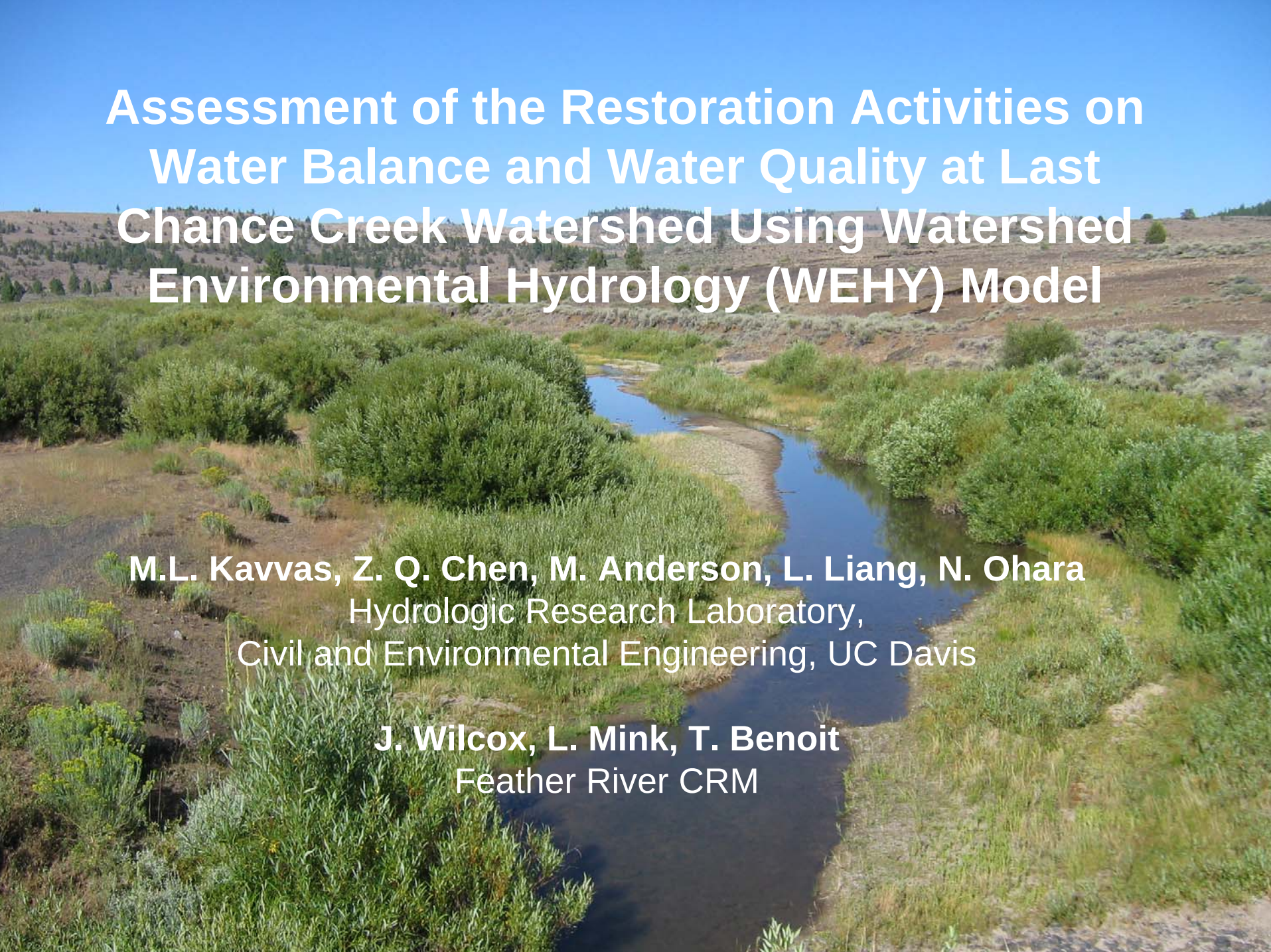
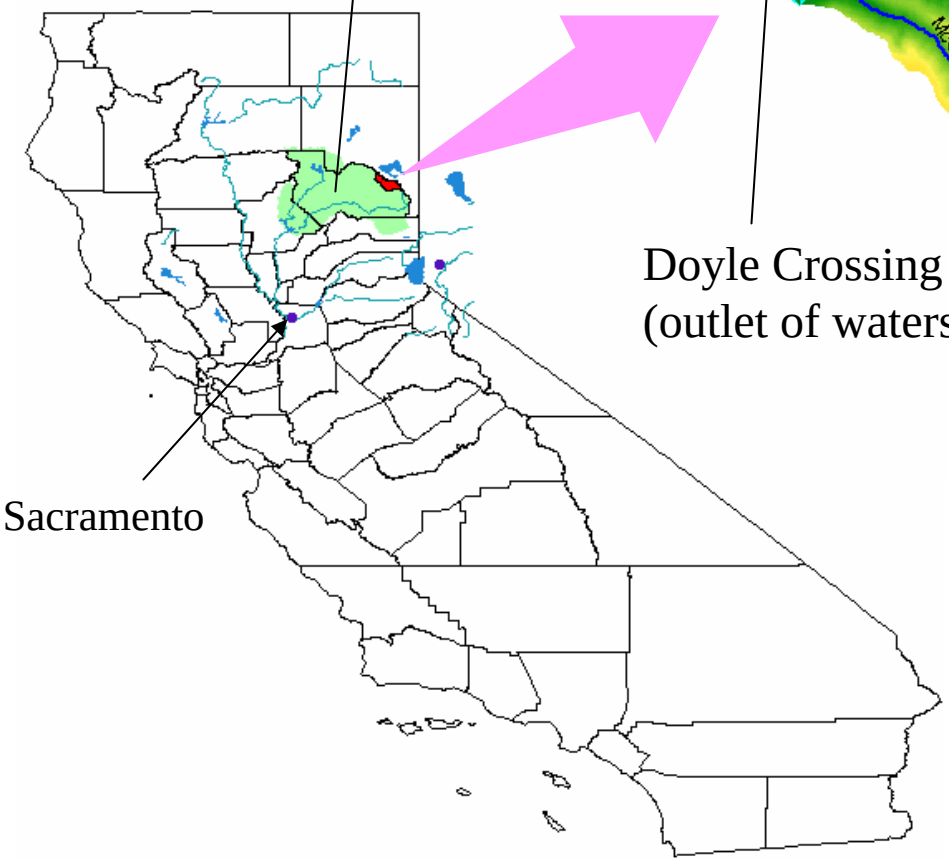


Assessment of the Restoration Activities on Water Balance and Water Quality at Last Chance Creek Watershed Using Watershed Environmental Hydrology (WEHY) Model

M.L. Kavvas, Z. Q. Chen, M. Anderson, L. Liang, N. Ohara
Hydrologic Research Laboratory,
Civil and Environmental Engineering, UC Davis

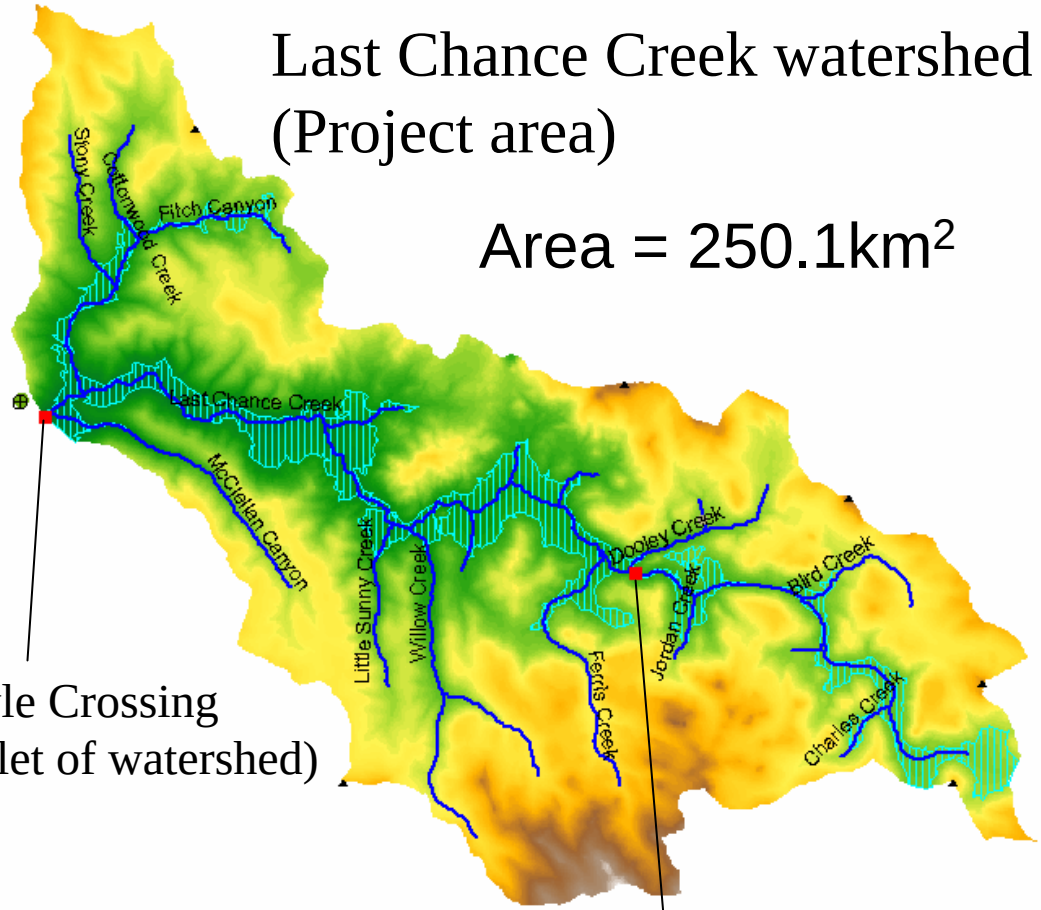
J. Wilcox, L. Mink, T. Benoit
Feather River CRM

Feather River Basin



Last Chance Creek watershed
(Project area)

Area = 250.1km²

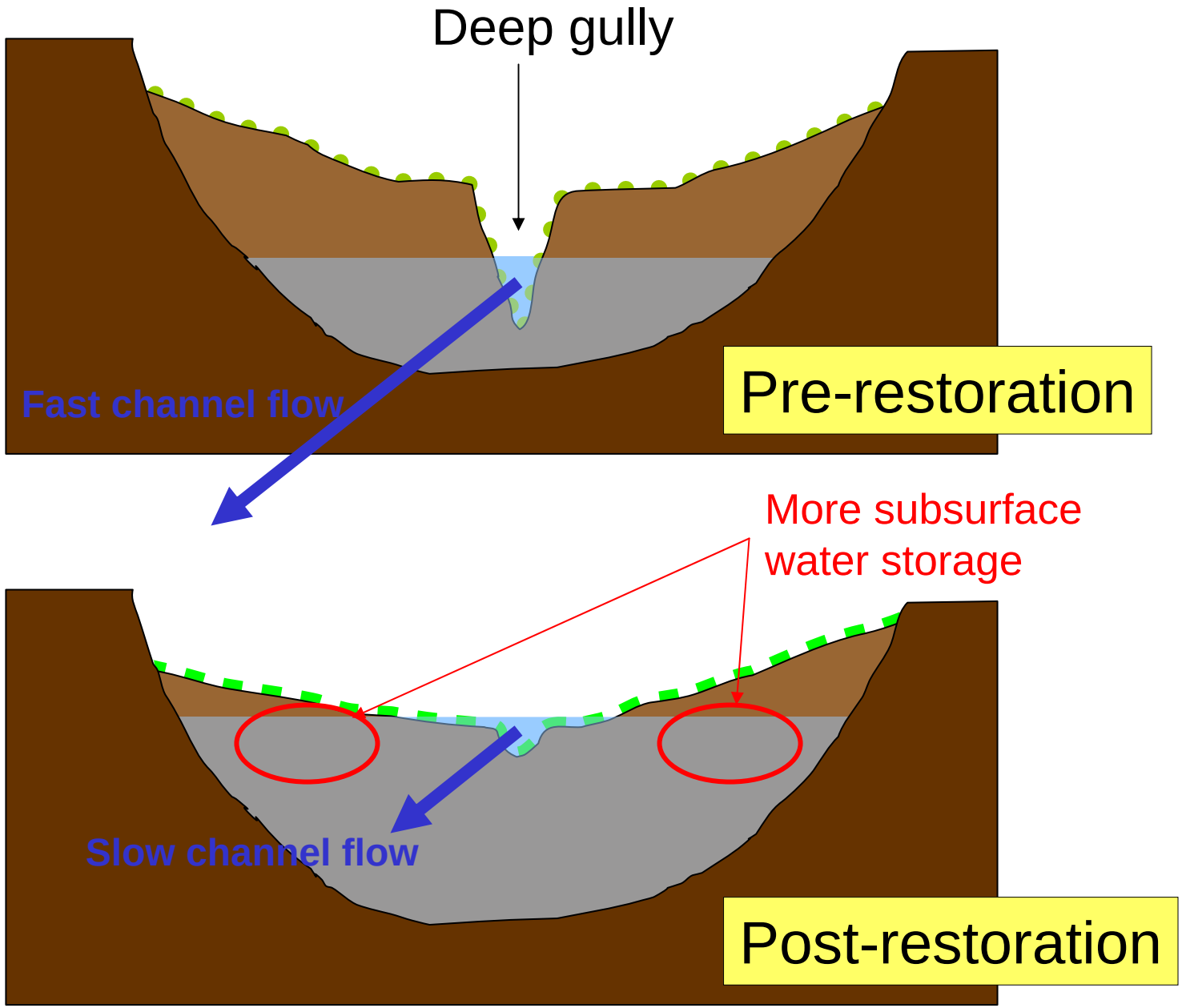


Doyle Crossing
(outlet of watershed)

Million $ Bridge

Pre-restoration condition
(May 5, 2002)
The deep gully due to instream erosion induces low groundwater level.

Post-restoration condition
(July 29, 2004)
The deep gully was filled, and a shallow channel was dug nearby.


Deep gully
Fast channel flow
Pre-restoration
More subsurface
water storage
Slow channel flow
Post-restoration

ISSUES TO ASSESS FOR RESTORATION ACTIVITIES IN THE LAST CHANCE CREEK WATERSHED

1. How does the restoration affect flood flows?

2. How does the restoration affect flows during the summer months?

3. How does the restoration affect the groundwater storage within the watershed?

4. How does the restoration affect sediment discharge from the watershed to downstream?

Use of a Watershed Model in NPS Studies

Watershed model provides a tool for watershed evaluation

to help

protect and restore source areas for

water supply and flood control

and

to reduce NPS substance releases from these areas.

