WATERSHED WORK PLAN
BUCKEYE WATERSHED
MARICOPA COUNTY, ARIZONA

OUR SOIL ★ OUR STRENGTH

OCTOBER 1963

Prepared under the authority of the Watershed Protection & Flood Prevention Act (Public law 566, 83rd. Congress, 68 Stat. 666) as amended.

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Prepared Under the Authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress, 68 Stat. 666), as amended

Prepared by: Flood Control District of Maricopa County
Agua Fria Soil Conservation District
Wickenburg Soil Conservation District
Buckeye-Roosevelt Soil Conservation District
Arizona Game and Fish Department

With Assistance by:

U. S. Department of Agriculture, Soil Conservation Service

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SUMMARY OF PLAN

Size and Location

This watershed is located in west central Maricopa County about 30 miles west of Phoenix and heads in the White Tank Mountains. (The original pilot watershed, "White Tanks", constructed in 1953, is located immediately adjacent to the east boundary of the Buckeye Watershed). The watershed drains onto a wide alluvial fan upon which lies irrigated farm lands that produce crop yields consistently above the state average. The flood plain area lies west of the rapidly expanding Phoenix Metropolitan area.

The total watershed area contains 128,310 acres, of which 28 per cent is cultivated farm land, one per cent is urban and commercial, and the remaining 71 per cent is range land. Sixty per cent of the watershed is in private ownership, eight per cent is in state ownership, and 32 per cent in the National Land Reserve. (See Figure 3)

Sponsoring Organizations

This work plan was prepared by the Flood Control District of Maricopa County, the Agua Fria Soil Conservation District, the Wickenburg Soil Conservation District, the Buckeye-Roosevelt Soil Conservation District, and the Arizona Game and Fish Department, with technical assistance furnished by the United States Soil Conservation Service.

Watershed Problems

During the last 45 years, fifteen floods, of varying magnitudes, have inundated agricultural lands, residences, roads, and the Southern Pacific Railroad, and have seriously disrupted, for critical periods, the supply of irrigation water within the watershed.

Runoff from these storms inundated intensively cropped irrigated farmland. Reductions in crop yields are sustained on cotton, alfalfa, and grain crops within the area. Irrigation laterals and ditches are rendered useless by washouts or sediment deposition. In-field irrigation borders are washed out, impairing irrigation efficiency. The two main irrigation canals, serving essentially all of the cultivated acreage, are frequently breached and washed out. This type of damage not only affects those acres flooded, but delays for a critical period the delivery of water to other cultivated lands within the watershed.

Restoration of the roadbed on the Southern Pacific Railroad is necessary after many of these storms. Many residences are affected by floodwater

ladened with sediment. The entire county road system suffers varying degrees of damage. Traffic flow is almost entirely halted until road restoration can be made. Floods inundate parts of U. S. Highway 80, causing destruction of the roadbed and halting traffic.

Floods within the watershed area also have a direct effect on processors of cotton. Reduced cotton yields sustained within the area mean suppressed returns to gins. Harvesting and processing schedules are disrupted, as well as transportation to market.

The need for supplemental water to fulfill peak demands for irrigation is always prevalent. This is especially true for those lands immediately below the Roosevelt Irrigation District Canal.

Available water supplies for wildlife are exhausted by early summer. This lack of water forces game to leave their habitat to obtain their necessary water supply from irrigated fields.

Works of Improvement to be Installed

The works of improvement, as proposed in this plan, include installation of land treatment measures in the flood plain area, structural flood prevention measures above the flood plain area, facilities to provide additional irrigation water, and wildlife measures to enhance the recreational aspects of the watershed.

All proposed land treatment measures are to be installed on private lands within the flood plain area. The proposed measures are an integral portion of the overall watershed protection and flood prevention objectives of the plan. Measures to be applied include conservation cropping systems, crop residue use, green manure crops, irrigation land leveling, irrigation ditch lining, irrigation pipelines, irrigation field ditches, and irrigation water management.

The flood prevention measures include a diversion, two floodwater retarding structures with a connecting floodway, and a common floodway to the Hassayampa River (See Project Map). The project will reduce floodwater and sediment damages by an estimated 72 per cent. The structural measures, with the exception of the diversion, are designed to temporarily store the runoff from storms up to and including the one per cent event (100-year storm). The diversion is designed to divert the runoff from storms up to and including the two per cent event (50-year storm). Structural measures to provide irrigation water consist of a reinforced concrete pipe with a gate and inlet structure near the east end of the West floodwater retarding structure, and a concrete lined canal to convey floodwaters south to the Roosevelt Irrigation District's main canal. Two 2500-gallon capacity wildlife watering facilities will be constructed to provide permanent water for wildlife. The installation period for this project is five years.

Total project cost of $4,693,105 will be shared by P.L. 566 funds and other funds as shown below:

Item	Costs		
	P.L. 566 Funds	Other Funds	Total
Land Treatment Measures	$ 23,550 1/	$ 907,825	$ 931,375
Structural Measures			
Flood Prevention	2,929,550	734,900	3,664,450
Irrigation Structure	54,300	38,800	93,100
Wildlife Watering Facilities	2,200	1,980	4,180
TOTAL	$3,009,600	$1,683,505	$4,693,105

1/ - Includes technical assistance only.

Average Annual Benefits Compared to Average Annual Costs

The total average annual benefits to accrue as a result of the installation of the proposed structural measures are estimated at $174,860. Average annual benefits accruing to flood prevention are $153,900; irrigation, $3,650; recreation, $310; and secondary benefits $17,000. Both primary and secondary benefits have been used for project justification. The average annual cost of the proposed structural measures is estimated at $128,280. The ratio of average annual benefits, including secondary benefits, to average annual cost is 1.4:1.0. The ratio of average annual benefits, without secondary benefits, to average annual cost is 1.23:1.0.

Arrangements for Installation, Operation and Maintenance

Land treatment measures will be applied and maintained by farmers cooperating with the Buckeye-Roosevelt Soil Conservation District.

The Flood Control District of Maricopa County will construct, operate, and maintain structural works for flood prevention and irrigation. The Arizona Game and Fish Department will be responsible for constructing, operating, and maintaining the wildlife watering facilities.

Operation and maintenance agreements will be executed between the responsible agencies and the Soil Conservation Service prior to issuing invitations to bid. Total average annual cost of operation and maintenance is estimated at $13,400.

DESCRIPTION OF THE WATERSHED

Physical Data

Location

The watershed is located in west central Maricopa County, Arizona about 30 miles west of Phoenix. This watershed, heading in the White Tank Mountains, drains onto a wide alluvial fan on which exists irrigated agricultural lands. The Town of Buckeye is located in the south central portion of the watershed. Palo Verde is located in the western portion, and Liberty in the eastern portion. U. S. Highway No. 80 and the Southern Pacific Railroad traverse the entire width of the watershed. Immediately adjacent to this watershed on the eastern boundary is located the White Tanks Watershed Project which was constructed in 1953 under the Soil Conservation Act of 1935 (P.L. 46, 75th Congress).

Land Use and Status

The total watershed area contains 128,310 acres, of which 36,600 acres are cultivated farm land, 770 acres are urban and commercial, and the remaining 90,940 acres are range land.

There are 77,360 acres of the watershed in private ownership, 41,320 acres are Federal (1,190 acres in Buckeye Military Reservation), and 9,630 acres are state owned. Land use and status are shown in Figure 3.

Land Resource Units

Land resource units have been used to describe the soil, vegetative cover, topography, geology, and erosion characteristics of the watershed. Resource units delineated in the watershed include the following:

Resource Unit	Acres	Per Cent of Area
Mountains	18,770	15
Valley Slopes	53,030	41
Valley	56,510	44
TOTAL	128,310	100

Topography

Elevations range from 780 feet at the Gila River to 4,080 feet in the White Tank Mountains. The general slope of the land is to the south toward the Gila River.

Following is a tabulation of slope variations in the resource units:

Resource Unit	Per Cent Slope
Mountains	3 - 40
Valley Slopes	1 - 3
Valley	less than 3

Geology

Physiographically, the area is part of the Sonoran Desert section of the Basin and Range province. The mountains are composed mainly of granite, gneiss, and related crystalline rocks. Gentle alluvial slopes extend basinward from the mountains. Caliche and siltstone underlie portions of the alluvial fan area at varying depths.

Soils

Soil conditions differ considerably in the watershed. A general description of the soils by land resource units follows:

Mountains - Shallow, stony, residual soils with moderately coarse to coarse textures have developed in this unit. Twenty to 30 per cent of the area is rock outcrop.

Valley Slopes - Soils are moderately deep to deep having coarse to medium textures. Limey soils are also present in this unit.

Valley - This unit consists of deep, medium textured soils weakly to moderately developed in alluvium.

Vegetation and Range Condition

Mountains - Vegetation of this unit is mainly perennial shrubs and trees with seasonal undercover of annuals. Perennial grasses and forbs are few. The tree shrub species consist of paloverde, ironwood, creosotebush, bursage, burrobrush, cholla, saguaro, hedgehog cacti, bisagna, and associated species. Range condition is poor.

Valley Slopes - Vegetation of this unit is mainly perennial shrubs and trees with an occasional undercover of annuals in wet years. Perennial grasses and forbs are lacking. The tree and shrub species consist of paloverde, creosotebush, bursage, cholla, saguaro, bisagna, hedgehog cacti, and associated species. Range condition is poor.

Valley - Most of this area is irrigated cropland. Crops grown consist of cotton, alfalfa, and grains. Vegetation on the uncultivated area is mainly perennial shrubs and trees with occasional seasonal undercover of annuals. Perennial grasses and forbs are lacking. The tree and shrub species on this uncultivated area consist of paloverde, ironwood, creosotebush, bursage, cacti, and associated species. Range condition in this area is poor.

Stream Channels

There are no perennial streams within the watershed. Channels within the mountains are well defined but upon reaching the valley slopes unit branch out into many small and shallow channels that are not continuous

in character. Upon reaching the valley unit, these channels meander and disappear. In the cultivated area, farmers, in preparing land for irrigation, have for the most part erased any vestiges of the original drainage pattern. Stream channels in the cultivated area consist of man-made ditches along county road rights-of-way leading toward the Gila River at the southernmost watershed boundary.

Climate

The climate in the Buckeye area is hot and dry. The average annual precipitation for the watershed is 7.5 inches, with 2.2 inches coming in the months of July and August. The Weather Bureau Station data at Buckeye is typical of the entire watershed. Mean monthly precipitation is as follows:

Month	Precipitation (Inches) (Buckeye Station)
January	.89
February	.74
March	.70
April	.31
May	.10
June	.08
July	1.01
August	1.14
September	.63
October	.45
November	.62
December	.85

During July, August, and September late afternoon or early evening thunderstorms may occur in a very brief period. These storms are associated with moist, tropical air that flows into the state from the Gulf of Mexico. The maximum daily precipitation occurred at Buckeye in September 1916, and amounted to 3.29 inches. These storms often make the difference between a wet and dry summer.

The mean yearly temperature at Buckeye is 69° F. with the mean January temperature 50.5° F., and the mean July temperature 89.6° F. The highest recorded temperature was 121° in July 1905, and lowest temperature 11° in January 1913.

The mean yearly daytime humidity is 21 per cent; the mean July daytime humidity is nine per cent; and the mean December daytime humidity is 35 per cent. In the late spring and early summer, when air is exceptionally dry, the temperature normally varies by more than 40° between daybreak and the early afternoon.

There are an average of 321 frost-free days during the year. Temperatures rarely fall below 24° F.

Water Resources

At the present time, water utilized in the watershed is obtained from: (1) pumpage of underground water in and adjacent to the watershed and delivered by irrigation canals, (2) surface runoff originating in the northern portion of the watershed, and (3) surface runoff originating in the drainage area of the Gila River.

Water utilized on the irrigated land between the Roosevelt Irrigation District Canal and the Buckeye canal, and in a small area north of the Roosevelt Irrigation District Canal, is obtained by underground pumpage. A system of wells, located east of the watershed area, supplies ground water to a main canal which in turn delivers the water to the area.

Water utilized on the irrigated land between the Buckeye canal and the Gila River is obtained almost entirely from wells. The wells are located at points along the Buckeye canal. Some of the water used in this area originates from flood flows of the Gila River which are pumped into the canal. The pumping station for this supply is located six miles east of the east watershed boundary near the junction of the Gila and Agua Fria Rivers. This surface supply, however, furnishes only a small fraction of the water needed as the source is an extremely intermittent and undependable flow of the Gila River.

The ground water table varies from 50 to 80 feet below the ground surface in the Buckeye area, and has been declining on the average of one to two feet per year as pumpage exceeds replenishment from surface sources. The town of Buckeye receives its municipal water supply from wells in and adjacent to the town.

Wildlife Resources

The Buckeye Watershed area is included in Game Management Unit 42. The White Tank Mountains are not an important game range but become a marginal big game habitat during periods when browse conditions are good. At present there is a small resident deer population in the White Tanks and it is quite evident that there is sufficient browse to justify an increase in deer numbers. Basic wildlife food found in the area include coffeeberry, mesquite, false mesquite, range ratany, Mormon tea, paloverde, buckwheat, and annual grasses.

Wildlife species found in this area include desert mule deer, mourning doves, white-winged doves, and cottontail rabbits. Deer are usually seen in the lower elevations during the dry seasons and at higher elevations during periods of moist conditions.

Economic Data

The Buckeye Watershed area has an estimated population of 4,500 people according to the 1960 census studies, and supplemental studies prepared

by the Maricopa County Planning and Zoning Commission. Population growth studies indicate that the population within the watershed will be 8,000 by 1980.

The Town of Buckeye, located in the east central portion of the flood plain area, has an estimated population of 3,300. The Town of Liberty, located near the eastern boundary of the watershed, and the Town of Palo Verde, located in the southwest portion of the flood plain, are the other two areas of population growth.

The economy of the watershed is based mainly on an agricultural-trade service foundation, with the Town of Buckeye being the trade center of its own agricultural region.

Agriculture within the watershed is well established and highly developed. The first lands open to agricultural use came into production around 1887 with the opening of the Buckeye canal.

At the present time irrigation water is supplied by the Roosevelt Irrigation District, the Buckeye Irrigation Company, Arlington Canal, and by a number of private wells. There are 36,600 acres of cultivated land within the watershed. Cotton, alfalfa, and grains are the main crops grown, with safflower gaining popularity among agricultural producers. Cotton comprises some 43 per cent of the cropland. The remaining 57 per cent is made up of alfalfa, grains, and miscellaneous use. These crops are grown on 120 farms having an average size holding of 300 acres. The weighted average gross income per acre realized from these crops is estimated at $170. The estimated value of this farm land is $34,920,000.

The large acreage of cotton within the watershed creates a demand for seasonal on-farm and gin laborers. Five ginning companies are located within or near the watershed. Most of the cotton produced within the watershed is ginned through these companies.

