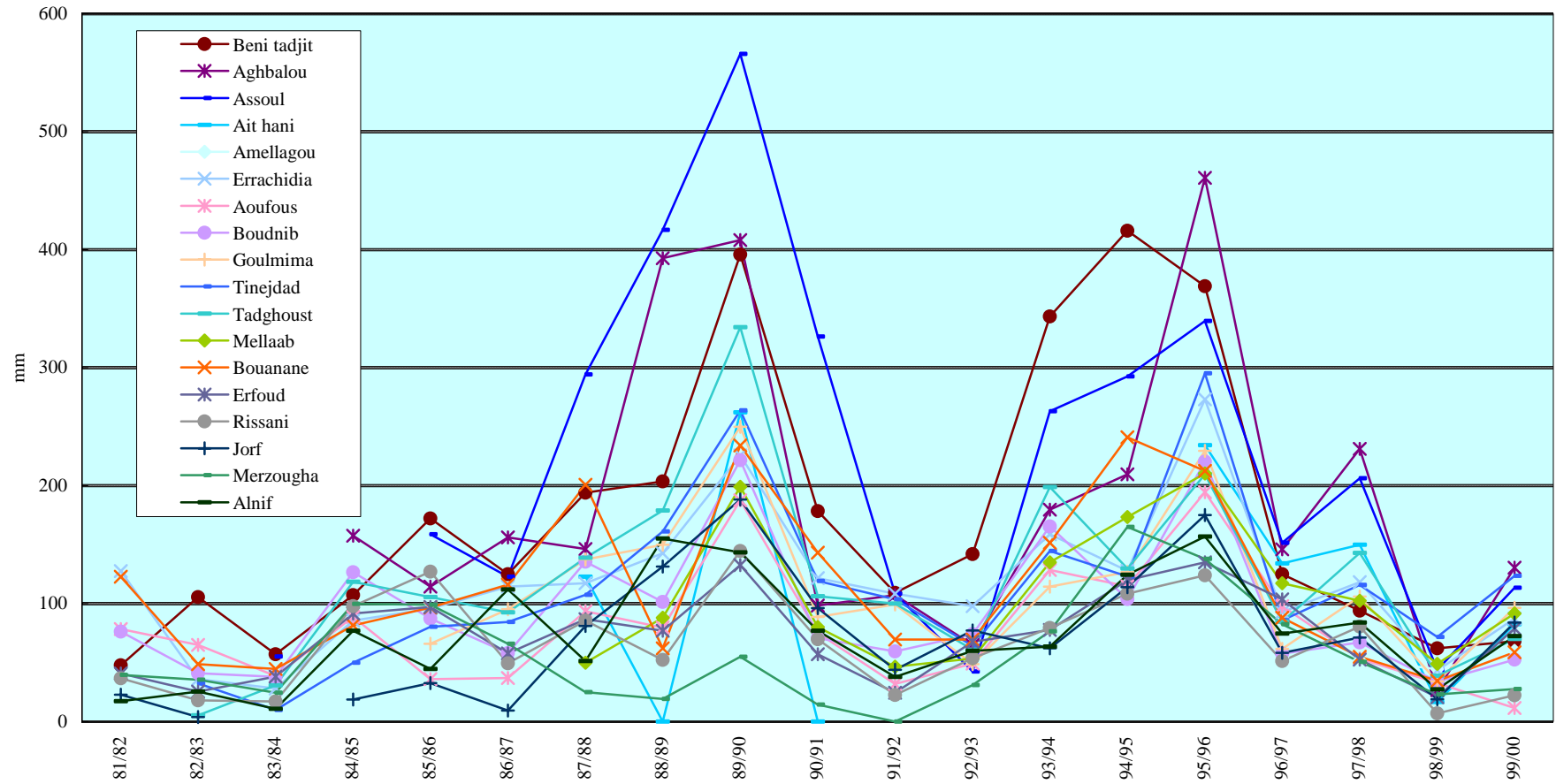


Annual Rainfall (1981-2000)



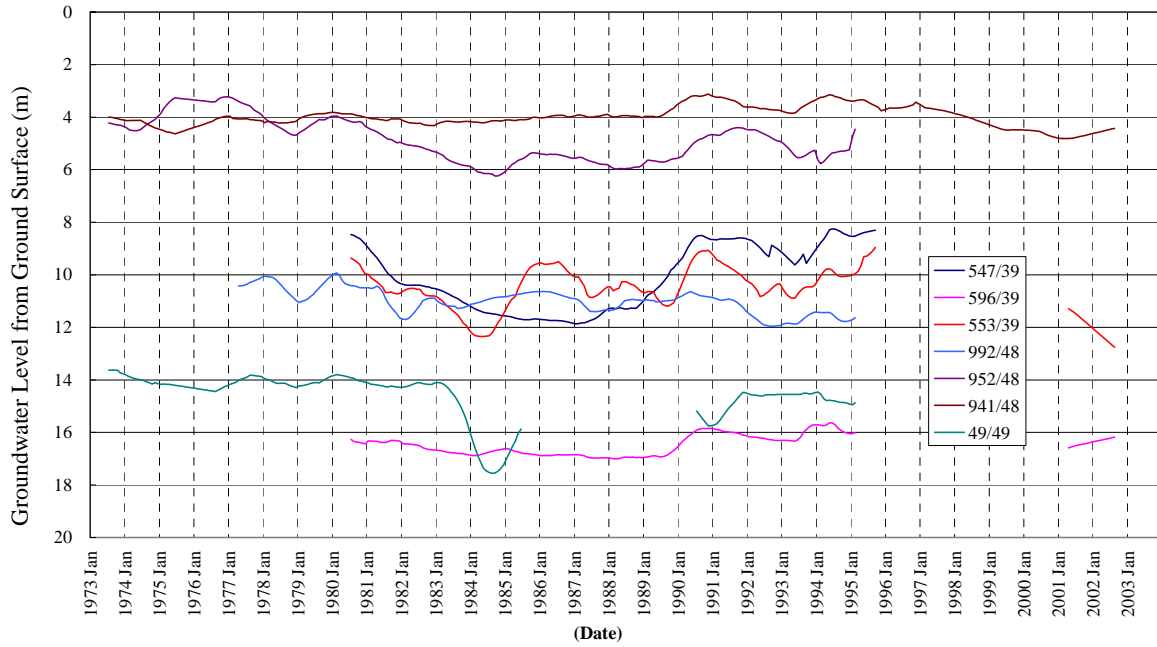
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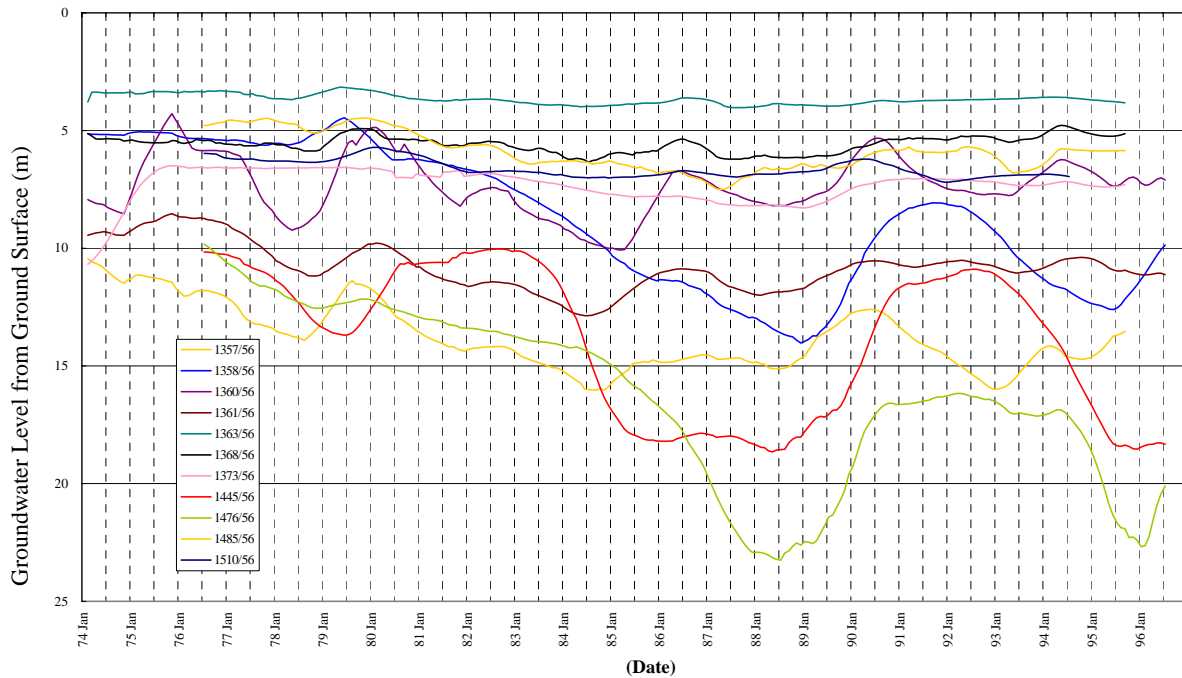
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Figure 3.2.3
 Rainfall Fluctuation in the Study Area
 for recent 20 years

Groundwater Level Record (River Basin Guir: Goulmima - Boudenib)



Groundwater Level Record (River Basin Todrha: Tinejdad/Tourong and El Kebir)



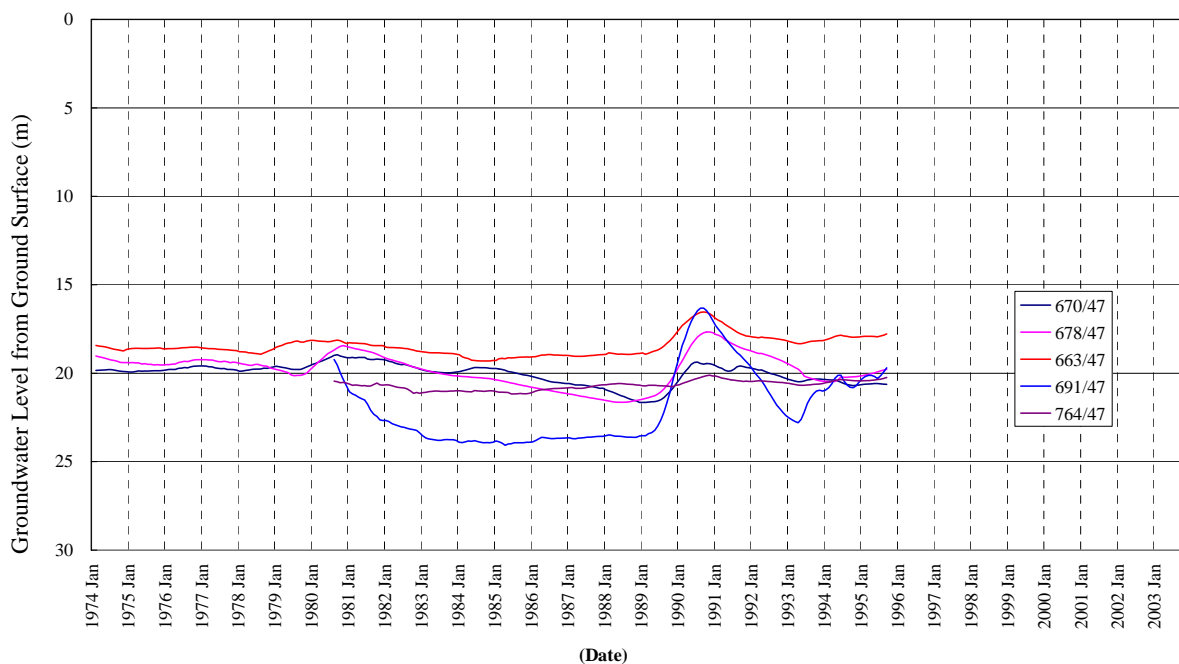
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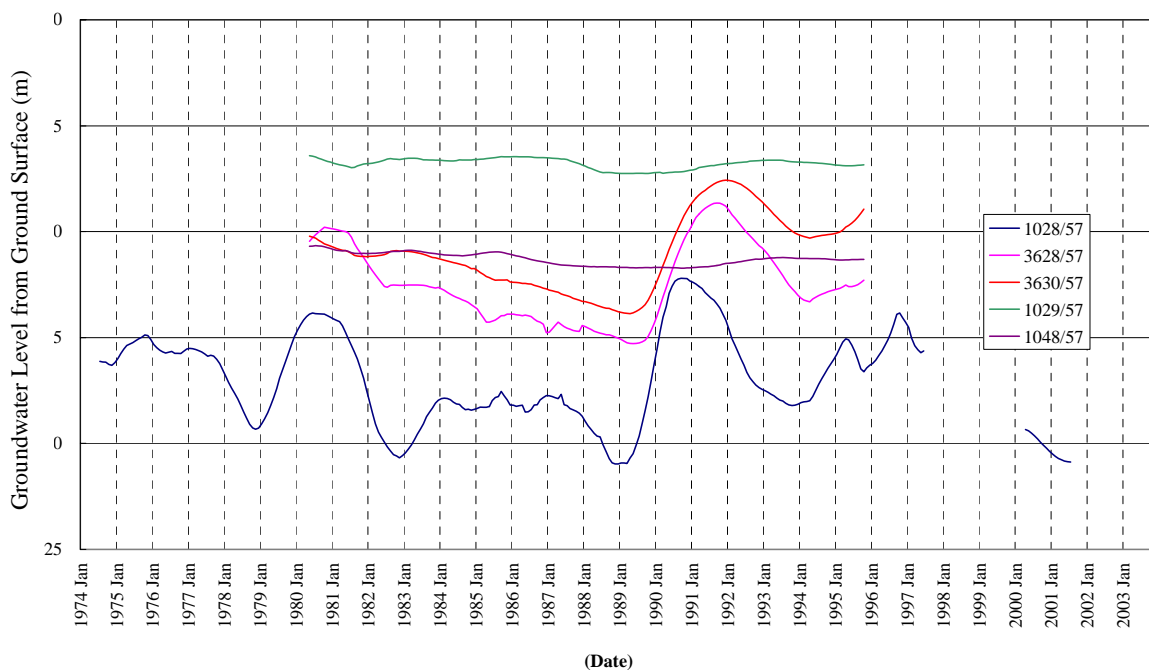
Figure 3.2.4

Groundwater Level Record (1)
(Moving average for 12 months)

Groundwater Level Record (River Basin Gheris: Goulmima , Tilouine and Todrha)



Groundwater Level Record (River Basin Gheris: Fezna, Jorf, Bouya/Krair and Hannabou)



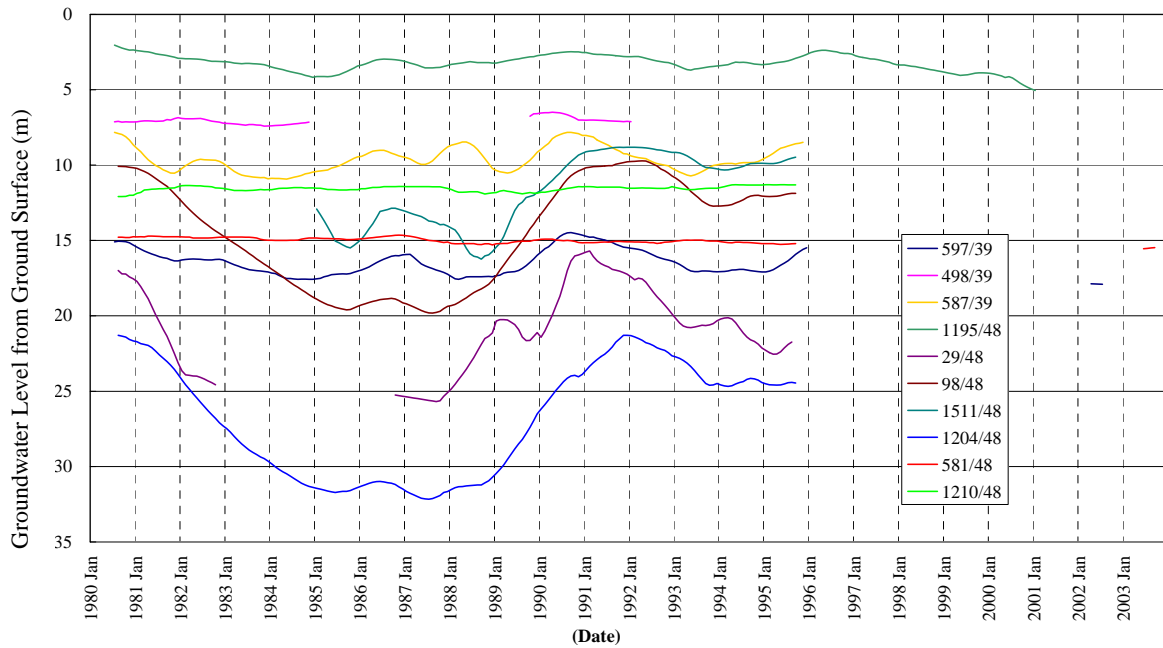
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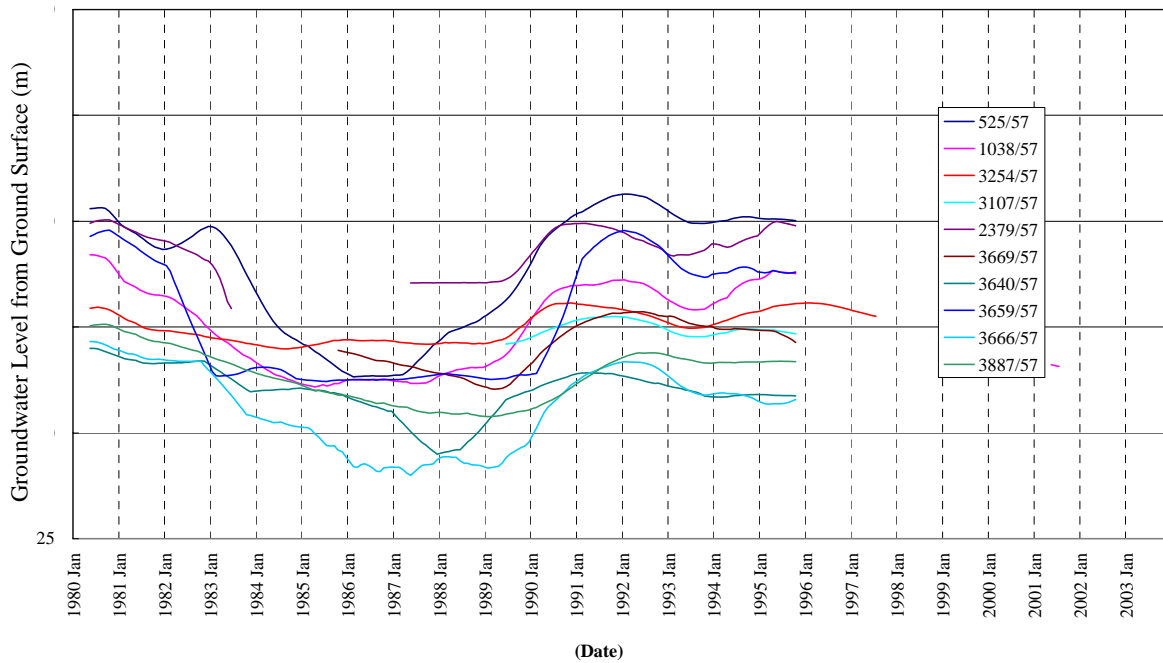
Figure 3.2.5

Groundwater Level Record (2)
(Moving average for 12 months)

Groundwater Level Record (River Basin Ziz: Rich, Errachidia, Meski and Aoufous)



Groundwater Level Record (River Basin Gherisand Ziz: Sifa, Oulad Zohras and Rissani)



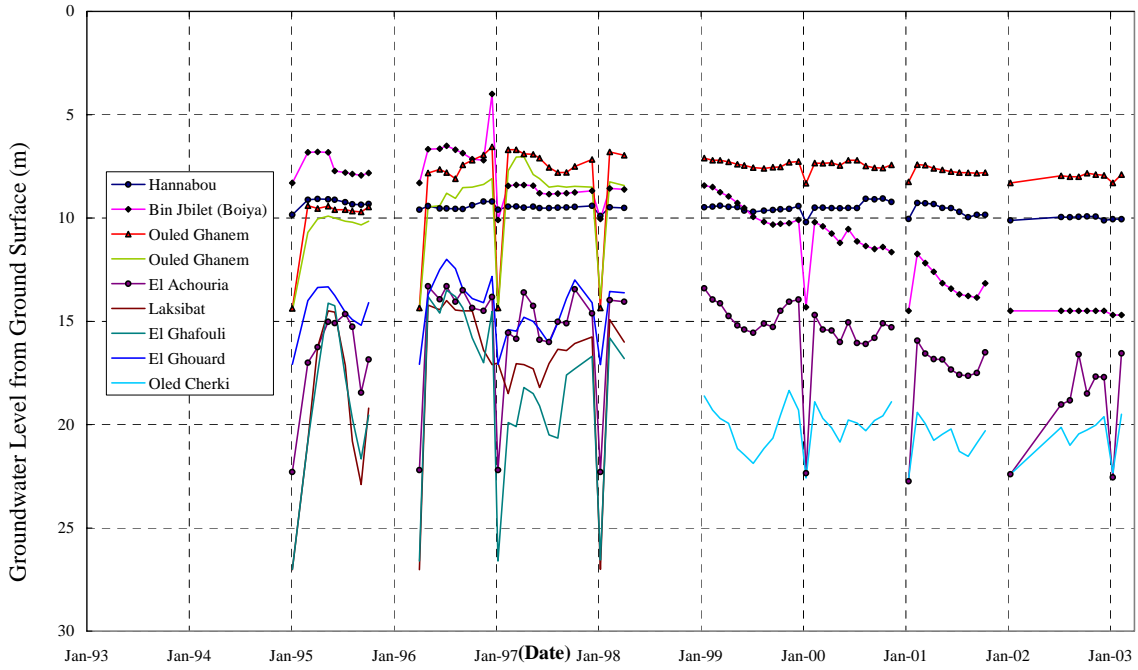
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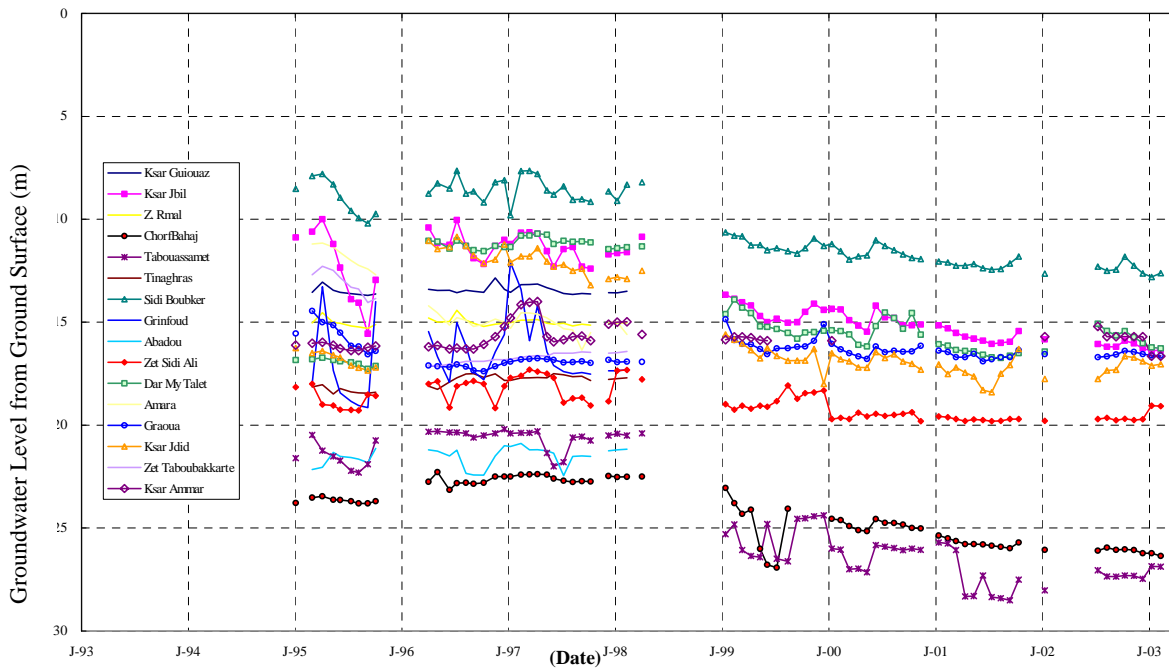
Figure 3.2.6

