

*eRAMS*

# A Web-Technology for Conservation Planning and Watershed Management

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Colorado State University





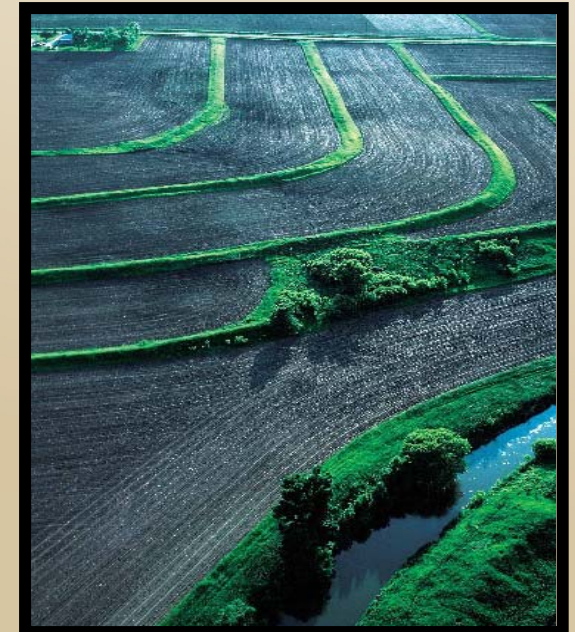
# Watershed Management

- 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



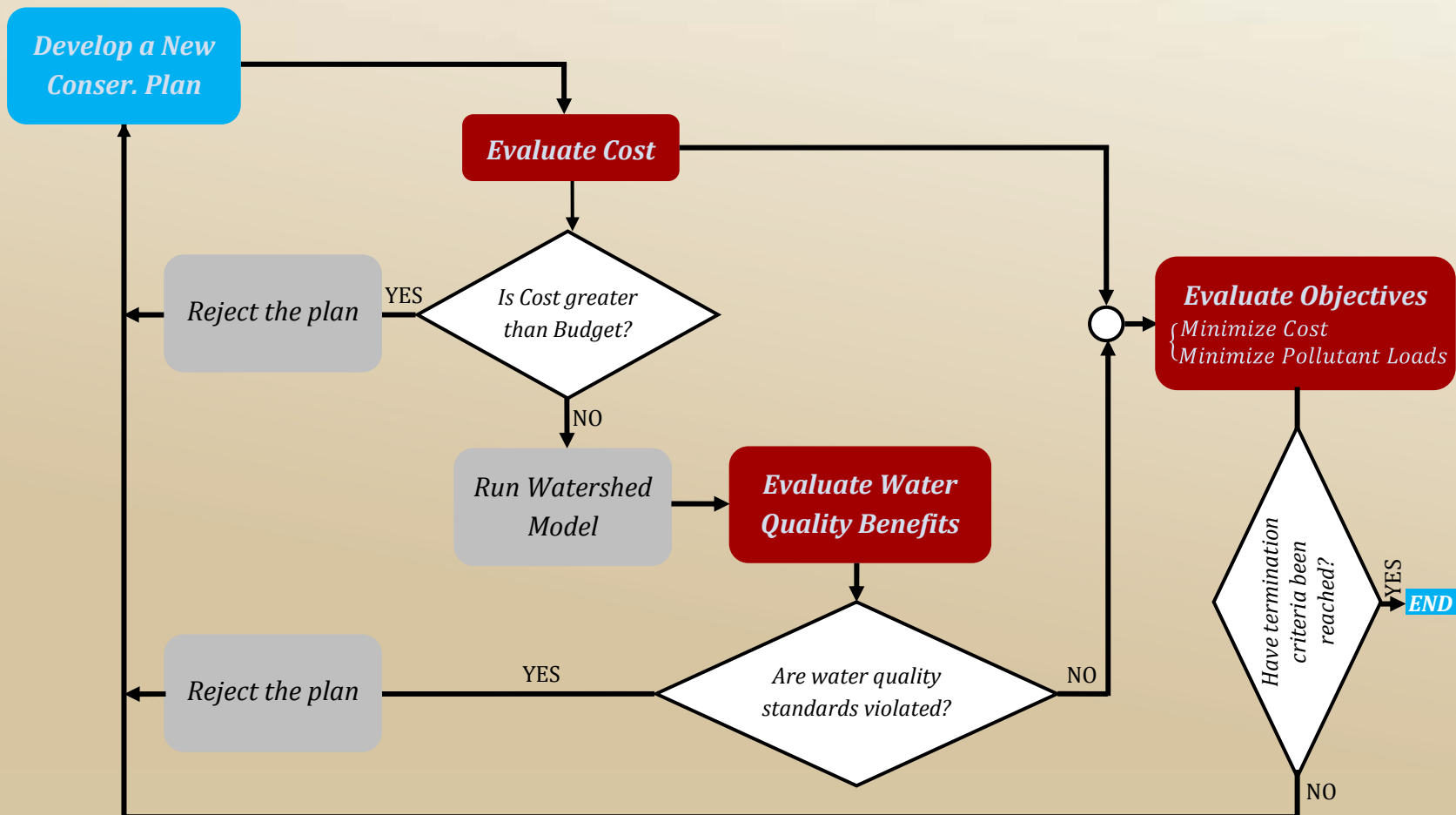


# Overall Goal

- 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

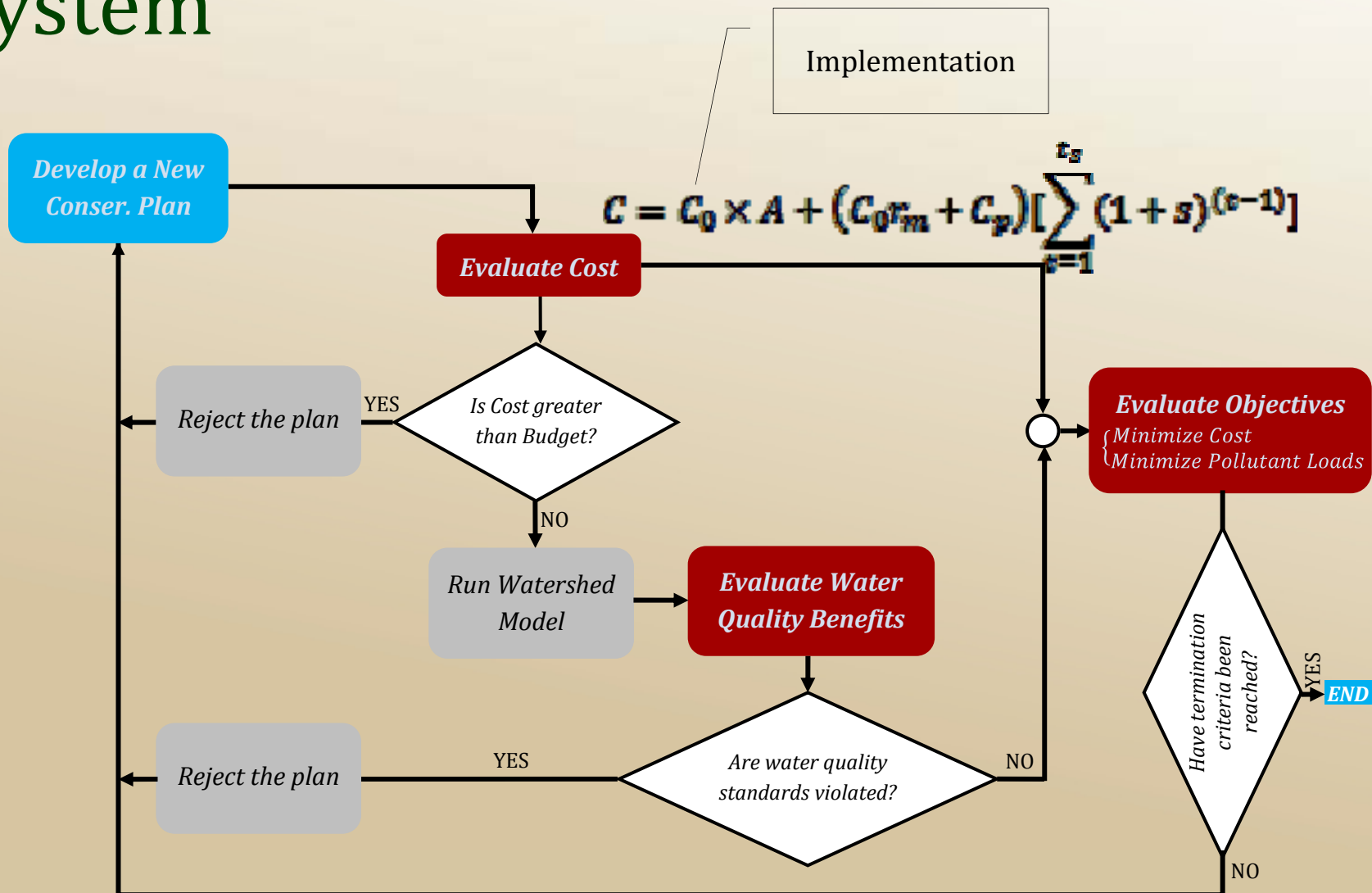


