

DEEP INJECTION WELL CONSTRUCTION AND OPERATION

**MORGAN COUNTY
PLANNING AND ZONING DEPARTMENT
UIC WELL STAKEHOLDERS**



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INTRODUCTION TO DEEP INJECTION WELLS

- (1) The types of fluids managed with deep injection wells (DIWs);
- (2) History of DIWs and use;
- (3) How DIWs are regulated and permitted;
- (4) Advantages of DIWs compared to other methods of WW management;
- (5) Injection well operation;
- (6) Reservoir behavior – how does subsurface injection work?;
- (6) Common concerns associated with DIWs; ; and,
- (8) Summary and discussion.

WHAT ARE DEEP INJECTION WELLS? WHY ARE DEEP INJECTION WELLS NEEDED?

Injection well definition (EPA)

- **Underground injection:** Subsurface emplacement of fluids through a well.
- **UIC:** Underground Injection Control – EPA and State programs that regulate injection wells used to manage wastewater from various operations (mining, oil and gas, chemical plants, refineries, municipalities, food processors, etc.).
- ❑ Deep injection wells are unique in that they remove constituents from the environment.
- ❑ Commonly involve large volumes of fluid (50 gpm to 100s of gpm).

WHAT TYPE OF WASTE ARE MANAGED WITH DIWs?

- Reverse Osmosis (RO) brine (municipal water treatment; e.g., Sterling, CO [Class I]).
- Produced brine, flowback water and gas storage/transportation (oil and gas operations) (Class II wells)
- RO brine - (mining operations; food processing; medical) (Class I).
- BOD/COD process waters (fruit and vegetable operations) (Class I).
- Organic chemicals – chemical plants, pharmaceutical plants, environmental cleanup projects (Class I)
- NaSO_4 waste – chemical plants (Class I).
- Acid waste – steel and pigment manufacturing (Class I).

DEEP INJECTION WELLS – WHY ARE THEY OFTEN THE BEST METHOD TO MANAGE WASTEWATER?

- Minimize volume whenever possible.
- Surface discharge – increases TDS in rivers/streams and shallow groundwater.
- Biological treatment – difficult to treat inorganic compounds.
- Aerobic/anaerobic digesters - difficult to treat inorganic compounds.
- Land application – potential impacts to surface and shallow groundwater.
- Evaporation ponds – ecological issues; potential impacts to shallow groundwater; eventual solids management.
- Deep Injection wells – optimum with suitable geology.

INJECTION WELL HISTORY

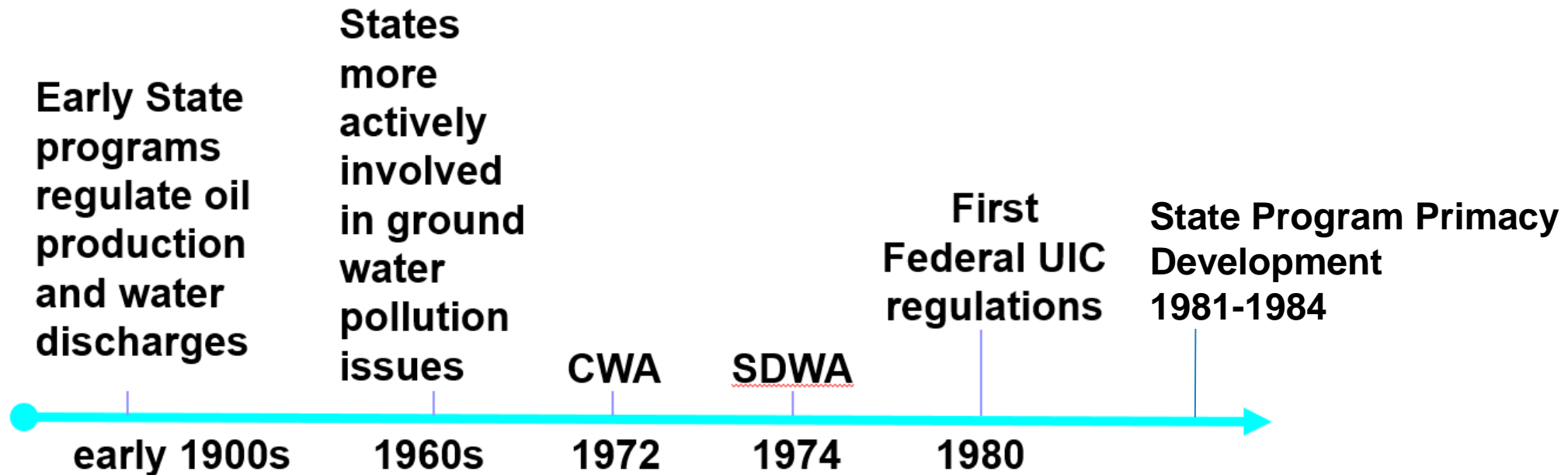
Early Injection

- **1930s:** Oil companies began injecting wastes into depleted reservoirs through converted oil production wells
- **1950s:** Injection of hazardous chemical and steel industry wastes began
- **1960s:** Injection practices increase sharply as the manufacturing of chemicals boomed

