ATTACHMENT 1-1
LETTERS

IN THE COMMISSIONERS COURT
OF
ANDREWS COUNTY, TEXAS

A resolution in support of establishing a site in Andrews County for consolidated interim storage of spent nuclear fuel and high-level radioactive waste.

WHEREAS, Andrews County, Texas, as host to two low-level radioactive waste disposal facilities operated by Waste Control Specialists LLC ("WCS"), greatly benefits directly and indirectly from the economic activity associated with disposal of radioactive materials; and

WHEREAS, Andrews County recognizes the importance of a diversified economy to the livelihood of the citizens of Andrews County; and

WHEREAS, Andrews County is home to a specialized workforce with expertise concerning radioactive materials, and WCS currently employs more than 170 full-time employees with an annual payroll of more than $13 million in Andrews County; and

WHEREAS, Andrews County has invested in the success of the low-level radioactive waste disposal facilities operated by WCS by issuing $75 million in bonds and using that revenue to purchase property leased by WCS as part of the operation of the disposal facilities; and

WHEREAS, Andrews County receives five percent of the gross receipts from waste disposed of at the two low-level radioactive waste disposal facilities, which receipts to date have totaled over $5 million directly paid to Andrews County and are expected to total more than $3 million per year in the future; and

WHEREAS, WCS has consistently shown its commitment to the environment and the citizens of Andrews County by, among other things, designing and operating safe, state-of-the-art radioactive materials facilities, working to ensure that Andrews County shares in economic benefits because of WCS operations, and working to ensure that local stakeholders are kept informed and made an integral part of the decision-making process concerning WCS operations; and

WHEREAS, there are substantial quantities of Spent Nuclear Fuel ("SNF") and High-Level Radioactive Waste ("HLW") currently stored at sites throughout Texas and the United States; and

WHEREAS, much of the SNF and HLW is currently stored at sites that are vulnerable to natural disasters and located near large metropolitan centers; and

WHEREAS, the United States Department of Energy (the "DOE") concluded in 2013 that a geologic repository for the permanent disposal of SNF and HLW will not be available until 2048, at the earliest; and

WHEREAS, the federal Blue Ribbon Commission on America's Nuclear Future in 2012 recommended "prompt" efforts to develop one or more consolidated SNF and HLW interim storage facilities while further efforts are made to develop a permanent disposal site; and

WHEREAS, the Texas Commission on Environmental Quality ("TCEQ") analyzed the challenges associated with creating a consolidated SNF and HLW interim storage solution in Texas in its March 2014 *Assessment of Texas's High Level Radioactive Waste Storage Options* report (the "Report"); and

WHEREAS, the TCEQ, in the Report, noted that consolidated SNF and HLW interim storage in Texas would offer electricity consumers significant savings compared to storage at each nuclear power plant and that the siting and construction of a consolidated SNF and HLW interim storage facility is "not only feasible but could be highly successful" so long as the approach "minimizes local and state opposition through stakeholder meetings, finding volunteer communities, financial incentives, and a process that is considered fair and technically rigorous;" and

WHEREAS, the Texas Radiation Advisory Board issued an official statement of its position "that it is in the state's best interest to request that Texas be considered by the Federal Government as a consolidated SNF storage site;" and

WHEREAS, the Governor of Texas noted that Texas should "begin looking for a safe and secure solution for HLW in Texas;" and

WHEREAS, the workforce, the geography, and the geology of Andrews County make it an ideal location for safe storage of radioactive materials, and Andrews County is a volunteer community that wishes to offer its unique resources to help solve the state's and country's SNF and HLW storage problems.

NOW, THEREFORE, BE IT RESOLVED AND ORDERED that the Commissioners Court of Andrews County, Texas, meeting in open session, believes that the construction and operation of a consolidated SNF and HLW interim storage facility in Andrews County (the "Facility"), licensed by the Nuclear Regulatory Commission and developed by WCS, will enhance the health, safety, and welfare of the citizens of Andrews County; and

BE IT FURTHER RESOLVED AND ORDERED that the Commissioners Court of Andrews County does hereby declare and express the commitment of Andrews County to explore the development of the Facility, and in support thereof does hereby call upon and ask:

the State of Texas, all its agencies, officials and political subdivisions, and all members of the Texas congressional delegation to work cooperatively with all relevant entities towards the creation of the Facility, including taking actions to evidence approval of the development of the Facility, such as executing and delivering letters of support, cooperative agreements, or other documents needed in connection with the site selection, siting and licensing of the Facility; and

the State of Texas, all its agencies and officials, and all members of the Texas congressional delegation to assist Andrews County in securing all federal incentives that may be available, as a result of siting the Facility, from the DOE or another appropriate federal entity; and

