WATER RESOURCE INVESTIGATIONS:

CACHE RIVER ARKANSAS

White River Basin Comprehensive
Summer 2010 Inter-Agency Meeting

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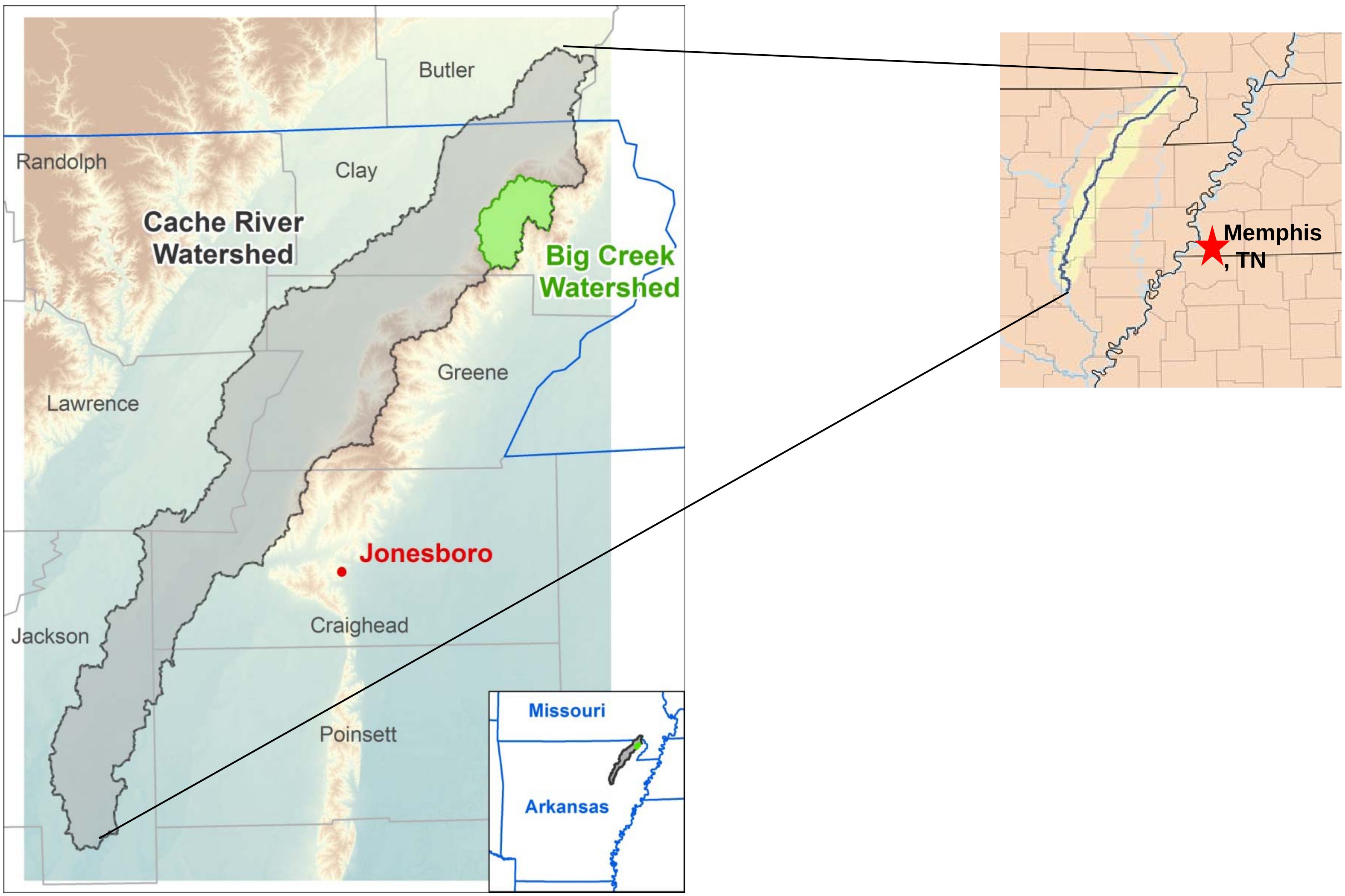
US Army Corps of Engineers
BUILDING STRONG®

Objectives

- Where we have been (recap of situation and what's been done in previous years)
- Where we are in analysis (what we've been doing this year)
- Preliminary Sedimentation Results
  - Alternatives
  - AGNPS modeling
  - Sediment Transport modeling

Cache River, Arkansas



Background

- The Cache River watershed is located between the White River and Crowley's Ridge in eastern Arkansas and extends into southeastern Missouri.
- The basin is approximately 200 miles north to south and is only about 10 miles wide.
- Upper basin, Grubbs and upstream, have been channelized by local interests.
- Basin between Grubbs and outlet developed for agriculture (clearing and floodplain encroachment), but river has a "historic" meandering planform.
- Lowest 7 miles was channelized by the Corps of Engineers
- Development of the watershed for agriculture began in the early 20th century.
- Blockages below Grubbs, AR cause significant flooding to community and surrounding area.

- There is significant interest in the basin for agriculture and the environment.
- The US Fish and Wildlife Service own and manage the Cache River Wildlife Refuge located in the lower part of the watershed.
- The Nature Conservancy has interest within the basin to preserve habitat and river function.
- EPA provided funds in 2004-2005 to TNC for data collection that targets evaluation of sedimentation and water quality within the basin.

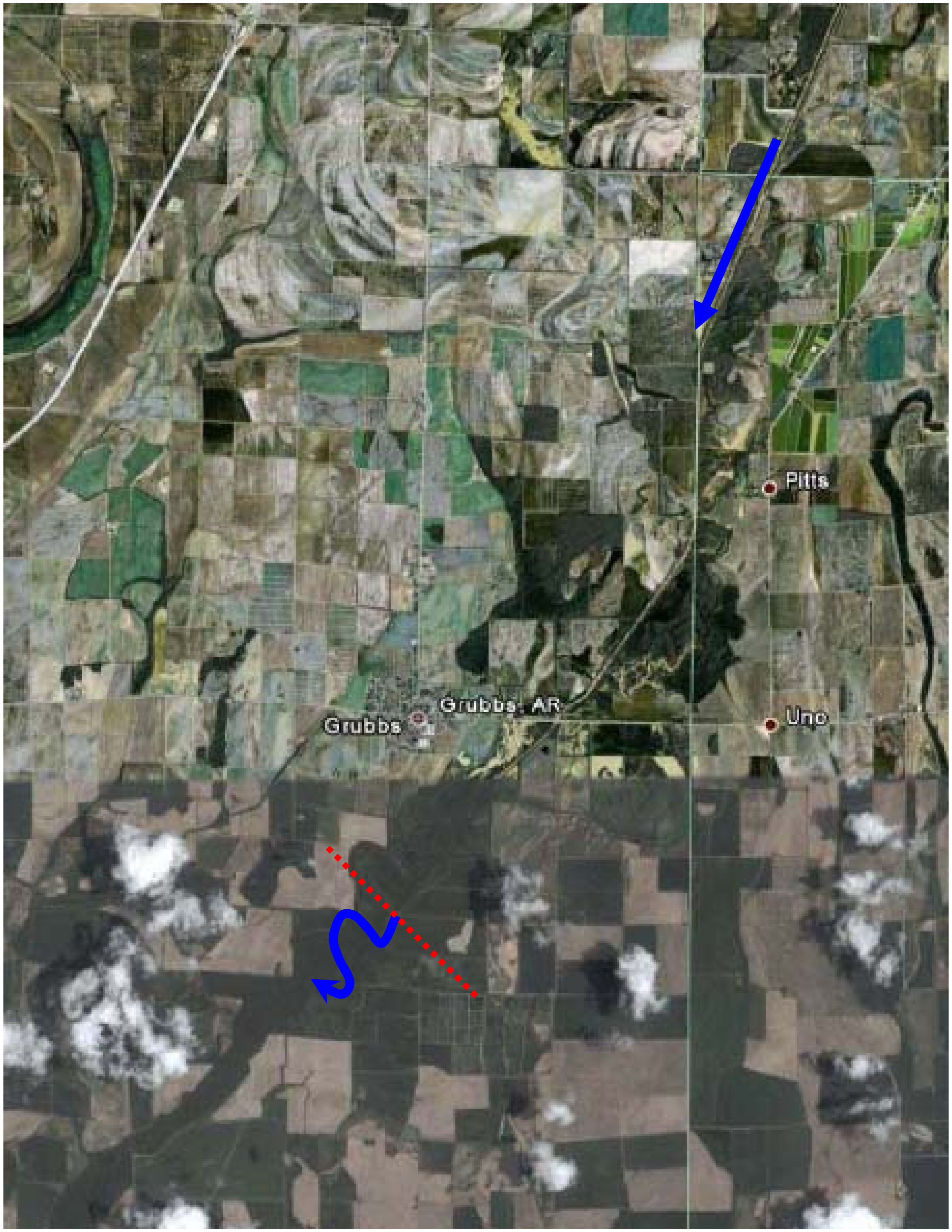
Basinwide Concerns

- Flooding in communities
- Sustaining Agriculture
- Water Quality
- Waterfowl
- Hunting
- Irrigation
- Bottomland Hardwood Forest Health
- Federal Wildlife Management Areas
- State Wildlife Management Areas
- National Attention (TNC, DU, etc.)

Sediment Problems

- Blockages below Grubbs completely fill channel
- High sediment load coming from upper watershed
- Transport capability significantly less in lower reach
- Water quality reduced due to sediment
- Continual channel maintenance perpetuates water quality issues
- Restricted floodplain width from agricultural development limits natural system function
- Declining health of bottomland hardwoods and swamps
- Limited data on quantity of sediments and quality of water

- NEED: sediment budget and sediment balance to assess system health and function; Will also allow evaluation of measures that may be used to change landuse and/or practices.



Source: GoogleEarth


Source: TNC Sediment Data Collection Report

Alternatives

- Sediment Coming From Watershed
  - Do Nothing
  - Change tillage practices
  - Implement conservation practices at waterways
  - Reduce gully erosion
  - Reduce in-channel erosion
- Sediment Blockage
  - Do Nothing
  - Restore channel function at blockage reach
  - Provide distributed transition between channelized and un-channelized reach

Modeling OUTLINE
Watershed Component

- Basic AGNPS concepts/inputs
- Landuse
- DEM
- Soils
- Gross Erosion
- Gully
- In-stream
- Yield
- Delivery
- Sub-basin/Cells
- Highest sources
- Base Condition vs Alternative Scenarios

- Big Creek Sub-basin

- Cache Basin upstream of Grubbs, AR

AnnAGNPS Model

Erosion Engine Based on the Revised Universal Soil Loss Equation

$$A = R * K * LS * C * P$$

Where:

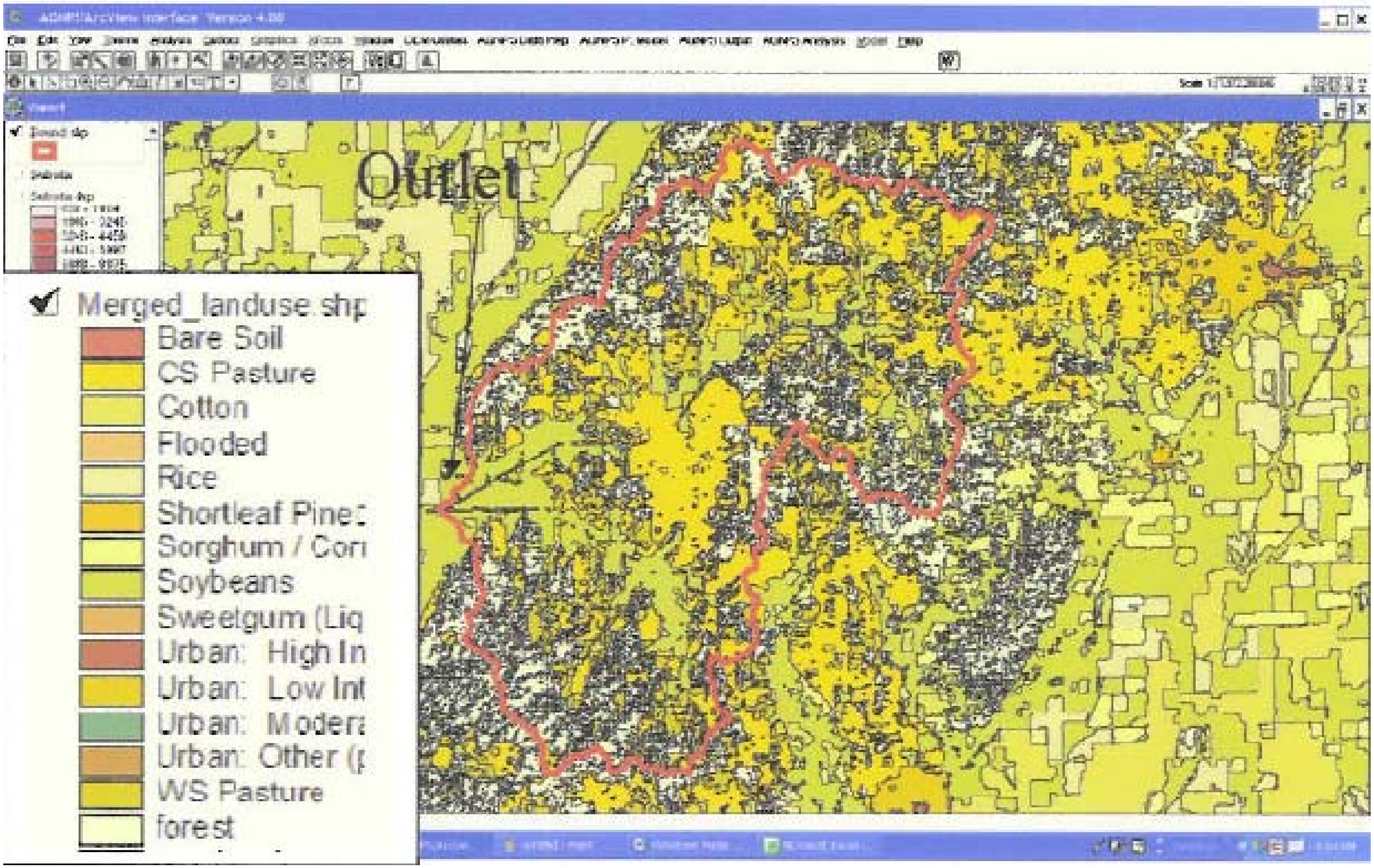
A = estimated average soil loss in tons per acre per year
R = rainfall-runoff factor
K = soil erodibility factor
L = slope length factor
S = slope steepness factor
C = Cover-management factor
P = support practice factor

AnnAGNPS Analysis

- Hypothetical hydrology for 30-year simulation
- GIS layers for each parameter in RUSLE
  - Landcover
  - Soil Type
  - Precipitation/Runoff
  - Management Practice
  - Slope
  - Length (network)
- Outputs
  - Annualized sediment yield for surface and rill erosion from RUSLE
  - Average annual Gully Erosion to be estimated using enhanced techniques implemented in AGNPS
  - Average annual In-Channel Erosion estimated using hydraulic geometry and generalized hydraulics for multiple reaches in stream network