Model can identify source areas (sediment, nutrients, groundwater recharge, runoff)

Model can evaluate potential restoration activities for effectiveness at any watershed

Model can assess any land use/management scenarios

WEHY (Watershed Environmental Hydrology) Model

is a

physically-based, spatially-distributed

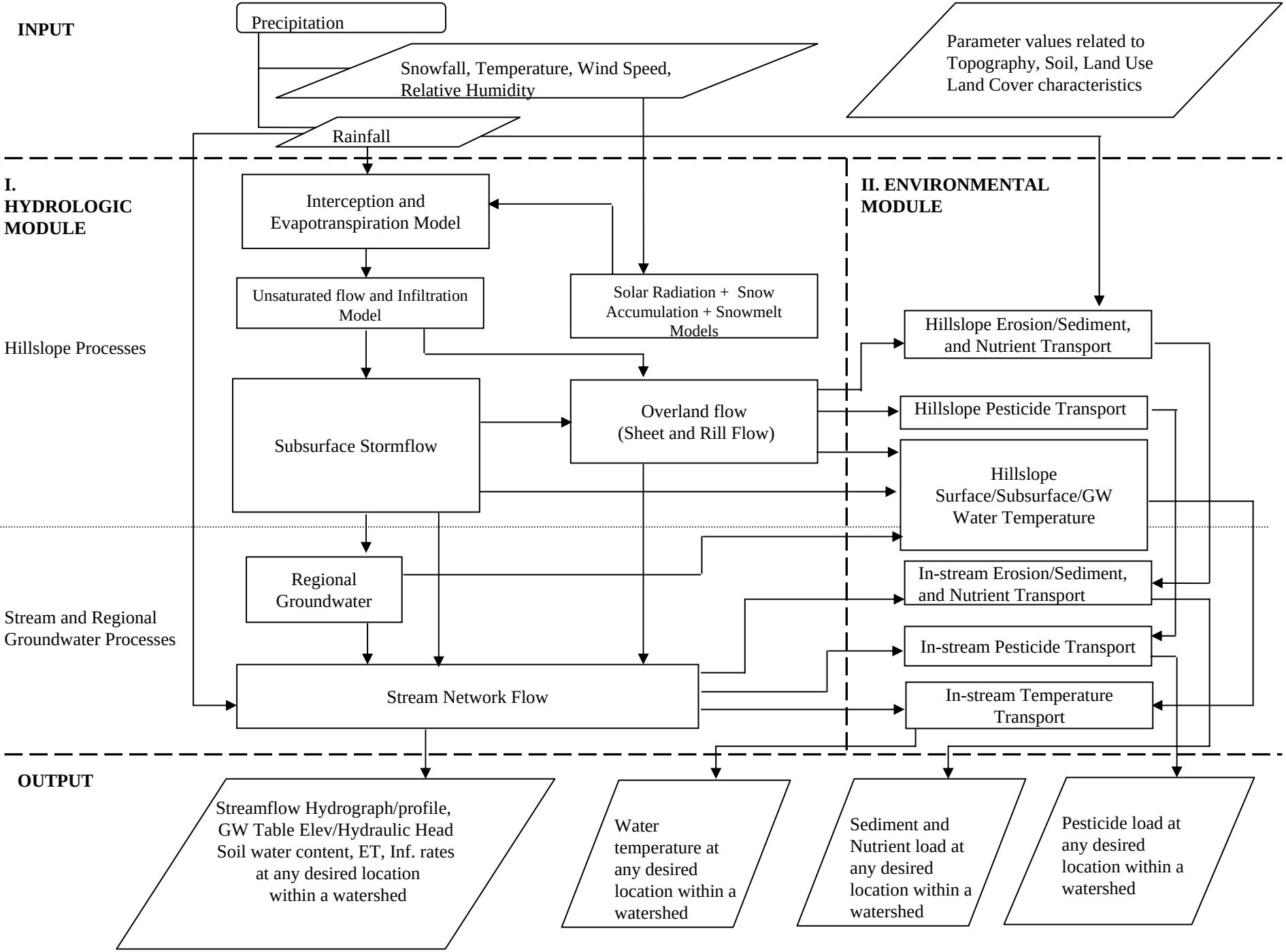
continuous simulation model

of

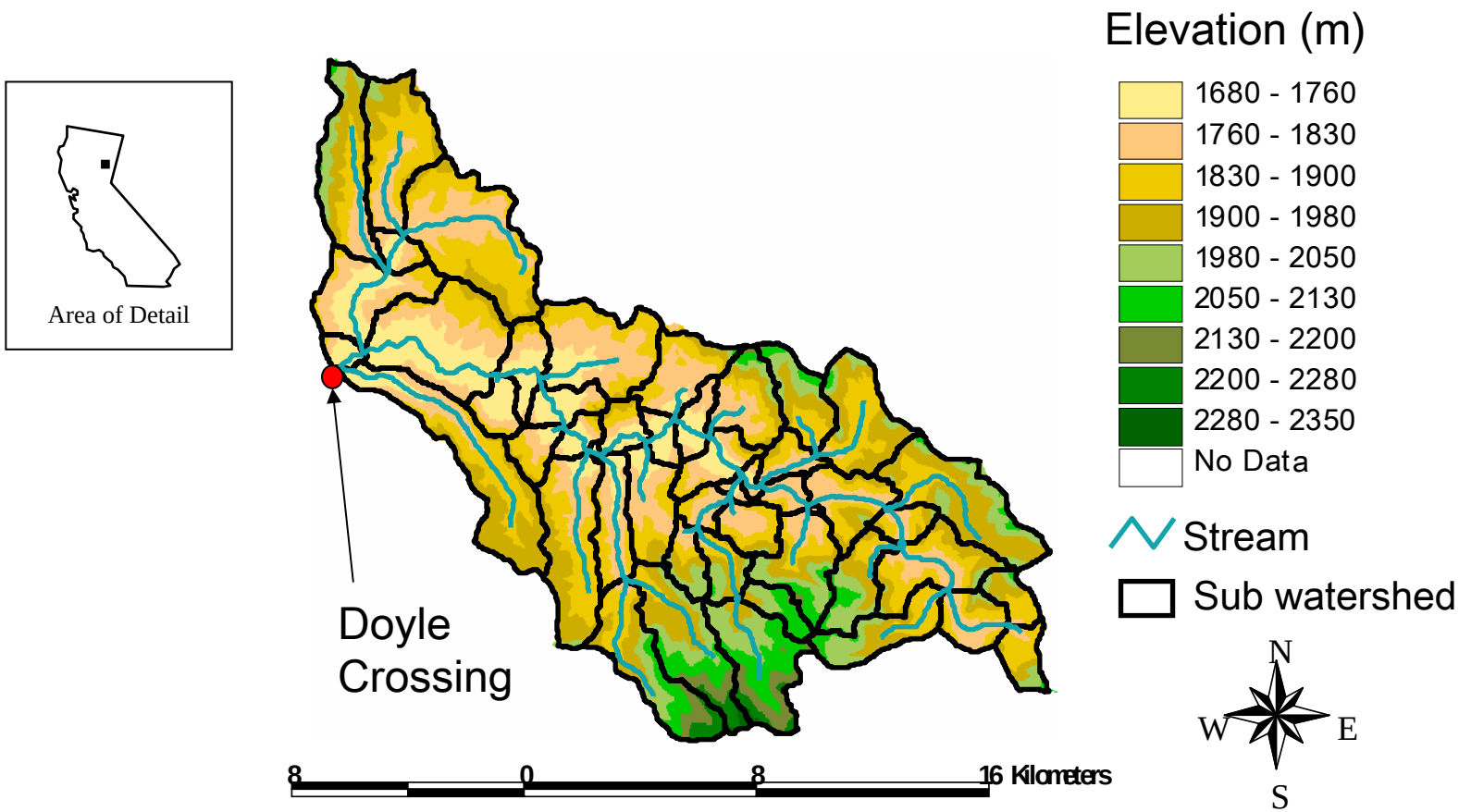
hydrologic and environmental processes.

It was peer-reviewed and published

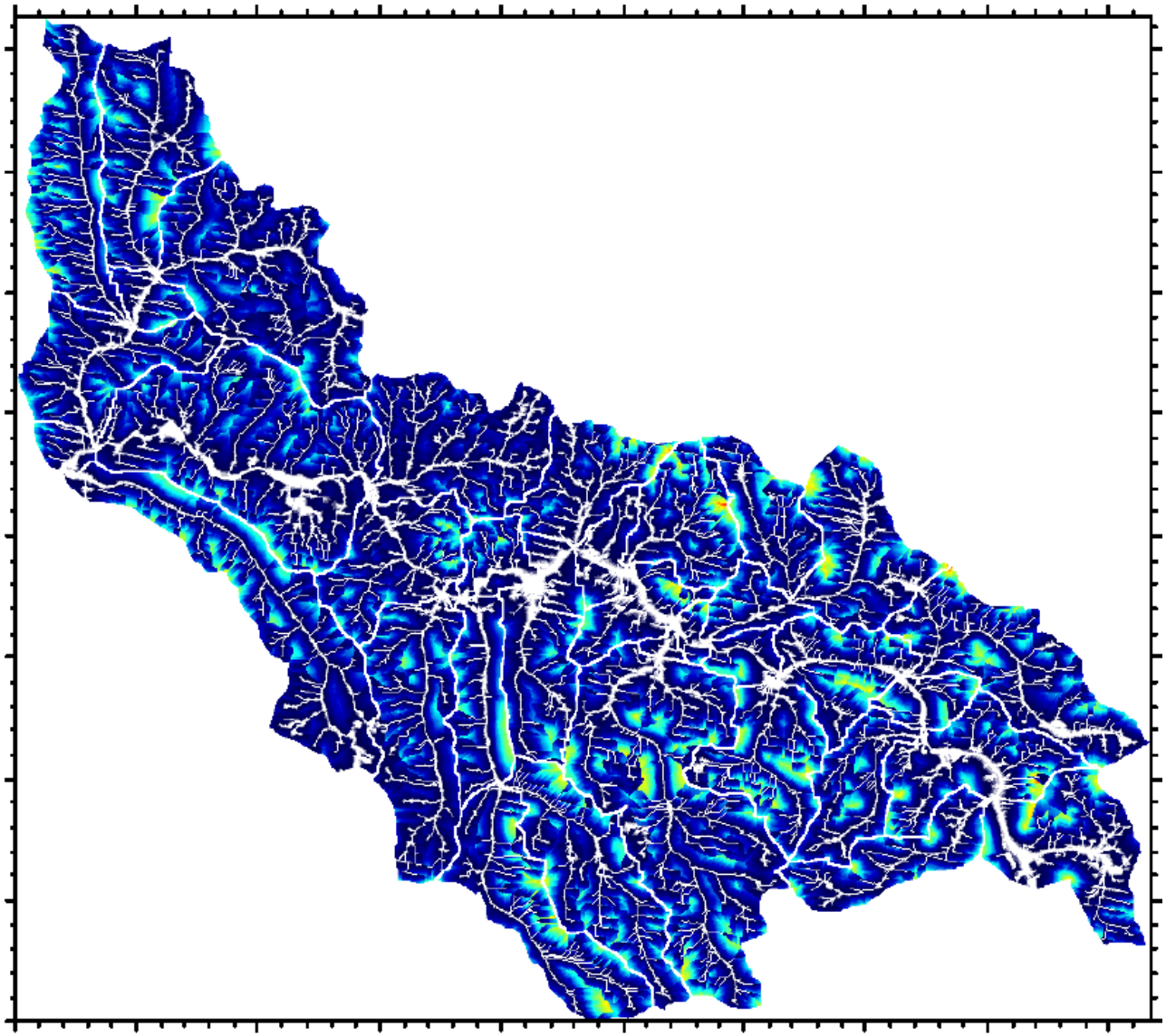
(Nov/Dec 2004 issue of Journal of Hydrologic Engineering).


INPUT
Precipitation
Snowfall, Temperature, Wind Speed, Relative Humidity
Rainfall
Parameter values related to Topography, Soil, Land Use Land Cover characteristics
I. HYDROLOGIC MODULE
II. ENVIRONMENTAL MODULE
Interception and Evapotranspiration Model
Unsaturated flow and Infiltration Model
Solar Radiation + Snow Accumulation + Snowmelt Models
Hillslope Processes
Subsurface Stormflow
Overland flow (Sheet and Rill Flow)
Hillslope Erosion/Sediment, and Nutrient Transport
Hillslope Pesticide Transport
Hillslope Surface/Subsurface/GW Water Temperature
Regional Groundwater
Stream and Regional Groundwater Processes
In-stream Erosion/Sediment, and Nutrient Transport
In-stream Pesticide Transport
Stream Network Flow
In-stream Temperature Transport
OUTPUT
Streamflow Hydrograph/profile, GW Table Elev/Hydraulic Head Soil water content, ET, Inf. rates at any desired location within a watershed
Water temperature at any desired location within a watershed
Sediment and Nutrient load at any desired location within a watershed
Pesticide load at any desired location within a watershed

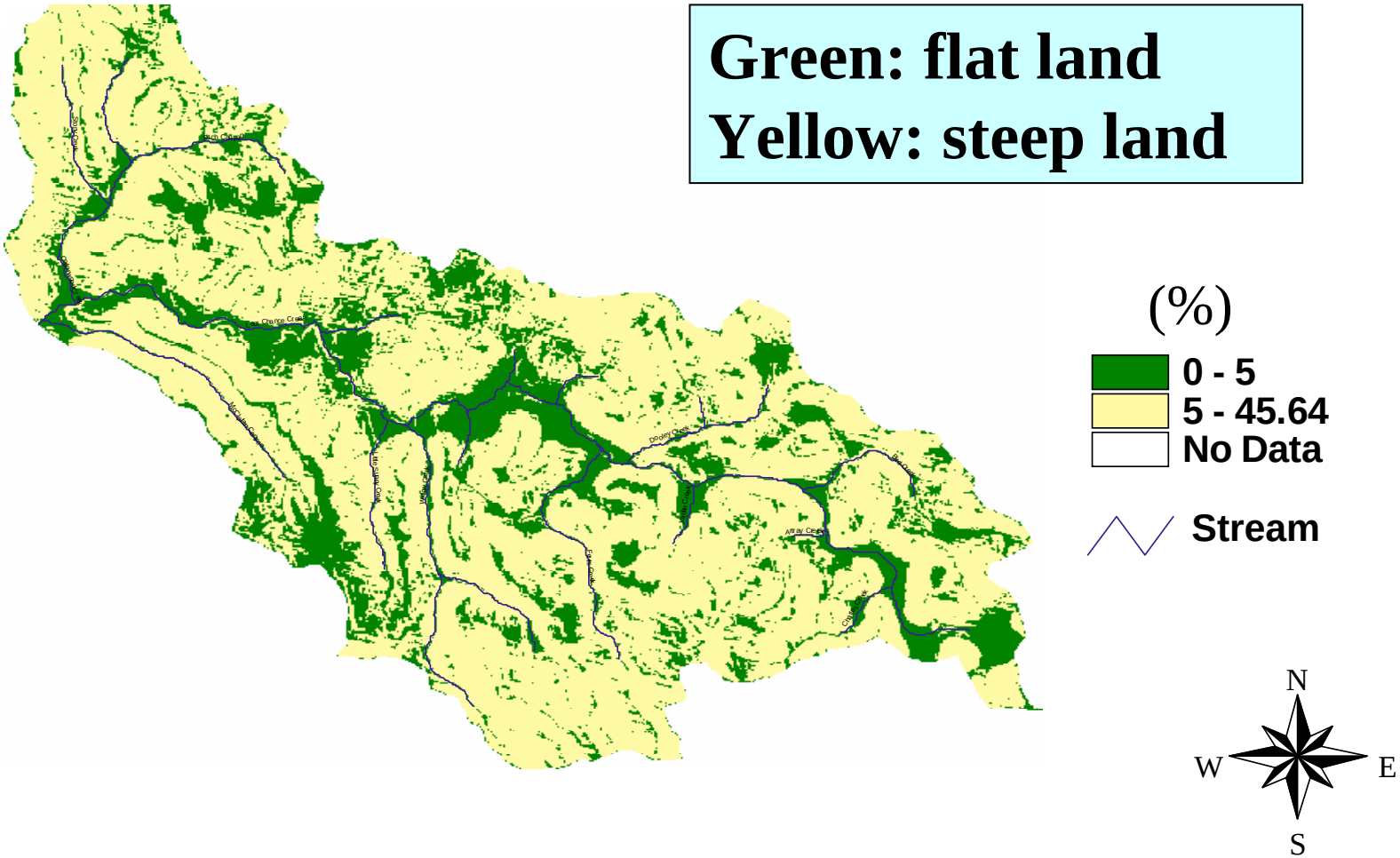
Develop the GIS (Geographical Information System) for the watershed based upon existing databases and build model parameters



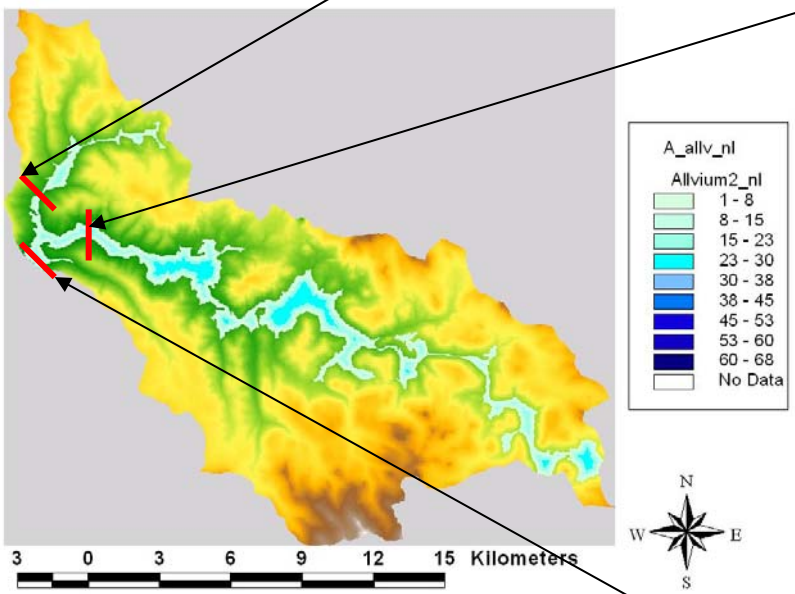
Stream network at Last Chance Creek watershed