Supplementing the crop segment of the agricultural economy is the presence of a number of large livestock operations. Hay and grain crops grown within the area are for the most part fully utilized by livestock.

U. S. Highway No. 80 traverses the watershed. Traffic flow on this interstate route is estimated at 5,375 vehicles per day. The watershed economy is further served by county and farm roads built on a north-south, east-west flow pattern throughout the agricultural area. The Southern Pacific Railroad traverses the watershed in close proximity to U. S. Highway No. 80 and the Town of Buckeye. Freight movement along this line is heavy. Transportation within and through the watershed will be enhanced with the construction of the contemplated Interstate Highway No. 10 approximately three miles north of the Town of Buckeye.

Luke Air Force Base has two auxiliary air fields within the watershed.

WATERSHED PROBLEMS

Floodwater Damages

Historically, during the last 45 years, 15 floods of varying magnitudes have inundated agricultural lands, residences, roads, and the Southern Pacific Railroad, and have seriously disrupted, for critical periods, the supply of irrigation water within the watershed. Three of these floods, January 1916, September 1939 and August 1951, have been similar in magnitude according to local residents and have inflicted serious damage to the watershed economy.

The occurrence of flood flows on an annual equivalent basis causes a reduction in cotton yields equivalent to the per capita consumptive needs of 33,800 persons. A flood which occurred August 27, 1951 damaged cotton crops to the extent that the reduced yields amounted to enough lint cotton to meet the per capita consumptive needs of 181,390 persons. This type loss is not only a serious drain on the local economy of the watershed but affects to some degree the cotton economy on a state and regional level.

Frequent flooding occurs in the cultivated area north of the Roosevelt Irrigation District Canal and some type of damage occurs each year.

Flood waters flow south from this area onto the agricultural lands between the Roosevelt Irrigation District Canal and the Buckeye canal. Floodwaters breach the Roosevelt Irrigation District Canal and cause breaks on both the north and south banks of the canal. These breaks occur about once every three years according to the canal company's records. This disrupts the delivery of vitally needed irrigation water to21,960 acres of cultivated lands. The months of July, August, and September are the most critical months for water needs. Of the 15 floods which have disrupted schedules, 12 have occurred during the months of July, August, and September.

Floods in this area also damage on-farm irrigation facilities. Many of these irrigation ditches are concrete lined and are washed out or filled in with sediment. Flood flows over cultivated fields necessitate filling in badly washed areas and re-leveling.

The frequency of floodwater inundation of crop and pasture lands between the Roosevelt Irrigation District Canal and the Buckeye canal is approximately once every three years. About 840 acres of cultivated land are inundated. The county road system in this area is so physically situated that it bears the initial brunt of the floodwaters. Consequently, damages occur almost yearly from runoffs that flow from the north down the county roads and over road crossings on the Roosevelt Irrigation District Canal. The Southern Pacific Railroad which parallels the Buckeye canal to the north suffers damages from roadbed cutting. Residences within this area are also affected by floodwaters on the frequency of once every three years.

Floodwaters, as they intercept the Southern Pacific Railroad and the Buckeye canal, are either diverted into the Hassayampa River by the canal's north bank or breach the canal bank and continue south over another highly intensified agricultural area. Flood volumes of a magnitude which would occur every five years are for the most part diverted into the river. A flood volume of the magnitude of occurring once every ten years will find its way through weak spots in the canal banks and inundate an estimated 1,090 acres of crops and pastures. County roads, located south of the Buckeye canal, will receive damages on a more frequent basis. This occurs mainly from storm runoff collecting in the roads above the canal and flowing over existing road crossings on the canal.

The flood of August 27, 1951, was one which would occur once every 25 years. Runoff from this storm inundated 12,240 acres of cultivated land. These lands have an estimated value of $11,872,800 and contain an estimated 5,880 acres of cotton, 3,300 acres of alfalfa, and 3,060 acres of grains. The floodwaters of this storm directly affected some $682,000 worth of residential property. The total damages in the watershed to agricultural and non-agricultural facilities from this storm are estimated at $1,108,330. Of this amount, $955,580 is estimated damages to crops, pastures and other agricultural facilities. The remaining $152,750 is damage sustained to state and county roads, the railroad, residential property, and the main irrigation canals.

Floodwater runoff from this 1951 storm inundated approximately 2,330 acres of cultivated lands north of the Roosevelt Irrigation District Canal. Reductions in yields were sustained on all crops grown in this area. On-farm irrigation facilities were washed away or filled in with sediment. An on-farm dike north of the cultivated fields was breached and washed out in many places along the dike's nine-mile length.

Floodwaters flowed south from this area onto the cultivated area between the Roosevelt Irrigation District Canal and the Buckeye canal. Floodwaters breached the main canal of the Roosevelt Irrigation District and caused 81 breaks on the north and south banks of the canal. Damage to the canal disrupted the delivery of irrigation water to the cultivated lands. The 1951 flood inundated an estimated 7,220 acres of cultivated land in this area between the Roosevelt Irrigation District Canal and Buckeye canal. Reduced yields were suffered on crops in the area. Land leveling and filling in of badly washed areas were necessary. The flood also damaged on-farm irrigation facilities in the area.

County roads were damaged and the Southern Pacific Railroad suffered heavy roadbed cutting. Restoration of 10.1 miles of roadbed was necesary after the 1951 flood. Some 95 homes in the area were also directly affected by the storm.

Floodwaters from the 1951 storm which intercepted the Southern Pacific Railroad and the Buckeye canal, continued south over another cultivated

area. The Buckeye canal was breached and washed away in a number of places. Major washouts during 1951 occurred between the towns of Liberty and Buckeye and directly north of the Town of Palo Verde. Runoff from the storm inundated an estimated 2,690 acres of crop and pasture lands in this area south of the Buckeye canal. As in the other flood areas, the crops in this area suffered reduced yields on all lands inundated. On-farm irrigation facilities were heavily damaged. Land leveling and filling in of badly scoured sections were also necessary in this area. U. S. Highway No. 80 between the towns of Liberty and Buckeye was inundated. Traffic flow was disrupted for the better part of one day. The county road system underwent heavy inundation. Palo Verde Road, north from the Town of Palo Verde was completely washed out. Flood flows on this paved road scoured out pavement and roadbed some two to three feet deep. Residents of Palo Verde had to use row boats in the vicinity of Palo Verde school in their rescue operations.

The overall effect of floodwater inundations to the economy of the watershed is detrimental and is mainly two-fold in nature concerning direct or primary losses. For those lands that receive direct floodwater inundation there is sustained a loss of crop yields and farm equipment. Stored baled hay is inundated and lost. Farmers must repair their on-farm irrigation facilities as soon as possible to irrigate their crops during the critical months. Irrigation efficiency is impaired unless lands are brought back to proper grades. Water borne weed seeds are deposited on cultivated fields. Farmers are faced with excess cultivation costs over and above normal operations in order to maintain control of weed infestation. Farmsteads are damaged. Harvest operations are delayed either through the inability to put machinery in the fields or through the inability to haul the products over the badly damaged roads. Carpeting and tile floors are ruined in homes.

The second effect, having perhaps a greater influence on the economy than the one described above, is the inability to irrigate those acres not directly inundated by floods. Serious breaks in the Roosevelt Irrigation District Canal and the Buckeye canal prevent proper delivery of water to these lands. Although canal breaks are repaired as soon as possible by the irrigation companies concerned, a one or two day delay in delivery of water during the months of July, August and September can have serious impact on the cotton lands within the watershed. As mentioned previously, 12 of the last 15 recorded floods have occurred during these three months. The time period to repair breaks in the main canals has ranged from five days to 17 days. Yield reductions to cotton in most cases are higher from the inability to irrigate because of lack of water than those sustained from direct inundations.

Other aspects of floodwater problems as they affect the watershed area concern disruption of harvesting schedules on the farm and the disruption of ginning schedules. Loss of net income due to reduced yields is accelerated up from the initial producer to the initial processor and up through the various marketing facilities. The overall effects of flooding on such a cotton based economy are far reaching.

Sediment Damages

Deposition of sediments on irrigated fields and into irrigation ditches is one of the main problems confronting the agricultural producer. Sediment deposition on alfalfa fields will "smother out" the crop and cause the need for replanting. Cotton bolls on the lower parts of the plant are covered with sediment. This not only lowers cotton quality but causes extensive problems with sediment getting into the moving parts of mechanized pickers. This type of damage is also felt in the ginning process. Excess sediment on cotton increases maintenance cost on the ginning machines. For the 1951 flood, estimated damages of $169,670 are attributed to sediment deposition as it occurs to agricultural facilities, residences, roads and canals.

Erosion Damages

Erosion in the form of flood plain scour occurs as a result of floodwaters. This scouring action mainly occurs immediately below dike or ditch obstructions. Flood flows breaking over these obstructions scour out the cultivated lands causing disruption of efficient irrigation applications. Producers must, for the most part, haul in fill and then relevel the scoured area. The estimated damage as a result of this erosion in 1951 was $13,920.

Problems Relating to Water Management

Irrigation water is supplied to the majority of the cultivated lands by the Buckeye Irrigation Company and Roosevelt Irrigation District. Consumptive use requirements for those lands served by the Buckeye Irrigation Company are for the most part fulfilled. Peak seasonal demands for water on those lands serviced by the Roosevelt Irrigation District are not entirely met due to an inadequate water supply. Farmers must either curtail plantings or type of crop or obtain reduced yields resulting from inadequate water application. The need for additional water for irrigation purposes in this area is prevalent.

Problems Relating to Public Recreation

Most of the available water for wildlife in this area, particularly deer, small game and birds, is of a temporary nature and usually all supplies are exhausted during dry seasons. There are no wildlife watering facilities in the upper watershed. This factor forces game to leave their habitat and obtain their water requirements from irrigated fields. Some damage to cotton fields is reported annually. Damages have been caused principally by deer breaking off bolls from cotton plants. There is sufficient cover in the upper watershed to support an increased population of deer and small game animals through the dry periods. More efficient use of available cover, both in this area and adjoining ranges will result if water is made available. There is a definite local interest by sportsmen groups to alleviate the problem.

PROJECTS OF OTHER AGENCIES

The Buckeye Irrigation Company and the Roosevelt Irrigation District operate and maintain their own extensive irrigation systems located in the watershed. These systems will be benefited by the structural works of improvement proposed in this plan. The Arlington Canal, located near the south boundary of the watershed, primarily serves farm land located west of the watershed.

The Roosevelt Irrigation District has an approved plan for improvements to their irrigation system under the Bureau of Reclamation, Small Reclamation Project Act. The purpose of the project, as stated in the loan application report, is to: improve the effeciency of the pumping system and thereby reduce power costs and permit delivery of irrigation water in amounts adequate to meet peak demands during the summer months; reduce seepage losses from the canal and lateral system; reduce operation and maintenance costs; and permit a higher standard of maintenance. Major works of improvement included in the plan are irrigation well rehabilitation, patching of the main canal and collection system, and lining of irrigation laterals. There is no conflict in purpose between the Roosevelt Irrigation District's Small Reclamation Project proposal and those contained within this plan. Instead, the two proposals are complimentary in nature and provide for the basic foundations for a sustained agricultural economy and a general strengthening of the watershed's overall economy.

The Arizona State Highway Department has a proposed plan for the construction of Interstate Highway No. 10. Considerable benefits will be afforded this proposed highway as a result of the structural measures proposed in this plan. Considerable savings will result from reduced construction costs of water carrying structures of the highway.

BASIS FOR PROJECT FORMULATION

The project, as formulated herein, presents a unified effort by the local people to: (1) protect productive irrigated land from floodwater, sediment, and erosion damage, (2) prevent floodwater damage to irrigation canals and laterals, (3) protect on-farm irrigation facilities from floodwater and sediment damage, (4) reduce floodwater and erosion damage to roads and highways, (5) reduce floodwater and sediment damages to residences and commercial properties, (6) make better use of floodwater for irrigation purposes, and (7) enhance the opportunities for the enjoyment of hunting in the watershed.

The land treatment measures will meet a portion of the above objectives by reducing runoff and erosion and increasing the infiltration rates and water-holding capacities of the soils. In determining the magnitude of the land treatment program to be applied, emphasis was placed on selecting measures which would meet program objectives and which would fit the

needs and agricultural conditions found on the flood plain.

The structural measures were determined by a careful consideration of various alternatives that would meet the sponsors objectives and be within Soil Conservation Service standards and policy. These alternatives are discussed in detail in the Investigations and Analyses section of this plan. A system of structural measures placed in series to utilize one common outlet to the Hassayampa River was more economical and afforded a desired level of protection to the downstream watershed areas. Consideration was given to economic, geologic, and topographic factors.

These structural measures are planned upstream from the irrigated cropland and the irrigation canal systems. Selection of structural locations further affords protection to the proposed Federal Interstate Highway No. 10.

Mutual agreement has been reached on the desired level of flood protection and project development. The project will afford protection up to and including the 100 year expected flood for the floodplain area below the floodwater retarding structures and protect the floodplain area below the diversion up to and including the 50 year expected flood. Control of 29 per cent of the total watershed area will afford a 72 per cent reduction in total flood damages to the area subject to flooding. Watershed residents will be able to make better use of their available resources without fear of seriously damaging floods.

A biological reconnaissance of the area by the Arizona Game and Fish Department showed that the area could support increased numbers of deer and other game. The fact that the Department has recently completed some water developments in the Big Horn Mountains, which lie to the west of the White Tank Mountains, increases the value of the White Tank range. To fully utilize the habitat possibilities, permanent water at the higher elevations would be required. This would extend the range of the existing game population, provide for an increase in the population and eliminate the need for seasonal migration of big game from the higher elevations to the irrigated area during dry periods. Previous experience of the Department in furnishing permanent water for game in desert areas determined the type, size, and location of watering facilities. Capacity of the facility and size of the collecting apron is based on water requirements and annual rainfall, and locations and spacing on range forage conditions, topography, and daily cruising radius of the game animals and birds.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

The land treatment measures prescribed within this plan include only those measures and practices which contribute to program objectives, by reducing runoff and erosion, increasing the infiltration rates and

water-holding capacities of the soils, and contribute to better agricultural water management. All of these measures are considered essential to the successful function of the watershed project and are an integral part of the overall project formulation. The measures provide for the use of land within its capabilities and treatment in accordance with its needs for sustained agricultural production. Table 1 shows the quantity to be installed within the installation period of the project and estimated costs. The practices recommended for inclusion in this plan are conservation cropping systems, cover and green manure crops, crop residue use, irrigation water management, irrigation land leveling, irrigation ditch lining, irrigation pipelines, and irrigation field ditches. The total cost of installing these measures, including the cost of technical assistance, is estimated at $931,375.

Conservation cropping systems are the growing of crops in combination with needed cultural and management measures. Cropping systems include the use of rotations that contain grasses and legumes, as well as sequences in which the desired benefits are achieved without the use of such crops.

