Chapter 6 Bridges

Many bridges have been built to allow roads and rails to cross the Mejerda River and its tributaries in Zone D2, but it is clear that they need to be improved (replaced, raised) because there are places where the design river channel of this Study will not have sufficient downflow capacity.

Thus, as in the Master Plan, this Study includes improvements to existing bridges and the building of new bridges to accompany river improvements. The 11 bridges investigated in the Master Plan will be improved to accommodate changes to the design high-water level and channels. This section covers investigations of the bridge improvement plans required to improve the river, conducted according to the following procedures:

1. Fully understanding the current state of existing bridges and the capabilities they lack with respect to river improvements
2. Investigation of policy for improving existing bridges, selection of places in which to build new bridges
3. Improvement plans for existing bridges
4. Plans to build new bridges

Since the bridges in question are used differently for roads, highways and railways, this section also includes information on various design standards.

6.1 Fully Understanding the Current State of Existing Bridges and the Capabilities They Lack with Respect to River Improvements

6.1.1 Current State of Existing Bridges

Basic information about existing bridges was gathered prior to investigating bridge improvement policy. In addition to gathering the basic bridge specifications that serve as basic information, the team also surveyed existing structures and organizations that manage structures and verified the extent of damage at each site.

(1) Bridges Built in Zone D2

1) Bridges built in Zone D2

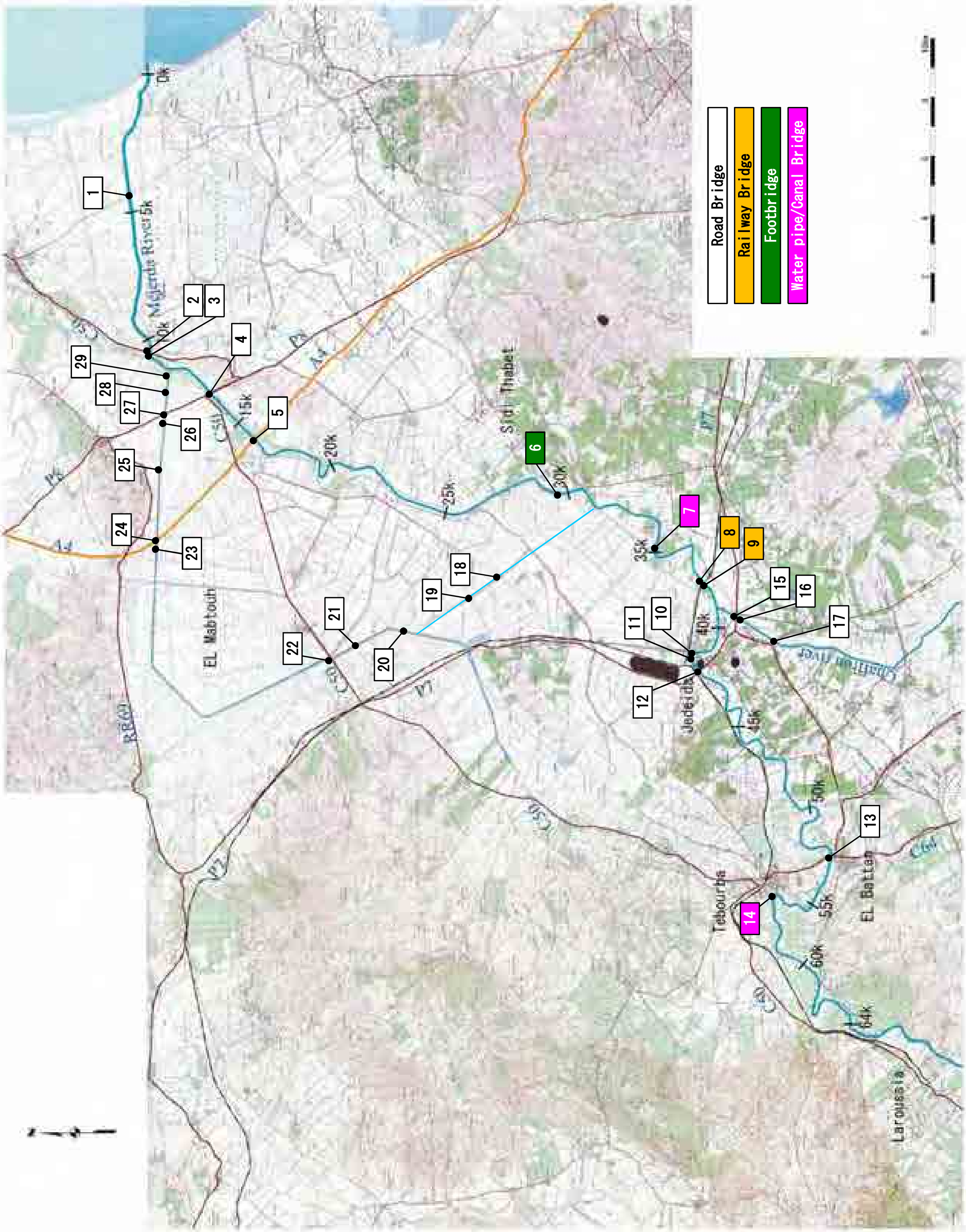
The list on the next page shows the 29 locations in which bridges have been built in Zone D2. Documentation Package 4.1 includes images and specifications for typical bridges confirmed through site surveys.

Table 6.3-1 Existing Bridges

Source: JICA Survey Team

No.	Bridge Name	Channel		Route	Bridge Length	Bridge Width	Remarks
		Name	Distance				
1	K.LANDAOUS BRIDGE	Medjerda	4.664	Rue Sadok Belhadi	19.600	8.750	
2	TOBIAS BRIDGE	Medjerda	10.828	MC50	87.400	10.500	
3	TOBIAS OLD BRIDGE	Medjerda	10.836	MC50	81.400	5.100	New bridge and location of piers do not match up
4	GP8 BRIDGE OVER OUED MEJERDA	Medjerda	13.728	GP8	145.200	9.040	
5	A4 MOTORWAY BRIDGE	Medjerda	16.017	MOTORWAY A4	126.500	14.500	
6	FOOTBRIDGE	Medjerda		Sidewalk	60.000	1.200	Wooden suspension bridge
7	WATER PIPE BRIDGE	Medjerda	34.440	Water supply	-	5.540	
8	JEDEIDA RAILWAY OLD BRIDGE	Medjerda	37.848	RAILWAY	60.500	4.160	New bridge and location of piers do not match up
9	JEDEIDA RAILWAY BRIDGE	Medjerda	37.834	RAILWAY	63.000	10.000	Girders show evidence of afflux from flooding
10	JEDEIDA BRIDGE	Medjerda	41.071	RVE507	87.200	12.000	
11	JEDEIDA OLD BRIDGE	Medjerda	41.091	RVE507	64.500	5.600	Historical bridge over narrow channel
12	JEDEIDA BRIDGE ON GP7	Medjerda	41.926	GP7	73.600	11.300	
13	EL BATTAN BRIDGE	Medjerda	53.111	MC64	94.070	8.500	Historical bridge
14	TEBOURBA IRRIGATION CANALS BRIDGE	Medjerda	56.899	IRRIGATION CANALS	125.000	5.540	
15	GP7 BRIDGE ON CHAFUROU	Chafurou		GP7	38.200	11.000	Bridge abutments located in flood channel
16	GP7 OLD BRIDGE ON CHAFUROU	Chafurou		GP7	-	-	New bridge and location of piers do not match up
17	EL H'BIBIA BRIDGE	Chafurou		Local Road	16.900	8.140	
18	Bridge on the local road	Mabtouh		Local Road	20.700	5.700	
19	FARM BRIDGE ON Driving CHANNEL	Mabtouh		Farm Road	-	-	Bridge for small farm road
20	FARM BRIDGE ON Driving CHANNEL	Mabtouh		Farm Road	-	-	Bridge for small farm road
21	FARM BRIDGE	Mabtouh		Farm Road	-	-	Bridge for small farm road
22	MC50 EL MABTOUH BRIDGE	Mabtouh		MC50	20.460	14.610	
23	FARM BRIDGE ON Oued Mabtouh	Mabtouh		Farm Road	-	-	Bridge for small farm road
24	A4 BRIDGE OVER Mabtouh	Mabtouh		MOTORWAY A4	52.600	14.000	
25	FARM BRIDGE ON Oued Mabtouh	Mabtouh		Farm Road	-	-	Bridge for small farm road
26	FARM BRIDGE ON Oued Mabtouh	Mabtouh		Farm Road	-	-	Bridge for small farm road
27	GP8 BRIDGE AND ROAD OVER Mabtouh	Mabtouh		GP8	36.500	9.900	
28	FARM BRIDGE ON Oued Mabtouh	Mabtouh		Farm Road	-	-	Bridge for small farm road
29	FARM BRIDGE ON Oued Mabtouh	Mabtouh		Farm Road	-	-	Bridge for small farm road

Source: JICA Survey Team



Source: JICA Survey Team

Figure 6.1-1 Current Bridge Locations

2) Organizations that manage bridges

The table below shows organizations that manage bridges in Zone D2 and organizations that manage various bridges:

Table 6.1 2 Organizations that Manage Bridges and Structures

Source: Preparatory Study

Structures	Organization
Bridges built for roads (national, governorate and regional roads)	MEHAT*, Civil Engineering Department
Tunis-Bizerte Highway	Tunisia Highways
Railway bridges	SNCFT**, Equipment Survey Department
Bridges built for farm roads (short, do not require technology)	MA***
Historical bridges	Ministry of Culture

*MEHAT: Ministry of Equipment, Housing and Land Development

*SNCFT: Tunisian Railways

***MA: Ministry of Agriculture

Table 6.1 3 Bridges and Responsible Organizations

	No.	Name	Organization
Roads Highways	1	K.LANDAOUS BRIDGE	MEHAT
	2	TOBIAS BRIDGE	MEHAT
	3	TOBIAS OLD BRIDGE	MEHAT
	4	GP8 BRIDGE OVER OUED MEJERDA	MEHAT
	5	A4 MOTORWAY BRIDGE	Tunisia Highways
	10	JEDEIDA BRIDGE	MEHAT
	11	JEDEIDA OLD BRIDGE	MEHAT
	12	JEDEIDA BRIDGE ON GP7	MEHAT
	13	EL BATTAN BRIDGE	MEHAT
	15	GP7 BRIDGE ON CHAFUROU	MEHAT
	17	EL H'BIBIA BRIDGE	MEHAT
	22	MC50 EL MABTOUH BRIDGE	MEHAT
	24	A4 BRIDGE OVER Mabtouh	Tunisia Highways
	27	GP8 BRIDGE AND ROAD OVER Mabtouh	MEHAT
Railways	8	JEDEIDA RAILWAY OLD BRIDGE	SNCFT
	9	JEDEIDA RAILWAY BRIDGE	SNCFT
Small Roads Farm Roads	16,18,19, 20,21,28, 29	FARM BRIDGE	MA
Irrigation Pipes	7	WATER PIPE BRIDGE	MA
	14	TEBOURBA IRRIGATION CANALS BRIDGE	MA

	No.	Name	Organization
Footbridges	6	FOOTBRIDGE	Unofficial

Source: Preparatory Study

(2) Studies of Existing Bridges

1) Documentation of existing bridges

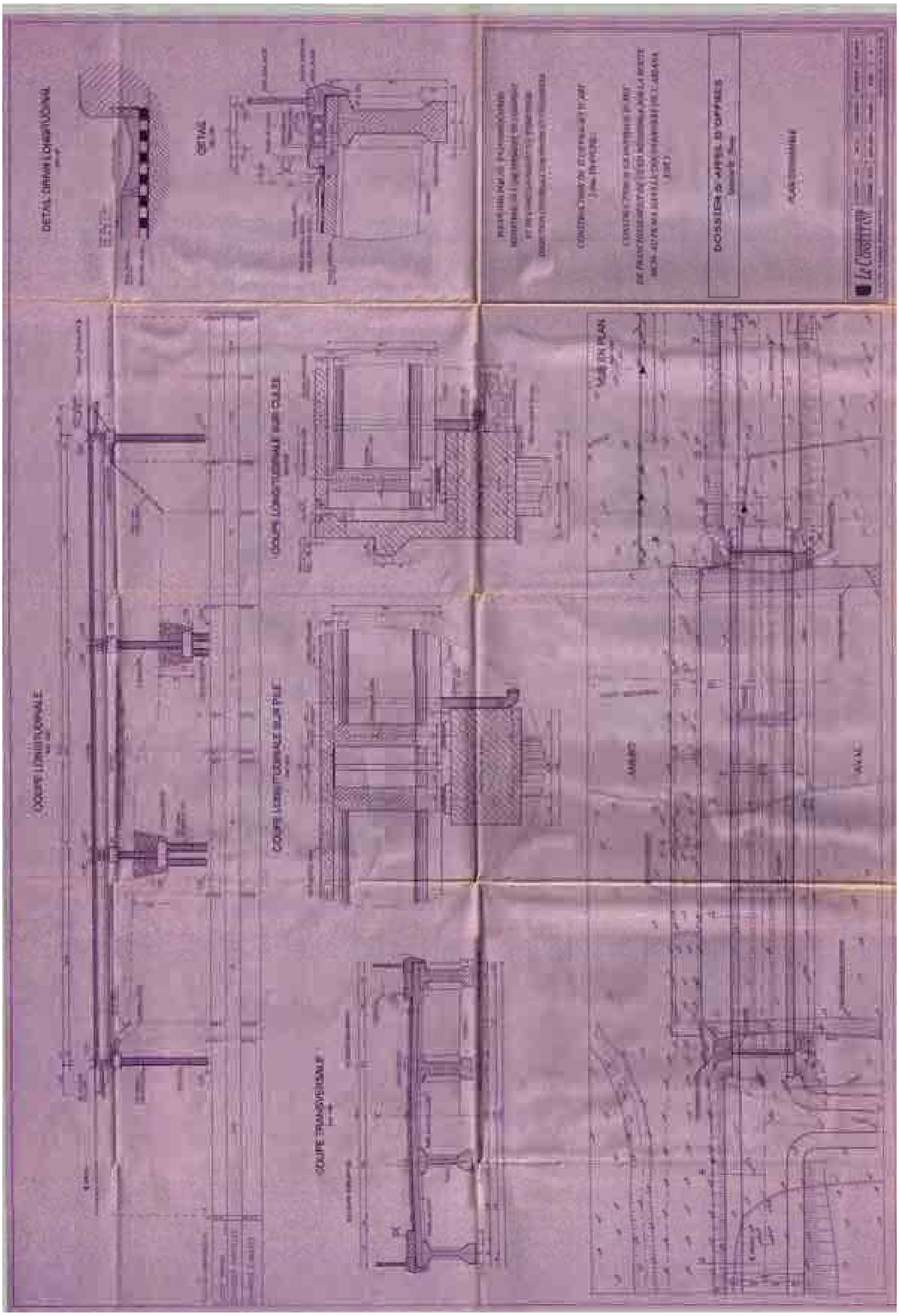
During site surveys, a study was done to determine whether design drawings serving as documentation for existing bridges existed. Design drawings could only be confirmed for the three bridges on the table below.

Typical drawings are shown on the next several pages, and the Material Package 4.2 includes all drawings.

Table 6.1-4 Bridges Confirmed on Design Drawings

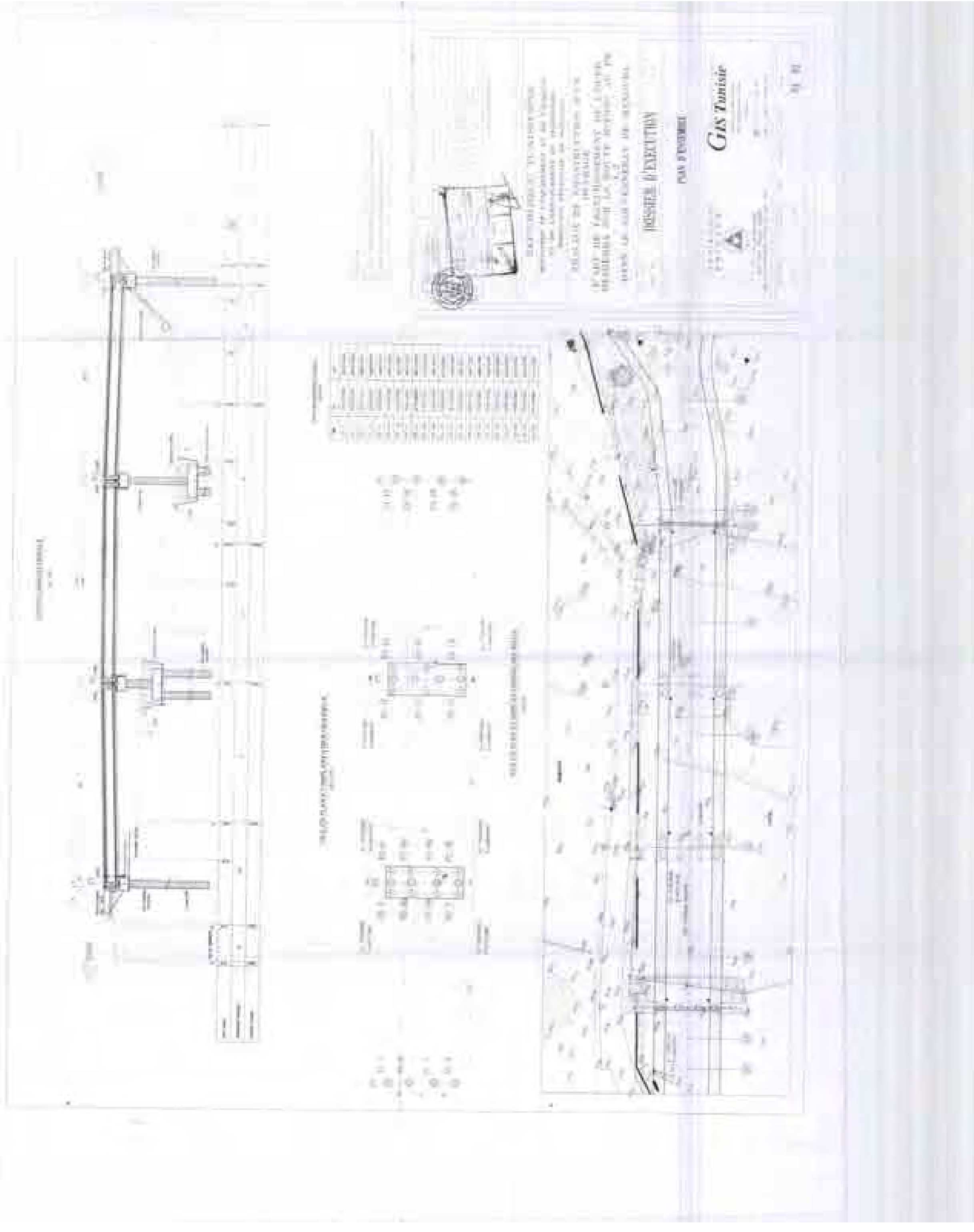
Source: JICA Survey Team

No.	Name	Drawings
2	TOBIAS BRIDGE	13 structural and other drawings
10	JEDEIDA BRIDGE	Overall drawings
9	JEDEIDA RAILWAY BRIDGE	Seven overall and other drawings



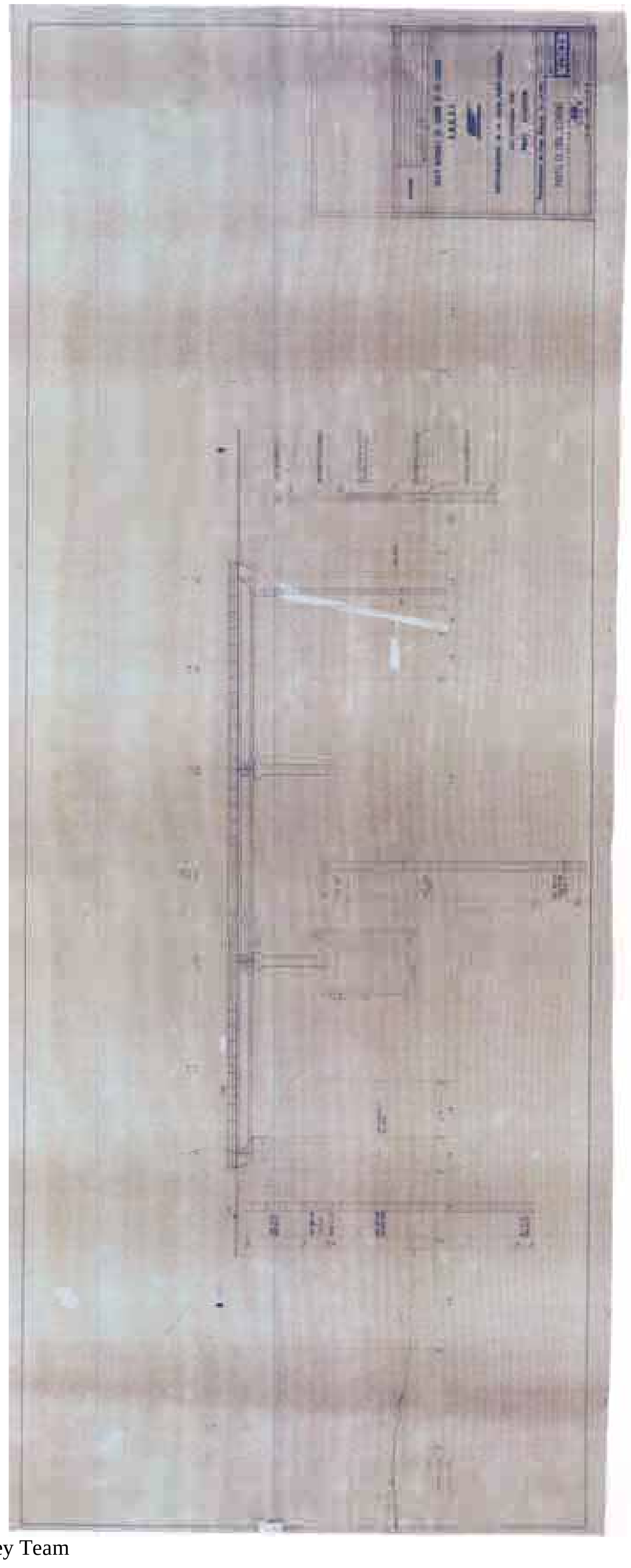
Source: JICA Survey Team

Figure 6.1 2 Existing Drawing for Tobias Bridge



Source: JICA Survey Team

Figure 6.1 3 Existing Drawing for Jedeida Bridge



Source: JICA Survey Team

Figure 6.1 4 Existing Drawing for Jedeida Railway Bridge

2) Historical bridges

Bridges of historical value in Tunisia can be designated as important cultural properties. Of the 29 bridges listed in the table above, the Jedeida Old Bridge and El Battan Bridge have received that designation.

