Watershed Modeling and Biomonitoring to Determine Optimal Restoration Strategies for Intermitted Transboundary Streams between Palestine and Israel

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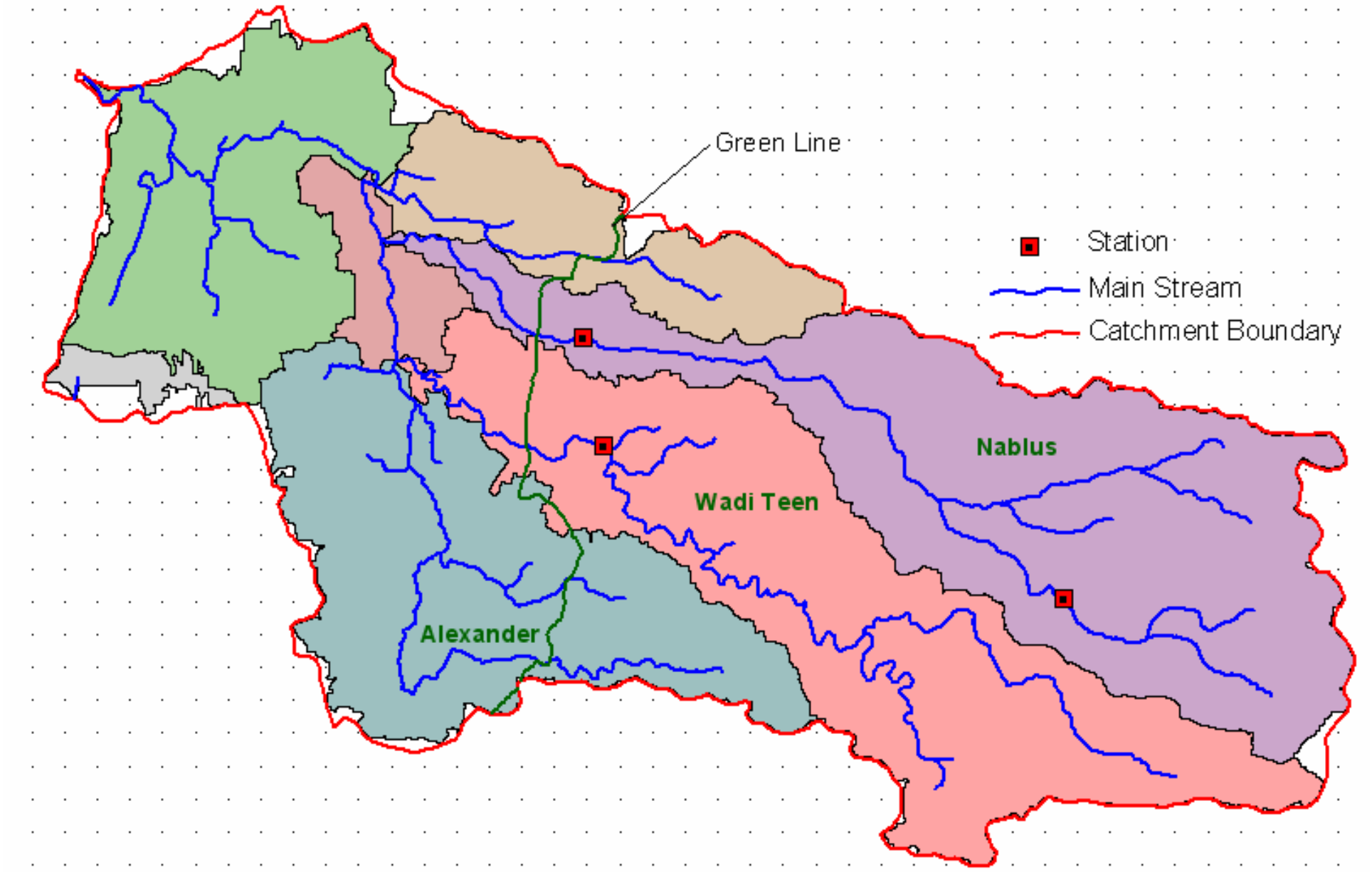
Stage One : Selection the Monitored Streams

- The Palestinian-Israeli research teams selected sites and streams.
- They drew up an inventory of wastewater treatment facilities discharging into the transboundary streams, finalized monitoring protocols and timetable.
- The selected streams in the two catchments are:-
  - Alexander Catchment: (Wadi Alexander Wadi Zeimar and Wadi Al Teen) in the North of the West Bank.
  - Besor Catchment: (Wadi Hebron) in the South of the West Bank.
- It has been decided that we are going to model Wadi Zeimar and Wadi Al Teen in Alexander Catchment.



Three main sub basins (Zeimar, Wadi Teen and Alexander) were defined to be modeled.

Stage Two : Collection and Inventory of all Available Monitoring Data

- The main flow of Wadi Zeimar is wastewater discharged from the localities along the wadi mainly from Nablus City (in winter, the wastewater mixes with rainfall runoff), so the following data were collected:
  - Wastewater generation from the Palestinian localities and Israeli Settlements.
  - Their water quality.

- There are many point sources of pollution in Alexander Catchment that are highly polluting the water, these:
  - Stone cutting.
  - Dumping Sites (mainly Tulkarem Dumping Site).
  - Olive mills.
  - Gas Stations.
  - Cesspits.

- The coordinates of most of these point sources of pollution were determined by using MAGELLAN /eXplorist 100 GPS, with accuracy ranges between 3-20 meters.

Tulkarem Dumping Site

The Effect of Stone Cutting

Wastewater Wadis as Hotspots

- Wastewater Wadis Versus wells
- Effect of Zeimar on GW in the WAB
- Wadis affect wells of Eastern Basin (AL FAR'A)

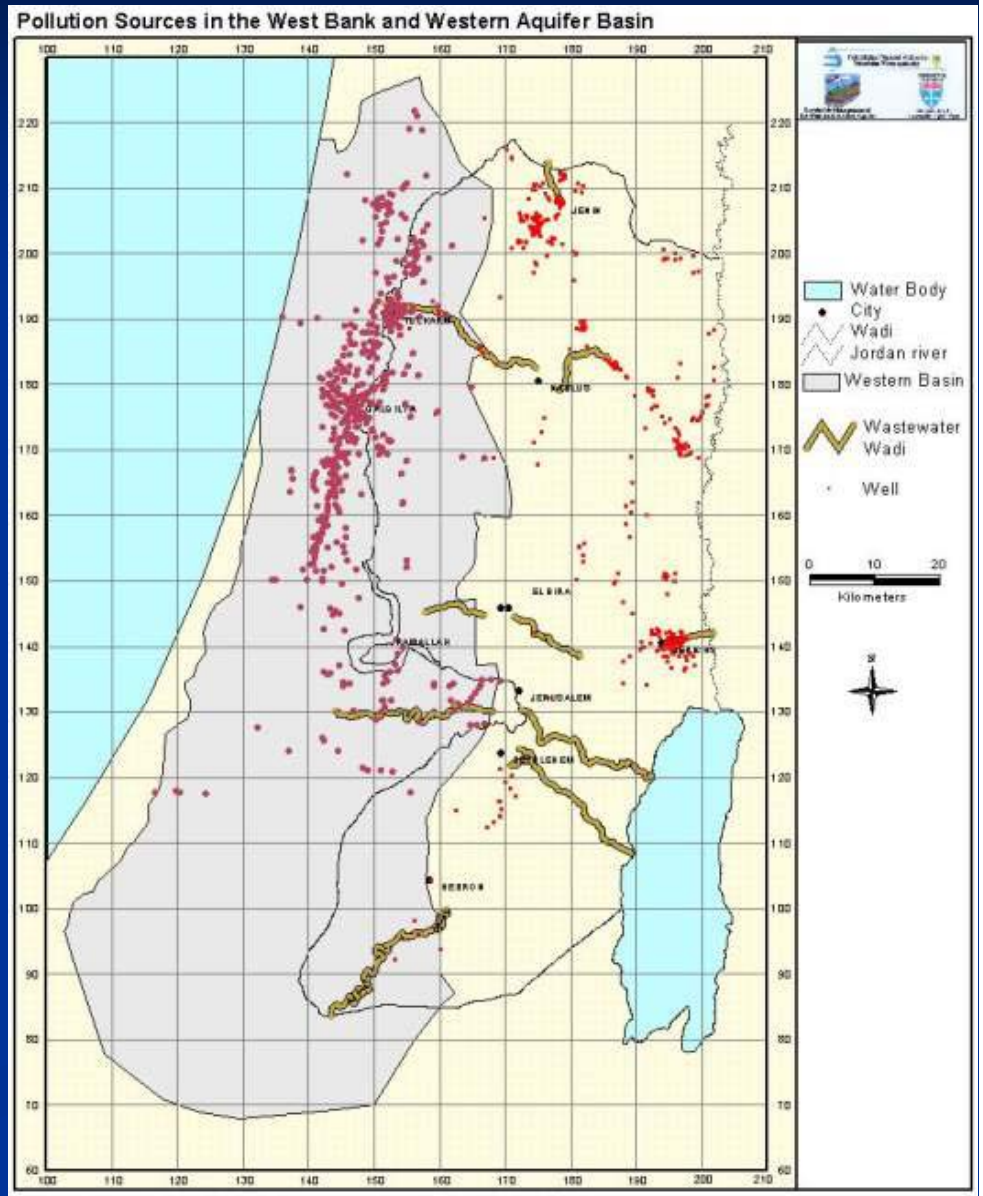
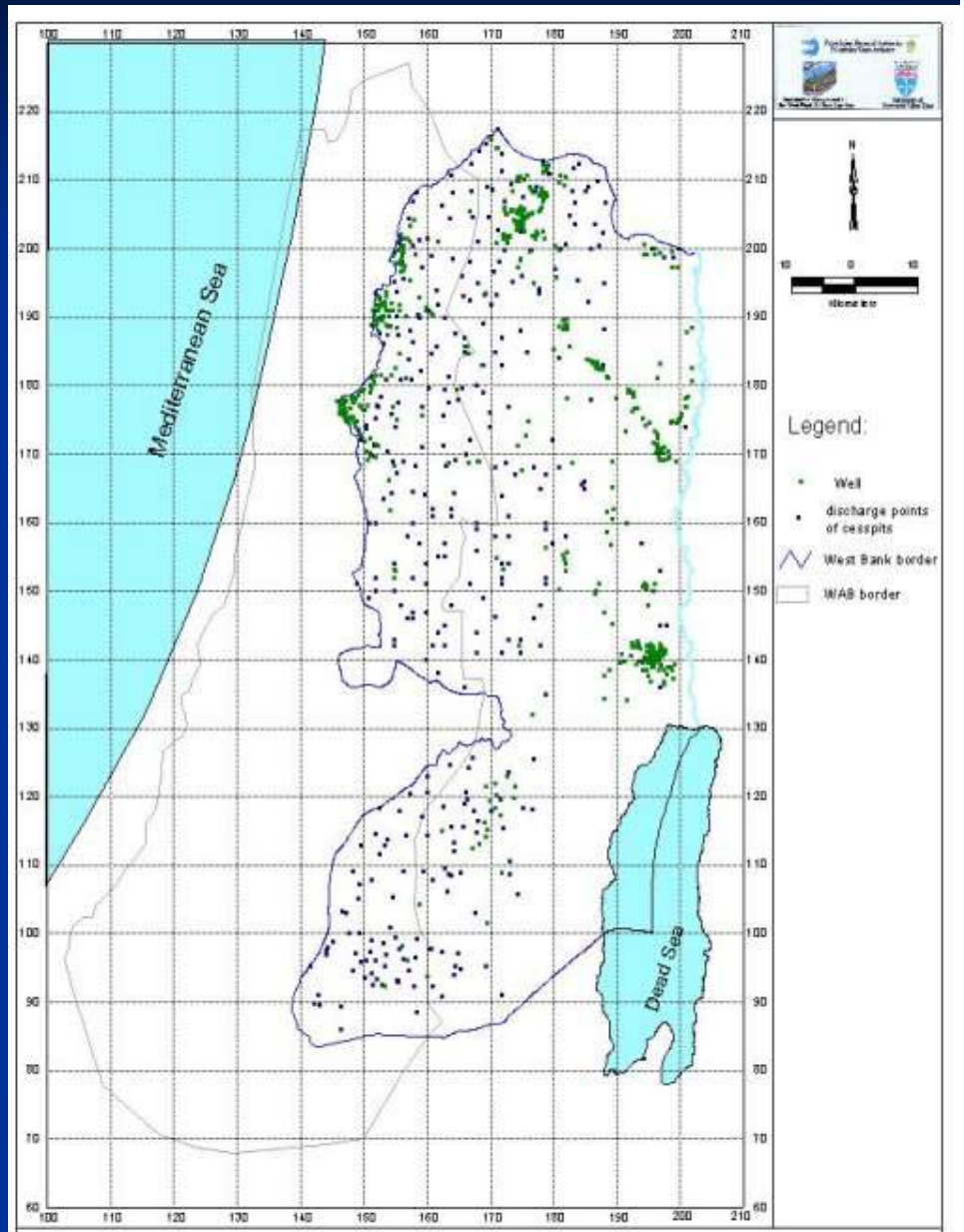


Figure 5: Wastewater Wadis versus Wells in the Study Area

Discharge Points of Cesspits

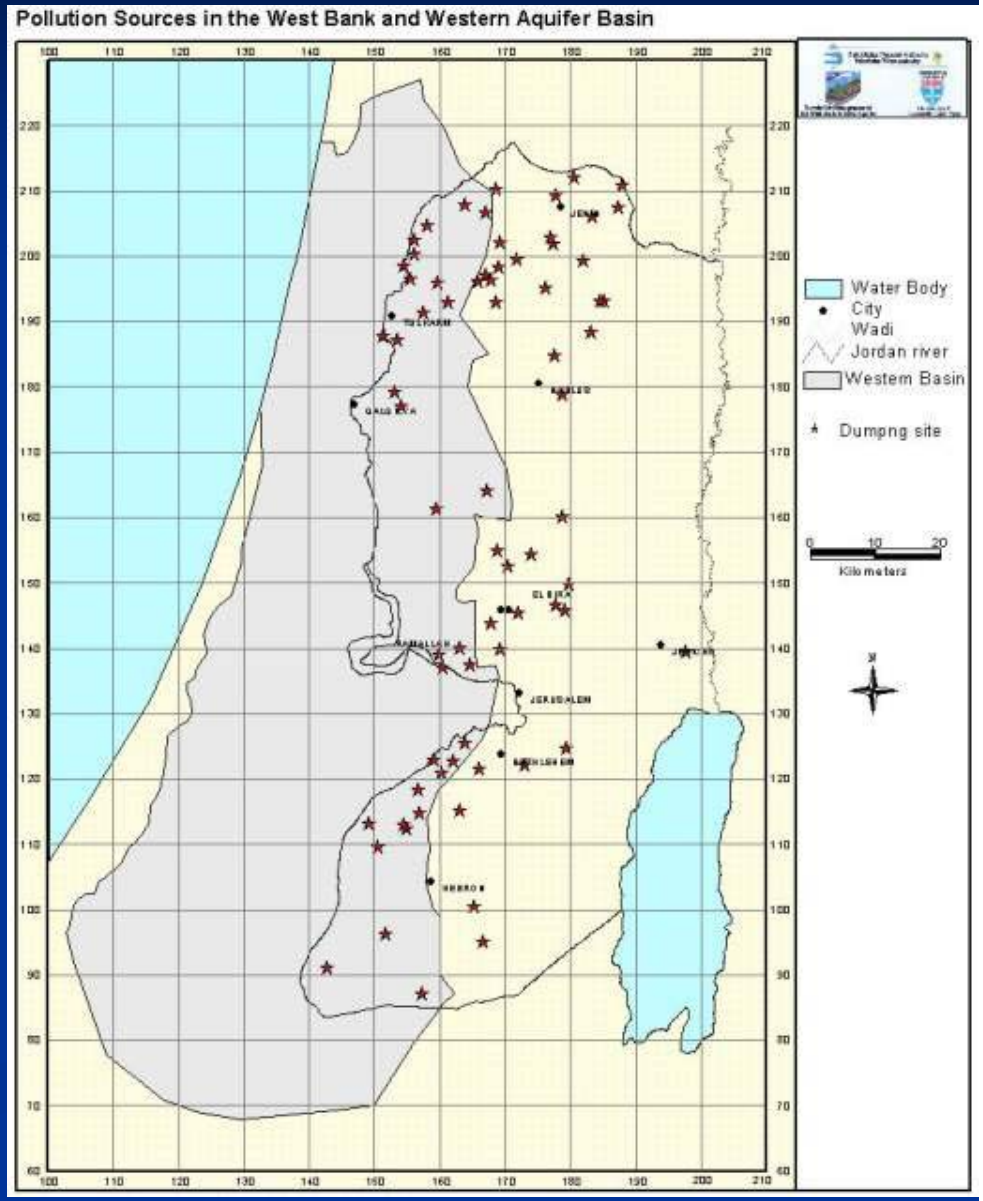
Intensive, *could affect water quality specially for shallow aquifers such as Pleistocene in Jericho, Eocene in Jenin and Quaternary in Qalqilya and Tulkarem*



Map 6: Discharge points of cesspits vs wells in West Bank

Location of the Dumping Sites

Characterized by diversity of pollutants from the solid wastes



Location of the WW Networks

There are just some points of sewer discharge points from networks,

But

with relatively high discharge since they are connected to the main cities.