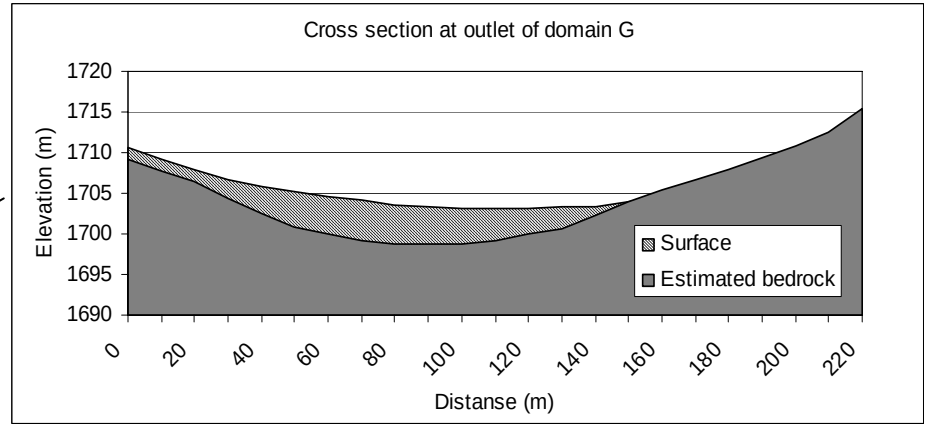


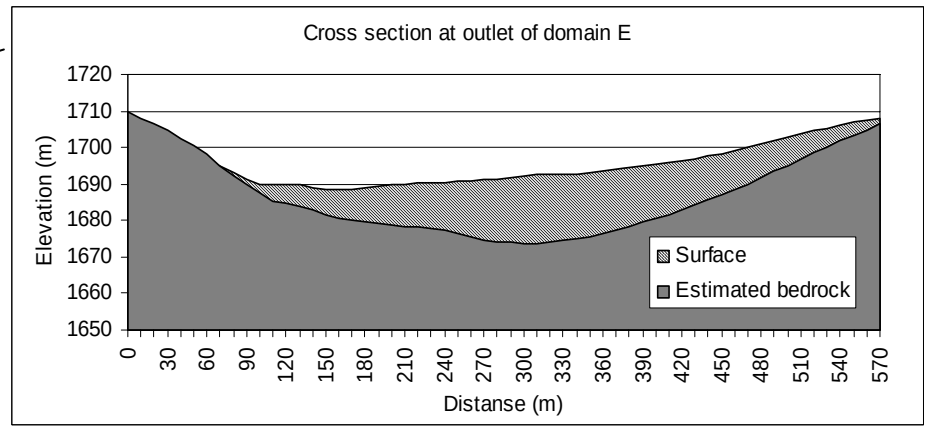
Slope map and delineation of meadow land

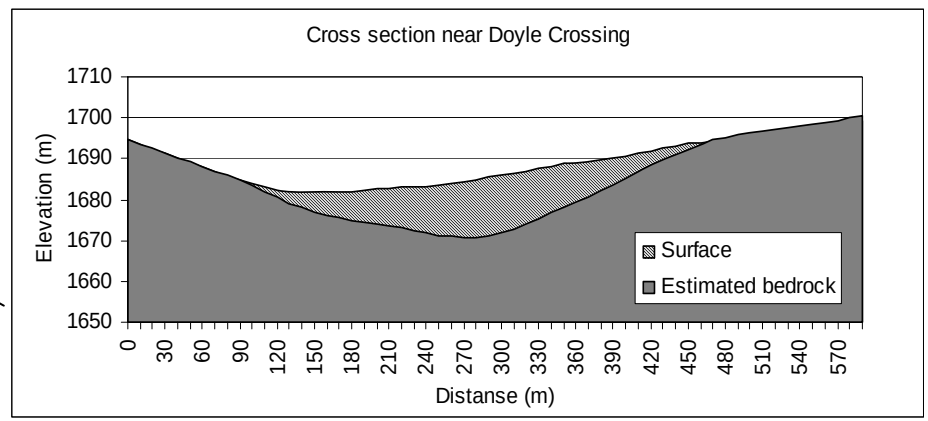


Groundwater Flow Domain









Soil database (USFS soil survey)

Soil map unit

105
108
109
143
157
158
160
161
164
170
172
174
183
184
191
192
193
199
231
232
233
234
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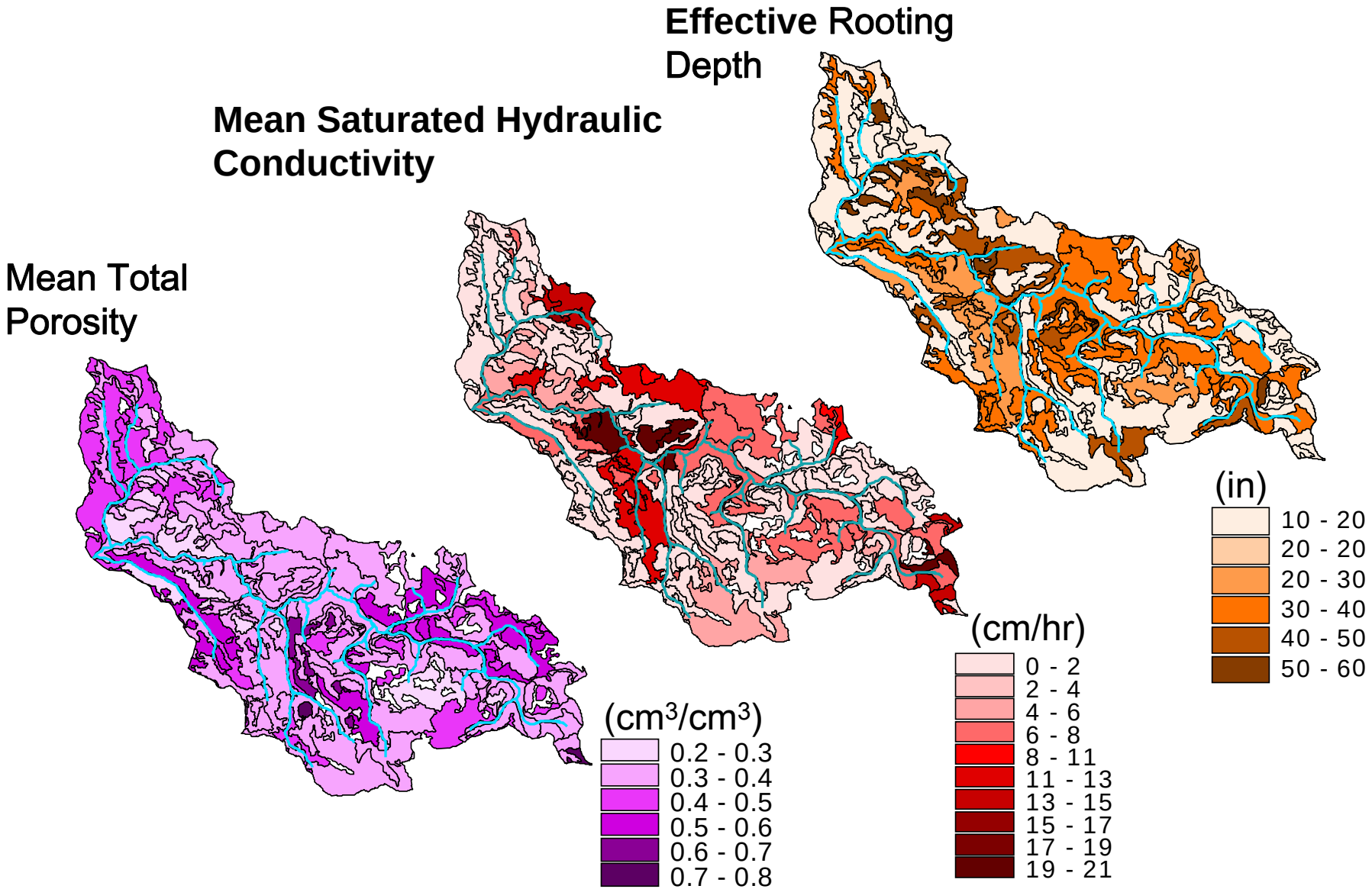
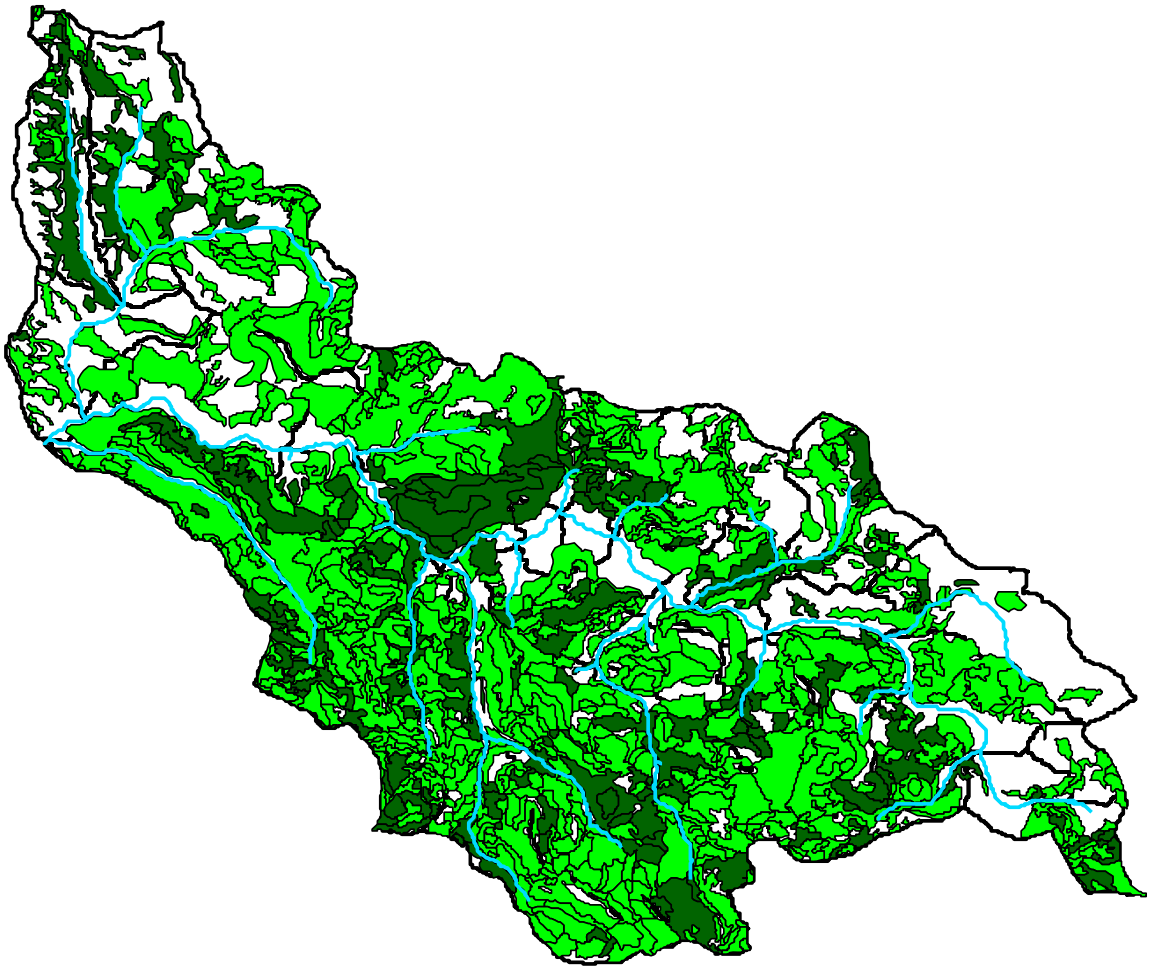
293
294
304

Estimated soil parameters for WEHY model over Last Chance Creek watershed (selected)



Vegetation Map (USFS)



