Stratigraphic Characterization of the Birds Nest Aquifer in the Uinta Basin, Utah: Updated Research Regarding the Aquifer's Potential as a Significant Saline Water Disposal Zone

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Project Web site: http://geology.utah.gov/emp/UBwater_study

Panel 1

ABSTRACT

During deposition of the upper Green River Formation in the late Eocene, Utah's Lake Uinta transitioned from a balanced-filled basin dominated by organic-rich, laminated marlstone, to an underfilled restricted basin. During this time, the saline mineral nahcolite formed within the deep-lake sediments (depocenter in central Uintah County) as isolated crystals, nodules ranging up to one foot in diameter, and beds ranging from less than an inch to 2 feet thick. Post-deposition, the saline mineral shortite was deposited in fracture zones several feet thick. More recently, the Birds Nest aquifer formed from the dissolution of these saline minerals and is targeted by natural gas producers as a potential saline water disposal zone.

Recently completed core descriptions, measured sections, and five newly constructed stratigraphic cross sections show that the total thickness of the Saline zone ranges from <100 feet on the basin's eastern and southern margins to >300 feet in the basin's depocenter. Only in the basin's depocenter, where the Birds Nest aquifer comprises two stratigraphic zones of dissolution each between ~40 and ~100 feet thick, is there potential for extensive saline water disposal. Ongoing research and monitoring programs seek to determine if these individual zones are hydraulically connected or if the Birds Nest as a whole is vertically connected via fractures/joints (possibly gilsonite veins) to other water-bearing zones both above and below.

Regional water sampling shows that the Birds Nest's water chemistry in the north (averaging >10,000 mg/L TDS and as high as 100,000 mg/L TDS) is distinct from that in the south (averaging <10,000 mg/L TDS and as low as about 1000 mg/L TDS). This abrupt change in water chemistry is most likely due to the differing amounts of saline mineral dissolution in the two areas; the southern area may have been flushed clean, whereas saline minerals in the northern area are still actively dissolving. The presence of intact nahcolite in the Utah State 1 core (section 26, T. 9 S., R. 21 E.) – on display with this poster – demonstrates that there are still zones of no dissolution north of the 10,000 mg/L TDS line. Just to the south of this well, the saline minerals in the Birds Nest show significant dissolution, as seen in the Utah State 13X-2 core (section 2, T. 10 S., R. 21 E.) – also on display. Separating these two areas is a prominent gilsonite vein that cross-cuts the Birds Nest aquifer. The northwest-trending gilsonite veins in the area seem to influence groundwater flow patterns in the Birds Nest by creating "channels" of dissolution and impermeable barriers to flow.

The Birds Nest aquifer's spatial and stratigraphic extent and variability, water chemistry, and zones of differential dissolution will determine possible saline water disposal volumes and safe disposal practices, both of which could directly affect the success of increased petroleum production and potential oil shale development in the region.