Cover and green manure crops are a crop of close-growing grasses, legumes, or small grains used primarily for summer or winter protection, and for soil improvement. It usually occupies the land for a period of one year or less, except where there is permanent cover, as in orchards.

Crop residue use is utilizing plant residue left in cultivated fields by incorporating them into the soil or leaving them on the surface during that part of the year when critical erosion periods usually occur.

Irrigation water management is the use and management of irrigation water, where the quantity of water used for each irrigation is determined by the moisture holding capacity of the soil, where the water is applied at a rate and in such a manner that the crops can use it efficiently and significant erosion does not occur.

Irrigation land leveling is reshaping the surface of land to be irrigated to planned grades.

Irrigation ditch lining is fixed lining of impervious material installed in existing or newly constructed irrigation field ditches.

Irrigation pipeline is a pipe or other closed conduit installed in an irrigation system.

Irrigation field ditch is a permanent irrigation ditch constructed to convey water from the source of supply to a field or fields within the farm distribution system.

Structural Measures

Structural measures to be installed are those needed to reduce flood damage, those features needed for irrigation and those facilities needed to provide permanent water for game. A diversion, two floodwater retarding structures, a connecting floodway between these structures, and a common floodway to the Hassayampa River are the flood control structures included in this plan. The irrigation features are a 36-inch reinforced concrete pipe and gate valve installed near the east end of the West floodwater retarding structure and a lined canal to convey the floodwaters to the Roosevelt Irrigation District Canal. The wildlife watering facilities are two, 2500-gallon rainwater catchment basins for game in the White Tank Mountains.

The total installation cost of these structural measures is estimated to be $3,761,730. Distribution of cost is shown in Table 2. Floodwater retarding structural data are shown in Table 3 and floodway and diversion structural data are shown in Table 3A. The locations of these structural measures are shown on the project map, Figure 4. Typical structural details are shown in Figures 1, and 2.

East Floodwater Retarding Structure

This structure will be built north of the Yuma road and south of the south slopes of the White Tank Mountains at an estimated total installation cost of $850,000. It will provide floodwater storage for runoff from the one per cent event. It will have a total storage capacity of 1,680 acre-feet with 1,240 acre-feet allocated to floodwater storage and 440 acre-feet allocated to a 100-year accumulated sediment storage. The dam will be 2.8 miles long and will have a maximum height of 23.5 feet. The maximum release rate from the 36-inch diameter reinforced concrete pipe principal spillway will be 147 cubic feet per second (c.f.s.) and will release the runoff from the one per cent event in about nine days. The emergency spillway will be constructed in earth and will be located around the east end of the embankment. Additional structural data are shown in Table 3.

West Floodwater Retarding Structure

This structure will be built south of the Yuma road and between the Hassayampa River and the White Tank Mountains at an estimated total installation cost of $2,058,000. It will provide floodwater storage for runoff from the one per cent event. It will have a total storage capacity of 4,700 acre-feet with 3,500 acre-feet allocated to floodwater storage and 1,200 acre-feet allocated to a 100-year accumulated sediment storage. The dam will be 7.6 miles long and will have a maximum height of 25.0 feet. The maximum release rate from the 60-inch diameter reinforced concrete pipe principal spillway will be 442 c.f.s. and will release the runoff from the one per cent event in about ten days. The

emergency spillway will be constructed in earth and will be located around the west end of the embankment. Additional structural data are shown in Table 3.

Diversion

This diversion will be built to the east and north of the East floodwater retarding structure to divert floodwaters from the fringe areas of the watershed into the retarding structure. The diversion embankment will be 3.0 miles long and will have a maximum height of 7.5 feet. It will be built at an estimated total installation cost of $261,950. It will divert runoff up to and including the two per cent event. The outlet of the diversion into the retarding structure will be protected by rock riprap. Additional structural data are shown in Table 3A.

East Floodway

This floodway conveys floodwater from the principal spillway near the west end of the East floodwater retarding structure into the east end of the West floodwater retarding structure. It is an earth channel 1.0 mile long and 12 feet wide and contains two reinforced concrete drop spillways. It has a capacity of 147 c.f.s. and will be built at an estimated total installation cost of $36,500. Additional structural data are shown in Table 3A.

West Floodway

Floodwaters released from the principal spillway near the west end of the West floodwater retarding structure are conveyed by this floodway to the Hassayampa River. This is an earth channel 30 feet wide and 3.0 miles long with three, 8 feet x 8 feet inverted siphons to allow floodwaters from major drainageways to bypass the floodway. A chute spillway is planned at the bank of the Hassayampa River to allow floodwaters to flow safely down this bank. The capacity of this floodway varies from 442 c.f.s. to 685 c.f.s. The estimated total installation cost of this floodway is $458,000. Additional structural data are shown in Table 3A.

Irrigation Features

The structural works for irrigation consist of a 36-inch diameter reinforced concrete pipe with a gate valve and inlet structure placed near the east end of the West floodwater retarding structure and a concrete lined canal to convey floodwaters south to the Roosevelt Irrigation District's main irrigation canal. The trapezoidal canal has side slopes of 1.25 horizontal to 1 vertical and is 1.4 miles long. Floodwaters will be retained in the sediment pool of the West floodwater retarding structure for short periods of time after storm runoff and only until such time as is necessary for the Roosevelt Irrigation District to utilize them. The estimated total installation cost of these irrigation features is $93,100. Additional structural data is shown in Table 3A.

Wildlife Watering Facilities

Two, 2500-gallon capacity rainwater catchments will be constructed to provide permanent water for game in the White Tank Mountains' area of the watershed. One catchment will be constructed in Section 6 and the other in Section 21, T. 2 N., R. 3 W., Gila and Salt River Meridian. The estimated total installation cost of these features is $4,180.

EXPLANATION OF INSTALLATION COSTS

Land Treatment Measures

Unit costs of establishing the various land treatment measures prescribed were obtained from a sample of basic farm plans containing cost of applying the land treatment measures to be applied under the accelerated program. These costs were compared with similar cost data for like agricultural areas in the state. The landowner on whose property these measures will be applied will bear the cost of application.

Costs of applying the land treatment measures were derived on the basis of the going program with the addition of those measures needed to accomplish the objectives of the local sponsors through accelerated planning. Cost of technical assistance was likewise derived on the basis of what is being accomplished from regular appropriations of the Soil Conservation Service and what is needed under the accelerated program. Cost of technical assistance for accelerating the rate of installation of the land treatment measures will be met by P.L. 566 funds.

Structural Measures

The total installation cost of structural measures includes: (1) construction cost, (2) installation services, (3) the cost of land, easements, and rights-of-way, and (4) the cost of administering contracts. Construction costs are engineering cost estimates plus a contingency item of 20 per cent.

The costs of construction items, shown in the engineer's estimate, have been based on costs of previous contracts for flood prevention projects in Arizona. Cost data from pipe and irrigation companies have also been used for computing cost estimates. The contingency item is based on additional costs that may be incurred as a result of final detailed surveys and studies and any increased costs needed at the time of construction.

Installation services reflect those costs required for detailed engineering surveys, intensive geologic investigations, design, layout and supervision of construction and other engineering services. Engineering costs were estimated at 20 per cent of the construction cost and "Other" services at 10 per cent of the construction cost for the flood prevention and irrigation measures. Since standard designs of the

Arizona Game and Fish Department will be used for the construction of the wildlife watering facilities, installation services for these measures are estimated at 6.7 per cent of the construction cost.

Land, easements, and rights-of-way costs were determined by the sponsors after reviewing the records of recent land sales in the area. The costs of bridges, road relocations, powerline relocations and telephone cable crossings are included as a part of the rights-of-way costs. These rights-of-way items and costs have been determined by the sponsors and the Soil Conservation Service and are mutually understood. The wildlife watering facilities will be located on Federal land and will require no costs for rights-of-way acquisition.

The cost of administration of contracts includes all local costs for administrative, legal, and clerical services incurred by the contracting local organization in carrying out contracts. Administration of contracts is estimated at one per cent of the construction cost.

Cost Sharing

The total installation cost of the project is estimated at $4,693,105 (Table 1) of which $3,009,600 are from P.L. 566 funds and $1,683,505 are from other funds.

The following costs will be borne by P.L. 566 funds:

1. The cost of technical assistance needed to accelerate the application of land treatment measures. ($23,550 estimated)

2. The construction cost of the structural measures for flood protection. ($2,254,000 estimated)

3. The Federal share of the construction cost of the irrigation features for agricultural water management. (50%, $33,900 estimated)

4. The Federal share of the construction cost of the wildlife watering facilities. (50%, $1,940 estimated)

5. The cost of the installation services for all structural measures. ($696,210 estimated)

The following costs will be borne by other funds:

1. The cost of installing land treatment measures on non-Federal land. ($863,025 estimated) Cost sharing assistance that is available under other programs will be utilized.

2. The cost of technical assistance for the existing land treatment programs on non-Federal lands. ($44,800 estimated)

3. The non-Federal share of the construction cost of the irrigation features for agricultural water management. (50%, $33,900 estimated)

4. The non-Federal share of the construction cost of the wildlife watering facilities. (50%, $1,940 estimated)

5. The total cost of land, easements, and rights-of-way for structural measures. This item includes bridges, road relocations, powerline changes, etc. made necessary by the construction of flood control features. ($717,200 estimated)

6. The cost of administration of contracts. ($22,640 estimated)

Sharing of costs allocated to agricultural water management and public recreation is based on P.L. 566 funds bearing 50 per cent of the construction costs and all costs of installation services.

Installation costs for each fiscal year during the installation period are shown as follows:

	P. L. 566			Other			
	Land Tr. Measures	Structural Measures		Land Tr. Measures	Structural Measures		
F.Y.	Non-Fed. Land ($)	Non-Fed. Land ($)	Fed. Land ($)	Non-Fed. Land ($)	Non-Fed. Land ($)	Fed. Land ($)	Total
1st yr.	4,750	220,000	0	181,565	200,000	0	606,315
2nd yr.	4,700	2,000,000	2,200	181,565	530,200	1,980	2,720,645
3rd yr.	4,700	763,850	0	181,565	43,500	0	993,615
4th yr.	4,700	0	0	181,565	0	0	186,265
5th yr.	4,700	0	0	181,565	0	0	186,265
TOTAL	23,550	2,983,850	2,200	907,825	773,700	1,980	4,693,105

EFFECTS OF WORKS OF IMPROVEMENT

The proposed structural works of improvement will reduce the estimated floodwater and sediment damages by 72 per cent. The protection afforded will provide substantial benefits to the 120 farmers operating 36,600 acres of cultivated land. The proposed works will all but eliminate first floor damage as suffered by the 136 residential and business properties within the flood plain.

Crop, pasture and associated on-farm damages will be reduced by an estimated 76 per cent. Damages from interruption of delivery of irrigation water because of canal breaks will be reduced an estimated 89 per cent. Residential and business floodwater and sediment damages will be reduced an estimated 83 per cent. Breaches and washouts of the two main irrigation canals will be reduced 69 per cent. Damages sustained to county and state roads and to the Southern Pacific Railroad will be reduced an estimated 41 per cent.

Reduction of agricultural damages in the area north of the Roosevelt Irrigation District Canal is estimated at 66 per cent. Acres inundated from a storm of the magnitude of one which will occur every other year will be reduced from 510 acres to 160 acres after installation of structural works.

In the area between the Roosevelt Irrigation District Canal and the Buckeye canal, crop and pasture damages and associated on-farm losses will be reduced 83 per cent. The structural works will eliminate damages up to and including the ten per cent event. Residential damages will be reduced by an estimated 83 per cent. Roads will receive 41 per cent less floodwater and sediment damages as a result of the project.

Agricultural damages will be reduced by an estimated 77 per cent in the cultivated area south of the Buckeye canal. The structural works will eliminate crop and pasture damage up to and including the 20 per cent event.

Of the 12,240 acres inundated by the 1951 storm, an estimated 9,820 acres will be free of flood flows after installation of the proposed program. North of the Roosevelt Irrigation District Canal, 1,550 acres of the 2,330 acres of crops and pastures inundated by the storm will be flood-free. Between the Roosevelt Irrigation District Canal and the Buckeye canal, 6,220 acres of the 7,220 cultivated acres inundated will be free from flooding. South of the Buckeye canal, 2,050 acres of the 2,690 cultivated acres inundated by the 1951 storm will be flood-free as a result of the structural program.

In addition, there are other effects that will be realized from this program. Better farm layout, more efficient use of irrigation water, reduced harvesting delays and delays of transporting goods are expected benefits of the program. Development of this nature should increase the demand for both semi-skilled and unskilled labor on the farm.

Flood plain improvements that make for a more sustained agricultural production, such as proposed in this plan, will help stabilize this agriculturally based economy and make for a more firm foundation upon which the area's tax base can be built.

The program will have an effect on reducing the loss of net income of processors of agricultural goods. Cotton produced in the watershed is almost entirely ginned at local ginning companies. The hay and grain crops produced within the watershed are for the most part utilized by local and area livestock producers. From these facts the benefits to be derived on the level of the first processor or user will be substantial. The spread between the average retail value of a bale of cotton and the farm value is considerable. Hence, a more reliable production base will generate increased net income many times over.

Transportation delays due to washouts and inundations on county and state roads will be reduced. This is especially important on the present Interstate Highway U. S. 80 to Yuma, and southern California. Rerouting of traffic from Phoenix to Yuma because of flood damage to this highway results in travel distance increases of up to 100 miles.

The structural program will have a substantial effect on the proposed Interstate Highway No. 10 from Phoenix to Los Angeles. This highway as proposed will be constructed immediately south of the floodwater retarding structures. Not only will the structures provide flood protection to the highway but considerable savings should be afforded in the construction costs of such items as highway culverts and other water carrying structures. These unevaluated savings as estimated by the State Highway Department will approximate $500,000.

One significant effect of the structural works will be the protection provided to the Roosevelt Irrigation District Canal and the Buckeye canal. This protection will not only reduce maintenance costs on the canals but will reduce greatly the threat of disrupted water schedules during critical summer months. This type damage will be eliminated for events up to and including the five per cent event.

No changes in land use are anticipated for agricultural lands as a result of this project. The works of improvement as proposed will provide for a sustained agricultural production and a more stable economy. The irrigation facilities of the proposed works will provide for the beneficial use of floodwaters for irrigation. An average of 360 acre-feet of acceptable irrigation water will be made available annually.

The installation of two wildlife watering facilities for the development of wildlife resources will have the effect of increased population of deer over a much wider area. In view of the tremendous hunting pressure on all available hunting areas in Arizona, and the ready accessibility of the watershed area to the Greater Phoenix Area, the development will be of notable public significance. It is estimated that these facilities will result in an increase of 620 hunter days in the area.

