Exhibit 334/434

Offered by

Cheyenne River Sioux Tribe and Oglala Sioux Tribe

for

Contested Case Hearing in the Matter of Clean Nuclear Energy Corp.
Uranium Exploration Permit Application
EXNI 453

Risk Factors Regarding the Clean Nuclear Energy Corp. Uranium Exploration Permit Dated March 11, 2024

Prepared on behalf of

Cheyenne River Sioux Tribe and
Oglala Sioux Tribe

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RISK FACTORS REGARDING THE
CLEAN NUCLEAR ENERGY CORP.
URANIUM EXPLORATION PERMIT
DATED MARCH 11, 2024

Topsoil Handling

Plan

- The plan does not address topsoil handling as part of site disturbance or reclamation.
- The plan indicates that procedures contained in NRCS CPS 342 will be followed for site reclamation. This standard indicates that a "minimum topsoil dressing of six inches [should] be applied" as a seedbed.

Comments/Recommendations (Based on my experience as well as UDOGM Soils Guidelines[1]; NRCS CPS 342[2]):

- I recommend that all topsoil (the complete A horizon or six inches, whichever is greater) be stripped from pads and routes of ingress and egress prior to any other disturbance.
- The salvaged topsoil should be stored in an area that will not be impacted by site operations. Silt fences, straw wattles, berms, and/or other suitable erosion control materials should be installed at the base of all topsoil stockpiles.
- The plan, as updated, indicates that 38 exploration holes will be drilled, each hole requiring up to 2 weeks to drill. Thus, the exploration project may last up to about 18 months. To protect the topsoil stockpiles from wind and water erosion, I recommend that all topsoil stockpiles be seeded with a rapid-growing cover crop (e.g., triticale)[3] immediately after stockpiling. This vegetation can be incorporated into the topsoil as a green manure soil amendment during redistribution.

Site Sediment Control

Plan

- The plan does not address sediment control during exploration operations.
- In his November 2025 deposition, Michael Blady indicated that the site is "very flat. We're expecting none to extremely limited amounts of surface erosion. . . We're drilling on a flat grazing pasture."
- With respect to erosion from rainfall or snowmelt, Mr. Blady indicated in his November 2025 deposition that the area is "flat so it's going to percolate into the ground or evaporate. . . Most likely if it's raining too hard or there's too much snow, we'll immediately shut down operations and wait for the conditions to improve."
- These comments from Mr. Blady suggest that erosion control is a low priority for the drilling project.

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[1] Utah Division of Oil, Gas and Mining. 2021. Guidelines for Management of Topsoil and Overburden. Salt Lake City, Utah. Available at https://ogm.utah.gov/wp-content/uploads/2023/06/soilsguidev2.pdf.

[2] U.S. Natural Resources Conservation Service. 2016. Conservation Practice Standard: Critical Area Planting, Code 342. U.S. Department of Agriculture. Washington, D.C. Available at https://www.nrcs.usda.gov/sites/default/files/2022-09/Critical_Area_Planting_342_CPS.pdf.

[3] https://extension.sdstate.edu/extend-grazing-season-cover-crops

- In his 2 Jan 2026 affidavit, Michael Blady committed to implementing "erosion control as needed" but did not expound on that concept.

Comments/Recommendations

- The ground within the planned area of exploration slopes generally to the southwest and to the south, depending on the location. Based on data obtained from Google Earth, ground slopes at the site average 3.4% from the north-central to the southwest and 6.0% from the north-central to the south-central areas of the site. These slopes are not "flat" as Mr. Blady stated.
- Data downloaded from the U.S. Natural Resources Conservation Service ("NRCS") Web Soil Survey (see Attachment A) indicate that soil in the northwestern portion of the exploration area has a moderately high runoff potential (i.e., Hydrologic Soil Group "C"). These data also indicate that soil in the southeastern portion of the exploration area (where slopes are steepest) has a high runoff potential (Hydrologic Soil Group "D").
- NRCS data (Attachment A) indicate that most of the soil in exploration area has a moderate to severe erosion potential as evidenced by the Road and Trail Erosion Hazard. This conclusion is supported by the moderate to high K Factors[4] for most of the soils in the proposed exploration area (attachment A). Furthermore, NRCS data (Attachment A) indicate that nearly one-third of the proposed exploration area (primarily in the southeast portion of the area) is moderately to highly susceptible to degradation due to wind and water erosion.
- Data downloaded from the NRCS Web Soil Survey (Attachment A) indicate that soils in the area have a high wind erosion potential (48 to 86 tons/acre/yr). Unless disturbed areas are properly controlled, substantial wind erosion of the disturbed soils and radioactive drill cuttings could occur.
- Taken together, the slope steepness, runoff potential, and erosion potential indicate that the soil within the exploration area should be managed as though it is moderately to highly erodible.
- SDCL 45-6D-37 requires that "all roads and trails developed for the uranium exploration project [shall be constructed] to minimize sedimentation and erosion by the placement of water bars and similar structures, road placement on the contour, revegetation of the roadwork and embankment slopes, or by using other necessary methods." Specific methods to minimize sedimentation and erosion must be addressed in the plan, not only for roads and trails but also for drill pads.
- The South Dakota Department of Agriculture and Natural Resources requires that a stormwater permit be obtained for all construction activities where the total area of disturbance is over one acre[5]. The revised permit application indicates that up to 38 drill pads will be constructed, with each drill pad occupying 0.08 acre, resulting in a total drill-pad disturbance of 3.04 acres. Off-road access routes will create additional disturbance. Thus, it will be necessary for CNEC to obtain a stormwater permit.
- Stormwater permits require the preparation of a stormwater pollution prevention plan ("SWPPP")[6]. Although it is not necessary to submit a SWPPP for agency approval prior to

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[4] Soil erosion is typically quantified using the Universal Soil Loss Equation. In that equation, the inherent erodibility of a soil is addressed with the K Factor. Soils increase in erodibility as the value of K increases. K Factors range from 0.02 to 0.69 and are generally classified as follows: <0.20: low erodibility; 0.20-0.40: moderate erodibility; >0.40 high erodibility (see http://www.iwr.msu.edu/rusle/kfactor.htm#)

[5] See https://danr.sd.gov/OfficeOfWater/SurfaceWaterQuality/stormwater/StormWaterConstruction.aspx

[6] See https://www.epa.gov/system/files/documents/2022-01/swppp-template.docx

site disturbance, the plan must be prepared at least 15 days prior to site disturbance and must be available for agency review upon request. I am not aware of a SWPPP having been prepared yet for the exploration project.

- An adequate SWPPP should include provisions to control runoff and sediment from all disturbed areas. Control measures should include the proper installation of wattles, silt fences, and/or berms at the downstream edges of all disturbed areas. These control measures should be installed prior to site disturbance and remain in place until the associated disturbed area is regraded and revegetated with an adequate stand of vegetation.

Extent of Post-Exploration Regrading

Plan (see permit application page 3, item 1):

- "The pad will be recontoured (if needed . . ."
- "Drill sites will be recontoured to eliminate excessive rutting regardless of the pre-project condition."
- "Pits will be backfilled with excavation materials and any excess materials spread evenly on the pad."
- "Overly compacted areas at the drill sites that are not located in an active roadbed will be roughed either manually or mechanically to enhance seeding viability and minimize erosion."

Comments/Recommendations (see UDOGM Soils Guidelines; NRCS CPS 342):

- The plan commits to regrading of disturbed areas but does not provide details with respect to regrading.
- To minimize long-term impacts in light of the potential for high erosion due to wind and water, I recommend that all disturbed areas, including off-road travel routes, drill pads, and mud pits, should be regraded within 2 weeks of the end of necessary access to those areas. Final grading of a disturbed area should be to the approximate original contour of the area (see SDCL 45-6D-38).
- Data downloaded from the NRCS Web Soil Survey indicate that soils in the area of the proposed exploration activities are moderately to highly susceptible to soil compaction (see Attachment A). Hence, it should be assumed that all disturbed areas are "overly compacted." During regrading, I recommend that all disturbed areas be ripped along the contour of the slope to a depth of at least 2 feet. The distance between rippers should be approximately equal to the depth ripped. The ripper should be lifted from the soil every 10 to 20 feet to reduce the chance of creating long water pathways subject to erosion.
- Following regrading and ripping, topsoil salvaged from that area should be evenly spread over the regraded areas. Topsoil should be spread with tracked equipment to preclude over-compaction. The topsoil should then be mulched and revegetated with the appropriate seed mix.

Mulching

Plan

- The plan does not directly address mulching as part of site reclamation.

- The plan indicates that procedures contained in NRCS CPS 342 will be followed. This standard indicates that mulch should be applied "where practical." However, no specific plans are noted for mulch application.

Comments/Recommendations (NRCS CPS 484[7] and 543[8]):

- In my experience, soil organic matter is critical to revegetation success. Organic matter increases water retention, improves soil structure, decreases wind and water erosion, and improves plant productivity and health by improving the chemical and biological properties of soil.
- As a general rule of thumb, a minimum soil organic matter content of 3% is considered necessary for disturbed-land reclamation, with 5% to 6% often cited as an optimal target[9]. Data obtained from the NRCS Web Soil Survey (Attachment A) indicate that the natural organic matter content of soils in the area of planned exploration is 1.5 to 2.0%. Furthermore, the NRCS data indicate that natural soils in the area have a moderately high to high risk of organic matter depletion (see Attachment A). Thus, the addition of organic matter to the soil will be critical to successful reclamation of areas disturbed by exploration activities.
- I recommend that shredded weed-free alfalfa or grass hay be uniformly applied to reclaimed sites following application of the revegetation seed mix. The mulch should be applied at a rate of at least 2 tons per acre, ensuring that the mulch materials cover at least 90% of the prepared soil surface.
- Data downloaded from the NRCS Web Soil Survey (Attachment A) indicate that soil in the exploration area is moderately to highly erodible from wind action. Thus, the mulch should be crimped or otherwise incorporated into the soil to minimize loss due to wind.

<u>Protection of Revegetated Areas</u>

Plan

- The permit application does not address protection of reclaimed areas from livestock and wildlife prior to adequate establishment of vegetation.
- In his 6 Nov 2025 deposition, Mr. Blady indicated that the land on which the exploration activities are planned is used for livestock grazing and wildlife.
- NRCS CPS 342 states that revegetated areas "shall be protected from pests (e.g., weeds, insects, diseases, livestock, or wildlife) as necessary to ensure long-term survival."

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[7] U.S. Natural Resources Conservation Service. 2017. Conservation Practice Standard: Mulching, Code 484. U.S. Department of Agriculture. Washington, D.C. Available at https://www.nrcs.usda.gov/sites/default/files/2022-09/Mulching_CPS_484_Oct_2017.pdf.

[8] U.S. Natural Resources Conservation Service. 2017. Conservation Practice Standard: Land Reclamation, Abandoned Mined Land, Code 543. U.S. Department of Agriculture. Washington, D.C. Available at https://www.nrcs.usda.gov/sites/default/files/2022-09/Land_Reclamation_Abandoned_Mined_Land_543_NHCP_CPS.pdf.

[9] See https://www.researchgate.net/post/What-is-the-optimal-amount-of-organic-matter-in-agricultural-soil. See also Loveland, P. and J. Webb. 2003. Is there a critical level of organic matter in the agricultural soils of temperate regions: a review. Soil & Tillage Research. Vol. 70, Issue 1, pp 1-18. Available at https://www.sciencedirect.com/science/article/abs/pii/S0167198702001393.

Comments/Recommendations (NRCS CPS 342; USFS RMRS-GTR-136[10]):

- Multiple authors recommend a minimum of 2 years of non-grazing following revegetation of rangeland[11]. Excluding livestock from the reclaimed sites will require either fencing (the entire site or individual disturbed areas) or restricting all livestock access from the site during the period of exclusion.
- SDCL 45-6B-45(2) states that "No grazing may be permitted on reclaimed land until the planting is firmly established. The board, in consultation with the landowner and the local conservation district, if any, shall determine when grazing may start." Although this rule does not directly apply to uranium exploration in South Dakota, the concept is valid for any land reclamation in the State.
- CNEC should provide a plan for excluding livestock from revegetated areas. As a minimum, this plan should include a discussion of the exclusion measures that will be implemented, methods and timetables for monitoring vegetative success, criteria for determining when exclusion efforts are no longer necessary, and decision criteria to determine if revegetation success criteria have been met.

Integrity of Backfilled Mud Pits

Plan

- The permit application states that mud pits will be "backfilled with excavation materials" but does not commit to compaction of those materials.

Comments/Recommendations

- The materials must be compacted during backfilling to ensure the structural integrity of the site soils.
- Based on my experience, I recommend that the soil be compacted in lifts no thicker than 12 inches (loose thickness) to a minimum of 95% of standard Proctor density.
- A minimum of one density test should be performed in each backfilled mud pit. If that test fails, all backfill in that pit should be re-compacted and re-evaluated to ensure proper compaction.
- Only the final topsoil layer should be left in an uncompacted state.

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[10] Monsen, S.B., R. Stevens, and N.L. Shaw. 2004. Restoring Western Ranges and Wildlands. General Technical Report RMRS-GTE-136. U.S. Forest Service, Rocky Mountain Research Station. Available at https://research.fs.usda.gov/treesearch/7377.

[11] See, for example, Sanders, K.D. 2000. How Long Should Rangelands be Rested from Livestock Grazing Following a Fire? Rangeland Center Collection, University of Idaho Digital Collections. Pocatello, ID. Available at How Long Should Rangelands Be Rested from Livestock Grazing Following a Fire? | Rangeland Center Collection.
See also Fedrigo, J.K., P.F. Ataide, J.A. Filho, L.V. Oliveira, M. Jaurena, E.A. Laca, G.E. Overbeck, and C. Nabinger. 2018. Temporary Grazing Exclusion Promotes Rapid Recovery of Species Richness and Productivity in a Long-Term Overgrazed Campos Grassland. Restoration Ecology. Vol. 26, No. 4, pp. 677-685. Available at https://onlinelibrary.wiley.com/doi/10.1111/rec.12635.

Reclamation Bond

Plan

- The plan calls for CNEC to post a surety bond with the State of South Dakota, based on estimated reclamation costs of $2,400/drill pad and $25/m of borehole.

Comments/Recommendations

- Based on my experience, the estimated cost for hole plugging is reasonable.
- However, the bond amount for surface reclamation is insufficient and should be increased to at least $5,370/drill pad (see Attachment B).
- Since the CNEC permit application does not provide details regarding their reclamation cost estimate, the reason for the discrepancy between their estimate and my estimate is unclear.

Protection from Long-Term Radiation

Plan

- The permit application indicates that "Drill fluids will be contained in recirculation pits to allow solids to settle and fluids to infiltrate/evaporate. Pits will be backfilled with excavation materials and any excess materials spread evenly on the pad."
- During his November 2025 deposition, Michael Blady indicated that the uranium concentration of the drill cuttings would be "very low, . . . less than a thousand ppm typically." This is equivalent to 1,000 mg/kg.

