Hydrodynamic Simulation of Passive In-Stream Wetland in Rural Areas of Egypt

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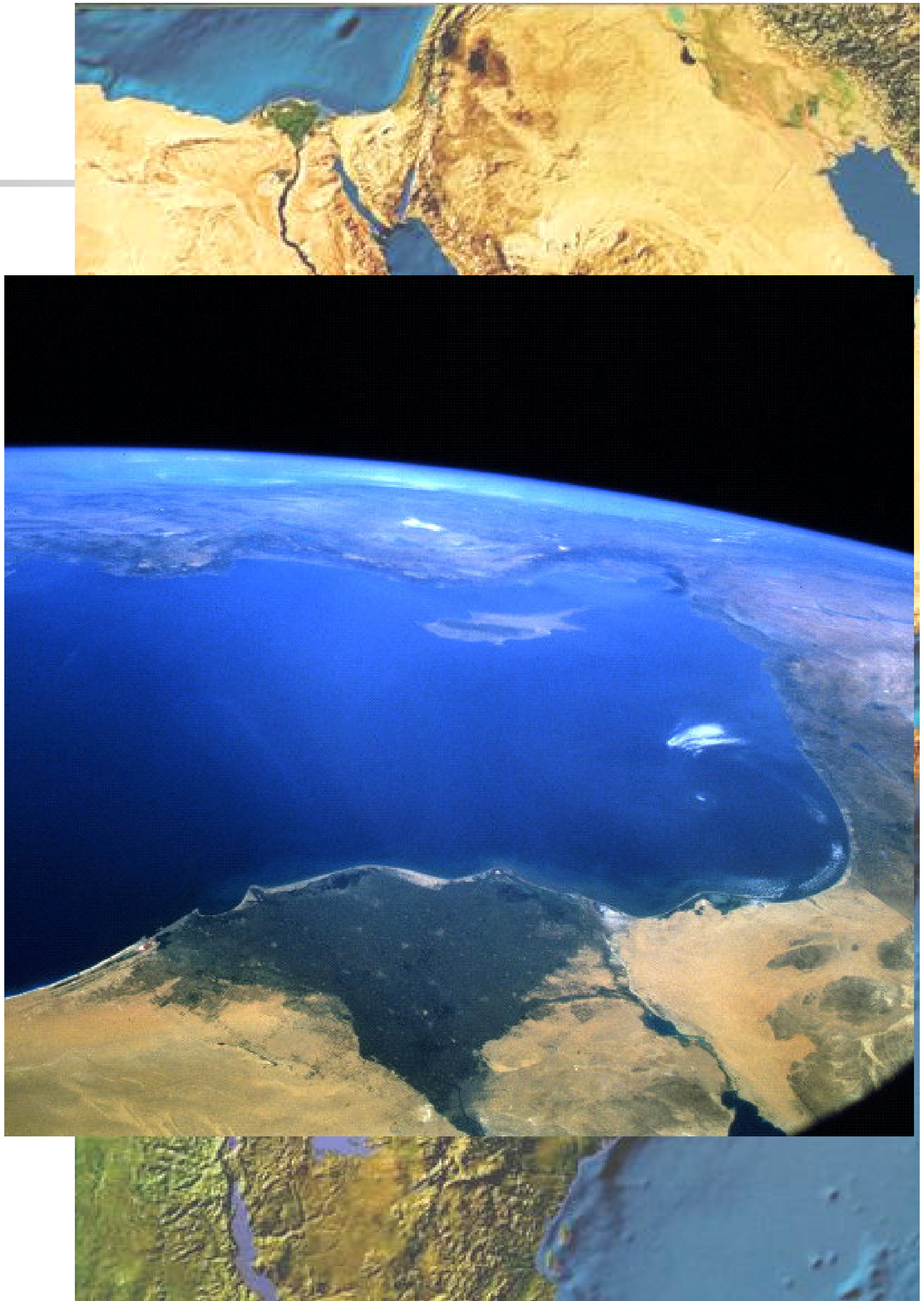
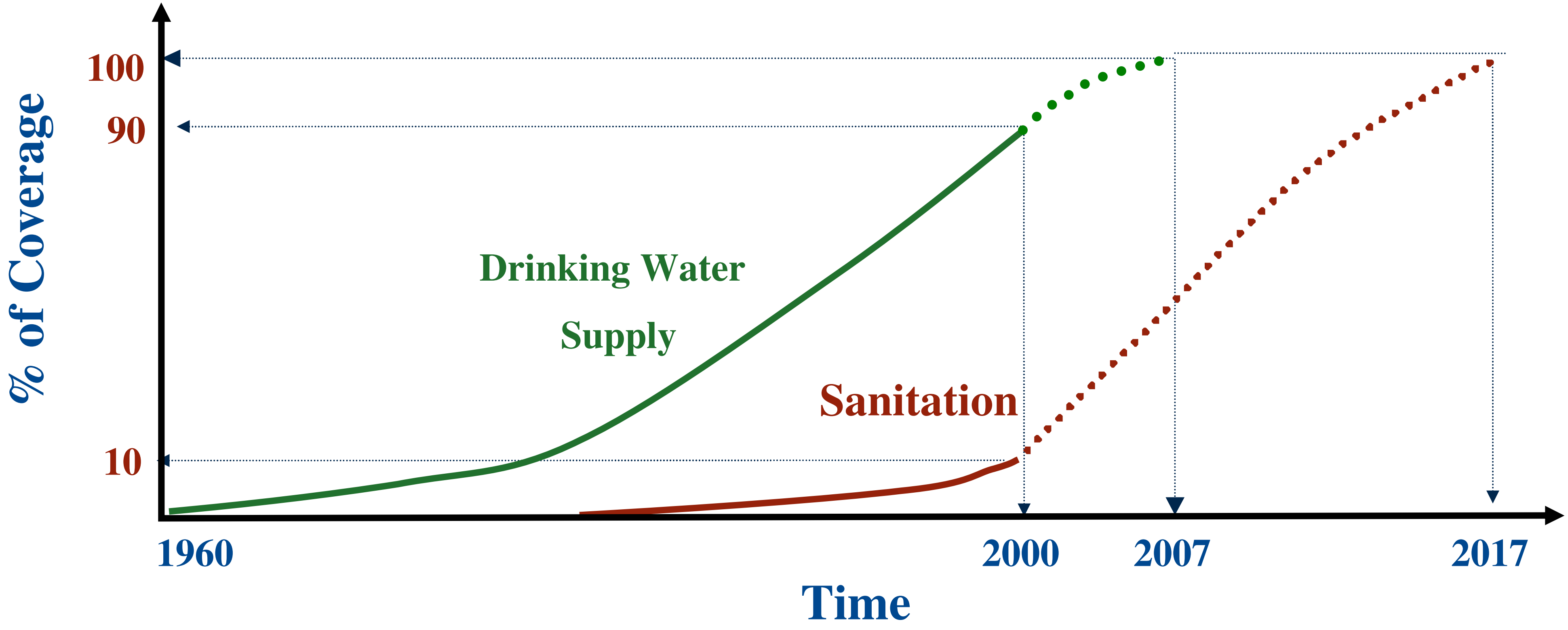
Problem Background



- Over 95 % desert and arid
- Poor in natural wetland
- Community need for low cost treatment technique
- Engineering wetland an option
    - Off-stream
    - Instream

Problem Background



Lack of sanitation facilities in rural area (Cause)

What is the Community do ? (Cause)