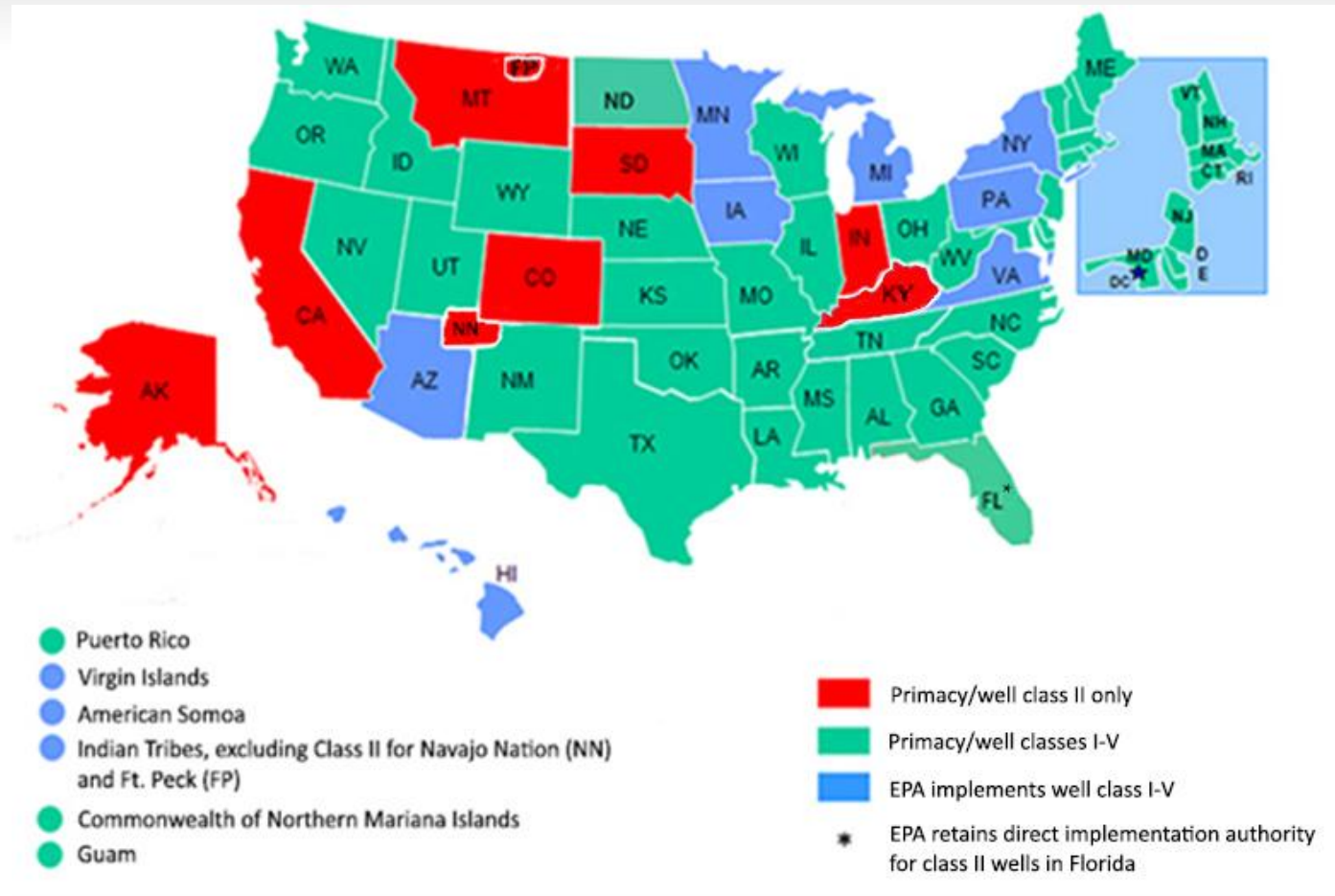
To enhance protection of underground sources of drinking water, the USEPA in 1980 passed the Underground Injection Control (UIC) regulations as part of the Safe Drinking Water Act.

DEEP INJECTION WELL REGULATION

Regulatory Timeline



UIC REGULATORY DESIGNATION



Source: <https://www.epa.gov/uic/primary-enforcement-authority-underground-injection-control-program>

CLASSES OF INJECTION WELLS

- Class I (Industrial & Municipal Waste Injection Wells)
- Class II (Upstream Oil and Gas Related Injection Wells)
- Class III (In-situ Mining Wells [salt, potash, uranium])
- Class IV (Shallow Hazardous and Radioactive Injection Wells; prohibited)
- Class V (“Other” and Municipal Wells); may be shallow or deep
- Class VI (Geologic Sequestration Wells [primarily CO₂])

NUMBER AND TYPE OF INJECTION WELLS

Number of Injection wells in US by Class (2016; EPA)

<https://www.epa.gov/uic/underground-injection-well-inventory>

➤ Class I Hazardous	140
➤ Class I non-Hazardous	692
➤ Class II Injection/Disposal	38,169
➤ Class II Recovery	145,707
➤ Class III In-situ Mining	24,669
➤ Class IV	20
➤ Class V	498,190
➤ Class VI	7