Comments/Recommendations

- Uranium-contaminated drill cuttings will be brought to the surface during drilling.
- The current Regional Screening Levels published by the U.S. Environmental Protection Agency[12] for uranium are as follows (based on a target cancer risk of 1E-06 and a target hazard quotient of 1.0):
    - Residential soil level = 16 mg/kg
    - Industrial soil level = 230 mg/kg
    - Risk-based soil-to-groundwater level = 1.8 mg/kg
    - MCL-based soil-to-groundwater level = 14 mg/kg
- Thus, cuttings with a uranium concentration of 1,000 mg/kg will represent a potential hazard to humans, particularly if left exposed and potentially if left in the recirculation pits in a manner that does not minimize infiltration potential.
- Soil placed into the recirculation pits should be compacted as outlined above to minimize the potential for infiltration of water through the uranium-impacted cuttings that remain in the pits.
- An ecological risk assessment should be conducted to determine target concentrations that are considered protective of livestock and wildlife.
- All areas disturbed by exploration activities, as well as adjacent areas, should be scanned for gamma radioactivity as well as uranium and radium-226 soil concentrations prior to and following the completion of exploration activities. Radium-226 should be included in the assessment because it is a product of uranium decay. Any area where radiation levels, uranium concentrations, and/or radium-226 concentrations exceed pre-disturbance levels

[12] Dated November 2024. Available at https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables.

should be remediated. Remediation standards should be justified based on pre-disturbance levels and/or typical State and Federal standards.
- Radon emanation from the closed mud pits should be monitored to ensure that these levels are protective of human health and the environment.

Spill Prevention and Control

Plan
- The permit application does not address the prevention and control of petroleum hydrocarbon spills.
- In their 21 Feb 2025 comment letter, SHPO requested that fuel storage areas should be lined and bermed. They also requested that spill containment materials be maintained on site.
- Michael Blady committed to appropriate spill control in his 2 Jan 2026 affidavit.

Comments/Recommendations
- These commitments should be formalized into the permit application or another document submitted to a regulatory agency with the authority to require implementation.
- Spill prevention and control measures implemented during exploration activities should comply with the requirements of the U.S. Environmental Protection Agency as promulgated in 40 CFR 112.

Groundwater Protection

Plan
- The permit application acknowledges that “The drill holes are planned to penetrate the lnyan Kara Group rocks, which are water-bearing units or aquifers in some locations of the Black Hills.”
- The permit application commits to plugging the holes in accordance with South Dakota requirements.
- Mr. Blady appears to focus only on the impacts of grouting operations with respect to the potential impacts to groundwater from exploration activities (see his 2 Jan 2026 affidavit as well as his deposition).
- In his deposition, Mr. Blady expresses his opinion that groundwater in the Inyan Kara Group is of “poor quality.” He opines that it is “highly [naturally] contaminated with sulfates, total dissolved solids, radionuclides” and that “sulfates and total dissolved solids [concentrations in the groundwater] render the aquifer unusable, nonpotable.”
- When asked if CNEC was planning to take any precautions to prevent contamination of the aquifer as a result of exploration activities other than using bentonite as the drilling mud and then plugging the holes with bentonite and/or cement following drilling, Mr. Blady replied: “Potentially, but not at this time.” When pressed for information regarding available options to prevent exploration-related contamination of the aquifer, Mr. Blady replied: “sampling the water is a good way to prevent and using bentonite and plugging the hole.”

Summary of Published Reports

- The map and associated report prepared by Gott and Schnabel (1963)[13] show the following:
  - A fault passes through the southeast portion of the proposed exploration area. The displacement of this fault is approximately 30 feet.
  - Several faults with displacement of less than 100 feet exist in the region. These faults formed during the Black Hills uplift.
  - Faulting in the region also occurred due to subsidence following solution of underlying carbonate rocks.
- Bowles (1968)[14] reported the following:
  - Groundwater quality in the southern Black Hills (i.e., the area of the proposed CNEC exploration program) undergoes natural geochemical evolution as it flows along fractures "formed by recurrent structural deformation along northeast-trending Precambrian fault zones."
  - Bowles (1968) specifically identifies the Long Mountain structural zone as a fault zone where groundwater changes from a sodium sulfate water to a sodium bicarbonate water "as a result of intense reduction of sulfate and accompanying chemical reactions."
  - Bowles (1968) postulated that this chemical evolution occurs where "rapid circulation of artesian water from the [underlying] Minnelusa" Formation occurs. He indicated that this is common on the upthrown or north block of the Dewey structural zone and the Long Mountain structural zone. The area of the proposed CNEC exploration is on the north (upthrown) block of the Long Mountain structural zone.
- Keene (1973)[15] reported the following:
  - The Fall River Formation (representing approximately the upper third of the Inyan Kara Group) "is the largest producing aquifer in western Fall River County. Most of the wells obtaining water from this formation are located upstream from Edgemont within the Cheyenne River valley."
  - The Lakota Formation (representing approximately the lower two-thirds of the Inyan Karas Group) "is the second largest producing aquifer in the area."
  - "Yields obtained from the Lakota aquifer are generally a little better than the Fall River Formation. Most yields from the Lakota ranged from 10 to 30 g.p.m. ["gallons per minute"]."
- The maps and associated report prepared by Gott et al. (1974)[16] indicate the following:
  - The upper part of the Lakota Formation consists of a siltstone, mudstone, and shale layer known as the Fuson Member of the Lakota Formation.

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[13] Gott, G.B. and R.W. Schnabel. 1963. Geology of the Edgemont NE Quadrangle, Fall River and Custer Counties, South Dakota. U.S. Geological Survey Bulletin 1063-E. Reston, VA.
[14] Bowles, C.G. 1968. Theory of Uranium Deposition from Artesian Water in the Edgemont District, Southern Black Hills. Pp. 125-130 *in* Black Hills Area: South Dakota, Montana, Wyoming; 20th Field Conference Guidebook. Wyoming Geological Guidebook. Cheyenne, WY.
[15] Keene, J.R. 1973/ Ground-Water Resources of the Western Half of Fall River County, South Dakota. Report of Investigations No. 109. South Dakota Geological Survey. Science Center, University of South Dakota, Vermillion, SD.
[16] Gott, G.B., D.E. Wolcott, and C.G. Bowles. 1974. Stratigraphy of the Inyan Kara Group and Localization of Uranium Deposits, Southern Black Hills, South Dakota and Wyoming. U.S. Geological Survey Professional Paper 763. Washington, D.C.

- The area of proposed exploration is located within the Long Mountain structural zone.
  - Sedimentary rocks in this area (including the Inyan Kara Group) "were repeatedly deformed along northeast trends during the Mesozoic Era and the Laramide orogeny. This deformation . . . is most evident in the Dewey and Long Mountain structural zones, where mild structural adjustments affected deposition of the Inyan Kara Group prior to faulting that displaced the Inyan Kara."
  - The Long Mountain structural zone is described as a zone of "intense fracturing and (or) faulting."
  - Pre-historic drainage patterns in the southern Black Hills were primarily to the northwest. However, the dominance of the Long Mountain and Dewey structural zones was such that this drainage pattern was diverted to the northeast in that zone.
  - Breccia pipes are common on the uplifted (i.e., north) side of faults in the Long Mountain structural zone. The area of planned exploration is on the north side of the fault that passes through the southeast portion of the proposed exploration area, suggesting that breccia pipes may be common in the area of proposed exploration.
  - Breccia pipes provide a shorter path for artesian groundwater to rise to the surface and/or spread laterally. These breccia pipes extend upward from the Minnelusa Formation and permit large volumes of artesian water to ascend into the Inyan Kara Group.
- As part of a detailed study of the uranium potential of the Inyan Kara Group, Dandavati and Fox (1980)[17] noted the following:
  - Uranium deposits in the Black Hills "generally occur as elongate tabular lenses and pods in the host sandstone."
  - "In plan view, tongues of oxidation [behind which uranium was deposited] protrude in the direction of water movement, mainly along zones of more porous and permeable sandstones."
  - "Uranium and other metals which are carried in the oxidizing ground water are precipitated as [geochemical conditions change from oxidizing to reducing]. Other metals precipitated include selenium, vanadium, and molybdenum."
  - "Most of the uranium deposits in the southern Black Hills occur in porous and permeable channel sandstones in the Lakota and Fall River Formations.
  - an area on the southeast flank of the Black Hills, about 25 miles east-northeast of the area of proposed drilling
- Based on long-term pumping tests conducted on wells completed in the Lakota Formation and the Fall River Formation (the approximate lower two-thirds and upper one-third of the Inyan Kara Group, respectively) at a location approximately 14 miles northwest of the proposed CNEC exploration area, Boggs and Jenkins (1980)[18] concluded the following:

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[17] Dandavati, K.S. and J.E. Fox. 1980. Sedimentology and Uranium Potential of the Inyan Kara Group, Near Buffalo Gap, South Dakota: Final Report. National Uranium Resource Evaluation Report GJBX-66(81). Prepared for the U.S. Department of Energy, Grand Junction Office, Colorado. Report published by South Dakota School of Mines and Technology. Rapid City, SD.

[18] Boggs, J.M. and A.M. Jenkins. 1980. Analysis of Aquifer Tests Conducted at the Proposed Burdock Uranium Mine Site, Burdock. South Dakota. Report No. WR28-1-520-109. Tennessee Valley Authority, Office of Natural Resource, Division of Air and Water Resources, Water Systems Development Branch. Norris, TN.

- “The Fall River and Lakota formations which form the Inyan Kara Group are the principal aquifers in the region.”
- “The two aquifers are hydrologically connected via (1) general leakage through the Fuson shale, and (2) direct pathways, probably in the form of numerous old (pre-TVA) unplugged exploration boreholes.”
- The Lakota aquifer pumping test was conducted for 73 hours at an average rate of 203 gallons per minute (“gpm”). The transmissivity of the aquifer was determined to be 1400 gpd/ft (190 ft^2/day), with a storativity of $1.8x10^{-4}$.
- The Fall River aquifer pumping test was conducted for 49 hours at an average rate of 8.5 gpm. The transmissivity of the aquifer was determined to be 150 gpd/ft (20 ft^2/day), with a storativity of $1.4x10^{-5}$.
- The vertical hydraulic conductivity of the Fuson shale was estimated to be 10^{-4} to 10^{-3} ft/day.
- Boggs and Jenkins (1980) evaluated the pumping test data using methods that assume that the aquifer is isotropic (i.e., assuming that the hydraulic properties of the aquifer are the same in all directions). However, the drawdown plots presented in Figures 19 and 20 show a trough of depression rather than a uniform cone of depression, indicating that the aquifer is anisotropic (i.e., where the hydraulic properties are a function of direction). These plots indicate that the transmissivity of the aquifer at the tested location is greater in the northeast-southwest direction than in the northwest-southeast direction. This is typical of fractured bedrock aquifers and indicates that northeast-southwest trending fractures have the greatest influence on groundwater flow in the area.

* Rahn (1981)[19] provides data showing:
    - Of all bedrock formations in the Black Hills, the Inyan Kara aquifer contains the second highest amount of recoverable groundwater having a total dissolved solids (“TDS”) concentration of less than 1,000 mg/L.
    - Of all bedrock formations in the Black Hills, the Inyan Kara aquifer has the second highest specific yield (i.e., the available pumping rate yielded by a properly completed well per foot of drawdown).
* In a study of hydrogeological conditions in the southwestern Black Hills, Cohan (1984)[20] reported the following:
    - A properly constructed well completed in the Lakota Formation should yield 15 to 35 gpm.
    - A borehole drilled with the intent of constructing a monitoring well could not be completed, when left open for a period of less than one week, due to “expansive shales above the Lakota Formation” (presumably the Fuson shale). Cohan (1984) further described this layer as “a zone of bentonitic mudstones.”
    - Samples obtained in 1978 and 1984 from wells reportedly completed the Lakota Formation within about 2 miles of the area of proposed exploration contained TDS

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[19] Rahn, P.H. 1981. Ground Water Stored in the Rocks of Western South Dakota. Pp. 154-173 *in* F.J. Rich (ed.). Geology of the Black Hills. Field Trip Guidebook, Geological Society of America, Rocky Mountain Section, 1981 Annual Meeting, Rapid City, SD. American Geological Society. Falls Church, VA.

[20] Cohan, W.T. 1984. Report on Water Sampling and Limited Aquifer Testing, Chord Project, Fall River County, South Dakota, August & September 1984. Unpublished project report prepared by W.T. Cohan P.E., Inc. Grand Junction, CO.

concentrations of 827 to 3,760 mg/L. The available data did not indicate either a temporal or a geographical trend in the TDS concentrations.

- Downey and Dinwiddie (1988)[21] present maps indicating:
    - The geology of the northern Great Plains (of which the Black Hills is a part) was extensively altered during a period known as the Laramide orogeny, which began in the late Cretaceous period (70 to 80 million years ago) and concluded 35 to 55 million years ago.
    - The Black Hills formed during this period of significant geologic deformation.
    - Geologic structures (i.e., anticlines, domes, uplifts, etc.), faults, and fractures are ubiquitous throughout the 300,000 mi^2 region that was part of the investigation.
    - A structural lineament cutting east-west through the center of the Black Hills "has a major effect on the ground-water flow system near the Black Hills area."
    - The dominant source of recharge to the Cretaceous (i.e., Inyan Kara) aquifer system is likely upward leakage from deeper Paleozoic rocks (i.e., the Madison and Minnelusa Formations).
- Strobel et al. (1999)[22] categorize the Inyan Kara Group as "A major regional aquifer".
- A potentiometric surface map prepared by Strobel et al. (2000)[23] indicates the following:
    - Groundwater in the Inyan Kara aquifer beneath the area of planned exploration flows to the south-southwest at a hydraulic gradient of about 0.076 ft/ft.
    - The elevation of the Inyan Kara aquifer potentiometric surface beneath the proposed exploration area is about 3,800 feet above mean sea level. With a ground elevation of about 4,100 feet[24], this places the groundwater surface about 300 feet below the ground surface.
- According to Williamson and Carter (2001)[25]:
    - "Water from the Inyan Kara aquifer is fresh to slightly saline, with the highest salinity occurring in the southern Black Hills."
    - Based on 111 samples collected from Black Hills, the average TDS concentration in the Inyan Kara aquifer is 760 mg/L.
    - From a review of data provided in Figure 14 of this document, I estimate the TDS concentration of groundwater from the Inyan Kara Group in the area of proposed exploration is approximately 1,000 to 1,100 mg/L (based on a specific conductance of 1,500 microsiemens at 25° C and the relationship between specific conductance and TDS concentration provided in Table 5 of the report).

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[21] Downey, J.S. and G.A. Dinwiddie. 1988. The Regional Aquifer System Underlying the Northern Great Plains in Parts of Montana, North Dakota, South Dakota, and Wyoming – Summary. U.S. Geological Survey Professional Paper 1402-A. Washington, D.C.

[22] Strobel, M.L., G.J. Jarrell, J.F. Sawyer, J.R. Schleichter, and M.D. Fahrenbach. 1999. Distribution of Hydrogeologic Units in and Black Hills Area, South Dakota. U.S. Geological Survey Hydrologic Investigations Atlas HA-743, Sheet 2 of 3. Denver, CO.

[23] Strobel, M.L., J.M. Galloway, G.R. Hamade, and G.J. Jarrell. 2000. Potentiometric Surface of the Inyan Kara Aquifer in the Black Hills Area, South Dakota. U.S. Geological Survey Hydrologic Investigations Atlas HA-745-A, Sheet 2 of 2. Denver, CO.

[24] As indicated on Google Earth

[25] Williamson, J.E. and J.M. Carter. 2001. Water-Quality Characteristics in the Black Hills Area, South Dakota. U.S. Geological Survey Water-Resources Investigations Report 01-4194. Rapid City, SD.

