Richard B. Scott

SHAMALAN UNIT

HELMAND ARGHANDAB VALLEY DEVELOPMENT PROJECT

AFGHANISTAN

FEASIBILITY REPORT

SEPTEMBER 1968

APPENDIX B

PROJECT LANDS
DRAINAGE
PLANS AND ESTIMATES

UNITED STATES DEPARTMENT OF INTERIOR
STEWART L. UDALL, SECRETARY

BUREAU OF RECLAMATION
FLOYD E. DOMINY, COMMISSIONER

FOR: HELMAND ARGHANDAB VALLEY AUTHORITY
AND
AGENCY FOR INTERNATIONAL DEVELOPMENT
UNITED STATES DEPARTMENT OF STATE

United States Department of the Interior
Stewart L. Udall, Secretary
Bureau of Reclamation
Floyd E. Dominy, Commissioner

Appendix B

PROJECT LANDS

DRAINAGE

PLANS AND ESTIMATES

[redacted] Feasibility Report
Shamalan Unit
Helmand Arghandab Valley Development Project

United States Bureau of Reclamation
for
Helmand Arghandab Valley Authority
and
U. S. Agency for International Development

Bost, Afghanistan
September 1968

Appendix B

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PROJECT LANDS

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Introduction

This appendix presents the information that has been compiled from the detailed land classification survey and related investigations of the Shamalan Unit, Helmand Valley Project, Afghanistan. The lands of the Unit were investigated and classified as to suitability for irrigation development.

Authority to make this investigation is provided in an agreement between the United States Agency for International Development and the Royal Government of Afghanistan.

This appendix contains ten sections setting forth the following information:

(1) An introduction to the subject matter.

(2) A general description of the Unit area.

(3) A discussion of the soils - their characteristics and extent.

(4) A description of the Unit topography.

(5) Drainability characteristics and problems of the lands.

(6) A description of salinity and alkalinity conditions.

(7) A discussion of quality of irrigation water supplies.

(8) A discussion of the land classification.

(9) Conclusions of the investigations.

(10) Supporting data available.

Purpose of the Investigation

The purpose of the land classification is to systematically appraise the lands and separate them into categories on the basis of similar characteristics. These categories, or land classes, depict the extent and degrees of suitability for sustained irrigation agriculture. The potential production, cost of land development and costs of production determine the ability of the lands to economically support farm units and the ability to repay project development and operation costs. The classification is also designed to provide sound and relatively permanent basic data essential to solving existing agricultural, economic and engineering problems, and to planning a sound irrigated agriculture for the Unit.

Nature, Date and Extent of Survey

The land classification of the Shamalan Unit is detailed in scope. It was conducted during the period March 1965 to November 1966, and involved the classification of irrigated and nonirrigated lands comprising the Unit.

Arable Land Classification Map

The arable land classification map showing the results of the survey of the Shamalan Unit is on drawings 501-123 through 501-127 at the front of this appendix.

General Description of Unit

Physical Characteristics

Location and Extent of the Unit Area. The Shamalan Unit is located in southwestern Afghanistan on the west side of the Helmand River extending both northward and southward from the confluence of the Helmand and Arghandab Rivers. The Unit is 64 kilometers (40 miles) in length, ranging from approximately one to seven kilometers (0.6 to 4.3 miles) in width, with an approximate average width of four kilometers (2.5 miles), and comprises a gross area of approximately 259 square kilometers (100 square miles). The general outline and location of the Unit are shown on the Key Map which is in the front of this appendix.

There are numerous villages of various size within the Unit, but Bost, on the east side of the Helmand River near the north end of the Unit is the only town in the area. Chah-i-Anjir, the headquarters of the Helmand Arghandab Construction Unit (HACU), originally built as a construction camp by Morrison-Knudsen Afghanistan, is located approximately two kilometers from the northwestern tip of the Unit, west of the Helmand River.

Physiography and Geology. The Shamalan Unit is located on the first and second terrace levels bordering the Helmand River, varying from one to four meters (3 to 13 feet) above the normal river surface. It is bounded on the east by the Helmand River, and on the west by a third, higher, older terrace, probably of the Tertiary geologic period. Altitudes within the Unit range from 789 meters (2,588 feet) above mean sea level at the northern end to 708 meters (2,323 feet) at the southern extremity with an approximate mean average gradient of 1.3 meters per kilometer (6.9 ft per mile). East-west gradient within terrace levels is nearly flat for most of the area.

The soils of the Unit are derived largely from alluvial materials of the Quaternary geologic period with areas of aeolian deposits occurring in a narrow strip along the western edge of the Unit. These aeolian materials originate from the vast desert to the west of the Unit known as the Dasht-i-Margo.

The alluvial sediments, from which the bulk of the soils in the Unit are derived, consist largely of medium textured materials, varying from moderately fine to moderately sandy in texture. These materials generally range from approximately two to four meters (6 to 13 feet) in depth, below which they grade into sands and gravelly sands. All of the Unit lands are underlain by gravel at various depths ranging from at or near the surface to maximum depths exceeding five meters (16 feet). Occasional gravel bars are found on the land surface. On the basis of explorations conducted to date the gravelly substrata appear to be open and non-consolidated. Observations of the deeper gravel strata have been limited due to lack of suitable equipment for carrying out such explorations.

Climate

General. The climate of the Helmand River Valley is similar to that of the deserts of southwestern United States and is comparable to continental desert climate in similar latitudes and situations in other countries. It is characterized by hot, dry summers and mild winters with a long growing season. Temperature data reported in the International Engineering Co.,"Report on Soil and Water Resources of Southwest Afghanistan" (1959) show an average of 32 days annually with minimum temperatures of 0° Centigrade (32° Fahrenheit), or less. Generally the low temperatures last only a few hours with most of the day in the 4 - 16° C (40 - 60° F) range. The lowest temperature recorded during their record period of January 1951 to December 1956 was - 11° C (12° F). The climate is favorable for the growing of a wide variety of crops under irrigation including small grains, corn, grain sorghums, root crops, alfalfa, clovers, pasture, tree fruits, grapes, and vegetables. The following is a brief summary of climatic conditions in the Bost - Chah-i-Anjir area:

The average annual precipitation is 135 millimeters (5.3 inches) of which 121.1 millimeters (4.77 inches), or approximately 90% occurs during the period November through April. The three months of highest precipitation are December, January and March, with 22.4%, 24.6% and 18.4% respectively, or a total of 65.4% of the average annual precipitation. The period May through October is extremely dry with a yearly average total precipitation of 14.3 millimeters (0.56 inch). 1/

1/ Precipitation data are based on records from Chah-i-Anjir for the period October 1951 through December 1954 and for Bost for the period January 1955 through July 1965.

The average annual evaporation from a free water surface is 2,141 millimeters (84.3 inches). 1/ Summarized temperature data from the Bost weather station for the period of January 1955 through September 1965 are as follows:

Temperatures (degrees)

A. Annual				B. July Averages				C. January Averages			
Avr	Max	Avr	Min	Avr	Max	Avr	Min	Avr	Max	Avr	Min
C	F	C	F	C	F	C	F	C	F	C	F
28.9	84.0	16.7	62.1	41.7	107.1	14.2	57.6	14.2	57.6	1.9	35.4

Hottest During Record Period				Coldest During Record Period			
July 1958				December 1964		January 1960	
Maximum		Minimum		Minimum		Maximum	
C	F	C	F	C	F	C	F
46.3	115.3	16.7	62.1	-11.6	11.1	24.8	76.6

The area is subject to frosts which impose some cropping limitations. The average number of days at Chah-i-Anjir with minimum temperatures below 0° C (32° F) (January 1951 - December 1956) are as follows:

January, 11; February, 5.5; March, 1.5; November, 2.0; December, 12; for a total annual average of 32 days.

Effect on Soils. The soils of the Shamalan Unit have developed largely from relatively recent alluvial deposits, under the controlling influences of a hot, arid continental climate and a very sparse vegetative cover. As a result of developing under these conditions they are very light in color and are virtually devoid of organic matter. The soils are nearly all uniformly calcareous throughout their profiles, with no evident zones of lime accumulation, showing that little leaching of lime has taken place. Although leaching and depletion of fertility elements have occurred, these are the result of irrigation rather than climate.

Effect on Productivity. The central Helmand River Valley has a climate generally favorable to irrigation agriculture. The long growing season plus relatively mild winters give rise to a wide range of crop adaptability and to potentially favorable yields. Small grains, alfalfa, clovers, corn, cotton, grapes, vegetables, melons, and tree fruits have all along been

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1/ Based on weighted averages using pan evaporation records (converted to free water surface evaporation by applying a coefficient of 0.75) from Chah-i-Anjir for the period of January 1951 through November 1954 and from Bost from April 1955 through September 1966.

grown in the valley. Sugar beets, grain sorghums and soybeans have been grown successfully on an experimental basis. Alfalfa, pasture grass and the commonly grown clovers continue to produce through the winter months, although production during the coldest weather is limited. The more hardy vegetables are also grown throughout the winter months.

Present Land Use. The Shamalan Unit is one of the older farmed areas in the valley and is also one of the better areas to consider for irrigation agricultural development. There are in the neighborhood of 200 villages within the Unit with an estimated combined total of approximately 24,000 persons. Statistics are incomplete and it is possible that the area population may be much larger than the reported figure. The villages, which vary in size from a few families to relatively large communities, are typical mud-hut construction, with no floors or windows, no sewage systems and no sanitary water supplies. The villages are temporary and are frequently relocated to remove themselves from the accumulation of wastes. The typical life of a village is eight years, after which the huts are demolished and the land is again farmed.

Preliminary information developed by the Cadastral Survey Unit indicates that individual farmed tracts within the Shamalan Unit average approximately 1.2 hectares (3 acres) each. Individual or joint owners in the West Shamalan Division frequently own several separate tracts, with average total holdings of approximately 7.4 hectares (18.3 acres) each. There is an average of approximately two tenants per ownership in this division.

The principal crops presently grown in the West Shamalan Division are wheat, cotton, corn, and mung beans, with minor amounts of barley, alfalfa, fruit, vegetables, grapes and other horticultural crops. Wheat is the basic crop, occupying about one-half of the cropped land. Small numbers of livestock are kept, principally for draft purposes. Sheep and goats are purchased from nomads in the fall and are fattened for winter meat. Small numbers of poultry are kept for eggs and meat. Farming methods and practices in the valley are for the most part extremely backward and crop yields are low to very low.

Anticipated Future Land Use.

The irrigated area in the Shamalan Unit under project development will essentially be the same as that of the present, with no new lands being added. The aims of project development are to improve water distribution and control, greater intensification of land use, the establishment of greatly improved cropping patterns and rotations, and the general upgrading of agricultural practices as discussed in detail in Appendix A "Agricultural Economics". Projections for the area are based on expectations of little change in the range of crops that will be grown but anticipate a considerable shift in relative percentages of the land occupied by individual crops. Projections are that by the 50th year under project operations in the Shamalan Unit, alfalfa will be grown on approximately 24 percent of the land as compared with five percent at present. Wheat will continue to be the principal crop, but will drop from its present 47 percent to 38 percent of the cropped acreage. Cotton will occupy 22 percent of the irrigated land as compared with 27 percent at the present time. Corn and mung beans will continue to be important crops within the Unit, with minor increases in acreages of each. Some increase is also predicted in the total area for orchard, garden, vineyard, carrots, and sesame or sunflower production. The latter crops will amount to a total of approximately 15 percent of the total cropped acreage. Corn, carrots, mung beans, and sesame or sunflower are all to be grown as part of a double cropping system, and some wheat will be grown as a second crop after cotton.

The planned changes in cropping pattern will permit establishment of good soil building crop rotations as well as contributing to a better balanced agriculture with considerably enhanced income.

Soils

General Description

The great majority of the soils of the Shamalan Unit have been derived from relatively young alluvial materials on low to moderately low-lying first and second terraces along the west side of the Helmand River. Sandy aeolian deposits, varying from low, shallow hummocks to medium height sand dunes occur as overburden along the western side of the area where the river terrace lands are bordered by a vast desert. Discontinuous strips and small bodies of stratified, sandy, recent alluviums occur in low-lying portions bordering the river which are subject to periodic flooding. These stratified alluviums and the sandy aeolian deposits are almost all included in the non-arable lands of the Unit. The bulk of the alluvial soils of the Unit have deep, relatively uniform profiles, ranging in texture from moderately light silty clay loams to fine sandy loams, with medium textures (loams and silt loams) predominating throughout most of each of the individaul profiles and usually range from approximately 2 to 3 meters (6 to 10 feet) in depth. Some shallower bodies occur, however, and gravel bars are occasionally found on the surface. The soils typically become gradually more sandy in the lower profile sections and are frequently underlain by open loamy sand to sand immediately above the underlying gravel strata. Soil profiles with light silty clay or loamy sand horizons are found occasionally within this general group of soils, but are confined to small areas. All of the Unit soils are underlain by gravel strata at various depths, typically occurring at two to four meters (6 to 13 feet) below the surface, and ranging from at or near the surface to more than five meters (16 feet) in depth. On the basis of subsurface explorations conducted to date, consisting of auger holes, bank exposure observations, and a limited number of deep core drill holes, (40 meters, or 130 feet in depth) these gravel strata appear, in general, to be open and unconsolidated.

The Unit soils are predominantly very light brown to light grayish brown in color and are very low in organic matter, typical of soils developing under very arid conditions with sparse vegetation. They show little effect of weathering due to the prevailing climatic conditions. Very low precipitation, high evaporation, sparse vegetative cover and a very low level of microbiological activity have restricted soil development processes to a minimum. The soils show little to no structural development and are normally uniformly highly calcareous throughout the profiles, with no discernible evidence of leaching or zones of lime accumulations.

Typical Profiles

The profiles of the alluvial soils of the second terrace level, which comprises the great majority of the project lands, typically have relatively uniform medium textured soils consisting largely of loams and silt loams. A typical profile for these soils has from 30-40 centimeters (12-16 inches) of light grayish brown friable calcareous loam. This is underlain by a layer of light yellowish brown loam, or slightly sticky silt loam to light silty clay loam, which may have some visible disseminated lime and lime splotches, extending to from 90 to 180 cm (36-72 inches) depth. This, in turn, is frequently underlain by a layer of light brown, slightly compact loam approximately 30 cm (12 inches) in thickness. Below this third level the soil becomes increasingly sandy with depth, varying from sandy loam to loamy sand and is gray in color. The sandy layer normally continues to the underlying gravel.

The soils are normally uniformly to very nearly uniformly calcareous throughout the profile and show little or no structural development. Principal variations within profiles are thickness of the horizons, textural variations, and depths to underlying gravel. Textures vary from moderately sandy to moderately fine, with medium textures predominating throughout the profiles except for the sandy layer normally encountered immediately above the gravel. Selected typical profiles are graphically illustrated and described on the following pages.

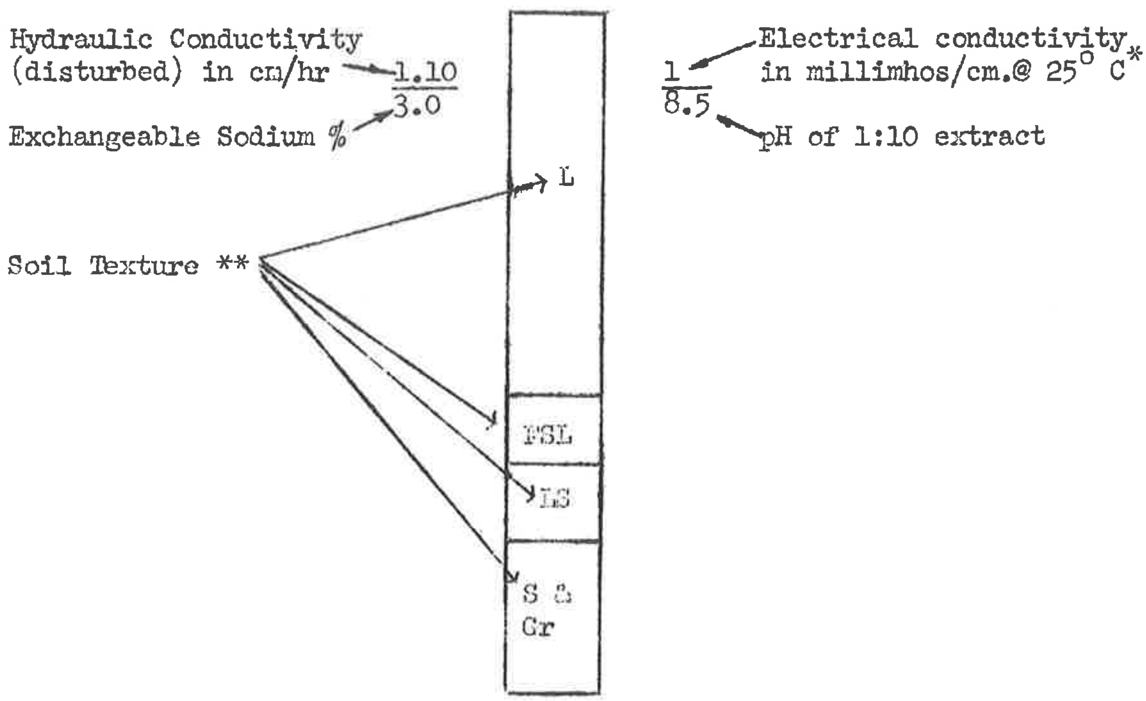
Available Moisture Capacity

The soils of the arable lands in the Shamalan Project have good to high available moisture capacities. Field moisture capacities and wilting point determinations performed at the Kabul University Faculty of Agriculture on a limited number of samples of medium to moderately fine textures showed field capacities varying from 28 to 30 percent and wilting points varying from eight to ten percent. Available moisture percentages ranged from 18-20 percent for the medium to moderately fine textured soils, which predominate in the arable lands of the Unit. Water holding capacities of the moderately sandy soils of the Unit have not been determined by laboratory testing during the course of this investigation but would be somewhat lower than those of medium textured soils.

The International Engineering Company, Inc., in their investigations of the soil resources of southwest Afghanistan during the years 1952 to 1958, analyzed and tested a large number of samples from throughout the valley. A

LEGEND FOR GRAPHIC TYPICAL SOIL PROFILES

(Pages 8-13 inc)

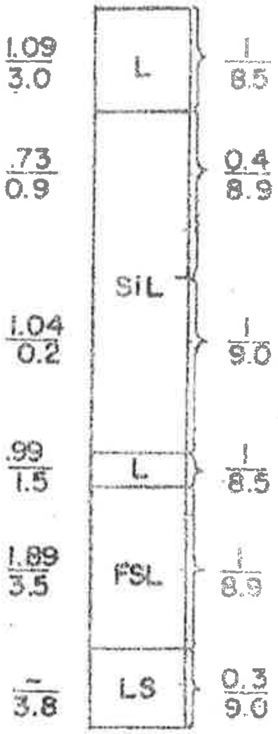


*Measured on 1:10 extract and converted to 1:1

**Soil Textures

S	- Sand	L-	Loam
LS	- Loamy sand	Sil-	Silt loam
SL	- Sandy loam	SCL-	Sandy clay loam
FSL	- Fine sandy loam	Gr-	Gravel

(**Texture list includes only textures indicated in the following "Typical Soil Profiles")

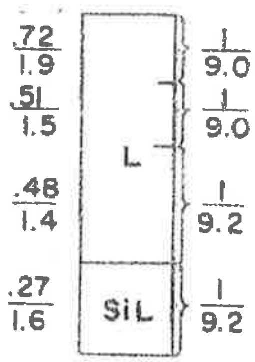


Typical Soil Profile
Class 1

Uniform flat. Good crops. 0-45 gray brown (10 yr 5/2); 45-195 yellowish brown (10 yr 5/4), slightly sticky; 195-315 brown to grayish brown (10 yr 5/3 to 5/2), sand increases gradually with depth. 45-60 cm soil is lightly to moderately dispersed. Water at 288.

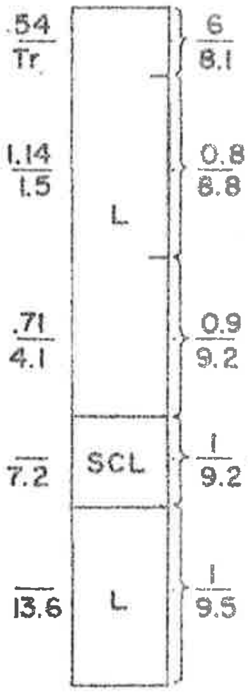
Depth in (CMs)	pH paste	Saturation Ext. Meq/L CATION			ANION				ESP by SAR	ESP by Flame Pho'meter Meq/100 grams			ESP %	Boron in ppm
		Na	K	Ca+Mg	Cl	HCO_3	CO_3	SO_4		Ext Na	Sol Na	CEC		
0 - 45	7.5	3.0		7.9					1.0	.46	.14	10.5	3.0	.13
45 - 120	7.9	1.9		3.3					.9					.16
120 - 195	8.0	1.1		3.6					.2					
195 - 210	8.1	2.7		4.1					1.5					
210 - 285	7.9	5.3		5.5					3.5					
285 - 315	8.1	5.3		4.7					3.8					

Typical Soil Profile
Class 1



Uniform flat, good wheat. 0-60 yellowish brown (10 yr 5/4), friable but moderately sticky, some sand but good body; 60-110 slightly coarser texture but darker color; 110-150 brown (10 yr 5/3), friable, moist, no free water. 90+ random fine gravel.

Depth in (CMs)	pH paste	Saturation Ext. Meq/L CATION Na	K	Ca+Mg	ANION Cl	HCO_3	CO_3	SO_4	ESP by SAR	ESP by Flame Pho'meter Meq/100 grams Ext Na	Sol Na	CEC	ESP %	Boron in ppm
0 - 30	7.7	1.15	.66	7.5	3.5	4.4	0	4.5	1.9					.25
30 - 60	7.6	.71	.18	5.0	1.8	3.6	0	2.7	1.5					.25
60 - 110	7.7	.85	.37	6.2	2.7	3.4	0	3.5	1.4					.27
110-150	7.9	.60	.13	4.2	1.2	3.2	0	2.7	1.6					.54

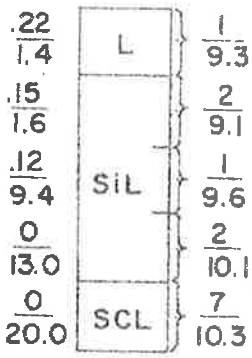


Typical Soil Profile
Subclass 2sa
Present Conditions

(Reclaimable to class 1)

Uniform flat. Crops are only fair to poor. 0-110 brown (7.5 yr 5/4) sticky; 110-180 grayish brown (10 yr 5/2), moisture increasing; 180-220 reddish brown, very sticky, light; 220-300 brown, moderate yellow and gray mottling. Silty zones. Water at 230

Depth in (CMs)	pH paste	Saturation ext. Meq/L							ESP by SAR	ESP by Flame Pho'meter				Boron in ppm
		CATION			ANION					Meq/100 grams			ESP %	
		Na	K	Ca+Mg	Cl	HCO_3	CO_3	SO_4		Ext Na	Sol Na	CEC		
0 - 30	7.8	3.0	.6	45.0	1.6	2.3	0	44.7	Tr					.21
30 - 110	8.3	2.1	.2	2.7	1.1	2.8	0	1.1	1.5					.20
110 - 180	8.3	4.1	.1	2.5	1.0	3.1	.1	2.5	4.1	LIME 26%				.28
180 - 220	8.0	13.1	.3	9.4	1.0	1.7	0	20.1	7.2					
220 - 300	8.4	6.1	.1	1.4	1.4	3.7	.1	2.3	13.6					

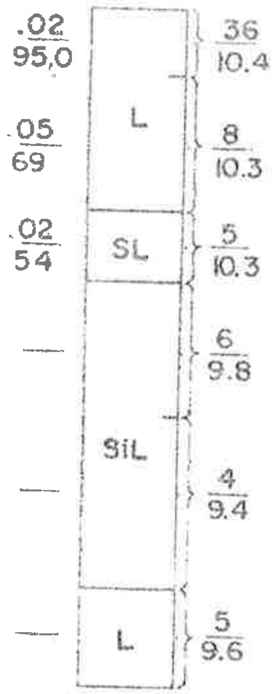


Typical Soil Profile
Subclass 3sd
Present Conditions

(Reclaimable to class 1)

Uniform flat. Moderate to heavy salt grass. No visible salts here but evident on surface to east. 0-60 brown (10 yr 5/3) friable but sticky; 60-90 more compact; 90-120 grayish brown (10 yr 5/2); 120-150 yellow and Fe mottling, sand increasing, still compact and slick. Water table at 85 cm.

Depth in (CMs)	pH paste	Saturation ext. Meq/L CATION			ANION				ESP by SAR	ESP by Flame Pho'meter Meq/100 grams			ESP %	Boron in ppm
		Na	K	Ca+Mg	Cl	HCO_3	CO_3	SO_4		Ext Na	Sol Na	CEC		
0 - 30	7.7	4.0	.8	10.2	2.8	4.0	0	8.3	1.4					.15
30 - 60	7.9	5.5	.2	15.4	1.9	2.2	0	17.0	1.6					.45
60 - 90	8.0	7.6	.3	1.8	3.1	5.0	0	1.1	9.4					1.46
90 - 120	9.1	11.0	.1	2.0	2.6	2.8	0	7.7	13.0					.32
120 - 150	8.9	14.3	.2	1.2	2.7	6.2	0	5.6	20.0					—



Typical Soil Profile

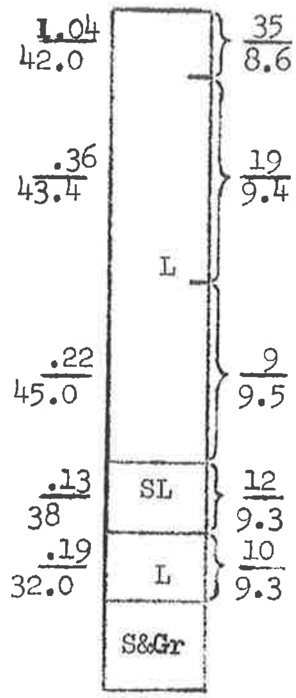
Class 6

Uniform flat. One of several small salty spots. 0-90 brown, friable, but very sticky; 90-120 coarse sandy loam; 120-180 grayish brown, some sand; 180-225 light grayish brown, very silty and sticky; 255-300 grayish brown, fine Fe mottling, very sticky. Water at 143 cm.

Depth in (CMs)	pH paste	Saturation ext. Meq/L CATION			ANION				ESP by SAR	ESP by Flame Pho'meter Meq/100 grams			ESP %	Boron in ppm
		Na	K	Ca+Mg	Cl	HCO_3	CO_3	SO_4		Ext Na	Sol Na	CEC		
0-30	9.6	1062	80	1.5	399	48	205	492	95	$CaCO_3$ - 15 %				11.8
30-90	9.4	123	-	1.5										6.3
90-120	9.4	70	-	1.7										1.9
120-180														
180-255														
255-300														

Typical Soil Profile

Class 6



Uniform nearly level. Moderate salt grass with numerous bare spots. 0-240 cm uniform brown, very little stickiness and no mottling. 120-165 cm some hard $CaCO_3$ nodules. 150-240 cm very moist but no **free** water. Gravel is fine and not cemented.

Note: EC_e and pH shown in profile obtained from 1:10 extract and converted to 1:1

Depth in (CMs)	pH Paste	Saturation Ext. Meq/L CATIONS Na	K	Ca + Mg	ANIONS Cl	HCO_3	CO_3	SO_4	ESP by SAR	ESP by Flame Photo. Meq/100 Grams Ext.Na	Sol.Na	CEC	ESP %	Boron in ppm
0- 30	7.8	350.0		97.5					42					3.20
30-120	8.4	192.0		42.5					37	11.80	8.85	6.80	43.4	1.41
120-180	8.3	181.0		22.25					45					
180-210	8.1	163.0		30.0					38					
210-240	8.0	181.0		33.25					30					

summary of the results of their work with respect to general relationships of saturation percentages, textural grades, field permeability and available moisture is shown in the diagram which follows this page. This indicates that available moisture in the medium textured soils (loams and silt loams) which predominate in the Shamalan Unit would be from approximately 4.3 to 5.0 cm per 30 cm (1.7 to 2.0 inches per foot) of soil.

Calcareous Development

The soils of the Shamalan Unit are nearly all quite uniformly calcareous throughout the profiles. The very low rainfall, characteristic of the Valley, has caused little leaching of calcium carbonate from the surface soils and virtually no discernible lime concentration in the subsoils.

Drainage

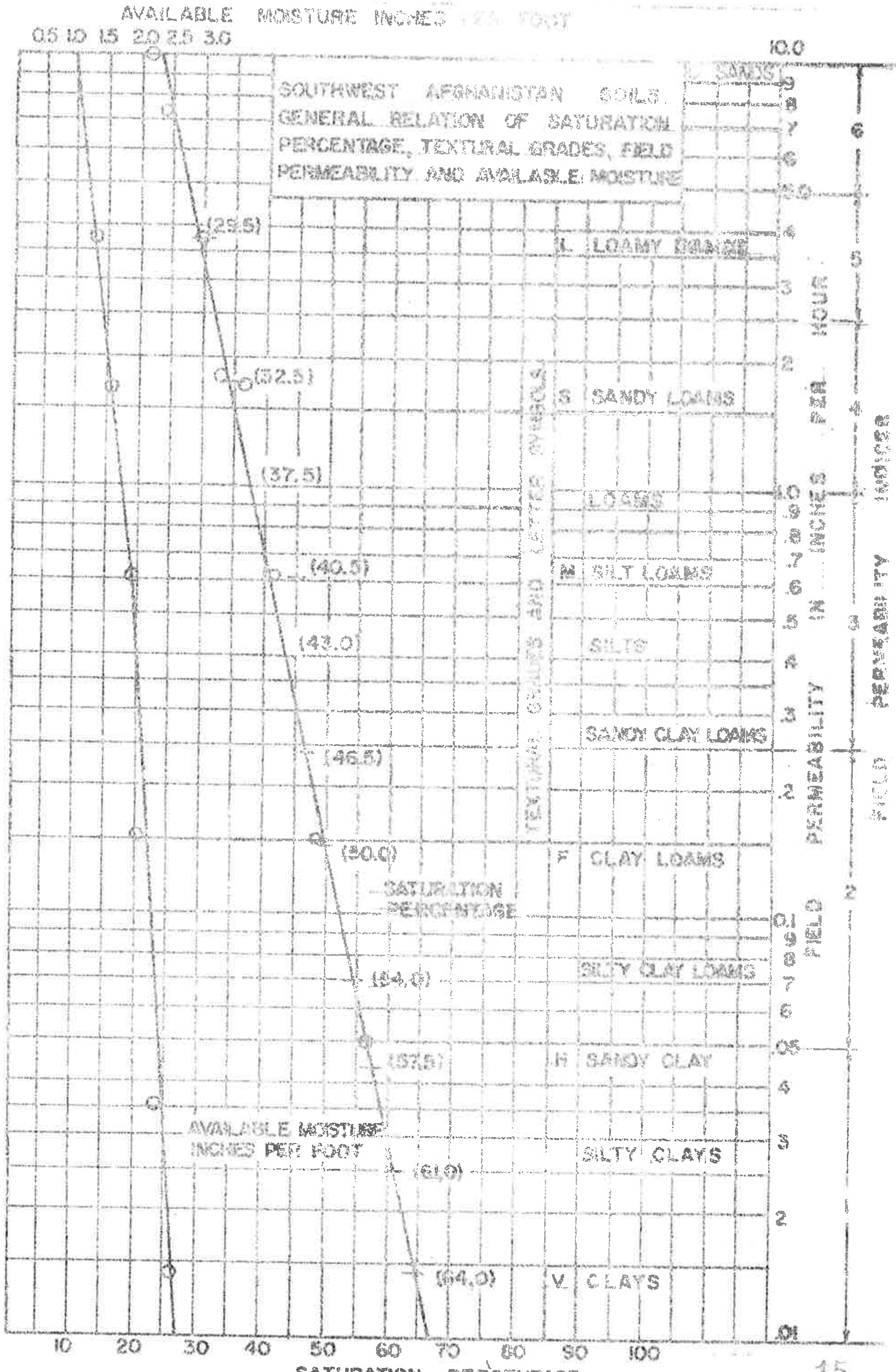
The majority of the soils in the Shamalan Unit are at present affected by drainage problems of varying degrees which inhibit crop growth and contribute to salinization of the soils. These conditions are discussed in greater detail in the section on drainage in this appendix. However, drainage investigations conducted to date show that the lands classed as arable have favorable natural drainage characteristics and indicate that drainage facilities required to keep water tables at safe levels can be provided at reasonable costs. The predominant medium textured soils have moderate infiltration rates, averaging approximately one cm (0.4 inch) per hour, and, with good irrigation practices, deep percolation losses will not be excessive. Borings and exposed profiles indicate that the entire area is underlain by open, porous gravel strata, largely at or near depths the drains would intercept.

The project development plan provides for the provision of necessary drainage facilities, including deepening and improving existing drains, construction of additional drains needed on the basis of drainage investigations which have been made in the Unit, and adding additional drains where need develops following project development.

Salinity and Alkalinity

Salinity and high exchangeable sodium constitute moderate to serious problems in the majority of the soils of the Shamalan Unit under present conditions. Concentrations of both occur in sporadic and highly variable patterns with conditions ranging from soils which are unaffected or only slightly affected to those classed as totally unsuitable for irrigation agriculture because of high levels of soluble salts and exchangeable sodium occurring under conditions such that reclamation is considered impractical.

These problems are usually associated with seasonal or constant high water table conditions but there are sizable areas of saline and/or sodic soils where there are no evident associated water table problems.



SOURCE-INTERNATIONAL ENGINEERING CO., REPORT ON S.W. AFGHANISTAN

The less seriously affected soils can be reclaimed by relatively simple to moderate means if adequate drainage facilities are provided. These would include corrective measures such as simple leaching where slight to moderate salt excesses are present, and combinations of use of calcium amendments, such as gypsum, and leaching on reclaimable sodic soils.

These problems and their correction are discussed in greater detail in the section on salinity and alkalinity in this appendix. In the future it may be found feasible to reclaim part of the lands now classed as nonarable due to excessive exchangeable sodium concentrations. Feasibility of reclaiming these lands can be ascertained only by appropriate field and laboratory research studies to determine cost and effectiveness of reclamation methods.

Fertility and Organic Matter

The Shamalan Unit lands are among the oldest irrigated lands in the Helmand River Valley. They have been farmed for many centuries, and with minor exceptions, without use of fertilizers of any kind and with little or no organic residues being returned to the land. The only exceptions of note are small areas located near villages which have received rather heavy applications of animal and human manures. The result is that the great majority of the soils are seriously depleted in fertility and nearly all have very low organic matter levels.

