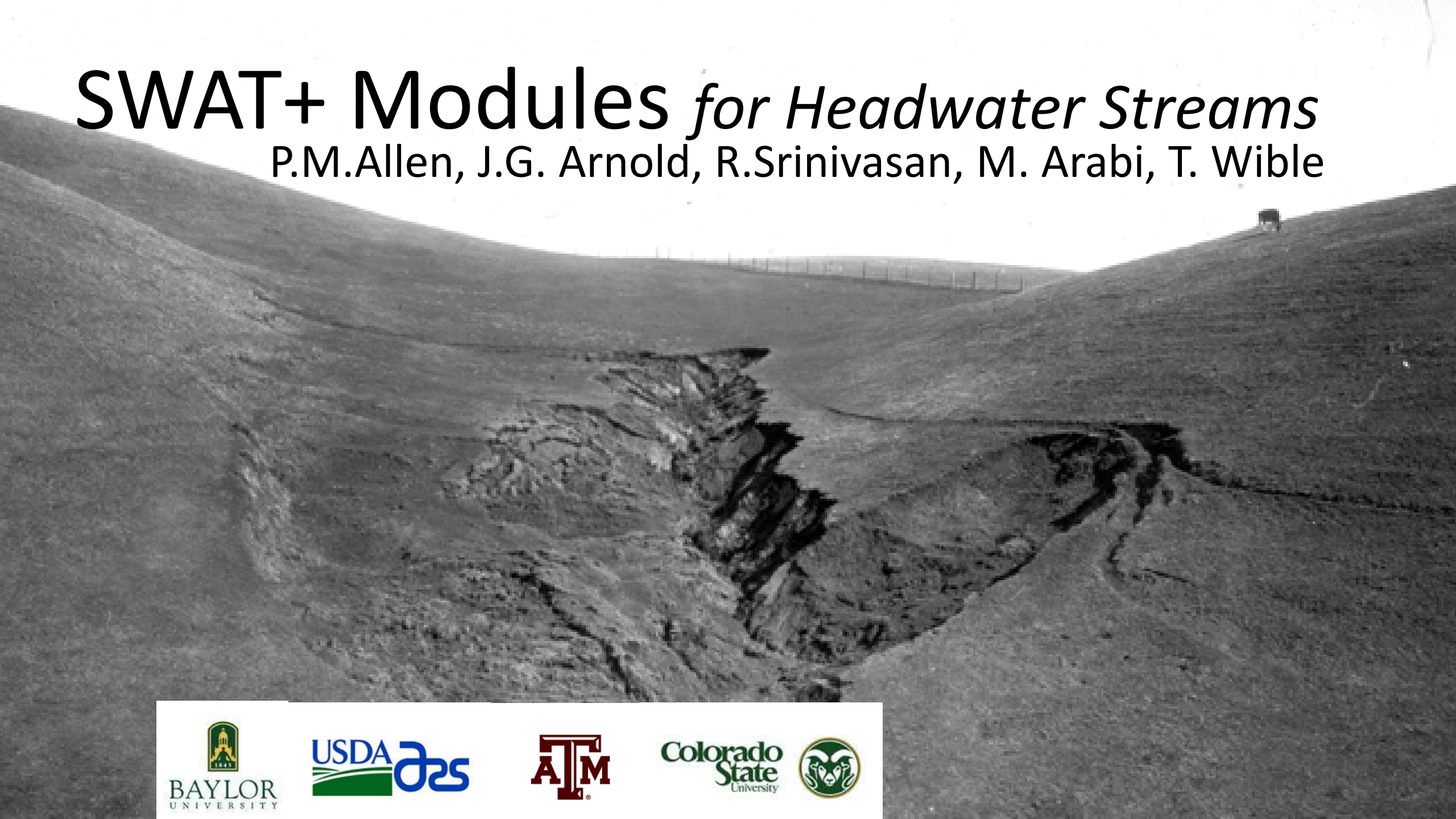
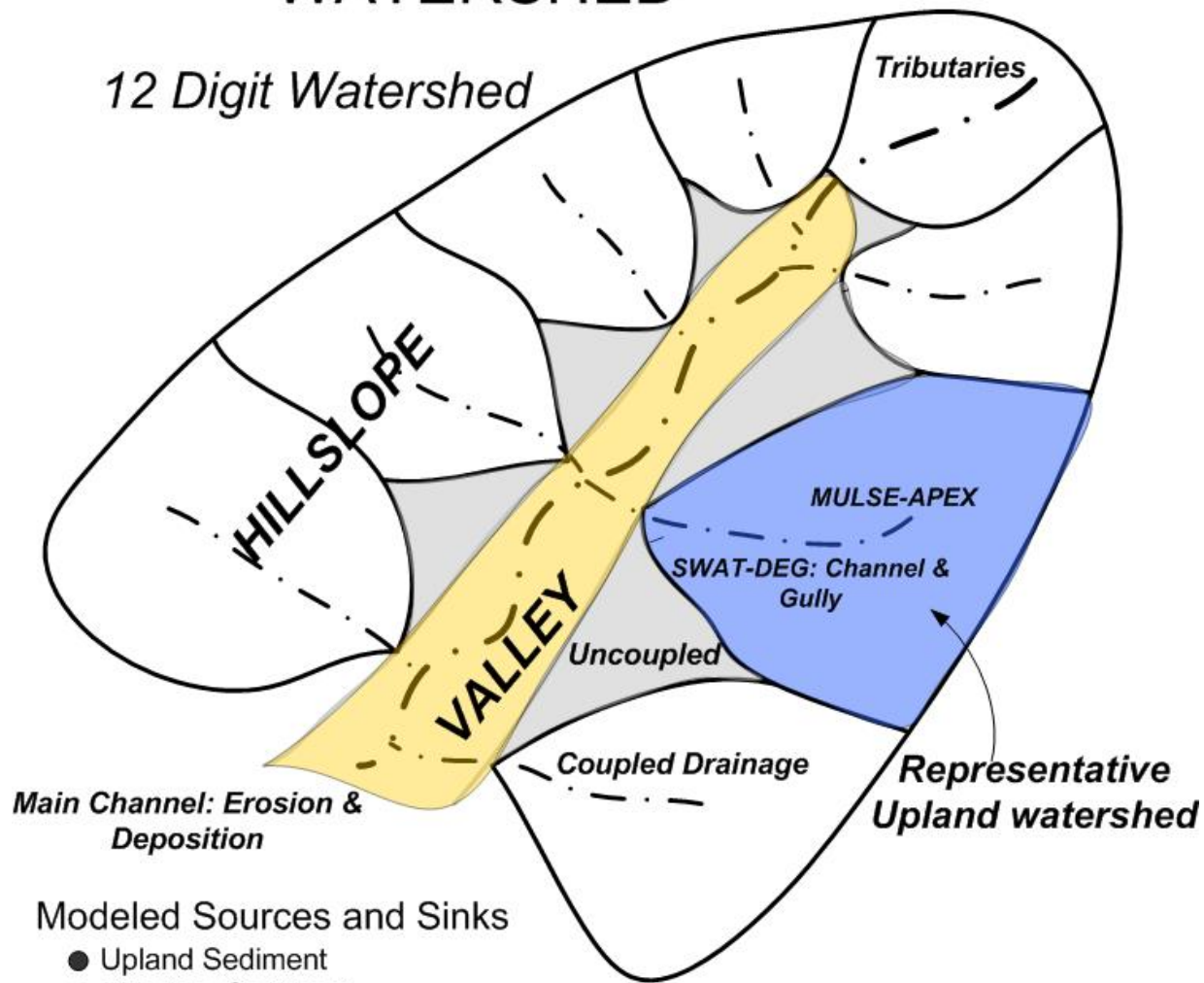
SWAT+ Modules *for Headwater Streams*

P.M.Allen, J.G. Arnold, R.Srinivasan, M. Arabi, T. Wible



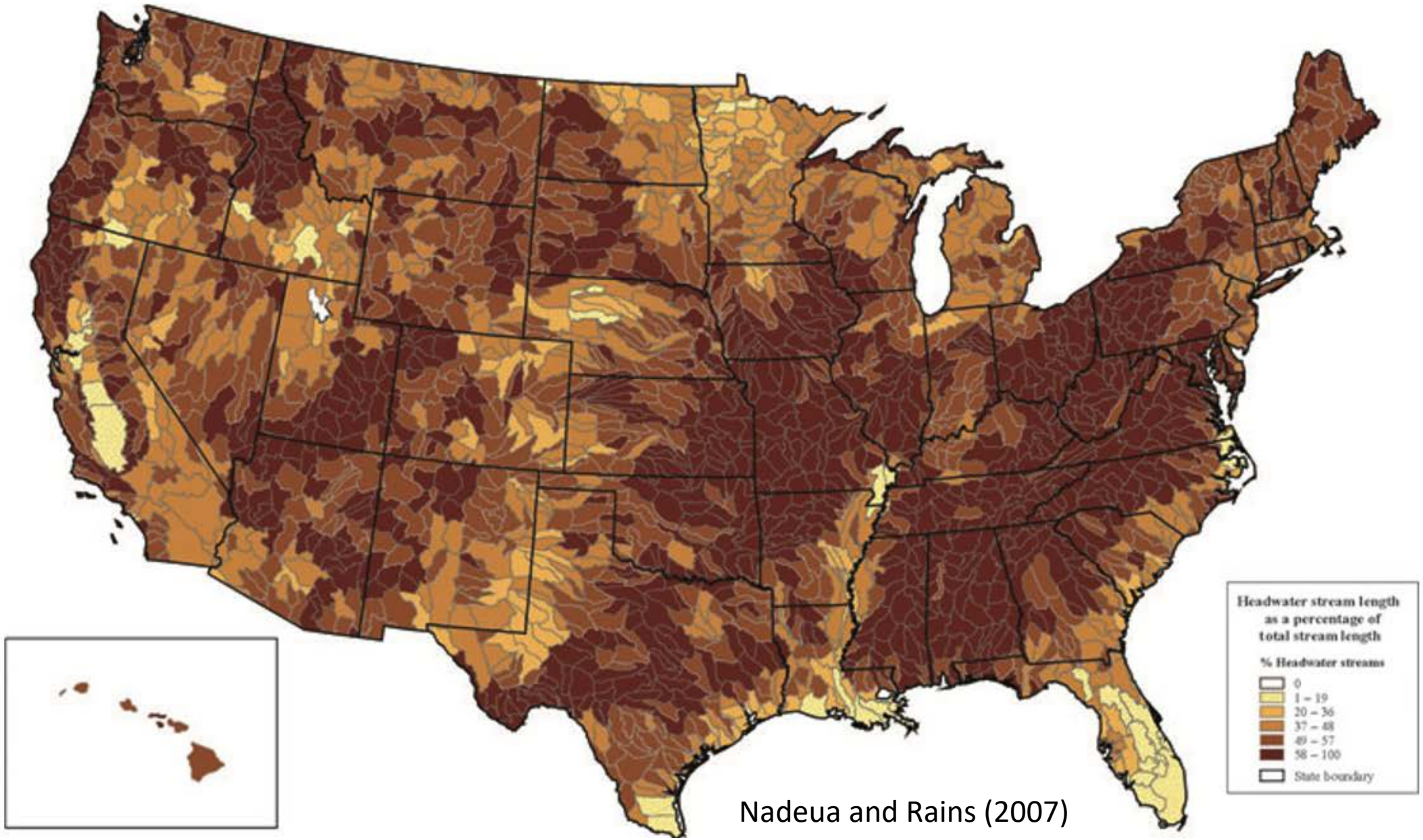
CONCEPTUAL SWAT + WATERSHED



Modeled Sources and Sinks

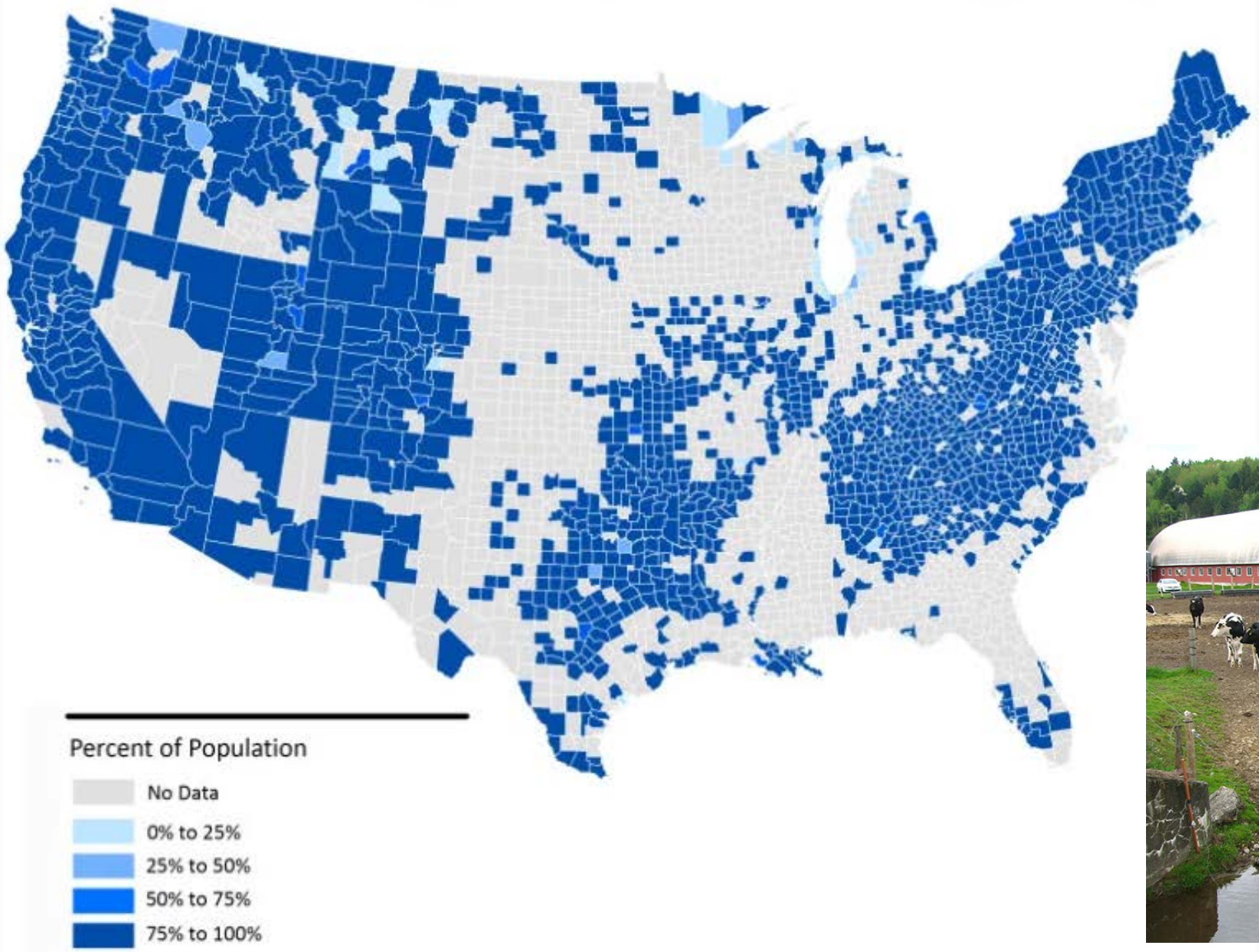
- Upland Sediment
- Tributary Sediment
- Gully Sediment
- Main Channel
- Overbank Deposition

Headwater Length as % Total Stream Length in United States

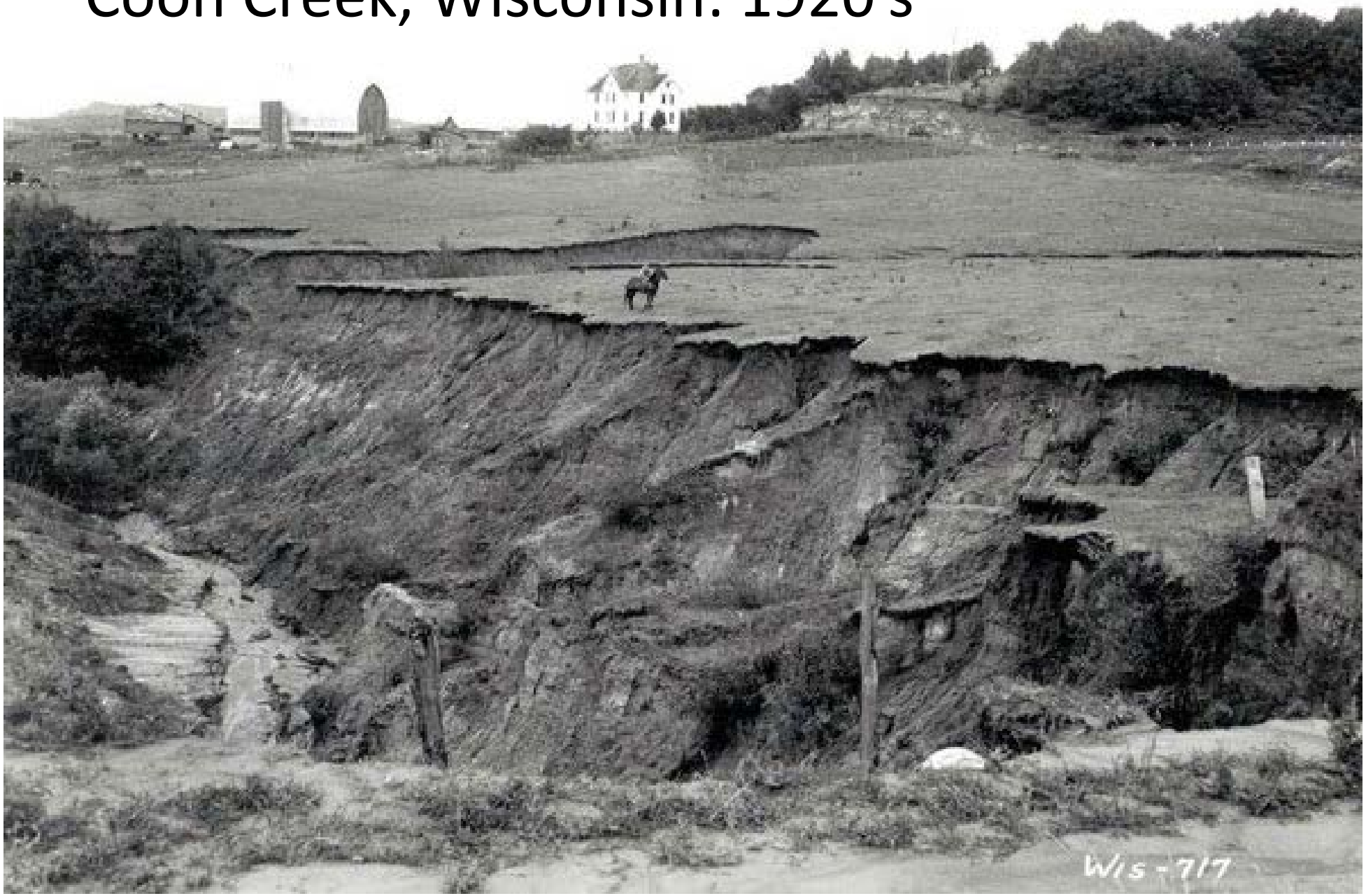


Nadeua and Rains (2007)