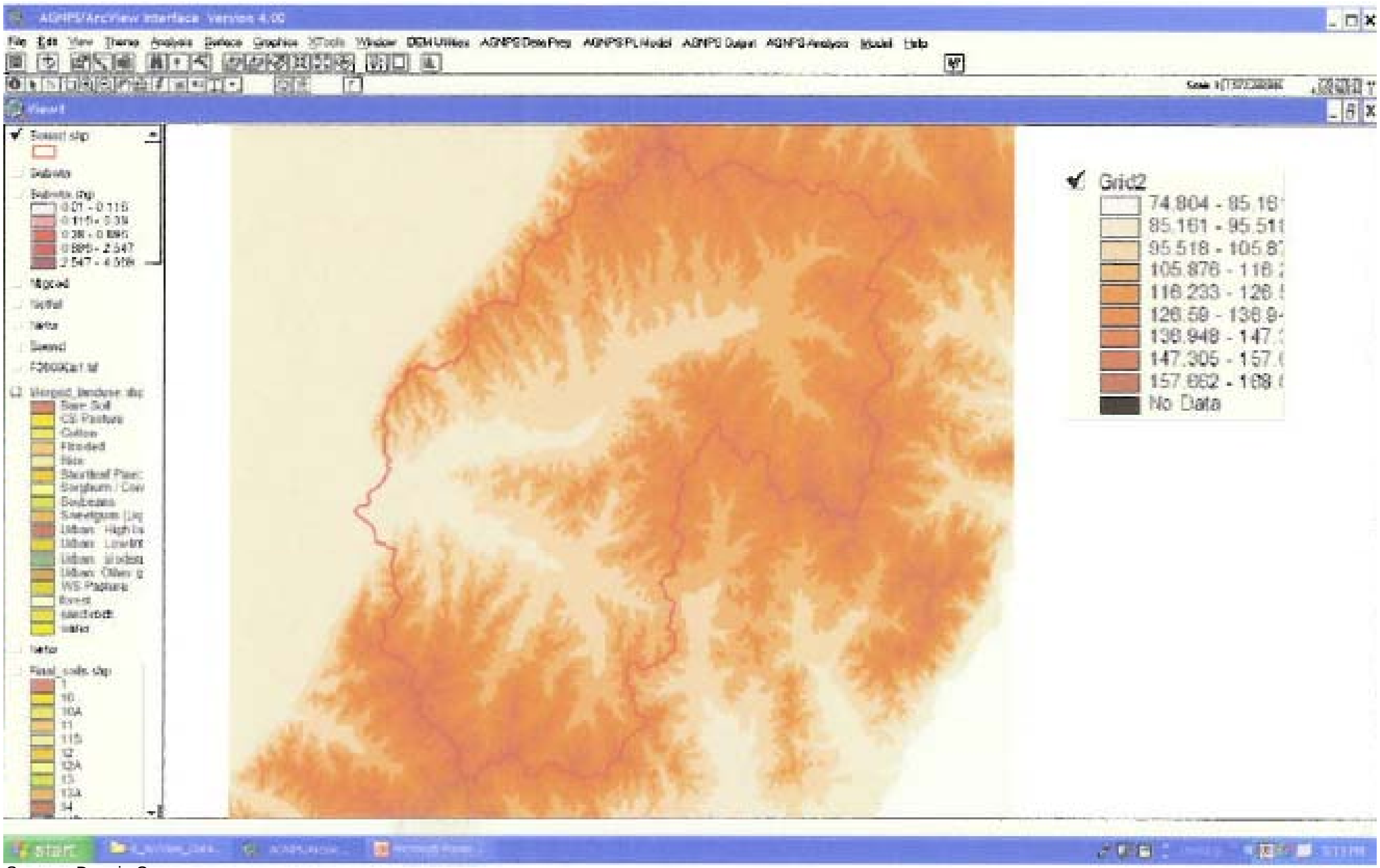
BIG CREEK SUB-BASIN

Landuse—Big Creek Basin



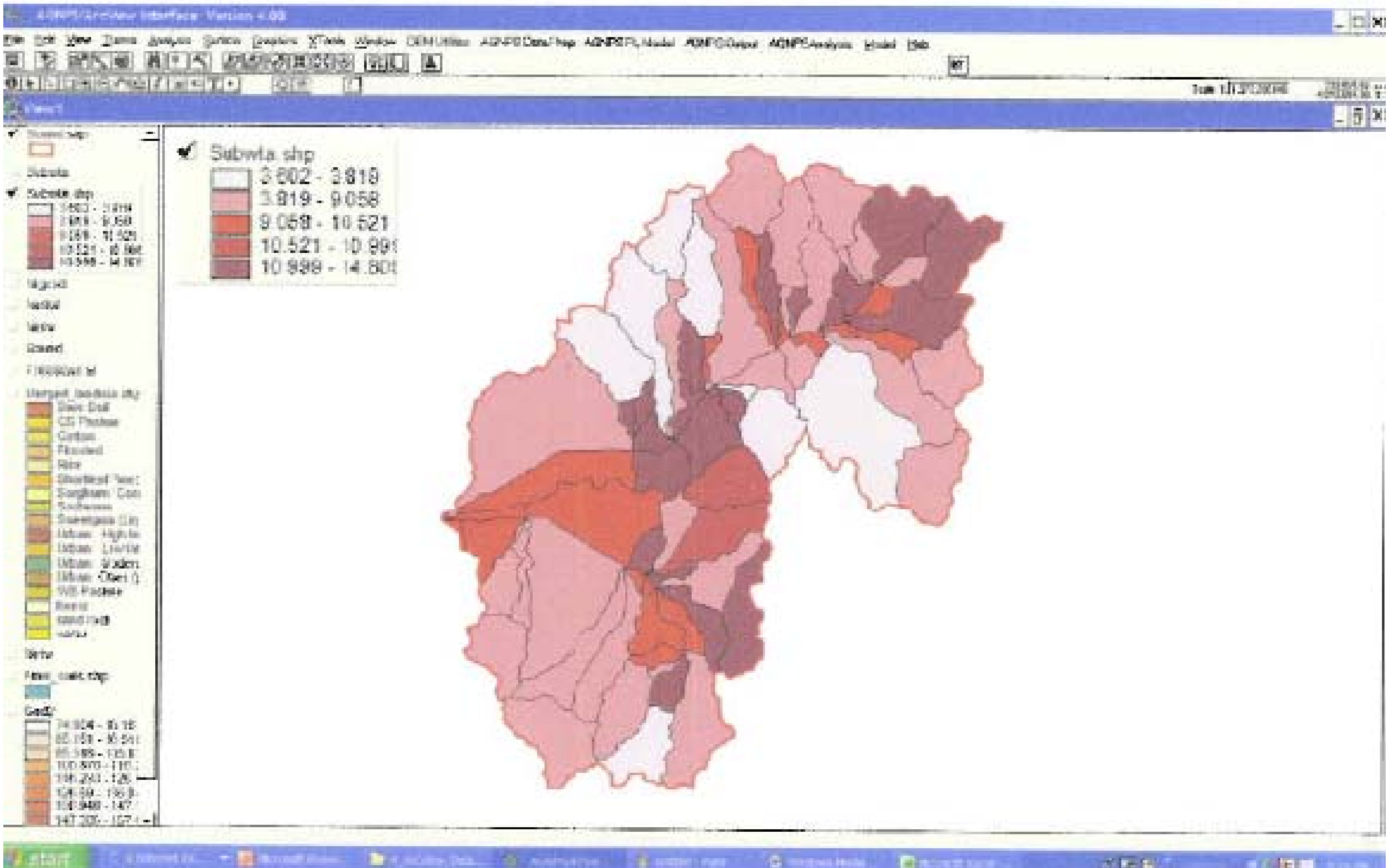
Source: Dennis Carmen

Elevations—Big Creek Basin



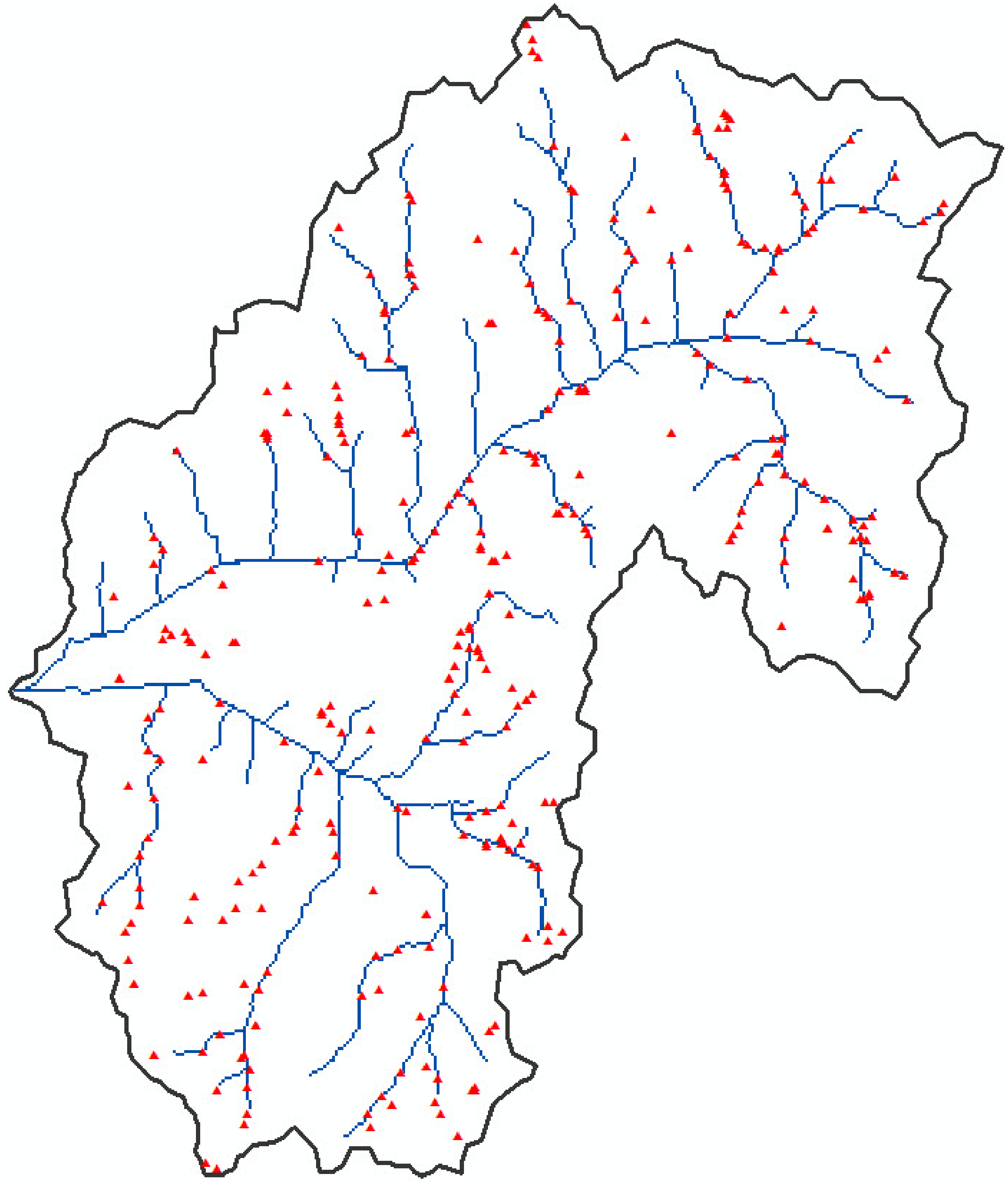
Source: Dennis Carmen

Runoff by Cell—Big Creek



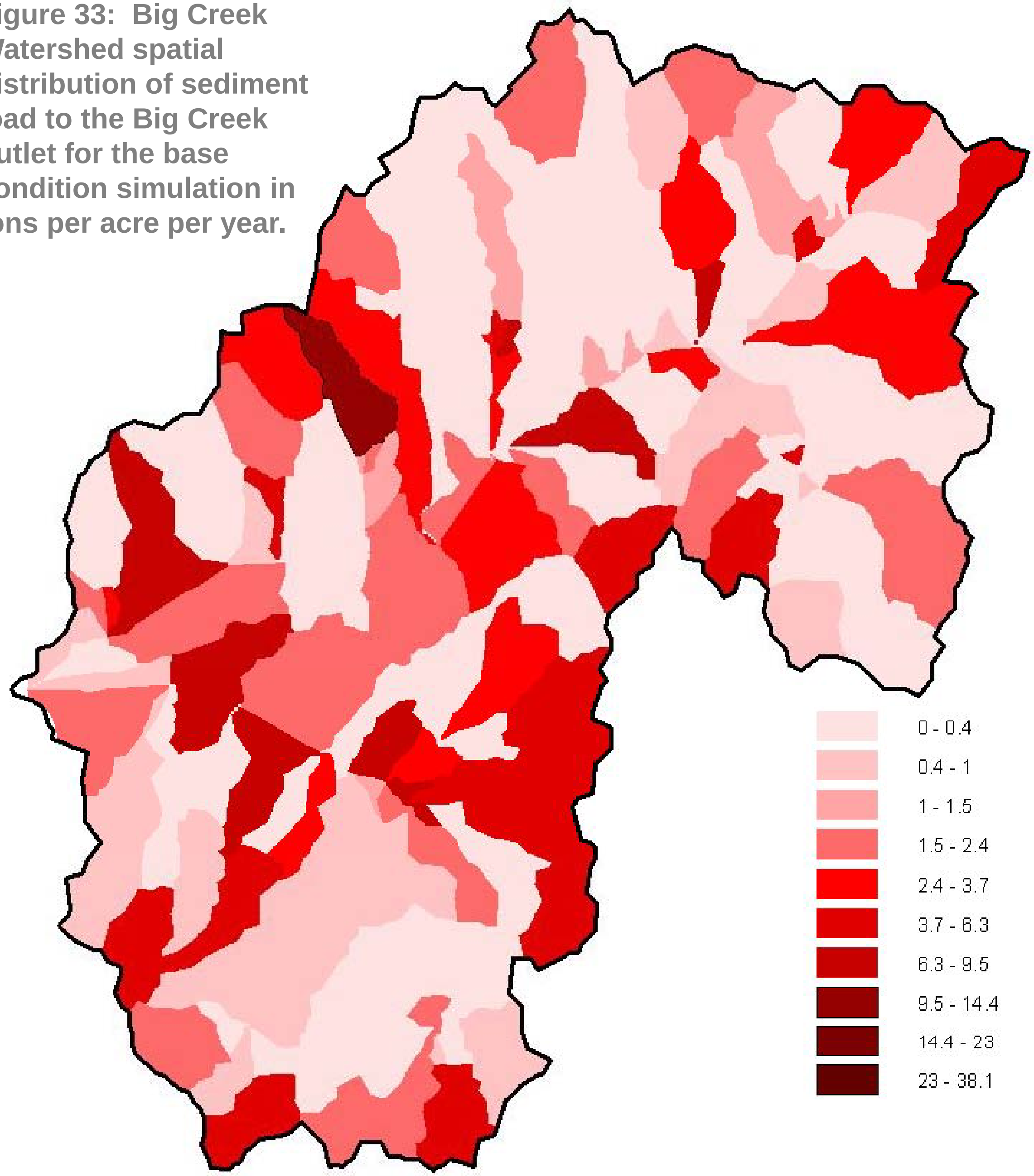
Source: Dennis Carmen

BIG CREEK
GULLY LOCATIONS



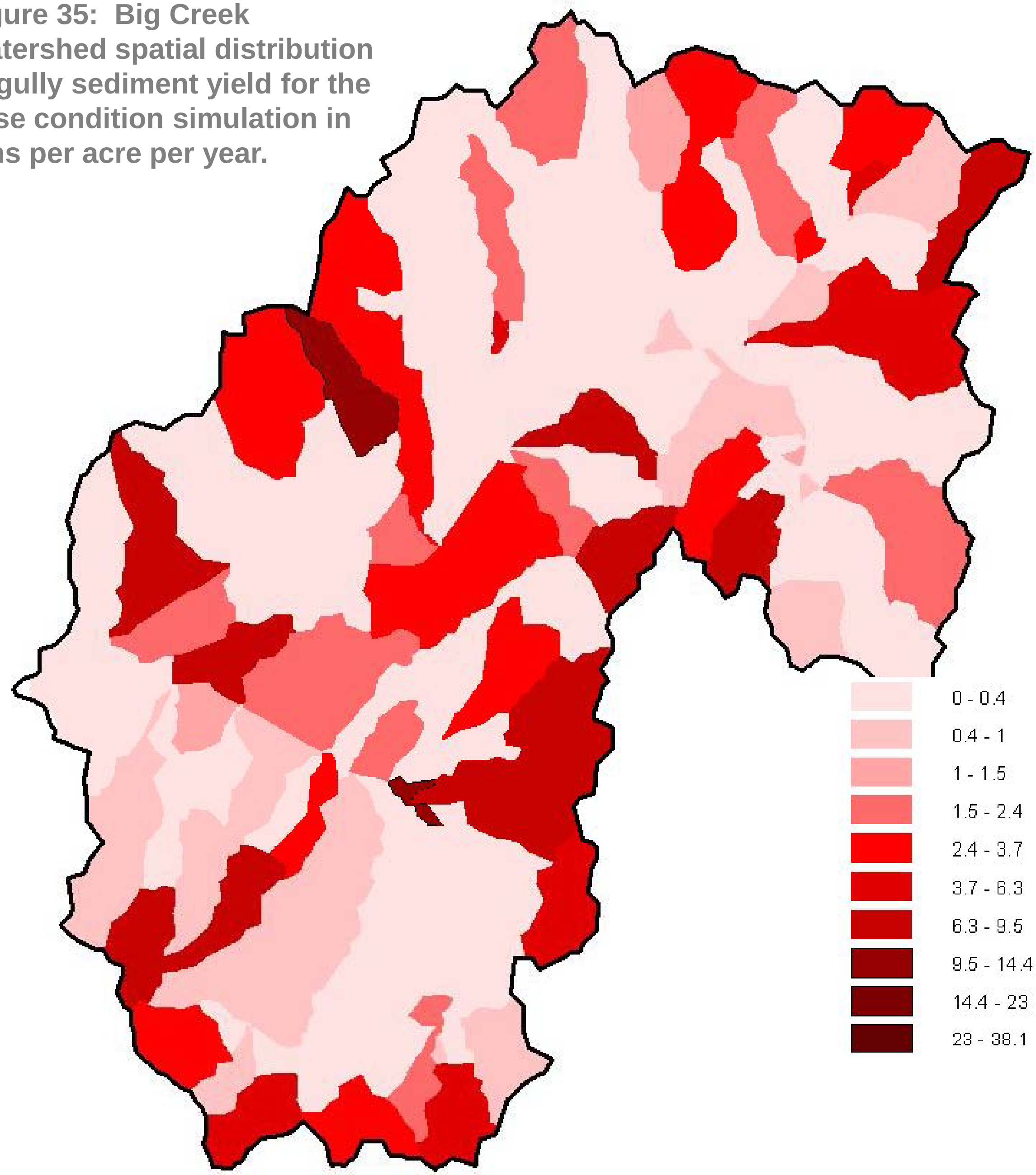
BASE CONDITION SEDIMENT LOAD

Figure 33: Big Creek Watershed spatial distribution of sediment load to the Big Creek outlet for the base condition simulation in tons per acre per year.



BASE CONDITION GULLY SEDIMENT YIELD

Figure 35: Big Creek Watershed spatial distribution of gully sediment yield for the base condition simulation in tons per acre per year.



Red = Top 10% sources
Yellow = Greater than watershed average sources

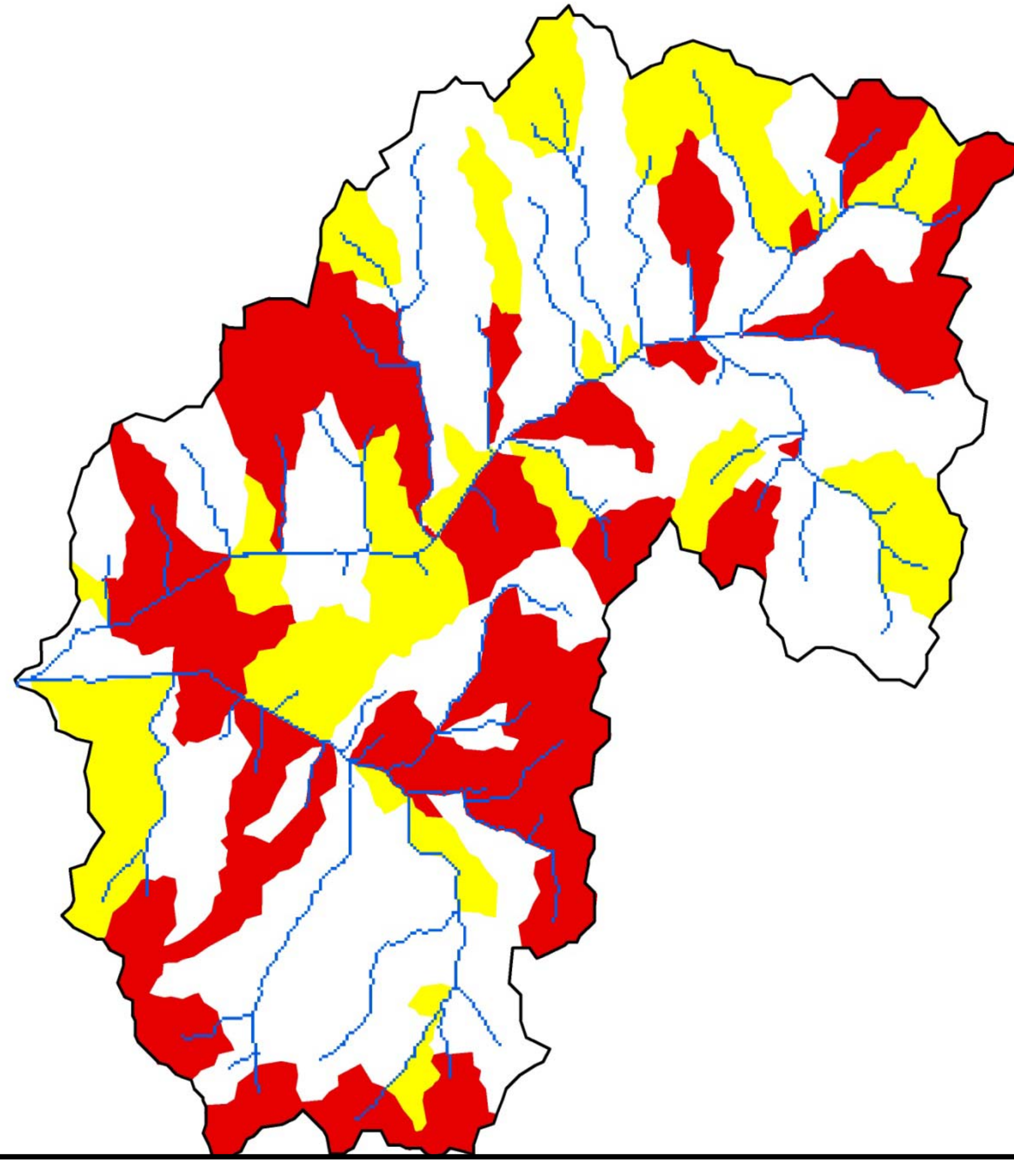
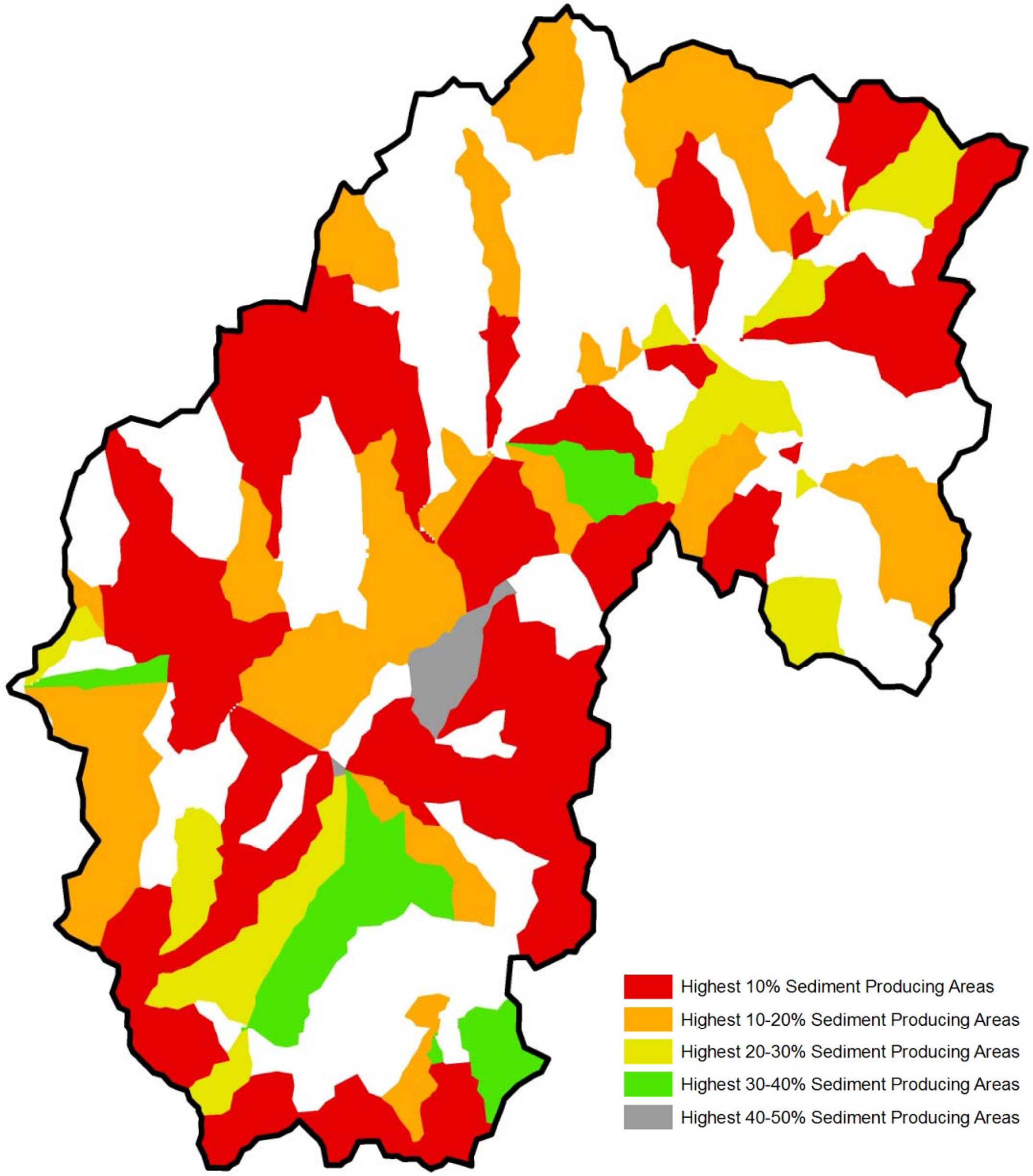


Figure 38: Big Creek Watershed portion of Cache River Watershed showing the top 10% sediment load producing areas in red and areas that produce sediment higher than the watershed average (yellow) from the base simulation with no gully control.

Big Creek Sub-Basin Highest Sediment Producing Areas - Base



Big Creek Sub-Basin

Table 9: Summary of Big Creek base condition simulation output

Item	Amount	Units
Watershed Average Runoff	7.54	in/yr
Watershed Average Total Rate of Erosion	5.11	t/ac/yr
Watershed Total Tons of Erosion	150,039	t/yr
Watershed Sediment Yield to Streams	2.18	t/ac/yr
Sediment Loading Rate to Watershed Outlet	1.90	t/ac/yr
Sediment Loading Amount to Watershed Outlet	55,817	t/yr
Highest Erosion from an Individual Cell w/gully	31.29	t/ac/yr
Highest Erosion from Individual Cell-Sheet&Rill	12.98	t/ac/yr

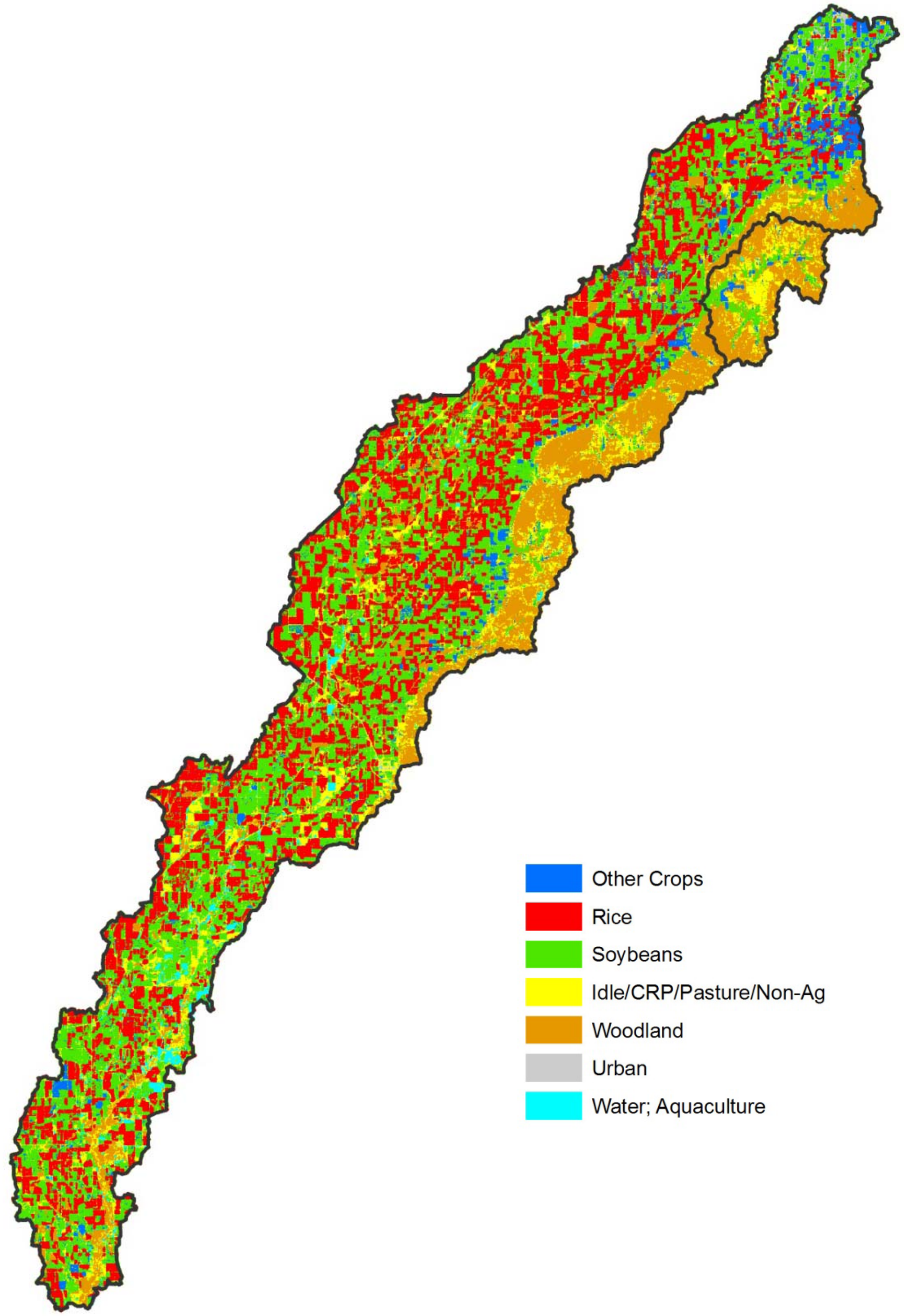
CACHE RIVER WATERSHED

UPSTREAM OF GRUBBS, AR

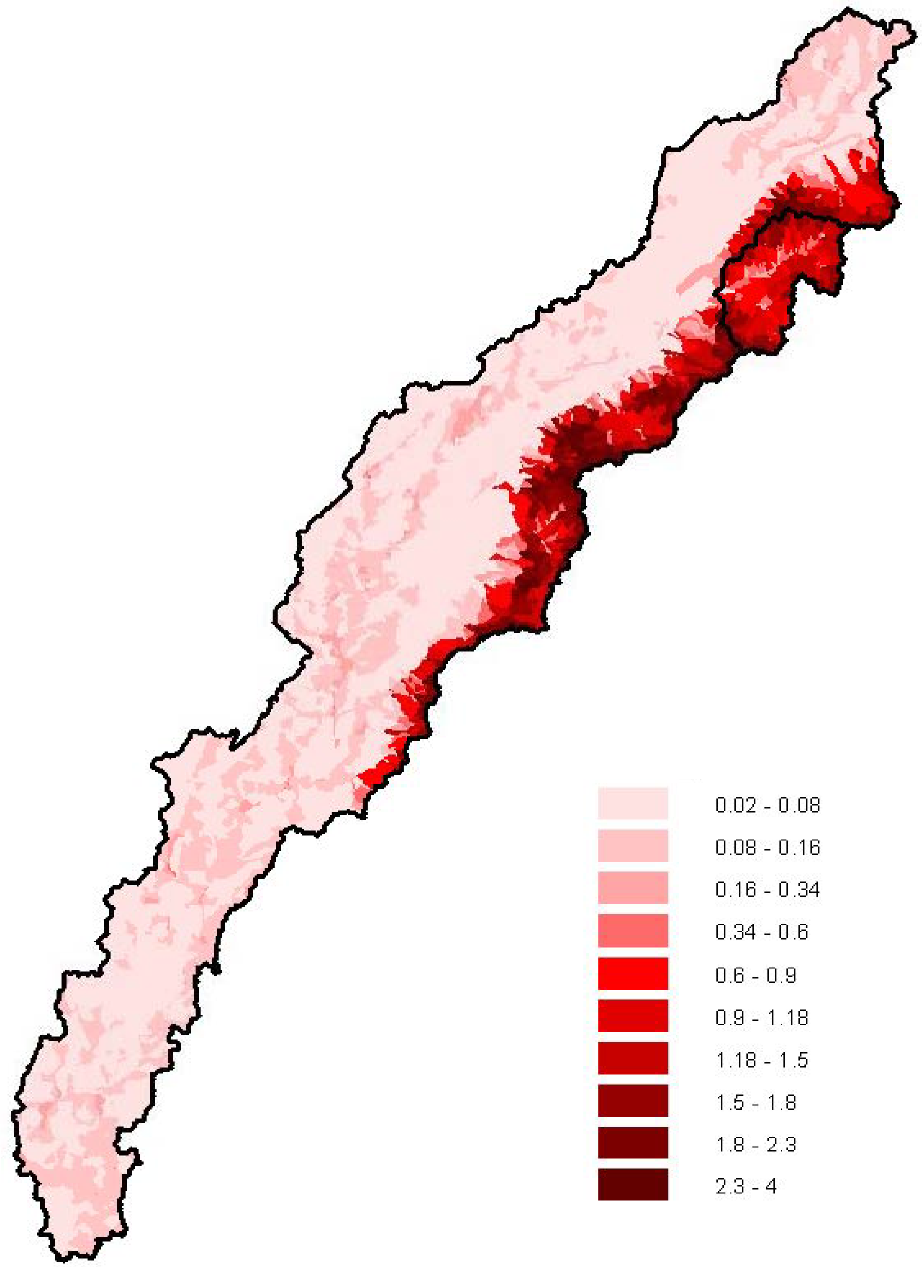
2004 NASS CDL for the Cache River Watershed.

Note the dominance of rice (red) and soybeans (bright green) in the flat areas.

Pasture (yellow) and forest (dull green) dominate in the Crowley's Ridge area.