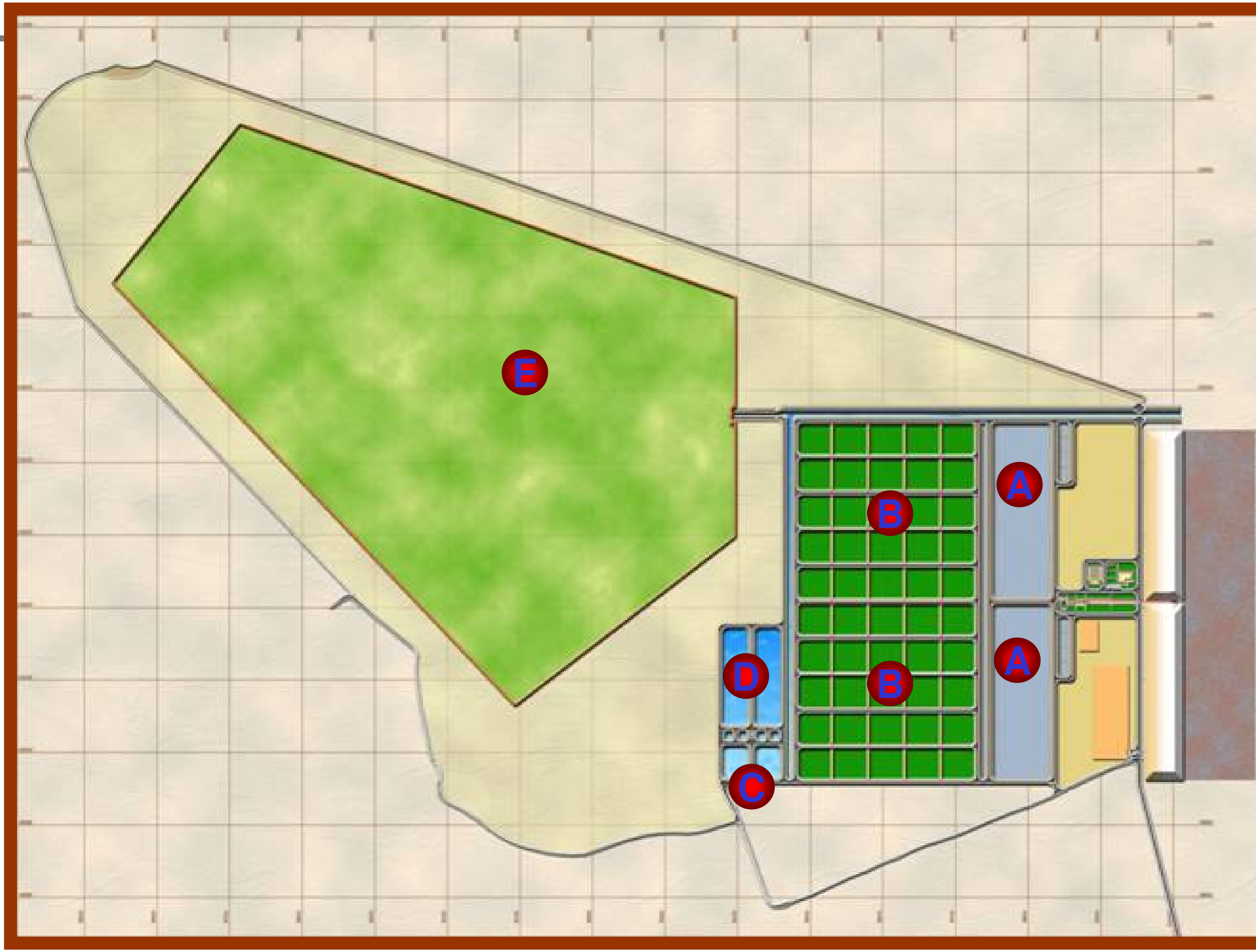
Solution: What are the possible alternatives ?

- Do nothing
- Reuse without treatment
- Treatment and reuse of wastewater
  - Conventional techniques
  - Natural techniques
    - Waste Stabilization Ponds
    - Aquaculture System
    - Land Treatment System
    - Engineering Wetland
      - Surface
      - Subsurface
      - In-stream

Motivation

Treatment Technology	Cost		Treatment Efficiency	Land Requirement	Potential Use	Applied technology
	initial	Operation				
Conventional Treatment	H	H	1.00	1	Limited	H
Natural Treatment						
WSP	M	L	0.95	10	H	L
Aquaculture	M-H	M	0.97	30	M	L
Land Treatment	L	L	0.92	5	M	L
Wetland	L	L	0.90	1 -3	H	L

Motivation (successful case)



Sedimentation Basin	A
Surface flow beds	B
Subsurface flow beds	C
Fishery ponds	D
Agricultural zone	E

Disadvantages

Objective

General:

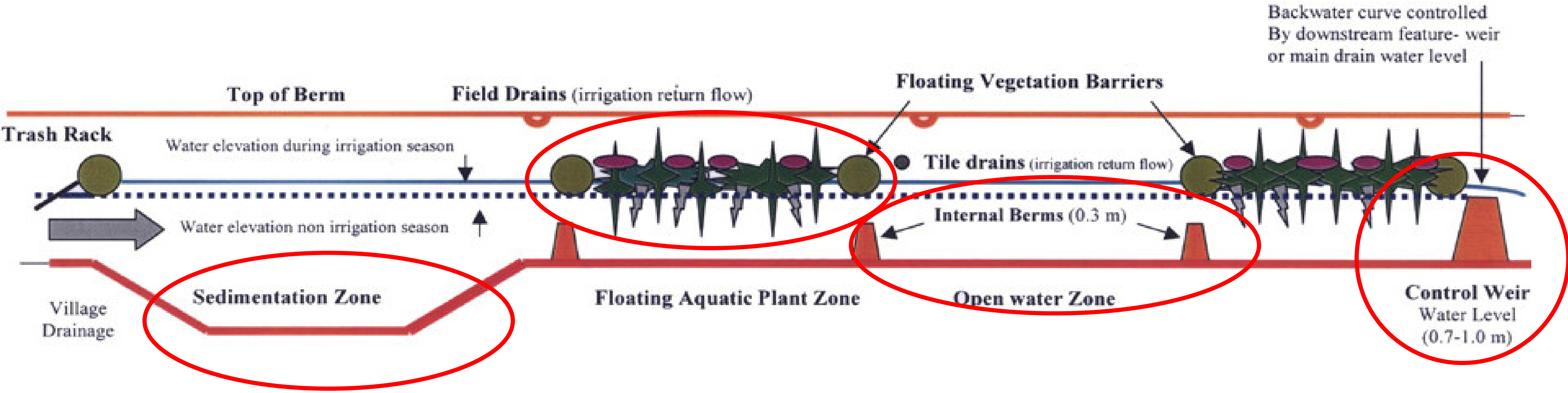
Investigate the potentiality of the in-stream wetland treatment system as the most appropriate natural treatment systems that can be used in rural areas of Egypt

Specific:

Investigate (for different proposed designs):

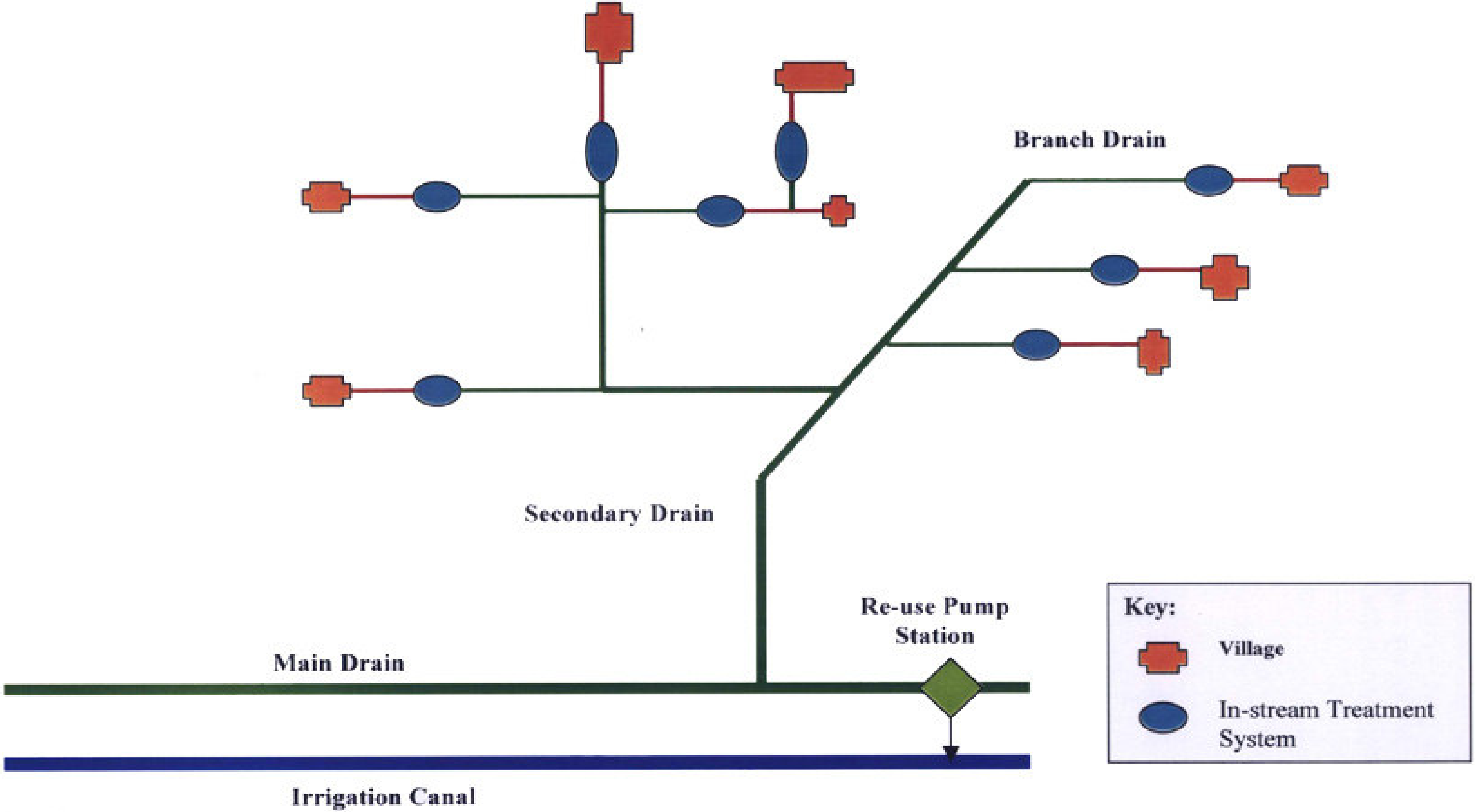
- the hydraulic performance
- the pollutant removal efficiency