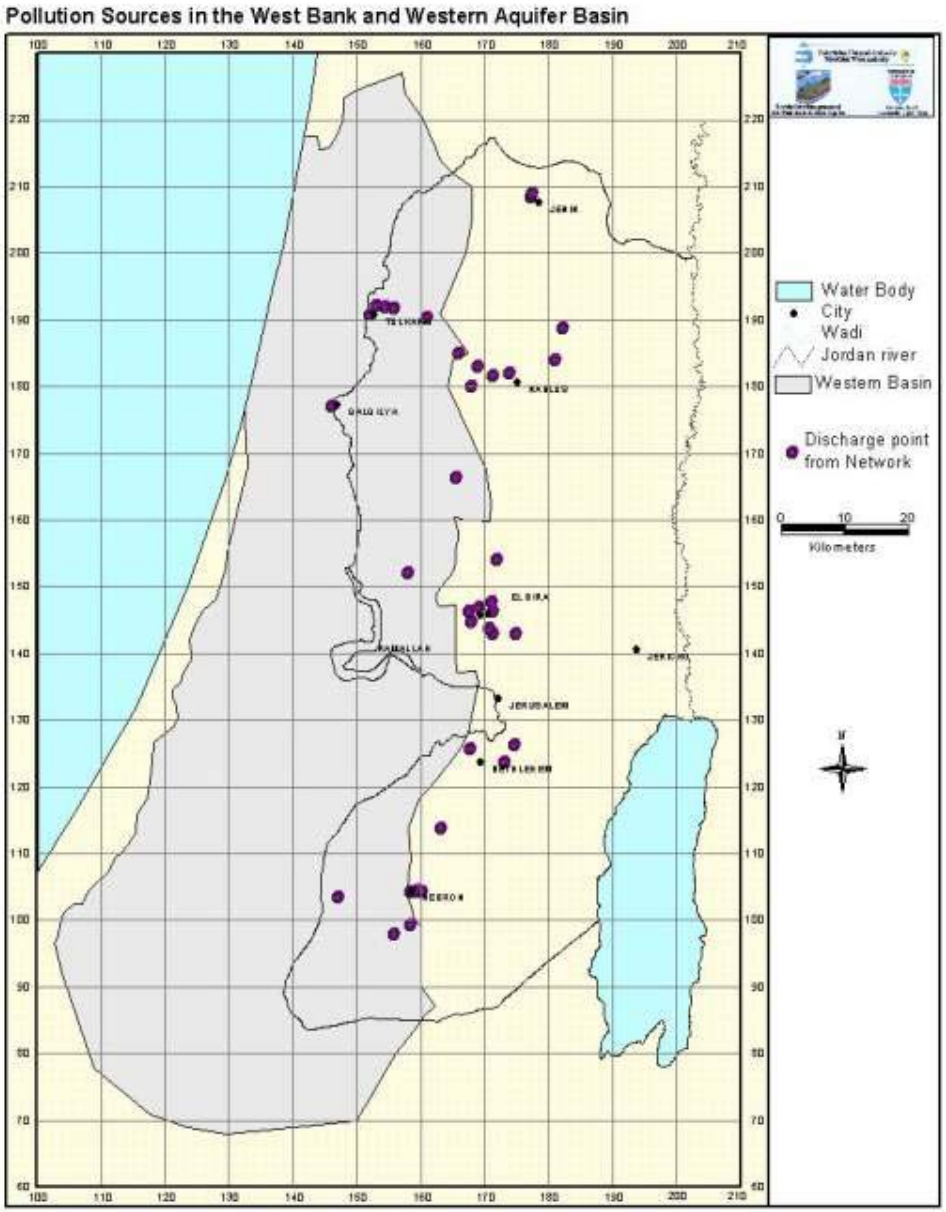


Figure 2: Discharge points from Networks

Pollution inputs in relation to Abstractions

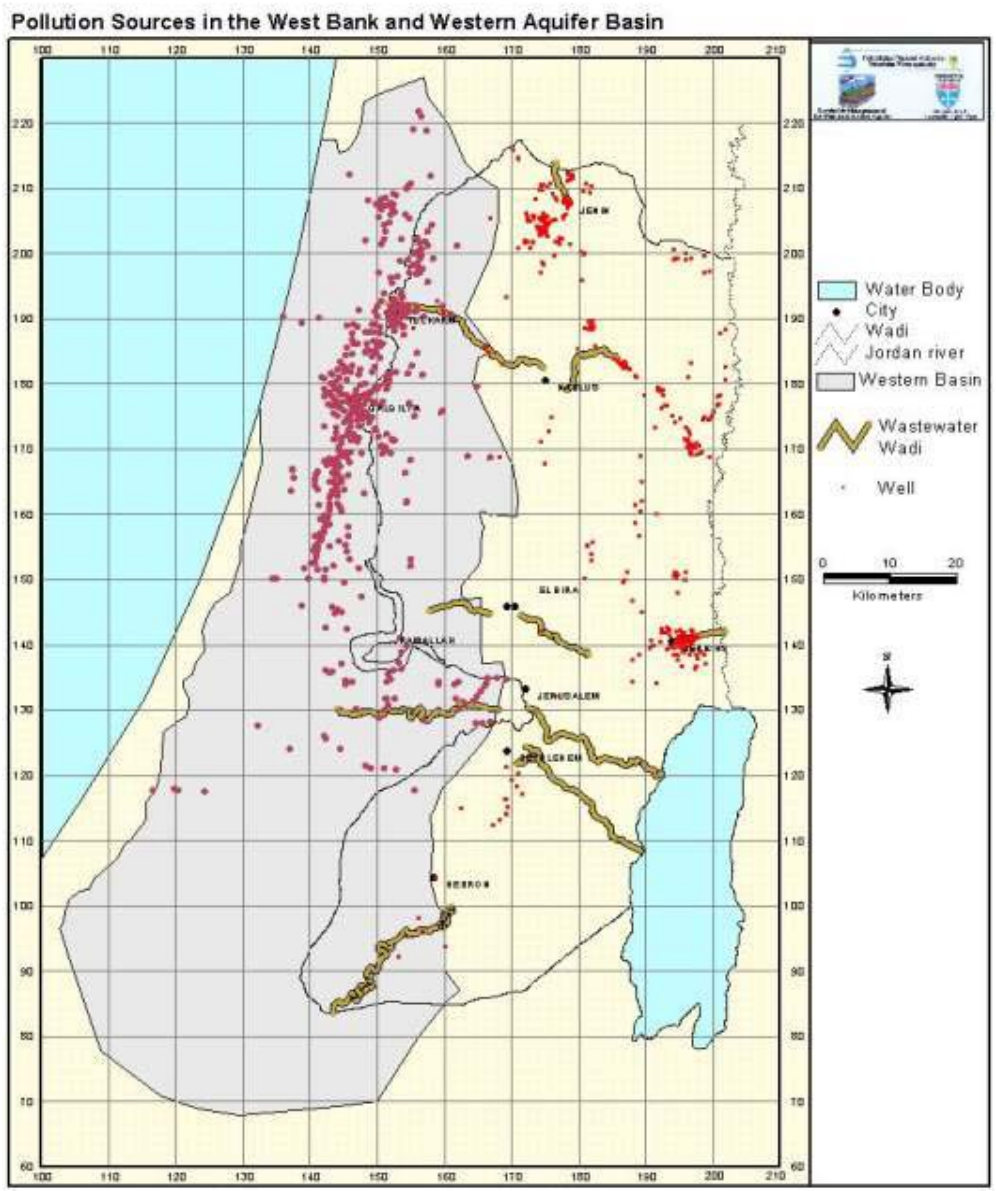
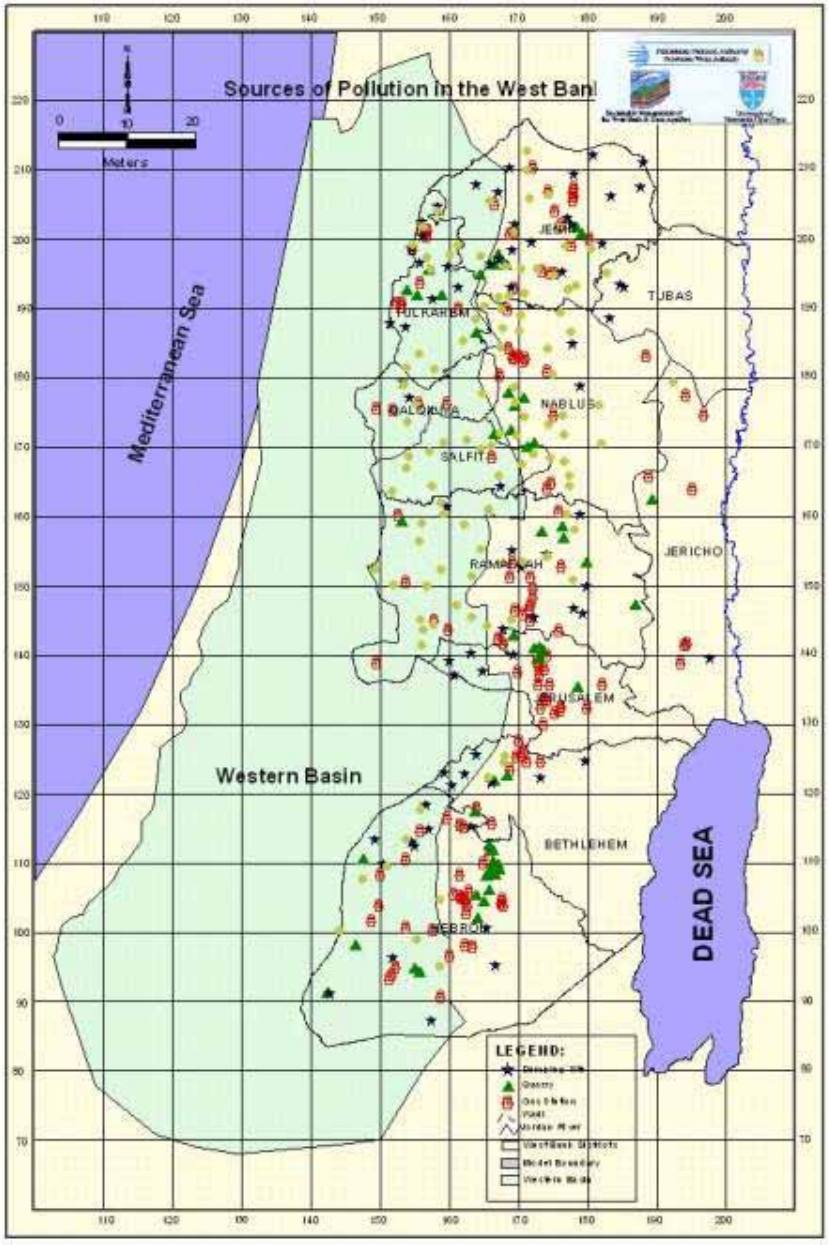
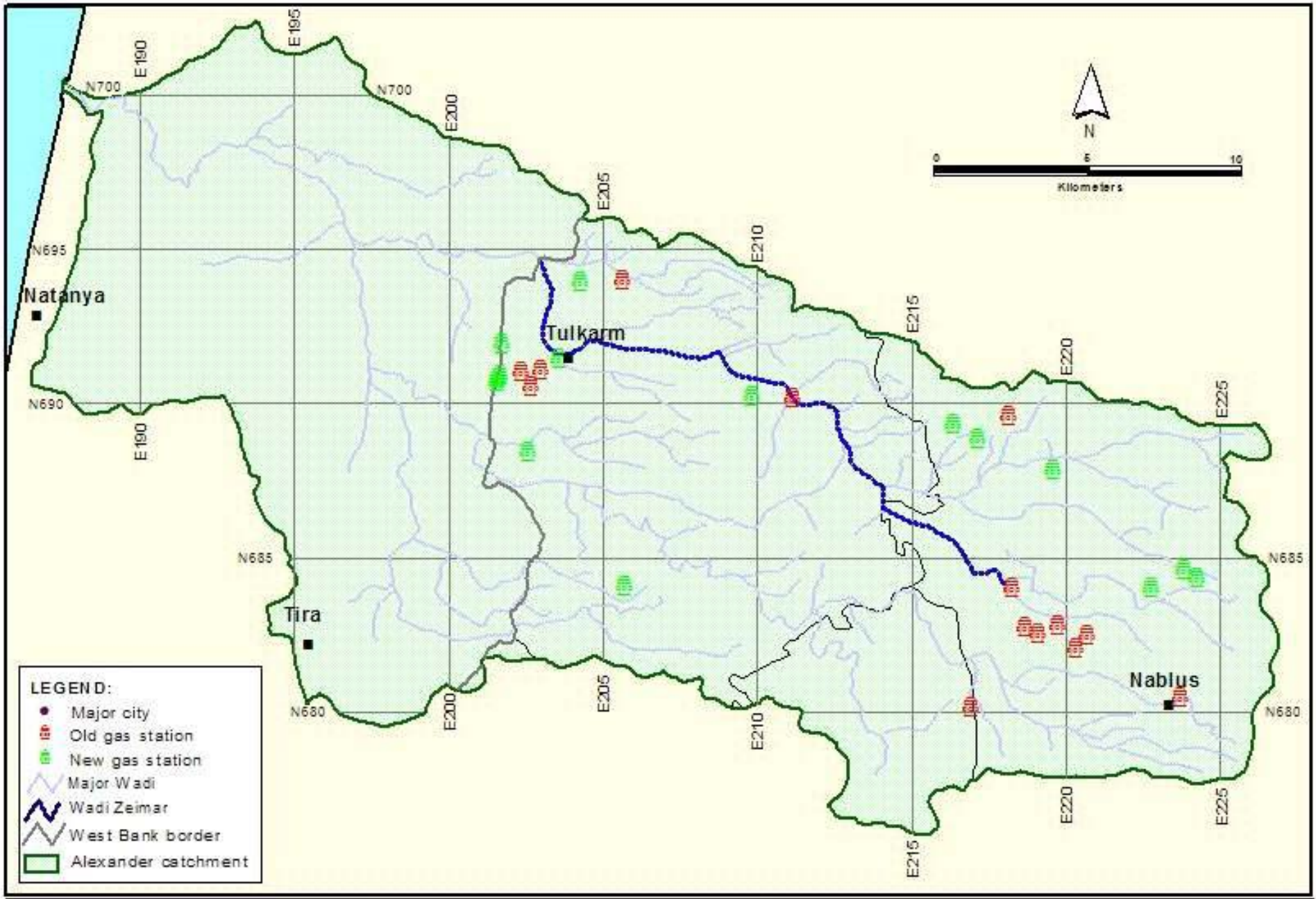


Figure 5: Wastewater Wadis versus Wells in the Study Area

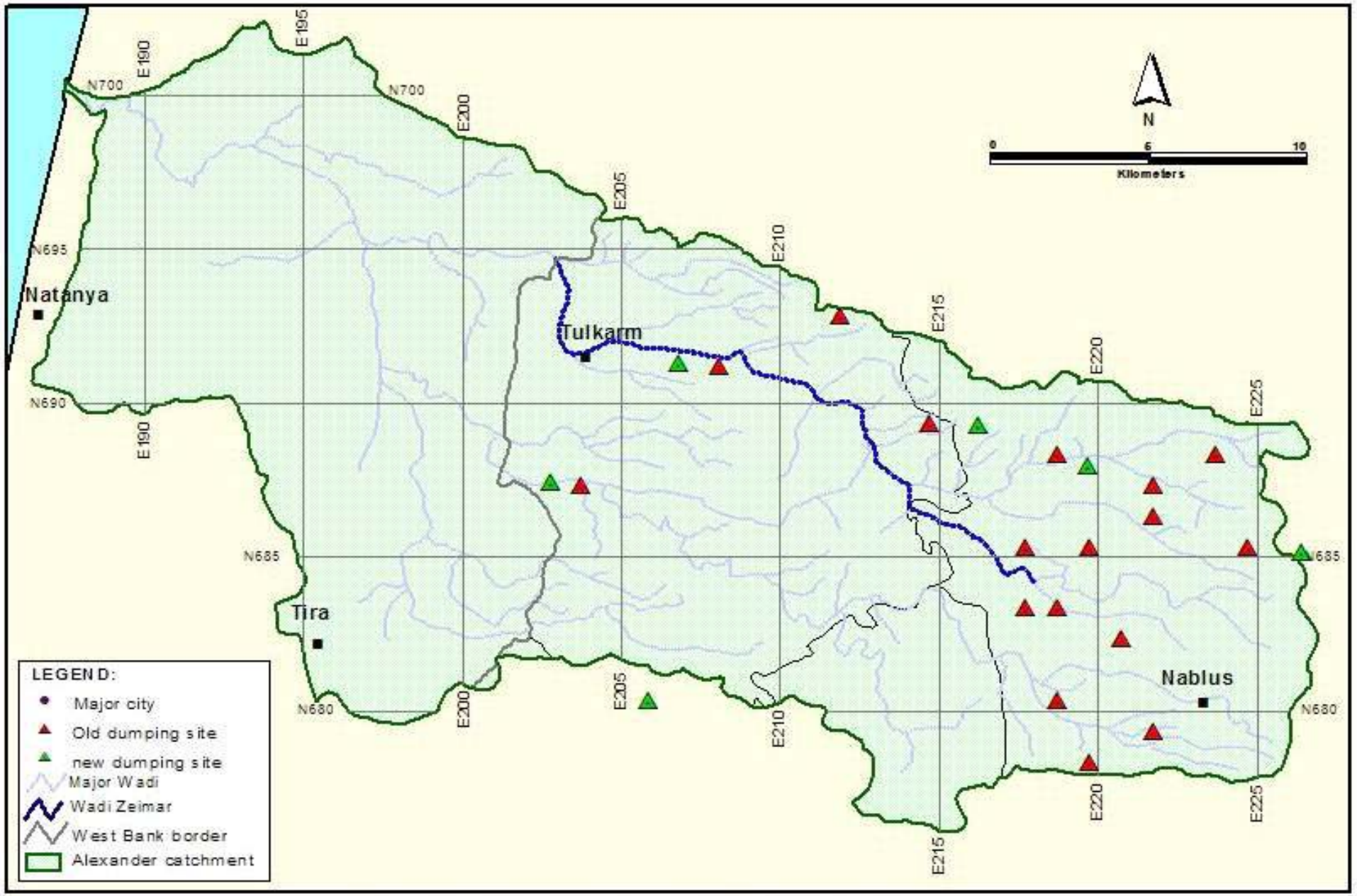
Hazard hot spots occur where pollution sources are in sensitive areas in proximity to abstractions



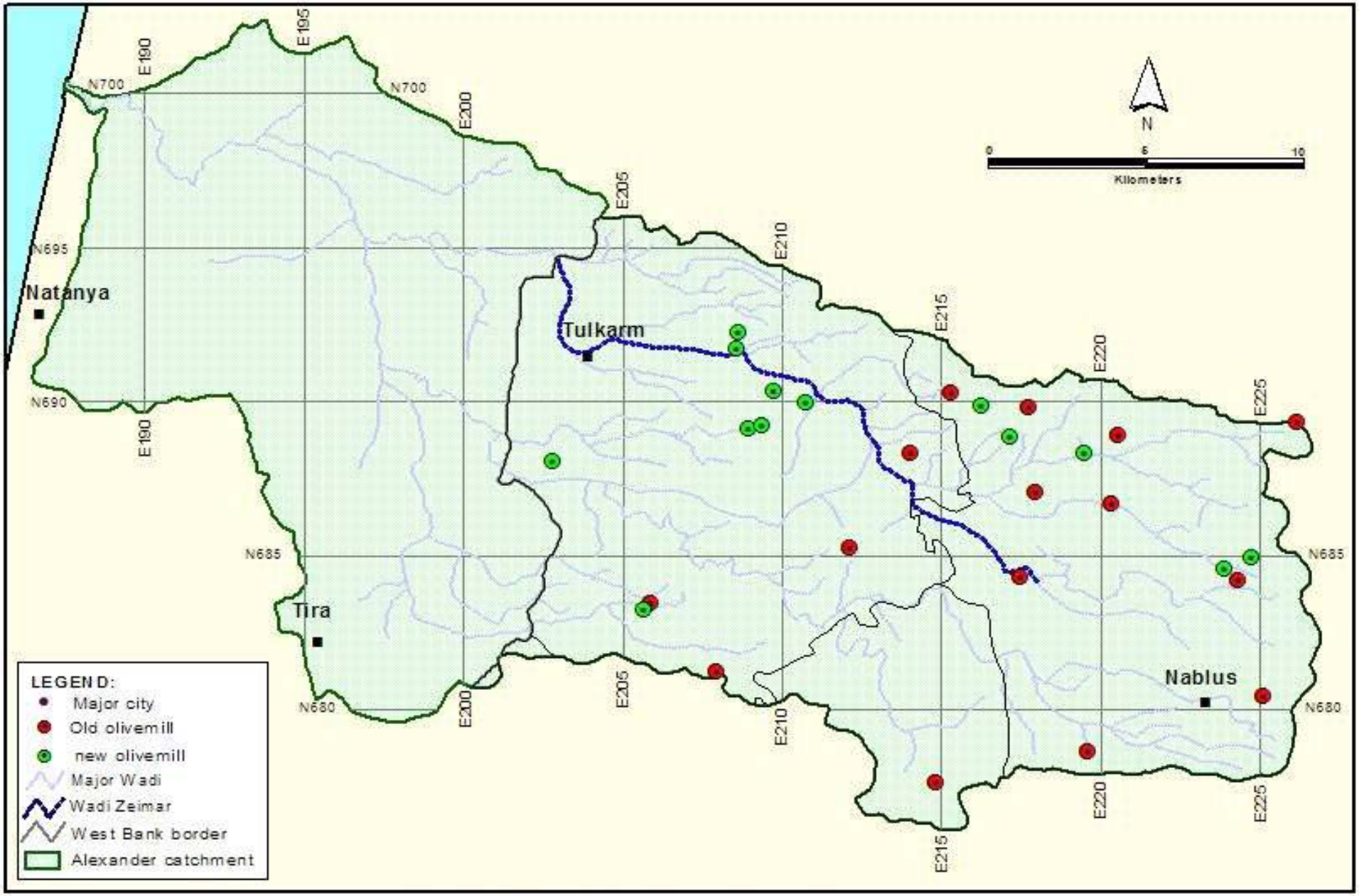
Locations of Gas stations, quarries, dumping sites and olive mills in the WB