# Integrated Modeling & Optimization System





# Integrated Modeling & Optimization System

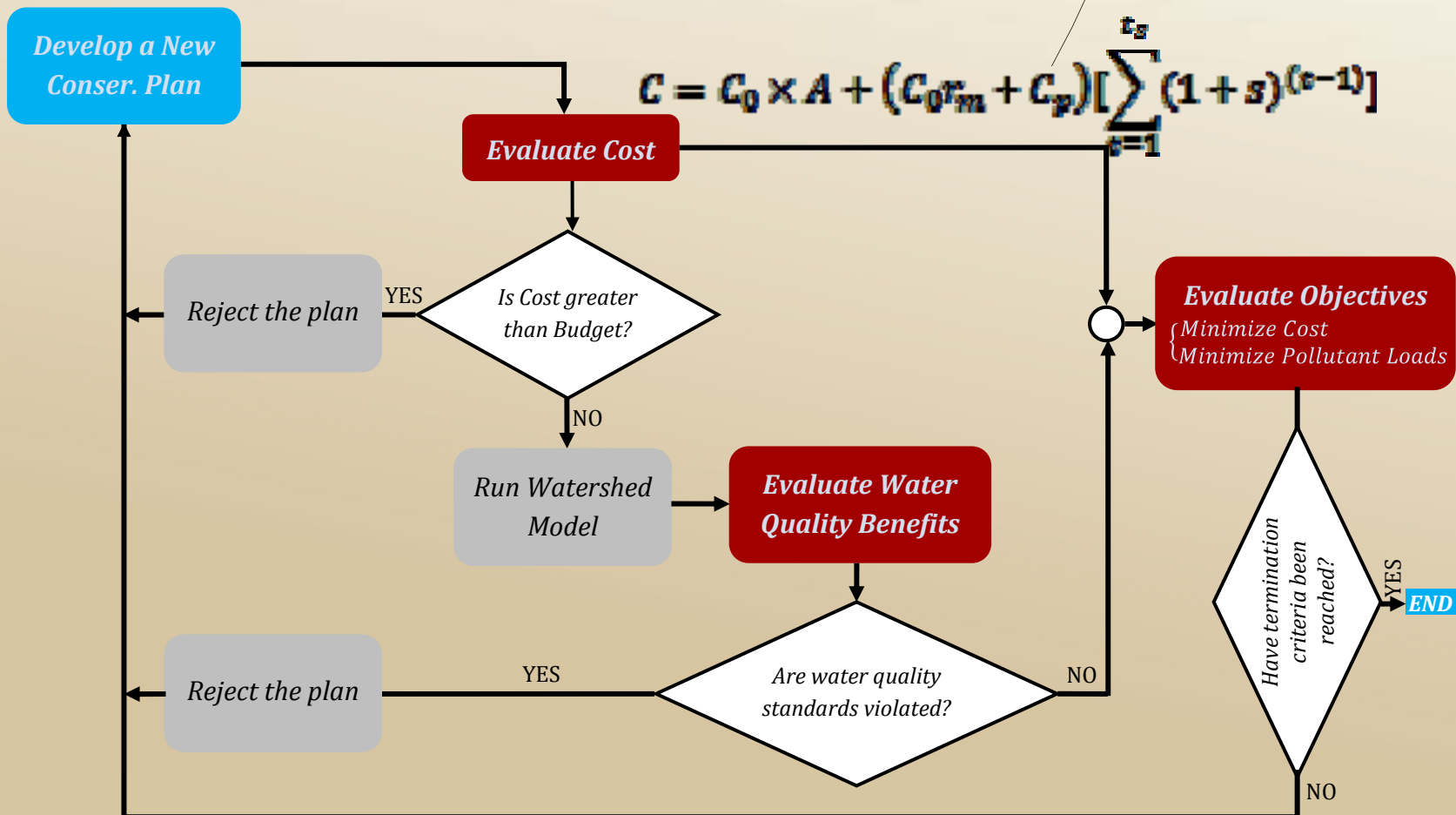






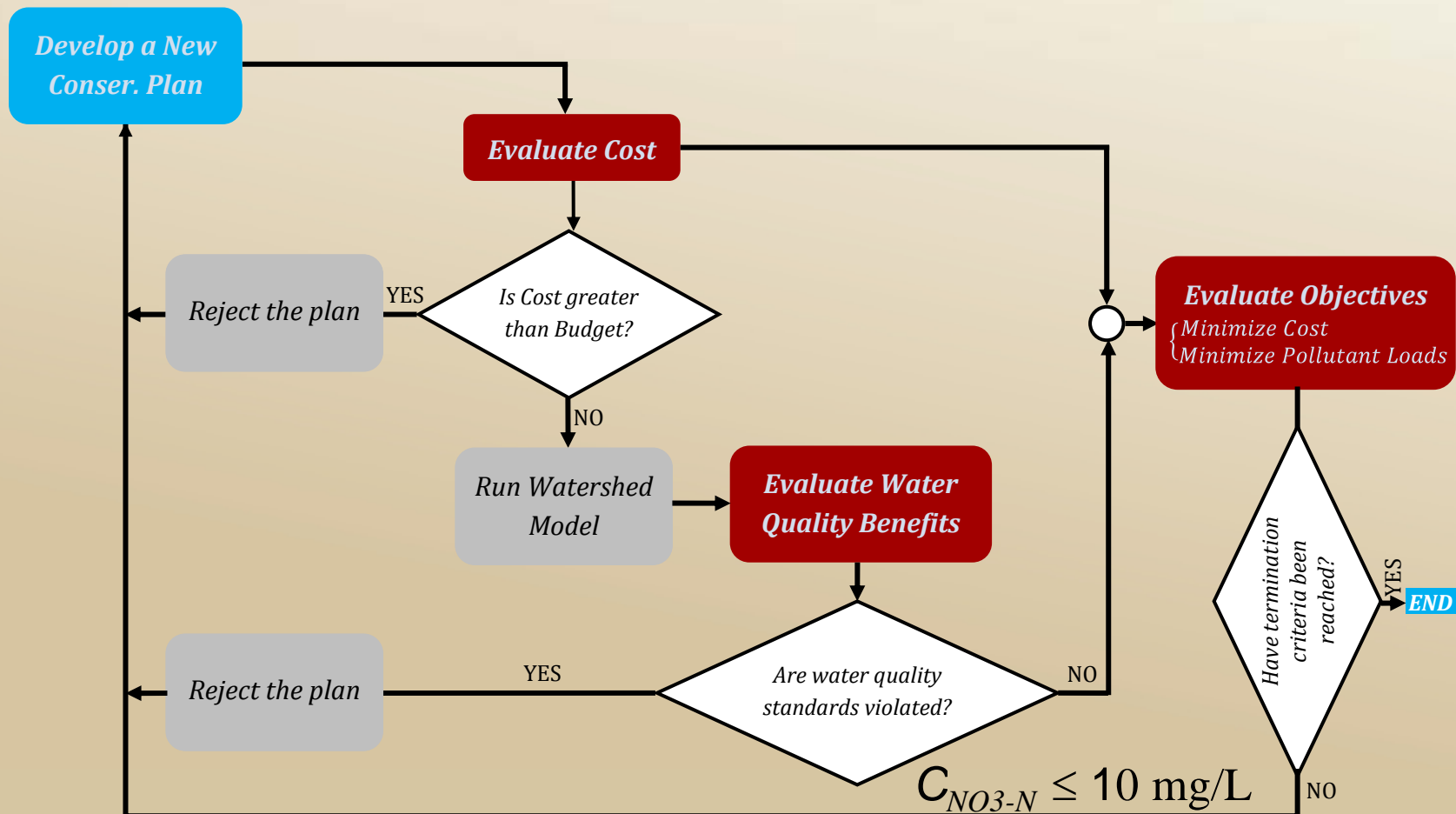
# Integrated Modeling & Optimization System

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





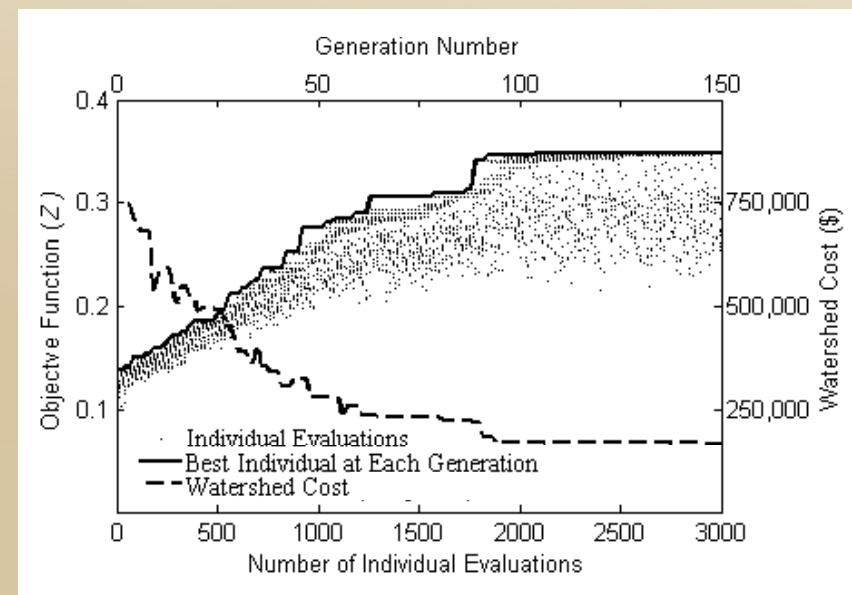
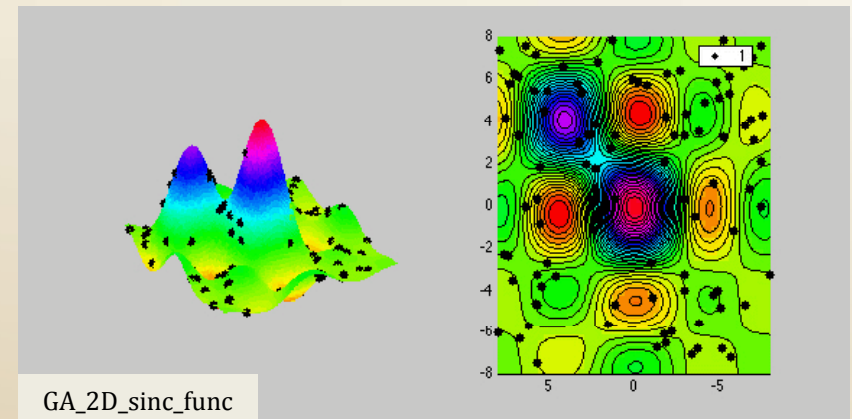
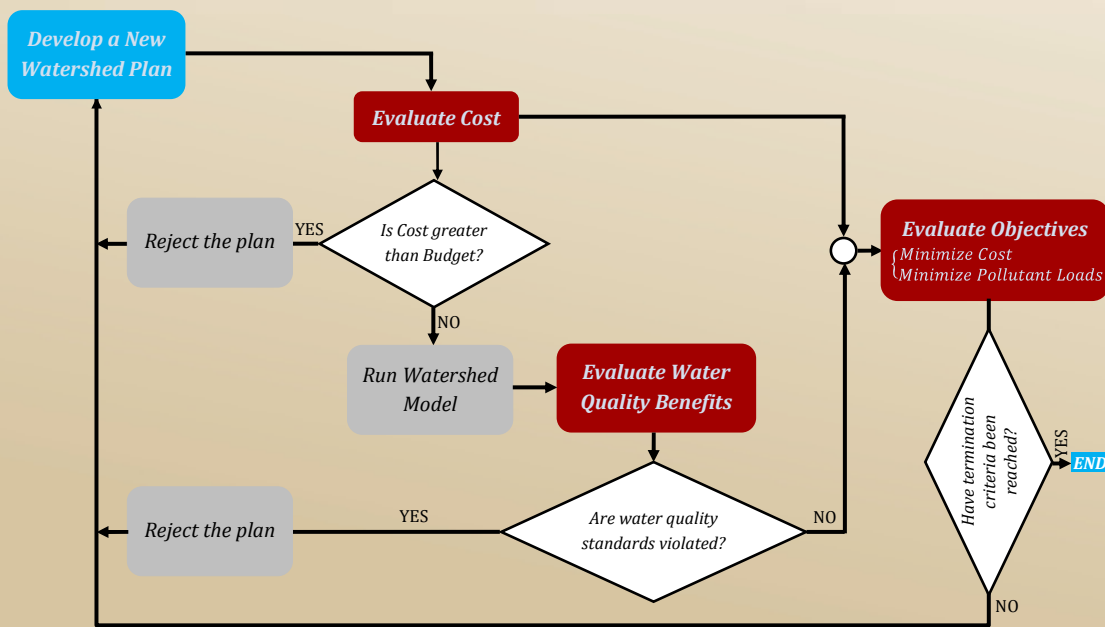
# Integrated Modeling & Optimization System for Watershed Management





