

# RECLAMATION

*Managing Water in the West*

## Geographical Assessment of Potential for Beneficial Use of Produced Water

**Steve Dundorf**

**Katie Benko**

**(Denver - Technical Service Center)**



U.S. Department of the Interior  
Bureau of Reclamation

# Outline

- Reclamation Role
- Produced Water Potential
- 3 Examples



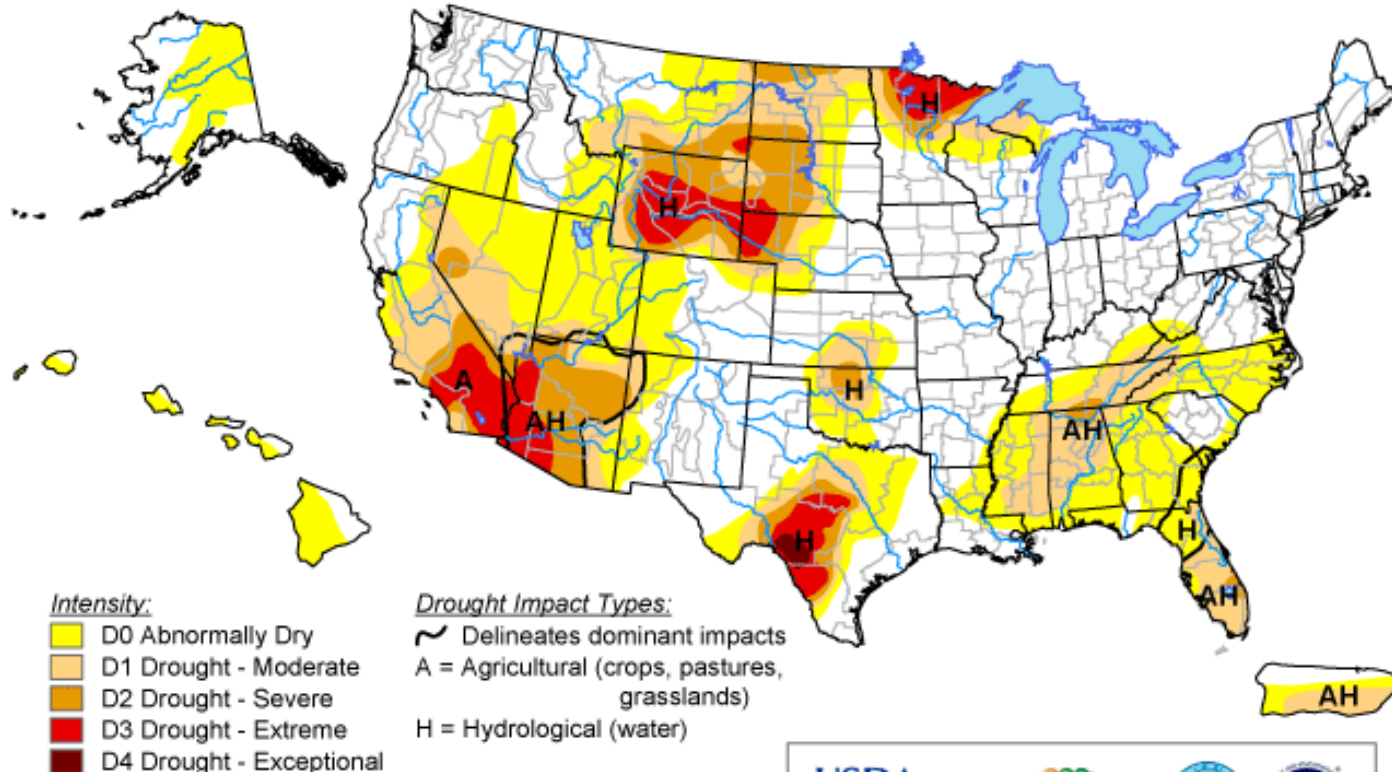
# RECLAMATION

# Desalination in the U.S.

## ***U.S. Drought Monitor***

**March 20, 2007**

Valid 8 a.m. EDT



*The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.*

<http://drought.unl.edu/dm>



**Released Thursday, March 22, 2007**  
**Author: Brad Rippey, U.S. Department of Agriculture**

# RECLAMATION

# Bureau of Reclamation

The mission of the Bureau of Reclamation is to:

Manage, Develop, & Protect Water and related resources in an Environmentally and Economically sound manner in the interest of the American public.

RECLAMATION



# Bureau of Reclamation

## Where do we fit in to Produced Water?

- Develop new water sources
- Develop in an environmentally sound manner
- Assist states in maintaining river compacts
- Fulfilling Indian Trust responsibilities

## Potential Specific Uses of Produced Water

- Discharge to streams
- Agricultural use
- Municipal & Industrial use (indirect or direct)

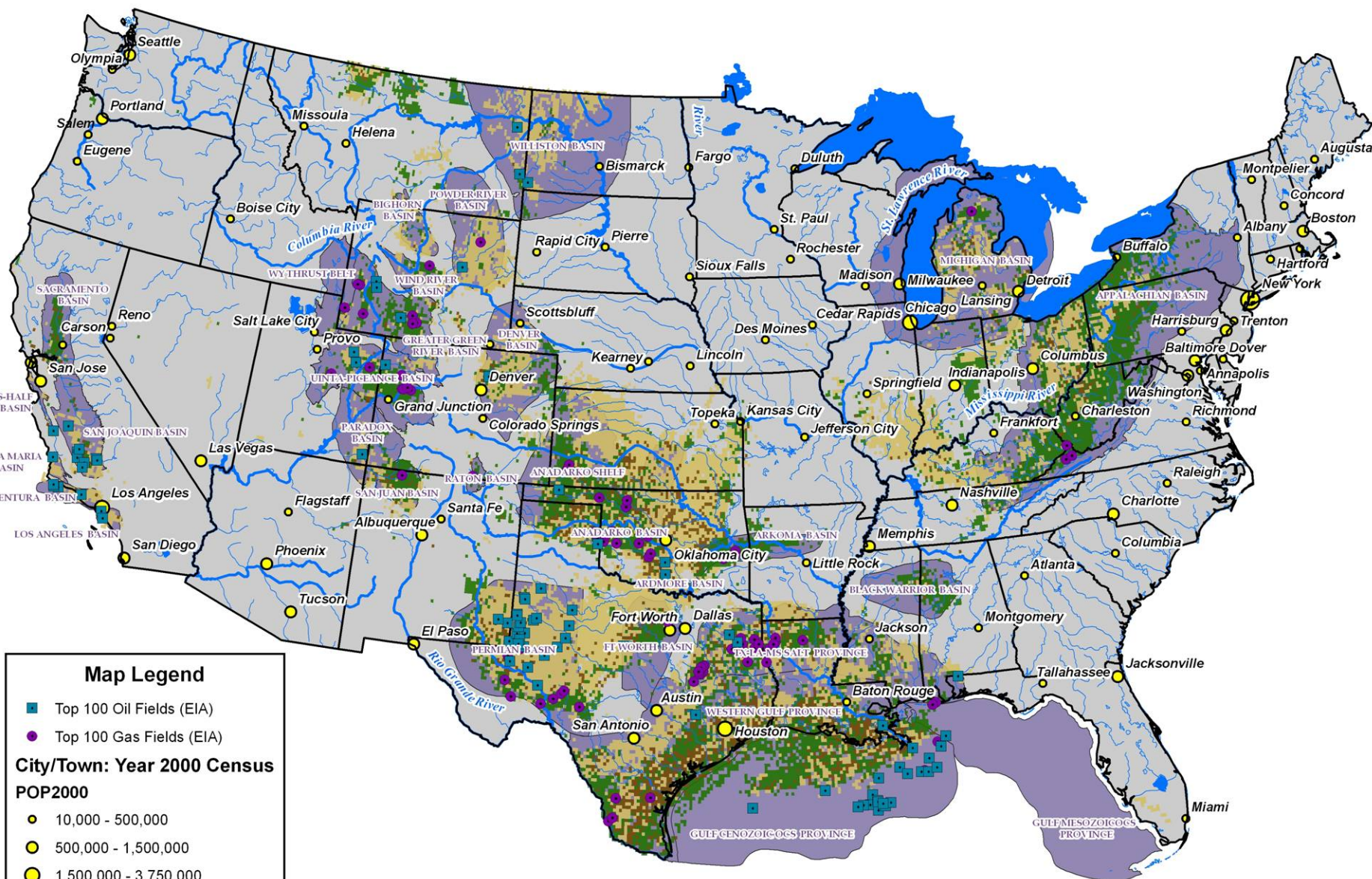
RECLAMATION

# Outline

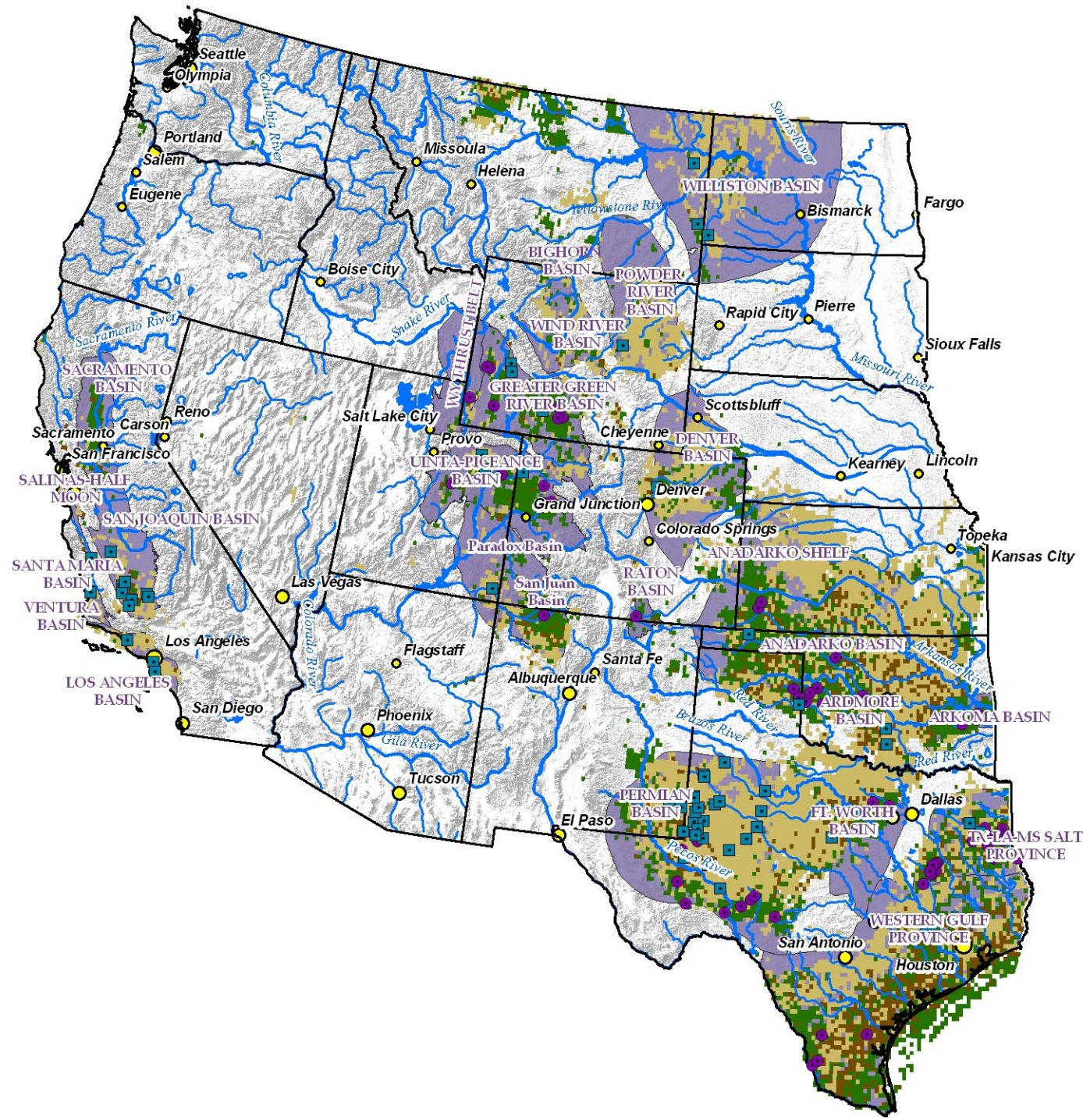
- Reclamation Role
- **Produced Water Potential**
- 3 Examples



RECLAMATION







## Map Legend

- Top 100 Oil Fields (EIA)
- Top 100 Gas Fields (EIA)

## City/Town: Year 2000 Census

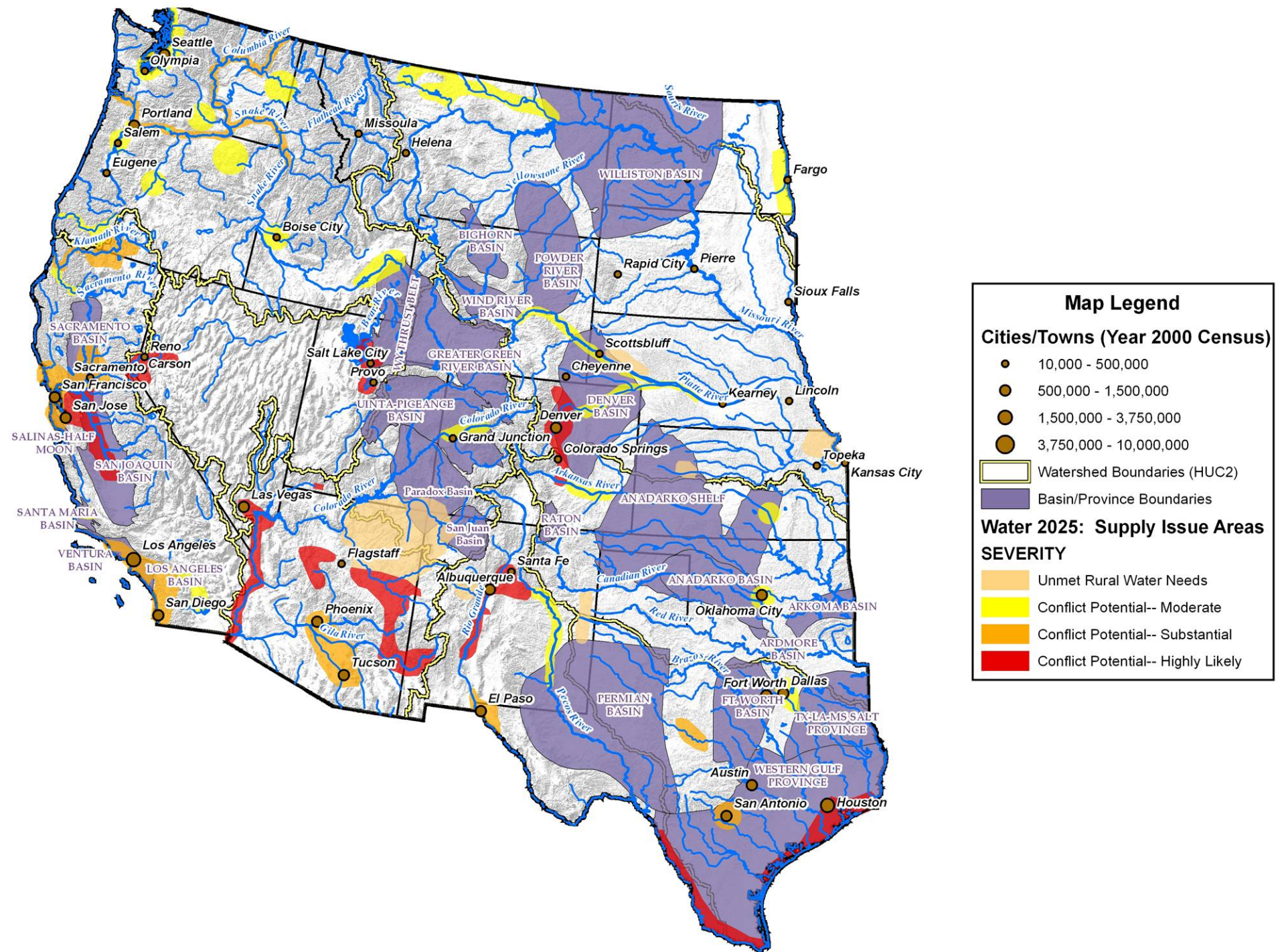
- 10,000 - 500,000
- 500,000 - 1,500,000
- 1,500,000 - 3,750,000
- 3,750,000 - 10,000,000

- Rivers
- Lakes/Reservoirs
- Basin/Province Boundaries

## Distribution of Gas/Oil

- Oil
- Gas
- Oil & Gas





# Occurrence of PW in Western U.S.

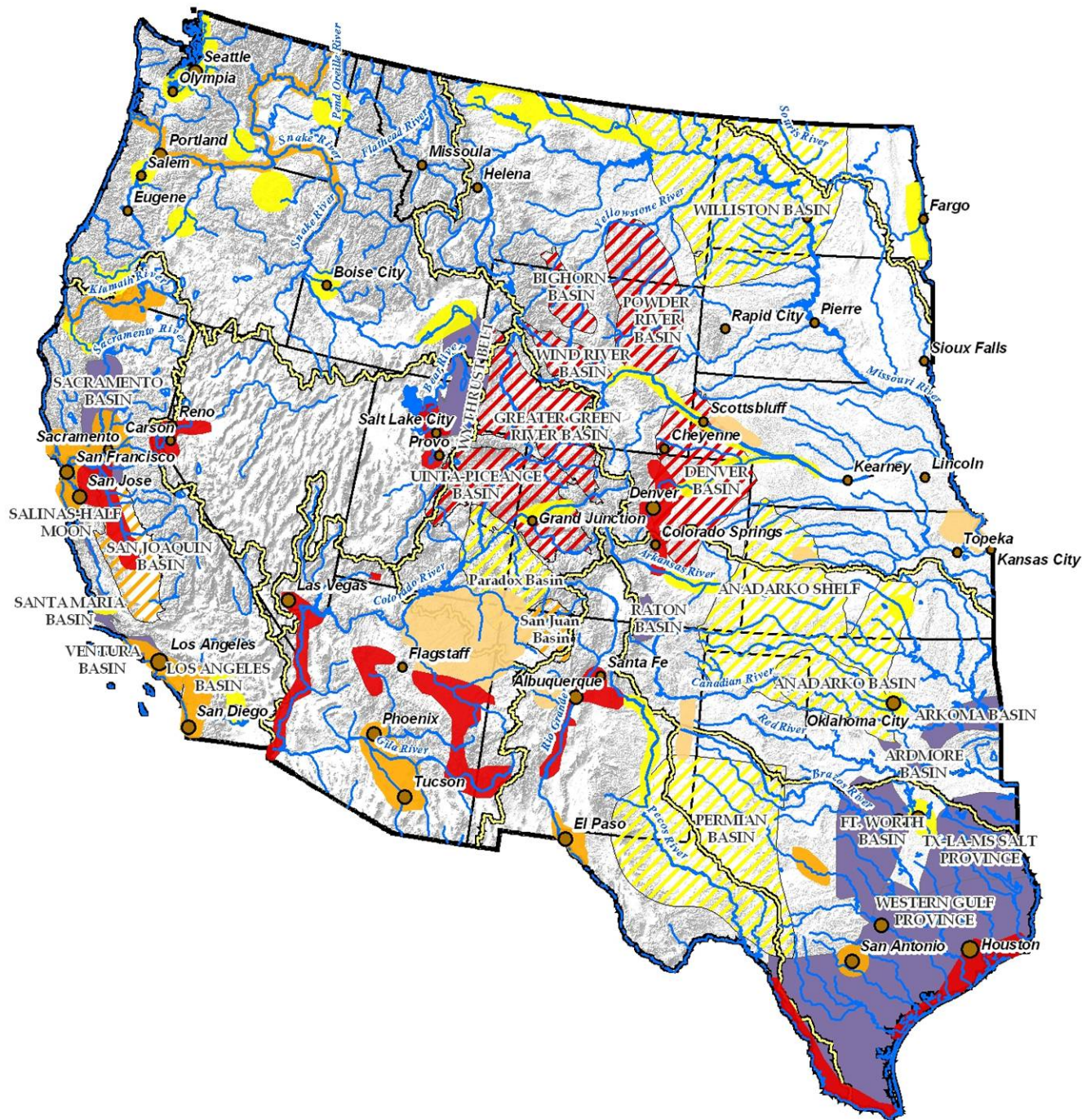
**Conventional  
oil and gas  
co-produced  
water  
generation**

Geologic Basin	Water Production		Median TDS	Potential for treatment
	m <sup>3</sup> /day	mgd	(mg/L)	
Williston	18,000	4.9	132,400	Low
Powder River	370,000	97	7,300	Very high
Big Horn	360,000	94	4,900	Very high
Wind River	54,000	14	5,300	Very high
Green River	41,000	11	9,400	High
Denver	14,000	3.8	10,200	High
Uinta-Piceance	42,000	11	13,200	High
Paradox	21,000	5.6	67,000	Low
San Juan	14,000	3.6	22,700	Medium
Anadarko	34,000	8.9	132,200	Very low
Permian*	250,000	65	89,200	Low
San Joaquin	NA	NA	22,700	Medium
Los Angeles	NA	NA	30,330	Medium

\* For natural gas only and only for the New Mexico portion of the Permian Basin.