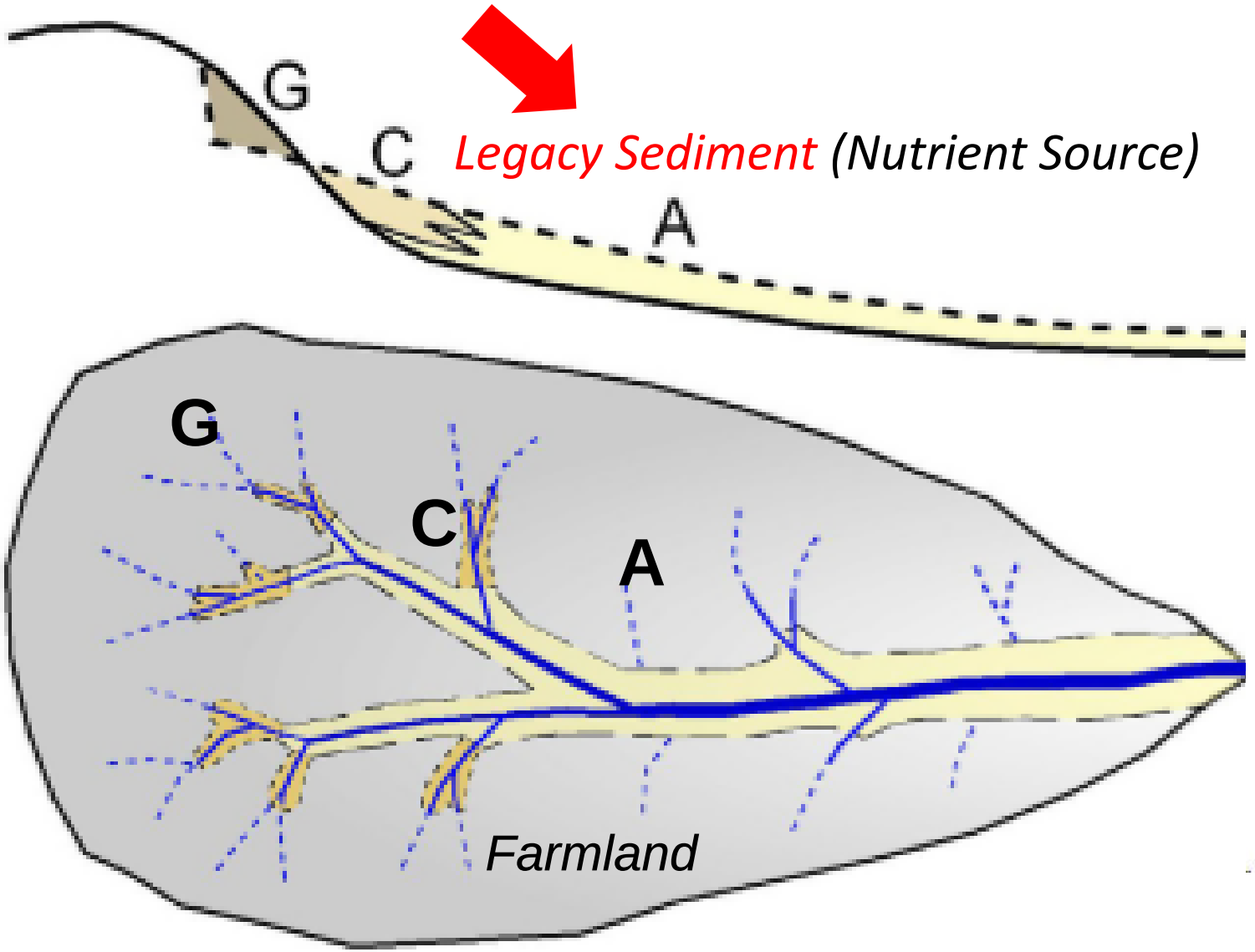
Percent of population that depends on drinking water from intermittent, ephemeral, or headwater streams, by county



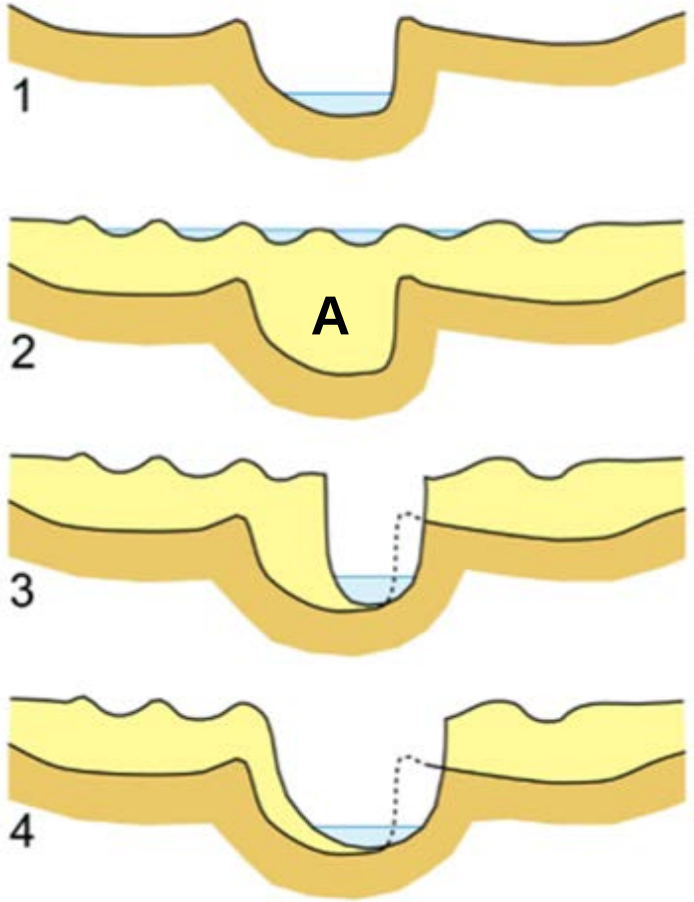
Coon Creek, Wisconsin: 1920's



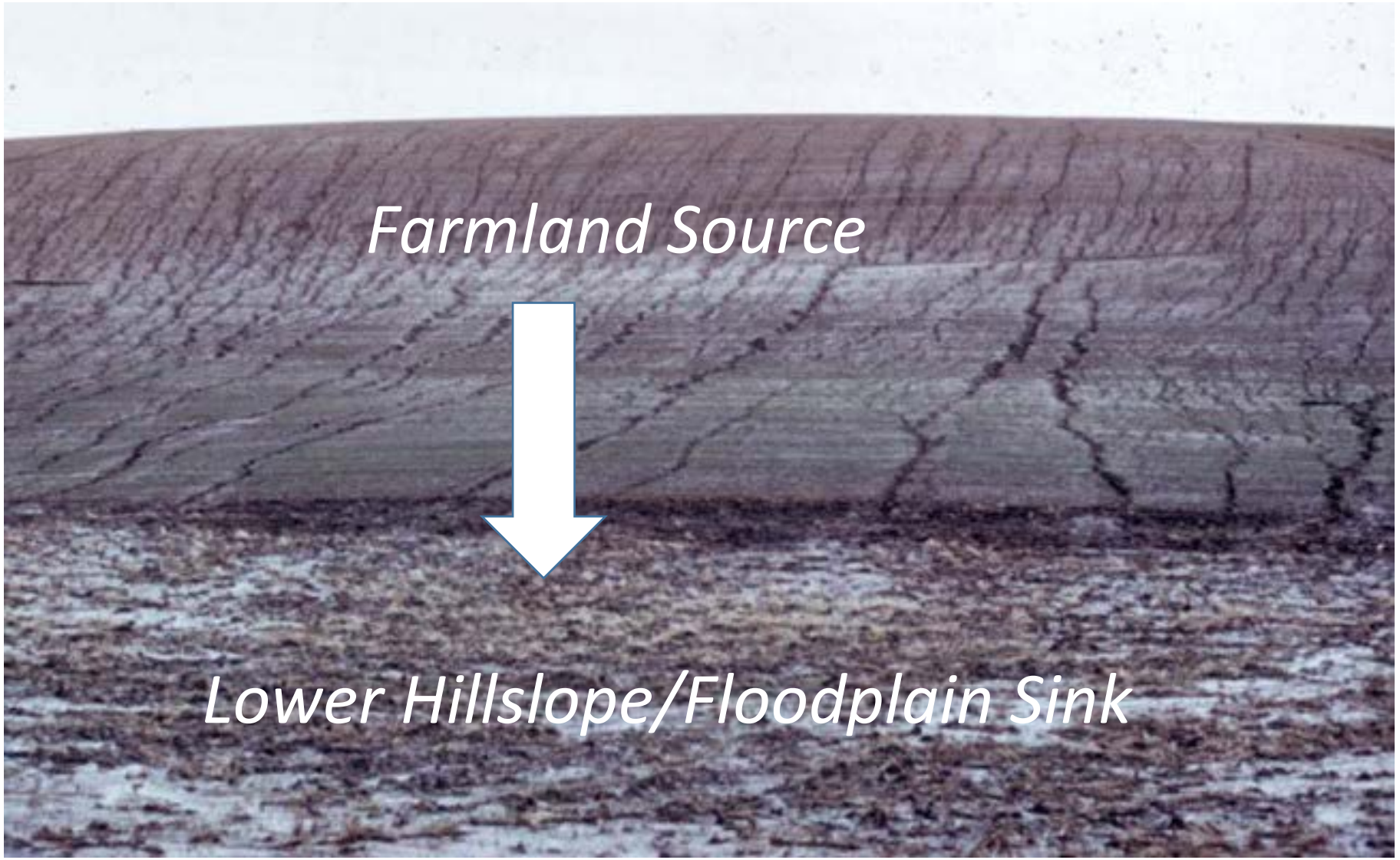
Farmland Erosion Pre-USDA

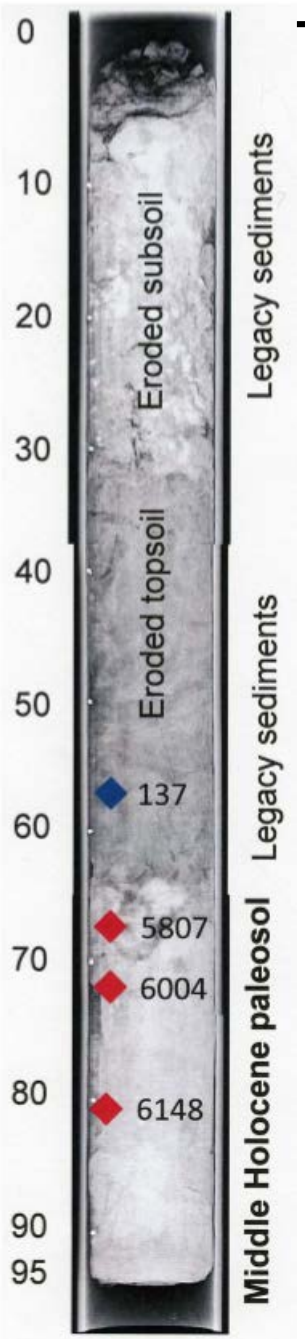


Legacy Sediment (Nutrient Source)



James (2013)

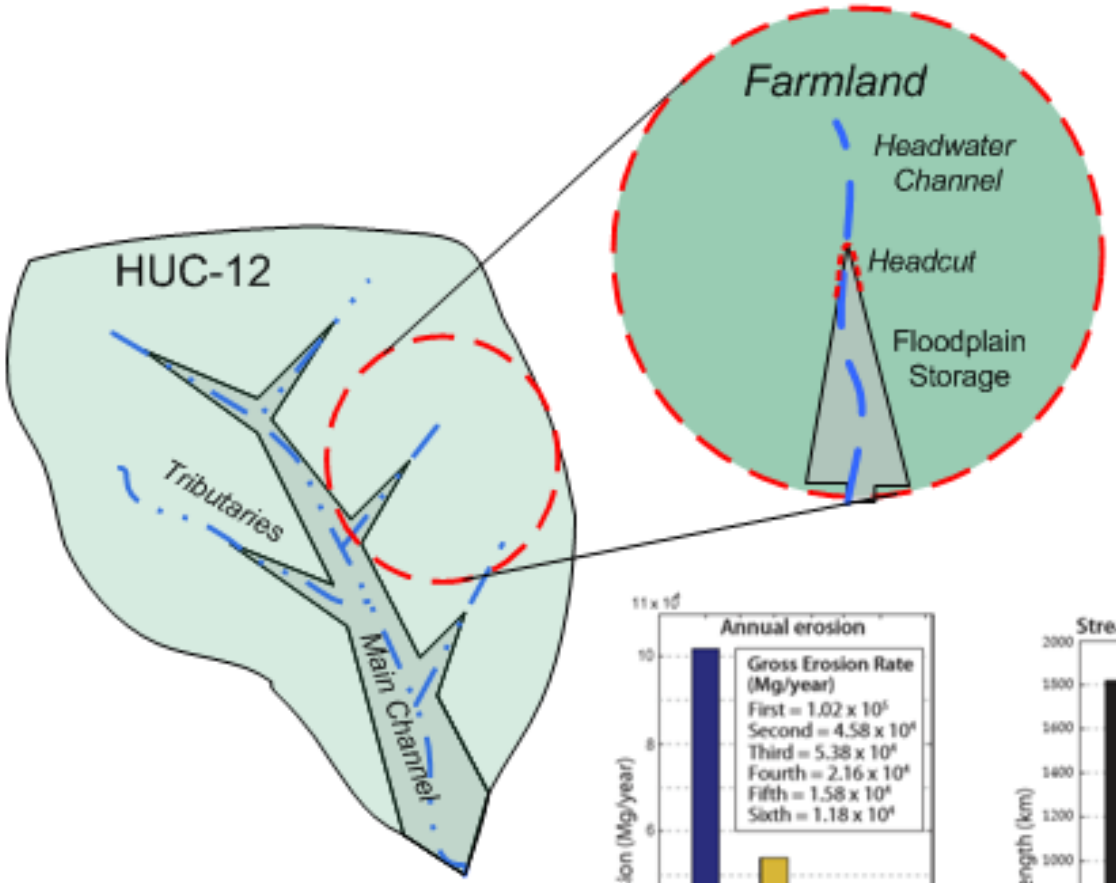




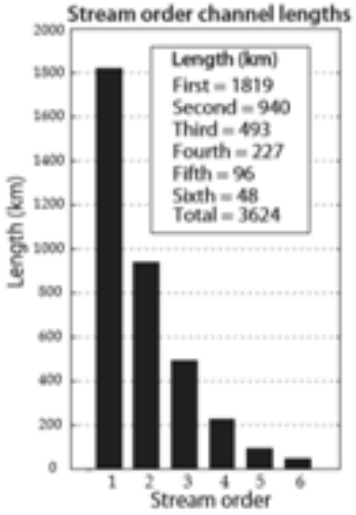
Legacy Sediment

Driese, et.al. (2017)

SWAT Architecture and Basin Erosion-Nutrient Framework



Most Sediment and Nutrients from Tributaries



SWAT + Modules

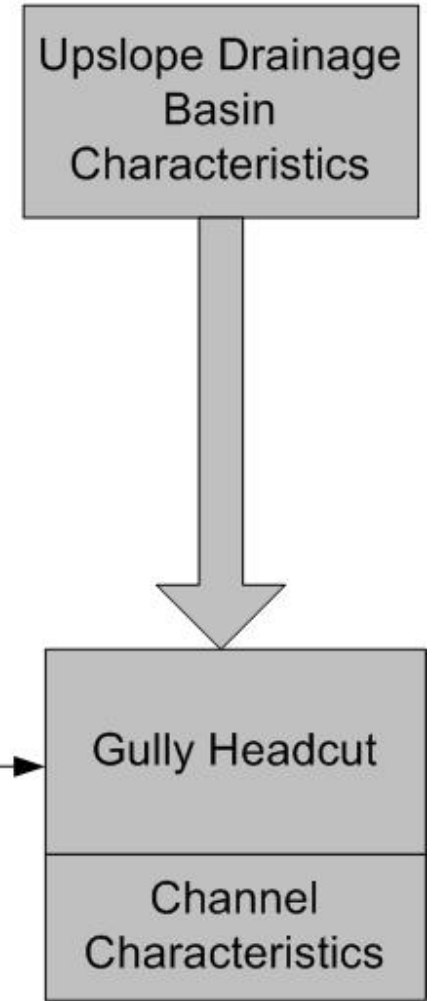
Channel Morphology

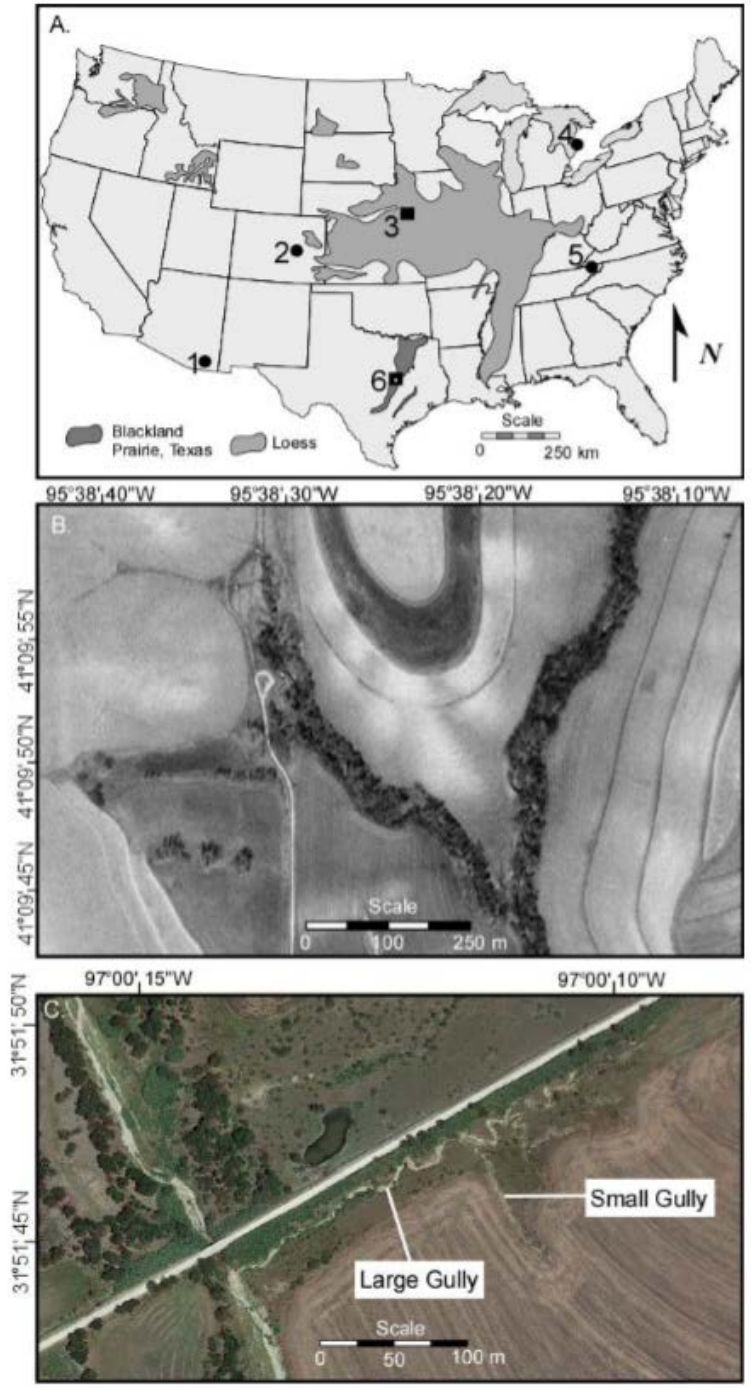
- *Headcut Model (gullys)*
- *SWAT-HW(Streams)*