Groundwater Level Record (3)
(Moving average for 12 months)

Groundwater Level Record (Pump Stations in Zone D)



Groundwater Level Record (Pump Stations in Zone E and F)

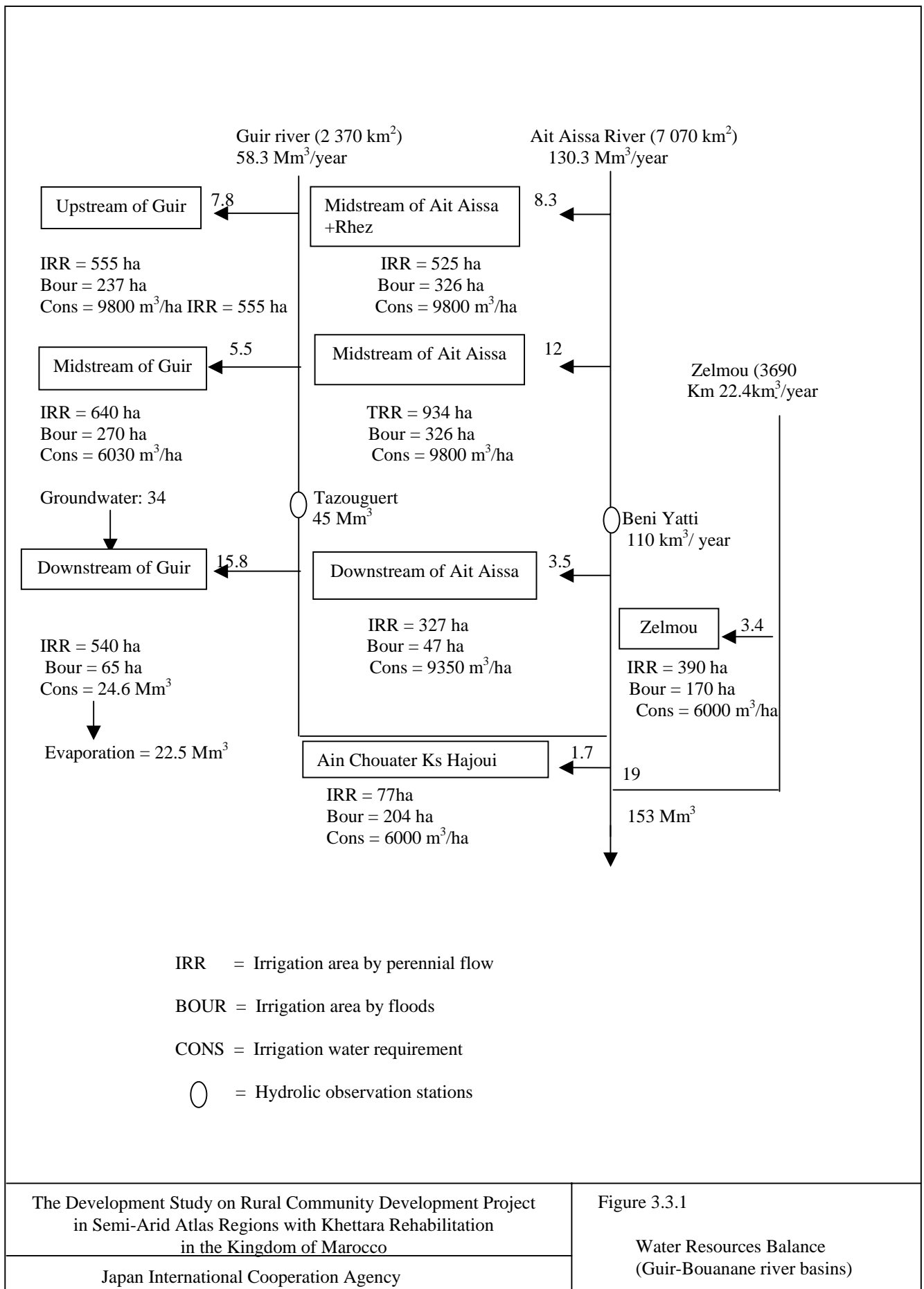


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Figure 3.2.7

Groundwater Records observed at
Pump Stations

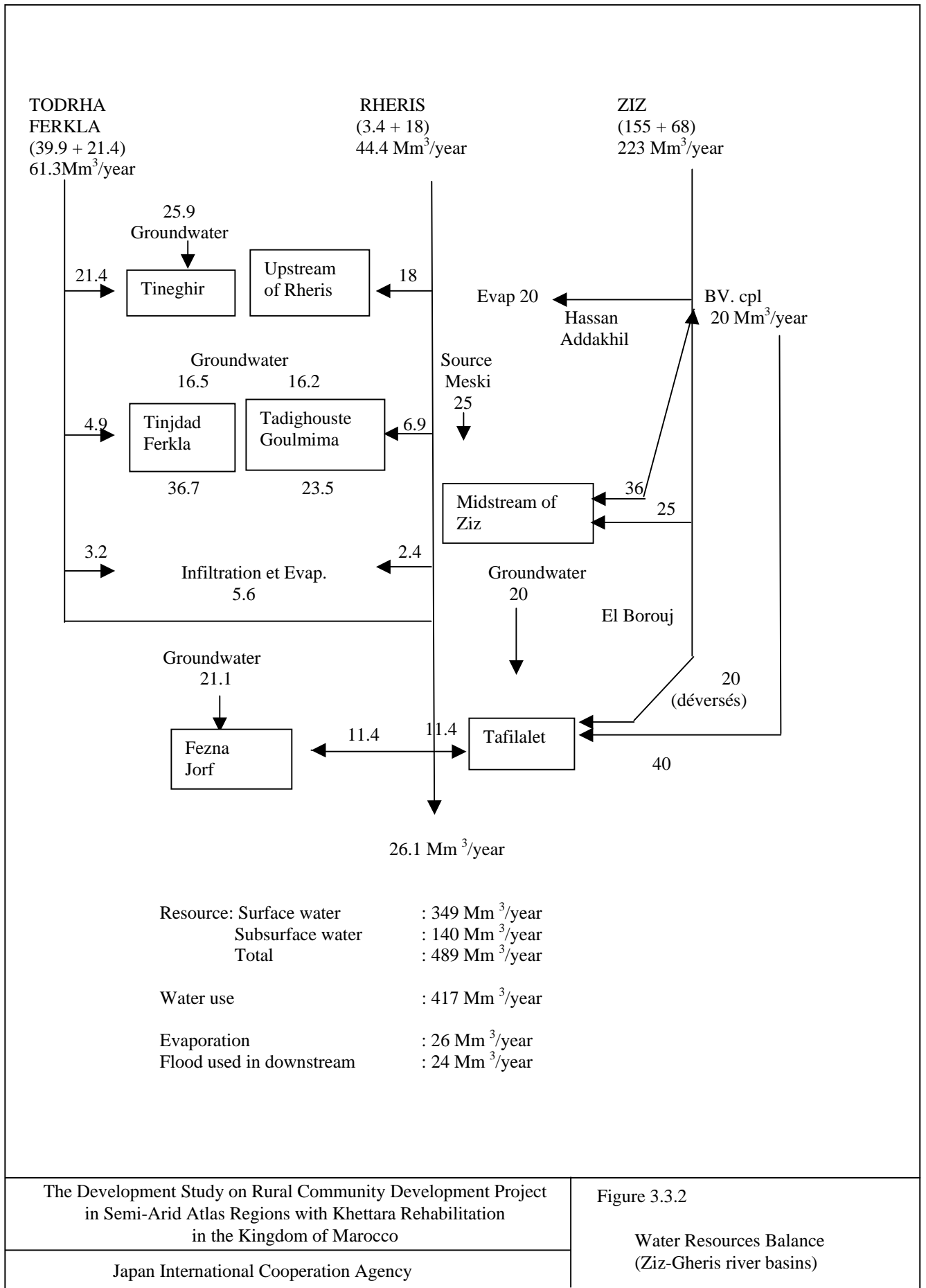


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Figure 3.3.1

Water Resources Balance
(Guir-Bouanane river basins)

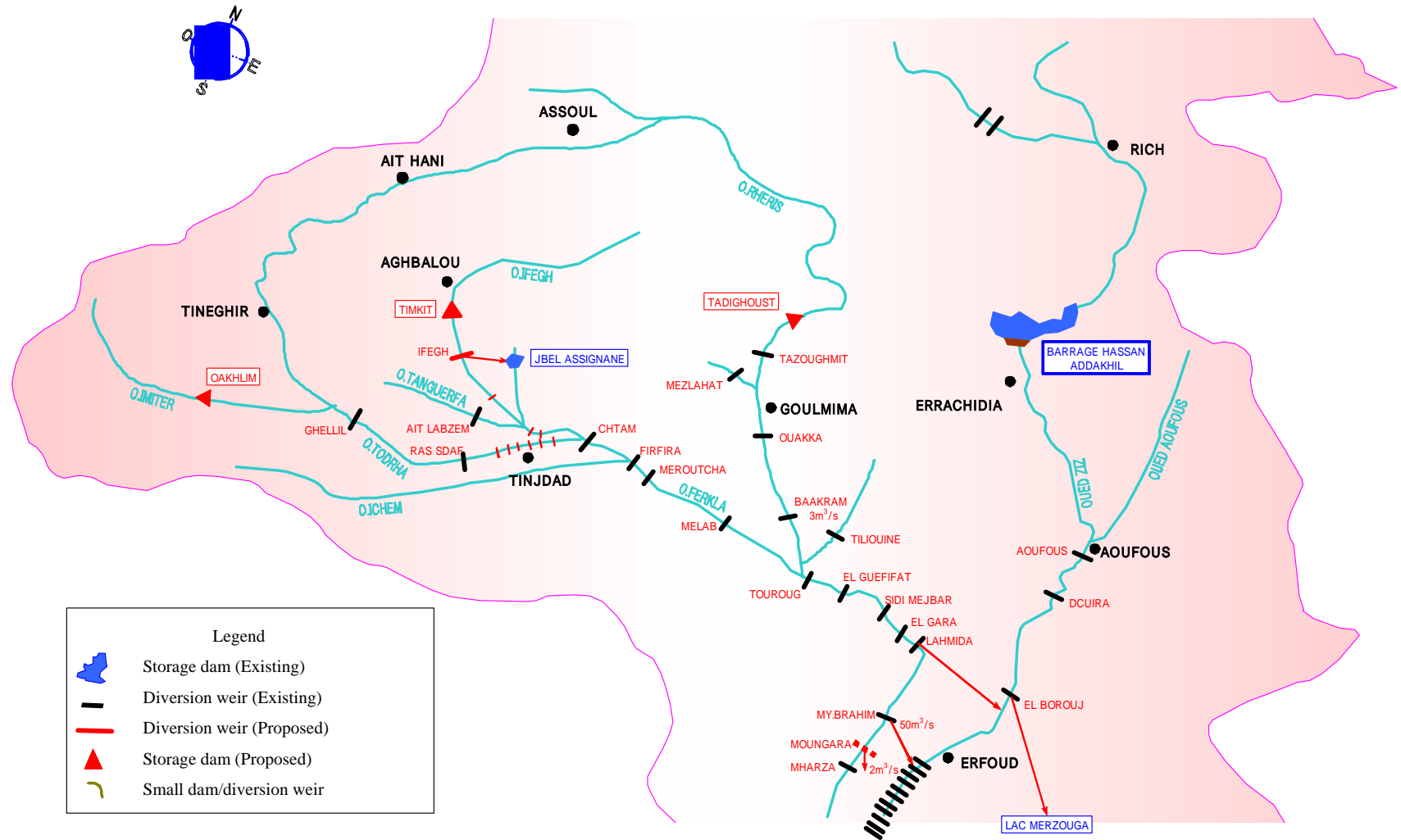


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Figure 3.3.2

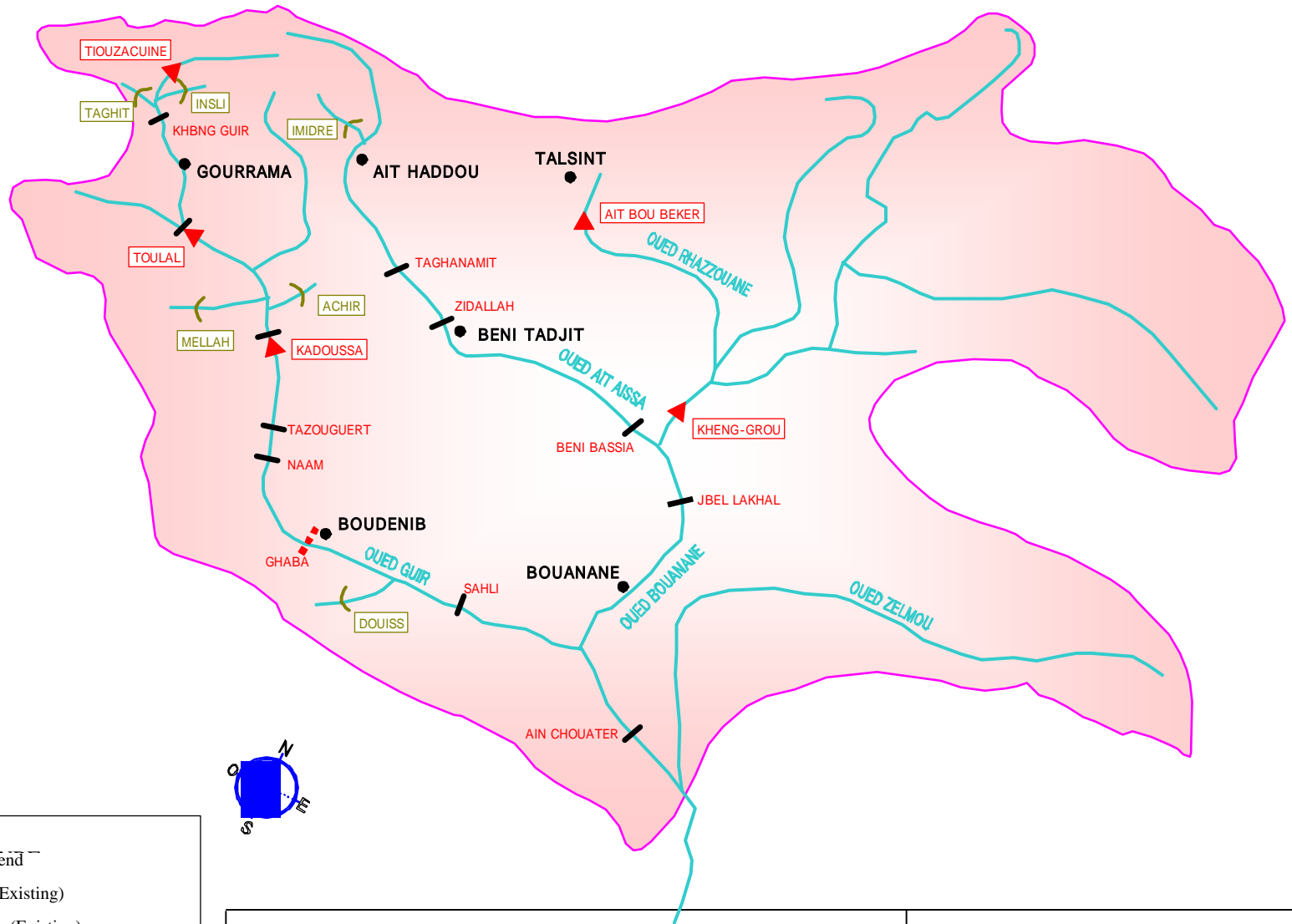
Water Resources Balance
(Ziz-Gheris river basins)



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Figure 3.3.3
 Location Map of Diversion Facilities in
 Gheris - Ziz River Basins



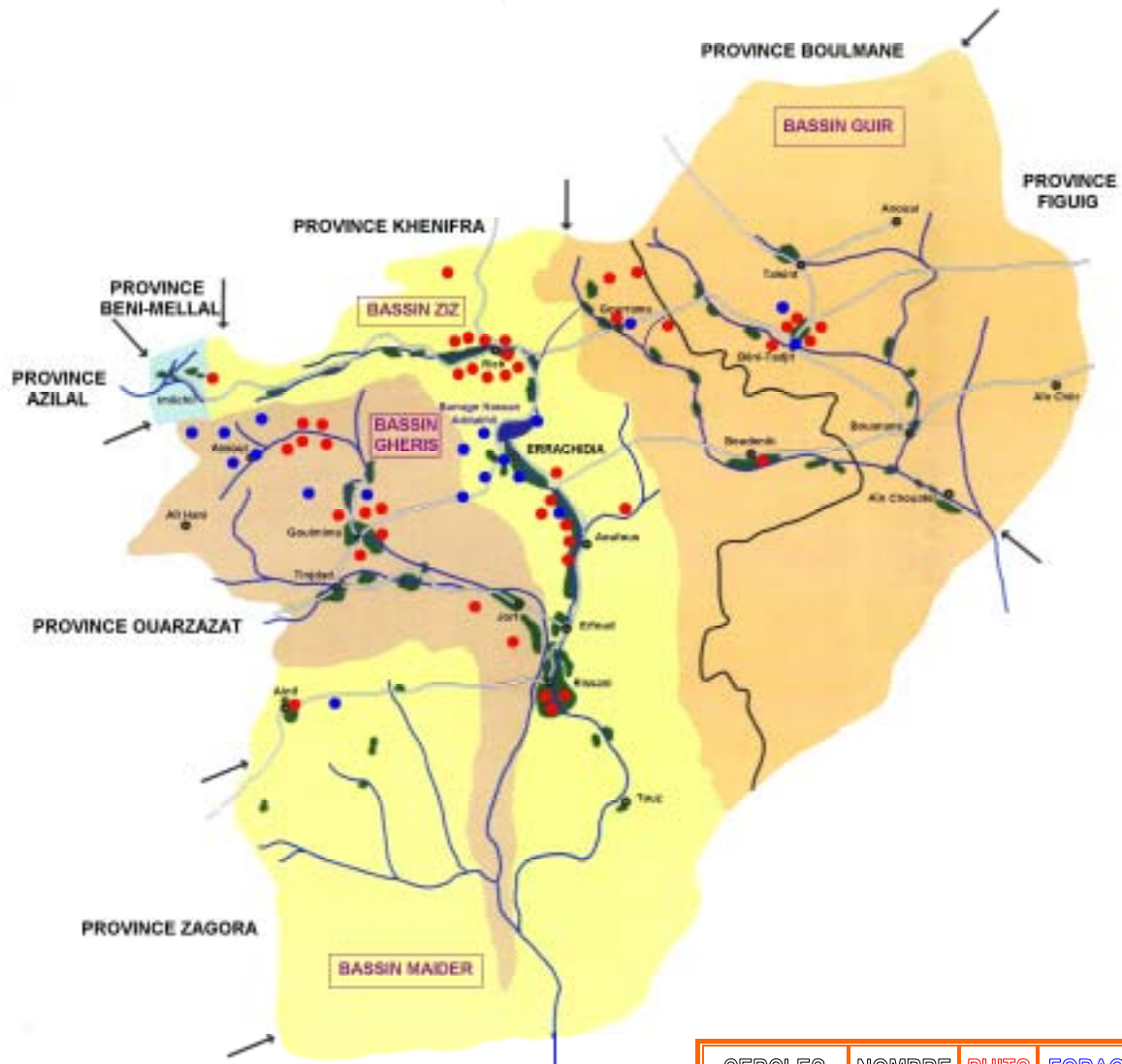
Legend	
	Storage dam (Existing)
	Diversion weir (Existing)
	Diversion weir (Proposed)
	Storage dam (Proposed)
	Small dam/diversion weir

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Figure 3.3.4
Location Map of Diversion Facilities in
Guir River Basins

Location Map of Communal Pump Stations



- PUIITS (Wells with depth of 20 to 50 m)
- FORAGE (Wells with depth of 50 m or more)