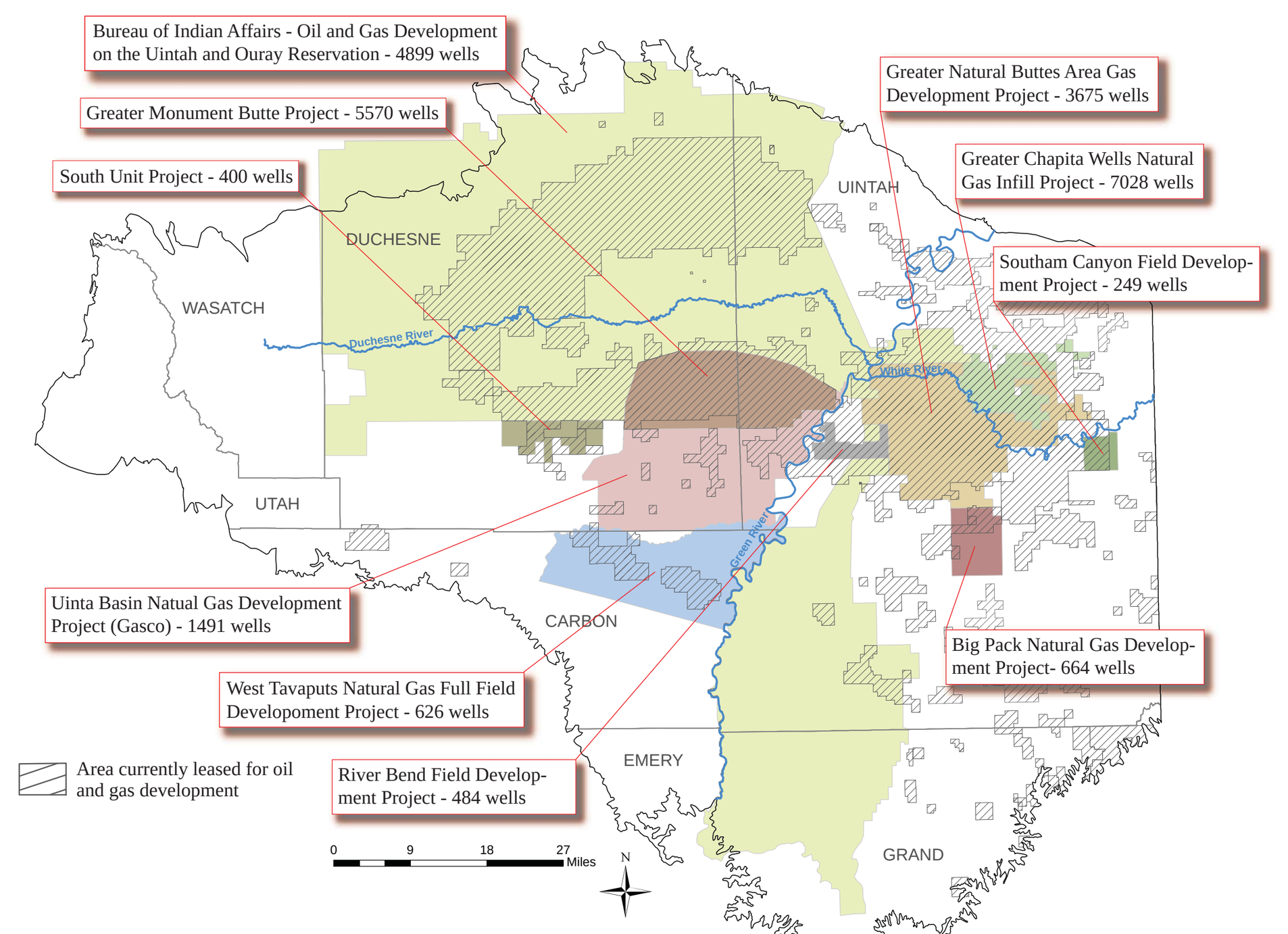
PROBLEM

The Birds Nest aquifer is poorly understood and needs further study to determine potential impacts of using this aquifer as a saline water disposal zone.

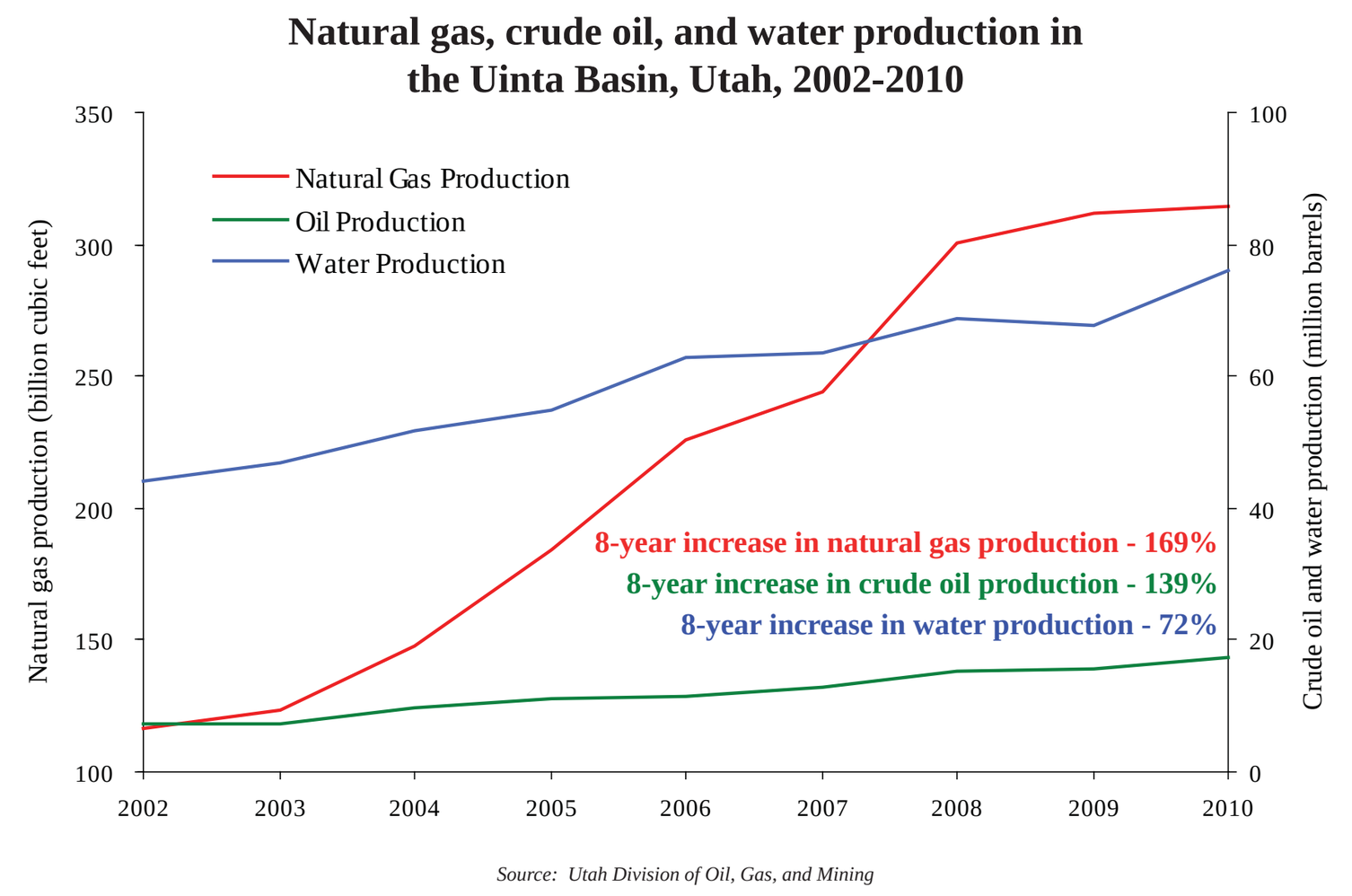
- What is the aquifer's areal and stratigraphic extent?
- How is this aquifer related to Utah's oil shale deposits?
- What causes the aquifer's differing zones of dissolution and salinity?

