Channels - 3 : drainage area (M3), discharge (Q3)

Note: Channel - 3 is a channel below the junction
Therefore, M3 = M1 + M2

1. When the drainage area of one of the upstream channels is 40 to 50% of the total area, determining the discharge of the channel - 3 by adding the discharges above the junction.

   Therefore ; $Q3 = Q1 + Q2$

2. When the drainage area of one of the upstream channels is less than 20% of the total area, determining the discharge of the channel - 3 by the drainage equation with the total area.

   Therefore ; $Q3 = C\ M3^{5/6}$

3. When the drainage area of one of the upstream channels is 20 to 40% of the total area, determining the discharge of channel - 3 by the proportion of the discharges obtained by method 1 at 20% and by method 2 at 40%. (details are Appendix B. 3. 6. 3(2))

   Generally ; $C\ M3^{5/6} < Q3 < Q1 + Q2$

2) Sub-surface Drainage Rate

Sub-surface drainage rate is estimated under the climatic conditions in November, that the temperature is not low as winter and the berseem has grown up.

5 - day rainfall (1/10 - year)	:	212 mm	
Percolation	:	21 mm	(4.2 mm/day)
Deep percolation	:	10 mm	(2.0 mm/day)
Required drainage rate	:	11 mm	(2.2 mm/day)
in case with farming drainage	:	4 mm	(0.8 mm/day)

(4) Sub-surface Drainage Method and Areas

As shown in the Figure 4. 4 - 6, the Project Area is divided into two primary areas from a viewpoint of the existing sub-surface drainage condition, that are the well-drained area and the poorly-drained area. In the well-drained area, groundwater is kept sufficiently lower and sub-surface drainage is not necessary.

1) Depth of the Terminal Drainage Ditch

In the land consolidation area, the depth of drainage ditch is different by the existing sub-surface drainage condition, that the depth of 0.60 m for the well-drained area and the depth of 1.0 m for the poorly-drained area.

2) Sub-surface Drainage Method and Equations for Analysis

Sub-surface drainage is proposed to introduce the tile system. The Ellipse Equation and the Modified Ellipse Equation have been applied for analysis. (Reference DR - 1)

The Ellipse Equation is applied when the impermeable layer is located at sufficient depth from the field surface, and the Modified Ellipse Equation is applied when shallow. The Modified Ellipse Equation is solved with a monograph which counts the equivalent depth from the drain to the impermeable layer defined by Hooghoudt. (Details are in Appendix B. 3. 7)

3) Areas by Sub-surface Drainage Systems

The Project Area is divided primarily into two areas by existing conditions; the well-drained area and the poorly-drained area. The on-farm drainage ditches are provided with the depths of 0.60 m in the well-drained area and of 1.0 m in the poorly-drained area. The poorly-drained area is divided further into 5 areas according to the sub-surface drainage systems which are necessary to be introduced to accommodate the existing difficulties of soils and groundwater. The sub-surface drainage system of the poorly-drained area consists of the areas with tile drainage or without, and the areas with farming drainage or without. Consequently, the Project Area is divided totally into 6 sub-surface drainage systems. The areas of tile drainage system (Area - 3 to 5 in Table below) count 24,100 ha, equivalent to 32% of the entire area.

The area distribution of the sub-surface drainage systems is shown in the Figure 4. 4 - 6. The Table below shows the district-wide areas by the sub-surface drainage systems;

District-wide Areas by the Sub-surface Drainage System

Sub-surface Drainage System	Div.	Haraz		Amol		Total	Remarks
		West	East	West	East		
Well-Drainage Area	(0)	6,213	7,699	0	0	13,912	
Open Drainage Area	(1)	0	0	4,106	1,180	5,286	
Tile Drainage Area (70 m space)	(2)	2,595	7,922	10,745	10,116	31,378	with F.D
Tile Drainage Area (70 m space)	(3)	1,872	3,044	2,612	7,935	15,463	
Tile Drainage Area (70 m space)	(4)	0	4,033	0	1,925	5,958	with F.D
Tile Drainage Area (30 m space)	(5)	0	1,307	0	1,372	2,679	
Non-Subsurface Drainage Area	(6)	0	0	0	1,309	1,309	
Total		10,680	24,005	17,463	23,837	75,985	

Note:
1. Sub-district-wide areas are described in the the Table 4. 4 - 1.
2. In the non-subsurface drainage area, groundwater is hardly controlled due to difficulty in the lower elevation.
3. F.D. : Farming drainage.

4. 4. 8 River Training Plan

(1) Rivers to be Improved and the Improvement Methods

The rivers, which are necessary to be improved, are the Alesh and the Babol river, and the Kari Rud canal. The locations of improvement section are shown in the Figure 4. 4 - 1. The improvement methods are decided by the investigation on topography, river section, and river profile.

1) Improvement of the Alesh River

The Alesh river has not sufficient cross sectional flow capacity to pass the floods, therefore the flood spreads over the land and flows down in the forest. The drainage system of this river shall be changed largely by diverting the drainage discharge of the Haraz West District into this river through the Amol West Main Rain (AWMD). The AWMD shall join with the Alesh river at the point No. 10+000, consequently the flood discharge shall increase below the junction. Improvement method of this river is as follows;

(a) Since the surrounding area of the Alesh river is covered by forest, the daily average flood discharge shall be applied as a design flood discharge.

(b) The upper reach of the junction point No. 10+000 shall not be considered as a subject of river improvement. In this reach, the flood protection dike of right bank shall be provided along the forest, and the flood shall be enclosed in the forest by the dike. The dike shall be utilized as a public road.

(c) The lower reach of the junction point NO. 10+000 shall be improved to accommodate the flood discharge increase by the AWMD. Design flood is 221 cms at the junction point.

(d) The peak flood discharge upstream of the junction will be retarded and stored in the forest by the said flood protection dike.

(e) The necessary height of the said dike will be 1.00 m for the section of 12.5 km long between the points N. 12+000 and NO. 24+000, and No. 10+000 and No. 12+000. In the above improvement scheme, the forest is considered as a stream channel to pass the flood.

(f) The flood control schemes, as the above as retarding the flood in the forest and mitigating the peak flood discharge taking into consideration a large value of the roughness coefficient of the forest, are recently introduced in Japan for controlling the medium and small rivers flowing into the urbanization area or for prevention of the land erosion.

2) Improvement of the Babol River

Overtopping of the flood is not allowed in the Babol river, because many villages are located beside the both banks. From a viewpoint of effective utilization of land resources, flood intrusion has to be also avoided. The peak flood discharge is, therefore, applied for the improvement of the Babol river. It is clarified by the flood mark survey that the Babol had been over topped at the lower reach between No. 7+000 and No. 8+000. The river capacity of this section is estimated at 530 to 650 cms, that the river capacity is smaller than the design flood discharge of 664 cms. Consequently, the improvement of this river shall be conducted enlarging the river section for 2 km long between No. 6+500 and No. 8+500.

3) Improvement of the Kari Rud

The flood of the Kari Rud is caused by the flood from the Garma Rud. The peak flood discharge is estimated at 130 cms in once every twenty five probable years. Since the capacity of the Kari Rud is only about 50 cms at lower reach and several villages are located on both banks, it is necessary to divert the excess flood discharge, that is 80 cms, to the adjacent river. From topographical and economic viewpoints, the excess flood is to be diverted to the Kharan river.

(a) The design peak flood discharge is 130 cms in once every twenty five probable years.

(b) The Kari Rud shall be enlarged to pass 130 cms for the section of 4.6 km long between No. 18+400 and No. 23+000.

(c) The excess flood discharge, 80 cms is diverted at the point No. 18+400, and released to the point No. 5+850 of the Tabakoo Rud (the tributary of the Kharan Rud) through the proposed floodway, The length of the floodway is about 1.5 km long.

(d) The excess flood of the Kari Rud and the drainage discharge of the Kari Right Bank Sub-district shall be drained to the Kharan river which is formed with a terrace and a cliff on both banks. The Kharan river is likely large enough to retard and pass the flood through its channel. If improvement is given to the Kharan river, further improvement will be necessary for the Babol river. Therefore , it is not recommended to improve the Kharan river.

(2) Design Flood Discharge

For the improvement of the rivers, the peak flood discharge or the daily flood discharge of 1/25 year is applied as a design discharge. The rivers, which the daily flood discharge is applied for, has to enable to drain the drainage discharge from adjacent areas without any obstructions in 1/10- year.

The design flood discharges at the key points are as follows;

Design Flood Discharge

River & Design Section	1/10 - year Flood		1/25 - year Flood	
	Daily Discharge	Peak Discharge	Daily Discharge	Peak Discharge
Alesh River				
No. 10 + 000 - No. 5 + 200	172	271	221	362
No. 5 + 000 - No. 4 + 500	173	272	222	363
No. 4 + 500 - No. 0 + 500	175	274	225	365
No. 0 + 000 - No. 0 + 000	182	281	233	374
Babol River				
No. 40 + 500 - No. 21 + 600	-	-	-	580
No. 21 + 600 - No. 0 + 000	-	-	-	664
Kari Rud				
No. 24 + 400 - No. 18 + 400	-	-	-	130
Kari Floodway	-	-	-	80
No. 18 + 400 - No. 12 + 800	-	-	-	50

4. 4. 9 Justification of the Irrigation/Drainage Development

(1) Justification of the Irrigation Plan by the HWDP-I Plan

As the leading plan of this project, the HWDP-I Plan has been prepared by the MOE. The irrigation area of the HWDP-I Plan includes the Expansion Area of about 9,900 ha in the left bank area, which is located beyond the boundary of this F/S Plan at the right bank of the Kari Rud. The following table shows the planning concept, excluding the said Expansion Area, of irrigation in the HWDP-I Plan;

Items	Haraz East	Haraz West	Amol East	Amol West	Total
1. Irrigation Area (ha)					
- Surface Water	17,506	8,989	13,137	7,808	47,440
- Groundwater	16,135	1,845	6,567	8,374	32,921
Total	33,641	10,834	19,704	16,182	80,361
2. Irrigation Requirement (MCM)					
- Surface Water	229.7	116.0	169.9	102.1	617.7
- Groundwater	168.8	193.0	69.5	88.4	346.0
Total	398.5	135.3	239.4	190.5	963.7
3. Peak Intake Discharge (m^3/s)					
- Surface Water	40.0	22.5	20.5	12.7	95.7

On the other hand, amount of water resources in both plans are compared as below;

Items	HWDP - I	This Study F/S	Difference
	(1)	(2)	(3) = (2) - (1)
1. Irrigation Area (ha)	90,285	78,850	△11,435
2. Available Water (MCM)			
- Surface Water	624.4	642.0	17.6
- Groundwater	358.0	143.0	△215.0
- Abbandans	97.6	50.0	△47.6
- Return Flow	-	87.0	87.0
- Storage Water	-	133.0	133.0
Total	1,080.0	1,055.0	△25.0

From the comparison of above two tables and the existing report of HWDP-I Plan, the following facts are to be noted;

- The unit irrigation requirement estimated by this F/S Plan is slightly higher than that by HWDP-I Plan.

  This F/S Plan : 13,380 m^3/ha

  HWDP-I Plan : 11,970 m^3/ha

- The available amount of groundwater is much lower at about 215 MCM. Consequently, the groundwater has to be investigated by further study.
- The overall irrigation efficiency of groundwater is 79% by this F/S Plan, and 86% by the HWDP-I Plan.
- The available water of abbandans is very different at 50 MCM by this F/S Plan, and 97 MCM by the HWDP-I Plan.

(2) Justification of the Drainage Plan by the HWDP-I Plan

As mentioned in the para 3. 8. 3, this drainage plan has likely been prepared based on the same criteria as the HWDP-I Plan. However, some of the criteria have been modified taking into consideration the economic evaluation of design year, the tolerance of berseem for groundwater, and the selection of the rainfall gauging station.

1) Difference on the Surface Drainage Discharge

Difference of the surface drainage discharge is caused by the differences on the design year (HWDP-I Plan : 1/5-year, This Plan : 1/10-year) and the rainfall station (HWDP-I Plan : Larim, This Plan : Babolsar).

Surface Drainage Discharge of The Main Drain

(Unit:cms)

Main Drains	HWDP - I Plan	This Plan
Amol West	27.54	47.59
Amol East	41.13	66.11

2) Difference on the Sub-surface Drainage Rate

The sub-surface drainage rate of the HWDP-I Plan is based on the criteria, that 2-day rainfall is drained within 2-days, and the groundwater table is kept at a depth lower than 50 cm from the field surface. On the other hand, this Plan is setting the criteria, that 5-day rainfall is drained within 5 days, and the groundwater table is kept at 0.2 m or lower. Other than those differences, this Plan considers farming drainage and deep percolation, and these considerations make the drainage rate smaller.