- Carter et al. (2002)[26] note the following:
  - The Inyan Kara aquifer has the highest effective porosity of all major aquifers in the Black Hills area (porosity of 0.17 for the Inyan Kara Group vs. 0.01 to 0.05 for all other major aquifers in the region).
  - Ther Inyan Kara aquifer contains the highest quantity of recoverable groundwater in storage in the Black Hills area.
- Driscoll et al. (2002)[27] note the following:
  - "The Black Hills area of South Dakota and Wyoming is an important recharge area for several regional, bedrock aquifer systems and various local aquifers; . . . The major aquifers in the Black Hills area are the Deadwood, Madison, Minnelusa, Minnerath, and *Inyan Kara aquifers*." (emphasis added)
  - "The Black Hills strongly influence the hydrology of western South Dakota and northeastern Wyoming."
  - The effective porosity of the Inyan Kara aquifer is the highest of all major aquifers in the Black Hills area. Because of this, the Inyan Kara aquifer stores the largest volume of groundwater of all major aquifers in the Black Hills region.
  - Of the aquifers in the Black Hills area, the Inyan Kara aquifer accounts for the second highest quantity of water that flows out of the immediate area to surrounding regions.
- Wicks et al. (2010)[28] note the following regarding the Fall River Formation, which constitutes the upper third of the Inyan Kara Group:
  - "The Fall River Formation around the Black Hills uplift is pervasively fractured by layer-perpendicular joints. Systematic joints in the formation maintain consistent orientations over large areas and are commonly abutted by layer-formed fractures, resulting in an orthogonal pattern."
  - "Three structural zones transect the southwestern Black Hills in an east of northeast direction. The Dewey and Long Mountain zones consist of sets of NE-trending normal faults in the region . . . The Edgemont zone is defined by the termination of several folds. Collectively, the Dewey-Long Mountain-Edgemont structural zones constitute a major lineament zone across the southern Hills."
  - The Long Mountain structural zone represents a sharp boundary in the direction of fracture patterns in the Black Hills, with patterns north of that zone being predominantly to the northwest while those within and south of that zone being predominantly to the northeast.
- Rahn (2014)[29] states the following:
  - "The Inyan Kara aquifer, originally called the Dakota aquifer, underlies much of South Dakota and is one of the most famous aquifers in the United States."

[26] Carter, J.M., D.G. Driscoll, J.E. Williamson, and V.A. Lindquist. 2002. Atlas of Water Resources in the Black Hills Area, South Dakota. U.S. Geological Survey Hydrologic Investigations Atlas HA-747. Reston, VA.

[27] Driscoll, D.G., J.M. Carter, J.E. Williamson, and L.D. Putnam. 2002. Hydrology of the Black Hills Area, South Dakota. U.S. Geological Survey Water-Resources Investigations Report 02-4094. Rapid City, SD.

[28] Wicks, J.L., S.L. Dean, and B.R. Kulander. 2016. Regional Tectonics and Fracture Patterns in the Fall River Formation (Lower Cretaceous) Around the Black Hills Foreland Uplift, Western South Dakota and Northeastern Wyoming. Pp. 145-165 *in* J.W. Cosgrove and M.S. Ameen (eds.). 2000. Forced Folds and Fractures. The Geological Society of London. Special Pubklication 169. London, England.

[29] Rahn, P.H. 2014. Permeability of the Inyan Kara Group in the Black Hills Area and Its Relevance to a Proposed In-Situ Leach Uranium Mine. Proceedings of the South Dakota Academy of Sciences. Vol. 93, pp. 15-32.

- "The Inyan Kara Group in the southern Black Hills has complex stratigraphy and hence has considerable variability."
- Based on multiple laboratory and field tests of the hydraulic properties of the Inyan Kara Group, Rahn (2014) presents the following hydraulic properties for the Inyan Kara Group aquifer:
  - Lakota Formation hydraulic conductivity = 2.56 to 4.92 ft/day
  - Lakota Formation transmissivity = 187 to 587 ft^2/day
  - Fall River Formation hydraulic conductivity = 0.45 ft/day
  - Fall River Formation transmissivity = 53.5 ft^2/day
- Using an average hydraulic conductivity of 2.31 ft/day, a typical hydraulic gradient of 0.0079 ft/ft, and an average effective porosity of 10%, Rahn (2014) concluded that "The Inyan Kara Group includes permeable sandstone channels that could carry groundwater faster than an average value of 66 ft/year."
- Based on an evaluation of twelve tests of the hydraulic properties of bedrock in the Inyan Kara Group, Rahn (2014) also concludes that there is a 10% probability that the hydraulic conductivity (and therefore the average linear groundwater velocity) could be about 4 times higher than the above rate (i.e., resulting in an average linear groundwater velocity of approximately 260 ft/year as compared to 66 ft/year). This evaluation did not account for the anisotropic nature of the aquifer (as measured but not evaluated by Boggs and Jenkins [1980]). Thus, the rate of groundwater flow through the area of the proposed exploration project could be substantially higher than presented above.

Interpretation

The Black Hills formed approximately 40- to 80-million years ago during the Laramide orogeny when a massive oceanic tectonic plate (known as the Farallon plate) subducted under (i.e., dove beneath) the west coast of the North American tectonic plate at a shallow angle. This action compressed the western portion of North America and created, among other geologically complex regions, the Rocky Mountains, the Black Hills, and associated basins.

The mountain building event that created the Black Hills uplift resulted in substantial faulting and fracturing of bedrock formations in the region. Gott et al. (1974) found that this geological deformation was sufficiently large to alter the pre-historic drainage patterns in the southern Black Hills from being primarily to the northwest prior to the uplift to being primarily to the northeast after the uplift. The Long Mountain structural zone (which includes the area where the proposed exploration is planned) was a major line at which these drainage patterns were altered. As Gott et al. (1974) stated, the Long Mountain structural zone is a zone of "intense fracturing and (or) faulting."

The extensive deformation caused by the Black Hills uplift created a widespread network of orthogonally oriented faults and fractures, striking horizontally in approximately northeast-southwest and northwest-southeast directions throughout the Black Hills and the broader region. These faults and fractures extend vertically through the Inyan Kara Group (the focus of the proposed exploration program) as well as through overlying and underlying formations.

The Inyan Kara Group in the Black Hills is comprised of interbedded sandstones, siltstones, and shales. It consists of the Fall River Formation (comprising approximately the upper third of the Group) and the underlying Lakota Formation (comprising approximately the lower two-thirds of the Group). The Fuson Member of the Lakota Formation lies at the top of the Lakota Formation and serves as the boundary between the Lakota and Fall River Formations. This shale was described by Cohan (1984) as an "expansive shale" and a "bentonitic mudstone."

Given the extensive fracturing as well as the presence of permeable sandstone channels, the Inyan Kara aquifer is labeled by many authors as a major regional aquifer. Data presented by Rahn (1981) indicate that, of all major aquifers in the region, the Inyan Kara Group contains the second largest amount of recoverable groundwater with a TDS of less than 1,000 mg/L and has the second highest specific capacity.

According to Driscol et al. (2002), the Inyan Kara aquifer accounts for the second highest quantity of water that flows out of the Black Hills to surrounding regions. From a more local perspective, Keene (1973) noted that most of the wells in in western Fall River County that obtain water from the Inyan Kara aquifer "are located upstream from Edgemont within the Cheyenne River valley." This area of the Cheyenne River valley is directly downgradient from the area of the proposed exploration activities.

Given these factors, the Inyan Kara aquifer in which the proposed exploration drilling is planned is of critical importance to water resources both locally and in the surrounding region. Thus, any impact to the Inyan Kara aquifer resulting from the proposed exploration drilling could have both local and regional consequences.

The South Dakota Department of Health has established a 30-day average TDS concentration of 1,000 mg/L as a standard for domestic water supplies (see Administrative Rule 74:51:01:44). Based on data presented by Williamson and Carter (2001), TDS concentration of groundwater in the area of proposed drilling is approximately 1,000 to 1,100 mg/L. Some of the data reported by Cohan (1984) substantiate this estimate. Thus, groundwater in the area of proposed exploration may be useable as a domestic water supply.

Rahn (2014) estimated that the average linear velocity of groundwater flowing in the Inyan Kara aquifer is 66 ft/year and has a 10% chance of being four times higher (i.e., as high as 260 ft/year). His calculations were based on an average hydraulic conductivity determined from several samples and/or tests in the Black Hills, a hydraulic gradient of 0.0079 ft/ft and did not account for the anisotropy of the aquifer.

Data presented by Strobel et al. (2000) indicate that the hydraulic gradient in the Inyan Kara aquifer is 0.076 ft/ft in the area of the proposed exploration drilling. This is 9.6 times higher than the hydraulic gradient used in the calculations presented by Rahn (2014). Hence, not accounting for aquifer anisotropy, the average linear groundwater velocity in the area of proposed drilling is 630 ft/yr (i.e., 9.6 x 66 ft/yr), with a 10% chance of being as high as 2500 ft/yr (i.e., 9.6 x 260 ft/yr).

I used a method developed by Hantush and Thomas (1966)[30] to estimate the anisotropic properties of the fractured Inyan Kara aquifer, based on the average hydraulic conductivity presented by Rahn (2014) and the drawdown data presented by Boggs and Jenkins (1980). According to this methodology, ellipses of equal drawdown are drawn using data collected near the end of a pumping test and the major and minor axes of those ellipses are scaled. The transmissivity (and hydraulic conductivity) of the aquifer along the major and minor axes of anisotropy are then determined as follows:

$T_x = (a/b)T_e$
$T_y = (b/a)T_e$

where T_x = aquifer transmissivity parallel to the primary anisotropy axis
T_y = aquifer transmissivity perpendicular to the primary anisotropy axis
T_e = average aquifer transmissivity determined from pumping test data
a = radius of the major ellipse axis
b = radius of the minor ellipse axis

The hydraulic conductivity of an aquifer is determined by dividing the transmissivity by the aquifer thickness. Since the aquifer thickness is the same on both sides of the equations, the ratios presented above also apply to hydraulic conductivity.

Boggs and Jenkins (1980) presented drawdown ellipses for pumping tests conducted in the Fall River Formation (the approximate upper third of the Inyan Kara Group) and the Lakota Formation (the approximate lower two-thirds of the Inyan Kara Group). The ratios of major-to-minor radii from these drawdown ellipses are 1.59 in the Fall River Formation and 1.42 in the Lakota Formation.

Assuming conditions in the area of proposed exploration drilling are similar to those in the area studied by Boggs and Jenkins (1980), the above calculation indicates that the average linear groundwater flow velocity in the area of proposed drilling is likely 1.4 to 1.6 times higher than calculated by methods that do not account for anisotropy. Thus, instead of an average linear groundwater velocity of 630 ft/yr as presented above, groundwater in the area of proposed drilling could flow at rates of 880 to 1,000 ft/yr (i.e., 1.4 x 630 to 1.6 x 630). The flow could be four times higher (i.e., 3,500 ft/yr to 4,000 ft/yr) if the "intense fracturing" noted by Gott et al. (1974) in the locale has created a condition where the hydraulic conductivity of the aquifer in the area of proposed drilling is in the upper 10% of the region as discussed by Rahn (2014).

The "intense fracturing" of bedrock in the area of the proposed drilling creates a situation where drilling fluids could easily escape from the boreholes through what is known as "lost circulation." Lost circulation is the unplanned loss of drilling fluids into the formation. The risk for lost circulation is high in areas that are extensively faulted and/or fractured, such as the area of the proposed exploration drilling. The primary environmental consequence of lost circulation is the escape of drilling fluids that contain not only bentonite but also other

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[30] Hantush, M.S. and R.G. Thomas. 1966. A Method for Analyzing a Drawdown Test in Anisotropic Aquifers. Water Resources Research. Vol. 2, No. 2, pp. 281-285.

drilling fluid additives as well as cuttings and formation fluids that are introduced into zones in which these materials are not native.

As noted by Gott et al. (1974), the Fuson Member of the Lakota Formation, which lies at the top of the Lakota Formation and below the Fall River Formation, consists of siltstone, mudstone, and shale. Boggs and Jenkins (1980) found that the vertical hydraulic conductivity of the Fuson Member was substantially lower than the horizontal hydraulic conductivity of the remainder of the underlying Lakota Formation and the overlying Fall River Formation. Thus, the Fuson Member acts as a barrier to the natural flow of groundwater between the Fall River Formation and the Lakota Formation.

During drilling, the Fuson Member will be perforated, allowing drilling fluids, cuttings, and groundwater to flow readily between the Fall River and Lakota Formations. Even if no drilling fluids are used other than water and bentonite, drilling will allow cuttings and groundwater to mix between the Lakota Formation and the Fall River Formation. As noted by Dandavati and Fox (1980), the cuttings will likely contain not only uranium but also selenium, vanadium, and molybdenum.

Bowles (1968) found that the Long Mountain structural zone, which includes the area of proposed exploration drilling, is an area where "intense" geochemical reactions occur. During drilling, rock that has been undisturbed for millions of years will be pulverized, greatly increasing the surface area subject to geochemical interaction. Groundwater will also be aerated and mixed between the Fall River Formation and the Lakota Formation. These actions have the potential to mobilize elements such as uranium, selenium, vanadium, and molybdenum, as well as other elements, into groundwater zones where those elements do not currently exist (in the case of lost circulation) or in which those elements are currently geochemically bound. Hence, given the probable high groundwater flow in the area of proposed exploration, the potential exists for drilling fluids, cuttings, and impacted groundwater to be transported long distances from the borehole locations if circulation is lost during exploration drilling.

Recommendations

Contrary to Mr. Blady's statement in his deposition, sampling is not "a good way to prevent" groundwater contamination. It is, however, a standard approach for determining whether or not groundwater contamination has occurred. Therefore, prior to beginning exploration drilling, I recommend that groundwater monitoring wells be installed in a minimum of six locations in the area of the exploration program, with at least one monitoring location being upgradient from the area of exploration and at least five monitoring locations being downgradient from the area of exploration.

I acknowledge that the standard approach for monitoring groundwater in an area of potential impact is to install a minimum of one upgradient and three downgradient monitoring wells. However, this exploration effort is planned to occur in an elongated rectangle, with the north and south sides of the rectangular area being four times longer than the east and west ends. A potentiometric surface map prepared by Strobel et al. (2000) indicates that groundwater in the Inyan Kara Group flows to the south-southwest beneath the area of planned exploration. Hence, the downgradient edge of the project area is represented by a long southern boundary and a short western boundary. As a result, additional wells will be needed, particularly to monitor the long, southern downgradient boundary of the project area. The downgradient monitoring wells should be spaced along the southern and western project boundaries in locations that minimize the potential for bypass of contaminants if the groundwater is impacted by exploration operations.

As noted above, Boggs and Jenkins (1980) found that the vertical hydraulic conductivity of the Fuson Member of the Lakota Formation was substantially lower than the horizontal hydraulic conductivity of the remainder of the underlying Lakota Formation and the overlying Fall River Formation. Furthermore, Cohan (1984) observed that a borehole that had been left open for less than a week could not be completed as a monitoring well due to "expansive shales above the Lakota Formation." Thus, the Fuson Member of the Lakota Formation acts as a potential barrier to the vertical flow of groundwater within the Inyan Kara Group (between the overlying Fall River Formation and the underlying Lakota Formation).

Given the presence of an apparent hydraulic barrier within the zone targeted for exploration drilling, I recommend that groundwater monitoring wells be completed in both the Fall River Formation and the Lakota Formation at each of the six monitoring locations, resulting in a minimum of 12 groundwater monitoring wells. Each monitoring well should be completed to adequately evaluate the potentiometric surface and groundwater quality in the respective formation at that location, accounting for geologic conditions observed during drilling. All monitoring wells should be constructed and sampled in accordance with USEPA's "RCRA Ground-Water Monitoring Technical Enforcement Guidance Document"[31], USEPA's "Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers,"[32] and/or other regulatory-agency approved methods.