The purpose of this designation is to regulate construction on these structures and in the areas surrounding them, preserve their historical and cultural value and make the public aware of their existence and value. Types of these structures are set forth in the Tunisian Cultural Heritage Law (Law No. 34-94, 24 February 1944). Chapter 2 (On Preservation) of this law includes details about construction on these structures and in the areas surrounding them:

- Article 9: A permit from the ministry in charge of cultural heritage is required to do construction within the borders of a cultural site
- Article 10: . . . no more than two (2) months shall pass before a permit application is answered . . .
- Article 12: All construction is subject to scientific and technical studies conducted by entities given authority by the ministry in charge of cultural heritage

Table 6.1 5 Bridges/Structures Designated as Important Cultural Properties

Source: JICA Survey Team

No.	Name	Registered on	Photo
11	JEDEIDA OLD BRIDGE	15 January 2001	
13	EL BATTAN BRIDGE	15 January 2001	

Source: Preparatory Study

Figure 6.1-5   Display Showing Structure's Registry as Important Cultural Property

3) Site survey

Current conditions were confirmed and measurements done during site surveys to fully understand the extent of damage and structural dimensions of existing bridges. Relevant authorities were also interviewed to see whether or not they had developed improvement plans for the future.

Table 6.1-6 Current State of Each Bridge

Source: JICA Survey Team

No.	Bridge Name	Channel		Condition
		Name	Distance	
1	K.LANDAOUS BRIDGE	Medjerda	4.664	
2	TOBIAS BRIDGE	Medjerda	10.828	Newly built in 2011
3	TOBIAS OLD BRIDGE	Medjerda	10.836	
4	GP8 BRIDGE OVER OUED MEJERDA	Medjerda	13.728	Not Good concrete deterioration, rebar corrosion apparent rebar, segregation concrete
5	A4 MOTORWAY BRIDGE	Medjerda	16.017	Good
6	FOOTBRIDGE	Medjerda		
7	WATER PIPE BRIDGE	Medjerda	34.440	
8	JEDEIDA RAILWAY OLD BRIDGE	Medjerda	37.848	General light corrosion of steel plates Massive stone pier, surrounded by sediment deposit and vegetation
9	JEDEIDA RAILWAY BRIDGE	Medjerda	37.834	Massive concrete pier, with some impact marks showing uncover rebars
10	JEDEIDA BRIDGE	Medjerda	41.071	Newly built in 2011
11	JEDEIDA OLD BRIDGE	Medjerda	41.091	Main span,Seriouusly damaged at several places Massive stone piers,Partially filled with debris jam and sediment deposit
12	JEDEIDA BRIDGE ON GP7	Medjerda	41.926	
13	EL BATTAN BRIDGE	Medjerda	53.111	Narrowness of gates call for jamming of debris Massive stone abutment,Fill with debris jam and sediment deposit
14	TEBOURBA IRRIGATION CANALS BRIDGE	Medjerda	56.899	Not Good
15	GP7 BRIDGE ON CHAFUROU	Chafurou		Good
16	GP7 OLD BRIDGE ON CHAFUROU	Chafurou		Not Good
17	EL H'BIBIA BRIDGE	Chafurou		Not Good
18	Bridge on the local road	Mabtouh		Good
19	FARM BRIDGE ON Driving CHANNEL	Mabtouh		
20	FARM BRIDGE ON Driving CHANNEL	Mabtouh		
21	FARM BRIDGE	Mabtouh		
22	MC50 EL MABTOUH BRIDGE	Mabtouh		Good
23	FARM BRIDGE ON Oued Mabtouh	Mabtouh		
24	A4 BRIDGE OVER Mabtouh	Mabtouh		Good
25	FARM BRIDGE ON Oued Mabtouh	Mabtouh		
26	FARM BRIDGE ON Oued Mabtouh	Mabtouh		
27	GP8 BRIDGE AND ROAD OVER Mabtouh	Mabtouh		Not Good
28	FARM BRIDGE ON Oued Mabtouh	Mabtouh		
29	FARM BRIDGE ON Oued Mabtouh	Mabtouh		

6.1-2 Current State of Downflow Capacity at Bridges

A study was done to confirm whether the vertical clearances and lengths of bridges in their current state were satisfactory in terms of design river cross section specifications and design high-water levels. The table below shows the results of the study.

The two assessment items are:

- Is vertical clearance satisfactory in terms of HWL?
- Is bridge length satisfactory in terms of HWL/river width?

Comments that explain reasons why some places were considered problematic in terms of downflow capacity are included in the Assessment column in the table below:

Table 6.1-7 Review of Current State of Downflow Capacity at Bridges

No.	Bridge Name	Channel		Water level calculation (W=1/10)	HWL (m)	Elevation (girder bottom) (m)	Bridge Length (m)	Riverwidth (HWL) (m)	Evaluation
		Name	Distance						
1	K.LANDAOUS BRIDGE	Medjerda	4.664	3.312	3.670	1.330	19.600	100	NG (girder elevation)
2	TOBIAS BRIDGE	Medjerda	10.828	6.951	7.092	9.680	87.400	82	OK
3	TOBIAS OLD BRIDGE	Medjerda	10.836	6.951	7.096		81.400	82	NG *1
4	GP8 BRIDGE OVER OUED MEJERDA	Medjerda	13.728	8.466	8.542	10.110	145.200	82	OK
5	A4 MOTORWAY BRIDGE	Medjerda	16.017	9.556	9.686	11.980	126.500	82	OK
6	FOOTBRIDGE	Medjerda		17.242	17.508			82	OK *2
7	WATER PIPE BRIDGE	Medjerda	34.440	17.562	17.793			100	OK *2
8	JEDEIDA RAILWAY OLD BRIDGE	Medjerda	37.848	19.178	19.275		60.500	100	NG *1
9	JEDEIDA RAILWAY BRIDGE	Medjerda	37.834	19.184	19.269	19.200	63.000	100	NG (girder elevation)
10	JEDEIDA BRIDGE	Medjerda	41.071	20.719	20.849	21.400	87.200	Existing Width	OK *3
11	JEDEIDA OLD BRIDGE	Medjerda	41.091	20.728	20.859		64.500	Existing Width	OK *3
12	JEDEIDA BRIDGE ON GP7	Medjerda	41.926	21.144	21.276	25.130	73.600	100	NG (bridge length)
13	EL BATTAN BRIDGE	Medjerda	53.111	26.436		28.050	94.070	Existing Width	OK *3
14	TEBOURBA IRRIGATION CANALS BRIDGE	Medjerda	56.899	30.773			125.000	Existing Width	OK *2
15	GP7 BRIDGE ON CHAFUROU	Chafurou					38.200	61	NG (bridge length)
16	GP7 OLD BRIDGE ON CHAFUROU	Chafurou					38.200	56	NG (bridge length)
17	EL H'BIBIA BRIDGE	Chafurou					16.900	62	NG (bridge length)
18	Bridge on the local road	Mabtouh					20.700		NG *4
19	FARM BRIDGE ON Driving CHANNEL	Mabtouh					20.700		NG *4
20	FARM BRIDGE ON Driving CHANNEL	Mabtouh					20.700		NG *4
21	FARM BRIDGE	Mabtouh					20.700		NG *4
22	MC50 EL MABTOUH BRIDGE	Mabtouh					20.460		NG *4
23	FARM BRIDGE ON Oued Mabtouh	Mabtouh					20.700		OK
24	A4 BRIDGE OVER Mabtouh	Mabtouh					52.600		OK
25	FARM BRIDGE ON Oued Mabtouh	Mabtouh					20.700		OK
26	FARM BRIDGE ON Oued Mabtouh	Mabtouh					20.700		OK
27	GP8 BRIDGE AND ROAD OVER Mabtouh	Mabtouh					36.500		OK
28	FARM BRIDGE ON Oued Mabtouh	Mabtouh					20.700		OK
29	FARM BRIDGE ON Oued Mabtouh	Mabtouh					20.700		OK

*1 : The pier locations are not aligned with the streamline
*2 : No problems with flooding in the past
*3 : Impossible to repair, because histrical bridge
*4 : Enormous change of the cross section

Source: JICA Survey Team

6.1.3 Problems with Current Conditions

The table above shows problems with bridges in their current state; the table below lists those problems and aligns them with the need for bridge improvement. Fifteen of the 29 bridges need to be replaced, and three need to be built anew. It is worth noting that the Kalaat Landaous Bridge, the bridge farthest downstream, needs to be replaced as part of river channel improvement, but it is outside the scope of this project because it will probably be treated as a road project.

Table 6.1-8 Problems with Bridges in Their Current State

Source: JICA Survey Team5.3-9

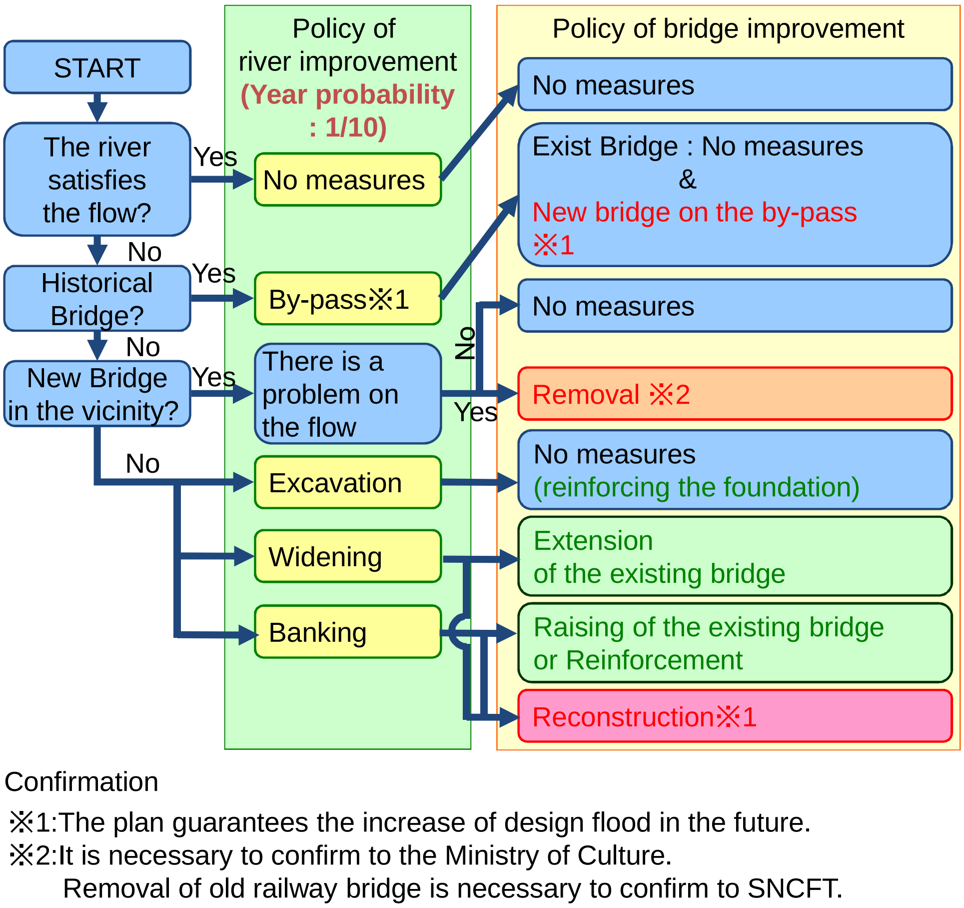
No.	Bridge Name	Channel		Downflow Capacity	Condition	Historical Bridge
		Name	Distance			
1	K.LANDAOUS BRIDGE	Medjerda	4.664	NG		
2	TOBIAS BRIDGE	Medjerda	10.828			
3	TOBIAS OLD BRIDGE	Medjerda	10.836	NG		
4	GP8 BRIDGE OVER OUED MEJERDA	Medjerda	13.728		Not Good	
5	A4 MOTORWAY BRIDGE	Medjerda	16.017			
6	FOOTBRIDGE	Medjerda				
7	WATER PIPE BRIDGE	Medjerda	34.440			
8	JEDEIDA RAILWAY OLD BRIDGE	Medjerda	37.848	NG	Not Good	○
9	JEDEIDA RAILWAY BRIDGE	Medjerda	37.834	NG		
10	JEDEIDA BRIDGE	Medjerda	41.071			
11	JEDEIDA OLD BRIDGE	Medjerda	41.091		Not Good	
12	JEDEIDA BRIDGE ON GP7	Medjerda	41.926	NG		
13	EL BATTAN BRIDGE	Medjerda	53.111			○
14	TEBOURBA IRRIGATION CANALS BRIDGE	Medjerda	56.899		Not Good	
15	GP7 BRIDGE ON CHAFUROU	Chafurou		NG		
16	GP7 OLD BRIDGE ON CHAFUROU	Chafurou		NG	Not Good	
17	EL H'BIBIA BRIDGE	Chafurou		NG	Not Good	
18	Bridge on the local road	Mabtouh		NG		
19	FARM BRIDGE ON Driving CHANNEL	Mabtouh		NG		
20	FARM BRIDGE ON Driving CHANNEL	Mabtouh		NG		
21	FARM BRIDGE	Mabtouh		NG		
22	MC50 EL MABTOUH BRIDGE	Mabtouh		NG		
23	FARM BRIDGE ON Oued Mabtouh	Mabtouh				
24	A4 BRIDGE OVER Mabtouh	Mabtouh				
25	FARM BRIDGE ON Oued Mabtouh	Mabtouh				
26	FARM BRIDGE ON Oued Mabtouh	Mabtouh				
27	GP8 BRIDGE AND ROAD OVER Mabtouh	Mabtouh		Shorter than existing dike	Not Good	
28	FARM BRIDGE ON Oued Mabtouh	Mabtouh				
29	FARM BRIDGE ON Oued Mabtouh	Mabtouh				
30	FARM BRIDGE(NEW)	Mabtouh				
31	FARM BRIDGE(NEW)	Mabtouh				
32	FARM BRIDGE(NEW)	Mabtouh				

* Outside the scope of the Project

6.2 Improvement Policy Selection Flowchart

6.2.1 Improvement Policy Selection Flowchart

Below is a selection flowchart used to develop bridge improvement policy in response to the problems with current conditions described in the previous sections:

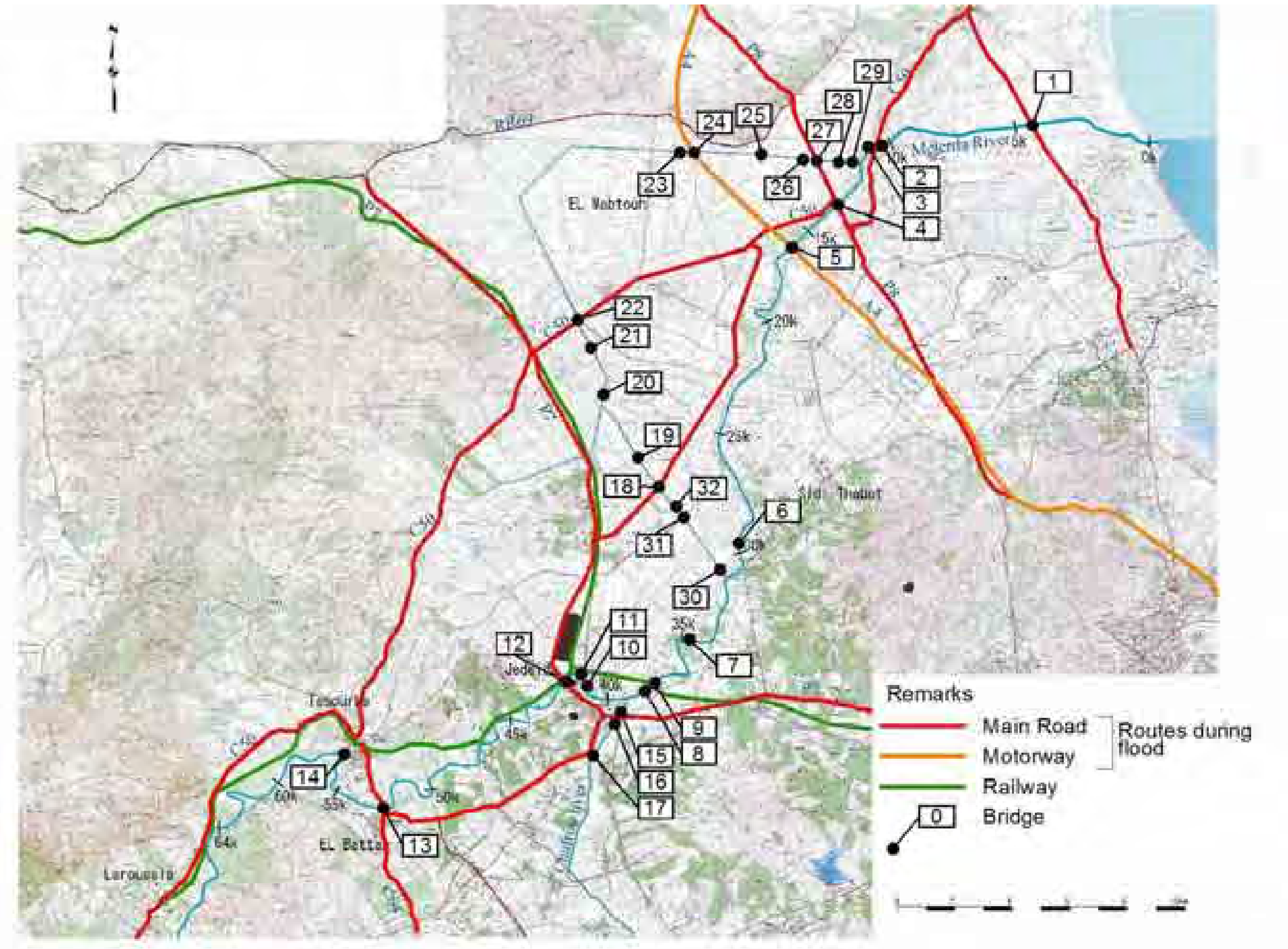


Source: JICA Survey Team

Figure 6.2-1 Bridge Improvement Policy Selection Flowchart

Required capabilities differ for each location in which bridges are to be replaced or built anew, so the size of each improved bridge must be configured appropriately. Deliberations with the Ministry of Agriculture and the Ministry of Equipment resulted in policy that required main roads to be passable during floods so that people and supplies could be moved and transported. Deliberations did not require bridges on farm roads to be passable on the condition that consideration was given such that the bridges' impassability would not cause areas to become isolated during floods. Deliberations with SNCFT resulted in a guarantee that railways would be passable during floods.

Based on the above policy, roadways were configured to ensure passability during floods (with ten-year flood design HWL). In addition to highways, national roads and other main roads and railways, the El Mabtouh Retarding Basin was selected in such a way that large areas would not become isolated. Below are the results of these roadway configurations:



Source: JICA Survey Team

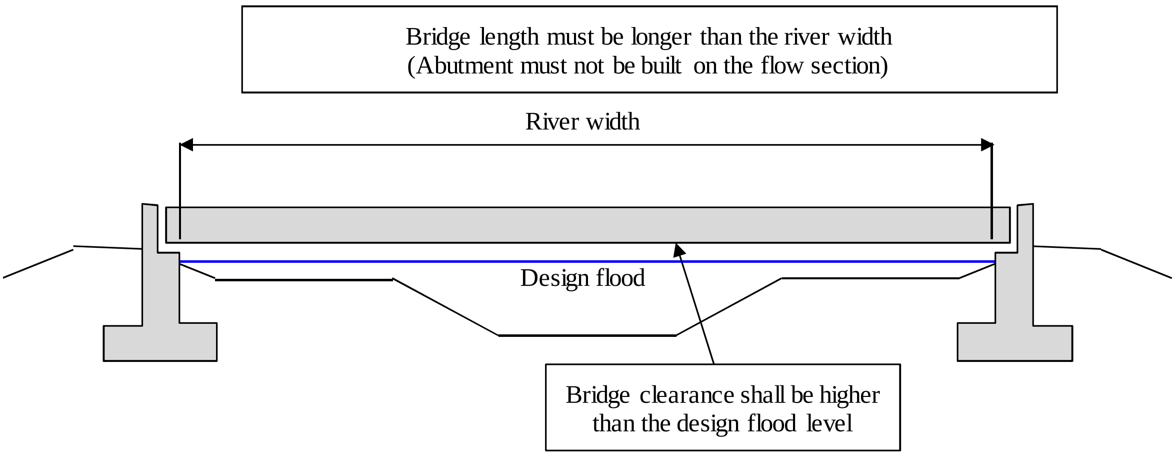
Figure 6.2-2 Roadways Guaranteed During Floods

Bridges to be replaced or built anew and those located on roadways guaranteed during floods will have Class A capabilities as described on the table below; bridges over all other roadways will have Class B capabilities.