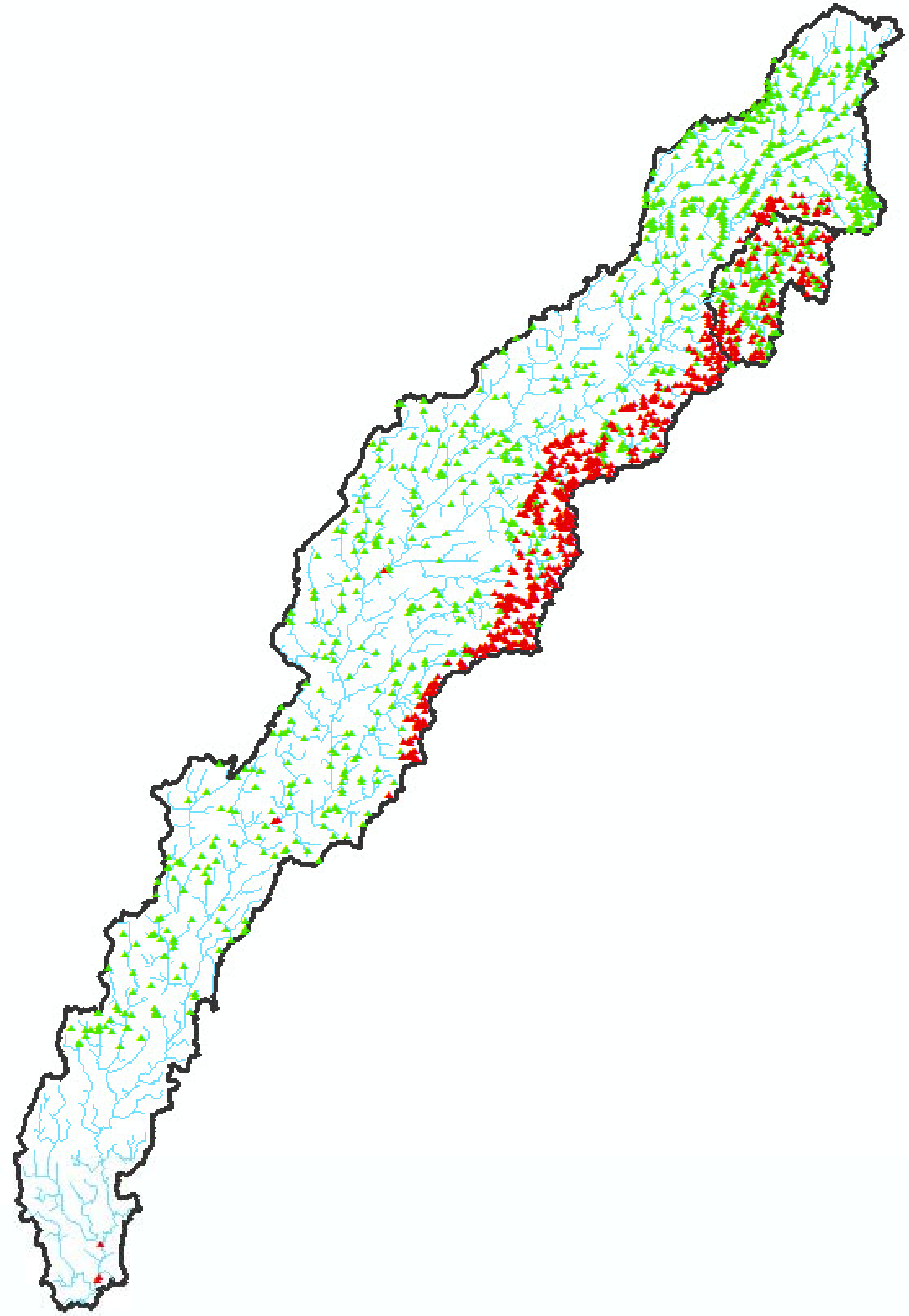


RUSLE LS-Factors designated
for each AnnAGNPS cell



GULLY LOCATIONS

USACE gully locations (green), and the AGNPS-generated gully locations (red)



BASE CONDITION SEDIMENT LOAD

Figure 21: Spatial distribution of sediment load for the base condition simulation in tons per acre per year.

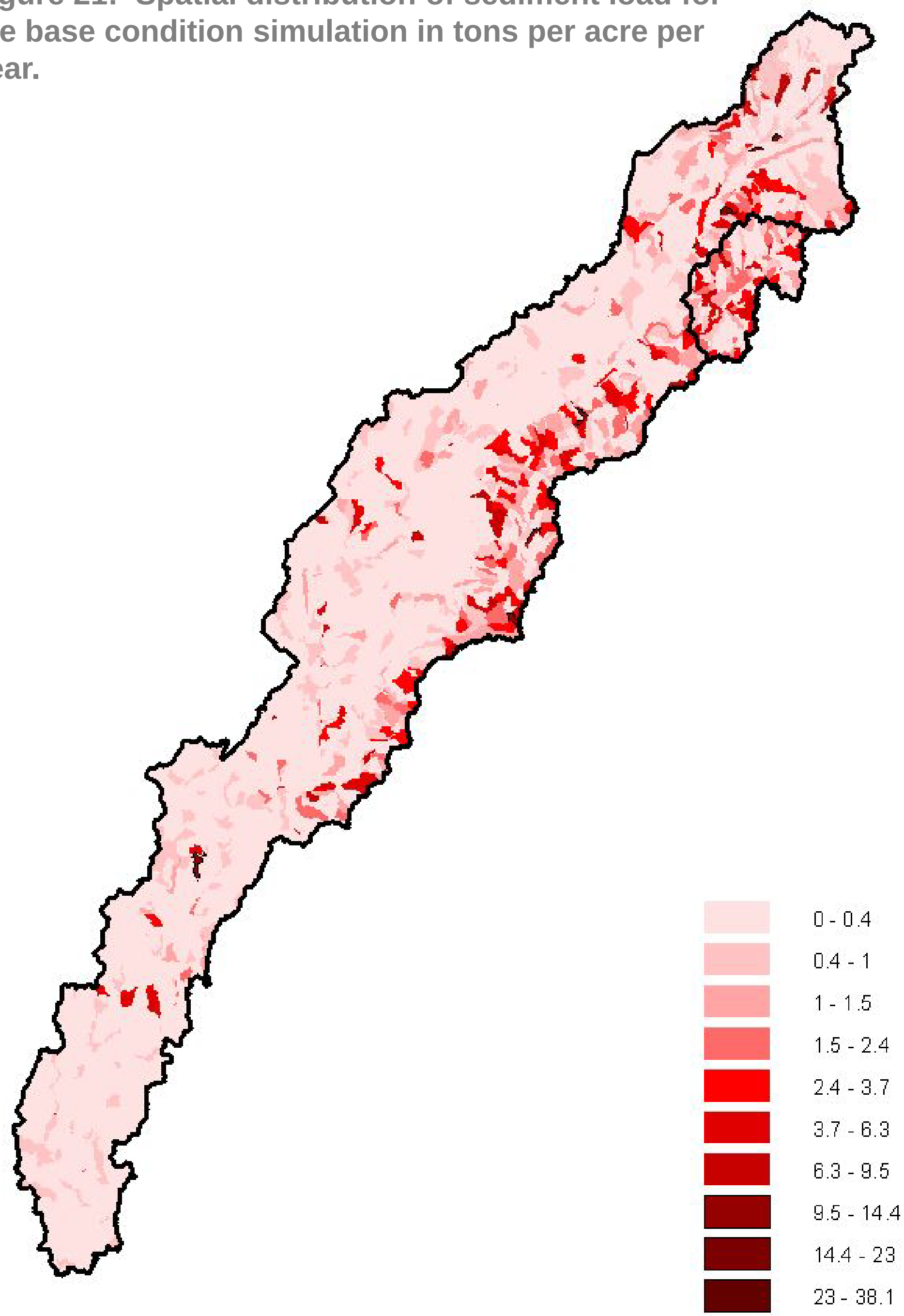
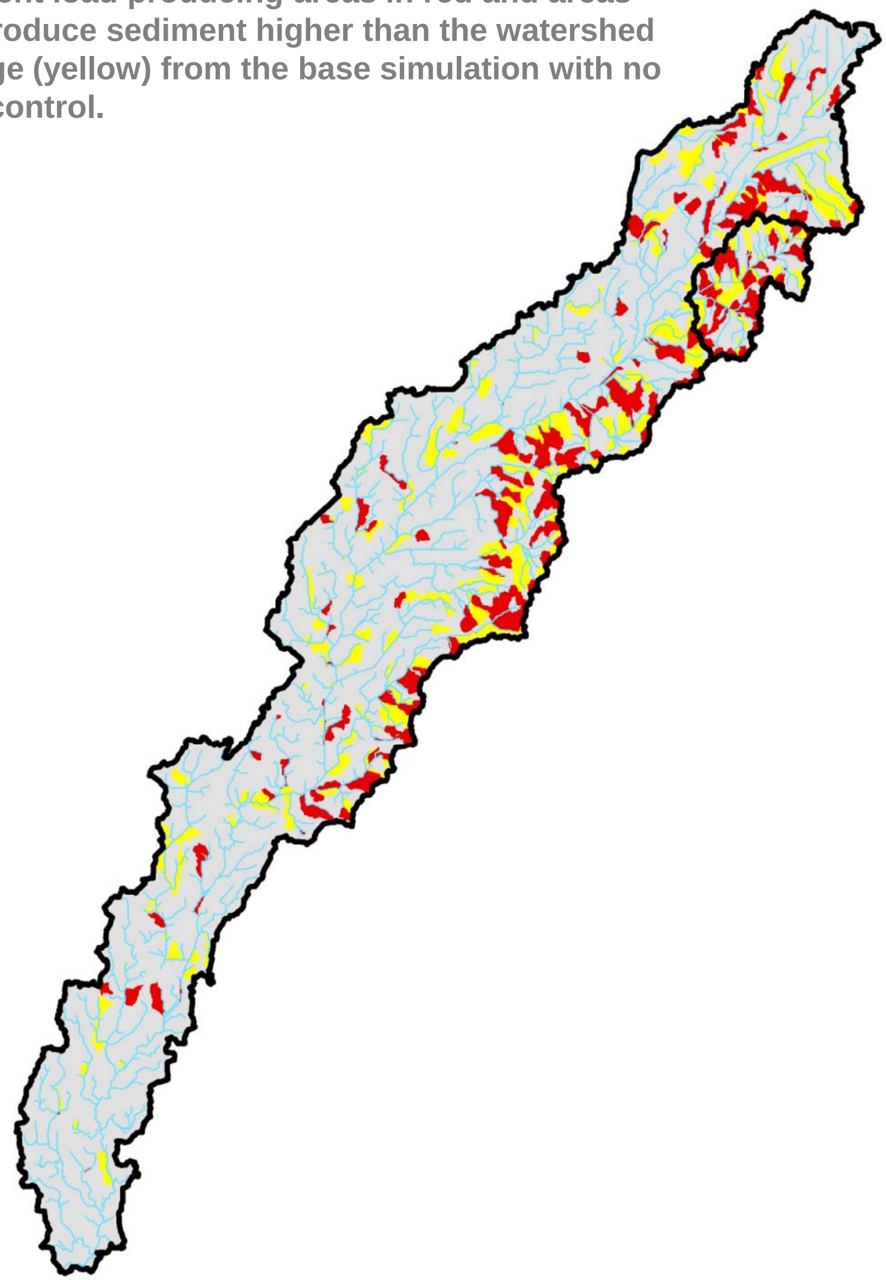


Figure 26: Cache River Watershed top 10% sediment load producing areas in red and areas that produce sediment higher than the watershed average (yellow) from the base simulation with no gully control.

Red = Top 10% sources
Yellow = Greater than watershed average sources



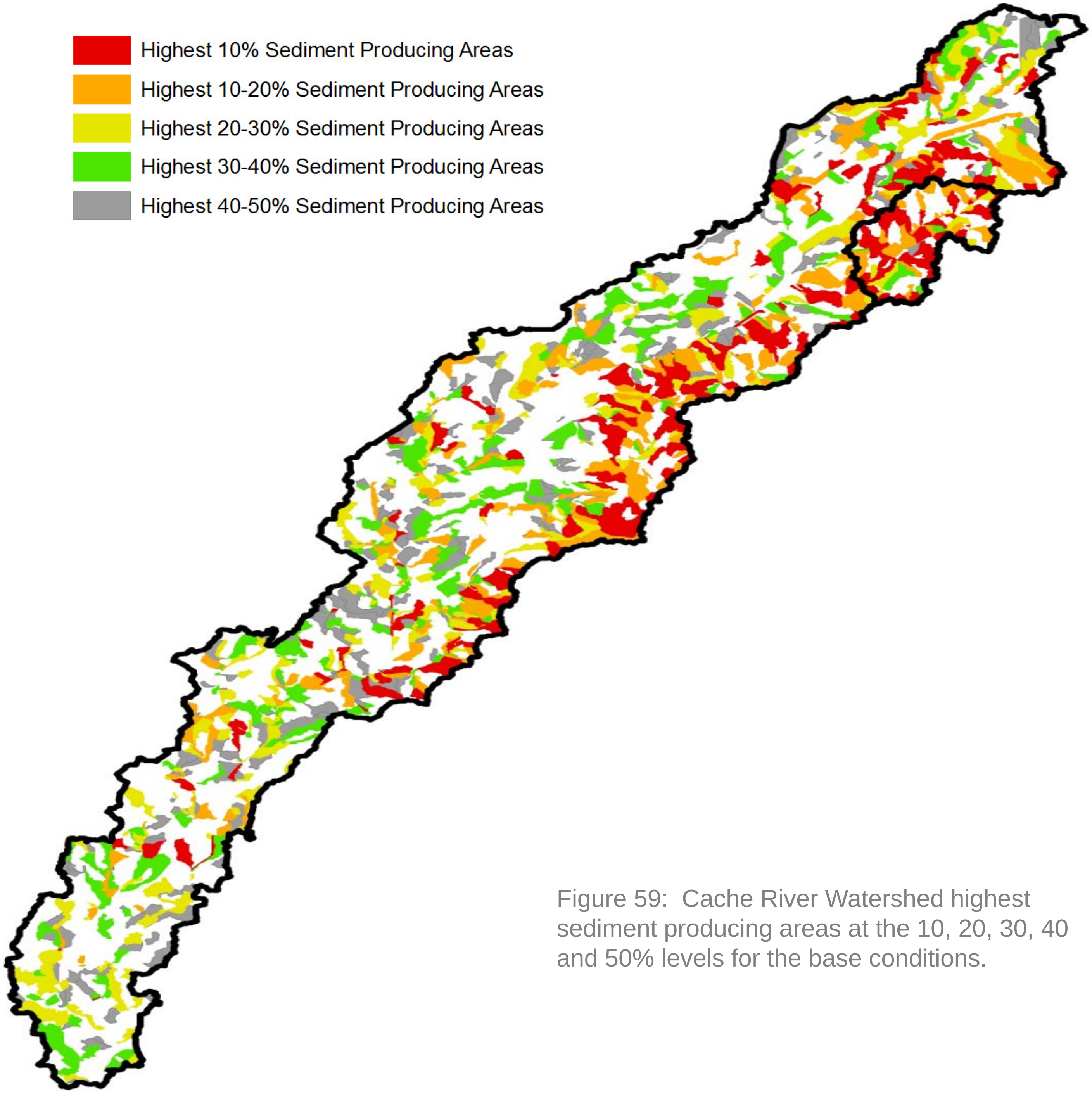


Figure 59: Cache River Watershed highest sediment producing areas at the 10, 20, 30, 40 and 50% levels for the base conditions.

Cache River Watershed

Upstream of Grubbs, AR

Table 7: Summary of base condition simulation output

Item	Amount	Units
Watershed Average Runoff	14.50	in/yr
Watershed Average Total Rate of Erosion	2.27	t/ac/yr
Watershed Total Tons of Erosion	1,364,690	t/yr
Watershed Sediment Yield to Streams	0.84	t/ac/yr
Sediment Loading Rate to Watershed Outlet	0.59	t/ac/yr
Sediment Loading Amount to Watershed Outlet	352,072	t/yr
Highest Erosion from an Individual Cell w/gully	38.14	t/ac/yr
Highest Erosion from Individual Cell-Sheet&Rill	17.86	t/ac/yr

Comparison of Big Creek and Cache River above Grubbs, AR AnnAGNPS Outputs (BASE)

Base Condition Simulation Output Comparison

Item	Amount (Big Creek)	Amount (Entire Watershed)	Units
Watershed Average Runoff	7.54	14.5	in/yr
Watershed Average Total Rate of Erosion	5.11	2.27	t/ac/yr
Watershed Total Tons of Erosion	150,039	1,364,690	t/yr
Watershed Sediment Yield to Streams	2.18	0.84	t/ac/yr
Sediment Loading Rate to Watershed Outlet	1.90	0.59	t/ac/yr
Sediment Loading Amount to Watershed Outlet	55,817	352,072	t/yr
Highest Erosion from an Individual Cell w/gully	31.29	38.14	t/ac/yr
Highest Erosion from Individual Cell-Sheet&Rill	12.98	17.86	t/ac/yr

AGNPS Scenarios

- Base Condition (circa present day, 2004)
- Gully Control
  - Entire Watershed
  - Crowley's Ridge only
  - Big Creek
- Conservation Tillage (no/minimum till)
- CRP
  - Entire Watershed
  - Crowley's Ridge only
- Flashboard Risers
- Reforestation
  - Entire Watershed
  - Cropland
  - Uplands (primarily Crowley's Ridge)
- Channel stabilization
- Various Combinations of Above

Change in Sedimentation between mid-1980's and 2010

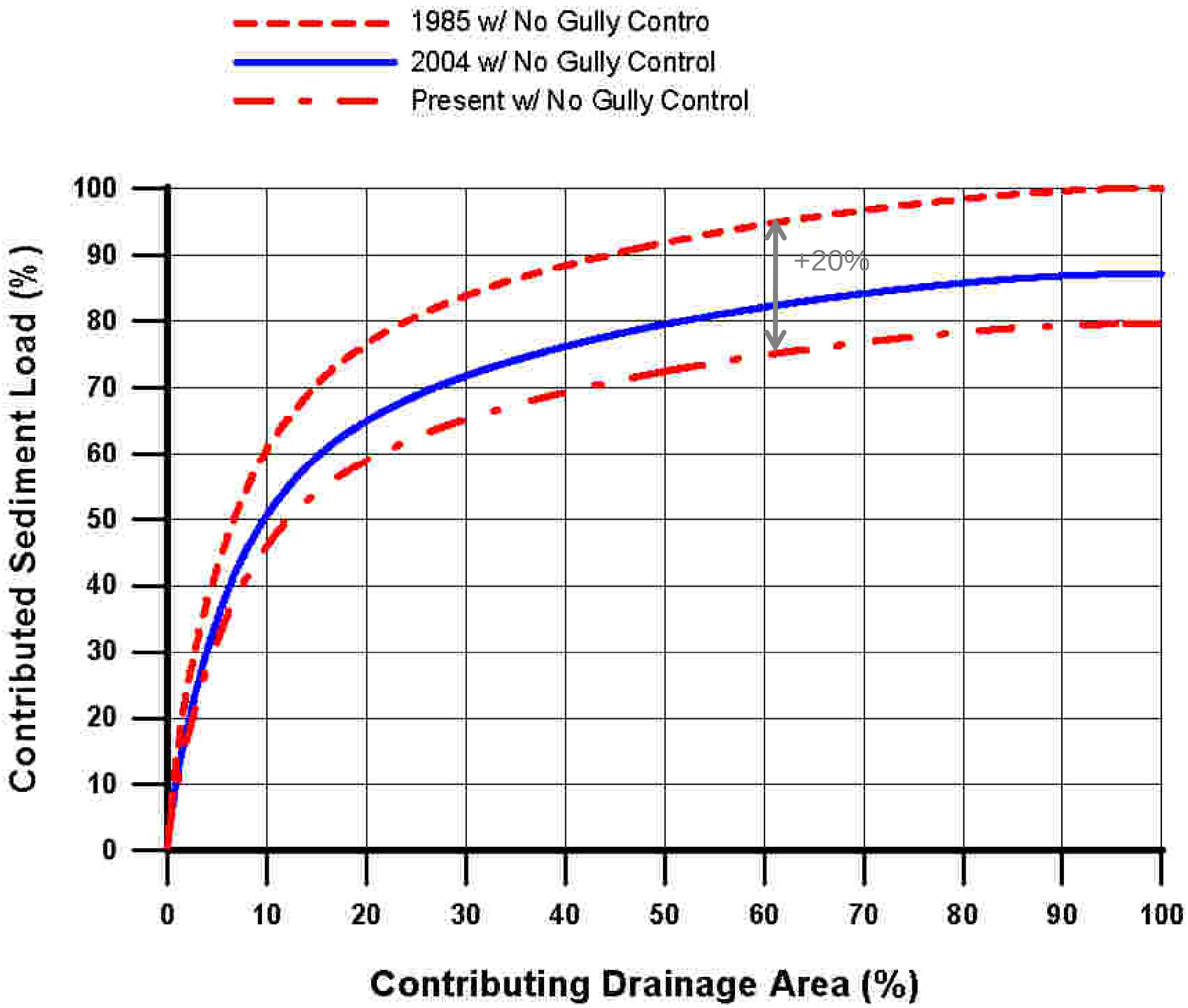
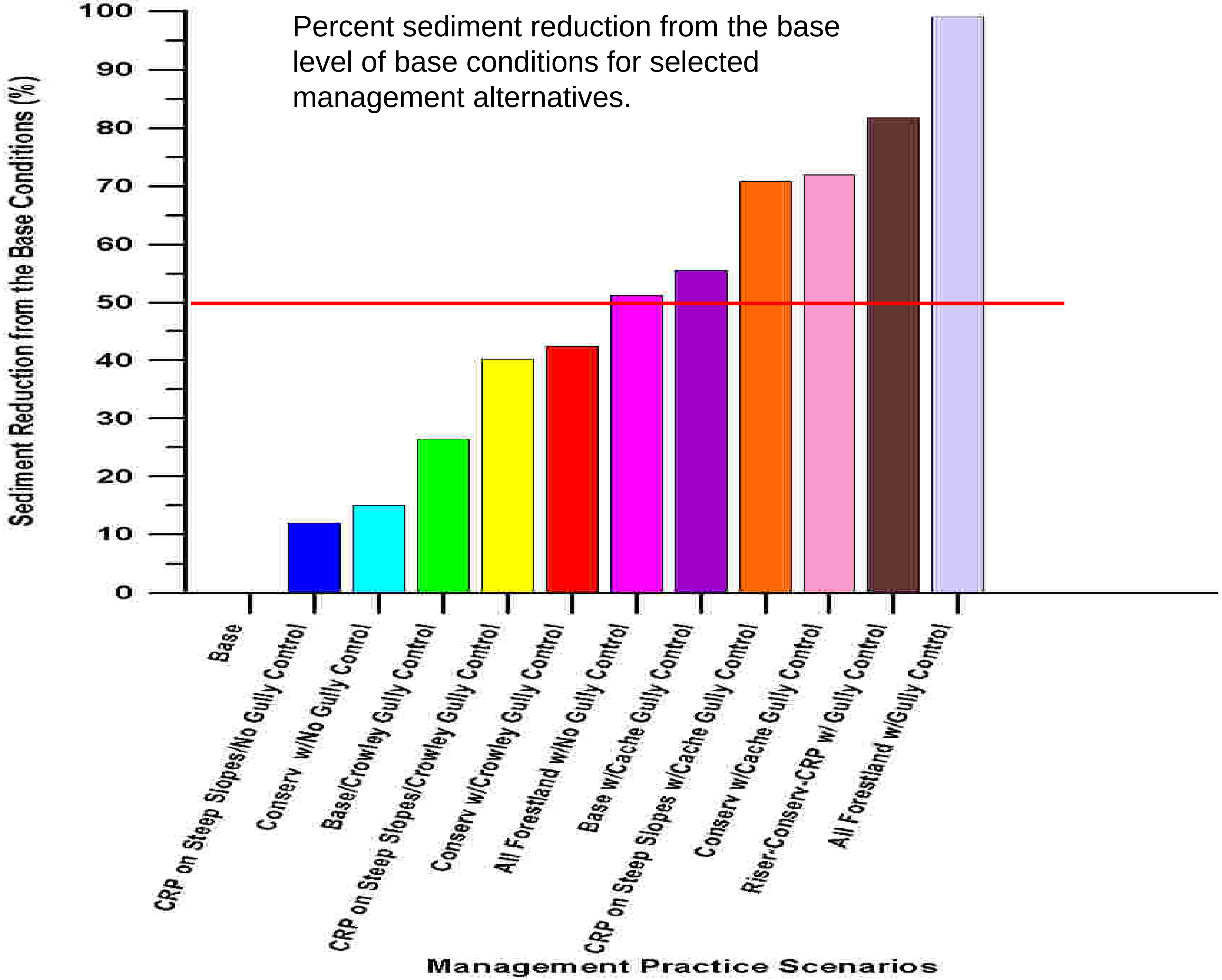


Table 8: Summary of Sediment load at the outlet of Cache River watershed with and without channel erosion control.