Eastern Uinta Basin natural gas producers have identified the Birds Nest aquifer, located in the Parachute Creek Member of the Green River Formation, as the most promising reservoir suitable for large-volume saline water disposal. This aquifer formed from the dissolution of saline minerals which left behind large open cavities and fractured rock. Understanding the aquifer's areal extent, thickness, water chemistry, and zones of differential dissolution will help determine possible saline water disposal volumes and safe disposal practices, both of which could directly impact the success of increased hydrocarbon production in the region.

The Birds Nest aquifer is typically several hundred feet above the richest oil shale interval called the Mahogany zone. A significant concern is that saline water disposal into the Birds Nest by conventional gas producers could hinder oil shale development by creating unforeseen water disposal problems.



Origin of the Birds Nest aquifer name, mud swallow nests in nahcolite cavities.



Source: Utah Division of Oil, Gas, and Mining

More than 25,000 oil and gas wells are currently proposed for drilling in the Uinta Basin

This future drilling will greatly increase the amount of produced water needing proper disposal

- West Tavaputs Natural Gas Full Field Development Project - 626 new wells - approved
- Uinta Basin Natural Gas Development Project (Gasco) - 1491 new wells - proposed, draft EIS
- Greater Natural Buttes Area Gas Development Project - 3675 new wells - proposed, draft EIS
- South Unit Oil and Gas Development Project - 400 new wells - proposed, draft EIS
- Greater Chapita Wells Natural Gas Infill Project - 7028 new wells - proposed, EIS in process
- Greater Monument Butte Project - 5570 new wells - proposed, EIS in process
- Bureau of Indian Affairs - 4899 new wells - proposed, EIS in process
- River Bend Field Development Project - 484 new wells - proposed, EA in process
- Big Pack Natural Gas Development Project - 664 new wells - proposed, EA in process
- Southam Canyon Field Development Project - 249 new wells - proposed, EA in process