RECLAMATION





### Map Legend

#### Cities/Towns (Year 2000 Census)

- 10,000 - 500,000
- 500,000 - 1,500,000
- 1,500,000 - 3,750,000
- 3,750,000 - 10,000,000

#### Water 2025: Supply Issue Areas SEVERITY

- Unmet Rural Water Needs
- Conflict Potential-- Moderate
- Conflict Potential-- Substantial
- Conflict Potential-- Highly Likely
- states\_temp\_Dissolve
- Watershed Boundaries (HUC2)

#### Basins: Potential for Treatment

##### Conventional Oil & Gas

- High
- Medium
- Low
- N/A

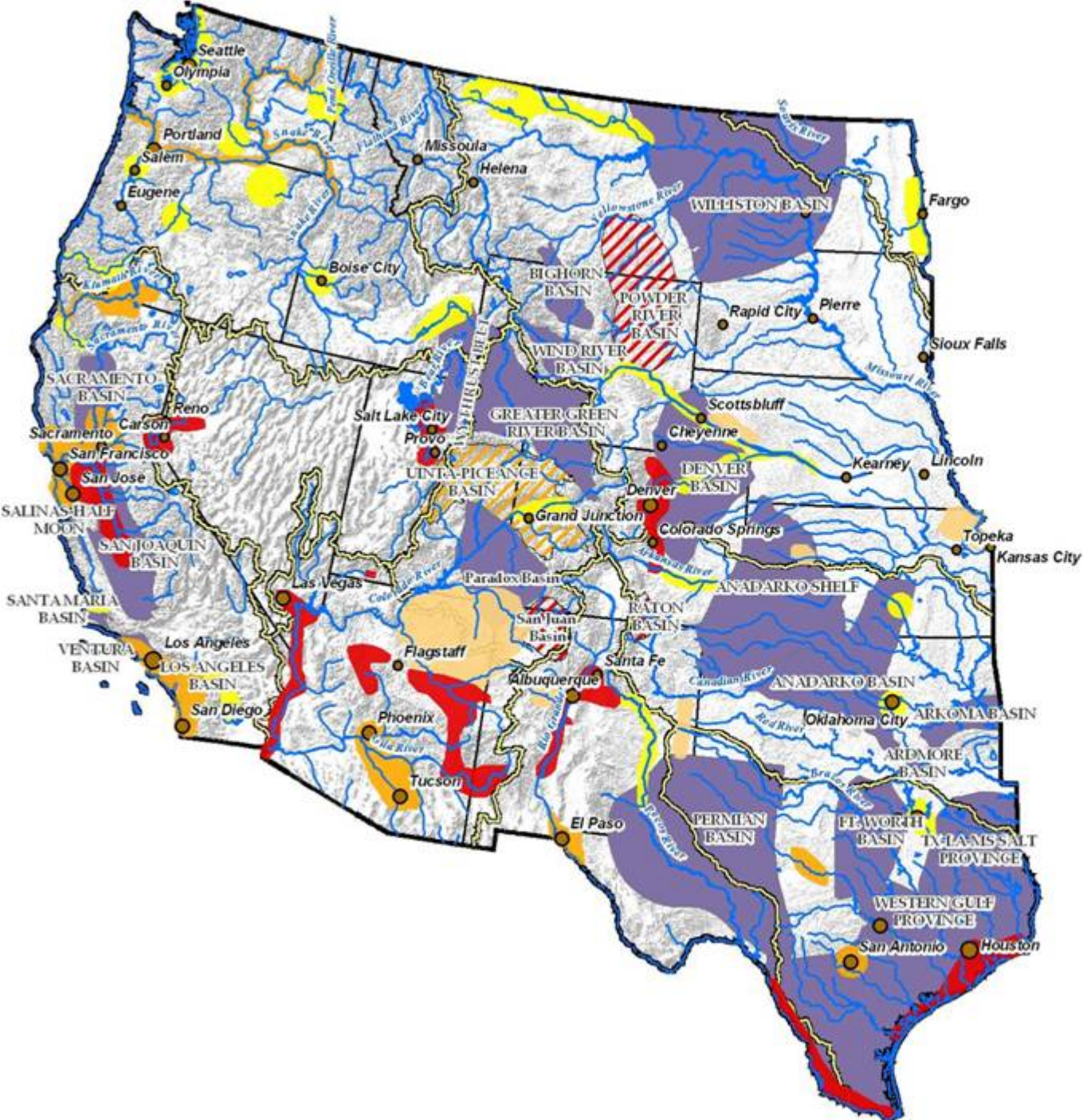
# Occurrence of PW in Western U.S.

## Coalbed Methane Co-Produced Water Generation (Partial List)

Geologic Basin	Water Production		Median TDS (mg/L)	Potential for Treatment
	m <sup>3</sup> /day	mgd		
Powder River	170,000	46	840	Very High
Uinta	19,000	5.1	15,000	Medium
San Juan	12,000	3.2	8,000	High
Raton	13,000	3.6	1,500	High

RECLAMATION





**Map Legend**

**Cities/Towns (Year 2000 Census)**

- 10,000 - 500,000
- 500,000 - 1,500,000
- 1,500,000 - 3,750,000
- 3,750,000 - 10,000,000

**Water 2025: Supply Issue Areas**

**SEVERITY**

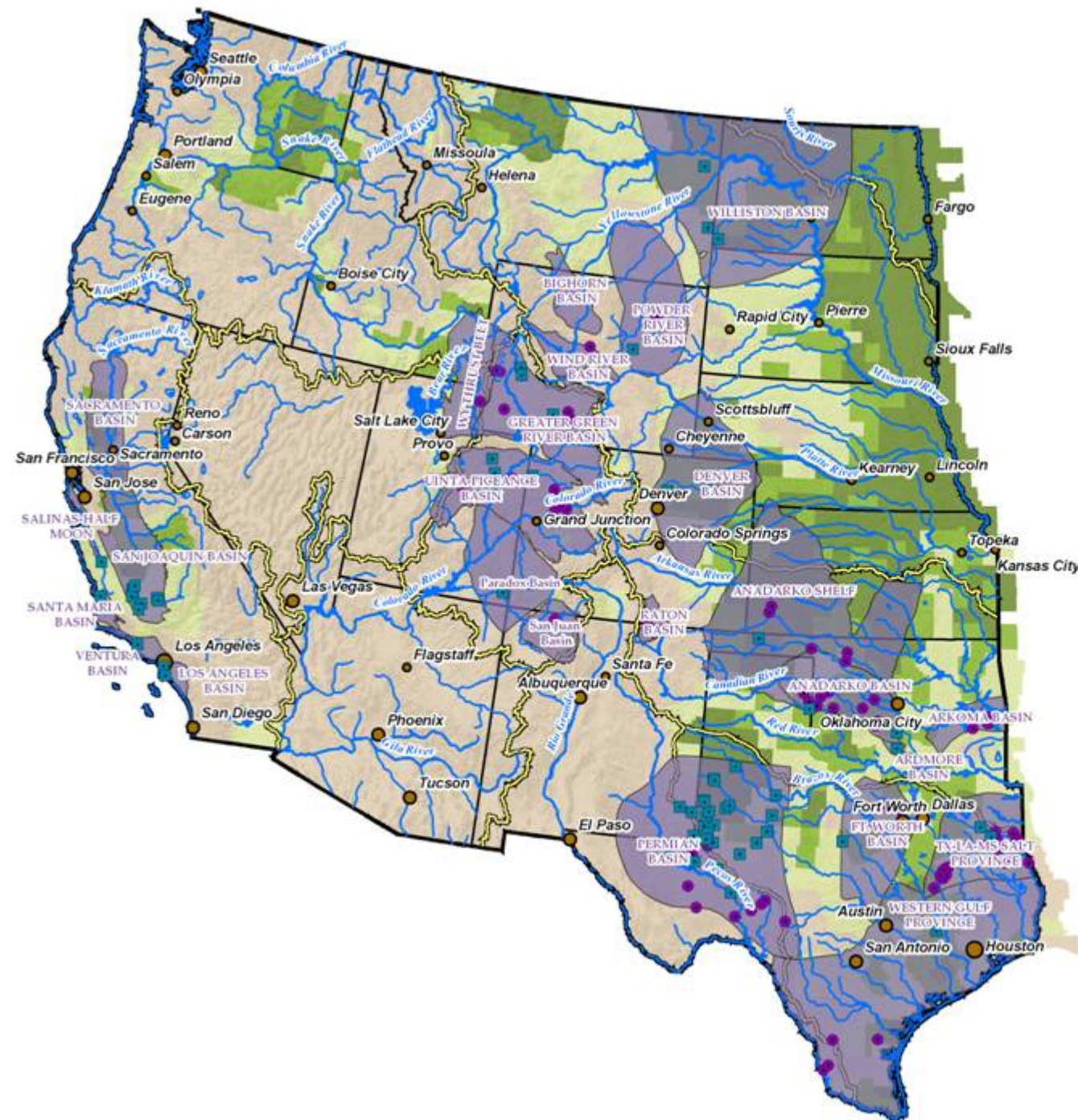
- Unmet Rural Water Needs
- Conflict Potential-- Moderate
- Conflict Potential-- Substantial
- Conflict Potential-- Highly Likely
- states\_temp\_Dissolve
- Watershed Boundaries (HUC2)

**Basins: Potential for Treatment**

**Coalbed Methane**

- High
- Medium
- Low
- N/A

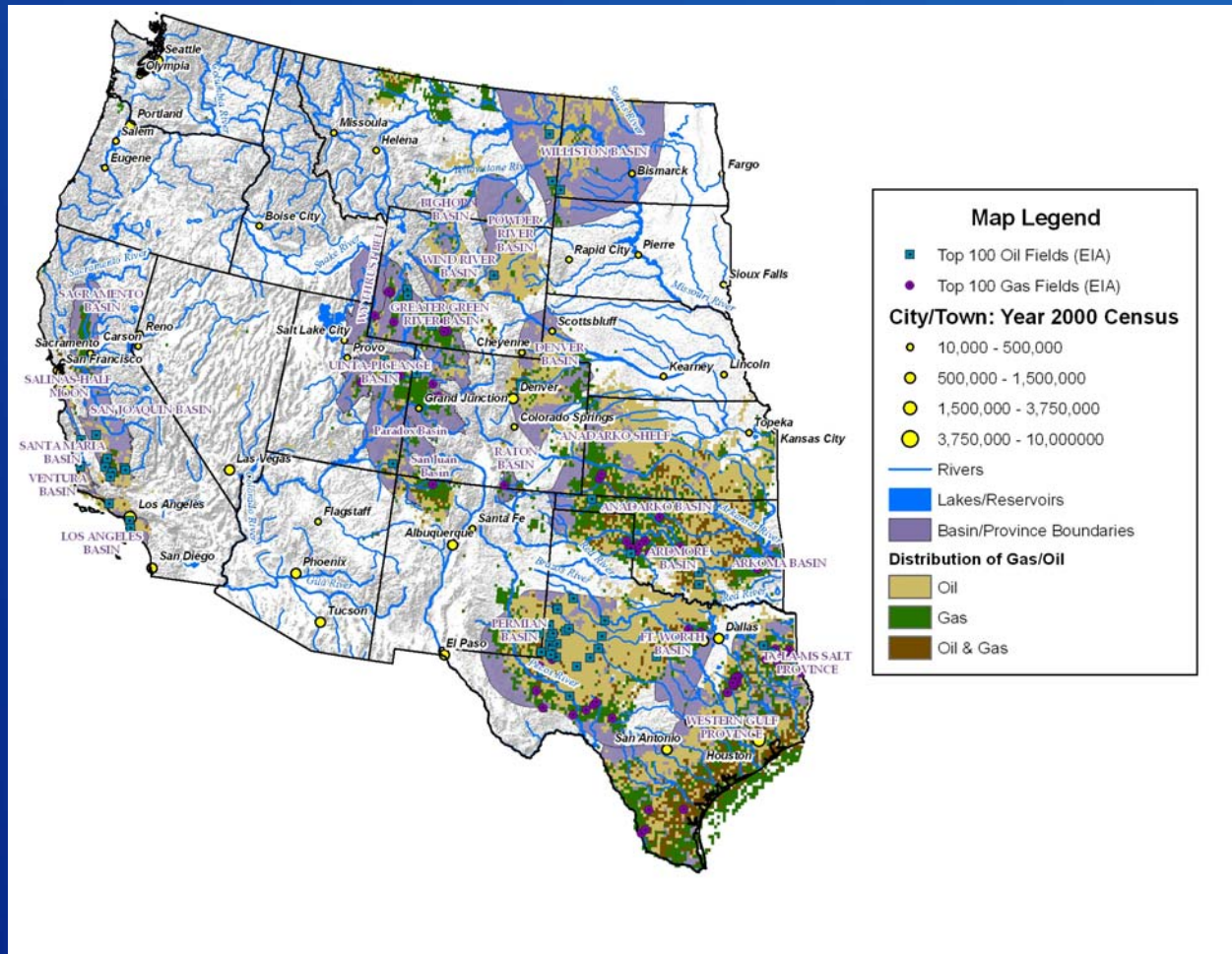




**Map Legend**

- Top 100 Oil Fields (EIA)
- Top 100 Gas Fields EIA
- Cities/Towns (Year 2000 Census)**
- POP2000**
  - 10,000 - 500,000
  - 500,000 - 1,500,000
  - 1,500,000 - 3,750,000
  - 3,750,000 - 10,000,000
- Watershed Boundaries (HUC2)
- Basin/Province Boundaries
- Agriculture**
- Acres of Total Cropland**
  - 50 or more
  - 31 - 50
  - 10 - 30
  - Less than 10

# Occurrence of Produced Water in U.S.



RECLAMATION



## Water

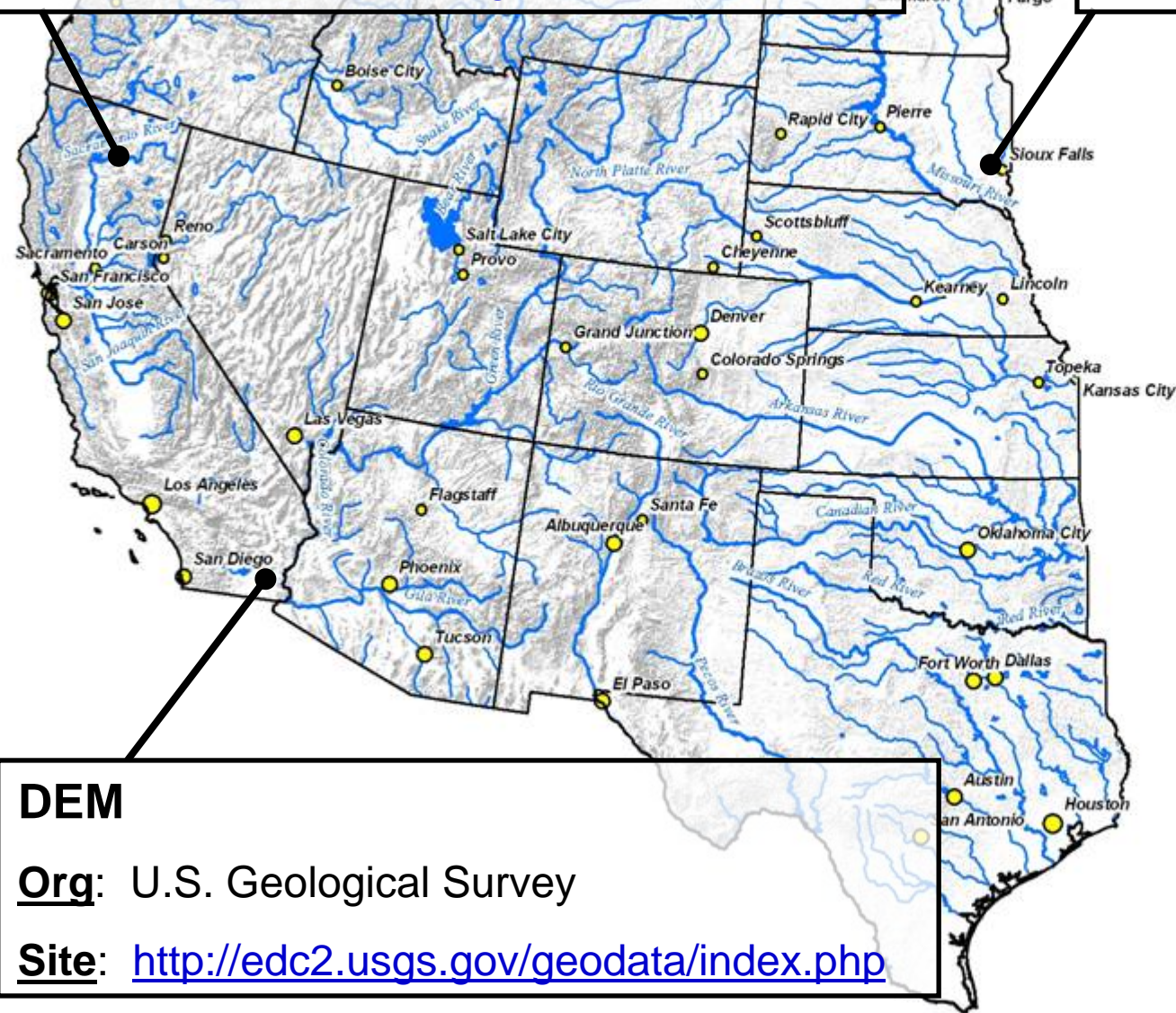
Org: U.S. Geological Survey

Site: <http://nationalatlas.gov/atlasftp-na.html>

## Cities

Org: ESRI - Redlands, CA

Site: [www.esri.com](http://www.esri.com)



### Map Legend

#### City/Town: Year 2000 Census

- 10,000 - 500,000
- 500,000 - 1,500,000
- 1,500,000 - 3,750,000
- 3,750,000 - 10,000,000

Rivers

Lakes/Reservoirs

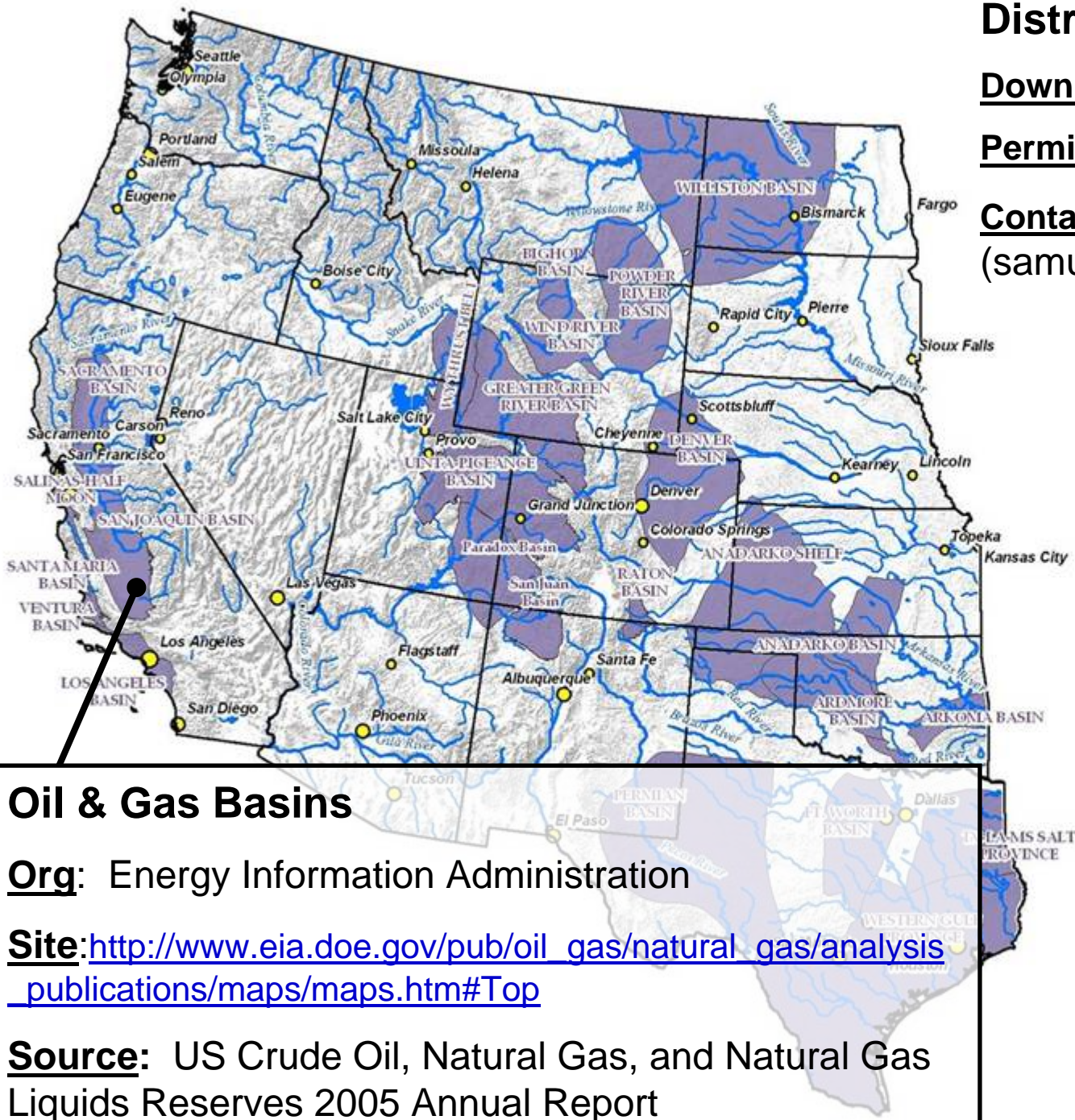


# Distribution

Download: No

Permission: On a request basis

Contact: Samuel Limerick  
(samuel.limerick@eia.doe.gov)



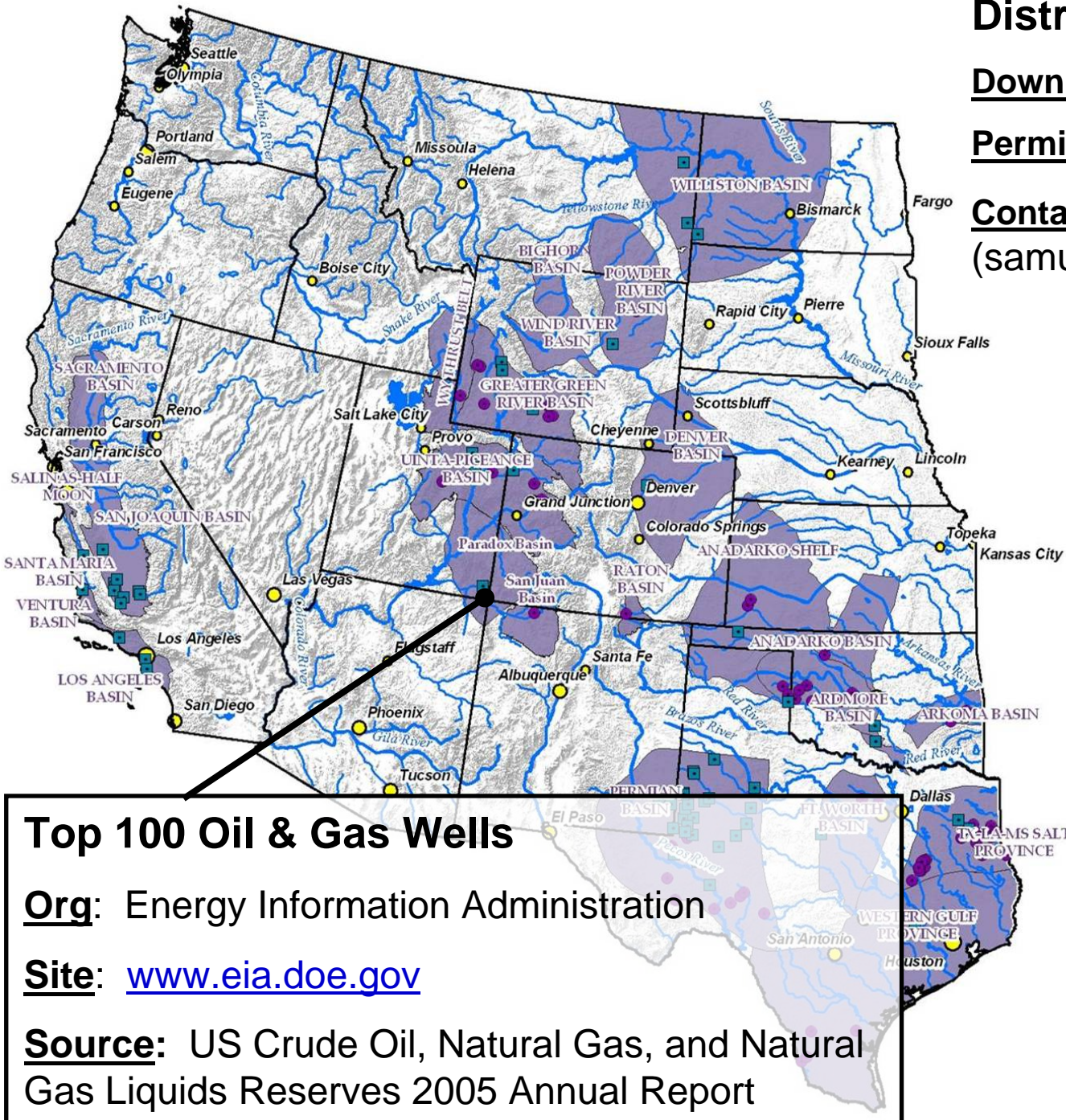


# Distribution

Download: No

Permission: On a request basis

Contact: Samuel Limerick  
(samuel.limerick@eia.doe.gov)