Location of Gas stations at the catchment area



Location of dumping sites at the catchment area



Location of olivemills in the catctchment area

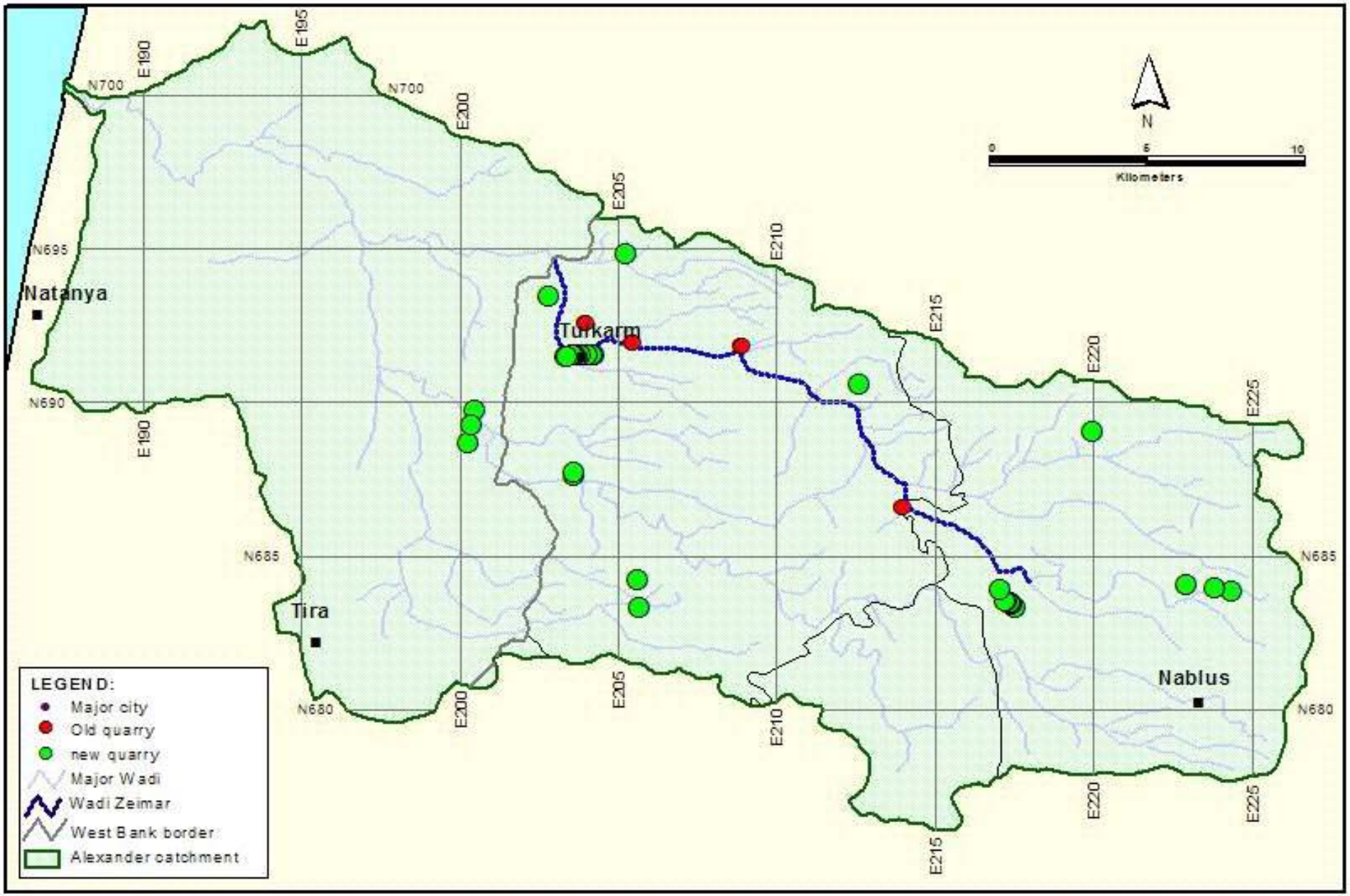


Figure5: Location of quarries at the catchment area

Stage Three : Preparing Data-base Framework

- The collected data are to be organized in a dada-base framework as shown below

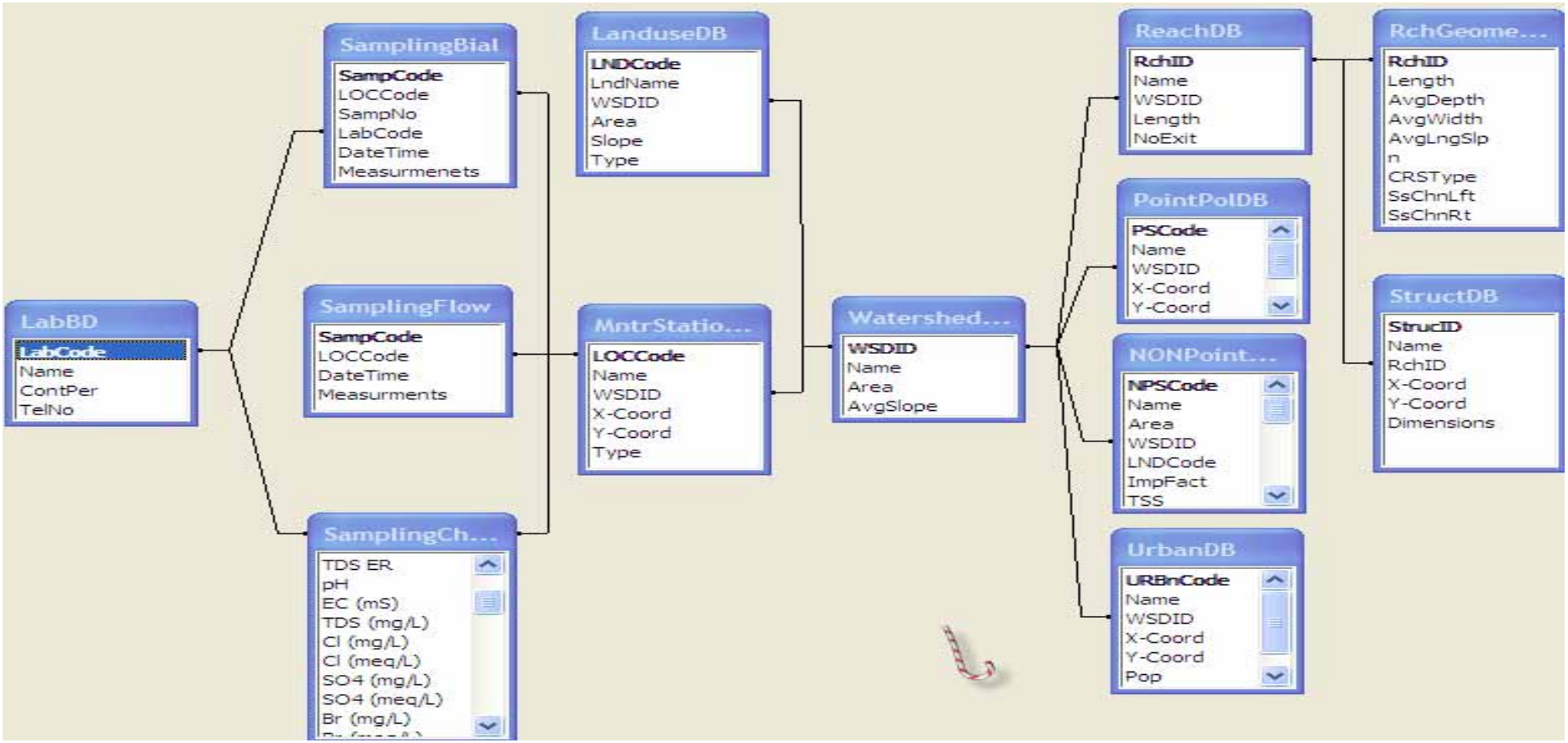


Table 1 (WatershedDB): Watershed database, Contains information of all sub-watersheds within the main watershed.

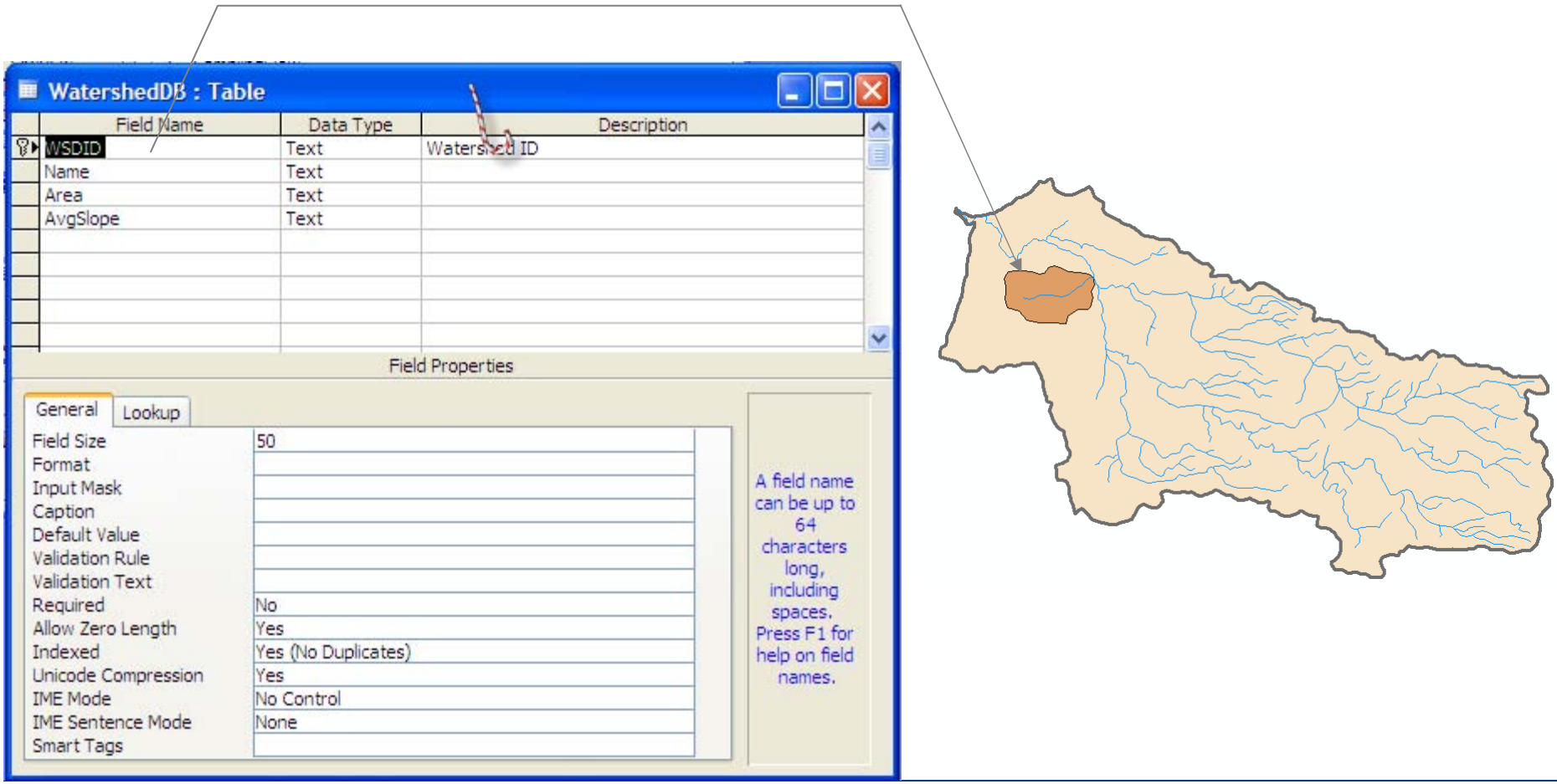


Table 2 (ReachDB): Reach (river segment) database

ReachDB : Table

Field Name	Data Type	Description
RchID	Text	Reach code
Name	Text	
WSDID	Text	Watershed Code
Length	Number	
NoExit	Number	Number of exits

Field Properties

General | Lookup

Field Size	50
Format	
Input Mask	
Caption	
Default Value	
Validation Rule	
Validation Text	
Required	No
Allow Zero Length	Yes
Indexed	Yes (No Duplicates)
Unicode Compression	Yes
IME Mode	No Control
IME Sentence Mode	None
Smart Tags	

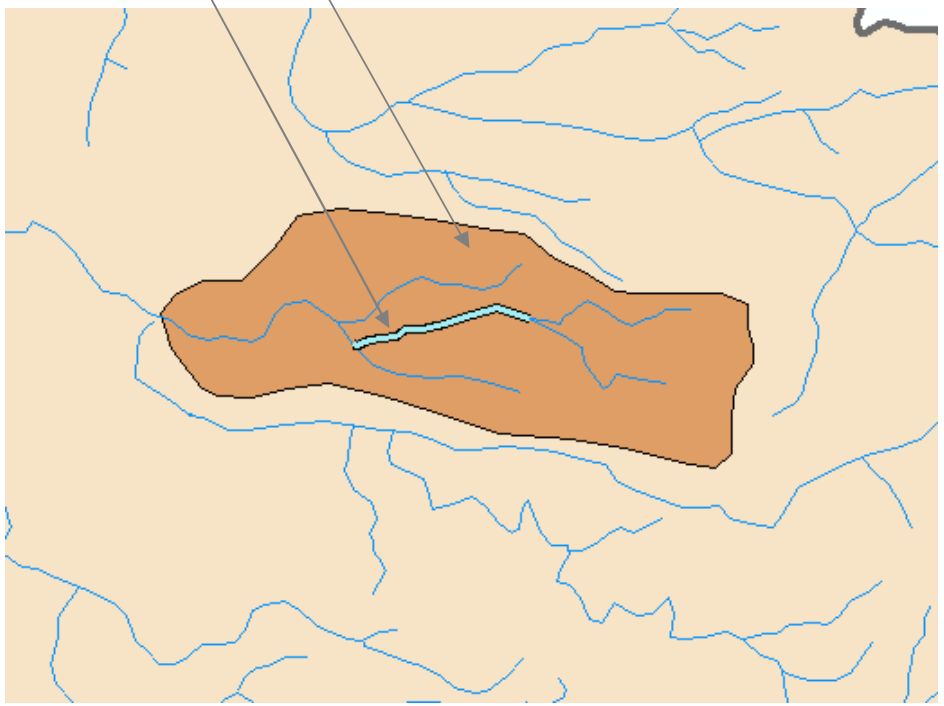


Table 3 (RchGeometryDB): Geometrical description of Reachs (river segments) within the main watershed

RchGeometryDB : Table

Field Name	Data Type	Description
RchID	Text	Reach Code
Length	Text	
AvgDepth	Text	
AvgWidth	Text	
AvgLngSlp	Text	Average long slope
n	Text	Mannings Roughness Coeff.
CRSType	Text	Type of x-section (Trapezoidal, Rectangular, ...)
SsChnLft	Text	Side slope of channel left
SsChnRt	Text	Side slope of channel Right

Field Properties

General | Lookup

Field Size	50
Format	
Input Mask	
Caption	
Default Value	
Validation Rule	
Validation Text	
Required	No
Allow Zero Length	Yes
Indexed	Yes (No Duplicates)
Unicode Compression	Yes
IME Mode	No Control
IME Sentence Mode	None
Smart Tags	

A field name can be up to 64 characters long, including spaces. Press F1 for help on field names.

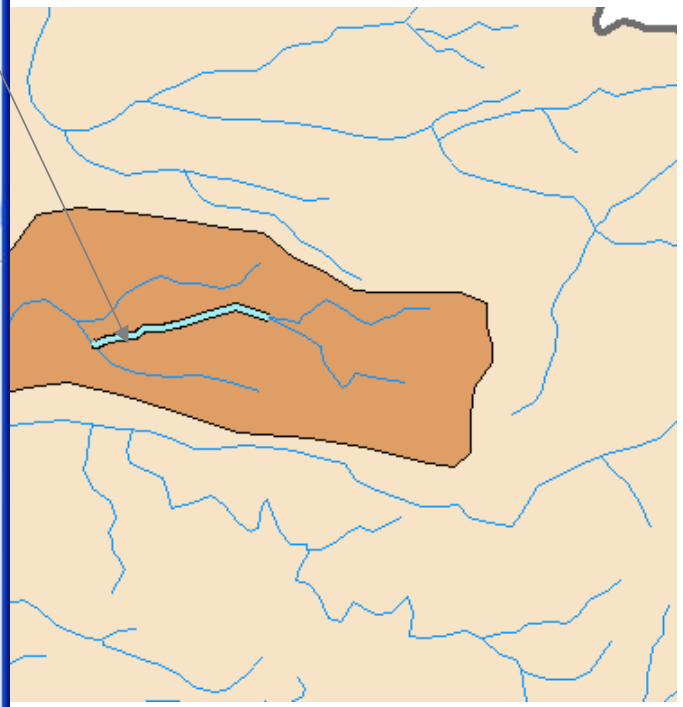


Table 4 (StructDB): Structural database: Locations and Description of all structures within all reaches.

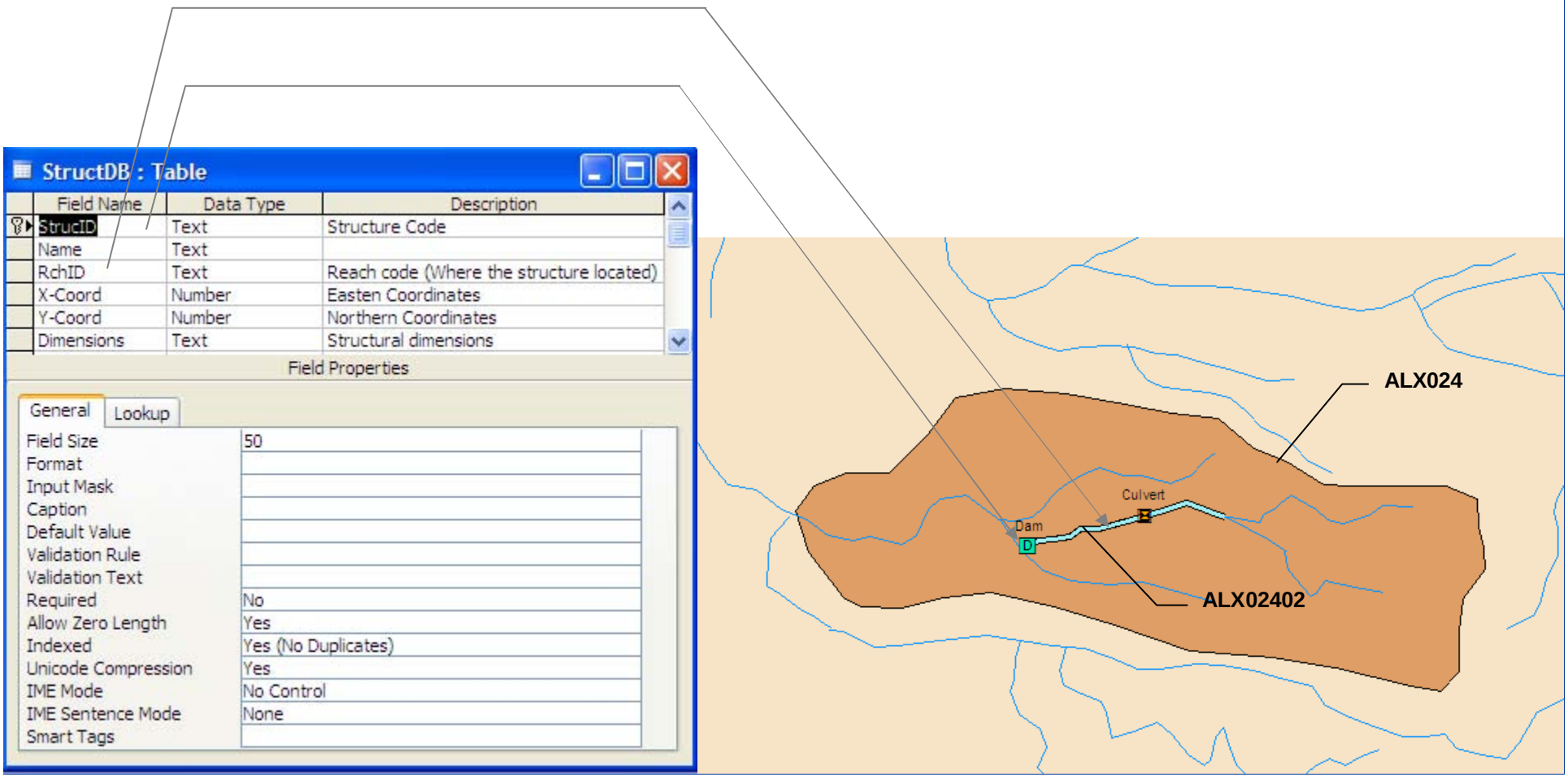


Table 5 (PointPolDB): point source of pollution database: Locations and pollution loads of all point sources of pollutions within watershed.

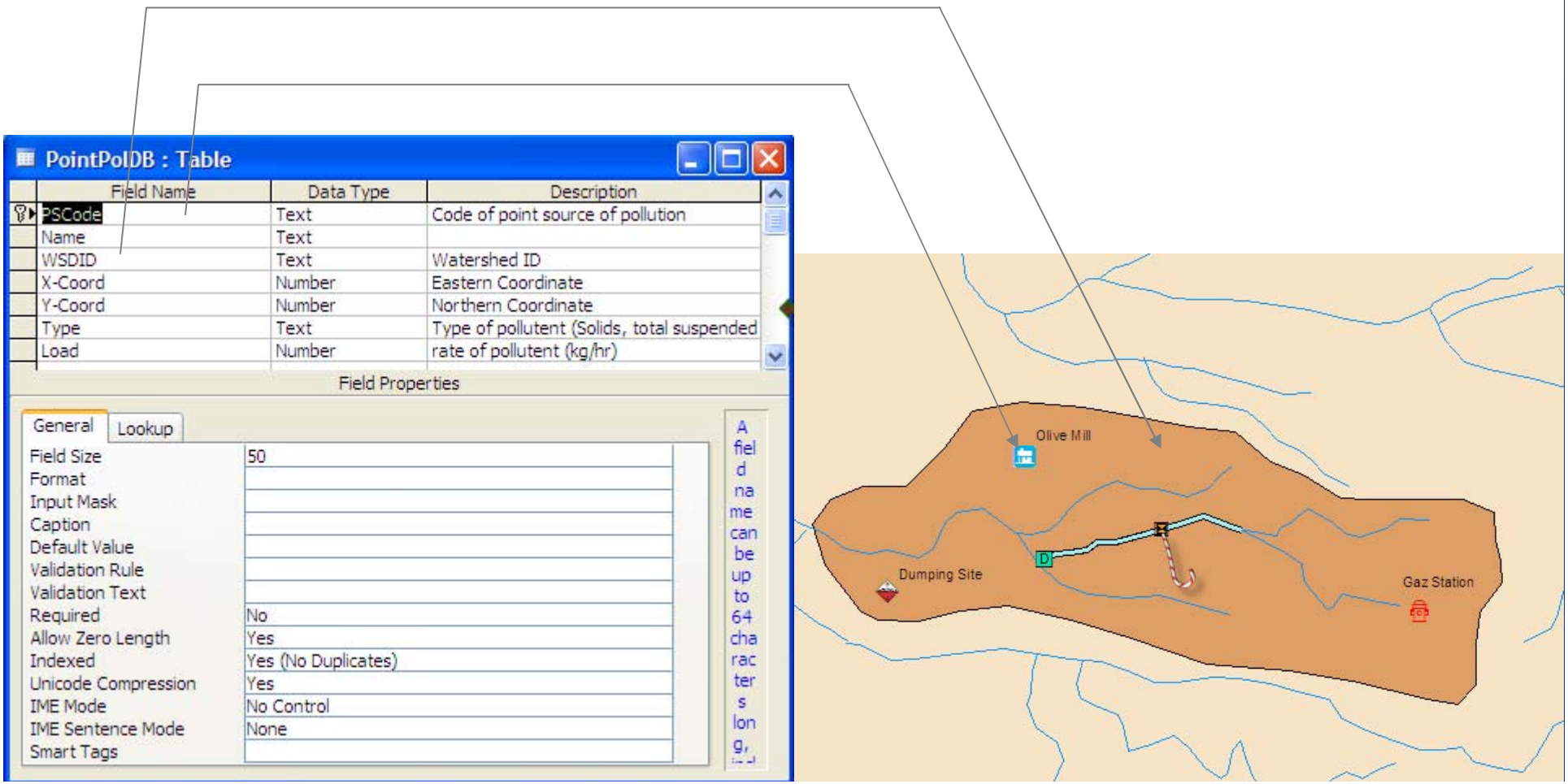


Table 6 (NONPointPolDB): non-point source of pollution database: Locations and pollution load rates of all non-point source of pollutions within watershed.