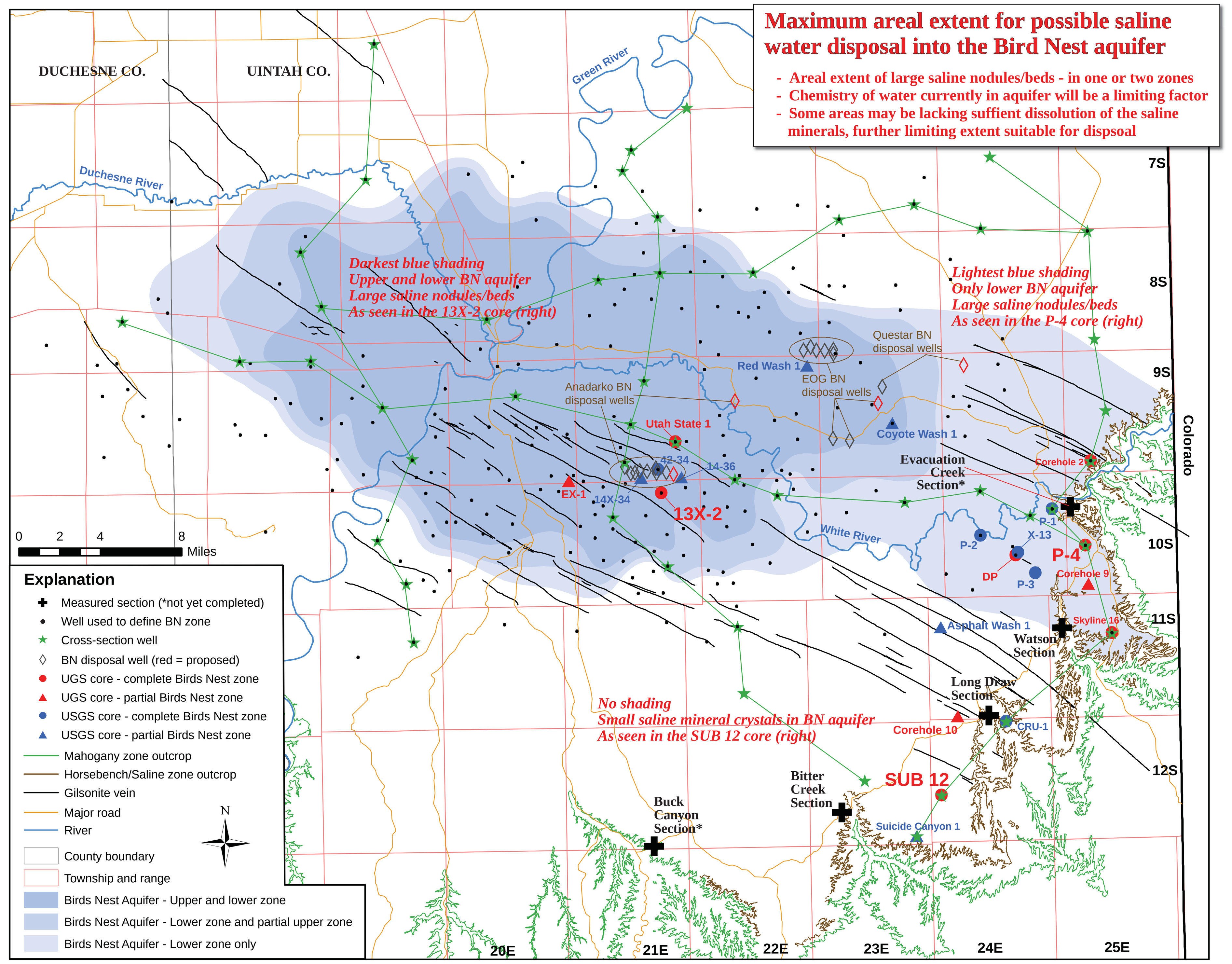
Source: U.S. Bureau of Land Management

RESEARCH / DELIVERABLES

- Conduct comprehensive literature review and historic data collection (finished, but not presented on this poster)
- Evaluate the Birds Nest aquifer in core:
  - 22 wells have been identified as having all or part of the Birds Nest captured in core; 21 of the 22 cores have been examined (The DP core was not examined becasue of its close proximity to the examined X-13 core) (see below)
- Evaluate the Birds Nest aquifer on outcrop:
  - Good outcrop exposures can be found on the southeastern side of the basin (3 measured sections have been completed (see map below), but are not presented on this poster)
- Evaluate the Birds Nest aquifer on geophysical logs (~330 wells examined, 5 regional cross sections completed, see map below)
- Determine how disposal into the Birds Nest aquifer could affect future oil shale development (ongoing)
- Determine how gilsonite veins might influence water flow and saline mineral dissolution (see panel 2)
- Create a GIS database and maps showing:
  - Outcrop (see map below)
  - Thickness (see maps below and right)
  - Lateral extent (see map below)
  - Water quality (see panel 2)
  - Interburden between Birds Nest and "economic" oil shale zones (see panel 2)

Maximum areal extent for possible saline water disposal into the Bird Nest aquifer

- Areal extent of large saline nodules/beds - in one or two zones
- Chemistry of water currently in aquifer will be a limiting factor
- Some areas may be lacking suffient dissolution of the saline minerals, further limiting extent suitable for dispsoal