BE IT FURTHER RESOLVED AND ORDERED that the Andrews County Judge is hereby authorized to negotiate terms of any interlocal agreements and other contracts and agreements related to financial incentives that may be available to Andrews County as a result of siting the Facility, which terms and agreements or contracts will be subject to approval by this Commissioners Court; and

BE IT FURTHER RESOLVED AND ORDERED that Andrews County is committed to exercising its regulatory and service-providing powers, including such powers as those related to transportation planning, infrastructure development, and police and fire protection, in a manner that protects the health, safety, and welfare of the citizens of Andrews County by facilitating the development of the Facility; and

BE IT FURTHER RESOLVED AND ORDERED that a copy of this resolution be sent to the Texas Governor, the Texas Lieutenant Governor, the Speaker of the Texas House, the State Representative for Texas House District 81, the State Senator for State Senate District 31, the United States Representative for Congressional District 11, the United States Senators for the State of Texas, the Commissioners of the United States Nuclear Regulatory Commission, and the United States Secretary of Energy.

Passed and Approved this 20th day of January, 2015.

County Judge Richard H Dolgener

Commissioner, Pct 3

Jeneanne Anderegg

Commissioner, Pct 1 Barney Fowler

Commissioner,Pct. 4 Jim Waldrop

Commissioner, Pct 2 Brad Young

ATTEST:

County Clerk

Low-level radioactive waste disposal: On August 28, TCEQ issued Amendment No. 26 to RML R04100 as a major amendment. The amendment 1) revised the performance assessment, 2) adjusted the amount of financial assurance required, and 3) increased the licensed volume of the compact disposal facility. Waste Control Specialists is now authorized under the license to accept all Class A, B, and C low-level radioactive waste for disposal, including depleted uranium in concentrations greater than 10 nanocuries/gram.

Uranium Mining:

Major amendments for license area expansion at two in situ uranium mining licenses were declared technically complete in July and August. Public notice was published in the *Falfurrias Facts* on August 7, 2014 for the Mesteña Alta Mesa Project, with the comment period ending on September 8, 2014. Public notice for the South Texas Mining Venture Palangana Project will be published soon. A major amendment application from Signal Equities for a license area expansion on their Brown Project and a new license application from UEC for their Burke Hollow project are both currently under technical review.

TCEQ had begun working towards obtaining partial release from the NRC of a portion of the former licensed area of the abandoned IEC Lamprecht/Zamzow site. On August 12, 2014, a team of 14 TCEQ field workers along with 3 individuals from DSHS began gamma surveys and soil sampling in support of an effort to release non-operational areas for unrestricted use. Using GPS data units coupled to survey meters, 2-man teams collected data across 775 acres in a portion of the formerly licensed area. Two more field days are currently planned to finish data collection. When all data have been collected and analyzed, a Completion Review Report will be written and submitted to the NRC for their concurrence in a partial release of these areas for unrestricted use. TCEQ has also initiated its contracting process to be able to contract for the clean-up of the operational portion of this site.

By-product material disposal: Operation of the byproduct waste disposal facility continues under its current license. By license condition, the byproduct disposal operation is limited to receiving only the Fernald byproduct waste. Staff members continue to review WCS's environmental monitoring reports and related data.

Underground Injection Control: TCEQ is processing two applications for new Class III UIC permits for in situ uranium mining and one application for expansion of the permit area of an existing in situ uranium mining site. One of the new applications (UEC Burke Hollow site) is for an unmined site in Bee County. The other new application (Signal Equities Brown site) is for a previously-mined site (USX Boots-Brown) in Live Oak County. The application for expansion (STMV Palangana site) is in Duval County.

Office of the Governor

RICK PERRY
GOVERNOR

March 28, 2014

The Honorable David Dewhurst
Lieutenant Governor
State of Texas
State Capitol, Room 2E.13
Austin, Texas 78701

The Honorable Joe Straus
Speaker of the House
Texas House of Representatives
P.O. Box 2910
Austin, Texas 78768

Dear Governor Dewhurst and Speaker Straus:

Enclosed is a report completed at my request by the Texas Commission on Environmental Quality (TCEQ). This report evaluates the challenges posed by spent nuclear fuel and other high-level radioactive waste (together "HLW") currently stored on-site at the six Texas nuclear reactors.

In light of recent developments regarding the interim storage and disposal of HLW by the federal government, Texas now faces the very real possibility that it will have to find a solution to the long-term issue of safe and secure handling of this waste. The citizens of Texas — and every other state currently storing radioactive waste — have been betrayed by their federal government after contributing billions of dollars to fund a federal solution for HLW disposal, because a federal solution still does not exist.