NONPointPolDB : Table

Field Name	Data Type	Description
NPSCode	Text	Code of non-point source of pollution
Name	Text	
Area	Number	
WSDID	Text	Watershed ID
LNDCode	Text	Code of landuse area
ImpFact	Number	Percentage of imperviousness for each land use
TSS	Memo	
TDS	Number	
BOD	Number	
COD	Number	
Phosph	Number	Phosphorous
Nitrogen	Number	
Nitrate	Number	
Nitrite	Number	
TKN	Number	
Ammonia	Number	
FclClfrm	Number	Feacal Coliform
Lead	Number	
Zinc	Number	

Field Properties

General | Lookup

Field Size	50
Format	
Input Mask	
Caption	
Default Value	
Validation Rule	
Validation Text	
Required	No
Allow Zero Length	Yes
Indexed	Yes (No Duplicates)
Unicode Compression	Yes
IME Mode	No Control
IME Sentence Mode	None
Smart Tags	

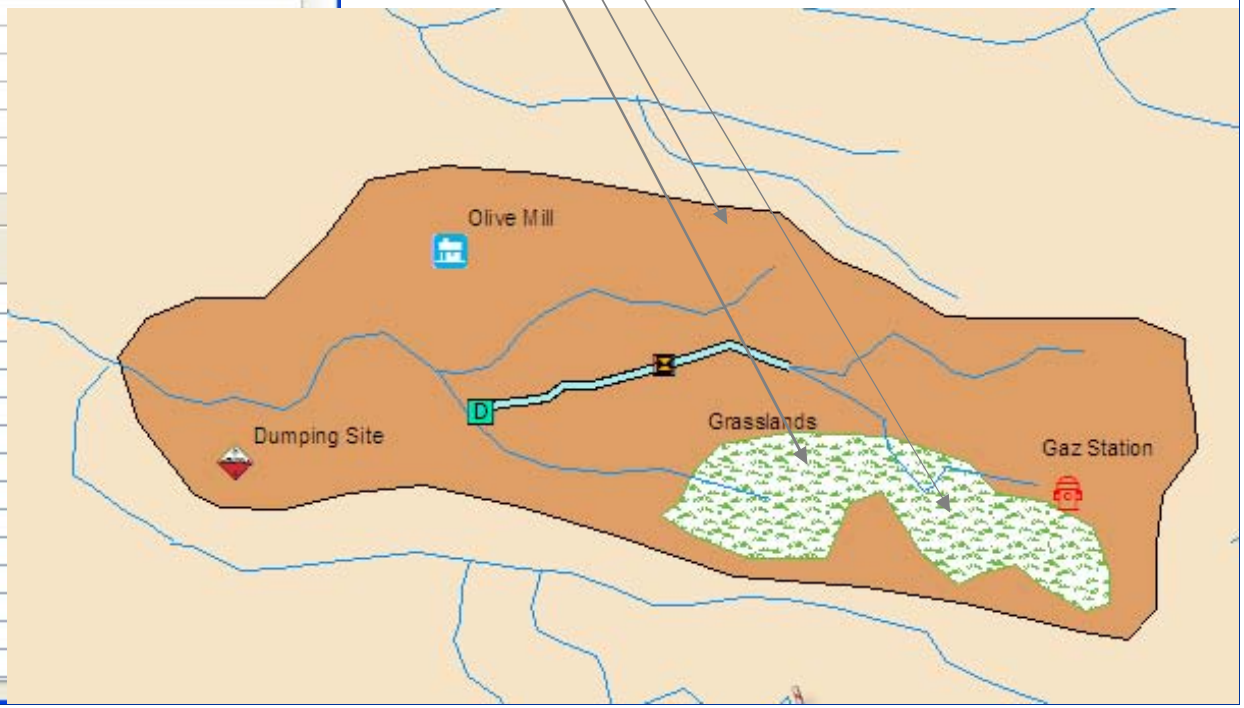


Table 7 (UrbanDB): Urban areas database: Locations of urban areas within watershed.

UrbanDB : Table

Field Name	Data Type	Description
URBnCode	Text	Code of the Urbanized area
Name	Text	
WSDID	Text	Watershed ID
X-Coord	Number	Eastern Coordinate
Y-Coord	Number	Northern Coordinate
Pop	Number	Population
PopGth	Number	population Growth

Field Properties

General | Lookup

Field Size	50
Format	
Input Mask	
Caption	
Default Value	
Validation Rule	
Validation Text	
Required	No
Allow Zero Length	Yes
Indexed	Yes (No Duplicates)
Unicode Compression	Yes
IME Mode	No Control
IME Sentence Mode	None
Smart Tags	

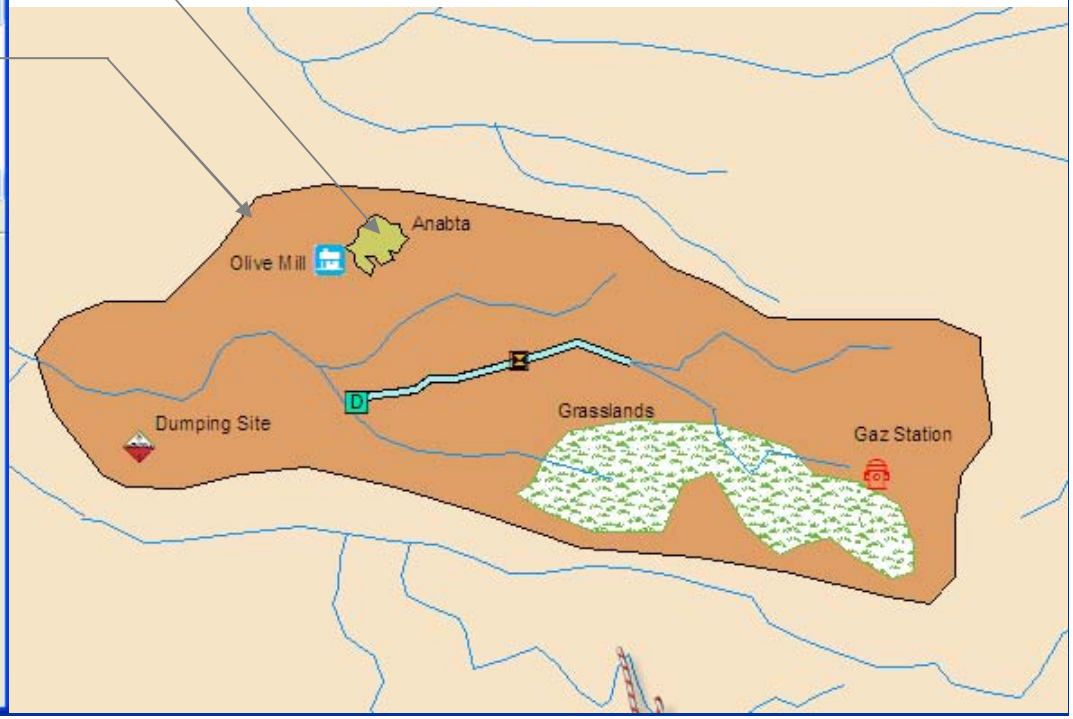


Table 8 (LanduseDB): Landuse database

LanduseDB : Table

Field Name	Data Type	Description
LNDCode	Text	Code of landuse area
LndName	Text	Landuse name (Forest, Agricultueral, Urban, .
WSDID	Text	Watershed ID
Area	Number	
Slope	Number	
Type	Text	Impervious or Pervious

Field Properties

General | Lookup

Field Size	50
Format	
Input Mask	
Caption	
Default Value	
Validation Rule	
Validation Text	
Required	No
Allow Zero Length	Yes
Indexed	Yes (No Duplicates)
Unicode Compression	Yes
IME Mode	No Control
IME Sentence Mode	None
Smart Tags	

A field name can be up to 64 characters long, including spaces. Press F1 for help on field names.

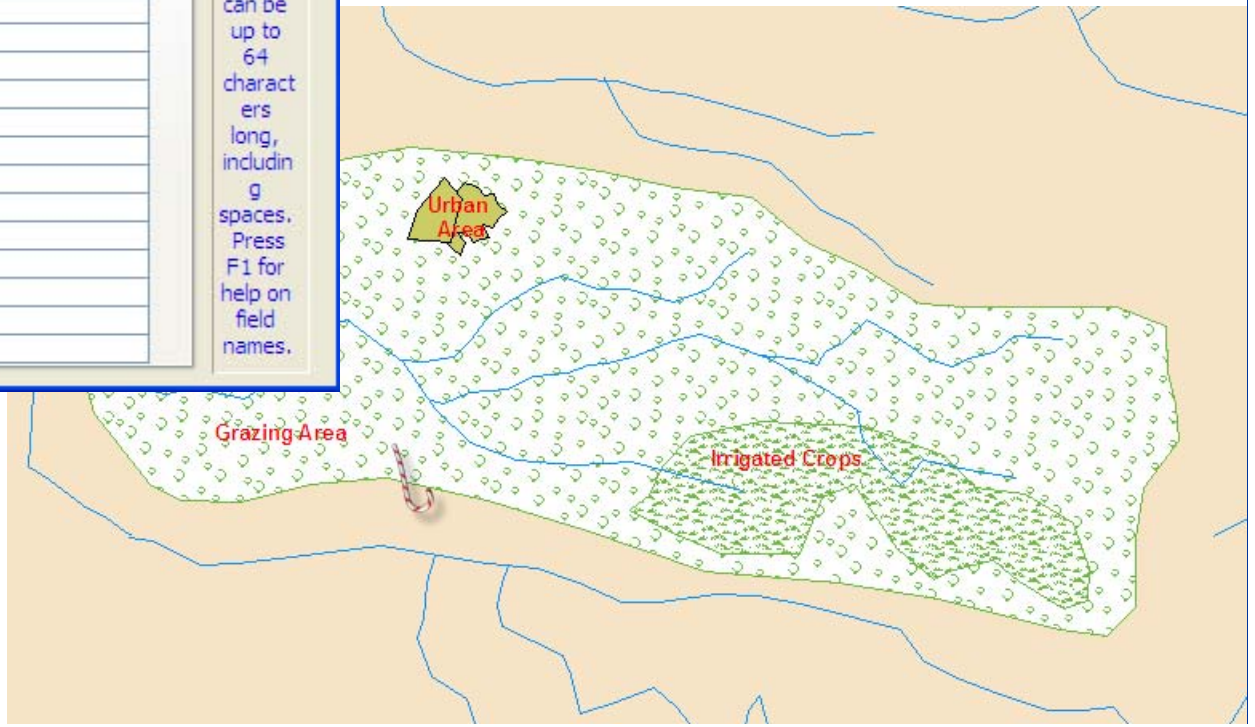


Table 9 (MntrStationsDB): Location of Monitoring stations

Table 10 (SamplingBial): Biological Sampling

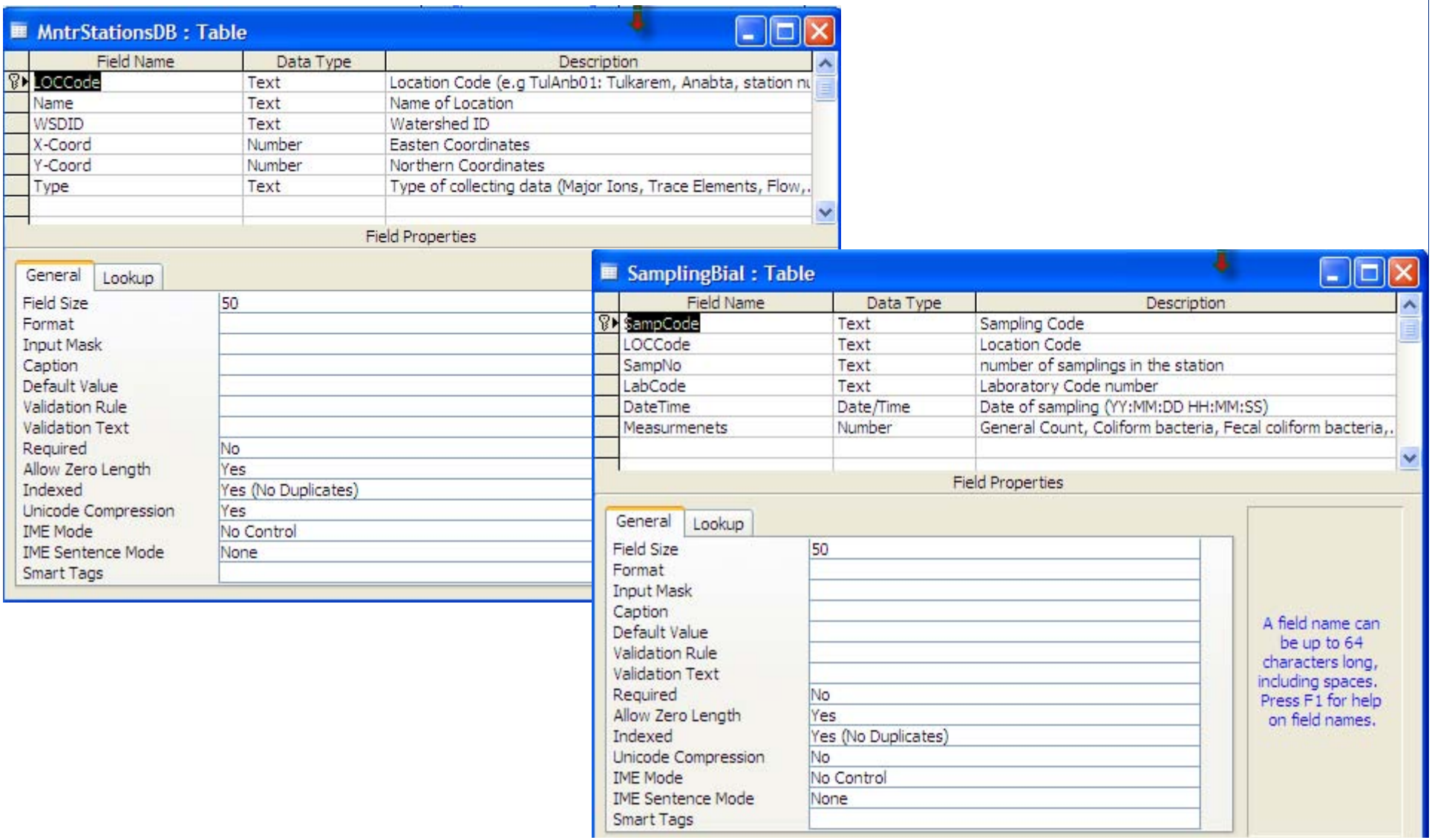
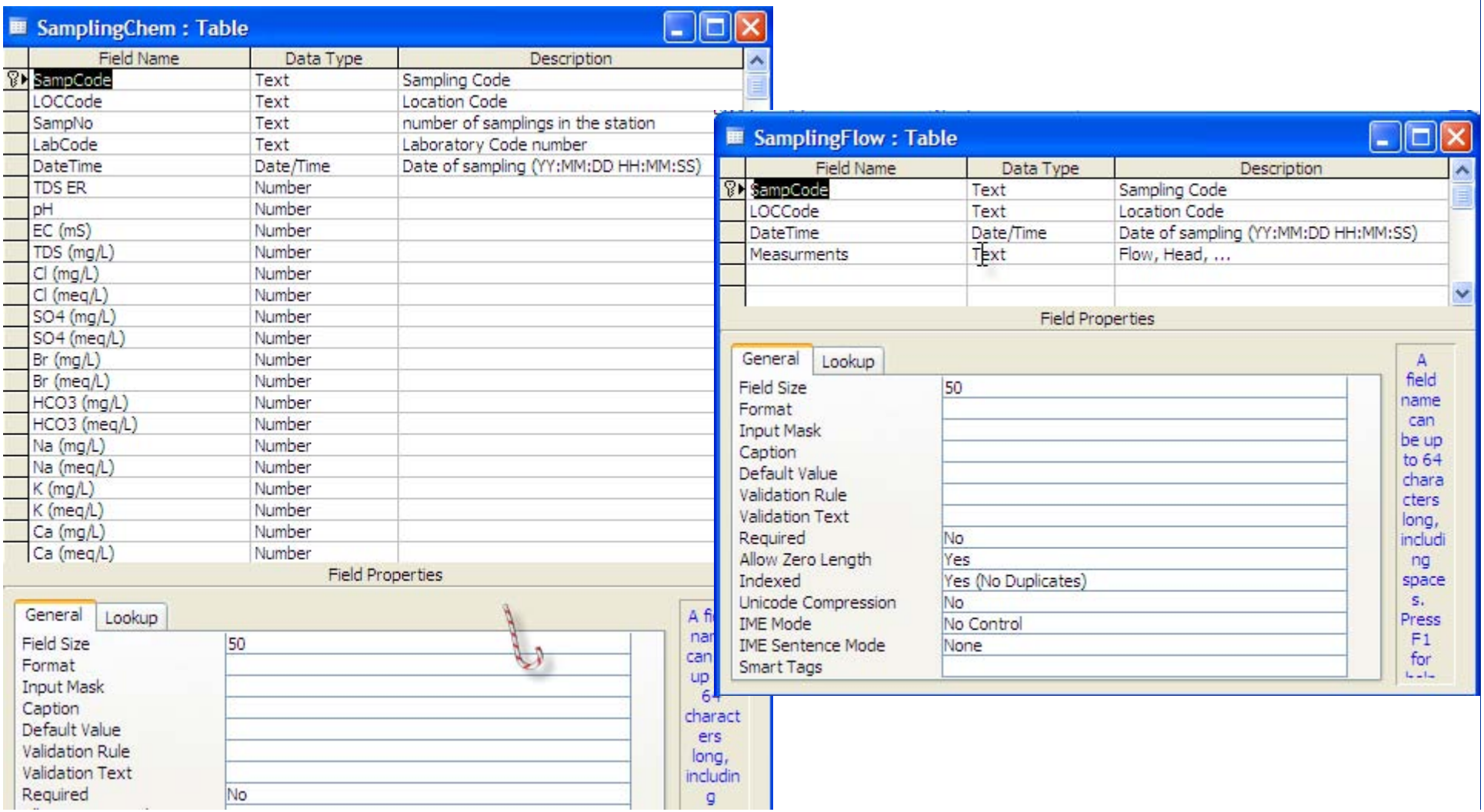


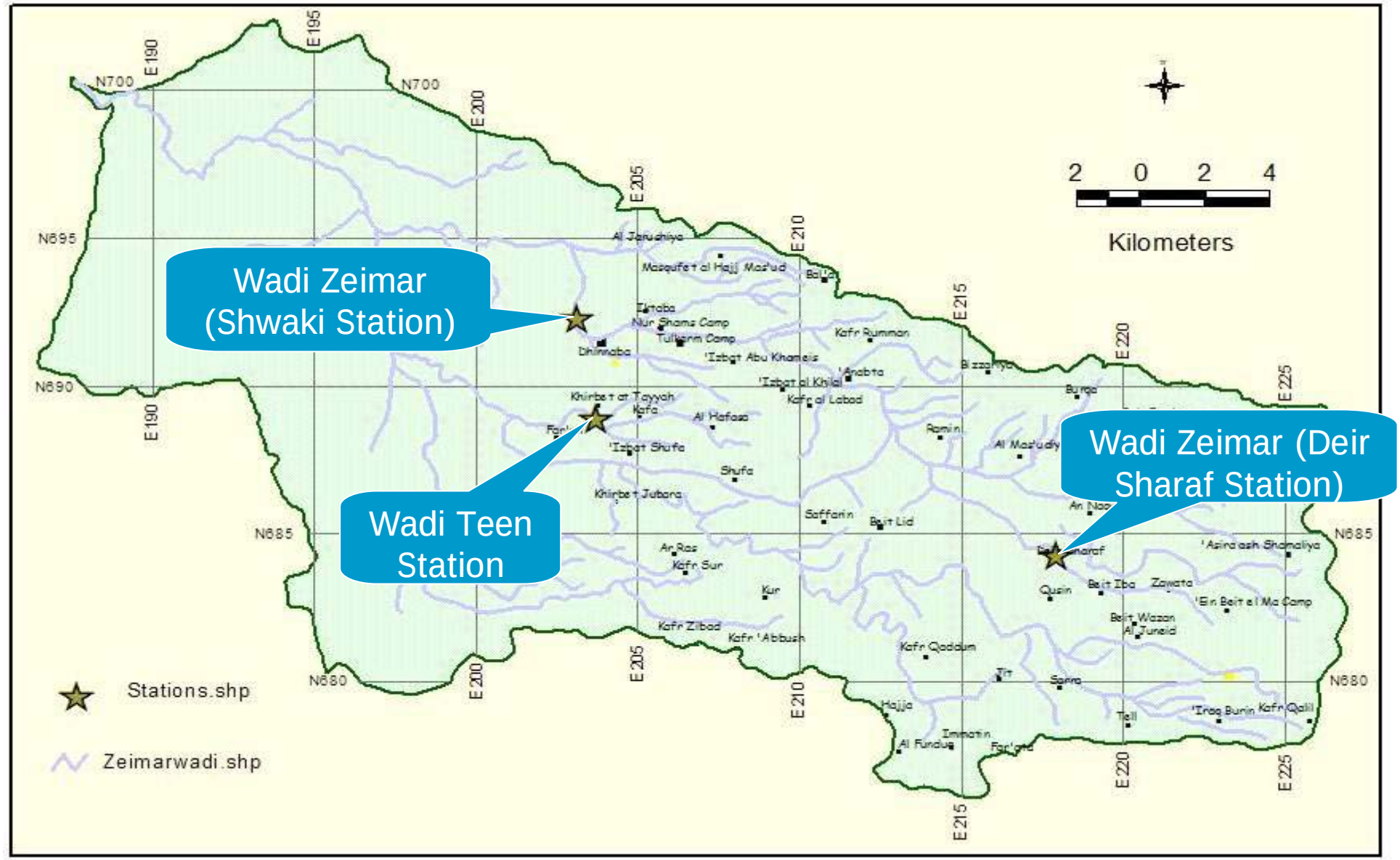
Table 11 (SamplingChem): Chemical sampling

Table 12 (SamplingFlow): Flow measurements



Stage Four : Monitoring for HSPF Parameters Commences

- Three monitoring stations were installed in the Alexander Catchment - Palestinian side , two of them were at Wadi Zeimar, and the other was at Wadi Al Teen.
- Some preparations were made for the three sites before installing the devices as shown in the following pictures.
- The installed device is “Sigma 900 MAX Portable Sampler”
- Three sensors were installed in the wadis:
  - Submerged Pressure Sensor – to measure height of water in the wadis.
  - Electric Conductance (EC) probe.
  - Strainer (for the pump to take samples from the wadi in fluid time)
- The device has a modem so that we can get the data by connecting the modem by telephone.



