IRRIGATION AND POWER DEPARTMENT
GOVERNMENT OF PUNJAB
THE ISLAMIC REPUBLIC OF PAKISTAN

NO. 1

BASIC DESIGN STUDY REPORT
ON
MITHAWAN HILL TORRENT PILOT PROJECT
IN
THE ISLAMIC REPUBLIC OF PAKISTAN

DECEMBER, 1997

JAPAN INTERNATIONAL COOPERATION AGENCY
NIPPON GIKEN INC.
CTI ENGINEERING CO., LTD.

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PREFACE

In response to a request from the Government of the Islamic Republic of Pakistan the Government of Japan decided to conduct a basic design study on Mithawan Hill Torrent Pilot Project in the Islamic Republic of Pakistan and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Pakistan a study team from 13 October to 29 October, 1997.

The team held discussions with the officials concerned of the Government of Pakistan, and conducted a field study at the study area. After the team returned to Japan, further studies were made, as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Islamic Republic of Pakistan for their close cooperation extended to the teams.

December 1997

Kimio Fujita
President
Japan International Cooperation Agency

December, 1997

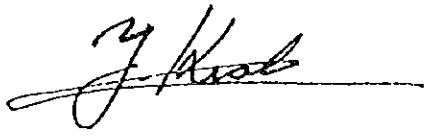
Letter of Transmittal

We are pleased to submit to you the basic design study report on Mithawan Hill Torrent Pilot Project in the Islamic Republic of Pakistan.

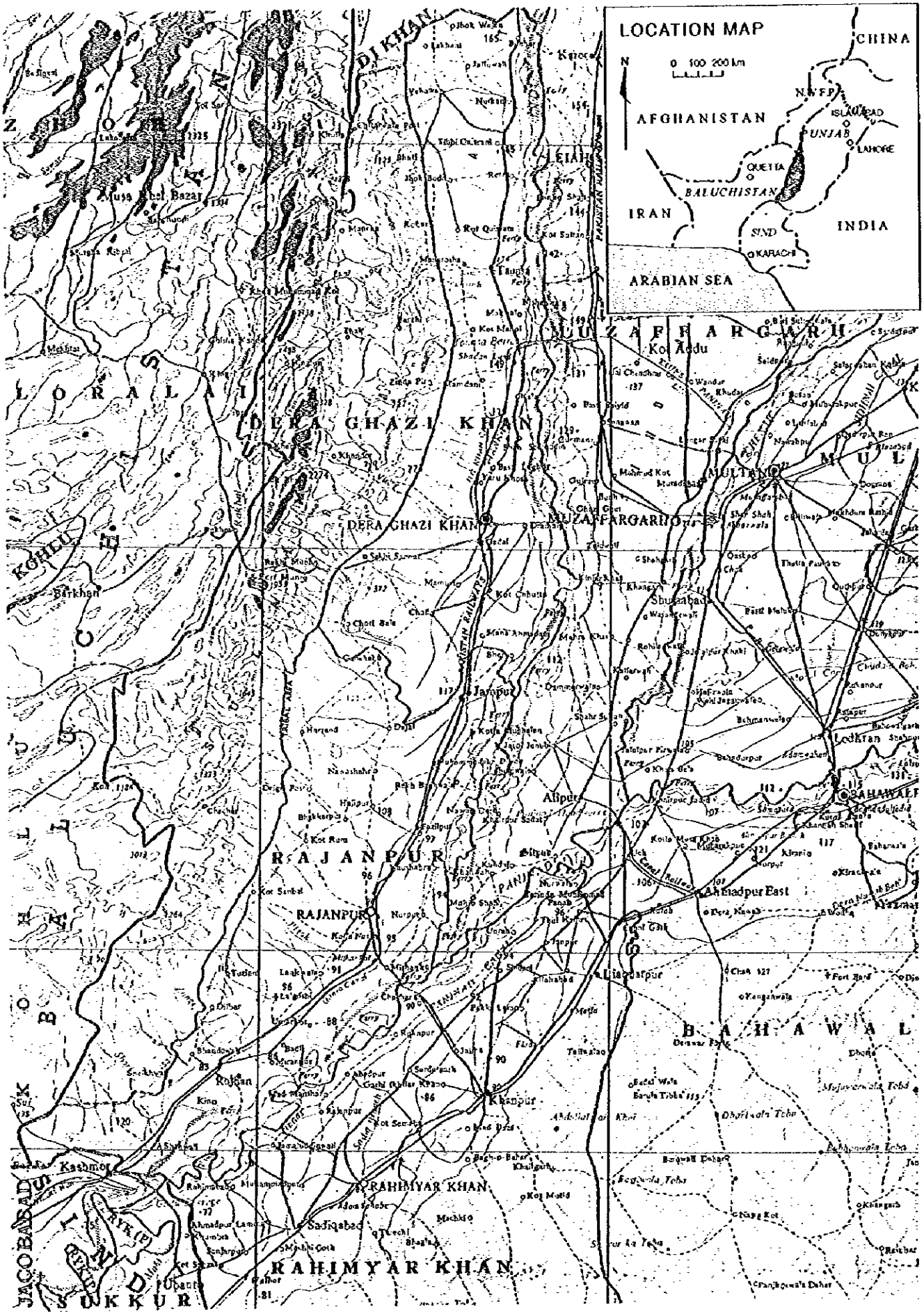
The study was conducted by Nippon Giken Inc. and CTI Engineering Co., Ltd., under a contract to JICA, during the period from October, 1997 to December, 1997. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Pakistan and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

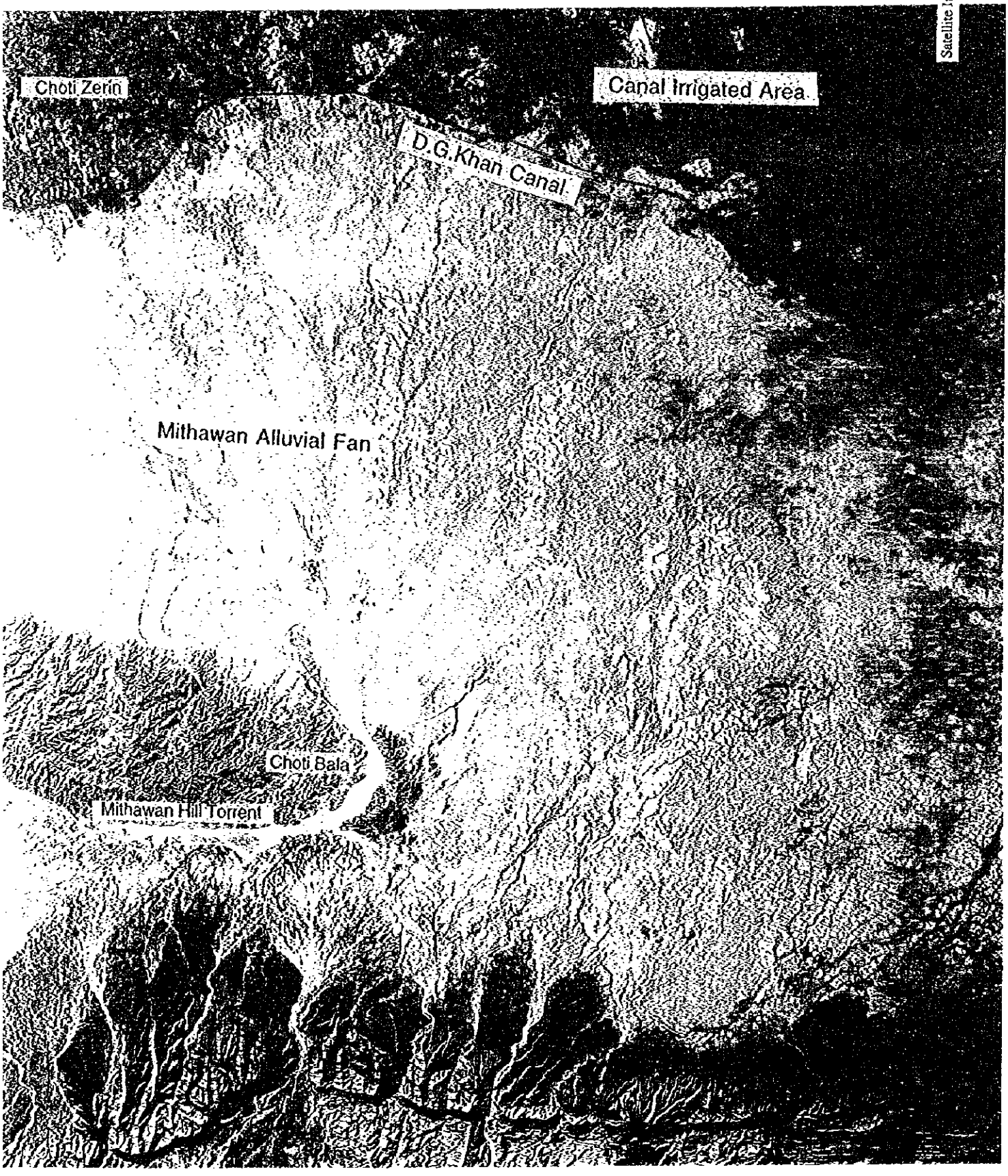
Very truly yours,



Yoichi Kishi
Project manager,
Basic design study team on
Mithawan Hill Torrent Pilot Project
Nippon Giken Inc.
CTI Engineering Co., Ltd.,



Project Area



Satellite Image of the Area

TABLE OF CONTENTS

Preface
Letter of Transmittal
Location Map / Satellite Photo
Abbreviations
List of Figures / List of Tables

CHAPTER 1 BACKGROUND OF THE PROJECT.....1

CHAPTER 2 CONTENTS OF THE PROJECT.....5

2.1 Objectives.....5
2.2 Basic Concept of the Project.....6
2.2.1 Previous Studies.....6
2.2.2 Previous Works in the Area.....6
2.2.3 Basic Concept of the Mithawan Hill Torrent Developing Project...7
2.2.4 Design Conditions.....8
2.3 Basic Concept of the Equipment and Materials.....18
2.3.1 Design Concept.....18
2.3.2 Basic Design.....21
2.4 Project Implementation Plan.....31
2.4.1 Executive Organization.....31
2.4.2 Budget.....32
2.4.3 Personnel and Technical Level.....35

CHAPTER 3 PROJECT IMPLEMENTATION PLAN.....37

3.1 Implementation Plan for Procurement of Equipment and Materials.....37
3.1.1 Concept of Implementation Plan for Procurement.....37
3.1.2 Considerations in Implementation Plan.....37
3.1.3 Conditions of Implementation Plan.....38
3.1.4 Supervision of Implementation Plan.....38
3.1.5 Implementation Plan.....39
3.1.6 Implementation Schedule.....42
3.1.7 Obligation of the Government of Pakistan.....43
3.2 Operation and Maintenance Plan.....44
3.2.1 Operation and Maintenance Organization.....44
3.2.2 Personnel for Operation and Maintenance.....44
3.2.3 Cost Estimate for Operation and Maintenance.....46

CHAPTER 4 PROJECT EVALUATION AND RECOMMENDATION....49
4.1 Project Effect 49
4.1.1 Project Effect 49
4.1.2 Feasibility of the Project 54
4.2 Technical Cooperation with Other Donors 55
4.3 Recommendation.....55

APPENDICES

1. Member list of the team
2. Schedule of the Study
3. List of Party Concerned in the Recipient country
4. Minutes of Discussion
5. Cost Estimates Borne by the Recipient Country
6. References

Report on Hydraulic Model Test (Part 1)
Report on Hydraulic Model Test (Part 2)
Characteristics of the Channels on Mithawan Alluvual Fan
Project Area
Report on Social Soundness Analysis
Drawings

List of Figures

Fig. 2.1	Scour downstream of the Distributor
Fig. 2.2	Location Plan of Mithawan Distributor Site
Fig. 2.3	Mithawan Flood Distributor
Fig. 2.4	Location Plan of the Contour Bunds
Fig. 2.5	Contour Bund and Spillway
Fig. 2.6	Organization of Irrigation and Power Department, Punjab
Fig. 2.7	Organization of D.G.Khan Zone, Irrigation
Fig. 3.1	Procurement Schedule

List of Tables

Table-2.1	Eroded Sediment at Talha Wah in 1994 Flood
Table-2.2	Items of work and materials
Table-2.3	List of equipment to be procured
Table-2.4	Quantity of earth-work in the first year
Table-2.5	Quantity of earth-work in the second year
Table-2.6	Quantity of stone in the first year
Table-2.7	Quantity of stone in the second year
Table-2.8	Number of Equipment
Table-2.9	Personnel in Multan Workshop
Table-3.1	Procured Equipment and their Number
Table-3.2	Cost for Construction of Contour Bunds
Table-3.3	Operation cost of equipment
Table-3.4	Cost for Machinery Operation
Table-3.5	Maintenance cost in 2-year construction period
Table-3.6	Cost for operation and maintenance of machinery after completion
Table-4.1	Irrigated area by probable flood after completion of the project
Table-4.2	Crop production after completion of the project
Table-4.3	Average annual crop produce
Table-4.4	Crop produce at present
Table-4.5	Flood losses in D.G. Khan and Rajanpur districts (Rs./ha)
Table-4.6	Area and peak flood of the hill torrents
Table-4.7	Flood losses by probable flood
Table-4.8	Reduced annual flood loss

Terms

Hill Torrent	– A ephemeral stream in semi-arid and arid area.
Ephemeral stream	– A stream or portion of a stream which flows only in direct response to precipitation and whose channel is completely dry at certain times.
Haqooq	– The area or channel having water rights on flood flows of hill torrents
Non-haqooq	– The area or channel having no water rights on flood flows of hill torrents.
Saropa Paina	– The upper fields on a hill torrent are called Saropa and have prior rights while the lower fields are called Paina and have secondary right over flood flows. This is a relative term and is used for all the fields on a hill torrent with respect to their location to each other.
Lath	– Earthen embankment constructed around the fields to flood water for basin irrigation
Bund	– Field surround by earthen embankments (Lath)
Gandah	– Any obstruction constructed across the bed of torrent or its branch for diverting flood flows.
Wakra	– Any obstruction constructed in wah or wahi for basin irrigation of fields.
Shakh / Wah	– A natural channel off-taking from main hill torrent.
Wahi	– A natural channel off-taking from wah.
Darrah	– The site or the place at which a torrent or a nallah comes out of hills. Below darrah the torrent fans out into different branches.
Pachad	– It means west side of any reference line.
Pachad Area	– The area lying on the western side of the reference line. In D.G.Khan and Rajanpur districts, the area lying on the western side of canal system upto the toe of hills is called Pachad Area.
Kala pani	– Perennial flow of a hill torrent.
Rhod kohi	– Hill Torrent
Kamara System	– A system prevalent in D. G. khan areas where work for diversion of flood flows is carried out on self help basis in accordance with the share fixed under Minor Canal Act of 1905.

Abbreviations

GOJ	Government of Japan
GOP	Government of Pakistan
JICA	International Development Agency
PID	Irrigation and power Department
FFC	Federal Flood Commission
RKD	Rod Kohi Department
SCD	Soil Conservation Department
ABAD	Authority for Barani Area Development
DC	Deputy Commissiner
C.E.	Chief Engineer
S.E.	Superintended Engeener
XEN	Exexcutive Engeener
SDO	Sub-Divisional Officer
O&M	Operation and Maintenance

Conversion Tables

To change	to	Multiply by
Millimeter (mm)	inches	0.03937
Centimeter (cm)	inches	0.3937
Meter (m)	feet	3.2808
	yards(yd)	1.0936
Kilometer (km)	miles	0.62137
Inches (in.)	mm	25.4
	cm	5.54
foot (ft.)	m	0.3048
Miles (mil)	km	1.60934
Reduced distance (RD)	feet	1000
	m	304.8
Square meters ($m^{2)}$	sq. ft	10.7639
Square kilometers ($km^{2)}$	sq. miles	0.3861
Hectares (ha)	acre	2.471
Square feet (sq. ft)	square meters	0.092903
Square miles (sq. mil.)	km^2	2.58999
Acre (A)	ha	0.404685
Cubic meters (cum, $m^{3)}$	cu. ft	35.3147
Liters (lit.)	cu. ft	0.0353
Million cubic meters (MCM)	acre feet	810.71
Cubic feet (cu. ft)	m^3	0.028317
	lit.	28.317
Acre feet (AF)	m^3	1233.48
	MCM	0.001233
Kilograms (kg)	lb	2.20462
Pounds (lb)	kg	0.45359
Cumec (cum/s, m^3/s)	cusec (cfs, cu ft/sec)	35.310
Cusec (cfs, cu ft/sec)	cumec (cum/s, m^3/s)	0.028317

CHAPTER 1 BACKGROUND OF THE PROJECT

Economy of Pakistan is based on agriculture sector, that contributes 25 % of gross domestic product (GDP) and absorbs about 50 % of total labor force of the country. About 60 % of the territory, however, including main crop production area of Sind and Punjab belongs to a dry region where annual rainfall is less than 250 mm. Since irrigation is, as a result, inevitable for the crop production, Pakistan is a distinguished irrigated country in the world having 16 million hectares of irrigated land that is equivalent to 20 % of the territory of 800,000 square km or 76 % of the cultivated land. However, since water resources are limited in the country because of its scarce rainfall, a major target of government of Pakistan (GOP) is to maximize effective use of water for irrigation.

GOP places major goal of policy in water resources development to be that of uplifting agro-based economy of the country by maximizing crop production in Eighth Five Year Plan (EFYP) for 1993 to 1998. Strategy is utilizing flood water for augmenting water availability for irrigation in backward regions through flood irrigation schemes, efficient use of flood water, etc., along with improvement of the irrigation systems, improvement of O&M by farmer's participation, exploitation of good quality ground water, and protection from water-logging and salinity.

The area called D. G. Khan hill torrent belt including Mithawan hill torrent is located in the west-most part of Punjab. There are 13 major and more than 200 minor hill torrents coming from Suleiman range to Indus plains. An alluvial fan, called Pachad, has been created along eastern hill foot of Suleiman by hill torrents, and local people have cultivated using hill torrent floods for irrigation. On the other hand, D. G. Khan canal which constructed in 1960's along the edge of the alluvial fan has been suffered from flood damage by hill torrent floods and its irrigated area occasionally has been inundated by the floods.

Federal Flood Commission (FFC) and Irrigation and Power Department of Punjab (PID) performed a study of flood management for D. G. Khan hill torrent in 1984 aiming at minimizing flood damage in the irrigated areas and enhancing crop production in alluvial fans, in which Mithawan area was selected for the pilot project. While GOP requested government of Japan (GOJ)

to conduct a feasibility study on irrigation development over the D. G. Khan hill torrent belt excluding Mithawan and Kaha, then the study conducted in 1991 and 1992 by the Japan International Cooperation Agency (JICA).

On the basis of their study in 1984 by FFC and PID, GOP requested Japan's grant aid assistance for implementation of Mithawan Pilot Project on September in 1992. Requested components were followings:

(a) Main Dispersion Structure in Mithawan Hill Torrent,
(b) Improvement of Bhattiwala Bund,
(c) Dispersion Structure in Choti Nallah,
(d) Improvement of Distributor in Nangar Nallah,
(e) Watershed management in Dholi, and
(f) Improvement of existing road.

JICA sent a preliminary study team on May in 1993 by the request, then a basic design study team on August in 1993. As a result, above components of (c), (e) and (f) were constructed by Japan's grant aid assistance called "The Project for Watershed Management and Irrigation Development in Mithawan (WAMID)" in the period from September in 1994 to March in 1996.

GOP hopes to achieve all the components in their request since the project has regarded as a pilot project for development of wide-spread hill torrent area over the territory along with promotion on crop production in rainfed areas that is one of the important target in EFYP. Completed structures in the above WAMID project, however, were regarded being unable to remove the flood damage immediately in D.G. Khan canal irrigated area and in Pachad, GOP consequently requested strongly construction of the main dispersion structure in Mithawan hill torrent which could expand flood irrigation area and reduce flood damage directly.

Despite planned and carried out several projects for flood control by means of flood irrigation in Pakistan, they have been technical and economical problems. GOJ reviewed carefully requested construction project of the main distributor accordingly. Consequently GOJ sent a preliminary study team to collect additional information and details of the structure and to confirm topographical and geographical conditions.

Succeeding the preliminary study, a basic design study for the Mithawan pilot project aiming at construction of the Mithawan main dispersion structure

commenced on October in 1995. The study continued until March in 1997, including 3 times of field studies and 2 times of hydraulic model tests. The study concluded that the Mithawan distributor would be not only costly for its construction but also necessary expensive regular maintenance because its life must be very short without proper maintenance and repair works after every high flood. Finally, the study team concluded that construction of the main dispersion structure in Mithawan hill torrent is not practicable by the Japan's grant aid assistance.

On June in 1997, a mission was sent to Pakistan to convey the conclusion of the basic design study on the Mithawan Pilot Project. The mission explained that implementation of the project was not feasible, and that promotion of a watershed management was basic necessity for the area development for an alternative instead. Pakistan side understood it, however, insisted to construct flexible structures in Mithawan hill torrent using a fund of GOP. Then, GOP requested GOJ assistance on a watershed management and construction of flexible structures.

GOP planned to construct flexible structures at the apex of the Mithawan alluvial fan and requested GOJ assistance for its construction. Contents of the request are heavy equipment mainly that is used in construction work such as bulldozer and back hoe, gabion manufacturing machine, and further, materials such as wires. GOJ decided to conduct a basic design study and JICA dispatched a mission team to the site from 13 to 29 October in 1997.

