials will be placed with an average relative density (ASTM D 2049) of 85 percent with no portion of the embankment having a relative density less than 80 percent in accordance with EM 1110-2-2300. For this reason, the test samples were remolded to 85-percent relative density.

6.73 The results of the "R" tests are summarized on plate 37 and presented in attachment B. A summary of maximum p-q values and design total shear strength is presented in figure 17. The total shear

strength parameters ranged from C = 1200 lb/ft^2 and Ø = 12 degrees to c = 1000 lb/ft^2 and Ø = 29 degrees.

6.74 The design effective shear strength was developed from the "R" triaxial compression tests and the measured pore pressures. The results of the test are summarized on plate 37 and in figure 18. The effective shear strength parameters ranged from Ø' = 37 degrees to Ø' = 43 degrees.

6.75 Since excess pore pressures are not expected because of the arid conditions, anticipated range of placement moisture (the material will be placed dry), and the relative coarseness of the pervious shell materials, "Q" triaxial shear tests were not performed.

6.76 Permeability tests were conducted on samples representative of the gradational range of the blended pervious shell materials. The samples were compacted to 85-, 90-, and 95-percent relative density (ASTM D 2049). The permeability test results are summarized in table 7 and presented on plate 37.

Table 7. Pervious shell material laboratory permeability.*

Gradation	Percent ASTM D 2049 relative density (%)	Permeability (fpd)
Upper quartile	85	0.9
Upper quartile	90	0.09
Upper quartile	95	0.05
Median	85	0.9
Median	90	0.4
Median	95	0.15
Lower quartile	85	20
Lower quartile	90	7
Lower quartile	95	3

*Based on minus 2-inch sample.

TRANSITION

6.77 Transition materials will be obtained by excavating and blending the soil between 3 and 13 feet below original ground surface in borrow area No. 3 (pl. 46) and then removing the plus 3-inch materials. A statistical analysis of the blended gradations of the materials after excavation, blending, and removal of the plus 3-inch materials, presented in figure 19 indicates that this material will meet filter requirements for the core and pervious shell materials.

6.78 The statistical analysis of the percent passing the No. 4 and No. 200 sieves after blending and removal of the plus 3-inch material is summarized in this next tabulation.

Borrow area No. 3, transition materials, 3 to 13 feet.

	Sieve (No.)	Coarse limit	Lower quartile	Median	Upper quartile	Fine Limit
			Percent finer			
Blended	No. 4	33	42	46	48	64
	No. 200	2	5	6	7	15

6.79 The unit weights, shear strength, and permeability of these materials were developed from the tests performed on the pervious shell materials. These values are valid because the minus 2-inch portion of the pervious shell materials was tested to develop the shear strength and permeability while the minus 3-inch (coarser) portion of the pervious shell materials will be used for transition materials.

STONE REVETMENT

6.80 After the inspection of existing gravel plants on the Salt River, Aqua Fria River, New River, Skunk Creek, and Cave Creek, it was concluded that there would not be enough plus 12-inch stone readily available after processing to meet the gradation and quantity requirements for Type I stone revetment. In addition, existing quantities of oversize stone may not be present when construction of New River Dam commences, because of possible flood emergency use and processing for Adobe Dam.

6.81 Laboratory tests were performed on the large angular volcanic rock stockpiled near the CAP aqueduct. The results of petrographic analyses and other laboratory tests are shown in attachment A. Because of the small quantity of rock available (approximately 1500 cubic yards), this waste pile, which contained a significant amount of 3- to 4-cubic yard rock, may be suitable as toe stone to protect the downstream slope of the proposed dam from damage caused by off-road vehicles.

6.82 A reconnaissance of the Phoenix area revealed no existing or potential rock quarries where appreciable amounts of oversize material would provide sources of Type I stone revetment. Cores of drill holes and trenches at the design spillway were examined to determine the quality and potential size of breakage of the rock. Laboratory tests were performed on selected core samples to determine the rocks suitability as a source for stone revetment. The results of petrographic analyses and other laboratory tests are shown in attachment A. The felsite, because of its physical characteristics, was the only

rock considered for use as stone revetment. Based on information from the core holes and the two test trenches (TT-93 and TT-94), the average size of stone that could be produced from the spillway excavation was estimated to be about 6 inches. The apparent specific gravity of the felsite samples tested ranged from 2.65 to 2.72. However, breakdown along incipient fractures occurred during the wetting and drying tests performed on the felsite cores. It was concluded that the felsite would not be suitable for upstream slope protection, but could be used as bedding stone, downstream slope protection, or gravel drain material.

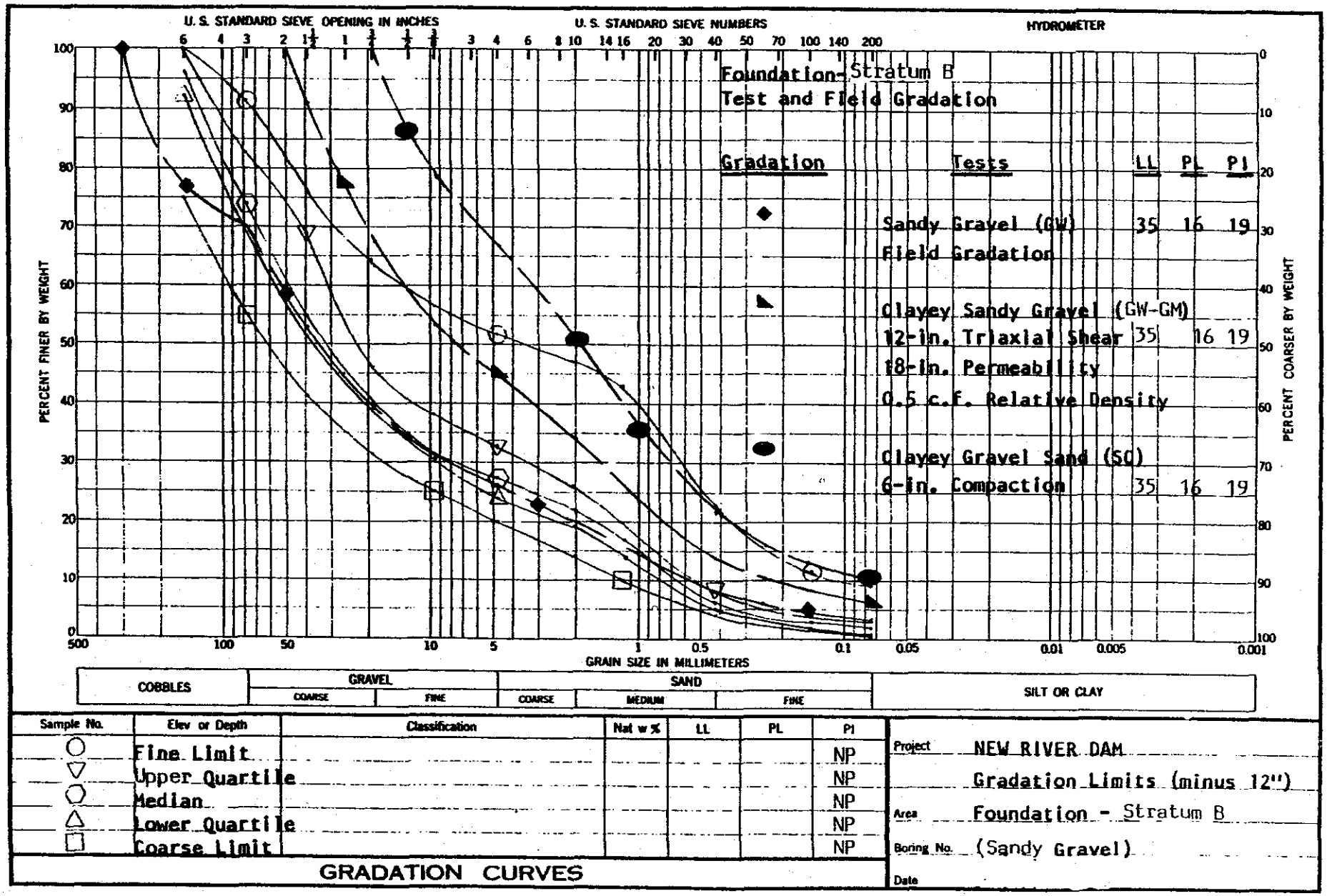
6.83 On-site processing of the pervious shell material or processing the material from an Arizona Department of Transportation gravel pit on the New River, approximately 8 miles north of the damsite on Federal lands administered by the Bureau of Land Management, would provide Type I stone. Mass gradation samples will be obtained in the vicinity of the New River pit to verify the visual estimates of the amount of material that needs to be processed to obtain the amount of Type I stone required. Laboratory tests will be performed on samples of material from the damsite and the New River pit to determine their suitability for stone protection.

7. *Foundation Treatment*

Foundation Treatment--Dam Embankment

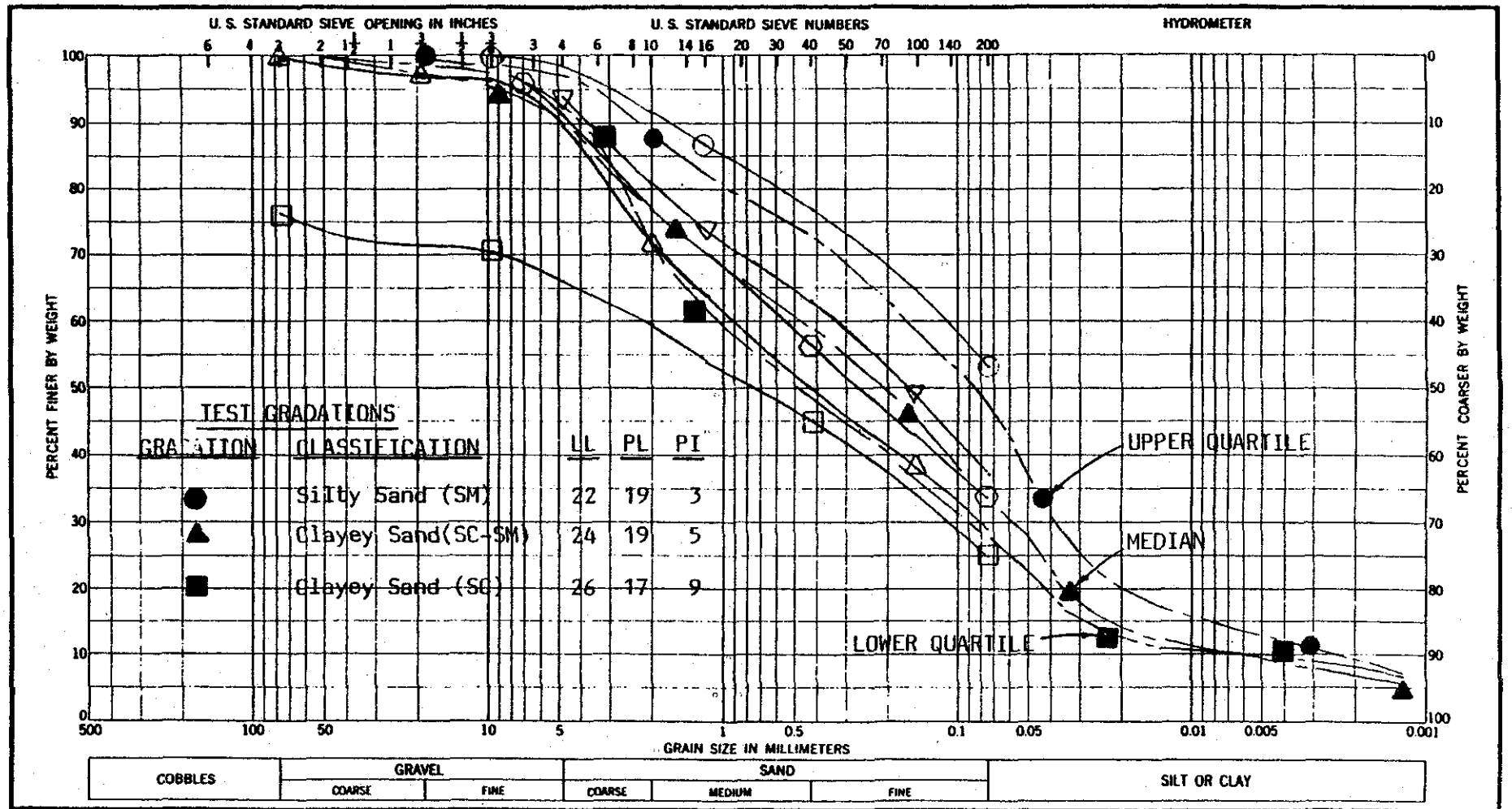
STREAMBED

7.01 After clearing and grubbing, which requires the removal of about 9 inches of surficial soil material, Stratum A will be excavated from beneath the entire embankment as indicated on plate 47. The excavation will remove foundation materials (Stratum A) that exhibit undesirable settlement properties and would have a low shear strength. A core trench, with a base width of 20 feet and sideslopes no steeper than 1.0V to 1.5H, will be excavated through pervious foundation materials (Stratum B) and into Stratum C or bedrock. Between the left abutment and station 16+50 along the centerline of the embankment, the core trench will be excavated to sound bedrock. Between stations 16+50 and 20+00, the core trench will be excavated through Stratum B and Stratum C to sound bedrock and will have 15-foot benches upstream and downstream from the core that will allow the transition zones to be founded on Stratum C. The benches will be at elevation 1378 feet above msl at station 16+50 and will slope to elevation 1370 at station 20+00. Between stations 20+00 and 31+00, the core trench will be excavated to elevation 1365 and will have 15-foot benches at elevation 1370 upstream and downstream from the core. Between station 31+00 and the right abutment, the core trench will be excavated through Stratum B and Stratum C to sound bedrock, and will have 15-foot benches at elevation 1370 upstream and downstream from the core.



ENG FORM 1 MAY 63 2087

Figure 1. Stratum B field gradations and test gradations.



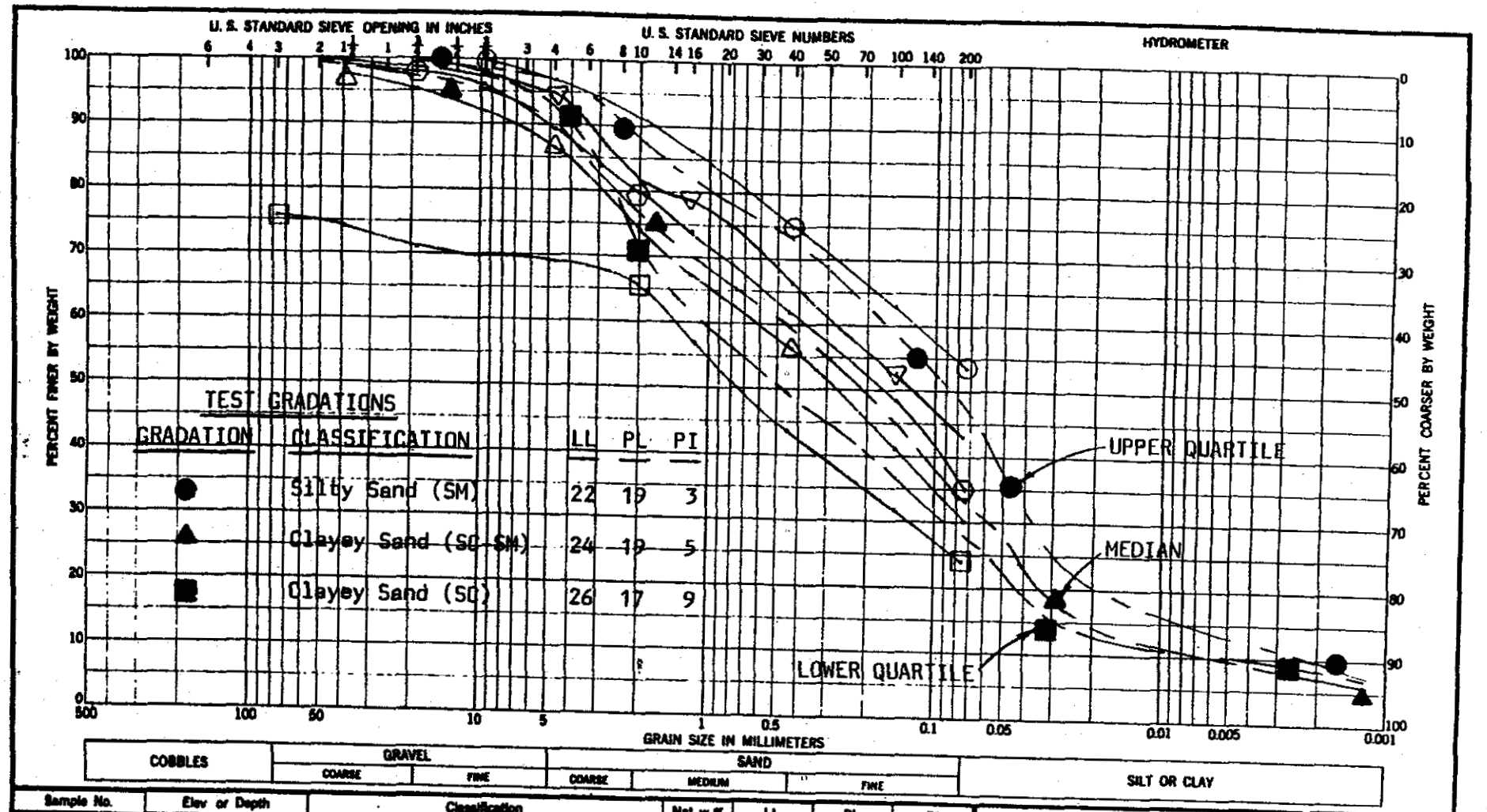
Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
○	Fine Limit			57	20	37
▽	Upper Quartile					NP
⬡	Median					NP
△	Lower Quartile					NP
	Coarse Limit					NP

GRADATION CURVES

Project NEW RIVER DAM
Blended Gradation
Area Core Material
Boring No. Borrow Area #1
Date

ENG FORM 1 MAY 63 2087

Figure 7. Core borrow area No. 1 field gradations and core test gradations.



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
○	Fine Limit			26	20	6
△	Upper Quartile					NP
▽	Median					NP
▲	Lower Quartile					NP
□	Coarse Limit					NP

GRADATION CURVES

Project NEW RIVER DAM
Blended Gradation

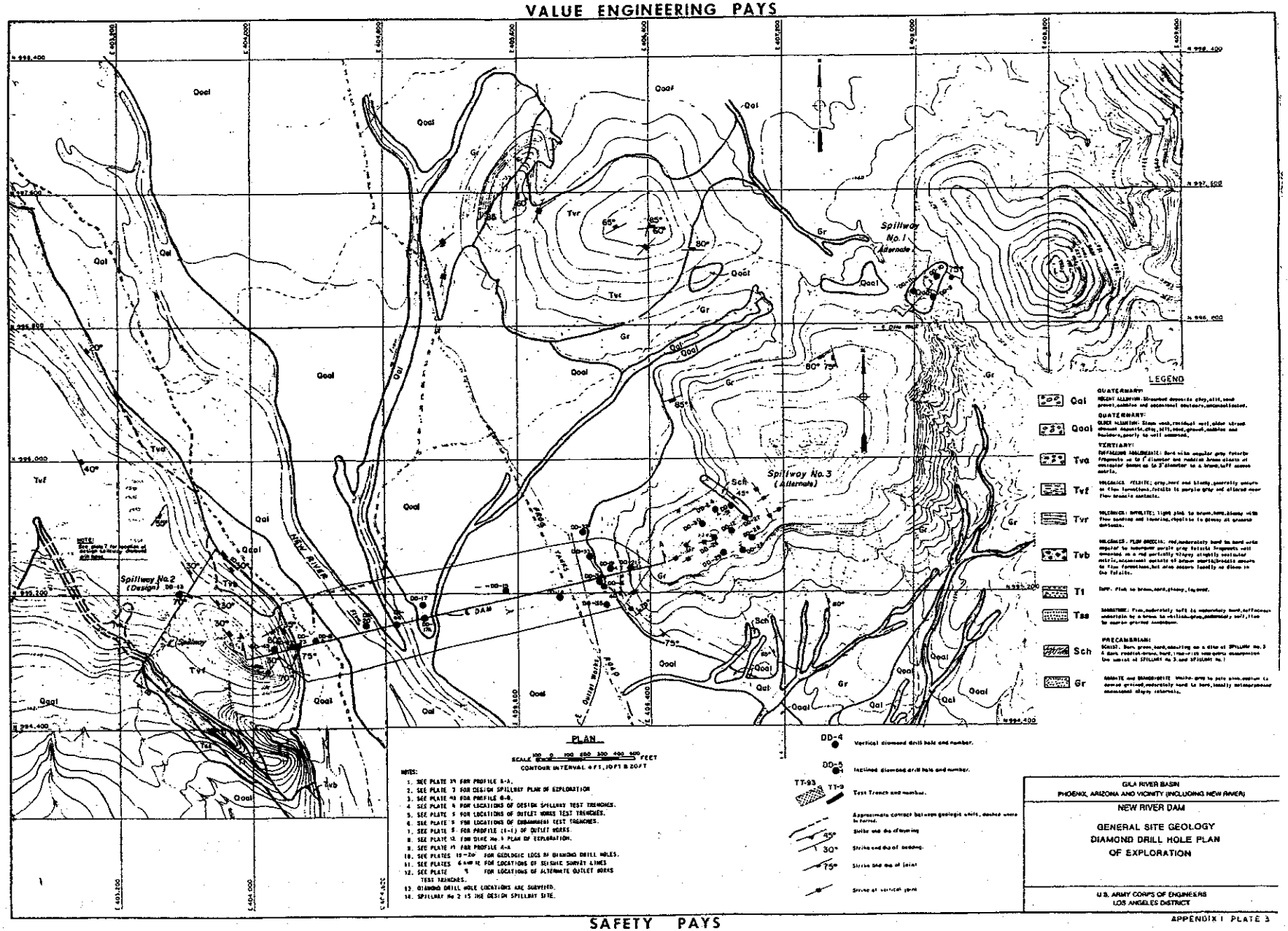
Area Core Material

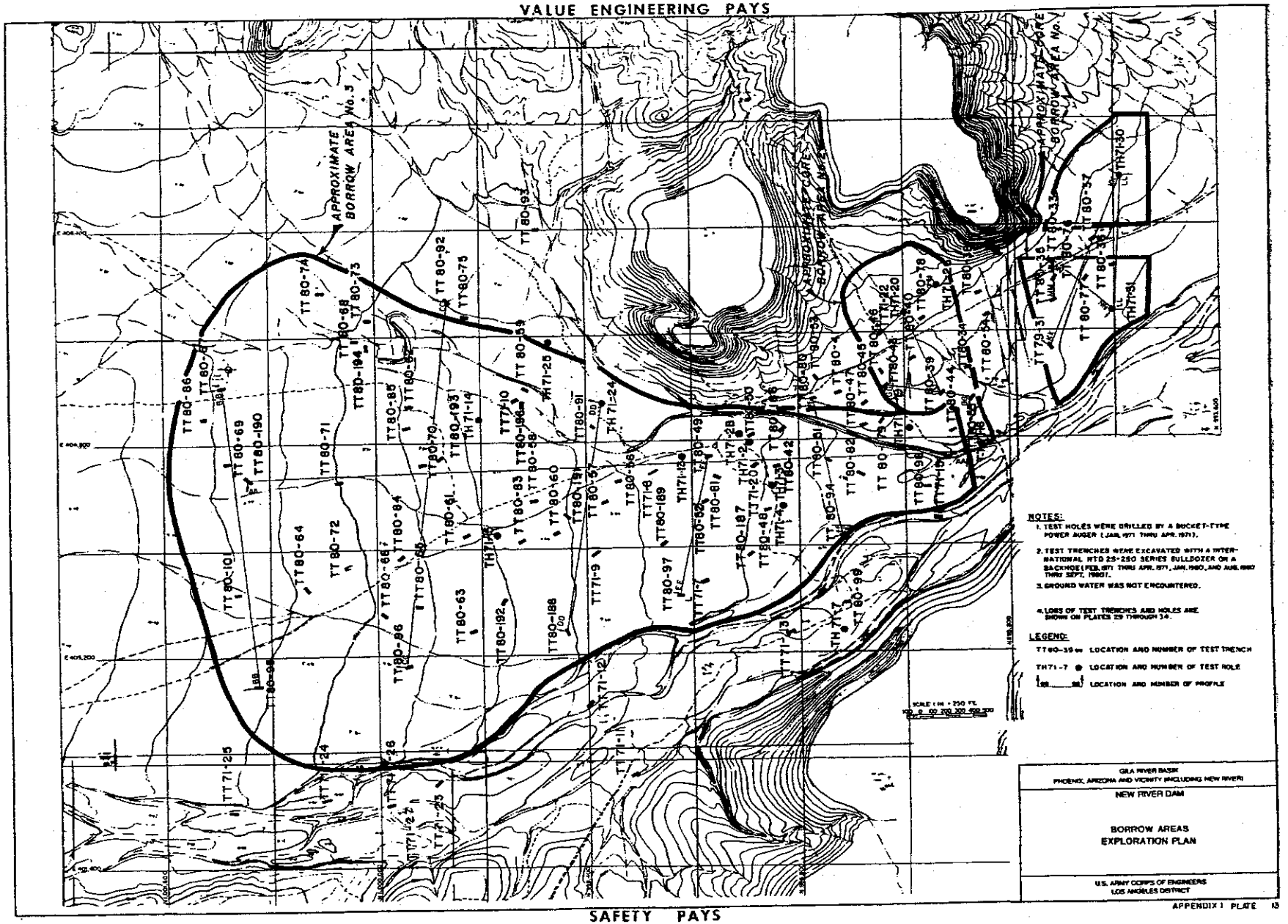
Boring No. Borrow Area #2

Date

ENG FORM 1 MAY 63 2087

Figure 8. Core borrow area No. 2 field gradations and core test gradations.


Spillway No.1 (Alternate)
Spillway No.2 (Design)
Spillway No.3 (Alternate)
NEW RIVER
℄ DAM
Qal
Qaal
Tvr
Tvf
Tvb
Gr
Sch
LEGEND
Qal
Qaal
Tva
Tvf
Tvr
Tvb
Ti
Tss
Sch
Gr
DD-4 Vertical diamond drill hole and number.
DD-5 Inclined diamond drill hole and number.
TT-93 TT-9 Test Trench and number.
Approximate contact between geologic units, dashed where inferred.
Strike and dip of bedding.
Strike and dip of joint
Strike of vertical joint
PLAN
SCALE 100 0 100 200 300 400 500 FEET
CONTOUR INTERVAL 4 FT, 10 FT & 20 FT
NOTES:
1. SEE PLATE 39 FOR PROFILE A-A.
2. SEE PLATE 7 FOR DESIGN SPILLWAY PLAN OF EXPLORATION
3. SEE PLATE 40 FOR PROFILE B-B.
4. SEE PLATE 8 FOR LOCATIONS OF DESIGN SPILLWAY TEST TRENCHES.
5. SEE PLATE 5 FOR LOCATIONS OF OUTLET WORKS TEST TRENCHES.
6. SEE PLATE 5 FOR LOCATIONS OF EXCAVATION TEST TRENCHES.
7. SEE PLATE 5 FOR PROFILE (I-I) OF OUTLET WORKS.
8. SEE PLATE 12 FOR DIKE No. 1 PLAN OF EXPLORATION.
9. SEE PLATE 41 FOR PROFILE A-A
10. SEE PLATES 19-20 FOR GEOLOGIC LOGS OF DIAMOND DRILL HOLES.
11. SEE PLATES 6 AND 12 FOR LOCATIONS OF SEISMIC SURVEY LINES
12. SEE PLATE 9 FOR LOCATIONS OF ALTERNATE OUTLET WORKS TEST TRENCHES.
13. DIAMOND DRILL HOLE LOCATIONS ARE SURVEYED.
14. SPILLWAY No 2 IS THE DESIGN SPILLWAY SITE.
GILA RIVER BASIN
PHOENIX, ARIZONA AND VICINITY (INCLUDING NEW RIVER)
NEW RIVER DAM
GENERAL SITE GEOLOGY
DIAMOND DRILL HOLE PLAN
OF EXPLORATION
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT


APPROXIMATE BORROW AREA No. 3
APPROXIMATE BORROW AREA No. 2
APPROXIMATE BORROW AREA No. 1
NOTES:
1. TEST HOLES WERE DRILLED BY A BUCKET-TYPE POWER AUGER (JAN. 1971 THRU APR. 1971).
2. TEST TRENCHES WERE EXCAVATED WITH A INTERNATIONAL RTD 25-250 SERIES BULLDOZER OR A BACKHOE (FEB. 1971 THRU APR. 1971, JAN. 1980, AND JUN. 1980 THRU SEPT. 1980).
3. GROUND WATER WAS NOT ENCOUNTERED.
4. LOGS OF TEST TRENCHES AND HOLES ARE SHOWN ON PLATES 29 THROUGH 34.
LEGEND:
TT80-39 LOCATION AND NUMBER OF TEST TRENCH
TH71-7 LOCATION AND NUMBER OF TEST HOLE
LOCATION AND NUMBER OF PROFILE
SCALE: 1 IN = 750 FT.
GILA RIVER BASIN
PHOENIX, ARIZONA AND VICINITY (INCLUDING NEW RIVER)
NEW RIVER DAM
BORROW AREAS
EXPLORATION PLAN
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

VALUE ENGINEERING PAYS

EMBANKMENT DD-14

DEPTH	PRESSURE PSI	Q	K
24.8	NO TEST		
26.0	0	.04	.02
46.1	0	.04	.01
57.2	10	0.8	0.1
	20	0.8	0.1
	30	1.5	0.2
	50	10.4	0.8
57.2-74.5	10	6.6	0.7
64.0	20	19.7	1.5
74.5	10	10.6	1.7
	20	19.8	2.5

ELEV 1394.9'

ALLUVIUM: silty sand to gravelly silty sand.

