Study of Emerging Technologies for Colorado Water Management

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Background: HB21-1268

The act declares that **new technologies** such as:

- improved sensors
- Blockchain
- Advanced aerial observation platforms

can improve monitoring, management, conservation, and allocation of water to fulfill obligations under Colorado water law and enhance confidence in the reliability of data underlying water rights transactions. To advance the potential use of these new technologies, the act: Authorizes and directs the University of Colorado and Colorado State University to conduct feasibility studies and pilot deployments management in Colorado.
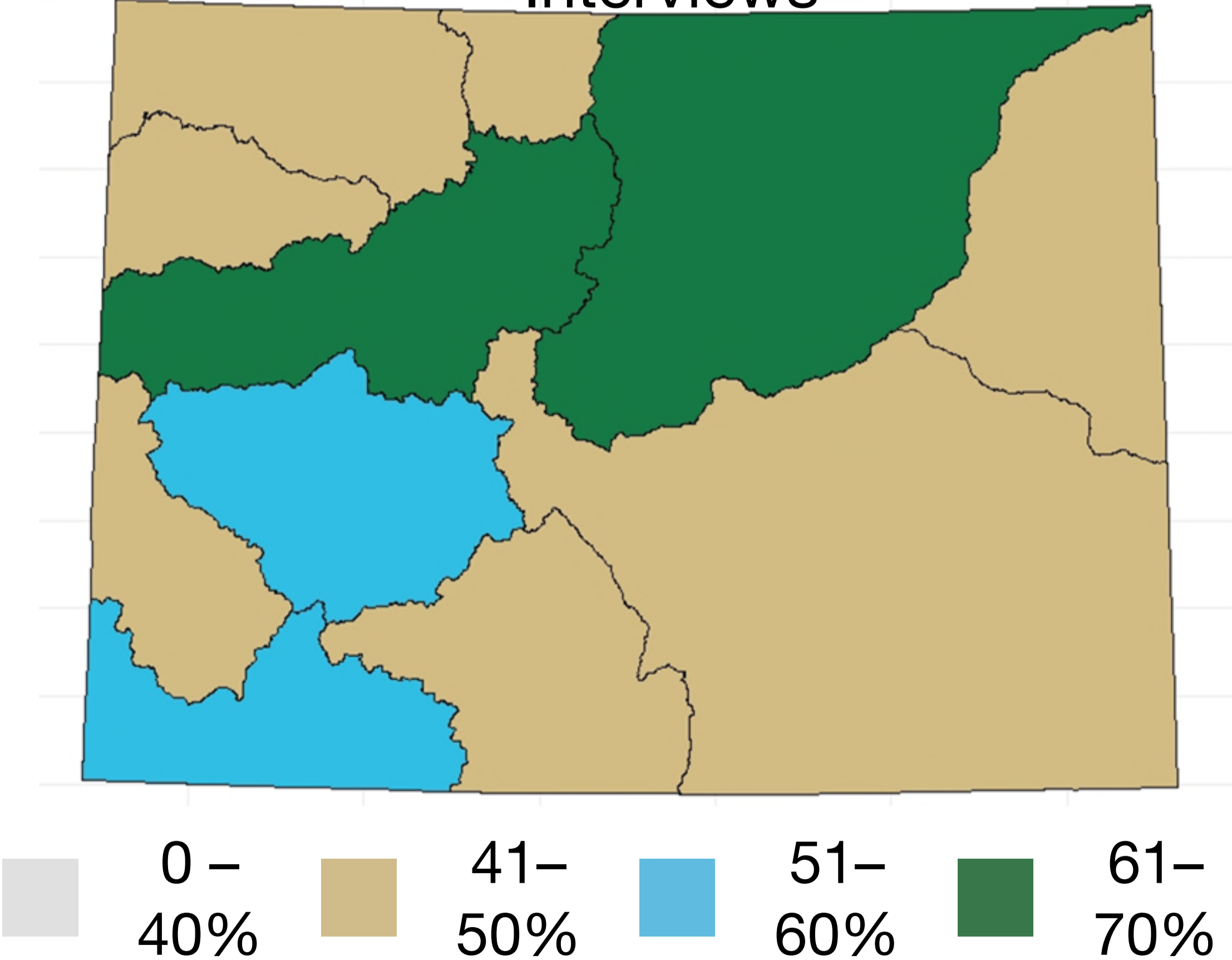
First Regular Session | 73rd General Assembly