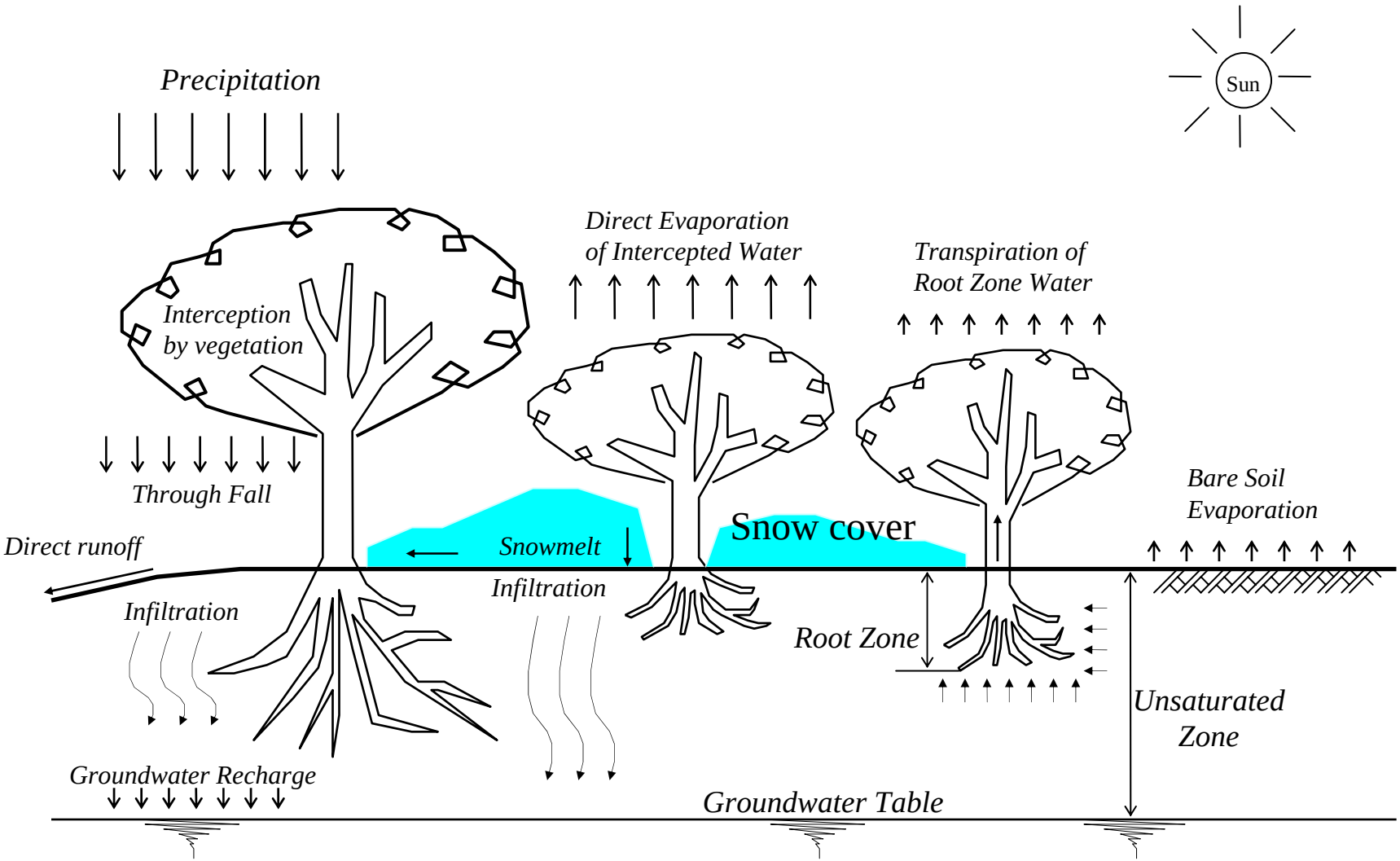
Number of
Vegetation Layers

1: Grass & shrub
2: Forest

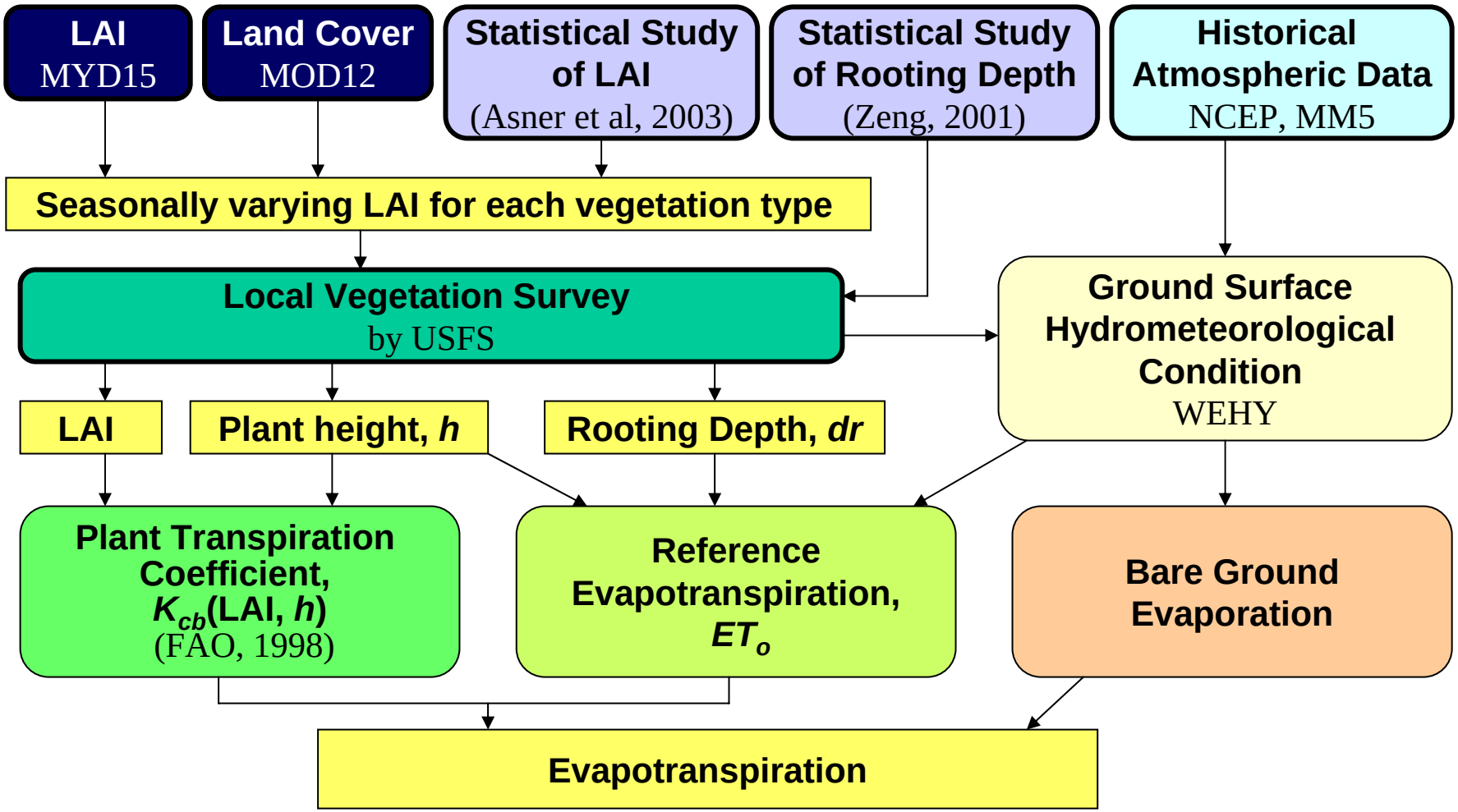
Stream

7 0 7 14 **Kilometers**

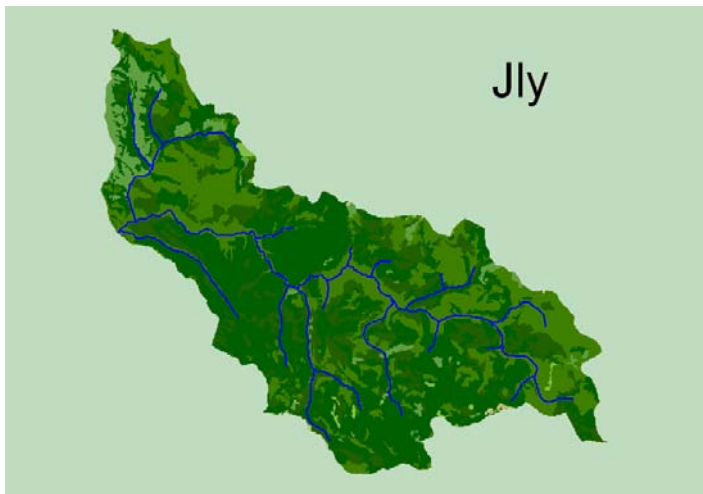
N
W E
S


Precipitation
Sun
Direct Evaporation
of Intercepted Water
Transpiration of
Root Zone Water
Interception
by vegetation
Through Fall
Bare Soil
Evaporation
Direct runoff
Snowmelt
Snow cover
Infiltration
Infiltration
Root Zone
Unsaturated
Zone
Groundwater Recharge
Groundwater Table

Methodology for evapotranspiration with natural vegetation



Estimated monthly LAI based on local vegetation survey and MODIS data



Leaf Area Index

- 0 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 1.8
- 1.8 - 2.2
- 2.2 - 2.7
- 2.7 - 3.3
- 3.3 - 10

RECONSTRUCTION OF HISTORICAL ATMOSPHERIC DATA OVER THE WATERSHED AT 9 KM RESOLUTION

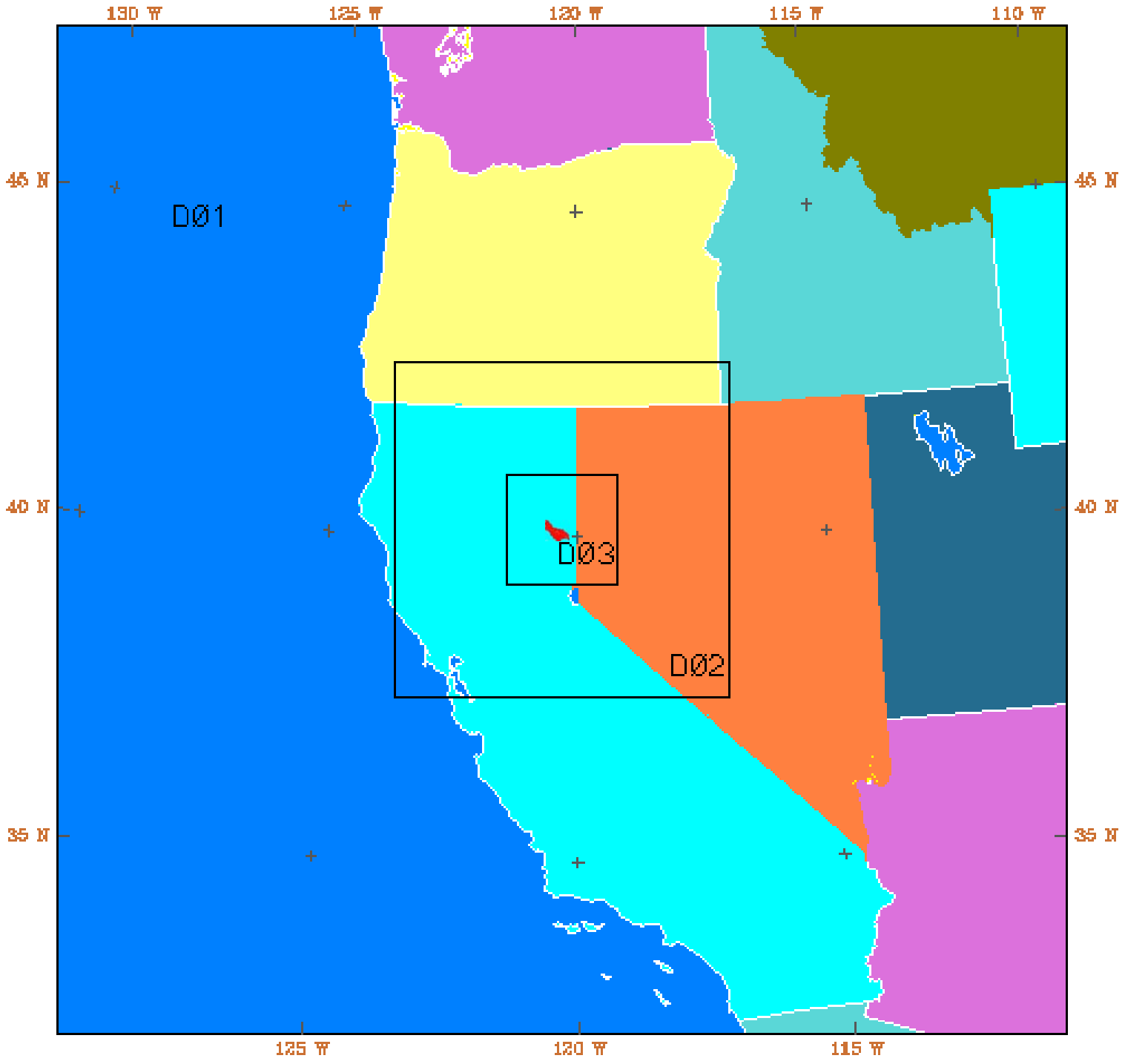
BY

DOWNSCALING FROM COARSE RESOLUTION (~280KM) GLOBAL DATASETS

MM5 Domain Nesting

for

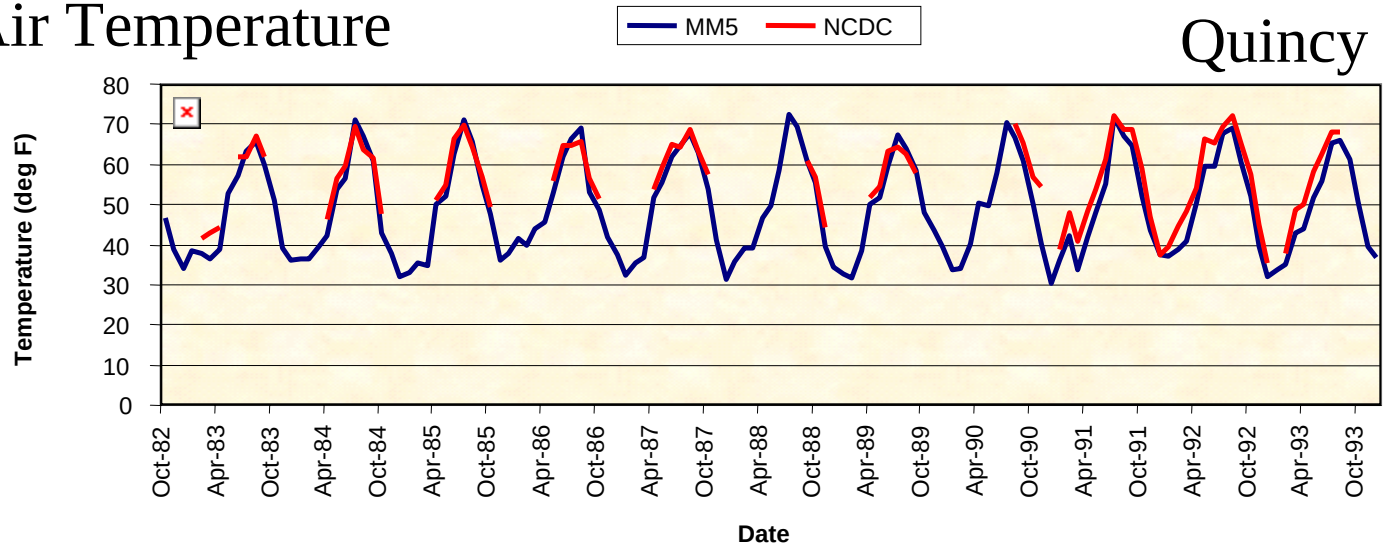
Last Chance Creek Watershed Model



Reconstructing distributed atmospheric data for validation and for critical hydrologic periods