## Map Legend

- Top 100 Oil Fields (EIA)
- Top 100 Gas Fields (EIA)

### City/Town: Year 2000 Census

- 10,000 - 500,000
- 500,000 - 1,500,000
- 1,500,000 - 3,750,000
- 3,750,000 - 10,000,000

- Rivers
- Lakes/Reservoirs
- Basin/Province Boundaries

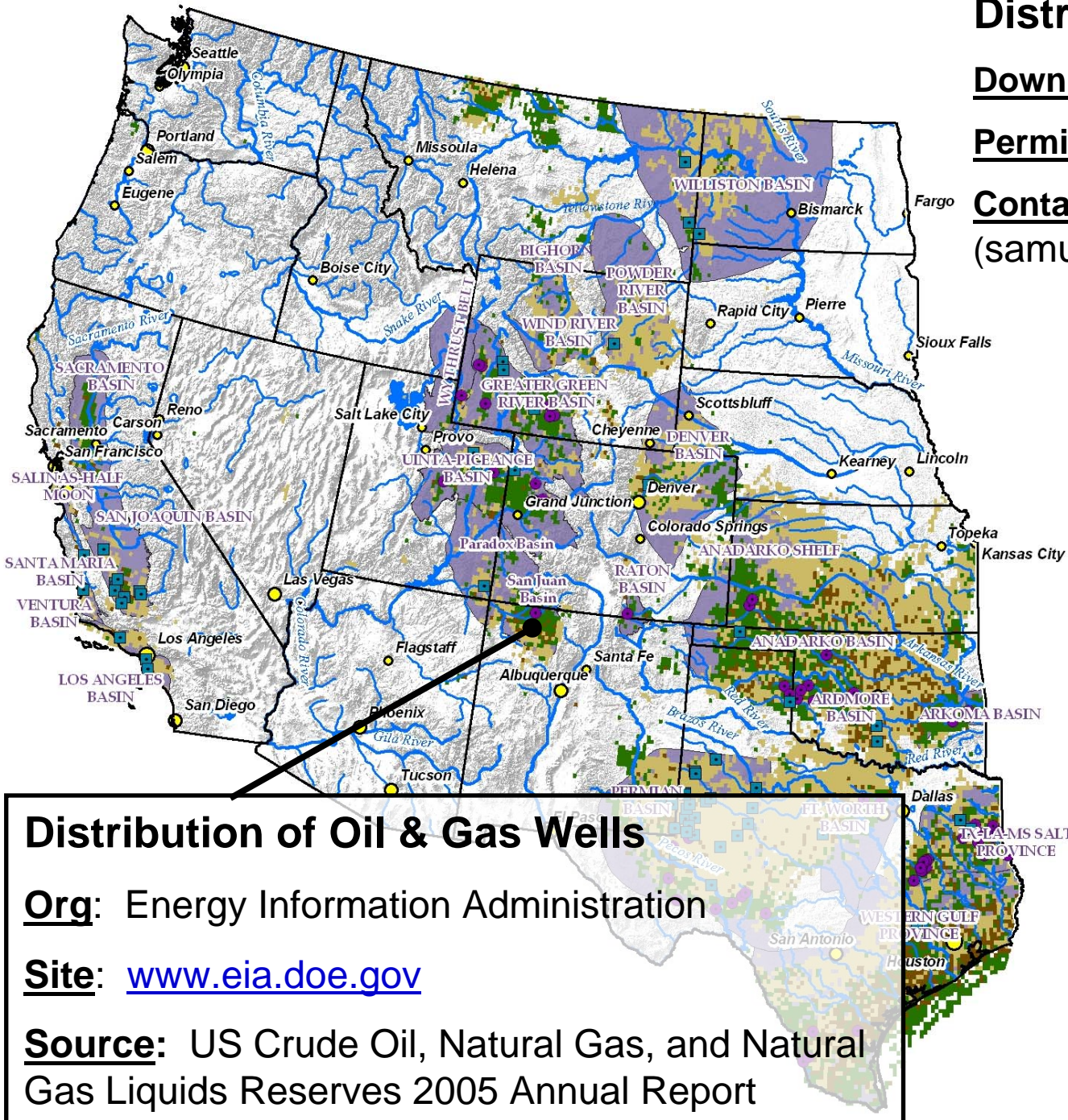


# Distribution

Download: No

Permission: On a request basis

Contact: Samuel Limerick  
(samuel.limerick@eia.doe.gov)



■ Top 100 Oil Fields (EIA)

● Top 100 Gas Fields (EIA)

## City/Town: Year 2000 Census

● 10,000 - 500,000

● 500,000 - 1,500,000

● 1,500,000 - 3,750,000

● 3,750,000 - 10,000,000

— Rivers

■ Lakes/Reservoirs

■ Basin/Province Boundaries

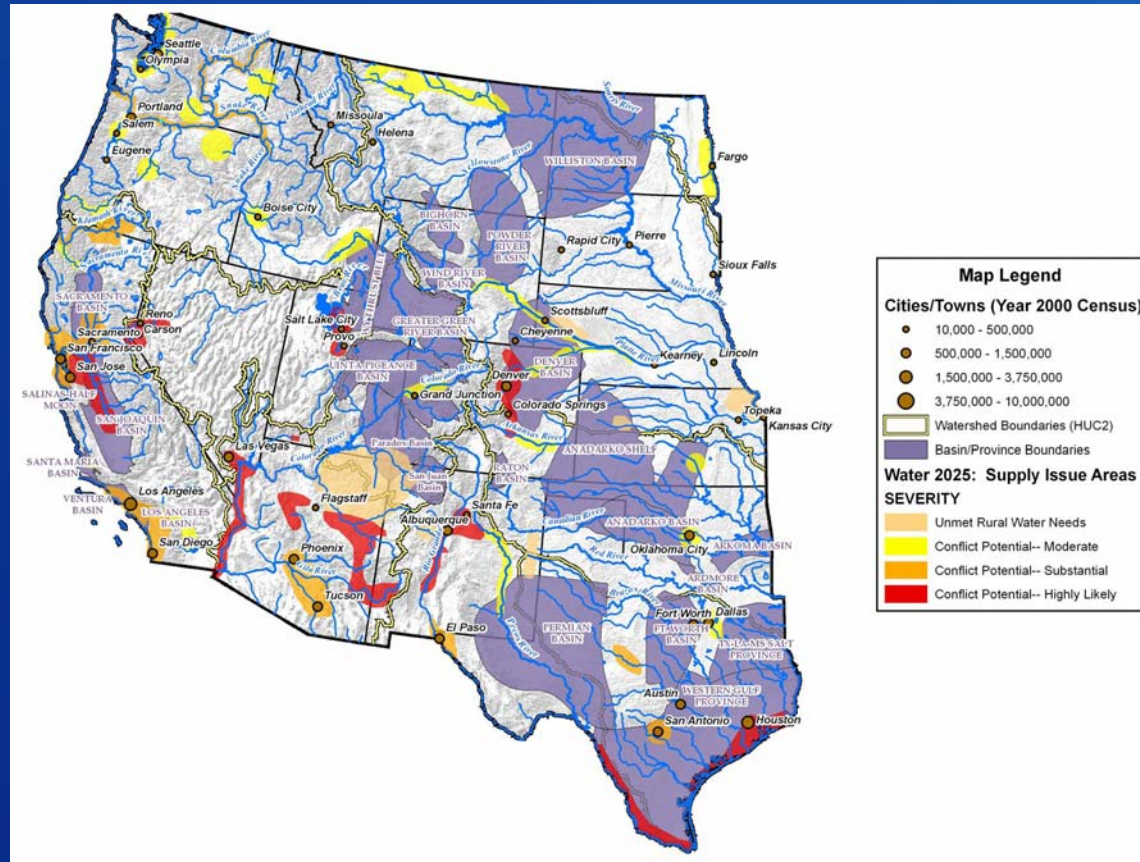
## Distribution of Gas/Oil

■ Oil

■ Gas

■ Oil & Gas

# PW in Relation to Conflict Potential & Hydrologic Units



RECLAMATION



# Base Map

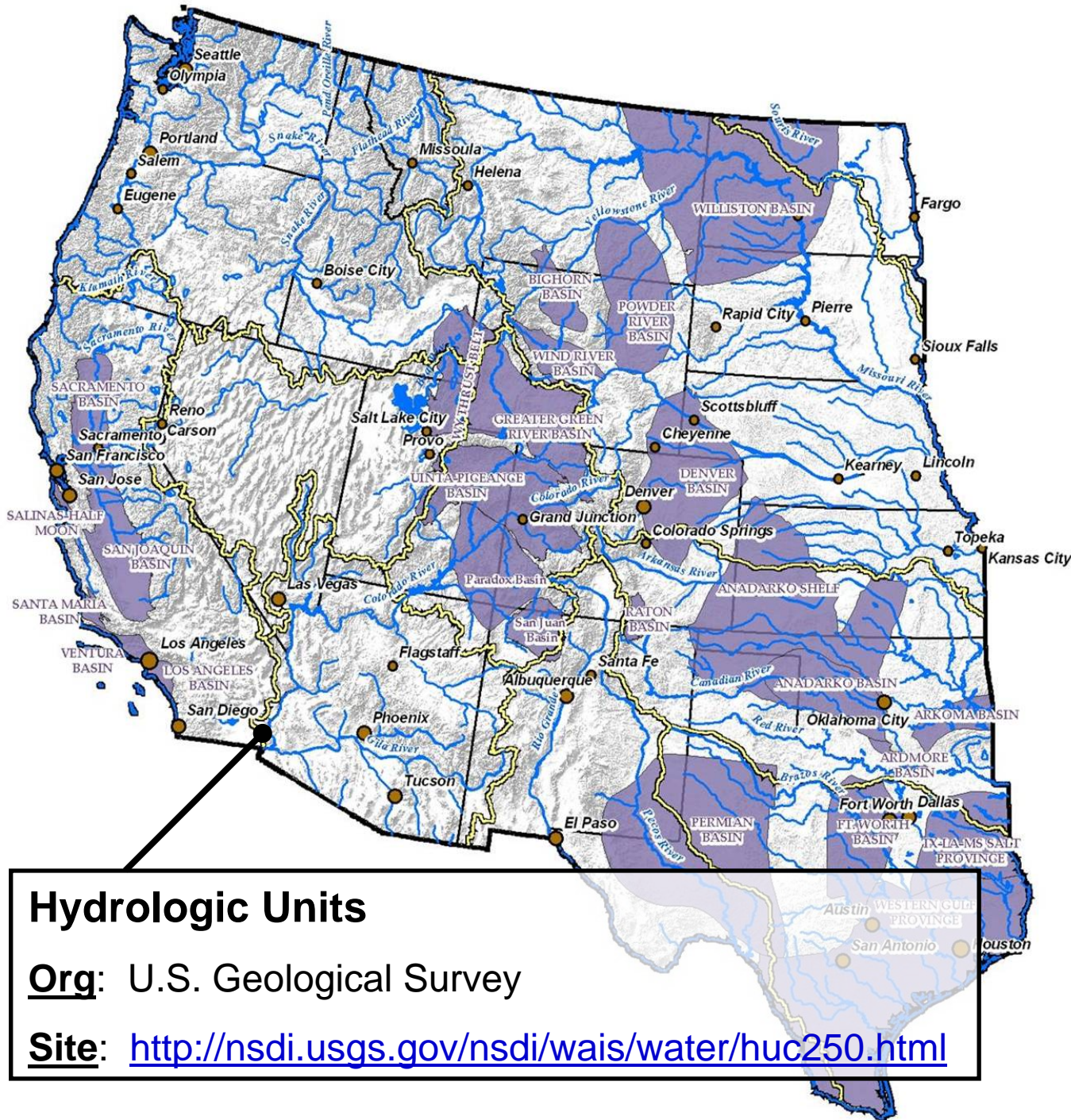




# Distribution

Download: Yes

HUC 2 to HUC 8



## Map Legend

### Cities/Towns (Year 2000 Census)

- 10,000 - 500,000
- 500,000 - 1,500,000
- 1,500,000 - 3,750,000
- 3,750,000 - 10,000,000

- states\_temp\_Dissolve
- Watershed Boundaries (HUC2)
- Basin/Province Boundaries

## Hydrologic Units

Org: U.S. Geological Survey

Site: <http://nsdi.usgs.gov/nsdi/wais/water/huc250.html>

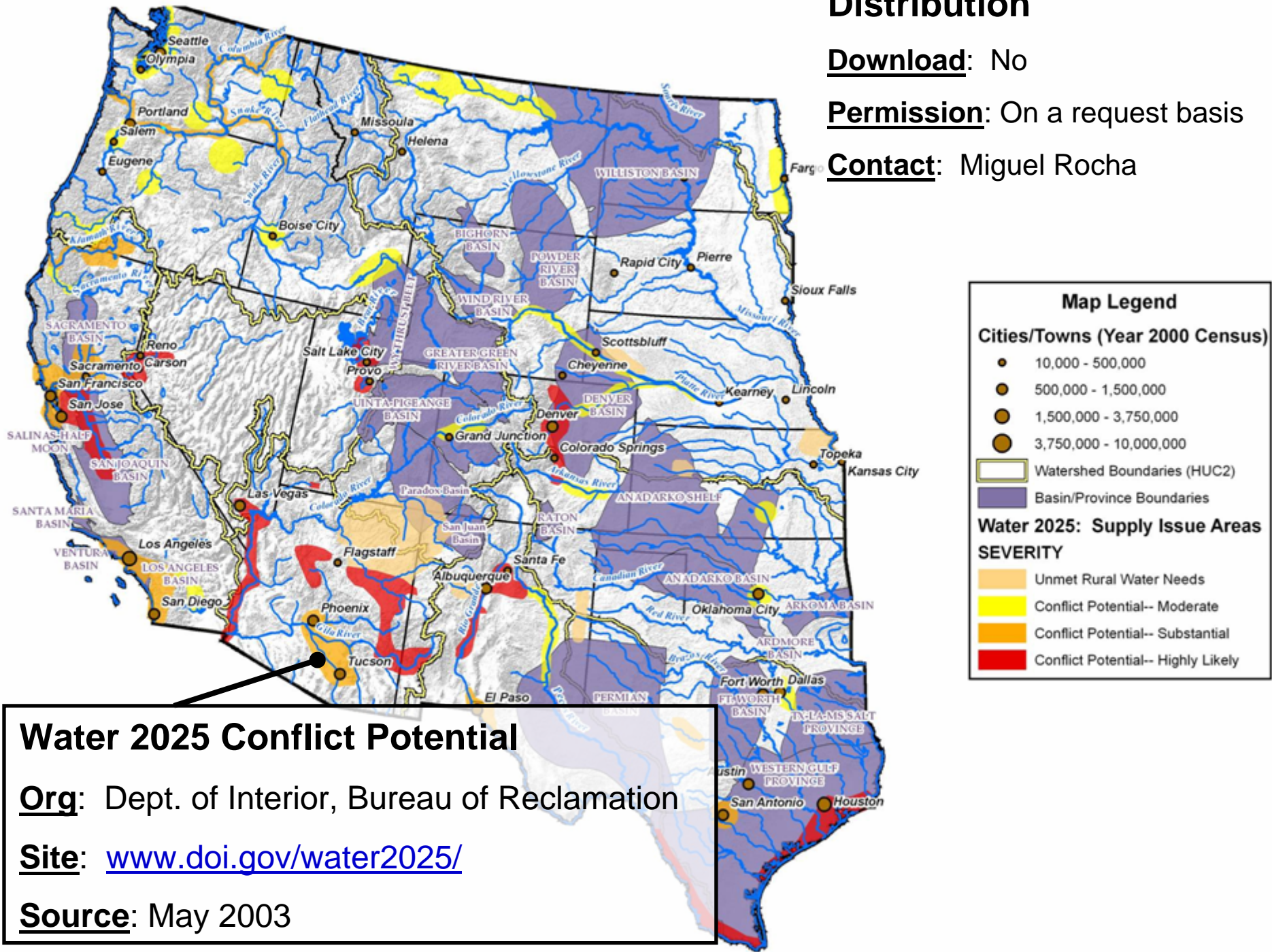


# Distribution

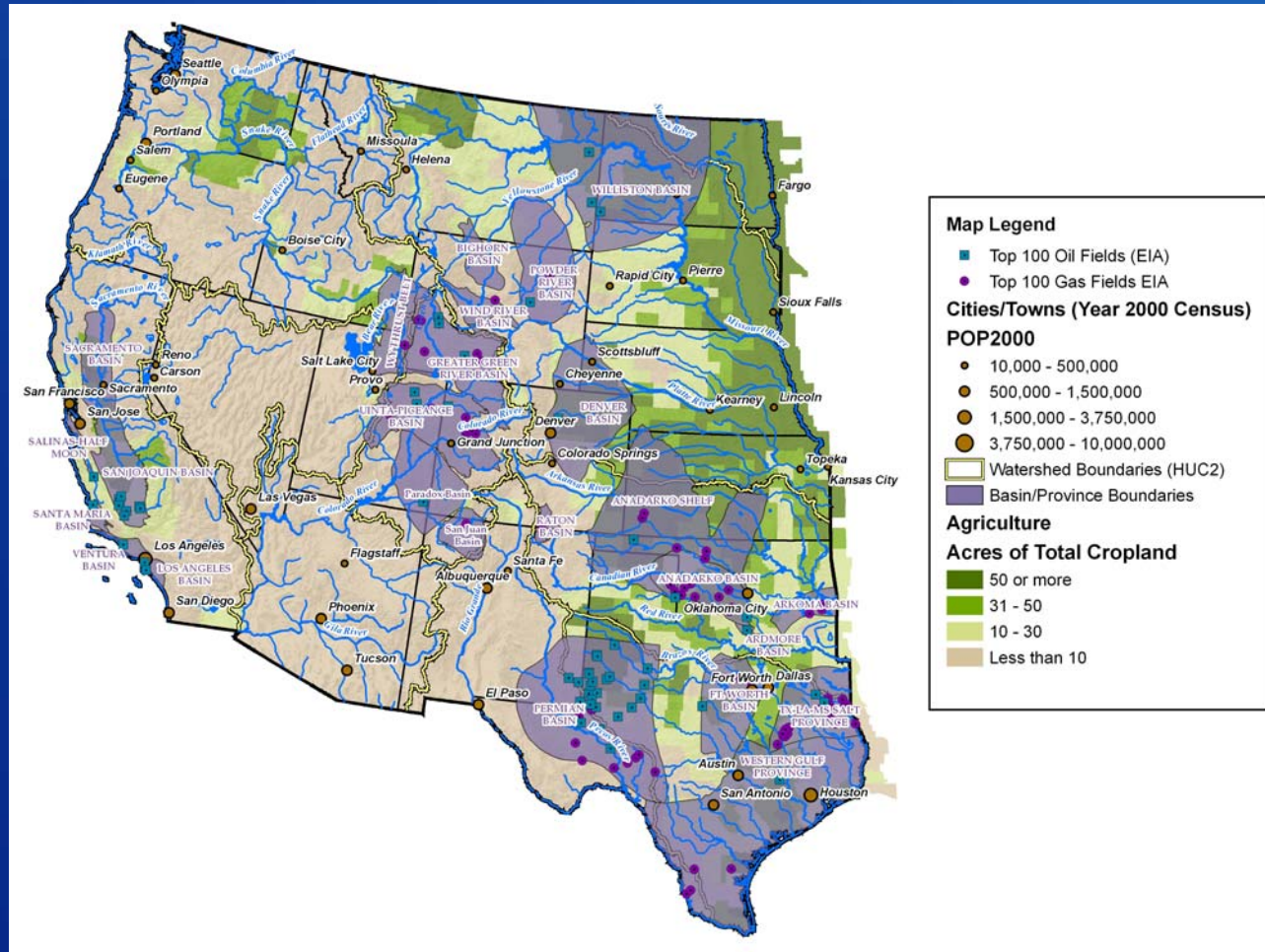
Download: No

Permission: On a request basis

Contact: Miguel Rocha



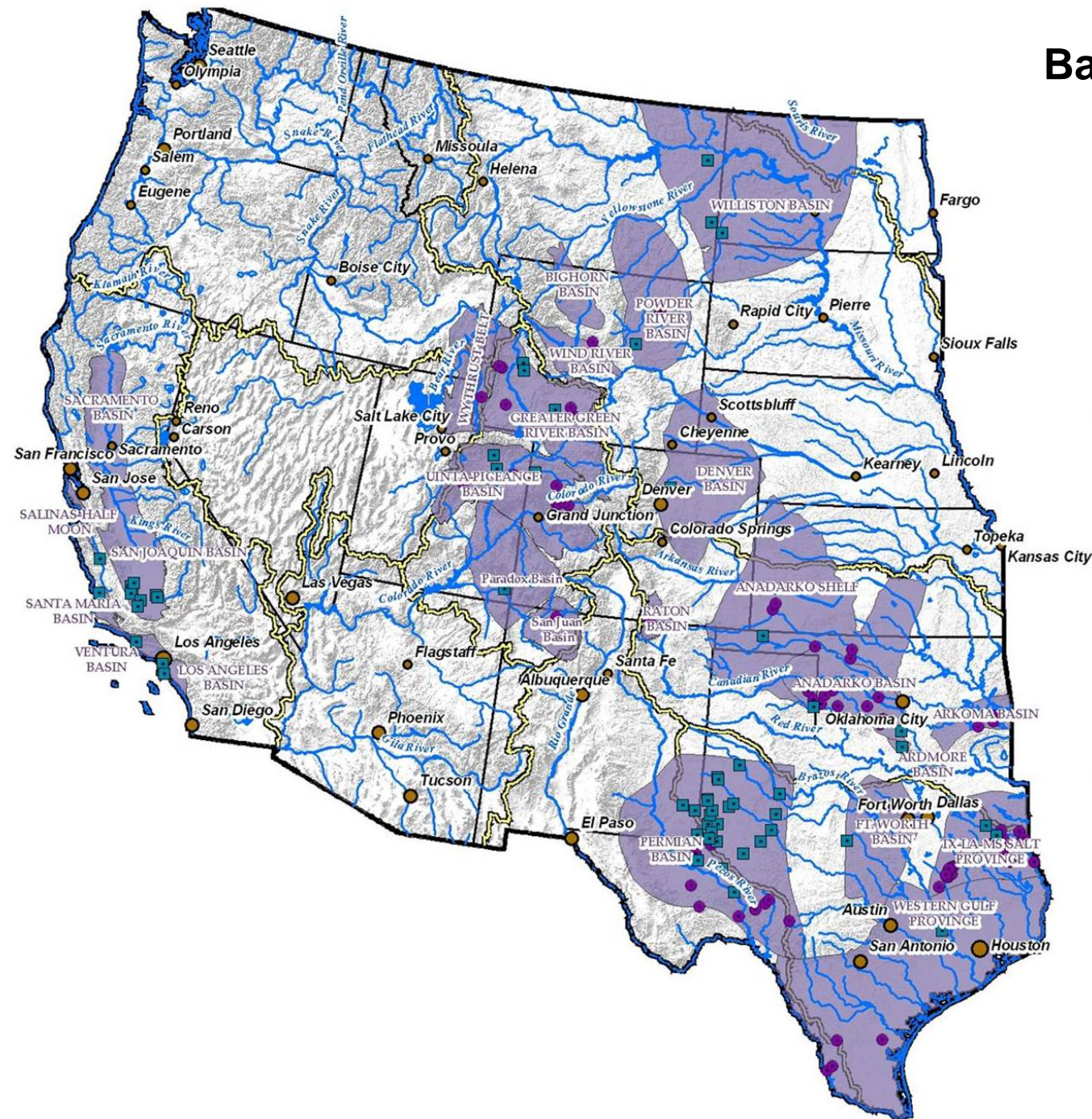
# PW in Relation to Agriculture



RECLAMATION



# Base Map



## Map Legend

■ Top 100 Oil Fields (EIA)