The study team discussed with Pakistan side on technical issues. In the course of the discussions, both sides recognized that the proposed distributor at the fan-head must be collapsed by severe scouring below it, which induced by riverbed degradation downstream. They recognized also that measures to stop these events are construction of contour bunds and riverbed fixing structures to control morphological variation of a fan, such as channel riverbed degradation and horizontal shifting of channels. Accordingly Pakistan side proposed construction of contour bunds. GOP requested, as a result, Japan's grant aid assistance to procure equipment which needs to construct the proposed contour bunds .

CHAPTER 2 CONTENTS OF THE PROJECT

2.1 Objectives

Stabilization in crop yields on the Mithawan fan and mitigation of flood damage in a canal irrigated area are accomplished by expansion of flood irrigation over the Mithawan alluvial fan. There have been several plans that construct a distributor at the fan-head to enhance effective use of flood flows. In the early plans, dikes were proposed to construct near fan-head of the Mithawan fan. However, the plans were not worked into practice, because it was predicted that the reservoir would not be able to bear the large amount of siltation.

Feasibility study conducted by GOP in 1984 suggested a plan that construction of a distributor at the fan-head and carrying out flood irrigation widely in the fan area. Based on this suggestion, GOJ dispatched a basic design study team on the Mithawan hill torrent pilot project in 1995 and conducted hydraulic model tests. According to the results, though the distributor is constructed, the possibility that massive scouring during high floods would break the dispersion is high as long as there is riverbed lowering. It is also confirmed in the basic design study that because the fan is on active forming process, it is necessary to control morphological change of the fan protecting from riverbed degradation for continuous utilization of the fan.

Construction of the contour bunds accomplishes sustainable use of the fan and it must protect the proposed distributor from breach by controlling morphological changes of the fan. The contour bunds store flood water of high sediment concentration, then solid material in the water deposits in the reservoir, which makes the ground surface of the fan flat. Accordingly, flood flows will not concentrate in a specific channel, riverbed lowering would, as a result, be able to prevent. Construction of the contour bunds starting from the lowest part of the fan toward fan-head controls morphological change on it, that must bring sustainable use of the fan.

Objectives of the Mithawan pilot project are to reduce flood damage and to promote crop produce by constructing contour bunds using procured equipment and materials by Japan's grant aid.

2.2 Basic Concept of the Project

2.2.1 Previous Studies

Four times of feasibility study have been conducted on construction of detention dams or bunds in the Mithawan hill torrent since 1945. All the proposals, however, were abandoned because immense amount of sedimentation was estimated.

In 1984, another feasibility study conducted by PID proposed several alternatives on flood control. As a result, alternative of managing flood flows using for irrigation in the sub-mountainous and Pachad area was selected. In the feasibility study, GOP conducted hydraulic model test to decide width and elevation of outlets of the distributor to assure required shares of flood flows before designing of the distributor. The hydraulic model test showed development of sand bars upstream of the structure, which suggested possibility of unequal shares of flood distribution.

After this study, GOJ dispatched a basic design study team on Mithawan hill torrent pilot project as Japan's grant aid. In this study, the result of the hydraulic model test done by the Pakistan side was reviewed, and it is pointed out that proposed narrow outlets of the distributor would create troubles for sustainable use of the fan. Because increased flow velocity through narrow outlets would cause severe scouring resulting collapse of the distributor. Then, prioritized shares of flood distribution result the area having water right higher than the area of without water right and hinder appropriate fan formation for sustainable use. Furthermore, it is concluded that this project is not practicable to apply the Japan's grant aid, because addition to its high construction cost, the structure is worried to be collapsed without extremely careful maintenance works which must overburden PID and local irrigator's organization.

2.2.2 Previous Works in the Area

Most of structures in the Mithawan hill torrent are located at the fan-head and four major bunds have constructed in the fan-head. The structures are pitched with durable stones that do not need frequent restoration works. At a

beginning of 1980's, Hadwari bund which had been for keeping channels from horizontal shifting and Chitri bund which had been for protecting flood water flowing into the lowered riverbed were built in Mithawan alluvial fan. However, it was resulted that Hadwari bund brought concentration of flood flows into North Branch and its riverbed degradation. Besides, Chitri bund left Sharti wah being severely scoured and malfunctioning as an irrigation channel.

2.2.3 Basic Concept of the Mithawan Hill Torrent Developing Project

In the Mithawan alluvial fan which is on an active process of fan formation, necessary measures on its sustainable use are to keep channels for regular irrigation and to mitigate secondary fan formation which would bury farmlands. For achieving them, hill torrent floods have to be dispersed over the fan at the fan-head, which prevents concentration of floods into a particular channel and hinders riverbed lowering and formation of secondary fan.

Result of hydraulic model tests in the 'Mithawan Pilot Project' on 1996 showed that riverbed degradation in the middle and the lower reaches of channels would cause local scouring below the structure endangering its safety. Riverbed raising is necessary for protection of the distributor to the level of existing fan surface along channels, that assures regular irrigation from channels.

To accomplish this, contour bunds which have storage capacity for flood flows, are recommended to construct. Solid material in the flood water deposits in the reservoir area by storing, then the reservoir area will be flattened from depressions, such as eroded riverbed. Spillway is placed to the contour bunds at major channels, then the channels will be fixed the route and will not shift in future. Construction of the contour bunds from the lowest part in the fan makes it easy to spread water for wider areas, besides ground surface in the fan become flat and finally it will stop riverbed degradation resulting the distributor at the fan head to be safe.

The distributor can be constructed after completion of the contour bunds, that will stabilize channels by flattening the fan and keeping the channels from horizontal shifting in the course of development of the Mithawan alluvial

fan of which present surface condition is shown in photo-1 in the following page.

2.2.4 Design Conditions

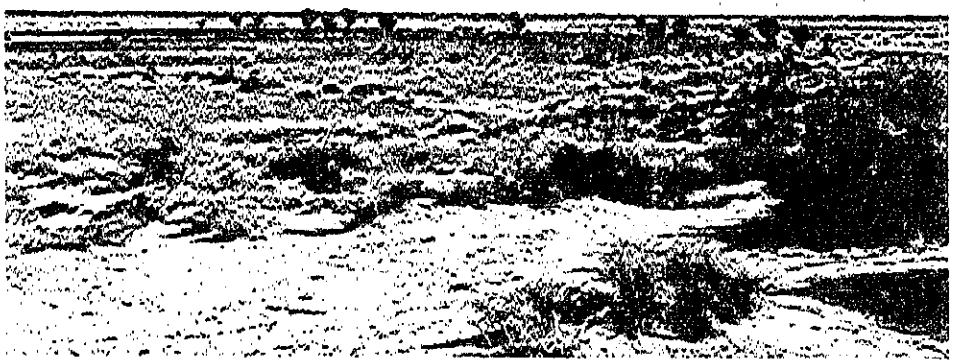
GOP has already constructed distributors and bunds for fan management in several hill torrents in the vicinity of the Mithawan hill torrent. In this section, we show GOP's design on the facilities in Mithawan fan.

(1) Degradation of channels on the fan

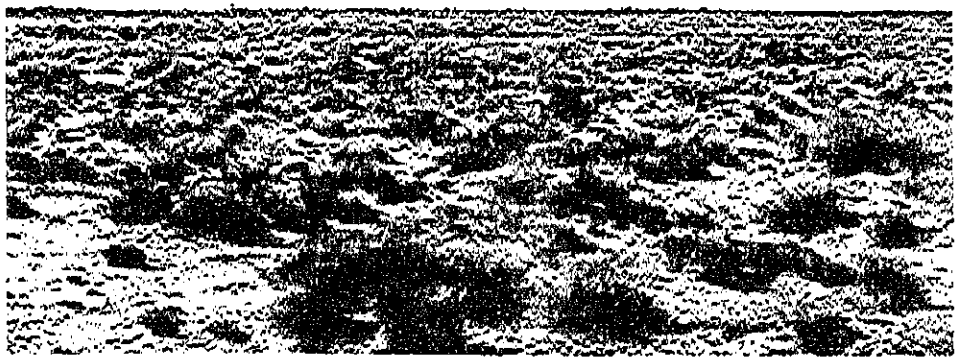
Mithawan alluvial fan is on forming process with immense supply of eroded materials from the upper reaches. To maintain sustainable flood irrigation on an alluvial fan, construction of a distributor is proposed at the fan-head to keep equal distribution of flood flows and even deposition of sediment over the alluvial fan. However, severe local scouring might occur below the distributor if riverbed lowered in the middle and the lower reaches of channels. Fig. 2.1 shows relation between riverbed level and depth of local scouring below the distributor shown in the hydraulic model test performed in the Mithawan hill torrent pilot project. The test result suggests that only one flood might breach the distributor if bed degradation developed down the channel from it.

Riverbed degradation in the Mithawan alluvial fan in 1994's flood was; in the North branch of Talha wah (Fig. 2-2) near Chitri bund was about 3.5m, near the bifurcation of Talha wah and Behu wah was about 1.5m, and near the bifurcation of Talha wah and Moldi wah was about 2.5m. Eroded wahs are shown in photo-2 in following page. Since such vast riverbed degradation must damage structures in channels, measures mitigating harmful events are necessary to provide.

Mithawan alluvial fan, about 4 km upper from the D.G. Khan Canal



Farm land on the fan,
about 4 km upper from the D.G. Khan Canal



The lower reaches of eroded Sharti wah

Table-2.1 Eroded Sediment at Talha Wah in 1994 Flood

Section	Distance (km)	Width of riverbed (m)	Riverbed lowering (m)	Eroded Sediment (m^3)
Chitori bund - Bif.* of Talha and Behu	2.5	200 - 226	3.5 - 1.5	1,330,000
Bif. of Talha and Behu - Halowani	1	226 - 110	1.5 - 2.5	336,000
Halowani - Bif. of Talha and Moldi	0.7	110 - 70	2.5 - 3.5	157,000

*: Bif. bifurcation,

(2) Distributor

Proposed location for the distributor is in the Hadwari bund site, which is near proposed structure site in the Mithawan hill torrent pilot project. The distributor branches the flood water in three channels as shown in Fig. 2.2, 2.3. Dimensions of the structure are as following; overflow sections for North and South Branches are 108 m long each, that for Escape is 244 m, guide dike on a left bank is 335 m long each for above and below the distributor, that on a right bank is using existing Hadwari bund as its part and 800 m long extension of embankment upstream and 200 m downstream, separating walls are 600 m long for the one between North and South Branches and 1,500 m long for another between South Branch and Escape.

The structure will be mainly built of gabions and protected with concrete on its surface. At downstream end of the dissipator, 5 m deep cutoff is provided in the foundation against local scouring. For assuring the structure durable, geotextile filter is placed on a riverbed protecting riverbed material under gabions from sucking out by flood flows. Since the contour bunds and the riverbed fixing structures will be constructed for mitigation of riverbed lowering, the distributor will be without deep foundation against riverbed degradation.

(3) Contour Bunds

Construction of contour bunds across the alluvial fan is planned to disperse flood water and sediments widely over the fan as shown in Fig. 2.4 and 2.5. Sites of contour bunds were selected considering present land use, irrigation and road network.

The area of 1.5 km wide along the D.G. Khan canal at the edge of the Mithawan alluvial fan is irrigated by pumps from the canal. Tube-well irrigation is extending in the area of 3 to 5 km from the canal, which is located in higher part of the pump irrigated area. Though, in the area of tube-well irrigation, farmers want to use flood water too. By this reason, the lowest line of the contour bund is determined along the upper boundary of tube-well irrigation area. Moreover, there are major villages in the mid-fan. Proposed site for the most downstream contour bund is, as a result, situated 5 km apart from the D.G. Khan canal. The plan includes construction of three lines of contour bunds across the fan shown in Fig. 2.4.

Intervals of contour bunds were determined considering land slope and storage capacity. Height of the contour bunds is 4 m in average, in which maximum water depth is 3 m and free board is 1 m. Since average slope of the fan is 1/250, longitudinal length of the water surface will be 750m when water depth is 3 m at the bunds, then water storage per one meter of bund will be 1,125 m^3 with average water depth of 1.5 m. The total quantity of runoff of the design flood is estimated at 60 million m^3. Total required length of bunds is computed 53 km, but it is determined 50 km. This 50 km length is divided into 3 sections on the fan. Each length is 6 km, 13 km and 22 km respectively when contour bunds are located at 7 km, 10 km and 16 km from the fan-head. Addition to this, auxiliary dikes are constructed from both ends of each bund toward upper fan to store water, and other minor dikes that are one meter lower than contour bund, are provided at 2.5 km interval on the main bund toward upstream for minimizing damage by a breached main bund.

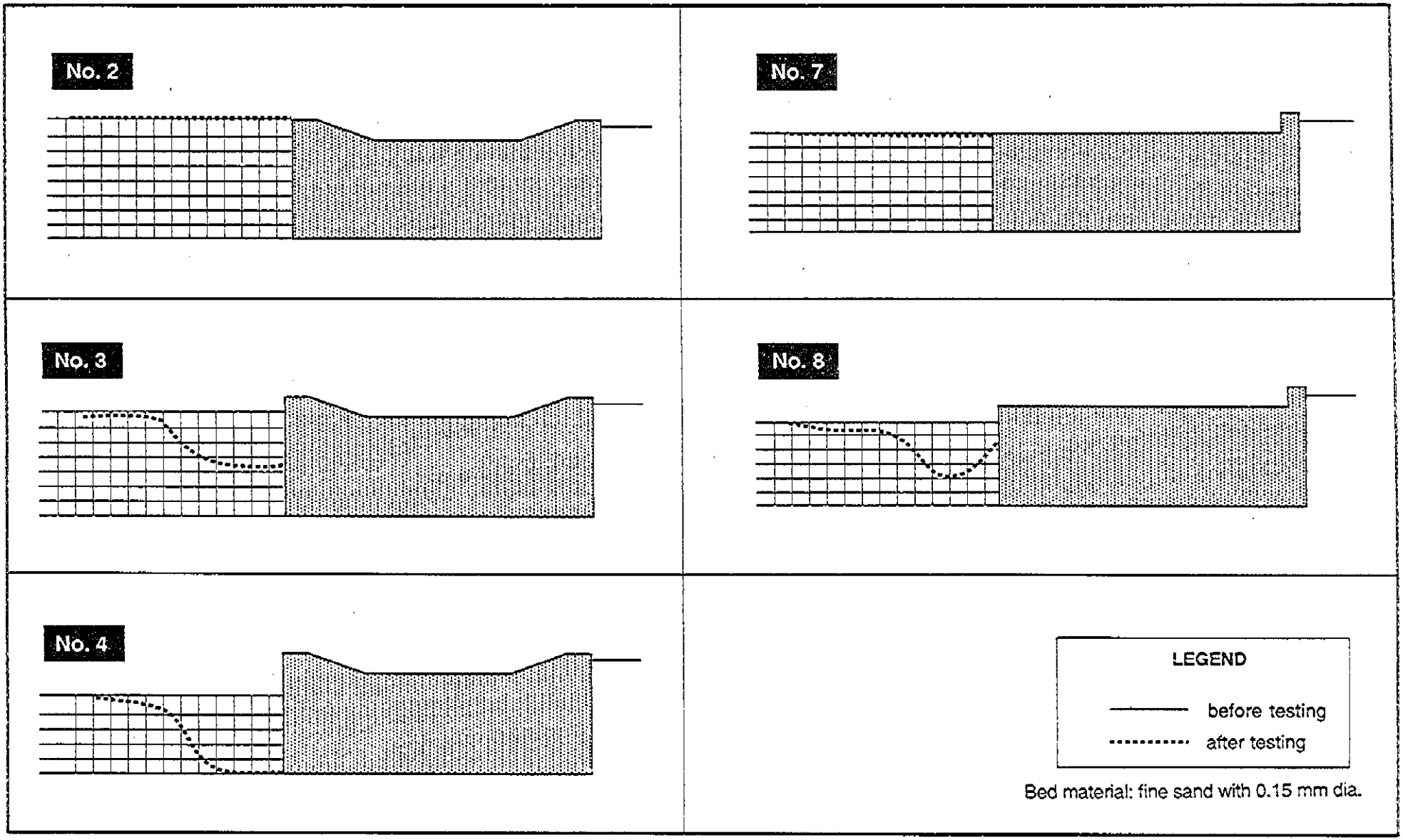
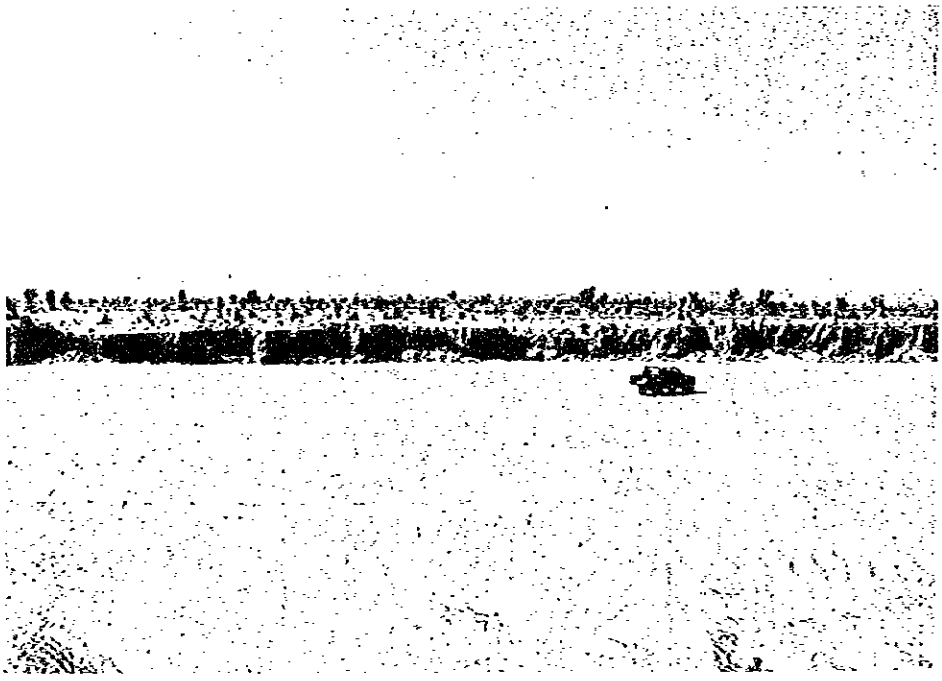


Fig. 2.1 Scour downstream of the Distributor

Eroded bund in Sharti wah, Height of the bund : 18 feet
Bed degradation : 5 feet by washing away of the bund



Degradation in Talha wah, the bed lowered 12 feet in one flood
Width of the wah : 360 feet