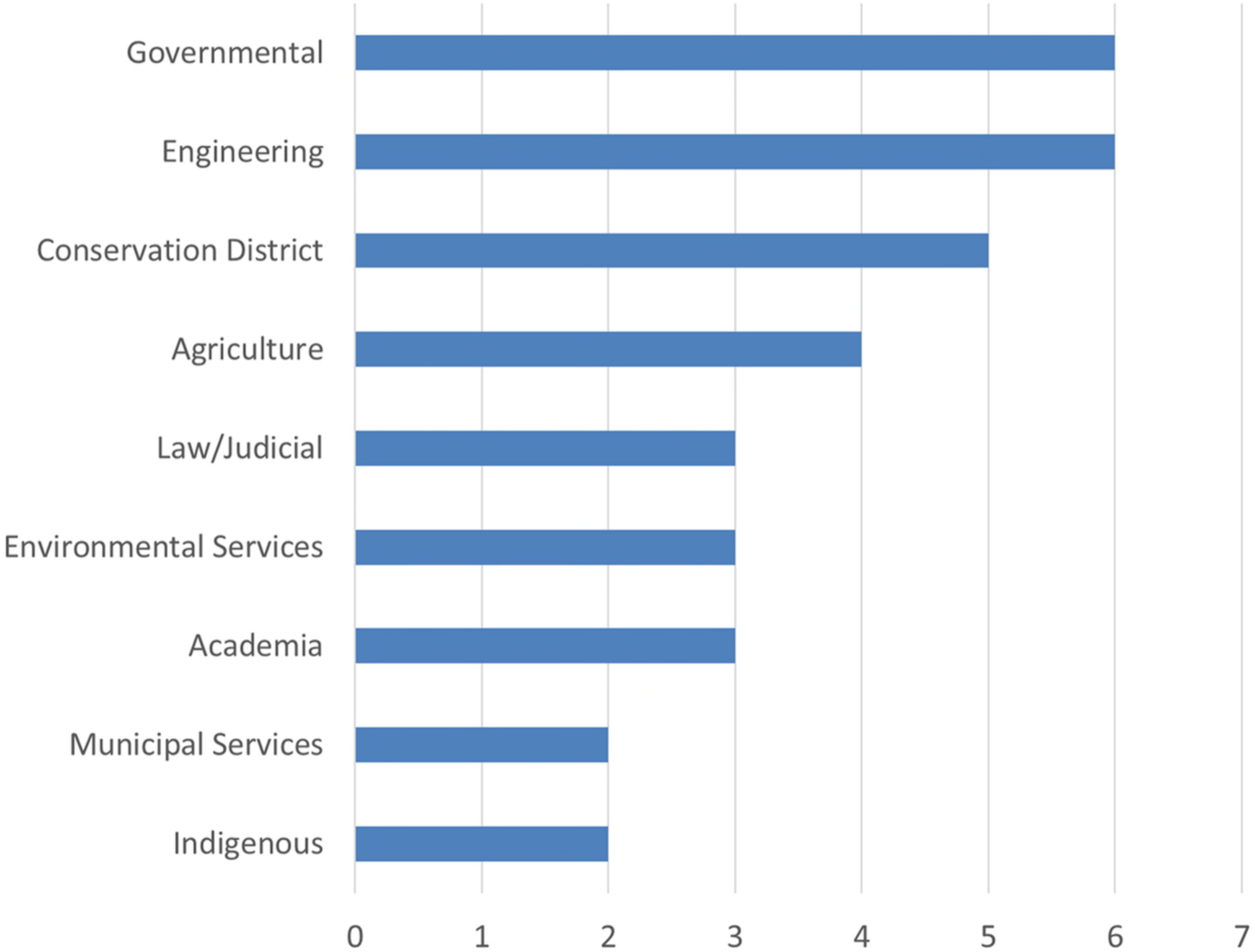Colorado General Assembly

Methodology
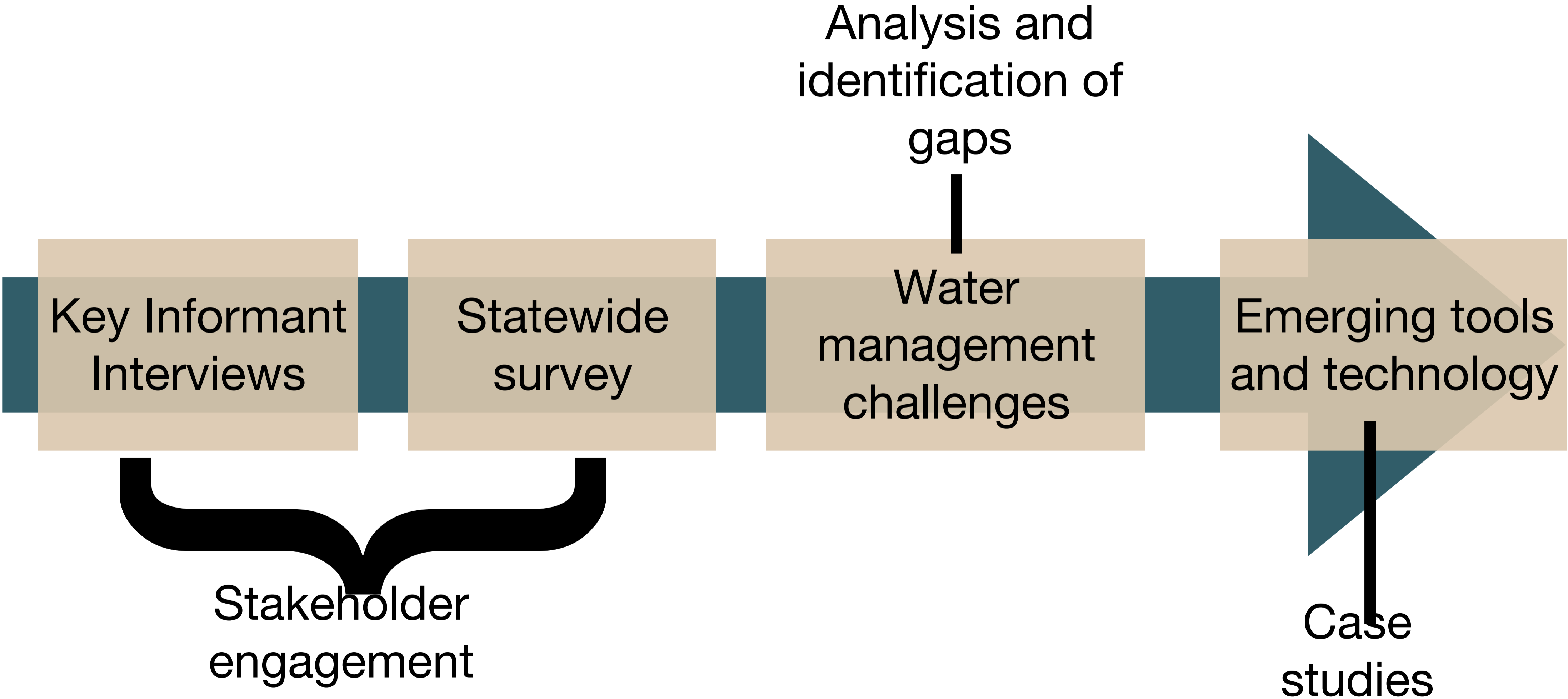
Colorado Stakeholders: Who did we talk to?

Distribution of Basin Representation in Interviews

Legend: 0 – 40%, 41–50%, 51–60%, 61–70%

Sector Representation in Interviews

Governmental, Engineering, Conservation District, Agriculture, Law/Judicial, Environmental Services, Academia, Municipal Services, Indigenous
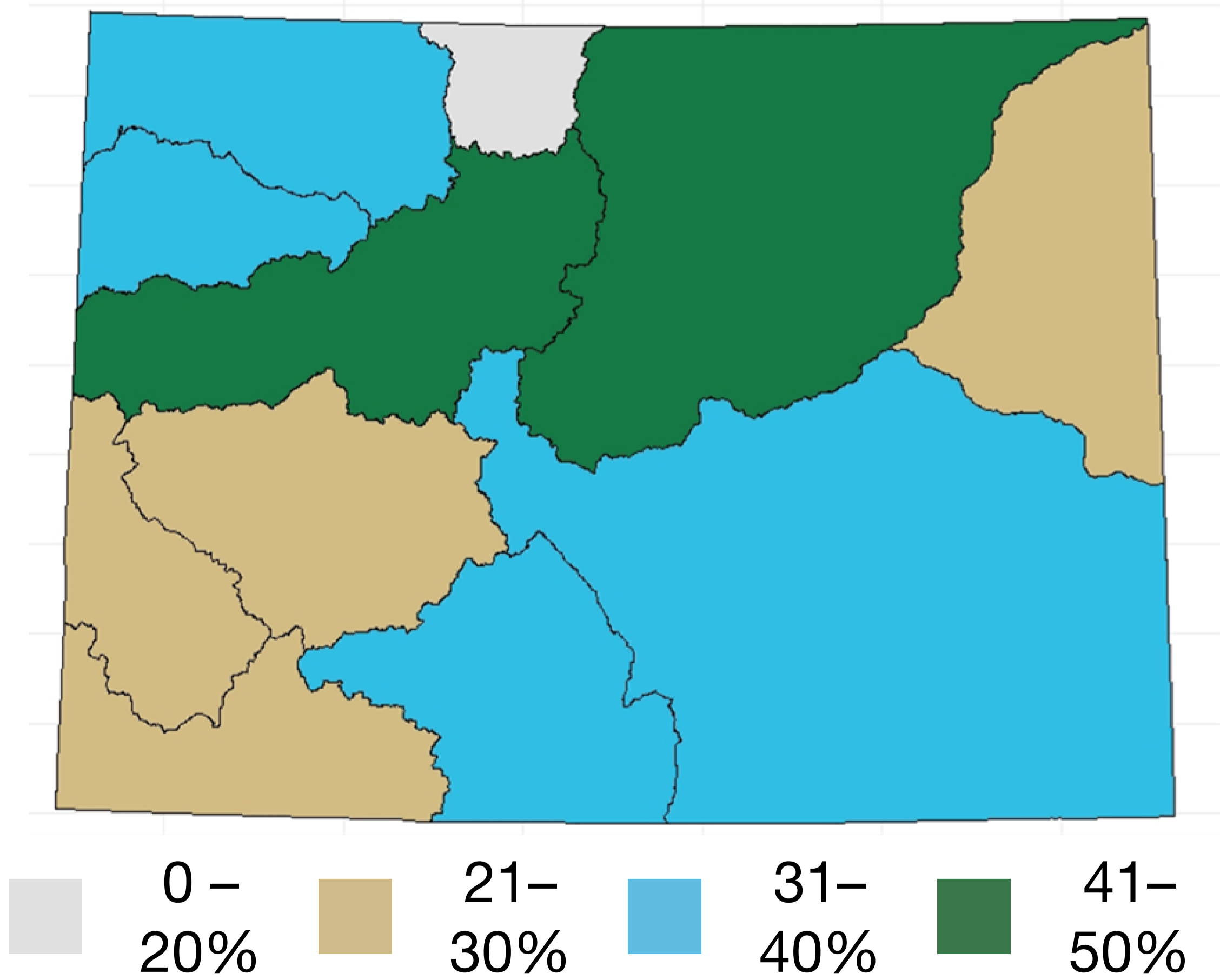
Stakeholder Interviews