I recommend that the project monitoring wells be sampled quarterly for at least one year prior to the start of exploration activities in order to establish baseline conditions in the project area. Once exploration activities begin, I recommend that the monitoring wells be sampled at least quarterly during exploration activities and continue at that frequency until at least one year after site reclamation is completed.

The data outlined in Table 1 should be collected during each monitoring event. All data should be evaluated in accordance with USEPA's "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance"[33] to establish baseline conditions and to assess the potential for changes in those conditions during the monitoring period. I recommend that all data collected from the monitoring wells, and the associated statistical analyses, be available through an easily accessible public source within 60 days of sampling.

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[31] U.S. Environmental Protection Agency. 1986. RCRA Ground-Water Monitoring Technical Enforcement Guidance Document. OSWER-9950.1. Office of Waste Programs Enforcement, Office of Solid Waste and Emergency Response. Washington, D.C.

[32] Yeskis, D. and B. Zavaia. 2002. Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers. EPA 542-S-02-001. Office of Solid Waste and Emergency Response. Washington, D.C.

[33] U.S. Environmental Protection Agency. 2019. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance. EPA 530-R-09-007. Office of Resource Conservation and Recovery, Program Implementation and Information Division. Washington, D.C. Available at https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P10055GQ.TXT.

In order to allow rapid response to potential lost circulation events, I recommend that lost circulation materials be stockpiled on site during all drilling operations. I further recommend that drilling of any borehole where drilling fluids are used (whether an exploration borehole or a monitoring well) be stopped as soon as circulation is lost at that borehole. An assessment of the cause of the lost circulation and a plan to counter the lost circulation should be made before drilling resumes at that borehole. If all reasonable attempts to regain circulation fail, that borehole should be abandoned in accordance with South Dakota requirements, without further drilling.

TABLE 1

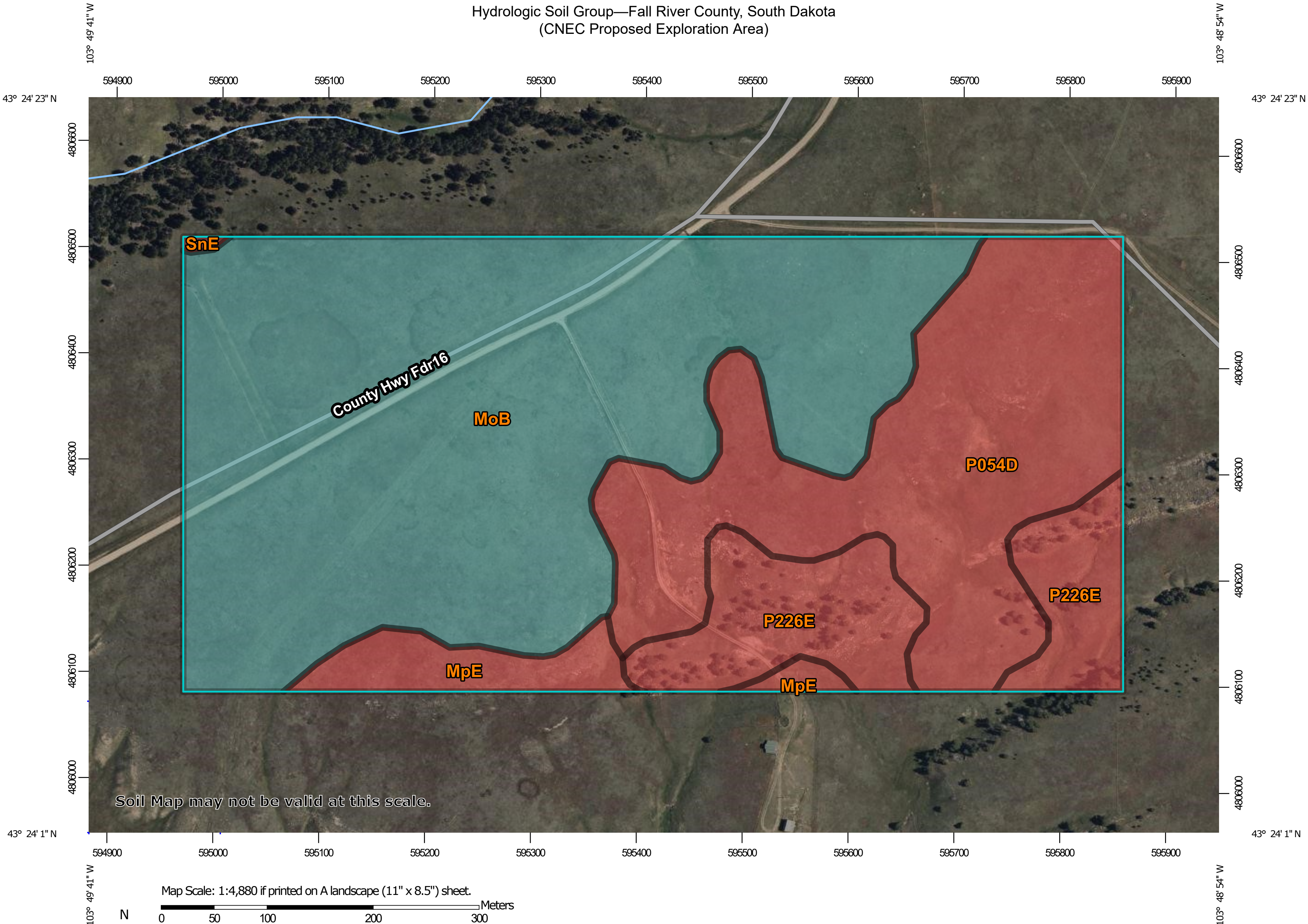
Recommended Groundwater Monitoring Parameters

Field Measurements
Water level (depth from ground surface and elevation)
pH
Specific conductance
Temperature
Laboratory Measurements (based on field-filtered samples)
Total dissolved solids
Total hardness (as $CaCO_3$)
Bicarbonate
Carbonate
Chloride
Nitrate
Sulfate
Calcium
Magnesium
Potassium
Sodium
Arsenic
Barium
Boron
Cadmium
Chromium
Copper
Iron
Lead
Manganese
Molybdenum
Radium-226
Selenium
Thorium-230
Uranium
Vanadium
Zinc

ATTACHMENT A

Soil Data Downloaded from
Web Soil Survey

Hydrologic Soil Group—Fall River County, South Dakota
(CNEC Proposed Exploration Area)



Map Scale: 1:4,880 if printed on A landscape (11" x 8.5") sheet.

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Fall River County, South Dakota
Survey Area Data: Version 29, Sep 10, 2025

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 8, 2022—Jun 21, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
MoB	Minnequa silt loam, 2 to 6 percent slopes	C	53.6	56.8%
MpE	Minnequa-Midway silty clay loams, 6 to 25 percent slopes	D	4.0	4.2%
P054D	Butche-Boneek, dry complex, 3 to 15 percent slopes	D	25.5	27.1%
P226E	Mathias, very stony-Samsil-Rock outcrop complex, 15 to 30 percent slopes	D	11.1	11.7%
SnE	Shingle-Penrose-Rock outcrop complex, 15 to 40 percent slopes	D	0.1	0.1%
Totals for Area of Interest			**94.4**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

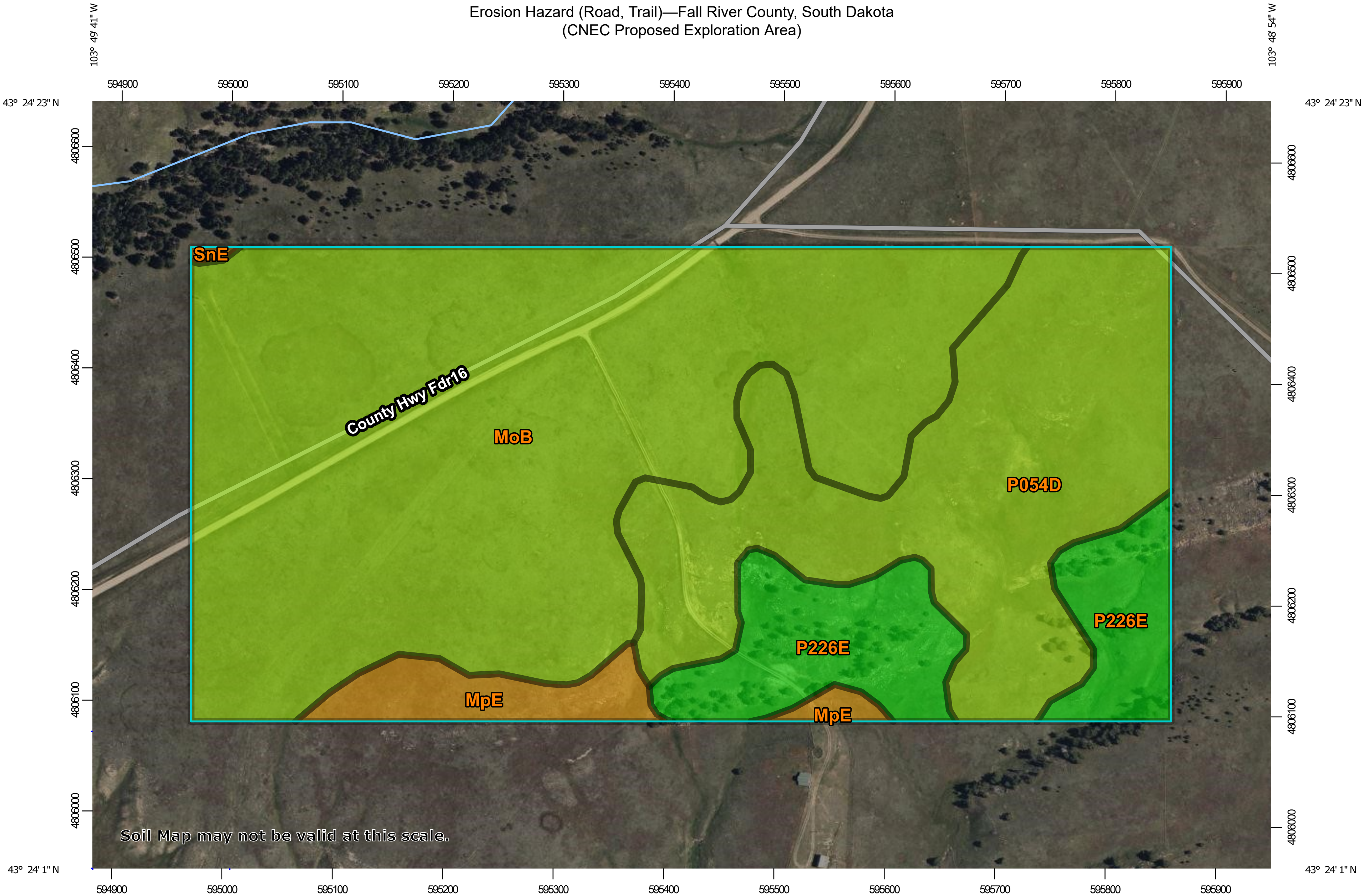
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Erosion Hazard (Road, Trail)—Fall River County, South Dakota
(CNEC Proposed Exploration Area)



Map Scale: 1:4,880 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 50, 100, 200, 300

Feet: 0, 200, 400, 800, 1200

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- Erosion hazard very severe
- Erosion hazard severe
- Erosion hazard moderate
- Erosion hazard slight
- Not rated or not available

Soil Rating Lines

- Erosion hazard very severe
- Erosion hazard severe
- Erosion hazard moderate
- Erosion hazard slight
- Not rated or not available

Soil Rating Points

- Erosion hazard very severe
- Erosion hazard severe
- Erosion hazard moderate
- Erosion hazard slight
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Fall River County, South Dakota
Survey Area Data: Version 29, Sep 10, 2025

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 8, 2022—Jun 21, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Erosion Hazard (Road, Trail)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
MoB	Minnequa silt loam, 2 to 6 percent slopes	Erosion hazard moderate	Minnequa (90%)	Slope, K, Fragments (0.23)	53.6	56.8%
			Pierre (5%)	Slope, K, Fragments (0.18)		
			Midway (5%)	Slope, K, Fragments (0.53)		
MpE	Minnequa-Midway silty clay loams, 6 to 25 percent slopes	Erosion hazard severe	Minnequa (50%)	Slope, K, Fragments (0.95)	4.0	4.2%
			Pierre (3%)	Slope, K, Fragments (0.80)		
			Shingle (2%)	Slope, K, Fragments (0.70)		
P054D	Butche-Boneek, dry complex, 3 to 15 percent slopes	Erosion hazard moderate	Butche, dry (55%)	Slope, K, Fragments (0.55)	25.5	27.1%
			Boneek, dry (30%)	Slope, K, Fragments (0.62)		
P226E	Mathias, very stony-Samsil-Rock outcrop complex, 15 to 30 percent slopes	Erosion hazard slight	Mathias (50%)		11.1	11.7%
SnE	Shingle-Penrose-Rock outcrop complex, 15 to 40 percent slopes	Erosion hazard severe	Shingle (45%)	Slope, K, Fragments (0.88)	0.1	0.1%
				Steep slope (0.30)		
			Penrose (25%)	Slope, K, Fragments (0.95)		
				Steep slope (0.30)		
			Minnequa (5%)	Slope, K, Fragments (0.95)		
Totals for Area of Interest					**94.4**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Erosion hazard moderate	79.2	83.9%
Erosion hazard slight	11.1	11.7%
Erosion hazard severe	4.1	4.4%
Totals for Area of Interest	**94.4**	**100.0%**

Description

FOR - Forestry

The ratings in this interpretation indicate the hazard of soil loss from unsurfaced roads and trails. The ratings are based on soil erosion factor K, slope, and content of rock fragments.