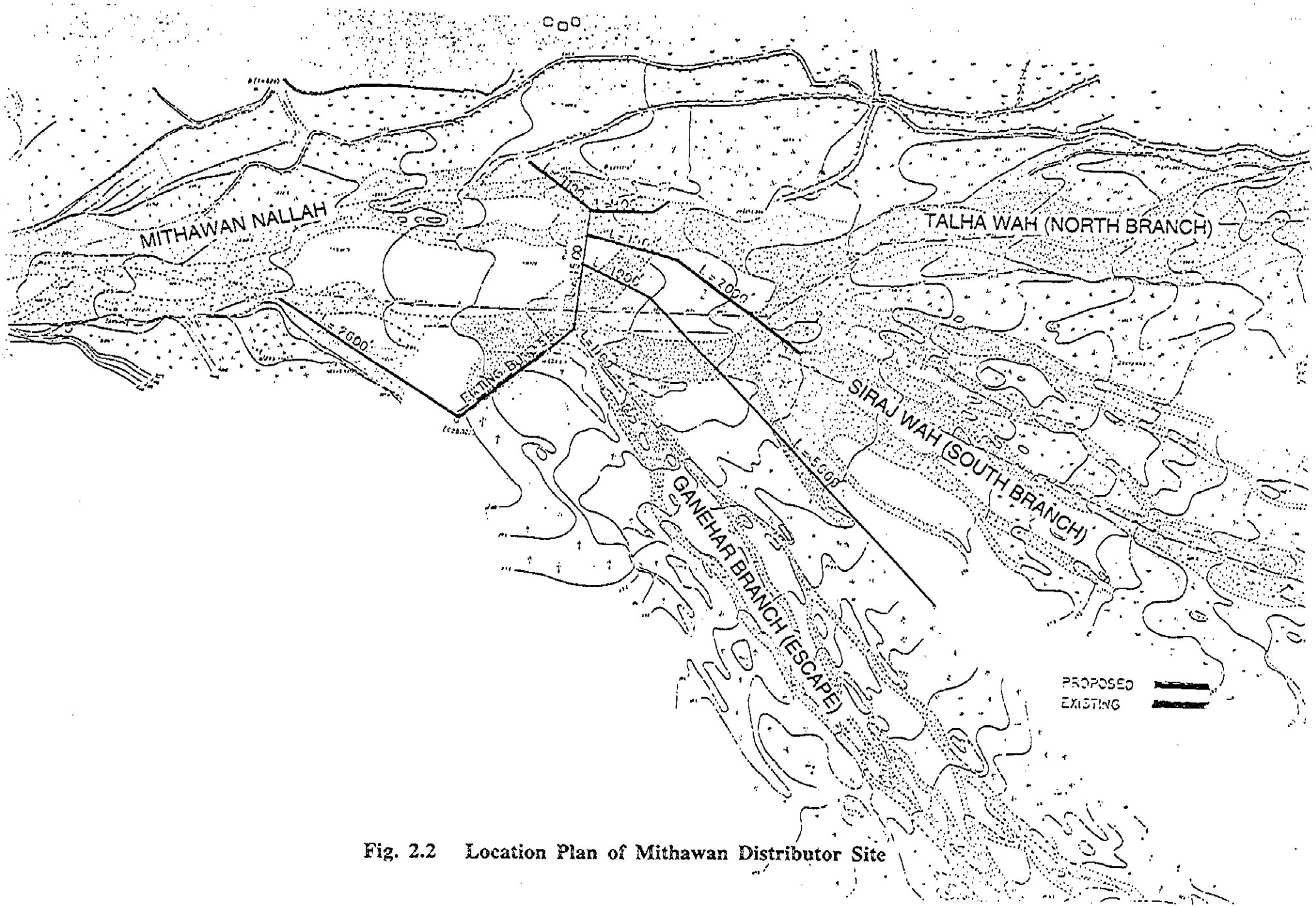


Fig. 2.2 Location Plan of Mithawan Distributor Site

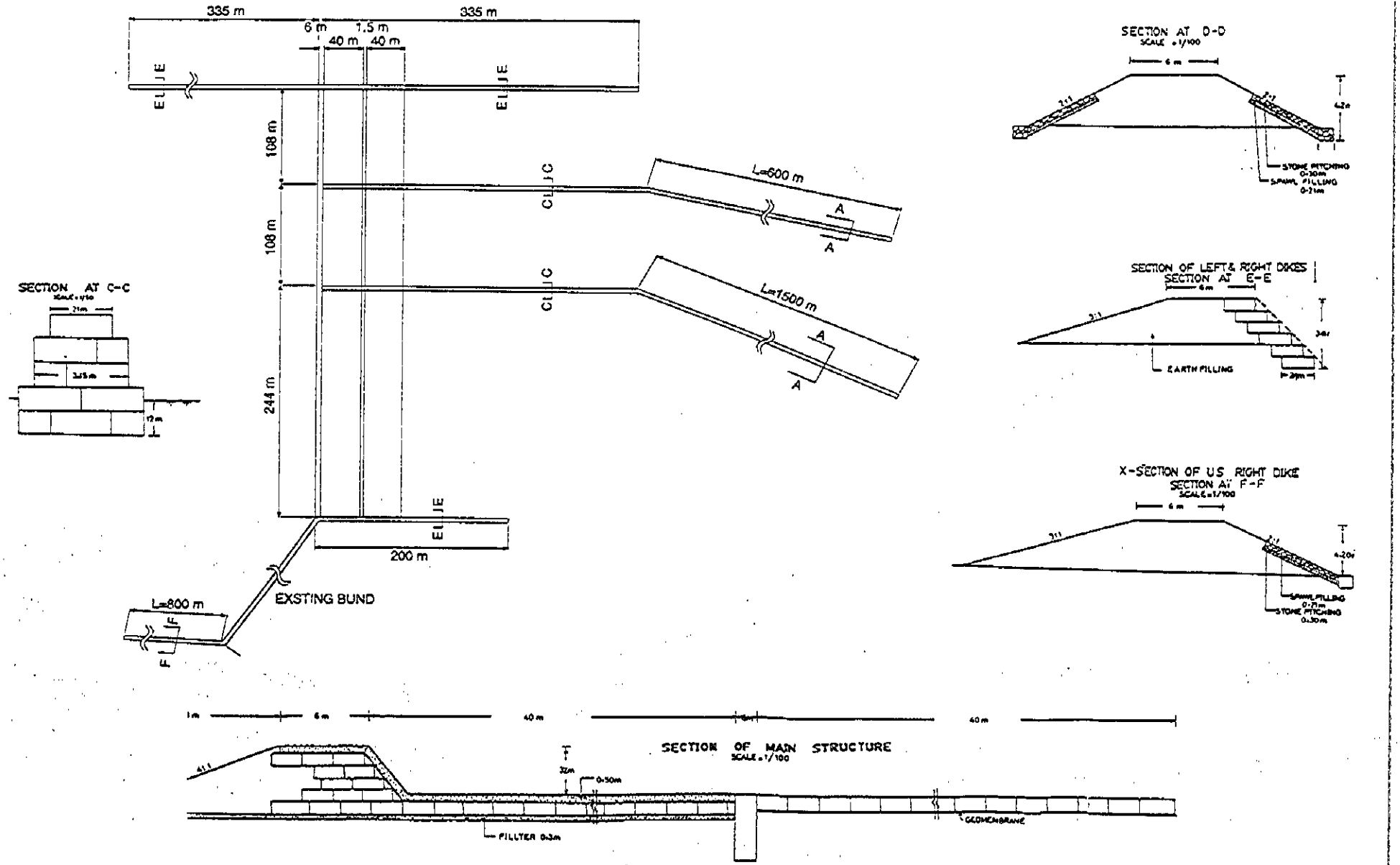


Fig. 2.3 Mithawan Flood Distributor

Since contour bunds have storage capacity, farmlands below the bunds can be irrigated by its stored water. Further, instead of present hasty intake of water, farmers can take their time to draw water, irrigation will be effective and done in wider area accordingly. At present, water depth in existing farmlands is 0.75m in average varying between 0.6 to 0.9 m, while that in the reservoir of contour bunds is 1.5 m. Then, water volume in the reservoir is able to feed twice of the area. Moreover, the area of the reservoir can be used for cultivation when it is empty since soil contains sufficient moisture by ponding.

Embankment work must start from the lowest sections of the lowest contour bund for raising the lowered riverbeds. Side borrow provides material for embankment, but sprinkling is necessary one night before the earth work since top soil layer is dried up. Regards to spillway, the downstream-most contour bund has one, on the other hand, the middle and upstream-most bunds have three each. The spillway is designed as a causeway used for traffic too, using gabions. Under the gabions, geotextile filter is placed protecting sand grains sucking out from the riverbed. Gabions are covered with thick concrete, for the sections for causeway with 50 cm thick and for the floor of the dissipator with 30 cm thick. At the downstream end of the dissipator, 5 m deep cutoff is provided.

(4) Riverbed fixing

Bed fixing works are planned to be constructed in the Sharti wah, the Talha wah of the North Branch and the Escape. In upstream-most sections of the Talha wah and the Escape, their role is for stopping lowering riverbed mainly, and in the middle and the lower reaches of Sharti wah and Talha wah, it is for raising the riverbed by accelerating sedimentation. Both banks are easily eroded in channels, above and below the structure must be protected. However, the locations are not be determined yet.

(5) Evaluation of Structures Plan

GOP has a plan to construct the distributor, the contour bunds and the riverbed fixing structures. However, according to GOJ's evaluation, as

suggested by the hydraulic model test during basic design study of the Mithawan hill torrent pilot project, flow during high floods would damage the distributor heavily and breach it unless it is protected from riverbed lowering. Contour bunds must be constructed first to stabilize the fan, then the distributor is constructed in the following phase.

2.3 Basic Concept of the Equipment and Materials

2.3.1 Design Concept

The area called D. G. Khan hill torrent belt including Mithawan area is consisted of alluvial fans formed by hill torrents coming from the Suleiman range. Local people have cultivated using hill torrent floods for crop cultivation as the flood irrigation. On the other hand, D. G. Khan canal that constructed in 1960's along the edge of alluvial fan has suffered from flood damage by hill torrent floods and its irrigated area occasionally has been inundated by the floods.

In the Mithawan fan, gushing hill torrent floods have flown into a specific channel causing degradation of the riverbed, moreover they have breached D.G. Khan canal dikes resulting inundated the canal irrigated area. Accordingly GOP intends to develop the Mithawan fan to promote farming and mitigating flood damage by constructing contour bunds, distributor and riverbed fixing works.

The Project procures equipment and materials which is used for construction of the contour bunds in the Mithawan fan. In the study for this procurement plan, we examine the types and number of equipment based on the request for construction of the proposed distributor from the view point of PID's capacity and capability on operation and maintenance including personnel, budget, etc. It is also taken future use of the equipment for watershed management and for development of other hill torrent into account.

The equipment and materials manufactured in Pakistan are recommended, in principle. They may be procured from Japan and any other third countries, if necessary. Regards to a unit price of materials to be procured, the lowest unit price is adapted, in general, examining the unit price collected in market in Pakistan and any survey after that.

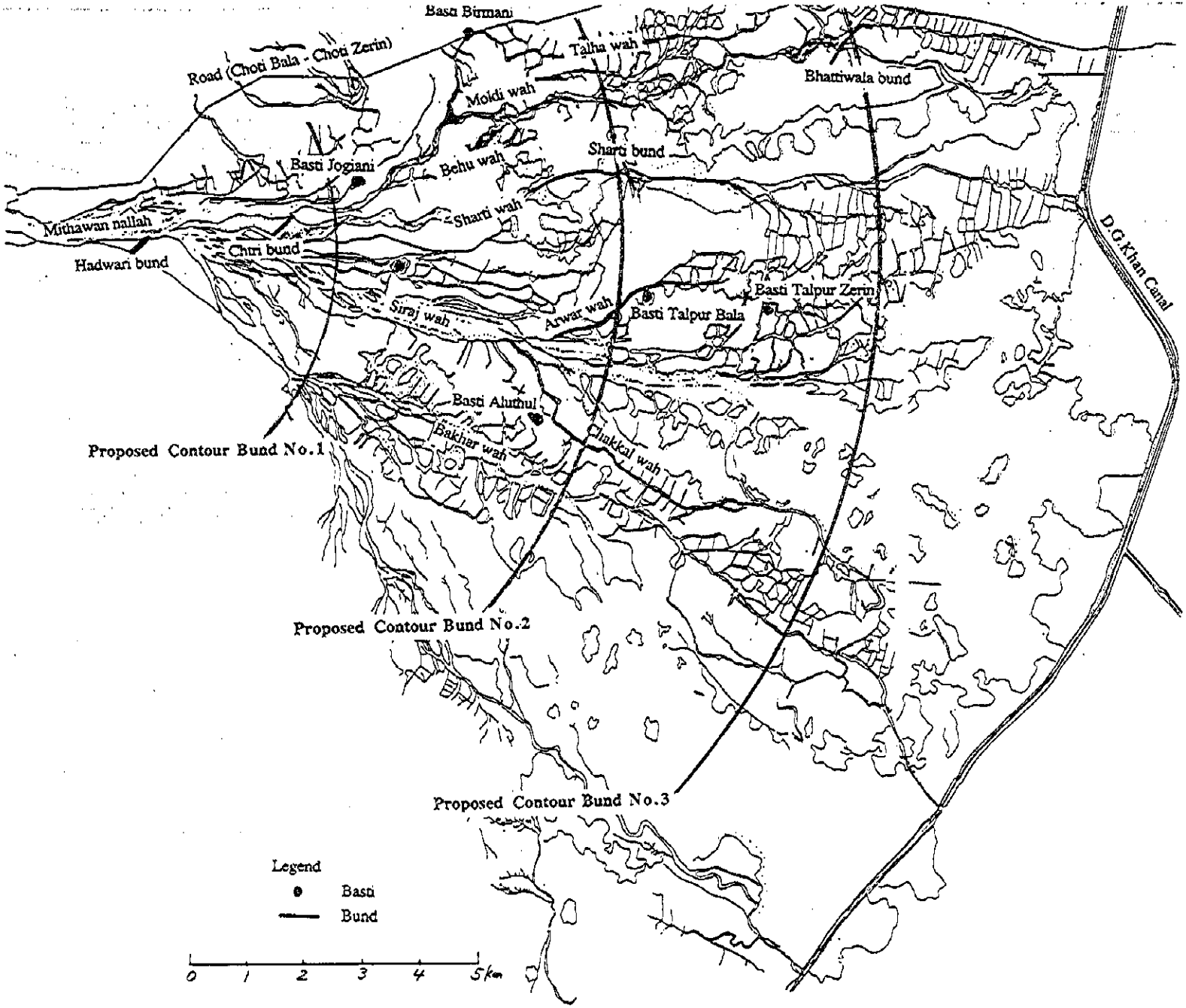


Fig. 2.4 · Location Plan of the Contour Bunds

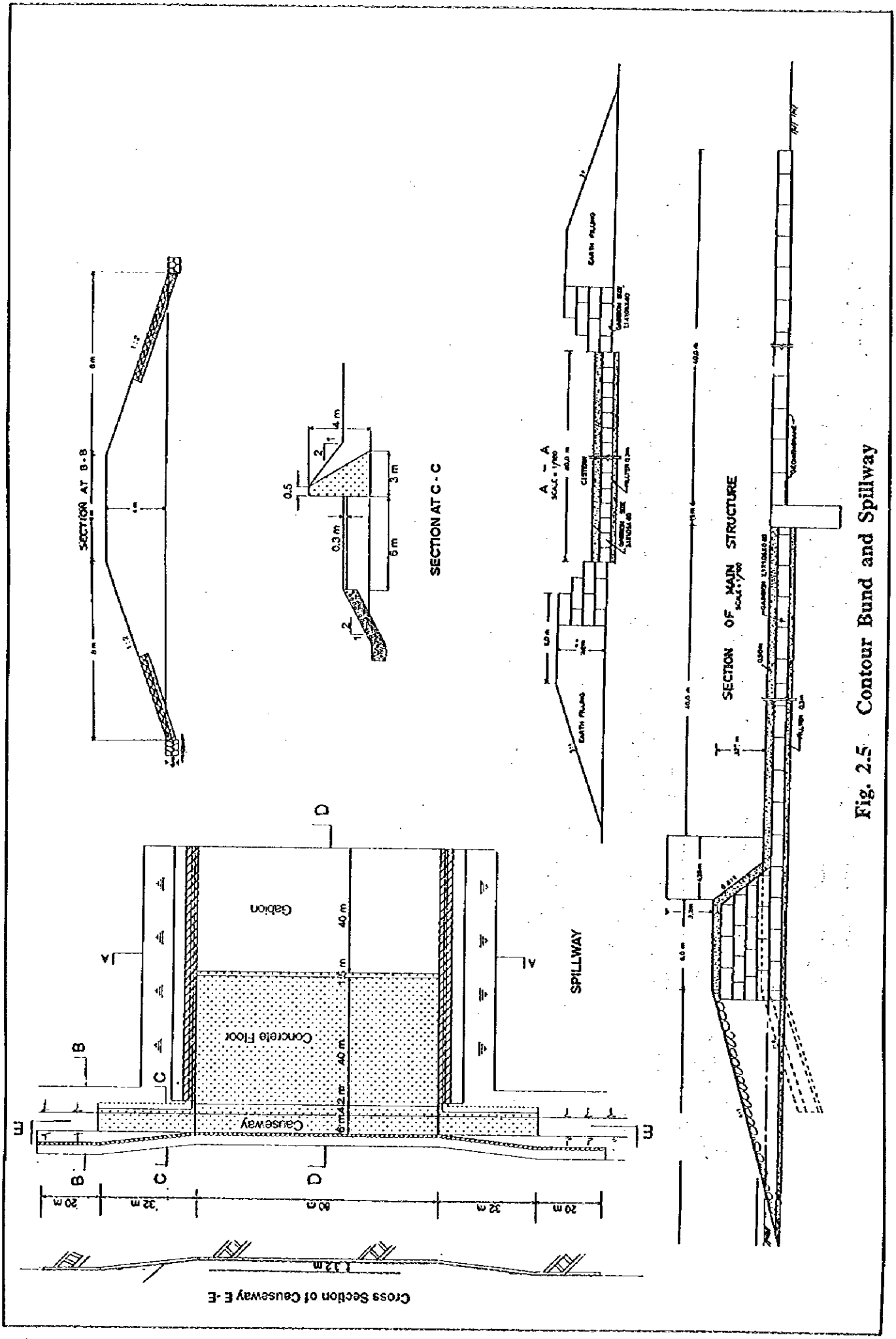


Fig. 2.5 Contour Bund and Spillway

2.3.2 Basic Design

(1) Construction Works

Construction works that GOP is planning are the distributor at the fan-head and three lines of contour bunds over the alluvial fan. However, as the result of GOJ's evaluation of this plan, for the stability of the distributor, contour bunds should be constructed first. Items of the construction work and materials are as follows.

Table-2.2 Items of work and materials

Items of Work	Contour Bund No. 1 L= 9 km	Contour Bund No. 2 L= 13 km	Contour Bund No. 3 L= 22 km	Total L= 50 km
Earth Filling (m^3)	432,000	720,000	1,248,000	2,400,000
Excavating (m^3)	73,000	93,000	123,000	292,000
Concrete (m^3)	6,194	6,194	2,043	14,431
Gabions (m^3)	29,400	29,400	9,800	68,600
Stone Pitching (m^3)	7,509	7,509	2,503	17,521
Geotextile for Filter (m^2)	10,080	10,080	3,360	23,520

(2) Construction methods and necessary equipment

GOP plans to complete the construction work within two years. Judging from the earthwork quantity, contour bund No. 3 downstream-most will be constructed in the first year (Phase I), and bunds No. 1 and No. 2 will be constructed in the second year (Phase II).

For construction of the contour bunds, material will be collected by bulldozer from side borrow pits and compacted. Stones used for pitching and gabion filling will be collected by bulldozer with ripper in Nangar nullah fan which is located 20 km far from the site. Stones material will be loaded by wheel loader and carried by trolley tractors to the site. Gabion works and stone pitching are done by manual workers at the site.

Works in spillway involve concrete work, such as cutoff wall, concrete lining on the gabions, retaining walls, etc. Considering sites condition and

future use in mountainous area, portable concrete mixer is preferred. In concrete works of the spillway, belt conveyors carry concrete. Water tank lorries carry water for mixing concrete from D.G. Khan canal, because there is no water source at the construction sites.

Following table 2.3 shows necessary machines and equipment to be procured for the construction work.

Table-2.3 List of equipment to be procured

Equipment	Purpose
Bulldozer	excavating, earth moving, compacting
Bulldozer with ripper	collecting stone
Wheel loader	loading stone
Truck trailer	carrying heavy machines
4WD truck	carrying spare parts and tools
Trolley with tractor	carrying stone
Water tank lorry with tractor	concrete works, earth work
Portable concrete mixers	concrete works
Vibratory concrete compactor with generator	concrete works
Belt conveyor	concrete works

(3) Equipment

(A) Bulldozer

Bulldozer will be used for construction of contour bunds and collecting stone.

1) Construction of bunds

(a) Selection of type

Works of bund construction are mainly earth works, such as excavation, moving soil, placing, compacting, etc. Bulldozer of 24-ton class is suitable for the works. Since each excavating capability of bulldozer of 24-ton class and 21-ton class is 144.89 m^3/hr and 110.11 m^3/hr respectively, 21-ton bulldozer has the capability below requirement and the construction work will not be completed in the scheduled period.

(b) Number of machines

In the first year, the contour bund No. 3 will be constructed.

Table-2.4 Quantity of earth-work in the first year

Item of work	Contour bund No. 3
Excavation	126,000 m^3
Embankment	1,248,000 m^3

Total working days required are,

(1,248,000+126,000)m^3 ÷ (144.89 m^3/hr x 8 hr/day) x 30/26

= 1,367.75 day/unit

Number of bulldozers is;

1,367.75 day/unit ÷ 4 unit = 342 days < 1 year

As a result, four (4) bulldozers will be necessary to complete the work of No. 3 contour bund in a year.

In the second year, the contour bund No. 1 (the most upstream) and No. 2 will be constructed.

Table-2.5 Quantity of earth-work in the second year

Item of work	Contour bund No. 1	Contour bund No. 2
Excavation	73,000 m^3	93,000 m^3
Embankment	432,000 m^3	720,000 m^3

Total working days required are,

(432,000+73,000+720,000+93,000) m^3

÷ (144.89m^3/hr x 8 hr/day) x 30/26 = 1,312 day/unit

Number of bulldozers is;

1,312 day/unit ÷ 4 unit = 328 days < 1 year

As a result, four (4) bulldozers will be necessary to complete the work of second year's contour bund in a year.

From the above, four (4) bulldozers are necessary for the construction of the contour bund.

2) Collection of Stone

(a) Selection of type

27-ton class of bulldozer is suitable. Excavating capability of 27-ton class of bulldozer with ripper is 47.58 m³/hr, while that of 21-ton class is 38.41 m³/hr and its capability is short to the requirement.

At present, manual workers collect boulders and stone on the ground surface, load them on trolley and carry to the construction site. However, considering necessary quantity of stone for the structure, manual work must be difficult to collect required quantity of stone within a limited period. Bulldozer with ripper can excavate boulders and stone in the ground easily in a short time, accordingly, it is necessary to collect stone in a limited period. Further, for the future plan of construction of the structures for watershed management, road will be constructed in rocky or stony areas, then, bulldozer with ripper is preferred.

(b) Number of machines

Assuming the percentage of boulders in excavated material 50 %, capability of gathering stones by ripper excavation is;

$$48.39\ m^3/ha \times 0.5 = 24.20\ m^3/hr$$

In the first year, the contour bund No. 3 will be constructed.

Table-2.6 Quantity of stone in the first year

Item of work	Contour bund No. 3
Stone for gabions	9,800 m^3
Stone for pitching	2,503 m^3
Total	12,303 m^3

In the second year, the contour bund No. 1 (the most upstream) and No. 2 will be constructed.

Table-2.7 Quantity of stone in the second year

Item of work	Contour bund No. 1	Contour bund No. 2	
Stone for gabions	29,400 m^3	29,400 m^3	
Stone for pitching	7,509 m^3	7,509 m^3	
Total	36,909 m^3	36,909 m^3	Grand total 73,818 m^3

Required working days in Phase-I are;

12,303 m^3 ÷ (24.20 m^3/hr x 8 hr/day) x 30/26 = 73.3

say 74 days

Required working days in Phase-II are;

73,818 m^3 ÷ (24.20 m^3/hr x 8 hr/day) x 30/26 = 440 days

Required days for collecting stones is 514 days through Phase-I and -II. Since stones for the Phase-I and -II works can be collected before and during the periods for gabion works and stone pitching, collection of stones for Phase-II works can start immediately after completion of stone collection for Phase-I. On the other hand, 139 working days are required including 104 days for concrete work, 10 days for embankment, 15 days for stone pitching and 10 days for miscellaneous works after stone collection, then 591 days throughout the period of phase -I and -II will be available for stone collection. As a result, one bulldozer with ripper is sufficient.