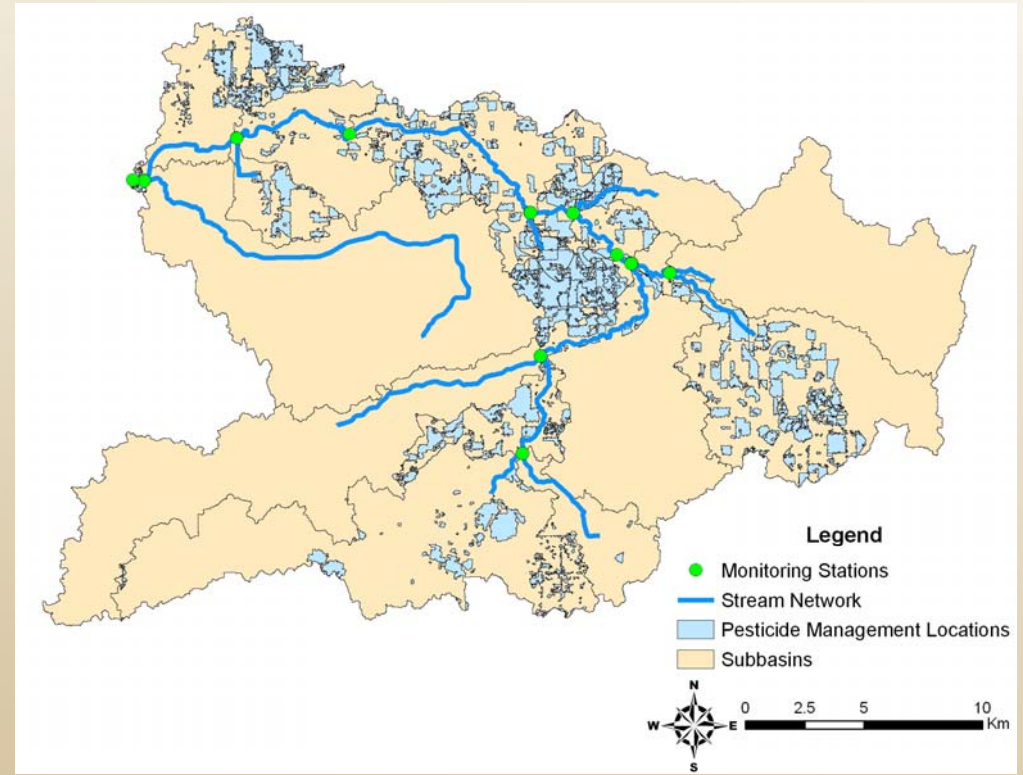
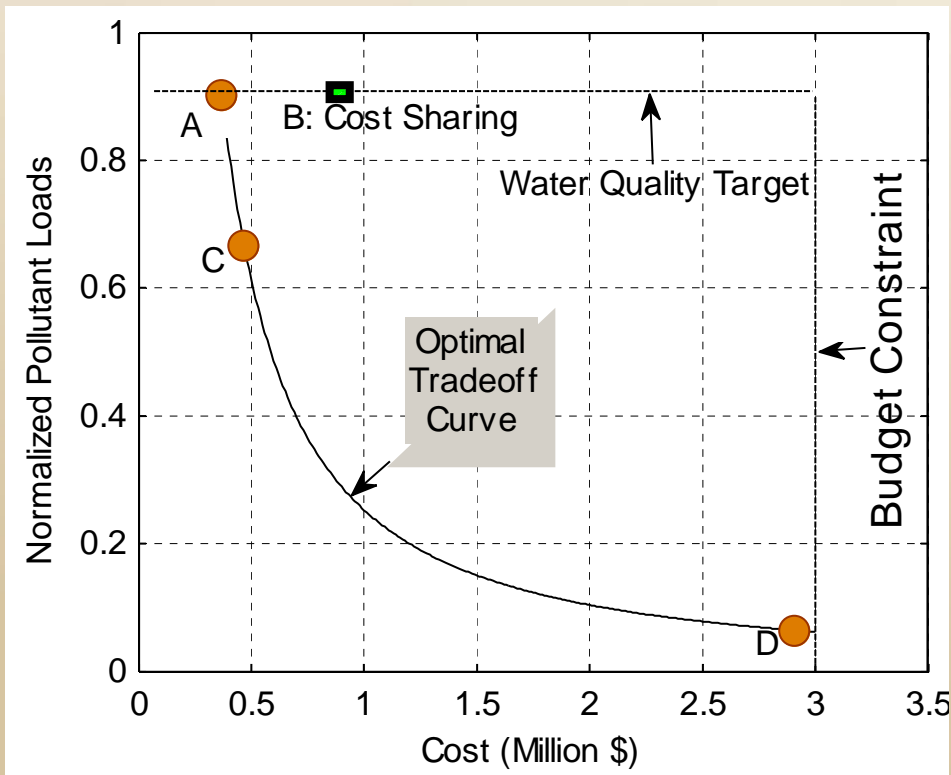


# Integrated Modeling & Optimization System





# 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

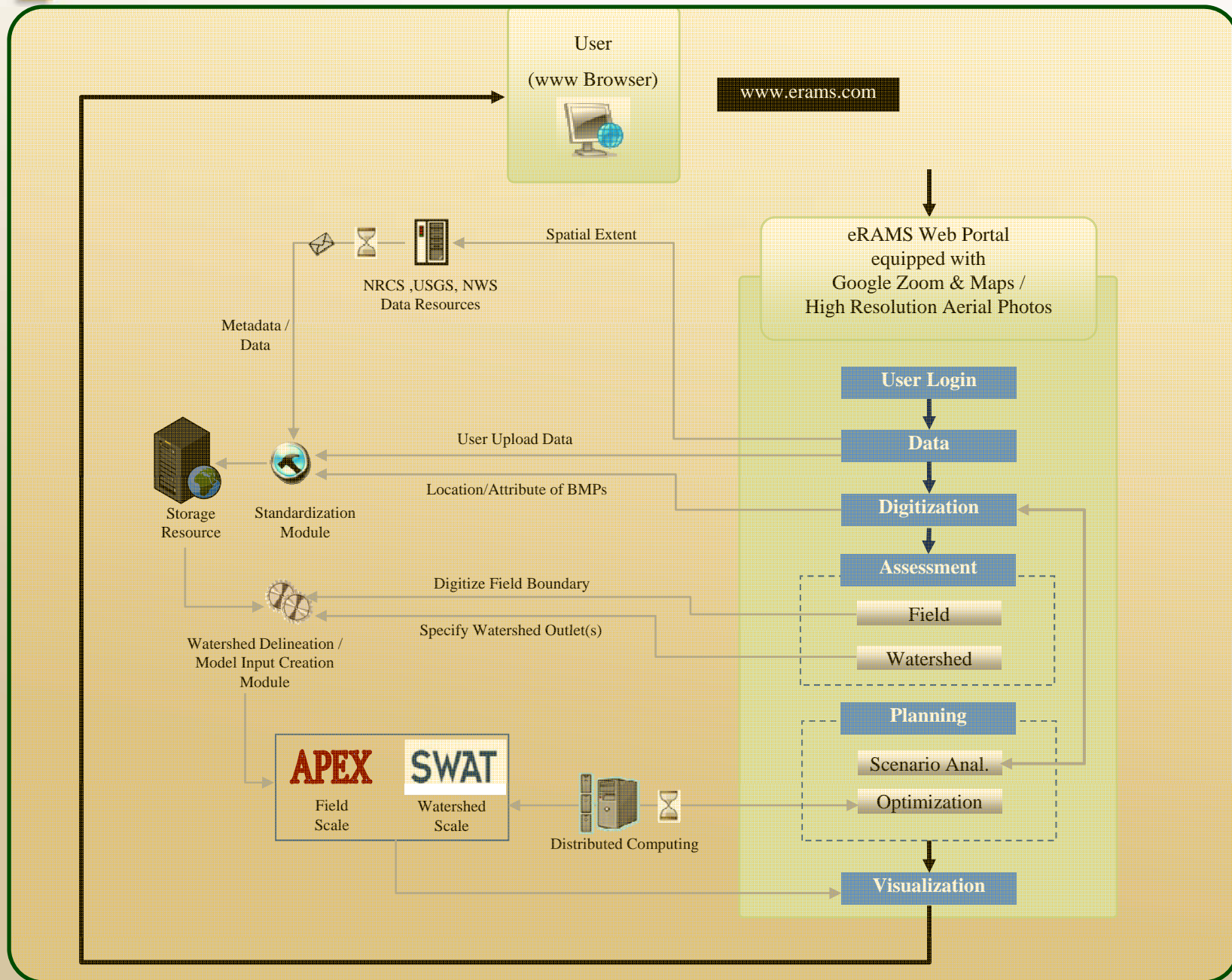
- No specific hardware or software requirements
  - Reduce training requirements
  - Eliminating the collection of duplicate data across agencies
  - Reduce long-term development and maintenance costs
  - Mobile system accessible, end-to-end, on the web
- Compatibility with existing databases/GIS technologies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