- Semi-structured, conversational style with 26 stakeholders selected based on:
  - Knowledge of issues relevant to the study
  - Sector / organization
  - Contributions to Colorado water
- Findings informed stakeholder survey questions including gaps in:
  - **Groundwater monitoring**
  - **Snowpack, streamflow data**
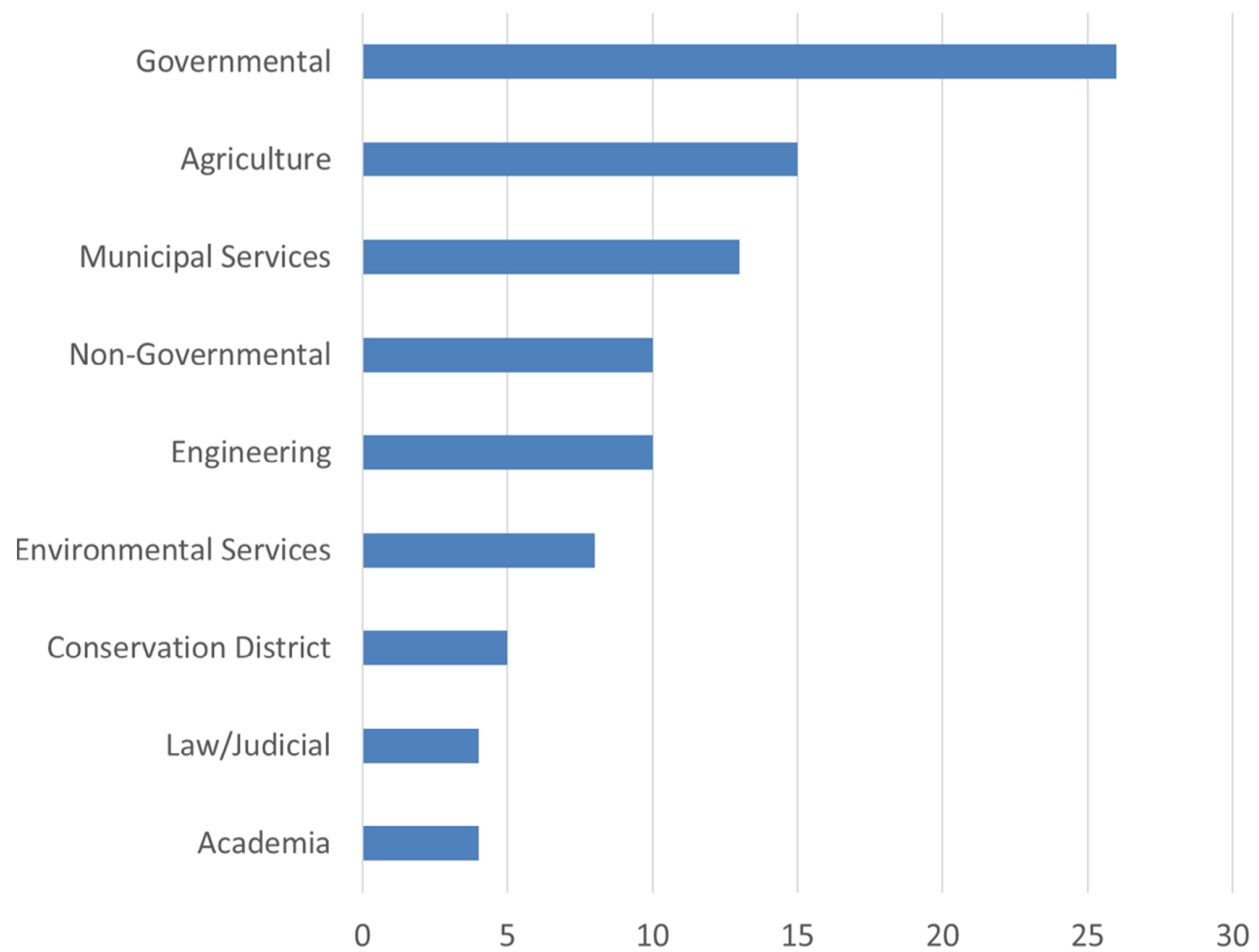 - **Watershed health**
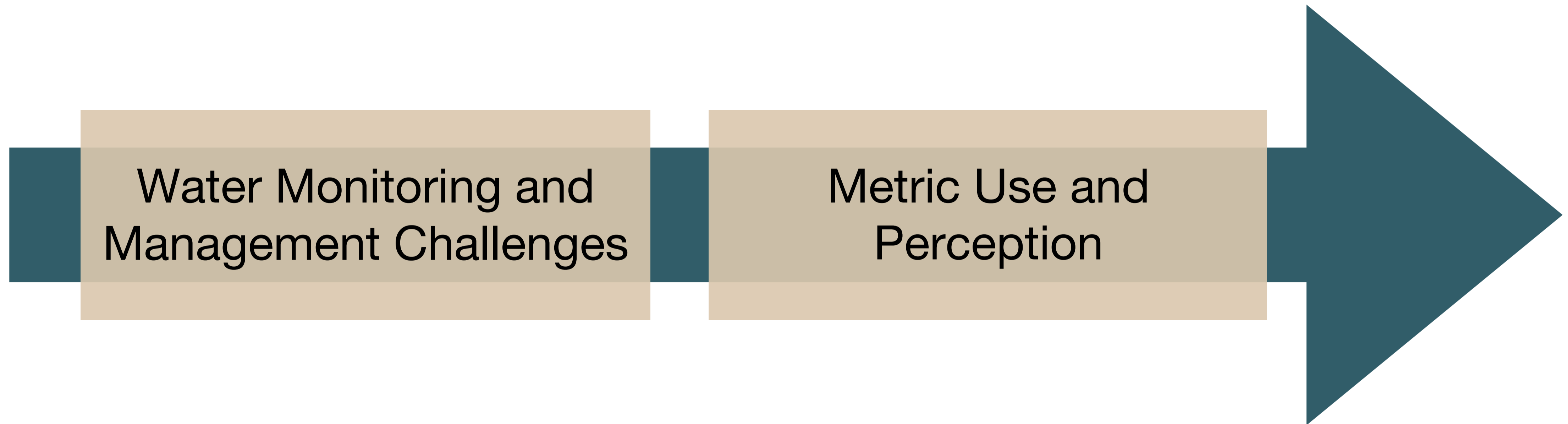
Colorado Stakeholders: Who did we survey?