Table 6.2-1 New Bridge Classifications

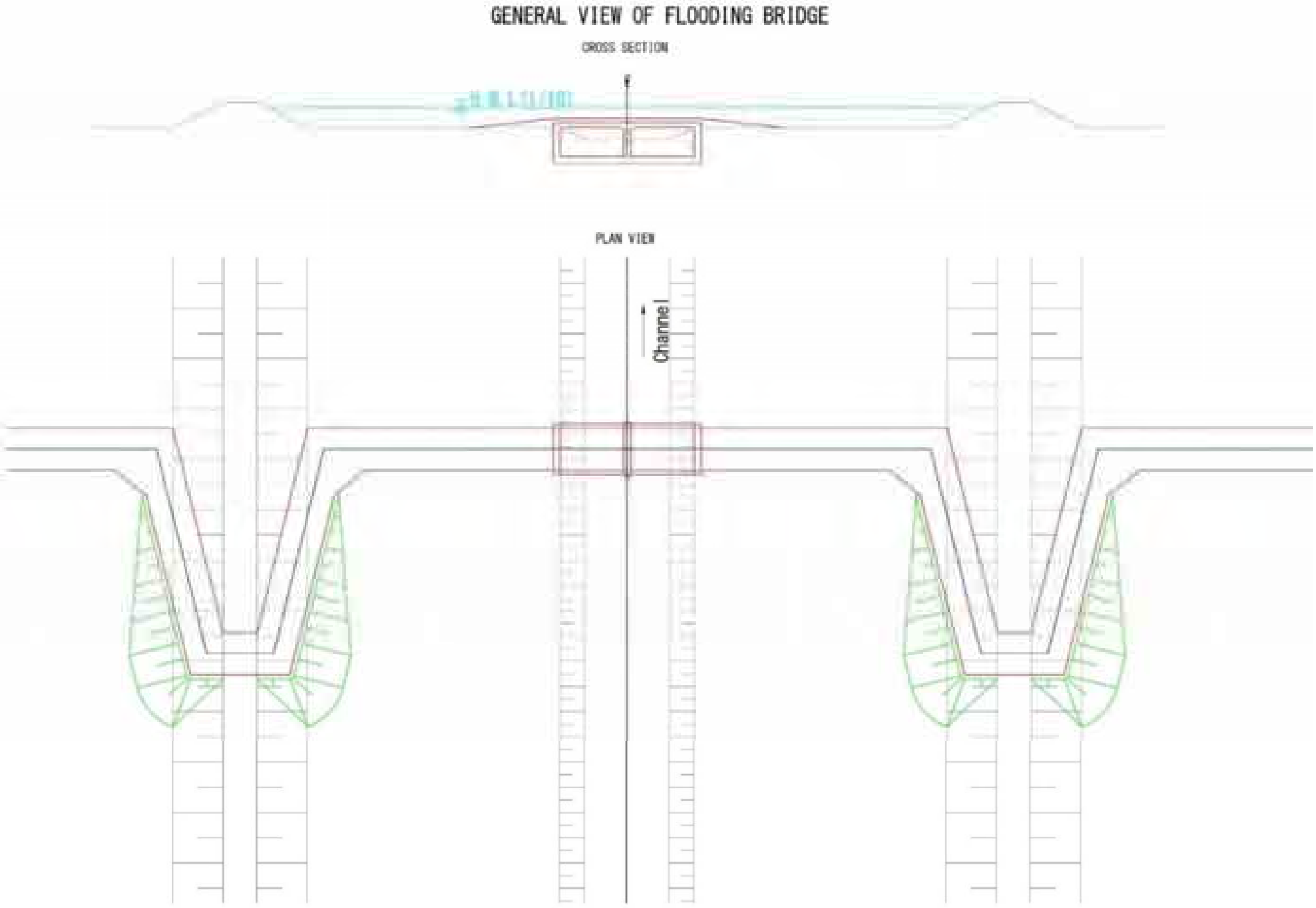
	Class A	Class B
Description	Passable during floods to move people and transport supplies	Bridges of minimum length to reduce costs since they are impassable during floods and necessitate detours to other bridges
Passability	Normal times: Passable	Normal times: Passable
	During floods: Passable	During floods: Impassable
Required Capabilities	Bridge functions guaranteed, even during floods	Bridge functions over low-channel rivers guaranteed during normal times
Bridge Plans	Vertical clearance higher than design high-water level, length longer than river width	These bridges only cross low channels; they are designed to become submerged during floods

Source: JICA Survey Team



Source: JICA Survey Team

Figure 6.2-3 Overview of Class A Bridges



Bridges over roadways not guaranteed during floods will be of the minimum possible scale and only cross low channels passable under normal flow conditions. They are designed to become submerged during floods.

However, such roads will run diagonally up and down the slopes of dikes to avoid causing discontinuity of the dikes.

Source: JICA Survey Team

Figure 6.2-4 Overview of Class B Bridges

6.2.2 Bridge Improvement Policy Selection Results

The table below shows the results of improvement policy selected based on the flowchart above:

Table 6.2-2 Improvement Policy Selection Results

No.	Bridge Name	Channel		Histrical Bridge	flow	Condition	Policy of bridge improvement
		Name	Distance				
1	K.LANDAOUS BRIDGE	Medjerda	4.664		NG		Reconstruction(Outside the scope of the project)
2	TOBIAS BRIDGE	Medjerda	10.828		OK		No measures
3	TOBIAS OLD BRIDGE	Medjerda	10.836		NG *1		Removal
4	GP8 BRIDGE OVER OUED MEJERDA	Medjerda	13.728		OK	Not Good	Reconstruction
5	A4 MOTORWAY BRIDGE	Medjerda	16.017		OK		No measures
6	FOOTBRIDGE	Medjerda			OK		No measures
7	WATER PIPE BRIDGE	Medjerda	34.440		OK		No measures
8	JEDEIDA RAILWAY OLD BRIDGE	Medjerda	37.848		NG *1	Not Good	Removal
9	JEDEIDA RAILWAY BRIDGE	Medjerda	37.834		NG		Extension of the existing bridge
10	JEDEIDA BRIDGE	Medjerda	41.071		-- *2		No measures
11	JEDEIDA OLD BRIDGE	Medjerda	41.091	○	-- *2	Not Good	No measures
12	JEDEIDA BRIDGE ON GP7	Medjerda	41.926		NG		Extension of the existing bridge
13	EL BATTAN BRIDGE	Medjerda	53.111	○	-- *2		No measures
14	TEBOURBA IRRIGATION CANALS BRIDGE	Medjerda	56.899		-- *2	Not Good	No measures
15	GP7 BRIDGE ON CHAFUROU	Chafurou			NG		Reconstruction
16	GP7 OLD BRIDGE ON CHAFUROU	Chafurou			NG *1	Not Good	Removal
17	EL H'BIBIA BRIDGE	Chafurou			NG	Not Good	Reconstruction as "Flooding Bridge"
18	Bridge on the local road	Mabtouh			NG		Reconstruction
19	FARM BRIDGE ON Driving CHANNEL	Mabtouh			NG		Reconstruction as "Flooding Bridge"
20	FARM BRIDGE ON Driving CHANNEL	Mabtouh			NG		Reconstruction as "Flooding Bridge"
21	FARM BRIDGE	Mabtouh			NG		Reconstruction as "Flooding Bridge"
22	MC50 EL MABTOUH BRIDGE	Mabtouh			NG		Reconstruction
23	FARM BRIDGE ON Oued Mabtouh	Mabtouh			-- *2		No measures
24	A4 BRIDGE OVER Mabtouh	Mabtouh			-- *2		No measures
25	FARM BRIDGE ON Oued Mabtouh	Mabtouh			-- *2		No measures
26	FARM BRIDGE ON Oued Mabtouh	Mabtouh			-- *2		No measures
27	GP8 BRIDGE AND ROAD OVER Mabtouh	Mabtouh			NG *3	Not Good	Reconstruction
28	FARM BRIDGE ON Oued Mabtouh	Mabtouh			-- *2		No measures
29	FARM BRIDGE ON Oued Mabtouh	Mabtouh			-- *2		No measures

*1 : The pier locations are not aligned with the streamline
*2 : No river channel improvement
*3 : Lower than the existing levee

Source: JICA Survey Team5.3-13

6.2.3 New Bridge Design

The river improvement of this Project includes improvements to the Mejerda and Chafrou Rivers as well as to the El Mabtouh Retarding Basin. Irrigation channels run through the section from the Mejerda River to the El Mabtouh Retarding Basin and feature bridges where they intersect roads, but the figure on the next page shows places in which there are no existing waterways and, thus, no existing bridges.

However, this Project calls for a channel to the retarding basin to be built, and new bridges will be built in places in this section where the new channel intersects existing roads.

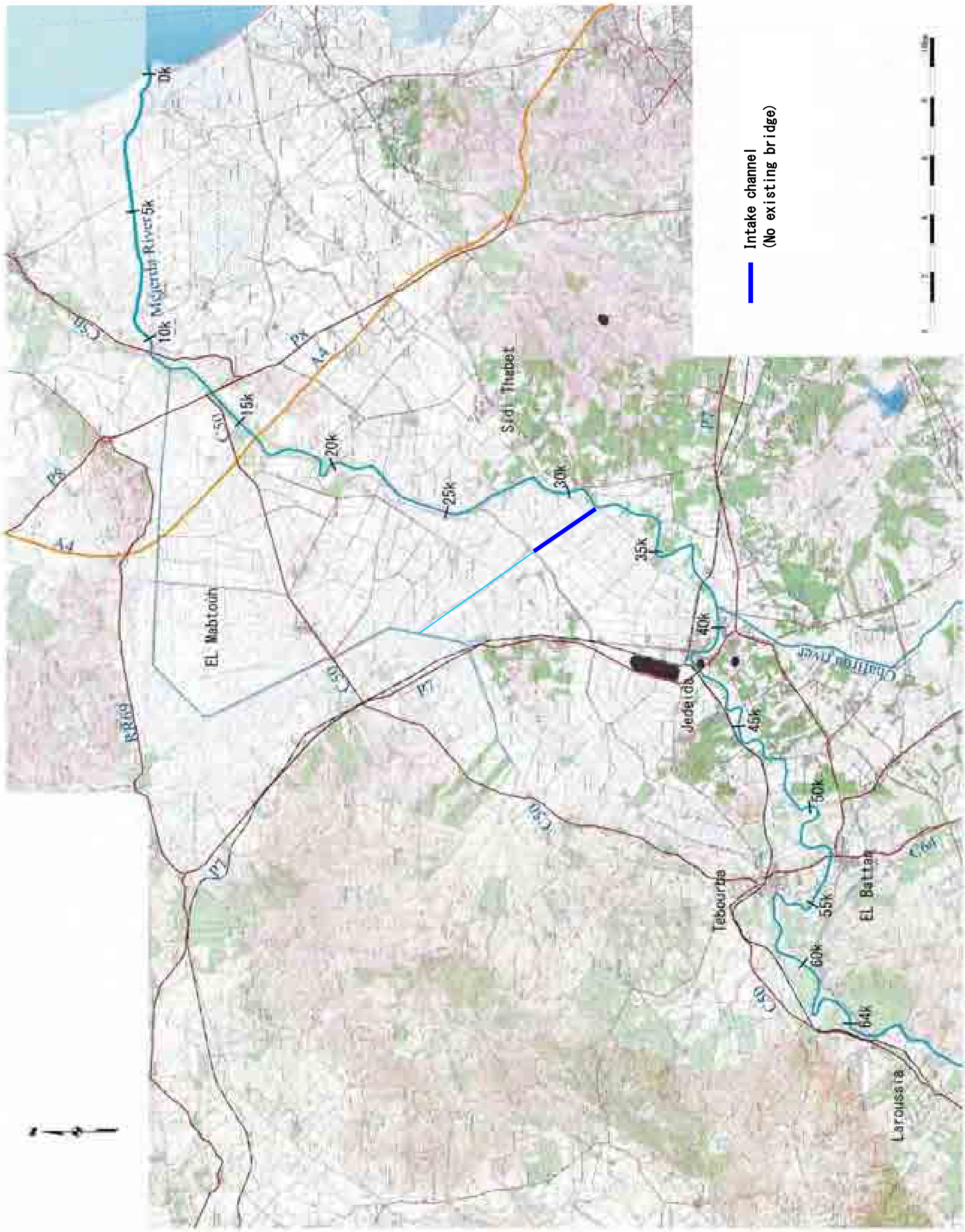


Figure 6.2-5 Location where New Bridge is Required

6.2.4 List of Bridges Requiring Improvement (Bridge Reconstruction/New Bridge Construction)

As mentioned above, 15 of the 29 existing bridges need to be replaced, and three need to be built anew. It is worth noting that the Kalaat Landaous Bridge, the bridge farthest downstream, needs to be replaced as part of river channel improvement, but it is outside the scope of this project because it will probably be treated as a road project.

Table 6.2-3 List of Bridges Requiring Improvement

No.	Bridge Name	Channel		Route	Policy of bridge improvement	Classification
		Name	Distance			
1	K.LANDAOUS BRIDGE	Medjerda	4.664	Rue Sadok Belhadi	Reconstruction *	
2	TOBIAS BRIDGE	Medjerda	10.828	MC50	No measures	
3	TOBIAS OLD BRIDGE	Medjerda	10.836	MC50	Removal	
4	GP8 BRIDGE OVER OUED MEJERDA	Medjerda	13.728	GP8	Reconstruction	A
5	A4 MOTORWAY BRIDGE	Medjerda	16.017	MOTORWAY A4	No measures	
6	FOOTBRIDGE	Medjerda		Sidewalk	No measures	
7	WATER PIPE BRIDGE	Medjerda	34.440	Water supply	No measures	
8	JEDEIDA RAILWAY OLD BRIDGE	Medjerda	37.848	RAILWAY	Removal	
9	JEDEIDA RAILWAY BRIDGE	Medjerda	37.834	RAILWAY	Extension of the existing bridge	
10	JEDEIDA BRIDGE	Medjerda	41.071	RVE507	No measures	
11	JEDEIDA OLD BRIDGE	Medjerda	41.091	RVE507	No measures	
12	JEDEIDA BRIDGE ON GP7	Medjerda	41.926	GP7	Extension of the existing bridge	
13	EL BATTAN BRIDGE	Medjerda	53.111	MC64	No measures	
14	TEBOURBA IRRIGATION CANALS BRIDGE	Medjerda	56.899	IRRIGATION CANALS	No measures	
15	GP7 BRIDGE ON CHAFUROU	Chafurou		GP7	Reconstruction	A
16	GP7 OLD BRIDGE ON CHAFUROU	Chafurou		GP7	Removal	
17	EL H'BIBIA BRIDGE	Chafurou		Local Road	Reconstruction	B
18	Bridge on the local road	Mabtouh		Local Road	Reconstruction	A
19	FARM BRIDGE ON Driving CHANNEL	Mabtouh		Farm Road	Reconstruction	B
20	FARM BRIDGE ON Driving CHANNEL	Mabtouh		Farm Road	Reconstruction	B
21	FARM BRIDGE	Mabtouh		Farm Road	Reconstruction	B
22	MC50 EL MABTOUH BRIDGE	Mabtouh		MC50	Reconstruction	A
23	FARM BRIDGE ON Oued Mabtouh	Mabtouh		Farm Road	No measures	
24	A4 BRIDGE OVER Mabtouh	Mabtouh		MOTORWAY A4	No measures	
25	FARM BRIDGE ON Oued Mabtouh	Mabtouh		Farm Road	No measures	
26	FARM BRIDGE ON Oued Mabtouh	Mabtouh		Farm Road	No measures	
27	GP8 BRIDGE AND ROAD OVER Mabtouh	Mabtouh		GP8	Reconstruction	A
28	FARM BRIDGE ON Oued Mabtouh	Mabtouh		Farm Road	No measures	
29	FARM BRIDGE ON Oued Mabtouh	Mabtouh		Farm Road	No measures	
30	FARM BRIDGE(NEW)	Mabtouh		Farm Road	New construction	B
31	FARM BRIDGE(NEW)	Mabtouh		Farm Road	New construction	B
32	FARM BRIDGE(NEW)	Mabtouh		Farm Road	New construction	B

* Outside the scope of the project

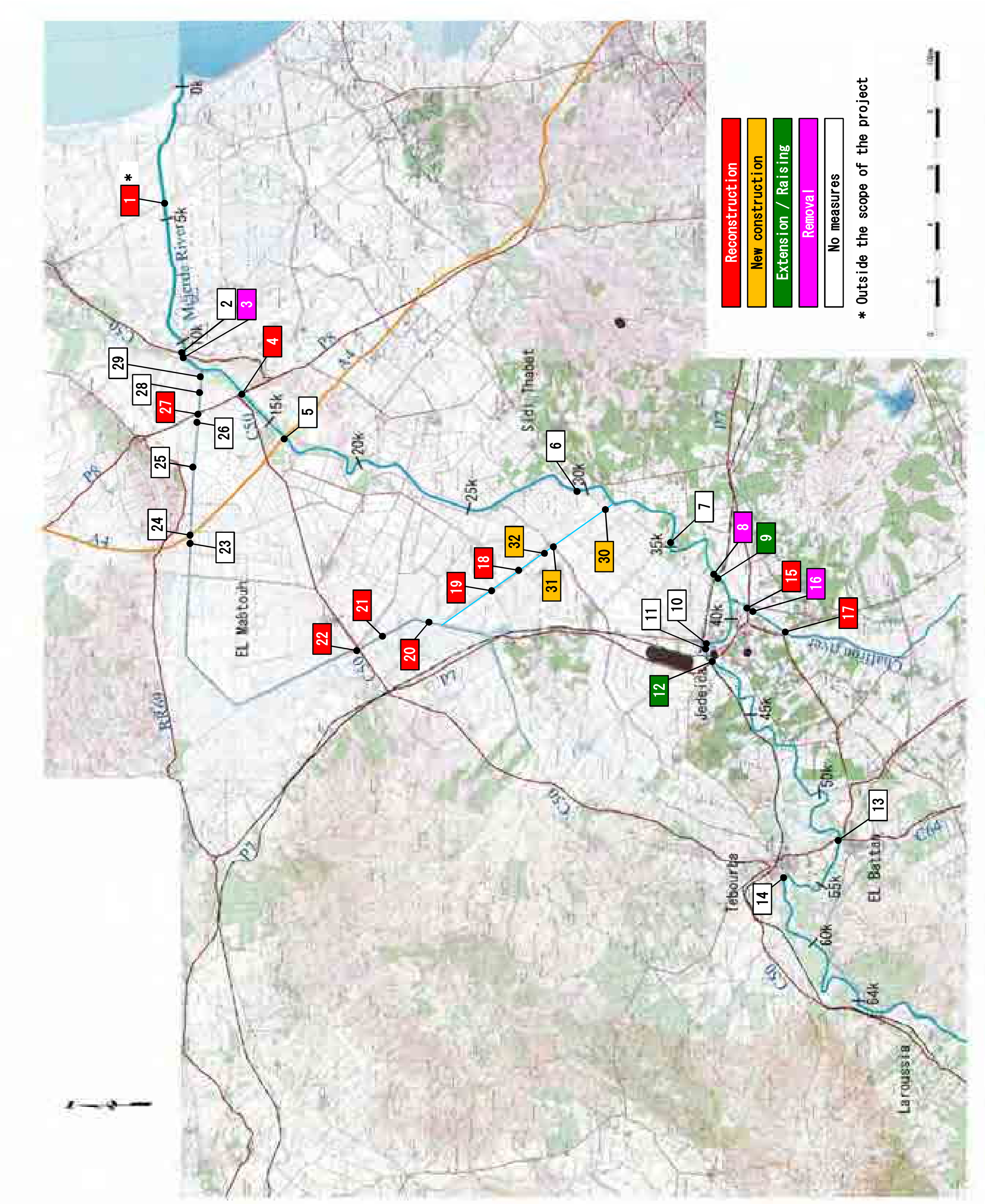
Source: JICA Survey Team

Table 6.2-4 Numbers of Bridges

Policy of bridge improvement	Medjerda	Chafurou	Mabtouh	TOTAL
Reconstruction	1	1	3	5
Reconstruction as "Flooding Bridge"		1	3	4
Extension of the existing bridge	2			2
Removal	2	1		3
No measures	8		6	14
Reconstruction *1	1			1
Existing bridge	14	3	12	29
New construction as "Flooding Bridge"			3	3
TOTAL	14	3	15	32

Source: JICA Survey Team

*1 Outside the scope of the project(K.LANDAOUS BRIDGE)



Source: JICA Survey Team

Figure 6.2-6 Locations of Bridges to be Reconstructed/Newly Built

6.3 Existing Bridge Improvement Plans

6.3.1 No. 1 K.LANDAOUS BRIDGE

(1) Overview

- This submersible bridge is on the primary route connecting Ariana to Kalaat Landaous, a two-lane road with mid-level traffic or lower.
- RC consecutive box culvert construction
- See picture:

Figure 6.3-1 K. Andalous Bridge in August 2012

(2) Hydrological Assessment

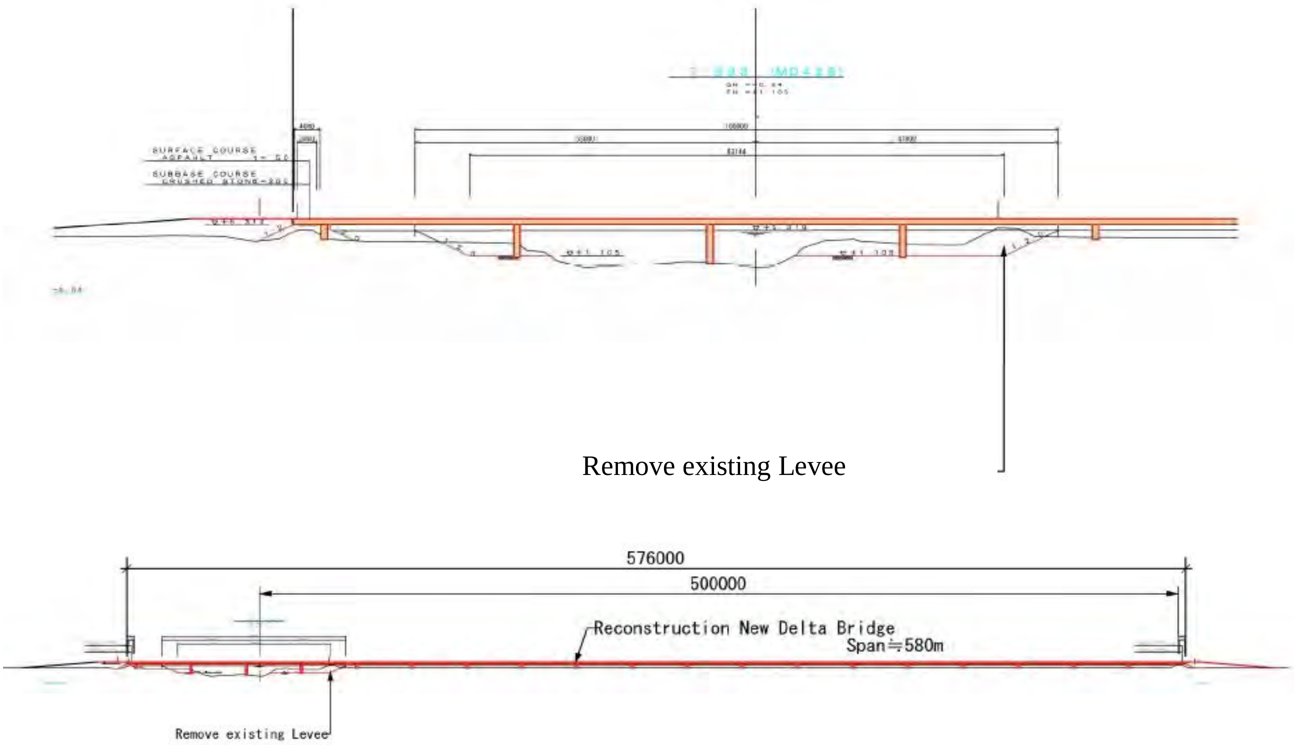
The vertical clearance on this bridge is lower than the design high-water level, inhibiting the downflow cross section and causing the structure to become submerged during floods and cutting off traffic for several weeks.

The design high-water level is 3.670 meters; a 1.0-meter freeboard must be added to that to ensure a 4.670-meter vertical clearance.