The two wildlife watering facilities will provide a year-round water supply for wildlife and thus discourage the migration of game out of the watershed area during dry periods.

PROJECT BENEFITS

The installation of the proposed structural measures for flood damage reduction will result in average annual benefits estimated to be $153,900. Of this amount, $124,980 is estimated to be reduction of flooding on agricultural lands and $28,920 is estimated to be reduction of flooding to state and county roads, residences, businesses, the Southern Pacific Railroad and the main irrigation canals. Floodwater reduction to crops, pastures, and associated on-farm aspects is estimated to be $96,290. Sediment reduction on crops, pastures and associated on-farm aspects is

estimated to be $18,260. Flood plain scour to agricultural lands will be reduced substantially and these benefits are estimated to be $1,740.

Damage reduction to residential, retail-commercial properties, roads, the railroad and canals is estimated to be $24,560.

In addition to these benefits from the structural measures, the land treatment measures to be installed in the cultivated area of the watershed will further reduce floodwater damages by an estimated $3,300 annually.

Prevention of indirect losses to agricultural and non-agricultural facilities is estimated to be $13,050.

Benefits to accrue to the irrigation features of the structural program are estimated at $3,650 yearly. These measures will provide an additional 360 acre-feet of water each year as a supplement to present irrigation supplies.

Benefits accruing to public recreational features (wildlife watering facilities) have been evaluated on the basis of fifty cents per hunter day use of the area served within a 20 mile radius of the facilities. Annual benefits are estimated at $310.

Secondary benefits from a national viewpoint were not considered pertinent to the economic evaluation of this project. "Local" secondary benefits, however, were considered to stem from and be induced by the project. These benefits are estimated to be $17,000 annually.

COMPARISON OF BENEFITS AND COSTS

The total average annual benefits to accrue as a result of the installation of the proposed structural measures are estimated at $174,860. Average annual benefits accruing to flood prevention are $153,900; irrigation, $3,650; public recreation, $310; and secondary benefits, $17,000. Both primary and secondary benefits have been used for project justification. The average annual cost of the proposed structural measures is estimated at $128,280. The ratio of average annual benefits, including secondary benefits, to average annual cost is 1.4:1.0. The ratio of average annual benefits, without secondary benefits, to average annual cost is 1.23:1.0.

PROJECT INSTALLATION

The execution of this plan will be a joint undertaking of private, local, state and Federal interests. To carry out a coordinated acceleration of installation of land treatment measures with structural measures, along with the going conservation programs within the watershed, close cooperation and specific responsibilities are required of all interests participating and assisting in this project.

Land Treatment Measures

Buckeye-Roosevelt Soil Conservation District will:

1. Provide technical assistance to land owners and operators in the district to assure the application of land treatment measures outlined in Table 1.

2. Conduct such information and education programs as required to inform local people of the project.

Bureau of Land Management will:

1. Continue its existing management program which it administers. (32 per cent of total watershed area). The field office of the Bureau of Land Management has concurred in the features of this plan relating to land under its jurisdiction.

Soil Conservation Service will:

1. Furnish technical assistance through the Buckeye-Roosevelt Soil Conservation District to private land owners for the application of land treatment measures outlined in this work plan.

Agricultural Conservation Program Service will:

1. Provide Federal cost-sharing assistance in accordance with existing Agricultural Conservation Program Service policies and procedures to individual farmers and ranchers in applying approved conservation practices on their farms and ranches.

Structural Measures

The Flood Control District of Maricopa County will assume the local responsibilities for the installation, operation, and maintenance of structural measures except the recreation features which will be assumed by the Arizona Game and Fish Department.

The Flood Control District of Maricopa County will:

1. Assume and carry out all responsibility and liability for construction, operation and maintenance of structural measures except the recreation features.

2. Acquire or provide assurance that land owners or water users have acquired the necessary water rights.

3. Acquire and bear costs for all land, easements, and rights-of-way needed in connection with the structural measures except the recreation features. The power of eminent domain will be exercised if necessary.

4. Act as contracting organization for the construction of all the structural measures except the recreation features.

The Arizona Game and Fish Department will:

1. Assume and carry out all responsibility and liability for construction, operation and maintenance of the wildlife watering facilities.

2. Furnish the non-Federal share of the construction cost of the wildlife watering facilities.

3. Acquire easements for the installation of all wildlife watering facilities.

4. Cooperate with the other sponsoring local organizations and local, state, and Federal agencies in studies and surveys involving wildlife resources in the watershed.

5. Maintain close liaison with sponsors and Federal agencies involved on the project and assist in appropriate revisions of the work plan as necessary.

Soil Conservation Service will:

1. Furnish installation services for engineering surveys, design, construction plans, and specifications of structural works of improvement, and supervision of construction.

2. Allot construction money in accordance with cost-sharing and the installation schedule outlined in this plan or as may be revised by mutual agreement. Money allocations will be in accordance with National priorities and availability of funds at the time of installation.

3. Maintain liaison with sponsors, state, local, and Federal agencies involved to the end that united effort and coordinated action will produce effective results.

Installation Schedule

Installation of the structural measures will begin as soon as practical after the work plan is approved and after P.L. 566 funds are made available for participation in the project. The construction period for the structural measures is planned for three years. Land treatment measures shown in Table 1 will be applied during a five-year period.

This schedule will require P.L. 566 funds during the first fiscal year for surveys, investigations, detailed design, and technical assistance to sponsors on contractual and easement matters for the West floodwater retarding structure and floodway, and the irrigation features. During this period the local sponsors will secure all land, easements,

and rights-of-way needed for these structures. Technical assistance will be furnished to the Soil Conservation District for surveying, planning, and applying land treatment measures.

During the second fiscal year the West floodwater retarding structure and floodway and irrigation features will be constructed after all land, easements, and rights-of-way have been secured for the entire project. Detailed designs will be completed for the East floodwater retarding structure and floodway and diversion. The application of land treatment measures will continue and installation of the wildlife watering facilities will be accomplished.

During the third fiscal year the East floodwater retarding structure and floodway and diversion will be constructed. The application of land treatment measures will continue.

The acceleration of the land treatment program will continue for an additional two years after the structural works have been installed.

FINANCING PROJECT INSTALLATION

The Flood Control District of Maricopa County is a public political taxing subdivision of the State of Arizona and a municipal corporation. As such, the District will construct, operate, and maintain structural works of improvement for flood prevention and irrigation outlined in this plan. It has the power to acquire land by eminent domain or otherwise, and issue bonds. At present, taxes are being levied for the benefit of the District.

The District has analyzed its financial needs in consideration of the scheduled installation of flood prevention measures and irrigation features so that funds will be available when needed through cash resources on tax or assessment levies. The loan provision of the Act will not be utilized.

Local cost-sharing funds for installation of the wildlife watering facilities outlined in this work plan will be provided from the Arizona Game and Fish Department. The above commitments are made with the view of making the maximum possible contribution to a solution of watershed problems and to promote a program of recreation through wildlife resource improvement in the watershed.

The sponsoring organizations concerned have given the Soil Conservation Service adequate assurance that their share of the project costs will be available at the time and in the amounts required.

Federal assistance for carrying out the works of improvement on non-Federal land, as described in the work plan, will be provided under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress, 68 Stat. 666), as amended.

Financial and other assistance to be furnished by the Soil Conservation Service in carrying out this project is contingent on the appropriation of funds for this purpose.

In the installation of land treatment measures described in this plan, Federal assistance in cost-sharing will be utilized under the Agricultural Conservation Program.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

Farmers cooperating with the Buckeye-Roosevelt Soil Conservation District will be responsible for the maintenance of land treatment measures installed on their farms.

Structural Measures

The Flood Control District of Maricopa County will maintain all structural works of improvement for flood prevention and irrigation after they are installed.

Representatives of the sponsoring local organization and the Soil Conservation Service will make a joint inspection of the structural measures annually (about October 1) or after each major flood. This inspection(s) will be made to determine if and what maintenance work is necessary to insure proper functioning of the flood prevention structures and the irrigation features.

The sponsors and the Soil Conservation Service will enter into specific operation and maintenance agreements prior to the issuance of invitations to bid.

Total annual operation and maintenance cost for structural measures for flood prevention is estimated to be $12,950. Cost of operating and maintaining the irrigation features is estimated to be $300.

The Arizona Game and Fish Department will operate and maintain the wildlife watering facilities installed for game habitat improvement following their standards and specifications. Estimated average annual cost of operation and maintenance is $150.

Those items considered necessary for the proper operation and maintenance of the structural works of improvement are as follows:

Operation--

1. The structural measures for flood protection are automatic in their operation. The principal spillways are ungated and will begin to release water as soon as the floodwaters reach them.

2. Regulation of the gate valve on the pipe near the east end of the West floodwater retarding structure will control the flow of water to be utilized for irrigation purposes.

Maintenance--

1. Keep gate valve in good mechanical condition and free from debris and sediment accumulation.

2. Remove trash and debris from principal spillway, siphon, and chute inlets.

3. Grade faces of earth embankments when needed.

4. Repair damage to emergency spillways as needed.

5. Maintain proper drainage through reservoir basins.

6. Repair damage to floodways, inverted siphons, and chute spillway.

7. Maintain concrete irrigation canal in good condition.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST

Buckeye Watershed, Arizona

Installation Cost Item	Unit	Number		Estimated Cost (Dollars) 1/						Total
				P.L. 566 Funds			Other			
		Fed. Land	Non-Fed. Land	Fed. Land	Non-Fed. Land	Total	Fed. Land	Non-Fed. Land	Total	
LAND TREATMENT										
Soil Conservation Service										
Conservation Cropping System	Acre		16,600					16,600	16,600	16,600
Cover and Green Manure Crops	Acre		1,850					37,000	37,000	37,000
Crop Residue Use	Acre		16,650					24,975	24,975	24,975
Irrigation Water Management	Acre		750					750	750	750
Irrigation Land Leveling	Acre		6,425					514,000	514,000	514,000
Irrigation Ditch Lining	L.F.		264,000					253,440	253,440	253,440
Irrigation Field Ditches	L.F.		100,300					4,010	4,010	4,010
Irrigation Pipelines	L.F.		3,500					12,250	12,250	12,250
Technical Assistance					23,550	23,550		44,800	44,800	68,350
TOTAL LAND TREATMENT					23,550	23,550		907,825	907,825	931,375
STRUCTURAL MEASURES										
Soil Conservation Service										
Floodwater Retarding Structures	No.		2		1,736,000	1,736,000				1,736,000
Floodway Construction	Miles		4.0		358,500	358,500				358,500
Diversions	Miles		3.0		159,500	159,500				159,500
Irrigation Facilities	No.		1		33,900	33,900		33,900	33,900	67,800
Wildlife Watering Facilities	No.	2		1,940		1,940	1,940		1,940	3,880
Subtotal - Construction				1,940	2,287,900	2,289,840	1,940	33,900	35,840	2,325,680
Installation Services										
Soil Conservation Service										
Engineering Services				260	464,000	464,260				464,260
Other					231,950	231,950				231,950
Subtotal - Installation Services				260	695,950	696,210				696,210

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST
(Continued)
Buckeye Watershed, Arizona

Installation Cost Item	Unit	Number		Estimated Cost (Dollars) 1/						
				P.L. 566 Funds			Other			
		Fed. Land	Non-Fed. Land	Fed. Land	Non-Fed. Land	Total	Fed. Land	Non-Fed. Land	Total	Total
Other Costs										
Land, easements, rights-of-way								717,200	717,200	717,200
Administration of Contract							40	22,600	22,640	22,640
Subtotal - Other							40	739,800	739,840	739,840
TOTAL STRUCTURAL MEASURES		2,200	2,983,850	2,986,050	1,980		773,700		775,680	3,761,730
TOTAL PROJECT		2,200	3,007,400	3,009,600	1,980		1,681,525		1,683,505	4,693,105

1/ Price Base - 1962 prices.

October 1963

TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT
(at time of work plan preparation)

Buckeye Watershed, Arizona

Measures	Unit	Applied to Date	Total Cost (Dollars) 1/
LAND TREATMENT			
Non-Federal			
Conservation Cropping Systems	Acres	2,360	2,360
Crop Residue Use	Acres	3,390	5,090
Green Manure Crops	Acres	330	6,600
Irrigation Land Leveling	Acres	11,960	956,800
Irrigation Ditch Lining	L.F.	369,600	354,800
Irrigation Pipelines	L.F.	10,130	35,450
Irrigation Field Ditches	L.F.	264,000	2,900
Irrigation Water Management	Acres	710	710
Technical Assistance	Dollars		75,320
Federal			
Stockwater Development	No.	3	4,000
Range Management	Acres	41,320	--
Technical Assistance	Dollars		1,100
TOTAL	Dollars		1,445,130

1/ Price Base - 1962 prices.

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TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION

Buckeye Watershed, Arizona

(Dollars) 1/

Structure Name	Installation Cost P.L. 566 Funds				Installation Cost - Other Funds				Total Install. Cost
		Install. Serv.		Total PL 566		Other			
	Construction	Engineering	Other	Costs	Construction	Adm. of Contract	Ease. R/W	Total Other	
Floodwater Retarding Structures									
East	532,000	106,000	53,000	691,000		5,000	154,000	159,000	850,000
West	1,204,000	241,000	120,000	1,565,000		12,000	481,000	493,000	2,058,000
Floodways									
East	22,500	4,500	2,200	29,200		300	7,000	7,300	36,500
West	336,000	67,000	34,000	437,000		3,000	18,000	21,000	458,000
Diversion	159,500	31,900	15,950	207,350		1,600	53,000	54,600	261,950
Irrigation Features	33,900	13,600	6,800	54,300	33,900	700	4,200	38,800	93,100
Wildlife Watering Facilities	1,940	260	---	2,200	1,940	40	---	1,980	4,180
GRAND TOTAL	2,289,840	464,260	231,950	2,986,050	35,840	22,640	717,200	775,680	3,761,730

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1/ Price Base - 1962 prices.