Item	Total Load w/ Channel Erosion (t/ac/yr)	Total Load w/out Channel Erosion (t/ac/yr)
Base	0.6164	0.5866
Base with gully control over the entire watershed	0.3078	0.2865
Base with gully control on Crowley's Ridge only	0.1879	0.0062
All Forest without gully control	0.3372	0.2613
All Forest with gully control over the entire watershed	0.4776	0.432
Conservation tillage with gully control on Crowley's Ridge only	0.2387	0.165
Conservation tillage with gully control over the entire watershed	0.3827	0.338
Conservation tillage without gully control	0.5273	0.4984
CRP with gully control over the entire watershed	0.2495	0.1712
CRP with gully control on Crowley's Ridge only	0.4007	0.3506
CRP with gully control	0.5531	0.5162


Percent sediment reduction from the base level of base conditions for selected management alternatives.
Sediment Reduction from the Base Conditions (%)
100
90
80
70
60
50
40
30
20
10
0
Base
CRP on Steep Slopes/No Gully Control
Conserv w/No Gully Control
Base/Crowley Gully Control
CRP on Steep Slopes/Crowley Gully Control
Conserv w/Crowley Gully Control
All Forestland w/No Gully Control
Base w/Cache Gully Control
CRP on Steep Slopes w/Cache Gully Control
Conserv w/Cache Gully Control
Riser-Conserv-CRP w/ Gully Control
All Forestland w/Gully Control
Management Practice Scenarios

SEDIMENT LOAD BY CONTRIBUTING DRAINAGE AREA

CURRENT CONDTIONS

No gully control (blue)

Gully control for Crowley's Ridge (green)

Gully control for entire watershed (red)

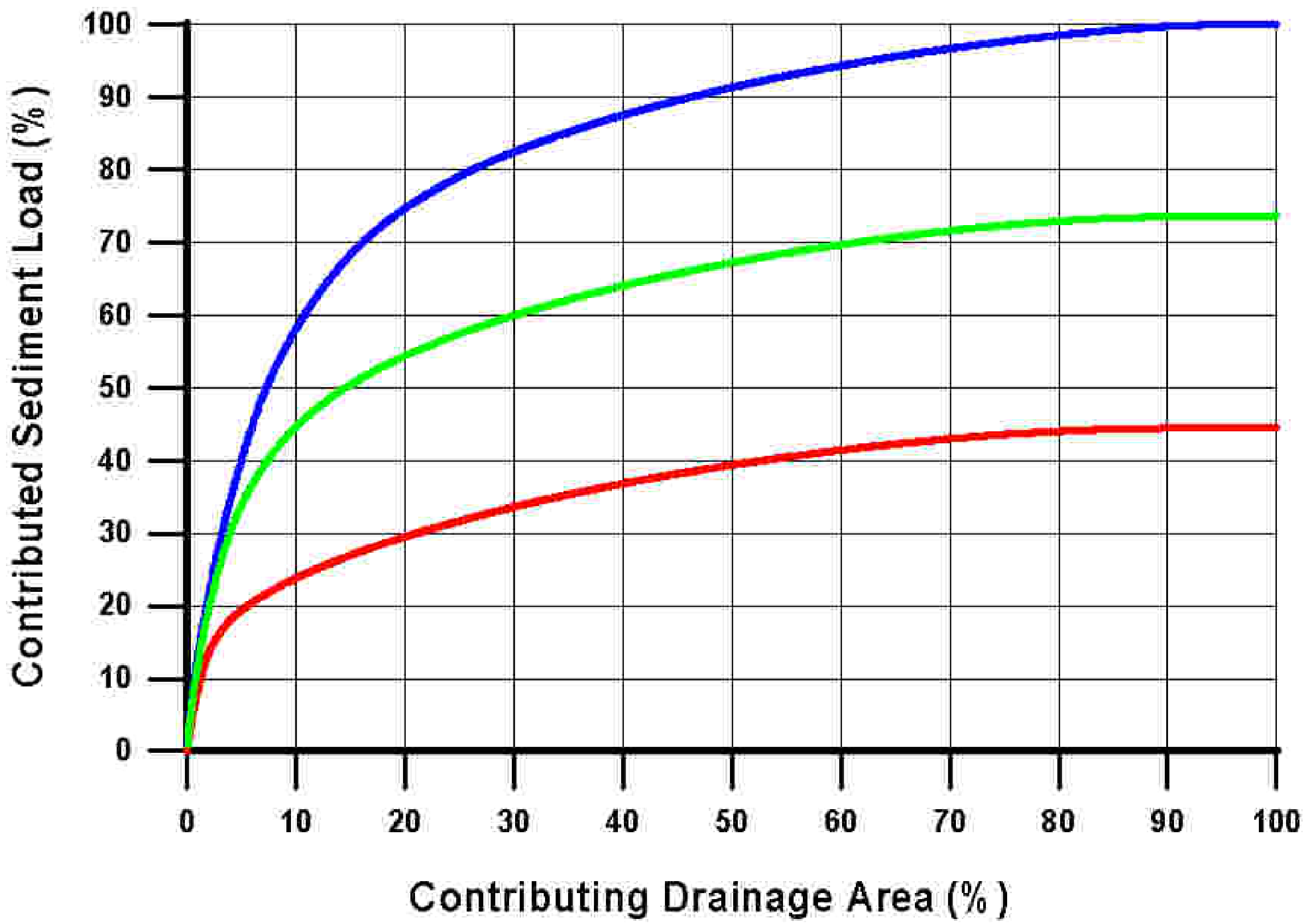


Figure 28: Cache River Watershed Sediment Load by contributing drainage area for all conditions including those with no gully control, gully control for the entire watershed, and gully control only for Crowley's Ridge.

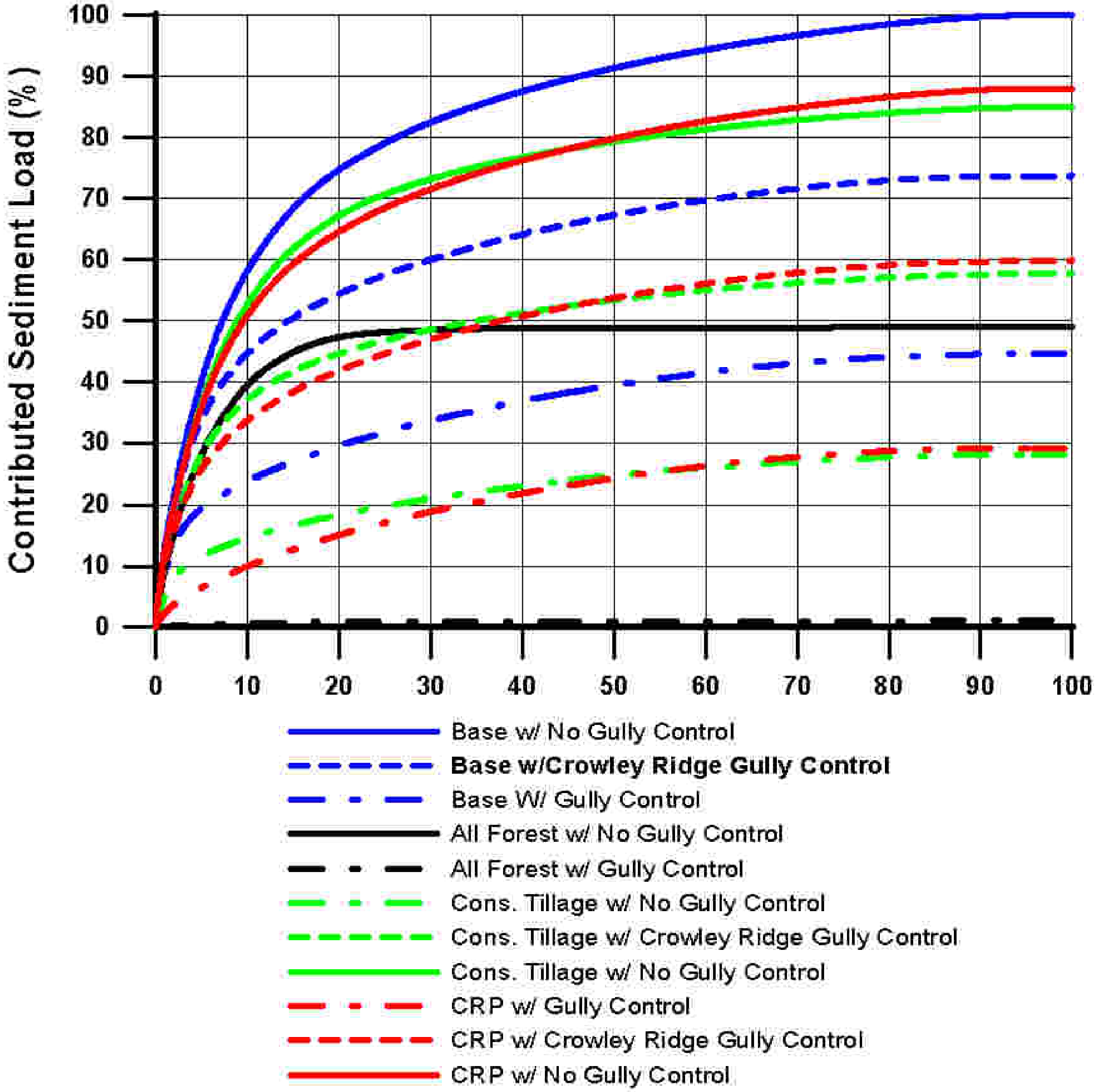
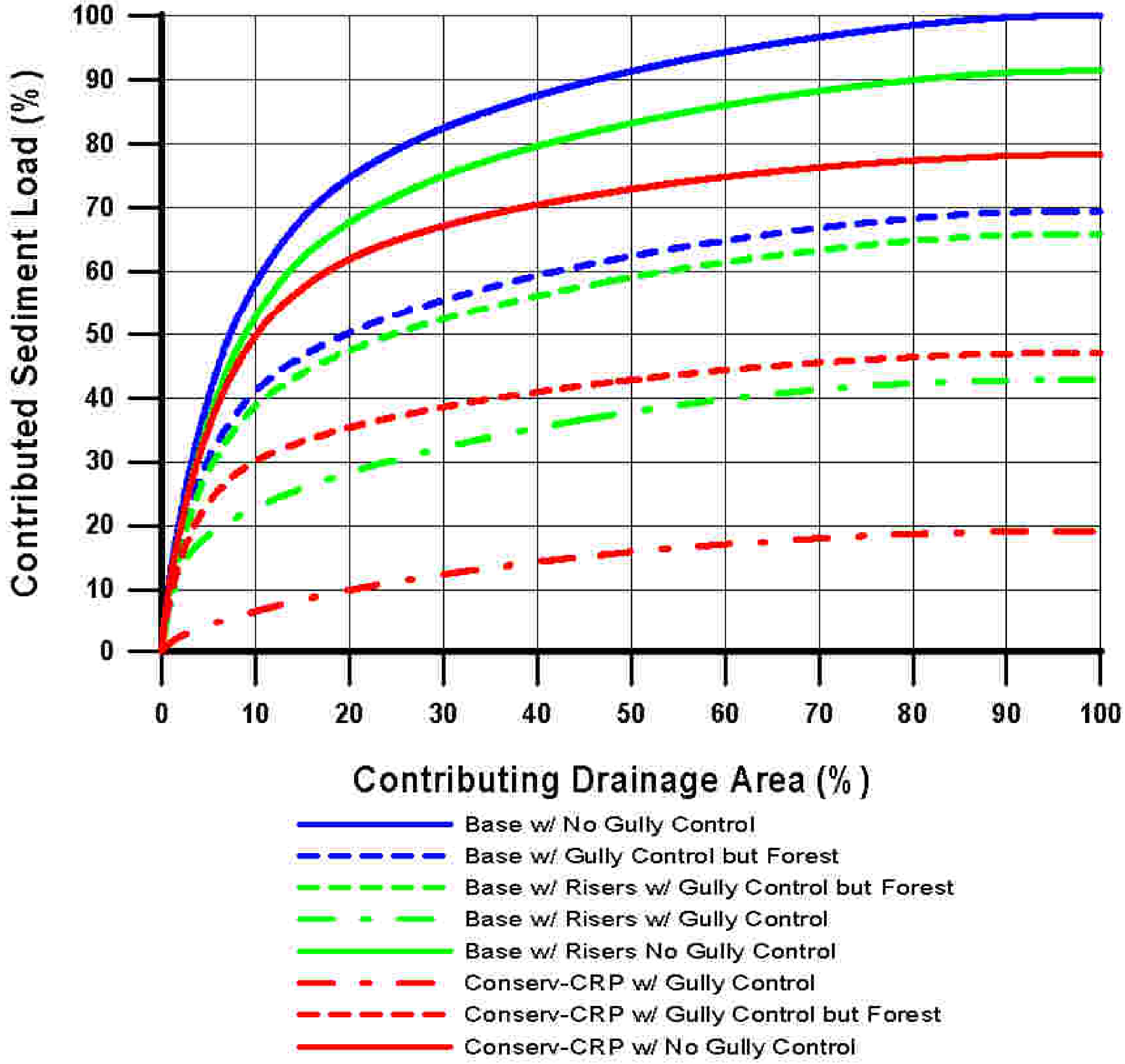
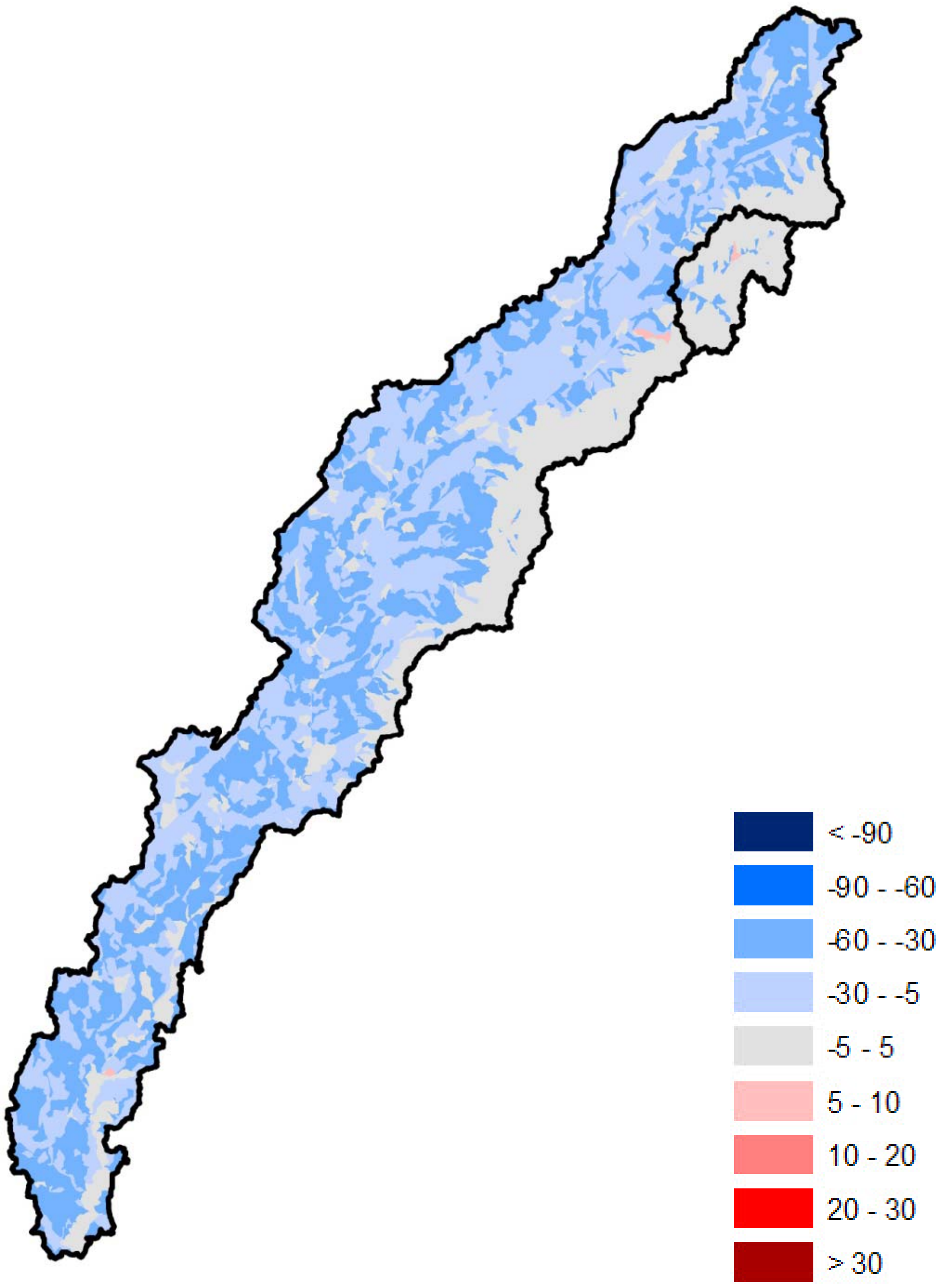


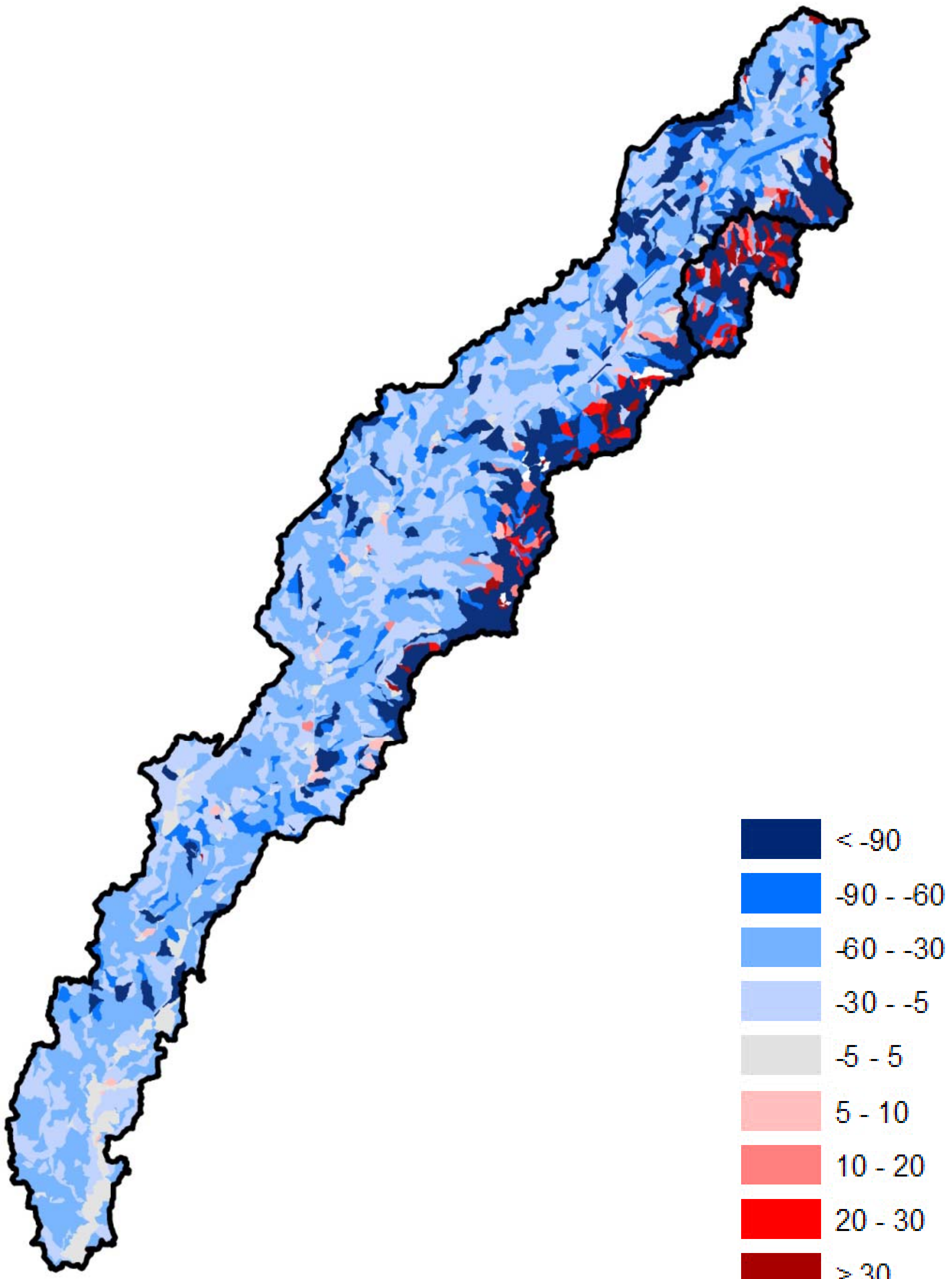
Figure 29: Cache River Watershed Sediment Load by contributing drainage area for additional conditions including those with gully control for the entire watershed but forests, riser boards, and no-tillage conservation practices with CRP.



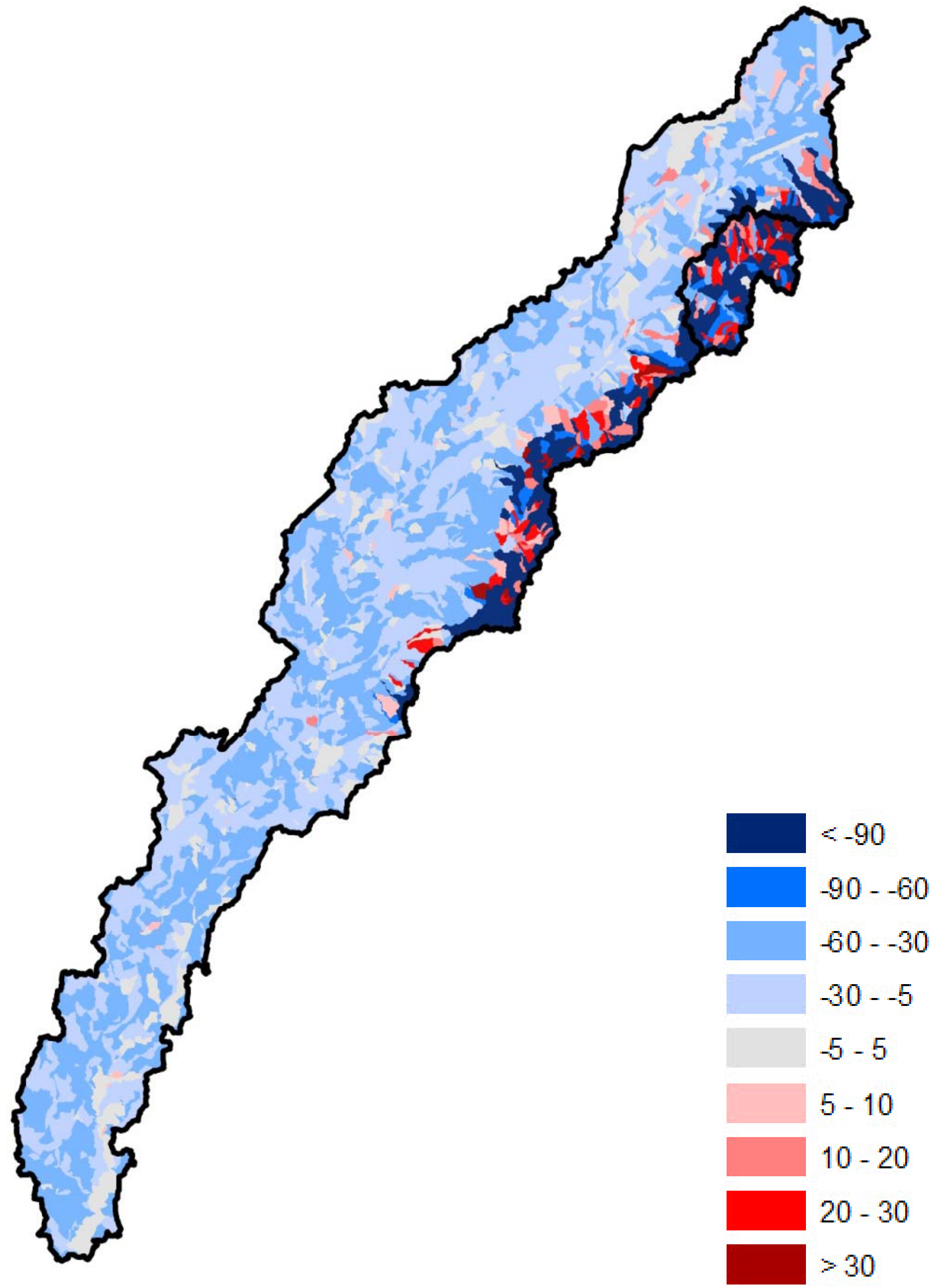
Load Reductions (BLUE) and Increases (RED) from base condition—Conservation Tillage for entire watershed and no gully control.