(3) Existing Bridge Improvement Plan

Traffic is heavy on the primary road connecting Ariana and Kalaat Andalous, and many shoreline development projects have been planned in the area.

The Ministry of Equipment planned the replacement of this bridge, so that part has been eliminated from this Project. In addition to vertical clearance of 4.670 meters, the bridge needs to be around 580 meters long to ensure that it spans the river as shown in the figure below:



Source: JICA Survey Team

Figure 6.3-2 K. Landaous Bridge Reconstruction Specifications

6.3.2 No. 3　TOBIAS OLD BRIDGE

(1) Overview

・Bridge by which MC50 crosses the Mejerda River; a new bridge is being built downstream of it

・A dilapidated structure built before 1948

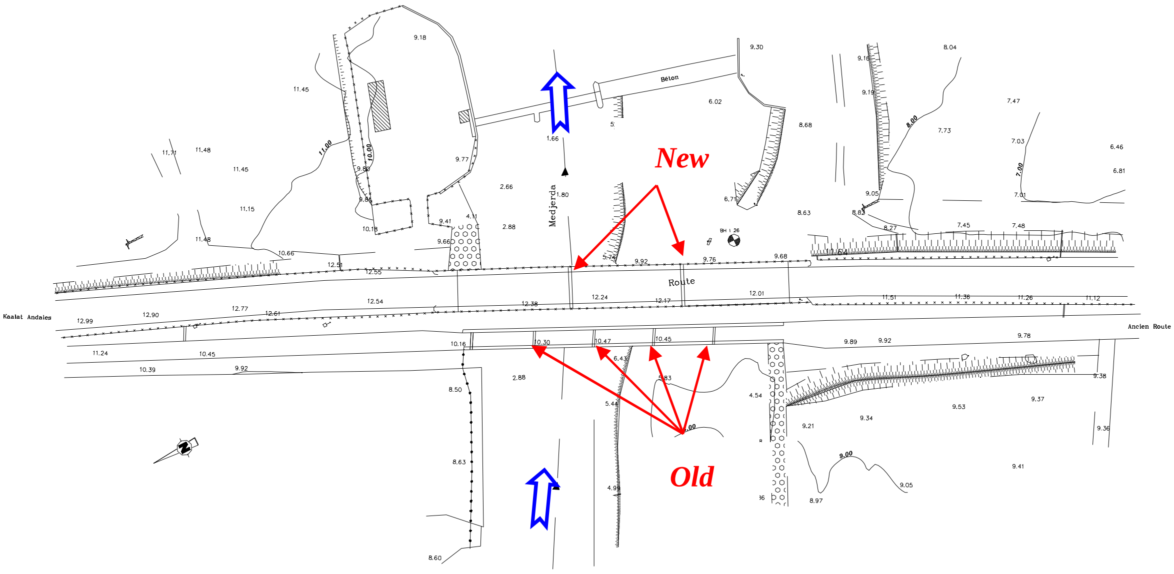
・Five-span Gerber RC bridge

・See picture:

Figure 6.3-3 Tobias Old Bridge in August 2012

(2) Hydrological Assessment

This bridge is parallel to the new bridge, but, as the figure below shows, the pier locations are not aligned with the streamline, and the streamline has become disturbed. This inhibits the downflow of floodwaters and causes local scouring and otherwise negatively impacts the bridge structure.



Source: JICA Survey Team

Figure 6.3-4 Location of Bridge Piers

(3) Existing Bridge Improvement Plan

This bridge is slated to be demolished. It is problematic in terms of downflow, and the new bridge features a pedestrian walkway on the downstream side, so the demolition of the old bridge would not present a problem to pedestrian or automobile passage.

6.3.3. No. 4 GP8 BRIDGE OVER OUED MEJERDA

(1) Overview

- Bridge by which GP8 crosses the Mejerda River
- Built in 1973 at the latest
- Nine-span simple RC bridge
- See picture:

Figure 6.3-5　Current Status of GP8 Bridge Over Oued MejerdaBridge（Aug., 2012）

・The cross sections of the two 60 cm x 60 cm piers on this bridge are small compared to those of other bridges.

・Much damage has been confirmed; this bridge has health problems. Typical damage includes abrasion and rebar exposure on piers and main girders as shown in the figure below, damage to expansion apparatus and main girder cracking.

1) Abrasion/exposed rebar on piers, main girders　　2) Main girder cracking (curved cracks appearing midspan)

Source: JICA Survey Team

Figure 6.3-6 Extent of Damage

(2) Hydrological Assessment

The vertical clearance and length of this bridge in its current state can ensure the required cross section specifications through the excavation of sand piled up at the bridge's location.

(3) Existing Bridge Improvement Plan

Verification of the current state of the existing bridge revealed much damage, and its health and load bearing capacity are probably insufficient. Major reinforcement of the substructure is required if the current structure is to be used, but the superstructure will probably need to be updated soon as well, so there is little merit to using the current structure.

Thus, this bridge is slated to be replaced.

6.3-4 No. 8 JEDEIDA RAILWAY OLD BRIDGE

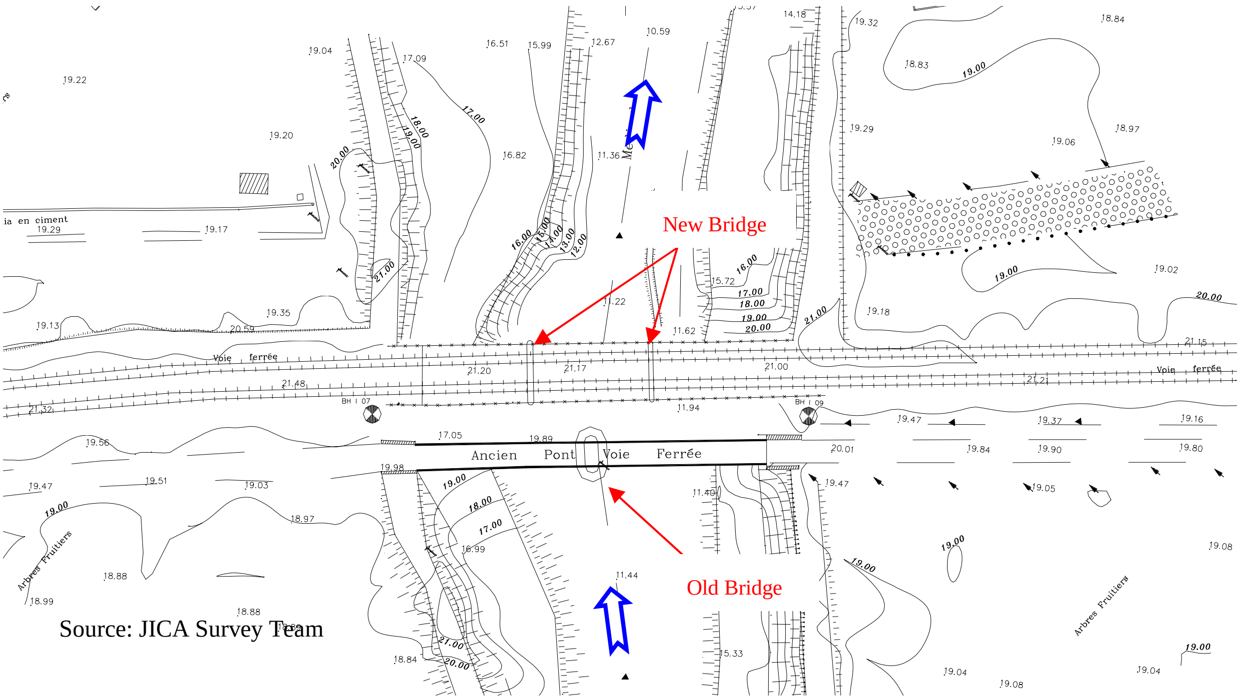
(1) Overview

- Bridge by which the Tunis-Bizerte Line crosses the Mejerda River; the new bridge was built downstream.
- The tracks have been abandoned; they are not being used.
- Demolition possible (result of deliberations with SNCFT)
- Two-span simple steel through truss bridge
- See picture:

Figure 6.3-7 Current Status of Jedeida Railway Old Bridge (Aug., 2012)

(2) Hydrological Assessment

This bridge is parallel to the new bridge, but, as the figure below shows, the pier locations are not aligned with the streamline, and the streamline has become disturbed. This inhibits the downflow of floodwaters and causes local scouring and otherwise negatively impacts the bridge structure.



Source: JICA Survey Team

Figure 6.3-8 Location of Bridge Piers

(3) Existing Bridge Improvement Plan

This bridge is slated to be demolished. It is problematic in terms of downflow, and the Tunis-Bizerte Line runs on the new bridge downstream, so the demolition of the old bridge would not present a problem to railway passage.

That said, water pipes have been added to the bridge, so they need to be moved to the new bridge after the demolition of the old bridge (SNCFT has confirmed and approved this relocation).

6.3.5 No. 9 JEDEIDA RAILWAY BRIDGE

(1) Overview

- Bridge by which the Tunis-Bizerte Line crosses the Mejerda River; the old bridge is located upstream.
- Three-span two PCT girder bridge
- Built in 1981-1982
- Two sets of one-way tracks, isolated superstructure and integrated substructure
- Evidence of afflux from flooding on girder surfaces, concrete damage and rebar exposure likely caused by impact from floating objects during floods
- See picture:

Figure 6.3-9 Current Status of Jedeida Railway Bridge (Aug., 2012)

(2) Hydrological Assessment

The current vertical clearance is 19.200 meters, but the design high-water level is 19.269 meters, so a 1.0-meter freeboard must be added to that to ensure a 20.369-meter vertical clearance. Length of 100 meters must also be ensured to fulfill downflow cross section specifications.

(3) Existing Bridge Improvement Plan

Thirty years have passed since this bridge was built, but there are no signs of major damage, and it can be used in its current state. However, it will be jacked up and spans added to ensure vertical clearance and length. Deliberations with SNCFT resulted in instructions to satisfy the following requirements so that the roadway can function during construction, so they must be considered when devising detailed plans.

・Conduct a thorough structural safety investigation after jacking up the bridge.
・The longitudinal grade of the temporary roadway will be less than 9%.
・One road will be guaranteed during construction.

＊ The setting contents at the review of this time are shown on Reference Package 4.3.

6.3.6 No. 12 JEDEIDA BRIDGE ON GP7

(1) Overview

・Bridge by which GP7 crosses the Mejerda River
・Built in 1945, replaced in 2009.
・Five-span PC girder bridge
・Two sets of one-way tracks, isolated superstructure and integrated substructure
・Evidence of afflux from flooding on girder surfaces, concrete damage and rebar exposure likely caused by impact from floating objects during floods
・See picture:

Figure 6.3-10 Current Status of Jedeida Bridge on GP7 (Aug., 2012)

(2) Hydrological Assessment

The current vertical clearance is 25.130 meters, which is satisfactory with respect to the design high-water level of 21.276 meters, but the current length does not fulfill downflow cross section specifications (100 meters).

(3) Existing Bridge Improvement Plan

Seventy years have passed since this bridge was built, but it was replaced in 2009 and there are no signs of major damage. However, spans will be added in order to provide the required length.

6.3.7 No. 15 GP7 BRIDGE ON CHAFROU

(1) Overview

・Bridge by which GP7 crosses the Chafrou River; the old bridge is located upstream.

・Three-span PC hollow slab bridge

・See picture:

Figure 6.3-11 Current Status of GP7 Bridge on Chafurou (Aug., 2012)

(2) Hydrological Assessment

The current vertical clearance is 18.9 meters, but the design high-water level is 19.800 meters, so including a 1.0-meter freeboard, the bridge must be given a 20.800-meter vertical clearance. Length of 61 meters must also be ensured to fulfill downflow cross section specifications.

(3) Existing Bridge Improvement Plan

This bridge shows no signs of major damage. However, improving the current structure would be difficult because its vertical clearance and length are significantly lacking, so it is slated to be replaced.

6.3.8 No. 16 GP7 OLD BRIDGE ON CHAFROU

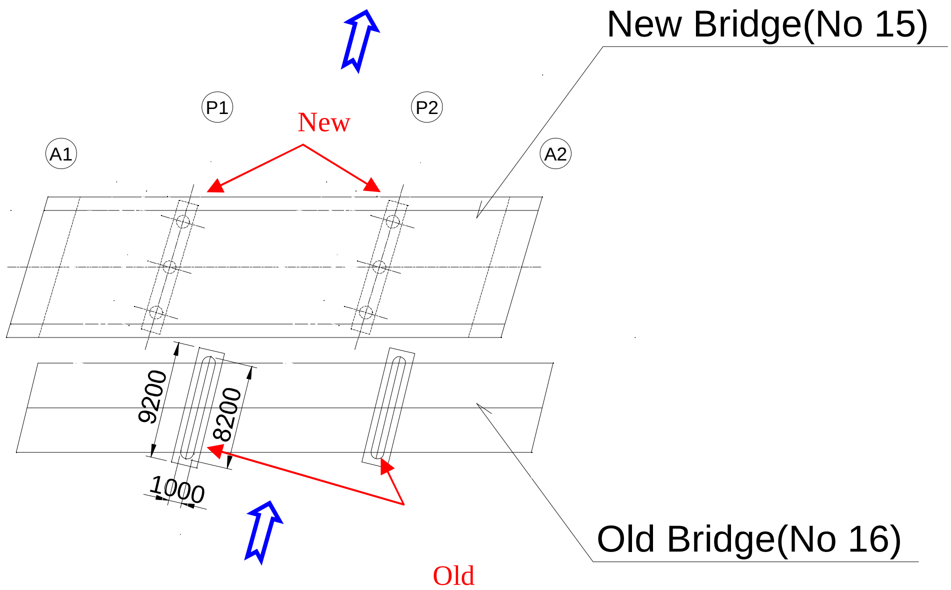
(1) Overview

・Bridge by which GP7 crosses the Chafrou River; the new bridge was built downstream.
・Three-span concrete bridge
・See picture:

Figure 6.3-12 Current Status of GP7 Old Bridge on Chafurou(Aug., 2012)

(2) Hydrological Assessment

This bridge is parallel to the new bridge, but, as the figure below shows, the pier locations are not aligned with the streamline, and the streamline has become disturbed. This inhibits the downflow of floodwaters and causes local scouring and otherwise negatively impacts the bridge structure.



Source: JICA Survey Team

Figure 6.3-13 Location of Bridge Piers

(3) Existing Bridge Improvement Plan

This bridge is slated to be demolished. It is problematic in terms of downflow, and the new bridge features a pedestrian walkway on the downstream side, so the demolition of the old bridge would not present a problem to pedestrian or automobile passage.

6.3.9 No. 17 EL H'BIBIA BRIDGE

(1) Overview

- A low-traffic bridge that crosses the Chafrou River.
- Four-span concrete bridge
- See picture:

Figure 6.3-14 Current Status of El H'Bibia Bridge (Aug., 2012)

(2) Hydrological Assessment

The current vertical clearance is about 19.5 meters, but the design high-water level is 19.800 meters, so a 1.0-meter freeboard must be added to that to ensure a 20.800-meter vertical clearance. Length of 62 meters must also be ensured to fulfill downflow cross section specifications.

In addition, the picture below shows how the water level rose at the bridge's location during the flood of January 2003.

Source: Preparatory Study

Figure 6.3-15: Picture from El H'Bibia Bridge on January 13, 2003

(3) Existing Bridge Improvement Plan

Improving the current structure would be difficult because its length is significantly lacking, so it is slated to be replaced.

6.3.10 No. 18 Bridge on the local road, No. 22 MC50 EL MABTOUH BRIDGE

(1) Overview

・Bridges located on the channel from Mejerda River to El Mabtouh Retarding Basin
・No. 18: concrete bridge; No. 22: box culvert construction
・See picture:

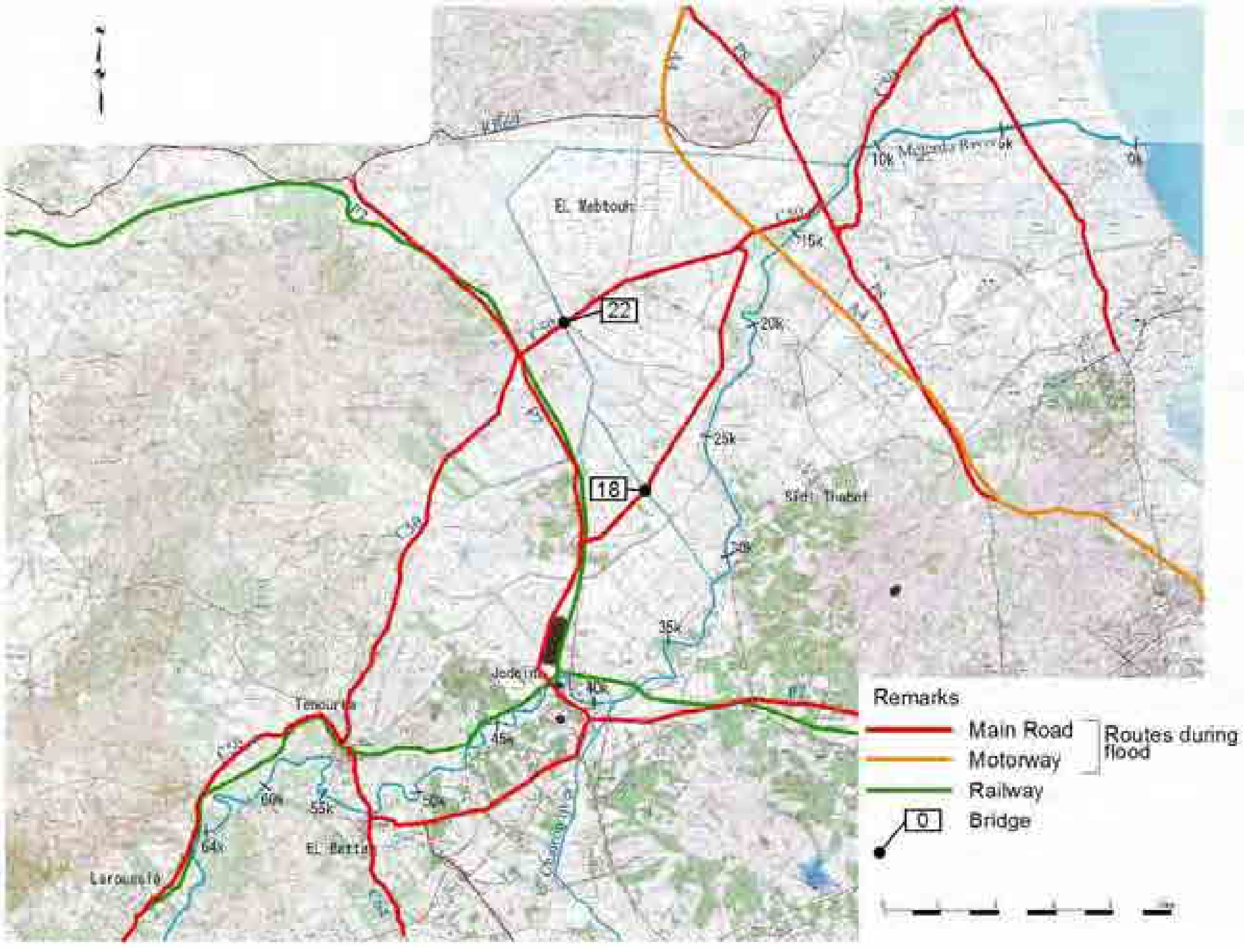


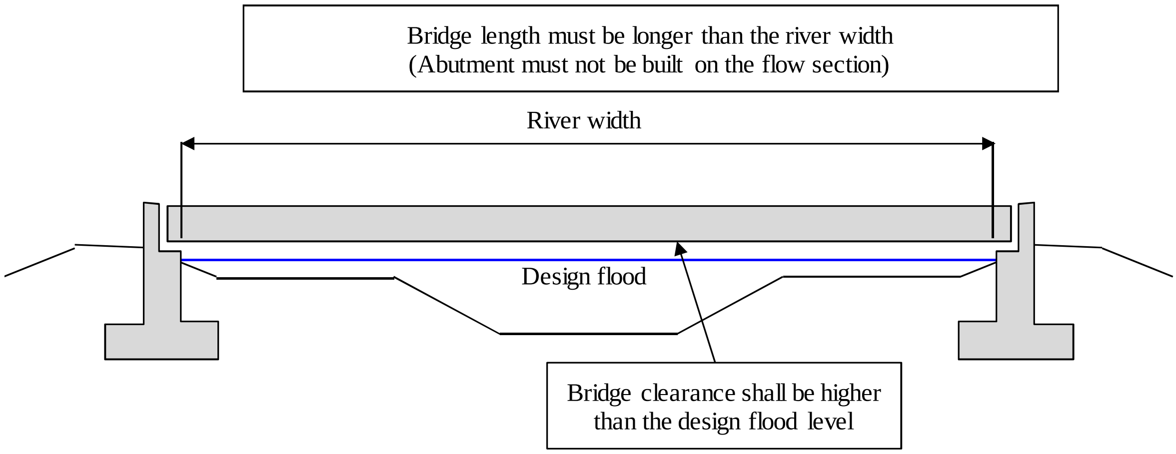
Figure 6.3-16 Location of Bridge Nos. 18 and 22

(2) Hydrological Assessment

The channel in the section from the Mejerda River to the El Mabtouh Retarding Basin is too narrow to fulfill downflow cross section specifications required for the design flow rate of this Project. Thus, the channel is slated to be widened.

(3) Existing Bridge Improvement Plan

These bridges will be replaced because downflow cross section specifications are significantly lacking. Bridge Nos. 18 and 22 are to become Class A bridges to remain passable during floods.



