

WATERSHED WORK PLAN

INDIAN WASH WATERSHED

Mesa County, Colorado

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

Prepared by:

Upper Grand Valley Soil Conservation District
Mesa County, Colorado
City of Grand Junction

With Assistance by:

U. S. Department of Agriculture, Soil Conservation Service
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Colorado Water Conservation Board

September 1961

TABLE OF CONTENTS

	<u>Page</u>
SECTION 1 - THE WATERSHED WORK PLAN	1
SUMMARY OF PLAN	1
DESCRIPTION OF THE WATERSHED	4
Physical Data	4
Economic Data	7
WATERSHED PROBLEMS	9
Floodwater Damage	9
Figure 1 - Damage Area Map	
Sediment and Erosion Damage	10
Plate 1	
Plate 2	
Plate 3	
Problems Relating to Water Management	11
EXISTING OR PROPOSED WORKS OF IMPROVEMENT	11
WORKS OF IMPROVEMENT TO BE INSTALLED	13
Land Treatment Measures for Watershed Protection	13
Structural Measures for Flood Prevention	14
Table 1 - Estimated Project Installation Cost	15
Figure 2- Land Treatment Program - Federal Watershed Lands	
Figure 3- Typical Floodwater-Retarding Structure	
BENEFITS FROM WORKS OF IMPROVEMENT	17
COMPARISON OF BENEFITS AND COSTS	19
ACCOMPLISHING THE PLAN	19
Land Treatment Measures	20
Structural Measures	20
PROVISIONS FOR OPERATION AND MAINTENANCE	21
Land Treatment Measures	21
Structural Measures	22
COST SHARING	22
CONFORMANCE OF PLAN TO FEDERAL AND STATE LAWS AND REGULATIONS	23

TABLE OF CONTENTS -- Continued

	<u>Page</u>
SECTION 2 - INVESTIGATIONS, ANALYSES, AND SUPPORTING TABLES	24
INVESTIGATIONS AND ANALYSES	24
Project Formulation	24
Hydraulic and Hydrologic Investigations	26
Sedimentation Investigations	28
Geologic Investigations	30
Economic Investigations	31
Engineering Investigations	34
SUPPORTING TABLES	
Table 1a - Status of Watershed Works of Improvement	37
Table 2 - Estimated Structure Cost Distribution	38
Table 3 - Structure Data - Floodwater-Retarding Structure	39
Table 4 - Summary of Physical Data	40
Table 5 - Summary of Plan Data	41
Table 6 - Annual Costs	42
Table 7 - Monetary Benefits from Structural and Land Treatment Measures	43
Table 8 - Benefit-Cost Analyses	44
Figure 4 - Project Map	

SECTION 1

THE WATERSHED WORK PLAN

INDIAN WASH WATERSHED

Mesa County, Colorado

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SUMMARY OF PLAN

General

The proposed watershed protection and flood prevention project for Indian Wash Watershed is sponsored by the Upper Grand Valley Soil Conservation District, Mesa County, and the City of Grand Junction, Colorado. The U.S. Corps of Army Engineers participated with the U. S. Soil Conservation Service in a joint preliminary investigation to determine if detailed studies were justified. The Soil Conservation Service, U. S. Department of Agriculture, the Bureau of Land Management, U. S. Department of Interior, and the Colorado Water Conservation Board provided technical assistance in the detailed studies leading to the preparation of the watershed work plan.

The area covered by this work plan includes 15.06 square miles (9,640 acres) in the drainage basin of Indian Wash in Mesa County, Colorado. Indian Wash heads on the escarpment of the Little Book Cliffs northeast of Grand Junction and drains southward through the eastern edge of the city to the Colorado River. Approximately 73.2 percent of the area is desert rangeland, 13.1 percent irrigated cropland, and 13.7 percent urban or miscellaneous.

The principal watershed problem is extensive damage from floodwater and sediment to irrigated cropland, irrigation facilities, residential and commercial property, streets, highways, bridges, and railroads in and adjacent to the City of Grand Junction. These floodwater and sediment damages are caused by high intensity, short duration thunderstorms, which occur primarily in the upper portions of the watershed. Storms of this type cause damaging floods on the average of once every six years.

This work plan outlines a three-year project for installation of land treatment and structural measures for the protection of the watershed. The estimated total project cost is \$482,166. The Public Law 566 share of this cost will be \$431,586. Funds from other sources will be \$50,580 and include local funds as well as funds available under other Federal authority. In addition, local organizations will bear the entire cost of operation and maintenance of the structural measures. This is estimated to be \$2,387 annually.

Land Treatment Measures

Approximately 5,735 acres of the upper watershed area is public rangeland under the administration of the U. S. Bureau of Land Management. The cost of proposed land treatment to be applied by the Bureau of Land Management in this area over a two-year period is estimated to be \$46,530. The Public Law 566 share will be \$40,530, and other funds will amount to \$6,000.

Of the 2,490 acres of privately-owned agricultural land, 1,260 acres are irrigated cropland and 1,230 acres are desert rangeland. The cost of proposed land treatment on these lands over a three-year period is estimated to be \$46,600. The Public Law 566 share will be \$3,000, and \$43,600 will be obtained from other funds.

Structural Measures

One floodwater-retarding structure having a total storage capacity of 1,615 acre-feet is proposed on Indian Wash above the area subject to damage. Of the total capacity, 1,045 acre-feet is allotted to floodwater detention and 570 acre-feet to sediment storage. The floodwater detention capacity is equivalent to 3 inches of storm runoff from the watershed area controlled and will provide flood protection from storms occurring less frequently than once in a hundred years. The principal spillway flow from this structure will be carried to the Colorado River through the existing Indian Wash channel. The total cost of the floodwater-retarding structure not including operation and maintenance is estimated to be \$389,036. The average annual cost including operation and maintenance is \$16,447.

The sponsors will contract for construction of the floodwater-retarding structure and will furnish personnel and funds for administration of the contract. The costs involved in obtaining land, easements, and rights-of-way for the proposed structure will be borne by the sponsors.

Damages and Benefits

Average annual damages without the project are estimated at \$25,615. With the project installed, these damages will be reduced to \$1,725, a reduction of 93 percent. The average annual primary benefits accruing to the floodwater-retarding structure are \$22,740. The ratio of the average annual primary benefits (\$22,740) to the average annual cost of the proposed structure (\$16,447) is 1.38 to 1.00.

Figure 1 shows the area subject to damage without the project and the area remaining subject to flooding after the project is installed.

Operation and Maintenance

The land treatment measures installed on public rangeland will be maintained by the Bureau of Land Management. Funds for this will be other than those provided by Public Law 566. The land treatment measures on privately-owned agricultural land will be maintained by the individual landowners or operators of the farms and ranches on which the measures are installed.

The watershed project sponsors will be responsible for operation and maintenance of the floodwater-retarding structure and the existing Indian Wash flood channel. The average annual cost of this is estimated at \$1,887 for the structure and \$500 for the flood channel for a total of \$2,387.

Provisions for Financing

The City of Grand Junction will be the contracting local organization and with Mesa County will provide the necessary funds for the costs involved in administration of the construction contract, in obtaining land, easements, and rights-of-way, and in accomplishing operation and maintenance. These funds will be obtained from the allocation of a portion of the annual funds presently derived through the normal taxation powers of these public agencies.

DESCRIPTION OF THE WATERSHED

Physical Data

Location.- Indian Wash Watershed is located in Mesa County in west-central Colorado and includes lands in the drainage basin of Indian Wash in and adjacent to the northeast portions of the City of Grand Junction, Colorado. The watershed contains 15.06 square miles (9,640 acres) and has a length of about 9 miles and an average width of 1.7 miles. The area lies along the north side of the Colorado River and is tributary to that stream.

Indian Wash heads in the Little Book Cliffs northeast of Grand Junction and drains southward for several miles across desert rangeland to the High Line Canal, which is carried across the stream channel by a concrete flume with automatic spilling of excess water into the Indian Wash channel. Two smaller drainages (Hartman Draw and Stub Draw) lie to the east of Indian Wash above the High Line Canal and are tributary to the Indian Wash channel through the diverting capacity of the High Line Canal. The area included in the watershed above the High Line Canal is 10.24 square miles or 68 percent of the total watershed area.

Below the High Line Canal, Indian Wash follows a deeply incised channel for about 1 1/3 miles to the flume crossing of the Grand Valley Canal. From Orchard Avenue, which is a few hundred feet downstream from the Grand Valley Canal, the wash flows in a man-made channel to its confluence with the Colorado River. Although Indian Wash is an intermittent stream in its upper reaches, there is generally a small flow in its lower reach, which comes from waste water and return flow from existing irrigation canals and drainage systems.

Physiography and Geology.- The watershed lies within the Grand Valley portion of the Colorado Plateau physiographic province. The total relief in the area is about 2,300 feet. Elevations range from a maximum of about 6,800 feet on the high escarpment of the Little Book Cliffs at the north end of the watershed to about 4,550 feet at the junction of Indian Wash with the Colorado River.

The steep face of the Little Book Cliffs averages 1,000 feet in height. Thick resistant sandstone layers of the Mesaverde group form the upper part of the Cliffs and relatively soft shale of the Mancos formation the lower part. Mancos shale underlies the remainder of the watershed. The Mancos is predominantly a relatively uniform silty clay shale. It weathers on the surface to a friable semipowdery mass that forms a sticky clay when wet. Some thin beds of hard siltstone and fine grained sandstone are present in the shale, as well as a few very thin bentonite layers. Seams of gypsum and calcite are common locally.

The area between the High Line Canal and the foot of the Little Book Cliffs lies at elevations between 4,750 and 5,800 feet. It contains relatively smooth gravel-capped mesas alternating with shale badlands and relatively steep dry washes. The surfaces of the higher mesas slope gently southwestward and are underlain by a protective mantle of gravel and larger rock fragments. These mesas represent remnants of former erosion surfaces lying at various levels from 50 to 400 feet above the present stream channels. The shale badlands occupy irregular areas between the mesas and are most sharply dissected along the foot of the Little Book Cliffs and in places where the gravel cover of former mesas has been removed by erosion, leaving steep, narrow shale ridges.

A considerable portion of the shale area consists of rolling uplands on which an intricate pattern of shallow ravines and gullies has been cut.

The area below the High Line Canal is between 4,550 and 4,750 feet in elevation and is part of a broad alluvial plain formed by coalescing alluvial fans and stream floodplains at the lower ends of dry washes along the north side of the Colorado River. This plain is about 3 miles in width along Indian Wash and contains most of the irrigated land in the watershed as well as the City of Grand Junction.

Soils.- The soils in the watershed are developed on parent materials derived mainly from the Mancos shale with some influence locally from sandstones of the Mesaverde group. The soils are all light-colored and typical of those developed under a desert climate in this region. In their virgin state, the soils contain a very low percentage of organic matter. They generally have a high content of lime carbonate, gypsum, and salts of sodium, potassium, magnesium, and iron.

In the area above the High Line Canal, the soils range widely in stage of development. Raw shale occurs at the surface on most of the steeper slopes. Thin residual soils are present on the more gently rolling areas underlain by shale. Soils on the floodplains of the larger streams have had only a short period of time for development and have no definite concentration of lime or clay in the subsoil. On the higher terraces and mesas, soils are developed on thin eolian deposits overlying the gravels. These soils have weathered a long time without being subjected to severe erosion or to deposition, and as a result, have high concentrations of lime in the subsoil. In places, they have a subsoil somewhat finer textured than the surface soil. The soils on the mesas are moderately deep and are characterized by a pronounced reddish tinge.

Soils in the area below the High Line Canal are dominantly silty clay loam and silty clay. Under natural conditions they contain a moderate concentration of salts derived from the parent materials. Generally, these soils are without visible lime, but they are calcareous. Internal drainage is usually slow. Although moderately fine textured, these soils generally are highly productive under good management. Many of the soils having favorable physical characteristics have become more productive through the years of cultivation as a result of the incorporation of additional organic matter and the leaching of salts by irrigation water. Some of the soils in this area have limited agricultural suitability because restricted internal drainage causes waterlogging and the accumulation of high concentrations of salts.

Range Sites.- The principal range sites in the watershed are Desert Shale, Desert Upland, and Desert Floodplain. The area has an arid climate, and natural vegetation is sparse. The dominant plant on most of the alluvial flats is greasewood, a salt-tolerant shrub. The gently undulating to sharply rolling uplands that are underlain by shale support a moderate to scant cover consisting chiefly of saltbush, rabbitbrush, shadscale, and galletagrass. The higher terraces and mesas support a cover consisting dominantly of shadscale, galletagrass, Indian ricegrass, sacaton, and western wheatgrass.

Land Use.- The acreage and percentage distribution of land use in the watershed is shown in the following table:

<u>Land Use</u>	<u>Acres</u>	<u>Percent</u>
Rangeland		
Bureau of Land Management	5,735	59.4
Private	1,230	12.8
City of Grand Junction <u>1/</u>	<u>100</u>	<u>1.0</u>
Total Rangeland	7,065	73.2
Irrigated Cropland	1,260	13.1
Residential and Commercial	780	8.1
Miscellaneous <u>2/</u>	535	5.6
Total	9,640	100.0

1/ Land owned outside City limits.

2/ Miscellaneous includes Indian Wash channel, canals, roads, railroads, and farmsteads.

Climate.- The climate is arid. The average annual precipitation at Grand Junction is 9.08 inches. Snowfall averages about 20 inches annually. The mean daily temperature is 52.1 degrees. The average length of the growing season is 189 days, beginning April 16 and ending October 23.

Flood-producing storms occur most frequently during the summer or early fall and are characterized by localized, short duration, torrential thunderstorms that increase in intensity toward the Little Book Cliffs. Rainfall amounts in this type of storm also increase toward the higher elevations.

Water Uses and Sources.- The irrigated cropland in the watershed is served by the High Line Canal, the Grand Valley Canal, the Mesa County Canal, and the Stub Ditch. All of these canals obtain water by diversion from the Colorado River. The High Line Canal was financed and constructed as a part of the Grand Valley Project by the U. S. Bureau of Reclamation. In 1949, the Grand Valley Water Users' Association assumed the care, operation, and maintenance of the canal along with other project facilities. The Grand Valley Canal and the Mesa County Canal are owned and operated by the Grand Valley Irrigation Company. The Stub Ditch is owned and operated by the Mesa County Irrigation District and obtains water by pumping from the High Line Canal.