It is anticipated that heavy applications of certain fertilizers will be required to bring the soils up to a satisfactory level of production. Subsequent applications, sufficient to meet year-to-year crop needs, will be required. Findings in recent years in the Western United States and in a number of irrigated areas in other parts of the world with long histories of irrigation indicate that serious depletion of phosphate is a strong possibility, and unless required applications are made to meet soil adsorption capacities, the land cannot be brought up to a satisfactory level of productivity. On the basis of experience in Western United States, this requirement could range up to 450 to 900 kilograms of available P_2O_5 per hectare (400 to 800 lbs per acre) on part of the soils. Zinc deficiency is another possibility. Once the serious depletions have been overcome, subsequent fertilizer applications sufficient to meet annual crop requirements will be required to maintain fertility levels.

Low organic matter levels affect soils adversely in many ways, causing poor soil structure, poor soil tilth, poor soil-moisture and soil-air relationships, reduced biological activity and by making fertility maintenance more difficult. In order to correct these conditions in the Shamalan soils, as well as in other irrigated areas in the Helmand River Valley, it will be necessary to institute and follow sound soil organic matter building programs. These consist primarily of soil building crop rotations, which include alfalfa, clover and grasses, plowing under green manure crops, and use of adequate quantities of animal manures. Building up favorable organic matter levels in the soils will also increase availability of fertility elements by increasing microbiological activity.

Another very important function served by organic matter as related to soil fertility is its effect on increasing the soil cation exchange capacity, as organic matter has a much higher cation exchange capacity than the inorganic clay portion of the soils. The soils of the Shamalan area in general have relatively low base exchange capacities (averaging approximately 8.8 me/100 grams) and can be expected to respond favorably in this respect to buildup of soil organic matter.

Suitability for Irrigation

The great majority of soils of the arable lands of the Shamalan Unit are physically well suited to irrigation farming. In general they have deep, uniform profiles of moderately fine to moderately sandy textures, with medium textures predominating, have good to high available moisture holding capacities and have favorable internal drainage characteristics. On the basis of physical characteristics the great majority of these soils would meet class 1 specifications. However, long years of irrigation farming following archaic practices has led to development of a number of problems and deterioration of the lands. Damaging water table conditions have developed, soils have become affected to various degrees by accumulation of harmful salts, fertility has been depleted to very low levels, and other problems have developed which seriously limit agricultural production on nearly all of the soils. Correction of these problems, however, is considered feasible in the lands classed as arable, following which these soils will be capable of good to high yields of a wide variety of crops.

Topography

General Description and Major Topographic Features

The lands of the Shamalan Unit are located on a low, relatively uniform, nearly level to gently sloping river terrace, which ranges from approximately one to four meters (3 to 13 feet) in elevation above the normal river water surface. The average gradient from north to south is approximately 1.3 meters per kilometer (approximately 6.9 feet per mile) and east-west gradients are nearly level within terrace segments. Principal topographic variations consist of short slopes into river channels, some nearly flat backwater areas or oxbows, and sand dunes and hummocks which encroach in a narrow strip along the west side of the terrace from the desert to the west.

Land surfaces within the Unit are generally quite uniform with minor undulations caused by weeds and shrubs collecting windblown materials in uncultivated areas. The sand dunes and hummocks which have invaded the western edge of the Unit are not included in the lands classed as arable.

Specific Topographic Problems

Surfaces of most of the arable lands of the Unit are sufficiently level to achieve effective irrigation water distribution under the present system of small fields enclosed by small, low dykes, or borders. These fields have been leveled by hand or by the use of oxen and crude implements over the centuries, with small segments of each cultivator's holdings being leveled each year. The resultant pattern, however, is one of very small fields which, although generally meeting the needs of the present farming methods, would not meet the requirements of mechanical farming, or even more efficient farming methods where animal power is used. Conversion to mechanical farming with modern methods of irrigation would require broad-scale land leveling, or grading. Unit leveling requirements would, however, be low due to the general uniform relatively smooth surface features of the land.

Clearing trees from the banks and leveling out the old jui system, which now serves most of the Unit would be a principal item in leveling and reshaping fields into patterns meeting the needs of modern agriculture.

Costs for accomplishing the total leveling requirements of the Unit would be relatively low. On the basis of the present estimates, total leveling and grading costs would average approximately $115.00 per hectare ($47.00 per acre).

Drainage

General Description

Although the majority of the Shamalan Unit lands are presently affected by drainage problems, the irrigable lands in general have good drainability characteristics. The soils, which are predominantly of medium textures, ranging from moderately fine to moderately sandy textures, have medium to moderately low surface infiltration rates and do not pose serious deep percolation hazards.

Field infiltration tests conducted over the area to determine moisture penetration rates into and through the upper soil zones gave rates ranging from approximately 0.2 to 4.0 centimeters per hour (0.1 to 1.6 inches per hour), averaging approximately 1.0 cm/hr (0.4 inch per hour). Laboratory permeability rates averaged approximately two-thirds the field rates. Deep percolation losses from irrigation, with good irrigation practices, should be moderate.

Observations and explorations conducted to date indicate that all of these lands are underlain by open porous gravel or gravelly strata with relatively high permeability rates at or near depths which would be intercepted by drains. The gravel strata are normally encountered at depths of from two to four meters ($6\frac{1}{2}$ to 13 feet), with depths of three to four meters (10 to 13 feet) predominating. In places the gravel is found at the surface and the maximum depth to gravel observed was approximately seven meters (23 feet). On the basis of observations of a limited number of deep holes drilled to date, the gravel strata range from four to ten meters (13 to 33 feet) in thickness and are usually underlain by compacted fine-grained sandy materials or sandstone, but are in places underlain by hard tightly cemented, impervious conglomerate. The sandstone stratum is very slowly permeable and thus forms a definite effective drainage barrier. The surface of this stratum is, however, relatively uniform, without appreciable undulation and does not form extensive horizontal drainage barriers.

The Unit has generally smooth topography with relatively uniform, gentle slope and few significant irregularities that woul cause accumulation of surface and ground water or would pose serious problems in the construction of required drains. The irrigable lands are situated high enough above existing drain outlets to the river to provide adequate outfalls.

A series of ground water wells was established in December 1964 to study depth to fluctuation and direction of flow of ground water in the Unit. A small number of village domestic wells were also selected for observation at that time. These wells were read from time of installation until mid-May 1965. An additional ground water observation system was established in the West Shamalan Division during November 1965, consisting of auger holes, village wells, and deep holes drilled with a core drill to the west of the Unit. Piezometric type tests were conducted on six of the deep holes to determine the extent of ground water flow into the Shamalan Unit from the desert. Depth to ground water readings in the West Shamalan Division system have been made from the time of installation and are being continued. These observations and tests are discussed in detail in the Drainage Appendix of the Shamalan Unit Feasibility Report. The results of the studies of the ground water investigations further substantiate the favorable inherent drainage characteristics of the Shamalan Unit project lands.

Results of observation well readings show that the ground water reaches its highest level during December just prior to the winter season shutdown of the canals, that there is a general rapid drop in the water table level during the shutdown period and that buildup in the water table occurs following resumption of irrigation during the spring. The rapid drop-off in water table level is especially indicative of favorable internal drainage characteristics considering that ground water must travel long distances (as far as 9 kilometers, or 5.6 miles) to reach surface at the outlet drains. In some wells near outlet drains, the rate of fall was as much as five cm (2 inches) per day.

Shallow well (auger hole) pump-out tests were conducted over most of the Unit on a basic 500 meter grid spacing and on a grid of 250 meter spacing in areas with high water table conditions. The tests showed the gravelly material to have consistently high permeability rates in nearly all of the locations where tests were conducted. The sandy horizons immediately above the gravel also had consistently high permeability rates. No extensive shallow horizontal barriers were found above the gravel strata. The water table studies also indicated that the gravel strata have high water moving capabilities.

No measurements have been made to determine seepage losses from the Shamalan Canal and the existing laterals. Based on data from the field infiltration tests, and laboratory disturbed permeability tests, seepage losses from the farm ditches and small laterals should be moderate. Auger borings and pits along the proposed West Shamalan Lateral indicate short reaches where seepage losses could be considerably higher and are quite probably excessive. Provisions for lining these reaches are included in the project plan.

In view of the generally favorable inherent drainage characteristics of the Shamalan Unit area lands, it is anticipated that the necessary drainage facilities to correct existing problems and to meet needs under the planned future developments can be met at moderate costs.

Drainage Problems

Although the Shamalan Unit lands in general have favorable drainability characteristics, the majority of them are at present affected by drainage problems of varying degrees. High water table conditions are prevalent in a large part of the Unit lands which contribute to salinization of the soils and otherwise inhibit crop growth. The only sizable contiguous block of lands within the Unit not affected at present by high water table conditions is the area comprising approximately the southern one-third of the South Shamalan Division where irrigation water is perennially in short supply.

The major contributing factor to existing problems is the lack of an effective, well maintained drainage system. There are no natural drainageways within the Unit and the existing constructed drains are not adequate to control the water table at safe levels from the standpoints of depth, location, spacing, and maintenance. The current existing drains are of inadequate depth and are poorly maintained. Considering all of these factors, the existing drains do have considerable flow, further indicating favorable subsurface drainage characteristics.

Other factors which are now contributing to the widespread drainage problems are irrigation system losses, poor distribution, and lack of effective and adequate water distribution controls.

With the sizable increase in irrigation water supply to the Unit planned in the proposed project development, accretions to the ground water will be increased considerably and drainage problems will become more severe unless the necessary remedial measures are provided. However, it is anticipated that drainage development, improvement of the irrigation system and other related developments provided for in the project plan of development will correct existing drainage problems and will keep water tables at safe levels under the full irrigation of the lands.

Salinity and Alkalinity

General Discussion

Investigations for salinity and alkalinity included collection and analysis of representative soil samples from the project Unit during the detailed land classification. Sampling was done on an intensive basis with all appropriate horizons being sampled in all locations where sampled profiles were observed and logged. The rate of soil profile examination and sampling exceeded the minimum requirements for detailed land classification with an average rate of one logged and sampled profile for each 12 hectares (30 acres). All samples were subjected to laboratory tests for electrical conductivity and pH of 1:10 dilutions. A large number of selected samples were subjected to additional analyses and tests including insoluble carbonates, mechanical analysis, hydraulic conductivity, total dissolved solids, analysis of saturation extract for soluble cations and soluble anions in milliequivalents per liter, cation exchange capacity, extractable sodium, soluble sodium, exchangeable sodium, and soluble boron.

Table 1 on the following page presents typical laboratory data depicting types of analyses and typical analytic results. Data from laboratory tests and analyses were used in conjunction with field observations to complete the information required to accomplish a sound and complete detailed classification of the Unit lands. The data from these tests were applied in the delineation of arable from nonarable lands and in the separation of the arable lands into classes according to limits set up for each class in the land classification specifications. (See Table 4 "Land Classification Specifications"). In part "A", "Present Conditions" of the specifications these limit soils in class 1 lands to electrical conductivities of the saturation extract not to exceed 4 millimhos/cm, pH less than 9.0 (1:10 dilution) and exchangeable sodium concentrations so low as to not cause any adverse effects. Soils included in class 2 lands can have a maximum conductivity of 8 mmhos/cm, pH of 9.5 or less (1:10 dilution), and exchangeable sodium must not exceed 10%, or 2 milliequivalents/100 grams. The maximum limits permitted in the soils of class 3 lands are electrical conductivities of 10 mmhos/cm in the surface 30 centimeters (12 inches) and 15 mmhos/cm in the soil profile; pH not to exceed 9.8 (1:10 dilution); and exchangeable sodium not to exceed 15% or 3 meq/100 grams. In the part of the specifications considering the lands "Following Project Development" it is assumed that reclamation of saline and sodic soils included in the irrigable project lands to bring them up to class 1 specifications in these respects will have been accomplished. The only exception to this is that unreclaimable sodic spots sufficient to reduce overall yields up to 15% will be permitted in class 2 lands, and up to 30% reductions from this are permitted in class 3 lands. Salt limits permitted in class 3 under present conditions may appear relatively high, but these were arrived at after careful study of the actual crop conditions and yield measurements, correlating crop yields with salinity levels. The salt concentrations in these areas occur in highly variable and sporadic patterns in which the soils with maximum concentrations permitted by the specifications are interspersed with soils varying downward to relatively salt-free conditions. Furthermore, as discussed in the section on drainage in this appendix, all of the irrigable lands of the Unit are underlain by open, permeable gravel strata and drainability conditions in general are favorable. Leaching of excess salts where needed, and control of salt levels within safe limits can be accomplished by good irrigation practices if the necessary drainage system, recommended in the project plan, is provided and properly maintained. Also, nearly all of the crops now grown, or anticipated to be grown following project development, are moderately salt tolerant.

TABLE 1

Typical Laboratory Data - Soil Analysis

Planning Department Soils Laboratory - Bost, Afghanistan

Project Shamalan Unit

Laboratory Number	Field Number	Location/ Photo No.	Hole No.	Depth (Cms)	Texture by M. A.	Sat. %	P H Sat. paste	P H 1:5	P H 1:10	EC_e mmhos	Saturation Extract Cations - Meq/L Na	K	Ca	Mg	Anions - Meq/L Cl	HCO_3	CO_3	SO_4**	ESP by SAR	ESP by Fl. Pho'meter Meq / 100 grams Ext. Na	Sol. Na	CEC	% ESP	Hydr. Cond. Cm/Hr	Sol. Boron (ppm)	Lime ($CaCO_3$) in %	Gypsum meq/ 100g
67-1762	M.S.#2	19-86	1	0-30	SiL*	43.47	7.8	8.2	8.5	1.39	2.70	0.45	7.6	5.2	0.65	6.75	1.0	8.55	0.5	0.42	0.12	8.3	3.6	0.28	0.35	20.7	1.29
67-1763	M.S.#2	19-86	1	30-95	SiL	44.62	7.7	8.6	9.0	0.64	1.65	0.29	2.5	1.9	0.40	3.35	0	2.59	0.5	0.33	0.07	7.5	3.5	0.26	0.17	26.1	1.51
67-1764	M.S.#2	19-86	1	95-150	L	33.11	7.7	8.4	8.8	1.22	4.85	0.62	5.0	2.6	0.40	8.75	0	3.92	2.2	0.50	0.16	4.9	6.9	0.39	0.10	24.0	0.75
67-1759	M.S.#1	2/A-37	1	0-34	SiL	35.64	8.7	9.4	9.6	136.00	1312.0	27.5	12.5	8.5	862.5	1.75	4.0	492.2	85.0	50.00	41.2	10.4	84.6	0.01	3.04	23.0	0.21
67-1760	M.S.#1	2/A-37	1	34-94	SiCL	51.00	9.0	9.8	10.0	11.00	108.0	0.86	1.0	2.5	32.5	7.80	2.8	69.26	55.5	12.50	5.5	11.7	59.8	0.01	3.88	25.3	0.56
67-1761	M.S.#1	2/A-37	1	94-150	SiL	41.30	8.9	9.8	9.9	4.80	45.0	0.11	0.90	2.3	8.15	2.75	1.2	37.11	34.5	4.40	1.85	6.3	40.5	0.04	0.95	26.8	0.37
67-341	171	12-324	24	0-30	SCL		7.8		9.1	.70	3.05	0.28	Ca+Mg 5.2		1.90	4.40	1.6	0.58	1.6					0.44	3.00		
67-342	172	12-324	24	30-60	SL		8.1		9.0	.66	2.45	0.22	4.2		2.00	3.06	0	1.27	1.2					0.32	0.30		
67-343	173	12-324	24	60-150	SL		8.0		9.2	.75	3.15	0.16	4.9		1.70	3.80	0	2.76	1.7					0.29	0.3		
67-344	174	12-324	24	150-195	L		7.7		9.0	1.15	4.25	0.66	7.5		3.50	4.40	0	4.51	1.9					0.72	0.20		
67-345	175	12-324	24	195-210	L		7.6		9.0	0.71	2.95	0.18	5.0		1.80	3.60	0	2.68	1.5					0.51	0.20		
67-346	176	12-324	24	210-250	SiL		7.7		9.2	0.85	3.05	0.37	6.2		2.80	3.40	0	3.47	1.4					0.48	0.30		
67-347	177	12-324	24	250-300	SiCL		7.9		9.2	0.60	2.75	0.13	4.2		1.20	3.20	0	2.68	1.6					0.27	0.60		
45-9094	164	19-102	8	0-30	SiL		7.7		9.3	1.20	4.10	0.90	10.0		2.80	4.00	0	8.20	1.4					0.22	0.15		
45-9095	165	19-102	8	30-60	SiCL		7.9		9.1	1.60	5.50	0.20	15.40		1.90	2.20	0	17.00	1.6					0.15	0.45		
45-9096	166	19-102	8	60-90	L		8.0		9.6	1.30	7.60	0.30	1.80		3.10	5.00	0	1.10	9.4					0.12	1.50		
45-9097	167	19-102	8	90-120	CL		9.1		10.1	2.20	11.00	0.10	2.00		2.60	2.80	0	7.70	13.0					0	0.32		
45-7830	7771	21-177	3	0-30	L	39.20	9.1		10.0	17.0	454.0	-	2.2						86	22.7	17.8	8.8	56	.04	0.15		
45-7831	7772	21-177	3	30-60	SL	38.10	9.0		9.9	10.0	163.0	-	2.0						72	10.3	6.2	6.2	66				
45-7832	7773	21-177	3	60-90	L	51.10	8.4		9.8	4.2	49.0	-	4.0						30	4.8	2.5	6.6	35	.01			
45-7833	7774	21-177	3	90-120	SCL	53.10	8.0		9.3	4.8	44.0		12.8						20	3.8	2.3	7.7	19	.02	1.1		
45-7834	7775	21-177	3	120-150	SL	30.10	8.3		9.5	5.5	108.0		14.9						37	4.8	3.3	4.0	39				

* Particle size distribution (sand, silt and clay) by percentages reported when requested by land classifier. (Available in laboratory for all samples on which mechanical analysis performed.)

** Sulphates calculated by difference.

Present Conditions

Salinity and exchangeable sodium constitute moderate to severe problems on the majority of the Shamalan Unit lands. Concentrations of both occur in sporadic and highly variable patterns with conditions ranging from soils which are unaffected, or only slightly affected, to those classed as totally unsuitable for irrigation agriculture due to high levels of soluble salts, exchangeable sodium, or combinations of both. Moderately high to high concentrations of boron are also found but these are consistently associated with very high salt concentrations and exchangeable sodium concentrations. Only a few scattered profiles were found where boron was present in damaging quantities where the soils were otherwise arable.

In the Shamalan Unit approximately 82 percent of the irrigated lands are affected by salt and/or exchangeable sodium. Of the total irrigated area approximately 30 percent is affected to a moderate degree by salt concentrations; approximately 10 percent is affected by moderate concentrations of salt and exchangeable sodium, approximately 17 percent is affected by combinations of relatively high salinity and exchangeable sodium, but can be reclaimed by moderate applications of gypsum and by leaching, assuming adequate drainage; and approximately 25 percent of these lands have such high concentrations of salts and/or exchangeable sodium that reclamation is not considered feasible. In the majority of the affected lands, salt and exchangeable sodium excesses are associated with seasonal or constant high water table conditions, but there are sizable areas of saline and/or sodic soils where water table is not a problem.

Salt and exchangeable sodium are erratic in occurrence throughout the affected areas with wide variations in both. The moderately to severely affected areas are typically interspersed with areas virtually free of salts and with low exchangeable sodium percentages. Many of these unaffected areas are too small and irregular in shape to be separated out on the land classification map.

Potential Conditions

Because of the prevailing favorable drainability characteristics of the project lands, their generally favorable infiltration rates, and since the project plan of development provides for construction and maintenance of the necessary drainage facilities and provision of ample quantities of good quality irrigation water, no significant additional salinity or alkalinity problems are anticipated following project development. Furthermore, it is anticipated that most of the lands classed as arable now affected by salinity and alkalinity can be effectively and economically reclaimed to class 1, or near class 1 productivity levels. Lands classed as arable where soluble salt excesses constitute the only inhibiting factor can be reclaimed by leaching. The great majority of the lands placed in class 2 because of moderate exchangeable sodium concentrations can be reclaimed by use of green manures, crop residues, animal manures, and leaching. The more severely affected sodic soils that were included in the arable lands as subclass 3sa will, in addition to these treatment measures, require moderate applications of gypsum to achieve full reclamation within a reasonable length of time. Gypsum is available locally in ample quantities to meet project needs in the form of "gotch" averaging 60-70 percent gypsum content.

It may in the future prove feasible to reclaim part of the lands now classed as nonarable due to excessive salts and/or exchangeable sodium. Feasibility of reclamation of these lands can be ascertained only by appropriate research studies and will depend upon effectiveness of leaching, amount of gypsum necessary to reduce exchangeable sodium concentrations to safe levels, costs of drainage and other reclamation measures required and response of the soils to treatment.

Quality of Water

Source of Water

The Helmand River is the source of irrigation water for the Shamalan Unit and for other irrigated lands of the Helmand Valley except where small areas are irrigated by kareezes. The main stem of the Helmand River rises west of Kabul on the southern slope of the Koh-i-Baba and Hazara ranges which form part of the Hindu Kush range and reach elevations as high as 4,400 meters (14,400 feet) above mean sea level. The river flows are stored and regulated in the Kajakai Reservoir for irrigation and flood control purposes. River elevation at Kajakai is approximately 960 meters (3,150 feet). Most of the streamflow in the Helmand River originates either from rainfall in the winter and spring at intermediate elevations or from snow melt in the higher elevations during the late spring and early summer. The lower elevations in the basin are desert areas with little or no runoff, except for flash floods resulting from relatively intense, but usually local, rainstorms.

Irrigation water for the Shamalan Unit, along with water for the Marja and Nad-i-Ali Units, is initially diverted into the Boghra Canal from the Helmand River at a point near Girishk, approximately 75 kilometers (45 miles) below Kajakai Dam. The bifurcation point into the Shamalan Canal, which serves all of the Shamalan Unit lands, is approximately 30 kilometers (18 miles) below the Boghra Diversion near Chah-i-Anjir.

In the project plan of development it is contemplated that the Nad-i-Ali Wasteway will be used to carry additional irrigation water supplies from the Boghra Canal to the lands of the West Shamalan Division of the Shamalan Unit lying to the south of the wasteway. This will necessitate mixing the wasteway flows, which at present consist of a combination of drain water from Nad-i-Ali lands, with Boghra Canal water which is spilled into the wasteway.

Suitability of Water for Irrigation

General. The characteristics of irrigation water that are most important in determining its degree of suitability for irrigation provide a basis for predicting the effects of the water on the soils over long years of irrigation farming. The three principal hazards from this standpoint are salinity, exchangeable sodium, and boron. Therefore, the characteristics of irrigation water that are most important in determining its quality are: (1) total soluble salts; (2) relative proportion of sodium to other cations; (3) the bicarbonate concentration as related to the concentration of calcium plus magnesium; and (4) concentration of boron or other elements that may be toxic. Each of these factors is treated below for Helmand River waters and for the mixed waters from the Boghra Canal and the Nad-i-Ali Wasteway.

Total Concentrations of Dissolved Salts. The total concentration of dissolved salts can be expressed in terms of electrical conductivity (micromhos/cm) or by quantity (parts per million). Both means of expression provide good indices as to the quality of water with respect to normal plant growth, and the degree of hazardous buildup of toxic concentrations of salts in the soil. Electrical conductivity is recognized as the more accurate guide for making these determinations.

Proportion of Sodium to Other Cations. The alkali or exchangeable sodium hazard involved in the use of water for irrigation is determined by absolute and relative concentrations of the cations. If the proportion of sodium is high, the alkali hazard is high; and conversely if calcium and magnesium predominate, the alkali hazard or danger of exchangeable sodium buildup is low. The sodium-adsorption-ratio (SAR) has been found to be a useful and reliable index for designating this hazard.

Bicarbonates and Carbonates. In waters containing high concentrations of bicarbonate ions there is a tendency for calcium and magnesium to precipitate as carbonates as the soil solution becomes more concentrated. This reaction does not normally go to completion, but insofar as it occurs the concentrations of calcium and magnesium are reduced and the relative proportion of sodium is increased. Thus, the relative proportions of bicarbonate ions must be considered in evaluation of suitability of irrigation waters. The effect of the bicarbonate ion on water quality is expressed in terms of residual sodium carbonate (RSC), or the amount of sodium carbonate that would remain in the water if all of the calcium and magnesium were precipitated out as carbonates by reacting chemically with bicarbonate and carbonate ions present in the water. This concept is defined in the following equation:

$$RSC = (CO_3{}^{--} + HCO_3{}^{-}) - (Ca^{++} + Mg^{++})$$

(Residual Sodium Carbonate) (Carbonates) (Bicarbonates) (Calcium) (Magnesium)

Laboratory and field studies conducted by the USDA Salinity Laboratory in the early 1950's, and substantiated by more recent research, indicate that waters containing less than 1.25 milliequivalents/liter residual sodium carbonate are probably safe for most irrigation purposes. Waters containing 1.25 to 2.5 meq/L are marginal and those containing more than 2.5 meq/L are not suitable for irrigation purposes. None of the waters being considered for irrigation use in the Shamalan Unit contain any residual sodium carbonates.

Boron. Boron, although necessary in minute amounts for plant growth, is highly toxic to plants at only a few parts per million in the soil solution. Because boron tends to accumulate in the soil from even low concentrations in the irrigation waters, this constituent must be considered in assessing quality of irrigation waters. Generally accepted limits of tolerance for boron in irrigation waters are as follows:

Sensitive crops............	0.3 to 1.0 ppm
Semitolerant crops..........	1.0 to 2.0 ppm
Tolerant crops	2.0 to 4.0 ppm

With the exception of grapes and tree fruits, all of the crops grown at present or anticipated to be grown in the Shamalan Unit are in the boron semitolerant to tolerant range.

Irrigation Water Classification

The analysis of irrigation water provides information on its suitability for irrigation and also indicates the management practices that should be followed to maintain the soil in a healthy state. The successful use of irrigation water of a particular quality also depends upon characteristics of the soil, drainage conditions, amount of water used and management practices. The USDA Salinity Laboratory system of classifying irrigation waters shown in Agriculture Handbook 60 is referred to in evaluating the irrigation waters to be used in the Shamalan Unit. This system assumes that the waters "will be used under average conditions with respect to soil texture, infiltration rate, drainage, quantity of water used, climate and salt tolerance of crop". The limitations of this classification system and its application are recognized, but it is considered to be useful as a guide in evaluating the irrigation waters under consideration in this appendix. In general these limiting factors will fall within the average range.

Helmand River Water. The Helmand River carries water of very good quality for irrigation purposes. This conclusion is supported by data taken from the International Engineering Co., Inc. "Report on Soil and Water Resources - Southwestern Afghanistan, 1959" and is substantiated by collection and analysis of water samples from the Boghra and Shamalan Canals during 1966 and 1967. These samples were analyzed in the HAVA Planning Department Soil and Water Laboratory at Chah-i-Anjir. There is very little difference in quality of water as determined by the 1966 analysis and that shown in the International Engineering Company report (1959). The results of the analytic data from both sources are tabulated and summarized in Table 2 following this page. The analysis shows that the waters are moderately low in soluble salts, with an average electrical conductivity of 336 micromhos/cm (215 ppm total dissolved solids); low in sodium content, with an average of 0.50 milliequivalents/liter, or 15 percent of total cations; are very low in boron content, with an average concentration of 0.21 ppm. The highest boron content found was 0.28 ppm, which is so low as not to affect the most sensitive crops.

TABLE 2

ality of Water - Boghra Canal and
Boghra Canal Water with Nad-i-Ali Wasteway Water

Percent NA	Percent Ca+ Mg	Boron ppm	Milliequivalents/Liter Cations Na	K	Ca+Mg	Anions SO_4	Cl	CO_3	HCO_3	Sodium Adsorption Ratio (SAR) 2/	3/	Exch Sodium at Equil 2/	3/	Irrig Water Class 4/
15	85	0.21	0.50	-	3.02	0.24	0.50	0.34	2.61	0.44	2.6	Neg.	2.4	C2-S1
47	53	0.77	7.80	.08	8.89	10.68	3.80	0.40	1.90	3.7	4.3	4.0	4.7	C3-S1
35	68	0.37	2.59	-	4.71	3.22	1.44	0.36	2.26	1.6	2.3	1.1	2.1	C2-S1

ty to parts per million + 0.64 x ECX10[6] for irrigation waters in the range
))

i are precipitated out as $CaCO_3$ and $MgCO_3$.

f Irrigation Waters".

According to the USDA Agriculture Handbook 60 diagram for classification of irrigation waters, the Helmand River water would be class C2-S1. According to definition C2 water (medium salinity hazard) can be used on almost all soils and on all but the most salt sensitive crops, with little danger of accumulation of harmful salts if a moderate amount of leaching occurs. Class C2 includes waters ranging in electrical conductivity from 250 to 750 micromhos/cm. Helmand River water with an average conductivity of 336 is well toward the low side of the C2 category approaching the C1, or "low salinity hazard" category. It is safe to assume that the Helmand River water poses little or no threat of salt buildup in normal soils if adequate irrigation water is applied, using good irrigation practices and if the necessary drainage facilities are provided. Furthermore this water is of very good quality for leaching soils presently affected by high salt concentrations. Class S1 (low sodium) waters can be used on all soils with little danger of development of harmful levels of exchangeable sodium. This class includes waters ranging in sodium-adsorption-ratio (SAR) values from 0 to 10. The Boghra and Shamalan canal waters tested ranged from 0.35 to 0.55 and the Helmand River water tested by International Engineering Company averaged 0.75 in SAR value. All of these are so low as to pose negligible exchangeable sodium buildup hazard insofar as the quality of the water is concerned. However, the same precautions related to irrigation management practices and drainage conditions apply as those relating to salinity hazards. Buildup of sodium salts in the soils can occur and can lead to buildup of exchangeable sodium levels if high water table conditions develop or persist.

Boron concentrations in the Helmand River water as previously stated, are very low, and would not affect the most sensitive crops.

There would be no residual sodium carbonate in this water.

Nad-i-Ali Wasteway - Boghra Canal Mixed Water. One of the very important considerations in the plan of development for the Shamalan Unit is the provision of adequate water supplies to lands which are now water-short. Present plans call for construction of a new lateral, known as the West Shamalan Lateral and diverting from the Shamalan Canal, to supply lands of the West Shamalan Division. In order to meet the water requirements of the irrigable lands in the Shamalan Unit, the Nad-i-Ali Wasteway will be used to bring additional water diverted from the Boghra Canal to the West Shamalan Lateral. The water now carried in the wasteway during the irrigation season consists of a combination of drain water from the Nad-i-Ali Project area and canal water spilled from the Boghra Canal into the wasteway.

Data from measurements taken during 1966 and the first half of 1967 show that average conditions in the wasteway are approximately 1.75 cubic meters/second (62 cfs) flow during the irrigation season, with an average approximate electrical conductivity of 1,550 micromhos/cm, and that peak flow varies up to 2.07 cubic meters/ second (73 cfs) with an average conductivity of approximately 1,400 micromhos/cm, depending upon the amount of canal water being spilled into the wasteway. During the canal shutdown period when no irrigation water is being applied, flow in the wasteway consisting entirely of drain water drops to an average of 0.23 to 0.25 cubic meter per second (8-9 cfs) with electrical conductivity averaging approximately 3,400 micromhos/cm. Flow and analytic data on measurements and analysis of water samples collected from Nad-i-Ali Wasteway from December 1961 through May 1967 are summarized in Table 2. This table also presents an analysis of the effects on water quality of mixing Boghra Canal water with wasteway water in a ratio of 2.5:1.0 (canal water:wasteway water) - assuming average wasteway flow of 1.75 cubic meters/second (62 cfs) with electrical conductivity of 1,550 micromhos/cm and average ionic distribution as shown for this water in Table 2. This rate of mix would supply a flow of approximately 6.15 cubic meters/second (217 cfs). The actual rate of mix may be more nearly 3.0 to 3.5 parts canal water to 1.0 part wasteway water in which case the salt concentrations would be proportionately lower than those presented in the following discussion.

Concentrations of Dissolved Solids

Waters resulting from the mix for which calculations were made will have an electrical conductivity of 731 micromhos/cm (468 ppm). Although the mixed water would contain approximately double the total dissolved solids present in the river water they would be in irrigation water class C2 (250 to 750 micromhos/cm) according to the USDA Handbook 60 irrigation water classification diagram. They can be used on most soils and all but the most sensitive crops with little danger of salt accumulation, if a moderate amount of leaching occurs. Because of the higher salt content of these mixed waters, greater care will be required in use of these mixed waters than will be required for the straight canal waters. The proposed allocation of one cubic meter/second for 571.5 hectares (1 cfs for 40 acres) will provide ample irrigation to prevent buildup of harmful accumulations of salts, and to accomplish leaching of salts where required within the arable lands of the Unit. The plan of development provides for construction of an adequate drainage system to meet drainage requirements, and the project lands have generally favorable drainability characteristics. These mixed waters can therefore be considered suitable for irrigation purposes provided reasonable care is exercised in their use.

Proportion of Sodium to Other Cations.

Based on direct laboratory analysis, sodium content of the mixed water would be 2.59 milliequivalents/liter (35% of total cations) for the 2.5:1.0 ratio mix considered (canal water:wasteway water at 1.75 cubic meters/second (62 cfs) flow in the wasteway with $ECX10^6$ of 1,550) and the SAR value would be 1.6. Assuming that all bicarbonates and carbonates reacted with calcium and magnesium and were precipitated out as insoluble carbonates, the mixed water would then have 58% sodium and an SAR value of 2.3. This water would be well toward the lower side of class S1 (low sodium hazard) according to the U. S. Salinity Laboratory Standards.

Bicarbonates

The relative proportions of bicarbonates plus carbonates to calcium plus magnesium are low in the mixed water considered and there would be no residual sodium carbonate.

Boron

Boron content would be low in the mixed Boghra Canal and Nad-i-Ali Wasteway waters averaging 0.37 in the 2.5:1.0 ratio mixed waters. Boron in these concentrations would not be toxic to any of the crops now grown or anticipated to be grown following project development.

Land Classification

Objectives. The land classification survey was made to determine the extent and character of the lands and to classify them according to their capability, under a proper agriculture program, to produce higher agricultural yields and returns. Land classification also provides definite, sound and relatively permanent data which are essential in the solving of agronomic, economic and engineering problems.

Factors Considered. The basic factors considered in the land classification were soils, topography, and drainage. Within each of the basic factors the following characteristics were considered in determining the land class delineations.

Soils	Topography	Drainage
Texture	Surface relief	Soil texture
Depth	Position	Infiltration rates
Structure	Field size & shape	Subsurface permeability
Compaction	Elevations	Depth to drainage barrier
Infiltration	Development costs	Irrigation water quality
Permeability	Preparation costs	Outlets and relief
Water holding capacity	Management costs	Water table conditions
Fertility	(None of the project lands have slopes exceeding 1% and cover is not a significant factor).	Nature of understrata
Drainability		Soil salinity and alkalinity
Salinity & alkalinity		
(All of the project soils are very low in organic matter, show little or no calcareous development and are free from rock or cobble.)		

These physical factors are correlated with the economic factors related to productivity and costs of production to obtain relative income and benefit level.

Segregations Involved

The classification involved separating the arable from the nonarable lands and delineating the arable lands into three classes on the basis of productive capacity. The three arable classes were further subdivided into subclasses on the basis of factors or deficiencies involved in limiting the land class.