Monitoring Stations at Alexander Catchment

Wadi Zeimar (Shwaki Station) - Preparation of the Site

- Situation before and after installing the devices in the Wadi

before

after

Wadi Zeimar (Shwaki Station)
Installation and Calibration of the Device

Wadi Zeimar (Deir Sharaf Station) -Preparation of the Site

- Situation before and after installing the devices in the Wadi

before

after

Wadi Zeimar (Deir Sharaf Station)
Installation and Calibration of the Device

Wadi Teen Station - Preparation of the Site

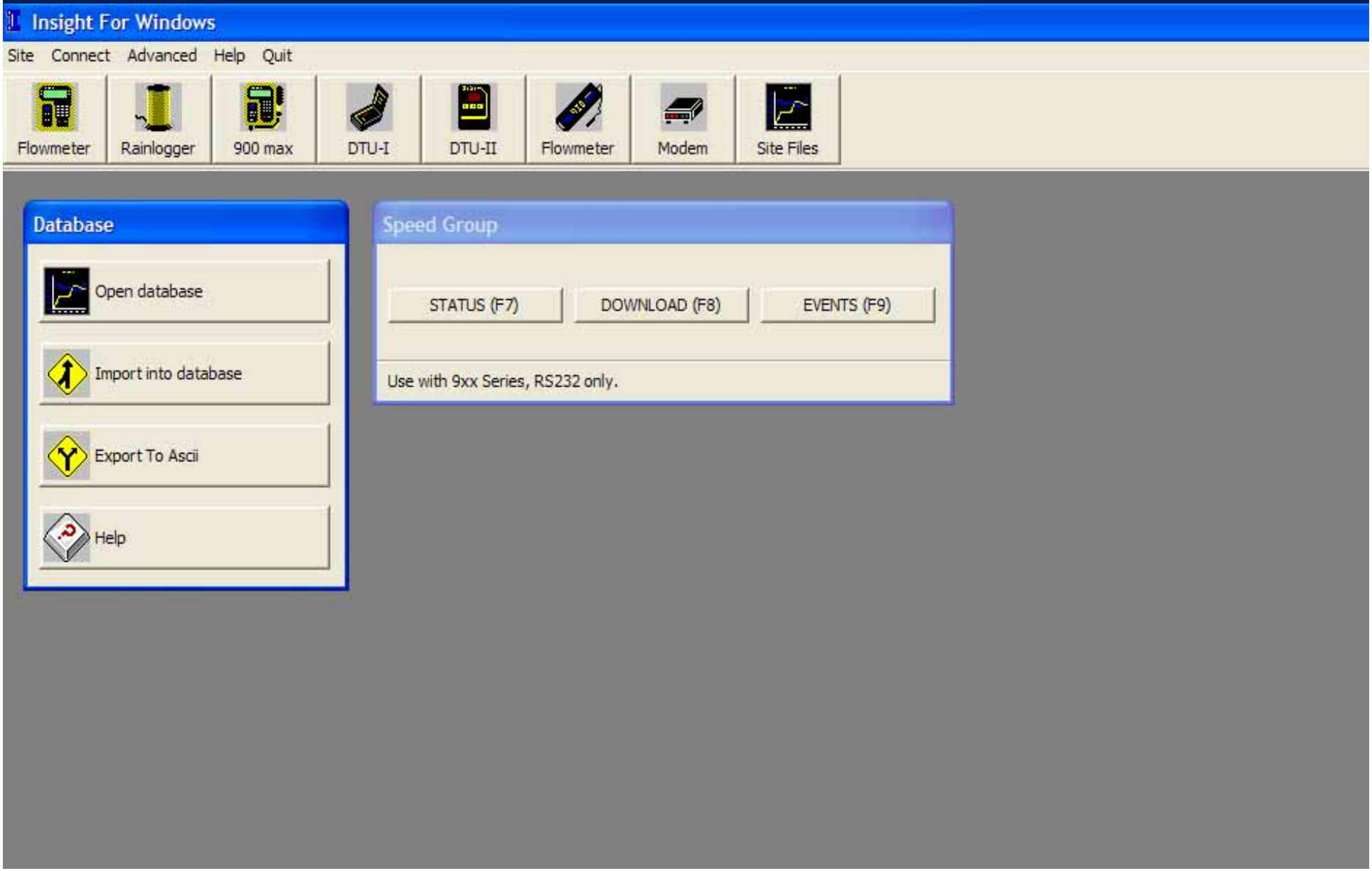
Gathering the Data from the Devices

- We use ***Insight Suite, V5.6.5 program*** which was published by HACH Company to connect with the modems of the installed **Sigma 900 MAX Portable Samplers** in the Wadis.

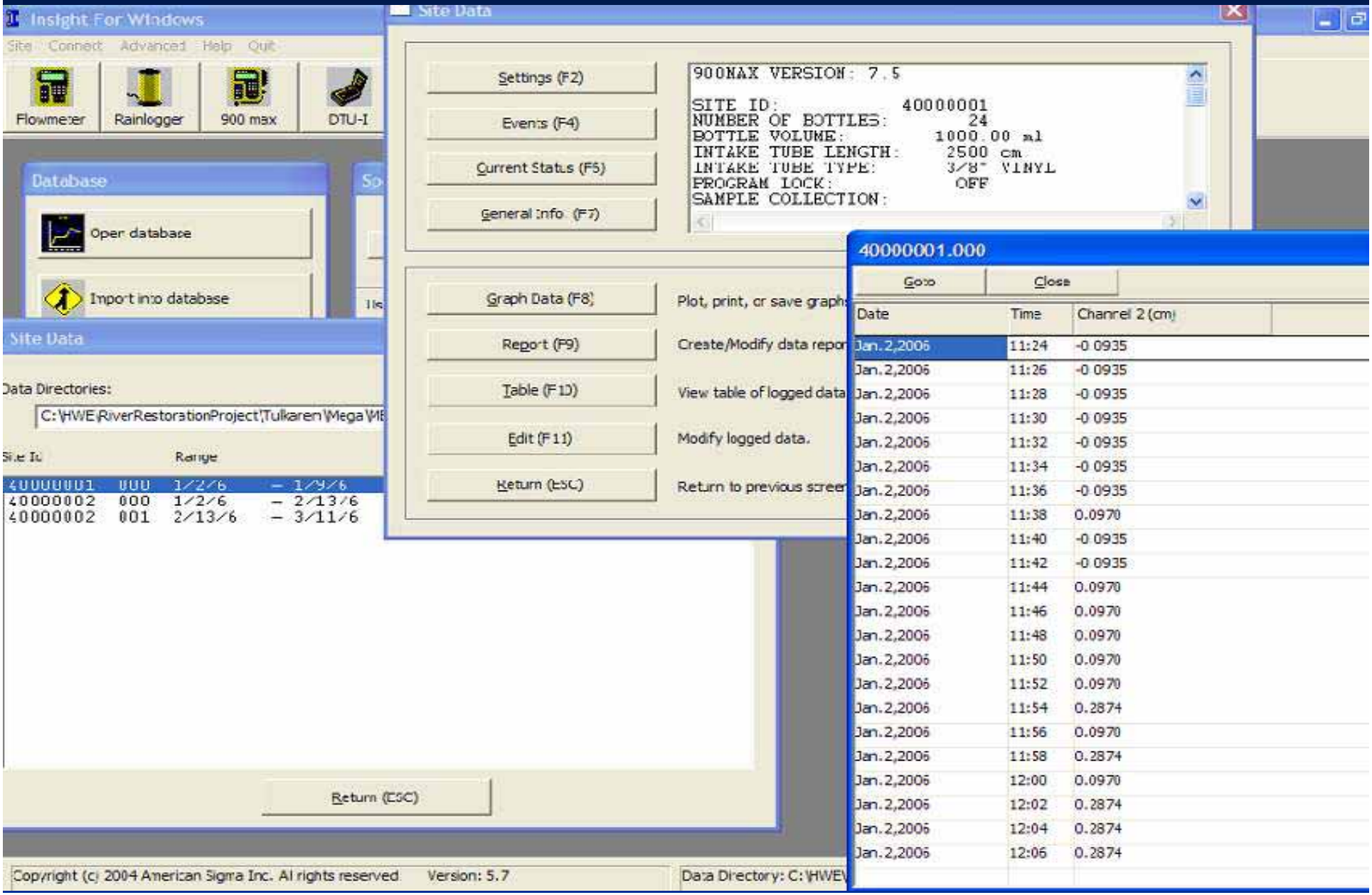
- The following slides show how this software works.

- After installing the data from the Samplers, we prepare Excel sheets to calculate the discharges in the wadis during rainfall storms. So as to understand the response of the wadis to rainfall.

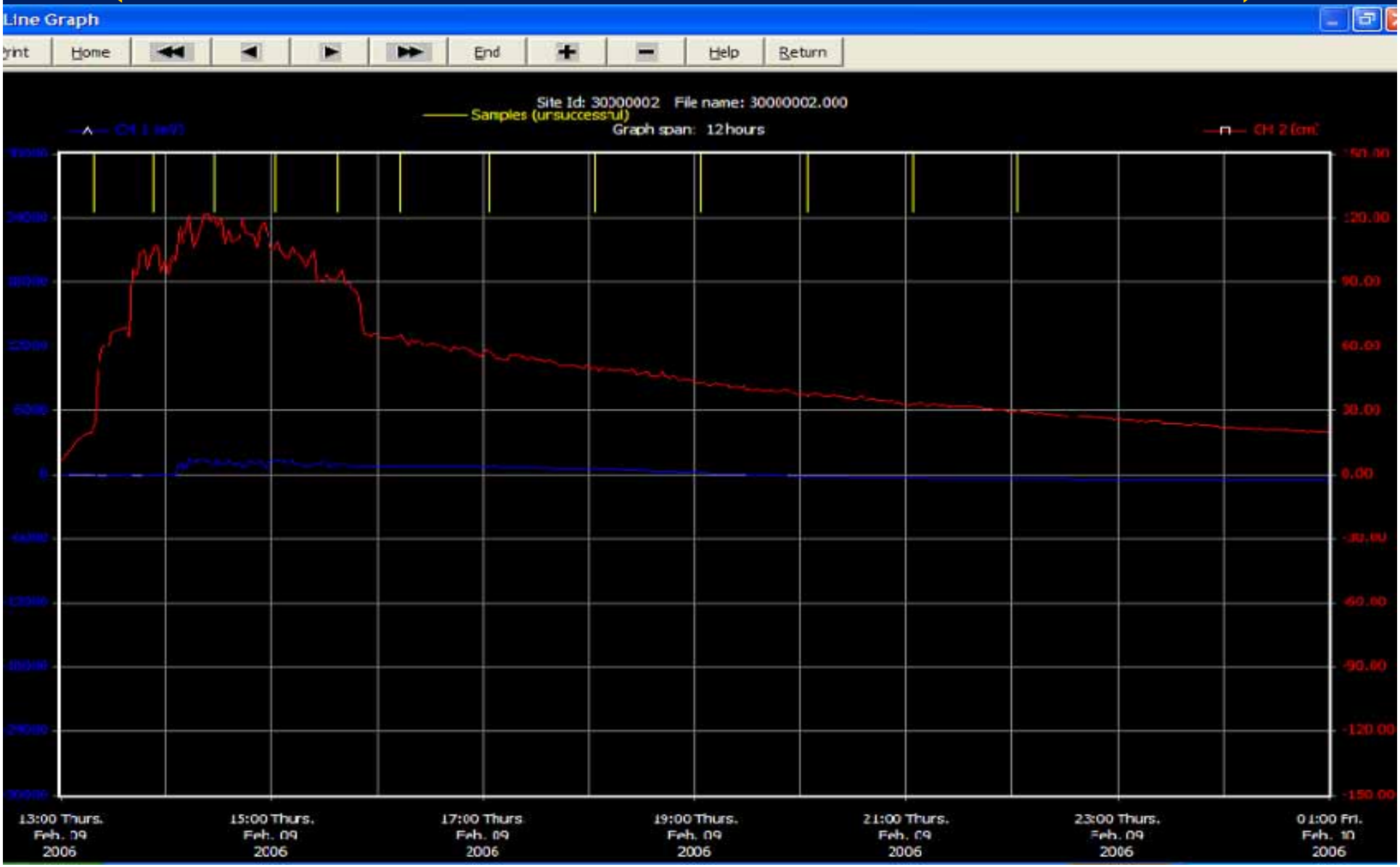
Insight Suite, V5.6.5



Collected Data



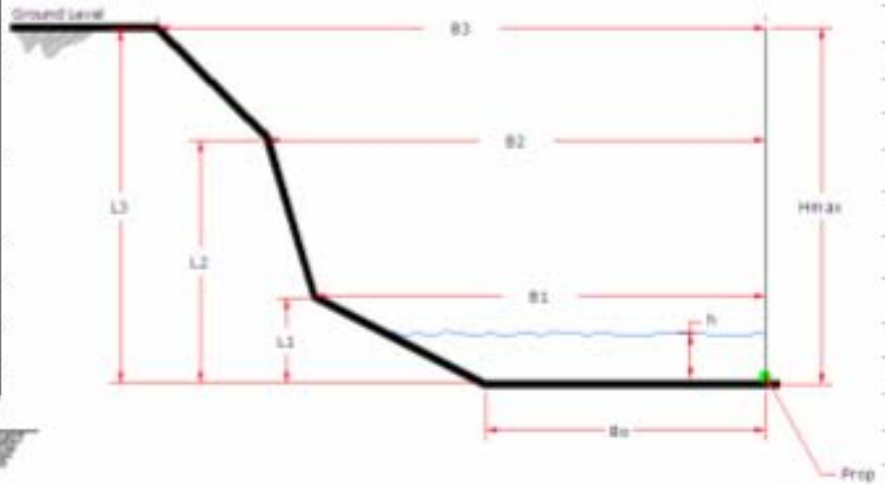
Graph of H & EC Values (Obtained from Wadi Al Teen Station)

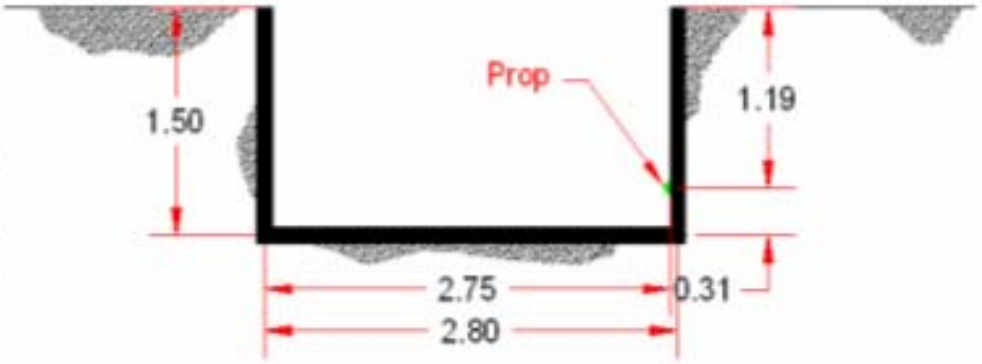


Calculating Discharge of Wadi Zeimar (Deir Sharaf Station)

Left Hand Side			Right Hand Side		
Node	Li	Bi	Node	Li	Bi
0	0	2.75	0	0	0.05
1	1.19	2.75	1	1.19	0.05
2	999	999	2	999	999
3	999	999	3	999	999
4	999	999	4	999	999
5	999	999	5	999	999

Manning Coefficient	S_o
0.015	0.02
BaseFlow Parameters	
Max. Head (m)=	0.31
Min. Head (m)=	0.25
A_{max} =	0.87
P_{max} =	3.42
A_{min} =	0.70
P_{min} =	3.30
Max. Baseflow=	3.78
Min. Baseflow=	3.36





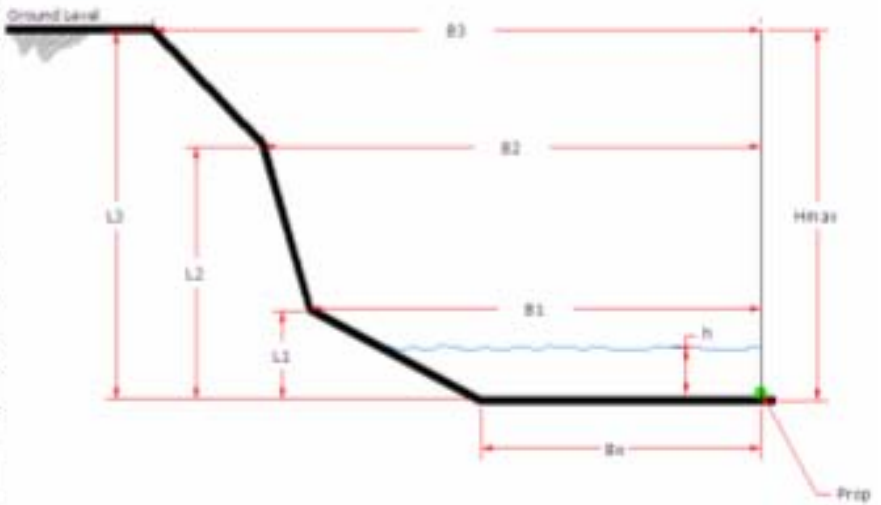
Note: all dimensions are in meter

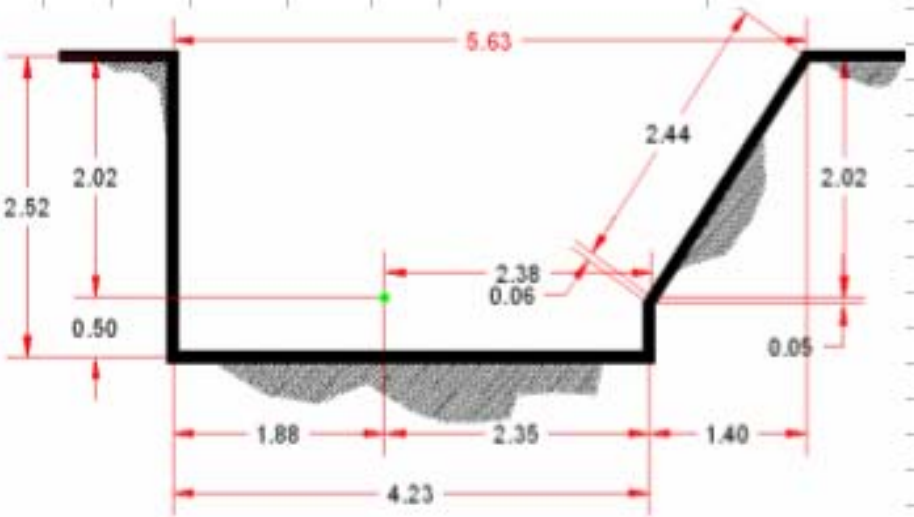
Click here to import the head file and convert it to flow

Calculating Discharge of Wadi Zeimar (Shwaki Station)

Left Hand Side			Right Hand Side		
Node	Li	Bi	Node	Li	Bi
0	0	1.88	0	0	2.38
1	2.02	1.88	1	2.02	3.75
2	999	999	2	999	999
3	999	999	3	999	999
4	999	999	4	999	999
5	999	999	5	999	999

Manning Coefficient	S_o
0.015	0.02
BaseFlow Parameters	
Max. Head (m)=	0.5
Min. Head (m)=	0.1
A_{max} =	2.12
P_{max} =	5.23
A_{min} =	0.42
P_{min} =	4.43
Max. Baseflow=	5.16
Min. Baseflow=	1.97