Source: JICA Survey Team

Figure 6.3-17 Overview of Class A Bridges

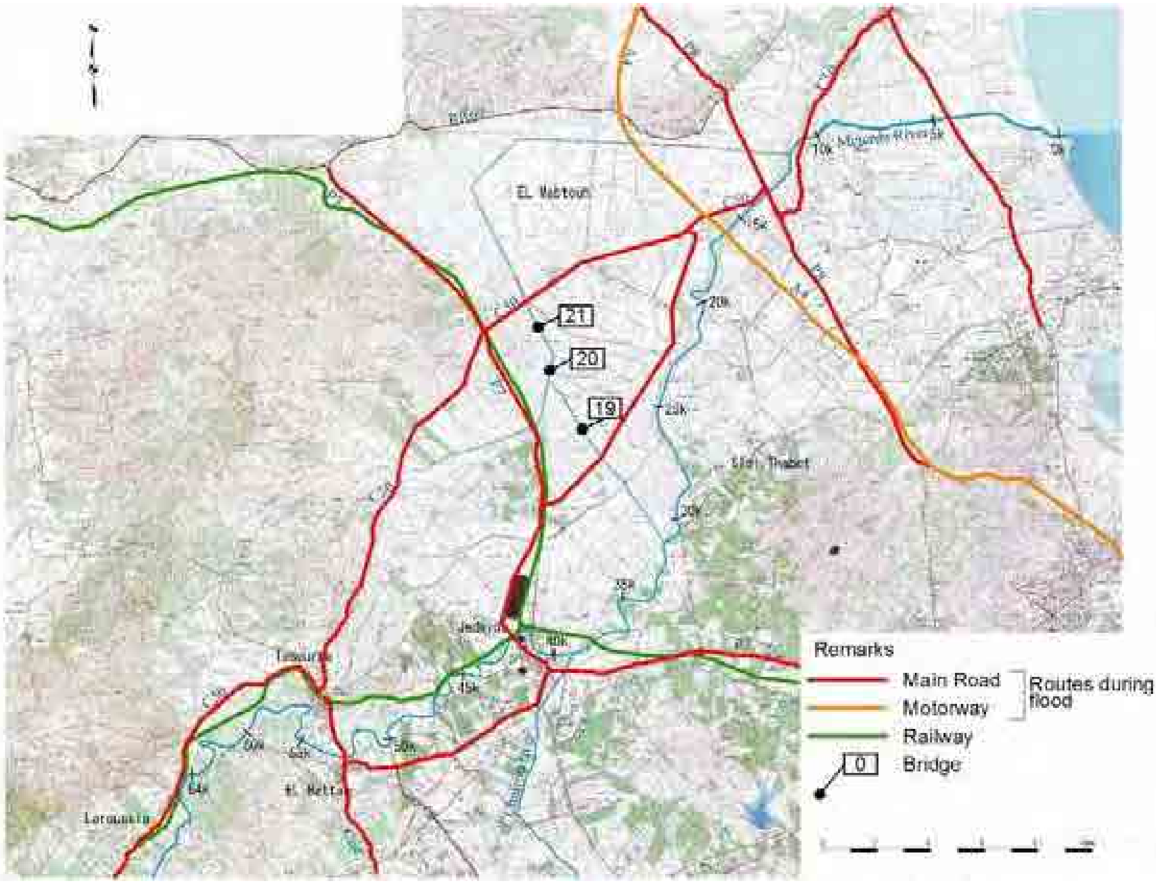
6.3.11 No. 19-21 FARM BRIDGE

(1) Overview

・Bridges located on the channel from Mejerda River to El Mabtouh Retarding Basin

・Concrete bridges

・See picture:



Source: JICA Survey Team

Figure 6.3-18 Location of Bridges No. 19-21

(2) Hydrological Assessment

The channel in the section from the Mejerda River to the El Mabtouh Retarding Basin is too narrow to fulfill downflow cross section specifications required for the design flow rate of this Project.

(3) Existing Bridge Improvement Plan

These bridges will be replaced because downflow cross section specifications are significantly lacking. However, since these routes are used mostly for agriculture and are not primary routes, the bridges over them are to be Class B bridges, built to the minimum scale such that they cross low channels under normal flow conditions and become submerged during floods. They will run diagonally up and down the slopes of dikes to avoid causing discontinuity of the dikes.

Figure 6.3-19 Overview of Class B Bridges

6.3.12 No. 27 GP8 BRIDGE AND ROAD OVER Mabtouh

(1) Overview

・Bridge by which GP8 crosses over the diversion channel

・Four-span RC girder bridge

・See picture:

Figure 6.3-20 Current Status of GP8 Bridge and Road Over MabtouhBridge (Aug., 2012)

・Damage was confirmed, and there are health problems. Typical damage includes abrasion/exposed rebar on the slabs and cracks on the bearings.

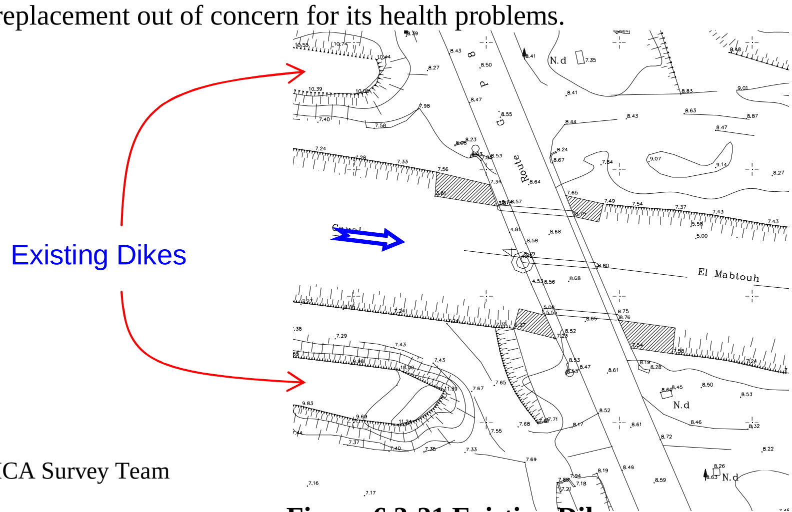
(2) Hydrological Assessment

The existing cross section of the diversion channel generally allows a flow rate that enables downflow, but the three piers located where the river narrows are inhibiting 10% of the river cross section.

In addition, a dike that cuts off that area has caused flooding in the past.

(3) Existing Bridge Improvement Plan

The downflow capacity of the river cross section in its current state is satisfactory, but the current structure significantly inhibits that cross section and the existing dike cuts it off. Thus, this bridge is slated for replacement out of concern for its health problems.



Source: JICA Survey Team

Figure 6.3-21 Existing Dikes

6.4 Plans for New Bridges

This section presents the results of investigations of structure types and specifications of bridges to be replaced and bridges to be built anew, including the new sections of bridges to be improved.

Structure types and specifications were determined according to construction experience in Japan and construction experience studied in Tunisia.

6.4.1 Bridge Construction Experience Study

(1) Bridges on the Mejerda River

A study of bridge construction experience in Tunisia revealed that RC T-girder, PC I-girder, steel girder and many other superstructure types were adopted according to the sizes of the bridges. However, PC I-girder was the main superstructure type adopted for bridges that cross the Mejerda River. The table below shows specifications and girder heights-to-span ratios for bridges on general roads studied:

Table 6.4-1 Superstructure construction results (PCI girder)

Source: JICA Survey Team

No	Channel	Max span (m)	Girder Heights (m)	Girder Heights /Span
1	Mejerda	28.0	1.8	1/15.6
2	Mejerda	28.0	1.8	1/15.6
3	Mejerda	37.0	2.0	1/18.5

For the substructures, steel or concrete three-column piers and wall type piers were adopted, and reverse piles were often used to build foundations. It is worth noting that steel piles have also been used.

(2) Box Culverts

Box culvert structures have been adopted often in Tunisia, especially on small structures in the area surrounding the El Mabtouh Retarding Basin in Zone D2.

6.4.2 Superstructures

(1) Class-A Bridges

1) Structure Type

Class A bridges will be around 150 meters long with substructure clearance of around 10 meters to ensure that their lengths are longer than the width of the river and that their design heights include enough freeboard to clear the design high-water level.

It is best to drastically reduce the number of piles that inhibit the river cross section, but there is little merit to adopting PC box girder, steel girder or other structure types that increase span lengths because there is no need to build large temporary structures for substructure construction since flow rates are low during normal times.

Thus, PC I-girder superstructures, the type often used on bridges that cross the Mejerda River, will be adopted.

2) Structure Specifications

The figures below are cross sections of new bridges approved by the Ministry of Agriculture that qualify as Class A bridges. The rationale:

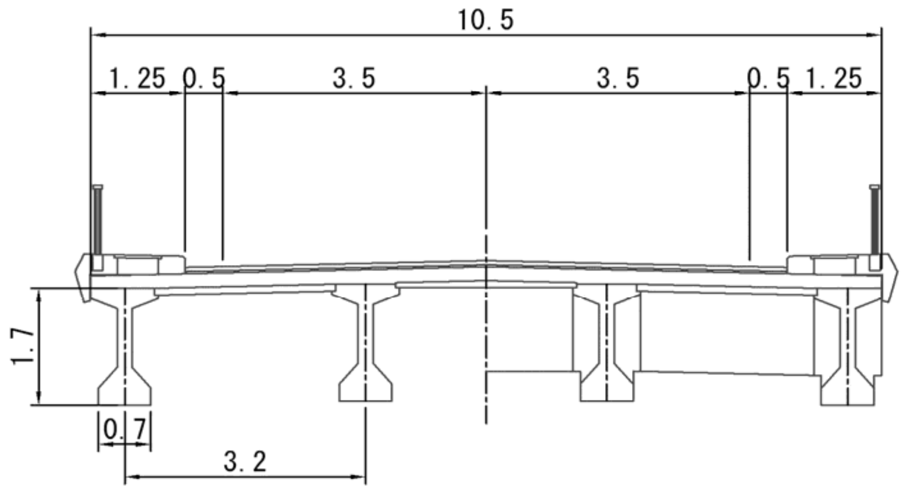
- Roads in their current state have two lanes and thus fall into Category 1 with road width 2 @ 3.5 meters.

Roads in Tunisia are divided into the following three categories:
Category 1: Road Width 2 @ 3.5 meters (two lanes)
Category 2: Road Width 1 @ 5.0 meters (one lane)
Category 3: Road Width 1 @ 3.0 meters (one lane)

- The maximum span length is between 28 and 37 meters historically, so the basic span length is set at 30 meters, with span lengths of 25.0 meters, 30.0 meters and 35.0 meters applicable in individual cases.
- PC I-girders have historically had a girder height-to-span ratio between 1/15 and 1/18 in Tunisia, so the ratio was set at 1/15 for this Study and girder heights were configured according to that ratio:

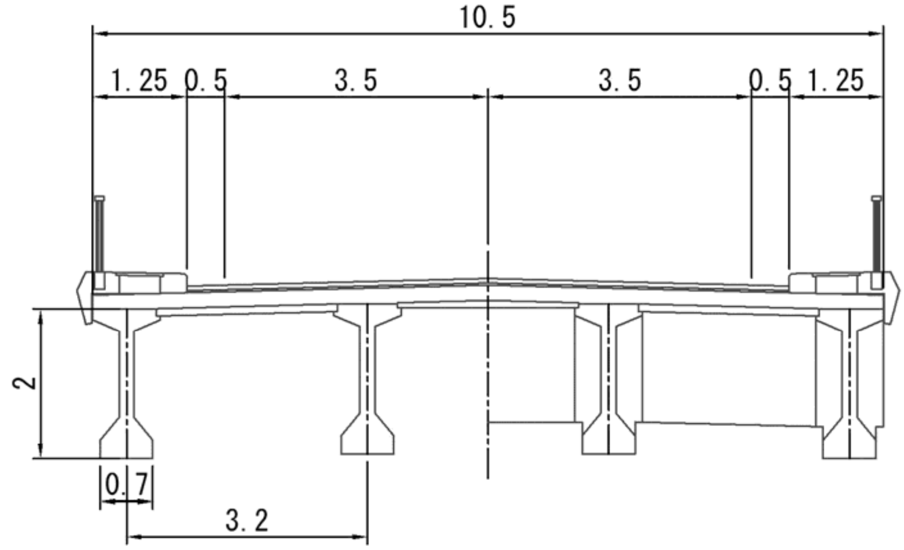
Span Length 25.0 meters = Girder Height 1.7 meters
Span Length 30.0 meters = Girder Height 2.0 meters
Span Length 35.0 meters = Girder Height 2.4 meters

- The number of main girders was set according to main girder spacing on existing bridges; there will be four main girders spaced 3.2 meters apart on two-lane roads (total width 10.5 meters).



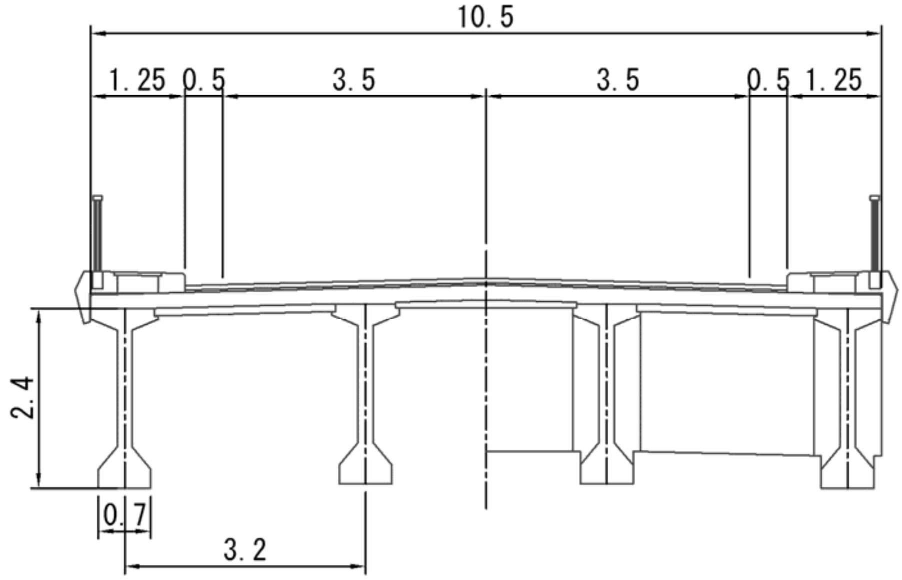
Source: JICA Survey Team

Figure 6.4-1: The cross section of a bridge (Span length=25.0m)



Source: JICA Survey Team

Figure 6.4-2 The cross section of a bridge(Span length=30.0m)



Source: JICA Survey Team

Figure 6.4-3 The cross section of a bridge (Span length=35.0m)

(2) Class B Bridges

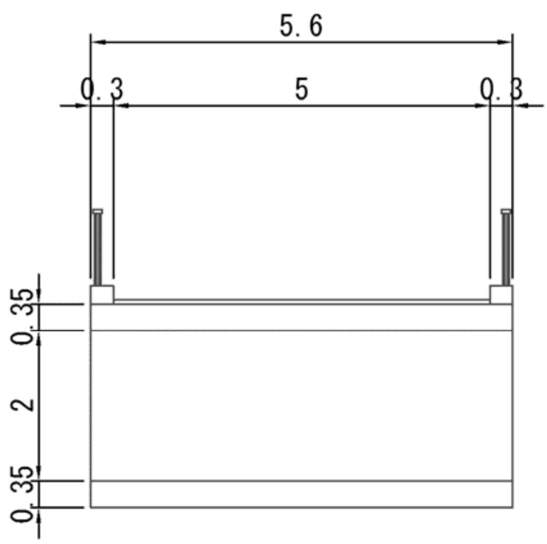
1) Structure Type

Class B bridges cross over low channels, are about 30 meters long and have substructure clearance of around two meters; this is not an economically efficient bridge type. Therefore, they will be box culvert bridges.

2) Structure Specifications

The figure below is a cross section of a Class B bridge. The rationale:

- Farm roads were measured and found to be 5.6 meters wide with effective widths of 4.4 meters. They will be treated as Category 2 roads, and an effective width of 5.0 meters will be ensured.



Source: JICA Survey Team

Figure 6.4-4: The cross section of a bridge

6.4.3 Substructures

(1) Abutment Types

Various types of abutments have been adopted according to structure height, supporting soil conditions, and economic efficiency. In general, however, the appropriate abutment type from those shown on the table below is determined according to the structure height.

Design height for abutments in this Study is between 5.0 and 12.0 meters and supporting soil conditions are not good, so inverted T-type abutments will be used.

Table 6.4-2 Abutment Types and Standard Height

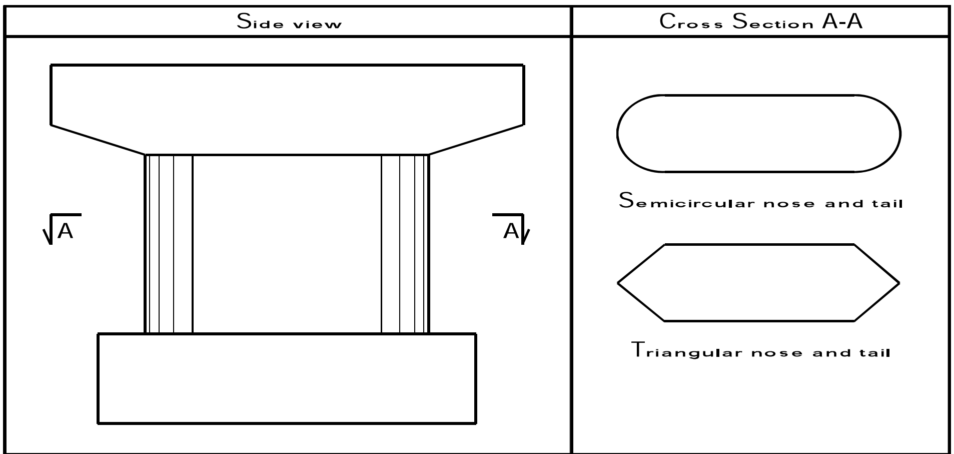
Source: JICA Survey Team

Abutment Type	Height(m)			Remarks
	10	20	30	
Grabity Type				
Semi-grabity Type				
Cantilever Type				
Counterfort Type				
Rigid Frame Type				

(2) Pier Types

Interviews about earthquake resistant designs in Tunisia revealed that seismic forces were either not considered at all or were small enough to be negligible. Therefore, it is possible to make pier structures for this Study small.

It is obviously important to make sure that piers fulfill required capabilities for structures in the course of investigating pier types, but it is also best to use as few materials as possible and to build economically efficient structures. Therefore, in terms of economic efficiency, column piers, which Tunisians have worked with before, should be used. However, the piers used in this design were wall type piers (shown below) that do not inhibit the flow of the river.



Source: JICA Survey Team

Figure 6.4-5: The wall type pier

6.4.4 Foundations

(1) Geological Properties

The soil is principally comprised of clay that is sometimes consolidated (clay that includes sand and/or silt) to a depth greater than 45 meters (not confirmed to rock layers). The various geologies studied in the target region of this Study are comprised of generally uniform, thin soils; there is little chance of encountering rock layers locally. The table below shows supporting layers at the locations of main bridges:

Table 6.4-3 Supporting Layers

Location	Boring	Layer Name	N Value	Supporting Layer Location (m)		
				Top Surface Depth	Bottom Surface Depth	Thickness
Jedeida Bridge	BHI25	Sand Bedrock	50+ 60+	13	30 (hole bottom)	17+
Railway Bridge	BHI07 (left bank)	Sand/clay	30+	28	33 (hole bottom)	5+
	BHI09 (right bank)	Silty clay/sandy clay	20+	25	30 (hole bottom)	5+
Highway Bridge	BHI22 (left bank)	Sandy clay	20+	29	45 (hole bottom)	16+
			(50+	38	45 (hole bottom)	7+)
	BHI23 (left bank)	Silty clay	20+	31	45 (hole bottom)	14+
			(50+	41	45 (hole bottom)	4+)
	BHI24 (right bank)	Sandy clay	20+	34	45 (hole bottom)	11+
			(50+	41	45 (hole bottom)	4+)
GP8 Bridge	BHI14 (left bank)	Silty clay	20+	29	45 (hole bottom)	16+
	BHI15 (left bank)	Sandy clay	(50+	38	45 (hole bottom)	7+)
	BHI16 (right bank)	Sandy clay	20+	35	45 (hole bottom)	10+
			(50+	41	45 (hole bottom)	4+)
			20+	28	45 (hole bottom)	17+
			(50+	38	45 (hole bottom)	7+)
Tobias Bridge	BHI26 (right bank)	Silty clay/sand	30+	42	50 (hole bottom)	18+
Kalaat Anadalous Bridge	BHI21 (right bank)	Sandy clay	10+ (40-45 m)	No supporting layer at 45-meter hole bottom		
El Mabtouh Retarding Basin	BHII06	Silty clay	20+ (26-27 m) 30+ (29-30 m)	Unable to confirm supporting layer to 30-meter hole bottom		

(Source: Prepared during this Study based on Preparatory Study Soil Survey Report data)

(2) Foundation Types

Pile foundations will be used since layers considered to be supporting layers are very deep. Pile foundations support loads via end bearing capacity and skin friction, but supporting layers are deep in

Zone D2 and interviews with local construction workers revealed that friction piles had been used, so friction piles will be used for foundations in this Study.

(3) Structure Specifications

The Mejerda River region does not contain supporting soil or solid layers, so friction piles with relatively small diameters are effective as foundation piles (in order to increase the proportion of pile area to load). Therefore, pile diameters will be uniform without regard to superstructure span length, and one-meter piles, which have been used to build bridges that cross the Mejerda River, will be used.

6.4.5 Plans for New Bridges

Design drawings for new bridges planned under the above conditions are shown on the Design Drawing Package.

6.5 Design Standards

6.5.1 Road Bridges

The use of the following standards on facility and road drawings and facility designs was proposed during discussions held at the October 20, 2010 meeting between MEHAT (Civil Engineering Department) and the JICA Survey Team.

(1) Drawings (Longitudinal Cross Sections, Design Drawings)

- Technical Recommendations Related to Overall and Geometrical Concepts

Primary road facilities (excluding expressways and two-lane highways)
Technical Guide SETRA August 1994 Code: B9413

- ICTAAL: Regulations on Technical Conditions of Interurban Expressway Facilities

Notice dated December 12, 2000, SETRA (transportation/road facility study organization)
Issued December 2000 Code: B0103

(2) Structural Design (Road Structures)

- Building Embankments and Clearing Roadbeds (abbreviated GTR) –Technical Guide-

SETRA (transportation/road facility study organization), LCPC (civil engineering research institute)
Issued September 1992 Code: D9233

- Designing and Building Embankments -Technical Guide-

SETRA (transportation/road facility study organization), Issued March 2007 Code: 0702

(3) Structural Design (Concrete Structures)

Table 6.5-1 Regulations on Concrete Facility Designs

Item	Standard/Regulation	Version
Live load	CCTG (General Technical Specifications) Vol. 61, Issue 2 “Structural Designs, Live Loads on Road Bridges” Special live loads are different for each bridge.	June 1977
Foundation construction	CCTG (General Technical Specifications) Vol. 62, Issue 5 “Technical Regulations for Civil Structure Foundation Construction Plans and Designs”	December 1993
Superstructure-rebar concrete	CCTG (General Technical Specifications) Volume 62, Issue 1, Chapter 1 “Technical Regulations for Reinforced Concrete Structure and Building Plans and Designs Under the Limit State Design Method – 1999 Revision of BAEL91” • Allowable cracking conditions depend on the surrounding environment (three classes of environment: Good, Normal, Bad) • In general, the environment is Normal.	April 1999
Prestressed concrete	CCTG (General Technical Specifications) Volume 62, Issue 1, Chapter 1 “Technical Regulations for Reinforced Concrete Structure and Building Plans and Designs Under the Limit State Design Method – 1999 Revision of BAEL91” • Prestressed classes are different for each bridge (three classes: 1, 2, 3) • In general, Class 2.	April 1999
Regulations related to earthquake resistance concepts	“Guide on General Bridge-Design in Earthquake-Prone Areas”	January 2000

Source: Preparatory Study

(4) Structural Design (Steel Components, Other Components)

Refer to Eurocodes when the regulations above are insufficient.

