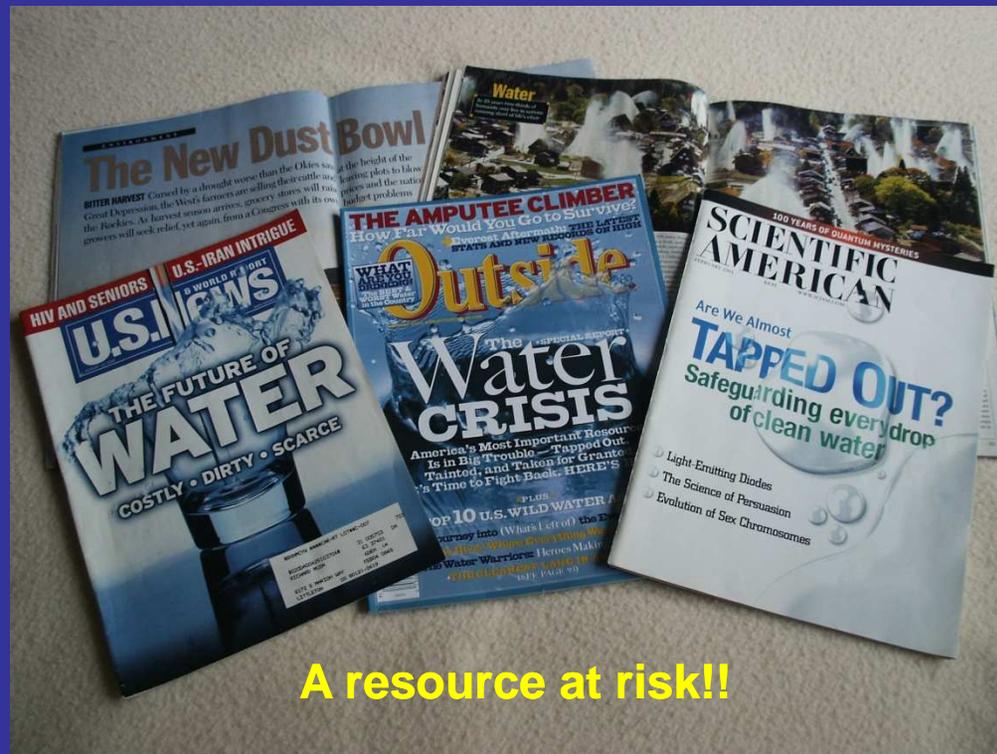


GROUND WATER VULNERABILITY

An Overview of Concepts and Assessment Methodologies

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A resource at risk!!

7th National Water Monitoring Conference – Denver, CO - April 25-29, 2010

DEFINITIONS OF GW SENSITIVITY / VULNERABILITY

- ❑ **Foster (1987)**
 - ◆ **Aquifer Pollution Vulnerability**
 - ◆ **GW Pollution Risk**
- ❑ **Aller (1987)**
 - ◆ **Groundwater Pollution Potential**
- ❑ **US GAO (1991)**
 - ◆ **Hydrogeologic Vulnerability**
 - ◆ **Total Vulnerability**
- ❑ **Pettyjohn (1991)**
 - ◆ **Aquifer Vulnerability**
 - ◆ **Aquifer Sensitivity**
- ❑ **US EPA (1993)**
 - ◆ **Aquifer Sensitivity**
 - ◆ **GW Vulnerability**
- ❑ **NRC (1993)**
 - ◆ **Intrinsic GW Vulnerability**
 - ◆ **Specific GW Vulnerability**
- ❑ **US EPA Source Water Protection Program**
 - ◆ **Susceptibility**
- ❑ **Well vulnerability**
 - ◆ **Considers physical condition of well**

MAIN CONCEPTS

- **GW Sensitivity** — the potential for groundwater to become contaminated based on intrinsic hydrogeologic characteristics. Sensitivity is not dependent on land use practices or contaminant properties
- **GW Vulnerability** — the relative ease with which a contaminant can migrate to ground water under a given set of land use practices, contaminant properties and sensitivity conditions
- **All groundwater is vulnerable!!**
- **Uncertainty is inherent!!**

