Appendix 6 - Paleontological Report

Final Paleontological Resource Impact Evaluation for the Summit Carbon Solutions Midwest Carbon Express Project, North Dakota

Project Name:
Summit Carbon Solutions Midwest Carbon Express

Document Number:
SCS-0700-ENV-02-RPT-032

Date:
September 23, 2022

REVISION HISTORY

DATE	REVISION	REVISION DESCRIPTION	PREPARED BY:	REVIEWED BY:	APPROVED BY:
09-23-2022	0	Prepare Final Plan	Stantec	JB	EB

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EXECUTIVE SUMMARY

Stantec Consulting Services, Inc. (Stantec) conducted a paleontological resources impact evaluation on behalf of EXP Energy Services (EXP) for the Summit Carbon Solutions Midwest Carbon Express Project (the MCE Project) across portions of Burleigh, Cass, Dickey, Emmons, Logan, McIntosh, Morton, Oliver, Richland, and Sargent counties in North Dakota. The North Dakota portion of the MCE Project is hereafter referred to as the "Project". This paleontological study was conducted in support of Summit Carbon Solutions, LLC for the proposed carbon dioxide pipeline.

This paleontological study was conducted as an exercise in due diligence, as paleontological resources are afforded protections as nonrenewable natural resources by the federal government and the State of North Dakota. This study consisted of a records search from the North Dakota Geological Survey, a review of the most recent geologic mapping and relevant scientific literature, and a search of the Paleobiology Database. This research was used to apply Potential Fossil Yield Classification (PFYC) rankings of the Bureau of Land Management (BLM) (2016, 2020) for the geologic units present in the Project area, either at the surface or in the subsurface. Although there is no BLM involvement in the Project, the PFYC is widely used by both federal and non-federal agencies as a predictive tool for evaluating potential impacts for scientifically important paleontological resources.

The results of this impact evaluation indicate that 22 mapped geologic units are present in the Project area: 15 facies of Holocene-aged surficial sediments that are assessed by the BLM (2020) as having low paleontological potential (PFYC 2); sands of the Oahe and older formations that date from the Holocene to the Pliocene and are assessed as having moderate paleontological potential (PFYC 3); the Sentinel Butte Formation, Bullion Creek Formation, and Cannonball Formation with high paleontological potential (PFYC 4) and the Slope Formation, with moderate paleontological potential (PFYC 3), all of which date to the Paleocene; the Hell Creek Formation, which dates to the Late Cretaceous and has very high paleontological potential (PFYC 5); and the Fox Hills Formation, which dates to the Late Cretaceous and has high paleontological potential (PFYC 4).

Recommended mitigation measures for this Project are as follows:

Private Lands. There are no laws or regulations that require the mitigation of construction impacts to paleontological resources on private lands in North Dakota, which are the property of private landowners. Because construction could result in damage or destruction of paleontological resources on private lands and therefore result in an economic impact to the landowner, Stantec recommends the following:

1. The development of a Worker's Environmental Awareness Program training that educates construction personnel on the types of fossils that could be encountered during construction and communicates the requirements and procedures for the inadvertent discovery of paleontological resources. The training program should be developed by a qualified paleontologist (meeting BLM [2008] qualifications as a paleontological principal investigator) and presented to construction personnel prior to the onset of ground disturbance. Any subsurface bones or other potential paleontological resources that are found by construction personnel should be evaluated by a qualified paleontologist remotely using photographs, and if they are confirmed as paleontological resources, they should be transferred to the applicable landowner.

State Lands. Paleontological resources on North Dakota state lands are protected under Chapters 54-17.3 and 43-04 of the North Dakota Century and Administrative Codes. In order to comply with North Dakota law, Stantec recommends the following:

1. A qualified paleontologist (meeting BLM [2008] qualifications as a paleontological principal investigator) should be retained to oversee all aspects of paleontological mitigation.
2. An initial analysis should be completed to determine if any state lands crossed by the project contain exposures of geologic units with moderate (PFYC 3) to very high paleontological potential (PFYC 5) (sand of the Oahe and older formations; the Sentinel Butte Formation; the Bullion Creek Formation; the Slope Formation;

the Cannonball Formation; the Hell Creek Formation; and the Fox Hills Formation), and if these geologic units will be disturbed by construction. If possible, the depth of surficial sediments should be taken into consideration. For all such areas identified, steps 3-6 should be completed.

3. The development and implementation of a Paleontological Resource Monitoring and Mitigation Plan (PRMMP) which outlines field survey and construction monitoring procedures, provides details of survey and monitoring locations, and provides the specific evaluation, notification and fossil/data recovery procedures to be followed in the event of the discovery of paleontological resources. The PRMMP should include specific recommendations made by the NDGS and include an Unanticipated Discovery Plan that outlines steps to follow in the event of a paleontological discovery by construction personnel in the absence of a paleontological monitor.
4. The development of a Worker's Environmental Awareness Program training that educates construction personnel on the types of fossils that could be encountered during construction and communicates the requirements and procedures for the inadvertent discovery of paleontological resources. The training program should be developed by a qualified paleontologist and presented to construction personnel prior to the onset of ground disturbance, and it should be included in the PRMMP.
5. A field survey of areas identified in #2. This survey can be completed immediately prior to construction as a preliminary step to the monitoring program. The field survey should include specific recommendations made by the NDGS.
6. Construction monitoring of areas identified in #2. The monitoring should be conducted by a qualified paleontological monitor (meeting BLM [2008]). Should subsurface conditions indicate paleontological potential is lower than anticipated, the principal paleontologist may recommend a reduction in monitoring.
7. In the event that paleontological resources are encountered during construction activities, all work must stop in the immediate vicinity of the finds while the paleontological monitor documents the find and the paleontological principal investigator evaluates its scientific importance. Further treatment of the find (i.e., salvage, curation, etc.) shall be determined pending the outcome of the assessment and in consultation with the Project Owner and the NDGS. All recovered paleontological resources should be transferred to the NDGS for curation and permanent storage.

The recommendations for state lands meet the standards of the BLM (1998, 2008, 2016) and conform to industry best practices (e.g., Murphey et al. 2019). Based on the findings in this study the proposed project will not cause an adverse impact to paleontological resources on state lands with the incorporation of the above mitigation recommendations. Should the project location or plans change from those assessed here, this assessment will need to be revised to address those changes.

Abbreviations

ABBREVIATION	DEFINITION
BLM	Bureau of Land Management
NDPSC	North Dakota Public Service Commission
NDGS	North Dakota Geological Survey
NEPA	National Environmental Policy Act
PBDB	Paleobiology Database
PFYC	Potential Fossil Yield Classification
PRPA	Paleontological Resources Protection Act
SVP	Society of Vertebrate Paleontology

Glossary

TERM	DEFINITION
Paleontological Resource	Any fossilized remains, traces, or imprints of organisms, preserved in or on the earth's crust, that are of paleontological interest and that provide information about the history of life on earth, except that the term does not include— (A) any materials associated with an archaeological resource (as defined in section 3(1) of the Archaeological Resources Protection Act of 1979 (16 U.S.C. 470bb(1)); or (B) any cultural item (as defined in section 2 of the Native American Graves Protection and Repatriation Act (25 U.S.C. 3001)). [Paleontological Resources Preservation Act; Sec. 6301: Definitions]
Paleontological Principal Investigator	The person listed as Permittee on the Paleontological Resources Use Permit is the Principal Investigator and is responsible for all actions under the permit (BLM 2008). Permittees must be able to demonstrate the following: a. professional instruction in a field of paleontology relevant to the work proposed (vertebrate, invertebrate, trace, paleobotany, etc.), obtained through formal education resulting in a graduate degree from an accredited institution in paleontology, or in geology, biology, botany, zoology or anthropology if the major emphasis is in paleontology or equivalent paleontological training and experience including at least 24 months under the guidance of a professional paleontologist who meets this qualification, that provided increased responsibility leading to professional duties similar to those in qualification (1) above; b. demonstrated experience in collecting, analyzing, and reporting paleontological data, similar to the type and scope of work proposed in the application; c. demonstrated experience in planning, equipping, staffing, organizing, and supervising crews performing the work proposed in the application; and d. demonstrated experience in carrying paleontological projects to completion as evidenced by timely completion and/or publication of theses, research reports, scientific papers and similar documents (BLM 1998).

1 INTRODUCTION

Stantec Consulting Services, Inc. (Stantec) conducted a paleontological resources assessment on behalf of EXP Energy Services (EXP) for the Summit Carbon Solutions Midwest Carbon Express Project (the Project) across portions of Burleigh, Cass, Dickey, Emmons, Logan, McIntosh, Morton, Oliver, Richland, and Sargent Counties in North Dakota. This paleontological study was conducted in support of Summit Carbon Solutions, LLC (SCS) for the proposed carbon dioxide (CO_2) pipeline under the jurisdiction of the North Dakota Public Service Commission (NDPSC).

1.1 PROJECT DESCRIPTION

SCS intends to construct a CO_2 capture, pipeline system, and sequestration project in North Dakota, South Dakota, Nebraska, Minnesota, and Iowa. The Project will consist of the construction of approximately 2,000 miles of new pipeline extending from various ethanol plants and CO_2 capture facilities, pump stations, mainline valves, and access roads in the five states. The portion of the Project that falls under the jurisdiction of NDPSC, will include approximately 320 miles ofCO_2 pipelines and associated facilities which will cross through portions of 10 counties in the state of North Dakota. The Project will require a United States Army Corps of Engineers (USACE) permit pursuant to Section 10 of the Rivers and Harbors Act, and Section 404 of the Clean Water Act, as well as authorizations from United States Fish and Wildlife Service (USFWS).

1.2 PROJECT LOCATION

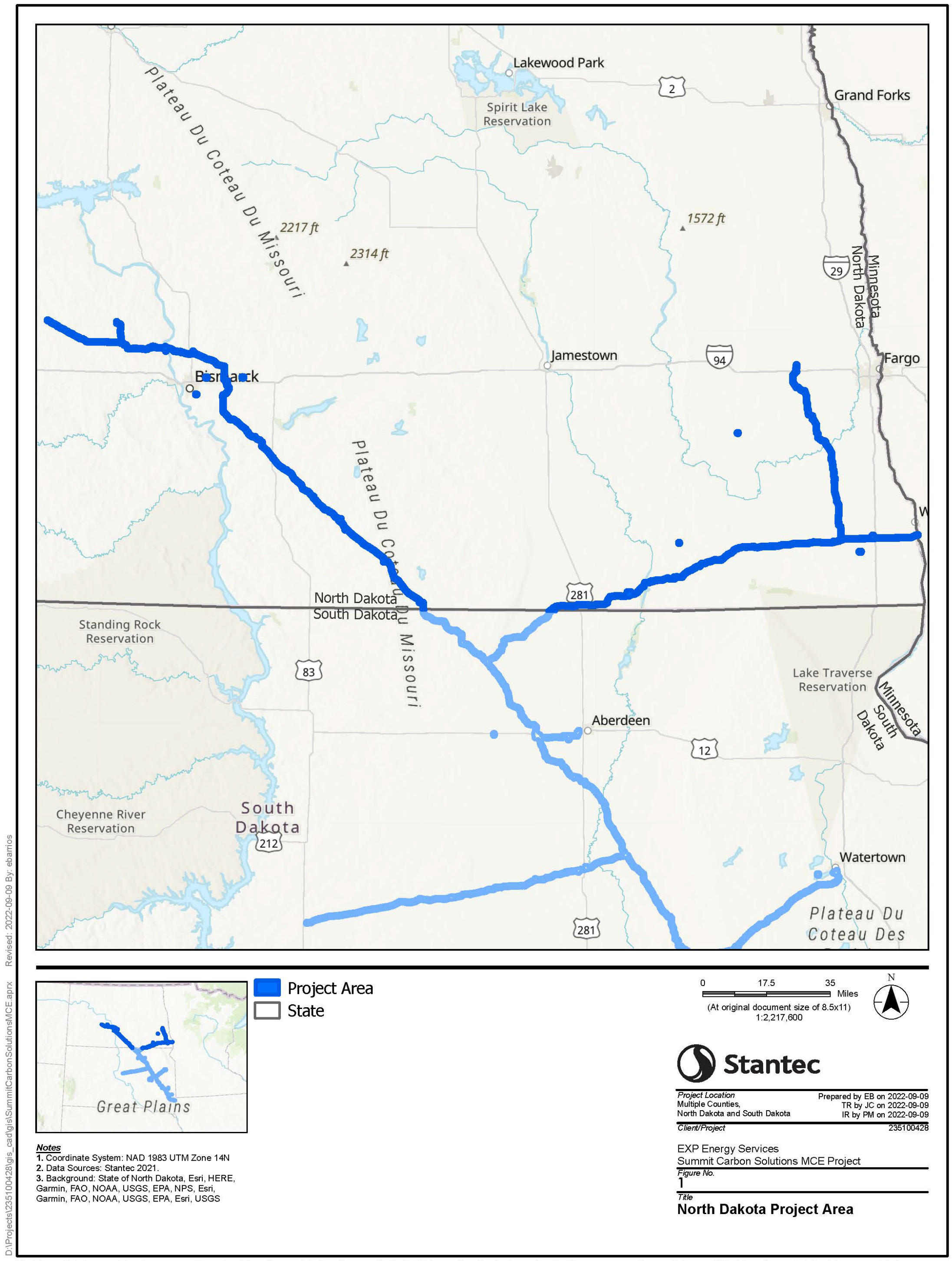
The North Dakota portion of the Project that is under the jurisdiction of the NDPSC is located in Burleigh, Cass, Dickey, Emmons, Logan, McIntosh, Morton, Oliver, Richland, and Sargent counties (Figure 1). The Public Land Survey System crossed by the Project is shown in Appendix A.

1.3 PALEONTOLOGICAL RESOURCES

Paleontological resources, or fossils, are any evidence of ancient life. This includes the remains of the body of an organism, such as bones, skin impressions, shell, or leaves, as well as traces of an organism's activity, such as footprints or burrows, called trace fossils. In addition to the fossils themselves, geologic context is an important component of paleontological resources, and includes the stratigraphic placement of the fossil as well as the lithology of the rock in order to assess paleoecologic setting, depositional environment, and taphonomy. Fossils are protected by federal, state, and local regulations as nonrenewable natural resources.

The Society of Vertebrate Paleontology (SVP) (2010), the Bureau of Land Management (BLM) (2016) and a number of scientific studies (Eisentraut and Cooper 2002, Murphey and Daitch 2007, Murphey et al. 2019) have developed guidelines for professional qualifications, conducting paleontological assessments, and developing mitigation measures for the protection of paleontological resources.

Figure 1: North Dakota Project Area



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These guidelines are broadly similar, and include the use of museum records searches, scientific literature reviews, and, in some cases, field surveys to assess the potential of an area to preserve paleontological resources. Should that potential be high, accepted mitigation measures include paleontological monitoring, data recordation of all fossils encountered, collection and curation of scientifically important fossils and associated data, and in some cases screening of sediment for microfossils.

Both the SVP (1995, 2010) and the BLM (2008, 2016) have established standard guidelines that outline professional protocols and practices for conducting paleontological resource assessments and surveys, monitoring and mitigation, data and fossil recovery, sampling procedures, and specimen preparation, identification, analysis, and curation. Both the BLM and USFS, as well as other federal and state agencies, have endorsed the best practices in mitigation paleontology proposed by Murphey et al. (2019).

As defined by the SVP, scientifically important paleontological resources are:

> fossils and fossiliferous deposits, here defined as consisting of identifiable vertebrate fossils, large or small, uncommon invertebrate, plant, and trace fossils, and other data that provide taphonomic, taxonomic, phylogenetic, paleoecologic, stratigraphic, and/or biochronologic information. Paleontological resources are considered to be older than recorded human history and/or older than middle Holocene (i.e., older than about 5,000 radiocarbon years). [SVP 2010: 11].

As defined by the BLM (2008), scientifically important paleontological resources are:

> any paleontological resource that is considered to be of scientific interest, including most vertebrate fossil remains and traces, and certain rare or unusual invertebrate and plant fossils. A significant paleontological resource is considered to be scientifically important because it is a rare or previously unknown species, it is of high quality and well-preserved, it preserves a previously unknown anatomical or other characteristic, provides new information about the history of life on earth, or has identified educational or recreational value. Paleontological resources that may be considered to not have paleontological significance include those that lack provenience or context, lack physical integrity because of decay or natural erosion, or that are overly redundant or are otherwise not useful for research. Vertebrate fossil remains and traces include bone, scales, scutes, skin impressions, burrows, tracks, tail drag marks, vertebrate coprolites (feces), gastroliths (stomach stones), or other physical evidence of past vertebrate life or activities. [BLM 2008: 19].

These definitions are similar in that both recognize any type of fossil (invertebrate, vertebrate, plant, or trace fossils) can be scientifically important if it is identifiable or well preserved and contributes scientifically valuable data. The definition of paleontological resources differs fundamentally from the definition for archaeological resources as follows:

> It is extremely important to distinguish between archaeological and paleontological (fossil) resource sites when defining the sensitivity of rock units. The boundaries of archaeological sites define the areal extent of the resource. Paleontological sites, however, indicate that the containing sedimentary rock unit or formation is fossiliferous. The limits of the entire rock formation, both areal and stratigraphic, therefore define the scope of the paleontological potential in each case. [SVP 2010: 2].

Many archaeological sites contain features that are visually detectable on the surface. In contrast, fossils are often contained within surficial sediments or bedrock and are therefore not observable or detectable unless exposed by erosion or human activity.

It should be noted that the threshold for the importance of a fossil varies with a variety of factors, including geologic unit, geographic area, and the current state of scientific research, and may also vary between different agencies (Murphey et al. 2019). In general, fossils can be considered scientifically important if one or more of the following criteria apply:

- The fossils provide information on the evolutionary relationships and developmental trends among organisms, living or extinct.
- The fossils provide data useful in determining the age(s) of the rock unit or sedimentary stratum, including data important in determining the depositional history of the region and the timing of geologic events, through biochronology or biostratigraphy and the correlation with isotopic dating.
- The fossils provide ecological data, such as the development of biological communities, the interaction between paleobotanical and paleozoological biotas, or the biogeography of lineages.
- The fossils demonstrate unusual or spectacular circumstances in the history of life.
- The fossils provide information on the preservational pathways of paleontological resources, including taphonomy, diagenesis, or preservational biases in the fossil record.
- The fossils are in short supply and/or in danger of being depleted or destroyed by the elements, vandalism, or commercial exploitation, and are not found in other geographic locations.
- The fossils inform our understanding of anthropogenic affects to global environments or climate.

A geologic unit known to contain scientifically important paleontological resources is considered sensitive to adverse impacts if there is a high probability that earth-moving or ground-disturbing activities in that rock unit will either disturb or destroy fossil remains directly or indirectly.

In summary, in the absence of observable fossil resources on the surface, paleontologists must assess the potential of geologic units as a whole to yield paleontological resources based on their known potential to produce scientifically important fossils elsewhere. Monitoring by experienced paleontologists greatly increases the probability that fossils will be discovered during ground-disturbing activities and that, if these remains are scientifically important, successful mitigation and salvage efforts may be undertaken to prevent adverse impacts to these resources.

2 REGULATORY FRAMEWORK

Paleontological resources are limited, nonrenewable resources of scientific, cultural, and educational value and are afforded protection under federal, state, and local laws, ordinances, and regulations. The following sections describe specific laws, ordinances, and regulations that the federal government and the State of North Dakota have enacted to protect paleontological resources. This investigation was conducted as an exercise in due diligence. The Project is located almost entirely on private lands and is not subject to federal regulations governing paleontological resources. State regulations are discussed below.

2.1 STATE OF NORTH DAKOTA REGULATIONS

The State of North Dakota recognizes paleontological resources under Chapters 54-17.3 and 43-04 of the North Dakota Century and Administrative Codes. These regulations establish that any paleontological resource found or located upon any land owned by the State or its political subdivisions may not be destroyed, defaced, altered, removed, or otherwise disposed of in any manner without approval of the state geologist (Chapter 54-17.3-06), and provide guidelines and procedures for the issuance of permits, the assessment of discoveries, and the reporting and treatment of significant discoveries.

3 METHODOLOGY

The paleontological resources impact evaluation reported herein consisted of an analysis of existing data, including a records search from the North Dakota Geological Survey (NDGS) as well as a review of the relevant scientific literature and the most recent geologic mapping, and a review of the BLM (2020) PFYC assessments for North Dakota. To evaluate if paleontological resources are likely to be encountered in any given area, the paleontological potential of the geologic units present in the area is assessed. This is determined by rock type, history of the geologic unit in producing scientifically important fossils, and fossil localities recorded from that unit.

Paleontological potential is derived from the known fossil data collected from the entire geologic unit, not just from a specific survey. Following the evaluation of paleontological potential, Project plans were programmatically reviewed to assess the Project's potential to impact paleontological resources.

The paleontological resources impact evaluation presented in this report was conducted under the supervision of Paul C. Murphey, Ph.D., who served as project manager. The analysis of existing data, paleontological potential evaluation, and impacts evaluation was conducted by Senior Paleontologist Alyssa Bell, Ph.D., who authored this report. Dr. Murphey and Dr. Bell both meet the BLM definition of a paleontological principal investigator. GIS graphics were generated by Sarah Troedson, M.S. The review of online open access paleontology databases was conducted by Emily Zajac, B.S. Copies of this report will be submitted to EXP. An electronic copy will be retained by Stantec along with copies of relevant data..

3.1 ANALYSIS OF EXISTING DATA

In order to evaluate the paleontological potential of the geologic units in the Project area, the most recent geologic mapping was consulted to identify all geologic units present at the surface or likely present in the subsurface. The scientific literature was then consulted to investigate the history of each of these units for preserving fossil resources. A records search of the Project area and vicinity was requested from the NDGS, with the results received from the NDGS on December 21, 2021. The search returned the closest known paleontological localities of the NDGS to the Project area from geologic units that are present at the Project area, either at the surface or in the subsurface. As the search results included location data for the localities, which is sensitive and should be kept confidential, these results are summarized here and not presented in full. Additionally, the Paleobiology Database (PBDB), an open access online database, was searched for paleontological localities in the vicinity of the Project area. PFYC mapping by the BLM (2020) for the State of North Dakota was consulted to review the current BLM assessment of the geologic units mapped in the Project area.

3.2 PALEONTOLOGICAL RESOURCES EVALUATION

The BLM's PFYC system provides baseline guidance for predicting, assessing, and mitigating impacts to paleontological resources. The PFYC system ranks geologic formations or members on a 1 to 5 scale, with 5 having the highest potential for preserving fossil resources and uses geologic mapping as a predictive tool to identify areas of paleontological potential. Although there is no BLM involvement in the Project, the PFYC is widely used by both federal and non-federal agencies as a predictive tool for evaluating potential impacts for scientifically important paleontological resources.

This classification does not reflect rare or isolated occurrences of scientifically important fossils or individual localities, only the relative occurrence on a formation or member-wide basis. Any rare occurrences will require additional assessment and mitigation if they fall within the area of anticipated impacts. The PFYC system is based on the relative abundance of vertebrate fossils or scientifically important invertebrate or plant fossils and their sensitivity to adverse impacts (BLM 2016).

The descriptions of paleontological potential rankings shown in Table 1 are drawn directly from the BLM guidelines (2016).

Table 1: Summary of the BLM's (2016) Potential Fossil Yield Classification		
PFYC Designation	**Assignment Criteria Guidelines**	**Management Summary**
1 = Very Low Potential	Geologic units are not likely to contain recognizable paleontological resources.	Management concern is usually negligible, and impact mitigation is unnecessary except in rare or isolated circumstances.
	Units are igneous or metamorphic, excluding air-fall and reworked volcanic ash units.	
	Units are Precambrian in age.	
2 = Low Potential	Geologic units are not likely to contain paleontological resources.	Management concern is generally low, and impact mitigation is usually unnecessary except in occasional or isolated circumstances.
	Field surveys have verified that significant paleontological resources are not present or are very rare.	
	Units are generally younger than 10,000 years before present.	
	Recent aeolian deposits.	
	Sediments exhibit significant physical and chemical changes (i.e., diagenetic alteration) that make fossil preservation unlikely.	
3 = Moderate Potential	Sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence.	Management concerns are moderate. Management options could include records searches, pre-disturbance surveys, monitoring, mitigation, or avoidance. Opportunities may exist for hobby collecting. Surface-disturbing activities may require sufficient assessment to determine whether significant paleontological resources occur in the area of a proposed action and whether the action could affect the paleontological resources.
	Marine in origin with sporadic known occurrences of paleontological resources.	
	Paleontological resources may occur intermittently, but these occurrences are widely scattered.	
	The potential for authorized land use to impact a significant paleontological resource is known to be low-to-moderate.	

Table 1: Summary of the BLM's (2016) Potential Fossil Yield Classification

PFYC Designation	Assignment Criteria Guidelines	Management Summary
4 = High Potential	Geologic units that are known to contain a high occurrence of paleontological resources.	Management concern is moderate to high depending on the proposed action. A field survey by a qualified paleontologist is often needed to assess local conditions. On-site monitoring or spot-checking may be necessary during land disturbing activities. Avoidance of known paleontological resources may be necessary.
	Significant paleontological resources have been documented but may vary in occurrence and predictability.	
	Surface-disturbing activities may adversely affect paleontological resources.	
	Rare or uncommon fossils, including nonvertebrate (such as soft body preservation) or unusual plant fossils, may be present.	
	Illegal collecting activities may impact some areas.	
5 = Very High Potential	Highly fossiliferous geologic units that consistently and predictably produce significant paleontological resources.	Management concern is high to very high. A field survey by a qualified paleontologist is almost always needed and on-site monitoring may be necessary during land use activities. Avoidance or resource preservation through controlled access, designation of areas of avoidance, or special management designations should be considered.
	Significant paleontological resources have been documented and occur consistently.	
	Paleontological resources are highly susceptible to adverse impacts from surface disturbing activities.	
	Unit is frequently the focus of illegal collecting activities.	
U = Unknown Potential	Geologic units that cannot receive an informed PFYC assignment.	Until a provisional assignment is made, geologic units with unknown potential have medium to high management concerns. Field surveys are normally necessary, especially prior to authorizing a ground-disturbing activity.
	Geological units may exhibit features or preservational conditions that suggest significant paleontological resources could be present, but little information about the actual paleontological resources of the unit or area is known.	

Table 1: Summary of the BLM's (2016) Potential Fossil Yield Classification		
PFYC Designation	**Assignment Criteria Guidelines**	**Management Summary**
	Geologic units represented on a map are based on lithologic character or basis of origin but have not been studied in detail.	
	Scientific literature does not exist or does not reveal the nature of paleontological resources.	
	Reports of paleontological resources are anecdotal or have not been verified.	
	Area or geologic unit is poorly or under-studied.	
	BLM staff has not yet been able to assess the nature of the geologic unit.	

3.3 PALEONTOLOGICAL RESOURCES IMPACTS ASSESSMENT

Impacts to paleontological resources can be classified as direct, indirect, or cumulative. Impacts can also be considered as adverse impacts or as positive impacts. Direct adverse impacts on paleontological resources are the result of damage or destruction of these nonrenewable resources by surface disturbing actions including construction excavations. Therefore, in areas that contain paleontologically sensitive geologic units, ground disturbance has the potential to adversely impact paleontological resources, by damaging or destroying them and rendering them permanently unavailable to science and society. Positive direct impacts, however, may result when paleontological resources are identified during construction and then appropriately documented and salvaged, thus ensuring the specimens are protected for future study and education.

Indirect adverse impacts typically include those effects which result from the continuing implementation of management decisions and resulting activities, including normal ongoing operations of facilities constructed within a given project area. They also occur as the result of the construction of new roads and trails in areas that were previously less accessible. This increases public access and therefore increases the likelihood of the loss of paleontological resources through vandalism and unlawful collecting, thus constituting an adverse indirect impact. Human activities that increase erosion also cause indirect impacts to surface and subsurface fossils as the result of exposure, transport, weathering, and reburial.

Cumulative adverse impacts can result from incrementally minor but collectively significant actions taking place over time. The incremental loss of paleontological resources over time from construction-related surface disturbance or vandalism and unlawful collection would represent a significant cumulative adverse impact because it would result in the destruction of non-renewable paleontological resources and the associated irretrievable loss of scientific information.

Positive impacts can result from the preservation of scientifically important paleontological resources identified during construction, a direct impact, or following Project activities, an indirect impact. By successfully identifying, salvaging, and curating scientifically important paleontological resources in a federally accredited repository, they are preserved in perpetuity and may contribute to scientific understanding and public education and awareness.

The impact assessment conducted here takes into consideration all planned Project activities in terms of aerial and subsurface extents, including the possibility of subsurface geologic units having a different paleontological potential than surficial units. For example, younger surficial sediments (alluvium, lacustrine, eolian, etc.) have low potential to preserve fossil resources due to their age; yet sediments increase in age with depth and so these surficial deposits often overly older units that have high paleontological potential. In areas with this underlying geologic setting surficial work may be of low risk for impacting paleontological resources while activities that require excavations below the depth of the surficial deposits would be at greater risk of impacting paleontological resources. For this reason, the impact assessment takes into consideration both the surface and subsurface geology and is tailored to Project activities.

4 RESULTS

The results of the paleontological potential and impacts assessment are described below.

4.1 PROJECT AREA GEOLOGY

Geologic mapping by Clayton et al. (1980) indicates the surface of the Project area consists of 22 geologic units (Appendix B). The majority of these units are different types of surficial sediments that date from the Holocene: younger facies of the Oahe Formation, offshore lacustrine sediments, river sediments, and glacial sediments (Clayton et al. 1980). A smaller number of mapped units are older than the Holocene: the older sand facies of the Oahe Formation, which dates from the Holocene to the Pliocene; the Sentinel Butte Formation, Bullion Creek Formation, Slope Formation, and Cannonball Formation, all of which date to the Paleocene; and the Hell Creek Formation and Fox Hills Formation, both of which date to the Late Cretaceous (Clayton et al. 1980).

In general, the Project area consists of Cretaceous to Paleocene sedimentary bedrock covered with much more recent surficial sediments deposited since the last glacial event. The western Project area consists of outcrops of these bedrock units, increasing in age from Paleocene units in the west to Cretaceous units in the east, interspersed with Holocene-aged sediments, while the eastern Project area lacks any surficial exposure of the older bedrock units but instead has extensive areas of Holocene- to Pliocene-aged sands of the Oahe and older formations interspersed with Holocene-aged surficial sediments. The specific geologic units mapped in the Project area are described below.

Holocene-aged Surficial Sediments (Qor, Qod, Qol, Qcof, Qcoh, Qcrf, Qcrh, Qcdc, Qccg, Qccr, Qccu, Qcdg, Qcdn, Qct, Qcew in Appendix B). Large portions of both the western and eastern parts of the Project area are covered in surficial sediments that are Pre-Wisconsinan in age, indicating they were deposited from recent times up to the Wisconsinan glaciation, which began approximately 9,500 years ago (Syverson and Colgan 2004). These sediments vary widely in depositional setting, including river sediments (Qor, Qcrh), lacustrine sediments (Qcof, Qcoh), and glacial sediments (Qcdc, Qccg, Qccr, Qcdg, Qcdn, Qct, Qcew). These sediments are broadly similar in that they are all Holocene in age and consist of unconsolidated sediments broadly deposited across the ground surface (Clayton et al. 1980).

Sand of the Oahe and Older Formations, undivided (QTou in Appendix B). The Oahe Formation is a widely deposited unit mapped across much of the surface of North Dakota (Clayton et al. 1976), consisting of several facies, most of which date to the Holocene and are included in the Holocene-aged surficial sediments discussed above (i.e., Qor, Qod, Qol). However, there is one mapped facies of the Oahe Formation that has a much older date range, from the Holocene to the Pliocene. This unit is mapped as sand of the undivided Oahe and older formations and consists of windblown sand up to 3 meters thick with an undulating, wind-scoured surface (Clayton et al. 1980). This facies is mapped at the surface across large portions of the eastern part of the Project area.

Fort Union Group. The Fort Union is recognized as a formation by the U.S. Geological Survey (USGS), with several constituent members, but elevated to group status by the NDGS, with members elevated to formation status. As the mapping used in this report is from the NDGS (Clayton et al. 1980), the Fort Union is treated as a group here, with several constituent formations present in the Project area. The Fort Union is from the earliest Paleocene, recording the aftermath of and biotic recovery from the end-Cretaceous mass extinction event that resulted in the loss of a wide variety of terrestrial and marine organisms, most famously the non-avian dinosaurs.

Sentinel Butte Formation (Ts in Appendix B). The Sentinel Butte Formation consists of poorly lithified gray-brown silt, sand, clay, sandstone, and lignite deposited in rivers, lakes, and swamps during the Paleocene (Clayton et al. 1980). Thermally altered beds referred to as clinker are locally present, where adjacent coal seams burned once the sediments were buried. The total thickness of the Sentinel Butte Formation varies from 600 to 750 feet (183 to 229 meters) (Clayton et al. 1980). The Sentinel Butte Formation is the uppermost formation of the Fort Union Group. The Sentinel Butte Formation is mapped across the surface of the westernmost side of the western Project area, where it may also be present in the subsurface underlying nearby Holocene-aged surficial sediments at an undetermined depth.

Bullion Creek Formation (Tb in Appendix B). The Bullion Creek Formation consists of yellow-brown silt, sand, clay, sandstone, and lignite deposited in rivers, lakes, and swamps during the Paleocene (Clayton et al. 1980). Although sandstones comprise a small percentage of the formation, sandstone beds form prominent features, usually preserved as recognizable channel deposits composed of cross-stratified, fine- to medium-grained lenticular sandstone bodies. The Bullion Creek Formation has a maximum thickness of approximately 600 feet (183 meters) (Clayton et al. 1980). While the mapping used in this report (Clayton et al. 1980) recognizes the Bullion Creek as beds previously attributed to the Tongue River Formation, other work has reverted to the original Tongue River Formation for these beds (e.g., Warwick et al. 2004, Kihm and Hartman 2004). This disagreement is largely based on comparisons of the beds in question where they are present in North Dakota in relation to rocks assigned to the Tongue River Formation in Wyoming and Montana (Murphy 2001). The Bullion Creek Formation conformably underlies the Sentinel Butte Formation and unconformably overlies the Slope Formation in the vicinity of the Project area (Clayton et al. 1980). The Bullion Creek Formation is mapped across the surface of the westernmost side of the western Project area, where it may also be present in the subsurface underlying nearby Holocene-aged surficial sediments at an undetermined depth.

Slope Formation (Tp in Appendix B). The Slope Formation consists of gray-brown to yellow-brown silt, sand, clay, sandstone, and lignite deposited in rivers, lakes, and swamps during the Paleocene (Clayton et al. 1980). This formation was originally recognized from rocks that occurred between two marine tongues of the Cannonball Sea below the Tongue River Formation (equivalent to the Bullion Creek Formation, as described above) (Belt et al. 2004). Recently, authors have suggested that the name “Slope” be abandoned because additional marine units were found below these tongues of the Cannonball Sea. Instead, these authors consider the rocks mapped as the Slope Formation to be part of the Ludlow Formation or Tongue River Formation (Belt et al. 2004), even though there are some distinguishing characteristics including the high number of lignite beds. As originally described, the Slope Formation unconformably underlies the Bullion Creek Formation, as marked by the white siliceous Rhame Bed (Warwick et al. 2004) and overlies the Cannonball Formation in the vicinity of the Project area (Clayton et al. 1980). The Slope Formation is mapped at the surface in a single location in the central part of the western Project area.

Cannonball Formation (Tc in Appendix B). The Cannonball Formation consists of olive-brown sand, shale, and siltstone deposited along the shore and submarine slope of a marine transgression during the Paleocene, when the area was flooded by rising sea levels of the late Western Interior Seaway (Belt et al. 2004). The Cannonball Formation interfingers with the Ludlow Formation, which is not mapped within the Project area (Peppe et al. 2009). Within the Project area, the Cannonball Formation is mapped at the surface in the central portion of the western Project area, where it may underlie the nearby Holocene-aged sediments at an undetermined depth.

Hell Creek Formation (Kh in Appendix B). The Hell Creek Formation consists of gray sand, silt, clay, and sandstone deposited as river sediments during the Late Cretaceous (Clayton et al. 1980). The Hell Creek Formation was deposited in a lowland environment as the Western Interior Seaway was retreating to the northeast. The upper formation contact is close to or equivalent with the Cretaceous-Tertiary boundary horizon, which marks the end-Cretaceous mass extinction event when the non-avian dinosaurs and numerous other taxa likely succumbed to the environmental effects of a meteor impact. This horizon is preserved at the boundary between the Hell Creek Formation and the overlying Fort Union Group in many places across the extent of the unit, including localities in North Dakota (Bercovici et al. 2009, Nichols and Johnson 2002). The Hell Creek Formation overlies the Fox Hills Formation, which it interfingers with in places. In the Project area the Hell Creek Formation is mapped at the surface in the central portion of the eastern Project area, where it may underlie the nearby Holocene-aged sediments at an undetermined depth.

Fox Hills Formation (Kf in Appendix B). The Fox Hills Formation in the vicinity of the Project area consists of olive-brown sand, shale, and sandstone deposited as shoreline and offshore sediments of the Western Interior Seaway during the Late Cretaceous (Clayton et al. 1980). While in some places in Montana, Wyoming, and North Dakota various members of recognized within the Fox Hills Formation, as mapped in the Project area the unit is undivided (Clayton et al. 1980). The Fox Hills Formation conformably overlies the Pierre Shale, which is not mapped in the Project area, and underlies and sometimes interfingers with the Hell Creek Formation. Within the Project area, the Fox Hills Formation is mapped in the central and eastern portions of the western Project area, where it may underlie the nearby Holocene-aged sediments at an undetermined depth.

4.2 PALEONTOLOGICAL POTENTIAL OF GEOLOGIC UNITS IN THE PROJECT AREA

In order to assess the potential of the geologic units present at the surface or in the subsurface to preserve paleontological resources, Stantec conducted a review of existing data, including a records search from the NDGS (summarized in Table 2) and of the online PBDB. The results of this investigation are described below for each of the geologic units in the Project area (Table 3).

Table 2: North Dakota Geological Survey Paleontological Localities within One Mile of the Project Area

Locality Number	Geologic Unit	Age	Taxa	Approximate Location
NDGS L1481, L1488	Holocene/Pleistocene Sediments	Holocene - Pleistocene	Invertebrates	Township 140 North, Range 80 West; Burleigh County
NDGS L1924	Holocene/Pleistocene Sediments	Holocene - Pleistocene	Horse (*Equus hatcheri*)	Township 139 North, Range 79 West; Burleigh County
NDGS L1486	Sentinel Butte Formation	Paleocene	Invertebrates	Township 140 North, Range 80 West; Burleigh County

Table 2: North Dakota Geological Survey Paleontological Localities within One Mile of the Project Area				
Locality Number	**Geologic Unit**	**Age**	**Taxa**	**Approximate Location**
NDGS L2770	Bullion Creek Formation	Paleocene	Invertebrates	Township 140 North, Range 81 West; Burleigh County
NDGS L2756	Bullion Creek Formation	Paleocene	Invertebrates	Township 139 North, Range 79 West; Burleigh County
NDGS L4, L1477	Cannonball Formation	Paleocene	Gastropod (*Euspira* sp.) and other invertebrates	Township 140 North, Range 80 West, Burleigh County
NDGS L1468	Cannonball Formation	Paleocene	Invertebrates	Township 137 North, Range 77 West, Burleigh County
NDGS L1581	Hell Creek Formation, Breien Member	Upper Cretaceous	Ichnofossils (*Ophiomorpha*), oyster steinkerns	Township 136 North, Range 77 West, Emmons County

Holocene-aged Surficial Sediments (Qor, Qod, Qol, Qcof, Qcoh, Qcrf, Qcrh, Qcdc, Qccg, Qccr, Qccu, Qcdg, Qcdn, Qct, Qcew in Appendix B). Holocene-aged surficial sediments are generally younger than 9,500 years across the Project area, correlative with the beginning of the last glacial period (Clayton et al. 1980) and are therefore generally considered too young to preserve paleontological resources (BLM 2016). Therefore, deposits of Holocene age sediments have low paleontological potential and are considered by the BLM (2016) as PFYC Class 2. This assessment is adopted here for the Holocene-aged sediments in the Project area. It should be noted that the depth of these deposits is largely undetermined in the Project area, and these sediments are likely underlain by older geologic units that have higher paleontological potential, as described below.

Sand of the Oahe and Older Formations, undivided (QTou in Appendix B). The Oahe Formation ranges in age from the Holocene to the Pliocene. While the younger, Holocene-aged sediments of this unit are not old enough to preserve paleontological resources, the older Pleistocene and Pliocene sediments are of an age to preserve them. A review of NDGS (2021) records, the PBDB, and the scientific literature indicates scientifically important paleontological resources have been recovered from Pleistocene surficial sediments, including those assigned to the Oahe Formation, across the region. The closest localities to the Project area come from within one mile of the central line of the Project, where invertebrates and a horse jaw were recovered from two different localities (Table 2). The records of the NDGS indicate there are an additional 11 paleontological localities outside of the one-mile buffer but within the vicinity of the Project area from surficial sediments of a similar age as the Olahe Formation; however, these units do not have formal names assigned. These localities preserved fossils of invertebrates (9 localities), plants (one locality), and vertebrates (one locality) (NDGS 2021). The PBDB (2021) has an additional Pleistocene locality in the vicinity of the Project in Emmons County, where a ground sloth (*Megalonyx*) specimen was recovered. A limited number of paleontological localities from the Oahe Formation have been reported in the scientific literature, including sites that preserved mammoth and bison (Clayton et al. 1976, Davis and Wilson 1985). The BLM has assessed the Oahe Formation as a whole as having low paleontological potential (PFYC 2) (BLM 2020). However, the mapping used in this assessment identities the older facies of the Oahe as separate from the Holocene-

aged facies. As the facies of the Oahe Formation mapped as "sand of the Oahe and older formations" is both of an age to preserve paleontological resources and has a demonstrated history of preserving scattered paleontological localities of limited abundance, including within one mile of the Project area, it is here assessed as having moderate paleontological potential (PFYC 3).