Type of Survey

The survey was a detailed land classification. Land features were examined and recorded in sufficient detail to provide information as to the extent and character of the lands to a high degree of accuracy. Basic data with respect to pertinent detail were obtained to determine proper land use, size of farm units, irrigable area, irrigation requirements, irrigation and drainage systems, land development requirements, and agricultural benefits anticipated under project development. Minimum requirements for a detailed land classification are presented in Table 3 following this page.

Previous Survey

A general utilitarian type of soil survey/land classification was made in the Helmand and Arghandab valleys by International Engineering Co.,Inc. (1952-1958). The survey was primarily reconnaissance by nature and does not supply the detail necessary for a feasibility study by Bureau of Reclamation standards. Full advantage was taken of this survey during the preliminary stages of the detailed land classification treated in this appendix. It was found that many changes had taken place in salinity and alkalinity conditions, water tables, land development, etc., to the extent that much of the information from the previous survey was negated. None of the previous information was carried over to the present classification.

Base Maps

Base maps used for the classification were rectified aerial photographic enlargements with a scale of 1:5,000, or 1 cm = 50 meters (1" = 416.67'). The scale on which the photos were flown is 1:10,000. Horizontal control used for rectification of the photographic enlargements consisted of a surveyed triangulation grid. Each photographic enlargement is 50 x 51 centimeters (20" x 20.4") in size. Match lines were put on the sheets prior to their use in the field, exercising care to confine the area to be utilized on each sheet to the part where the rectification would be most accurate, and to avoid, insofar as possible, using outside areas where some distortion might be present.

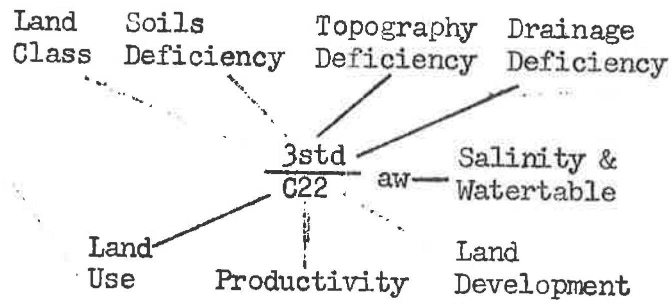
TABLE 3

Minimum Requirements of the Detailed Land Classification

Land classes recognized	1 - 2 - 3 - 6
Scale of base maps............................	1:5,000
Maximum distances between traverses, kilometers	.4 (.25 mile)
Accuracy - percent............................	97
Field progress per day (one land classifier and crew) - hectares.............	32-65 (80-160 acres)
Minimum area of class 6 to be segregated from larger arable areas - hectares	.1 (.2 acre)
Minimum area for change to lower class of arable land - hectares	.8 (2 acres)
Minimum area for change to higher class of arable land - hectares...................	4 (10 acres)
Minimum soil and substrata examination	
Borings or pits (1.5 meters, or 5 feet) per square kilometer	6 (16 per square mile)
Deep holes (3 meters, or 10 feet) per 100 square kilometers........................	27 (25 per township)

Methods and Procedures

The delineations were made in the field after careful examination and appraisal of all significant physical factors. The deficiencies which caused the land to be graded down in class were designated in the numerator of the mapping symbol by letters: soil deficiency by the letter "s"; topographic deficiency by the letter "t"; and drainage deficiency by the letter "d". Salinity and alkalinity problems were indicated by the letter "a" and water table problems by the letter "w" immediately to the right of the fractional symbol. The accumulative effects of two or more deficiencies usually caused the land to be placed in a lower class. The following is an illustrative example of a typical land classification symbol with the natures of the factors and deficiencies indicated:



As shown in the example, the number preceding the numerator indicates the land class, while the letters and numbers in the denominator indicate, in sequence, present land use, productivity and land development requirements.

The land classification data, except for the profile logs, were recorded directly on the aerial photo enlargements in the field. Locations were determined by discernible physical features on the photos or by pacing from known locations. Soil borings were made by hand auger at intervals consistent with complexity of land patterns to meet the accuracy requirements of the detailed land classification. The soil profile of each boring was studied in detail with regard to soil depth, texture, color, structure, indications of drainage problems and other factors pertinent to the land classification.

All soil profiles were checked for lime by use of dilute hydrochloric acid throughout the first year of the classification, or approximately the first half of the period during which the classification was made. It was found that all the soils consistently reacted strongly throughout the profiles, so this test was discontinued in the field. It was, however, continued throughout the classification on approximately 20% of the samples submitted to the laboratory, selected at random, and the same strong reaction was consistently obtained. Quantitative lime tests performed on selected laboratory samples showed 20-27% lime content.

Soil profile logs, noting the observed data, were recorded in peg books in the field, and samples were taken from each horizon of each logged soil profile and submitted to the soil and water laboratory at Chah-i-Anjir for testing and analysis. As described in the section on salinity and alkalinity of this appendix, determinations of salinity and pH were made on all samples. Selected samples were subjected to additional analysis and testing including insoluble carbonates; gypsum; hydraulic conductivity; mechanical analysis; total dissolved solids; analysis of saturation extract for soluble cations and anions; extractable, soluble and exchangeable sodium; and soluble boron.

All soil profile logs,including the results of the laboratory analysis were recorded on the backs of the field sheets and the results of the laboratory analysis were incorporated with the field observations to arrive at the final classification of the lands. The land classification sheets were checked for accuracy of detail and matched with adjoining sheets. The completed field sheets provide a permanent record of the classification.

After the field sheets were completed, the land classification was traced onto rectified reproducible grid sheets of the same scale (1:5,000) as the field sheets, with four square kilometers (2 km x 2 km) on each sheet, for reproduction. Prints were made from the tracings and each sheet was then planimetered by subclass tracts within each square kilometer. The results were tabulated and a summary of the tabulation is presented in Table 5, "Results of Land Classification, (Present Conditions) - Shamalan Unit - Helmand Valley Project, Afghanistan". The soil profile logs, complete with the laboratory data, were also recorded on reproducible sheets from which prints can be made.

Detail of Coverage

Due to the complexities found in a number of factors entering into the classification of these lands, and the nearly total lack of existing basic information concerning the Unit lands, detail of coverage considerably exceeds minimum Bureau of Reclamation requirements for a detailed land classification of new lands. This was done, even though all of the Shamalan Unit Project lands have been farmed under irrigation for many years. For example, the frequency of logged and sampled soil profiles in the Shamalan Unit classification averaged approximately one per six hectares (15 acres) as compared with the USBR minimum requirements of one per 16 hectares (40 acres) on new lands and one per 65 hectares (160 acres) on fully developed or highly uniform new land areas. Deep borings of three meters (10 feet) or more average approximately one per 40 hectares (100 acres) as compared with the minimum USBR requirement of one per 2,225 hectares (5,500 acres) for new lands and one per 4,450 hectares (11,000 acres) for developed or highly uniform new lands. Laboratory tests and analyses were performed on a correspondingly intensive scale.

Traverses never exceeded 300 meters (990 feet, or 3/16 mile) except on large areas of obviously nonarable lands, and averaged approximately 200 meters (720 feet, or 2/16 mile). Spacing of traverses and frequency of soil borings were greatest in the lower classes of arable land as the class 1 lands and large tracts of obviously class 6 lands were considerably more uniform in character than the areas predominantly class 3 and class 2.

Classification Specifications

The land classification specifications which were used in the Shamalan Unit were developed by the Project Planning Division of the USBR team in Bost. They are based on a correlation of the physical factors of soil topography and drainage with land development costs, production costs, and anticipated crop production under irrigation farming, assuming a full water supply and improved agricultural practices, as discussed in the Agricultural Economics Appendix.

The specifications are divided into two parts: Part A, "Present Conditions" and Part B "Conditions Following Project Development". Part A depicts the specifications applied in the field land classification of the Unit, reflecting existing land conditions. In general these conform with those outlined in Volume V of the Bureau of Reclamation Manual except that modifications have been made in allowable limits of salinity and pH. These changes were based on studies of the lands and crop conditions in the Unit and fit the classes as defined. Certain factors in the general specifications are not applicable in the Shamalan Unit, including depth to shale or rock, depth to penetrable lime zone, and rock clearing. None of the lands are underlain by shale or rock formations within applicable depths; none of the soils have discernible lime accumulation zones; and no rock clearing will be required on the project lands. Very limited information was available for use in evolving land development costs and potential productivity of the Unit lands, hence factors related to these items were based almost entirely on estimates. The only significant positive information on productivity was that derived from results of wheat yield and related economic studies conducted jointly by economic and land classification personnel in 1965. In these studies typical tracts of land classes 1, 2, 3 and 6, as being mapped in the detailed land classification, were selected, yield measurements were made, and information was obtained from the cultivators relative to production practices, costs, and related economic considerations. The results of these studies bore out the separation of classes as being mapped on the basis of productivity under present conditions.

Part B of the land classification specifications sets forth the limits for the final land classes following development or under full project conditions. Only noncorrectable deficiencies are considered in this part of the specifications and no development costs are indicated. This part of the specifications is applied in showing the potential economic land class after requirements for development measures including drainage, land leveling, leaching, gypsum application, etc. have been met. The land classification specifications are presented in Table 4.

General Description of Land Classes

Land Classes Under Present Conditions

Class 1 - Arable. Class 1 lands are highly suitable for irrigation farming in every respect, capable of providing sustained and relatively high yields of a wide range of adapted crops at reasonable production costs. They have smooth surfaces and are nearly level to gently sloping, with maximum slopes of less than one percent. The soils are deep, with moderately fine to moderately sandy textures; mellow open structures, allowing easy penetration of roots, air and water; have free drainage, yet have good water holding capacities; and are free from harmful accumulations of soluble salts or exchangeable sodium. Soil, topography, present water table levels and understrata conditions are such that no specific farm drainage requirements are anticipated. Erosion hazard from irrigation is minimal and land development can be accomplished at relatively low costs.

TABLE 4

Detailed Land Classification Specifications

Shamalan Unit - Helmand Valley Development Project - Afghanistan

A. Present Conditions

Land Characteristics	Class 1 (Arable)	Class 2 (Arable)	Class 3 (Arable)
Soils			
Texture	Sandy loam to friable clay loam.	Loamy sand to very permeable clay.	Loamy sand to very permeable clay.
Depth			
To sand or gravel	90 cm (36") plus of good free working soil of fine sandy loam or finer; or 105 cm plus (42") of sandy loam.	60 cm (24") plus -- of good free working soil of fine sandy loam or finer, or 75 cm (30") plus of sandy loam to loamy sand.	45 cm (18") plus -- good free working soil of fine sandy loam or finer; or 60 cm (24") plus of permissible coarser textured soil.
To shale or rock	Not applicable. None of the soils of the arable lands are underlain by shale or rock formations within depths that would affect irrigation suitability.		
To penetrable lime zone	Not applicable. No discernable lime zones in Unit soils.		
Alkalinity	pH less than 9.0 (1:10 dilution). Total salts are low and exchangeable sodium is negligible.	pH is 9.5 (1:10 dilution) or less. Total salts are low and exchangeable sodium does not exceed 10% or 2 milliequivalents/100 grams.	pH is 9.8 (1:10 dilution) or less. Total salts are low and exchangeable sodium does not exceed 15% or 3 milliequivalents/100 grams.
Gypsum requirement	No gypsum required.	Not to exceed requirement of 7.5 ton per hectare (3 ton per acre).	Not to exceed 15 ton per hectare (6 ton per acre).
Salinity	Electrical conductivities of saturation extract not to exceed 4 mmhos/cm. May be higher in open permeable soils and under good drainage conditions.	Electrical conductivities of saturation extract not to exceed 8 mmhos/cm. May be higher in open permeable soils and under good drainage conditions.	Electrical conductivities of saturation extract not to exceed 10 mmhos/cm in the surface 30 cm (12") or not to exceed 15 mmhos/cm in the profile; higher in open, permeable soils and under good drainage conditions.
Leaching requirements	Not to exceed .6 hectare-meter/hectare (2 acre-feet/acre).	Not to exceed .9 hectare-meter/hectare (3 acre-feet/acre).	Not to exceed 1.2 hectare-meter/hectare (4.0 acre-feet/acre).
Topography			
Slopes	Smooth slopes up to 1% in general gradient. (Slope restrictions not applicable as none of the project lands exceed 1% slope).	Same as class 1.	Same as class 1.
Surface	Even enough to require only small amount of leveling and no heavy grading. Total leveling and grading requirements not to exceed 175 cubic meters per hectare (100 cu yd/acre).	Moderate grading required but in amounts not exceeding 450 cubic meters per hectare (240 cu yd/acre).	Heavy and expensive grading required but in amounts not exceeding 740 cubic meters per hectare (400 cu yd/acre).
Field size and shape	120 meters (400') minimum irrigation run. 2.5 hectare (6 acre) minimum field size.	90 meters (300') minimum irrigation run. 1.65 hectare (4 acre) minimum size field.	45 meters (150') minimum irrigation run. .8 hectare (2 acre) minimum size.

Page 1 of 3 pages.

TABLE 4 - continued

Land Characteristics	Class 1 (Arable)	Class 2 (Arable)	Class 3 (Arable)
Cover (Trees, shrubs, etc.) (No areas requiring rock clearing included in arable lands).	Insufficient to modify productivity or cultural practices, or clearing cost small.	Sufficient to reduce productivity and/or interfere with cultural practices; clearing required but costs will be moderate.	Not applicable. None of the arable lands have vegetative cover exceeding permissible limits of class 2.
Drainage	No specific drainage problems in evidence under present conditions. Subsurface drainage requirements will be met by the project drainage system.	Moderate drainage problems under present conditions. Water tables rise to within the root zone during the irrigation season. Project drainage requirements will be greater than for areas primarily class 1 lands. No specific farm subsurface drainage requirements.	Moderately severe drainage problems under present conditions. Crops affected at present. Crop growth inhibited by high water table. Project drainage requirements will be greater in area of primarily subclass 3d lands than for areas predominantly class 1 and class 2. A limited amount of farm subsurface drainage may be required.
Maximum water table level	More than 150 cm (5') below land surface.	More than 90 cm (3') below land surface.	More than 30 cm (1') below land surface.
Maximum permissible development costs*	$25	$65	$120

* Leveling, clearing, soil amendments, leaching and farm drainage. Leveling, clearing, mining and delivery of gypsum to farm site and drainage are project costs. Leaching and soil amendment applications will be farm costs. Figures shown include total permissible costs within land classes.

Class 6 lands (nonarable) include lands which do not meet the minimum requirements of class 3 or small areas of arable land lying within larger bodies of nonarable land.

TABLE 4 - continued

B. Following Project Development

Land Characteristics	Class 1 (Arable)	Class 2 (Arable)	Class 3 (Arable)
Soils			
Texture	Sandy loam to friable clay loam.	Loamy sand to very permeable clay.	Loamy sand to very permeable clay.
Depth			
To sand or gravel	90 cm (36") plus -- of good, free working soil of fine sandy loam or finer, or 105 cm (42") plus of sandy loam.	60 cm (24") plus of good, free working soil of fine sandy loam or finer, or 75 cm (30") plus of sandy loam to loamy sand.	45 cm (18") plus -- good free working soil of fine sandy loam or finer; or 60 cm (36") plus of permissible coarser textured soil.
To shale or rock	Not applicable. None of the soils of the arable lands are underlain by shale or rock formations within depths that would affect irrigation suitability.		
To penetrable lime zone	Not applicable. No discernable lime zone in soils.		
Alkalinity	pH less than 9.0 (1:10 dilution) total salts are low and exchangeable sodium is negligible.	Same as class 1 lands except that class 2 lands may have unreclaimable sodic spots of sufficient magnitude to reduce yields up to 15%.	Same (Can have unreclaimable sodic spots of sufficient magnitude to reduce yields up to 30%).
Gypsum requirements	No gypsum required	No gypsum required after project development.	No gypsum required after project development.
38 Salinity	Electrical conductivities of saturation extract not to exceed 4 mmhos/cm.	Same as class 1 after project development.	Same as class 1 after project development.
Leaching requirements	Not applicable after project development. Require only normal leaching resulting from good irrigation practices.	Same as class 1.	Same as class 1.
Topography			
Slopes	Smooth slopes up to 1% in general gradient.	Same as class 1. None of the arable lands exceed 1% slope.	Same as class 1.
Surface	Required leveling will be project function. No leveling requirements after project development.	Same as class 1.	Same as class 1.
Field size and shape	120 meters (400') minimum irrigation runs. 2.5 hectare (6 acre) minimum size.	90 meters (300') minimum irrigation runs. 1.65 hectare (4 acre) minimum size.	45 meters (150') minimum irrigation runs. 0.8 hectare (2 acre) minimum size.
Cover (Trees, shrubs, etc.)	Not applicable.	Not applicable.	Not applicable.
Drainage	Not applicable. All drainage will be project function.	Same as class 1.	Same as class 1.
Maximum permissible development costs	Not applicable under project conditions.	Not applicable under project conditions.	Not applicable under project conditions.

Class 6 lands (nonarable) include lands which do not meet the minimum requirements of class 3 or small areas of arable land lying within larger bodies of nonarable land.

Class 2 - Arable. Class 2 lands are moderately well suited to irrigation agriculture under present conditions, but are of measurably lower productive capacity than class 1 lands because of slight to moderate deficiencies in one or more of the factors considered in the classification. The bulk of the class 2 lands in the Shamalan Unit were so classed because of intermediate levels of salt and/or exchangeable sodium, frequently associated with drainage problems. These conditions, if allowed to persist, will decrease crop yields, but are correctable at reasonable costs to class 1 levels. When correction has been fully accomplished these lands will have class 1 productivity levels. However,in the interim period yields will be lower than for class 1 lands and additional expenses for correction will be incurred.

A lesser part of the class 2 lands have shallower soils, coarser soil textures, higher leveling costs, and less favorable drainage characteristics than are permitted in class 1 lands. The drainage and topographic deficiencies in class 2 lands are correctable at reasonable costs.

Class 3 - Arable. Class 3 lands are suitable for irrigation development but are restricted to near marginality because of more extreme deficiencies in soil, topographic and drainage characteristics than are permitted in class 2 lands. The limitation(s) may consist of a single greater deficiency in one of the factors, or may be the result of two or more factors of class 2 magnitude. The bulk of class 3 lands have smooth topography, favorable soil textures and depths, but have moderately high concentrations of salines and exchangeable sodium, frequently aggravated by inadequate drainage conditions. The remainder of the class 3 lands have either limiting soil depths, coarser soil textures than are permitted in class 2 lands, or topographic deficiencies which can be corrected by leveling. Where deficiencies in the class 3 lands (present conditions) are correctable, costs will be moderately high but within the limits of economic feasibility.

Class 6 - Nonarable. Class 6 lands include those considered permanently nonarable because they do not meet minimum requirements for other classes of land. They also include small isolated arable tracts within class 6 areas not large enough to warrent segregation. Class 6 lands consist of those having strongly saline-sodic soils, shallow soils over gravel or sand, excessively coarse textured soils, unfavorable topography, excessive drainage deficiencies, and include the sand dune areas lying within the Unit boundaries.

Class 6 lands include 4,497.2 hectares (11,112.7 acres) of land now irrigated, and 8,140.7 hectares (20,115.8 acres) which are not irrigated.

Land Classes Following Development

As previously stated, this part of the classification shows the potential economic land class following full development of the lands and considers noncorrectable deficiencies only.

Class 1 - Arable. Class 1 lands potentially meet the same requirements outlined for class 1 under present conditions. They will include, however, all lands that can be brought to meet class 1 specifications through leaching, use of calcium amendments, provision of required drainage facilities, land leveling and any other required reclamation measures. It is estimated that all of the lands places in class 2 and 90% of those placed in class 3 due to salinity, exchangeable sodium and/or drainage deficiencies will be in class 1 following development and reclamation.

Class 2 - Arable. Lands in this category include those lands meeting the requirements for, but permanently limited to, class 2 capabilities because of noncorrectable topographic deficiencies, soil depths and textures and saline-sodic soils that can be raised from their present class 3 status to class 2 level by reclamation. It is estimated that 10% of the lands placed in class 3 due to salinity, exchangeable sodium and/or drainage deficiencies will be in class 2 following development and reclamation.

Class 3 - Arable. These lands are permanently limited to class 3 because of noncorrectable deficiencies, including soil texture and depth, and noncorrectable topographic deficiencies.

Class 6 - Nonarable. Class 6 lands are those classed as permanently nonarable because they do not meet the minimum requirements for the arable classes.

Description of Subclasses

As described earlier in this appendix, the field land classification of the Shamalan Unit was based on and depicts existing land conditions. The classification is also being interpreted as to potential land classes and land subclasses following full development of the lands.

The land classification of the Unit showing present conditions includes the delineation of class 1 land and 10 subclasses in classes 2 and 3. The subclasses were delineated and so designated to show the deficiency factors of "s", "t" and "d" for soil, topography and drainage.

The land classification tabulation showing the potential land classes and subclasses includes class 1 and 8 subclasses of classes 2 and 3. The subclasses were designated to show the deficiency factors of "s" and "t". No drainage deficiencies will remain in the irrigable lands after project development.

Class 1. Lands designated as class 1, under present conditions, comprise 20.7 percent of the project irrigable area. These lands are largely located on the second terrace level. They have no limiting soil, topographic or drainage deficiency. The soils are deep, moderately fine to moderately sandy textured, with medium textures predominating, have good physical characteristics and have good moisture holding capacities. They are free from harmful concentrations of salts and exchangeable sodium and have no limiting drainage problems. Their topography is smooth with nearly level slopes.

Lands categorized as class 1 following drainage and reclamation comprise 93.2 percent of the Unit arable lands. These, in addition to the lands in class 1 under present conditions, will include those now affected by limiting concentrations of salines and exchangeable sodium and/or drainage deficiencies which can be reclaimed. Following reclamation they will meet the requirements of class 1 as described under present conditions. It is estimated that all of the lands placed in class 2 and 90 percent of the lands placed in class 3 because of salinity, alkalinity, and drainage deficiencies will become class 1 after project development.

Subclass 2sa. This subclass includes 41.5 percent of the Unit irrigable lands under present conditions. They meet the specifications for class 1 lands except for moderate concentrations of salts and/or exchangeable sodium, frequently associated with drainage problems. Typically this subclass consists of lands where saline or alkali spots are interspersed with salt- and alkali-free lands in a heterogeneous pattern. Crop yields on these lands may be reduced by up to 15 percent below class 1 levels, due to salt and exchangeable sodium conditions. All lands classed as subclass 2sa under present conditions are reclaimable at reasonable cost, and are potentially class 1 lands following project development and reclamation. Lands placed in subclass 2sa following project development include ten percent of those classified as 3sa and 3sd under present conditions. Their capabilities and limitations will be similar to the lands classified as 2sa under present conditions. They comprise 3.0 percent of the total irrigable lands.

Subclass 2sd. This subclass comprises 3.7 percent of the Unit irrigable lands under present conditions. These lands have moderate limiting drainage and salt problems sufficient to lower their productivity to class 2 levels. They are reclaimable, at reasonable costs, to class 1. No lands were categorized as 2sd after project development.

Subclasses 2sk, 2st, and 2sv. These three subclasses comprise only 0.8, 0.1 and 0.5 percent respectively of the total irrigable lands of the Unit and thus are not of sufficient significance to warrent detailed description. Subclass 2sk lands include lands with soils shallower to gravel than are permitted in class 1 but meet class 2 requirements; subclass 2st lands have a combination of minor noncorrectable soil and topographic deficiencies limiting them to class 2; and 2sk lands have soils with sandier textures than are permitted in class 1 but meet class 2 requirements. These lands will be in the same respective subclasses after project development.

Subclass 3sa. This subclass comprises 22.7 percent of the Unit irrigable lands under present conditions. They have either general moderately high levels of salt and/or exchangeable sodium concentrations which limit crop yields to class 3 levels, or have sufficient highly saline and sodic spots interspersed with relatively salt- and alkali-free soils to limit overall production to class 3 levels, as defined in the land classification specifications. These lands meet class 1 specifications in all other respects. Approximately 90 percent of these lands are fully reclaimable to class 1 levels and the other 10 percent to class 2.

Subclass 3sd. Subclass 3sd lands under present conditions, constitute 7.4 percent of the Unit irrigable lands. They have moderately severe combinations of drainage deficiencies and salt or exchangeable sodium concentrations which limit the present productivity to class 3 levels. In other respects they meet class 1 specifications. The deficiencies in these lands are either totally or partially correctable. Approximately 90 percent of these lands are reclaimable to class 1 and ten percent to class 2 levels.

Subclasses 3sk, 3st and 3sv. These subclasses constitute only 0.9, 0.9, and 0.7 percent, respectively, of the total irrigable area of the Unit. Subclass 3sk includes shallower soils over gravel than are permitted in land class 2 and may have moderate amounts of gravel throughout the soil profile; subclass 3st includes lands with combinations of noncorrectable soil and topographic deficiencies which limit them to permanent class 3 status. The soil deficiencies include limiting depths and sandy textures and the topographic deficiencies are related to field size and shapes. Subclass 3sv lands have sandy textured soils which limit their productive capacity to class 3 levels.

Table 5 presents a tabulation of the arable lands by classes and subclasses under present conditions for each division and for the total Unit. Table 6 presents a summary of the potential arable land classes and subclasses by hectares and acres following project development for the entire Shamalan Unit.

TABLE 5

Results of Land Classification
Present Conditions

Land Classes and Subclasses

	1	2sa	2sk	2sd	2st	2sv	Total Class 2	3sa	3sk	3sd	3st	3sv	Total Class 3	Total Arable	Irrigated Class 6	Nonirrig Class 6	Total Classified
								NORTH SHAMALAN DIVISION									
Hectares	97.1	642.4		54.9		0.5	697.8	322.3	0.6	30.4	11.7	1.3	366.3	1,161.2	277.9	623.2	2,062.3
Acres	239.9	1,587.4		135.6		1.3	1,724.3	796.5	1.4	75.1	29.0	3.2	905.2	2,869.4	686.7	1,539.8	5,095.9
								WEST SHAMALAN DIVISION									
Hectares	1,213.6	2,297.0	34.8	100.3	7.4	-	2,439.5	1,031.4	36.3	657.5	8.8	-	1,734.0	5,387.1	1,032.8	2,141.7	8,561.6
Acres	2,998.8	5,675.9	85.9	247.8	18.2	-	6,027.8	2,548.6	89.7	1,624.7	21.8	-	4,284.8	13,311.5	2,551.9	5,292.3	21,155.7
								EAST SHAMALAN DIVISION									
Hectares	1,219.1	1,223.7	40.0	232.7	9.3	59.8	1,565.5	886.7	61.6	276.6	86.4	33.2	1,344.5	4,129.1	1,301.7	1,739.1	7,170.0
Acres	3,012.3	3,023.7	98.9	575.1	22.9	147.8	3,868.4	2,191.0	152.2	683.6	213.5	82.2	3,322.5	10,203.1	3,216.6	4,297.4	17,717.1
								SOUTH SHAMALAN DIVISION									
Hectares	217.3	1,338.2	28.4	108.4	-	2.6	1,477.6	770.9	13.4	15.1	10.8	53.9	864.1	2,559.0	1,884.8	3,636.7	8,080.6
Acres	537.0	3,306.8	70.2	267.7	0.1	6.4	3,651.2	1,904.9	33.1	37.4	26.7	133.1	2,135.2	6,323.4	4,657.4	8,986.3	19,967.1
								TOTALS - SHAMALAN UNIT									
Hectares	2,747.1	5,501.3	103.2	496.3	16.7	62.9	6,180.4	3,011.3	111.9	979.6	117.7	88.4	4,308.9	13,236.4	4,497.2	8,140.7	25,874.5
Acres	6,788.0	13,593.9	255.1	1,226.2	41.1	155.5	15,271.8	7,441.0	276.5	2,420.8	291.0	218.5	10,647.8	32,707.6	11,112.7	20,115.8	63,936.0

TABLE 6

Results of Land Classification
Following Project Development

Arable Land Classes and Subclasses

Land Class or Subclass	Hectares	Acres	Percent of Arable Area
Class 1	12,336.6	30,483.7	93.2
2sa	399.0	986.0	3.0
2sk	103.2	255.1	0.8
2st	16.7	41.1	0.1
2sv	62.9	155.4	0.5
Subtotal Class 2	581.8	1,437.9	4.4
3sk	111.9	276.5	0.8
3st	117.7	291.0	0.9
3sv	88.4	218.5	0.7
Subtotal Class 3	318.0	786.0	2.4
TOTAL, Arable	13,236.4	32,707.6	100.0

Determination of Irrigable Area

All of the arable and a sizable part of the nonarable lands in the Shamalan Unit are now irrigated. Project water will be provided for essentially all of the lands of the three arable classes, excluding only a few very small areas that occur in bodies too small to be included in farm units. Engineering studies indicate that approximately six percent of the lands will be taken up by rights-of-way, etc., but that juis which will be leveled and become project lands now occupy about two percent of the arable area. Therefore, the irrigable area was determined by deducting four percent from the total arable lands.

Results of Selection

The project irrigable area is the part of the arable acreage which will be included in farm units and for which project water will be provided. The farm unit boundaries have not as yet been determined. A summary of the irrigable acreage figures reflecting potential conditions following project development is presented by hectares, acres and percent of irrigable area in Table 7 "Summary of Irrigable Area" which follows.

There are 4,497 hectares (11,112 acres) of irrigated class 6 lands (class 6W) within the project area. Capacity will be provided in the irrigation system to supply water to these lands on the same basis as prior to project development. They will not, however, be provided with any additional project facilities.

TABLE 7

Summary of Irrigable Area Following Project Development

Shamalan Unit

Land Class or Subclass	Irrigable Hectares	Irrigable Acres	Percent of Irrigable Area
Class 1	11,843.0	29,264.4	93.2
2sa	383.1	946.7	3.0
2sk	99.1	244.9	0.8
2st	16.0	39.5	0.1
2sv	60.4	149.3	0.5
Subtotal Class 2	558.6	1,380.4	4.4
3sk	107.4	265.4	0.8
3st	113.0	279.3	0.9
3sv	84.9	209.8	0.7
Subtotal Class 3	305.3	754.5	2.4
TOTAL	12,706.9	31,399.3	100.0

Total Unit Land Area

A total of 25,874.5 hectares (63,936.0 acres) was classified in the Shamalan Unit land classification. Of this, 12,706.9 hectares (31,339.3 acres) were classed as irrigable and will be divided into farm units. In addition to the irrigable land the gross area includes 4,497.3 hectares (11,112.9 acres) of class 6 land now irrigated (class 6W), 529.6 hectares (1,308.3 acres) for rights-of-way, etc., and 8,140.7 hectares (20,115.8 acres) of nonirrigated class 6 lands.

Conclusions

Suitability for Development

The Shamalan Unit is suitable for development as an irrigation project. The irrigable lands are capable of sustaining good production under irrigation, provided the necessary improvements in agricultural practices are effected. Additional construction, rehabilitation, and operation and maintenance costs can be justified by increased returns from the land.

Soils

The soils are generally deep, of moderately firm to moderately sandy textures, with medium textures predominating. They are river terraces which have been deposited by the Helmand River.

Topography

The project area consists of a relatively uniform, very gently sloping to nearly level river terrace paralleling the Helmand River with an average north-south gradient of approximately 1.3 meters per kilometer (6.9 feet per mile). East-west gradients are nearly level. Leveling costs will be low to moderate on the arable lands to achieve efficient irrigation water distribution.

Drainage

Although the majority of the lands are now affected by drainage problems, the irrigable lands in general have favorable drainability characteristics. The open, porous gravel understrata underlying the soils of the Unit will provide excellent internal drainage. Surface wastes will not create a serious problem and can be effectively removed by the planned drainage system. Drainage requirements can be met at reasonable cost.

Other Features

The irrigable lands of the Shamalan Unit are not susceptible to flooding. All of the lower-lying lands which would be subject to periodic flooding have been excluded from the arable lands. Flood control is therefore not considered a problem.

Supporting Data

The following supporting data of the land classification investigations for the Shamalan Unit are on file in the Bureau of Reclamation office at Bost, Afghanistan.

(1) Land classification field sheets and soil profiles.
(2) Soil laboratory analyses data, including total soluble salts, pH, lime, mechanical analysis, hydraulic conductivity rates, analysis of saturation extract for soluble cations and anions, exchangeable sodium (milliequivalents/liter and %) cation exchange capacity.
(3) Water analysis, results from the Helmand River, Nad-i-Ali Wasteway, and drains within the Unit.
(4) Area tabulations by land classes, reported in hectares and acres.

DRAINAGE

Appendix B

DRAINAGE

General

In general, lands classified as irrigable in the Shamalan Project area have good to excellent drainage characteristics. An excellent drainage aquifer underlies practically all of the project area. It is defined as the zone above the effective horizontal drainage barrier through which most of the ground water movement occurs. In the Shamalan Project area this zone extends from the top of the ground water table down to 8-12 meters (26-39 feet) below the ground surface.

Over practically all of the project area the drainage aquifer is comprised of two parts. The upper part is a stratum of loam to loamy sand material 2-4 meters (6.6-13.0 feet) thick encountered 2-4 meters below the ground surface. The lower part is a stratum of unconsolidated rounded and subrounded gravelly material usually with a loamy sand or sandy matrix. This part of the drainage aquifer is 6-8 meters (20-26 feet) thick and generally overlies a sandstone stratum encountered 10-12 meters (33-39 feet) below the ground surface. In a few places it overlies a stratum of conglomerate material 8-10 meters (26-33 feet) below the ground surface. Deep exploration holes showed the sandstone stratum to be more than 30 meters (98 feet) thick.

Both the sandstone and conglomerate strata constitute effective horizontal drainage barriers.

Permeability rates in the upper part of the drainage aquifer range from 2-10 meters per day (3.3-16.4 inches per hour), increasing with depth. The lower part of the drainage aquifer has permeability rates on the order of 10-50 meters and higher per day (16-82 inches per hour).

There is little indication of vertical drainage barriers within the drainage aquifer, and shallow horizontal drainage barriers above the gravelly stratum apparently do not affect extensive areas of irrigable lands. Over practically all of the project area there should be no critical resistance to movement of ground water downward and toward existing and proposed drains.

Effective open drains can easily be constructed to depths of 2-4 meters, (7-13 feet) in stable material with bottoms of drains being in and over strata that offers noncritical resistance to movement of ground water upward into drains.

On irrigable lands, the soil surface infiltration rates are low to moderate. If reasonably good irrigation and water management is practiced, leaching can be accomplished without excessive additions to the ground water table.

Because of the good to excellent quality of the irrigation water supply, the leaching requirement is only about 10-15% of irrigation input.

The project area has a relatively uniform and gentle slope down the valley, with few excessive irregularities to cause accumulation of surface and ground water. Most project lands are situated relatively high above outlets to the river, and the general slope of the land permits orderly layout and construction of adequate distribution and drainage systems with gravity flow. Due to low rainfall intensities and the gentle slope of the lands, surface drainage and protection of project works from storm runoff is not a significant problem.