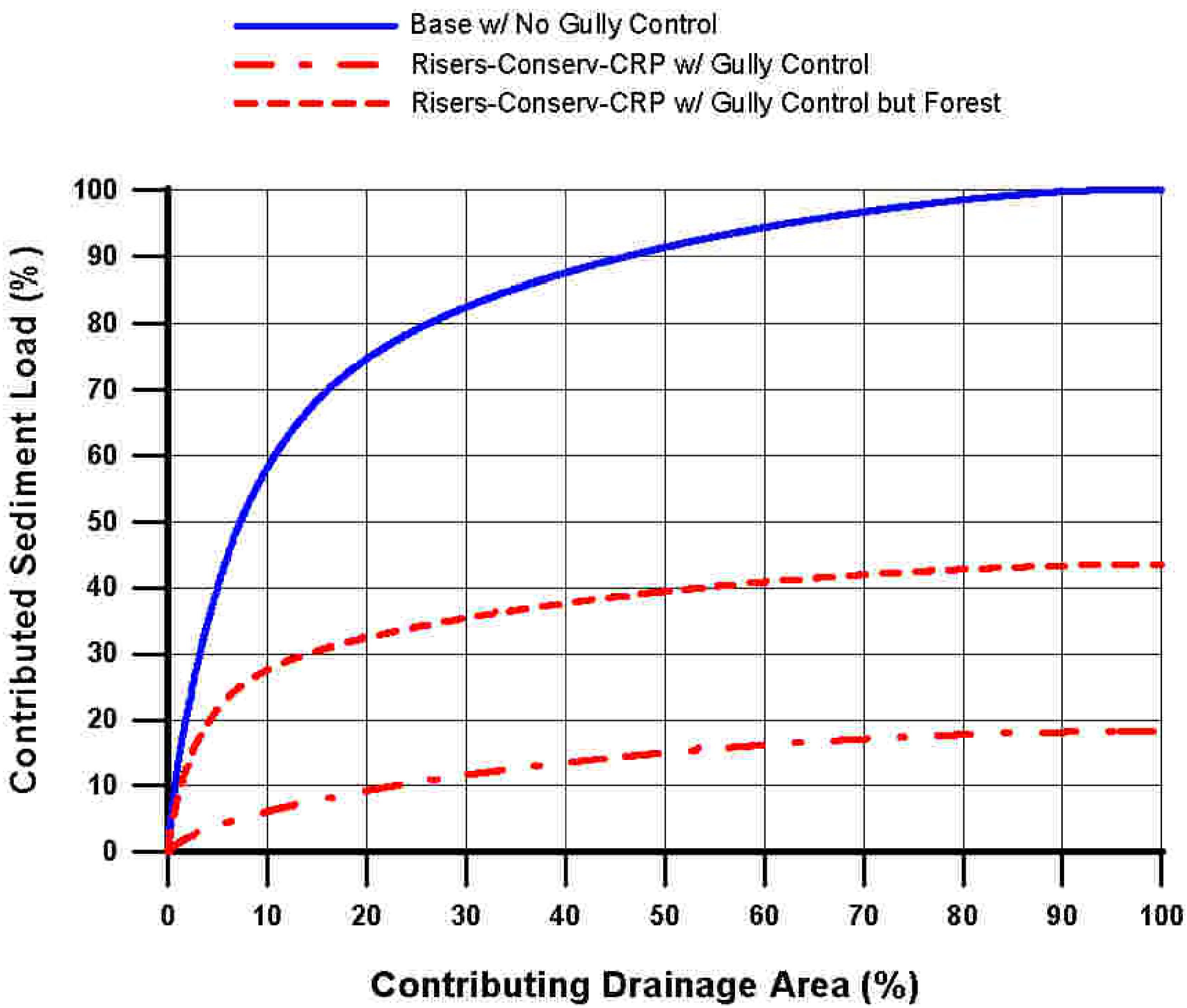


Load Reductions (BLUE) and Increases (RED) from base condition—Conservation Tillage and gully control entire watershed.

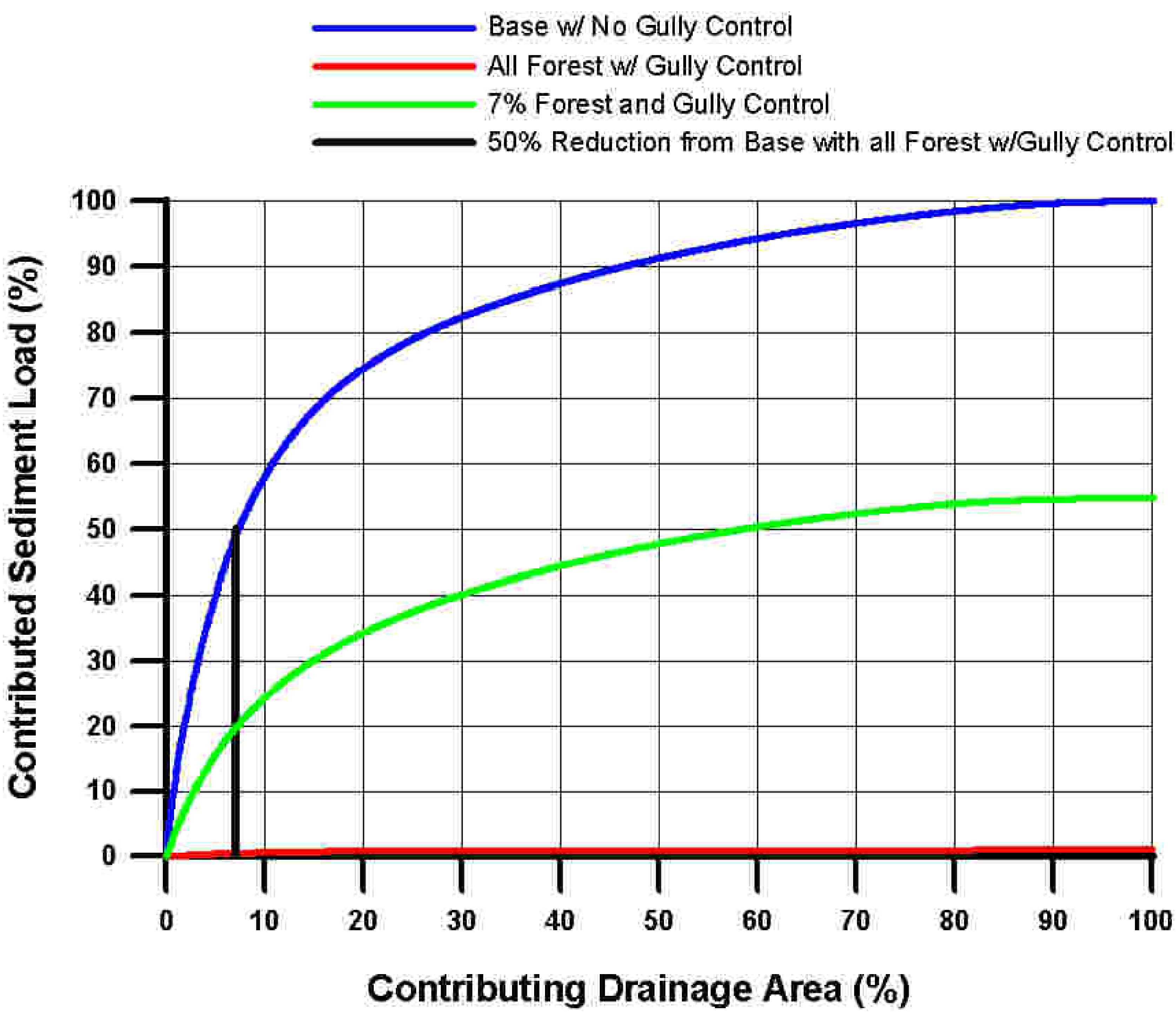


Load Reductions (BLUE) and Increases (RED) from base condition—Conservation Tillage and gully control only in Crowley's Ridge area.





Base w/ No Gully Control
Risers-Conserv-CRP w/ Gully Control
Risers-Conserv-CRP w/ Gully Control but Forest
Contributed Sediment Load (%)
0
10
20
30
40
50
60
70
80
90
100
Contributing Drainage Area (%)

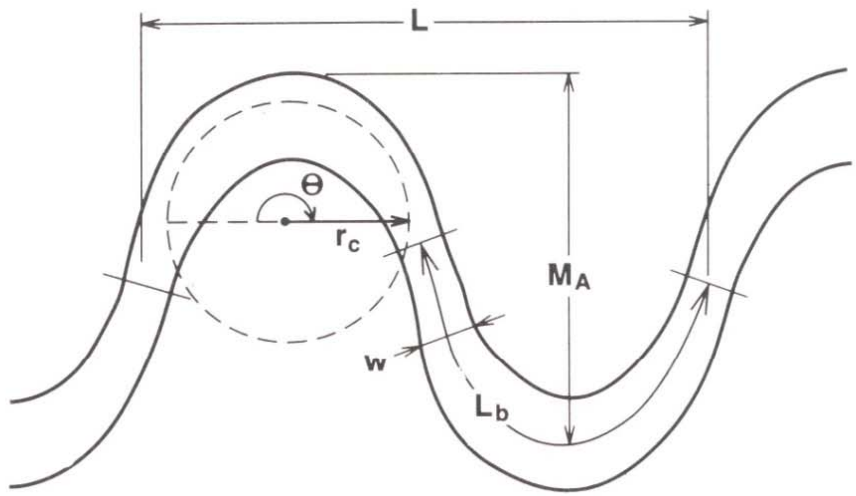


Base w/ No Gully Control
All Forest w/ Gully Control
7% Forest and Gully Control
50% Reduction from Base with all Forest w/Gully Control
Contributed Sediment Load (%)
0
10
20
30
40
50
60
70
80
90
100
0
10
20
30
40
50
60
70
80
90
100
Contributing Drainage Area (%)

Sedimen Transport Model

- •HEC-RAS Sediment – 1-D numerical model used for simulation
- •Existing Conditions model from 1992 used in calibration
- •Base Conditions—Previous HEC-6 model geometry updated with 2007 surveys
- •Alternatives—
  - •Avoid existing historic channel alignment due to blockages and physical access, constructability, and maintenance issues
  - •Use “reference reach” approach to define alignment and geometry for alternative channels
  - •Sediment Loads
    - •Initial same as in 1990’s model
    - •Adjust to reflect reduced loads with changed farming practices (2010 vs 1985)
    - •Consider several reductions as indicated by watershed sediment modeling with AGNPS
  - •Sediment Trap(s) to preserve channel capacity without passing problem downstream

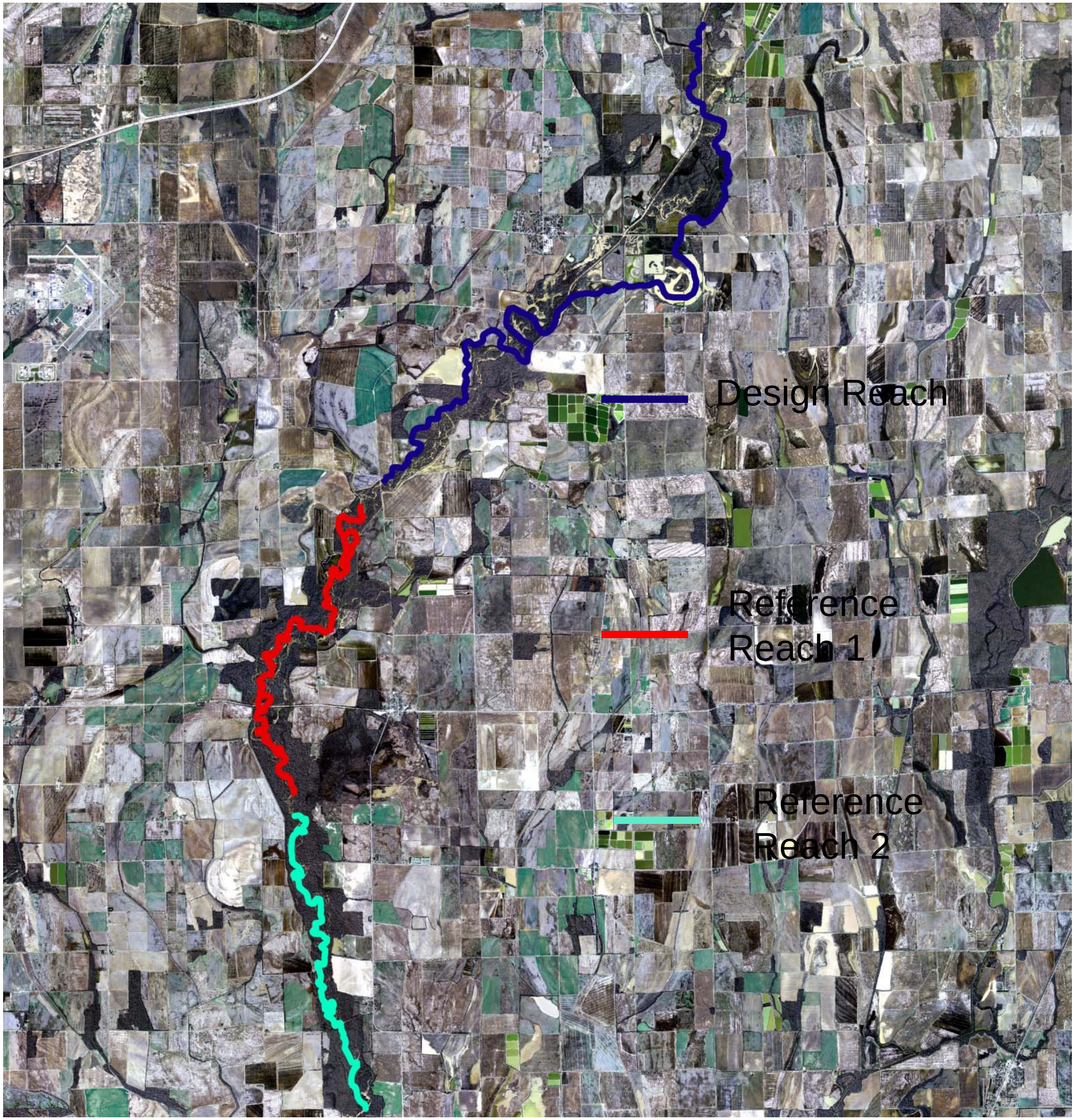
Reference Reach Approach for Alternative Alignments

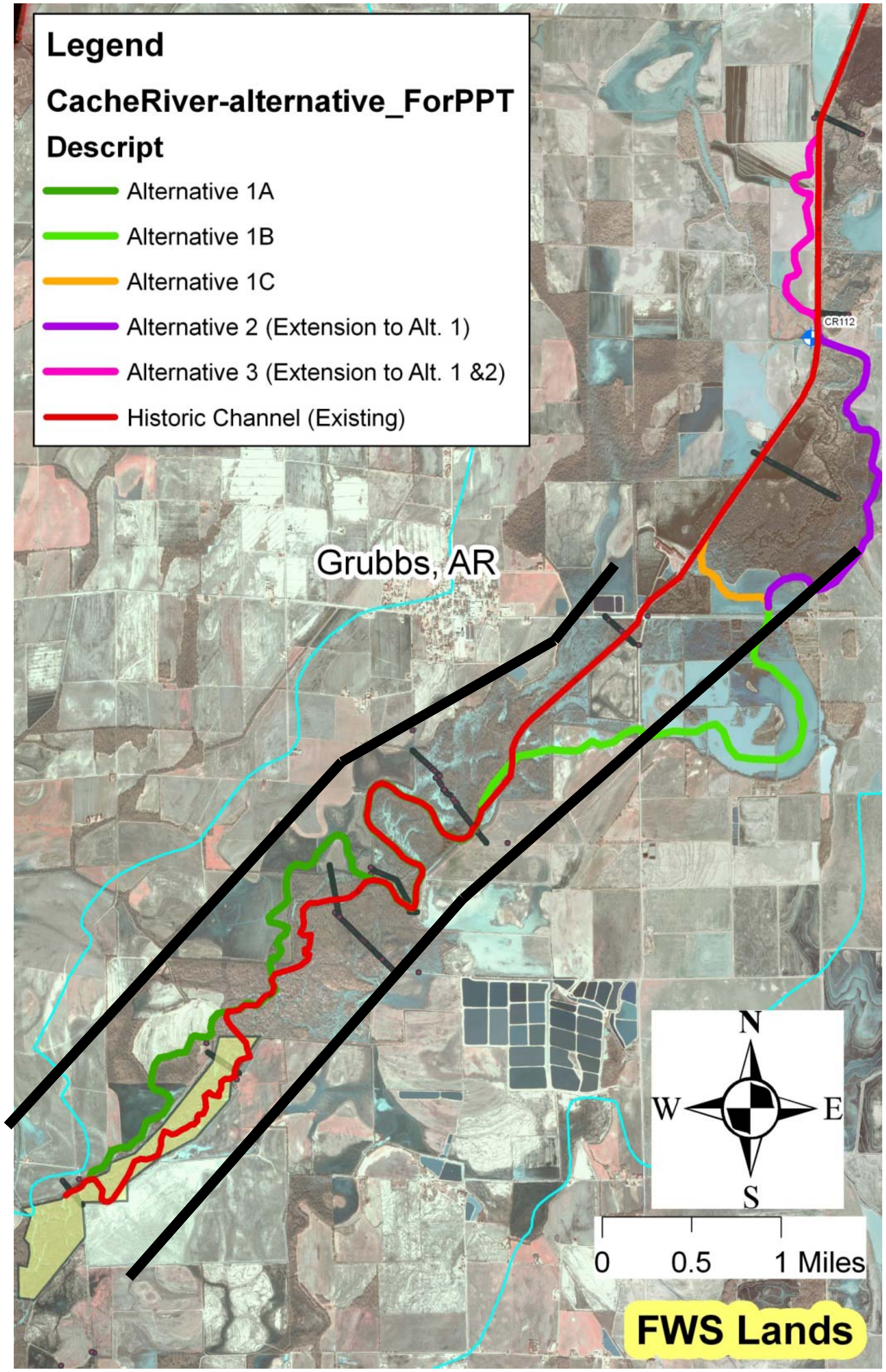


L Meander wavelength
L_b Meander arc length
w Average top bank width
M_A Meander amplitude
r_c Radius of curvature
Θ Arc angle

Figure 2.3 Variables used to describe and design meanders (adapted from Rechard and Hasfurther 1980)

Reference Reach





Legend
CacheRiver-alternative_ForPPT
Descript
Alternative 1A
Alternative 1B
Alternative 1C
Alternative 2 (Extension to Alt. 1)
Alternative 3 (Extension to Alt. 1 &2)
Historic Channel (Existing)
CR112
Grubbs, AR
N
W
E
S
0
0.5
1 Miles
FWS Lands

Summary

- Upper Cache Sediment Study (Watershed sediment budget)
  - AnnAGNPS modeling component nearing completion
    - A Number of management practice scenarios considered
      - Separately
      - Various combinations
    - Considered Reasonable level of participation
    - Identified highest sources of sediment contribution
      - Ranked model cell sediment loads into 10% intervals to aid in focusing future efforts
    - Attempted to give relationships to guide in selecting appropriate level of implementation to achieve various degree of sediment load reduction
  - AnnAGNPS results give good relative comparisons between alternatives and the base. Results are not quantitative, but give consistent estimates for each scenario modeled.

Summary (continued)

- Upper Cache Sediment Study (Sediment Routing)
  - HEC-RAS sediment simulation analyzed sediment reduction necessary to achieve short-term AND long-term solution to blockages
    - Can long-term target be achieved?
      - Target can be reasonably be achieved (technically), but costs will be high (on order of $100-200 million or more for full implementation)
      - Likely require additional Congressional authorizations to implement watershed measures
    - What maintenance can be expected for short-term solution?
      - Still working this question, but outlook is frequent maintenance will be required until additional watershed features could be in place. USDA-NRCS currently working MRBI (~$3 million funding to start 5 year program)

? Questions *?*

THE END

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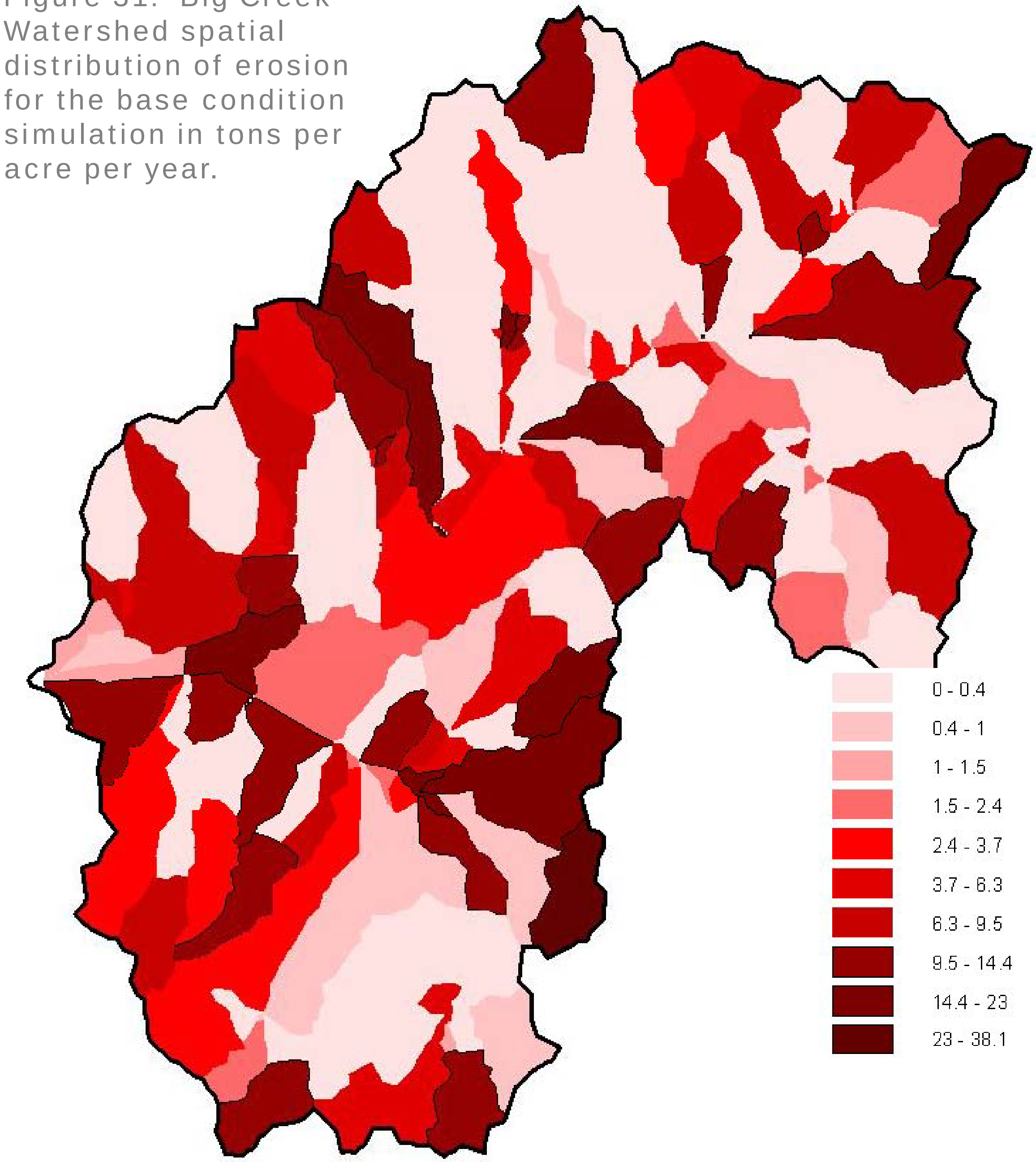
SUPPORTING MATERIAL FOLLOWS

BASE CONDITION EROSION

Figure 31: Big Creek Watershed spatial distribution of erosion for the base condition simulation in tons per acre per year.



BASE CONDITION
GULLY EROSION

Figure 34: Big Creek Watershed spatial distribution of gully erosion for the base condition simulation in tons per acre per year.

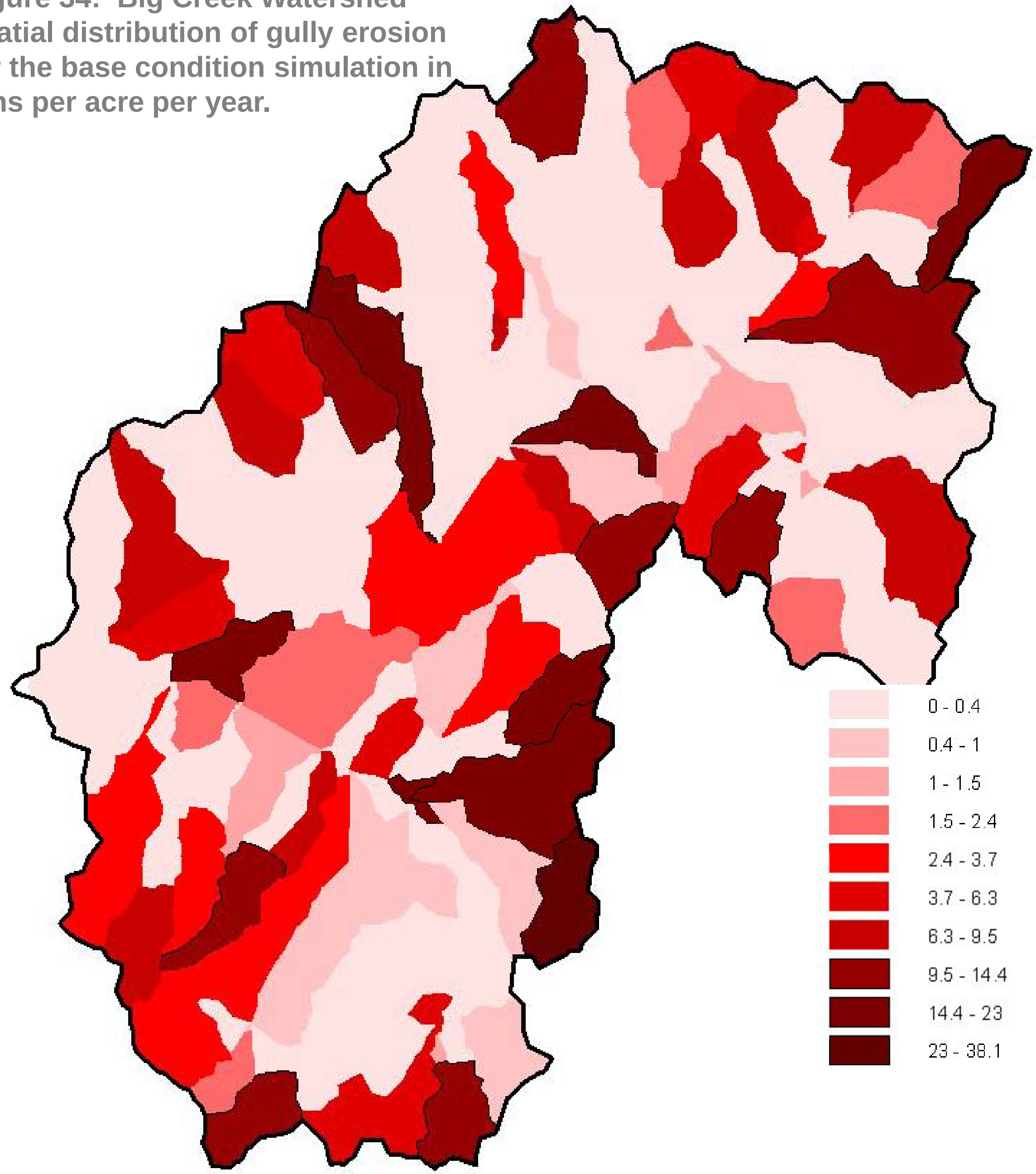


Figure 19: Spatial distribution of erosion for the base condition simulation in tons per acre per year.