TABLE 3 STRUCTURE DATA

FLOODWATER RETARDING STRUCTURES

Buckeye Watershed, Arizona

Item	Unit	East	West	Total
Drainage Area	Sq. Mi.	14.6	42.7	57.3
Storage Capacity				
Sediment	Ac. Ft.	440	1200	1640
Floodwater	Ac. Ft.	1240	3500	4740
Total	Ac. Ft.	1680	4700	6380
Surface Area				
Sediment Pool	Ac.	80	260	340
Floodwater Pool	Ac.	240	730	970
Volume of Fill	Cu. Yd.	535,000	1,430,000	1,965,000
Elevation Top of Dam	Ft.	1116.5	1092.0	
Maximum Height of Dam	Ft.	23.5	25.0	
Emergency Spillway				
Crest Elevation	Ft.	1111.5	1087.0	
Bottom Width	Ft.	800	1200	
Type		Earth	Earth	
Chance of Use	Per Cent	1	1	
Average Curve Number-Condition II		90.1	90.5	
Emergency spillway hydrograph				
Storm rainfall (6-hour)	In.	4.98	3.90	
Storm runoff	In.	3.87	2.88	
Velocity of flow (V_c) 1/	Ft/Sec.	3.96	2.94	
Discharge rate 1/	c.f.s.	4660	5450	
Max.w.s. elevation 1/	Ft.	1113.5	1088.7	
Freeboard hydrograph				
Storm rainfall (6-hour)	In.	9.02	7.00	
Storm runoff	In.	7.82	5.88	
Velocity of flow (V_c) 1/	Ft/Sec.	5.90	4.80	
Discharge rate 1/	c.f.s.	12,200	18,400	
Max. w.s. elevation 1/	Ft.	1115.1	1090.7	
Principal Spillway				
Capacity at crest of emergency spillway	c.f.s.	147	442	
Time of release	Days	8.7	10	
Capacity Equivalents				
Sediment volume	In.	0.56	0.47	
Detention volume	In.	1.60	1.54	
Spillway storage	In.	1.80	2.10	
Class of Structure		B	B	

1/ Maximum during passage of hydrograph.

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TABLE 3A - STRUCTURE DATA
FLOODWAY STABILIZATION
Buckeye Watershed, Arizona

Channel Designation	Sta. Numbering for Reach Sta. Ft.	Sta. Ft.	Type Channel	R/W Width Feet	Required Channel Capacity c.f.s.	Bottom Width Feet	Side Slope Hor. to Vert.	Design Depth Feet	Head or Slope Ft/Ft	Veloc. Ft/Sec	Vol of Excav. Cu.Yd.	Vol.of Embank. Cu.Yd.	Vol. of Concrete Cu. Yd.	Vol. of Rock Riprap Cu. Yd.
Diversion	0+00	150+00	Earth	300	1910	--	3:1	4.7	0.0010	3.0	--	151,000	--	--
	150+00	164+00	Rock Riprap	150	1910	90	1:1	2.2	0.0200	9.9	20,000	--	--	10,000
	164+00=	Sta. 302+00 ℄ East FRS												
East Floodway	0+00=	Sta. 302+00 on ℄ East FRS												
	0+55	23+00	Earth	100	147	12	3:1	3.0	0.0010	2.5	15,000	--	--	--
	23+00	23+20	R/C Drop Structure		147	10	Vert.	3.1	--	--	--	--	40	8
	23+20	43+00	Earth	100	147	12	3:1	3.0	0.0010	2.5	9,500	--	--	--
	43+00	43+20	R/C Drop Structure		147	10	Vert.	3.1	--	--	--	--	40	8
	43+20	52+00	Earth	100	147	12	3:1	3.0	0.0010	2.5	6,000	--	--	--
	52+00	36-inch diameter R/C pipe with gate valve												
	52+00=	Sta. 935+50 ℄ West FRS												
West Floodway	0+00=	Sta. 1280+00 on ℄ of West FRS												
	0+70	20+70	Earth	100	442	30	3:1	4.4	0.0005	2.5	23,100	1,400	--	--
	20+70	32+00	R/C siphon	100	530	Box	8'x8'	-	4.0	9.4	7,800	--	1,060	22
	32+00	46+00	Earth	100	530	30	3:1	4.8	0.0005	2.5	12,500	1,500	--	--
	46+00	49+40	R/C siphon	100	530	Box	8'x8'	-	2.0	9.1	2,400	--	380	22
	49+40	101+80	Earth	100	530	30	3:1	4.8	0.0005	2.5	54,500	10,200	--	--
	101+80	106+50	R/C siphon	100	638	Box	8'x8'	-	3.0	10.4	2,600	--	490	22
	106+50	132+00	Earth	100	638	30	4:1	5.0	0.0005	2.5	28,300	6,400	--	--
	132+00	133+50	R/C chute	100	685	17	3:1	-	41.4	-	2,200	--	180	66
	133+50	156+00	Earth	100	685	30	4:1	5.2	0.0005	2.6	19,800	--	--	--
	156+00	Main channel of Hassayampa River												
Irrigation Features	0+00=	Sta. 935+50 on ℄ of West FRS												
	0+00	0+60	36-inch diameter R/C pipe with gate valve											
	0+60	11+00	Slip-formed Conc.	50	100	3	1.25:1	2.5	0.0080	10.0	825	--	133	--
	11+00	41+00	" "	50	100	3	1.25:1	2.4	0.0150	12.5	2,250	--	352	--
	41+00	73+00	" "	50	100	3	1.25:1	2.5	0.0085	10.0	2,400	--	385	--
	73+00	Roosevelt Irrigation District Canal												

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Design Storm Frequency as follows: Diversion - 2%; East Floodway - 1%;
West Floodway - 1%; Irrigation Features - None.

TABLE 4 - ANNUAL COST

Buckeye Watershed, Arizona

(Dollars) 1/

Evaluation Unit	Amortization of Installation Cost 2/	Operation and Maintenance Cost	Total
East and West Floodwater Retarding Structures and Corresponding Floodways and Diversion	111,850	12,950	124,800
Irrigation Features	2,900	300	3,200
Wildlife Watering Facilities	130	150	280
TOTAL	114,880	13,400	128,280

1/ Price Base - Installation Costs - 1962 prices.
- O&M Costs - long term price levels.

2/ Amortized at 2 7/8% for 100 years.

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TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Buckeye Watershed, Arizona

(Dollars) 1/

Item	ESTIMATED AVERAGE ANNUAL DAMAGE		Damage Reduction Benefit
	Without Project	With Project	
FLOODWATER			
Crop and Pasture	86,820	15,920	70,900
Other agricultural	37,690	9,000	28,690
Non-Agricultural (including residential, business, road, railroad, canals, etc.)	40,930	19,790	21,140
Subtotal	165,440	44,710	120,730
SEDIMENT			
Crop and Pasture	4,570	1,090	3,480
Other Agricultural	19,420	4,640	14,780
Non-Agricultural	7,430	4,010	3,420
Subtotal	31,420	9,740	21,680
EROSION			
Flood Plain Scour	2,280	540	1,740
Subtotal	2,280	540	1,740
INDIRECT	20,320	7,270	13,050
TOTAL	219,460	62,260	157,200

1/ Price Base - Long term price levels.

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TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Buckeye Watershed, Arizona

(Dollars) 1/

Evaluation Unit	Average Annual Benefits					Average Annual Cost	Benefit Cost Ratio
	Flood Prevention Damage Reduction	Agricultural Water Management Irrigation	Recreation	Secondary	Total		
Floodwater Retarding Strs. - Diversion - Floodways	153,900	-	-	16,630	170,530	124,800	1.4:1
Irrigation Features	-	3,650	-	370	4,020	3,200	1.3:1
Wildlife Watering Facilities	-	-	310	-	310	280	1.1:1
Total	153,900 2/	3,650	310	17,000	174,860	128,280	1.4:1

1/ Price Base - Benefits: Long term price levels. Costs: 1962 prices

2/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $3300 annually.

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WATERSHED WORK PLAN

Buckeye Watershed

INVESTIGATIONS AND ANALYSES

INVESTIGATIONS & ANALYSES

Land Use and Treatment

Land treatment measures to be applied as an essential part of this plan were based on soil surveys, technical guide data, conservation needs inventory and past accomplishments of the going program. Cost of technical assistance was based on average work performance time for each of the particular measures to be applied at the average hourly rate as shown in Adivsory Notice--Arizona No. 363, dated September 28, 1961. The cost of accelerated technical assistance to be borne by P.L. 566 funds was determined by subtracting the cost of technical assistance available within the watershed under the going program from the total estimated cost of technical assistance.

Hydrologic Investigations

Basic Data

There are no stream gaging stations located within the watershed. Weather Bureau precipitation data includes 57 years of daily records at the Town of Buckeye in the south central portion of the watershed, 12 years of daily records at the Caterpillar Proving Grounds located on the east slope of the White Tank Mountains seven miles east of the watershed, 44 years of daily record at Litchfield Park located ten miles east of the watershed, and 13 years of record at the J. L. Hodge's residence located about four miles north of the Town of Liberty.

There is an hourly recording station located at Phoenix which has 39 years of continuous records.

Soil groupings and on-site range conditions were determined for various areas of the watershed.

Flood Volume Determinations

A determination was made of frequencies of the 24-hour, two-day, three-day, four-day and monthly precipitation values for the Weather Bureau Station at Buckeye. The daily frequency values were compared to TP#40 and agreed very closely. For durations less than 24 hours, TP#40 values were used.

An isohyetal map was drawn of the 1951 storm event and a determination of a value of area to point rainfall was made. This compared favorably with figure 3.4-1 of the National Engineering Handbook, Sec. 4, Supplement A (Hydrology Guide). This figure was used for subsequent area reduction computations.

Runoff volumes for the various events up to the one-day duration were then computed using the methodology from sections 3.7 to 3.10 of the

Hydrology Guide. From one day to ten days, volumes were computed on the basis of George Watt's determination for Queen Creek in his paper entitled, "Development for Runoff Duration Curves". These volumes were used in subsequent studies in relation to Technical Release #10, dated March 30, 1959, for computation of storage detention and principal spillway release requirements for proposed floodwater retarding structures.

Volumes of runoff for the emergency spillway and freeboard hydrographs were determined by the procedure shown in Sec. 3.21 of the Hydrology Guide and by the criteria shown in Soil Conservation Service Engineering Memorandum #27, dated March 14, 1958.

Hydrograph Development

Field surveys were made to determine 12 channel cross sections and slopes. Times of concentration were determined by the following steps:

1. Computation of a stage discharge curve for each cross section.

2. By successive trials, a time of concentration was determined so that the velocity used in finding the time of concentration coincided with the velocity for the peak discharge on the state-discharge curve.

3. For several reaches of channel, the times of concentration were summated from reach to reach so that a total time of concentration was arrived at for the point in question.

The principal spillway hydrograph was determined by computing the c.f.s. inflow at three-hour intervals from zero to 72 hours, using the volumes of inflow from the previous study in relation to Technical Release #10.

After determination of times of concentration, the emergency spillway and freeboard hydrographs were developed by referring to figures in Washington Advisory Notice 2018 dated November 17, 1961, relating to the minimum six-hour precipitation for class (b) structures and modifying this by the area-depth relationship curve labeled "Arid and Semi-arid Climate" in figure 21.10 of the Hydrology Guide. The hydrographs were derived by the method shown in Sec. 3.21-1 of the Hydrology Guide; also using tables 3.21-15 to 3.21-71 and figures 3.21-7 to 3.21-8.

Water Yield Determination for Agricultural Water Management

Average annual yield was determined from the floodwater volumes derived at various frequency events. It was assumed that the four-day yields computed would be equal to the yield for the entire year in the watershed. The yields at the various frequencies were then totaled and averaged to obtain the average annual yield. The results were compared to the map entitled, "AVERAGE ANNUAL WATER YIELDS, ARIZONA", published July 1951. The results compared reasonably well.

The amount of water available for irrigation was computed on the basis that only the sediment pool of the West floodwater retarding structure would be available for release for this purpose. All frequency events that yielded floodwater volumes above the sediment pool storage were assumed to discharge to the Hassayampa River.

Sedimentation Investigations

Sediment Source Areas

Investigation shows that the major source of sediment is from all areas above the proposed structure sites and from the uncontrolled area upstream from the irrigated farm lands. Range condition is poor. The principal soil loss is through sheet erosion with gully erosion being of minor importance. Other sources of sediment are erosion of irrigation canal banks and laterals and farm and county roads.

Sediment Storage Requirements

Estimates of sediment storage requirements for the floodwater retarding structures were based on stock pond surveys and sedimentation data from watersheds in the state having topographic, soil, cover and rainfall conditions similar to the conditions in the Buckeye Watershed. Correlation of data was necessary since there were no stock ponds in or adjacent to the watershed from which to obtain sedimentation information. On-site erosion rates were assigned to appropriate hydrologic soil groups present in the watershed. By using these correlated erosion rates and previously developed sediment delivery rate curves, a method was established for estimating sedimentation rates and sediment storage requirements for the structures. Sediment source areas and factors that influence sediment yield were considered in the analysis. The most important of these factors was the difference in size of the drainage areas of the correlated stock ponds used in the analysis and the size of the drainage areas above the proposed structures. The larger size of the drainage areas above the structures gives a much greater opportunity for sediment deposition before it reaches the reservoir basins. This deposition occurs in the stream channels and at the mouths of the discontinuous drainageways that are characteristic of the alluvial slopes above the proposed structures. Size of the drainage areas above the reservoir basins were taken into consideration to some degree by analyzing sediment yields on a subwatershed basis, taking into account individual drainage patterns within the watershed. Based on these considerations, it is estimated that sediment from the drainage area above the East structure will accumulate in the reservoir basin at the rate of 0.30 acre-foot per square mile per year, and sediment from the drainage area above the West structure will accumulate in the reservoir basin at the rate of 0.28 acre-foot per square mile per year. Sediment storage requirements for the 100-year period are estimated to be 440 acre-feet for the East structure, and 1200 acre-feet for the West structure.

Geologic Investigations

Foundation and Borrow

To evaluate the general feasibility of the dam sites and related diversion structure, a preliminary investigation was made to determine the foundation conditions present and the nature of available borrow materials. The investigation included analysis of test pit and drill boring logs and surface studies of watershed slopes, channel banks, and rock outcrops. Fifteen test borings were drilled along the centerline of the East floodwater retarding structure to depths of five to 30 feet and seven pits were dug in the borrow area to depths of two and one-half to seven feet. Twenty-three test borings were drilled along the centerline of the West structure to depths of two to 30 feet and 16 pits were dug to depths of three to ten feet. The diversion was investigated by visual inspection of the surface conditions and by correlation of logs of 16 test borings and eight pits located approximately 0.5 mile downstream.

The investigation of the East structure shows that the structure site is generally underlain by deposits of gravelly silty sand interbedded with layers of slightly to moderately indurated silty sand and sandy siltstone. Localized areas of silty sand materials containing cobbles were also present at varying depths in the foundation.

Soil materials upstream from the centerline of the East structure range from silty sand (SM) to sandy gravel (GP). Indurated sandy siltstone underlies the soil materials throughout a major portion of the borrow area.

The emergency spillway will be cut into erosive silty sand materials.

The investigation of the West structure shows that the structure site is generally underlain by shallow deposits of silty sand and somewhat compressible sandy silt over interbedded layers of slightly to moderately indurated sandy siltstone and silty sand. The deposits of compressible sandy silt are more prevalent along the western end of the proposed centerline of the dam. The eastern end of the dam is located around the base of the foothills of the White Tank Mountains and is underlain by silty sand over siltstone, caliche, or granite bedrock.

Soil materials upstream from the centerline of the West structure range from silty sand (SM) to sandy silt (ML) and are generally underlain by siltstone. Poorly graded sand (SP) was found in some of the major washes.