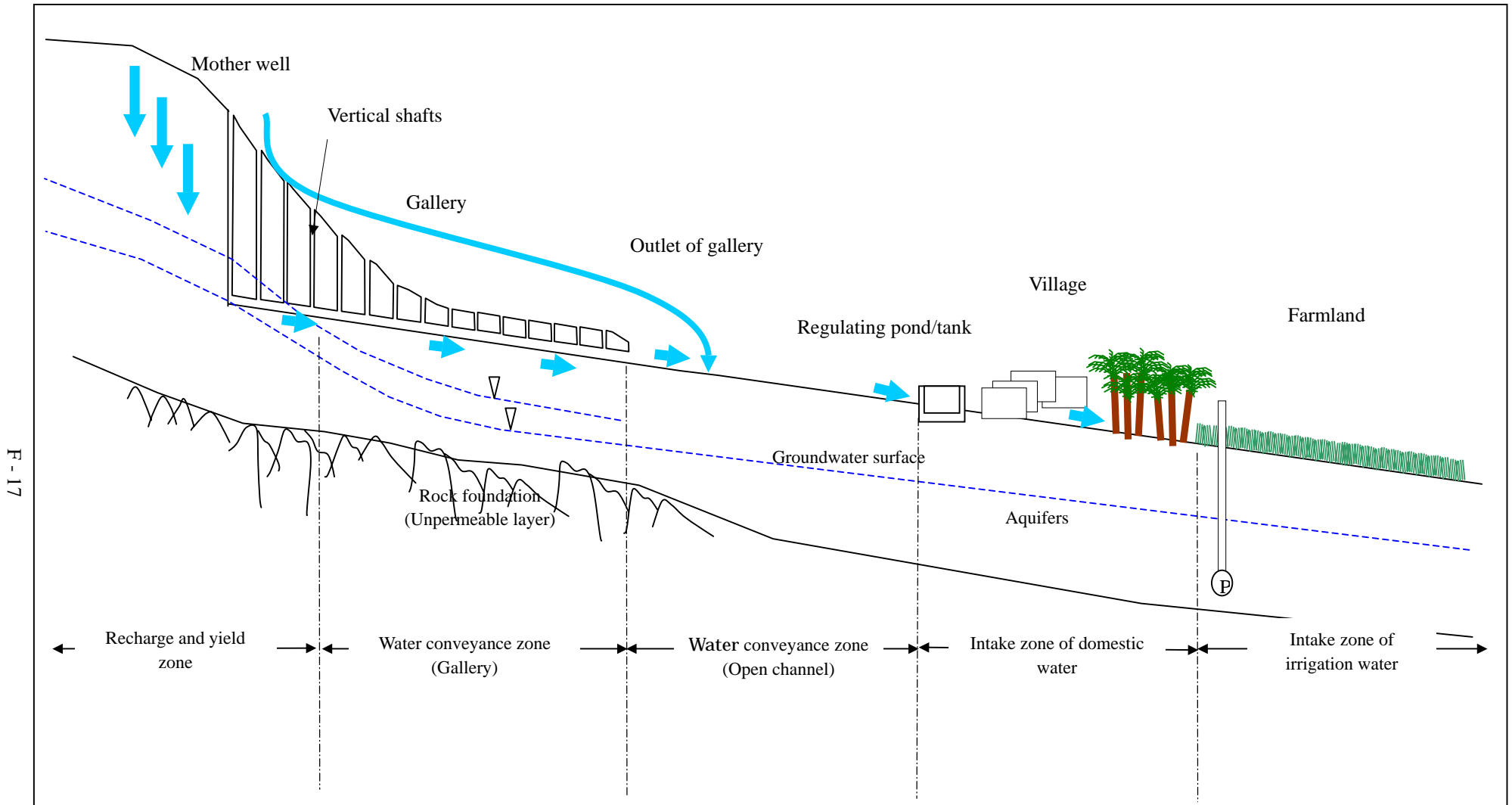
CERCLES	NOMBRE	PUITS	FORAGES
ERRACHIDIA	22	14	8
RICH	12	11	1
ERFOUD	4	3	1
RISSANI	3	3	0
GOULMIMA	7	5	2
ASSOUL	10	5	5
IMILCHIL	1	1	0
BENI TADJIT	7	6	1
TOTAL	66	48	18

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Figure 3.3.5

Location Map of Communal Pump Stations by ORMVA/TF



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Figure 3.4.1
 Schematic Diagram of Kheffara

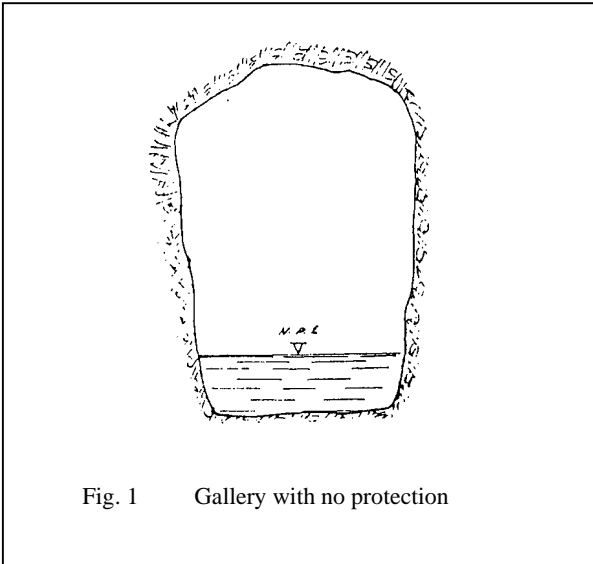


Fig. 1 Gallery with no protection

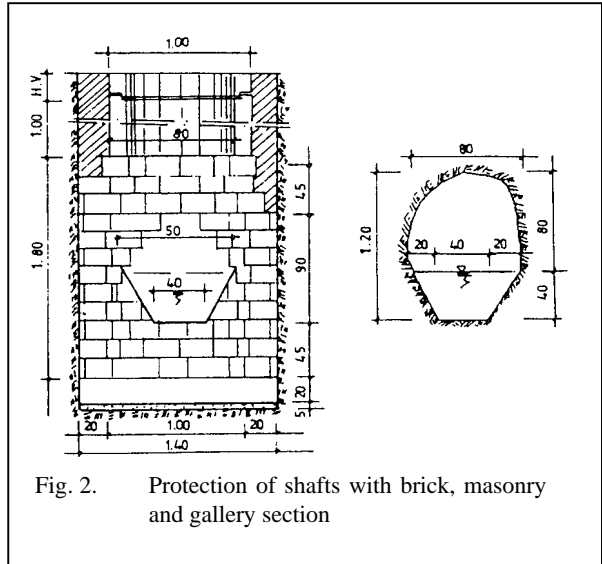


Fig. 2. Protection of shafts with brick, masonry and gallery section

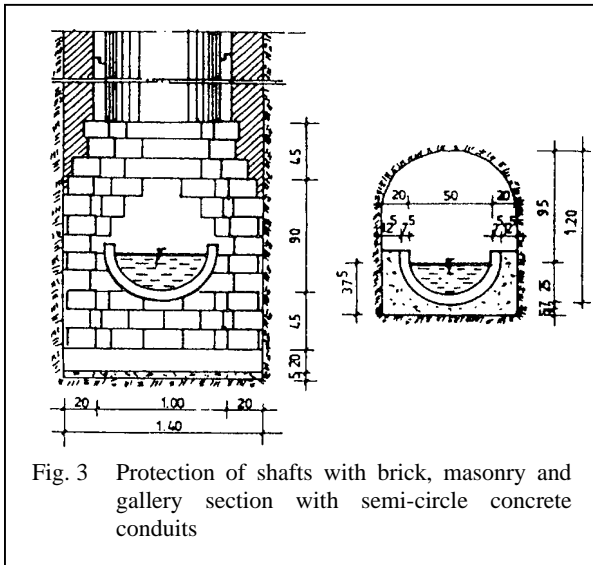


Fig. 3 Protection of shafts with brick, masonry and gallery section with semi-circle concrete conduits

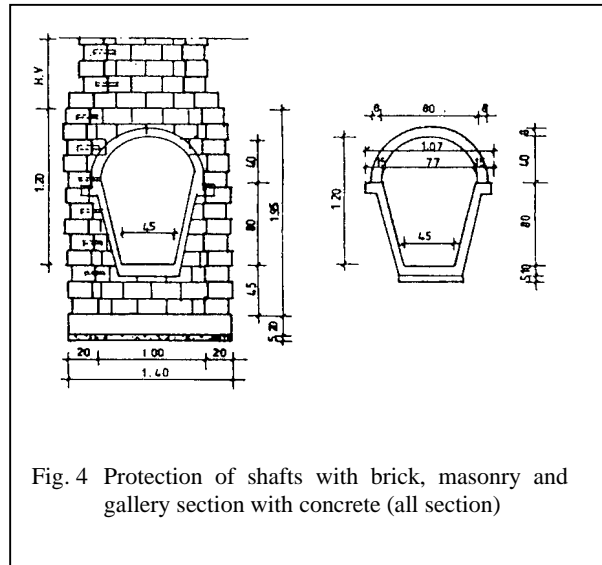


Fig. 4 Protection of shafts with brick, masonry and gallery section with concrete (all section)

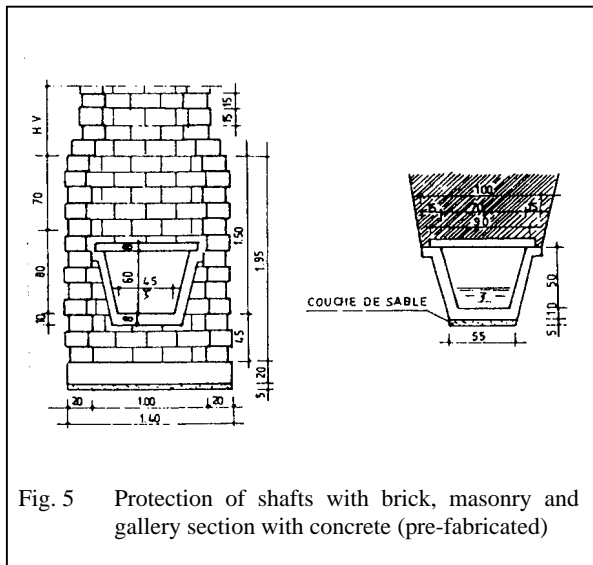


Fig. 5 Protection of shafts with brick, masonry and gallery section with concrete (pre-fabricated)

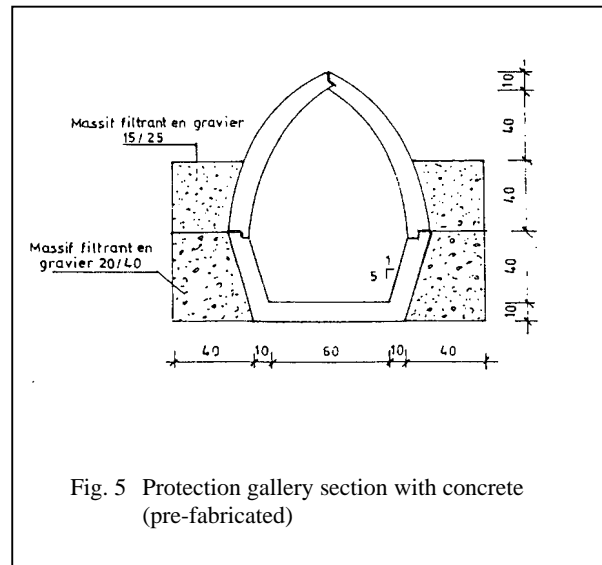


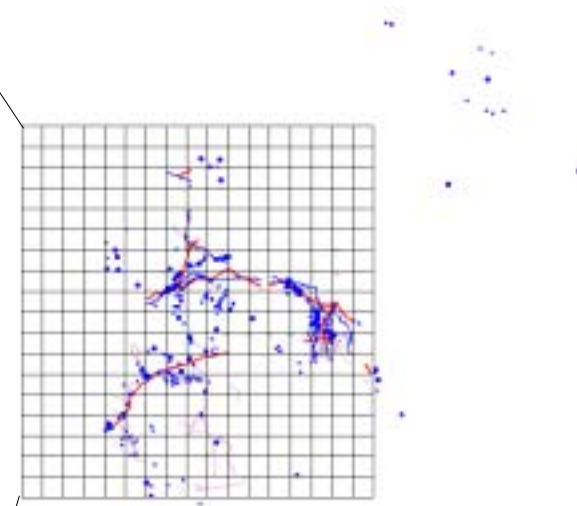
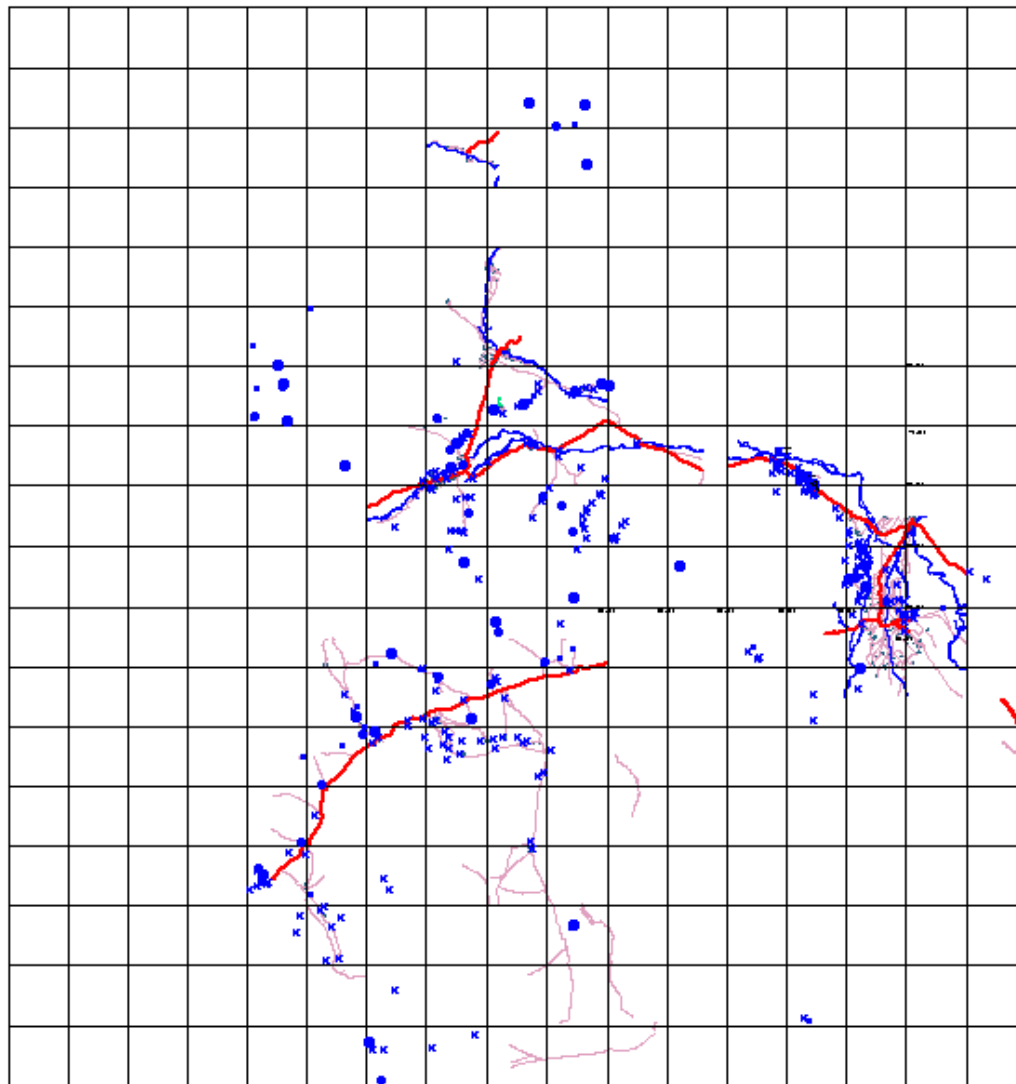
Fig. 5 Protection gallery section with concrete (pre-fabricated)

Source: PROJECT DE REHABILITATION DES KHETTARAS DANS LE TAFILALET

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Figure 3.4.2
Typical Section of Khetarra

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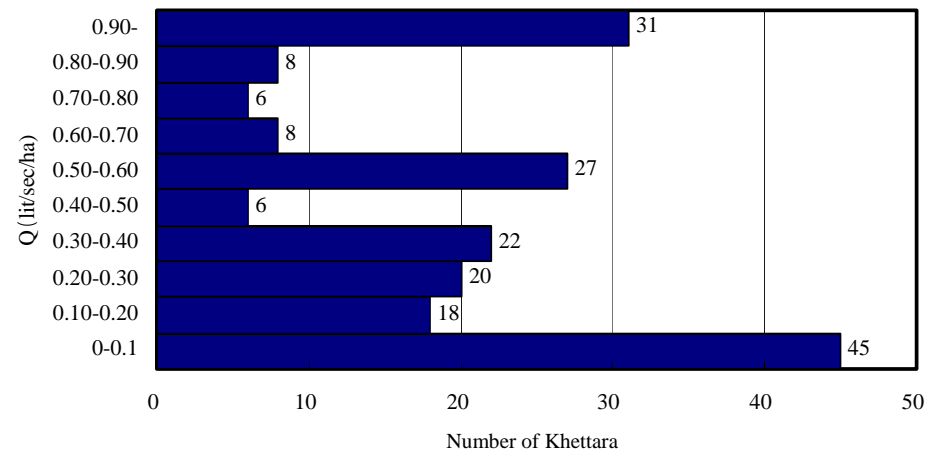
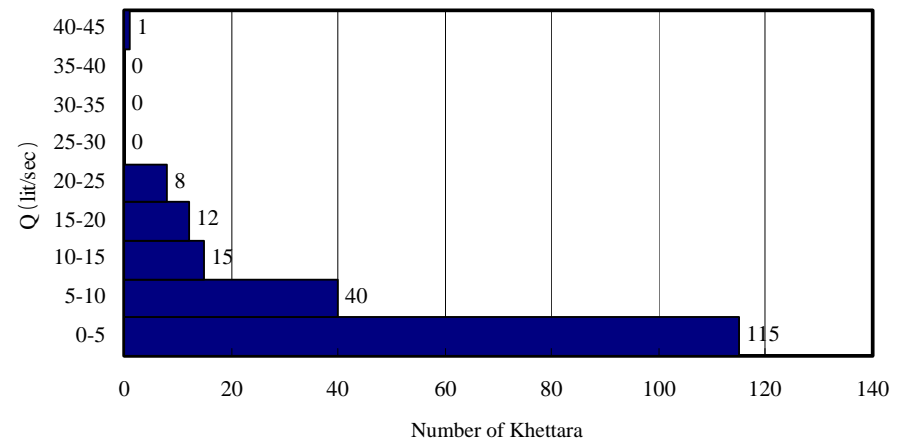
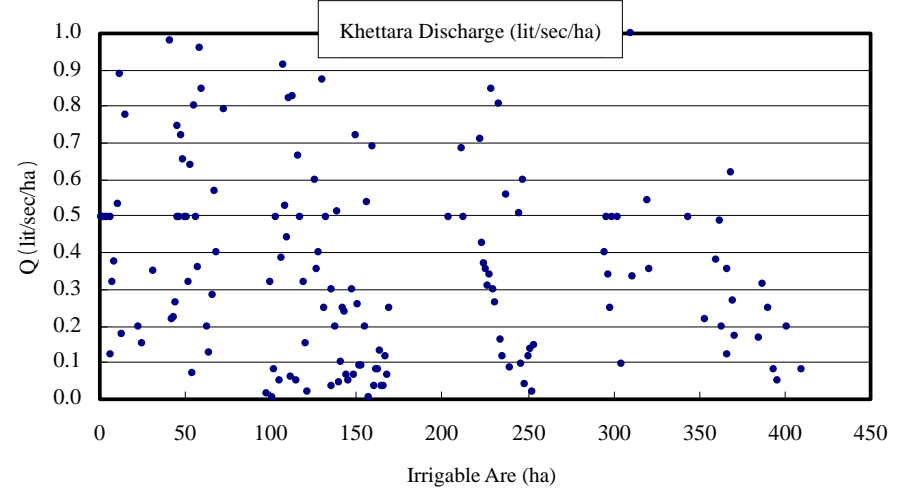
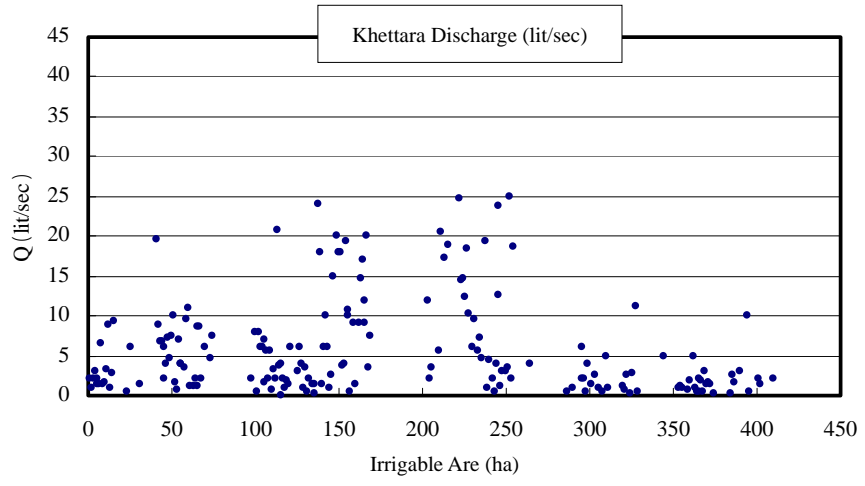
- × Q=0
- 0<Q<1
- 1<Q<2
- 2<Q<5

Note: Khettaras with their discharge is 5.0 lit/sec or more are not plotted in the figure.