Click here to import the head file and convert it to flow

Note: all dimensions are in meter

Calculating Discharge of Wadi Al Teen

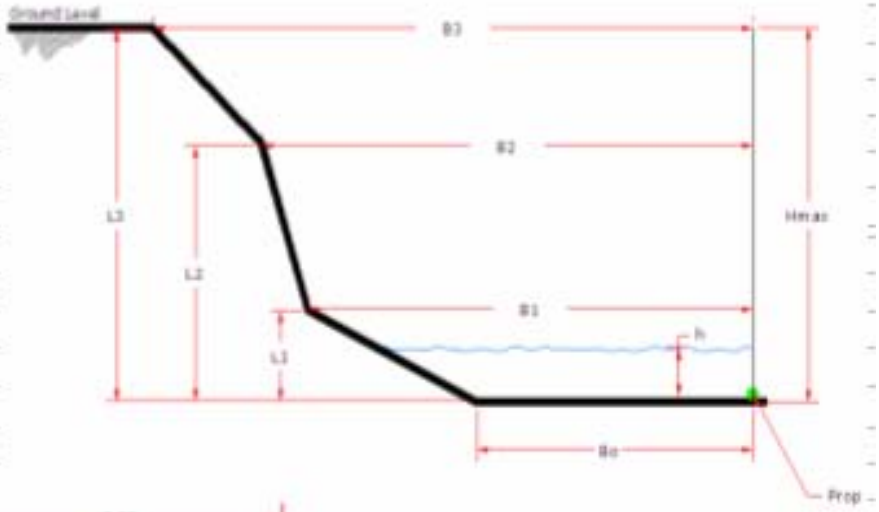
	Left Hand Side			Right Hand Side			Manning Coefficient	S_o
	Node	Li	Bi	Node	Li	Bi		
	0	0	5.359	0	0	1.39	0.02	0.02
	1	1.27	8.45	1	1.44	3.6		
	2	999	999	2	999	999		
	3	999	999	3	999	999		
	4	999	999	4	999	999		
	5	999	999	5	999	999		

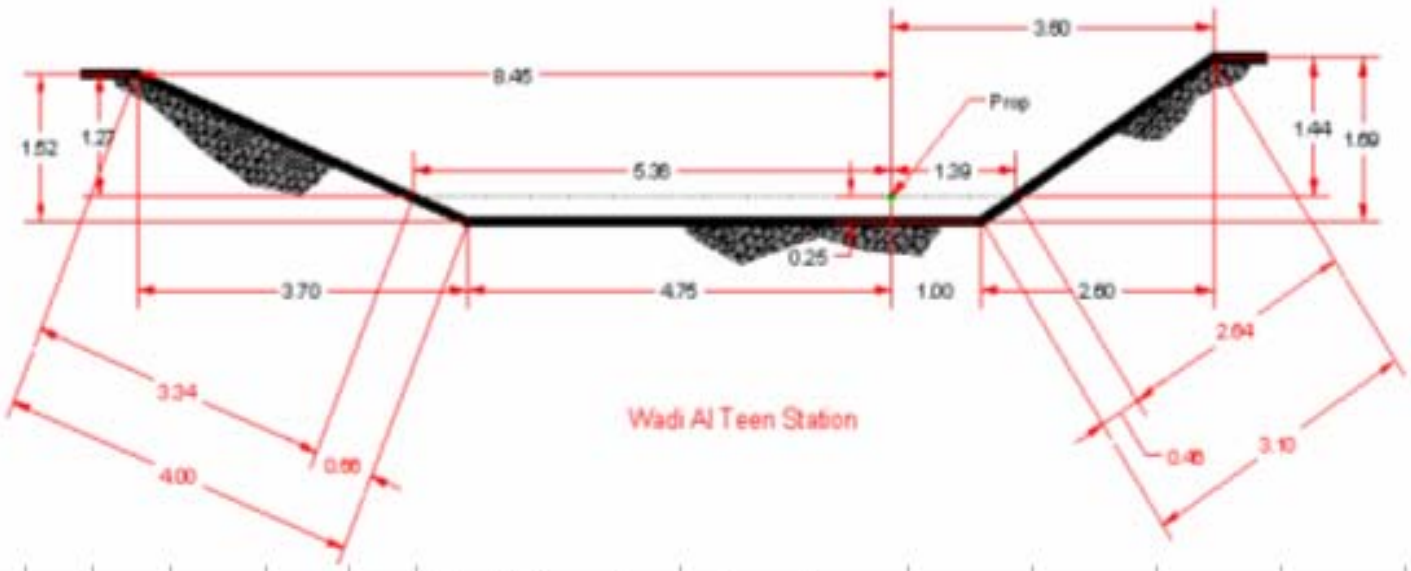
Base flow parameters		
A=	0.3125	m^2
P=	5.88	m

Baseflow =	0	-	5.489	m^3

0 : Dry period (all summer days and most low rainfall events)

Baseflow max: very wet events (h>0)





Click here to import the head file and convert it to flow

Note: all dimensions are in meter

9.9432

Quality of Water in Wadi Zeimar

No.sample	Date	TDS	pH	EC	TDS	Cl	SO4	Br	HCO3	Na	K	Ca	Mg	alkalinity	CO3	NO3	PO4	NH4
		ER		mS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mgCaCO3	mg/L	mg/L	mg/L	mg/L
TUL 0001	3/15/2005	608	7.23	0.950	666	67.0	24.3	0	408	75.4	14.0	65.2	12.4	334	0	4.92	14.6	21.6
TUL 0002	3/15/2005	849	7.16	1.326	826	130	26.8	0	459	108	16.4	72.5	12.9	376	0	20.2	11.1	33.9
TUL 0003	3/15/2005	1696	7.26	2.650	1561	427	43.6	4.68	664	285	29.7	83.4	23.2	544	0	67.2	20.6	72.8
TUL 0007	6/15/2005	1585	7.02	2.48	1558	345	65.5	0	755	276	21.9	76.9	18.1	619	0	3.5	30.2	87.5
TUL 0008	6/19/2005	1555	7.37	2.43	1570	370	35.6	0	741	298	23.0	83.2	18.7	607	0	46.2	28.2	61.8
TUL 0009	6/19/2005	1920	7.24	3.00	1908	430	73.7	0	915	384	19.2	79.4	7.10	750	0	13.5	17.2	101

No.sample	Date	TSS	total N	total P	COD	COD	total BOD	filter TOC
		mg/L	mg/L	mg/L	mgO2/L	mgO2/L	mgO2/L	mg/L
TUL 0001	3/15/2005	78.0	29.9	4.71	119	92.5	51.5	105
TUL 0002	3/15/2005	14.0	43.2	5.31	146	124	47.9	105
TUL 0003	3/15/2005	25.0	72.0	8.63	250	255	82.7	175
TUL 0007	6/15/2005	40	66.6	10.3	392			35.7
TUL 0008	6/19/2005	40	52.7	7.88	260			43.2
TUL 0009	6/19/2005	14	75.1	9.63	363			42.6

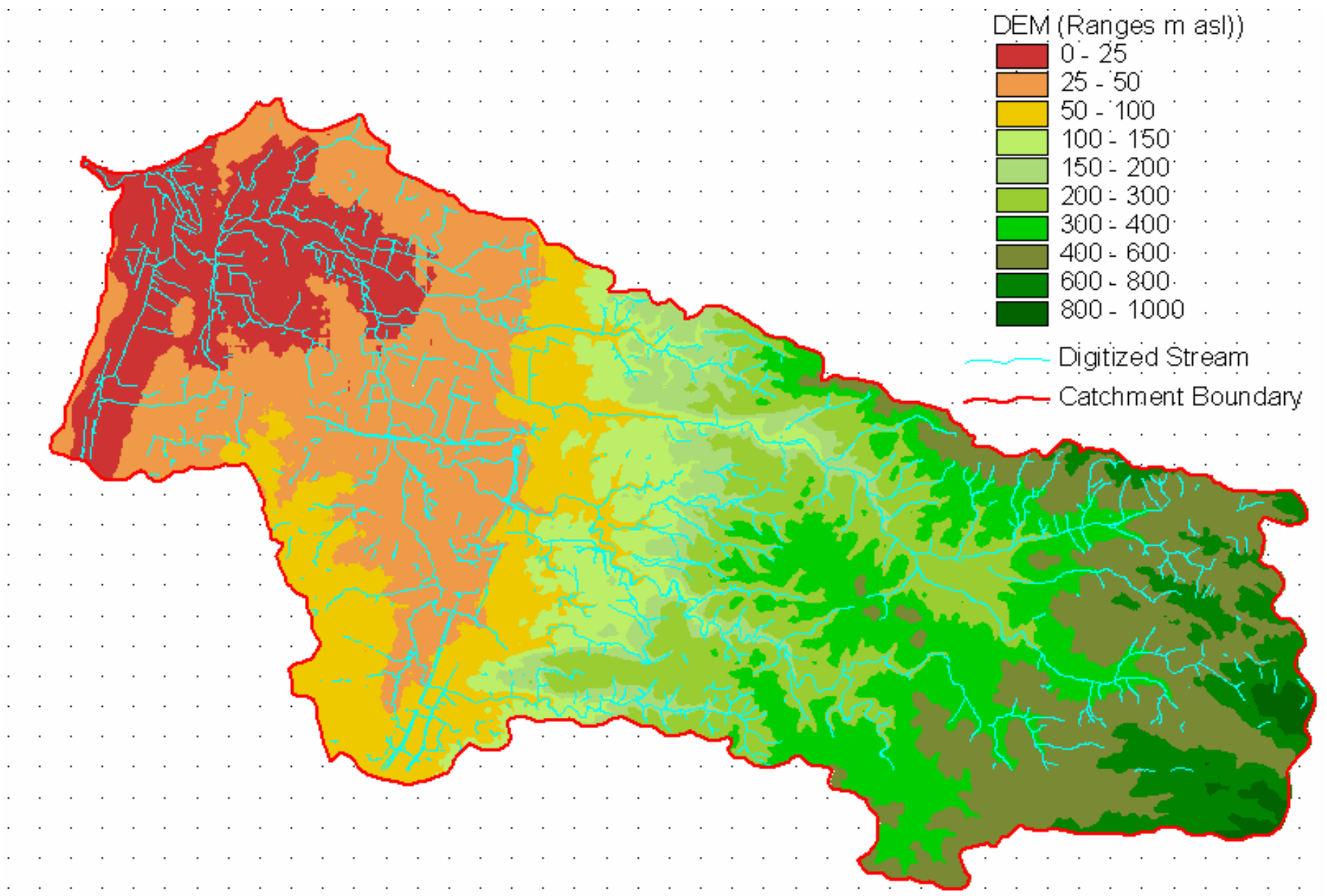
No.sample	Date	CO3	NO2	PO4	NH4	NO3	Cl	SO4	Br	HCO3	Na	K	Ca	Mg	∑A meq	∑K meq	∑A/∑K	EC
		meq/L	meq/L	meq/L	meq/L	meq/L	meq/L	meq/L	meq/L	meq/L	meq/L	meq/L	meq/L	meq/L	meq/L	meq/L		mS
TUL 0001	3/15/2005	0.0	0.0	0.30	1.20	0.08	1.89	0.51	0.00	6.69	3.28	0.36	3.25	1.02	9.47	9.11	-0.02	0.950
TUL 0002	3/15/2005	0.0	0.0	0.23	1.88	0.33	3.67	0.56	0.00	7.52	4.70	0.42	3.62	1.06	12.3	11.67	-0.03	1.326
TUL 0003	3/15/2005	0.0	0.0	0.43	4.04	1.08	12.05	0.91	0.06	10.88	12.40	0.76	4.16	1.91	25.41	23.26	-0.04	2.650
TUL 0007	6/15/2005	0.0	0.0	0.63	4.9	0.06	9.73	1.36	0.00	12.37	12.01	0.56	3.84	1.49	24.16	22.74	-0.03	2.48
TUL 0008	6/19/2005	0.0	0.0	0.59	3.4	0.75	10.44	0.74	0.00	12.14	12.96	0.59	4.15	1.54	24.66	22.67	-0.04	2.43
TUL 0009	6/19/2005	0.0	0.0	0.36	5.6	0.22	12.13	1.53	0.00	15.00	16.70	0.49	3.96	0.58	29.24	27.34	-0.03	3.00

Stage Five : Building HSPF Model

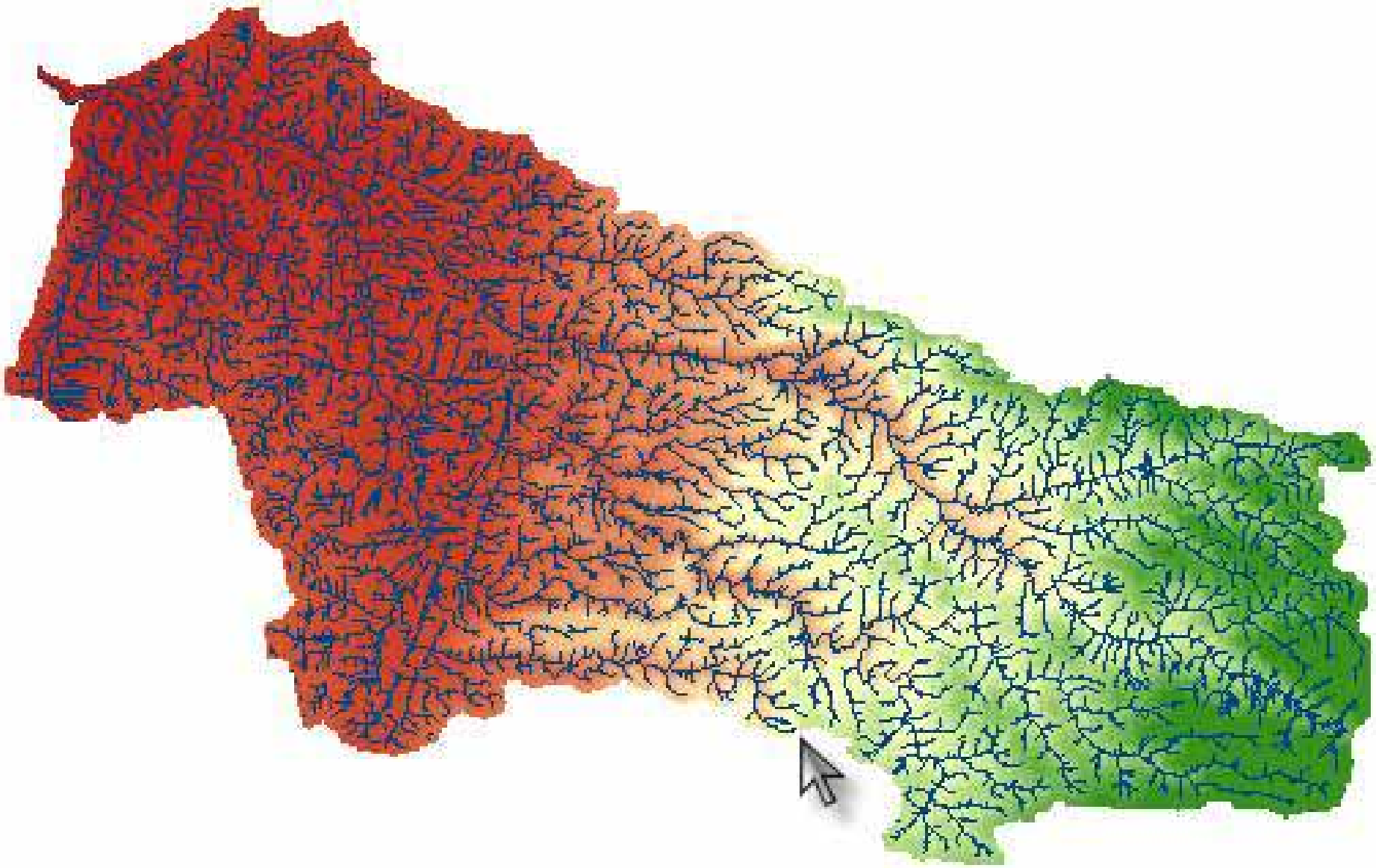
- HSPF has many parameters to prepare data for;
- The following analysis were prepared:
  - DEM Analyses
    - Divide the Alexander basin in sub-watersheds.
    - Divide the Alexander watersheds into drainage segments.
    - Estimating LSUR and SLSUR and other basin parameters

      LSUR : Length of assumed overland flow plane

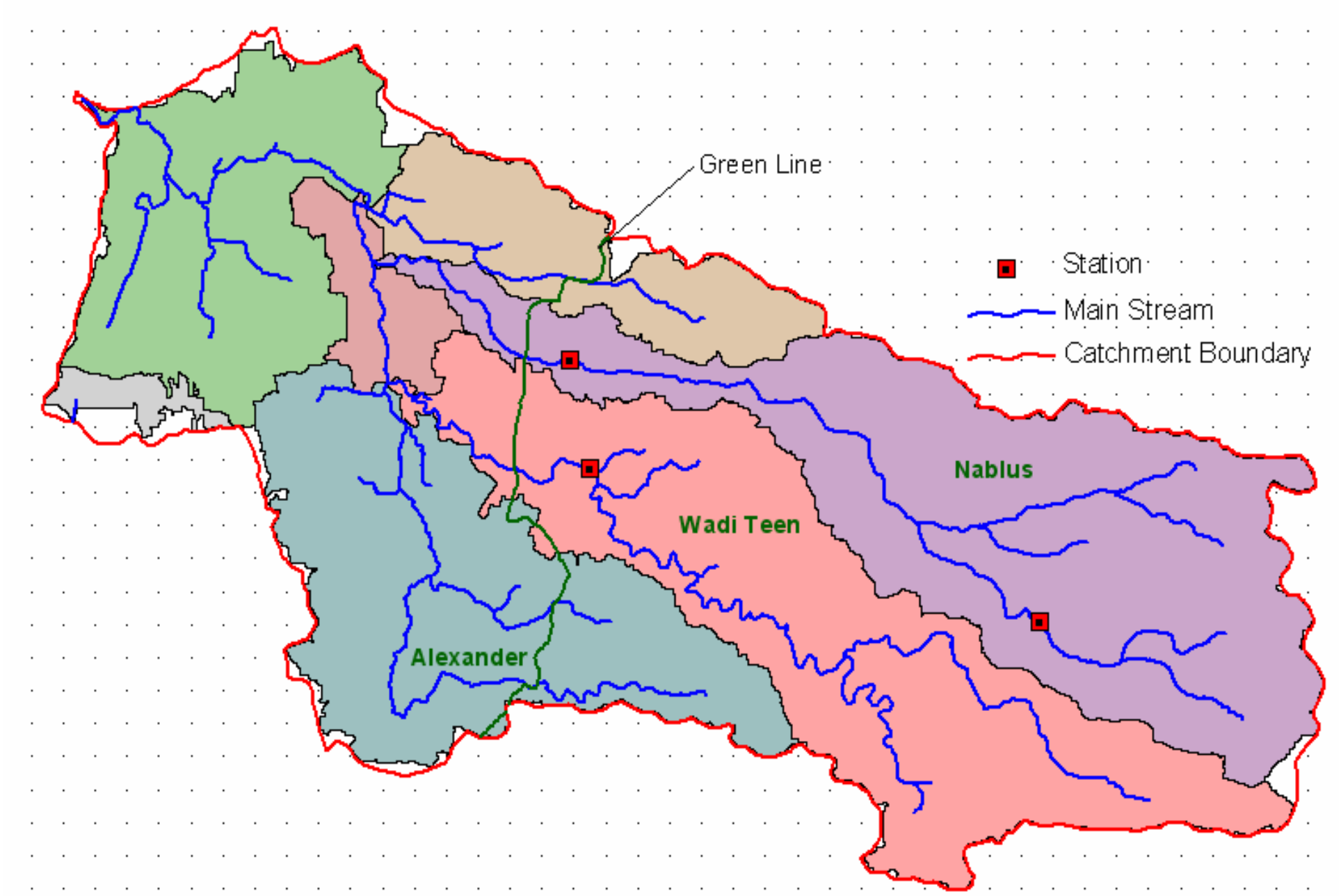
      SLSUR: Average slope assumed overland flow plane
- Metrological Analysis
  - Building a Watershed Data Management (WDM) file.