Fort Union Group. As a whole, the Fort Union Formation contains a diversity of fossils that includes vertebrates, invertebrates, and plants. The fossil flora of the Fort Union Formation has been an important source of information for research on vegetational response to climate change at the K-T boundary (Johnson 2002). The Fort Union fossil invertebrate assemblage includes marine ichnofossils (Belt et al. 1997) and mollusks as well as freshwater gastropods (Bickel 1977; Delimata 1969). Among the vertebrates, reptiles (Flores and Beus 1987) include lizards (Sullivan 1982), alligatorids (Erickson 1982; Holroyd and Hutchison 2002), and turtles (Hutchison and Archibald 1986). The formation is best known and studied for its fossil mammal fauna (Leite 1992). This diverse assemblage includes such groups as carpolestids (Bloch et al. 1998), primates (Gazin 1971; Gidley 1922; Burger and Honey 2008), insectivores (Gunnell 1988), multituberculates (Weil 1998), and condylarths (Williamson and Lucas 1989). From the study of the mammalian fossils, it appears that the Fort Union Formation spans four North American Land Mammal Ages (NALMA) (Archibald et al. 1987), extending from the Puercan through the Clarkforkian. Fossil footprints have also been recorded in the Fort Union (Gilmore 1928).

Sentinel Butte Formation (Ts in Appendix B). The Sentinel Butte Formation has a history of preserving paleontological resources. The closest documented locality to the Project area is within one mile of the center line of the Project and preserved invertebrate fossils (Table 2; NDGS 2021). Outside of the one-mile buffer of the Project area, the NDGS (2021) has a record of one other locality, where invertebrates were preserved from the vicinity of the Project area. The scientific literature indicates a variety of types of fossils are known from the Sentinel Butte Formation in North Dakota, including a diversity of dozens of plant taxa (Crane 1990, PBDB 2021), fish (Newbrey and Bozek 2003), over 15 mammalian taxa from five localities, including multituberculates, marsupials, and eutherians (Kihm et al. 2004), and an abundant assemblage of fossils at the Medora Site which includes the crocodile-like reptile *Champsosaurus* and the crocodile *Borealosuchus*, at least two taxa of birds, several fish and mammal taxa, freshwater turtles, and the giant salamander *Piceorpeton* (Hoganson et al. 2011). Because scientifically important paleontological resources have been documented from localities in North Dakota, some of which preserve abundant remains of numerous species, the BLM has assessed the Sentinel Butte Formation as having high paleontological potential (PFYC 4) (BLM 2020).

Bullion Creek Formation (Tb in Appendix B). Fossil collections from the Bullion Creek Formation include mammals, reptiles, fish, fossil trackways, invertebrates, and plants (Hanks et al. 2002). The nearest documented paleontological localities in the Bullion Creek Formation to the Project area are within one mile of the center line of the Project, where the NDGS (2021) has records of two localities that preserved invertebrate fossils. The NDGS (2021) has additional records of 14 localities that are outside of a one-mile radius of the Project area but within the near vicinity. Of these, 12 preserved invertebrate fossils, one preserved vertebrate fossils, and two preserved microfossils (NDGS 2021). The PDBD (2021) has records of one locality in the counties crossed by the Project, where over 40 taxa pf fish, crocodilians, birds, and mammals were collected. There are a number of highly productive vertebrate fossil localities reported in the scientific literature from the Bullion Creek Formation. One of the best known is Wannagan Creek in west-central North Dakota, which is famous for a diverse reptilian fauna, including birds and crocodilians, as well as turtles, mammals, crocodile and arthropod tracks and invertebrate burrows (Erickson 2005, 2012; Erickson and Pickett 1987; Melchoir and Erickson 1979). First collected in 1971 by the Science Museum of St. Paul, Wannagan Creek has produced thousands of fossil vertebrates. Another productive locality is the mammal rich Judson locality, which was for a time thought to be within the Slope Formation, and also preserves fossils of birds and invertebrates (Benson 1999, Kihm and Hartman 2004, Krause 1987). Fossils collected indicate that the Bullion Creek is of Torrejonian and Tiffanian NALMA (Kihm and Hartman 2004). Fossils are relatively abundant in the Bullion Creek Formation (Tongue River Formation). Therefore, the BLM has assessed the Bullion Creek Formation as having high paleontological potential (PFYC 4) (BLM 2020).

Slope Formation (Tp in Appendix B). There are limited records of paleontological localities in the Slope Formation. The NDGS does not have any records of localities in the vicinity of the Project area. The PBDB (2021) has a single record of a locality in Morton County where a specimen of the extinct reptile *Simoedosaurus* was collected. Two productive Tiffanian NALMA vertebrate fossil localities (Judson and Brisbane) were considered for a time to be from the “Slope Formation” (originally mapped in this area as the Tongue River Formation). However, recent research has again placed these localities in the Tongue River Formation (Bullion Creek) (Kihm 1986; Kihm and Hartman 2004). Mammalian fossils still attributed to the originally defined “Slope” beds are indicative of a Torrejonian NALMA for the Slope Formation (Belt et al. 1997). Although fossils are known from the Slope Formation, it appears that these occurrences are uncommon. Therefore, the BLM has assessed the Slope Formation as having moderate paleontological potential (PFYC 3) (BLM 2020).

Cannonball Formation (Tc in Appendix B). The Cannonball Formation has a record of preserving a variety of paleontological resources. The nearest documented paleontological localities in the Cannonball Formation to the Project area are within one mile of the center line of the Project, where the NDGS (2021) has records of two localities that preserved invertebrate fossils. The NDGS (2021) has additional records of 20 localities that are outside of a one-mile radius of the Project area but within the near vicinity. Of these, 16 preserved invertebrate fossils, eight preserved vertebrate fossils, two preserved trace fossils, and one preserved plant fossils (NDGS 2021). The PBDB (2021) has records of 21 localities in the Cannonball Formation from the counties that are crossed by the Project. These preserved primarily bivalves as well as one crab and one locality with shark teeth (PBDB 2021). The scientific literature documents a variety of fish, including sharks, chimaeroids, and ray-finned fish, as well as reptiles and invertebrate fossils of crabs, lobsters, and bivalves (Cvancara and Hoganson 2010, Holland and Cvancara 1958). Fossil distribution from the Cannonball Formation has been described as not generally abundant, but sometimes locally abundant, and predominantly consisting of bivalves, with vertebrate fossils rare (Cvancara 1966, Cvancara and Hoganson 2010). The Cannonball Formation is well known for preserving abundant marine invertebrates as well as fossils of fish, dinosaurs, reptiles, and mammals; therefore, the BLM has assessed the Cannonball Formation as having high paleontological potential (PFYC 4) (BLM 2020).

Hell Creek Formation (Kh in Appendix B). The Hell Creek Formation contains an abundant and diverse fossil fauna and flora. Barnum Brown collected the first fossils from the Hell Creek of Montana in the early 1900s, and interest in the formation has continued to increase throughout the last century. The nearest documented paleontological locality in the Hell Creek Formation to the Project area is within one mile of the center line of the Project, where the NDGS (2021) has records of one locality that preserved trace fossils and invertebrate fossils. The NDGS (2021) has additional records of 17 localities that are outside of a one-mile radius of the Project area but within the near vicinity. Of these, 14 preserved invertebrate fossils, four preserved vertebrate fossils, and one preserved plant fossils (NDGS 2021). The PBDB (2021) has records of 12 localities in the Hell Creek Formation from the counties crossed by the Project. These preserved a wide range of over 30 taxa including dinosaurs, crocodilians, fish, and invertebrates (PBDB 2021).

Clemens (2002) completed a detailed account of historical and current paleontological research around Fort Peck Lake, Montana. Known best for dinosaurs (Molenar 1980, Ott 2007), including the type specimen of *Tyrannosaurus rex* (Osborn 1905), the Hell Creek Formation has also produced important mammalian, reptilian, and plant fossil assemblages. Mammals of the Hell Creek Formation provide important information for understanding the evolution of modern orders (Clemens 2002, Hunter and Archibald 2002, Hunter and Pearson 1996). In addition to its important mammalian fauna, the Hell Creek Formation's fossil record also includes plants (Shoemaker 1966, Johnson 1996), bivalves (Hartman 1998, Scholz and Hartman 2007a), trace fossils, fish (Estes 1969), amphibians (Estes 1965), turtles (Holroyd and Hutchison 2002), crocodiles (Estes et al. 1969), dinosaurs (Carpenter 1982, Russell and Manabe 2002, Sloan et al. 1986, Rohrer and Konizeski 1960, Griffin et al. 1988), pterosaurs (Henderson and Peterson 2006), and birds (Sankey et al. 2003). Two particularly well-known fossil localities in the Hell Creek Formation include Bug Creek and Harbicht Hill in McCone County, Montana (Sloan and Van Valen 1965, Lofgren 1995). The Hell Creek Formation is primarily important for understanding changes in the animal and plant biotas from the Cretaceous to the Paleocene, and for testing hypotheses regarding the global mass extinction event at the end of the Cretaceous Period (Scholz and Hartman 2007b, Hunter et al. 1997, Johnson 1993, Hutchison and Archibald 1986, Archibald 1982, Bryant 1989, Hartman et al. 2002, Johnson et al. 1989, Johnson and Hickey 1990). Given the extensive record of scientifically important vertebrate fossils preserved in the Hell Creek Formation, the BLM has assessed the Hell Creek Formation as having very high paleontological potential (PFYC 5) (BLM 2020).

Fox Hills Formation (Kf in Appendix B). The Fox Hills Formation has a record of paleontological resource preservation. While the NDGS (2021) does not have any record of localities in the vicinity of the Project area, the PBDB (2021) has records of 21 localities in the Fox Hills Formation from the counties crossed by the Project. These preserved a wide range of over 20 taxa, primarily fish, but also plants and invertebrates (PBDB 2021).

Extensive paleontological research has been presented in the scientific literature on the Fox Hills Formation, with most projects focused on exposures in North and South Dakota. Plant fossils have been reported from the unit (Delevoryas 1964), and recently Peppe et al. (2007) described a number of fossil plant species from central North Dakota. Fossil invertebrate research encompasses a large range of topics including studies of ammonites (Landman and Waage 1993) including Baculites (Cobban and Kennedy 1992), bivalves (Erickson 1973, 1974; Feldmann and Kammer 1976; Speden 1970), bryozoans (Cobban and Kennedy 1992; Cuffey et al. 1981), echinoids (Holland and Feldmann 1967), beetles (Northrop 1928), and decapod crustaceans (Crawford et al. 2006; Feldmann et al. 1976). In addition, Harries and Schopf (2007) examined gastropod densities from drill cores, and Erickson (1973) used gastropods to study Maastrichtian paleogeography. Oman (1937) discovered preserved insect remains in the Fox Hills Formation of Colorado. Trace fossils of burrowing invertebrates from southwestern North Dakota have also been described (Daly 1997). The Fox Hills also contains the important trace fossil Ophiomorpha, which consist of 0.5- to 1.0-inch-diameter burrows formed by the tunneling activities of callanassid shrimp. These fossils indicate marginal marine to littoral conditions deposited in tidal environments (Rigby and Rigby 1990). Other reported trace fossils include structures interpreted as sea turtle nests (Bishop 2002). Although much less common than invertebrates, vertebrate fossils have been collected and studied (Cope 1876; Hoganson et al. 1994; Hoganson and Erickson 2004). Vertebrates of the Fox Hills Formation include bony fish (Hoganson and Erickson 2005), sharks (Becker et al. 2004), amphibians, reptiles including dinosaurs (Nelson et al. 2003), and mammals (Wilson 1987). The Red Owl and Iron Lightning localities are two famous Fox Hills terrestrial mammal localities in northwestern South Dakota (Wilson 1987). The Fox Hills Formation is well known for preserving abundant marine invertebrates as well as fossils of fish, dinosaurs, reptiles, and mammals; therefore, the BLM has assessed the Fox Hills Formation as having high paleontological potential (PFYC 4) (BLM 2020). Table 1 PFYC rankings of geologic units within the Project area.

Table 3: PFYC rankings of geologic units within the Project area			
Geologic Unit (map bbreviation)	Age	PFYC*	PFYC Justification
Holocene-aged surficial sediments (Qor, Qod, Qol, Qcof, Qcoh, Qcrf, Qcrh, Qcdc, Qccg, Qccr, Qccu, Qcdg, Qcdn, Qct, Qcew)	Holocene to Pre-Wisconsinan	2, Low	Too young to preserve paleontological resources.
Sand of the Oahe and older formations (QTou)	Holocene to Pliocene	3, Moderate	Scattered occurrences of paleontological localities; fossils preserved are primarily invertebrate with some vertebrate fossils.
Sentinel Butte Formation (Ts)	Paleocene	4, High	Vertebrate fossil localities, some preserving diverse or abundant fossils of reptiles, mammals, and plants are well documented.
Bullion Creek Formation (Tb)	Paleocene	4, High	Vertebrate fossil localities, some preserving diverse or abundant fossils of reptiles and mammals, are well documented.
Slope Formation (Tp)	Paleocene	3, Moderate	Paleontological localities of vertebrate and invertebrate fossils are documented but rare.
Cannonball Formation (Tc)	Paleocene	4, High	Paleontological localities are well-documented and include scientifically important fossils of fish and reptiles.
Hell Creek Formation (Kh)	Late Cretaceous	5, Very high	Abundant, well-documented occurrence of scientifically important paleontological resources, including dinosaurs and other reptiles, mammals, fish, invertebrates, and plants.
Fox Hills Formation (Kf)	Late Cretaceous	4, High	Paleontological localities are well-documented and include scientifically important fossils of fish and reptiles.

4.3 PALEONTOLOGICAL RESOURCES IMPACTS ASSESSMENT

The paleontological potential evaluation presented above indicates that the Project area includes geologic units mapped at the surface that range from low (PFYC 2) to very high (PFYC 5) paleontological potential. Should paleontological resources preserved in these units be impacted by Project activities it would constitute a direct adverse impact. Therefore, an impacts assessment was conducted to evaluate planned Project activities and their likelihood to pose an adverse impact to paleontological resources.

The Project plans to install a CO_2 pipeline. This work will entail a variety of activities, including brushing or grubbing, grading for access roads and pipeline right-of-way, trenching with excavators and/or ditching machines, horizontal directional drilling of drainage crossings, and pipe installation. Of these activities, those that require ground disturbance that will extend into previously undisturbed geologic units with moderate (PFYC 3) to very high (PFYC 5) paleontological potential, whether present at the surface or in the subsurface, are at risk of posing a direct adverse impact to paleontological resources.

As this Project is not expected to result in increased erosion to the area following construction and is not expected to involve increased visitation or access to the area by the public, it is not anticipated to pose any indirect impact to paleontological resources.

Because this Project has the potential to cause direct adverse impacts to paleontological resources, Stantec has developed recommendations for mitigating these impacts, presented below..

5 RECOMMENDATIONS AND MANAGEMENT CONSIDERATIONS

As part of the current paleontological resources impact evaluation, an analysis of existing data was conducted to evaluate the potential of the geologic units in the Project area to preserve paleontological resources. The results of this study show that the following geologic units are present in the Project area:

- Holocene-aged surficial sediments – low paleontological potential (PFYC 2);
- Sand of the Oahe and older formations – moderate paleontological potential (PFYC 3);
- Sentinel Butte Formation – high paleontological potential (PFYC 4);
- Bullion Creek Formation – high paleontological potential (PFYC 4);
- Slope Formation – moderate paleontological potential (PFYC 3);
- Cannonball Formation – moderate paleontological potential (PFYC 3);
- Hell Creek Formation – very high paleontological potential (PFYC 5); and
- Fox Hills Formation – moderate paleontological potential (PFYC 3).

Project activities may include brushing or grubbing, grading for access roads and pipeline right-of-way, trenching with excavators and/or ditching machines, horizontal directional drilling of drainage crossings, and pipe installation. These activities may result in direct adverse impacts to surface and/or subsurface paleontological resources.

5.1 PRIVATE LANDS

There are no laws or regulations that require the mitigation of construction impacts to paleontological resources on private lands in North Dakota, which are the property of private landowners. Because construction could result in damage or destruction of paleontological resources on private lands and therefore result in an economic impact to the landowner, Stantec recommends the following:

1. The development of a Worker's Environmental Awareness Program training that educates construction personnel on the types of fossils that could be encountered during construction and communicates the

requirements and procedures for the inadvertent discovery of paleontological resources. The training program should be developed by a qualified paleontologist (meeting BLM [2008] qualifications as a paleontological principal investigator) and presented to construction personnel prior to the onset of ground disturbance. Any subsurface bones or other potential paleontological resources that are found by construction personnel should be evaluated by a qualified paleontologist remotely using photographs, and if they are confirmed as paleontological resources, they should be transferred to the applicable landowner.

5.2 STATE LANDS

Paleontological resources on North Dakota state lands are protected under Chapters 54-17.3 and 43-04 of the North Dakota Century and Administrative Codes. In order to comply with North Dakota law, Stantec recommends the following:

1. A qualified paleontologist (meeting BLM [2008] qualifications as a paleontological principal investigator) should be retained to oversee all aspects of paleontological mitigation.

2. An initial analysis should be completed to determine if any state lands crossed by the project contain exposures of geologic units with moderate (PFYC 3) to very high paleontological potential (PFYC 5) (sand of the Oahe and older formations; the Sentinel Butte Formation; the Bullion Creek Formation; the Slope Formation; the Cannonball Formation; the Hell Creek Formation; and the Fox Hills Formation), and if these geologic units will be disturbed by construction. If possible, the depth of surficial sediments should be taken into consideration. For all such areas identified, steps 3-6 should be completed.

3. The development and implementation of a Paleontological Resource Monitoring and Mitigation Plan (PRMMP) which outlines field survey and construction monitoring procedures, provides details of survey and monitoring locations, and provides the specific evaluation, notification and fossil/data recovery procedures to be followed in the event of the discovery of paleontological resources. The PRMMP should include specific recommendations made by the NDGS and include an Unanticipated Discovery Plan that outlines steps to follow in the event of a paleontological discovery by construction personnel in the absence of a paleontological monitor.

4. The development of a Worker's Environmental Awareness Program training that educates construction personnel on the types of fossils that could be encountered during construction and communicates the requirements and procedures for the inadvertent discovery of paleontological resources. The training program should be developed by a qualified paleontologist and presented to construction personnel prior to the onset of ground disturbance, and it should be included in the PRMMP.

5. A field survey of areas identified in #2. This survey can be completed immediately prior to construction as a preliminary step to the monitoring program. The field survey should include specific recommendations made by the NDGS.

6. Construction monitoring of areas identified in #2. The monitoring should be conducted by a qualified paleontological monitor (meeting BLM [2008]). Should subsurface conditions indicate paleontological potential is lower than anticipated, the principal paleontologist may recommend a reduction in monitoring.

7. In the event that paleontological resources are encountered during construction activities, all work must stop in the immediate vicinity of the finds while the paleontological monitor documents the find and the paleontological principal investigator evaluates its scientific importance. Further treatment of the find (i.e., salvage, curation, etc.) shall be determined pending the outcome of the assessment and in consultation

with the Project Owner and the NDGS. All recovered paleontological resources should be transferred to the NDGS for curation and permanent storage.

The recommendations for state lands meet the standards of the BLM (1998, 2008, 2016) and conform to industry best practices (e.g., Murphey et al. 2019). Based on the findings in this study the Project will not cause an adverse impact to paleontological resources on state lands with the incorporation of the above mitigation recommendations. Should the Project location or plans change from those assessed here, this assessment will need to be revised to address those changes.

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APPENDIX A
Public Land Survey System Location for the Project Area

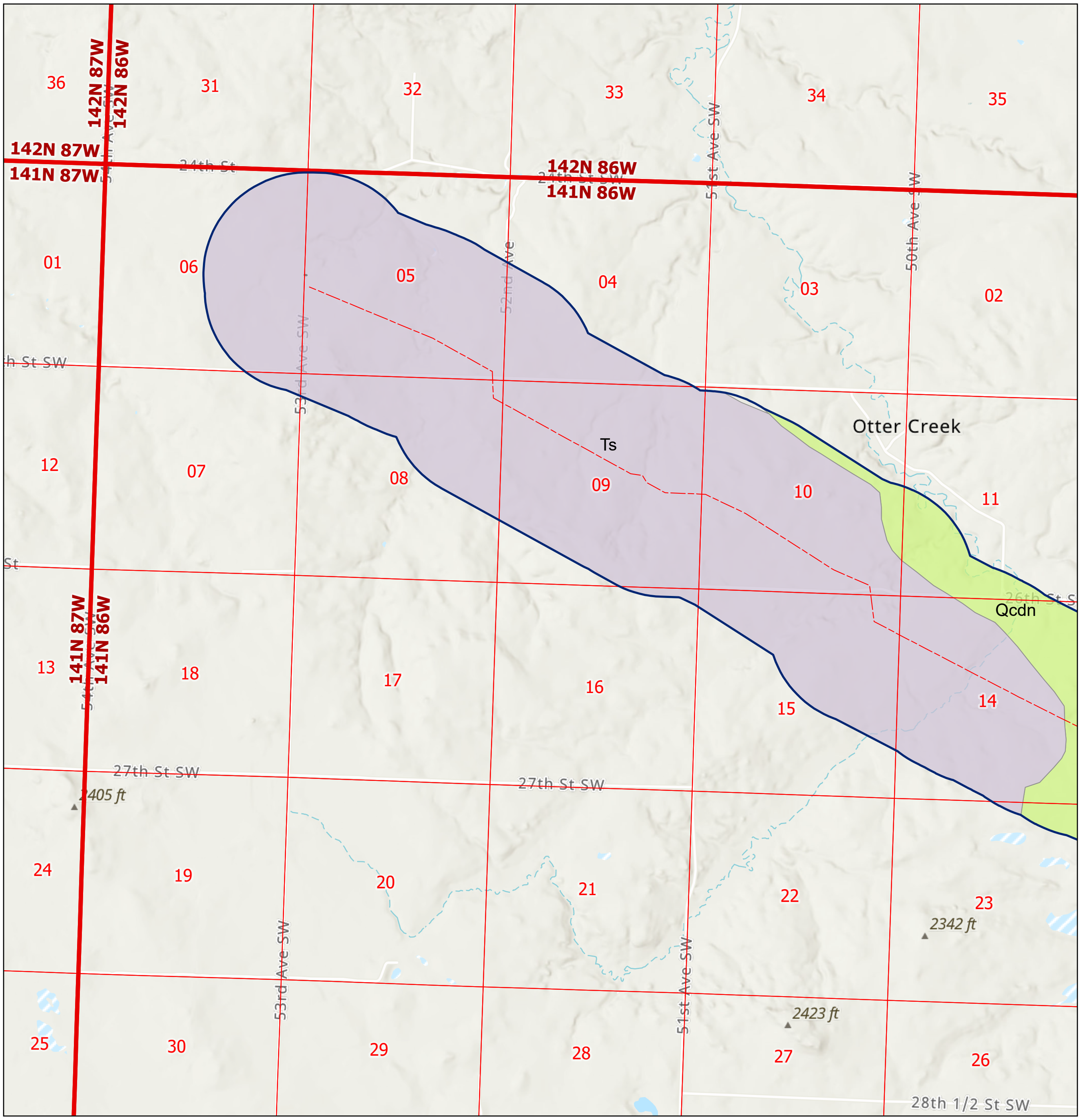
Township and Range	County Name
138N 79W	Burleigh
137N 79W	Burleigh
137N 77W	Burleigh
137N 78W	Burleigh
139N 78W	Burleigh
138N 78W	Burleigh
140N 80W	Burleigh
140N 79W	Burleigh
140N 81W	Burleigh
140N 78W	Burleigh
139N 79W	Burleigh
136N 51W	Cass
138N 52W	Cass
137N 52W	Cass
140N 52W	Cass
139N 52W	Cass
137N 51W	Cass
130N 60W	Dickey
129N 60W	Dickey
130N 59W	Dickey
129N 63W	Dickey
129N 62W	Dickey
129N 61W	Dickey
130N 58W	Dickey

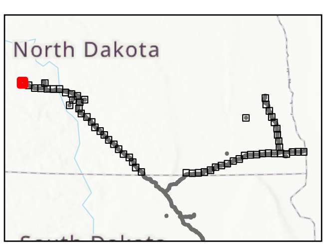
Township and Range	County Name
129N 64W	Dickey
136N 77W	Emmons
134N 74W	Emmons
136N 78W	Emmons
135N 77W	Emmons
137N 77W	Emmons
135N 76W	Emmons
133N 73W	Emmons
132N 74W	Emmons
134N 76W	Emmons
132N 73W	Emmons
134N 75W	Emmons
133N 74W	Emmons
133N 73W	Logan
132N 74W	Logan
129N 71W	McIntosh
130N 71W	McIntosh
131N 73W	McIntosh
132N 73W	McIntosh
131N 71W	McIntosh
131N 72W	McIntosh
129N 70W	McIntosh
129N 70W	McPherson
141N 83W	Morton

Township and Range	County Name
140N 83W	Morton
140N 82W	Morton
140N 85W	Morton
140N 81W	Morton
141N 85W	Morton
140N 84W	Morton
141N 83W	Oliver
141N 86W	Oliver
141N 85W	Oliver
131N 53W	Richland
132N 51W	Richland
131N 51W	Richland
132N 50W	Richland
131N 52W	Richland
132N 49W	Richland
132N 48W	Richland
132N 47W	Richland
136N 51W	Richland
135N 51W	Richland
133N 51W	Richland
134N 51W	Richland
131N 53W	Sargent
131N 56W	Sargent
131N 57W	Sargent

Township and Range	County Name
131N 55W	Sargent
130N 57W	Sargent
130N 58W	Sargent
131N 54W	Sargent

APPENDIX B
Geologic Maps for the Project Area





- - - Centerline Route
— Pipeline Access Road
0.5 mile Buffer
Township
Section

Project Geology

Qcdn - Glacial Sediment Draped over Pre-existing Topography (Holocene to Pre-Wisconsinan)

Ts - Sentinel Butte Formation (Paleocene)

0 2,000 4,000 Feet
(At original document size of 8.5x11)
1:48,000

N

Stantec

Project Location
Multiple Counties,
Northeast South Dakota

Prepared by EB on 2022-09-12
TR by JC on 2022-09-12
IR by PM on 2022-09-12

Client/Project
235100428

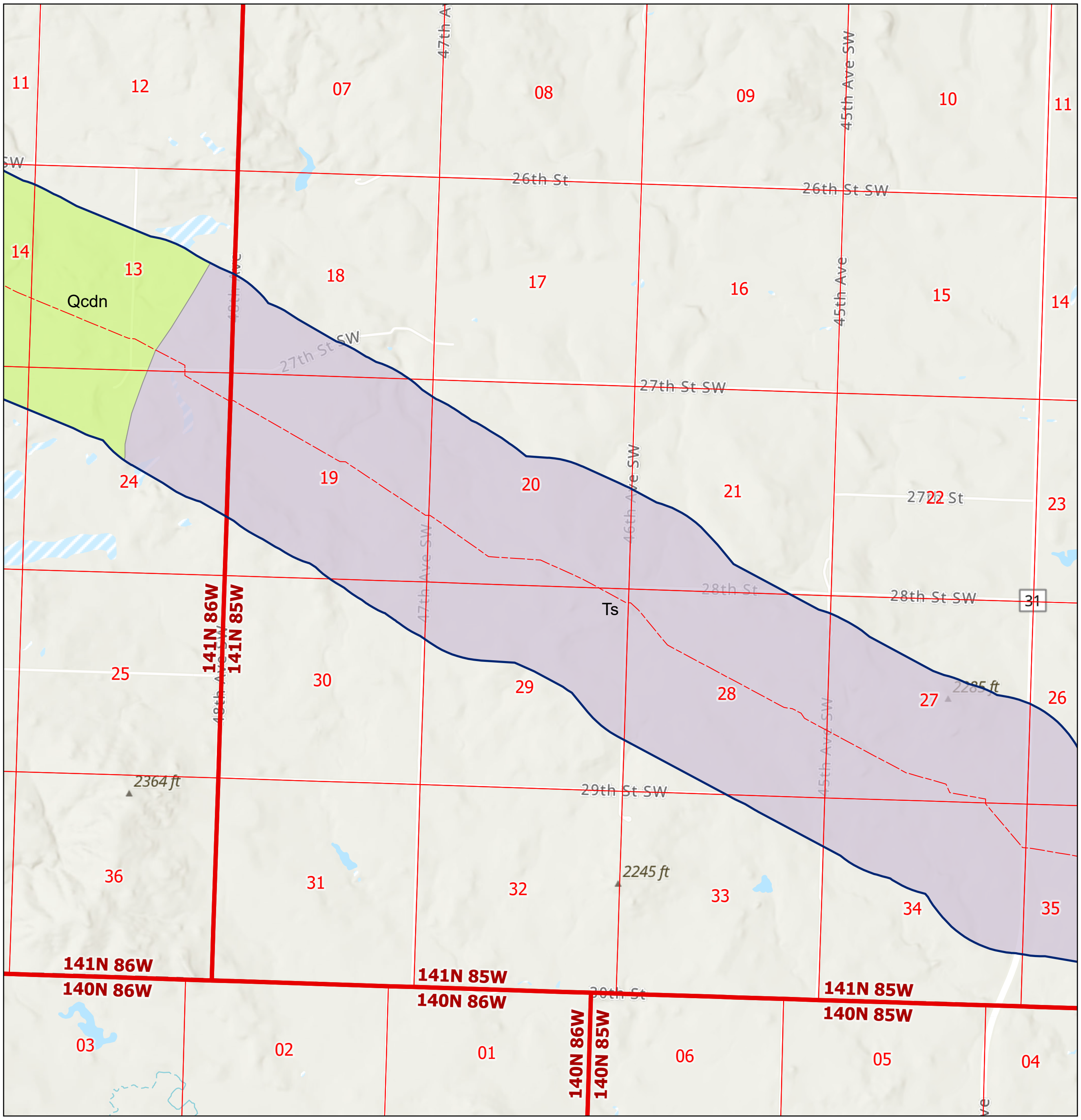
EXP Energy Services
Summit Carbon Solutions MCE Project

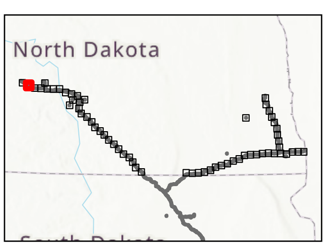
Figure No.
1

Title
North Dakota Geology

Notes
1. Coordinate System: NAD 1983 UTM Zone 14N
2. Data Sources: Stantec 2021. Geologic Map of North Dakota, Clayton et. al., 1980.
3. Background: State of North Dakota, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, Esri, NASA, NGA, USGS, FEMA, Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, Esri, USGS

D:\Projects\235100428\gis_cad\gis\SummitCarbonSolutionsMCE.aprx Revised: 2022-09-23 By: ebarrios





- - - Centerline Route
0.5 mile Buffer
Township
Section

Project Geology

Qcdn - Glacial Sediment Draped over Pre-existing Topography (Holocene to Pre-Wisconsinan)

Ts - Sentinel Butte Formation (Paleocene)

0 2,000 4,000 Feet
(At original document size of 8.5x11)
1:48,000

N

Stantec

Project Location
Multiple Counties,
Northeast South Dakota

Prepared by EB on 2022-09-12
TR by JC on 2022-09-12
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Client/Project
235100428

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Figure No.
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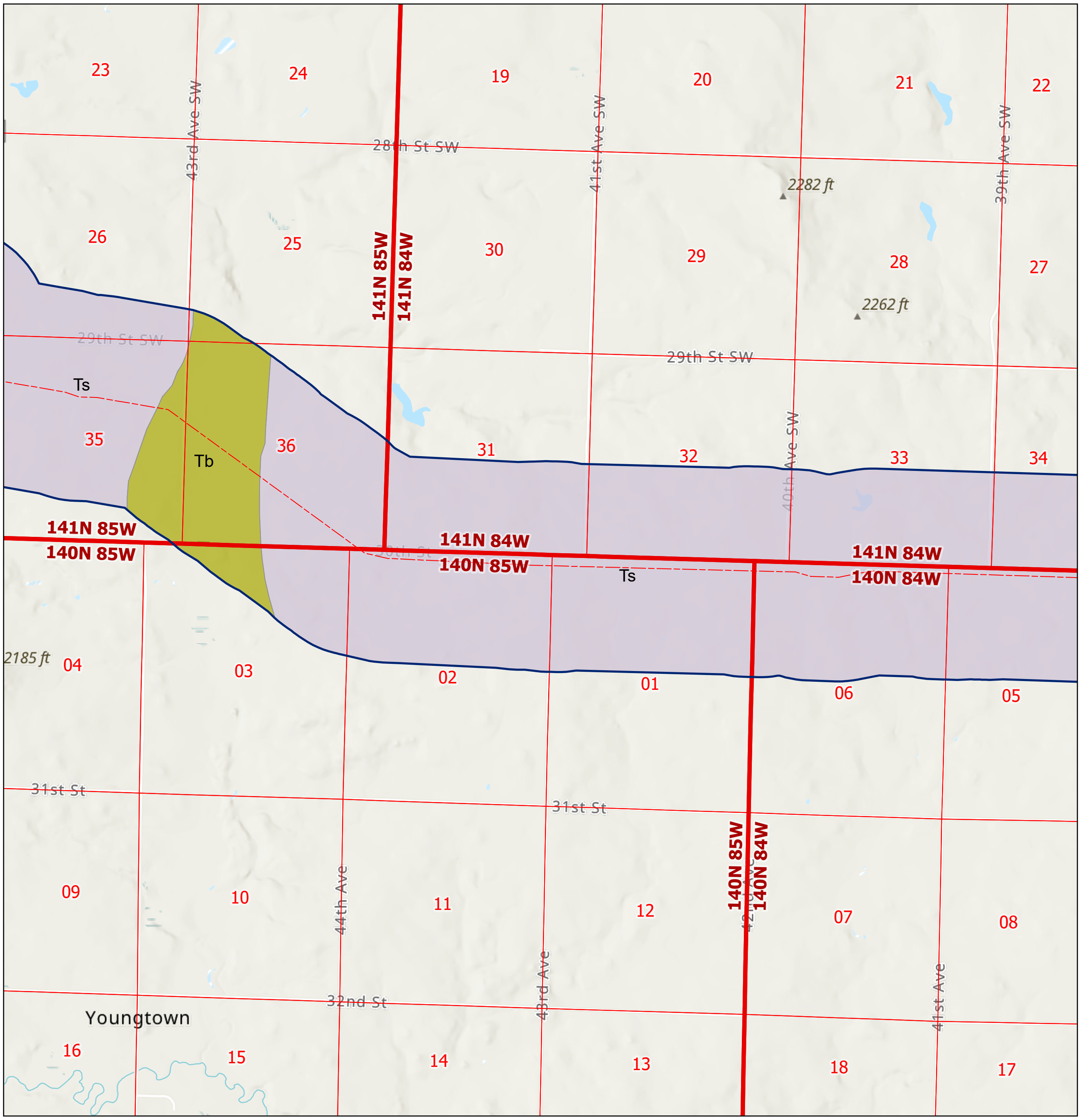

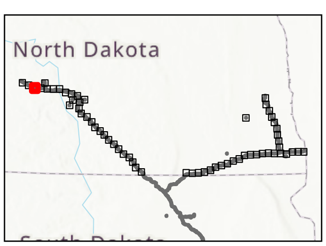

--- Centerline Route

0.5 mile Buffer

Township

Section

Project Geology

Ts - Sentinel Butte Formation (Paleocene)

Tb - Bullion Creek Formation (Paleocene)

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N

Stantec

Project Location
Multiple Counties,
Northeast South Dakota

Prepared by EB on 2022-09-12
TR by JC on 2022-09-12
IR by PM on 2022-09-12

Client/Project
235100428

EXP Energy Services
Summit Carbon Solutions MCE Project

Figure No.
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North Dakota Geology

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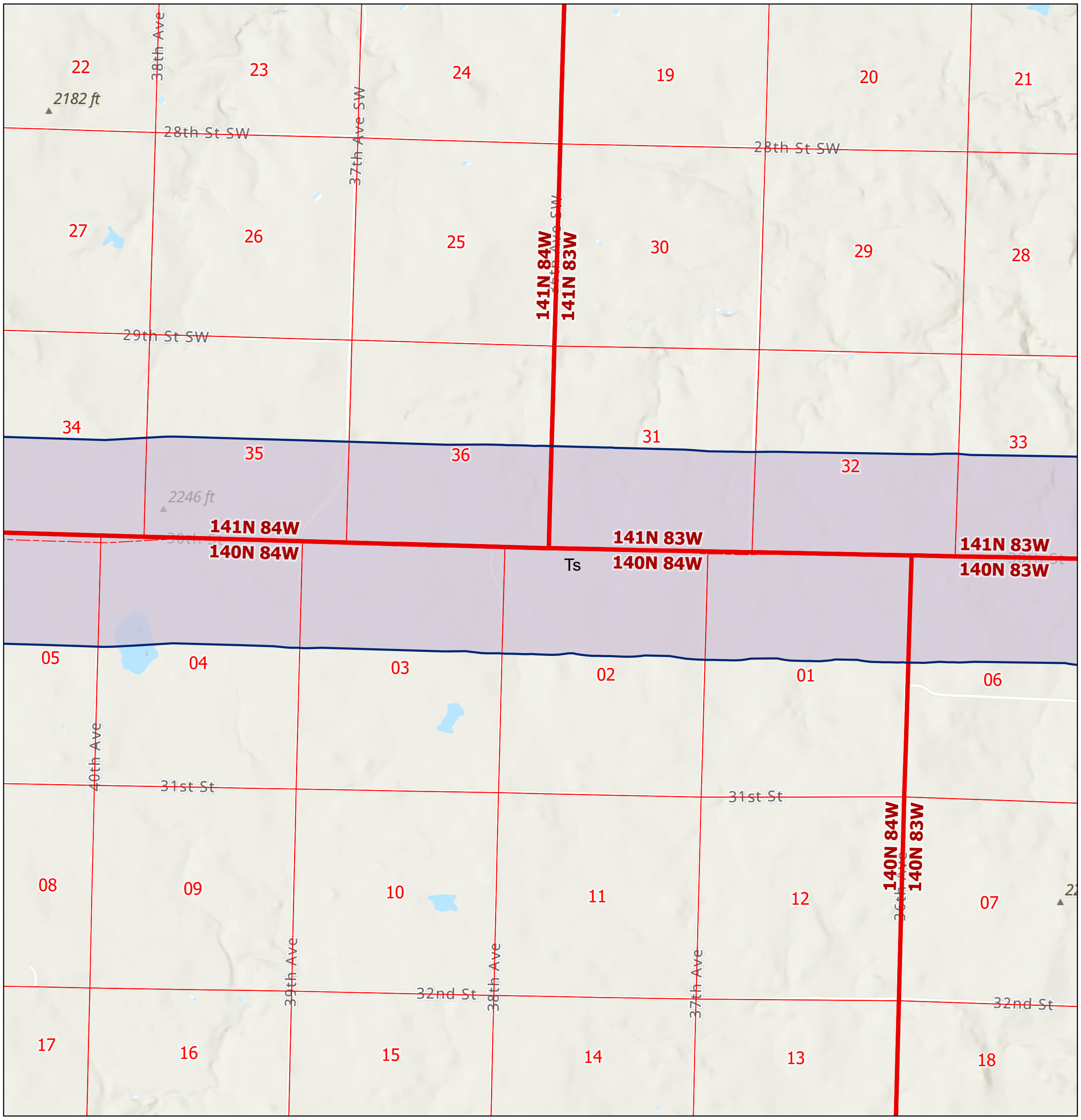

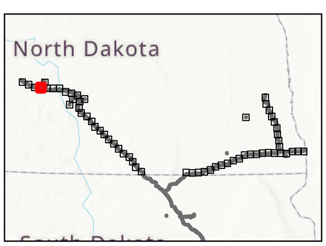

Centerline Route
0.5 mile Buffer
Township
Section

Project Geology

Ts - Sentinel Butte Formation (Paleocene)