GRANITE: white to brown, coarse-grained, soft, highly weathered.
Top of Rock from 77-46

GRANITE: white to gray, coarse-grained moderately soft, highly weathered with moderately hard to hard lenses and nodules of fresher material; shattered.

GRANITE: gray, hard, coarse-grained slightly weathered, moderately to highly fractured.

moderately soft, 44.6-45.7'.

shattered: 46.6-48.5', 52.5-57.6', 57.9-58.5'.

Joints dip primarily 45-80° and near vertical and are slightly weathered with minor rust staining.

40% Recovery January 1980

Drilled with a tri-cone rock bit from 0.0 to 19.6' from 19.6 to 74.5' for N X sized core; N X casing set from 0.0 to 57.5'. 100% drill water return from 0.0 to 57.5' and 72.5 to 74.5'. 20% drill water loss from 57.5 to 72.5'.

EMBANKMENT DD-15

DEPTH	PRESSURE PSI	Q	K
38.1	NO TEST		
70.1	10	11.2	0.8
	30	17.0	0.9
	40	36.0	0.8
	70	44.3	1.1

ELEV 1394.9'

ALLUVIUM: silty sand to sandy gravel with 20% cobbles and occasional boulders.

GRANITE: white to gray, hard, coarse-grained, slightly to moderately weathered, slightly fractured; moderately hard: 46.1-46.5', 56.7-56.9', 64.5-67.4', 68.0-70.1'.

brecciated: 34.0-34.0', 36.5-37.4', 42.6-44.5'.

brecciated and rehealed: 36.2-36.5', 56.7-58.0', 66.8-67.5', 68.8-70.1'.

void or very soft zone: 30.1-34.7'.

Joints dip 20° in N X with minor rust staining and red clay, are slightly to moderately weathered.

40% Recovery September 1980

Alluvium cemented by D-8 dozer and backhoe to 33.0'. Drilled from 33.0 to 70.1' for N X sized core. 25% drill water loss for the entire hole.

EMBANKMENT DD-16

DEPTH	PRESSURE PSI	Q	K
6.4	NO TEST		
20.5	10	4.8	1.4
	20	8.5	1.5
34.2	10	13.1	2.7
	20	17.7	2.5
	30	23.3	2.5
44.4	10	7.7	1.6
	20	11.3	1.7
	40	13.1	1.9
48.2	10	7.1	2.8
	20	10.7	3.1
50.5	40	15.2	2.9
62.2	10	10.5	1.1
61.6	20	20.3	1.5
61.6-75.5	0	18.4	2.9
70.3			
75.5	6	24.6	6.4

ELEV 1389.1'

ALLUVIUM: Residual sandy silty sandy gravel.

GRANITE: gray, hard, coarse-grained slightly weathered to unweathered, moderately to highly fractured to 70.0; moderately fractured: 70.0-75.5'; moderately soft to moderately hard: 7.0-8.5'.

moderately soft, highly weathered with clay gouge: 23.1-25.4'.

shattered: 6.6-6.8', 12.0-12.5, 25.1-29.4', 37.0-37.5', 37.6-38.0, 38.2-39.6', 30.0-30.4', 40.1-41.5', 42.7-43.6', 60.0-60.5', 69.7-61.8'.

brown to gray, altered, rust-stained: 5.3-6.6', 16.3-17.5'.

Joints are primarily N V and 30-60° and are slightly weathered to unweathered; from staining greatest from 8.8 to 10.6', 16.4-20.3' and 49.8-51.0'.

89% Recovery February 1980

Drilled with a tri-cone rock bit from 0.0 to 4.3; from 4.3 to 75.5' for N X sized core, N X casing set from 0.0 to 5.5'. 100% loss of drill water 30.3 to 32.8', 69.5 to 75.5'. 50-100% return all other intervals.

EMBANKMENT DD-17a

DEPTH	PRESSURE PSI	Q	K
146.1	NO TEST		
150.1	NO TEST		
161.5	10	0.1	0.0
	20	0.4	0.02
	40	0.9	.04
	70	1.3	0.3

DD-17a

EMBANKMENT DD-4

DEPTH	PRESSURE PSI	Q	K
106.0	NO TEST		

EMBANKMENT DD-18

DEPTH	PRESSURE PSI	Q	K
27.0	NO TEST		
35.0	10	0.0	0.0
47.9	20	1.0	0.1
	30	1.5	0.1
75.5	10	1.1	0.05
	20	2.7	0.1
	40	7.0	0.3
	60	9.6	0.3

ELEV 1396.8'

ALLUVIUM: silty sand, gravelly silty sand with layers of cobbles and boulders.

FELSITE: gray, hard, moderately fractured.

moderately hard to hard: 25.0-35.0'.

shattered: 38.1-38.5'.

Joints dip primarily 40-70° and are usually clay lined, slightly weathered with occasional slickensides and minor calcite filling.

Possible shear zone: 40.7-40.3'.
(brown clay gouge with breccia dipping 60°.)

89% Recovery June 1980

Drilled with a tri-cone rock bit from 0.0 to 35.0'; from 35.0 to 75.5' for NW sized core. 100% drill water return 0.0 to 75.5'.

EMBANKMENT DD-20

DEPTH	PRESSURE PSI	Q	K
92.0	NO TEST		
65.8	NO TEST		
	20	0.0	0.0

ELEV. 1377.8'

ALLUVIUM: sandy gravel, always sandy gravel. 20-30% cobbles and boulders to 18" depth.

Encountered water at 35' depth.

NOTE: SEE PLATE 20 FOR DRILL LOG, SECTION 20-20 OF THIS DRILL, 0.0 TO 92.5'.

TUFFACEOUS AGGLOMERATE: hard, with regular to subangular gray, felsite fragments up to 1" in diameter and rounded brown clasts of vesicular basalt up to 2" in diameter in a brown tuffaceous matrix, slightly fractured.

EMBANKMENT DD-23

DEPTH	PRESSURE PSI	Q	K
15.1	NO TEST		
34.1	10	5.9	1.0
	20	8.8	1.0
	30	9.6	0.8
49.1	10	1.2	0.2
	30	5.4	0.3
	30	13.3	0.8

ELEV 1389.3'

ALLUVIUM: silty sandy gravel and clean sand.

FELSITE: gray, hard, moderately to highly fractured.

shattered: 11.5-12.3', 29.1-31.0', 39.7-34.1', 38.3-42.7'.

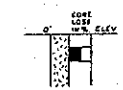
Joints dip 20-70° and are slightly weathered with minor clay filling, no rust-staining.

20% Recovery September 1980

Drilled from 0.0 to 49.1' for N X sized core. 100% drill water return, 0.0 to 14.8' and 24.1 to 34.1'. 25% loss, 14.8 to 24.1' and 34.1 to 49.1'.

PRESSURE TESTS

DEPTH	PRESSURE PSI	Q
5.0	NO TEST	
11.4	5	4.0

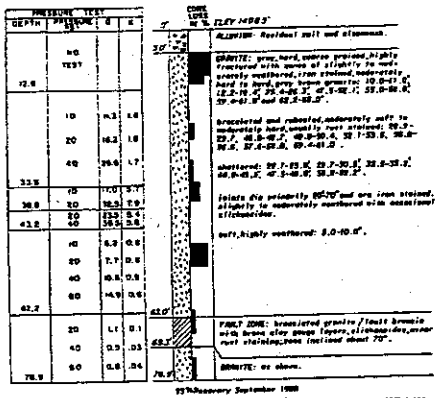


NOTES:

1. SEE PLATE 3 FOR THE GEOLOGIC MAP AND DIAGRAM DRILL HOLE PLAN OF EXPLORATION.
2. [illegible]

LEFT ABUTMENT

DD-19 (Inclined 45°)

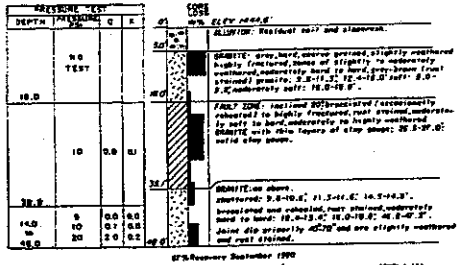


97% Recovery September 1990

Drilled from 0.0 to 78.9' for 8.7' sized core. 100% drill water return 0.0 to 38.0'; 0% return 38.0 to 45.2'; 30% return 45.2' to 78.9'.

LEFT ABUTMENT

DD-21 (Inclined 45°)

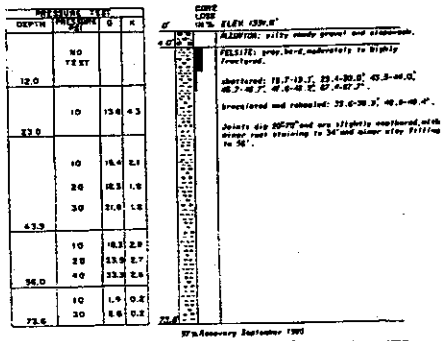


87% Recovery September 1990

Drilled from 0.0 to 46.3' for 8.7' sized core. 100% drill water return 0.0 to 40.0'.

RIGHT ABUTMENT

DD-22 (Inclined 30°)

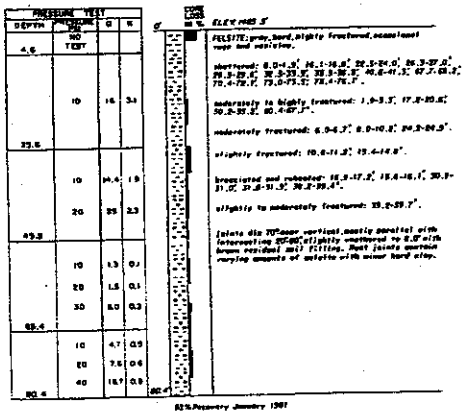


97% Recovery September 1990

Drilled from 0.0 to 73.6' for 8.7' sized core. 100% drill water return from 0.0 to 18.3', 23.4 to 39.3' [illegible]

RIGHT ABUTMENT

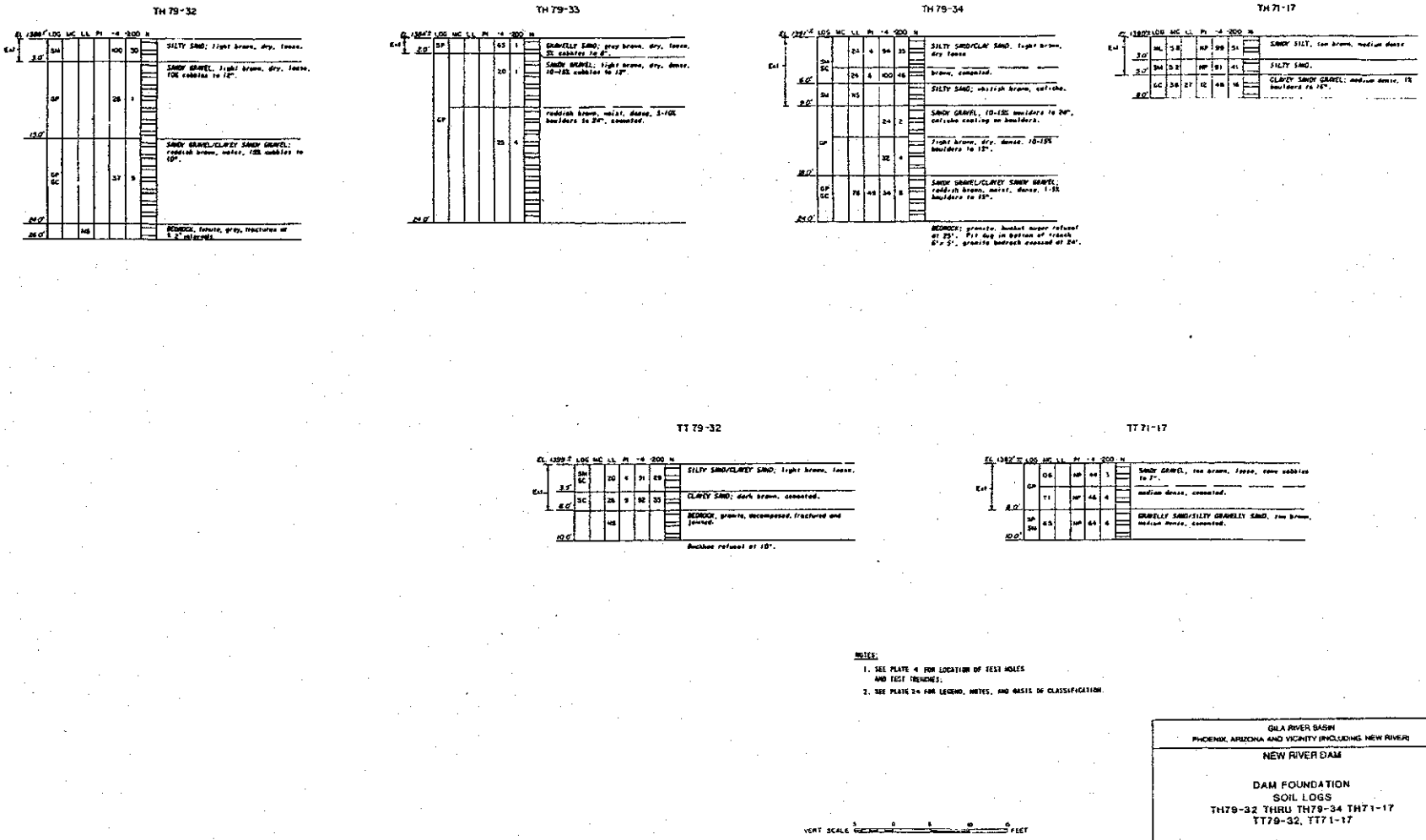
DD-45 (Inclined 45°)

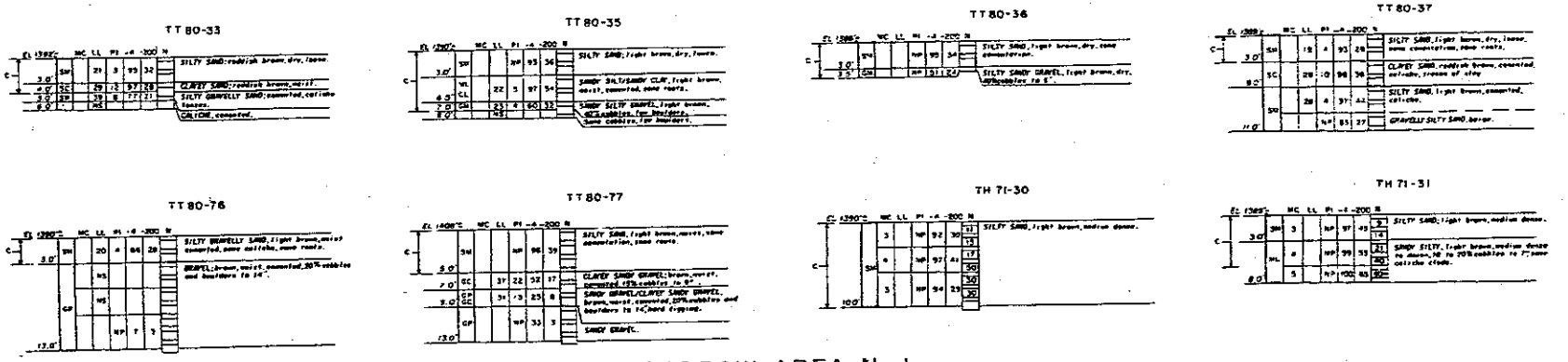


82% Recovery January 1991

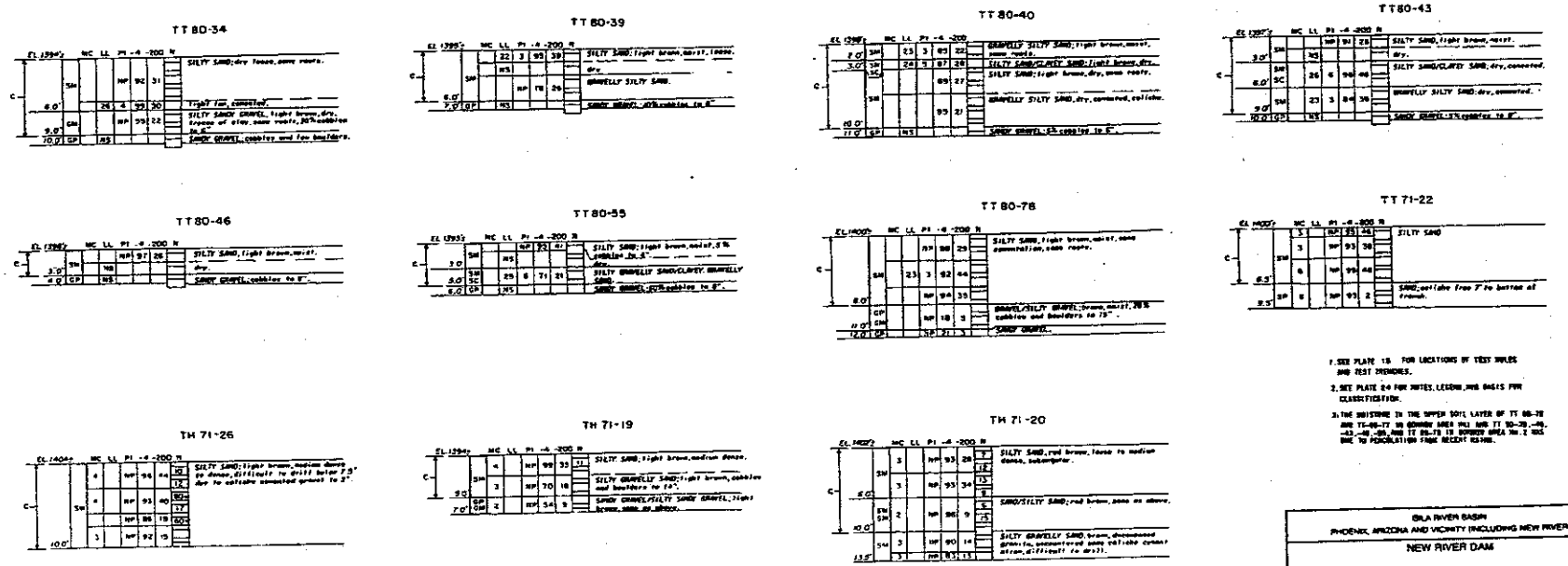
NOTES:

1. SEE PL
HOLE 7
2. SEE PL
3. SEE PI
4. DRIMP
5. ALL DI
6. DRAWI


TH 79-32
SILTY SAND; light brown, dry, loose.
SANDY GRAVEL; light brown, dry, loose, 10% cobbles to 12".
SANDY GRAVEL/CLAYEY SANDY GRAVEL; reddish brown, moist, 10% cobbles to 10".
BEDROCK, felsite, gray, fractures w/ 1/2" calcareous
TH 79-33
GRAVELLY SAND; gray brown, dry, loose, 5% cobbles to 6".
SANDY GRAVEL; light brown, dry, dense, 10-15% cobbles to 12".
reddish brown, moist, dense, 5-10% boulders to 24", cemented.
TH 79-34
SILTY SAND/CLAY SAND, light brown, dry loose
brown, cemented.
SILTY SAND; whitish brown, caliche.
SANDY GRAVEL, 10-15% boulders to 24", caliche coating on boulders.
light brown, dry, dense, 10-15% boulders to 12".
SANDY GRAVEL/CLAYEY SANDY GRAVEL reddish brown, moist, dense, 1-5% boulders to 15".
BEDROCK; granite, bucket auger refusal at 29'. Pit dug in bottom of trench 6'x 5', granite bedrock exposed at 24'.
TH 71-17
SANDY SILT, tan brown, medium dense
SILTY SAND.
CLAYEY SANDY GRAVEL; medium dense, 1% boulders to 15".
TT 79-32
SILTY SAND/CLAYEY SAND, light brown, loose.
CLAYEY SAND; dark brown, cemented.
BEDROCK, granite, decomposed, fractured and jointed.
Backhoe refusal at 10'.
TT 71-17
SANDY GRAVEL, tan brown, loose, some cobbles to 7".
medium dense, cemented.
GRAVELLY SAND/SILTY GRAVELLY SAND, tan brown, medium dense, cemented.
NOTES:
1. SEE PLATE 4 FOR LOCATION OF TEST HOLES AND TEST TRENCHES.
2. SEE PLATE 24 FOR LEGEND, NOTES, AND BASIS OF CLASSIFICATION.
VERT SCALE
FEET
GILA RIVER BASIN
PHOENIX, ARIZONA AND VICINITY (INCLUDING NEW RIVER)
NEW RIVER DAM
DAM FOUNDATION
SOIL LOGS
TH79-32 THRU TH79-34 TH71-17
TT79-32, TT71-17
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



BORROW AREA No. 1



BORROW AREA No. 2

1. SEE PLATE 18 FOR LOCATIONS OF TEST HOLES AND TEST TRENCHES.
2. SEE PLATE 24 FOR NOTES, LEGEND, AND BASIS FOR CLASSIFICATION.
3. THE BOULDERS IN THE UPPER SOIL LAYER OF TT 80-78 AND TT-80-77 IN BORROW AREA NO. 1 AND TT 80-39, -40, -43, -46, -55, AND TT 80-78 IN BORROW AREA No. 2 WERE DUE TO RECONSTITUTION FROM RECENT FLOODS.

SALT RIVER BASIN
PHOENIX, ARIZONA AND VICINITY (INCLUDING NEW RIVER)

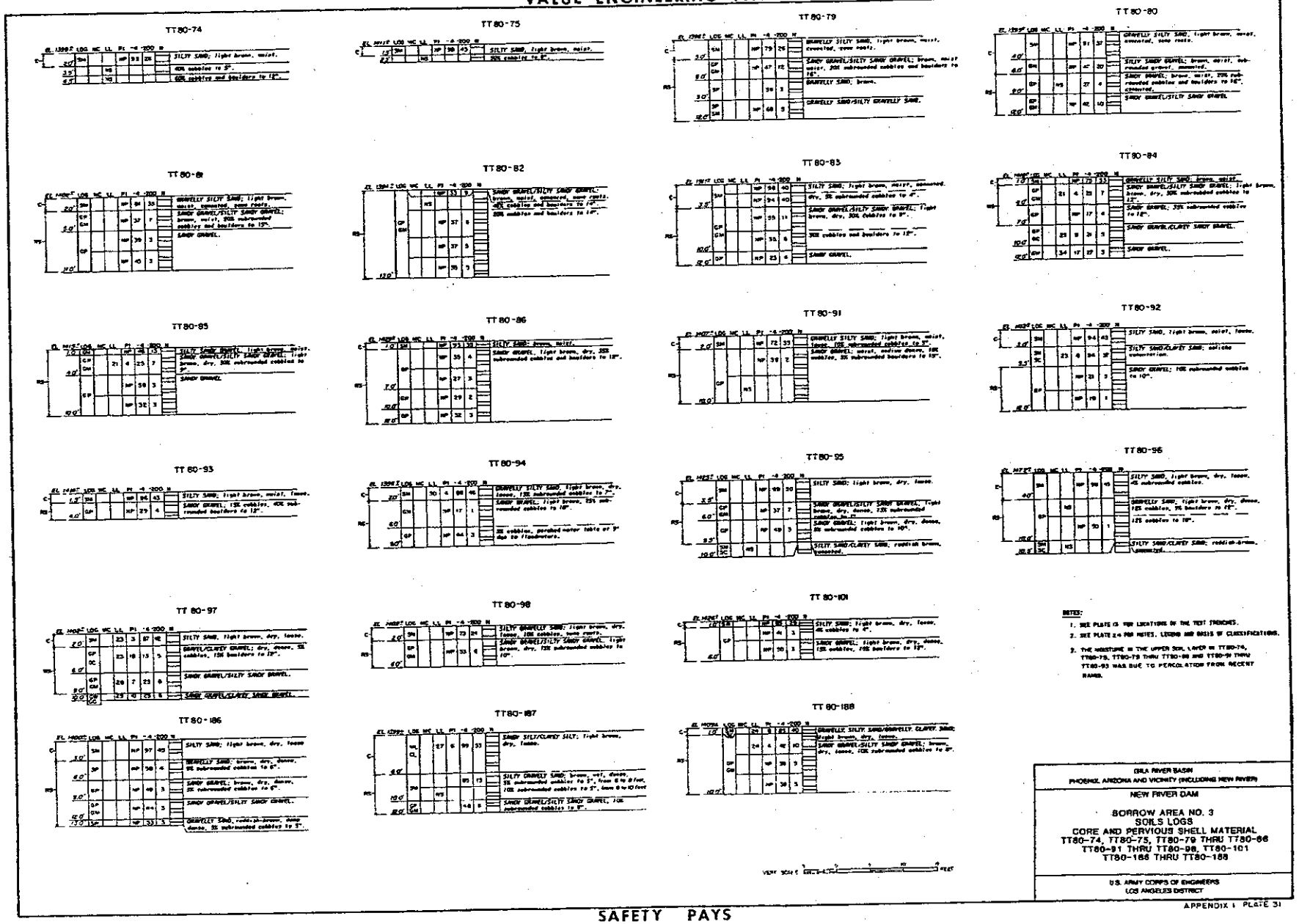
NEW RIVER DAM

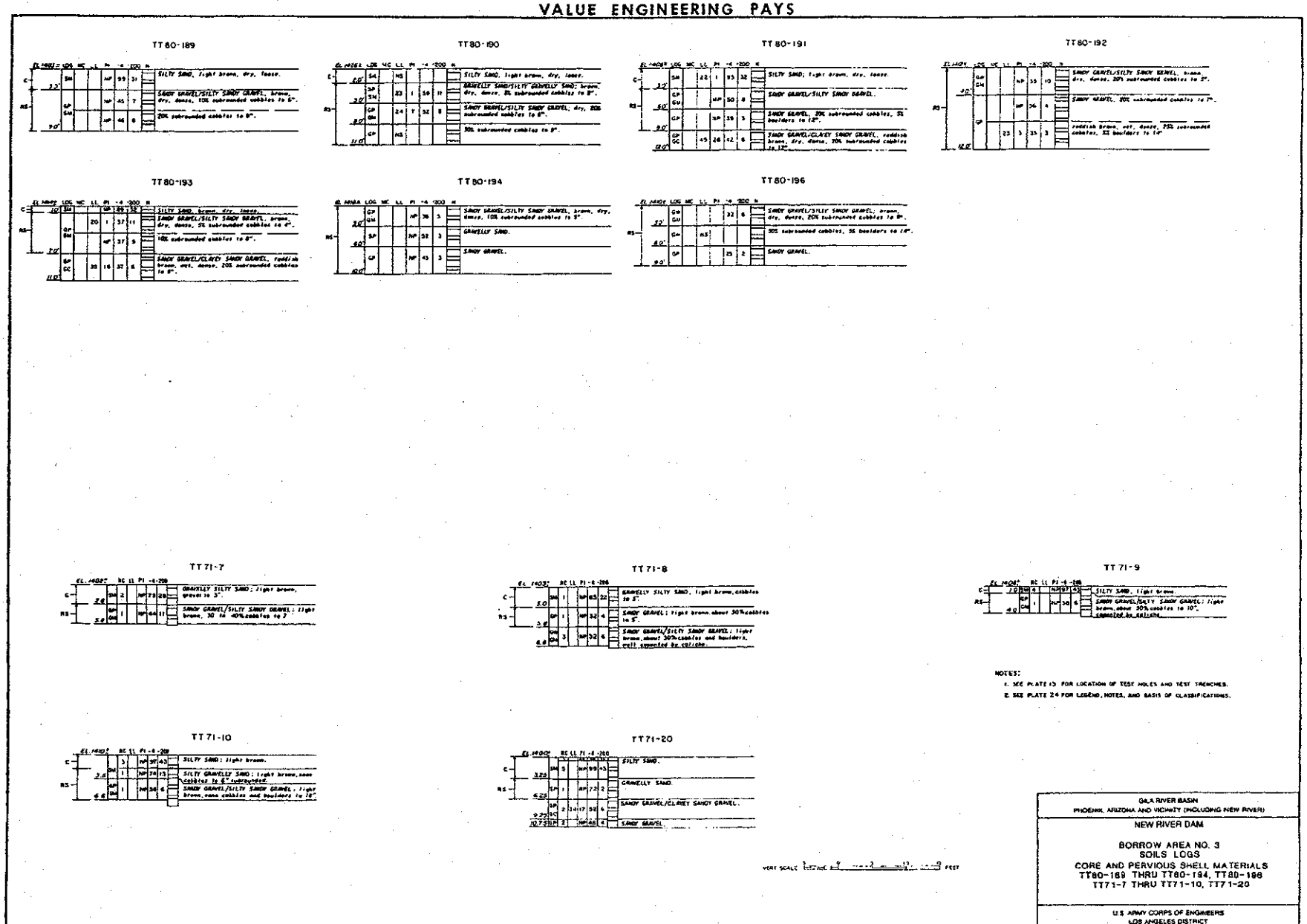
BORROW AREA NO'S 1 AND 2
SOIL LOGS
CORE MATERIAL