Some undesirable characteristics of the Shamalan Project area which create drainage problems and make the cost of drainage and development higher do exist. The drainage system requires long outlet drains because of the shortage of suitable outlets to the river, the gentle slope of the lands, and the position of the lands in relation to the Shamalan Canal and the river. Some potentially good areas have such location, slope and elevation that adequate relief by drains with gravity flow is not possible. The general direction of ground water movement is along the river valley, not toward the river. Over large areas under present conditions the ground water has to travel more than 10 kilometers (6 miles) before reaching an effective drain or the river.

The location of existing project facilities, such as the Shamalan Canal and most major outlet drains, hinders orderly planning and results in more expensive construction of an adequate drainage and distribution system.

The operation of the Marja and Nad-i-Ali Projects creates drainage problems in the Shamalan Project area. Operational waste water and subsurface drain water from these projects flows across the Shamalan Valley in two major wasteway-outlet drains. The Marja Wasteway in particular interferes with the movement of ground water down the river valley, and seepage from this wasteway adds to the ground water table.

High runoff of the Helmand River during the spring raises the level of the river significantly, more than 1.5 meters (5 feet), thus affecting drainage of lands near the river and restricting flow of outlet drains where they empty into the river. Present operations of Kajakai Reservoir for flood control substantially reduce duration of high level flows below the reservoir. However, the high rate of sediment deposition in the reservoir will greatly reduce its effectiveness for flood control in the future.

Existing Drainage System

General. The existing drainage system consists mostly of outlet drains constructed in topographic lows that meander along the river valley. Few lateral interceptor or lateral relief drains to intercept the water table slope have been constructed. The location of all existing drains is shown on Project Map, Drawing Nos. 501-130 through 134.

The outlet drains were built to conform to the existing jui system. They serve as combination outlet and relief drains and give fairly adequate drainage protection to most lands adjacent to the Shamalan Canal which receive adequate water. On some of these lands, irrigation and resultant deep percolation losses are excessive. The existing drainage system provides little relief to lands more distant from the Shamalan Canal.

Engineering surveys and observations show most existing drains have bottom widths too wide, 2-4 meters, and side slopes too flat, 2.0:1.0 to 3.0:1.0. Recent construction and maintenance in the Shamalan and Darweshan areas indicate that, in most areas, material in which the drains have been excavated will permit side slopes of 1.5:1.0 to 1.0:1.0.

The excessively wide bottom width causes poor flow characteristics with resulting increase in sedimentation and vegetative growth. Proper bottom widths would create higher velocities, thus carrying out sediment and restricting vegetative growth.

In summary, because of the type of design and construction, existing drain costs were higher than necessary due to excessive excavation, more land was taken out of cultivation than needed, maintenance costs are increased, and drains are not as effective as they should be.

Observations indicate that during most of the year nearly all drain flow results from subsurface water coming in from the drainage aquifer through the bottom of drains. During the "drain-out" periods all of the flow is from this subsurface source. Inspection of the drain cross section also shows that there are no shallow horizontal drainage barriers above the drain bottoms.

Drain Outflow

Most drain flow measurements were made during drain-out periods when the Shamalan Canal was closed. During the period of investigation there were three drain-out periods: December 8, 1964 - February 12, 1965; December 12, 1965 - January 26, 1966; and December 22, 1966-- February 16, 1967. Representative drain flow measurements are shown on the following pages.

These measurements indicate that total outflow of subsurface drainwater from the drainage system during the drain-out period December 22, 1966 to February 16, 1967 varies from 1.27 to 3.54 cubic meters per second (45 to 125 cubic feet per second). Presently about 15.58 cubic meters per second (550 cfs) of irrigation water is delivered to the project area on a sustained basis. There is probably some additional outflow of ground water directly to the river which cannot be estimated accurately. Total outflow of ground water from the Project area is greatest when water tables are highest during the early spring, and from November to the start of the drain-out period. The outflow of ground water is at a minimum during the last part of the drain-out period and during the summer when ground water table drops significantly because of high evapotranspiration. It is notable that cleaning vegetation from Drain "C", Station No. 9, resulted in an increase in drain flow from 0.11 to 0.15 cubic meters per second (4.0 to 5.7 cubic feet per second) from the beginning to the end of the drain-out period.

Drain Flow Measurements

Station		Dec 26-31 1966	Jan 28 - Feb 4, 1967	March 8-12 1967	April 25-29 1967	June 4-7 1967
Sta. No. 1 - Zarest Drain about 1500 meters above outlet to river	cms	0.17	0.11	0.15	-	0.13
	cfs	6.1	4.0	5.3	-	4.7
	$ECX10^6$	5250	5500	5000	-	3600
Sta. No. 2 - Outlet Drain G about 800 meters above outlet to river	cms	0.14	0.11	0.11	-	0.08
	cfs	5.0	3.8	3.9	-	3.0
	$ECX10^6$	2900	3000	3000	-	2600
Sta. No. 3 - Marja Wasteway 100 meters below confluence with Outlet Drain H	cms	2.04	0.73	1.82	2.53	2.94
	cfs	71.9	25.7	64.2	89.5	103.8
	$ECX10^6$	2400	3000	2200	2100	1600
Sta. No. 4 - Marja Wasteway 100 meters above confluence with Outlet Drain F	cms	1.52	0.61	1.38	2.00	2.14
	cfs	53.6	21.6	48.7	70.8	75.6
	$ECX10^6$	2900	3600	2800	2400	2000
Sta. No. 5 - Marja Wasteway above chute drop at desert escarpment	cms	1.12	0.45	-	1.83	2.49
	cfs	39.4	15.8	-	64.8	87.8
	$ECX10^6$	3000	4200	-	2400	1900
Sta. No. 6 - Outlet Drain F above confluence with Marja Wasteway	cms	0.41	0.13	0.42	0.52	0.49
	cfs	14.4	4.6	14.7	18.4	17.4
	$ECX10^6$	1050	1000	900	900	780
Sta. No. 7 - Outlet Drain E 100 meters above outlet to river	cms	0.27	0.14	0.31	0.39	0.44
	cfs	9.5	5.0	10.8	14.1	15.7
	$ECX10^6$	850	800	750	700	580
Sta. No. 8 - Outlet Drain B about 100 meters above confluence with Wasteway No. 3	cms	0.98	0.44	0.54	1.23	1.06
	cfs	34.7	15.6	19.0	43.6	37.4
	$ECX10^6$	900	1100	1050	900	800

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Drain Flow Measurements

Station	Unit	Dec 26-31 1966	Jan 28 - Feb 4, 1967	March 8-12 1967	April 25-29 1967	June 4-7 1967
Sta. No. 9 - Outlet Drain C just above confluence with Outlet Drain B	cms	0.11	0.16	0.27	0.43	0.39
	cfs	4.0	5.7	9.4	15.2	13.9
	$ECX10^6$	950	1100	950	850	750
Sta. No. 10 - Outlet Drain B just above confluence with B Spur No. 2	cms	0.33	0.08	0.16	0.38	0.32
	cfs	11.8	3.0	5.5	13.3	11.3
	$ECX10^6$	950	1150	1100	1050	800
Sta. No. 11 - Outlet Drain B Spur No. 2 about 500 meters above confluence with Outlet Drain B	cms	0.18	0.10	0.12	0.23	0.18
	cfs	6.4	3.4	4.3	8.0	6.4
	$ECX10^6$	1100	1220	1200	1100	1100
Sta. No. 12 - Drain B Spur No. 3 at confluence with B Spur No. 2	cms	-	-	-	-	0.07
	cfs	-	-	-	-	2.3
	$ECX10^6$	-	-	-	-	950
Sta. No. 13 - Outlet Drain "B" about 100 meters below confluence with B Spur No. 1	cms	-	-	-	-	0.24
	cfs	-	-	-	-	8.6
	$ECX10^6$	-	-	-	-	980
Sta. No. 14 - Drain "B" Spur No. 1, about 500 meters above confluence with Drain B	cms	-	-	-	-	0.09
	cfs	-	-	-	-	3.3
	$ECX10^6$	-	-	-	-	700
Sta. No. 15 - Outlet Drain A above confluence with Nad-i-Ali Wasteway	cms	0.67	0.27	0.76	1.27	0.85
	cfs	23.7	9.6	26.7	44.8	30.1
	$ECX10^6$	1200	1350	1200	1200	1100
Sta. No. 16 - Nad-i-Ali Wasteway at chute drop near desert escarpment	cms	0.44	0.24	1.83	1.50	2.06
	cfs	15.4	8.5	64.8	53.1	72.6
	$ECX10^6$	3500	3500	1800	2300	1400

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Drain Flow Measurements

Station	Unit	Dec 26-31 1966	Jan 28 - Feb 4, 1967	March 8-12 1967	April 25-29 1967	June 4-7 1967
Sta. No. 17 - Nad-i-Ali Waste-way about 200 meters below Bost to Marja road crossing. (Represents outflow from Nad-i-Ali Project.)	cms	0.48	0.26	1.85	1.53	2.00
	cfs	16.9	9.1	65.3	53.9	70.7
	$ECX10^6$	3580	3600	1800	2200	1500
Sta. No. 18 - Outlet Drain A at Bost to Marja road crossing.	cms	0.25	0.17	0.41	0.42	0.40
	cfs	8.9	5.9	14.5	14.8	14.3
	$ECX10^6$	1350	1500	1300	1300	1200

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Outlet Drains

Generally the location and position of most of the outlet drains make them less than fully effective in collecting ground water directly from the drainage aquifer, since they do not cross or intercept the general ground water slope. However, some of the outlet drains, "D", "E", "G" and "H", are more effective in collecting water directly from the drainage aquifer, because they are positioned in good topographic lows. These drains have an average depth of about 2.5 meters (8.2 feet) and fairly uniform bottom grades with a slope of about 0.0012. Effective depth of the drains averages about 2.0 meters (6.6 feet).

Other outlet drains, "B", "C" and "F", collect and dispose of considerable quantities of ground water, which is especially significant considering their location, position, shallow depth, slope, and condition of maintenance. The main accounting for the relatively high drain flow is the apparent high transmissibility (thickness times permeability) of the drainage aquifer underlying the project area. Another reason could be excessive additions to the ground water table through deep percolation from irrigation of lands adjacent to the canal and seepage from the Shamalan Canal. Most lands near the canal are irrigated heavily and laterals, sublaterals, and farm ditches run almost continuously during most of the irrigation season.

Outlet drains "A", "D", "E", "G" and "H" were constructed deep enough through most sections, but long segments of the other outlet drains, "B", "C" and "F", are less than 2 meters (6.6 feet) deep. Their effective depth is further reduced by the deep flow of water in the drains, primarily due to poor flow characteristics resulting from vegetative growth, obstructions, excessive bottom width, and irregular bottom grade. With proper maintenance and a limited amount of rehabilitation, the flow characteristics could be greatly improved.

The Zarest Drain and Zarest Drain Spur 1 are very effective in collecting and disposing of ground water, although the large area they serve receives a limited amount of irrigation water and correspondingly small deep percolation and seepage losses. Seepage from the Marja Wasteway causes ground water flow down the valley toward the Zarest Drain.

Through most of its length the Zarest Drain has an effective depth of about 1.8 meters (5.9 feet) and a bottom grade of 0.001. Outflow of the drain during most of the year is about 0.14 cubic meter per second (5 cubic feet per second) and consists mostly of subsurface drainwater since there is no surface waste from irrigation in this water short area. The effectiveness of the Zarest Drain indicates that drainability of the western part of the project area is good. This, together with water table studies, deep hole drilling and sampling, and permeability tests, supports drainage plans for providing drainage protection to irrigable lands lying toward the western side of the project.

Lateral Drains

Lateral drain "B - Spur 3" is the only effective lateral drain that has been built. It gives excellent drainage protection to the adjacent lands that receive a nearly adequate irrigation water supply. It is the best example in the project area of how effective lateral drains can be if they are designed, located and constructed properly. It has a length of 1,168 meters (3,832 feet), an average depth of about 3 meters (9.8 feet) and a bottom grade of .0003. Water table observations show that its range of effectiveness is wide, as water tables about 1,000 meters (3,281 feet) above it and 500 meters (1,640 feet) below it are generally in gravelly material more than two meters below the ground surface. Maximum ground water outflow from lateral drain "B - Spur 3" is about 0.65 cubic meter per second (2.3 cfs). Effectiveness of lateral drain "B - Spur 3" greatly influenced the lateral drain requirement determinations made through this investigation.

Lateral drains "1", "2" and "3" emptying into Outlet Drain "B" are not effective in collecting ground water since the land between them receives practically no irrigation. Also, drain "3" is blocked by high level flow in Outlet Drain "B" resulting from constriction of flow due to an inadequate size culvert at the road crossing below confluence of "B - Spur 1".

The lateral drain, named "Outlet Drain F - 1", emptying into Outlet Drain "F" does not collect and remove any ground water since it is practically level and its effective depth is less than 1.0 meter.

Lateral drains in the Zarest area, emptying into the Marja Wasteway are practically ineffective due to their shallow depth of less than 1.0 meter, alinement with ground water slope, and the fact their outlets are blocked by high flow level in the Marja Wasteway during most of the irrigation season. The water level through some sections of the Marja Wasteway in the Zarest Area is actually higher than adjacent lands during most of the year.

It is notable that during the shutdown periods when Boghra Canal water is shut off from the Marja Project, the water level in the Marja Wasteway falls, permitting the wasteway and the lateral drains emptying into it to function as relief and interceptor drains to lower the ground water table in the Zarest area. Measurements of drain flow show that during drain-out periods, the Marja Wasteway above Outlet Drain "F" intercepts, collects, and carries out ground water at the rate of 3.3 cubic meters per second (11.7 cubic feet per second).

Conclusions

Although the existing drainage system is not laid out, designed, and constructed properly, and generally is in a poor state of maintenance, it is effective in collecting and disposing of ground water to provide fairly adequate drainage protection to nearly all lands adjacent to the Shamalan Canal, which presently receive most of the irrigation water for the project area. The existing drainage system cannot give adequate drainage protection to large areas in the West and South Divisions which are far removed from the existing drains. Most existing drains could be made much more effective if flow characteristics were improved by cleaning and shaping bottom cross sections.

Although the existing drainage system is effective in collecting and disposing of ground water, much more drainage protection could have been realized if the drains had been constructed diagonally southeasterly toward the river with sufficient grade to maintain velocity of flow. Drains in this alinement would cross or intercept the general ground water slope and be fully effective in collecting and disposing of ground water.

The existing drainage and distribution system interferes greatly with orderly planning of a proposed adequate drainage and distribution system. It will be costly in much of the area to construct an adequate system to the existing facilities as they are now located. Had the Shamalan Canal been located toward the west side of the project area, there would have been little need for outlet drains which have taken land out of cultivation and added unnecessarily to construction and maintenance costs.

Effect of Marja and Nad-i-Ali Projects. Drainage of project lands is affected in areas where wasteways from the Marja and Nad-i-Ali Projects cross the Shamalan area. The Marja Wasteway creates drainage problems in the southern part of the project area by restricting ground water movement down the valley, and by adding to ground water through seepage. During much of the year, the level of water in the Marja Wasteway is actually higher than surrounding lands. The Marja Wasteway crossing of Shamalan Canal is not adequate to handle present flows and without expensive rehabilitation the wasteway cannot be used to remove additional drain and waste water flow resulting from planned increased water supply.

The Nad-i-Ali Wasteway is located and positioned so that it aids drainage in the project area. It provides an outlet for Outlet Drain "A" and probably provides some other drainage relief since it intercepts the ground water slope down the valley.

There is probably some ground water movement under the desert and into the project area resulting from seepage losses of the Nad-i-Ali Wasteway on the desert before it enters the project. Limited studies indicate that ground water movement under the desert directly from the Marja and Nad-i-Ali Projects is not enough to significantly affect drainage of project lands after installation of the proposed drainage system.

Investigations

General

Drainage investigations were made to evaluate drainability of project lands, determine effectiveness of existing drainage system, estimate drainage requirements for proposed project development, and prepare plans and estimate cost for an adequate drainage system.

Water table studies were made to determine source, movement and fluctuation of ground water. Deposition and permeability of substrata were determined through deep hole exploration and permeability tests. The effectiveness of the existing drainage system was evaluated through drain flow measurements and general field observations.

As much use as possible was made of previous investigations in determining future drainage requirements and preparing plans for a drainage system. However, most plans and determinations were based on data collected during this investigation.

Previous Drainage Investigations

Previous drainage investigations of the Shamalan area have been primarily of a reconnaissance nature. Two reconnaissance soils, irrigation, and drainage studies have been made of the area by Charles R. Maierhofer, Head, Office of Drainage and Ground Water Engineer, Bureau of Reclamation, United States Department of the Interior. The first study was made during the summer of 1953, and, "Drainage and Related Problems of Irrigation Development in the Helmand Valley of Afghanistan", with findings and recommendations was published in 1954. In this study, Mr. Maierhofer inspected lands over a wide area of southwestern Afghanistan, principally lands supplied with water from the Helmand and Arghandab Rivers. One section of the report is on the Shamalan branch of the Boghra Canal system, which is referred to as the Shamalan Unit throughout this report.

Mr. Maierhofer made a second reconnaissance study of the Helmand Valley Project during November 1960, at the request of the Project Manager, Bureau of Reclamation. The findings of this study, titled, "Helmand Valley Development Project, Afghanistan, Drainage and Related Problems", was published in April 1961. Both of the above studies covered wide areas in a relatively short period of time, and only very general observations were made with recommendations based on experience in other similar areas.

A general drainage investigation was made of the Shamalan area during 1953 by International Engineering Company in conjunction with their general study and economic analysis of irrigated lands in the Helmand-Arghandab River Valleys. Discussion of drainage conditions and problems is very general in their report. Apparently there was no separate drainage appendix published and much of the basic data and field notes have been lost or misfiled. Based on information gained from the report and office files, the investigation would be classified as reconnaissance grade according to Bureau of Reclamation standards.

Other drainage studies were made in the Shamalan area in conjunction with operation, maintenance, and development of the Helmand Valley project. They included specific problem areas where development was anticipated and were usually made under the direction and supervision of the United States Bureau of Reclamation engineers. Basic data from these drainage investigations have been used in the Shamalan Unit study.

Since completion of the above studies and investigations, some additional drains and new laterals and sublaterals have been constructed. These facilities have significantly affected ground water additions, movement, and fluctuations.

Operation of the Marja and Nad-i-Ali Projects has also affected drainage and operation of the Shamalan area.

Water Table Studies

Since November 1964, 410 ground water observation wells were established at succeeding intervals of the investigations to measure depth to water table. Location of most observation wells is shown on Drainage Investigation Map, Drawing Nos. 501-151 through 155. Except for established village wells, all of the observation wells consist of open pits or holes dug with a hand auger. No pipe or casing was available for installation in the auger holes and consequently they were difficult to maintain. Measurements of depth to water table were made in most observation wells every 3-4 weeks during most of the year, and every 1-2 weeks during drain-out periods.

Depth to water table hydrographs of about 25% of the observation wells are shown on Drawing Nos. 501-144 through 150. To avoid bias in presenting observation well data, a hydrograph was made of every other well on alternate lines across the river valley.

Study of the hydrographs shows that the general water table over the project area rises during the early spring irrigation season after water is put in the Shamalan Canal, then drops significantly during the summer due to increased evapo-transpiration. The water table rises during fall and early winter months and falls rapidly during the drain-out period. Over most of the project area the water table is generally highest during April and early December. Rapid fall of the water table during the drain-out period indicates that the drainage aquifer has a very high transmissibility over most of the project area. During the drain-out period there is no irrigation; moisture movement upward or downward through the unsaturated zone is negligible; evapo-transpiration balances moisture added from precipitation; and ground water movement and fluctuation is not affected by seepage from or level of water in the canals and juis.

The lowering of the water table is especially significant, considering that over some areas the ground water has to move as much as 10 kilometers (6 miles) before reaching the ground surface at outlet drains. In some of the wells nearer the outlet drains, where both the ground and water table slope are toward the drains, the rate of fall was as much as 5 centimeters (2 inches) a day during the first part of the drain-out periods. The flow level in some outlet drains, particularly the Marja Wasteway, drops significantly, resulting in less interference with natural movement of ground water.

A map showing depth to water table over the project area for high water table period during April 1967 was made. This map, Drawing Nos. 501-138 through 142, also shows water table contours, topography, and location of existing project facilities.

Seepage and Deep Percolation

Since permeability rates generally increase with depth over the project area, deep percolation losses from irrigation and seepage losses from the canals, laterals, and farm ditches are largely influenced by infiltration rates into and through the upper soil zone. Topography, irrigation practices, and distribution system operation and maintenance also affect deep percolation and seepage losses.

Field infiltration tests conducted over the area to determine moisture penetration rates into and through the upper soil zones gave rates ranging from approximately 0.2 to 4.0 centimeters per hour (0.08 inch to 1.57 inches per hour), averaging approximately 1.0 cm/hr (0.39 inch per hour). Laboratory permeability rates averaged 2/3 the field rates. Observations of farm irrigation showed that infiltration rates and lateral movement of moisture is low to moderate. Deep percolation from irrigation, assuming good irrigation practices, will be from 10-15% of net input, which is sufficient to meet leaching requirements. Over large areas of the project irrigation water will have to be ponded to insure sufficient infiltration to saturate crop root zone and accomplish leaching.

Important data is lacking on seepage losses from the Shamalan Canal. No data was found on seepage loss measurements and during the investigation period no ponding tests or flow measurements were made to determine seepage losses from the Shamalan Canal or lateral canals. Based on data from cylinder infiltrometer tests, seepage from most sublaterals and farm ditches should be low to moderate. Seepage losses from Shamalan Canal and lateral canals could be much higher and excessive in some reaches.

During the spring runoff period, water diverted at the Boghra Diversion Dam is silt laden. Most of this silt is deposited on the land or in sublaterals and farm ditches, but a significant portion of it is laid down in the supply and main lateral canals. Examination of the Shamalan Canal during shutdown periods showed that it was armoured with silt and other fine materials through much of its length, although in some reaches it was badly scoured.

Deep Hole Drilling, Sampling, and Testing

Shallow well pump-out permeability tests were conducted at 850 sites from

June 1965 through April 1967. The test sites were on an approximate 500 meter grid (1,640 feet) over most of the north, east, west, and part of the south Shamalan Project Area. Where the water table was high over broad areas, the tests were made on a closer grid of about 250 meters (820 feet). Tests were generally not conducted where the water table was in the gravelly stratum or more than three meters (10 feet) below the ground surface. Drainage Investigation Map, Drawing Nos. 501-151 through 155, shows the location of the above auger hole pump-out permeability test sites conducted during this investigation, and 50 sites where tests were conducted in previous drainage investigations.

A gravelly stratum usually encountered about 4 meters (13 feet) beneath the ground surface was difficult or impossible to drill with a hand auger. Permeability tests made where the gravelly material was augered into showed the stratum to have permeability rates on the order of 10-50 meters per day (16-82 inches per hour) and higher. Permeability at sites where tests were conducted in zones just above the gravelly material showed very high rates, which were probably influenced by nearness to gravel stratum. The other main difficulty encountered in obtaining accurate data from the pump-out permeability tests was sloughing of fine loamy sand or sandy material into the auger hole during the test. The use of casing at these sites was tried without good results. If better casing had been available, the results would probably have been satisfactory. The tests, however, did show that the 1-2 meter (3.3-6.6 feet) thick loamy sand or sandy material strata above the gravelly stratum had permeability rates ranging from 2-10 meters per day (3.3-16.4 inches per hour).

A log was made of the material in the auger holes in instances where no ground water table was encountered. No pump-in type permeability tests were conducted, since pump-out type permeability tests in similar materials in adjacent areas usually did not indicate extensive shallow horizontal drainage barriers above the gravelly stratum. Also, water table studies and observation of existing drains showed no shallow horizontal barrier of extensive area in the project. Very few pump-out permeability test results showed shallow horizontal drainage barriers. Where pump-out tests did show a shallow horizontal drainage barrier, additional pump-out tests were conducted at the same sites or sites nearby. The additional pump-out permeability tests always showed that possible shallow horizontal barriers indicated were not extensive in area. Sloughing of material into the auger hole during some of the above tests probably gave results indicative of a shallow horizontal drainage barrier.

Core Drilling and Piezometer Type Permeability Tests

From October 1965 to March 1966 a core drill was used for exploration into and through the gravelly stratum. Holes were drilled at 22 sites in the West Shamalan study area and at eight sites on the desert between the Shamalan area and the Marja area. A four-inch power auger was also used for deep exploration at 132 locations. Location of the above core drill and power auger hole sites is shown on Drainage Investigation Map, Drawing Nos. 501-151 through 155.

Due to nonavailability of adequate drilling equipment and inaccessability over much of the area, fewer deep exploration holes were dug into and through the gravelly stratum than would have been desirable. However, one line of holes was dug with the core drill on about 500 meter (1,640 feet) spacing across the central and widest part of the west Shamalan study area. A multiple profile of the holes along the above east-west line showing strata deposition and computed permeability rates is shown on Drawing No. 501-143.

The method of drilling the core drill holes was to drive casing into the material, break the material up by churning with a drill bit, and then washing the broken material to the surface by hydraulics. No attempt was made to determine permeability of material drilled through by any testing procedure on holes CD1, CD1A, CD2, and CD3. Much of the gravelly material encountered was very permeable since it was difficult to wash the dug material to the surface even when the casing was driven into this material.

In order to estimate the permeability of the various strata in the other core-drill holes, piezometer type permeability tests were conducted. The piezometer type pump-out testing procedure used was as follows: A hole was dug below the bottom of the driven casing by churning with the drill bit and washing the loosened material to the surface. Water was bailed out of the hole, and a recording was made of the rate of recovery, or the rate of rise in the casing. From the estimated dimensions of the cavity below the casing, the diameter of the casing, and the rate of recovery, the permeability rate was computed for the material in which the cavity was located.

Permeability rates, as computed, are not accurate since it was impossible to construct or make accurate measurements of a uniform or natural cavity in the gravelly material below the casing. Also the churning action of the drill bit would compact the material and the hydraulic action of the drill water would wash fine material out of the gravelly stratum. The end result was that the computed permeability rates could be either very much greater or very much less than the actual rates. However, the piezometer type permeability tests are valuable in that they do give an indication of the relative permeability of the gravel stratum and probable location of horizontal drainage barriers. Piezometer type permeability tests conducted in the sandstone below the gravelly stratum show this stratum to be a definite effective horizontal drainage barrier.

No equipment was available to conduct more accurate tests such as pumping wells, observing drawdown through observation wells, and computing the average permeability rates from drawdown and discharge measurements.

<u>Holes Drilled with Power Auger</u>

A four-inch power auger was used for deep exploration at 132 sites in the project area. Most sites are along lands adjacent to canals and drains since it was nearly impossible to move the equipment in areas away from roads. The power auger could not drill completely through the gravelly stratum at any site. Usually it would be stopped by large rock about 8-10 meters (26-33 feet) below the ground surface. At most of the sites the power auger was able to penetrate the gravel stratum 4-6 meters (13-20 feet) without augering material out of the holes. Ease of penetration indicated that the gravel stratum was loose and unconsolidated. Fine gravel material augered out at a few sites usually had a loamy sand or sand matrix.

In summary, exploration with the power auger and core drill showed that a stratum of unconsolidated gravelly material underlies most of the project area. The stratum is usually 4-6 meters (13-20 feet) below the ground surface and 6-8 meters (20-26 feet) thick. Logs of the deep exploration holes show the various strata of materials to be fairly homogeneous in disposition and the sandstone or conglomerate strata that constitutes a horizontal drainage barrier not undulating enough to form vertical drainage barriers. The piezometer type permeability tests, although not very accurate, do show the gravelly stratum to be heterogeneous as to hydraulic conductivity and water moving capabilities.

Drainage Requirements

Requirement for outlet drains can be determined by studying topography and planning outlet drains to fit in with existing outlet drains and proposed lateral canals. Lateral drain requirements cannot be determined as easily because of the many variable indeterminate factors affecting spacing and location of lateral drains.

Principal factors affecting spacing, location, and cost of lateral drains are: Depth of drain, depth to drainage barrier, permeability of various strata down to the drainage barrier, and ground water additions. Since open lateral drains are proposed, lateral drain spacing influences and is influenced by layout of farm unit boundaries and sublateral canals.

All of the above factors, except permeability of various strata down to the drainage barrier, could be determined or estimated accurately enough to use in drain spacing computations. With available equipment it was not possible to measure accurately the permeability of the gravelly stratum underlying most of the project area. However, through deep hole exploration, water table studies, and observation of existing drainage system functioning, it was determined that the gravelly stratum has high transmissibility. This stratum constitutes the lower part of the drainage aquifer described previously.

Considering the characteristics of the drainage aquifer and other factors, it was determined that lateral drains dug 2.5 meters (8 feet) deep and spaced 500-1500 meters (1,640-4,920 feet) apart will provide adequate drainage protection by keeping the water table more than 1.5 meters (5 feet) below the ground surface. Spacing depends mostly on transmissibility and homogeneity of the drainage aquifer. Where existing and proposed outlet drains provide adequate drainage relief there will be no requirement for lateral drains.

Width and length of farm units and distance between sublaterals will vary from 500-1,000 meters depending upon land distribution.

To reduce requirement for rights-of-way, lateral drains, roads, and sublateral canals should be planned to occupy contiguous strips between farm units where possible. Construction costs can then be reduced by constructing these facilities at the same time since material excavated during construction of the drains could be used to build up the base of roads and sublaterals where needed.

Considering all of the above factors it was estimated that 91 kilometers (56.5 miles) of lateral drains dug 2.5 meters (8.2 feet) deep will provide adequate drainage protection to the project after rehabilitation of existing drains and construction of proposed outlet drains.

Lateral drain requirement will be greatest in the West and South Shamalan Divisions. Planned improvement of existing outlet drains in the North and East Divisions should substantially reduce the requirement for lateral drains in these areas.

Requirements for Future Investigations

During development of the project, drainage investigations should continue so that more accurate determinations can be made for spacing, location, and construction of lateral drains. The initial phase of development should include rehabilitating existing drains and constructing new outlet drains. Observation wells should be established for water table studies to determine effectiveness of improved existing and new outlet and lateral drains. Lateral drain requirements will be reduced where outlet drain effectiveness is significant.

Additional deep exploration with well drilling equipment is needed to determine drainage aquifer characteristics.

Transmissibility of drainage aquifer could be more accurately measured if wells were pumped and drawdown was observed in observation wells.

Horizontal and vertical drainage barriers need to be better defined. It is possible that a portable refraction seismograph can be used for this purpose.

PLANS AND ESTIMATES

Appendix B

PLANS AND ESTIMATES

General

The major engineering features which form the framework of the facilities that are required for the full development of the Shamalan Unit are shown on the Project Map Drawings No's. 501-130 through 501-134 and on the Key Map Drawing No. 501-91. They include improvement of the Shamalan Canal, rehabilitation of the Nad-i-Ali Wasteway and Drain (which provides a means of introducing additional water into the Shamalan system from the Boghra Canal), the principal water distribution laterals, and the proposed outlet drains.

Supply Canals

The Shamalan Canal, which is the only existing supply canal into the Project area, was designed to carry 21.24 cubic meters per second (750 cubic feet per second). Presently it is operated at a maximum capacity of about 15.57 cubic meters per second (550 cubic feet per second). It is estimated that a supply canal capacity of about 27.75 cubic meters per second (980 cfs) into the Project area is required to furnish a full irrigation water supply during the summer peak demand period to 12,707 hectares (31,399 acres) of irrigable lands proposed to be developed. Most of the nonirrigable lands with a prior water right will be supplied with water only during the spring, fall, and winter months as they are now.

Planned rehabilitation of the Shamalan Canal to bring it to design capacity is limited to the protection of drop structures by extending the concrete transition sections and adding riprap. A reconnaissance survey was made to determine the approximate yardage of concrete and riprap required at each structure. Estimated capital costs for rehabilitation of the Shamalan Canal are $29,000 including 25% for contingencies.

With the Shamalan Canal operating at its designed capacity, there would still be a shortage of supply into the Project area of about 6.51 cubic meters per second (230 cfs). This can be solved by improving the existing Nad-i-Ali Wasteway so that water diverted into it from the Boghra Canal can be brought into the Project area. The Nad-i-Ali Wasteway (now diverting into the Nad-i-Ali Drain) passes through the Shamalan Project area carrying subsurface drain and irrigation waste water from the Nad-i-Ali Project. Flow of the Nad-i-Ali Wasteway during the peak irrigation demand period is about 1.75 cubic meters per second (62 cfs) of water unsuitable for irrigation use. Additional water, about 5.92 cubic meters per second (209 cfs), diverted from the Boghra Canal into the Nad-i-Ali Wasteway, would result in a mixture of water suitable for irrigation. Total flow of the Nad-i-Ali Wasteway would then be about 7.67 cubic meters per second (271 cfs). After supply canal losses, estimated to be about 20%, flow of the Nad-i-Ali Wasteway into the Project to meet lateral canal requirements would be about 6.14 cubic meters per second (217 cfs).

The principal improvement of Nad-i-Ali Wasteway and Drain required to furnish the supplemental water supply to the Shamalan area is cleaning the existing channel and constructing and reshaping the cross section to hydraulic design. Based upon engineering survey data and general observations it is estimated that 10.7 kilometers (6.6 miles) of the wasteway would require improvement. Cleaning and shaping the bottom cross section is estimated to cost $1.60 per linear meter, and bank stabilization and construction is estimated to cost $0.60 per linear meter. The total estimated capital cost is $21,000 including 25% for contingencies.

Main Distribution Laterals

The plan of development for the Shamalan Unit includes the construction of the proposed new West Shamalan Lateral, and the re-design and realinement of the remaining jui lateral and sublateral system presently serving the major land segments exclusive of the West Shamalan Division.

The West Shamalan Lateral would divert from Shamalan Canal near the drop structure at Station 22+610. It is designed for an initial capacity of 6.1 cubic meters per second (215 cfs) from its point of diversion to its crossing at Nad-i-Ali Wasteway and Drain. After the crossing the design capacity is reduced to 4.7 cubic meters per second (165 cfs). At the crossing a structure would be provided to divert releases made from the Boghra Canal via Nad-i-Ali Wasteway and Drain into the West Shamalan Lateral. Releases carried by the wasteway in excess of the lateral capacity would by-pass the diversion structure and continue on down the wasteway to Outlet Drain "A".

From Nad-i-Ali Wasteway and Drain to approximately Station 13+820, the West Shamalan Lateral would be located along the toe of the escarpment which borders the western side of the Helmand Valley. From Station 13+820 to its end, the lateral would follow generally the location of an old existing jui in the West Shamalan Division.

Soil auger borings were made and test pits constructed for observation of the materials along the line of location from the beginning of West Shamalan Lateral to Station 13+820. Logs of materials classification were plotted on the plan and profile sheets of the proposed location. These studies indicated that approximately two kilometers of the location would require lining in reaches along the toe of the escarpment.