The ratings are both verbal and numerical. The hazard is described as "slight", "moderate", "severe", or "very severe". A rating of "slight" indicates that little or no erosion is likely; "moderate" indicates that some erosion is likely, that the roads or trails may require occasional maintenance, and that simple erosion-control measures are needed; and "severe" indicates that significant erosion is expected, that the roads or trails require frequent maintenance, and that costly erosion-control measures are needed. Erosion hazard "very severe" means that the combination of slope and soil erodibility render the site impractical for equipment use due to extreme erosion.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the specified aspect of forestland management (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

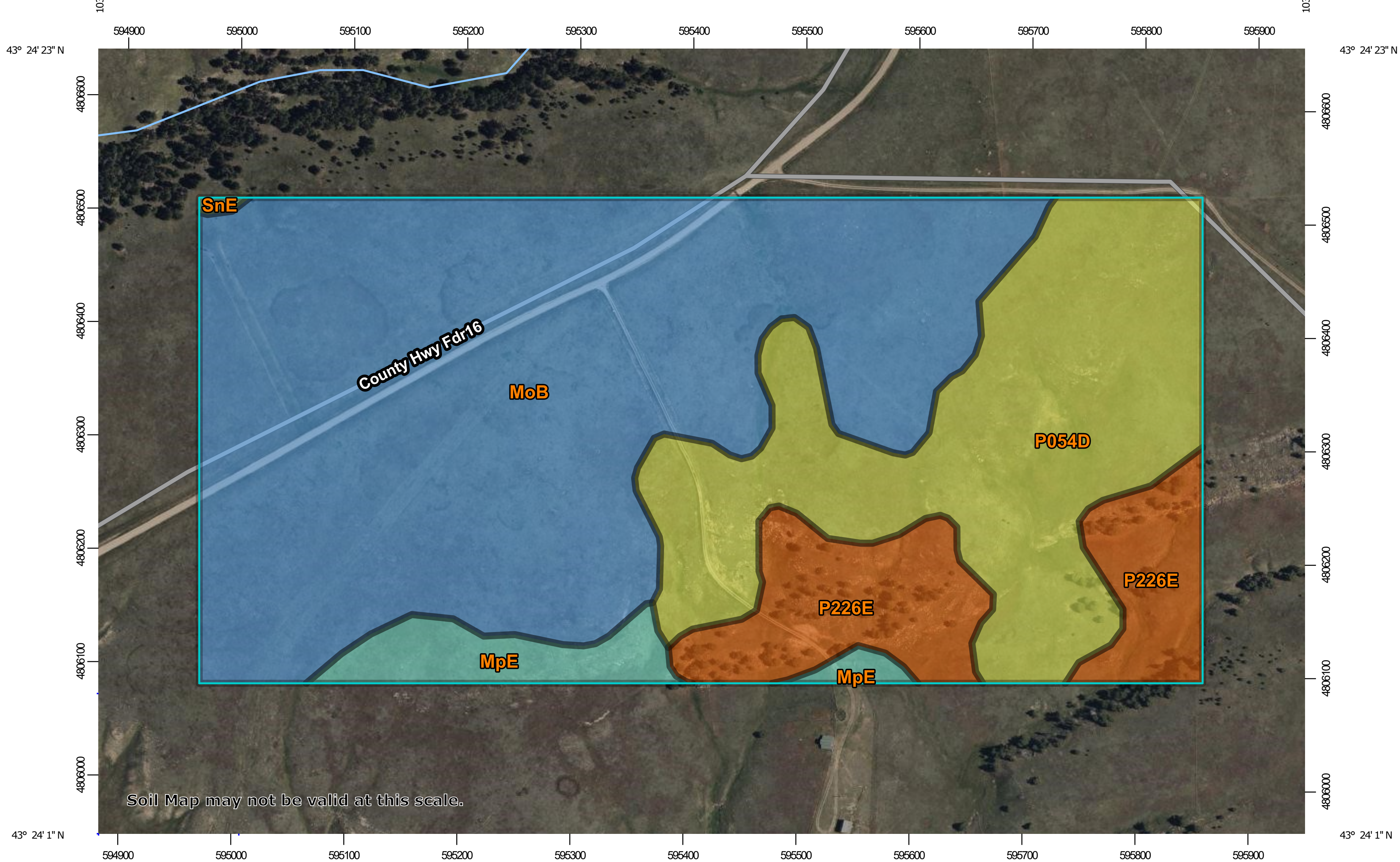
Rating Options

Aggregation Method: Dominant Condition

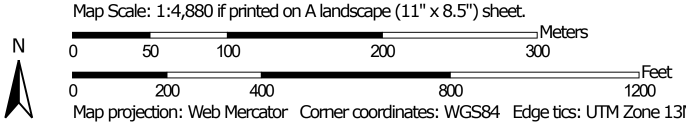
Component Percent Cutoff: None Specified

Tie-break Rule: Higher

K Factor, Whole Soil—Fall River County, South Dakota
(CNEC Proposed Exploration Area)



Map Scale: 1:4,880 if printed on A landscape (11" x 8.5") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- .02
- .05
- .10
- .15
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- .49
- .55
- .64
- Not rated or not available

Soil Rating Lines

- .02
- .05
- .10
- .15
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- .49
- .55
- .64
- Not rated or not available

Soil Rating Points

- .02
- .05
- .10
- .15
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- .49
- .55
- .64
- Not rated or not available

Water Features

Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Fall River County, South Dakota
Survey Area Data: Version 29, Sep 10, 2025

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 8, 2022—Jun 21, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

K Factor, Whole Soil

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
MoB	Minnequa silt loam, 2 to 6 percent slopes	.43	53.6	56.8%
MpE	Minnequa-Midway silty clay loams, 6 to 25 percent slopes	.32	4.0	4.2%
P054D	Butche-Boneek, dry complex, 3 to 15 percent slopes	.20	25.5	27.1%
P226E	Mathias, very stony-Samsil-Rock outcrop complex, 15 to 30 percent slopes	.05	11.1	11.7%
SnE	Shingle-Penrose-Rock outcrop complex, 15 to 40 percent slopes	.28	0.1	0.1%
Totals for Area of Interest			**94.4**	**100.0%**

Description

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

"Erosion factor Kw (whole soil)" indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Factor K does not apply to organic horizons and is not reported for those layers.

Rating Options

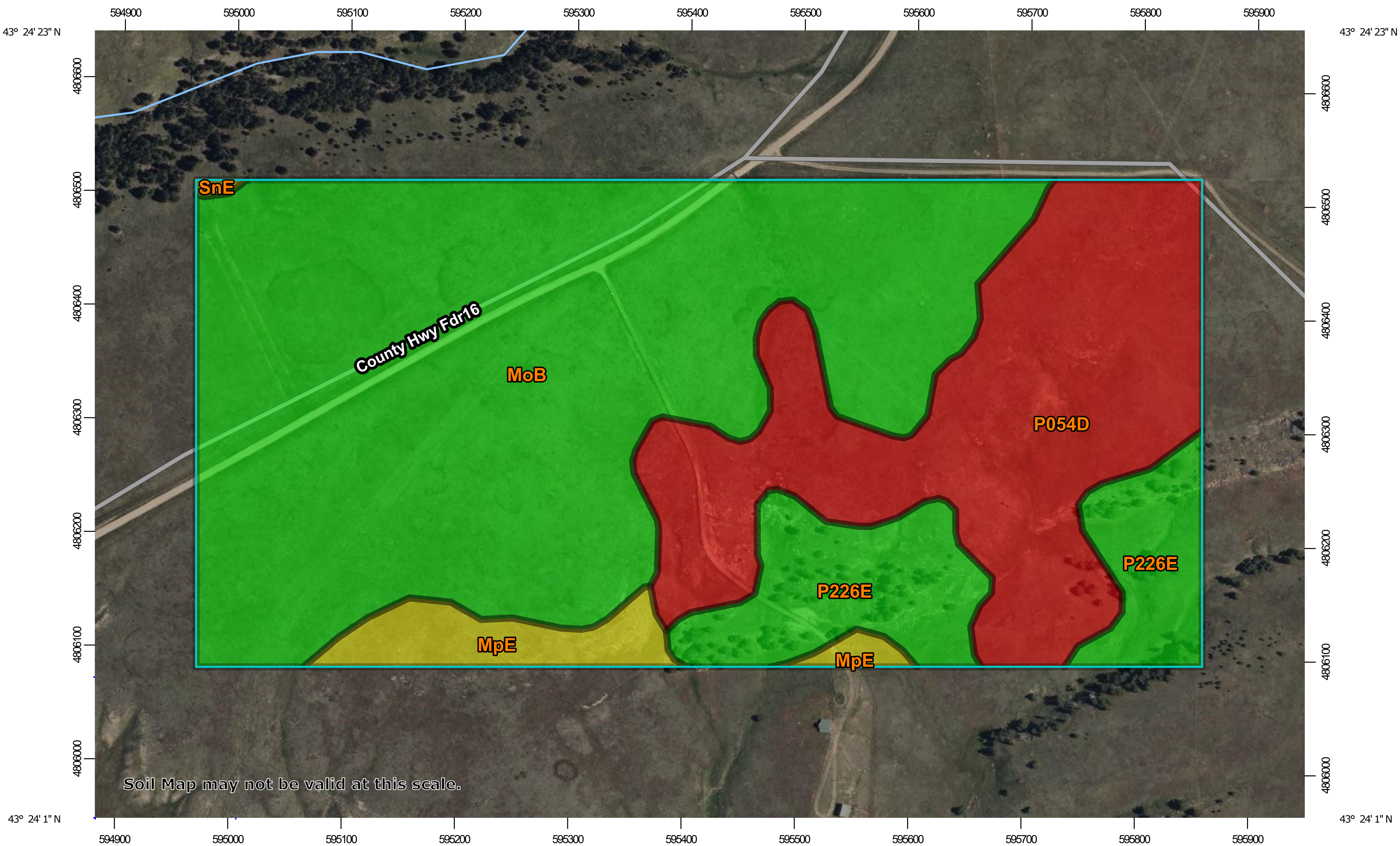
Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Layer Options (Horizon Aggregation Method): Surface Layer (Not applicable)

Site Degradation Susceptibility—Fall River County, South Dakota
(CNEC Proposed Exploration Area)



Map Scale: 1:4,880 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 50, 100, 200, 300

Feet: 0, 200, 400, 800, 1200

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

Highly susceptible

Moderately susceptible

Slightly susceptible

Not rated or not available

Soil Rating Lines

Highly susceptible

Moderately susceptible

Slightly susceptible

Not rated or not available

Soil Rating Points

Highly susceptible

Moderately susceptible

Slightly susceptible

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Fall River County, South Dakota
Survey Area Data: Version 29, Sep 10, 2025

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 8, 2022—Jun 21, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Site Degradation Susceptibility

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
MoB	Minnequa silt loam, 2 to 6 percent slopes	Slightly susceptible	Minnequa (90%)		53.6	56.8%
MpE	Minnequa-Midway silty clay loams, 6 to 25 percent slopes	Moderately susceptible	Minnequa (50%)	Water erosion (0.02)	4.0	4.2%
			Midway (40%)	Water erosion (0.44)		
				Restrictive layer (0.26)		
			Penrose (5%)	Wind erosion (0.99)		
				Restrictive layer (0.80)		
				Water erosion (0.78)		
			Pierre (3%)	Wind erosion (0.99)		
			Shingle (2%)	Restrictive layer (0.16)		
P054D	Butche-Boneek, dry complex, 3 to 15 percent slopes	Highly susceptible	Butche, dry (55%)	Restrictive layer (1.00)	25.5	27.1%
				Wind erosion (0.99)		
			Rock outcrop, sandstone (7%)	Restrictive layer (1.00)		
P226E	Mathias, very stony-Samsil-Rock outcrop complex, 15 to 30 percent slopes	Slightly susceptible	Mathias (50%)		11.1	11.7%
SnE	Shingle-Penrose-Rock outcrop complex, 15 to 40 percent slopes	Moderately susceptible	Shingle (45%)	Wind erosion (0.99)	0.1	0.1%
				Restrictive layer (0.89)		
				Water erosion (0.76)		
			Penrose (25%)	Wind erosion (0.99)		
				Water erosion (0.76)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Restrictive layer (0.46)		
			Midway (5%)	Wind erosion (0.99)		
				Water erosion (0.96)		
				Restrictive layer (0.80)		
			Minnequa (5%)	Wind erosion (0.99)		
Totals for Area of Interest					**94.4**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Slightly susceptible	64.7	68.6%
Highly susceptible	25.5	27.1%
Moderately susceptible	4.1	4.4%
Totals for Area of Interest	**94.4**	**100.0%**

Description

BLM - Bureau of Land Management

This interpretation rates each soil for its susceptibility for soil degradation to occur during disturbance, which is a function of resistance to degradation. Resistance to degradation of a rangeland or woodland site is a measure of its ability to function without change throughout a disturbance. The magnitude of decline in the capacity to function determines the degree of resistance to change. Resistance to degradation thus could be described as an area's buffering capacity. This depends upon soil type, vegetation, climate, land use, disturbance regime, temporal and spatial scales. The disturbance regime determines the type of stresses placed upon the soil, vegetation, and wildlife components of the site. Thus, soil factors of vulnerability will vary based upon the disturbance regime for a particular site.

The ratings represent the relative risk of water and wind erosion, salinization, sodification, organic matter and nutrient depletion and/or redistribution, and loss of adequate rooting depth to maintain desired plant communities. Dynamic soil properties which vary with time, e.g. microbial biomass/diversity and carbon/nitrogen ratio, are not used since they are not contained within the soil database.

Steep slopes increase the potential for water erosion. Shallow rooting depth, and excess salt or sodium can reduce plant diversity, resistance to stress, and seedling survival.

This rating should be used with the objective to protect vulnerable sites from the type of degradation that would result in accelerated erosion, reduction in water and air quality, invasion by annual grasses or noxious weeds, and other large scale potential natural plant community conversions. When degradation of soil and natural plant community characteristics goes beyond the threshold for the ecological site, the ecological site characteristics cannot be restored without artificial restoration efforts.

There may be unique circumstances where accelerated soil processes that are normally considered contributing to site degradation are actually beneficial to some attribute of the site, such as Indian ricegrass (Achnatherum hymenoides) being more competitive in shifting sands than most species.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the potential for degradation. "Highly susceptible" indicates that the soil has one or more features that are very favorable for degradation. "Moderately susceptible" indicates that the soil has features that are moderately favorable for damage to occur. "Slightly susceptible" indicates that the soil has features that generally make it unfavorable for degradation to occur.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

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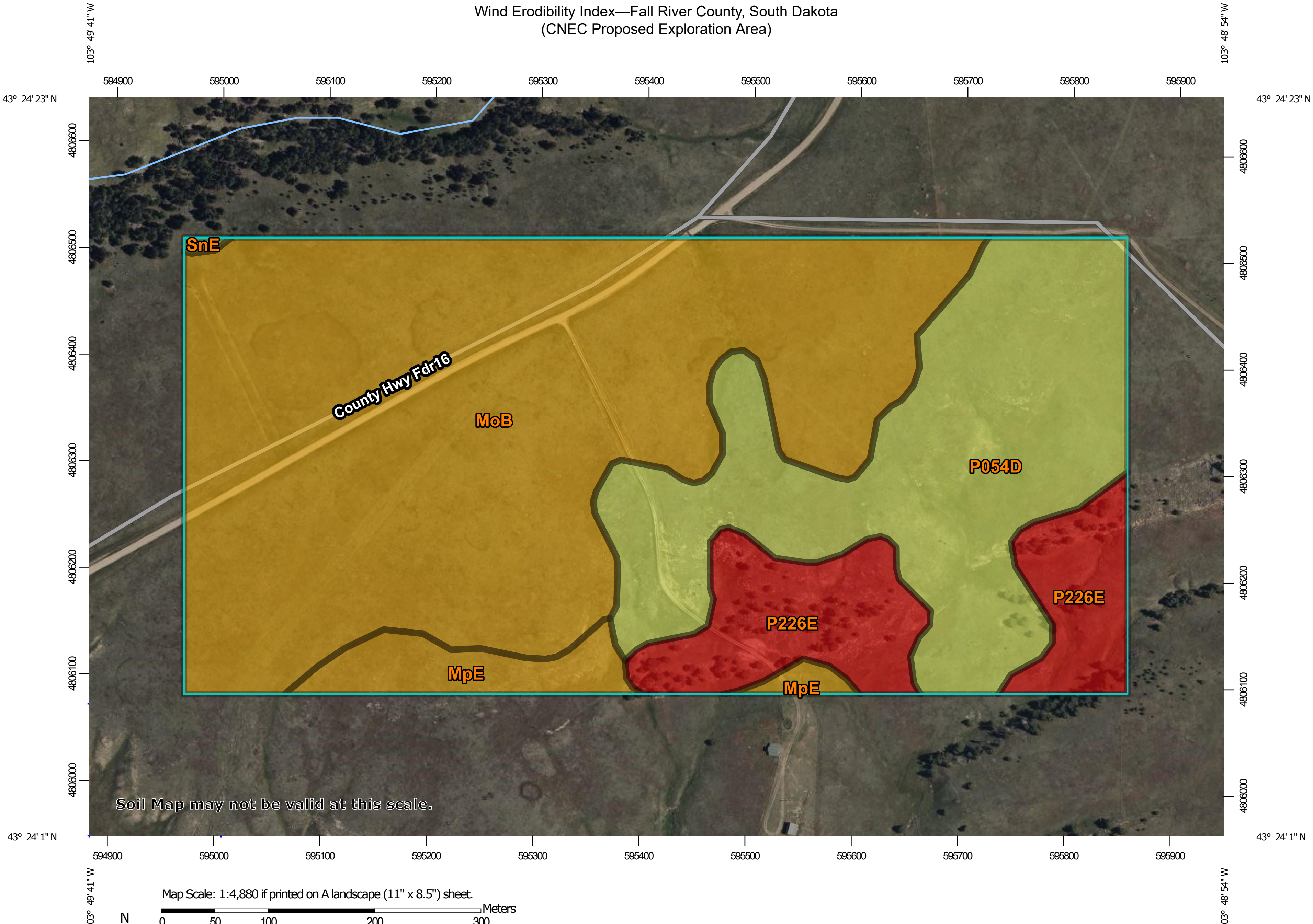
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Wind Erodibility Index—Fall River County, South Dakota
(CNEC Proposed Exploration Area)