● Top 100 Gas Fields EIA

## Cities/Towns (Year 2000 Census)

● 10,000 - 500,000

● 500,000 - 1,500,000

● 1,500,000 - 3,750,000

● 3,750,000 - 10,000,000

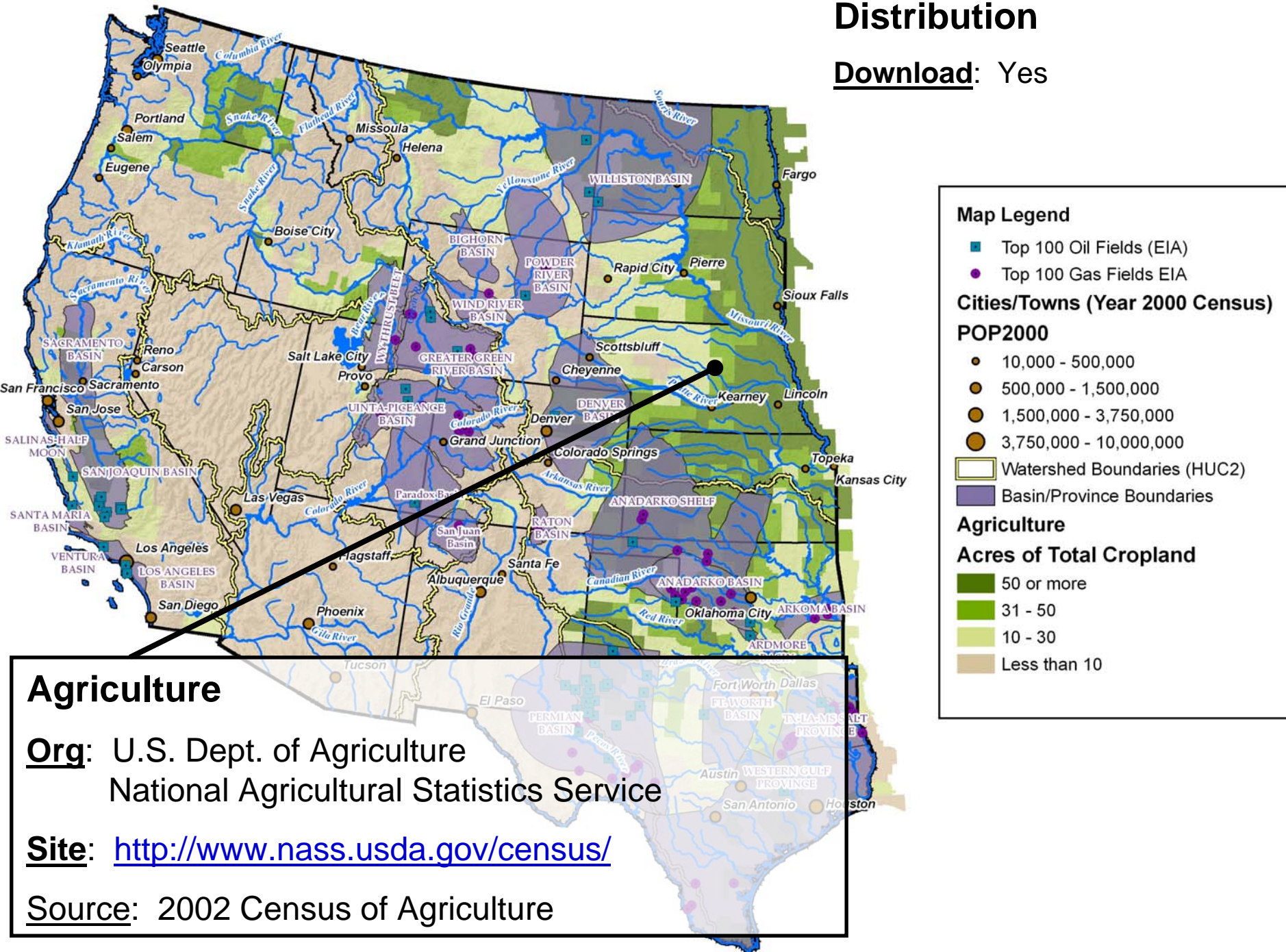
▭ Watershed Boundaries (HUC2)

▭ Basin/Province Boundaries



# Distribution

Download: Yes



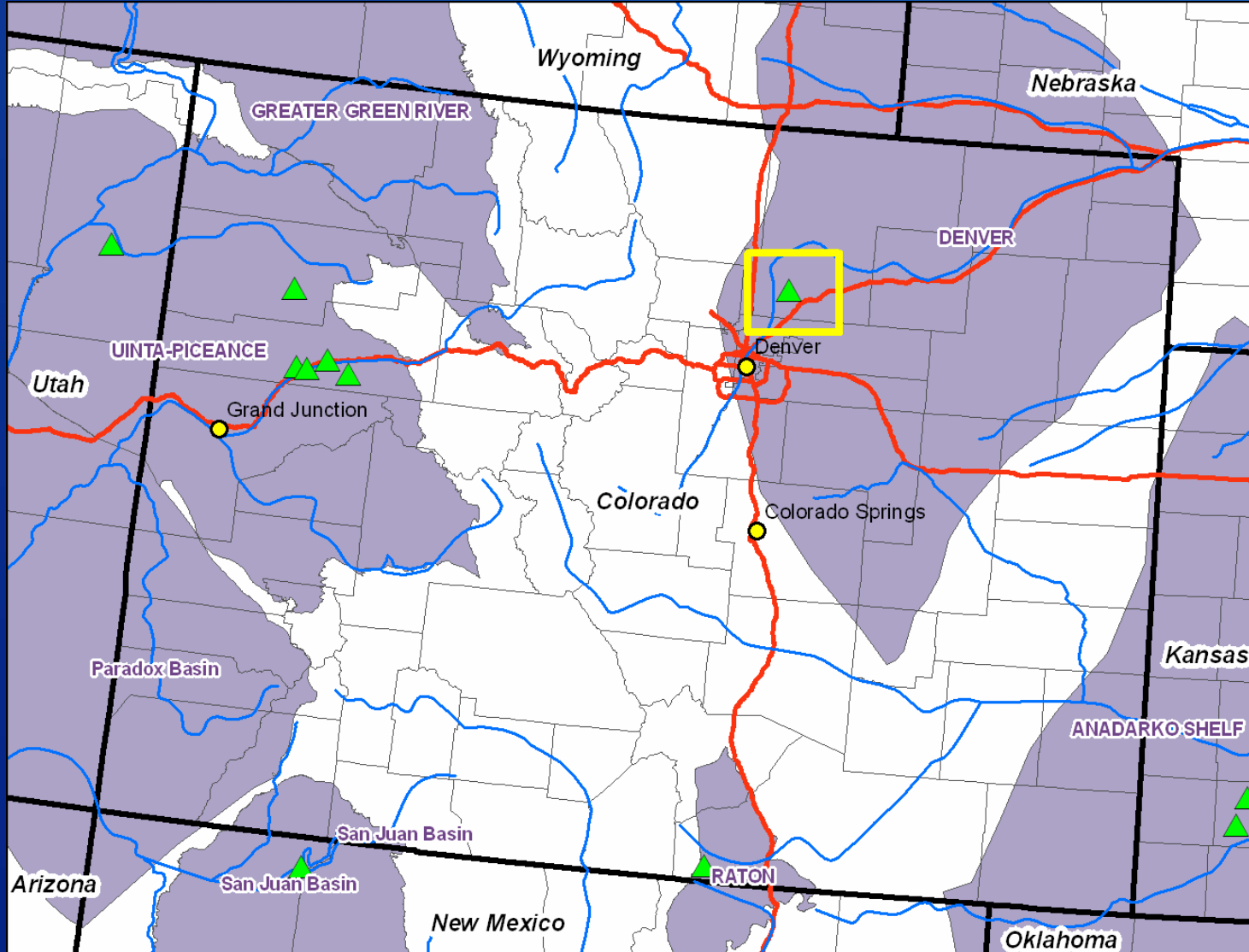
# Outline

- Reclamation Role
- Produced Water Potential
- **3 Examples**



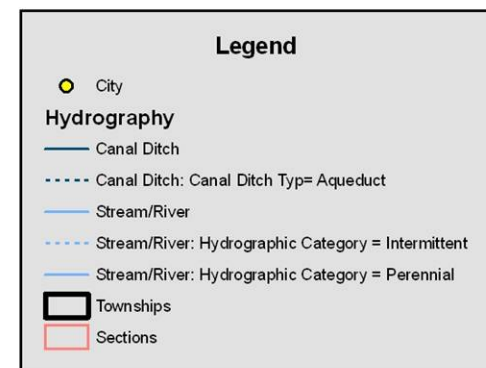
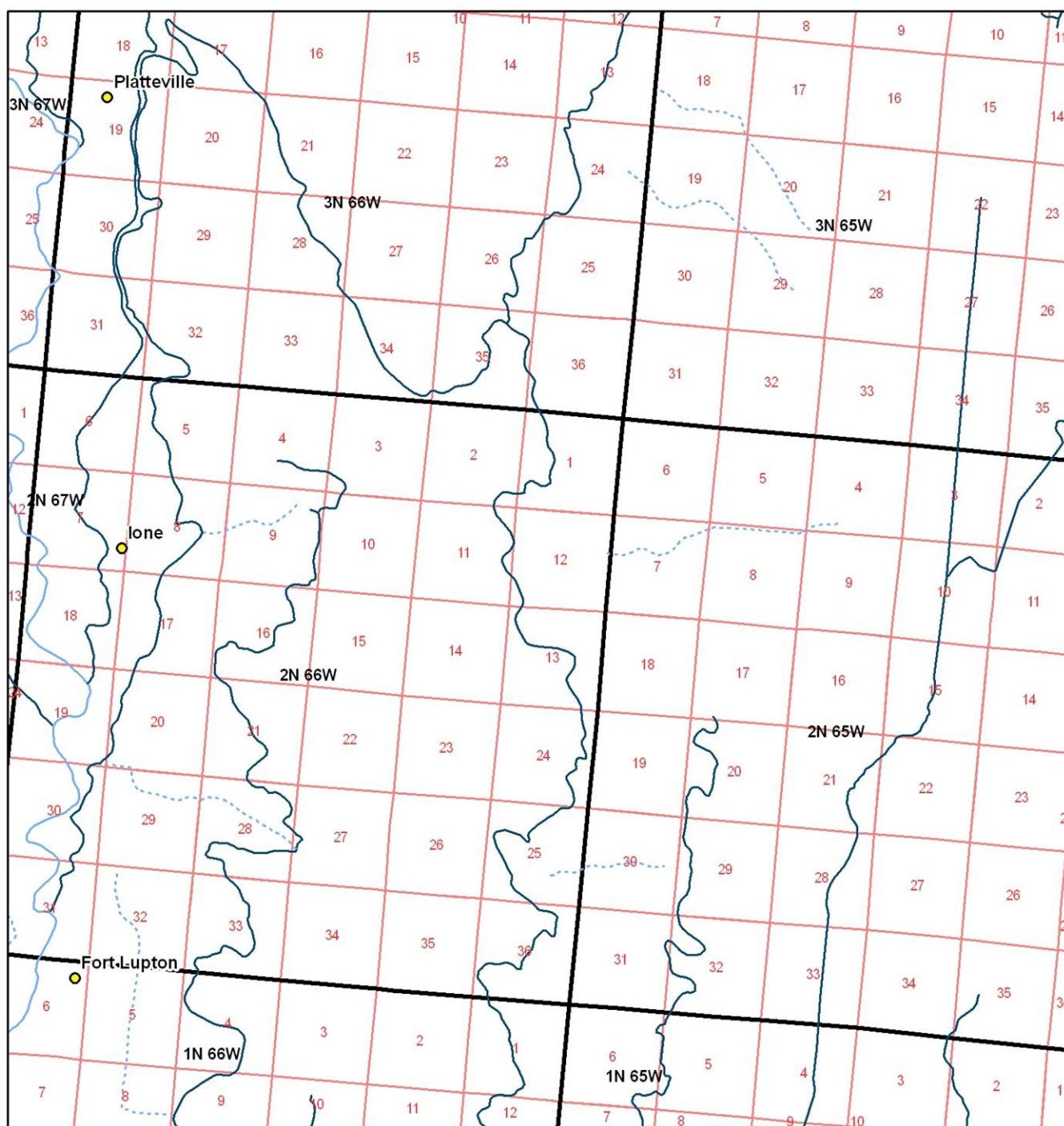
# RECLAMATION

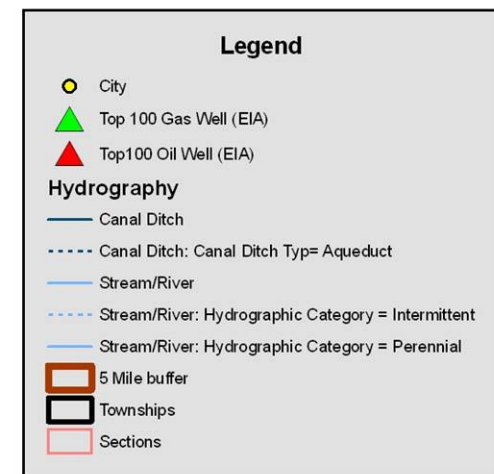
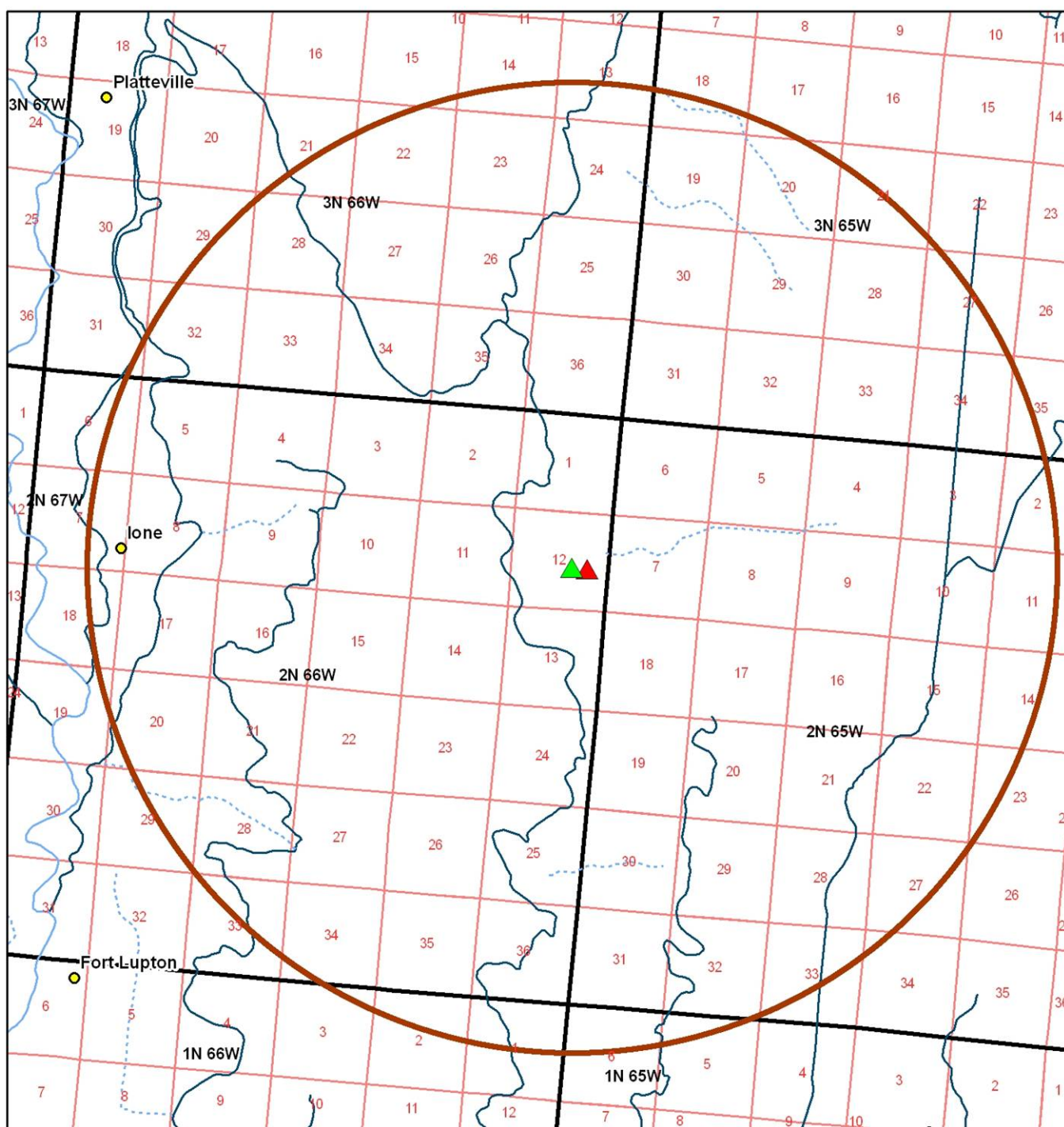
# Denver Basin Example



RECLAMATION









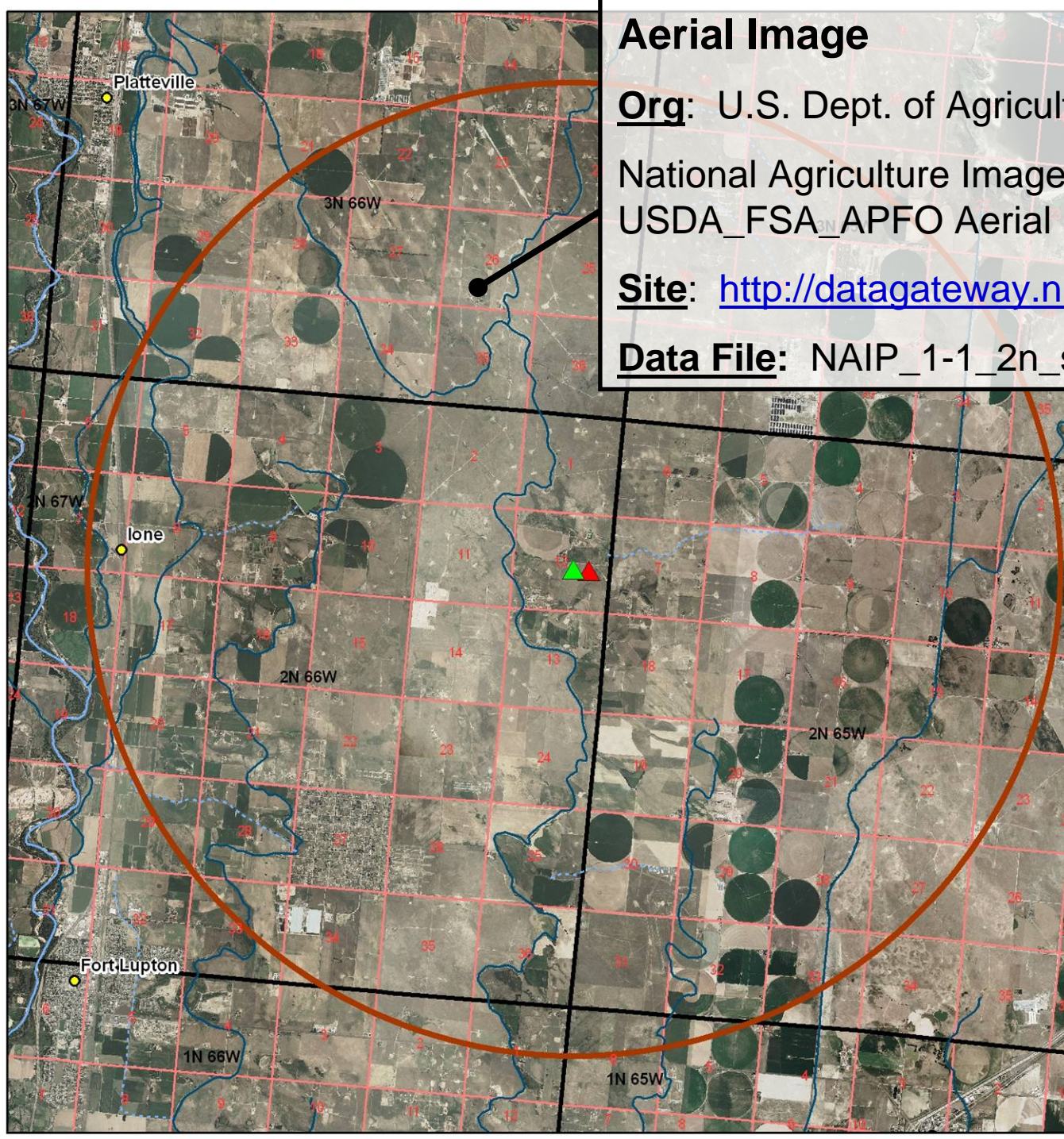
# Aerial Image

**Org:** U.S. Dept. of Agriculture

National Agriculture Imagery Program (NAIP);  
USDA\_FSA\_APFO Aerial Photography Field Office

