eRAMS
A Web-Technology for Conservation Planning and Watershed Management

Mazdak Arabi

Department of Civil & Environmental Engineering

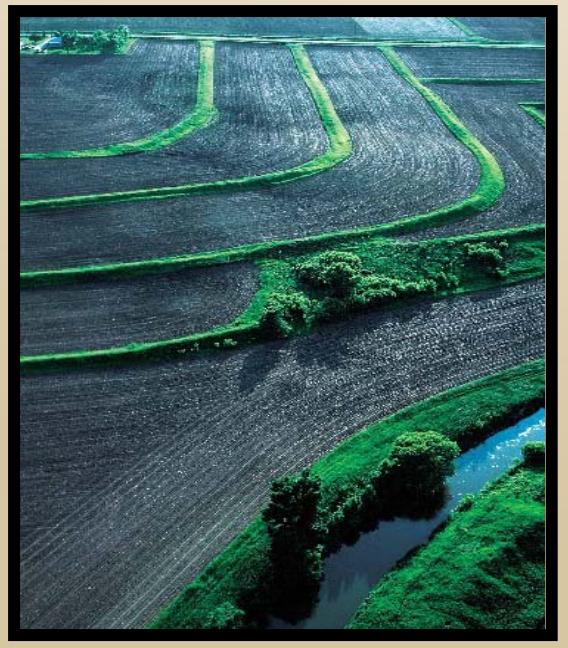
Colorado State University

Watershed Management

- Water quality (environmental)
  - Sediment
  - Nutrients
  - Pesticides
  - Pathogens
- Economic Criteria
  - Cost
  - Benefits
- Institutional Criteria

Nonpoint Source Pollution Control

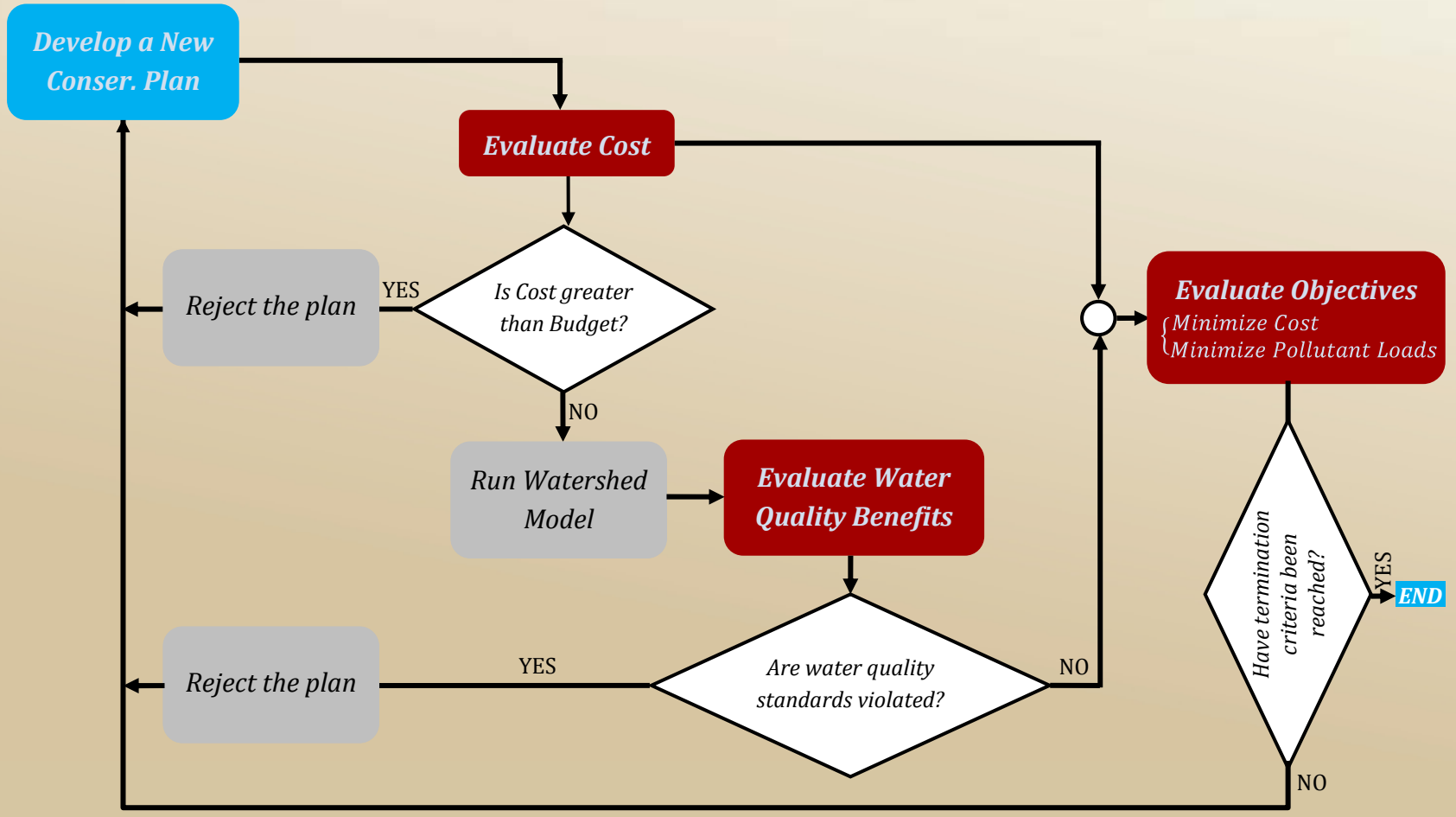
- Implementation of conservation practices / BMPs
  - Prevent or minimize pollution rather than retrospectively respond to it.
- Current Approaches
  - Cost-sharing
  - Targeting



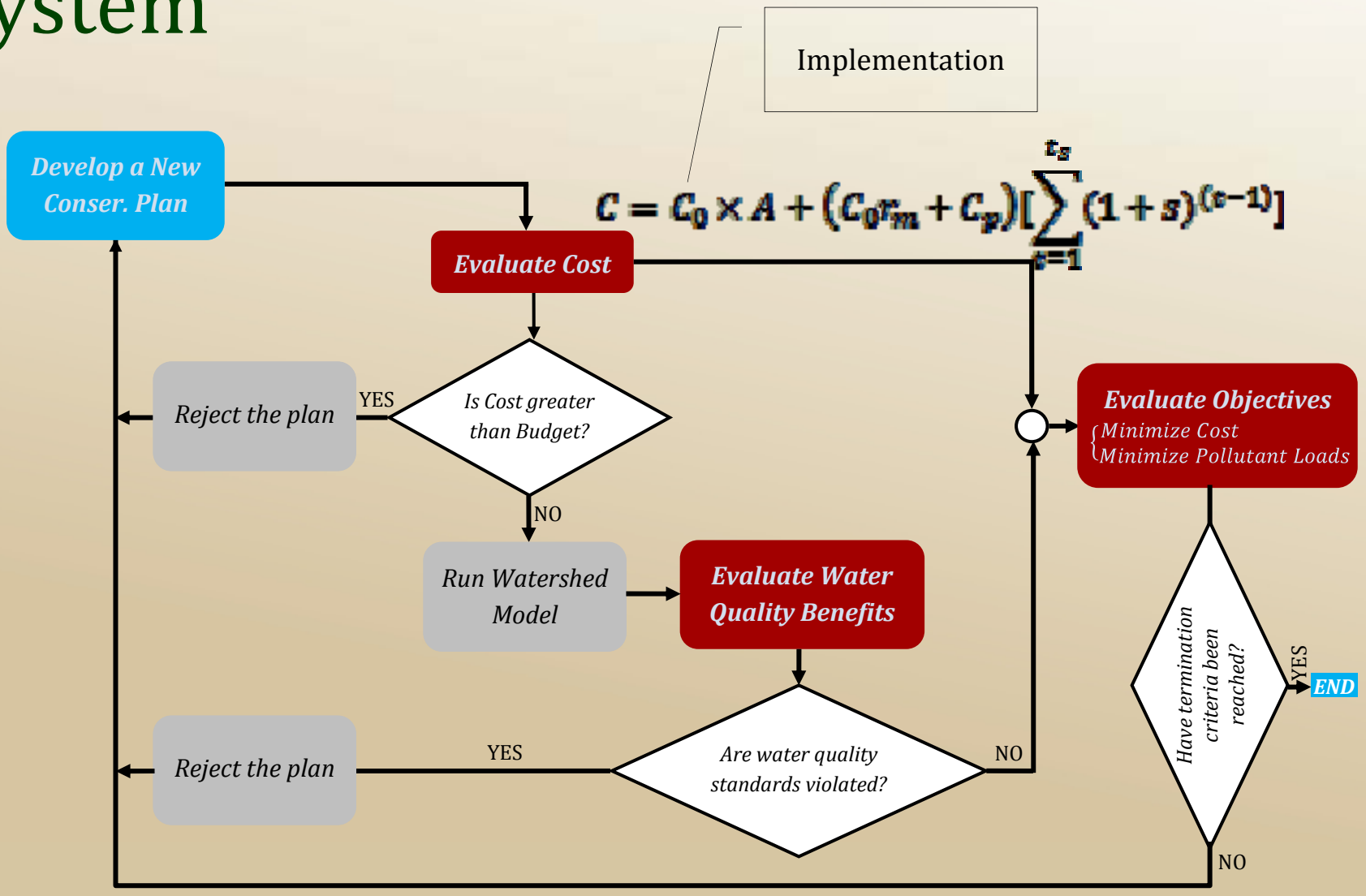
Overall Goal

- Develop a decision support system to
  - Establish baseline conditions for a field/watershed
  - **Assessment**: costs and environmental benefits of a given set of management actions
  - **Planning**: scenario analysis and system optimization for developing sound resource management alternatives

Integrated Modeling & Optimization System



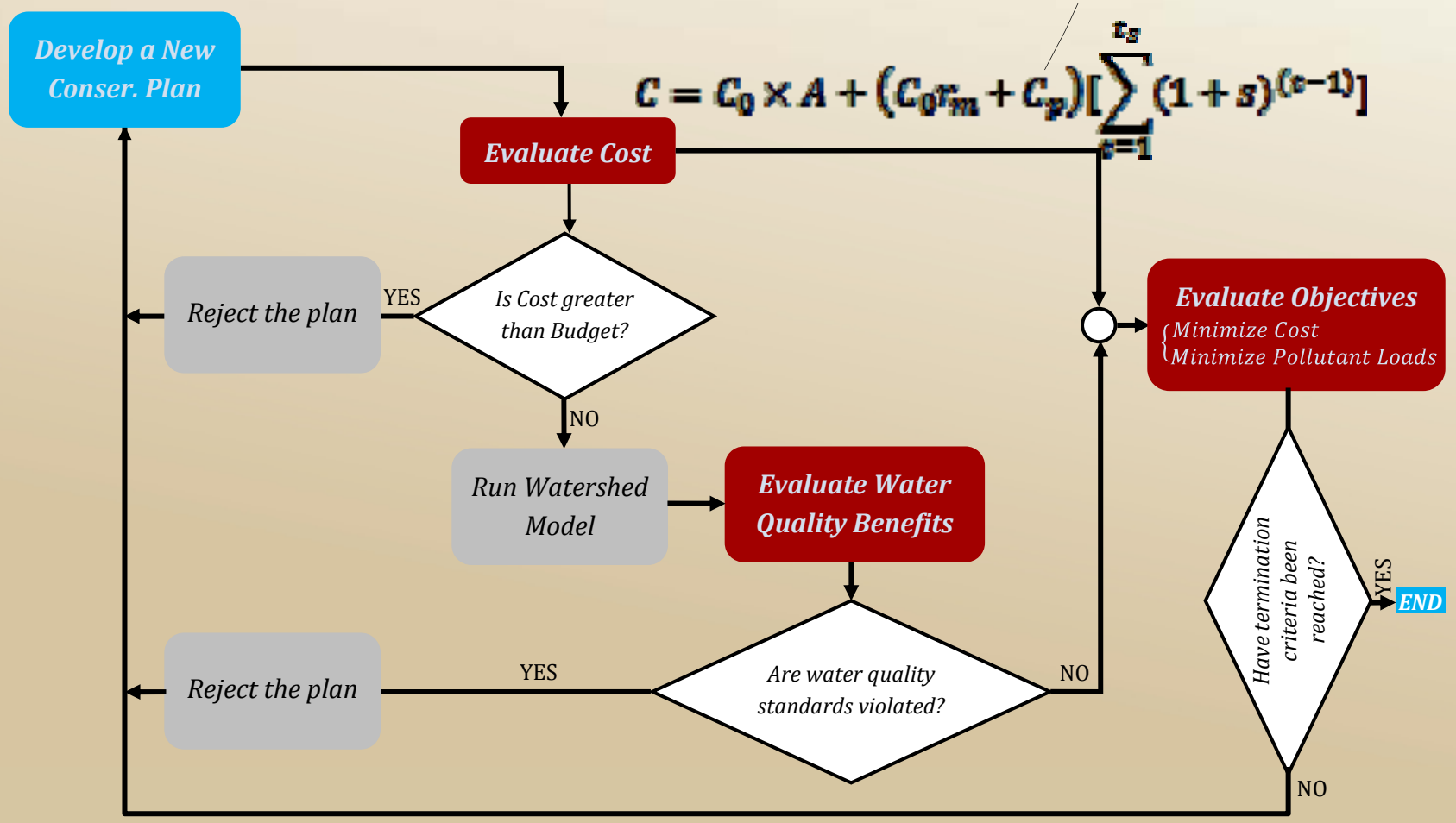
Integrated Modeling & Optimization System



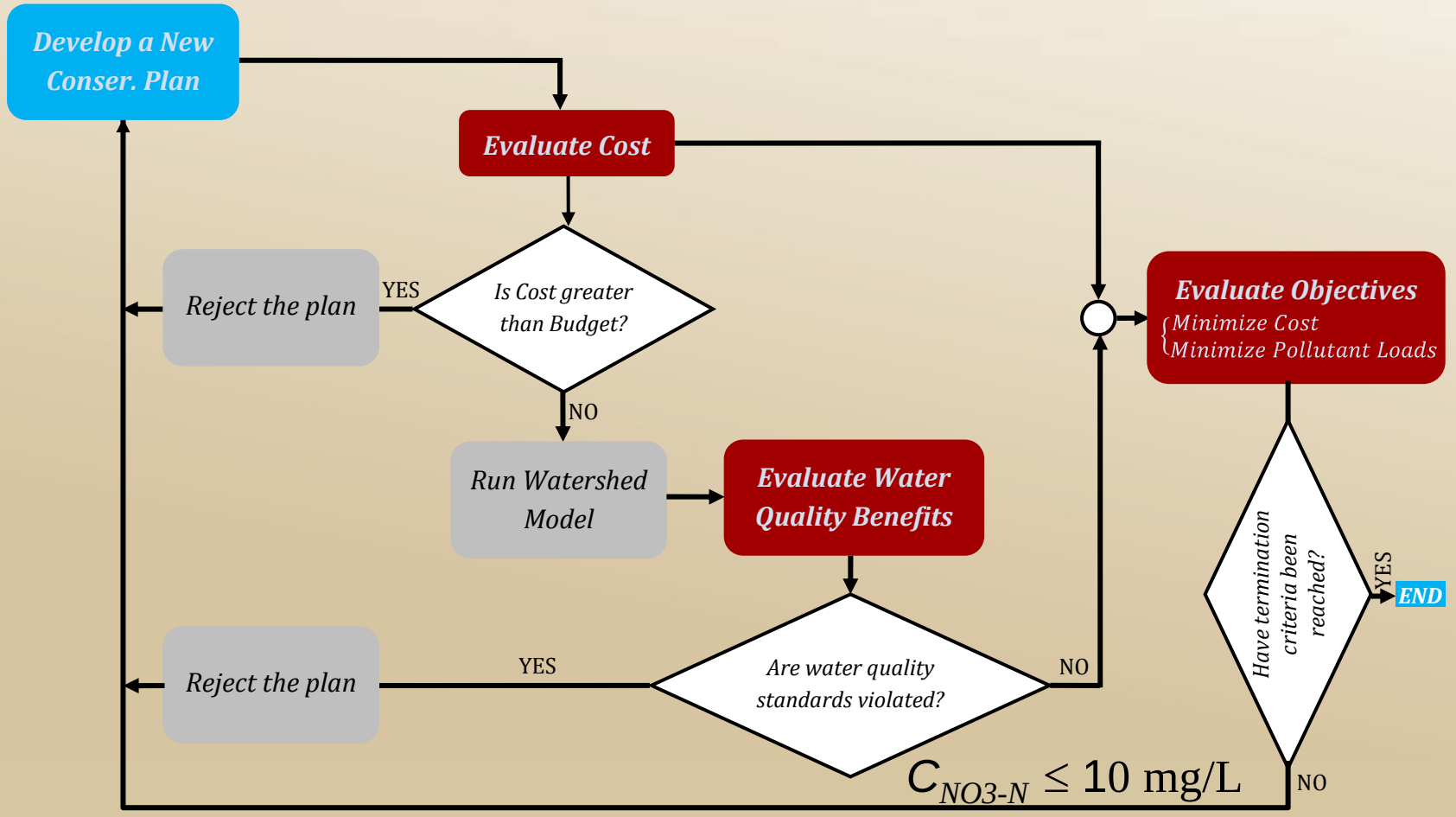
Integrated Modeling & Optimization System

Reduced crop Productivity:
- Land out of production,
- Reduction of fertilizer application

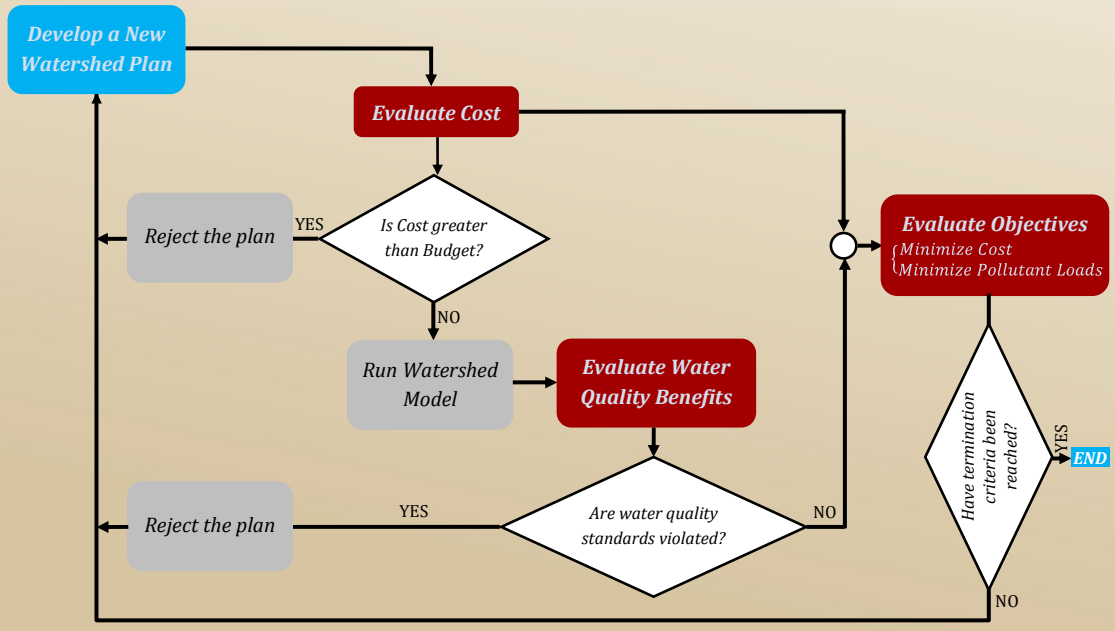
$$C = C_0 \times A + (C_0 r_m + C_p)\left[\sum_{s=1}^{t_s} (1+s)^{(s-1)}\right]$$