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

APPENDIX I PLATE 29

TT 80-41
TT 80-42
TT 80-44
TT 80-45
TT 80-47
TT 80-48
TT 80-49
TT 80-50
TT 80-51
TT 80-52
TT 80-53
TT 80-56
TT 80-57
TT 80-58
TT 80-59
TT 80-60
TT 80-61
TT 80-62
TT 80-63
TT 80-64
TT 80-65
TT 80-66
TT 80-67
TT 80-68
TT 80-69
TT 80-70
TT 80-71
TT 80-72
TT 80-73
NOT TO SCALE
NOTES:
1. SEE PLATE 13 FOR LOCATIONS OF THE TEST TRENCHES.
2. SEE PLATE 24 FOR NOTES, LEGEND AND BASIS OF CLASSIFICATION
3. THE MOISTURE IN THE UPER SOIL LAYER IN TEST TRENCHES IS DUE TO PERCOLATION FROM RECENT RAIN.
VERT SCALE
FEET
GILA RIVER BASIN
PHOENIX, ARIZONA AND VICINITY (INCLUDING NEW RIVER)
NEW RIVER DAM
BORROW AREA NO. 3
SOIL LOGS
CORE AND PERVIOUS SHELL MATERIAL
TT80-41, TT80-42, TT80-44, TT80-45
TT80-47 THRU TT80-53, TT80-56 THRU TT80-73
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT


TT80-74
TT80-75
TT80-79
TT80-80
TT80-81
TT80-82
TT80-83
TT80-84
TT80-85
TT80-86
TT80-91
TT80-92
TT80-93
TT80-94
TT80-95
TT80-96
TT80-97
TT80-98
TT80-101
TT80-186
TT80-187
TT80-188
NOTES:
1. SEE PLATE C1 FOR LOCATIONS OF THE TEST TRENCHES.
2. SEE PLATE 2-4 FOR NOTES, LEGEND AND BASIS OF CLASSIFICATIONS.
3. THE MOISTURE IN THE UPPER SOIL LAYER IN TT80-74, TT80-75, TT80-79 THRU TT80-86 AND TT80-91 THRU TT80-93 WAS DUE TO PERCOLATION FROM RECENT RAINS.
GILA RIVER BASIN
PHOENIX, ARIZONA AND VICINITY (INCLUDING NEW RIVER)
NEW RIVER DAM
BORROW AREA NO. 3
SOILS LOGS
CORE AND PERVIOUS SHELL MATERIAL
TT80-74, TT80-75, TT80-79 THRU TT80-86
TT80-91 THRU TT80-96, TT80-101
TT80-186 THRU TT80-188
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT
APPENDIX 1 PLATE 31

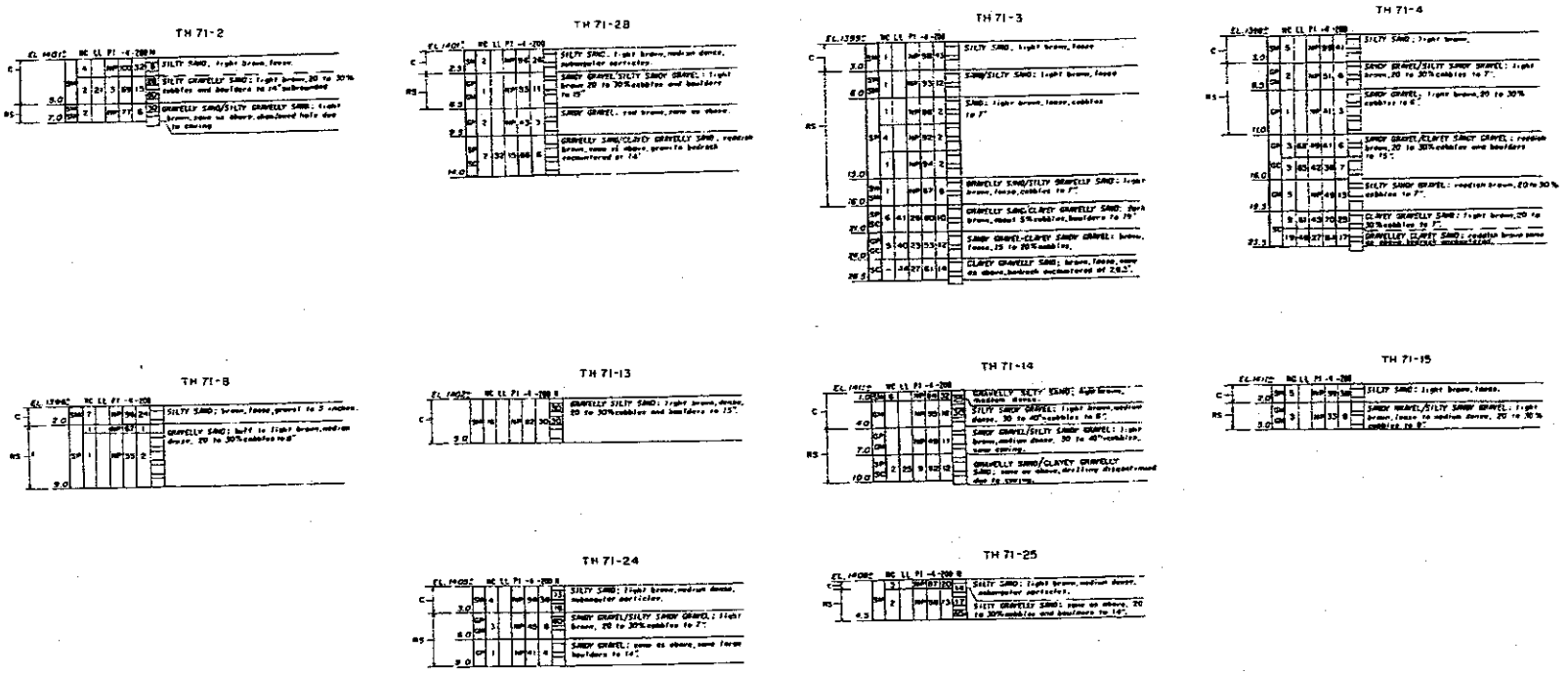


GILA RIVER BASIN
PHOENIX, ARIZONA AND VICINITY (INCLUDING NEW RIVER)

NEW RIVER DAM

BORROW AREA NO. 3
SOILS LOGS
CORE AND PERVIOUS SHELL MATERIALS
TT80-189 THRU TT80-194, TT80-196
TT71-7 THRU TT71-10, TT71-20

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



NOTES

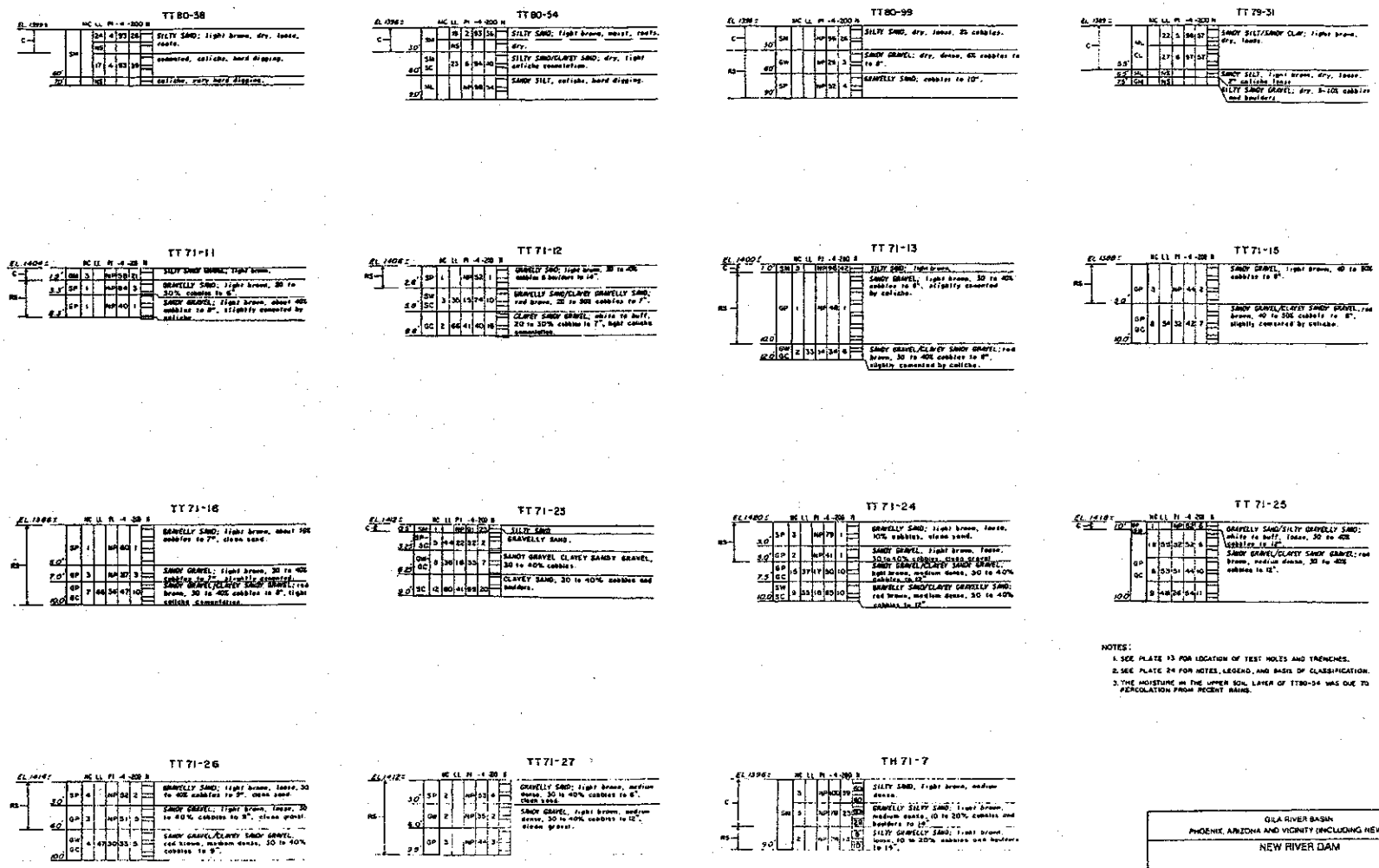
1. SEE PLATE 13 FOR LOCATIONS OF TEST HOLES AND TEST TRENCHES.
2. SEE PLATE 34 FOR LEGEND, NOTES AND BASIS OF CLASSIFICATION

GILA RIVER BASIN
PHOENIX, ARIZONA AND VICINITY (INCLUDING NEW RIVER)

NEW RIVER DAM

BORROW AREA NO. 3
SOILS LOGS
CORE AND PERVIOUS SHELL MATERIALS
TH71-2 THRU TH71-4, TH71-8
TH71-13 THRU TH71-15, TH71-24, TH71-25

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



GILA RIVER BASIN
PHOENIX, ARIZONA AND VICINITY (INCLUDING NEW RIVER)

NEW RIVER DAM

BORROW EXPLORATION
OUTSIDE BORROW AREAS NO. 1, 2, AND 3
SOILS LOGS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

gravel. Below this, to a depth of approximately 100 feet (32 metres), are layers of coarse-grained sandy gravels and clayey sandy gravels. The steep mountain slopes within the project area are covered by thin soil accumulations or are exposed rock surfaces.

SLOPE

4.09 The project area contains three broad categories of slope, each of which influences potential use and intensity of use. Most of the area is characterized by slopes between 0 and 10 percent, making them potentially useful for all activities. Smaller portions of the area are in moderately sloping alluvial fans and steeper mountain faces. These slope categories would permit moderate and restricted use, respectively.

MINERALS

4.10 There are no known resources of coal, crude oil, metallic minerals, or nonmetallic minerals in the New River Dam project area. Sand and gravel deposits, however, are present in the exposed and buried stream channels and alluvial fans. Until now, there have been no known sand and gravel operations within the project area. This resource, however, has only limited availability in the Phoenix area and demand for construction material is increasing. Therefore, additional pressures for excavation within the project area are foreseen. The FCDMC has applied for conveyance of mineral rights from the BLM under Section 209 of the FLPMA.

sites at New River Dam can provide an increasingly valuable study tool of the regional Hohokam culture.

4.15 An initial survey by Arizona State University in 1976 identified a total of 43 cultural resource sites in the project area. In 1979 the Museum of Northern Arizona inventoried and tested 22 of these sites for archeological significance in the upstream portion of the New River authorized damsite. Studies currently underway by the Museum of Northern Arizona will provide data on an additional 11 sites downstream from the damsite and spillway area. A cultural resource management program, based on the results of testing in both the upstream and downstream areas, will be developed. The New River cultural resources have been listed in the National Register of Historic Places as the New River Archeological District.

4.16 The 22 sites inventoried represent a wide range of archeological features, with variations of site function and time period. Site functions include habitation sites, agricultural fields, food gathering camps, and campsites. Representative time periods range from the Archaic (prior to AD 300) to the Sacaton Phase (AD 900-1100). Three historic period sites, including a stage station, have also been identified. Many of the sites have been disturbed by erosion, roads, animal burrows, off-road vehicles, and pot-hunters. Construction of the New River Dam will impact several archeological sites. In addition, frequent inundation will alter many sites. Prior to construction, the impact on all sites within the construction work limits will be mitigated. Impact on remaining sites in the project area will be mitigated during construction.

Limit damage to the cultural resource during construction

6.25 Project construction will destroy many of the identified archeological sites. Archeological data within the construction work limits will, therefore, be retrieved through mitigation prior to construction. To prevent further loss of the resource, haul roads have been located in areas of lower cultural significance. In addition, sites discovered on BLM land during construction will be examined by an archeologist in the field and will be reported to the authorized officer of the BLM, who will determine their significance as well as the course of action necessary to preserve the resource. Sites discovered on any other project lands during construction will be examined in the field by a Corps of Engineers archeologist, who will determine the significance of the sites, as well as the action needed to preserve the resource.

Manage the cultural resource so that further damage is minimized

6.26 Preliminary archeological investigation of all 22 sites in the basin resulted in the recommendation that two of the sites be preserved for their critical interpretative value. These two sites are representative of the diversity of site function and time phase that exist at New River Dam. In addition, the two sites are not subject to direct impact from project construction or frequent inundation.

6.27 Two archeological management areas have been established within the project area to preserve these major sites. The management zone, when feasible, will provide opportunities for passive observational activities and future research and interpretation. Because of the

fragile nature of the surface and subsurface archeological deposits at these sites, access will be greatly limited during the interim phase and will remain so until a suitable management sponsor becomes available.

RECREATIONAL

Provide for present and future recreational use consistent with the objectives of environmental preservation and enhancement and prevent incompatible development

6.28 Previous contact with local agencies in the form of recreation task force meetings has produced a recommendation that the New River damsite be retained in its natural state as a wildlife habitat area. The recreational objectives outlined below support this goal.

6.29 The continuing growth of the Phoenix area in the direction of New River Dam increases the possibility of some recreational use in the future. The project area has many natural resources with inherent esthetic, ecological, cultural, and open space values. The Resource Use Plan (pl. 6) usage zones have been developed so as to allow future recreational development that minimizes damage to the original resource base. As recreational sponsors become available in the future, the FCDMC can lease lands to them to provide recreational services in accordance with the use levels outlined below.

Low intensity use area—to preserve environmental resources

6.30 The low intensity use area encompasses lands of high erosion potential, slope hazard, potential for vegetation and wildlife disturbance, archeological and historic value and/or proximity to

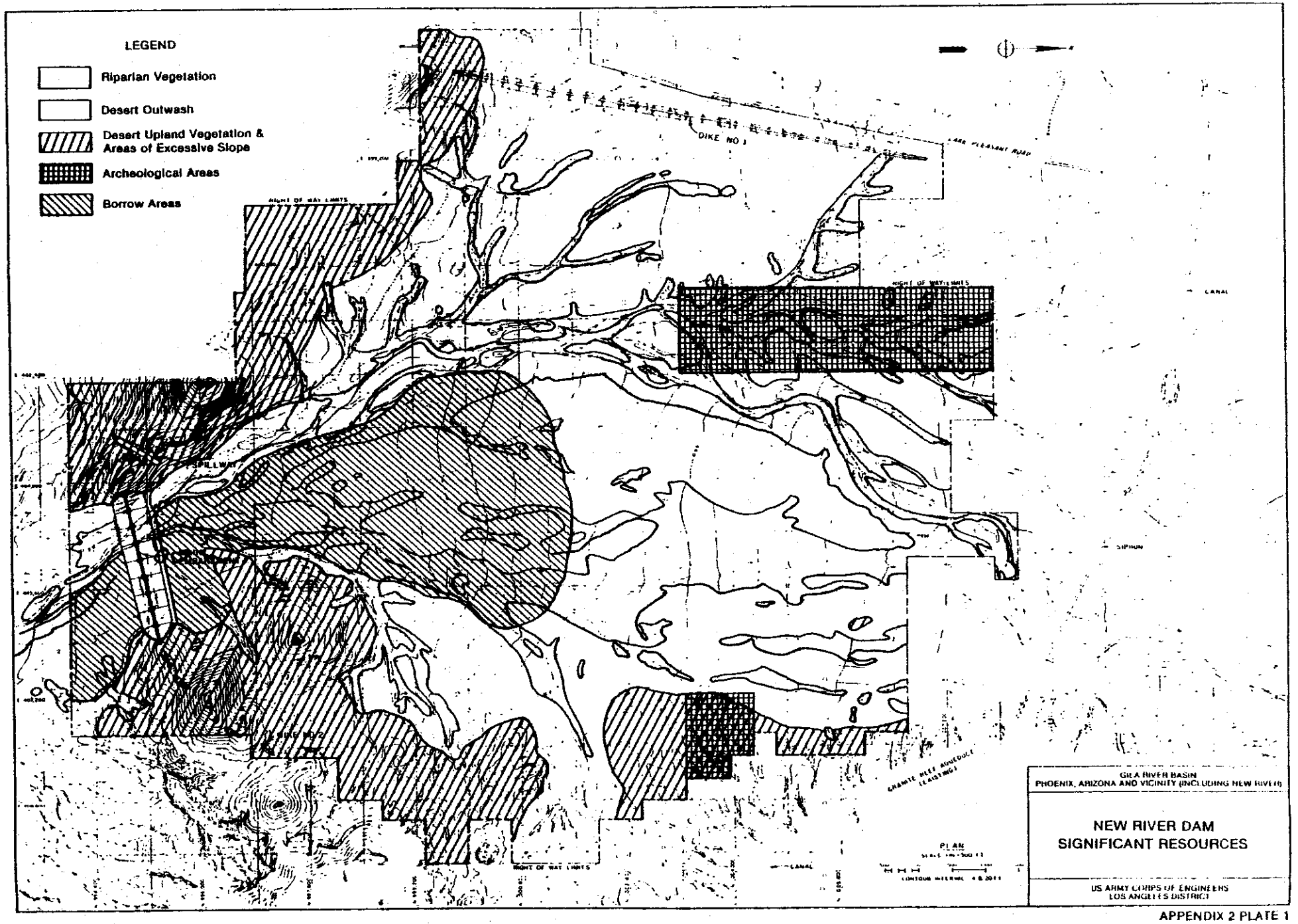
project structures. Because of these qualities, the area is most sensitive to disturbance. Possible uses of this land include passive observational activities, such as hiking, bird watching, and interpretation. Vehicular access will not be permitted. Included in the low intensity use area are those portions designated as wildlife/vegetation management and archeological management zones.

Moderate intensity use area—to preserve environmental resources and to provide for moderate intensity recreational use

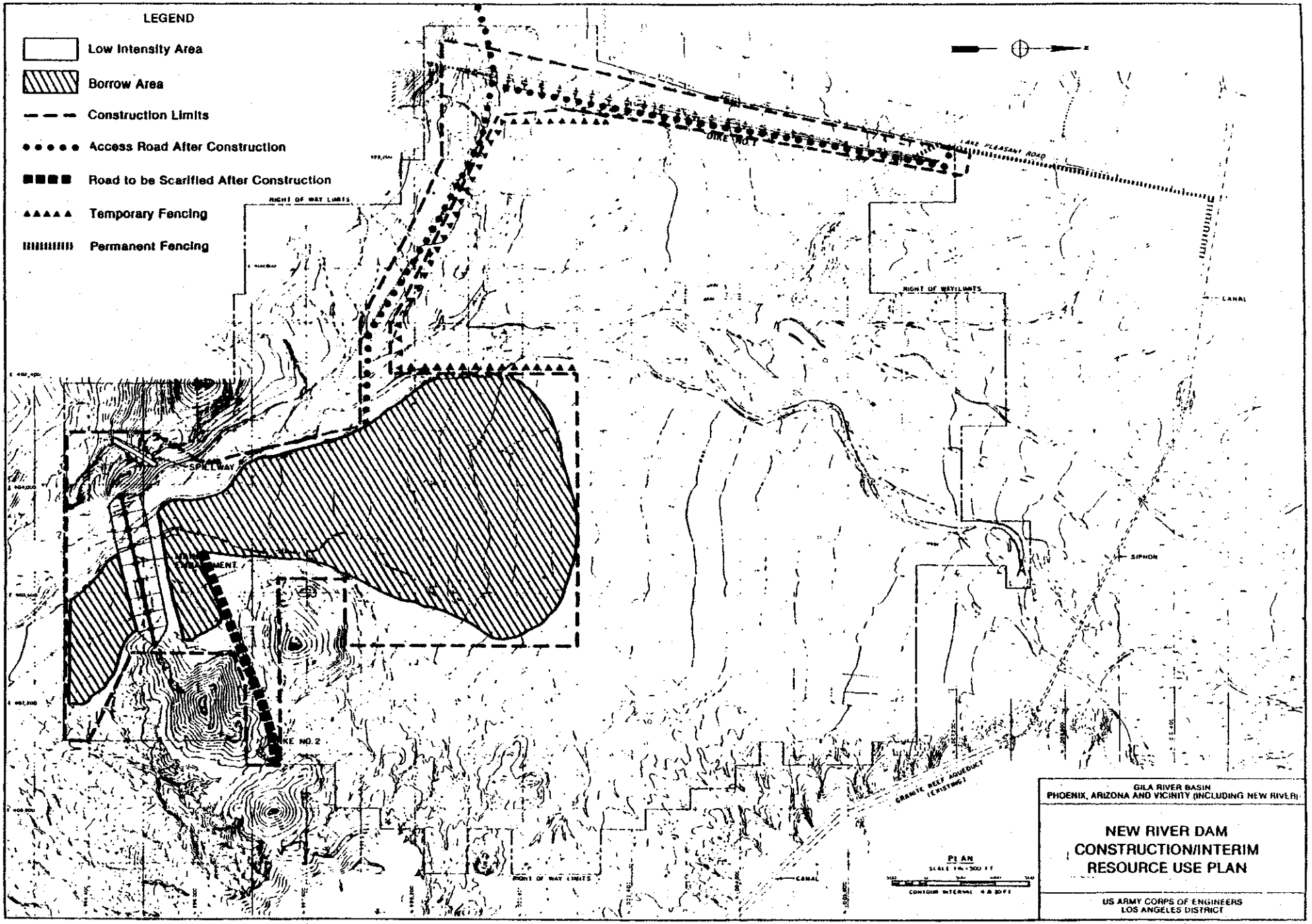
6.31 The moderate intensity use area is located in relatively flat upland. Sensitivity to disturbance varies within the area but the resource base, in general, can withstand moderate levels of environmental stress without detrimental effects. Possible uses in the area are hiking, equestrian riding, passive observational activities, interpretation, and other moderate level recreational activities.

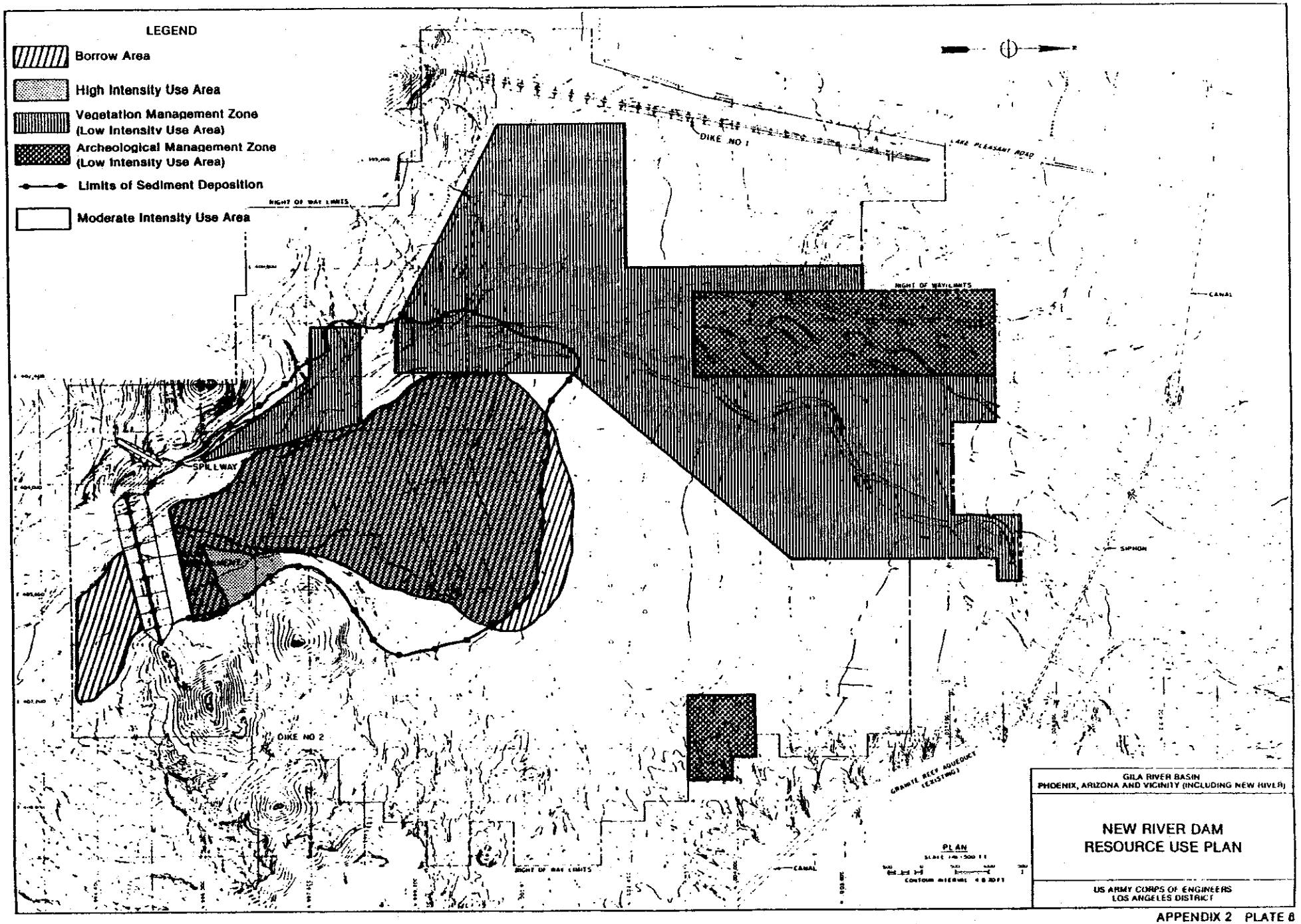
High intensity use area—to provide for maximum economic and recreational use of the resources therein

6.32 The high intensity use area is located in the borrow area, which will be a highly altered landscape as a result of project construction. Additional disturbance within this area will only marginally affect the environmental quality of the New River Dam Basin as a whole. Possible uses include extraction of minerals and all moderate and low intensity recreational uses.