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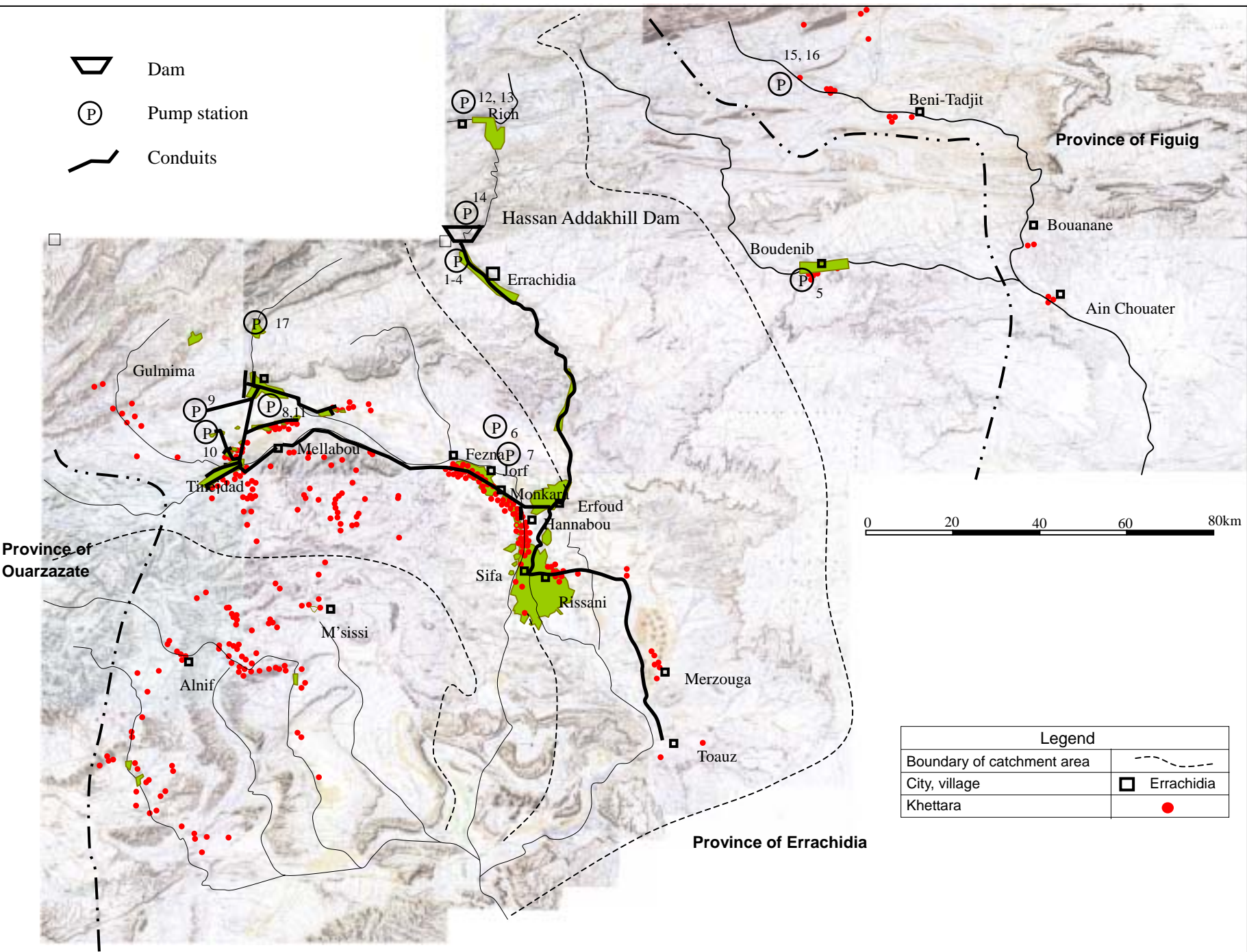
Figure 3.3.6
Discharge of Khettaras (Q<5lit/sec)



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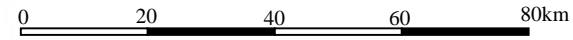
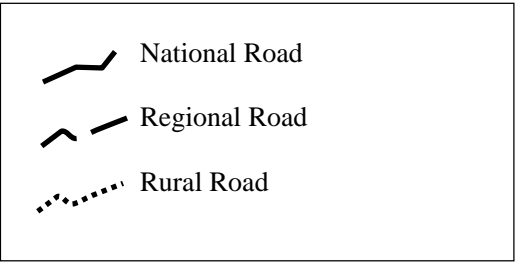
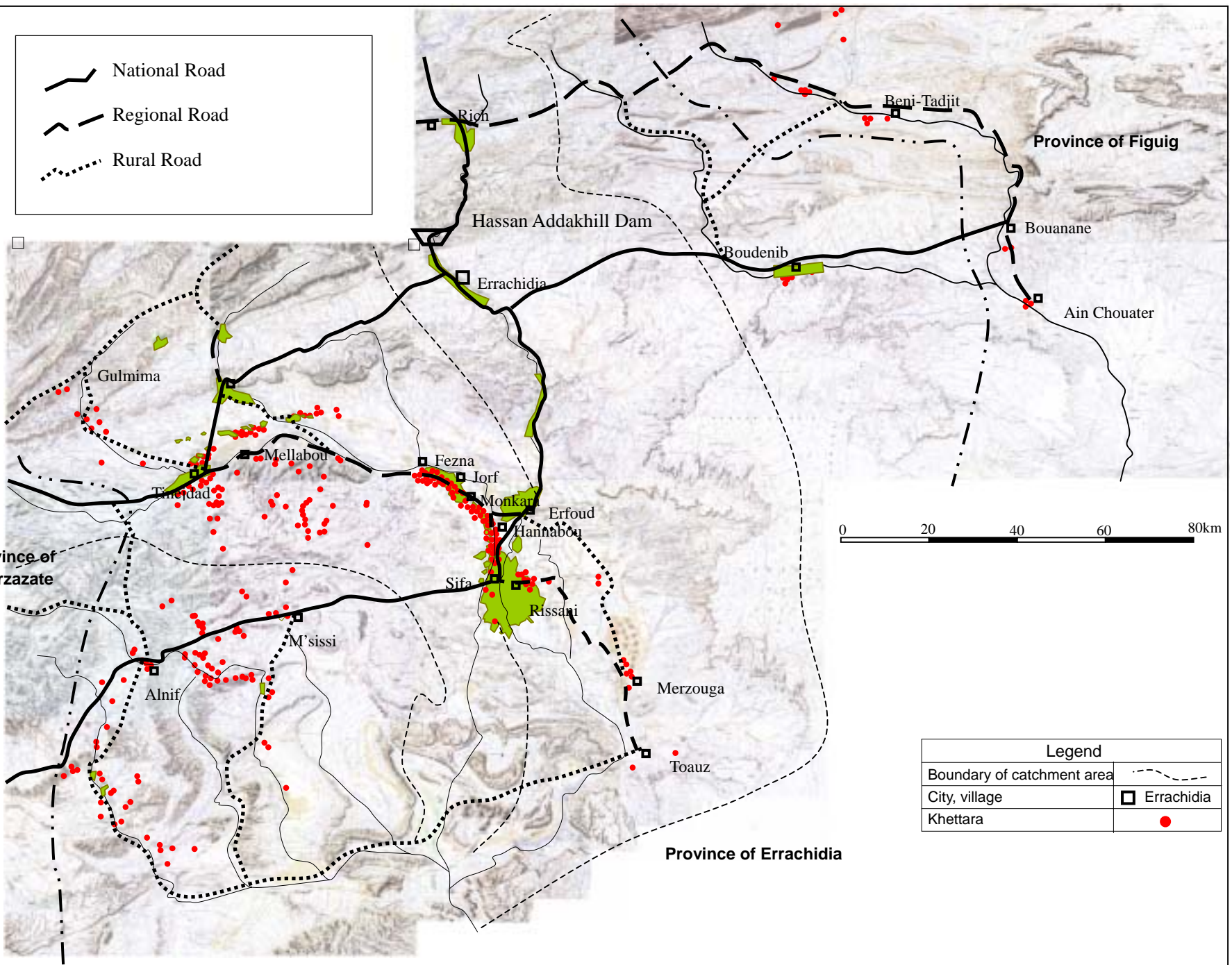
Figure 3.4.3
Distribution of Khattara Discharge



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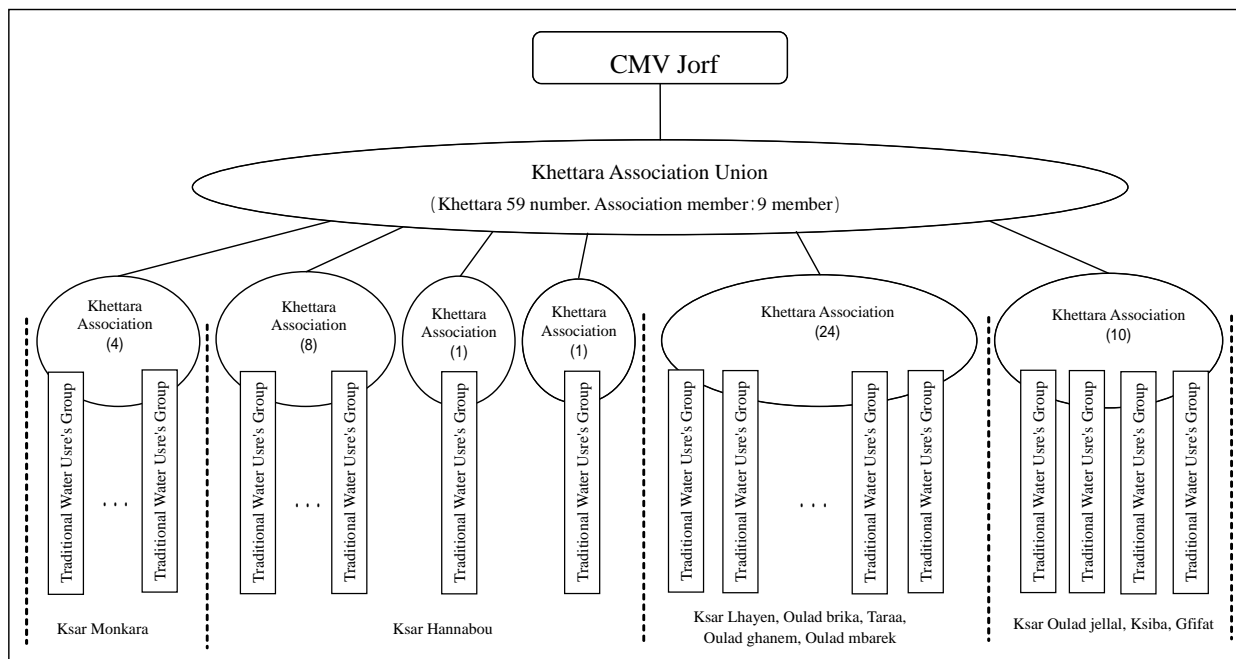
Figure 3.7.1 Location Map of Pump Station and Conduits Network (ONEP)



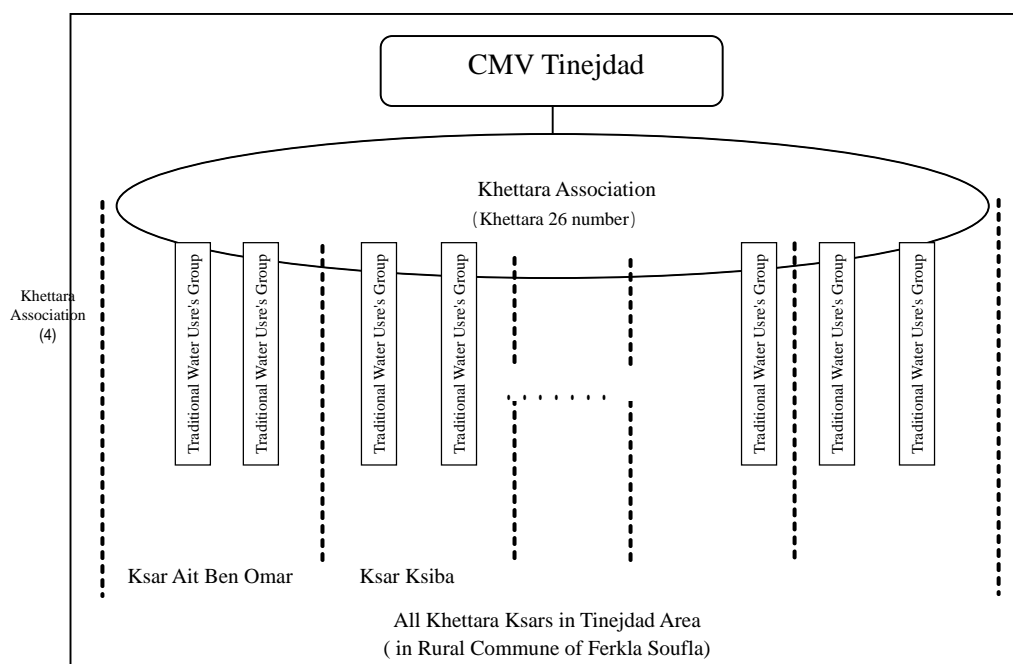
Legend	
Boundary of catchment area	
City, village	
Khetara	

Figure 3.7.2

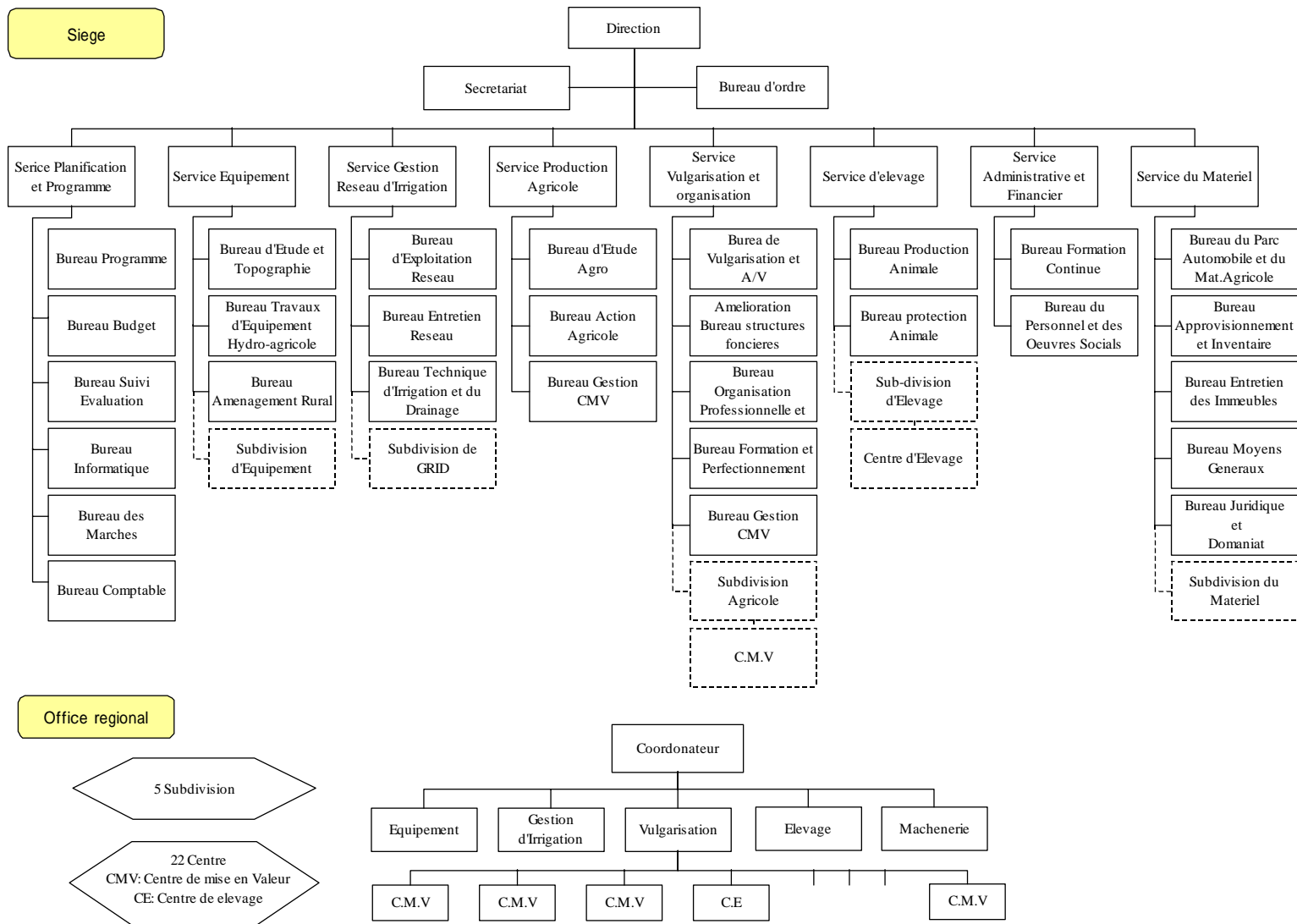
Road Networks in Errachidia Province



Value in the parenthesis () indicates number of khettara and traditional water users association included in the khettara
Traditional Water Users' groups and Khettara Associations in Jorf Area



Traditional Water Users' groups and Khettara Associations in Tinejdad Area

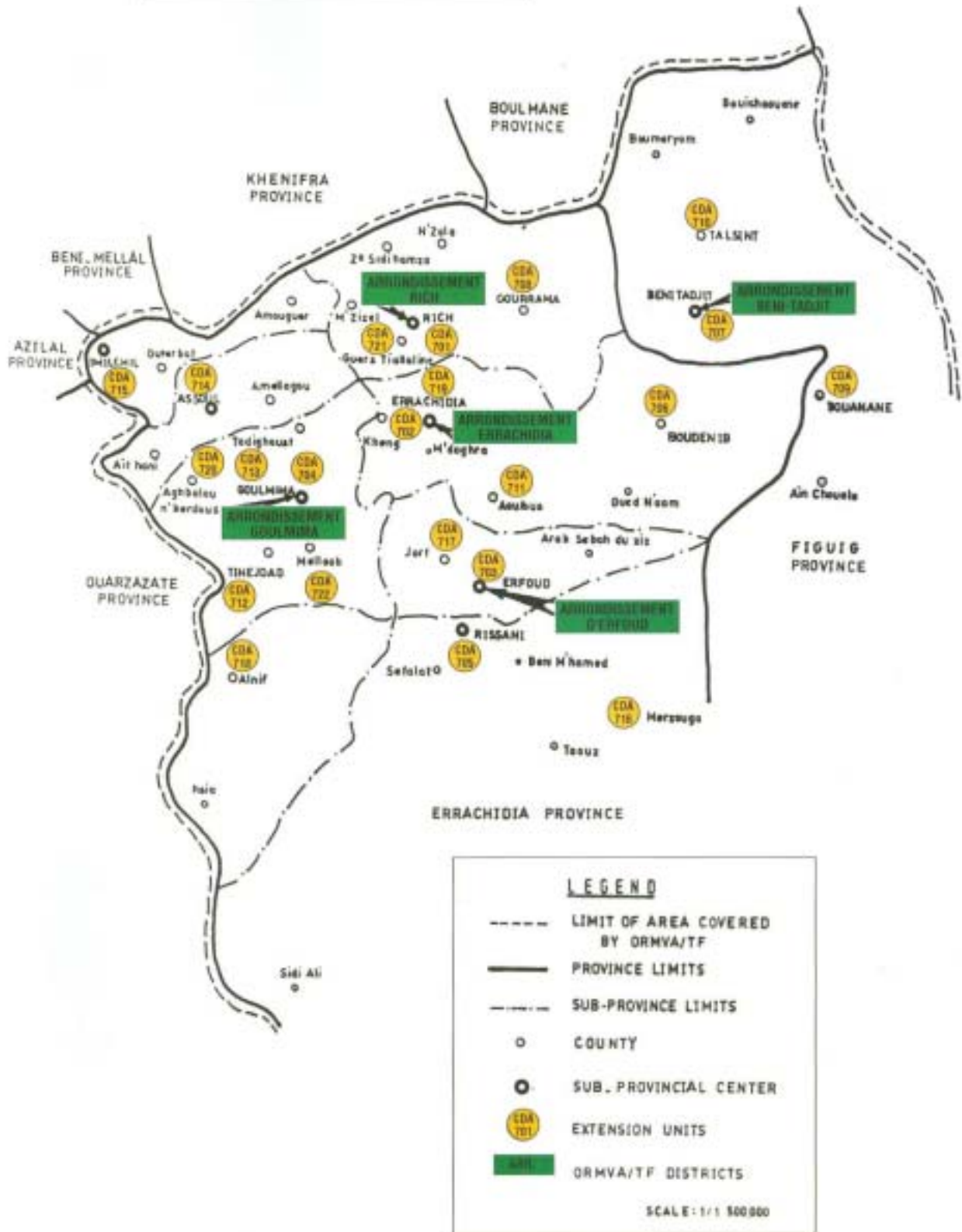


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Figure 3.9.1 Organization Chart of ORMVA/TF

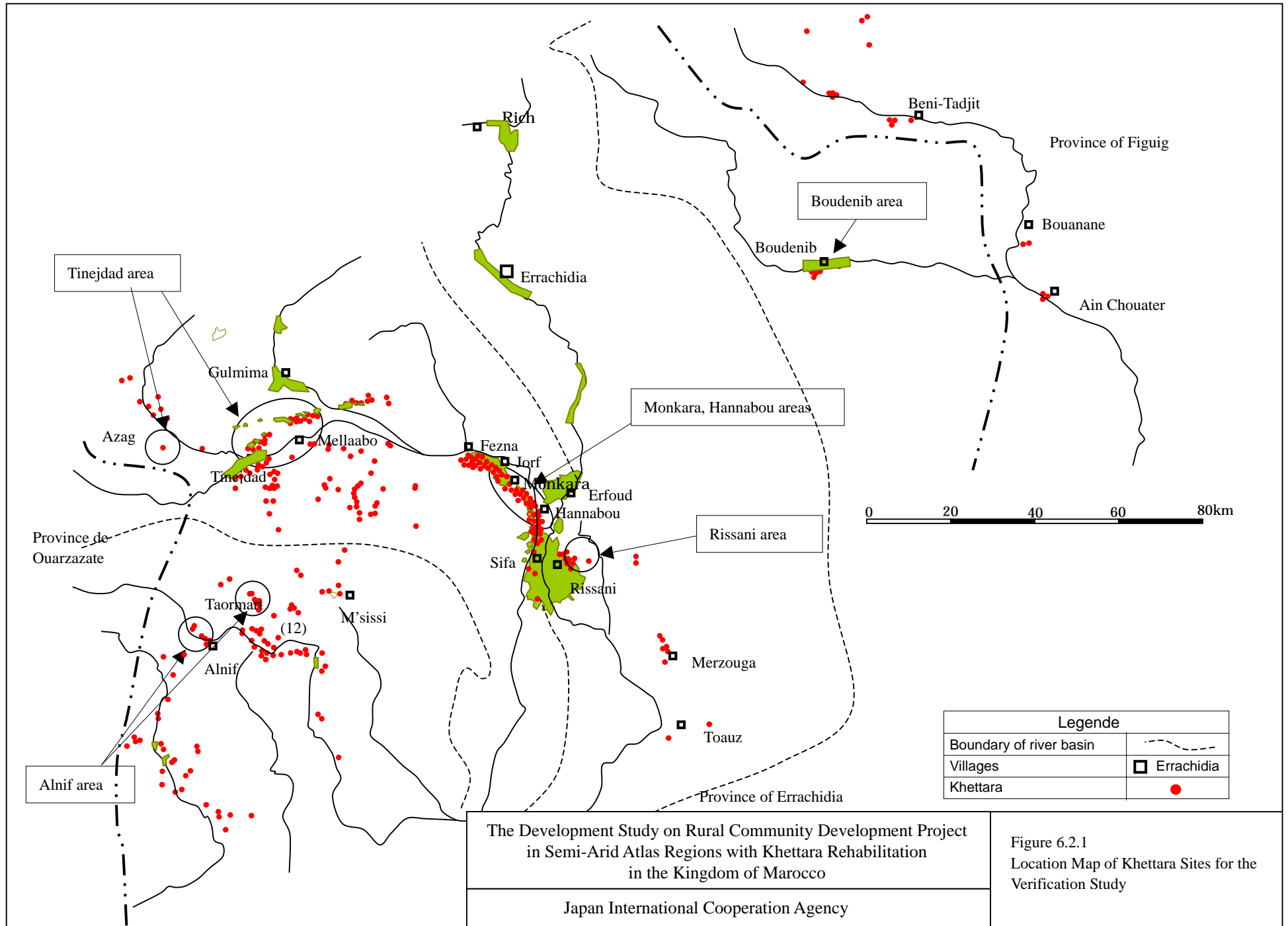
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ADMINISTRATIVE ORGANIZATION OF ORMVA / TF



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Figure 3.9.2
Location Map of ORMVA/TF Offices

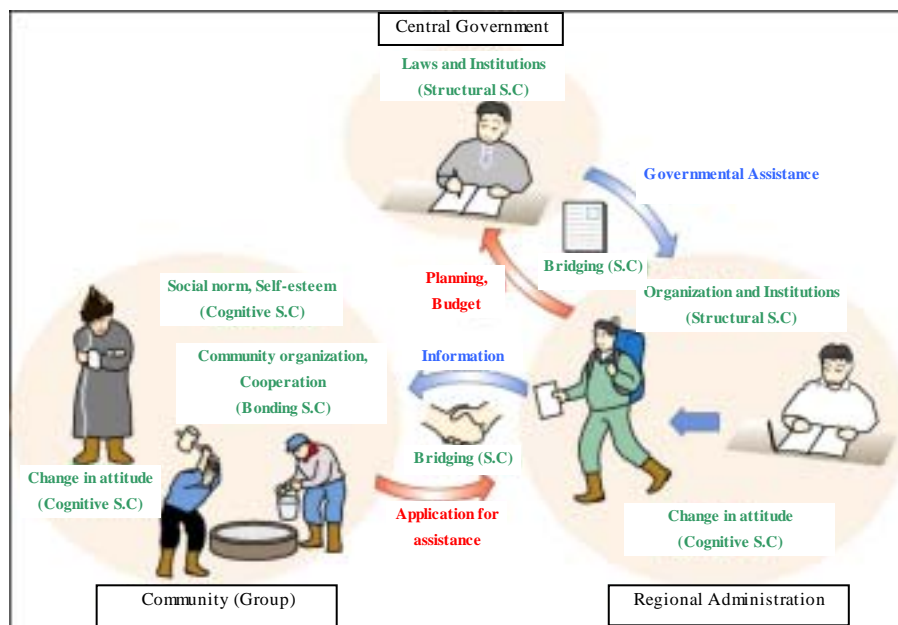


Social Capitals (S.C) are generally classified into 2 groups. The first group is composed with “Structural S.C” and “Cognitive S.C”. In this classification, existence of organization and formal institution is identified as “Structural S.C”, and existence of un-formal institutions which affect people’s psychological attitude such as social norm and self-esteem is recognized as “Cognitive S.C”. In this case, written institution of administrative supporting for poor community is categorized as “Structural S.C”, and unwritten rules, norms and self-esteem are categorized as “Cognitive S.C”.