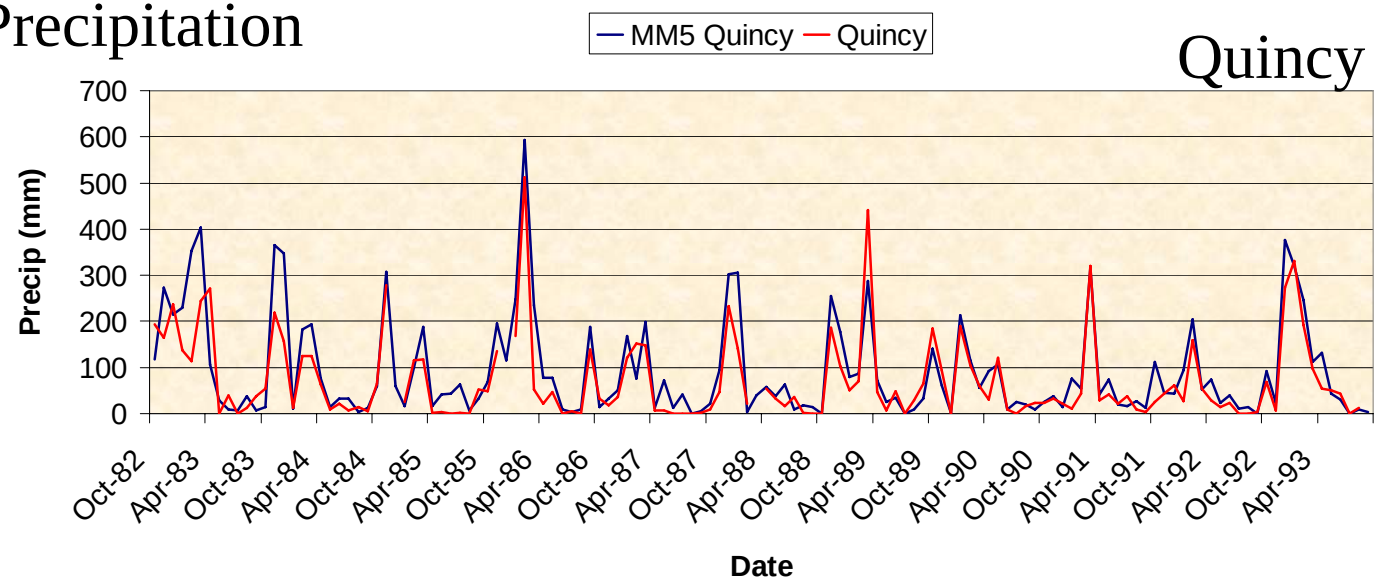
Air Temperature

Quincy

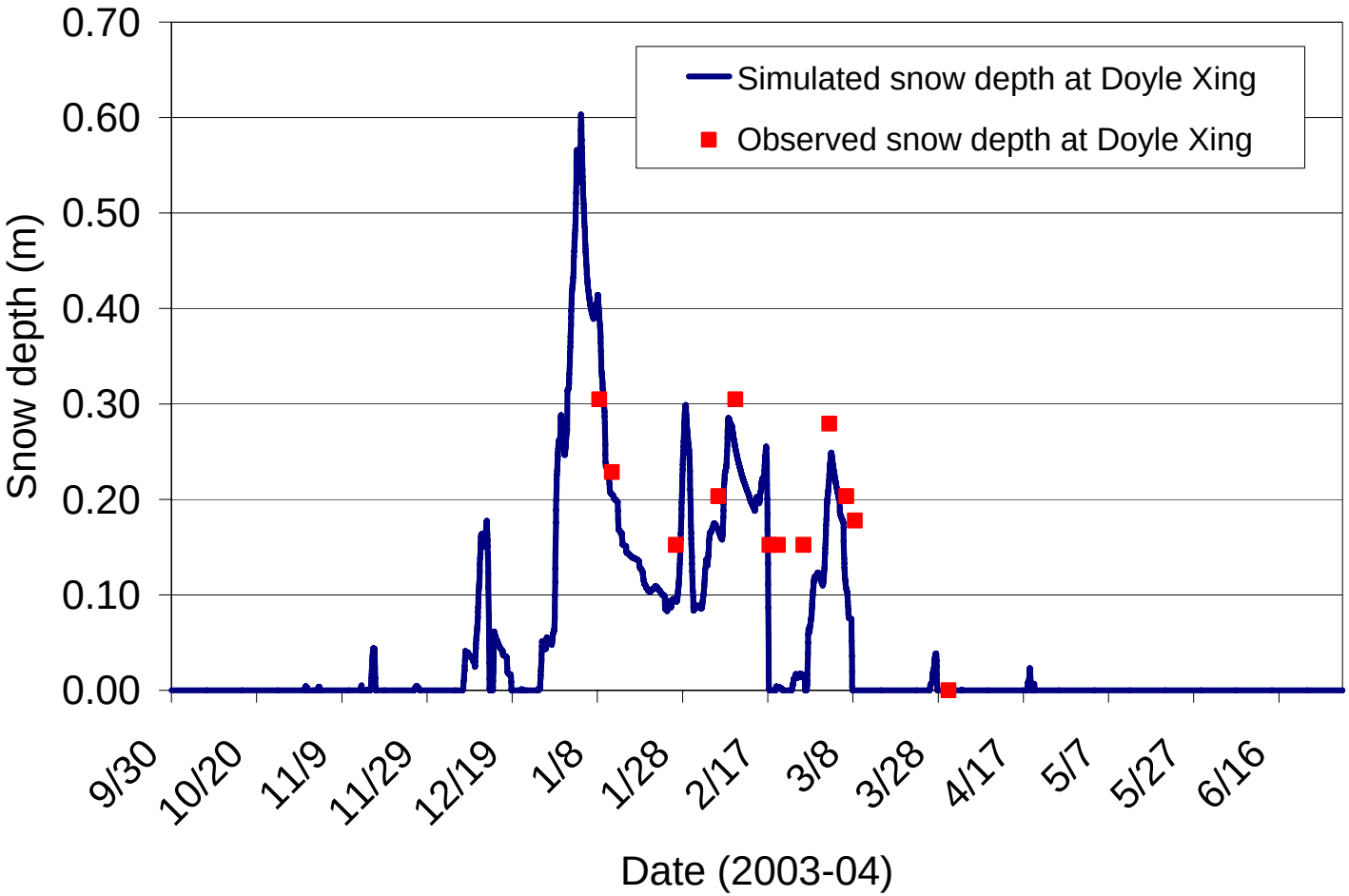


Precipitation

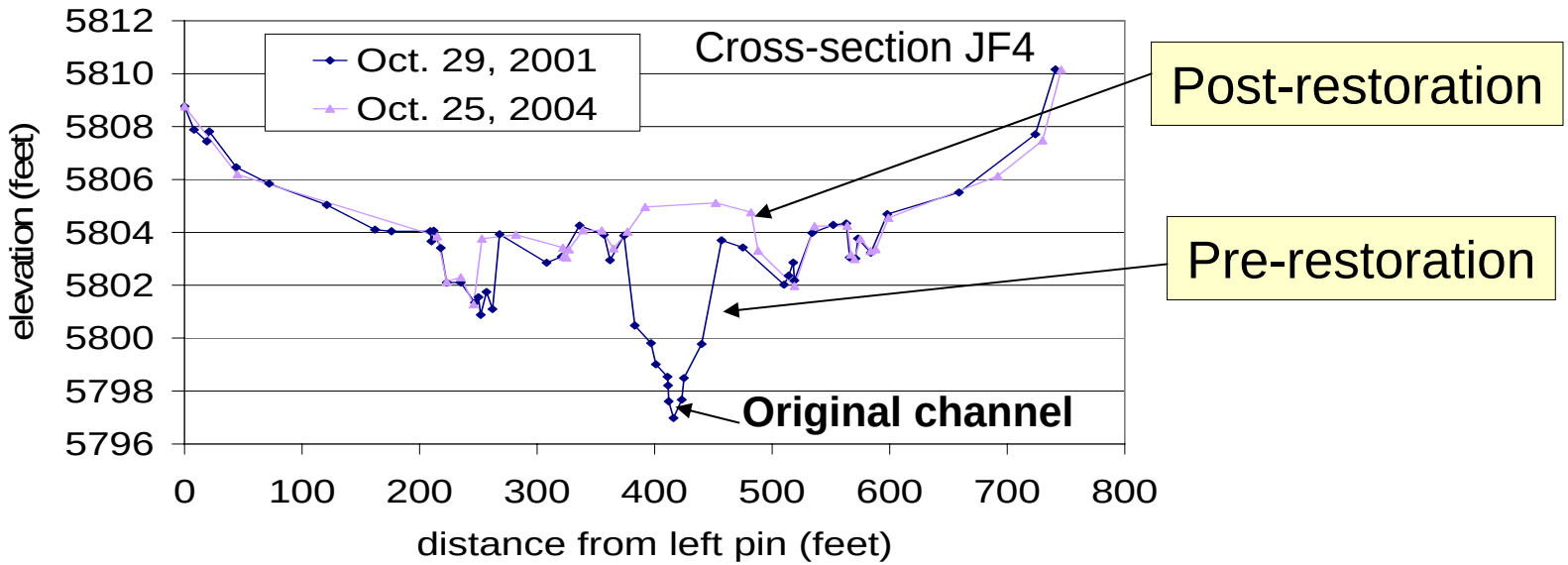
Quincy

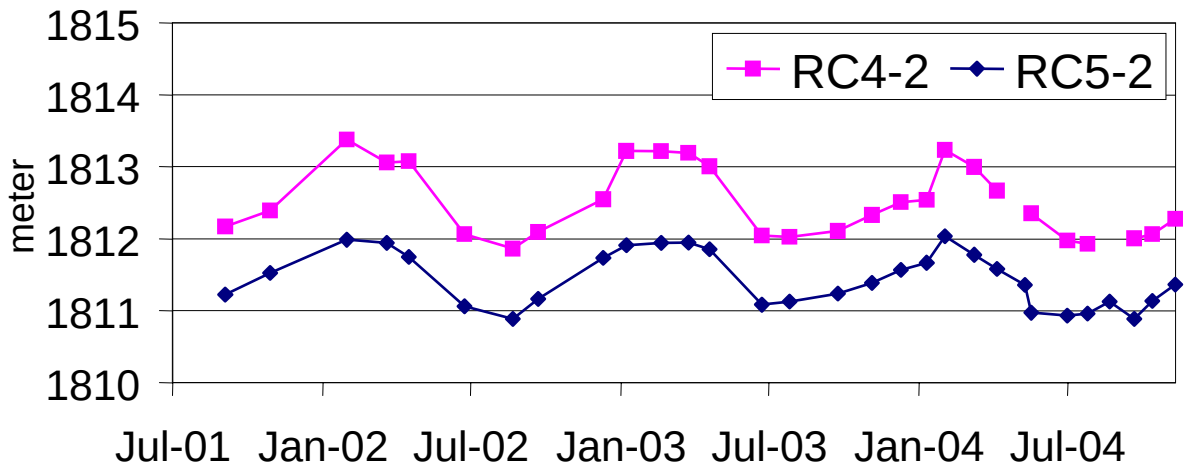


Snow module to simulate accumulation and melt processes of snow

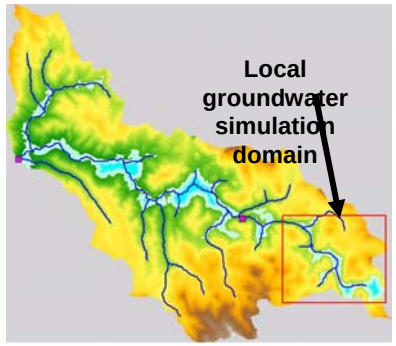


Monitored Data Collected for Model Validation

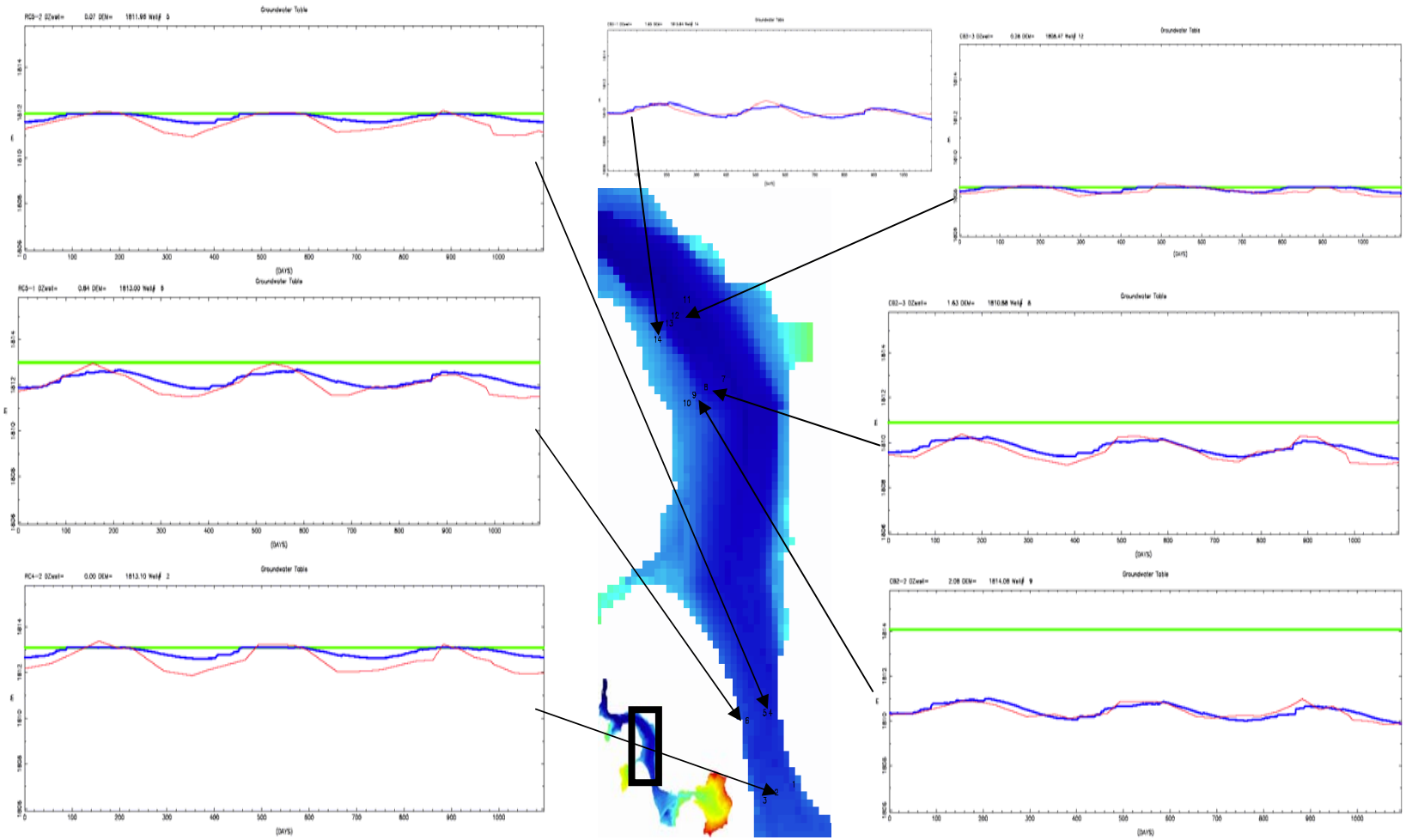




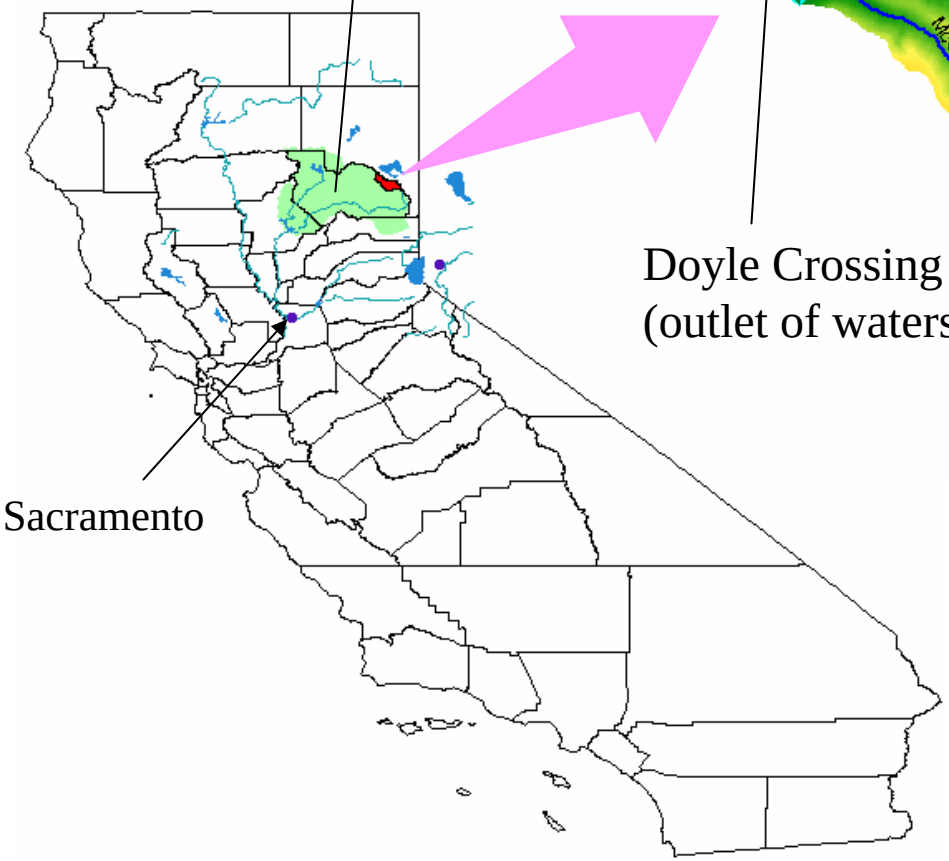
Local Groundwater Simulation
at Rowland-Charles Reach
(Oct 1, 2001 – Sep 30, 2004)



Observed Groundwater Table
Simulated Groundwater Table
Ground Surface

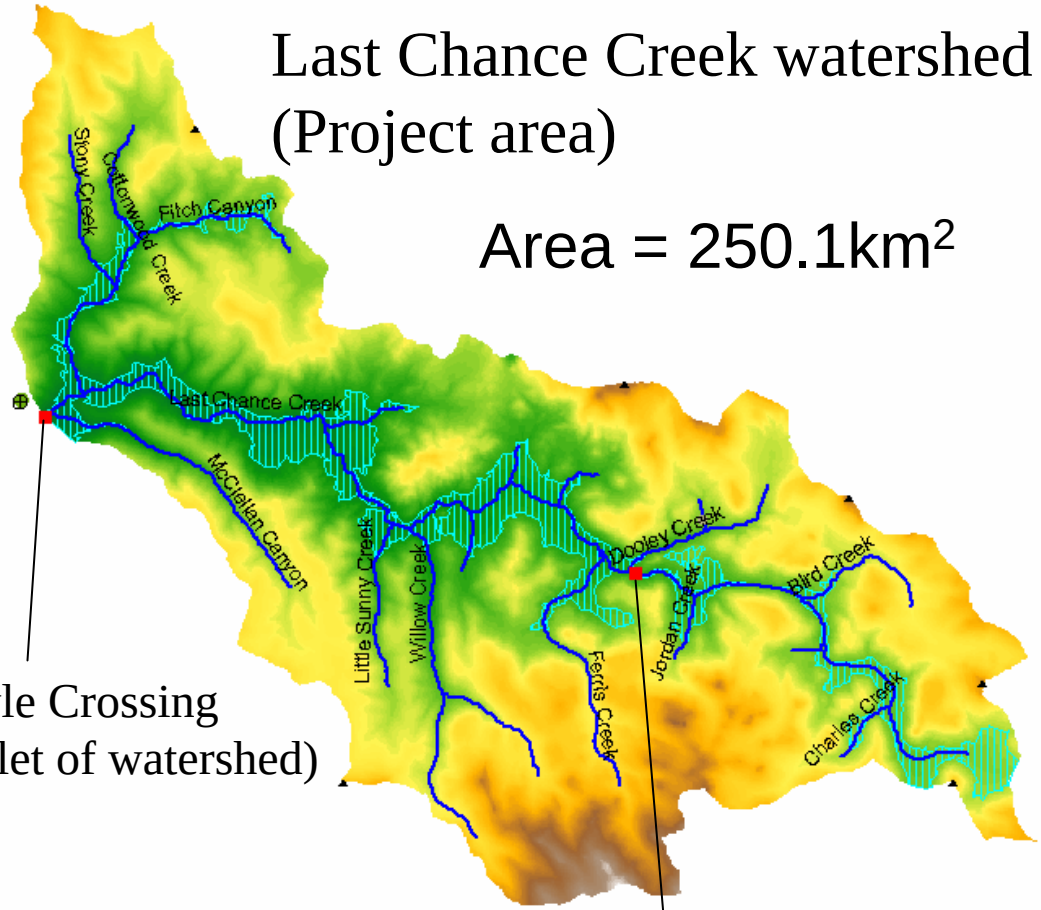


Feather River Basin



Last Chance Creek watershed
(Project area)