DEFINITIONS OF GW SENSITIVITY / VULNERABILITY

☐ Foster

- ◆ **Aquifer Pollution Vulnerability (S)**

☐ Aller

- ◆ **Groundwater Pollution Potential (S)**

☐ US GAO

- ◆ **Hydrogeologic Vulnerability (S)**
- ◆ **Total Vulnerability (V)**

☐ Pettyjohn

- ◆ **Aquifer Vulnerability (S)**
- ◆ **Aquifer Sensitivity (V)**

☐ US EPA

- ◆ **Aquifer Sensitivity (S)**
- ◆ **GW Vulnerability (V)**

☐ NRC

- ◆ **Intrinsic GW Vulnerability (S)**
- ◆ **Specific GW Vulnerability (V)**

☐ US EPA Source Water Protection Program

- ◆ **Susceptibility (V)**

SENSITIVITY METHODS

- **Hydrogeologic Settings Classification Methods**
 - *Delineate / map subareas (hydrogeologic settings) within an area of assessment that have similar hydrogeologic characteristics*

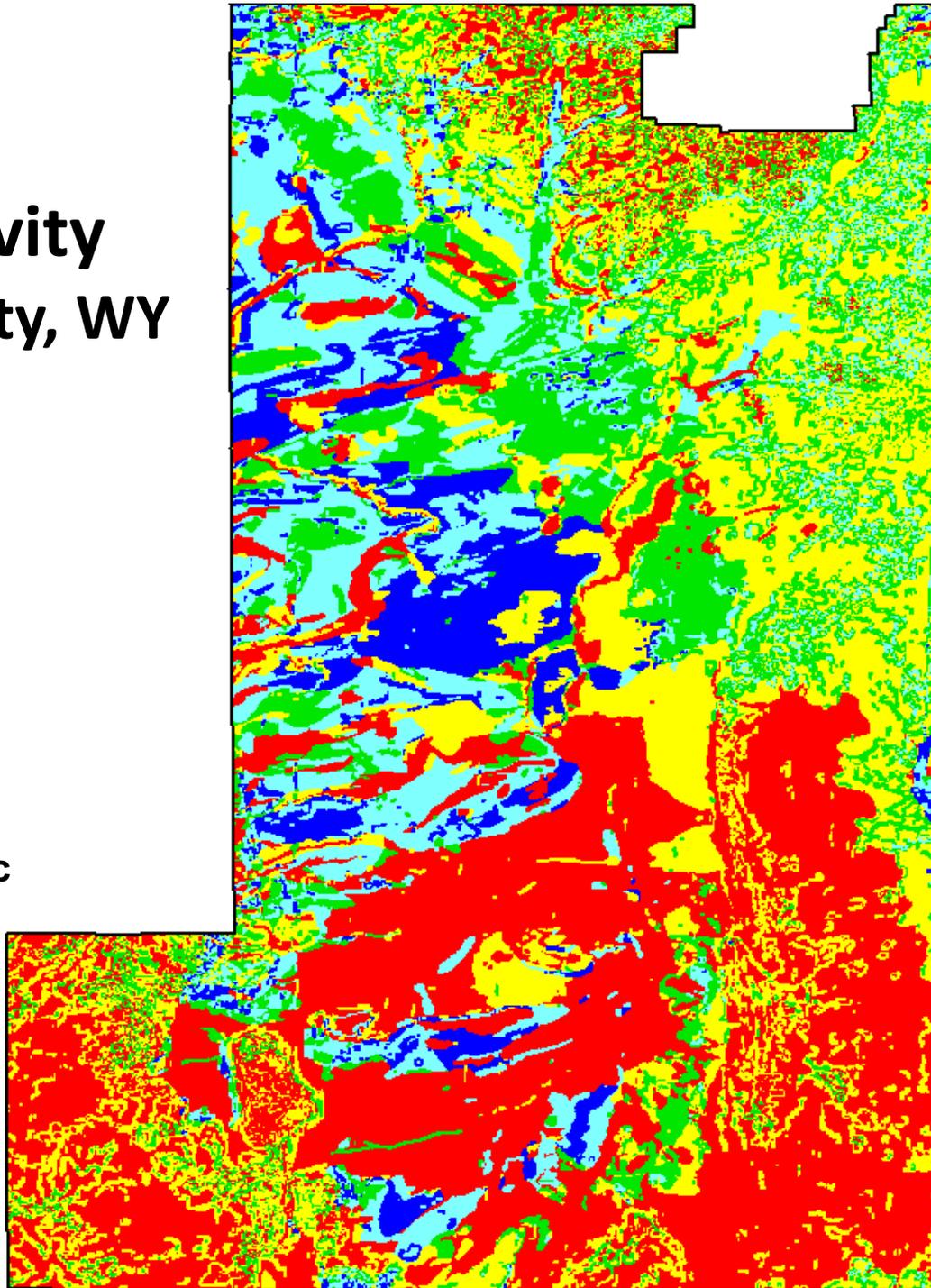
- **Scoring Methods**
 - *Assign numerical ranking or rating to hydrogeologic settings with different sensitivity characteristics*
 - *Can also use without mapping hydrogeologic settings*