Eurocode 0: Basis of structural design (EN1990)
Eurocode 1: Actions on structures (EN1991)
Eurocode 2: Design of concrete structures (EN1992)
Eurocode 3: Design of steel structures (EN1993)
Eurocode 4: Design of composite steel and concrete structures (EN1994)

Eurocode 5: Design of timber structures (EN1995)

Eurocode 6: Design of masonry structures (EN1996)

Eurocode 7: Geotechnical design (EN1997)

Eurocode 8: Design of structures for earthquake resistance (EN1998)

Eurocode 9: Design of aluminum structures (EN1999)

(5) Structural Conditions for Rivers

Conditions for structural designs with respect to rivers are defined based on recommendations in Technical Guide "River and Bridges, SETRA, Issued 2007, Code: DT4263." The table below shows the main measures:

Table 6.5-2 Regulations on Hydrological Designs for Bridges (based on SETRA Guide)

Source: "Rivers and Bridges" SETRA 2007 Code: DT4263

Flooding	Probability	Water Use Purpose	Facility Purpose	Design Measures
Full capacity	Two years (99.9% chance of happening within 10 years)	No noticeable impact on riverbed.	—	Types and locations that minimize impact to riverbed
Intense flooding	50 years (18% chance of happening within 10 years)	—	Structures must not suffer damage.	Endurable flow (verify serviceability limits) - anti-erosion measures
Exceptional flooding	100 years (10% chance of happening within 10 years)	No noticeable impact on surrounding area.	—	Build inner rings of arches higher than maximum water level* -emergency drainage facilities- road dike protection
Unparalleled flooding	200-500 years	—	No major damage to structures	Ultimate flow (verify ultimate limit state)

*Design freeboard such that floating objects can pass through. Theory on this is below.

This guide will serve as a reference when assessing erosion risk and investigating the scales of protective facilities and foundation construction.

Source: "Rivers and Bridges" SETRA 2007, Eurocode: DT4263

1) Minimum Span of Structures (danger from floating objects)

The SETRA Guide does not refer directly to span lengths with which structures over rivers should comply, but Page 303 of the Japanese standard ("Revised Explanation/Ordinance for Structural Standards for River Administration Facilities" Japan River Association, November 1999) offers the following:

$L = 20 + 0.005Q$

L: span length (m), Q: flow rate (m^3/s)

The design high-water flow rate with respect to this project is 800 m^3 per second from Laroussia Dam to the El Mabtouh Retarding Basin diversion channel and 600 m^3 per second from the diversion channel to Kalaat Landaous Bridge. Therefore, the distance between spans must be at least 24.0 meters (20 + 0.005(800)).

2) Clearance Beneath Structures (allowing floating objects to pass underneath structures)

The aforementioned SETRA Guide says the following:

"The fixed height of the inner ring must be determined based on reference floods (in general, hundred-year floods) and consideration must be made for riverbed buildup due to solid deposits, riverbank expansion due to the way the river moves (flow velocity, curvature at curved reaches), and to ensure a minimum amount of space to allow floating objects to pass underneath. In its discussion of the Sejournet Process, SETRA Model Document Ohvm63 requires clearance of 0.60 to 1.50 meters in line with aperture size 2 to 8 meters."

Page 115 of the Japanese standard (River Structure Facility Standards" Japan River Association, November 1999) uses the following relationships in terms of the flow rates considered:

Table 6.5-3 Defining Freeboard (Japanese Standard)

Source: "River Structure Facility Standards" Japan River Association, November 1999

Flow Rate (m^3/s)	**< 200**	**200<… <500**	**500<… <2000**	**2000<… <5000**	**5000<… <10000**	**>10000**
Freeboard (clearance) (m)	0.6	0.8	1.0	1.2	1.5	2

Source: "River Structure Facility Standards" Japan River Association, November 1999

Overall, the natures of the Japanese and French standards are the same.

Freeboard depends on the size of dangerous floating objects that could be swept downriver during floods. The sizes of floating objects differ; while France and Japan have thick forests and tall trees, the forests of the Mediterranean coastal nation of Tunisia are not very dense and contain small trees. It follows that freeboard in Tunisia would be smaller, but interviews with local construction workers revealed that a roughly 1.0-meter freeboard had been ensured along the Mejerda River, so the plan calls for 1.0 meters of freeboard.

6.5.2 Railway Bridges

Based on discussions held at the October 22, 2010 meeting between Tunisian Railways and the JICA Study Team, the French standard enacted in 1960 (25-ton axle load) will be applied. This standard is stricter than the UIC (International Union of Railways) standard (22.5-ton axle load).

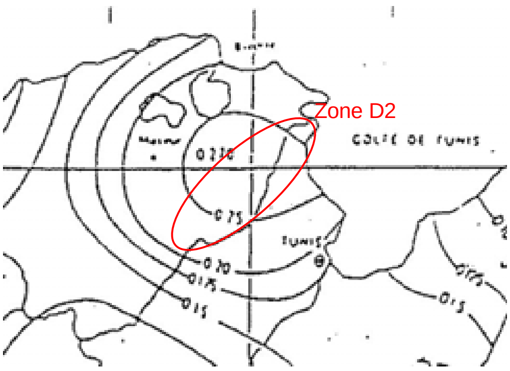
6.5.3 Earthquake Resistance Standards

According to the May 1997 proposal on Tunisian earthquake resistance standards, seismic acceleration on foundations involving bridges in Section D2 is 0.25 g = 2.45 m/s^{-2}.

However, verifying acting seismic forces with standards and updated bridge designs in mind through on-site interviews showed that road bridges crossing the Mejerda River have dead loads of 0.3-0.5% and that no clear standards exist for railway bridges because the acting seismic forces on them are not considered.

Thus, dead loads in terms of seismic force taking designs into consideration were set at 0-0.5% for each bridge, and detailed designs with the following guidelines need to be determined through discussion:

1) Class A Road Bridges Dead Load 0.5%
2) Class B Road Bridges Dead Load 0% (not considered)
3) Railway Bridges Dead Load 0% (not considered)



Source: Preparatory Study

Figure 6.5-1 Proposal on Tunisian Earthquake Resistance Standards

Chapter 7 Construction Plan and Project Cost Estimation

7.1 Overview of Construction and Compensation

7.1.1 Construction

The table below contains details of the main construction to be implemented during this Project:

Table 7-1 Mejerda River Improvement Project Construction Details

River Improvement Construction	Main Construction Details
1. Preparation work	・Material and equipment yard ・Setting up worker lodging, management office
2. Temporary works	・Construction roads, river-crossing roads, temporary docks ・Cofferdams, cut-and-cover work, large sandbags
3. River earthwork	・Remove trees/roots, demolish existing structures, scrape topsoil ・Excavation and banking
4. River structures 4.1 Protective dikes	・Stone pitching, riprap work, gabions
4.2 Groundsill work	・Main groundsill work, front aprons, bed protection work ・Sidewall protection, crest concrete
4.3 Overflow dike/diversion facilities	・Main overflow dike work, front aprons, bed protection work ・Sidewall protection, crest concrete
4.4 Sluiceways/sluice gates	・Main sluiceway work, flap gate work
5. Bridge work	・Bridge improvement ・Bridge building ・Bridge demolition

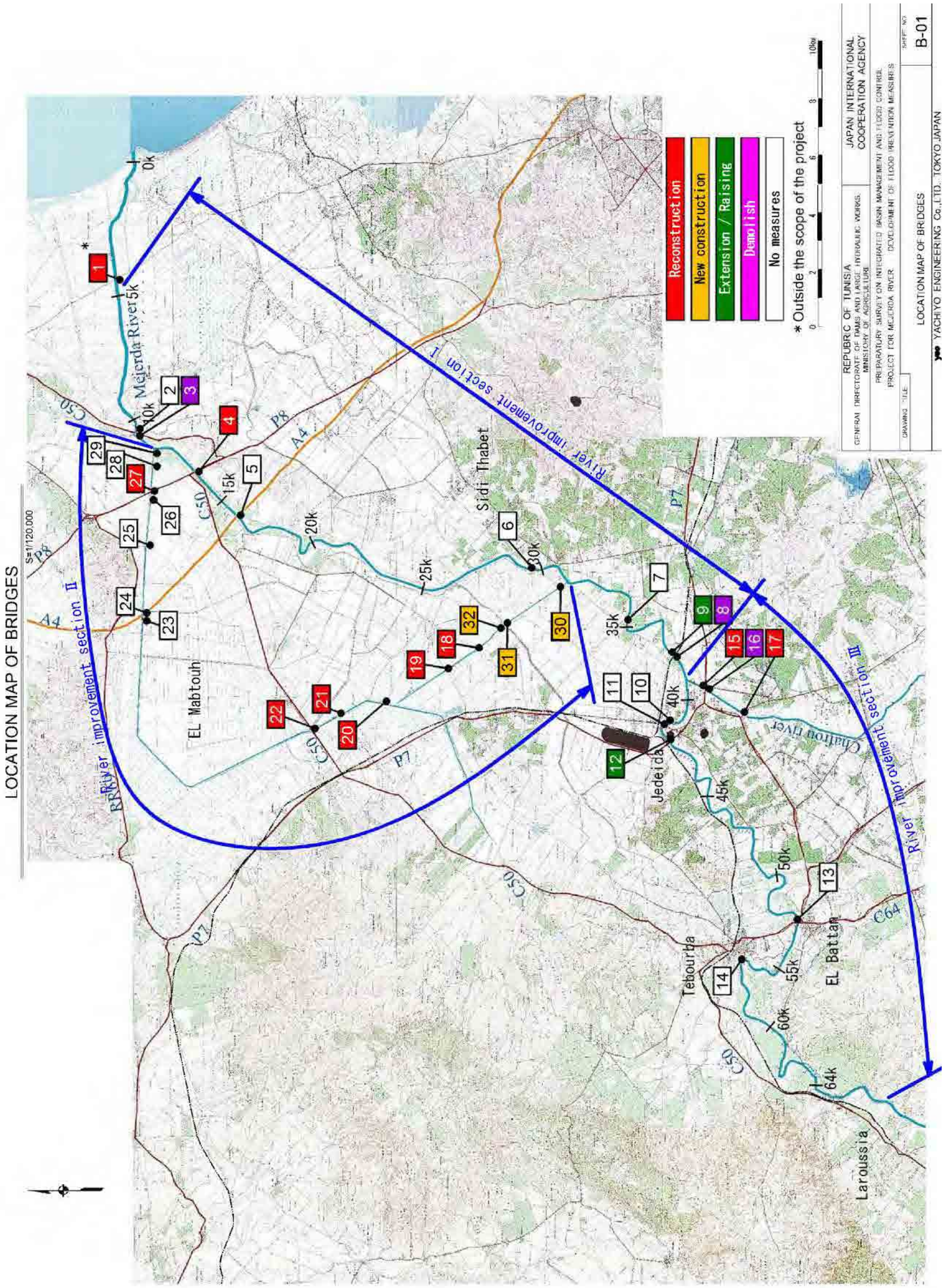
1) Tree/Root Removal
   Before excavation, tamarisk and other trees that grow in flood channels will be removed along with their roots. The reeds that proliferate in the El Mabtouh Channel will also be removed.
2) Topsoil Scraping
   Topsoil will be scraped to a depth of 30-50 centimeters, separated along with general soil and hauled away either to dumping areas or to storage areas. Topsoil contains organic matter and thus will be diverted to use outside of construction.
3) Excavation Work
   The dirt left behind after topsoil scraping will be excavated as general soil and used for embankments (dikes) and in other areas of construction. Leftover soil will be transported to dumping areas.
4) Banking Work
   The resulting soil will be used to build up dikes or fill in areas around structures.
5) Concrete Work
   For volume, management, quality and cost purposes, concrete for the overflow dike and other construction projects will be purchased from local batching plants.
6) Protective Dike and Bed Protection Work (concrete slope cribwork, gabion work)
   Concrete slope cribwork and gabions will be constructed to protect riverbanks and riverbed areas expected to suffer erosion.
7) Soil Transportation Work
   The dirt from topsoil scraping and general soil will be separated, transported and stored. General soil will be used as-is for embankments. It will be transported an average distance of three kilometers or less. Four-meter-wide construction roads will be built along the riverside.
8) Transporting and Disposing of Construction Materials and Soil (dumping areas, temporary dumping areas)
   Topsoil scraped during flood channel excavation will be transported to dumping areas, general soil will be used for banking, and leftover soil will be transported to dumping areas. Discussions with implementing agencies resulted in the plan to have a dumping area within four kilometers of each construction zone. The soil will be transported an average distance of about three kilometers. (Dumping areas are to be 200 m x 300 m x 1 m)
9) Bridge Improvement
   Existing bridges that require improvement due to insufficient river down flow capacity with the current structure in place will be replaced, raised or expanded, whichever method is most appropriate at each location.
10) Bridge Building
   The plan calls for new channels, and new bridges will be built in places where bridges do not yet exist.
11) Bridge Demolition
   Existing bridges that present channel flow problems will be demolished when possible.

7.1.2 Construction Zones

Construction work under this Project has been divided into three major construction zones, each of which is divided into smaller construction zones.

Table 7-2 Construction Zone Chart

JOB DIVISION No.		STATION No. (Point No.)	NOTE	DISTANCE SUPPLEMENTARY (km)	DISTANCE SECTION (km)	FLOW DISCHARAGE (m^3/sec)	TYPICAL CROSS SECTION
I	I -1	MD447-α	RIVER-MOUTH	0.00		600	MD428
					4.66		
		MD434	K.LANDAOUS BRIDGE	4.66			
					6.12		
		MD416	TOBIAS DAM	10.78			
					1.03		
		MD411	OUTLET WORKS	11.81		600	MD380
					20.54		
	I -2	MD353	DIVERTING WEIR	32.35		800	MD344
					5.50		
	I -3	MD338	JEDEIDA OLD(NEW) RAILAWAY BRIDGE	37.85			
					0.94		
		MD336	CHAFFROU RIVER CONFLUENCE	38.79			
II (EL MABTOUH BASIN)	II -1	-- (POINT⑩)	OUTLET WORKS	0			
					6.16		
		85(POINT⑧)	EXPRESSWAY CROSS POINT	6.16			
					1.61		
		78(POINT⑦)	CONTOROL GATE WORKS	7.77			
					5.86		
		54(POINT⑥)	OVERFLOW WEIR	13.63			
					4.75		
		36(POINT⑤)	ROAD CROSS POINT (C50)	18.38			
					3.72		
		22(POINT④)	CONFLUENCE PIONT	22.10			
					5.17		
		1(POINT②)		27.27			
					3.73		
		-- (POINT①)	DIVERTING WEIR	31.00		200	
III	III-1	MD336	CHAFFROU RIVER CONFLUENCE	38.79		800	MD296
					2.28		
		MD328	JEDEIDA ROAD BRIDGE	41.07			
					12.04		
	III-2	MD285	EL BATTANE WEIR BRIDGE	53.11			
					11.86		
		MD252	LARROUSIA DAM	64.97			



Source: JICA Survey Team

Figure 7-1 Construction Zone Map

7.1.3 Construction Figures

(1) Main Types of Construction

The table below shows the main types of construction in each construction zone:

Table 7-3 Main Types of Construction in Each Construction Zone

(1) Construction Zone I: Mejerda River Improvement (Lower)	
(1) Channel excavation work (widening)	
(2) Banking (protective dike) work	
(3) Bridge work	・Demolition/rebuilding ・Expanding/raising ・Demolition
(4) Sluiceway work	・Demolition/rebuilding ・Demolition
(2) Construction Zone II: Retarding Basin Improvement	
(1) Inflow channel work	・Excavation ・Banking
(2) Channel bridge work	・Demolition/rebuilding ・Building
(3) Overflow dike work	
(4) Flow control (gate) work	
(5) Diversion channel improvement (dike leveling)	
(6) Diversion gate work	
(7) Raising area roads	
(8) Bridge work	・Demolition/rebuilding ・Building
(3) Construction Zone III: Mejerda River Improvement (Upper)	
(1) Channel excavation work (widening)	
(2) Banking (protective dike) work	
(3) Bridge work	・Expanding/raising

(2) Construction Figures

The table below shows figures related to river construction and bridge construction:

Table 7-4 Quantities and Types of River Construction

Classification	Job Division	Works	Unit	River Improvement I	River Improvement II	River Improvement III	Total
Structural Measures	Length		Km	34.1	31.2	26.1	91.4
	River Improvement						
		Excavation	1000m3	5,659	2,361	2,048	10,068
		Embankment	1000m3	508	525	73	1,106
		Removal	1000m3	5,151	1,815	1,975	8,941
	River Facilities						
	El Mabtouh						
		Inflow Weir	Unit	-	1	-	1
		Discharge Control	Unit	-	1	-	1
		Outflow Gate	Unit	-	1	-	1
		Overflow Weir	Unit	-	1	-	1
	Mejerda River						
		Sluiceway	Unit	5	0	4	9
	Bridges			9	15	8	32
		Reconstruction	Bridge	2	6	2	10
		Construction	Bridge	0	3	0	3
		Raising	Bridge	1	0	1	2
		Demolish	Bridge	2	0	1	3
		No Measures	Bridge	4	6	4	14

Source: JICA Survey Team

7.1.4 Compensation Figures

(1) Acquiring Work Sites

At Construction Zone I and II, land acquisition cost is required for the expansion of river channel in the course of improving the Mejerda River. At the El Mabtouh retarding basin (Zone II), land acquisition is required to the new construction and expansion of discharge channel. Work site acquisition costs have been calculated based on the results of the plans devised during this Study.

Construction Zone II is divided into two (2) areas, state-owned land and private land (described in detail later in (2) 4) (c), Chapter 8: 8.2.2 Social Environment Survey Results, refer to Figure 8-8.), and state-owned land, so no acquisition is necessary. The area requiring land acquisition cost is shown on the Table below. Land for expansion of access road width is also required for bridge height increase. However, the latter is extremely smaller than land needed for the expansion of river channel and the Tunisia side is responsible for work site acquisition costs.

Table 7-5 Breakdown of Work Sites Acquisition Areas

Construction Zone	River Channel Width (m^2)	Expansion of Bridge Access Road Width (m^2)
Zone I	619,000	3,630
Zone II	1,254,800	1,910
Zone III	443,800	1,110
Subtotal	2,318,200	6,650
Total	2,324,850 m^2	

Source: JICA Survey Team

(2) House Compensation

Two houses will have to be moved to widen the river channel in the course of improving the Mejerda River. Loan money cannot be applied toward the money used for house compensation; the Tunisia side is responsible for the resulting cost.

Table 7-6 Resident Relocation Compensation Figures

Construction Zone, Distance Marker	House Compensation Area (m^2)
Zone I, 24.7 km (right bank)	150
Zone III, 46.5Km (left bank)	500

Source: JICA Survey Team

7.2 Construction Plan

7.2.1 Methods for Main Types of Construction

(1) Removing Trees/Roots (flood channel)

Tamarisk and reeds will be removed by hand and by machine. Removed tamarisk and reeds will be loaded into dump trucks by hand or by backhoes (with thumbs attached) and transported to a temporary dumping area (distance of one kilometer or less). Temporary dumping areas for tamarisk and reeds will be set up at one-kilometer intervals throughout construction zones. At temporary dumping areas, tamarisk and reeds will be fed through wood chippers, and the chips will be strewn about the slopes by machine to reuse them as vegetation base material. Roots will be dug out by bulldozers with rippers and piled up. Roots will be loaded into dump trucks by backhoes (with thumbs attached) and transported to temporary dumping areas. Roots will also be fed through wood chippers, finely chopped and strewn about the slopes by machine to reuse them as vegetation base material.

(2) Topsoil Scraping/Excavation (flood channels and slopes)

Bulldozers will scrape the topsoil from the tops of slopes toward the bottoms efficiently (30-50 centimeters thick). Then, the bulldozers will scrape 30-50 centimeters of topsoil from the flood channel and pile it up every 100 meters or so along the flood channel. That dirt will be transported to dumping areas within a distance three kilometers by wheel loaders or dump trucks. After topsoil scraping, bulldozers will excavate again in the same order and pile up that dirt along the flood channel in the same way as in the topsoil scraping. That dirt will be piled up every 100 meters or so along the flood channel and then transported to embankments by wheel loaders or dump trucks. After excavation, the bulldozers will shape the slopes by compacting them and shape the flood channel (keeping drainage in mind and making slopes drain in the direction of the channel).

(3) Banking

Areas to be banked will be split into 50-meter zones. First, bulldozers will scrape topsoil and transport that soil to dumping areas. After the topsoil has been scraped, bulldozers will transport dirt excavated from the flood channel, compact the dirt to a thickness of 35 centimeters with rollers, and finish the banks to a thickness of 30 centimeters. Then, after it has been compacted by bulldozers, the soil will be re-compacted with tire rollers.

After piling up embankments to the requisite height, backhoes will compact and shape their slopes and crowns.

(4) Concrete Slope Cribwork and Bed Protection Work as Part of Protective Dike Work

Slopes will be excavated to the requisite locations by bulldozers (backhoes) and then concrete slope cribwork will be done, followed by the laying of siphon prevention material and foundational broken stone. Next, slope cribwork will be filled by backhoes with natural stones (30-50 centimeters) transported to the sites.

At work yards, gabions will be stuffed with riprap by backhoes and lowered by cranes into the river channel, excavated to the requisite cross section by backhoes.

(5) Expanding El Mabtouh Retarding Basin, Excavating Low Channels

Construction in channels will start after water is pumped out of them by submersible pump and their insides dried to the extent possible.

Reeds inside channels will be removed along with their roots, piled up temporarily and transported to disposal areas.

Channels will be excavated by backhoes to expand them, and the dirt will be loaded into dump trucks and transported to places in the retarding basin or along the main river where banking will occur. Soil that contains moisture and is unfit for use in banking will be piled up temporarily so that it can dry.

(6) Banking in El Mabtouh Retarding Basin

Before building embankments, topsoil at banking locations will be scraped and banking soil prepared. Soil excavated from the vicinity will be used for banking. Bulldozers will be used to roll banks to a thickness of 35 centimeters, and then finished by compaction to a thickness of 30 centimeters. Then, banks will be compacted with tire rollers.