Most of the water used for domestic and commercial purposes in the watershed is supplied by the Grand Junction water system, which obtains water from Kahnah Creek about 25 miles southeast of the city. Water from shallow wells in the area is generally not satisfactory for most purposes because of the high content of salts. In the upper watershed area, runoff water can be obtained intermittently for livestock use by storage in small ponds.

Economic Data

The original town site of Grand Junction was established in 1881. In 1883 the area now comprising Mesa County was taken from the western part of Gunnison County and organized as a political unit. The completion of the Denver and Rio Grande Western Railroad through the area in 1883 greatly facilitated early settlement. The agricultural development of the Grand Valley began with the completion of the first system of irrigation canals in 1885. The largest irrigation canal in the Grand Valley, the High Line Canal, was completed in 1914.

Grand Junction, with a population of 18,694 (1960 census), is the county seat of Mesa County and the largest city in western Colorado. It is the major trade center for Mesa County, as well as for surrounding areas in west-central Colorado and east-central Utah. Manufacturing, mining, and ore processing are among the principal industries of the area. The importance of agriculture to the economy of the area is illustrated by the fact that Mesa County ranks among the leading counties in the nation in production of certain types of livestock, fruit, and other farm products.

The 5,735 acres of Federal rangeland, over which the U. S. Bureau of Land Management has jurisdiction, constitute 87 percent of the watershed area above the High Line Canal. This land is a part of the Mount Garfield Grazing Unit and is included with the surrounding area in winter-spring grazing allotments for cattle. At one time much of this area was traversed by the old Utah-Colorado stock driveway and was all but depleted of forage resources, a condition typical of the adjacent rangelands. Passage of the Taylor Grazing Act in 1934 stopped many of the abuses, although large numbers of animals continue to use the land.

Of the privately-owned agricultural land in the watershed, there are 1,260 acres of irrigated cropland and 1,230 acres of rangeland. Approximately equal areas of the range land are located above and below the High Line Canal. All of the irrigated cropland lies below the High Line Canal, except for two small tracts that are located in the tributary area to the east of the main Indian Wash channel and are served by pumping from the High Line Canal.

Irrigation farming is the basis of the agricultural economy and includes 79 ownerships, with an average of 16 acres of irrigated land. The largest unit of irrigated cropland contains 198 acres. The principal crops grown are alfalfa, corn, small grain, irrigated pasture, fruit, and vegetables. Much of the crop production is marketed for cash, but some is utilized in livestock enterprises. The composite acre gross of the flood-free crop production in this area is estimated to average about \$110 per acre. The current market value of land in the benefited area averages \$500 per acre for the irrigated land.

Most of the farm units are either owner-operated or rented by long-term tenants. There is an increasing tendency toward urbanization of the agricultural lands adjoining the City of Grand Junction, and it is expected that eventually a large part of the irrigated land in the watershed below the Grand Valley Canal will be converted to residential and commercial use.

About 780 acres in the watershed are developed for residential and commercial use at the present time. The homes in this area range in value from \$8,000 to \$16,000. Commercial establishments in the area include motels, trailer parks, warehouses, a drive-in theater, a radio station, and various small retail stores. The estimated value of individual buildings ranges from about \$10,000 to over \$200,000. Prices of the land used for residential and commercial purposes range from \$1,800 upward per 50-foot lot.

The Grand Junction area is served by U. S. Highway 50, U. S. High 6-24, and several major state highways, as well as an excellent system of county roads. Both the main and bypass routes of Highway 6-24 cross the lower part of the watershed. Grand Junction is the main freight center on the Denver and Rio Grande Western Railroad between Denver and Salt Lake City. In 1952 the railroad completed construction of a \$3,500,000 classification yard, most of which lies within the watershed boundaries. The Grand Junction municipal airport is located west of the watershed above the High Line Canal. Two airlines, United and Frontier, operate daily flights to Denver, Salt Lake City, and other points.

WATERSHED PROBLEMS

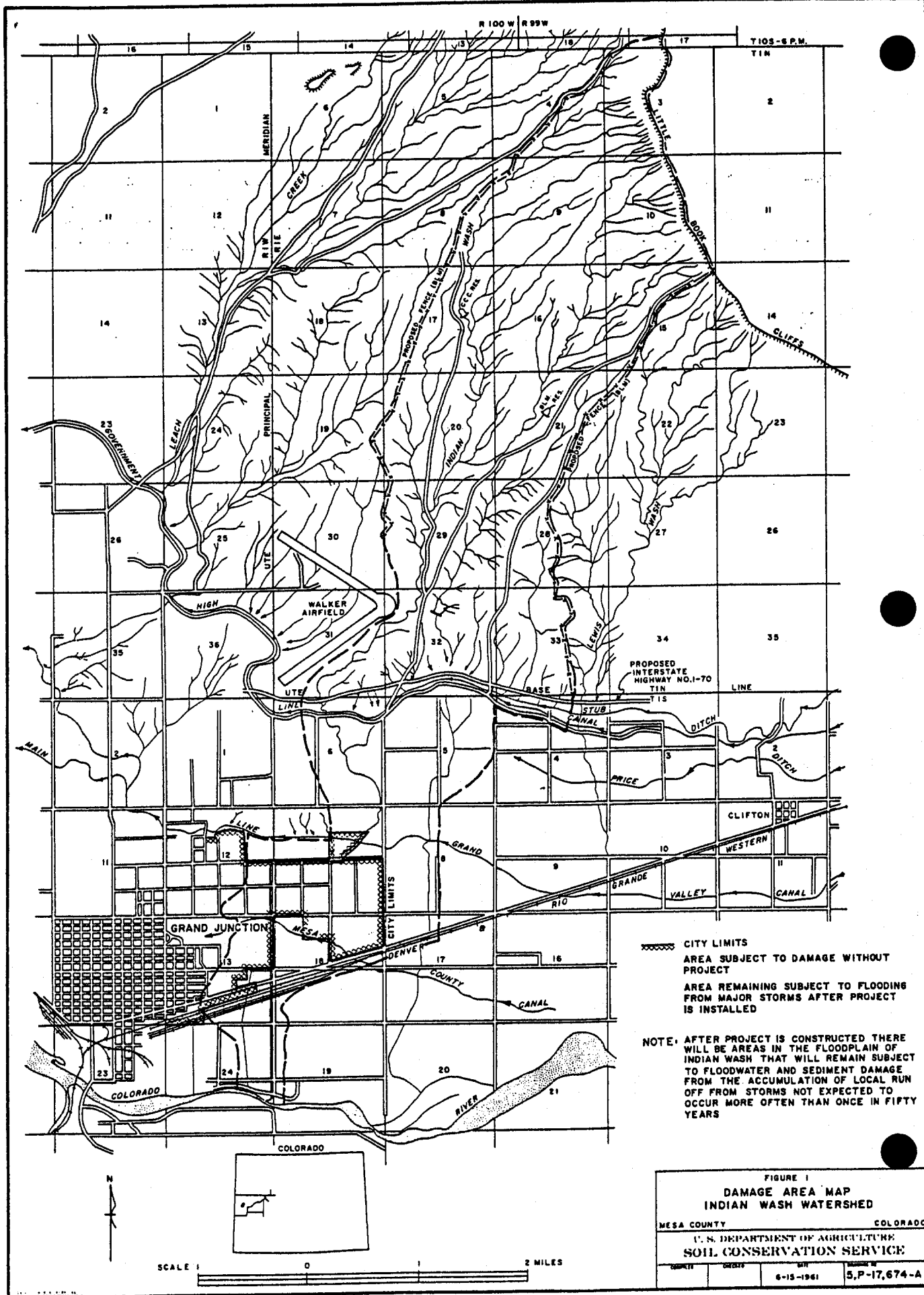
The principal problem in the watershed is the extensive floodwater and sediment damage to irrigated cropland, irrigation facilities, residential and commercial property, streets, highways, bridges, and railroads in and adjacent to the City of Grand Junction. This damage is caused by floods originating primarily from localized, high intensity thunderstorms over the steeply sloping desert rangelands in the upper two-thirds of the watershed. In general, rainfall amounts and intensities in this type of storm become higher with the increase in elevation between the High Line Canal and the steep escarpment of the Little Book Cliffs at the north edge of the watershed. Runoff in this area is also more rapid, and sediment production is greater than in the more gently sloping lower one-third of the watershed.

Amounts of runoff and sediment originating in the area below the High Line Canal are seldom great enough to constitute a major source of damage in themselves. However, the runoff from this area adds to the overall problem of floodwater disposal through existing channel facilities whenever this runoff occurs in conjunction with heavy flood flows originating in the upper part of the watershed.

The areas subject to significant damages are shown on the Damage Area Map, Figure 1. Estimates of average annual damages are presented in Table 7.

Floodwater Damage

Intense thunderstorms occurring over the upper part of the watershed during the summer and early fall have been the most frequent cause of damaging floods on Indian Wash. Information obtained from local residents indicates that damaging floods have occurred in the watershed on the average of once every six years. However, very little factual information is available concerning dates and amounts of monetary damage of these floods. Records of precipitation at the Grand Junction U. S. Weather Bureau Station indicate that large storms occurred in the area on the following dates: September 23, 1896; May 24, 1906; October 16-18, 1908; and August 20-25, 1921. It should be noted, however, that a large storm can occur in the upper watershed area with little or no precipitation being recorded at the weather station. Storms of this type produced damaging floods on Indian Wash in August 1938, June 1954, and May 1955.



--- CITY LIMITS
 - - - AREA SUBJECT TO DAMAGE WITHOUT PROJECT
 . . . AREA REMAINING SUBJECT TO FLOODING FROM MAJOR STORMS AFTER PROJECT IS INSTALLED

NOTE: AFTER PROJECT IS CONSTRUCTED THERE WILL BE AREAS IN THE FLOODPLAIN OF INDIAN WASH THAT WILL REMAIN SUBJECT TO FLOODWATER AND SEDIMENT DAMAGE FROM THE ACCUMULATION OF LOCAL RUN OFF FROM STORMS NOT EXPECTED TO OCCUR MORE OFTEN THAN ONCE IN FIFTY YEARS

FIGURE I
 DAMAGE AREA MAP
 INDIAN WASH WATERSHED
 MESA COUNTY COLORADO
 U. S. DEPARTMENT OF AGRICULTURE
 SOIL CONSERVATION SERVICE
 DATE: 6-15-1961
 DRAWING NO: S,P-17,674-A

The only flood event on Indian Wash for which there is an adequate record of peak flow and an estimate of monetary damages is the flood resulting from the storm of June 6, 1958. This storm was concentrated in the upper watershed area with very little rainfall in the principal damage areas located downstream from the High Line Canal. The precipitation recorded at the U. S. Weather Bureau Station at the Grand Junction airport was 0.63 inch.

In their "Report on Flood of 6 June 1958 on Indian Wash, Grand Junction and Vicinity, Colorado" dated August 1958, the U. S. Corps of Army Engineers estimated the peak discharge was 2,700 c.f.s. in the Indian Wash channel near the High Line Canal flume and the total damages to be about \$25,000. The principal damage was to residences, business establishments, and streets as shown by photographs taken during and after the flood (see Plates 1, 2 and 3).

The principal reason for the lack of reliable data concerning previous flood damages on Indian Wash is that the build-up of residential and commercial property in the area subject to damage has taken place fairly recently, mostly since about 1955. Consequently, floods that occurred at earlier dates were generally much less damaging than those occurring more recently. Urbanization of agricultural land in the damage area is continuing at a steady rate, and large floods occurring in the future will have a much higher damage potential than floods of similar size would have at the present time.

Sediment and Erosion Damage

The higher peak discharges of floods on Indian Wash are accompanied by large amounts of sediment derived mainly from highly erodible lands above the High Line Canal. The principal sediment damage results from the deposition of silt, sand, and other debris on lawns, parking lots, city streets, and in buildings, as well as on irrigated cropland and in irrigation and drainage ditches. Removal of sediment and debris from lawns, streets, basements, and main floors of buildings in particular involves considerable expense to the City of Grand Junction and to private interests.

Sheet, gully, and streambank erosion are all major sources of sediment in the upper watershed area. They also act to reduce forage production on the rangeland. Sheet and gully erosion are most damaging in the areas where shale lies at or near the surface. Above the High Line Canal, channel entrenchment into alluvial floodplain deposits has occurred along Indian Wash and most of the larger tributaries. Downcutting is reaching stability, but widening of the channels through streambank erosion is still taking place.

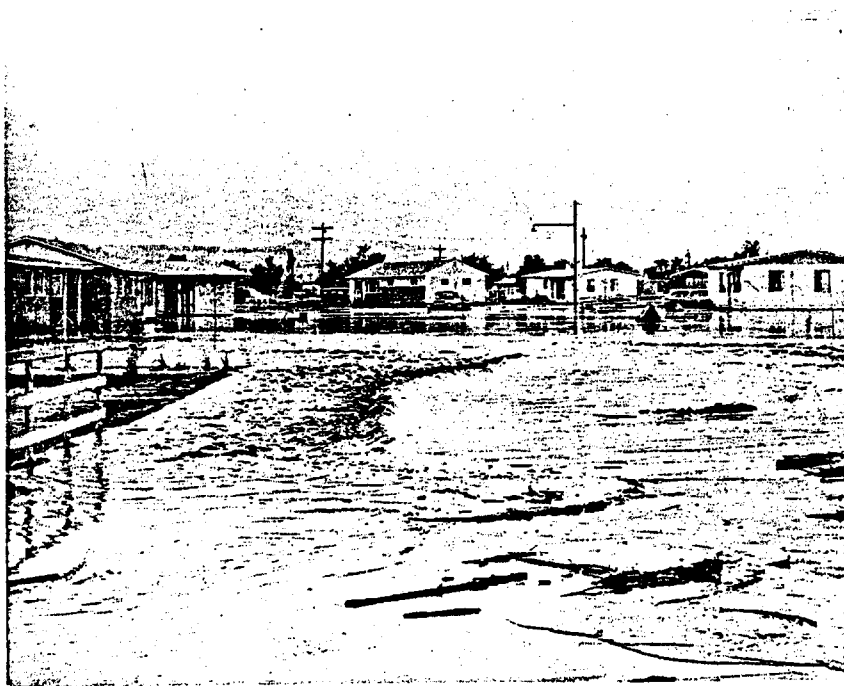


Photo 1. - Kennedy Court. Street, yard and residential flooding. Late afternoon, June 6, 1958. (Daily Sentinel Photo).