To sum up, four 24-ton bulldozers and one 27-ton bulldozer with ripper are necessary for the works.

(B) Wheel Loader (capacity 1.2 m^3)

Stones collected at the quarry by ripper bulldozer will be loaded on trolleys. Five buckets can fill one trolley of 4.7 m^3. Loading capability of wheel loader is 35.1 m^3/hr.

Carrying capability is 21.1 m^3/hr (2.11 m^3/hr x 10 tractor trolleys) by ten tractor trolleys, then one wheel loader will be sufficient for loading.

(C) Truck Trailer

The work site of the Mithawan is 60 km apart from D. G. Khan where heavy machinery is kept. Additionally, the workshop in Multan is 90 km far from D.G. Khan. Since heavy machines can't drive themselves from the construction site to the workshop, truck trailer is necessary to carry them. The truck trailer is expected not to work frequently, however D.G.Khan Irrigation has to be equipped the trailer for carrying heavy machines since there are no leasing trailers in D.G.Khan and Multan region.

Further, the D.G. Khan hill torrent belt which is managed by D. G. Khan Irrigation is extending 300 km from north to south centering D. G. Khan. Trailers will be necessary for future development of this area.

(D) 4WD truck

The 4WD truck will be used to carry mechanics, spare parts and tools for repairing when heavy machinery breaks down at the site. It is 150 km far from site to Multan where mechanics station. Accordingly at least two (2) 4WD trucks, one for the site and the other for carrying spare parts, are necessary considering local traffic situation.

(E) Trolley with tractor (capacity of 4.7 m^3)

Stones will be carried about 20 km in one way from quarry to construction site by tractor trolleys. Average speed of tractor trolleys measured at 10 km/hr at the site. Carrying capability of the tractor trolley is 2.11 m^3/hr considering carrying distance.

Stones in Phase -I and -II works can be carried before and during the gabion work, on the condition that gabion works should complete before concrete works. Carrying stones will be able to continue throughout Phase -I and -II, then workable days for carrying stones are estimated 591 days as same as stone collection work.

Total quantity of required stone is 86,121 m^3 as shown in table 2.6 and 2.7. Required number of tractor is;

86,121 m^3 ÷ 591 x 26/30 days = 168.14 m^3/ day

168.14 m^3/ day ÷ (2.11 m^3/hr x 8 hr/day) = 9.96 unit

By above calculation, 10 tractors are necessary.

(F) Water tank lorry with tractor

Water for concrete mixing will be carried by water tank lorry from D.G. Khan canal which is average 15 km far from the site , because there is no water sources at the construction sites. To carry water, tractors will tow 5,000-liter water tank which is generally used in the area. Calculated by placing volume of concrete, water of 2.5 m^3/hr is needed to mix concrete. As the capability of water tank is 3.86 m^3/hr, one tank lorry is sufficient.

Addition to the requirement for the concrete works, earth works also need water sprinkling when much dried surface soil is used to construct contour bunds. Daily excavation volume for embankment is 4,632 m^3 by 1 m deep stripping 24 m wide and 96.5 m long each on both sides of dike, since top layer of 0.15 m thick is increased 10 % of moisture contents by sprinkling from natural moisture contents of 5 % with 1.1 t/m^3 in situ dry density, then total required volume of water is 60 m^3 per day. Accordingly two (2) water tanks are necessary for the work.

To sum up, three (3) water tanks are necessary.

(G) Portable Concrete Mixer

Concrete volume for the Phase-I construction work is as below.

Contour bund No. 3	spillway	80 m x 40 m x 0.3 m =	960 m^3
(spillway)	cut off wall	80 m x 5 m x 1.5 m =	600 m^3
	retaining wall		483 m^3
	total		2,043 m^3

Concrete volume for the Phase-II construction work is as shown below.

Contour bund No. 1	spillway	80 m x 40 m x 0.3 m =	960 m^3
(spillway)	cut off wall	80 m x 5 m x 1.5 m =	600 m^3
	retaining wall		483 m^3
	sub-total		2,043 m^3
	total	2,043 m^3 x 3 =	6,129 m^3
Contour bund No. 2	spillway	80 m x 40 m x 0.3 m =	960 m^3
(spillway)	cut off wall	80 m x 5 m x 1.5 m =	600 m^3
	retaining wall		483 m^3
	sub-total		2,043 m^3
	total	2,043 m^3 x 3 =	6,129 m^3

Capacity of portable concrete mixer is 3 m^3/hr. Number of portable concrete mixer necessary for the work is as below.

Cut off wall of spillway (80 m long)

total concrete volume		600 m^3
length of concrete placing per day		10 m
daily volume of placing concrete	10 m x 5 m x 1.5 m =	75 m^3/day
working days (placing every 3 day)		
	600 m^3 ÷ 75 m^3 x 30/26 x 3 =	30 days
number of mixer necessary	75 m^3 ÷ (3 m^3/hr x 7 hr) =	4 units

Dissipator;

total concrete volume		960 m^3
volume placing per one block		
	10 m x 10 m x 0.3 m =	30 m^3/block
number of times of placing	960 m^3 ÷ 30 m^3 =	32 times
working days (placing every 2 day)	32 x 30/26 x 2 =	74 days
number of mixer necessary	30 m^3 ÷ (3 m^3/hr x 7 hr) =	2 units

Retaining wall of spillway (4 m high, 78 m long)

total concrete volume		483 m^3
height of placing per one block		2 m
length of placing per one block		10 m
volume of placing of lower half per one block		47.5 m^3
volume of placing of upper half per one block		22.5 m^3
number of times placing	78 m ÷ 10 m x 2 =	16 times
working days (placing every 3 day)	16 x 30/26 x 3 =	56 days
number of mixer necessary	48 m^3 ÷ (3 m^3/hr x 7 hr) =	2.2 units

By above calculation, four (4) concrete mixers will be necessary to mix concrete for cutoff walls of spillway, and two (2) mixers each for dissipaters and retaining walls of spillway. Workable days of concrete works per each spillway will be 104 days (74 days + 30 days).

No. 1 and No. 2 contour bunds in phase-II work have three spillways each. Placing concrete for cutoff is executed every three day at one site. Because of limited period, concrete placing shall be done every day changing the working site, then it takes 30 days for 3 cutoff walls. Placing concrete for dissipator is executed every 2 day, then days required for placing concrete altering the site is 74 days. After this work remained one dissipator will be completed, then days required for construction for one contour bund is 178 days (30 + 74 + 74). In the period, two contour bunds are constructed simultaneously and total days required are 356 days that is within one year. Concrete work is executed before and after gabion works.

Accordingly, four (4) portable concrete mixer is required.

(H) Vibratory Concrete Compactor

To make concrete good quality, compacting work for concrete is necessary. Suitable compacting of concrete will improve its quality, such as strength, durability and water-tightness. For compacting concrete, vibratory compacting is the most effective way. Capability of vibratory compactor is around 4 to 8 m^3/hr for general small type. Since volume of concrete placing is estimated 11 m^3 per hour for cut off walls, three (3) vibratory compactors are necessary considering width and length of concrete placing at the site. Further, generators for those compactors will be necessary.

(I) Belt Conveyor

Because it is difficult to carry raw concrete by a wheelbarrow to go through on gabions during concrete placing work, belt conveyor will be used. Two concrete mixers use one belt conveyor. Another belt conveyer is provided for carrying material, such as cement, sand and gravel. Each belt conveyor is equipped with engine.

(J) Gabion crates

Gabion crates are major material for the spillways. Necessary number of gabion crates is,

Phase-I	9,800 m^3 ÷ (2.1m x 1.05 m x 0.8 m) =	5,560
Phase-II	58,800 m^3 ÷ (2.1m x 1.05 m x 0.8 m) =	33,340
	Total	38,900

Gabion crates are made with galvanized wire and its diameter is 4 mm. Size of openings of the crate is at least 10 cm not to drop stone out.

(K) Geotextile filter

Geotextile filter is used for preventing sand particles under gabions sucking out in the dissipator of the spillway. Since ground water level is 60 m low from ground surface and there are no water flows in the channels and riverbed materials are dried most of time. Moreover, period of flooding is less than 24 hours, then riverbed under gabions never be saturated. In such circumstances, both pervious and impervious material can be used for protecting sand under the gabion from suction. Since 3,360 m^2 of filter is necessary for one (1) spillway, 23,520 m^2 of geotextile filter is necessary for seven (7) spillways.

(4) Number of equipment

Number of equipment concluded is as follows.

Table-2.8 Number of Equipment

Machinery/Equipment	Specifications	Number
Bulldozer	24 tons	4 units
Bulldozer with ripper	27 tons	1 unit
Wheel loader	1.2 m^3	1 unit
Truck trailer	30 tons	1 unit
4WD pickup	carry for spare parts, tools	2 unit
Trolley with tractor	78HP, 4.7 m^3	10 units
Water tank lorry with tractor	45HP 5,000 lit	3 units
Portable concrete mixers	0.45 m^3	4 units
Vibratory concrete compactor with generator	D=60mm	3 units
Belt conveyor with engine	15 m x 0.45 m	3 units
(Material)		
Gabion crates	galvanized wire, openings 10 cm	38,900 Pieces
Geotextile filter	semi-pervious	23,520 m^2

2.4 Project Implementation Plan

2.4.1 Executive Organization

Executing body of major flood irrigation structures in Mithawan area is under management of Chief Engineer (CE) Irrigation, D.G. Khan of PID, which is covering not only Mithawan hill torrent but also operation and management (O&M) of irrigation systems of both Muzaffargah and D.G. Khan whose area extents 0.8 million ha, SCARP and river training of the Indus river. Organization of D.G. Khan Irrigation zone is in Fig. 2.6 and that of PID is in Fig. 2.7.

For O&M of hill torrent management, the area is divided in two, the Jampur construction division is in charge of southern part of the area from Kaha, while the D.G. Khan canal division is in charge of northern part from Mithawan. New construction works will be managed by the Project Circle of D.G. Khan Irrigation. This division consists of one superintending engineer,

one executive engineer and three SDOs, and is in charge of drainage project, flood management of the Indus river and hill torrents also. D.G.Khan Irrigation has performed many construction and rehabilitation works of structures other than distributors in Kaha hill torrent and Vidore hill torrent.

O&M of heavy machinery such as regular maintenance and repairing work is conducted at the workshop belonged to NTWD of SCARP Circle. This workshop is located in Multan 90 km far from D.G. Khan and was established to conduct repairing work of tube-wells. Function of maintenance and repair of heavy machinery was added to this workshop by USAID assistance in 1987.

2.4.2 Budget

GOP is requested to disburse direct operation cost of the procured equipment by Japan's grant aid for construction of the contour bunds, which include machine operation cost, machine maintenance cost, concrete construction cost, labor cost, etc. Total direct cost is estimated about Rs. 63 million. Also regular maintenance cost has to be disbursed, which is estimated Rs. 510,000 as shown in Sec. 3.2.3.

D.G. Khan Irrigation has conducted a large variety of O&M works such as O&M of canals and intake facilities of irrigation systems, flood managing of the Indus river, etc. Budget for D.G. Khan Irrigation including personnel costs and office managing costs was Rs. 357 million in 1995-96. Personnel costs of NTWD workshop which is expected to perform O&M of heavy machinery are included in the above budget. The costs for maintaining and repairing of heavy machinery at the NTWD workshop during the construction period will be provided by the project cost.

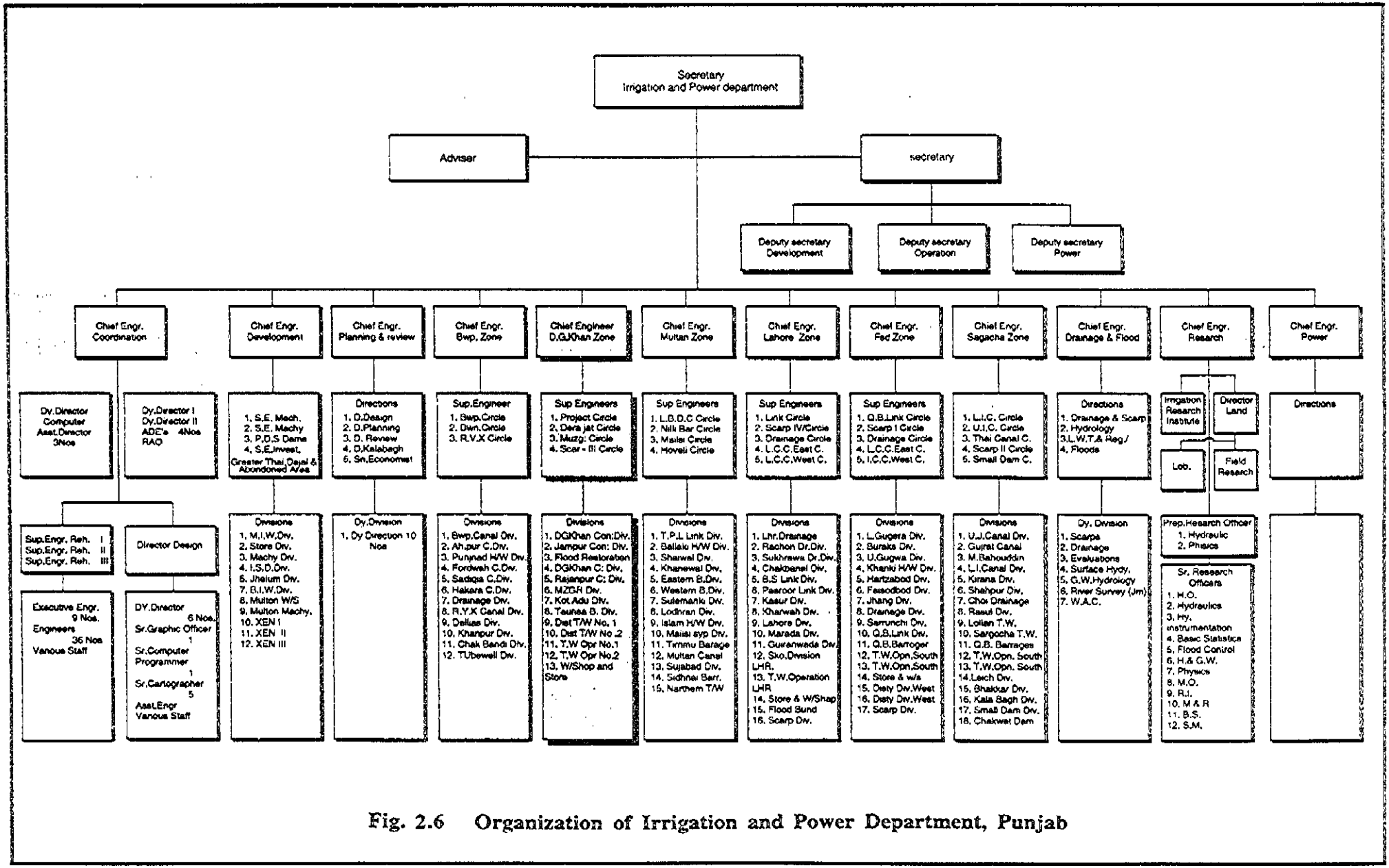


Fig. 2.6 Organization of Irrigation and Power Department, Punjab

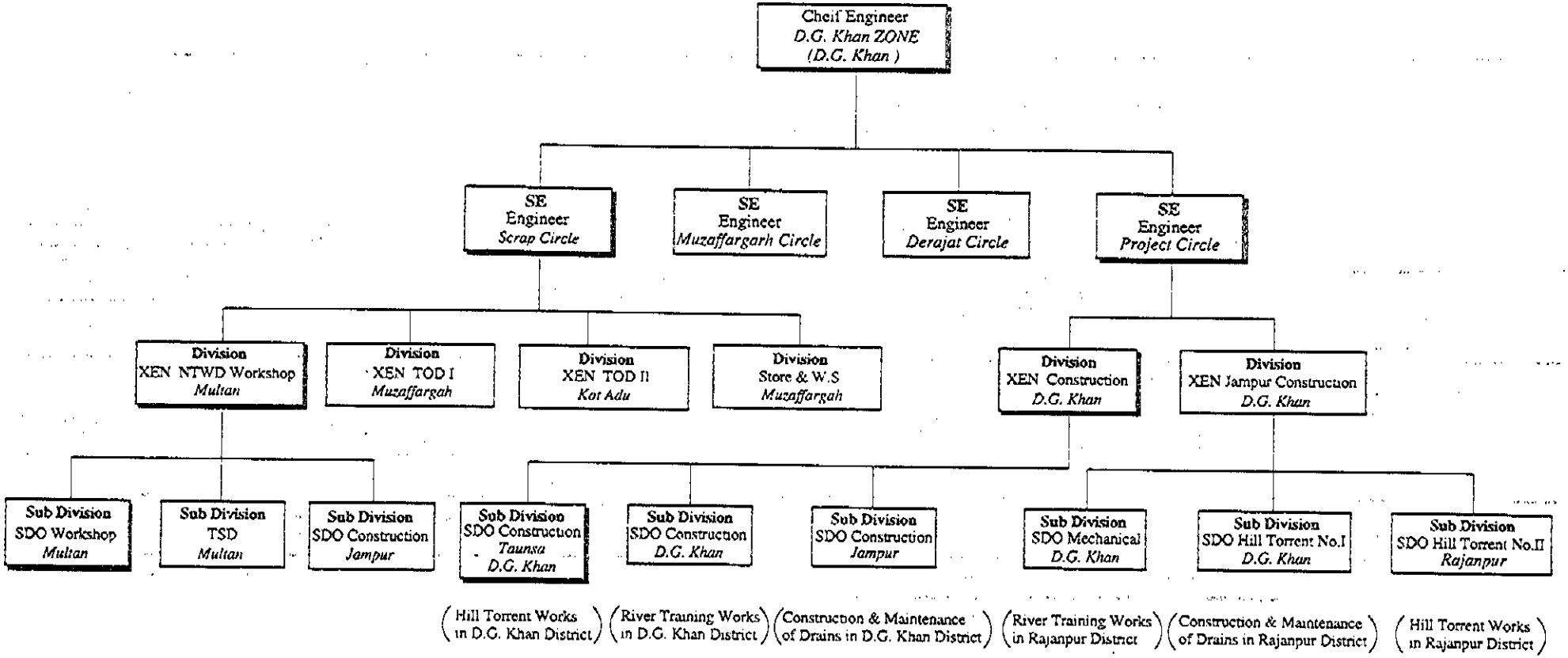


Fig. 2.7 Organization of D.G.Khan Zone, Irrigation

2.4.3 Personnel and Technical Level

In the D.G. Khan hill torrent belt, there are many hill torrents other than Mithawan. D.G. Khan Irrigation has constructed and maintained the structures in the area, such as the distributors in Kaha hill torrent and Vidore hill torrent, accordingly it has enough personnel who have worked for hill torrent. In terms of technical level, there were some problems in the design of structures and construction supervision of the Kaha project, while in the Vidore project, facilities were completed in six months and construction supervision was finished satisfactory though it had a large quantity of concrete works.

O&M of heavy machines belonging to PID is performed by the Mechanical Circle stationed at Lahore as a rule. In this case, however, there are problems on O&M because the procured equipment are kept and maintained far from the site. Heavy machines procured in the Project will consequently be controlled by C.E. Irrigation, D.G. Khan, to avoid procedural difficulties and to have them all to the hill torrent project.

O&M of heavy machinery, such as regular maintenance and repair is conducted at the NTWD workshop of the SCARP Circle. This workshop was established to repair tube-wells including electric motors, pumps, etc. Function of maintenance and repair for earth machines was attached to this workshop by USAID assistance in 1987. The workshop has the personnel of 20 persons as shown in table 2.9, and enough capacity as a workshop. Further, in D.G. Khan, there are parking garages for heavy machinery established during construction of D. G. Khan canal in 1960's, which can be used anytime for parking and inspection.

In the area of D.G. Khan, D.G. Khan Unit of Agriculture has an office and a workshop which manage farm lands in the area, and have eighteen (18) bulldozers and two (2) truck trailers for carrying bulldozers to the site. Most repair works can be done in this workshop and mechanics will come to the site for minor repairs. This workshop consists of seventeen (17) mechanics, nine (9) mechanical engineers and six (6) guards. Emergency repair can be done here.

Table-2.9 Personnel in Multan Workshop

Item No.	Title	Allowable number	Actual number
1.	Sub engineer	1	1
2.	Foreman	1	1
3.	Rebuild up machine operator	1	1
4.	Auto electrician	1	1
5.	Milling man	1	1
6.	Engine mechanic	1	1
7.	Dino meter	1	1
8.	Hydraulic operator	1	1
9.	Calibration operator	1	1
10.	Mechanic	1	1
11.	Molder	1	1
12.	Milling machine operator	1	1
13.	Welder	1	1
14.	Crane operator	1	1
15.	Tool issuer	1	1
16.	Helper	4	4
17.	Auto electrician	1	1
	Total	20	20

CHAPTER 3 PROJECT IMPLEMENTATION PLAN

3.1 Implementation Plan for Procurement of Equipment and Materials

3.1.1 Concept of Implementation Plan for Procurement

In implementation of the Project, equipment and materials, including their type and number, are examined, then necessary equipment and materials are procured for construction of the contour bunds. Necessary spare parts for the equipment during operation and maintenance are also examined.