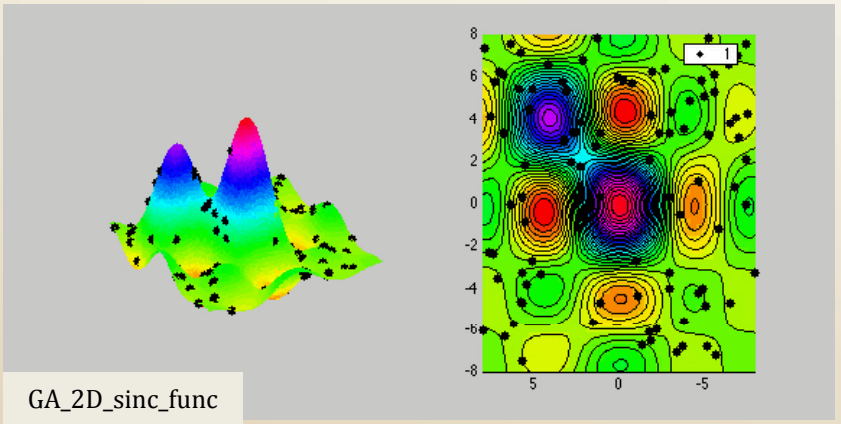


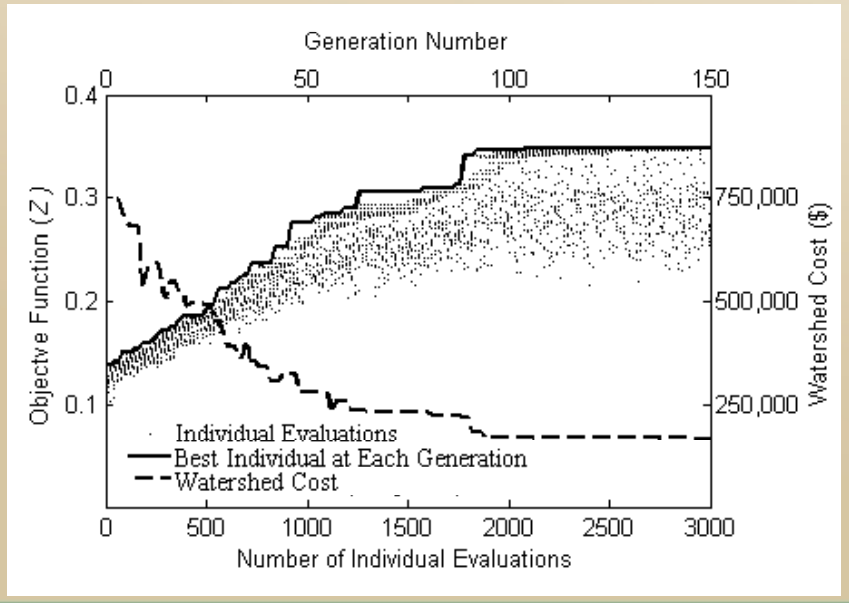
Integrated Modeling & Optimization System for Watershed Management



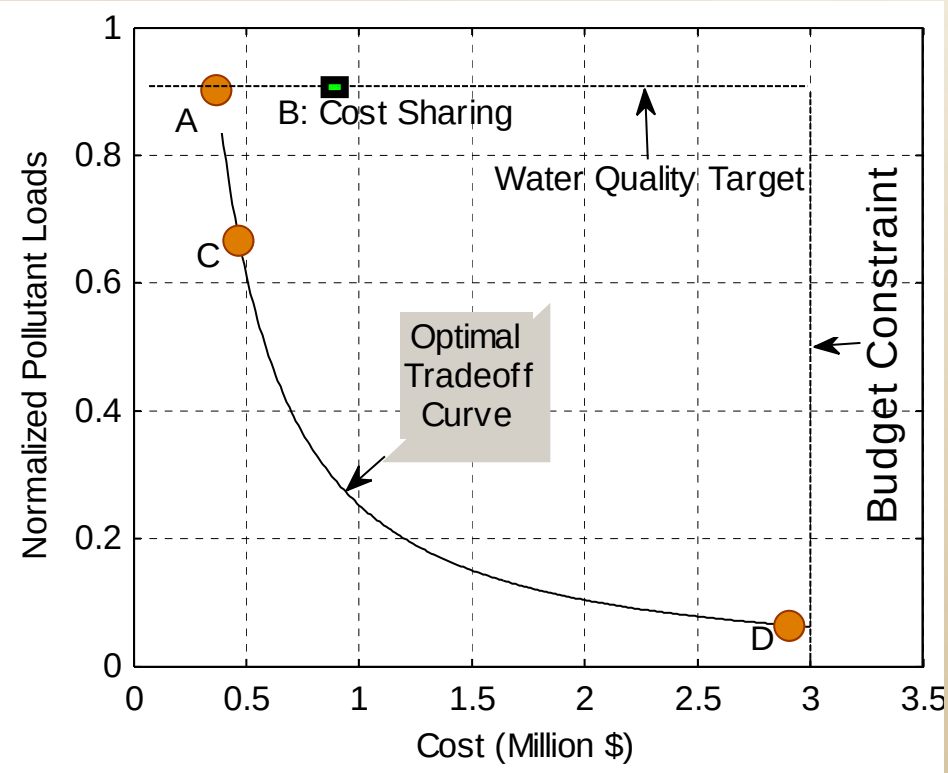
Integrated Modeling & Optimization System

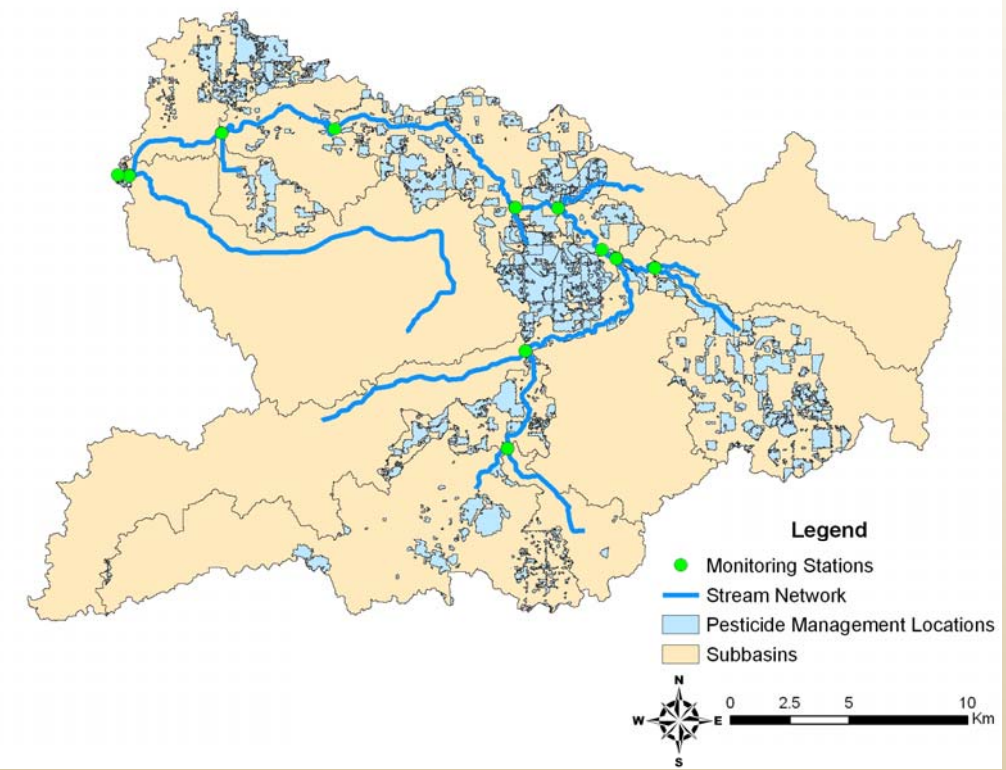






Watershed Planning: Tradeoffs & Targets





eRAMS: Participatory GIS

- Facilitate collection, organization and sharing of geospatial data
  - Identify problems
  - Determine stakeholders' objectives, preferences and values
  - Location and type of practices

eRAMS: Participatory GIS

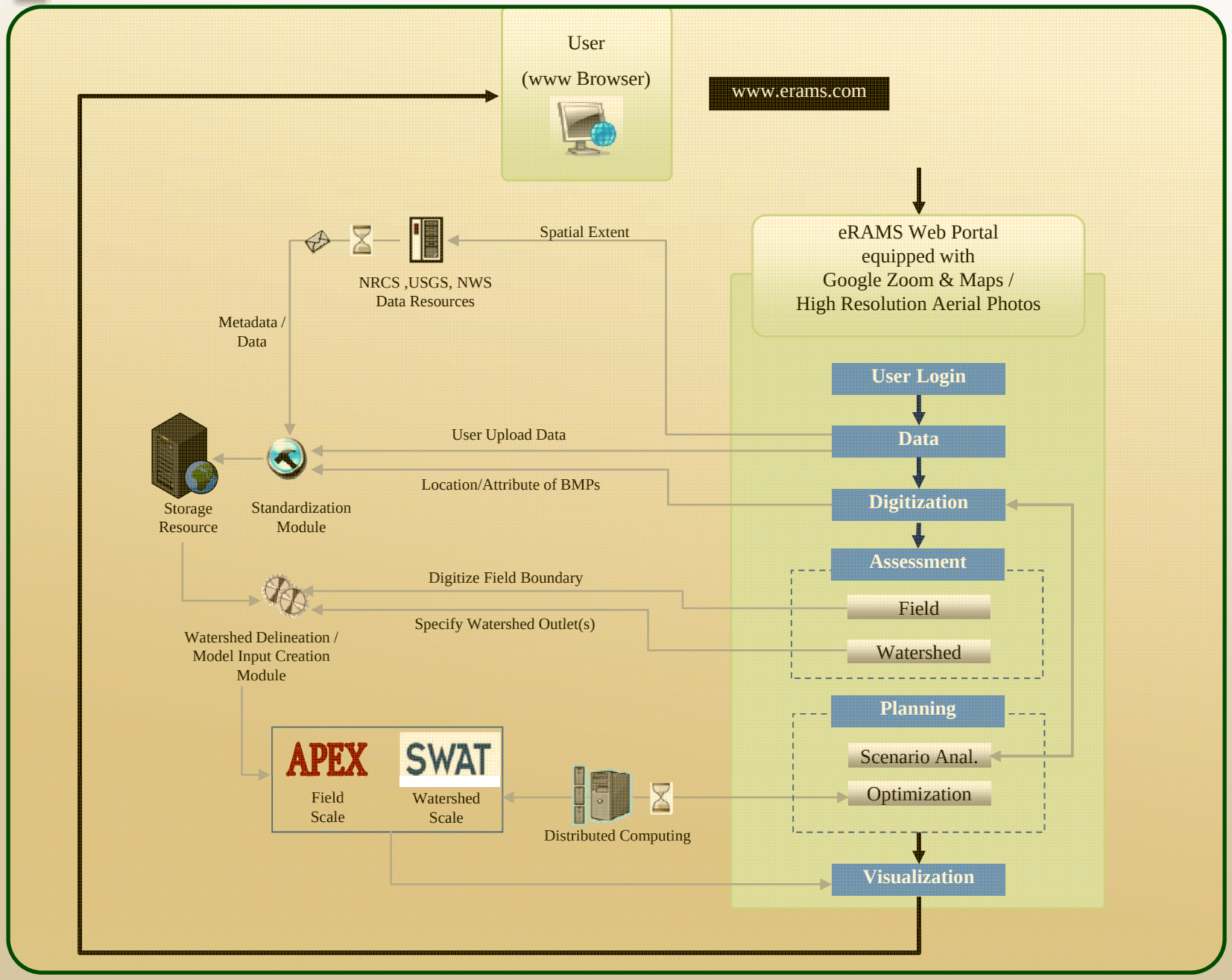
- Facilitate automation of complex modeling and system analysis processes
  - Conservation assessment and planning: natural resource models, e.g., APEX /SWAT and MODFLOW
  - Plug-in applications for diverse set of problems
  - “Decentralized” group of users

Technology Drivers

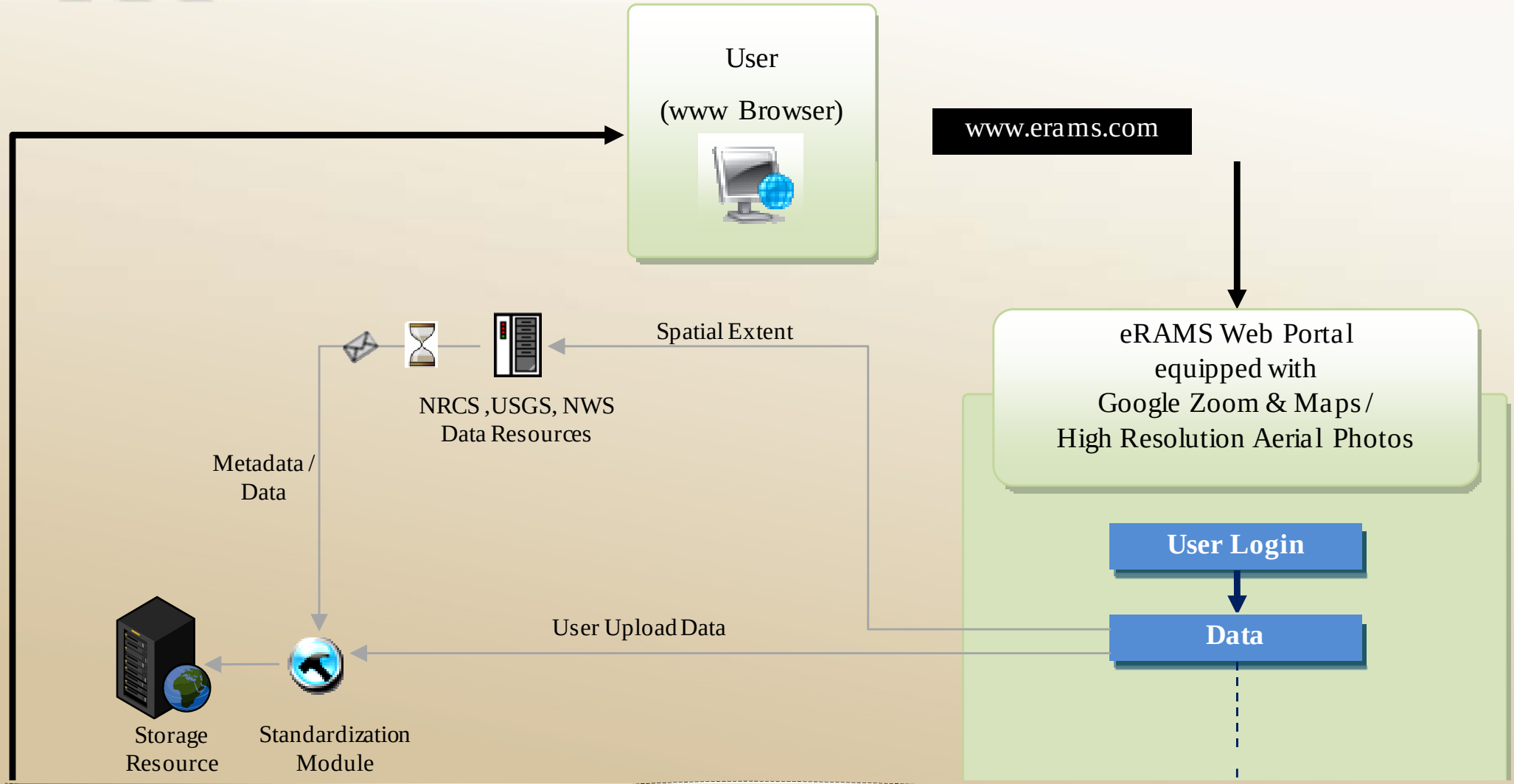
- No specific hardware or software requirements
  - Reduce training requirements
  - Eliminating the collection of duplicate data across agencies
  - Reduce long-term development and maintenance costs
  - Mobile system accessible, end-to-end, on the web
- Compatibility with existing databases/GIS technologies
  - Take advantage of readily available data

Technology Drivers

- Benefit from Google products and other commonly-used internet technologies
  - Common "look and feel" interface
  - High resolution aerial photos, etc.
- Compatibility with long-term vision of institutions involved with management of natural resources
- Working across scales: field to watershed



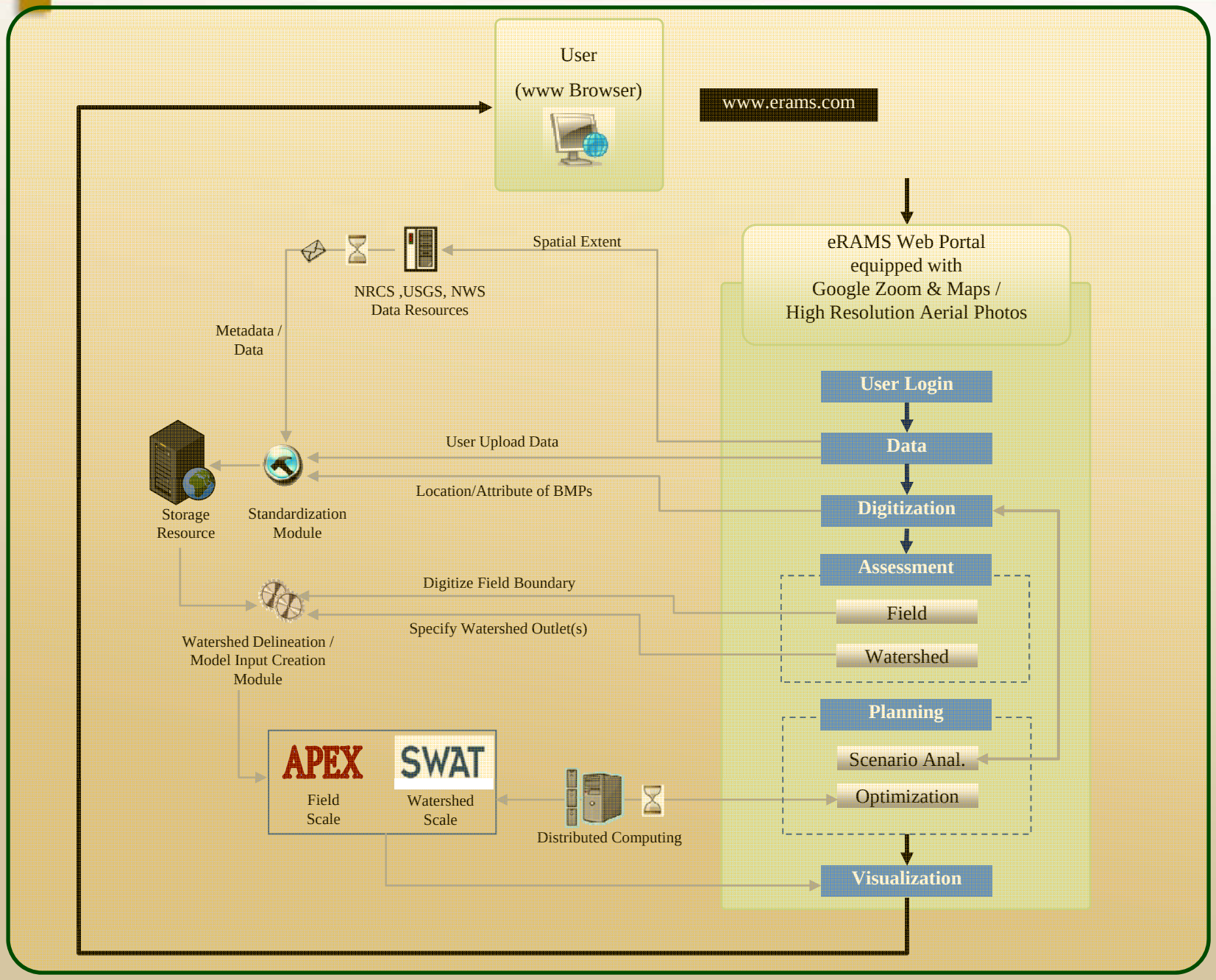
eRAMS Architecture for Conservation Planning and Assessment