Photo 2. - Kennedy Court. Morning after storm, June 7, 1958. (Daily Sentinel Photo).

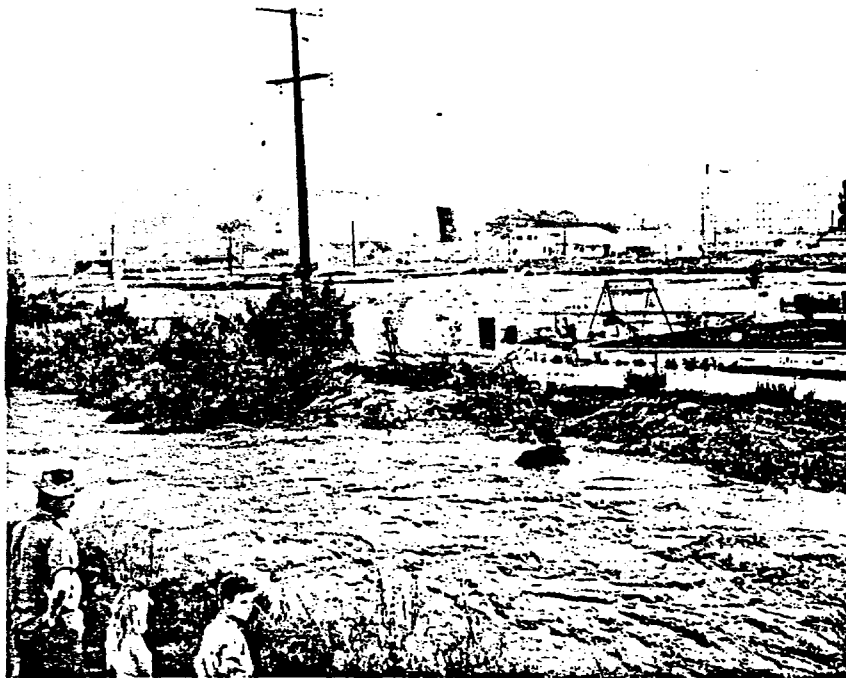


Photo 3. - Indian wash flood channel and overflow area looking southwest into Grand Junction. -Buildings are along North Avenue. June 6, 1958. (Daily Sentinel Photo).

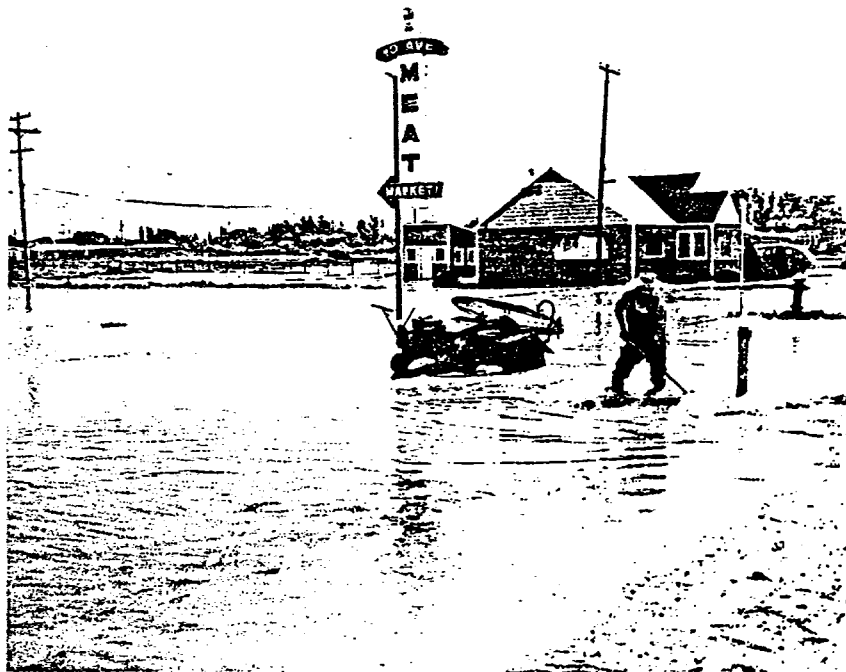


Photo 4. - North Avenue looking northeast opposite of Photo 3. Morning after storm of June 6, 1958. Cleaning of storm sewers. (Daily Sentinel Photo).

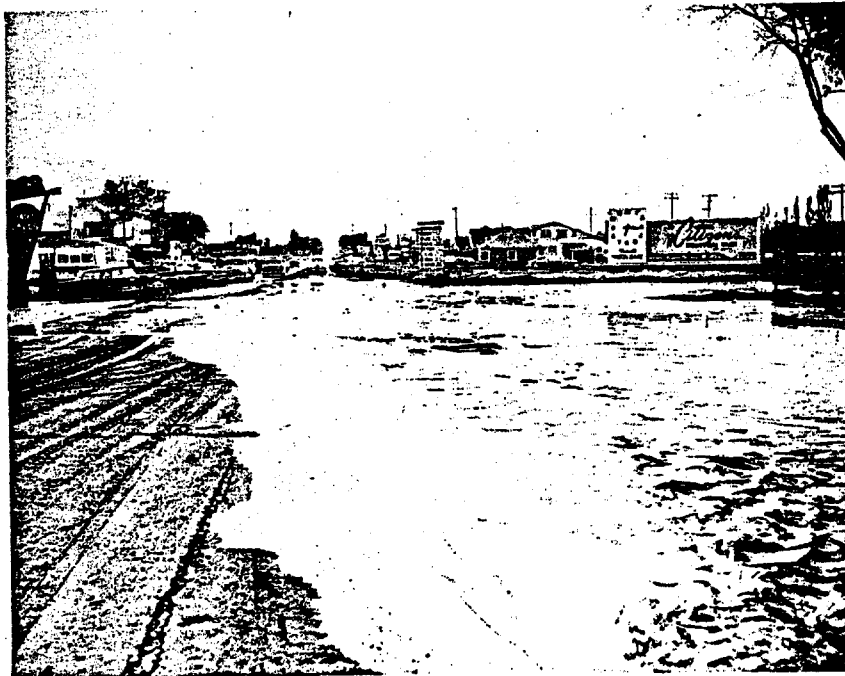


Photo 5. - Beginning of flood to the west along North Avenue. Storm of June 6, 1958. Time: 6:15 P.M. (Daily Sentinel Photo).



Photo 6. - Same building as shown in Photos #4 and 5. The afternoon following the storm. Lawn and sidewalk buried under sediment and other debris that washed in. (SCS Photo).

In the area downstream from the High Line Canal, the channel of Indian Wash is comparatively stable for the average annual peak flow. Little or no degrading of the channel is taking place, mainly because of the presence of culverts and concrete bridge sills. In the upper and lower reaches through this area, the channel is underlain by coarse gravel layers, which tend to resist degradation. Minor amounts of bank cutting occur locally along the channel during the larger flood flows.

Problems Relating to Water Management

There has been no expression of interest in obtaining water storage facilities within the watershed area for irrigation, municipal, or industrial uses or for recreation and wildlife purposes. The Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service, studied the watershed and made the following observation in a report dated January 13, 1960: "Based on our knowledge of the area and proposed developments, we believe that fish and wildlife resources will not be significantly affected. The project offers no appreciable opportunities for fisheries development, or for wildlife improvement."

The irrigated lands in the watershed are served by the High Line Canal, the Grand Valley Canal, the Mesa County Canal, and the Stub Ditch. These canals, together with a fairly extensive system of open drainage ditches, provide a good level of irrigation water management and high crop yields. With the increasing urbanization of the irrigated cropland, the principal water management need is for additional land treatment measures, similar to those now being applied.

EXISTING OR PROPOSED WORKS OF IMPROVEMENT

Indian Wash Watershed lies within the Upper Grand Valley Soil Conservation District. The District and its cooperators are actively carrying out a soil and moisture conservation program with technical assistance furnished by the Soil Conservation Service. Basic conservation plans have been prepared on 17 operating units containing approximately 50 percent of the irrigated cropland within the watershed. The public rangeland constituting the major portion of the upper watershed area is under the jurisdiction of the U. S. Bureau of Land Management and as such has a continuing program of soil and moisture conservation.

The City of Grand Junction, the Colorado Department of Highways, Mesa County, and the Grand Junction Drainage District have been working jointly to improve the channel of Indian Wash downstream from the Grand Valley Canal in order to immediately reduce the added flood hazard resulting from channel constrictions which were the principal points of overbank flow during the flood of June 6, 1958. Between the Grand Valley Canal and the railroad, there were several constrictions where the channel had less capacity than the maximum capacity (1,000 cubic feet per second) of the culvert passing under the railroad classification yard.

Investigation of the railroad culvert during preliminary planning determined that enlargement or replacement was not feasible because of the prohibitive costs involved. No proposal has been put forth by any agency for the enlargement of the railroad culvert. Therefore, the group doing the channel improvement has concentrated on removing channel constrictions and making other channel improvements between the Grand Valley Canal and the railroad, so that this reach will have a minimum capacity equivalent to the maximum capacity of the railroad culvert. In addition, this group plans to increase the channel capacity downstream from the railroad culvert to about 1,200 cubic feet per second in order to handle any additional floodwater inflow to this reach up to 200 cubic feet per second from the existing borrow ditches and open drains.

Since June 1958, approximately \$30,600 has been spent for: (1) cleaning and shaping of the channel between the Grand Valley Canal and North Avenue; (2) building revetments at two right-angle channel turns along Orchard Road; (3) installing a new highway culvert at North Avenue; and (4) replacing the Mesa County Canal flume. The remaining work, which will be completed prior to July 1962, involves an estimated \$43,000 for: (1) riprapping channel banks in a reach about 1,300 feet long between Orchard Avenue and the Elm Avenue bridge; (2) replacing the Kennedy Avenue bridge; (3) cleaning the channel from North Avenue to the railroad to obtain 1,000 c.f.s. capacity and (4) cleaning the channel to obtain 1,200 c.f.s. capacity from the railroad to the Colorado River.

This improvement group plans to operate and maintain the channel in its improved condition as a flood prevention facility.

The City of Grand Junction has recently created a Department of Development to carry forward planning for future development areas in and adjacent to the city. This planning, together with existing city ordinances, will provide a sound basis for future regulation of storm drainage, storm sewer, and sanitary sewer requirements in both existing and new subdivisions within the watershed area.

The presently proposed location of Interstate Highway 70 crosses Indian Wash about 700 feet upstream from and parallel to the High Line Canal. If the proposed watershed project is approved for construction and final designs are made prior to those of this section of Interstate Highway 70, a definite saving can be made in the size of culverts for the highway at Indian Wash. The proposed highway grade is about six feet above the normal ground and will have some retarding effects on flood peaks into the High Line Canal.

There are no proposals under consideration at the present time involving any major changes in structures or methods of operations of the High Line Canal or the Grand Valley Canal. A study has been made by the Bureau of Reclamation regarding the possibility of irrigating lands extending both east and west from the Grand Junction municipal airport by pumping from the High Line Canal. It is not anticipated that the proposed watershed project would affect this possible irrigation unit.

At the time joint preliminary studies of the Indian Wash Watershed were being made by the U. S. Corps of Army Engineers and the U. S. Soil Conservation Service, the Corps of Engineers evaluated a flood prevention program depending primarily upon the installation of a much larger floodway channel on Indian Wash. Such a program was determined not to be economically feasible because of the high costs involved in replacing bridges and culverts to carry the higher capacity. The Corps of Engineers discontinued further studies and recommended that the Soil Conservation Service continue the evaluation of flood prevention by floodwater-retarding structures.

There are no other existing or proposed works of improvement of other agencies that would affect or be affected by the measures proposed in this plan.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures for Watershed Protection

The U. S. Bureau of Land Management has jurisdiction of the Federal rangelands that constitute 87 per cent of the watershed area above the High Line Canal. This land, consisting of 5,735 acres, is a part of the Bureau of Land Management Grand Junction District's Mount Garfield Grazing Unit. Prior to the passage of the Taylor Grazing Act of 1934, this area had been traversed by the old Utah-Colorado stock driveway and was all but depleted of forage resources and subjected to intensive erosion.

Studies made by the Bureau of Land Management indicate that an excessive amount of time would be necessary to effect vegetative changes by restrictive use. This would apply in particular to the time required for such changes to have a significant effect on runoff and sediment production in an area of poor soil and low precipitation such as this. The Bureau of Land Management, therefore, believes that emphasis should be placed on the application of the more enduring types of land treatment measures, which will also act immediately to reduce excessive runoff and erosion damage to the land. A two-year land treatment installation program is proposed and will consist of the construction of retention reservoirs (stock water ponds), diversions, and check dams, as well as fencing and some range seeding. These measures will permit proper management, improve vegetative conditions, and reduce the amount of sediment delivered to downstream areas.

Of the privately-owned rangelands in the watershed, 650 acres lie above the High Line Canal, and 580 acres are below. These lands are mostly in small tracts. They generally have flatter slopes, and erosion is not as serious a problem as on the Federal rangelands. The principal land treatment measure to be applied over a three-year period is "proper range use." Continuance of this practice will assure improvement, protection, and maintenance of vegetative cover.

On the 1,260 acres of privately-owned irrigated cropland, an accelerated three-year program is proposed for: (1) the establishment of such practices as improved water application, crop residue use, and fertilizing; and (2) the installation of conservation cropping systems, pasture planting, land leveling, ditch lining, irrigation pipelines, open ditch structures, and tile drains. These measures are essential for the continued successful conservation operation of the land and will improve forage stands and crop production, as well as reduce local runoff and sediment production.