Estimates of quantities for the main distribution system laterals are based upon design criteria obtained from capacity requirements and field location surveys, and include yardage for excavation, borrow, and compaction. Estimates of quantities, including concrete, structural excavation, compacted backfill, pipe, and miscellaneous metal were made for control structures, turnouts, and crossings. All laterals and sublaterals are considered to be unlined except for two kilometers of West Shamalan Lateral. Quantities and prices for lining portions of West Shamalan Lateral are based upon the use of concrete.

Requirements for acquisition of rights-of-way for the main laterals and drainage system were determined but no monetary values have been assigned. It is the intention of the RGA to purchase the project lands for development purposes and after development to re-allocate the lands to the prospective project farmers.

Sublateral Distribution System

Cost estimates for the sublateral system are based upon a paper layout for a representative area comprising 2,263 acres of the Shamalan Unit. Structural quantities were developed from this layout for sublaterals, farm ditches, control structures, turnouts, crossings and surface drains to arrive at an estimated capital cost of $90 per acre, including 25% contingencies. This unit cost was projected over the irrigable acreage of the Project (31,399 acres) to obtain the total project estimated cost for sublaterals of $2,826,000.

Land Development

Land development costs include leveling of the project lands for efficient irrigation and the removal of trees from the existing jui banks to permit leveling of the old jui system to make way for a modern, controlled distribution system.

Based upon sample layouts, estimated average quantities and costs for land leveling were developed as follows:

(Metric System)

Average cubic meters of earth to be moved per hectare	350 cm
Estimated cost per cubic meter	$0.30
Total leveling cost per hectare	$105.00

(English System)

Average cubic yards of earth to be moved per acre	185 cy
Estimated cost per cubic yard	$0.23
Total leveling cost per acre	$42.50

Leveling of the juis is estimated to cost $18.50 per hectare ($7.50 per acre).

No capital cost is assigned to the removal of trees from the jui banks as the salvage value of the wood is estimated to equal the cost of clearing.

Total estimated capital costs for land development of the Shamalan Unit are $124 per hectare ($50 per acre) for 12,707 hectares (31,399 acres), or $1,570,000.

The following is a tabulation of construction costs including 25% contingencies for the distribution system and land development, by divisions of the Shamalan Unit.

<u>West Shamalan (12,779 irrigable acres)</u>	
Laterals	$561,000
Sublaterals	$1,150,000
Land development	$639,000
<u>North Shamalan (2,755 irrigable acres)</u>	
Laterals	$67,000
Sublaterals	$247,800
Land development	$138,000
<u>East Shamalan (9,795 irrigable acres)</u>	
Laterals	$335,000
Sublaterals	$881,500
Land development	$489,500
<u>South Shamalan (6,070 irrigable acres)</u>	
Laterals	$152,000
Sublaterals	$546,300
Land development	$303,500
<u>Subtotals - All Divisions</u>	
Laterals	$1,215,000
Sublaterals	$2,826,000
Land development	$1,570,000
TOTAL	$5,511,000

Drainage System

<u>Existing Outlet Drains</u>. The plan of development includes costs for the rehabilitation of the existing outlet drains in the Shamalan Unit. The work would consist of cleaning, reshaping, and restoring to grade the bottom cross sections; spreading and hauling spoil; rehabilitating existing and constructing new road cross sections at two kilometer intervals; the construction of river protection works to lessen erosion of project lands and drain outlets; and the construction required to lower Marja Wasteway crossing.

Cleaning and shaping 118 kilometers of existing outlet drains	$195,500
Rehabilitation of existing, and construction of new, road crossings	$50,500
River protection works	$27,500
Marja Wasteway crossing at Shamalan Canal	$48,000
	$321,500
Plus contingencies @ 25% ± of total	$80,500
TOTAL	$402,000

New Outlet Drains. Approximately 28.5 kilometers (17.7 miles) of new outlet drains are planned for construction in the Shamalan Unit. Cost estimates are based upon the following design criteria: average depth, 3.5 meters (11.5 feet); side slopes, 1.0:1.0; and bottom width, 1.0 meter (3.3 feet). An allowance of 25% is made for over-excavation where less stable materials might be encountered. The adopted unit price for excavation is $0.30 per cubic meter ($0.23 per cubic yard). Road crossings utilizing 36 inch reinforced concrete pipe for culverts are estimated to cost $825 per installation.

Outlet Drain "J"

Length 8,000 meters (4.97 miles)	
Excavation	$47,250
Road crossings, 4 @ $825	$3,300

Outlet Drain "K"

Length 13,200 meters (8.20 miles)	
Excavation	$77,960
Road crossings, 5 @ $825	$4,130
Crossing under Shamalan Canal	$48,000

Outlet Drain "L"

Length 3,600 meters (2.24 miles)	
Excavation	$21,260
Road crossings, 2 @ $825	$1,650

Outlet Drain "M"

Length 3,700 meters (2.30 miles)	
Excavation	$21,850
Road crossings, 2 @ $825	$1,650

Summary

Outlet Drain "J"	$50,550
Outlet Drain "K"	$130,090

Outlet Drain "L"	$22,910
Outlet Drain "M"	$23,500
Subtotal	$227,050
Plus contingencies @ 25% ±	$56,950
TOTAL	$284,000

Lateral Drains. Project costs for lateral drains are estimated on the requirement for 91 kilometers (56.4 miles) with the following design criteria: average depth 2.5 meters (8.2 feet); side slopes, 1.0:1.0; and bottom width, 1.0 meters (3.3 feet). Road crossings utilizing 24 inch reinforced concrete pipe are estimated to cost $540 per installation.

The estimated cost for lateral drains is:

Excavation	$298,594
Road crossings (182) @ $540	$98,280
Surface inlets (546) @ $100	$54,600
Subtotal	$451,474
Plus contingencies @ 25% ±	$112,526
TOTAL	$564,000

Unit Prices

Unit prices adopted for determining estimated project costs were derived from records of actual cost data developed by the Helmand Arghandab Valley Authority in constructing irrigation works during recent years. Adjustments were made where applicable to reflect present construction cost trends and situations.

Unit Prices

Item	Unit	Price
Structural excavation	cubic meters	$ 2.60
Excavation from borrow	" "	0.40
Excavation for canal	" "	0.35
Excavation for surface drains	" "	0.30
Excavation for stripping	" "	0.40
Excavation for roadway	" "	0.32
Trimming earth foundation for concrete lining	" "	0.32
Overhaul	kilometer-meter	0.24
Compacting embankments	cubic meter	0.46
Backfill about structures	" "	1.00
Compacting backfill about structures	" "	3.30
Riprap	" "	6.50
Gravel surfacing	" "	4.00
Sand and gravel bedding for riprap	" "	4.00

Item	Unit	Price
Concrete in structures	cubic meters	100.00
Concrete in canal lining	" "	50.00
Furnishing and handling cement	bbls	7.50
Furnishing and placing reinforcing	pounds	0.20
Nonreinforced concrete pipe		
10"	per linear meter	4.30
12"	" " "	5.20
14"	" " "	6.72
18"	" " "	15.85
Reinforced concrete pipe	per linear meter	
24"	" " "	23.70
36"	" " "	36.70
48"	" " "	60.80
Miscellaneous metal	per pound	0.75
Lumber		
Class 1	per board foot	0.04
Class 2	" " "	0.03
Class 3	" " "	0.03
Class 4	" " "	0.04

Estimates

Estimates of the construction costs for the Shamalan Unit are shown in the Basic Estimate, DC-1's on the following pages.

OFFICE PREPARED BY:

Bureau of Reclamation
Helmand Arghandab Valley Project
Bost, Afghanistan

SHAMALAN UNIT FEASIBILITY ESTIMATE

BASIC ESTIMATE DC-1

SUMMARY

PROJECT SHAMALAN UNIT
DATE OF ESTIMATE June 1967
PRICES AS OF
SHEET 1 OF 1

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	PAY ITEM	DESCRIPTION	QUANTITY AMOUNT	QUANTITY UNIT	LABOR AND MATERIALS BY CONTRACTOR UNIT COST	LABOR AND MATERIALS BY CONTRACTOR TOTAL COST	FIELD COST PLANT ACCOUNT	FIELD COST IDENTIFIED PROPERTY	SERVICE FACILITIES IDENTIFIED PROPERTY	TOTAL COST IDENTIFIED PROPERTY
1				2	3		4		5	6	7	8
				SHAMALAN UNIT - TOTAL CAPITAL COST								10,578,000
05				CANALS AND CONDUITS								1,265,000
06				PROJECT LATERALS								2,826,000
07				REHABILITATION OF EXISTING DRAINS								402,000
07				OUTLET DRAINS								284,000
07				PROJECT DRAINS								564,000
08				LAND DEVELOPMENT								1,570,000
				ROADS								314,000
				DOMESTIC WATER SYSTEM								230,000
				SOIL AMENDMENTS								432,000
				RESETTLEMENT COSTS								153,000
				ENGINEERING AND OVERHEAD								2,010,000
				INTEREST DURING CONSTRUCTION								528,000

OFFICE PREPARED BY:
Bureau of Reclamation
Helmand Arghandab Valley Project
Bost, Afghanistan

SHAMALAN UNIT FEASIBILITY ESTIMATE

BASIC ESTIMATE DC-1

PROJECT SHAMALAN UNIT
DATE OF ESTIMATE June 1967
PRICES AS OF 1967
SHEET 1 OF 15

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	PAY ITEM	DESCRIPTION	QUANTITY AMOUNT	QUANTITY UNIT	LABOR AND MATERIALS BY CONTRACTOR UNIT COST	LABOR AND MATERIALS BY CONTRACTOR TOTAL COST	FIELD COST PLANT ACCOUNT	FIELD COST IDENTIFIED PROPERTY	SERVICE FACILITIES IDENTIFIED PROPERTY	TOTAL COST IDENTIFIED PROPERTY
1				2	3			4	5	6	7	8
05				CANALS AND CONDUITS								1,265,000
	01			WEST SHAMALAN CANAL						498,000	37,200	535,200
				0 + 000 - 6 + 518 Capacity (215 cfs)								
				6 + 518 - 15 + 700 " (165 cfs)								
				15 + 700 - 18 + 900 " (130 cfs)								
				18 + 900 - 20 + 865 " (85 cfs)								
				20 + 865 - 21 + 430 " (50 cfs)								
				21 + 430 - 24 + 743 " (15 cfs)								
		30		LAND AND RIGHTS								
			1	Aquisition of rights-of-way	47	Hectare	1/					
		31		RELOCATION OF EXISTING PROPERTY	L.S	LS	LS	11,071		13,800		
				Contingencies (25% ±)				2,729				
				Field Cost				13,800				
		33		CANALS						227,200		
			1	Excavation, unclassified	9,725	cm	2.60	25,285				
			2	Backfill	3,400	cm	1.00	3,400				
			3	Compacting backfill	2,652	cm	3.30	8,751				
			4	Coarse gravel	443	cm	6.50	2,880				
			5	Cement, handling and furnishing	1272	bbl	7.50	9,540				
			6	Reinforcing bars	73,340	lbs	0.20	14,668				
			7	Concrete in structures	636	cm	100.00	63,600				
			8	Gates	39557	lbs	0.75	29,668				
			9	Lumber	2,410	B.F.	0.04	96				
			10	Misc. Metals	5,474	lbs	0.75	4,105				
			11	Precast concrete culvert pipe, 48 inch diameter	205	LM	60.80	12,464				
			12	" " " " 36 inch diameter	31	LM	36.70	1,138				
			13	" " " " 24 " "	123	LM	23.70	2,916				
			14	" " " " 18 " "	92	LM	15.85	1,458				
			15	" " " " 10 " "	9	LM	4.30	39				
				Subtotal				180,008				
				Contingencies (25% ±)				47,192				
				Field Cost				227,200				
				.02 --- Lined Canal, concrete from Sta 7 + 000 to Sta 9 + 000						257,000		
			1	Excavation, common for canal	195,964	cm	0.35	68,588				
			2	Compacting canal embankment	68,877	cm	0.46	31,684				
			3	Excavation for and placing concrete lining	2,260	cm	2.60	5,876				
			4	Concrete lining	1,480	cm	50.00	74,000				
			5	Excavation from borrow	63,405	cm	0.40	25,362				
				Subtotal				205,510				
				Contingencies (25% ±)				51,490				
				Field Cost				257,000				

1/ No consideration given to monetary value.

OFFICE PREPARED BY:
Bureau of Reclamation
Helmand Arghandab Valley Project
Bost, Afghanistan

SHAMALAN UNIT FEASIBILITY ESTIMATE

BASIC ESTIMATE DC-I

PROJECT SHAMALAN UNIT
DATE OF ESTIMATE June 1967
PRICES AS OF 1967
SHEET 2 OF 15

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	PAY ITEM	DESCRIPTION	QUANTITY AMOUNT	QUANTITY UNIT	LABOR AND MATERIALS BY CONTRACTOR UNIT COST	LABOR AND MATERIALS BY CONTRACTOR TOTAL COST	FIELD COST PLANT ACCOUNT	FIELD COST IDENTIFIED PROPERTY	SERVICE FACILITIES IDENTIFIED PROPERTY	TOTAL COST IDENTIFIED PROPERTY
1				2	3			4	5	6	7	8
	02			LATERAL 43.43 0 + 000 to 5 + 185; Capacity (20 cfs)						23,400	200	25,600
		30		LAND AND RIGHTS								
			1	Aquisition of rights-of-way	9	Hectare	1/					
		31		RELOCATION EXISTING PROPERTY	L.S	LS	LS	652		800		
				Contingencies (25% ±)				148				
				Field Cost				800				
		33		CANALS						22,600		
			1	Excavation, unclassified	644	cm	2.60	1,674				
			2	Backfill	286	cm	1.00	286				
			3	Compacting backfill	191	cm	3.30	630				
			4	Coarse gravel	45	cm	6.50	292				
			5	Cement, handling and furnishing	90	bbl	7.50	675				
			6	Reinforcing bars	5170	lbs	0.20	1034				
			7	Concrete in structures	45	cm	100.00	4500				
			8	Gates	2,639	lbs	0.75	1,979				
			9	Lumber	550	B.F.	0.04	22				
			10	Misc. metals	267	lbs	0.75	200				
			11	Excavation, common for canal	3,386	cm	0.35	1,185				
			12	Compaction and embankment	4,052	cm	0.46	1,864				
			13	Excavation from borrow	3,739	cm	0.40	1,492				
			14	Precast concrete culvert pipe, 24 inch diameter	62.62	LM	23.70	1,484				
			15	" " " " 18 " "	47.26	LM	15.85	749				
				Subtotal				18,064				
				Contingencies (25% ±)				4,535				
				Field Cost				22,600				
	03			SUBLATERAL 13.82 0 + 000 to 5 + 962 Capacity (20 cfs)						23,400	2,200	25,600
		30		LAND AND RIGHTS								
			1	Aquisition of rights-of-way	10	Hectare	1/					
		31		RELOCATION EXISTING PROPERTY	L.S.	LS	LS	652		800		
				Contingencies (25% ±)				148				
				Field Cost				800				
		33		CANALS						22,600		
			1	Excavation, unclassified	527	cm	2.60	1,370				
			2	Backfill	292	cm	1.00	202				
			3	Compacting backfill	233	cm	3.30	768				
			4	Coarse gravel	42	cm	6.50	274				
			5	Cement handling and furnishing	88	bbl	7.50	660				
			6	Reinforcing bars	5,060	lbs	0.20	1,012				

1/ No consideration given to monetary value.

OFFICE PREPARED BY:

Bureau of Reclamation
Helmand Arghandab Valley Project
Bost, Afghanistan

SHAMALAN UNIT FEASIBILITY ESTIMATE

BASIC ESTIMATE DC-1

PROJECT SHAMALAN UNIT
DATE OF ESTIMATE June 1967
PRICES AS OF 1967
SHEET 3 OF 15

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	PAY ITEM	DESCRIPTION	QUANTITY AMOUNT	QUANTITY UNIT	LABOR AND MATERIALS BY CONTRACTOR UNIT COST	LABOR AND MATERIALS BY CONTRACTOR TOTAL COST	FIELD COST PLANT ACCOUNT	FIELD COST IDENTIFIED PROPERTY	SERVICE FACILITIES IDENTIFIED PROPERTY	TOTAL COST IDENTIFIED PROPERTY
				2	3			4	5	6	7	8
			7	Concrete in structures	44	cm	100.00	4,400				
			8	Gates	2,639	lbs	0.75	1,979				
			9	Lumber	650	B.F.	0.04	26				
			10	Misc. metals	486	lbs	0.75	364				
			11	Excavation, common for canal	6,632	cm	0.35	2,321				
			12	Compacting canal embankment	4,052	cm	0.46	1,864				
			13	Excavation from borrow	3,730	cm	0.40	1,492				
			14	Precast concrete culvert pipe, 24 inch diameter	42.83	LM	23.70	1,015				
			15	" " " " 18 " "	20.32	LM	15.85	322				
			16	" " " " 10 " "	9.30	LM	4.30	40				
				Subtotal				18,049				
				Contingencies (25% ±)				4,551				
				Field Cost				22,600				
	04			LATERAL 39.745						68,100	6,400	74,500
				0 + 000 to 2 + 675 Capacity (65 cfs)								
				2 + 695 to 5 + 220 " (40 cfs)								
				5 + 220 to 7 + 191 " (15 cfs)								
		30		LAND AND RIGHTS								
				Aquisition of rights-of-way	13	Hectares 1/						
		31		RELOCATION EXISTING PROPERTY	L.S.	LS	LS	1,920		2,400		
				Contingencies (25% ±)				480				
				Field Cost				2,400				
		33		CANALS						65,700		
			1	Excavation, unclassified	1,763	cm	2.60	4,584				
			2	Backfill	1,000	cm	1.00	1,000				
			3	Compacting backfill	909	cm	3.30	3,000				
			4	Coarse gravel	104	cm	6.50	676				
			5	Cement handling and furnishing	136	bbl	7.50	1,028				
			6	Reinforcing bars	7,878	lbs	0.20	1,572				
			7	Concrete in structures	68.5	cm	100.00	6,850				
			8	Gates	7,697	lbs	0.75	5,773				
			9	Lumber	1,575	B.F.	0.04	63				
			10	Misc. metals	407	lbs	0.75	305				
			11	Excavation, common for canal	45,217	cm	0.35	15,826				
			12	Compacting canal embankment	11,817	cm	0.46	5,436				
			13	Excavation from borrow	10,880	cm	0.40	4,352				
			14	Precast concrete culvert pipe, 48 inch diameter	19.84	LM	60.80	1,206				
			15	" " " " 24 " "	7.51	LM	23.70	178				
			16	" " " " 18 " "	42.84	LM	15.85	679				
				Subtotal				52,528				
				Contingencies (25% ±)				13,172				
				Field Cost				65,700				

1/ No consideration given to monetary value.

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Bost, Afghanistan

SHAMALAN UNIT FEASIBILITY ESTIMATE

BASIC ESTIMATE DC-1

PROJECT SHAMALAN UNIT
DATE OF ESTIMATE June 1967
PRICES AS OF 1967
SHEET 4 OF 15

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	PAY ITEM	DESCRIPTION	QUANTITY AMOUNT	QUANTITY UNIT	LABOR AND MATERIALS BY CONTRACTOR UNIT COST	LABOR AND MATERIALS BY CONTRACTOR TOTAL COST	FIELD COST PLANT ACCOUNT	FIELD COST IDENTIFIED PROPERTY	SERVICE FACILITIES IDENTIFIED PROPERTY	TOTAL COST IDENTIFIED PROPERTY
				2	3			4	5	6	7	8
	05			LATERAL 9.827 0 + 000 to 6 + 864 Capacity (25 cfs)	13	Hectare	1/			34,800	3,300	38,100
		30		LAND AND RIGHTS								
			1	Aquisition of rights-of-way								
		31		RELOCATION OF EXISTING PROPERTY	LS	LS	LS	1,520		1,900		
				Contingencies (25% ±)				380				
				Field Cost				1,900				
		33		CANALS						32,900		
			1	Excavation, unclassified	676	cm	2.60	1,757				
			2	Backfill	214	cm	1.00	214				
			3	Compacted backfill	179	cm	3.30	591				
			4	Coarse gravel	138	cm	6.50	897				
			5	Cement handling and furnishing	144	bbl	7.50	1,080				
			6	Reinforcing bars	8,280	lbs	0.20	1,656				
			7	Concrete in structures	72	cm	100.00	7,200				
			8	Gates	6,796	lbs	0.75	5,097				
			9	Lumber	3,450	B.F.	0.04	138				
			10	Misc. metals	343	lbs	0.75	257				
			11	Excavation, common for canal	10,520	cm	0.35	3,682				
			12	Compacting canal embankment	3,580	cm	0.46	1,647				
			13	Excavation from borrow	3,293	cm	0.40	1,317				
			14	Precast concrete culvert pipe, 36 inch diameter	11.74	LM	36.70	431				
			15	" " " " 18 " "	25.99	LM	15.85	412				
				Subtotal				26,376				
				Contingencies (25% ±)				6,524				
				Field Cost				32,900				
	06			LATERAL 25.395 0 + 000 to 4 + 862, Capacity (30 cfs)						26,400	2,500	28,900
		30		LAND AND RIGHTS								
			1	Aquisition of rights-of-way	9	Hectare	1/					
		31		RELOCATION OF EXISTING PROPERTY	LS	LS	LS	1,122		1,400		
				Contingencies (25% ±)				278				
				Field Cost				1,400				
		33		CANALS						25,000		
			1	Excavation, unclassified	576	cm	2.60	1,497				
			2	Backfill	228	cm	1.00	228				
			3	Compacted backfill	158	cm	3.30	521				
			4	Coarse gravel	57	cm	6.50	371				
			5	Cement handling and furnishing	107	bbl	7.50	802				
			6	Reinforcing bars	6,151	lbs	0.20	1,230				

1/ No consideration given to monetary value.

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Bureau of Reclamation
Helmand Arghandab Valley Project
Bost, Afghanistan

SHAMALAN UNIT FEASIBILITY ESTIMATE

BASIC ESTIMATE DC-1

PROJECT SHAMALAN UNIT
DATE OF ESTIMATE June 1967
PRICES AS OF 1967
SHEET 5 OF 15

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	PAY ITEM	DESCRIPTION	QUANTITY AMOUNT	QUANTITY UNIT	LABOR AND MATERIALS BY CONTRACTOR UNIT COST	LABOR AND MATERIALS BY CONTRACTOR TOTAL COST	FIELD COST PLANT ACCOUNT	FIELD COST IDENTIFIED PROPERTY	SERVICE FACILITIES IDENTIFIED PROPERTY	TOTAL COST IDENTIFIED PROPERTY
				2	3			4	5	6	7	8
			7	Concrete in structures	53.4	cm	100.00	5,340				
			8	Gates	5,147	lbs	0.75	3,860				
			9	Lumber	2,600	lbs	0.04	104				
			10	Misc. metals	655	lbs	0.75	491				
			11	Excavation, common for canal	6,846	cm	0.35	2,396				
			12	Compaction canal embankment	2,711	cm	0.46	1,247				
			13	Excavation from borrow	2,495	cm	0.40	998				
			14	Precast concrete culvert pipe, 36 inch diameter	11.72	LM	36.70	430				
			15	" " " " 18 " "	33.19	LM	15.85	526				
				Subtotal				20,049				
				Contingencies (25% ±)				4,999				
				Field Cost				25,000				
	07			SUBLATERAL 3.226 0 + 000 to 7 + 710, Capacity (12 cfs)						15,500	1,600	17,100
		30		LAND AND RIGHTS								
			1	Aquisition of rights-of-way	15	Hectare 1/						
		31		RELOCATION OF EXISTING PROPERTY	LS	LS	LS	400		500		
				Contingencies (25% ±)				100				
				Field Cost				500				
		33		CANALS						15,000		
			1	Excavation, Unclassified	392	cm	2.60	1,019				
			2	Backfill	155	cm	1.00	155				
			3	Compacted backfill	93	cm	3.30	306				
			4	Coarse gravel	34	cm	6.50	221				
			5	Cement handling and furnishing	66	bbl	7.50	495				
			6	Reinforcing bars	3,795	lbs	0.20	759				
			7	Concrete in structures	33	cm	100.00	3,300				
			8	Gates	2,165	lbs	0.75	1,624				
			9	Lumber	1,100	B.F.	0.04	44				
			10	Misc. metals	279	lbs	0.75	209				
			11	Excavation, common for canal	3,657	cm	0.35	1,280				
			12	Compaction canal embankment	2,480	cm	0.46	1,141				
			13	Excavation from borrow	2,283	cm	0.40	913				
			14	Precast concrete culvert pipe, 24 inch diameter	13.21	LM	23.70	313				
			15	" " " " 18 " "	14.64	LM	15.85	232				
			16	" " " " 10 " "	10.00	LM	4.30	43				
				Subtotal				12,054				
				Contingencies (25% ±)				2,946				
				Field Cost				15,000				
	08			SUBLATERAL 4.02 0 + 000 to 3 + 232, Capacity (12 cfs)						9,400	900	10,300

1/ No consideration given to monetary value.

OFFICE PREPARED BY:
Bureau of Reclamation
Helmand Arghandab Valley Project
Bost, Afghanistan

SHAMALAN UNIT FEASIBILITY ESTIMATE

BASIC ESTIMATE DC-1

PROJECT SHAMALAN UNIT
DATE OF ESTIMATE June 1967
PRICES AS OF 1967
SHEET 6 OF 15

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	PAY ITEM	DESCRIPTION	QUANTITY AMOUNT	QUANTITY UNIT	LABOR AND MATERIALS BY CONTRACTOR UNIT COST	LABOR AND MATERIALS BY CONTRACTOR TOTAL COST	FIELD COST PLANT ACCOUNT	FIELD COST IDENTIFIED PROPERTY	SERVICE FACILITIES IDENTIFIED PROPERTY	TOTAL COST IDENTIFIED PROPERTY
1				2	3			4	5	6	7	8
		30		LAND AND RIGHTS								
			1	Aquisition of rights-of-way	6	Hectare	1/					
		31		RELOCATION OF EXISTING PROPERTY	LS	LS	LS	240		300		
				Contingencies (25% ±)				60				
				Field Cost				300				
		33		CANALS						9,100		
			1	Excavation, unclassified	236	cm	2.60	613				
			2	Backfill	93	cm	1.00	93				
			3	Compacted backfill	56	cm	3.30	184				
			4	Coarse gravel	20	cm	6.50	130				
			5	Cement handling and furnishing	38	bbl	7.50	285				
			6	Reinforcing bars	2,185	lbs	0.20	437				
			7	Concrete in structure	19	cm	100.00	1,900				
			8	Gates	1,301	lbs	0.75	976				
			9	Lumber	650	B.F.	0.04	26				
			10	Misc. metals	168	lbs	0.75	126				
			11	Excavation, common for canal	2,200	cm	0.35	770				
			12	Compacting canal embankment	1,491	cm	0.46	686				
			13	Escavation from borrow	1,373	cm	0.40	549				
			14	Precast concrete culvert pipe, 24 inch diameter	7.93	LM	23.70	188				
			15	" " " " 18 " "	14.64	LM	15.85	232				
			16	" " " " 10 " "	10.00	LM	4.30	43				
				Subtotal				7,238				
				Contingencies (25% ±)				1,862				
				Field Cost				9,100				
	09			LATERAL 38.145					528	18,500	1,700	20,200
				0 + 000 to 3 + 778, Capacity (15 cfs)								
		30		LAND AND RIGHTS								
			1	Aquisition of rights-of-way	7	Hectare	1/					
		31		RELOCATION OF EXISTING PROPERTY	LS	LS	LS	400		500		
				Contingencies (25% ±)				100				
				Field Cost				500				
		33		CANALS						18,000		
			1	Excavation, unclassified	438	cm	2.60	1,138				
			2	Backfill	189	cm	1.00	189				
			3	Compacted backfill	133	cm	3.30	439				
			4	Coarse gravel	48.77	cm	6.50	317				
			5	Cement handling and furnishing	70	bbl	7.50	525				
			6	Reinforcing bars	4,025	lbs	0.20	805				
			7	Concrete in structures	35	cm	100.00	3,500				
			8	Gates	2,555	lbs	0.75	1,916				

1/ No consideration given to monetary value.

OFFICE PREPARED BY:
Bureau of Reclamation
Helmand Arghandab Valley Authority
Bost, Afghanistan

SHAMALAN UNIT FEASIBILITY ESTIMATE

BASIC ESTIMATE DC-1

PROJECT SHAMALAN UNIT
DATE OF ESTIMATE June 1967
PRICES AS OF 1967
SHEET 7 OF 15

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	PAY ITEM	DESCRIPTION	QUANTITY AMOUNT	QUANTITY UNIT	LABOR AND MATERIALS BY CONTRACTOR UNIT COST	LABOR AND MATERIALS BY CONTRACTOR TOTAL COST	FIELD COST PLANT ACCOUNT	FIELD COST IDENTIFIED PROPERTY	SERVICE FACILITIES IDENTIFIED PROPERTY	TOTAL COST IDENTIFIED PROPERTY
	1			2	3			4	5	6	7	8
			9	Lumber	1,300	B.F.	0.04	52				
			10	Misc. metals	476	lbs	0.75	357				
			11	Excavation, common for canal	6,077	cm	0.35	2,127				
			12	Compacting canal embankment	2,926	cm	0.46	1,346				
			13	Excavation from borrow	2,693	cm	0.40	1,077				
			14	Precast concrete culvert pipe, 18 inch diameter	34.70	LM	15.85	550				
			15	" " " " 10 " "	7.00	LM	4.30	30				
				Subtotal				14,368				
				Contingencies (25% ±)				3,632				
				Field Cost				18,000				
	10			ZAREST SUBLATERAL								
				0 + 000 to 6 + 563, Capacity (45 cfs)						49,000	5,000	54,000
		30		LAND AND RIGHTS								
			1	Aquisition of rights-of-way	12	Hectare 1/						
		31		RELOCATION OF EXISTING PROPERTY	LS	LS	LS	1,120		1,400		
				Contingencies (25% ±)				280				
				Field Cost				1,400				
		33		CANALS						47,600		
			1	Excavation, unclassified	1,066	cm	2.60	2,772				
			2	Backfill	491	cm	1.00	491				
			3	Compacting backfill	266	cm	3.30	877				
			4	Coarse gravel	89.70	cm	6.50	583				
			5	Cement handling and furnishing	152	bbl	7.50	1,140				
			6	Reinforcing bars	8,740	lbs	0.20	1,748				
			7	Concrete in structures	76	cm	100.00	7,600				
			8	Gates	6,841	lbs	0.75	5,131				
			9	Lumber	3,450	B.F.	0.04	138				
			10	Misc. metals	1,663	lbs	0.75	1,247				
			11	Excavation, common for canal	25,577	cm	0.35	8,952				
			12	Compacting canal embankment	7,837	cm	0.46	3,605				
			13	Excavation from borrow	7,213	cm	0.40	2,885				
			14	Precast concrete culvert pipe, 36 inch diameter	13.30	LM	36.70	488				
			15	" " " " 18 " "	29.53	LM	15.85	468				
			16	" " " " 10 " "	4.42	LM	4.30	19				
				Subtotal				38,144				
				Contingencies (25% ±)				9,456				
				Field Cost				47,600				
	11			LATERAL 48.48						97,100	10,000	107,100
				0 + 000 to 2 + 681, Capacity (110 cfs)								
				2 + 681 to 6 + 123 " (80 cfs)								
				6 + 123 to 12 + 612 " (55 cfs)								
				12 + 612 to 15 + 643 " (30 cfs)								

1/ No consideration given to monetary value.

OFFICE PREPARED BY:

Bureau of Reclamation
Helmand Arghandab Valley Project
Bost, Afghanistan

SHAMALAN UNIT FEASIBILITY ESTIMATE

BASIC ESTIMATE DC-1

PROJECT SHAMALAN UNIT
DATE OF ESTIMATE June 1957
PRICES AS OF 1957
SHEET 8 OF 15

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	PAY ITEM	DESCRIPTION	QUANTITY AMOUNT	QUANTITY UNIT	LABOR AND MATERIALS BY CONTRACTOR UNIT COST	LABOR AND MATERIALS BY CONTRACTOR TOTAL COST	FIELD COST PLANT ACCOUNT	FIELD COST IDENTIFIED PROPERTY	SERVICE FACILITIES IDENTIFIED PROPERTY	TOTAL COST IDENTIFIED PROPERTY
	1			2	3			4	5	6	7	8
		30		LANDS AND RIGHTS								
			1	Aquisition of rights-of-way	30	Hectare	1/					
		31		RELOCATION OF EXISTING PROPERTY	LS	LS	LS	2,240		2,800		
				Contingencies (25% ±)				560				
				Field Cost				2,800				
		33		CANALS						94,300		
			1	Excavation, unclassified	2,115	cm	2.60	5,498				
			2	Backfill	973	cm	1.00	973				
			3	Compacting backfill	527	cm	3.30	1,739				
			4	Coarse gravel	178	cm	6.50	1,157				
			5	Cement handling and furnishing	298	bbl	7.50	2,235				
			6	Reinforcing bars	17,135	lbs	0.20	3,472				
			7	Concrete in structures	149	cm	100.00	14,900				
			8	Gates	13,569	lbs	0.75	10,177				
			9	Lumber	6,850	B.F.	0.04	274				
			10	Misc. metals	3,297	lbs	0.75	2,473				
			11	Excavation, common for canal	50,723	cm	0.35	17,753				
			12	Compacting canal embankment	15,541	cm	0.46	7,149				
			13	Excavation from borrow	14,305	cm	0.40	5,722				
			14	Precast concrete culvert pipe, 36 inch diameter	26.38	LM	36.70	968				
			15	" " " " 18 " "	58.55	LM	15.85	928				
			16	" " " " 10 " "	8.84	LM	4.30	38				
				Subtotal				75,412				
				Contingencies (25% ±)				18,888				
				Field Cost				94,300				
	12			LATERAL 30.1						39,300	4,094	43,300
				0 + 000 to 0 + 750, Capacity (85 cfs)								
				0 + 750 to 7 + 925 " (20 cfs)								
		30		LAND AND RIGHTS								
			1	Aquisition of rights-of-way	15	Hectare	1/					
		31		RELOCATION OF EXISTING PROPERTY	LS	LS	LS	880		1,100		
				Contingencies (25% ±)				220				
				Field Cost				1,100				
		33		CANALS						38,200		
			1	Excavation, unclassified	1,252	cm	2.60	3,255				
			2	Backfill	548	cm	1.00	548				
			3	Compacting backfill	349	cm	3.30	1,152				
			4	Coarse gravel	99	cm	6.50	644				
			5	Cement handling and furnishing	114	bbl	7.50	855				
			6	Reinforcing bars	6,555	lbs	0.20	1,311				
			7	Concrete in structures	57	cm	100.00	5,700				

1/ No consideration given to monetary value.