APPENDIX 2 PLATE 1


LEGEND
Low Intensity Area
Borrow Area
Construction Limits
Access Road After Construction
Road to be Scarified After Construction
Temporary Fencing
Permanent Fencing
LAKE PLEASANT ROAD
DIKE NO.1
RIGHT OF WAY LIMITS
SPILLWAY
SIPHON
CANAL
GRANITE REEF AQUEDUCT (EXISTING)
PLAN
GILA RIVER BASIN
PHOENIX, ARIZONA AND VICINITY (INCLUDING NEW RIVER)
NEW RIVER DAM
CONSTRUCTION/INTERIM
RESOURCE USE PLAN
US ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT


LEGEND
Borrow Area
High Intensity Use Area
Vegetation Management Zone (Low Intensity Use Area)
Archeological Management Zone (Low Intensity Use Area)
Limits of Sediment Deposition
Moderate Intensity Use Area
DIKE NO 1
LAKE PLEASANT ROAD
RIGHT OF WAY LIMITS
SPILLWAY
DIKE NO 2
CANAL
SIPHON
GRANITE REEF AQUEDUCT (EXISTING)
PLAN
GILA RIVER BASIN
PHOENIX, ARIZONA AND VICINITY (INCLUDING NEW RIVER)
NEW RIVER DAM
RESOURCE USE PLAN
US ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

108

GILA RIVER BASIN
NEW RIVER AND PHOENIX CITY STREAMS

DESIGN MEMORANDUM NO. 3
GENERAL DESIGN MEMORANDUM - PHASE I
PLAN FORMULATION

MARCH 1976

MAIN REPORT

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

Design Memorandum No. 3

General Design Memorandum – Phase I
Plan Formulation
For
New River and Phoenix City Streams, Arizona

SYLLABUS

The purpose of this study was to review the New River and Phoenix City Streams, Arizona, flood control project, as authorized (H Doc. 89-216, 1st Sess.), and either reaffirm the plan or reformulate and develop a plan more suitable under existing conditions, taking into account environmental and technical considerations, economic feasibility, social impact, and public opinion and needs.

A flood hazard exists in the Phoenix metropolitan area in southcentral Arizona along Cave Creek from the existing Cave Creek Dam to the Salt River, along and below the Arizona Canal between 40th Street and Skunk Creek, and along Skunk Creek and the New and Agua Fria Rivers. Present development within the standard project flood overflow area consists of 17,680 acres of residences, 4,060 acres of commercial and industrial businesses, 12,530 acres of farmland 2,800 acres of public and semi-public lands, 260 acres of parks, and 13,170 acres of undeveloped land.

A combination structural-nonstructural plan, compatible with the desires of local interests has been determined to be the best solution for the flood problem in the project area. The recommended plan of improvement, which differs from the authorized plan, involves the construction of Dreamy Draw, Cave Buttes, Adobe, and New River Dams, and the Arizona Canal diversion channel from 40th Street to Skunk Creek. Skunk Creek and the New and Agua Fria Rivers, however, would remain natural. Development in those reaches of Skunk Creek and New River upstream from the diverted floodwater would be controlled through flood plain management; flowage easements would be required downstream from the diversion channel to the Gila River.

All dams are earthfill dams designed to provide standard project flood protection. Dreamy Draw Dam was completed in 1973 subsequent to approval of Design Memorandum No. 1, Feature Design for Dreamy Draw Dam. The design capacities of the detention basins are 317 acre-feet for Dreamy Draw Dam, 46,600 acre-feet for Cave Buttes Dam, 18,350 acre-feet for Adobe Dam, and 34,500 acre-feet for New River Dam. In addition to the dams, the recommended plan includes 17.3 miles of channelization along the Arizona Canal (Arizona Canal diversion channel) designed to intercept 100-year-frequency floodflows. This channelization includes 8.1 miles of rectangular channel from 40th Street to the confluence of Cave Creek, 4.8 miles of concrete-lined trapezoidal channel from Cave Creek to Cactus Road, and 4.4 miles of unlined trapezoidal channel from Cactus Road to the confluence with Skunk Creek. Flowage easements, which are generally coincident with the 100-year flood plain after project construction except where structural measures have been included, would be acquired along 1.8 miles of Skunk Creek, 7.6 miles of New River, and 10.1 miles of the Agua Fria River to its confluence with the Gila River.

Physical Data – Channels

	Design Discharge (cfs)	Top Width (ft)	Depth (ft)
Cave Creek			
Below Cave Buttes Dam	500	**	**
At Greenway Road	17,500	**	**
At Arizona Canal	15,000*	140	10
Skunk Creek			
Below Adobe Dam	1,950	**	**
Above Arizona Canal diversion channel confluence	2,000	**	**
Below Arizona Canal diversion channel confluence	39,000	***	***
At New River confluence	39,000	***	***
New River			
Below New River Dam	2,700	**	**
Above Skunk Creek confluence	9,000	**	**
Below Skunk Creek confluence	41,000	***	***
At Agua Fria River confluence	39,000	***	***
Agua Fria River			
Below New River confluence	45,000	***	***
At Gila River confluence	43,000	***	***
Dreamy Draw			
Below Dreamy Draw Dam	220	**	**
At Arizona Canal diversion channel	1,000	**	**
Arizona Canal diversion channel			
At 40th Street	6,800	36	21
At Dreamy Draw confluence	10,000	50	24.5
Above Cave Creek confluence	15,000	60	22.5
Below Cave Creek confluence	26,000	168	22
At Skunk Creek confluence	36,000	445	20

*The design discharge was limited by the capacity of Peoria Avenue bridge. The 100-year discharge is estimated at 21,000 cfs.

**These sections would be managed in accordance with flood plain management criteria. The width and depth of the flood plain varies.

***Flowage easements would be acquired at these sections. The width of the flowage easement and depth of flow varies.

Physical Data – Dams (Continued)

NEW RIVER DAM

Drainage area	sq mi	164
Dam (rolled earthfill)		
Crest elevation	ft msl	1,481.7
Maximum height above streambed	ft	91
Crest length	ft	2,800
Freeboard	ft	6.5
Spillway (detached, concrete lined)		
Crest elevation	ft msl	1,455.3
Crest length	ft	220
Elevation of maximum water surface	ft msl	1,475.2
Outlet conduit		
Diameter	ft	8.5
Length	ft	450
Intake elevation	ft msl	1,392.0
Saddle dike No. 1 (west dike)		
Crest length	ft	5,800
Maximum height above existing ground	ft	30
Reservoir		
Area at spillway crest	acre	1,460
Capacity (gross) at spillway crest	acre-ft	34,500
Storage allocation below spillway crest		
Flood control	acre-ft	29,580
Sedimentation	acre-ft	4,920
Standard project flood		
Total volume	acre-ft	39,000
Peak inflow	cfs	48,000
Peak outflow	cfs	2,590
Drawdown time	hr	185
Peak spillway discharge	cfs	63,300

feet. The unlined spillway, excavated in rock about 400 feet southeast of the left abutment of the main embankment, had a concrete sill with a length of 275 feet at elevation 1,410 feet. The spillway was designed to pass a spillway-design flood having a peak discharge of 9,700 cfs with 5 feet of freeboard. The outlet was a 36-inch-diameter ungated reinforced-concrete conduit located in the main embankment. The capacity of the outlet was 100 cfs with the water surface at the spillway crest. Two earthfill dikes just upstream from the main embankment and along the right bank of Dreamy Draw were required. One dike, about 950 feet long, had a maximum height of 22 feet; the other had a length of 850 feet and a maximum height of about 12 feet. The detention basin had a capacity of 450 acre-feet at the spillway crest, of which 150 acre-feet was allocated for the accumulation of sediment over a 100-year period. The detention basin would have reduced a standard project flood with a peak inflow of 2,180 cfs to a peak outflow of 100 cfs.

ADOBE DAM

Adobe Dam was recommended for construction on an unnamed tributary of Skunk Creek, about 7 miles north of Bell Road and about 1 mile west of the Black Canyon Highway. The embankment was a compacted earthfill structure with a maximum height of about 76 feet above streambed. The crest of the dam (elevation 1,561 feet) had a length of 3,850 feet. An unlined spillway, excavated in rock 700 feet north of the left abutment of the embankment, had a concrete sill with a length of 250 feet at elevation 1,542 feet. The spillway was designed to pass a spillway-design flood having a peak discharge of 105,000 cfs with 5 feet of freeboard. The outlet was an 8-foot-diameter ungated reinforced-concrete conduit located through the embankment near the right abutment. The capacity of the outlet was 2,000 cfs with the water surface at the spillway crest. The detention basin had a capacity of 19,400 acre-feet of which 5,500 acre-feet was allocated for the accumulation of sediment over a 100-year period. The detention basin would have reduced a standard project flood with a peak inflow of 50,000 cfs to a peak outflow of 2,000 cfs.

An earth diversion channel about 2.5 miles long was required to divert the design flood on Skunk Creek to the Adobe detention-basin area. The channel was located with its downstream end about 5,000 feet north of the left abutment of the main embankment, just above the water surface of the standard project flood in the detention basin. A revetted earth levee, set back 100 feet from the channel, was required to prevent the standard project flood from bypassing the detention basin under adverse channel conditions. Construction of the diversion channel would require construction of a bridge for the Black Canyon Highway.

NEW RIVER DAM

The New River Dam basin was recommended for construction on the New River about 8 miles upstream from the confluence with Skunk Creek. The main embankment was a compacted-earthfill structure with a maximum height of about 80 feet above streambed. The crest of the embankment (elevation 1,474 feet) was 2,700 feet long. An unlined spillway, excavated in rock 1,600 feet east of the left abutment of the main embankment, had a concrete sill with a length of 800 feet at elevation 1,458 feet. The spillway was

The river, which is fairly well defined for high-frequency flow, is spanned by three bridges of varying capacities. The bridge capacities, without freeboard, are estimated at 150,000 cfs at Indian School Road, and 75,000 cfs at both the Southern Pacific Railroad bridge and at U.S. Highway 80 (Buckeye Road) bridges in Avondale. Dip crossings presently exist across the Agua Fria River at Thomas Road, McDowell Road, Van Buren Street, and Lower Buckeye Road.

NEW RIVER

The New River, the major tributary of the Agua Fria River, rises in the New River Mountains about 40 miles north of Phoenix and flows generally southward for about 40 miles to its confluence with the Agua Fria River, about 15 miles west of downtown Phoenix. Its drainage area is 340 square miles.

The New River, between the authorized dam and Skunk Creek, is fairly well defined for a capacity ranging upwards from 9,000 cfs. The only bridge crossing in this reach is at Bell Road, which has a capacity, without freeboard, of about 35,000 cfs. Dip crossings exist at Union Hills Drive and 83d Avenue.

The New River, between the Skunk Creek confluences and the Agua Fria River, is fairly well defined for high-frequency flows. Five bridges of varying capacities span the river. The bridge capacities, without freeboard, are estimated at 29,000 cfs at the Santa Fe Railroad bridge and the two Highway 60-89-93 bridges (Grand Avenue) in Peoria, 50,000 at Peoria Avenue, 37,000 at Olive Avenue, and 40,000 at Glendale Avenue.

SKUNK CREEK

Skunk Creek, the major tributary to the New River, rises in the New River Mountains about 35 miles north of downtown Phoenix and flows generally southwestward for about 30 miles to its confluence with the New River about 15 miles northwest of downtown Phoenix. The drainage area is 110 square miles.

The existing capacity of Skunk Creek from Deer Valley Drive to the New River ranges from 2,500 to about 10,000 cfs in a fairly well-defined channel. Skunk Creek is spanned by seven bridges, four of which involve the Black Canyon Highway and frontage road crossings upstream from Deer Valley Drive. The capacity of these four bridges, without freeboard, is estimated at 20,000 cfs. The capacities of the other three bridges, without freeboard, are estimated at 8,000 cfs at 59th Avenue, 22,000 at Bell Road and 24,000 at 83d Avenue. Dip crossings exist at Beardsley Road and 67th Avenue.

CAVE CREEK

Cave Creek rises at an elevation of 5,000 feet in the New River Mountains and flows generally southward for about 48 miles, passing through the center of Phoenix before entering the Salt River. The drainage area at the Salt River is 311 square miles.

On the morning of 22 June 1972, a heavy thunderstorm hit northeastern Phoenix. The maximum unofficial intensity reported was 5.25 inches during an estimated 2-hour period in the vicinity of 24th Street and Camelback Road in Phoenix. The storm in the Phoenix area was highly localized centering on an area of 10 square miles (4 inches or more) in the vicinity of Squaw Peak. Heavy runoff occurred from the south slopes of the Phoenix Mountains; and sheetflow inundated large areas in Paradise Valley and on the southwest slopes of the McDowell Mountains. Flooding occurred along Indian Bend Wash from Paradise Valley through Scottsdale and Tempe to the Salt River. A U.S. Geological Survey recording stream gage at Indian Bend Road indicated a peak discharge of 17,000 cfs. In addition, an estimated 3,000 cfs flowed across Indian Bend Road for a total peak flow of 20,000 cfs. This flood is estimated to have a frequency of occurrence of once every 70 years. Flooding also occurred at the Arizona and Grand Canals as floodwaters ponded behind the canal levees. Peak discharges ranged from 4,200 cfs estimated on Cudia City Wash 1,000 feet upstream from McDonald Drive (approximately a 50-year flood) to 860 cfs on Dreamy Draw at 16th Street. Immediately following the flood, the Los Angeles District conducted a flood damage survey. The results of this survey were published in the "Report on Flood of 22 June 1972, Phoenix Metropolitan Area, Arizona" dated October 1972. The survey revealed that the principal areas of flood damage were along a 14-mile reach of Indian Bend Wash ($1.9 million damages); along 16 miles of the Arizona Canal from Cave Creek to Indian Bend Wash ($1.8 million damages); along eight major breaks in the Arizona Canal ($4.3 million damages); along 8 miles of the Grand Canal from 15th Avenue to 44th Street ($1.7 million damages); and along four breaks in the Grand Canal ($0.9 million damages). The total damages due to flooding (1972 price level) were estimated at $10.6 million. Under present (1975) conditions of development and price levels, these damages would amount to about $15 million. The proposed Arizona Canal diversion channel would prevent 70 percent of these damages which would amount to approximately $7.4 million (1972 conditions) or $10.5 million (1975 conditions).

FLOOD FREQUENCIES

Discharge-frequency values were computed for all concentration points in each of the plans investigated using graphical methods of frequency analysis where streamgage data are available and a regression analysis for ungaged watersheds. Discharge-frequency values were computed for with and without project conditions and for present and future conditions of development. These values are presented in table 1 of Appendix 1 of this report.

Additional hydrologic data have been compiled and analyzed since the project document studies. New topographic maps with more detail and recent storms of record have been incorporated into a revision of earlier hydrologic values (See appendix 1). A comparison of flood magnitudes for two representative concentration points follows:

TABLE 2

Comparison of Flood Magnitudes

Frequency (Years)	Peak Discharge* (cfs) Cave Creek at Arizona Canal Present Values	Cave Creek at Arizona Canal Project Document Survey Values	New River below Skunk Ck. Confluence Present Values	New River below Skunk Ck. Confluence Project Document Survey Values
SPF	50,000	65,000	86,000	126,000
100	26,000	29,500	58,000	58,000
50	14,000	19,500	44,000	38,000
25	7,000	--	31,000	--
10	2,400	6,000	17,000	11,500
5	900	3,000	8,400	6,000
2	500	--	1,700	--

*Uncontrolled discharge under present conditions of development.

STANDARD PROJECT FLOOD

The standard project flood (SPF) represents the flood that would result from the most severe combination of meteorologic and hydrologic conditions considered reasonably characteristic of the region. It normally is larger than any past recorded flood in the area and can be expected to be exceeded in magnitude only on rare occasions. It thus constitutes a standard for design that will provide a high degree of flood protection. The SPF is produced by centering the most severe storm of record in the general region critically over the drainage area when ground conditions are conducive to a high rate of runoff.

The August 1954 thunderstorm that centered over the Queen Creek drainage area southeast of Phoenix was determined to be the local storm with the most severe flood peak producing relationship between rainfall, depth, area, duration and isohyetal pattern that may reasonably be expected to occur over the central portion of Arizona, and was thus used as the standard project storm for design and economic considerations for all areas except Cave Buttes and New River damsites. For the mountaineous drainages behind the

purposes for agricultural land not already under cultivation when the ban was placed in effect. The overdraft of ground water is one of the primary reasons for the development of the Central Arizona Project. The legal use of ground water for esthetic and/or promotional displays is currently being explored by the Arizona Water Commission and State Land Department. Future legal and legislative decisions can be expected to control more closely the use of water within the ground water basin.

TABLE 5

Depth to Water in Wells*

Project Area	Depth to Water (feet)
Cave Buttes Dam	30 to 240**
Adobe Dam	400 to 500
New River Dam	400 to 500
Cave Creek	0 to 400
Skunk Creek	300 to 500
New River	100 to 500
Agua Fria	0 to 200
Arizona Canal	0 to 300
Salt River (Cave Creek to Gila River)	0 to 100

*Principally in alluvial deposits (1972). Depth based mainly on measurement where depth of water is less than 400 feet and inferred mainly where depth is greater than 400 feet.

**Depth to water in wells that principally tap consolidated rocks taken from "Map showing Depth to Water in Wells in the Phoenix Area, Arizona, 1972" by W. R. Osterkamp, 1973.

The recommended plan at the Cave Buttes site includes a 110-foot-high earthfill dam, about 2,280 feet in length, with a basin capacity of 46,600 acre-feet at spillway crest of which 5,730 acre feet would be for the accumulation of sediment. The reservoir would reduce a standard project flood peak inflow of 54,000 cfs to 494 cfs through an ungated outlet. The natural stream below Cave Buttes Dam can convey a non-damaging flow of 750 cfs to the Arizona Canal.

ADOBE DAM. Four sites for Adobe Dam were studied. These sites were analyzed as single dams and in combination with each other. Their locations ranged from a site near Deer Valley Drive, about 16 miles northwest of Phoenix, to a site about 25 miles north of Phoenix. The authorized site, on an unnamed tributary to Skunk Creek, is about 20 miles northwest of Phoenix.

Alternative damsite No. 4, which is located on Skunk Creek near Deer Valley Drive, was selected as the recommended site because (a) from a locational viewpoint, it is more desirable since it would eliminate the diversion levee that would be required to divert Skunk Creek flows out of its natural watercourse, across the Black Canyon Highway, and into the detention basin of the authorized dam; (b) it would provide additional downstream flood protection benefits in that it would control floodwaters from a larger drainage area; (c) it would be nearer to present and projected future downstream development, thereby reducing the potential for floods being generated immediately below the dam; and (d) this site is the least costly site. For the purpose of plan formulation, this site was used in the determination of cost estimates and related social and environmental impacts. During Phase II studies, costs and benefits will be developed in more detail for Adobe damsite No. 4 and for a combination of dams, one on Skunk Creek, 9 miles upstream of site No. 4 (Adobe damsite No. 1), and a smaller dam at site No. 4 (Adobe damsite No. 4a). Additional studies are required to fully evaluate the economics and social and environmental impacts of these two plans to either confirm the selection of Adobe Dam site No. 4 as the recommended site or to favor the combination of dams. However, a change in damsites would have no effect on project formulation.

The recommended dam (site No. 4) would be a 63-foot-high earthfill dam, about 2.1 miles in length, having a basin capacity of 18,350 acre-feet at spillway crest of which 2,700 acre feet would be for the accumulation of sediment. The recommended dam would reduce the standard project flood peak inflow of 66,000 cfs to 1,890 cfs through an ungated outlet. The natural stream below Adobe Dam has a capacity of 2,500 cfs.

NEW RIVER DAM. Three sites for the New River Dam were considered. One site, 2 miles downstream of the authorized site, was rejected because the construction cost was almost double that at the recommended site with no significant increase in benefits. Another site, located about 2,000 feet downstream of the authorized site, was visually inspected but no subsurface investigation was made. Further investigation and evaluation of a dam at this site will be made during Phase II studies.

The detention basin would have a capacity of 18,350 acre-feet at the spillway crest of which 2,700 acre-feet would be for the accumulation of sediment over a 100-year period, and 15,650 acre-feet would be for flood control. The detention basin would reduce a standard project flood with a peak inflow of 66,000 cfs to an outflow of 1,890 cfs.

Three streets presently pass through the Adobe Dam detention basin area. Pinnacle Peak Road would not be affected by project construction except during a 100-year and less frequency flood, floodwaters detained behind the dam would cause temporary closure for less than a day. Deer Valley Drive would be blocked by the dam, and would not be relocated. The frequently used 35th Avenue would be ramped over the dam to provide continuous access to the area north of the detention basin; it would be above the standard project flood line.

Channelization of Skunk Creek in the vicinity of the Black Canyon Highway (designated Skunk Creek diversion channel), about 2 miles northeast of the left abutment of the dam, would be required to assure conveyence of the standard project flood to the Adobe detention basin. About 6,900 feet of the existing creek would be excavated to a greater depth (10-foot maximum) and widened from an existing 265 feet to 365 feet. A 7,600-foot-long levee immediately south of the channel would be constructed from the excavated material. It would range in height from 6 to 13 feet above the channel invert and would have a 2-foot layer of stone revetment on the waterside slope. The two existing eight-span Black Canyon Highway and two frontage road bridges would be utilized; however, four additional spans would be added to each of the four bridges, extending the overall bridge length from 268.8 to 402.8 feet.

NEW RIVER DAM

The New River Dam would be constructed on the New River about 8 miles upstream from the confluence with Skunk Creek. The main embankment would be a compacted-earthfill structure with a maximum height of about 91 feet above streambed. The crest of the embankment (elevation 1,481.7 feet) would be 2,800 feet long. An earthfill dike, about 7,000 feet northwest of the right abutment of the main embankment, would be required along the west edge of the detention-basin area to confine the design flood. The dike would have a crest length of 5,800 feet and a maximum height of about 30 feet. A concrete-lined spillway 1,600 feet east of the left abutment of the main embankment would be rectangular in cross section, varying in width from 220 feet at the crest (elevation 1,455.3 feet) to 173 feet at the downstream end of the chute. This rectangular section, which would be 589 feet long, would include 94 feet of approach channel, 470 feet of chute structure, and a 25-foot long flip-bucket structure. The spillway, in conjunction with the outlet works, would pass a peak discharge of 63,300 cfs with 6.5 feet of freeboard.

The outlet works would consist of an intake structure, conduit, and an energy dissipator. The 8.5-foot diameter concrete conduit, which would have an intake elevation of 1,392, would be 450 feet in length and would be capable of releasing up to 2,590 cfs when the

natural conditions. This decrease in velocity would not be sufficient to affect existing erosion patterns. The reservoirs that would be created behind the dams would act as a stilling basin, reducing the level of suspended solids in the impounded flood flows. During floods, increased scour will occur downstream of the dams until the sediment load of the released flows has been restored. The length of downstream channel affected will vary with the time that flows remain ponded behind the dams. Increased scouring will occur for a few miles below the dams.

NATURAL RESOURCES

Sand and gravel occur in recoverable quantities along the stream beds of the project area. Aggregate materials have been excavated from numerous locations along Cave Creek, Skunk Creek, and the Agua Fria, Salt and Gila Rivers. The major sources of supply close to the City of Phoenix, along the Salt and Gila Rivers, will not be affected by the proposed project. The only potential resource that will be permanently removed is the land under the proposed embankments. The stream channels will still be available for mining. The proposed floodways and flowage easements will restrict urban development along the stream channels, helping to preserve sources of material adjacent to urban areas. The area behind the dams will be available for mining before the development of recreational facilities or in areas where no facilities are planned. The proposed dams will trap some of the sediments that normally replenish the streambeds. This will not significantly affect the quantity of sand and gravel available downstream. Sediments not removed by mining interests will be periodically excavated during maintenance operations. To maintain the storage capacity of the reservoir no existing active mining operations will be disturbed by construction of the project.

The dam embankments, dikes and levees will require approximately 75 million cubic yards of material, primarily sands, silts and gravels. An estimated 640 acres will be excavated as borrow to supply construction materials. Over 95% of this acreage will be located within the proposed reservoir areas. With many miles of stream channel available for mining in the study area, the construction of the proposed project will not significantly effect the quantity or location of aggregate material in the Phoenix area.

HYDROLOGY

The surface hydrology in the study area would be modified by the project. The recommended project will affect the volume, velocity, duration, and course of surface flows downstream from the three dams. By controlling the release of storm runoff from the dams, peak floodflows and velocities would be reduced, while the duration of the flows would increase.

The proposed Arizona Canal diversion channel would divert water from the Cave Creek watershed to Skunk Creek. This diversion would increase the total volume (acre-feet) of flows along Skunk Creek and the New and Agua Fria Rivers. Adobe and New River Dams would detain floodwaters emanating from their respective upstream drainage areas for

TOPOGRAPHY AND DRAINAGE.

The proposed project would cause significant changes to the existing topography and drainage patterns of the study area. The dams would detain floodwaters and the diversion channel would divert floodwaters from the Cave Creek watershed to the adjacent Agua Fria River watershed. However, the net effect of constructing the two dams (Adobe and New River) and the diversion channel (Arizona Canal diversion channel) would be a reduction in the acreage along Skunk Creek, and the New and Agua Fria Rivers that would be subject to inundation by a 100-year flood. Flowage easements would be acquired along Skunk Creek and the New and Agua Fria Rivers downstream of the diversion channel confluence and would be managed in accordance with floodplain management policies.

Permanent alterations would occur as a result of the construction of the three dams, the diversion channel and associated recreational facilities. In the vicinity of the dams a total of 4,630 acres would be altered by periodic flooding, 440 acres would be altered by channelization of Skunk Creek at Black Canyon Highway and construction of embankment dikes and spillways, and 110 acres would be altered immediately downstream of Cave Buttes Dam and dike No. 1. Behind Cave Buttes and Adobe Dams, 3,170 acres of the detention basin area would be altered because of recreational development. Along the Arizona Canal, 506 acres would be altered through construction of the diversion channel, and associated recreational features and approximately 1,200 acres of land would be altered along Cave Creek for development of Cave Creek Regional Park. The streambeds along Skunk Creek and the New and Agua Fria Rivers downstream of the dams would remain as natural floodways. However, 60 acres of land along these rivers downstream of the diversion channel would be altered because of channelization, levee construction, and bank stabilization. Additionally, 8,510 acres of flowage easements would be acquired and managed in accordance with flood plain management policies. In summary, 2,204 acres of land would be altered significantly because of the construction of structures, 4,630 acres would be altered because of periodic flooding, and 8,510 acres would be altered slightly because of a change in flood patterns.

Temporary disturbances would result from excavation and grading operations, especially in borrow areas and along haul roads. Areas outside the immediate limits of construction which are disturbed would be returned to a preconstruction condition.