INJECTION WELLS IN COLORADO

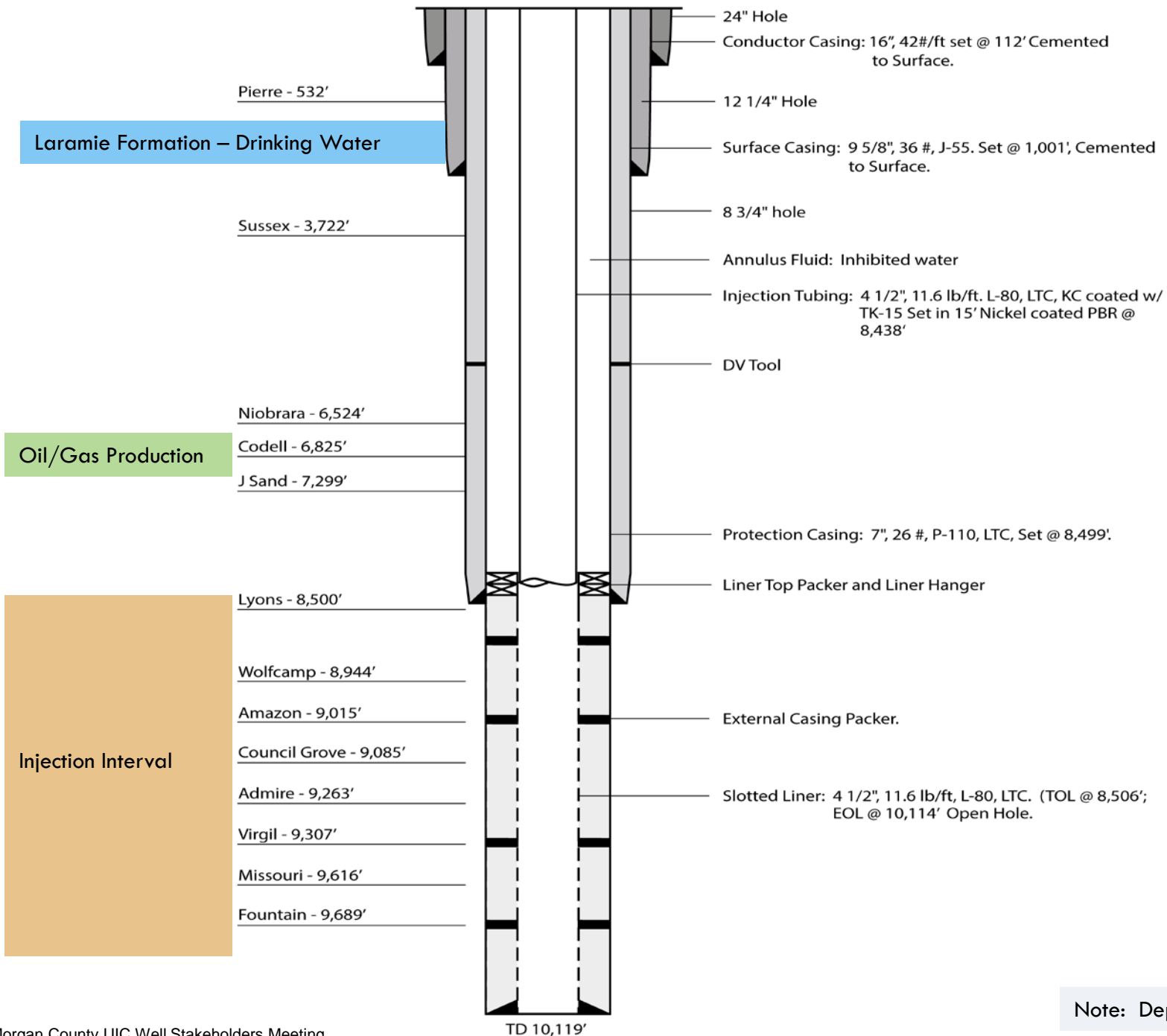
- 18 - Class I
- 384 - Class II Disposal
- 574 – Class II Recovery
- 22 - Class III
- 2,573 – Class V

Source: COGCC and EPA

INJECTION WELL CONSTRUCTION – DJ BASIN

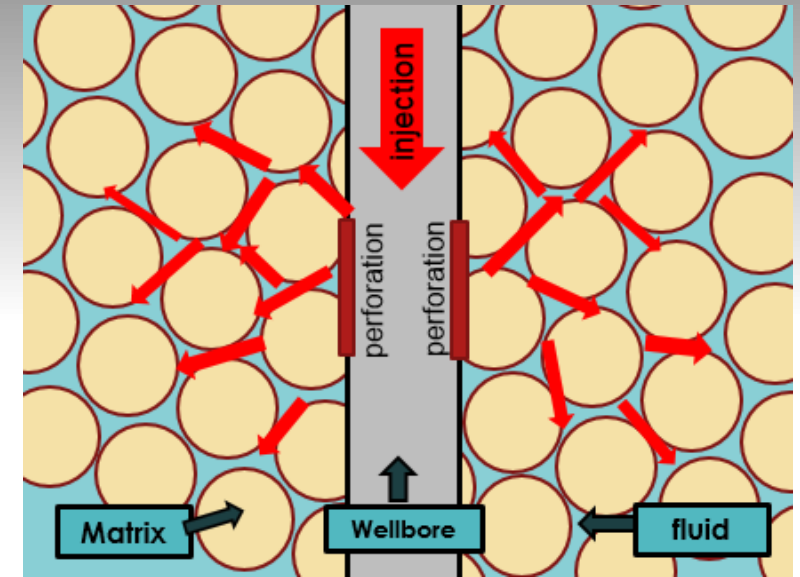
- Conductor casing - stabilize shallow sediments (60-90 feet below ground surface)
- Surface casing – isolate and protect shallow groundwater resources (900-3,000 feet bgs)
- Intermediate casing – isolate oil/gas resources (6,000-9,000 feet bgs)
- Slotted liner – stabilize open hole injection zone (9,000-10,500 bgs)
- Injection tubing – isolate injection fluid from protection casing