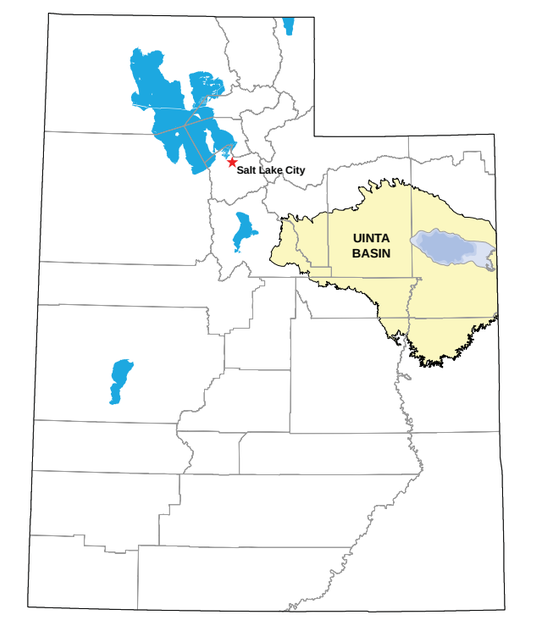


RESULTS: SPATIAL EXTENT AND THICKNESS

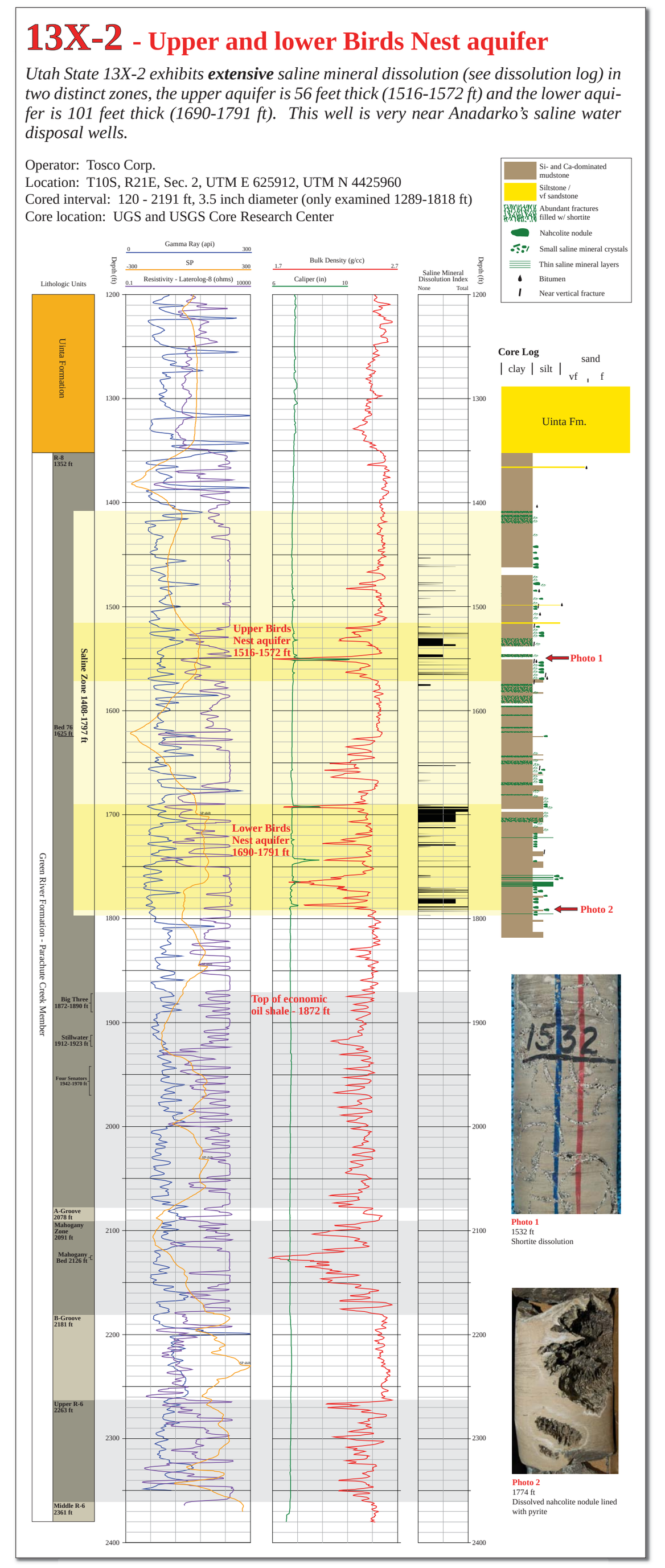
Research methods: Core, outcrop, and geophysical log examinations

The Saline zone is nearly 400 feet thick in the basin's paleo-depocenter. Within the Saline zone, the Birds Nest aquifer is separated into an upper and lower zone where dissolution of the saline minerals has created significant porosity and permeability for the transmission of water (see 13X-2 core log). The large saline mineral nodules and beds in the paleo-depocenter are recorded as spikes to low density on geophysical logs. To the east, the upper zone disappears and only the lower zone exists (as seen in the P-4 core). Radiating out from the depocenter, the Saline zone thins to ~130 feet and contains much smaller saline mineral crystals (<1 inch) as compared to the large (up to 1 foot) nodules found near the basin's center, and the bulk density signature is lost (there is still a zone of dissolution in the lower portion of the Saline zone which could transport water and is roughly equivalent to the lower Birds Nest zone found in the basin's center). This transition is confirmed to the south where cores and outcrop exposures are present (see SUB 12 core log). It is presumed that the same transition to small saline crystals exists to the north and west, but no cores exist to confirm this suspicion.