In-stream Wetland

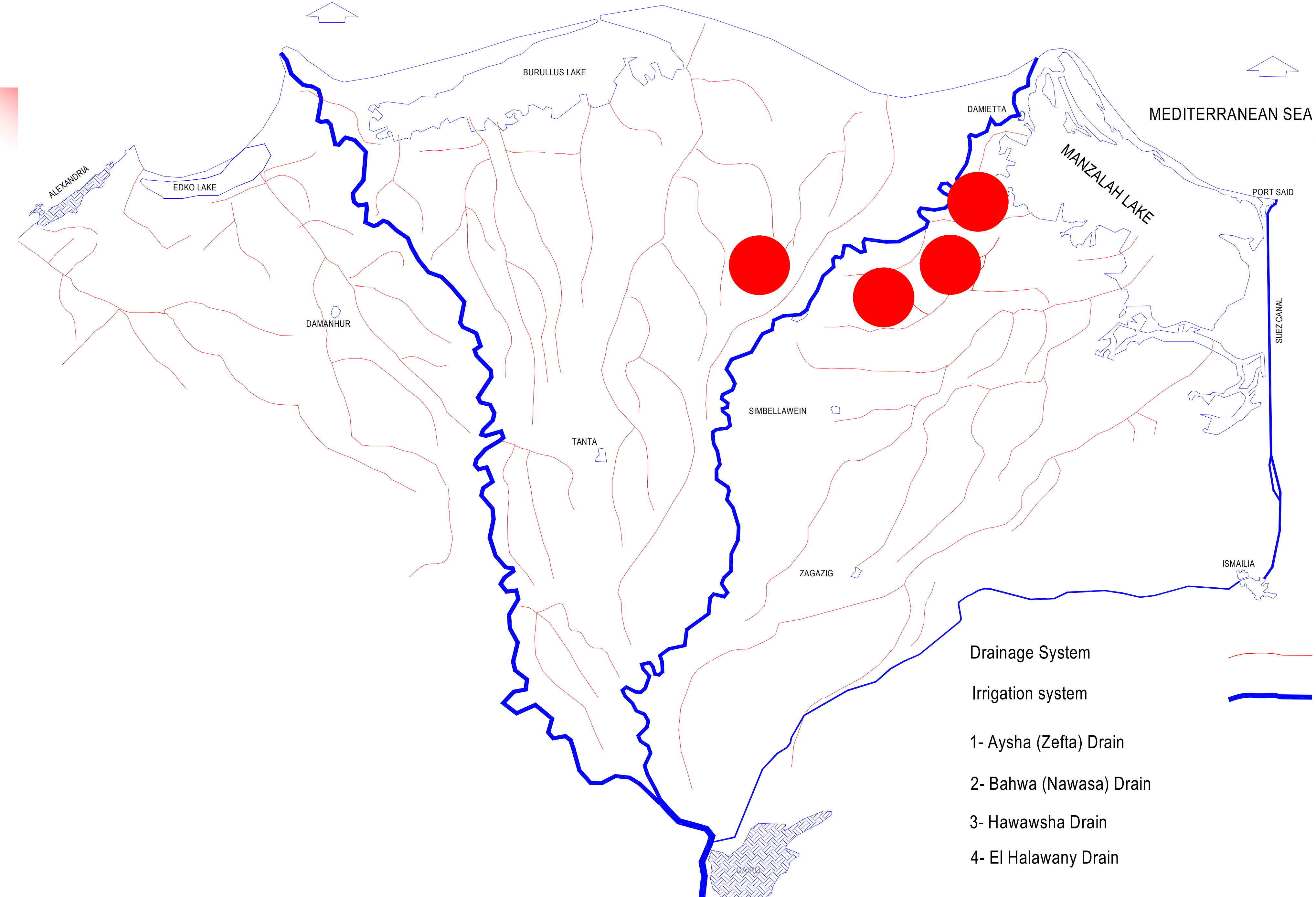


In-Stream Wetland

Applicability and Limitation



Select potential sites



1- Aysha (Zefta) Drain

2- Bahwa (Nawasa) Drain

3- Hawawsha Drain

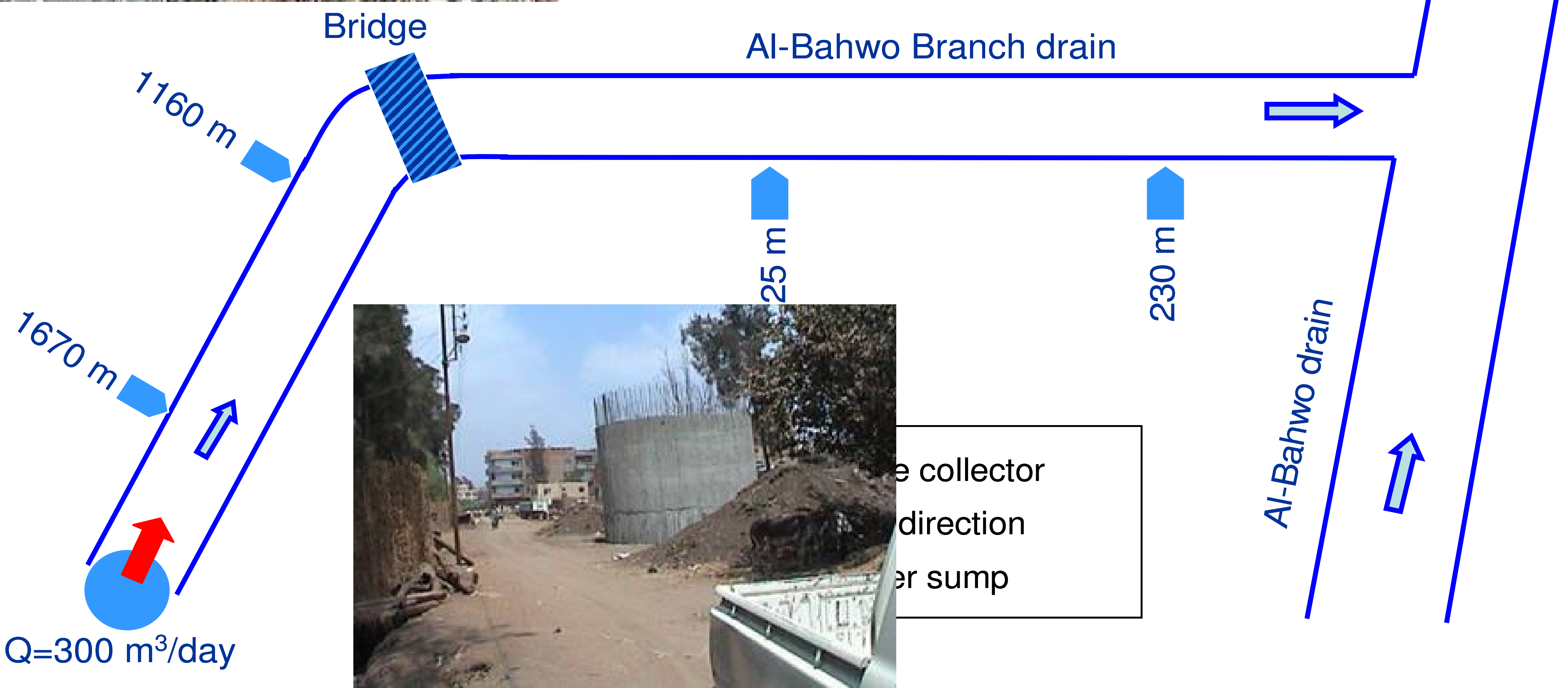
4- El Halawany Drain

Site Selection Criteria

- Drain level (tertiary)
- Physical condition drain cross-section
- Physical Obstacles
- Pollution level and type
    - Medium sewage
    - Absence of toxic industrial waste
- Hydraulic capacity
    - Flow allows for reasonable resident time (population up to 10,000 capita)
- Community Acceptance & appreciation