Equipment and material manufactured in Pakistan are recommended in principle. They may be procured from Japan and any other third countries, if necessary.

Regards to a unit price of materials to be procured, the lowest unit price is adopted in general, examining unit price collected in the markets in Pakistan and any survey after that.

3.1.2 Considerations in Implementation Plan

Equipment and materials manufactured in Pakistan are recommended in principle.

Regarding machines to be considered, bulldozers manufactured by Japanese firms prevail in Pakistan, for the reason that two (2) firms are able to render services of their operation and maintenance in Pakistan. Wheel loaders manufactured in Japan also prevail in Pakistan. Procurement of earth machines from Japan is considered to be appropriate for smooth implementation of services for operation and maintenance.

Spare parts for heavy machines would cost amount equivalent to 36% of a body price of earth machines, to 90% in maximum, in their economic life span, that varies with their type and working condition. Spare parts are procured for the first two years out of the entire economic life, because construction period of the contour bunds is planned two years.

About equipment and material manufactured in Pakistan, those made in Pakistan is recommended to be procured even if only manufacturer is available.

3.1.3 Conditions of Implementation Plan

Concerning the bulldozers to be procured, which are one of the major machine for the Project, only two Japanese manufacturers' bulldozers prevail in Pakistan, accordingly agents able to render services for operation and maintenance in Pakistan are limited to the two firms. Regarding wheel loader, that manufactured in Japan also prevail with a large share in Pakistan. Procurement of earth machines from Japan would be appropriate for smooth implementation of services by skilled workmen for operation and maintenance as well as for the above reason. Earth machines manufactured in Japan are recommended to be procured consequently.

About a truck trailer, that of approximate capacity of 27-tons manufactured in Japan is recommended, for the reason that truck trailers with its capacity of less than 27-tons class are hard to carry a bulldozer of 27-tons class.

In reference to a four-wheel driven truck with single cabin, that manufactured in Japan is recommended, because though there are manufacturers in Pakistan, the truck made in Japan is cheaper than that of made in Pakistan even including the cost for transportation.

Trolleys, water tanks, tractors with attachment and gabion crates are procurable in Pakistan, then they are recommended to be procured.

The origin of country of the equipment and material to be procured is shown in table 3-1.

3.1.4 Supervision of Implementation Plan

In the detailed design, estimate of the equipment and materials to be procured is reviewed for preparation of the tender documents. Approximately four (4) months would be necessary for detailed design period including site survey, study in Japan and confirmation with the authorities for preparation of tendering and the contract documents, as shown in the schedule for implementation .

For the equipment to be procured from Japan, expert for machine arrangement plan in the study team conducts inspection and tests in the factory of the manufacturers before shipment of the equipment.

For the equipment to be procured in Pakistan, chief consultant of the study team conducts inspection and tests at the interim of manufacturing period.

Upon delivery of the equipment to the designated place, both of the chief consultant and the expert for machine arrangement plan assist the client in executing inspection and tests.

3.1.5 Implementation Plan

The bulldozers and wheel loaders, major machinery for the Project, manufactured in Japan prevail with a large share in Pakistan. Procurement of major construction machinery from Japan is considered to be appropriate, for smooth implementation of services by skilled workmen for operation and maintenance. The construction machinery manufactured in Japan is recommended consequently.

Trolleys, water tanks, tractors with attachment and gabion crates manufactured in local prevail in Pakistan. They are procurable in Pakistan consequently.

Spare parts for heavy machines would cost amount equivalent to 36% to 90% in maximum of a body price of heavy machine varying with their type and working condition during their economic life span. It is estimated that the amount equivalent to 7% of the body price is considered to be procured for the cost of the spare parts in the first two (2) years out of the entire life.

Equipment with driving parts are procured spare parts, such as bulldozer, wheel loader, tractor, trolley, truck trailer, 4 wheel drive truck, concrete mixer, vibrator and generator. Others are not provided spare parts.

Types and quantities of the equipment and material in table 3-1 are recommended to be procured in the Project.

Table-3.1 Procured Equipment and their Number

Equipment	Origin of Country	Number
Bulldozer (24 tons)	Japan	4 units
Bulldozer with ripper (27 tons)	Japan	1 unit
Wheel loader (1.2 m^3)	Japan	1 unit
Truck trailer (30 tons)	Japan	1 unit
4WD truck (2,700 cc)	Pakistan	2 units
Trolley with 78HP tractor with front blade	Pakistan	10 units
Water tank lorry with 48HP tractor	Pakistan	3 units
Portable concrete mixers (0.48m^3)	Pakistan	4 units
Vibratory concrete compactor with generator (D=60mm)	Japan	3 units
Belt conveyor (15m)	Pakistan	3 units
Gabion crate	Pakistan	38,900 PCs
Geotextile filter	Japan	23,520 m^2

Specification of the major machinery to be recommended is as follows:

(1) Bulldozer (24 tons)

1) Operation weight : 24,510 kg
   Engine : 225 HP ~230 HP
   Blade type : straight tilt
   Attachment : with ROPS and without ripper
   Use for excavation, embankment and compacting

2) Operation weight : 27,360 kg
   Engine : 225HP ~230 HP
   Blade type : straight tilt
   Attachment : without ROPS and with ripper
   Use for collection of stone materials

(2) Wheel loader

   Operation weight : 7,640 kg
   Engine : 85 HP
   Bucket : 1.2 m^3
   Attachment : with ROPS
   Use for collection of stone materials

(3) Truck trailer

Load capacity	:	30 tons
Engine	:	320 HP (Diesel engine)

Use for transportation of construction machinery

(4) 4 WD truck

Load capacity	:	350 kg
Engine	:	Diesel engine (2,700 cc)
Attachment	:	single cabin

Use for transportation of mechanics, tools and spare parts

(5) Tractor for trolley

Engine	:	78 HP (Diesel engine)
Attachment	:	trolley of $4m^3$ capacity, front blades

Use for transportation of stone materials

(6) Tractor for water tank lorry

Engine	:	48 HP (Diesel engine)
Attachment	:	water tank lorry of capacity $5m^3$

Use for transportation of water

Specification of the materials to be recommended is as follows:

(1) Gabion crate

Size	:	2.1m x 1.05m x 0.8m
Material	:	Galvanized wire
Opening	:	10 cm

(2) Geotextile filter

Material procurable in local is impermeable plastic plate imported from the United States. Its size is roughly $4m^2$ for one plate, then it needs considerable work for joining plates by glue. As compared with it, material manufactured in Japan is permeable geotextile filter with its size of about $80m^2$ and it is necessary to sew them together, however the work is reduced to 1/20 of the work for another one.

Geotextile filter manufactured in Japan is recommended, due to the lower cost and reduced joining works.

3.1.6 Implementation Schedule

Implementation schedule is shown in table 3-2. Regard to placing geotextile filter, technician is dispatched for guidance of stitching.

(1) Implementation schedule of the Consultant

1) Before contract with a Contractor

Exchange of Notes (E/N)---> Contract with Consultant ---> Detailed design ---> Cost estimate ---> Preparation for tender documents--->Tendering ---> Evaluation of tendering ---> Contract with a contractor

In the period of detailed design, the consultants will perform review of estimate, confirmation in authority's preparation on acceptance and use of the equipment and detailed study on specification for the equipment and materials.

2) After contract with a Contractor

Order for equipment and materials---> Approval of the drawings ---> Inspection and test in the factory ---> Final inspection on the delivery

For the equipment to be procured from Japan, expert for machine arrangement plan in the study team inspects them in a factory before shipment. For the equipment to be procured in Pakistan, chief consultant of the study team inspects at interim of manufacturing period. Upon delivery of the equipment to the designated place, both the chief consultant and expert for machine arrangement plan assist the client in executing inspection and tests.

(2) Implementation schedule of the Contractor

1) For equipment procured in Japan

Ordered ---> Manufacturing (about 4 months) ---> Shipping ---> Custom clearance (about 1 week) ---> Inland transportation (1 week) ---> Fixing ---> Delivery

2) For equipment procured in Pakistan

Ordered ---> Manufacturing ---> Inland transportation ---> Delivery

In this case, it takes about 12 months from E/N to Deliver.

3.1.7 Obligation of the Government of Pakistan

Obligation of GOP is;

- to design appropriate structure for stabilizing alluvial fan,
- to construct the structure using the machines procured by Japan,
- to operate and maintain machines and structures properly with suitable personnel and budget.

Responsible government authority is PID of Punjab. GOP must exempt the Japanese who works for the Project and products made in Japan which need or are included in the Project from custom duties. GOP must prepare funds for construction of the contour bunds including machine operation cost, maintenance cost for the machines, etc., which estimated roughly Rs. 63 million. Its detail is shown in table 3.2. GOP also shall disburse cost for O&M estimated Rs. 0.5 million annually.

Table-3.2 Cost for Construction of Contour Bunds

Items	Unit cost (Rs./m^3)	Quantity (m^3)	Price (Rs. '000)
Machine operation		L.S.	7,080
O&M for machines		L.S.	2,525
Concrete works	3,000	14,431	43,293
Labor cost			
earth work	0.086	2.5 mil.	216
gabion work	95[3]	68,600	6,517
stone pitching	56	17,521	981
geotex. filter placing	0.76	23,520	18
sub total			7,732
Overhead			2,551
Grand total			63,182

Overhead is estimated at 5 % cost of concrete and labor works.

3.2 Operation and Maintenance Plan

The equipment to be procured will be used for construction of the structures in similar projects in other hill torrents, as well as for construction of the contour bunds in the Mithawan fan.

In PID of Punjab, operation and maintenance of heavy equipment is usually task of the mechanical circle stationed in Lahore. The equipment to be procured, however, are used only in the D.G. Khan hill torrents belt , then C.E. Irrigation in D.G. Khan zone shall control them.

3.2.1 Operation and Maintenance Organization

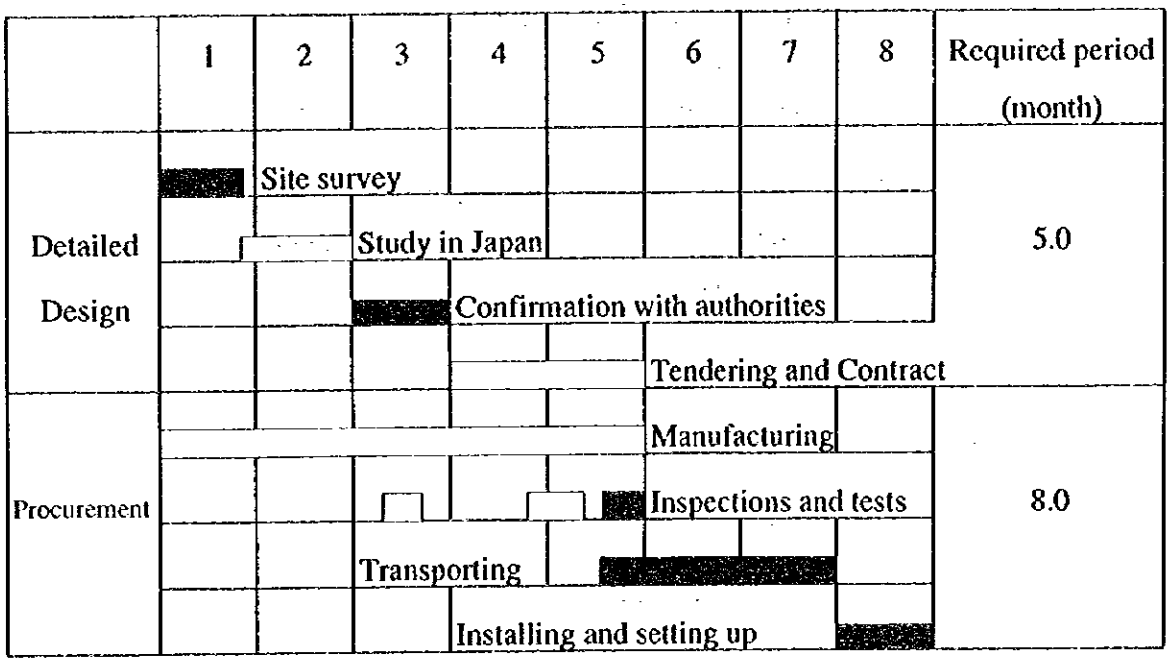
D.G. Khan Irrigation zone has a workshop in Multan which belongs to Northern Tube-well Division (NTWD) of SCARP circle. Regular inspection and maintenance by disassembly will be done at this workshop which is equipped with facilities for maintenance and repair of earth machines. Parking and daily inspections are possible in a garage in D.G. Khan.

3.2.2 Personnel for Operation and Maintenance

The NTWD workshop in Multan was attached section of maintenance and repair for earth machines by USAID assistance in 1987, addition to existed section to repair electric motors, pumps, etc., for tube-wells. The workshop has the personnel of 20 persons as shown in table 2.9, and enough capacity as a workshop.

Further, in D.G. Khan, D.G. Khan Unit of Agriculture has an office and a workshop which manage farm lands in the area, and have eighteen (18) bulldozers and two (2) truck trailers for carrying bulldozers to the site. Most repair works can be done in this workshop and mechanics will come to the site for minor repairs. This workshop consists of seventeen (17) mechanics, nine (9) mechanical engineers and six (6) guards. Emergency repair can be done here.

Fig. 3-1 Procurement Schedule



3.2.3 Cost Estimate for Operation and Maintenance

Estimate for construction of the contour bunds and annual maintenance cost of the equipment are as following.

1) In construction period (two years)

operation cost	Rs. 7,079,893
maintenance cost	Rs. 2,525,498

2) Annual maintenance cost after completion

operation cost	Rs. 405,336
maintenance cost	Rs. 105,229

(1) In construction period

1) Machine operation cost

Unit operation cost for the major machines to be procured is estimated as shown in table 3-3.

Table-3.3 Operation cost of equipment

Item	Cost per hour (Rs.)	Cost per day (Rs.)	Cost per month (Rs.)
Bulldozer (24 tons)	226.08	1,808.64	47,024.64
Bulldozer with ripper (27 tons)	226.08	1,808.64	47,024.64
Wheel Loader (1.2m3)	138.38	1,107.04	28,783.04
Tractor (78HP) with trolley	54.66	437.28	11,369.28
Tractor (48HP) with water tank	44.45	355.60	9,245.60

The costs in table 3.3 are estimated on the condition that each equipment operates 8 hours per day and 26 days per month.

Table-3.4 Cost for Machinery Operation

Item	Quantity	Work hours machine (Hrs.)	Total operation cost (Rs.)
Bulldozer (24 tons)	4	17,480	3,951,878
Bulldozer with ripper (27 tons)	1	2,363	534,227
Wheel Loader (1.2m3)	1	1,203	166,471
Tractor (78HP) with trolley	10	35,729	1,952,947
Tractor (48HP) with water tank	4	10,672	474,370
Total			7,079,893

Total cost for machine operation in the proposed construction works is estimated to Rs 7,079,893 as shown in table 3-4.

2) Maintenance cost

Following items consist maintenance cost.

Maintenance cost -------repair cost ---------- servicing
------ repair
-------other expenses ---------- safekeeping
------ tax
------ insurance

Repair cost is the cost of supporting machinery efficient excluding cost of spare parts. Servicing cost is the cost of regular maintenance works for reducing accidents during works and for recovering lowered efficiency. Repair cost is the cost of repairing troubled machines by accidents during working.

Repair and inspection for the equipment are performed in Multan workshop. Accordingly servicing cost includes transportation of the equipment by the truck trailer from the sites to Multan which is estimated Rs. 18,235 and operation cost of Multan workshop that is estimated Rs. 1,098,235. Repair cost is estimated Rs. 74,514 for travels between Multan and the sites. Safe keeping is Rs. 90,000 as salary for 3 guards. As a result, total maintenance cost in the construction period is estimated Rs. 2,525,498 as shown in table 3-5.

Table-3.5 Maintenance cost in 2-year construction period

Repair cost	Cost (Rs.)
servicing	2,196,470
repair	149,028
Other expenses	
safekeeping	180,000
Total	2,525,498

(2) Annual maintenance cost after completion

Costs of O&M after completion consist of machine operation and its maintenance costs for regular inspection and repair cost of the structure. It is estimated Rs. 510,565 of which break down is shown below.

Duration for regular maintenance work of the structures is expected one month in which every procured equipment are used. In other time except regular maintenance period, all machines are used in other construction works, then required expenses are paid by them. Operation and maintenance cost of the machines in regular maintenance of the structures after completion the work is estimated as in table 3-6.

Table-3.6 Cost for operation and maintenance of machinery after completion

Item	Quantity	Monthly operation cost(Rs.)	Maintenance cost (Rs.)
Bulldozer	4	47,024	188,099
Bulldozer with ripper	1	47,024	47,024
Wheel Loader	1	28,783	28,783
Trolley with Tractor	10	11,369	113,693
Water tank with tractor	4	9,246	27,737
Total			405,336

Machine operation cost in the maintenance period is estimated Rs. 405,336, while maintenance cost of the machines in this period is estimated Rs. 105,229. Addition to this, cement, gabion crates, etc., are necessary if structures are damaged.

CHAPTER 4 PROJECT EVALUATION AND RECOMMENDATION

4.1 Project Effect

4.1.1 Project Effect

GOP will construct structures for stabilizing alluvial fan including contour bunds and distributor, which aims at reduction of flood damage in the canal irrigated areas by enhancing flood irrigation in the Mithawan fan. The contour bunds that is constructed using earth machines procured by Japan's grant aid can store flood flows and stabilize alluvial fan. They shall contribute to support crop production and mitigate flood damage. However channels cannot evade from horizontal shifting without construction of the proposed distributor, contour bunds consequently cannot control more than 10-year flood.

Contour bunds are expected to produce benefits shown below by increase of crop production and decrease of flood damages.

(1) Benefit by increase of crop production	Rs. 2.13 million
(2) Benefit in reduced flood damage	Rs. 16.99 million
Total Benefit	Rs. 19.12 million

(1) Increase of crop production

Jowar and bajra are cultivated as kharif crops, while wheat, gram and oilseeds are as rabi crops in the fan. Area of flood irrigation varies with floods discharge and construction of the contour bunds and the distributor must expand area of flood irrigation. Possible irrigated area by probable floods is shown in table 4.1 after completion of the distributor.

Table-4.1 Irrigated area by probable flood after completion of the project

Return period	Irrigated Area (ha)							
	Kharif			Rabi				Total
	Jowar	Bajra	Total	Wheat	Gram	Oilseed	Total	
5-year	4,056	2,055	6,111	718	223	851	1,792	7,903
10-year	5,196	2,633	7,828	1,259	390	1,493	3,143	10,971
15-year	6,085	3,083	9,168	1,655	516	1,973	4,154	13,322
20-year	7,698	3,901	11,599	2,238	693	2,654	5,586	17,185

Table 4.2 shows crop produce on the basis of expected yield of each crop, 736 kg/ha for jowar, 645 kg/ha for bajra, 554 kg/ha for wheat, 415 kg/ha for gram and 370 kg/ha for oilseed.

Table-4.2 Crop production after completion of the project

Return period	Production (million rupees)					
	Jowar	Bajra	Wheat	Gram	Oilseed	Total
5-year	11.88	9.38	1.49	0.40	2.45	25.61
10-year	15.22	12.02	2.62	0.70	4.29	34.85
15-year	17.83	14.08	3.46	0.92	5.67	41.96
20-year	22.55	17.81	4.65	1.24	7.62	53.88

Using data shown in table 4.1 and 4.2, average annual amount of crop produce is calculated. Completion of both the contour bunds and the distributor would result crop produce Rs. 13.81 million as shown in table 4.3, while with only contour bunds which would control floods lower than 10-year flood, annual crop produce is expected at Rs. 11.25 million.

Table-4.3 Average annual crop produce

Frequency	Produce (Mil. Rs.)	Average Produce (Mil. Rs.)	Frequency Interval	Amount of Produce (Mil. Rs.)
0.9	3.60			
0.8	5.30	4.45	0.1	0.445
0.7	7.20	6.25	0.1	0.625
0.6	9.4	8.30	0.1	0.83
0.5	12.00	10.70	0.1	1.07
0.4	15.10	13.55	0.1	1.36
0.3	19.20	17.15	0.1	1.72
0.2	25.00	22.10	0.1	2.21
0.1	34.90	29.95	0.1	3.00
0.067	41.96	38.43	0.033	1.27
0.04	53.88	47.92	0.027	1.29
TOTAL				13.81

Table 4.4 shows estimate on crop produce in 3 years from 1992 to 1994 based on actual harvested area by crop. Since the Mithawan fan received unusually much water in 1994 by three times of flood, harvest of the year was

extremely good. Average of remained two years are to be regarded annual produce amount at present. Then produce of Rs. 9.12 million is supposed to be average annual amount in the Mithawan fan and increases of produce by constructing contour bunds is estimated Rs. 2.13 million, since expected annual produce is Rs. 11.25 million.

Table-4.4 Crop produce at present

Year	Produce (million rupees)					
	Jowar	Bajra	Wheat	Gram	Oilseed	Total
1992	3.54	4.19	1.64	0.30	0.18	9.85
1993	3.38	3.65	0.77	0.32	0.27	8.38
1994	10.02	11.67	0.93	0.85	0.39	23.85

(2) Reduced Flood Losses

Canal irrigated area by the D. G. Khan canal extends both D. G. Khan district and Rajanpur district. Damage by the flood was estimated by the final report for the 'feasibility study on flood protection in Taunsa-Gudu Reach, Indus river' as shown in table 4.5. In this basic design study, average loss in the two districts used for the basis of estimating flood losses.