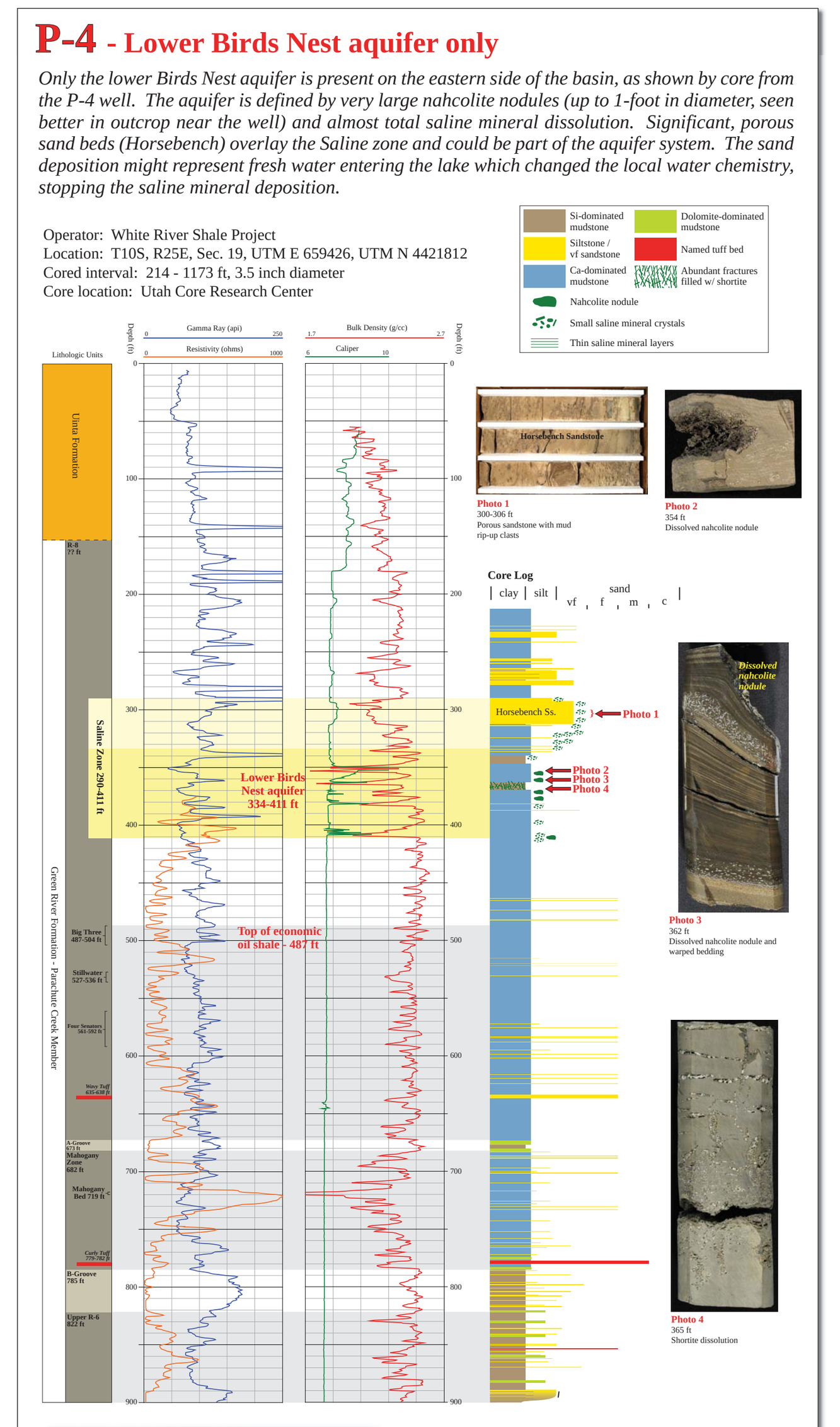
- **Highlight:** Using geophysical logs, UGS has mapped the spatial extent and thickness of the Birds Nest aquifer where large nodules exist in both an upper and/or lower zone. This represents the maximum area with potential for saline water disposal, but only where water currently within the zone is greater than 10,000 mg/L TDS and where saline mineral dissolution has already taken place.



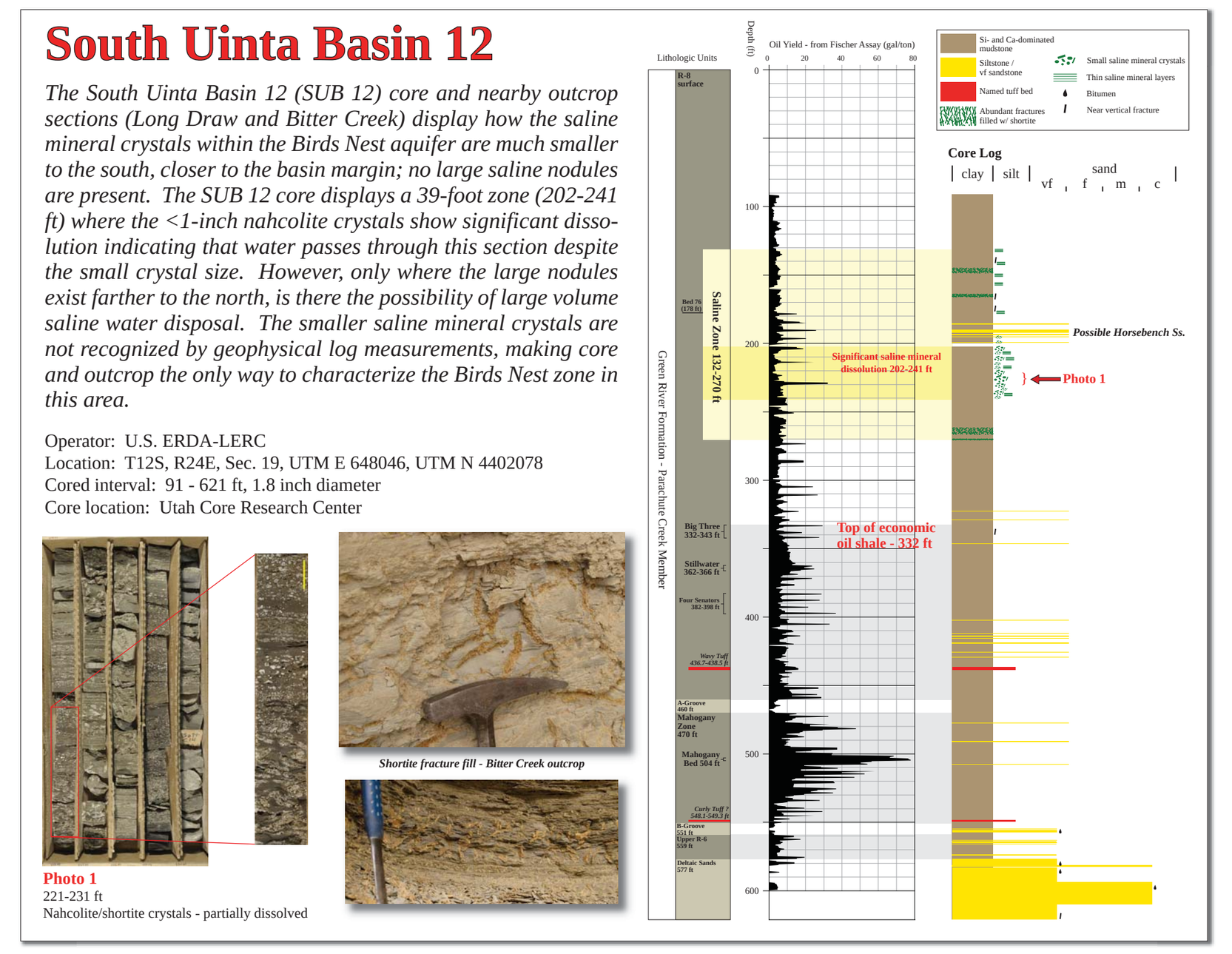
13X-2 - Upper and lower Birds Nest aquifer