OFFICE PREPARED BY:
Bureau of Reclamation
Helmand Arghandab Valley Project
Bost, Afghanistan

SHAMALAN UNIT FEASIBILITY ESTIMATE

BASIC ESTIMATE DC-1

PROJECT SHAMALAN UNIT
DATE OF ESTIMATE June 1967
PRICES AS OF 1967
SHEET 9 OF 15

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	PAY ITEM	DESCRIPTION	QUANTITY AMOUNT	QUANTITY UNIT	LABOR AND MATERIALS BY CONTRACTOR UNIT COST	LABOR AND MATERIALS BY CONTRACTOR TOTAL COST	FIELD COST PLANT ACCOUNT	FIELD COST IDENTIFIED PROPERTY	SERVICE FACILITIES IDENTIFIED PROPERTY	TOTAL COST IDENTIFIED PROPERTY
				2	3			4	5	6	7	8
			8	Gates	5,491	lbs	0.75	4,118				
			9	Lumber	2,750	B.F.	0.04	110				
			10	Misc. metals	1,821	lbs	0.75	1,366				
			11	Excavation, common for canal	11,891	cm	0.35	4,162				
			12	Compacting canal embankment	6,289	cm	0.46	2,893				
			13	Excavation from borrow	5,788	cm	0.40	2,315				
			14	Precast concrete culvert pipe, 48 inch diameter	23.98	LM	60.80	1,458				
			15	" " " " 24 " "	11.73	LM	23.70	278				
			16	" " " " 18 " "	19.56	LM	15.85	310				
			17	" " " " 10 " "	17.67	LM	4.30	76				
				Subtotal				30,551				
				Contingencies (25% ±)				7,649				
				Field Cost				38,200				
	13			SUBLATERAL 3.7 0 + 000 to 4 + 783, Capacity (12 cfs)						13,800	1,400	15,200
		30		LAND AND RIGHTS								
			1	Aquisition of rights-of-way	9	Hectare	1/					
		31		RELOCATION OF EXISTING PROPERTY	LS	LS	LS	320		400		
				Contingencies (25% ±)				80				
				Field Cost				400				
		33		CANALS						13,400		
			1	Excavating, unclassified	348	cm	2.60	905				
			2	Backfill	138	cm	1.00	138				
			3	Compacting backfill	82	cm	3.30	271				
			4	Coarse gravel	30	cm	6.50	195				
			5	Cement handling and furnishing	58	bbl	7.50	435				
			6	Reinforcing bars	3,335	lbs	0.20	667				
			7	Concrete in structures	29	cm	100.00	2,900				
			8	Gates	1,924	lbs	0.75	1,443				
			9	Lumber	975	B.F.	0.04	39				
			10	Misc. metals	248	lbs	0.75	186				
			11	Excavation, common for canal	3,251	cm	0.35	1,138				
			12	Compacting canal embankment	2,204	cm	0.46	1,014				
			13	Excavation from borrow	2,030	cm	0.40	812				
			14	Precast concrete culvert pipe, 24 inch diameter	11.73	LM	23.70	278				
			15	" " " " 18 " "	13.00	LM	15.85	206				
			16	" " " " 10 " "	8.84	LM	4.30	38				
				Subtotal				10,665				
				Contingencies (25% ±)				2,735				
				Field Cost				13,400				

1/ No consideration given to monetary value.

OFFICE PREPARED BY:
Bureau of Reclamation
Helmand Arghandab Valley Project
Bost, Afghanistan

SHAMALAN UNIT FEASIBILITY ESTIMATE

BASIC ESTIMATE DC-I

PROJECT SHAMALAN UNIT
DATE OF ESTIMATE June 1967
PRICES AS OF 1967
SHEET 10 OF 15

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	PAY ITEM	DESCRIPTION	QUANTITY AMOUNT	QUANTITY UNIT	LABOR AND MATERIALS BY CONTRACTOR UNIT COST	LABOR AND MATERIALS BY CONTRACTOR TOTAL COST	FIELD COST PLANT ACCOUNT	FIELD COST IDENTIFIED PROPERTY	SERVICE FACILITIES IDENTIFIED PROPERTY	TOTAL COST IDENTIFIED PROPERTY
1				2	3			4	5	6	7	8
	14			LATERAL 42.00						38,800	4,000	42,800
				0 + 000 to 0 + 220, Capacity (80 cfs)								
				0 + 200 to 3 + 530 " (40 cfs)								
				3 + 530 to 9 + 631 " (20 cfs)								
		30		LAND AND RIGHTS								
			1	Aquisition of rights-of-way	18	Hectare	1/					
		31		RELOCATION OF EXISTING PROPERTY	LS	LS	LS	880		1,100		
				Contingencies (25% ±)				220				
				Field Cost				1,100				
		33		CANALS						37,700		
			1	Excavation, unclassified	815	cm	2.60	2,119				
			2	Backfill	355	cm	1.00	355				
			3	Compacting backfill	253	cm	3.30	835				
			4	Coarse gravel	77	cm	6.50	500				
			5	Cement handling and furnishing	112	bbl	7.50	840				
			6	Reinforcing bars	6,440	lbs	0.20	1,288				
			7	Concrete in structures	56	cm	100.00	5,600				
			8	Gates	5,423	lbs	0.75	4,067				
			9	Lumber	2,750	B.F.	0.04	110				
			10	Misc. metals	903	lbs	0.75	677				
			11	Excavation, common for canal	20,434	cm	0.35	7,152				
			12	Compacting canal embankment	6,211	cm	0.46	2,857				
			13	Excavation from borrow	5,718	cm	0.40	2,287				
			14	Precast concrete culvert pipe, 36 inch diameter	14.66	LM	36.70	538				
			15	" " " " 24 " "	11.73	LM	23.70	278				
			16	" " " " 18 " "	39.05	LM	15.85	619				
				Subtotal				30,122				
				Contingencies (25% ±)				7,578				
				Field Cost				37,700				
	15			SUBLATERAL .73						22,800	2,300	25,100
				0 + 734 to 2 + 718, Capacity (55 cfs)								
				2 + 718 to 3 + 226 " (40 cfs)								
				3 + 226 to 3 + 793 " (25 cfs)								
				3 + 793 to 6 + 416 " (15 cfs)								
		30		LAND AND RIGHTS								
			1	Aquisition of rights-of-way	12	Hectare	1/					
		31		RELOCATION OF EXISTING PROPERTY	LS	LS	LS	560		700		
				Contingencies (25% ±)				140				
				Field Cost				700				

1/ No consideration given to monetary value.

OFFICE PREPARED BY:

Bureau of Reclamation
Helmand Arghandab Valley Project
Bost, Afghanistan

SHAMALAN UNIT FEASIBILITY ESTIMATE

BASIC ESTIMATE DC-1

PROJECT SHAMALAN UNIT
DATE OF ESTIMATE June 1967
PRICES AS OF 1967
SHEET 11 OF 15

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	PAY ITEM	DESCRIPTION	QUANTITY AMOUNT	QUANTITY UNIT	LABOR AND MATERIALS BY CONTRACTOR UNIT COST	LABOR AND MATERIALS BY CONTRACTOR TOTAL COST	FIELD COST PLANT ACCOUNT	FIELD COST IDENTIFIED PROPERTY	SERVICE FACILITIES IDENTIFIED PROPERTY	TOTAL COST IDENTIFIED PROPERTY
1				2	3			4	5	6	7	8
		33		CANALS						22,100		
			1	Excavation, unclassified	545	cm	2.60	1,417				
			2	Backfill	235	cm	1.00	235				
			3	Compacting backfill	166	cm	3.30	548				
			4	Coarse gravel	61	cm	6.50	397				
			5	Cement handling and furnishing	84	bbl	7.50	630				
			6	Reinforcing bars	4,830	lbs	0.20	966				
			7	Concrete in structures	42	cm	100.00	4,200				
			8	Gates	3,184	lbs	0.75	2,388				
			9	Lumber	1,600	B.F.	0.04	64				
			10	Misc. metals	593	lbs	0.75	445				
			11	Excavation, common for canal	7,571	cm	0.35	2,650				
			12	Compacting canal embankment	3,646	cm	0.46	1,677				
			13	Excavation from borrow	3,358	cm	0.40	1,343				
			14	Precast concrete culvert pipe, 18 inch diameter	43.28	LM	15.85	686				
			15	" " " " 10 " "	8.84	LM	4.30	38				
				Subtotal				17,684				
				Contingencies (25% ±)				4,416				
				Field Cost				22,100				
	16			LATERAL 63.6						115,000	10,700	125,700
				0 + 000 to 2 + 919, Capacity (120 cfs)								
				2 + 919 to 10 + 005 " (65 cfs)								
				10 + 005 to 13 + 005 " (35 cfs)								
				13 + 005 to 15 + 303 " (15 cfs)								
		30		LAND AND RIGHTS								
			1	Aquisition of rights-of-way	31	Hectare	1/					
		31		RELOCATION OF EXISTING PROPERTY	LS	LS	LS	5,440		6,800		
				Contingencies (25% ±)				1,360				
				Field Cost				6,800				
		33		CANALS						103,200		
			1	Excavation, unclassified	2,471	cm	2.60	6,424				
			2	Backfill	799	cm	1.00	799				
			3	Compacting backfill	497	cm	3.30	1,640				
			4	Coarse gravel	533	cm	6.50	3,465				
			5	Cement handling and furnishing	368	bbl	7.50	2,760				
			6	Reinforcing bars	21,160	lbs	0.20	4,232				
			7	Concrete in structures	184	cm	100.00	18,400				
			8	Gates	21,765	lbs	0.75	16,324				
			9	Lumber	10,875	B.F.	0.04	435				
			10	Misc. metals	2,335	lbs	0.75	1,751				
			11	Excavation, common for canal	38,243	cm	0.35	15,385				
			12	Compacting canal embankment	16,133	cm	0.46	7,421				
			13	Excavation from borrow	14,855	cm	0.40	5,942				

1/ No consideration given to monetary value.

OFFICE PREPARED BY:
Bureau of Reclamation
Helmand Arghandab Valley Project
Bost, Afghanistan

SHAMALAN UNIT FEASIBILITY ESTIMATE

BASIC ESTIMATE DC-I

PROJECT SHAMALAN UNIT
DATE OF ESTIMATE June 1967
PRICES AS OF 1967
SHEET 12 OF 15

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	PAY ITEM	DESCRIPTION 2	QUANTITY AMOUNT 3	QUANTITY UNIT	LABOR AND MATERIALS BY CONTRACTOR UNIT COST	LABOR AND MATERIALS BY CONTRACTOR TOTAL COST 4	FIELD COST PLANT ACCOUNT 5	FIELD COST IDENTIFIED PROPERTY 6	SERVICE FACILITIES IDENTIFIED PROPERTY 7	TOTAL COST IDENTIFIED PROPERTY 8
			14	Precast concrete culvert pipe, 36 inch diameter	14.66	LM	36.70	538				
			15	" " " " 24 " "	14.68	LM	23.70	348				
			16	" " " " 18 " "	39.05	LM	15.85	619				
			17	" " " " 10 " "	17.67	LM	6.30	76				
				Subtotal				86,560				
				Contingencies (25% ±)				21,640				
				Field Cost				108,200				
	17			LATERAL 57.060								
				0 + 000 to 2 + 638, Capacity (15 cfs)						9,500	900	10,400
		30		LAND AND RIGHTS								
			1	Aquisition of rights-of-way	5	Hectare 1/						
		31		RELOCATION OF EXISTING PROPERTY	LS	LS	LS	480		600		
				Contingencies (25% ±)				120				
				Field Cost				600				
		33		CANALS						8,900		
			1	Excavation, unclassified	212	cm	2.60	551				
			2	Backfill	75	cm	1.00	75				
			3	Compacting backfill	45	cm	3.30	148				
			4	Coarse gravel	16	cm	6.50	104				
			5	Cement handling and furnishing	40	bbl	7.50	300				
			6	Reinforcing bars	2,300	lbs	0.20	460				
			7	Concrete in structures	20	cm	100.00	2,000				
			8	Gates	1,793	lbs	0.75	1,345				
			9	Lumber	900	B.F.	0.04	36				
			10	Misc. metals	135	lbs	0.75	101				
			11	Excavation, common for canal	1,763	cm	0.35	617				
			12	Compacting canal embankment	1,328	cm	0.46	611				
			13	Excavation from borrow	1,225	cm	0.40	490				
			14	Precast concrete culvert pipe, 24 inch diameter	6.37	LM	23.70	151				
			15	" " " " 18 " "	7.07	LM	15.85	112				
			16	" " " " 10 " "	4.88	LM	4.30	21				
				Subtotal				7,122				
				Contingencies (25% ±)				1,778				
				Field Cost				8,900				
	18			LATERAL 58.790								
				0 + 000 to 2 + 104, Capacity (15 cfs)						8,200	800	9,000
		30		LAND AND RIGHTS								
			1	Aquisition of rights-of-way	4	Hectare 1/						

1/ No consideration given to monetary value.

OFFICE PREPARED BY:

Bureau of Reclamation
Helmand Arghandab Valley Project
Bost, Afghanistan

SHAMALAN UNIT FEASIBILITY ESTIMATE

BASIC ESTIMATE DC-I

PROJECT SHAMALAN UNIT
DATE OF ESTIMATE June 1967
PRICES AS OF 1967
SHEET 13 OF 15

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	PAY ITEM	DESCRIPTION	QUANTITY AMOUNT	QUANTITY UNIT	LABOR AND MATERIALS BY CONTRACTOR UNIT COST	LABOR AND MATERIALS BY CONTRACTOR TOTAL COST	FIELD COST PLANT ACCOUNT	FIELD COST IDENTIFIED PROPERTY	SERVICE FACILITIES IDENTIFIED PROPERTY	TOTAL COST IDENTIFIED PROPERTY
1				2	3			4	5	6	7	8
		31		RELOCATION OF EXISTING PROPERTY	LS	LS	LS	400		500		
				Contingencies (25% ±)				100				
				Field Cost				500				
		33		CANALS						7,700		
			1	Excavation, unclassified	184	cm	2.60	478				
			2	Backfill	65	cm	1.00	65				
			3	Compacting backfill	39	cm	3.30	128				
			4	Coarse gravel	14	cm	6.50	91				
			5	Cement handling and furnishing	34	bbl	7.50	255				
			6	Reinforcing bars	1,955	lbs	0.20	391				
			7	Concrete in structures	17	cm	100.00	1,700				
			8	Gates	1,555	lbs	0.75	1,166				
			9	Lumber	775	B.F.	0.04	31				
			10	Misc. metals	117	lbs	0.75	88				
			11	Excavation, common for canal	1,529	cm	0.35	535				
			12	Compacting canal embankment	1,152	cm	0.46	530				
			13	Excavation from borrow	1,060	cm	0.40	424				
			14	Precast concrete culvert pipe, 24 inch diameter	5.53	LM	23.70	131				
			15	" " " " 18 " "	6.12	LM	15.85	97				
			16	" " " " 10 " "	4.19	LM	4.30	18				
				Subtotal				6,128				
				Contingencies (25% ±)				1,572				
				Field Cost				7,700				
	19			LATERAL 62.220								
				0 + 000 to 2 + 549, Capacity (15 cfs)						6,300	600	6,900
		30		LAND AND RIGHTS								
			1	Aquisition of rights-of-way	9	Hectare	1/					
		31		RELOCATION OF EXISTING PROPERTY	LS	LS	LS	320		400		
				Contingencies (25% ±)				80				
				Field Cost				400				
		33		CANALS						5,900		
			1	Excavation, unclassified	142	cm	2.60	369				
			2	Backfill	50	cm	1.00	50				
			3	Compacting backfill	30	cm	3.30	99				
			4	Coarse gravel	11	cm	6.50	72				
			5	Cement handling and furnishing	26	bbl	7.50	195				
			6	Reinforcing bars	1,495	lbs	0.20	299				
			7	Concrete in structures	13	cm	100.00	1,300				
			8	Gates	1,199	lbs	0.75	899				
			9	Lumber	600	B.F.	0.04	24				
			10	Misc. metals	89	lbs	0.75	67				
			11	Excavation, common for canal	1,180	cm	0.35	413				

1/ No consideration given to monetary value.

OFFICE PREPARED BY:

Bureau of Reclamation
Helmand Arghandab Valley Project
Bost, Afghanistan

SHAMALAN UNIT FEASIBILITY ESTIMATE

BASIC ESTIMATE DC-I

PROJECT SHAMALAN UNIT
DATE OF ESTIMATE June 1967
PRICES AS OF 1967
SHEET 14 OF 15

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	PAY ITEM	DESCRIPTION	QUANTITY AMOUNT	QUANTITY UNIT	LABOR AND MATERIALS BY CONTRACTOR UNIT COST	LABOR AND MATERIALS BY CONTRACTOR TOTAL COST	FIELD COST PLANT ACCOUNT	FIELD COST IDENTIFIED PROPERTY	SERVICE FACILITIES IDENTIFIED PROPERTY	TOTAL COST IDENTIFIED PROPERTY
1				2	3		4		5	6	7	8
			12	Compacting canal embankment	889	cm	0.46	409				
			13	Excavation from borrow	817	cm	0.40	327				
			14	Precast concrete culvert pipe, 24 inch diameter	4.26	LM	23.70	101				
			15	" " " " 18 " "	4.73	LM	15.85	75				
			16	" " " " 10 " "	3.26	LM	4.30	14				
				Subtotal				4,713				
				Contingencies (25% ±)				1,187				
				Field Cost				5,900				
	20			REHABILITATION - SHAMALAN CANAL	LS		LS	29,000		29,000		29,000
	21			REHABILITATION, NAD-I-ALI WASTEWAY AND DRAIN	LS		LS	21,000		21,000		21,000
06				PROJECT LATERALS	31,399	Acres	90.00	2,826,000		2,826,000		2,826,000
07				DRAINS								1,250,000
	01			Outlet Drain "J" 0 + 000 to 8 + 000						63,200		63,200
		30		LAND AND RIGHTS								
				Aquisition of rights-of-way	21	Hectare	1/					
		33	1	Excavation	126,000	cm	0.30	37,800				
			2	Over-excavation	31,500	cm	0.30	9,450				
			3	Road crossings	4	ea	825	3,300				
				Subtotal				50,550				
				Contingencies (25% ±)				12,650				
				Field Cost				63,200				
				Outlet Drain "K" 0 + 000 to 13 + 200						162,600		162,600
		30		LAND AND RIGHTS								
				Aquisition of rights-of-way	34	Hectare	1/					
		33	1	Excavation	194,900	cm	0.30	58,470				
			2	Over-excavation	64,967	cm	0.30	19,490				
			3	Road crossings	5	ea	825	4,125				
			4	Crossing under Shamalan Canal	1	ea	48,000	48,000				
				Subtotal				130,085				
				Contingencies (25% ±)				32,515				
				Field Cost				162,600				
				Outlet Drain "L" 0 + 000 to 3 + 600						28,600		28,600

1/ No consideration given to monetary value.

OFFICE PREPARED BY:

Bureau of Reclamation
Helmand Arghandab Valley
Bost, Afghanistan

SHAMALAN UNIT FEASIBILITY ESTIMATE

BASIC ESTIMATE DC-I

PROJECT SHAMALAN UNIT
DATE OF ESTIMATE June 1967
PRICES AS OF 1967
SHEET 15 OF 15

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	PAY ITEM	DESCRIPTION	QUANTITY AMOUNT	QUANTITY UNIT	LABOR AND MATERIALS BY CONTRACTOR UNIT COST	LABOR AND MATERIALS BY CONTRACTOR TOTAL COST	FIELD COST PLANT ACCOUNT	FIELD COST IDENTIFIED PROPERTY	SERVICE FACILITIES IDENTIFIED PROPERTY	TOTAL COST IDENTIFIED PROPERTY
1				2	3		4		5	6	7	8
		30		LAND AND RIGHTS								
				Aquisition of rights-of-way	9	Hectare	1/					
		33	1	Excavation	53,150	cm	0.30	15,945				
			2	Over-excavation	17,717	cm	0.30	5,315				
			3	Road crossings	2	ea	825	1,650				
				Subtotal				22,910				
				Contingencies (25% ±)				5,690				
				Field Cost				28,600				
				Outlet Drain "M"						29,600		29,600
		30		LAND AND RIGHTS								
				Aquisition of rights-of-way	10	Hectare	1/					
		33	1	Excavation	54,627	cm	0.30	16,388				
			2	Over-excavation	18,207	cm	0.30	5,462				
			3	Road crossings	2	ea	825	1,650				
				Subtotal				23,500				
				Contingencies (25% ±)				6,100				
				Field Cost				29,600				
				LATERAL DRAINS (91 kilometers)						564,000		564,000
		30		LAND AND RIGHTS								
				Aquisition of rights-of-way	182	Hectare	1/					
		33	1	Excavation	746,483	cm	0.30	223,945				
			2	Over-excavation	248,830	cm	0.30	74,649				
			3	Road crossings	182	ea	540	98,280				
			4	Surface inlets	546	ea	100	54,600				
				Subtotal				451,474				
				Contingencies (25% ±)				112,526				
				Field Cost				564,000				
07				REHABILITATION OF EXISTING DRAINS	118	kms	LS	402,000		402,000		402,000

1/ No consideration given to monetary value.

Alternate Considerations

The West Shamalan Division is the largest single body of land in the Shamalan Unit, comprising about 12,300 irrigable acres. It is bounded on the west by the escarpment and on the east by Outlet Drain "B", the Shamalan Canal, and Outlet Drain "F". (See Key Map Drawing No. 501-91.) It is a body of land which readily lends itself to alternate consideration of plans for its full development.

Study of the area indicates that an orderly layout of lands to form recommended farm sizes, and provide the irrigation and drainage system which would be adaptable to both present and hoped-for future farming practices, could be accommodated by constructing the sublaterals, lateral drains, and roads parallel and adjacent to each other in a combined right-of-way. Optimum spacing requirement of the engineering facilities to form recommended farm sizes would be 500-700 meters. Lateral drains dug two to three meters (6.6 to 8.0 feet) deep on this spacing would provide sufficient drainage protection to a majority of the project lands. In some areas such spacing would provide more than adequate protection. In the relative few areas where the adopted 500-700 meter spacing would not provide necessary drainage, intermediate lateral drains could be provided and the initial drains utilized to serve as outlets for farm subsurface drains which might be needed.

Development as outlined above would not only insure adequate drainage protection but would save on right-of-way acquisition and construction costs. Each farm unit would be provided a lateral drain and road at its upper and lower boundary. Drains would be accessible for maintenance work by the farmers themselves. About 200 meters (656 feet) of lateral drain would have to be constructed and maintained for each 12 hectares (29.6 acres). Besides providing subsurface drainage relief, each lateral drain would serve as an outlet for disposing of farm irrigation surface waste.

In view of the above considerations an alternative plan for the West Shamalan Division would be: eliminate proposed Outlet Drains "J" and "K", and laterals 39.745, 13.82 and 21.24; extend existing Outlet Drain "F" to a point near Station 39+750 on the Shamalan Canal; redesign and relocate the proposed West Shamalan Lateral from Station 13+820 to skirt along the western edge of the project lands; and implement the layout for the sublaterals, lateral drains, and roads, as discussed above, to lie in common right-of-way about 500-700 meters apart depending upon requirements for farm sizing.

Time has not permitted the development of estimated costs of above alternate considerations for the purpose of this report. Studies will continue and this aspect of the plan will be given further consideration in definite plan stages.

Further consideration should also be given to the feasibility of constructing concrete-lined sublaterals in connection with the alternate plan.

Materials excavated in constructing the lateral drains would be suitable for compacting pads in which to place the sublateral section. Principal benefits to be obtained from the use of concrete lining would be better operation and control, reduced maintenance, and significant decrease in irrigation wastes and seepage losses. Lateral drains would be more effective and easier to maintain and outlet drains would be required to carry less flow.

Estimate of the Cost of Operation and Maintenance

The following is an estimate of the probable costs of operating and maintaining the Helmand Arghandab Valley Project after all of the irrigation canals, laterals and drains are completed and the 296,100 acres of land tabulated in Table 1 are completely developed and receiving delivery of irrigation water.

Due to the shortage of data relative to the cost of operating and maintaining irrigation facilities in this area, it was necessary to make numerous assumptions and build up cost information from many sources and revise it to best fit conditions.

Although the entire 296,100 acres will not be developed for some time and may possibly never be, it was necessary to use a figure to base the requirements on for ultimate development. A complement of men, equipment, materials and supplies was assumed as the requirements to operate and maintain the 296,100 acre project. The cost of operating this complement for one year was the basis used to arrive at the estimated cost of operation and maintenance per acre per annum.

Using this method, the cost arrived at was $2.73 per acre, $0.75 of which was for operations and $1.98 for maintenance. The cost figures used for estimating were based on the present pay scale shown in Table 2. It is believed that these salaries will have to be revised upward in the future and this increase could bring the cost of operation and maintenance to $3.00 per acre.

It is realized that the cost per acre using the acreage in Table 1 as a basis would be less than using a smaller acreage if total development is not reached. If the acreage is reduced, the complement of equipment, labor, supplies and materials could also be reduced proportionately and the cost per acre would remain approximately the same.

The following is a tabulation of the approximate acreages considered as the ultimate development and it is this total that is used as the basis to determine costs per acre. The complement of labor, equipment and material is also based on the requirements for this acreage.

TABLE 1

Project Acreage

Kajakai to Shamalan	36,000 acres
Seraj area	35,000 "
Nad-i-Ali	13,000 "
Marja	20,000 "
Shamalan	40,000 "
Darweshan	40,000 "
North Arghandab	27,000 "
Central Arghandab	68,000 "
North Tarnak	15,000 "
South Tarnak	2,100 "
TOTAL	296,100 acres

Table 2 is a tabulation of the present salaries paid to classified permanent employees of Helmand Arghandab Valley Region. Code No. 112 indicates the base pay annually for each grade. Each employee also receives afs. 1,080 per year as a food allowance for the noon meal under Code No. 136. All classified employees of HAVA receive 50% of their base pay as an extra for working in the Helmand Arghandab area. This is paid under Code No. 138. Another additive under Code No. 133 is the extra pay allowance for education. If the individual has completed the 9th grade he receives afs. 600 extra, 12th grade afs. 1,200, BA or BS Degree afs. 2,400, and afs. 3,600 for a M.A. Degree. This amount is added to the subtotal in column 5 to get the total salary for each grade for each individual person.

TABLE 2

Salaries of Afghan Permanent Classified Employees

Grade Number	Code 112 Annual Salary	Code 136 Food Allowance	Code 138 HAVA Extra Allowance	Subtotal Cost of Position
1	68,400	1,080	34,200	103,680
2	57,600	1,080	28,800	87,480
3	46,800	1,080	23,400	71,280
4	32,400	1,080	16,200	49,680
5	28,800	1,080	14,400	44,280
6	25,200	1,080	12,600	38,880
7	21,600	1,080	10,800	33,480
8	18,000	1,080	9,000	28,080
9	16,200	1,080	8,100	25,380
10	14,400	1,080	7,200	22,680
11	12,600	1,080	6,300	19,980
12	11,520	1,080	5,760	18,360
13	10,800	1,080	5,400	17,280

Table 3 indicates the salaries paid to contract employees who work in various labor categories.

TABLE 3

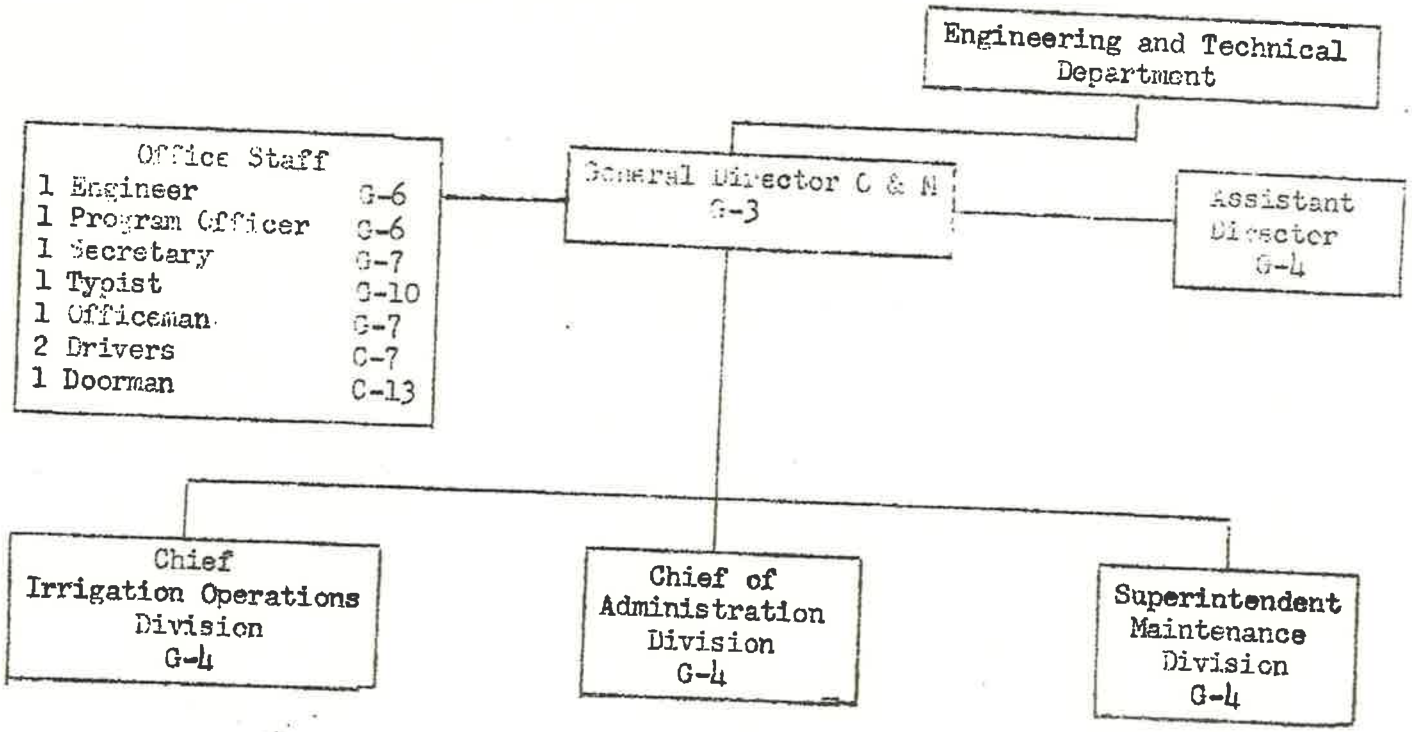
Salaries of Afghan Contract Employees

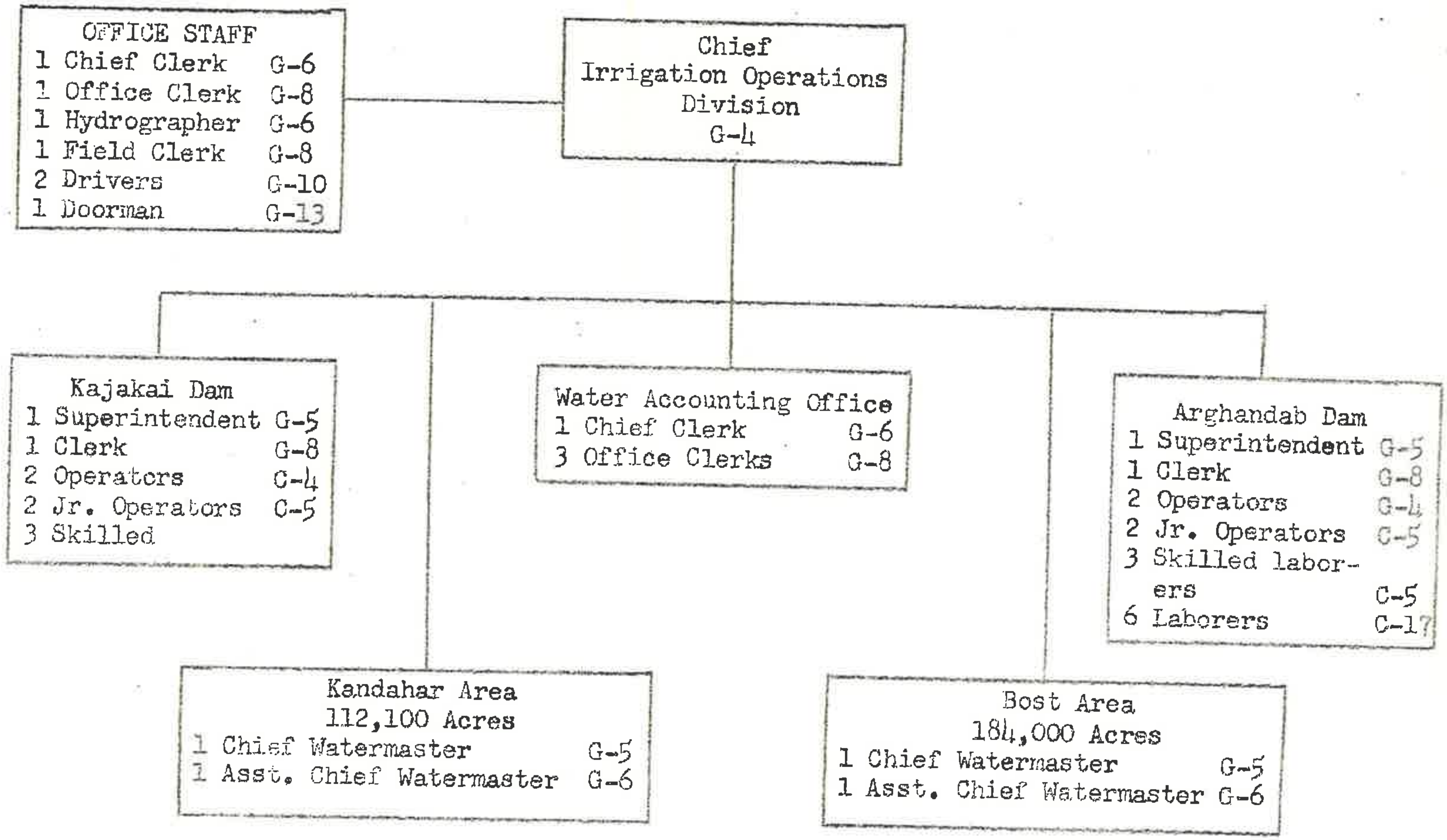
Employee Grade Number	Code 114 Annual Salary	Description
1	48,600	Skilled technicians
2	41,400	Foremen
3	34,200	Assistant foremen
4	30,600	Skilled equipment operator H.D. mechanic
5	23,400	Welders, Jr. operators
6	19,800	H.D. Truck drivers and labor foremen
7	16,200	Drivers for officials
8	12,600	Truck drivers
9	10,440	
10	9,360	
11	8,280	Apprentice to skilled laborers
12	7,920	
13	7,560	
14	7,200	Laborers,permanent
15	6,840	
16	6,480	
17	6,120	Janitors, watchmen, temporary laborers

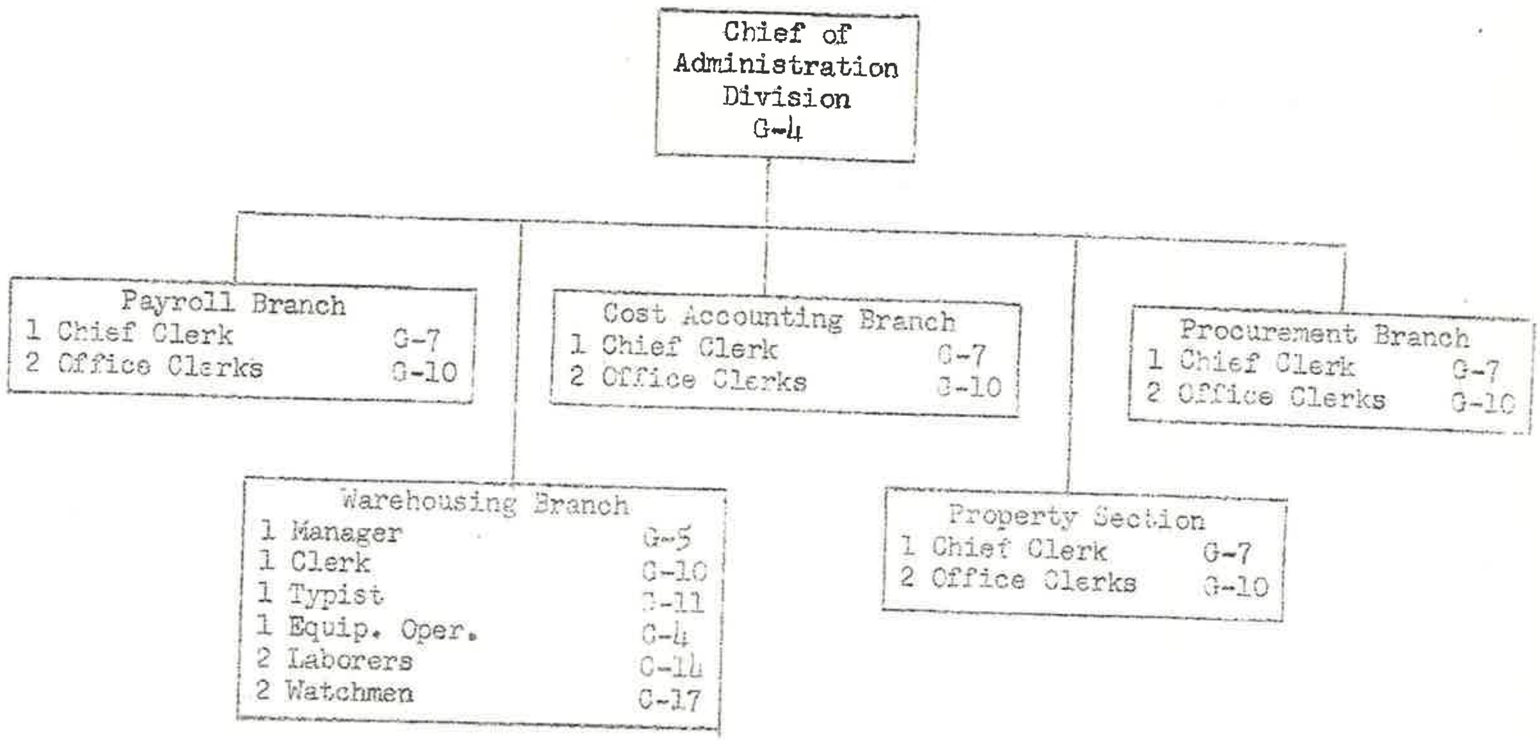
Requirements for Personnel

The attached organization chart indicates the personnel that would be required to man the O & M organization. The classified employees are placed in various grades and salary classifications as shown on page 88.