BASE CONDITION EROSION

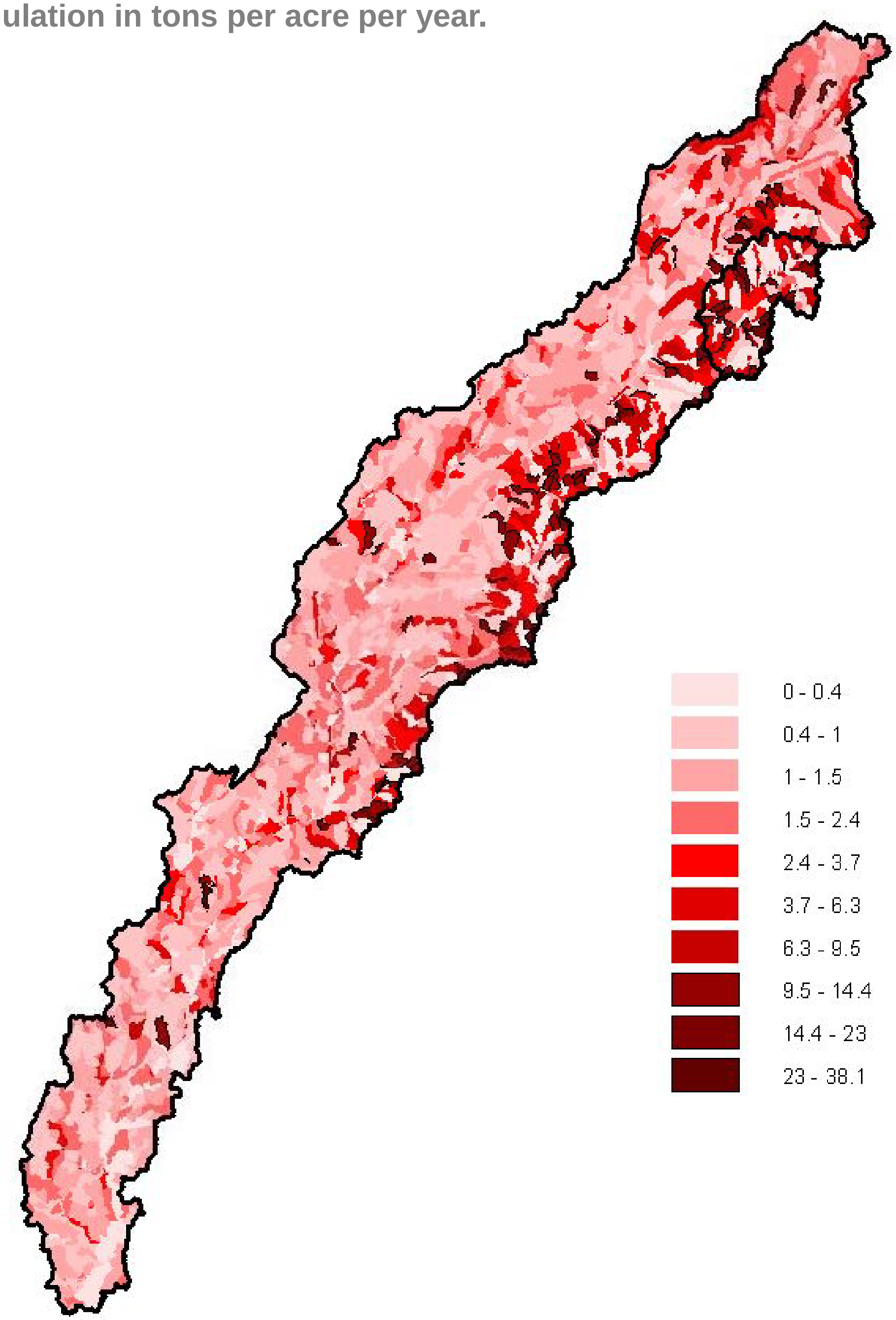
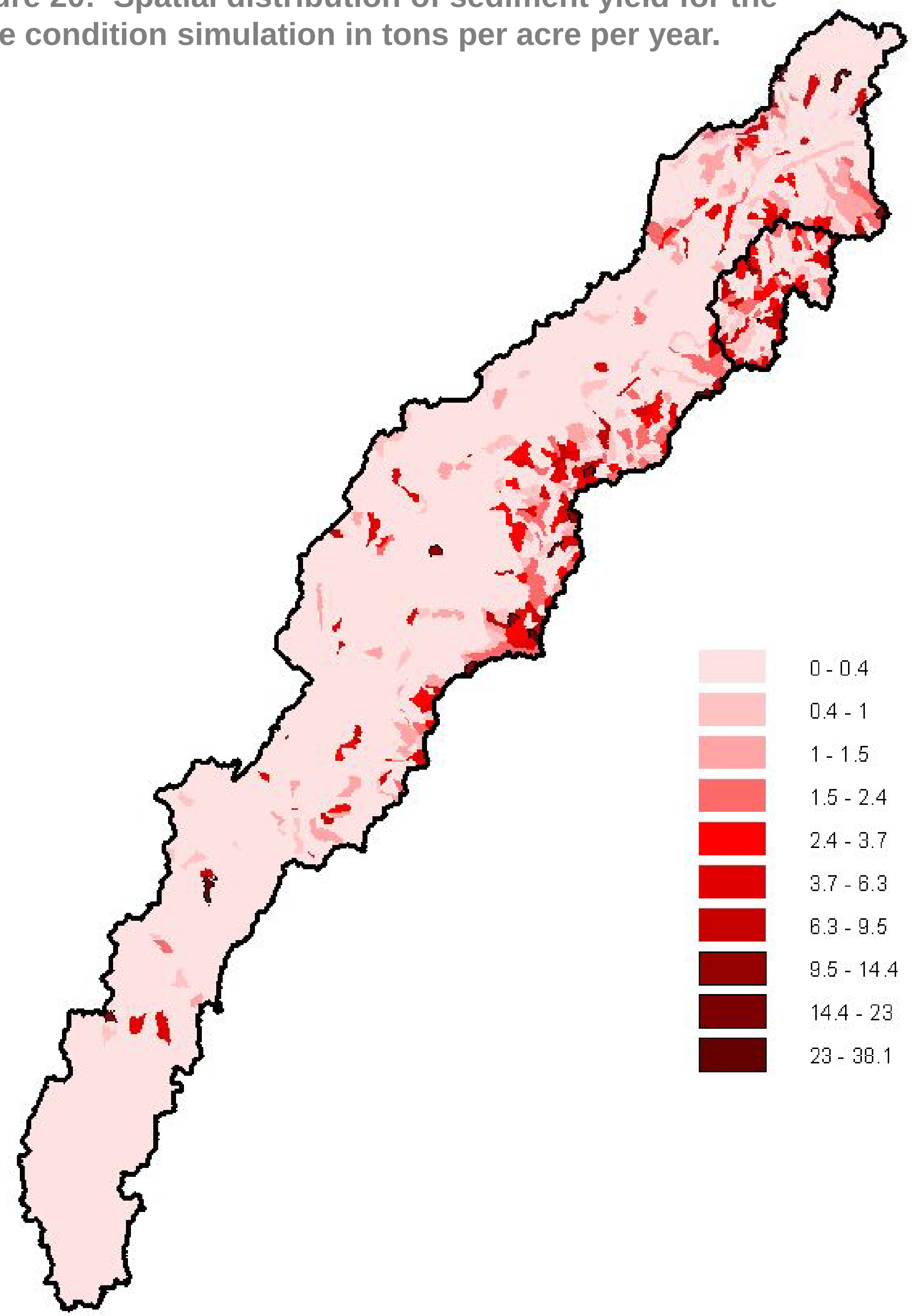
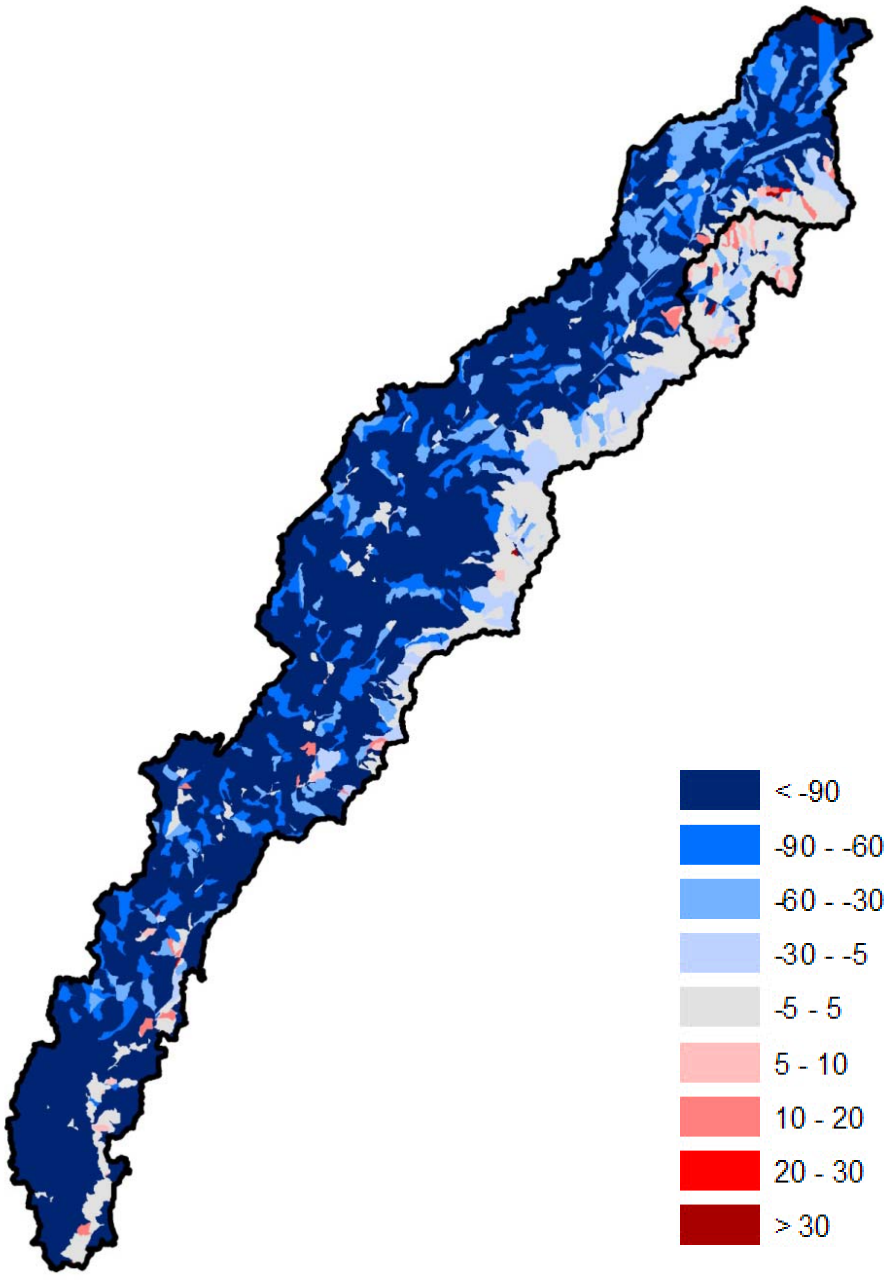


Figure 20: Spatial distribution of sediment yield for the base condition simulation in tons per acre per year.

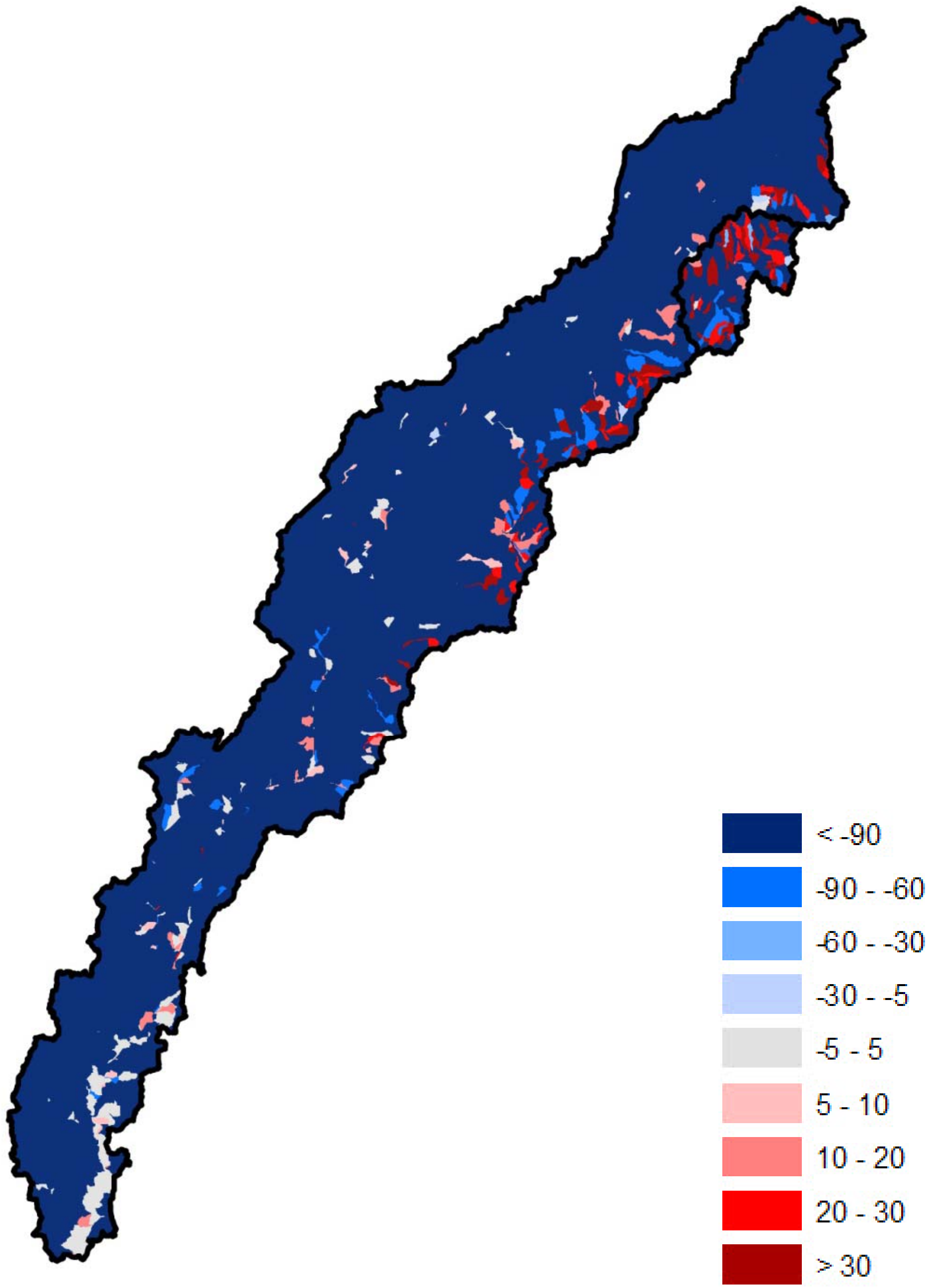
BASE CONDITION SEDIMENT YIELD



Load Reductions (BLUE) and Increases (RED) from base condition—all forest and no gully control.



Load Reductions (BLUE) and Increases (RED) from base condition—all forest WITH all gully control.



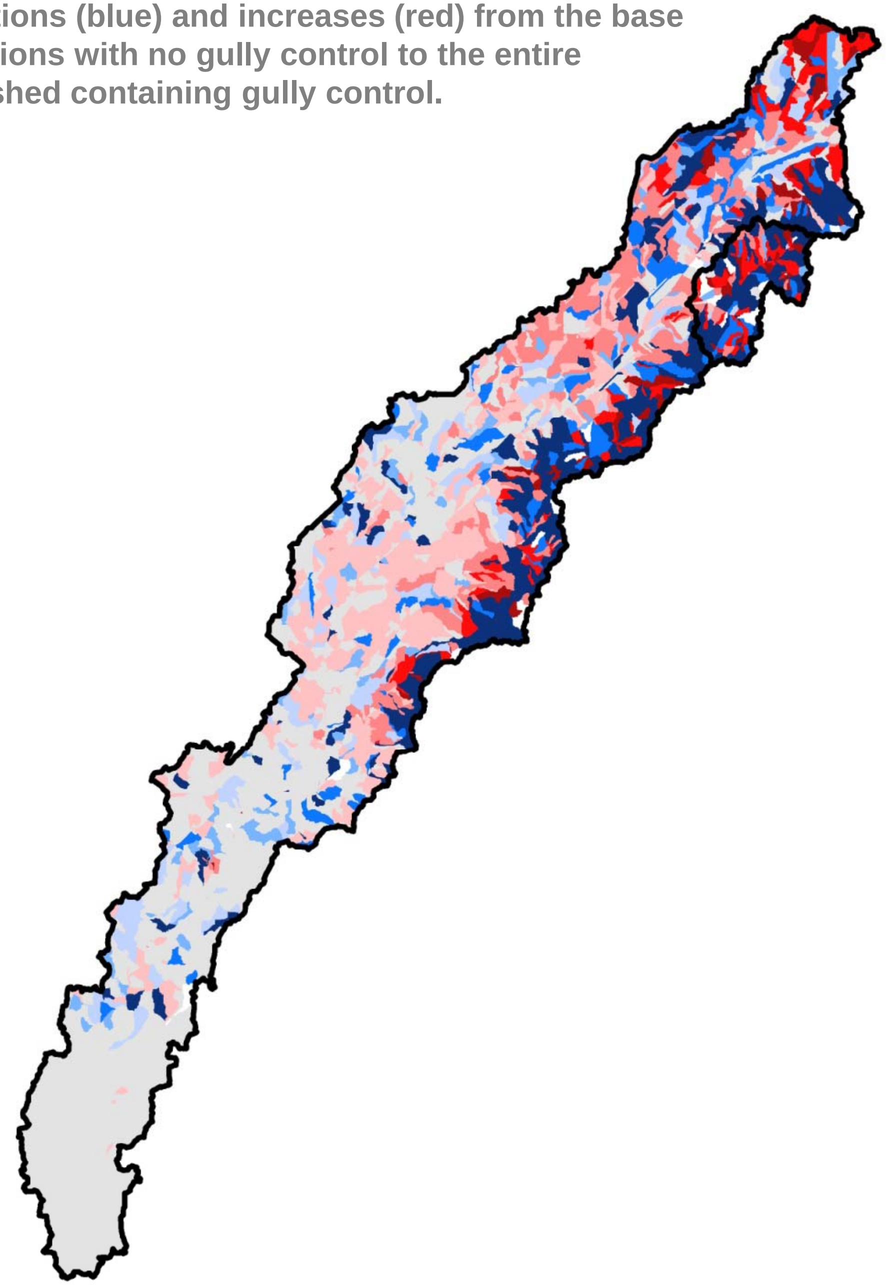
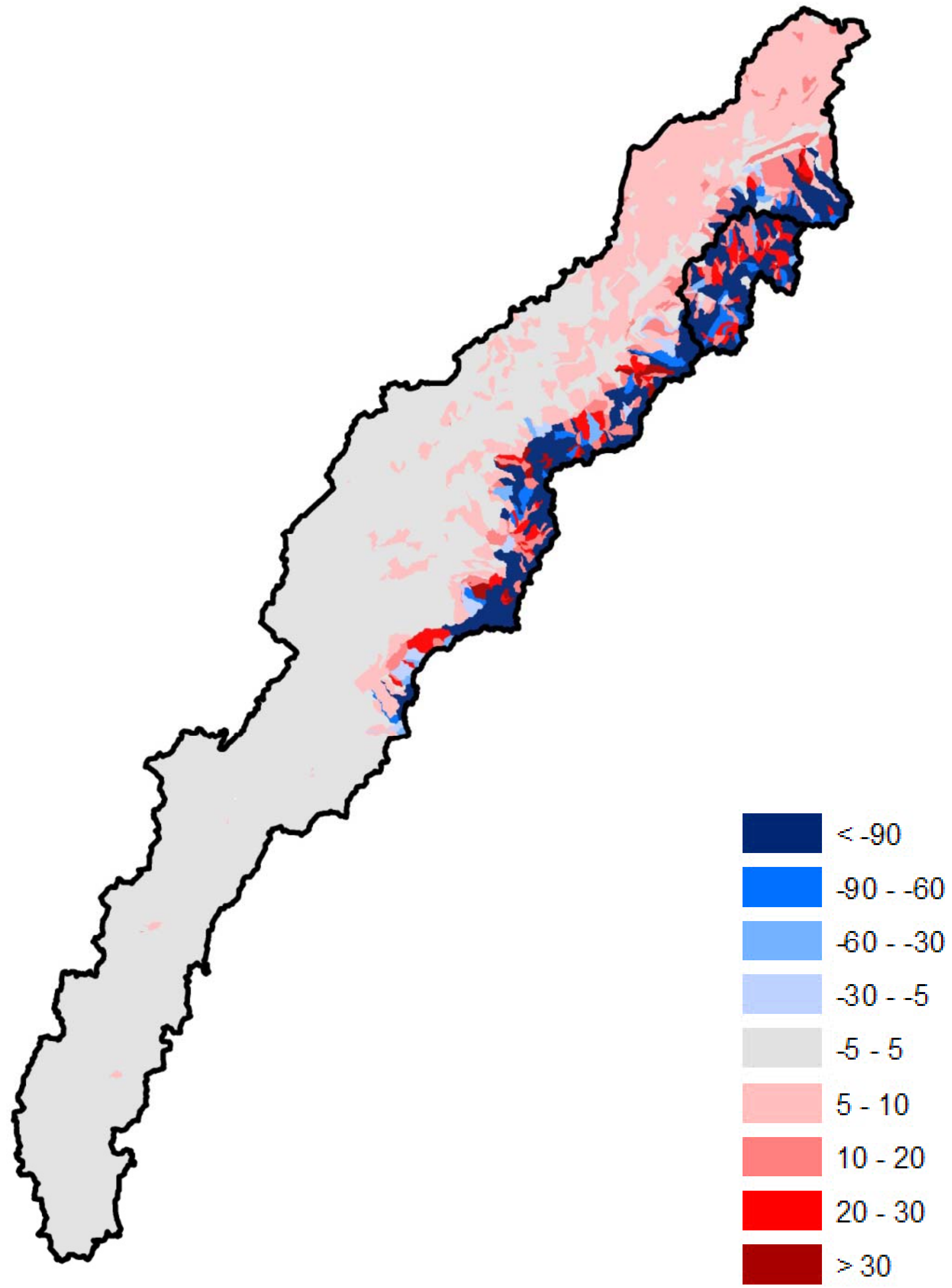
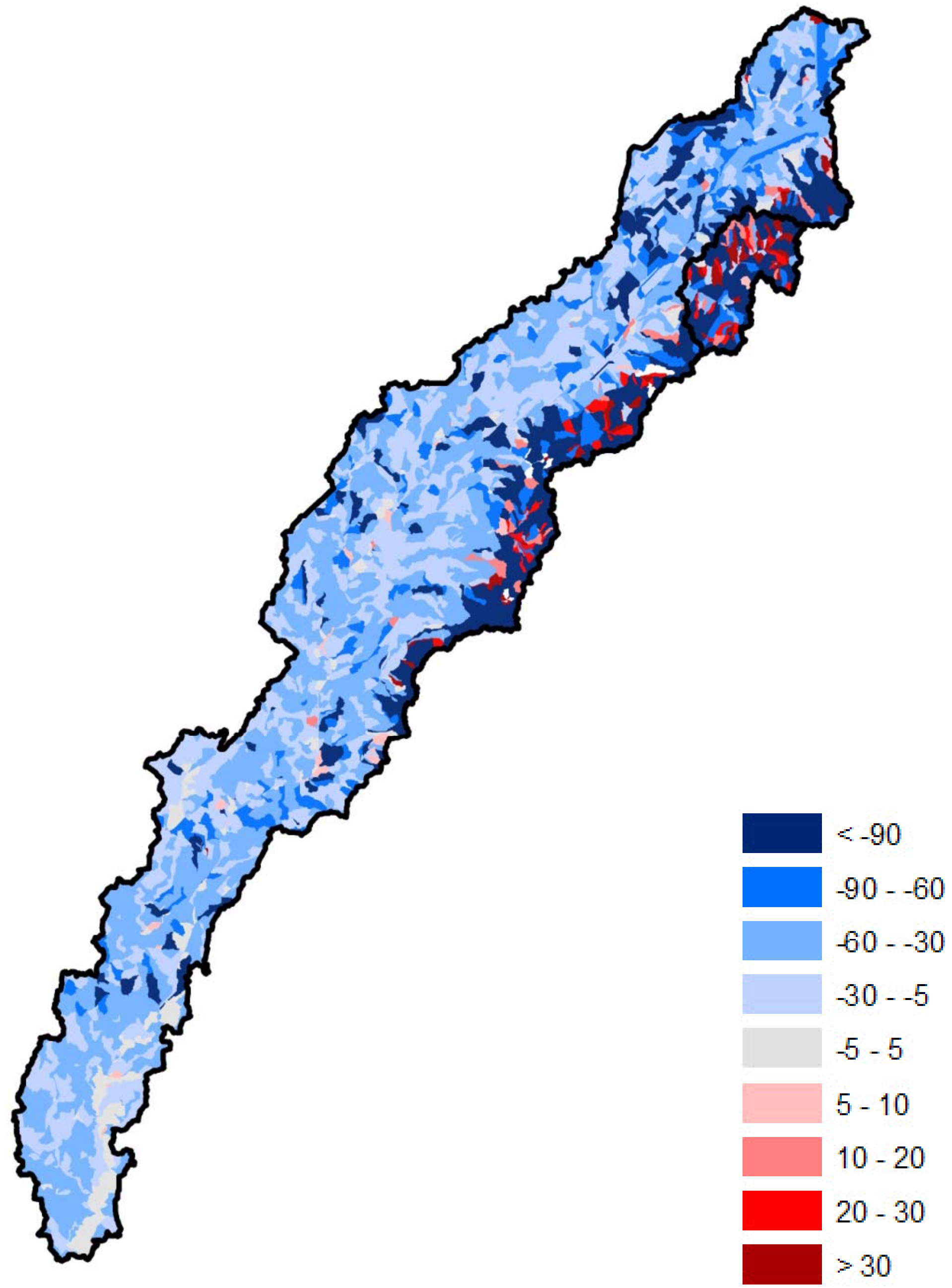


Figure 27: Cache River Watershed Sediment Load reductions (blue) and increases (red) from the base conditions with no gully control to the entire watershed containing gully control.