Sub-Surface Drainage Rate

(Unit:mm/day)

Drainage Condition	HWDP-I Plan	This Plan
Without Farming Drainage	5.45	2.2
With Farming Drainage	-	0.8

TABLE 4.4-1 ACREAGE OF CLASSIFIED SUB-SURFACE DRAINAGE METHOD SUB-DISTRICT WIDE

District Sub-District (zone)		Gross Area (ha)	Paddy Area (ha)	Acreage by the Sub-Surface Drainage Systems (ha)						
				0	1	2	3	4	5	6
Haraz West										
HW-(I)	(HWU,HW)	15,026	10,680	6,213	0	2,595	1,872	0	0	0
	Ratio (%)		100	58.2	0.0	24.3	17.5	0.0	0.0	0.0
Haraz East										
HE-(I)	(HE1-5)	13,485	11,019	4,142	0	2,691	1,284	2,902	0	0
HE-(II)	(KL1-6)	11,287	8,539	656	0	5,113	874	1,131	765	0
HE-(III)	(KR1-5)	5,480	4,447	2,901	0	118	886	0	542	0
		30,252	24,005	7,699	0	7,922	3,044	4,033	1,307	0
	Ratio (%)		100	32.1	0.0	33.0	12.7	16.8	5.4	0.0
Amol West										
AW-(I)	(AW1-4)	9,046	5,486	0	720	2,630	2,136	0	0	0
AW-(II)	(AW5-9)	15,784	11,977	0	3,386	8,115	476	0	0	0
		24,830	17,463	0	4,106	10,745	2,612	0	0	0
	Ratio (%)		100	0.0	23.5	61.5	15.0	0.0	0.0	0.0
Amol East										
AE-(I)	(AE1-3)	8,336	5,924	0	60	3,446	2,349	0	0	69
AE-(II)	(AE4-6)	9,185	7,379	0	822	3,784	1,331	583	244	615
AE-(III)	(AE7-11)	15,016	10,534	0	298	2,886	4,255	1,342	1,128	625
		32,537	23,837	0	1,180	10,116	7,935	1,925	1,372	1,309
	Ratio (%)		100	0.0	5.0	42.4	33.3	8.1	5.8	5.5
Total		102,645	75,985	13,912	5,286	31,378	15,463	5,958	2,679	1,309
Ratio(%)			100	18.3	7.0	41.3	20.4	7.8	3.5	1.7

Note : Sub-surface Drainage System is Classified into Following 6 Areas
0: Well-drained area (Depth of drainage ditch : 0.60m)
1: Open drainage area
2: Open drainage area (with Farming Drainage)
3: Tile drainage area (70m Spacing)
4: Tile drainage area (70m Spacing with Farming Drainage)
5: Tile drainage area (30m Spacing)
6: Non-subsurface drainage area

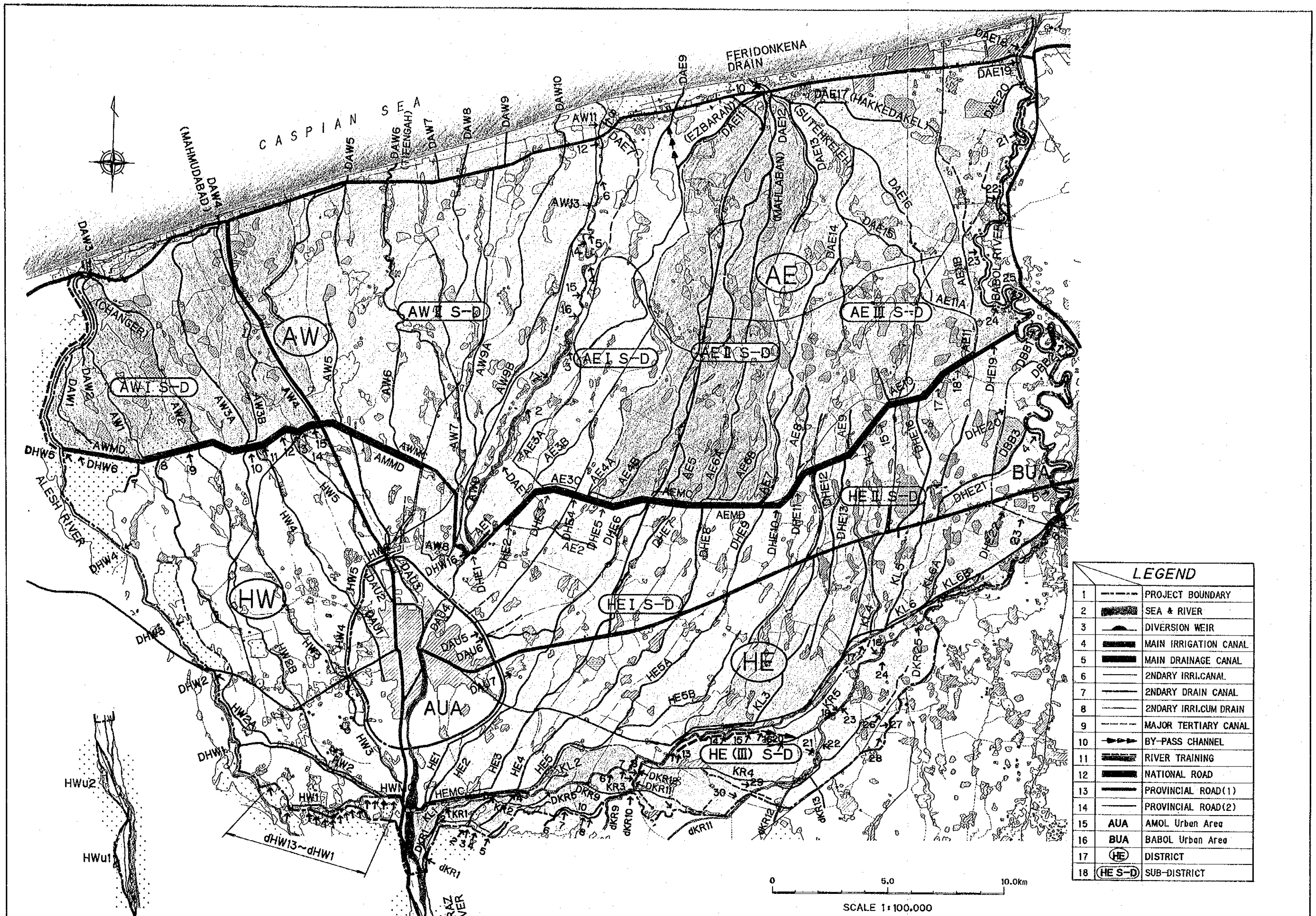
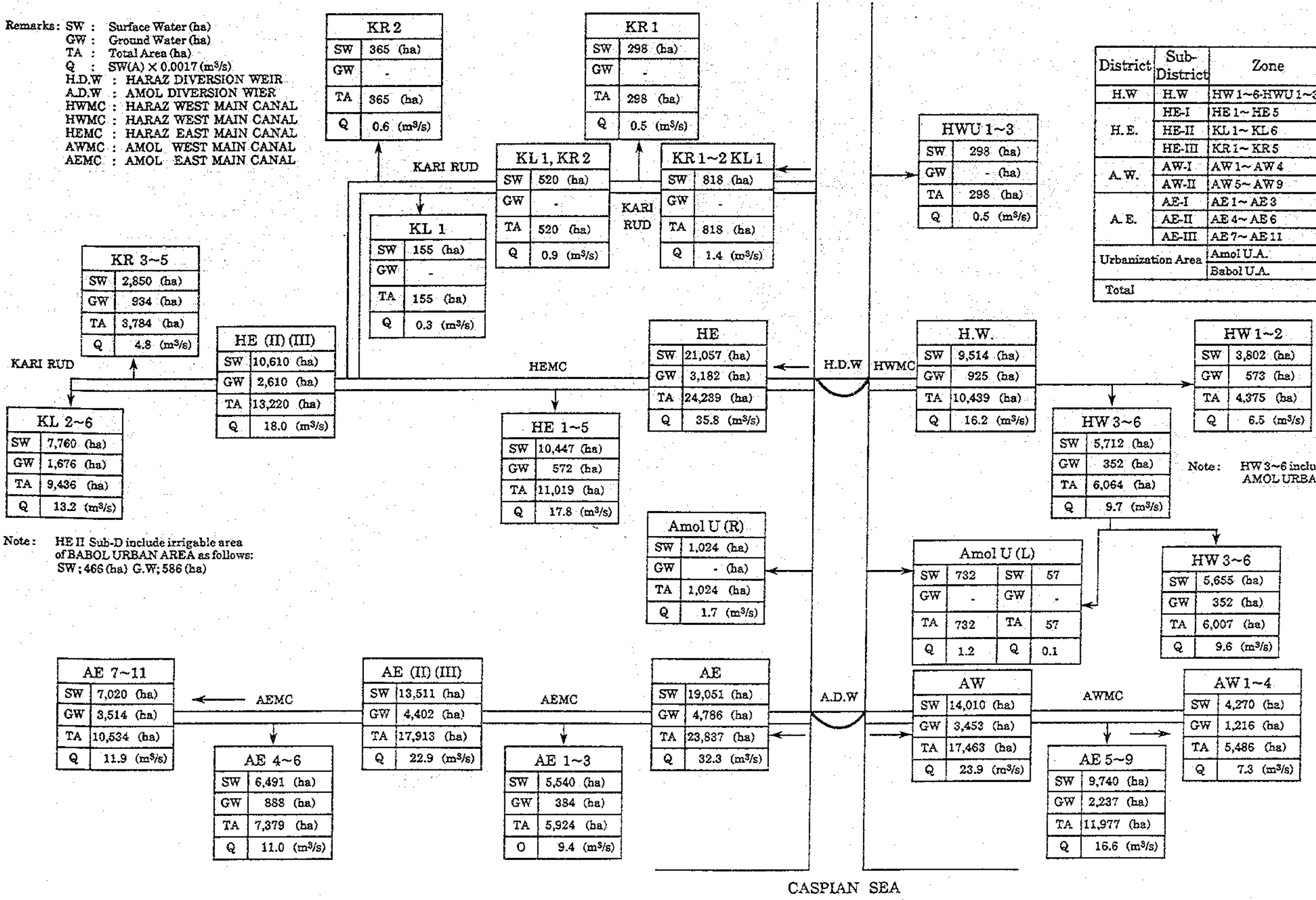


FIGURE 4.4-1 PROPOSED IRRIGATION AND DRAINAGE NETWORK AND LOCATION OF RIVER TRAINING

FIGURE 4.4-2 PROPOSED IRRIGATION SCHEMATIC DIAGRAM (SUB-DISTRCIT LEVEL)

Remarks:
- SW : Surface Water (ha)
- GW : Ground Water (ha)
- TA : Total Area (ha)
- Q : SW(A) × 0.0017 (m³/s)
- H.D.W : HARAZ DIVERSION WEIR
- A.D.W : AMOL DIVERSION WIER
- HWMC : HARAZ WEST MAIN CANAL
- HWMC : HARAZ WEST MAIN CANAL
- HEMC : HARAZ EAST MAIN CANAL
- AWMC : AMOL WEST MAIN CANAL
- AEMC : AMOL EAST MAIN CANAL

District	Sub-District	Zone	A (ha)
H.W	H.W	HW 1~6·HWU 1~3	10,680
H.E.	HE-I	HE 1~HE 5	11,019
	HE-II	KL 1~KL 6	8,539
	HE-III	KR 1~KR 5	4,447
A.W.	AW-I	AW 1~AW 4	5,486
	AW-II	AW 5~AW 9	11,977
A.E.	AE-I	AE 1~AE 3	5,924
	AE-II	AE 4~AE 6	7,379
	AE-III	AE 7~AE 11	10,534
Urbanization Area		Amol U.A.	1,813
		Babol U.A.	1,052
Total			78,850



Note: HE II Sub-D include irrigable area of BABOL URBAN AREA as follows: SW; 466 (ha) G.W; 586 (ha)