On the other hand, in second classification, factors which tighten cooperating attitude inside a community or group are identified as “Bonding S.C”, and factors strengthening relationship with outside organizations and formal institutions are recognized as “Bridging S.C”. In this case, establishment of people’s organization and originate cooperative works inside a community are categorized as formulation and strengthen of “Bonding S.C”, then expansion on provision of information and administrative assistance to a community are categorized as “Bridging S.C”.

These classifications of Social Capital are summarized on the following table and figure.

	Social Capital (S.C)	Concept	Example
Group 1	Structural S.C	Existence of organization and institution	Community organization, written institutions of governmental supports
	Cognitive S.C	Social norm, self-esteem	Unwritten rural, norm, self-esteem
Group 2	Bonding S.C	Factors tightening cooperative works inside a community or group	Establishment of people’s organization, strengthening cooperative works
	Bridging S.C	Factors strengthening cooperation between organizations and institutions	Expansion on provision of information to people by administrative organizations



Classification of Social Capitals

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Figure 6.5.1

Classification and General Concept of Social Capital

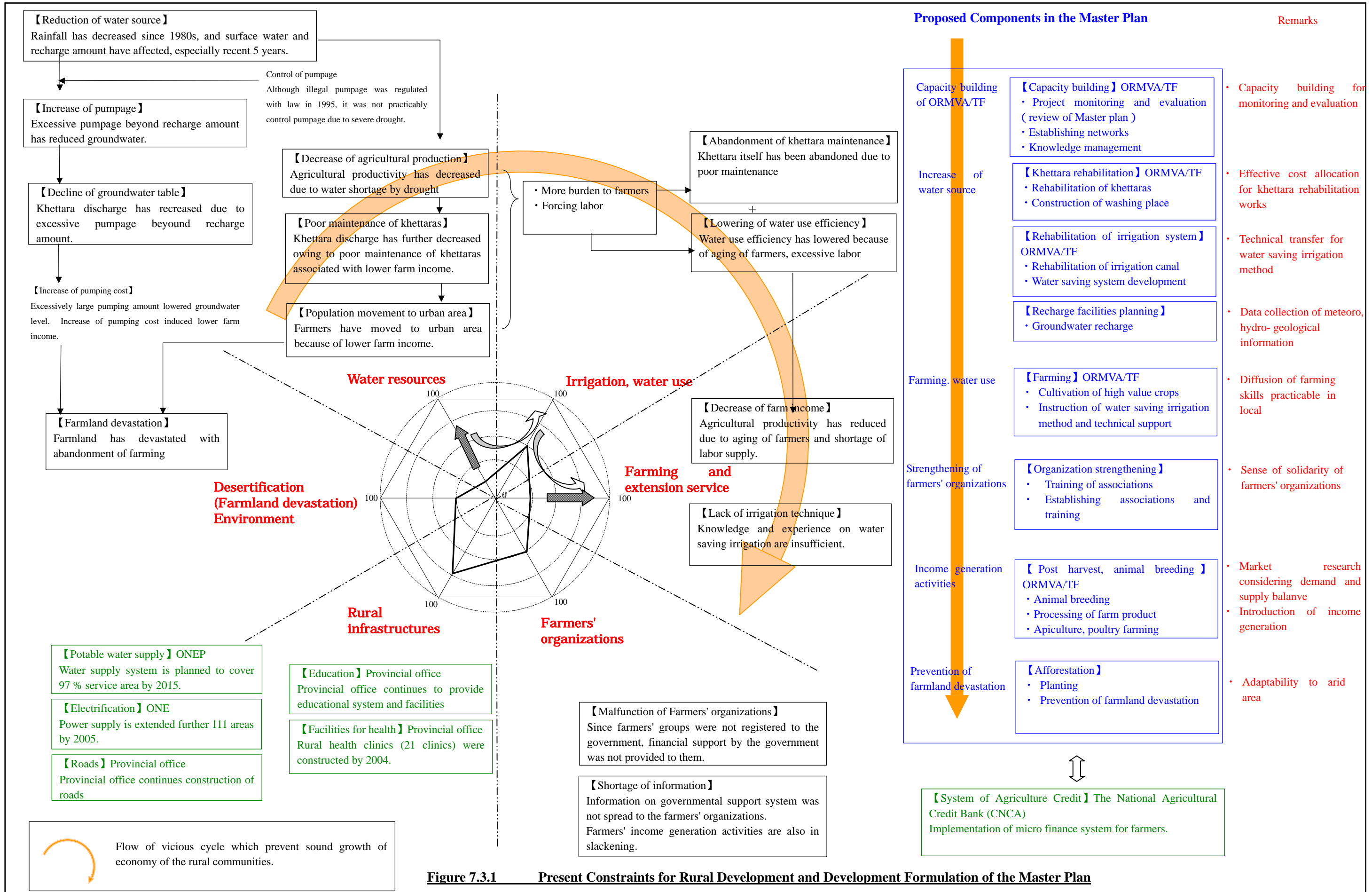


Figure 7.3.1 Present Constraints for Rural Development and Development Formulation of the Master Plan

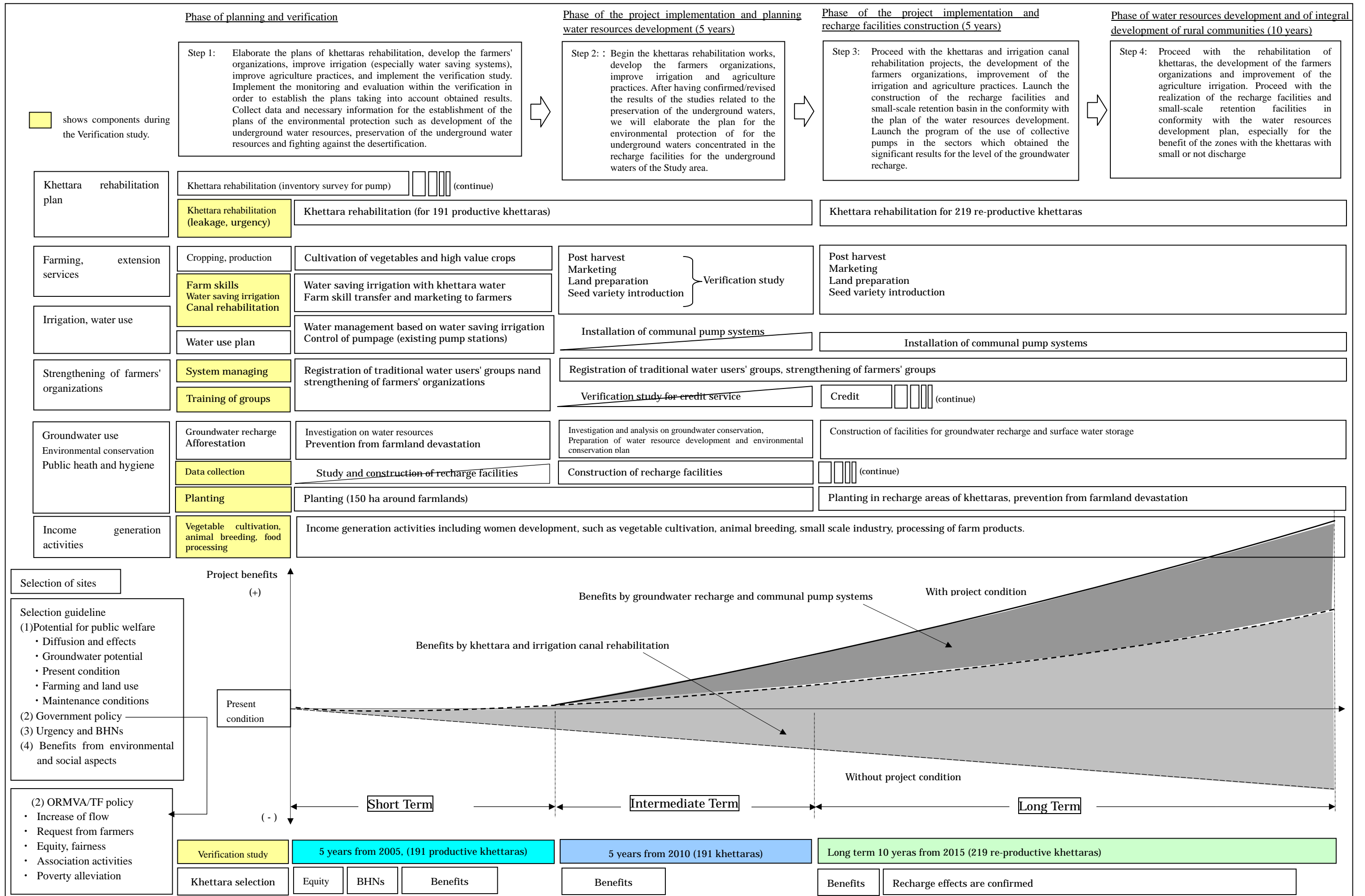


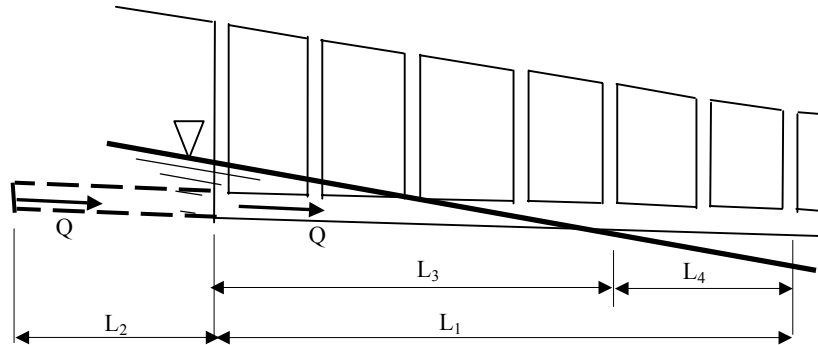
Figure 7.3.2 Phasing Development of Khetarra Rehabilitation and Rural Community Development Project

Extension of gallery

Increase rate of the discharge by extension of the gallery depends on elevation between gallery base and groundwater surface. Increase discharge Q is roughly calculated by following equation. Incremental discharge depends on the length L_3 that varies by groundwater surface elevation.

$$\Delta Q = \frac{L_2}{L_3} \times Q$$

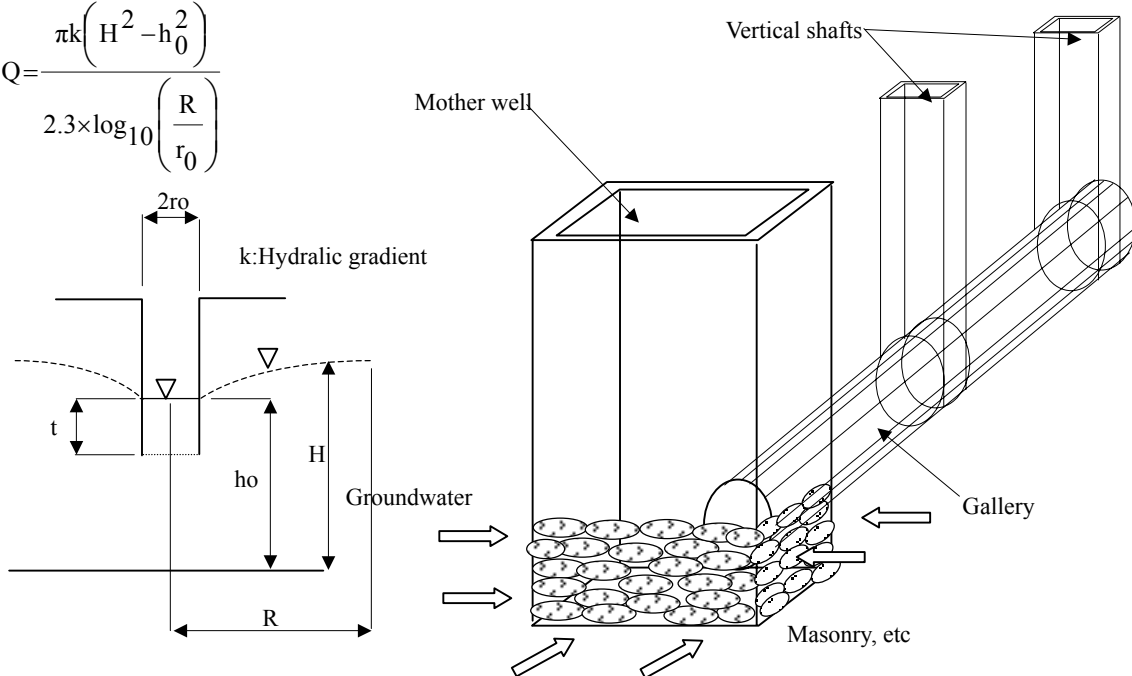
In the case groundwater surface exists near the mother well, small extension of the gallery results in large increase of the yield.



Widening of mother well

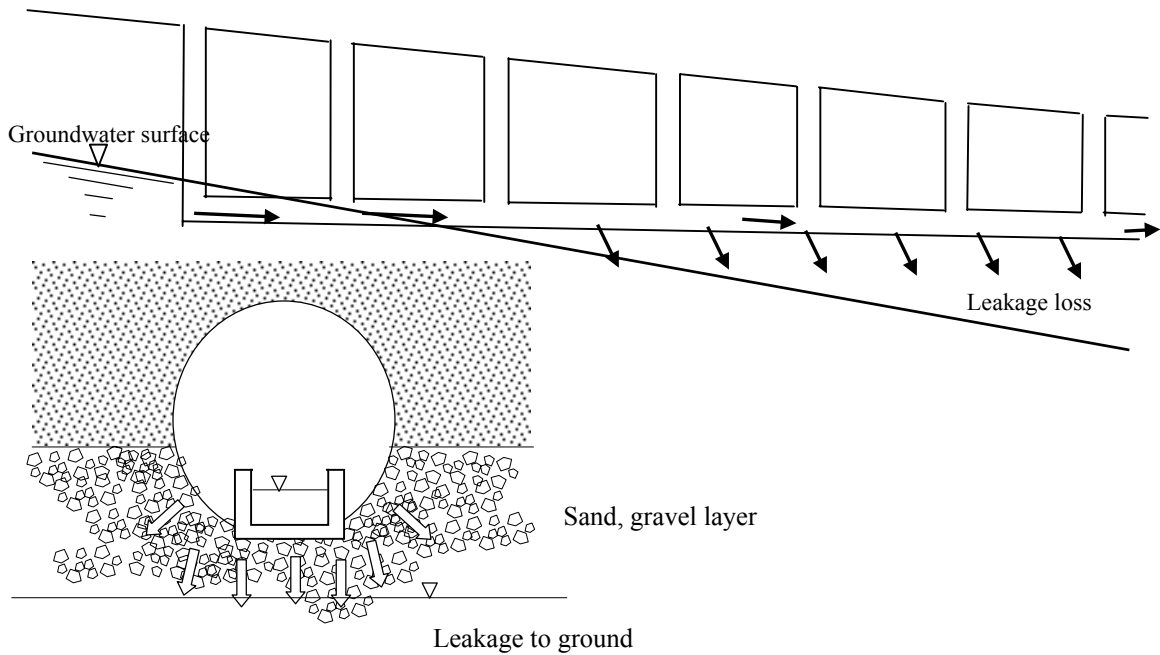
In general, following equation expresses inflow discharge into the well. When permeable layer exists near the mother well, widening of well results in increase of yield.

$$Q = \frac{\pi k (H^2 - h_0^2)}{2.3 \times \log_{10} \left(\frac{R}{r_0} \right)}$$



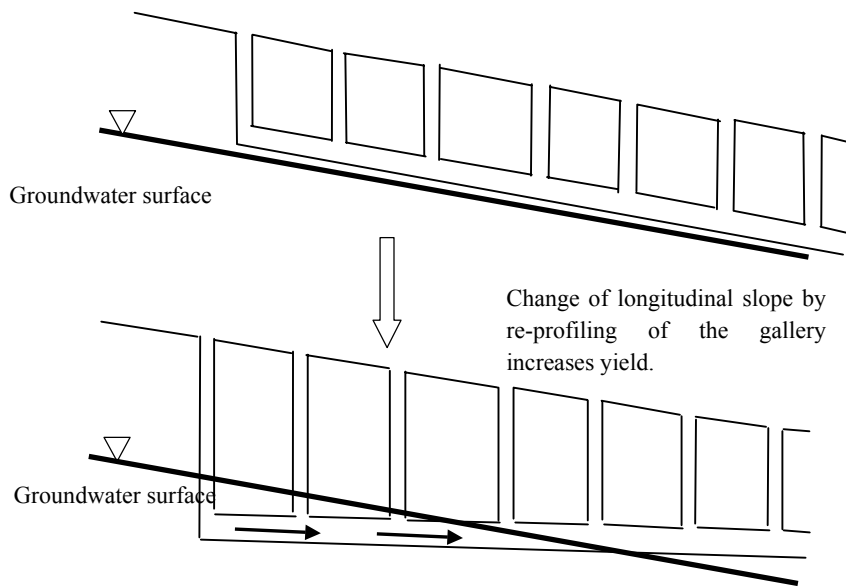
Leakage loss reduction with lining

Adequate leakage loss is observed in the section groundwater level is lower the gallery base. Canal lining is most effective to reduce leakage loss.



Re-profiling of gallery

When groundwater surface situates above gallery base by re-profiling of the galley, yield volume increases corresponding to its length. (In case present longitudinal slope of the gallery is gentle, incremental discharge is limited.)