**Site:** <http://datagateway.nrcs.usda.gov/>

**Data File:** NAIP\_1-1\_2n\_s\_co123\_2006\_1.sid



## Legend

- City
- Top 100 Gas Well (EIA)
- Top 100 Oil Well (EIA)
- Hydrography**
  - Canal Ditch
  - Canal Ditch: Canal Ditch Typ= Aqueduct
  - Stream/River
  - Stream/River: Hydrographic Category = Intermittent
  - Stream/River: Hydrographic Category = Perennial
- 5 Mile buffer
- Townships
- Sections

**Distribution**

**Download:** Yes



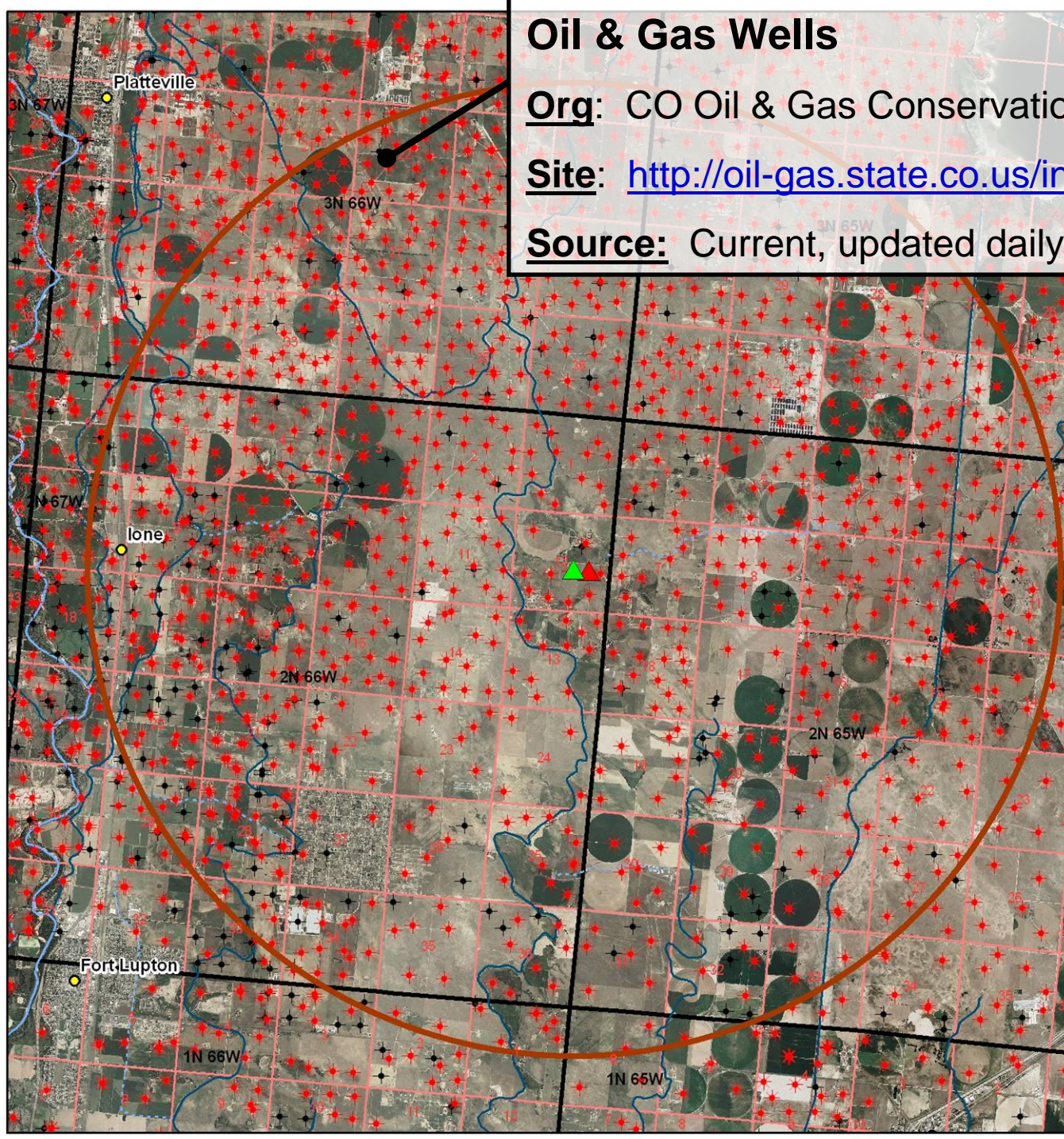
Website Easy to  
Navigate

# Oil & Gas Wells

Org: CO Oil & Gas Conservation Commission

Site: <http://oil-gas.state.co.us/infosys/Maps/gismain.cfm>

Source: Current, updated daily



## Legend

● City

### WELLS

✦ Abandoned Well

✦ Producing Well

▲ Top 100 Gas Well (EIA)

▲ Top 100 Oil Well (EIA)

### Hydrography

— Canal Ditch

- - - Canal Ditch: Canal Ditch Typ= Aqueduct

— Stream/River

- - - Stream/River: Hydrographic Category = Intermittent

— Stream/River: Hydrographic Category = Perennial

5 Mile buffer

Townships

Sections

## Distribution

Download: Yes

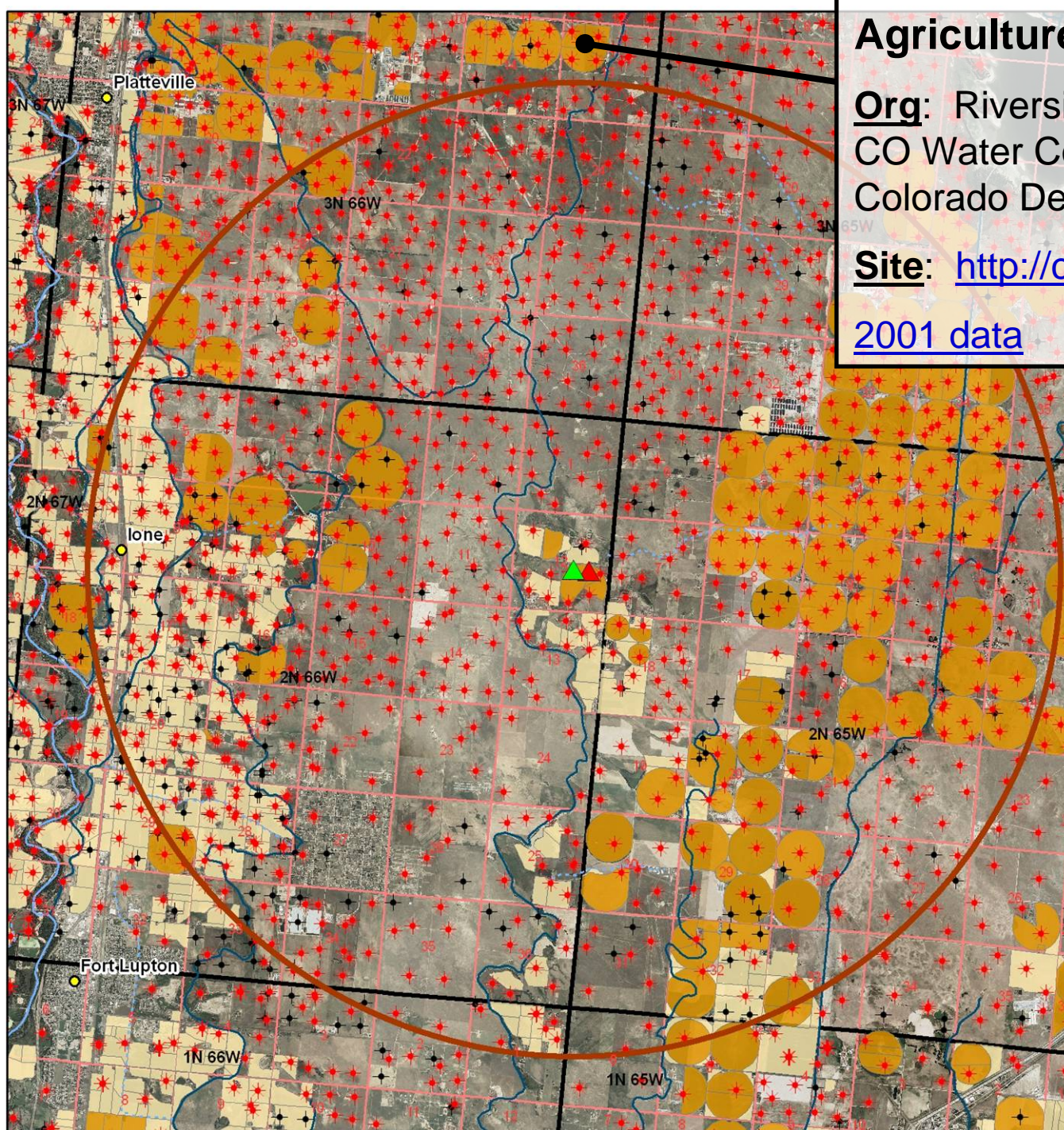


# Agriculture

Org: Riverside Technology, inc for  
CO Water Conservation Board  
Colorado Decision Support System

Site: <http://cdss.state.co.us>

2001 data



## Legend

### WELLS

- Abandoned Well
- Producing Well
- Top 100 Gas Well (EIA)
- Top100 Oil Well (EIA)

### Hydrography

- Canal Ditch
- Canal Ditch: Canal Ditch Typ= Aqueduct
- Stream/River
- Stream/River: Hydrographic Category = Intermittent
- Stream/River: Hydrographic Category = Perennial