Community: Acceptance & appreciation

Pilot Area


Bridge
Al-Bahwo Branch drain
1160 m
1670 m
25 m
230 m
Al-Bahwo drain
e collector
direction
er sump
Q=300 m³/day

Pilot Area

- Drain length 1800 m
- Population 3,000 capita
- agricultural served land of 1300 acre
- Drainage water is estimated as 9,200 m^3/day

Baseline Studies

- **Physical Characteristics**

  Drain cross section, bed slop, sources of pollution, land use
- **Hydraulic characteristics**

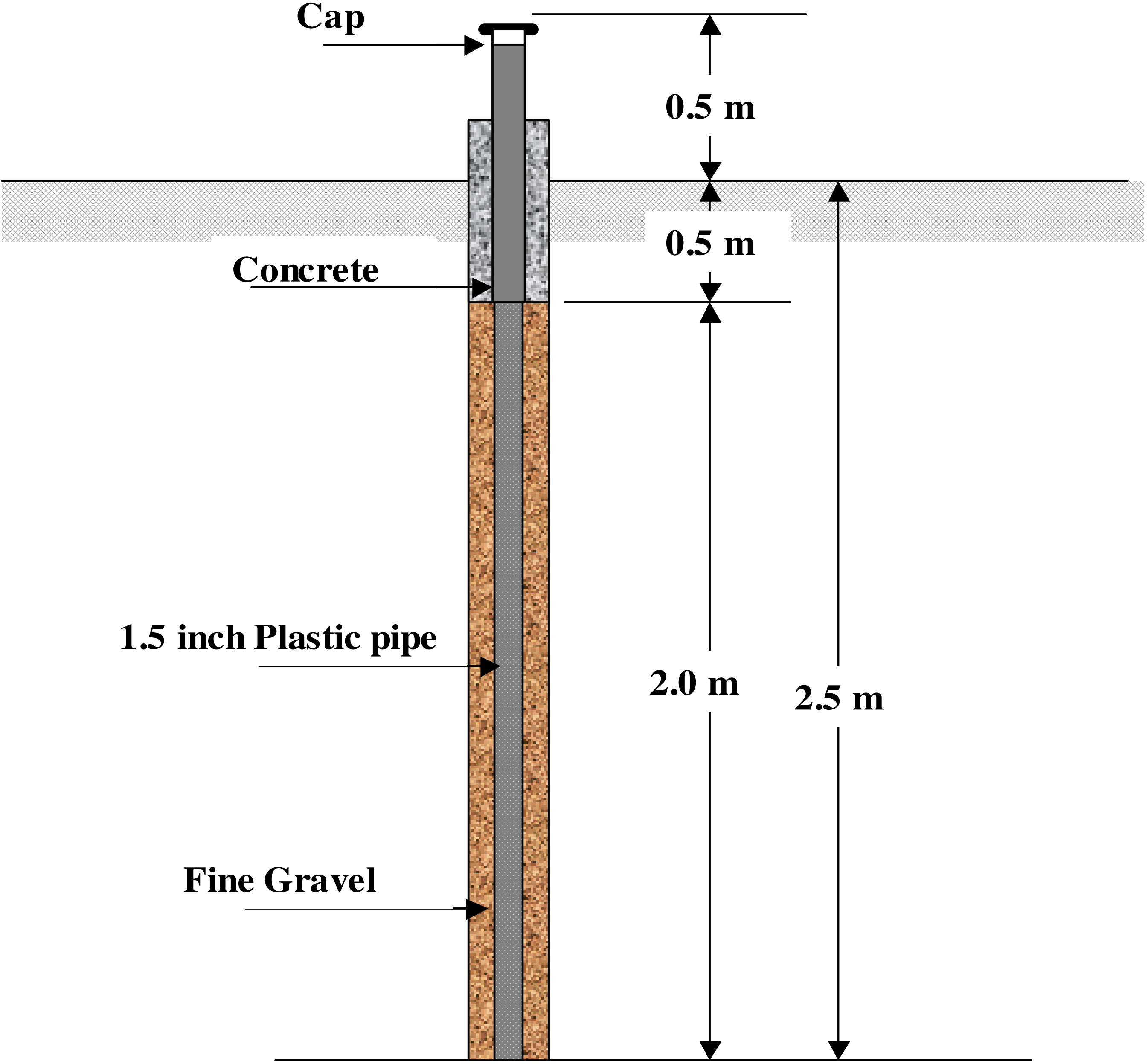
  Flow, drain water level, subsurface level
- **Quality characteristics**

  Water

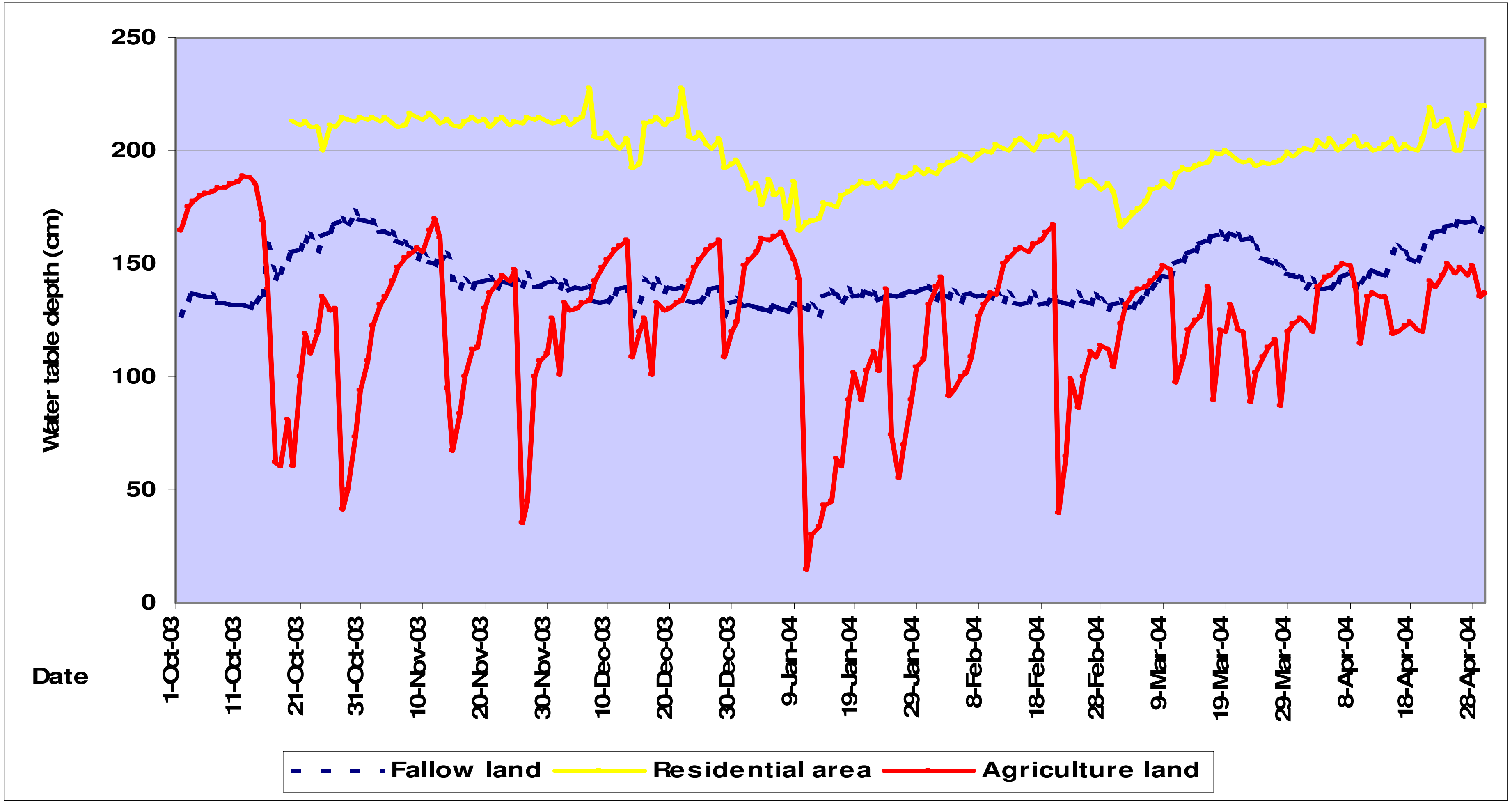
  Plant

  Sediment
- **Socioeconomic**


90
80
70
60
50
40
30
20
10


Cap
0.5 m
0.5 m
Concrete
1.5 inch Plastic pipe
2.0 m
2.5 m
Fine Gravel

Sample of the Baseline data
Observation wells



Design Criteria

- **Minimum retention time (> 1 day)**
- **No short cut flow paths**
- **Minimum physical interventions and cost**
- **High removal efficiency**
- **Raised water level should b lower than the lowest inver of the tile drains by at least 0.25 m**

