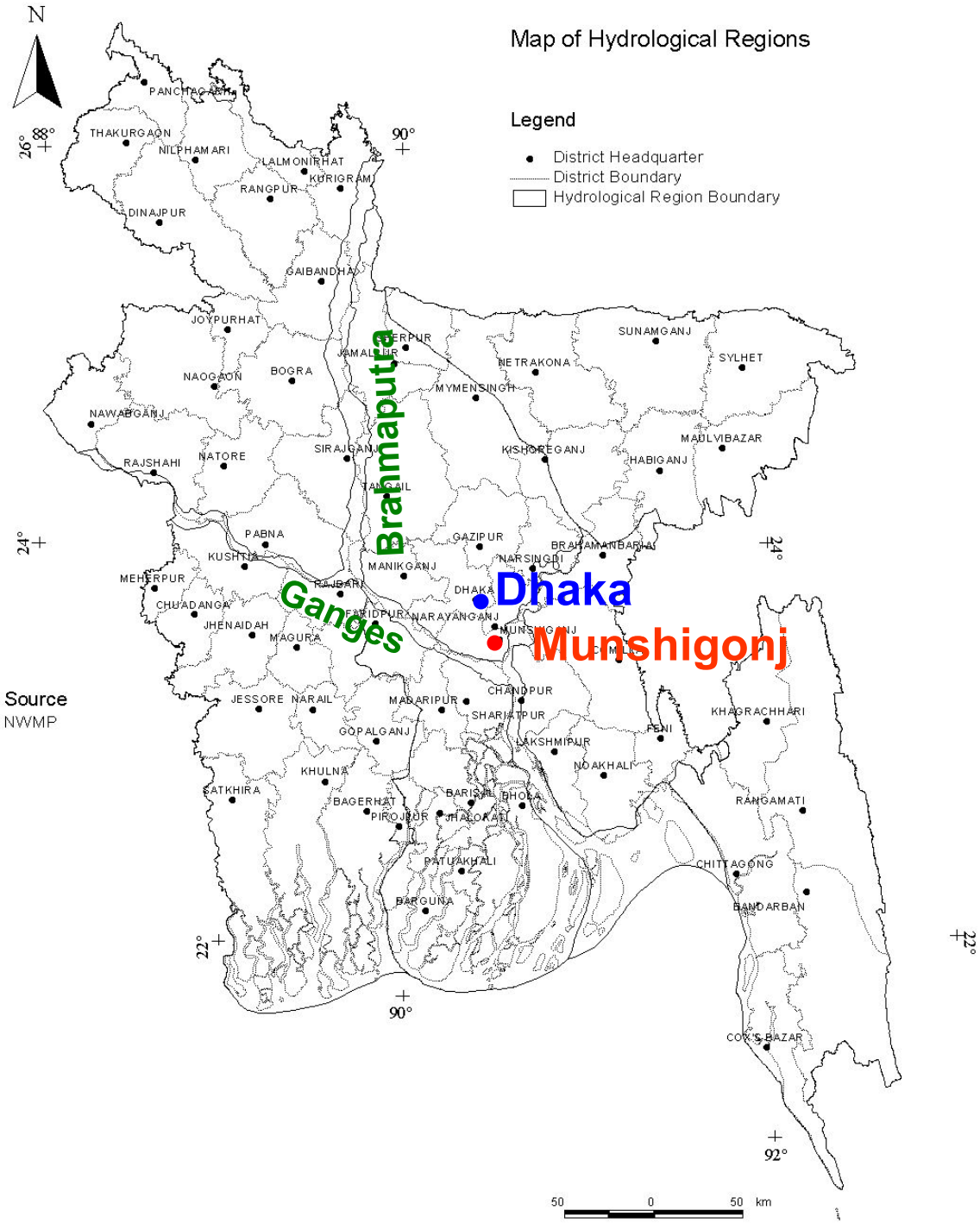
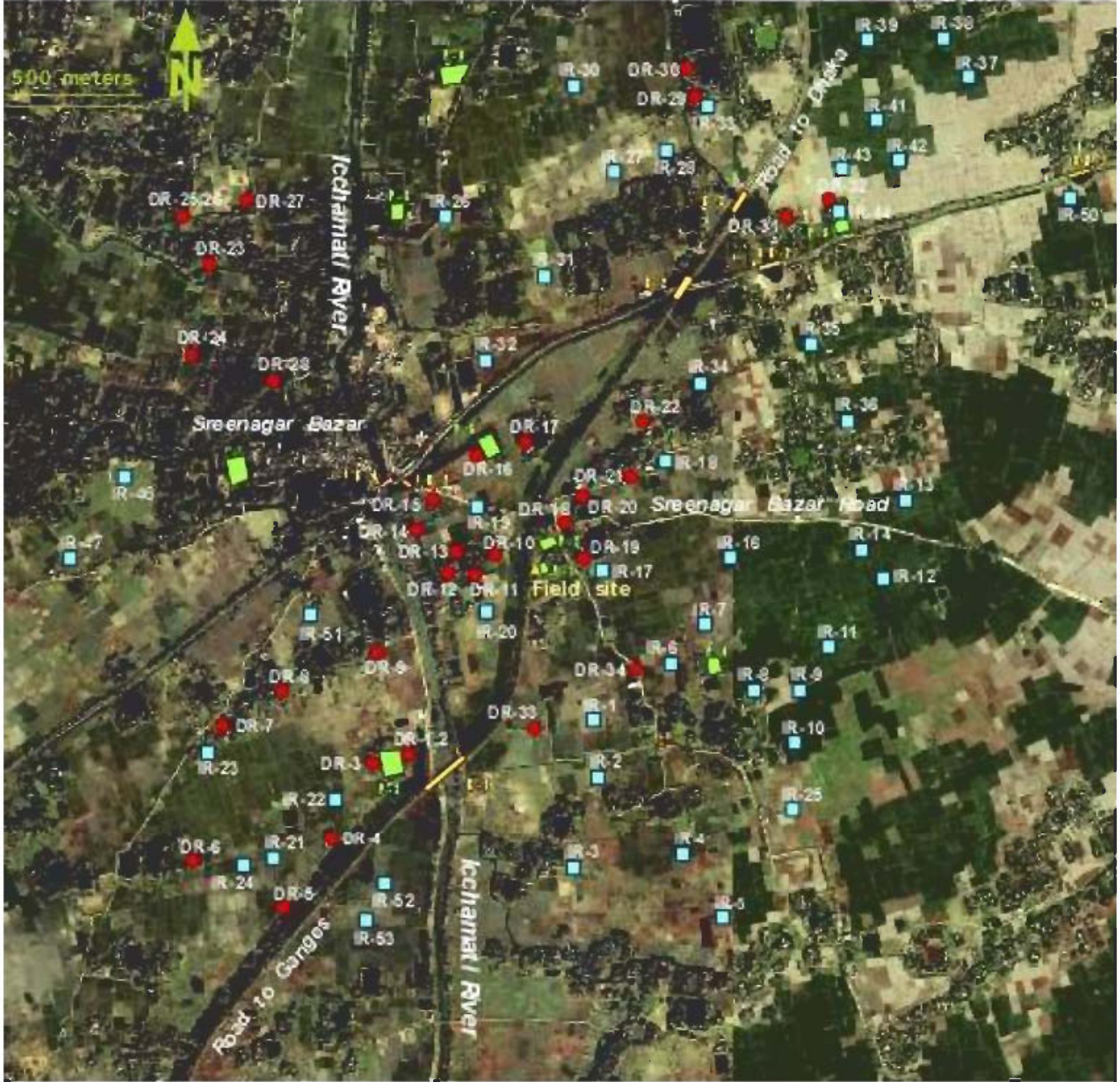
Bangladesh Case Study