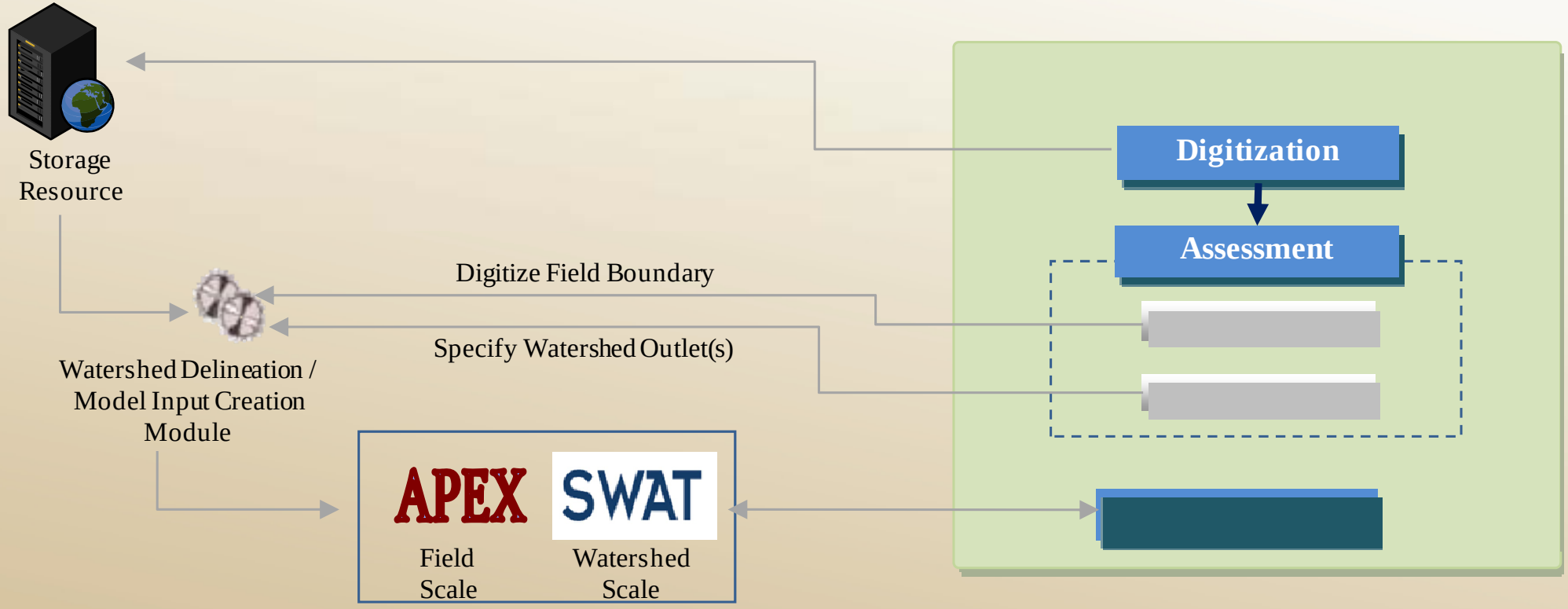
Identification

- What relevant data are available? Semantically rich metadata
- CLIPS, SWEET, GeoSemantic

Extraction /Transformation: different sources, different formats and scales

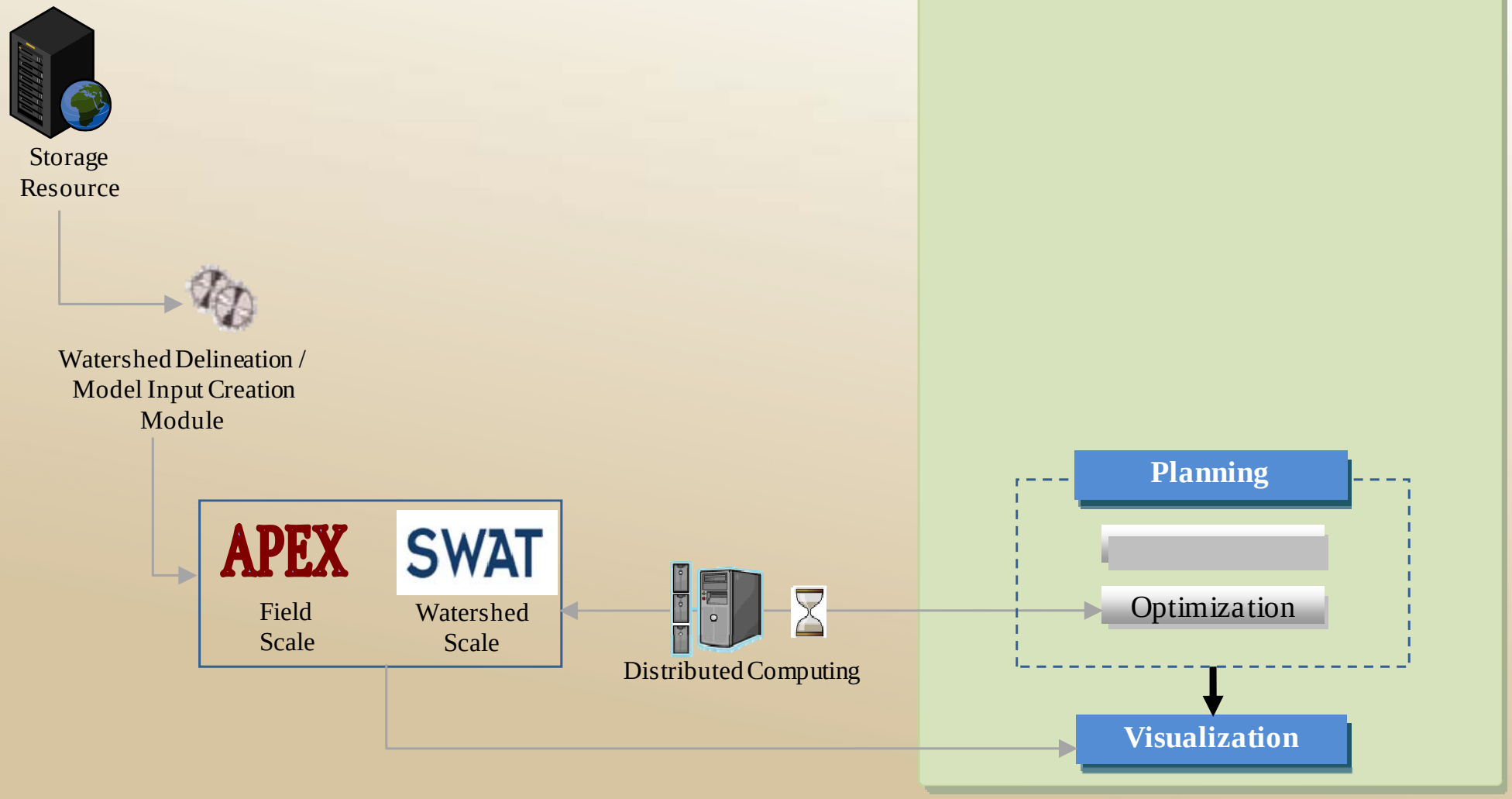


eRAMS Architecture for Conservation Planning and Assessment



Representation of Practices

Assessment Module: Costs and Environmental Benefits



Planning Module: Scenario Analysis / Optimization

eRAMS

share your geographic perspective . . .

What is eRAMS?

a participatory web-based *Geographical Information System* (GIS) that facilitates:

- collection, organization and sharing location based information
- integration of data with complex modeling and decision support systems

Why eRAMS?

The eRAMS technology provides an easy to use platform for participation between various stakeholders to manage land, water and energy resources. **Read More**

Could not log in user spaltte

Username: splatte
Password:
Sign In

Or create a new account

eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Google™ Custom Search | Search

Map | Resource Center | My Account | Groups | Contact Us

User | Map | Renewable Energy

Project Settings

Choose Project: SPRB | Create

Delete

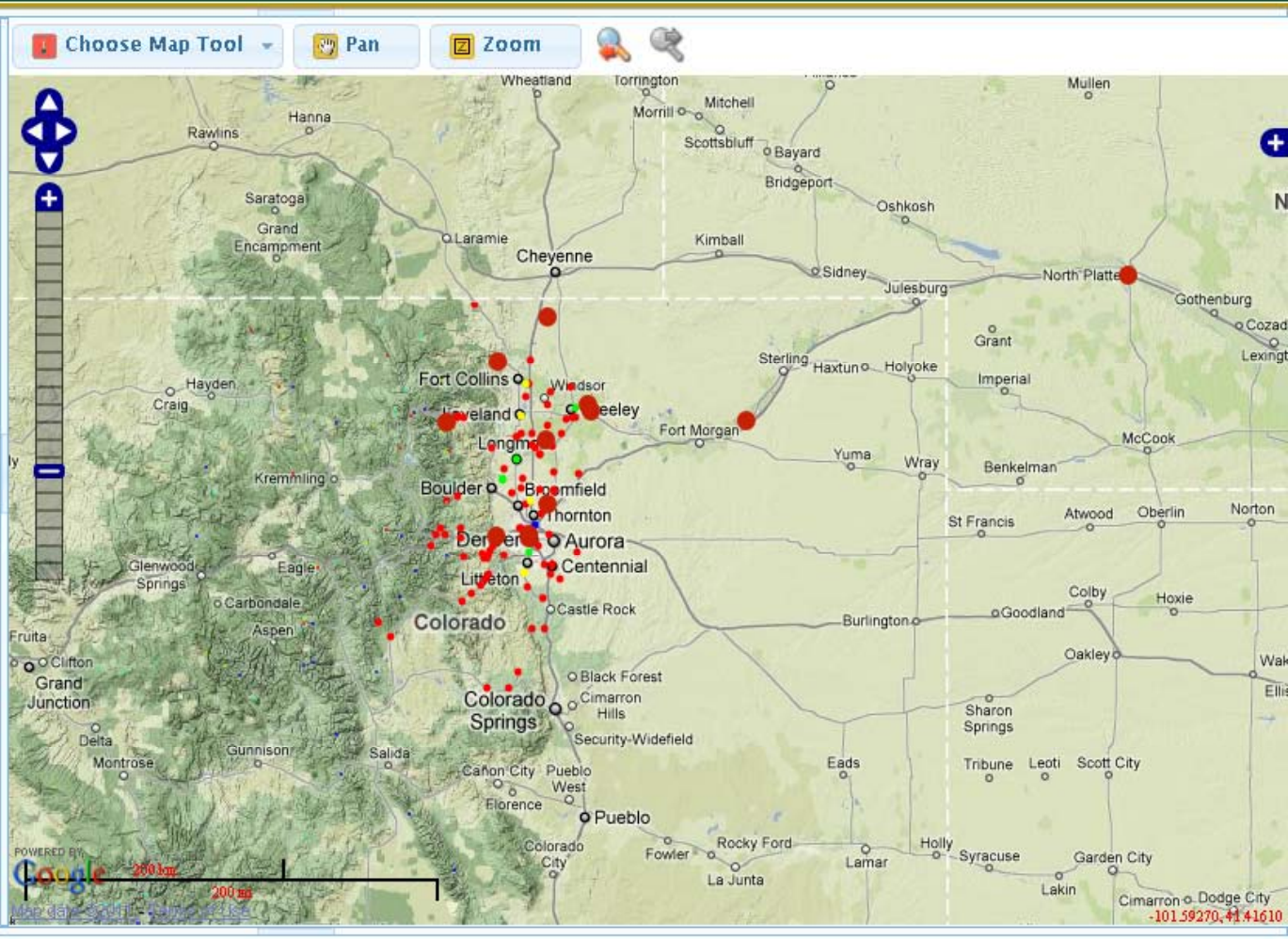
Copy project from other user: Boxelder Creek

Copy

Choose Project Type:

Renewable Energy

☐ This project is public



eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Google™ Custom Search | Search

Map | Resource Center | My Account | Groups | Contact Us

User | Map | Renewable Energy

Project Settings

Choose Project: SPRB | Create

Delete

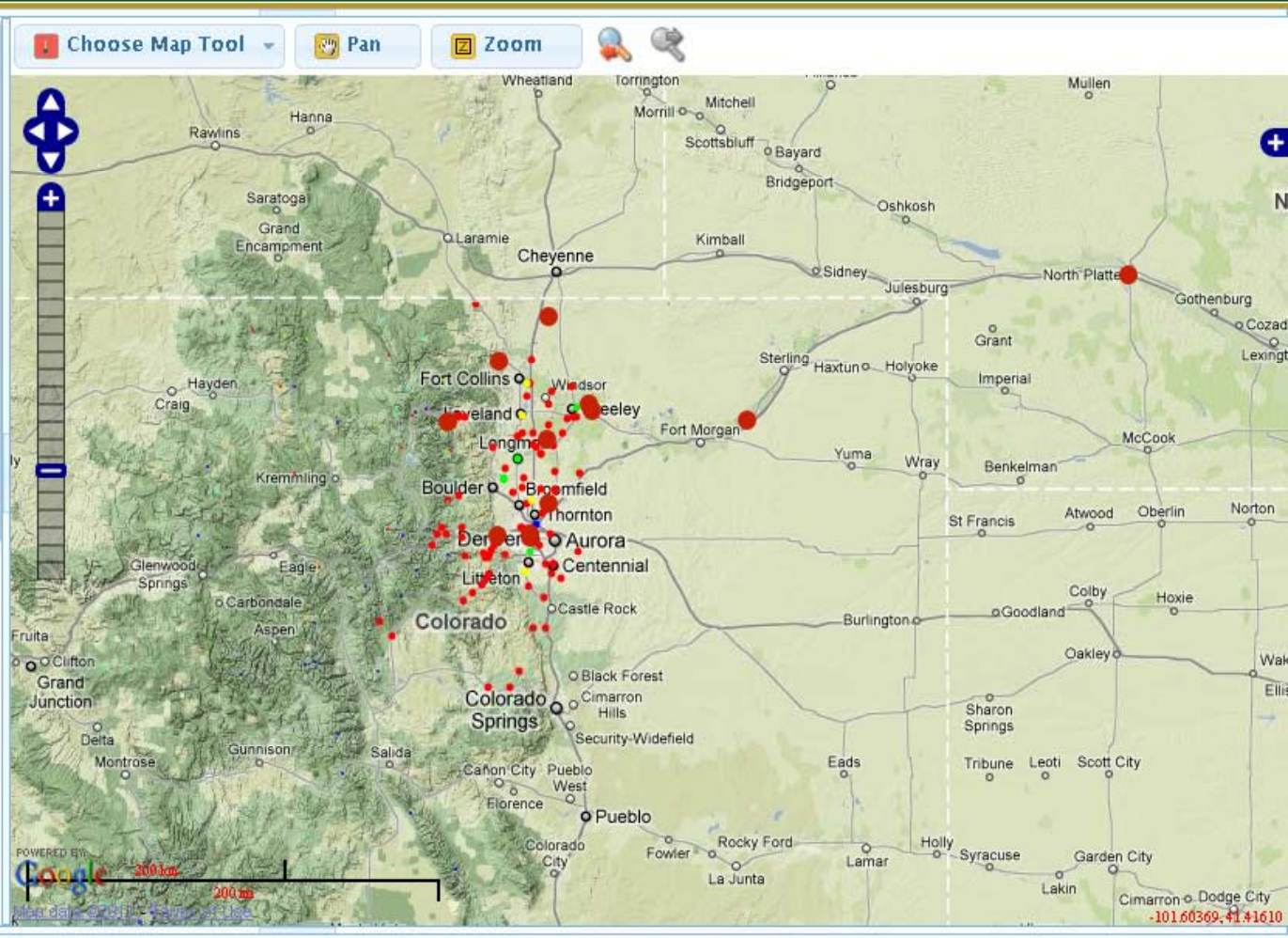
Copy project from other user: Boxelder Creek

Copy

Choose Project Type:

Renewable Energy

- None
- Watershed Management
- Urban Drainage
- Recreation
- Location-based Information Management
- Renewable Energy
- WIRSOL Solar Tracker
- TBET
- RUSLE2
- Irrigation



eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Google™ Custom Search | Search

Map | Resource Center | My Account | Groups | Contact Us

User | Map | LUI | Scenarios | Assessment | Planning | System Analysis

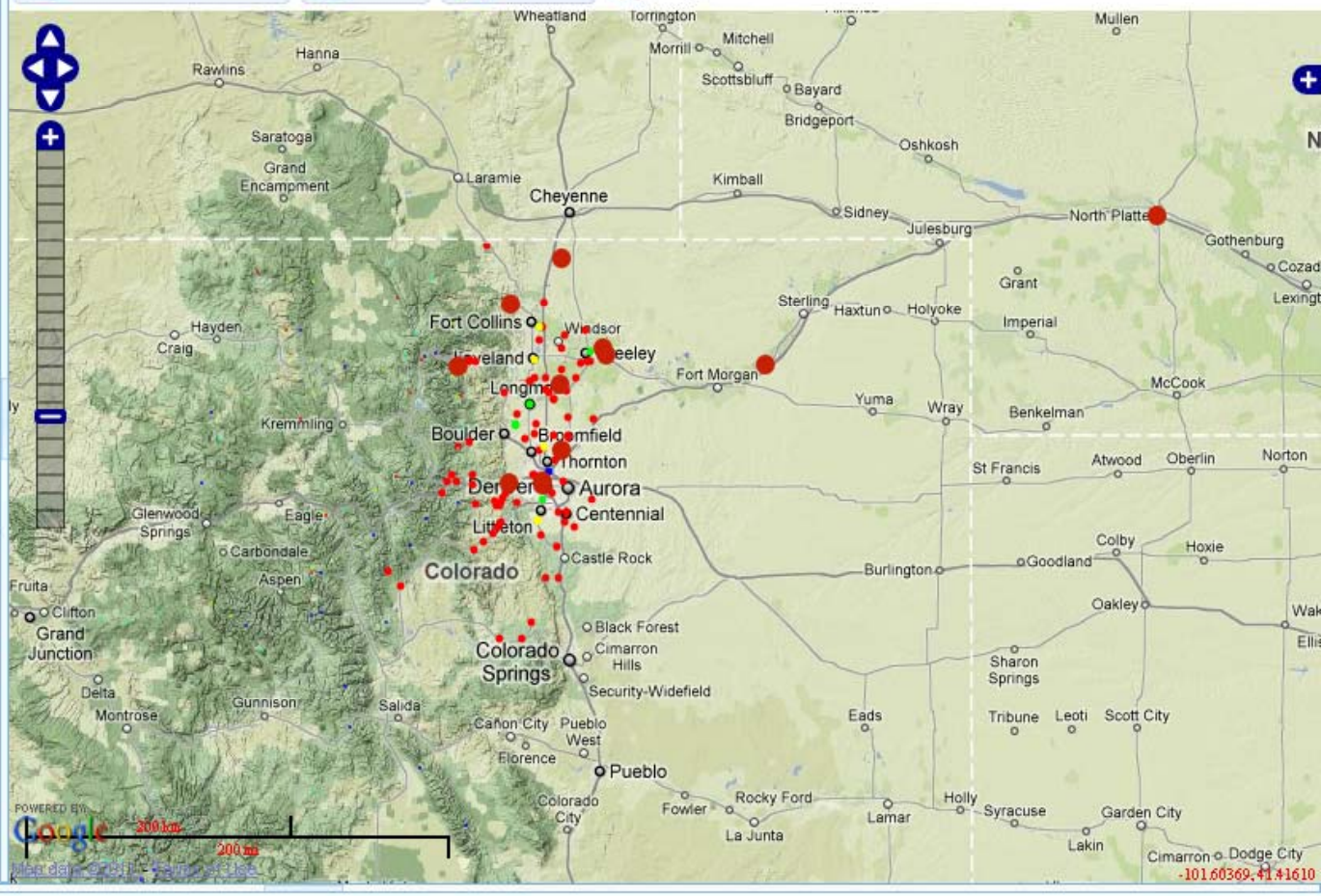
Project Settings

Choose Project: SPRB | Create | Delete

Copy project from other user: Boxelder Creek | Copy

Choose Project Type: Watershed Management

☐ This project is public



eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Google™ Custom Search | Search