EXAMPLE INJECTION WELL SCHEMATIC DJ BASIN



HOW DOES INJECTION WORK?

- Fluid is injected into saturated pores with high-TDS water
 - Native water is displaced and the fluid and matrix are compressed
 - Compression of system will increase reservoir pressure
 - Injection reservoirs should be large, infinite-acting systems where possible
 - $\Delta P = \Delta V_w / (V_w C_w)$; $C_w = 5 \times 10^{-6} / \text{PSI}$
- For a 1-mile square box, 100' thick zone (12% porosity), $dP = 520$ psi at 25 gpm for 6 months
- Critical factors for capacity:
 - Permeability-thickness
 - Porosity-thickness
 - System (rock & fluid) compressibility (i.e., large reservoir volume, thickness & lateral extent)
 - Wellbore efficiency

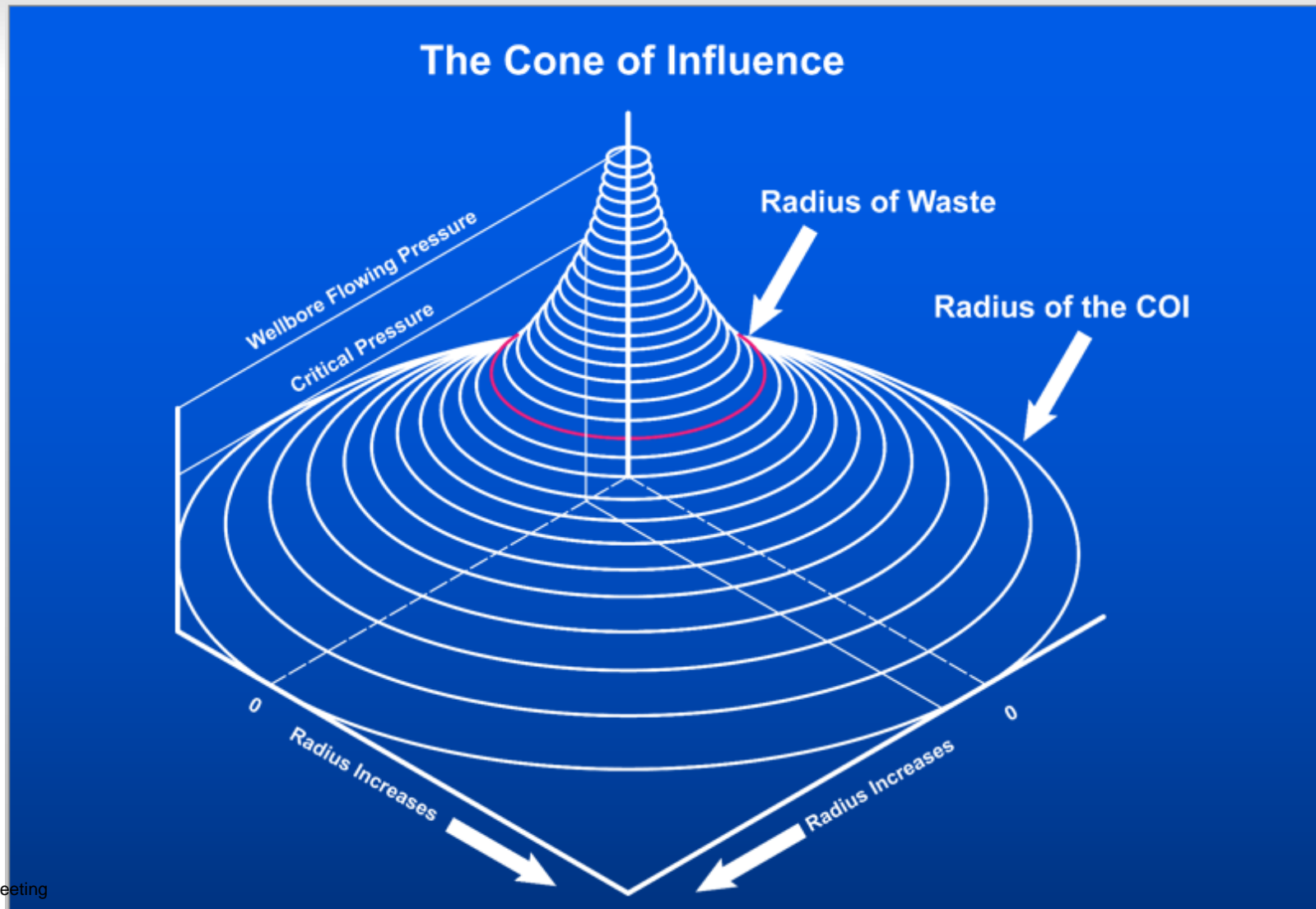


RESERVOIR BEHAVIOR AND FLUID DISPLACEMENT

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$$dp = -70.6(qBu/kh)[\ln((1,688*\phi*u*ct*rw^2)/(kt))-2s]$$