Distribution of Basin Representation in Survey Respondents

Legend:
- 0 – 20%
- 21– 30%
- 31– 40%
- 41– 50%

Sector Representation in Survey Respondents

- Governmental
- Agriculture
- Municipal Services
- Non-Governmental
- Engineering
- Environmental Services
- Conservation District
- Law/Judicial
- Academia

(x-axis: 0, 5, 10, 15, 20, 25, 30)

Survey Results

Which of the following are important challenges in the monitoring and management of Colorado water?

| Selection	Academia	Agriculture	Conservancy District	Engineering	Environmental Services	Govermental	Law/Judicial	Municipal Services	Non-Governmental Organization
Monitoring snow pack	25.0%	52.9%	83.3%	69.2%	87.5%	56.0%	50.0%	76.9%	66.7%
Monitoring soil health	0.0%	35.3%	83.3%	46.2%	37.5%	28.0%	25.0%	38.5%	75.0%
Monitoring surface water contaminates	25.0%	29.4%	33.3%	30.8%	50.0%	44.0%	0.0%	61.5%	16.7%
Monitoring groundwater contaminates	25.0%	17.6%	33.3%	7.7%	50.0%	44.0%	25.0%	15.4%	33.3%
Monitoring pipe leakage	0.0%	11.8%	16.7%	7.7%	37.5%	20.0%	25.0%	30.8%	25.0%
Monitoring the effects of pumping on streamflow	25.0%	35.3%	50.0%	53.8%	75.0%	72.0%	50.0%	46.2%	58.3%
Ease of trading water units	25.0%	0.0%	16.7%	23.1%	12.5%	24.0%	25.0%	23.1%	33.3%
Ensuring redundancy in water supplies	0.0%	11.8%	33.3%	38.5%	37.5%	32.0%	25.0%	46.2%	33.3%
Maintaining data privacy	0.0%	11.8%	16.7%	0.0%	25.0%	8.0%	25.0%	0.0%	8.3%
Meeting compact compliance	25.0%	41.2%	33.3%	53.8%	62.5%	44.0%	25.0%	23.1%	58.3%
Accuracy of data sources	50.0%	29.4%	83.3%	53.8%	75.0%	72.0%	50.0%	61.5%	58.3%
Ease of data access	50.0%	17.6%	50.0%	38.5%	62.5%	48.0%	25.0%	30.8%	41.7%

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Metric Use and Perception
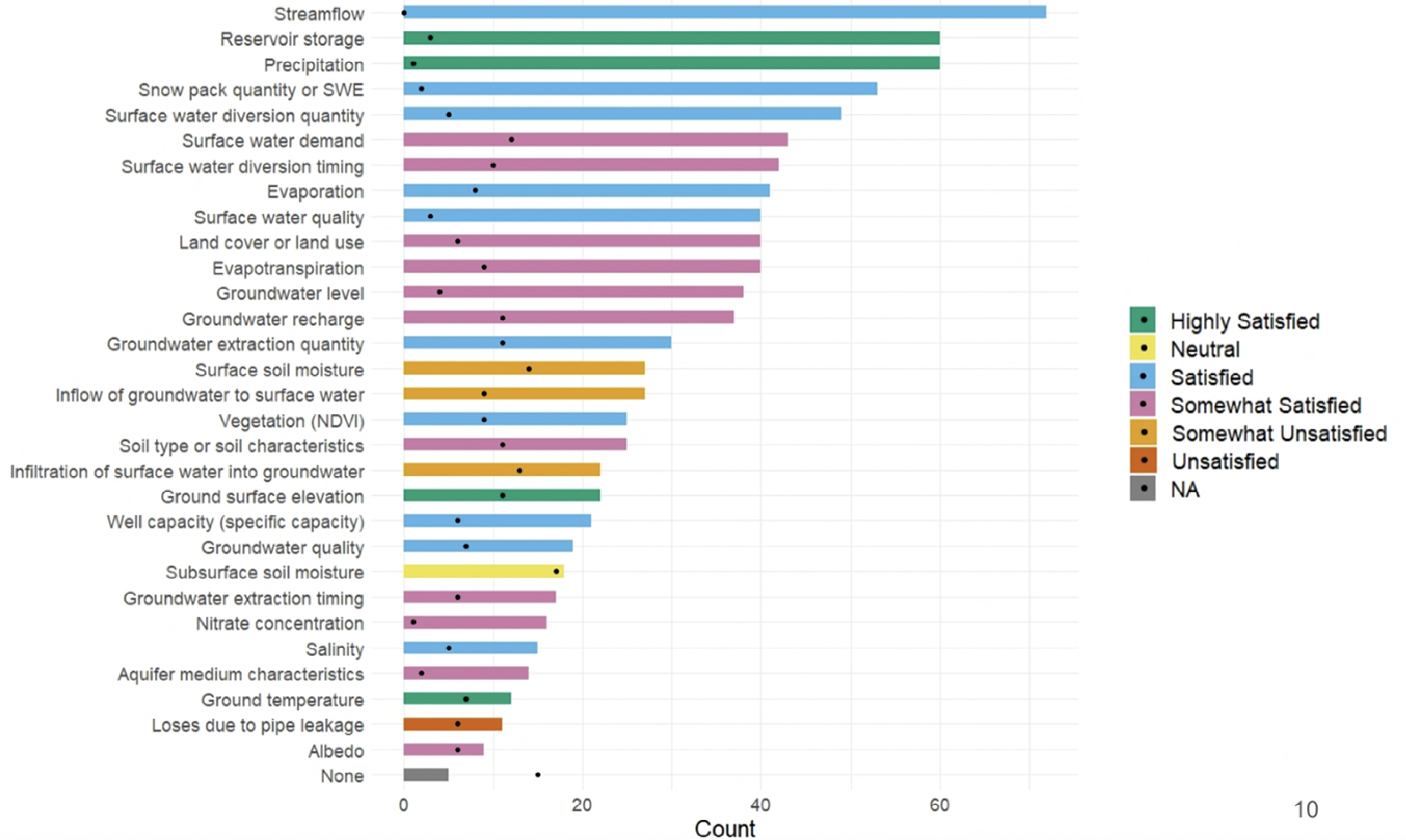
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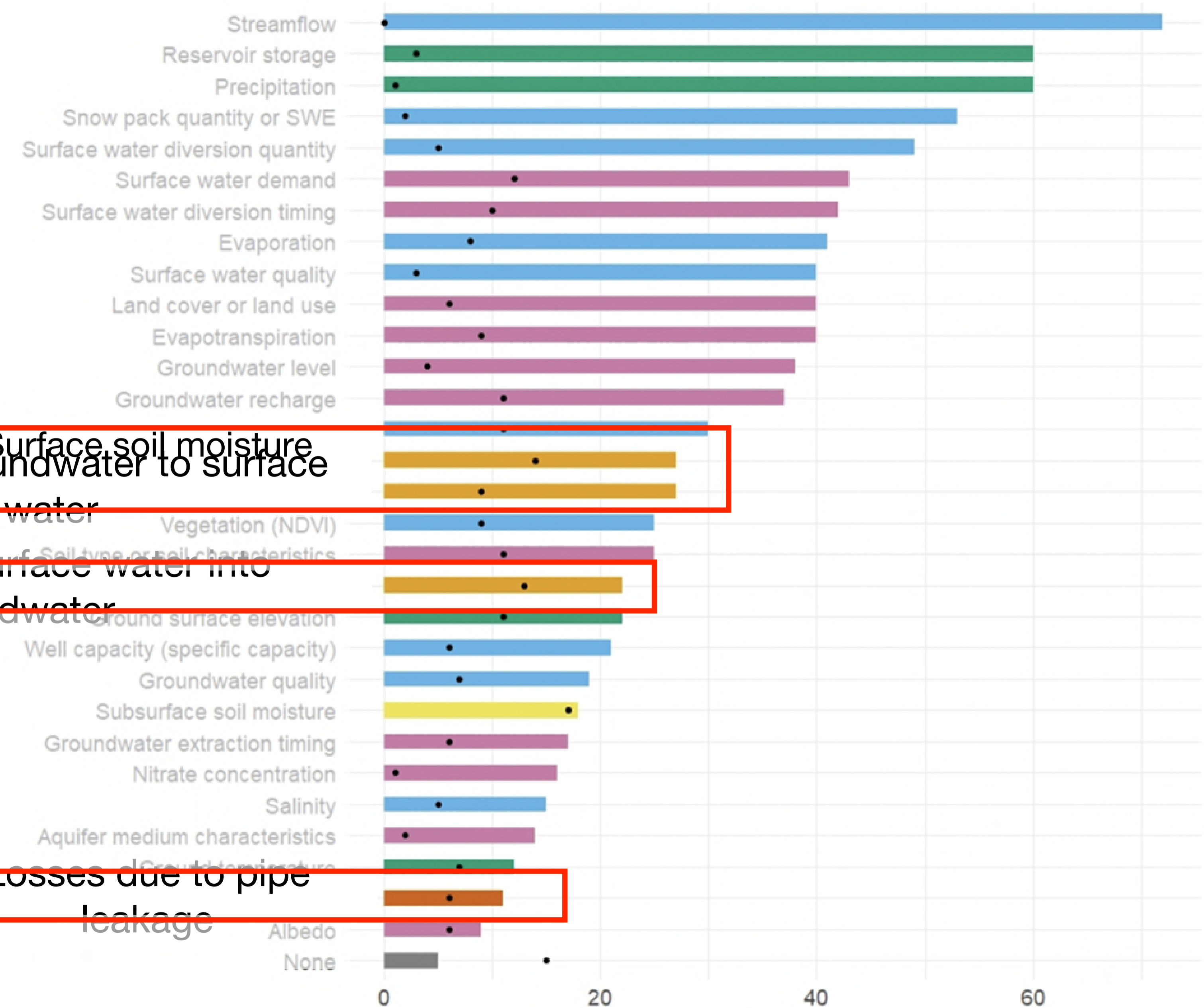
Case studies: summary
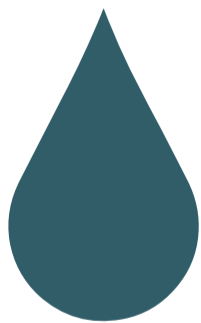
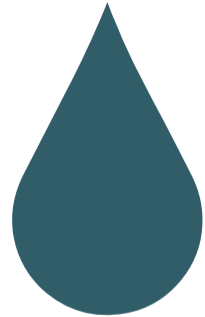| Groundwater monitoring | Streamflow forecasting | Snowpack modeling | Watershed health | Water rights & transactions | Soil moisture monitoring |