GEOLOGY AND SOILS

The downstream transport of sediments (sand, silts, gravels, etc.) from upstream sources would be significantly reduced by the three recommended dams. An estimated 13,350 acre-feet of sediment would be trapped by the three dams during their 100-year project life. The dams would provide for the controlled releases of floodflows into the downstream watercourses. These controlled flows would have velocities lower than those occurring under

c. Gathering sites: An area of scattered cultural material, often primarily or wholly lithic, situated in the proximity of vegetation with a high potential for wild food production such as paloverde, mesquite, saguaro, cholla, and barrel cactus.

d. Agricultural sites: This designation has been given to sites at which the major component is the agricultural system. The most common form consists of a field or fields characterized by relatively open areas of short grass and some creosote, alluvial soil, and a predominantly lithic assemblage of artifacts. Additional features are present, such as evidences of subsurface ovens or field houses. These features are marked by clusters of cobbles and accumulations of ceramics and stone tools.

e. Habitation sites: An area with a dense scatter of cultural material. There is a high proportion of ceramics and there are ground stone implements such as mano and metate fragments. Usually, evidences of structures are present.

f. Multicomponent sites: At three sites, at least two of the above-mentioned characteristics are present. Two sites cover such a large area that many different manifestations occur. They are agricultural fields, secondary trash mounds, peripheral scatter of cultural material and small field areas, trash mound and village area, reservoir, fields with associated trash mounds, rock terraces and alinements, petroglyphs, bedrock metate, and six house mounds with associated fields, canals, and rock alinements.

g. There are four sites which do not fit into any one of the above categories. Each can be considered a site type but have been lumped into a group of miscellaneous types. They consist of:

(1) Three parallel channels about 1,300 feet long that extend from the toe of a hill westward but end abruptly before reaching the main channel of New River;

(2) A ring of fire-cracked rock 6.6 feet in diameter which is situated on the edge of a minor drainage;

(3) A quartz outcrop which shows signs of having been quarried;

(4) A small, horseshoe-shaped basalt boulder structure on a basalt-covered hill that is suggestive of an outlook or a shrine.

The State Historic Preservation Officer has recommended that an area comprising all of Sections 1, 2, and 3, and the north 1/2 of Sections 11 and 12 of Township 4 North, Range 1 East and the south 1/2 of Sections 13, 14, and 15, and all of Sections 22, 23, 24, 25, 26, 27, 34, 35, and 36 of Township 5 North, Range 1 East which includes all of the individual sites, be nominated to the National Register of Historical Places as an archeological district. The reservoir area of the recommended damsite extends into parts of Section 22, 23, 24, 25, 26, 27, and 35. Evidence of one possible historic site exists in the New River damsite area. It is the foundation of a structure that may have been an early stage station.

sites suggests that only in the southernmost part of the project area were there sufficient resources - available moisture, concentration of wild floodstuffs, and/or arable lands - to meet the requirements of even a small prehistoric population.

At least four major activity patterns are postulated based on the attributes of five recorded sites. They are camping, agriculture, gathering and artwork. Concentrations of firecracked rock occur near scattered circles of stone which are interpreted as the margins of hearths and the locations of subsurface ovens. Stone tools consisting of choppers, hammerstones and a knife were noted along with ceramics which indicated an occupation within the period A.D. 900 to 1100. Basalt boulders on the lower, east-facing slope of Hedgpeth Hills are covered with petroglyphs. Most of the representations occur within a 328-foot span and extend 82 feet up the slope. Some time depth is represented since there is superimposition of figures and there is a redevelopment of patina where the rocks have been pecked. Figures include human and animal forms, combinations of biomorphic forms, and geometric designs.

The State Historic Preservation Officer has recommended that the area bounding this sites, which includes the individual sites, be nominated to the National Register of Historic Places as the Skunk Creek Archeological District. The area comprises Section 21 and the southwest 1/4 of Section 22, Township 4 North, Range 2 East. The reservoir area of the recommended damsite extends into a part of Section 21. There are no known historical sites in the study area.

New River Dam

An intensive survey of archeological and historical resources survey in the recommended New River damsite area resulted in the recording of 20 archeological sites. No single attribute, except for the presence of material culture remains on the surface, is characteristic of all the manifestations. In terms of size, the archeological sites range from a sherd and/or lithic tool scatter within a circle only a few yards in diameter to a continuous distribution of remains over an area of about 0.45 square miles. A definition of site types, which has been possible in this locality because of the number present, was developed as the sites were located. Seven categories eventually were used, the last being a catch-all for unexplained sites. These categories are as follows:

a. Sherd and/or lithic scatter: This is an amount of material characterized as light, moderate, or dense area of scattered cultural material in a situation where no functional interpretation could be applied with confidence.

b. Campsite or possible campsite: An area of scattered cultural material, predominantly ceramic, located in the vicinity of a favorable wild food gathering area or along a trail.

Skunk Creek

An intensive examination of the lands along Skunk Creek, an inspection of adjacent lands, and a review of the literature failed to reveal the existence of archeological or historic resources. Not a single piece of ceramic material (not including modern refuse) or a stone tool was recovered.

New River

The only archeological remains found in the course of the investigations were located along the New River channel, 0.9-mile west of the channel, and on the terrace overlooking the Agua Fria River. Both are outside of the project overflow area. No evidences of prehistoric remains or historic sites were found along the New River.

Agua Fria River

Three archeological sites were identified along the Agua Fria River - two outside the study area and one inside the study area. The two sites outside of the study area occupy the slope of the terrace overlooking the east side of the Agua Fria River flood plain, and are at an elevation of about 18 feet above the edge of the flood plain. Ceramics are suggestive of an intermittent occupation extending from shortly before A.D. 900 to as late as A.D. 1300. The site that was found along the Agua Fria River in the study area is a habitation area that extends for about 720 feet in a northeast-southwest direction and about 360 feet in a northwest-southeast direction. In all three cases, the units occupy an older river alluvial terrace remnant which remains only in isolated cases at the edge of the Agua Fria River flood plain.

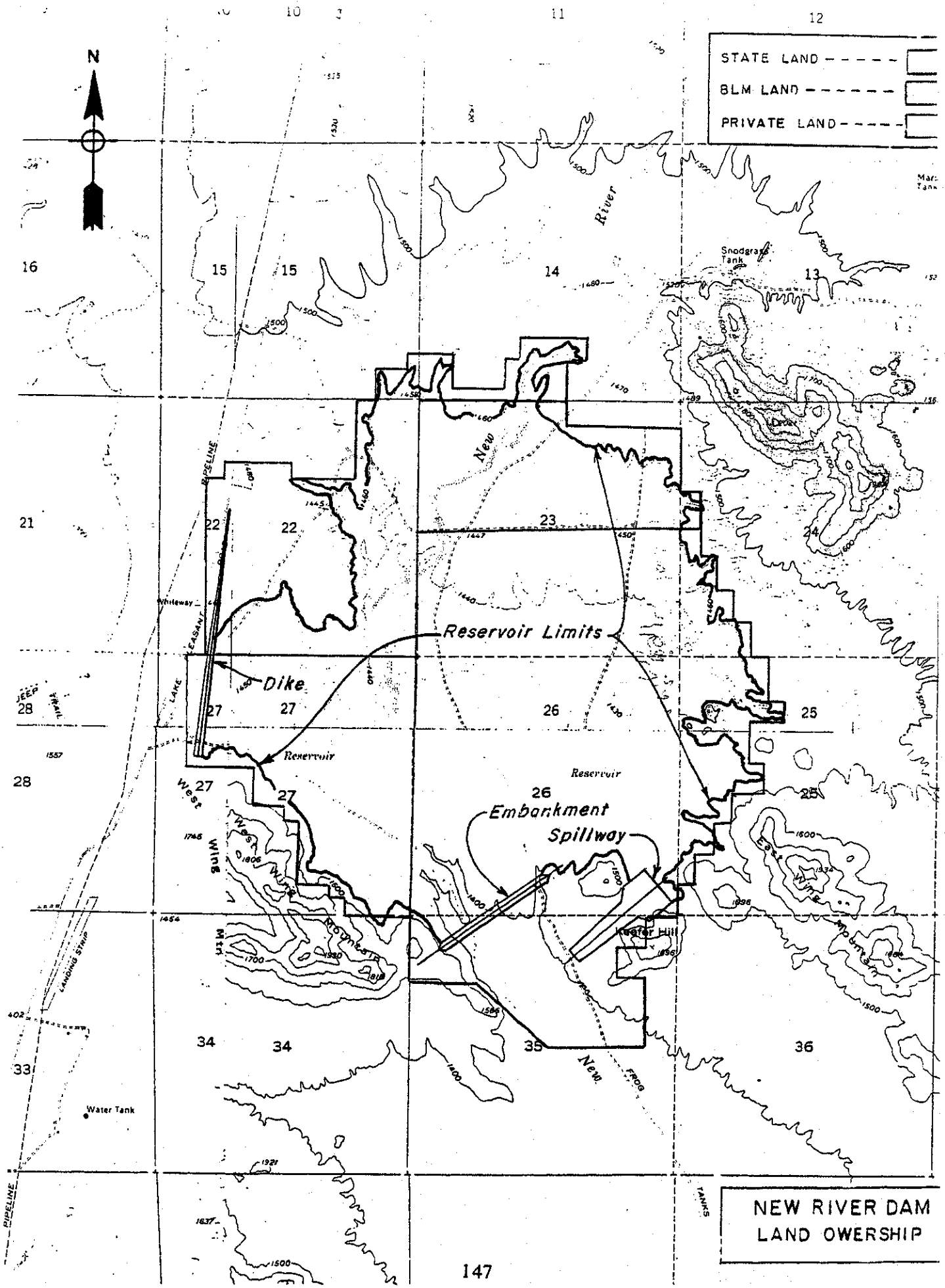
The artifactual collection indicates a Hohokam settlement occupied the area about A.D. 100 to 900. The majority of the plainwares are Gila Plain and its local varieties, together with smaller numbers of unidentified brownwares, redwares, and variations of Wingfield Plain. Stone tools from the site are not well represented. Over half of the items collected can be associated with grinding activity.

Arizona Canal Diversion Channel

Neither the search of site records nor the archeological field survey yielded information on archeological or historic resources that would be affected by construction of the Arizona Canal diversion channel.

Cave Creek

The portion of Cave Creek from Cave Creek Dam to the Arizona Canal intersects three habitation and agricultural sites and a petroglyph site, and it is close to a concentration of ceramics.


STATE LAND
BLM LAND
PRIVATE LAND
N
Reservoir Limits
Dike
Reservoir
Embankment
Spillway
New River
West Wing Mtn
East Wing Mtn
Water Tank
Snodgrass Tank
Water Hill
PIPELINE
LANDING STRIP
TANKS
NEW RIVER DAM
LAND OWERSHIP

Benefits

The primary benefit that will accrue from the recommended plan of improvement is the reduction of flood damages in metropolitan Phoenix. Without a project (but with Dreamy Draw Dam), equivalent annual damages amounting to $17,853,000 would occur in the project area over the period 1978-2077. This figure does not include any estimate of the damages that would occur if the existing Cave Creek Dam should fail. The proposed project will reduce these flood losses to $4,948,000. All dams will be designed to control the standard project flood, while channels will carry the 100-year flood. A reduction of standard project floodflows will result from the project. However, significant floodflows will continue to occur for storms of rare occurance. A summary showing floodflow characteristics from storms of future standard project flood magnitude is shown with and without the recommended plan in table 23. Damages that will continue to occur with the recommended plan will be absorbed by local residents (out of pocket or through flood insurance premiums) and by general taxpayers (through subsidized flood insurance premiums and flood disaster relief).

Table 23

Standard Project Flood Characteristics in Overflow Areas
(Without and With Project)

Overflow Area	SPF*	Peak Flow (cfs)	Flood Duration (hr.)	Width (ft.)	Max. Depth (ft.)	Ave. Depth (ft.)	Velocity (fps)
Cave Creek below	w/o	50,000	60**	4,500	5.6	3.9	2.9
Arizona Canal	w/	18,000	2***	3,600	3.5	2.4	1.9
Cave Creek at the	w/o	37,000	60**	12,200	6.8	3.6	1.6
Salt River	w/	31,000	16***	11,100	6.5	3.4	1.5
Cudia City Wash at	w/o	14,800	9	9,600	1.8	1.0	1.1
Arizona Canal	w/	3,800	9	1,500	1.5	1.5	1.0
Skunk Creek above	w/o	60,000	24	4,000	10.8	3.5	5.7
Arizona Canal	w/	4,000	24†	110	5.0	4.7	10.0
Agua Fria River below	w/o	90,000	27	7,400	6.3	3.2	4.3
New River	w/	82,000	27††	7,300	6.1	3.0	3.9

*Standard project flood without (w/o) and with (w/) project under future conditions of development.

**Reflects existence of existing Cave Creek Dam.

***Reflects existence of Cave Buttes Dam and Arizona Canal diversion channel.

†Discharges from Adobe Dam (1,900 cfs max.) would flow for 5 days.

††Discharges from Cave Buttes Dam (494 cfs max.) would flow for 48 days and from New River Dam (2,600 cfs max.) for 8 days.

STATE DOCS. ARIZ.

76-80-0064

A15011 256304

STATE DOCS. ARIZ.

related 75-80-0041
74-60-0015

FINAL ENVIRONMENTAL IMPACT STATEMENT

NEW RIVER & PHOENIX CITY STREAMS

MARICOPA COUNTY, ARIZONA

U.S. ARMY ENGINEERS
LOS ANGELES DISTRICT
CORPS OF ENGINEERS

MARCH 1976

TABLE OF CONTENTS

FINAL ENVIRONMENTAL STATEMENT
NEW RIVER AND PHOENIX CITY STREAMS
FLOOD CONTROL PROJECT
MARICOPA COUNTY, ARIZONA

SECTION I
New River and Phoenix City Streams
Flood Control Project

	Page
PROJECT DESCRIPTION	I-1
Introduction and purpose	I-1
Organization of the environmental statement	I-1
Project location	I-1
Project authorization	I-1
Project purpose	I-2
Authorized project plan	I-2
Recommended project plan	I-3
ENVIRONMENTAL SETTING WITHOUT THE PROJECT	I-7
Topography and drainage	I-7
Geology and soils	I-8
Earthquake hazard	I-8
Natural resources	I-9
Mineral and fossil fuels	I-9
Metallic minerals	I-9
Nonmetallic minerals	I-9
Sand and gravel	I-9
Climate	I-9
Surface hydrology	I-10
Flood hazard	I-11
Flood damages	I-12
Flood-prone areas	I-12
Urban development subject to flooding	I-13
Existing water resource facilities affecting flood control	I-14
Proposed water resource facilities affecting flood control	I-15
Subsurface hydrology	I-16
Water quality	I-18
Air quality	I-19
Vegetation and wildlife	I-21
Endangered wildlife	I-25
Rare and endangered vegetation	I-25
Archeological and historical resources	I-25
National Register sites	I-26
Esthetics	I-27
Land use	I-27

CONTENTS – Continued

Page

Demographic characteristics I-28
Housing I-29
Employment I-30
Income I-31
Economy I-31
Transportation I-32
Recreational resources I-33
Pertinent legislation I-33
RELATIONSHIP OF THE PROPOSED ACTION TO
LAND USE PLANS I-35
THE PROBABLE IMPACT OF THE PROPOSED ACTION
ON THE ENVIRONMENT I-37
Introduction I-37
Topography and drainage I-37
Geology and soils I-37
Natural resources I-38
Hydrology I-38
Water quality I-39
Air quality I-39
Vegetation and wildlife I-41
Wildlife habitat mitigation I-43
Archeological and historical resources I-43
Population I-44
Land use I-44
Transportation I-44
Economics I-45
Social I-45
Recreation I-46
Esthetics I-47
Construction-related temporary impacts I-48
ANY PROBABLY ADVERSE ENVIRONMENTAL EFFECTS
WHICH CANNOT BE AVOIDED I-50
ALTERNATIVES TO THE PROPOSED ACTION I-51
Alternative 1 (No Further Federal Action) I-51
Description of Alternative 1 ..... I-51
Environmental effects of Alternative 1 ..... I-51
Reasons Alternative 1 was rejected I-52
Alternative 2 (Dams and Channels) I-52
Description of Alternative 2 ..... I-52
Environmental effects of Alternative 2 ..... I-52
Reasons Alternative 2 was rejected I-55
Alternative 3 (Cave Buttes Dam Only) I-55
Description of Alternative 3 ..... I-55
Environmental effects of Alternative 3 ..... I-56
Reasons Alternative 3 was rejected I-58

CONTENTS – Continued

Page

Alternative 4 (Channels Only) I-58
Description of Alternative 4 ..... I-58
Environmental effects of Alternative 4 ..... I-59
Reason Alternative 4 was rejected I-61
Alternative 5a (Dams and Channels) I-61
Description of Alternative 5a I-61
Environmental effects of Alternative 5a I-62
Reasons Alternative 5a was rejected I-64
Other Alternatives I-64
Cave Creek Channel-Arizona Canal to Salt River I-64
Arizona Water Commission Plan I-65
THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY I-67
ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION SHOULD IT BE IMPLEMENTED I-68
COORDINATION I-69

SECTION II – CAVE BUTTES DAM

A Feature of the New River-Phoenix City Streams Flood Control Project

SECTION III – ADOBE DAM

A Feature of the New River-Phoenix City Streams Flood Control Project

SECTION IV – NEW RIVER DAM

A Feature of the New River-Phoenix City Streams Flood Control Project

SECTION V – SKUNK CREEK, NEW AND AGUA FRIA RIVER

A Feature of the New River and Phoenix City Streams Flood Control Project

SECTION VI – ARIZONA CANAL DIVERSION CHANNEL, CAVE CREEK AND DREAMY DRAW WASH

A Feature of the New River and Phoenix City Streams Flood Control Project

SECTION I

NEW RIVER AND PHOENIX CITY STREAMS FLOOD CONTROL PROJECT

I-1. PROJECT DESCRIPTION

I-1.01 INTRODUCTION AND PURPOSE. This environmental statement, which is submitted in compliance with the National Environmental Policy Act of 1969 (Public Law 91-190), concerns the New River and Phoenix City Streams Flood Control Project. The environmental statement describes (a) the recommended plan for the project, (b) the environmental setting without the project, (c) the relationship of the project to existing land use plans, (d) the probable impact of the project on the environment, (e) the probable adverse environmental effects which cannot be avoided, (f) the alternatives to the recommended plan for the project, (g) the relationship between the short-term use of the environment and the maintenance and enhancement of long-term productivity, (h) the irreversible and irretrievable commitments of resources which would be involved in the project should it be implemented, and (i) the coordination effort which has taken place.

I-1.02 ORGANIZATION OF THE ENVIRONMENTAL STATEMENT. The environmental statement has six sections. The first section, Section 1, describes the overall project, the regional environmental setting, and the alternatives considered in developing the recommended plan. This section also addresses the regional effects of the recommended and alternative plans, the unavoidable adverse effects of the recommended plan, regional relationships between short-term uses of the environment and long-term productivity, regional irreversible commitments of resources, and the overall regional coordination effort. Sections II through VI concern individual project features. These sections describe in detail the individual project features, the local environmental setting, the impacts of the project features, and the detailed alternatives for the project features, such as specific alternative sites or alinements.

I-1.03 During detailed design studies, the environmental statement will be revised as required. Prior to construction of the recommended project features, pertinent sections of the environmental statement will be re-examined and updated or supplemented if required.

I-1.04 Plates, tables, photos, references, a glossary of technical terms, and Appendix A (Letters of Comment) follow the last feature section of the report.

I-1.05 PROJECT LOCATION. The New River and Phoenix City Streams project is located in Maricopa County in the southcentral portion of the State of Arizona. The project area extends from the Salt and Gila Rivers north about 30 miles to the base of the Hieroglyphic, McDowell, and Usery Mountains and east from the White Tank Mountains to the base of the McDowell Mountains (pl. 1). This area contains both desert and irrigated lands, as well as the Phoenix metropolitan area.

I-1.06 PROJECT AUTHORIZATION. The New River and Phoenix City Streams project was authorized by the Flood Control Act of 1965, Public Law 89-298, approved October 27, 1965. The project is an integral part of a five-phase flood control plan for the

Dreamy Draw channel would extend from Dreamy Draw Dam to the authorized Arizona Canal diversion channel. Cave Creek channel would extend from the authorized Cave Buttes Dam to the authorized Union Hills diversion channel. The Union Hills diversion channel would extend from 40th Street to Skunk Creek. Skunk Creek channel would extend from a point on Skunk Creek just upstream from its confluence with the Union Hills diversion channel to its confluence with New River. New River channel would extend from the mouth of Skunk Creek to the confluence of the New and Agua Fria Rivers. The Agua Fria channel would extend from the mouth of New River to a point about 2 miles downstream of the U.S. Highway No. 80 crossing. The authorized Arizona Canal diversion channel would generally parallel the north side of the Arizona Canal from approximately 12th Street to Skunk Creek. A more detailed description of the uncompleted features of the authorized project is given in Sections II through VI of this statement.

I-1.09 RECOMMENDED PROJECT PLAN. The recommended plan (pl. 4a) for the uncompleted features of the project, which differs from the authorized plan, is described in the following subparagraphs.

a. Cave Buttes Dam. The recommended Cave Buttes Dam will be constructed at a location 1.2 miles north of the authorized site, approximately 0.7 miles downstream from the existing Cave Creek Dam. The main embankment will be a 2,280-foot long compacted-earthfill structure rising a maximum of 110 feet above the streambed. Three additional earthfill dikes will be required, with lengths of up to 9,010 feet and maximum heights of up to 56 feet. An unlined spillway, west of the right dam abutment, in conjunction with the outlet works will pass a peak discharge of 101,500 cfs. The outlet works will be capable of releasing 494 cfs. The detention basin will have a capacity of 46,600 acre-feet at spillway crest of which 5,730 acre-feet will be for the accumulation of sediment.

b. Adobe Dam. Adobe Dam will be constructed on Skunk Creek, across Deer Valley Drive, 1 mile west of the Black Canyon Highway. This site is approximately 4 miles south of the authorized site. The main embankment will be a compacted-earthfill structure, a maximum of 63 feet high and 2.1 miles long. A concrete-lined spillway, west of the main embankment, in conjunction with the outlet works will pass a peak discharge of 14,800 cfs. The outlet works will be capable of releasing up to 1,890 cfs. The detention basin will have a capacity of 18,350 acre-feet of which 2,700 acre-feet will be used for the accumulation of sediment over a 100-year period. Channelization of Skunk Creek will be required in the vicinity of Black Canyon Highway to assure conveyance of the standard project flood to the Adobe detention basin. The two existing highway bridges and two frontage road bridges must be lengthened 134 feet to accommodate the wider channel.

c. New River Dam. New River Dam will be constructed on New River at the authorized site, 8 miles upstream from the confluence with Skunk Creek. The main embankment will be a compacted-earthfill structure 2,800 feet long having a maximum height of 91 feet. An earthfill dike will be required along the west edge of the detention basin. A concrete-lined spillway, east of the left abutment, in conjunction with the outlet works, will pass a peak discharge of 63,300 cfs. The outlet structure will be capable of releasing up to 2,590 cfs. The detention basin will have a capacity of 34,500 acre-feet, of which 4,920 acre-feet will be used for the accumulation of sediments over a 100-year period.

d. Arizona Canal Diversion Channel. The Arizona Canal diversion channel will be built immediately north of and generally parallel to the Arizona Canal from 40th Street, at the upstream end, to Skunk Creek. The channel will continue to be concrete lined to approximately Cactus Road. From Cactus Road to Skunk Creek the channel will become a wide earth-lined channel suitable for development into a recreational greenbelt. At the time of construction of the project, local interests will construct 26 bridges, at all streets and highways that presently cross the Arizona Canal.

e. Floodways. In order to assure the long-term capacity to operate the four dams as designed, local interests will be required to manage and maintain floodways and floodway fringe areas along Dreamy Draw Wash from 14th Street to the Arizona Canal diversion channel, along Cave Creek from Cave Buttes Dam to Peoria Ave., along Skunk Creek from Adobe Dam to the Arizona Canal diversion channel and along New River, from New River Dam to the confluence with Skunk Creek. Limits of the floodways and floodway fringe areas will be delineated by the Corps of Engineers. Along Cave Creek between Peoria Avenue and the Arizona Canal 0.7 mile of concrete channel will be required along with a confluence structure at the Arizona Canal diversion channel. These structures are described in detail in Section VI of this report. As part of the project, local interests will construct 8 bridges at existing dip crossings, as required by urban development.

f. Flowage Easements. Downstream of the confluence of the Arizona Canal diversion channel with Skunk Creek flowage easements will be required along Skunk Creek and the New and Agua Fria Rivers to assure positive control of the flood plain under the condition of diverted flows discharging from the diversion canal. Within these reaches evacuation of portions of the flood plain and some structural measures such as flood proofing, bank stabilization, and levee construction will be required along with some channelization and channel clearing. These structural measures are discussed in more detail in Section V of this report and are shown on plates 13 through 19 in Appendix 5 of the General Design Memorandum. As part of the project, local interests will construct 11 bridges at existing dip crossings, as required by urban development. In addition, one railroad bridge will require modification.

I-1.10 Recreational opportunities will be provided at Cave Buttes Dam and Adobe Dam and along the Arizona Canal diversion channel, Cave Creek, Skunk Creek and the New and Agua Fria Rivers. Facilities proposed for the damsites include picnicking and camping areas, riding and hiking trails, equestrian areas, and nature areas. No recreational facilities are planned for Dreamy Draw Dam, however future development is not precluded. Recreational facilities will not be provided at New River Dam; instead, in accordance with the suggestions of the Recreation Task Force, the acreage behind the dam will remain in its natural state. Facilities along the channels generally include trails and conveniently located rest stops with comfort stations and picnic tables. A regional park with an outdoor education center and recreation facilities is planned along Cave Creek. A low intensity recreational greenbelt is planned along the Arizona Canal diversion channel west of Cactus Road. Other facilities are planned by local interests.

I-2. ENVIRONMENTAL SETTING WITHOUT THE PROJECT

I-2.01 TOPOGRAPHY AND DRAINAGE. The project area is within the Gila River Basin, which is the largest drainage area tributary to the lower Colorado River and comprises 58,200 square miles. About 70 percent of the drainage area is mountainous while the remainder is alluvial valley. The mountains are characterized by rugged terrain and steep gradients, while the valleys are fairly flat with regular slopes.

I-2.02 The area pertinent to flood problems in Phoenix and vicinity is in Maricopa and Yavapai Counties in the central part of Arizona (see pl. 2), and comprises approximately 2,730 square miles. The area is roughly oval, with a maximum length and width of approximately 90 and 45 miles respectively. Elevations range from 910 feet at the confluence of the Agua Fria and Gila Rivers to 7,000 feet in the mountains near the headwaters of the Agua Fria River. The topographic characteristics of the major watercourses draining the project area are described in the following subparagraphs.

a. Agua Fria River. The Agua Fria River originates about 7,000 feet above sea level in the mountains of central Arizona and flows southward for about 130 miles before emptying into the Gila River, 15 miles west of downtown Phoenix, at elevation 910 feet. The course of the stream is nearly equidistant between two parallel mountain ranges, the Black Hills-New River Mountains and the Bradshaw Mountains, that form the eastern and western boundaries of the drainage area. The gradient of the Agua Fria River ranges from about 300 feet per mile in the headwaters to about 10 feet per mile at the Gila River.

b. New River. New River, the major tributary of the Agua Fria River, has its headwaters in the New River Mountains, roughly 40 miles north of Phoenix. New River flows generally southward for about 40 miles to its confluence with the Agua Fria River, about 15 miles west of Phoenix. The drainage area of New River at its mouth is 340 square miles, of which approximately one-third is mountainous. Elevations in the basin range from a little over 5,000 feet in the New River Mountains to about 1,040 feet at the confluence with the Agua Fria River. The stream gradient ranges from 370 feet per mile in the mountains to 10 feet per mile in the valley.

c. Skunk Creek. Skunk Creek, the major tributary of New River, rises in the New River Mountains about 35 miles north of Phoenix and flows generally southwestward for about 30 miles to its confluence with New River about 15 miles northwest of Phoenix. The drainage area of Skunk Creek is 110 square miles, of which about 20 percent is mountainous. Stream gradients on Skunk Creek decrease from 650 feet per mile in the mountains to 20 feet per mile near its confluence with the New River.

d. Cave Creek. Cave Creek has its source in the New River Mountains to the north of Phoenix, where elevations rise to as high as 5,000 feet. The stream then descends to the alluvial fan near the community of Cave Creek and flows south for 13 miles to Cave Creek Dam, which controls the 175 square mile drainage area upstream from the dam. Cave Creek then flows across an alluvial fan which is undergoing urbanization between Cave Creek Dam and the Arizona Canal. Floodflows on Cave Creek exceeding the freeboard capacity of the Arizona Canal flow directly through metropolitan Phoenix to the Salt River. The total drainage area of Cave Creek at the Salt River is 311 square miles. The stream gradient ranges from 500 feet per mile in the mountains to 25 feet per mile near the Arizona Canal.

e. Dreamy Draw. Dreamy Draw, a tributary of Cave Creek, rises in the Phoenix Mountains and flows generally southwestward for about 5 miles to its confluence with Cave Creek in Phoenix. Dreamy Draw Dam controls 1.3 square miles of the 2.0-square-mile drainage area above the Arizona Canal.

f. Cudia City Wash. Cudia City Wash, with a drainage area of 4.9 miles above the Arizona Canal, rises in the Phoenix Mountains northeast of Phoenix and upstream from the Arizona Canal.