Table-4.5 Flood losses in D.G. Khan and Rajanpur districts (Rs./ha)

Area	Direct				Indirect	Total
	Crop	Houses	Roads Railways	Others		
D. G. Khan	5,998	2,440	190	2,590	2,242	13.460
Rajanpur	4,650	2,010	250	2,073	1,797	10,780

Feasibility study for the Mithawan Pilot Project in 1984 estimated about 32,000 ha of inundated area by floods came from hill torrents. A part of flood loss by the Mithawan hill torrent is estimated 35 % of total flood loss, since a percentage of the Mithawan drainage area to the total drainage area of hill torrents affecting the D.G. Khan canal shown in table 4.6, since heavy rains generating flood losses pour simultaneously over the D. G. Khan hill torrent belt.

Table-4.6 Area and peak flood of the hill torrents

Name	Drainage area (square km)	Share of area (%)	Peak flood discharge at 25-year (cumecs)
Sori Lund	520	23	1,500
Vidore	770	35	1,796
Sakhi Sarwar	160	7	739
Mithawan	792	35	2,500
Total	2342	100	

Table 4.7 shows flood losses by probable flood of Mithawan hill torrent.

Table-4.7 Flood losses by probable flood

Return Period	Peak Flood	Area affected	By Mithawan Hill Torrent	
	(cumecs)	(ha)	Area affected (ha)	Losses (mil. Rs)
2	917	1,695	593	7.19
2.5	1,100	5,060	1,771	21,46
3.33	1,257	8,770	3,070	37.20
5	1,658	13,895	4,863	58.94
10	1,952	22,260	7,791	94.43
25	2,500	32,380	11,333	137.36

Reduced losses are estimated Rs. 23.94 million annually as shown in table 4.8 and total reduced loss in 25 years will reach Rs. 598.5 million when both the distributor and the contour bunds are completed. While only with the contour bunds controlling lower than 10-year flood, then reduced loss is expected Rs. 16.99 million.

Table-4.8 Reduced annual flood loss

Frequency	Losses (Mil. Rs.)	Average Losses (Mil. Rs.)	Frequency Interval	Annual Losses (Mil. Rs.)
0.54	0			
0.5	7.19	3.6	0.04	0.14
0.4	21.46	14.33	0.1	1.43
0.3	37.20	29.33	0.1	2.93
0.2	58.94	48.07	0.1	4.81
0.1	94.43	76.69	0.1	7.67
0.04	137.36	115.90	0.06	6.95
TOTAL				23.94

(3) Project effect

The project is evaluated by benefit versus cost as below.

a. Benefit (annual)

Increase crop production	Rs. 2.13 million
Reduced flood loss	Rs. 16.99 million
Total benefit	Rs. 19.12 million

b. Construction cost of contour bunds

GOP expense *	Rs. 63.18 million
Equipment **	Rs. 53.36 million
Material	Rs. 24.23 million
Total construction cost	Rs. 141.77 million

*: Detail of GOP expense shown in Sec. 3.1.7,
**: Equipment cost is allocated here only for construction period of 2 years while its life is 6 years.

c. Operation and Maintenance (annual)

O & M cost	Rs. 0.51 million

Total benefit by construction of the contour bund is estimated Rs. 478 million in 25-year project life. While operation and maintenance cost and total construction cost including price of the equipment and materials procured by Japan's grant aid is Rs. 154 million. When the cost is counted only expenses by Pakistan side, it is estimated Rs. 76 million that is expenditure for construction

and expense for maintenance. It is consequently concluded the project is feasible concerning cost versus benefit.

(3) Benefited population

Population in the Mithawan fan is estimated about 14,000 and all of them will be benefited directly by development of flood irrigation. Number of beneficiaries by reduced flood loss is estimated about 40,000 in canal irrigated area, since affected area is assumed 113 square km at a 25-year flood and 23 houses per square km with average family number of 15.

4.1.2 Feasibility of the Project

The Project area belongs to the area where an alluvial fan is on its process of formation. Frequent shifting of water courses and occurrence of riverbed degradation on the fan have resulted in flood irrigation harmed often, which has left harvest of the flood irrigation farming poorer and the farmers have been suffering from extreme poverty. Flood irrigation farming on the fan that has been maintained by tremendous effort of the local farmers is facing to be ruined by excessive degradation of riverbed, that results destroying environment of life and basis of livelihood of local population, if no measure will be taken. Construction of the contour bunds aiming to stabilize the fan is expected the first step to turn from present deteriorating status into its revival. A long term effort, however, would be required for its betterment since construction of the contour bunds cannot be expected immediate success.

The Project is feasible in terms of cost versus benefit. Besides, local population is able to perform operation and maintenance with their own finance and technique after its completion.

The practices for stabilizing fan and water harvesting in the Project must contribute to enhance carrying capacity in a similar dry region not only in Pakistan but also in Western China, Central Asian and Middle East countries.

By such circumstance, it is worth to support the construction of the structures for stabilizing the fan and achieving sure flood irrigation and it is regarded that the Project will be feasible.

4.2 Technical Cooperation with Other Donors

Financial limitation in Pakistan has curbed to allocate funds for projects which generate minor benefit such as development of hill torrent or conservation projects like disaster prevention. As a result, personnel concerning these kinds of projects are limited, and engineering for these projects has not been paid attention, then engineers have had little interest in this engineering. Though interest in developing depressed rainfed region including hill torrent area has been increasing because national agricultural productivity is decreasing recently, actual activities have not been put into practice yet.

Five-year participatory watershed management project has been implemented in the upper reaches of the Project area as a joint project of JICA and FAO since April in 1995. Local people have established organizations in each village and are working actively to introduce vegetable and fruit growing, to improve irrigation facilities, to establish saving cooperatives, etc. Furthermore, limited grazing on a trial basis and water and soil conservation works on hill slope have been implemented since 1996. The Project in the Mithawan fan is requested to enlighten farmers through such activities done in watershed management project. However, most government organizations in Pakistan have not been enthusiastic about such projects in which local population participates.

Engineering in steep rivers and alluvial fans has not been established in Pakistan, and there are little experience of watershed management with farmers' participation. Cooperation with experienced organizations is essential to enhance the ability in such projects.

4.3 Recommendation

Enormous supply of sediment from its drainage area is forming the Mithawan alluvial fan actively. For stable farming on it, the fan must be kept its variation harmless. Dispersion of flood flows over the fan is the most important by eliminating flow concentration into a specific channel.

GOP will construct the contour bunds on mid-fan in the first phase and the distributor at the fan-head in the succeeding phase using procured equipment and materials. Further, development works in the watershed of the Mithawan hill torrent and other hill torrents will be executed. Since construction of the proposed structures will stabilize alluvial fan, flood irrigation farming on the fan will be enhanced and flood damage of the D.G. Khan canal and in the canal irrigated area will be reduced. Output of the Project consequently materializes enhancement of a living standard of local residents and improves a basis of crop produce. The Project generating these benefits is feasible in above points to apply Japan's grant aid.

PID would be able to maintain and operate the structures properly technically and financially in future. For better operation and maintenance, local irrigator's association, Kamaras, must be involved to it. Since Kamaras have performed operation and maintenance of the flood irrigation facilities by their own funds and efforts for a long time, they have active practical experience in the fan. Transferring responsibility on regular operation and maintenance to Kamara including daily inspection and minor repairs is the best way to maintain the structures in operational status. Involving Kamaras from the planning stage is recommended, and PID must have responsibility to stimulate Kamaras' participation in operation and maintenance and to show the steps splitting the roles between PID and Kamaras.

Improving flood irrigation practice on the fan of the hill torrents helps advancement of water harvesting technique in a dry region. Implementation of the Project is accordingly significant contributing to strengthen a population carrying capacity not only in Pakistan but also in other arid areas on the earth.

APPENDICES

Appendices

1. *Member list of the team*
2. *Proposed Itinerary of the Survey Team*
3. *List of Party Concerned Officers*
4. *Minutes of Discussion*
5. *References*

1. *Members of the Survey Team*

Masayuki WATANABE	Leader	Development Specialist, Institute for International Cooperation, JICA
Yoichi KISHI	Chief Consultant	Nippon Giken Inc.
Hiroei ISHIHARA	Equipment Plan and Cost Estimate	Nippon Giken Inc.

2. *Proposed Itinerary of the Survey Team*

Date	No.	Activities	Movement
Oct. 13 (Mon)	1	Watanabe, Kishi, Ishihara: Narita (12:55)-Islamabad (20.:15)	Arrival at Islamabad
Oct. 14 (Tue)	2	Courtesy Call to JICA office Courtesy Call to Embassy of Japan Courtesy Call and Explanation to Ministry of Water and Power, Federal Flood Commission Islamabad to Lahore	Islamabad Arrival at Lahore
Oct. 15 (Wed)	3	Explanation to Irrigation and Power Department, Punjab Lahore to Islamabad	Lahore Arrival at Islamabad
Oct. 16 (Thu)	4	Joint Meeting at irrigation and Power Department	Islamabad
Oct. 17 (Fri)	5	Signing of Minutes of Meeting Report to JICA Office, Embassy of Japan	Islamabad
Oct. 18 (Sat)	6	Removal: Islamabad to D. G Khan	
Oct. 19 (Sun)	7	Survey Watanabe: D. G Khan - Lahore -	D. G Khan
Oct. 20 (Mon)	8	Watanabe: Bangkok - Bangkok - Manila Kishi, Ishihara: Survey	D. G Khan
Oct. 20 (Mon) to Oct. 26 (Sun)		Survey	D. G Khan
Oct. 27 (Sun)		Survey D. G Khan to Islamabad	D. G Khan
Oct. 28 (Tue)	16	Kishi, Ishihara: Report to JICA Office Islamabad - Lahore -	Arrival at Lahore
Oct. 29 (Wed)	17	-Bangkok - Narita	Arrival at Narita

3. *List of Concerned Officers*

Federal Flood Commission (FFC)

Dr. S. M. Bhutta	Chief Engineering Adviser/ Chairman, Federal Flood Commission, Ministory of Water and Power
Mr. I.B.Sheikh	Chief Engineer (Floods)/ Secretary, Federal Flood Commission

Economic Affairs Division, Ministry of Finance and Economic Affairs (EAD)

Mr. Rashid Mahmood Ansari	Joint Secretary

Irrigation and Power Department, Government of Punjab (I&P)

Mr. Shafqat Masood	Additional Secretary,
Mr. Sheikh Abdul Ali	Deputy Secretary,
Mr. Iftikhar Bhutta	Superintending Engineer, Project Circle, Irrigation Zone, D.G.Khan,

Planning and Development Department, Government of Punjab (P&D)

Mr. Tariq Sultan	Chairman
Mr. Abdul Hafeez	Chief (Water and Power)

Irrigation, D.G.Khan, I&P, Punjab

Chief Engineer, D.G.Khan:	Mr. Muzaffar Hussain
Superintending Engineer, Project Circle:	Mr. Iftikhar Ahmad Butta
Executive Engineer, Construction Division	Mr. Rai Muhammad Amin
Sub Divisional Officer, Construction Division	Mr. Jahanzeb Khan
Sub Divisional Officer, Mechanical Sub-Division, Rajanpur Div.	Mr. Saifullah Sheikh

4. Minutes of Discussions

MINUTES OF DISCUSSIONS

BASIC DESIGN STUDY ON MITHAWAN HILL TORRENT PILOT PROJECT IN THE ISLAMIC REPUBLIC OF PAKISTAN

In response to the request from the Government of Pakistan, the Government of Japan decided to conduct a Basic Design Study for Mithawan Hill Torrent Pilot Project (hereinafter referred to as "the Project") in the Islamic Republic of Pakistan and entrusted the study to the Japan International Cooperation Agency (hereinafter referred to as JICA).

JICA sent to the Islamic Republic of Pakistan a study team (hereinafter referred to as "the Team"), which was headed by Mr. Masayuki Watanabe, Development Specialist, JICA, from 13 October to 28 October, 1997.

The Team held discussions with the officials concerned of the Islamic Republic of Pakistan and conducted a field survey at the proposed project sites.

In the course of the discussions and field survey, the authorities concerned of the Islamic Republic of Pakistan and the Team confirmed the main items described in the attached sheets. The Team will proceed to further studies and prepare the Basic Design Study report.

Islamabad October, 17, 1997

Mr. Masayuki WATANABE
Leader,
Basic Design Study Team,
JICA

Mr. Suleman GHANI
Secretary,
Irrigation and Power Department,
Government of Punjab

Dr. S. M. BHUTTA
Chief Engineering Advisor,
Ministry of Water and Power
Chairman,
Federal Flood Commission

Mr. Rashid Mahmood ANSARI
Joint Secretary,
Economic Affairs Division

ATTACHMENT

1. Objective

The objective of the Project is to assist the Government of Punjab to construct the flood irrigation system including watershed management by providing machinery and construction materials.

2. Project site

The project area is shown in ANNEX I.

3. Executing Organization

(1)Responsible organization

Ministry of Water and Power,
Government of the Islamic Republic of Pakistan

(2)Implementing organization

Irrigation and Power Department,
Government of Punjab.

4. Items requested by the Islamic Republic of Pakistan

After a series of discussion with the Team, the items requested by the Pakistan side are shown in Annex II.

However, the components of the Project will be finalized after the completion of the Basic Design Study.

5. Japan's Grant Aid System

(1) The Pakistan side has understood Japan's Grant Aid system in ANNEX III as explained by the Team.

(2) The Pakistan side will take necessary measures described in ANNEX IV for the smooth implementation of the Project, in the event the grant aid assistance by the Japanese government is extended to the Project.

6. Schedule of the Study

(1) The Team will proceed to further studies in the Islamic Republic of Pakistan until 28 October, 1997.

(2) JICA will complete the final report and send it to the Islamic Republic of Pakistan by the end of February, 1998.

7. Other relevant issues

(1) Pakistan side explained the utilization of gabion for the sake of following ideas;

1) In order to ensure sustainability of a flood irrigation system, engineering structures must be located and designed taking full into account morphologic changes in the channels.

2) In order to attain the above requirement, the above system is comprised of the following components;

a) Consolidation

Cross structures in the reaches from mid fan to fan end will be included in the estimate in order to disperse flood water evenly.

b) Stabilization

At present degradation has been taking place in the upper reaches of certain wahs. For stabilization of above wahs, cross bunds should be included in the estimate to avoid degradation and to help aggradation.

c) Dispersion

Dispersion structure will be constructed at the fan head preventing scouring at the foundation and associated degradation.

3) The watershed management is important to reduce the peak flood and sediment for developing Mithawan hill torrent basin.

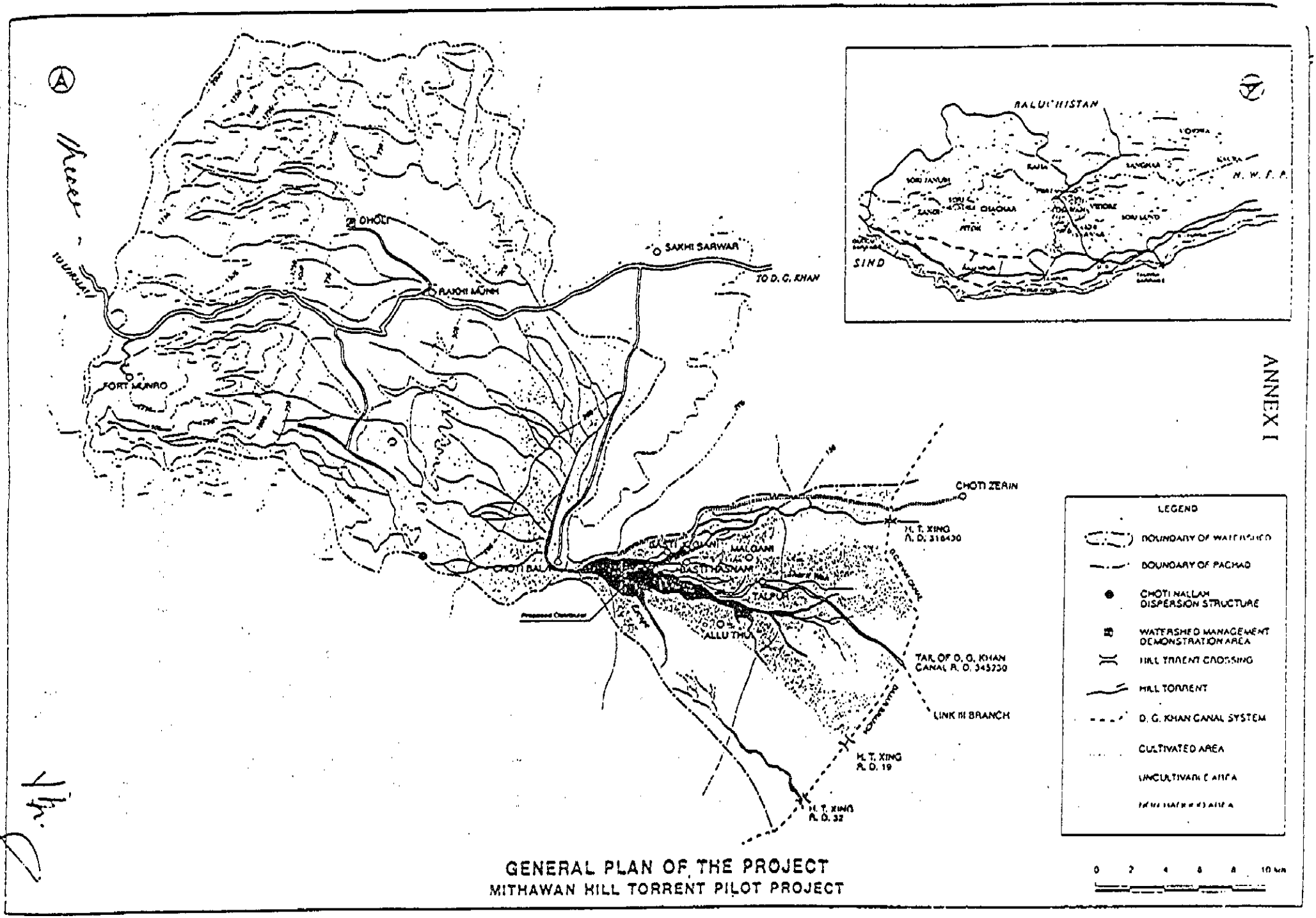
(2) Pakistan side further explained the method of excution as followings;

1)Plan and design of the structures shall be completed by the Irrigation and Power Department, Government of Punjab.

2)Construction of structures shall be completed by the Irrigation and Power Department, Government of Punjab.

3)Maintenance of the structures shall be done by the Irrigation and Power Department, Government of Punjab.

4)Pakistan side shall make necessary measures to prepare the covered parking area for equipment as well as storage facility for the material to be procured by the Project.



GENERAL PLAN OF THE PROJECT
MITHAWAN HILL TORRENT PILOT PROJECT

ANNEX I

A-7

ANNEX II List of Equipment and Materials requested by Pakistan side

Machinery / Equipment	No of units	Specifications
(A) Machinery		
(1) Bulldozers	3	27 tons with rippers
(2) Back hoes	3	0.7 m^3 capacity, with hydraulic breaker
(3) Tractors with trolley	12	
(4) Front end Loaders	3	1.2 to 1.5 m^3 capacity
√(5) Concrete Batching Plant	1	40 to 60 m^3/hr
√(6) Conveyor Belts With Engine	3	
(7) Vibrating Concrete Compactors	6	10 Kg
(8) Water Trolley with Tractor	6	1,000 Gallons
(9) Trailer truck	1	30 tons capacity
√(10) Gabion Manufacturing Machine	1	
(11) Pickups	2	Light 4 by 4 vehicle

(B) Materials

(1) Mild steel wires	1,000 tons.
(2) Geo-membrane	17,000 sq. m
(3) Reinforcement bars	450 tons

Notes; Kinds and numbers of machinery and materials shall be decided in the Basic Design Study.

Annex III Japan's Grant Aid Scheme

1 Grant Aid Procedures

1) Japan's Grant Aid program is executed through the following procedures.

Application	(Request made by a recipient country)
Study	(Basic Design Study conducted by JICA)
Appraisal & Approval	(Appraisal by the Government of Japan and Approval by Cabinet)
Determination of Implementation	(The Notes exchanged between the Governments of Japan and the recipient country)

2) Firstly, the application or request for a Grant Aid project submitted by a recipient country is examined by the Government of Japan (the Ministry of Foreign Affairs) to determine whether or not it is eligible for Grant Aid. If the request is deemed appropriate, the government of Japan assigns JICA (Japan International Cooperation Agency) to conduct a study on the request.

Secondly, JICA conducts the study (Basic Design Study), using (a) Japanese consulting firm (s).

Thirdly, the government of Japan appraises the project to see whether or not it is suitable for Japan's Grant Aid program, based on the Basic Design Study report prepared by JICA, and the results are then submitted to the Cabinet for approval.

Fourthly, the project, once approved by the Cabinet, becomes official with the Exchange of Notes signed by the Governments of Japan and the recipient country.

Finally, for the implementation of the project, JICA assists the recipient country in such matters as preparing tenders, contracts and so on.

2 Basic Design Study

1) Contents of the Study

The aim of the Basic Design Study (hereafter referred to as "the Study"), conducted by JICA on a requested project (hereafter referred to as "the Project") is to provide a basic

ANNEX IV Necessary Measures to be taken by the Islamic Republic of Pakistan

Necessary measures to be taken by the Islamic Republic of Pakistan on condition that Japan's Grant Aid is executed;

1. To secure land necessary for sites of the project, prior to the construction of the facilities.

2. To ensure all expanses and prompt execution for unloading, customs clearance at the port/airport of disembarkation and international transportation of the products purchased under the Grant Aid.