Assumptions

- Typical Manning coefficient n=0.04 used to calculate the shear resistance
- Manning coefficient, n, increased to n=0.06 throughout the specified aquatic plant zones
- Contraction and expansion losses coefficients adopted (i.e. K= 0.1 for contraction losses and K=0.3 for expansion losses)

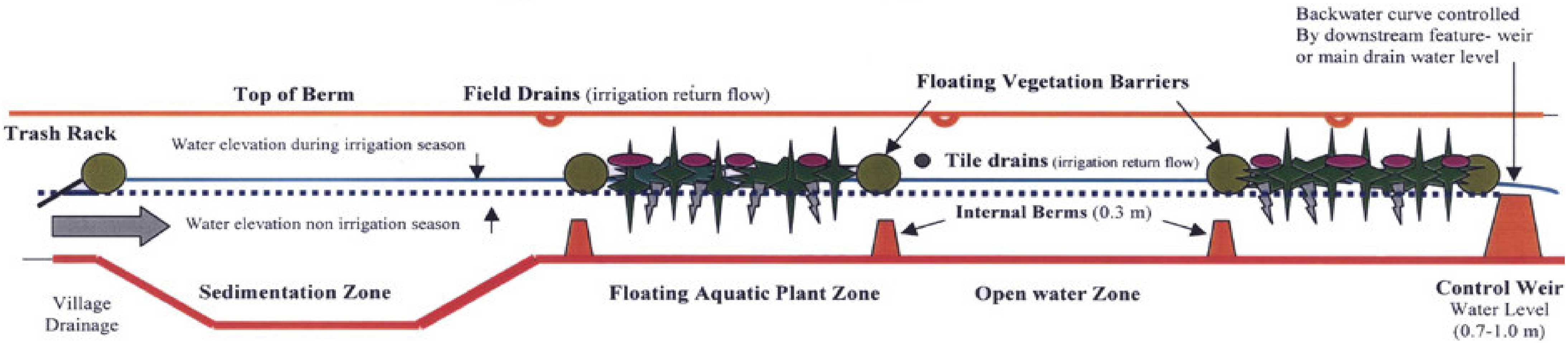
SIMULATION TOOLS

- **HEC-RAS Package**
  - integrated system of software developed by US-Army Corps of Engineers designed for interactive use in a multi-task environment

- **MATLAB Package**
  - interactive software system for numerical computations designed for matrix computations

Design Scenarios

25 numerical runs



Design Scenarios

- **Set 1: Without aquatic plant (**runs 1 to 3)
- **Set 2: With weir or baffles (**runs 4 to 10)
  - with sedimentation trap zone and one weir
- **Set 3: With aquatic plant (**runs 11 and 12)
- **Set 4: Typical PIW (**runs 13 to 22)
- **Set 5: Variable discharges**
  - runs 23 to 25 is similar to set 4 with different discharge flux

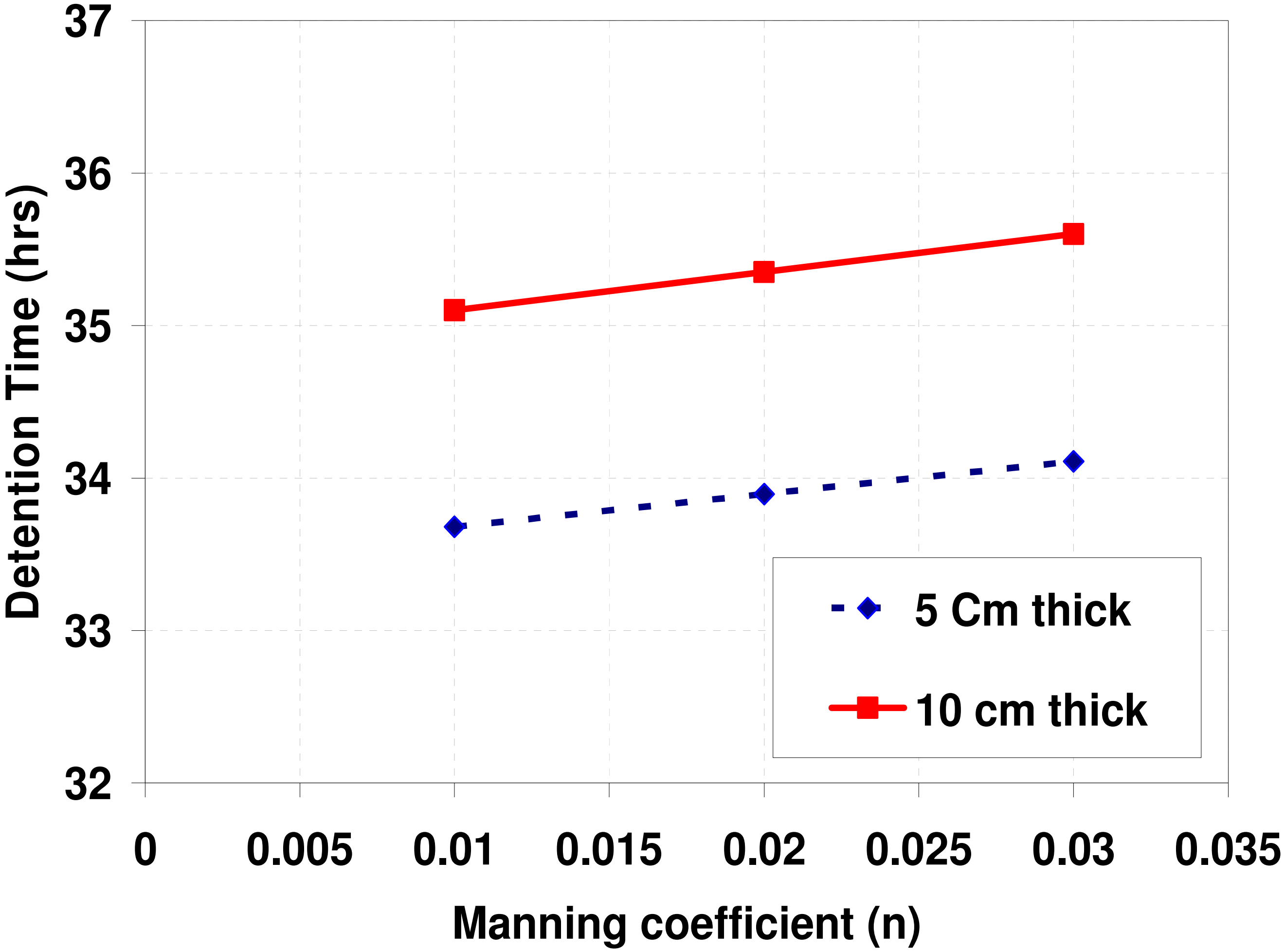
List of numerical runs and calculated detention time

Run	Q%	Depression	Weirs height (cm)		Baffles height (cm)		Vegetation		Time (hr)
			A	D	B	C	A→B	C→D	
1	100%	No							
2	100%	No							9.29
3	100%	yes							12.92
4	100%	yes	30						14.46
5	100%	yes	50						24.43
6	100%	yes		30					14.66
7	100%	yes		50					30.8
8	100%	yes		75					66.55
9	100%	yes	50	50					35.11
10	100%	yes	50	50	25	25			35.11
11	100%	yes	50	50	25	25	n=.06		35.11
12	100%	yes	50	50	25	25	n=.06	n=.06	35.54
13	100%	yes	50	50	25	25	n=.03, t=5 cm		33.78