The unclassified or wage board type of employees are classified as contract employees in various categories as shown on this page.


Engineering and Technical Department
General Director C & M G-3
Assistant Director G-4
Office Staff
1 Engineer G-6
1 Program Officer G-6
1 Secretary G-7
1 Typist G-10
1 Officeman G-7
2 Drivers C-7
1 Doorman C-13
Chief Irrigation Operations Division G-4
Chief of Administration Division G-4
Superintendent Maintenance Division G-4


Chief
Irrigation Operations
Division
G-4
OFFICE STAFF
1 Chief Clerk G-6
1 Office Clerk G-8
1 Hydrographer G-6
1 Field Clerk G-8
2 Drivers G-10
1 Doorman G-13
Kajakai Dam
1 Superintendent G-5
1 Clerk G-8
2 Operators G-4
2 Jr. Operators G-5
3 Skilled
Water Accounting Office
1 Chief Clerk G-6
3 Office Clerks G-8
Arghandab Dam
1 Superintendent G-5
1 Clerk G-8
2 Operators G-4
2 Jr. Operators G-5
3 Skilled labor-ers G-5
6 Laborers G-17
Kandahar Area
112,100 Acres
1 Chief Watermaster G-5
1 Asst. Chief Watermaster G-6
Bost Area
184,000 Acres
1 Chief Watermaster G-5
1 Asst. Chief Watermaster G-6


Chief of Administration Division G-4
Payroll Branch
1 Chief Clerk G-7
2 Office Clerks G-10
Cost Accounting Branch
1 Chief Clerk G-7
2 Office Clerks G-10
Procurement Branch
1 Chief Clerk G-7
2 Office Clerks G-10
Warehousing Branch
1 Manager G-5
1 Clerk G-10
1 Typist G-11
1 Equip. Oper. G-4
2 Laborers G-14
2 Watchmen G-17
Property Section
1 Chief Clerk G-7
2 Office Clerks G-10

Superintendent
Maintenance
Division
G-4

Hand Labor Crews

4	Foremen	C-6
100	Laborers	C-17

Heavy Equipment

1	Foreman	C-3
1	Clerk	G-8
1	Dragline Oper.	C-4
3	Truck crane Oper.	C-4
4	Gradall Oper.	C-4
6	Tractor Oper.	C-4
1	Loader Oper.	C-4
4	Motor Grader Oper.	C-4
15	H.D. Truck Driver	C-6
7	L.D. Truck Driver	C-8
2	Welders	C-4
3	Oilers	C-9

Structure Maintenance
Bost-Helmand Area

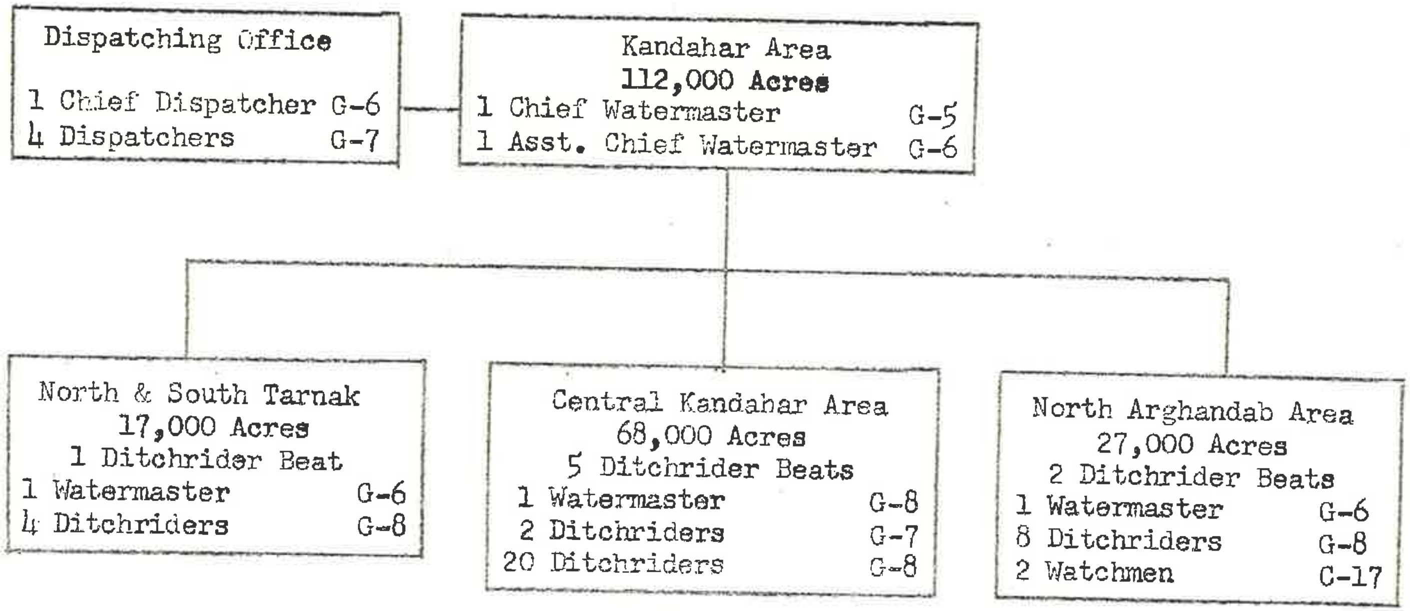
1	Foreman	C-3
1	Clerk	G-8
3	Carpenters	C-4
2	Conc. Finishers	C-4
2	Painters	C-4
1	Welder	C-4
1	Truck Driver	C-8
6	Laborers	C-17

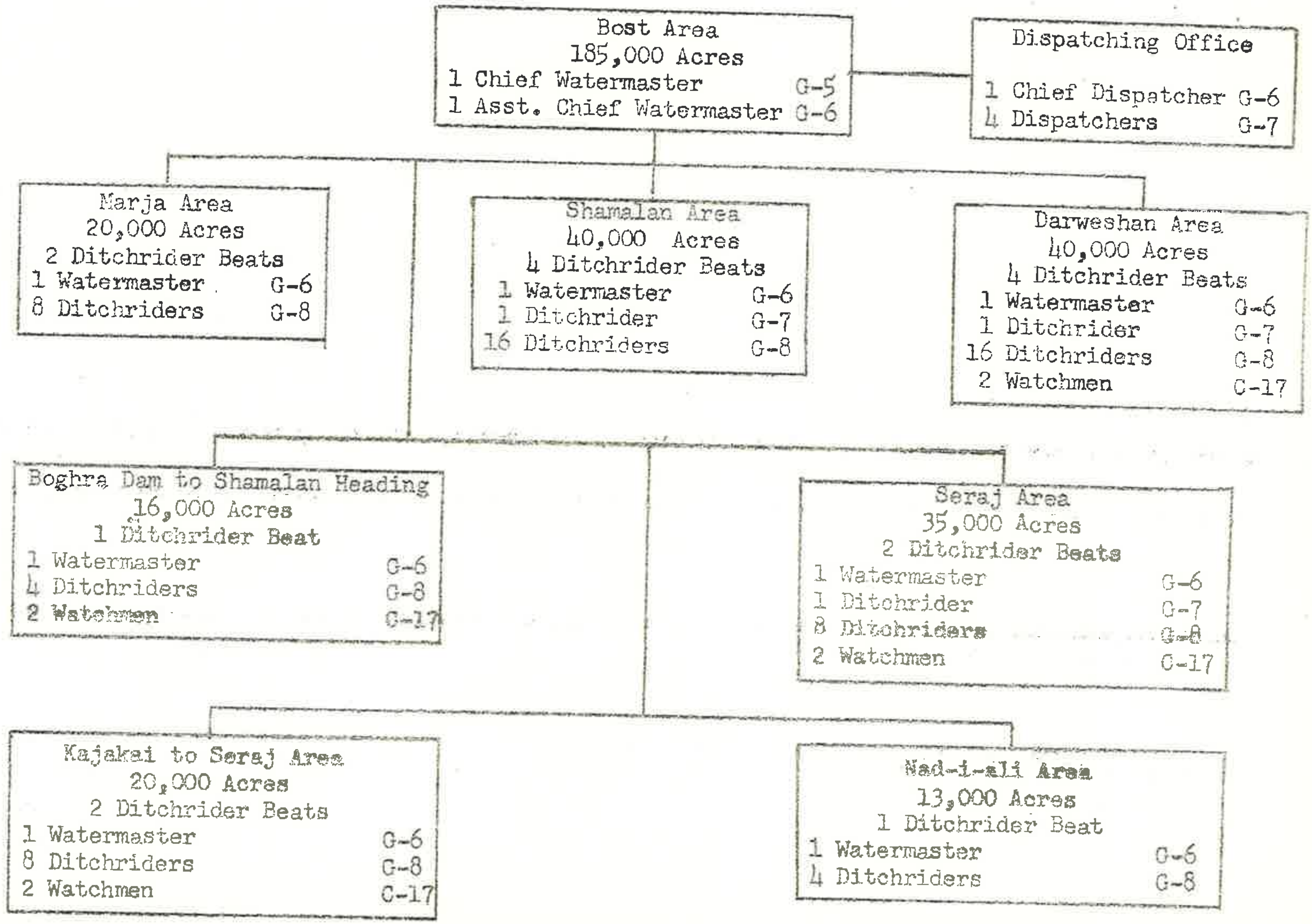
Kandahar Area

1	Foreman	C-3
1	Clerk	G-8
2	Carpenters	C-4
2	Conc. Finishers	C-4
1	Painter	C-4
1	Welder	C-4
1	Truck Driver	C-8
4	Laborers	C-17

Equipment Repair Shop

1	Foreman	C-2
1	Asst. Foreman	C-3


Dispatching Office
1 Chief Dispatcher G-6
4 Dispatchers G-7
Kandahar Area
112,000 Acres
1 Chief Watermaster G-5
1 Asst. Chief Watermaster G-6
North & South Tarnak
17,000 Acres
1 Ditchrider Beat
1 Watermaster G-6
4 Ditchriders G-8
Central Kandahar Area
68,000 Acres
5 Ditchrider Beats
1 Watermaster G-8
2 Ditchriders G-7
20 Ditchriders G-8
North Arghandab Area
27,000 Acres
2 Ditchrider Beats
1 Watermaster G-6
8 Ditchriders G-8
2 Watchmen C-17


Bost Area
185,000 Acres
1 Chief Watermaster G-5
1 Asst. Chief Watermaster G-6
Dispatching Office
1 Chief Dispatcher G-6
4 Dispatchers G-7
Marja Area
20,000 Acres
2 Ditchrider Beats
1 Watermaster G-6
8 Ditchriders G-8
Shamalan Area
40,000 Acres
4 Ditchrider Beats
1 Watermaster G-6
1 Ditchrider G-7
16 Ditchriders G-8
Darweshan Area
40,000 Acres
4 Ditchrider Beats
1 Watermaster G-6
1 Ditchrider G-7
16 Ditchriders G-8
2 Watchmen C-17
Boghra Dam to Shamalan Heading
16,000 Acres
1 Ditchrider Beat
1 Watermaster G-6
4 Ditchriders G-8
2 Watchmen C-17
Seraj Area
35,000 Acres
2 Ditchrider Beats
1 Watermaster G-6
1 Ditchrider G-7
8 Ditchriders G-8
2 Watchmen C-17
Kajakai to Seraj Area
20,000 Acres
2 Ditchrider Beats
1 Watermaster G-6
8 Ditchriders G-8
2 Watchmen C-17
Nad-i-ali Area
13,000 Acres
1 Ditchrider Beat
1 Watermaster G-6
4 Ditchriders G-8

Equipment Repair Shop

1	Foreman	C-2
1	Asst. Foreman	C-3

Office Staff

1	Clerk	G-8
1	Tool Crib Man	C-7
2	Watchmen	C-17
1	Janitor	C-17

Heavy Equipment Shop

1	Foreman	C-3
6	Mechanics	C-4
6	Apprentices	C-11
2	Laborers	C-17

Automotive Repair

1	Foreman	C-3
6	Mechanics	C-4
6	Apprentices	C-11
1	Laborer	C-17

Diesel & Auto Electric

1	Foreman	C-3
1	Batteryman	C-4
1	Auto Electrician	C-4
1	Diesel System Mech.	C-4
3	Apprentices	C-11

Machine Shop

1	Machinist	C-4
2	Apprentice	C-11

Field Mechanics

1	Mechanic	C-4
1	Apprentice	C-11

Blacksmith Shop

1	Foreman	C-3
2	Welders	C-5
1	Blacksmith	C-4
3	Apprentices	C-11

Lubrication Shop

1	Foreman	C-4
2	Servicemen	C-7
2	Cleaner Oper.	C-7
2	Car Washers	C-8
2	Tire Repairman	C-7
1	Laborer	C-7

Paint and Body Shop

1	Body & Fenderman	C-4
1	Painter	C-4
1	Apprentice	C-11

The above organization is set up to handle the completed 296,100 acre project. If the entire acreage is not developed the complete organization will not be required. It is estimated that a reduced acreage will also mean a corresponding reduction in personnel which should maintain costs at about the same rate per acre.

Overhead Cost

If the present program of HAVA is carried out for the next year it is estimated that 55% of all funds programmed will be spent under the direction of the Engineering and Technical Department. The amount of afs. 8,960,267 is allocated to overhead above the office of the Director General of Operation and Maintenance. Fifty-five percent of this amount would be afs. 4,928,156, which would be charged as overhead to Operation and Maintenance, Engineering Division, Land Development and Planning and the Architectural Division. Assuming 40% of afs. 4,928,156 is charged directly to Operation and Maintenance, a rounded figure of afs. 2,000,000 is used as the overhead charged to O & M above the Director General's office.

TABLE 4

Operations Cost
Overhead Director General's Office

Description		Number	Unit Cost	Amount	Totals
HAVA Overhead					2,000,000
O & M Office					
Director General	G-3	1	74,880	74,880	
Assistant Director	G-4	1	53,280	53,280	
Engineer	G-6	1	42,480	42,480	
Programs Officer	G-6	1	42,480	42,480	
Secretary	G-7	1	34,680	34,680	
Typist	G-10	1	25,080	25,080	
Officeman	C-7	1	16,200	16,200	
Drivers	C-7	2	16,200	32,400	
Doorman	C-13	1	7,560	7,560	329,040
3 cars @ 40,000 @ 6 afs.				720,000	720,000
Misc. Office Expense				100,000	100,000
Overhead Director's Office					1,149,040
Administrative Branch					
Branch Chief	G-4	1	53,280	53,280	
Chief Clerks	G-7	4	35,880	143,520	
Clerks	G-10	8	25,080	200,640	397,440
Misc. Office Expense				100,000	100,000
Administrative Branch Overhead					497,440
Total Overhead, Afs.					3,646,480

Distribution of Overhead

Maintenance = Afs. 2,000,000

Kandahar Area

$\frac{112,100}{296,100}$ X 2,000,000 = Afs. 757,177

Helmand-Bost Area

$\frac{184,000}{296,100}$ X 2,000,000 = Afs. 1,242,823

Operations = Afs. 1,646,480

Kandahar Area

$\frac{112,100}{296,100}$ X 1,646,480 = Afs. 623,338

Helmand-Bost Area

$\frac{184,000}{296,100}$ X 1,646,480 = Afs. 1,023,142

Proposed Method of Operating the Irrigation System

It is proposed that the present system of handling irrigation water deliveries be revised and updated to use a water dispatcher system. A dispatching office would be located in the main office at Bost to handle all releases and water deliveries from Kajakai Dam. A dispatching office in Kandahar would handle all releases and deliveries from Arghandab Reservoir. Diversions and deliveries from Darweshan Diversion Dam would be controlled from Bost. Under this system the ditchrider would collect all water order forms from locked boxes located throughout the system. These orders would be read by radio to the dispatching office. The dispatcher would make up a schedule of all deliveries and advise the ditchrider of the turns of each water user in the rotation of each irrigation head. He would direct the ditchrider on duty as to all adjustments in the irrigation system. The ditchrider would be contacting the water user, measuring irrigation deliveries and advising the dispatchers as to the amount of water being delivered and estimating the turnoff time for each head of water being delivered.

Approximately two hours before each irrigation is finished he would advise the dispatcher who would give him the name of the next water user so that he could be alerted. A schedule board would be located in at least one place in each ditchrider's beat and the schedule posted and kept current by radio communications between the dispatcher and ditchrider. Any water user could check the schedule and determine his turn in the rotation of irrigation heads and the approximate time he would get water.

There would be one ditchrider on duty at all times for each 10,000 acres of irrigated land. He would make all readings in the field, call them by radio to the dispatcher who would make all computations of the amounts of water flowing and request the ditchrider to make any adjustments necessary to insure proper delivery.

With this system, the complete over-all control of the water would be in the hands of one person who could see the entire picture, and because of this, he could make decisions for changes necessary before minor troubles could develop into major difficulties.

Each ditchrider would be required to turn on and turn off each head of water and he would be expected to check and measure each head of water in his beat twice each eight-hour shift and report it to the dispatcher. He would be required to do only the work he is instructed to do by the dispatcher. He would work eight hours per day, five days each week. He would have two consecutive days off each week and once each four weeks he would have four consecutive days off.

The dispatcher would record all the water measurements called in by the ditchriders and make the cards charging the water to the various accounts.

The cards would be checked by the Water Accounting office personnel and charges made directly to each water user's ledger account.

Each water user would be provided with a set of rules and regulations to govern the delivery of irrigation water. These rules should be revised from time to time to include changes appropriate to fit existing conditions. The following is a suggested set of regulations for controlling the delivery of water:

Proposed Regulations for the Helmand Arghandab Valley Authority

1. Water Orders

a. All orders for water shall be placed with the ditchrider or deposited in the collection box located in the area. Wherever possible orders shall be placed not later than noon on Wednesday for the week beginning the following Friday at 12:01 a.m. Placing of the order at this time will greatly facilitate the scheduling of water in advance; however, if the water order cannot be placed prior to noon on Wednesday for the following week, water orders will be accepted and scheduled later, but the water user making the request will have to take his turn after others are through with the water.

b. The following information is required for each order:

(1) Name of water user.
(2) Serial number of owner or user.
(3) Canal system, lateral and turnout.
(4) Size of irrigation head in cfs.
(5) Number of jiribs to be irrigated.
(6) Estimated hours of the run.

2. Water Schedules and Notice to Water User

a. Upon the receipt of water orders, the schedule of deliveries and the order of rotation will be established by the dispatcher. At any time a water user contacts a ditchrider, the ditchrider shall contact the dispatcher and advise the water user as to the estimated time of his turnon. The ditchrider shall also maintain a schedule board at a central location in each ditchrider's beat. The schedule board will indicate the rotation of each head of water in the beat and show the estimated turnon and turnoff time to each water user.

3. Water Measurements

a. The exact turnon and turnoff time will be observed by the ditchrider and transmitted to the ditchpatcher who shall record it and shall keep an accurate record of all observations taken during the irrigation run to each water user. These records will be received and recorded by the dispatcher and will become official records and the basis for all water charges. Actual elapsed time and the average of all water measurements will be used in determining the quantity of water delivered. Allowance for carriage losses will be made whenever measurements for farm deliveries are made in the lateral system above the farmer's turnout.

TABLE 5

Operations Cost
Overhead. Division Office

Description		No.	Unit Cost	Amount	Totals
Division Office					
Division Chief	G-4	1	52,080	52,080	
Chief Clerk	G-6	1	40,080	40,080	
Office Clerk	G-8	1	29,280	29,280	
Hydrographer	G-6	1	40,080	40,080	
Field Clerk	G-8	1	29,280	29,280	
Drivers	G-10	2	23,280	46,560	
Doorman	G-13	1	17,280	17,280	
2 Cars 20,000 Miles @ Afs. 6				120,000	
Misc. Office Expense				75,000	449,640
Water Accounting Office					
Chief Clerk	G-6	1	40,080	40,080	
Water Clerks	G-8	3	29,280	87,840	
Accounting Equip. Deprec.				75,000	
Misc. Office Supplies				150,000	352,920
Dispatcher Office					
Chief Dispatcher	G-6	1	40,080	40,080	
Dispatchers	G-7	4	34,680	138,720	
Radio Equip.				127,500	
Misc. Office Expense.				44,140	350,440
TOTAL				Afs.	1,153,000

Distribution of Overhead

Kandahar Area

$\frac{112,100}{296,100}$ X 1,153,000 = Afs. 436,512

Helmand Bost Area

$\frac{184,000}{296,100}$ X 1,153,000 = Afs. 716,488

Afs. 1,153,000

TABLE 6

Operations Cost
Helmand-Bost Area - 184,000 Acres

Description		No.	Unit Cost	Amount	Totals
General Overhead					1,023,142
Division Office Overhead					716,488
Kajakai Dam					
Superintendent	G-5	1	46,680	46,680	
Clerk	G-8	1	29,280	29,280	
Operator	C-4	2	30,600	61,200	
Jr. Operator	C-5	2	23,400	46,800	
Painter	C-5	1	23,400	23,400	
Mechanic	C-5	2	23,400	46,800	
Laborer	C-17	6	6,120	36,720	
Misc. Office Expense				75,000	
Car Mileage 20,000 Miles @ afs. 8				160,000	
Materials and Supplies				449,120	
Total Cost Operation					975,000
Chief Watermaster's Office					
Chief Watermaster	G-5	1	45,480	45,480	
Assistant Chief Watermaster	G-6	1	40,080	40,080	
2 Pickups - 40,000 Miles @ afs. 8				320,000	
Misc. Office Expense				89,440	495,000
Marja Area, 20,000 Acres					
Watermaster	G-6	1	40,080	40,080	
Ditchriders	G-8	8	29,280	234,240	
3 Pickups - 100,000 Miles @ afs. 8				800,000	
Misc. Expense				15,680	1,090,000
Nad-i-Ali Area, 13,000 Acres					
Watermaster	G-6	1	40,080	40,080	
Ditchriders	G-8	4	29,280	117,120	
2 Pickups - 60,000 Miles @ afs. 8				480,000	
Misc. Expense				2,800	640,000

Page 1 of 2 pages.

Description		No.	Unit Cost	Amount	Totals
Shamalan Area 40,000 Acres					
Watermaster	G-6	1	40,080	40,080	
Ditchrider	G-7	1	34,680	34,680	
Ditchrider	G-8	16	29,280	468,480	
5 Pickups - 180,000 Miles @ Afs. 8				1,440,000	
Misc. Expense				6,760	1,990,000
Darweshan Area 40,000 Acres					
Watermaster	G-6	1	40,080	40,080	
Ditchrider	G-7	1	34,680	34,680	
Ditchrider	G-6	16	29,280	468,480	
5 Pickups - 180,000 Miles @ Afs. 8				1,440,000	
Misc. Expense				6,760	1,990,000
Boghra Div. Dam to Shamalan Hd. 16,000 Acres					
Watermaster	G-6	1	40,080	40,080	
Ditchriders	G-8	4	29,280	113,120	
Watchmen	C-17	2	6,120	12,400	
2 Pickups - 60,000 Miles @ Afs. 8				480,000	
Misc. Expense				4,400	650,000
Seraj Area 35,000 Acres					
Watermaster	G-6	1	40,080	40,080	
Ditchrider	G-7	1	34,680	34,680	
Ditchrider	G-8	8	29,280	234,240	
3 Pickups - 100,000 Miles @ Afs. 8				800,000	
Misc. Expense				6,000	1,115,000
Kajakai to Seraj Area 20,000 Acres					
Watermaster	G-6	1	40,080	40,080	
Ditchrider	G-8	8	29,280	234,240	
Watchmen	C-17	2	6,120	12,400	
3 Pickups - 100,000 Miles @ Afs. 8				800,000	
Misc. Expense				3,280	1,090,000
Field Radio Equipment					
Mobile units					
Cost to own & operate sets		30			381,522
Contingency item					1,643,848
TOTAL					13,800,000

Afs. $\frac{13,800,000}{184,000 \text{ Acres}}$ = Afs. 75

TABLE 7

Operations Cost
Kandahar Area - 112,100 Acres

Description		No.	Unit Cost	Amount	Totals
H.A.V.A. Overhead					623,338
Operations Office Overhead					436,512
Arghandab Dam					
Superintendent	G-5	1	46,680	46,680	
Clerk	G-8	1	29,280	29,280	
Operators	C-4	2	30,600	61,200	
Jr. Operators	C-5	2	23,400	46,800	
Painter	C-5	1	23,400	23,400	
Mechanic	C-5	1	23,400	23,400	
Electrician	C-5	1	23,400	23,400	
Laborers	C-17	6	6,120	36,720	
Misc. Office Expense				75,000	
1 Pickup - 20,000 Miles @ Afs. 8				160,000	
Materials and Supplies				314,120	840,000
Chief Watermaster's Office					
Chief Watermaster	G-5	1	45,480	45,480	
Assistant Chief	G-6	1	40,080	40,080	
2 Pickups - 40,000 Miles @ Afs. 8				320,000	
Misc. Office Expense				89,440	495,000
Central Kandahar Area 68,000 Acres					
Watermaster	G-6	1	40,080	40,080	
Ditchrider	G-7	2	34,680	69,360	
Ditchrider	G-8	20	29,280	585,600	
Watchmen	C-17	2	6,120	12,240	
6 Pickups - 240,000 Miles @ Afs. 8				1,920,000	
Misc. Expense				52,720	2,680,000
North Arghandab 27,000 Acres					
Watermaster	G-6	1	40,080	40,080	
Ditchrider	G-8	8	29,280	234,240	
Watchmen	C-17	2	6,120	12,240	
3 Pickups - 100,000 Miles @ Afs. 8				800,000	
Misc. Expense				13,440	1,100,000
No. & So. Tarnak 17,000 Acres					
Watermaster	G-6	1	40,080	40,080	
Ditchriders	G-8	4	29,280	117,120	
2 Pickups - 60,000 Miles @ Afs. 8				480,000	
Misc. Expense				22,800	660,000

TABLE 7 - continued

Description	No.	Unit Cost	Amount	Totals
Field Radio Equipment Cost to own and operate sets	16	each	203,478	203,478
Contingencies				1,369,172
Kandahar - Grand Total				8,407,500

$$\frac{8,407,500}{112,100} = \text{Afs. } 75 \text{ per acre}$$

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TABLE 8

Cost of Radio Equipment

Based on Motorola Equipment
Quotations November 1, 1966

Permanent Installations			
B91LPS-1105A Indoor Transistorized Base Station, 500 Watts, R.F. Power output, 25-50 MC-IF-RCVR 117 V-A.C. 50/60 cps.	4 each	$3,100.00	$12,400.00
Remote Control Console	4 each	200.00	800.00
T.U-532A Microphone	4 each	27.75	111.00
TAB-1050A Slim Profile coaxial antenna	4 each	96.50	386.00
Cost 4 permanent station equipment			$13,697.00
Inland freight to New York			303.00
Ocean freight to Karachi			1,000.00
Transportation Karachi to Bost			500.00
Installation costs			1,500.00
Estimated Cost 4 Base Installations or $4,250.00 each station			$17,000.00
Bost Station		$4,250.00	
Kandahar Station		4,250.00	
Kajakai Dam Station		4,250.00	
Arghandab Dam Station		4,250.00	
Portable Car Installed Radios			
U71LHT-1100-25-50 MC-MoTrac FM Radio with channel elements. 100 watts, 12 volts, IF-TMTR-IF-RCVR, Positive ground, with Truck mounting accessories			
Estimated Cost Chicago	60 each	895.00	$53,700.00
Inland freight to New York			1,100.00
Ocean freight to Karachi			2,000.00
Transportation Karachi to Bost			1,000.00
Installation charges	60	20.00	1,200.00
Estimated Cost 60 Portable Radios			$59,000.00

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TABLE 8 - continued

Radio Equipment Cost

Distribution of Cost.

Base Stations Installed	$17,000.00
Depreciation 10 years 100% 50% to Operations 50% to Maintenance	
Maintenance Charges	
Permanent Stations	
50% X $17,000 ÷ 10 years = depreciation	850.00
Repair Cost 50% of depreciation	425.00
Interest $3\frac{1}{2}$% on 55% of $17,000.00	327.25
Contingencies	97.75
Annual Charges to Maintenance $1700.00 @ Afs. 75 = Afs. 127,500	$1,700.00
Operations Charges	
Permanent Stations	
Same as Maintenance Charges	
Annual Charge to Operations $1700.00 @ Afs. 75 = Afs. 127,500	$1,700.00
Maintenance Charges - 14 sets	
Portable Radio Sets	
$59,000.00 ÷ 60 sets X 14 sets ÷ 10 yrs = Depreciation	$1,376.66
Repairs 50% of depreciation	688.33
Interest at $3\frac{1}{2}$% X 55% of $59,000.00 X 14/60	265.00
Contingencies	70.01
Annual Cost to own and operate 14 Portable Radios $2400.00 @ Afs. 75 = $1.00 = Afs. 180,000	$2,400.00
Operations Charge 46 sets	
Portable Radio Sets	
$59,000.00 ÷ 60 sets X 46 sets ÷ 10 yrs = Depreciation	$4,523.32
Repairs 50% of depreciation	2,261.66
Interest at $3\frac{1}{2}$% X 55% of $59,000.00 X 46/60	870.75
Contingencies	144.27
Annual Cost to own and operate 46 Portable Radios	$7,800.00

Distribution Cost 46 sets used in Operations

Bost Helmand Area

30/46 X $7800.00 = $5086.96 @ Afs. 75 = $1.00 = Afs. 381,522

Kandahar Area

16/46 X $7800.00 = $2713.04 @ Afs. 75 = $1.00 = Afs. 203,478

Cost of Owning and Operating O & M Equipment

The complement of heavy equipment listed in Table 9 was established as the requirement to properly maintain the 296,100 acre irrigation project. Very little information is available on the cost of operating heavy equipment in this area so it was necessary to make various assumptions and to build up the information on the cost of operating the equipment. The cost information that is available would not necessarily indicate that the same cost would apply to new equipment, especially if it is to be used under different conditions.

Some information was available on purchase cost of new equipment but in many instances it was necessary to estimate this cost plus the various additives to get the delivered price.

For depreciation purposes all heavy equipment was estimated to have a useful life of 10 years. The cost of maintenance and repairs was estimated at 50% of the depreciation charges. The tabulation indicates that $77,900 or afs. 5,842,500 is allocated to the repairs on equipment annually. The labor charges in the repair shop amount to afs. 1,255,800. Of this amount it is estimated afs. 1,000,000 will go into repairing equipment, leaving afs. 4,842,500 for repair parts. The other afs. 255,800 of labor charges incurred in the shop is allocated to shop orders for repairing structures or work other than equipment.

The average annual cost of interest is based on the average value of the equipment during its useful life. This value was obtained by establishing a schedule of values for the beginning of each year that the equipment is to be used. The following illustrates the method of determining the average value of equipment:

Original cost of equipment	$25,000
Estimated useful life = 5 years	
Annual cost of depreciation, $25,000 ÷ 5	5,000

Beginning of Year	Cumulative Depreciation	Value of Equipment
1	0	$25,000
2	5,000	20,000
3	10,000	15,000
4	15,000	10,000
5	20,000	5,000
6	25,000	0
Total Value Equipment		$75,000

Average value $75,000 ÷ 5 = $15,000

Average value as % of original cost $\frac{15,000}{25,000}$ X 100 = 60%

Thus the average value of equipment having an estimated life of five years is 60% of the original cost. Using this method of computations the following formula will give the average value in % of the original cost:

$$\text{Average value} = \frac{(1 + n) \times 100}{2n} = \% \text{ of original cost.}$$

n = number of years in depreciation period.

The following is a schedule of average values for equipment for various years of life:

Estimated Average Life	Average Value as % of Original Cost
2	75.00
3	66.67
4	62.50
5	60.00
6	58.33
7	57.14
8	56.25
9	55.55
10	55.00
11	54.54
12	54.17

This method was used to compute interest cost and the rate was 3½% annually.