3. To exempt Japanese nationals from customs duties, international taxes and other fiscal levies which will be imposed in the recipient country with respect to the products and services under the verified contract.

4. To accord Japanese nationals, whose services may be required in connection with the supply of products and the services under the verified contracts, such facilities as may be necessary for their entry into the Islamic Republic of Pakistan and stay therein for the execution of the Project.

5. The Islamic Republic of Pakistan is required to maintain and use the facilities constructed under the Grant Aid properly and effectively and to assign staff necessary for this operation and maintenance as well as to bear all the expenses other than those covered by the Grant Aid.

6. The products purchased under the Grant Aid shroud not be re-exported from the Islamic Republic of Pakistan.

7. To bear advising commission of Authorization to Pay (A/P) and payment commission to a Japanese foreign bank for the banking services based on the banking arrangement.

Annex V

List of Participants

Federal Flood Commission	
Dr. S.M.Bhutta	Chief Engineering Adviser/ Chairman, Federal Flood Commission Ministry of Water and Power
Mr. I.B.Sheikh	Chief Engineer (Floods)/ Secretary, Federal Flood Commission
Economic Affairs Division	
Mr. Rashid Mahmood Ansari	Joint Secretary
Irrigation and Power Department Government of Punjab	
Mr. Shafqat Masood	Additional Secretary
Mr. Sheikh Abdul Ali	Deputy Secretary
Mr. Iftikhar Bhutta	Superintending Engineer Project Circle,Irrig: Zone, D.G.Khan
Planning and Development Department Government of Punjab	
Mr. Tariq Sultan	Chairman
Mr. Abdul Hafeez	Chief (Water & Power)
Basic Design Study Team	
Mr. Masayuki Watanabe	Leader, JICA
Mr. Yoichi Kishi	Chief Consultant Flood
Mr. Horoei Ishihara	Equipment plan and cost estimate,
JICA Pakistan Office	
Mr. Noriaki Nagatomo	Deputy Resident Representative

5. References

GOVERNMENT OF THE PUNJAB
IRRIGATION & POWER DEPARTMENT

ESTIMATE
OF

Constructing Mithawan Distributor Near Choti Bala

Project Circle D.G.Khan
D.G.Khan Irrigation Zone D.G.Khan

REPORT

CONSTRUCTING MITHAWAN DISTRIBUTOR

BACKGROUND

Mithawan Hill Torrent is one out of thirteen major Hill Torrents emerging out from Koh Suleman range located towards west of DGKhan and Rajanpur Districts. The total water shed of Mithawan Hill Torrent is about 741 square kilometre. Most of the part of this watershed consists of denuded mountains with a little or no vegetation cover. The slope of the off shoots of all water carrying channels are very steep. There is lot of erosion and sediment movement during the rain fall season. Rain fall is erratic and mostly concentrated in monsoon season. When the hill torrent emerges out of Koh Suleman range; it enters into the fan area called PACHAD. The livelihood of residents of PACHAD is dependent on the effective utilization of flood water from the watershed of Mithawan hill torrent. They have their own Kamara system (Water User Association) responsible for control and usage of water. The water rights are established on the theory of first come first serve basis. The upper riparians use the first freshet and after full filling their demand; the water is allowed to the next user and so on.

TECHNICAL ASPECTS

As the flood water enters in PACHAD, it is fanned out in different directions. The fan area is still under formation stage and no defined water routs are available. Due to sediment movement and deposition in the fan area; the water routs are changed. The local inhabitants can use the water for irrigation if it is passing near by them. If the flood water has changed its course they usually remain dry and can not grow their crops for livelihood. At the proposed site of construction of distribution structure, the Mithawan hill torrent is sub divided into three branches. One on left side, second on right side and third in the middle. Left sided and middle one have water rights; whereas the right side branch works as escape channel in

case of excessive flood. Because the flood water changes its routes due to sediment movement and deposition; therefore all the above branches can not draw water according to their share. In one year if the water is flowing in left branch; next year may flow either in middle one or escape. To avoid this phenomenon a distribution structure has been proposed to divert water according to the requirement of local inhabitants. Long divide walls down stream of the weir have been proposed to avoid any chance of intermixing of branches further down stream (Figure - 1). Crest level of weir for left side and middle have been kept 2.8 ft. lower than the crest level of escape (figure - 2). By this arrangement the high flood will be distributed equally in three branches; but upto 10,000 Cusec it will only flow into left branch and middle one. The weir has been proposed to be placed and constructed one the alluvial strata. To avoid any damage to weir structure on down stream side due to scouring a stilling basin has been provided upto 60 ft. length. Down stream of stilling basin is placed on R.C.C. 100 ft. deep piles placed 60 ft apart. A 10 ft deep and 2 ft. wide self supported R.C.C. beam have been placed on the top of piles through out the whole length of the weir. This beam has been tied and connected at 120 ft. interval with the help of R.C.C. beams (2 ft. deep, 2 ft. wide and 64 ft. long) to R.C.C. beam 12.5 ft. deep and 2 ft. thick placed on the top of piles (50 ft. deep and 2 ft. diameter) at 60 ft. interval just sown stream of flexible gabion weir. The top of gabion weir has been grouted with concrete to avoid steeling of wire and misplacement of stones. In between these two rows of R.C.C. piles the bed of stilling basin consisting of 2 rows of gabion and covered with grouted concrete has been provided to avoid any movement of stone during passing of floods. It has been experienced that stones refix their position during floods and usually the gabion become loose and need refilling. Hence concrete grouting has been provided to avoid this phenomenon and geo-membrane beneath the gabions to avoid movement of sand particles have also been provided. Down stream of stilling basin, gabions in a length of 60 ft. have beam placed over a geo-membrane. The geo-membrane will help against scouring beneath the gabions due to flood water passing over and in the gabions. Upto a certain length divide walls have been provided totally with gabions to avoid any damage due to concentration of flow of flood. After that when the flood water is expanded in a wider sheet, a simple earthen embankment with pitching is proposed. The embankment of the weir have been pitched gabion to protect against side erosion.

ESTIMATED COST OF WORK

With above said technica' provisions, the details have been worked out and are based on the enclosed drawings. Th: rates are prevailing market rates and subject to escalation in future. The details of quantities, rates and costs are as under.

Sr. No	Item of Work	Quantity	Unit	Rate (Rs.)	Amount (Rs.)
1.	Earth Work	221262	cum	21	4646502.00
2.	Stone Work	67276	cum	441	29668716.00
3.	Gabion	29024	no.	1625	47164000.00
4.	R.C.C	2303	cum	3200	7369600.00
5.	P.C.C	7329	cum	2500	18322500.00
6.	Piles	1280	m	6562	8399360.00
7.	Geo-membrane	16723	sq.m	1200	20067600.00
8.	Reinforcement bars	450	Ton	35000	15750000.00
	Total:				151388278.00

In the above woks, materials such as gabion crates. geo-membrane, cement, reinforcement bars and stone share more than 90% of total cost. We would like to request procuring wires for gabion crates, geo-membrane, cement, reinforcement bars.

1	Mild steel wires	3.22 mm	4.000	Tons
2	Geo-membrane	2 mm,impermeable	17.000	sq.m
3	Cement	50 Kg.	60.000	Sacks
4	Reinforcement		450	Tons

The above works must complete within 6 months, Present manual stone collection works cannot supply the required quantity, so that machine woks, using back-hoes. front-end loaders and dump trucks, shall be introduced. And also for concrete works. we would like to request concrete batching plant and equipment for concreting. Below is the list of required machinery and equipment.

MACHINERY AND EQUIPMENT REQUIREMENT

Sr. No.	NAME OF MACHINERY/EQUIPMENT	No. OF UNITS REQUIRED	SPECIFICATIONS
1.	Bulldozers	4	18 - 20 Tons
2.	Back hoes	4	1 M^3 capacity
3.	Rear Dumps Trucks	6	50 Tons
4.	Front end Loaders	2	2 M^3 capacity
5.	Vibrating Sheep Foot Roller (Compactor)	2	20 Tons
6.	Concrete Batching Plant	3	4 M^3 capacity
7.	Transit Concrete Mixers Mounted on Trucks	3	4 M^3 capacity
8.	Conveyor Belts With Engines	3	
9.	Vibrating Concrete Compactors With Generators	6	10 Kg.
10.	Water Trucks With Pressure Sprinkling System	10	1000 Gallons.
11.	Truck Mounted Drilling Machines With Bits & Casings	2	2 Ft. - 3 Ft.
12.	Gabion Manufacturing Machine	1	4" , 6" and 8" mesh gabbions
13.	Toyota Pickups	4	4 x 4, double cab

The machinery and equipment will be operated and maintained by a mechanical division of irrigation department which is already equipped with repair arrangements. The cost of repair and operation will be charged to works on which the machinery will be deployed. It is pertinent to mention here that this machinery/equipment will be deployed on several other project beside Mithawan project. The other projects to be executed for development of irrigation are proposed on the following hill torrents.

1 - Sori Lund hill torrent.
2 - Sakhi Sarwar hill torrent.
3 - Sanghar hill torrent.
4 - Chachar hill torrent.
5 - For maintenance of already constructed projects on Kaha and Vidore hill torrents.
6 - On the works of Water Shed Management in Mithawan hill torrent Watershed

OPERATION AND MAINTENENCE

The repair and maintenance of gabbions placed along the embankments, divide walls and down stream of stilling basin will be needed. Similarly repair to earthen embankment and pitching along them will be required annually or when needed. The whole cost involves for repair of the structure has been estimated on the bases of 2% of original cost and it comes out to be Rs. two millions. The project circle of irrigation and power department is responsible for repair and maintenance of structures on receipt of funds from irrigation department.

The staff of the project circle will form a body in collaboration with existing Kamaras (Water User Associations) for better utilization of flood water. The existing Kamaras are responsible to control and irrigate their lands from the floods in hill torrents.

Executive Engineer,
Construction Division (Irrig.)

Superintending Engineer,
Project Circle, DGKhan.

ESTIMATES

CONSTRUCTING MITHAWAN DISTRIBUTOR

CONSTRUCTION COSTS

Structure	Earth Work cu.m	Stone Work cu.m	Gabbion cu.m	R.C.C. 1:2:4 cu.m	Reinfored Bars Ton	P.C.C. 1:2:4 cu.m	Piles m	Geomem-brane sq.m
A - Main Weir	15730	627	4601			767		
B - Stilling Basin	26708		13355	2303	400	6561		8361
C - Foundation					50		1280	
D - Protection	6677		6679					8361
E - Left & Right Dikes	35089	1660	9871					
F - Right Dike u/s Hadwali	39441	2160	1334					
G - Separating Dike (W/Gabbion)	5026		8180					
H - Separating Dike (Earthen)	92592	11632	7179					
T o t a l	221262	16079	51198	2303	450	7328	1280	16723
Unit Cost (Rs/m3,m2,m)	21	441	1362	3200	35000	2500	6562	1200
Amounts	4,646,504	7,090,839	69,732,134	7,369,600	15,750,000	18,322,500	8,400,410	20,067,048
Shares (%)	3.07	4.68	46.06	4.87	10.40	12.10	5.55	13.26
Total (Rs.)	151,379,035							

A – 20

Material Statement

Concrete Volume	9631	cu m
Earth Work	221262	cu.m
Stone Work	67277	cu m
Gabbions	29024	No.
Geo-membrane	16723	sq m
Reinforcement Bars	450	Ton

Sub Divisional Officer
Taunsa Construction Sub Division
Dera Ghazi Khan

Sub Divisional Officer
Executive Engineer
Construction Sub Division
Construction Division (Irrig.)
Divisional Taunsa
Dera Ghazi Khan.

Superintending Engineer
Project Circle
Dera Ghazi Khan

CONSTRUCTING MITHAWAN DISTRIBUTOR

ABSTRACT OF QUANTITIES

Sr. No.	Structure	Earth Work cu.m	Stone Work cu.m	Gabbion No.	Conc: 1:2:4 Reinforced cu.m	Conc: 1:2:4 Plain cu.m	Piles m	Geomem-brane sq.m
1.	Main Weir	15730	5228	2608		767		
2.	Stiling Basin	26708	13355	7571	2303	6562		8361
4.	Foundation						1280	
5.	D/S Protection	6677	6677	3786				8361
6.	Left & Right Dikes	35089	11532	5596				
7.	Right Dike u/s Hadwali	39441	3493	756				
8.	Separating Dike (Gabbion Str.)	5026	8179	4637				
9.	Separating Dike (Earthen Sect.)	92592	18812	4070				
	T o t a l :	221262	67276	29024	2303	7329	1280	16723

Sub Divisional Officer
Taunsa Construction Sub Division
Dera Ghazi Khan

Superintending Engineer
Proect Circle
Dera Ghazi Khan

CONSTRUCTING MITHAWAN DISTRIBUTOR

ABSTRACT OF QUANTITIES

Sr. No.	Structure	Earth Work Cft.	Stone Work Cft.	Gabbion No.	Conc: 1:2:4 Reinforced Cft.	Conc: 1:2:4 Plain Cft.	Piles Lft.	Geomem-brane Sft.
1.	Main Weir	555517	184621	2608		27078		
2.	Stiling Basin	943200	471600	7571	83353	231713		90000
4.	Foundation						4200	
5.	D/S Protection	235800	235800	3786				90000
6.	Left & Right Dikes	1239183	407210	5596				
7.	Right Dike u/s Hadwali	1392876	123375	756				
8.	Separating Dike (Gabbion Str.)	177514	288829	4637				
9.	Separating Dike (Earthen Sect.)	3269941	664280	4070				
	T o t a l :	7814031	2375715	29024	83353	258791	4200	180000

Sub Divisional Officer
Taunsa Construction Sub Division
Dera Ghazi Khan

Executive Engineer,
Construction Division (Irrig.)
Dera Ghazi Khan

CONSTRUCTING MITHAWAN DISTRIBUTOR

DETAIL OF QUANTITIES

A- MAIN WEIR Length = 1500 Ft.

1. **Earth Work**

$$\frac{20.78 + 43.74}{2} \times 11.5 = 370.34 \text{ Sft.}$$

Contents 370.3 x 1500 = 555517 Cft.

2. **Bajjri**

1500 x 14.77 x 1 = 22155 Cft.

3. **Gabbions**

First Step	13.78 x	2.62 x	1500	=	54155 Cft.
First Step	10.34 x	5.24 x	1500	=	81272 Cft.
First Step	6.88 x	2.62 x	1500	=	27038 Cft.
			Total	=	162466 Cft.

Contents of one Gabbion = 62.29

Number of Gabbions = 2608 No.

4. **Concrete 1 : 2: 4 Plain**

1500 x 6.89 x 2.62 = 27078 Cft.

B- STILLING BASIN

1. **Earth Work**

1500 x 60 x 10.5 = 943200 Cft.

2. **Concrete 1:2:4 Reinforced**

Beam U/S	=		1500 x	13.1	x	2.00	=	39300 Cft
Beam D/S	=		1500 x	10.49	x	2.00	=	31470 Cft
End Beams	=	2 x	120 x	17.7	x	2.00	=	8496 Cft
X-Beams	=	13 x	60 x	2.62	x	2.00	=	4087 Cft
						Total	=	83353 Cft

3. **Concrete 1:2: 4 Plain**

1474 x 60 x 2.62 = 231713 Cft

4. **Gabbions**

1500 x 5.24 x 60 = 471600 Cft.

Contents of one Gabbion = 62.29

Number of Gabbions = 7571 No.

6. **Geo membrane**

1500 x 60 = 90000 Sft.

C - FOUNDATION

1. Piles

28 x 50 = 1400 Lft.
28 x 100 = 2800 Lft.
Total : = 4200 Lft.
R.C.C = 13188 Cft

D- D/S PROTECTION

1. Earth Work

1500 x 60 x 2.62 = 235800 Cft.

2. Gabbions

1500 x 2.62 x 60 = 235800 Cft.

Contents of one Gabbion = 62.29

Number of Gabbions = 3786 No.

3. Geo membrane

1500 x 60 = 90000 Sft.

E- LEFT AND RIGHT DIKES

Left Dike = 2200
Right Dike = 1650
Total = 3850

1. Earth Work

i) $\frac{8.72 + 47.44}{2} \times 10 = 280.80$ Sft.

ii) $\frac{10.88 + 14.16}{2} \times 3.28 = 41.07$ Sft.

Total = 321.866 Sft.
321.9 x 3850 = 1239183 Cft

2. Gabbions

$\frac{3850}{3.44} = 1119.19$ No.

1119.186 x 5 = 5595.93 No.

3. Bajjri

3850 x 30.46 0.5 = 58635.5 Cft.

F- RIGHT DIKE U/S HADWALI

1. Earth Work

i) $\frac{15 + 73}{2} \times 11.6 = 510.40$ Sft.

ii) $\frac{4.44 + 11}{2} \times 3.28 = 25.32$ Sft.

Total = 535.722 Sft.
535.7 x 2600 = 1392876 Cft

2. Gabbions

$$\frac{2600}{3.44} = 755.814 \text{ No.}$$

3. Stone Work

2600 x 14.67 x 2 = 76284 Cft

G- SEPARATING DIKE (GABBION STRUCTURE)

1. Earth Work

$$\frac{23.78 + 30.34}{2} \times 3.3 = 88.76 \text{ Sft.}$$

88.76 x 2000 = 177514 Cft

2. Gabbions

First Step	13.78	x	5.24 x	2000	=	144414 Cft.
First Step	10.34	x	5.24 x	2000	=	108363 Cft.
First Step	6.88	x	2.62 x	2000	=	36051 Cft.
				Total	=	288829 Cft.

Contents of one Gabbion = 62.29 Cft.
Number of Gabbions = 4637 No.

H- SEPARATING DIKE (EARTHEN SECTION)

1. Earth Work

i) $\frac{15 + 59.64}{2} \times 11.2 = 416.49$ Sft.

ii) $\frac{4.44 + 11}{2} \times 3.28 = 25.32$ Sft.