Map | Resource Center | My Account | Groups | Contact Us

User | Map | LUI | Scenarios | Assessment | Planning | System Analysis

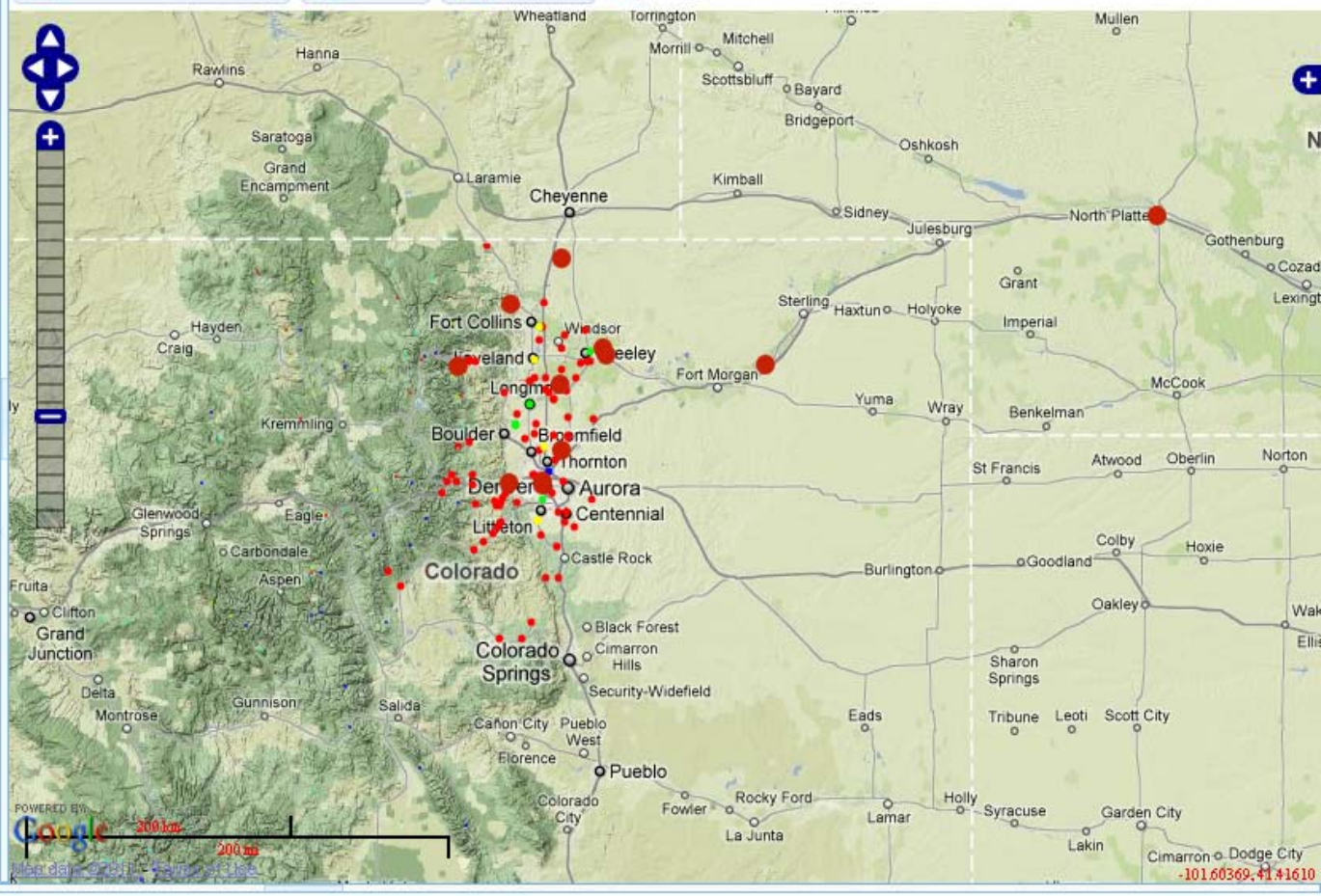
Project Settings

Choose Project: SPRB | Create | Delete

Copy project from other user: Boxelder Creek | Copy

Choose Project Type: Watershed Management

☐ This project is public



eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Google™ Custom Search | Search

Map | Resource Center | My Account | Groups | Contact Us

User | Map | LUI | Scenarios | Assessment | Planning | System Analysis

Zoom to Address: 80521 Go

Settings

Distance Units: Miles

Area Units: Sq. Miles

Scale: 1:1,000,000

Coordinate System: Lat/Long

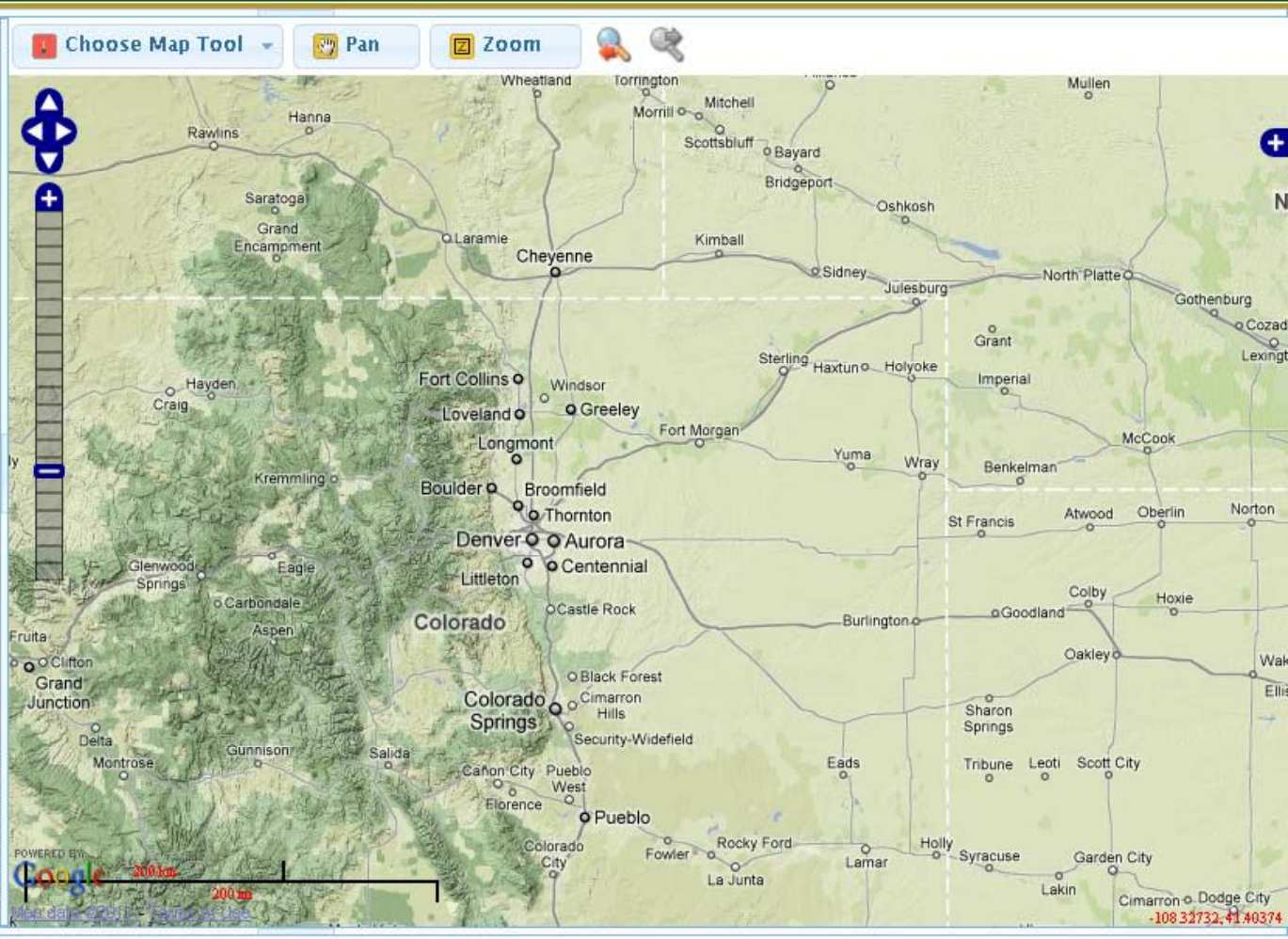
Font size fraction: 1

BMP Edit Style: Tabs with Popup Form

Switch Theme

Base Layers

World Layers



eRAMS
share your geographic perspective . . .

Home | Sign In | Help

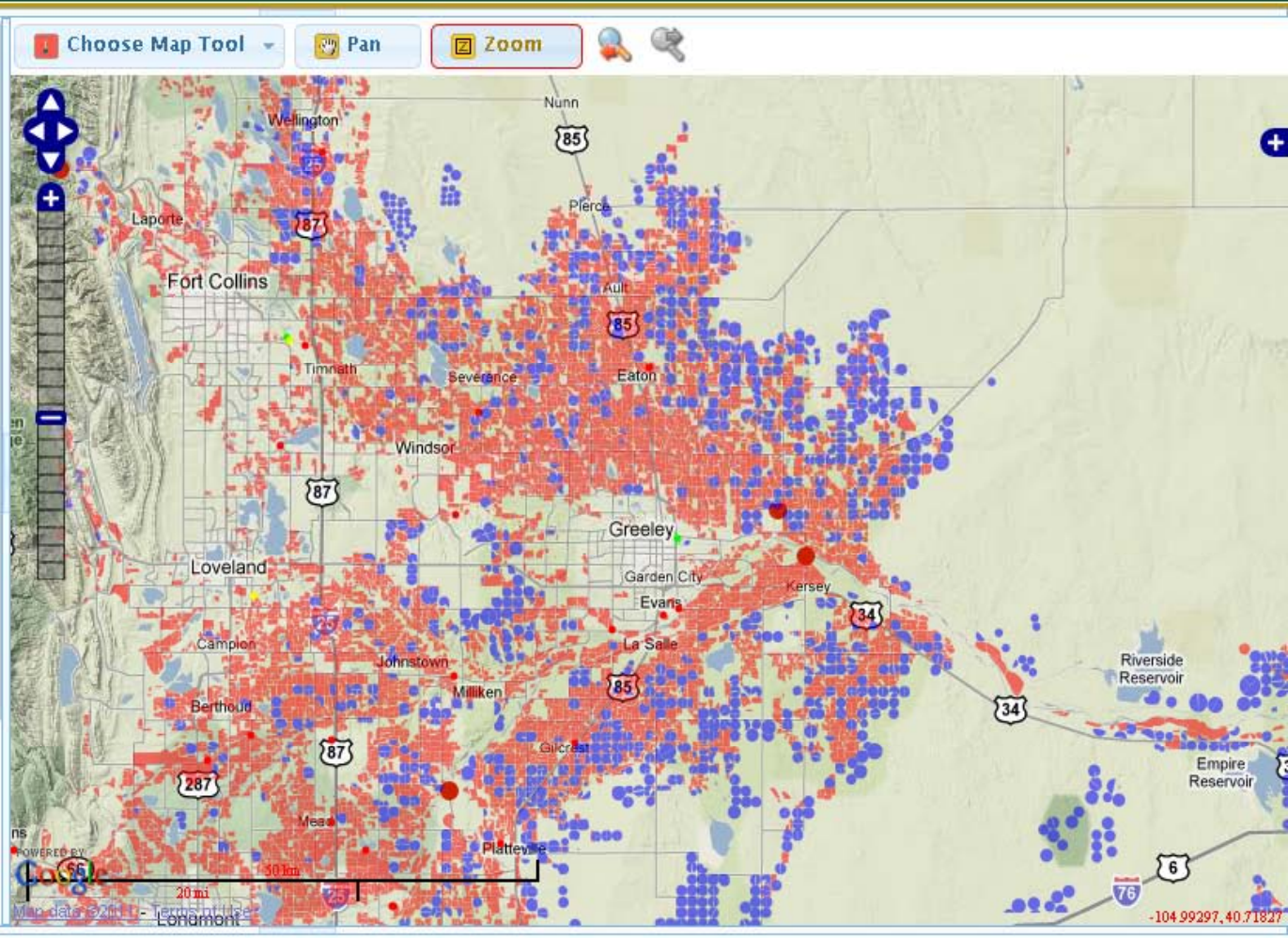
Google™ Custom Search | Search

Map | Resource Center | My Account | Groups | Contact Us

User | Map | LUI | Scenarios | Assessment | Planning | System Analysis

Zoom to Address: 80521 Go

- Settings
- Base Layers
  - Google: Physical Streets Hybrid Satellite
  - Bing: Shaded Hybrid Aerial
- World Layers
- User Layers
- Project Layers
- Editing Layer



eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Google™ Custom Search | Search

Map | Resource Center | My Account | Groups | Contact Us

User | Map | LUI | Scenarios | Assessment | Planning | System Analysis

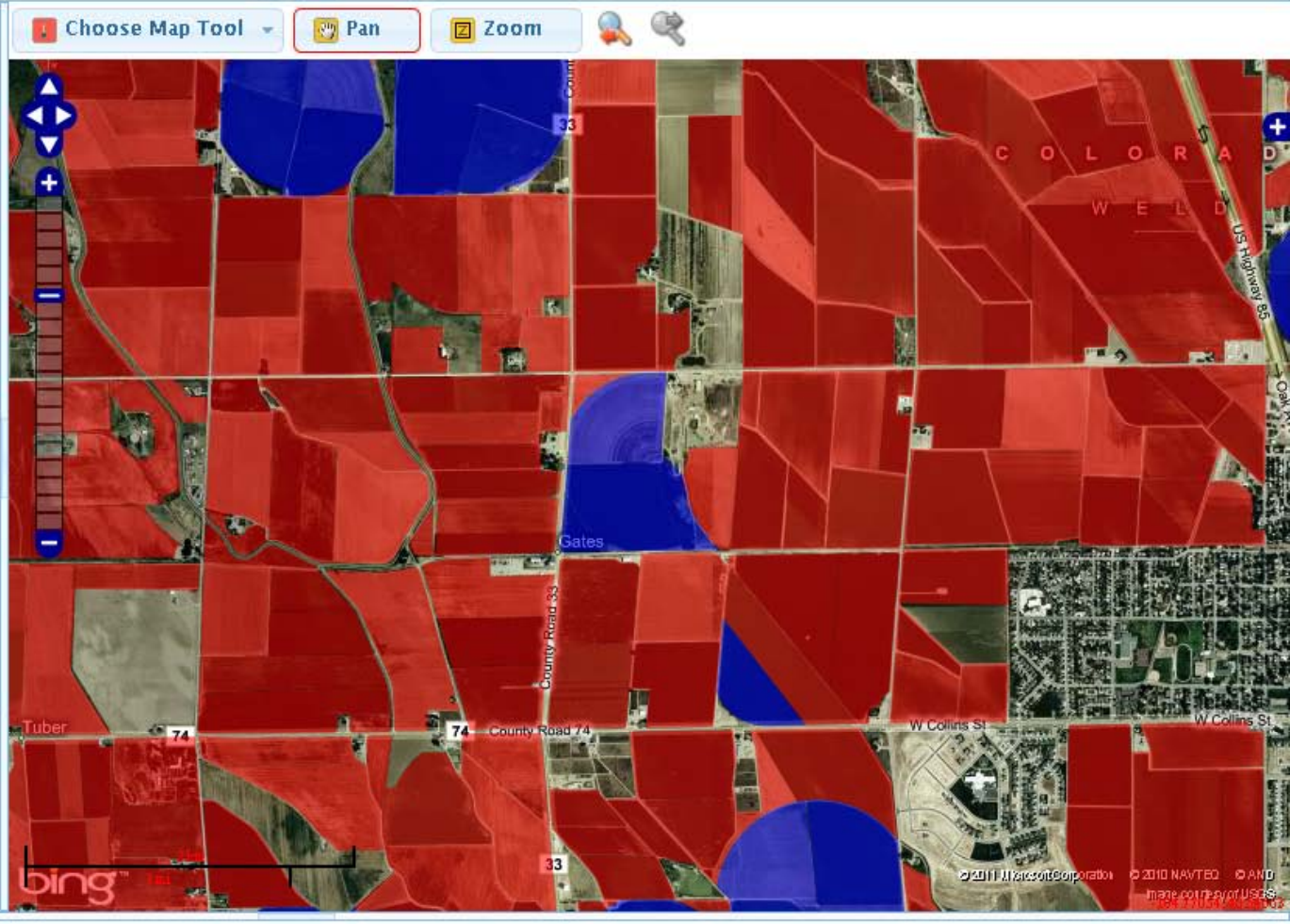
Zoom to Address: 80521 Go

- Settings
- Base Layers

Google
Physical Streets Hybrid Satellite

Bing
Shaded Hybrid Aerial

- World Layers
- User Layers
- Project Layers
- Editing Layer



eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Google™ Custom Search | Search

Map | Resource Center | My Account | Groups | Contact Us

- 3149.2 - 3345.6
- COAGMET
  - elevation
    - 3570.0 - 4407.0
    - 4407.0 - 5244.0
    - 5244.0 - 6081.0
    - 6081.0 - 6918.0
    - 6918.0 - 7755.0
- Aquifers
  - aqu3fou
    - aqu3fou
  - aqu3den
    - symbol
      - 21
      - 48
      - 52
      - 55
      - 60
      - 93
  - aqu3vfa
    - symbol
      - aqu3vfa
- Irrigated Fields
  - div1_irrig_2005_Clip
    - irrig_type
      - FLOOD
      - SPRINKLER
  - div1_irrig_2001_Clip
    - irrig_type
      - FLOOD
      - SPRINKLER

Choose Map Tool | Pan | Zoom

Edit Symbols for div1_irrig_2005_Clip

Classify Fields | Edit Symbols

Set symbol field: acres

Min Color:

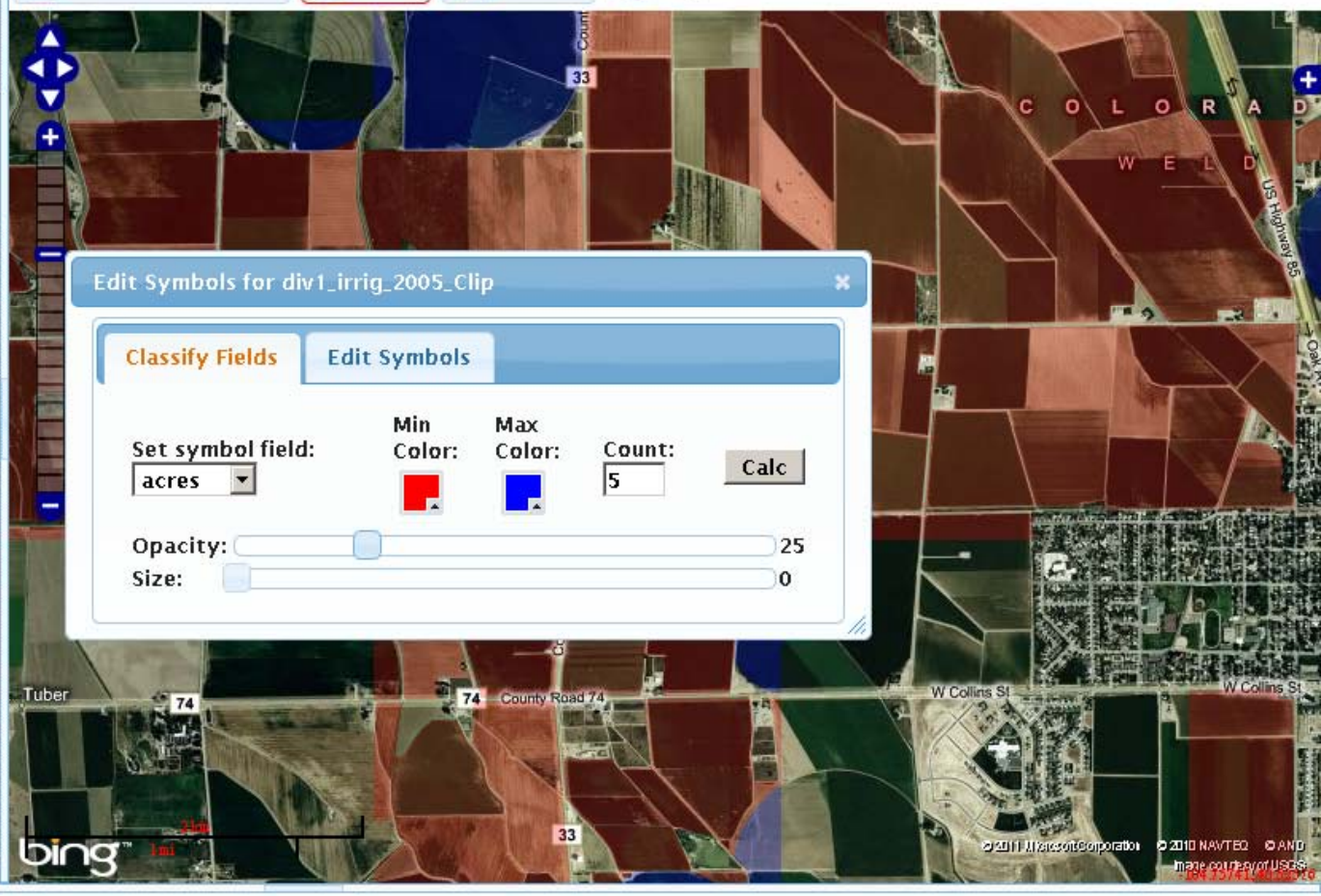
Max Color:

Count: 5

Calc

Opacity: 25

Size: 0



eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Google™ Custom Search | Search

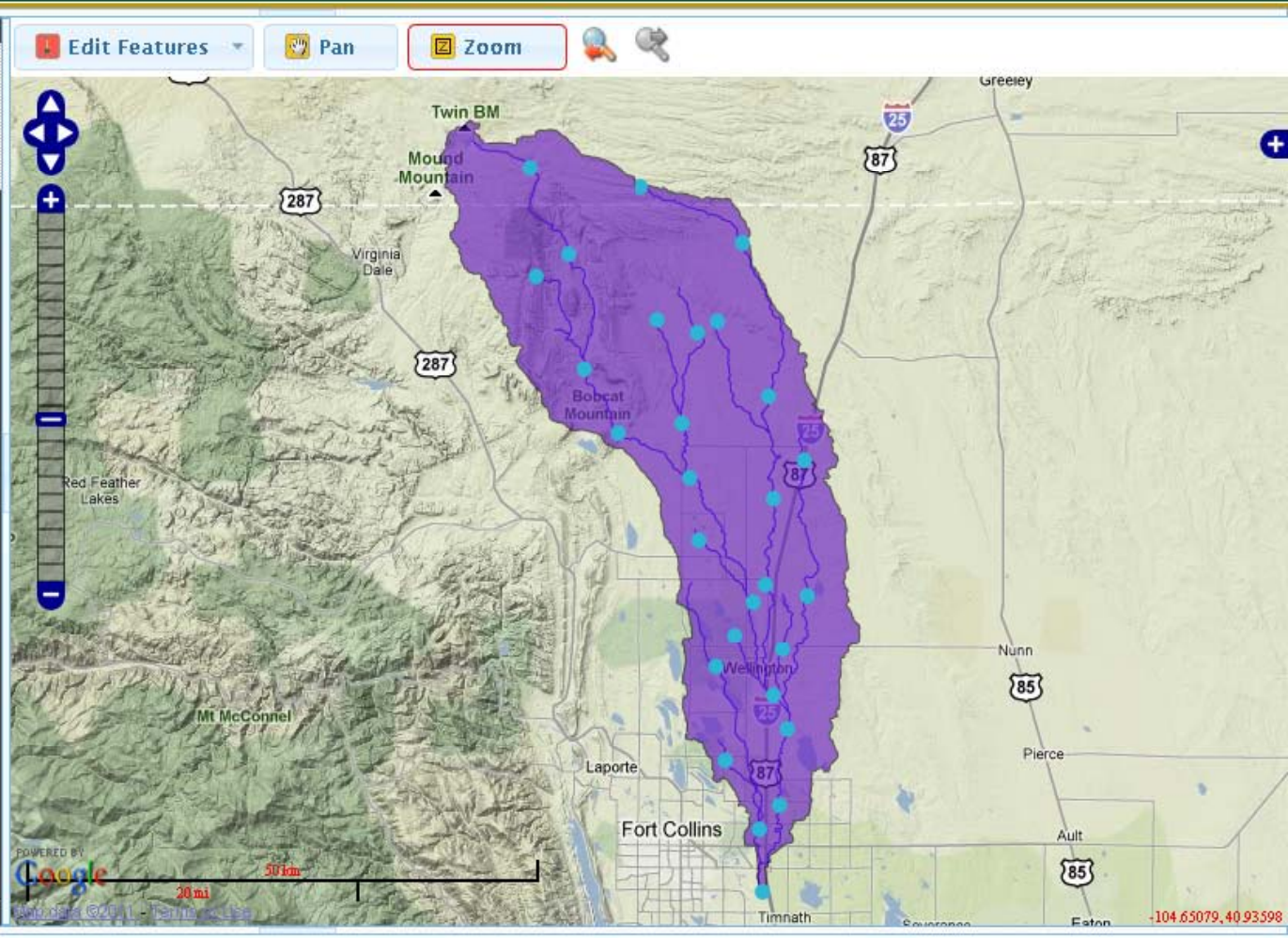
Map | Resource Center | My Account | Groups | Contact Us

- Settings
- Base Layers
- World Layers
- User Layers
- Project Layers

Available Layers
- Outlets
  - Outlets
- Hydrologic Response Units
  - hru1
- Watershed Boundary
  - Basin
- Streams
  - subbasin
  - 1.0 - 28.0
- Subwatersheds
  - OrgPYId
  - subs1

Add Shapefiles

- Editing Layer



eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Google™ Custom Search | Search

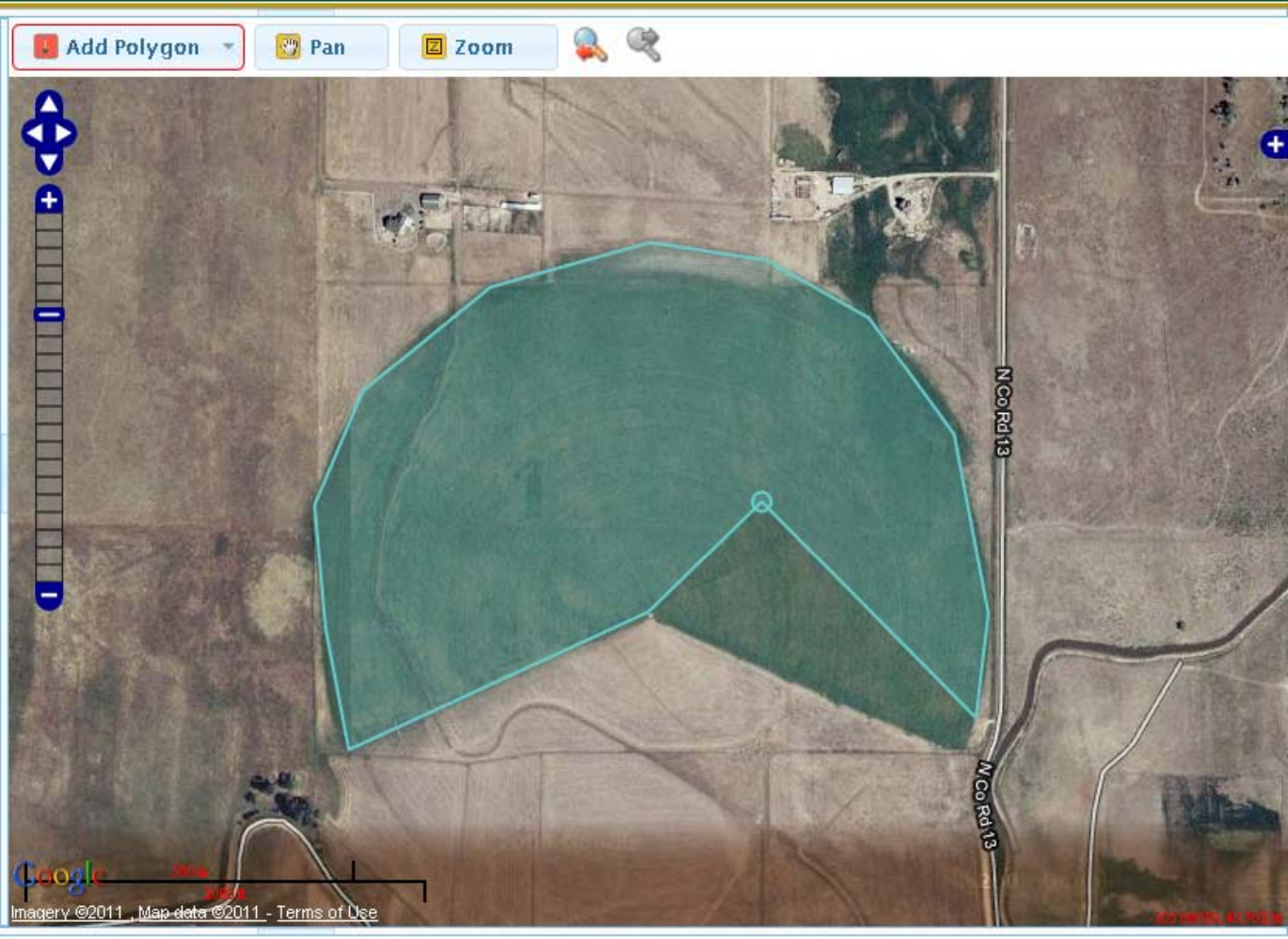
Map | Resource Center | My Account | Groups | Contact Us

User | Map | LUI | Scenarios | Assessment | Planning | System Analysis

Zoom to Address: 80521 Go

- Settings
- Base Layers
- World Layers
- User Layers
- Project Layers
- Editing Layer

Select layer to edit: Polygons



eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Google™ Custom Search | Search

Map | Resource Center | My Account | Groups | Contact Us

User | Map | LUI | Scenarios | Assessment | Planning | System Analysis

Zoom to Address: 80521 Go

- Settings
- Base Layers
- World Layers
- User Layers
- Project Layers
- Editing Layer

Select layer to edit:
Polygons

Add Polygon | Pan | Zoom

eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Google™ Custom Search | Search

Map | Resource Center | My Account | Groups | Contact Us

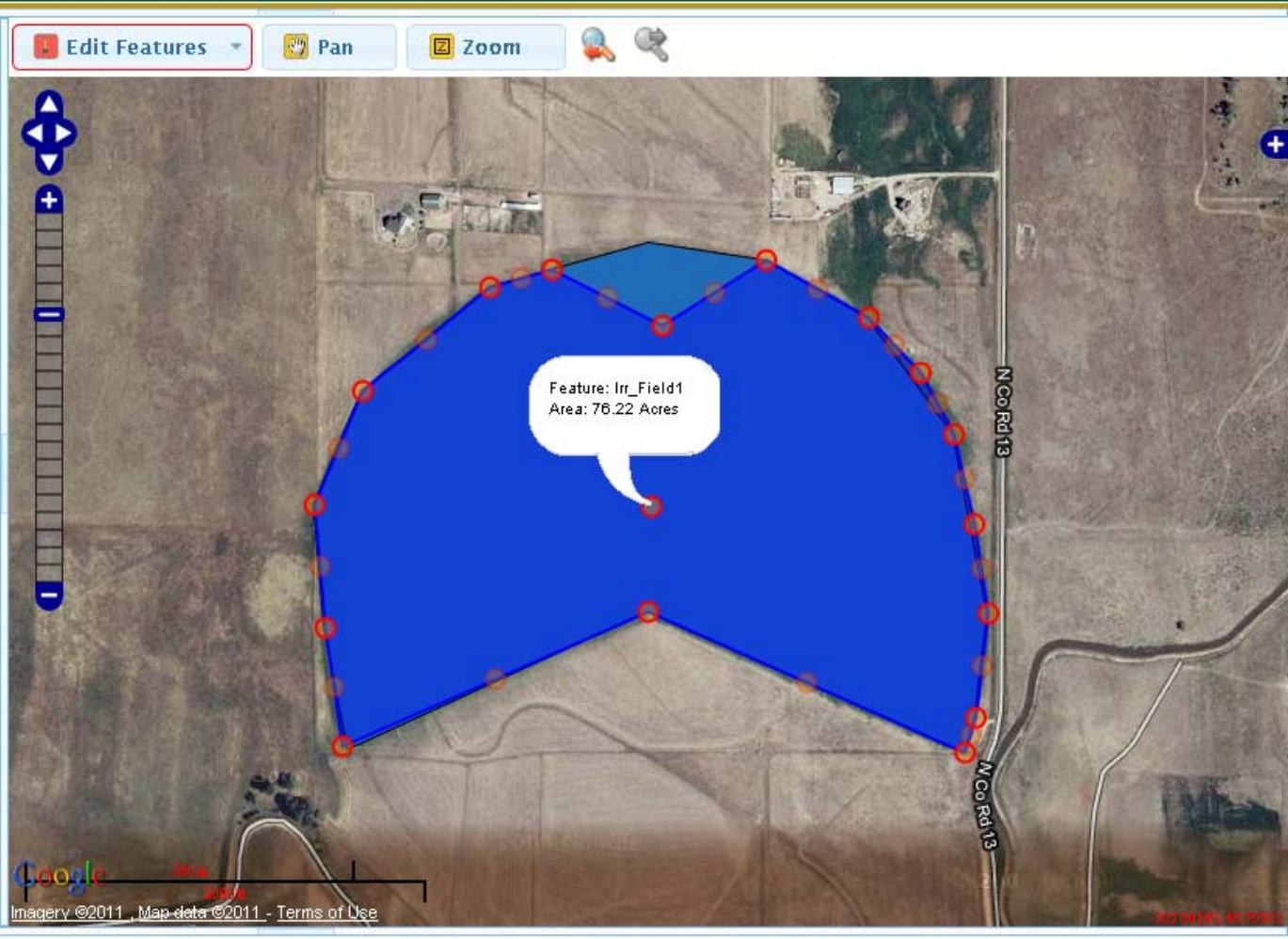
User | Map | LUI | Scenarios | Assessment | Planning | System Analysis

Zoom to Address: 80521 Go

- Settings
- Base Layers
- World Layers
- User Layers
- Project Layers
- Editing Layer

Select layer to edit:
Polygons

Delete Selected | Save Feature Edits | Undo Feature Edits



eRAMS
share your geographic perspective . . .

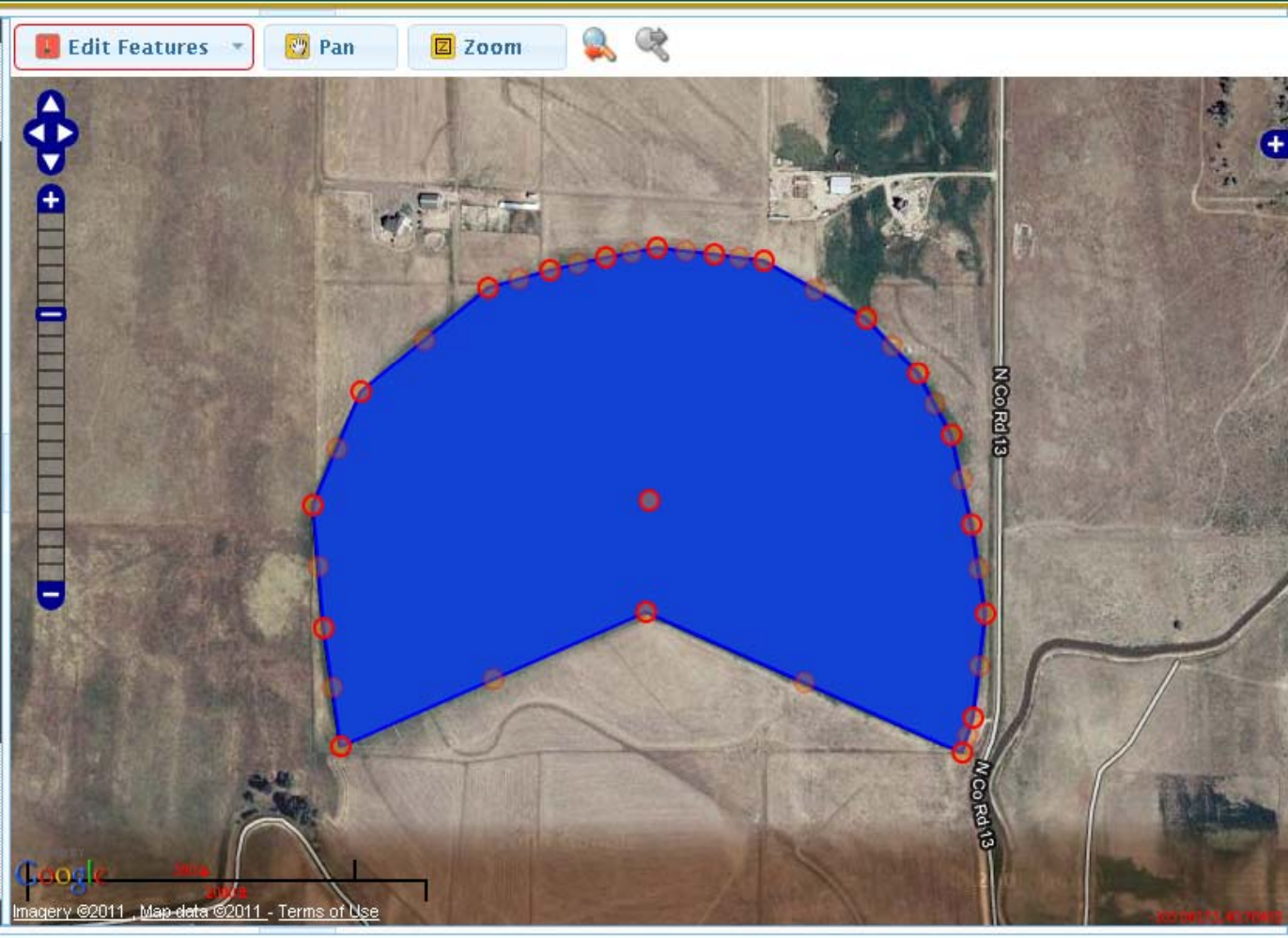
Home | Sign In | Help

Google™ Custom Search Search

Map | Resource Center | My Account | Groups | Contact Us

Select fields with name: Irr_Field1 Go

- Bank Stabilization
- Contouring
- Crop Rotation
- Fertilizer Management
- Field Borders
- Filter Strips
- Grade Stabilization Structure
- Grassed Waterway
- Grazing
- Irrigation
- Land Use
- Pesticide Management
- Ponds
- Riparian Strips
- Sediment Detention Basin



eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Google™ Custom Search | Search