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Project Location
Multiple Counties,
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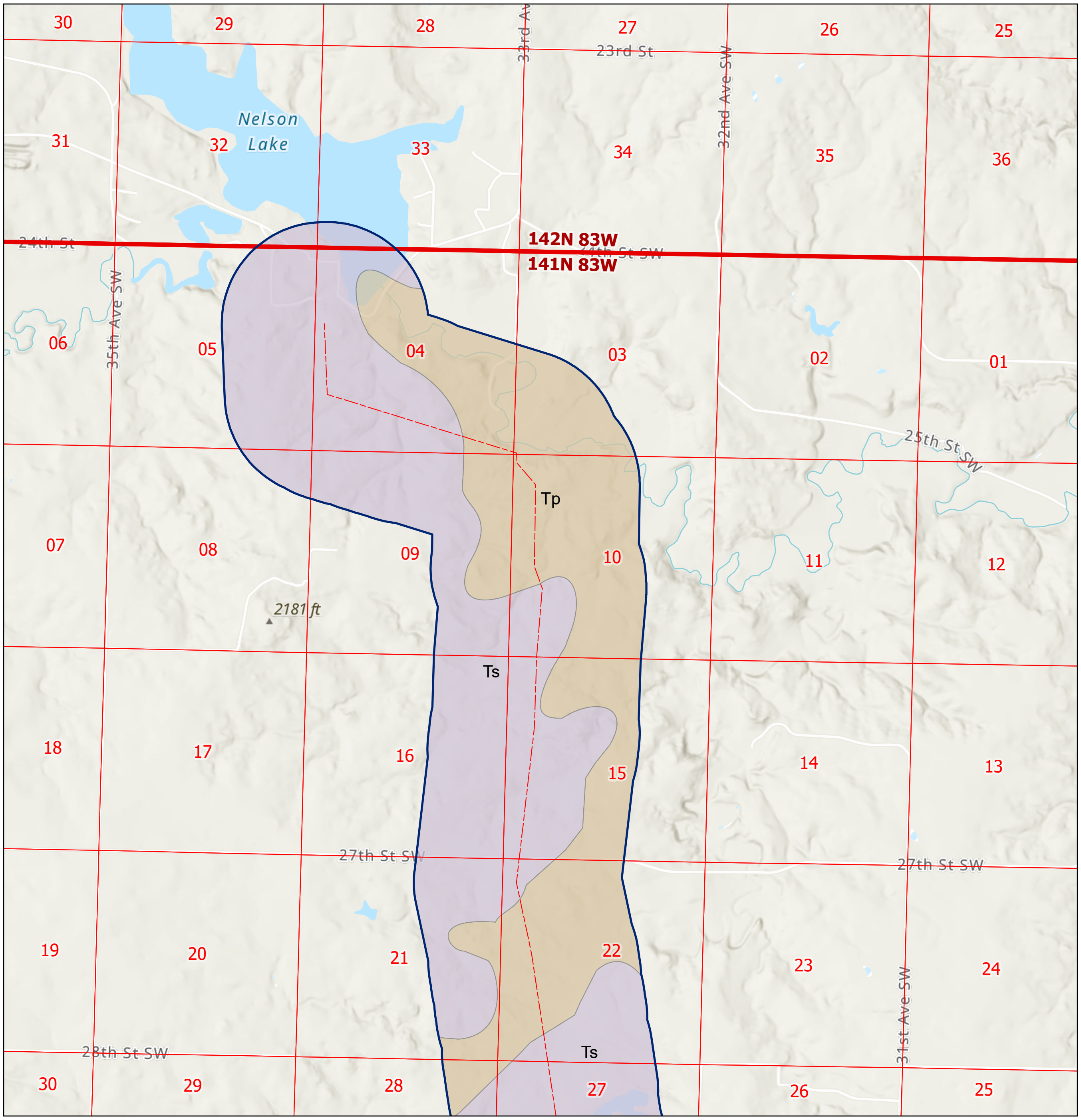

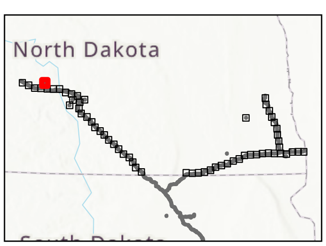

Centerline Route
0.5 mile Buffer
Township
Section

Project Geology
Ts - Sentinel Butte Formation (Paleocene)
Tp - Slope Formation (Paleocene)

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Project Location
Multiple Counties,
Northeast South Dakota

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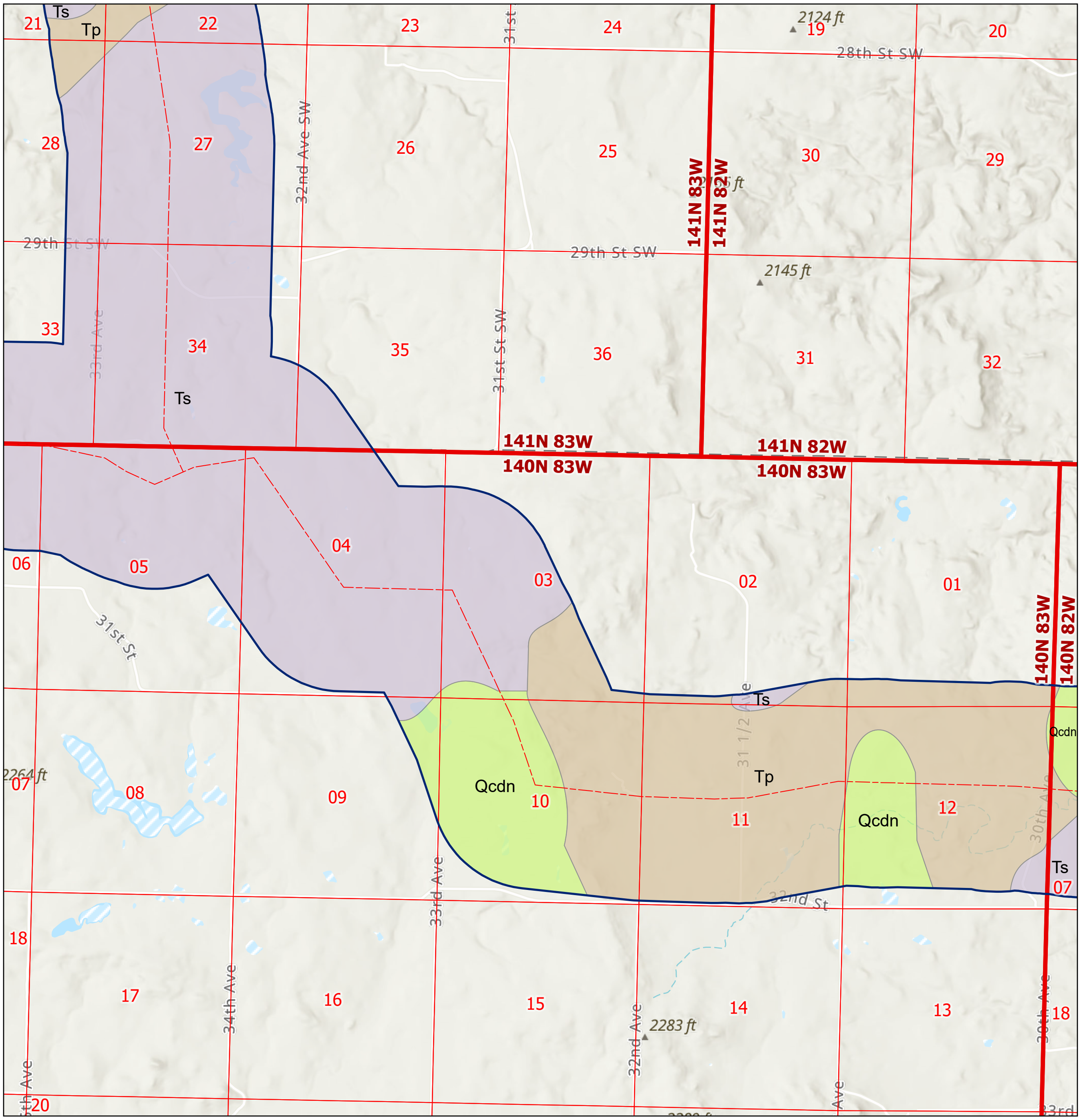


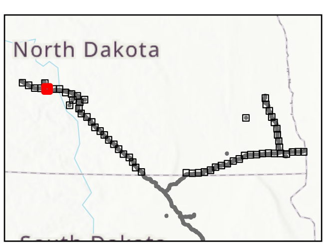
- - - Centerline Route
0.5 mile Buffer
Township
Section

Project Geology

Qcdn - Glacial Sediment Draped over Pre-existing Topography (Holocene to Pre-Wisconsinan)

Ts - Sentinel Butte Formation (Paleocene)

Tp - Slope Formation (Paleocene)



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Project Location
Multiple Counties, Northeast South Dakota

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EXP Energy Services
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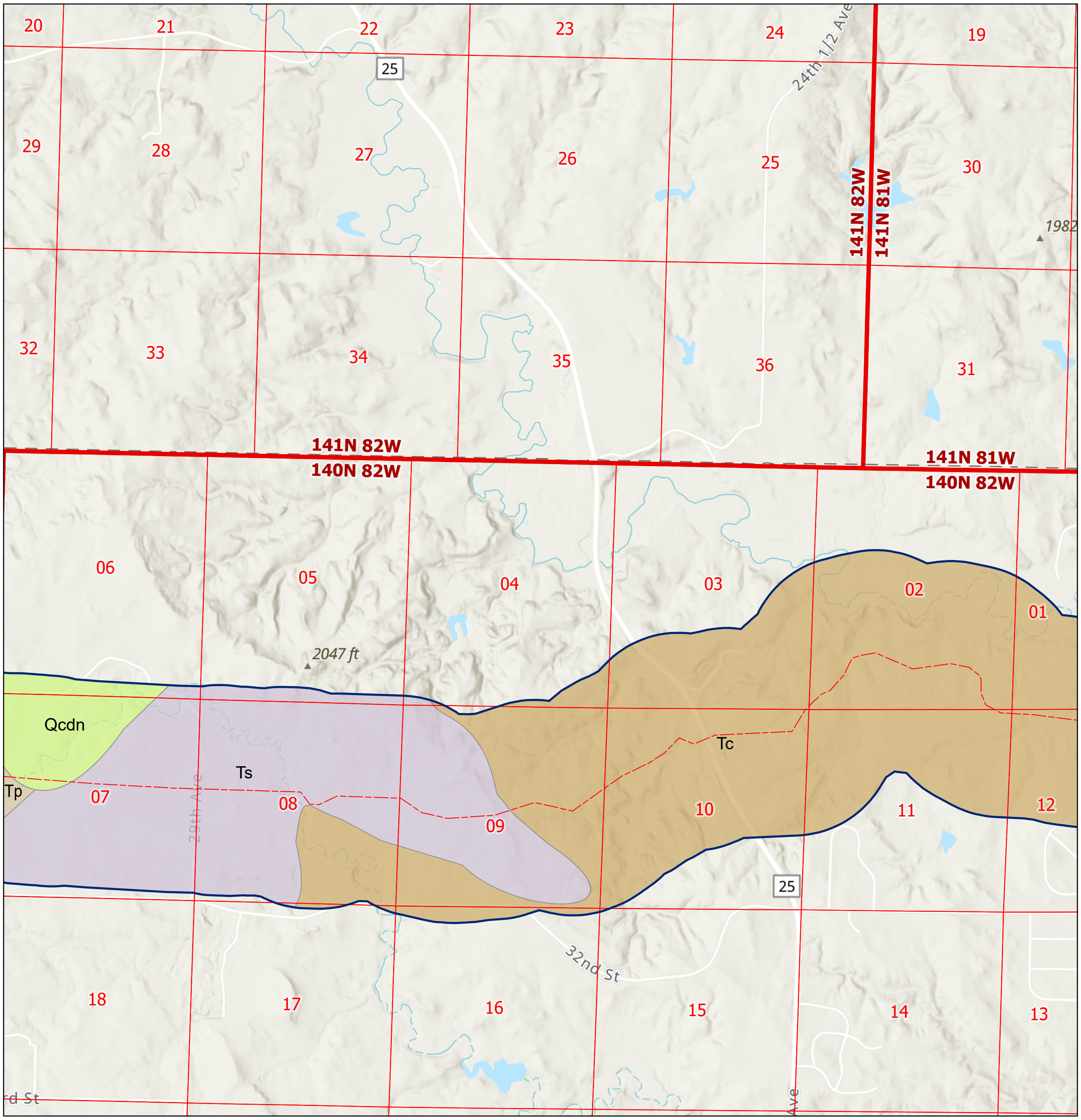

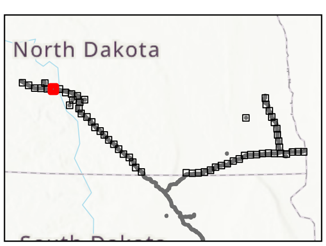

- - - Centerline Route
0.5 mile Buffer
Township
Section

Project Geology

Qcdn - Glacial Sediment Draped over Pre-existing Topography (Holocene to Pre-Wisconsinan)

Ts - Sentinel Butte Formation (Paleocene)

Tp - Slope Formation (Paleocene)

Tc - Cannonball Formation (Paleocene)

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Stantec

Project Location
Multiple Counties,
Northeast South Dakota

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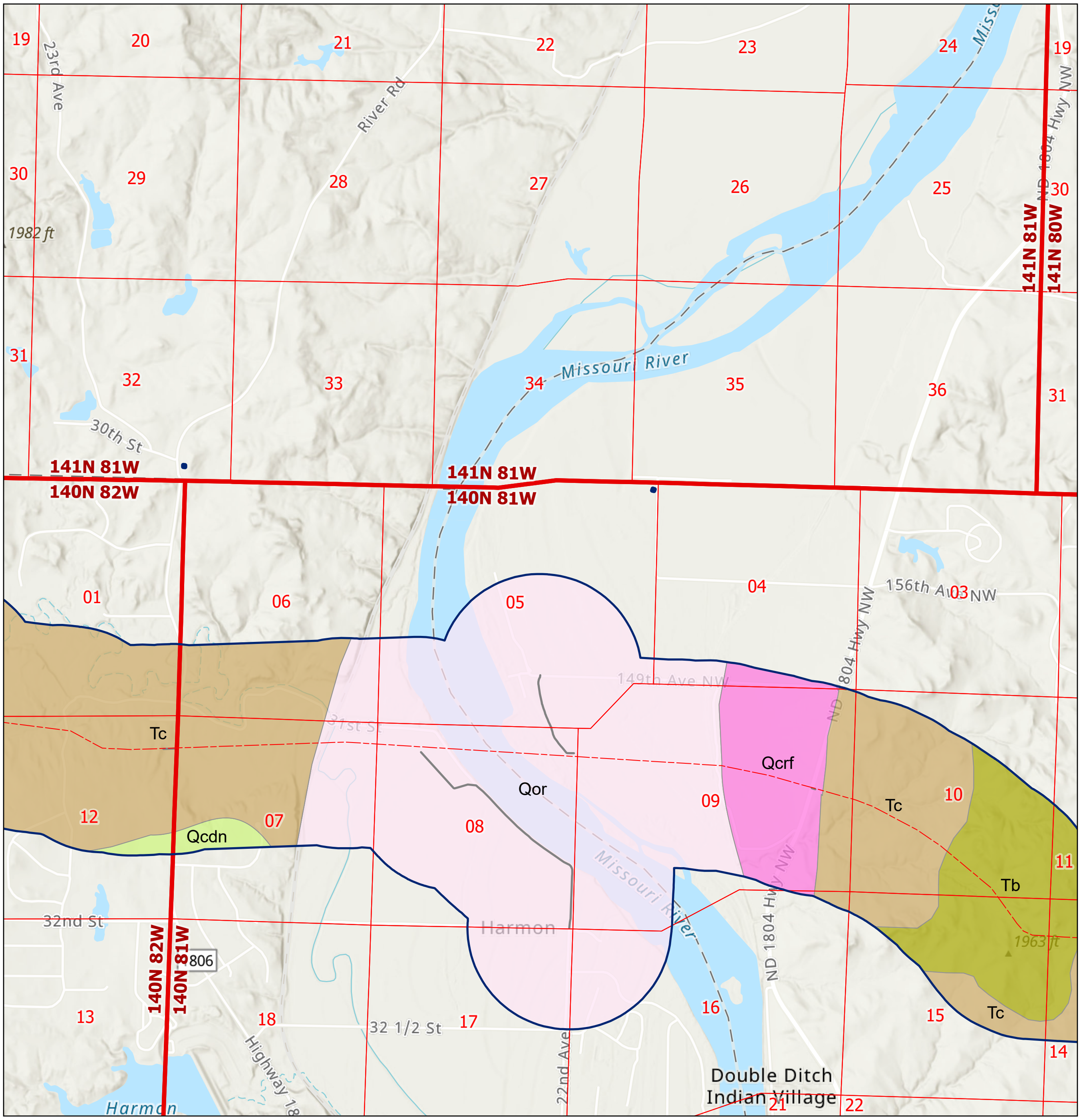

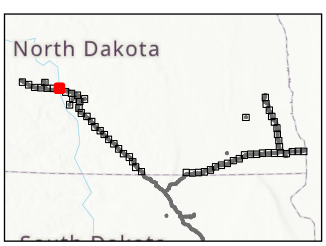

- Centerline Route
- Pipeline Access Road
- Mainline Valves
- 0.5 mile Buffer
- Township
- Section

Project Geology

- Qor - River Sediment (Holocene)
- Qcrf - Uncollapsed River Sediment (Holocene to Pre-Wisconsinan)
- Qcdn - Glacial Sediment Draped over Pre-existing Topography (Holocene to Pre-Wisconsinan)
- Tb - Bullion Creek Formation (Paleocene)

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Stantec

Project Location
Multiple Counties,
Northeast South Dakota

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EXP Energy Services
Summit Carbon Solutions MCE Project

Figure No.
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North Dakota Geology

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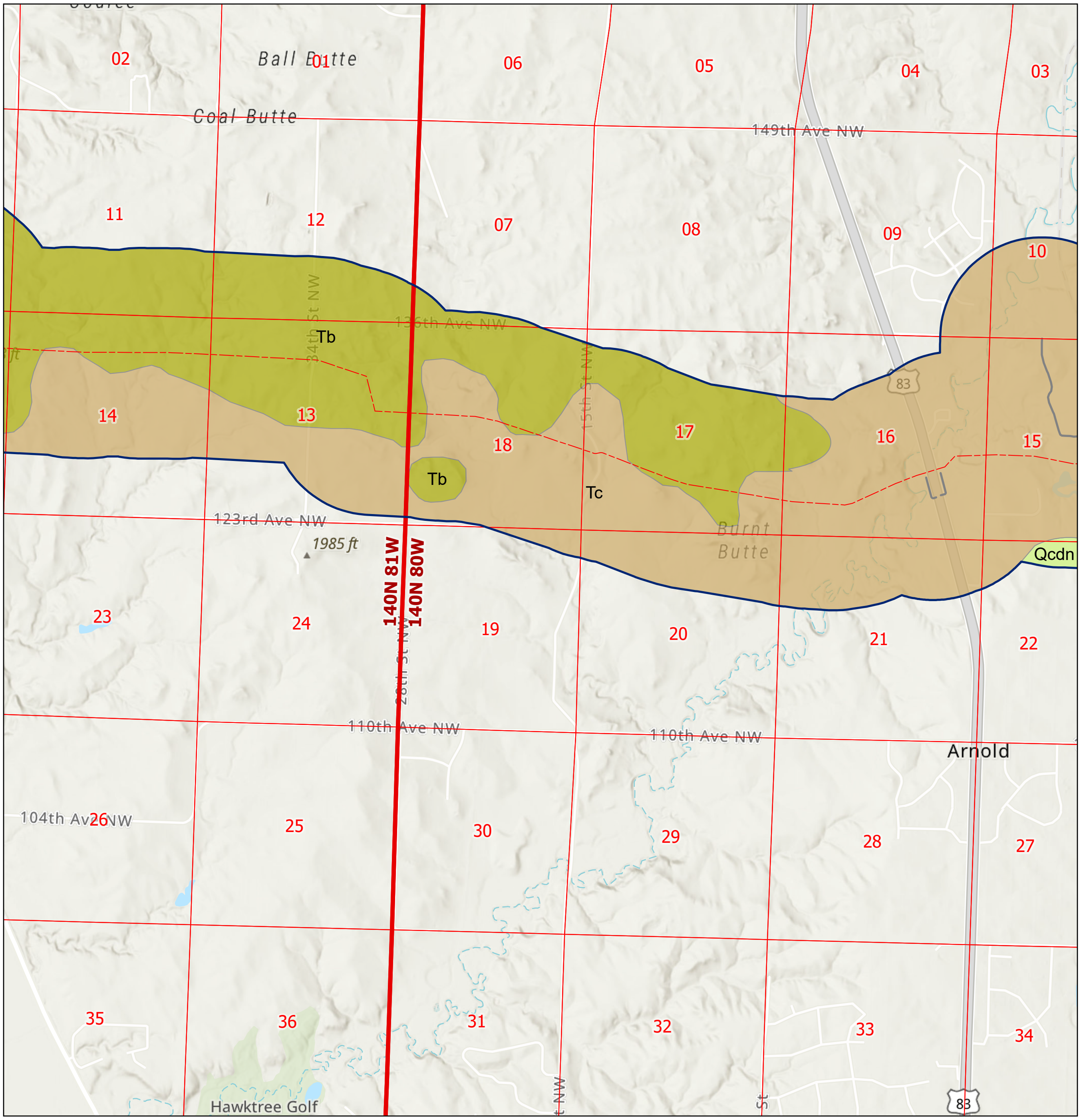

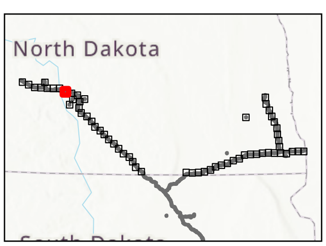

- - - Centerline Route
— Pipeline Access Road
0.5 mile Buffer
Township
Section

Project Geology

Qcdn - Glacial Sediment Draped over Pre-existing Topography (Holocene to Pre-Wisconsinan)

Tb - Bullion Creek Formation (Paleocene)

Tc - Cannonball Formation (Paleocene)

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Stantec

Project Location
Multiple Counties,
Northeast South Dakota

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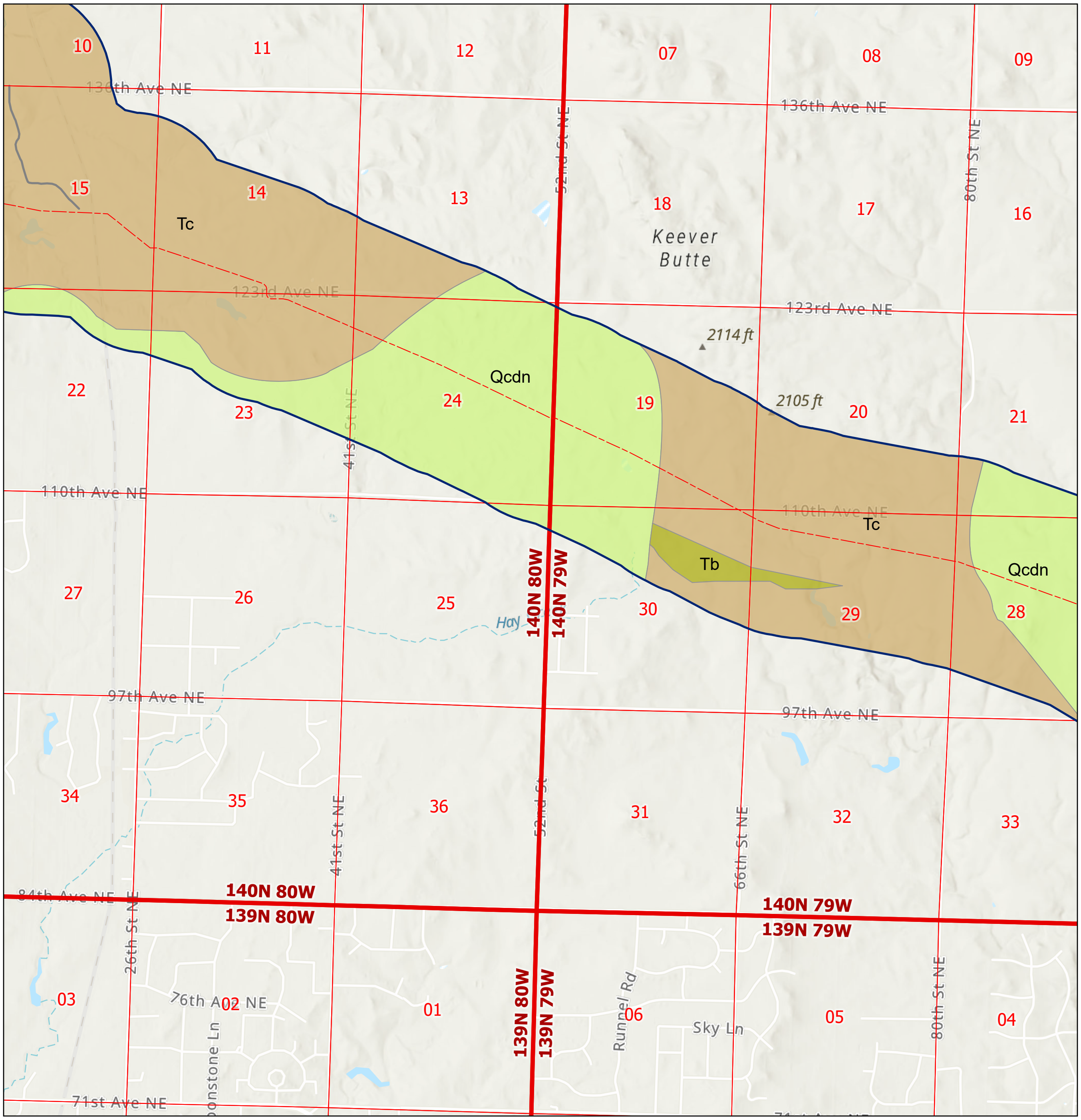

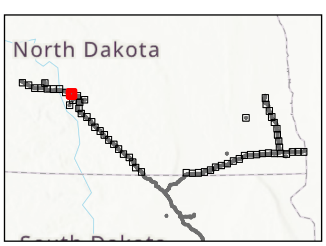

- Centerline Route
- Pipeline Access Road
- 0.5 mile Buffer
- Township
- Section

Project Geology

- Qcdn - Glacial Sediment Draped over Pre-existing Topography (Holocene to Pre-Wisconsinan)
- Tb - Bullion Creek Formation (Paleocene)
- Tc - Cannonball Formation (Paleocene)

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EXP Energy Services
Summit Carbon Solutions MCE Project

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North Dakota Geology

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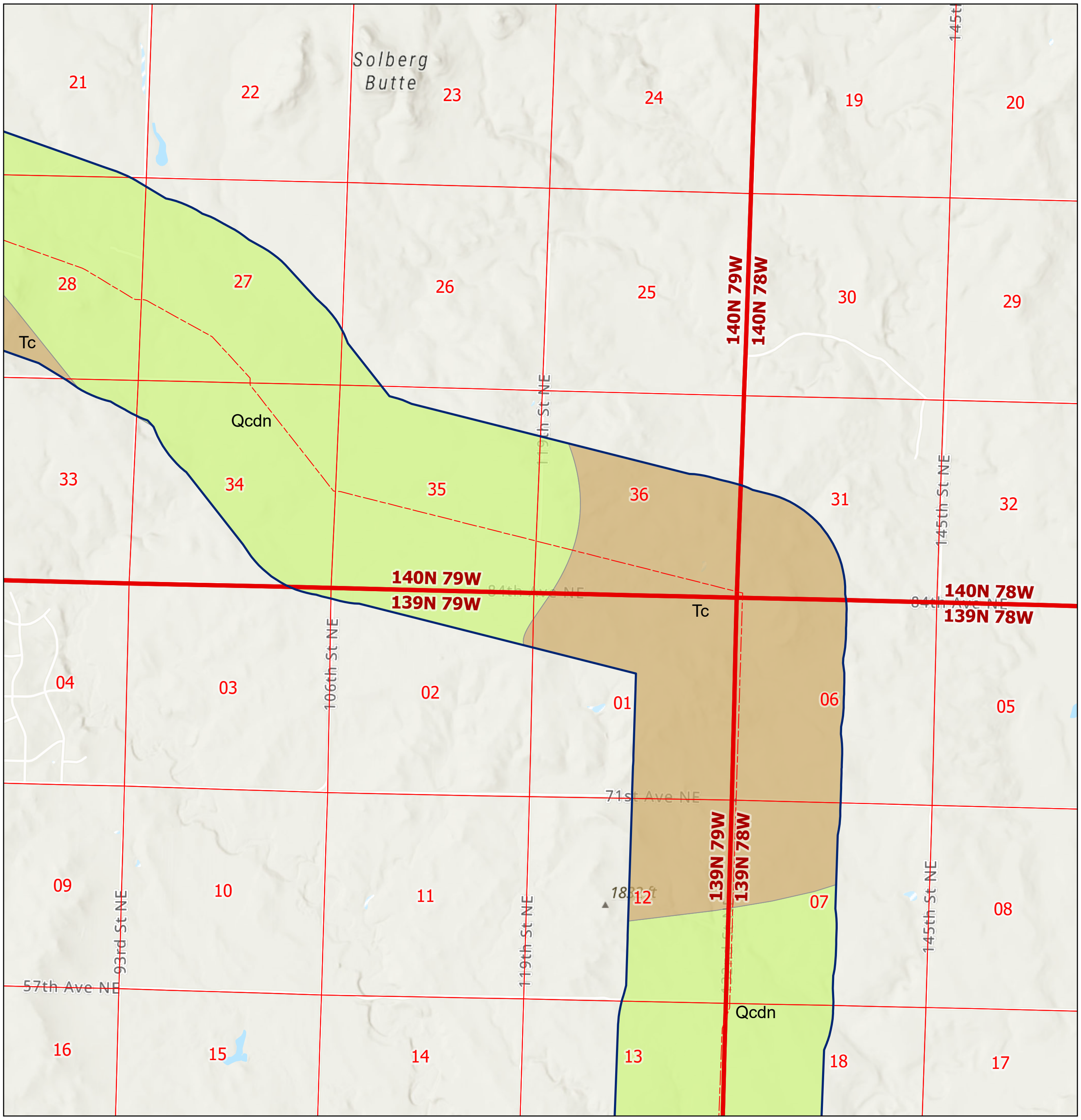

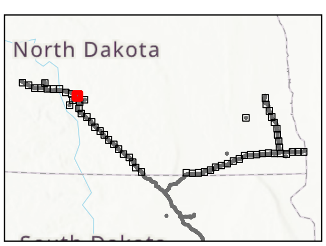

- - - Centerline Route
— Pipeline Access Road
0.5 mile Buffer
Township
Section

Project Geology

Qcdn - Glacial Sediment Draped over Pre-existing Topography (Holocene to Pre-Wisconsinan)

Tc - Cannonball Formation (Paleocene)

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Stantec

Project Location
Multiple Counties,
Northeast South Dakota

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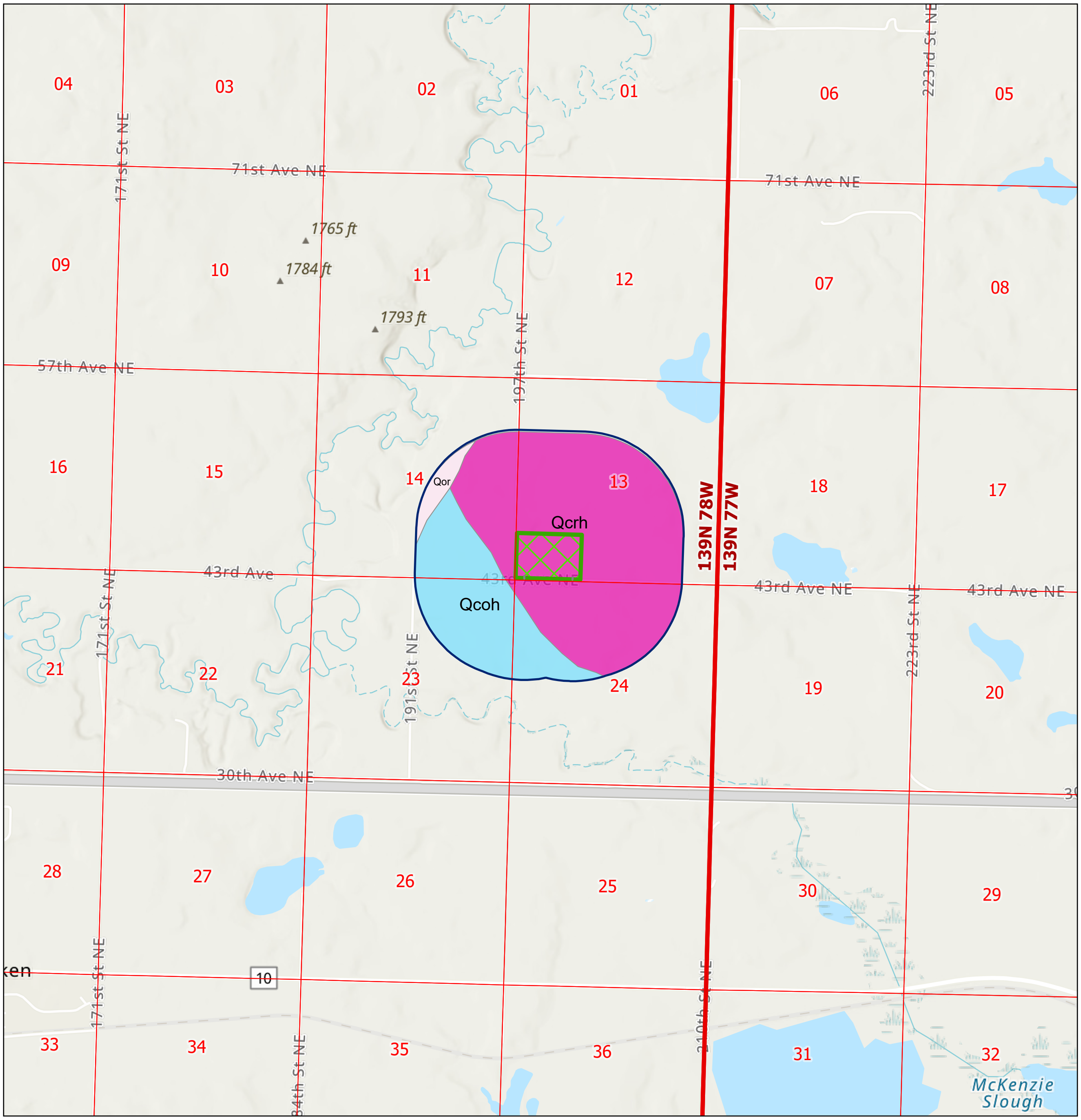

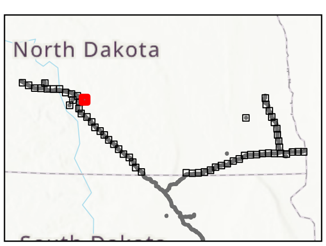

- Pipeline Access Road
- Contractor Yards
- 0.5 mile Buffer
- Township
- Section

Project Geology

- Qor - River Sediment (Holocene)
- Qcoh - Ice-Walled-Lake Sediment or Collapsed Supra-Glacial-Lake Sediment (Holocene to Pre-Wisconsinan)
- Qcrh - Collapsed River Sediment (Holocene to Pre-Wisconsinan)

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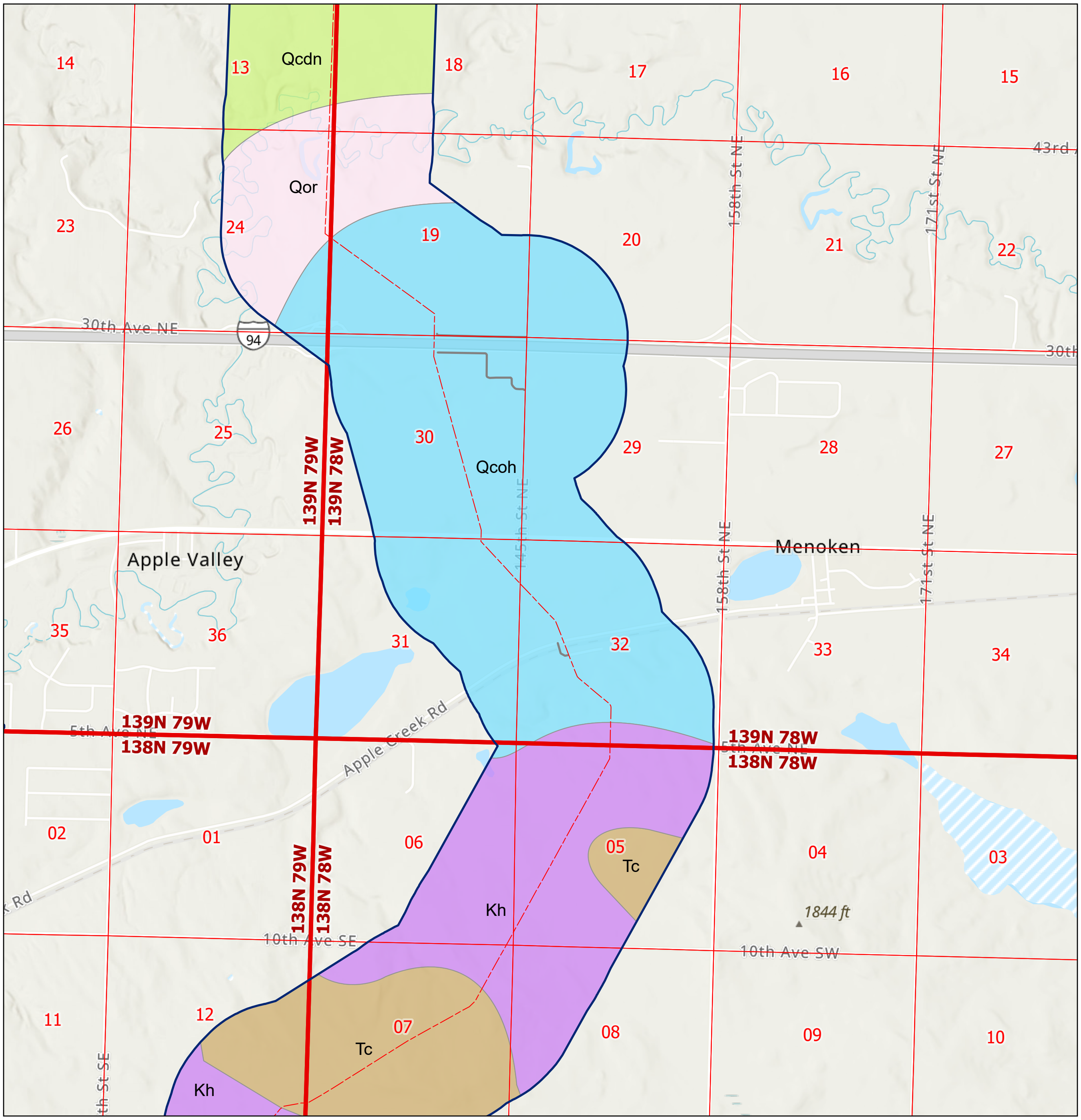

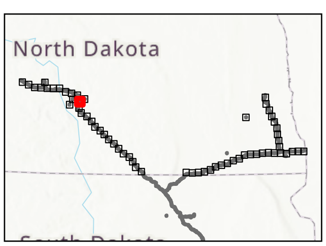

- - - Centerline Route
— Pipeline Access Road
0.5 mile Buffer
Township
Section

Project Geology

- Qor - River Sediment (Holocene)
- Qcoh - Ice-Walled-Lake Sediment or Collapsed Supra-Glacial-Lake Sediment (Holocene to Pre-Wisconsinan)
- Qcdn - Glacial Sediment Draped over Pre-existing Topography (Holocene to Pre-Wisconsinan)
- Tc - Cannonball Formation (Paleocene)

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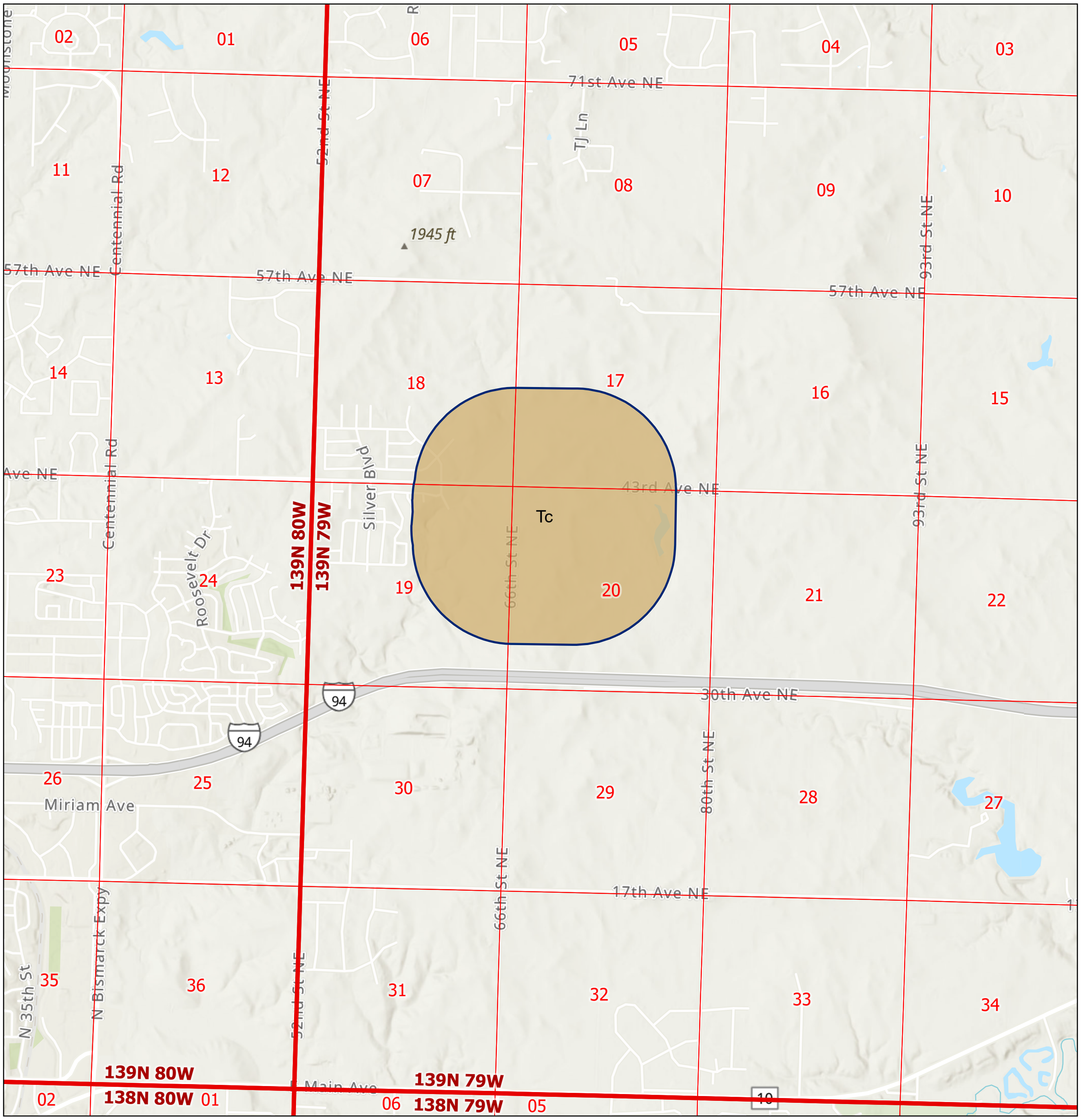