On-site benefits from land treatment measures on privately-owned lands were not claimed for project justification (Table 1).

The quantities of land treatment planned for installation during the project period by the Bureau of Land Management and by the owners or operators of private lands are shown in Table 1. The total estimated cost of planning and installing these measures is \$93,130.

Figure 2 shows the enduring type of land treatment measures to be installed on Federal lands by the Bureau of Land Management.

Structural Measures for Flood Prevention

This work plan proposes the installation of one floodwater-retarding structure (IW-1) on Indian Wash at a point about two miles upstream from the High Line Canal (Figure 4). It will be located on desert rangeland mostly under Federal ownership. This structure in combination with the controlling effects of the High Line Canal and the existing Indian Wash channel will afford an adequate level of flood protection to the area now subject to damage.

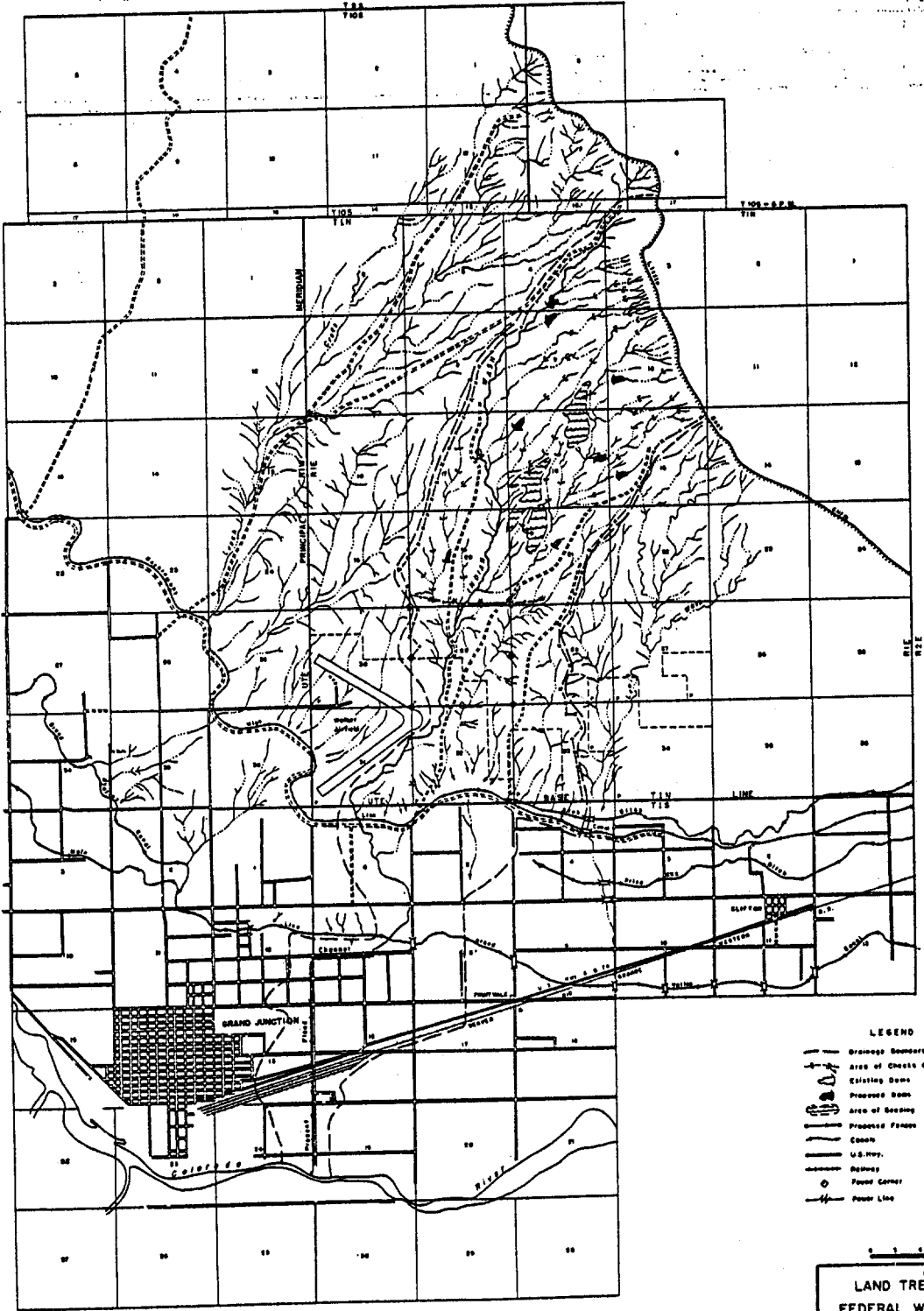
The proposed floodwater-retarding structure will control runoff from 6.53 square miles or nearly 64 per cent of the flood-producing area above the High Line Canal. The structure will provide floodwater detention storage for three inches of runoff from the area controlled. This provides enough capacity to control the runoff from storm rainfall intensities greater than the 100-year frequency storm event.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST

Indian Wash Watershed, Colorado

Item	Unit	No. to be Applied	Estimated Cost (Dollars) 1/		
			P. L. 566 Funds	Other Funds	Total
LAND TREATMENT MEASURES					
Watershed Protection					
Soil Conservation Service (Non-Federal Land)					
<u>Irrigated Cropland</u>					
Conservation Cropping System	Acre	250		375	375
Crop Residue Use	Acre	120		150	150
Fertilizing	Acre	250		2,500	2,500
Pasture Planting	Acre	60		1,500	1,500
Land Leveling	Acre	125		5,625	5,625
Ditch Lining	L.Ft.	12,000		13,800	13,800
Irrigation Pipelines	L.Ft.	5,280		5,500	5,500
Improved Water Application	Acre	200		800	800
Open Ditch Structures	Number	40		1,600	1,600
Tile Drains	Mile	.5		3,120	3,120
<u>Rangeland</u>					
Proper Range Use	Acre	1,086		1,630	1,630
Technical Assistance			3,000	7,000	10,000
SCS Subtotal			3,000	43,600	46,600
Bureau of Land Management (Federal Land)					
<u>Rangeland</u>					
Fencing	Mile	10	14,080		14,080
Reservoir-Retention	Number	7	4,675	1,870	6,545
Diversions & Check Dams	Cu.Yds.	82,000	16,420		16,420
Seeding	Lbs.	7,500		2,625	2,625
Technical Assistance			5,355	1,505	6,860
BLM Subtotal			40,530	6,000	46,530
TOTAL LAND TREATMENT			43,530	49,600	93,130
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater-Retarding Structure	Each	1	303,168		303,168
Subtotal - Construction			303,168		303,168
<u>Installation Services</u>					
Engineering Services			42,444		42,444
Other			42,444		42,444
Subtotal - Installation Services			84,888		84,888
<u>Other Cost</u>					
Land, Easements and Rights-of-Way				380	380
Administration of Contracts				600	600
Subtotal - Other				980	980
TOTAL STRUCTURAL MEASURES			388,056	980	389,036
TOTAL PROJECT			431,586	50,580	482,166
SUMMARY					
Subtotal - SCS			391,056	44,580	435,636
Subtotal - BLM			40,530	6,000	46,530
TOTAL PROJECT			431,586	50,580	482,166

1/ Price Base: 1961 Price Levels



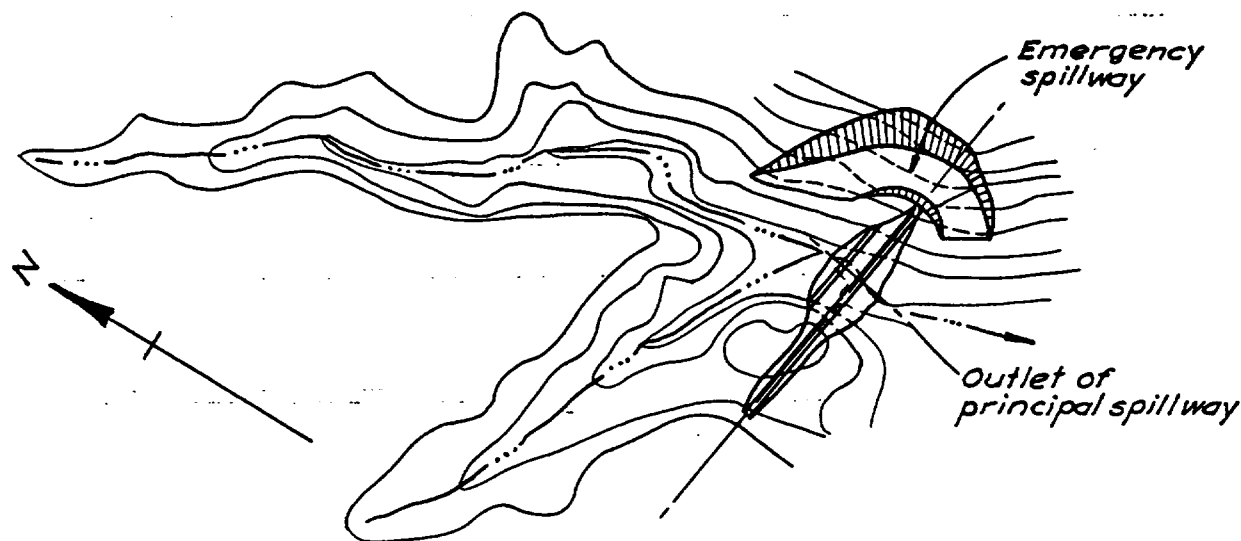
- LEGEND**
- Drainage Boundary
 - Area of Check & Diversion
 - Existing Dam
 - Proposed Dam
 - Area of Seepage
 - Proposed Fence
 - Canal
 - U.S. Hwy.
 - Railway
 - Power Corner
 - Power Line

Scale 0 1 2 3 4 5 Miles

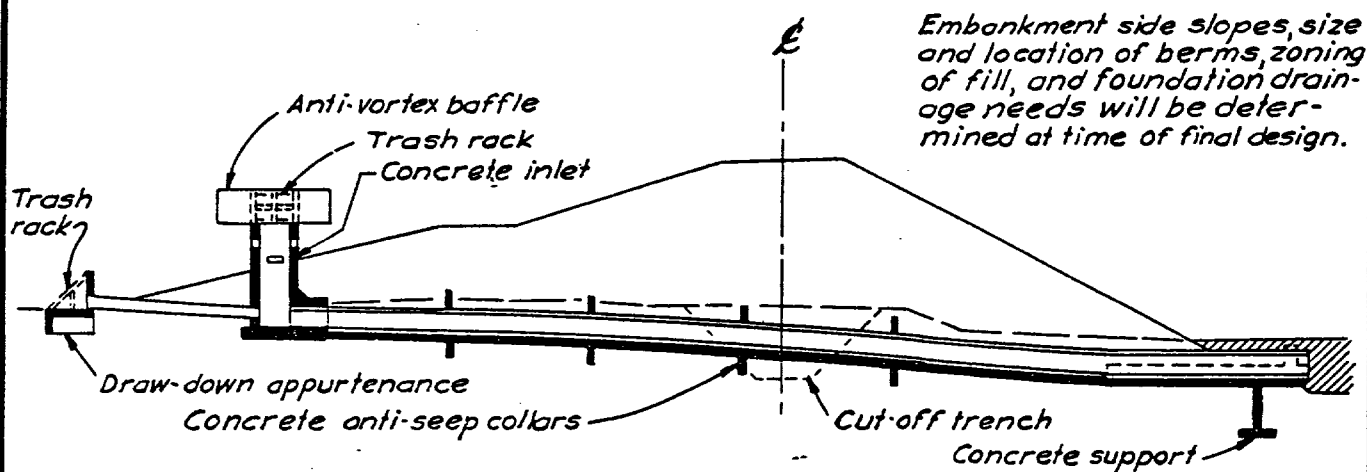
FIGURE 3
LAND TREATMENT PROGRAM
FEDERAL WATERSHED LAND TREATMENT PROGRAM
MESA COUNTY COLORADO
 UNITED STATES DEPARTMENT OF THE INTERIOR
 BUREAU OF LAND MANAGEMENT

Compiled by	Checked by	Date	Drawn by
W. C. Brown	R. L. Anderson	July 23, 1954	W. C. Brown

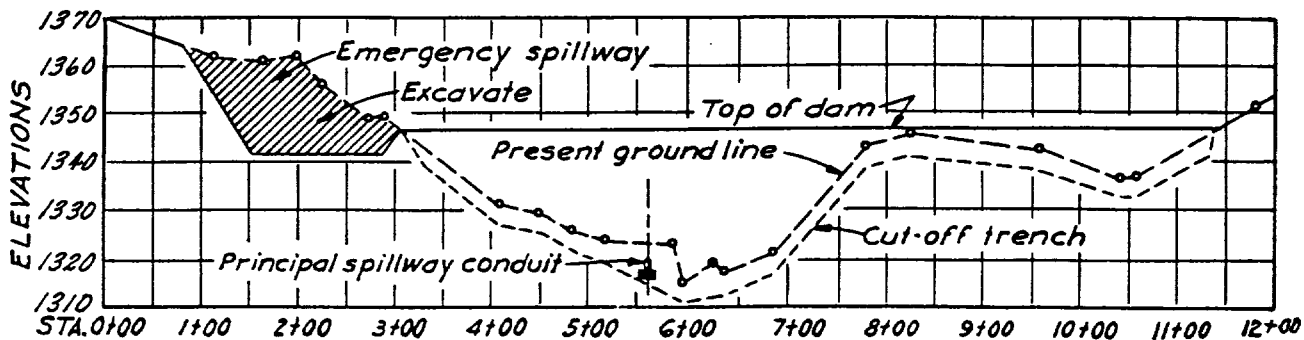
TYPICAL FLOODWATER RETARDING STRUCTURE



GENERAL PLAN



CROSS SECTION OF DAM ALONG Q-Q OF PRINCIPAL SPILLWAY



PROFILE ALONG Q-Q OF DAM

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
COLORADO

Figure No. 3

5.L-16,600

The total storage capacity of the structure will be 1,615 acre-feet, of which 1,045 acre-feet will be allotted to flood detention storage. In addition, 570 acre-feet of storage will be provided for the accumulation of sediment estimated to occur over a 50-year period. This is equivalent to 1.64 inches of sediment.