Map | Resource Center | My Account | Groups | Contact Us

Select fields with name: Irr_Field1 | Go

- Bank Stabilization
- Contouring
- Crop Rotation
- Fertilizer Management
- Field Borders
- Filter Strips
- Grade Stabilization Structure
- Grassed Waterway
- Grazing
- Irrigation
- Land Use
- Pesticide Management
- Ponds
- Riparian Strips
- Sediment Detention Basin

Edit Features | Pan | Zoom

Irrigation

Enable

Option: No Irrigation

Source Location:

Minimum in-stream (m^3/s):

Flow Fraction:

Irrigation Depth (mm):

Unit Cost ($/unit): 60 ha

NRCS Standards

Photo courtesy of NRCS

eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Map | Resource Center | My Account | Gro

Crop Rotation
Fertilizer Management
Field Borders
Filter Strips
Grade Stabilization Structure
Grassed Waterway
Grazing
Irrigation
Land Use
Pesticide Management
Ponds
Riparian Strips
Sediment Detention Basin
Terraces
Tillage/Residue Management
Wetland

Save | Undo

Tillage/Residue Management

Enable ☐

Curve No. Unit Reduction: 2

Old Tillage Type:
- generic fall plowing operation
- generic spring plowing operation
- generic conservation tillage
- generic no-till mixing
- DUCKFOOT CULTIVATOR
- FIELD CULTIVATOR GE15FT
- FIELD CULTIVATOR LT15FT
- FURROW-OUT CULTIVATOR
- MARKER (CULTIVATOR)
- ROLLING CULTIVATOR GE15FT

New Tillage Type:
- generic fall plowing operation
- generic spring plowing operation
- generic conservation tillage
- generic no-till mixing
- DUCKFOOT CULTIVATOR
- FIELD CULTIVATOR GE15FT
- FIELD CULTIVATOR LT15FT
- FURROW-OUT CULTIVATOR
- MARKER (CULTIVATOR)
- ROLLING CULTIVATOR GE15FT

Photo courtesy of NRCS

Percent Cover: 50 kg/ha

Unit Cost ($/unit): 50 ha

SWAT Conservation Practice Sheets

SWAT No Till.pdf (application/pdf Object) - Mozilla Firefox

http://www.eramsinfo.com/media_erams/eRAMS Practices/SWAT Representation Sheets/SWAT No Till.pdf

1 / 2 64.7% Find

No Till

(Residue and tillage management no till/ strip till/ direct seed

DESCRIPTION

No till agriculture involves the amount, orientation and distribution of crop and other plant residue on the soil surface year round while limiting soil-disturbing activities to only those necessary to place nutrients, condition residue and plant crops.

No-Till reduces sheet and rill and wind erosion. The practice works to improve soil organic matter content. Reduce CO_2 losses from the soil. Reduce soil particulate emissions. Increase plant-available moisture. Provide food and escape cover for wildlife.

USDA-NRCS, 2003. *National Conservation Practice Standards.* http://www.nrcs.usda.gov/technical/standards/nhcp.html

Photo Courtesy USDA-NRCS Online Photo Gallery

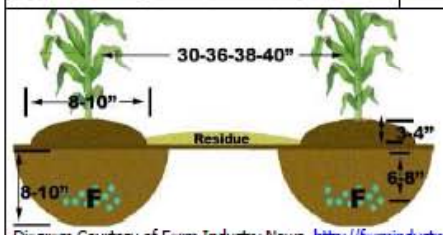


Diagram Courtesy of Farm Industry News http://farmindustrynews.commag/farming_striptill_teamwork/

POLLUTANT REMOVAL

Pesticides= moderate to substantial
Nutrients and Organics= Slight
Suspended Sediment= Slight to substantial
Salinity= Slight
Heavy Metal= Slight
Temperature= Not Applicable
Pathogens= Slight

IMPLEMENTATION REQUIREMENTS

Cost
Operation and Maintenance
Training

LANDUSE APPLICATION=
Cropland, Pasture

Done

Tillage/Residue Management

Enable

Curve No. Unit Reduction: 2

Old Tillage Type:

- generic fall plowing opera
- generic spring plowing op
- generic conservation tilla
- generic no-till mixing
- DUCKFOOT CULTIVATOR
- FIELD CULTIVATOR GE15FT
- FIELD CULTIVATOR LT15FT
- FURROW-OUT CULTIVATOR
- MARKER (CULTIVATOR)
- ROLLING CULTIVATOR GE1

New Tillage Type:

- generic fall plowing opera
- generic spring plowing op
- generic conservation tilla
- generic no-till mixing
- DUCKFOOT CULTIVATOR
- FIELD CULTIVATOR GE15FT
- FIELD CULTIVATOR LT15FT
- FURROW-OUT CULTIVATOR
- MARKER (CULTIVATOR)
- ROLLING CULTIVATOR GE1

Percent Cover: 50 kg/ha

Unit Cost ($/unit): 50 ha

SWAT Conservation Practice Sheets

Photo courtesy of NRCS

eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Google™ Custom Search | Search

Map | Resource Center | My Account | Groups | Contact Us

User | Map | LUI | Scenarios | Assessment | Planning | System Analysis

Zoom to Address: 80521 Go

- Settings
- Base Layers
- World Layers
- User Layers
- Project Layers

Available Layers
- Outlets
  - Outlets
- Hydrologic Response Units
  - Hydrologic Response Units
- Watershed Boundary
  - Watershed Boundary
- Streams
  - subbasin
    - 1.0 - 28.0
- Subwatersheds
  - OrgPYld

Edit Features | Pan | Zoom

eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Google™ Custom Search | Search

Map | Resource Center | My Account | Groups | Contact Us

User | Map | LUI | Scenarios | Assessment | Planning | System Analysis

▸ Select GIS layers

▾ Design Scenario

Choose Scenario: Baseline | Create | Delete

Baseline
scen1

Scenario: Baseline

Model inputs have been specified for this scenario. To change the inputs, either upload new zipped model input files or copy them from another scenario.

Add Model Input

Or base scenario on: scen1 | Copy

▸ Location and Type of Conservation Practices for *Baseline*

Edit Features | Pan | Zoom

eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Google™ Custom Search | Search

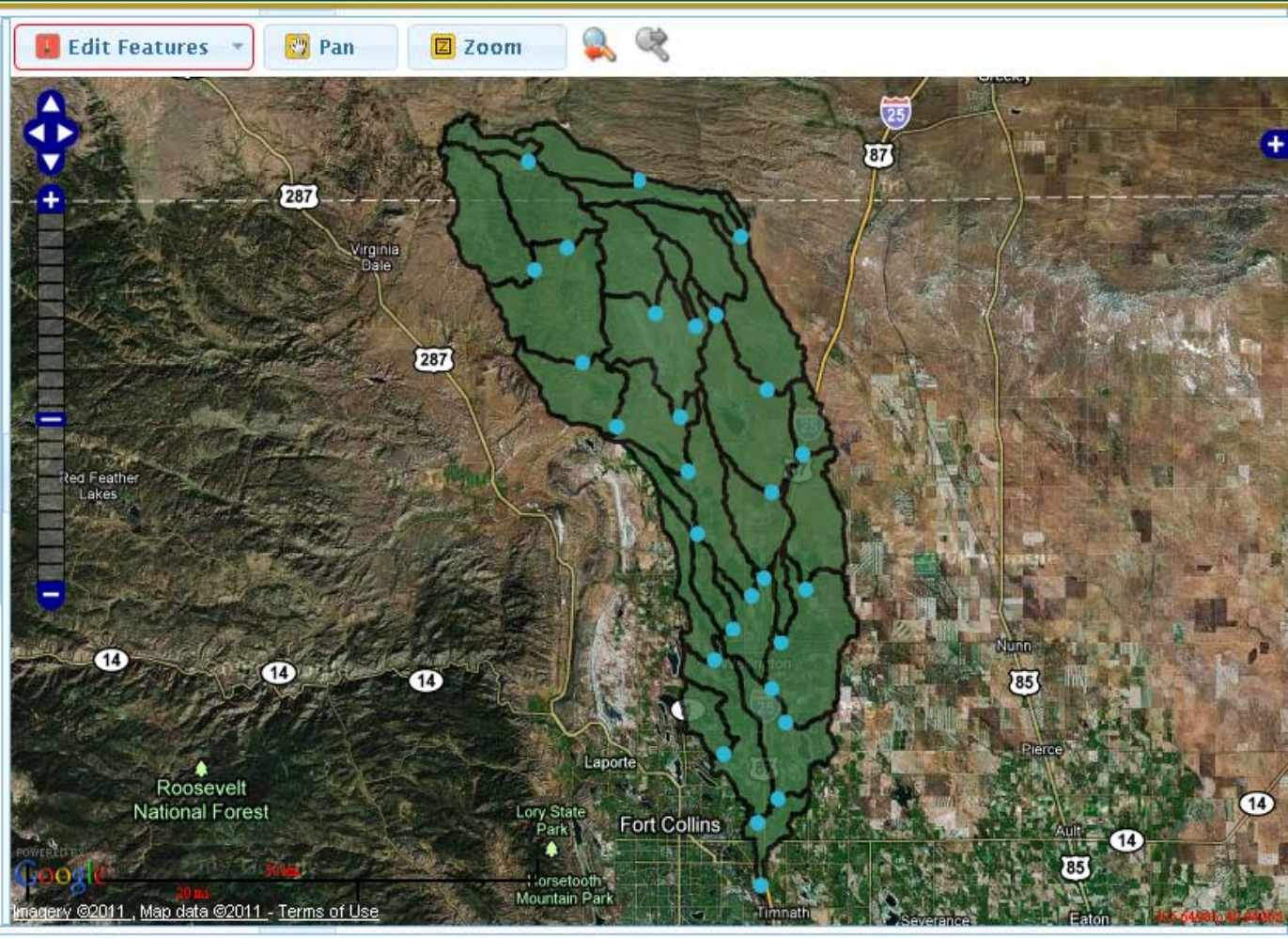
Map | Resource Center | My Account | Groups | Contact Us

User | Map | LUI | Scenarios | Assessment | Planning | System Analysis

- Select GIS layers
- Design Scenario
- Location and Type of Conservation Practices for *scen1*

Choose query: q1 | Create | Delete

- Select By Attribute
- Select By Spatial Location
- Assign Conservation Practices



eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Google™ Custom Search | Search

Map | Resource Center | My Account | Groups | Contact Us

User | Map | LUI | Scenarios | Assessment | Planning | System Analysis

- Select GIS layers
- Design Scenario
- Location and Type of Conservation Practices for *scen1*

Choose query: q1 | Create | Delete

- Select By Attribute

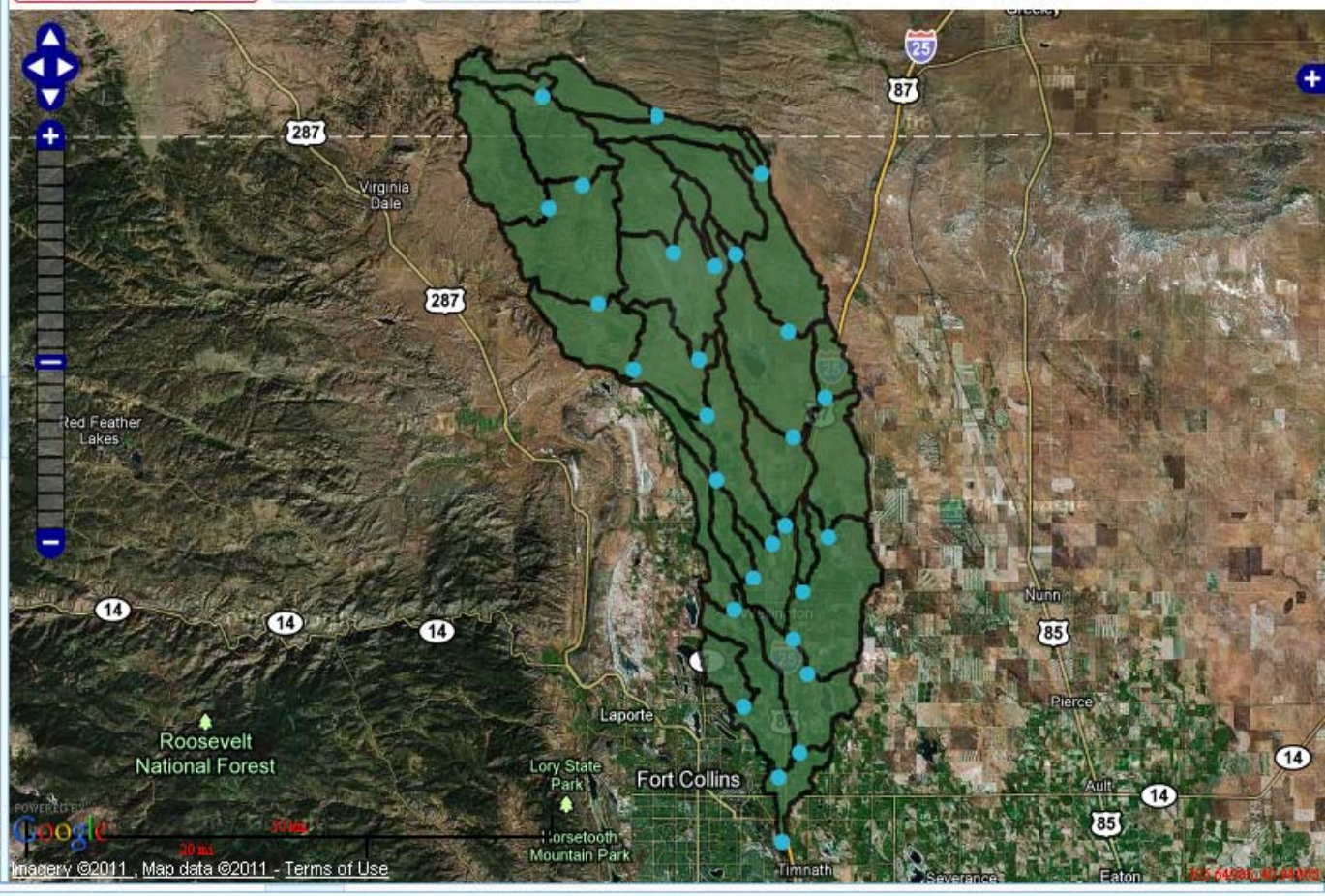
Land Use | <empty>

All
Flood Irr
Flood Irr
Flood Irr
Flood Irr
Flood Irr
Flood Irr
Forest-E
Pasture
Range-Bi

<empty>
Subbasin:
Soil Type
Hydro Group

- Select By Spatial Location
- Assign Conservation Practices

Edit Features | Pan | Zoom



eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Google™ Custom Search | Search

Map | Resource Center | My Account | Groups | Contact Us

User | Map | LUI | Scenarios | Assessment | Planning | System Analysis

- Select GIS layers
- Design Scenario
- Location and Type of Conservation Practices for *scen1*

Choose query: q1 | Create | Delete

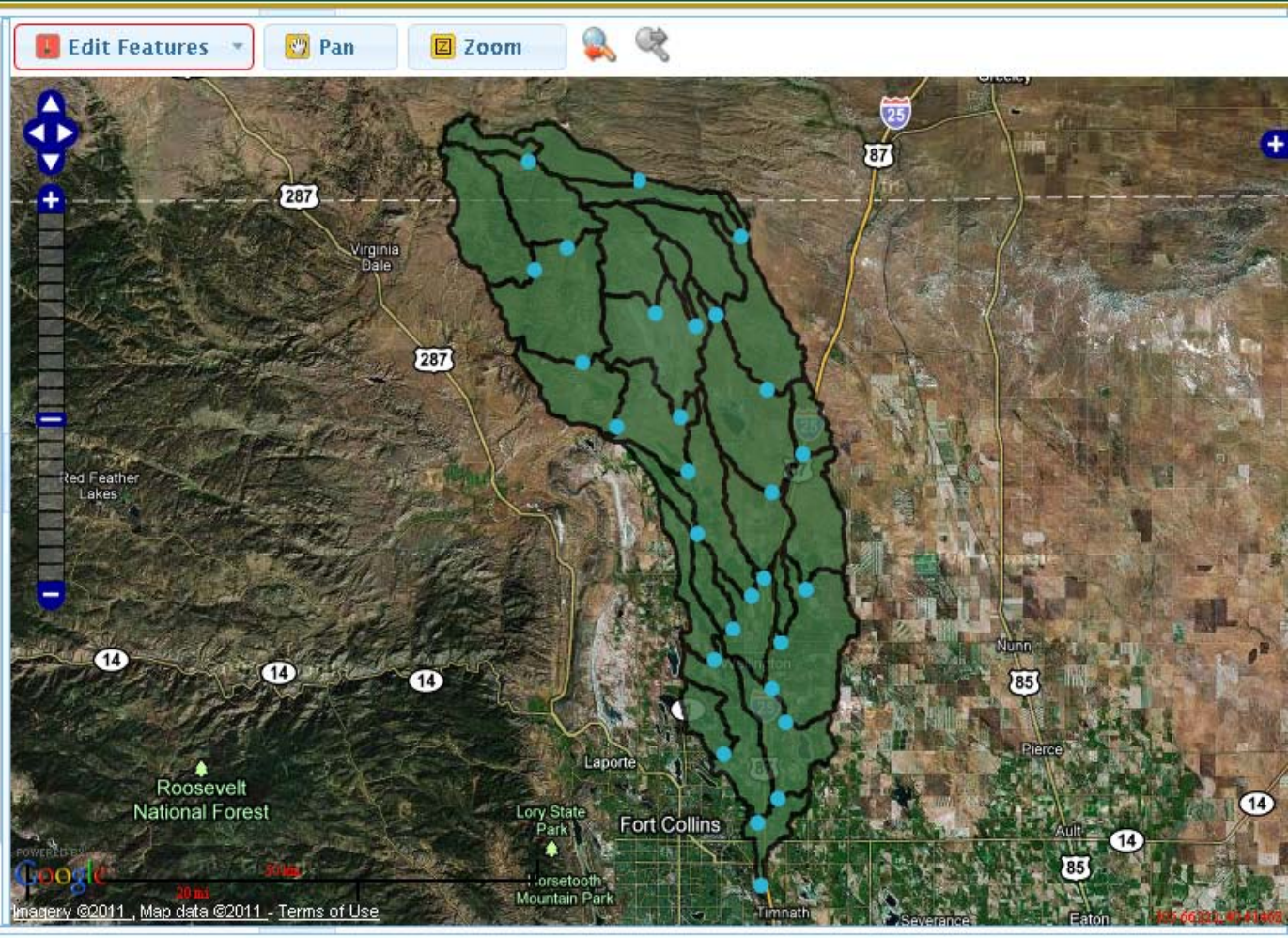
- Select By Attribute
- Select By Spatial Location