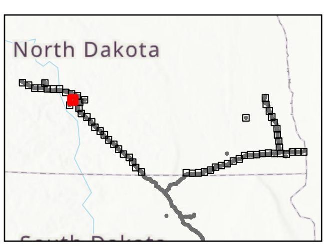

0.5 mile Buffer

Township

Section

Project Geology

Tc - Cannonball Formation (Paleocene)

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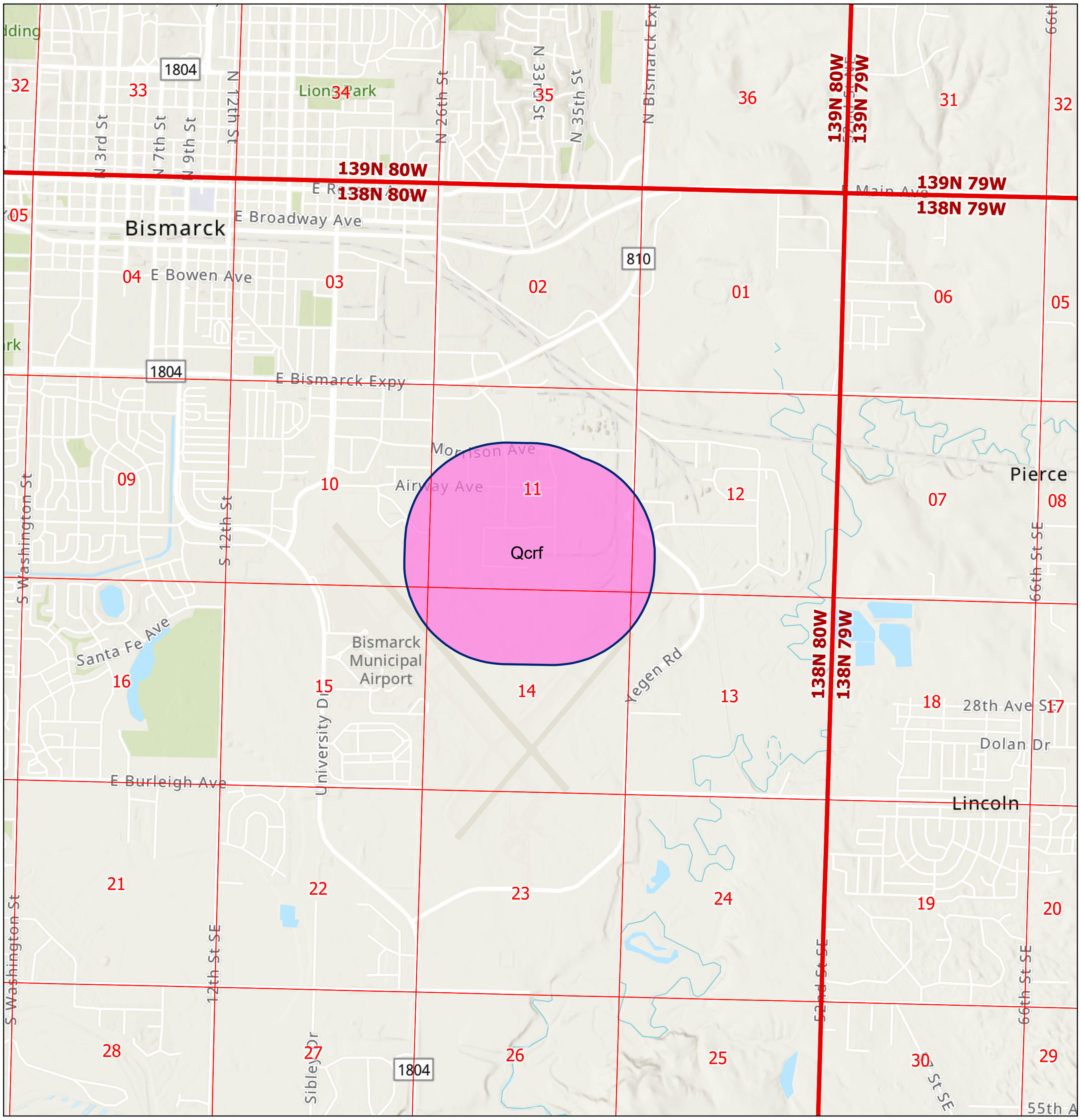

	0.5 mile Buffer
	Township
	Section

Project Geology

Qcrf - Uncollapsed River Sediment (Holocene to Pre-Wisconsinan)

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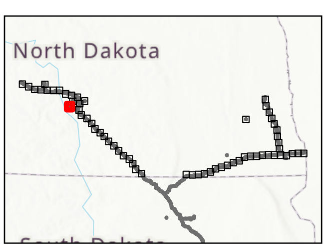

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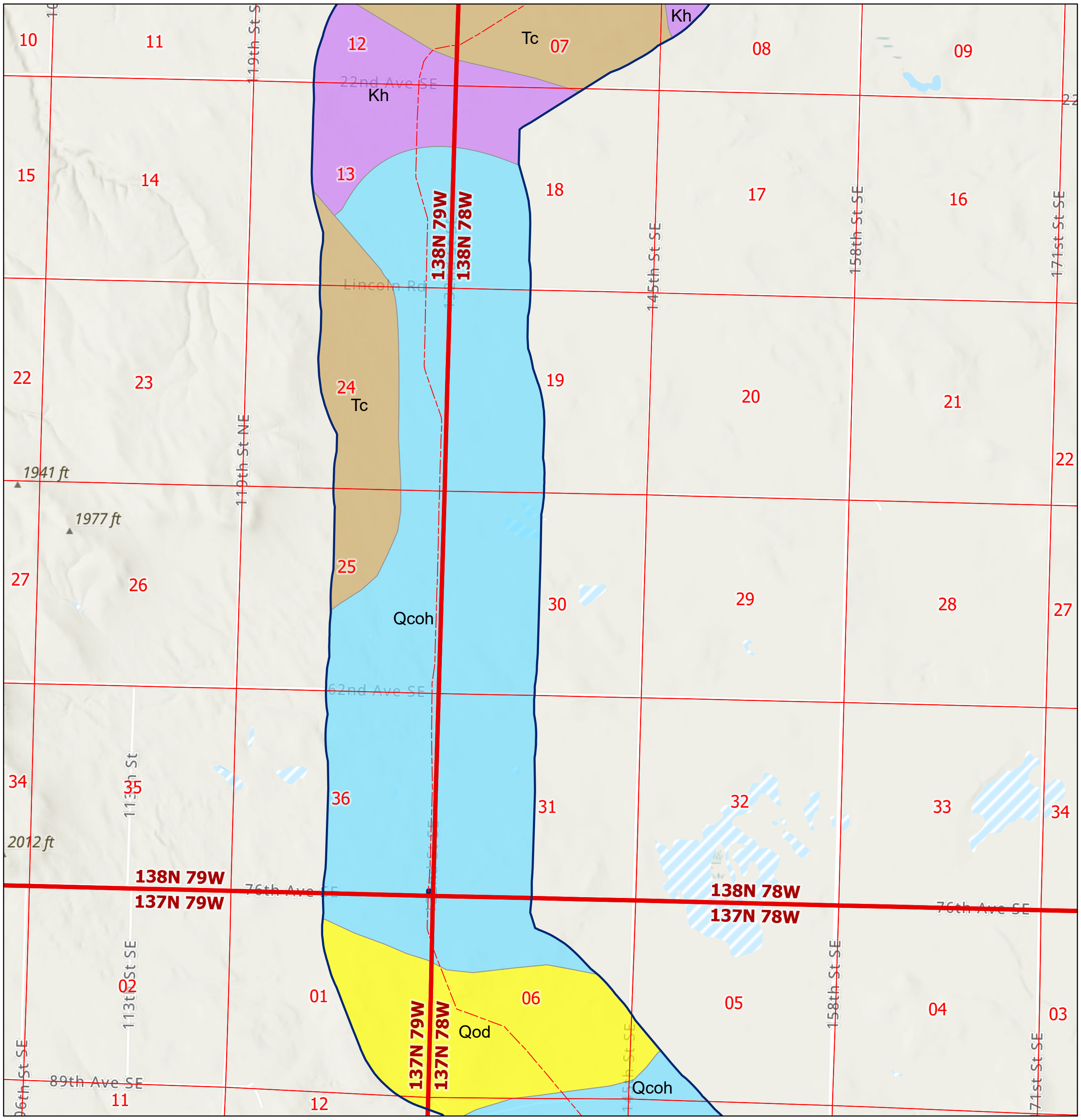

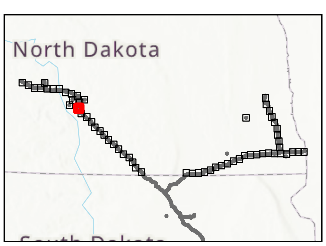

- Centerline Route
- Mainline Valves
- 0.5 mile Buffer
- Township
- Section

Project Geology

- Qod - Windblown Sand (Holocene)
- Qcoh - Ice-Walled-Lake Sediment or Collapsed Supra-Glacial-Lake Sediment (Holocene to Pre-Wisconsinan)
- Tc - Cannonball Formation (Paleocene)
- Kh - Hell Creek Formation (Upper Cretaceous)

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Stantec

Project Location
Multiple Counties,
Northeast South Dakota

Prepared by EB on 2022-09-12
TR by JC on 2022-09-12
IR by PM on 2022-09-12

Client/Project
235100428

EXP Energy Services
Summit Carbon Solutions MCE Project

Figure No.
1

Title
North Dakota Geology

Notes
1. Coordinate System: NAD 1983 UTM Zone 14N
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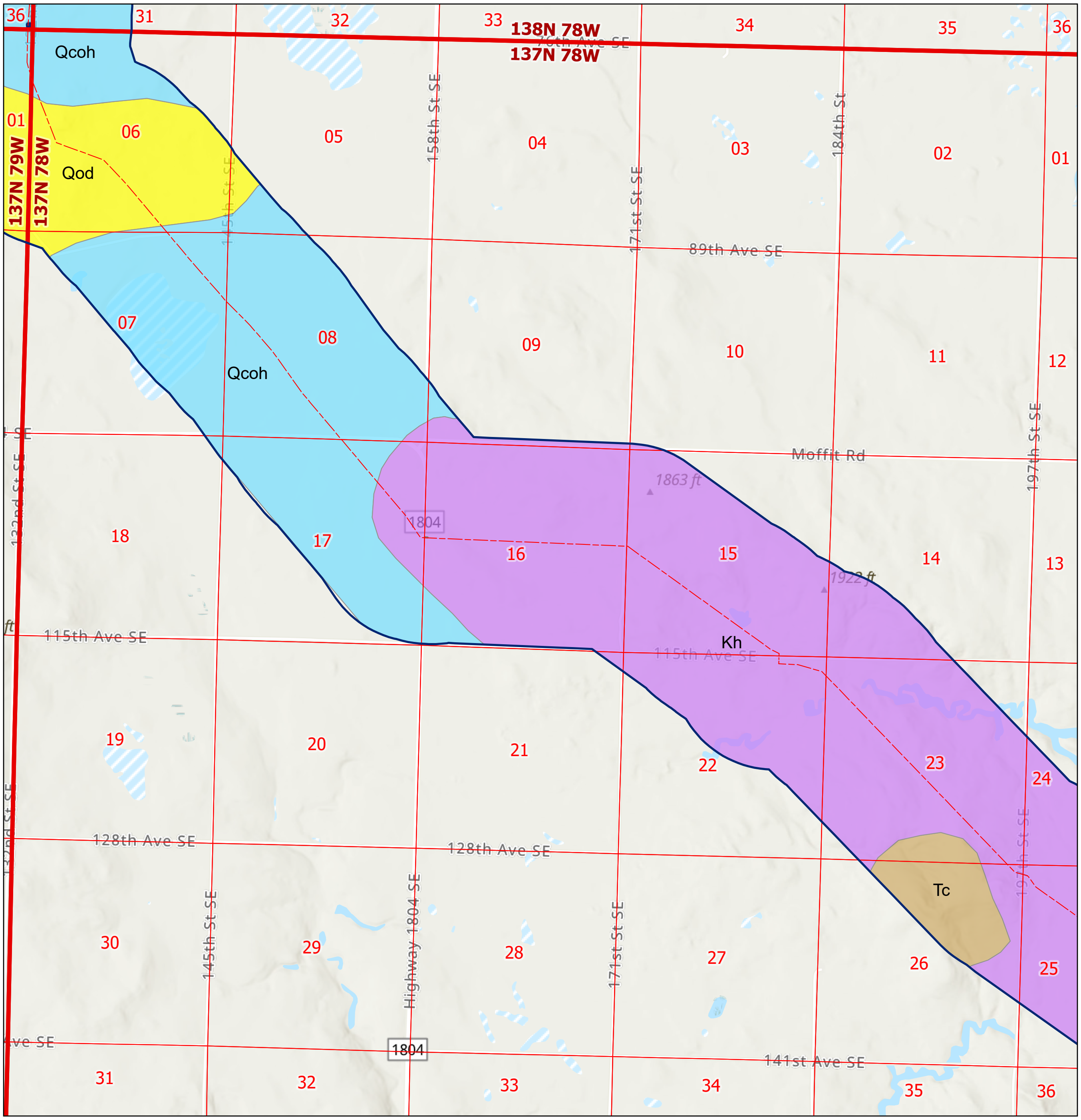

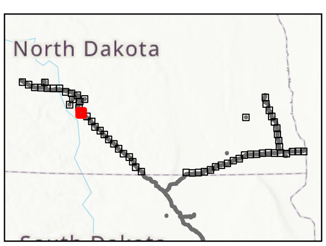

- Centerline Route
- Pipeline Access Road
- Mainline Valves
- 0.5 mile Buffer
- Township
- Section

Project Geology

- Qod - Windblown Sand (Holocene)
- Qcoh - Ice-Walled-Lake Sediment or Collapsed Supra-Glacial-Lake Sediment (Holocene to Pre-Wisconsinan)
- Tc - Cannonball Formation (Paleocene)
- Kh - Hell Creek Formation (Upper Cretaceous)

0 2,000 4,000 Feet

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Stantec

Project Location
Multiple Counties,
Northeast South Dakota

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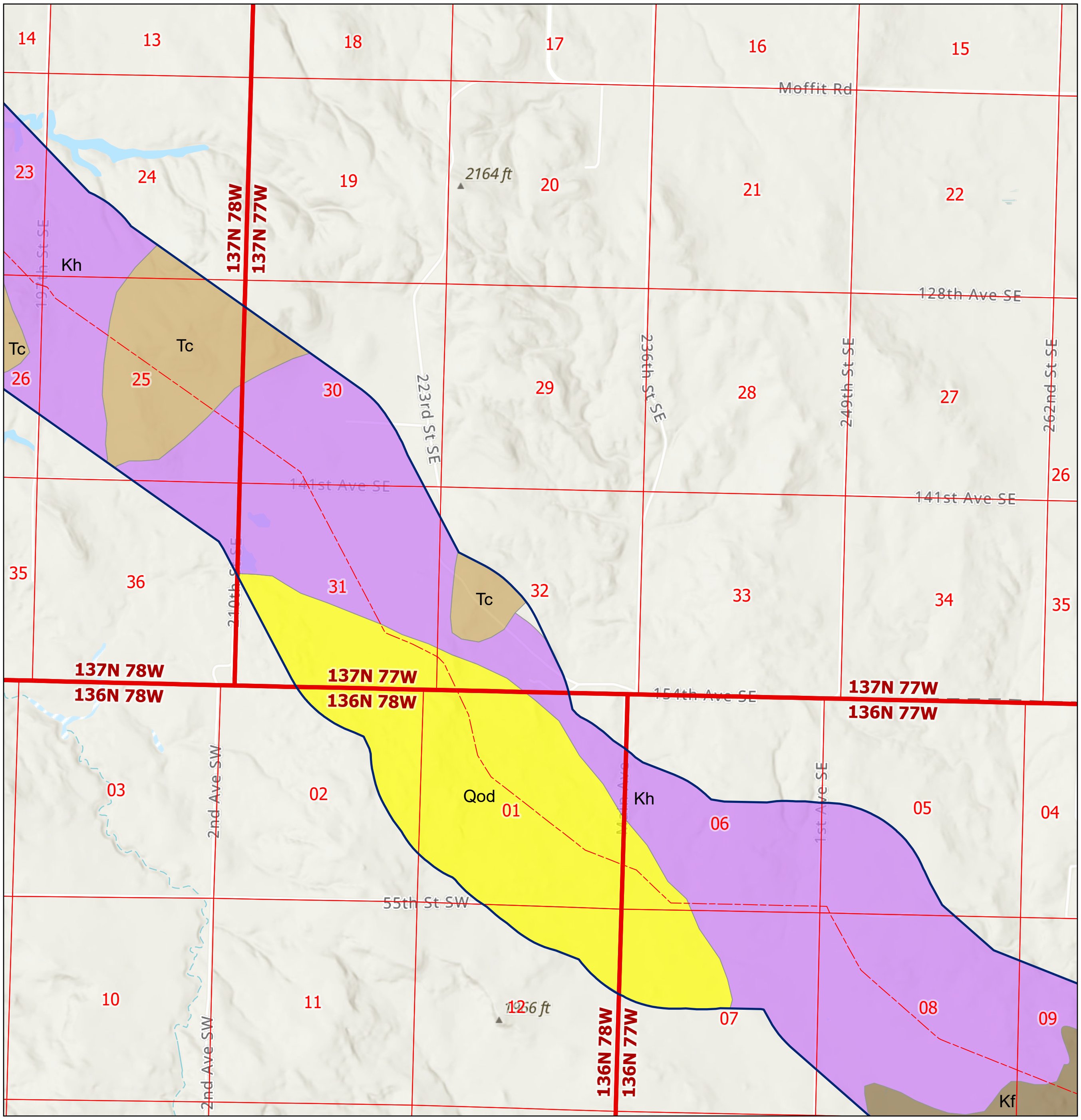

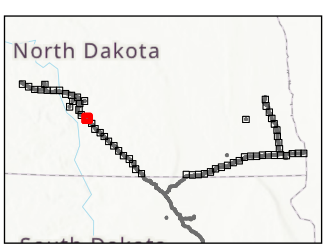

Centerline Route
0.5 mile Buffer
Township
Section

Project Geology

Qod - Windblown Sand (Holocene)

Tc - Cannonball Formation (Paleocene)

Kh - Hell Creek Formation (Upper Cretaceous)

Kf - Fox Hills Formation (Upper Cretaceous)

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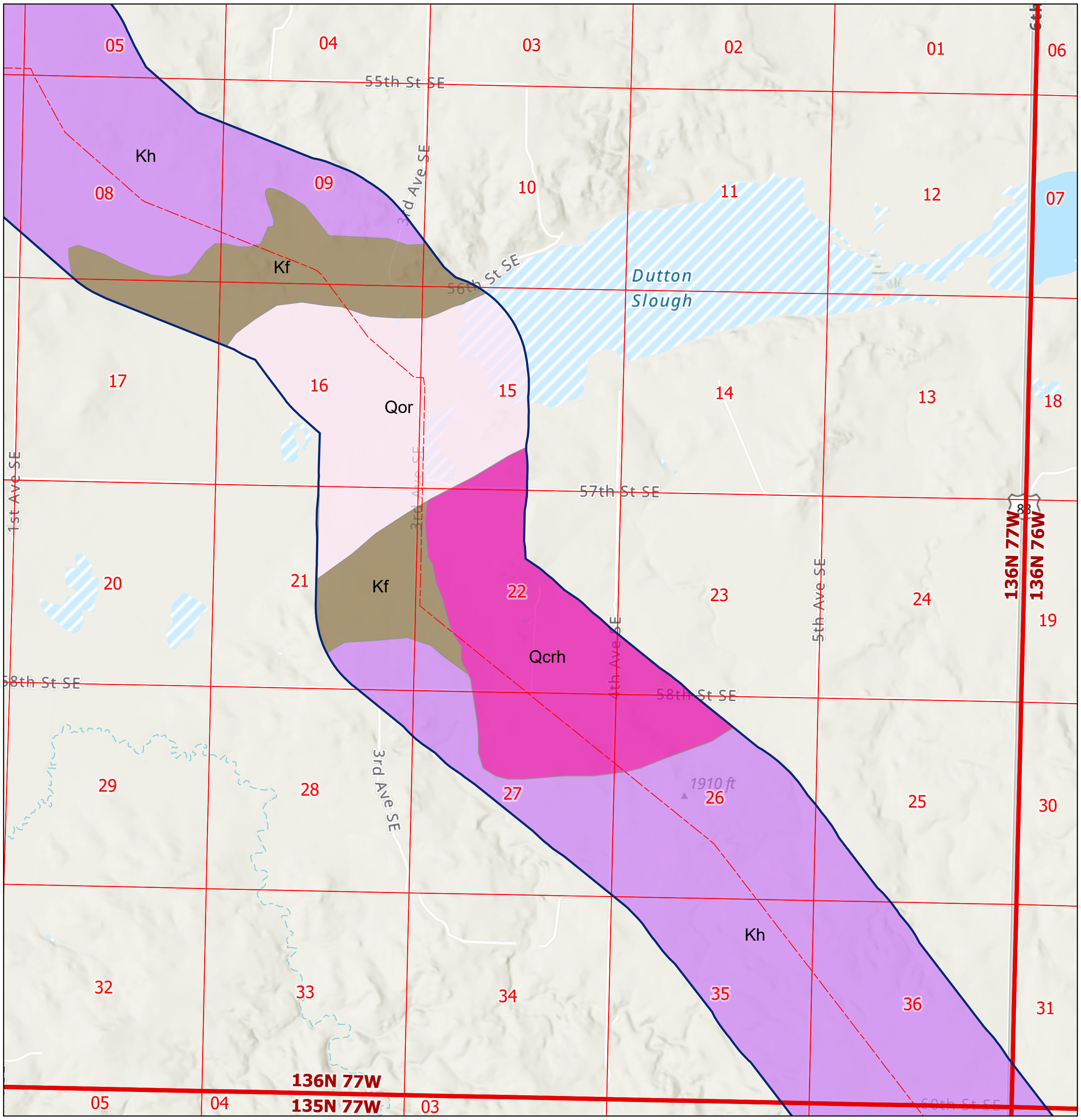

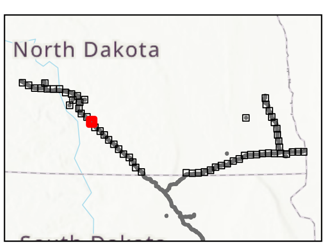

- - - Centerline Route
0.5 mile Buffer
Township
Section

Project Geology

Qor - River Sediment (Holocene)

Qcrh - Collapsed River Sediment (Holocene to Pre-Wisconsinan)

Kh - Hell Creek Formation (Upper Cretaceous)

Kf - Fox Hills Formation (Upper Cretaceous)

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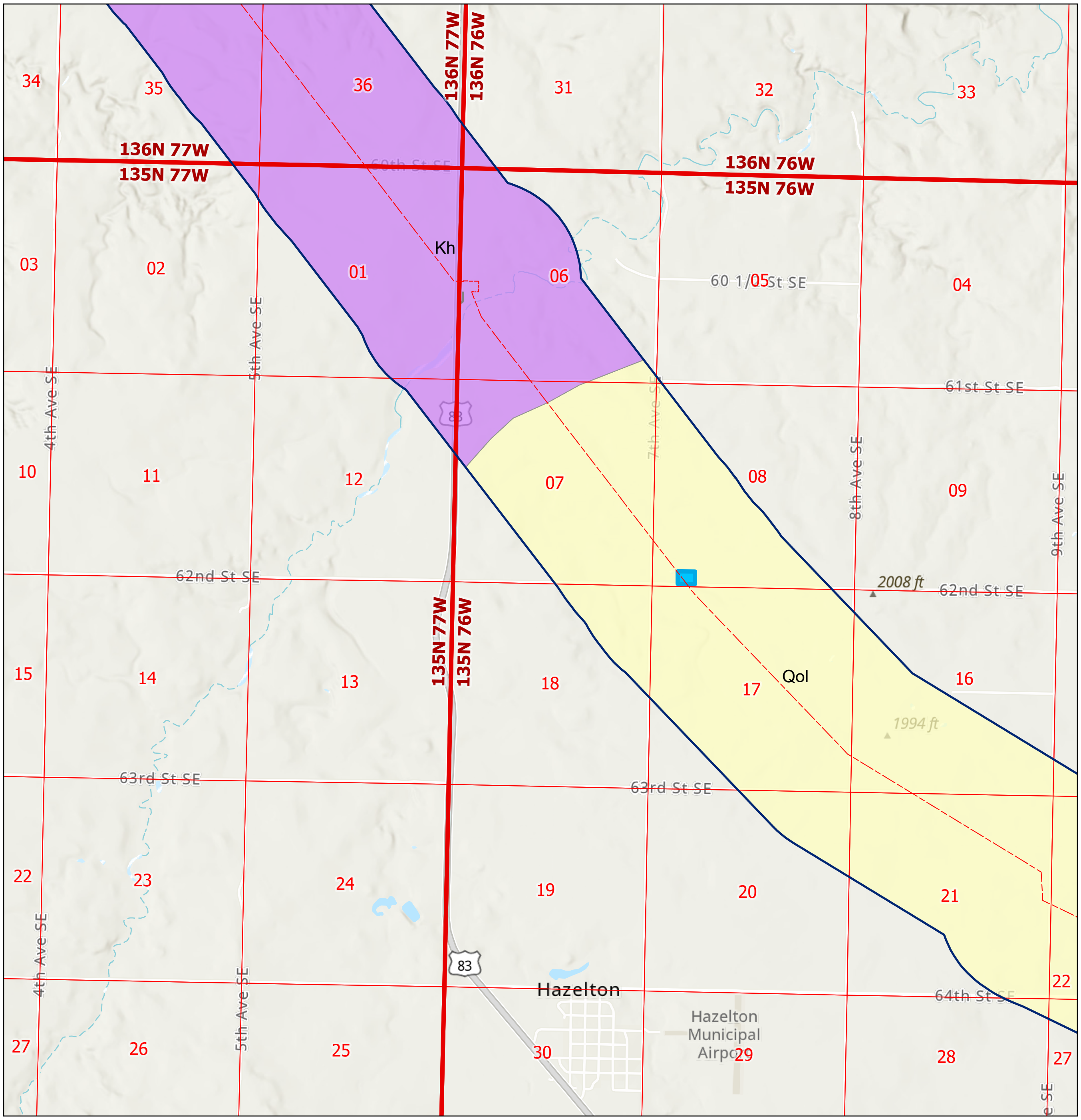

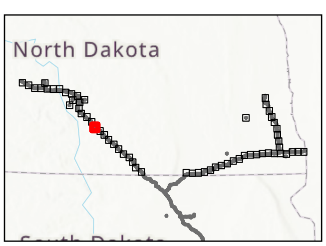

- Centerline Route
- Pipeline Access Road
- Pump Station
- 0.5 mile Buffer
- Township
- Section

Project Geology

- Qol - Windblown Silt (Holocene and Wisconsinan)
- Kh - Hell Creek Formation (Upper Cretaceous)

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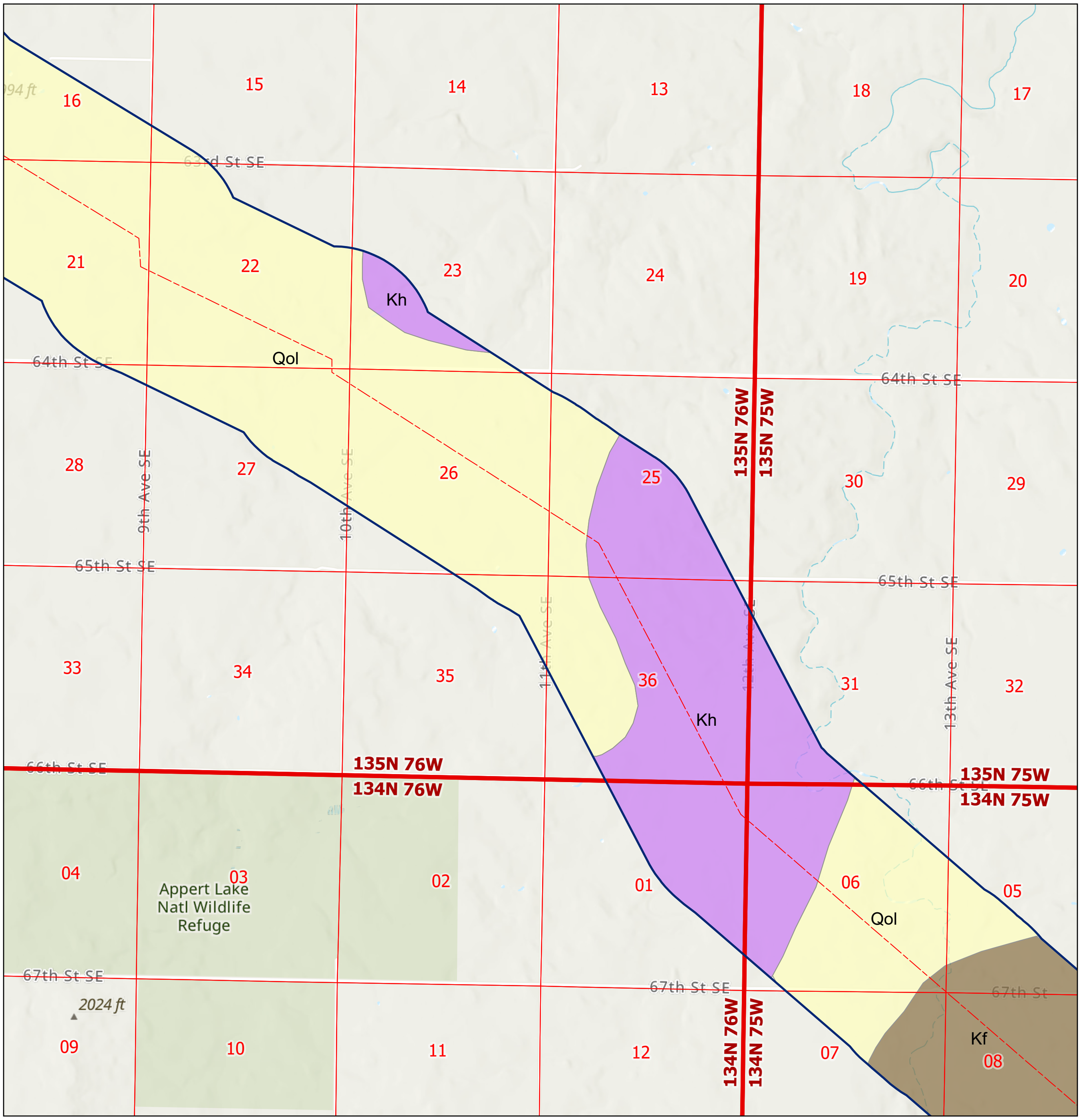

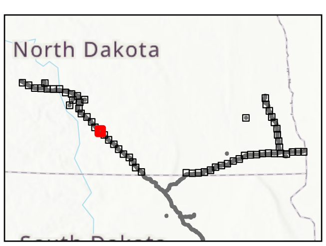

- Centerline Route
- 0.5 mile Buffer
- Township
- Section

Project Geology

- Qol - Windblown Silt (Holocene and Wisconsinan)
- Kh - Hell Creek Formation (Upper Cretaceous)
- Kf - Fox Hills Formation (Upper Cretaceous)

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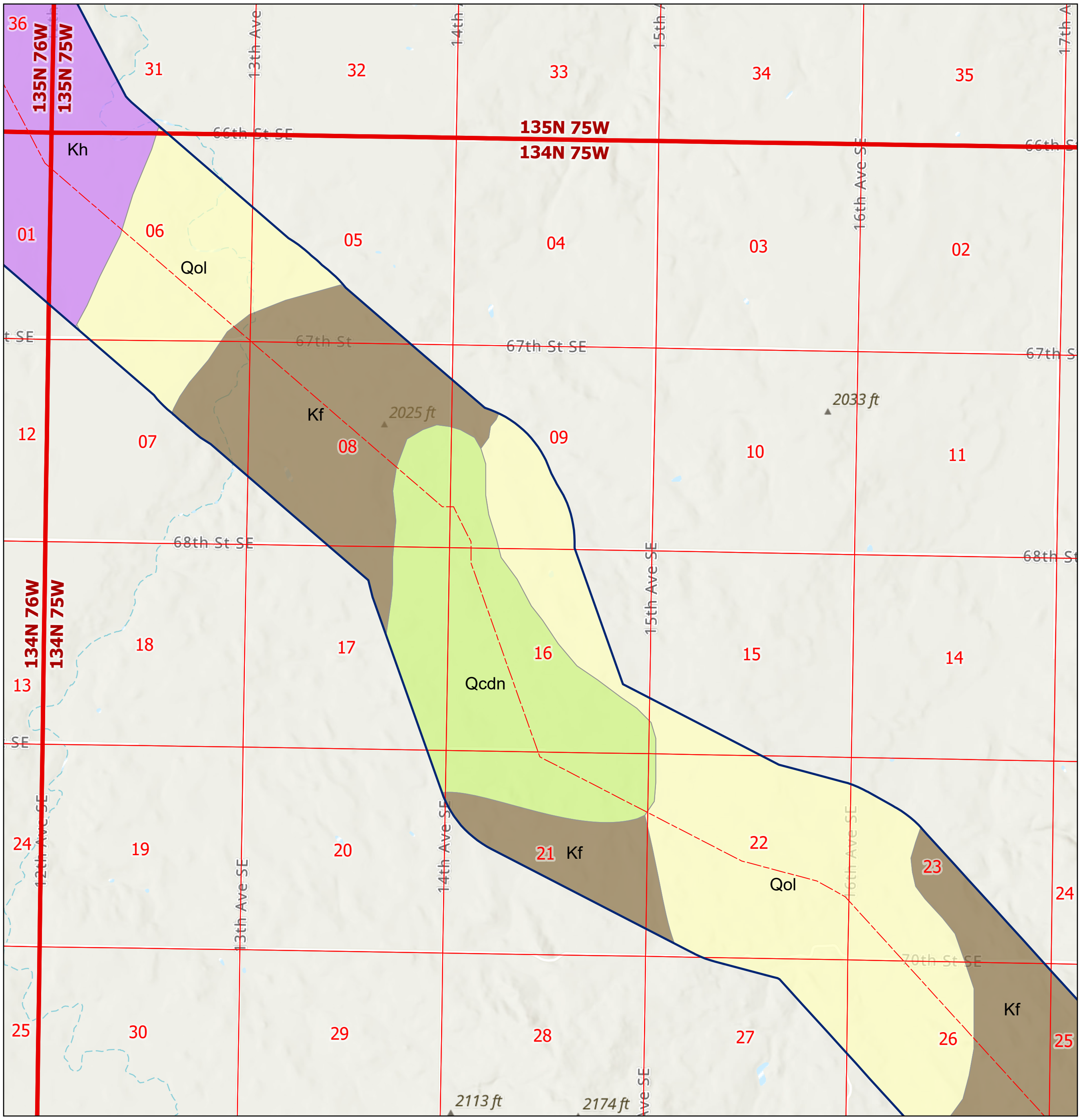

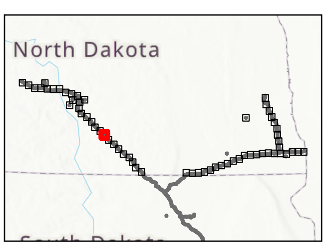

- - - Centerline Route
0.5 mile Buffer
Township
Section

Project Geology

Qol - Windblown Silt (Holocene and Wisconsinan)

Qcdn - Glacial Sediment Draped over Pre-existing Topography (Holocene to Pre-Wisconsinan)

Kh - Hell Creek Formation (Upper Cretaceous)

Kf - Fox Hills Formation (Upper Cretaceous)

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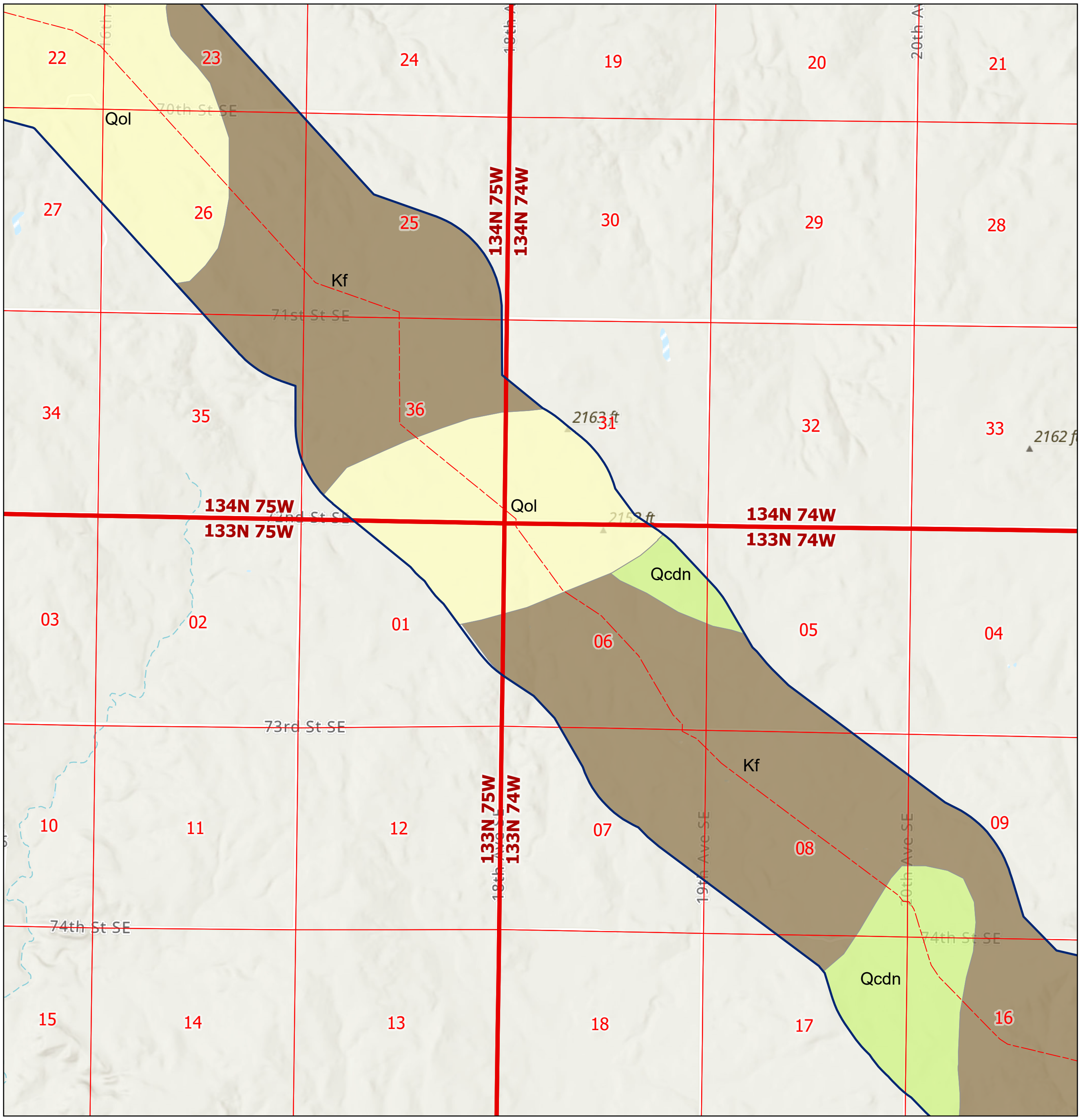

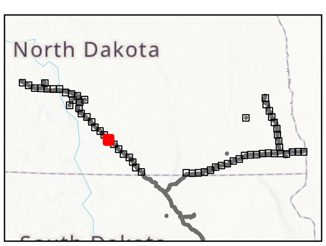

- - - Centerline Route
0.5 mile Buffer
Township
Section

Project Geology

Qol - Windblown Silt (Holocene and Wisconsinan)

Qcdn - Glacial Sediment Draped over Pre-existing Topography (Holocene to Pre-Wisconsinan)

Kf - Fox Hills Formation (Upper Cretaceous)

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Multiple Counties,
Northeast South Dakota