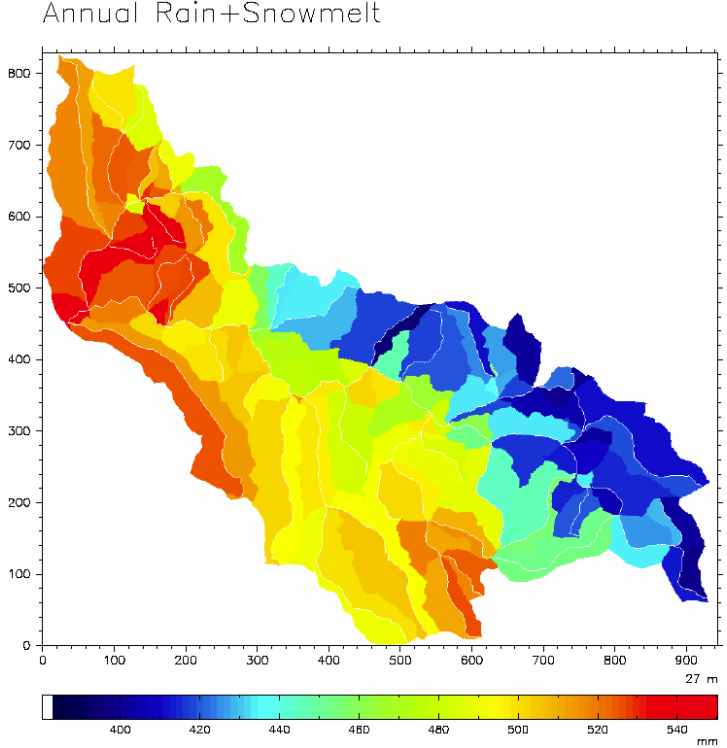
Area = 250.1km²

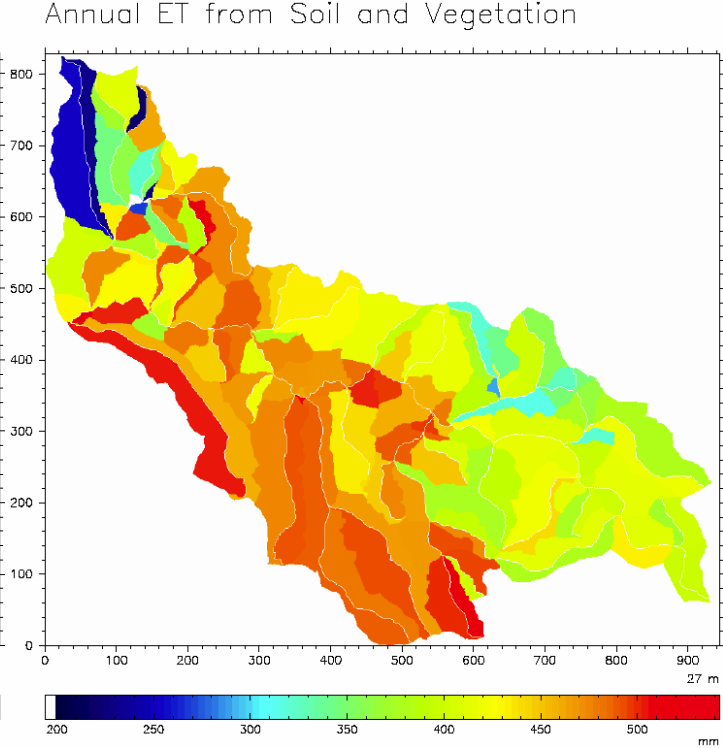


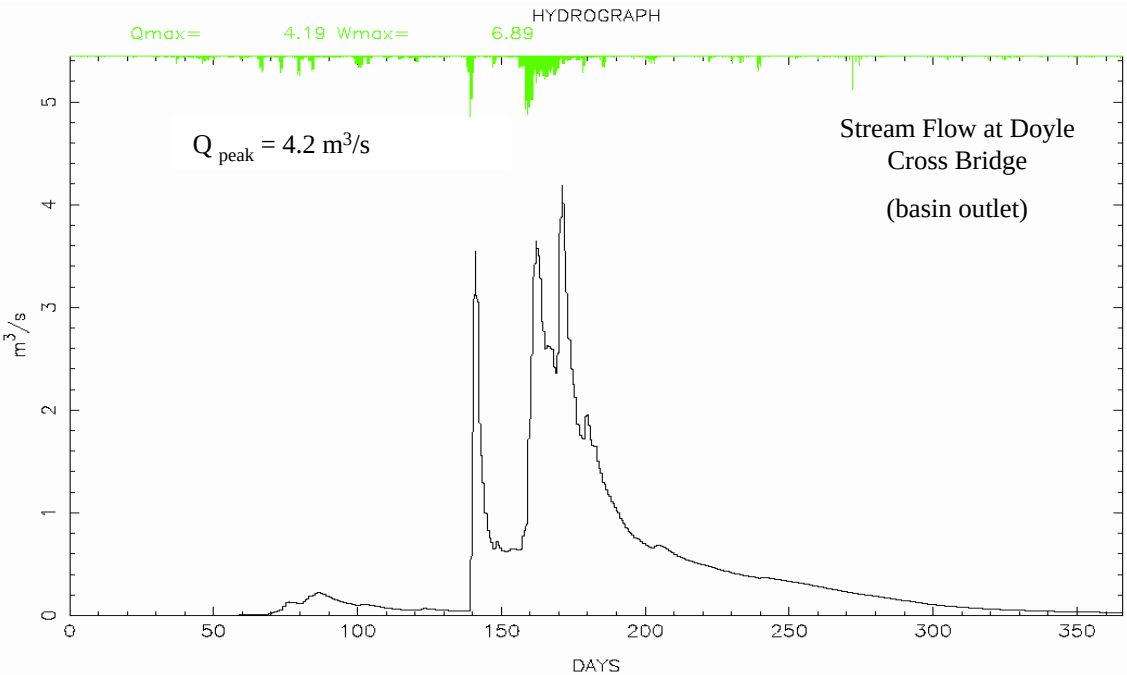
Doyle Crossing
(outlet of watershed)

Million $ Bridge

Simulated Hydrological Conditions Water Year 10/2003-9/2004



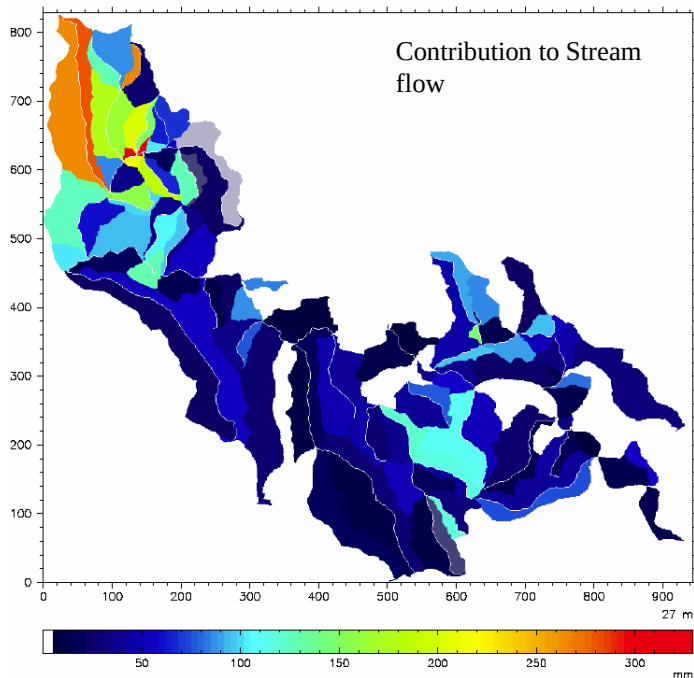




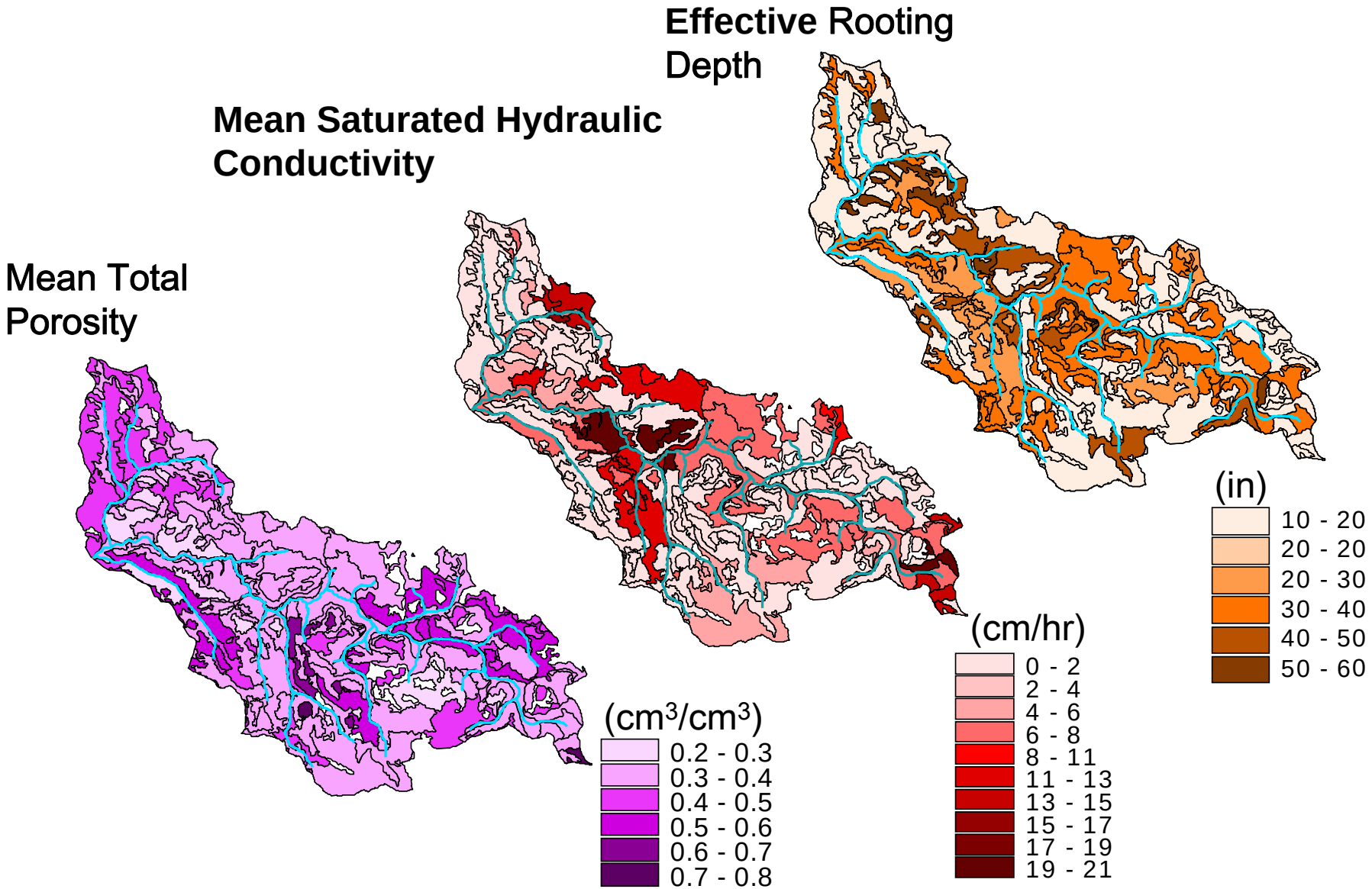
$Q_{peak} = 4.2\ m^3/s$

Stream Flow at Doyle Cross Bridge

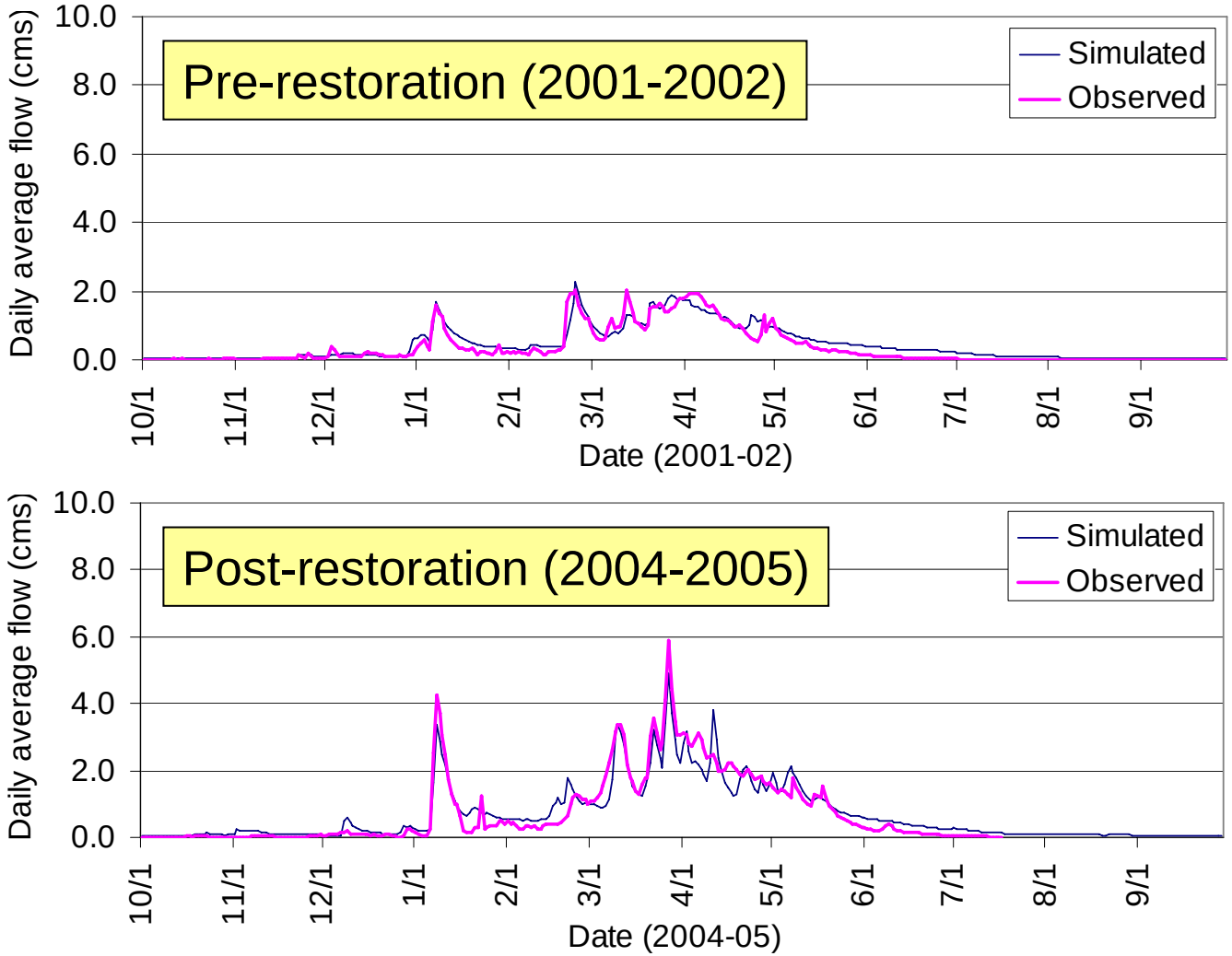
(basin outlet)