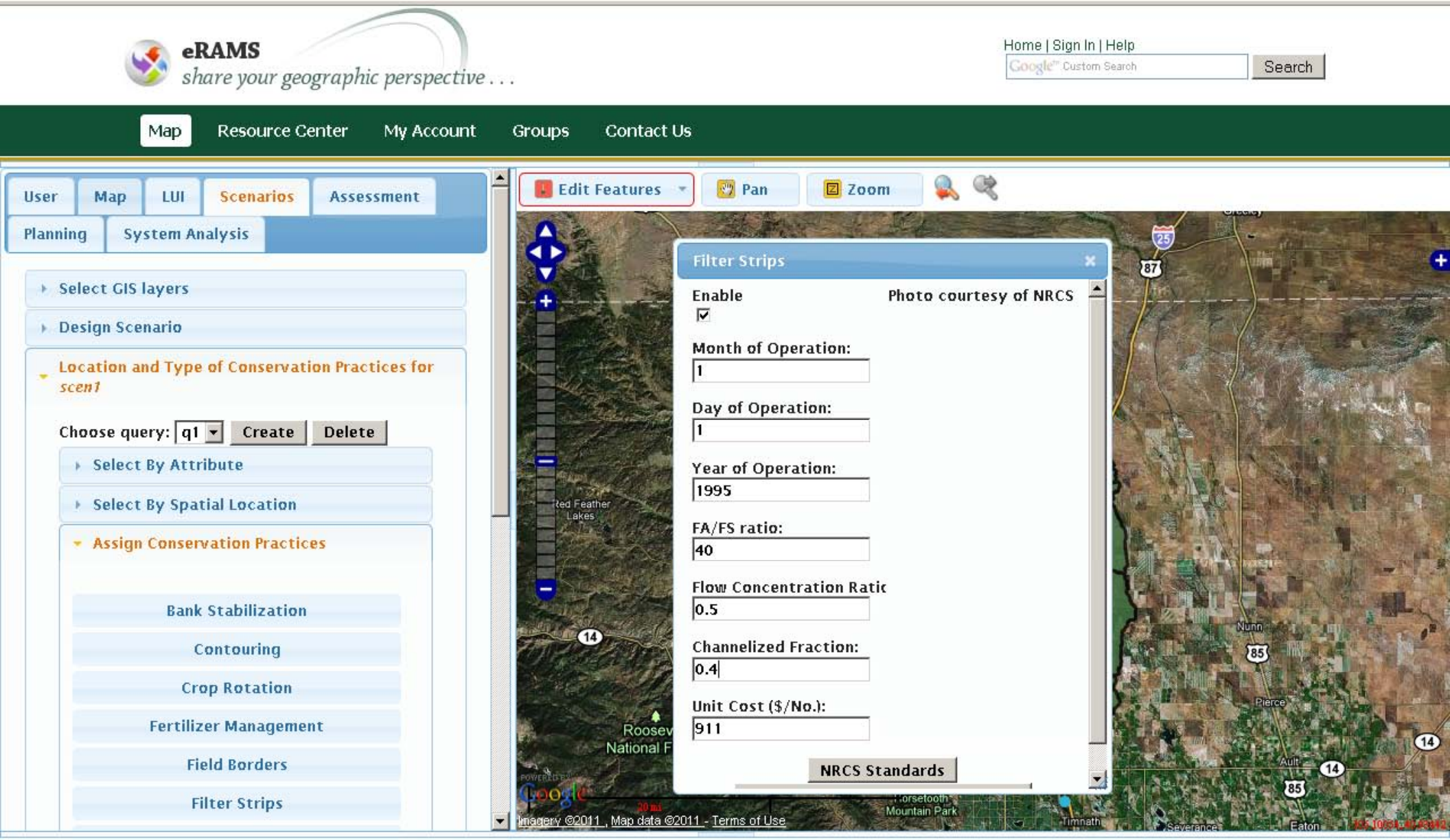
Select from HRU Map

Or intersect using the following polygons: | Calc

Results of selection:

- Assign Conservation Practices




eRAMS
share your geographic perspective . . .
Home | Sign In | Help
Google™ Custom Search
Search
Map
Resource Center
My Account
Groups
Contact Us
User
Map
LUI
Scenarios
Assessment
Planning
System Analysis
Select GIS layers
Design Scenario
Location and Type of Conservation Practices for scen1
Choose query: q1
Create
Delete
Select By Attribute
Select By Spatial Location
Assign Conservation Practices
Bank Stabilization
Contouring
Crop Rotation
Fertilizer Management
Field Borders
Filter Strips
Edit Features
Pan
Zoom
Filter Strips
Enable
Photo courtesy of NRCS
Month of Operation:
1
Day of Operation:
1
Year of Operation:
1995
FA/FS ratio:
40
Flow Concentration Ratic
0.5
Channelized Fraction:
0.4
Unit Cost ($/No.):
911
NRCS Standards
Imagery ©2011 , Map data ©2011 - Terms of Use

eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Google™ Custom Search | Search

Map | Resource Center | My Account | Groups | Contact Us

User | Map | LUI | Scenarios | Assessment | Planning | System Analysis

General Analysis Settings

Scenarios: scen1

Time step: Monthly

start date: 01/01/1978

end date: 12/31/2004 Run

Visualization Settings

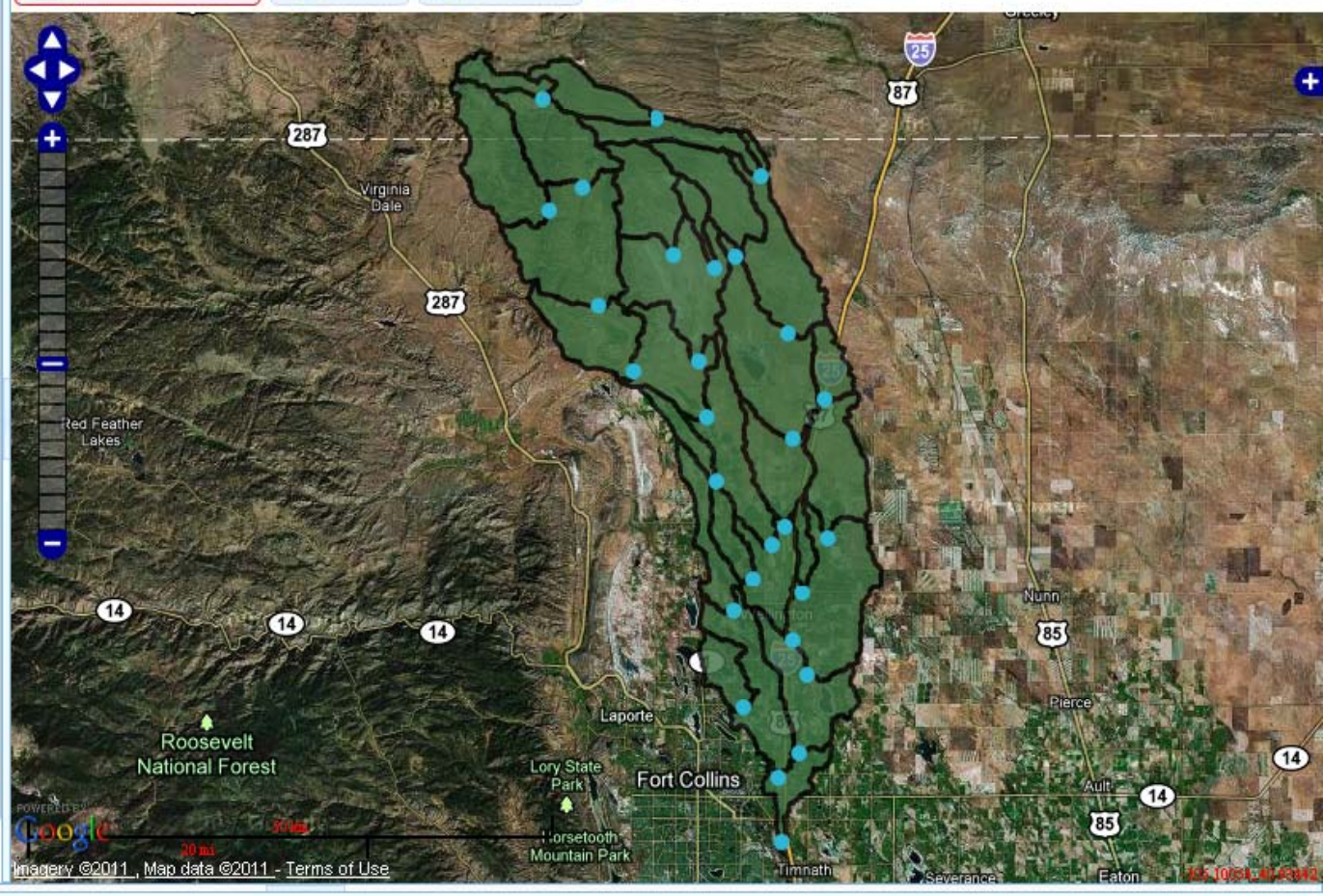
Choose Scenarios: scen1, Baseline

Period to Display:

start date: 01/01/1978

end date: 12/31/2004

- Field
- Outlet
- Watershed
- Cost



eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Google™ Custom Search | Search

Map | Resource Center | My Account | Groups | Contact Us

User | Map | LUI | Scenarios | Assessment | Planning | System Analysis

General Analysis Settings

Scenarios: scen1

Time step: Annual

start date: 01/01/1990

end date: 12/31/2000 Run

Visualizatio

Choose Sce

Period to Di

start date:

end date:

December 2000

Su	Mo	Tu	We	Th	Fr	Sa
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

- Field
- Outlet
- Watershed
- Cost

Edit Features | Pan | Zoom

eRAMS
share your geographic perspective . . .

Home | Sign In | Help

Google™ Custom Search | Search

Map | Resource Center | My Account | Groups | Contact Us

- Base Layers
- World Layers
- User Layers
- Project Layers

Available Layers

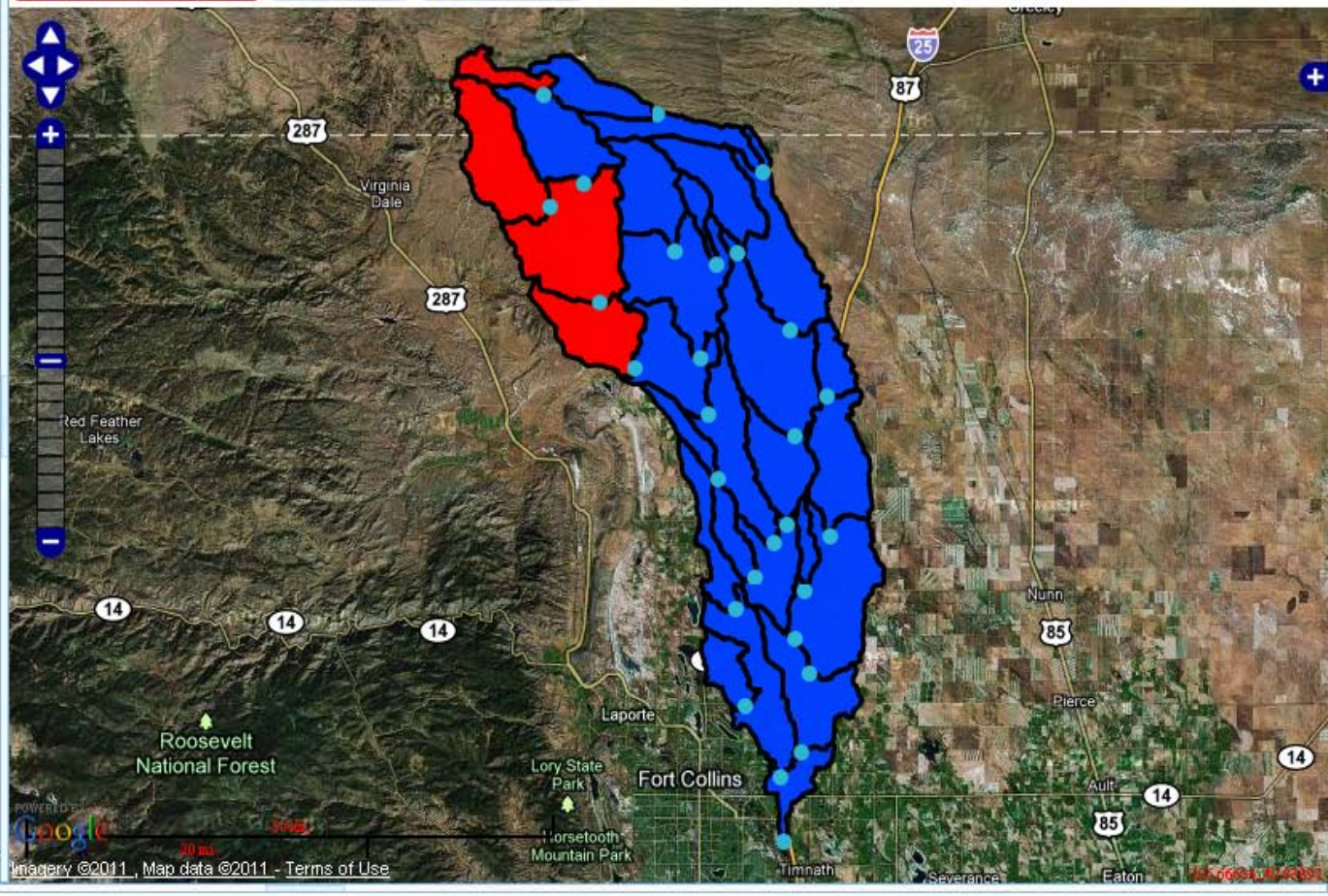
- **Outlets**
  - Outlets
- **Hydrologic Response Units**
  - Hydrologic Response Units
- **Watershed Boundary**
  - Watershed Boundary
- **Streams**
  - subbasin
  - 1.0 - 28.0
- **Subwatersheds**
  - OrgPYld
  - 0.000365 - 0.0132978
  - 0.0132978 - 0.0262306
  - 0.0262306 - 0.0391634
  - 0.0391634 - 0.052[illegible]
  - 0.0520962 - 0.065[illegible]

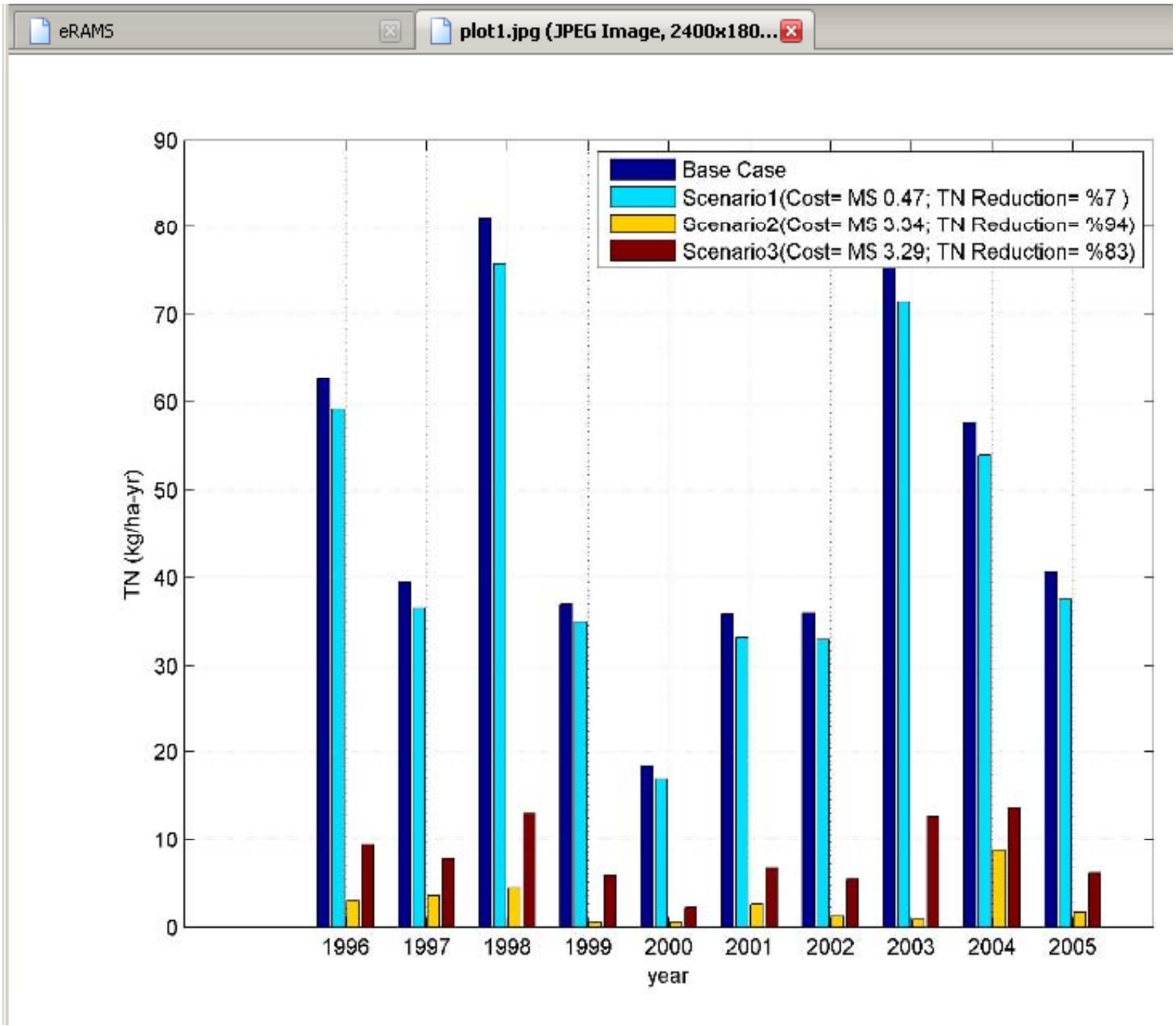
Left-Click to Edit; Right-Click for Commands