- 5 Mile buffer
- Townships
- Sections

### Irrigation Type

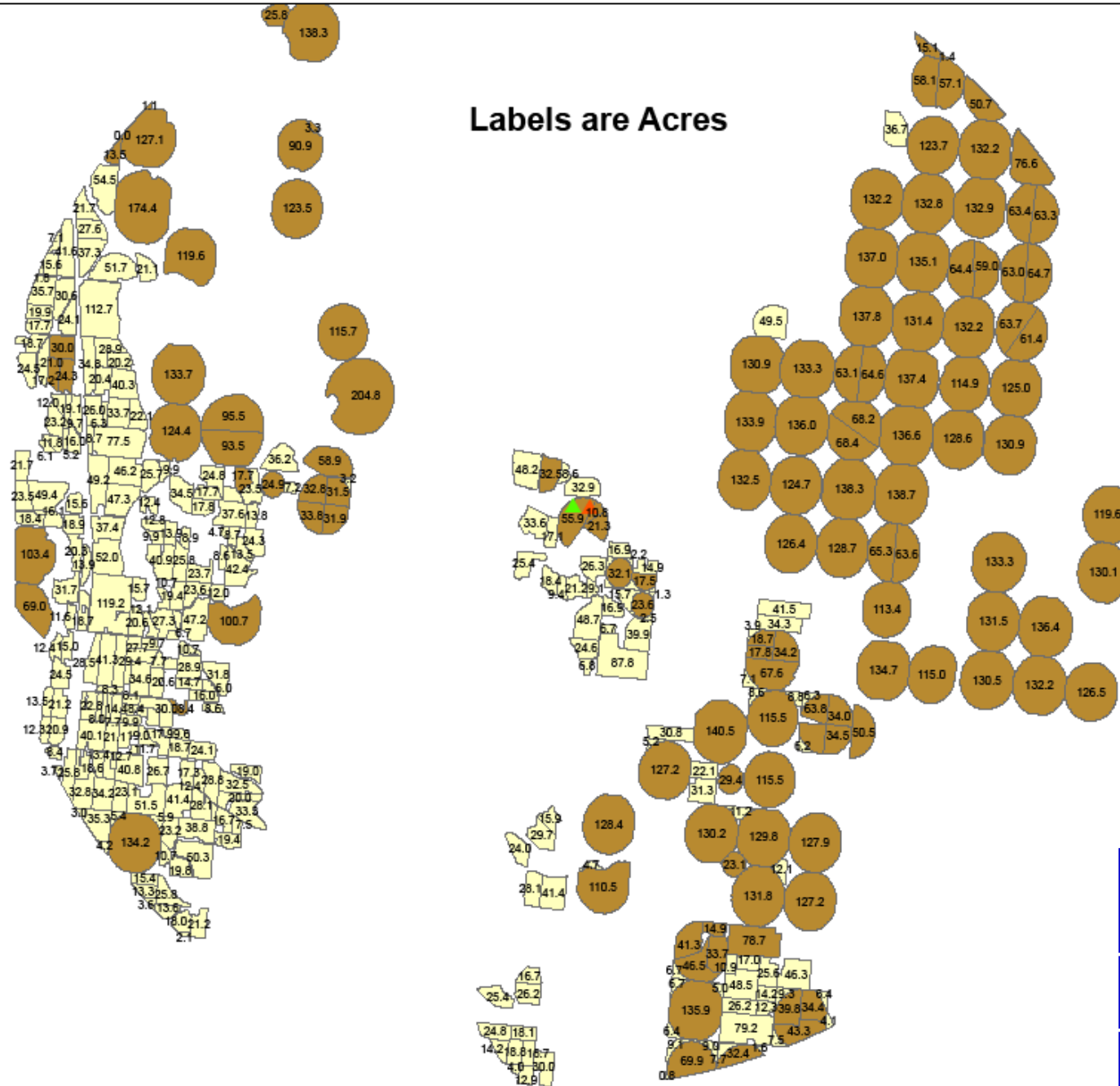
- FLOOD
- SPRINKLER

**Distribution**

Download: Yes



Labels are Acres



### Legend

▲ EIA\_Top100gas\_2

▲ EIA\_Top100oil\_20

### CO\_Irrigated\_Clip

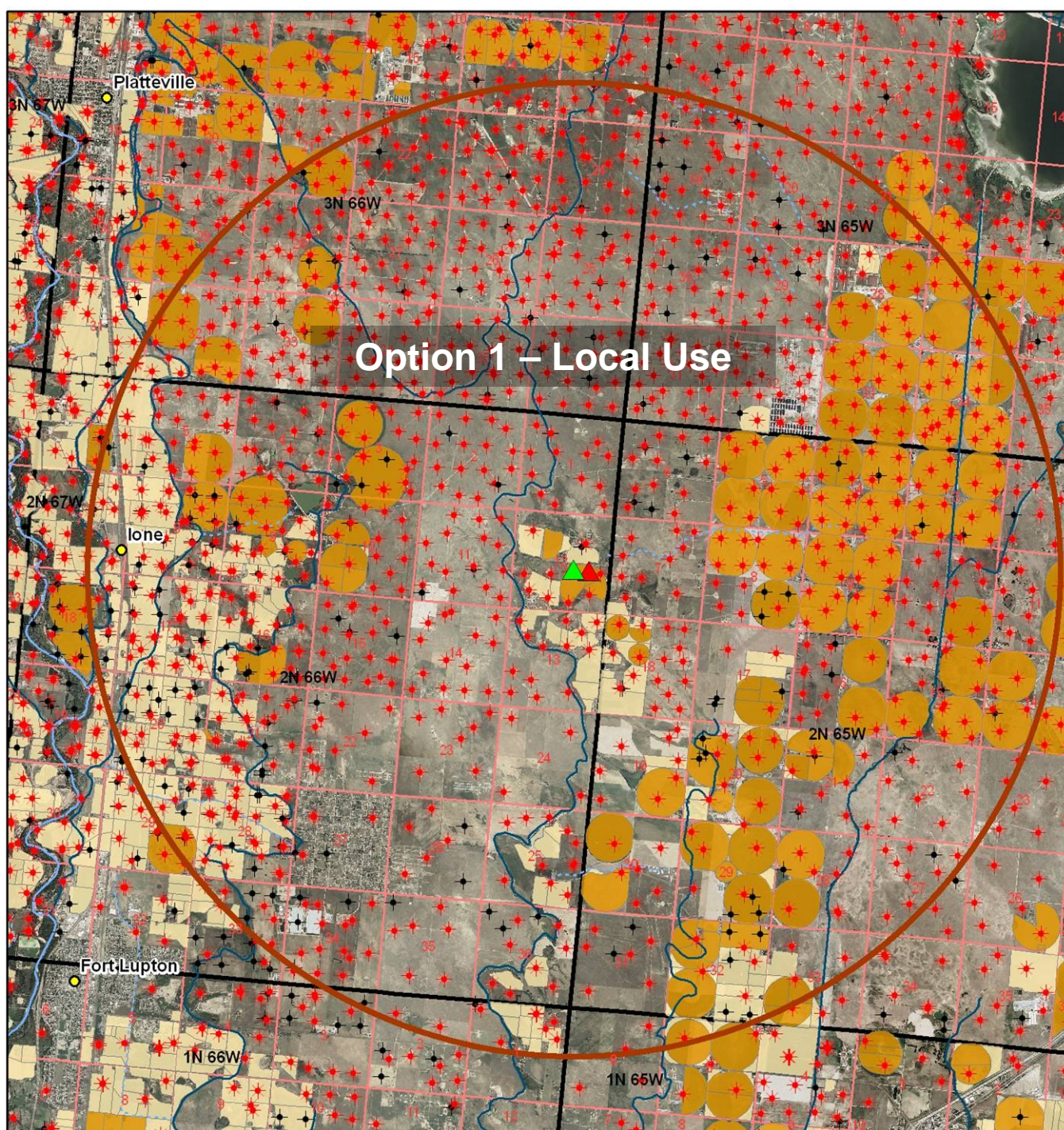
#### IRRIG\_TYPE

■ FLOOD

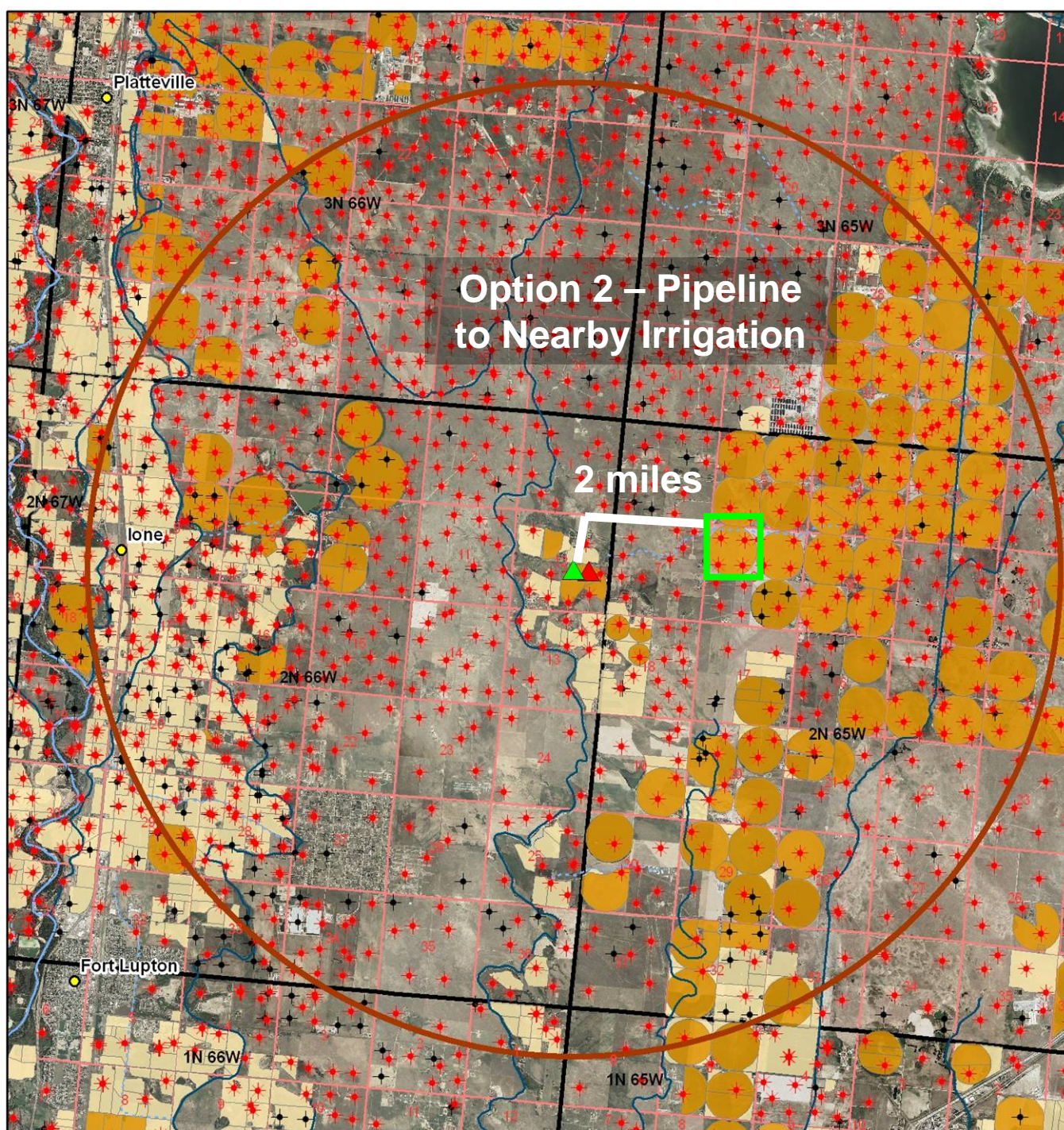
■ SPRINKLER

Irrigation Type	Area (Acres)
Flood	5565
Sprinkler	10,809









## Within Square

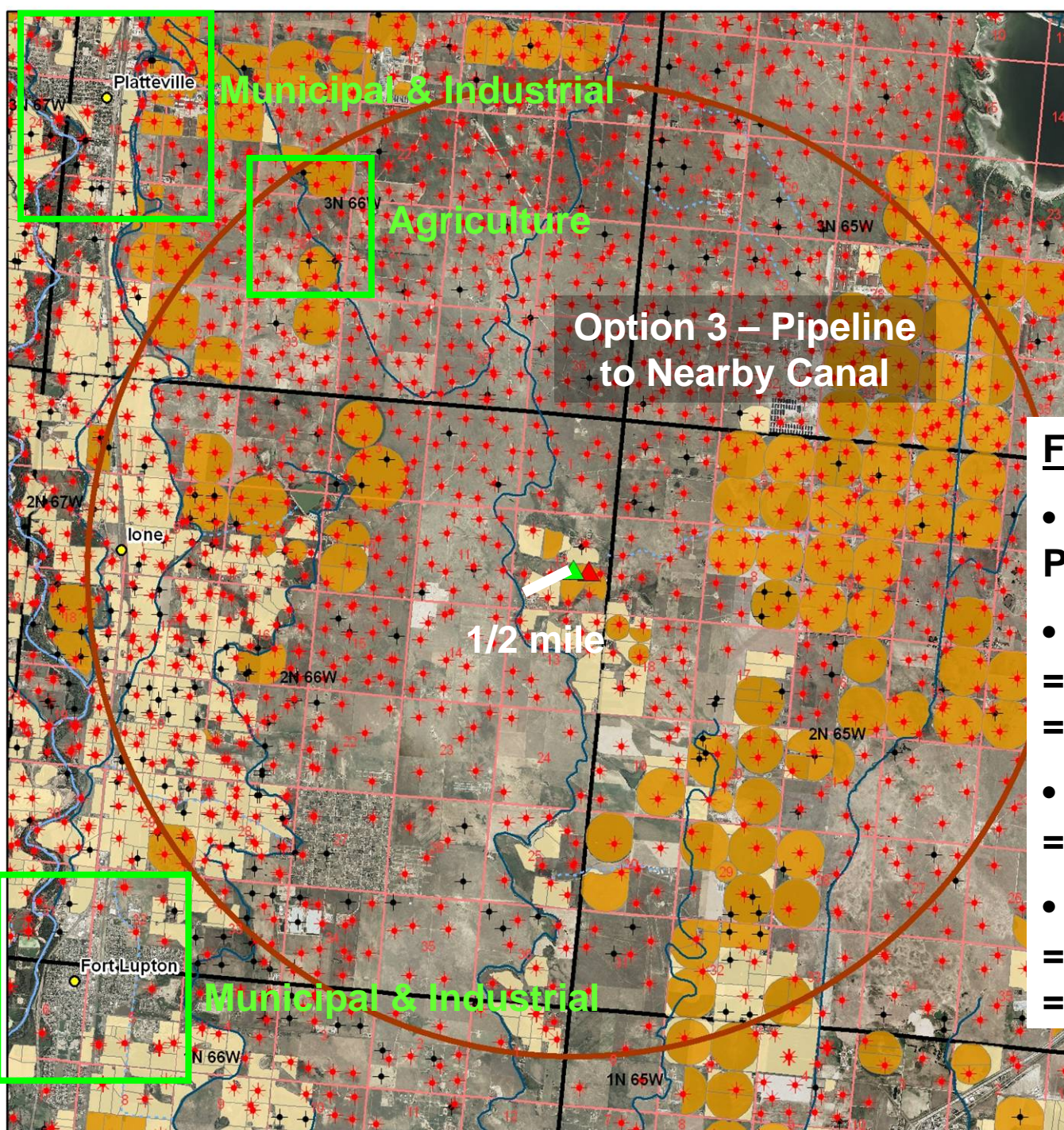
- Area = 125 acres
- 700 gpm per circle

## Single Well

- Flow = 20 gpm
- Need combined well system of 35 wells
  - “+” wells w/ treatment
  - “-” wells w/ water storage

Crop	Rate (in.)
Wheat	26
Corn for Grain	39
Alfalfa	54



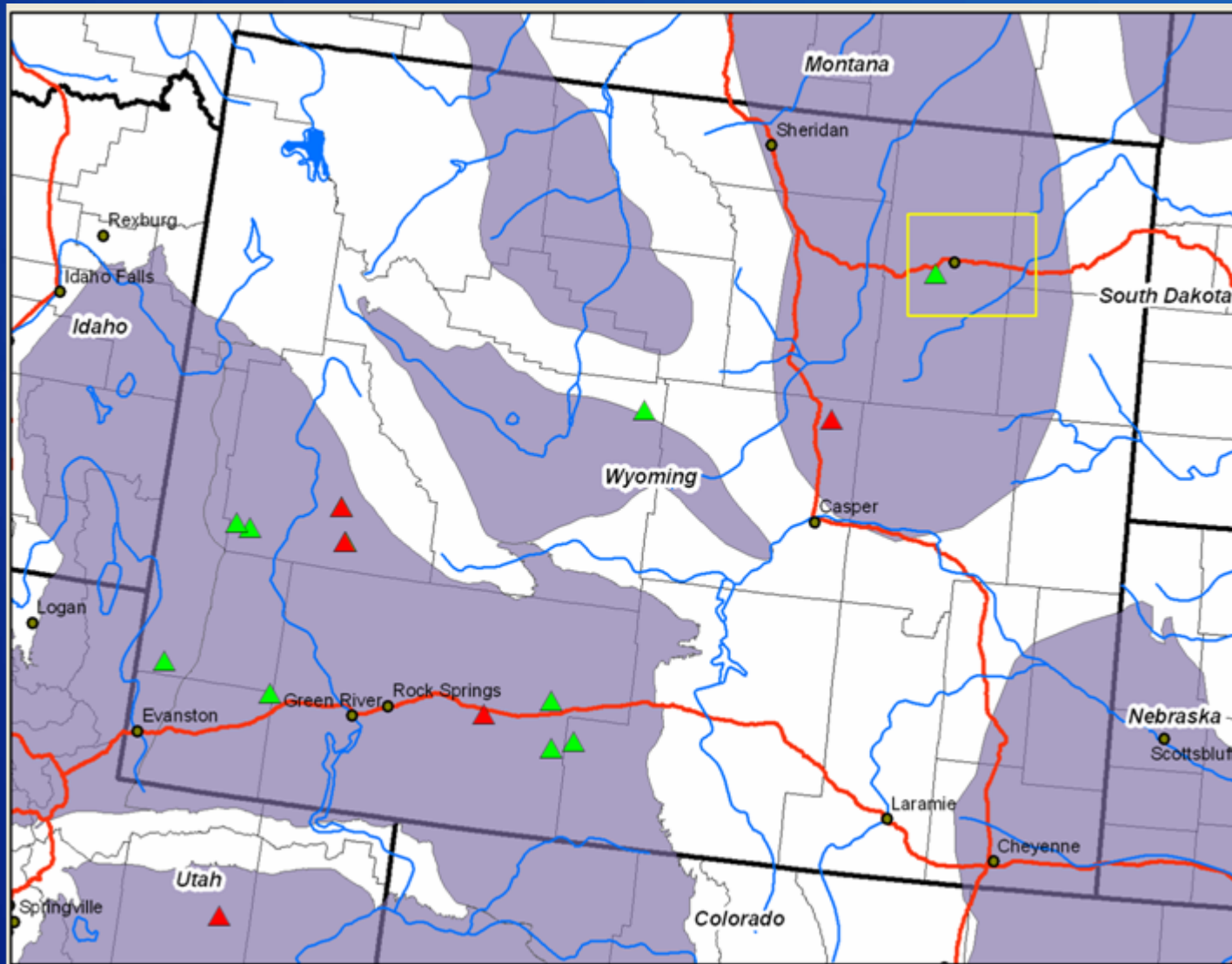


### Fort Lupton

- Treated Water Production = 4.3 MGD
- Raw Water Cost = \$1 mil per year = \$1.67 per 1000 gal
- Treatment Cost = \$0.50 per 1000 gal
- Total Water Cost = \$2.17 per 1000 gal = \$0.10 per barrel

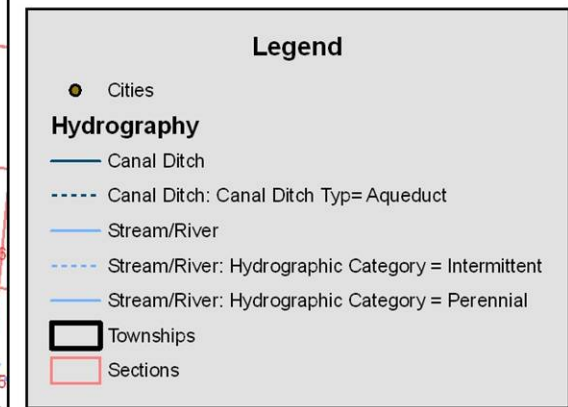
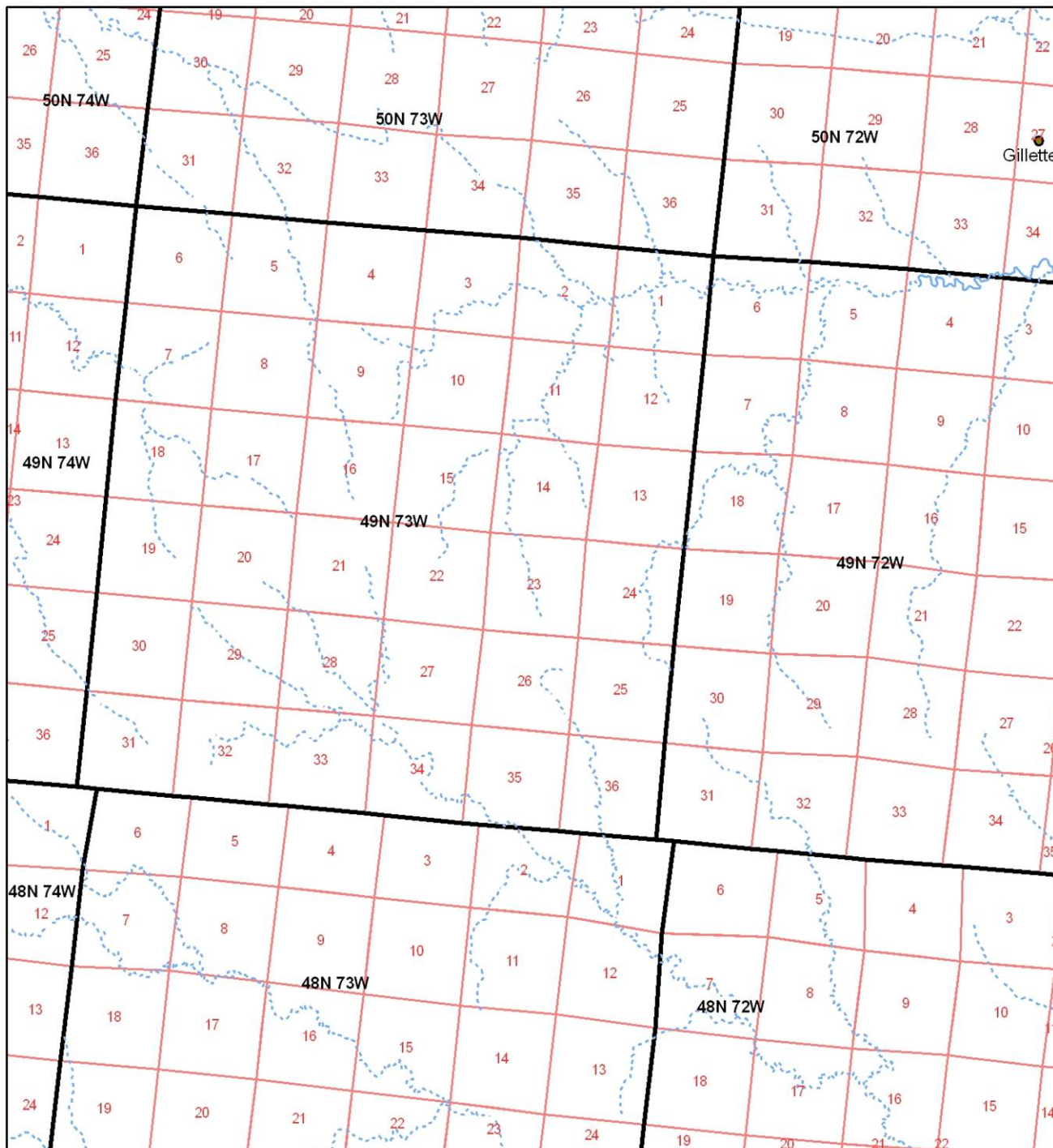


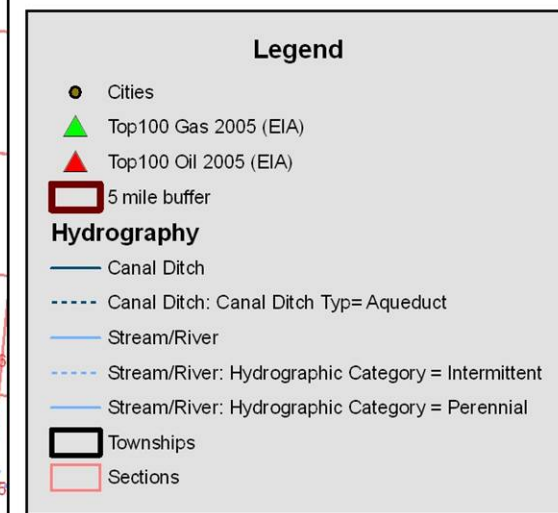
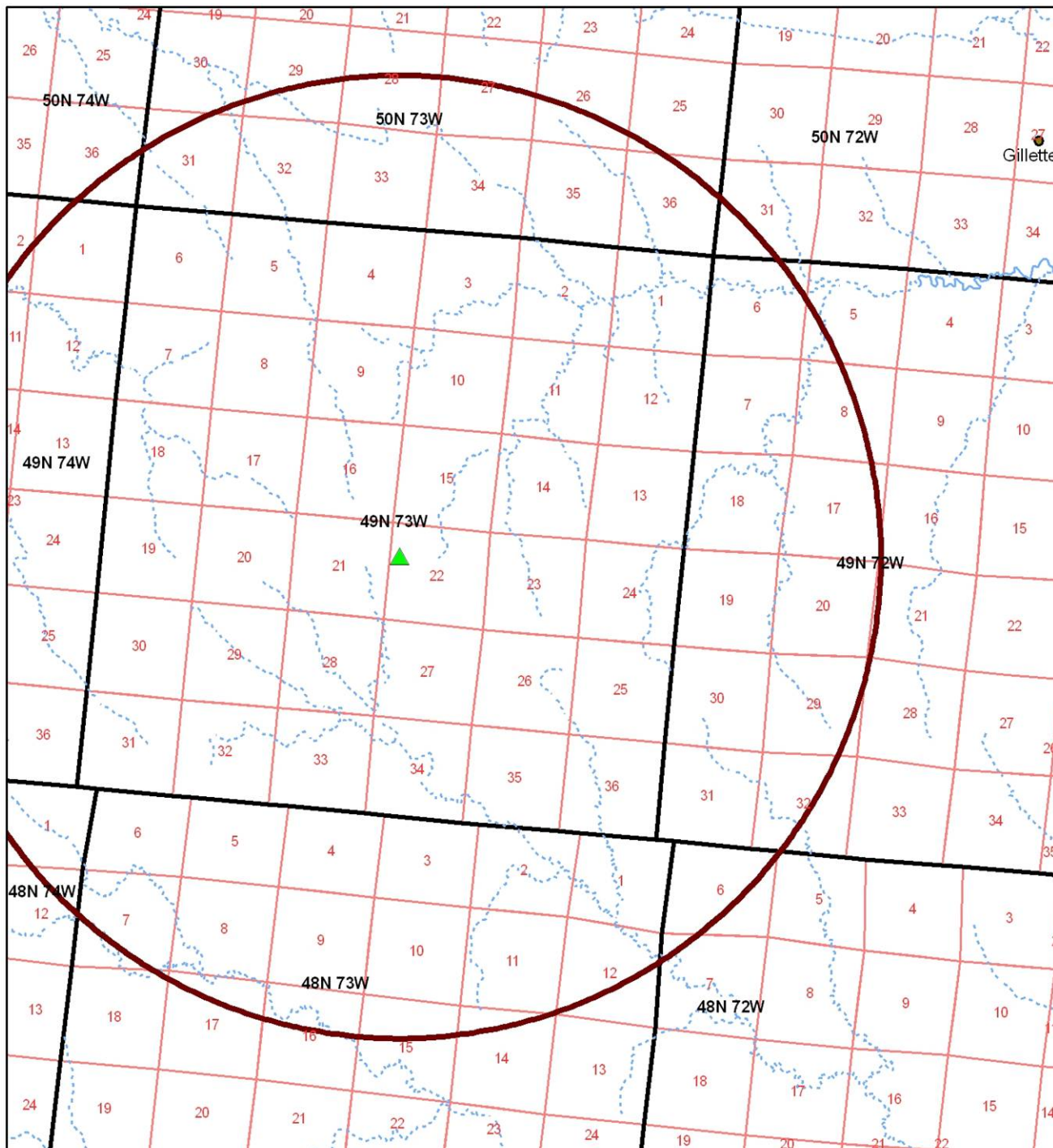
# Powder River Basin



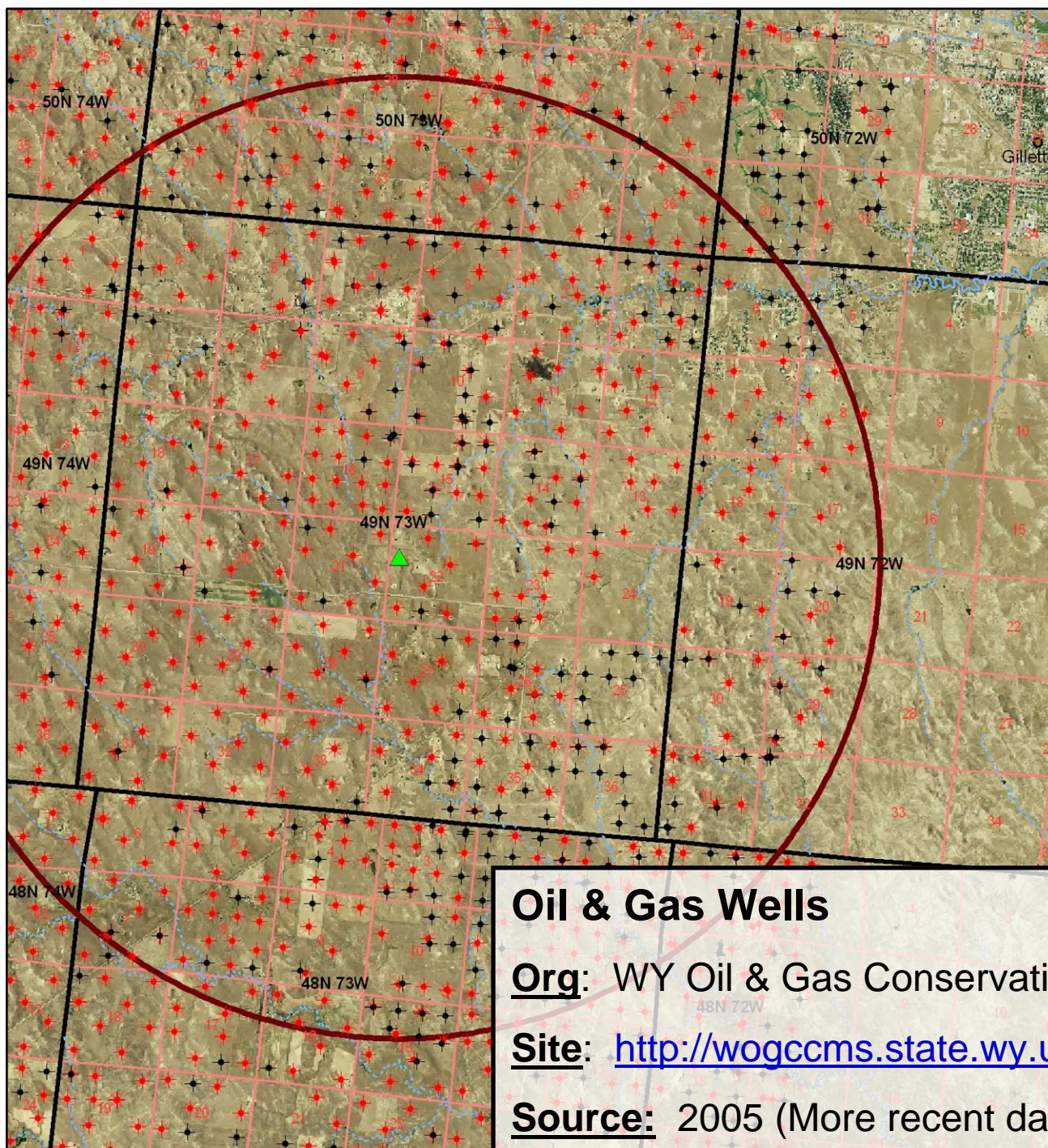
RECLAMATION











### Legend

- Cities
  - ▲ Top100 Gas 2005 (EIA)
  - ▲ Top100 Oil 2005 (EIA)
- Wells**
- ★ Producing Well
  - ★ Abandoned Well
  - 5 mile buffer
- Hydrography**
- Canal Ditch
  - - - Canal Ditch: Canal Ditch Typ= Aqueduct
  - Stream/River
  - - - Stream/River: Hydrographic Category = Intermittent
  - Stream/River: Hydrographic Category = Perennial
  - Townships
  - Sections