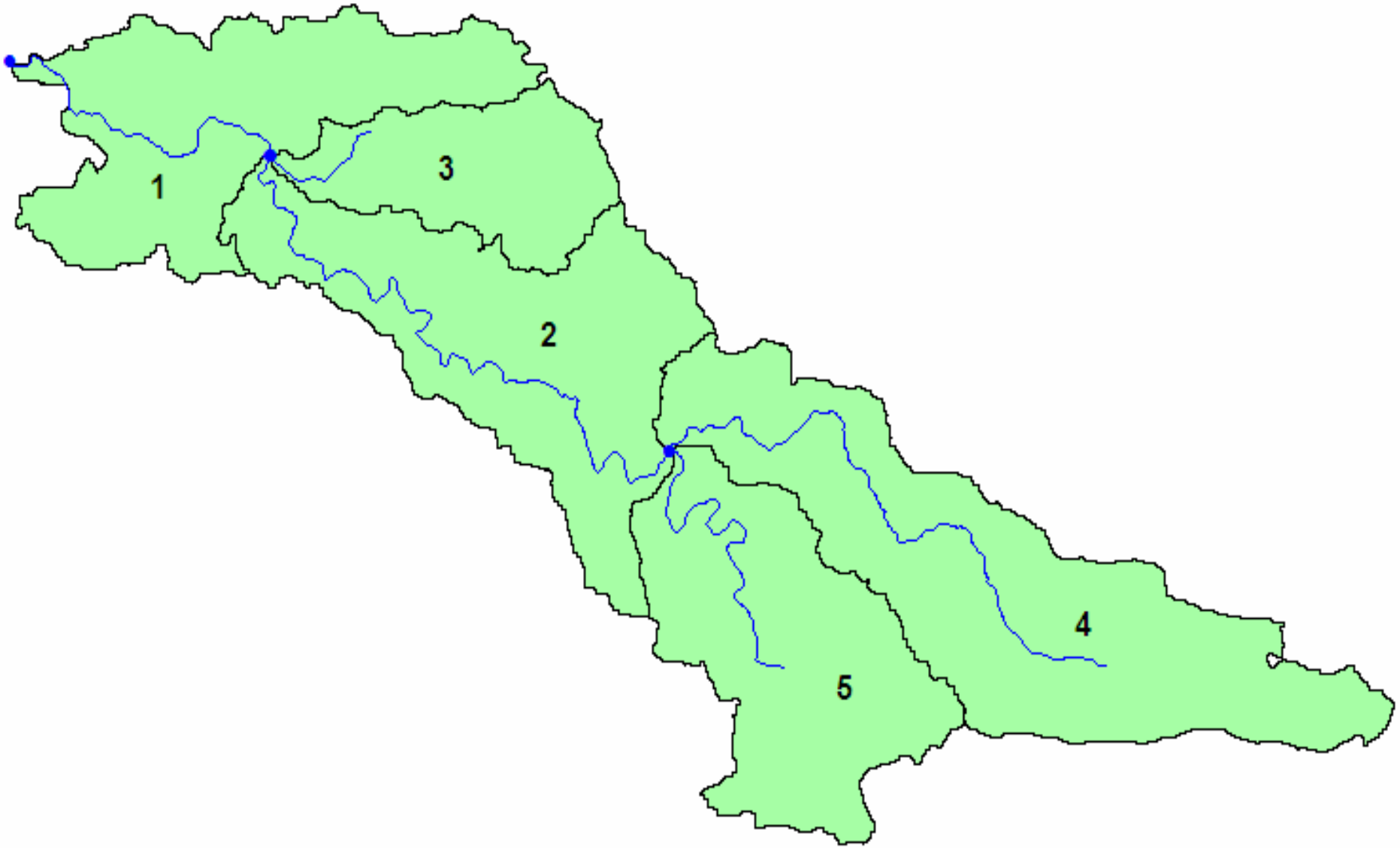
From DEM and the digitized stream and using the Arc Hydro software, very detailed streams network have been obtained. (Next Slide)



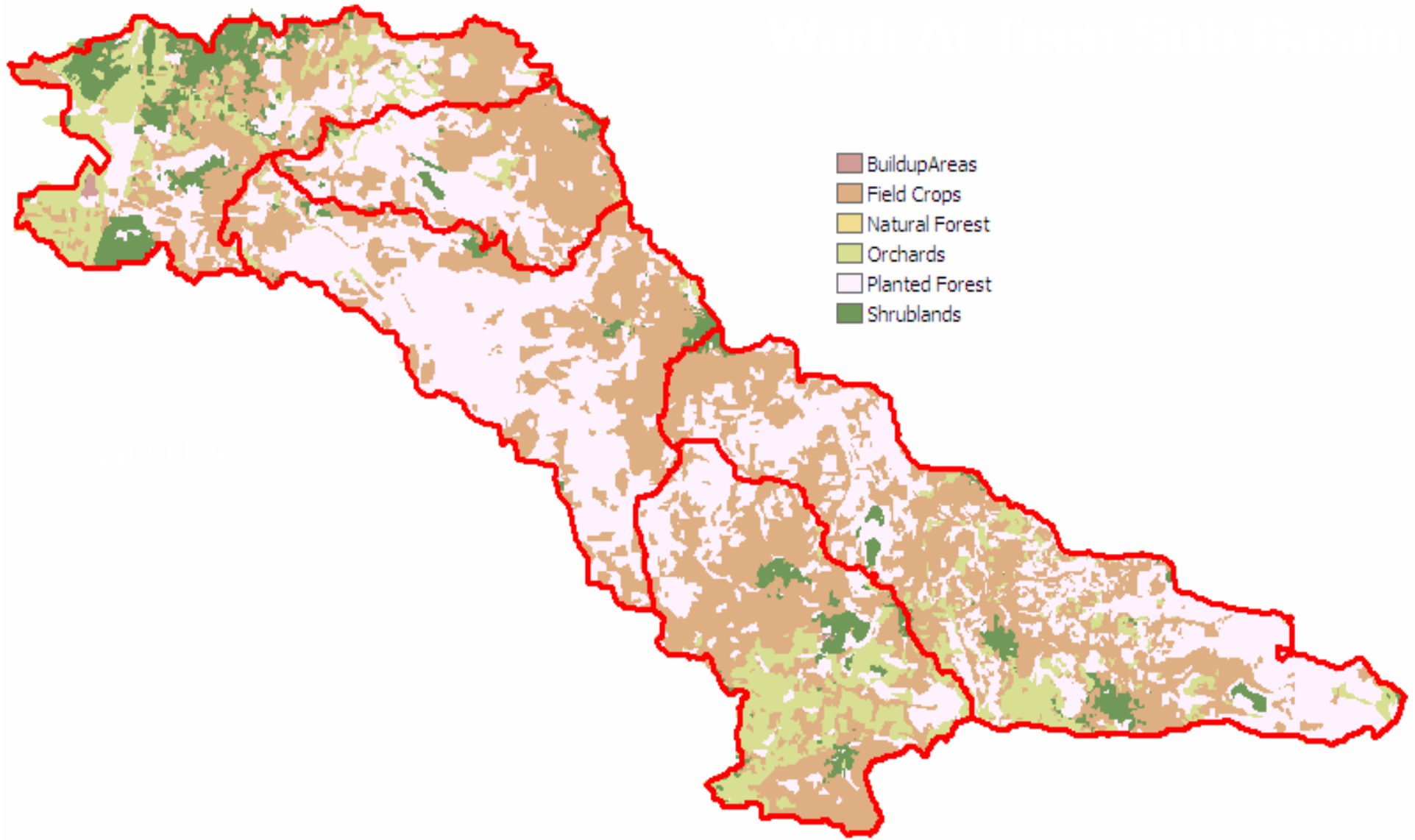
This detailed stream network will be useful in estimating the LSUR parameter for the HSPF model.



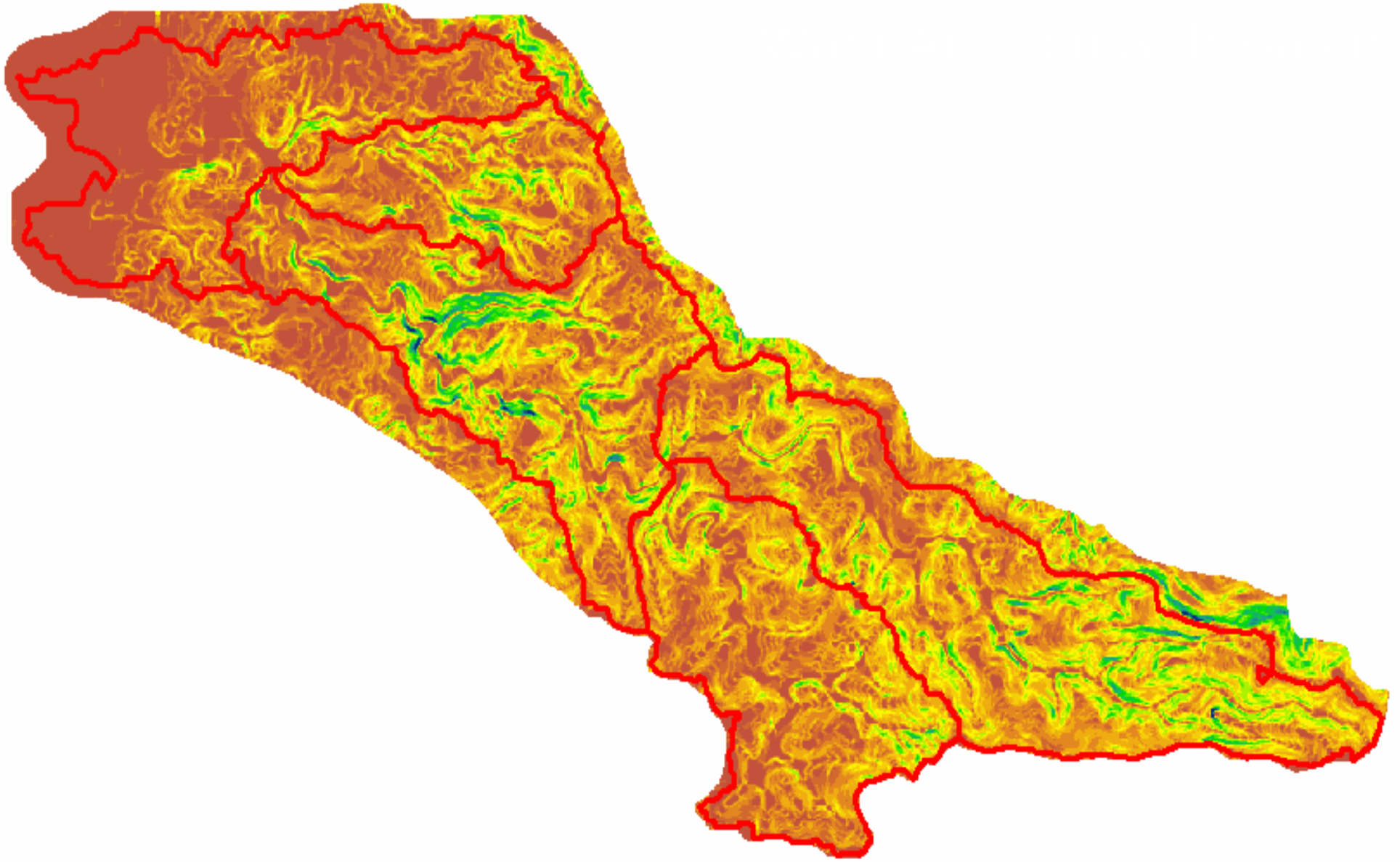
Three main sub basins (Nablus, Wadi Teen and Alexander) were defined to be modeled.



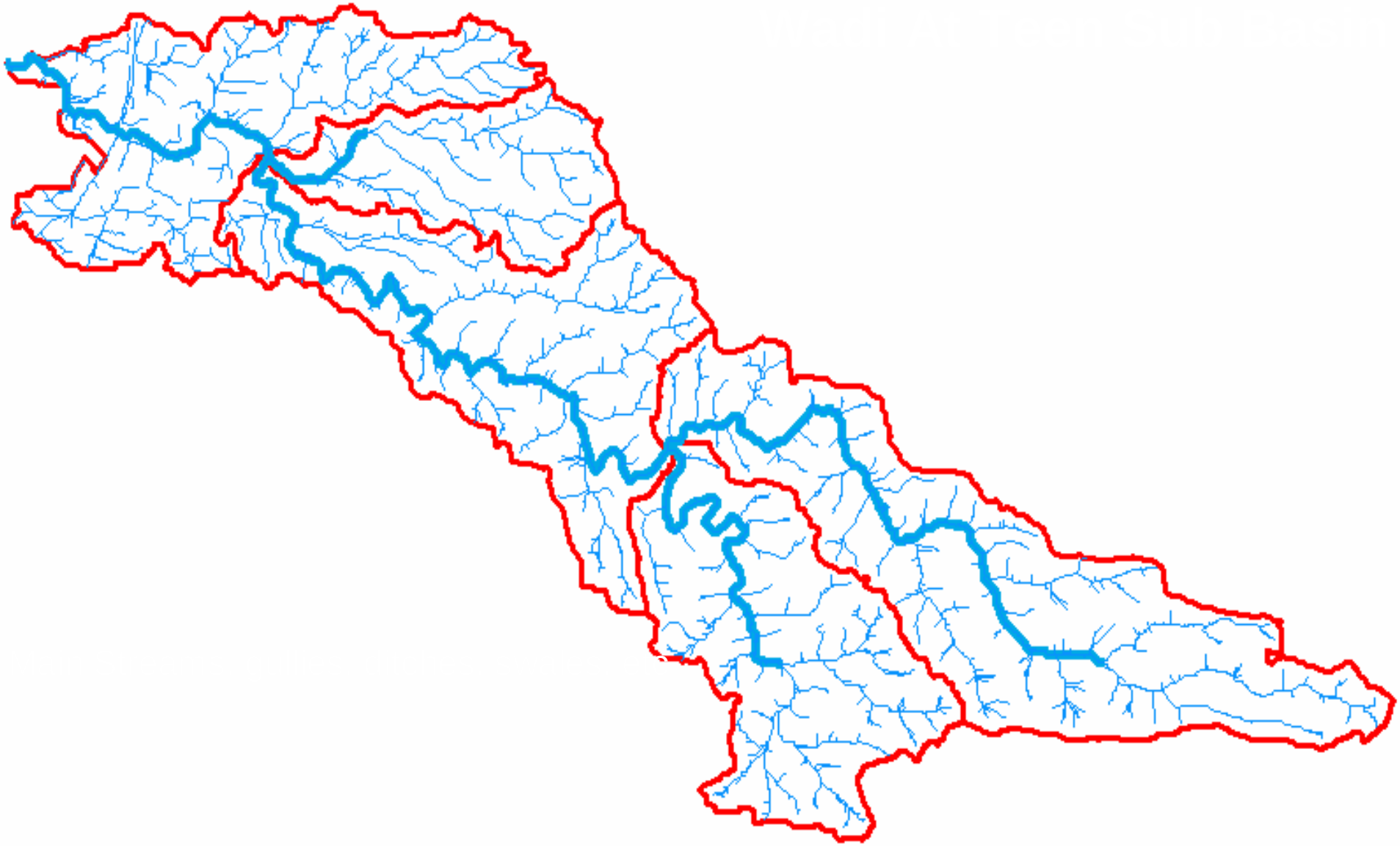
Wadi At Teen Case: simple delineation has been developed using (DEM, Detailed digitized stream network)



Estimating the LSUR and SLSUR parameters: using the Draft land use map, the generated Slope map and the generated detailed stream network.



Estimating the LSUR and SLSUR parameters: using the Draft land use map, the generated Slope map and the generated detailed stream network.



Estimating the LSUR and SLSUR parameters: using the Draft land use map, the generated Slope map and the generated detailed stream network.

LSUR

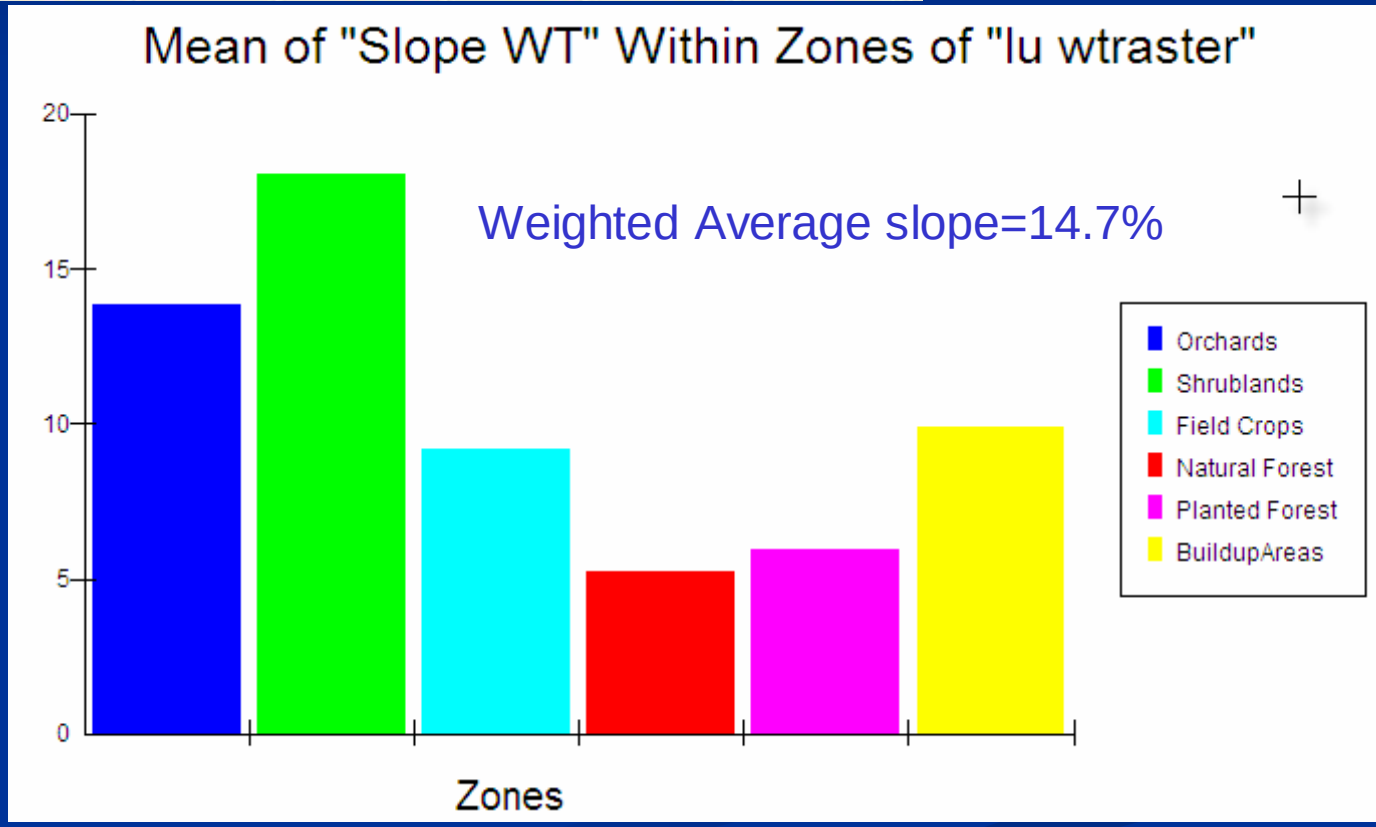
- LSUR: length of assumed overland flow plane (ft), the LSUR approximates the average length of travel for water to reach the stream reach.
- Typical values range from 200ft to 500ft for slopes ranging from 15% to 1%
- LSUR is inversely proportional to slope

$$LSUR_i = \frac{(Watershed\ Area)_i}{2 \times (length\ of\ all\ small\ streams\ in\ the\ watershed\ area)_i}$$

$$Where: \quad i = Landuse\ type\ i$$

Stats of "Slope_WT" Within Zones of "lu_wtraster"

LULC	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD
Orchards	90898	5.68112E+07	0	72.5439	72.5439	13.8598	8.86602
Shrublands	83861	5.24131E+07	0	86.7332	86.7332	18.0621	11.2471
Field Crops	25550	1.59688E+07	0	58.0978	58.0978	9.21231	8.49743
Natural Forest	38	23750	0.72111	22.5621	21.841	5.22546	6.74016
Planted Forest	186	116250	0.316225	17.1261	16.8099	5.93567	4.65749
BuildupAreas	14587	9116880	0	86.511	86.511	9.90675	8.13698



Wadi At Teen case: note that the slopes for different landuse types are almost within the accepted range (5.2-18%)

- Main streams length = 47109.8 m = 143590.6 ft
- All types of streams = 399995.1m = 1219185.1 ft
- Net length of all small streams = 1219185.1- 143590.6
  = 1075594.5 ft
- Area = 131224375 m^2 = 1219114.3 ft^2
- LSUR= 1219114.3 /(2* 1075594.5) = 566.7 ft
- (Average Slope =14.7%)

Landuse	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	Mean*Count	LSUR	SLSUR
Orchards	90898	56811200.0	0.0	72.5	72.5	13.9	8.9	1259828.1	535.4	0.14
Shrublands	83861	52413100.0	0.0	86.7	86.7	18.1	11.2	1514705.7	697.8	0.18
Field Crops	25550	15968800.0	0.0	58.1	58.1	9.2	8.5	235374.5	355.9	0.09
Natural Forest	38	23750.0	0.7	22.6	21.8	5.2	6.7	198.6	201.9	0.05
Planted Forest	186	116250.0	0.3	17.1	16.8	5.9	4.7	1104.0	229.3	0.06
BuildupAreas	14587	9116880.0	0.0	86.5	86.5	9.9	8.1	144509.8	382.7	0.10
Sum	215120							3155721		
							Weighted Average Slope %=	14.7		

Estimated LSUR and SLSUR Values for different land use types.