- Supplemental slides


Map of Hydrological Regions
Legend
District Headquarter
District Boundary
Hydrological Region Boundary
N
Source
NWMP
Brahmaputra
Ganges
Dhaka
Munshigonj
PANCHAGARH
THAKURGAON
NILPHAMARI
LALMONIRHAT
KURIGRAM
RANGPUR
DINAJPUR
GAIBANDHA
JOYPURHAT
NAOGAON
BOGRA
JAMALPUR
SUNAMGANJ
SYLHET
NETRAKONA
MYMENSINGH
NAWABGANJ
SIRAJGANJ
KISHOREGANJ
MAULVIBAZAR
HABIGANJ
RAJSHAHI
NATORE
PABNA
KUSHTIA
GAZIPUR
BRAHAMANBARIA
NARSINGDI
MANIKGANJ
MEHERPUR
RAJBARI
CHUADANGA
FARIDPUR
NARAYANGANJ
JHENAIDAH
MAGURA
JESSORE
NARAIL
MADARIPUR
CHANDPUR
SHARIATPUR
KHAGRACHHARI
GOPALGANJ
LAKSHMIPUR
NOAKHALI
KHULNA
SATKHIRA
BAGERHAT
BARISAL
BHOLA
RAMGAMATI
PIROJPUR
JHALOKATI
PATUAKHALI
CHITTAGONG
BARGUNA
BANDARBAN
COX'S BAZAR
88°
90°
92°
26°
24°
22°
50 0 50 km