Note: HW 3~6 include 57 (ha) of AMOL URBAN AREA

FIGURE 4.4-3 PROPOSED DRAINAGE SCHEMATIC CHART

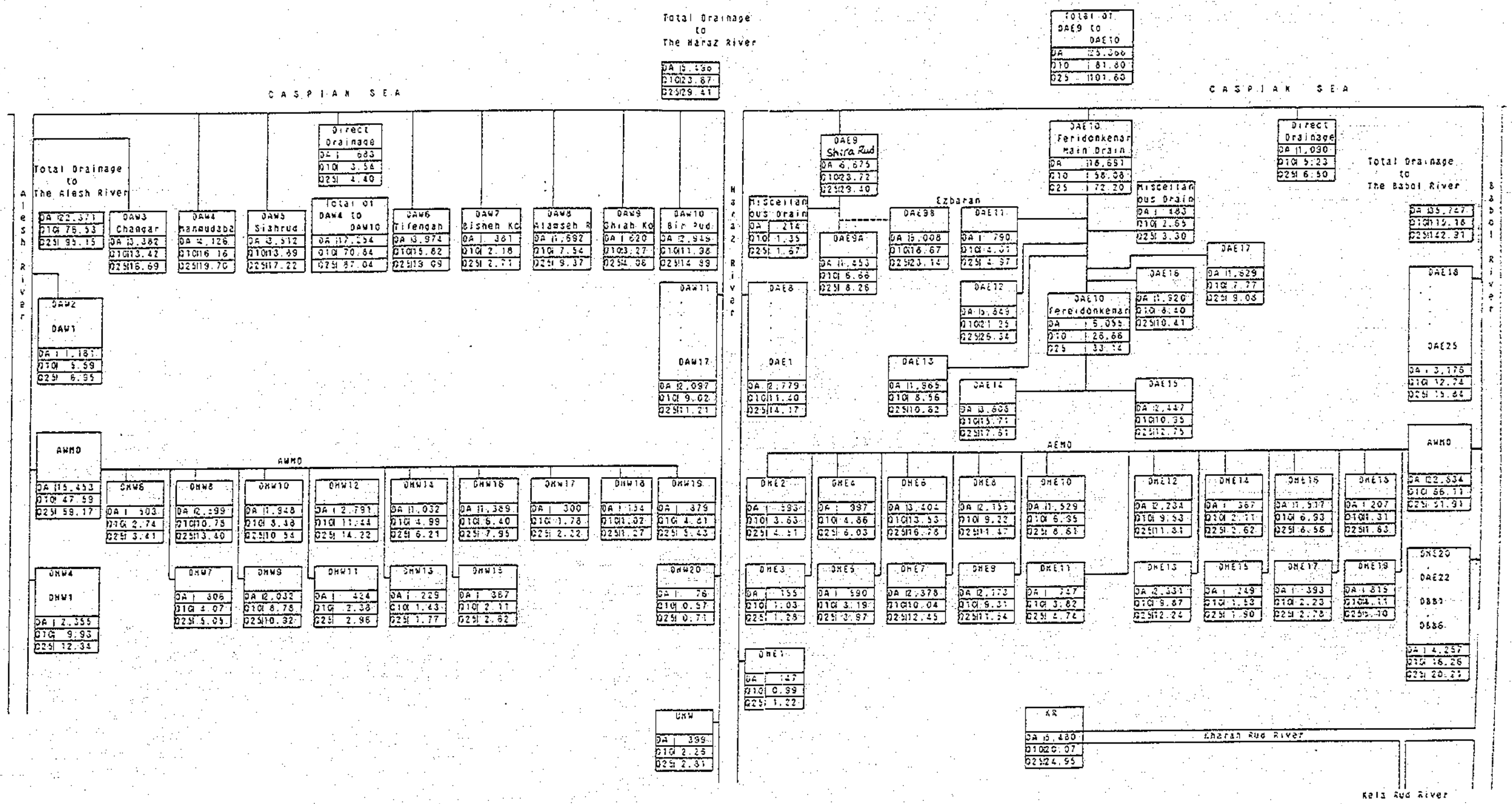


FIGURE 4.4-4 LOCATION MAP OF PROPOSED STORAGE DAM

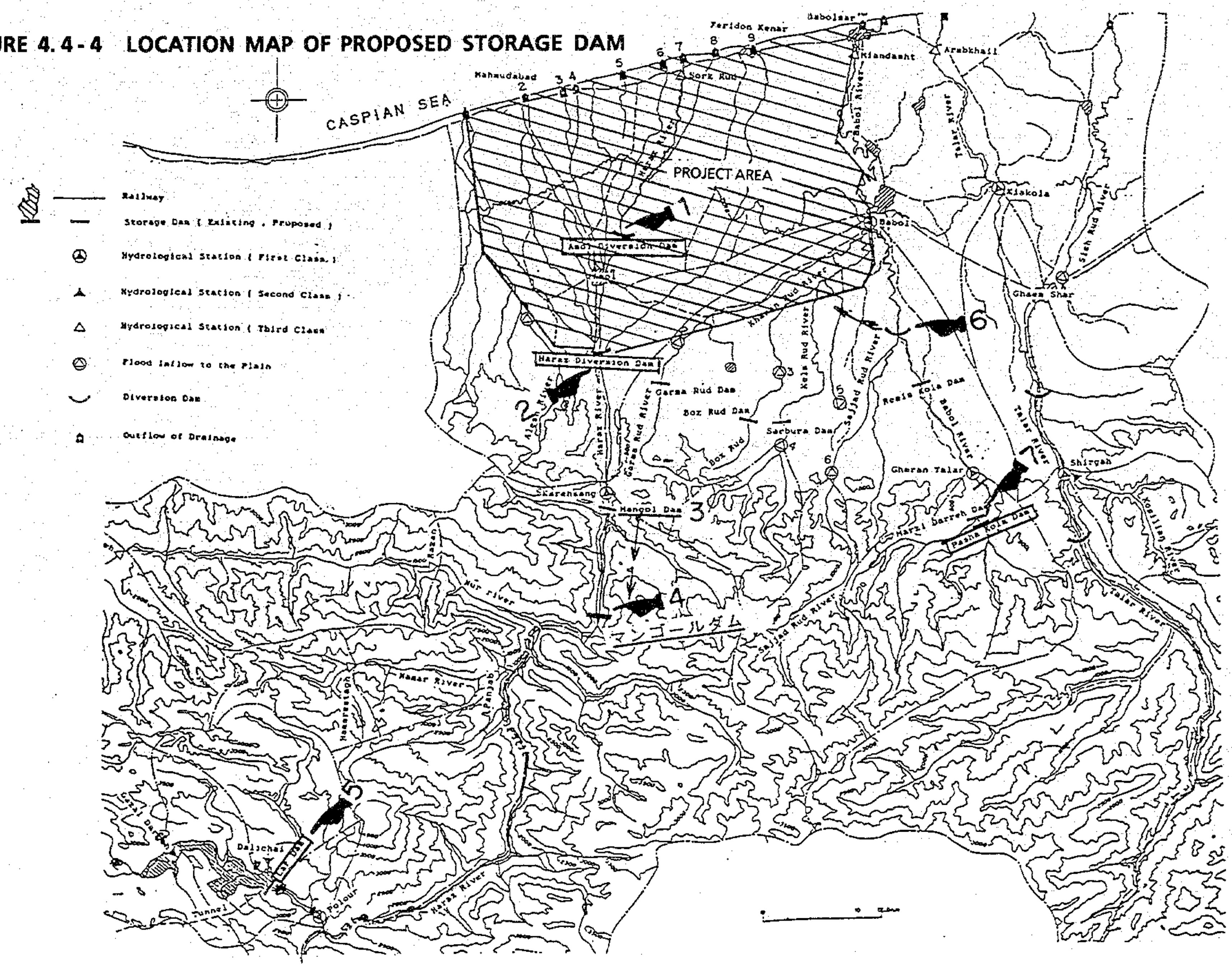


FIGURE 4.4-5 CALCULATION DIAGRAM OF SURFACE DRAINAGE RATE

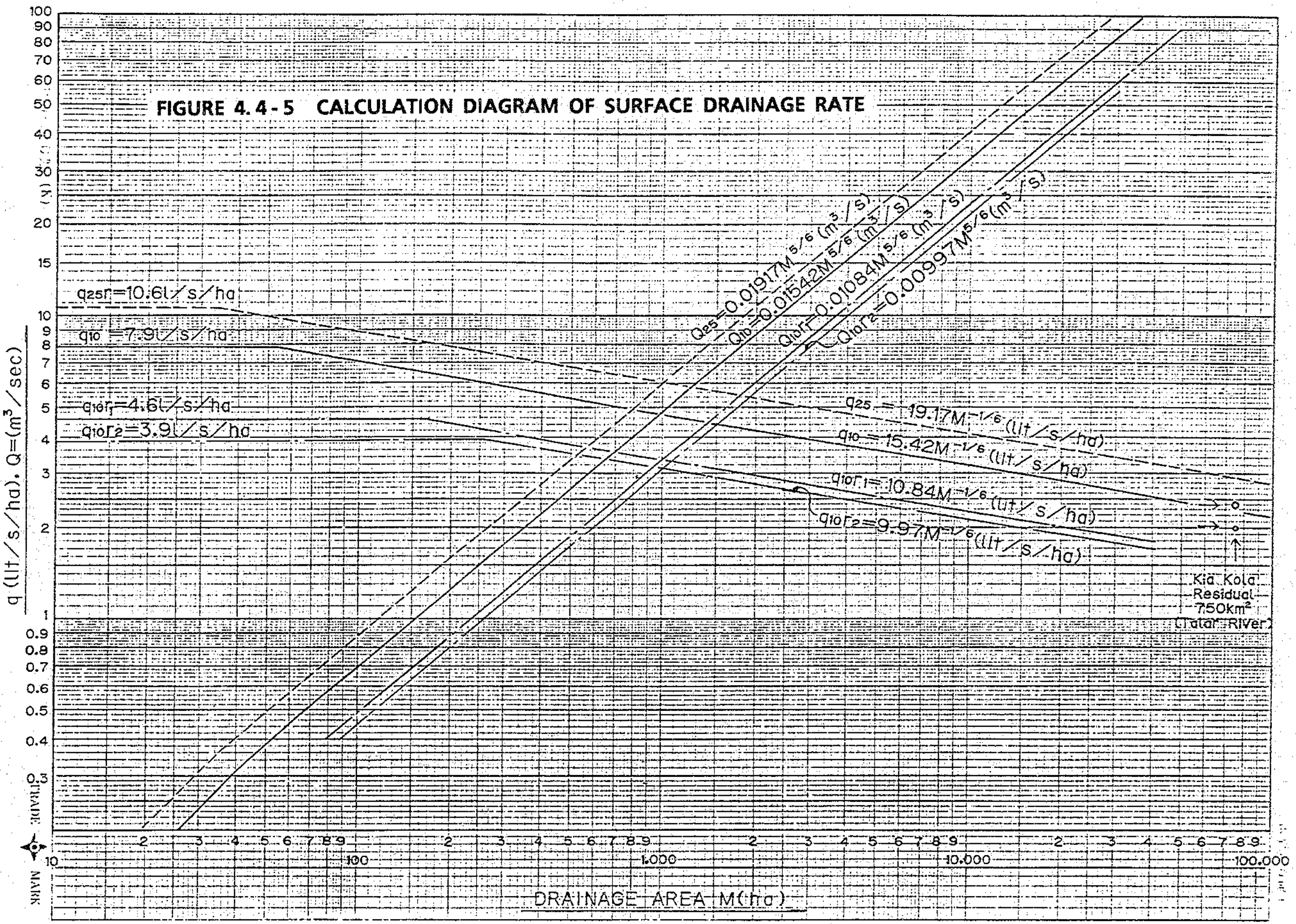
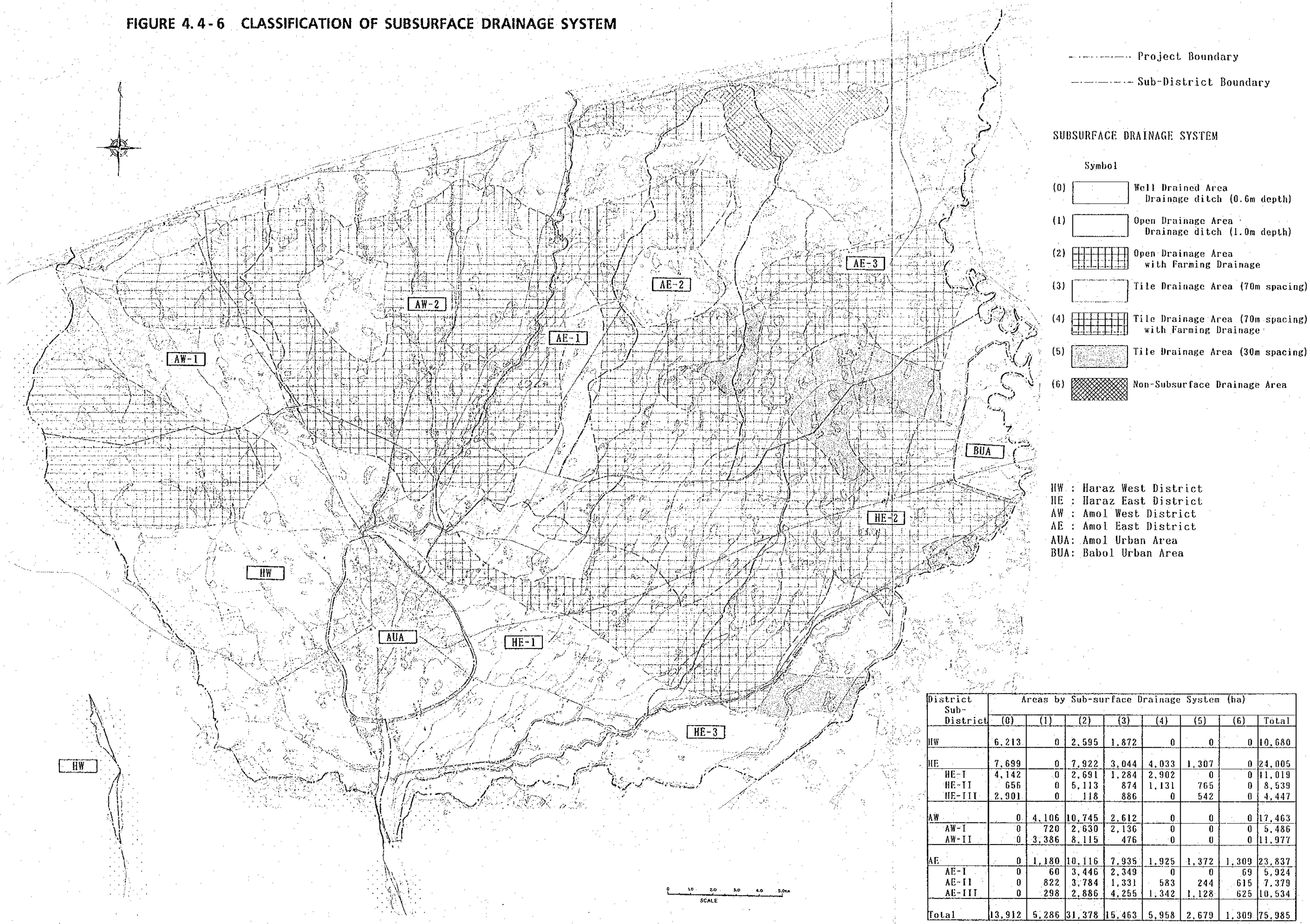