Map Scale: 1:4,880 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 50, 100, 200, 300

Feet: 0, 200, 400, 800, 1200

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- 0
- 38
- 48
- 56
- 86
- 134
- 160
- 180
- 220
- 250
- 310
- Not rated or not available

Soil Rating Lines

- 0
- 38
- 48
- 56
- 86
- 134
- 160
- 180
- 220
- 250
- 310
- Not rated or not available

Soil Rating Points

- 0
- 38
- 48
- 56
- 86
- 134
- 160
- 180
- 220
- 250
- 310
- Not rated or not available

Water Features

Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

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Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

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Wind Erodibility Index

Map unit symbol	Map unit name	Rating (tons per acre per year)	Acres in AOI	Percent of AOI
MoB	Minnequa silt loam, 2 to 6 percent slopes	48	53.6	56.8%
MpE	Minnequa-Midway silty clay loams, 6 to 25 percent slopes	48	4.0	4.2%
P054D	Butche-Boneek, dry complex, 3 to 15 percent slopes	86	25.5	27.1%
P226E	Mathias, very stony-Samsil-Rock outcrop complex, 15 to 30 percent slopes	0	11.1	11.7%
SnE	Shingle-Penrose-Rock outcrop complex, 15 to 40 percent slopes	86	0.1	0.1%
Totals for Area of Interest			**94.4**	**100.0%**

Description

The wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Rating Options

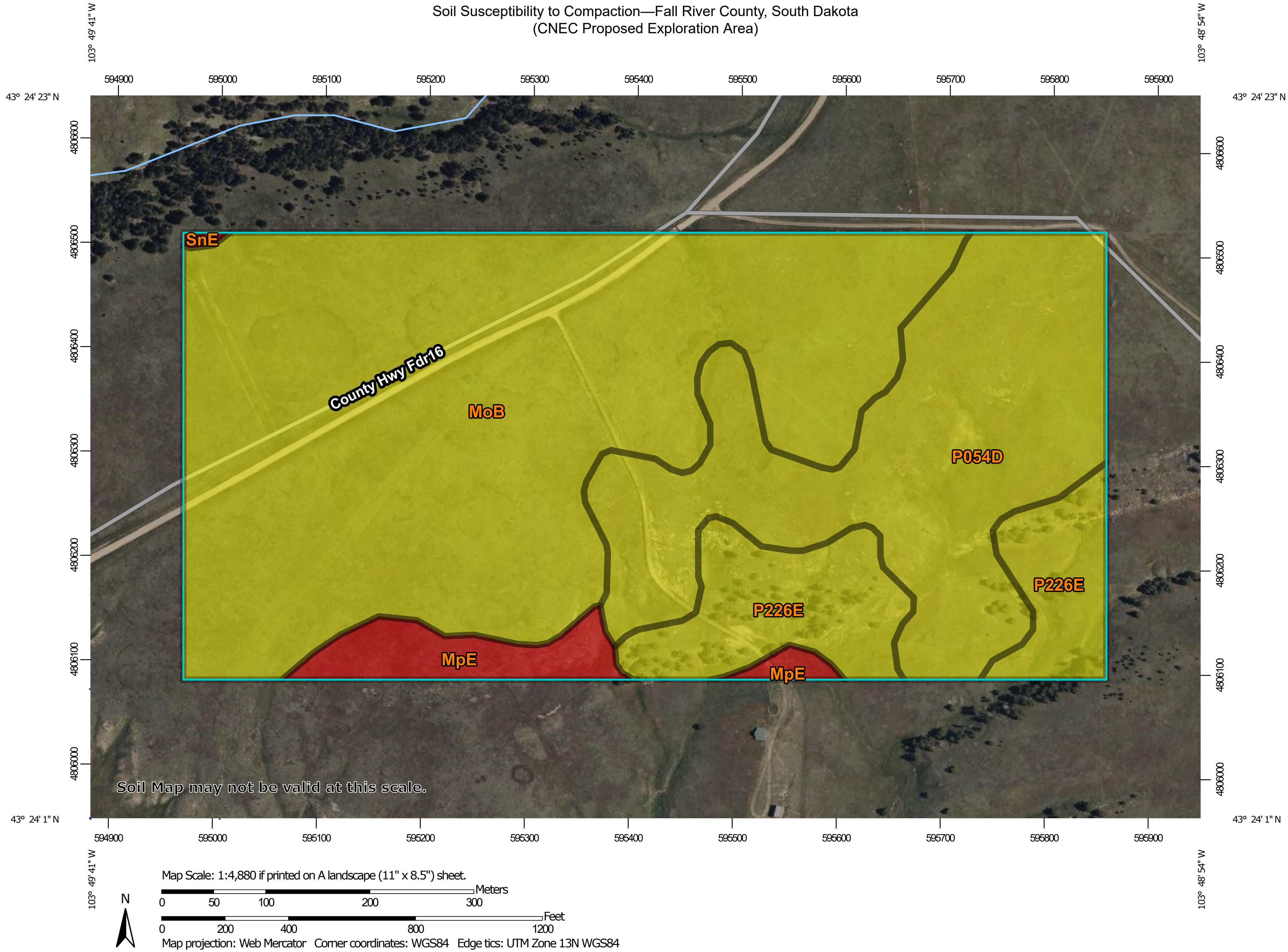
Units of Measure: tons per acre per year

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Soil Susceptibility to Compaction—Fall River County, South Dakota
(CNEC Proposed Exploration Area)



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

High

Medium

Low

Not rated or not available

Soil Rating Lines

High

Medium

Low

Not rated or not available

Soil Rating Points

High

Medium

Low

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

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Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

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Date(s) aerial images were photographed: Jun 8, 2022—Jun 21, 2022

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Soil Susceptibility to Compaction

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
MoB	Minnequa silt loam, 2 to 6 percent slopes	Medium	Minnequa (90%)	Soil texture, 0-12 inches (1.00)	53.6	56.8%
				Rock fragments, 0-12 inches (1.00)		
				Soil structure grade, 0-12 inches (1.00)		
				Organic matter content, 0-30 cm (1.00)		
				Subaerial (1.00)		
			Pierre (5%)	Rock fragments, 0-12 inches (1.00)		
				Soil structure grade, 0-12 inches (1.00)		
				Subaerial (1.00)		
				Organic matter content, 0-30 cm (0.97)		
				Soil texture, 0-12 inches (0.50)		
			Midway (5%)	Soil texture, 0-12 inches (1.00)		
				Rock fragments, 0-12 inches (1.00)		
				Soil structure grade, 0-12 inches (1.00)		
				Organic matter content, 0-30 cm (1.00)		
				Subaerial (1.00)		
MpE	Minnequa-Midway silty clay loams, 6 to 25 percent slopes	High	Minnequa (50%)	Soil texture, 0-12 inches (1.00)	4.0	4.2%
				Rock fragments, 0-12 inches (1.00)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Soil structure grade, 0-12 inches (1.00)		
				Bulk density-compactibility to 30cm (1.00)		
				Organic matter content, 0-30 cm (1.00)		
			Penrose (5%)	Soil texture, 0-12 inches (1.00)		
				Rock fragments, 0-12 inches (1.00)		
				Soil structure grade, 0-12 inches (1.00)		
				Bulk density-compactibility to 30cm (1.00)		
				Organic matter content, 0-30 cm (1.00)		
			Shingle (2%)	Soil texture, 0-12 inches (1.00)		
				Rock fragments, 0-12 inches (1.00)		
				Soil structure grade, 0-12 inches (1.00)		
				Bulk density-compactibility to 30cm (1.00)		
				Organic matter content, 0-30 cm (1.00)		
P054D	Butche-Boneek, dry complex, 3 to 15 percent slopes	Medium	Butche, dry (55%)	Soil texture, 0-12 inches (1.00)	25.5	27.1%
				Rock fragments, 0-12 inches (1.00)		
				Soil structure grade, 0-12 inches (1.00)		
				Organic matter content, 0-30 cm (1.00)		
				Subaerial (1.00)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Boneek, dry (30%)	Soil texture, 0-12 inches (1.00)		
				Rock fragments, 0-12 inches (1.00)		
				Soil structure grade, 0-12 inches (1.00)		
				Subaerial (1.00)		
				Organic matter content, 0-30 cm (0.81)		
			Mathias (8%)	Soil texture, 0-12 inches (1.00)		
				Soil structure grade, 0-12 inches (1.00)		
				Organic matter content, 0-30 cm (1.00)		
				Subaerial (1.00)		
				Bulk density-compactibility to 30cm (0.82)		
P226E	Mathias, very stony-Samsil-Rock outcrop complex, 15 to 30 percent slopes	Medium	Mathias (50%)	Soil texture, 0-12 inches (1.00)	11.1	11.7%
				Soil structure grade, 0-12 inches (1.00)		
				Bulk density-compactibility to 30cm (1.00)		
				Organic matter content, 0-30 cm (1.00)		
				Subaerial (1.00)		
			Samsil (20%)	Soil texture, 0-12 inches (1.00)		
				Rock fragments, 0-12 inches (1.00)		
				Soil structure grade, 0-12 inches (1.00)		
				Organic matter content, 0-30 cm (1.00)		
				Subaerial (1.00)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Butche (15%)	Soil texture, 0-12 inches (1.00)		
				Rock fragments, 0-12 inches (1.00)		
				Soil structure grade, 0-12 inches (1.00)		
				Organic matter content, 0-30 cm (1.00)		
				Subaerial (1.00)		
SnE	Shingle-Penrose-Rock outcrop complex, 15 to 40 percent slopes	High	Shingle (45%)	Soil texture, 0-12 inches (1.00)	0.1	0.1%
				Rock fragments, 0-12 inches (1.00)		
				Soil structure grade, 0-12 inches (1.00)		
				Bulk density-compactibility to 30cm (1.00)		
				Organic matter content, 0-30 cm (1.00)		
			Midway (5%)	Soil texture, 0-12 inches (1.00)		
				Rock fragments, 0-12 inches (1.00)		
				Soil structure grade, 0-12 inches (1.00)		
				Bulk density-compactibility to 30cm (1.00)		
				Organic matter content, 0-30 cm (1.00)		
			Minnequa (5%)	Soil texture, 0-12 inches (1.00)		
				Rock fragments, 0-12 inches (1.00)		
				Soil structure grade, 0-12 inches (1.00)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Bulk density-compactibility to 30cm (1.00)		
				Organic matter content, 0-30 cm (1.00)		
Totals for Area of Interest					**94.4**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Medium	90.2	95.6%
High	4.1	4.4%
Totals for Area of Interest	**94.4**	**100.0%**

Description

SOH - Soil Health

Soils are rated based on their susceptibility to compaction from the operation of ground-based equipment for planting, harvesting, and site preparation activities when soils are moist. Soil compaction is the process in which soil particles are pressed together more closely that in the original state. Typically, the soil must be moist to be compacted because the mineral grains must slide together. Compaction reduces the abundance mostly of large pores in the soil by damaging the structure of the soil. This produces several effects that are unwanted in agricultural soils since large pores are most effective at transmitting water and air through the soil. Compaction also increases the soil strength which can limit root penetration and growth. The ability of soil to hold water is adversely affected by compaction since the large pores hold water. The degree of compaction of a soil is measured by its bulk density, which is the mass per unit volume, generally expressed in grams per cubic centimeter.

Compacted soils are less favorable for good plant growth because of high soil bulk density and hardness, reduced pore space, and poor aeration and drainage. Root penetration and growth is decreased in compacted soils because the hardness or strength of these soils prevents the expansion of roots. Supplies of air, water, and nutrients that roots need are also less favorable when compaction decreases soil porosity and drainage.

Interpretation ratings are based on soil properties in the upper 12 inches of the profile. Factors considered are soil texture, soil organic matter content, soil structure, rock fragment content, and the existing bulk density. Each of these is thought to contribute to resisting the susceptibility of a soil to compaction when present. Organic matter in the soil provides resistance to compaction and the resilience to ameliorate the effects with time. Soil structure adds strength as discrete aggregates and it is the aggregates that are deformed or destroyed by compactive forces, thus strong soil structure lowers the susceptibility to compaction. Similarly, rock fragments in the soil can bridge and provide a framework to resist compaction. Finally, if a soil is already fairly dense causing further compaction is more difficult.

Definitions of the ratings:

Low - The potential for compaction is insignificant. This soil is able to support standard equipment with minimal compaction. The soil is moisture insensitive, exhibiting only small changes in density with changing moisture content.

Medium - The potential for compaction is significant. The growth rate of seedlings may be reduced following compaction. After the initial compaction (i.e., the first equipment pass), this soil is able to support standard equipment with only minimal increases in soil density. The soil is intermediate between moisture insensitive and moisture sensitive.

High - The potential for compaction is significant. The growth rate of seedlings will be reduced following compaction. After initial compaction, this soil is still able to support standard equipment, but will continue to compact with each subsequent pass. The soil is moisture sensitive, exhibiting large changes in density with changing moisture content.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

References:

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Geist, J.M.; Hazard, J.W.; Seidel, K.W. 1989. Assessing Physical Conditions of Some Pacific Northwest Volcanic Ash Soils After Forest Harvest. Soil Science Society of America Journal 53:946-950.

Froehlich, Henry A and David H. McNab. 1983. Minimizing Soil Compaction in Pacific Northwest Forests. Proceedings of Sixth North American Forest Soils Conference, University of Tennessee.

Page-Dumrose, Deborah S. 1993. Susceptibility of Volcanic Ash Influenced Soils in Northern Idaho to Mechanical Compaction. U.S. Forest Service Intermountain Research Station. Research Note INT-409.