500 meters
N
Icchamati River
Sreenagar Bazar
Field site
Sreenagar Bazar Road
Road to Dhaka
Road to Ganges
Icchamati River
DR-1
DR-2
DR-3
DR-4
DR-5
DR-6
DR-7
DR-8
DR-9
DR-10
DR-11
DR-12
DR-13
DR-14
DR-15
DR-16
DR-17
DR-18
DR-19
DR-20
DR-21
DR-22
DR-23
DR-24
DR-25
DR-26
DR-27
DR-28
DR-29
DR-30
DR-31
DR-32
DR-33
DR-34
IR-1
IR-2
IR-3
IR-4
IR-5
IR-6
IR-7
IR-8
IR-9
IR-10
IR-11
IR-12
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IR-15
IR-16
IR-17
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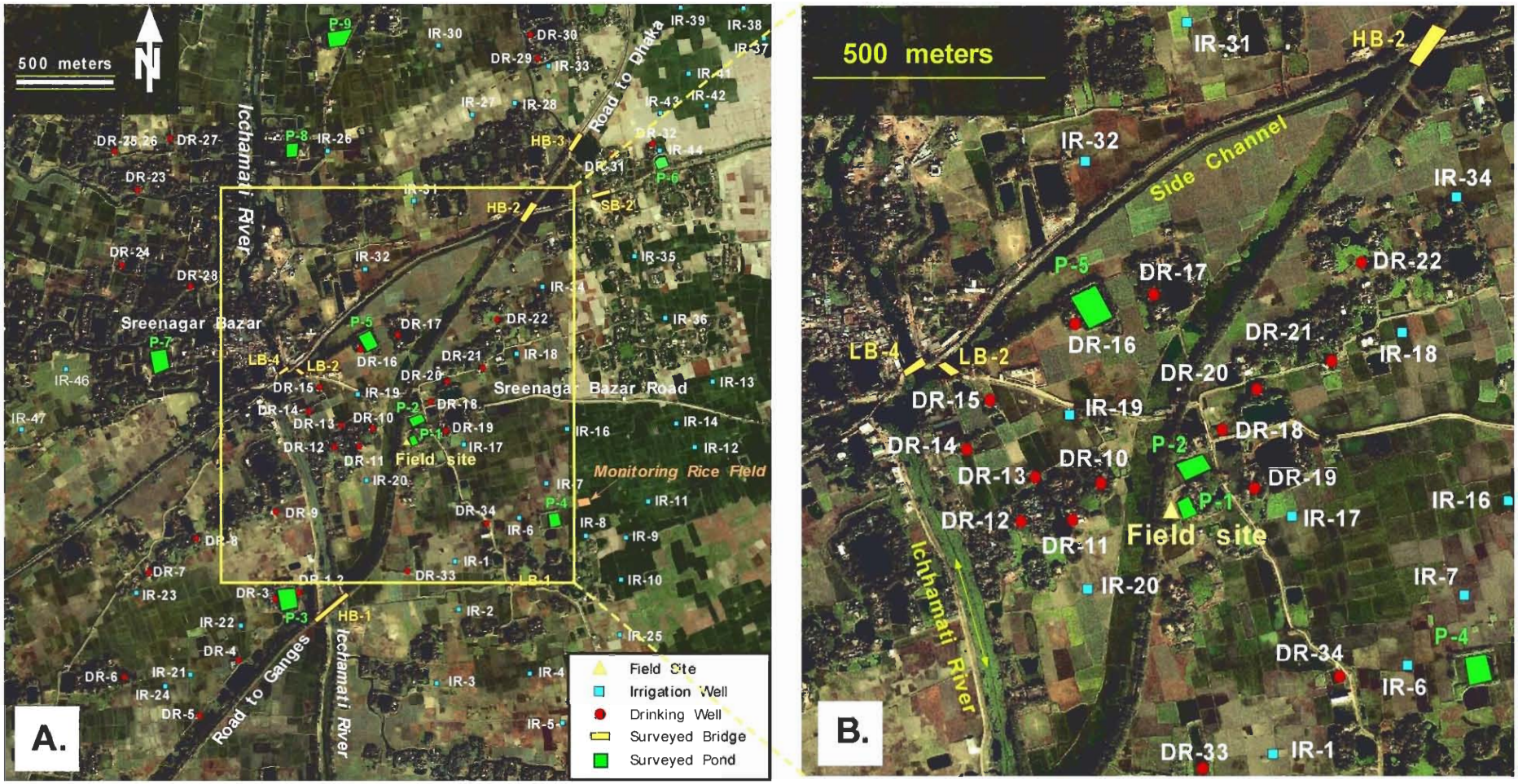
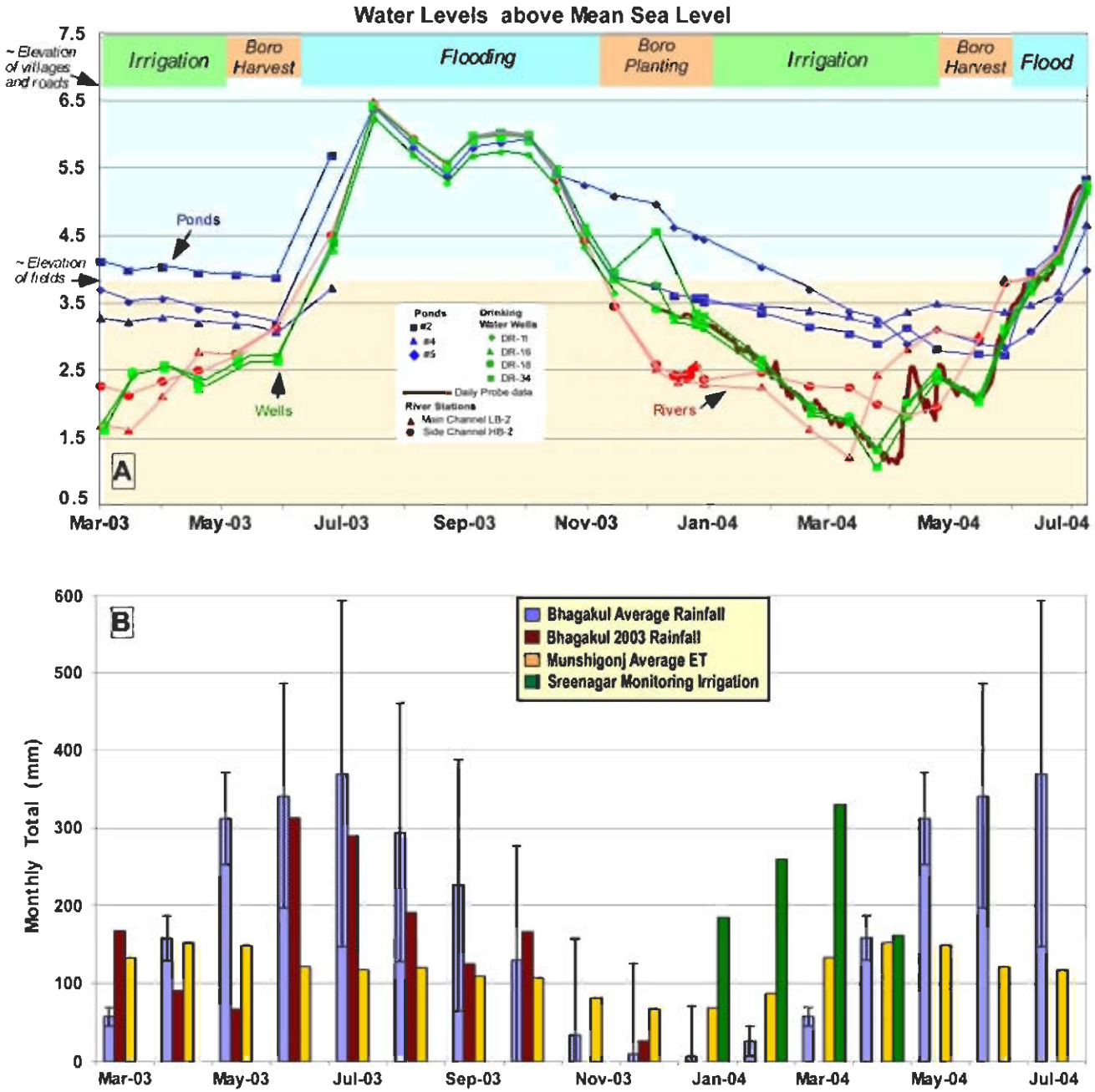
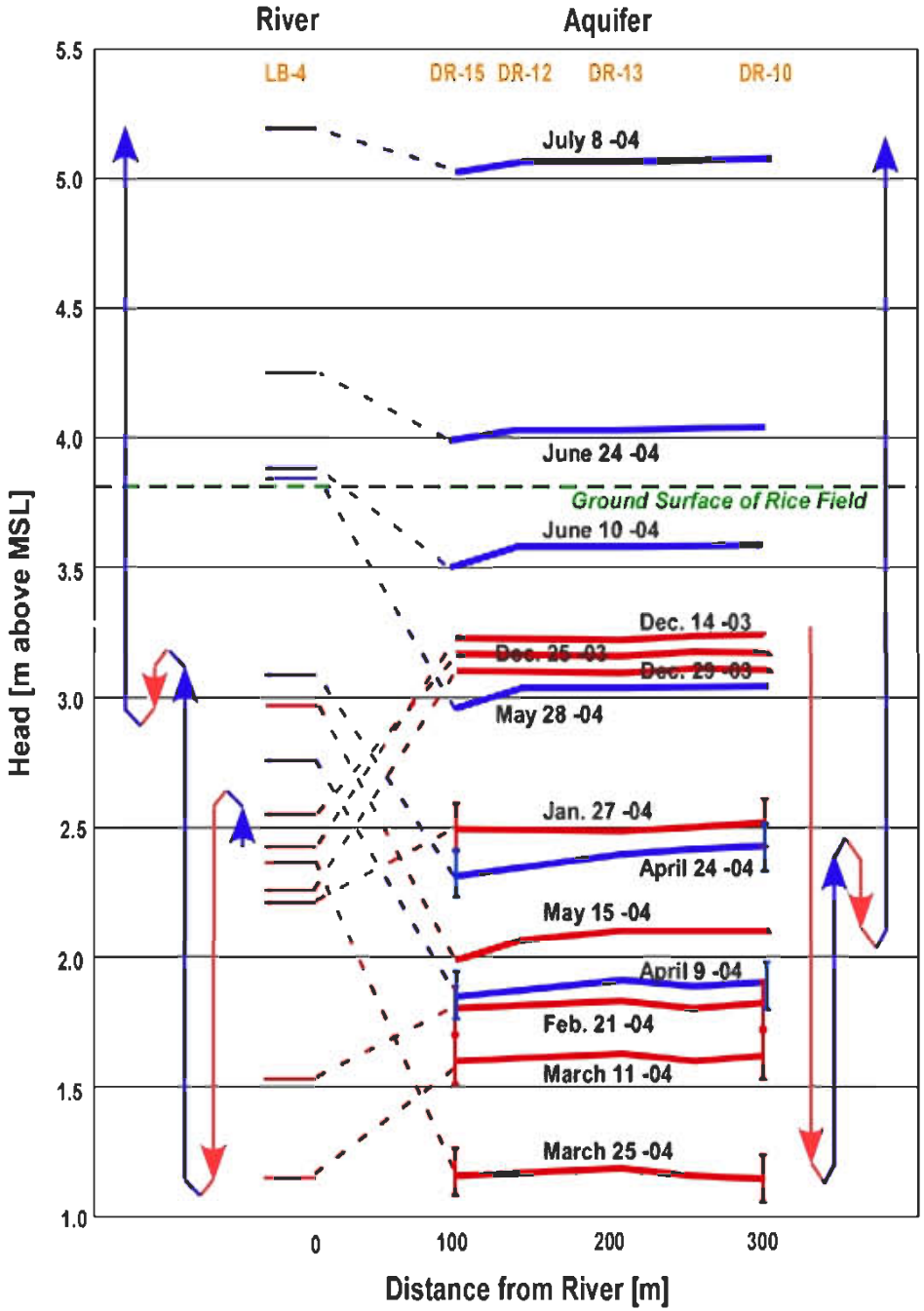
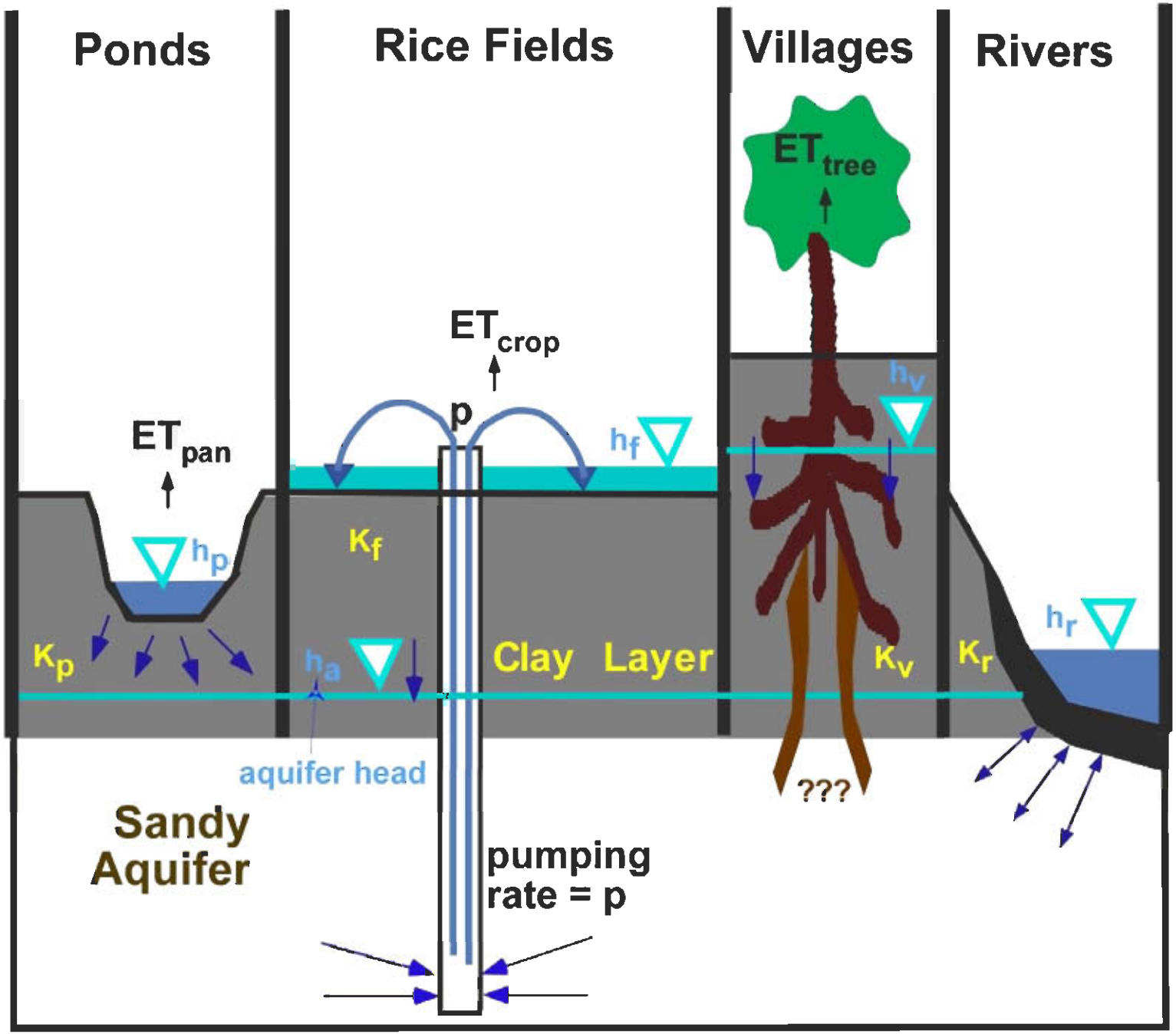
IR-50
IR-51
IR-52
IR-53