The emergency spillway of the West structure will be cut into erosive silty sand and sandy silt materials.

Visual inspection of the diversion location and correlation of nearby test borings and pits indicate that shallow silty and gravelly sand materials overlie slightly to moderately indurated sandy siltstone and slightly cemented silty sand materials.

Groundwater levels reported in the few wells in the vicinity of the structures range from 173 to 245 feet deep. Groundwater was not encountered in test borings during the investigation and water tables at these depths will not present a problem in the design or construction of the structures.

Conclusions

The structure sites are geologically feasible. Results of the investigation show that geologic problems at the sites can be overcome by proper design and construction.

The foundation of the East floodwater retarding structure is competent to support the load to be imposed without excessive settlement. Foundation materials of the West floodwater retarding structure in places is not competent to support the load to be imposed without excessive settlement and foundation materials along these sections of the dam will be excavated and remolded or compacted in place. Shallow cutoff trenches will generally be sufficient to prevent excessive seepage and piping through the foundation. Deeper cutoff trenches may be necessary in localized areas.

Borrow materials are available upstream from the East structure in sufficient quantities for construction of the proposed structure. Borrow materials are available upstream from the West structure except along the section of the dam which skirts the base of the White Tank Mountain foothills. The use of downstream sources of borrow materials may be desirable for construction of this section of the dam. Materials excavated from the emergency spillways of both dams are suitable for use as fill materials.

Foundation conditions are adequate for construction of the diversion. Borrow materials are available immediately upstream for construction of the diversion.

Additional geologic investigations will be required prior to the preparation of the final structural designs. These investigations will include in-place testing of foundation materials and additional borings and pits to correlate foundation materials and to adequately outline the borrow areas. Disturbed samples of borrow materials and undisturbed samples of foundation materials, as needed, will be collected and tested to provide information for design criteria.

Floodway Stability

An investigation was made to determine the stability of soils in the East floodway, the West floodway and the diversion. Five pits were dug along the centerline of the East floodway and 21 pits were dug along the centerline of the West floodway. The diversion was investigated by visual inspection and by correlation of nearby test pits and borings.

East floodway - Silty and gravelly sands with interbedded layers of caliche and sandy siltstone were found along the East floodway. With the inclusion of two concrete drop structures the average grade in the channel is 0.001 ft./ft. On this flat grade, the velocity of the water passing through the floodway will be low, and it was determined that the floodway could remain unlined.

West floodway - Materials along the West floodway vary from very sandy silts to well graded sands with interbedded layers of slightly to moderately indurated siltstone and caliche. The average slope is 0.0005 ft./ft. except in the concrete chute and concrete siphon sections. On this flat grade, the velocity of the water passing through the floodway will be low, and it was determined that this floodway could remain unlined.

Diversion - Materials along the diversion range from non-plastic silty sand to gravelly silty sand. Slightly indurated sandy siltstone also occurs erratically along the section. The average slope is 0.001 ft./ft. Although flood peak velocities will be moderately high they will be of short duration and reshaping and compaction of the diversion channel and embankment will be sufficient to maintain channel capacity and stability.

The exit channel of the diversion from the end of the diversion embankment to the sediment pool of the East floodwater retarding structure has a slope of 0.02 ft./ft. Soils range from silty sand to slightly clayey, gravelly sands. With this slope and type of soils present it was determined that the flood velocities produced would cause excessive erosion and the channel should be lined.

Engineering Investigations

Maps

State highway planning maps and 7½-minute United States Geological Survey maps with contour intervals of 10 and 20 feet were obtained of the watershed area and used for base maps and planning activities.

Surveys

Topographic maps were prepared with four-foot contour intervals and horizontal scale of one inch = 400 feet of the floodwater retarding structure

sites and reservoir areas. Centerline profiles were surveyed for each structure and used as the basis for computing volumes of embankments. Centerline profiles and cross-sections as needed were surveyed on the floodways and used as a basis for design and for computing volumes of excavation and embankment.

Design Criteria

The floodwater retarding structures were designed to contain the routed runoff from the one per cent event without use of the emergency spillways. Additional capacity was provided to contain a 100-year accumulation of sediment. The principal spillways were designed with enough capacity to pass the runoff from the one per cent event routed through the structures in series without use of the emergency spillways.

Principal spillways--These are ungated, reinforced concrete conduits through the dams with inlet and outlet structures. The pipe conduits will be laid on reinforced concrete cradles and will have cut-off collars to prevent seepage along the pipe. The impounded floodwaters in the reservoirs will be released in ten days or less.

Emergency spillways--Their design is in accordance with Soil Conservation Service standards for floodwater retarding structures in moderately hazardous situations. The widths of the emergency spillways were determined by routing the design storm hydrographs through the spillways at a safe velocity. Depths of freeboard were determined by routing the design hydrographs through the emergency spillways without overtopping the dams. The freeboard hydrographs were routed through the entire reservoir lengths for checking against overtopping at the upstream end of the floodwater retarding structures. (See Table 3.)

Earth embankment--The preliminary embankment design was based on a study of foundation and fill materials. The nature and characteristics of these materials were determined by preliminary subsurface investigations and laboratory test results of soil samples taken of the dam site.

Floodways--These are designed to carry the maximum discharges from the principal spillways of the floodwater retarding structures plus the runoff from a two per cent event from the uncontrolled drainage area above the floodways.

The East floodway will have two reinforced concrete drop structures in its channel to provide gradient control.

The West floodway will have three inverted siphons at points where major washes cross the channel alignment and a chute spillway at the bank of the Hassayampa River. These structures are of reinforced concrete and will permit the safe flow of floodwaters. (See Table 3A.)

Diversion--This is designed to carry the peak discharge for a two per cent event from the drainage area above the diversion. The diversion will consist of a compacted earthen dike with a riprapped channel emitting into the East floodwater retarding structure.

Irrigation features--These features include an inlet structure with a gate valve, a reinforced concrete pipe conduit through the earth dam and a concrete lined canal. These measures are designed to properly control the flow of floodwaters that will be used for irrigation purposes. They are designed for a maximum flow of 100 c.f.s. and will convey floodwaters safely to the Roosevelt Irrigation District Canal.

Wildlife Watering Facilities--The wildlife watering facilities are designed to supply permanent water to the existing and anticipated game numbers in the White Tank Mountains based on average annual rainfall of the area. The design is based on standards developed by the Arizona Game and Fish Department.

Structural designs and cost estimates have been made in sufficient detail to establish locations and feasibility. After work plan approval further studies will be made to supply the details necessary for the preparation of construction plans and specifications. These studies may dictate alterations within the current scope of the plan in accordance with technical standards of the Soil Conservation Service and the desires of the local sponsoring organizations.

Alternate Studies

Several alternate sites were considered for the structural measures during project formulation. The West floodwater retarding structure site was first considered as being immediately above the irrigated cropland and extending to the Hassayampa River to provide the highest level of protection possible. When field investigations disclosed that the location of the planned Federal Interstate Highway #10 would cross the centerline of the floodwater retarding structure, the site was moved upstream so that protection would also be given to the highway.

Further investigations revealed that few benefits would be obtained from impounding runoff water from a large wash near the west side of the watershed. Floodwaters from this wash go to the Hassayampa River and are not a serious problem to the irrigated farm lands in this watershed. For this reason, the West floodwater retarding structure was shortened in length to exclude this wash and siphons are planned in the West floodway to permit this floodwater to bypass the floodway.

The site of the East floodwater retarding structure was considered below the Yuma Road and above the irrigated cropland. This site location would require a lined floodway to safely convey floodwater south to the Gila River.

Preliminary designs and cost estimates were made of a concrete lined floodway with adequate capacity for the maximum release of floodwater from the two floodwater retarding structures that would convey water south to the Gila River. The cost of this floodway was more than the cost of the floodway included in this plan and was eliminated from further consideration.

The system of structural measures that proved to be most economical cost-wise was the combination of two floodwater retarding structures, two floodways, and one diversion that together would intercept, retard, and divert floodwaters through one outlet to the Hassayampa River.

Alternate design proposals and cost estimates were made of variations within this system. A study was made of the length and height of embankment for the East floodwater retarding structure to determine that particular combination of length and height that would result in the most economical structue. This study determined that a shorter dam in conjunction with a diversion was more economical and therefore is included in this work plan.

The East floodway, which conveys floodwater from the East floodwater retarding structure to the West floodwater retarding structure, was first designed and cost estimates prepared for a much longer channel. This channel was around the south side and at the base of the southernmost extension of the foothills of the White Tank Mountains. A portion of this floodway would be excavated into siltstone and granite rock. Included as a part of the design and cost of this floodway was a diversion to divert a wash away from the floodway and into the West floodwater retarding structure. A comparison was made of the cost of this floodway with the diversion and the cost of the embankment of the West floodwater retarding structure extended to the east to replace a portion of the floodway and its rock excavation. The cost of the embankment was less than the cost of the excavation, hence this design is included in this work plan.

Cost Estimates

Costs were based on quantities for each item involved and unit costs were based on prevailing construction costs in the area. Some factors considered in estimating quantities and costs are outlined below:

Clearing and grubbing--The dam site, borrow, and emergency spillway area will be cleared of scattered desert trees and shrubs. A unit price per acre was used to arrive at the total clearing and grubbing costs.

Foundation preparation--Most of the vegetation is shallow rooted and very little or no organic matter is present in the soil. Volume of excavation for foundation preparation gave consideration to reworking foundation materials as needed and this cost is included in the estimate.

Earth embankment--Fill materials are available upstream from the proposed structure and can be acquired along the length of the dam. No overhaul costs were considered. Volume of embankment was computed by the average end area method, based on centerline height of the dam. Five per cent of the volume was added to allow for settlement of the dam and foundation.

Concrete--All concrete placed in risers, principal spillways, floodways, and stilling basins will be steel reinforced and will require forming. Unit costs based on volumes of concrete were used to determine total costs of concrete structures. The costs of reinforcing steel, forming and placing of concrete were included in the unit price.

Irrigation features--The costs associated with irrigation features were those costs for the inlet structure, gate valve, reinforced concrete pipe conduit and concrete lined canal needed to properly manage and utilize floodwater for irrigation purposes. The construction cost of these features were cost-shared 50-50 between P.L. 566 and other funds.

Wildlife watering facilities--Unit costs used to determine the total cost of these wildlife watering facilities were furnished by the Arizona Game and Fish Department.

Land, easements, and rights-of-way--Present land values were used as a basis for computing rights-of-way costs. Cost estimates for the relocation of utilities and road and bridge construction were included in this item.

Operation and maintenance--Cost of operating and maintaining the structural measures, as proposed in this plan, are based on estimates as indicated in California Watershed Memorandum #6, dated August 15, 1958, and adjusted to meet local conditions.

Economic Investigations

The magnitude of floodwater and sediment damages was obtained from land owners, agricultural technicians, irrigation officials, and research bulletins as published by the various Federal and state agencies. Secondary sources were scanned and used to supplement damage information and frequency of flooding within the watershed. Long-term projected prices developed by the Agricultural Research Service and Agricultural Marketing Service were used in estimating monetary benefits.

For the purpose of determining the magnitude of crop and pasture damages and other associated farm losses, the flood plain area was divided into three evaluation reaches. The August 1951 storm was used as the basis for estimating floodwater and sediment damages. Use of the historical method to compute the magnitude of annual damages was deemed unfeasible. Sampling procedures were used and consisted of approximately

a 35 per cent sample of the total cultivated acreage damaged by the August 1951 flood.

Crop and pasture cost and return estimates were derived for each of the crops found in the watershed area. These estimates were computed with the help of farmers, irrigation officials and other agricultural technicians familiar with the agricultural economy of the watershed. The cost and return estimates were examined in the light of existing data on the subject as published by the various Federal and state agencies involved in the derivation of such estimates. Damageable values were calculated on various levels of productivity for each crop from the flood data collected in the field and the cost and return estimates. A composite weighted monthly damageable value for all crops was calculated and further refined to represent a composite weighted damage per acre for any given year by the use of a monthly-frequency analysis. This weighted composite damage is made up of losses as suffered on those acres directly affected by flood flows from loss of yields, increased production costs, loss to real farm property, excessive maintenance and other on-farm losses. Total damages to agricultural lands for various storm events were calculated and subsequently used in evaluating damages on an average annual basis.

Average annual damage appraisal to crops and pastures and other on-farm losses with and without the proposed project works was made on the basis of a volume-damage relationship for each of the three evaluation reaches. The volume-damage relationship used for each reach to reflect the magnitude of agricultural damages was adjusted to account for the volume of water carried by county roads, on-farm roads and irrigation facilities. This volume of water is considered as not contributing to crop and pasture damage. Per cent chance-volume relationships were derived along with volume-acres inundated to provide a basis for establishing the damage-frequency curve for each of the evaluation reaches. Effects of proposed works of improvement were analyzed in like manner as were the various alternative measures.

In addition to the hazard of floodwaters directly affecting agricultural lands, the frequent occurrence of flood flows damaging irrigation facilities and disrupting irrigation schedules on those lands not directly flooded is a serious problem. Flood flows that breach and break through the Roosevelt Irrigation District Canal can affect the irrigation scheduling on approximately 20,000 acres of cultivated land between the Roosevelt Irrigation District Canal and the Buckeye canal. Data pertaining to loss of yield due to the inability to irrigate because of disruption in the irrigation supply system was obtained in the evaluation of the White Tanks Pilot Watershed Project. The documentation of this pilot project contained a number of curves relating per cent decrease in loss of cotton yield to number of days without water for the three critical use months--July, August and September. This original data was checked in the field for its application to the Buckeye Watershed conditions. The two projects are quite similar as to physical characteristics and

level of agricultural production and it was determined that the damage curves were representative for the Buckeye project. Supplemental information was obtained from the Roosevelt Irrigation District and pertained to a complete historical record of breaks in their main canal due to flood flows and the number of days required to make proper restoration in order to meet water needs. From this information the magnitude of damages to cotton lands for various size events were calculated. Average annual damages were estimated by use of the frequency method. The estimated benefits to accrue as a result of the proposed works of improvement were based on the ratio of average annual acres flooded with the project and without the project. The frequency at which this type damage would begin was estimated through hydrologic procedures and taken into account in the estimate of annual damages.

Damage surveys were made for all residential property in the watershed's flood plain. Because of the large number of residential properties constructed in the flood plain since the August 1951 storm, a hypothetical stage-damage relationship was estimated based on an assumed water height around each property of one foot. Experienced high water marks of the 1951 storm were analyzed in selecting the one foot level. Those properties which were obviously out of the flood plain area were not considered in evaluating damages. Heights at which damage would begin and at which damage would be significant were noted for each property. Damage estimates were made six inches above and six inches below the assumed one foot level. The resultant stage-damage curve then becomes an indicator as to the magnitude of damages of various floodwater heights over the flood plain. The shape of this curve was checked for reasonableness through data published in Stanford Research Institute Bulletin, "A Study of Procedures in Estimating Flood Damage to Residential, Commercial and Industrial Properties in California". The average height of water to affect these properties in 1951 was computed by dividing the estimated flood volume in terms of acre-feet by the area affected. This average height was used as the basis for estimating total residential damages as a result of the 1951 storm. Average annual damages were estimated through the use of a volume-stage-damage relationship and expressed through use of a damage-frequency curve. Reduction in residential losses as a result of the structural works was analyzed in like manner to derive benefits.