$$ROFD = (qt/\pi h \phi)^{1/2}$$



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INJECTION WELL OPERATION

- Injection pressure and rate limited by COGCC permit.
- Injection volume and displacement radius limited by COGCC permit.
- Reporting of injection volumes and pressures.
- If concerns about loss of Mechanical Integrity (MI), notification of COGCC and workover operations to assess.
- If there is potential for seismic issues, required seismic monitoring and interface with COGCC.
- If seismic events occur, reduction in injection rate per COGCC.

INJECTION WELL OPERATION

- Demonstration of MI before authorization to inject.
- Step-rate testing to determine formation properties.
- Falloff testing to assess reservoir conditions.
- Monitor injection pressure and rate.
- Filter injection fluid and add corrosion inhibitors.
- Perform stimulation work to maintain injection capacity.

COMMON QUESTIONS ABOUT INJECTION WELLS

- Protection of shallow groundwater resources – will it impact my water supply?
- What about truck traffic, dust, noise, emissions?
- Is there potential for induced seismicity?
- Pore space conflicts – how does this impact pore space under my property?

LIMITED GROUNDWATER RESOURCES

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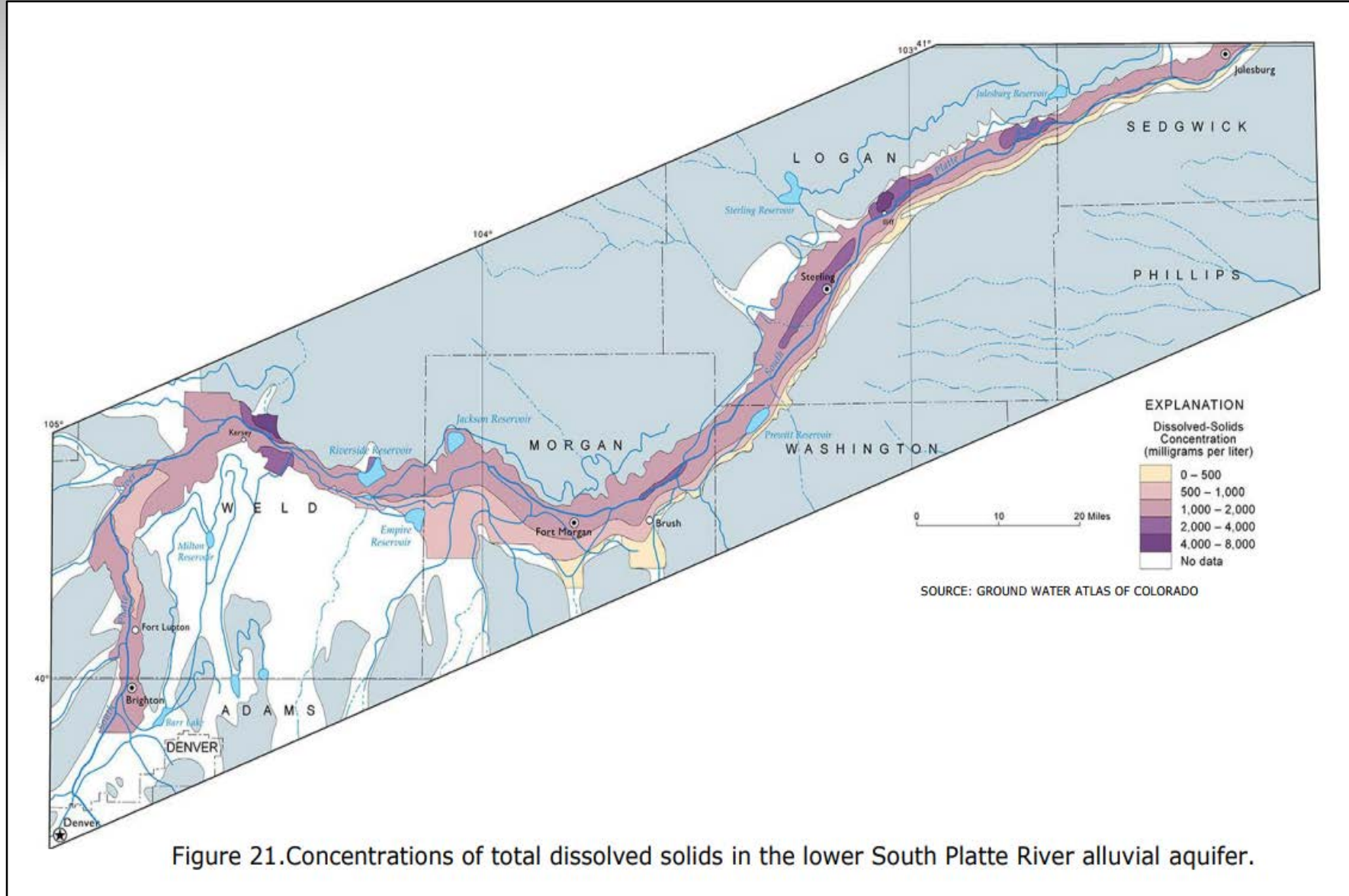
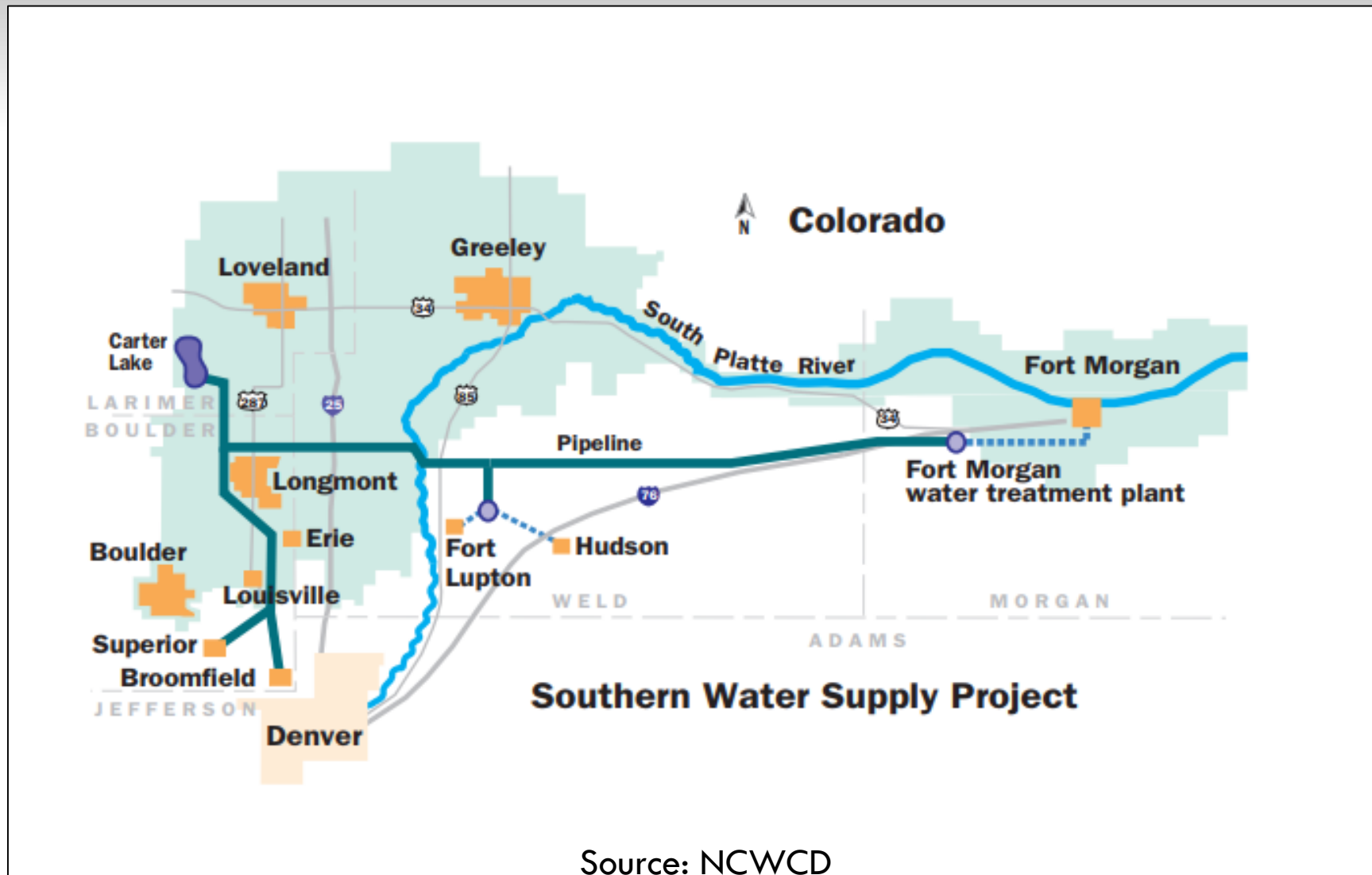


Figure 21. Concentrations of total dissolved solids in the lower South Platte River alluvial aquifer.