## Oil & Gas Wells

**Org:** WY Oil & Gas Conservation Commission

**Site:** <http://wogccms.state.wy.us/>

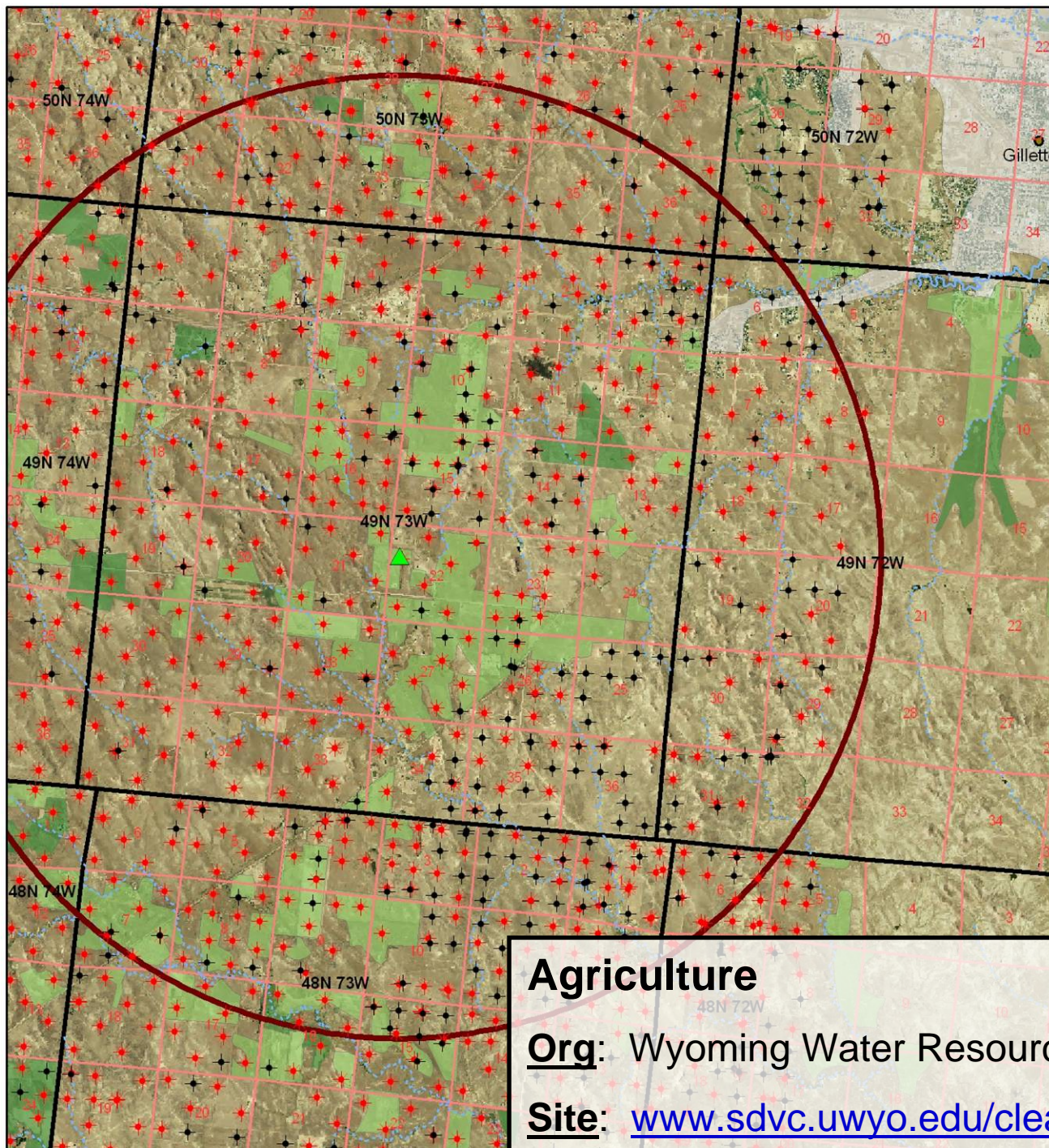
**Source:** 2005 (More recent data is restricted)

Difficult to  
Obtain Data



# Distribution

Download: Yes



## Legend

- Cities
- ▲ Top100 Gas 2005 (EIA)
- ▲ Top100 Oil 2005 (EIA)

### Wells

- ★ Producing Well
- ★ Abandoned Well

5 mile buffer

### Hydrography

- Canal Ditch
- - - Canal Ditch: Canal Ditch Typ=Aqueduct
- Stream/River
- - - Stream/River: Hydrographic Category = Intermittent
- Stream/River: Hydrographic Category = Perennial

Townships

Sections

### Irrigation Type

- Irrigated Cropland
- Non-irrigated Cropland
- Urban/Built up

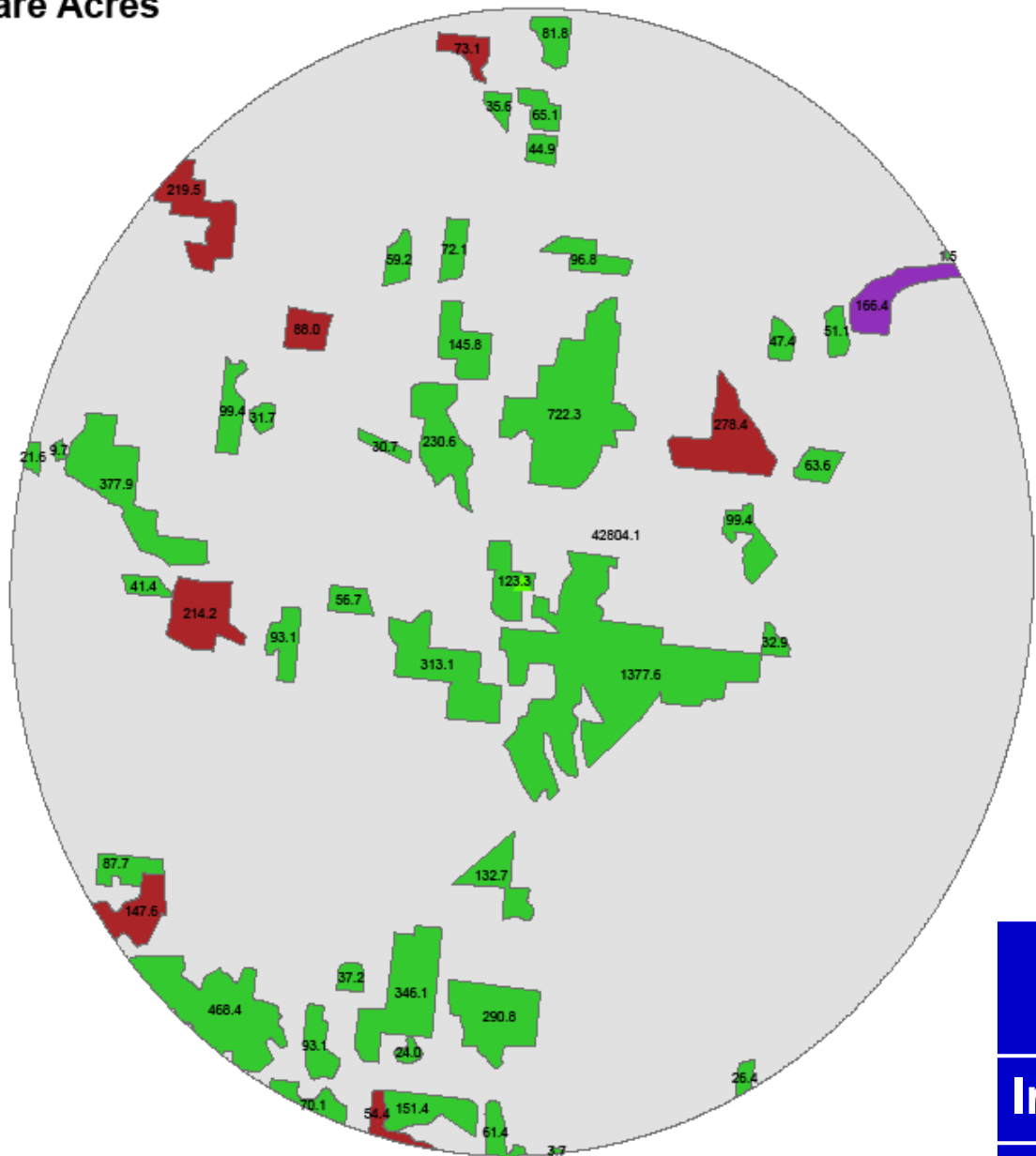
## Agriculture

Org: Wyoming Water Resources Center

Site: [www.sdvc.uwyo.edu/clearinghouse/gw\\_vuln.html](http://www.sdvc.uwyo.edu/clearinghouse/gw_vuln.html)



Labels are Acres



Legend

▲ EIA\_Top100gas\_

▲ EIA\_Top100oil\_2

WY\_Irrigated\_Clip

DESCRIBE

■ Irrigated

■ na

■ Non - Irrigated

■ Urban

Crop	Area (Acres)
Irrigated	1075
Non-Irrigated	6219

# Option 1 – Local Use by Conversion of Non-Irrigated Crops to Irrigated Crops

## Legend

- Cities
- ▲ Top100 Gas 2005 (EIA)
- ▲ Top100 Oil 2005 (EIA)

### Wells

- ✱ Producing Well
- ✱ Abandoned Well

5 mile buffer

### Hydrography

- Canal Ditch
- - - Canal Ditch: Canal Ditch Typ=Aqueduct
- Stream/River
- - - Stream/River: Hydrographic Category = Intermittent
- Stream/River: Hydrographic Category = Perennial

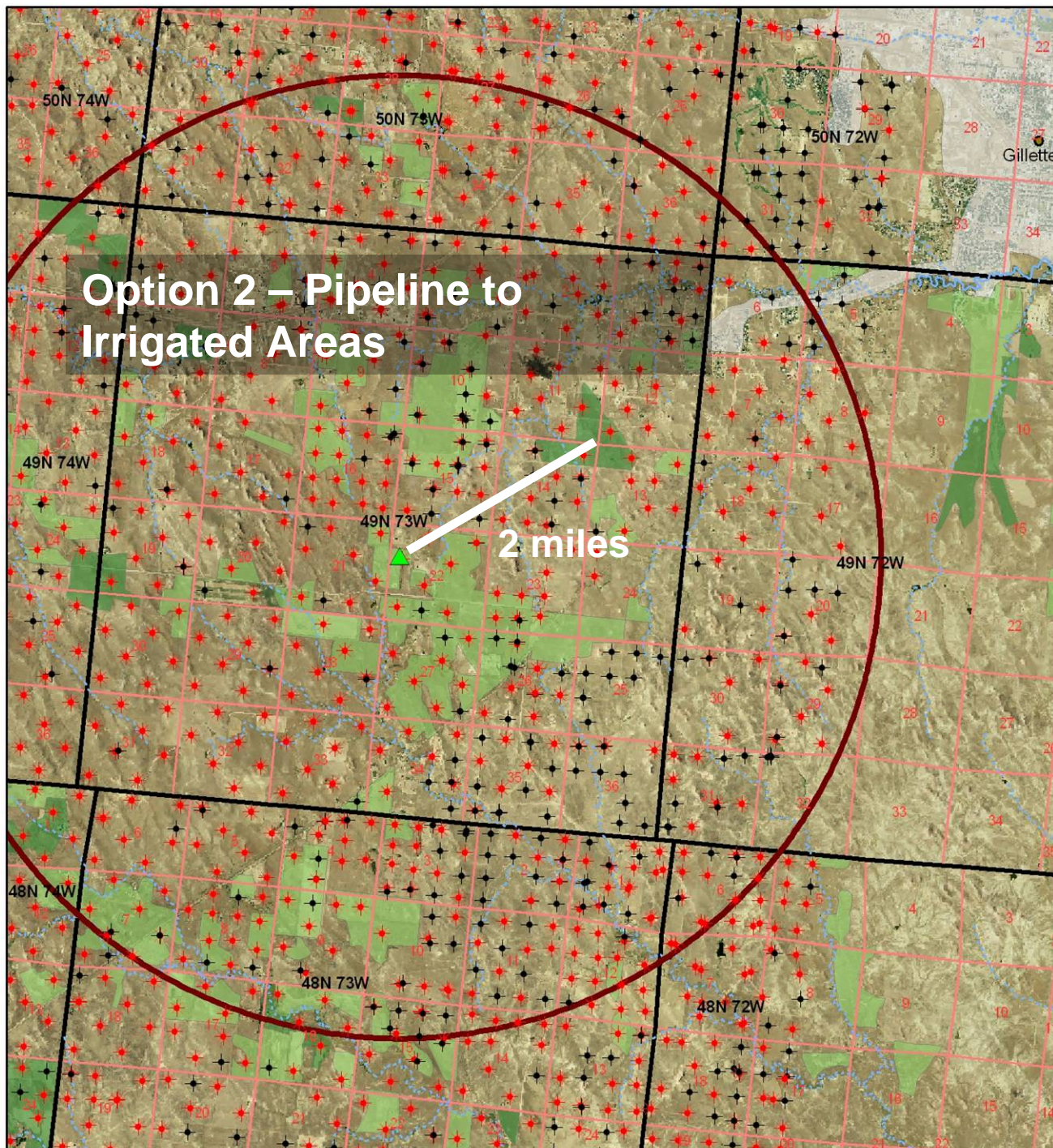
Townships

Sections

### Irrigation Type

- Irrigated Cropland
- Non-irrigated Cropland
- Urban/Built up





## Option 2 – Pipeline to Irrigated Areas

2 miles

### Legend

- Cities
- ▲ Top100 Gas 2005 (EIA)
- ▲ Top100 Oil 2005 (EIA)

#### Wells

- ★ Producing Well
- ★ Abandoned Well

5 mile buffer

#### Hydrography

- Canal Ditch
- - - Canal Ditch: Canal Ditch Typ=Aqueduct
- Stream/River
- - - Stream/River: Hydrographic Category = Intermittent
- Stream/River: Hydrographic Category = Perennial

Townships

Sections

#### Irrigation Type

- Irrigated Cropland
- Non-irrigated Cropland
- Urban/Built up



## Option 3 – Municipal & Industrial

Pipeline

4 miles

Direct Discharge to  
approved Drainage

Surface Discharge  
Groundwater Injection

### Legend

● Cities

▲ Top100 Gas 2005 (EIA)

▲ Top100 Oil 2005 (EIA)