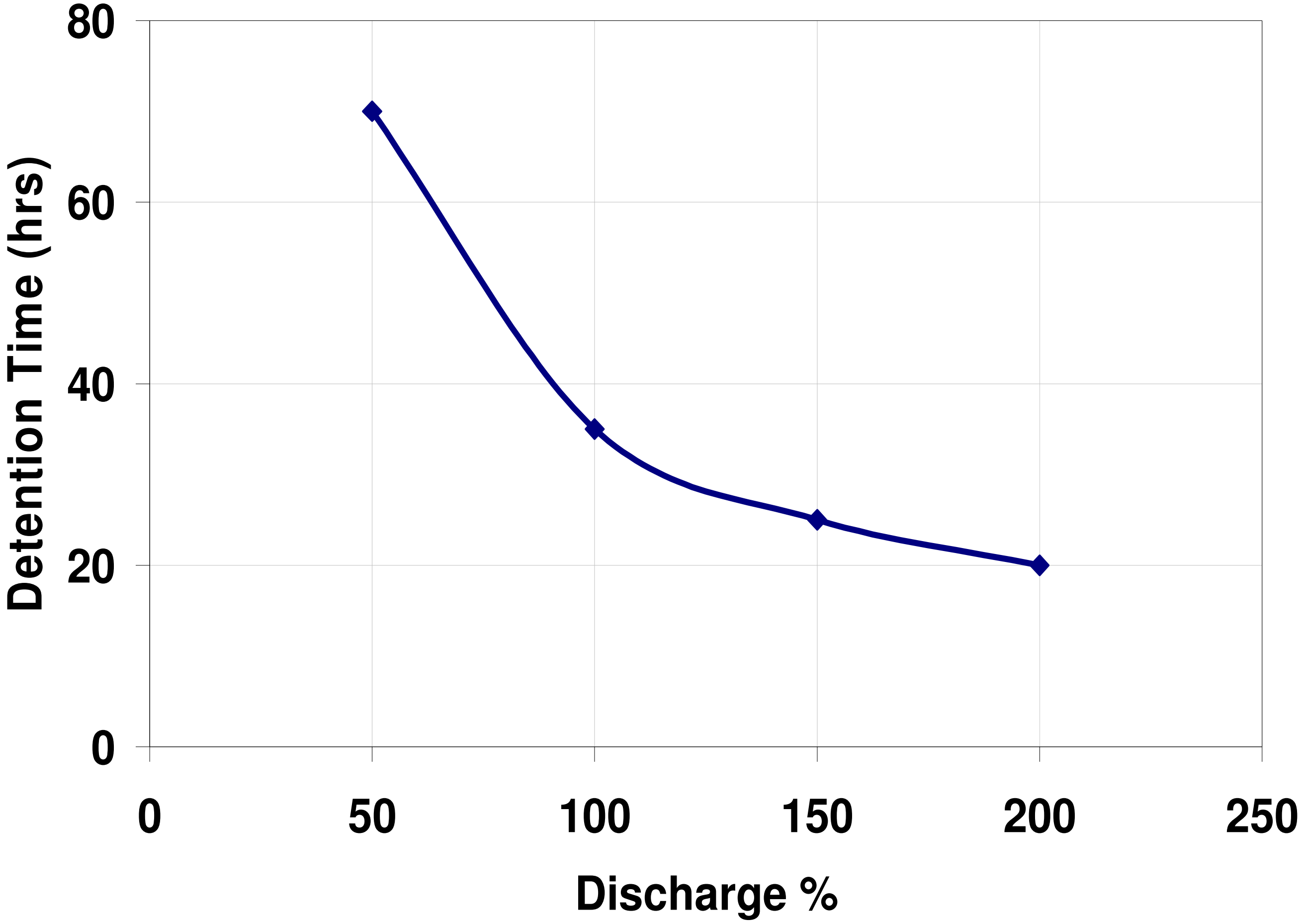
List of numerical runs and calculated detention time

Run	Q%	Depression	Weirs height (cm)		Baffles height (cm)		Vegetation		Time (hr)
			A	D	B	C	A→B	C→D	
14	100%	yes	50	50	25	25	n=.03, t=5 cm	n=.03, t=5 cm	34.06
15	100%	yes	50	50	25	25	n=.02, t=5 cm	n=.02, t=5 cm	33.85
24	150%	yes	50	50	25	25	n=.02, t=10 cm	n=.02, t=10 cm	24.35
25	50%	yes	50	50	25	25	n=.02, t=10 cm	n=.02, t=10 cm	68.66

Vegetation response to detention time



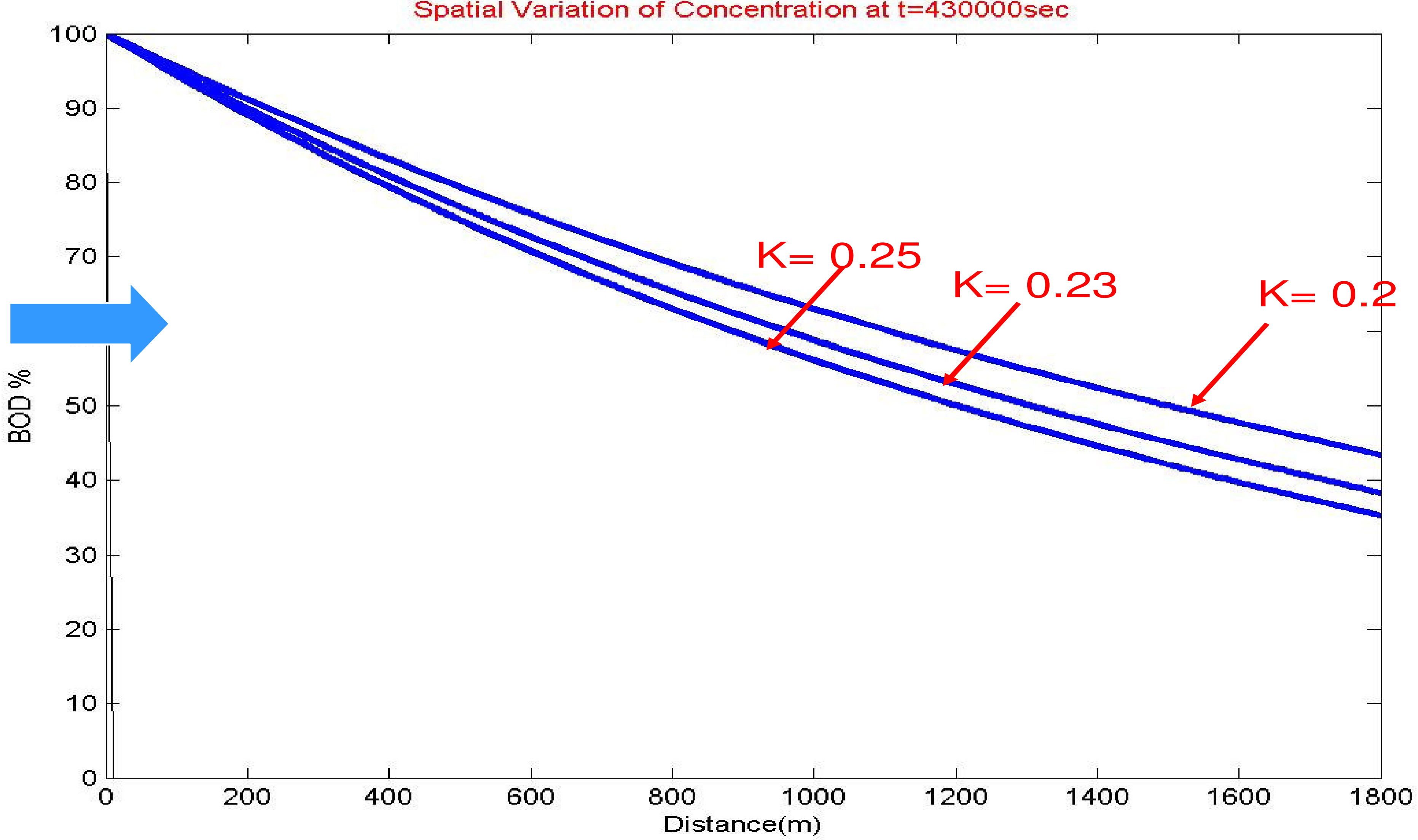
Effect of discharge variation on detention time