Damages to county roads, state roads, and the Southern Pacific Railroad from the 1951 storm were collected from the various agencies concerned with maintenance of such features. The estimates included only that money expended for flood repairs and discounted that money spent on normal operation and maintenance features. Damages for various size flood events were based on damage per volume of water as calculated for the 1951 storm. Average annual damages were estimated on a damage frequency relationship. Benefits to be accrued as a result of the proposed structural works were also based on a damage-frequency analysis.

Essentially the same procedure was used in calculating average annual damages to the Roosevelt Irrigation District Canal and the Buckeye canal as was used in calculating road and railroad damage. Damage per volume of water was calculated for the 1951 storm and projected for other events to the point where damages begin. The estimated average annual damage to the Roosevelt Irrigation District's system was checked for reasonableness through records of flood breaks to the system as kept by the District's office.

Indirect damages to all aspects contained in the damage picture were obtained in the field along with direct losses. Indirect damages varied from an estimated 10 to 20 per cent. The weighted indirect damage to all flood plain facilities is estimated at 10 per cent of direct.

Agricultural Water Management

Agricultural water management benefits to accrue as a result of the proposed measures for utilization of floodwaters for irrigation purposes were computed on the basis of the estimated crop return value divided by the weighted consumptive use of irrigation water for each crop in the benefited area. This value per acre-foot of irrigation water was then multiplied by the average annual yield of water expected from the controlled area to derive the magnitude of agricultural water management benefits.

Recreational Benefits

The State Game and Fish Department estimates a total of 80 deer hunters will frequent the area served by the wildlife watering facilities during each of the four days of the hunting season. No survey of additional hunters who will use the White Tank area for hunting rabbits and other small game has been made. A very conservative estimate, however, will allow at least 30 hunters for a period of ten days. These estimates amount to a total of 620 hunter days. Using a conservative value of 50 cents per hunter day these facilities will have an annual benefit of $310.

Other recreational benefits, which have not been evaluated include 300 to 400 hunters who frequent the watershed and nearby areas during the mourning and white-winged dove and quail season. Since birds will have access to and use the wildlife watering facilities, considerable additional benefits would accrue to additional hunters during the bird hunting season. This season during 1962-1963 amounted to a total of 103 days.

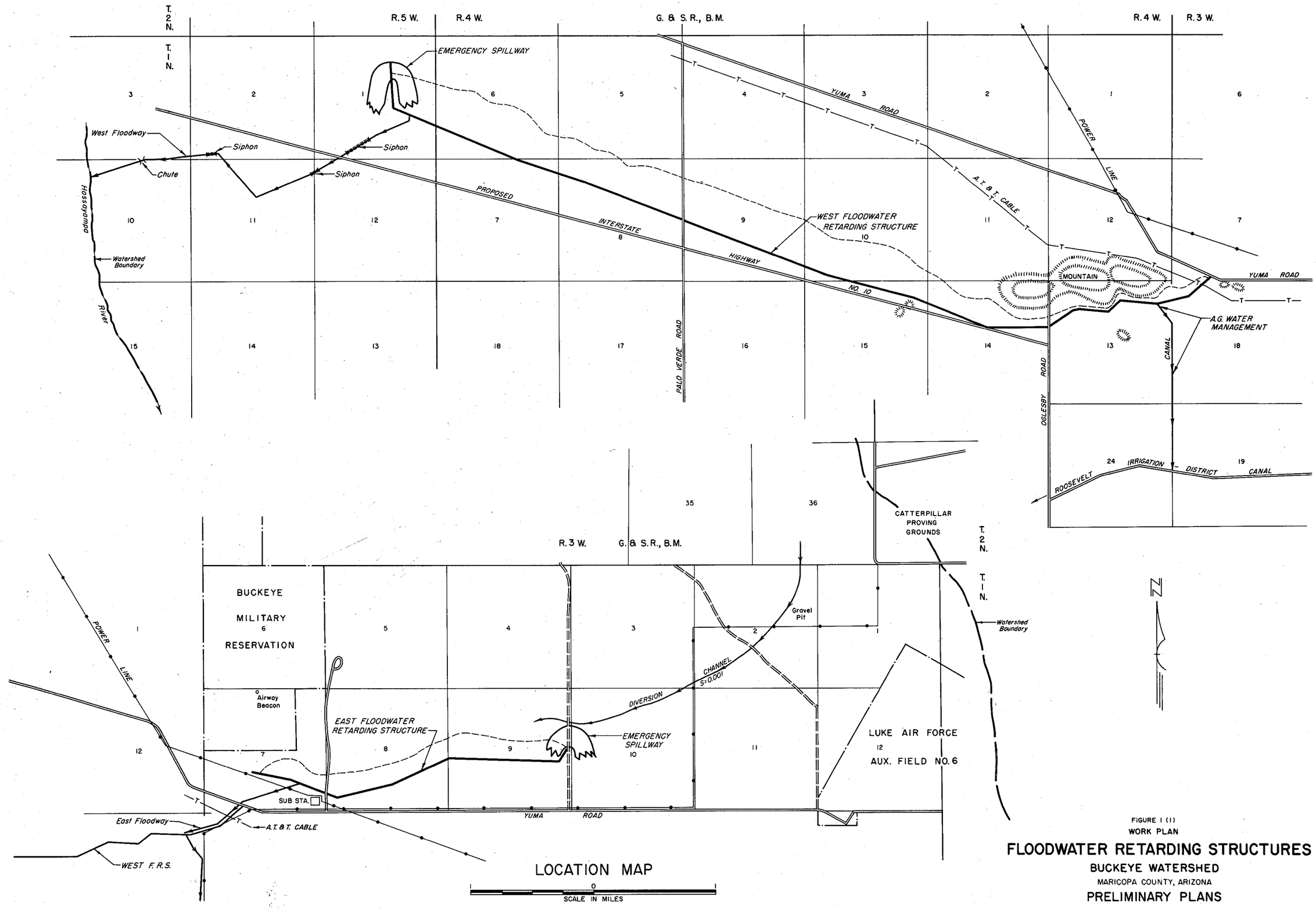
Secondary Benefits

Secondary benefits have been evaluated following procedures outlined in Watersheds Memo SCS-57, attachment 3. They include the value of local

secondary benefits stemming from and induced by the project. Ten per cent of the direct primary benefits excluding indirect benefits were computed to arrive at secondary benefit values stemming from the project.

From Table 6, total Primary Benefits of $157,550 less indirect benefits of $13,050 (Table 5) equals $144,500. Ten per cent of $144,500 equals $14,450 Secondary Benefits stemming from the project.

Secondary benefits induced by the project are equal to ten per cent of the increased cost that primary producers will incur in connection with increased (saved) production. An increased volume of business is realized by the ginning companies from the savings of 1572 bales of cotton annually. The long term charge to producers for ginning is $16.15. This will realize an increase of $25,500 annually. Ten per cent of this figure equals $2,550 secondary benefits induced by the project.



USDA-SCS-PORTLAND, OREG. 1963 M-3951

FIGURE 1 (1)

WORK PLAN

FLOODWATER RETARDING STRUCTURES

BUCKEYE WATERSHED

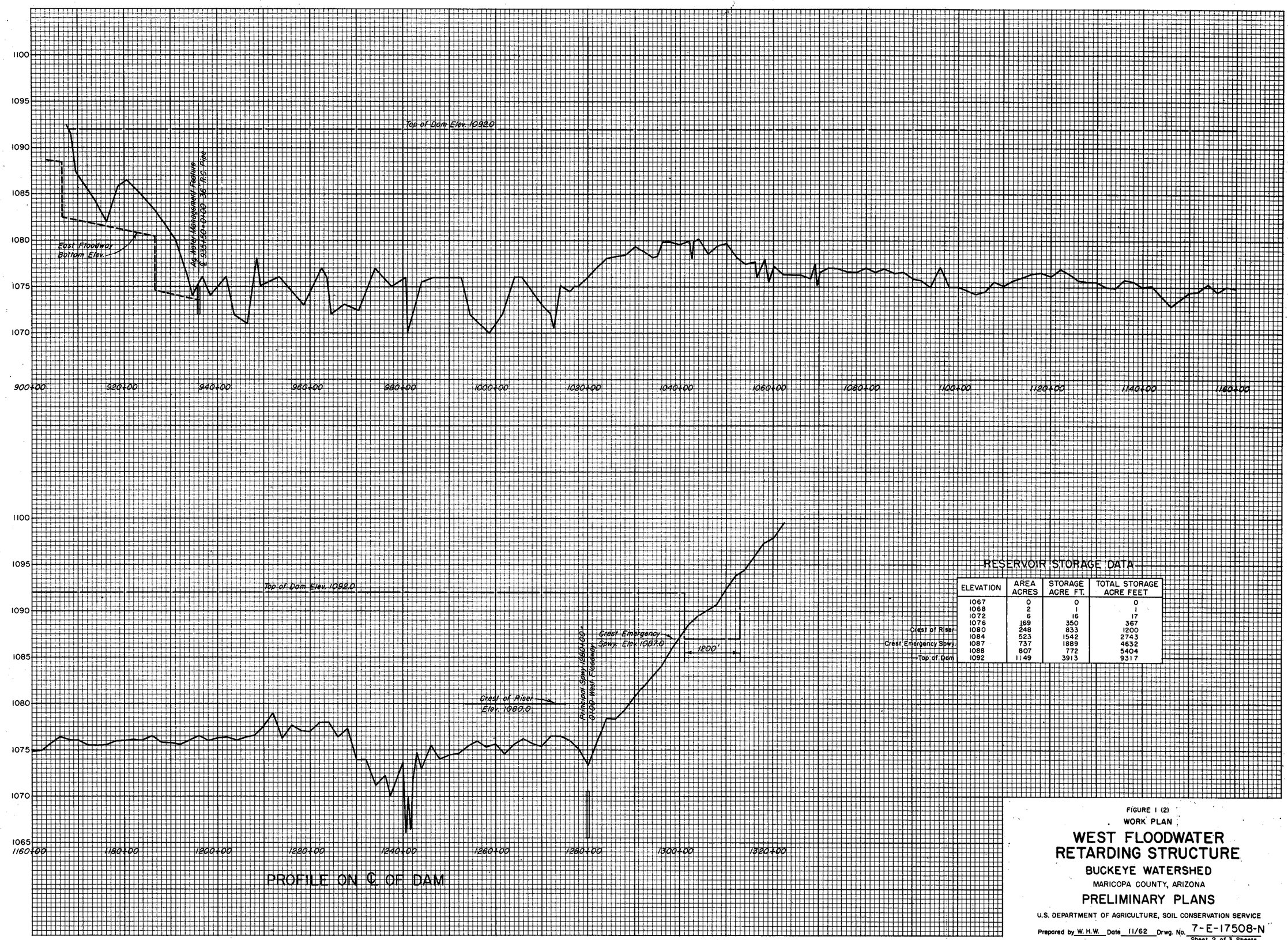
MARICOPA COUNTY, ARIZONA

PRELIMINARY PLANS

U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by W. H. W. Date 11/62 Drwg. No. 7-E-17508-N

Sheet 1 of 3 Sheets



PROFILE ON ℄ OF DAM

RESERVOIR STORAGE DATA

	ELEVATION	AREA ACRES	STORAGE ACRE FT.	TOTAL STORAGE ACRE FEET
	1067	0	0	0
	1068	2	1	1
	1072	6	16	17
	1076	169	350	367
Crest of Riser	1080	248	833	1200
	1084	523	1542	2743
Crest Emergency Spwy.	1087	737	1889	4632
	1088	807	772	5404
Top of Dam	1092	1149	3913	9317

FIGURE 1 (2)

WORK PLAN

WEST FLOODWATER RETARDING STRUCTURE

BUCKEYE WATERSHED

MARICOPA COUNTY, ARIZONA

PRELIMINARY PLANS

U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by W. H. W. Date 11/62 Drwg. No. 7-E-17508-N