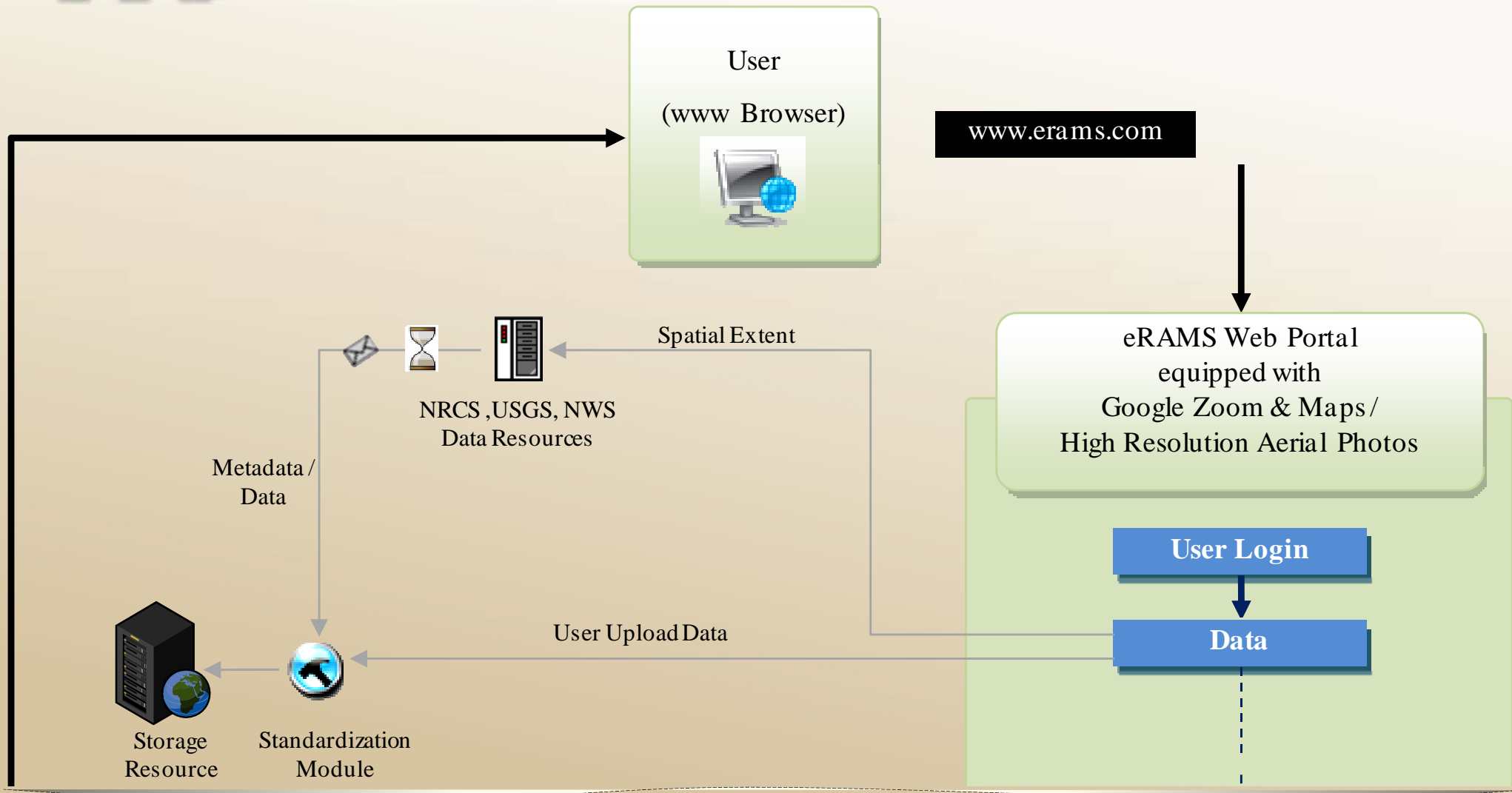
# Technology Drivers

- 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

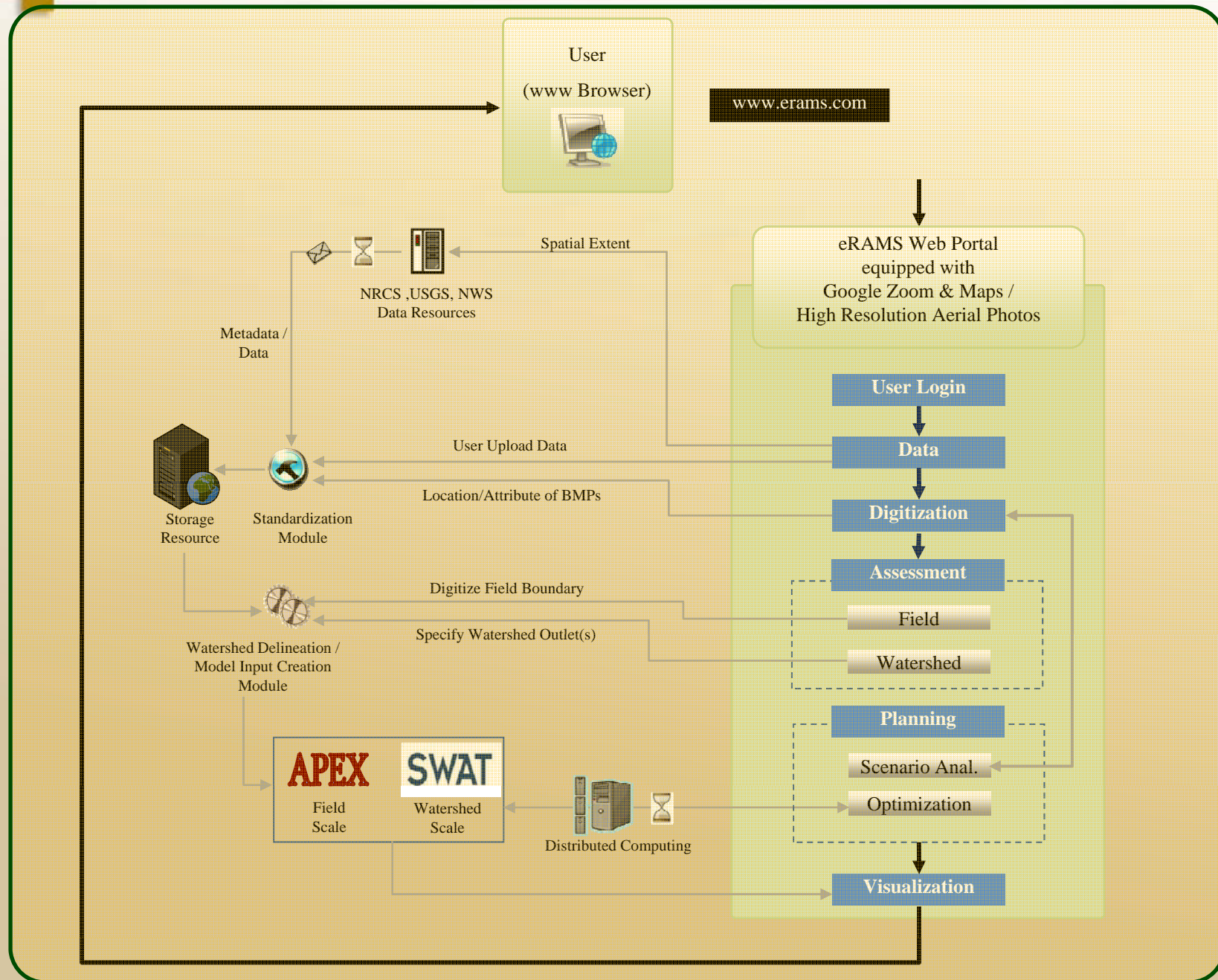


## Identification

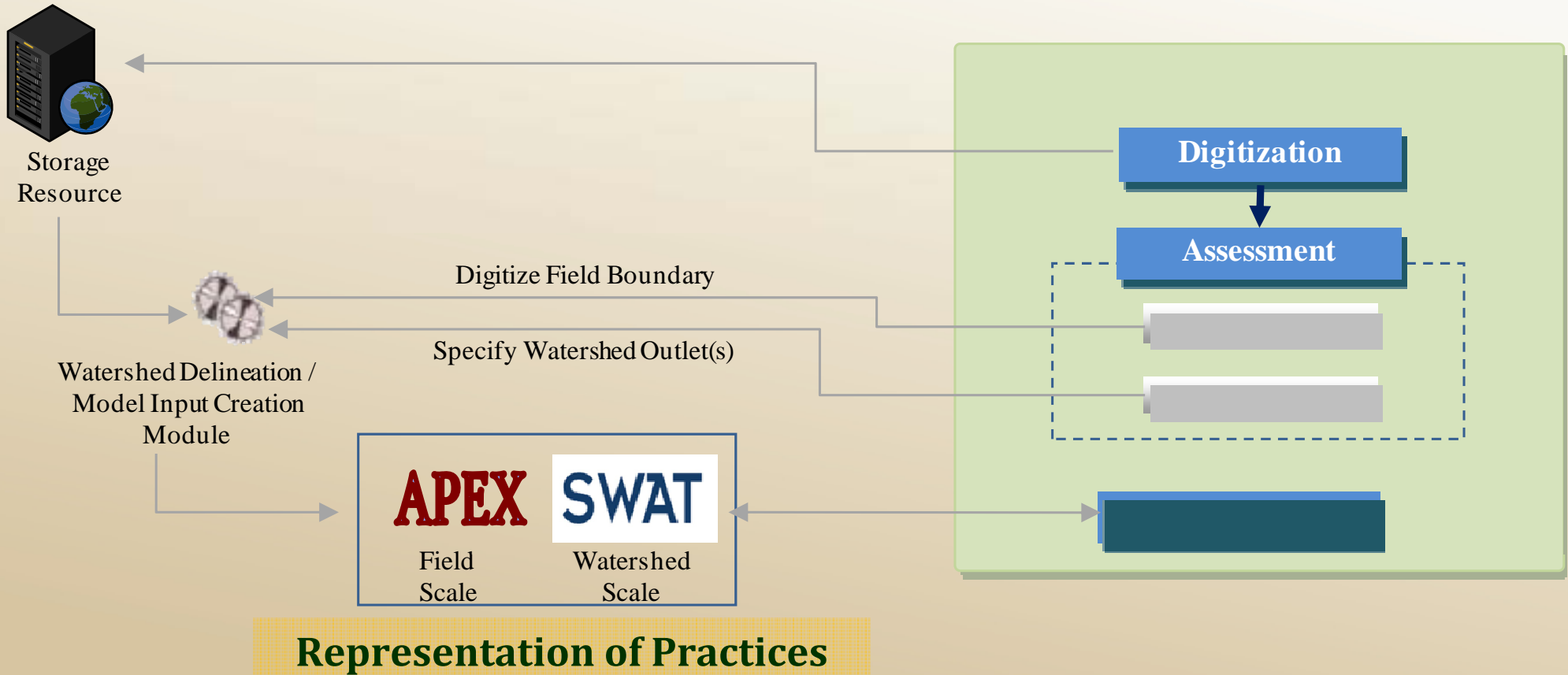
- What relevant data are available? Semantically rich metadata
- CLIPS, SWEET, GeoSemantic

**Extraction /Transformation:** different sources, different formats and scales





eRAMS Architecture for Conservation Planning and Assessment



Assessment Module: Costs and Environmental Benefits



Storage  
Resource

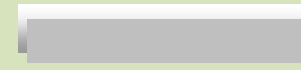


Watershed Delineation /  
Model Input Creation  
Module



Distributed Computing

Planning



Optimization

Visualization

Planning Module: Scenario Analysis / Optimization





### 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 spatte

Username:	<input type="text" value="spatte"/>
Password:	<input type="password"/>
	<input type="button" value="Sign In"/>

[Or create a new account](#)

User

Map

Renewable Energy

Project Settings

Choose Project: **SPRB**

Copy project from other user: **Boxelder Creek**

Choose Project Type:

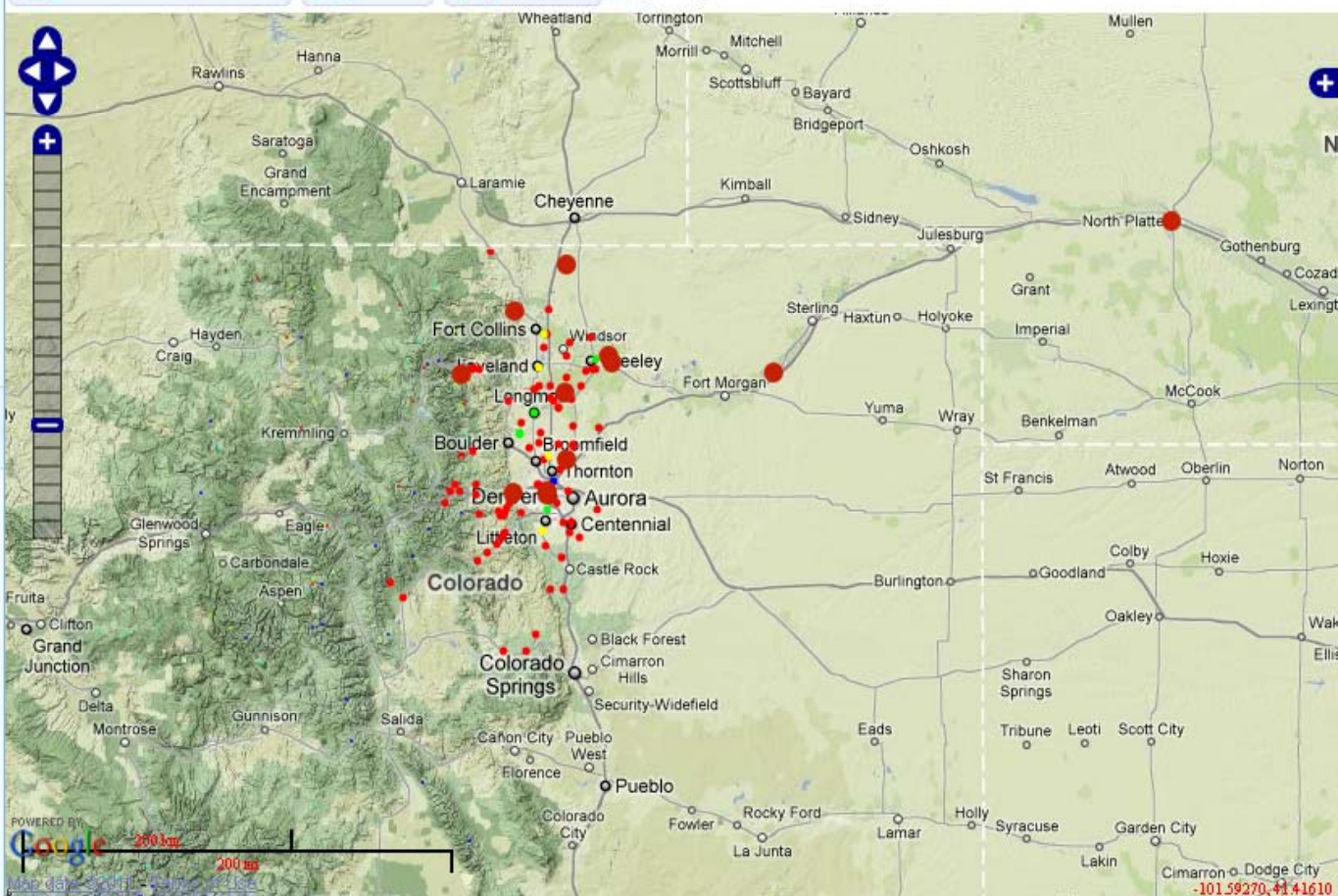
**Renewable Energy**

This project is public

Choose Map Tool

Pan

Zoom



200 mi 200 km

Cimarron o Dodge City  
-101.59270, 41.41610

User

Map

Renewable Energy

Project Settings

Choose Project:

Copy project from other user:

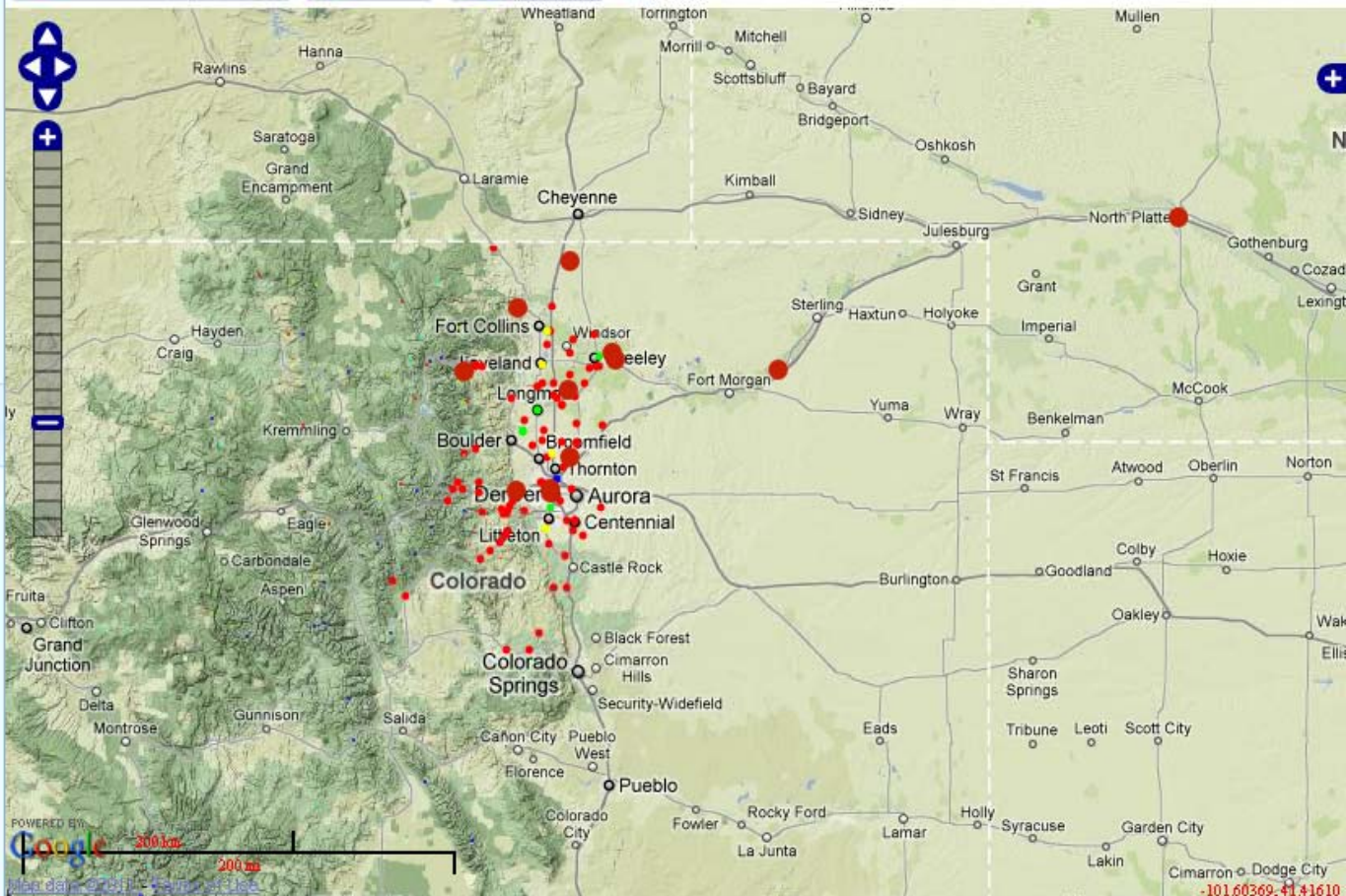
Choose Project Type:

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

Choose Map Tool

Pan

Zoom



POWERED BY Google

300 mi 200 km

Map data © 2011

Cimarron - Dodge City  
-101.60369, 41.41610



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

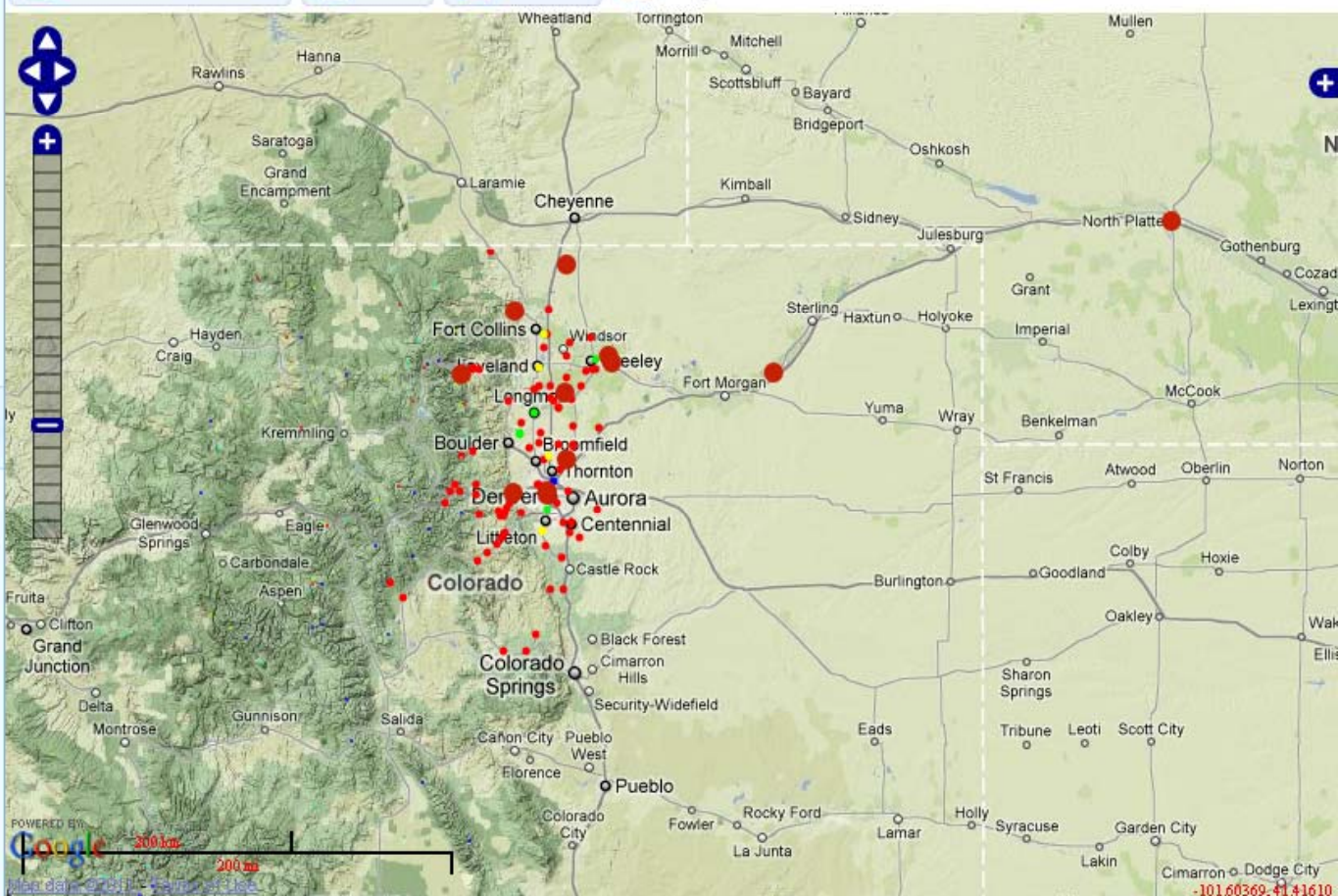
Choose Map Tool

Pan

Zoom



Map data © 2011 - Terms of Use



Cimarron - Dodge City  
-101.60369, 41.41610

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:

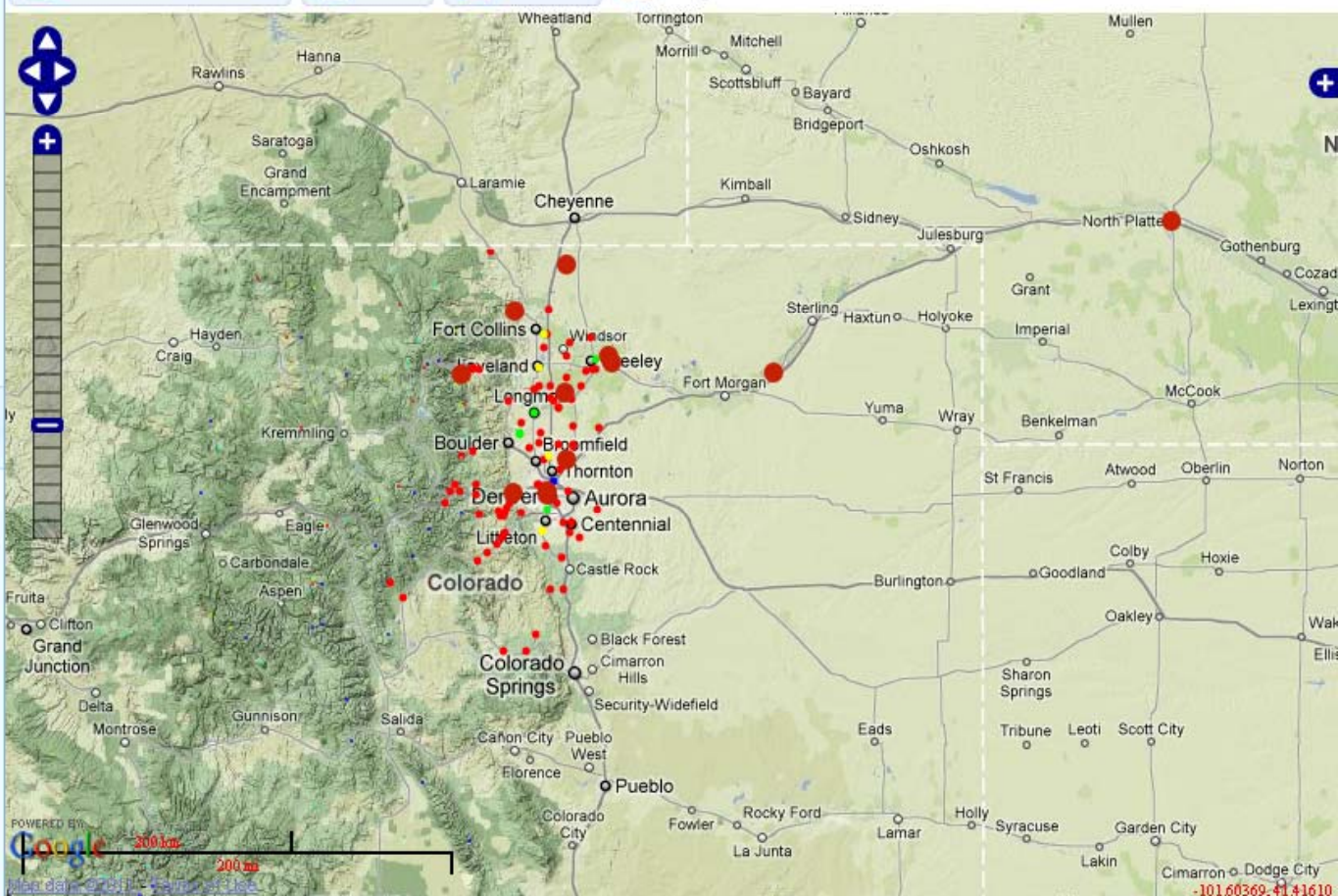
Watershed Management

This project is public

Choose Map Tool

Pan

Zoom



POWERED BY Google

300 mi 200 mi

Map data © 2011

Cimarron Dodge City -101.60369, 41.41610



User **Map** LUI Scenarios Assessment

Planning System Analysis

Zoom to Address:

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

Choose Map Tool

Pan

Zoom



POWERED BY Google

300 mi 200 mi

Map data © 2011

Cimarron Dodge City -108 32732, 41 40374





Map

Resource Center

My Account

Groups

Contact Us

User **Map** LUI Scenarios Assessment

Planning System Analysis

Zoom to Address:

Settings

Base Layers

Google

Physical  Streets  Hybrid  Satellite

Bing

Shaded  Hybrid  Aerial

World Layers

User Layers

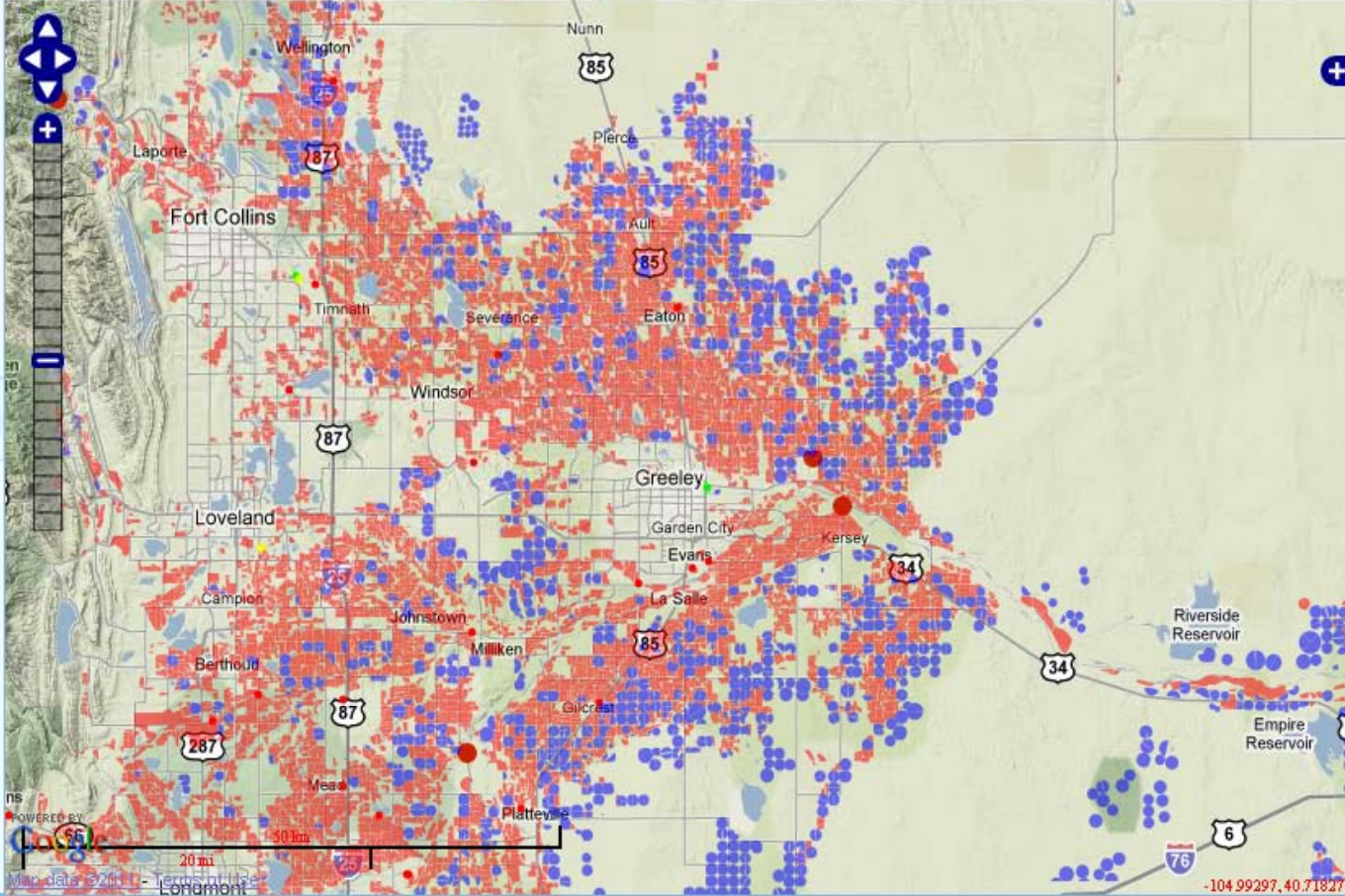
Project Layers

Editing Layer

Choose Map Tool

Pan

Zoom





User **Map** LUI Scenarios Assessment

Planning System Analysis

Zoom to Address:

Settings

Base Layers

Google

Physical  Streets  Hybrid  Satellite

Bing

Shaded  Hybrid  Aerial

World Layers

User Layers

Project Layers

Editing Layer

Choose Map Tool

Pan

Zoom







- 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:  Min Color:  Max Color:  Count:

Opacity:  25

Size:  0

bing

© 2011 Microsoft Corporation © 2010 NAVTEQ © AND  
made possible by USGS  
104 2011 10/20/11

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

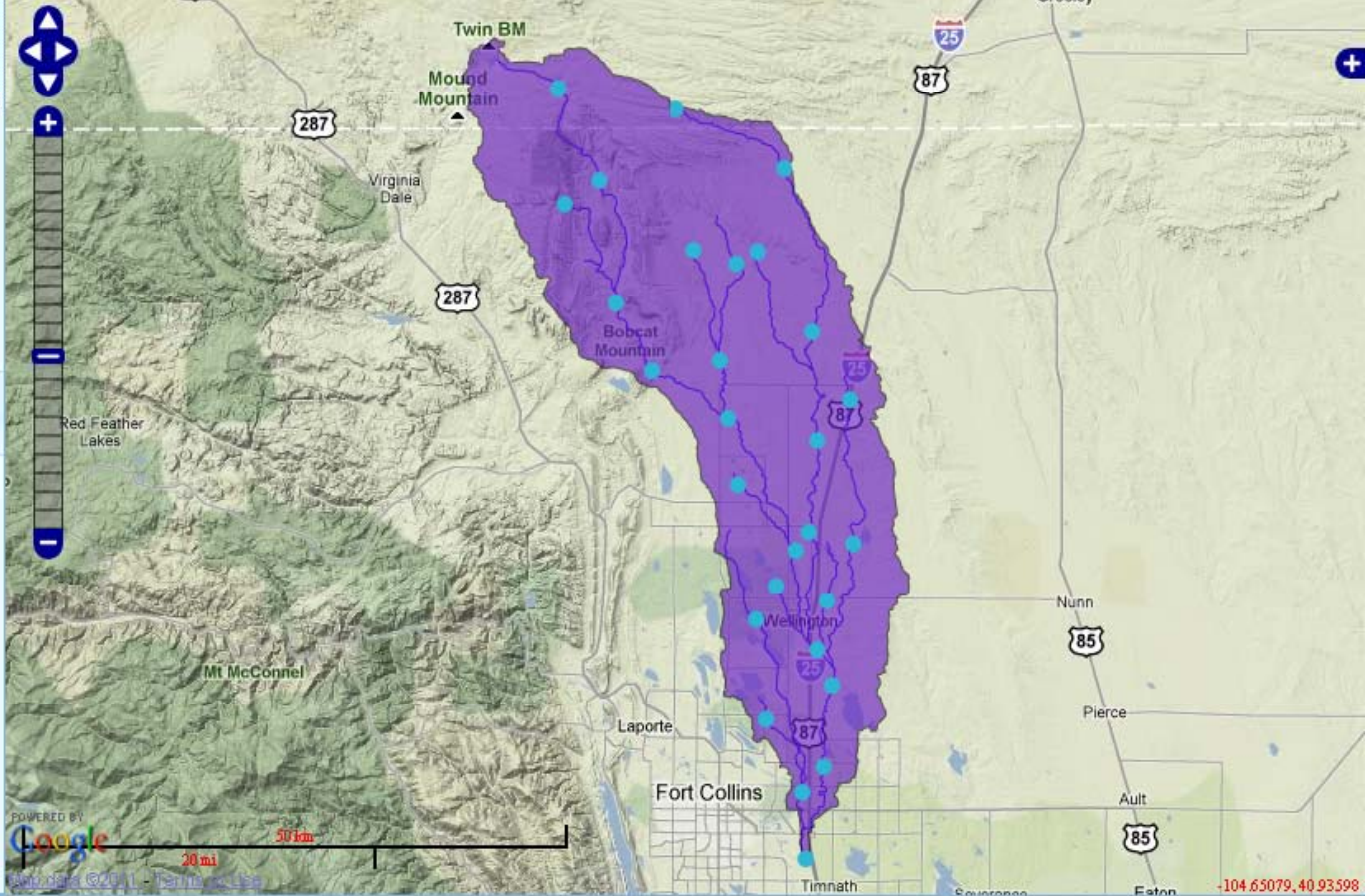
Add Shapefiles

Editing Layer

Edit Features

Pan

Zoom







User **Map** LUI Scenarios Assessment

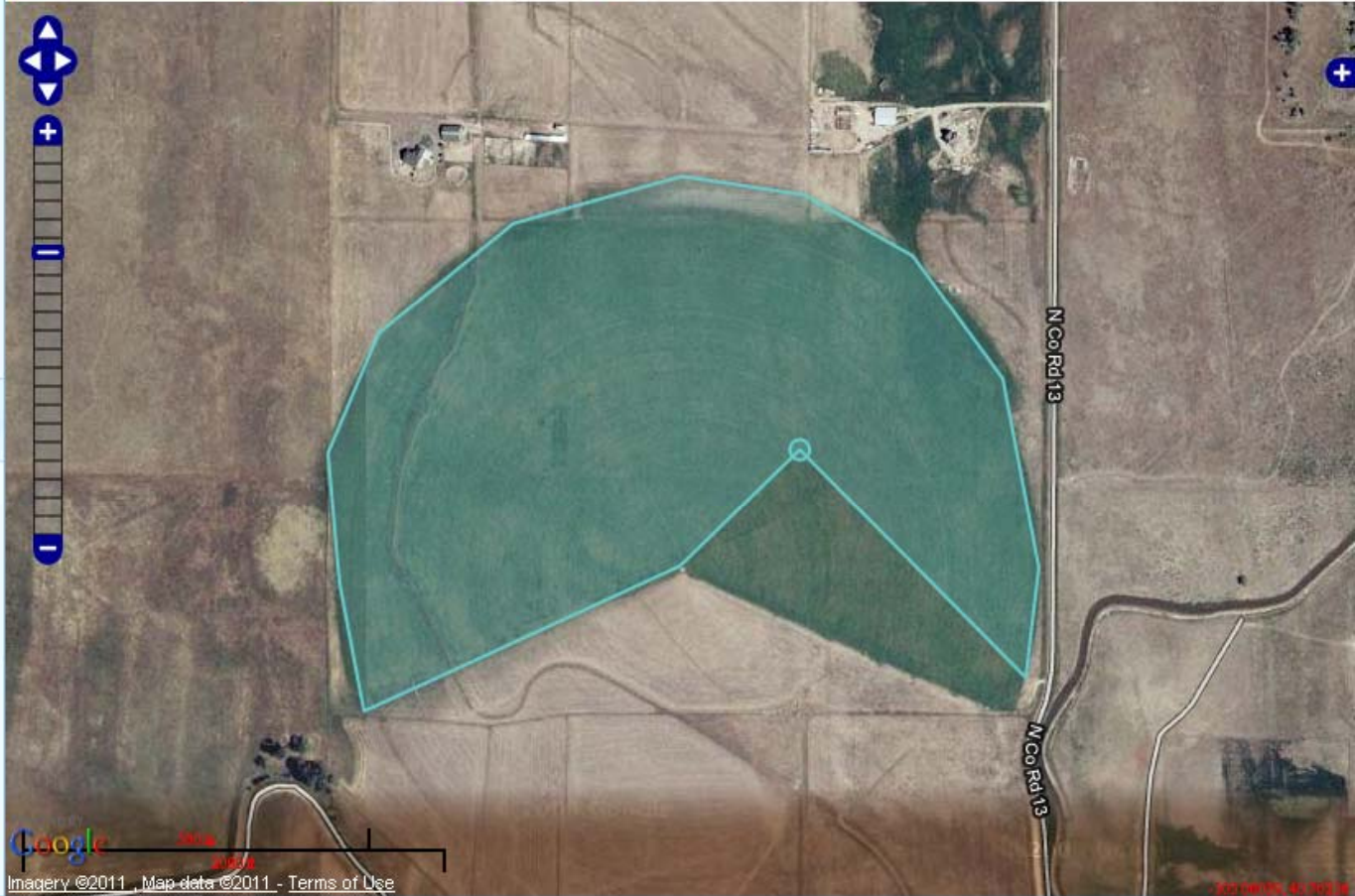
Planning System Analysis

Zoom to Address:

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

▼ Editing Layer

Select layer to edit:





User **Map** LUI Scenarios Assessment

Planning System Analysis

Zoom to Address:

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

▼ Editing Layer

Select layer to edit:







User **Map** LUI Scenarios Assessment

Planning System Analysis

Zoom to Address:

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

▼ Editing Layer

Select layer to edit:





Map

Resource Center

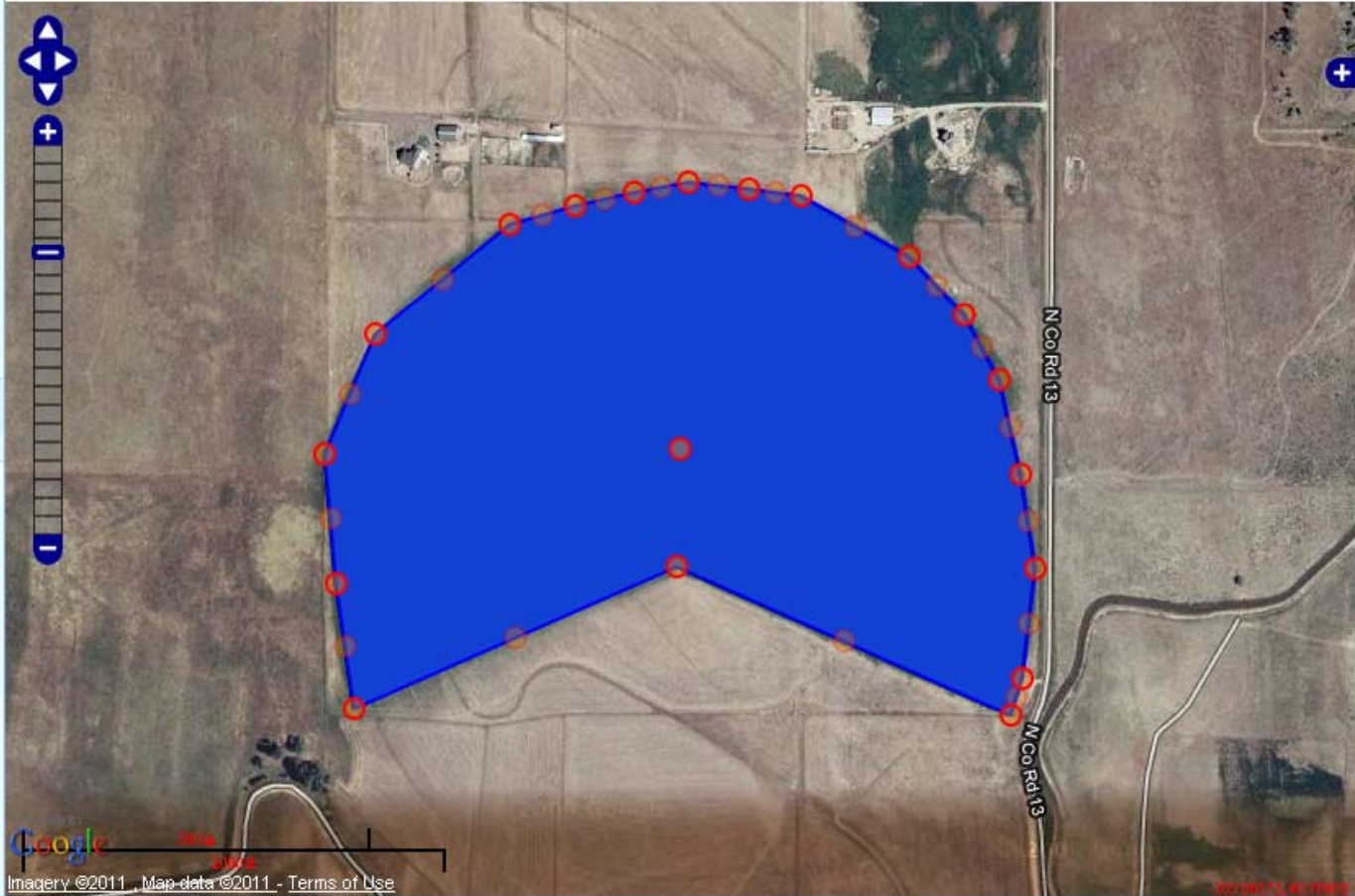
My Account

Groups

Contact Us

Select fields with name:

- 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







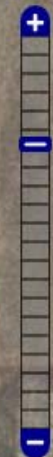
Select fields with name: Irr\_Field1 Go

- 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<sup>3</sup>/s):

Flow Fraction:

Irrigation Depth (mm):

Unit Cost (\$/unit):

60 ha



Photo courtesy of NRCS

NRCS Standards





Map

Resource Center

My Account

Group

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:

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

Percent Cover:

Unit Cost (\$/unit):

Photo courtesy of NRCS

SWAT Conservation Practice Sheets



# 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<sub>2</sub> 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

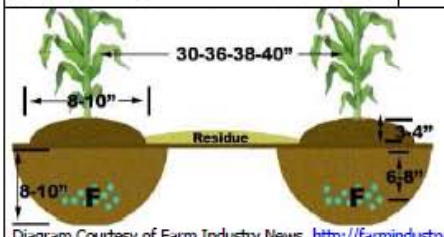


Diagram Courtesy of Farm Industry News [http://farmindustrynews.com/mag/farming\\_stripill\\_teamwork/](http://farmindustrynews.com/mag/farming_stripill_teamwork/)

**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

### Tillage/Residue Management

Enable

Curve No. Unit Reduction:

Old Tillage Type:  
 generic fall plowing oper: ▲  
 generic spring plowing of: ▲  
 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 oper: ▲  
 generic spring plowing of: ▲  
 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:  
 kg/ha ▼

Unit Cost (\$/unit):  
 ha ▼

**SWAT Conservation Practice Sheets**



Photo courtesy of NRCS



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



Imagery ©2011, Map data ©2011 - Terms of Use







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







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:  Create Delete

Select By Attribute

Select By Spatial Location

Assign Conservation Practices

Edit Features

Pan

Zoom







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

<empty>

Flood Irr

Subbasin:

Flood Irr

Soil Type

Flood Irr

Hydro Group

Flood Irr

Flood Irr

Flood Irr

Forest-E

Pasture

Range-Bi

Select By Spatial Location

Assign Conservation Practices

Edit Features

Pan

Zoom





User Map LUI **Scenarios** Assessment

Planning System Analysis

Select GIS layers

Design Scenario

Location and Type of Conservation Practices for *scen1*

Choose query:

Select By Attribute

Select By Spatial Location

Select from HRU Map

Or intersect using the following

polygons:

Results of selection:

Assign Conservation Practices

Edit Features

Pan

Zoom





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 Ratio

0.5

Channelized Fraction:

0.4

Unit Cost (\$/No.):

911

NRCS Standards





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

Edit Features

Pan

Zoom





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

December 2000

Visualization

Choose Scenario

Period to Display

start date:

end date:

Field

Outlet

Watershed

Cost

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						

Edit Features

Pan

Zoom







Map

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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 - 0.0520962