Case studies: summary

Virridy groundwater monitoring in Solano County, CA

Ungauged streamflow prediction model from CSU

Airborne Snow Observatories improved snowpack monitoring
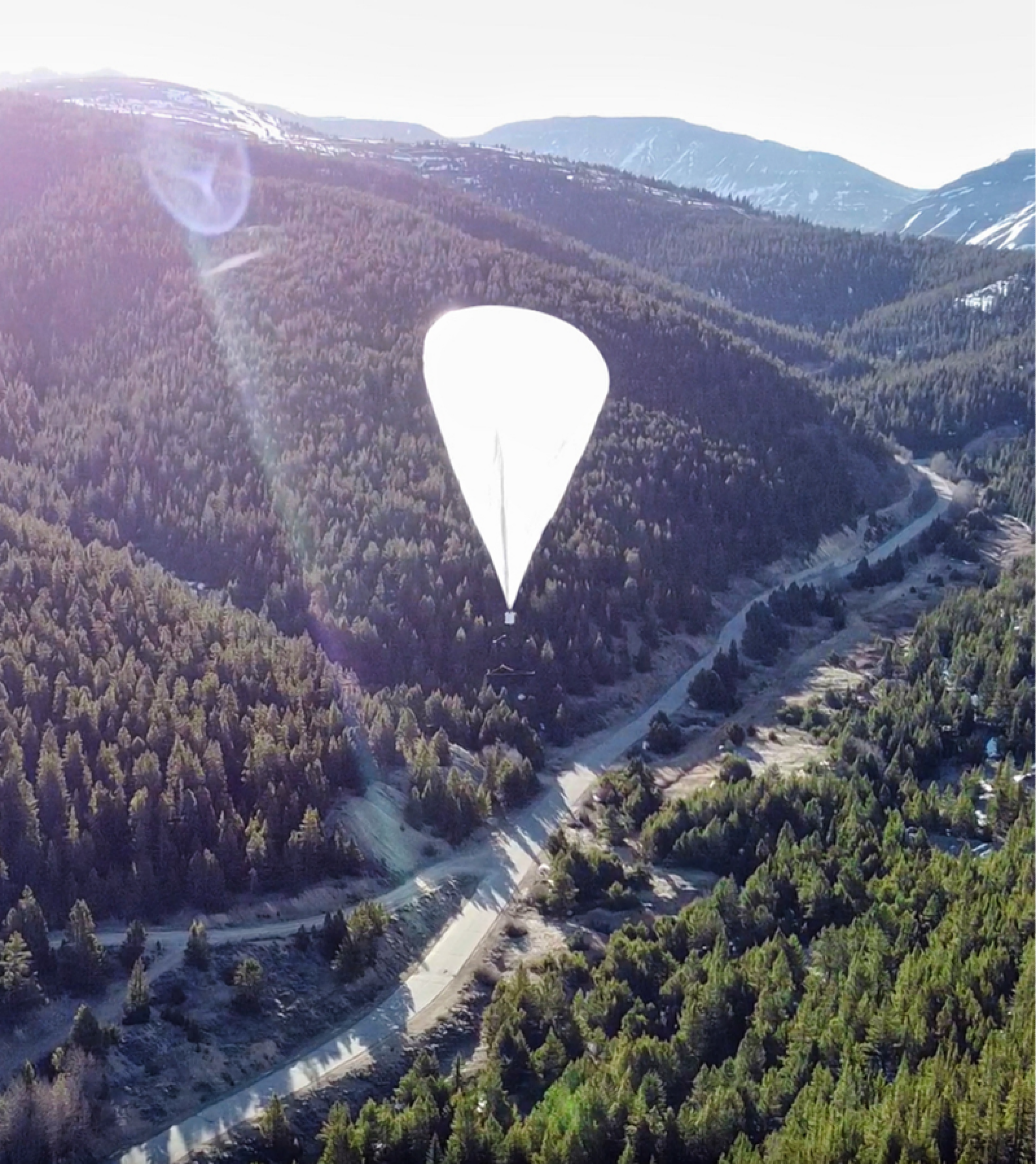
BasinScout decision support tool in Pueblo County

Colors of Water forecasting tool on the Arkansas River

Open-source, satellite-based evapotranspiration data from OpenEt

Leveraging Low-cost Stratospheric Monitoring Capabilities for Watershed Management

- Denver Water partnered with Urban Sky to asses the effects of wildfire and sedimentation on a key watershed

- Using Microballoon for advanced aerial observation:
  - broad area coverage
  - high refresh rate
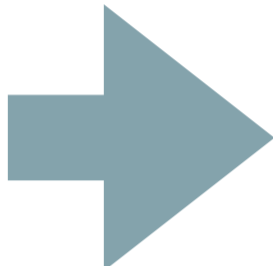 - low cost
  - high resolution