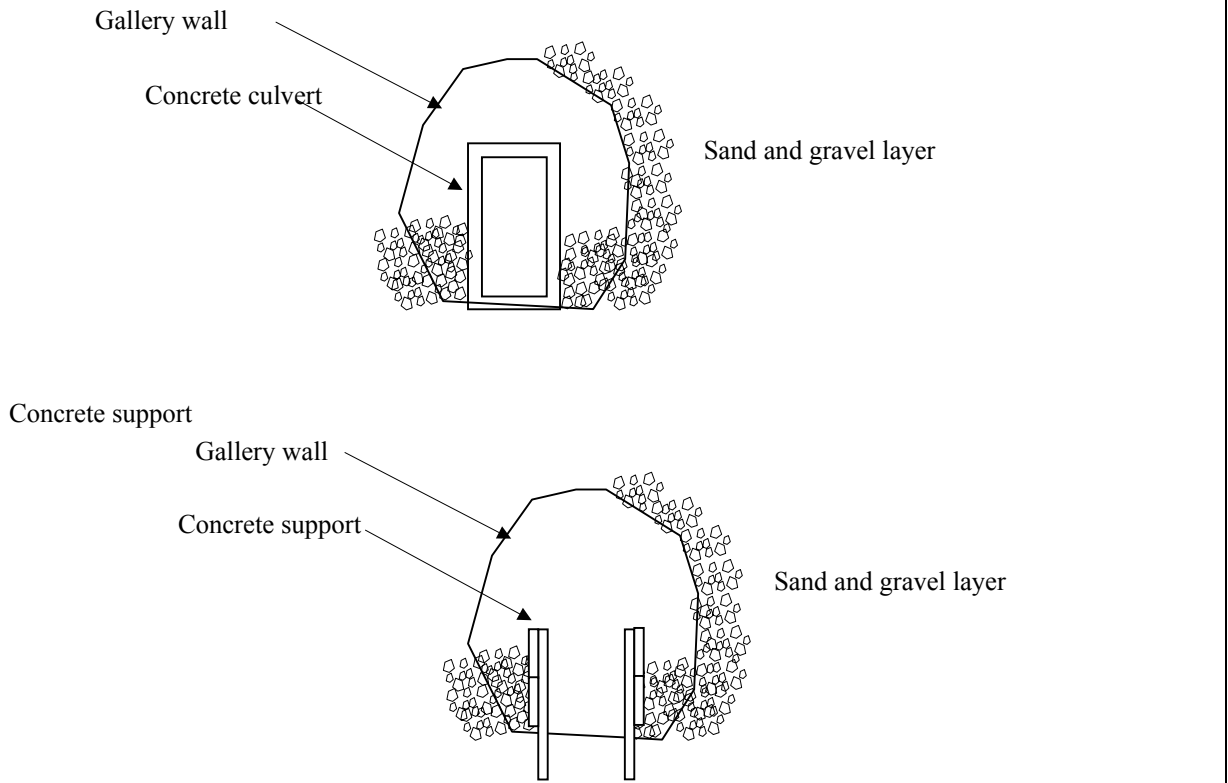
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Figure 7.5.1
Schematic Diagram for Khezzara
Rehabilitation (2/5)

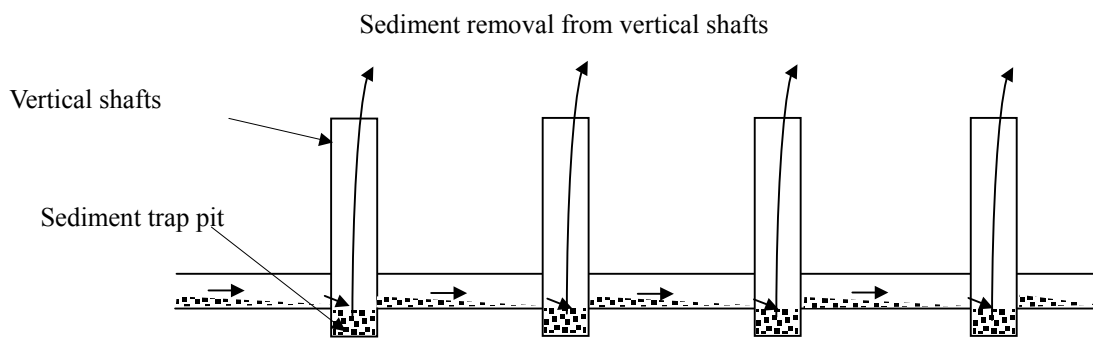
Protection of gallery wall to prevent from wall collapse

Steel support, concrete culvert prevents from sediment deposits in the gallery. It is most effective remedy to reduce labor requirement for the maintenance work. Internal section of width 0.6 m, height 1.2 - 1.5m is recommendable for maintenance work.



Sediment trap pit

installation of sediment trap pit increase labor requirement for a removal of sediment in the gallery.



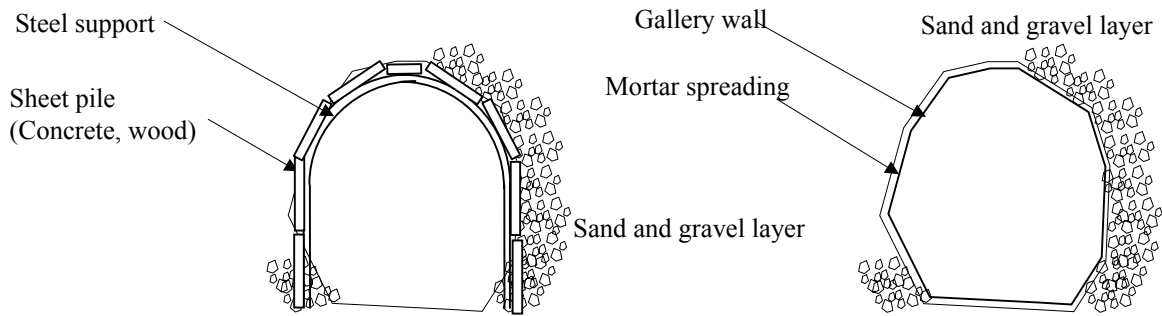
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Figure 7.5.1
Schematic Diagram for Kheffara
Rehabilitation (3/5)

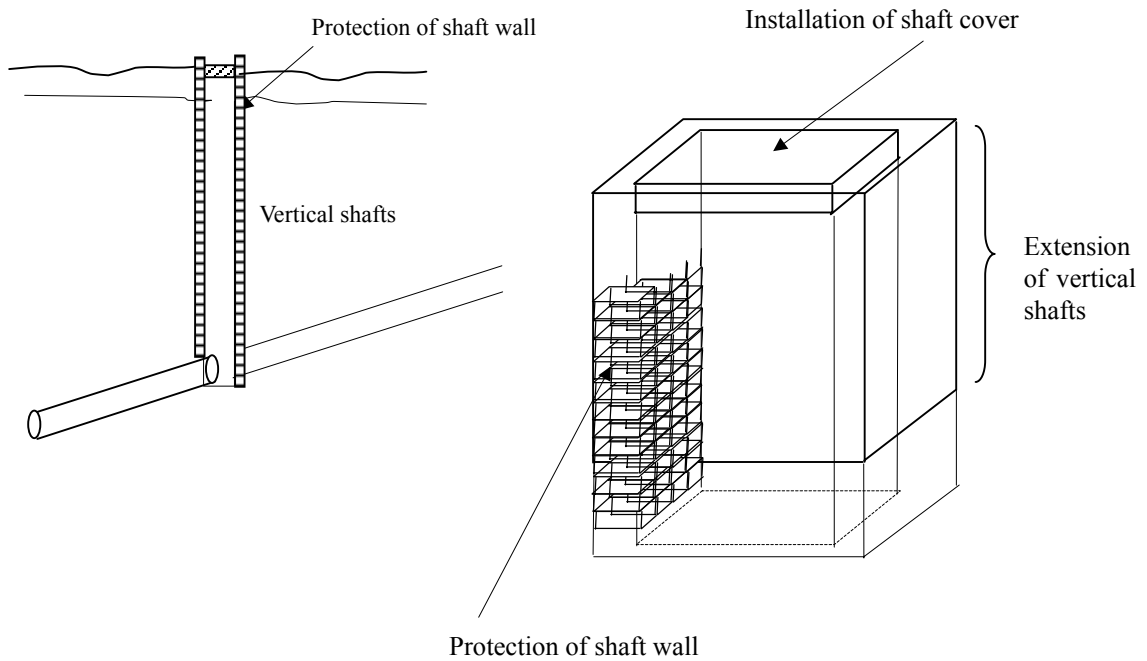
Prevention of gallery wall collapse

Sheet pile wall, steel support, mortar spreading are effective to prevent gallery wall from collapse. It reduces laborious maintenance work.



Protection of vertical shafts from sand material flow into the gallery

Extension of the vertical shafts, installation of cover, shaft protection are available to prevent sand materials from flow into the gallery, and it reduces laborious maintenance work.



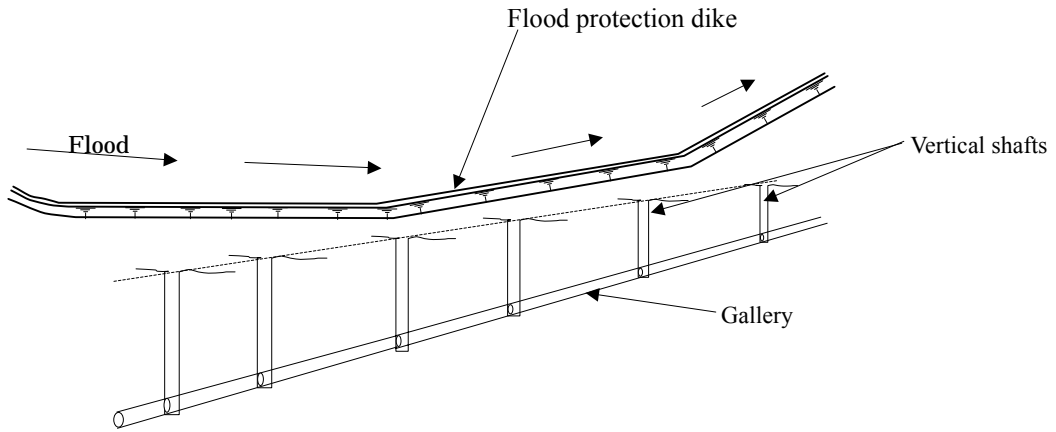
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Figure 7.5.1
Schematic Diagram for Kheffara
Rehabilitation (4/5)

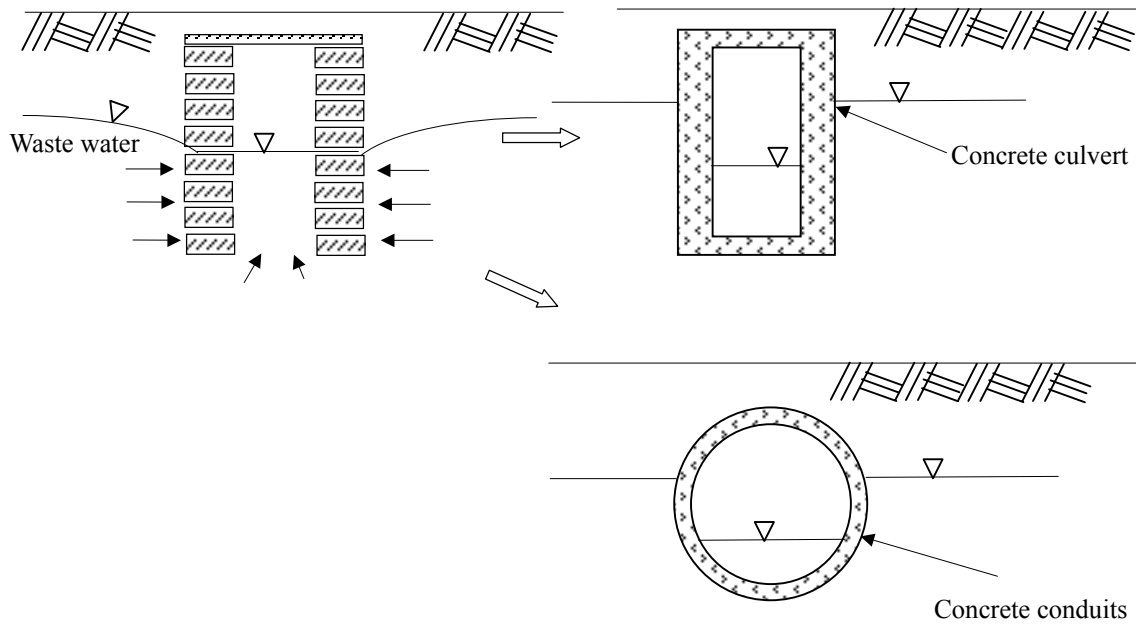
Khettara protection against flood damages

Flood protection dike, river revetment spur dike are effective to protect the khettara gallery and shaft from flood damages. It reduces laborious maintenance work.



Improvement for public health and hygiene

Concrete culvert and conduit are effective to prevent waste water from flow into the gallery. It is recommended to improve water quality from public health and hygiene viewpoints.

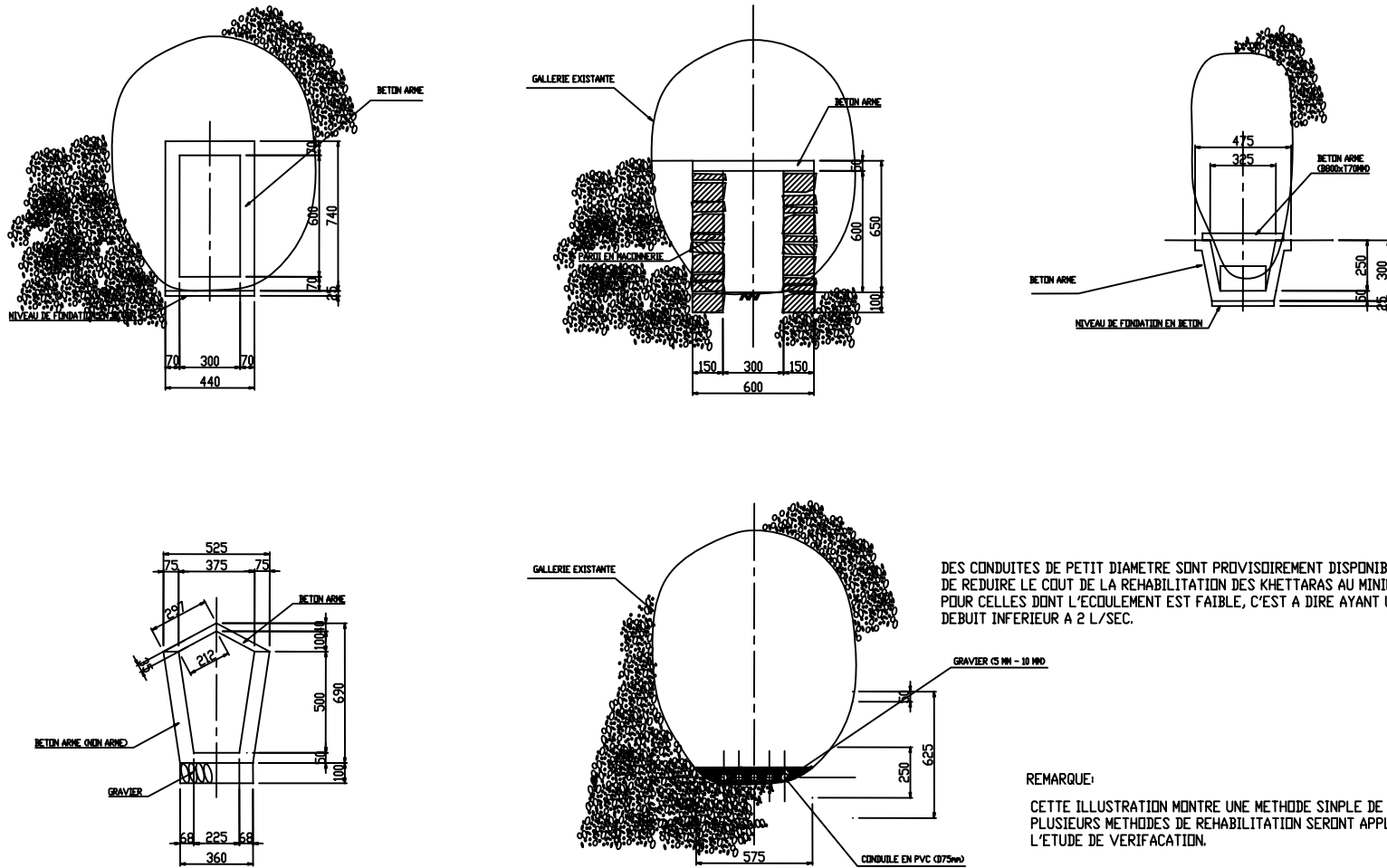


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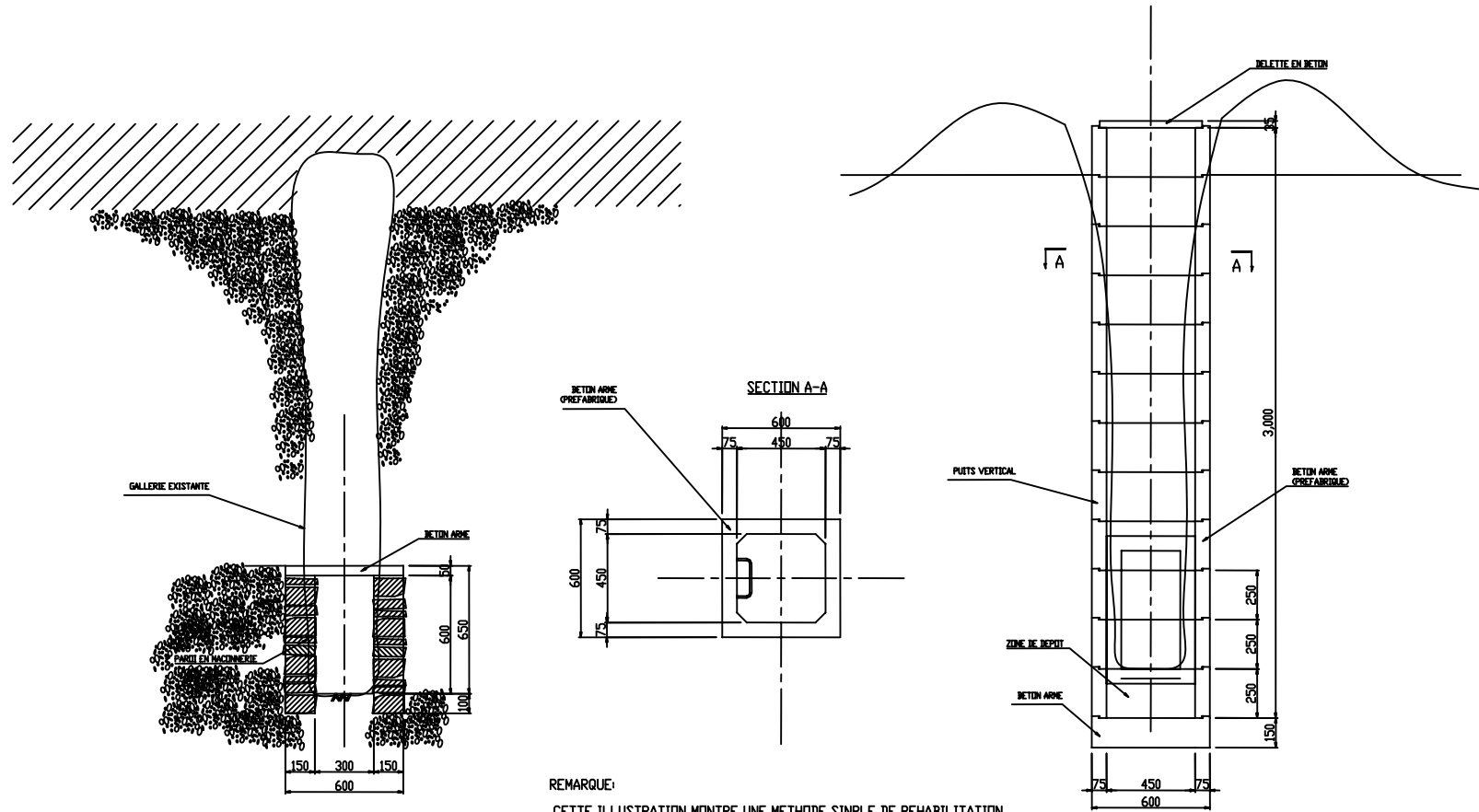
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Figure 7.5.1
Schematic Diagram for Khettara
Rehabilitation (5/5)

TSECTION TYPIQUE D'UNE GALLERIE DU KHETTARA



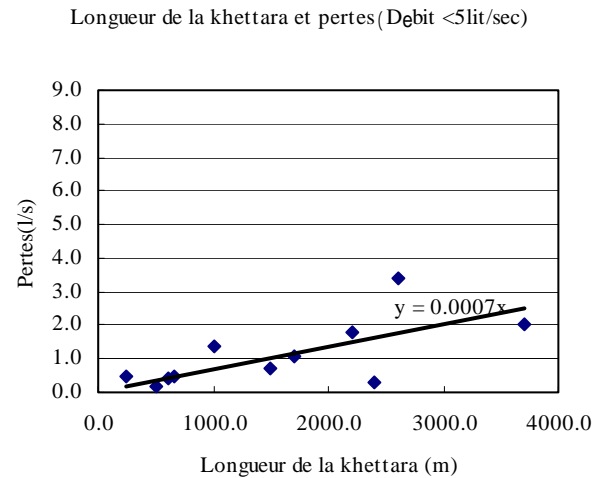
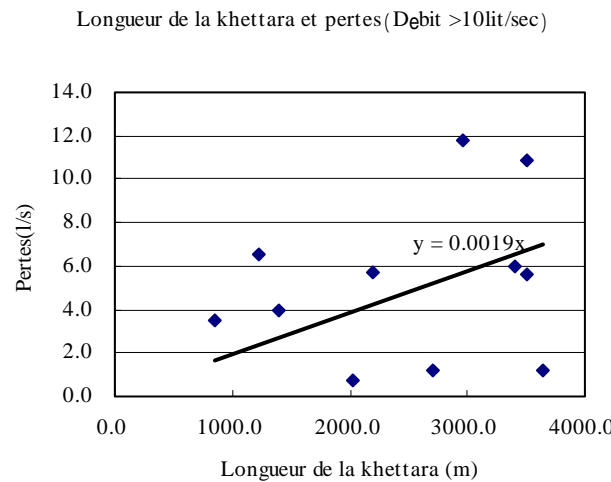
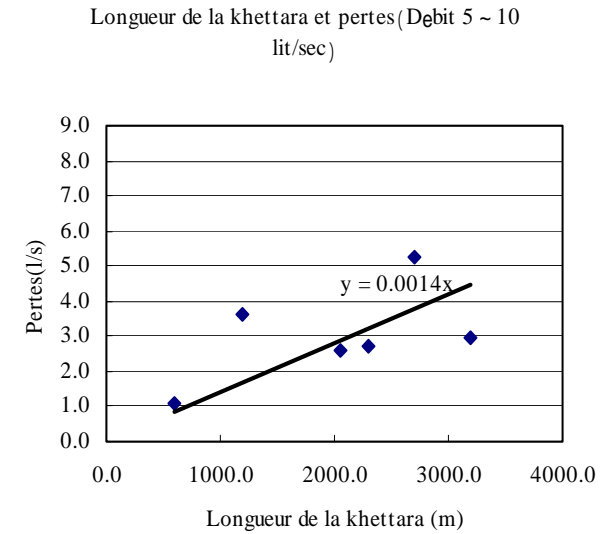
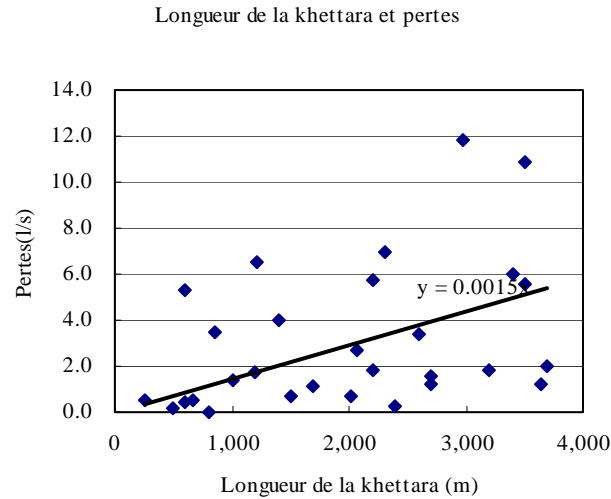
SECTION TYPIQUE D'UNE GALLERIE DU KHETTARA



REMARQUE:
 CETTE ILLUSTRATION MONTRE UNE METHODE SIMPLE DE REHABILITATION.
 PLUSIEURS METHODES DE REHABILITATION SERONT APPLIQUEES LORS DE
 L'ETUDE DE VERIFICATION.