Add Shapefiles

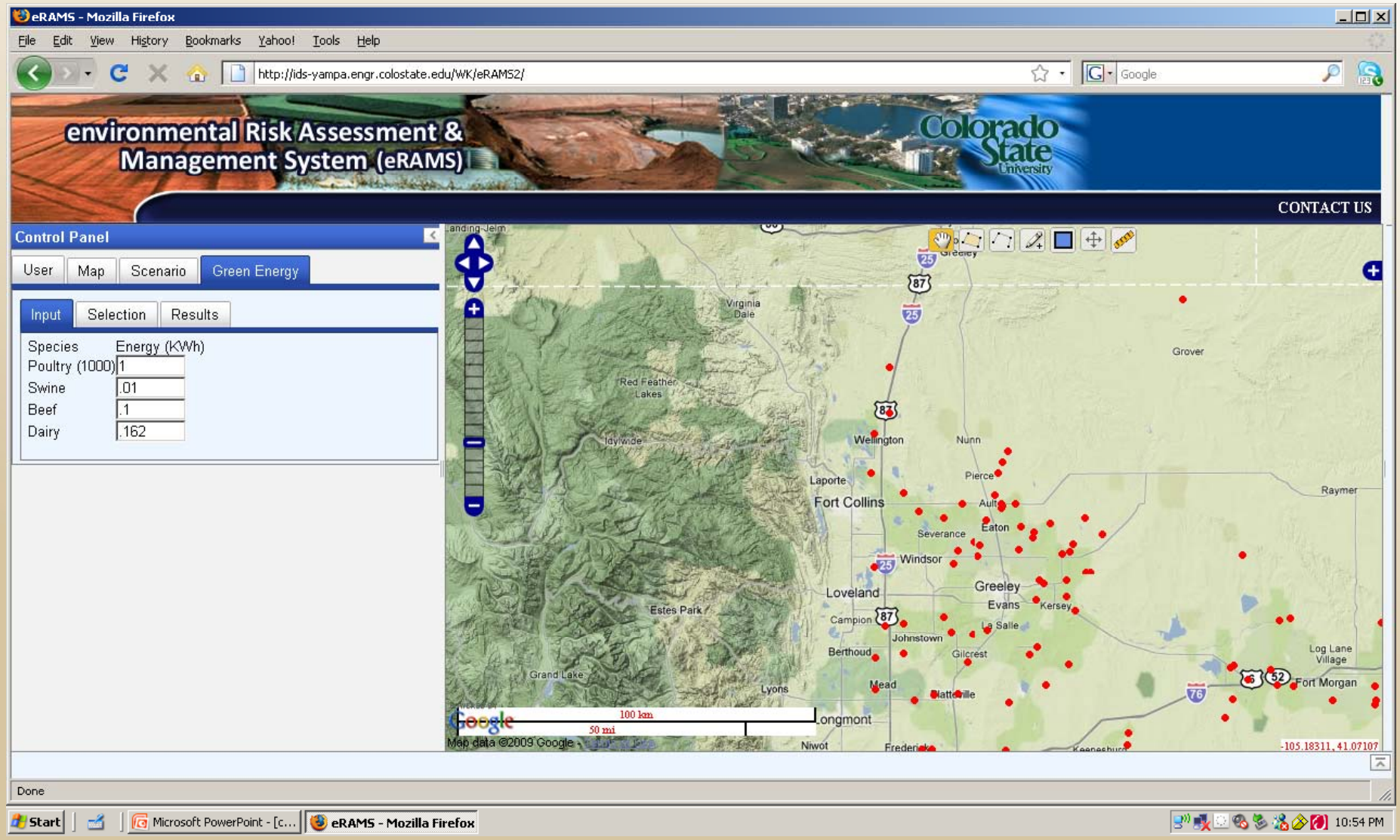
- Editing Layer

Edit Features | Pan | Zoom

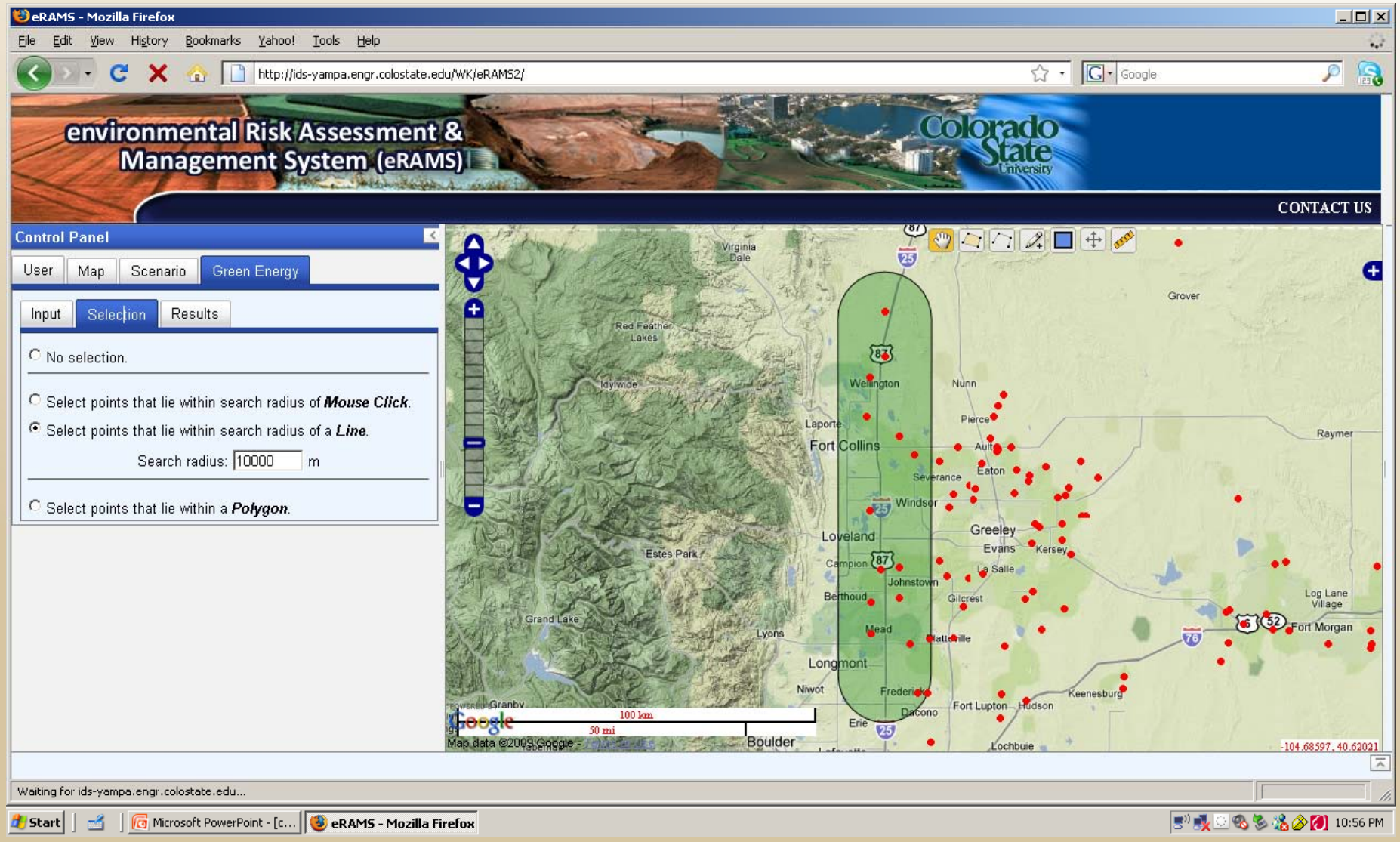



eRAMS
plot1.jpg (JPEG Image, 2400x180...
Base Case
Scenario1(Cost= MS 0.47; TN Reduction= %7)
Scenario2(Cost= MS 3.34; TN Reduction= %94)
Scenario3(Cost= MS 3.29; TN Reduction= %83)
TN (kg/ha-yr)
0
10
20
30
40
50
60
70
80
90
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
year

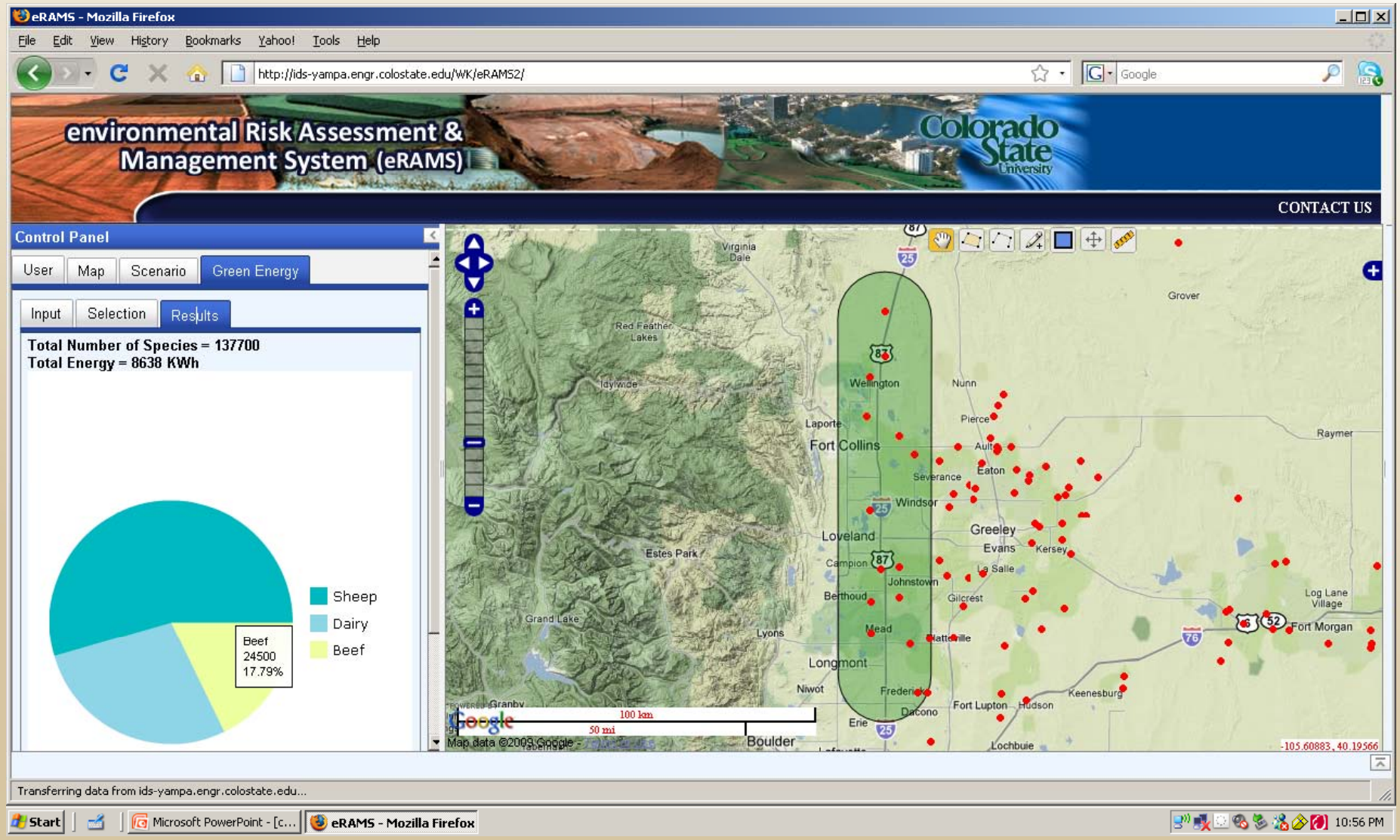
Biomass Energy



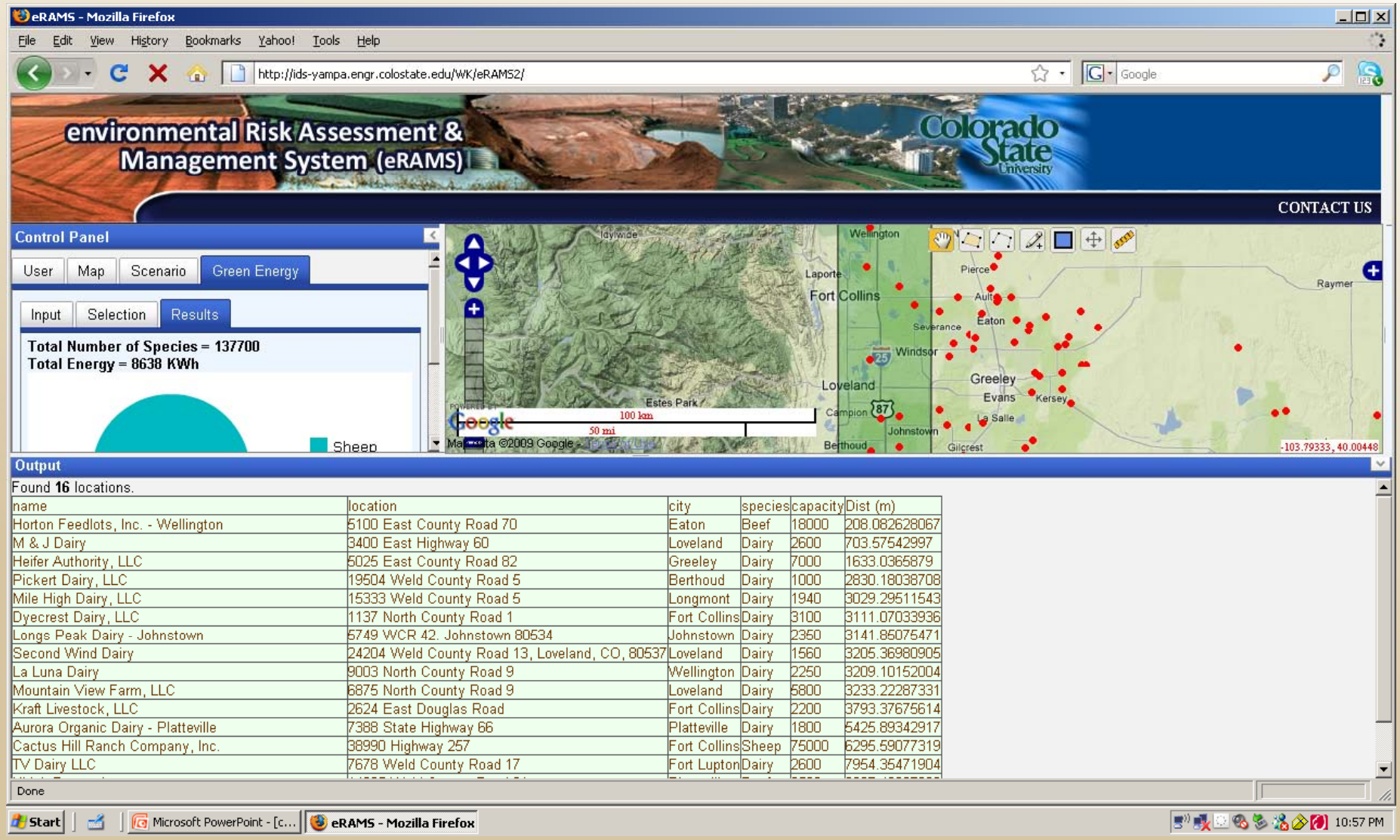
Biomass Energy



Biomass Energy



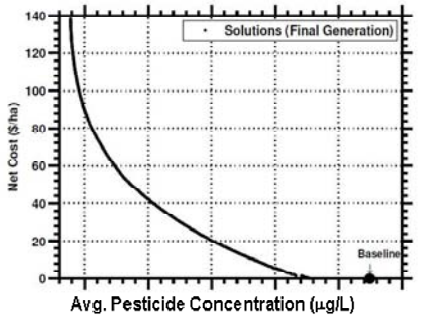
Biomass Energy



Efficient Communication / Outputs

Economic Conservation Practice Placement to Reduce Atrazine Concentration Levels in the Wildcat Creek Watershed

Wildcat Creek Watershed Objective: reduction of atrazine loads into the Kokomo reservoir by 10% (Concentration reduction target from average 3.31 µg/L to 3.0 µg/L, EPA MCL).

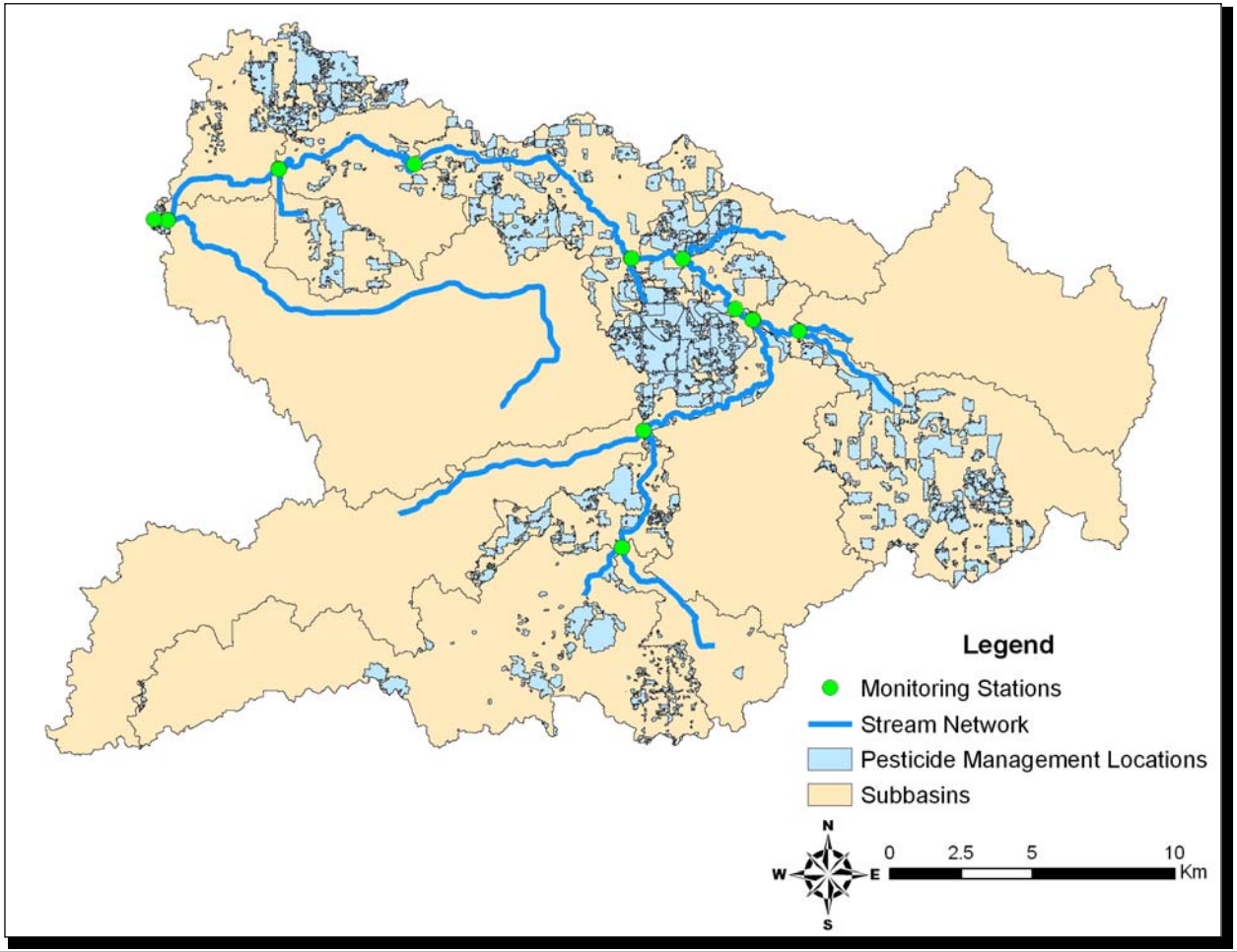


Finding a balance between cost and environmental improvements.

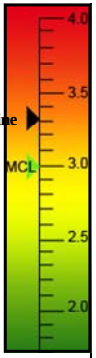
This recommendation on where to target conservation implementation (provided in the map to the right) is based on the above cost / benefit placement. As demonstrated by the curve, reducing pesticide concentration generally requires the increased cost of conservation practices installation. Choosing how to address water quality concerns is a unique decision for each community, and can be affected by a water quality improvement goal, or the budgetary resources available.

Cost Breakdown of Recommendation

Practice	Cost ($)
Pesticide Management	
Filter Strips	
Residue Management	
Tillage– No Till	
TOTAL COST ($)	$ xxxx.xx



Atrazine Concentrations and Targets



Source of Pollutant in Drinking Water
Runoff from herbicide used on row crops

Maximum Contaminant Level (MCL)
0.003 milligrams per Liter (mg/L) or 3 parts per billion (ppb)

Maximum Contaminant Level Goal (MCLG)
0.003 mg/L or 3 ppb

Health Effects
Some people who drink water containing atrazine in excess of the MCL over many years could experience problems with their cardiovascular system or reproductive difficulties.

More information
http://epa.gov/ogwdw/contaminants/basicinformation/atrazine.html#one

Targeted Conservation Practice Influences on Water Quality

Practice	Influence	Estimated Benefit(s) Across Watershed
Pesticide Management	Reduces application rates, etc.	xxx ug/L
Filter Strips	Filters surface	xxx ug/L
Residue Management/No Till	Reduces erosion	xxx ug/L

Funding Agencies

- US EPA
- NRCS
- USDA CSREES
- USDA AES
- NSF

Mazdak Arabi
Assistant Professor
Civil and Environmental Engineering
Colorado State University
Mazdak.Arabi@ColoState.Edu
Voice: (970) 491-4639