SWAT-Gully Headcut Subroutine Inputs

Site Name	BcGully_MianTrib	BcGully_Trib 1	Treylowa	
Drainage area	0.0572	0.02754	0.3	Km2
Curve number	93	93	79/70	Integer
Time of concentration	39	39	54	Minutes
Soil profile depth	1330	1330	1890	Millimeters
Land Surface Slope	0.02	0.02	0.04	m/m
Land Surface Slope Length	300	266	800	Meters(m)
Specific yield of shallow aquifer	0.05	0.05	0.05	Millimeters(mm)
Alpha factor groundwater	0.05	0.05	0.05	None
Re-evaporation co-efficient	0	0	0	None
Percolation co-efficient from shallow to deep aquifer	0.01	0.01	0.01	None
Initial soil water (Fraction of available water capacity)	0.5	0.5	0.5	Fraction
Initial shallow aquifer storage	3	3	3	Millimeters(mm)
Initial shallow aquifer flow	0	0	0	Millimeters(mm)
Initial deep aquifer Flow	300	300	300	Millimeters(mm)
Snow Water equivalent	0	0	0	Millimeters(mm)
Latitude	31°51'46.79"N	31°51'46.79"N		None
Soil textures (12 – Clay)	8	8	8	Integer(1-12)
Non tropical and tropical simulations(0 or 1)	0	0	0	Integer
Start of growing season	91	91	131	Julian Calendar
End of growing season	151	151	201	Julian Calendar
Plant types(Read from plants.plt)	4	4	1	Integer
Potential Evapotranspiration method(1 – Penman/ 0 - Hargrove Method)	1	1	1	Integer
Irrigation code(0 - NoIrr/ 1 - Irr)	0	0	0	Integer(0,1)
Irrigation source (0 - Outside Basin/ 1 - Shallaow Aquifer/ 2-Deep Aquifer)	0	0	0	Integer(0,1,2)
USLE Soil erodibility factor	0.37	0.37	0.32	None(0-1)
USLE cover factor	0.2	0.2	0.2	None(0-1)
USLE Equation support practice factor(P)	0.6	0.6	1	None(0-1)
USLE equation length of slope factor(LS)	0.32	0.32	0.53	None(0-10)

Name	Site Name	BcGully_MianTrib	BcGully_Trib1	Treylowa	
CHW	Width	8.373	7.6	21.9	meters
CHD	Depth	3.8	6.24	3.3	meters
CHS	Slope	0.0231	0.0247	0.0235	m/m
CHL	Length	0.3	0.266	0.8	kilometers
CHN	Manning's roughness co-efficient	0.05	0.05	0.05	None
CHK	Channel bottom conductivity	1	1	1	mm/hr
CHEROD	Channel erodibility	0.2	0.2	0.4	$cm^3/N\text{-}s$
CHCOV	Vegetation Cover factor	0.05	0	0	%
HC COV	HeadCut Cover	0.2	0	0.1	
CHSEQ	Equilibrium channel slope	0.01155	0.012	0.01175	m/m
D50	Channel median grain size	0.005	0.005	0.1	Millimeters
CLAY	Percent clay within bed	46	46	30	%
BD	Bulk Density	1.87	1.87	1.25	Tons/m3
CHSS	Side slope	0.53	0.53	0.312	m/m
BEDLD	Bedload Co-efficient	0.2	0.2	0.2	% of sediemnt as bedload
TC	Time of Concentration	39	39	55	Minutes
HC_KH	Head-cut erodibility factor	0.17	0.17	0.05	$cm^3/N\text{-}s$
HC_HGT	Headcut height	2.6	1.2	1.5	m
HC_INI	Initial gully channel length	0	0	0	meters



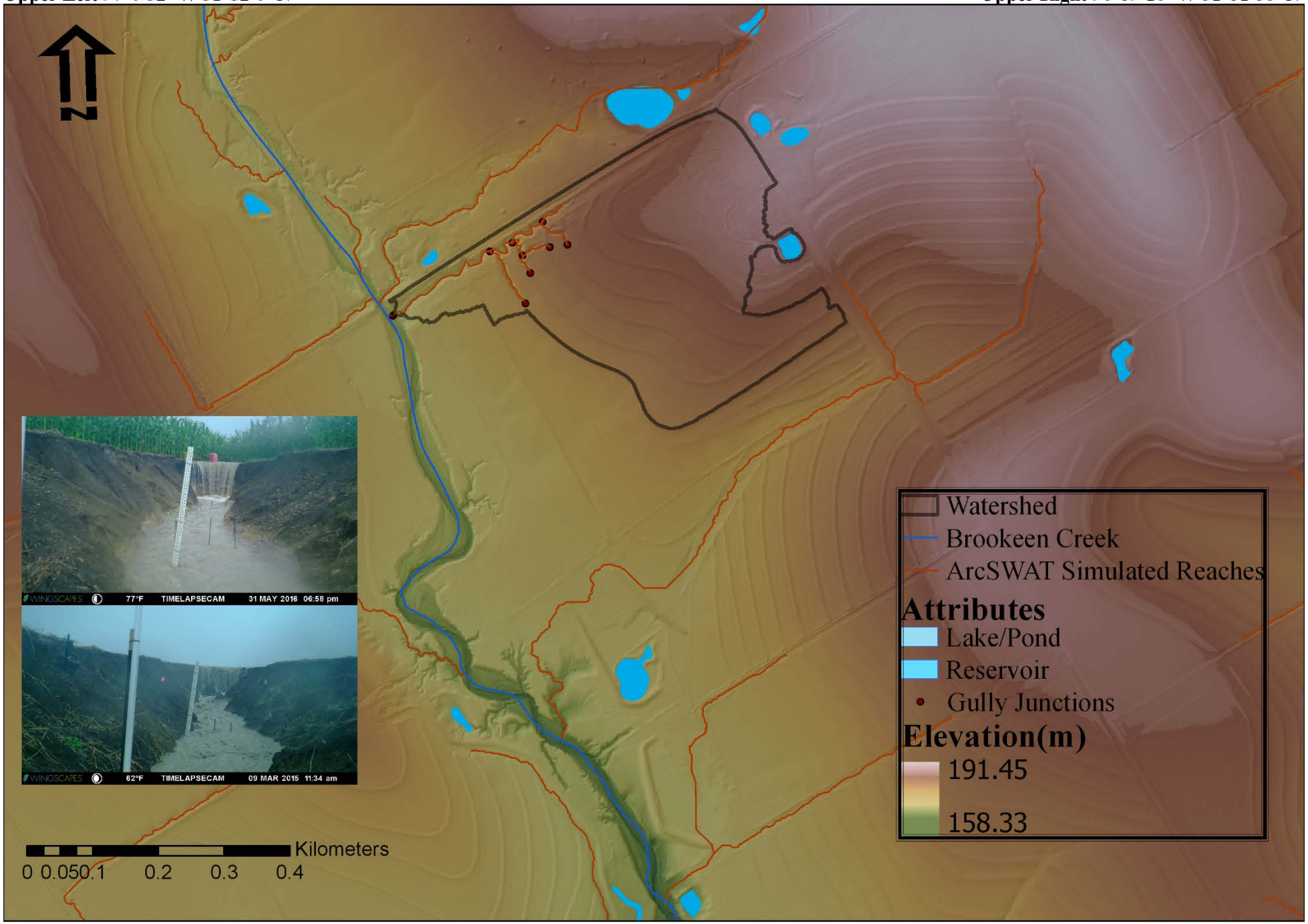


1. Gully Module

- Erosion > Deposition Headwater (Floodplain area)
- Stream/Gully Erosion>Field Erosion
- Legacy Nutrients Eroded~mined From Headwater Streams (2.3lbs/ton P)
- Time frame without Control > 1000 years Pizzuto et al.

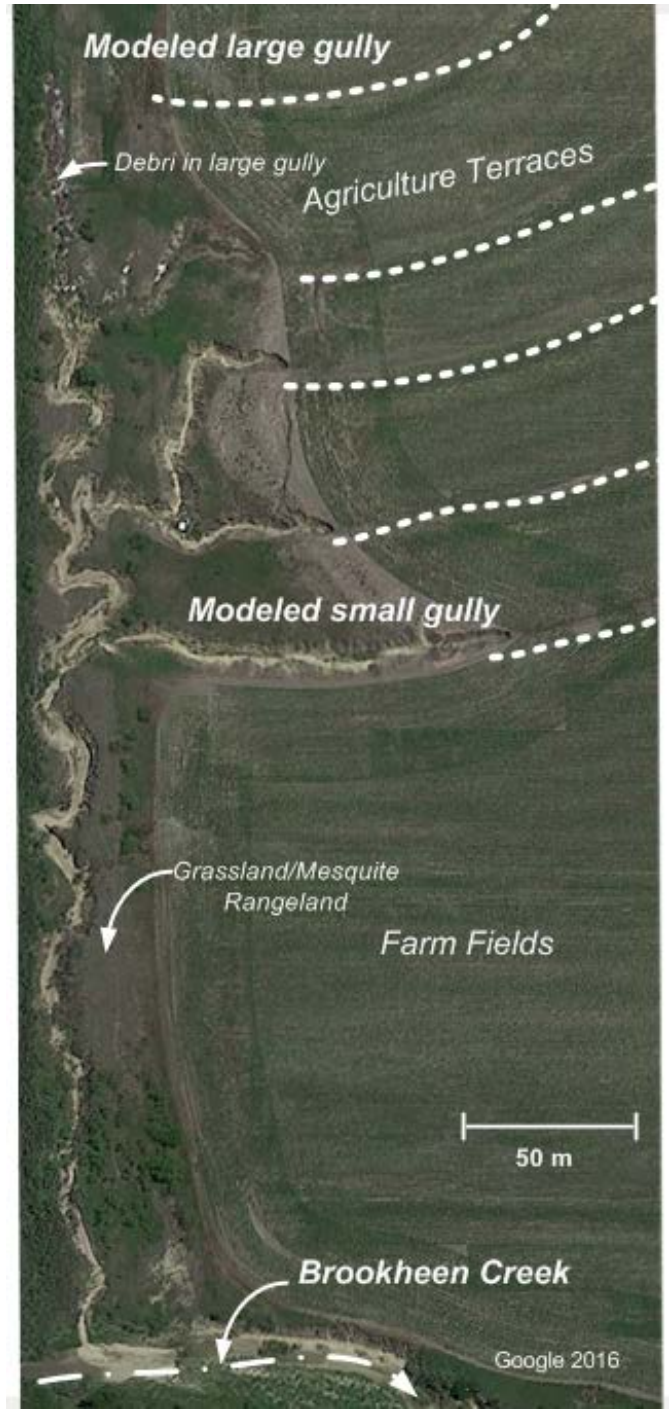
Upper Left 97°0'32"W 31°52'0"N

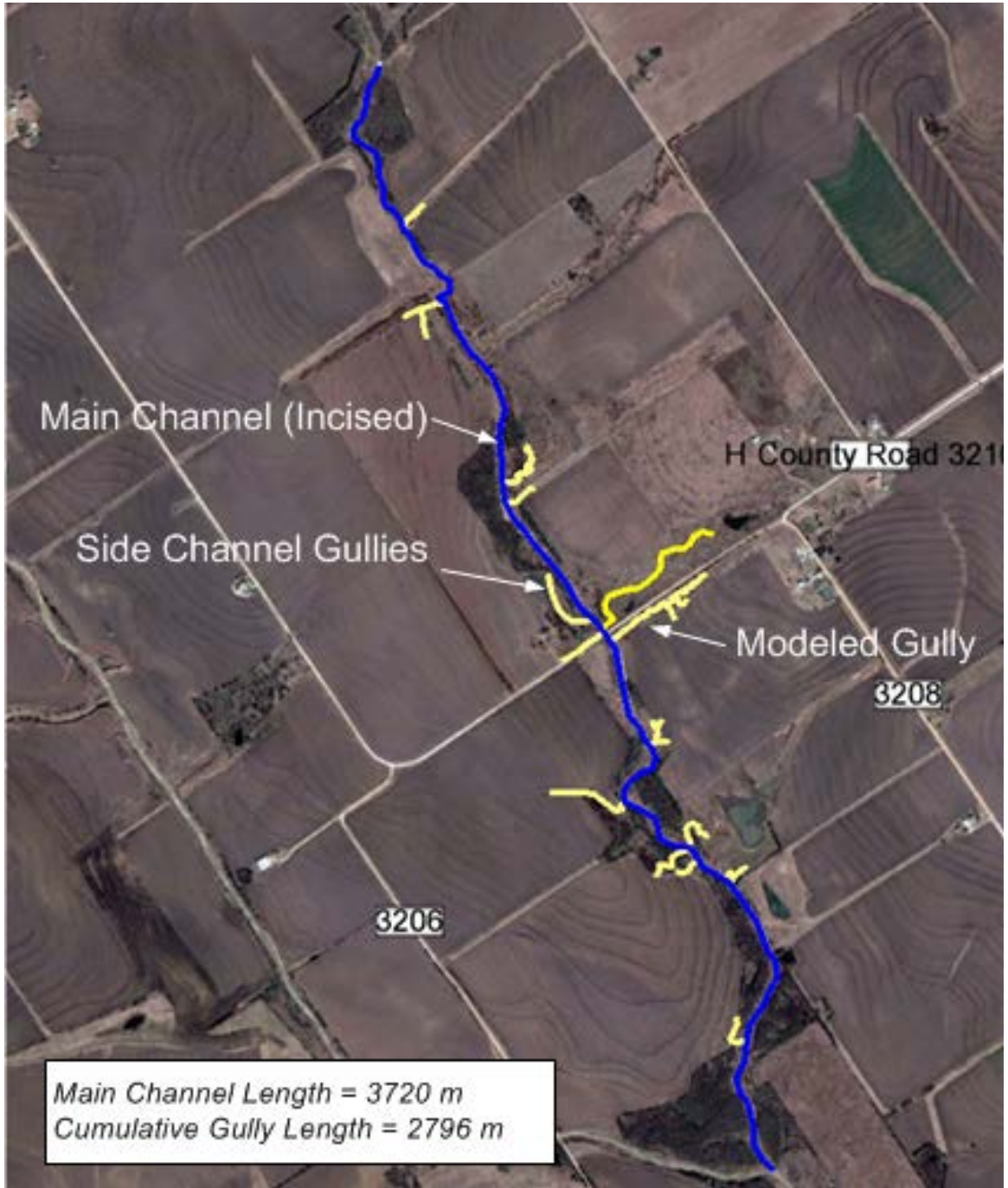
Upper Right 96°59'16"W 31°51'58"N

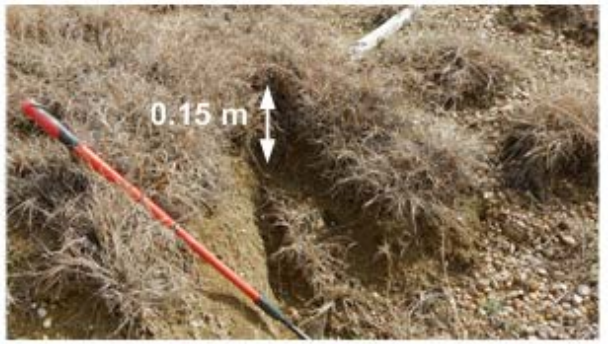


Lower Left 97°0'33"W 31°51'15"N

Lower Right 96°59'18"W 31°51'13"N


Modeled large gully
Debri in large gully
Agriculture Terraces
Modeled small gully
Grassland/Mesquite
Rangeland
Farm Fields
50 m
Brookheen Creek
Google 2016





Stage I: Incipient Gully

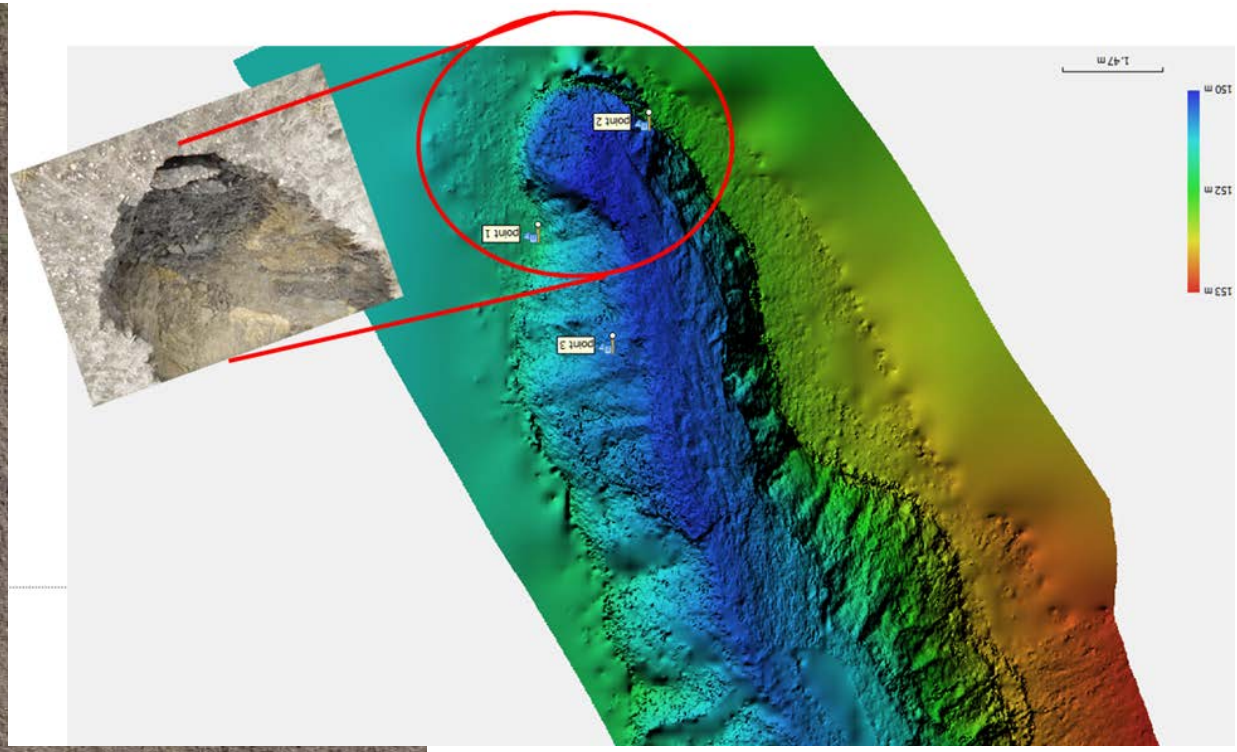
Headcut forms as grass is removed and undercut.

Stage II: Soil-Grass Gully

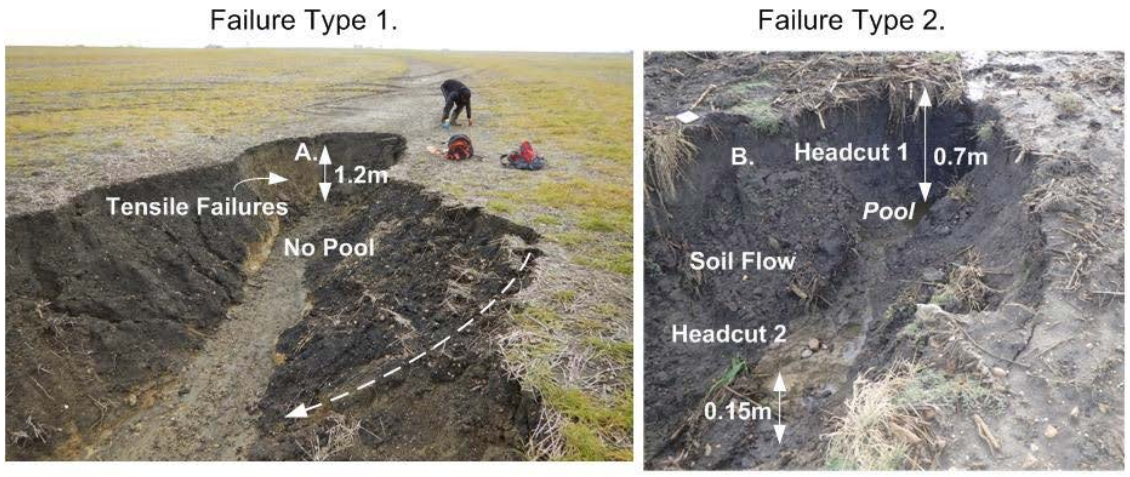
Headcut height increases below root zone and gully widens and elongates, cantilever failures.