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North Dakota Geology

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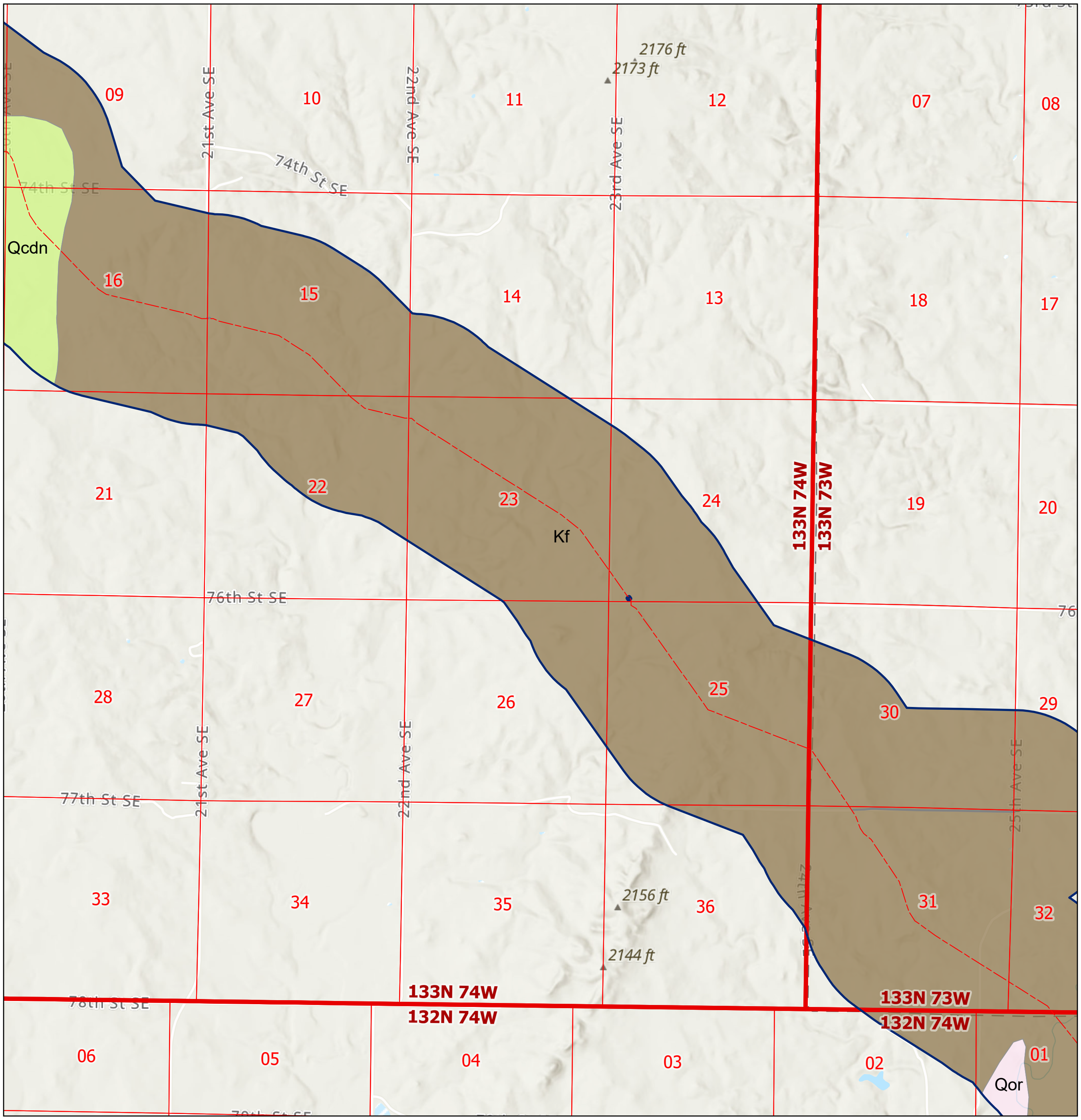

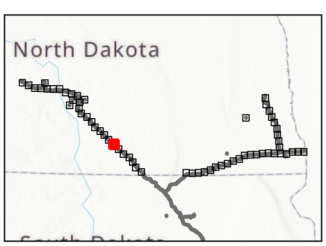

- - - Centerline Route
— Pipeline Access Road
Mainline Valves
0.5 mile Buffer
Township
Section

Project Geology

Qor - River Sediment (Holocene)
Qcdn - Glacial Sediment Draped over Pre-existing Topography (Holocene to Pre-Wisconsinan)
Kf - Fox Hills Formation (Upper Cretaceous)

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Feet
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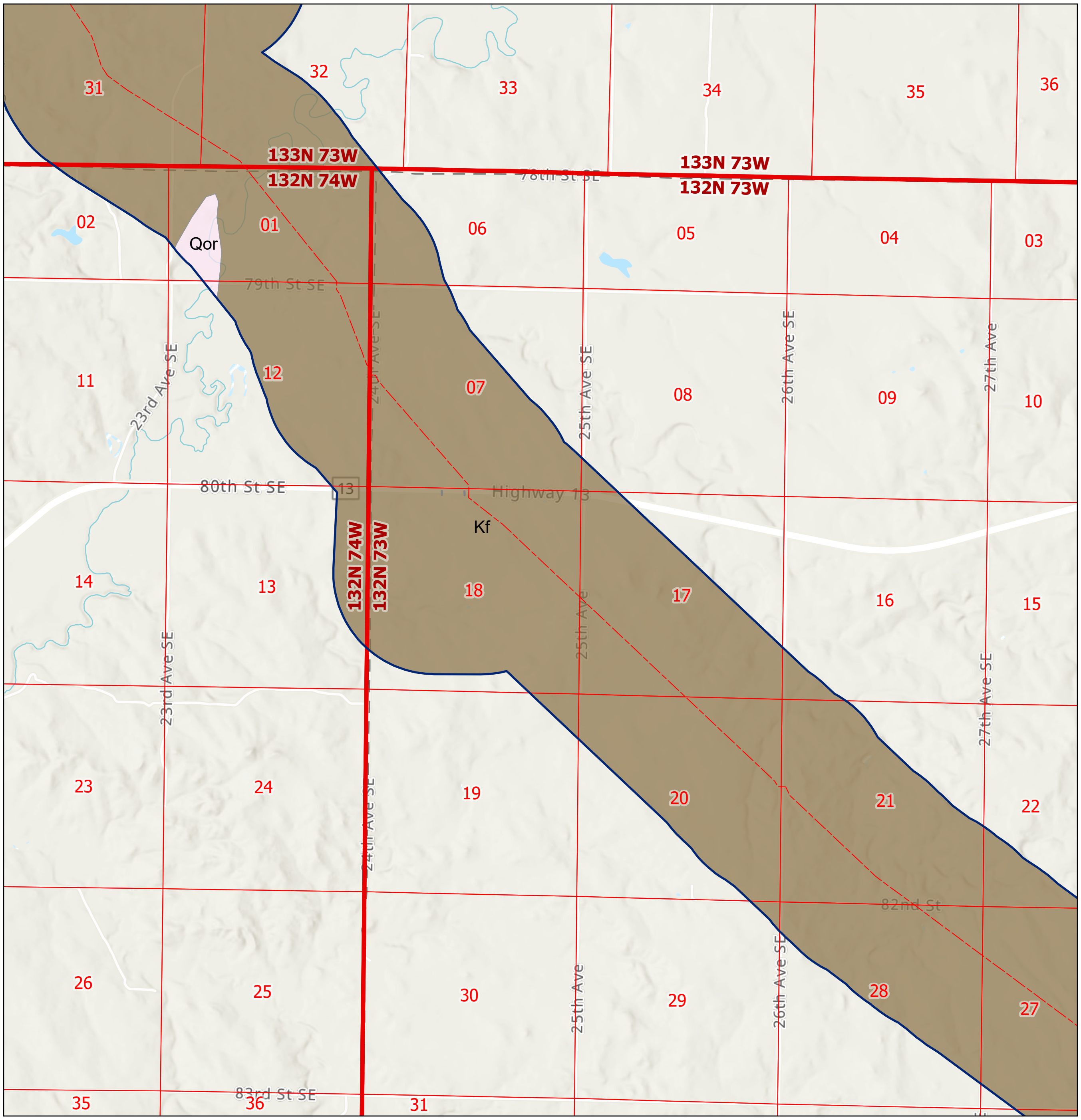

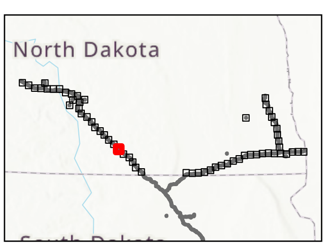

- - - Centerline Route
— Pipeline Access Road
0.5 mile Buffer
Township
Section

Project Geology

Qor - River Sediment (Holocene)

Kf - Fox Hills Formation (Upper Cretaceous)

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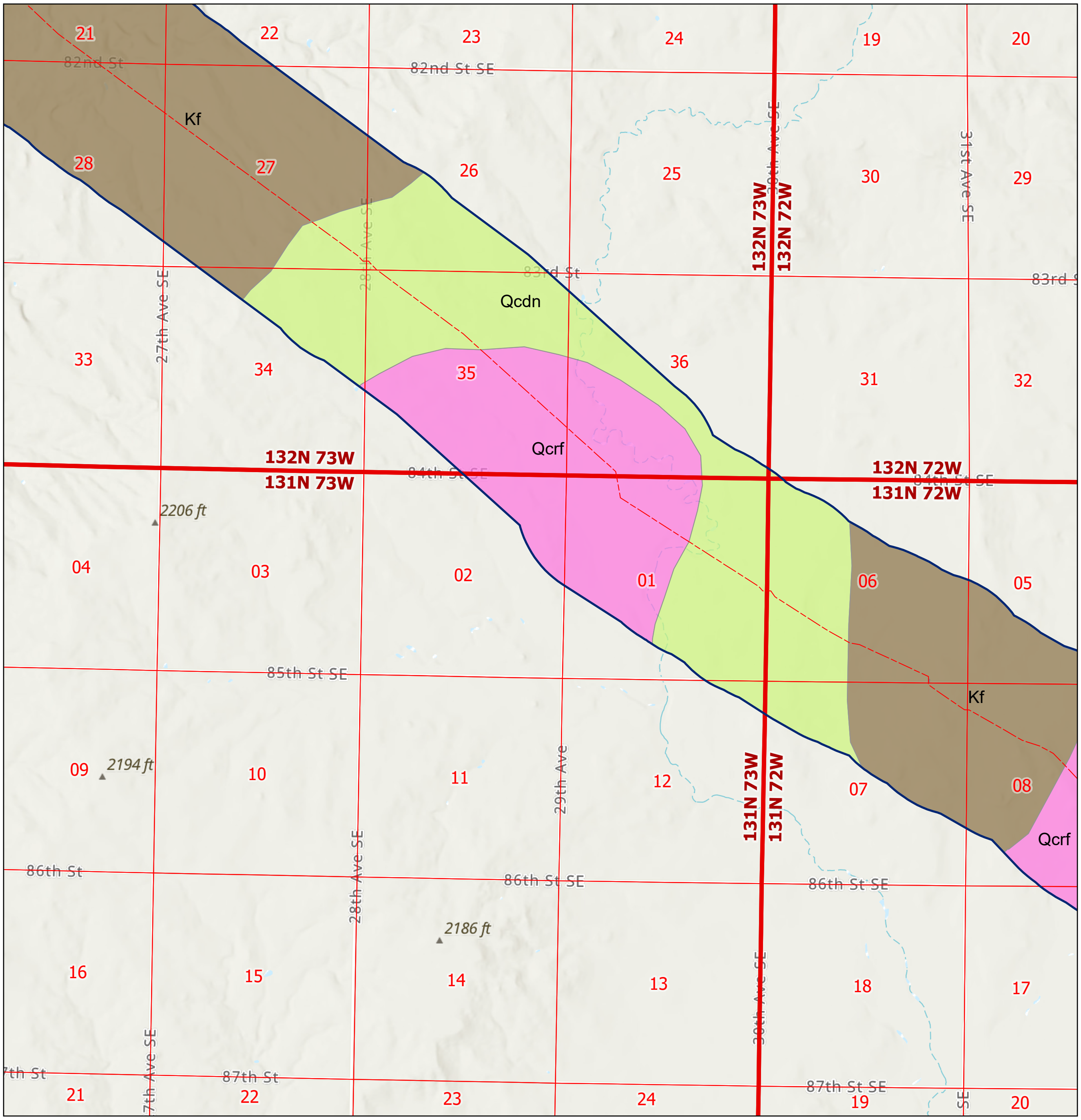

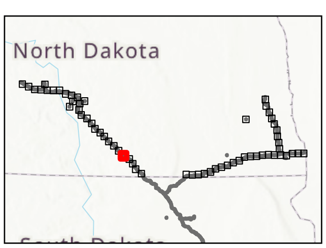

- - - Centerline Route
— Pipeline Access Road
0.5 mile Buffer
Township
Section

Project Geology

Qcrf - Uncollapsed River Sediment (Holocene to Pre-Wisconsinan)

Qcdn - Glacial Sediment Draped over Pre-existing Topography (Holocene to Pre-Wisconsinan)

Kf - Fox Hills Formation (Upper Cretaceous)

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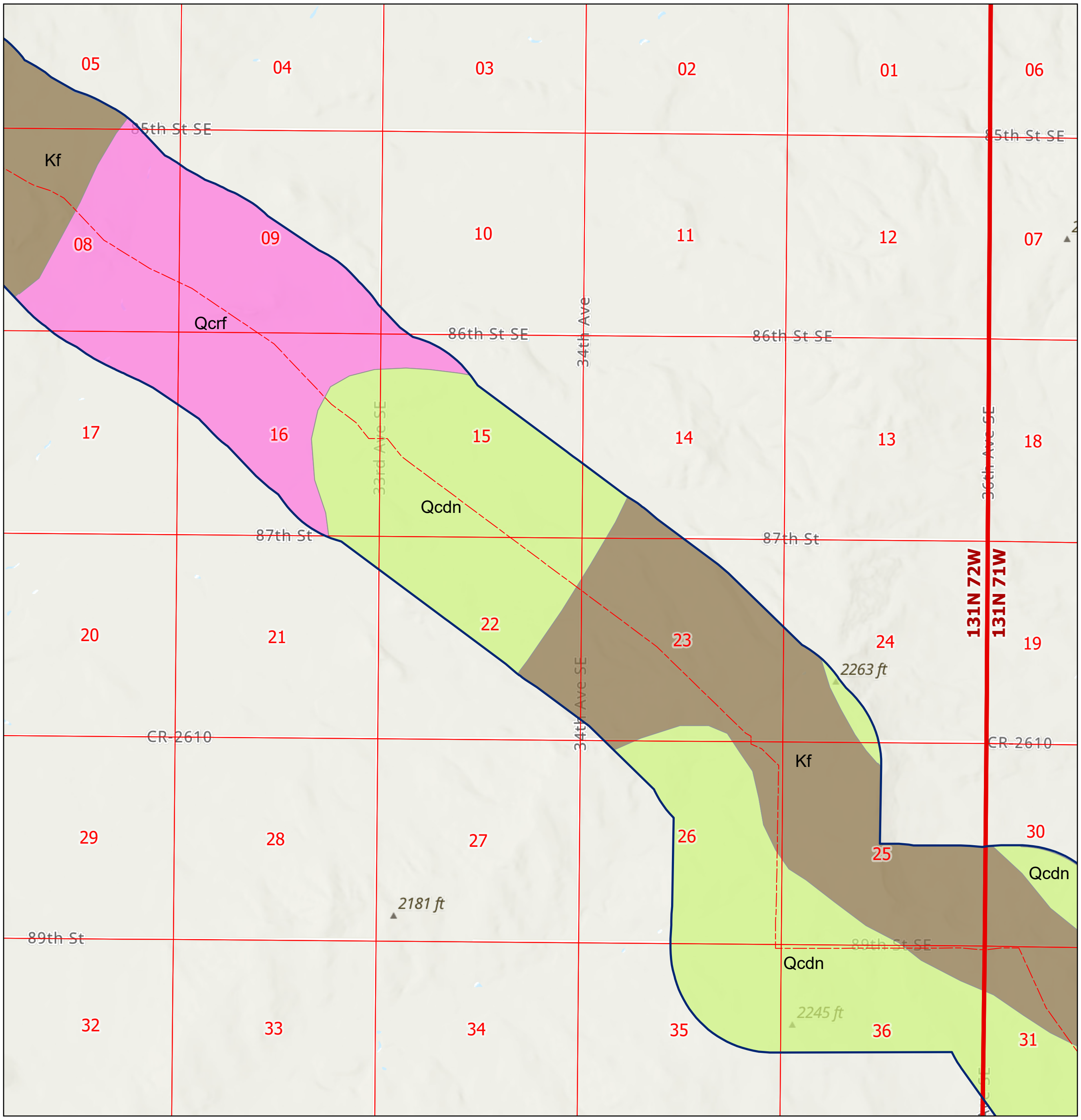

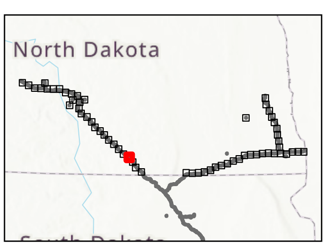

- Centerline Route
- 0.5 mile Buffer
- Township
- Section

Project Geology

- Qcrf - Uncollapsed River Sediment (Holocene to Pre-Wisconsinan)
- Qcdn - Glacial Sediment Draped over Pre-existing Topography (Holocene to Pre-Wisconsinan)
- Kf - Fox Hills Formation (Upper Cretaceous)

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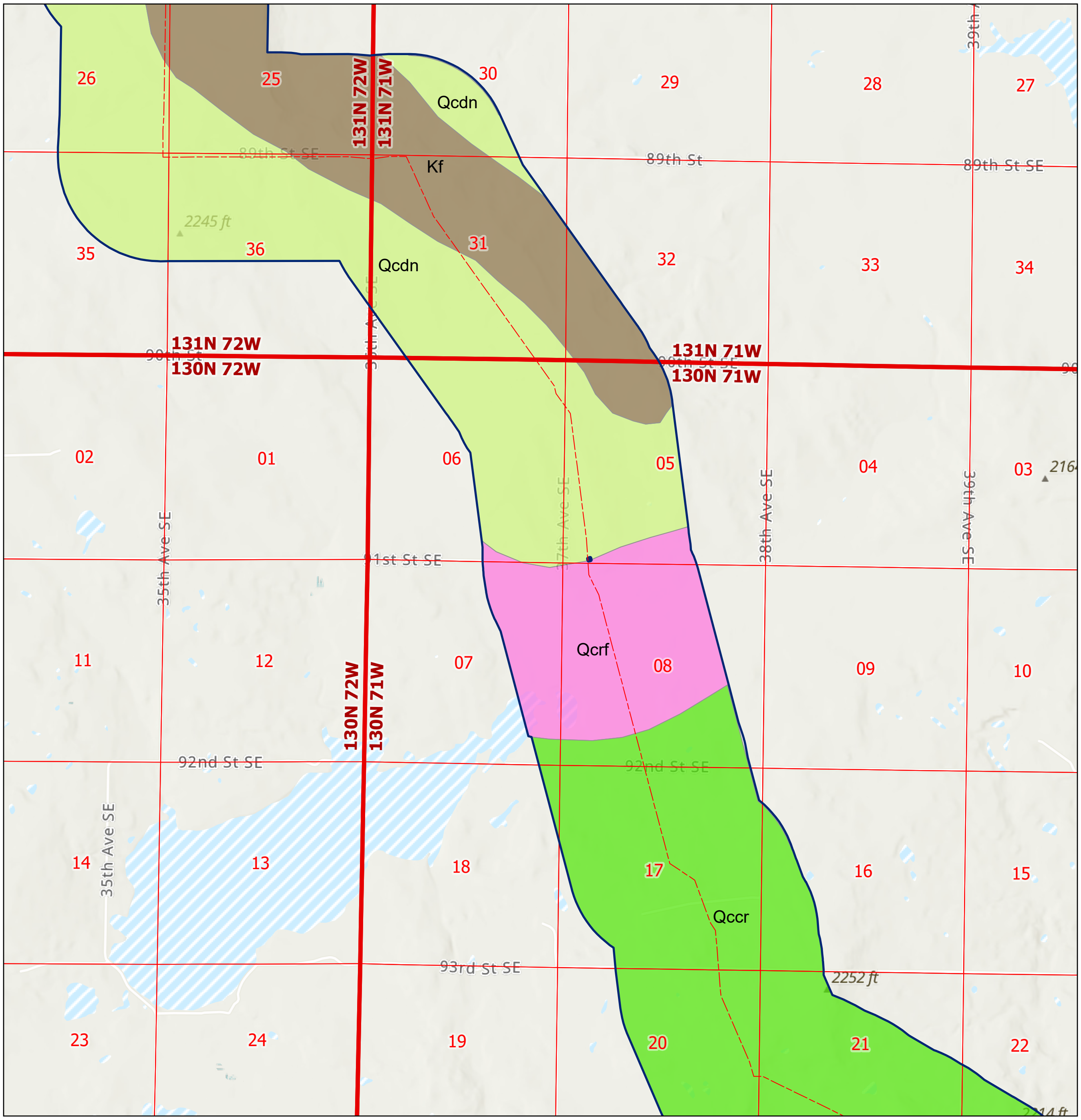

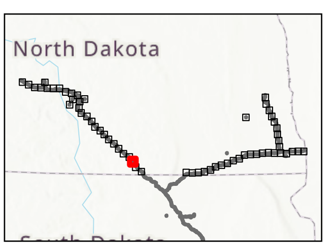

- - - Centerline Route
Mainline Valves
0.5 mile Buffer
Township
Section

Project Geology

Qcrf - Uncollapsed River Sediment (Holocene to Pre-Wisconsinan)
Qccr - Collapsed Glacial Sediment (Holocene to Pre-Wisconsinan)
Qcdn - Glacial Sediment Draped over Pre-existing Topography (Holocene to Pre-Wisconsinan)
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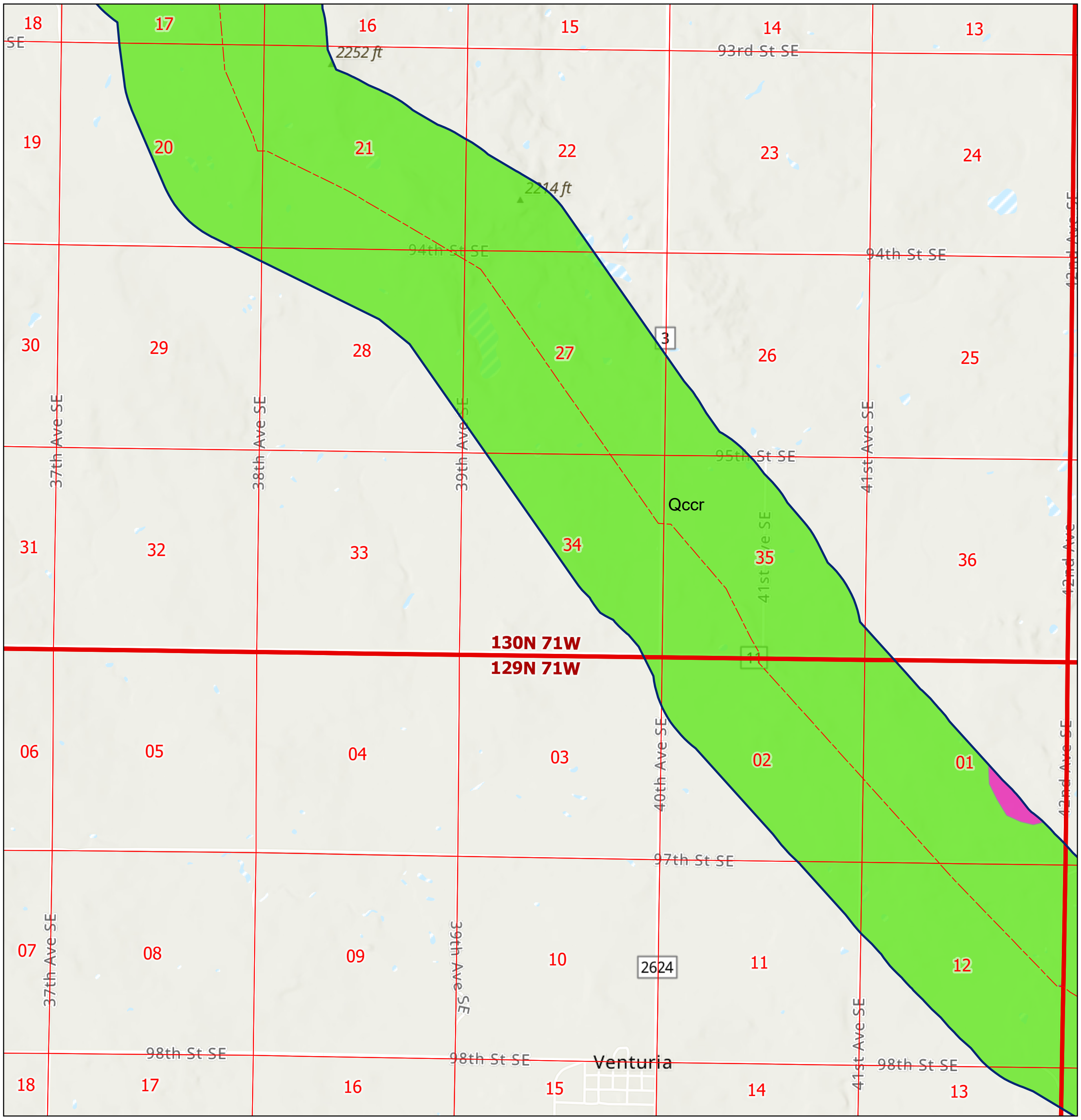

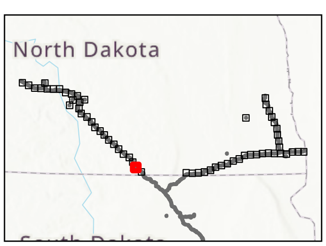

- - - Centerline Route
— Pipeline Access Road
0.5 mile Buffer
Township
Section

Project Geology

Qcrh - Collapsed River Sediment (Holocene to Pre-Wisconsinan)

Qccr - Collapsed Glacial Sediment (Holocene to Pre-Wisconsinan)

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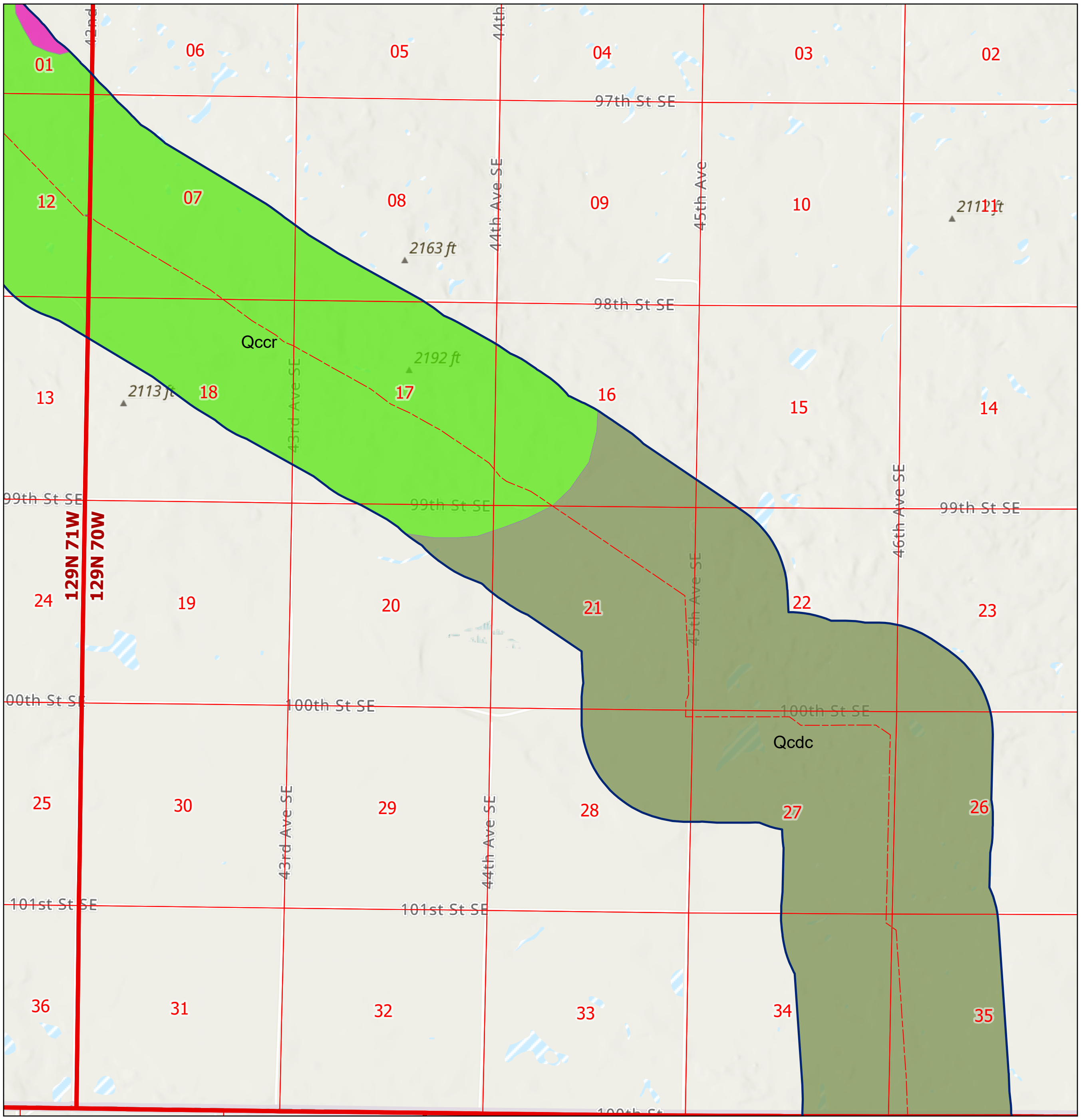

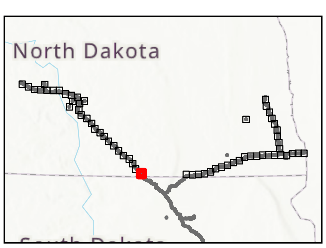

- - - Centerline Route
— Pipeline Access Road
0.5 mile Buffer
Township
Section

Project Geology

Qcrh - Collapsed River Sediment (Holocene to Pre-Wisconsinan)

Qccr - Collapsed Glacial Sediment (Holocene to Pre-Wisconsinan)

Qcdc - Collapsed/Draped Transition Sediments (Holocene to Pre-Wisconsinan)

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Project Location
Multiple Counties,
Northeast South Dakota

Prepared by EB on 2022-09-12
TR by JC on 2022-09-12
IR by PM on 2022-09-12

Client/Project
235100428

EXP Energy Services
Summit Carbon Solutions MCE Project

Figure No.
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Title
North Dakota Geology

Notes
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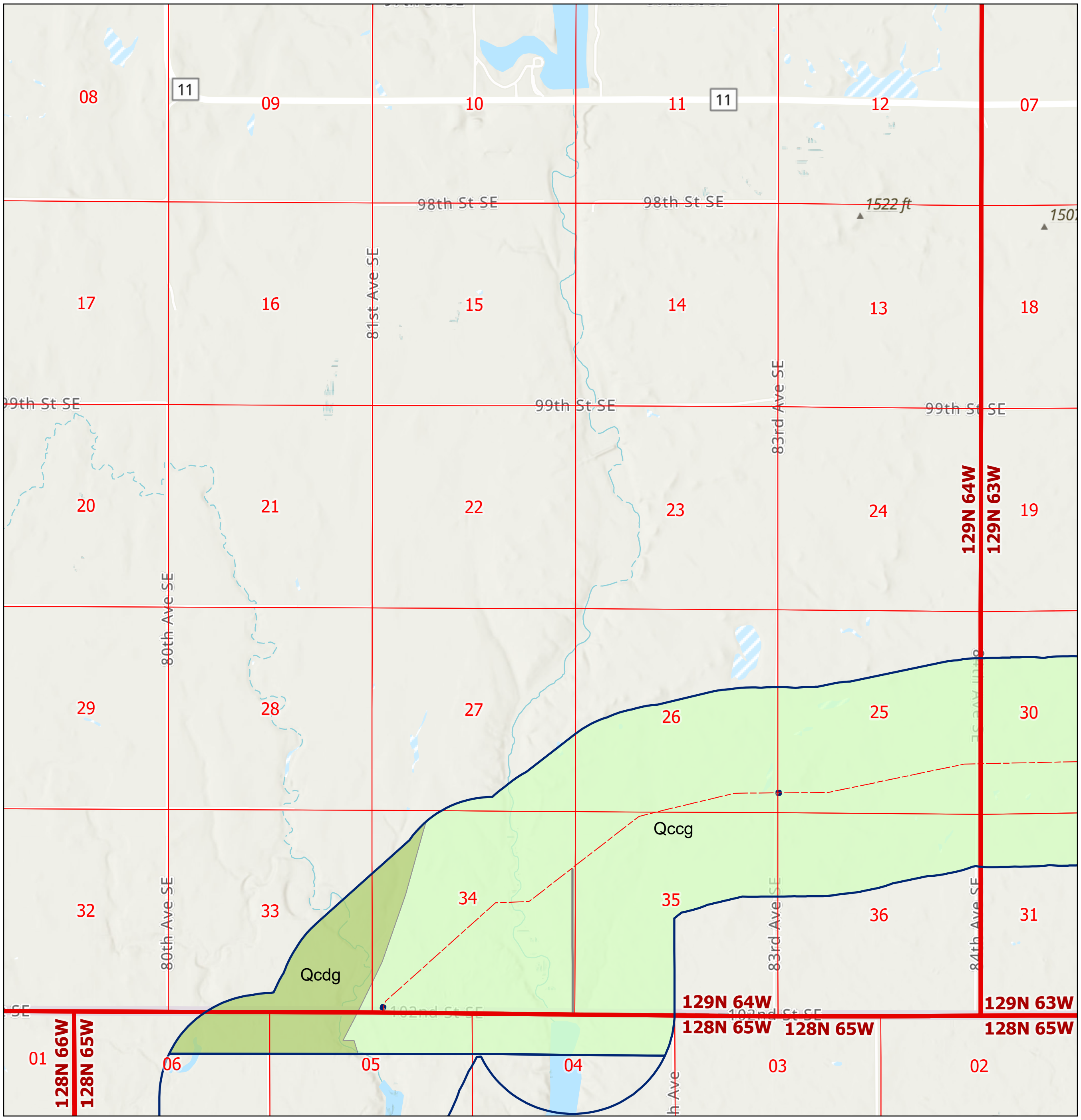

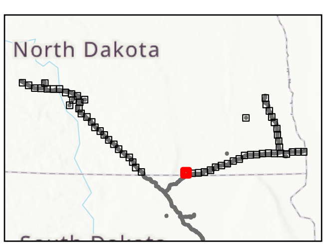

- - - Centerline Route
— Pipeline Access Road
Mainline Valves
0.5 mile Buffer
Township
Section

Project Geology

Qccg - Collapsed Glacial Sediment (Holocene to Pre-Wisconsinan)

Qcdg - Glacial Sediment Draped over Pre-existing Topography (Holocene to Pre-Wisconsinan)

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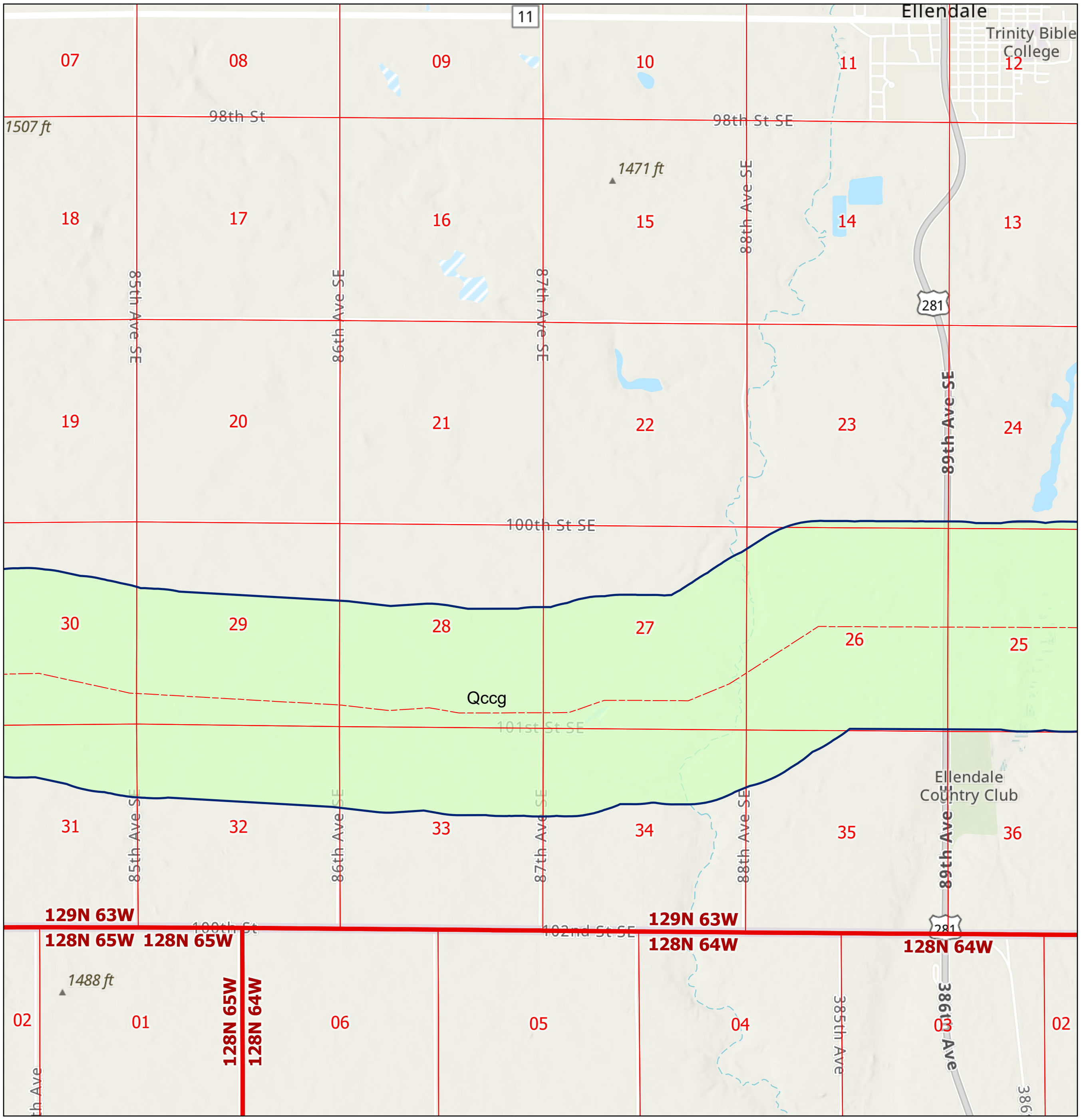

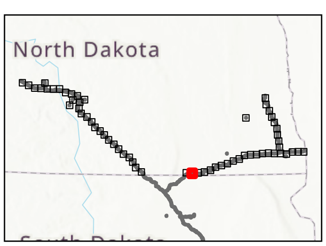

- - - Centerline Route
0.5 mile Buffer
Township
Section

Project Geology

Qccg - Collapsed Glacial Sediment (Holocene to Pre-Wisconsinan)

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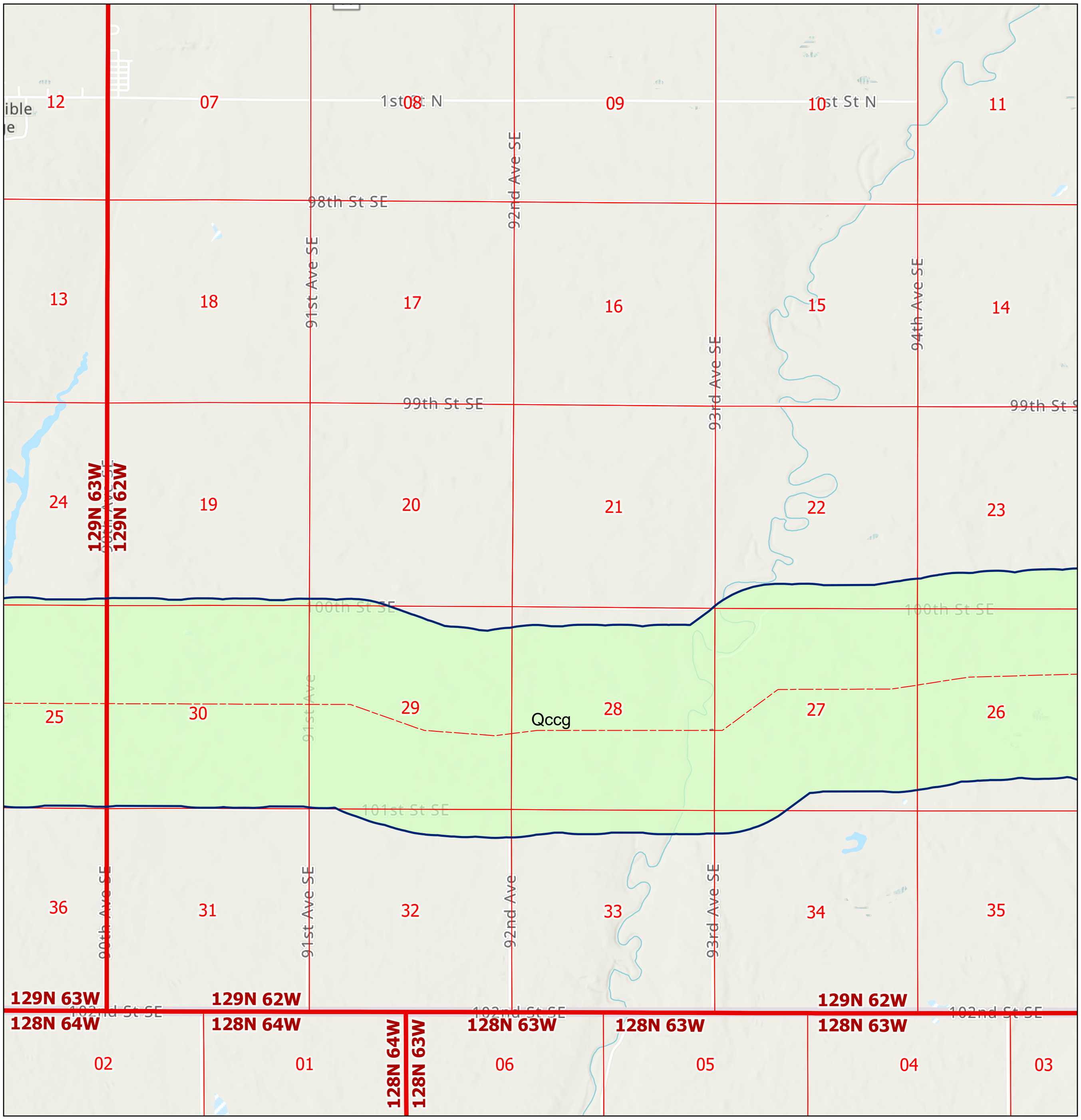