P-4 - Lower Birds Nest aquifer only

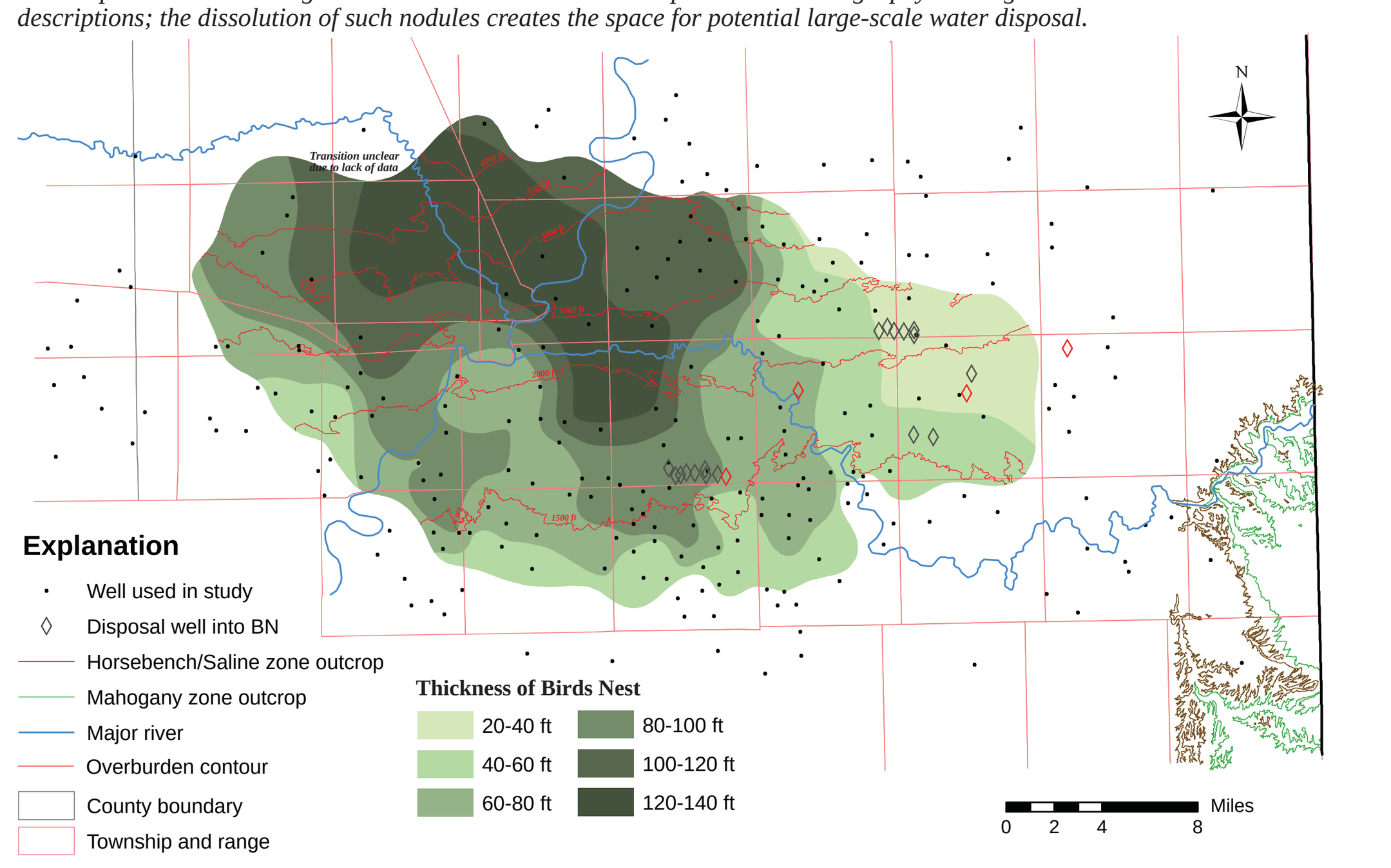


South Uinta Basin 12



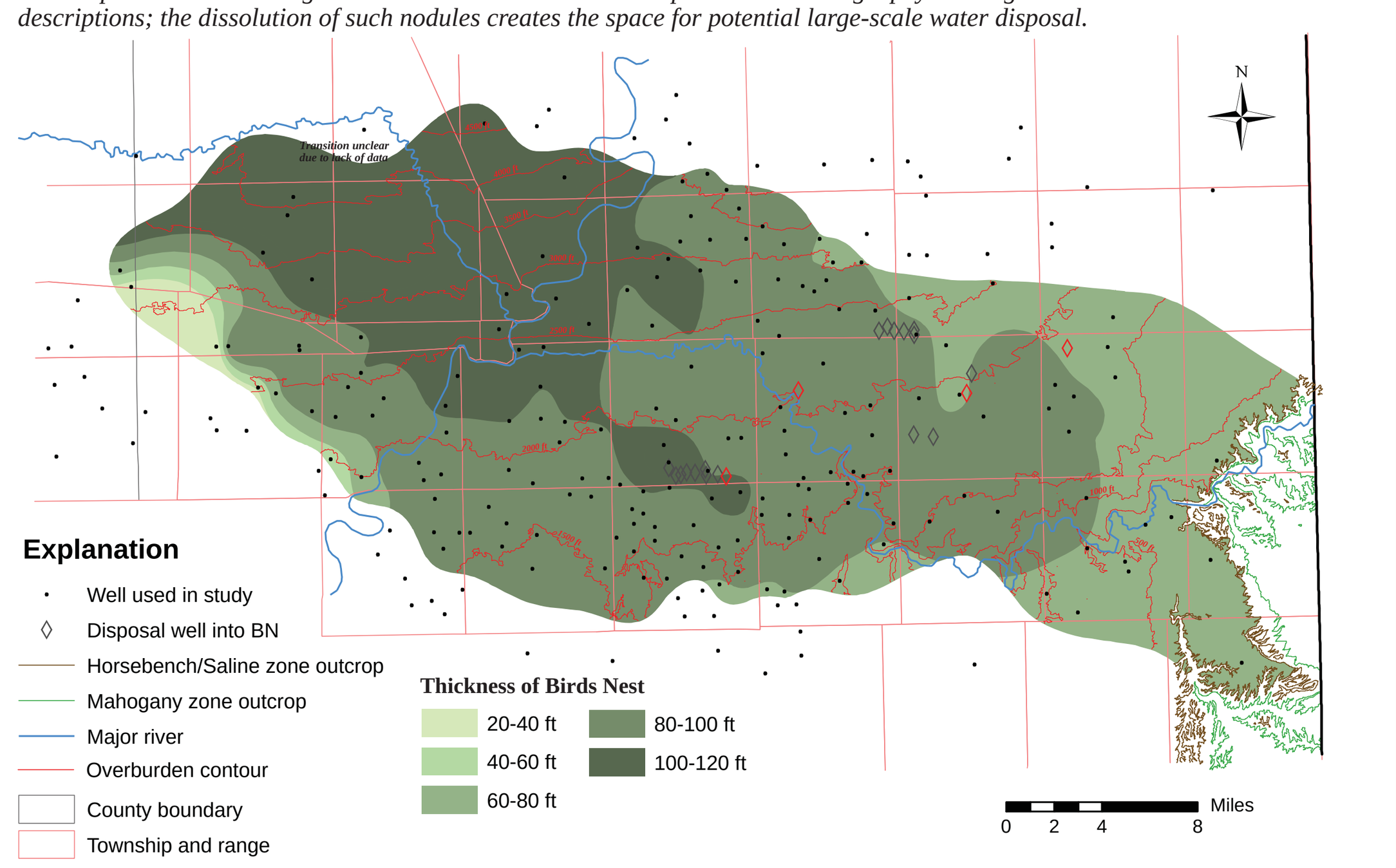
Upper Birds Nest Aquifer Isopach

This map records where large saline mineral nodules/beds are present based on geophysical logs and core descriptions; the dissolution of such nodules creates the space for potential large-scale water disposal.



Lower Birds Nest Aquifer Isopach

This map records where large saline mineral nodules/beds are present based on geophysical logs and core descriptions; the dissolution of such nodules creates the space for potential large-scale water disposal.



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