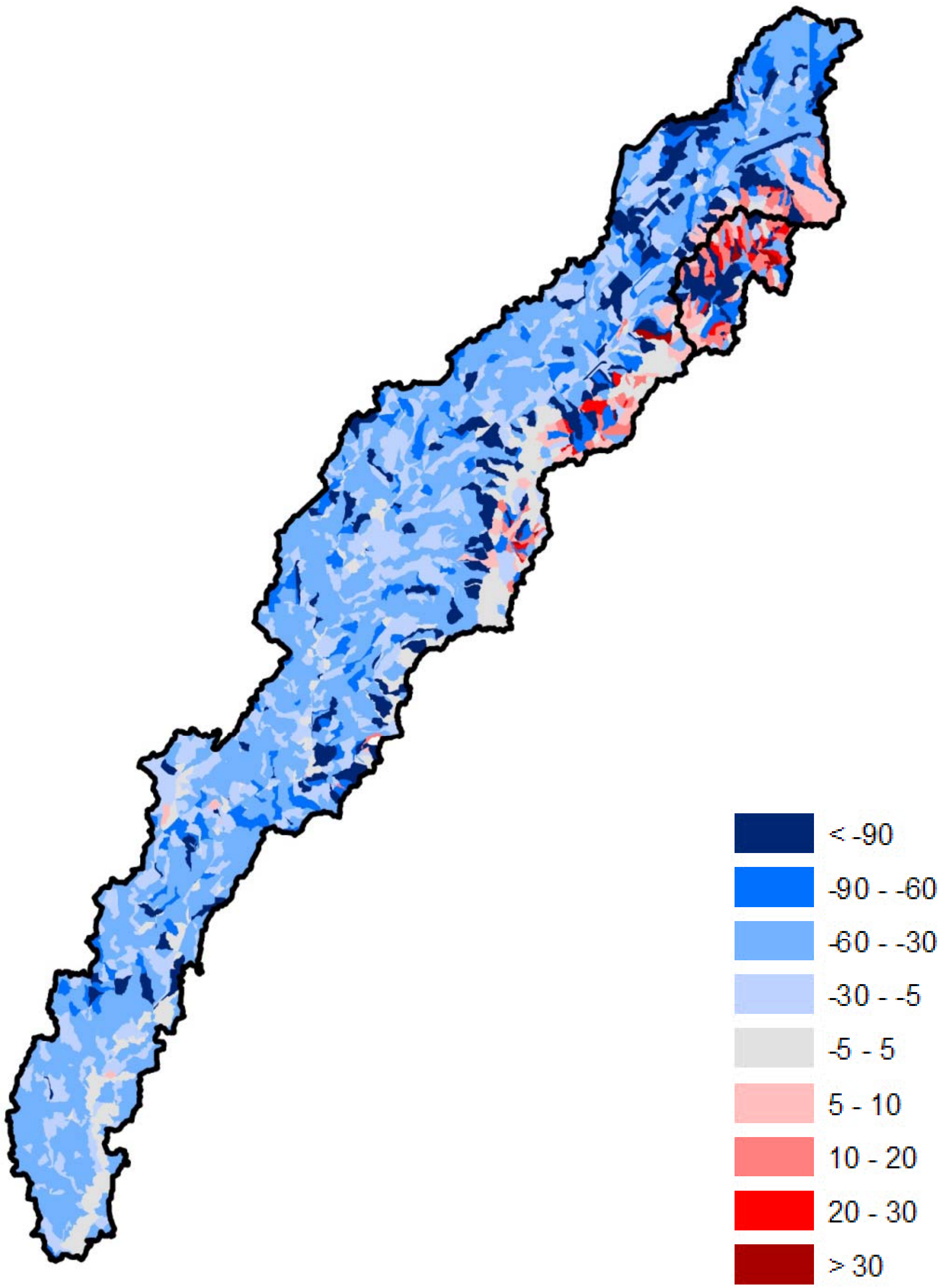
Load Reductions (BLUE) and Increases (RED) from base condition—Gully Control only in Crowley's Ridge area.



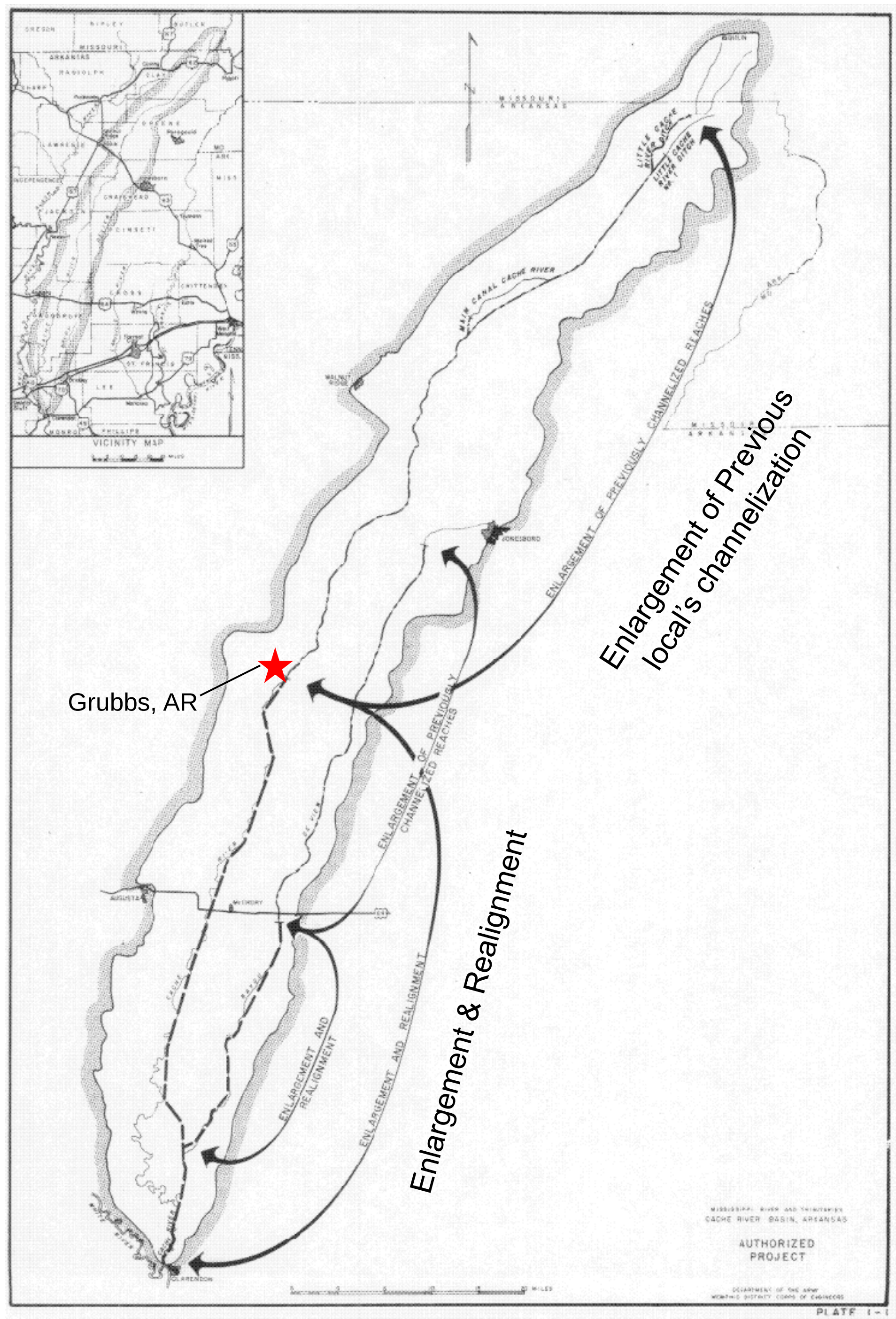
Load Reductions (BLUE) and Increases (RED) from base condition—CRP and gully control entire watershed.



Load Reductions (BLUE) and Increases (RED) from base condition—Risers + Conservation Tillage + CRP + gully control for entire watershed EXCEPT Forested Areas.



Flood Control Act of 1950--Authorized Project, Cache River circa 1960s



Upper Basin

- Blockages near Grubbs, AR, 1973

- Flooding Grubbs, AR May 1973

1: 24, 000
73/1363
12-81

- The Nature Conservancy Data Report, 2005

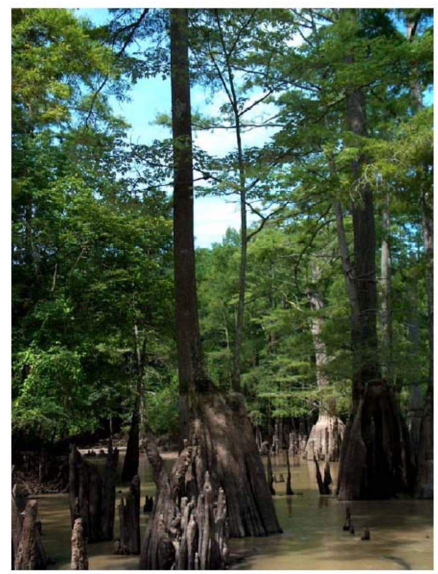
Cache River 319 Final Project Report
Grant #C9996103-09
Project 01-610

Summary of Hydrological, Water Quality, Biological, Channel Geometry, Sediment Flux Determinations, and Project Recommendations

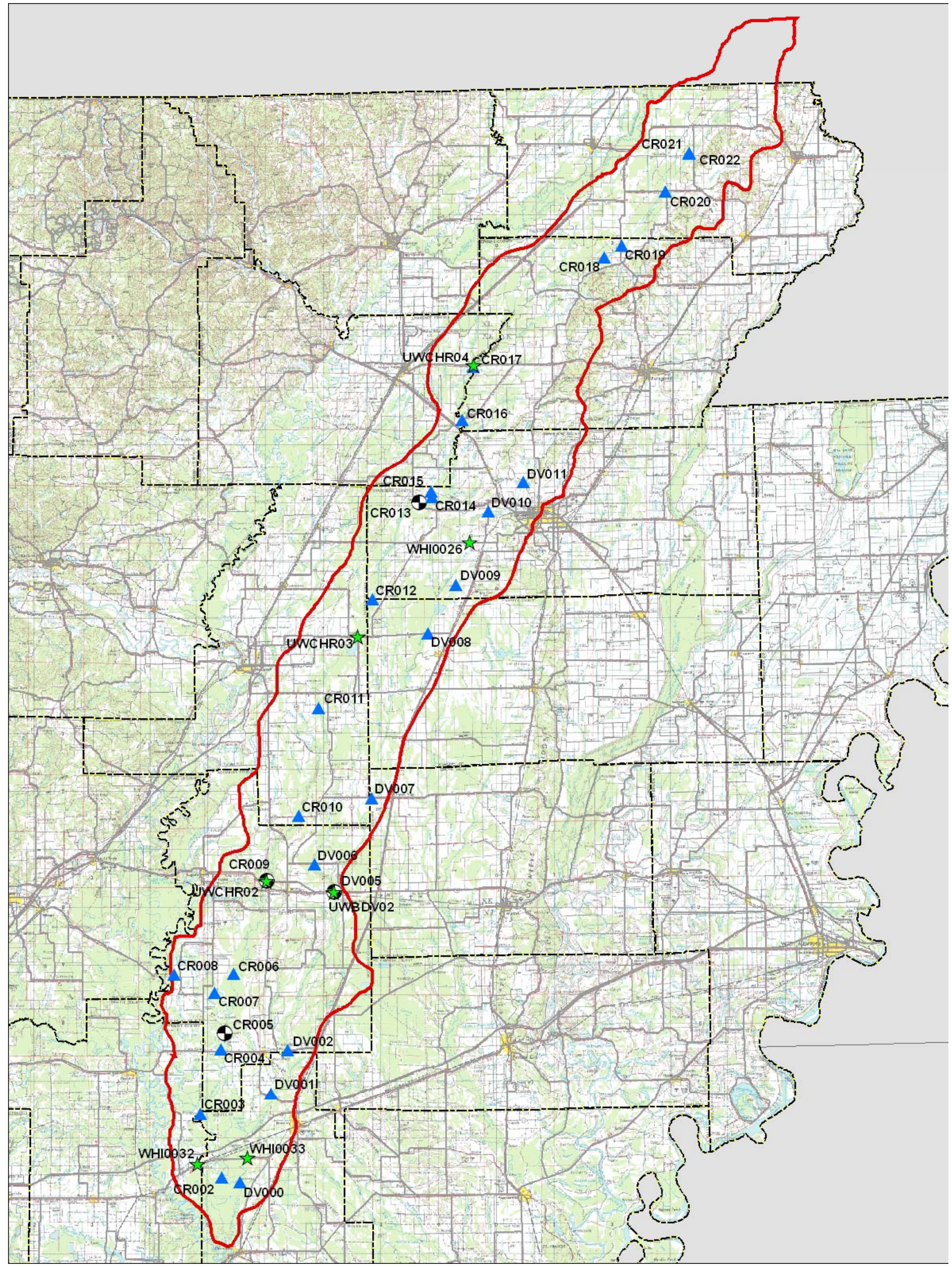
Submitted by:
The Nature Conservancy
Arkansas Field Office

Final Report

September 30, 2005



- TNC Sampling Sites, EPA 319 Grant



Sediment Studies

- HEC-6T model (circa 1990’s) to evaluate changed sediment load due to practices evaluated in AnnAGNPS.
  - Preliminary sensitivity indicates sediment load must be reduced approximately 50% to achieve sustainable channel with minimal long-term maintenance.
- Big Creek sub-Watershed
  - Pilot to assess BMP implementation on sediment production
  - Using AnnAGNPS model includes
    - Surface and Rill Erosion Sources
    - Gully Erosion Sources
    - In-Channel Erosion Sources
- Cache River upstream of Grubbs, AR
  - Use methodology from Big Creek pilot
  - Evaluate potential to reduce sediment loading to Grubbs Reach
  - Investigate possible methods to alleviate flooding caused by channel blockages
  - Lowering sediment load is critical to solving blockage problems at Grubbs

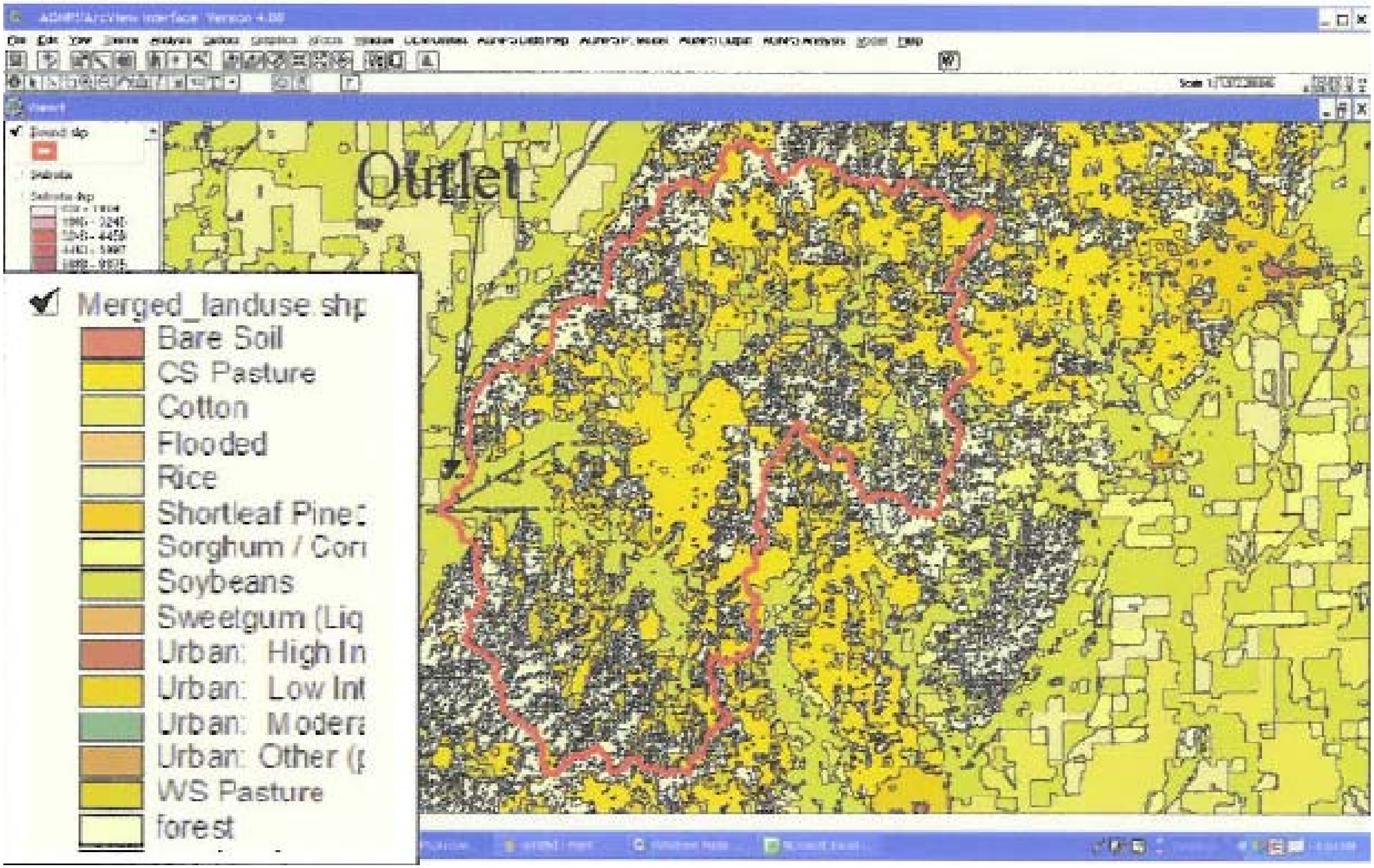
AnnAGNPS Analysis

- Hypothetical hydrology for 30-year simulation
- GIS layers for each parameter in RUSLE
  - Landcover
  - Soil Type
  - Precipitation/Runoff
  - Practice
  - Slope
  - Length (network)
- Outputs
  - Annualized sediment yield for gully and rill erosion from RUSLE
  - Average annual Gully Erosion to be estimated using new technique implemented in AGNPS
  - Average annual In-Channel Erosion estimated using hydraulic geometry and generalized hydraulics for multiple reaches in stream network

AnnAGNPS Analysis
Continued

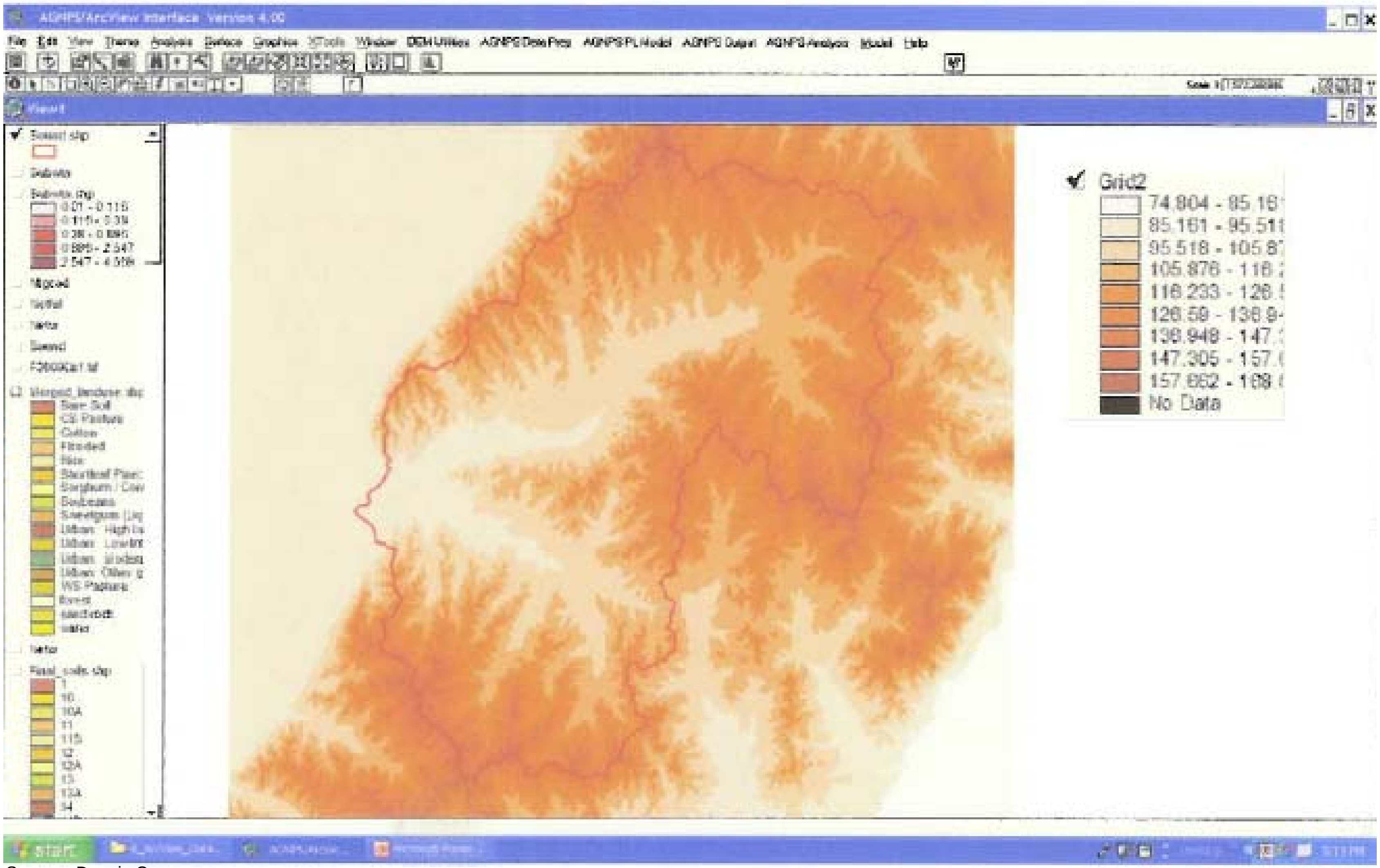
- Results provide:
  - Order of magnitude estimates of total sediment at point(s) of interest for each scenario
    - Broken down between sands, silts, and clays where input detail supports calculation
    - General locations of sources within basin/sub-basin
  - Mechanism to compare <u>relative</u> changes between treatment practices and/or structural measures
    - Measure A changes sediment total by X%, Measure B changes sediment total by Y%