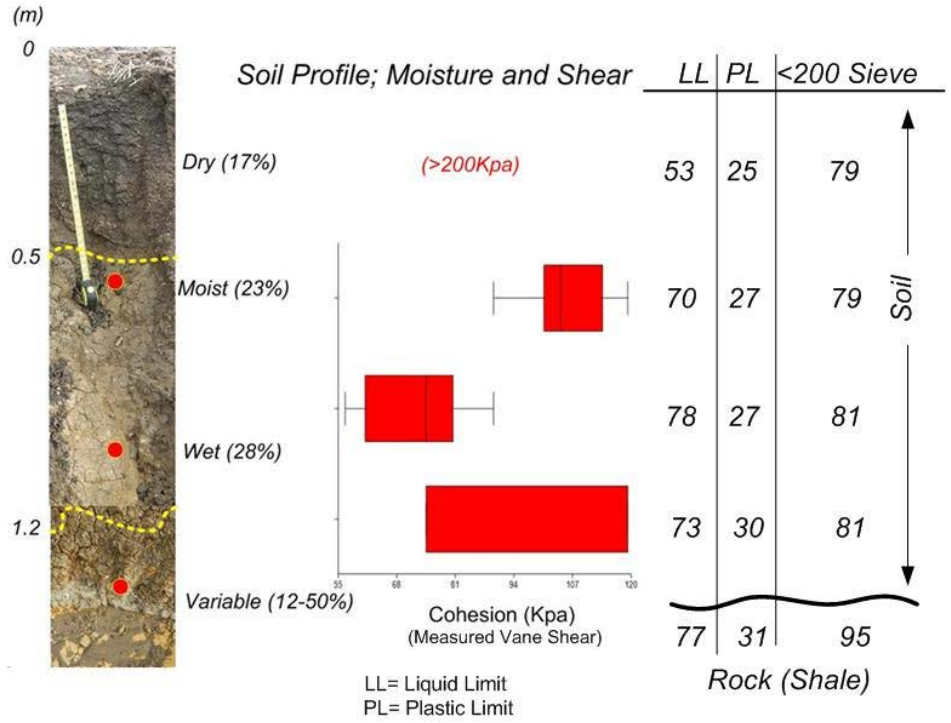
Stage III: Field Gully

Headcut fully formed; gully headcut moves up gradient with storm events; fixed width depth ratio established; thin wedge failures to shallow soil slips and sheet rill erosoin on gully sides.



Drone/Structure from Motion

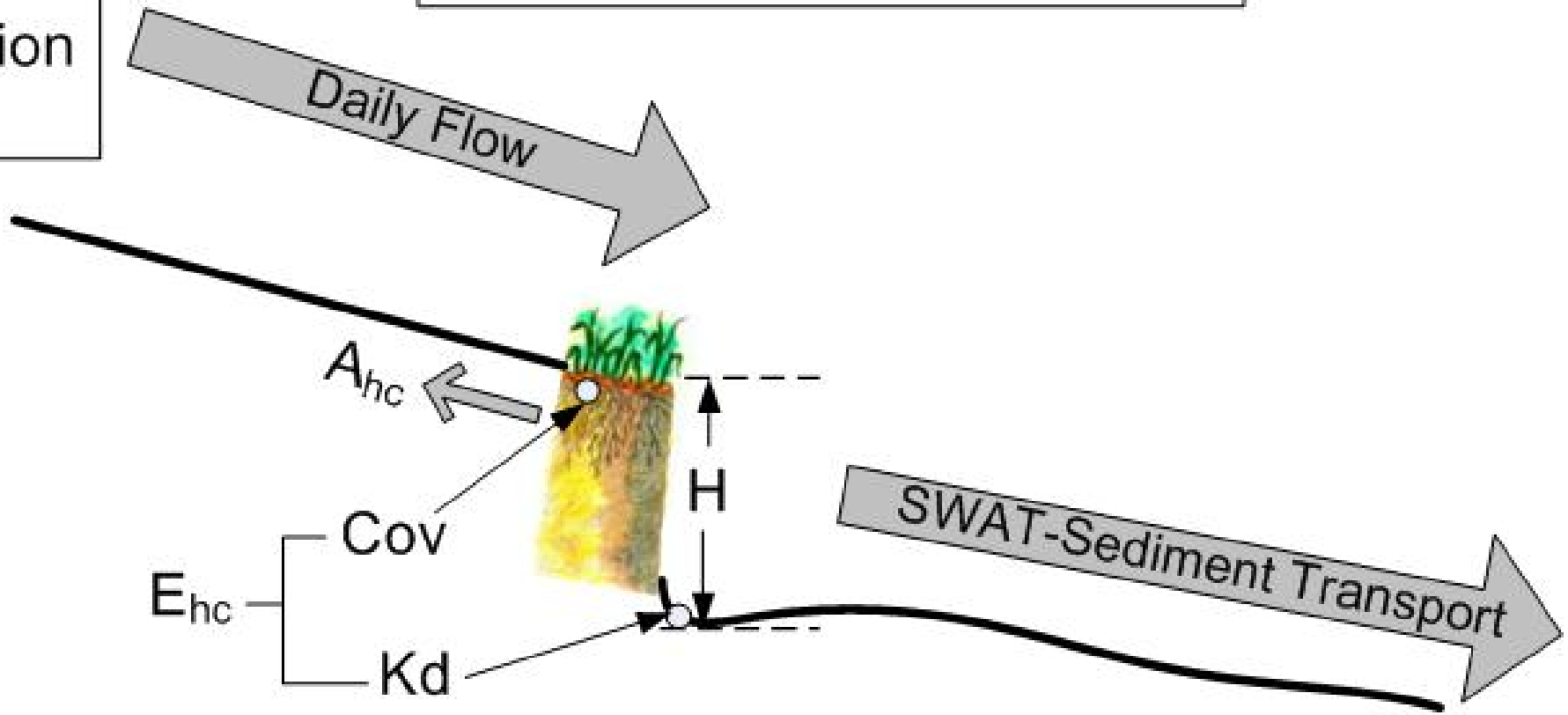


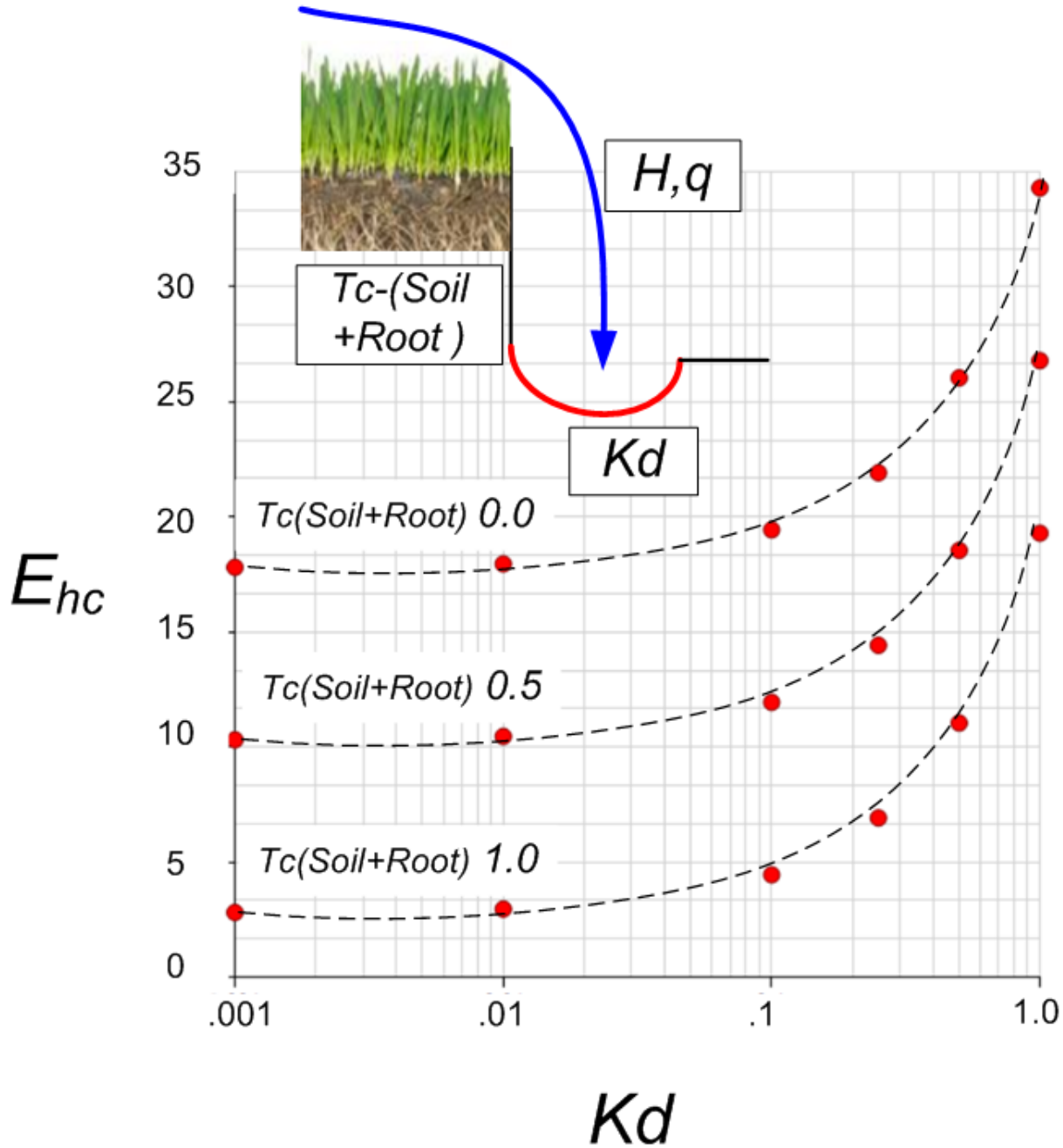


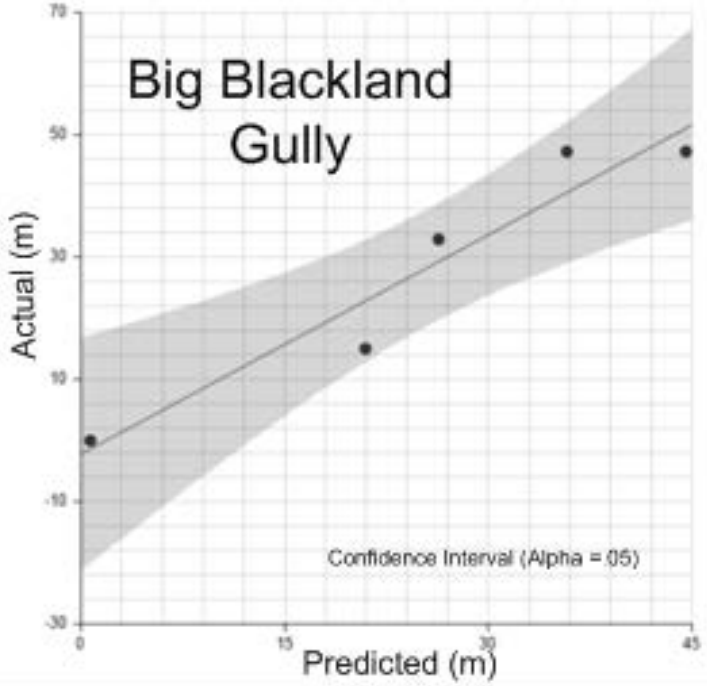
- Complicated lithologies
- Change strength moisture/depth
- Soil structural controls
- Related to cracking and moisture history
- Flow and headcut strength controlled vegetation/crops

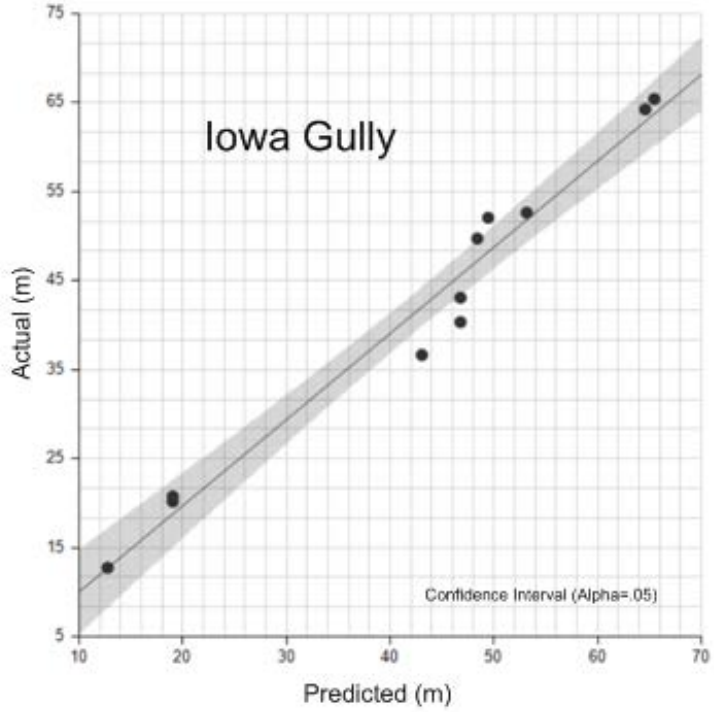
SWAT HRU
SUBBASIN
Flow Generation

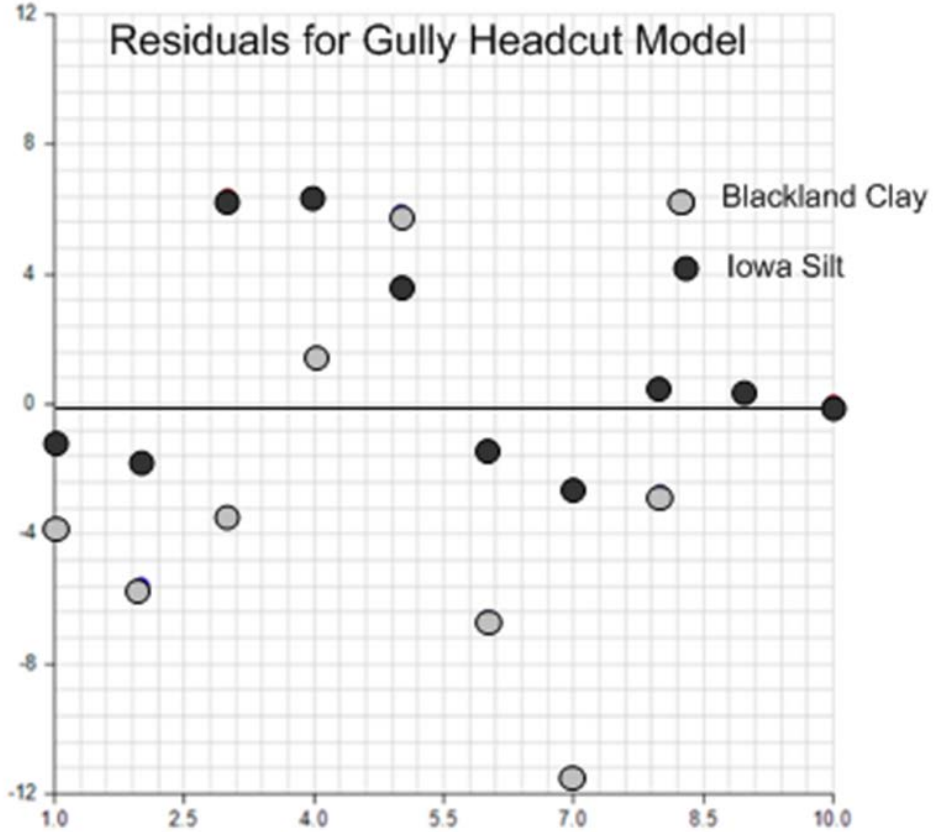
$$A_{hc} = c * E_{hc} * Q^{.5} * H^{.225}$$

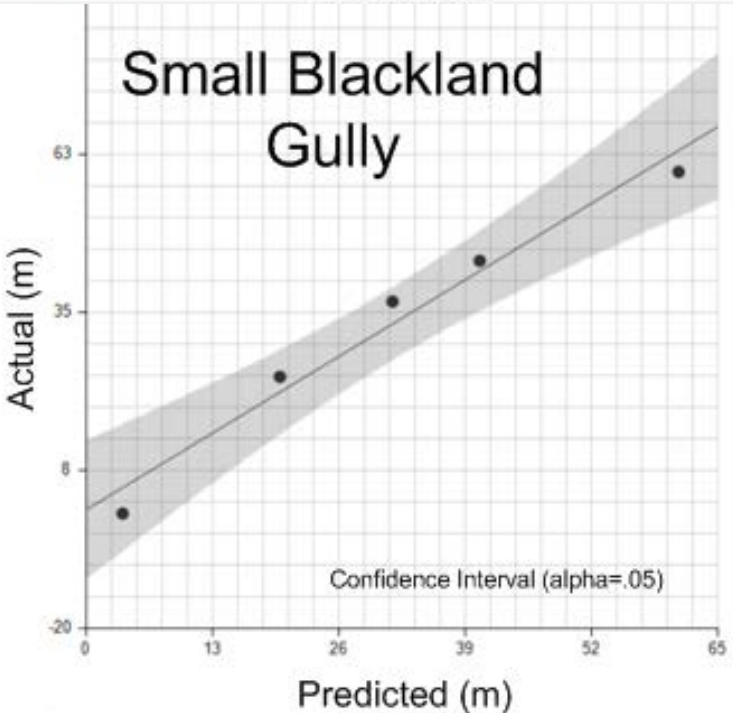



H,q
Tc-(Soil
+Root)
Kd
Tc(Soil+Root) 0.0
Tc(Soil+Root) 0.5
Tc(Soil+Root) 1.0
35
30
25
20
15
10
5
0
.001
.01
.1
1.0
Ehc
Kd



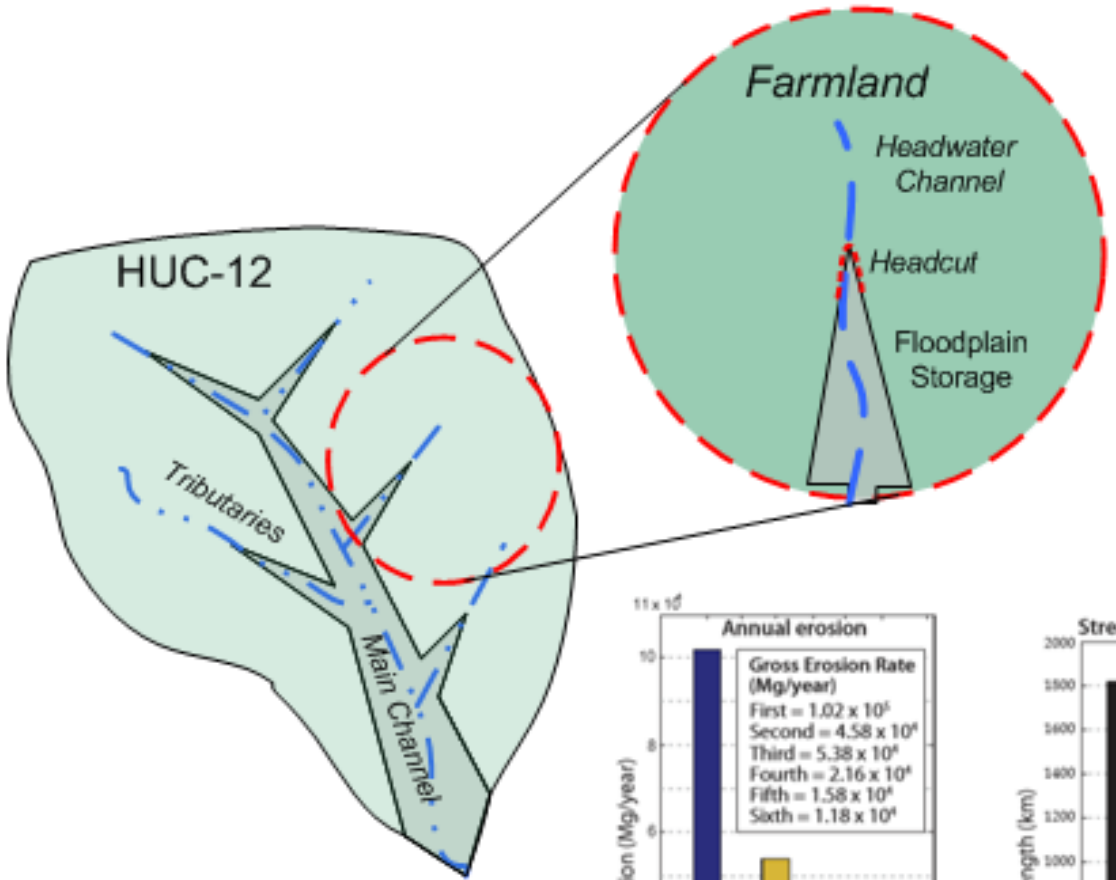




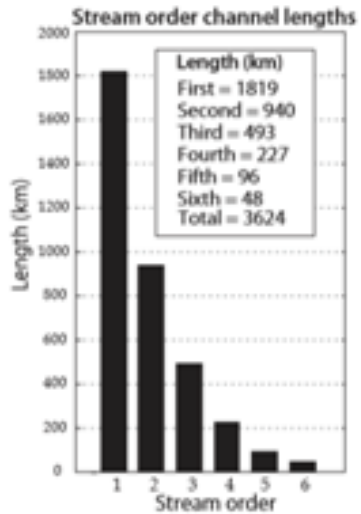


Location	Mean	Std. Dev.	Std. Error	Minimum	Maximum	Range
Blackland Small	-2.87	3.03	1.51	-5.58	1.47	7.05
Blackland Big	-3.73	7.35	3.67	-11.5	5.9	17.4
Iowa	1.048	3.3	1.04	-2.63	6.42	9.05