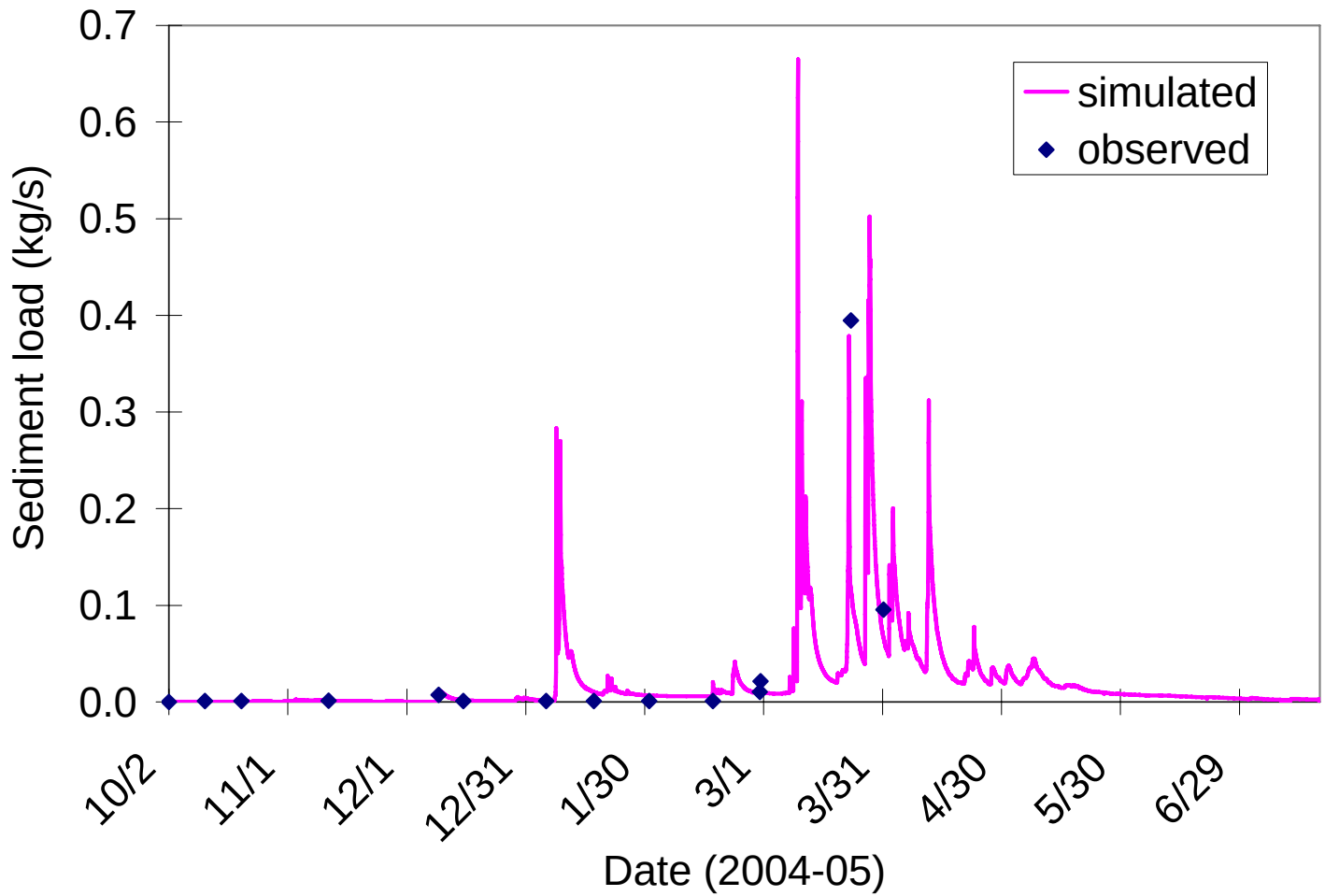
Estimated soil parameters for WEHY model over Last Chance Creek watershed (selected)



Comparison of model simulated and observed runoff at Doyle Crossing for Pre-restoration condition (Oct. 2001 - Sep.2002) and Post-restoration condition (Oct. 2004 - Sep.2005)



Comparison of model simulated and observed sediment load at Doyle Crossing for post-restoration condition (Oct. 2004 - Sep. 2005)



ASSESSMENT OF RESTORATION ACTIVITIES

IN

LAST CHANCE CREEK WATERSHED

FOR TWO SCENARIOS:

1) PRE-RESTORATION CONDITION;
2) POST-RESTORATION CONDITION,

under the same atmospheric inputs

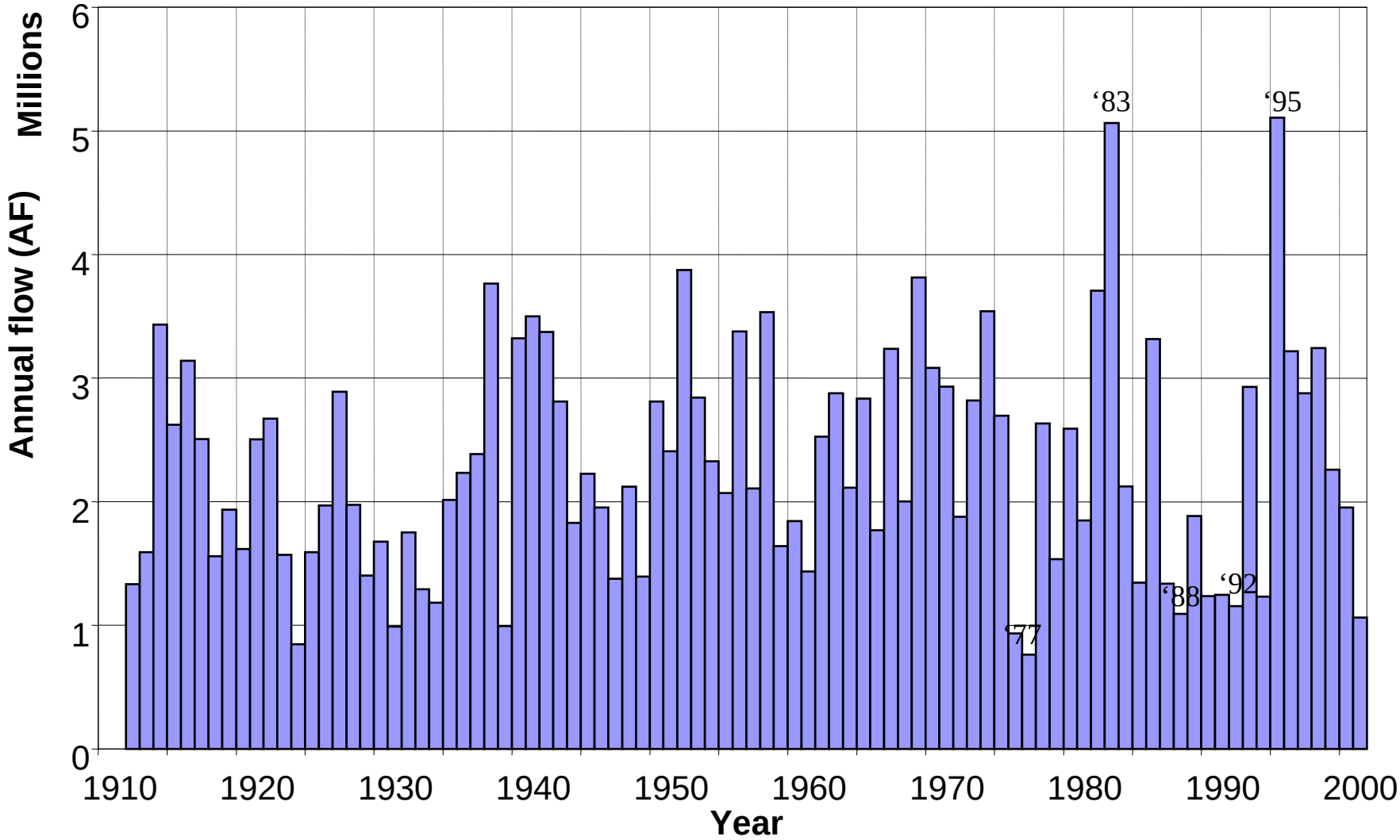
corresponding to wet water year

(Oct. 1982- Sep. 1983)

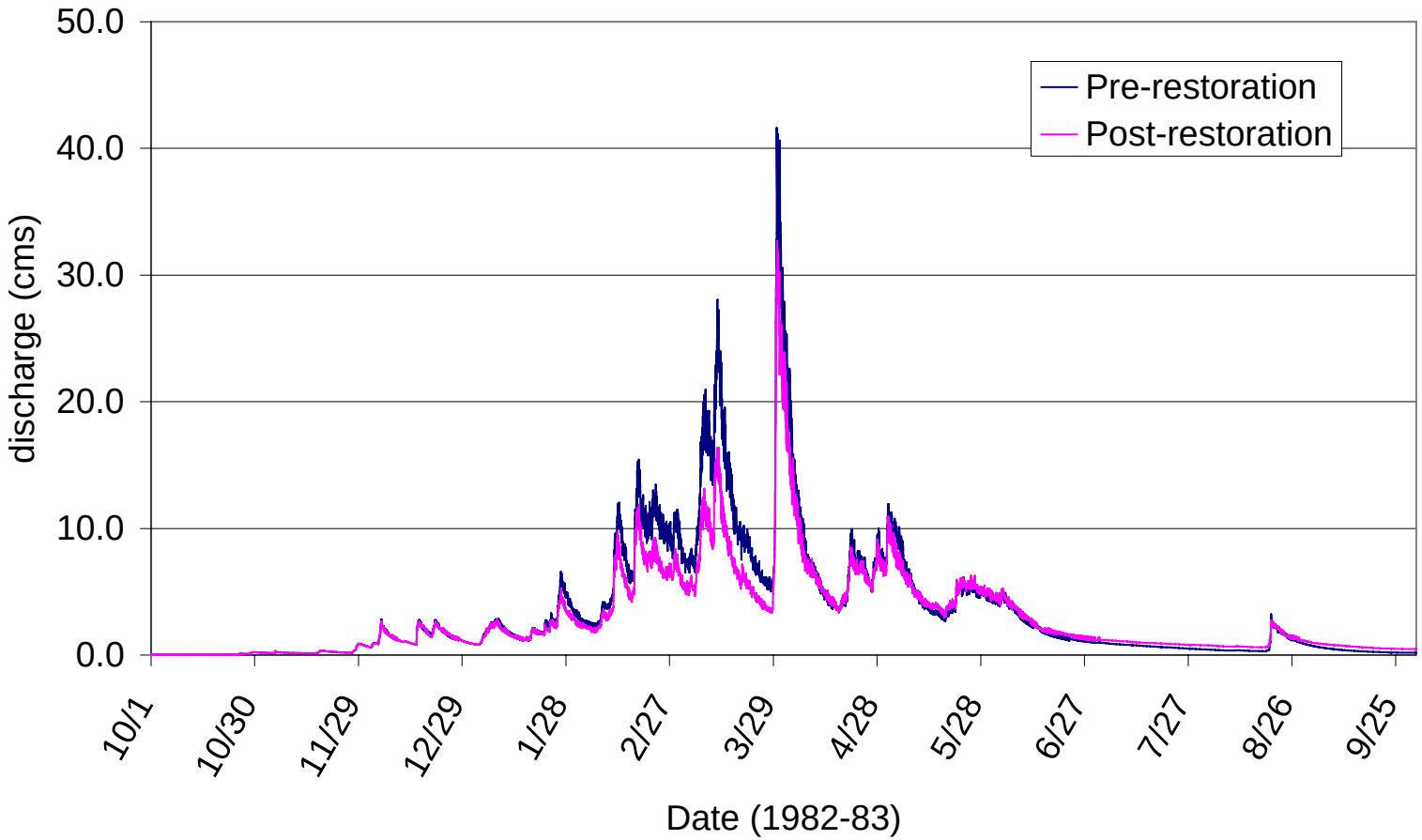
ARE

SIMULATED AND COMPARED.

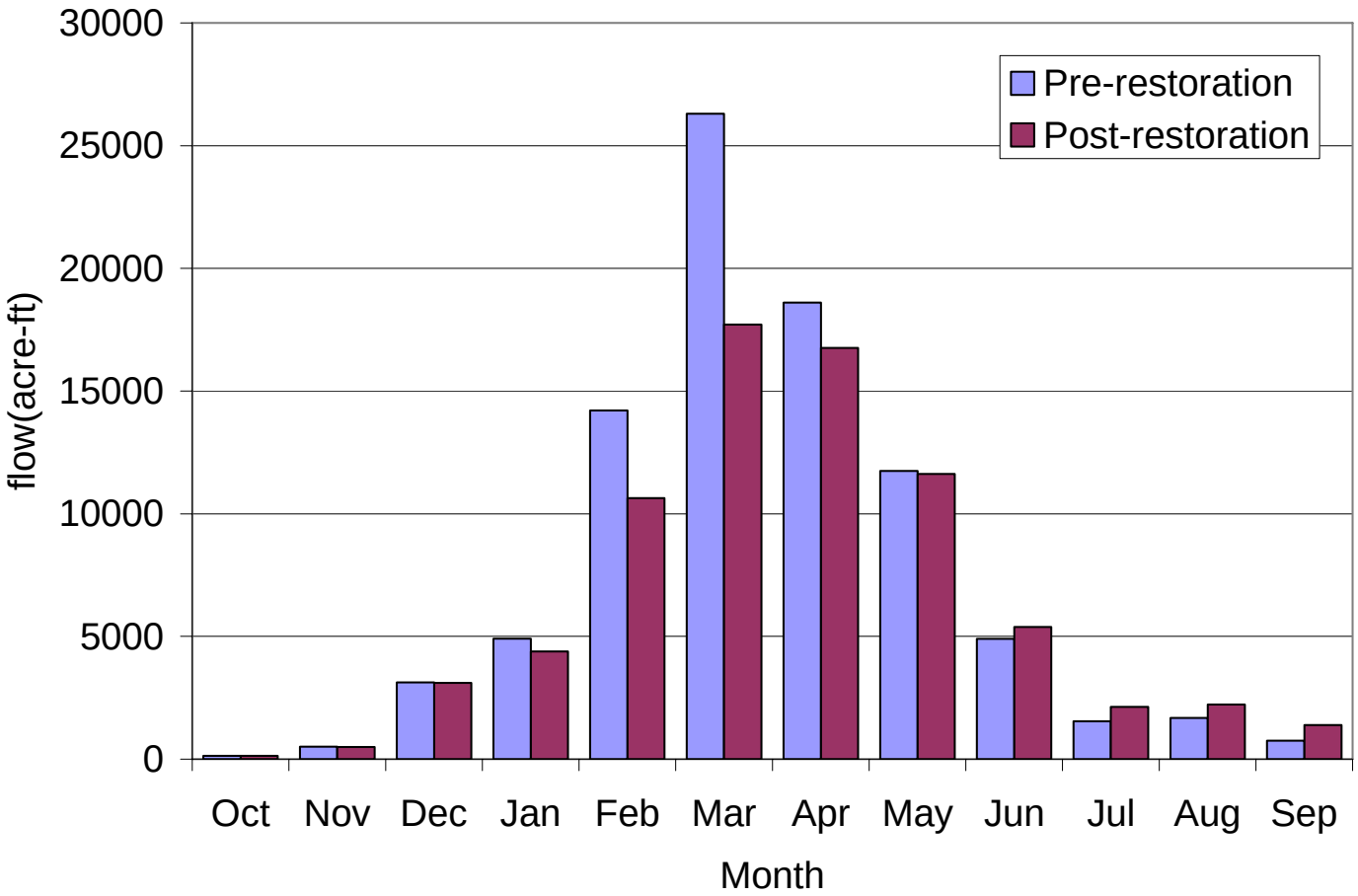
Annual flow at Pulga, Feather River North Fork
1912 - 2001



Comparison of flow discharge at Doyle Crossing between the pre-restoration and post-restoration conditions (Oct.1982 - Sep.1983)



Comparison of monthly flow at Doyle Crossing between pre-restoration and post-restoration conditions (Oct. 1982 - Sep. 1983)