Decision support tool to address conservation management in Pueblo County, Colorado
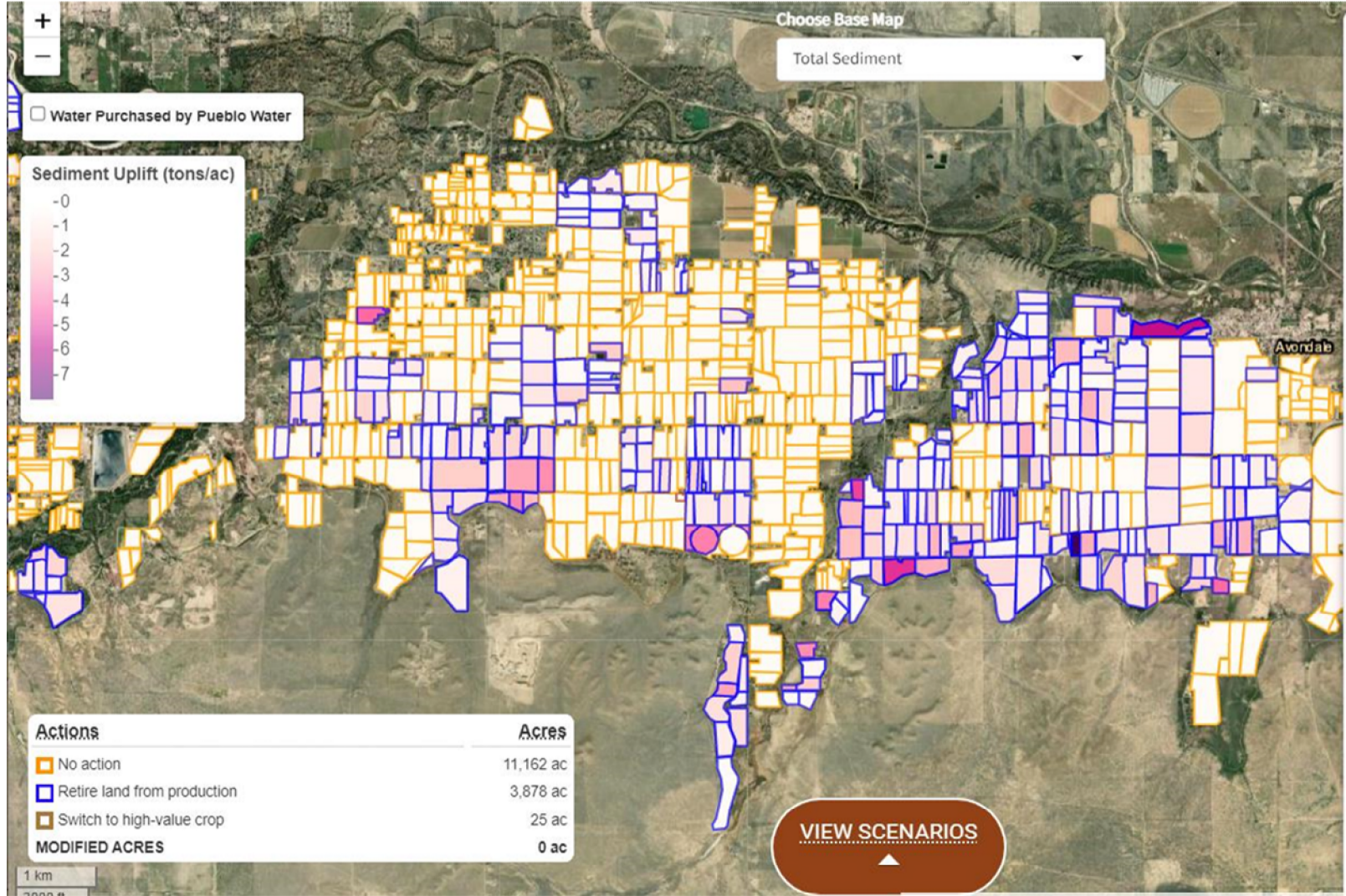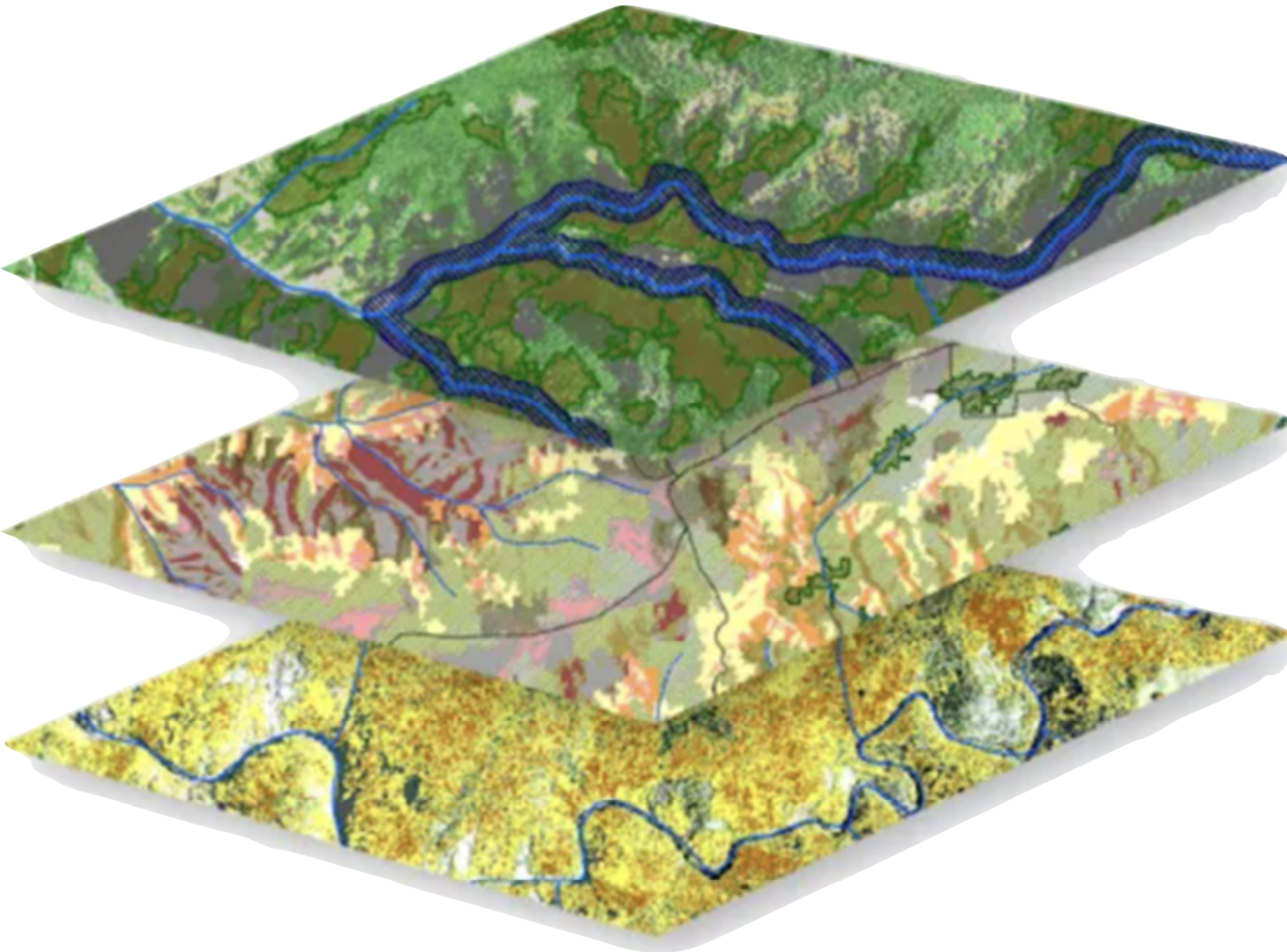

Overlay of available data sets on climate, soil, crops, conservation practices for comprehensive overview

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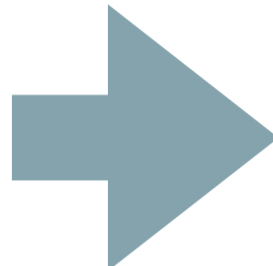
Production of watershed maps detailing where conservation efforts would have the greatest impacts

→

Targeted, effective action in on-the-ground restoration projects

A Digital Future for Colorado's water

- Provides legal context of Colorado water rights transactions

- Acquisition complexities

  - market weaknesses

  - Due diligence

  - Engineering support to change existing systems

  - Legal support to change existing systems

  - Barriers

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Opportunities for digitization & technology solutions

- Describes potential use of **blockchain** to track availability and sharing of water resources as a means to encourage collaboration between municipalities and agriculture water users

- Outlines opportunities for digitization & **technology solutions** in water management including monitoring software and development

- Highlights the potential of **digitization of water rights** to lower costs and increase efficiency, transparency, and security of water transactions

Deloitte.