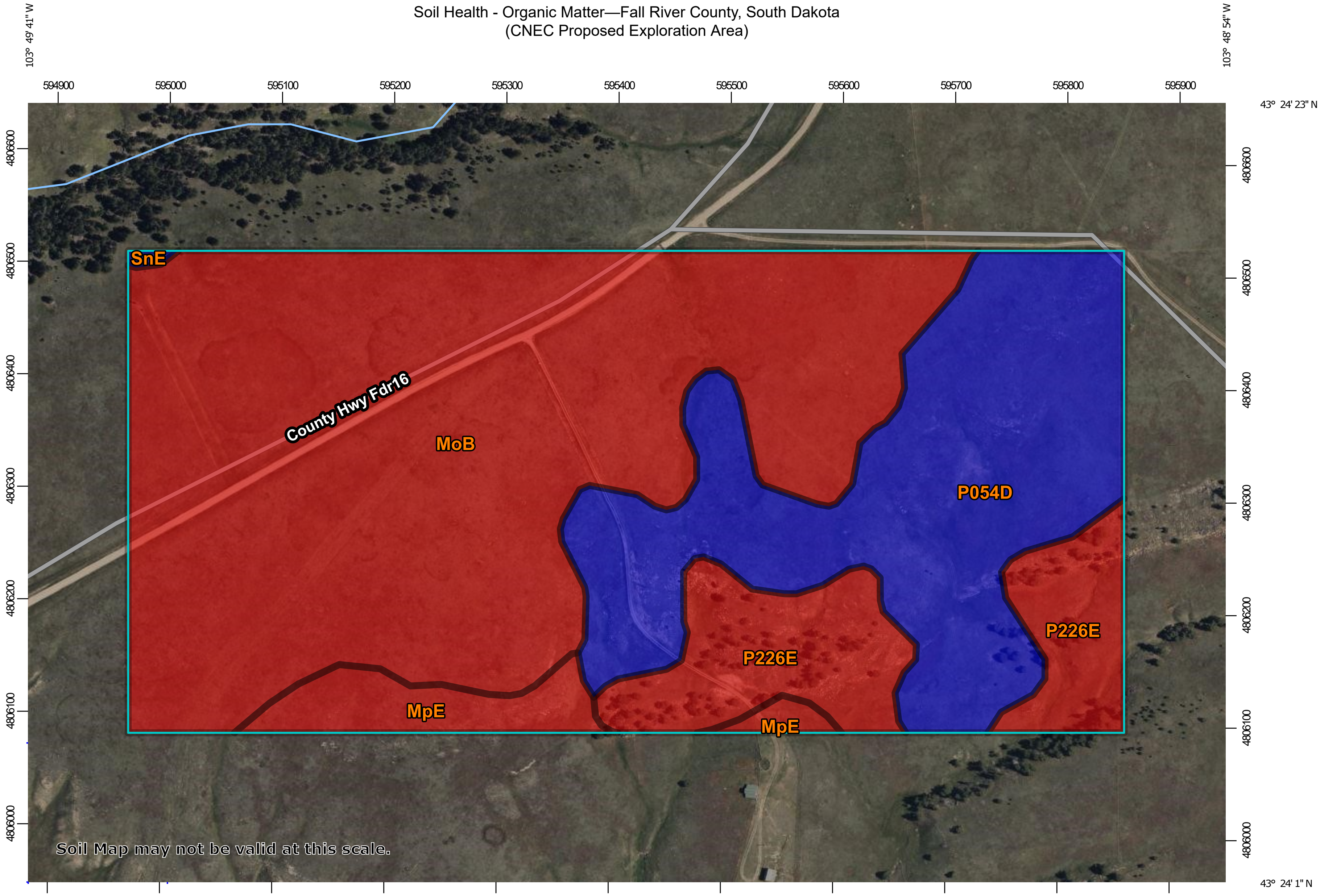
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Soil Health - Organic Matter—Fall River County, South Dakota
(CNEC Proposed Exploration Area)



Map Scale: 1:4,880 if printed on A landscape (11" x 8.5") sheet.

Meters: 0 50 100 200 300

Feet: 0 200 400 800 1200

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- <= 1.50
- > 1.50 and <= 2.00
- Not rated or not available

Soil Rating Lines

- <= 1.50
- > 1.50 and <= 2.00
- Not rated or not available

Soil Rating Points

- <= 1.50
- > 1.50 and <= 2.00
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Fall River County, South Dakota
Survey Area Data: Version 29, Sep 10, 2025

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 8, 2022—Jun 21, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Soil Health - Organic Matter

Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
MoB	Minnequa silt loam, 2 to 6 percent slopes	1.50	53.6	56.8%
MpE	Minnequa-Midway silty clay loams, 6 to 25 percent slopes	1.50	4.0	4.2%
P054D	Butche-Boneek, dry complex, 3 to 15 percent slopes	2.00	25.5	27.1%
P226E	Mathias, very stony-Samsil-Rock outcrop complex, 15 to 30 percent slopes	1.50	11.1	11.7%
SnE	Shingle-Penrose-Rock outcrop complex, 15 to 40 percent slopes	2.00	0.1	0.1%
Totals for Area of Interest			**94.4**	**100.0%**

Description

Organic matter percent is the weight of decomposed plant, animal, and microbial residues exclusive of non-decomposed plant and animal residues. It is expressed as a percentage, by weight, of the soil material that is less than 2 mm in diameter.

Significance:

Soil organic matter (SOM) influences the physical, chemical, and biological properties of soils far more than suggested by its relatively small proportion in most soils. The organic fraction influences plant growth through its influence on these soil properties. It encourages soil aggregation, especially macroaggregation, increases porosity, and lowers bulk density. Because the soil structure is improved, water infiltration rates increase. SOM has a high capacity to adsorb and exchange cations and is important to pesticide binding. It furnishes energy to microorganisms in the soil. As SOM is decomposed by soil microbes, it releases nitrogen, phosphorous, sulfur, and many micronutrients, which become available for plant growth. SOM is a heterogeneous, dynamic substance that varies in particle size, carbon content, decomposition rate, and turnover time. In general, the content of SOM is highest at the surfacewhere plant, animal, and microbial residue inputs are greatestand decreases with depth.

Total organic carbon (TOC) is the carbon (C) stored in SOM. Total organic carbon is also referred to as soil organic carbon (SOC) in the scientific literature. Organic carbon enters the soil through the decomposition of plant and animal residues, root exudates, and living and dead microorganisms. Inorganic carbon is common in calcareous soils in the form of calcium and magnesium carbonates. In calcareous soils, the content of inorganic carbon can exceed TOC.

Factors Affecting Content of SOM and SOC:

Inherent factors - Soil texture, parent material, drainage, climate, and time affect accumulation of SOM. Soils that are rich in clay have greater capacity to protect SOM from decomposition by stabilizing substances that bind to clay surfaces. The formation of soil aggregatesenabled by the presence of clay, aluminum and iron oxides, fungal hyphae, bacterial exudates (carbohydrates), and fine rootsprotects SOM from microbial decomposition. Extractable aluminum and allophanes, which are present in volcanic soils, can react with SOM to form compounds that are stable and resist microbial decomposition. Warm temperatures increase decomposition rates of SOM. High mean annual precipitation increases accumulation rates of SOM by stimulating the production of plant biomass.

Loss of SOM through erosion results in SOM variations along slope gradients. Areas of level topography tend to have much more SOM than areas with other slope classes. Both elevation and topographic gradients affect local climate, vegetation distribution, and soil properties. They also affect associated biogeochemical processes, including SOM dynamics. Analysis of factors affecting C in the conterminous United States indicates that the effects of land use, topography (elevation and slope), and mean annual precipitation on SOM are more obvious than the effects of mean annual temperature. However, when other variables are highly restricted, SOM content clearly declines with increasing temperature.

Dynamic factors - Dynamic gains and losses in SOM are due primarily to management decisions in combination with climate and microbial influences. Accumulation of SOM is controlled by the rate of C mineralization, the amount and stage of decomposition of plant residues, and the addition of organic amendments to soil.

Soil organic carbon comprises approximately 52 to 58% of the SOM and is the main source of energy for soil microorganisms. The C within plant residues, particulate organic matter, and soil microbial biomass is generally considered to be within the active pool of SOM. The emergent view of SOM focuses on microbial access to SOM and includes an emphasis on the need to manage C flows rather than discrete C pools. During decomposition of SOM, energy and nutrients are released and utilized by plant roots and soil biota. Recognizing that SOM is a continuum of decomposition products is a first step in designing management strategies for renewing SOM sources throughout the year.

Soil aggregates of various sizes and stabilities can act as sites at which SOM is physically protected from decomposition and C mineralization. Soil disturbance and aggregate destruction increase biodegradation of SOM. Aggregates are readily broken apart by tillage operations.

Crop residues incorporated into or left on the soil surface reduce erosion and the losses of SOM associated with sediment. In acidic soils, applications of lime increase plant productivity, microbial activity, organic matter decomposition, and CO2 release.

The diversity of the soil microbial population affects SOM. For example, while soil bacteria and some fungi participate in SOM loss by mineralizing C compounds, other fungi, such as mycorrhizae, facilitate stabilization and physical protection by aggregating SOM with clay and minerals. SOM is better protected from degradation within aggregates than in free-form.

Relationship to Soil Function:

SOM is one of the most important soil constituents. It affects plant growth by improving aggregate stability, soil structure, water availability, and nutrient cycling. SOM fractions in the active pool, described above, are the main source of energy and nutrients for soil microorganisms, which mediate nutrient cycling in the soil. Biochemically stable SOM participates in aggregate stability and in holding capacity for nutrients and water.

Microaggregates are formed by mineral interactions with iron and aluminum oxides and are generally considered an inherent soil characteristic. They are, however, impacted by current and past management. Fine roots, fungal hyphae, and organic carbon compounds, such as complex sugars (carbohydrates) and proteins (also referred to as glues), bind mineral particles and microaggregates together to form macroaggregates that are still porous enough to allow air, water, and plant roots to move through the soil.

An increase in SOM leads to greater biological diversity and activity in the soil, thus increasing biological control of plant diseases and pests.

Problems Associated with Low Organic Matter Levels:

Low levels of SOM result in energy-source shortages and thereby lowered levels of microbial biomass, activity, and nutrient mineralization. In noncalcareous soils, aggregate stability, infiltration, drainage, and airflow are also reduced. Scarcity of SOM results in less diversity in soil biota and a risk of disruption to the food chain equilibrium. This disruption can cause disturbance in the soil environment (e.g., increased plant pests and diseases and accumulation of toxic substances).

Improving SOM Levels:

An estimated 4.4x10 to the 9th power tons of C have been lost from soils of the United States due to traditional farming practices. Most of this carbon was SOC. Nearly half of the SOM has been lost from many agricultural soils. Other farming practices, such as no-till and cover cropping (especially when used together), can stop losses of SOM and even lead to increases. Continuous application of manure and compost can increase SOM. Burning, harvesting, or otherwise removing plant residues decreases SOM.

Measurement:

SOM is measured in the laboratory by determining total carbon (TC) content using either dry or wet-dry combustion. Current analytical methods do not distinguish between decomposed and nondecomposed residues, so soil is first sieved to 2 mm to remove as much of the recognizable plant material as possible. If no carbonates are present, TC is considered to be the same as TOC (or SOC). For calcareous soils, soil inorganic carbon in the form carbonates must also be measured and then subtracted from the TC to determine TOC content. Results are given as the percent TOC in dry soil. To convert percent TOC to percent SOM, multiply the TOC percentage by 1.724. To convert percent SOM to percent TOC, divide the SOM percentage by 1.724. Note that this value continues to be debated by researchers with possible values ranging from 1.4 to 2.5 (Pribyl, 2010). A conversion factor of 2 has been suggested for this database but has not yet been adopted. Detailed procedures for measurement of SOM are outlined in 'Soil Survey Investigations Report No. 42, Kellogg Soil Survey Laboratory Methods Manual, Version 5.0,' (Soil Survey Staff, 2014).

Many soil testing laboratories use a 'loss on ignition' method to estimate soil organic matter. The estimate produced by this method must be correlated to analytical TOC measurements for each area to improve accuracy. The loss on ignition method can provide a good indication of the trend in SOM content within a field. It is important to note that temperature and timing used for the loss on ignition approach vary across labs and can influence results. Thus, comparisons should be made using only results from within a given lab.

Currently, no standard method exists to measure TOC in the field. Attempts have been made to develop charts that match color to TOC content, but the correlation is better within soil landscapes and only for limited soils. Near-infrared spectroscopy has been tested for measuring C directly in the field, but it is expensive and sensitive to moisture content.

Estimates:

Color and feel are soil characteristics that can be used to estimate SOM content. Color comparisons in areas of similar parent materials and textures can be correlated with laboratory data and thereby enable a soil scientist to make field estimates. In general, darker colors or black indicate the presence of higher amounts of organic matter. The contrast of color between the A horizon and subsurface horizons is also a good indicator. Sandy soils tend to look darker with a lower content of SOM. In general, lower numbers for hue, value, and chroma (in the Munsell soil color system) tend to be associated with darker soil colors that are attributed to higher content of SOM, soil moisture, or both.

For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A 'representative' value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

References:

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Edwards, J.H., C.W. Wood, D.L. Thurlow, and M.E. Ruf. 1999. Tillage and crop rotation effects on fertility status of a Hapludalf soil. Soil Science Society of America Journal 56:15771582.

Pribyl, D.W. 2010. A critical review of the conventional SOC to SOM conversion factor. Geoderma 156:7583.

Sikora, L.J., and D.E. Stott. 1996. Soil organic carbon and nitrogen. In: J.W. Doran and A.J. Jones, editors, Methods for assessing soil quality. Madison, WI. p. 157167.

Schulze, D.G., J.L. Nagel, G.E. Van Scoyoc, T.L. Henderson, M.F. Baumgardner, and D.E. Stott. 1993. Significance of organic matter in determining soil colors. In: J.M. Bigham and E.J. Ciolkosz, editors, Soil color. Soil Science Society of America, Madison, WI. p. 7190.

Soil Survey Staff. 2014. Kellogg Soil Survey Laboratory methods manual. Soil Survey Investigations Report No. 42, Version 5.0. R. Burt and Soil Survey Staff (ed.). U.S. Department of Agriculture, Natural Resources Conservation Service.