- **GIS based composite / derivative maps using descriptive / quantitative information**
 - *Hydrogeologic / hydraulic characteristics of soil, vadose zone and aquifer*
 - *Can be weighted for specific parameters*

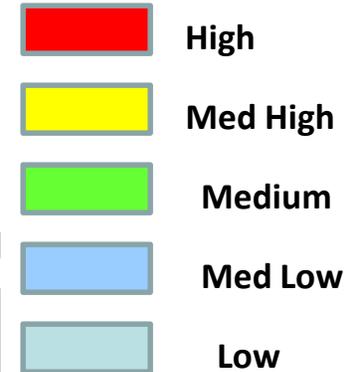
GW Sensitivity Albany County, WY

Based on

- Topography
- Recharge
- Soil
- Geology
- Vadose zone properties
- Aquifer hydraulic properties



Relative rating

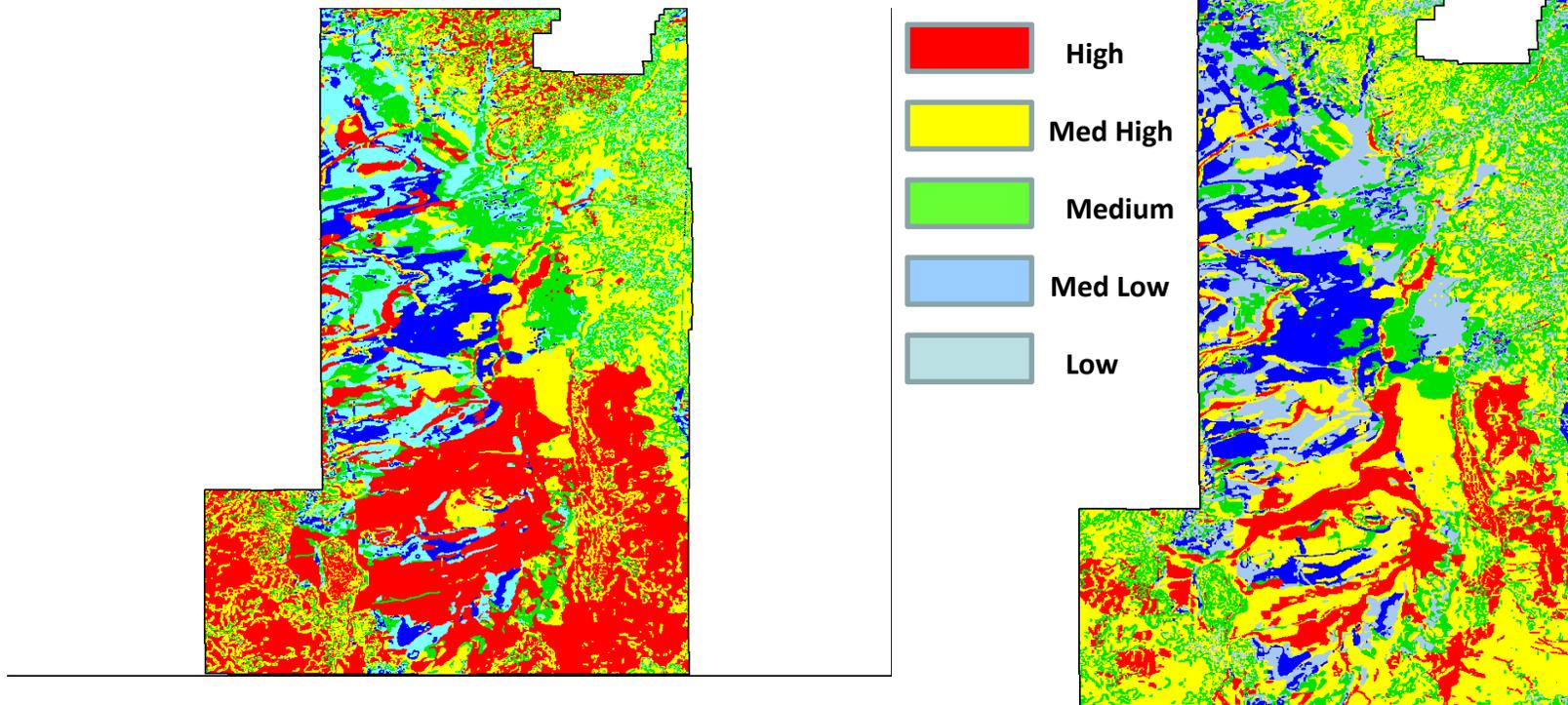


VULNERABILITY METHODS

➤ Qualitative contaminant information coupled with sensitivity

- *Areas of use*
- *Toxicity rating*
- *Method of use*
- *Chemical properties*
- *Other land use criteria*

Groundwater Sensitivity / Vulnerability Albany County, WY

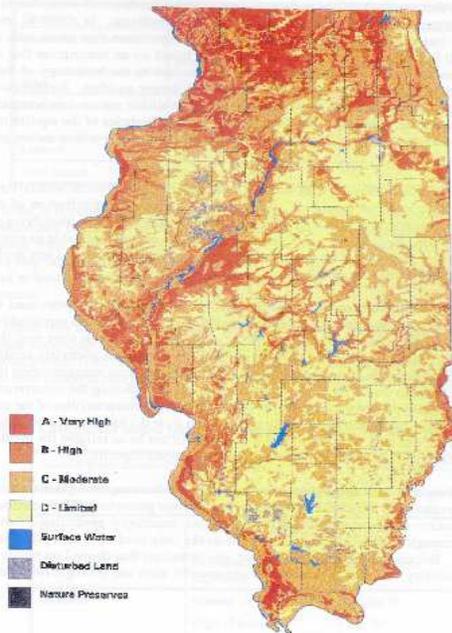


Groundwater Sensitivity

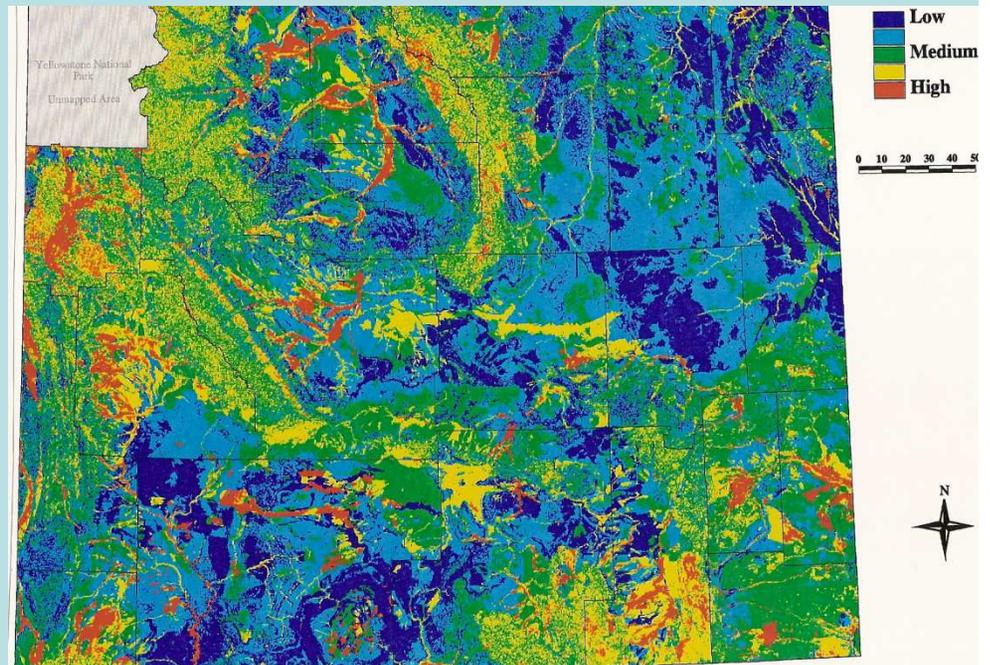
**Groundwater Vulnerability to
Pesticides**