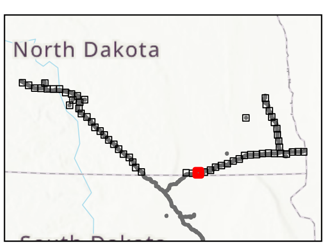

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Project Geology

Qccg - Collapsed Glacial Sediment (Holocene to Pre-Wisconsinan)

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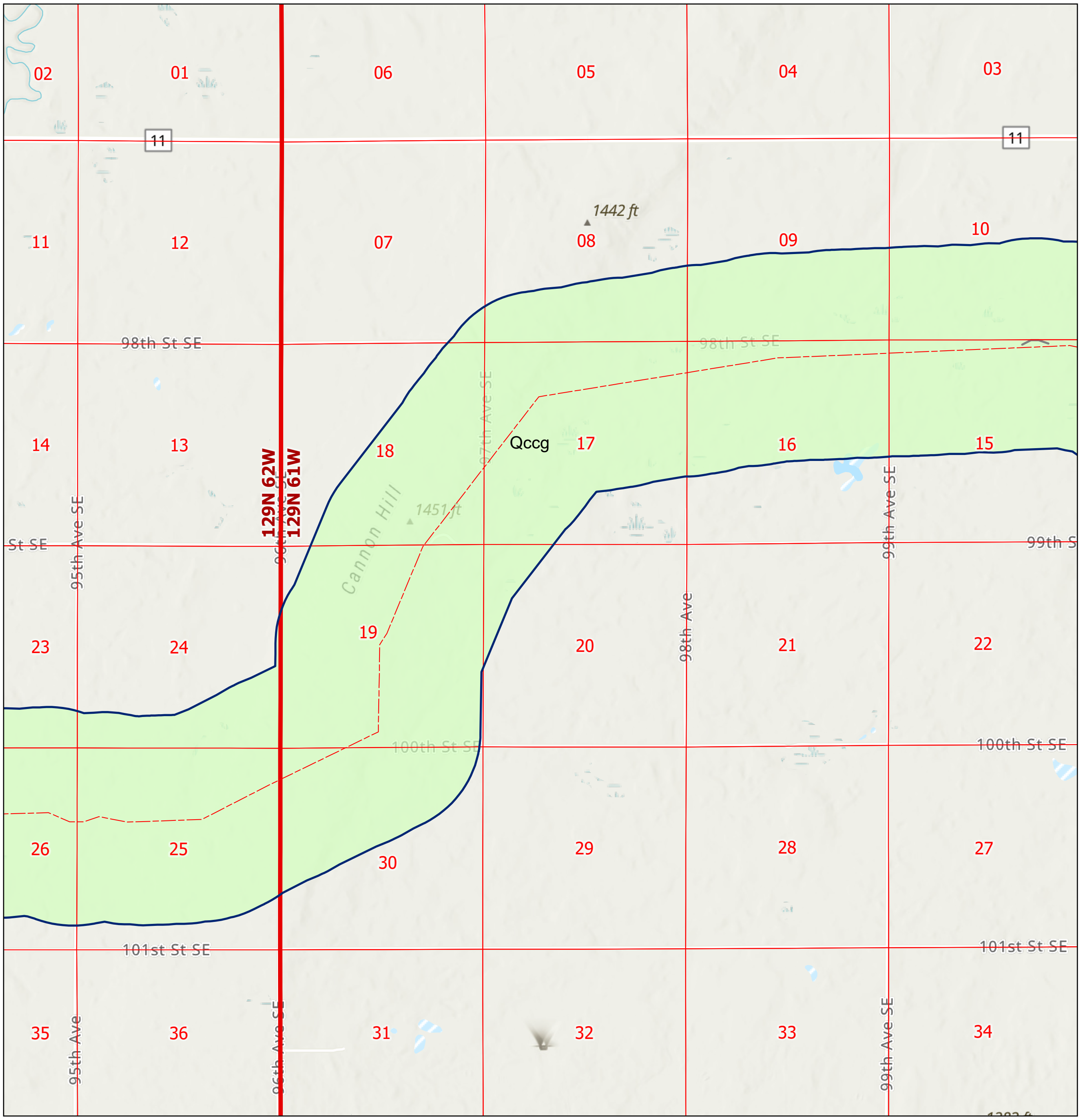

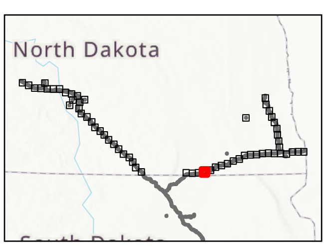

- - - Centerline Route
Pipeline Access Road
0.5 mile Buffer
Township
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Project Geology
Qccg - Collapsed Glacial Sediment (Holocene to Pre-Wisconsinan)

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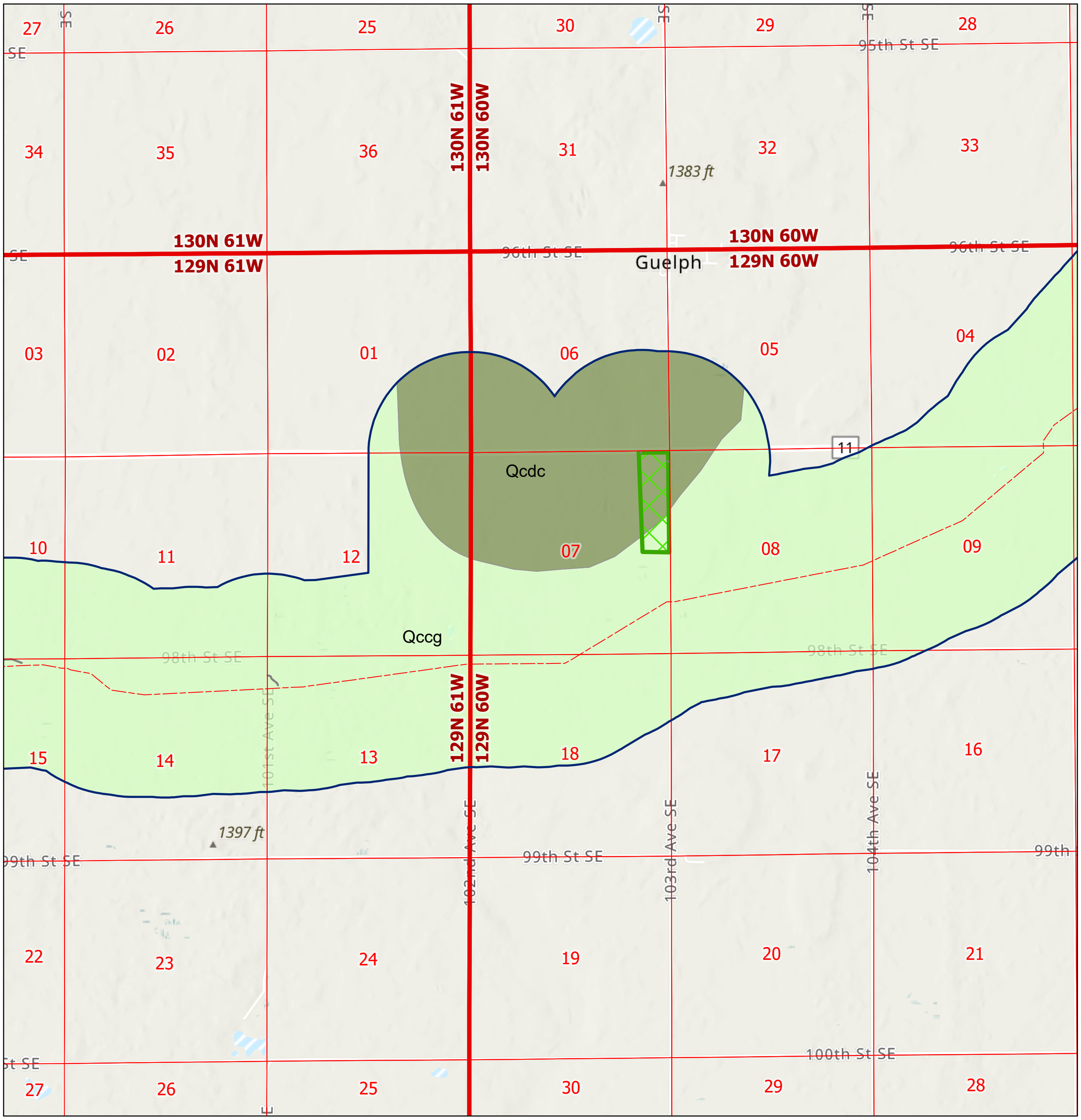

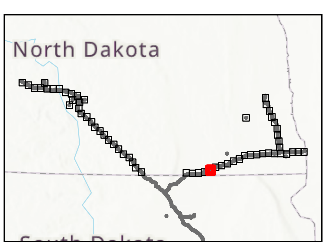

--- Centerline Route
— Pipeline Access Road
Contractor Yards
0.5 mile Buffer
Township
Section

Project Geology

Qccg - Collapsed Glacial Sediment (Holocene to Pre-Wisconsinan)

Qcdc - Collapsed/Draped Transition Sediments (Holocene to Pre-Wisconsinan)

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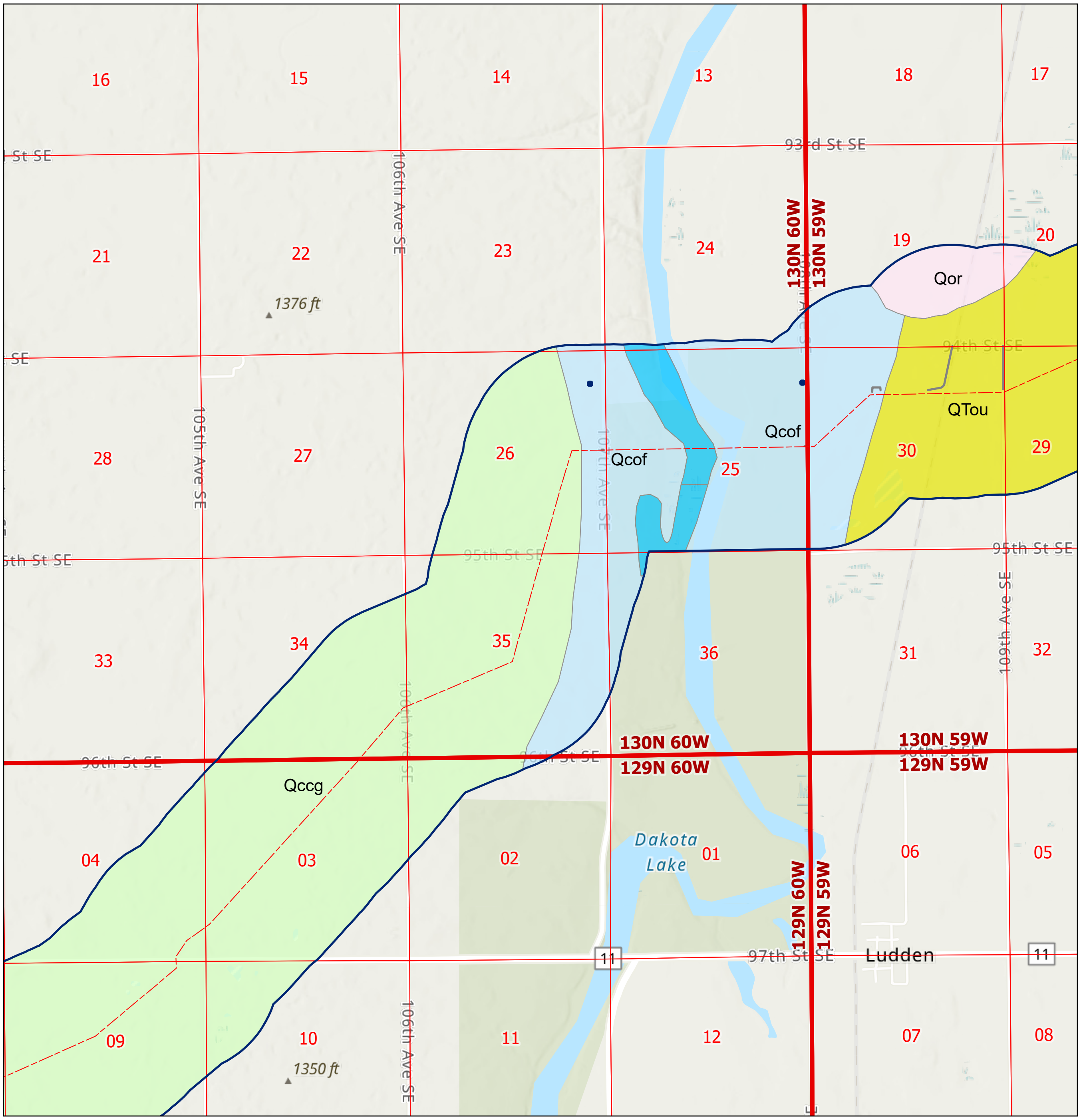

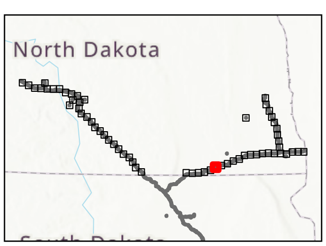

- Centerline Route
- Pipeline Access Road
- Mainline Valves
- 0.5 mile Buffer
- Township
- Section

Project Geology

- Qor - River Sediment (Holocene)
- QTou - Sand of the Oahe and Older Formations, Undivided (Holocene to Pliocene)
- Qcof - Proglacial-Lake Sediment (Holocene to Pre-Wisconsinan)
- Qccg - Collapsed Glacial Sediment (Holocene to Pre-Wisconsinan)

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North Dakota Geology

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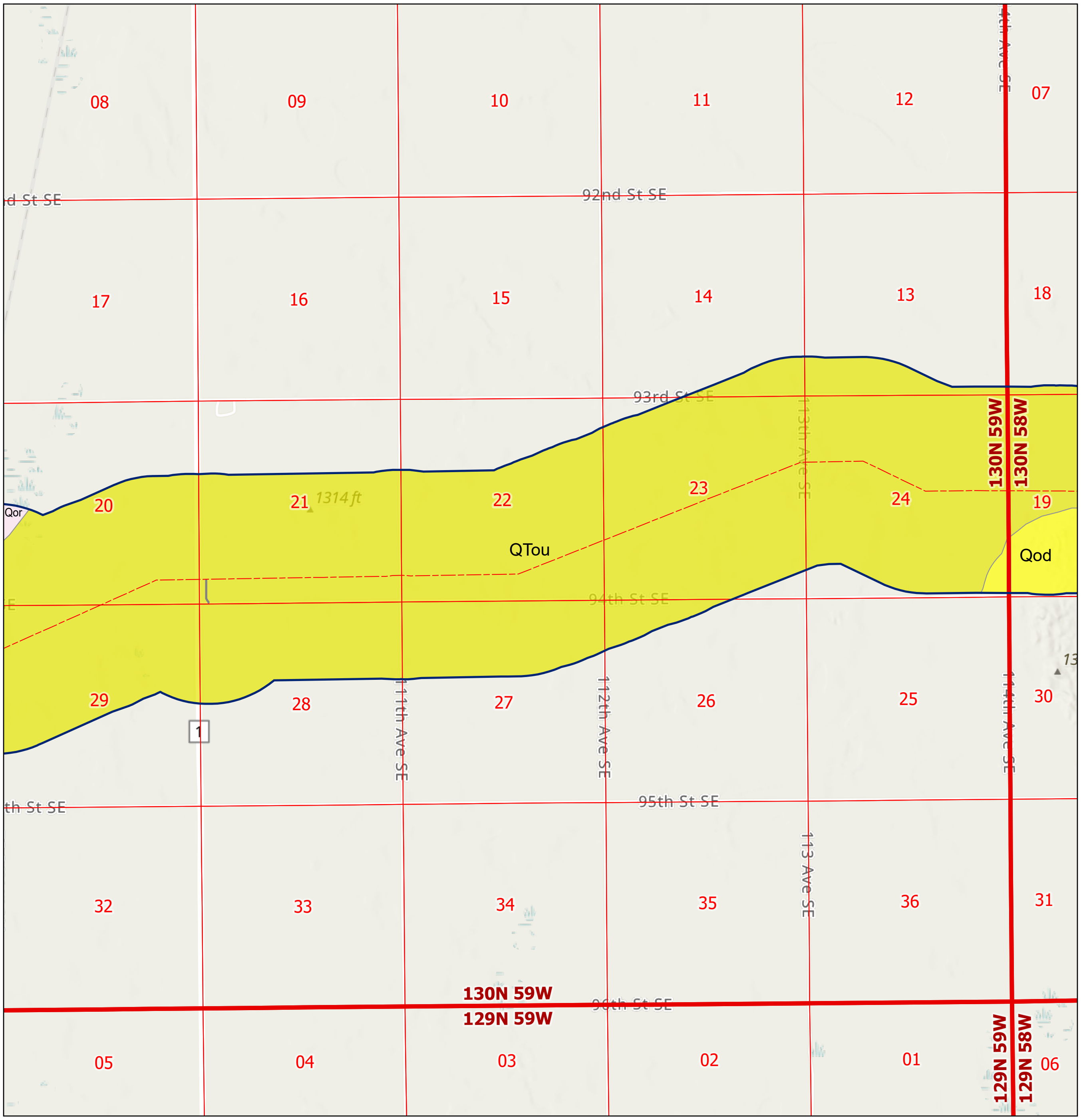

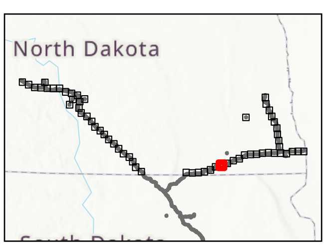

- - - Centerline Route
Pipeline Access Road
0.5 mile Buffer
Township
Section

Project Geology

Qor - River Sediment (Holocene)

Qod - Windblown Sand (Holocene)

QTou - Sand of the Oahe and Older Formations, Undivided (Holocene to Pliocene)

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Project Location
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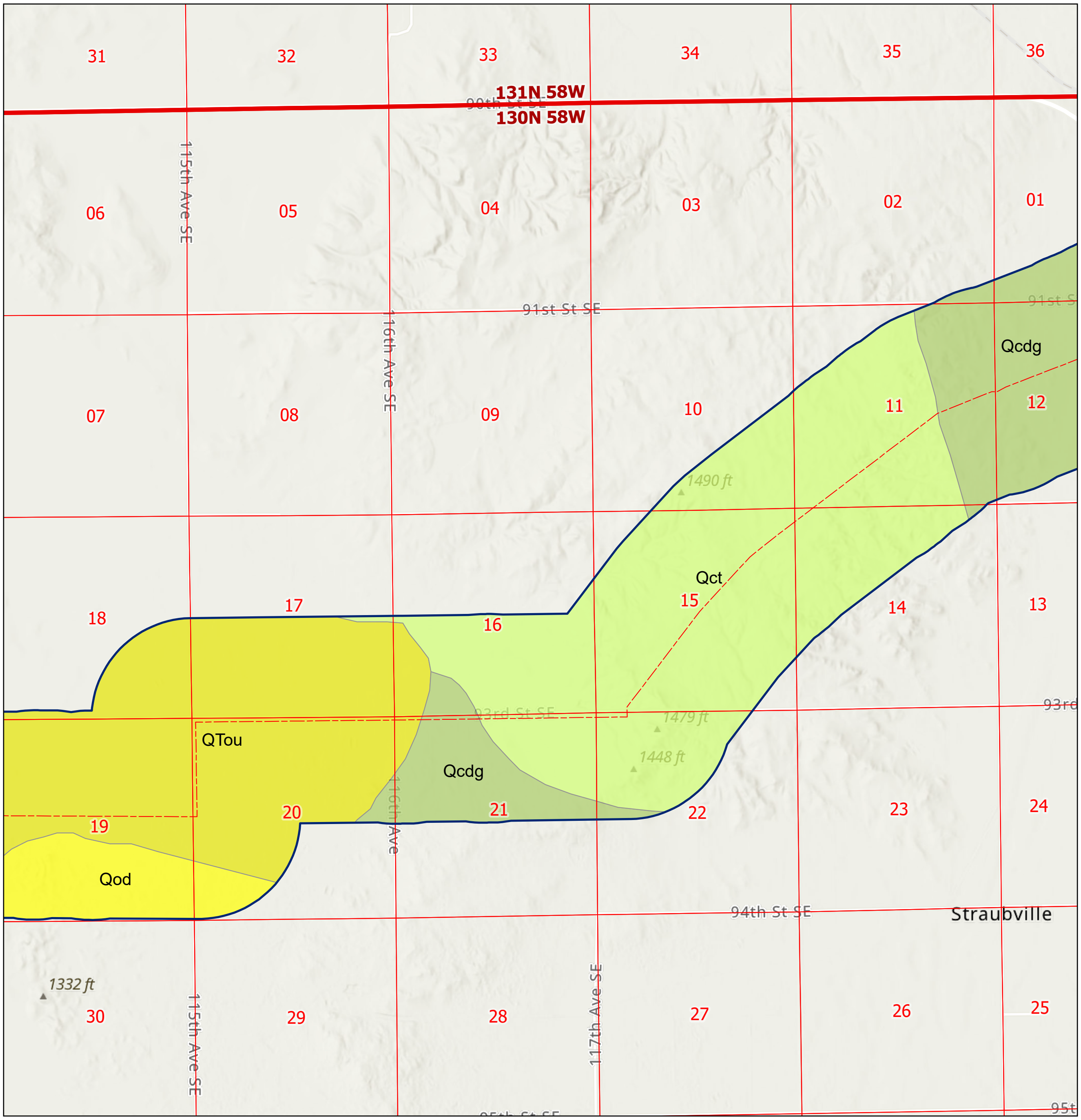

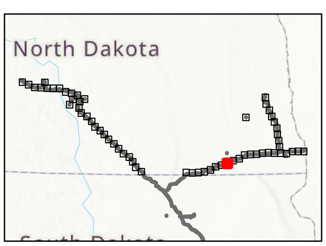

- - - Centerline Route
0.5 mile Buffer
Township
Section

Project Geology

Qod - Windblown Sand (Holocene)

QTou - Sand of the Oahe and Older Formations, Undivided (Holocene to Pliocene)

Qcdg - Glacial Sediment Draped over Pre-existing Topography (Holocene to Pre-Wisconsinan)

Qct - Glacial Sediment on Thrust Masses (Holocene to Pre-Wisconsinan)

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Project Location
Multiple Counties,
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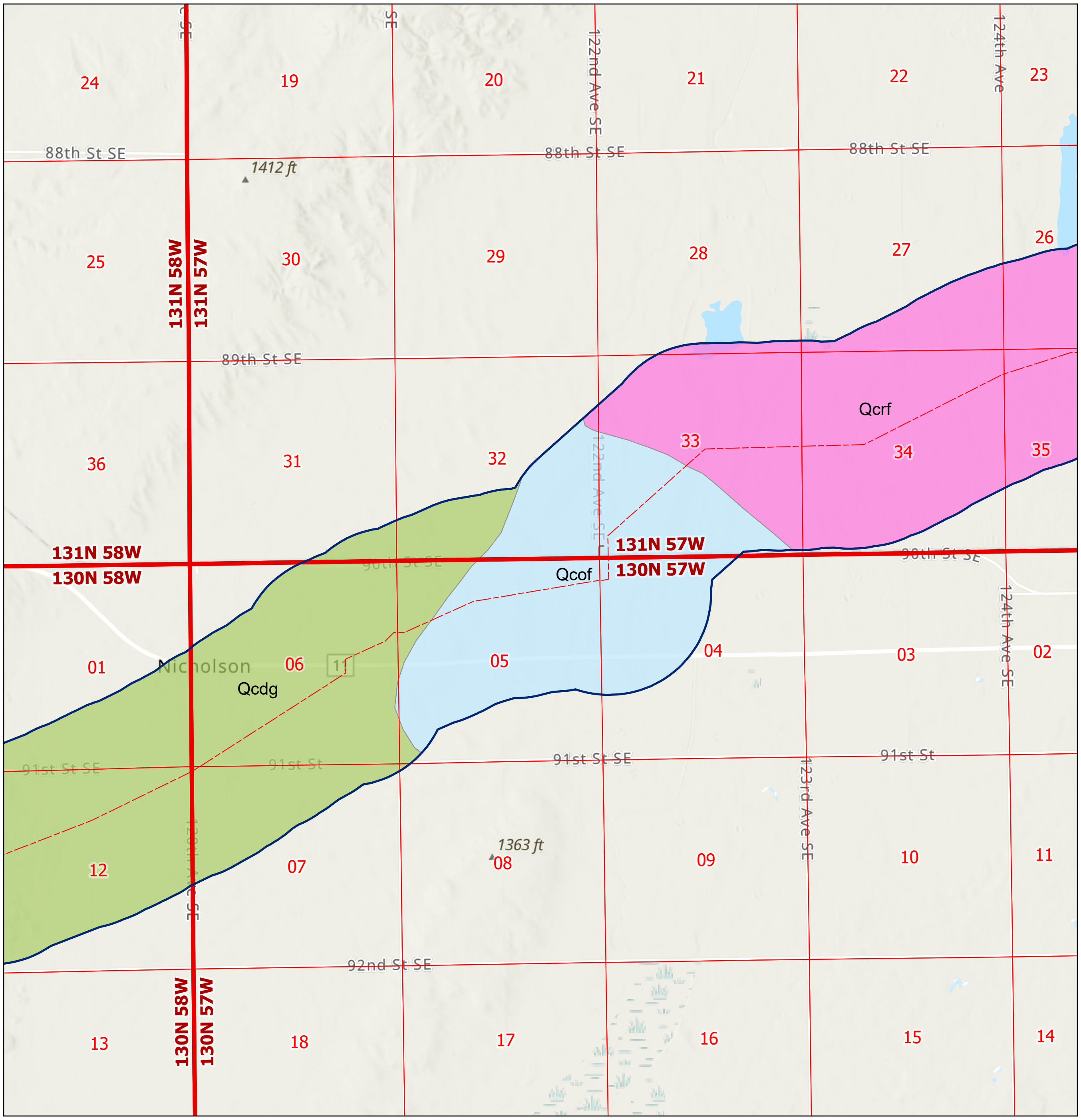

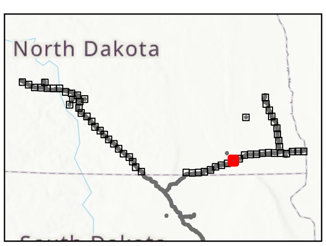

- - - Centerline Route
— Pipeline Access Road
0.5 mile Buffer
Township
Section

Project Geology

Qcof - Proglacial-Lake Sediment (Holocene to Pre-Wisconsinan)

Qcrf - Uncollapsed River Sediment (Holocene to Pre-Wisconsinan)

Qcdg - Glacial Sediment Draped over Pre-existing Topography (Holocene to Pre-Wisconsinan)

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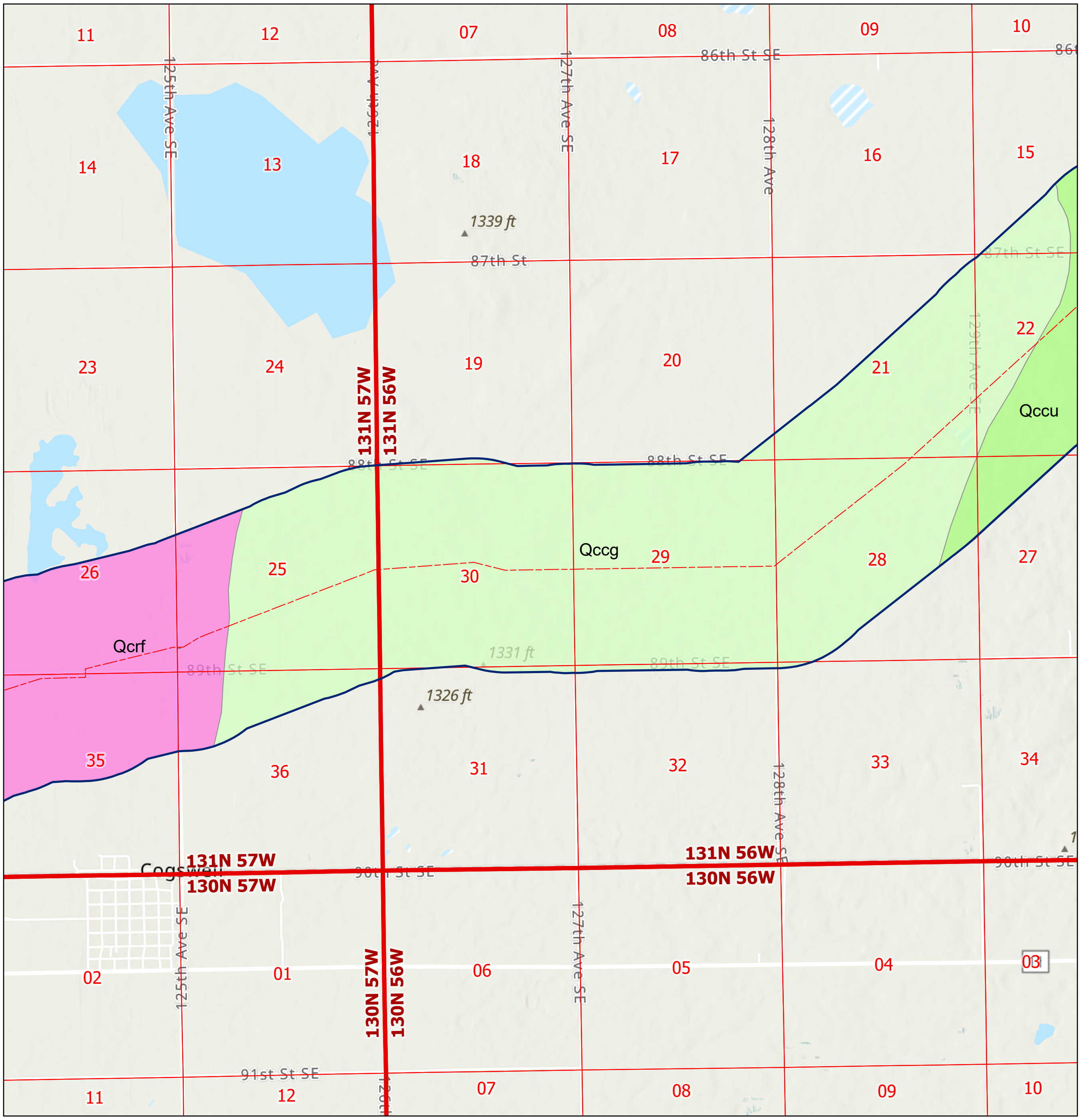

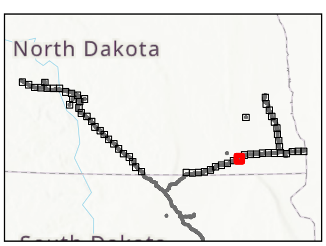

- - - Centerline Route
— Pipeline Access Road
0.5 mile Buffer
Township
Section

Project Geology

Qcrf - Uncollapsed River Sediment (Holocene to Pre-Wisconsinan)

Qccg - Collapsed Glacial Sediment (Holocene to Pre-Wisconsinan)

Qccu - Collapsed Glacial Sediment (Holocene to Pre-Wisconsinan)

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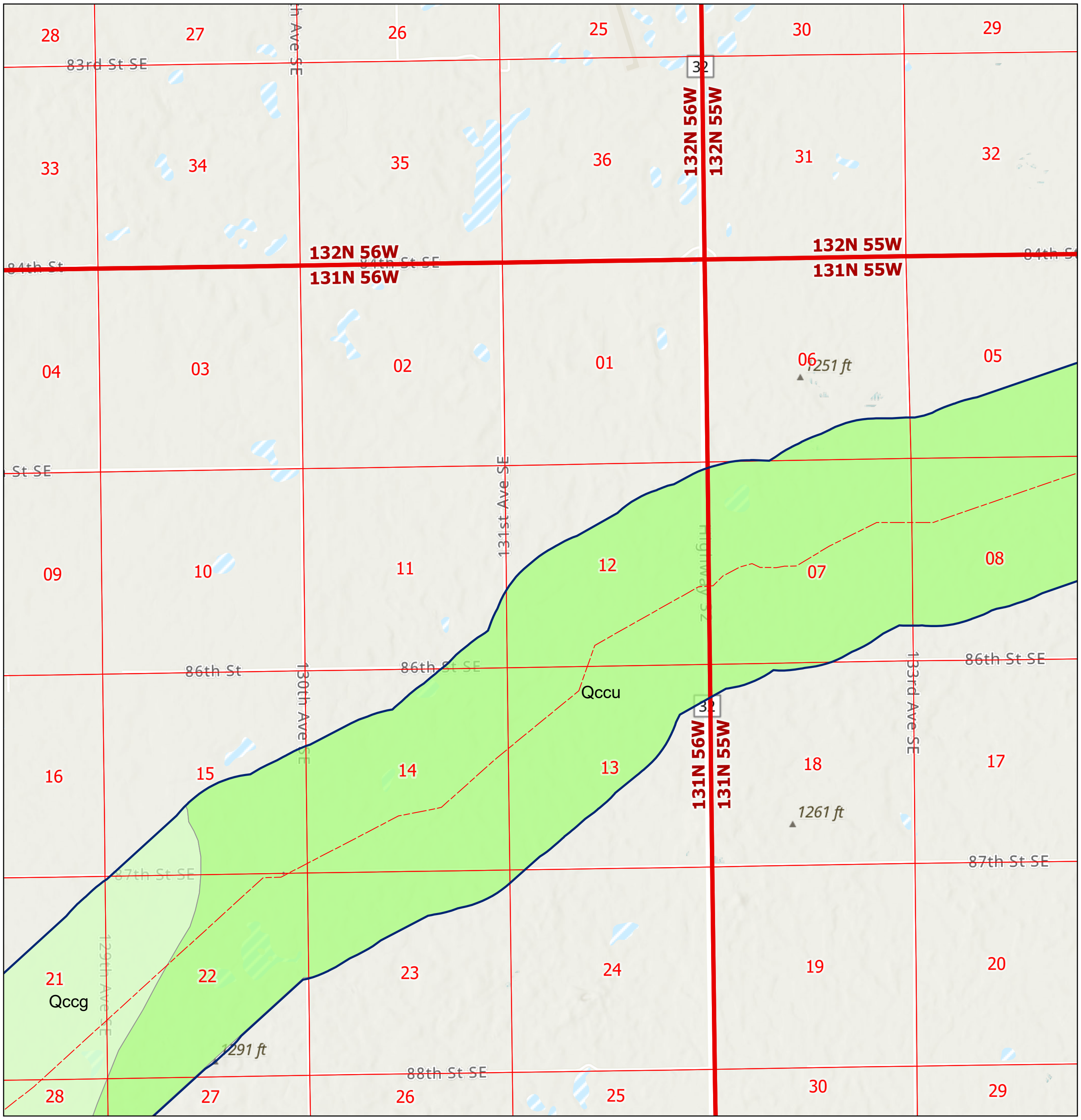

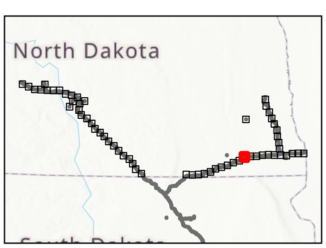

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Township
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Project Geology

Qccg - Collapsed Glacial Sediment (Holocene to Pre-Wisconsinan)

Qccu - Collapsed Glacial Sediment (Holocene to Pre-Wisconsinan)

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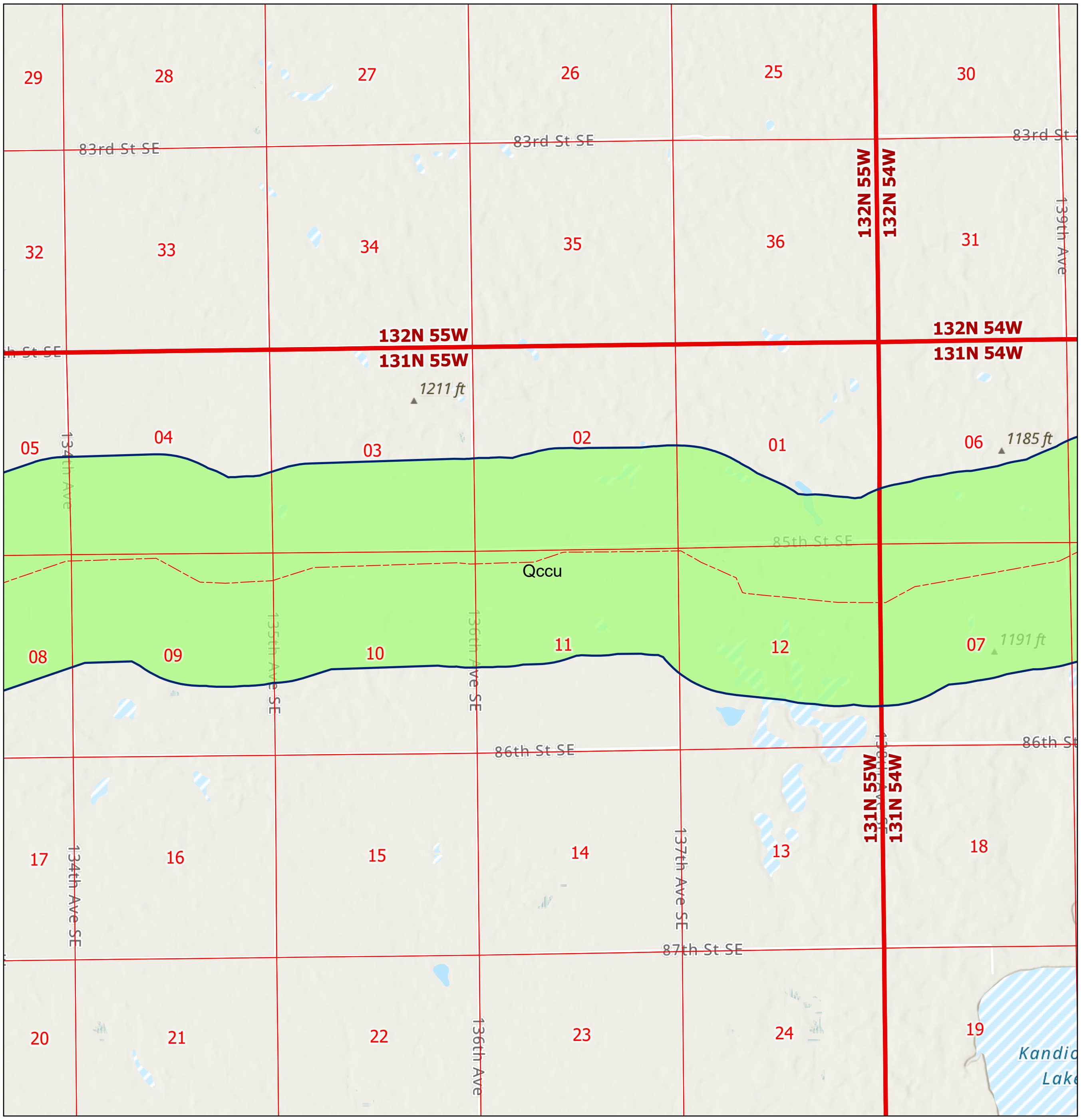

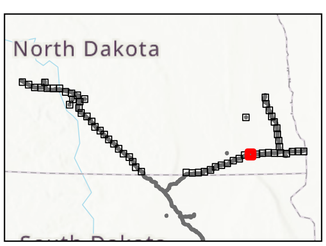

- - - Centerline Route
0.5 mile Buffer
Township
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Project Geology

Qccu - Collapsed Glacial Sediment (Holocene to Pre-Wisconsinan)