Preparing the WDM File

- Row data: 8-15/2/2006, 5 minutes intervals

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
		Temp	Hi	Low	Out		Wind		Wind	Hi	Hi	Wind	Heat				Rain	Heat	Cool	In	In	Wind	Wind	ISS	Arc.
Date	Time	Out	Temp	Temp	Hum	Dew	Speed	Dir	Run	Speed	Dir	Chill	Index	THW	Bar	Rain	Rate	D-D	D-D	Temp	Hum	Samp	Tx	Recept	Int.
2/8/2006	0:05	14.4	14.4	14.4	44	2.3	0	ESE	0	3.2	ESE	14.4	13.1	13.1	1003.4	0	0	0.014	0	21.3	39	114	1	100	5
2/8/2006	0:10	14.2	14.4	13.8	48	3.4	4.8	W	0.4	14.5	W	14	13.1	12.6	1003.4	0	0	0.014	0	21.3	39	113	1	99.1	5
2/8/2006	0:15	13.3	13.8	13.1	53	3.9	6.4	W	0.54	12.9	WNW	12.5	12.3	11.4	1003.8	0	0	0.018	0	21.3	39	114	1	100	5
2/8/2006	0:20	13.2	13.4	12.9	49	2.7	4.8	S	0.4	16.1	W	12.8	12.1	11.5	1003.8	0	0	0.018	0	21.3	40	114	1	100	5
2/8/2006	0:25	14	14.4	13.4	47	2.9	4.8	SW	0.4	12.9	WSW	13.8	12.8	12.3	1003.8	0	0	0.015	0	21.3	40	114	1	100	5
2/8/2006	0:30	14.6	14.7	14.4	49	4	1.6	SW	0.13	6.4	SW	14.6	13.4	13.4	1004	0	0	0.013	0	21.3	39	114	1	100	5
2/8/2006	0:35	14.9	15.1	14.7	50	4.5	3.2	SW	0.27	9.7	SW	14.9	13.8	13.7	1004	0	0	0.012	0	21.3	40	114	1	100	5
2/8/2006	0:40	15.2	15.3	15.1	50	4.9	3.2	SW	0.27	8	SW	15.2	14.1	14	1004	0	0	0.011	0	21.3	40	114	1	100	5
2/8/2006	0:45	15.4	15.4	15.4	52	5.6	0	SW	0	4.8	SW	15.4	14.4	14.4	1004	0	0	0.01	0	21.3	40	114	1	100	5
2/8/2006	0:50	15.4	15.6	15.4	54	6.1	1.6	S	0.13	8	S	15.4	14.4	14.4	1004	0	0	0.01	0	21.3	40	114	1	100	5
2/8/2006	0:55	15.7	15.7	15.6	53	6.1	3.2	SW	0.27	9.7	SW	15.7	14.7	14.6	1004	0	0	0.009	0	21.3	40	114	1	100	5
2/8/2006	1:00	15.8	15.9	15.7	53	6.2	3.2	S	0.27	9.7	SSE	15.8	14.8	14.7	1003.6	0	0	0.009	0	21.2	40	114	1	100	5
2/8/2006	1:05	16.2	16.3	15.9	52	6.3	4.8	SSW	0.4	12.9	S	16.2	15.2	14.9	1003.6	0	0	0.008	0	21.3	40	114	1	100	5
2/8/2006	1:10	16.3	16.4	16.3	54	7	3.2	S	0.27	12.9	S	16.3	15.4	15.4	1003.6	0	0	0.007	0	21.3	40	113	1	99.1	5
2/8/2006	1:15	16.5	16.6	16.4	54	7.2	4.8	S	0.4	12.9	S	16.5	15.6	15.3	1003.7	0	0	0.006	0	21.3	40	114	1	100	5
2/8/2006	1:20	16.6	16.6	16.6	54	7.3	4.8	S	0.4	11.3	S	16.6	15.7	15.5	1003.7	0	0	0.006	0	21.3	41	114	1	100	5
2/8/2006	1:25	16.7	16.7	16.6	55	7.6	3.2	S	0.27	9.7	S	16.7	15.8	15.8	1003.7	0	0	0.006	0	21.3	40	114	1	100	5
2/8/2006	1:30	16.6	16.7	16.2	57	8	3.2	SW	0.27	9.7	SW	16.6	15.8	15.8	1004.1	0	0	0.006	0	21.3	41	114	1	100	5
2/8/2006	1:35	16.1	16.2	16	61	8.5	3.2	S	0.27	12.9	SSE	16.1	15.4	15.4	1004.1	0	0	0.008	0	21.2	41	114	1	100	5
2/8/2006	1:40	16.1	16.2	16.1	61	8.6	4.8	S	0.4	12.9	S	16.1	15.5	15.2	1004.1	0	0	0.008	0	21.3	41	114	1	100	5
2/8/2006	1:45	16.2	16.3	16.2	60	8.4	3.2	S	0.27	9.7	SSW	16.2	15.6	15.5	1004	0	0	0.007	0	21.2	41	114	1	100	5
2/8/2006	1:50	16.4	16.5	16.3	60	8.6	4.8	S	0.4	11.3	S	16.4	15.7	15.4	1004	0	0	0.007	0	21.3	41	114	1	100	5
2/8/2006	1:55	16.6	16.7	16.5	60	8.8	4.8	S	0.4	11.3	SSE	16.6	15.9	15.7	1004	0	0	0.006	0	21.2	41	114	1	100	5
2/8/2006	2:00	16.7	16.7	16.7	61	9.1	4.8	S	0.4	12.9	S	16.7	16.1	15.8	1004	0	0	0.006	0	21.3	41	114	1	100	5

Preparing the WDM File

- Data Preparation for WDM file

5 minutes Temperature, maximum and minimum temperatures, dew temperature, wind speed and precipitation

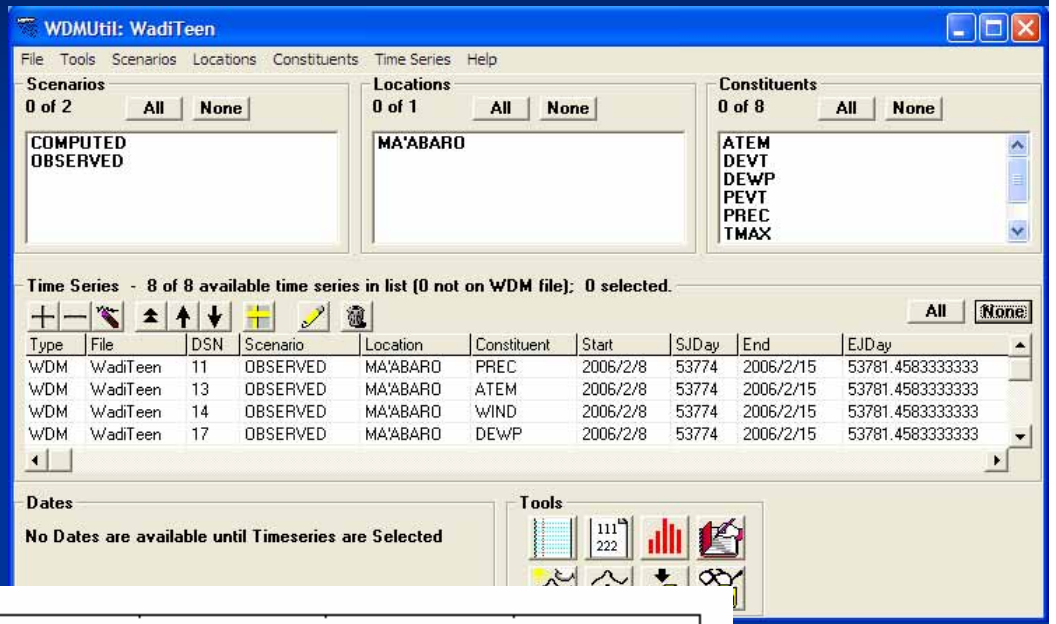
Hourly Temp, Max & Min Temps, Dew Temp, WS and Pecip.

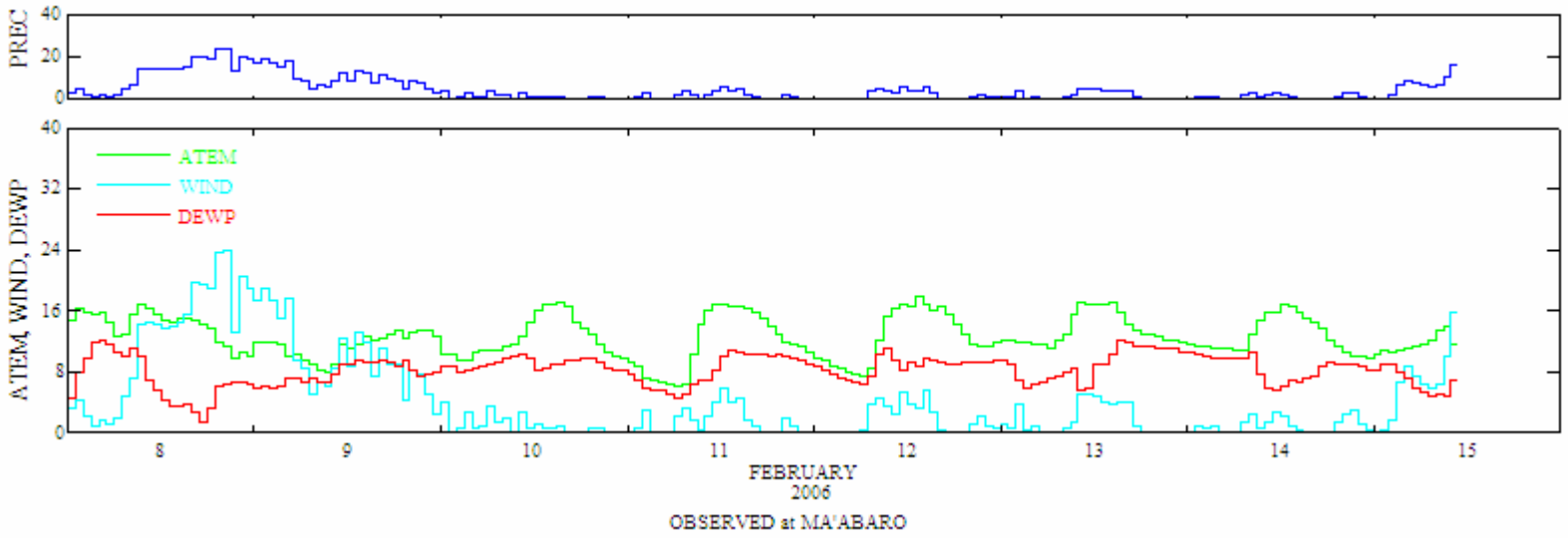
Daily Max & Min Temps

Time	Temp	Tmax	Tmin	Tdew	WindSpeed	Precipitation	Time	HrTemp	HrTdew	HrWS	HrPrec	DlyTmax	DlyTmin
2/8/2006 0:05	14.4	14.4	14.4	2.3	0	0							
2/8/2006 0:10	14.2	14.4	13.8	3.4	4.8	0							
2/8/2006 0:15	13.3	13.8	13.1	3.9	6.4	0							
2/8/2006 0:20	13.2	13.4	12.9	2.7	4.8	0							
2/8/2006 0:25	14	14.4	13.4	2.9	4.8	0							
2/8/2006 0:30	14.6	14.7	14.4	4	1.6	0							
2/8/2006 0:35	14.9	15.1	14.7	4.5	3.2	0							
2/8/2006 0:40	15.2	15.3	15.1	4.9	3.2	0							
2/8/2006 0:45	15.4	15.4	15.4	5.6	0	0							
2/8/2006 0:50	15.4	15.6	15.4	6.1	1.6	0							
2/8/2006 0:55	15.7	15.7	15.6	6.1	3.2	0							
2/8/2006 1:00	15.8	15.9	15.7	6.2	3.2	0	2/8/2006 1:00	14.675	4.383333	3.066667	0		
2/8/2006 1:05	16.2	16.3	15.9	6.3	4.8	0							
2/8/2006 1:10	16.3	16.4	16.3	7	3.2	0							
2/8/2006 1:15	16.5	16.6	16.4	7.2	4.8	0							
2/8/2006 1:20	16.6	16.6	16.6	7.3	4.8	0							
2/8/2006 23:50	10.2	10.4	10.2	6	16.1	0							
2/8/2006 23:55	10.4	10.6	10.4	5.8	16.1	0							
2/9/2006 0:00	10.7	10.8	10.6	5.4	16.1	0	2/9/2006 0:00	9.908333	6.291667	19.03333	0.76	17.2	9.1
2/9/2006 0:05	10.9	11.1	10.8	5.7	16.1	0							
2/9/2006 0:10	11.2	11.2	11.1	5.9	12.9	0							
2/9/2006 0:15	11.5	11.7	11.2	6	16.1	0							
2/9/2006 0:20	11.7	11.8	11.7	6	14.5	0							
2/9/2006 0:25	11.9	12.1	11.8	5.8	14.5	0							

Preparing the WDM File

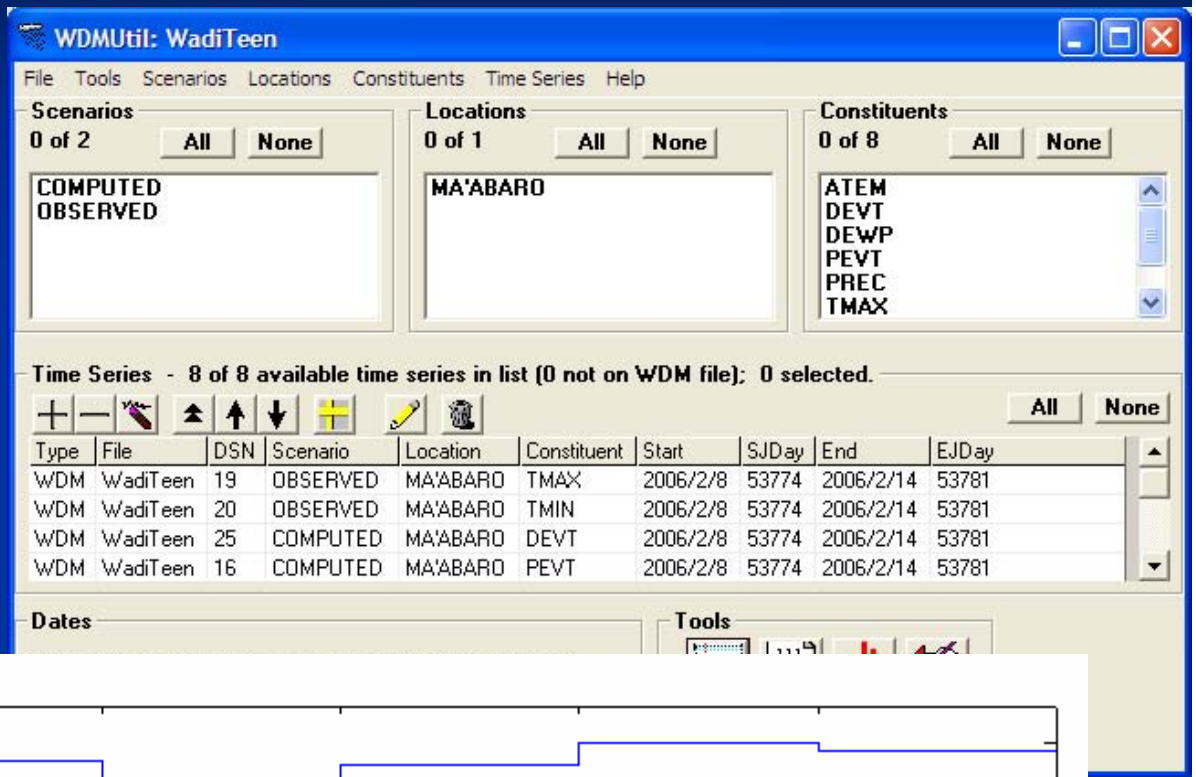
- WDM file:
  - PREC: measured “Hourly” precipitation
  - ATEM: measured “Hourly” temperature
  - WIND: measured “Hourly” wind speed
  - DEWP: measured “Hourly” dew temperature

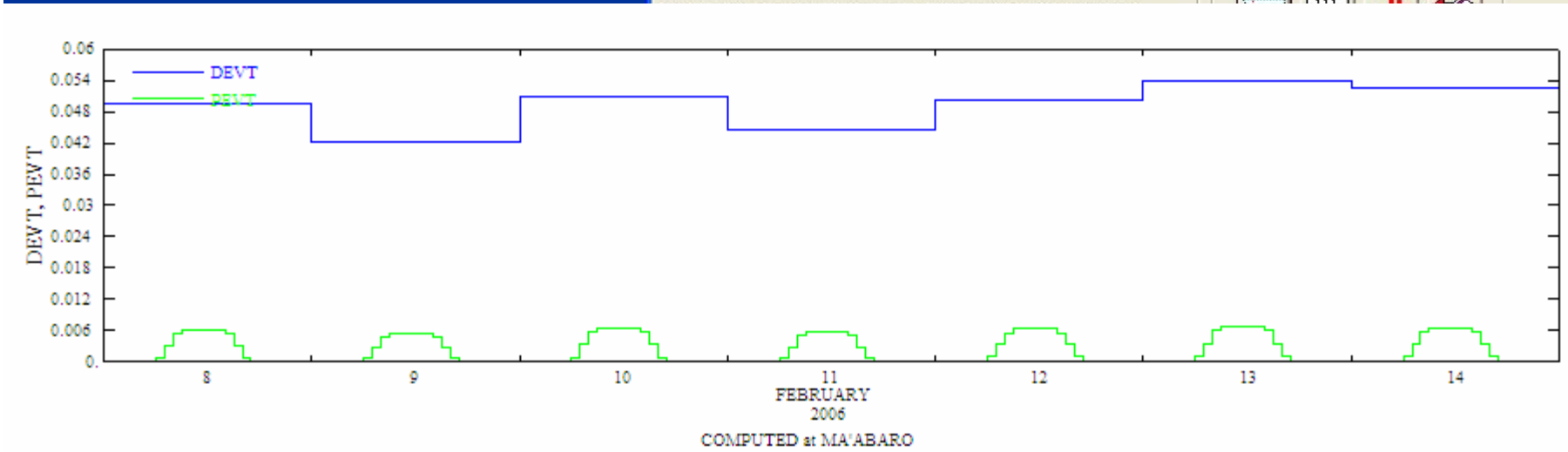




Preparing the WDM File

- WDM file:
  - TMAX: measured “Daily” maximum temperature.
  - TMIN: measured “Daily” minimum temperature.
  - DEVT: computed “Daily” potential evapotranspiration.
  - PEVT: computed “Hourly” potential evapotranspiration.

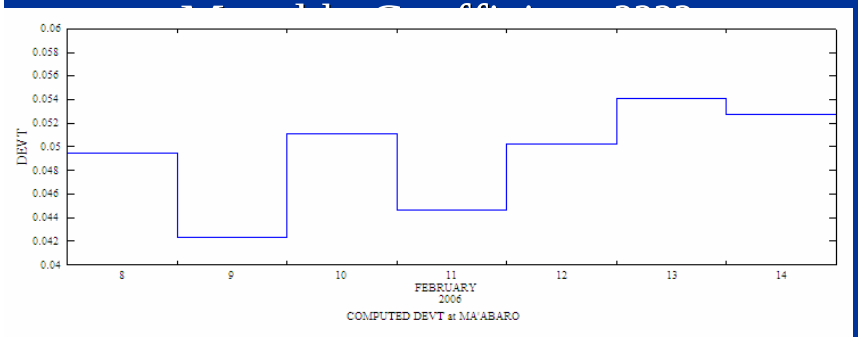


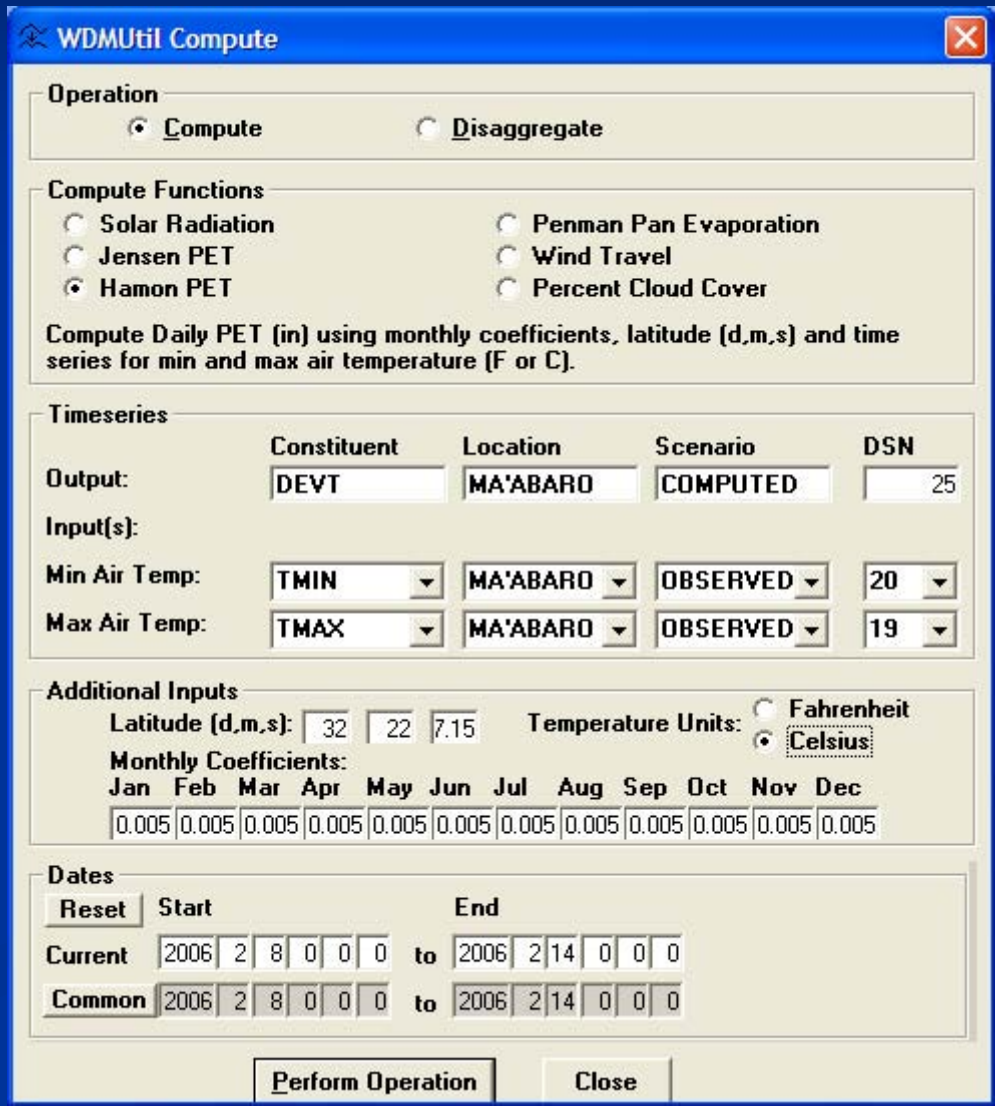


Preparing the WDM File

Estimating “Daily” potential evapotranspiration using “Hamon Method” by using:

- TMAX: measured “Daily” maximum temperature.
- TMIN: measured “Daily” minimum temperature.
- Latitude of the metrological station (32:22:7.15)





Preparing the WDM File

Disaggregate the estimated the "Daily" Potential Evapotranspiration using:

- DEVT: computed "Daily" Potential Evapotranspiration
- Latitude of the metrological station (32:22:7.15)