SWAT Architecture and Basin Erosion-Nutrient Framework



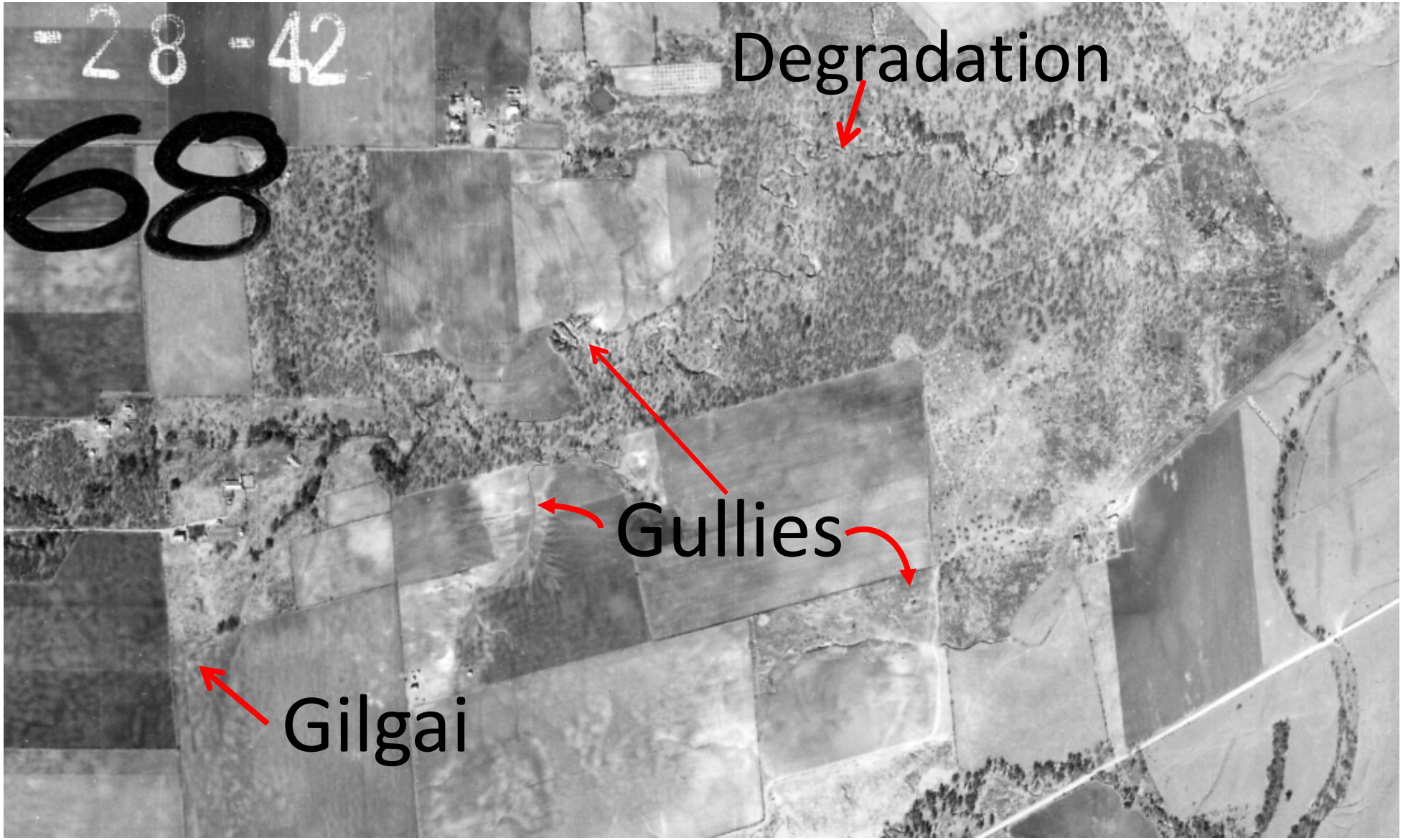
Most Sediment and Nutrients from Tributaries



2. Stream Erosion Module

Cedar Creek Watershed 1942

Cedar Creek Agriculture: 1942

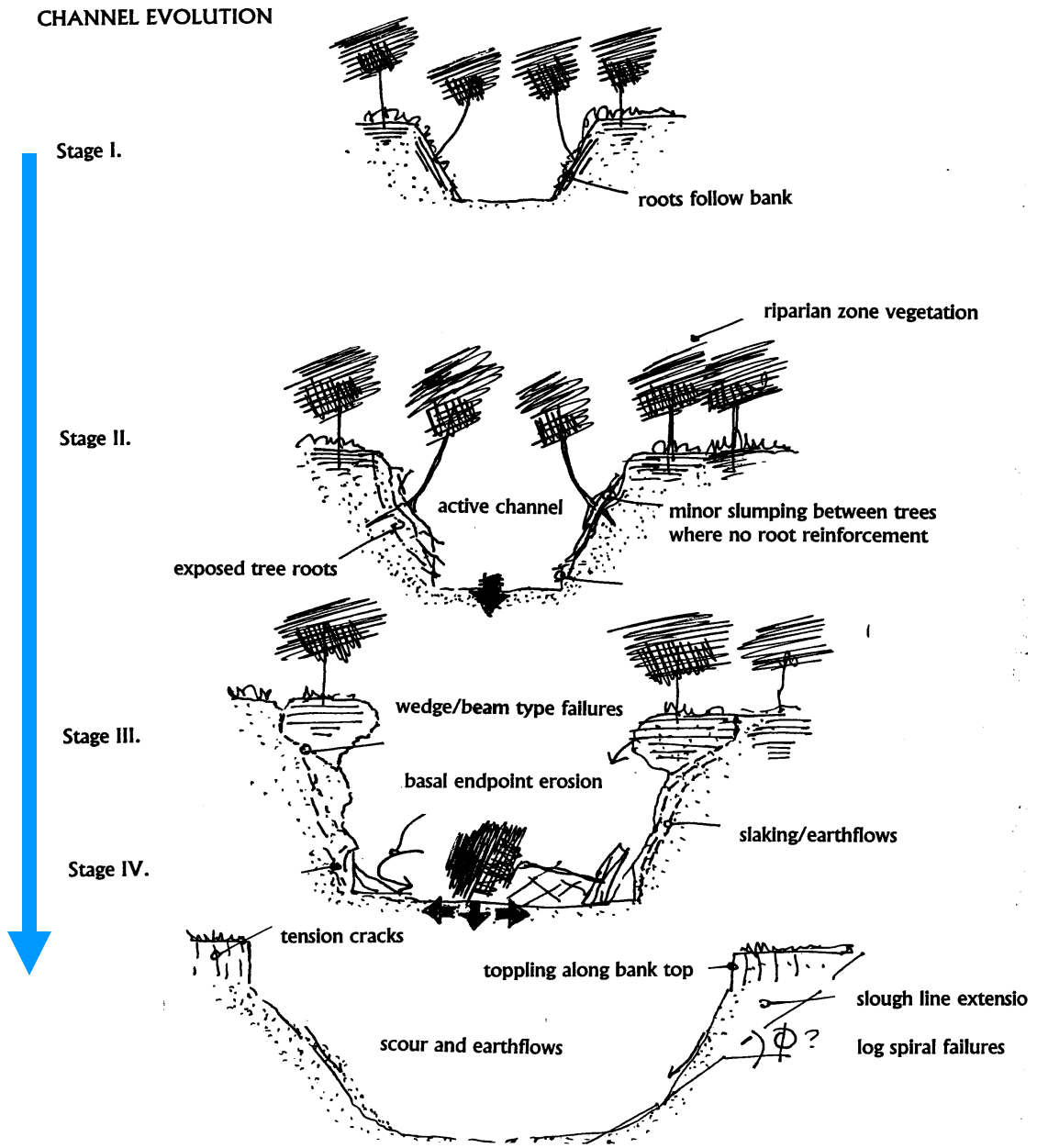


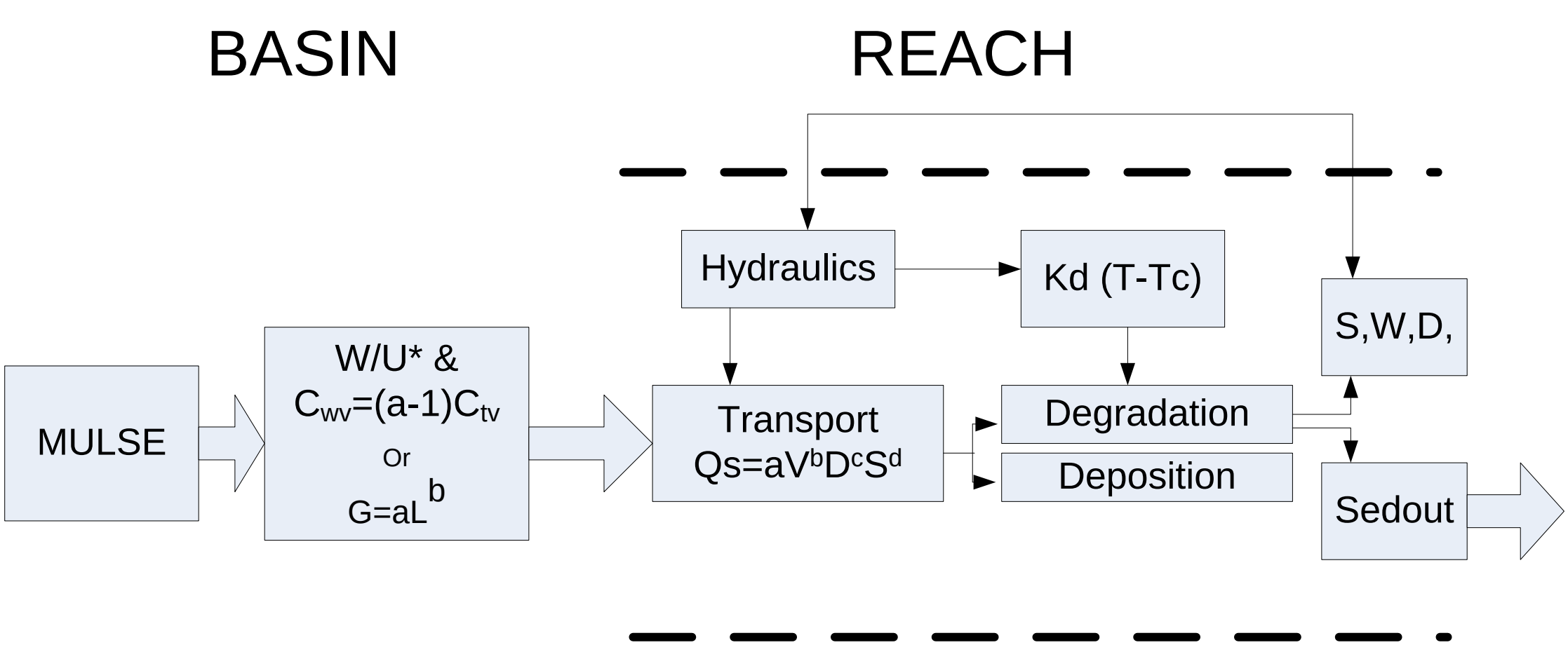
Cedar Creek Urbanized

Subbasin	Area		CN	% Impervious		Lag Time	TC	Stream	
	(ac)	(sq mi)		Existing	Future	(min)	(min)	Length (ft)	Slope (ft/ft)
S-1	137.87	0.2154	80	45	60	18.17	30.28	-	-
S-2	142.71	0.2230	80	62	63	19.62	32.70	2653	0.0014
S-3	65.35	0.1021	80	61	61	13.12	21.87	2131	0.0013
S-4	66.48	0.1039	80	38	39	15.68	26.13	-	-
S-5	83.28	0.1301	80	63	64	14.43	24.05	2566	0.0015
S-6	82.67	0.1292	78	30	32	16.82	28.03	-	-
S-7	183.98	0.2875	79	48	61	14.43	24.05	2440	0.0071
S-8	115.72	0.1808	76	35	49	46.96	78.27	875	0.0061
S-9	79.37	0.1240	80	23	26	15.63	26.05	3779	0.0058
S-10	78.76	0.1231	80	46	62	10.81	18.02	401	0.0032
S-11	26.30	0.0411	75	30	32	22.79	37.98	-	-
S-12	67.23	0.1050	78	48	51	11.90	19.83	2085	0.0047

Channel Evolution Model:

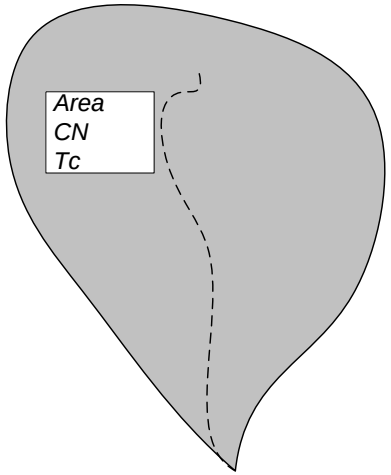
North Texas Trends



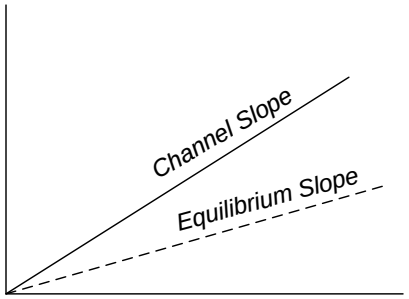


MULSE = Modified Universal Soil Loss
W/U* = Fall Velocity/Shear Velocity
Cwv = Yang and Simoes (2005) Wash Load Bedload Ratio
GaL^{b} = Turowski,et.al.(2010) Partitioning Suspended and Bedload