Landuse—Big Creek Basin



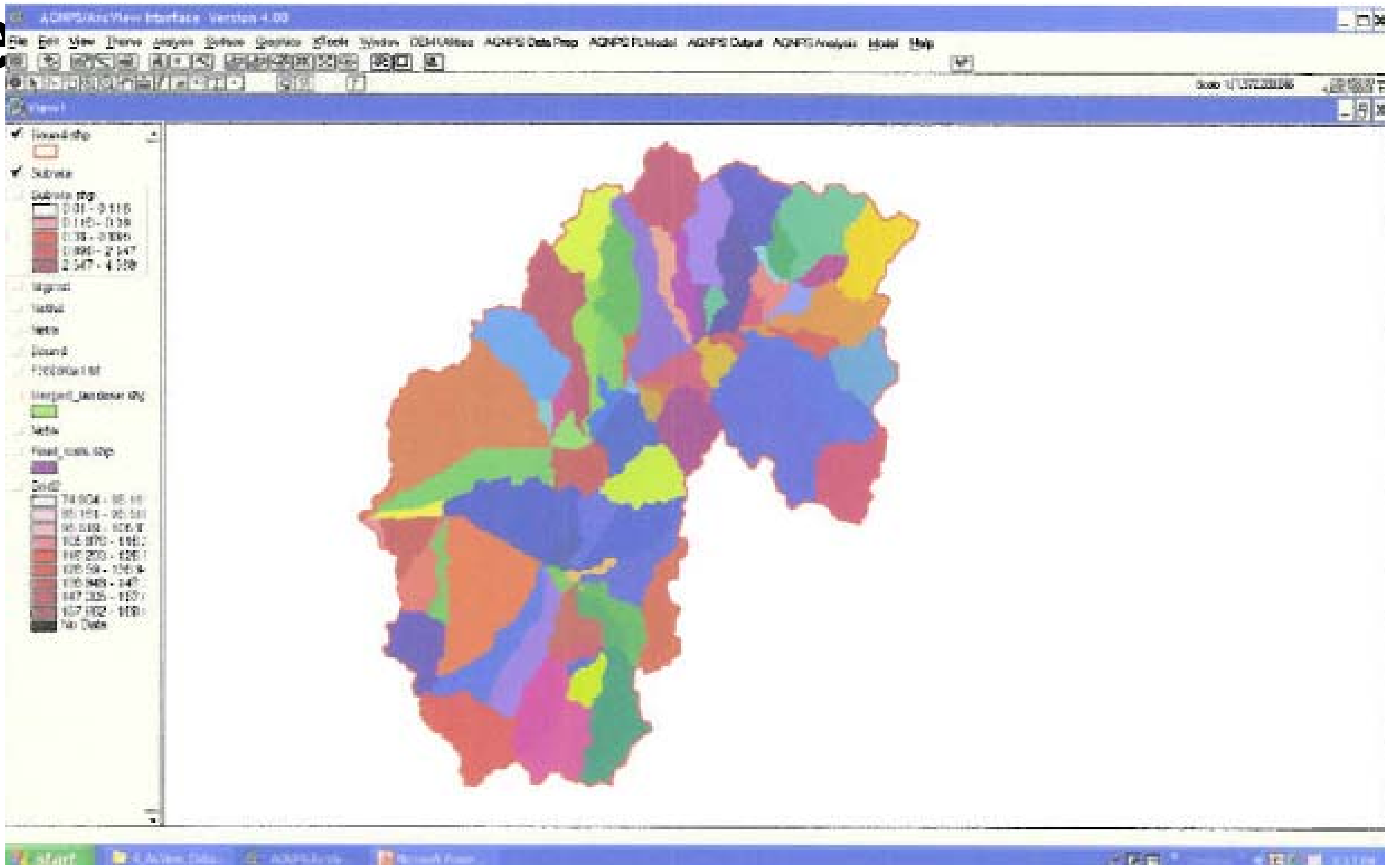
Source: Dennis Carmen

Elevations—Big Creek Basin



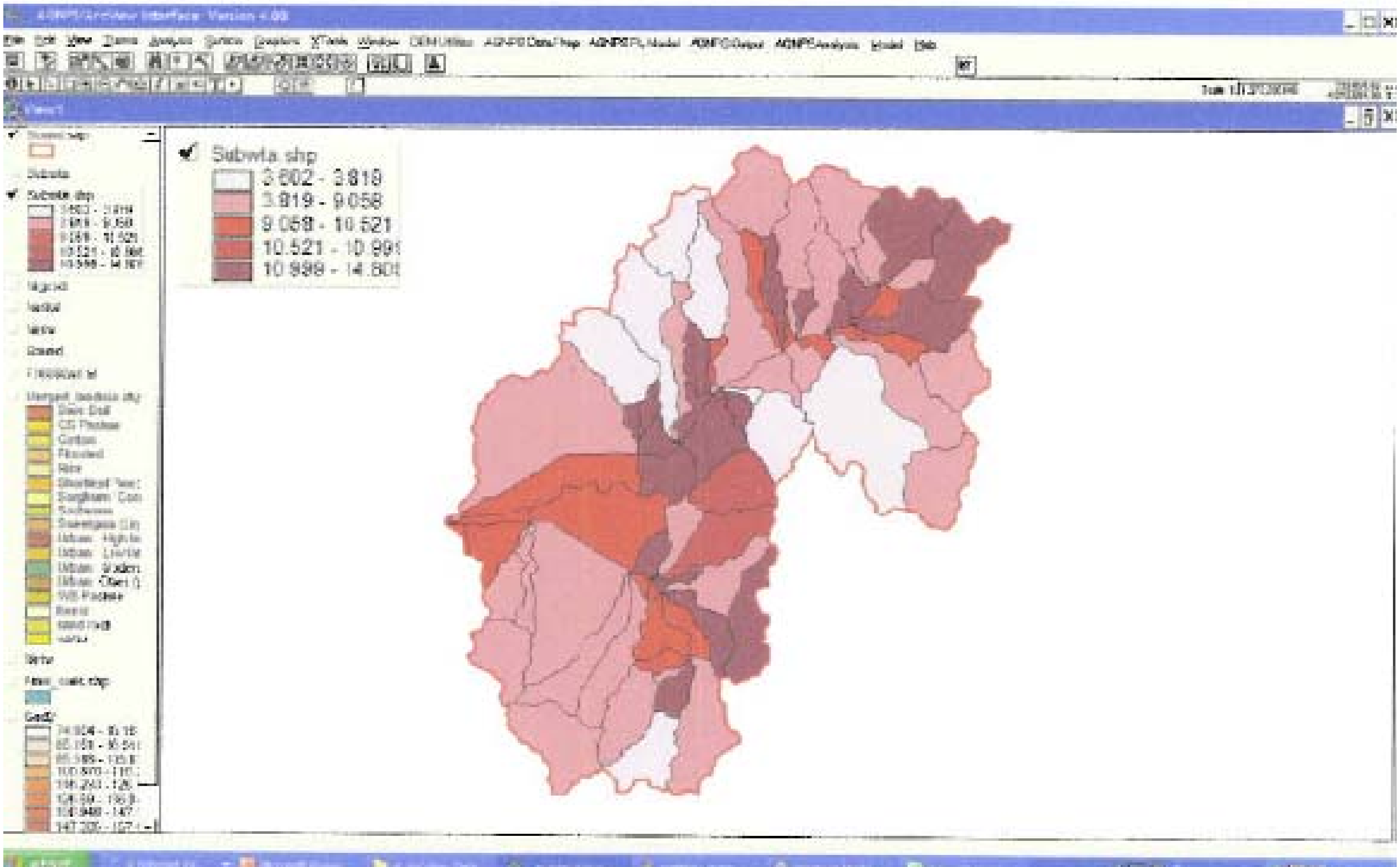
Source: Dennis Carmen

Soils, Landuse, sub-basins, & stream ne



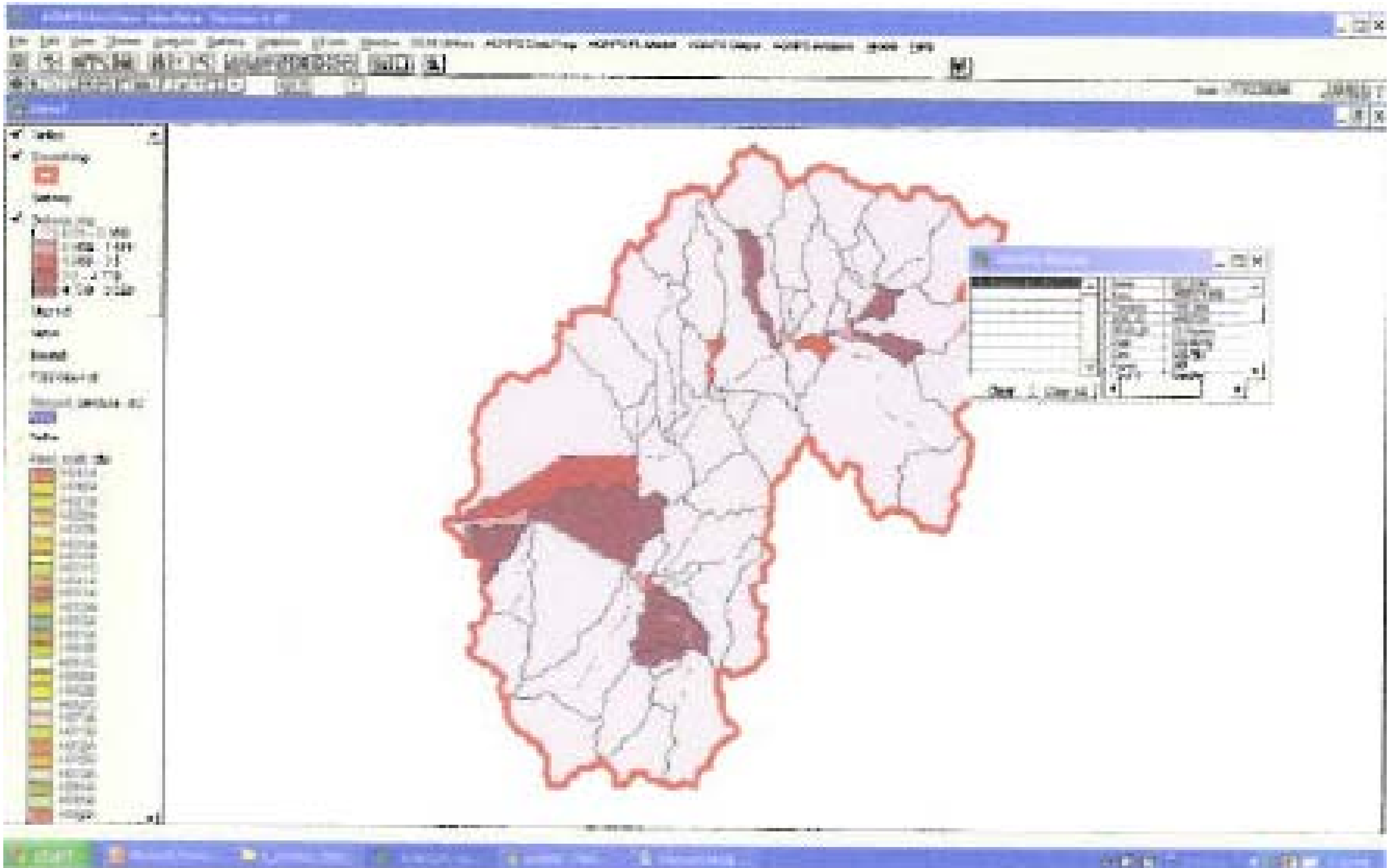
Source: Dennis Carmen

Runoff by Cell—Big Creek



Source: Dennis Carmen

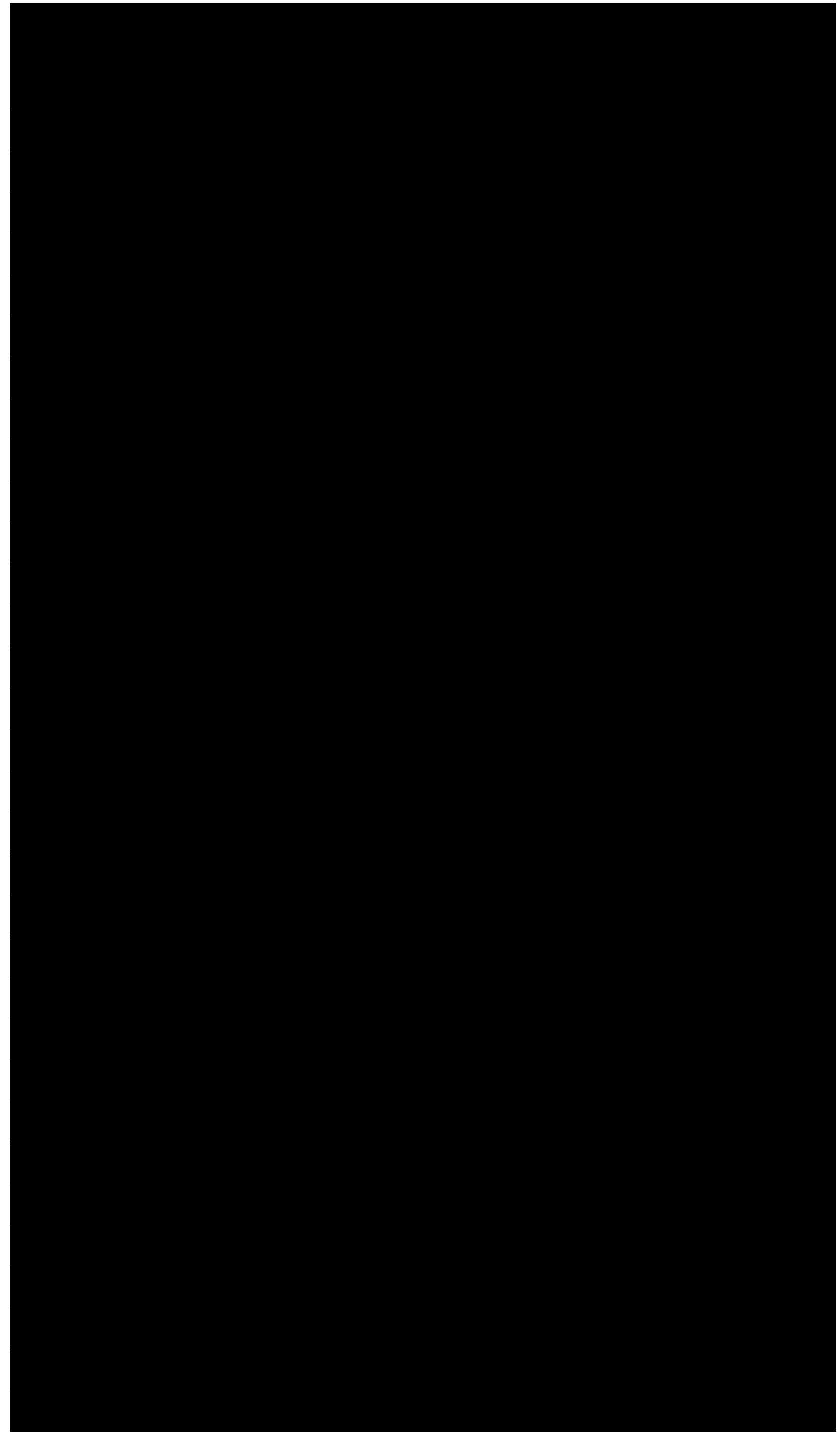
Surface/Rill Erosion Contribution to Outlet



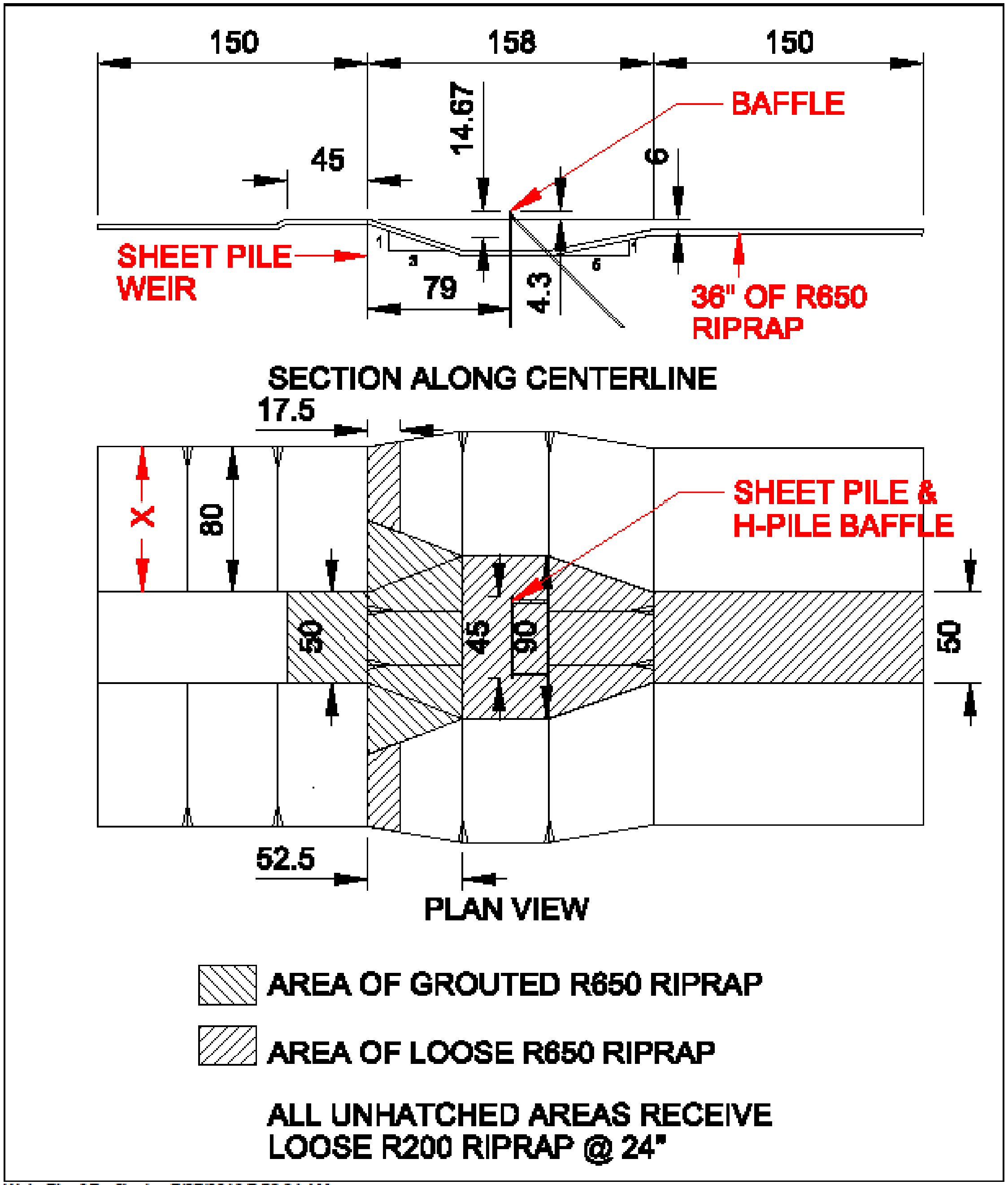
Source: Dennis Carmen

GULLY STRUCTURE LOCATIONS

Nearly 1800 Locations



SHEET PILE WEIR



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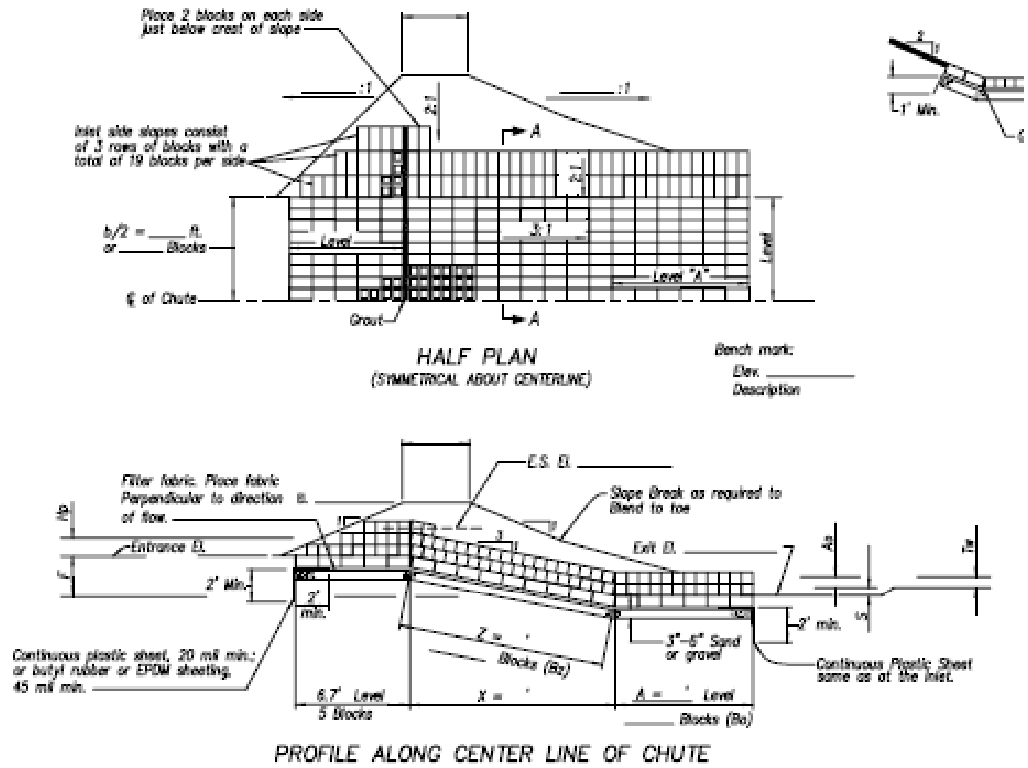
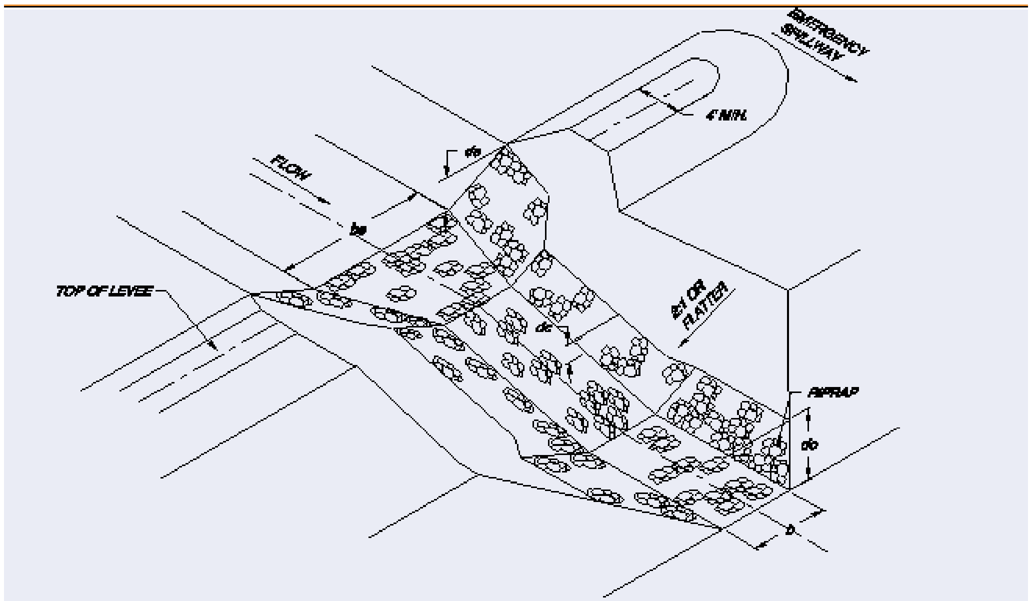
CONCRETE CHUTE

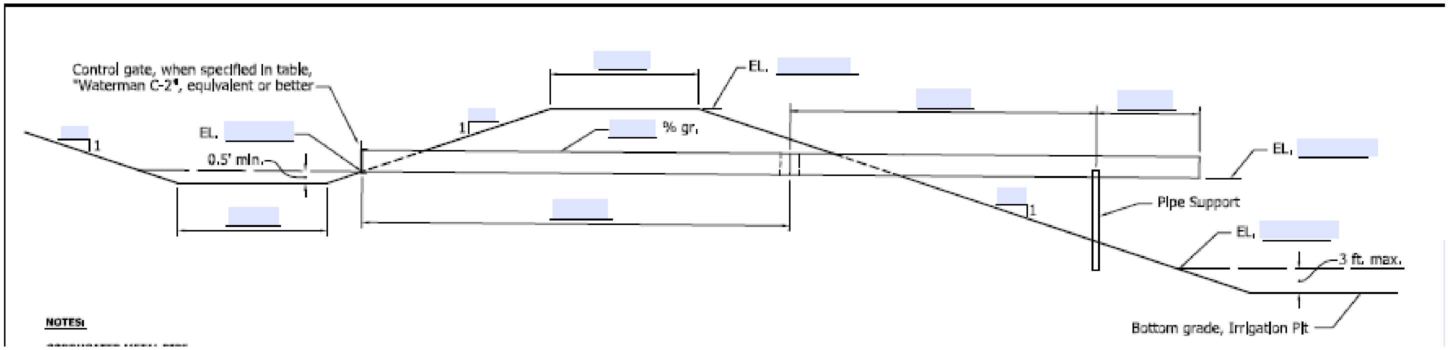


ROCK LINED CHUTE



ROCK LINED CHUTE

STRAIGHT PIPE



DROP INLET