I-2.03 GEOLOGY AND SOILS. The project area is located in the Sonoran Desert Section of the Basin and Range physiographic province. This province is characterized by steep mountains and broad alluvium-filled valleys. The mountain ranges, which are generally parallel and trend northwest to southeast, are composed of metamorphic and volcanic rock. The basins are filled with alluvial and colluvial materials, primarily gravel, sands and clays (ref. 5) to depths of over 1,000 feet. The valley floor was formed by extensive alluvium deposits, which have filled the basin and covered the foreslopes of the hills and mountains. Alluvium in the valley may extend to depths of over 1,000 feet and consists of coarse, unconsolidated, unsorted sands, gravels and cobbles. The deep dissection of the mountains and the extent of the alluvial fans suggest that the project area has had a long history of erosion and deposition.

I-2.04 The soil types in the study area are derived from parent materials characteristic of the Basin and Range physiographic province. The soils in the gently sloping valleys are deep, heterogeneous in texture, low in organic material and have not been leached of soil nutrients. The relatively level surface, combined with soils of favorable workability, provide areas of good cropland where irrigation is available. General soil types in theproject area are sandy loams, limy clay loans, and limy loamy soils (ref. 3). Stony and rocky soils are locally present on slopes greater than 30 percent. The soils in the study area are commonly affected by the precipitation of salts produced by weathering of rock-forming minerals and brought in by surface runoff. Because seepage from rainfall is usually not sufficient to carry salts down to the water table, they accumulate in the soil as the water evaporates. The effects are most noticable near mountains formed of calcium-bearing rocks, where alluvial deposits are commonly cemented by calcium carbonate to a concrete-like material called caliche. Farther down the basin slopes, calcium carbonate content decreases, but soluble alkali salts detrimental to agriculture are still present. Erosion from the drainage above the proposed dams was calculated by the Corps of Engineers for the purpose of determining sediment storage requirements in the reservoirs. The sediment yield of 0.3 acre-foot of sediment from each square mile was estimated for the drainage area upstream of the dams.

I-2.05 EARTHQUAKE HAZARD. The earthquake potential in the project area is considered low (ref. 4). Severe earthquakes in California and Mexico have been widely felt throughout southern Arizona, but only a few weak earthquakes have had epicenters in southern Arizona during the 122 years of recorded earthquake history. During that period, earthquake damage in southern Arizona has been minor (ref. 4). Based on available data, the largest earthquake expected in the project area would have an intensity of approximately V on the Modified Mercalli Scale, which ranges from I (weak) to XII (very strong) (ref. 4). The proposed project site is in a low seismic risk area, assigned to Zone 2, Seismic Risk Map of the United States (1969) (pl. 5).

I-2.06 NATURAL RESOURCES. The natural resources considered in this statement are those resources that have a large enough volume or value so that their exploitation would have a significant impact on the water use, land use, or economy of Maricopa County. The resources are discussed in three general groups: mineral and fossil fuels, metallic minerals, and nonmetallic minerals. All data is derived from the "Lower Colorado Region Comprehensive Framework Study", U.S. Dept. of Interior.

I-2.08 Mineral and Fossil Fuels. There are no known resources of coal or crude oil in Maricopa County. The nearest source of coal to the project area is the Deer Creek Field, a relatively minor field in eastern Pinal County, located about 100 miles southwest of downtown Phoenix.

I-2.08 Although appreciable uranium-vanadium deposits have been located in Coconino, Navajo, and Gila Counties, none have been located in Maricopa County. The closest uranium resource to the study area lies in the Sierra Ancha Mountains in the Tonto National Forest, 75 miles east of Phoenix.

I-2.09 Metallic Minerals. South of the study area, in a wide belt running south eastward through Pinal, Pima, and Santa Cruz Counties, lies a district in which disseminated copper and copper-molybdenum ores are being developed for future large-scale mining.

I-2.10 A large volume of potential iron resource occurs in the Hieroglyphic Mountains (Pikes Peak District) 35 miles northwest of Phoenix. Known resources in the area total about 90 million short tons.

I-2.11 Nonmetallic Minerals. Halite (common salt) has been discovered 20 miles west of Phoenix in wells drilled about 1 mile apart. In one well, below 880 feet, more than 3,000 feet of solid halite was penetrated. This resource could be used for underground storage as well as exploited as a raw material for the chemical industry.

I-2.12 Sand and gravel, a resource that is becoming more limited in the study area because of the vast quantities of aggregate materials used by the construction industry, occurs in recoverable concentrations in exposed and buried stream channels, on terraces near mountain fronts, and on alluvial fans. The materials near the mountain fronts contain a higher ratio of gravel to sand, whereas the basin fills are mostly sand and silt. In 1970, Maricopa County produced 6,363,000 tons of sand and gravel, which represented more than a third (35.7 percent) of the production for the state. Other significant mining activities include the production of scrap mica near Buckeye in Maricopa County, and miscellaneous clay and shale for manufacturing building brick, mined at the Tolleson pit in Maricopa County.

I-2.13 CLIMATE. The project area is located in the Sonoran Desert Climatic Zone (ref. 6), a zone characterized by long hot summers, short mild winters, low annual rainfall, low relative humidity, and a high percentage of possible hours of sunshine. July is the hottest summer month, with temperatures ranging from an average daily maximum of 105 degrees Fahrenheit to an average daily minimum of 75 degrees Fahrenheit. January is the coldest month, with average daily temperature ranging from a maximum of 66 degrees Fahrenheit to a minimum of 34 degrees Fahrenheit.

I-2.14 Precipitation is biseasonal, generally occurring as short heavy thundershowers in the summer and long, light showers in the winter. Most summer precipitation falls in the afternoon or evening. In late summer or early fall, tropical storms may bring heavy and widespread precipitation. Most winter precipitation results from cyclonic storms. Slightly more than 50 percent of the precipitation falls from November to April. Average annual precipitation is 7.2 inches in Phoenix and about 24 inches in the upper watersheds. The maximum monthly precipitation of record at Phoenix is 5.6 inches, and the maximum precipitation for a 24-hour period is 5.0 inches, which occurred in July 1911.

I-2.15 The project area has an average relative humidity ranging from 24 percent in the summer to 54 percent in the cooler, moister winter. Relative humidity has increased in the Phoenix area as the result of large irrigated areas, open canal systems, and introduced urban plantings.

I-2.16 The project area averages 86 percent of possible hours of sunshine annually with monthly averages ranging from 77 percent in December to 94 percent in June. Winds in the project area are generally from the east, having an average velocity of about 6 miles per hour. Peak gusts occasionally reach as much as 50 miles per hour. The strongest gust of record at Phoenix was 75 miles per hour.

I-2.17 The combination of high temperatures, low relative humidities, maximum amount of sunshine, and wind causes a high evaporation rate. The evaporation rate in the project area has been estimated to be 6.5 feet per year (ref. 7).

I-2.18 SURFACE HYDROLOGY. The watercourses of the Agua Fria River, New River, Gila River, and Skunk Creek are generally characterized by well-defined floodways and channels. The channels of Cave Creek and Dreamy Draw are well defined above the Arizona Canal; downstream from the Canal the natural floodways have been obliterated by urban development. Flows in the channels are ephemeral because climate and drainage characteristics are not conducive to continuous runoff. Flows occur only during and immediately after periods of heavy rainfall.

I-2.19 The United States Geological Survey has recorded discharge for surface waters at several recording gages within the project area. Precipitation and stream gages are located both above and below the sites for the proposed New River, Adobe, and Cave Creek Dams. Data presented in the subsequent subparagraphs are derived from these precipitation and stream gages.

a. The average annual total discharge for surface waters of Cave Creek at Phoenix, Arizona, is 1,900 acre-feet (ref. 8). The period of record was from October 1957 to 1972. The drainage area of Cave Creek above the gaging station at Phoenix is 252 square miles.

b. The average annual discharge for the New River at the Bell Road Gaging Station at Bell Road is 4,180 acre-feet, based on records of annual discharge for Water Years 1963, 1965, 1967, and annual maximums for 1968 through 1972. The drainage area is 187 square miles.

I-4.33 The diversion of floodwaters from Cave Creek to Skunk Creek will prevent floodwaters from reaching portions of the Salt River and the Gila River between the Salt and Agua Fria Rivers. Vegetation along the Salt River is already impoverished as a result of extensive sand and gravel mining, in conjunction with a lack of constant water supply. No significant change in vegetation is expected along the Salt River. The University of Arizona, under contract to the Corps of Engineers, compiled environmental information on the Gila River from the Salt River to Gillespie Dam (ref. 36). As part of this report, potential impacts due to increased or decrease flow were postulated. The most significant effects would occur when flows were substantially decreased. A lowering of the water table would be expected, resulting in a loss of vegetation in and along the river channel. The associated increase in salinity would adversely impact both native vegetation and agriculture. The distribution of existing riparian plant species will further shift toward salt-tolerant species, such as salt cedar and salt bush. Flows along the Gila River are not expected to decrease substantially as a result of the project.

I-4.34 WILDLIFE HABITAT MITIGATION. The U.S. Fish and Wildlife Service and the Arizona Game and Fish Department evaluated the effects of the construction of the proposed project on fish and wildlife habitat values. In a letter dated 20 January 1976, the U.S. Fish and Wildlife Service stated that the project construction will result in the direct loss of 1,600 acres of wildlife habitat, of which about 400 acres is good quality desert wash (riparian) habitat. The two agencies indicated the acquisition of additional lands as the only feasible means of providing partial conpensation for the habitat that will be destroyed by the project. The Arizona Game and Fish Department will operate and maintain the mitigation lands.

I-4.35 Three alternative mitigation proposals were considered. The original proposal consisted of the acquisition of a 400 acre parcel at the confluence of the Agua Fria and Gila Rivers. Preservation of the New River Dam detention basin as a wildlife area was also considered. As a result of problems encountered with these proposals, a third alternative was formulated. This proposal involves the acquisition of about 413 acres of land on the Gila River southwest of Buckeye, Arizona, to provide mitigation for both the proposed project and for wildlife losses associated with the Indian Bend Wash project. A letter from the Flood Control District of Maricopa County dated January 14, 1976 confirmed that the acquisition procedures have been initiated.

I-4.36 ARCHEOLOGICAL AND HISTORICAL RESOURCES. Construction of the three dams in the recommended plan will result in alteration or destruction of all or part of three archeological districts that have been nominated for inclusion in the National Register of Historical Places (Cave Creek, Skunk Creek and New River Archeological Districts). See plate 10.

I-4.37 The Corps of Engineers requested a consultation with the Advisory Council on Historic Preservation and prepared a preliminary case report as required under Section 106 of the National Historic Preservation Act of 1966. A meeting was held on October 2 and 3, 1975 at which all concerned agencies were present. An onsite inspection was conducted, and appropriate mitigation measures were discussed, preliminary to executing a Memorandum of Agreement. This agreement will be between the District Engineer, the Advisory Council on Historic Preservation and the State Historic Preservation Officer. Pending execution of the Memorandum of Agreement, the Corps of Engineers will take no action that will affect archeological or historical resources.

IV

FEATURE OF THE NEW RIVER & PHOENIX CITY STREAMS FLOOD CONTROL PROJECT

NEW RIVER DAM

TABLE OF CONTENTS

FINAL ENVIRONMENTAL STATEMENT
NEW RIVER AND PHOENIX CITY STREAMS
FLOOD CONTROL PROJECT
MARICOPA COUNTY, ARIZONA

SECTION IV
New River Dam
Feature of the
New River and Phoenix City Streams
Flood Control Project

Page

DESCRIPTION OF PROJECT FEATURE IV-1
Introduction and purpose IV-1
Project feature location IV-1
Authorized and recommended project feature IV-1
ENVIRONMENTAL SETTING WITHOUT THE PROJECT IV-2
Introduction IV-2
Topography IV-2
Geology and soils IV-2
Surface hydrology IV-3
Subsurface hydrology IV-3
Vegetation and wildlife IV-3
Archeological and historical resources IV-4
Population IV-4
Land use IV-5
Transportation IV-5
Recreation IV-5
Noise IV-5
Esthetics IV-5
RELATIONSHIP OF PROPOSED ACTION TO LAND USE PLANS IV-6
THE PROBABLY IMPACT OF THE PROPOSED PROJECT
FEATURE ON THE ENVIRONMENT IV-7
Topography IV-7
Natural resources IV-7
Subsurface hydrology IV-7
Water quality IV-7
Vegetation and wildlife IV-7
Archeological and historical resources IV-9
Population and land use IV-9
Social IV-10
Transportation IV-10
Recreation IV-10
Esthetics IV-10

SECTION IV

NEW RIVER DAM
Feature of the
New River and Phoenix City Streams
Flood Control Project

IV-1. PROJECT DESCRIPTION

IV-1.01 INTRODUCTION AND PURPOSE. This section describes the New River Dam feature of the New River and Phoenix City Streams Flood Control Project. This section includes: (a) a detailed description of the recommended New River Dam project feature, (b) a description of the environmental setting in the immediate area of the recommended damsite and alternative damsites, (c) the relationship of New River Dam to land use plans for the area, (d) the probable impact of New River Dam on the environment, (e) the probable adverse impacts which cannot be avoided should New River Dam be constructed, (f) an analysis of the alternative sites and facilities studied, (g) the relationship between the short-term use of the environment at the recommended damsite and the maintenance and enhancement of long-term productivity, (h) the irreversible and irretrievable commitments of resources which would be involved should the feature be constructed, and (i) the coordination effort which has taken place.

IV-1.02 PROJECT FEATURE LOCATION. The site of the recommended New River Dam feature is on the New River about 9 miles north of the New River-Skunk Creek confluence. This site, which is the authorized site, is located about 14 miles north of Glendale and 6-1/2 miles west of the Black Canyon Highway. The location of the recommended dam embankment, dike, and reservoir is shown on plate 19.

IV-1.03 AUTHORIZED AND RECOMMENDED PROJECT FEATURE. The authorized and recommended New River Dam is sited between the easterly tip of West Wing Mountain and an unnamed knoll northwesterly from Keefer Hill. The main elements of a dam at this site will include an embankment, a dike, a concrete-lined spillway, an ungated outlet works, and access roads. (See pl. 19.) These elements are described in the following subparagraphs.

a. Embankment. The dam embankment will have a length of 2,800 feet and a crest elevation of 1,482 feet, which will be a maximum of 91 feet above the elevation of the existing streambed. The embankment will be a compacted-earthfill structure.

b. Dike. The dike, which will extend northerly from West Wing Mountain paralleling Lake Pleasant Road, will have a length of 5,800 feet and a maximum height of about 30 feet above the lowest elevation along its centerline.

c. Spillway. The spillway will be concrete lined. Its width will vary from 220 feet at the crest to 173 feet at the downstream end of the chute. This rectangular section, which will be 589 feet long, will include 94 feet of approach channel, 470 feet of chute structure, and a 25-foot-long flip bucket.

d. Outlet Works. The outlet works will consist of an ungated intake structure, conduit, and an energy dissipator. Discharge through the outlet conduit, which will be 450 feet in length and 8.5 feet in diameter, will be 2,590 cfs with the water surface at spillway crest. At the downstream end of the conduit, an energy dissipator will reduce the velocity of flow from 60 to 14 feet per second before the water is discharged into the streambed.

e. Access Roads. Vehicular access to the dike, dam, and spillway will be provided by one road having its single entrance at the northernmost end of the dike, which ties into Lake Pleasant Road. The total length of the access and service roads will be approximately 18,500 feet, with a constant elevation of 1,484 feet.

f. No recreational facilities are presently planned at the recommended New River Dam. This will not preclude recreational or wildlife development at a later date.

IV-2. ENVIRONMENTAL SETTING WITHOUT THE PROJECT FEATURE.

IV-2.01 INTRODUCTION. The sites considered in selecting the recommended site for the New River Dam feature are in three locations on the New River. Both the recommended (authorized) site and Alternative Site 1 (which is located approximately 2,000 feet downstream from the recommended site) are located in a narrow valley between West Wing Mountain and outliers of East Wing Mountain. Alternative Site 2 is about 2.2 miles downstream from the recommended site. The environmental setting at the recommended and alternative sites is described in the following paragraphs.

IV-2.02 TOPOGRAPHY. The hills to the east of the recommended site and Alternative Site 1 are a northern extension of the Hedgpeth Hills, while the west side is composed of uplifts that separate New River from the Agua Fria River system. The hills adjacent to the damsites are over 2,020 feet in elevation, while the lowest part of the river valley is 1,325 feet. The valley at the recommended damsite is constricted by the West Wing Mountains and Keefer Hill, an outlier of East Wing Mountain. From this point southward to Alternative Site 1, New River is confined to a narrower bed. The valley area has a slope of 20 to 40 feet per mile.

IV-2.03 Alternative Site 2 is on a wide plain between Pitcher Hill on the east, which has a maximum elevation of 2,585 feet, and unnamed hills south of West Wing Mountain, which have a maximum elevation of over 1,850 feet. The wide flood plain has a slope of about 30 feet per mile.

IV-2.04 GEOLOGY AND SOILS. The embankments at both the recommended site and Alternative Site 1 would be on poorly consolidated alluvium (primarily silt, sand, and gravel, with occasional cobbles and boulders) that is about 90 feet deep. The alluvium is underlain by tuffaceous agglomerate and granite. The embankment at Alternative Site 2 would be on alluvium of unknown depth. At the recommended damsite, the west abutment is well-cemented tuffaceous agglomerate of undetermined thickness capped with felsite and andesite and the east abutment is granite and granodiorite overlain by felsite. Both abutments are thinly veneered with talus. At Alternative Site 1, the west abutment is felsite with occasional intervals of welded tuff and the east abutment is weathered granite. Talus is negligible at both abutments. At Alternative Site 2, the west abutment is granite and gneiss and the east abutment is felsite with an andesite cap. The spillway at the recommended

damsite will be excavated in granite; the spillway at Alternative Site 1 would be excavated in granite and crystalline quartzite; and the spillway at Alternative Site 2 would be excavated in felsite. The dike that is common to both the recommended site and Alternative Site 1 is on older alluvium (consolidated silt, sand, and gravel) of unknown thickness.

IV-2.05 The mountain soils in the study area are thin and poorly developed, while the valley soils are alluvial soils (sand, gravels and cobbles) in the drainages and sandy loam or loam on the gently sloping fans and valley slopes (ref. 3).

IV-2.06 SURFACE HYDROLOGY. New River and its tributaries drain the western slopes of the New River Mountains and then flow southward across the dissected plateau at the northwest end of Biscuit Flat. In the Biscuit Flat area, the drainages form a dense dendritic pattern that merges at the study area. Here, the water course is confined by hills before it flows onto the lower bajada of Deer Valley. A dam at the recommended site will control the runoff from 164 square miles. A dam at Alternative Site 1 would control the runoff from 176 square miles, and a dam at the Alternative Site 2 would control runoff from 164 square miles of drainage area. Based on stream gage records the average annual runoff for the New River study area is estimated to be 4,200 acre feet annually.

IV-2.07 SUBSURFACE HYDROLOGY. The U.S.G.S. reports that depths to groundwater in the study area generally range from 200 to 300 feet. Data for a well within the study area of the recommended damsite indicated depth-to-water of 126 feet in August of 1970. Groundwater depths in the area have been decreasing, with a drop of 49 feet during the decade from 1962 to 1972 (ref. 27). Wells in the area are capable of producing 1,000 or more gallons per minute. Infiltration rates in the area are high, often measured in the feet-per-day range. No water quality data are available for wells in the New River Dam area.

IV-2.08 VEGETATION AND WILDLIFE. The study area at the recommended site and at Alternative Site 1 is a natural desert landscape with little disturbance to the vegetative communities. (See photo 13 and pl. 26). About 350 acres of desert wash vegetation and 1,665 acres of desert outwash and upland vegetation are within the study area. An additional 25 acres are classified as having highly disturbed vegetation. The site is relatively isolated, which accounts for the lack of significant disruption to the natural communities. The vegetation is more varied and denser than at the sites for Cave Buttes or Adobe dams. Some of the largest specimens of ironwood (25-30 feet tall) seen near Phoenix grow near this site (see photo 14). Large ironwoods are unique in the Phoenix area, because many have been cut for firewood or have been removed for citrus planting.

IV-2.09 None of the land in the study area at the recommended site and Alternative Site 1 is currently under cultivation, and there is little evidence that farming occurred here historically. The area is used for grazing many types of domestic animals, including cattle, sheep, goats and horses. The disturbances to the vegetative communities are primarily from grazing and off-road vehicular uses. The area contains an extensive area of high quality riparian wildlife habitat, composed of dense growth of large mesquite, ironwood, blue paloverde and desert willow (photo 15). Riparian habitat of this quality in close proximity to metropolitan Phoenix is limited. This habitat, as well as bajada and upland habitats, provides food and cover for such game species as doves, quail and cottontail rabbits. A few

desert mule deer can also be found at the site. Many nongame wildlife species also inhabit the area, including many birds, large and small mammals, amphibians and reptiles.

IV-2.10 Comparing the three dams recommended as project features, based on habitat quality and least amount of disturbance, animal population densities should be greatest at the recommended New River Dam feature, followed in descending order by Cave Buttes and Adobe Dams.

IV-2.11 Alternative Site 2 has about 110 acres of desert wash vegetation and 1,500 acres of desert outwash and upland vegetation within the standard project flood overflow area. This site has experienced greater habitat disturbance than the recommended site or Alternative Site 1. The disturbance to the desert landscape has occurred from a mining operation, land clearing (about 10 acres), and a trailer site. An estimated 100 acres have highly disturbed plant communities. Extensive damage to the vegetation and land has occurred from use of the area by off-road vehicles. Open-land grazing occurs throughout the alternative site. As at the upper sites, game species are common, providing many hunting opportunities.

IV-2.12 ARCHEOLOGICAL AND HISTORICAL RESOURCES. An intensive survey of archeological and historical resources in the New River study area was conducted by Arizona State University, Department of Anthropology, under a contract with the Corps of Engineers. A total of 43 archeological sites were recorded in the study area, of which 20 were at the recommended site and Alternative Site 1, and 23 were at Alternative Site 2. No single attribute, except for the presence of material culture remains on the surface, is characteristic of all the manifestations. In terms of size, the archeological sites range from a sherd and/or lithic tool scatter within a circle only a few yards in diameter to a continuous distribution of remains over an area of about 0.45 square miles. The State Historic Preservation Officer has recommended that an area comprising all of Sections 1, 2, and 3, and the north 1/2 of Sections 11 and 12 of Township 4 North, Range 1 East, and the south 1/2 of Sections 13, 14, and 15, and all of Sections 22, 23, 24, 25, 26, 27, 34, 35, 36, of Township 5 North, Range 1 East be nominated to the National Register of Historical Places as an archeological district. (pl. 10) The New River Dams Archeological District was nominated to the National Register in July 1975 (ref. 29).

IV-2.13 A classification of site types within the archeological district includes sherd and/or lithic scatter areas, campsites, gathering sites, agricultural areas, habitation sites, multicomponent sites and 4 sites which do not fit in any of these categories. These 4 sites include three parallel channels 1,300 feet long; a ring of fire cracked rock, probably belonging to a food-processing unit of an early date; a ceremonial quartz rectangle; and a horseshoe-shaped basalt boulder structure suggestive of a lookout or shrine. One historical site has been identified at the recommended dam site.

IV-2.14 POPULATION. The New River study area contains no residential dwelling units. The pattern of development depicted in the following tabulation is based on population projections for Maricopa County made by the Bureau of Economic Analysis of the U.S. Department of Commerce and the Economic Research Service of the U.S. Department of Agriculture (OBERS). The projections were allocated by the Corps of Engineers within the county on the basis of data provided by the Maricopa Association of Governments, historical trends, local and regional land use plans, current zoning and the

National Flood Disaster Act of 1973. The population projections were calculated for an area with a radius of 5 miles from the recommended New River Dam.

Year	Population	Density (persons sq. mi.)
1979	Negligible	
1990	Negligible	
2020	25,000	320

IV-2.15 LAND USE. The majority of the land in the three New River damsites considered is used for grazing, although some land at Alternative Site 2 has been platted in preparation for future subdivision and development. There are several mineral mining leases on lands along the New River at Alternative Site 2. The present land ownership at the recommended site is shown on plate 27.

IV-2.16 TRANSPORTATION. Improved roads are scarce in the area; however, the sites can be reached by driving to the northernmost end of 83rd Avenue. The sites are also easily approached from Lake Pleasant Road. No railroads are present in the study area. A private landing strip is located 1.5 miles west of the recommended site.

IV-2.17 RECREATION. There are no formal recreational facilities at any of the sites. The sites show evidence of use by hunters and off-road vehicles, although some of this use involves trespass. Hunting is permissible on some public lands and on non-posted private lands.

IV-2.18 NOISE. There are no point sources of noise at any of the sites.

IV-2.19 ESTHETICS. Relative to all of the project damsites, these sites have the greatest esthetic value. The East Wing and West Wing Mountains provide a background of high visual quality to the extensive riparian vegetation in the New River floodway, which forms esthetically pleasing dark ribbon patterns on the lighter colored valley floor. Scenic vistas from the West Wing Mountains include the Hieroglyphic Mountains on the northwestern horizon across the dark desert wash vegetation of the Agua Fria flood plain. An unnamed hill bounds the northeast margin of the study area, providing an additional visual resource. Vistas to the south of the study area include the green agricultural development of the Deer Valley and a view of the encroaching urban development.

IV-4. THE PROBABLE IMPACT OF THE PROPOSED PROJECT FEATURE ON THE ENVIRONMENT

IV-4.01 TOPOGRAPHY. The topography at the recommended damsite will be altered by the construction of a main embankment, one dike, a concrete-lined spillway, and access roads. A total of 8,600 feet of embankment will rise as high as 91 feet above the streambed, and 1,460 acres will be affected periodically by inundation with flood waters. Sediment accumulation will alter the area upstream of the dam; 4,920 acre feet of storage has been allocated for sediment accumulation over a 100-year period.

IV-4.02 NATURAL RESOURCES. The recommended project feature will have a minimal effect on the quantity of sand and gravel available to be mined. The land under the embankments will be permanently inaccessible as a potential resource. The sediments that accumulate behind the dam will not be conveyed to the downstream channels. These sediments will be available to mining operations. The sediments not removed by mining will be periodically cleared to maintain the storage capacity of the reservoir. Construction of the embankments will require large quantities of material. An estimated 195 acres will be excavated as borrow to supply the necessary material. Approximately 143 acres of the designated borrow areas will be within the reservoir.

IV-4.03 SUBSURFACE HYDROLOGY. As a result of the construction of the dam, flood flows will be temporarily detained for release at a controlled rate. This will decrease the volume of surface flows in the downstream channels during periods of flooding, and will increase the duration of flows in the downstream channels. This, in turn, will increase the groundwater recharge potential. The potential recharge is not sufficient to affect the total groundwater regimen in the area. Riparian habitat along the downstream channels may benefit from the increased duration of available moisture.

IV-4.04 WATER QUALITY. The recommended project feature will have no effect on water quality in the area.

IV-4.05 VEGETATION AND WILDLIFE. The proposed project will cause a significant loss of native vegetation and wildlife habitat at the relatively unspoiled New River site. The habitat losses will not jeopardize the perpetuation of plant and animal communities locally or regionally since the species occur extensively throughout the Sonoran Desert; however, the impact of the loss is viewed as severe because of the excellent quality of the habitat, especially the native desert wash community, and its close proximity to Phoenix. Habitat of the quality found at New River will be in danger of elimination as Phoenix continues to grow and expand. The impact of the proposed action is significant enough to warrant mitigation for the loss of riparian vegetation. In total, about 300 acres of desert biotic communities will be removed by the recommended project feature. Construction of the proposed dam, dike, spillway and access roads will permanently remove about 100 acres of wildlife habitat. Borrow areas will eliminate natural vegetation from an estimated 200 acres of land. For construction of the dam and dike an estimated 225 acres of high quality (natural growth with little man-made alterations) desert wash or riparian vegetation, utilized by a diverse variety of wildlife species, will be removed by project related activities. The remaining vegetation to be affected by the project (about 75 acres) is desert outwash and upland vegetation with a fairly sparse assemblage of plants.