500 meters
N
Ichhamati River
Road to Dhaka
Road to Ganges
Sreenagar Bazar
Sreenagar Bazar Road
Field site
Monitoring Rice Field
HB-1
HB-2
HB-3
SB-2
LB-1
LB-2
LB-4
P-1
P-2
P-3
P-4
P-5
P-6
P-7
P-8
P-9
Field Site
Irrigation Well
Drinking Well
Surveyed Bridge
Surveyed Pond
A.
B.
Side Channel


Water Levels above Mean Sea Level
Irrigation
Boro Harvest
Flooding
Boro Planting
Irrigation
Boro Harvest
Flood
~ Elevation of villages and roads
~ Elevation of fields
Ponds
Wells
Rivers
A
B
Bhagakul Average Rainfall
Bhagakul 2003 Rainfall
Munshigonj Average ET
Sreenagar Monitoring Irrigation
Monthly Total (mm)
Mar-03
May-03
Jul-03
Sep-03
Nov-03
Jan-04
Mar-04
May-04
Jul-04


River
Aquifer
LB-4
DR-15
DR-12
DR-13
DR-10
July 8 -04
June 24 -04
Ground Surface of Rice Field
June 10 -04
Dec. 14 -03
Dec. 25 -03
Dec. 29 -03
May 28 -04
Jan. 27 -04
April 24 -04
May 15 -04
April 9 -04
Feb. 21 -04
March 11 -04
March 25 -04
Head [m above MSL]
Distance from River [m]
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0
100
200
300


Ponds
Rice Fields
Villages
Rivers
ET tree
ET crop
p
ET pan
h f
h v
h p
K f
K p
h a
Clay Layer
K v
K r
h r
aquifer head
???
Sandy Aquifer
pumping rate = p

The lumped-parameter model couples the mass-balance equation for the aquifer with that for irrigated fields, ponds, and non-irrigated areas