The principal spillway is an ungated concrete outlet conduit installed through the dam at channel grade and no storage other than sediment will occur in the reservoir.

The remaining 36 percent of the watershed area above the High Line Canal contains 3.75 square miles. The High Line Canal presently has adequate freeboard capacity below the crest of the high spoil bank to have a retarding effect on the runoff from this area in all storms up to about a 100-year frequency storm.

The sponsors have been working since the flood of 1958 to eliminate all channel restrictions in the Indian Wash channel and provide a uniform capacity equal to that of the culvert under the Denver and Rio Grande Western Railroad bridge. This capacity is about 1,000 cubic feet per second.

The release rate from the structure through the principal spillway when the reservoir is full to the level of the west emergency spillway is 211 c.f.s. However, the average release rate is 169 c.f.s. This rate will empty the floodwater-retarding pool from such a storm in three days.

The structure will be a rolled earth-fill dam with an ungated concrete principal spillway. Emergency spillway release will be provided by shaped earth section through the west abutment. It will be seeded to grass and designed to carry the maximum six-hour storm. (See Table 3 and additional data in Section 2). The total estimated cost of installing the structural works of improvement is \$389,036. The cost distribution is shown in Table 2.

A typical floodwater-retarding structure is shown on Figure 3.

BENEFITS FROM WORKS OF IMPROVEMENT

The floodwater-retarding structure IW-1 will provide a high level of protection to the lands and improvements in the area subject to damage. The peak discharge runoff from the 100-year frequency storm from the unreservoired area above the High Line Canal plus the principal spillway discharge from the structure will not exceed the flood channel capacity through Grand Junction. However, occasionally runoff from the uncontrolled area below the High Line Canal may combine with the above flows and reduce the above benefits by causing minor overbank flooding along the Indian Wash channel and backwater ponding and sediment damage along portions of North Avenue beginning about the fifty-year frequency storm. Minor damage from overland flows and local runoff may occur in ponding areas in the commercial area along the lower Highway 6-24 and the railroad grades at about the twenty-year frequency storm. These areas of remaining damages are shown on the Flood Damage Map, Figure 1.

With the project installed a recurrence of the storm of June 6, 1958, would produce no damages.

Flooding of floodplain lands will be reduced to that caused by local runoff, with the area flooded and the frequency of flooding greatly reduced. The floodplain area subject to flooding will be reduced from 2,500 acres to 450 acres with the project installed. On the basis of 2,050 acres benefited, the cost of the floodwater-retarding structure per acre benefited is approximately \$190.

The land use in the floodplain area is about 60 percent urban and commercial and 40 percent suburban, of which the suburban area is estimated to be about 65 percent agricultural and 35 percent miscellaneous. The cropping pattern used for the composite acre for the irrigated lands are:

<u>Crop</u>	<u>Percent</u>
Alfalfa	35.5
Corn	28.1
Irrigated Pasture	12.5
Small Grain	14.7
Truck Crop (Tomatoes)	2.2
Orchard (Peaches)	7.0
Total	100.0

With the project, the areas where backwater ponding may cause minor floodwater and sediment damages are primarily commercial in nature. The clean-up of sediment from streets, roads, loading areas, and lawns will be the principal cost because nearly all of the commercial buildings in these areas are built up above the depths of damaging ponding.

From an irrigation standpoint, the sporadic flows from Indian Wash have little value locally. The watershed project will reduce flood peaks in the Indian Wash channel and eliminate the possibility of a recurrence of interruption of irrigation services from damages to the Grand Valley Canal. There are approximately 37,380 acres of irrigated land serviced by this canal system. Since this canal is designed to operate under continuous flow capacity, any damage to the canal will necessitate emptying of the entire system until repairs are made. The flood history of this area indicates that nearly all high intensity storms occur during the crop season. Therefore, any interruption of irrigation services will be serious.

The estimated average annual damages of \$4,016 due to delay in water delivery through damage to the Grand Valley Canal without the project are eliminated with the proposed works of improvement.

The estimated average annual floodwater, sediment, and indirect damage in the watershed amounts to \$25,615. Land treatment measures to be installed will reduce these damages to \$24,465 or a reduction of approximately 4.5 percent. The structural measures will further reduce the remaining damages to \$1,725 or a reduction of approximately 89 percent.

Annual flood prevention benefits accruing to the floodwater-retarding structure are \$14,905 as a result of reduction of floodwater damages, \$5,555 from sediment damage reduction, and \$2,280 from reduction of indirect damages.

In addition to the above benefits there are secondary and intangible benefits that accrue to the project. Although not evaluated in monetary terms, a high level of flood protection to human life and property has a value to the individual and to this rapidly growing community. In addition, labor saved from clean-up and repair of flood damages can be utilized for the productive and professional services normally available to the community.

COMPARISON OF BENEFITS AND COSTS

The total estimated installation cost for the floodwater-retarding structure is \$389,036. This cost when amortized over a fifty-year period at 2 5/8 percent interest results in an annual equivalent cost of \$14,060. The average annual cost of operation and maintenance is estimated at \$2,387, making a total average annual cost of \$16,447 (Table 6).

When the project is completely installed and operating, the estimated average annual primary benefits will amount to \$22,740 (Table 7). The ratio of the average annual primary benefits to the average annual cost is 1.38 to 1.00.

ACCOMPLISHING THE PLAN

Federal assistance for carrying out the works of improvement described in this plan will be provided under authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, 68 Stat. 666), as amended. The Soil Conservation Service, the Bureau of Land Management, and other Federal, State, and private agencies concerned will assist the sponsors in the establishment of the works of improvement.

The concerned field offices of the land administering agencies of the Department of Interior have concurred in the features of the plan relating to land under the jurisdiction of the Department of Interior.

Table 1 gives the project installation costs. Estimated funds needed each year of the project period are as follows:

	<u>Public Law 566</u>	<u>Other Funds</u>
First Fiscal Year	\$ 49,557	\$ 12,475
Second Fiscal Year	\$310,729	\$ 11,945
Balance of Project	\$ 71,300	\$ 26,160
Total Project	\$431,586	\$ 50,580

The Extension Service will carry out the educational phase of the program through local meetings and public information channels. Particular stress will be directed toward encouraging the application of those land treatment measures which are particularly effective in reducing erosion and sediment damage.

Land Treatment Measures

The land treatment measures for watershed protection itemized in Table 1 will be applied on privately-owned agricultural lands and on Federal rangelands. The measures on privately-owned lands will be installed over a three-year period by farmers and ranchers in cooperation with the Upper Grand Valley Soil Conservation District. The cost of applying these measures will be borne by the owners and operators of the land. It is expected that they will be reimbursed for a portion of this cost through the Agricultural Conservation and other applicable Federal programs. Technical assistance for the planning and installation of the needed land treatment will be provided by the Soil Conservation Service through the Upper Grand Valley Soil Conservation District.

An accelerated program of land treatment on Federal rangelands will be installed over a two-year period by the U. S. Bureau of Land Management. The cost of applying these measures will be borne by Public Law 566 funds and regular funds available to the Bureau of Land Management. Technical assistance for the planning and installation of the measures will be provided by the Bureau of Land Management with Public Law 566 funds providing for the acceleration of technical assistance.

Structural Measures

The floodwater-retarding structure IW-1 will be installed by contract let by the City of Grand Junction, who will be the contracting local organization and will assume all duties and responsibilities as required by the Act. Construction will be started when Federal funds are available and the sponsors have: (1) obtained and recorded necessary land easements or deeds; (2) executed project agreement for construction of the works of improvement; and (3) executed proper maintenance and operation agreements. It is expected that the structural measures will be installed and operating by the end of the third year following project approval.

The two-year program of land treatment installation proposed by the Bureau of Land Management assures compliance with the provisions of the Act requiring that not less than 75 percent of the required land treatment measures will be installed or their installation commenced on any sediment source or excessive runoff areas that constitute a serious hazard to the satisfactory design, operation, or maintenance of the proposed structure.

Mesa County and the City of Grand Junction will provide the necessary funds for the costs involved in the administration of the construction contract (\$600) and in obtaining land, easements, and rights-of-way (\$380). Most of the land to be occupied by proposed structure IW-1 is Federal rangeland under the jurisdiction of the Bureau of Land Management, and as such will be provided without cost. The remaining easements on privately-owned land will be acquired by Mesa County and the City of Grand Junction under existing authority. The legal costs involved are estimated at \$100.

The services of technical specialists will be provided by the Soil Conservation Service to assist in designing structures, preparing and interpreting plans and specifications, checking and assisting in issuance of bids, supervising construction, preparing contract payment estimates, making final inspections, executing certificates of completion, and performing related duties in the establishment of the proposed floodwater-retarding structure.

The City of Grand Junction will be the contracting local organization.

A written agreement will be entered into between the Commissioners of Mesa County, the City of Grand Junction, and the Supervisors of the Upper Grand Valley Soil Conservation District, as sponsors, outlining the responsibilities that each organization will assume in connection with the installation and proper functioning of the project.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

The land treatment measures for watershed protection on privately-owned lands will be maintained by the individual landowners or operators of the farms and ranches on which the measures are applied under agreement with the Upper Grand Valley Soil Conservation District. Representatives of the District and the Soil Conservation Service will make periodic inspections of the land treatment measures to determine maintenance needs and will encourage owners and operators to perform necessary maintenance.

The land treatment measures installed on Federal rangelands will be maintained by the Bureau of Land Management. Funds for this will be other than those provided by Public Law 566.

Structural Measures

The floodwater-retarding structure IW-1 will be operated and maintained by the sponsors. The structure will be inspected at least once each year prior to the thunderstorm season and after each heavy rain or streamflow to determine maintenance needs.

These inspections will be made by representatives of the sponsors and the Soil Conservation Service. Items to be inspected will include: the principal spillway, riser ports, and trash rack; the emergency spillway; the earth-fill; and fences and gates installed as a part of the structure. Written reports will be prepared itemizing the maintenance needs, and a record will be kept by the sponsors showing completion of recommended maintenance with copies provided to the Soil Conservation Service and to the Colorado State Engineer.

Although the Indian Wash flood channel is not a project work of improvement, it is a definite part of the planned flood prevention program and, as such, the sponsors will be responsible to keep the channel in safe operating condition at all times. To accomplish this the Indian Wash channel will be subject to the same inspection and repair procedures as set up for the floodwater-retarding structure with the sponsors providing an annual operation and maintenance fund of \$500 for this purpose.

The estimated average annual operation and maintenance cost for structure IW-1 and the Indian Wash channel totals \$2,387. Funds and equipment for carrying out the necessary operation and maintenance are available through the allocation of a portion of the annual funds presently derived through the normal taxation powers of Mesa County and the City of Grand Junction. The sponsors understand their obligations for operation and maintenance and will execute specific operation and maintenance agreements with the Soil Conservation Service prior to the issuance of invitations to bid.

COST SHARING

The total estimated project cost is \$482,166, of which the Public Law 566 share is \$431,586. Funds from other sources will be \$50,580 and include local funds, as well as funds available under other Federal authority.

The cost of the land treatment measures to be applied as part of the project is estimated to be \$93,130. The cost of land treatment on the Federal rangelands is estimated to be \$46,530. The Public Law 566 share will be \$40,530 and other funds will amount to \$6,000. The cost of land treatment on privately-owned lands is estimated to be \$46,600. The Public Law 566 share will be \$3,000, and \$43,600 will be obtained from other funds. Cost-sharing assistance from other applicable Federal programs will be utilized in applying the land treatment measures.

The cost of the floodwater-retarding structure is estimated to be \$389,036, of which \$388,056 will be paid from Public Law 566 funds. This includes the cost of installation services estimated to be \$84,888. The required local or other cost, consisting of the cost of land, easements, and rights-of-way and the cost of administering contracts, is estimated to be \$980. In addition, local interests will provide the cost of operation and maintenance, estimated at \$2,387 annually.

CONFORMANCE OF PLAN TO FEDERAL AND STATE LAWS AND REGULATIONS

This project plan conforms to all Federal and State laws and regulations and will have no known detrimental effects on any downstream project that might be constructed in the future. No new land will be brought into agricultural production as a result of this project.

SECTION 2

INVESTIGATIONS, ANALYSES, AND SUPPORTING TABLES

INVESTIGATIONS AND ANALYSES

Project Formulation

The primary objective of this plan is to provide floodwater and sediment protection to: (1) the City of Grand Junction, (2) the surrounding public, commercial, and suburban developments, (3) the agricultural lands in the floodplain, and (4) public and private utilities, roads, and railroads.

The most satisfactory solution to achieve the stated objectives provides for: (1) the installation of one floodwater-retarding structure located about 1 1/2 miles above the High Line Canal which marks the approximate upper limits of the damage area, (2) utilization of the floodwater-retarding effects of the High Line Canal, (3) utilization of the improved section of the Indian Wash flood channel through the floodplain area, (4) the application of land treatment measures on the publicly-owned lands in the drainage area above the floodwater-retarding structure, and (5) the application of land treatment measures on the publicly and privately-owned agricultural lands that are above the principal floodplain damage areas.

The optimum and minimum levels of flood protection were agreed upon at a meeting between representatives of the Corps of Engineers, Los Angeles District, and the Soil Conservation Service. Following this meeting the kinds and intensities of studies to be undertaken during the preliminary planning stages along with project objectives were arrived at in a planning conference with members of the Lincoln Engineering and Watershed Planning Unit.

The preliminary studies were a joint investigation by the technicians of the Los Angeles Office of the U. S. Corps of Army Engineers and the U. S. Soil Conservation Service. The Corps obtained channel, bridge, and economic data in the agricultural and urban areas below the High Line Canal and the Soil Conservation Service obtained data on three possible dam sites on the rangelands above the High Line Canal. The Corps combined the joint study and cost data and made a letter report to the Soil Conservation Service

dated September 28, 1960. The Corps found that a flood prevention program depending primarily upon the enlargement and improvement of the Indian Wash flood channel could not be justified because of existing low capacities which would require replacement of: nine road bridges, two freeway (highway) bridges, and a railroad culvert about 600 feet long.