IV-4.06 In addition to the 300 acres of habitat physically removed by the proposed action, an estimated 1,460 acres of vegetation will be vulnerable to inundation from a standard project flood. However, probability of this occurrence is only once in a 200- to 300-year period. Inundation of vegetation over a much smaller area (acreage undetermined) is more likely to occur during smaller 50 or 100-year floods. A 100-year flood will inundate about 1,000 acres for 3 days and 80 acres for 7-1/2 days. A 10-year flood will cover about 300 acres for 1 day and 80 acres for 2-1/2 days. Prolonged inundation and heavy sedimentation probably would kill or severely damage large trees and shrubs in part of the overflow area. Vegetation characteristic of highly disturbed areas (i.e. many weedy annuals) would flourish while many desert wash and outwash plain species would be lost. An area behind the dam of perhaps 100 to 200 acres, where water will frequently impound and maintenance operations will be required, will be characterized by highly disturbed vegetation of mostly weedy forbs and grasses. The community structure probably would approximate that found in the area subject to inundation behind Cave Creek Dam. The weedy herbaceous growth and grasses behind Cave Creek Dam that thrive under such highly disturbed conditions provide excellent food and cover for wildlife, especially such game species as Gambel's quail, mourning and white-winged doves, and rabbits.

IV-4.07 When possible, borrow areas will be located where damage to natural vegetation, especially high quality riparian growth, will be reduced. Borrow areas will be contoured to facilitate reestablishment of natural vegetation. Exposed project areas will be landscaped with native vegetation to provide visual and habitat benefits. Suitable species of native vegetation in the borrow and excavation areas will be salvaged and used for landscaping when possible (i.e., saguaro cactus, barrel cactus). In those disturbed areas where surface soils are removed and not replaced, natural redevelopment of desert trees and shrubs may be very slow and forbs and grasses probably will predominate for many years. The downstream slope of the dam and dike will be landscaped, helping to recover some wildlife habitat losses. Wildlife expected to dominate the disturbed terrestrial habitats include lizards, snakes, pocket gophers, desert mice and rats, rabbits, doves and various song birds.

IV-4.08 The impoundment of water behind New River Dam during floods will influence the quality of the riparian vegetation behind the dam and downstream. The floodway below the dam will significantly decrease, resulting in a decrease in total plant cover and vigor along New River from the dam to Skunk Creek. A similar condition appears to predominate along Cave Creek below Cave Creek Dam although no empirical data are available to support this assumption. Riparian vegetation behind New River Dam probably will show increased vigor and cover in response to an additional water supply. However, any enhancement of riparian growth behind the dam probably will be at the expense of riparian and outwash vegetation downstream from the dam (i.e., a redistribution of total plant biomass). Salt cedar presently does not occur at the proposed New River Dam site. It is not known if the development of this dam will produce conditions favorable for salt cedar growth. For example, salt cedar growth behind the existing Cave Creek Dam is very rare. Although salt cedar provides wildlife habitat benefits for such species as white-winged doves, it is often at the expense of native vegetation which provides valuable food and cover sources.

IV-4.09 Large ironwood, mesquite, blue paloverde, and desert willow will be removed by the proposed action. The loss of these trees as well as other less prominent members of the desert wash community structure represents a significant adverse impact on wildlife species since such growth provides food, cover, nesting and resting habitat. The loss of saguaro cactus is also viewed as adverse. The saguaro cactus has been declining in numbers in Arizona because of limited recruitment of new plants. Several factors (i.e., temperature, moisture, land uses) are apparently responsible for the limited recruitment of new plants. This large prominent plant provides esthetic benefits as well as food and cover for various wildlife species (i.e., flicker, Gila woodpecker, white-winged dove, elf owl, woodrat). Every effort will be made to retain or salvage saguaro cactus during project construction.

IV-4.10 The proposed action will remove habitats that support a variety of wildlife species including lizards, snakes, rabbits, small rodents, song birds, doves, quail, hawks, badger, coyote, fox, javelina, and mule deer. Many small animals, especially rodents and reptiles, will be destroyed by construction activities and/or inundation of the overflow area during floods. Those animals not actually killed by construction activities will be displaced to surrounding habitats probably already supporting maximum wildlife populations and probably most would not survive.

IV-4.11 No threatened or endangered plant or animal species will be jeopardized by the proposed action.

IV-4.12 ARCHEOLOGICAL AND HISTORICAL RESOURCES. Construction of the recommended project feature will alter or destroy 20 archeological sites that are located within the New River Dams Archeological District, a property that has been nominated to the National Register of Historic Places (pl. 10). The type of land modification and inundation associated with the recommended damsite precludes preservation of the cultural resources. Mitigation measures proposed by the Corps of Engineers to the Advisory Council on Historic Preservation include the mapping of the location of artifacts, excavation, pollen analysis, carbon 14 and archaeomagnetism dating, identification of flora and fauna from archeological deposits, petrographic analysis of ceramics, and the formulation of an adequate research design and testing program to identify and interpret the cultural resources removed from the sites. The recovery ratio will vary, depending on the degree of impact and the importance of the site. Between 75 and 100 percent recovery is contemplated for sites that will be directly affected by construction or borrow operations, while the recovery of moderately and minimally affected sites will vary from 1 to 40 percent depending on the estimated value of the site.

IV-4.13 POPULATION AND LAND USE. Construction of a dam on New River at the recommended site will have no effect on future land use or population in the area. County and local land use plans presently indicate this site as the future location of New River Dam. The inundation basin behind the dam will become permanent open space. As a result of the construction of the dam, the floodway immediately below New River Dam will be reduced, and acreage will be released for other uses. Because of the remote location of this acreage, no impact on land use is expected to occur.

IV-5. ANY PROBABLY ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED

IV-5.01 Visual impairment will occur with construction of the recommended project feature. The dam and its appurtenances will be obviously artificial structures that many persons will consider unattractive.

IV-5.02 Sediments transported by New River will be impounded by the recommended dam; an estimated 4,920 acre-feet of sediments will be impounded over a 100-year period.

IV-5.03 Large quantities of material will be required for construction of the dam.

IV-5.04 Construction of the project feature will subject 1,460 acres to the effects of periodic inundation and sedimentation. Approximately 300 acres of desert biotic communities within the reservoir area will be removed by the construction. Of this total, approximately 225 acres are high quality desert wash or riparian vegetation.

IV-5.05 Twenty archeological sites within the New River Dams Archeological District will be altered or destroyed.

IV-8. ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION SHOULD IT BE IMPLEMENTED.

IV-8.01 The recommended feature would commit 1,460 acres of land to flood control purposes.

IV-8.02 Construction of this project feature will result in the destruction of archeological resources in the New River Dams Archeological District.

IV-8.03 Construction of New River dam and its appurtenances will require 1.8 million cubic yards (silt, sand, gravel and cobbles) of material.

IV-9. COORDINATION

IV-9.01 Detailed coordination for the New River Dam feature of this project has been carried out with the Recreation Task Force, the Arizona Conservation Council, the U.S. Fish and Wildlife Service, the Arizona Game and Fish Department, the National Park Service, and the Advisory Council on Historic Preservation.

V

FEATURE OF THE NEW RIVER & PHOENIX CITY STREAMS FLOOD CONTROL PROJECT

SKUNK CREEK, NEW RIVER & THE AGUA FRIA RIVER

UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
PACIFIC SOUTHWEST REGION
BOX 36098 • 450 GOLDEN GATE AVENUE
SAN FRANCISCO, CALIFORNIA 94102
(415) 556-8200

ER-75/837

October 30, 1975

Col. John V. Foley
U.S. Army Engineer District, L.A.
Corps of Engineers
300 N. Los Angeles Street
Los Angeles, CA 90054

Dear Col. Foley:

The Department of the Interior has reviewed the draft environmental statement and General Design Memorandum for flood control project, Gila River Basin, New River and Phoenix City Streams, Maricopa and Yavapai Counties, Arizona.

We are pleased that impacts on sand and gravel resources are acknowledged in both documents. Because of rapid growth and continuing development in the Phoenix area, these aggregate resources are of considerable value and significance. In fact, data more recent than the 1970 figure cited in the environmental statement (page 1-19) show an upsurge in the production of sand and gravel in Maricopa County. According to the Bureau of Mines' Minerals Yearbook, quantities produced rose from 6,363,000 tons ($6,866,000) in 1970 to 12,912,000 tons ($14,022,000) in 1971 and to 15,675,000 tons ($18,198,000) in 1972. We suggest that the discussion about overall effects of the project on this prosaic but vital mineral resource be expanded to show in more detail the magnitude of the impact and to discuss measures for mitigation.

Aggregate resources, of unspecified quality and quantity, would be lost at Cave Buttes Dam (DES, page II-19), at Adobe Dam (DES, page III-29), and at New River Dam (DES, page IV-13), and at the first two sites, ongoing mining operations apparently would be displaced (DES, pages II-19 and III-13). For the whole project, aggregate resources under some 6,100 acres required for channels, dams or dikes and impoundments would be committed (DES, pages I-79 and I-87); urban development that is expected to result from flood protection afforded by the project might cover another 1,200 acres of potential aggregate-bearing land (DES, page I-88); and the 8,300 acres of designated floodway/flowage easement would remain open for recovery of aggregate resources (DES, page V-31) subject to a lack of replenishment from upstream sources (DES, pages I-79 and -80).

The documents do not provide any analysis about the significance of project impacts in relation to the total supply of aggregate in the Phoenix area.

Basic to such analysis is proximity of available aggregate resources to markets. Since, generally, the price of aggregate at the quarry or pit is doubled after 25 miles of truck transportation, the importance of close-in recoverable resources of aggregate is obvious. If such resources are available only at some distance from the city because of encroachment and commitment of close-in deposits, the documents should recognize that costs of construction would be increased significantly. We suggest that the reports show not only the commitment of aggregate but also the overall impact of the project on the availability of sand and gravel in the Phoenix area. To mitigate or reduce the loss of this valuable resource, we urge that multiple sequential use of project lands be considered and practices wherever possible so that aggregate resources lying in the path of the project can be extracted before they are lost.

Some major construction requirements which would apparently entail major impacts in urban areas have been mentioned in a peripheral manner in widely scattered parts of the draft environmental statement. For example, the first mention of bridges that has been noted is that the channelization of Skunk Creek would require the lengthening by 134 feet of two existing highway bridges and two frontage road bridges (p. I-7, par. 3). Later it is noted that 20 dip crossings would be replaced by all-weather bridges (p. I-91, par. 2). Still later, a briefing reference is made to the requirement for 14 new highway bridges and one railroad bridge extension in providing the recommended floodways below the dams (p. V-3, par. 3). It is first mentioned in the supplementary section on the Arizona Canal Diversion Channel that 26 bridges would be required for streets and highways that presently cross the Arizona Canal (p. VI-4, line 19).

Similarly, the first mention of the proposed construction of fairly extensive levees in several places was found in the supplementary section on Skunk Creek, New River and the Agua Fria River. There it is noted that nearly 10,000 feet of levees from three- to eight-feet high are proposed around five residential subdivisions along the Agua Fria River (p. V-6) and that 5,700 feet of levee up to four-feet high would be constructed along New River (p. V-5). These proposed facilities do not appear to be included among the proposed levees and dikes delineated on Plate 4 (Recommended Plan, Flood Control). It would be helpful to provide a reference to the map on which these proposed facilities have been delineated, and to evaluate any impact of these levees.

ARIZONA STATE MUSEUM
THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

September 29, 1975

Ms. Constance LaMonica
State Clearinghouse Contact
1645 West Jefferson
Phoenix, AZ 85007

Project: Draft Environmental Impact Statement for New River and Phoenix City Streams

State Application Identifier: 75-80-0041

Dear Ms. LaMonica:

The Draft EIS for the New River and Phoenix City Streams represents an excellent consideration of the archaeological resources that will be affected by this project. The thoroughness exhibited in this aspect of the document is appreciated.

Sincerely,

Robert J. Hard
State Clearinghouse Contact
Arizona State Museum

R. Gwinn Vivian
Archaeologist
Arizona State Museum

RJH/RGV:sr

cc: Garth A. Fuguay

DEBITAGE – The waste chips of stone left over after a stone tool has been fashioned.

DEBRIS BASIN – A basin formed behind a low dam or excavated in a stream channel to trap debris carried by flood water.

DENDRITIC DRAINAGE – A tree-like pattern of converging tributaries upon a main river or stream.

DETENTION BASIN – (Also called a retarding basin) a reservoir wherein excess water is stored for a relatively brief period of time, until it can be safely released.

DIKE – An embankment constructed to prevent overflow from a body of water, to retain water in a reservoir, or to prevent water from inundating an area of lower elevation.

DIVERSION DAM – A fixed dam built to divert all or part of the water in a stream away from its natural course.

DROP STRUCTURE – Structure, vertical or inclined, installed for the purpose of dropping water to a lower level and dissipating its energy.

ECOSYSTEM – A basic unit of ecology referring to a balanced system of organisms with their environment. It is usually self-maintaining and self-stabilizing unless its organisms or environment are altered by natural or human influences.

ECOTONE – The boundary between two ecosystems. It is important to consider such areas in an environmental/ecological analysis. Because two different ecosystems are acting in such areas, there tends to be greater species diversity and activity (referred to as the "edge effect").

ENERGY DISSIPATOR – A structure designed to decrease the velocity or turbulence of flowing water.

ENTRENCHED – See intrenched.

EPHEMERAL STREAM – A stream which flows only during and following a period of rainfall.

FAUNA – The animals of a given region taken collectively.

FELSITE – A light-colored igneous rock having few or no conspicuous crystals.

FERRIGENOUS – Of or pertaining to iron.

FLAKE – Any bit of stone derived when a core is struck with another stone. It may be waste or may be fashioned into a tool.

FLIP BUCKET – An energy dissipating structure found on the spillway or outlet works of a dam.

FLOOD INSURANCE – Any insurance program designed to provide financial relief for damages incurred due to flooding.

FLOOD PLAIN – A belt of low, flat ground bordering a river or stream on one or both sides which is inundated when surface flows exceed the capacity of natural channel.

FLOOD PROOFING – Those adjustments, temporary or permanent, to a building or its contents, which are designed to keep water out or reduce effects due to inundation.

FLOOD WARNING – Any system of broadcasting an advance warning of possible flooding, to allow time to activate flood proofing devices or to evacuate a flood-prone area.

FLOODWAY – Is the portion of a flood plain required to carry and discharge the flood waters of a selected probability of occurence storm with an insignificant (less than 1 foot) increase in floodstage above that of normal conditions.

FLOODWAY FRINGE – The portion of the flood plain between the floodway and the normal outline of the selected flood.

FLOWAGE EASEMENT – The acquired legal right to flood land owned by others.

FLOW BRECCIA – Rock consisting of consolidated angular rock fragments larger than sand grains, formed in connection with a lava flow.

FORB – A pasture herb.

FRIABLE – Easily crumbled or pulverized.

GABIONS – Wire containers filled with stones and used to construct stabilizing structures.

GNEISS – A thickly banded (foliated) metamorphic rock of no specific composition.

GRADIENT – The steepness of a slope expressed either as a proportion between its vertical interval and its horizontal equivalent, e.g. 1V to 2H, or as an angular measurement from the horizontal.

HABITAT – The place where an organism lives or the place occupied by an entire community.

HERBACEOUS – Any plant that lacks woody tissue on which the leaves and stem fall to ground during periods of freezing or dry weather.

IGNEOUS ROCKS – Rocks formed by the solidification of hot flowing rock material (magma).

INCISED – Intrenched.

SOFT BOTTOM CHANNEL – A channel in which the bottom remains unlined; such a channel allows ground water recharge.

SPF – Standard project flood. The flood that may be expected from the most severe combination of meteorologic and hydrologic conditions that are considered reasonably characteristic of the region.

STILLING BASIN – A structure or excavation that reduces velocity or turbulence of flowing or falling water.

STORAGE DAM – A fixed dam used to impound water, usually for long periods of time.

STUDY AREA – The area impacted by a project feature.

SUBSTRATE – The layer upon which organisms grow, often used synonymously with surface of ground.

TACONITE – Bonded rock with high iron content.

TALUS – An accumulated heap of rock fragments derived from and lying at the base of a cliff or very steep slope.

TUFFACEOUS – Pertaining to or resembling tuff, a hardened mass of rock, predominantly consisting of fine grained volcanic ash and dust.

VESICULAR – A textural term indicating the presence of many small cavities in a rock.

WEIR – A structure with a crest and some side containment of known geometric shape, used to measure the flow of water.

XERIC – Characteristic of a scanty water supply.

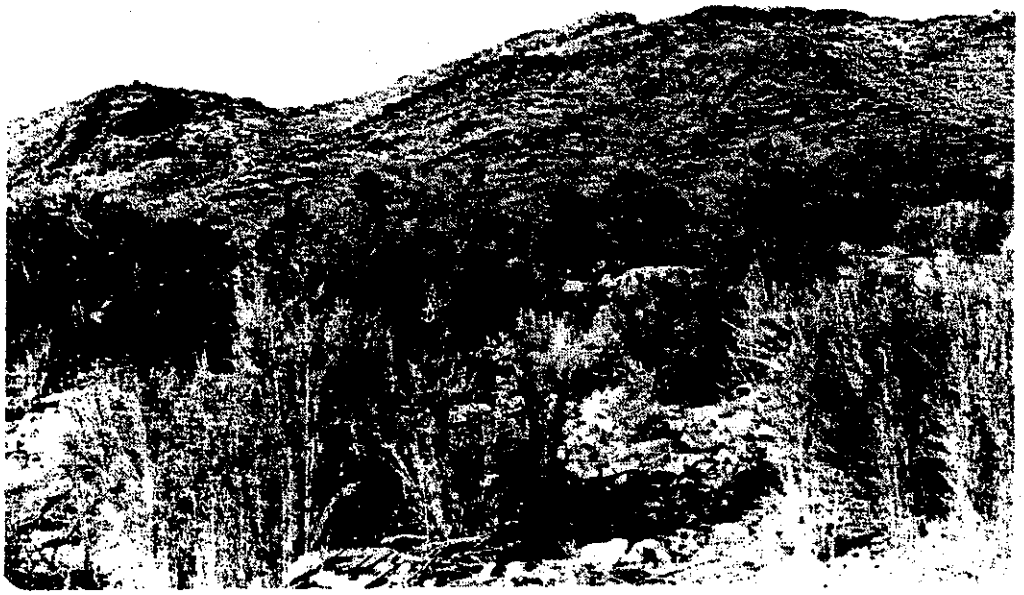


PHOTO 1. In the New River area, a desert wash or riparian plant community of ironwood, mesquite, blue paloverde, desert willow, catclaw acacia, desert broom, burrobrush, and saguaro cactus.

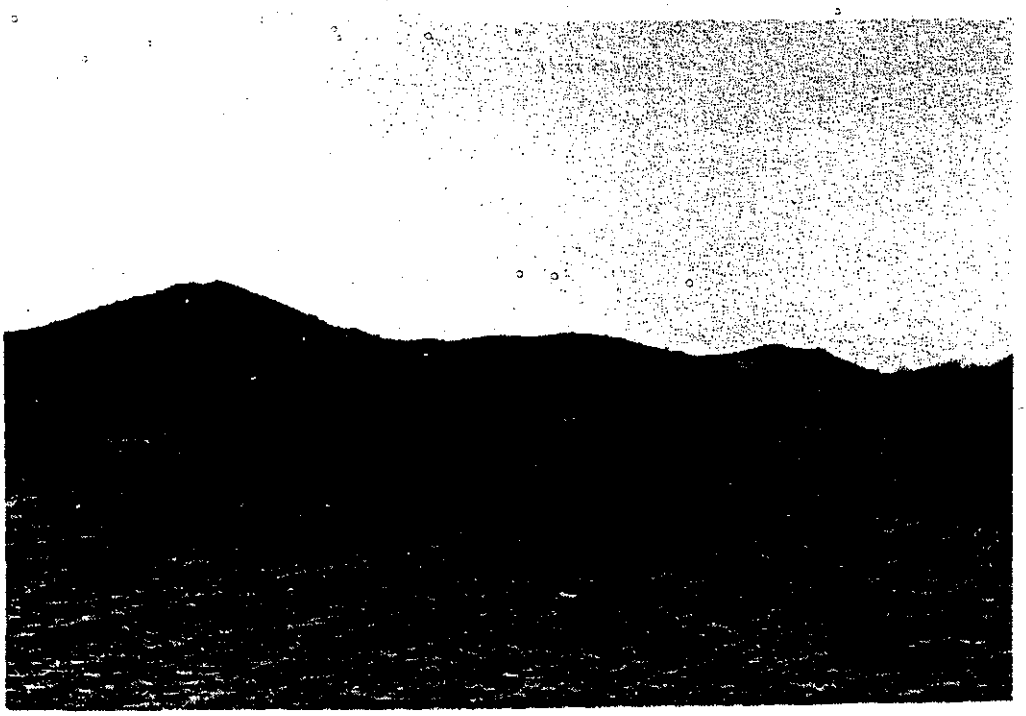


PHOTO 2. In the New River area, an outwash plain or bajada plant community of creosotebush and grasses with a scattering of bursages, cholla cactus and saguaro cactus.

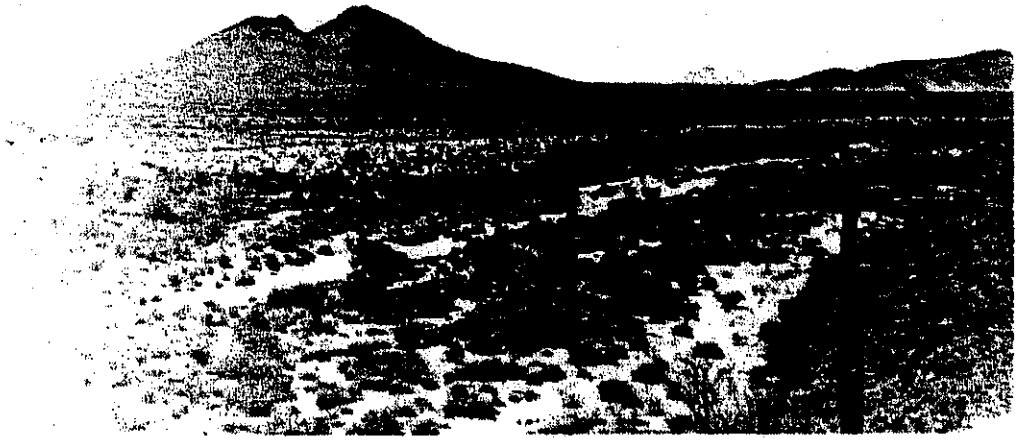


PHOTO 13. The recommended New River Dam site, looking southeast from the west abutment. Stream flow is from left to right.

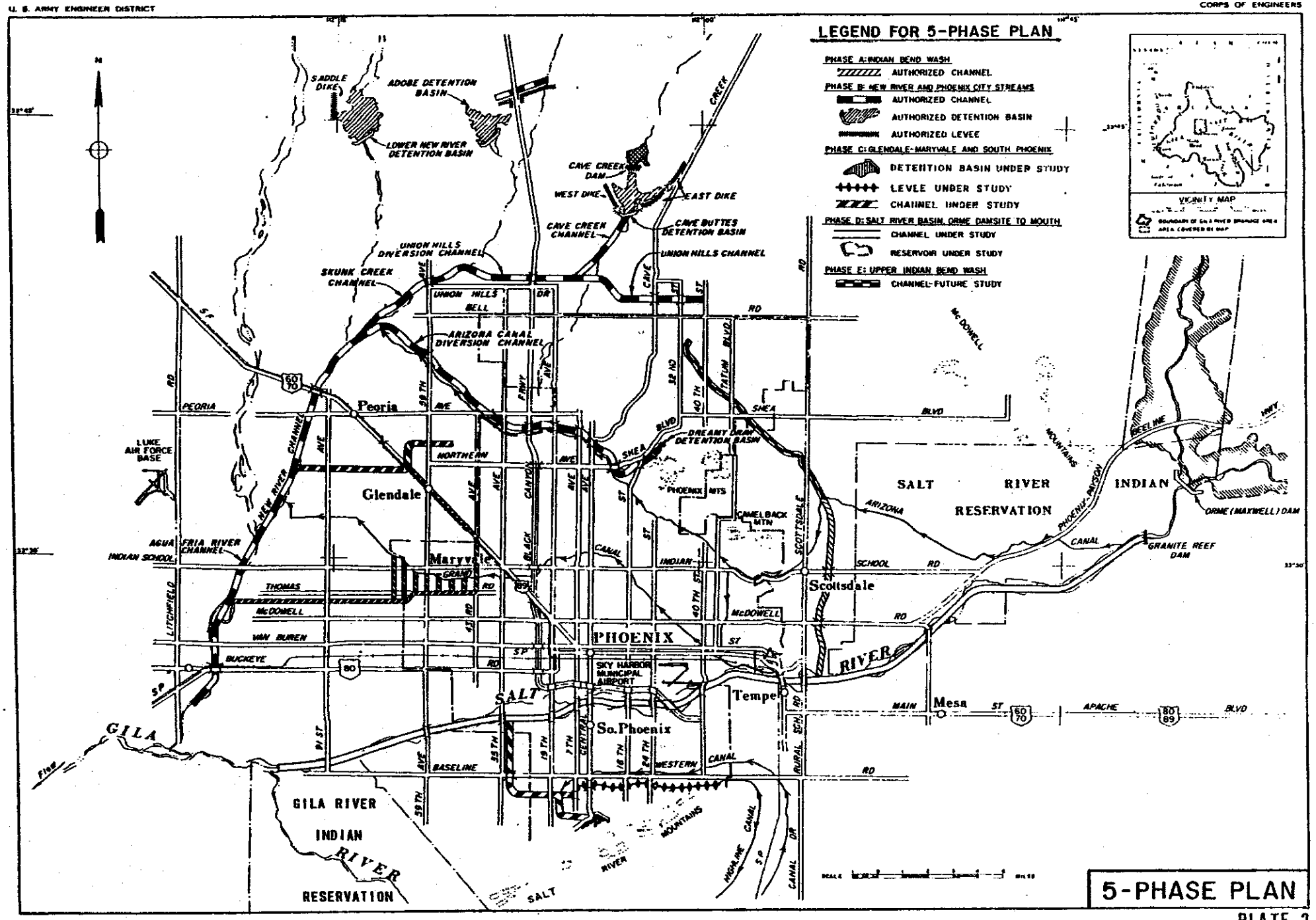
PHOTO 14. A large ironwood (Olneva tesota) about twenty-five feet tall in the vicinity of the proposed New River Dam site.

TABLE 2

DEPTH TO WATER IN WELLS PRINCIPALLY IN
ALLUVIAL DEPOSITS, IN FEET BELOW LAND SURFACE

New River Study Area	200' to 300'
Adobe Dam Study Area	200' to 500'
Cave Buttes Dam Study Area	300' to 400'
Along Cave Creek	33' to 239'
Along New River Channel Study Area	100' to 200'
Along Agua Fria Channel Study Area	100' to 200'
Along Salt River Channel Study Area	0' to 100'
Along Arizona Canal Channel Study Area	300' to 400'

Map showing Depth to Water in Wells in the Phoenix Area, Arizona, 1972, by W. R. Osterkamp, 1973.
Base from U.S. Geological Survey, Phoenix and Mesa 1954-69, Ajo 1953-69, Tucson 1956-62.