FIGURE 4.4-6 CLASSIFICATION OF SUBSURFACE DRAINAGE SYSTEM



District Sub-District	Areas by Sub-surface Drainage System (ha)							
	(0)	(1)	(2)	(3)	(4)	(5)	(6)	Total
HW	6,213	0	2,595	1,872	0	0	0	10,680
HE	7,699	0	7,922	3,044	4,033	1,307	0	24,005
HE-I	4,142	0	2,691	1,284	2,902	0	0	11,019
HE-II	656	0	5,113	874	1,131	765	0	8,539
HE-III	2,901	0	118	886	0	542	0	4,447
AW	0	4,106	10,745	2,612	0	0	0	17,463
AW-I	0	720	2,630	2,136	0	0	0	5,486
AW-II	0	3,386	8,115	476	0	0	0	11,977
AE	0	1,180	10,116	7,935	1,925	1,372	1,309	23,837
AE-I	0	60	3,446	2,349	0	0	69	5,924
AE-II	0	822	3,784	1,331	583	244	615	7,379
AE-III	0	298	2,886	4,255	1,342	1,128	625	10,534
Total	13,912	5,286	31,378	15,463	5,958	2,679	1,309	75,985

4.5 On-farm Development

4.5.1 Basic Concepts and Outline of On-farm Development

(1) Basic Concepts

On-farm system development (land consolidation) has following basic concepts:

- Land consolidation scheme is the part of long-term regional development plan in rural areas,
- Land consolidation is to increase agricultural (land and labor) productivity through comprehensive consolidation of agricultural lands. In line with this concept, the project should satisfy forecasted agricultural requirements and allow establishment of effective and rationalized farming,
- Land consolidation is to contribute to preserving a favorable rural production and living environment through comprehensive consolidation of agricultural lands.

On the other hand, the Project Area has following characteristics:

- Large scale expansion of farmland by means of reclamation of uncultivated land is hardly possible,
- The yield of paddy is currently high, therefore a drastic increase of the yield cannot be expected.

To attain further improvement and stabilization of farm economy under such circumstances, it is necessary to increase cropping intensity and labor productivity. Therefore, the following on-farm improvement is to be carried out:

- Improvement of on-farm irrigation system; to stabilize the yield by means of timely irrigation,
- Improvement of on-farm irrigation system; to increase the yield by means of application of intermittent irrigation method, to increase cropping intensity (introducing second crops) through draining the inundated water due to autumn-winter rain, and to increase

operation efficiency of agricultural machinery through improving the bearing capacity of soil,

- Improvement of farm road network; to avail access of agricultural machinery,
- Readjustment of field lot; to increase operation efficiency of agricultural machinery,
- Land replotting to increase the efficiency of farming works by means of collection of fragmented field lots.

(2) Basic Planning and Design Criteria of Land Consolidation

These criteria are prepared considering the present conditions of the Project Area and the above mentioned basic concepts. The salient features of these criteria are as follows:

1) Basic Layout

(a) Layout of farmland systems is determined to keep the shapes and sizes of field-lots in mind so as to minimize the ditch and the road densities. The most economical way to form field-lots is to lay the long side in parallel with contour lines.

(b) Layout of the terminal ditches is decided considering the proposed canal systems. Irrigation/drainage ditches border the short side of field-lots to control irrigation/drainage operation independently for each field-lot or field-block. Lateral irrigation/drainage ditches border the short side of field-blocks and farm-blocks.

(c) Layout of farm roads is determined in conformity with the present road networks, and is incorporated in the layout of farmland systems. Farm roads are planned along the lateral irrigation/drainage ditches and the irrigation ditches.

2) Shapes and Areas of Field-lot

On balance, the standard shapes and areas of field-lots are recommended, as follows:

Short side length: 30 - 60 m,
Long side length : 100 m
Field-lots area : 30 - 60 a.

These shapes and areas are determined based on the following studies:

(a) From the Viewpoint of Working Efficiency of Farm Machinery

In general, the higher efficiency of agri-machinery is expected if the field lots are larger and the ratio of long side to short side is bigger. However, the required minimum length of the short side is as follows:

Tractor	(40 PS Class):	more than 20 m
Combine	(Row 3.0 m) :	more than 30 m

On the other hand, the maximum length of the short side is limited to about 60 m from the viewpoint of land leveling and disease/pest control works. As for the maximum length of the long side, about 100 m is recommendable in view of the capacity of a rice transplanter.

(b) From the Viewpoint of Topographical Conditions

The difference in elevation between neighboring fields is desirably within 20 - 30 cm. In the case of sloping land of more than 1/100, a maximum difference of about 60 cm is acceptable. The standard lengths of the short side are studied in line with this concept.

(c) From the Viewpoint of Water Management

The maximum length of the long side is limited to about 100 m in view of effective water management as well as land leveling practicability.

(d) From the Viewpoint of Socio-economic Conditions

Farmland held by one farmer is planned to be collected in a few places. With this concept, the maximum area of field-lots can be estimated. Having a land holding size of 1.5 ha, it has 150 a, 75 a and 50 a in the cases of one, two and three place collections respectively.

3) Farm Road

(a) Farm Road Width

Farm road widths are decided by the expected kinds and types of vehicles, as follows:

- Main Farm Road

  Main farm roads are two-lane roads expecting pick-up trucks (1.6 m width) to pass each other. In the calculation of the effective width, the allowance between vehicles is designed to be 0.5 m. The width of the shoulder is designed to be 0.4 m.

  Effective width = 1.6 + 0.5 + 1.6 = 3.7 m,

  Total width = 0.4 + 3.7 + 0.4 = 4.5 m

- Lateral Farm Road

  Lateral farm roads are one-lane roads expecting combines (3.5 m width) to pass through. The width of the shoulder is designed to be 0.25 m.

  Effective width = 3.5 m

  Total width = 0.25 + 3.5 + 0.25 + 4.0 m

(b) Pavement

The pavement of farm roads is designed to be gravel.

4) Terminal Irrigation Ditch

The type of terminal irrigation ditches, separate or dual-purpose, is decided based on the field conditions. However, the separate type is recommended in the fields where different varieties are planted together. The smallest bottom-width of the ditch cross-section is 30 cm from the viewpoint of construction.

5) Terminal Drainage Ditch

(a) Design Rainfall

1/10 probable rainfall is used for on-farm drainage planning.

(b) Functions and Sections of Ditches

In those paddy fields where the groundwater table is low throughout the year, the drainage ditches are shallow in depth so as to drain only the field surface water. On the other hand, in the paddy fields of high groundwater table (Open Drainage Areas), the drainage ditches are deep, about 1.0 m below the field surface, for the surface and subsurface drainage. With regard to the tile drainage areas, the depth of the lateral drainage ditches is designed to be about 1.5 m depth from the field surface considering the outlets of tile drains. The smallest bottom-width of the ditch cross-section is 30 cm from the viewpoint of construction.

6) Surface Soil Handling

In principle, surface soil handling is not considered in this study from the viewpoint of soil conditions.

7) Shallow Well Works

The existing shallow wells for agricultural use are to be relocated along farm roads.

8) Spring Works

Spring water is planned to be led to irrigation and drainage ditches by a small ditch.

4. 5. 2 On-farm Improvement Level and Preliminary Design of Sample Areas

(1) On-farm Improvement Level

The following two levels of on-farm improvement are proposed in this study, considering the above basic criteria:

Type-A : The plan of changing size and shape of lots

The criteria are applied entirely.

Type-B : The plan of not changing size and shape of lots

Terminal irrigation and drainage ditches and farm roads are planned along the present lot boundaries. Therefore, land grading is not necessary to be carried out, however each lot will be faced to terminal irrigation and drainage ditches and farm road in principle.

(2) Preliminary Design of Sample Areas

The following preliminary design of 6 sample areas is carried out based on the above mentioned levels of on-farm improvement:

Location	Sample Area	Area (ha)	Field Elevation (m)	Ave. Land Slope	Type -A	Type -B
H.L.	Katiposht	85.0	94.3 to 110.2	1/80	0	
H.L.	Ejibar Kola	100.0	45.4 to 62.7	1/90	0	0
M.L.	Eslamabad	63.0	10.0 to 23.5	1/120	0	
M.L.	Darzi Kola	97.0	6.9 to 16.0	1/80&1/220	0	
L.L.	Moallem Kola	125.0	-19.0 to -13.5	1/400	0	
L.L.	Suteh	124.4	-23.6 to -21.5	1/760	0	0

Note :
1. Sample areas and types with mark (0) are the matters of study.
2. Darzi Kola area consists of sloped area (38% in area with 1/80 slope) and rather gentle sloped area (62% in area with 1/220 slope).
3. Area (ha) ; Gross paddy field area, not including upland fields, abbandan and residential areas, etc.
4. H.L. : High Land, M.L. : Middle Land, L.L. : Low Land.

(3) Surface Soil Handling

In the study of the on-farm improvement level and the preliminary design, the subsoils conditions were surveyed in order to judge the necessity of surface soil handling. The survey was carried out at 9 sites in the high land using a stick auger, and the thickness of plowing layers, etc. were observed within 1 m depth. The survey resulted in the confirmation of each soil series properties.

As a result, a surface soil handling is not to be considered in this study based on the following reasons:

- From the viewpoint of soil texture, about 96% of the Project Area is classified as loam to clay with very deep strata. The rest is classified as loamy sand located along the sea coast.
- With these soil properties, the subsoils provide the homogeneous soil features with the plowing layers in more than 30 cm thickness and can be turned into better quality plowing soils by reasonable and well-balance fertilization after land consolidation.

4.5.3 Application of Land Consolidation Criteria

(1) General

The selection of the on-farm improvement levels (Type-A or Type-B) comes first in the application of the land consolidation criteria. Then, the application criteria of how to apply the sample areas deigns (6 areas for Type-A and areas for Type-B) to the entire Project Area are determined in order to estimate the on-farm development costs.

(2) Selection of On-farm Improvement Level

The following basic idea is established aimed at selecting the on-farm improvement levels:

1) Optimum Investment Condition

The on-farm development is planned within the optimum investment range studied in the para. 5. 3. 1 "Improvement Level of Canal Facilities".

2) Application Limit of Type-A Improvement

The type-A improvement is applicable for the areas of which slopes are less than 1/50. This is because, in the areas more than 1/50 land slope, the short side length is limited to about 20 m from the view point of desired field elevation differences between neighboring fields, and this length does not satisfy the required minimum length of 30 m which is necessary for the high working efficiency of combines. Therefore, the type-B improvement is applied for the high lands whose slopes are more than 1/50.

3) Selection Conditions of Type-B Improvement

The both types are adoptable in the areas of less than 1/50 land slope. Selection conditions of the type-B improvement in these areas are described hereafter.

Present plots are to be used in the type-B improvement principally, thus the shapes and sizes of present plots are required to fulfill the conditions which enable farm machinery to work efficiently and farmers to manage irrigation and drainage water properly. Conclusively, a plot size needs to be more than 30 a. and shapes may as well be rectangular having the large long side to short side ratio (the maximum long side length is 100 m).

- Size of Plot:

  There exist large ranges in present plot-size-distributions area by area. At present, the average plot size is about 30 a. in the Project area, and that of low land tends to be bigger than the other areas.

  From the following data on sample areas, it can be said that the type-B improvement is applicable in the low land because the average plot size reaches at 40 a.

  On the other hand in the middle and the high lands, though some areas have average plot sizes more than 30 a., the average is generally below 30 a. In consequence, the type-B improvement is not considered for these areas for this study.