The letter report by the Corps of Engineers recommended that one of the alternative plans studied involving a single dam and reservoir on the mainstem of Indian Wash above the High Line Canal appeared to be the best plan that could be devised for flood protection along this stream and that this plan should be made the subject of detailed study by the Soil Conservation Service.

As a result of this letter report, the proposed program for further study was presented to the sponsors and received their approval. The sponsors expressed their wishes for more detailed information on this proposal. The Soil Conservation Service proceeded with the detailed planning.

In analyzing the structure for the desired flood detention capacity, consideration was given to providing the maximum capacity that would provide the desired level of protection consistent with economic justification (see maps, Figures 1 and 4).

The damage evaluations for present conditions were based on conditions without the improved Indian Wash flood channel. Damage evaluations with project conditions were based upon the improved capacity of the Indian Wash flood channel which is now in the process of completion by the sponsors.

The maximum rainfall recorded during 67 years of record at the Weather Bureau Station at Grand Junction occurred September 1896 when 3.03 inches were measured.

The selected flood detention capacity of the reservoir is 1,045 acre-feet. This storage equals three inches of runoff that might be expected from a 4.1-inch rainfall occurring in a six-hour period.

The selected structure provides storage at a minimum cost per acre-foot. The structure as planned will retard and by-pass through its spillways without overtopping the probable maximum six-hour storm.

The results of the investigations and analyses were presented to the sponsors for final acceptance. A watershed-wide meeting was held by the sponsors for review of the final watershed plan. It was determined that the proposed project meets the objectives of the sponsors.

Hydraulic and Hydrologic Investigations

Hydrologic investigations were related to the probability of various flood magnitudes and to the location and area of resulting damage. This relationship supported the economic justification of the recommended plan. Approved standard Service criteria and methods were used on hydrologic development.

Flood-producing storms in the Indian Wash area are characterized by local, high intensity, short duration storms that increase in intensity along the Little Book Cliffs. The hydrologic studies and flood damage evaluation for Indian Wash were based on the above characteristic storms having increasing rainfall depths with increasing elevation. This resulted in a design storm for floodwater-retarding storage ranging from 3.2 inches depth in the lower portion of the watershed, near Grand Junction, up to 4.6 inches at the upper extremity of the watershed, along the face of the Little Book Cliffs. It produced a weighted storm depth of 4.1 inches resulting in 3 inches of runoff to storage.

Rates of discharge, on which economic evaluation was determined, were based on this distribution of storm, according to elevation.

A rainfall record of 67 years was available for the Grand Junction station at the time of study. This record of rainfall was related to frequency and converted into six-hour amounts.

The result of this study is as follows:

<u>Frequency</u>	<u>Precipitation 6-Hr. Amounts</u>
100-year	2.4 inches
50-year	1.8 inches
25-year	1.5 inches
10-year	1.1 inches
5-year	0.8 inch

There are no streamflow records for the Indian Wash Watershed. The floodplain common to Indian Wash and the Colorado River is not classed as a damage area in this study.

A June 1958 flood on Indian Wash was the most recent flood of record. A depth of 0.63-inch of precipitation in 80 minutes was measured by the Weather Bureau at the airport. An estimated 2.2 inches of precipitation uniformly distributed over the watershed would be necessary to produce the estimated peak flow of 2,700 c.f.s. at the High Line Canal. This indicates that the rainfall was definitely much greater in the watershed area along the Little Book Cliffs than was recorded at the airport.

Runoff characteristics of the watershed above the High Line Canal were compared to the watershed area of Badger Wash. The Badger Wash study area is a project of the Pacific Southwest Inter-Agency Committee with four Federal agencies as active participants in the study. These include the U. S. D. A. Forest Service Rocky Mountain Forest and Range Experiment Station; and the Department of Interior Geological Survey, Bureau of Land Management, and Bureau of Reclamation. Badger Wash is approximately 30 miles northwest of Grand Junction and has runoff characteristics similar to those of Indian Wash. The Bureau of Land Management developed a map of the upper area of Indian Wash showing the range, site, and condition. The result of these studies determined that the soil-complex number for the area above the High Line Canal was 90 for both present and future conditions. The amount of roof tops and paved streets below the High Line Canal resulted in the selection of a soil-cover complex number of 93 for urban areas.

The floodwater storage of IW-1 was based on a storm of greater magnitude than a 100-year frequency with 4.10 inches of precipitation in six hours producing an average of 3.00 inches of runoff from over the watershed.

Triangular hydrographs were developed and used in flood routing. Time of concentrations for these and other hydrographs were based on bankfull velocity for channels and experiment station results for overland flow.

Stage-discharge relationship for the High Line Canal was based on water surface profiles as developed by use of Leach's method. Flood routing along the High Line Canal was accomplished by use of the stage-storage indication method.

Indian Wash channel and bridge capacities below the High Line Canal were based on stage discharge curves developed by the U. S. Corps of Army Engineers in their preliminary studies. These were checked and found suitable by the Soil Conservation Service for use in detailed planning.

Flood routings were made on: (1) present condition, (2) future condition with land treatment only, and (3) future condition with land treatment and structures.

Each city block in the floodplain was considered as an evaluation reach. Four peak rates of flow were associated with a dollar-damage for each section along the floodplain and this information was then used to construct discharge-damage curves for evaluation.

The routing reaches in these studies were based upon the known pattern of in-channel and overbank flow that occurred in the June 1958 flood. Beginning at the High Line Canal, the floods were routed downstream to each successive channel restriction, collecting enroute the appropriate local inflow. All flows within the watershed were thus accounted for and routed through the project area for each flood condition.

The reservoiring effect of the High Line Canal was determined by calculating its capacity over and above the normal flow of 600 c.f.s. of irrigation water by water surface profiles. Flood routing then determined the frequency at which overtopping would occur. An additional reservoiring effect will be gained when the new Interstate Highway that will cross the watershed parallel to and just north of the High Line Canal is completed.

Benefits from the proposed land treatment measures were evaluated to the extent in which floodwater and sediment storage could be reduced.

The emergency spillway of structure IW-1 was designed to pass the freeboard hydrograph (7.5" of point precipitation = 5.6" of runoff) without overtopping the dam. For comparison, the maximum probable amount of point precipitation for Indian Wash as determined by use of hydrologic data developed by the U. S. Weather Bureau for the U. S. Bureau of Reclamation's nearby Blue Mesa Project was 7.2 inches.

The IW-1 reservoir will fully contain the volume of the spillway hydrograph (3.0" of point precipitation = 1.71" of runoff) without the emergency spillway operating.

Sedimentation Investigations

No previous records of sediment production were available for the area included in the Indian Wash Watershed. Sedimentation rates at the proposed floodwater-retarding reservoir site were based on rates that have been measured by the U. S. Geological Survey in the nearby experimental Badger Wash Watershed and on the results of a reservoir sediment survey made at an old reservoir in the upper part of the Indian Wash drainage area.

The Badger Wash Watershed is located 8 miles northwest of Mack, Colorado, in an area very similar to parts of the Indian Wash drainage area. Measurements on 18 small reservoirs (installed by the Bureau of Land Management) in the Badger Wash Watershed showed an average annual sedimentation rate of 2.1 acre-feet per square mile. The period of record was five years.

The old reservoir in which sediment was measured as a part of the investigations is located on the west fork of Indian Wash. The drainage area above this reservoir is 1.75 square miles. The reservoir was constructed by the Civilian Conservation Corps and had been in operation for 23 years at the time of the survey. A total accumulation of 34 acre-feet of sediment was measured, giving an annual rate of 0.85 acre-foot per square mile. Since this reservoir is now filled with sediment to within six inches of the top of the dam, it is assumed that considerable quantities of sediment have been carried past the dam during the period of record.

The source of sediment produced by erosion in the Indian Wash drainage area above the proposed reservoir is estimated to be about equally divided between sheet and small gully erosion and channel cutting. Sheet and gully erosion are highest on the bare shale slopes, which are present over a large part of the area. Channel cutting is most significant along the larger drainages, most of which are in the process of additional bank cutting through old floodplain areas.

In computing future rates of sedimentation at the proposed reservoir site, consideration was given to the amount of reduction in sediment production that will result from proposed land treatment measures to be installed in the watershed. It is estimated that these measures will reduce the capacity required for sediment storage at the proposed reservoir by 5 percent. Consideration was given to the fact that some land treatment measures in this plan will become effective immediately after construction, while others will require several years from the start of the project to become effective.

The future rate of sedimentation at the proposed reservoir site with the project installed was determined as being 1.75 acre-feet annually per square mile of drainage area. The capacity equivalent of sediment storage in the reservoir is 1.64 inches. The estimated sediment storage requirement at the reservoir for a fifty-year period is 570 acre-feet. In arriving at this figure, a sediment trap efficiency of 80 percent was assumed for the proposed structure.

Since most of the sediment carried by Indian Wash consists of fine-grained materials (clay, silt, and fine sand), it is believed that almost all of the sediment will be deposited within the reservoir below the emergency spillway crest elevation. In time a certain amount of gravel, cobbles, and boulders may be deposited at the upper end of the reservoir above spillway crest elevation; but the volume of these materials should be relatively small.

Geologic Investigations

A preliminary geologic investigation was made at the proposed floodwater-retarding structure site IW-1. Because of the hazard class ("c") and height of the proposed structure and the presence of foundation materials of questionable bearing strength, it was decided that the preliminary investigations at this site should be somewhat more extensive than those usually made during the planning stage. An attempt was made to obtain the amount and type of geologic data and soil samples that would be needed by the Soil Mechanics Laboratory in making a general evaluation of site conditions as related to cost estimations for the work plan.

The investigations carried out at the IW-1 dam site included geologic mapping, the drilling of test holes along the dam centerline and in potential borrow areas, and the collection of both disturbed and undisturbed soil samples.

Twenty test holes were drilled with a power auger along the centerline of the proposed dam in order to obtain information on the type and extent of the materials underlying the foundation of the dam. All holes were drilled into shale bedrock except where large boulders or cobbles were encountered and the auger bit was unable to penetrate any deeper.

Bedrock underlying the dam site is the Mancos shale of Cretaceous age. The Mancos in this area consists primarily of a soft to firm, fissile to thin-bedded, silty clay shale. Occasionally very thin beds of hard siltstone and fine-grained sandstone are present. In this area the shale can be placed in four classes or zones, based mainly on the degree of weathering: (1) decomposed shale; (2) weathered shale; (3) partly weathered shale; and (4) unweathered shale.

The valley bottom at the proposed dam site is underlain by alluvial materials with a maximum thickness of about 33 feet. The materials consist mainly of silt and clay mixtures with some fine sand. Thin layers of gravelly well graded sand with some silt and clay also are present. Several representative undisturbed drive samples of the silty clay materials were obtained from the upper layers on both sides of the valley.

Several disturbed samples of possible borrow materials were obtained for laboratory analysis. Some of these samples tested high in soluble salts, and a number of additional samples were collected to be tested for the presence of soluble salts. Results of these tests indicated that adequate amounts of borrow materials with relatively low percentages of soluble salt could be obtained within a reasonable distance from the dam site. The upper few feet of material in the borrow areas generally appeared to be lower in soluble salt content.

Economic Investigations

The evaluation of flood damages and benefits associated with works of improvement proposed in this plan were based on items of current and historical record to the greatest possible extent. Damage investigations and evaluation methods used in this plan comply with procedures described in the Economics Guide for Watershed Protection and Flood Prevention.

Long-term projected prices (Agricultural Price and Cost Projections, 1959, by the Agricultural Research Service and the Agricultural Marketing Service) were used in computing monetary damages, benefits, and operation and maintenance costs. Current (1961) prices were used to estimate structural installation costs. Federal and other costs were amortized at 2 5/8 percent interest for 50 years.

All damage calculations were correlated with those developed by the U. S. Corps of Army Engineers during the preliminary investigation. Damages were also correlated with the damage and extent of flooding caused by the storm of June 6, 1958.

The damage and benefit evaluation of Indian Wash Watershed is divided into three main reaches. The first, and relatively the most important, is the damage area of Indian Wash proper which includes all of the area subject to overflow by Indian Wash from above F-Road down to Grand Avenue. The second, includes all of the area to the east of Indian Wash between 29 and 30 Roads from the High Line Canal down to the business route of U. S. Highway 6-24. The third, includes the area of flooding along the north side of the Denver and Rio Grande Western Railroad mainline track from 29-Road west to 12th Street (see Damage Location, Map, Figure 1).

Agricultural damage, as evaluated, reflects the net loss in income to the landowners and operators in the overflow area subject to damage based on the series of storms expected to occur in a 100-year period. Crop yields and distribution used in the evaluation were based on the Colorado Agricultural Statistics for Mesa County with adjustments by agricultural technicians to fit the information to specific areas and the expected application of technology.

Floodwater and sediment damages to irrigated crop and pasture land in the overflow area subject to damage are becoming relatively minor because of the rapid urbanization of the area. Damage calculations were based upon the area of crop and pasture land flooded under present conditions by selected flood discharges and the damage value per composite acre of crop and pasture land in the overflow area. The damages obtained were adjusted to account for any expected urbanization and commercialization during the evaluation period. In this evaluation, the overflow area of Indian Wash proper is calculated to be completely urbanized or commercialized by the 25th year of the evaluation period.

Off-site benefits due to the prevention of damages from the delay in water delivery or interruption of irrigation services are based on information furnished by the Grand Valley Irrigation Company, the Grand Valley Water Users Association and agricultural technicians familiar with the area. The High Line Canal has sufficient capacity to pass the flood flows of Indian Wash channel under the flume crossing Indian Wash without damage. The Grand Valley Canal flume over Indian Wash (of the Grand Valley Irrigation Company) has a calculated capacity of 1,650 c.f.s. for free-flow conditions and 1,830 c.f.s. with the water surface at the top of the flume headwall.