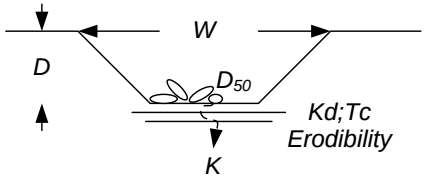
Input Components of SWAT-DEG



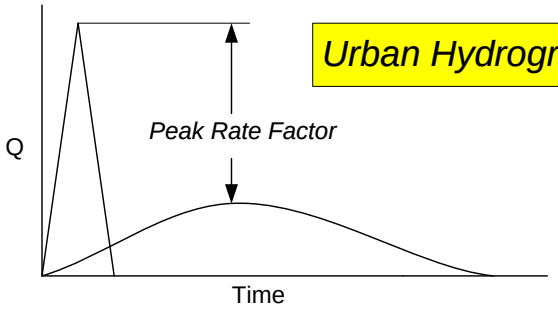
Basin



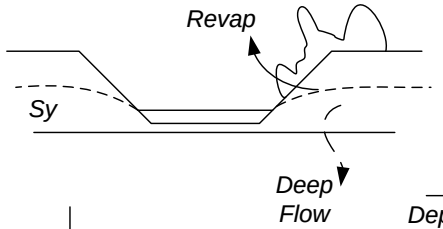
Channel

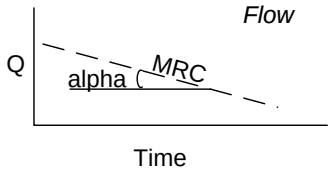


Urban Hydrograph

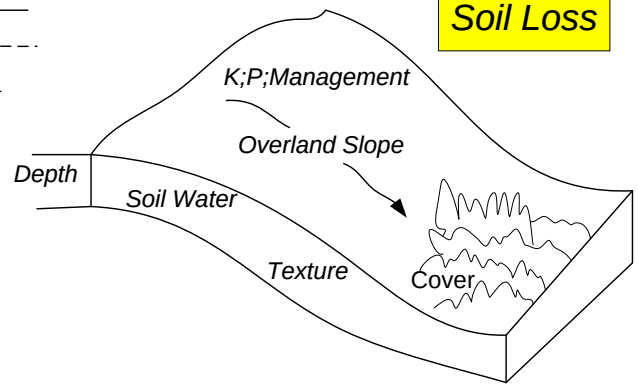


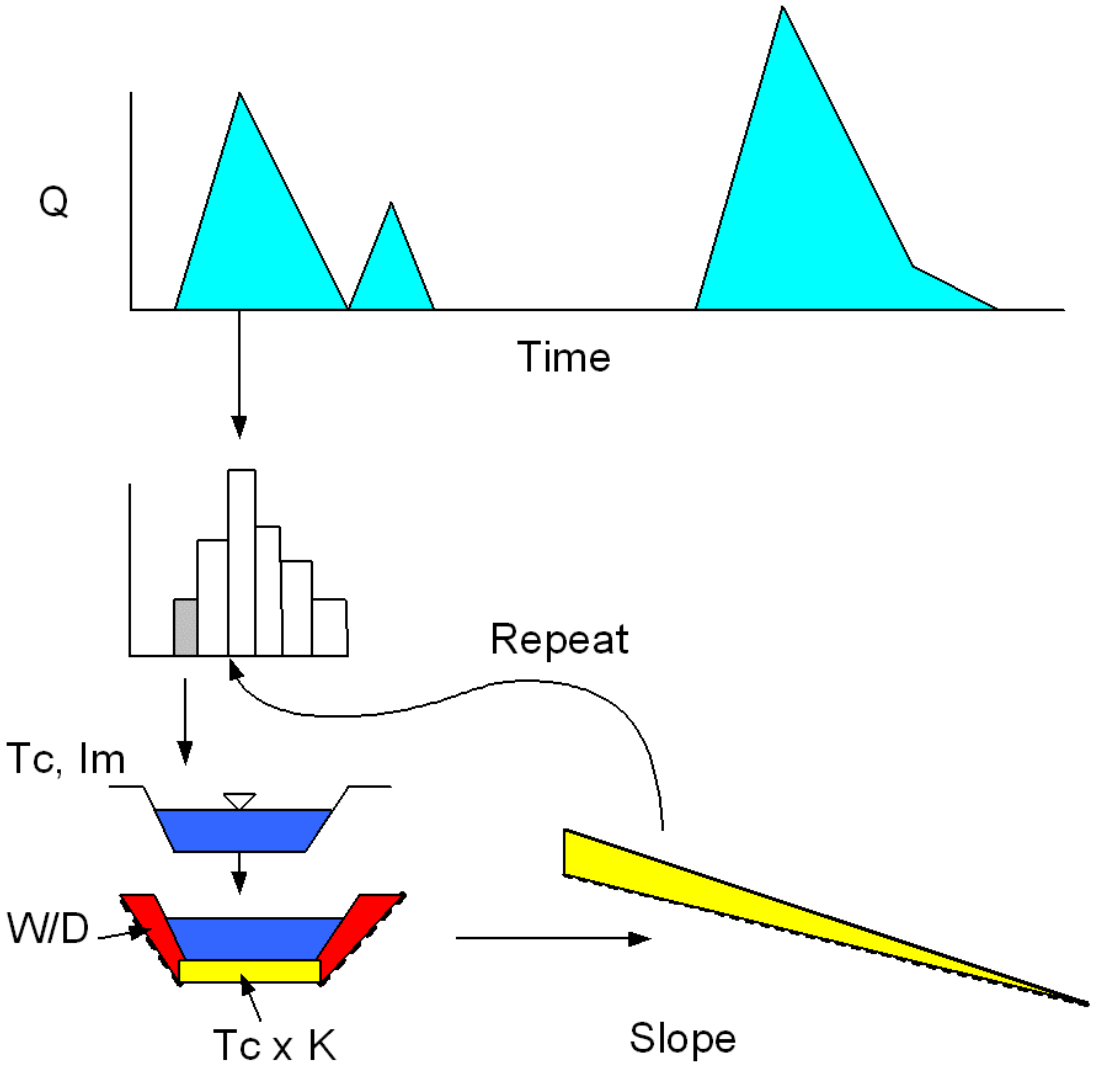
Groundwater





Soil Loss

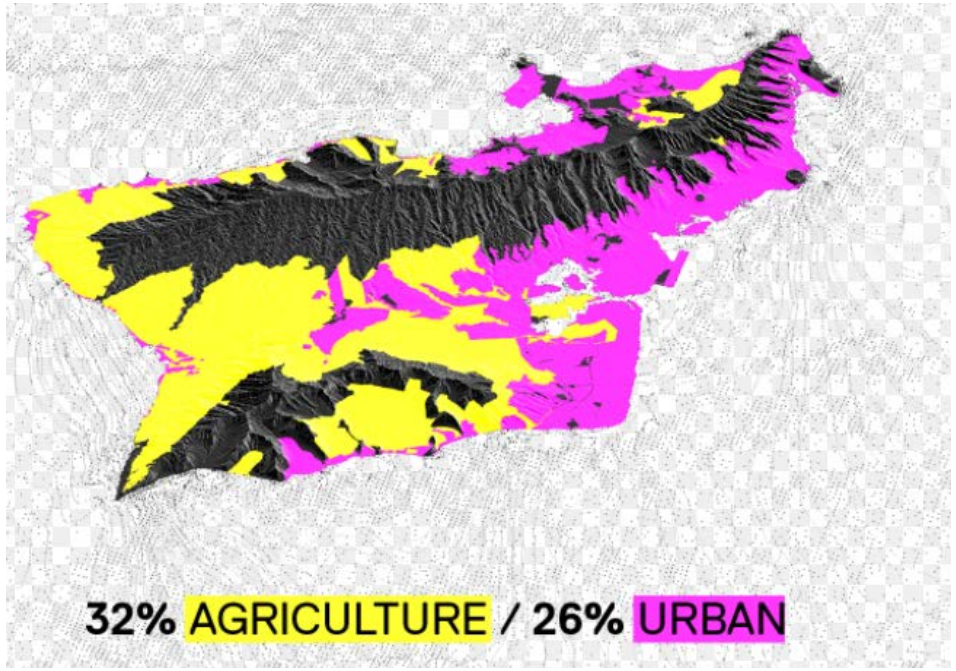


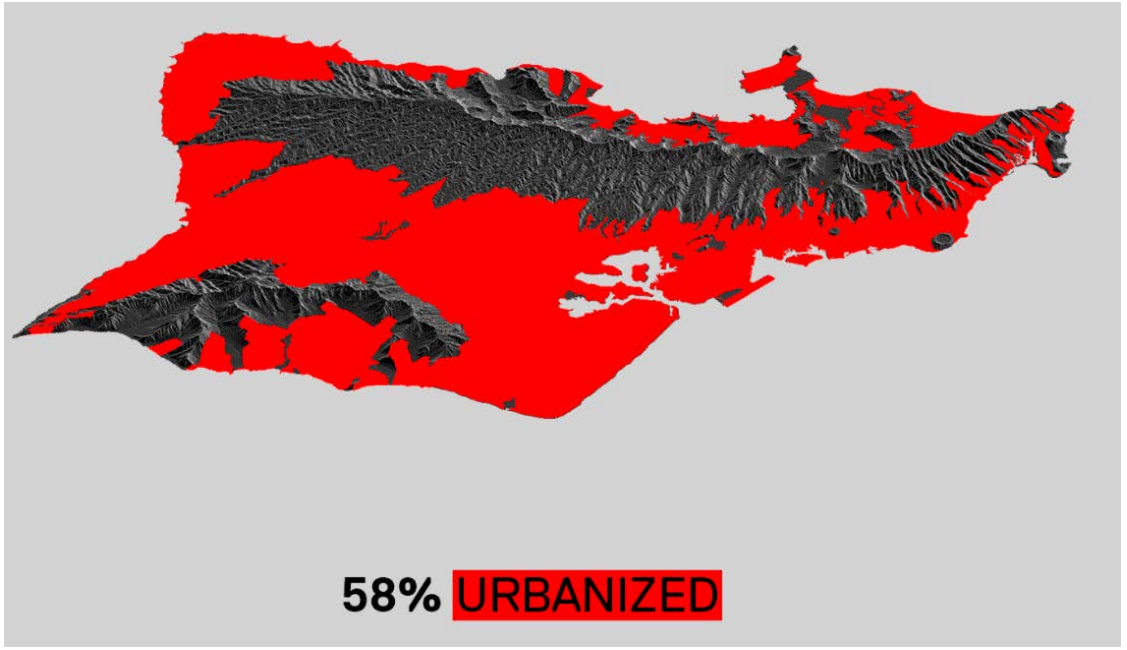


SWAT-DEG

INPUTS/OUTPUTS

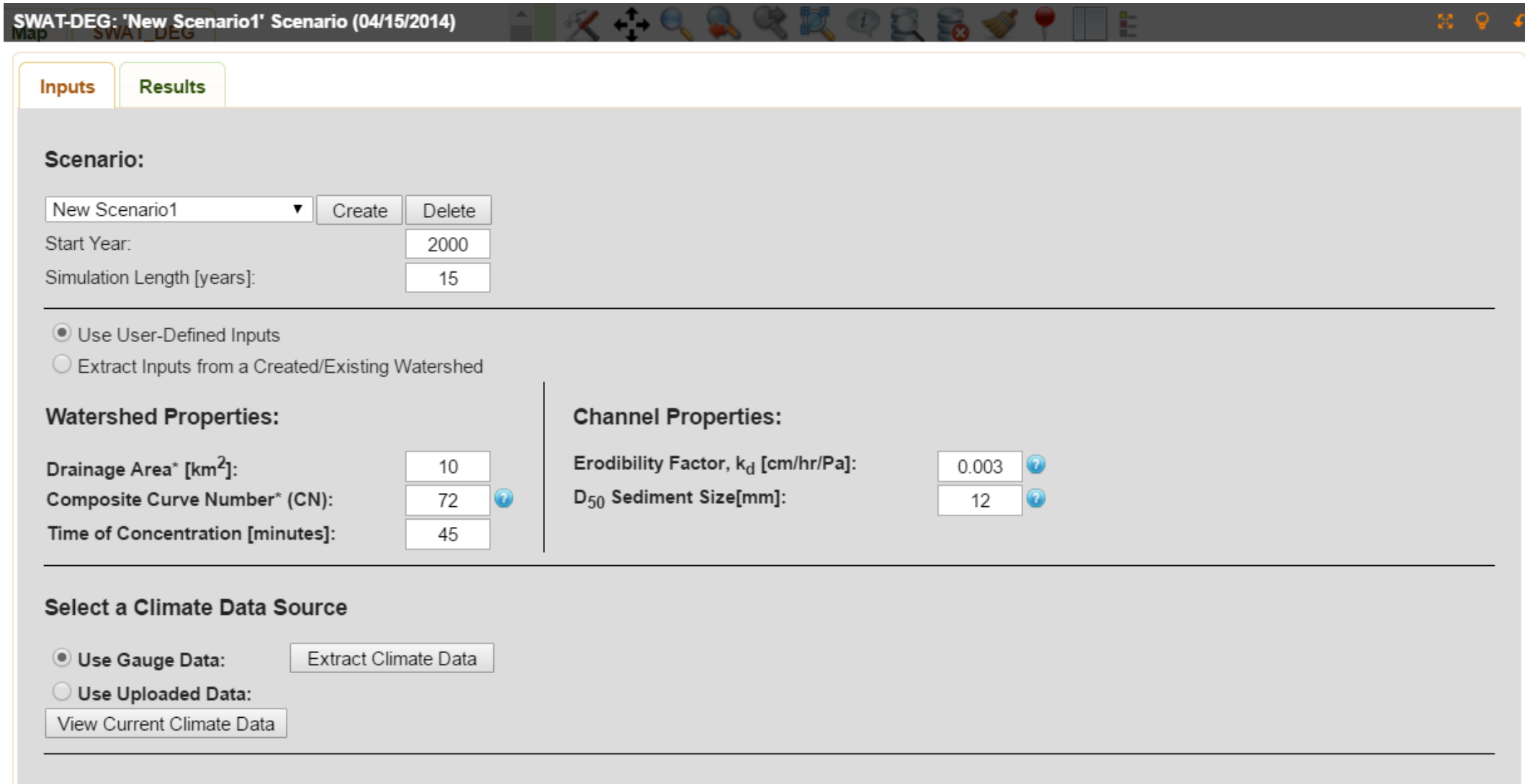
Landuse and Hydrology



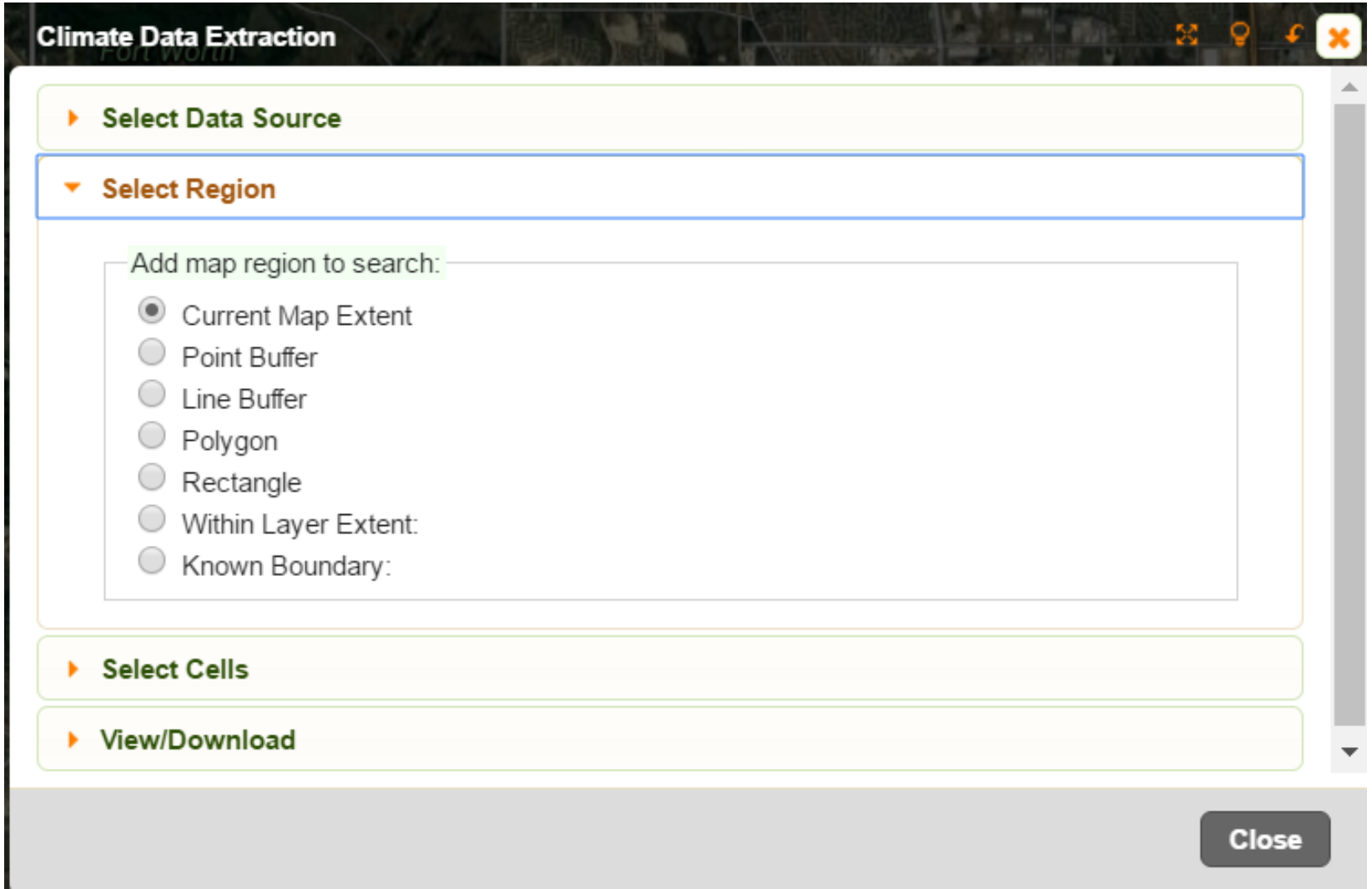


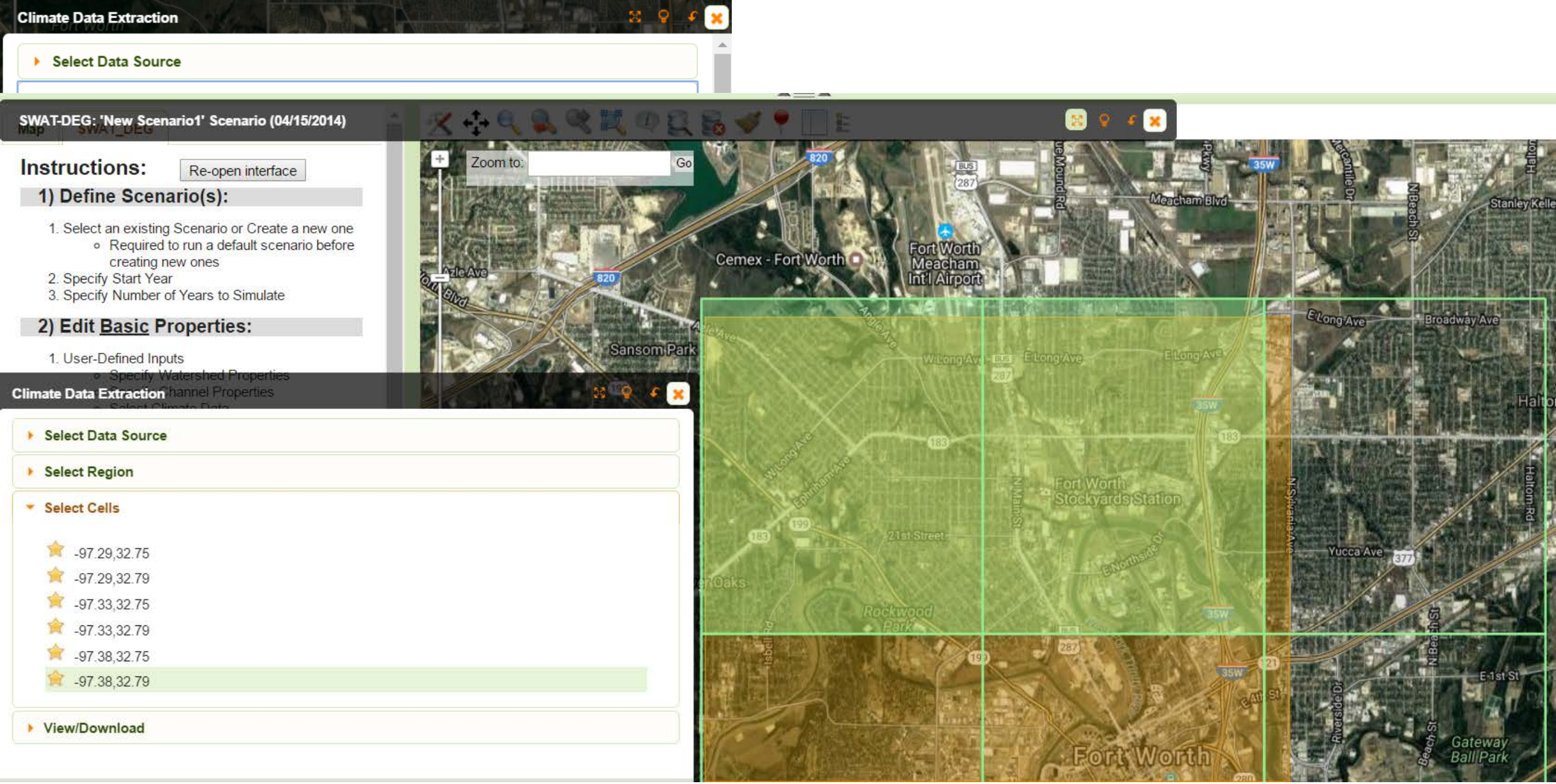
http://www.hawaii-futures.com/technics-lost