Sample Area	Land	Average Plot Size (are)
Katiposht	H.L. Undulated	31
Ejibar Kola	H.L. Undulated	28 H.L. Ave. 29
Eslamabad	M.L. Gentle	11
Darzi Kola	M.L. Gentle	34 M.L. Ave. 19
Moallem Kola	L.L. Flat	50
Suteh	L.L. Flat	33 L.L. Ave. 40

Note: H.L. = High Land, M.L. = Middle land, L.L. = Low Land.

- Shape of Plot:

  There is a great variety of plot shapes. The dominant shape is similar to a rectangle in the Project Area. Then, the shape conditions are described hereafter on the Suteh and Moallem Kola sample areas, which are located in the low land where the type-B improvement can be applied

  In the Moallem Kola sample area (average land slope 1/400), there are many plots which have a long side length of more than 100 m, and in this case, terminal irrigation, drainage ditches and farm roads are to be planned at 100 m intervals. In consequence, an arrangement of plot size enlargement by neighboring fields is necessary in order to obtain the required 30 a. area of a plot. As a result, the type-A improvement shall be conducted in this area.

  On the other hand, in the Suteh sample area (average land slope 1/760) which is smaller in slope and lower in elevation than the Moallem Kola area, the type-B is applicable as shown in the preliminary design. Therefore, in this study, the type-B improvement is to be applied in the low land whose land slope is less than about 1/800.

(3) Application Criteria of Type-A Improvement

1) Preliminary Cost Estimates of the Sample Design Areas

Cost estimates of the type-A consolidation works on the above six sample areas were carried out preliminarily. The results are shown as follows:

Sample Area	Ave. Land Slope	Unit Cost** ('000 Rls/ha)	Remarks
Katiposht	1/80	3,820	High land
Ejibar Kola	1/90	3,040	〃
Eslamabad	1/120	2,560	Middle land
Darzi Kola	1/130*	2,000	〃
Moallem Kola	1/400	1,790	Low land
Suteh	1/760	1,630	〃

Note : * Weighted land slope by area-wise.
** Direct cost divided by proposed net paddy field area(ha).
The direct cost does not include the costs of shallow well and spring works.

2) Basic Idea of Apply Method

At the beginning of the study, the six sample areas were chosen from the viewpoints of ground altitude, such as Katiposht and Ejibar Kola from high land, Eslamabad and Darzi Kola from middle land, Moallem Kola and Suteh from low land. However, the application method should depend on the land slope factor based on the following reasons.

- The cost of earth works (cutting and filling) counts for about 40 to 70% of the total direct cost, and the volume of cutting and filling is subject to the land slope.
- There exist gentle sloped lands (less than about 1/300 slope) in the middle land area.

3) Apply Method of the Sample Design

Considering the number of sample design areas (6) and the topographical conditions of the Project Area, it will be acceptable to classify the entire Project Area into three land types, such as much sloped land, middle sloped land and less sloped land. The application method is determined as follows:

Land Type	Avg. Land Slope	Applied Unit Cost*
Much sloped land	more than 1/100	Avg. of Cat. & Ejb.
Middle sloped land	1/100 to 1/200	Avg. of Esl. & Dar.
Less sloped land	less than 1/200	Avg. of Moa. & Sut.

Note: * Type-A land consolidation cost.

In the above table, 1/100 is considered as the medium slope between those of Ejibar Kola (1/90) and Eslamabad (1/120). In the same way, 1/200 is between Darzi Kola (1/130) and Moallem Kola (1/400).

(4) Application Criteria of Type-B Improvement

The type-B improvement does not include land grading works, and only terminal irrigation and drainage ditches and farm roads are to be developed. In this case, the improvement costs are not subject to the land slopes sensitivity. Therefore, the sample designs of Ejibar Kola and Suteh are to be applied to the high land and low land respectively.

(5) Application of Other Improvement Items

Other improvement items which shall be considered in an area wide application are shallow well works, spring works and classification of terminal drainage ditches. These items are applied to the Project Area, as follows:

1) Shallow Well Works

There are about 5,800 places of shallow wells, deep wells and artesian wells in the Project Area (excluding urban areas), and they are used for agricultural, industrial and drinking purposes. Of these wells, about 98% are shallow wells, which will be difficult to use after land consolidation. Therefore, the relocation of these wells is required. New wells are planned along farm roads, and drawn water will be discharged into lateral irrigation ditches. In general, these new wells will be managed by farmers groups.

2) Spring Works

There are about 70 springs in the Project Area, and their discharges range from 10 to 100 lit/s. About 60% of these, discharge is less than 10 lit/s. Spring water is led into irrigation and drainage ditches through a small ditch which is planned along lots boundary, and is used effectively in the downstream.

3) Type of Terminal Drainage Ditch

The following three types are planned for the terminal drainage ditches in relation to a groundwater table, etc.:

- In those paddy fields where the groundwater table is low throughout the year; The terminal drainage ditches are shallow in depth (about 60 cm below the field surfaces) so as to drain only field surface water.
- In the paddy fields of the occasional high groundwater tables within 1 m depth (Open Drainage Areas); The terminal drainage ditches are deep (about 1 m below the field surfaces) for the surface and subsurface drainage.
- In the tile drainage areas; The lateral drainage ditches are of a deeper type (about 1.5 m below the field surface) considering the junction of tile drains.

CHAPTER 5. PROJECT FACILITIES

CHAPTER 5. PROJECT FACILITIES

5.1 Project Description and Implementation Agency

5.1.1 Project Components

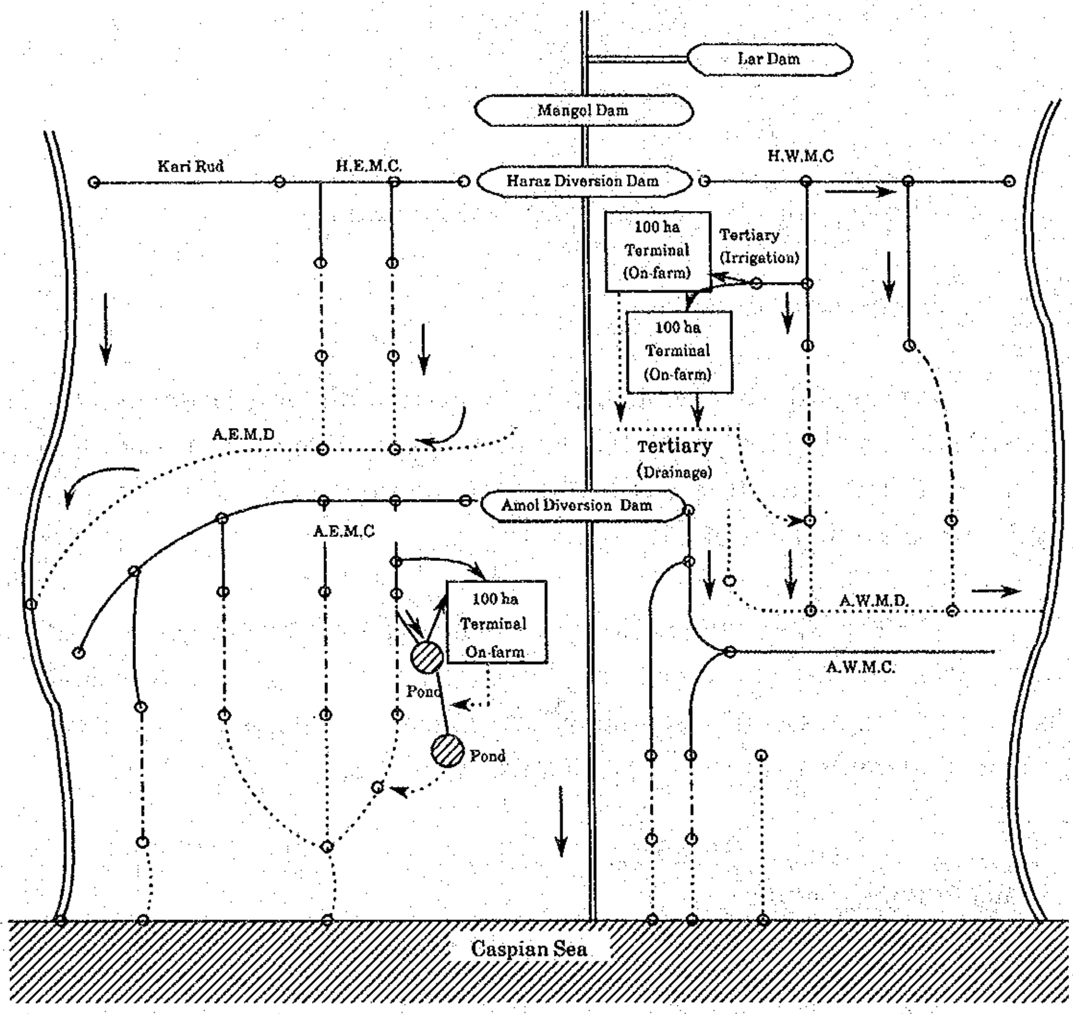
It is essential to implement construction and improvement of various facilities for raising the productivities of land and labor by means of cultivation of rice and berseem. It is important that the implementation has to proceed under a comprehensive and integrated plan.

On the other hand, the implementation of this project needs close cooperation among the project implementation agencies, viz., the MOE, the MOA, and the associations of beneficiary farmers. Major facilities and their responsible implementation agencies are as follows;

Facilities	Implementation Agency
Water Resources Facility	
Amol Diversion Dam	MOE
Amol East & West Main Canals	MOE
Amol East & West Main Drains	MOE
Feridon Kenar Main Drain	MOE
Secondary and Tertiary Irrigation Canal	MOE
Secondary and Tertiary Drainage Canal	MOE
Terminal On-farm Facilities	MOA (L. C. D.)
Abbandan Improvement	MOA (L. C. D.)
River and River-mouth Improvement	MOE

(Note) L.C.D.: Land Consolidation District

The schematic location and function of the facilities are as shown in the diagram below;



Note: I-C-D: Irrigation-cum-Drainage

5. 1. 2 Project Implementation Agency

In accordance with the agreement between MOA and MOE in 1991, following demarcation was imposed on the responsibility of the project implementation and operation/maintenance.

The MOE is responsible for;
Water resources facility, conveyance facility, diversion facility, and drainage facility

The MOA is responsible for;
On-farm facility

Land consolidation projects were under responsibility of the Agricultural Engineering Department, MOA, and the design and implementation were under its Regional Department in cooperation with the ARTSC. Since establishing the Soil and Water Engineering Service Corporation in provincial-wise in 1992, the responsibility of land consolidation has been transferred to this corporation.

The corporation is proceeding the works provincial-wise on planning, designing and implementation with a limited number of staff, and therefore, this corporation is not always the appropriate agency to conduct proceed an individual large project. Consequently, it is recommended to establish a particular project office for this project which requires long-term and large construction. This subject is detailed in the para. 6.2.

5.2 Main Facilities

5.2.1 Storage Dam

Storage dams concerned to the project are Lar dam and Mangol dam. Lar dam has been constructed in the Lar river, a tributary of the Haraz river. On the other hand, Mangol dam is proposed in the main river of the Haraz. Their dimensions are as follows;

Dimension		Lar Dam (Constructed)	Mangol Dam (Proposed)
Dam Height	(m)	105	220
Crest Length	(m)	1,500	1,000
Total Storage	(MCM)	960	490
Effective Storage	(〃)	860	320
Dead Storage	(〃)	100	170

5.2.2 Diversion Dam

Two diversion dams, the Haraz and the Amol diversion dams, are planned along the Haraz river by the MOE. The construction of the Haraz diversion dam (H.D.D) is nearly completed, and this dam is to be used as it is planned. As for the Amol diversion dam (A.D.D), whose design is ongoing, the MOE design is utilized as basic. The maximum diversion discharges of these dams are summarized as follows:

(Unit : m^3/s)

Facilities	Max. Discharge
Haraz Diversion Dam	
Right bank	35.8
Left bank	16.2
Amol Diversion Dam	
Right bank	32.4
Left bank	23.8

5. 2. 3 Main Irrigation Canal

The basic planning of the main irrigation canals has been formulated by the MOE. The construction of the Haraz East and the West Main Canals is almost completed, and these canals are to be incorporated into this study as they are planned. On the other hand, regarding the under design canals, the Amol East and the West Main Canals and the Kari Rud (including intake structure), the review was carried out in reference to the MOE design on: the locations of turnouts, the design discharges and the proposed canal profiles, etc. The maximum design discharges and length of these canals are as follows:

(Unit : m^3/s)

Canal	Max. Discharge	Canal Length (m)	Remarks
Haraz West	16.2	1,870	Nearly completed
Haraz East	35.8	5,390	- do-
Amol West	23.8	17,300	New constructions
Amol East	32.4	25,500	- do -
Kari Rud	18.0	10,000	Rehabilitations

Note: The MOE irrigation plan on the left bank areas of the Babolriver will be implemented within the scope of the Babol river system. Therefore, the irrigation water by the Kari Rud doesnot reach to the Babol river in the F/S.