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No.	Length (m)	Discharge		Leakage (lit/sec)
		Upstream (lit/sec)	Downstream (lit/sec)	
A74	600	5.3	6.6	1.3
D34	3,200	1.8	7.0	5.2
D31	3,500	5.6	26.3	20.7
D54	3,640	1.2	23.1	21.9
F38	1,500	0.7	2.5	1.8
G53	250	0.5	0.5	0.0
G64	1,200	1.7	5.1	3.4
G83	2,400	0.3	3.7	3.4
A74	660	0.5	1.3	0.8
D34	2,700	1.6	5.2	3.6
D31	2,200	5.7	20.7	15.0
D54	2,700	1.2	21.9	20.7
F38	2,200	1.8	1.8	0.0
G53	800	0.0	0.0	0.0
G64	1000	1.4	3.4	2.0
G83	2,600	3.4	3.4	0.0
A106	500	0.2	2.6	2.4
B17	850	3.5	24.2	20.7
C2	1,220	6.5	26.9	20.4
C6	1,400	4.0	21.6	17.6
D47	2,970	11.8	19.6	7.8
D58	3,500	10.9	35.8	24.9
D64	3,400	6.0	11.0	5.0
E15	2,300	7.0	7.0	0.0
E8	2,024	0.7	40.0	39.3
F24	3,700	2.0	2.0	0.0
G4	1,700	1.1	2.6	1.5
G63	600	0.4	1.4	1.0
G87	2,060	2.7	8.9	6.2

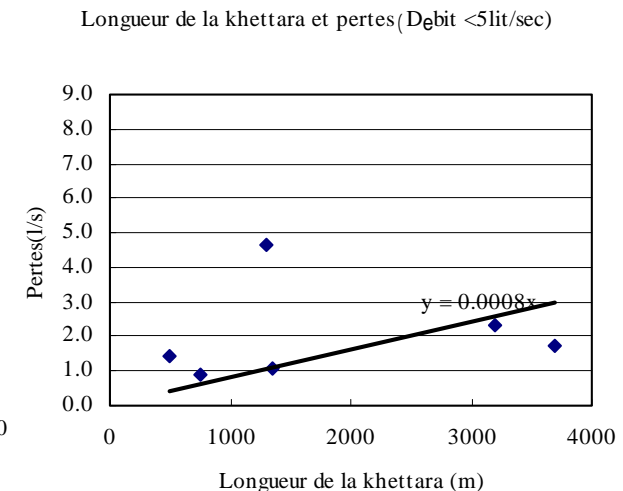
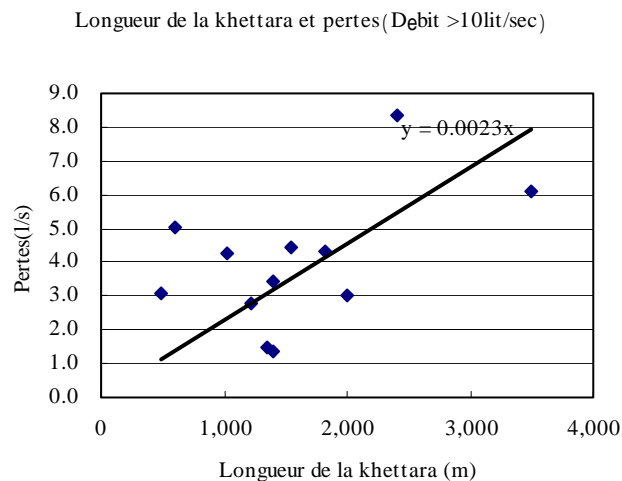
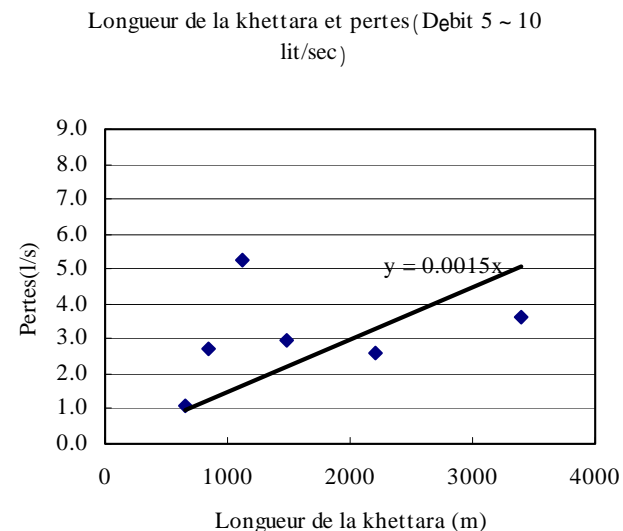
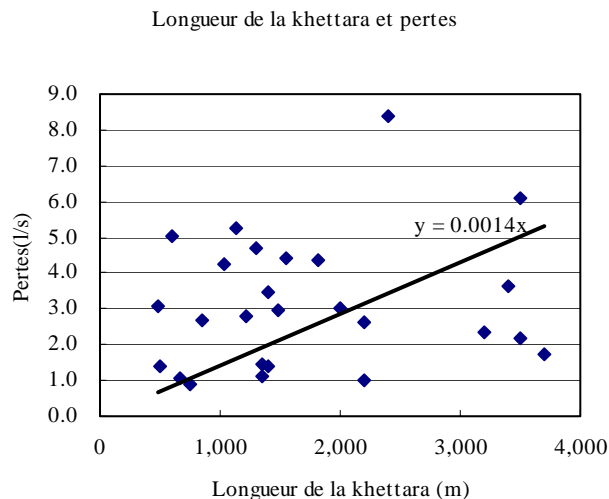


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Figure 7.5.3 (1)
Leakage Loss (Discharge: June 2003)

No.	Length (m)	Dischrage		Leakage (lit/sec)
		Upstream (lit/sec)	Downstream (lit/sec)	
A41	1,400	1.4	14.0	12.6
A50	484	3.1	10.5	7.5
A74	660	1.1	8.5	7.4
A106	500	1.4	4.4	2.9
C2	1,220	2.8	19.2	16.4
C6	1,400	3.5	23.8	20.3
D34	3,200	2.4	3.5	1.1
D34	1,350	1.1	1.1	0.0
D31	3,500	2.2	19.7	17.5
D31	2,200	1.0	17.5	16.5
D47	1,485	2.9	9.7	6.8
D54	1,820	4.4	27.4	23.1
D54	1,350	1.5	23.1	21.6
D58	3500	6.1	29.0	22.9
D64	1,550	4.4	14.2	9.7
D64	3,400	3.7	9.7	6.1
E14	2,000	3.0	52.2	49.1
E15	1,125	5.3	5.3	0.0
F24	3,700	1.7	1.7	0.0
F38	750	0.9	3.6	2.8
G4	850	2.7	6.7	4.0
G53	2200	2.62	5.22	2.6
G63	600	5.01	10.56	5.55
G83	2400	8.37	13.04	4.67
G83	1300	4.67	4.67	0
G87	1030	4.27	23.95	19.68

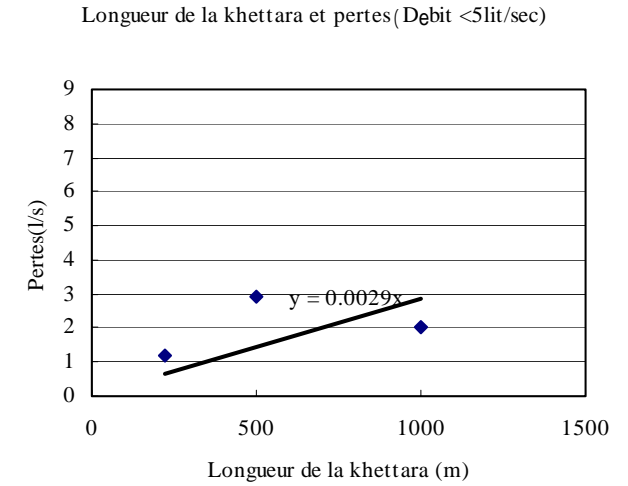
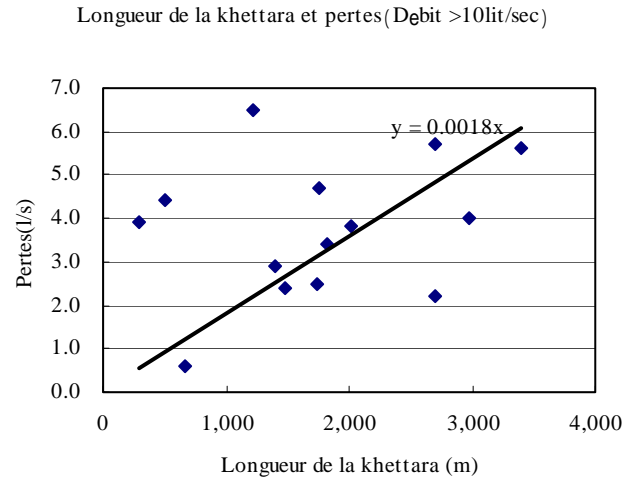
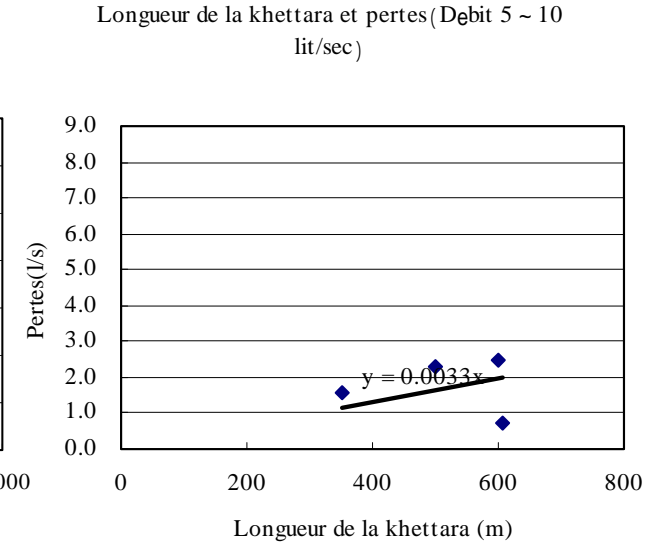
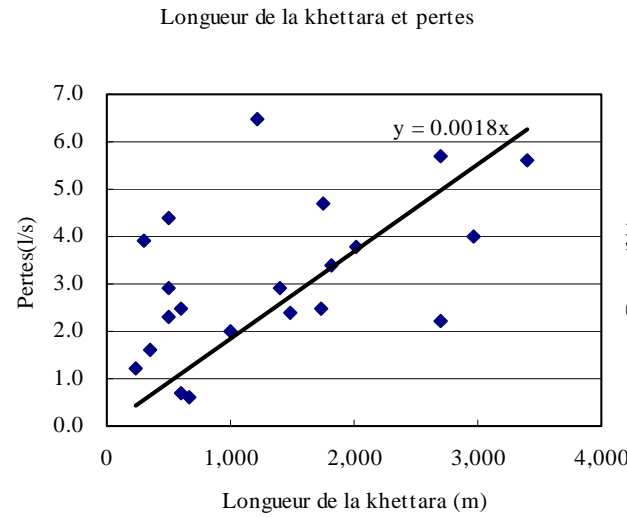


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Figure 7.5.3 (2)
Leakage Loss (Discharge: September 2003)

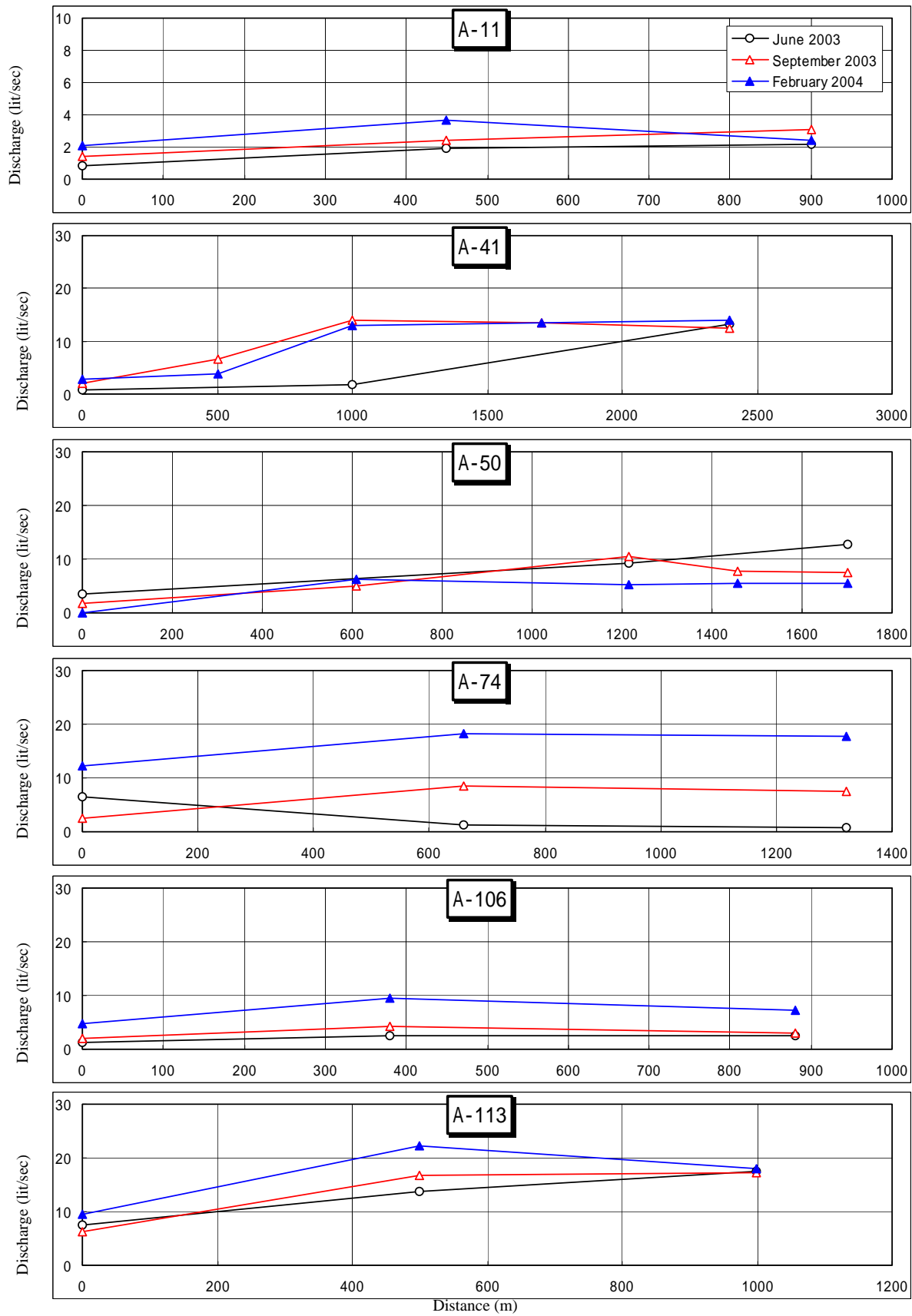
No.	Length (m)	Discharge		Leakage (lit/sec)
		Upstream (lit/sec)	Downstream (lit/sec)	
A11	225	1.2	3.7	2.5
A50	608	0.7	6.3	5.6
A74	660	0.6	18.3	17.7
A106	500	2.3	9.5	7.2
A113	500	4.4	22.3	17.9
B6	350	1.6	8.2	6.6
C2	1,220	6.5	33.0	26.5
C6	1,400	2.9	24.4	21.5
D34	2,700	5.7	12.9	7.2
D47	2,970	4.0	15.6	11.6
D47	1,485	2.4	11.6	9.2
D54	1,820	3.4	24.6	21.2
D54	2,700	2.2	21.2	19.0
D58	1750	4.7	30.0	25.3
D64	3,400	5.6	10.7	5.1
E17	2,024	3.8	34.7	30.9
E16	1,734	2.5	17.3	14.8
G55	300	3.9	12.3	8.4
G59	500	2.9	4.7	1.8
G53	600	2.5	9.9	7.4
G64	1,000	2.0	4.6	2.6



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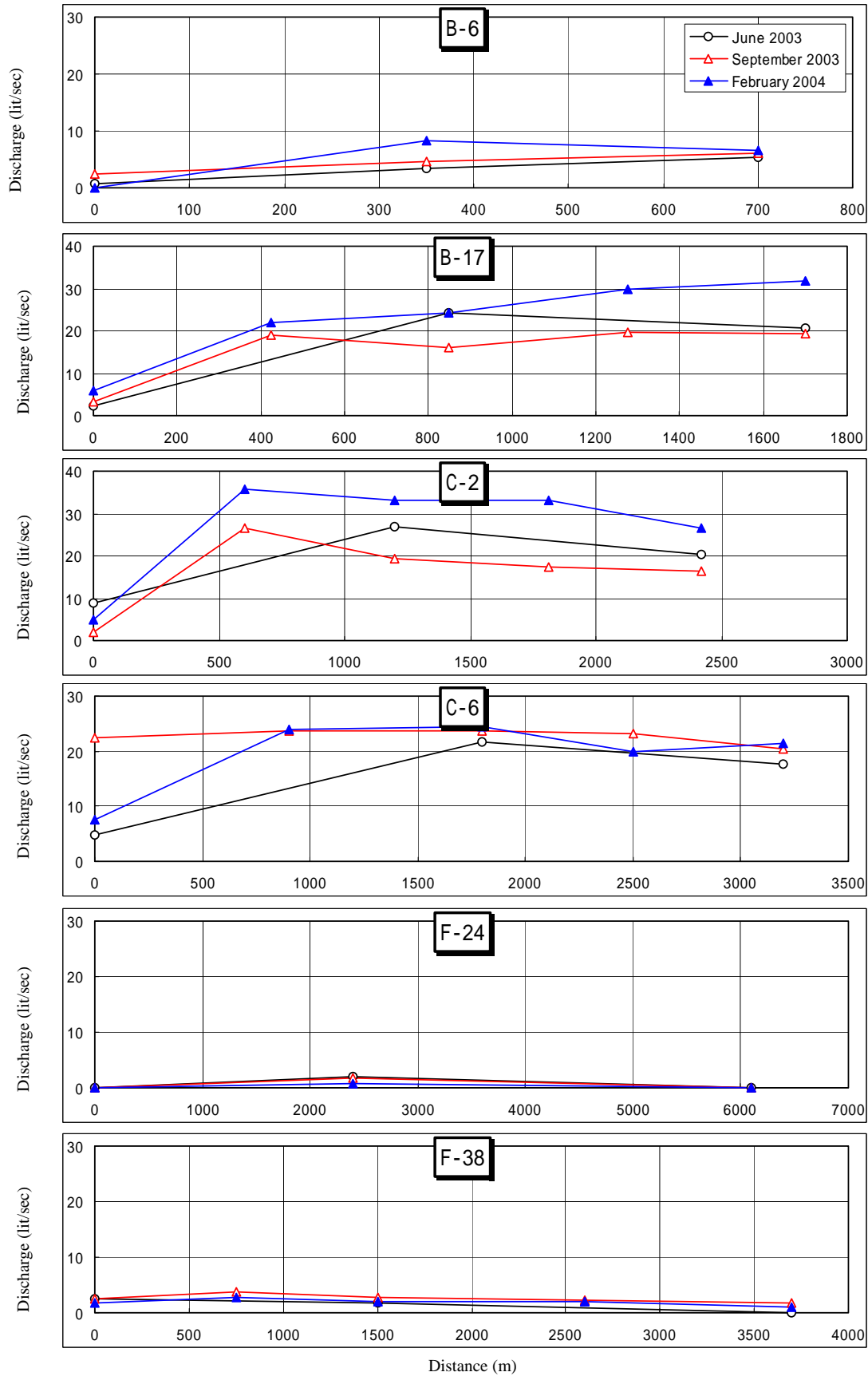
Figure 7.5.3 (3)
Leakage Loss (Discharge: February 2004)



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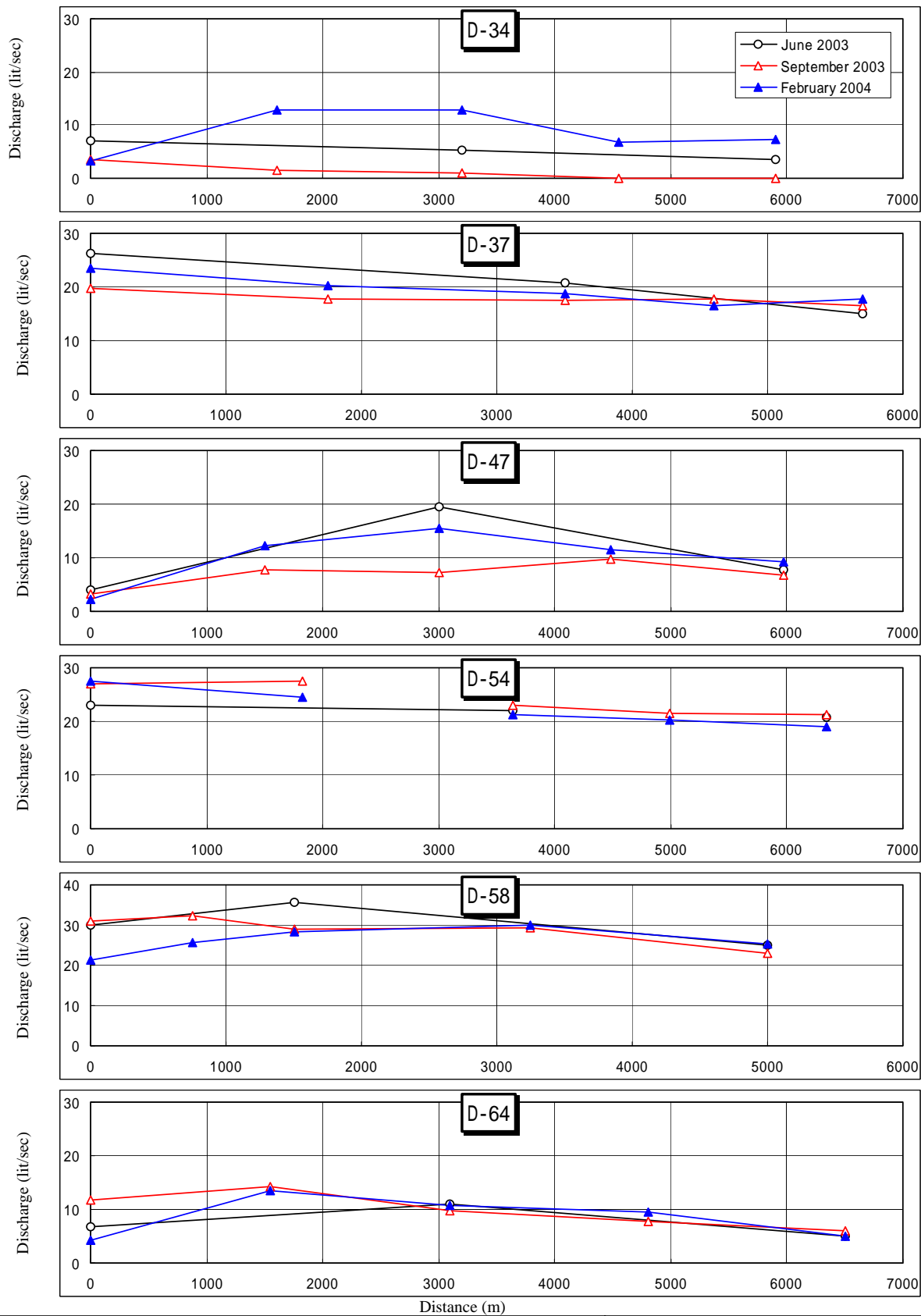
Figure 7.5.4 (1)
Discharge Measurement of 30 Khetarras



