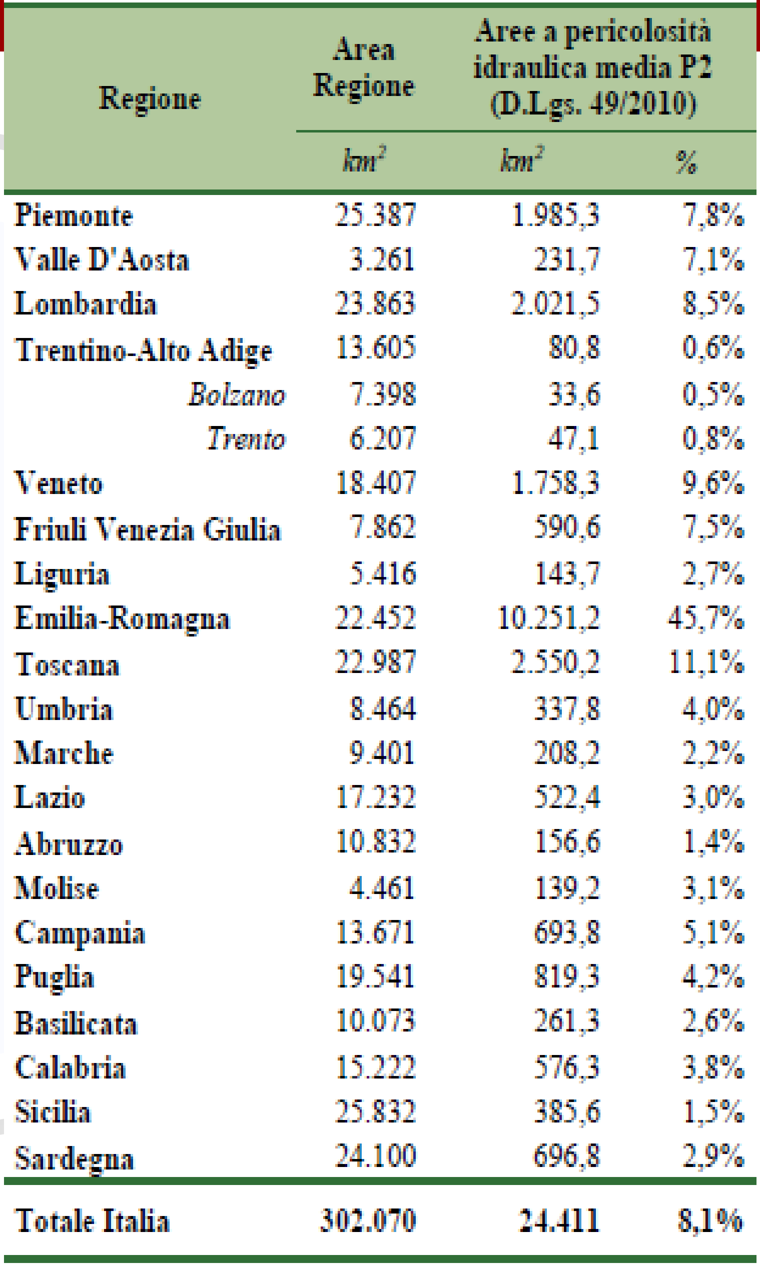
GIS-HEC-GeoRAS: SIMULAZIONE ONDA DI PIENA

Ing. Filippo Gagliano
Seriate 26 Gennaio 2018

Aree a pericolosità idraulica media P2 (D.Lgs. 49/2010)



Regione	Area Regione	Aree a pericolosità idraulica media P2 (D.Lgs. 49/2010)	
	km²	km²	%
Piemonte	25.387	1.985,3	7,8%
Valle D'Aosta	3.261	231,7	7,1%
Lombardia	23.863	2.021,5	8,5%
Trentino-Alto Adige	13.605	80,8	0,6%
Bolzano	7.398	33,6	0,5%
Trento	6.207	47,1	0,8%
Veneto	18.407	1.758,3	9,6%
Friuli Venezia Giulia	7.862	590,6	7,5%
Liguria	5.416	143,7	2,7%
Emilia-Romagna	22.452	10.251,2	45,7%
Toscana	22.987	2.550,2	11,1%
Umbria	8.464	337,8	4,0%
Marche	9.401	208,2	2,2%
Lazio	17.232	522,4	3,0%
Abruzzo	10.832	156,6	1,4%
Molise	4.461	139,2	3,1%
Campania	13.671	693,8	5,1%
Puglia	19.541	819,3	4,2%
Basilicata	10.073	261,3	2,6%
Calabria	15.222	576,3	3,8%
Sicilia	25.832	385,6	1,5%
Sardegna	24.100	696,8	2,9%
Totale Italia	**302.070**	**24.411**	**8,1%**

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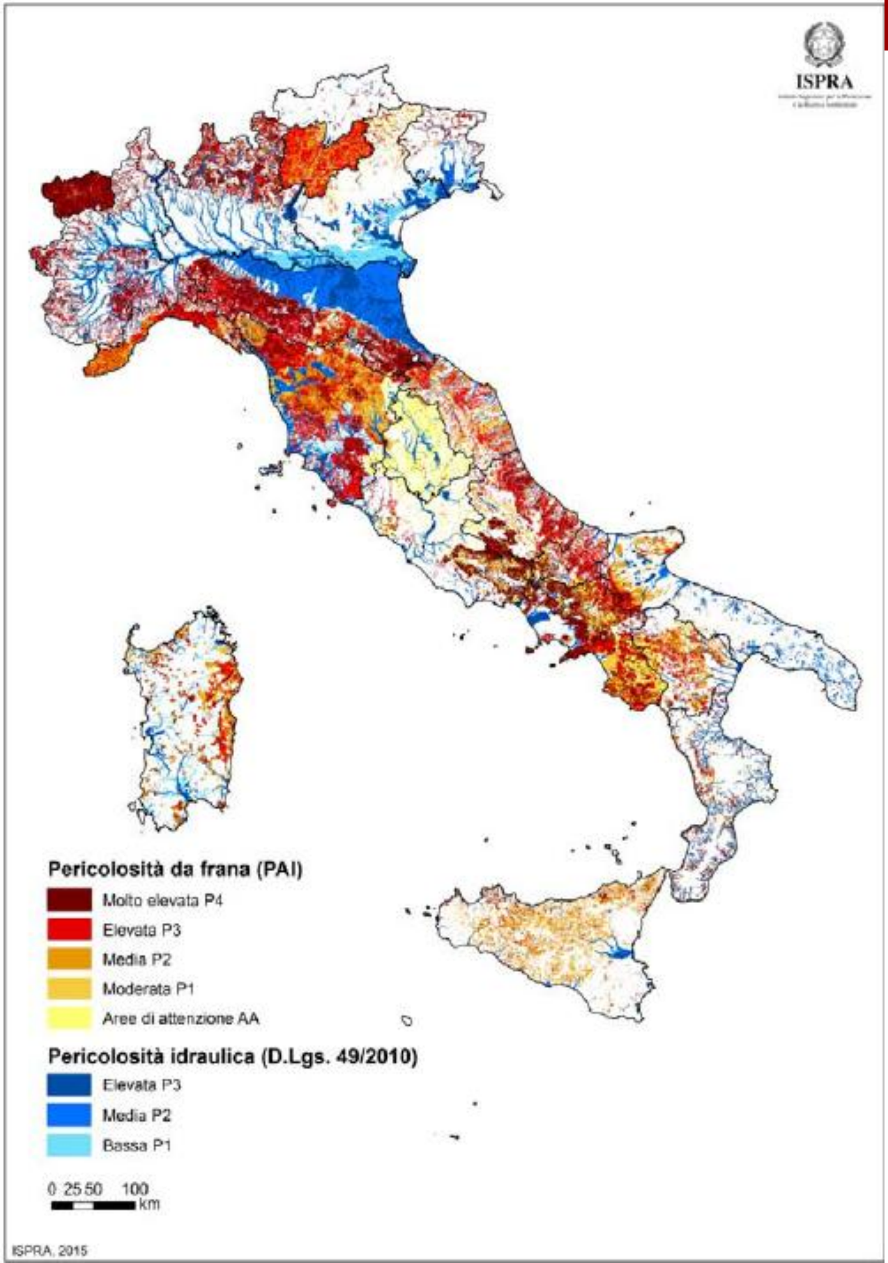
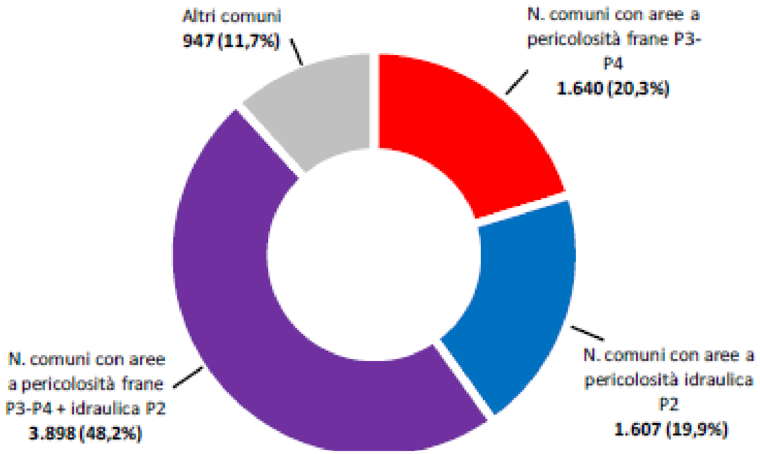
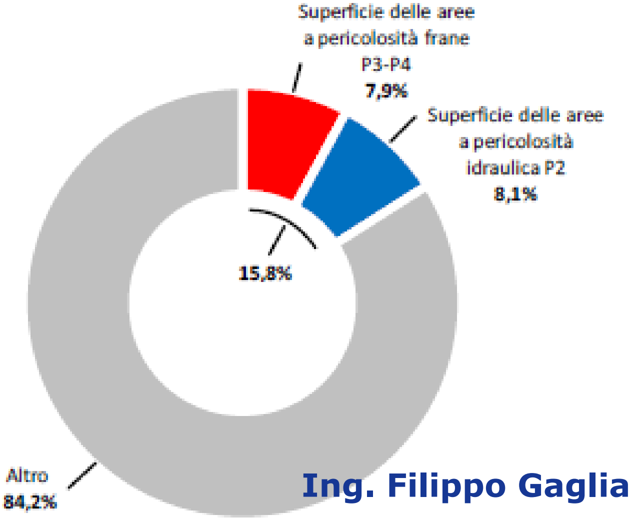
Aree a pericolosità da frana (PAI) e idraulica (D.Lgs. 49/2010)



Numero di comuni con aree a pericolosità da frana P3 e P4 (PAI) e idraulica P2 (D.Lgs. 49/2010)
7.145 comuni (88,3%)



Superficie delle aree a pericolosità da frana P3 e P4 (PAI) e idraulica P2 (D.Lgs. 49/2010)
15,8% del territorio nazionale



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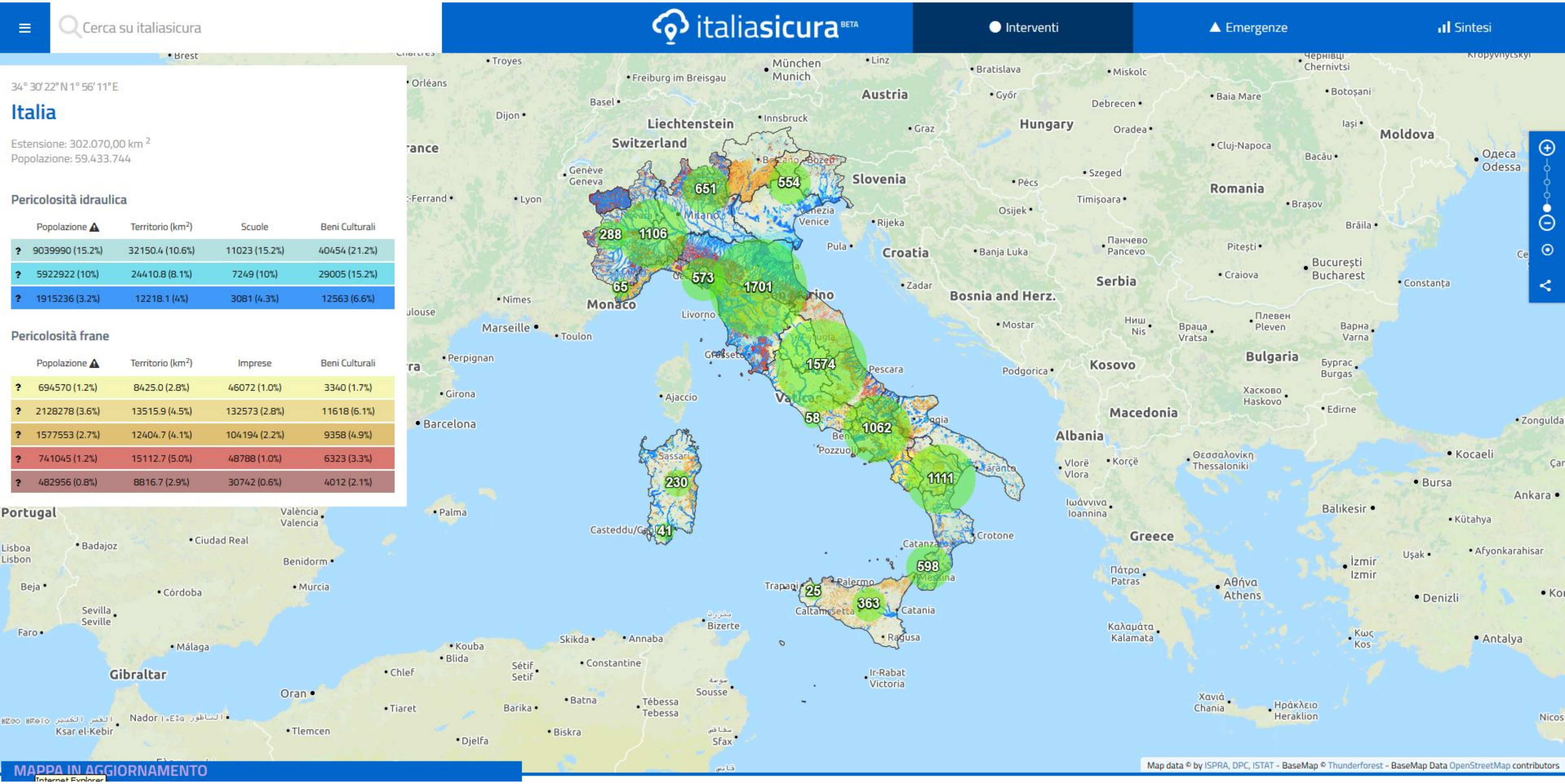
mappa.italiasicura.gov.it/#/interventi /



34° 30′ 22″ N 1° 56′ 11″ E

Italia

Estensione: 302.070,00 km ^{2}
Popolazione: 59.433.744

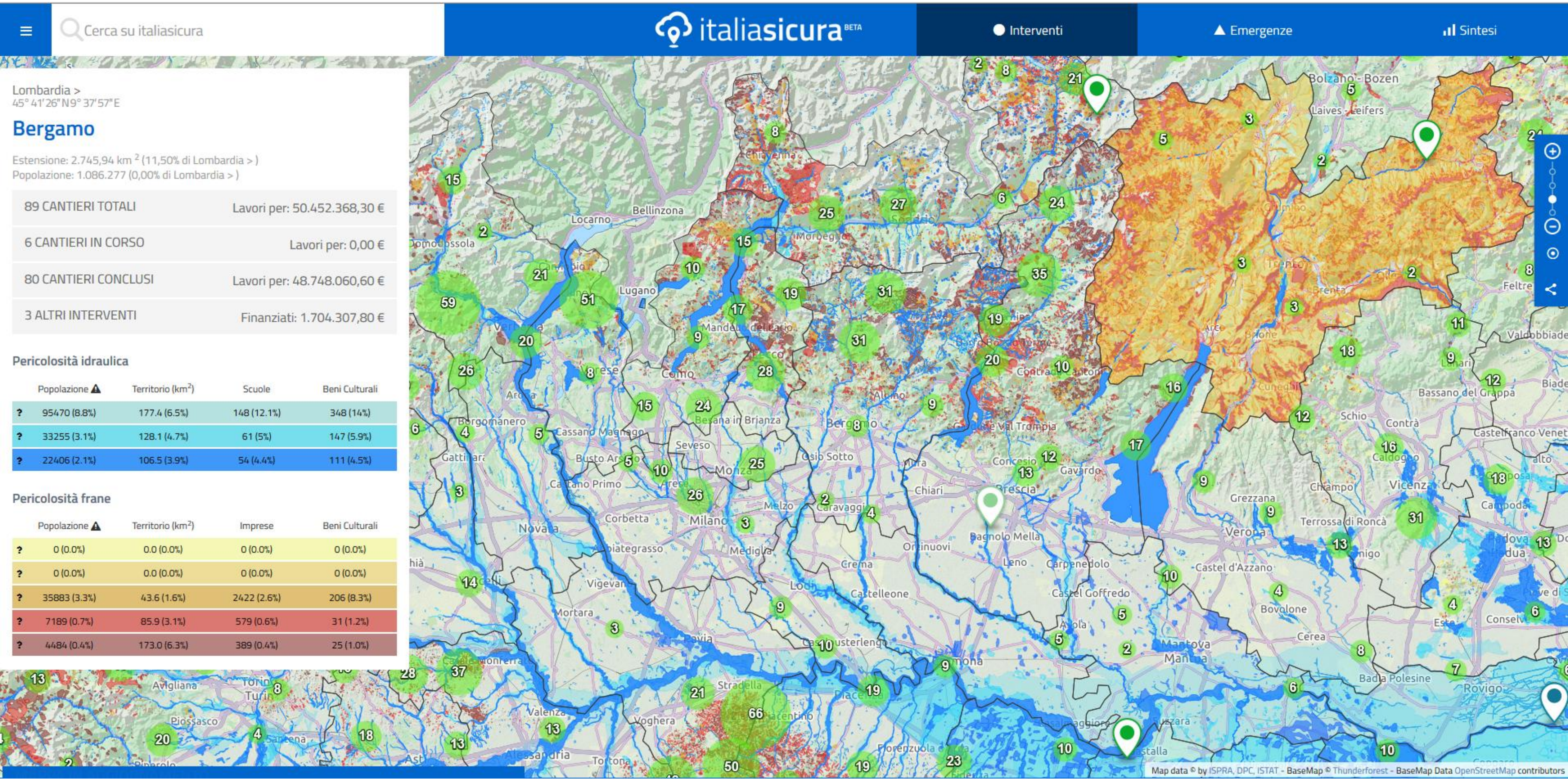
Pericolosità idraulica

	Popolazione ⚠	Territorio (km^2)	Scuole	Beni Culturali
?	9039990 (15.2%)	32150.4 (10.6%)	11023 (15.2%)	40454 (21.2%)
?	5922922 (10%)	24410.8 (8.1%)	7249 (10%)	29005 (15.2%)
?	1915236 (3.2%)	12218.1 (4%)	3081 (4.3%)	12563 (6.6%)

Pericolosità frane

	Popolazione ⚠	Territorio (km^2)	Imprese	Beni Culturali
?	694570 (1.2%)	8425.0 (2.8%)	46072 (1.0%)	3340 (1.7%)
?	2128278 (3.6%)	13515.9 (4.5%)	132573 (2.8%)	11618 (6.1%)
?	1577553 (2.7%)	12404.7 (4.1%)	104194 (2.2%)	9358 (4.9%)
?	741045 (1.2%)	15112.7 (5.0%)	48788 (1.0%)	6323 (3.3%)
?	482956 (0.8%)	8816.7 (2.9%)	30742 (0.6%)	4012 (2.1%)

Provincia di Bergamo



Lombardia >
45° 41′ 26″ N 9° 37′ 57″ E

Bergamo

Estensione: 2.745,94 km ^{2} (11,50% di Lombardia >)
Popolazione: 1.086.277 (0,00% di Lombardia >)

89 CANTIERI TOTALI	Lavori per: 50.452.368,30 €
6 CANTIERI IN CORSO	Lavori per: 0,00 €
80 CANTIERI CONCLUSI	Lavori per: 48.748.060,60 €
3 ALTRI INTERVENTI	Finanziati: 1.704.307,80 €

Pericolosità idraulica

	Popolazione ⚠	Territorio (km ^{2})	Scuole	Beni Culturali
?	95470 (8.8%)	177.4 (6.5%)	148 (12.1%)	348 (14%)
?	33255 (3.1%)	128.1 (4.7%)	61 (5%)	147 (5.9%)
?	22406 (2.1%)	106.5 (3.9%)	54 (4.4%)	111 (4.5%)

Pericolosità frane

	Popolazione ⚠	Territorio (km ^{2})	Imprese	Beni Culturali
?	0 (0.0%)	0.0 (0.0%)	0 (0.0%)	0 (0.0%)
?	0 (0.0%)	0.0 (0.0%)	0 (0.0%)	0 (0.0%)
?	35883 (3.3%)	43.6 (1.6%)	2422 (2.6%)	206 (8.3%)
?	7189 (0.7%)	85.9 (3.1%)	579 (0.6%)	31 (1.2%)
?	4484 (0.4%)	173.0 (6.3%)	389 (0.4%)	25 (1.0%)

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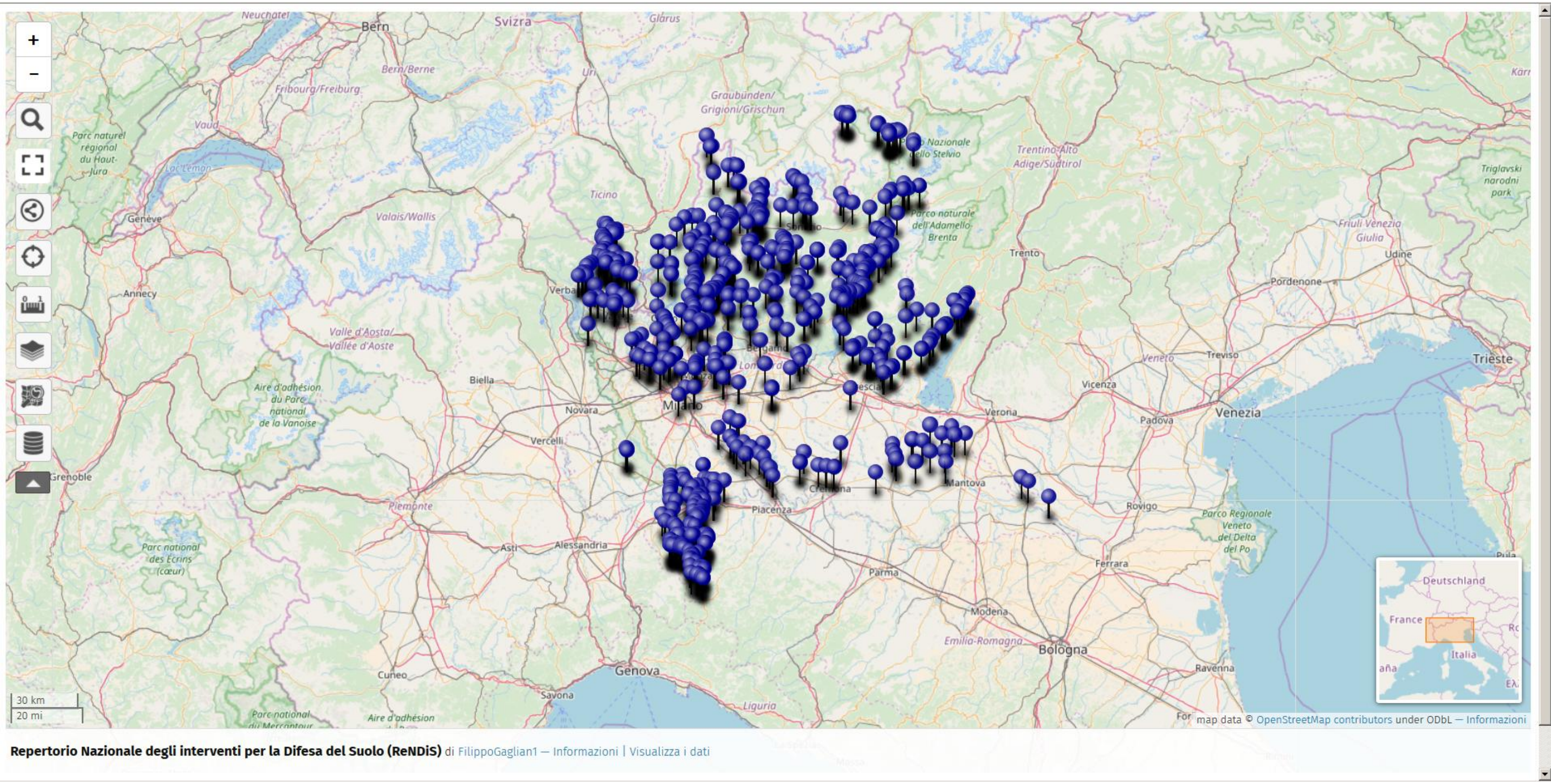
GIS strumento di indagine del territorio

http://www.igisweb.it/difesa_suolo/



Repertorio Nazionale degli interventi per la Difesa del Suolo (ReNDiS) di FilippoGaglian1 — Informazioni | Visualizza i dati

Hydrologic Engineering Center

US Army Corps of Engineers

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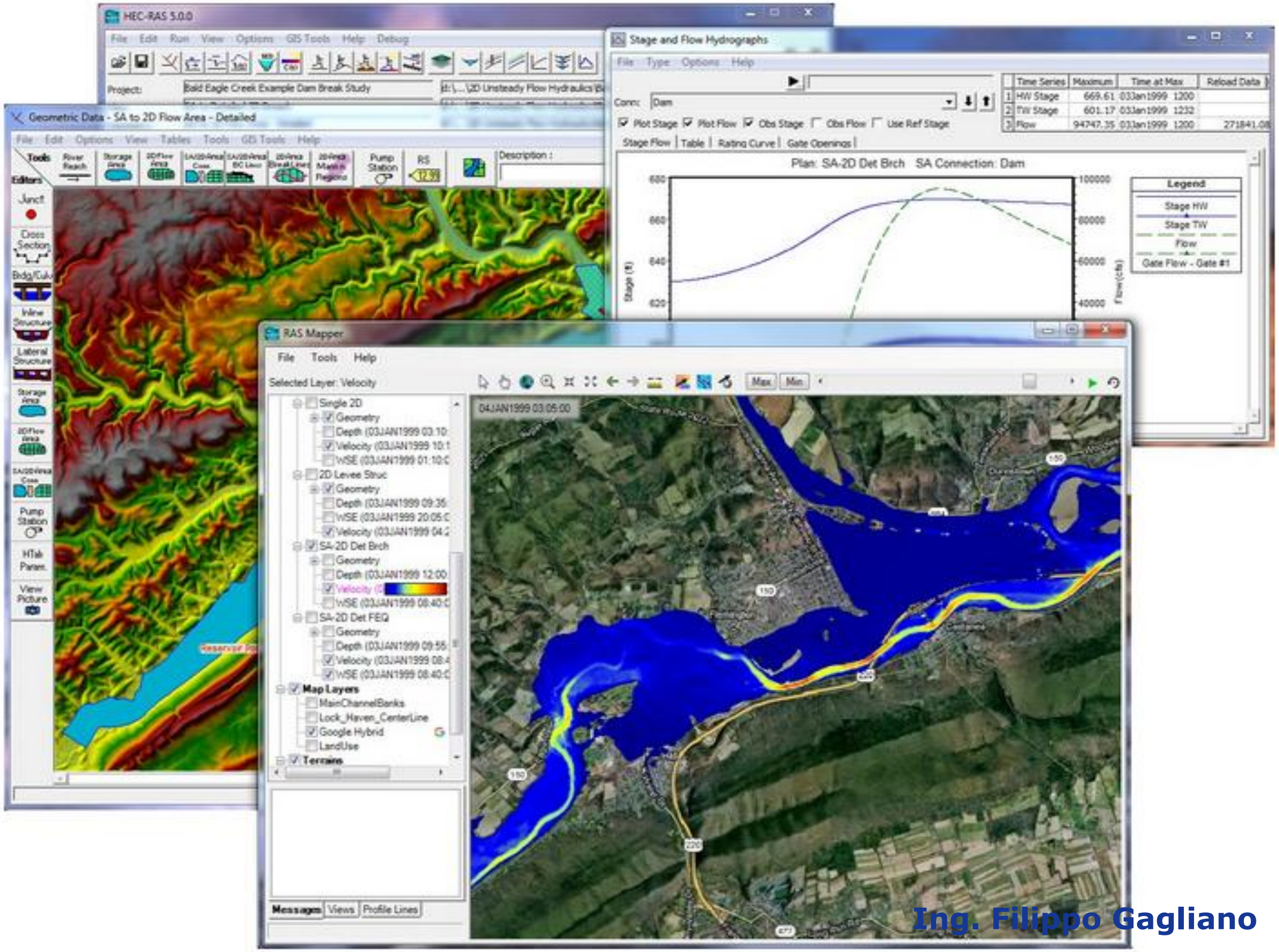

Project: Bald Eagle Creek Example Dam Break Study

Conn: Dam

	Time Series	Maximum	Time at Max	Reload Data
1	HW Stage	669.61	03Jan1999 1200	
2	TW Stage	601.17	03Jan1999 1232	
3	Flow	94747.35	03Jan1999 1200	271841.08

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Tutorial on using HEC-GeoRAS 10.1

- **Getting Started**
- **Exporting HEC-RAS Output**
- **Flood inundation mapping**
- **Hydraulic modeling**
- **Flooding in Unsteady Flow Conditions**
- **Visualization of HEC-RAS results in Google Earth**
- **2D Flooding using HEC-RAS (with and without levees)**

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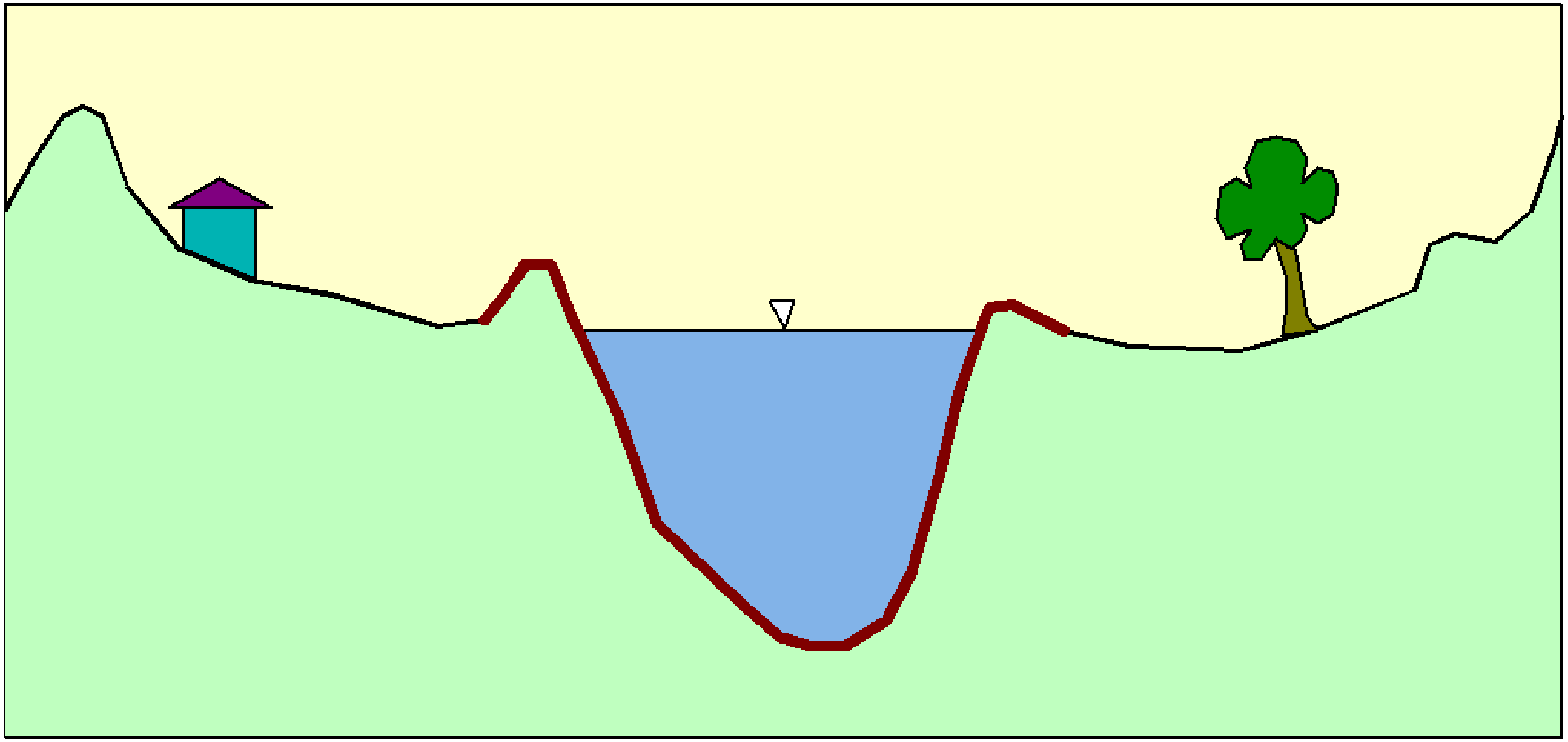
Getting Started
Flood Inundation



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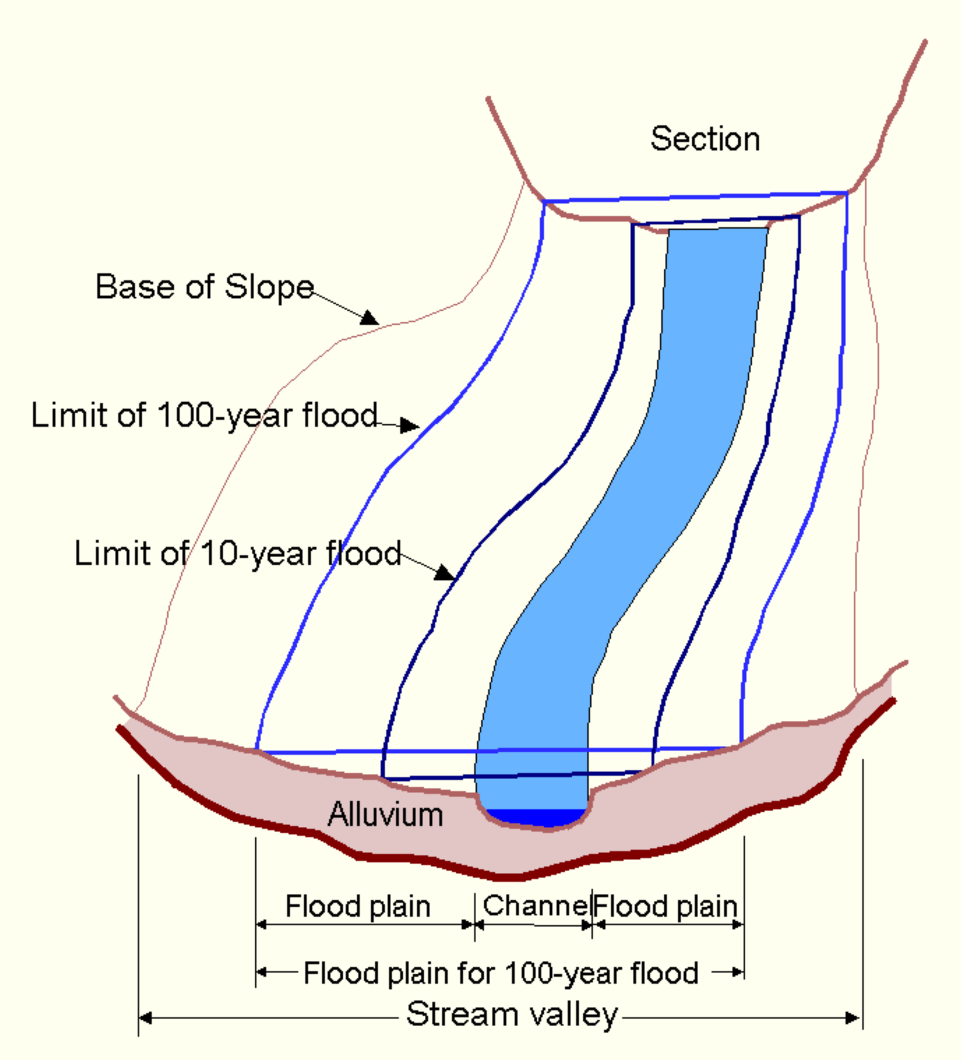
Floodplain Delineation



Steady Flow Solution

$$Z_2 + Y_2 + \frac{a_2 V_2^2}{2g} = Z_1 + Y_1 + \frac{a_1 V_1^2}{2g} + h_e$$

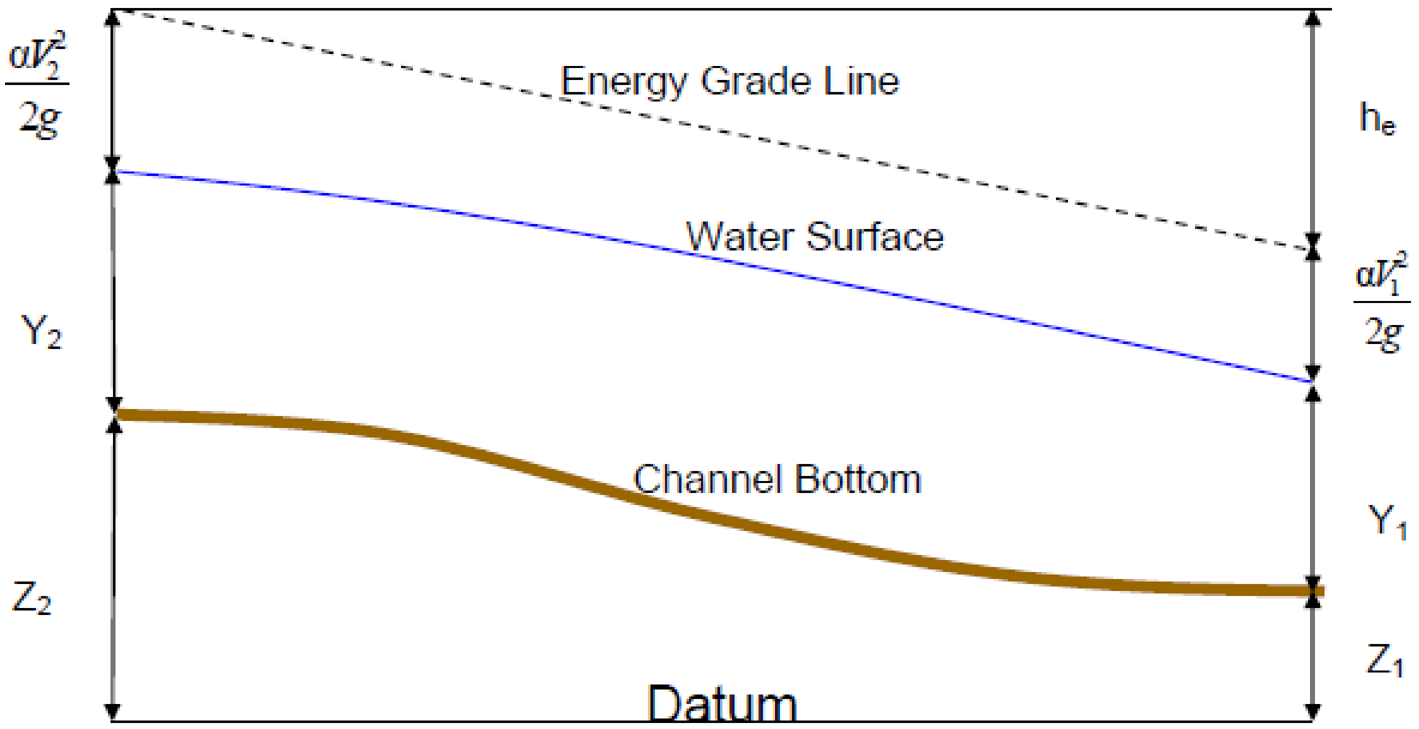
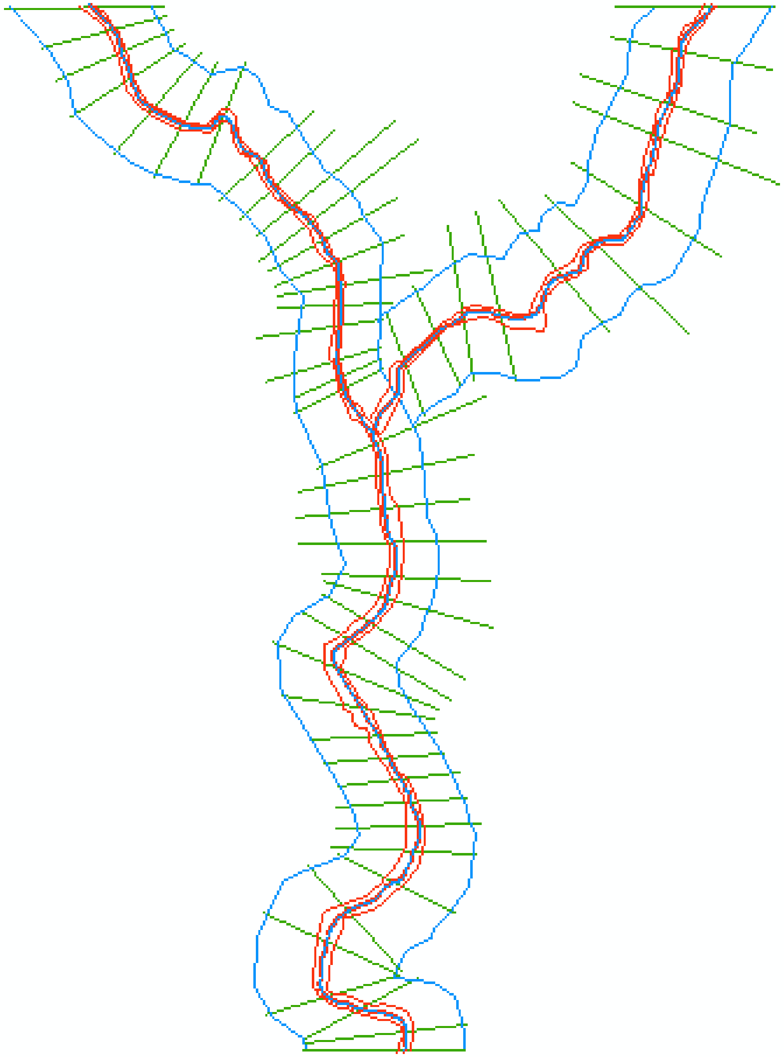


Figure 2-1 Representation of Terms in the Energy Equation

One-Dimensional Flow Computations



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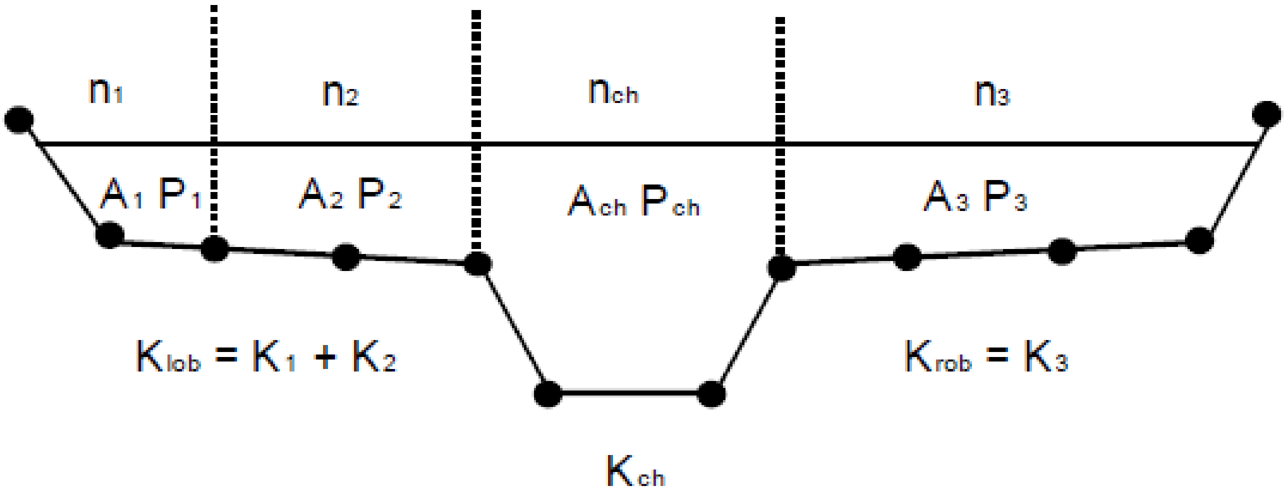
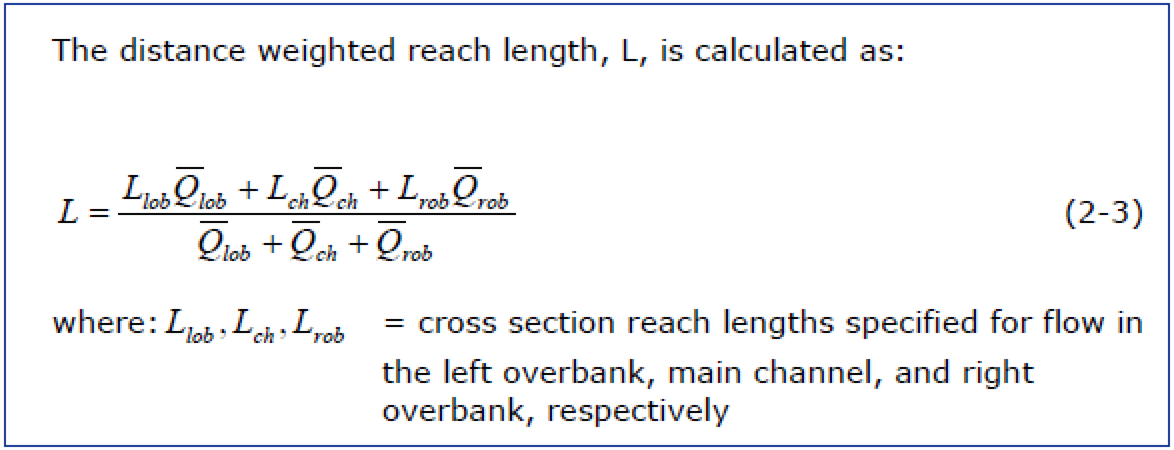
Flow Conveyance, K



$$Q = \frac{1.49}{n} A R^{2/3} S_f^{1/2}$$
$$or\ Q = K S_f^{1/2}$$

$$K = \frac{1.49}{n} A R^{2/3}$$
$$or\ K = \frac{1.49}{n} \frac{A^{5/3}}{P^{2/3}}$$

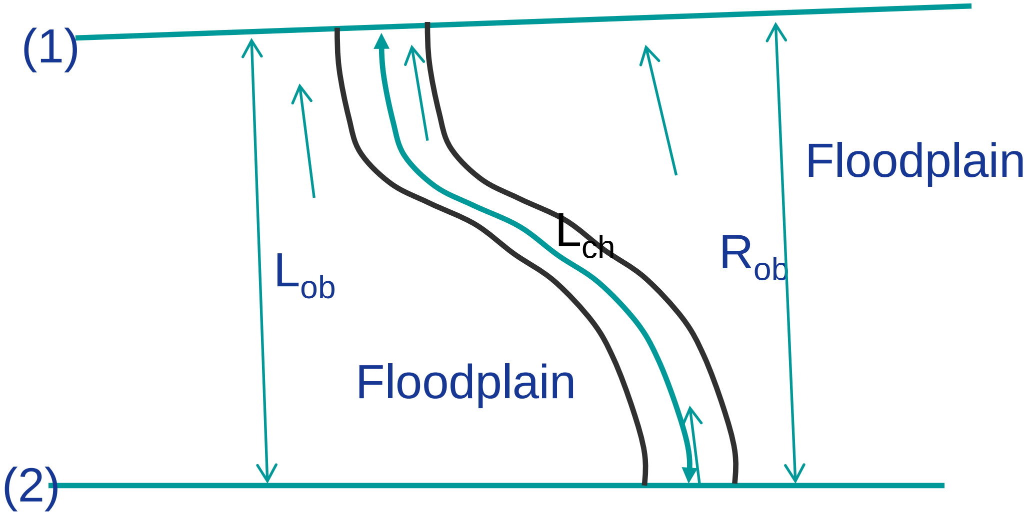
Reach Lengths



The distance weighted reach length, L, is calculated as:

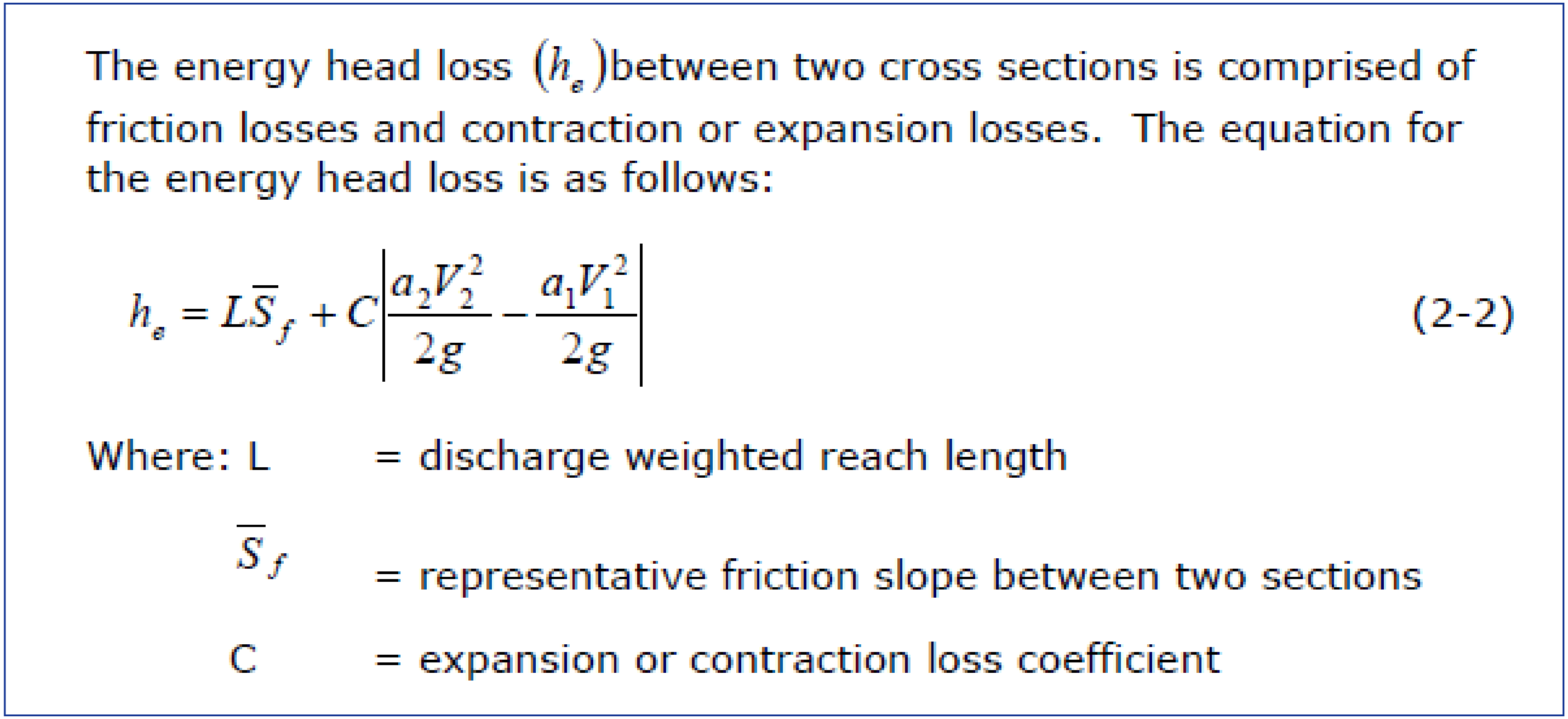
$$L = \frac{L_{lob}\overline{Q}_{lob} + L_{ch}\overline{Q}_{ch} + L_{rob}\overline{Q}_{rob}}{\overline{Q}_{lob} + \overline{Q}_{ch} + \overline{Q}_{rob}} \qquad (2\text{-}3)$$

where: L_{lob}, L_{ch}, L_{rob} = cross section reach lengths specified for flow in the left overbank, main channel, and right overbank, respectively



Left to Right looking downstream

Energy Head Loss



The energy head loss (h_e) between two cross sections is comprised of friction losses and contraction or expansion losses. The equation for the energy head loss is as follows:

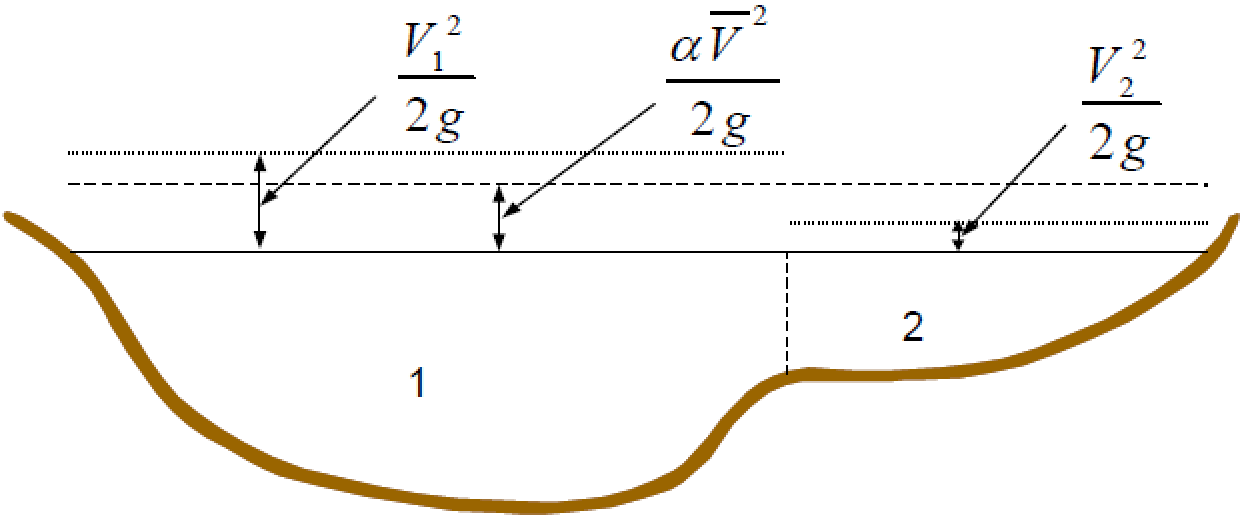
$$h_e = L\overline{S}_f + C\left|\frac{a_2V_2^2}{2g} - \frac{a_1V_1^2}{2g}\right| \tag{2-2}$$

Where: L = discharge weighted reach length

$\overline{S}_f$ = representative friction slope between two sections

C = expansion or contraction loss coefficient

Velocity Coefficient, α



V_1 = mean velocity for subarea 1

V_2 = mean velocity for subarea 2

$$a\frac{\overline{V}^2}{2g} = \frac{Q_1\frac{V_1^2}{2g} + Q_2\frac{V_2^2}{2g}}{Q_1 + Q_2}$$

Solving Steady Flow Equations

1. All conditions at (1) are known, Q is known
2. Select h_2
3. compute Y_2, V_2, K_2, S_f, h_e
4. Using energy equation (A), compute h_2
5. Compare new h_2 with the value assumed in Step 2, and repeat until convergence occurs

Q is known throughout reach

$$\boxed{Z_2 + Y_2 + \frac{a_2 V_2^2}{2g} = Z_1 + Y_1 + \frac{a_1 V_1^2}{2g} + h_e} \quad \text{(A)}$$

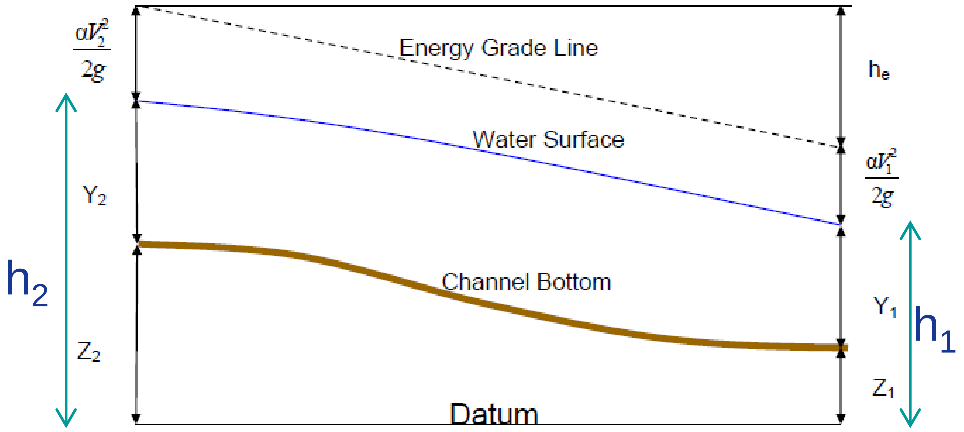
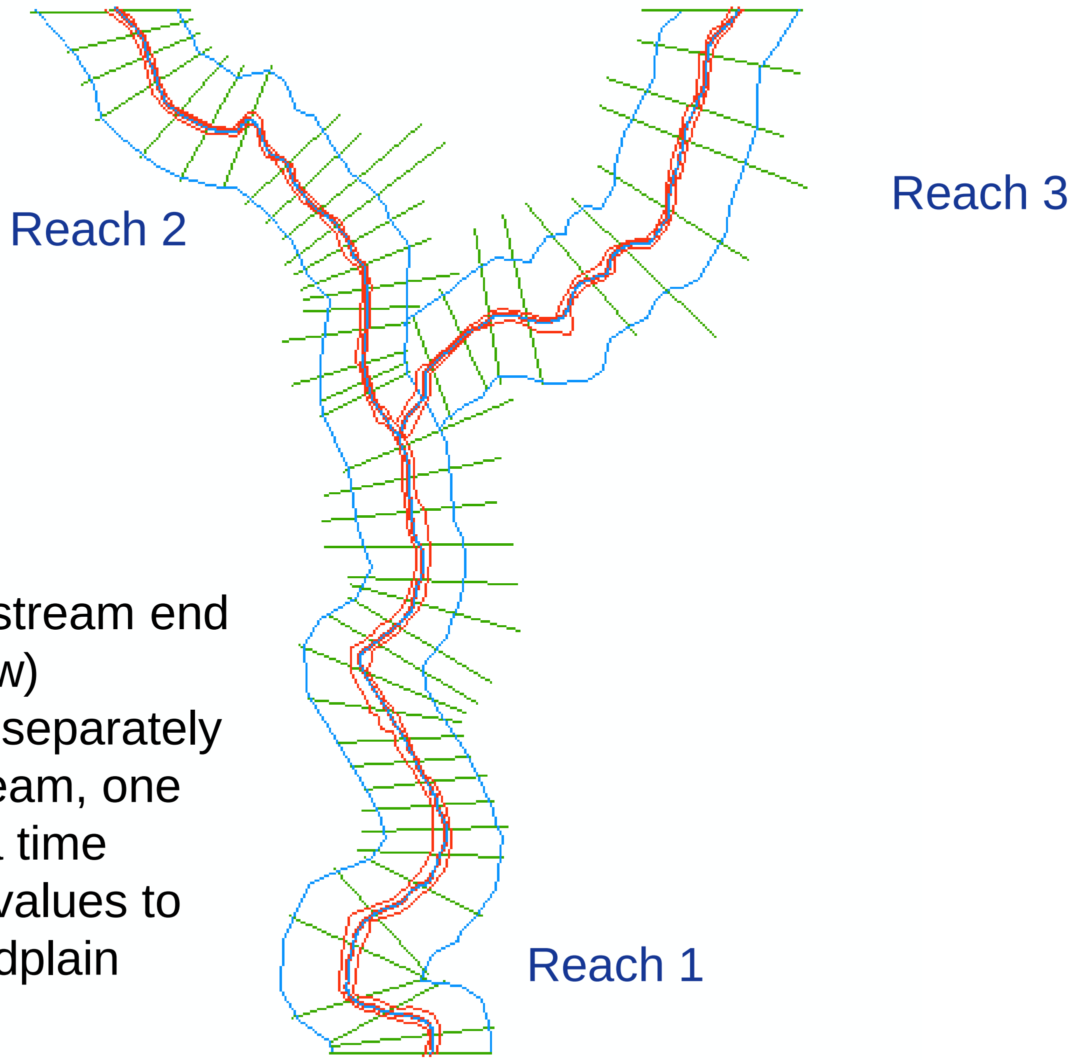


Figure 2-1 Representation of Terms in the Energy Equation

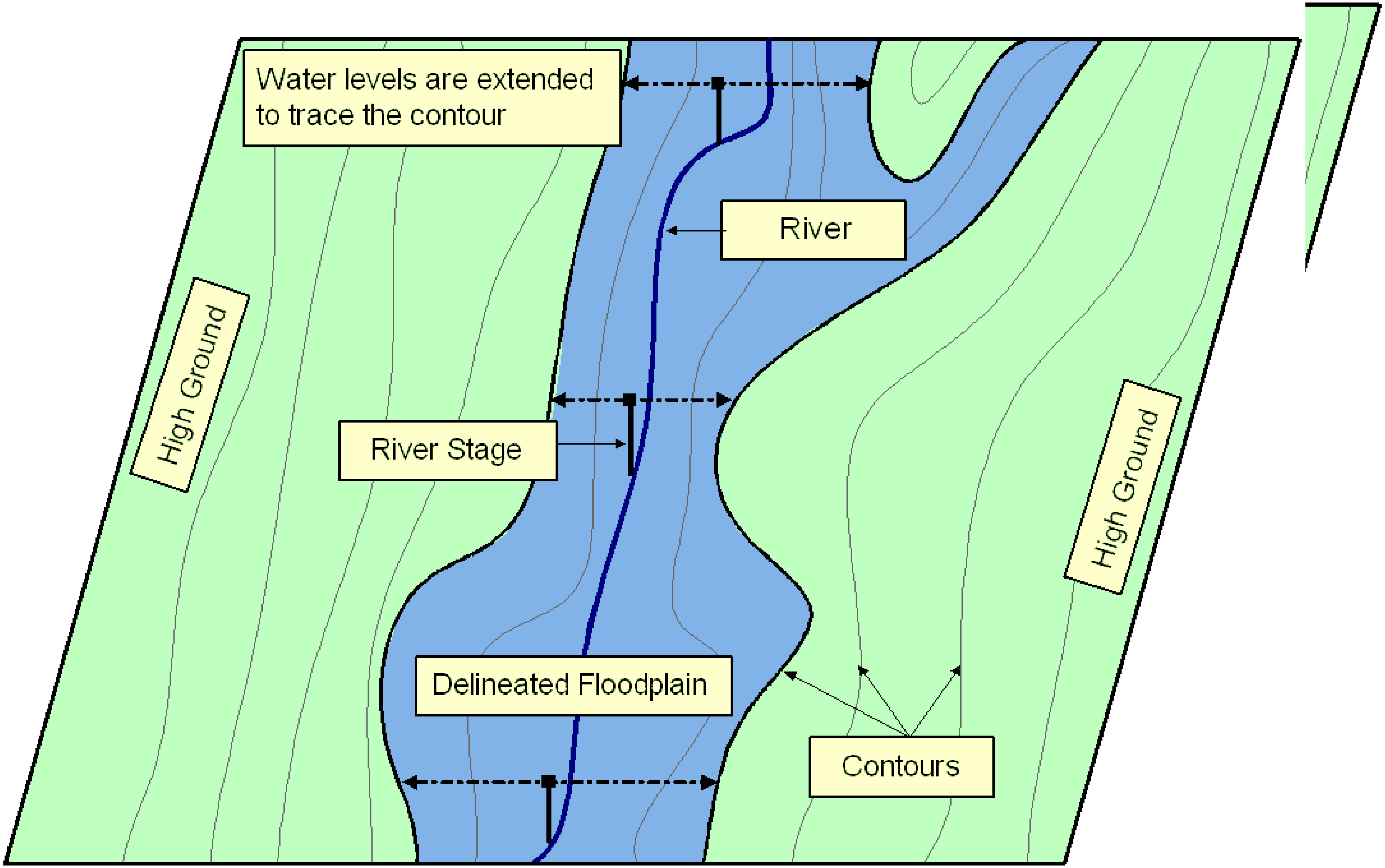
$$S_f = \left(\frac{Q}{K}\right)^2$$

Flow Computations



- Start at the downstream end (for subcritical flow)
- Treat each reach separately
- Compute h upstream, one cross-section at a time
- Use computed h values to delineate the floodplain

Floodplain Delineation



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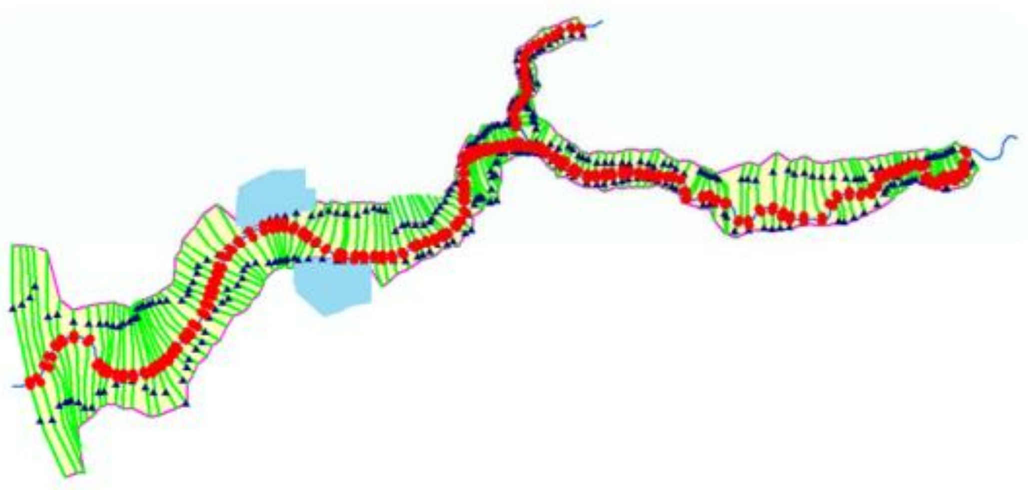
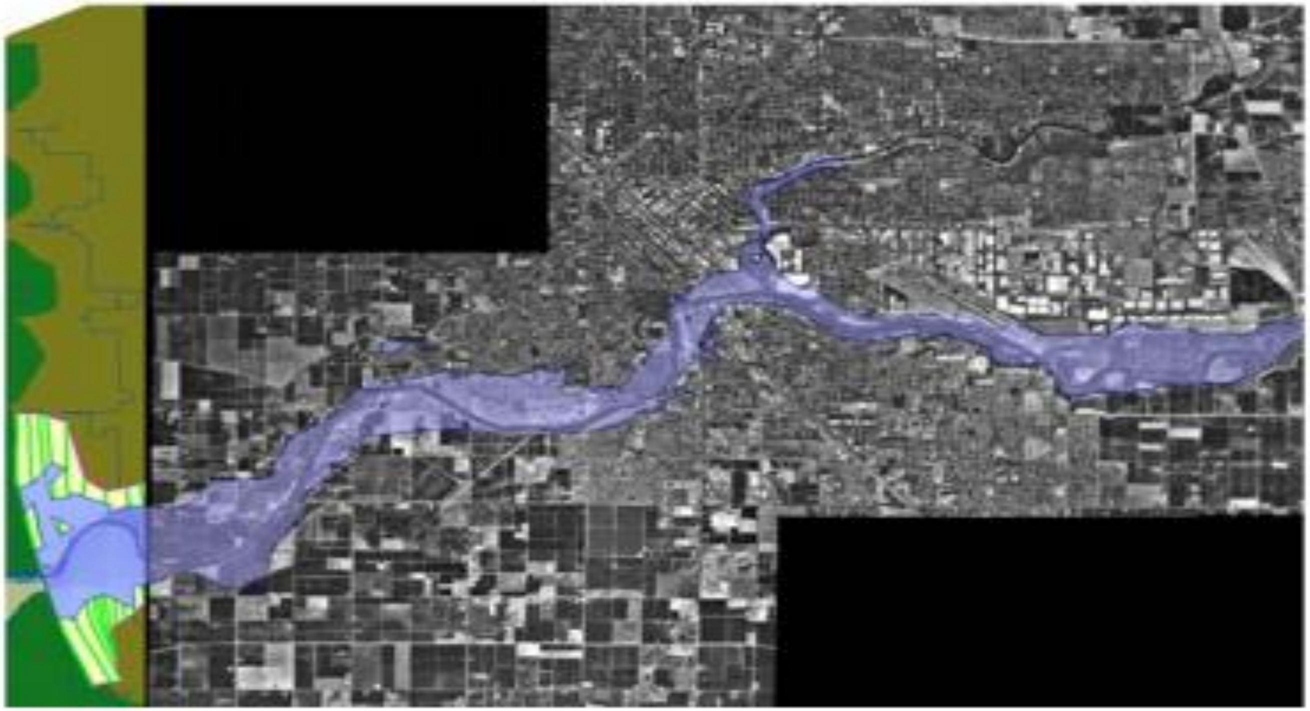
Section

This will create a bounding polygon, which basically defines the analysis extent for inundation mapping, by connecting the endpoints of XS Cut Lines.



After the analysis extent is defined, we are ready to map the inundation extent. Click on RAS Mapping/ Inundation Mapping/ Water Surface Generation. Select Biggest (profile with highest flow), and click OK. This will create a surface with water surface elevation for the selected profile. The TIN that is created in this step (t Biggest) will define a zone that will connect the outer points of the bounding polygon, which means the TIN will include area outside the possible inundation.

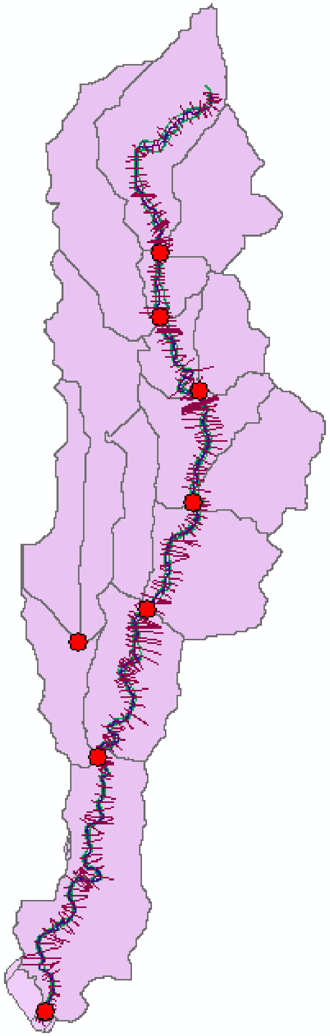
Aerials Maps



After the inundation map is created, you must check the inundation polygon for accuracy. You may want to superimpose your results with the aerial map, which is available in the Aerials folder in the working directory. It is very common to find errors in the terrain. If you detect these errors, you need to fix it in the HEC-RAS geometry file.

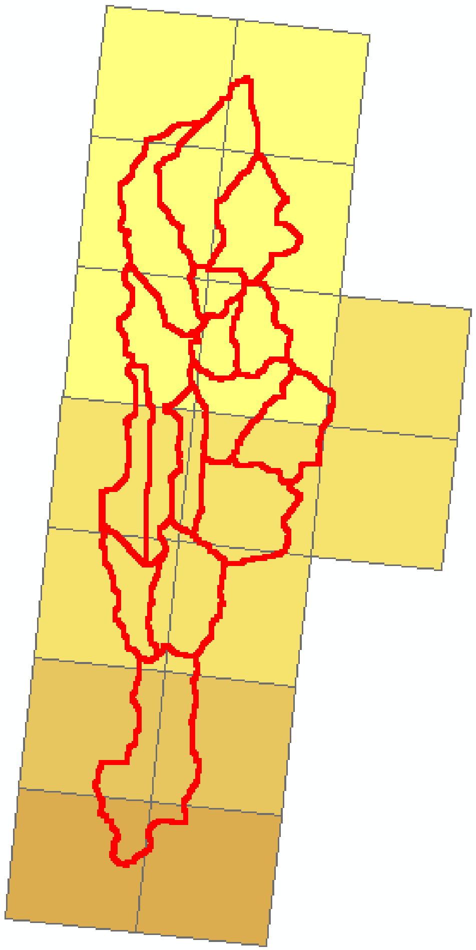
Integration Planning

- Identify where outputs from one model (HMS) become input to th second one (RAS)
  - Place hydrologic elements (subbasins, reaches, junctions) to capture flows at points of interest (confluences, structures)
  - Place hydraulic elements (cross-sections) at points of interest
  - Identify/specify element naming conventions between the two mod (persistent or transient names)



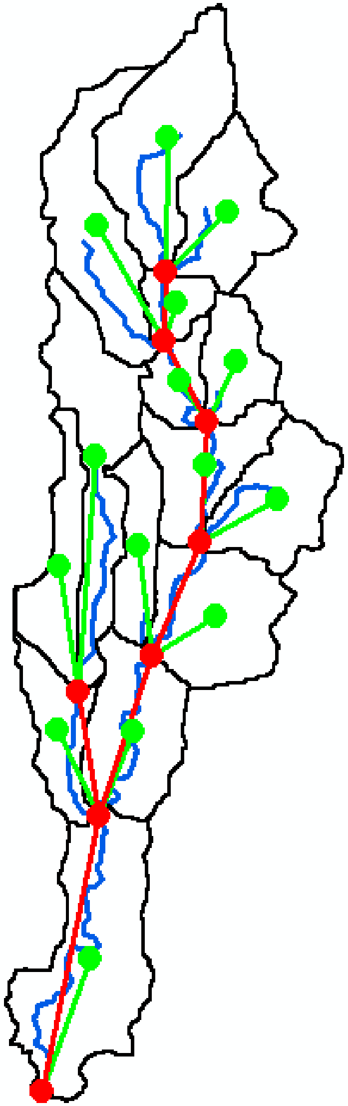
Precipitation Sources

- Identify sources of precipitation input into the hydrologic model and techniques for their incorporation into the dataset
  - Point (rain gage)
  - Polygon (Nexrad cells)
  - Surface (TIN/grid)



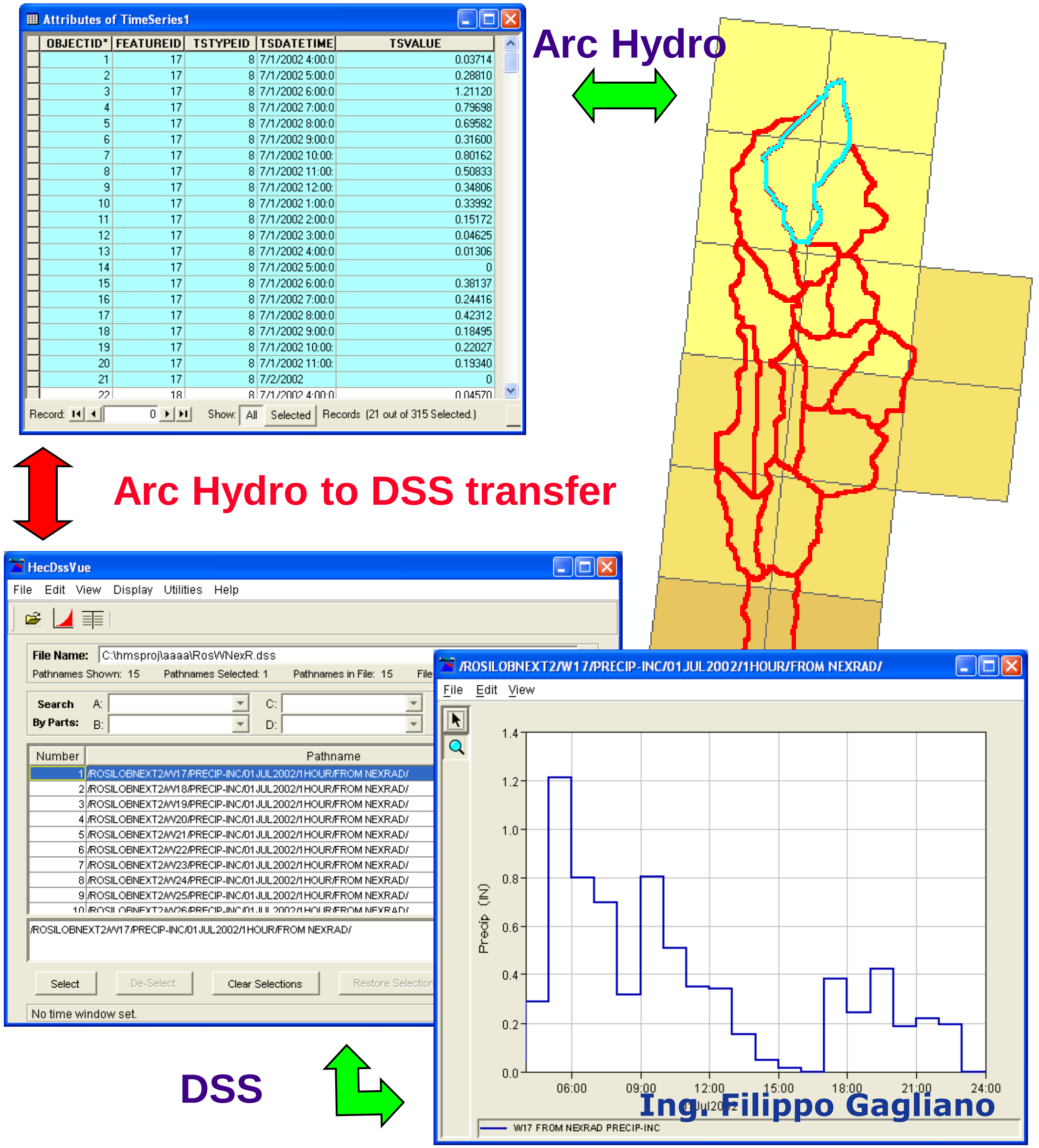
Develop GeoHMS model

- Follow all principles in development of a hydrologic model
- In addition, take into consideration integration planning aspects developed earlier
  - Placement of flow exchange points
  - Naming conventions
- Incorporate precipitation submodel
  - Develop Arc Hydro time series for the final subbasin delineation and export to DSS
- Export to HMS



Meteorological Component

- Develop a custom “gage” for each subbasin or for each rainfall observation element with corresponding weights for subbasins.
- Export the time series for the subbasin “gage” from Arc Hydro time series data structure into DSS



Arc Hydro

Attributes of TimeSeries1

OBJECTID*	FEATUREID	TSTYPEID	TSDATETIME	TSVALUE
1	17	8	7/1/2002 4:00:0	0.03714
2	17	8	7/1/2002 5:00:0	0.28810
3	17	8	7/1/2002 6:00:0	1.21120
4	17	8	7/1/2002 7:00:0	0.79698
5	17	8	7/1/2002 8:00:0	0.69582
6	17	8	7/1/2002 9:00:0	0.31600
7	17	8	7/1/2002 10:00:	0.80162
8	17	8	7/1/2002 11:00:	0.50833
9	17	8	7/1/2002 12:00:	0.34806
10	17	8	7/1/2002 1:00:0	0.33992
11	17	8	7/1/2002 2:00:0	0.15172
12	17	8	7/1/2002 3:00:0	0.04625
13	17	8	7/1/2002 4:00:0	0.01306
14	17	8	7/1/2002 5:00:0	0
15	17	8	7/1/2002 6:00:0	0.38137
16	17	8	7/1/2002 7:00:0	0.24416
17	17	8	7/1/2002 8:00:0	0.42312
18	17	8	7/1/2002 9:00:0	0.18495
19	17	8	7/1/2002 10:00:	0.22027
20	17	8	7/1/2002 11:00:	0.19340
21	17	8	7/2/2002	0
22	18	8	7/1/2002 4:00:0	0.04570

Record: 0 Show: All Selected Records (21 out of 315 Selected.)

Arc Hydro to DSS transfer

HecDssVue

File Name: C:\hmsproj\aaaa\RosWNexR.dss

Pathnames Shown: 15 Pathnames Selected: 1 Pathnames in File: 15

Search By Parts: A: B: C: D:

Number	Pathname
1	/ROSILOBNEXT2/W17/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/
2	/ROSILOBNEXT2/W18/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/
3	/ROSILOBNEXT2/W19/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/
4	/ROSILOBNEXT2/W20/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/
5	/ROSILOBNEXT2/W21/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/
6	/ROSILOBNEXT2/W22/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/
7	/ROSILOBNEXT2/W23/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/
8	/ROSILOBNEXT2/W24/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/
9	/ROSILOBNEXT2/W25/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/
10	/ROSILOBNEXT2/W26/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/

/ROSILOBNEXT2/W17/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/

No time window set.

/ROSILOBNEXT2/W17/PRECIP-INC/01JUL2002/1HOUR/FROM NEXRAD/

DSS

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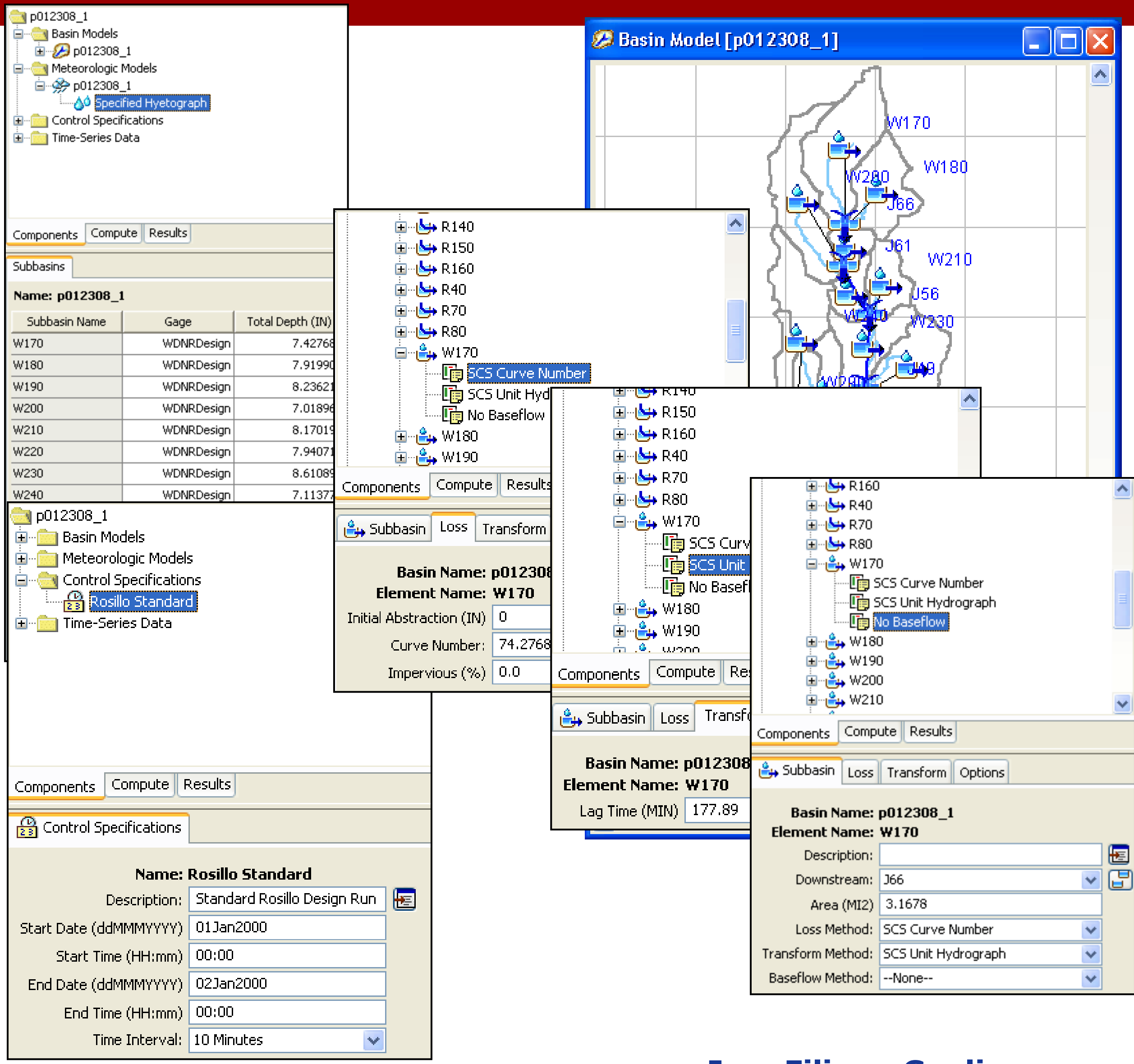
Finalize and Run HMS

- Complete HMS model with any additional parameters including meteorological model and control specifications
- Follow all principles in HMS model development (calibration, etc.)



Name: p012308_1

Subbasin Name	Gage	Total Depth (IN)
W170	WDNRDesign	7.42768
W180	WDNRDesign	7.91990
W190	WDNRDesign	8.23621
W200	WDNRDesign	7.01896
W210	WDNRDesign	8.17019
W220	WDNRDesign	7.94071
W230	WDNRDesign	8.61089
W240	WDNRDesign	7.11377

Name: Rosillo Standard
Description: Standard Rosillo Design Run
Start Date (ddMMMYYYY) 01Jan2000
Start Time (HH:mm) 00:00
End Date (ddMMMYYYY) 02Jan2000
End Time (HH:mm) 00:00
Time Interval: 10 Minutes

Basin Name: p012308
Element Name: W170
Initial Abstraction (IN) 0
Curve Number: 74.2768
Impervious (%) 0.0

Basin Name: p012308
Element Name: W170
Lag Time (MIN) 177.89

Basin Name: p012308_1
Element Name: W170
Description:
Downstream: J66
Area (MI2) 3.1678
Loss Method: SCS Curve Number
Transform Method: SCS Unit Hydrograph
Baseflow Method: --None--

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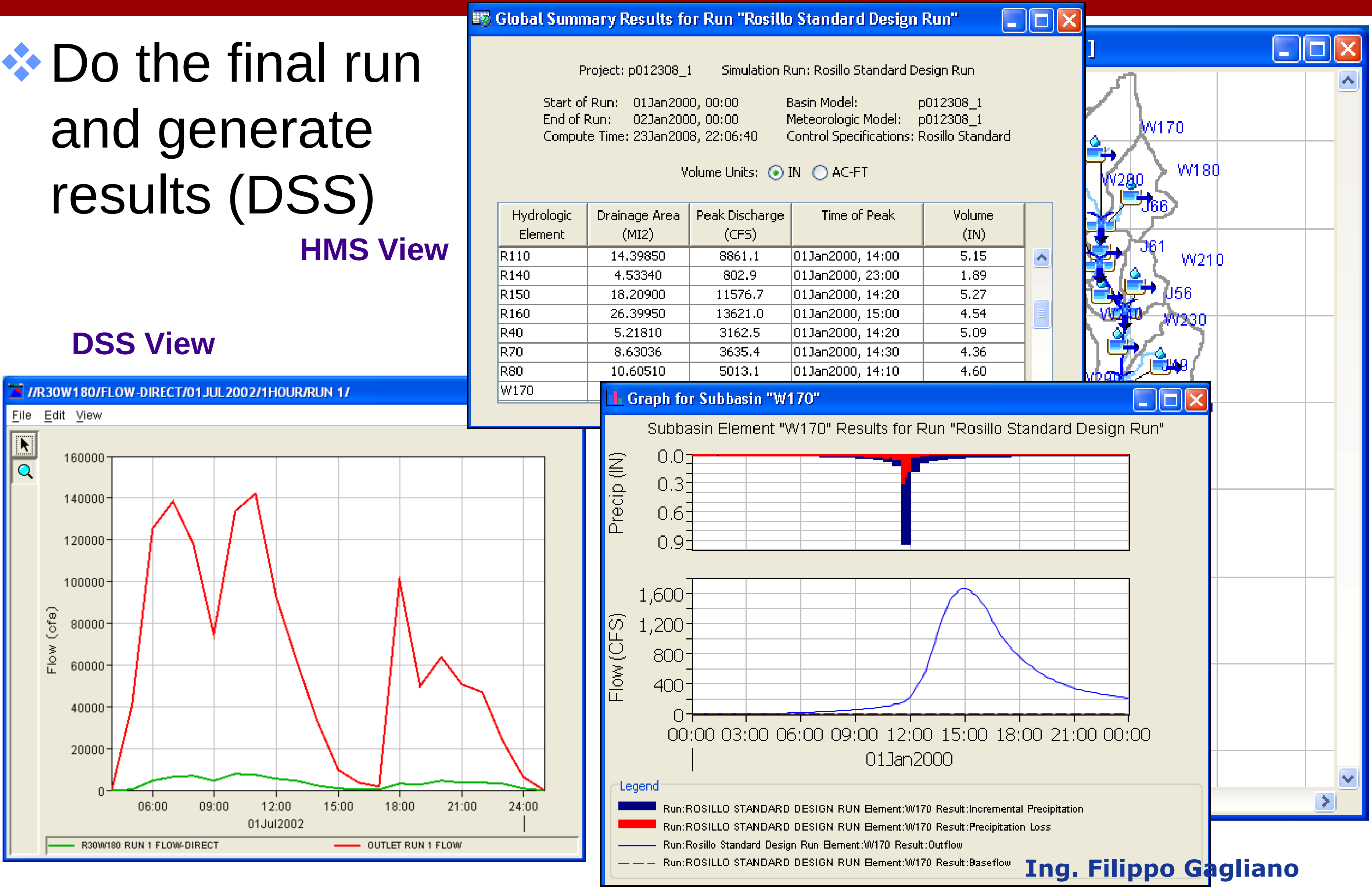
Finalize and Run HMS (2)

- Do the final run and generate results (DSS)

HMS View

DSS View



Global Summary Results for Run "Rosillo Standard Design Run"

Project: p012308_1 Simulation Run: Rosillo Standard Design Run

Start of Run: 01Jan2000, 00:00
End of Run: 02Jan2000, 00:00
Compute Time: 23Jan2008, 22:06:40

Basin Model: p012308_1
Meteorologic Model: p012308_1
Control Specifications: Rosillo Standard

Volume Units: ● IN ○ AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
R110	14.39850	8861.1	01Jan2000, 14:00	5.15
R140	4.53340	802.9	01Jan2000, 23:00	1.89
R150	18.20900	11576.7	01Jan2000, 14:20	5.27
R160	26.39950	13621.0	01Jan2000, 15:00	4.54
R40	5.21810	3162.5	01Jan2000, 14:20	5.09
R70	8.63036	3635.4	01Jan2000, 14:30	4.36
R80	10.60510	5013.1	01Jan2000, 14:10	4.60
W170				

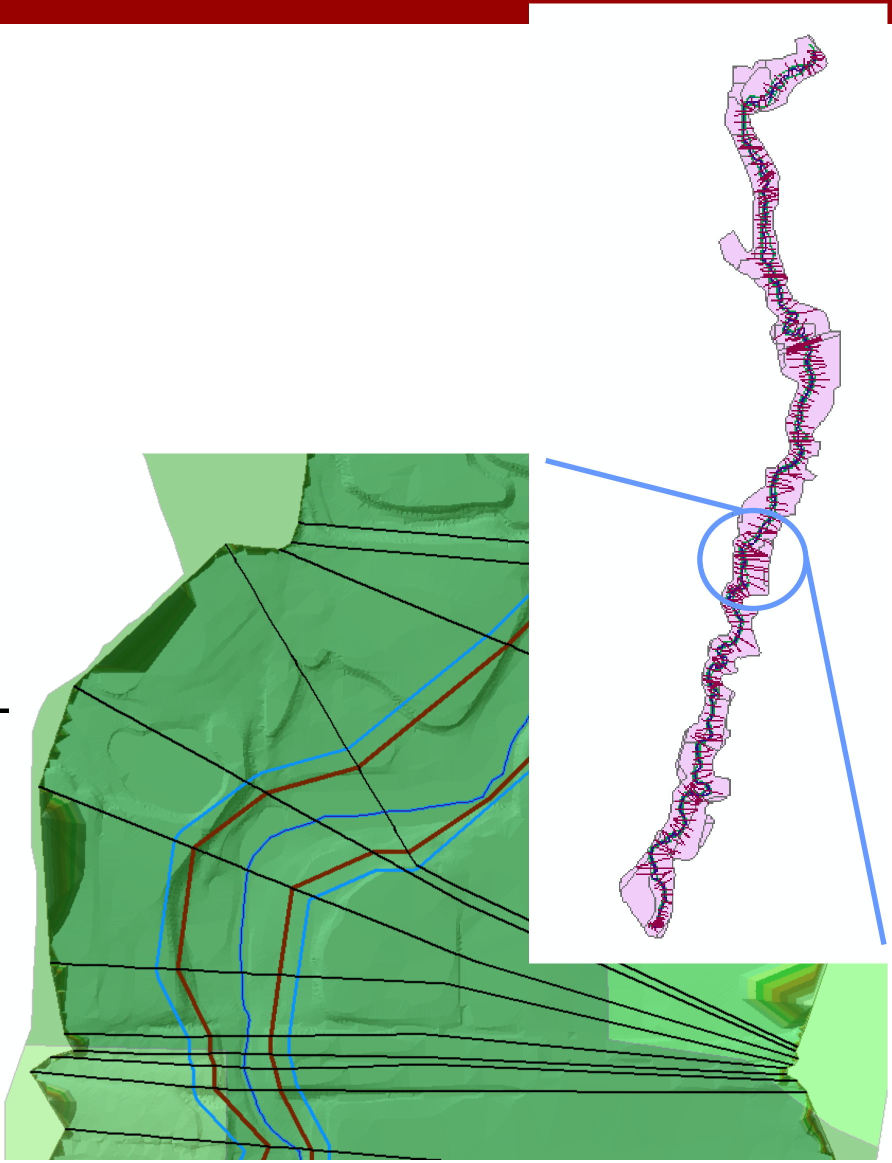
Graph for Subbasin "W170"

Subbasin Element "W170" Results for Run "Rosillo Standard Design Run"

- Run:ROSILLO STANDARD DESIGN RUN Element:W170 Result:Incremental Precipitation
- Run:ROSILLO STANDARD DESIGN RUN Element:W170 Result:Precipitation Loss
- Run:Rosillo Standard Design Run Element:W170 Result:Outflow
- Run:ROSILLO STANDARD DESIGN RUN Element:W170 Result:Baseflow

Develop GeoRAS model (pre-processing)

- Follow all principles in development of a hydraulic model for element placement (confluences, structures, …)
- In addition, take into consideration integration planning aspects developed earlier
  - Naming conventions (add name of the HMS element to the cross-section that will get the element's flows)
- Export to RAS



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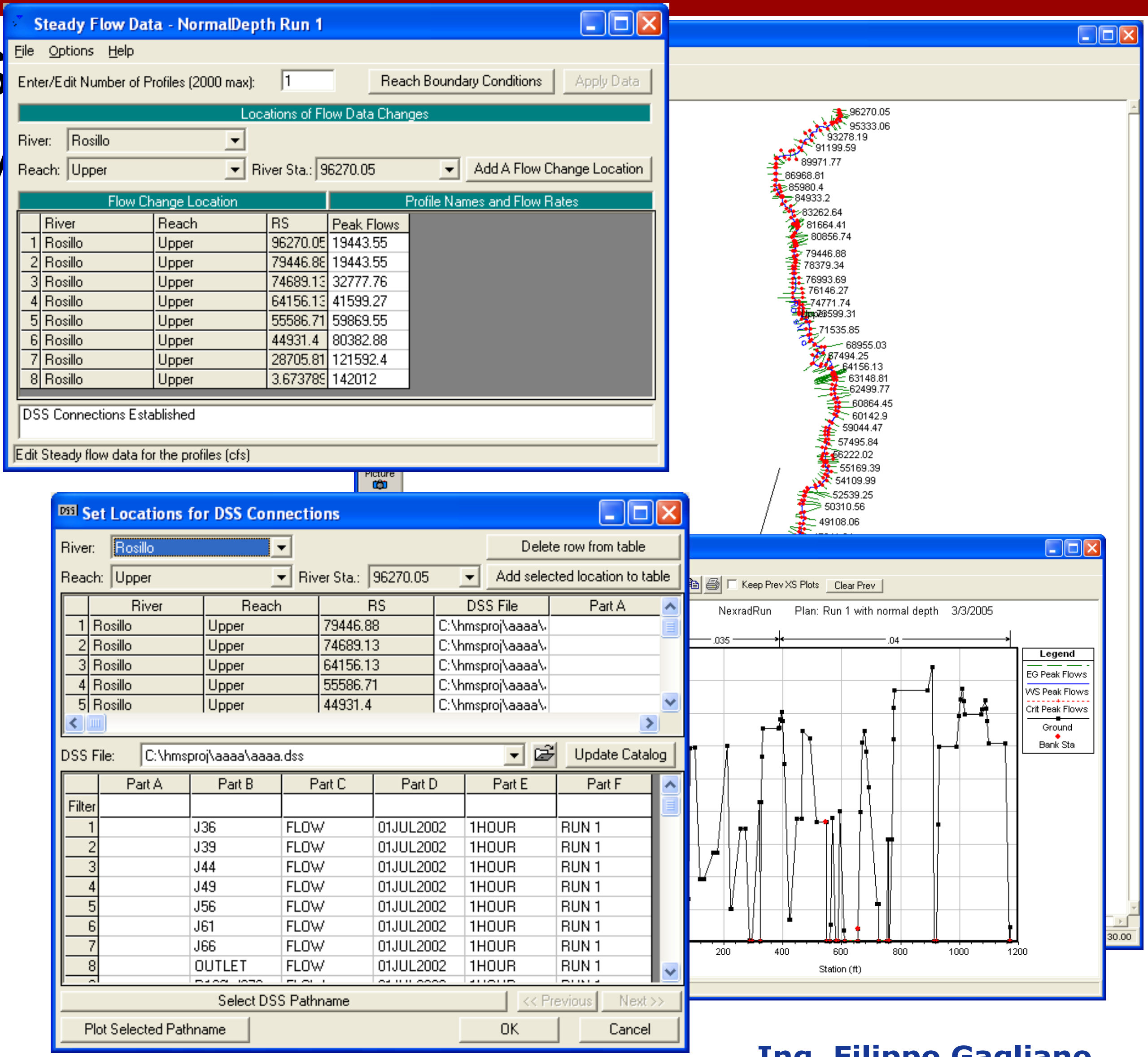
Finalize and Run RAS

- Complete RAS model with any additional parameters including initial and boundary conditions
- Follow all principles in RAS model development (calibration, etc.)



Steady Flow Data - NormalDepth Run 1

Enter/Edit Number of Profiles (2000 max): 1

Locations of Flow Data Changes

River: Rosillo

Reach: Upper   River Sta.: 96270.05

	River	Reach	RS	Peak Flows
1	Rosillo	Upper	96270.0	19443.55
2	Rosillo	Upper	79446.8	19443.55
3	Rosillo	Upper	74689.1	32777.76
4	Rosillo	Upper	64156.1	41599.27
5	Rosillo	Upper	55586.71	59869.55
6	Rosillo	Upper	44931.4	80382.88
7	Rosillo	Upper	28705.81	121592.4
8	Rosillo	Upper	3.673789	142012

DSS Connections Established

Edit Steady flow data for the profiles (cfs)

Set Locations for DSS Connections

River: Rosillo

Reach: Upper   River Sta.: 96270.05

	River	Reach	RS	DSS File	Part A
1	Rosillo	Upper	79446.88	C:\hmsproj\aaaa\	
2	Rosillo	Upper	74689.13	C:\hmsproj\aaaa\	
3	Rosillo	Upper	64156.13	C:\hmsproj\aaaa\	
4	Rosillo	Upper	55586.71	C:\hmsproj\aaaa\	
5	Rosillo	Upper	44931.4	C:\hmsproj\aaaa\	

DSS File: C:\hmsproj\aaaa\aaaa.dss

	Part A	Part B	Part C	Part D	Part E	Part F
Filter						
1		J36	FLOW	01JUL2002	1HOUR	RUN 1
2		J39	FLOW	01JUL2002	1HOUR	RUN 1
3		J44	FLOW	01JUL2002	1HOUR	RUN 1
4		J49	FLOW	01JUL2002	1HOUR	RUN 1
5		J56	FLOW	01JUL2002	1HOUR	RUN 1
6		J61	FLOW	01JUL2002	1HOUR	RUN 1
7		J66	FLOW	01JUL2002	1HOUR	RUN 1
8		OUTLET	FLOW	01JUL2002	1HOUR	RUN 1

NexradRun   Plan: Run 1 with normal depth   3/3/2005

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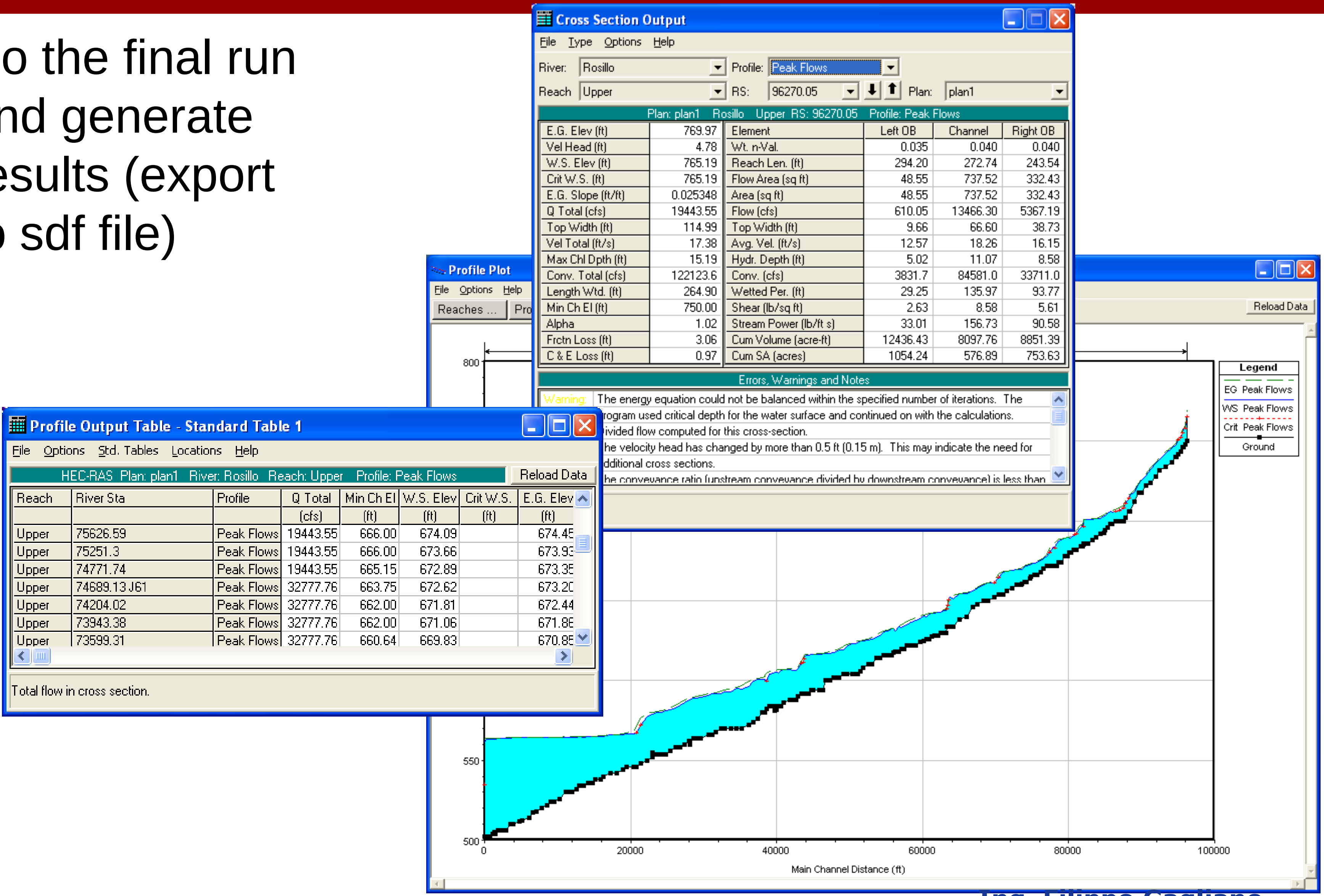
Finalize and Run RAS (2)

- Do the final run and generate results (export to sdf file)



River: Rosillo Profile: Peak Flows

Reach: Upper RS: 96270.05 Plan: plan1

Plan: plan1 Rosillo Upper RS: 96270.05 Profile: Peak Flows

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	769.97	Element	Left OB	Channel	Right OB
Vel Head (ft)	4.78	Wt. n-Val.	0.035	0.040	0.040
W.S. Elev (ft)	765.19	Reach Len. (ft)	294.20	272.74	243.54
Crit W.S. (ft)	765.19	Flow Area (sq ft)	48.55	737.52	332.43
E.G. Slope (ft/ft)	0.025348	Area (sq ft)	48.55	737.52	332.43
Q Total (cfs)	19443.55	Flow (cfs)	610.05	13466.30	5367.19
Top Width (ft)	114.99	Top Width (ft)	9.66	66.60	38.73
Vel Total (ft/s)	17.38	Avg. Vel. (ft/s)	12.57	18.26	16.15
Max Chl Dpth (ft)	15.19	Hydr. Depth (ft)	5.02	11.07	8.58
Conv. Total (cfs)	122123.6	Conv. (cfs)	3831.7	84581.0	33711.0
Length Wtd. (ft)	264.90	Wetted Per. (ft)	29.25	135.97	93.77
Min Ch El (ft)	750.00	Shear (lb/sq ft)	2.63	8.58	5.61
Alpha	1.02	Stream Power (lb/ft s)	33.01	156.73	90.58
Frctn Loss (ft)	3.06	Cum Volume (acre-ft)	12436.43	8097.76	8851.39
C & E Loss (ft)	0.97	Cum SA (acres)	1054.24	576.89	753.63

Errors, Warnings and Notes

Warning: The energy equation could not be balanced within the specified number of iterations. The
rogram used critical depth for the water surface and continued on with the calculations.
ivided flow computed for this cross-section.
he velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for
dditional cross sections.
he convevance ratio (unstream convevance divided bv downstream convevance) is less than

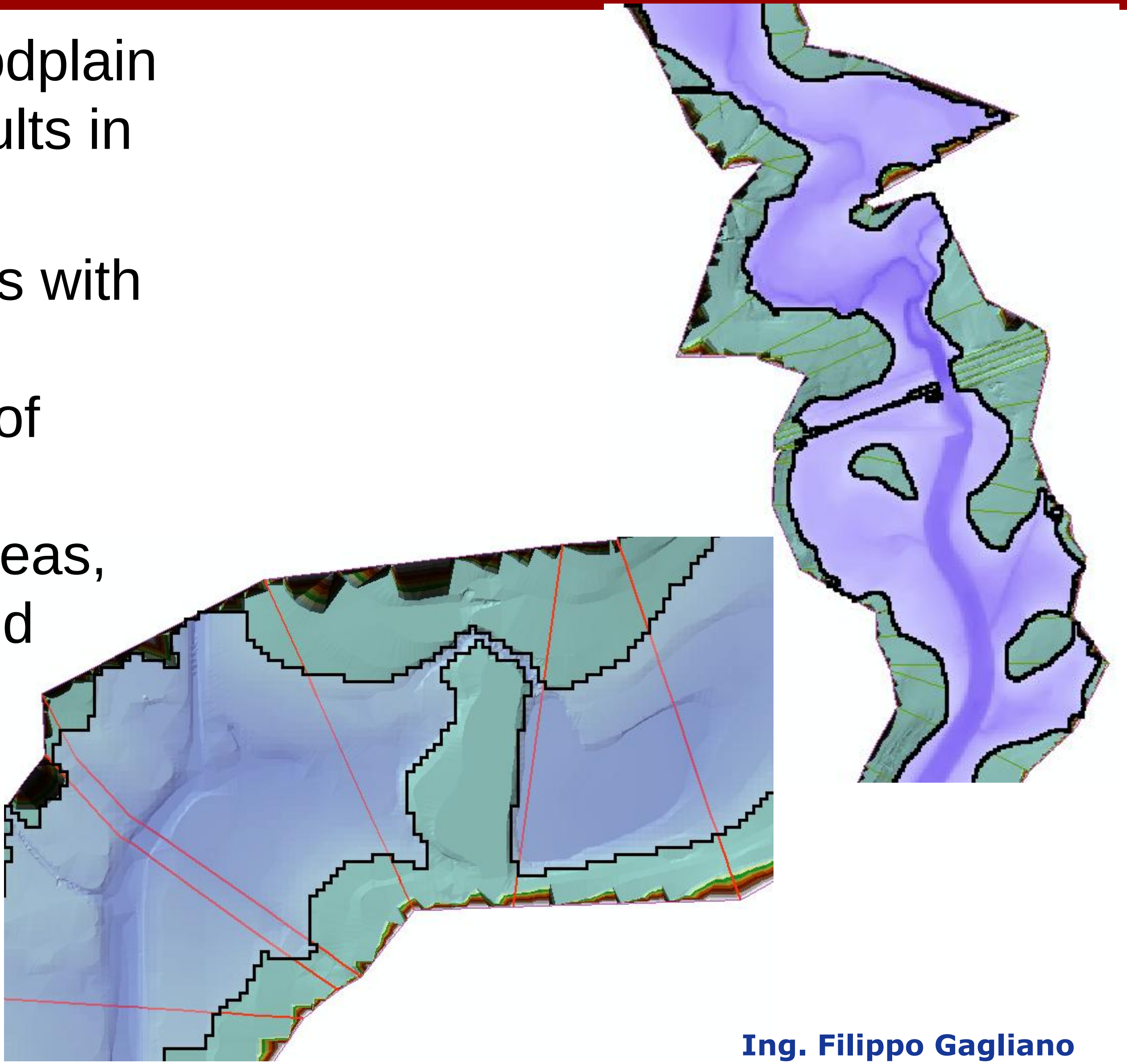
HEC-RAS Plan: plan1 River: Rosillo Reach: Upper Profile: Peak Flows

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev
			(cfs)	(ft)	(ft)	(ft)	(ft)
Upper	75626.59	Peak Flows	19443.55	666.00	674.09		674.45
Upper	75251.3	Peak Flows	19443.55	666.00	673.66		673.93
Upper	74771.74	Peak Flows	19443.55	665.15	672.89		673.35
Upper	74689.13 J61	Peak Flows	32777.76	663.75	672.62		673.20
Upper	74204.02	Peak Flows	32777.76	662.00	671.81		672.44
Upper	73943.38	Peak Flows	32777.76	662.00	671.06		671.86
Upper	73599.31	Peak Flows	32777.76	660.64	669.83		670.85

Total flow in cross section.

Process RAS results in GeoRAS

- Construct the floodplain based on the results in the sdf
- Review the results with respect to spatial integrity (extents of cross-sections, ineffective flow areas, disconnected flood areas, …)
- Clean results
- Revisit RAS



Conclusioni

“*Il tutto è maggiore della somma delle parti*“, diceva *Aristotele*.

$$0 + 0 = 0$$

Conclusioni

"*Il tutto è maggiore della somma delle parti*", diceva *Aristotele*.

NON È SEMPRE VERO!!!

$$0^0 + 0^0 = 2$$