0.0520962 - 0.0650290

Left-Click to Edit; Right-Click for Commands

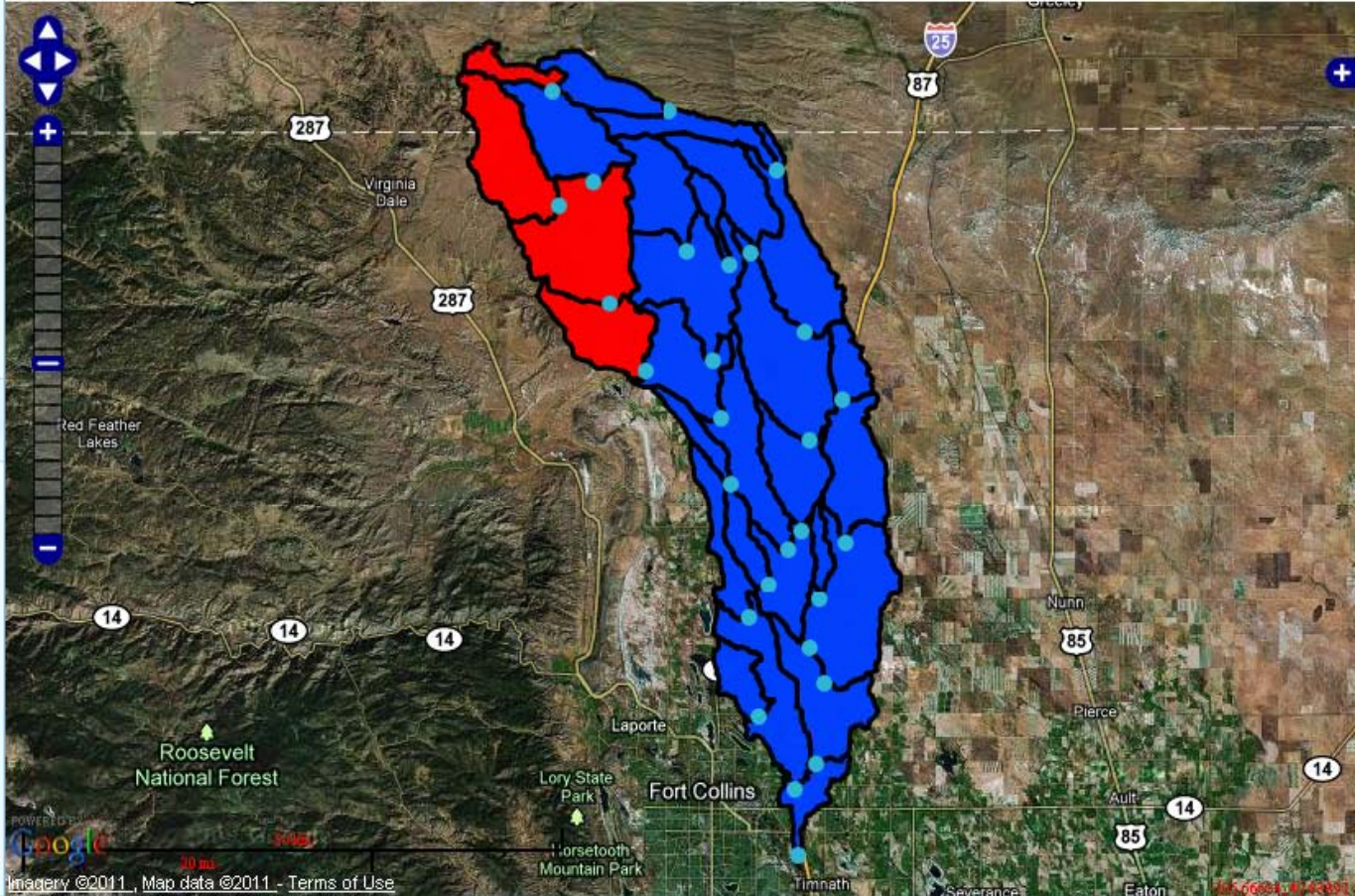
Add Shapefiles

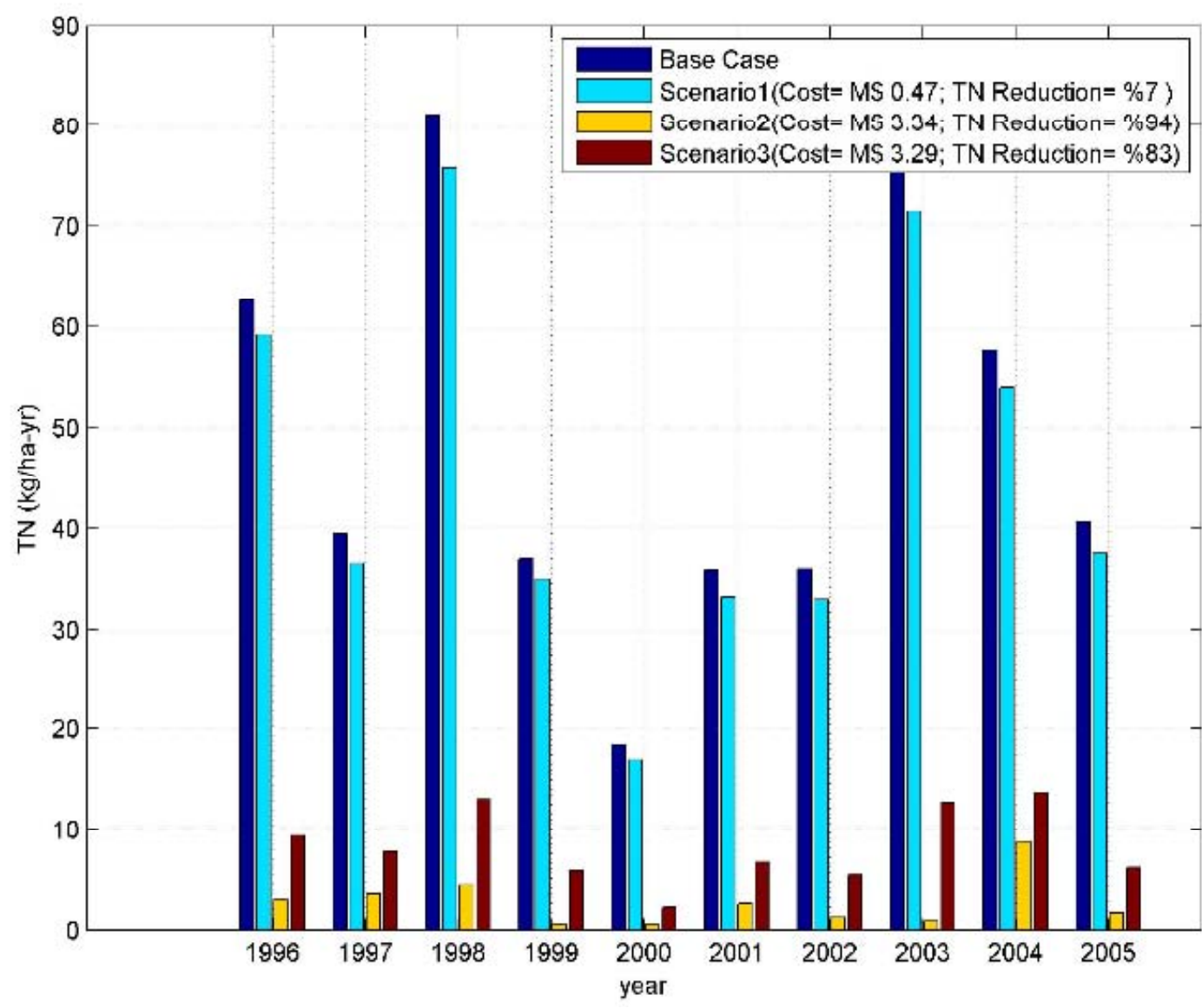
Editing Layer

Edit Features

Pan

Zoom









# Biomass Energy

The screenshot displays the eRAMS web application in a Mozilla Firefox browser. The browser's address bar shows the URL: <http://ids-yampa.engr.colostate.edu/WK/eRAMS2/>. The page header features the text "environmental Risk Assessment & Management System (eRAMS)" and the Colorado State University logo. A "CONTACT US" link is visible in the top right corner.

The main interface is divided into a "Control Panel" on the left and a map area on the right. The "Control Panel" includes tabs for "User", "Map", "Scenario", and "Green Energy". Under the "Green Energy" scenario, there are sub-tabs for "Input", "Selection", and "Results". The "Input" tab is active, showing a table with the following data:

Species	Energy (kWh)
Poultry (1000)	1
Swine	.01
Beef	.1
Dairy	.162

The map area displays a topographic map of a region in Colorado, including areas like Fort Collins, Greeley, and Loveland. Numerous red dots are scattered across the map, representing biomass energy potential. A scale bar at the bottom of the map indicates 100 km and 50 mi. The map data is attributed to Google, with a copyright notice for 2009. The coordinates at the bottom right of the map are -105.18311, 41.07107.

The browser's taskbar at the bottom shows the Start button, several open applications including Microsoft PowerPoint, and the eRAMS - Mozilla Firefox window. The system clock in the bottom right corner shows the time as 10:54 PM.



# Biomass Energy

eRAMS - Mozilla Firefox

File Edit View History Bookmarks Yahoo! Tools Help

http://ids-yampa.engr.colostate.edu/WK/eRAMS2/

environmental Risk Assessment & Management System (eRAMS)

Colorado State University

CONTACT US

Control Panel

User Map Scenario **Green Energy**

Input Selection Results

No selection.

Select points that lie within search radius of **Mouse Click**.

Select points that lie within search radius of a **Line**.

Search radius:  m

Select points that lie within a **Polygon**.

Waiting for ids-yampa.engr.colostate.edu...

Microsoft PowerPoint - [c...]

eRAMS - Mozilla Firefox

10:56 PM





# Biomass Energy

eRAMS - Mozilla Firefox

File Edit View History Bookmarks Yahoo! Tools Help

http://ids-yampa.engr.colostate.edu/WK/eRAMS2/

environmental Risk Assessment & Management System (eRAMS) Colorado State University

CONTACT US

Control Panel

User Map Scenario **Green Energy**

Input Selection **Results**

Total Number of Species = 137700  
Total Energy = 8638 KWh

Category	Value	Percentage
Sheep	24500	17.79%
Dairy		
Beef		

Transferring data from ids-yampa.engr.colostate.edu...

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# Biomass Energy

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http://ids-yampa.engr.colostate.edu/WK/eRAMS2/

environmental Risk Assessment & Management System (eRAMS)

Colorado State University

CONTACT US

Control Panel

User Map Scenario **Green Energy**

Input Selection **Results**

Total Number of Species = 137700  
Total Energy = 8638 KWh

Sheep

Output

Found 16 locations.

name	location	city	species	capacity	Dist (m)
Horton Feedlots, Inc. - Wellington	5100 East County Road 70	Eaton	Beef	18000	208.082628067
M & J Dairy	3400 East Highway 60	Loveland	Dairy	2600	703.57542997
Heifer Authority, LLC	5025 East County Road 82	Greeley	Dairy	7000	1633.0365879
Pickert Dairy, LLC	19504 Weld County Road 5	Berthoud	Dairy	1000	2830.18038708
Mile High Dairy, LLC	15333 Weld County Road 5	Longmont	Dairy	1940	3029.29611543
Dyecrest Dairy, LLC	1137 North County Road 1	Fort Collins	Dairy	3100	3111.07033936
Longs Peak Dairy - Johnstown	5749 WCR 42. Johnstown 80534	Johnstown	Dairy	2350	3141.85075471
Second Wind Dairy	24204 Weld County Road 13, Loveland, CO, 80537	Loveland	Dairy	1560	3205.36980905
La Luna Dairy	9003 North County Road 9	Wellington	Dairy	2250	3209.10152004
Mountain View Farm, LLC	6875 North County Road 9	Loveland	Dairy	5800	3233.22287331
Kraft Livestock, LLC	2624 East Douglas Road	Fort Collins	Dairy	2200	3793.37675614
Aurora Organic Dairy - Platteville	7388 State Highway 66	Platteville	Dairy	1800	5425.89342917
Cactus Hill Ranch Company, Inc.	38990 Highway 257	Fort Collins	Sheep	75000	6295.59077319
TV Dairy LLC	7678 Weld County Road 17	Fort Lupton	Dairy	2600	7954.35471904

Done

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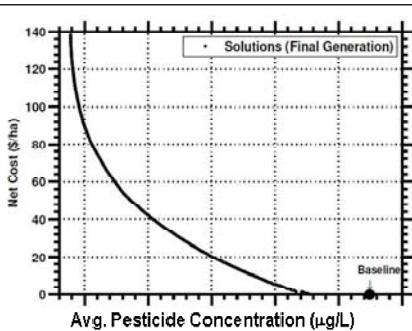




# Efficient Communication / Outputs

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

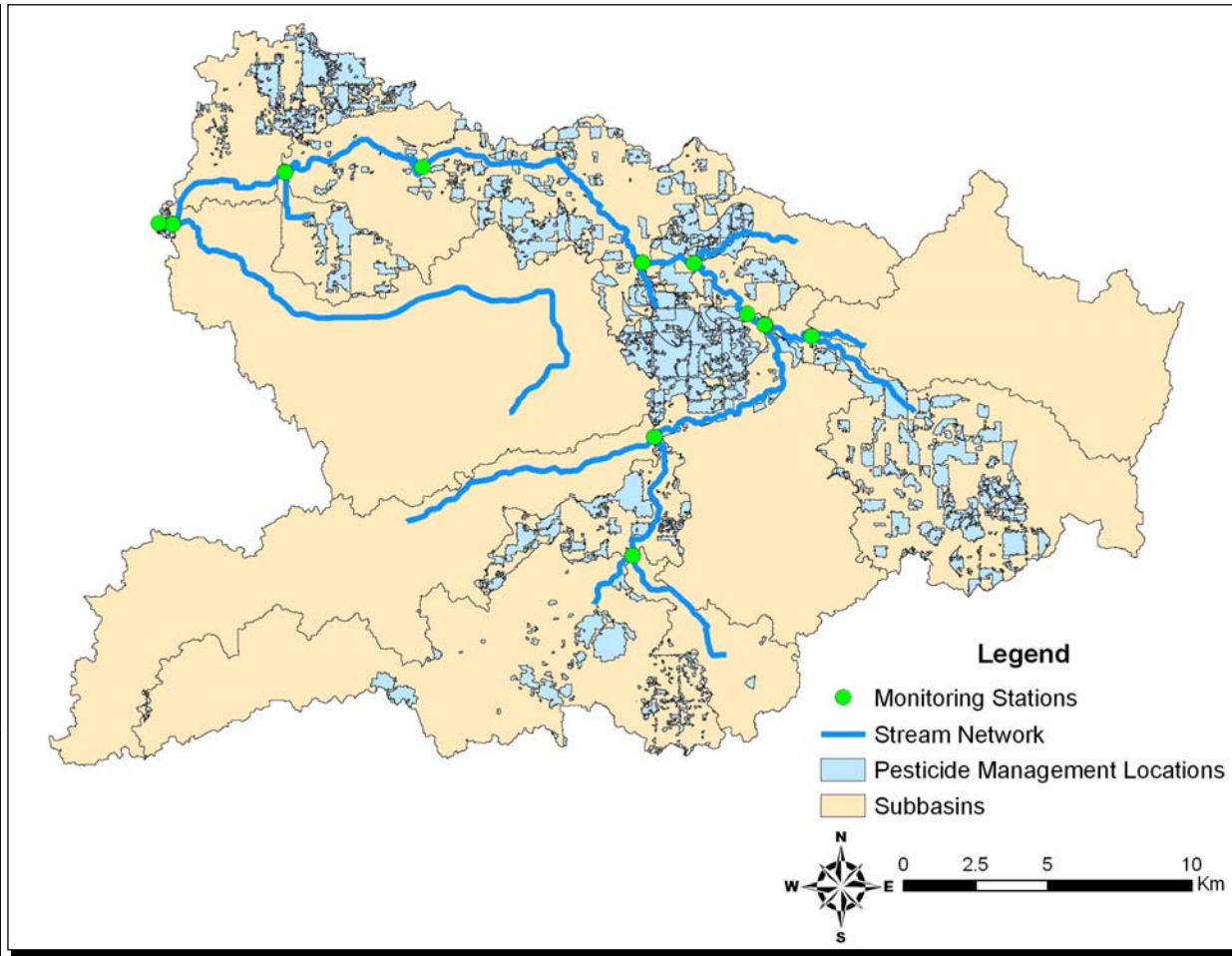
*Wildcat Creek Watershed Objective:* reduction of atrazine loads into the Kokomo reservoir by 10% (Concentration reduction target from average 3.31 µg/L to 3.0 µg/L, EPA MCL).



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	
<b>TOTAL COST (\$)</b>	<b>\$ xxxx.xx</b>



### 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

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