Rio Grande Conservation District groundwater monitoring

- Satellite-connected, remotely reporting sensor network

- Groundwater yield estimates derived from pump test coefficients

- Cost-effective alternative to flow meters

- Pilot test completed in California context, examine relevance for Colorado groundwater

- Installed sensors for groundwater monitoring

Colorado Master Irrigator:
Effective water management training

- Annual 4-day winter course, 4 days

- Wide range of proven water & crop management topics & technologies

- Local curriculum adaptation & leadership

- Pros, cons, COSTS, practical considerations

- Diverse participants, irrigation situations, soil types

- Small class size, peer-to-peer interaction

- Incentives & additional learning opportunities

- Involvement and support from local & regional groups, water districts, state agencies, NRCS

Testing Ag Performance Solutions Program

Farm management competition

Experiential learning to develop trust in tech

Irrigated corn, sorghum, cotton; dryland wheat

Top prizes for:

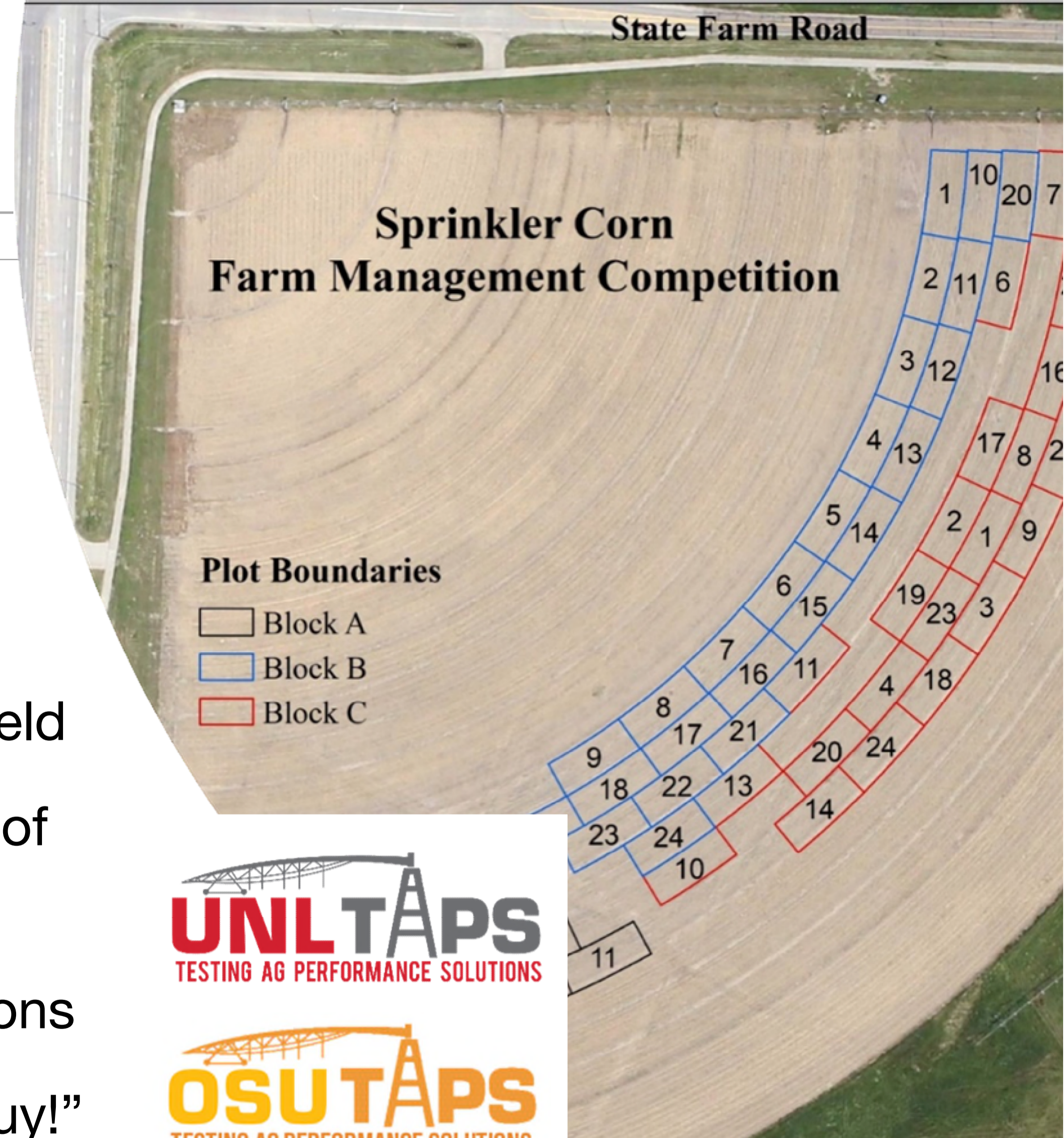**Most profitable operations**

Most input-use efficient operations

Grower decisions imposed on the same playing field

Yields new insights on tech utility & effectiveness of different management decisions, combinations