Areas to be banked will be split into 50-meter zones, and slopes will be shaped into straight banks by backhoes to finish them.

(7) El Mabtouh Retarding Basin, Flow Control Facilities, Overflow Dike, etc.

In principle, structural work will be done during the dry season. Work will be done on excavation surfaces with lower water levels, and sumping and cofferdam work with sandbags and such will be done at the same time.

Most excavation will be done by backhoes, and foundation excavation and leveling will be done by hand. Open excavation will be done on slope surfaces and the bottoms of foundations will be leveled and compacted. Then, they will be filled with riprap and chippings, compacted, and covered with blinding concrete.

Concrete will be poured by chute, crane or pump truck. Ready-mix concrete will be purchased from a manufacturer in the area.

(8) Bridge Construction, Replacement

Class A bridges all currently exist and are located along primary roads, so they will be demolished after traffic is detoured to temporary bridges. After the existing bridges are demolished, foundation piles will be driven in requisite positions, abutments and bridge frames will be built, and then girders will be installed. Girders will be manufactured at nearby yards, transported to bridge sites by truck and installed by crane.

Box culverts will be cast in place to create Class B bridges. In places where a bridge already exists, traffic will be detoured and the existing bridge demolished before box culverts are cast.

(9) Bridge Jacking, Expansion

Traffic will be detoured to temporary bridges. Main girders will be lifted temporarily off spans over which the bridge is to be jacked up or expanded, and jacks will be used to raise bridges to the requisite height. For expansion, girders for additional spans will be manufactured at nearby yards while the additional substructure is being built, transported to bridge sites by truck and installed by crane.

7.2.2 Construction Plan

(1) Construction Plan (Main Construction)

1) Preparation Work

Preparation work involves making arrangements for the main construction. Whether it is done properly or not has a huge effect on the efficiency, quality, economic efficiency and schedule of the construction. It is an extremely important part of proper construction management.

2) Preparatory Surveying (Groundbreaking Survey)

Before construction starts, preparatory surveying is done to verify compliance with design drawings. If preparatory surveying reveals inconsistencies with design drawings, the causes of those inconsistencies will be surveyed and proper actions taken promptly.

a. Setting Water Level Markers

Temporary water level markers will be set up using distance markers or the foundations of structures and other immovable objects. When such objects are not usable, temporary water level markers will be installed. They will be set up outside of construction areas on solid ground where there is no chance that they will be compromised by general traffic, and they require proper protection.

Positions of temporary water level markers will be determined by measuring the water level at existing water level markers and confirming positions by referencing at least one other existing water marker; temporary water markers cannot be placed unless this confirmation is done.

b. Setting Temporary Coordinates

Coordinate markers will be set up in addition to distance markers where necessary. As with the temporary water level markers, they will be set up outside of construction areas. These temporary markers will be placed upon confirming the positions of river structures and such with reference to design drawings.

Boundary markers and water survey markers will be verified before any measuring work is done. Boundary markers may be broken, removed or become lost if there is a time lapse between work site acquisition and start of construction, resulting in discrepancies. Thus, markers need to be verified to make sure that they are in the correct positions. In addition, implementing agencies must be consulted and proper measures taken before repositioning existing distance markers or water level markers when construction requires them to be repositioned.

3) Grade Stakes

Grade stakes serve as references in the course of working on structures and must remain in place during construction. They must be inspected regularly and verified and corrected when doubts exist.

As a rule, grade stakes will be placed at 10-meter intervals on straight reaches of the channel and at five-meter intervals on curved and other complicated reaches, but it is best to place them at closer intervals when necessary.

4) Drainage Earthwork

Drainage for earthwork includes draining spring water, standing water, groundwater and rainwater at excavation sites and expansion sites in construction areas and on transportation routes. Problems with drainage in civil engineering work carried out by machines are very closely related to the efficiency and quality of the work, so the most up-to-date considerations must be given to draining construction areas.

Unlined drainage ditches will be dug to drain standing water and other surface water to areas outside banks. Most situations do not call for large-scale drainage facilities; construction methods, sequences and the progression of the schedule should account for drainage, and a flexible approach is needed to account for the weather.

5) Procedures for Related Laws, Regulations and Agencies

When work permits are needed prior to beginning construction, procedures for related agencies must be carried out promptly with the number of days required for prior deliberations taken into account.

(2) Construction Plan (Temporary Works)

1) Construction Roads

General, primary roads will be used as construction roads, and new construction roads will also be built. Construction roads will be 4.0 meters wide within the banks of the river. Broken stone will be laid to a thickness of 20-30 centimeters to create roadbeds fully capable of supporting dump trucks.

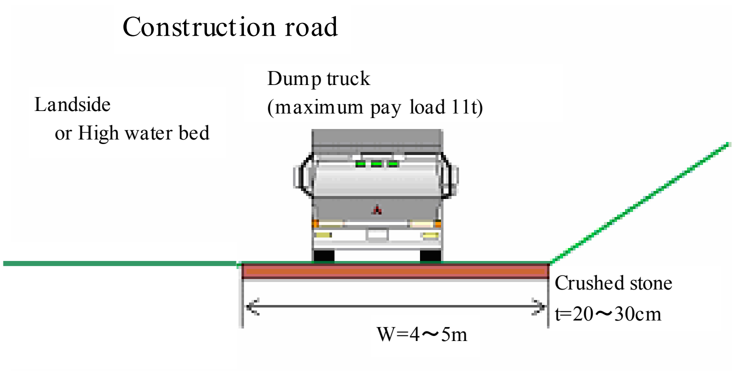
When building sloped construction roads from the crowns of dikes toward the river, dirt will be piled up above and outside the cross sections of the straight slopes of the dikes, and such roads will face downstream. One-lane roads will feature turnouts if traffic volume during the construction period requires them.

New, temporary dirt roads meant to cross flood channels will be built to extremely low heights so that they do not inhibit the flow of floodwaters. When there is no choice but to build them tall, they will be demolished or otherwise taken care of during flood season.

When construction roads require temporary bridges to cross channels or the river, the height, direction and structure of the bridges will be determined upon investigation of river conditions, construction scale and construction periods.

Steel plates will be placed as necessary to ensure traffic ability of construction roads and within construction areas.

When building detour roads outside of construction areas, consideration must be given such that the construction itself is not inhibited and also that road capacity does not suffer. Implementing agencies must be consulted to set up safety facilities and signage as the situation demands.



Source: JICA Survey Team

Figure 7-2: Construction Road

2) Temporary Facilities

There are two types of temporary facilities; those directly related to construction and those indirectly related.

a. Directly Related Temporary Facilities

1) Rebar/Formwork

Rebar and formwork fabrication yards are temporary facilities related to concrete. Permanent roofs must be installed over the yards to prevent exposure to rain and sunlight.

2) Machinery, Heavy Machinery

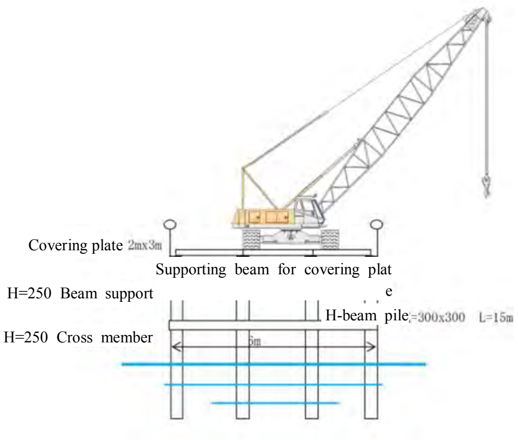
Repair shops for maintaining, inspecting and repairing machinery and heavy machinery are required. As with the yards above, these shops must have permanent roofs to prevent exposure to rain and sunlight. Particular care must be taken to set aside places to store fuels and oils used.

3) Temporary Bridges

Temporary bridges will be built to detour traffic around bridge construction.

4) Temporary Docks

Temporary docks will be built to build and install pier foundations and PC girders.



Source: JICA Survey Team

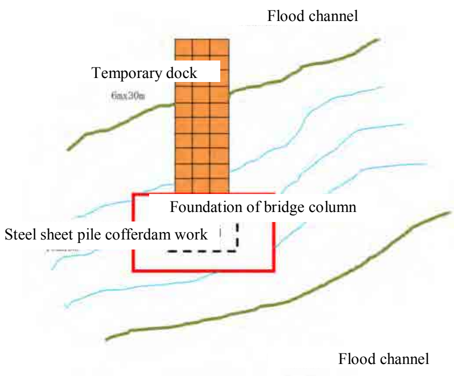
Figure 7-3: Temporary Docks

5) Jacking Work

Steel cradles that have steel H-piles or other temporary piles will be placed beneath each girder, and jacks placed atop the cradles will be used to jack up the existing superstructure. The same method will be used for temporary lifting employed during bridge expansion.

6) Steel Sheet Pile Cofferdams

Steel sheet pile cofferdams will be installed when cast-in-place pile work and substructure framework are done in the part of the river that flows.

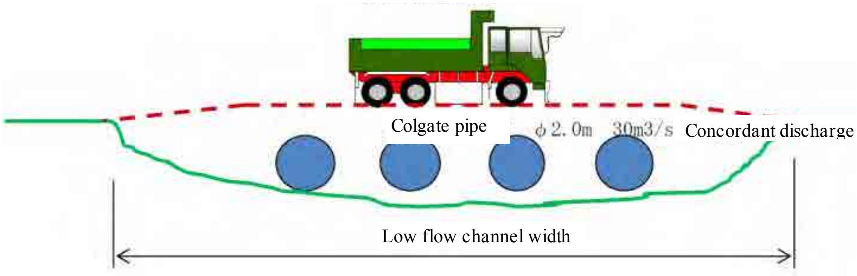


Source: JICA Survey Team

Figure 7-4 Bankup by Steel Sheet Pile

7) River-Crossing Roads

Corrugated pipes, large sandbags and excavation soil will be used to build construction roads that cross the river to ensure that the river can be crossed during construction.



Source: JICA Survey Team

Figure 7-5 Construction Road for River-Crossing

8) Cofferdam Work for Overflow Dike, Diversion Facilities

Large sandbags will be used to build cofferdams for foundation work during the dry season.

9) Drainage Work

Pumps will be used to drain spring water and other water that appears after cofferdams are built.

10) Dumping Areas

Dumping areas will be set up every four kilometers along embankments and will be 200 m x 300 m x 1 m.

b. Indirectly Related Temporary Facilities

1) Offices, Laboratories, Storehouses, Garages

Offices, laboratories, storehouses, garages, oil and fuel storage and transformer stations will be built within construction areas and as part of the construction schedule. Related laws and regulations will be observed as these facilities are built. Particular care must be taken to prevent theft when handling hazardous materials. These facilities will not be built outside the banks.

2) Lodging

Lodging will be built to accommodate the number of workers. Care must be taken to observe related laws and regulations and prevent pollution to the environment as these facilities are built. These facilities will not be built outside the banks.

3) Electricity

Power supply facilities on work sites are required to provide electricity for machinery facilities, construction lighting, water supply and drainage, cut-and-cover and office lighting.

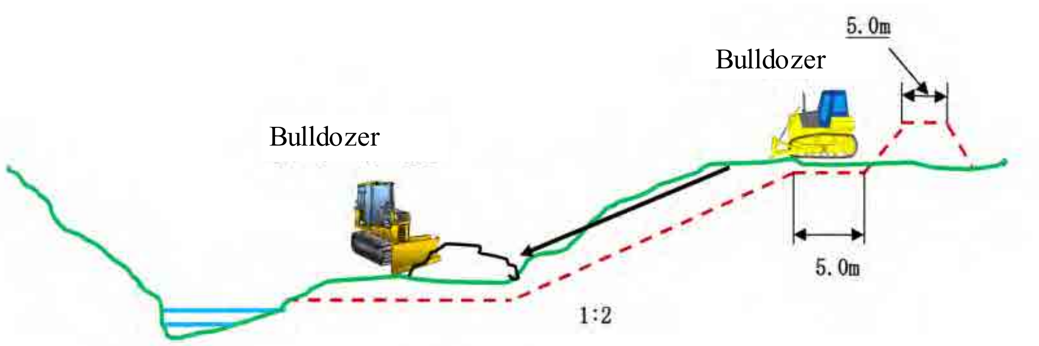
(3) Excavation and Transportation

1) Excavation

a. Bank excavation will be done by bulldozers from crown to foot.

b. The flood channel will be excavated after slope excavation is complete.

c. Dirt will be piled up in the flood channel.

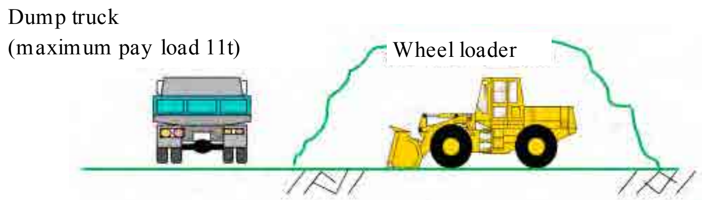


Source: JICA Survey Team

Figure 7-6 Excavation

2) Loading and Transportation

Excavated dirt piled up in the flood channel will be loaded into dump trucks by wheel loaders. The dirt will be transported to embankments or to dumping areas based on dirt transportation plans.

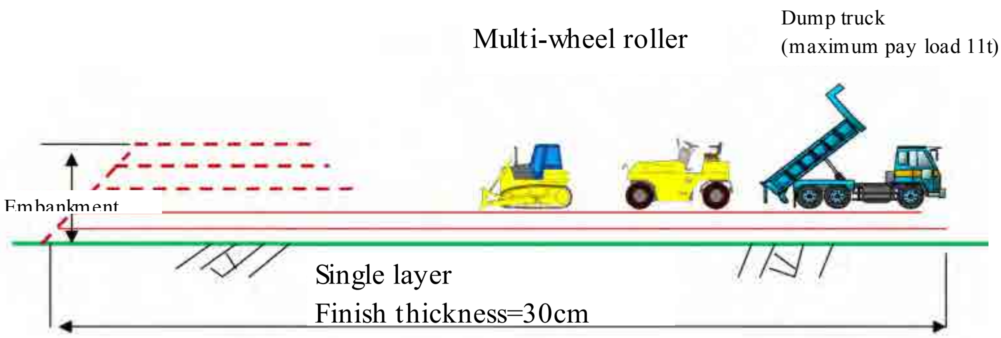


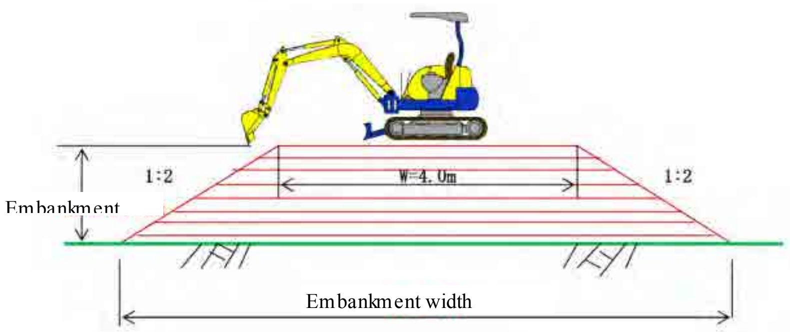
Source: JICA Survey Team

Figure 7-7 Loading and Transportation

(4) Banking

Dirt transported from the flood channel by dump trucks will be dumped in places where embankments are planned and compacted by bulldozers. Then, it will be re-compacted with tire rollers. It will be rolled to a thickness of 35 centimeters and finished to a thickness of 30 centimeters. Banking work will be done in 50- to 100-meter segments. After dirt is piled up, slopes will be shaped and compacted by backhoes. (See figure below)





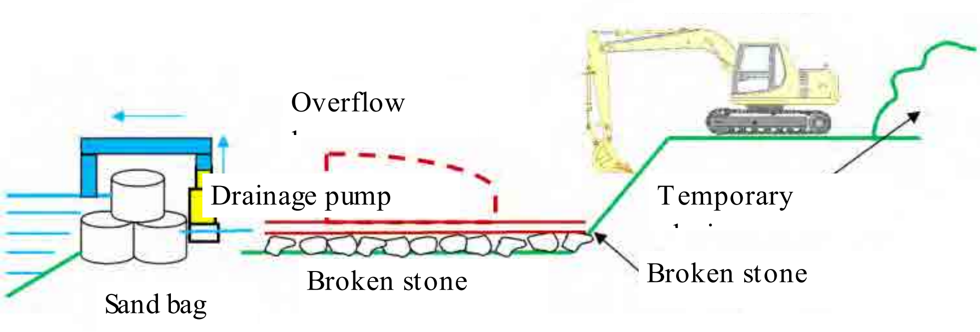
Source: JICA Survey Team

Figure 7-8 Banking

(5) Structure Construction (Diversion Facilities, Overflow Dike, etc.)

a. Structure Foundation Excavation

Cofferdams made of large sandbags will be built around areas to be excavated below the level of the river. If spring water appears, pumps will be used to drain it. After excavation is complete, dirt will be spread to the requisite dimensions and compacted. Then, riprap and chippings will be spread in that order and compacted to the requisite thickness.

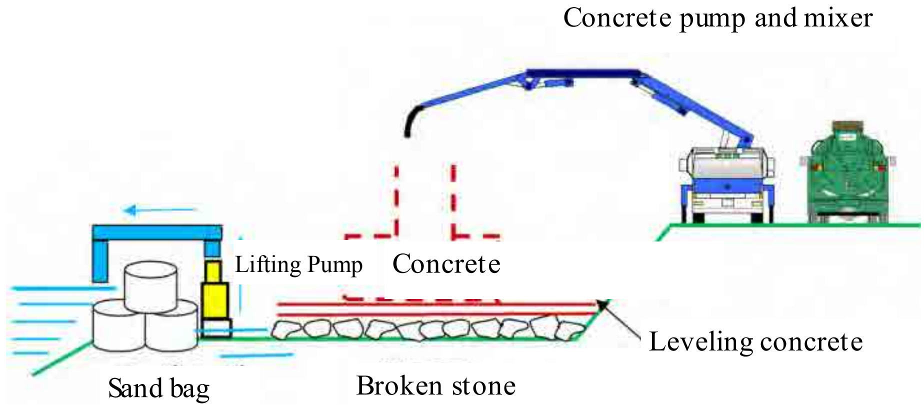


Source: JICA Survey Team

Figure 7-9 Structure Foundation Excavation

b. Pouring Concrete for Structures

Chutes will be used to pour concrete when the distance is short, cranes will be used when there is distance or height to be reckoned with, and pumps will be used when large amounts of concrete are to be poured at an isolated location.



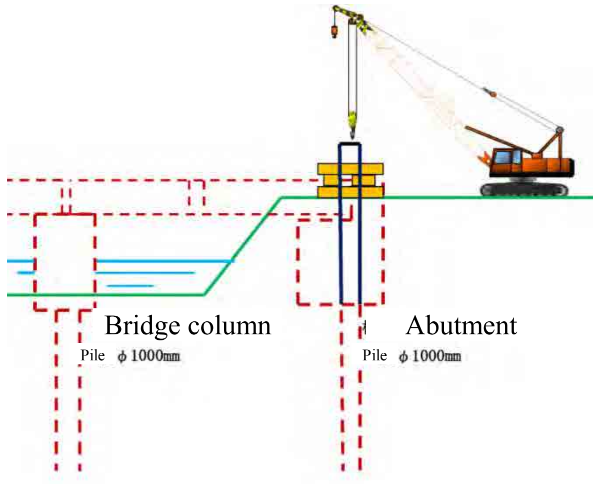
Source: JICA Survey Team

Figure 7-10 Pouring Concrete for Structures

(6) Bridge Work

a. Cast-in-Place Piles

An auger will be used to excavate to the requisite depth while the borehole walls are protected with a bentonite slurry. A crane will be used to raise a reinforced frame, and concrete will be poured from the pile tips up through a tremie pipe. The bentonite will be circulated and reused repeatedly.

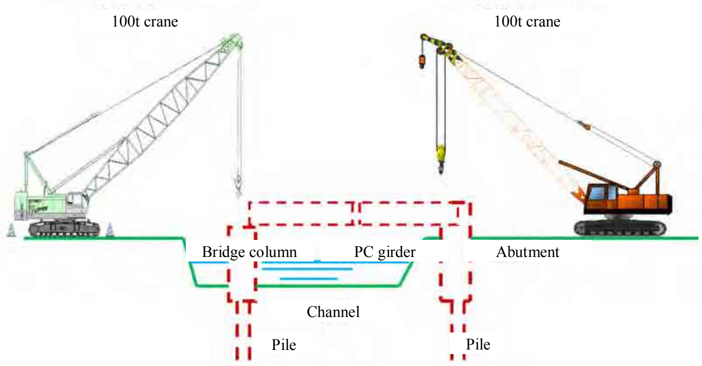


Source: JICA Survey Team

Figure 7-11 Cast-in-Place Pile Work

b. PC Girder Installation (Using Cranes)

Crossbeams will be cast in place and joined to main girders after cranes have lowered them to the requisite positions.



Source: JICA Survey Team

Figure 7-12 PC Girder Installation

c. Bridge Jacking

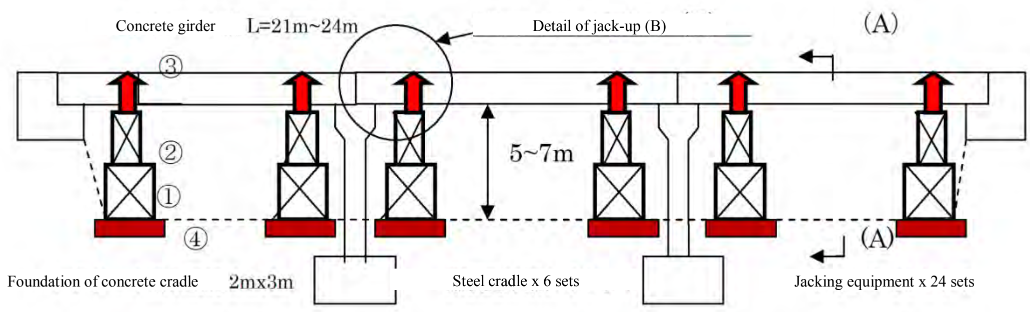
Reinforcement work on existing bridges will be completed and, depending on the condition of the ground, temporary piles or steel cradles on top of foundation concrete will be set up before jacking up bridges.

After setting up steel cradles, jacks will be placed atop the cradles to support each main girder and devices required to operate the jacks will be arranged. The figure below is an example of this setup on a three-span bridge.