Sheet 2 of 3 Sheets

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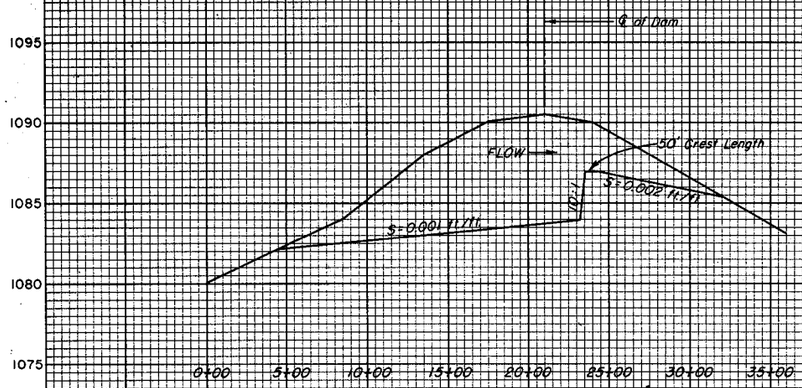
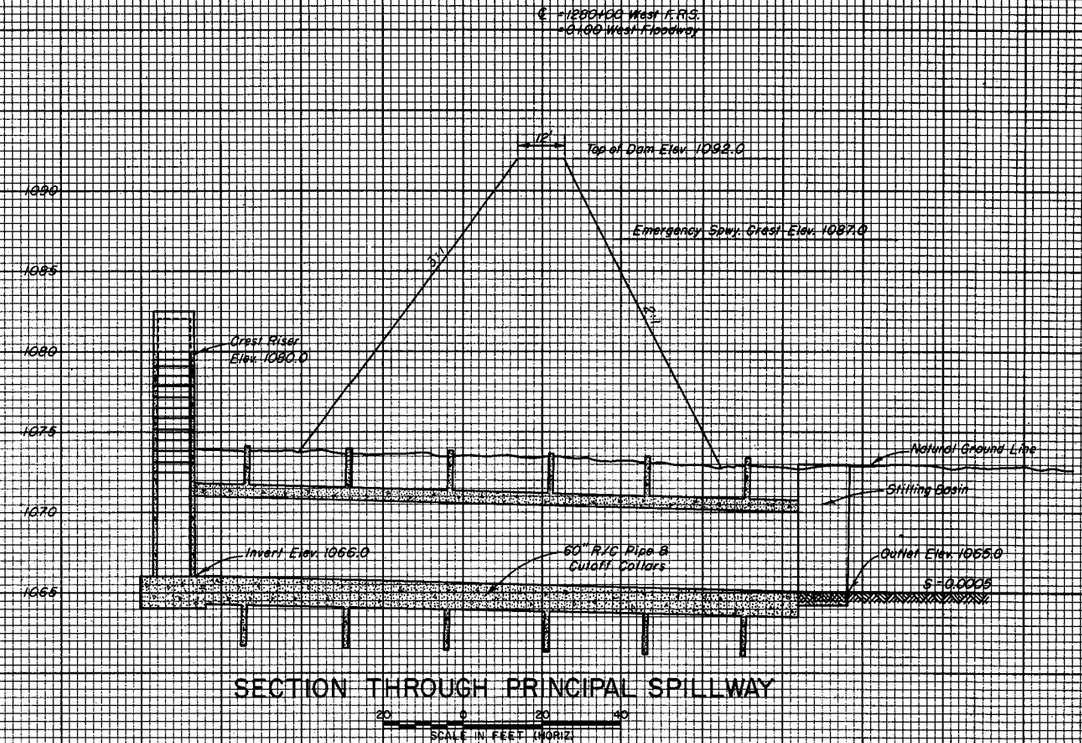
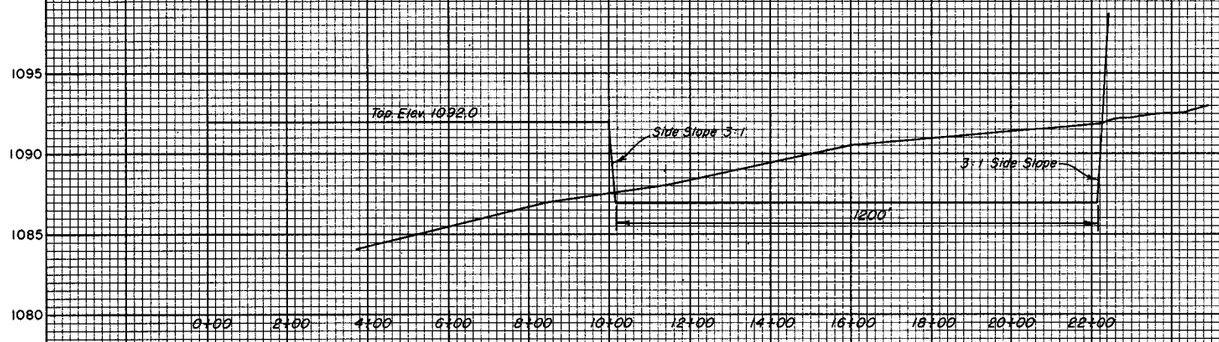


PROFILE ON ℄ OF EMERGENCY SPILLWAY



SECTION THROUGH PRINCIPAL SPILLWAY



CROSS SECTION OF EMERGENCY SPILLWAY

FIGURE 1 (3)
WORK PLAN

WEST FLOODWATER RETARDING STRUCTURE

BUCKEYE WATERSHED
MARICOPA COUNTY, ARIZONA

PRELIMINARY PLANS

U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by W.H.W. Date 11/62 Drwg. No. 7-E-17508-N
Sheet 3 of 3 Sheets

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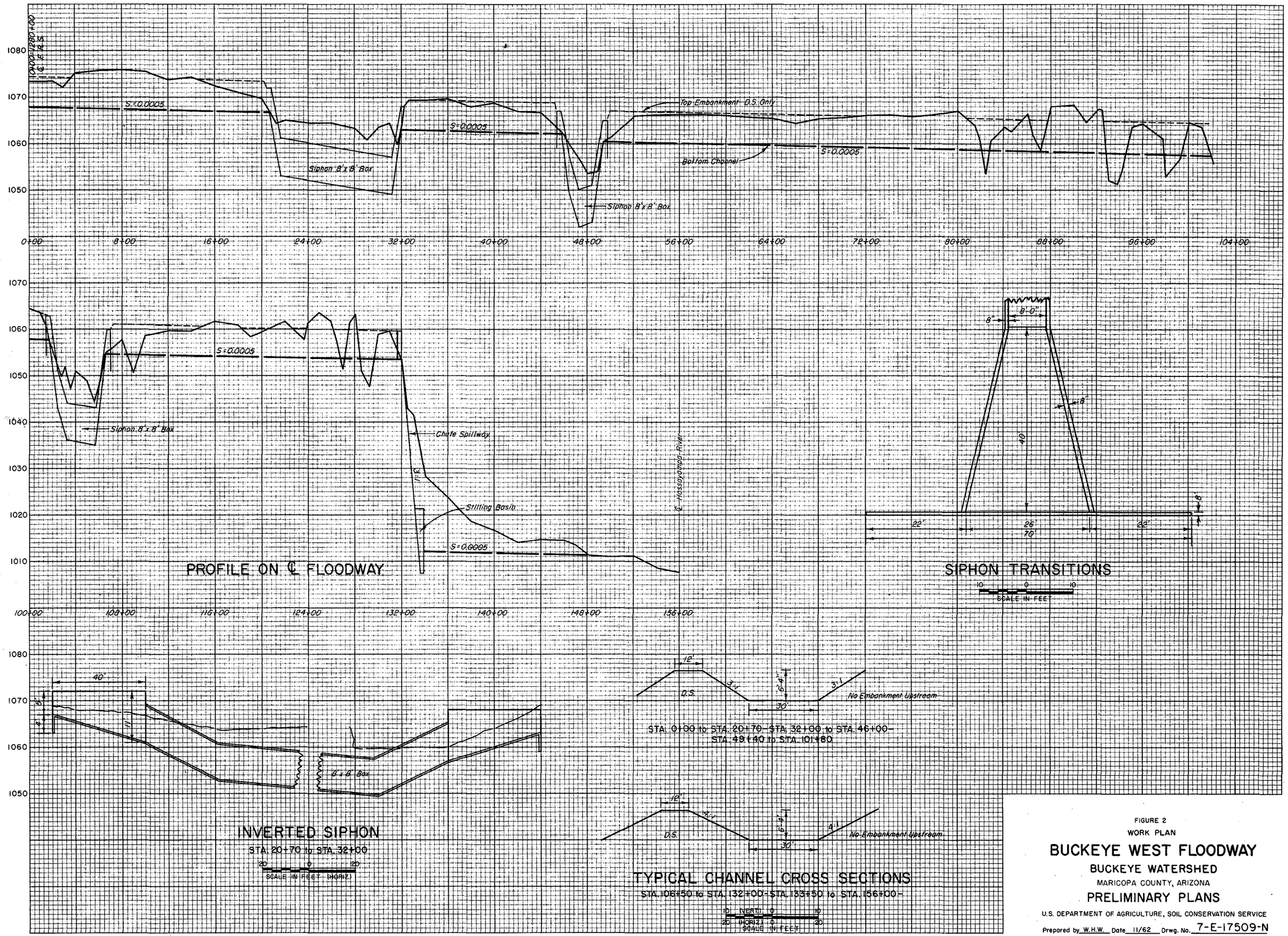

FIGURE 2

WORK PLAN

BUCKEYE WEST FLOODWAY

BUCKEYE WATERSHED

MARICOPA COUNTY, ARIZONA

PRELIMINARY PLANS

U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by W.H.W. Date 11/62 Drwg. No. 7-E-17509-N

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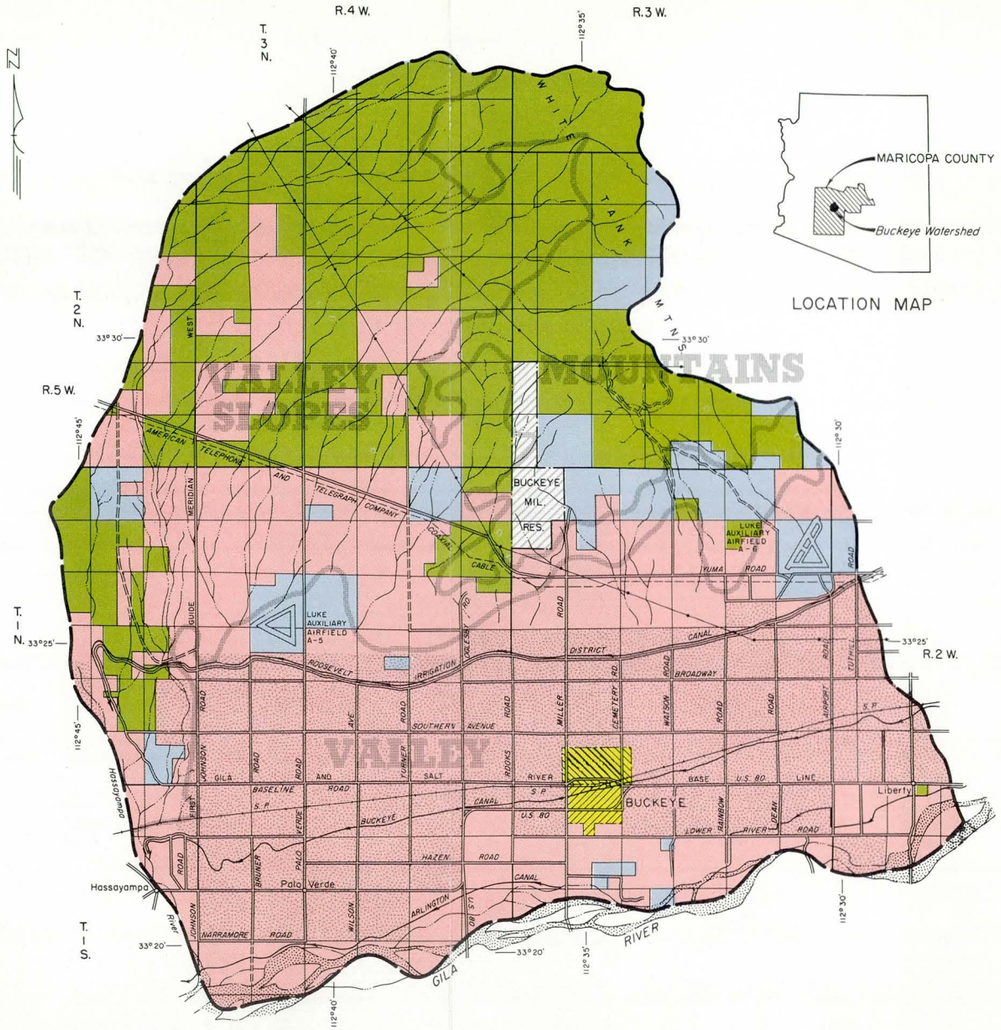


L E G E N D

- Private Land
- State Land
- National Land Reserve
- Urban and Commercial
- Military Reservation
- Cultivated

FIGURE 3

LAND STATUS, LAND USE & RESOURCE UNIT MAP

BUCKEYE WATERSHED

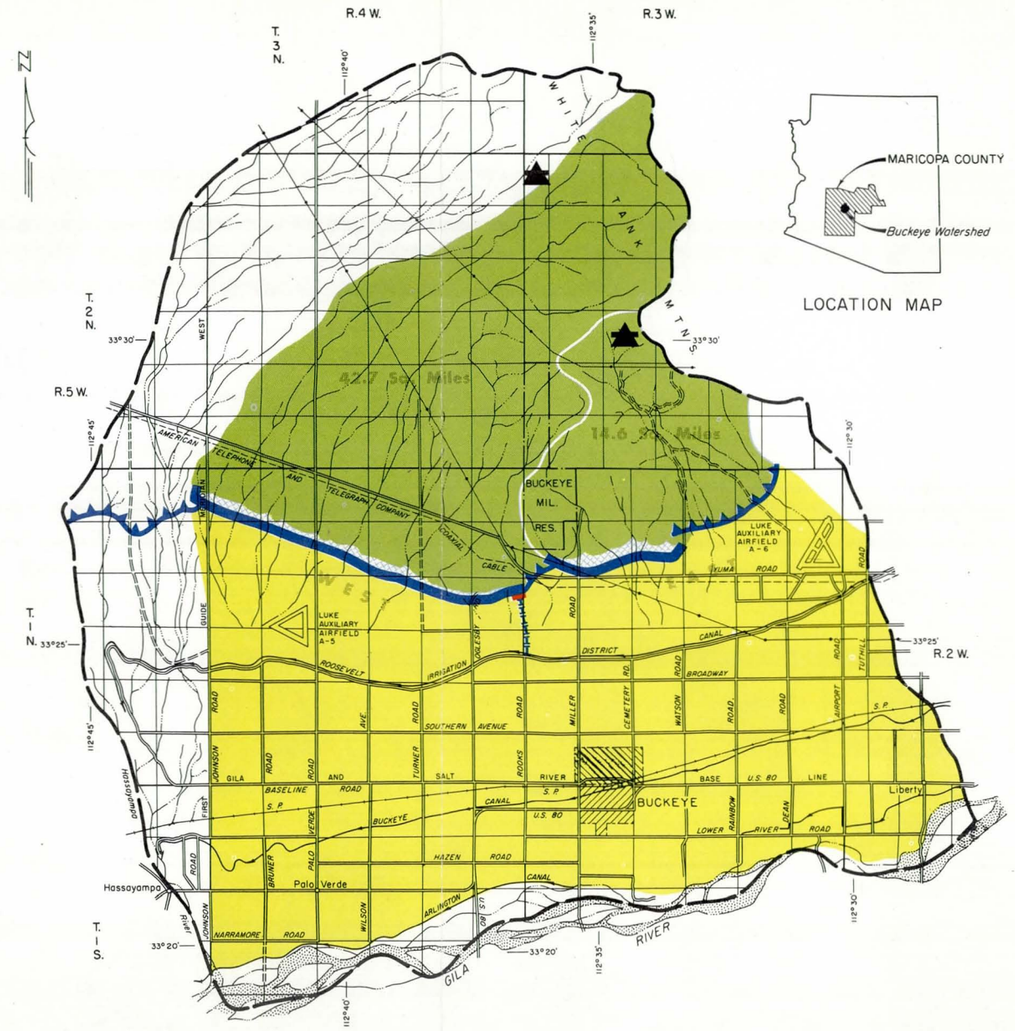
MARICOPA COUNTY, ARIZONA

MAY 1963

SCALE IN MILES 0 1 2 3

U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE USDA-SCS-PORTLAND, OREG. 1963 M-3951

BUCKEYE WATERSHED, ARIZONA 7-P-17510



L E G E N D

- Drainage Area Controled By Structure
- Area Benefited
- Floodwater Retarding Structure
- Floodway or Dike
- Multipurpose Structure
- Irrigation Canal
- Recreation Features

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE — M-3951

FIGURE 4

PROJECT MAP

BUCKEYE WATERSHED

MARICOPA COUNTY, ARIZONA

MAY 1963

SCALE IN MILES

BUCKEYE WATERSHED, ARIZONA 7-P-17510