#### Wells

★ Producing Well

✦ Abandoned Well

5 mile buffer

#### Hydrography

— Canal Ditch

- - - Canal Ditch: Canal Ditch Typ=Aqueduct

— Stream/River

- - - Stream/River: Hydrographic Category = Intermittent

— Stream/River: Hydrographic Category = Perennial

▭ Townships

▭ Sections

#### Irrigation Type

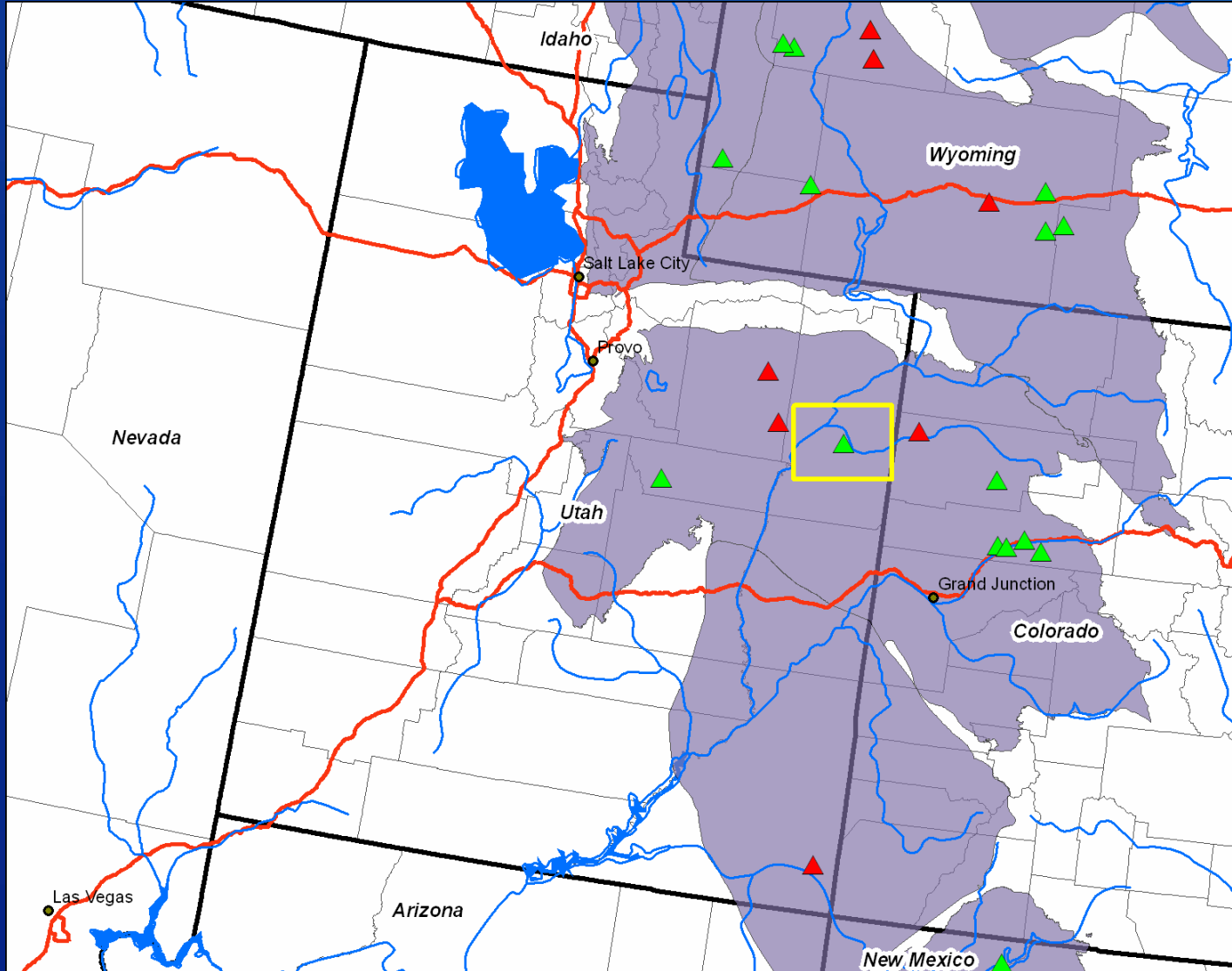
■ Irrigated Cropland

■ Non-irrigated Cropland

■ Urban/Built up

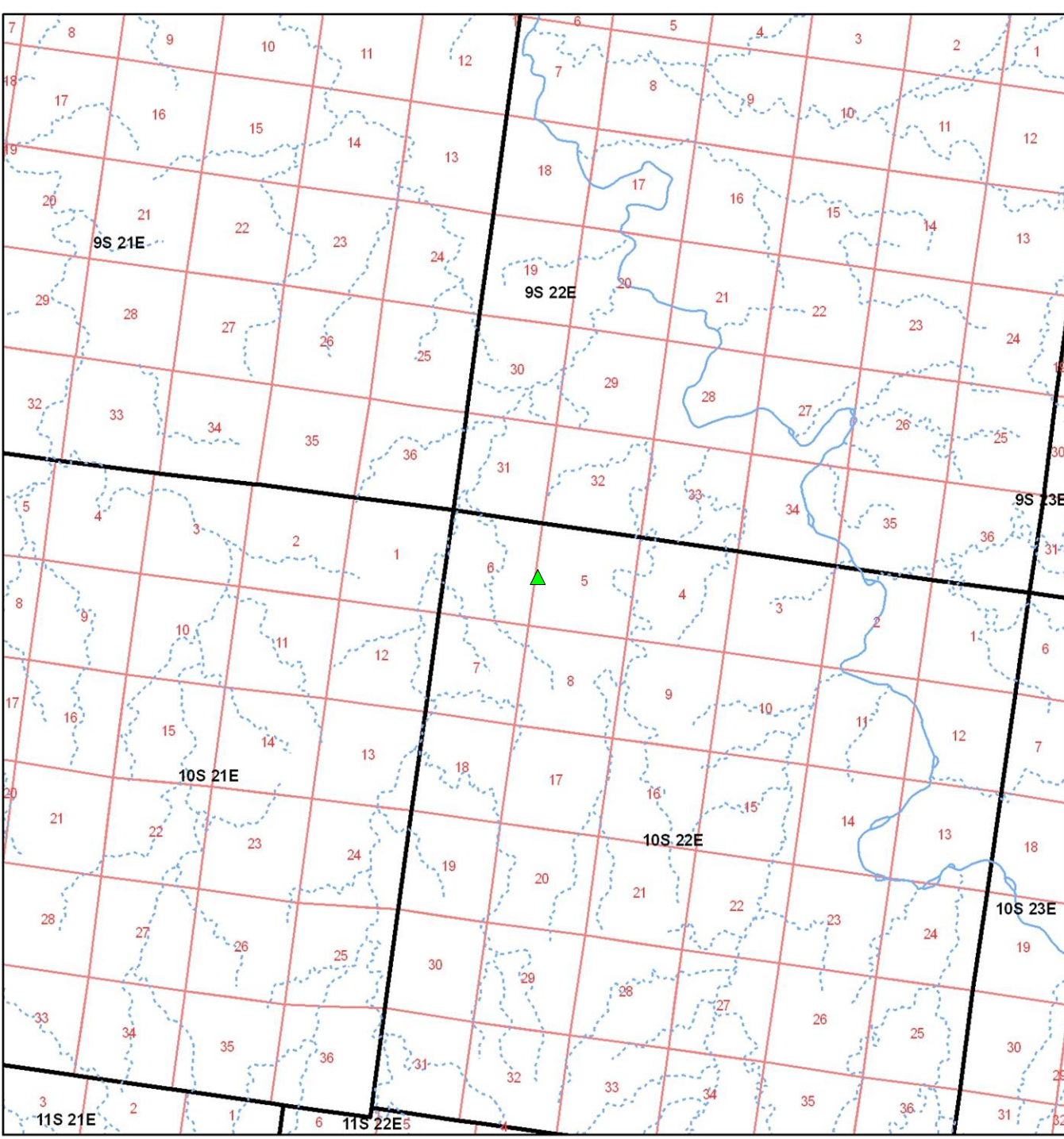


# Uinta-Piceance Basin

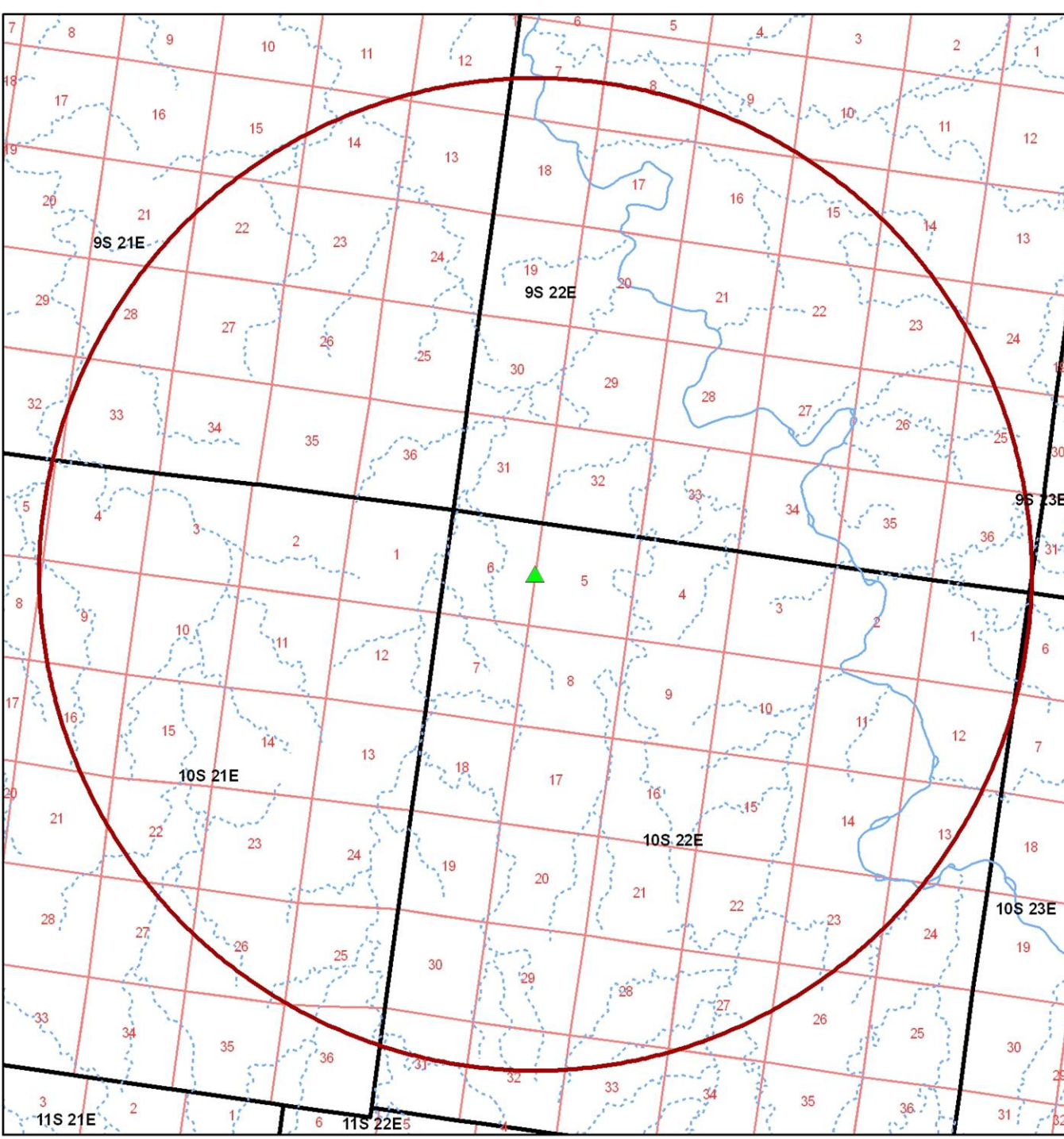


RECLAMATION

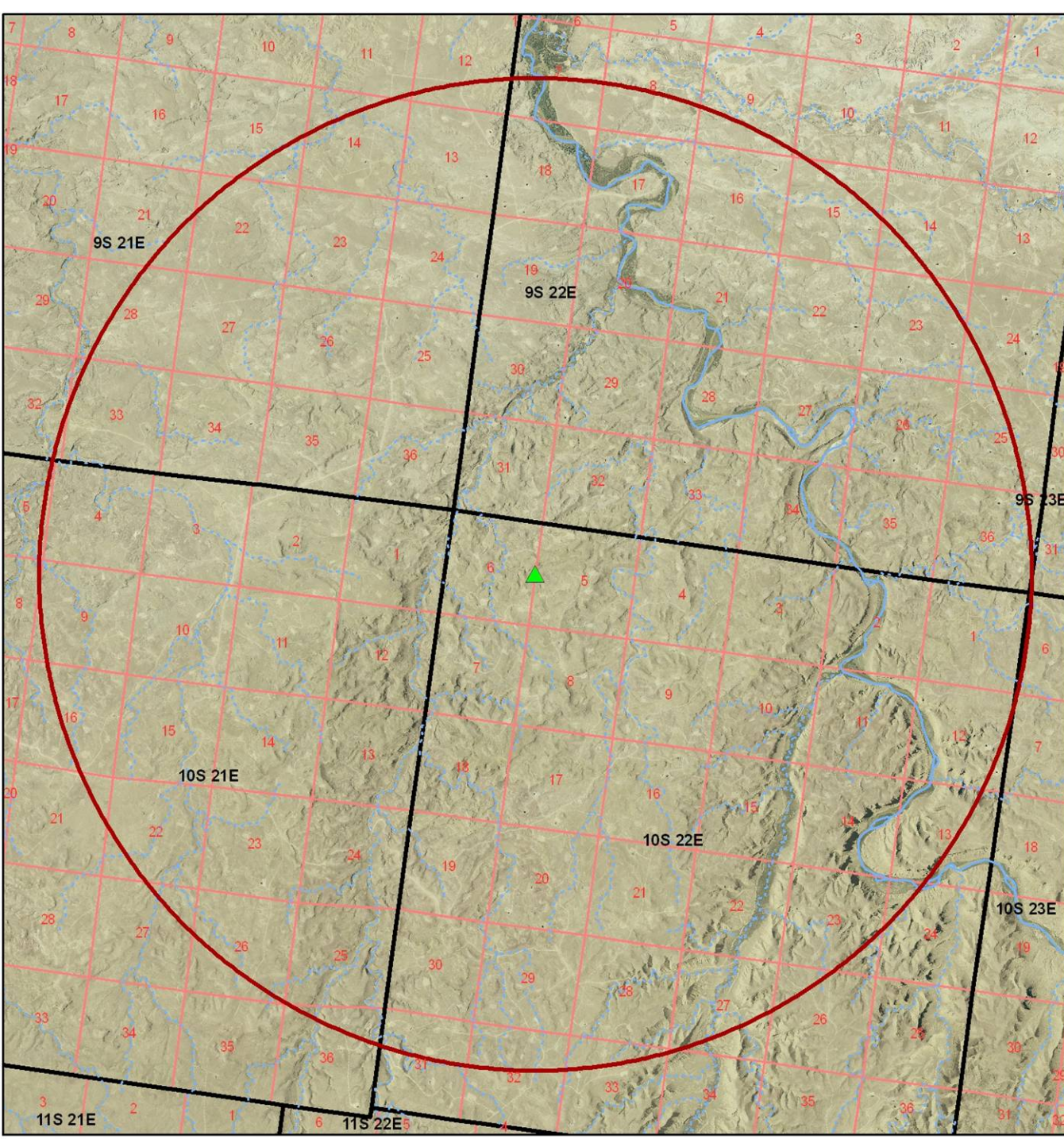




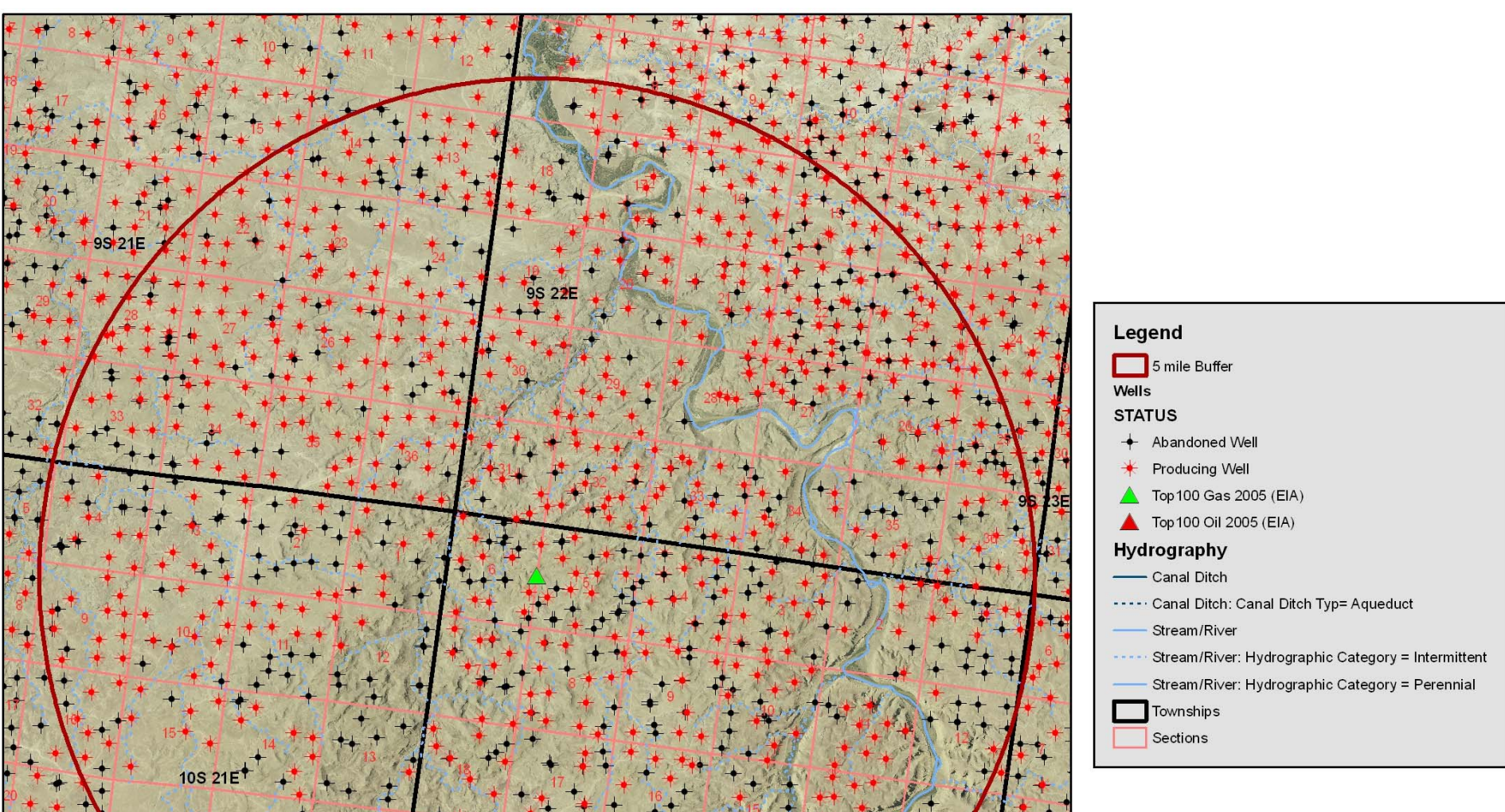












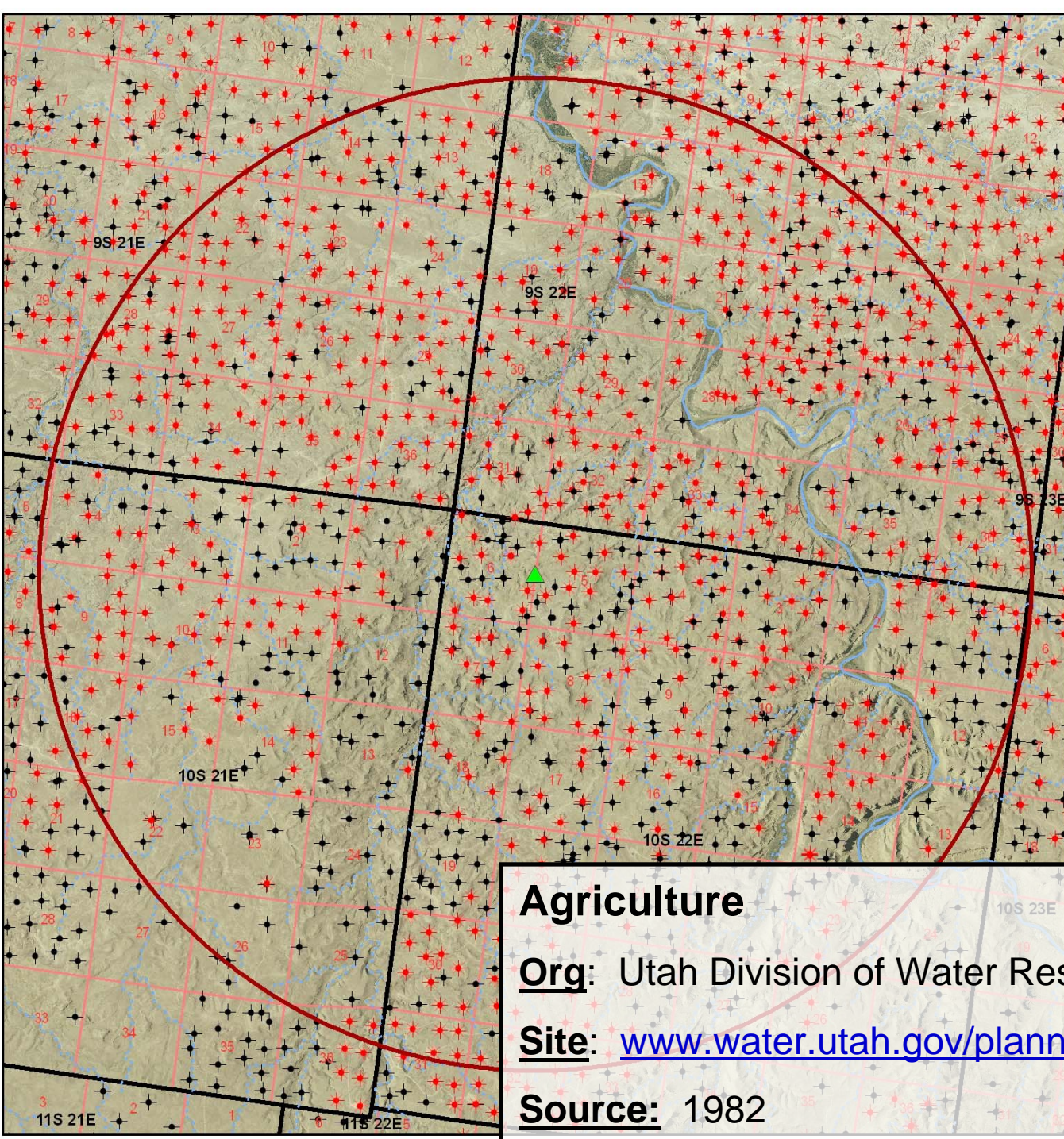
## Oil & Gas Wells

**Org:** Utah Department of Natural Resources  
Oil Gas and Mining Division.

**Site:** [http://agrc.utah.gov/agrc\\_sgid/sgidlib/SGID\\_U100\\_DNROilGasWells.htm](http://agrc.utah.gov/agrc_sgid/sgidlib/SGID_U100_DNROilGasWells.htm)

**Source:** Updated daily (<http://ogm.utah.gov>)





### Legend

5 mile Buffer

### Wells

#### STATUS

- Abandoned Well
- Producing Well
- Top100 Gas 2005 (EIA)
- Top100 Oil 2005 (EIA)

### Hydrography

- Canal Ditch
- Canal Ditch: Canal Ditch Typ= Aqueduct
- Stream/River
- Stream/River: Hydrographic Category = Intermittent
- Stream/River: Hydrographic Category = Perennial
- Townships
- Sections

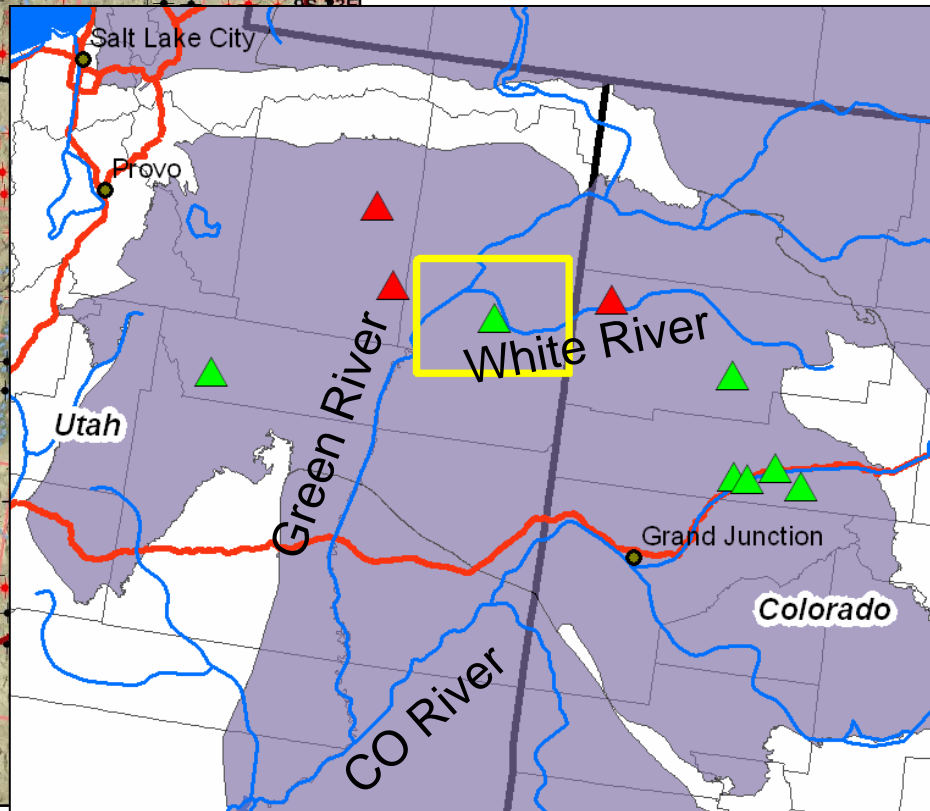
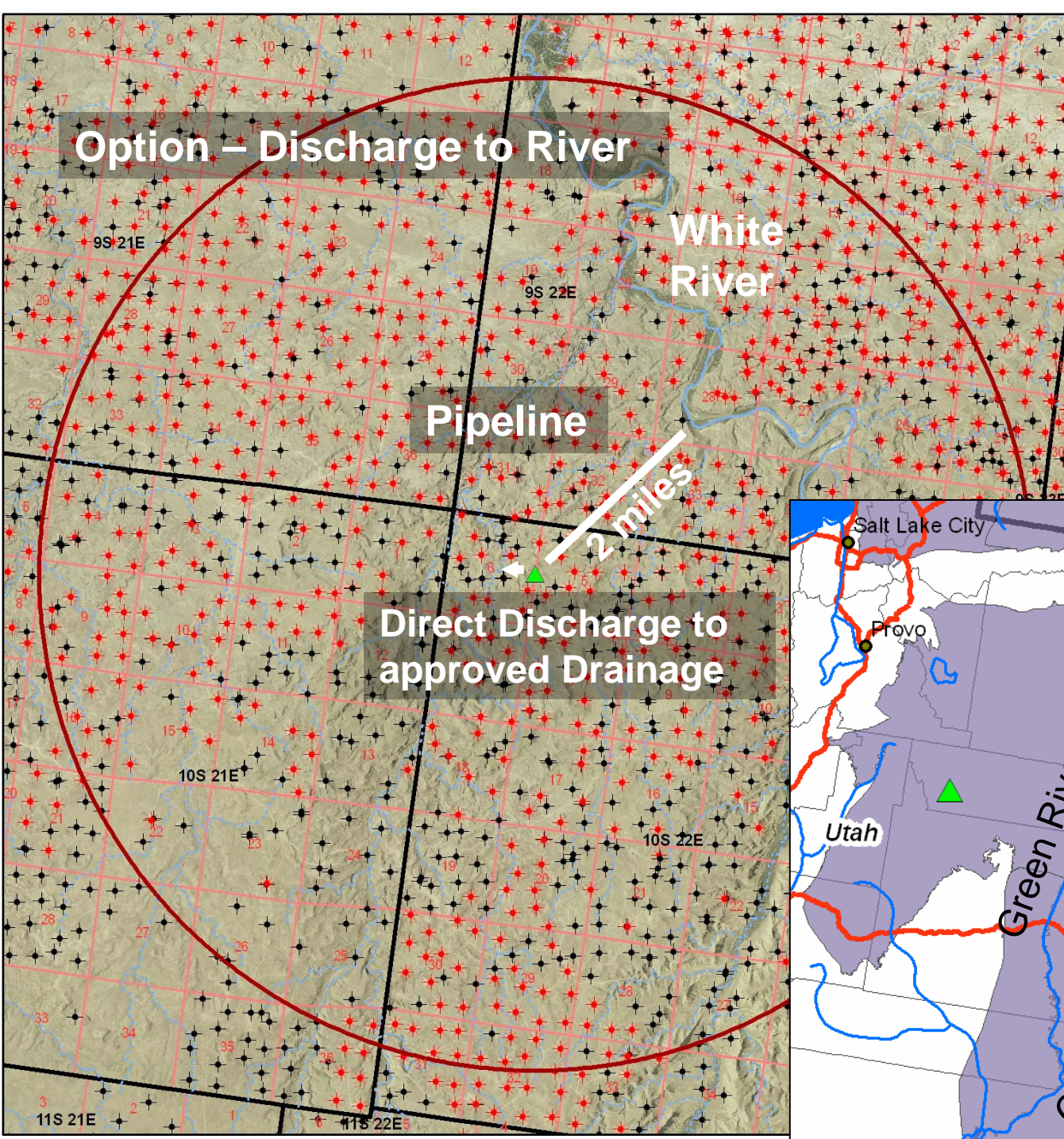
## Agriculture

**Org:** Utah Division of Water Resources

**Site:** [www.water.utah.gov/planning/landuse/index.html](http://www.water.utah.gov/planning/landuse/index.html)

**Source:** 1982







# Thank You



Colorado



## **Geographical Assessment of Potential for Beneficial Use of Produced Water**

Steve Dundorf

U.S. Department of Interior – Bureau of  
Reclamation  
(303)445-2263  
[sdundorf@do.usbr.gov](mailto:sdundorf@do.usbr.gov)

# RECLAMATION



Presented @ 2007 IPEC Conference - Houston

Wednesday – 11/07/07

Session: Beneficial Re-use of Produced Water

Time: 10:05 – 10:30 am

Presentation Length: 25 minutes (5<sup>th</sup> presentation)