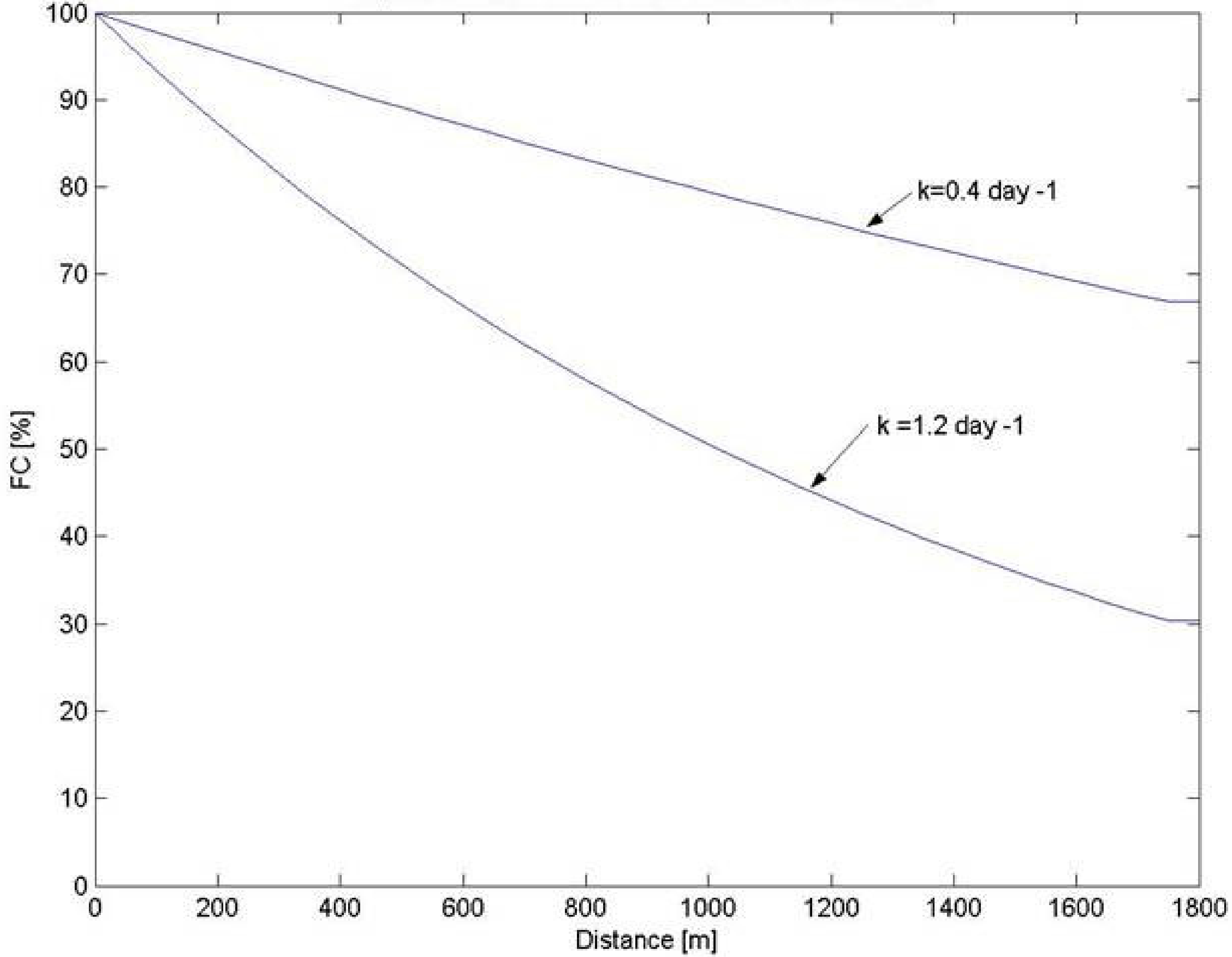
Major Findings

- The end weir plays the most important role in controlling the detention time throughout the PIW
- Interior baffles do not have significant effect on the produced detention time
- Aquatic floating plants have small effect on the produced detention time
- Discharge variation has a nonlinear response to detention time
    - For example, an increase of 50% in Q will cause the detention time to decrease by 36% whereas a decrease in Q by 50% causes the detention time to increase by 91%

BOD spatial decay along the drain pilot



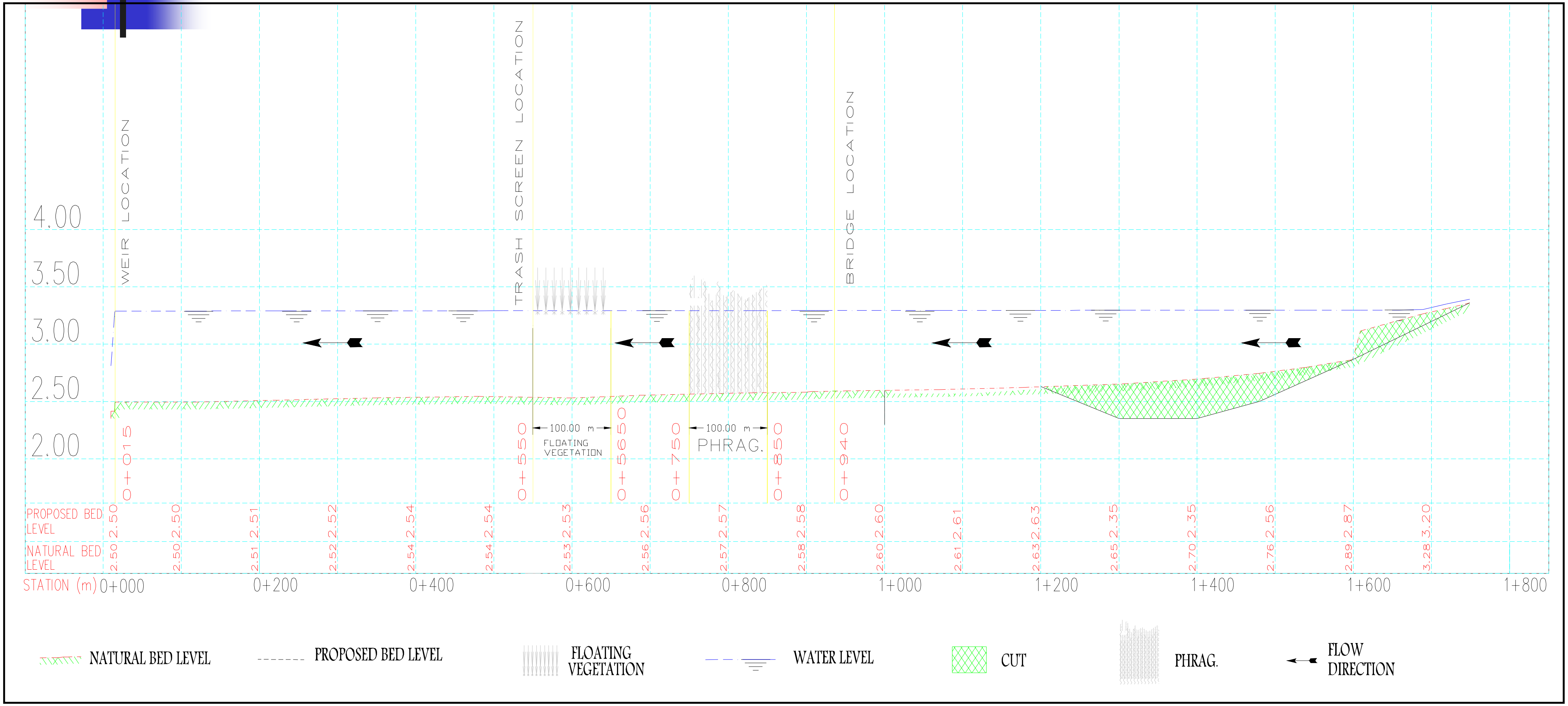
FC spatial decay along the drain pilot

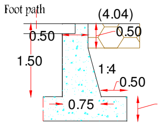


Pilot Area Drain Design

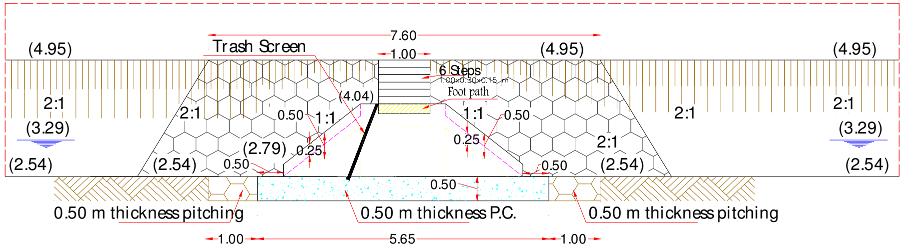
- Reformation of Drain Bed Profile
- Planting of Aquatic Plants
- End Weir
- Detention Time