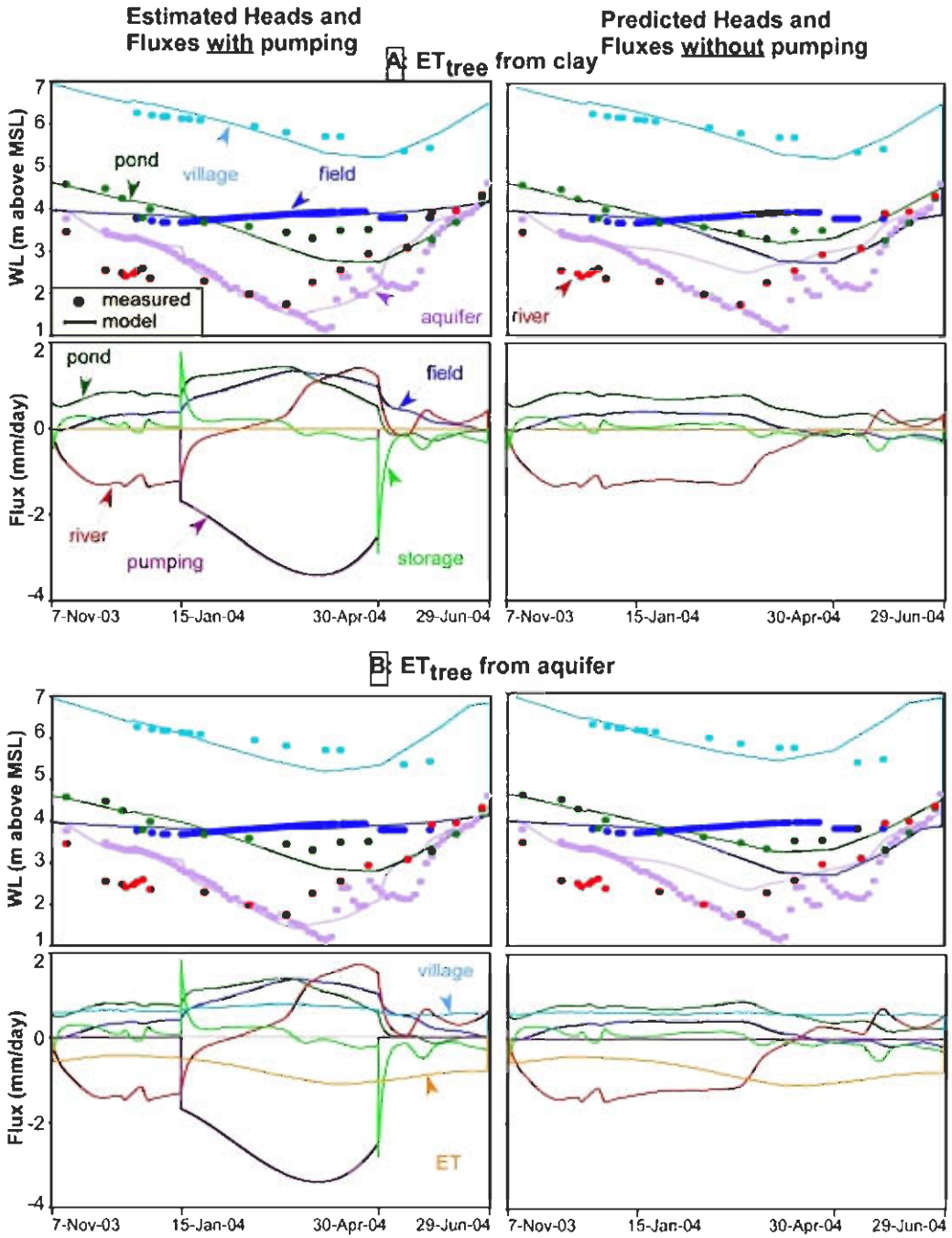
Aquifer:

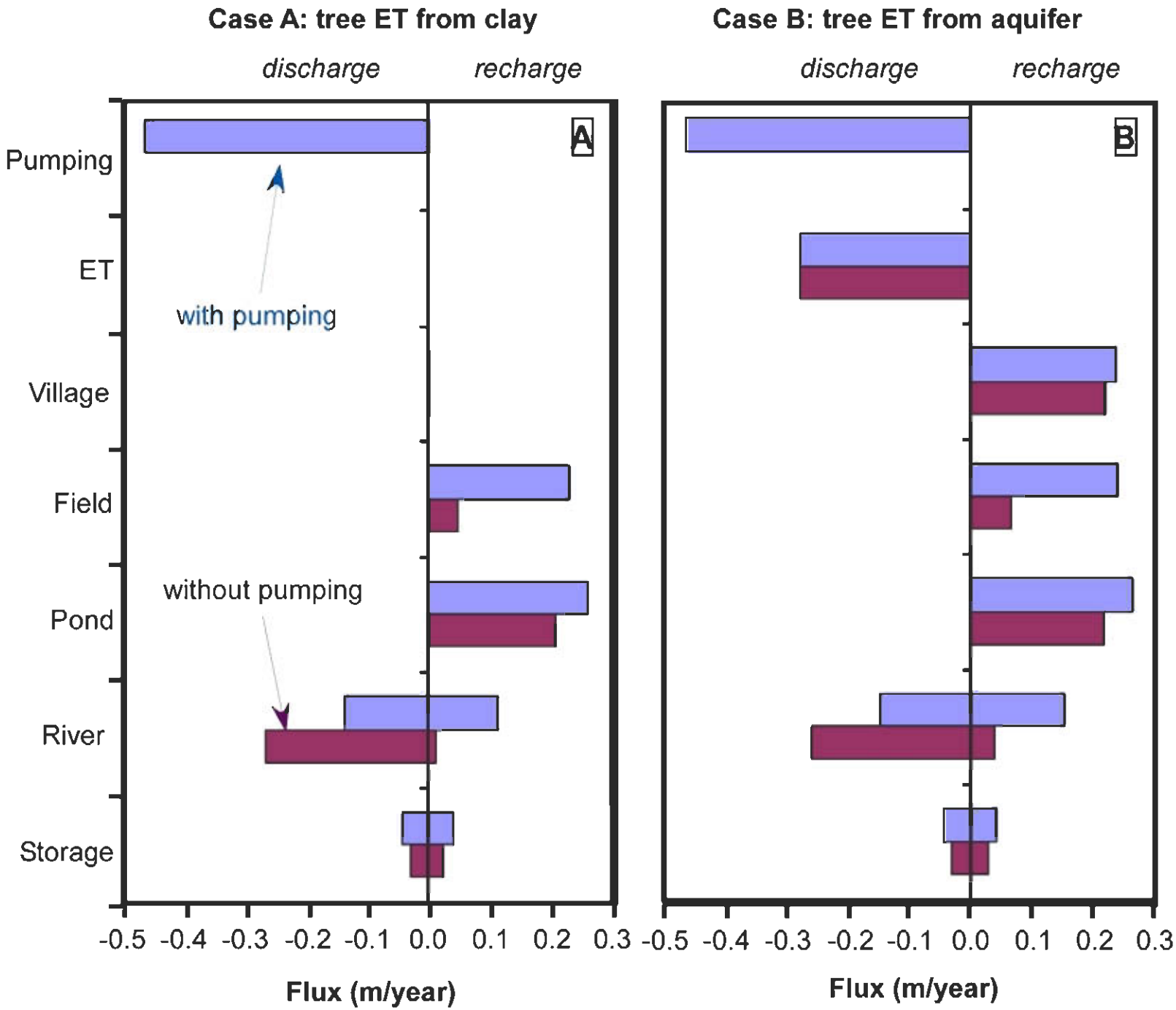
$$S\frac{dh_a}{dt} = \left(h_f - h_a\right)K_f f_f + \left(h_p - h_a\right)K_p f_p + \left(h_r - h_a\right)K_r f_r + \left(h_v - h_a\right)K_v f_v - q_I - f_{av}\alpha_v ET_0$$

Village: $$S_y \frac{dh_v}{dt} = \left(h_a - h_v\right)K_v - \left(1 - f_{av}\right)\alpha_v ET_0 + R$$

Field: $$S_y \frac{dh_f}{dt} = \left(h_a - h_f\right)K_f - \alpha_f ET_0 + R + \frac{q_I}{f_f}$$

Pond: $$\frac{dh_p}{dt} = \left(h_a - h_p\right)K_p - \alpha_p ET_0 + R$$


Estimated Heads and Fluxes with pumping
Predicted Heads and Fluxes without pumping
A: ET tree from clay
WL (m above MSL)
pond
village
field
measured
model
aquifer
river
Flux (mm/day)
pond
field
river
pumping
storage
7-Nov-03
15-Jan-04
30-Apr-04
29-Jun-04
B: ET tree from aquifer
village
ET


Case A: tree ET from clay
discharge
recharge
A
Pumping
ET
Village
Field
Pond
River
Storage
with pumping
without pumping
-0.5 -0.4 -0.3 -0.2 -0.1 0.0 0.1 0.2 0.3
Flux (m/year)
Case B: tree ET from aquifer
discharge
recharge
B
-0.5 -0.4 -0.3 -0.2 -0.1 0.0 0.1 0.2 0.3
Flux (m/year)

		Case-A	Case-B
		Village ET_{tree} from clay	Village ET_{tree} from aquifer
K_f (1/d) [conductance for field]		8.9e-4	8.9e-4
K_v (1/d) [conductance for village]		6.3e-6	9.1e-4
K_p (1/d) [conductance for pond]		9.3e-3	8.3e-3
K_r (1/d) [conductance for river]		7.7e-2	8.7e-2
Objective Function	***w/ pumping***	5.9e-1	5.7e-1
Residence Time (yrs)	***w/ pumping***	***19***	***13***
	w/o pumping	***42***	***22***