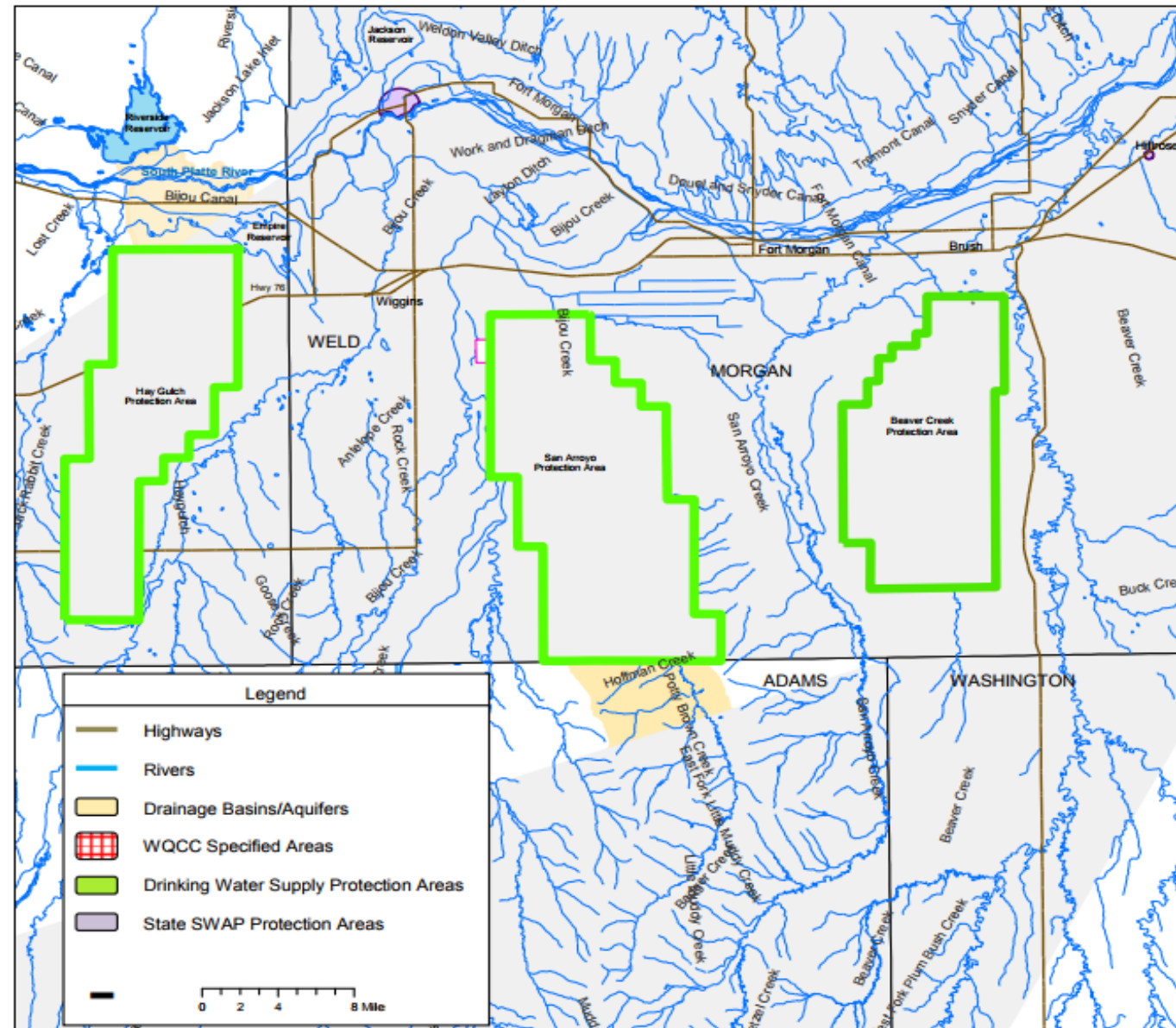
SUPPLY FROM NCWCD



FORT MORGAN WATER SUPPLY

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Figure 11. Map of the Delineated Source Water Protection Area