The quantity of fuel consumed by the internal combustion engines was estimated at 0.04 gallon per H.P. hour for diesel engines and 0.06 gallon per H.P. hour for gas engines. It is also estimated that the equipment will work 45 minutes of each hour and that 80% of the H.P. will be used. The time factor will be 45/60 X 100 or 75%. If the H.P. factor is 80 percent the overall efficiency will be 60%, so based on the above assumptions the 60% factor was used except for the gasoline engine driven motor in the small Gradall carrier where it was further reduced to 50% under the assumption that the truck motor in the small Gradall will not be used as much as other engines.

The quantity of lubricating oil used by the various engines was estimated considering the size of the crankcase and that oil would be changed every 120 hours of use. The quantity of oil consumed between changes was estimated and added to the amount required for each change of oil. The following formula was used to estimate the lubricating oil required:

$$Q = \frac{H.P. \times 0.6 \times 0.006 \text{ lbs H.P. Hr.}}{7.4 \text{ lbs per gal}} + \frac{C}{T}$$

Where: Q = Quantity of oil consumed gallon per hour.
HP = Rated H.P. of engine.
C = Capacity of crankcase.
T = Number of hours between changes.
0.60 = Operating efficiency factor.

The entire operating personnel's annual pay is charged into the cost of operating the equipment.

Six trucks smaller than the 10 cu. yd. dump trucks are charged on a lump sum basis and passenger cars, regular pickups, and the six-man cab pickups were charged into either operations or maintenance on an estimated mileage basis as follows: passenger car, afs. 6 per mile; regular pickups, afs. 8 per mile; and the six-man cab pickups at afs. 10 per mile.

TABLE 9

Summary of Equipment Requirements and Cost to Own and Operate

Number of Units	Description	Cost per Unit	Total Capital Investment	Annual Cost of Repairs	Annual Cost to Own and Operate in Afghanis
1	2 C.Y. Dragline	$100,000	$100,000	$5,000	1,406,400
3	3/4 C.Y. Truckcrane	60,000	180,000	9,000	3,190,500
1	G. 1000 Gradall	104,000	104,000	5,200	1,656,000
3	G. 600 Gradall	55,000	165,000	8,250	3,028,500
4	D-8 Tractors	57,000	228,000	11,400	3,636,000
2	D-7 Tractors	44,000	88,000	4,400	1,416,000
3	Motor Graders	34,000	102,000	5,100	1,746,000
1	1-3/4 C.Y. Loader	27,000	27,000	1,350	439,500
6	10 C.Y. Dump Trucks	13,000	78,000	3,900	1,525,500
3	5 Ton Flat-bed Trucks	5,000	15,000	1,500	621,000
3	2-1/2 Ton Cargo Trucks	4,000	12,000	1,200	549,000
53	3/4 Ton Regular Pickups	3,000	159,000	10,600	
16	3/4 Ton 6-man Cab Pickups	3,500	56,000	3,200	
3	5 Passenger Cars	3,000	9,000	600	
1	75-Ton Trailer and Truck		60,000	1,000	375,000
1	10-Ton Flat Bed Truck		13,000	1,000	375,000
1	Pitman Hydra-Lift Crane		7,000	200	100,000
	Misc. Small Equipment		50,000	5,000	700,000
	TOTAL		$1,453,000	$77,900*	20,764,400

* Afs. 75 = 1.00 = afs. 5,842,500.

TABLE 10

Operating Cost
2 Cu. Yd. Dragline

Model 955 P. & H. Dragline	$70,200.00
Cat. D337 Diesel Engine extra	2,000.00
Wide Track pads extra	2,000.00
Long Track assembly	2,000.00
Extra sheeve in crown block	400.00
2 Cu. Yd. M.D. Dragline Bucket	2,400.00
2 Cu. Yd. L.D. Perforated Dragline Bucket	1,600.00
2 Cu. Yd. Clamshell Bucket	3,000.00
Boom Extensions	1,800.00
Inland freight to New York	2,000.00
Ocean freight to Karachi	8,600.00
Transportation Karachi to Bost	3,000.00
Light plant and lights	1,000.00
Total cost delivered to Bost	$100,000.00

Operate 1,600 hours per year @ 60% efficiency.
Diesel engine 185 H.P. Crank case capacity $8\frac{1}{4}$ gallons.
Change oil 120 hours. Lub. oil 60¢ gallon.
Diesel fuel 16¢ gallon.
Depreciate 100% in 10 years.
Average investment 55% of original cost.

Fixed Costs Annually

Depreciation $100,000.00 ÷ 10 years =	$10,000.00
Repairs, 50% of depreciation	5,000.00
Interest $3\frac{1}{2}$% on 55% of original cost	1,925.00
Annual Fixed Cost	$16,925.00

Hourly Cost of Operation

Fixed cost $16,925.00 ÷ 1,600 hours =	$10.58
Fuel cost 185 H.P. X 60% X 0.04 gal. X .16 =	.71
Lub. oil cost $\frac{185 \text{ H.P.} \times 60\% \times 0.006 \text{ lbs}}{7.4 \text{ lbs.}} + \frac{8.25}{120} \times .60 =$	.09
Operator's wages Afs. 30,600 @ Afs. 75 = $1.00 ÷ 1,600 hours =	.25
Oiler's wages Afs. 10,400 @ Afs. 75 = $1.00 ÷ 1,600 hours =	.09
Total Hourly Cost to Own and Operate	$11.72

Hourly Cost in Afs. $11.72 X Afs. 75 = $1.00 = Afs. 879
Annual Cost $11.72 X 1,600 Hrs. = $18,752.00
Annual Cost in Afs. $18,752.00 X Afs. 75 = $1.00 = Afs. 1,406,400

TABLE 11

Operation Cost - Truckcrane

Estimated cost 30-ton Truckcrane	$40,000.00
Boom extensions 5' and 10'	1,600.00
2 sheeve in crown block	500.00
30-ton crane hook, 2 sheeves	300.00
3/4 cu. yd. heavy dragline bucket	1,600.00
3/4 cu. yd light perforated bucket	900.00
Tagline winder	600.00
3/4 cu. yd. clam bucket	1,200.00
Independent boom hoist	1,200.00
Power lowering	2,400.00
Lightplant and lighting	1,000.00
Inland freight to New York	2,000.00
Freight, New York to Karachi	5,000.00
Transportation Karachi to Bost	1,700.00
Total cost delivered to Bost	$60,000.00

Crane motor D.E.D. - 148 H.P.
Crankcase capacity 6 gallons @ 60¢ gallon.
Truck motor D.E.D. - 238 H.P.
Crankcase capacity 7 gallons @ 60¢.
Depreciate unit in 10 years.
Average cost 55%.
Operate 2,000 hours per year.

Fixed Costs

Depreciation $60,000 ÷ 10 years =	$6,000.00
Repairs 50% of depreciation =	3,000.00
Interest 3½% X $33,000.00	1,155.00
Annual Fixed Cost	$10,155.00

Hourly Operating Cost

Fixed cost $10,155 ÷ 2,000 hours = $5.08

Fuel cost crane

148 X 0.6 X 0.04 X 16¢ = 0.57

Fuel cost carrier

238 X 0.6 X 0.04 X 16¢ = 0.91

Lub. oil crane

$$\frac{148 \times 0.6 \times 0.006}{7.4} + \frac{6}{120} \times 60¢ = 0.08$$

Lub. oil carrier

$$\frac{238 \times 0.6 \times 0.006}{7.4} + \frac{7}{120} \times 60¢ = 0.10$$

Operator's wages afs. 30,600 ÷ 2,000 hrs ÷ 75 = 0.21

Driver's wages afs. 19,800 ÷ 2,000 hrs ÷ 75 = 0.14

Hourly Cost of Operation $7.09

Annual cost $7.09 X 2,000 hours $14,180.00

Hourly cost @ afs. 75 = $1.00 = afs. 532

Annual cost @ afs. 75 = $1.00 = afs. 1,063,500

TABLE 12

Operating Cost - G1000 Gradall

Model G1000 Gradall	$87,000.00
All diesel engines	4,200.00
34" Exc. 1 cu. yd. bucket	1,060.00
48" Exc. $1\frac{1}{4}$ cu. yd. bucket	1,225.00
8 ft. 1-3/4" cu. yd. cleaning bucket	1,150.00
9 ft. grading blade	690.00
8 ft. boom extension	1,395.00
Radiator guard	50.00
15 ton Hydraulic jack	50.00
Spare tire, tube and wheel	320.00
Front tow hook	30.00
Inland freight to New York	1,800.00
Ocean freight New York to Karachi	3,600.00
Transportation Karachi to Bost	1,430.00
Total delivered cost to Bost	$104,000.00

Depreciate 2,000 hours per year for 10 years.
Average investment 55%.
Repairs = 50% of depreciation.

Fixed Costs

Depreciation $104,000.00 ÷ 10 years	$10,400.00
Repairs = 50% of depreciation	5,200.00
Interest $3\frac{1}{2}$% X $57,200.00	2,002.00
Annual Fixed Cost	$17,602.00

Carrier engine 225 H.P.
Excavator engine 108 H.P.
Crankcase capacity, carrier engine 7 gallons.
Crankcase capacity, excavator engine 6 gallons.
Fuel @ 16¢; Lub. oil @ 60¢ gallon.

Hourly Operating Cost

Fixed cost $17,602.00 ÷ 2,000	=	$8.80
Fuel cost, carrier 225 X 0.6 X 0.04 X 0.16	=	0.86
Fuel cost, excavator 2 X 108 X 0.6 X 0.04 X 0.16	=	0.82
Lub. oil $\frac{(2X\ 108) + 225\ X\ 0.6\ X\ 0.006}{7.4} + \frac{13}{120}\ X\ 0.60$	=	0.19
Operator's wages afs. 30,600 ÷ 2,000 ÷ 75	=	0.21
Driver's wages afs. 23,400 ÷ 2,000 ÷ 75	=	0.16
Hourly cost of operation		$11.04

Annual cost $11.04 X 2,000 hours $22,080.00
Hourly cost afs. @ 75 per $1.00 = afs. 828
Annual cost afs. @ 75 per $1.00 = afs. 1,656,000

TABLE 13

Operating Cost - G-600 Gradall

Model G-600 Gradall 6X6	$41,450.00
Upperstructure GMC-3031-D Engine	2,095.00
Heater, upper cab	80.00
Defroster, upper cab	30.00
Carrier	
Torque converter	1,200.00
Heater and defroster	110.00
Spare wheel, tube and tire	240.00
Hydraulic jack	50.00
M8413 - 24" bucket	650.00
M2429 - 60" ditch cleaning bucket	770.00
M2440 - 72" dredge bucket	1,140.00
Inland freight to New York	2,000.00
Ocean freight to Karachi	3,600.00
Transportation Karachi to Bost	1,585.00
Total cost delivered to Bost	$55,000.00

Fixed Costs

Depreciation $55,000 ÷ 10 years	=	5,500.00
Repairs = 50% of depreciation	=	2,750.00
Interest $3\frac{1}{2}$% X 55% of $55,000.00		1,058.75
Annual Fixed Cost		$9,308.75

Upperstructure engine DED-76 H.P.
Crankcase capacity 5 gallons.
Carrier engine G.E.D. 214 H.P.
Crankcase capacity 5 gallons.
Depreciate 2,000 hours per year for 10 years.
Average investment 55%.
Diesel fuel, 16¢ gallon; Gas 20¢ gallon; Oil 60¢.

Hourly Operating Cost

Fixed cost $9,308.75 ÷ 2,000	=	$4.65
Fuel cost, carrier		
214 H.P. X 0.5 X 0.06 X 0.20	=	1.29
Fuel cost, upperstructure		
76 H.P. X 0.6 X 0.04 X 0.16	=	0.29
Lub. oil, carrier		
$\frac{214 \times 0.5 \times 0.006}{7.4} + \frac{5}{120} \times 0.60$	=	0.08
Lub. oil, upperstructure		
$\frac{76 \times 0.6 \times 0.006}{7.4} + \frac{5}{120} \times 0.60$	=	0.05
Operator's wages afs. 30,600 ÷ 2,000	=	0.21
Driver's wages afs. 23,400 ÷ 2,000	=	0.16
Hourly Cost of Operation	=	$6.73

Annual cost $6.73 X 2,000 hours $13,460.00
Hourly cost afs @ 75 per $1.00 = afs. 505
Annual cost afs @ 75 per $1.00 = afs. 1,009,500

TABLE 14

Operating Cost
D-8 Tractor and Dozer

Caterpillar D-8 Tractor, electric start on gasoline starting engine, 22" grousers, Hydraulic track adjusters, direct drive with suction fan	$40,300.00
Crankcase guard	399.00
Hook for front pulling	64.00
Track roller guard	530.00
8A dozer angle blade	5,490.00
128 Double drum cable control	4,170.00
Cable guides for scraper operation	147.00
Packing cost, tractor	65.00
Packing cost, dozer	5.00
Inland freight to New York	606.00
Freight New York to Karachi	3,728.00
Transportation Karachi to Bost	1,496.00
Cost delivered to Bost	$57,000.00

Depreciate 2000 hours per year for 10 years.
Value = 55% of cost
Repairs 50% of depreciation.

Fixed Costs

Depreciation $57,000 ÷ 10 years =	5,700.00
Repairs 50% of depreciation =	2,850.00
Interest 3½% of 55% of $57,000	1,097.50
Annual Fixed Cost	$9,647.50

Engine horse power 235
Operating factor 60%
Fuel cost 16¢ per gallon
Crankcase capacity 9.5 gallon.
Lub. oil cost, 60¢ per gallon

Hourly operating cost

Fixed cost $9,647.50 ÷ 2000 hours	$4.82
Fuel cost, $235 \times 60 \times 0.04 \times 0.16 =$	0.91
Lub. oil, $\frac{235 \times 60 \times 0.006}{7.4} + \frac{9.5}{120} \times 0.60$	0.12
Operator's wages, Afs. 30,600 ÷ 2000 hrs ÷ 75	0.21
Total Hourly Cost	$6.06

Annual cost $6.06 X 2000 hr. $12,120.00
Hourly cost @ Afs. 75 per $1.00 = Afs. 455
Annual cost @ Afs. 75 per $1.00 = Afs. 909,000

TABLE 15

Operating Cost
D-7 Tractor and Dozer

Caterpillar D-7 Tractor, electric start on gasoline starting engine, 20" grousers, Hydraulic track adjusters, direct drive with suction fan	$30,500.00
Crankcase guard	320.00
Hook for front pull	52.00
Track roller guards	425.00
Dozer angle blade	4,400.00
Double drum power cable control unit	3,400.00
Cable guides for scraper	120.00
Packing charges, tractor	65.00
Packing charges, dozer	5.00
Inland freight to New York	500.00
Freight New York to Karachi	3,000.00
Transportation Karachi to Bost	1,213.00
Total cost delivered to Bost	$44,000.00

Depreciate 2,000 hours per year for 10 years.
Repairs 50% of depreciation.
Interest 3½% X 55% of $44,000.00

Fixed Costs

Depreciation $44,000 ÷ 10 years	$4,400.00
Repairs 50% of depreciation	2,200.00
Interest 3½% on 24,200.00	847.00
Annual Fixed Cost	$7,447.00

Engine horsepower 180
Operating factor 60%
Fuel costs 16¢ per gallon.
Crankcase capacity 6.5 gallons.
Lub. oil cost 60¢ per gallon; change oil @ 120 hours.

Hourly Operating Cost

Fixed cost $7,447.00 ÷ 2,000 hours	$3.73
Fuel cost, 180 X 0.6 X 0.04 X .16	0.69
Lub. oil cost $\frac{180 \times 0.6 \times 0.006}{7.4} + \frac{6.5}{120} \times .60$	0.09
Operator's wages, afs. 30,600 ÷ 2,000 ÷ 75	0.21
Total Hourly Cost	$4.72

Annual Cost $4.72 X 2,000 hours	$9,440.00
Hourly Cost @ afs. 75 per $1.00 = afs. 354	
Annual Cost @ afs. 75 per $1.00 = afs. 708,000	

TABLE 16

Operating Cost
Motor Grader

Caterpillar No. 12 Motor Grader	$23,500.00
Cost of attachments	3,000.00
Freight and handling costs 30%±	7,500.00
	$34,000.00

Total Cost to Amortize
Depreciate 2000 hours per year for 10 years.
Cost of repairs 50% of depreciation
Interest 3½% of 55% of cost.

Fixed Costs

Depreciation $34,000.00 ÷ 10 =	$3,400.00
Repairs, 50% of depreciation	1,700.00
Interest 3½% of $18,700.00	654.50
Annual Fixed Cost	$5,754.50

Engine horse power 115
Operating factor 60%
Fuel cost 16¢ per gallon
Crankcase oil capacity 7.0 gallon.
Lub. oil cost 60¢ per gallon; change oil each 120 hours.

Hourly operating cost

Fixed cost $5,754.50 ÷ 2000 hours =	$2.88
Fuel cost, 115 X 0.06 X 0.04 X .16 =	0.44
Lub. oil, $\frac{115 \times 0.6 \times 0.006}{7.4} + \frac{7.0}{120} \times .60$	0.07
Cutting edges $22.00 per set and one set per 80 hours	0.28
Operator's wages Afs. 30,600	0.21
Total Hourly Cost	$3.88

Annual cost to own and operate 2000 hours $7,760.00
Hourly cost @ Afs. 75 per $1.00 = Afs. 291
Annual cost @ Afs. 75 per $1.00 = 582,000

TABLE 17

Operating Cost
Shovel Loader

955K Traxcavator: Series K, 66 inch gauge, Diesel engine, blower fan, crankcase guard, hood side door, power shift transmission, 15 inch triple grousers, hydraulic track adjusters, 1-3/4 cu. yd. bucket, gas starting engine, 12 volt electric starter	$23,400.00
Track roller guards	310.00
	$23,710.00
Packing charges	50.00
Inland freight to New York	279.00
Estimated forwarding charges	25.00
Ocean freight to Karachi	1,404.00
Transportation Karachi to Bost	1,532.00
Total cost delivered to Bost	$27,000.00

Depreciate 2000 hours per year for 10 years.
Repairs 50% of depreciation.
Interest 3½% of 55% of original cost.

Fixed Costs

Depreciation $27,000.00 ÷ 10 years	$2,700.00
Repairs, 50% of depreciation	1,350.00
Interest 3½% of $14,850.00	519.75
Annual Fixed Cost	$4,569.75

Engine horsepower 100
Operation factor 60%
Crankcase capacity 4 gallons.
Fuel cost 16¢ per gallon.
Lub. oil, 60¢ per gallon; change 120 hours

Hourly operating cost

Fixed cost $4,569.75 ÷ 2000 hours =	$2.28
Fuel cost, 100 HP X 0.6 X 0.04 X .16 =	0.38
Lub. oil, $\frac{100 \text{ HP} \times 0.6 \times 0.006}{7.4} + \frac{4}{120} \times .60$	0.06
Operator's wages Afs. 30,600 Afs. 30,600 ÷ 2000 ÷ 75 =	0.21
Total Hourly Cost	$2.93

Annual cost $2.93 X 2000 hours	$5,860.00
Hourly cost @ Afs. 75 per $1.00 = Afs. 220	
Annual cost @ Afs. 75 per $1.00 = Afs. 439,500	

TABLE 18

Operating Cost
10 Cu. Yd. Dump Truck

IHC - F1800 Truck with	
Tandem rear drive 6 x 4	
6 cylinder gas engine BD-282 @ 140 HP	
Cost and freight Karachi	$9,721.00
Dump body, extra	2,000.00
Transportation Karachi to Bost	1,279.00
Total Cost Delivered to Bost	$13,000.00

Depreciate 1,000 hours per year for 10 years.
Repairs 50% of depreciation.
Interest 3½% of 55% of original value.

Fixed Costs	
Depreciation $13,000.00 ÷ 10 years	$1,300.00
Repairs 50% of depreciation	650.00
Interest 3½% X $7,150.00	250.25
Annual Fixed Cost	$2,200.25

Engine horsepower 140
Crankcase capacity 2 gallons @ 60¢
Gas @ $0.20 per gallon.
1,000 hours use per year @ 60%

Hourly Operating Cost	
Fixed cost $2,200.25 ÷ 1,000 hours	$2.20
Fuel cost, 140 X 0.6 X 0.06 X .20	1.01
Lub. oil, $\frac{140 \times 0.6 \times 0.006}{7.4} + \frac{2.0}{120} \times .60$	0.05
Operator's wages afs. 19,800	
19,800 ÷ 1,000 ÷ 75	0.13
Total Hourly Cost	$3.39

Annual Cost $3.39 X 1,000 hours	$3,390.00
Hourly cost @ afs. 75 per $1.00 = afs. 254	
Annual cost @ afs. 75 per $1.00 = afs. 254,250	

TABLE 19

Operating Cost
5-Ton Flat Bed Truck

IHC Flat Bed Truck
- Tandem rear drive
- 6 cylinder gas engine
- Oversize clutch, oversize radiator
- 4 speed transmission
- Oil bath air cleaner
- Outside rear view mirror
- Heater and defroster
- Safety kit
- Heavy duty battery

Delivered to Karachi	$4,400.00
Transportation to Bost	600.00
Total cost delivered to Bost	$5,000.00

Depreciate 5 years - 1,000 hours per year.
Repairs 50% of depreciation.
Interest $3\frac{1}{2}$% on 60% of original cost.
Engine H.P. 120. Crankcase capacity 2 gallons @ 60¢.
Change oil @ 120 hours.

Fixed Costs

Depreciation $5,000 ÷ 5	$1,000.00
Repairs 50% of depreciation	500.00
Interest $3\frac{1}{2}$% X 60% of $5,000.00	105.00
Total Annual Fixed Cost	$1,605.00

Hourly Operating Cost

Fixed cost $1,605.00 ÷ 1,000	=	$1.60
Fuel cost, 120 H.P. X 0.6 X 0.06 X .20	=	0.86
Lub. oil $\frac{120 \text{ H.P. X } 0.6 \text{ X } 0.006}{7.4} + \frac{2.0}{120} \text{ X } .60$	=	0.04
Operator's wages afs. 19,800 ÷ 1,000	=	0.26
Total Hourly Cost		$2.76

Annual cost $2.76 X 1,000 hours $2,760.00
Hourly cost @ afs. 75 per $1.00 = afs. 207
Annual cost @ afs. 75 per $1.00 = afs. 207,000

TABLE 20

Operating Cost
2½ Ton Cargo Truck

2½ Ton Cargo Truck
Tandem rear drive
6 cylinder gas engine
H.D. oversize clutch; oversize radiator
4 speed transmission
Oil bath air cleaner
Outside rear view mirror
Heater and defroster
Safety kit; heavy duty battery

Delivered to Karachi	$3,500.00
Transportation to Bost	500.00
Total cost delivered to Bost	$4,000.00

Depreciate 5 years @ 1,000 hours per year.
Repairs 50% of depreciation.
Interest 3½% on 60% of original cost.
Engine H.P. 120. Crankcase capacity, 2 gallons @ 60¢.
Oil change 120 hours.

Fixed Costs	
Depreciation $4,000.00 ÷ 5	$800.00
Repairs 50% of depreciation	400.00
Interest 3½% X 60% of $4,000.00	84.00
Total Annual Fixed Cost	$1,284.00

Hourly Operating Cost	
Fixed cost $1,284.00 ÷ 1,000 hours	= $1.28
Fuel cost, 120 H.P. X 60% X 0.06 X .20	= 0.86
Lub. oil $\frac{120 \text{ H.P. X } 60\% \text{ X } 0.006}{7.4} + \frac{2.0}{120} \text{ X } .60$	= 0.04
Operator's wages afs. 19,800 ÷ 1,000 hours @ afs 75 = $1	= 0.26
Total Hourly Cost	$2.44

Annual cost $2.44 X 1,000 hours $2,440.00
Hourly cost @ afs. 75 = $1.00 X 2.31 = afs. 183
Annual cost @ afs. 75 = $1.00 X 2,310 = afs. 183,000

TABLE 21

Operating Cost
Reg. Pickup 3/4 Ton

I.H.C. 3/4 Ton Pickup Truck	$1,497.00
B.G. 265 Engine, extra	43.75
T-115 4-speed transmission	49.00
Tool kit	17.00
Additional 14 gallon fuel tank and valve	63.00
Oversized cooling system	7.75
H.D. oil bath air cleaner	9.50
Rear bumper	15.75
Heater and defroster	50.50
Outside rear view mirror	14.25
Heavy duty battery, extra	7.75
Heavy duty clutch	7.75
Safety kit	48.75
Crating	12.00
Export processing	9.25
Inland freight to New York	120.00
Ocean freight to Karachi	650.00
Transportation Karachi to Bost	300.00
Spot lamp top of cab	35.00
I.H.C. Reg. Cab Pickup	$2,958.00
Contingencies	42.00
	$3,000.00

Charges out @ afs. 8 per mile.

Repairs estimated @ $200.00 each pickup per year.

Fixed Costs

Depreciation in five years $3,000 ÷ 5 years	$600.00
Repairs 33-1/3 of depreciation	200.00
Interest $3\frac{1}{2}$% X 60% of original cost	63.00
Total Annual Fixed Cost	$963.00

TABLE 22

Operating Cost
Pickup Truck 6-Man Cab

I.H.C. Heavy Duty Pickup Truck 6-Man Cab	$1,997.00
B.G. 265 Engine, extra	43.75
T-115-4 speed transmission	49.00
Tool kit	17.00
Additional 14 gal. fuel tank and valve	63.00
Oversize cooling system	7.75
H.D. oil bath air cleaner	9.50
Rear bumper	15.75
Heater and defroster	50.50
Outside rear view mirror	14.25
Heavy duty battery	7.75
Heavy duty clutch	7.75
Safety kit	48.75
Crating	12.00
Export processing	9.25
Inland freight to New York	120.00
Ocean freight to Karachi	650.00
Transportation Karachi to Bost	300.00
I.H.C. Heavy Duty 6-Man Cab Pickup	$3,423.00
Contingencies	77.00
	$3,500.00

Charged out @ Afs. 10 per mile.

Fixed Costs	
Depreciation in five years $3500 ÷ 5 years	$ 700.00
Repairs	200.00
Interest 3½% X 60% of $3500.00	75.60
Total Annual Fixed Cost	$ 975.60

TABLE 23

Operation and Maintenance Cost
Automobile

5 Passenger 2 door sedan	$1,800.00
Low compression engine	40.00
Tool kit	17.00
Oversize cooling system	8.00
H.D. oil bath air cleaner	10.00
Heater and defroster	50.00
Outside rear view mirror	15.00
Heavy duty battery, extra	8.00
Heavy duty clutch	8.00
Safety kit	50.00
Crating	12.00
Export processing	10.00
Inland freight to New York	120.00
Ocean freight to Karachi	600.00
Transportation Karachi to Bost	200.00
Contingencies	52.00
Sedan Delivered to Bost	$3,000.00

To be charged out at afs. 6 per mile.

Depreciation	$600.00
Repairs	200.00
Interest	63.00

TABLE 24

Assignment of Transportation Equipment

	Passenger Cars	3/4 Ton Pickups	6-Man Cab Pickups
General Director	1		
Assistant Director	1		
Office Engineer		1	
Superintendent Maintenance		1	
Administrative Branch Chief	1		
Warehouse Manager		1	
Shop Foreman		1	
Field Mechanic			1
Heavy Equipment Foreman			1
Equipment Operators			4
Hand Labor Foreman			4
Structure Maintenance Foreman			2
Structure Field Crew			4
Welders		3	
Bost Helmand Area Operations		30	
Kandahar Area Operations		16	
TOTALS	3	53	16

TABLE 25

H.A.V.A.
Equipment Requirement - Bost Helmand Operations

3/4 Ton Pickup Truck, Radio Equipment with Spotlight on Top of Cab.

Chief Irrigation Operation Division	1
Hydrographer	1
Bost Helmand Area	
Chief Watermaster	1
Assistant Chief	1
Kajakai Dam	1
Marja Area	
Watermaster	1
Ditchriders	2
Nad-i-Ali Area	
Watermaster	1
Ditchrider	1
Shamalan Area	
Watermaster	1
Ditchriders	4
Darweshan Area	
Watermaster	1
Ditchriders	4
Boghra Dam to Shamalan Area	
Watermaster	1
Ditchriders	1
Seraj Area	
Watermaster	1
Ditchriders	2
Kajakai to Seraj Area	
Watermaster	1
Ditchriders	2
Extra Equipment for Spares	2
TOTAL	30

TABLE 26

H.A.V.A.
Equipment Requirements - Kandahar Area

3/4 Ton Pickup Trucks, Radio Equipment and Spotlight on Top of Cab.

Arghandab Dam	1
Kandahar Office	
Chief Watermaster	1
Assistant Chief	1
Kandahar Central Area	
Watermaster	1
Ditchriders	5
North Arghandab Area	
Watermaster	1
Ditchriders	2
North and South Tarnak Area	
Watermaster	1
Ditchriders	1
Extra Equipment for Spares	2
TOTAL	16

The cost of operating the warehouse facilities is estimated in the following table. This cost is charged as an expense item and for estimating purposes the cost is not distributed and charged into the value of warehoused items.

TABLE 27

Description		Number	Unit Cost	Amount	Total
Manager	G-5	1	46,680	46,680	
Clerk	G-10	1	23,880	23,880	
Clerk	G-11	1	21,180	21,180	
Equipment Operator	C-4	1	30,600	30,600	
Laborers	C-14	2	7,200	14,400	
Watchmen	C-17	2	6,120	12,240	148,980
Miscellaneous office expense					100,000
Materials and supplies					100,000
Warehousing Cost					$348,980

TABLE 28

O & M Cost
Structure Maintenance

Description		No.	Unit Cost	Amount	Total
Bost Helmand Area					
Foreman	C-3	1	34,200	34,200	
Clerk	G-8	1	29,280	29,280	
Carpenter	C-4	3	30,600	91,800	
Concrete Finisher	C-4	2	30,600	61,200	
Painters	C-4	2	30,600	61,200	
Welders	C-4	1	30,600	30,600	
Truck Driver	C-8	1	12,600	12,600	
Laborer		6	6,120	36,720	357,600
Kandahar Area					
Foreman	C-3	1	34,200	34,200	
Clerk	G-8	1	29,280	29,280	
Carpenter	C-4	2	30,600	61,200	
Concrete finisher	C-4	1	30,600	30,600	
Painter	C-4	1	30,600	30,600	
Welder	C-4	1	30,600	30,600	
Truck Driver	C-8	1	12,600	12,600	
Laborers		4	6,120	24,480	253,560
Equipment					
H.D. Pickup 6 man Cab 144,000 miles		4	10	1,440,000	
2½ Ton Trucks, 48,000 miles		2	15	720,000	
Misc. Equipment Lump Sum				800,000	2,960,000
Supplies and Material				1,500,000	1,500.000
Cables, pipe, paint, Form lumber, resteel, fabricated steel, welding rod, gate parts, conc. materials, etc.				255,800	255,800
Total Structure Maintenance Cost				Afs.	5,326,960

TABLE 29

O & M Cost
Hand Labor Crews

Description		No.	Unit Cost	Amount	Totals
Foreman	C-6	4	19,800	79,200	
Laborers	C-17	100	6,120	612,000	691,200
Transportation					
4 Pickups 80,000 miles			Afs. 6		480,000
Materials					1,000,000
TOTAL, Afs.					2,171,200

TABLE 30

O & M Cost
Repair Shop

Description		No.	Unit Cost	Amount	Total
Shop Foreman	C-2	1	41,400	41,400	
Assistant Shop Foreman	C-3	1	34,200	34,200	
Shop Clerk	C-8	1	29,280	29,280	
Janitor	C-17	1	6,120	6,120	
Watchman	C-17	2	6,120	12,240	
Tool Crib man	C-7	1	16,200	16,200	139,440
Heavy Equipment Shop					
Foreman	C-3	1	34,200	34,200	
H.D. Mechanic	C-4	6	30,600	183,600	
H.D. Mechanic Apprentice	C-11	6	8,280	49,680	
Laborers	C-17	2	6,120	12,240	279,720
Automotive Repair Shop					
Foreman	C-3	1	34,200	34,200	
Auto. Mechanic	C-4	6	30,600	183,600	
Auto. Mechanic Apprentice	C-11	6	8,280	49,680	
Laborer	C-17	1	6,120	6,120	273,600
Machine Shop					
Machinist	C-4	1	30,600	30,600	
Machinist Apprentice	C-11	2	8,280	16,560	47,160
Diesel & Auto Electric					
Foreman	C-3	1	34,200	34,200	
Battery man	C-4	1	30,600	30,600	
Auto Electrician	C-4	1	30,600	30,600	
Diesel Fuel System Mech.	C-4	1	30,600	30,600	
Apprentice	C-11	3	8,280	24,840	150,840
Blacksmith and Welding Shop					
Foreman	C-3	1	34,200	34,200	
Blacksmith	C-4	1	30,600	30,600	
Welders	C-5	2	23,400	46,800	
Apprentice	C-11	3	8,280	24,840	136,440
Paint & Body Shop					
Body & Fender man	C-4	1	30,600	30,600	
Painter	C-4	1	30,600	30,600	
Apprentice	C-11	1	8,280	8,280	69,480
Lubrication Shop					
Foreman	C-4	1	30,600	30,600	
Serviceman	C-7	2	16,200	32,400	
Steam Cleaners	C-7	2	16,200	32,400	
Car Washers	C-8	2	12,600	25,200	
Tireman	C-7	2	16,200	32,400	
Laborer	C-17	1	6,120	6,120	159,120
TOTAL, Afs.					1,255,800

TABLE 31

Summary of Annual Cost in Afghanis

Description	Operations Cost: Helmand-Bost Area	Operations Cost: Kandahar Area	Maintenance Costs	Totals
HAVA & Director Gen. O.H.	1,023,142	623,338	2,000,000	3,646,480
Operation Division O.H.	716,488	436,521		1,153,000
Operation Kajakai Dam	975,000			975,000
Operation Arghandab Dam		840,000		840,000
Bost Helmand Watermaster	495,000			495,000
Marja Area	1,090,000			1,090,000
Nad-i-Ali Area	640,000			640,000
Shamalan	1,990,000			1,990,000
Darweshan	1,990,000			1,990,000
Boghra Dam to Shamalan	650,000			650,000
Seraj Area	1,115,000			1,115,000
Kajakai to Seraj	1,090,000			1,090,000
Field Radio Equipment	332,625	177,375		510,000
Kandahar Watermaster		495,000		495,000
Central Kandahar		2,680,000		2,680,000
North Arghandab		1,100,000		1,100,000
North and South Tarnak		660,000		660,000
Hand Labor Crews			2,171,200	2,171,200
Structure Maintenance			5,326,960	5,326,960
Warehousing Cost			348,980	348,980
Equipment Cost			20,764,400	20,764,400
Base Radio Station			127,500	127,500
Field Radio Equipment			180,000	180,000
Contingencies	1,692,745	1,395,275	7,502,760	10,590,780
	13,800,000	8,407,500	38,421,800	60,629,300
	22,207,500			

Afs. 60,629,300 ÷ 296,100 acres = afs. 205 per acre @ 75 per $1.00 = $2.73. Say $3.00.