Jacking Equipment Arrangement and Number of Cradles

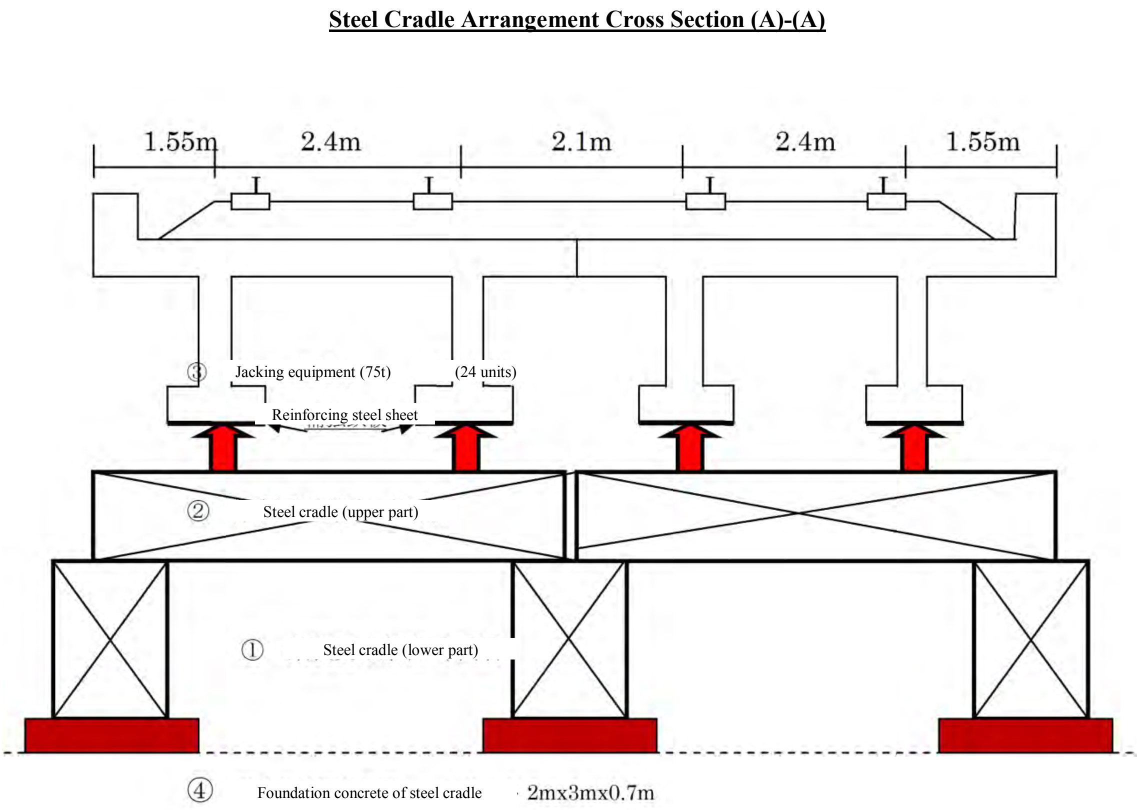
A set of six steel cradles is required to jack up a three-span bridge. There are 12 girders, so 24 jacks are required. A set of three pump units to connect to the jacks is required.

① Steel Cradle (Lower) 1.0t each	Total 18 cradles	18t
② Steel Cradle (Upper) 2.5t each	Total 18 cradles	30t
③ Jack 75t	Total 24 jacks	
④ Steel Cradle Foundation Concrete	Total 18 foundations	76 m^3



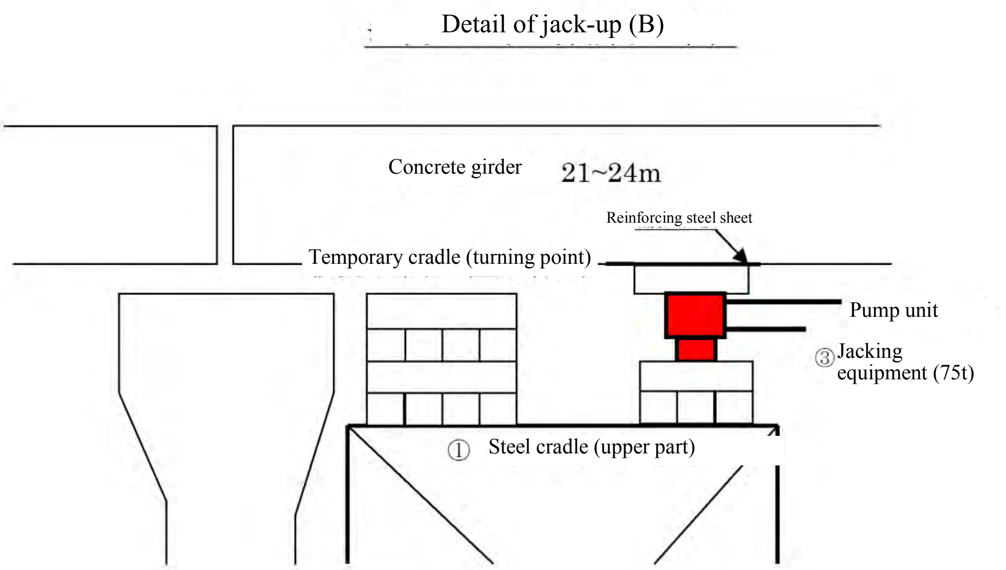
Source: JICA Survey Team

Figure 7-13 Example of Jacking Equipment, Cradle Arrangement for Bridge Jacking



Source: JICA Survey Team

Figure 7-14 Example of Jack Arrangement for Bridge Jacking (Cross Section)



Source: JICA Survey Team

Figure 7-15 Example of Jack Arrangement for Bridge Jacking (Detailed Drawing)

(7) Borrow Areas/Dumping Areas/Vegetation Dumping Areas

a. Borrow Areas

This construction requires protective dike materials (diameter 30-50 cm), broken stone for concrete (5-25 mm) and construction road crusher materials (0-30 mm), but there is no need to develop them anew; they will be procured from existing quarries. Quarries are located in Tebla and Sebala on the outskirts of Tunis. Materials will be transported from Tebla in the upper basin (about 5-10 kilometers) and from Sebala in the lower basin (12-14 kilometers).

There is no need to develop new borrowed areas because the excavated soil from the river and from the retarding basin is enough for the embankments.

b. Dumping Area

According to the site survey, confirmed candidates of dumping area are the following three locations. Since the surplus earth acceptable amount at the three sites becomes 13,825Km^3, processing of 7,931Km^3 surplus earth generated by the use is capable.

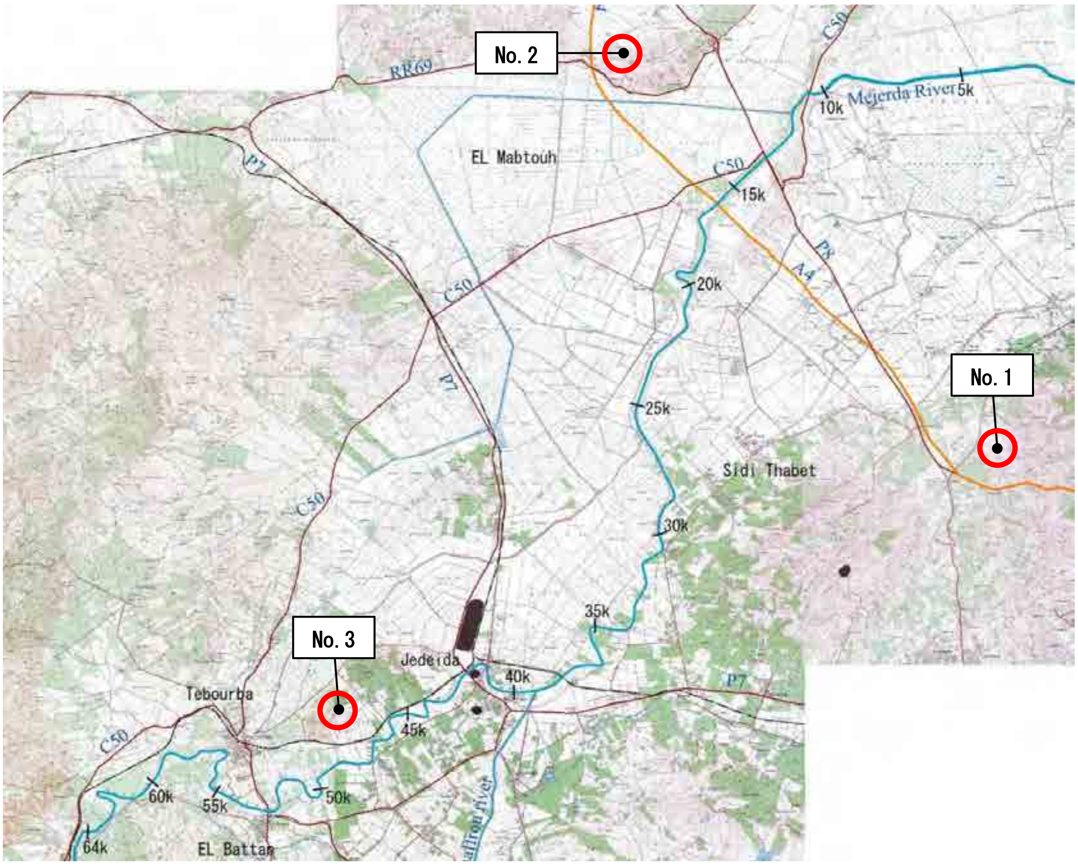


Figure 7-16: Candidates for Dumping Area

Table 7-7 Candidates for Dumping Area-1

Location	Nali, Ariana Governorate	Current Application	Empty Lot of Quarry/Soil Sampling
Capacity	6,950Km^3	● Calculated by Measured Area x Banking Height, 20m (value at hearing) from Map	
Full View Photo			
Current Photo			

Table 7-8 Candidates for Dumping Area-2

Location	Express Way Side in Bizerte Governorate	Current Application	Empty Lot of Soil Sampling for Express Way
Capacity	675Km^3	● Calculated by Measured Area x Banking Height, 5m (value at hearing) from Map	
Full View Photo			

Current Photo		

Table 7-9 Candidates for Dumping Area-3

Location	Charofi, Aiyari in Manouba Governorate	Current Application	Quarry/Soil Sampling Site
Capacity	6,200Km^3	● Calculated by Measured Area x Banking Height, 20m (value at hearing) from Map	
Full View Photo			
Current Photo			

c. Vegetation Dumping Areas

Branches and roots will be shredded at vegetation dumping areas and reused as vegetation base material on slopes. They will be strewn about the slopes by spraying machines.

The table below shows the work schedule based on the construction plans above. The construction is expected to take four years.

Table 7-10 River Construction Zone I Work Schedule

Job division	Type of works	Classification	BQ		Daily workload		Party formation	Number of days	Number of available day
River improvement I									
-1	Prelimanary work	Prelimanary work	1	LS					
-2	Bridge works	Reconstruction	1	Bridge	-		5M/B		
		New construction	0	Bridge	-		4M/B		
		Extension/Raising	2	Bridge	-		3M/B		
		Removal	2	Bridge	-		2M/B		
-3	Earth works	Clearing and grubbing(tama	2,470,614	m^2	-	m^2/day			
		Stripping	2,470,614	m^2	-	m^2/day			
		Excavation	6,987,235	m^3	300	m^3/day	41	568	860
		Embankment	391,495	m^3	690	m^3/day	7	81	130
		Trimming of slope	1,141,129	m^2	-	m^2/day			
		Surplus soil disporsal	6,595,740	m^3	-	m^3/day			
-4	Sluice way works	Main body	6	Num	-		3M/N		
		Gate works	6	Num	-		3M/N		
-5	Service road works	Asphalt pavement	10,239	m^3	-	m^3/day			
		Course base	40,956	m^3	-	m^3/day			
-6	Temporary construction roa	Crushed rock	54,608	m^3	-	m^3/day			
-7	Clearance work	Clearance work	1	LS					

Source: JICA Survey Team

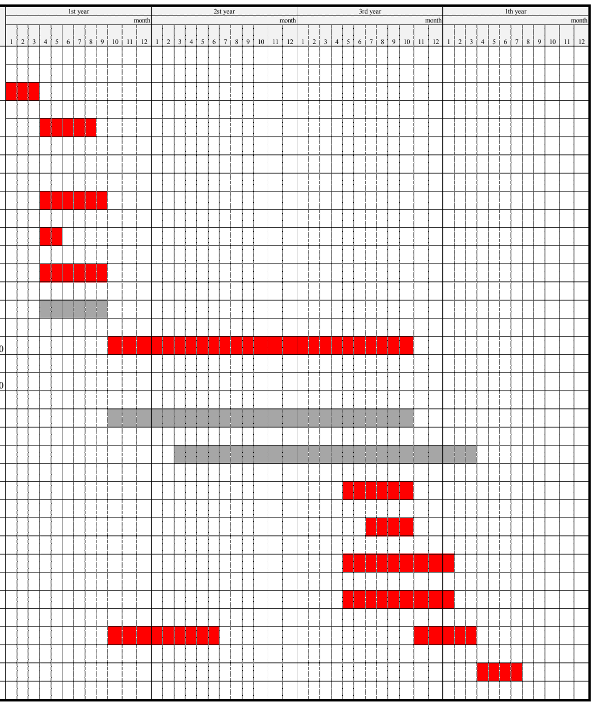
Table 7-11 River Construction Zone II Work Schedule

Job division	Type of works	Classification	BQ		Daily workload		Party formation	Number of days	Number of available day
River improvement II									
-1	Prelimanary work	Prelimanary work	1	Lump sum					
-2	Bridge works	Reconstruction	6	Bridge	-		5M/B		
		New construction	3	Bridge	-		4M/B		
		Extension/Raising	0	Bridge	-		3M/B		
		Removal	0	Bridge	-		2M/B		
-3	Earth works	Clearing and grubbing(tama	10,000	m^2	-	m^2/day			
		Stripping	10,000	m^2	-	m^2/day			
		Excavation	2,330,935	m^3	300	m^3/day	25	310	470
		Embankment	524,666	m^3	690	m^3/day	7	108	170
		Trimming of slope	501,893	m^2	-	m^2/day			
		Surplus soil disporsal	1,806,269	m^3	-	m^3/day			
-4	Facility works	Sluicing outlet works	1	Num					
		Contorol gate works	1	Num					
		Overflow weir	1	Num					
		Inlet overflow dike	1	Num					
-5	Service road works	Asphalt pavement	7,452	m^3	-	m^3/day			
		Course base	29,808	m^3	-	m^3/day			
-6	Temporary construction roa	Crushed rock	19,872	m^3	-	m^3/day			
-7	Clearance work	Clearance work	1	LS					

Source: JICA Survey Team

Table 7-12 River Construction Zone III Work Schedule

Job division	Type of works	Classification	BQ		Daily workload		Party formation	Number of days	Number of available day
River improvement III									
-1	Prelimanary work	Prelimanary work	1	LS					
-2	Bridge works	Reconstruction	1	Bridge	-		5M/B		
		New construction	0	Bridge	-		4M/B		
		Extension/Raising	2	Bridge	-		3M/B		
		Removal	1	Bridge	-		2M/B		
-3	Earth works	Clearing and grubbing(tama	2,371,908	m^2	-	m^2/day			
		Stripping	2,371,908	m^2	-	m^2/day			
		Excavation	6,039,726	m^3	300	m^3/day	41	491	740
		Embankment	0	m^3	690	m^3/day	7	0	0
		Trimming of slope	952,952	m^2	-	m^2/day			
		Surplus soil disporsal	6,039,726	m^3	-	m^3/day			
-4	Sluice way works	Main body	4	Num	-		3M/N		
		Gate works	4	Num	-		3M/N		
-5	Service road works	Asphalt pavement	7,854	m^3	-	m^3/day			
		Course base	31,416	m^3	-	m^3/day			
-6	Temporary construction roa	Crushed rock	41,888	m^3	-	m^3/day			
-7	Clearance work	Clearance work	1	LS					



Source: JICA Survey Team

7.3 Project Cost Estimation

7.3.1 Project Cost Estimation System

The system below was used to estimate the cost of the Mejerda River Improvement Project:

(A) Direct construction cost

(B) Consulting service (CS) cost (cumulative)

(C) Work site compensation cost (cumulative)

(D) Administrative cost (% of total project cost)

(E) Price increase (foreign currency: %, domestic currency: %)

(F) Reserves (%)

(G) Taxes (%)

(A) Direct Construction Cost (Direct Cost, Base Cost for Construction)

National standards for estimating costs do not exist in Tunisia, so direct construction costs were calculated based on work items in 6.1.3 Construction Figures and on the unit prices in 6.1.4. The unit price for each type of construction was set based on bidding prices on past projects implemented by the Ministry of Agriculture (MA) and on recent market price construction within Tunisia.

Also, according to interviews with the Ministry of Agriculture and local construction workers, most of the required materials, equipment and workforce can be procured from within Tunisia.

(B) Consulting Service Cost

The consulting service consists of the following and is calculated by multiplying the cost per engineer by the required man-month (MM).

1) Detailed design of river improvement and non-structure measures and bidding preparation for it

Costs for measurements required for detail design and other supplemental surveys, river improvement and bridges associated with improvement based on measurements, detail designs for river structures and auxiliary structures, drawing preparation, quantity estimation and the project are calculated. Also, tender documents will be prepared and assistance provided for bidding based on the results of detail design.

As for non-structures, dam flood management system, evaluation and flood disaster prevention, as well as organization strengthening and capability development are planned and their detailed design is produced.

Bidding document is prepared and bidding is supported based on detailed design results.

2) Construction Management in Construction Zones I, II and III

The following construction management in the three construction zones is performed: schedule control, quality control, performance management, environmental management, health and safety management, and handling of complaints from construction companies.

3) Handling of non-structures

Consulting service on dam flood control system, evacuation and flood prevention plan, as well as organization strengthening and capability development is performed based on the detailed design.

(C) Compensation Cost

1) Site Acquisition Cost

Work sites need to be acquired in the course of improving the Mejerda River. Site acquisition cost was calculated based on the plans developed from this Study. Construction Zone II is state-owned land, so no acquisition is necessary.

2) House Compensation Cost

Houses to be relocated will be recorded in the course of improving the Mejerda River.

(D) Administrative Cost

Administrative cost to the owners of this project of % of total project cost will be recorded.

(E) Inflation Costs (annual rate)

Inflation of % for foreign currency and % for domestic currency indicated by JICA will be recorded.

(F) Contingency

Contingency was reported as a uniform % of price increases for foreign and domestic currency.

(G) Tariffs/Taxes

Customs duties/ Value Added Tax (VAT) were set as %. The customs duties are exempted and the tax will be returned within 45 days after submission of receipt for the procured material to MA.

a. Exchange rates: 1 USD = 1.61 TND = 79.0 JPY
1 TND = 49.0 JPY (November 6, 2012)
b. Currency composition: Local Currency Portion (__)
Foreign Currency Portion (__)
c. Interesrt: construction: %, consultants: %
d. Commitment charge: %

(H) Project Taking-over and Defect Liability

The Project shall be taken over at the completion of construction.

As for the bond, the term of the performance security (bond) shall be until the construction completion and defect correction, and thus it applies also during the defect period. (Standard Bidding Documents Under Japanese ODA Loans, Procurement of Works, JICA, October 2012)

7.3.2 Project Cost Unit Price Estimation

The following unit price charts were used to calculate the cost of the Mejerda River Improvement Project. The construction unit price for each construction sort is set referring to the bit price for past project conducted by MA (Ministry of Agriculture) or market construction cost in Tunisia, and the division of foreign and local currencies of the unit price (FC, LC) is determined by the unit price of work type in reference to the following ratio used in the SAPROF (Special Assistance for Project Formation) survey of JBIC and JICA provided by the Ministry of Agriculture (MA).

Table 7-13 Ratio of Foreign and Local Currencies by Work Type (JBIC, SAPROF) (JBIC,SAPROF)

Description	Foreign currency (%)	Local Currency (%)
1.Transmission Pipeline		
1)Transportation of PC and fitting	70	30
2)Earthworks	70	30
3)Pipe installation and test	60	40
4)Civil works including building works	60	40
5)Installation of hydro-mechanical equipment & fitting	70	30
6)Other minor works	50	50
7)Supply of hydro-technical and fitting	90	10
8)Supply of PC pipes & fitting	55	45
9)Supply of Vehicle	95	5
2.Pump Station		
1)Transportation of PC and fitting	70	30
2)Earthworks	70	30
3)PC Pipe installation	60	40
4)Civil works including building works	60	40
5)Other minor works	50	50
6)Supply and Installation of pumping equipment	85	15
7)Supply of PC pipes & fitting	55	45

Source: Foreign and local currency portions applied in 1995 and in 2003 for the SAPROF studies of projects financed by JBIC and JICA (Ministry of Agriculture)

Table 7-14 Unit Prices for Construction Cost Estimation (1)

Table 7-15 Unit Prices for Construction Cost Estimation (2)

Table 7-16 Unit Prices for Construction Cost Estimation (3)

The consultant service (M/M) shall be as follows:

3)	Professional A :	yen	(	TND)
4)	Professional B:		(	TND)
5)	Supporting Staff :		(	TND)

7.3.3 Construction Figure Tables

Below are tables showing construction figures for each construction zone:

Table 7-17 Construction Figures for Construction Cost Estimation (Construction Zone I-1)

Table 7-18 Construction Figures for Construction Cost Estimation (Construction Zone I-2)

Table 7-19 Construction Figures for Construction Cost Estimation (Construction Zone I-3)

Table 7-20 Construction Figures for Construction Cost Estimation (Construction Zone II-1)

Table 7-21 Construction Figures for Construction Cost Estimation (Construction Zone II-2)

Table 7-22 Construction Figures for Construction Cost Estimation (Construction Zone II-3)

Table 7-23 Construction Figures for Construction Cost Estimation (Construction Zone II-4)

Table 7-24 List of Construction Figures for Cost Survey (Zone II-5)

Table 7-25 List of Construction Figures for Cost Survey (Zone II-6)

Table 7-26 List of Construction Figures for Cost Survey (Zone III-1)

Table 7-27 List of Construction Figures for Cost Survey (Zone III-2)

Table 7-28 List of Construction Figures for Cost Survey (Zone III-3)

Table 7-29 List of Construction Figures for Cost Survey (Zone IV)

7.3.4 Project Cost Estimation

The total project cost is shown in the table below. The total cost is billion JPY (million TND). Details of project cost of main construction zones follow the total cost.

Table 7-30 Total Project Cost

Table 7-31 Project Cost by Construction Zone (River Improvement Section I)

Table 7-32 Project Cost by Construction Zone (River Improvement Section II)

Table 7-33 Project Cost by Construction Zone (River Improvement Section III)

Table 7-34 Project Cost by Construction Zone (Gate Works)

Table 7-35 Land Acquisition Cost

Table 7-36 Consulting Service Fee