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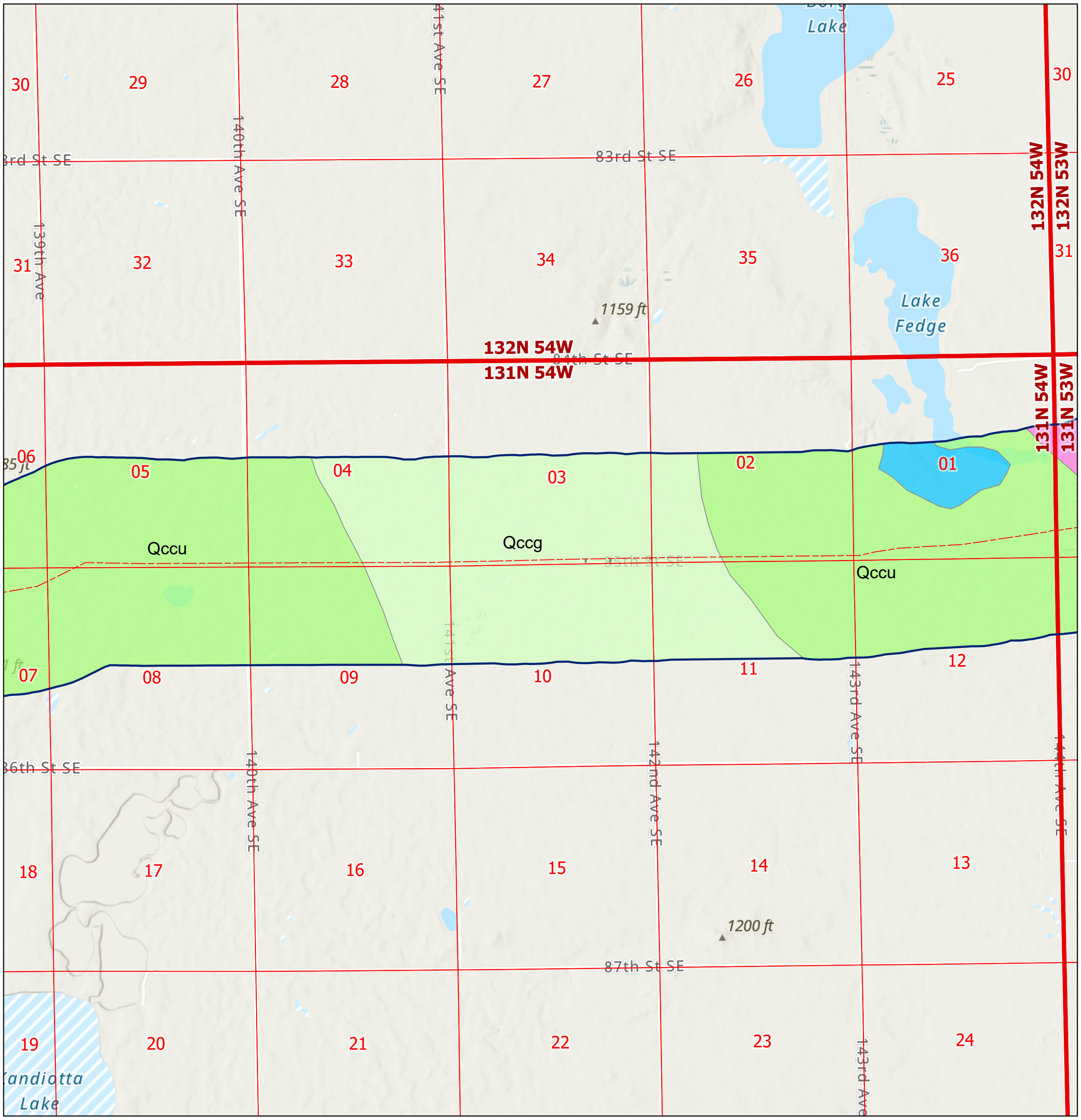

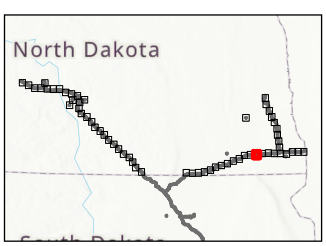

- - - Centerline Route
— Pipeline Access Road
0.5 mile Buffer
Township
Section

Project Geology

- Qcrf - Uncollapsed River Sediment (Holocene to Pre-Wisconsinan)
- Qccg - Collapsed Glacial Sediment (Holocene to Pre-Wisconsinan)
- Qccu - Collapsed Glacial Sediment (Holocene to Pre-Wisconsinan)
- surface water

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EXP Energy Services
Summit Carbon Solutions MCE Project

Figure No.
1

Title
North Dakota Geology

Notes
1. Coordinate System: NAD 1983 UTM Zone 14N
2. Data Sources: Stantec 2021. Geologic Map of North Dakota, Clayton et. al., 1980.
3. Background: State of North Dakota, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, Esri, NASA, NGA, USGS, Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, Esri, USGS

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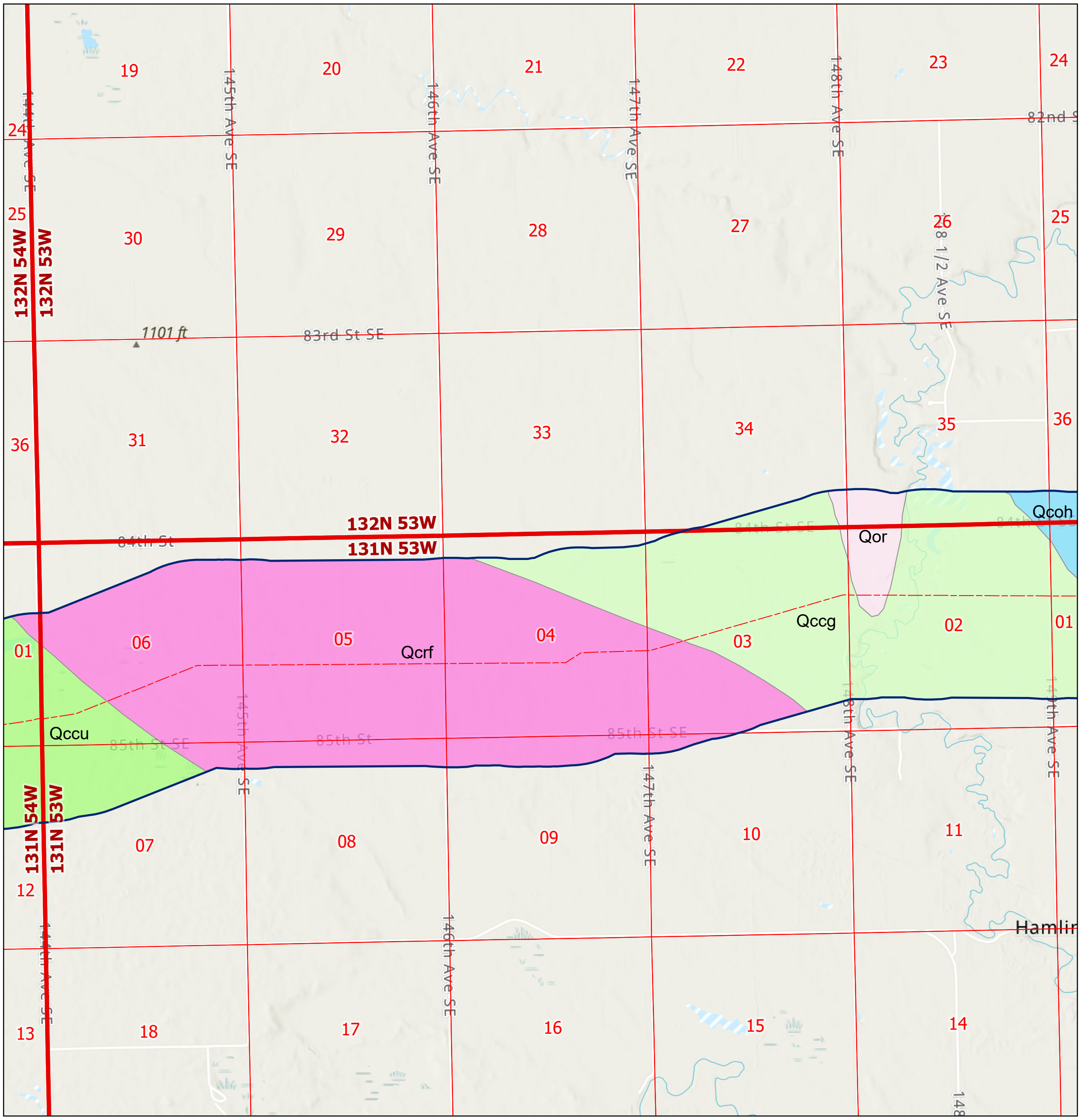

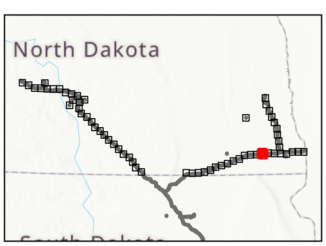

- Centerline Route
- 0.5 mile Buffer
- Township
- Section

Project Geology

- Qor - River Sediment (Holocene)
- Qcoh - Ice-Walled-Lake Sediment or Collapsed Supra-Glacial-Lake Sediment (Holocene to Pre-Wisconsinan)
- Qcrf - Uncollapsed River Sediment (Holocene to Pre-Wisconsinan)
- Qccg - Collapsed Glacial Sediment (Holocene to Pre-Wisconsinan)

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Stantec

Project Location
Multiple Counties,
Northeast South Dakota

Prepared by EB on 2022-09-12
TR by JC on 2022-09-12
IR by PM on 2022-09-12

Client/Project
235100428

EXP Energy Services
Summit Carbon Solutions MCE Project

Figure No.
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North Dakota Geology

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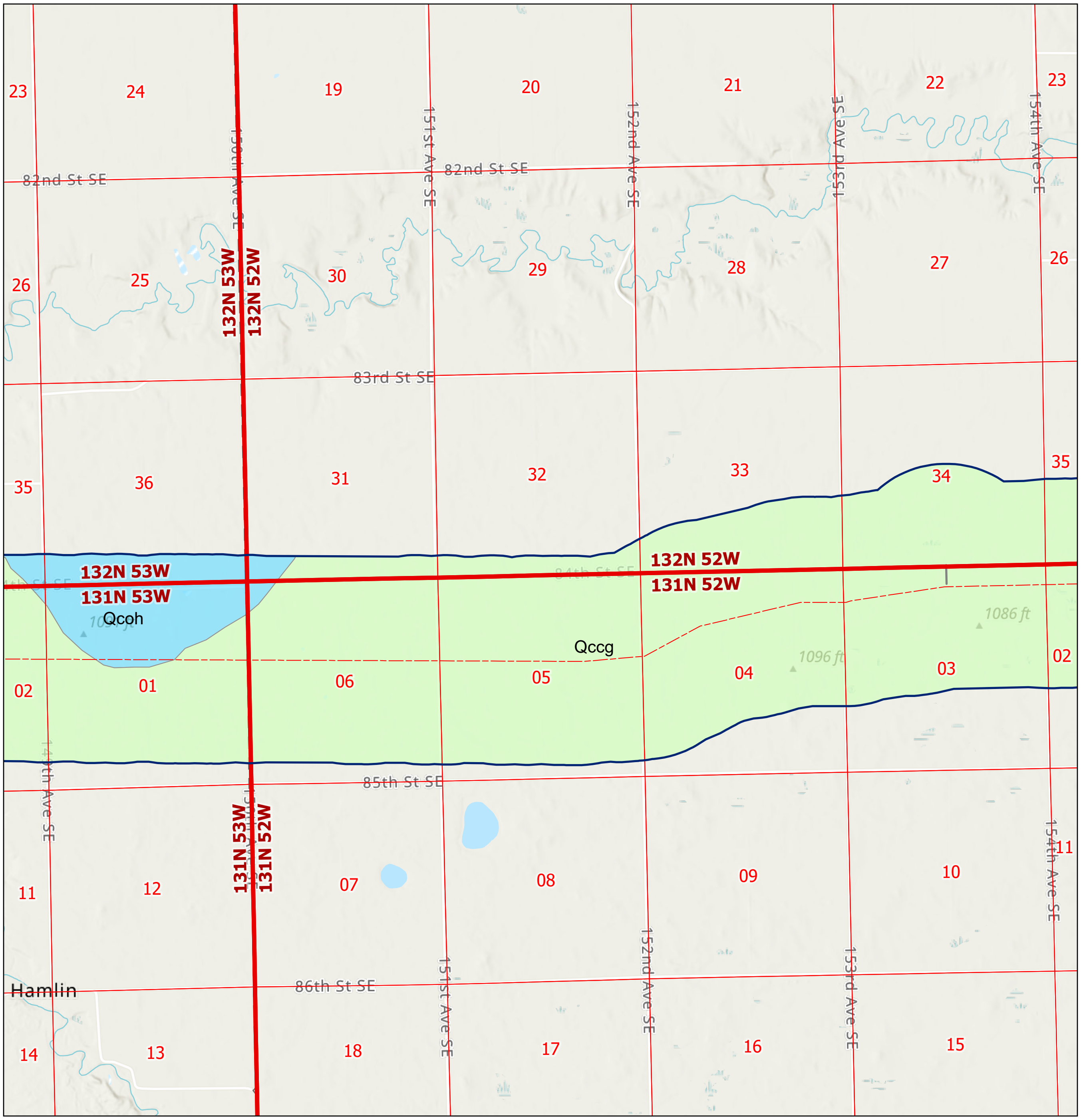

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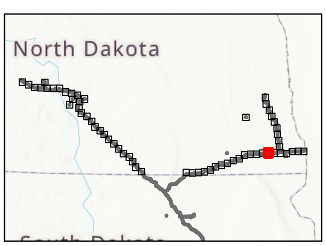

- Centerline Route
- Pipeline Access Road
- 0.5 mile Buffer
- Township
- Section

Project Geology

- Qcoh - Ice-Walled-Lake Sediment or Collapsed Supra-Glacial-Lake Sediment (Holocene to Pre-Wisconsinan)
- Qccg - Collapsed Glacial Sediment (Holocene to Pre-Wisconsinan)

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Stantec

Project Location
Multiple Counties,
Northeast South Dakota

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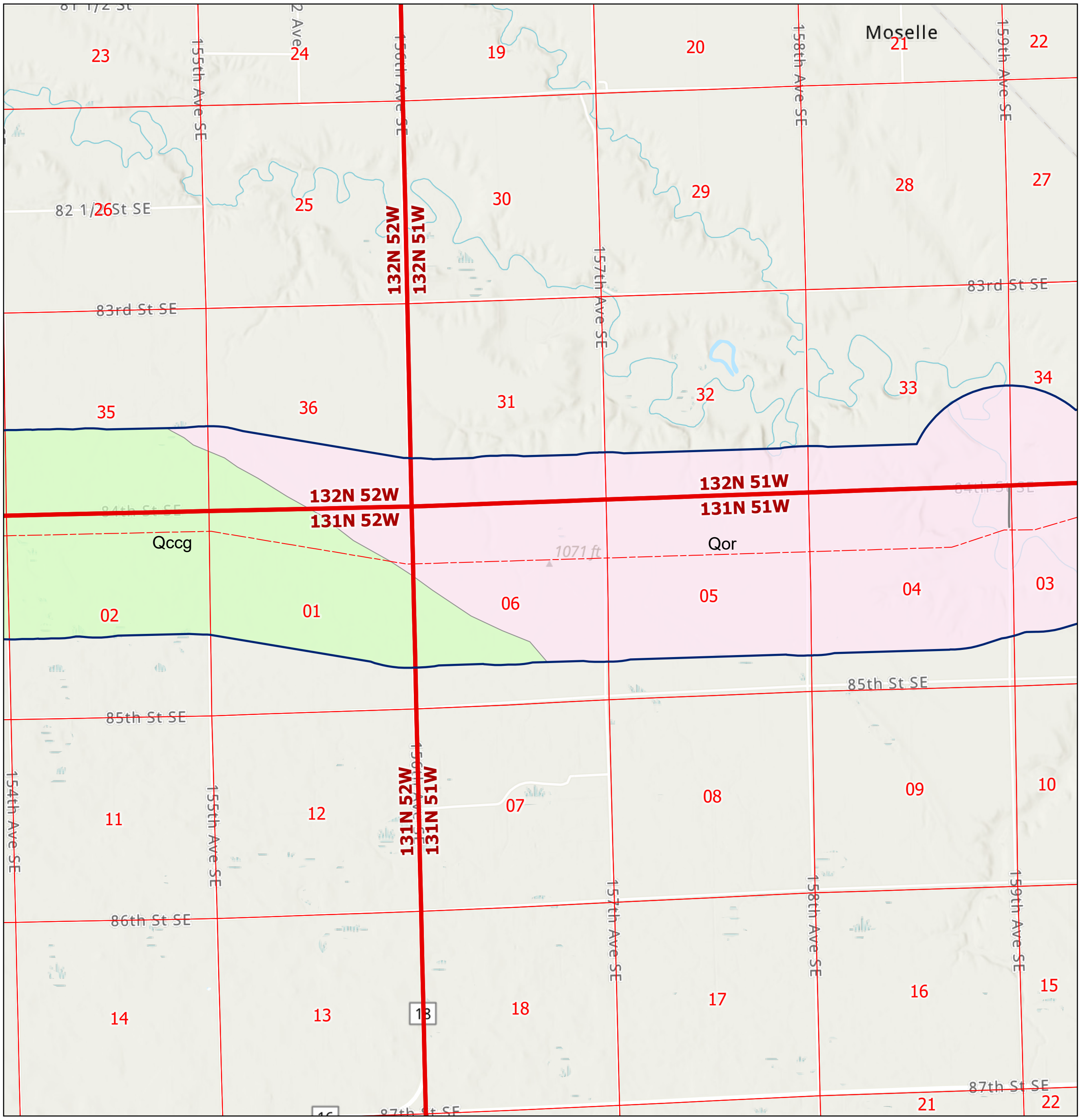

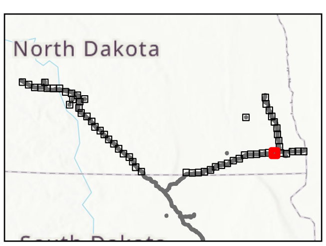

Centerline Route
Pipeline Access Road
0.5 mile Buffer
Township
Section

Project Geology

Qor - River Sediment (Holocene)

Qccg - Collapsed Glacial Sediment (Holocene to Pre-Wisconsinan)

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Stantec

Project Location
Multiple Counties,
Northeast South Dakota

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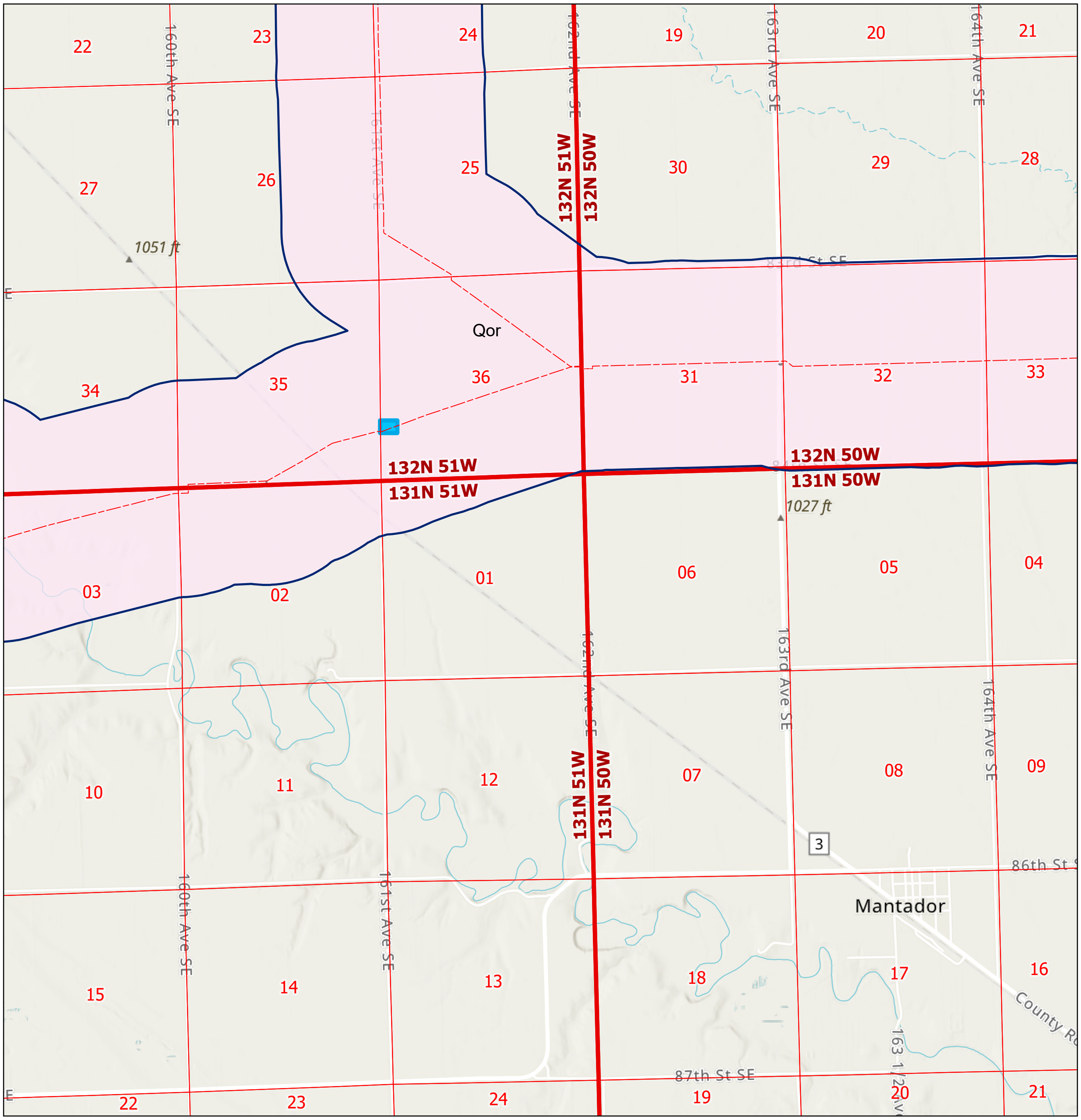

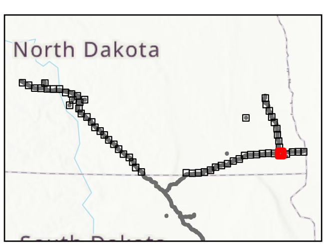

- Centerline Route
- Pipeline Access Road
- Pump Station
- 0.5 mile Buffer
- Township
- Section

Project Geology

Qor - River Sediment (Holocene)

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Project Location
Multiple Counties,
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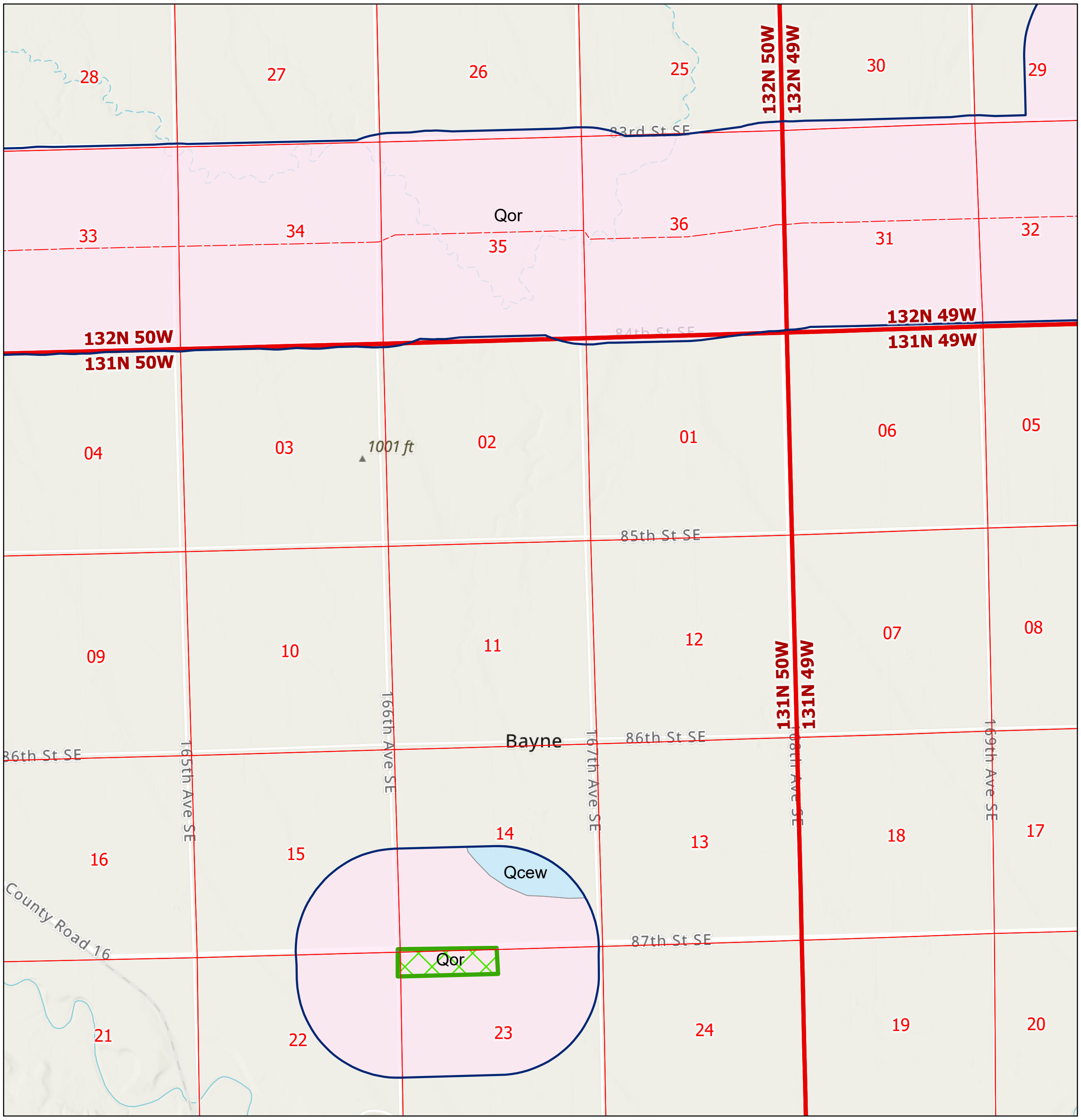

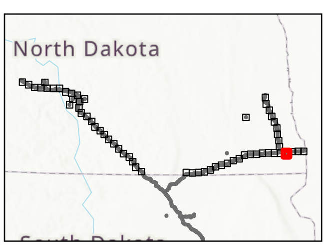

- Centerline Route
- Pipeline Access Road
- Contractor Yards
- 0.5 mile Buffer
- Township
- Section

Project Geology

- Qor - River Sediment (Holocene)
- Qcew - Wave-Eroded Glacial Sediment (Holocene to Pre-Wisconsinan)

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Project Location
Multiple Counties,
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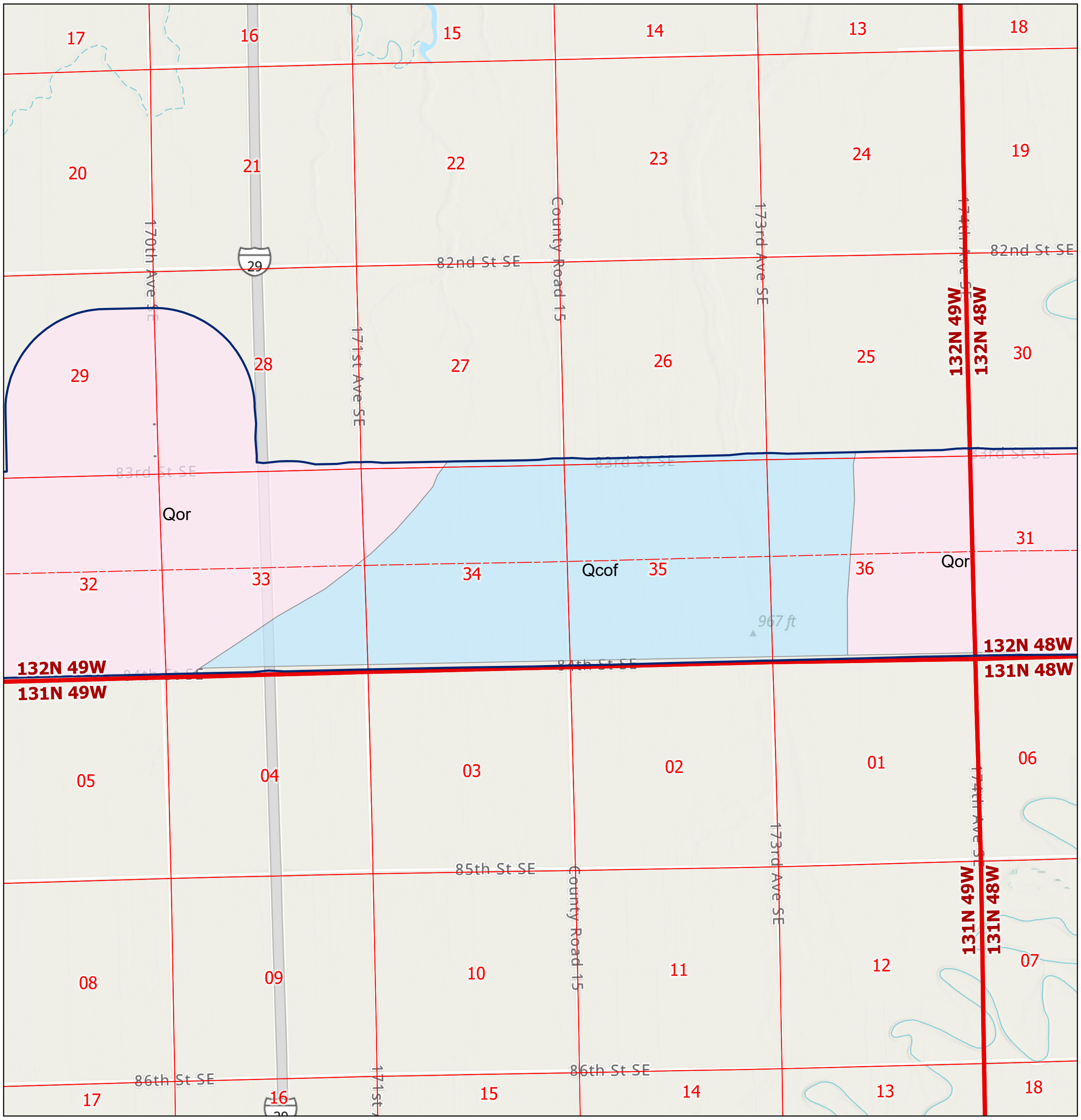

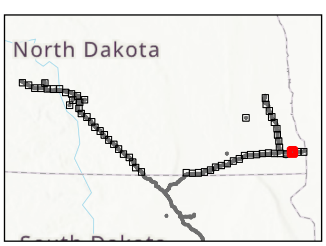

- Centerline Route
- Pipeline Access Road
- 0.5 mile Buffer
- Township
- Section

Project Geology

- Qor - River Sediment (Holocene)
- Qcof - Proglacial-Lake Sediment (Holocene to Pre-Wisconsinan)

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Project Location
Multiple Counties,
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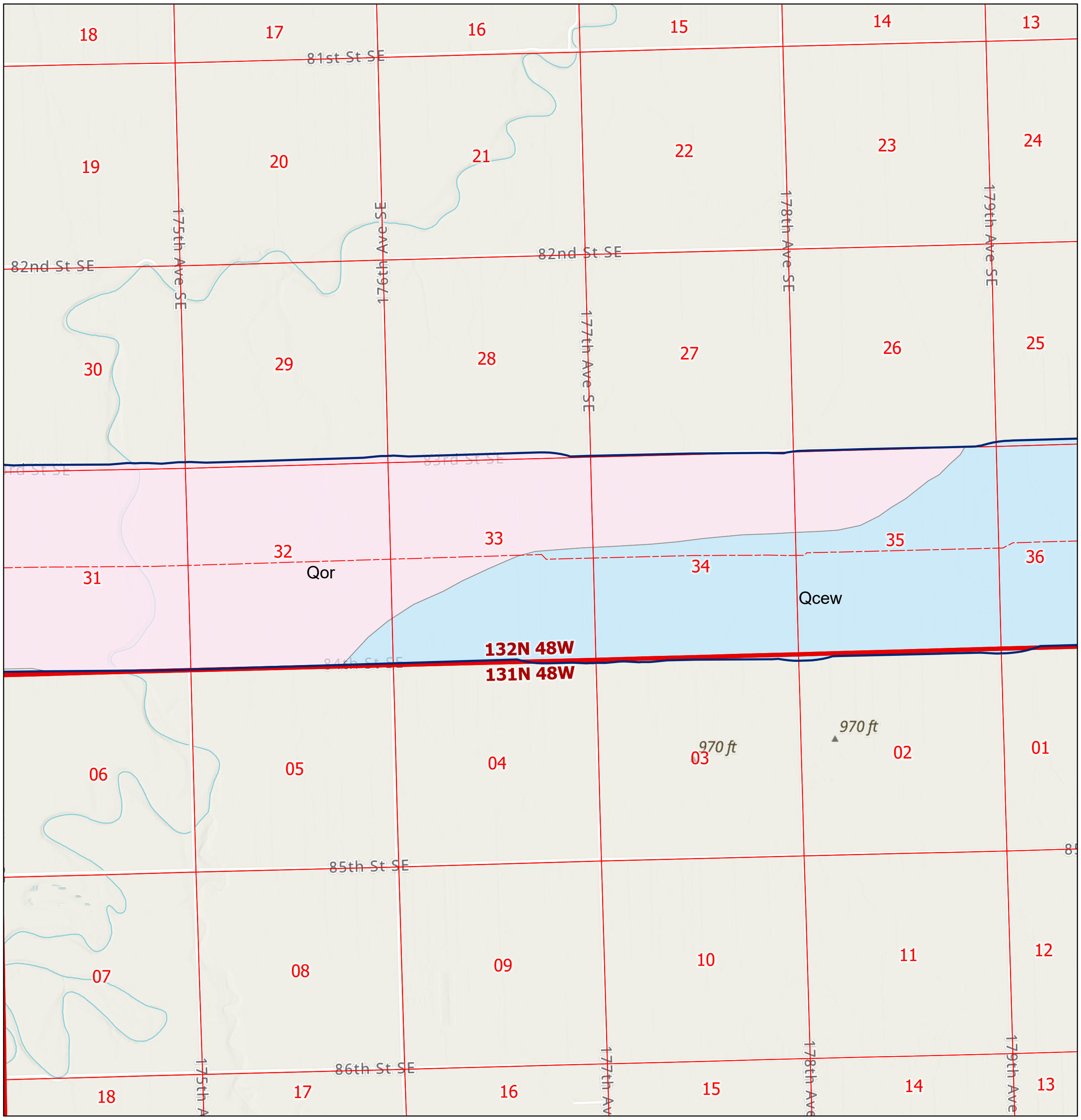

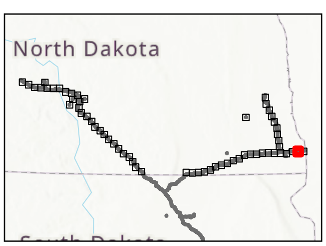

- - - Centerline Route
0.5 mile Buffer
Township
Section

Project Geology

Qor - River Sediment (Holocene)

Qcew - Wave-Eroded Glacial Sediment (Holocene to Pre-Wisconsinan)

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Stantec

Project Location
Multiple Counties,
Northeast South Dakota

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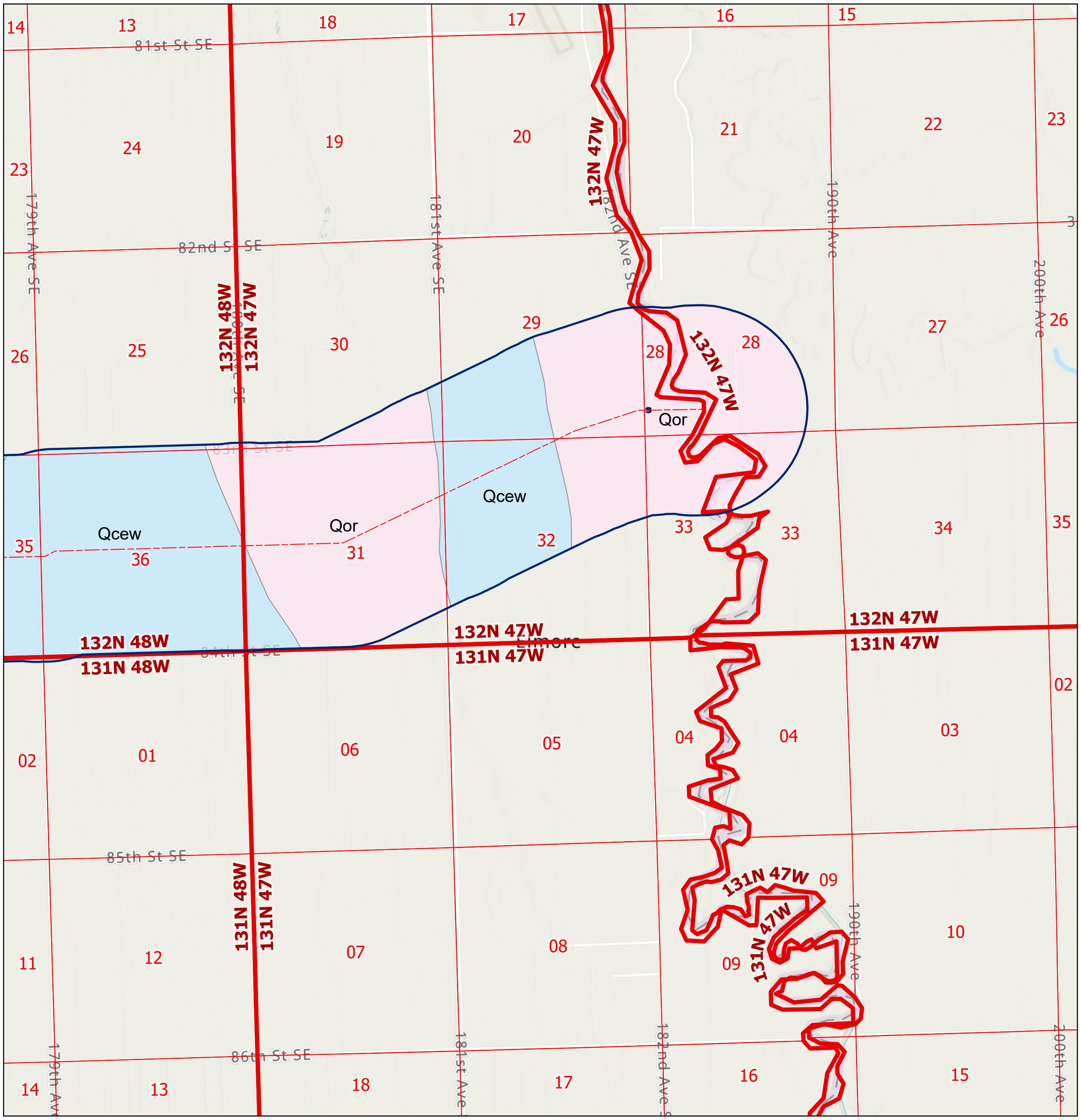

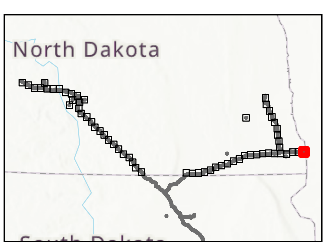

- - - Centerline Route
— Pipeline Access Road
Mainline Valves
0.5 mile Buffer
Township
Section

Project Geology

Qor - River Sediment (Holocene)

Qcew - Wave-Eroded Glacial Sediment (Holocene to Pre-Wisconsinan)

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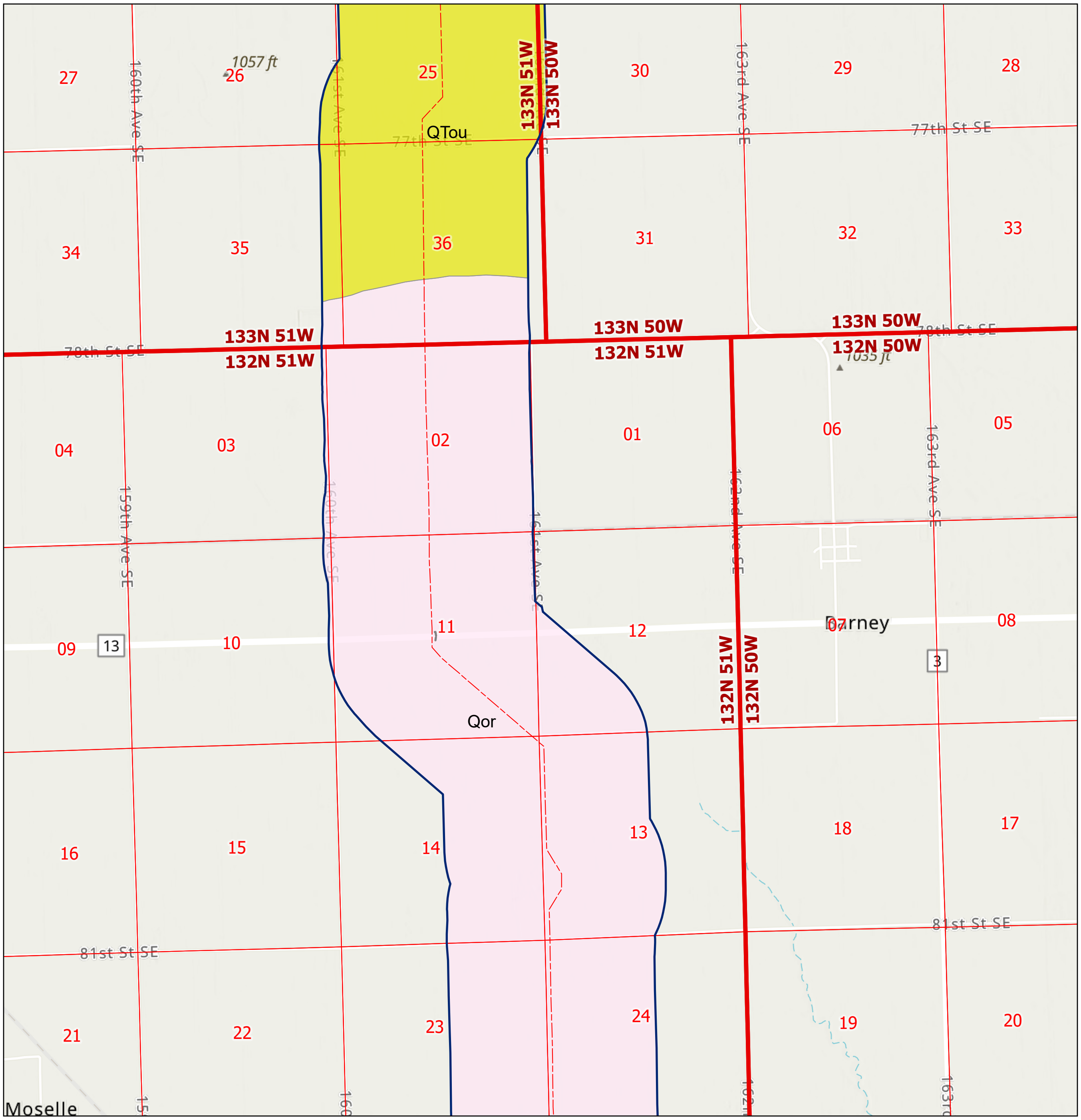