Basic Inputs

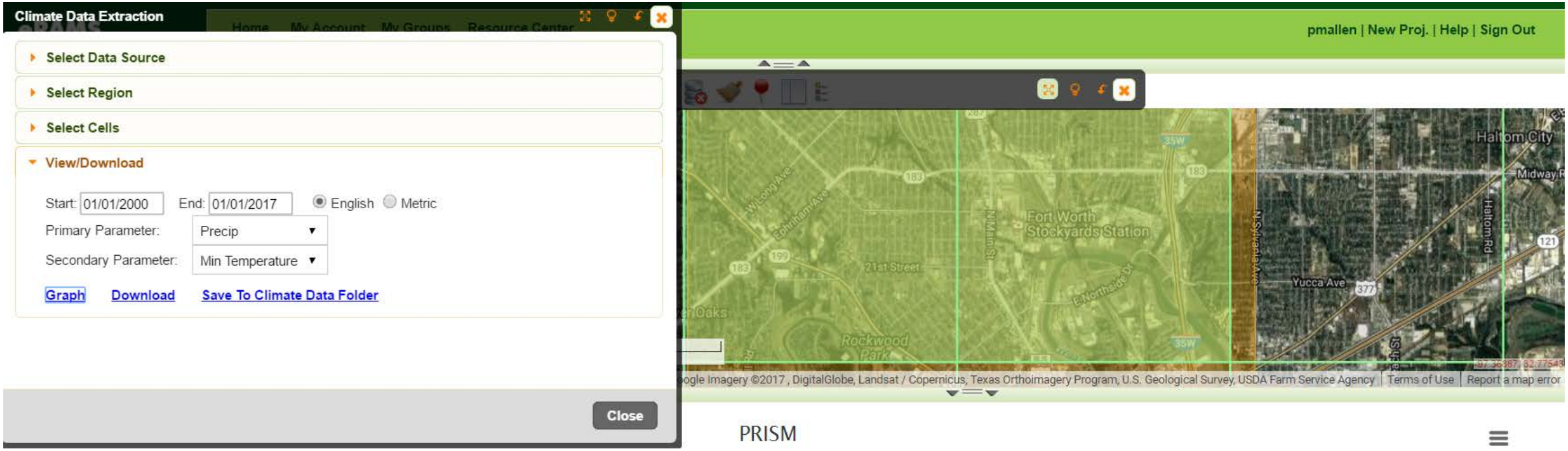


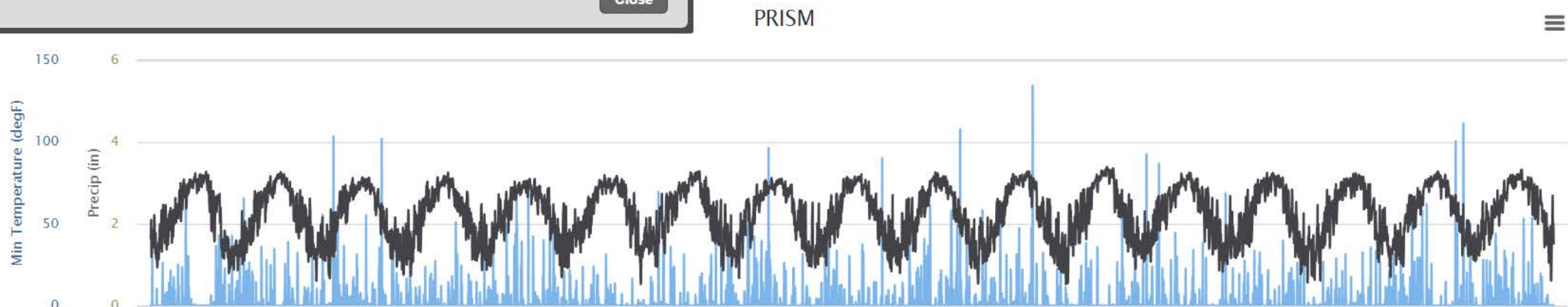
Climate Data Extraction



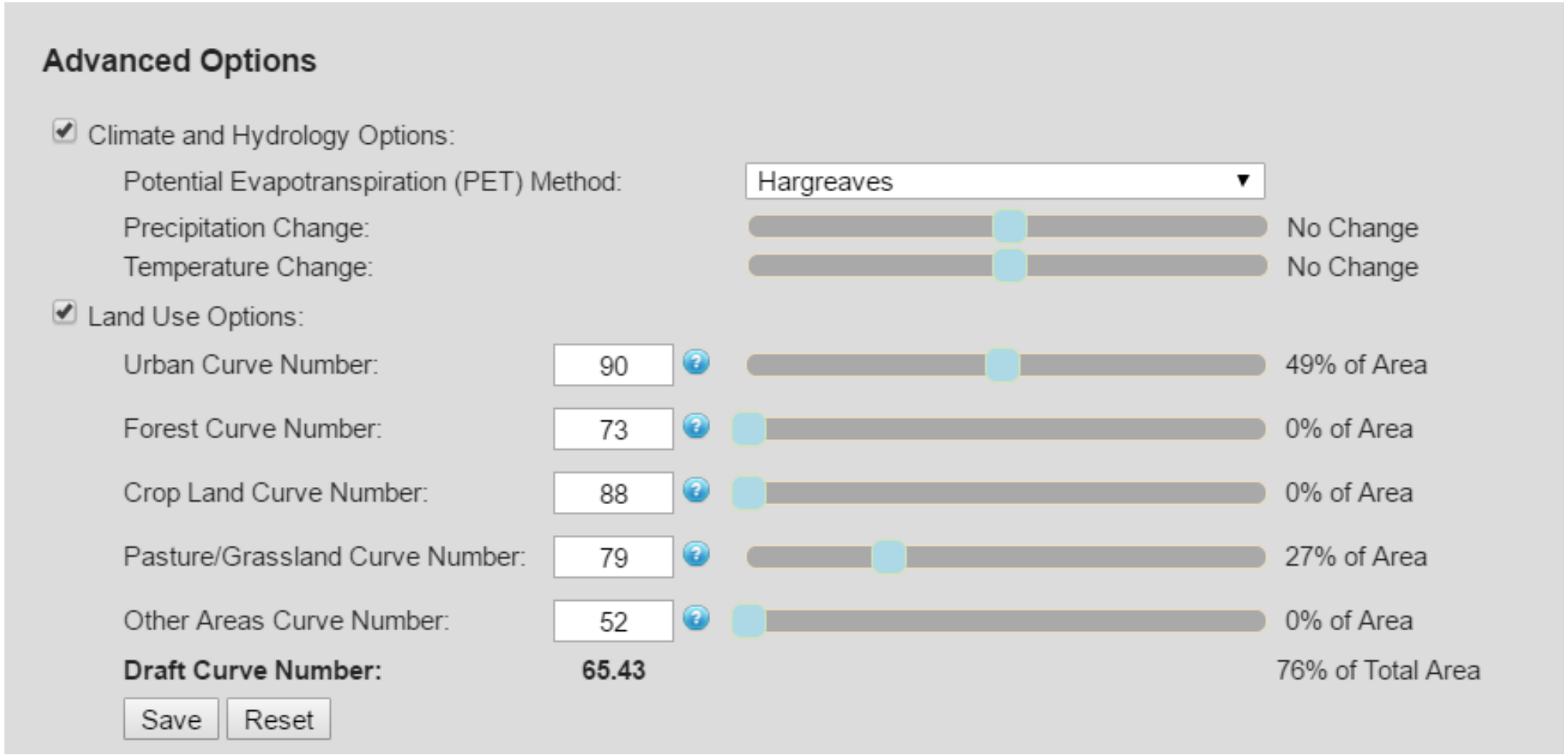

Climate Data Extraction
Select Data Source
SWAT-DEG: 'New Scenario1' Scenario (04/15/2014)
Instructions:
Re-open interface
1) Define Scenario(s):
1. Select an existing Scenario or Create a new one
Required to run a default scenario before creating new ones
2. Specify Start Year
3. Specify Number of Years to Simulate
2) Edit Basic Properties:
1. User-Defined Inputs
Specify Watershed Properties
Channel Properties
Zoom to:
Go
Cemex - Fort Worth
Fort Worth Meacham Int'l Airport
Sansom Park
Meacham Blvd
E Long Ave
Broadway Ave
Fort Worth Stockyards Station
Rockwood Park
Fort Worth
Gateway Ball Park
Yucca Ave
21st Street
Climate Data Extraction
Select Data Source
Select Region
Select Cells
-97.29,32.75
-97.29,32.79
-97.33,32.75
-97.33,32.79
-97.38,32.75
-97.38,32.79
View/Download

Climate Data Extraction





Climate and Land Use Options



Land Use Management & USLE

Management Options:

Select Growing Season: Start: April End: September

Select Land Cover: SOYBEANS

Select Irrigation: Irrigated from source outside of basin

Soil and Topography Options:

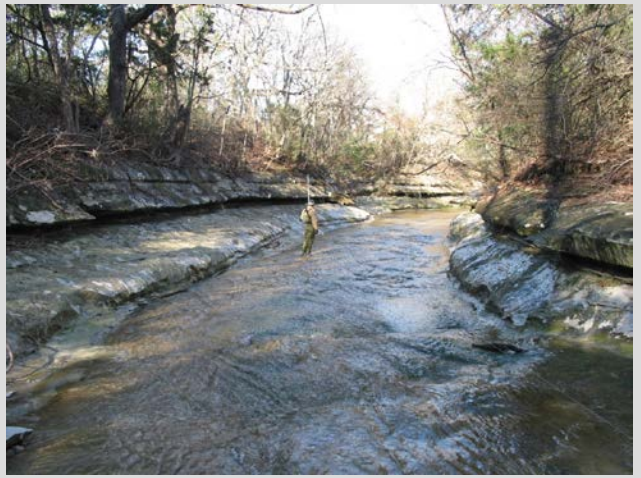
Parameter	Value
Latitude*:	31.6
Select Soil Texture*:	Sand
Soil Profile Depth [mm]:	1.5
Soil Water - Fraction [%]:	0.95
Snow Water Equivalent [mm]:	0
Land Surface Slope [m/m]:	0.002
Surface Slope Length [m]:	92
USLE Soil Erodibility Factor:	0.3
USLE Soil Cover Factor:	0.2
USLE Mgmt Practice Factor:	0.8

USLE = Universal Soil Loss Equation

Channel Parameters

Channel Options:

Parameter	Value
Channel Top Width [m]	5.5
Bankful Depth [m]	0.71
Channel Bed Slope [m/m]	0.007
Channel Length [km]	8
Channel Roughness (Manning's 'n')	0.05
Channel Bed Conductivity [mm/h]	1
Cover Factor	50
Width-Depth Ratio	3
Equilibrium Channel Bed Slope [m/m]	0.001
Channel Shear [Pa]	2.5
Fraction of the Day that Shear Force is Applied	0.04



Sediment Transport

Sediment Transport Properties

Parameter	Value
Sediment Bed Material Percent	0.5
Select Bed Transport Equation:	Modified Simon & Li
Transport Coefficient	2123.4
Velocity Export Coefficient	3.3
Depth Coefficient	0.468
Slope Coefficient	0.613

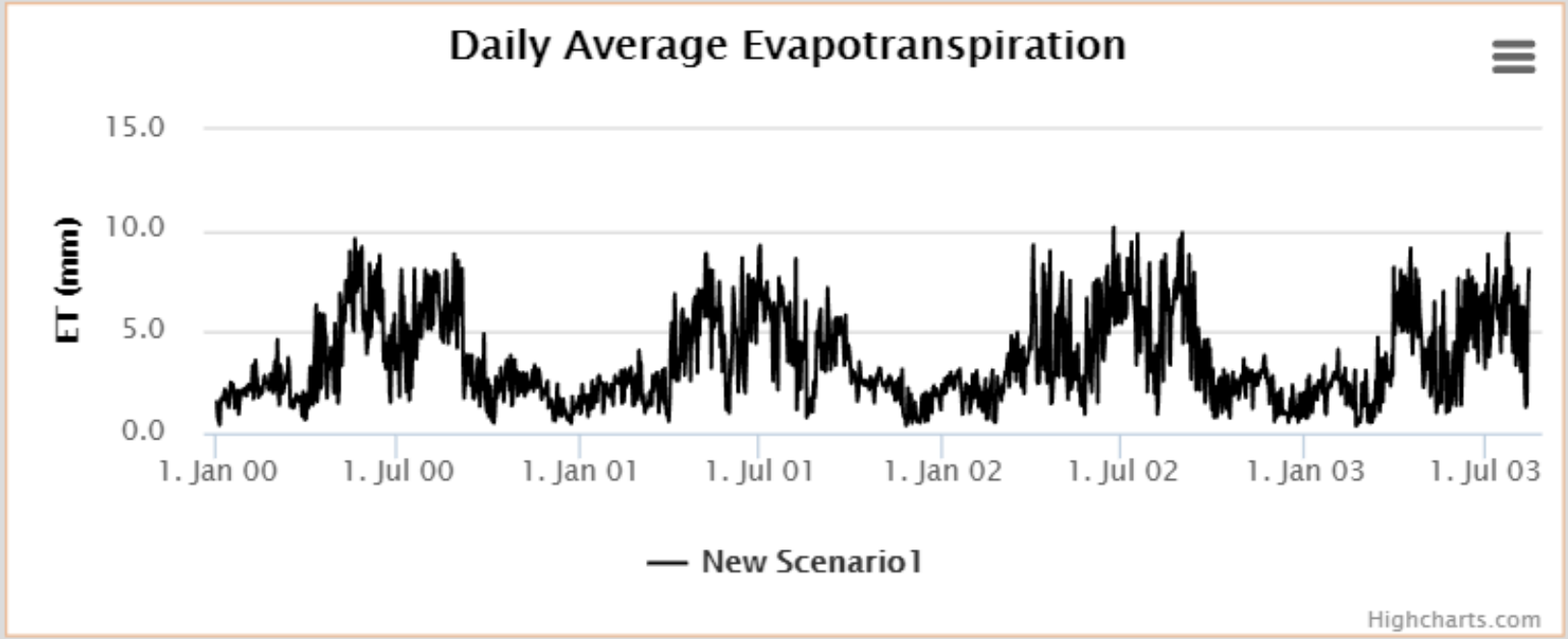
$$2123.4 * V^{3.3} * D^{0.468} * S^{0.613}$$

Groundwater

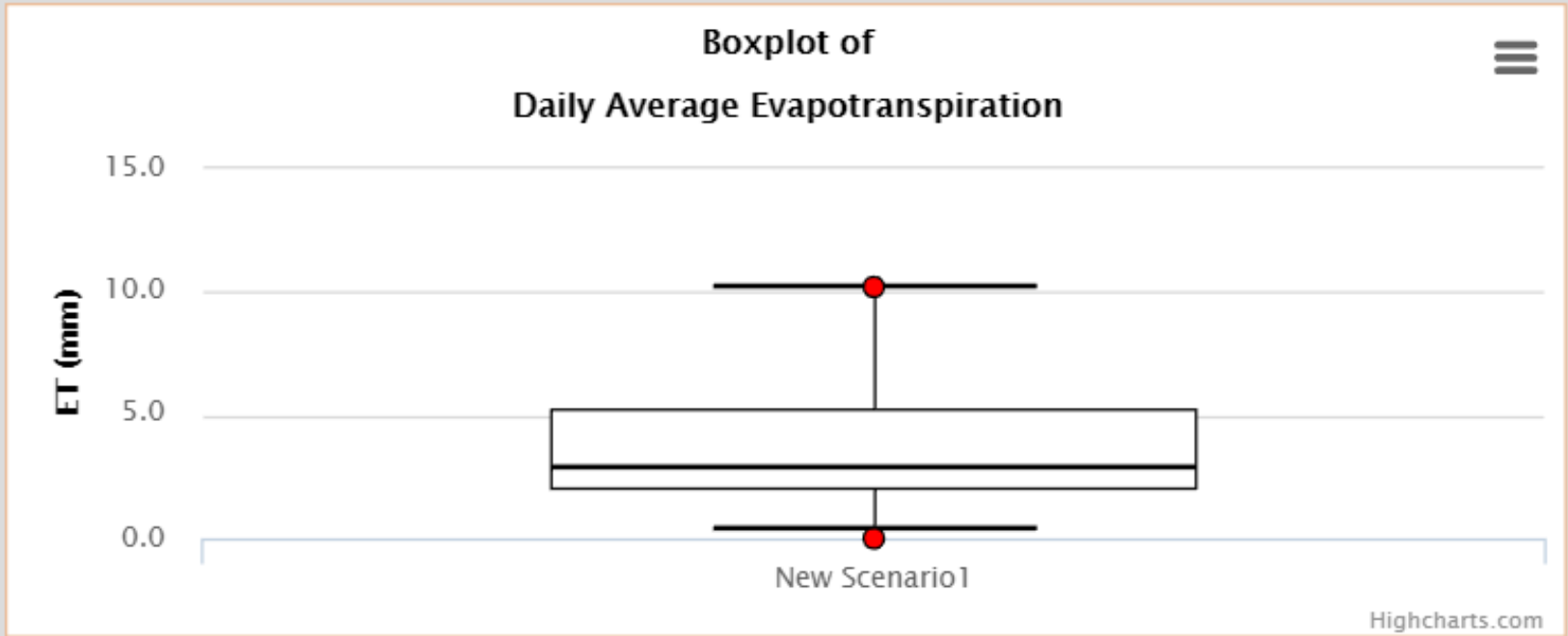
☑ Aquifer Options:

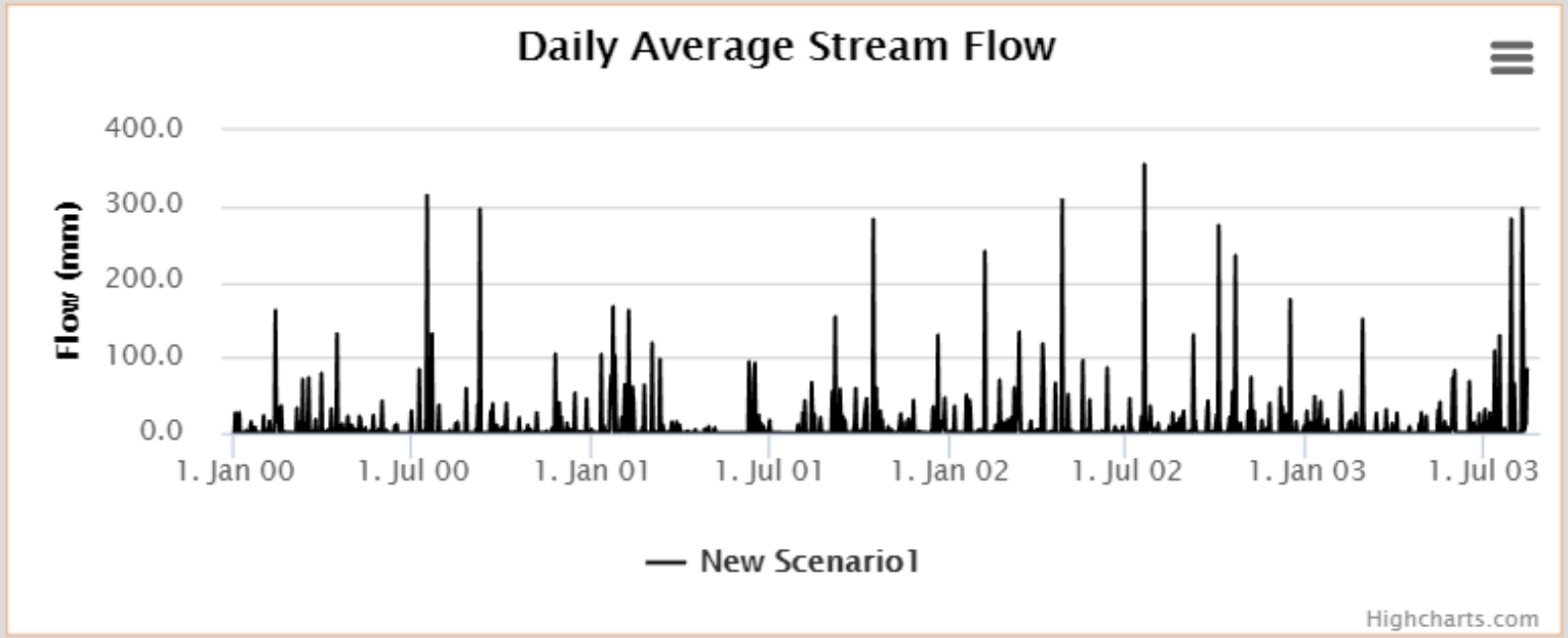
Parameter	Value
Shallow Aquifer's Specific Yield [mm]	0.1
Groundwater Alpha Factor	0.06
Revap Coefficient	0.1
Percolation Coefficient	0.01
Shallow Aquifer Storage [mm]	3
Shallow Aquifer Flow [mm]	0
Deep Aquifer Flow [mm]	300

* Indicates Parameters Estimated from Watershed HRU Layer



The "Boxplot" demonstrates the lower limit (Q1 - 1.5*IQR), Q1, median, Q3, and upper limit (Q3 + 1.5*IQR) of the data.
The red dots represent outliers from the data