This flume is a concrete structure built sometime in the early 1920's to replace an older structure which was destroyed by a flood. This flood damage was probably the one caused by the storm of August 1921 which had a recorded precipitation of 2.81 inches.

The storm of June 6, 1958, produced an estimated peak discharge of 2,200 c.f.s. in the Indian Wash channel at the Grand Valley Canal but did very little damage to the canal or the flume. Therefore, it is estimated that flood peaks of approximately 3,500 c.f.s. are necessary to cause severe damages to the canal and/or the flume, with a resultant delay in irrigation water delivery.

The Grand Valley Irrigation Company provides irrigation water to about 37,380 acres of crop and pasture land. The Ditch Superintendent states that if the Grand Valley Canal were broken at Indian Wash, the entire system would have to be shut down because all of the head ditches require a full canal to take out water.

Based on long-term projected prices for crops and factors of production, average crop yields, local production practices, and a composite average growing season of 153 days, the average daily gross return on the 37,380 acres in the Grand Valley Irrigation Company system is \$20,656 per day.

From the above information damages were estimated for the project design storm of 7,300 c.f.s. peak flow and the intermediate storm producing 3,700 c.f.s. peak flow at the Grand Valley Canal flume over Indian Wash channel. A discharge damage curve for a delay in water delivery was then constructed using these damages and with 3,500 c.f.s. discharge as the point of beginning damages. Average annual damages were then computed by relating damages to discharge and frequency of occurrence.

Floodwater and sediment damages to residential and commercial properties in and near the City of Grand Junction, Colorado, were obtained by field investigations and appraisals. Each city block in the overflow area subject to damage was considered as an evaluation reach in the damage appraisal.

This evaluation was aided by the use of an aerial photograph showing the boundaries of the 1958 flood which was provided by the City of Grand Junction. A work map and tabulations were prepared for the overflow area subject to damage showing the approximate location of all properties, type of construction, with or without basements, the estimated value of buildings and contents, and an appraisal of the damages which would result from the project design storm and two other selected storm frequencies.

Field appraisals and flood damage estimates of probable damages to floodplain roads and bridges were made with the assistance of the Grand Junction Director of Public Works and correlated with the damage estimates made by the U. S. Corps of Army Engineers during the preliminary investigations. In the absence of recorded damages to railroad property in the watershed, field appraisals and estimates were made of the probable flood damages to the Denver and Rio Grande Western Railroad mainline track and classification yard.

Discharge-damage curves were constructed for each kind of damage in the three main evaluation reaches from the above data. The hydrologist constructed discharge-frequency curves for each damage evaluation area under present conditions and with the proposed structural program installed. Average annual damages and benefits were then computed by developing the damage-frequency curves for each type of damage and measuring the area under the curves.

Damages to residential and commercial property were adjusted to take account of the expected urbanization and commercialization of the present agricultural lands in the overflow area of Indian Wash proper by the 25th year of the evaluation year. It is estimated that damageable values in this area will be approximately 150 percent of present values by the 25th year and that they will remain at about that level for the remainder of the 50-year evaluation period. The increase in damages was discounted to allow for lag in accrual.

Additional benefits that were not evaluated are the possible savings in the size of the culvert for the proposed new Interstate Highway I-70 crossing of the Indian Wash. The proposed route crosses Indian Wash about 700 feet above the High Line Canal.

In addition to direct floodwater damages, there are indirect damages such as loss of business, depreciation of property in the flooded areas, interruption of travel during flooding, extra travel due to road and bridge damage, and interruption of railroad traffic. For this evaluation indirect damages were estimated at 10 percent of direct agricultural damages, 15 percent of direct residential property damages, and 20 percent of commercial property, road, bridge and railroad damages.

Engineering Investigations

Field investigations to determine structural measure needs were conducted on the entire Indian Wash drainage above the High Line Canal. These investigations resulted in the selection of one site, IW-1, for a floodwater-retarding structure.

The site is located on the main tributary of the Indian Wash drainage in Section 29, Township 1 N., Range 1 E., of the Ute Principal Meridian approximately 1 1/2 miles north of the High Line Canal. Factors included in the selection of this structure site included: (1) maximum control of floodwater, (2) topography, (3) site conditions, and (4) existing facilities including Walker Airfield, proposed Interstate Highway, a power transmission line, and the High Line Canal. A detailed topographic map of the dam site and reservoir area was obtained by planetable survey.

Soil conditions are of primary concern in the structural analysis of the proposed floodwater-retarding dam. Throughout the Indian Wash drainage, gypsum in varying amounts exists in the soils. Extensive geologic and soil investigations have been made on the embankment foundation and borrow areas.

Based on the results of soil tests by the Soil Mechanics Laboratory, the following criteria were used in the planning design and estimation of structural quantities and costs:

Foundation.- The unconsolidated foundation materials classify as CL and CL-ML with a few strata of SM and GM materials.^{1/} Due to the consolidation differential of these foundation materials, the area under the entire embankment is to be preconsolidated probably by wetting prior to construction. The extra embankment to take care of this differential was allowed for in the embankment computations. Estimates for preconsolidating the foundation are incorporated in the associated costs.

Following preconsolidation a cutoff trench will be extended to unweathered shale under the major portion of the embankment and to weathered shale under the remaining sections of the dam.

Embankment Design.- The borrow materials range in classification from SM to CL ^{1/}. The embankment materials should be compacted to densities of about 95 percent of maximum modified at moisture contents on the wet side of optimum. From the resulting data on the slope stability analysis, the structure was designed with 4:1 slopes upstream and downstream with berms at the suggested elevations on both slopes. The final design will probably incorporate a zoned fill.

For purposes of planning design, a drain was included under the downstream section of the dam. In the final analysis and design, it may not be necessary to include this drain.

Future Work.- Before this project gets to the final stage, a great deal of additional foundation investigation work will have to be conducted. A careful delineation of proposed borrow areas will also be required so that proper selection of the least salty materials can be made. Due to the nature of these conditions, very close inspection and evaluation of materials in the field during the construction period will be necessary.

The planned principal spillway is a 36-inch I. D. reinforced concrete pipe barrel with encasement and a drop inlet. Entrance of the drop inlet is set at the sediment pool elevation. Peak discharge through the principal spillway is 211 cubic feet per second when the floodwater reservoir is filled to design capacity. Detention time for the design floodwater storage is computed at 3 days and 2 hours.

^{1/} Soil type based on Unified Soil Classification System.

Excavated materials from the emergency spillway should be less than 15 percent of the total material requirement of the dam. Design criteria for emergency spillway capacities are in the Hydrology Section of this work plan.

The IW-1 floodwater-retarding structure is classified as class "C" based on the interpretation of Engineering Memorandum SCS-27, revised. Capacity for sediment storage is provided to contain the estimated sediment accumulation at the site for the next 50 years. The floodwater-retarding capacity is based on the runoff of three inches occurring on the watershed less frequently than once in 100 years. There will be no dead storage in this structure. A typical structure is shown in Figure 3. Structure data for IW-1 is listed in Table 3.

TABLE 1a - STATUS OF WATERSHED WORKS OF IMPROVEMENT

(At time of Work Plan Preparation)

Indian Wash Watershed, Colorado

Measures	Unit	Applied To Date	Total Cost (Dollars) <u>1/</u>
<u>LAND TREATMENT 2/</u>			
<u>Irrigated Cropland</u>			
Conservation Cropping System	Acre	646	969
Crop Residue Use	Acre	270	333
Fertilizing	Acre	390	3,900
Pasture Planting	Acre	90	2,250
Land Leveling	Acre	300	17,550
Ditch Lining	L.Ft.	10,000	11,500
Irrigation Pipelines	L.Ft.	5,280	5,500
Improved Water Application	Acre	580	2,320
Open Ditch Structure	Number	50	2,000
Tile Drains	L.Ft.	900	1,080
<u>Rangeland</u>			
Proper Range Use	Acre	244	366
TOTAL			47,773

1/ Price Base: 1961 Price Levels

2/ Privately-owned and City-owned lands only.

Date: September 1961

TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION

Indian Wash Watershed, Colorado

(Dollars) 1/

Structure Site Number or Name <u>2/</u>	Installation Cost - P. L. 566 Funds					Installation Cost - Other Funds			
	Construction		Instal. Services			Adm. Of Con- tracts	Ease- ment & R/W	Total Other	Total Installation Cost
	Eng. Est.	Contin- gencies	Engin- eering	Other	Total P. L. 566				
Floodwater-Retarding Structure IW-1	263,624	39,544	42,444	42,444	388,056	600	380	980	389,036
Total	263,624	39,544	42,444	42,444	388,056	600	380	980	389,036

1/ Price Base: 1961 Price Levels

2/ One Construction Unit

Date: September 1961

TABLE 3 - STRUCTURE DATA

FLOODWATER-RETARDING STRUCTURE

Indian Wash Watershed, Colorado

Item	Unit	Structure Number IW-1
Drainage Area	Sq.Mi.	6.53
Storage Capacity		
Sediment	Ac.Ft.	570
Floodwater	Ac.Ft.	1,045
Total	Ac.Ft.	1,615
Surface Area		
Sediment Pool	Acre	43
Floodwater Pool	Acre	90
Volume of Fill	Cu.Yds.	528,587
Elevation Top of Dam	Feet	4947.0
Maximum Height of Dam	Feet	61.3
Emergency Spillway		
Crest Elevation	Feet	4942.0
Bottom Width	Feet	350
Type		Earth
Percent Chance of Use	Percent	Less than one
Ave. Curve No. - Cond. II		90
Emergency Spillway Hydrograph		
Storm Rainfall (6-hr) <u>2/</u>	Inch	2.70
Storm Runoff	Inch	1.71
Velocity of Flow (v_c) <u>1/</u>	Ft/Sec	<u>3/</u>
Discharge Rate <u>1/</u>	C.F.S.	<u>3/</u>
Max. w.s. elev. <u>1/</u>	Feet	4936.5
Freeboard Hydrograph		
Storm Rainfall (6-hr) <u>2/</u>	Inch	6.75
Storm Runoff	Inch	5.60
Velocity of Flow (v_c) <u>1/</u>	Ft/Sec.	3.0
Discharge Rate <u>1/</u>	C.F.S.	3,100
Max. w.s. elev. <u>1/</u>	Feet	4945.0
Principal Spillway		
Capacity - low stage, max.	C.F.S.	211
Capacity Equivalents		
Sediment	Inch	1.64
Detention Volume	Inch	3.00
Spillway Storage	Inch	1.80
Class of Structure		"C"

1/ Maximum during passage of hydrograph.

2/ After adjustment for area and class of structure.

3/ Emergency spillway will not operate during the occurrence of the emergency spillway flood.

TABLE 4 - SUMMARY OF PHYSICAL DATA

Indian Wash Watershed, Colorado

Item	Unit	Quantity Without Project	Quantity With Project
Watershed Area	Sq.Mi.	15.06	xxxxxx
Watershed Area	Acre	9,640	xxxxxx
Privately-owned	Acre	3,805	xxxxxx
Non-Federal (Public)	Acre	100	xxxxxx
Federal (BLM)	Acre	5,735	xxxxxx
Land Use			
Irrigated Cropland	Acre	1,260	1,005 <u>1/</u>
Grassland	Acre	7,065	7,065
Residential and Commercial	Acre	780	935 <u>1/</u>
Miscellaneous	Acre	535	535
Overflow land subject to damage <u>2/</u>	Acre	2,500	450
Area subject to: Sediment damage	Acre	1,500	270
Sediment Production <u>3/</u>	Ac./Ft./ Sq./Mi./ Year	1.84	1.75
Average Annual Rainfall	Inch	9.08	xxxxxx

1/ Expected change 25 years hence.

2/ From project design storm.

3/ Yield from 6.53 square miles above proposed structure IW-1.

Date: September 1961

TABLE 5 - SUMMARY OF PLAN DATA

Indian Wash Watershed, Colorado

Item	- Unit	Quantity
Years to complete project	Years	5
Total Installation Cost		
Public Law 566 Funds	Dollar	431,586
Other Funds	Dollar	50,580
Annual O and M Cost		
Other Funds	Dollar	2,387
Average Annual Monetary Benefits ^{1/}	Dollar	22,740
Agricultural	Percent	22.5
Nonagricultural	Percent	77.5
Structural Measures		
Floodwater-Retarding Structure	Each	1
Area Inundated by Structure		
Sediment Pool	Acre	43
Detention Pool	Acre	90
Watershed Area above Structure	Acre	4,179
Reduction of Floodwater Damage	Dollar	18,015
By Land Treatment Measures	Percent	4.6
By Structural Measures	Percent	95.4
Reduction of Sediment Damage	Dollar	5,875
By Land Treatment Measures	Percent	5.4
By Structural Measures	Percent	94.6

^{1/} From Structural Measures

Date: September 1961

TABLE 6 - ANNUAL COSTS

Indian Wash Watershed, Colorado

Dollars 1/

Measures	Amortization Of Installation Costs	Operation and Maintenance Costs	Total
		Other	
Floodwater-Retarding Structure IW-1	14,060	1,887	15,947
Indian Wash Flood Channel <u>2/</u>	—	500	500
Total	14,060	2,387	16,447

1/ Installation costs are based on 1961 price levels and operation and maintenance costs on long-term prices.

2/ Operation and maintenance for existing Indian Wash flood channel below Grand Valley Canal.