Wide range of tech and other data support decisions

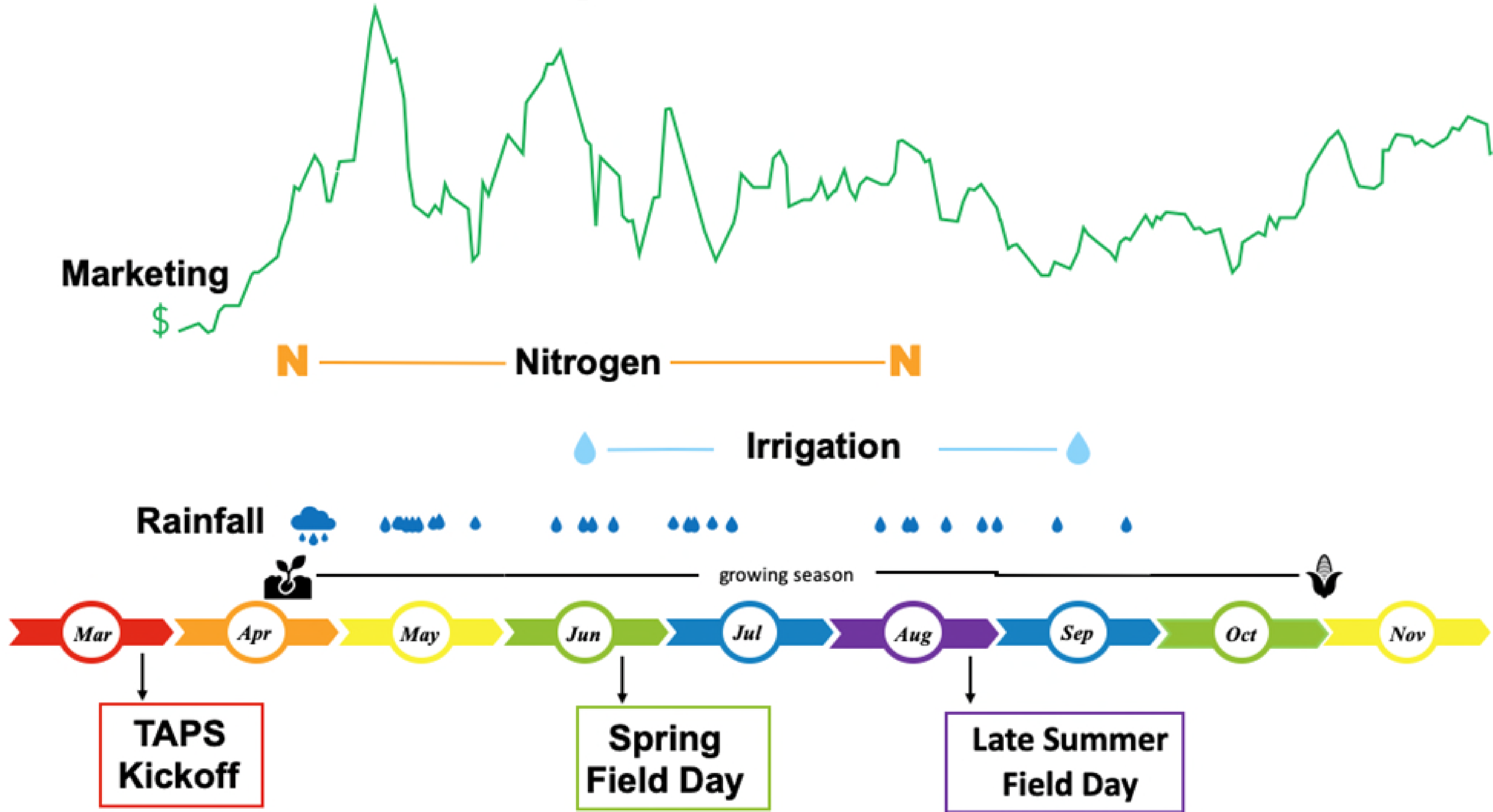No-risk opportunity with tech to "try before you buy!" and develop trust.

State Farm Road

Sprinkler Corn
Farm Management Competition

Plot Boundaries
- Block A
- Block B
- Block C

Coming in 2023: CSUTAPS

Competition Timeline

Marketing

Nitrogen

Irrigation

Rainfall

growing season

Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov

TAPS Kickoff

Spring Field Day

Late Summer Field Day

Pilot deployments at CSU-Ag Research, Development & Education Center (ARDEC-South): LoRaWAN Gateway

- Long range wireless communication for real-time monitoring

- Long-distance, low-power, low-cost

- Opportunity to scale real-time management decision support

- Gateway can handle millions of signals from sensors

- Can be used where cellular, broadband are not robust

- Secure end-to-end encryption

- ARDEC location: wide variety of opportunities to monitor and develop new use cases
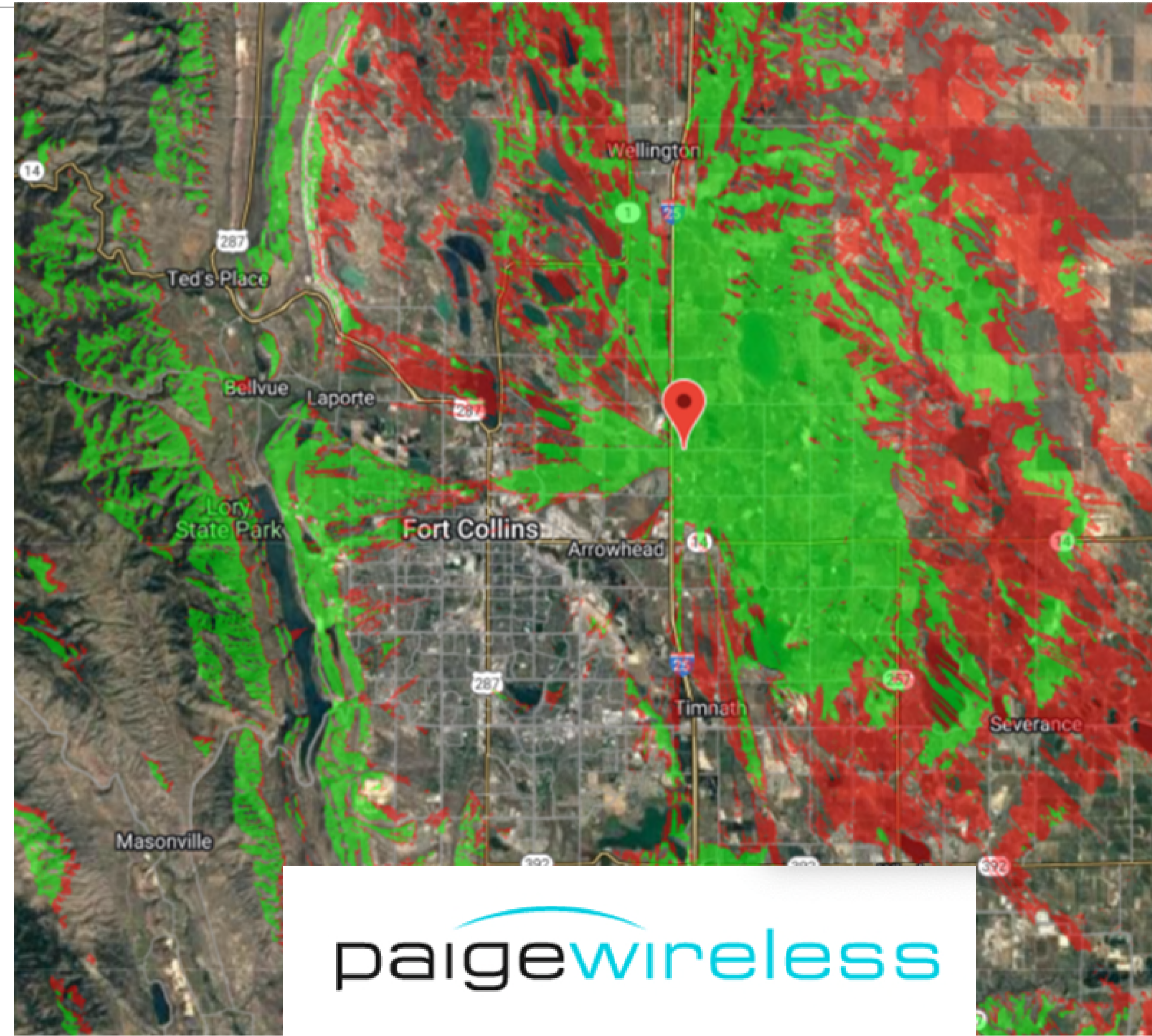
Pilot deployments at CSU-Ag Research, Development & Education Center (ARDEC-South): Low-cost wireless soil sensors

- Low-cost, durable, custom capacitive sensors
- Highly responsive to soil moisture, soil temperature
- In development: salinity sensor
- Modular for connectivity options
- Service includes: hardware, installations, data access, and data visualizations

Recommendations

1. Support for integration of emerging technologies with state agency operations.

2. Support anti-speculative digitization of water allocations for conservation, leasing, selling, retiring.

3. Support local and state-wide data-driven collective action for surface / groundwater management.

4. Explore technology cost / benefits / opportunities to incentivize management and conservation.
   a. Climate Finance Opportunities
   b. Federal Drought Funding

Acknowledgments

Read the report here