5. 2. 4 Main Drain

Of the main drains, the basic planning of the Amol East and the West Main Drains has been prepared by the MOE. Regarding these canals, a review was made in reference to the MOE design of: the locations of junctions, the design discharges and the proposed canal profiles, etc. On the other hand, the improvement of the Feridon Kenar Main Drain is planned and designed in this F/S. The maximum design discharges, drainage area and length of these canals are as follows:

(Unit : m^3/s)

Main Drains	Max. Discharge	Drainage Area (ha)	Canal Length (km)
Amol West	47.6	15,453	16.5
Amol East	66.1	22,834	25.1
Feridon Kenar	58.1	18,691	9.3

Note: A part of the drainage areas of the Feridon Kenar Main Drain was changed to those of the DAE9 drainage canal so as to mitigate the drainage burden of this Main Drain.

5.3 Irrigation and Drainage Facilities

The major irrigation and drainage facilities of the Project Area are diversion dams and canal networks (main, secondary and tertiary canals), and their basic planning has been formulated by the MOE. The construction of the Haraz diversion dam and the Haraz East and the West Main Canals are nearly completed, and these facilities are to be incorporated in this study as they are planned. On the other hand, as for the facilities of which designs are ongoing (such as the Amol diversion dam, the Amol East and the West Main Canals, the Amol East and the West Main Drains and the Kari Rud), the MOE designs were reviewed and the consistency with the project was achieved. Thus, the planning and design of the secondary and the tertiary canals are mainly described in this section.

5.3.1 Improvement Level of Canal Facilities

(1) Necessity of Existing Canals Improvement

Based on the following reasons, the improvement of existing canals is necessarily studied:

1) Consistency of Present Canal Sections and Designed Canal Capacities.

The irrigation and drainage areas of the present secondary and tertiary canals will be reduced drastically by the planned Amol Main Canals and the Amol Main Drains because they will divide the Project Area into two parts, upper and lower portions. In addition to this, the irrigation method will be changed to a more effective one. Therefore, the canal sections should be studied using the proposed discharges, and the consistency of the captured matter should be solved in the design.

2) Realization of Rational Water and Facilities Management

At present, the water intake operation and management are carried out by proportional modules, and the water levels are controlled by stop logs and weirs made of stones, soils or wooden boards. However, water distribution by quantity is necessary for stabilized and smooth water intakes. And the improvement of measuring devices, turnouts, checks and drops is indispensable to safeguard canals.

(2) Basic Idea of Canal Improvement Level

1) General

- The land for the improved canals is considered within the present right of way as much as possible.
- At present, almost all existing canals are earth canals. In this study, earth canals are also adopted for the greater part of the proposed canals.
- Drops are designed to slow down the flow velocities along steep longitudinal slope portions.
- Gentle longitudinal slopes of canals are to be improved to appropriate one in order to solve the sedimentation and inundation problems in and around the canals.
- Suitable appurtenant structures (turnouts, measuring devices, checks, junctions and road crossings, etc.) are proposed in order to keep the functions and the facilities of canals stable.
- Operation and maintenance roads are designed in principle.

2) Secondary Canal

- The intake unification of the existing small tertiary canals is planned and irrigable area of the canals at terminal point is about 500 ha.
- Regarding drainage canals, the drainage area of the canal at junction point of tertiary canal is about 500 ha, and the hydraulic profile planning is carried out taking the Caspian Sea level fluctuation into consideration. In addition, river mouth improvement and consolidation of mouths and routes are proposed,whenever they are necessary.

3) Tertiary Canal

- Tertiary canals are made up of the various scale ones. Their proposed canal routes are studied in relation to the land consolidation plan. The intake unification on secondary canals is also studied.

- As the present tertiary canals meander considerably, straightening their routes is to be considered.
- The beneficial area of irrigation and drainage tertiary canals ranges from 100 ha to 500 ha.

(3) Optimum Investment Level of the Canal Facilities Improvement

In order to determine the improvement level of irrigation and drainage system of the proposed secondary and tertiary canals, expected benefits and estimated costs incurred to the project implementation are compared tentatively. In this study, four (4) alternatives on the facilities improvement level are considered as follows:

Case-1 : Earth trapezoidal canal entirely.

Case-2 : Concrete canal for around 1/3 length in Case-1,

Case-3 : Provision of checks, drops and turnouts only,

Case-4 : Same as Case-2, however save construction equipment costs for land consolidation works.

As the results of calculation, the following EIRR (Economic Internal Rate of Return) are output:

(Unit : %)

Case	H.E.D.	H.W.D.	A.E.D.	A.W.D.	Overall
Case-1	11	10	12	12	11
Case-2	9	8	9	9	9
Case-3	15	14	13	18	17
Case-4	10	11	9	10	10

Note, H.E.D. : Haraz East District, A.E.D. : Amol East District,
H.W.D. ; Haraz West District, A.W.D. : Amol West District.

Based on this study, Case-4 is considered as the optimum investment level of the project. In line with this, the improvement level of on-farm facilities (the amount of investment) is considered within the range of Case-4.

5.3.2 Hydraulic Design Criteria

(1) Canal Design Discharge and Special Consideration of Groundwater Supply Area

The secondary and tertiary canal design discharges are computed based on the combined schematic diagram. The canal design discharge is determined as follows:

1) Irrigation Canal Design Discharge (Qi)

Based on the irrigation water requirement study, the following figures are adopted:

- Secondary canal : Qi = 1.7 (ℓ/sec/ha) × A (irri. area: ha)
- Tertiary canal : Qi = 2.0 (ℓ/sec/ha) × A

2) Drainage Canal Design Discharge (Qd)

As the results of the surface drainage study, the following relationships are applied for the secondary and tertiary canals:

- Design discharge (10-year return period):

  Qd = 15.42 $M^{5/6}$ (ℓ/sec) (M = drainage area: ha) and applying 20 - 40 rule at junctions. (refer to the para. 4.4.7)
- Check discharge for maximum canal capacity without freeboard (25-year return period):

  Qd' = 19.17 $M^{5/6}$ (ℓ/sec) and applying 20 - 40 rule at junctions. Checking will be made at sampled sections.

3) Irrigation-cum-drainage Canal Design Discharge (Qm)

The design discharge of an irrigation-cum-drainage canal is decided based on both of the above calculations as follows:

Qm = Qi, when Qi > = Qd (irrigation dominant type)
Qm = Qd, when Qd > = Qi (drainage dominant type)

4) Special Consideration on Groundwater Supply Areas of Secondary Canals

The following modification is considered to the groundwater supply areas in order to utilize surface water and canal facilities effectively:

- At first, the irrigation water requirements for the groundwater supply areas should be conveyed using the two third (2/3) of freeboard (the size of canal sections does not increase), and
- If the canal sections can not accommodate the above requirements, the size of canal sections should be enlarged, where the two third (2/3) of freeboard corresponds to the additional requirements.

(2) Design Criteria of Secondary Canal

1) Applied Hydraulic Formula

Manning's mean velocity formula is applied in the hydraulic calculation. The basic conditions are described below.

2) Irrigation Canal (Conveying irrigation water only)

- Canal type: trapezoidal earth, concrete
- Side slope: earth 1: 1.5
- Maximum permissible velocity (m/s): earth 0.9, thick concrete (approx. 18 cm) 3.0, thin concrete (approx. 10 cm) 1.5, riprap (L-type canal) 2.0
- Minimum permissible velocity (m/s): 0.5
- Coefficient of roughness considering O/M activities: earth 0.03, concrete 0.016, riprap 0.032
- Freeboard (m): 0.15 ($Qi \leqq 1.0\ m^3/s$), 0.3 ($1.0 < Qi \leqq 5.0$), 0.4($5.0 < Qi \leqq 15.0$), 0.5 ($Qi > 15.0$)

3) Drainage Canal (Conveying drainage water only)

- Maximum permissible velocity: under 1.5 times of the values mentioned above,

- Coefficient of roughness: earth 0.035 (main and secondary canals with good maintenance), earth 0.040 (secondary canals with ordinary maintenance)
- Other items: same to the irrigation canal values

4) Irrigation-cum-drainage Canal (Conveying irrigation and drainage water)

- Maximum permissible velocity (m/s),

  irrigation dominant type: irrigation-canal-values using Qi

  drainage dominant type : fulfill both conditions, drainage-canal-values using Qd and irrigation-canal-values using Qi
- Other items: same to the irrigation canal values

(3) Design Criteria of Tertiary Canal

The design criteria used in the standard design of the tertiary canal are basically the same as those of the secondary canals. However, adaptation is made for the small discharge found in the tertiary canals.

1) Average Velocity Equation (Manning's formula)

   $V = 1/n \times R^{2/3} \times I^{1/2}$ (m/s)

2) Coefficient of roughness (n)

   n=0.030 (irrigation canal, irrigation cum drainage portion of a drainage canal)

   n=0.045 (drainage canal)

3) Freeboard (Fb)

   Same as the secondary canal

4) Design discharge

   Irrigation canal

   2.0 ℓ/s/ha (peak flow in summer irrigation)

   Drainage canal

   $15.42M^{5/6}$ ℓ/s (1/10 year probability for winter rainfall). Applying the Cypress-Creek formula and the 20-40% rule.

5) Type and shape of cross section

   Open-type unlined trapezoidal cross-section is adopted as the most economical section.

6) Side slope (1 (vertical) : z (horizontal))
Side slope of 1:1.5 is adopted here.

7) h/b (water depth and bottom width) ratio
h/b = 1 ~ 2

8) Allowable velocity (Vmax, Vmin)
Allowable maximum velocity (Vmax)
Vmax = 0.9 m/s (for irrigation canal)
Vmax = 1.35 m/s (for drainage canal)
Allowable minimum velocity (Vmin)
Vmin = 0.3 m/s (both for irrigation and drainage canals)

9) Energy head loss
Energy head loss counts at 0.3 m for a turnout from a tertiary canal to a fourth canal.

10) Minimum bottom width

Bottom width of tertiary canal is a minimum of 0.5 m from a viewpoint of excavation by a backhoe, and increases at 0.1 m intervals.

11) Command area of a tertiary canal

Command area of a tertiary canal is to be whole paddy areas including groundwater supply areas within a commanding block by the following reasons;

- It is necessary to provide new irrigation network to convey groundwater not only to the present irrigation fields but to other fields in a irrigation block, because present wells are to be relocated to the side of ditches or canals by land consolidation.
- For the same reason as above, a conveyance facility such as a tertiary canal is necessary to use springs and wells effectively after land consolidation.
- Except some numbers of irrigation blocks, there is not much difference on canal sections for irrigating whole paddy areas and for irrigating only surface water irrigation areas, because groundwater supply area is generally small.
- When discharge of the Haraz river is more than irrigation demand, generally in April and May, it is able to save and preserve groundwater for the drought periods by using surplus of river water.

5.3.3 Water Management and Responsibilities

Improved irrigation facilities are to be operated and maintained in following manner;

- Water resources facilities (dam, diversion dam)	:	by MOE
- Main irrigation and drainage canals	:	by W.M.C. (proposed)
- Secondary canals	:	- ditto -
- Tertiary canals	:	- ditto -
- Terminal facilities	:	by L.C.D. under MOA

(Note) W.M.C.: Water Management Corporation
L.C.D.: Land Consolidation District

As a basic necessity of water management, it is required to supply water effectively and timely. Water charge is to be collected as a cost for operation and maintenance of above facilities. Terminal facilities below tertiary canal are operated and maintained by the beneficiary organization (L.C.D.). On the other hand, conveyance facilities of the above tertiary canals are managed by the governmental administration (W.M.C.) under MOE.

5.3.4 Canal Alignment Plan

(1) Secondary Canals

The canal alignment of secondary canals is studied considering the present irrigation and drainage systems, the topographic conditions, the locations of existing relevant facilities and the longitudinal slopes of canals, and so on. The canal alignment planning has been carried out based on the secondary canal survey maps, the TIB survey maps, the NCC maps and the zoning and blocking maps, and so on.

As for the longitudinal slopes of the existing canals in the Project Area, those of the Haraz East and West districts (excluding the Kari Rud areas) differ considerably from those of the Amol East and West districts and the Kari Rud areas.

In the Haraz East and West districts (excluding the Kari Rud areas), the upper reaches of the canals are steep and meander through undulated areas, and the farm fields along the canals are considerably higher than the normal water levels of the canals. In the on-farm development of these areas, it is difficult to change largely the present canal routes from the viewpoint of the locations of roads and villages. On the other hand, in the lower reaches, the canal routes are planned considering the functions of irrigation-cum-drainage canals and drainage exclusive canals.

In the Amol East and West districts and the Kari Rud areas, the land slopes are rather gentle (less than 1/500 slope), and the existing canals generally run in the higher portions and are utilized in the miscellaneous living purposes by the inhabitants. As the results, the canal routes are determined considering the canal functions, the water levels, the proposed irrigation and drainage systems and the locations of the Amol East and West Main Canals, and so on.