Date: September 1961

TABLE 7 - MONETARY BENEFITS FROM STRUCTURAL AND
LAND TREATMENT MEASURES

Indian Wash Watershed, Colorado

(Dollars) 1/

Item	Estimated Average Annual Damage				Average Annual Monetary Benefits
	Without Project	Reduction Due to Land Treatment	After Land Treatment For Watershed Protection	With Project	
<u>Floodwater Damage</u>					
Crop and Pasture	150	10	140	50	90
Other Agriculture					
Irrigation and Drainage Ditches	350	20	330	80	250
Delay in Water Delivery	4,225	210	4,015	-	4,015
Non-Agricultural					
Residential Property	5,795	235	5,560	320	5,240
Commercial Property	3,950	160	3,790	380	3,410
Road and Bridge	1,480	60	1,420	115	1,305
Railroad	700	30	670	75	595
Subtotal	16,650	725	15,925	1,020	14,905
<u>Sediment Damage</u>					
Overbank Deposition (Cropland)	130	5	125	45	80
Irrigation Drainage Ditches	345	15	330	80	250
Residential Property	3,865	195	3,670	210	3,460
Commercial Property	1,690	85	1,605	160	1,445
Road Grade and Ditches	370	20	350	30	320
Subtotal	6,400	320	6,080	525	5,555
Indirect Damage	2,565	105	2,460	180	2,280
Total - All Damage	25,615	1,150	24,465	1,725	22,740
TOTAL FLOOD PREVENTION BENEFITS					22,740

1/ Price Base: Long-term prices

2/ Benefits from structural measures

Date: September 1961

TABLE 8 - BENEFIT-COST ANALYSES

Indian Wash Watershed, Colorado

(Dollars) 1/

Measures <u>2/</u>	AVERAGE ANNUAL BENEFITS			Total	Average Annual Cost	Benefit-Cost Ratio
	Floodwater	Sediment	Indirect			
Floodwater-Retarding Structure IW-1	14,905	5,555	2,280	22,740	15,947	
Existing Indian Wash Flood Channel	-	-	-	-	500	
Total	14,905	5,555	2,280	22,740	16,447	1.38 to 1.00

1/ Price Base: Benefits - long-term prices
Costs - 1961 prices

2/ One evaluation unit

3/ Operation and maintenance for existing Indian Wash flood channel below the Grand Valley Canal.

Date: September 1961

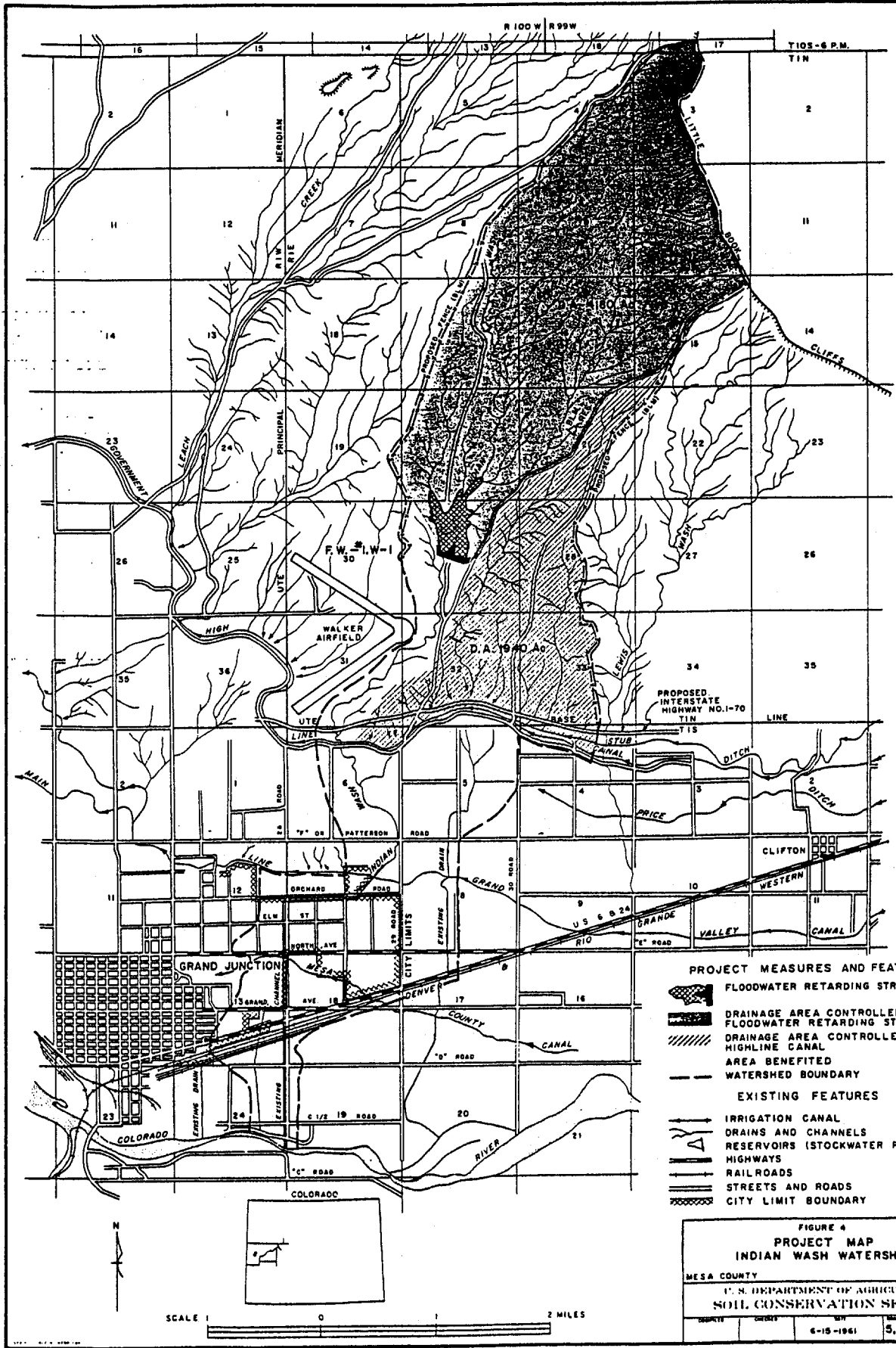
"The watershed area above the Highline Canal consists of approximately 10.24 square miles. Of this amount, 6.53 square miles of the Indian Wash drainage is controlled by floodwater-retarding structure IW-1 which provides an estimated 300-year level of protection. (This area is shown solid green.)

"The small tributary drainages east of Indian Wash flow out on a fairly flat floodplain which is crossed on the south edge by the Highline Canal. These comprise a total area of 3.03 square miles.

"The Highline Canal has a high spoil bank and road way along the south side which provides a capacity, in addition to the 600 c.f.s. normal irrigation flow, to intercept the runoff from the 3.03 square miles of unreservoired drainage area from a storm having a recurrence interval of 100 years. This additional intercepted flow is carried west by the Highline Canal and spilled into the Indian Wash channel through a weir spillway and chute just upstream from the Canal flume across Indian Wash. Thus the Highline Canal provides protection to the irrigated lands immediately below the canal, within the watershed boundary, from a storm having a recurrence interval of 100 years. (This area is shown cross-hatched in green.)

"Of the total area of 10.24 square miles above the Highline Canal, approximately 9.56 square miles is reservoired by the above structures.

"The floodplain area shown in yellow is the area estimated by the Corps of Engineers and Soil Conservation Service to be subject to floodwater and sediment damage from the Project Design Storm (300year frequency)."



- PROJECT MEASURES AND FEATURES**
- FLOODWATER RETARDING STRUCTURE
 - DRAINAGE AREA CONTROLLED BY FLOODWATER RETARDING STRUCTURE
 - DRAINAGE AREA CONTROLLED BY HIGHLINE CANAL
 - AREA BENEFITED
 - WATERSHED BOUNDARY
- EXISTING FEATURES**
- IRRIGATION CANAL
 - DRAINS AND CHANNELS
 - RESERVOIRS (STOCKWATER PONDS)
 - HIGHWAYS
 - RAILROADS
 - STREETS AND ROADS
 - CITY LIMIT BOUNDARY

FIGURE 4
PROJECT MAP
INDIAN WASH WATERSHED

MESA COUNTY COLORADO
 U. S. DEPARTMENT OF AGRICULTURE
 SOIL CONSERVATION SERVICE

DATE	BY	APPROVED BY

6-15-1961 5,P-17,574-B

SCALE 1 0 1 2 MILES

Emergency
at 555
242-4511

500
242-4511

Project: Indian Wash
State: Colorado

OPERATION AND MAINTENANCE AGREEMENT

THIS AGREEMENT, made and entered into the 26 day of March, 1965, by and between the Soil Conservation Service, United States Department of Agriculture, hereinafter referred to as the "Service", and the Upper Grand Valley Soil Conservation District; Mesa County, the City of Grand Junction, hereinafter referred to as the "Sponsors", relates to the operation and maintenance of the following Works of Improvement:

Structure IW-1, an earth fill, floodwater-retarding structure, having an ungated outlet, and sediment and detention pool of 1,615 acre-feet, located in Section 29, Twp. 1N, Range 1E.

Indian Wash Channel, a floodwater channel from the primary outlet of Structure IW-1 extending in a southwesterly direction to the Colorado River, a distance of approximately six miles.

The Indian Wash Channel is not a project Work of Improvement but is a definite part of the planned flood prevention program and will be subject to the inspection and repair procedures as set forth herein.

The estimated annual cost for operating and maintaining (a) Structure IW-1 is \$1,887.00; (b) Indian Wash Channel \$500.00; a total of \$2,387.00. The City of Grand Junction and Mesa County do hereby jointly assume responsibility for operation and maintenance of both the Structure IW-1 and the Indian Wash Channel, the cost of which will be shared equally by said City and said County.

I. OPERATION

The parties hereto agree as follows to the operation of the Works of Improvement:

- A. The Service will provide such technical services as are available for assistance in the proper operation of the Works of Improvement.
- B. The City of Grand Junction and Mesa County will:
 - 1. Be responsible for operation of IW-1 simultaneously with acceptance of the Works of Improvement from the contractor.
 - 2. Prohibit the installation of gates or other obstructions of any kind being placed in any portion of the principal or emergency spillway(s).

5 to Area 2 } 1 area
 } 1 unit
2/12/65 } 3 to Sponsors
 } 1 to City of Grand Junction

3. Prohibit any works to raise any portion of the spillways above the planned elevation or to deflect or decrease the planned flow through the spillways in any manner.
4. Prohibit the installation of dikes or other structures which may decrease the capacity of the flood channel or deflect the flow from the constructed channel bottom.
5. Keep the Indian Wash Channel in operating condition from the Structure IW-1 to its confluence with the Colorado River.
6. Take all other necessary steps to insure that the Works of Improvement are permitted to function in the manner for which they were designed, and are operated in accordance with any applicable State law.

II. MAINTENANCE

The parties hereto agree as follows to the maintenance of the Works of Improvement:

A. The Service will:

1. Inspect the Works of Improvement at least annually before the flood season.
2. Prepare and furnish to each of the Sponsors a report of inspection findings, including recommendations for maintenance work needed and when such work should be completed.
3. Provide such technical services as are needed and available for preparing plans, designs and specifications for needed maintenance of the Works of Improvement.

B. The City of Grand Junction and Mesa County will:

1. Be responsible for maintenance of IW-1 simultaneously with acceptance of the Works of Improvement from the contractor.
2. Perform, in accordance with applicable State laws, all maintenance needs on IW-1 and the Indian Wash Channel from the Structure IW-1 to the Colorado River, and all fences indicated by inspections and reports thereon within the time limits specified and in such manner as not to damage Works of Improvement in any way.

3. Perform the maintenance work by use of City or County-owned equipment, force account or local contract.
4. Obtain operation and maintenance funds through their regular annual budget.

III. IT IS MUTUALLY AGREED THAT:

- A. Government Representatives shall have the right of free access to inspect the Works of Improvement at any time.
- B. The Sponsors and the Service will inspect the Works of Improvement at least annually before the flood season and after every major storm or the occurrence of any other unusual condition that might adversely affect the Works of Improvement to insure proper functioning and to check for possible damage or deterioration. Items to be checked at time of inspection will include, but not be limited to, the following:
 1. Principal spillways
 - (a) Damage or obstructions
 - (b) Condition of outlet and riser
 - (c) Sediment level in relation to top of riser
 2. Emergency spillways - drainage ways
 - (a) Erosion
 - (b) Sedimentation
 - (c) Weeds, logs and other obstructions or accumulations reducing channel capacity
 - (d) Conformity with original design (deposition or sloughing)
 3. Embankments
 - (a) Settlement or cracking
 - (b) Erosion
 - (c) Leakage
 - (d) Rodent, wildlife or livestock damage
 - (e) Condition of vegetative cover
 4. Flood channel
 - (a) Sedimentation
 - (b) Bank cutting
 - (c) Debris accumulation
 - (d) Condition of riprap and other works
 - (e) Adjacent property damage
 5. Fences and gates - repairs needed
- C. The parties to this Agreement will make their annual inspections and reports jointly. It is desirable that the annual inspections be made during the month of May. Any supplemental inspections then determined necessary will be scheduled and agreed to at that time.

D. The Sponsors will secure prior Service approval of any agreement(s) to be entered into between themselves and/or with other parties for any operation or maintenance of these Works of Improvement and furnish the Service with two copies of such agreements.

No member of Congress or Resident Commissioner shall be admitted to any share or part of this Agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this Agreement if made with a corporation for its general benefit.

This action authorized at an official meeting of UPPER GRAND VALLEY SCD on 17 day of MARCH, 1965, at GRAND JUNCTION, State of COLORADO

Attest: Wendell R. Whisenand
(Name)
SECRETARY
(Title)

UPPER GRAND VALLEY SOIL CONSERVATION DISTRICT

By Fred Herbert
Title PRESIDENT
Date MARCH 17, 1965

This action authorized at an official meeting of CITY COUNCIL on 6 day of SEPTEMBER, 1961, at GRAND JUNCTION, State of COLORADO

Attest: John C. Johnson
(Name)
CITY CLERK
(Title)

CITY OF GRAND JUNCTION

By Joe M. Lacy
Title CITY MANAGER
Date MARCH 22, 1965

This action authorized at an official meeting of MESA COUNTY COMMISSIONERS on 22 day of MARCH, 1965, at GRAND JUNCTION, State of COLORADO

Attest: Ann M. Denton
(Name)
County Clerk & Recorder
(Title)

MESA COUNTY, COLORADO

By Arthur Jensen
Title Chairman BOARD OF MESA COUNTY COMMISSIONERS
Date MARCH 22, 1965

SOIL CONSERVATION SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

By J. J. Mark
State Conservationist

Date March 26, 1965