Rating Options

Units of Measure: percent

Aggregation Method: Dominant Component

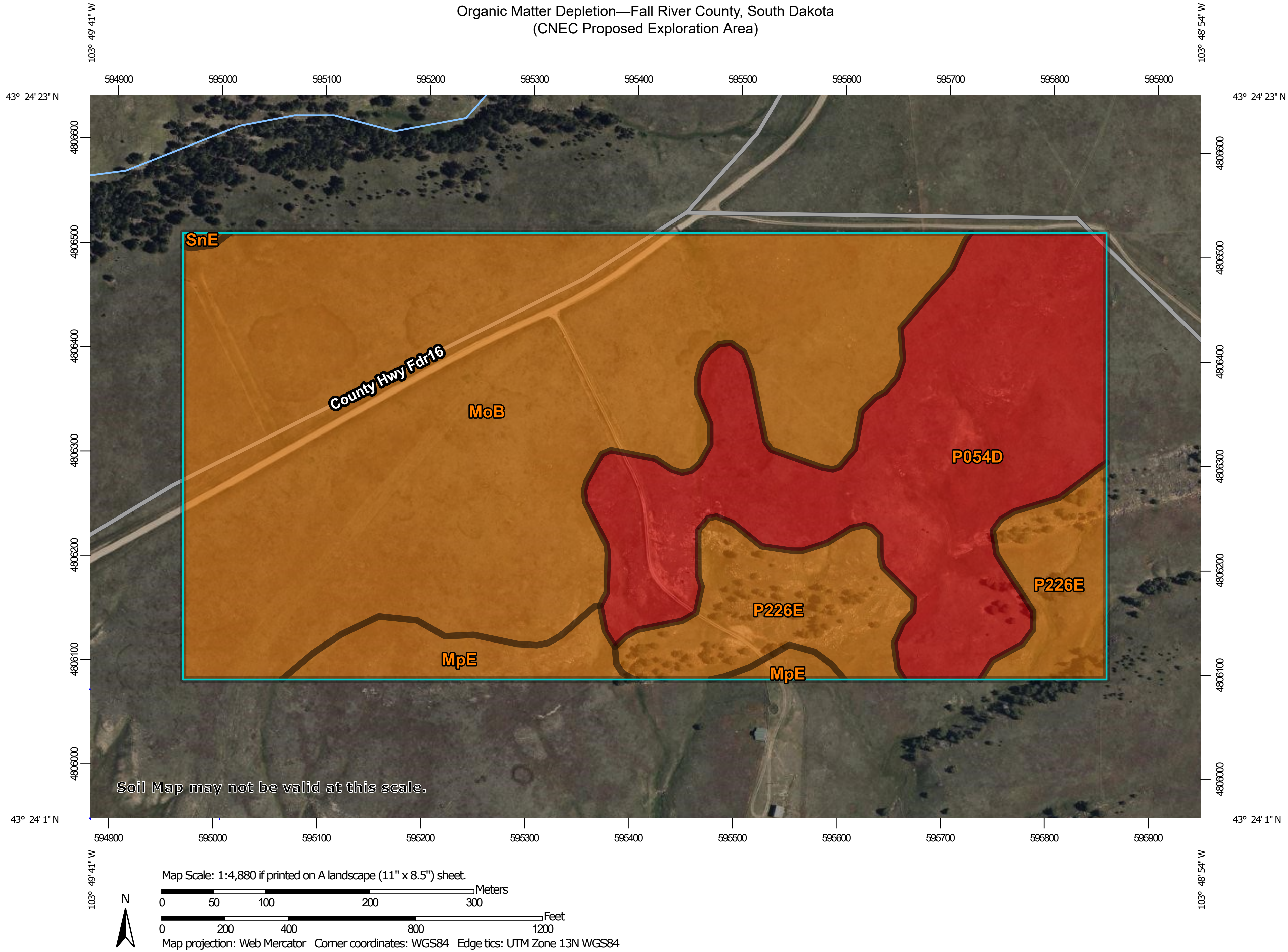
Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: No

Layer Options (Horizon Aggregation Method): Surface Layer (Not applicable)

Organic Matter Depletion—Fall River County, South Dakota
(CNEC Proposed Exploration Area)



Map Scale: 1:4,880 if printed on A landscape (11" x 8.5") sheet.

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- OM depletion high
- OM depletion moderately high
- OM depletion moderate
- OM depletion moderately low
- OM depletion low
- Not rated or not available

Soil Rating Lines

- OM depletion high
- OM depletion moderately high
- OM depletion moderate
- OM depletion moderately low
- OM depletion low
- Not rated or not available

Soil Rating Points

- OM depletion high
- OM depletion moderately high
- OM depletion moderate
- OM depletion moderately low
- OM depletion low
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Fall River County, South Dakota
Survey Area Data: Version 29, Sep 10, 2025

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 8, 2022—Jun 21, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Organic Matter Depletion

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
MoB	Minnequa silt loam, 2 to 6 percent slopes	OM depletion moderately high	Minnequa (90%)	Well aerated (1.00)	53.6	56.8%
				Not water gathering surface (1.00)		
				Moderate antecedent organic matter content (0.89)		
				Moderate moisture deficit (0.82)		
				Medium amount of clay surface area (0.76)		
			Pierre (5%)	Well aerated (1.00)		
				Not water gathering surface (1.00)		
				Moderate moisture deficit (0.82)		
				Moderate antecedent organic matter content (0.73)		
				Moderate oxidation rate (0.35)		
			Midway (5%)	Well aerated (1.00)		
				Not water gathering surface (1.00)		
				Moderate antecedent organic matter content (0.89)		
				Moderate moisture deficit (0.81)		
				Moderate oxidation rate (0.35)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
MpE	Minnequa-Midway silty clay loams, 6 to 25 percent slopes	OM depletion moderately high	Minnequa (50%)	Well aerated (1.00)	4.0	4.2%
				Not water gathering surface (1.00)		
				Moderate antecedent organic matter content (0.89)		
				Moderate moisture deficit (0.81)		
				Moderate oxidation rate (0.35)		
			Midway (40%)	Well aerated (1.00)		
				Not water gathering surface (1.00)		
				Moderate antecedent organic matter content (0.89)		
				Moderate moisture deficit (0.81)		
				Moderate oxidation rate (0.35)		
			Pierre (3%)	Well aerated (1.00)		
				Not water gathering surface (1.00)		
				Moderate moisture deficit (0.81)		
				Moderate antecedent organic matter content (0.73)		
				Moderate oxidation rate (0.35)		
			Shingle (2%)	Well aerated (1.00)		
				Not water gathering surface (1.00)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Moderate antecedent organic matter content (0.86)		
				Moderate moisture deficit (0.81)		
				Medium amount of clay surface area (0.79)		
P054D	Butche-Boneek, dry complex, 3 to 15 percent slopes	OM depletion high	Butche, dry (55%)	Well aerated (1.00)	25.5	27.1%
				Not water gathering surface (1.00)		
				Medium amount of clay surface area (0.98)		
				Moderate antecedent organic matter content (0.86)		
				Moderate moisture deficit (0.81)		
			Mathias (8%)	Well aerated (1.00)		
				Not water gathering surface (1.00)		
				Low amount of clay surface area (1.00)		
				Moderate antecedent organic matter content (0.91)		
				Moderate moisture deficit (0.81)		
P226E	Mathias, very stony-Samsil-Rock outcrop complex, 15 to 30 percent slopes	OM depletion moderately high	Mathias (50%)	Well aerated (1.00)	11.1	11.7%
				Not water gathering surface (1.00)		
				Low amount of clay surface area (1.00)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Moderate antecedent organic matter content (0.91)		
				Moderate moisture deficit (0.78)		
			Samsil (20%)	Well aerated (1.00)		
				Not water gathering surface (1.00)		
				Moderate antecedent organic matter content (0.92)		
				Moderate moisture deficit (0.78)		
				Moderate oxidation rate (0.29)		
			Butche (15%)	Well aerated (1.00)		
				Not water gathering surface (1.00)		
				Medium amount of clay surface area (0.96)		
				Moderate antecedent organic matter content (0.84)		
				Moderate moisture deficit (0.78)		
SnE	Shingle-Penrose-Rock outcrop complex, 15 to 40 percent slopes	OM depletion moderately high	Shingle (45%)	Well aerated (1.00)	0.1	0.1%
				Not water gathering surface (1.00)		
				Moderate antecedent organic matter content (0.86)		
				Moderate moisture deficit (0.75)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Medium amount of clay surface area (0.72)		
			Penrose (25%)	Low antecedent organic matter content (1.00)		
				Well aerated (1.00)		
				Not water gathering surface (1.00)		
				Medium amount of clay surface area (0.82)		
				Moderate moisture deficit (0.75)		
			Rock outcrop (20%)	Well aerated (1.00)		
				Not water gathering surface (1.00)		
				Moderate antecedent organic matter content (0.96)		
				Moderate moisture deficit (0.75)		
				Moderate oxidation rate (0.29)		
			Midway (5%)	Well aerated (1.00)		
				Not water gathering surface (1.00)		
				Moderate antecedent organic matter content (0.86)		
				Moderate moisture deficit (0.75)		
				Moderate oxidation rate (0.29)		
			Minnequa (5%)	Well aerated (1.00)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Not water gathering surface (1.00)		
				Moderate antecedent organic matter content (0.96)		
				Moderate moisture deficit (0.75)		
				Medium amount of clay surface area (0.64)		
Totals for Area of Interest					**94.4**	**100.0%**

Rating	Acres in AOI	Percent of AOI
OM depletion moderately high	68.8	72.9%
OM depletion high	25.5	27.1%
Totals for Area of Interest	**94.4**	**100.0%**

Description

SOH - Soil Health

Soil Organic Matter Depletion

Soil health is primarily influenced by human management, which is not captured in soil survey data at this time. These interpretations provide information on inherent soil properties that influence our ability to build healthy soils through management.

A fertile and healthy soil is the basis for healthy plants, animals, and humans. Soil organic matter is the very foundation for healthy and productive soils. Understanding the role of organic matter in maintaining a healthy soil is essential for developing ecologically sound agricultural practices. Perhaps just as important is identifying areas at greater risk of organic matter depletion. For organic matter to accumulate in soil, the processes that synthesize organic matter generally need to be greater than the processes that destroy organic matter. These processes occur at continental and local scales. Continental-scale factors include the mean annual temperature, which ultimately governs the rates of biological processes, including both the synthesizing and destroying of organic matter. Another continental-scale factor is the amount of water generally available for use by plants and soil microbes. The amount of available water is governed by the amount of rainfall or snowmelt that an area receives in relation to evapotranspiration. This interpretation does not take into account the application of irrigation water.

The continental-scale factors are modified by local factors. Oxygen is needed for both the accumulation and destruction of organic matter. It can be excluded from the soil by seasonal saturation, which generally favors the accumulation processes. The antecedent organic matter content is used as an indicator of the level of a soils vulnerability to loss of organic matter. In general, well aerated soils tend to have higher oxidation rates but may still accumulate organic matter, depending on other factors, such as ground cover, length of time that living roots are present in the soil, and management practices. Clay-sized particles in the soil help protect organic compounds and so tend to favor organic matter accumulation. The shape of the land surface also influences the organic matter content. Water and sediment tend to accumulate in concave areas while material tends to disperse in convex areas. The degree of limitation caused by each of these properties is rated for a soil and the sum of the ratings is the overall rating.

The ratings are both verbal and numerical. Numerical ratings indicate the propensity of the individual soil properties to influence organic matter degradation. The ratings are shown in decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest ability to enable organic carbon depletion (1.00) and the point at which the soil feature becomes least likely to allow organic matter depletion (0.00).

Rating class terms indicate the extent to which the soils enable the depletion of organic matter. "Organic matter depletion high" indicates that the soil and site have features that are very conducive to the depletion of organic matter. Very careful management will be needed to prevent serious organic matter loss when these soils are farmed. "Organic matter depletion moderately high", "Organic matter depletion moderate", and "Organic matter depletion moderately low" are a gradient of the level of management needed to avoid organic matter depletion. "Organic matter depletion low" indicates soils that have features that are favorable for organic matter accumulation. These soils allow more management options while still maintaining favorable organic matter levels.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

This interpretation is being provided for review and comment by the user community. Please forward any feedback to the Soils Hotline soilshotline@lin.usda.gov.

References

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Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

ATTACHMENT B

Estimated Reclamation Cost

CNEC Exploration Earthwork and Revegetation Cost Estimate

Assumptions:
1. Each of 38 drill pads will cover an area of 60 ft x 60 ft = 3600 ft^2 = 0.08 ac
2. 6" of topsoil has been salvaged from and stockpile adjacent to each disturbed area.
   One acre of topsoil removed to a depth of 6" = 810 CY.
3. Off-road access will be required between 30 of the drill pads.
4. If the 30 off-road holes are equally spaced, the distance between holes can be calculated using the equation $L = (A/n)^{1/2}$
   Where L = Distance between holes (ft); A = Study area (ft^2); n = Number of points
   With a study area of 49.5 acres and 30 off-road locations, the spacing between driullholes would be 268 feet.
   For each of the 40 holes, assume an average off-road trail width of 12 ft.
   Each off-road trail represents an area of 268 ft x 12 ft = 3216 ft2 = 0.07 ac
5. All off-road disturbed areas will be ripped to a depth of 2 ft. One acre of soil ripped to a depth of 2 ft = 3230 CY.
6. Each mud pit has dimensions as stated in the permit application (10 ft x 5 ft x 6 ft = 11 CY)
7. Unit prices are from Gordian Site Work and Landscape Costs with RS Means Data (2026).
8. All unit rates include overhead and profit.

Direct Costs:

Description	*Materials*	*Means Ref Number*	*Unit Cost*	*Unit*	*Area or Volume*	*Units*	*Number*	*Quantity*	*Unit*	*Direct Cost ($)*
Earthwork - Drill Pads										
Backfill mud pits	Backfill, 80 HP wheeled loader, 50' haul, common earth	31-23-23.14-2020	1.83	CY	11	CY	38	418	CY	765
Rip compacted disturbed area	Ripping, med/hard boulder/clay, 300 HP dozer, ideal	31-23-16.32-2820	0.65	CY	0.08	acre	38	9,819	CY	6,382
Regrade ripped area	300 HP dozer, 50' haul, common earth	31-23-16.46-5020	2.25	CY	0.08	acre	38	9,819	CY	22,093
Spread topsoil	300 HP dozer, 50' haul, common earth	31-23-16.46-5020	2.25	CY	0.08	acre	38	2,462	CY	5,540
SUBTOTAL										34,015
Revegetation - Drill Pads										
Apply hay mulch	1" deep. large power mulcher	32-91-13.16-0390	38.00	MSF	3.60	MSF	38	137	MSF	5,198
Seed material	CNEC seed mix (see below)	Great Basin Seed	235.59	ac	0.08	acre	38	3.04	ac	716
Seeding equipment labor	Mechanical (drill) seeding, equipment and labor only	32-92-19.13-0020	613.00	ac	0.08	acre	38	3.04	ac	1,864
SUBTOTAL										7,778
Earthwork - Off-Road Trails										
Rip compacted disturbed area	Ripping, med/hard boulder/clay, 300 HP dozer, ideal	31-23-16.32-2820	0.65	CY	0.28	acre	30	27,132	CY	17,636
Regrade ripped area	300 HP dozer, 50' haul, common earth	31-23-16.46-5020	2.25	CY	0.28	acre	30	27,132	CY	61,047
Spread topsoil	300 HP dozer, 50' haul, common earth	31-23-16.46-5020	2.25	CY	0.28	acre	30	6,804	CY	15,309
SUBTOTAL										93,992
Revegetation - Off-Road Trails										
Apply hay mulch	1" deep. large power mulcher	32-91-13.16-0390	38.00	MSF	12.00	MSF	30	360	MSF	13,680
Seed material	CNEC seed mix (see below)	Great Basin Seed	235.59	ac	0.28	acre	30	8.40	ac	1,979
Seeding equipment labor	Mechanical (drill) seeding, equipment and labor only	32-92-19.13-0020	613.00	ac	0.28	acre	30	8.40	ac	5,149
SUBTOTAL										20,808
TOTAL DIRECT COST										**156,976**

Indirect Costs:

Description	% of Direct Cost	Indirect Cost ($)
Mobilization/demobilization	10.0	15,698
Engineering/permitting	5.0	7,849
Construction inspection	5.0	7,849
Contingency	10.0	15,698
TOTAL INDIRECT COST		**47,094**

TOTAL ESTIMATED COST = **$ 204,070**

UNIT ESTIMATED COST PER DRILL PAD = **$ 5,370**

The following seed mix cost based on the application rates provided in the March 11,
Seed prices downloaded February 10, 2026 from greatbasinseeds.com

Common Name	Seeding Rate (lb PLS/ac)	Unit Cost ($/lb)	Mix Cost ($/ac)
Sideoats grama	0.79	29.00	22.91
Western wheatgrass	10.98	11.50	126.27
Blue grama	0.13	29.00	3.77
Green needlegrass	1.36	10.50	14.28
Slender wheatgrass	0.23	11.75	4.25
Purple prairie clover	0.11	4.65	24.00
Little bluestem	0.46	70.00	18.69
		Subtotal =	214.17
		10% increase to account for PLS requirement and re-seeding=	21.42
		Seed mix unit cost =	235.59