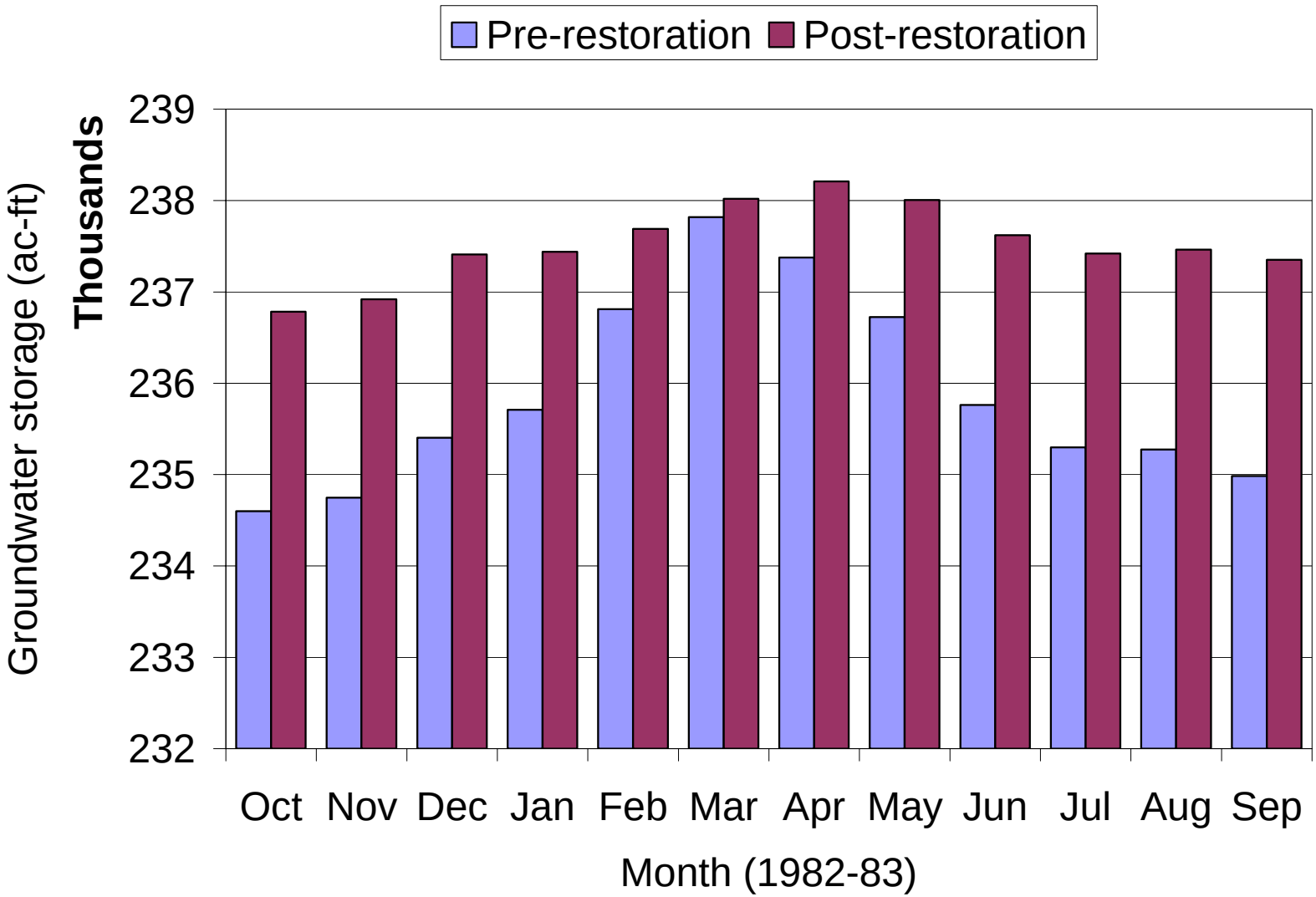


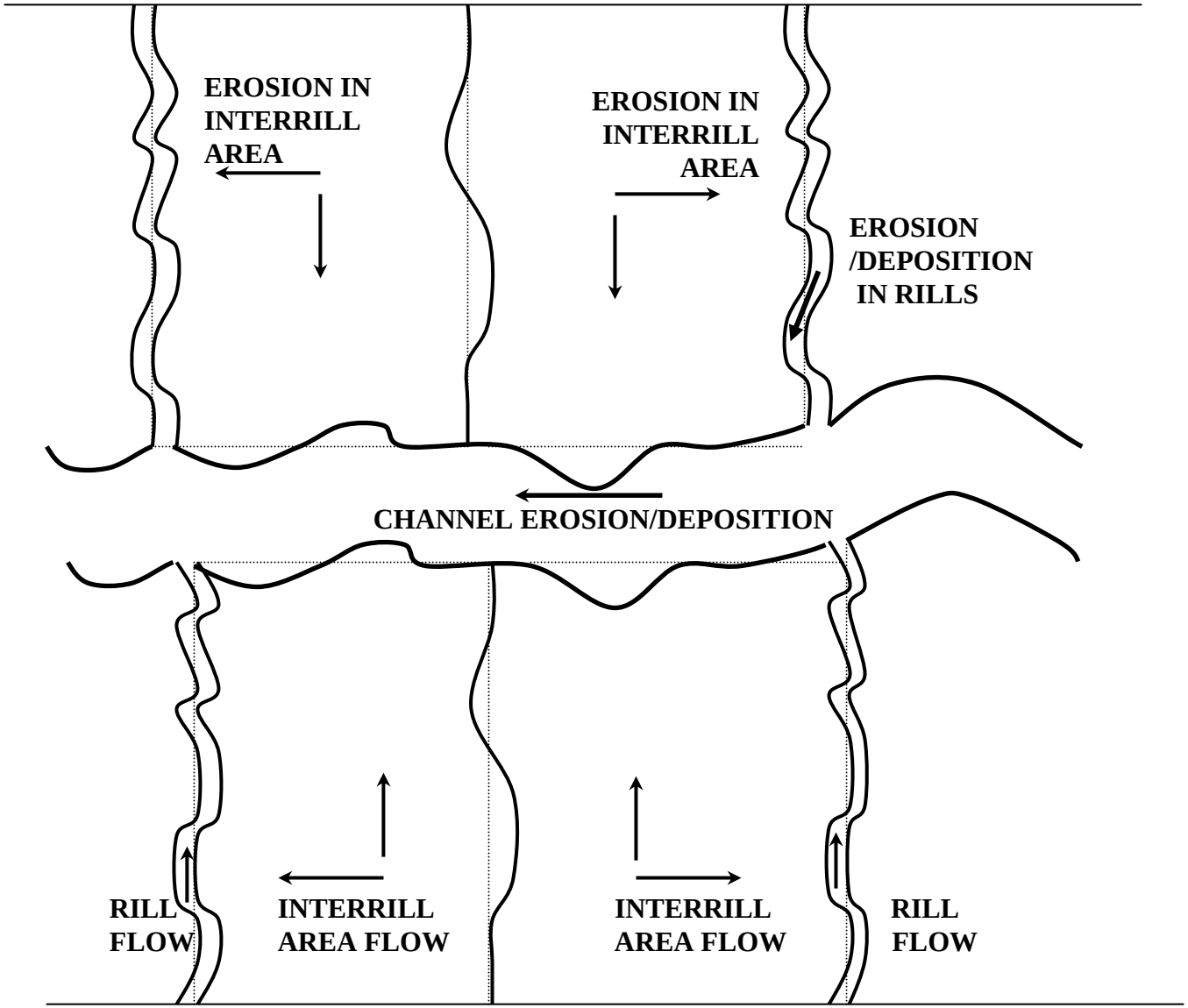
Assessment of restoration activities:
Monthly Flow at the Doyle Crossing (Oct.1982-Sep.1983)

	Pre-restoration (acre-ft)	Post-restoration (acre-ft)	absolute diff (acre-ft)	relative diff (%)
Oct	132	132	0	0.00
Nov	505	499	-5	-1.06
Dec	3133	3109	-24	-0.77
Jan	4916	4388	-528	-10.74
Feb	14204	10631	-3574	-25.16
Mar	26302	17709	-8594	-32.67
Apr	18600	16762	-1838	-9.88
May	11744	11628	-116	-0.99
Jun	4898	5386	488	9.97
Jul	1545	2129	584	37.82
Aug	1680	2222	542	32.28
Sep	749	1393	643	85.84
Annual	88408	75988	-12420	-14.05

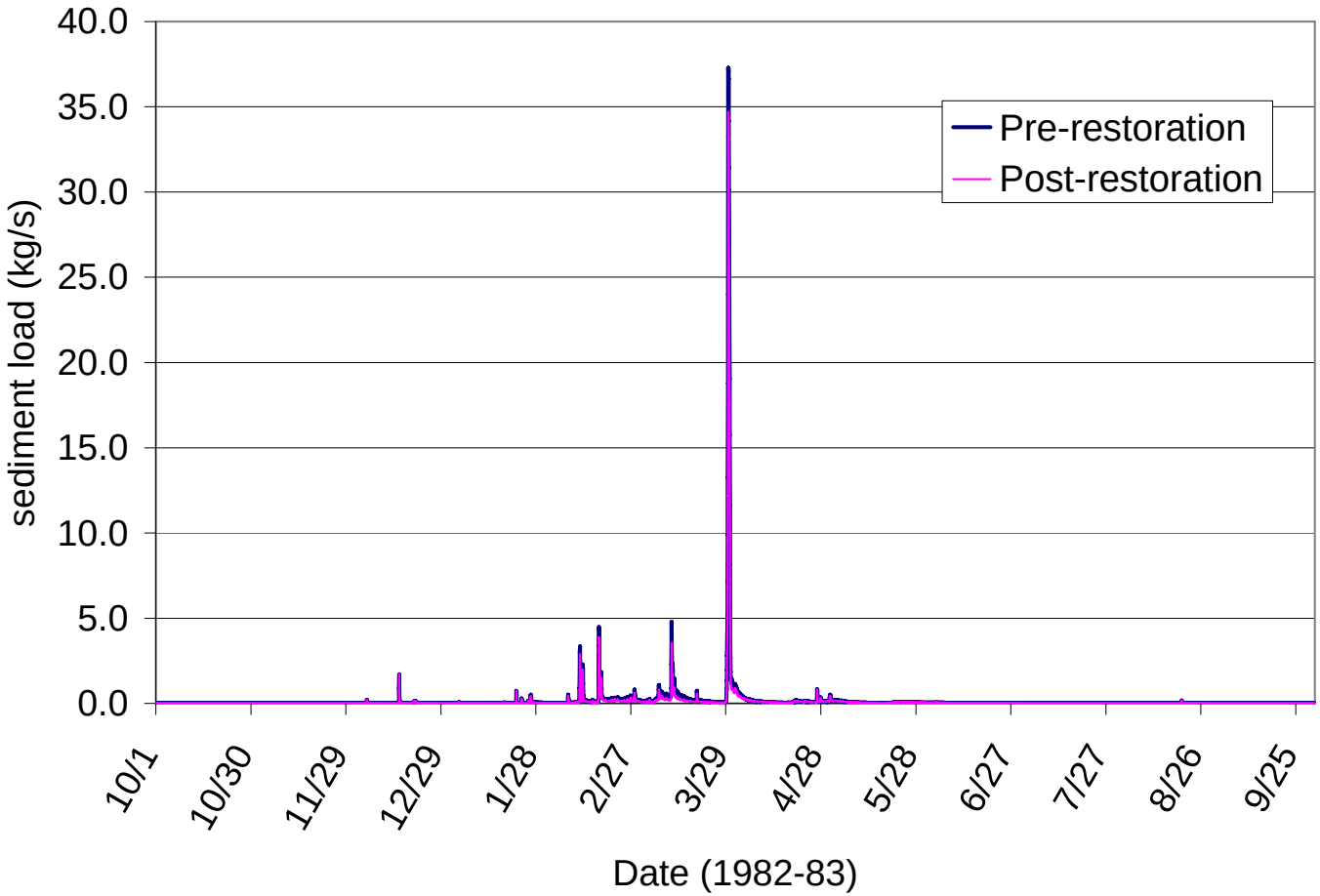
32.7% reduction of flow in March (wet month) may be expected, and
85.8% increase of flow in September (dry month) may be expected because of the restoration.

Comparison of monthly mean groundwater storage between the pre-restoration and post-restoration conditions (Oct.1982 - Sep.1983)

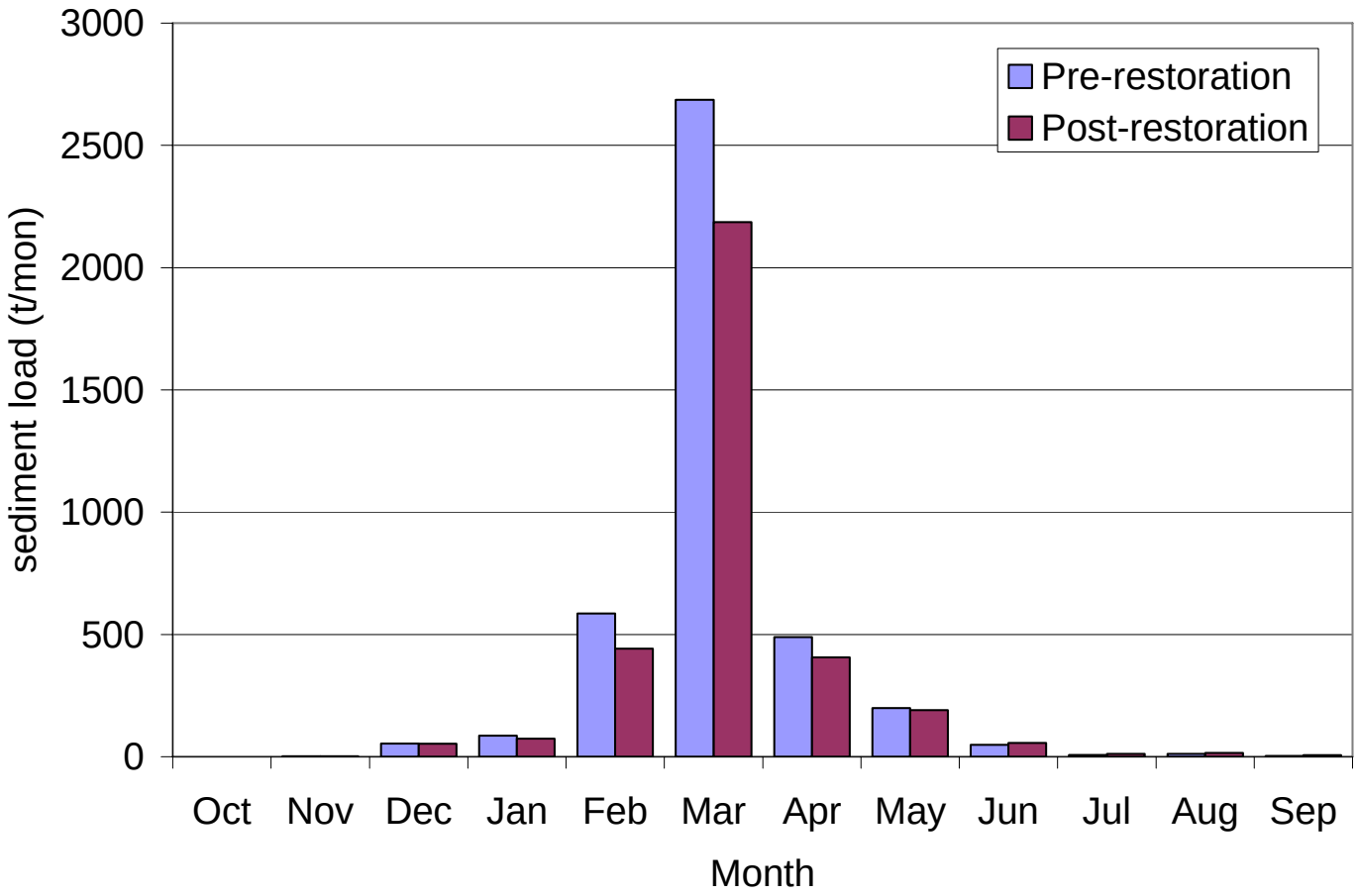



EROSION IN
INTERRILL
AREA
EROSION IN
INTERRILL
AREA
EROSION
/DEPOSITION
IN RILLS
CHANNEL EROSION/DEPOSITION
RILL
FLOW
INTERRILL
AREA FLOW
INTERRILL
AREA FLOW
RILL
FLOW

Comparison of sediment load at Doyle Crossing between the pre-restoration and post-restoration conditions (Oct.1982 - Sep.1983)



Comparison of monthly sediment load at Doyle Crossing between the pre-restoration and post-restoration conditions (Oct.1982 - Sep.1983)



Assessment of restoration activities:
Monthly Sediment load at the Doyle Crossing (Oct.82-Sep.83)

	Pre-restoration (t)	Post-restoration (t)	absolute diff (t)	relative diff (%)
Oct	0.2	0.2	0.0	-0.59
Nov	2.1	2.1	0.0	-2.02
Dec	53.7	53.0	-0.7	-1.37
Jan	85.6	73.2	-12.4	-14.45
Feb	585.3	442.0	-143.3	-24.49
Mar	2687.2	2186.4	-500.8	-18.64
Apr	489.1	406.2	-82.9	-16.94
May	199.5	191.1	-8.4	-4.19
Jun	48.9	55.6	6.7	13.62
Jul	7.2	11.4	4.3	59.24
Aug	11.8	15.3	3.5	29.74
Sep	2.7	6.2	3.5	133.46
Annual	4173.3	3442.8	-730.5	**-17.50**

17.5% reduction of annual sediment discharge may be expected because of the restoration.

Conclusions

1. WEHY (Watershed Environmental Hydrology) Model has been applied to the Last Chance Creek Watershed for the Assessment of the Impact of Restoration Activities on the Water Supply/Flood Control/NPS Pollutant Discharge;

2. WEHY Model demonstrated that restoration activities in Last Chance Creek will store more water during wet periods (reducing flood discharge) while increasing base flows during dry periods; groundwater storage in the watershed will increase by the restoration activities;

3. WEHY Model also demonstrated that the undertaken restoration activities will reduce the sediment discharge from Last Chance Creek watershed.

4. WEHY Model can be applied to any watershed in California for the assessment of restoration activities.

Acknowledgement:
This study was funded by CALFED Watershed Program.