Statewide GW Sensitivity & Vulnerability Maps

Figure 2. Shallow ground-water sensitivity to contamination surrounding nature preserves



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GROUNDWATER VULNERABILITY – PESTICIDES -
WYOMING

Sensitivity –shallow groundwater -
Illinois

VULNERABILITY METHODS

➤ Process –based simulation models

- *Simulate some combination of biological, physical, chemical processes that control movement of water, natural constituents & contaminants from land surface thru the soil and vadose zone to and thru the saturated zone*
- *Categories - Root zone , Vadose zone, saturated zone*
- *Product - Prediction of rates of water and contaminant movement as a function of location and time*
 - *Zone of contribution*
 - *Contributing recharge areas*
 - *Used to assign relative risk*
- *TANC – USGS NAWQA – Transport of Natural and Anthropogenic Contaminants*

VULNERABILITY METHODS

➤ Statistical methods

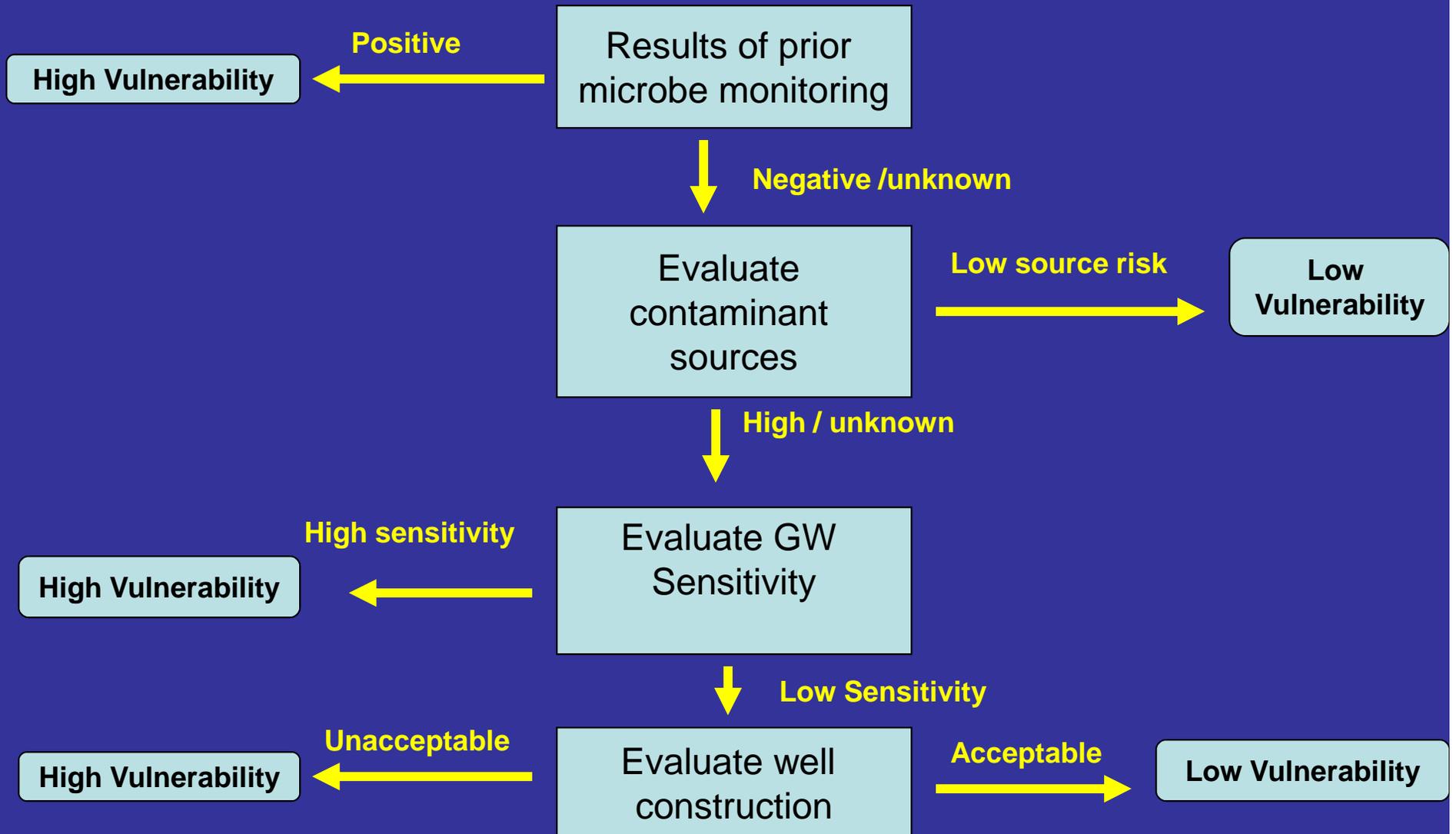
- *Provide estimates of the likelihood contamination based on the relationship of soil, hydrogeologic and / or anthropogenic factors to known or calculated contaminant distributions*