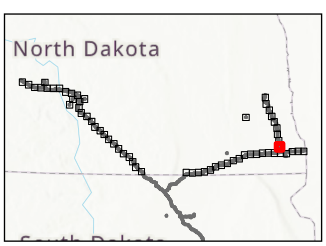

- Centerline Route
- Pipeline Access Road
- 0.5 mile Buffer
- Township
- Section

Project Geology

- Qor - River Sediment (Holocene)
- QTou - Sand of the Oahe and Older Formations, Undivided (Holocene to Pliocene)

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Notes
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Multiple Counties,
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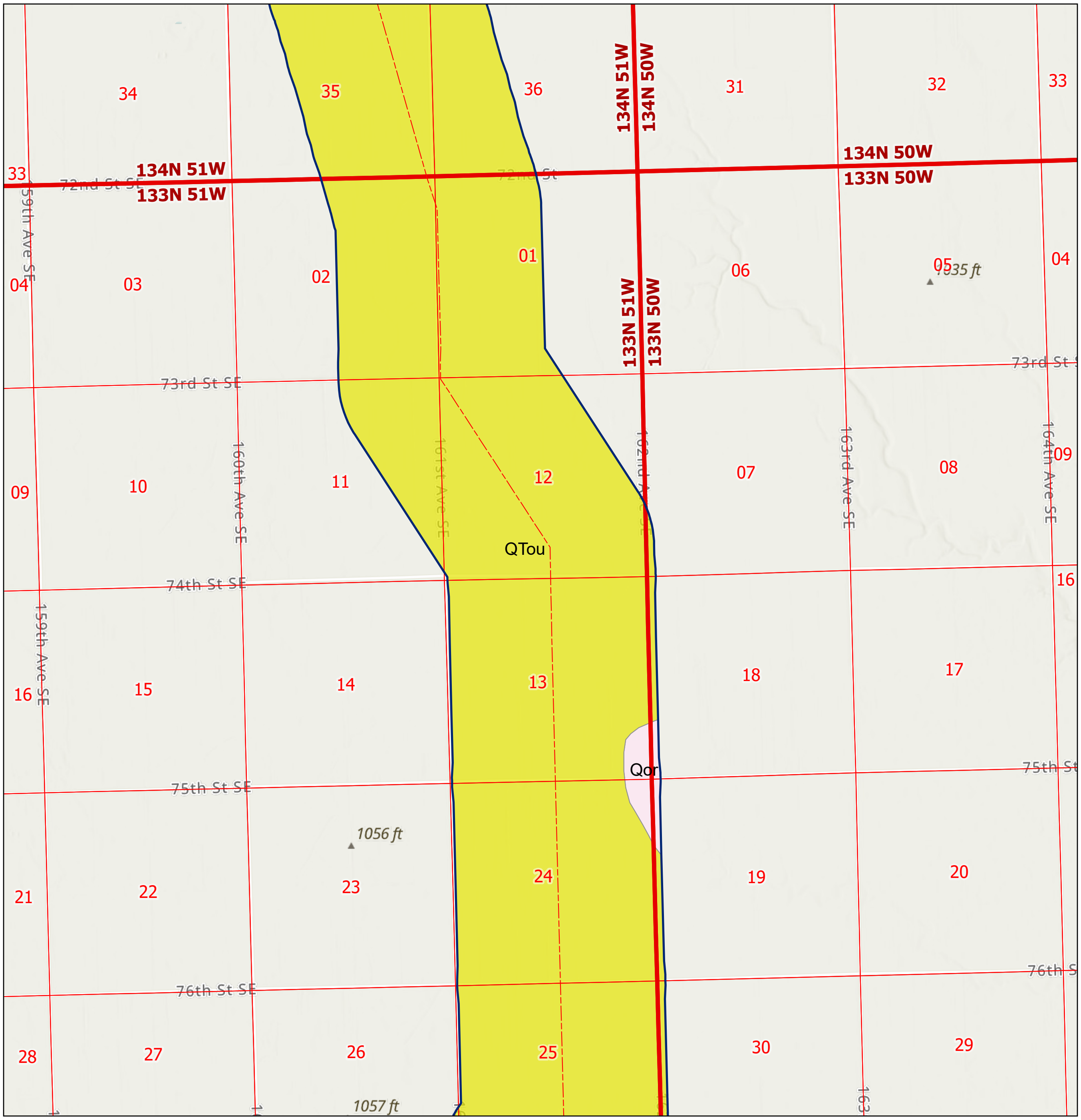

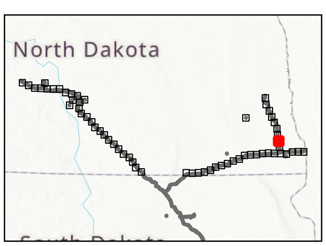

- - - Centerline Route
0.5 mile Buffer
Township
Section

Project Geology

Qor - River Sediment (Holocene)

QTou - Sand of the Oahe and Older Formations, Undivided (Holocene to Pliocene)

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Stantec

Project Location
Multiple Counties,
Northeast South Dakota

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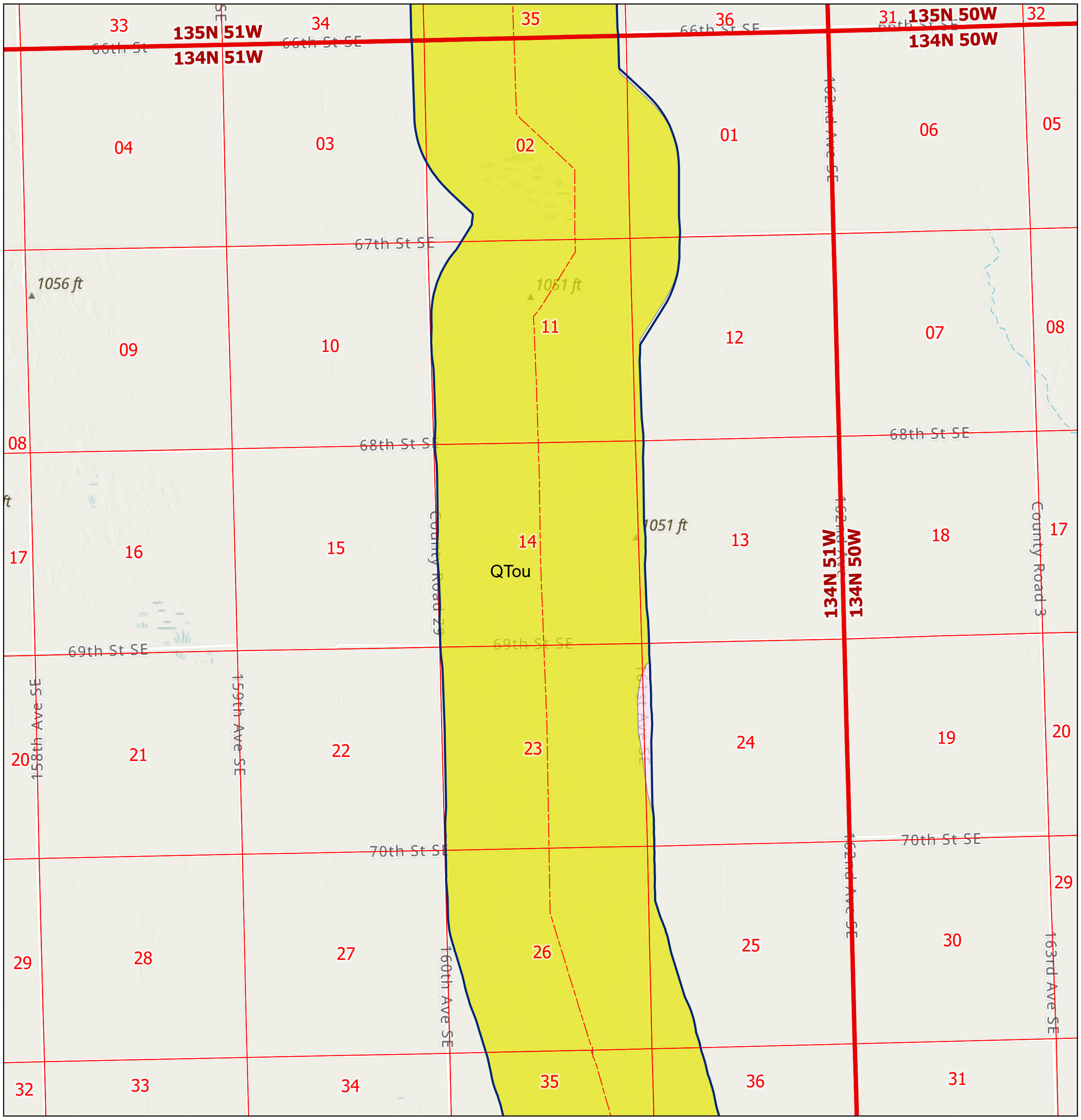

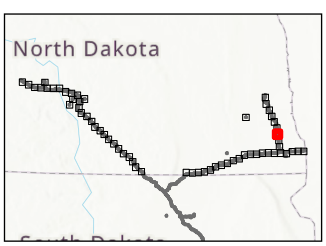

Centerline Route
Pipeline Access Road
0.5 mile Buffer
Township
Section

Project Geology

Qor - River Sediment (Holocene)

QTou - Sand of the Oahe and Older Formations, Undivided (Holocene to Pliocene)

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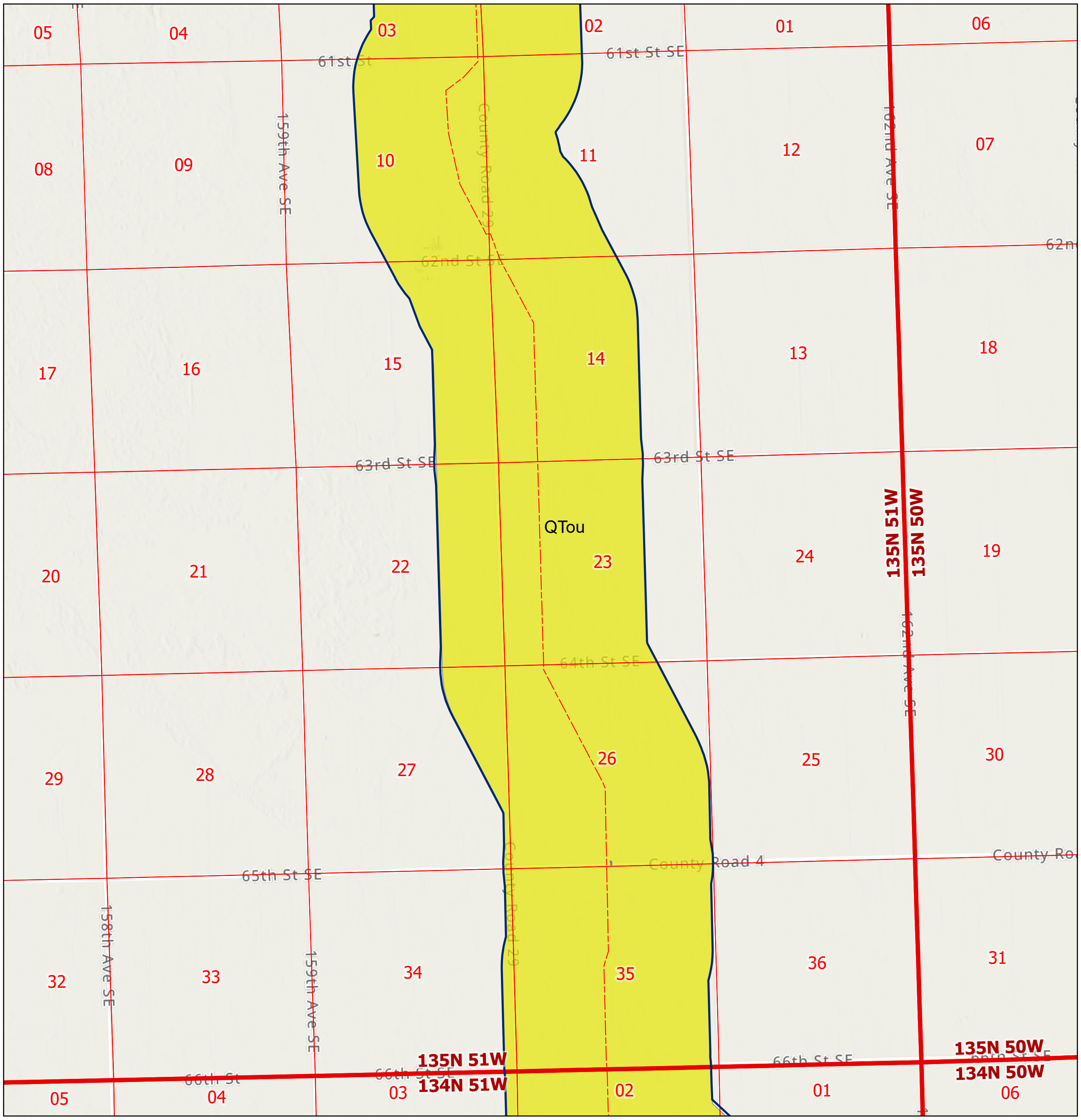

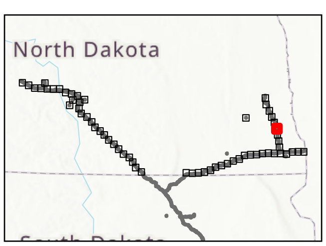

- Centerline Route
- Pipeline Access Road
- 0.5 mile Buffer
- Township
- Section

Project Geology

QTou - Sand of the Oahe and Older Formations, Undivided (Holocene to Pliocene)

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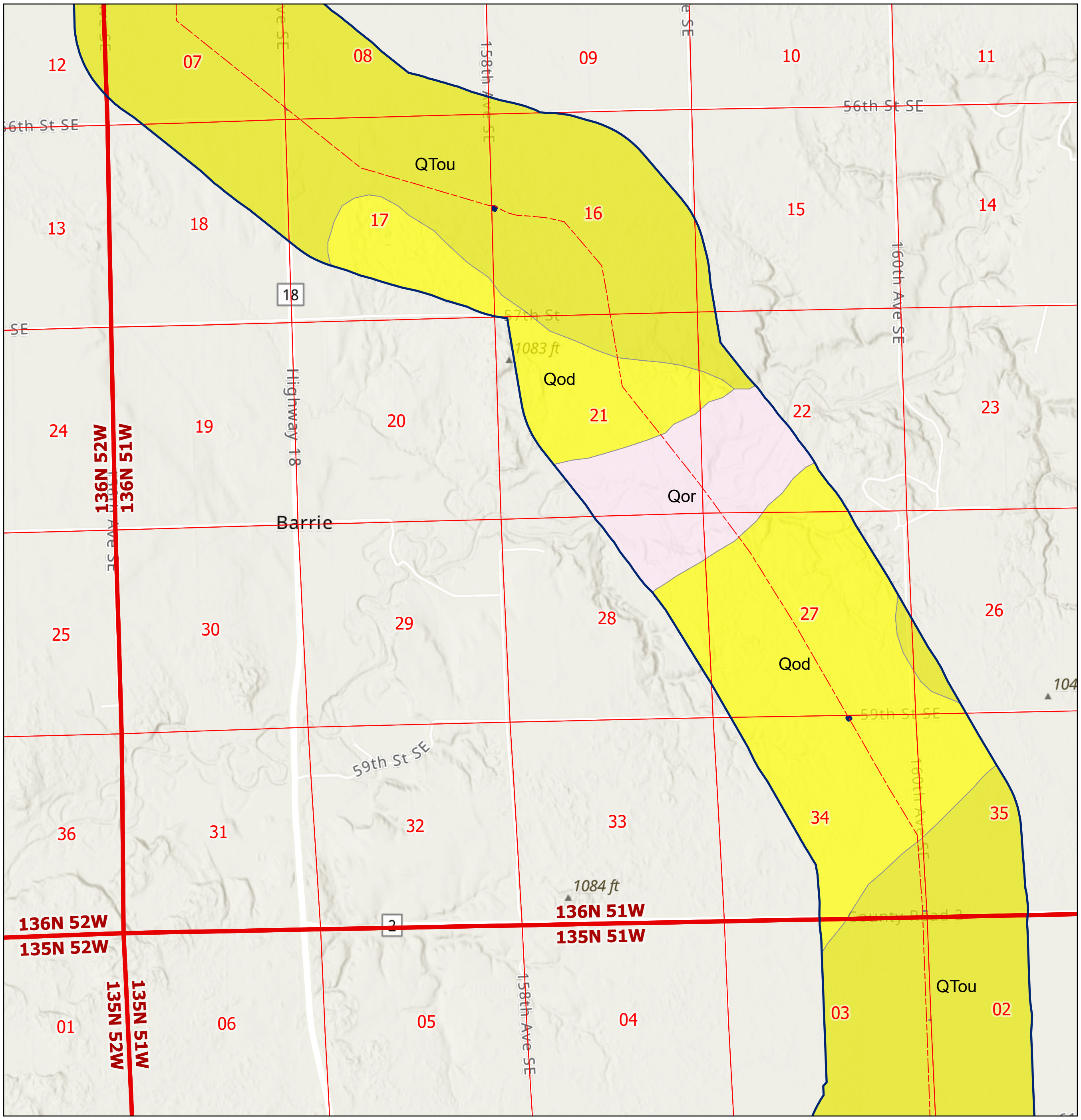

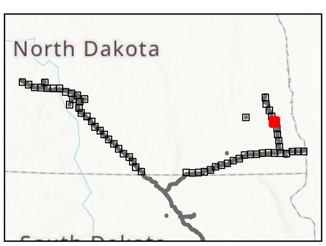

- - - Centerline Route
— Pipeline Access Road
Mainline Valves
0.5 mile Buffer
Township
Section

Project Geology

Qor - River Sediment (Holocene)

Qod - Windblown Sand (Holocene)

QTou - Sand of the Oahe and Older Formations, Undivided (Holocene to Pliocene)

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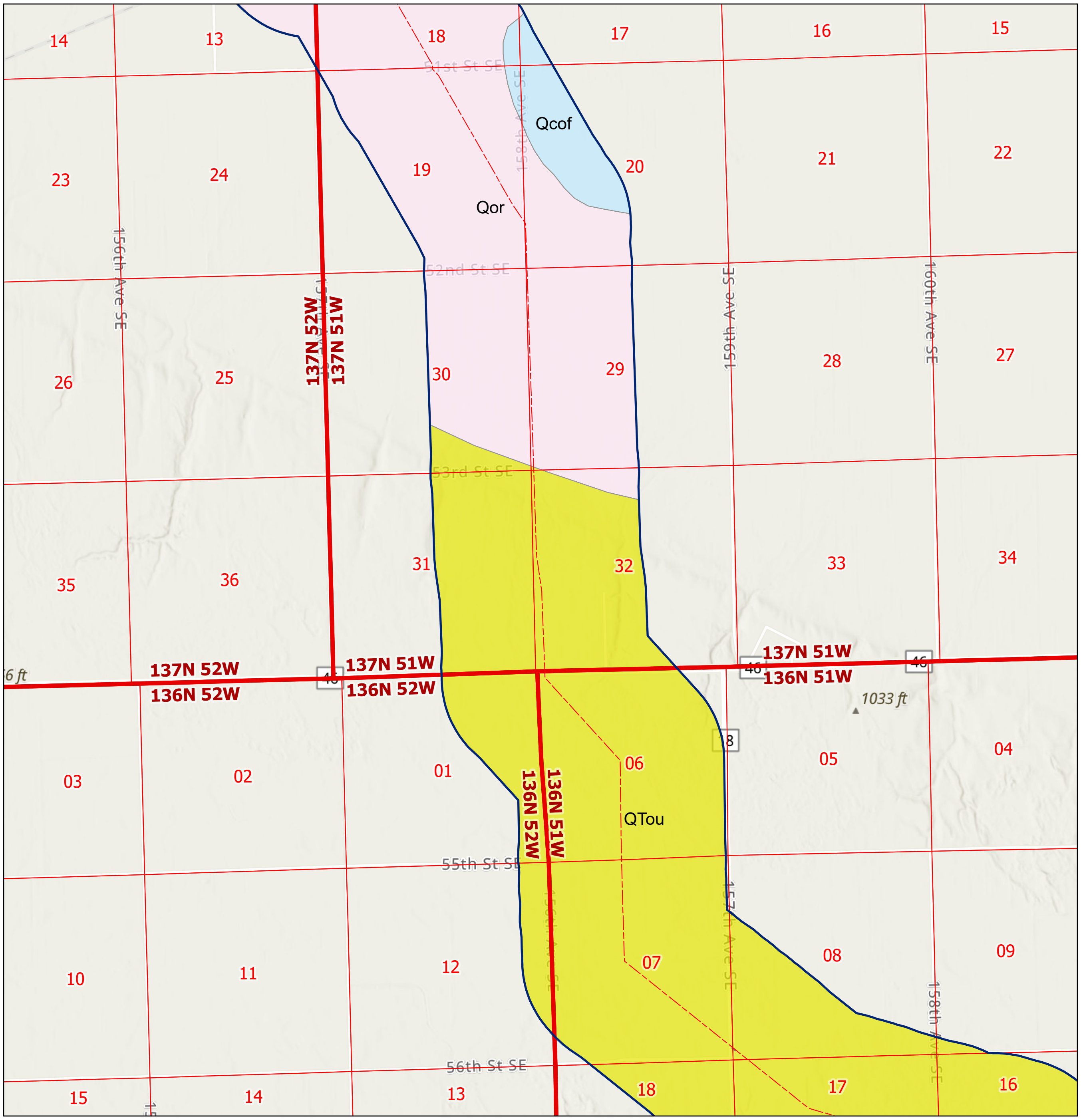

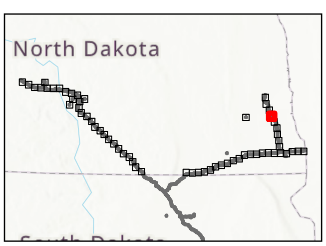

- Centerline Route
- Pipeline Access Road
- 0.5 mile Buffer
- Township
- Section

Project Geology

- Qor - River Sediment (Holocene)
- QTou - Sand of the Oahe and Older Formations, Undivided (Holocene to Pliocene)
- Qcof - Proglacial-Lake Sediment (Holocene to Pre-Wisconsinan)

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Notes

1. Coordinate System: NAD 1983 UTM Zone 14N
2. Data Sources: Stantec 2021. Geologic Map of North Dakota, Clayton et. al., 1980.
3. Background: County of Cass, ND, State of North Dakota, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, Esri, NASA, NGA, USGS, Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, Esri, USGS

Stantec

Project Location
Multiple Counties,
Northeast South Dakota

Prepared by EB on 2022-09-12
TR by JC on 2022-09-12
IR by PM on 2022-09-12

Client/Project
235100428

EXP Energy Services
Summit Carbon Solutions MCE Project

Figure No.
1

Title
North Dakota Geology

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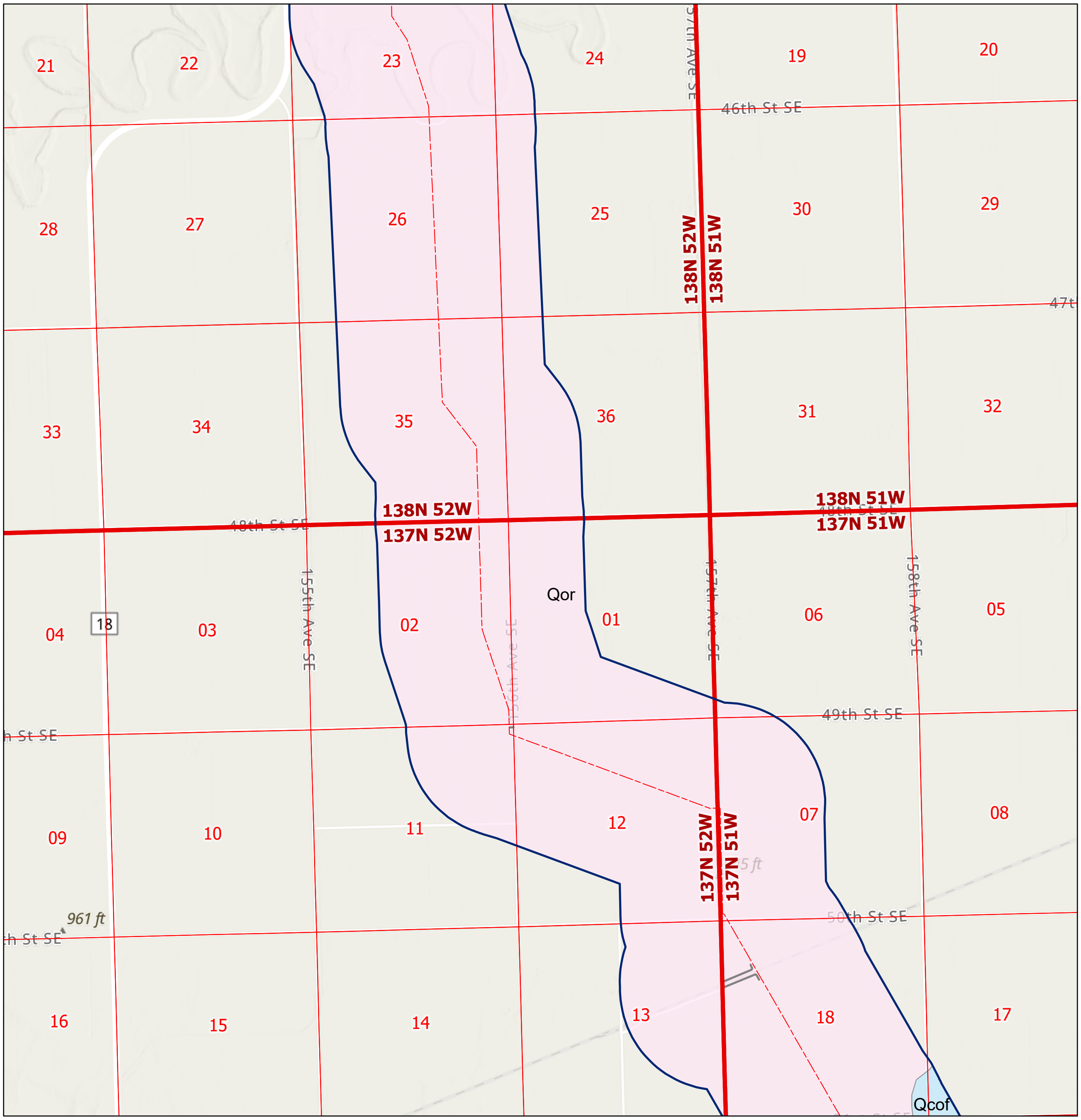

- - -	Centerline Route
—	Pipeline Access Road
☐	0.5 mile Buffer
☐	Township
☐	Section

Project Geology

Qor - River Sediment (Holocene)

Qcof - Proglacial-Lake Sediment (Holocene to Pre-Wisconsinan)

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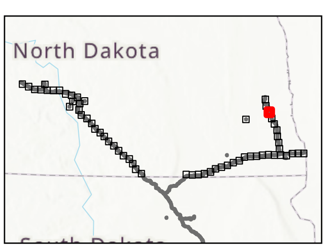

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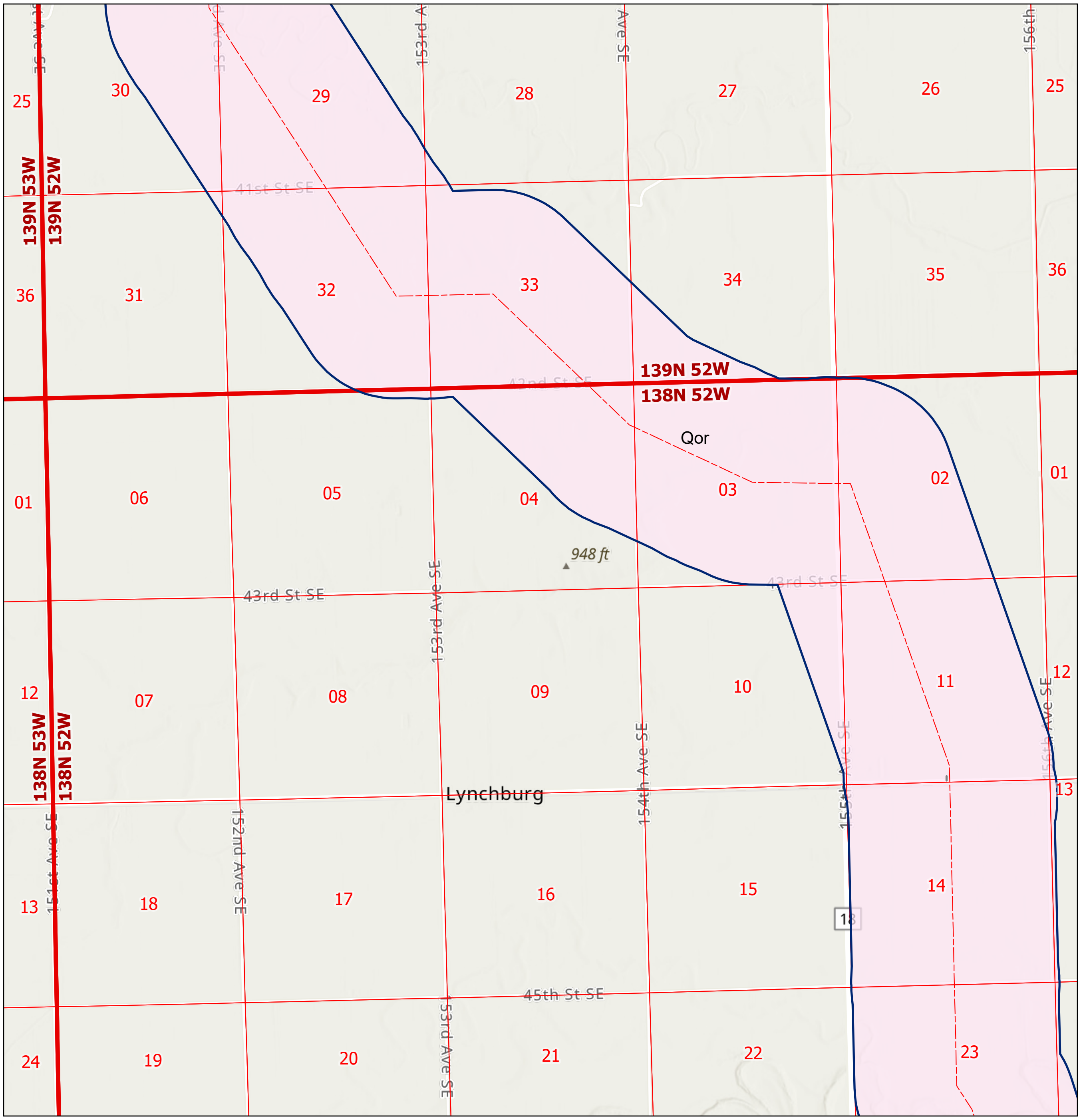

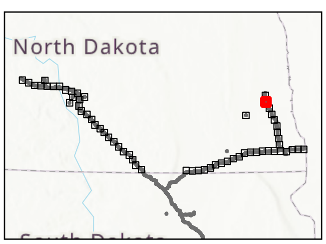

- - - Centerline Route
Pipeline Access Road
0.5 mile Buffer
Township
Section

Project Geology

Qor - River Sediment (Holocene)

0 2,000 4,000 Feet
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N

Stantec

Project Location
Multiple Counties, Northeast South Dakota

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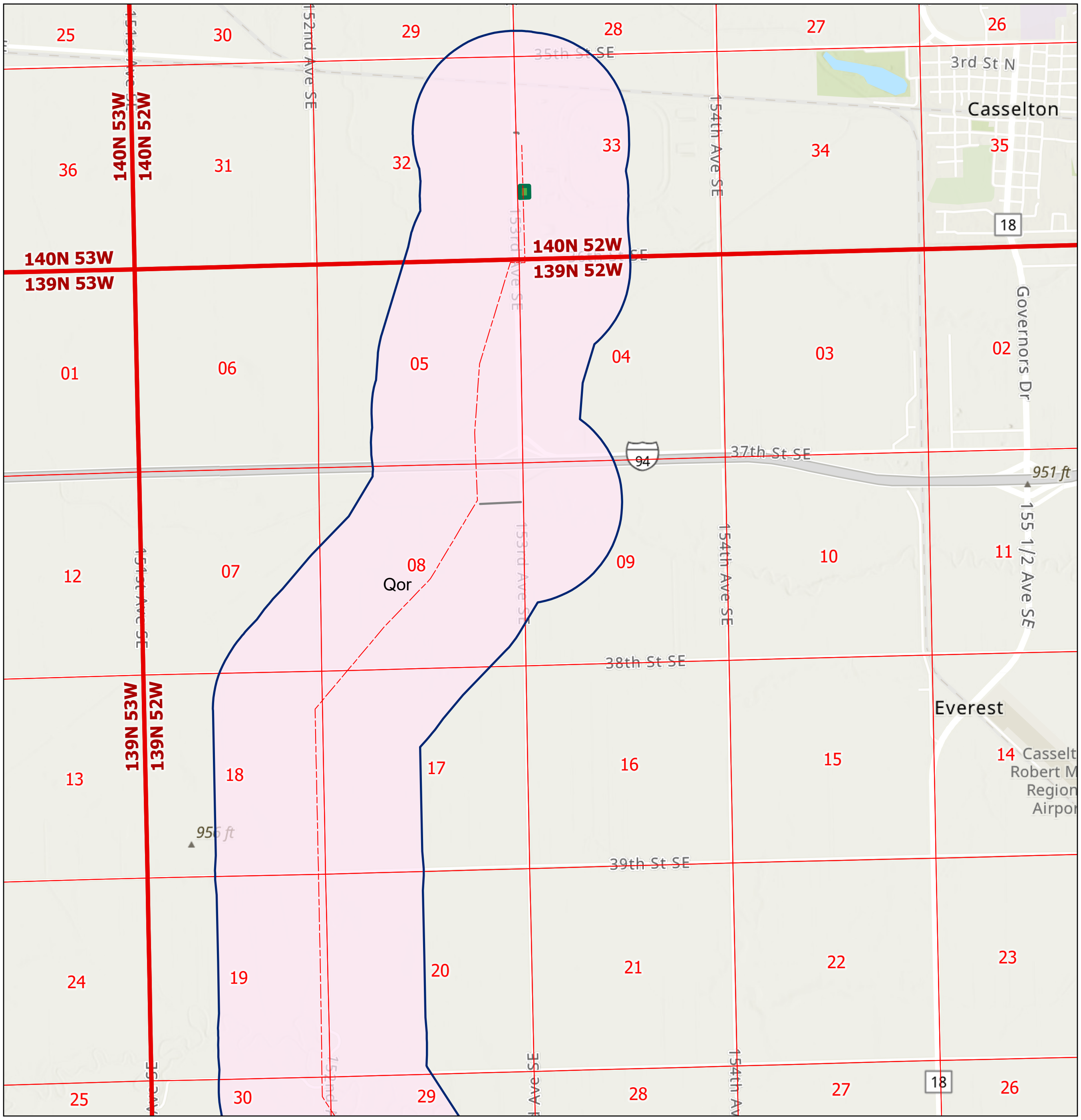

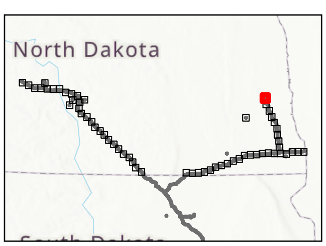

- - - Centerline Route
— Pipeline Access Road
Capture Facilities
0.5 mile Buffer
Township
Section

Project Geology

Qor - River Sediment (Holocene)

0 2,000 4,000 Feet

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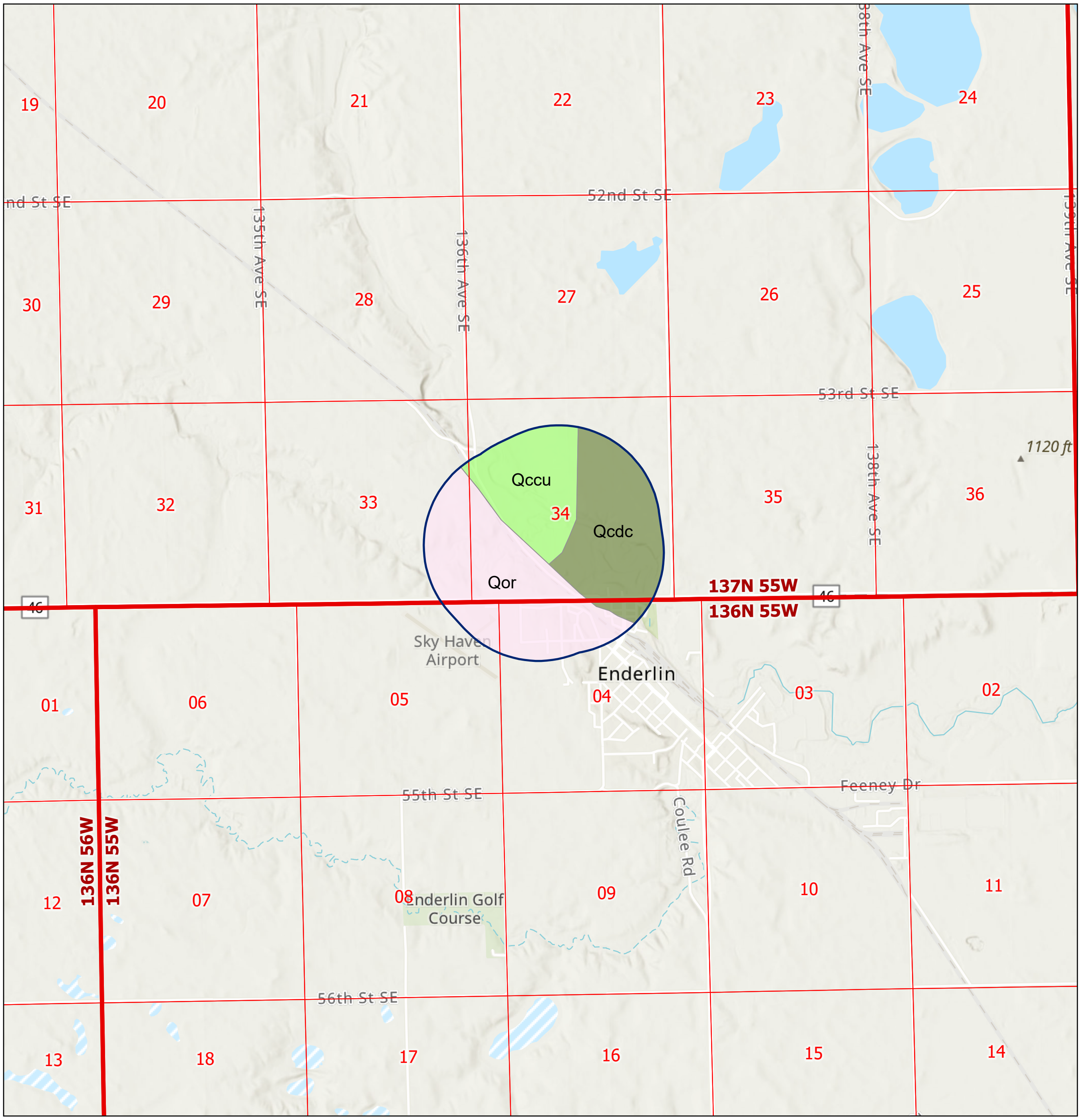

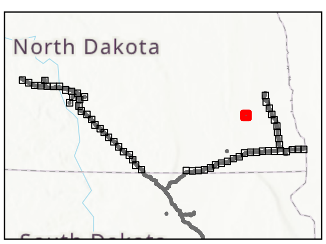

0.5 mile Buffer
Township
Section

Project Geology
- Qor - River Sediment (Holocene)
- Qccu - Collapsed Glacial Sediment (Holocene to Pre-Wisconsinan)
- Qcdc - Collapsed/Draped Transition Sediments (Holocene to Pre-Wisconsinan)

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