On the other hand, in most cases, the functions of the proposed secondary canals are; irrigation canals in the upper reaches, irrigation-cum-drainage canals in the middle reaches and drainage or return-flow-gathering canals in the lower reaches. Therefore, the canal routes are planned so as to realize the rational irrigation water distribution to the irrigation blocks and the reasonable drainage from the blocks and zones.

In addition, about 2/3 length of the proposed secondary canals are classified as rehabilitation canals using the present routes and about 1/3 length are new canals.

(2) Tertiary Canal

1) Existing Condition

The existing canal network, evolved over the years, is complex. Though most of the major tertiary canals are named, the size and boundary of command area are not necessarily known accurately. The command area ranges from 5 to over 500ha and the canal length from 0.1km to over 10km. Some of these canals function as irrigation-cum-drainage canals; conveying irrigation water diverted from the secondary canals and collecting return-flow and/or drainage water along its course.

Due to the steep topography of the highland region, the canal inverts of secondary canals are usually deep, far below the elevation of the surrounding paddy fields. Since it is difficult to obtain the required diversion head, many tertiary canals have their water intake facilities at far distance upstream conveying irrigation water through long approach canal.

At the middleland and lowland region, the canal gradient is much gentler, resulting in deposition of sand and silt. In some canals, the invert elevation is higher than the surrounding paddy fields.

2) Canal Alignment and Integration

Route alignment of the tertiary canals are planned as follows.

- The canal routes are planned using 1/20,000 map of the NCC which shows the contour lines and the existing canal alignment.
- The routes are planned by adopting the larger existing routes whenever possible. New canal routes are planned for cases where better water conveyance and distribution can be expected for irrigation, or for better drainage.
- The routes are planned in such a way that each tertiary canal irrigates, or drains water from, a block of approximately 100 to 500ha. The process of grouping the area within a zone into blocks, along the planned tertiary canal, is conducted taking into consideration integrating the existing intakes and canal routes, topographical conditions (e.g. contour lines, ridges and valleys, and slope orientation), the existing road network, village boundary, farm ponds and land consolidation.
- Since some of the existing canals are sinuous, linear (straight) alignment is considered in route alignment and in land consolidation to improve the excessive sinuous portion.
- Off-take structures in the tertiary canals are planned in such a way that each off-take irrigates an irrigation unit (about 100ha) through the fourth canal.
- The farm ponds in the vicinity are linked indirectly to the proposed tertiary canals. Drainage tertiary canals are linked to the farm

ponds through intake and spillway structures. Farm ponds are never planned as a part of a tertiary canal.

Since route alignment is planned by adopting some of the existing routes, the planned route will be either a rehabilitation canal, a new canal, or a combination of rehabilitation canal and new canal.

(a) Rehabilitation Canal

In the highland region where the slope is steep, the invert of the existing canal is usually 2 to 3m below the surrounding paddy fields. Utilization of these existing canal routes will require planning drop structures in the canal to keep the velocity within the permissible range. This will also allow linear alignment of the excessive sinuous portion. In the middleland and lowland region where the existing gradient is much gentler, deposition of sand and inundation of the surrounding paddy fields can be remitted by straightening the excessive sinuous portion.

Since the hydraulic elements (A, V, I, etc) of the planned canal are different from those of the existing ones, utilization of the existing canal route will entail improvement and conservation. TIB survey has shown that the existing canals adopted in the planning can be grouped under those irrigating more than 100ha and those irrigating less. Accordingly, improvement of existing portion is distinguished by these two groups.

(b) New Canal

In planning, effective and smooth conveyance of water is realized through relocation of some of the existing canals and construction of new ones as demanded by the topographical conditions. New canals will be constructed during land consolidation and are usually planned straight.

(3) Summary of Proposed Canals

Proposed canals are summarized on their lengths in Table 5. 3-1.

5. 3. 5 Longitudinal and Sectional Plan of Canals

(1) Secondary Canals

1) Basic Concepts

The longitudinal profiles and sections of the secondary canals are planned in accordance with the basic idea explained in the above para. 5. 3. 1 "Improvement Level of Canal Facilities". The said basic concepts are as follows:

(a) Canal Type

The standard canal type is an earth canal, and a retaining wall type canal is also adopted in accordance with the necessities and conditions around canals. As for a thin concrete lining canal, this type is not considered in this study based on the following reasons:

- As this type has a weak resistance to uplift pressure, this type can be applicable to only irrigation and irrigation-cum-drainage (irrigation dominant type) canals in principle. Consequently, this type can be applicable to the upper and middle reaches of the secondary canals.
- The canal sizes and the construction costs of this type take a middle position between those of earth canal and retaining wall type. Therefore, there are no special reasons for adopting this type for the above mentioned portions.

(b) Rehabilitation Canal and New Canal

About 2/3 length of the proposed secondary canals are planned by the rehabilitation of the existing canals, and the rest, about 1/3 length, are new canals. Therefore, the planning manners in question are prepared respectively.

(c) Basic Design Principle

- Revetments are designed for canal portions where scouring and slope failure are expected, e.g. the bends of earth canals.

- The volume balances between excavation and embankment are considered in the said planning.
- The study on the flow capacities of the existing cross culverts is carried out, and the results are incorporated in the planning.
- In the case of irrigation-cum-drainage canals, the design discharges of the middle reaches are smaller than those of the upper and lower reaches principally. However, in the design, the canal width of the lower portion is not narrowed.
- The design water levels of drainage canals are designed at 0.5 m below the original ground surfaces.

2) Longitudinal and Sectional Plan of Rehabilitation Canals

The captured plan is prepared by canal-type-wise, namely an earth canal and a retaining wall type. In this plan, the manners of canal type selection are described as below;

(a) Earth Canal

The said plan of earth canals is established for the gentle slope canals and the steep slope canals, which are of the present canal conditions.

- In the case of gentle slope canals (longitudinal slopes less than 1/200 - 1/300);

  In principle, the bottom-width and depth ratio (B/D) is designed at 1 to 5 approximately. Also drops are designed if necessary.

- In the case of steep slope canals (longitudinal slopes more than 1/200 - 1/300);

  The present widths of the steep canals range from 5 to 10 m in general. When these canals are improved as earth canal, construction cost and land occupation are subject to the B/D ratios and the canal slopes. Thus, the alternative study was carried out, and the type-2 was judged to be advantageous based on the following reasons. However, the retaining wall type is to be adopted for the portions where the type-2 merits will not be realized because of the site conditions.

  : Larger land occupation is required in the type-3 improvement,

  : The type-2 improvement is superior to the type-1 economically and practically, though in a part of canals some farm lands may be needed for the construction of the operation and maintenance roads.

Type	B/D	Bottom Width (m)	Canal Slope	Cost*	Land Occupation for Canal & O/M Road
1.	1 - 3	about 2	about 1/600	large	small
2.	around 10	about 5	1/300 - 1/500	middle	middle
3.	> 10	> 10	> 1/200	small	large

Note * : Considering amount of drops and earth works

(b) Retaining Wall Type

Though unit construction cost of this type is higher than earth canal, land occupation is narrower because of higher permissible velocity and steeper slope. Therefore, this type of canal is planned for the following sites:

- Where there is a limitation of canal width such as at villages,
- Where canal gradient is steeper (more than 1/200 to 1/300), and bottom-width is smaller than a planned width in case of earth canal.

In the design, a flume is adopted when the bottom-width is less than 2 m, a L-shape wall canal when more than 2 m. The salient features of this type of canal are as follows:

B/D	Bottom Width (m)	Canal Slope	Drops & Earth Works	Land Occupation for Canal & O/M Road
1-2	about 2	more than 1/200 - 1/300	no drops, back fill	improvement within present ROW*

Note *: ROW (Right of way)

3) Longitudinal and Sectional Plan of New Canals

The standard type of new canal is earth canal. In principle, the bottom-width and depth ratio (B/D) is designed at 1 to 3 in order to save the lands for canals. Drops are provided if necessary.

(2) Tertiary Canals

1) Basic Concepts

- The minimum bottom width is 50cm, and increment is 10 cm. Standard bottom widths are 50cm, 60cm, 70cm, 80cm, 90cm, 100cm, 120cm, 130cm, 140cm and 150cm.
- Standard slopes are 1/50, 1/100, 1/200, 1/300, 1/400, 1/500, 1/600, 1/700, 1/800, 1/900, 1/1,000, 1/1,250, 1/1,500, 1/2,000, 1/2,500, 1/3,000, 1/3,500, 1/4,000, 1/4,500 and 1/5,000.

- Four types of vertical drop structure, A-type = 2.0m, B-type = 1.0m, C-type = 0.5m and D-type = 0.25m are adopted.
- In topographically steep locations drop structures are planned in the canal to keep the velocity within the permissible range. For locations where the slope is gentler, velocity is planned above 0.3m/s to reduce deposition of sand.
- Freeboard, as determined by design discharge, is observed.
- For the shallow and deep drainage ditch area, the design depth of canal ranges from 0.6m to 1.0m and 1.0m to 1.5m, respectively. However, the water surface should be designed at 0.5m below ground surface.

2) Hydraulic Design

- Hydraulic design is based on the schematic flow diagram prepared for the tertiary canals (See Data Book Ⅳ, Canal Design Data, Flow Diagram). Design discharge is calculated for each interval by planning the off-take locations and off-take rates.
- The elevation of all contour lines crossing the proposed tertiary canal and the initial and end point of an interval (portion of a canal between two off-takes) are read from the 1/20,000 NCC maps. For the highland region and locations where the 10m-contour lines are close together, they are read to 10m. For the middleland and lowland region where the 2m-contour lines are wider apart, they are read to one decimal place. The distance between the contour lines and the interval are measured by a 'curvimeter' to 50m. This data is plotted to obtain the average slope of the ground surface and the average slope for the interval.

- For each design discharge, the combination of standard gradient, standard bottom width, water depth and velocity, which produces a velocity within the permissible range and the proposed h/b ratio, are read from the hydraulic tables (See Data Book IV, Canal Design Data, Hydraulic Tables). These tables are prepared for a combination of standard bottom widths and longitudinal slopes.
- The hydraulic profile for each tertiary canal is designed by plotting the combination of bottom width, water depth and longitudinal slope for the intervals (See Data Book IV, Canal Design Data, Profile).

5.3.6 Abbandan Improvement

(1) Abbandan Improvement

There are 206 abbandans in the Project Area, of which one abbandan (AE88) is located in the designated area of environmental protection and 5 abbandans in the urban areas. Therefore, the remaining 200 abbandans are proposed to be improved.

The improvement is planned with the aim to increase the storage capacities (about 14.4 million m^3) by excavating abbandan beds. The area of the excavation is 3,245 ha in total. The present abbandan beds are excavated horizontally, and the maximum depth of excavation is about 1 m. In addition to this, the basins for fishery are planned along abbandan banks. The area of a fishery basin is proposed at 10% of each abbandan, and the excavation depth is designed at 1 m. The district-wide improvement quantities are as follows:

(Unit: '000 m^3)

District	No. of Abbandans	Present Volume	Proposed Volume	Excavation Volume *
Haraz West	3	364	505	169
Haraz East	25	6,687	8,731	2,760
Amol West	81	10,200	15,754	6,669
Amol East	91	16,425	23,073	8,559
Sub-Total	200	33,676	48,063	18,157
	(6)	(2,324)	(2,324)	(-)
Total	206	36,000	50,387	18,157

Note *: The total excavation volume of abbandan beds and fishery basins.
Figures in parentheses fall outside of improvement.

(2) Related Facilities

The related facilities are to be improved in the plan. As the inflows from catchment areas are not expected to the improved abbandans in principle, spillway structures, high water level and dead water levels are not considered in the design. At present, the abbandans have 0.4 - 0.5 m free board, and this figure seems to be acceptable. Therefore, the present full water levels are used in the design.

1) Head Race

Improved abbandans and diversion sites are connected by head races, and diversion works are planned at the diversion sites. The basic head race capacity, which is subject to abbandan size, is designed so as to fill up the typical-size-abbandan in two days. The slope protection by gabions is designed at the junctions from head races to abbandans.

2) Connecting Channel

In case abbandans are located close to each other, these abbandans are connected by connecting channels. The capacity of the connecting channel is designed at about a half of head race.

3) Outlet Works

Outlet works are planned as gravity system principally. Gate is installed at the entrance of outlet works in order to regulate discharges. The capacity of the outlet works is designed the same as the head race.

4) Link Channel

Link channels are designed to convey water from the outlet works to the downstream canal.