- *Statistical techniques*
 - *Discriminant analysis*
 - *Regression analysis*
 - *Spatial estimation*

- *Appropriate for wells not areas*

EXAMPLE

VULNERABILITY OF PWS WELL TO MICROBIAL CONTAMINATION



SCALE OF VULNERABILITY ASSESSMENT

- **Scale is dependent on proposed use of assessment**
- **Political boundaries**
 - **Counties**
 - **States**
- **Hydrogeologic boundaries**
 - **Aquifers**
 - **Watersheds**
- **Well / wellfield**

Appropriate Scale of GW Sensitivity / Vulnerability Assessments (ASTM D 6030)

S - sensitivity V – vulnerability 1- least appropriate 5- most appropriate

METHOD	REGIONAL		COUNTY / AQUIFER		FIELD / WELLFIELD	
	<u>S</u>	<u>V</u>	<u>S</u>	<u>V</u>	<u>S</u>	<u>V</u>
Hydr. Settings / no scoring	4	3	3	2	2	1
Hydr. Settings / with scoring	5	4	5	5	4	4
Scoring / without hydrog. settings	1	1	3	3	4	4
Root zone models	N	N	N	N	N	3
Vadose zone models	N	N	N	N	4	4
Saturated zone models	3	1	4	3	4	3

USES FOR GW VULNERABILITY ASSESSMENTS

➤ **GW resource management**

- *WHP/SWP*
- *GW discharge programs*
- *Non – point source programs*
- *GW classification*