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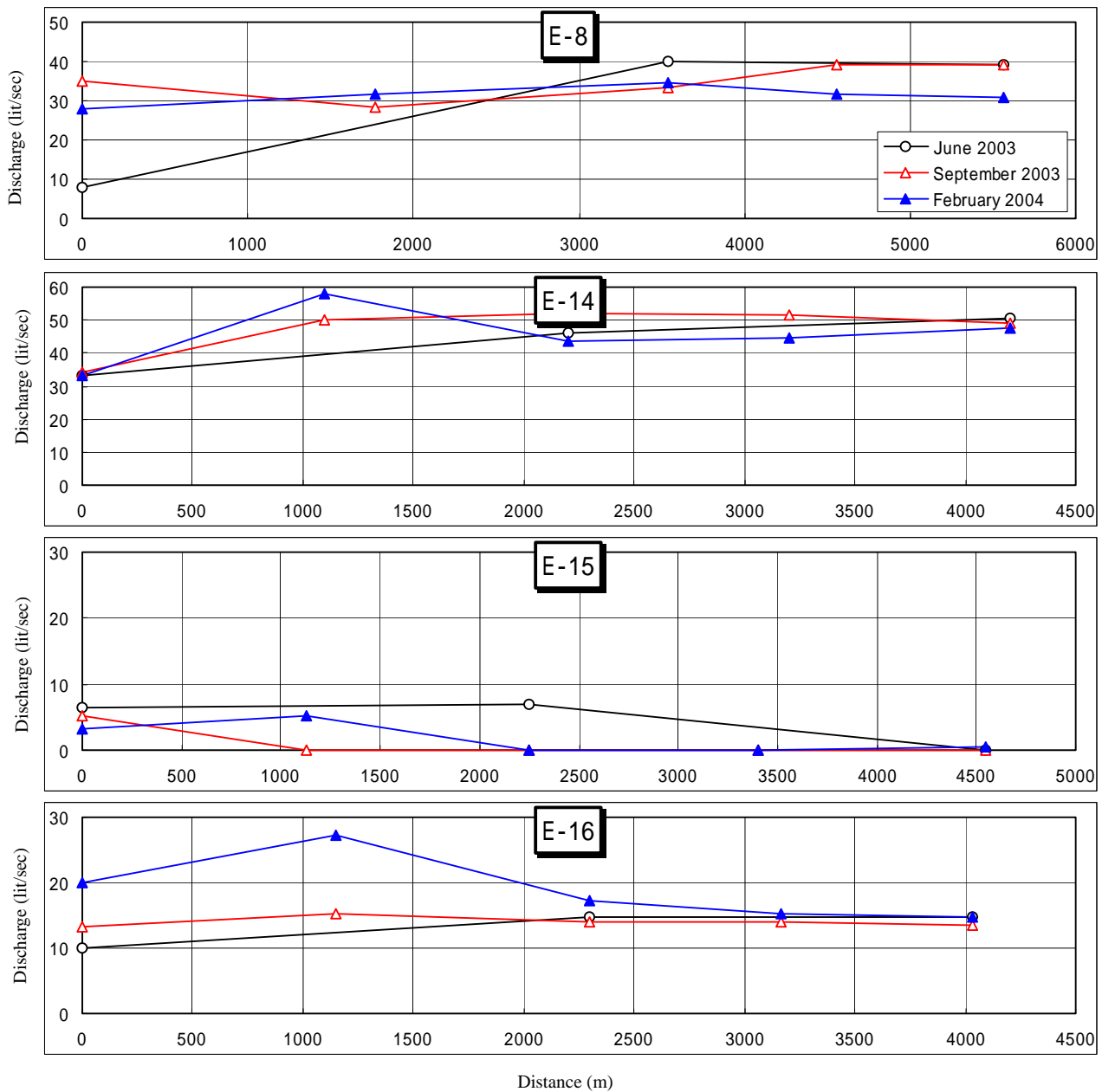
Figure 7.5.4 (2)
Discharge Measurement of 30 Khetaras



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Figure 7.5.4 (3)
Discharge Measurement of 30 Khetaras

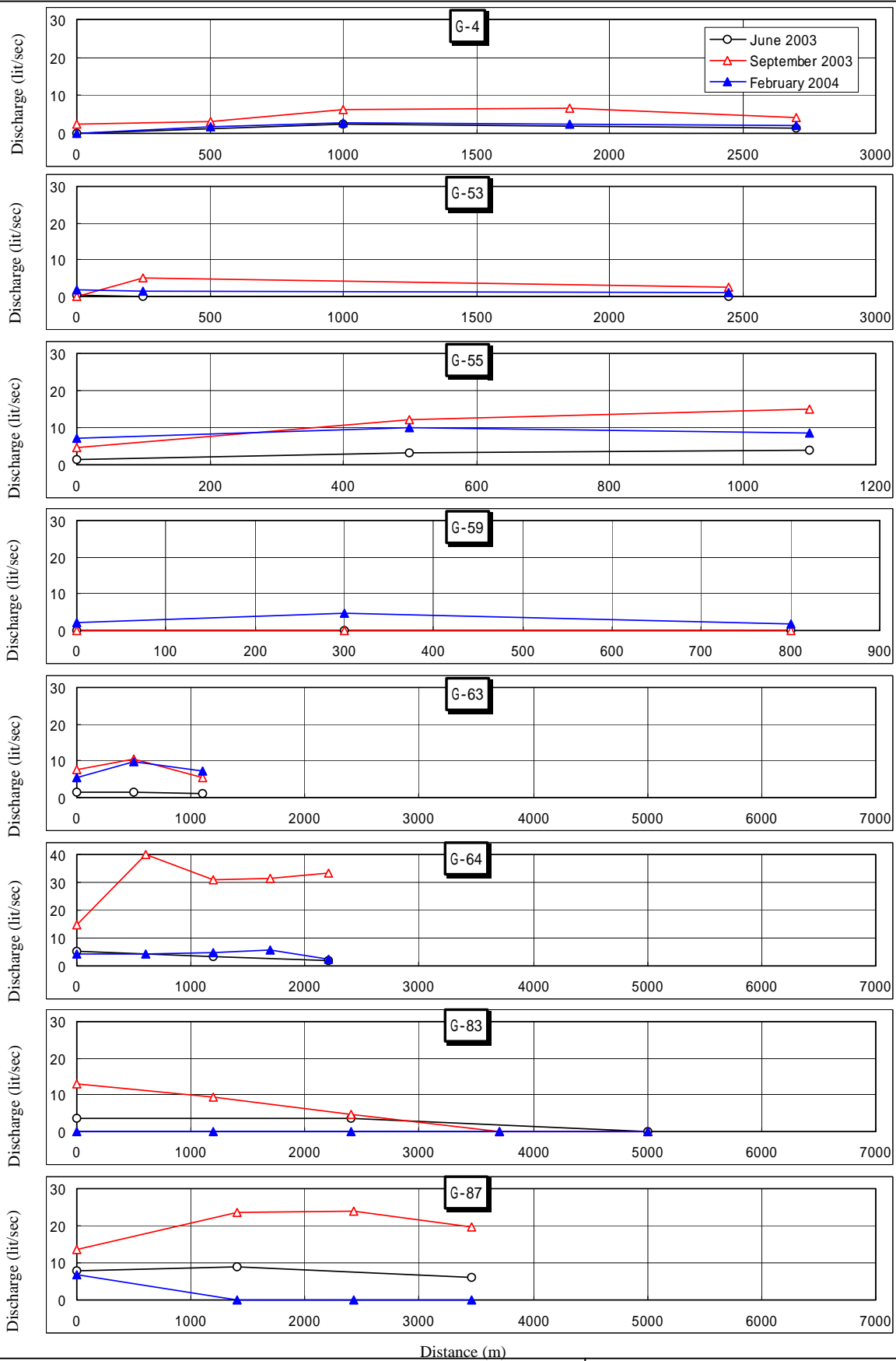
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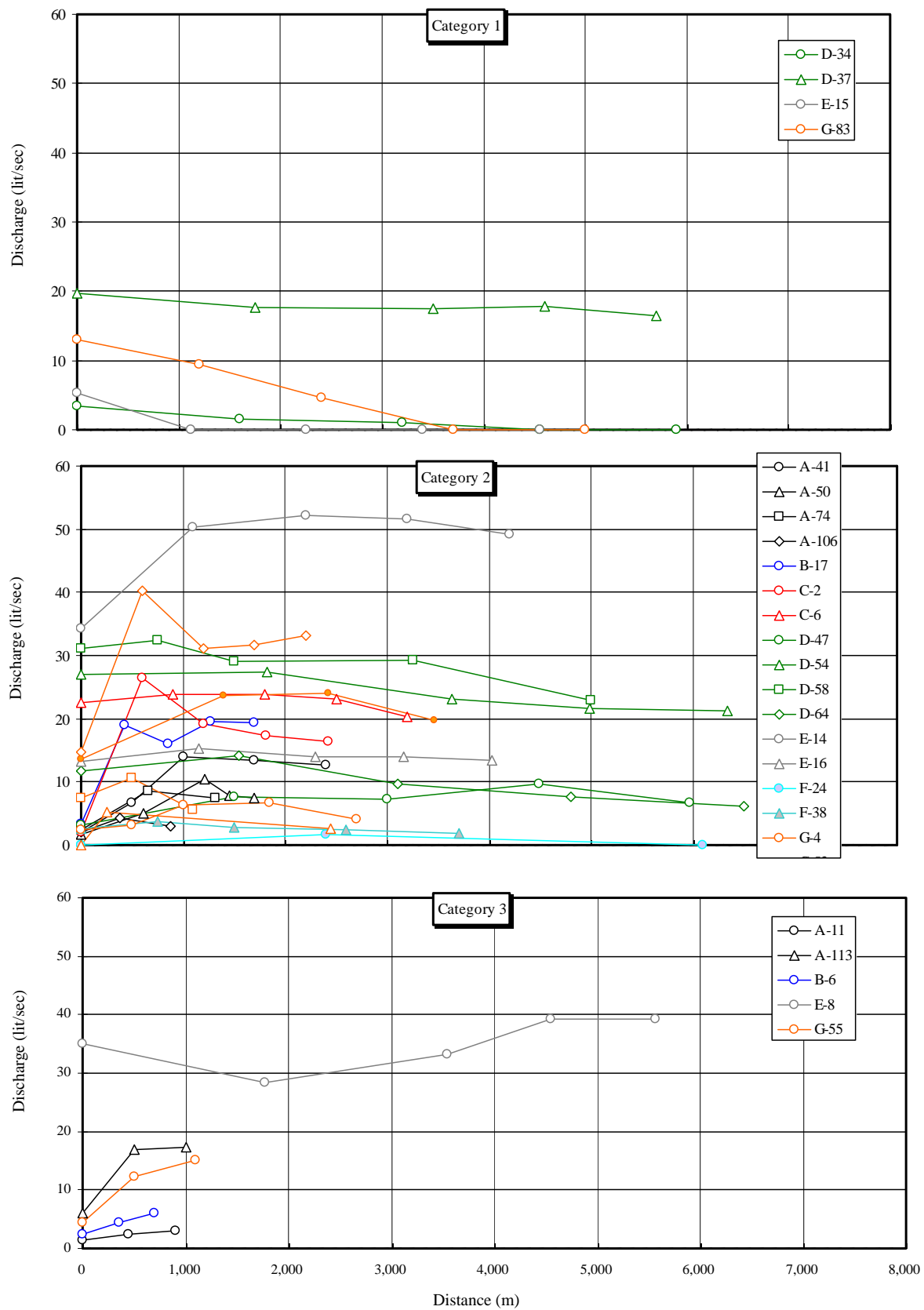
Figure 7.5.4 (4)
Discharge Measurement of 30 Khettaras



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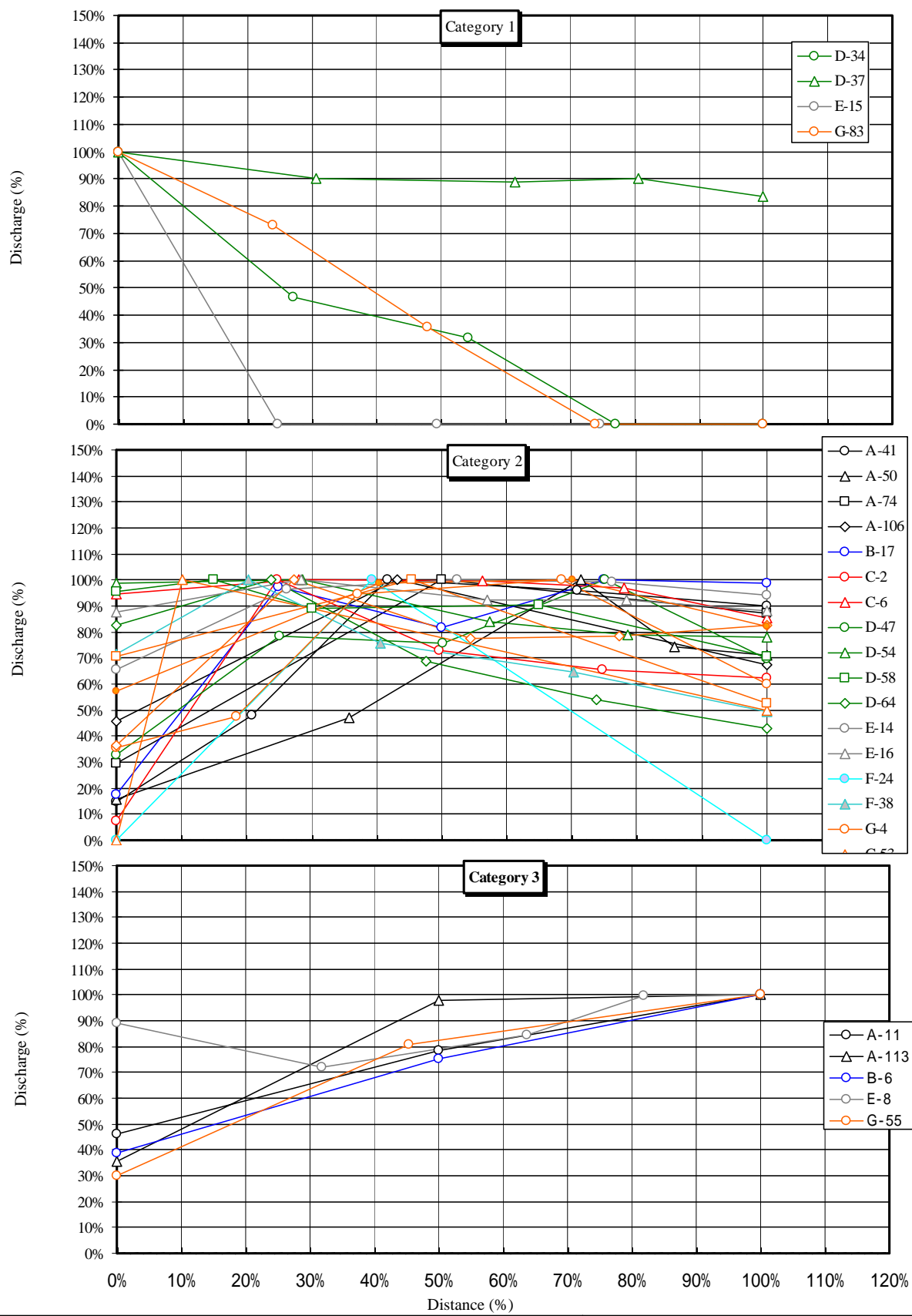
Figure 7.5.4 (5)
Discharge Measurement of 30 Khetarras



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Figure 7.5.5
Discharge Distribution along the Gallery
(in volume)

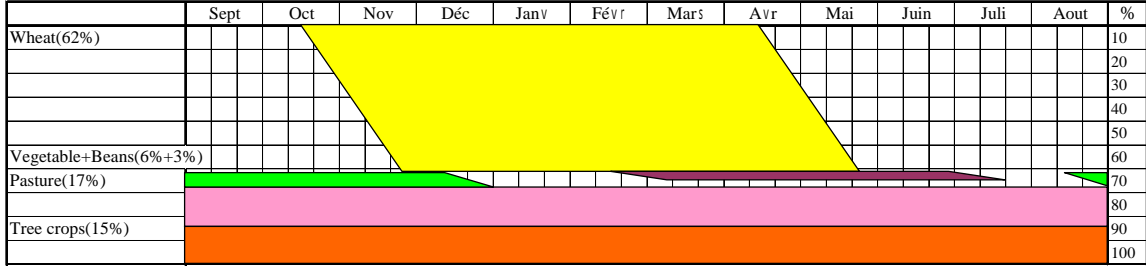


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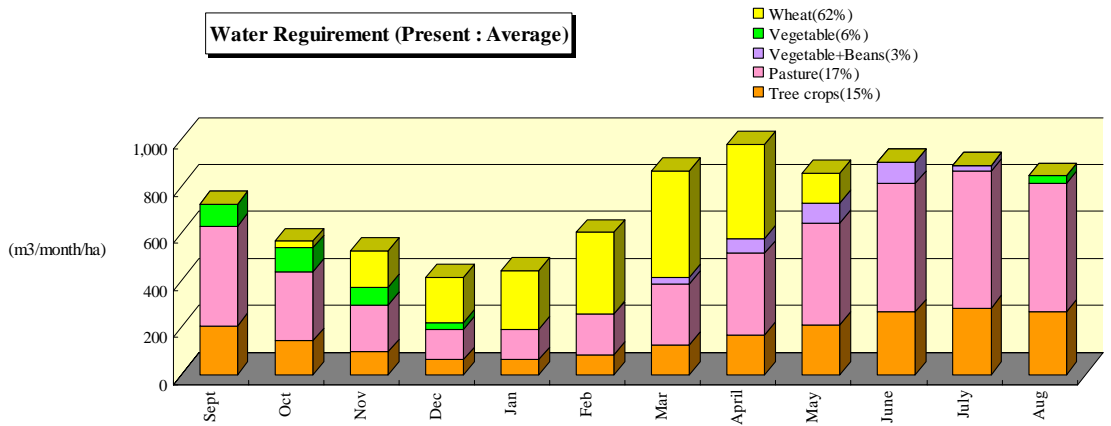
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Figure 7.5.6
Discharge Distribution along the Gallery
(in percentage)

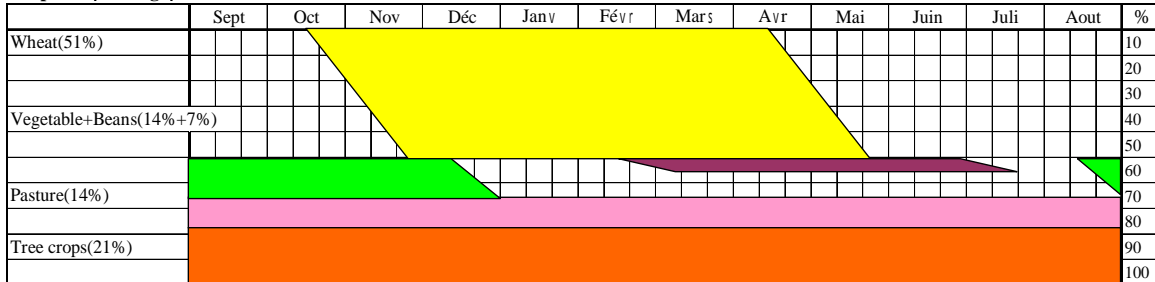
Present (Average)



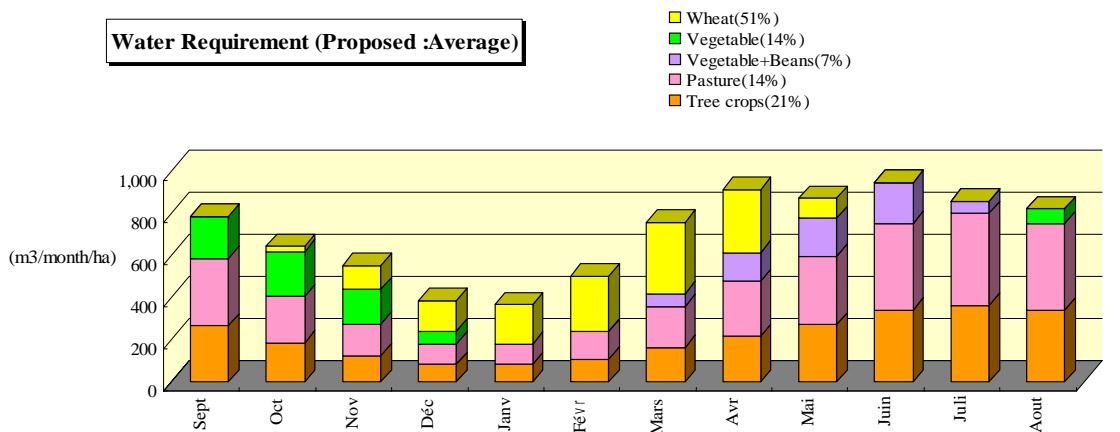
Water Requirement (Present : Average)



Proposed (Average)



Water Requirement (Proposed :Average)



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Figure 7.6.3
Water Requirement

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