25.32 x 2 = 50.6432 sFT
Total = 467.13 Sft.
467.1 x 7000 = 3269941 Cft

2. Gabbions

$$\frac{14000}{3.44} = 4069.77 \text{ No.}$$

3. Stone Work

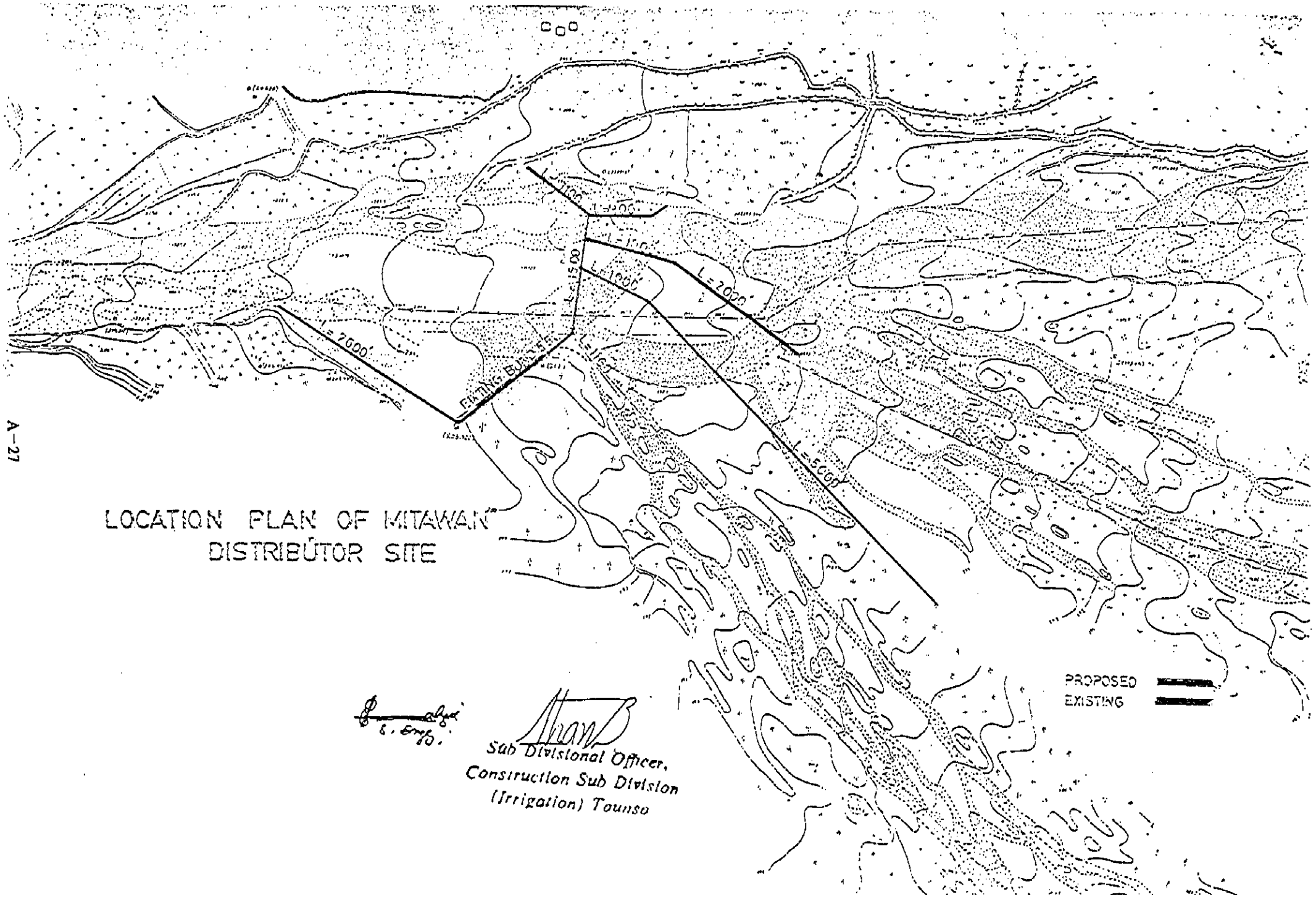
14000 x 14.67 x 2 = 410760 Cft

Sub Divisional Officer
Taunsa Construction Sub Division
Dera Ghazi Khan

PLANS

&

DRAWINGS



LOCATION PLAN OF MITAWAN DISTRIBUTOR SITE

Sub Divisional Officer,
Construction Sub Division
(Irrigation) Tounsa

Fig. 2

SECTION AT CC

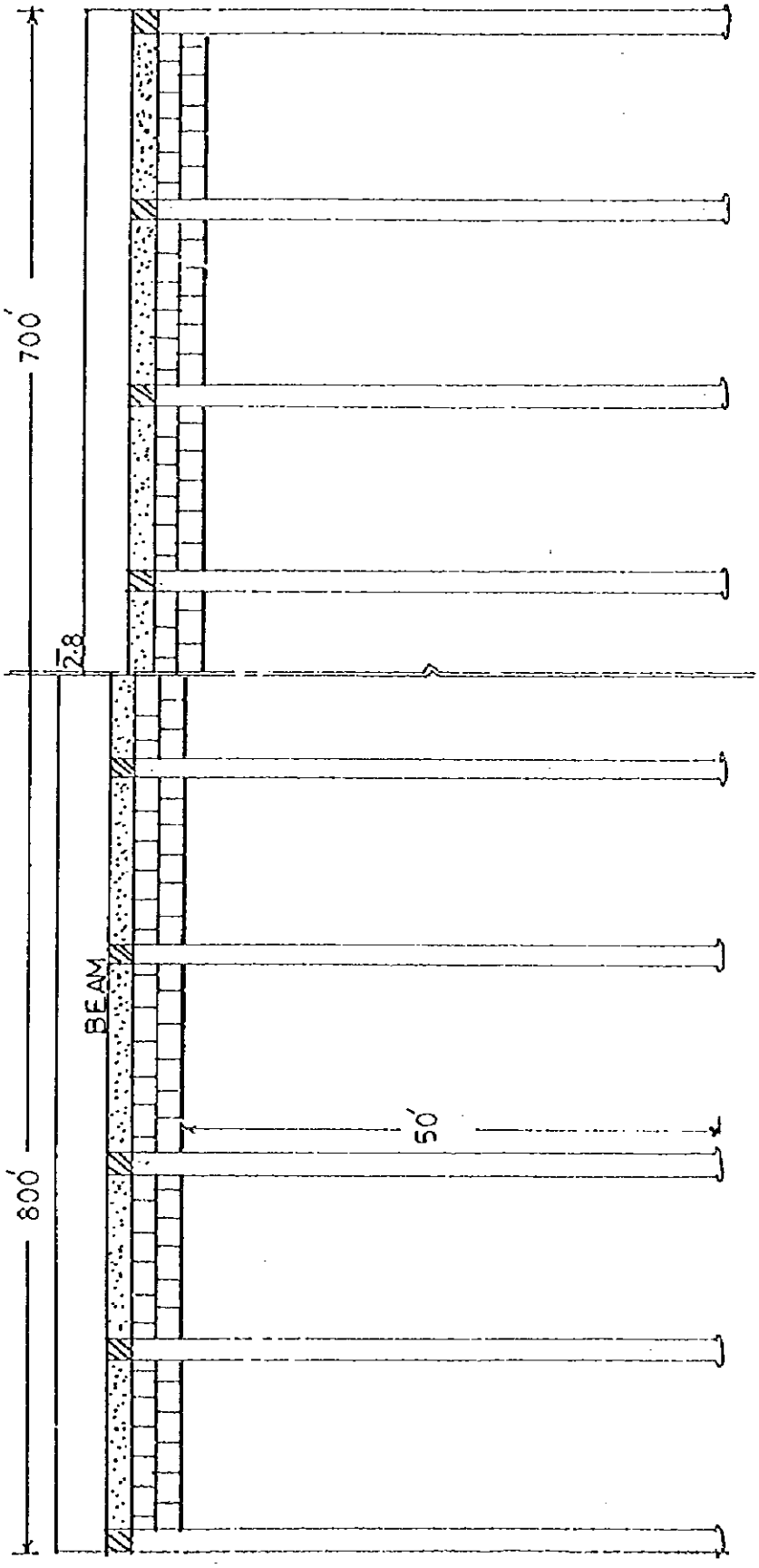


Fig 3

SECTION AT AA

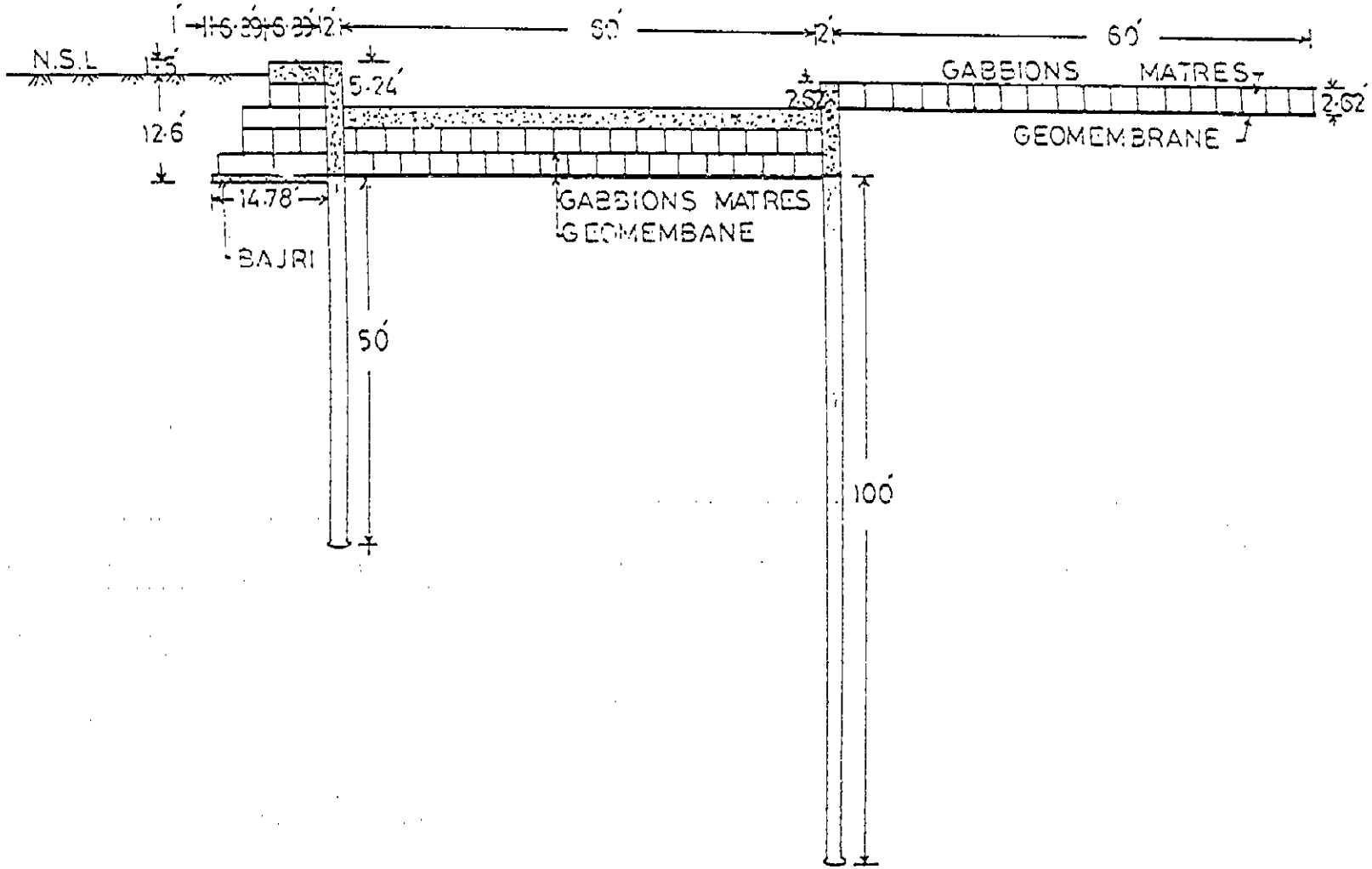
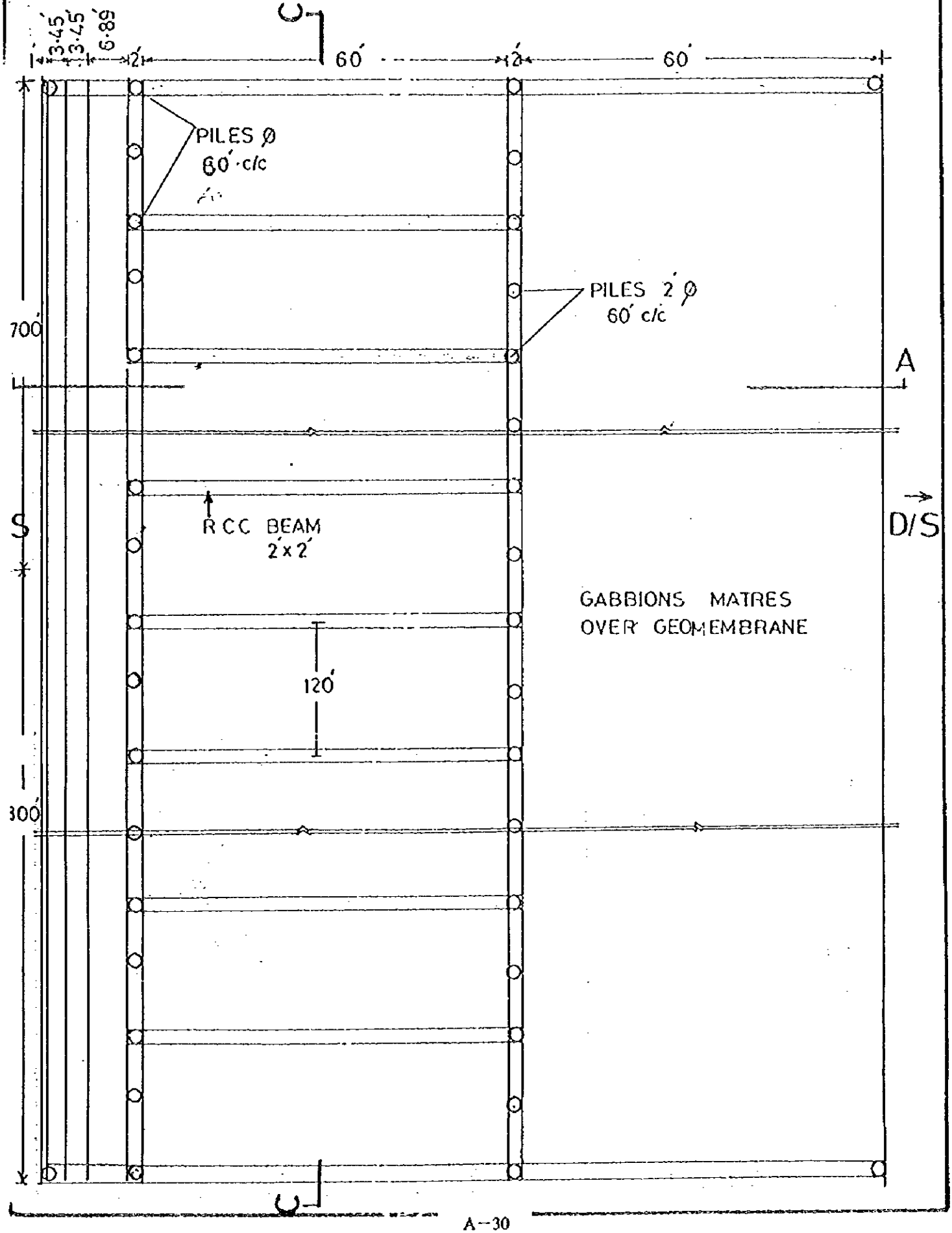


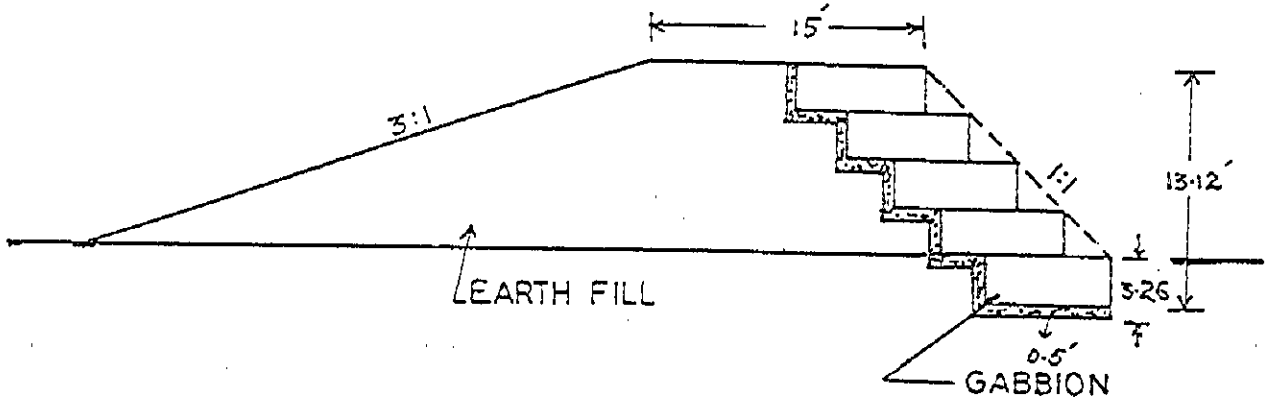
Fig: 4

PLAN OF MITHAWAN DISTRIBUTOR



TYPICAL X - SECTION OF LEFT & RIGHT DIKES

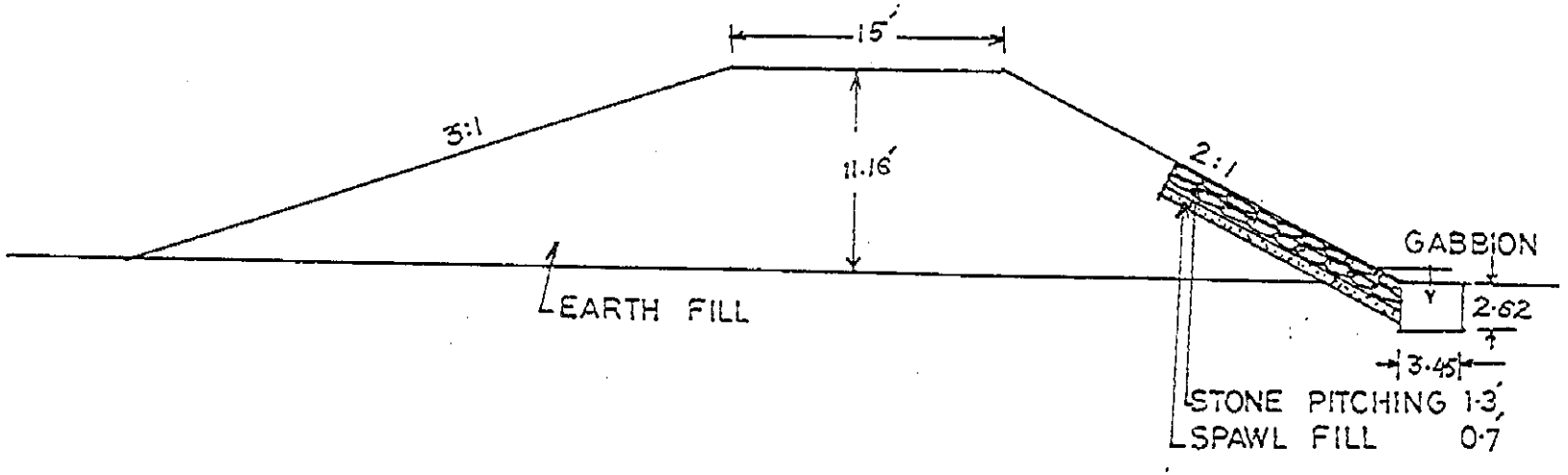
LENGTH = 3850'



Sub Divisional Officer,
Construction Sub Division
(Irrigation) Taunsa

TYPICAL X – SECTION OF RIGHT DIKE (U/S HADWALI BUND)

LENGTH = 2600'



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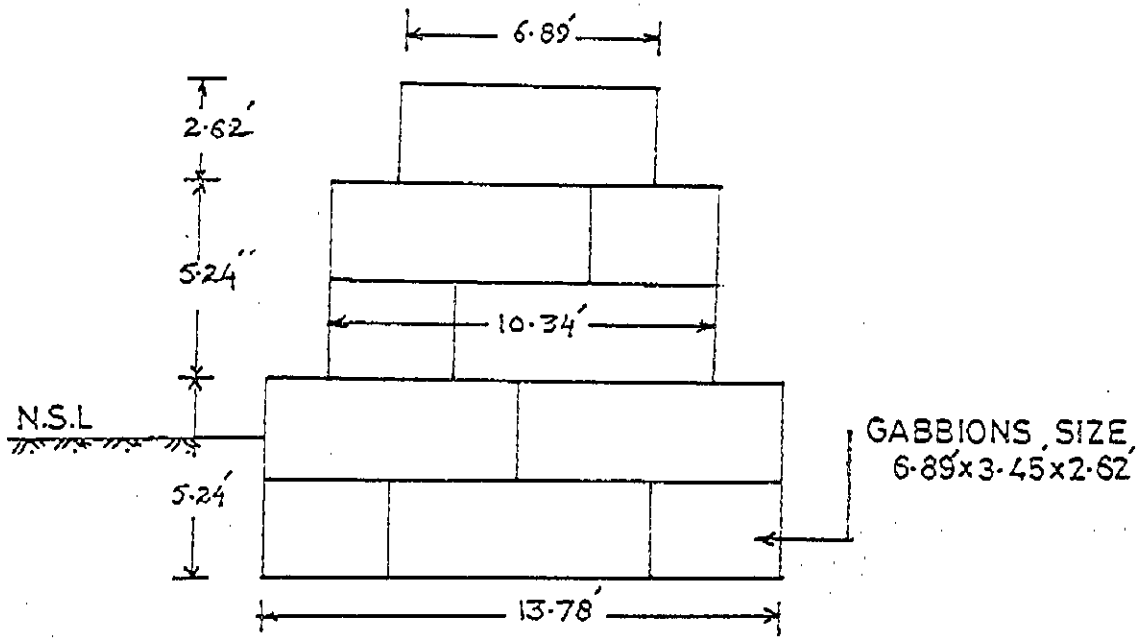
Construction Sub Division
(Irrigation) Taunsa

TYPICAL X — SECTION OF SEPARATING DIKE
(GABBION STRUCTURE)
LENGTH = 2000'



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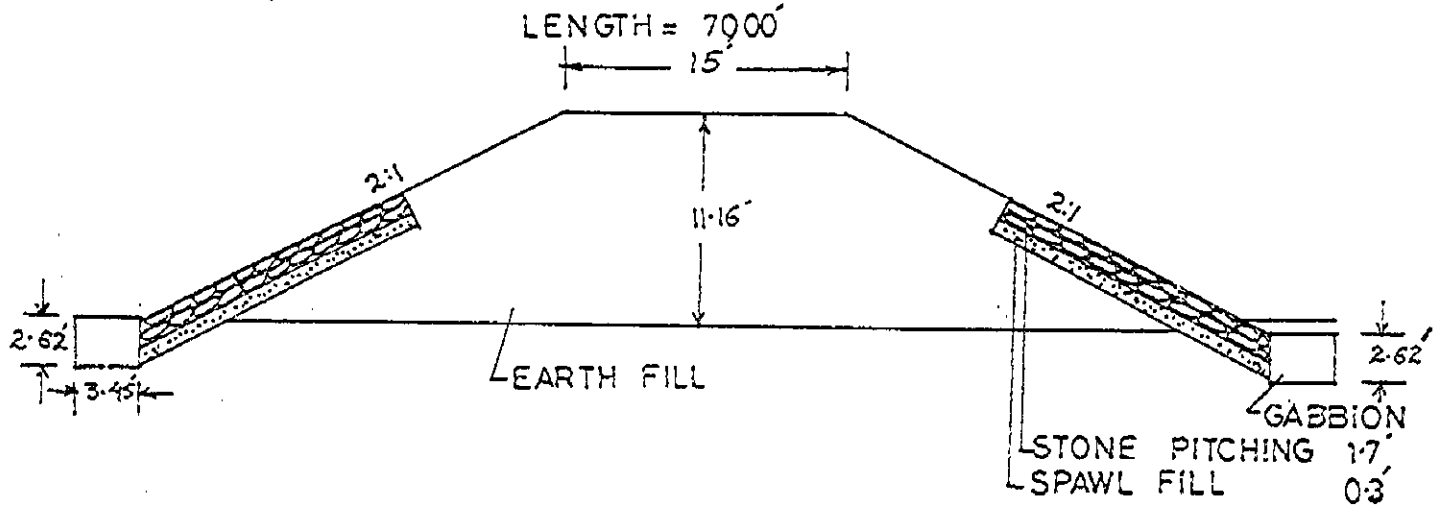
Construction Sub Division
(Irrigation) Taunsa

TYPICAL X - SECTION OF SEPARATING DIKE
(EARTHEN PORTION)



6.09.

Sub Divisional Officer.
Construction Sub Division
(Irrigation) Tounsa

JICA