➤ **Land use planning**

➤ **Prioritize remediation**

➤ **Facility siting**

THE VULNERABILITY ASSESSMENT PROCESS

PURPOSE OF VULNERABILITY ASSESSMENT

- Education
- Policy analysis
- Program management
- Land use decisions



APPROACHES

- Method selection
- Uncertainty



GW MANAGEMENT ACTIONS

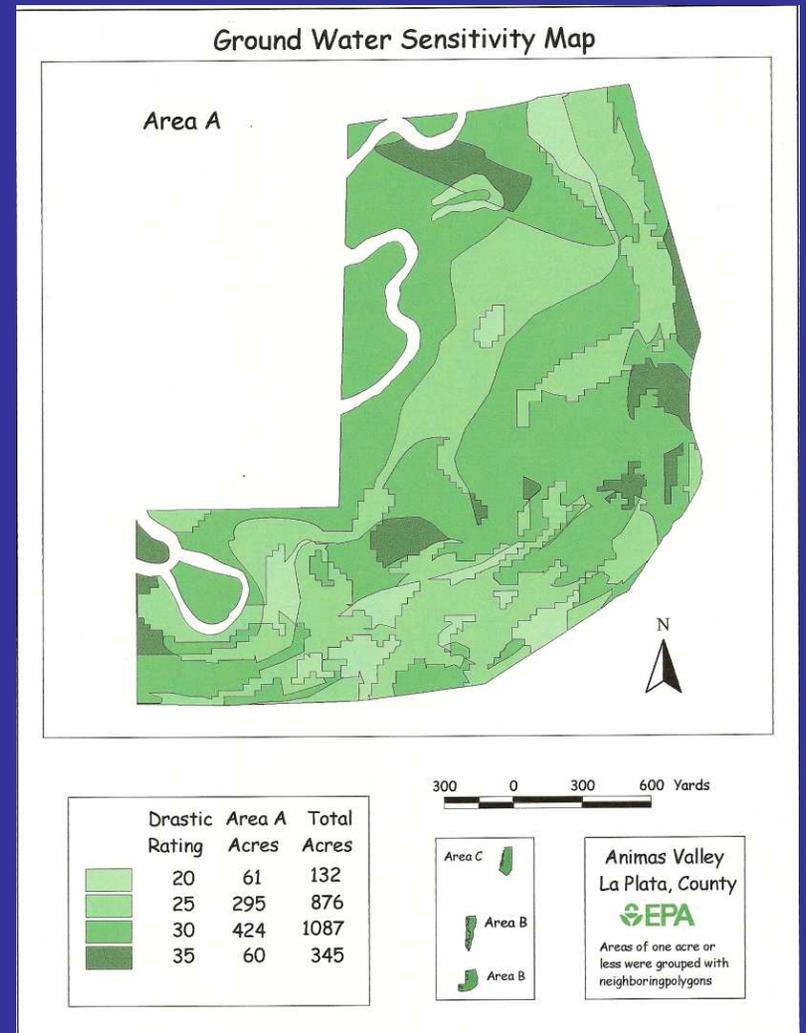
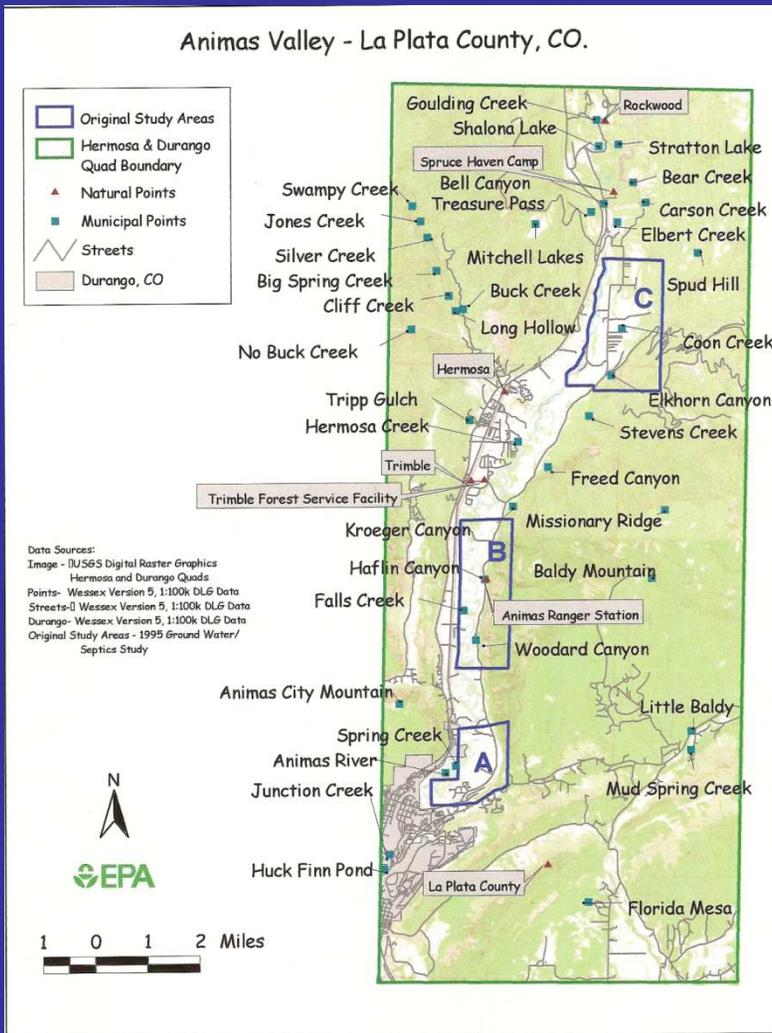
- Land use controls
- Well siting
- Prioritize remediation

DATA AND DATA BASES

- Topography
- Soils
- Hydrogeology
- Precipitation
- Land cover / land use



La Plata Cy, CO Groundwater Vulnerability Study



Issue – increased housing density along Animas River – w / ISDS use

THREE IMPORTANT REFERENCES

- Ground Water Vulnerability Assessment – Contaminant Potential Under Conditions of Uncertainty - National Research Council, 1993
- A Review of Methods for Assessing Aquifer Sensitivity and Ground Water Vulnerability to Pesticide Contamination - US EPA (1993)
- Standard Guide for Selection of Methods for Assessing Ground Water or Aquifer Sensitivity and Vulnerability – ASTM D- 6030 (1997)

Thank you

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