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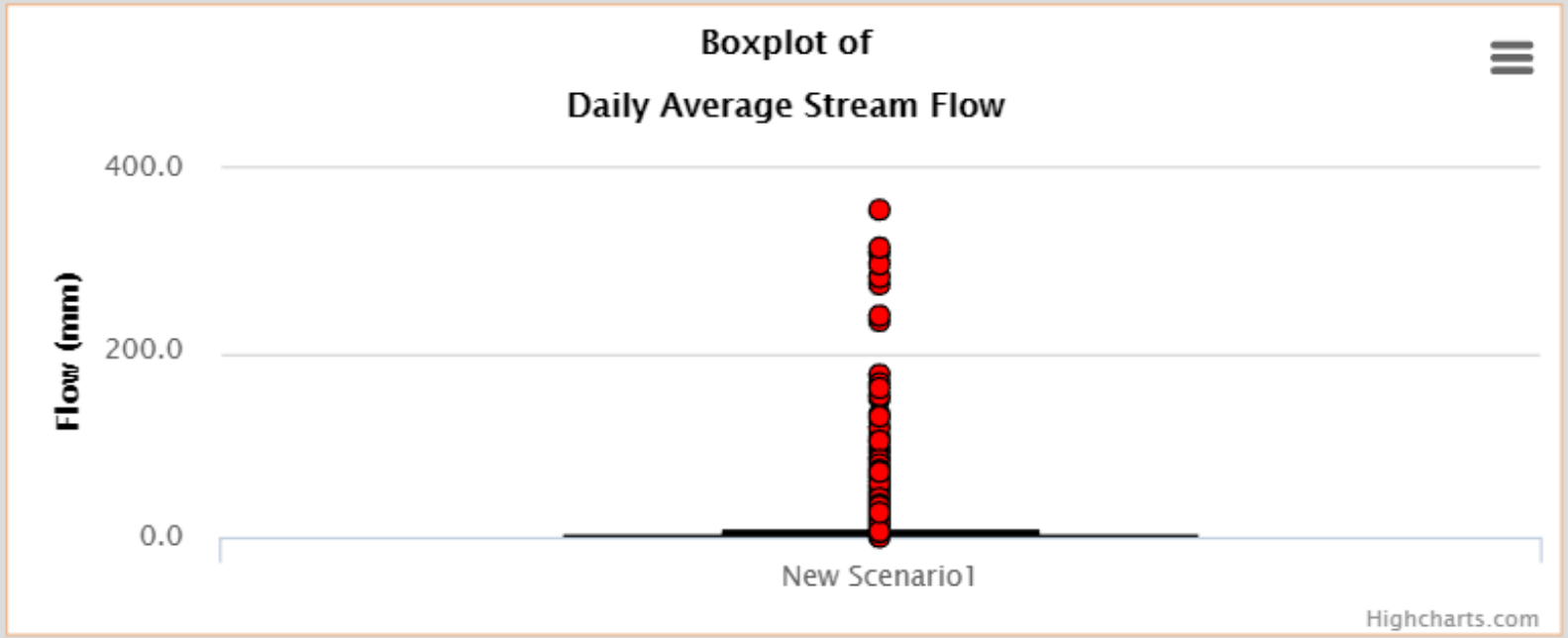
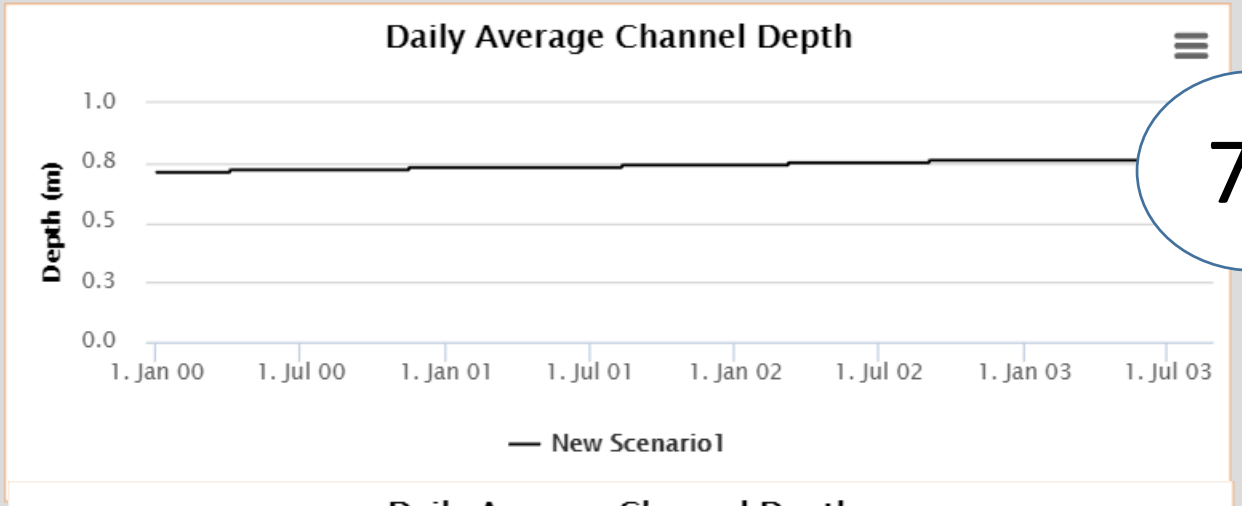


Select Scenario(s) to Graph: default, New Scenario3, New Scenario, New Scenario1 — Graph Output

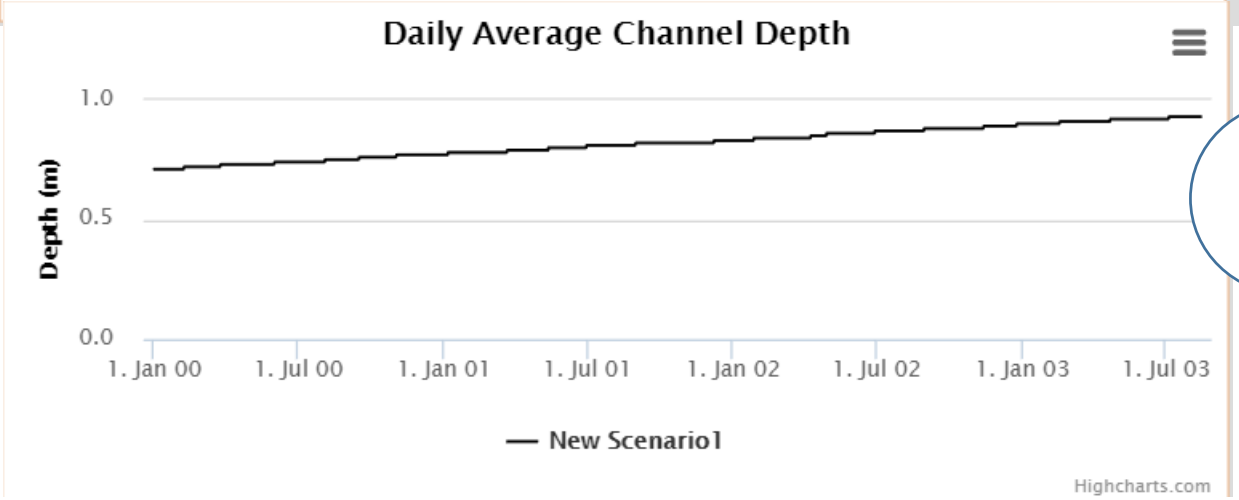
Select Result to Graph: Depth (m)

Select Timestep: Daily

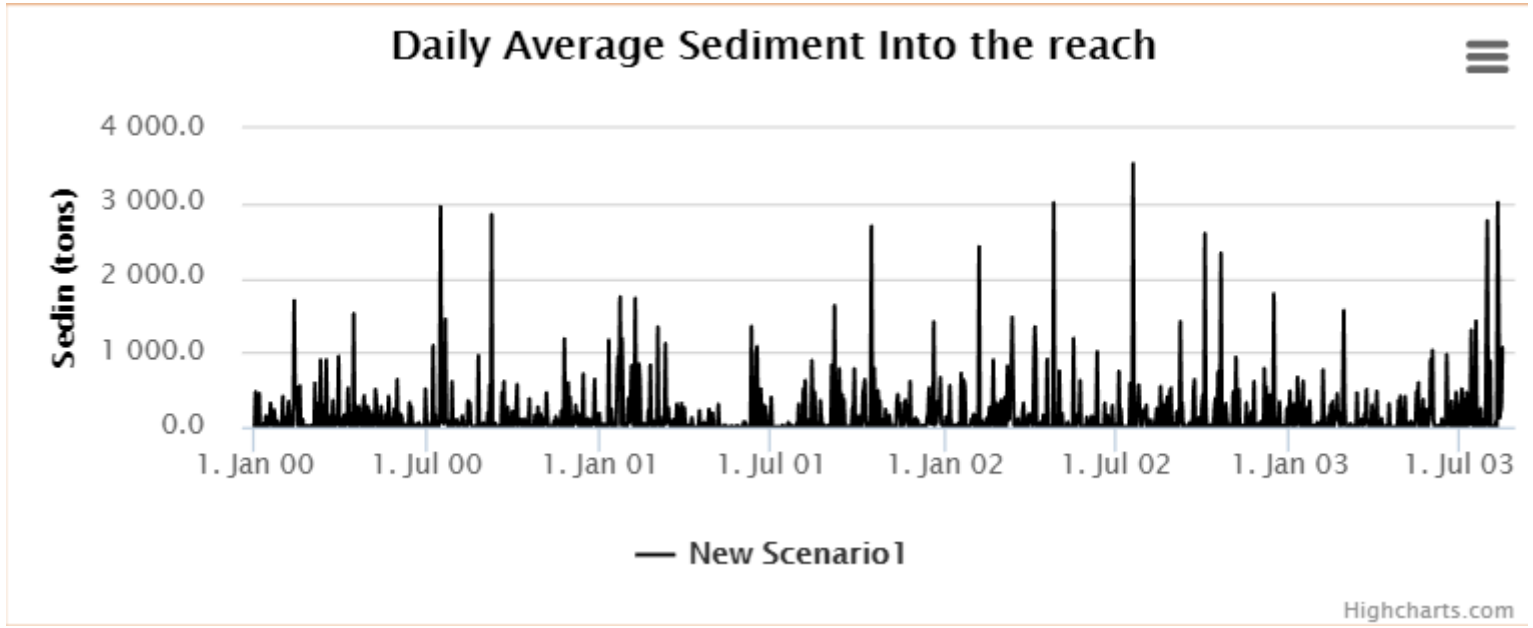
The "Timeseries" graphs plot data with time on the horizontal axis and the variable computed on the vertical axis.

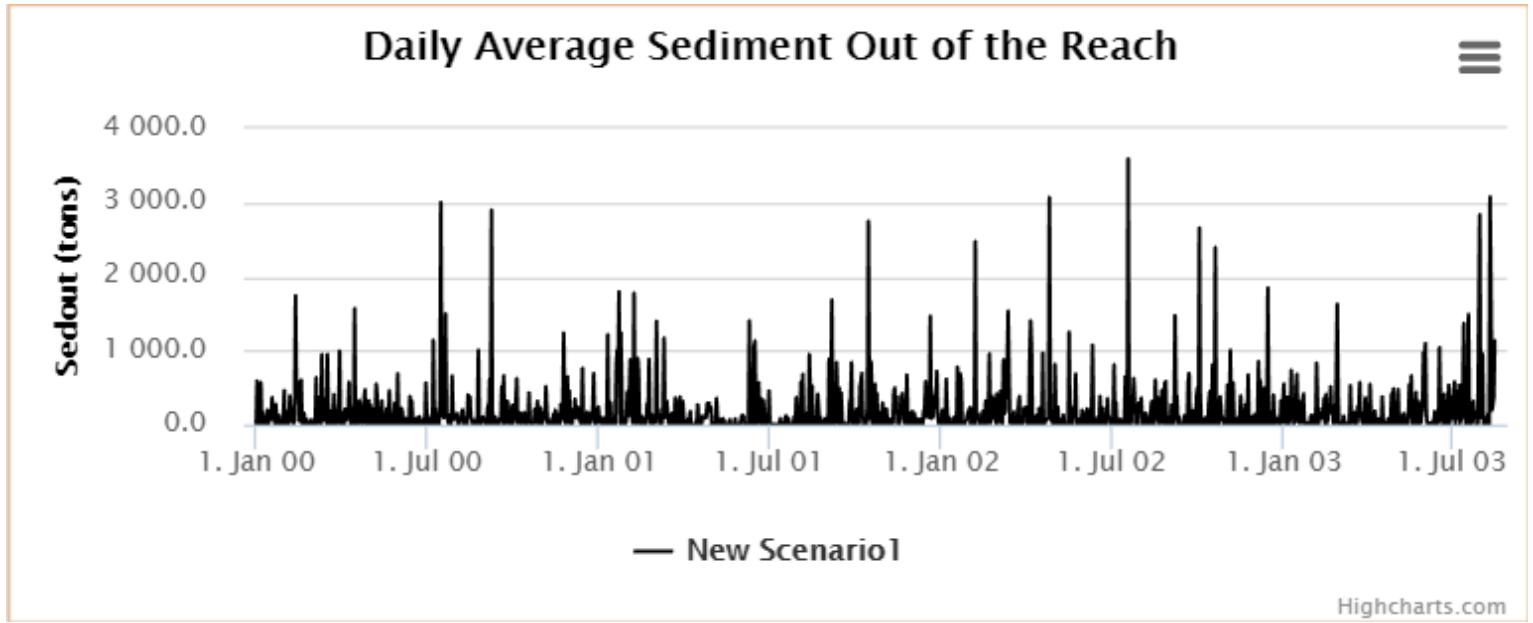


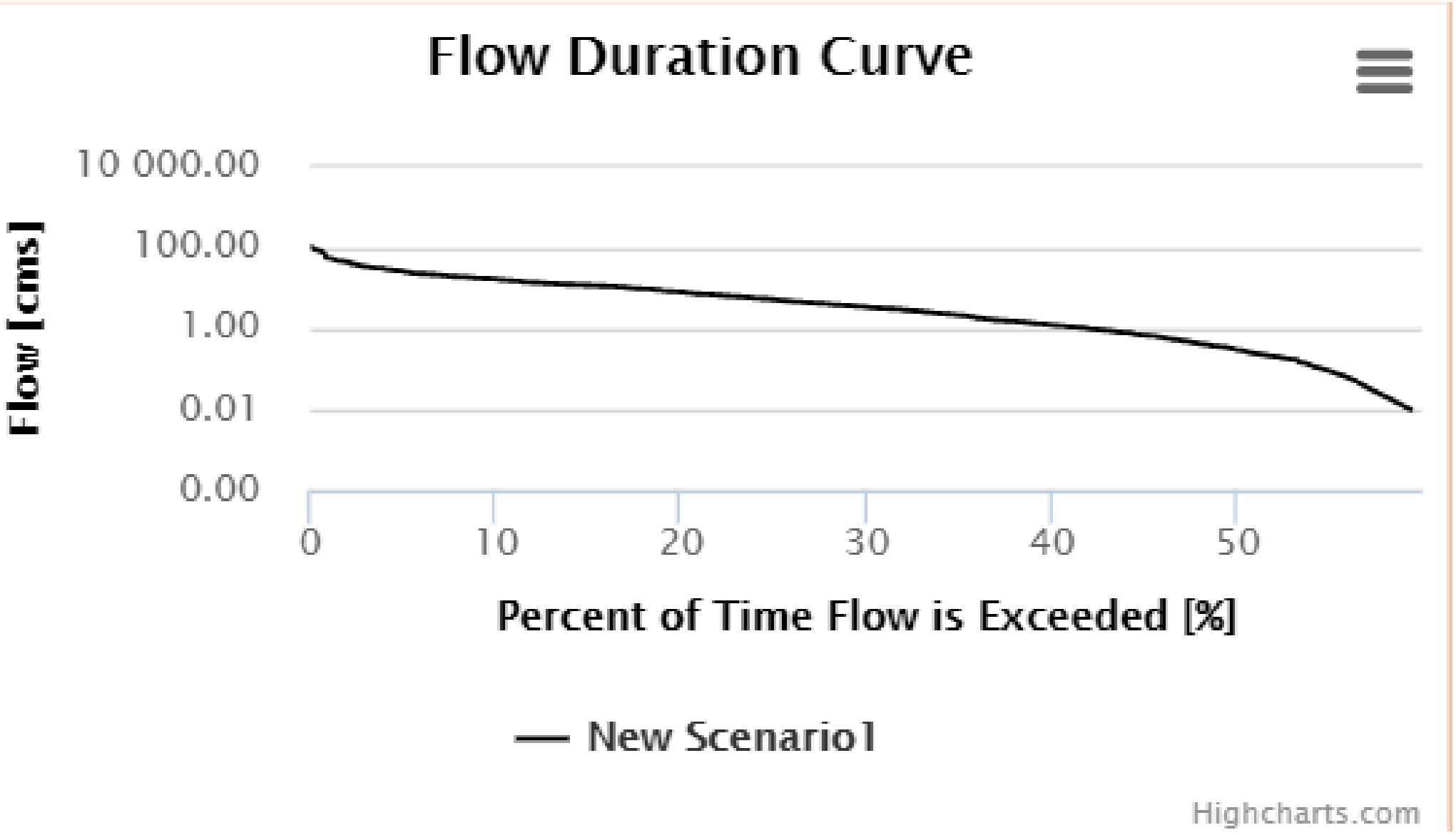
72



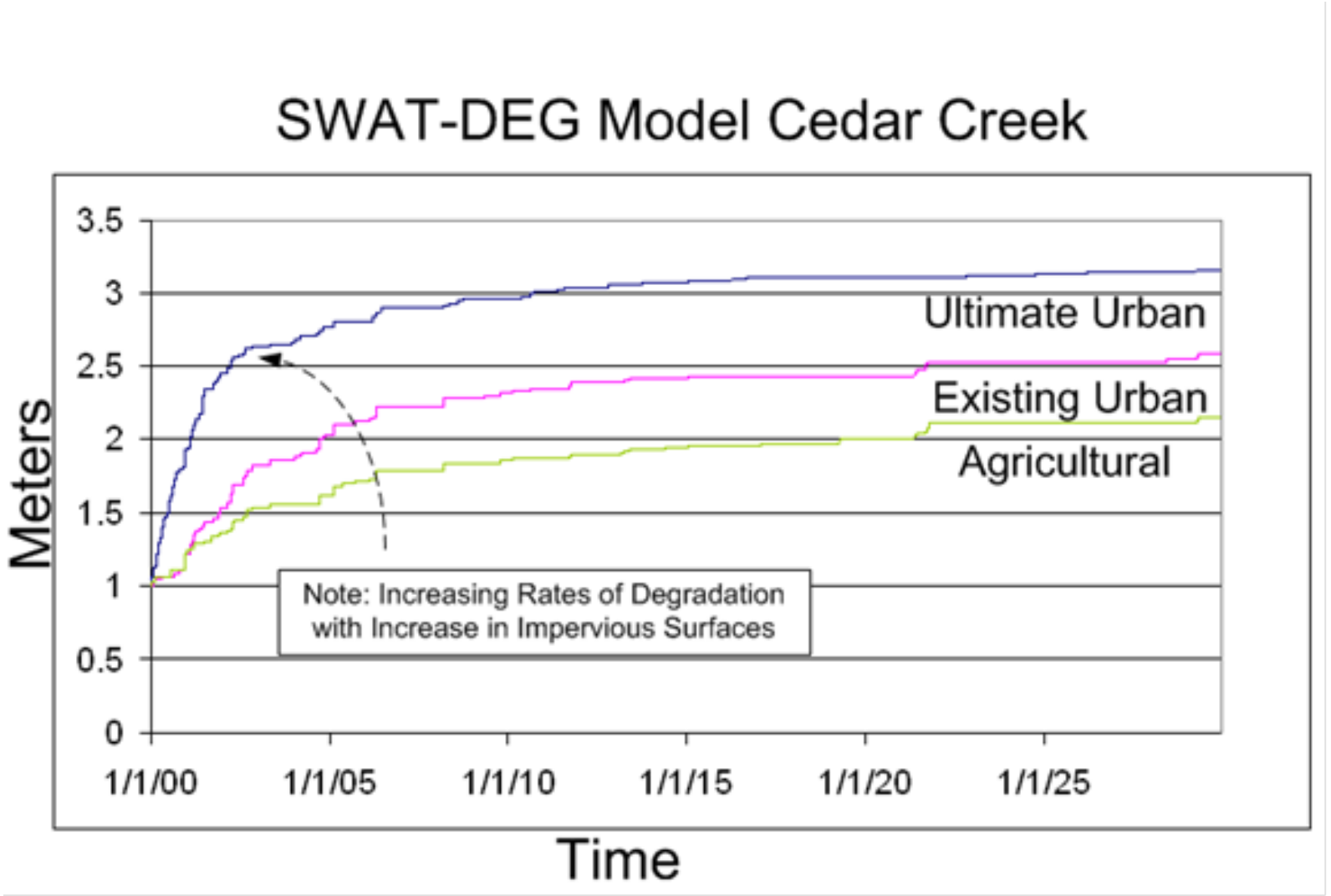
90


Daily Average Sediment Into the reach
Sedin (tons)
4 000.0
3 000.0
2 000.0
1 000.0
0.0
1. Jan 00
1. Jul 00
1. Jan 01
1. Jul 01
1. Jan 02
1. Jul 02
1. Jan 03
1. Jul 03
New Scenario1
Highcharts.com


Daily Average Sediment Out of the Reach
Sedout (tons)
4 000.0
3 000.0
2 000.0
1 000.0
0.0
1. Jan 00
1. Jul 00
1. Jan 01
1. Jul 01
1. Jan 02
1. Jul 02
1. Jan 03
1. Jul 03
New Scenario1
Highcharts.com


Flow Duration Curve
10 000.00
100.00
1.00
0.01
0.00
Flow [cms]
0
10
20
30
40
50
Percent of Time Flow is Exceeded [%]
New Scenario1
Highcharts.com

SWAT-DEG: Degradation/Widening




0 60
Headward Degradation
2001
2005
Widen
2007
2009
Google
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