5-PHASE PLAN

PLATE 2

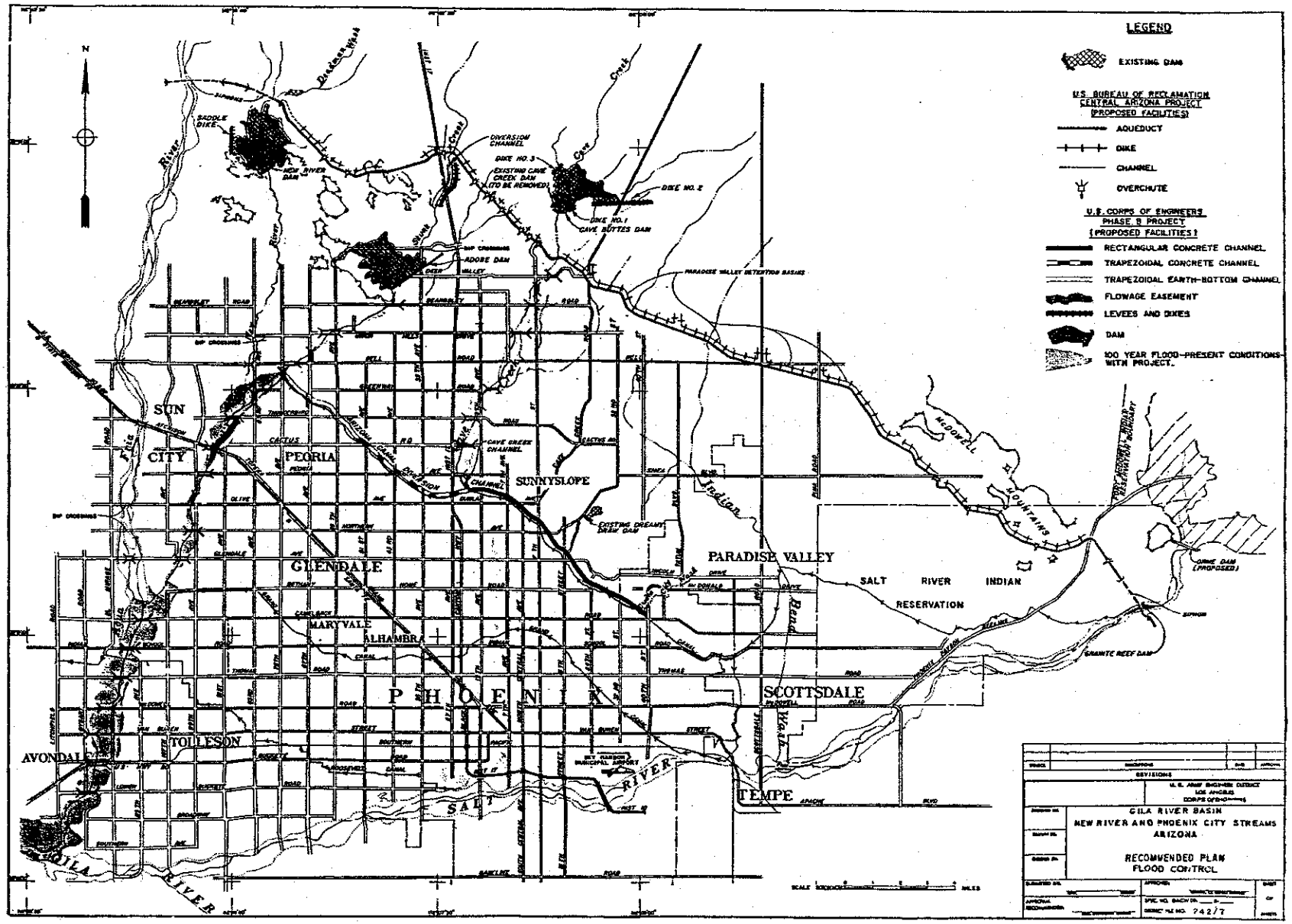

LEGEND
EXISTING DAM
U.S. BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT
(PROPOSED FACILITIES)
AQUEDUCT
DIKE
CHANNEL
OVERCHUTE
U.S. CORPS OF ENGINEERS
PHASE B PROJECT
(PROPOSED FACILITIES)
RECTANGULAR CONCRETE CHANNEL
TRAPEZOIDAL CONCRETE CHANNEL
TRAPEZOIDAL EARTH-BOTTOM CHANNEL
FLOWAGE EASEMENT
LEVEES AND DIKES
DAM
100 YEAR FLOOD-PRESENT CONDITIONS WITH PROJECT.
N
SADDLE DIKE
NEW RIVER DAM
DIVERSION CHANNEL
DIKE NO. 3
EXISTING CAVE CREEK DAM (TO BE REMOVED)
DIKE NO. 2
DIKE NO. 1
CAVE BUTTES DAM
ADOBE DAM
PARADISE VALLEY DETENTION BASINS
SUN CITY
PEORIA
CAVE CREEK CHANNEL
SUNNYSLOPE
EXISTING DREAMY DRAW DAM
GLENDALE
MARYVALE
ALHAMBRA
PHOENIX
PARADISE VALLEY
SALT RIVER INDIAN RESERVATION
SCOTTSDALE
TEMPE
TOLLESON
AVONDALE
SALT RIVER
GILA RIVER
McDOWELL MOUNTAINS
GRANITE REEF DAM
DIKE DAM (PROPOSED)
SCALE
MILES
REVISIONS
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS
GILA RIVER BASIN
NEW RIVER AND PHOENIX CITY STREAMS
ARIZONA
RECOMMENDED PLAN
FLOOD CONTROL
742/7

PLATE 4a

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS

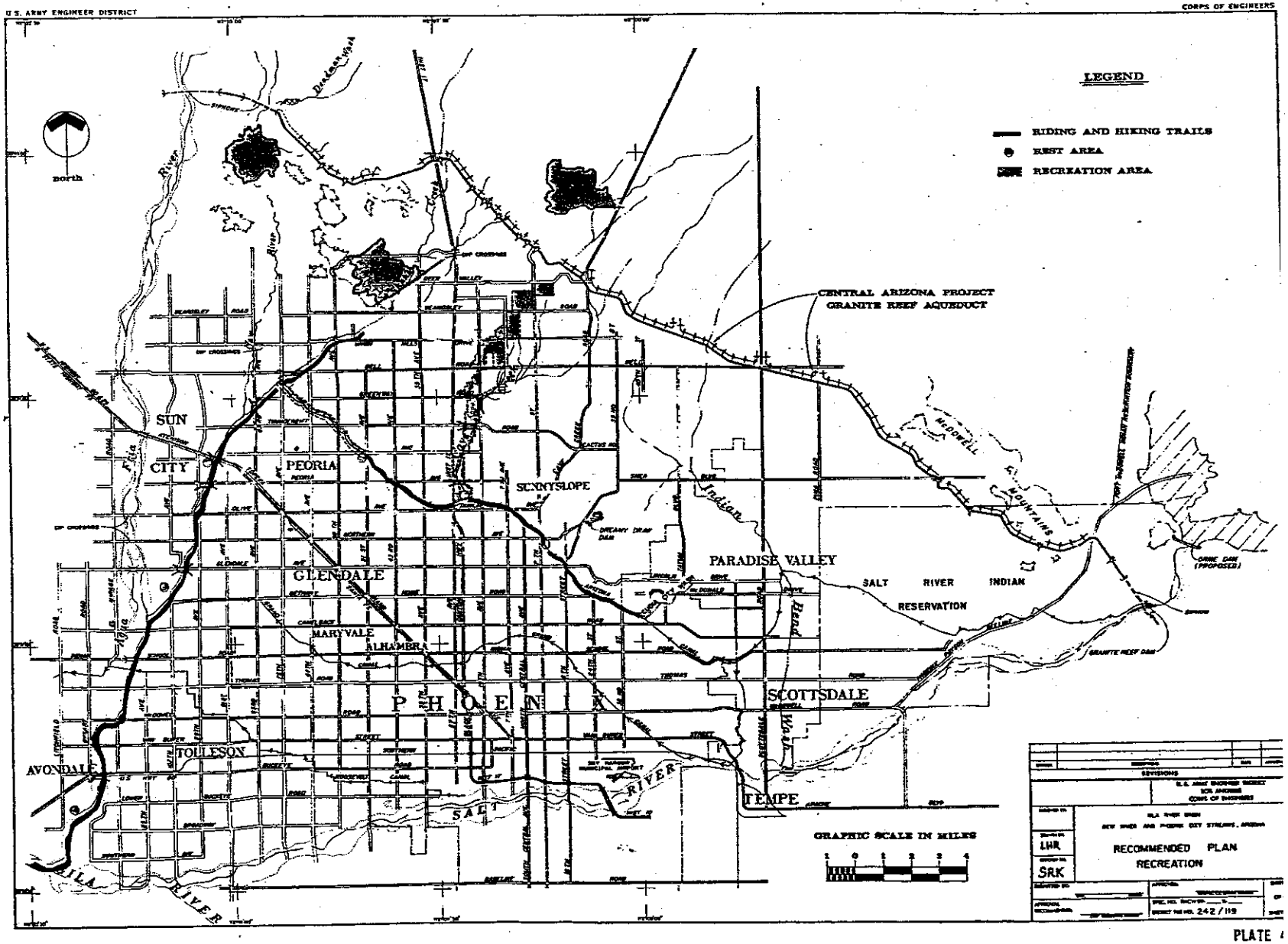
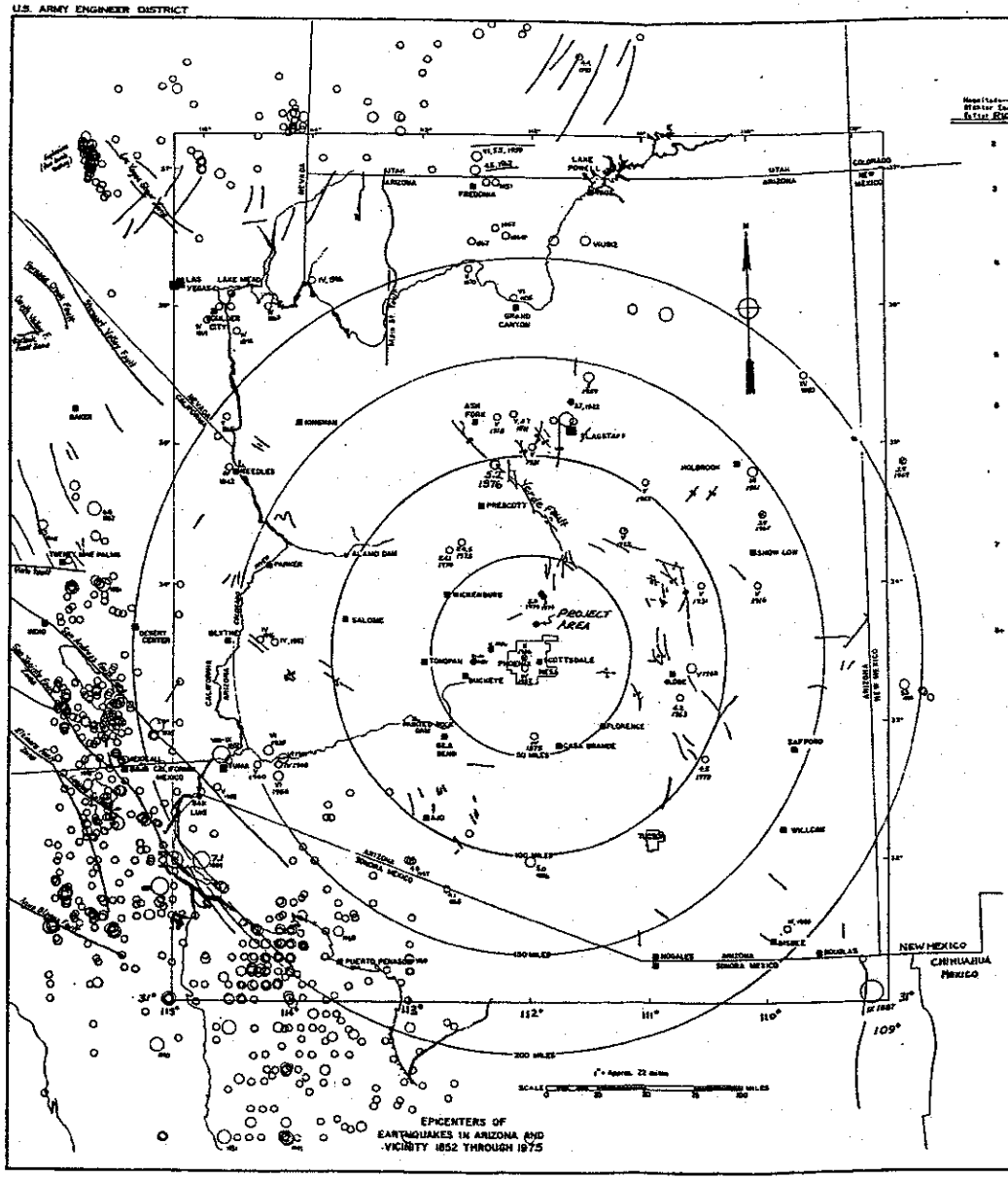


PLATE 4

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS



EPICENTERS OF EARTHQUAKES IN ARIZONA AND VICINITY 1852 THROUGH 1975

MODIFIED MERCALLI INTENSITY CHART

Magnitude—Approx. Richter Equivalent (after RICHTER)	Modified Mercalli Intensity (Average) Scale of 1931 (abbreviated)
2	I. Not felt except by a very few under especially favorable circumstances. (I Rossi-Forel Scale)
	II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing. (I to II Rossi-Forel Scale)
3	III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing of truck. Duration estimated. (III Rossi-Forel Scale)
4	IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably. (IV-V Rossi-Forel Scale)
5	V. Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (VI to VII Rossi-Forel Scale)
6	VI. Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damage chimney. Damage slight. (VI to VII Rossi-Forel Scale)
6	VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motorcars. (VIII Rossi-Forel Scale)
7	VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimney, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motorcars disturbed. (VIII+ to IX Rossi-Forel Scale)
7	IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX+ Rossi-Forel Scale)
8	X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks. (X Rossi-Forel Scale)
8+	XI. Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
	XII. Damage total. Waves seen on ground surface. Lines of sight and level disturbed. Objects thrown upward into the air.

SYMBOLS

- 7 — Earthquake epicenter, giving intensity (from Modified Mercalli Scale of 1931) in Roman numerals, and year of occur. Where no intensity is given, it is not known.
- 9.1 1963 — Earthquake of known magnitude, according to the Richter Curve.
- N — Location and intensities (both estimated), from Fate Verne Report, Apr. 1975.
- ⊙ NV 9.5 1888 — Earthquake of known magnitude and intensity.
- ⊙ EN.6 1972 — Artificial shock caused by mining activities.
- ● M<4.9
- ○ 4.9≤M<5.9
- ○ 5.9≤M<6.9
- ○ 6.9≤M<7.9
- ○ 7.9≤M<8.9
- ○ 8.9≤M
- Magnitude of shock determined on site of epicenter.
- ■ Town or city.
- Larger city.
- Quaternary fault traces, dashed where approximately located, dotted where concealed. B—Bartlett side; D—Deadman side

GENERAL NOTES

1. Richter Scale magnitude are a measure of the energy released at the focus (center of the earthquake), as determined by the amplitudes produced on a seismogram. Epicenter is the point on the Earth's surface directly above the focus.
2. Intensity—expressed on the Modified Mercalli Intensity Scale of 1931—is a measure of the effects of an earthquake on people and objects, as determined by experienced observers (See Chart, this sheet). Approximate equivalents of intensity and magnitude are shown 3. Intensities or their change are recorded at the epicenters.
3. Earthquake information gathered from U.S. Dept. of Commerce and Elevation, United States Earthquakes (1928 through 1972), and from U.S. Dept. of Commerce Environmental Data Service, Denver Colorado.
4. Earthquake not centered in this area (whether fault here or not) are not included.
5. Map of Arizona drawn using Rand-McNally Co. Company map of 1980 and Arizona Highway Dept. map of 1970.
6. Rossi-Forel Scale shown in part is still used by some countries in available earthquake effects.
7. Center of Phoenix is used as focal center of damage rings.
8. Longest Quaternary fault within 100 miles of Phoenix is 33 miles long.
9. Only earthquakes greater than 4 magnitude are shown outside of the 150-mile radius circle.
10. Earthquake of Dec. 30, 1935 in Maricopa—intensity felt in the vicinity of Phoenix was reported as III.
    Earthquake of May 18, 1940 near Imperial, Calif.—intensity felt in the vicinity of Phoenix was reported at about IV.
    Earthquake of Jan. 18, 1942 near Bagdad (VII)—intensity felt in vicinity of Phoenix was IV.
    The 1887(8) Sonora earthquake damaging was very felt by a few persons (i.e. mexico).
    Prior to 1975, 5 earthquakes were temporary felt at Phoenix. (i.e. 1902, 1906 (2), 1930 and 1937). These have no instrumentally located epicenters within Arizona. Of the events felt in Phoenix, two have epicentres in Baja and one near Flagstaff. (Gilmore and Jones, 1973).

SYMBOL	DESCRIPTION	DATE	APPROVED
	REVISIONS		

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SALA RIVER BASIN
NEW RIVER AND PHOENIX CITY STREAMS, ARIZONA

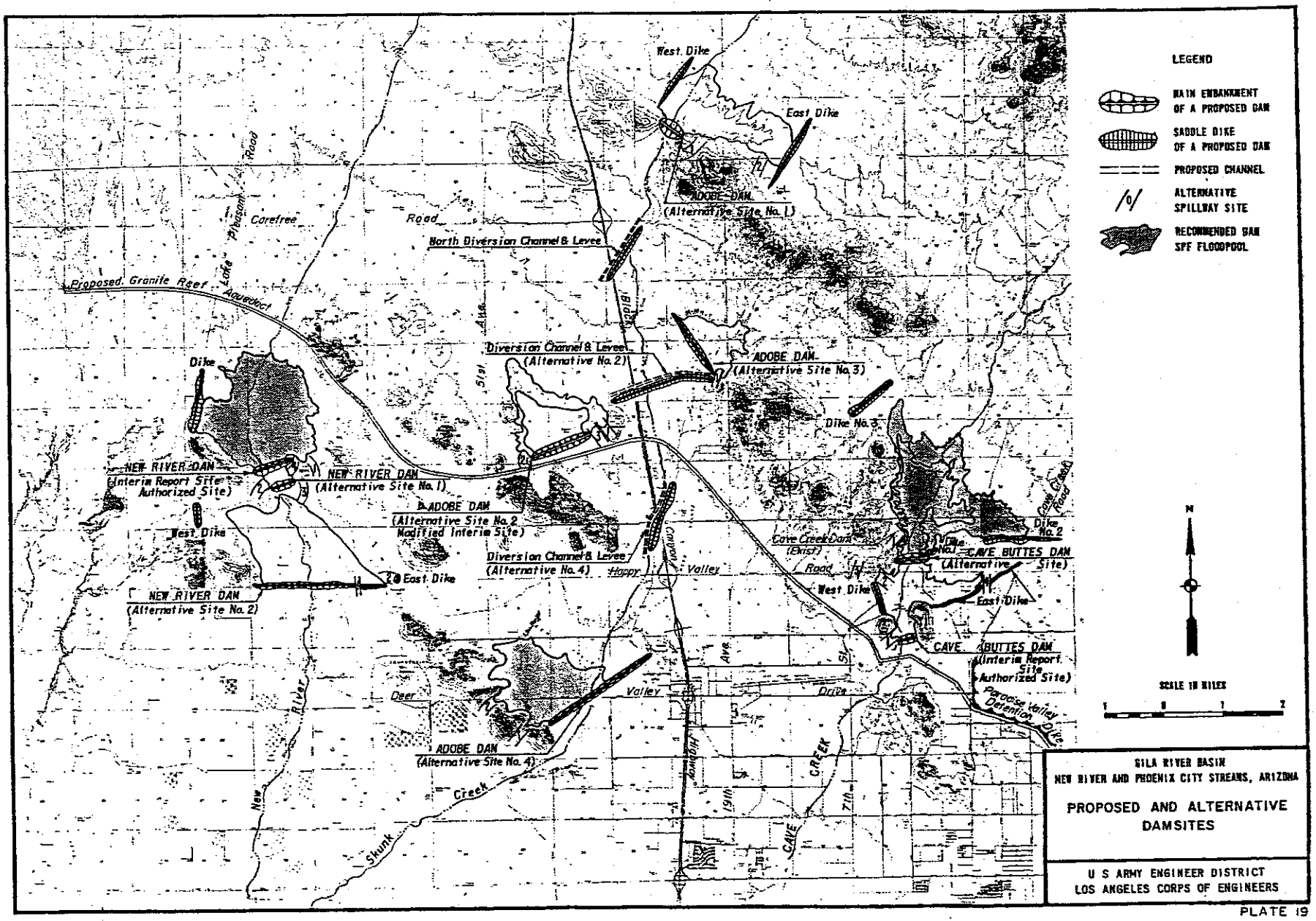
STRUCTURAL AND EARTHQUAKE MAP OF CENTRAL ARIZONA

DESIGNED BY: LMK
DRAWN BY: R.E.E.
CHECKED BY: J.J.

SUBMITTED BY: ____ DATE ____
APPROVAL RECOMMENDED: ____
APPROVED: ____
SPEC NO. SACW09-____-B-____
DISTRICT FILE NO. 242/41

SHEET ____ OF ____ SHEETS

PLATE 5

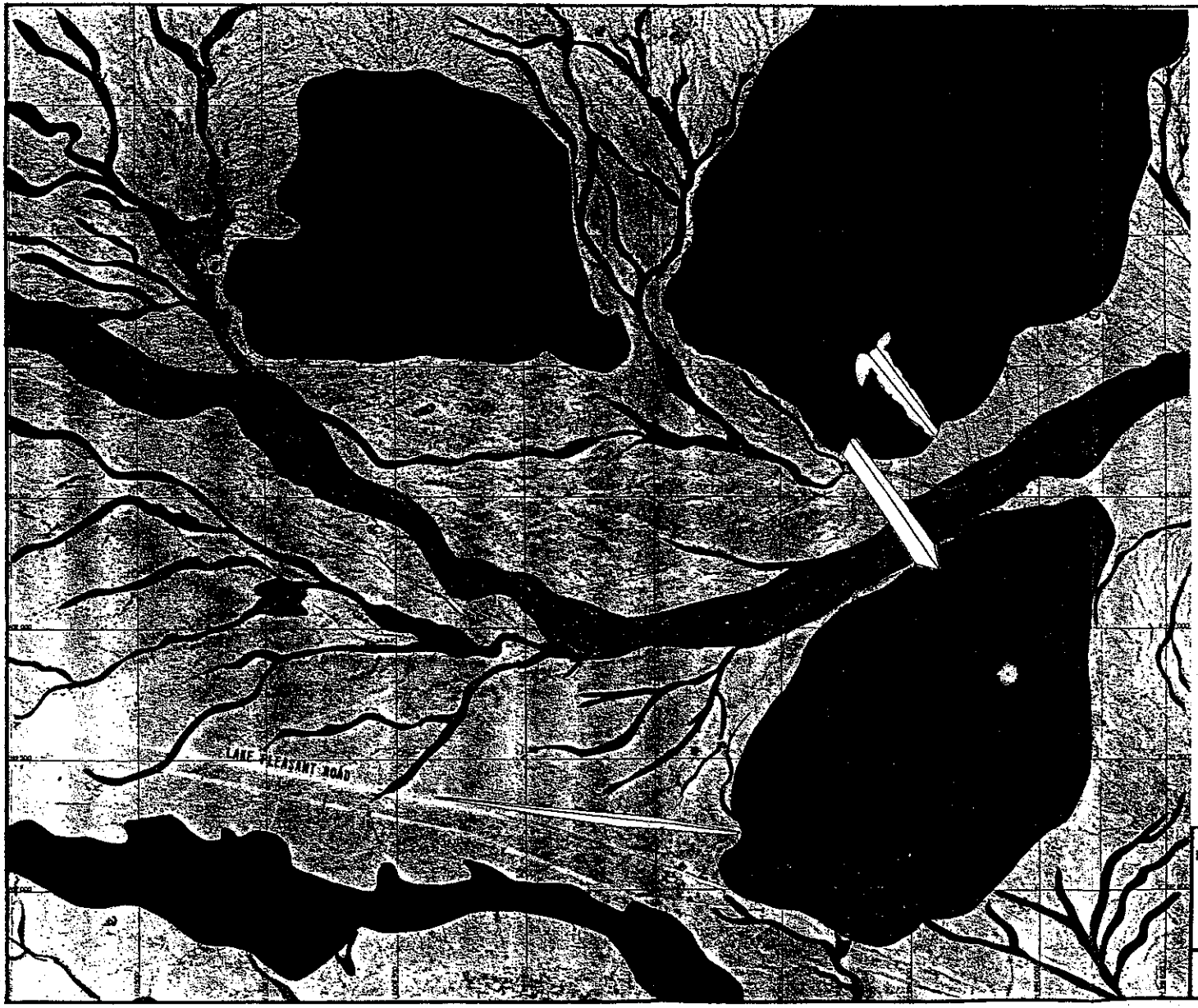


GILA RIVER BASIN
NEW RIVER AND PHOENIX CITY STREAMS, ARIZONA

PROPOSED AND ALTERNATIVE DAMSITES

U S ARMY ENGINEER DISTRICT
LOS ANGELES CORPS OF ENGINEERS

PLATE 19



LEGEND

UPLAND

OLDFIELD & OUTWASH

RIPARIAN

STOCK WATERING TANK

N

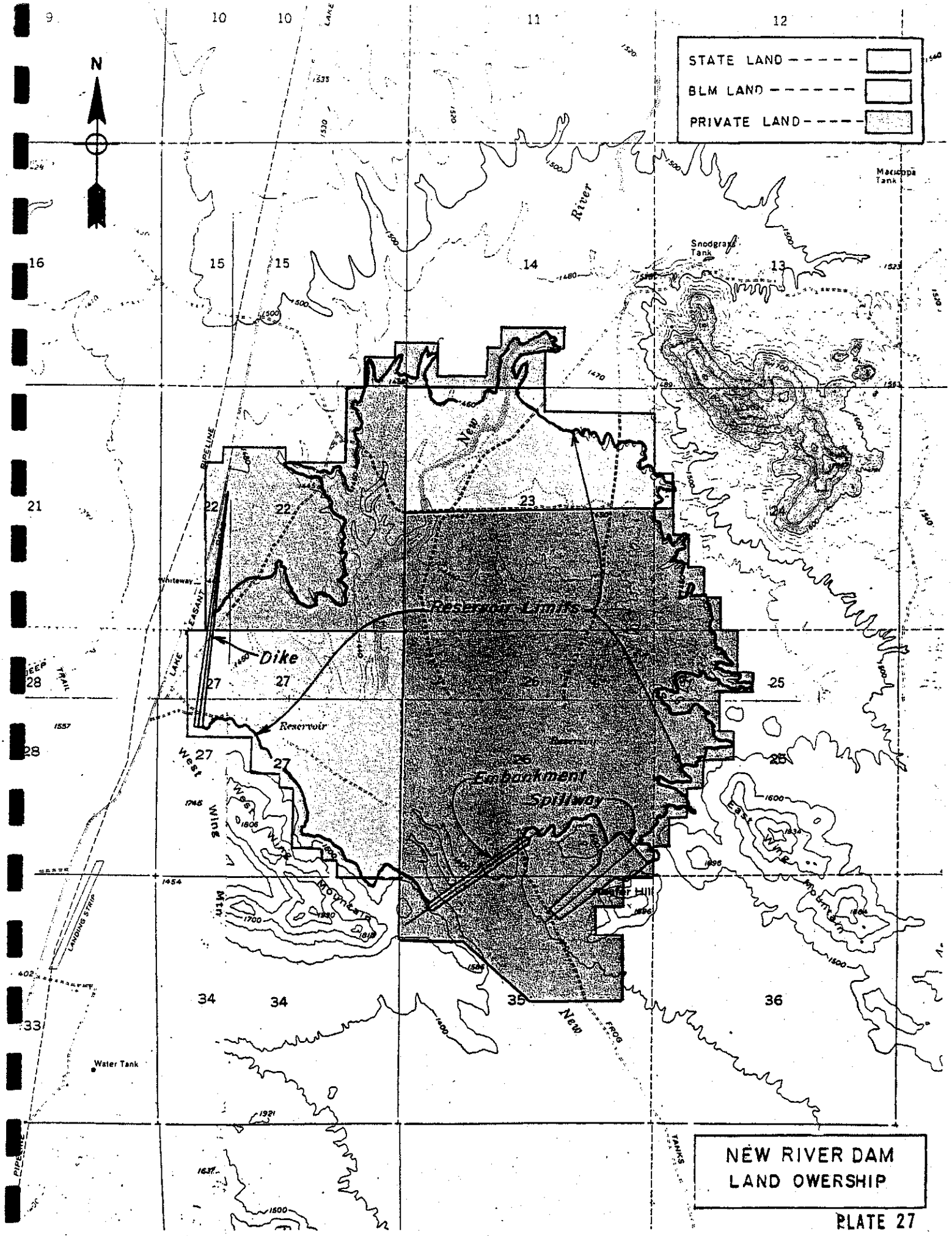
SCALE IN FEET

2000 0 2000

GILA RIVER BASIN
NEW RIVER AND PHOENIX CITY STREAMS, ARIZONA

LAND USE AND PLANT COMMUNITIES
NEW RIVER DAMSITE

U S ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS



NEW RIVER DAM
LAND OWERSHIP

PLATE 27

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.
Halloran et. al. v, Sierra Aggregate Co., CA, 1998.

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, Int. Assoc. of Assessing Officers Workshop, 1993-1998.

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