Profile of the drain pilot reformation

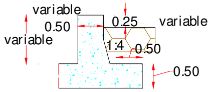




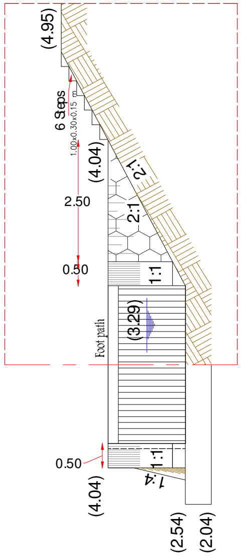
SECTION C- C



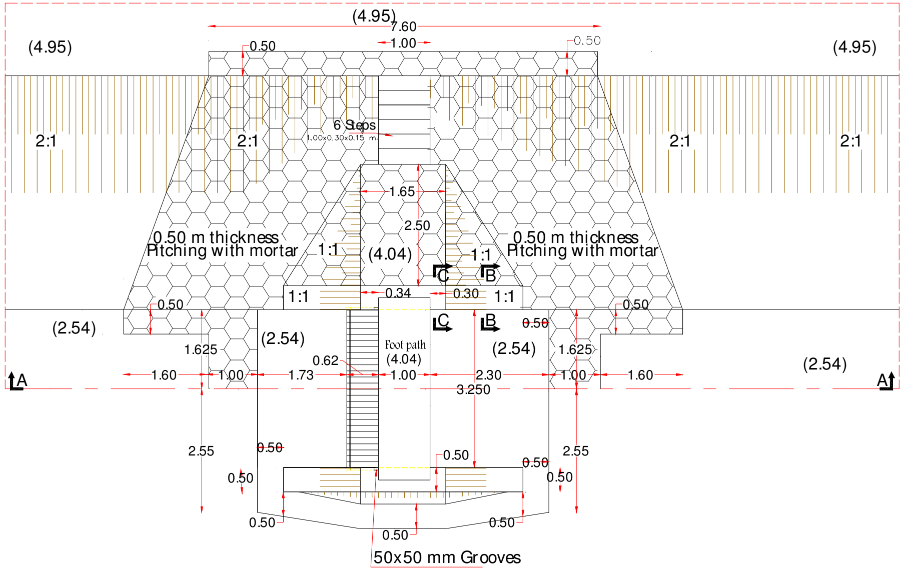
SECTION ELEVATION A- A



SECTION B- B

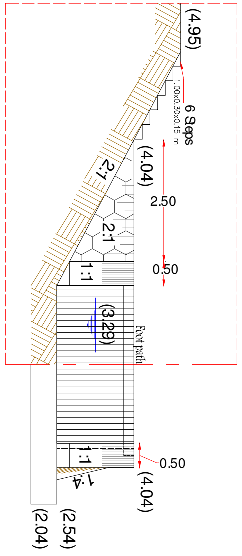


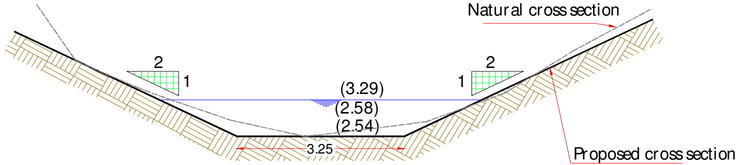
U.S SIDE VIEW



PLAN H.E. REMOVED

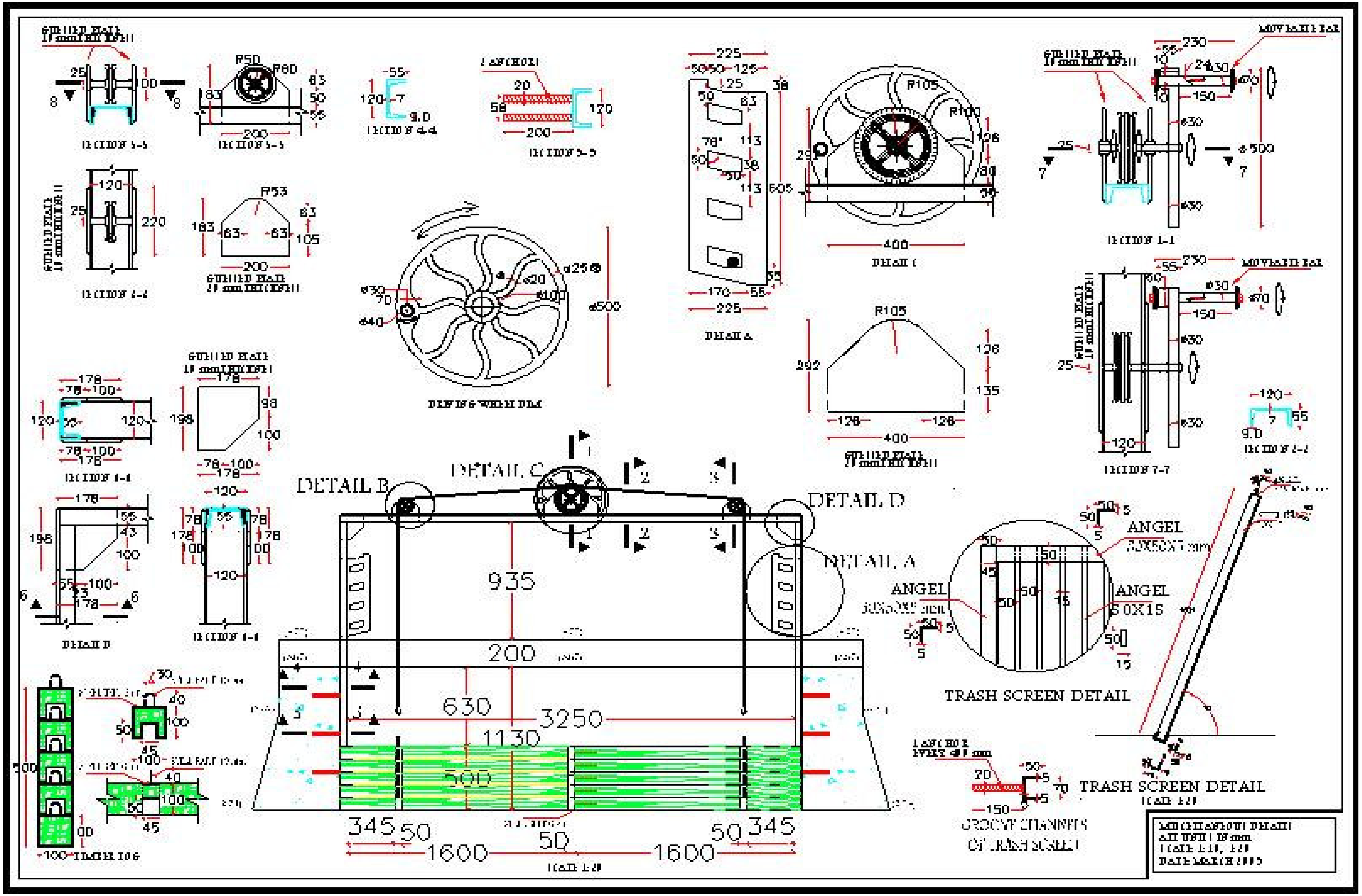
D.S SIDE VIEW





CROSS SECTION

TRASH SCREEN AT STATION 550 m
SCALE: 1:100
DATE: MARCH 2005

DETAIL B
DETAIL C
DETAIL D
DETAIL A
DRAIL A
DRAIL B
DRAIL C
DRIVING WHEEL DRUM
MOVEABLE BAR
ANGEL
ANGEL
50X50X5 mm
50X15
TRASH SCREEN DETAIL
TRASH SCREEN DETAIL
GROOVE CHANNELS OF TRASH SCREEN
ANCHOR
935
200
630
1130
3250
500
345
50
1600
50
1600
50
345
ø500
R105
R100
400
225
230
150
MECHANICAL DETAIL
ALL UNIT IN mm
SCALE 1:10, 1:20
DATE MARCH 2005

Conclusions

- The end weir plays important role in controlling the detention time throughout the PIW channel system
- The in-stream wetland with 36 hours detention time can reach up to 70% removal efficiency
- The discharge variation has a nonlinear response to the detention time
- The optimum case is to serve 5,000 to 10,000 capita