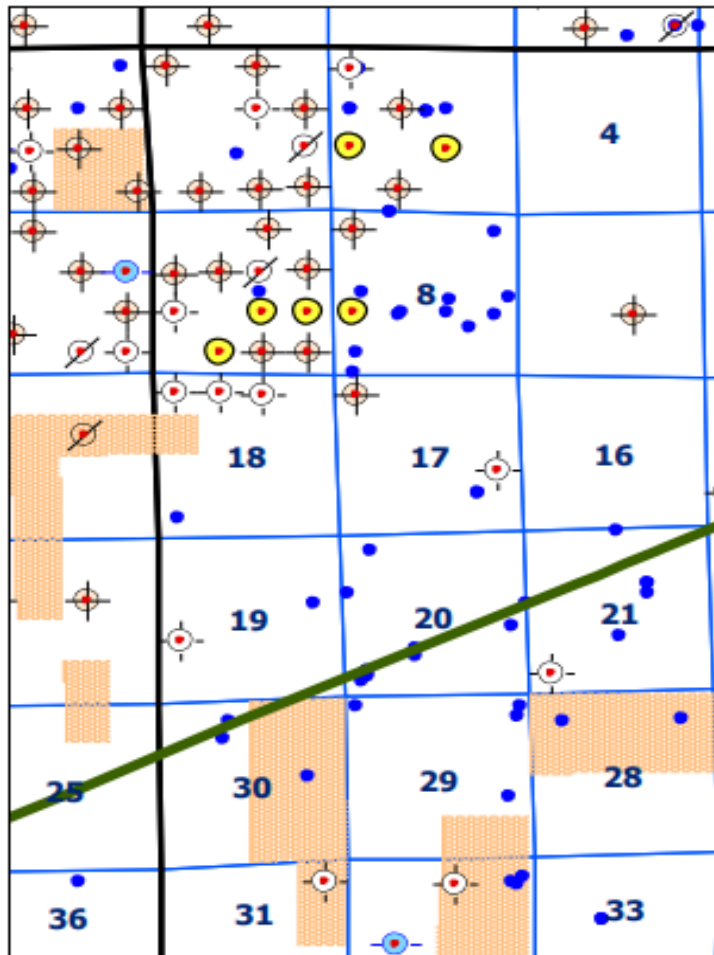


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EXISTING WATER SUPPLY AND OIL/GAS WELLS

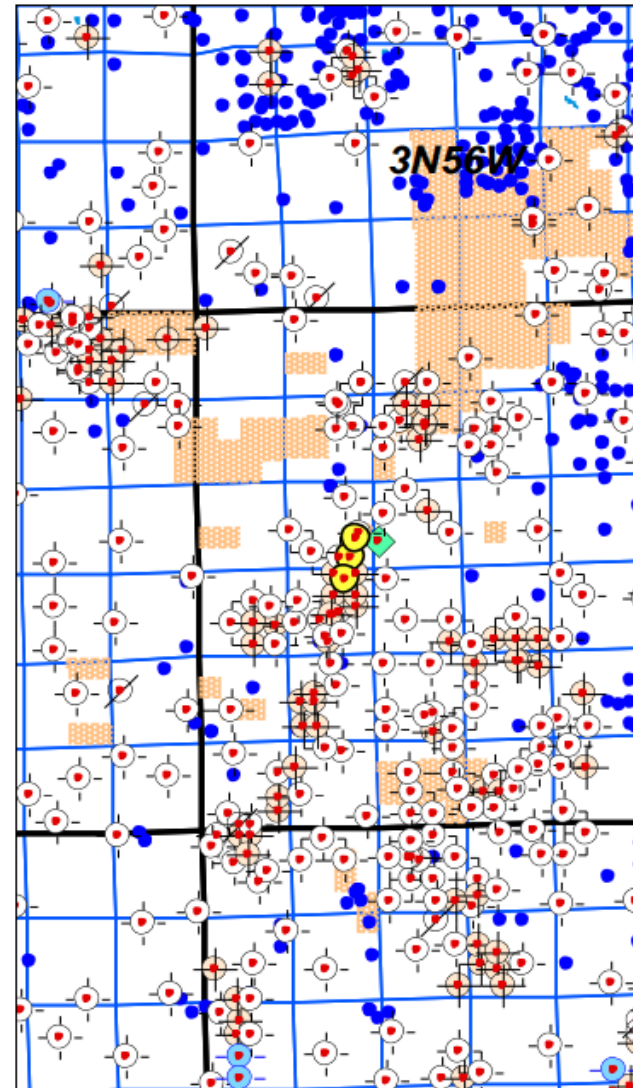
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Figure 18. Status of oil and gas wells within the upper Hay Gulch Source Water Protection Area



SOURCE: COLORADO OIL AND GAS CONSERVATION COMMISSION

Figure 20. Status of oil and gas wells within the Beaver Creek Source Water Protection Area



SOURCE: COLORADO OIL AND GAS CONSERVATION COMMISSION

Legend	
Oil/Gas Well Status	
	Producing
	Shut In
	Temporarily Abandoned
	Injection Well
	Plugged and Abandoned
	Dry and Abandoned
	Water Wells
	Federal Subsurface Rights

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PROTECTION OF GROUNDWATER RESOURCES: INJECTION WELL PERMITTING AND CONSTRUCTION

Injection wells are closely regulated and held to a higher standard than oil/gas wells

- Identify drinking water resources in permit application.
- Install surface casing to isolate GW resources; cement surface casing from TD to surface.
- Install protection casing to (1) further isolate GW and (2) isolate oil/gas zones.
- Install injection tubing to further isolate injection fluid.
- Monitor well operation to assure no leaks in tubing or casing.

HISTORIC OIL/GAS WELLS IN MORGAN COUNTY

- 2,858 historic oil/gas wells in Morgan County (producing, injection and plugged) (COGCC data).
- Salt water disposal (injection) wells are a key part of oil/gas drilling, completion and production operations.
- Local deep injection wells will reduce traffic, dust, emissions, and potential for ecological impacts (spills).
- Positive economic impacts (local employment and tax revenue).

SUMMARY

- Injection wells are a proven and effective technology for WW management.
- State UIC regulations are in place and CO has a mature program.
- Collaborative effort between County and State should consider:
 - Is GW adequately protected (State permitting issue)?
 - Is seismic monitoring warranted (State permitting issue)?
 - Have traffic and noise impacts been considered?
 - Do changes to road/traffic patterns need to be considered?
 - Are there limitations in traffic during harvest?
 - Does operations plan incorporate input from local Emergency Response personnel?
- Local outreach – community education regarding injection wells, permitting, safeguards, etc.

QUESTIONS/CONTACT INFORMATION

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