5.3.7 Design of Canal Related Facilities

(1) Turnout

From the viewpoint of economic, operation and maintenance aspects, sluice gate type and double orifice gate type are selected in this study. The double orifice gate type is adopted where submerged orifice conditions are realized, e.g. the deep depths of water. On the other hand, the sluice gate type is applied where partially submerged orifice conditions are expected, and measuring weirs are installed alongside as shown in the following table:

Item	Sluice Gate Type	Double Orifice Gate Type	Distributor
1) Measuring device	Necessary (a weir)	Not necessary	Not necessary
2) Head loss	0.3 - 0.4 m *	0.3 - 0.4 m	0.3 - 0.5 m
3) Cost	Medium **	Medium	High
4) Operation	Discharge controlled by one-gate operation	Discharge controlled by two-gates operation	Discharge controlled constantly by an autoregulator (Obstructive floating materials are inhibited)

Note * : Including head loss of a weir
** : Including measuring device facilities

(2) Measuring Device

In order to manage the water distribution for zones and blocks and to save O/M costs, the measuring devices are necessary. The candidates of device types are propeller type and measuring weir type for the project. Consequently, the measuring weir type is judged to be suitable for the Project Area from the viewpoint of the practicability of management works and the procurement of devices and parts. The weirs are to be installed at the beginning points of secondary and tertiary canals in principle. As for the division works of abbandans improvement, the measuring devices are not planned because of the unstableness of return flow.

(3) Check

Check structures are designed for irrigation and irrigation-cum-drainage canals in order to divert water firmly and to safeguard canals. Water levels and discharges are regulated manually or automatically, and manual gate (stop log) operation type is proposed principally in this study from the viewpoint of economical operation costs and similarity to the present. Then the check system becomes constant upstream level type. An overflow type stop log gate is designed as a movable weir, and bypass of fixed weir type is designed at both sides or one side of a check.

Water level is regulated by the stop log during the irrigation period, and the stop log is removed during the non-irrigation period in principle.

(4) Drop

Drop structures are made by reinforced concrete, and the upstream and downstream canal portions are protected by gabions. The combined structure of check and drop is advantageous from the economic point of view.

(5) Revetment

Revetments are planned for canal portions where scouring and slope failure are expected, e.g. the bends of canals. The structure of revetment is wet masonry in principle.

(6) Junction

At the confluences of secondary and main drainage canals, junction structures of concrete and wet masonry are planned. On the other hand, at the junctions of tertiary and secondary drainage canals, gabions are placed in order to protect canals.

(7) Syphon

There are two kinds of syphons relevant to secondary canals, as follows:

- Syphons in secondary canals: These syphons are planned in the irrigation canal portion of the HW1 secondary canal alone. The syphons are designed of ready-made RC pipe.
- Syphons across the Amol Main Canals and Drains: These syphons connect the Haraz east and west areas and the Amol east and west areas respectively, and convey return flow aiming at the effective use of water resources in summer. The structure of syphons is the same as the former.

(8) Aqueduct

Aqueducts are proposed when irrigation canals cross over drainage canals, etc. in principle. The type of aqueducts is designed as reinforced concrete flume.

(9) Cross Culvert

The flow areas of the existing cross culverts are judged to have the capacities required from the proposed design discharges. Therefore, the existing cross culverts are to be used as they are. On the other hand, for the new canals, box type cross culverts are designed if necessary.

5. 3. 8 Operation and Maintenance Road

The operation and maintenance roads are planned along one side of the secondary and tertiary canals in order to manage the canal facilities. The pavement mode is entirely designed as a graveling of which materials are to be taken from the Haraz river. The salient features of the said roads are as follows:

(1) Functions

- Water management after construction; Operation and control of turnouts and checks
- Facilities management after construction; Removal of weeds and sediments in canals, and management works such as maintenance inspection, improvement and restoration from calamities of canal, etc.

- Other function; Incidental usage as link roads among villages.

(2) Road Alignment

- The roads are planned on the intake sides in the case of irrigation and irrigation-cum-drainage canals, on the other hand, on the either side for drainage canals
- As the main and lateral farm roads are planned in the on-farm development, these roads are to be utilized as access roads and laybies for the said roads
- If a trunk public road runs parallel to canal, this road is to be used as the said road without or with improvement
- The said roads are not planned for the canal portions where the canal related facilities are not installed such as in the high land regions.

(3) Basic Idea of Design

- Width; Back hoes (2.8 m width) and trucks (greater than 6 ton class having 2.5 m width) are expected as maintenance vehicles, and the following widths are designed considering an one-lane traffic:

  Effective width = 0.35 + 2.8 + 0.35 = 3.5 m

  Total width = 0.5 + 3.5 + 0.5 = 4.5 m
- Curvature; the minimum radius of curve is 15 m in principle
- Pavement; Gravel pavement (t = 5 cm) is adopted

5. 3. 9 River Improvement

(1) Design Criteria

1) Magnitude of Planning

- Return Period

  25-year return period is adopted.
- Design Flood Discharge

Either peak flood discharge or daily flood discharge is adopted as the design flood discharge of river improvement. The objective rivers are, as follows:

Peak flood discharge; Peak flood discharge is applied to the rivers, along which overbank flows are not allowed because of the existence of residential areas along the rivers in question. Two rivers, the Babol and the Kari Rud rivers, are planned by a peak flood discharge.

Daily flood discharge; Daily flood discharge is applied to the rivers, along which occasional overbank flows are allowed because the rivers flow in the depressed area or in the forest. The Kharan and the Alesh rivers are planned by a daily flood discharge.

2) Flow Formula

The Manning's formula is applied in the calculation of flow capacities. The following roughness coefficients (n) are the results of floods study, and are applied in this design:

$n = 0.032$ (masonry),

$n = 0.035$ (meander, flood water levels reaching to weeds and 2 to 3-year-grown trees),

$n = 0.040$ (meander, flood water levels reaching to weeds and branches of big trees).

3) Permissible Velocity

Range of Permissible velocities of the river is principally same as the secondary canal. However, permissible velocity can be increased when acceptable from the viewpoint of present river conditions and bed materials.

4) Levee

Following criteria are set for the levee on the basis of conditions in the Project Area and the Japanese criteria as reference:

- Free Board

In accordance with design flood discharge (Qd), the following minimum free board (Fb) is applied:

Qd			Fb
	-	200 (m^3/m)	0.6 (m)
200	-	500	0.8
500	-	2,000	1.0

- Levee Crown Width

  In accordance with design flood discharge (Qd), the following minimum levee crown width (W) is applied:

Qd			Fb
	-	500 (m^3/m)	3 (m)
500	-	2,000	4

- O/M Road

  The O/M road is designed on the levee crown.

- Berm

  The minimum width of berm is 3 m, and berm is designed by the following manner:

  Water side ; 3- 5 m interval (when, levee height > = 6 m)
  Land side ; 2- 3 m interval (when, levee height > = 4 m)

- Side Slope

  The side slope of levee is designed at about 1 : 1.5

5) Revetment

Revetment is planned if necessary in order to protect the levee against scouring and seepage. The salient features of levee works are as follows:

- Height of Revetment

  Revetment top is designed at design high water level in principle.
- Depth of Embedment

  The depth of embedment is 1.0 m in principle

- Slope Pavement

  Concrete blocks pavement is applied in principle

(2) The Alesh River Improvement

The Alesh river improvement is planned for the lower portion from the confluence of the Amol West Main Drain, from No.0 to No.10 (10 km length). On the other hand, for the upper portion (from No.10), flood protection levee is planned on the right bank of the river.

(3) The Babol River Improvement

The Babol river improvement is planned for the portion, from No.6 + 500 to No.8 + 500 (2 km length). The present flow capacity of this portion is below the design flood discharge of 664 m^3/s.

(4) The Kari Rud Improvement

The Kari Rud improvement is planned for the 4.6 km length portion, viz., between the point about 1.4 km downstream from the junction of the Garma Rud river and the branching site of the Kari Rud floodway. The improvement together with the floodway is intended to accommodate the floods from the Garma Rud river (for details, refer to next section).

5. 3. 10 Kari Rud Flood way

The present flood capacities of the Kari Rud river after the junction of the Garma Rud river descend downstream, e.g. about 300 m^3/s just below the junction and about 50 m^3/s in the lower reach. Considering the design flood discharge 130 m^3/s of the Garma Rud river, the Kari Rud river can not satisfy the required capacity in the middle and the lower reaches. On the other hand, as houses are along the lower reach of the Kari Rud river, widening the river is difficult economically. Therefore, the construction of the Kari Rud floodway and the partial Kari Rud improvement are proposed in the study. The Kari Rud floodway is planned to have a capacity of 80 m^3/s, which is the difference between 130 m^3/s and 50 m^3/s, and to discharge to the Tabakoo Rud river, the tributary of the Kharan river. The outlines of the improvement and the floodway works are as follows (locations are illustrated below):

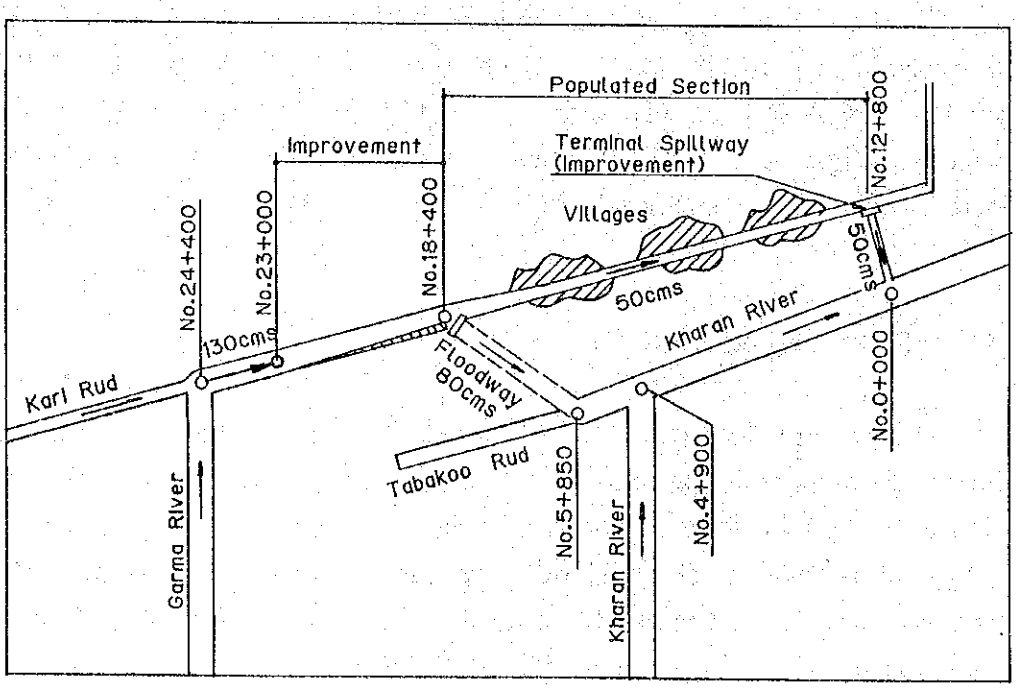
- Kari Rud Floodway

  The length of the floodway is 1,500 m, connecting the point No.18 + 400 of the Kari Rud and the point No.5 + 850 of the Tabakoo Rud, and the design discharge is 80 m^3/s. As the diversion works from the Kari Rud to the floodway, the drop structures without stilling basin are designed considering the bed load of soils and sands.

- Kari Rud Improvement

  The river widening is planned for the portion of 4,600 m length, from No.23 to No.18 + 400 points, where the present flood capacity is not fulfill the required one. The design discharge is 130 m^3/s. Terminal spillway structures are designed at the end of the Kari Rud.

Kari Rud Improvement and Floodway



5. 3. 11 River Mouth Improvement

The river mouth improvement is planned for the Feridon Kenar Main Drain alone. There are some other drains whose mouths are closed, however, it is able to avoid the effects of closing to provide a proper gradient to those drains, even if sea level reaches (-)25.0 m and canal bed rises.

By observation, the river mouth closing of the Feridon Kenar is caused mainly by the drift sand along the coast and beach. In this case, it is generally accepted that groins are effective to obstruct the movement of drift sand. A length of a groin is usually designed at 40% of the distance to a breaking wave point. The distance from the breaking wave point to the coast is observed at about 100-150 m. Then, the lengths of the groins are designed at about 50 m. As for the interval of groins, it is usually designed at three times of groin length. So it is designed at about 150 m intervals. In addition, training jetties are planned at both sides of the mouth. The sizes of the training jetties are designed based on those of the groins. The training jetties are installed perpendicularly north to west to avoid intrusion of waves, because prevailing direction of strong winds is north-west. On the other hand, the offshore breakwaters are effective for shore nourishment by mitigating waves and shore erosion. However, it is not recommendable to install the offshore breakwaters nearby the river mouth, because they deposit drift sand behind them.

The sea level is rising to date, and the coast is not of equilibrium condition, viz., under erosion, and consequently the breaking wave point is not stable. From this point of view, the groins may lose their effects. On the other hand, it seems that the artificial removal of closing sand might be a sure method, and this might be the most economical one in many cases. However, as the coast is in the process of eroding, the amount of drift sand is expected to be great. Therefore, the provision of exclusive dredgers is necessary, and the dredging works are promptly needed after strong winds.

5. 3. 12 Outline of Facilities

The components and the scale of the irrigation and drainage facilities are summarized, as follows: