Surface Water Transport and Groundwater Infiltration

Comparing Characteristics of Post Reclamation Channels with Preexisting Channels

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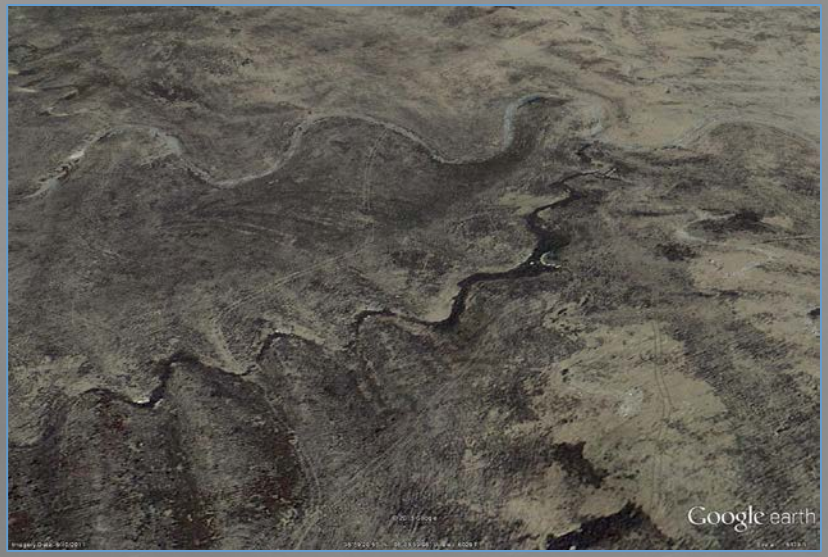
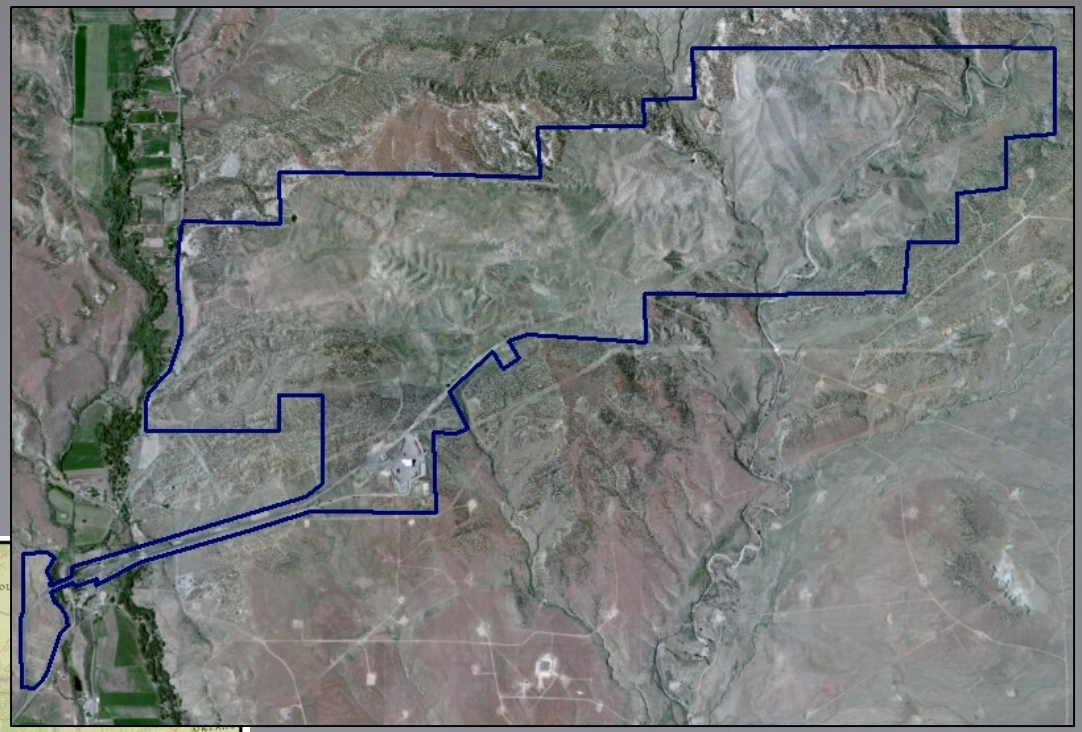
UNM | Civil Engineering

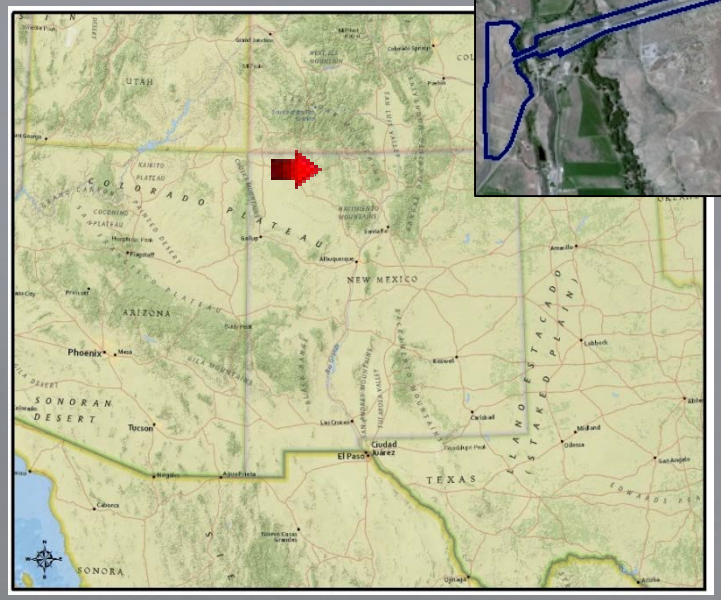
New Mexico emnrd Energy, Minerals and Natural Resources Department



Surface Water Conveyance and Groundwater Infiltration

La Plata Reclaimed Mine





- Open Pit Coal Mine ~ 20 years
- Geomorphic Land Reclamation initiated in 2003
- 560 Hectares Fully Reclaimed by 2009

Tension Infiltrometer

- 3 Infiltration Locations in Reclaimed Channel
- 2 Infiltration Testing Locations in Native Channel

SOIL MEASUREMENT SYSTEMS SMS

- In-situ soil hydraulic properties
- Estimate Hydraulic Conductivity in the field
- Remove the effect of preferential pathways

Single-Disc Radius with Multiple Tensions

10-cm Radius Porous Membrane Disc (r)

Tension Settings (h)

-10 cm tension

-5 cm tension

Steady State Infiltration Rate (Q(h))

- 350 seconds in Reclaimed Channel @ -5 cm
- 2,450 seconds in Native Channel @ -10 cm

$$Q(h_1) = \pi r^2 \left[1 + \frac{4}{\pi r \alpha}\right] K_{sat} \exp(\alpha h_1)$$

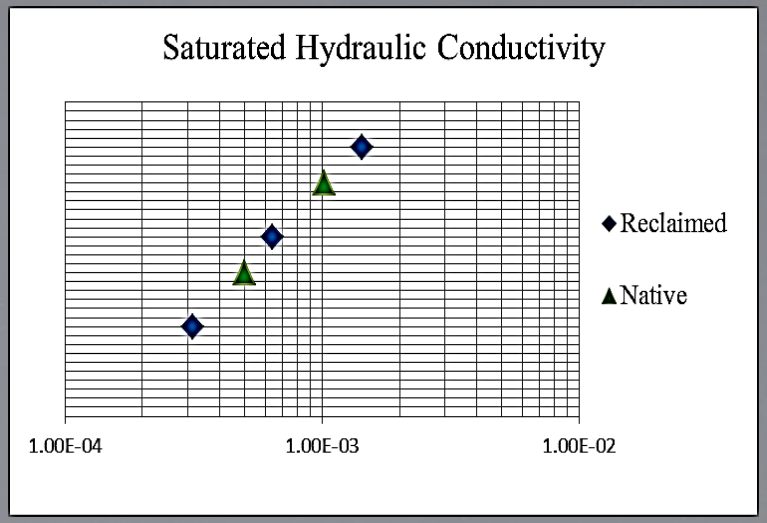
$$Q(h_2) = \pi r^2 \left[1 + \frac{4}{\pi r \alpha}\right] K_{sat} \exp(\alpha h_2)$$

$$\alpha = \frac{ln\left[Q(h_2)/Q(h_{1)}\right]}{h_2 - h_1}$$

Test 1				Test 2				Test 3		
h_2=	-10	cm		h_2=	-10	cm		h_2=	-8.34	cm
$Q(h_2)$=	0.2006	cm^3/sec		$Q(h_2)$=	0.1306	cm^3/sec		$Q(h_2)$=	0.4355	cm^3/sec
h_1=	-5	cm		h_1=	-5	cm		h_1=	-5	cm
$Q(h_1)$=	0.4122	cm^3/sec		$Q(h_1)$=	0.1882	cm^3/sec		$Q(h_1)$=	0.5210	cm^3/sec
α	0.1440	cm^{-1}		α	0.0730	cm^{-1}		α	0.0537	cm^{-1}
K_{sat} =	1.43E-03	cm/sec		K_{sat} =	3.14E-04	cm/sec		K_{sat} =	6.43E-04	cm/sec

Reclaimed Channel Hydraulic Conductivity Results

(average = 7.96E-04 cm/sec)



Test 1				Test 2		
h_2=	-10	cm		h_2=	-10	cm
$Q(h_2)$=	0.1011	cm^3/sec		$Q(h_2)$=	0.0498	cm^3/sec
h_1=	-5	cm		h_1=	-5	cm
$Q(h_1)$=	0.2380	cm^3/sec		$Q(h_1)$=	0.1166	cm^3/sec
α	0.1712	cm^{-1}		α	0.1704	cm^{-1}
K_{sat} =	1.02E-03	cm/sec		K_{sat} =	4.98E-04	cm/sec

Native Channel Hydraulic Conductivity Results

(average = 7.60E-04 cm/sec)

Geospatial Hydrologic Modeling Extension

- HEC-GeoHMS to HEC-HMS

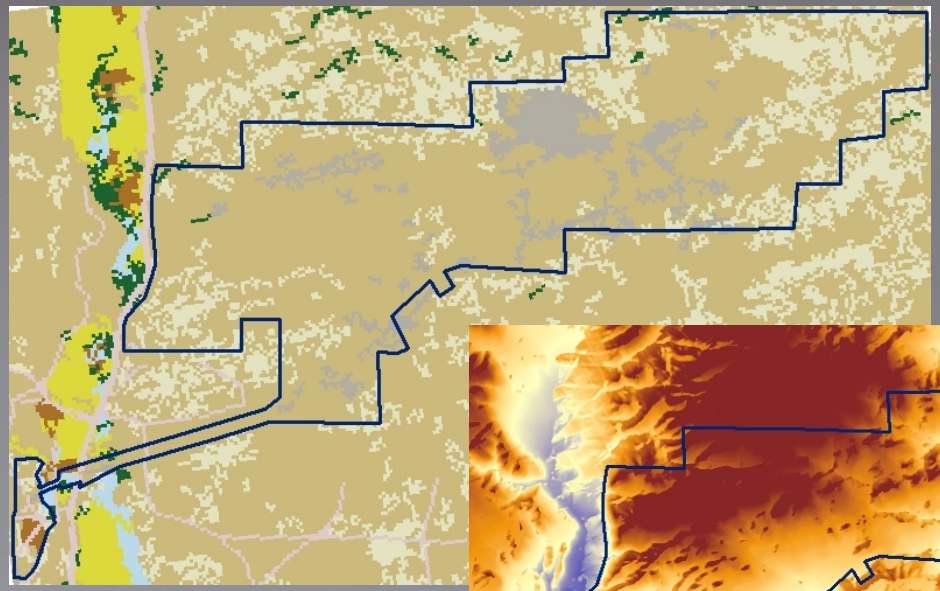
  - Surface Water Runoff
  - Flow through Outlet

- HEC-GeoRAS to HEC-RAS

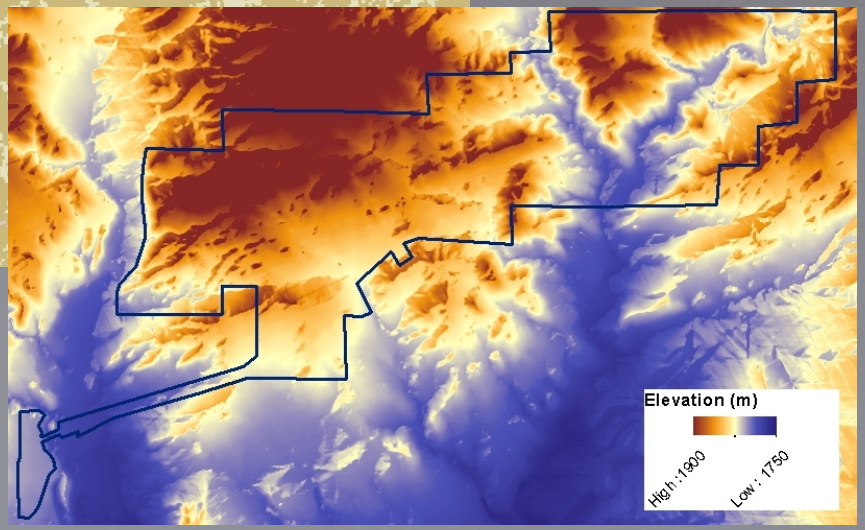
  - Channel Flow
  - Depth of Flow through Cross Section

US Army Corps of Engineers

Understanding our world.



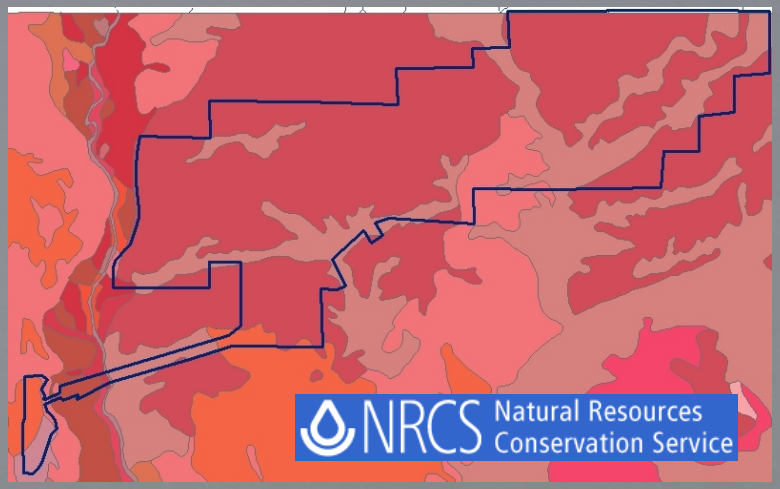
Land Use



1/3 Arc Second DEM

ArcGIS

Soil Data

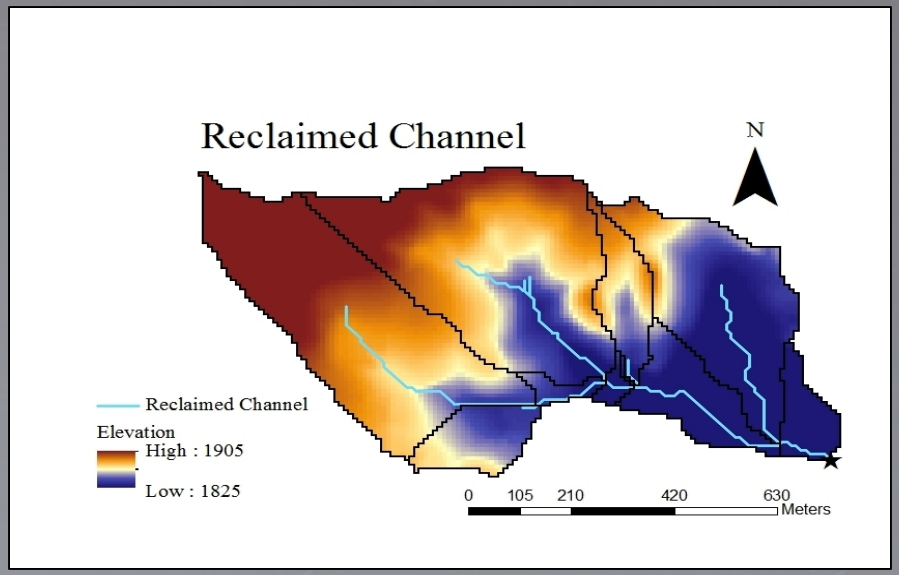


USGS science for a changing world

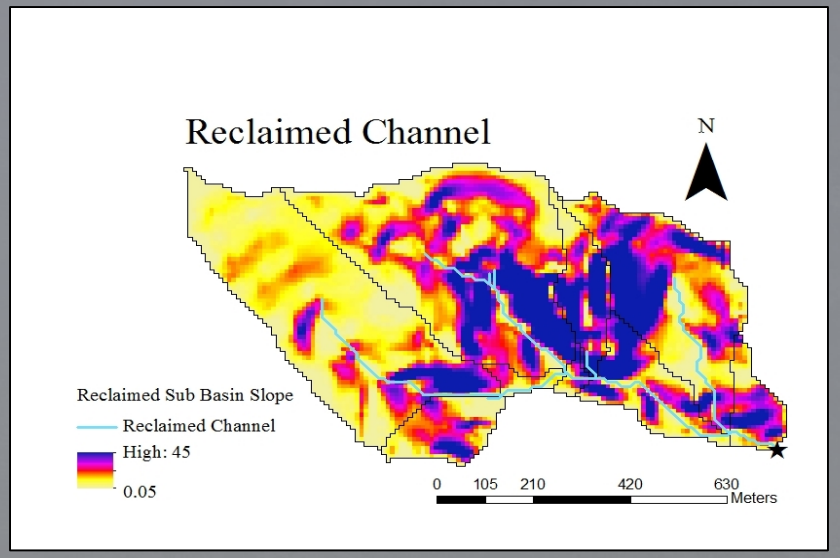
The National Map

HEC-GeoHMS

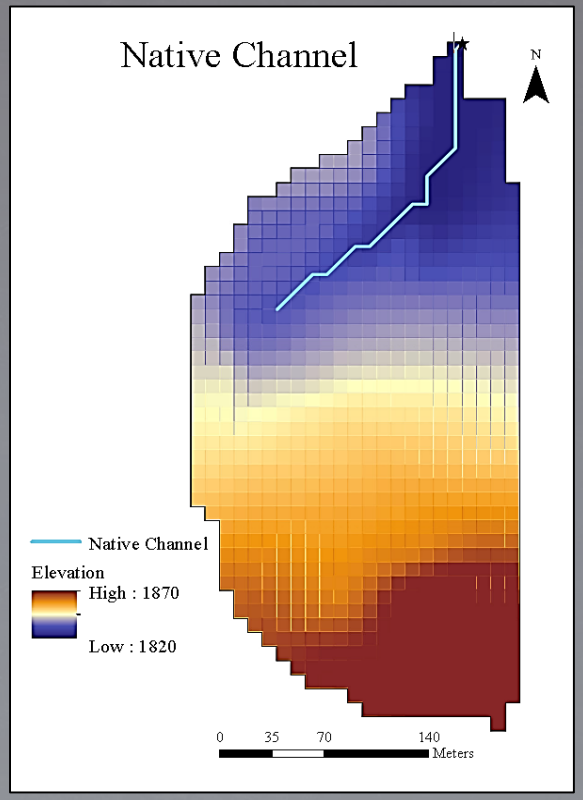
Reclaimed Watershed

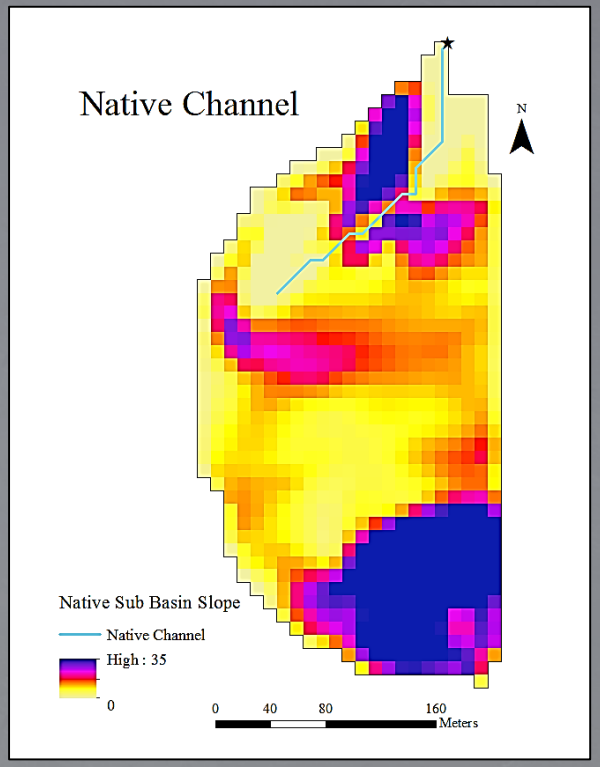


- Area = 60 Hectacres
- Longest Flow Path = 1,500 m.
- Average Basin Slope = 10 %
- Curve Number = 87
- Land Use = Forest & Agricultural
- Soil Type D = FA (NM618)



Native Watershed

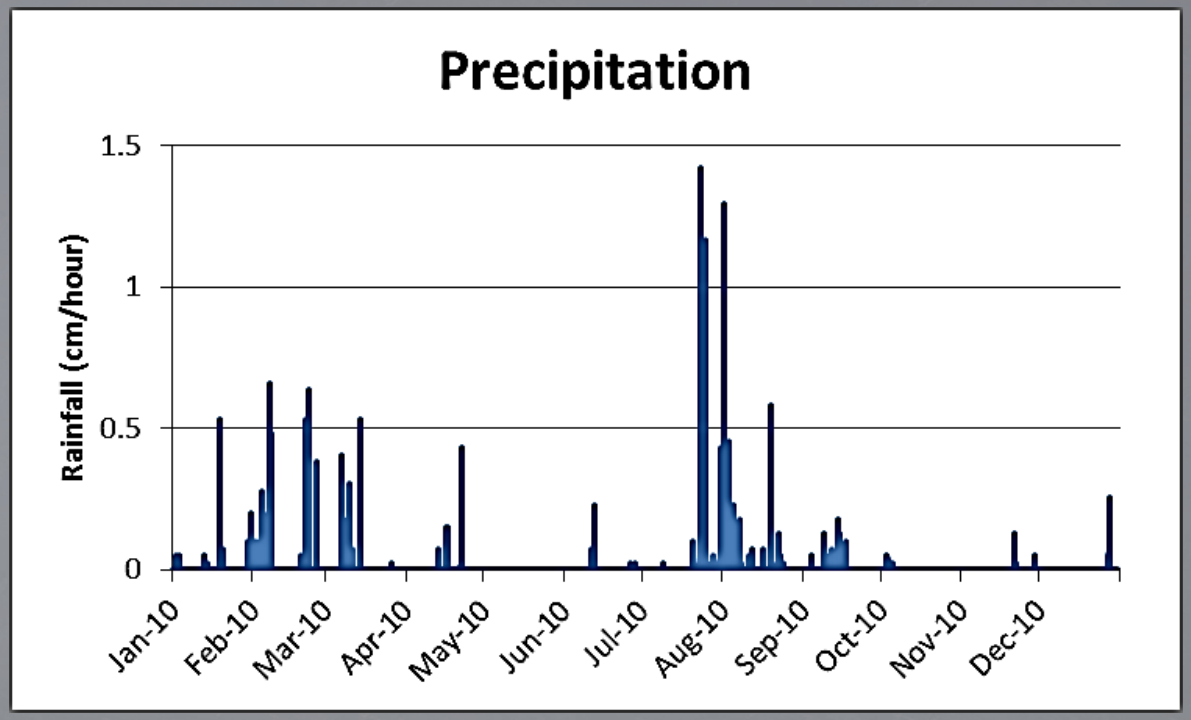




- Area = 8 Hectacres
- Longest Flow Path = 625 m.
- Average Basin Slope = 9.5 %
- Curve Number = 83
- Land Use = Agricultural
- Soil Type D = FA (NM618) and BT

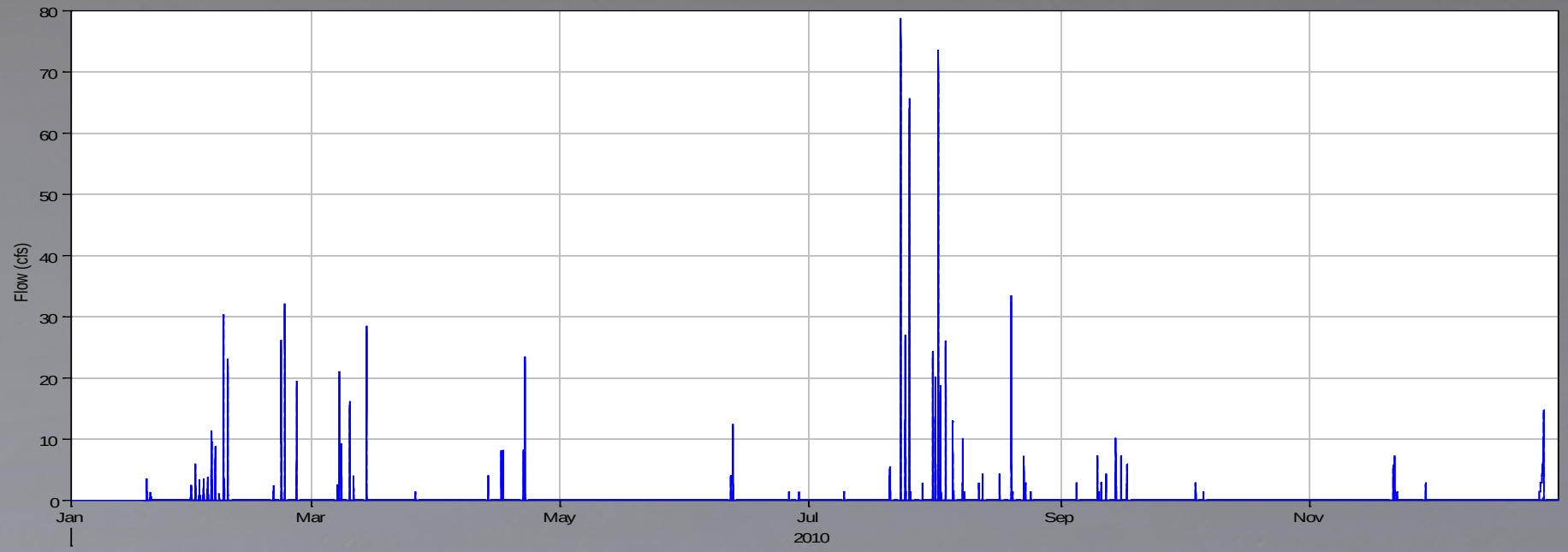
HEC-HMS

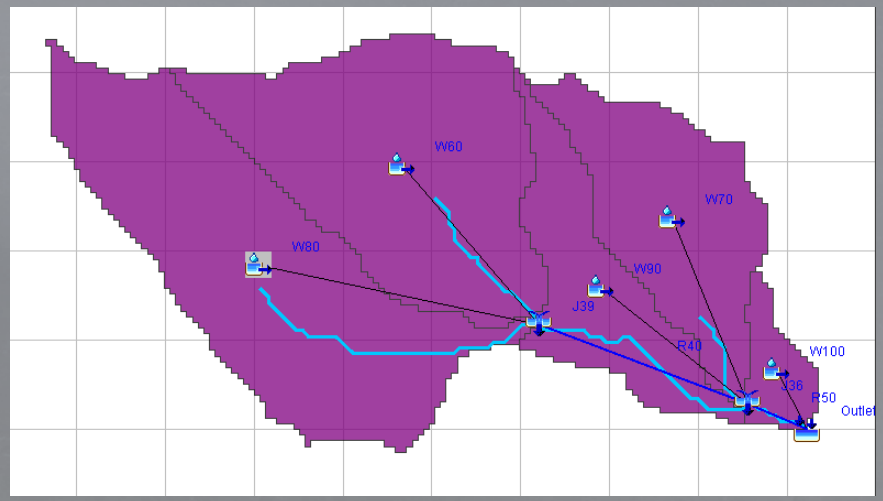
Loss Method: SCS Curve Number
Transform Method: SCS Unit Hydrograph
Routing Method: Kinematic Wave
2 minute increments



26 cm Precipitation in 2010

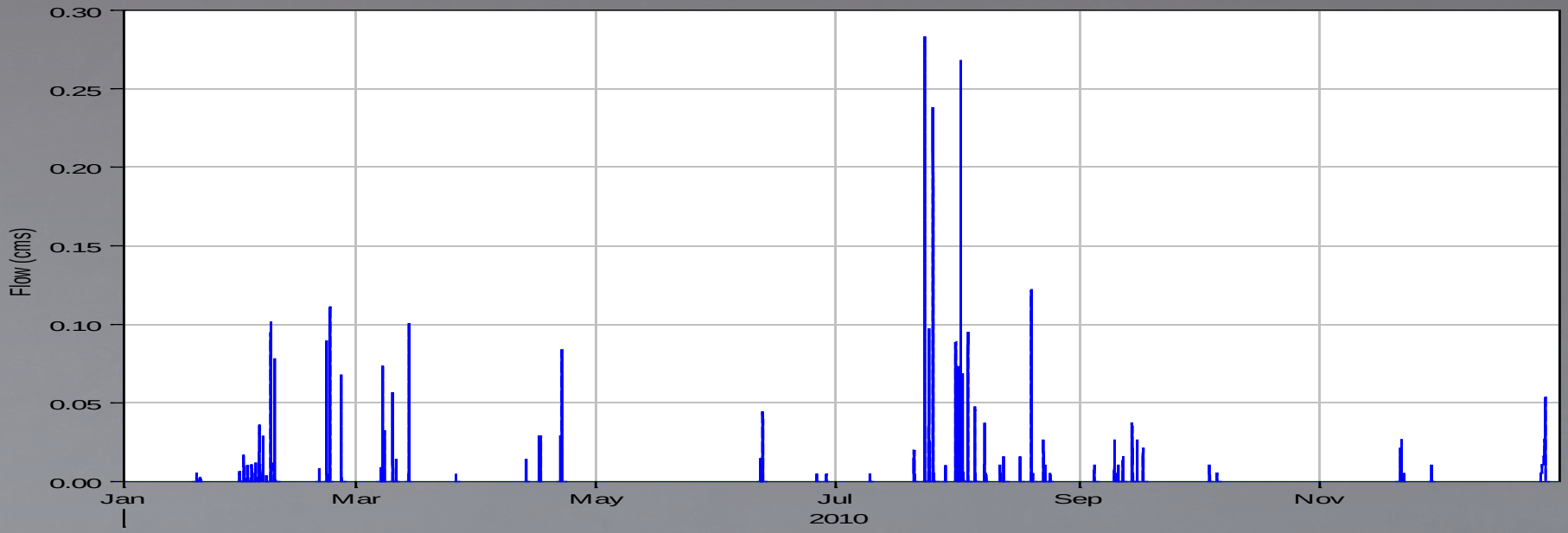
Flow through Outlet in Reclaimed Channel



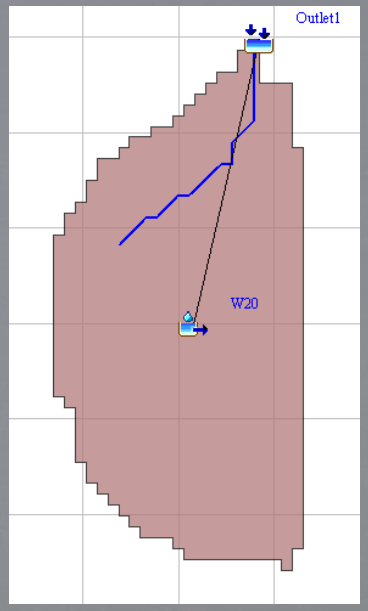


Max Flow on July 23, 2010
2.2 m3/sec

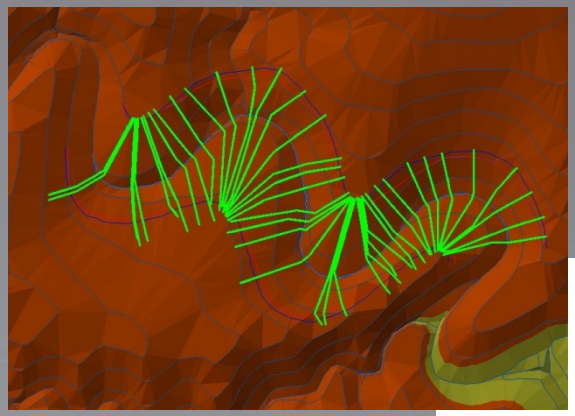
Flow through Outlet in Native Channel



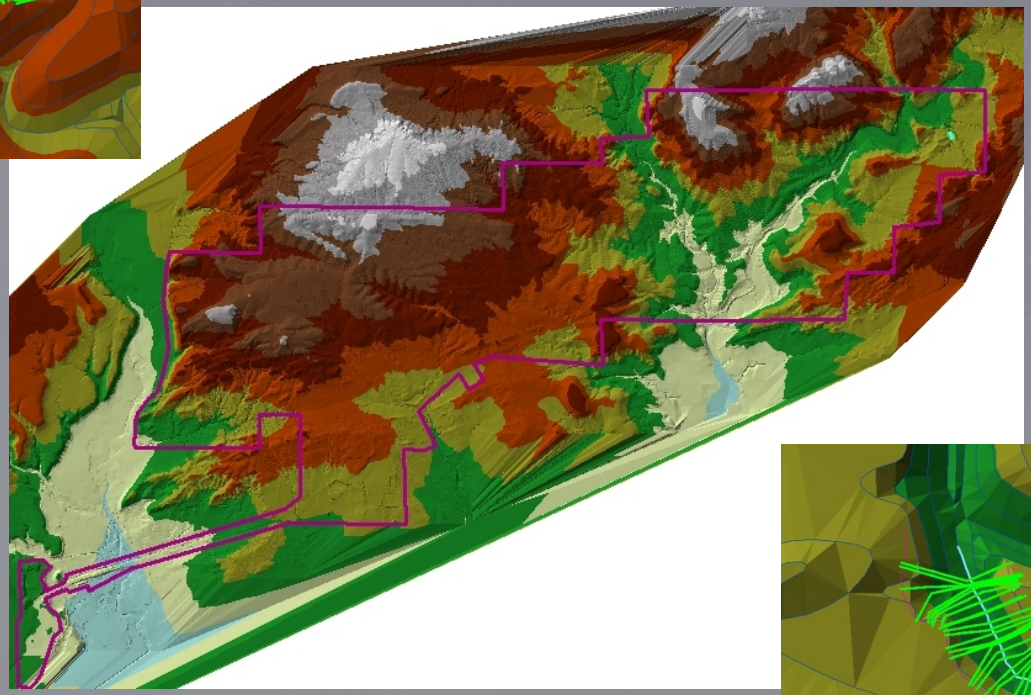
Max Flow on July 23, 2010
0.3 m^3/sec

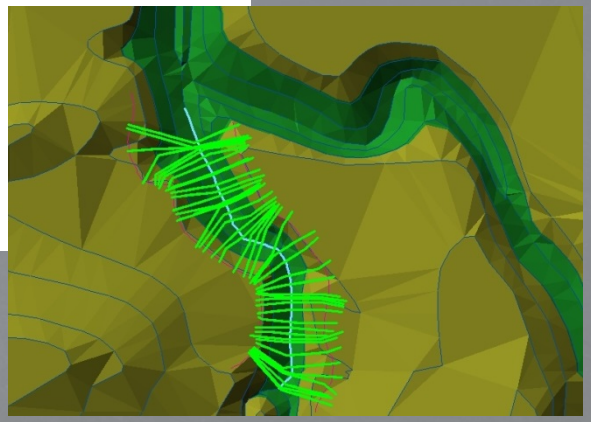


HEC-GeoRAS



Manning's n = 0.025
TIN Created from 1.5 meter
Topographic Lines





HEC-RAS

Reclaimed Channel

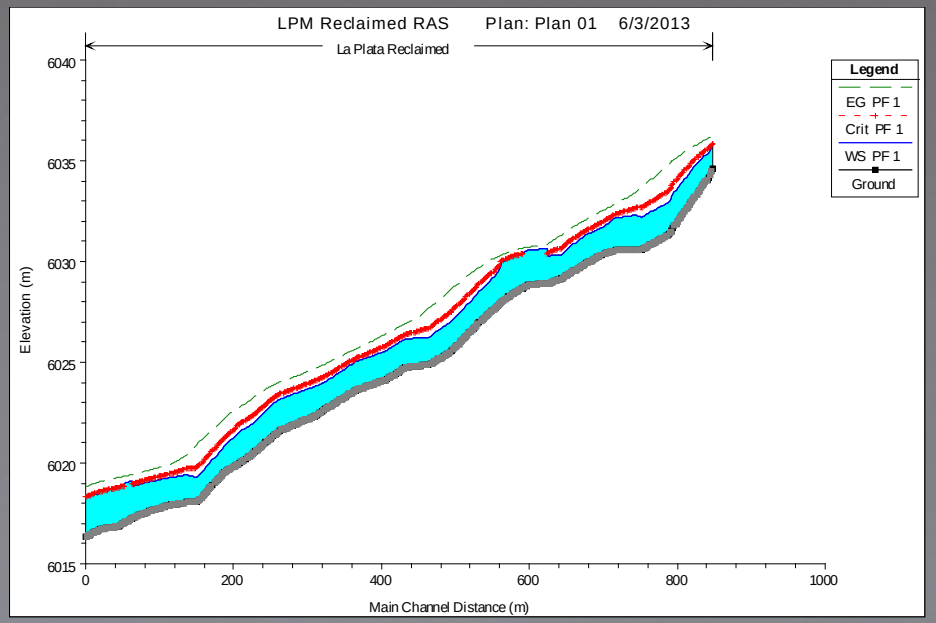
Cross Section @ 36 m from DS

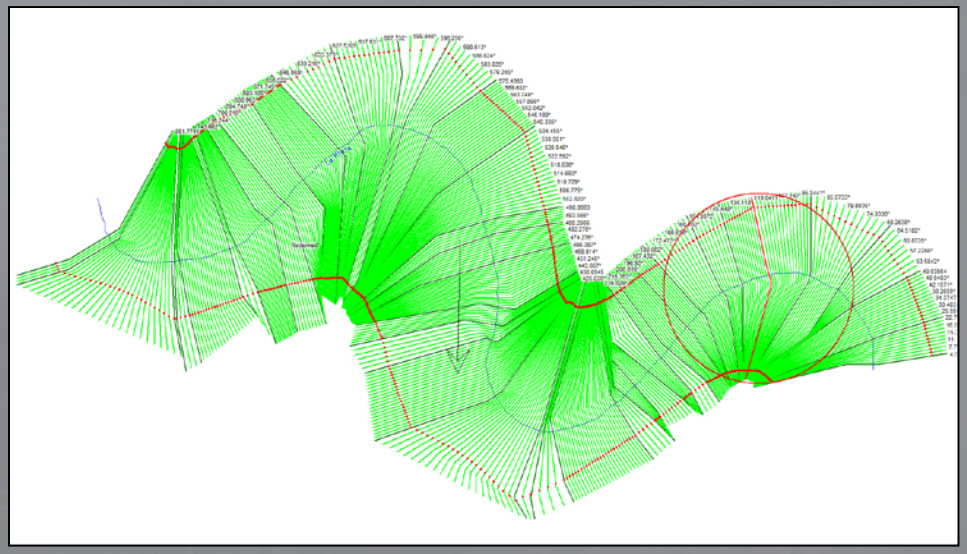
Channel Slope 0.02

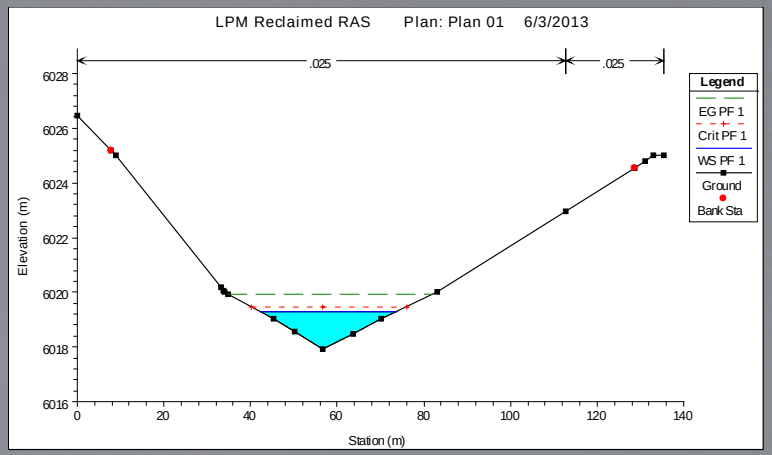
Steady Flow profiles w/ Mixed Flow

US Boundary = Critical Depth

DS Boundary = Normal Depth







HEC-RAS

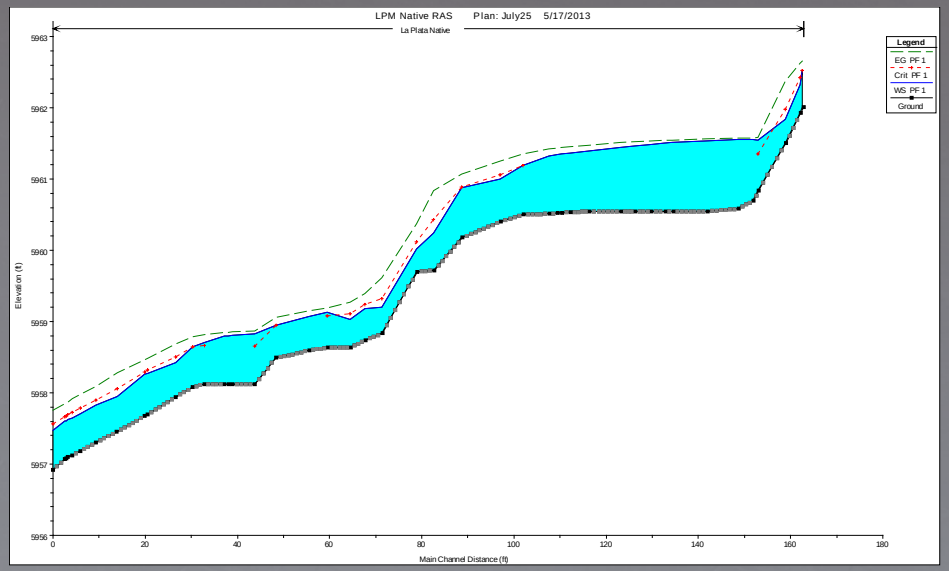
Native Channel

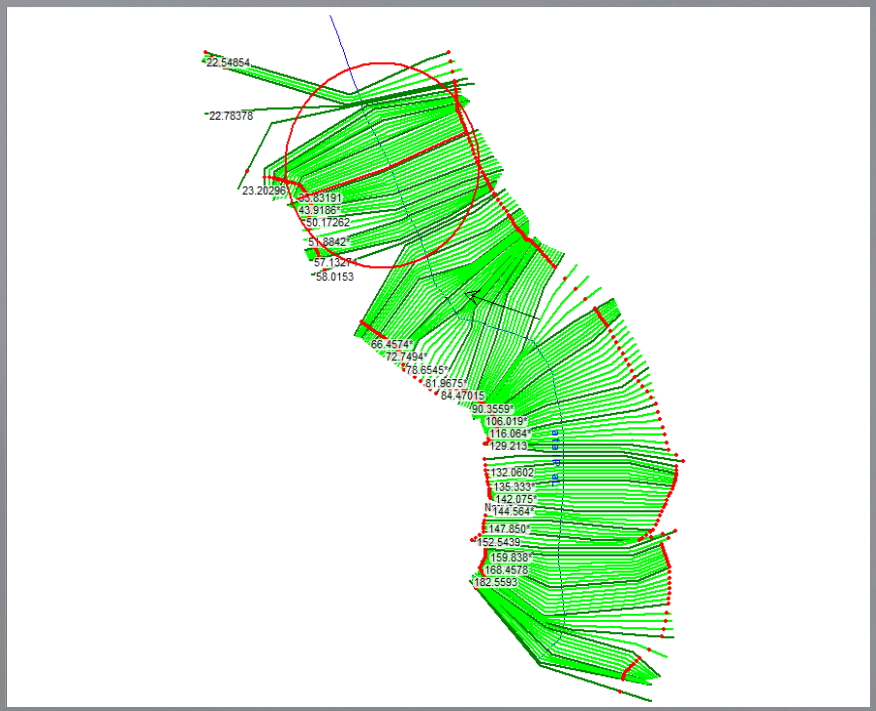
Cross Section @ 12 m from DS
Channel Slope 0.03

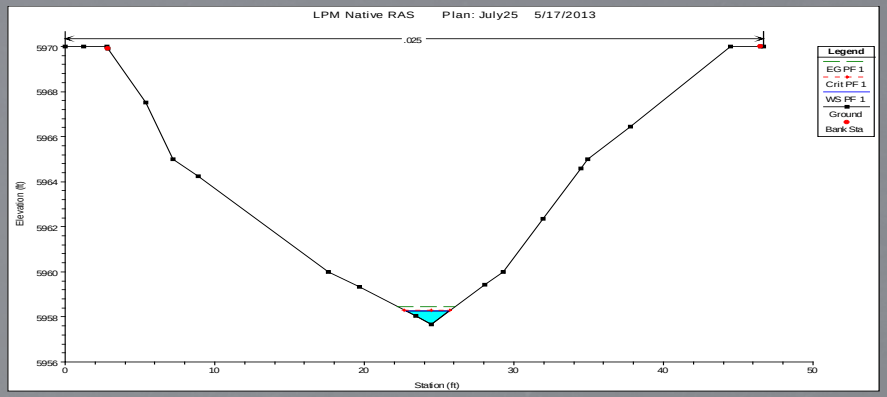
Steady Flow profiles w/ Mixed Flow

US Boundary = Critical Depth

DS Boundary = Normal Depth



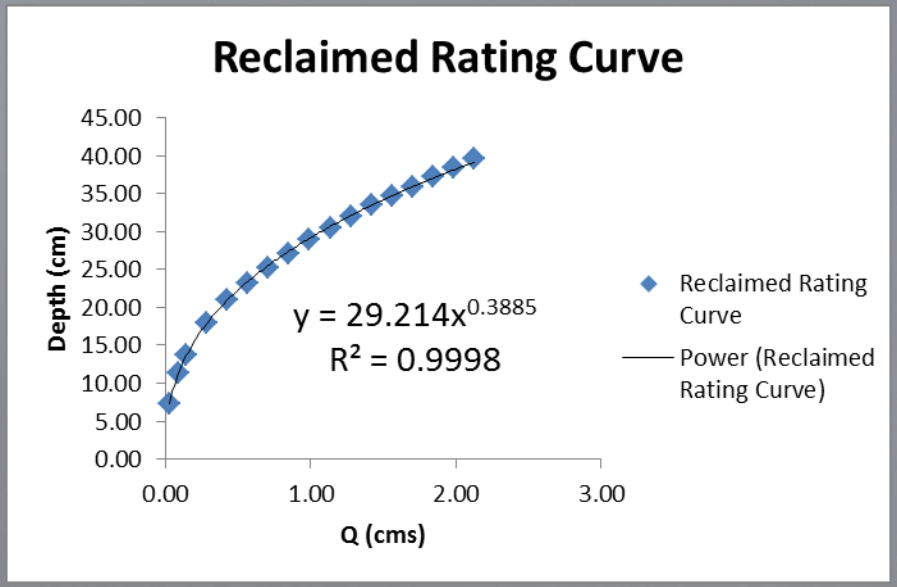


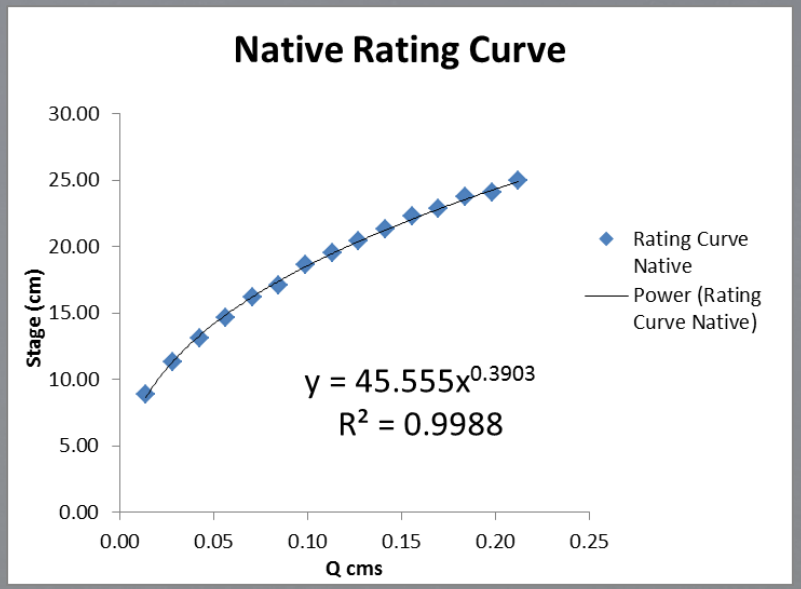


HEC-RAS

Q (m3/sec)	Depth (cm)
0.03	7.32
0.08	11.28
0.14	13.72
0.28	17.98
0.42	21.03
0.57	23.16
0.71	25.30
0.85	27.13
0.99	28.96
1.13	30.48
1.27	32.00
1.42	33.53
1.56	34.75
1.70	35.97
1.84	37.19
1.98	38.40
2.12	39.62

Q cms	Depth (cm)
0.01	8.84
0.03	11.28
0.04	13.11
0.06	14.63
0.07	16.15
0.08	17.07
0.10	18.59
0.11	19.51
0.13	20.42
0.14	21.34
0.16	22.25
0.17	22.86
0.18	23.77
0.20	24.08
0.21	24.99





Groundwater Modeling

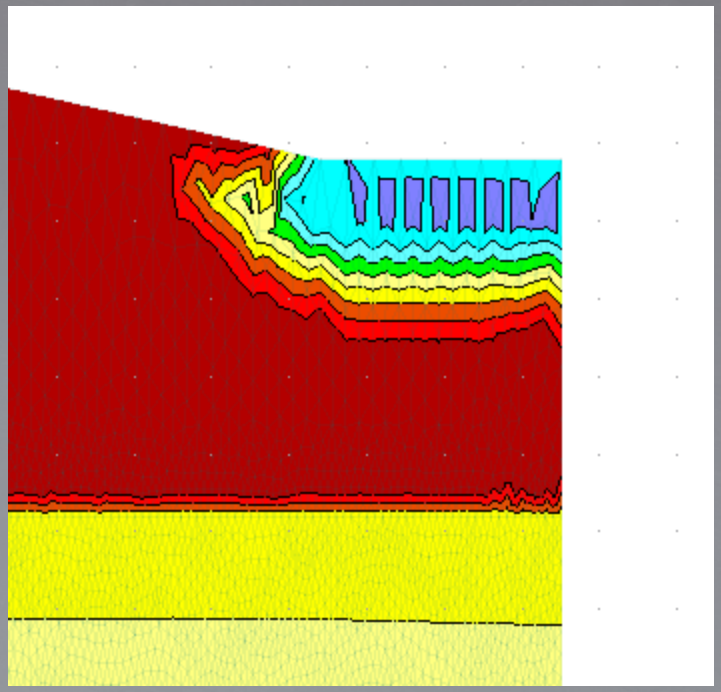
- Average Monthly Pan Evaporation
- Linearly interpolated water content from surface to bottom boundary

  (5% to 25%)
- van Genuchten parameters based on saturated hydraulic conductivity values

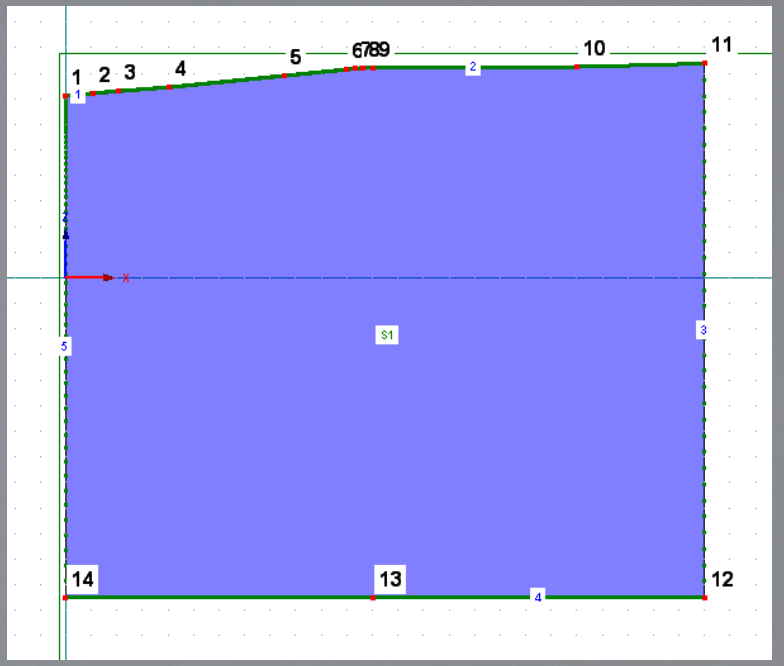
Hydrus 2D/3D ,
Version 2.x

PC-PROGRESS
Engineering software developer

Hydrus 2D Cross Section



Channel Cross Section
during Evaporation



Thank You

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