Since the U.S. Congress enacted the Nuclear Waste Policy Act in 1982, each state, including Texas, has been assured that the federal government would take possession and provide a disposal solution for any HLW generated within its borders. In 1987, the federal government identified Yucca Mountain in Nevada as being the ultimate disposal option with a completion date in 1998. After extensive litigation, delays and cost overruns, in 2009 President Obama abandoned any further development of Yucca Mountain and Congress ceased all funding in 2011 after more than $15 billion had been spent characterizing and developing the site.

Early in 2013, the U.S. Department of Energy announced that it was developing a new plan to replace Yucca Mountain — estimating that an HLW disposal solution would not be available until 2048. However, in November 2013, the U.S. Court of Appeals for the District of Columbia determined that the federal government has "no credible plan" to dispose of HLW.

2048, or whatever year Washington forecasts that a solution will be provided, is too long to wait.

I believe it is time for Texas to act, particularly since New Mexico is seeking to be federally designated for HLW disposal. The New Mexico proposed site is approximately 50 miles from the Texas border, and we must ensure our citizens are protected. We have no choice but to begin looking for a safe and secure solution for HLW in Texas — a solution that would allow the citizens of Texas to recoup some of the more than $700 million they have paid toward addressing this issue.

I hope the enclosed report will be sent to the appropriate oversight committees in your chamber. The leadership at TCEQ understands the importance of this issue, and I believe they will be a valued resource as we continue to develop a Texas solution for the long-term resolution of HLW currently residing inside our borders.

Sincerely,

Rick Perry

Rick Perry
Governor

RP:mmp

Enclosure

ATTACHMENT 1-2

TCEQ's ASSESSMENT OF HIGH LEVEL RADIOACTIVE WASTE STORAGE OPTIONS

Assessment of Texas's High Level Radioactive Waste Storage Options

March 2014

Radioactive Materials Division
Texas Commission on Environmental Quality

Assessment of Texas's High Level Radioactive Waste Storage Options

Prepared by
Radioactive Materials Division

March 2014

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Acryonms and Abbreviatons

°F	Degree Fahrenheit
AEC	Atomic Energy Commission
BRC	Blue Ribbon Commission
CFR	Code of Federal Regulations
DOE	United States Department of Energy
DOI	United States Department of the Interior
DOT	United States Department of Transportation
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
GEIS	Generic Environmental Impact Statement
GNEP	Global Nuclear Energy Partnership
HLW	High Level Waste
ISFSI	Independent Spent Fuel Storage Installation
MRS	Monitored Retrievable Storage
MTHM	Metric Ton Heavy Metal
MTU	Metric Ton Uranium
MW	Megawatt
MWd	Megawatt-day
NRC	Nuclear Regulatory Commission
NWF	Nuclear Waste Fund
NWPA	Nuclear Waste Policy Act
NWTRB	Nuclear Waste Technical Review Board
PFS	Private Fuel Storage
SNF	Spent Nuclear Fuel
STP	South Texas Project
TAD	Transportation, Aging, and Disposal
TRU	Transuranic
WIPP	Waste Isolation Pilot Plant

Background

Despite years of research and expense there is currently no federal disposal site for high level waste (HLW), which include spent nuclear fuel (SNF). Further, recent developments seem to imply that a federal solution is not immediately coming. Fortunately for Texans, the current practices for storage of HLW are environmentally sound. State and Federal regulations are adequate to protect the environment and public health. However, we know that most of the high level waste in storage is in the form of SNF and is stored at nuclear facilities which are within 100 miles of major metropolitan areas. Further, the continued availability of an appropriate storage area may prove challenging as the nuclear facilities face decommissioning at the end of their licenses.

The Texas Commission on Environmental Quality has been asked to make an assessment of the State's high level radioactive waste storage options and file a report with the Office of the Governor no later than March 1, 2014.

Executive Summary

Commercial nuclear power production began in December, 1957. For three decades afterwards, nuclear power plants were designed and built with the assumption that the used nuclear fuel, commonly called spent nuclear fuel (SNF), would be shipped to an off-site facility to be reprocessed and the resulting high level waste (HLW) disposed at a federal government operated and owned facility.

However, President Carter issued a presidential directive in 1977 that prohibited further commercial reprocessing. Even though President Reagan canceled this ban, as of yet the private sector has not attempted to build or license a commercial reprocessing facility since the one-time use fuel cycle is more economical.

With reprocessing of SNF not available, Congress passed The Nuclear Waste Policy Act (NWPA) of 1982, and amendment in 1987, to develop a geologic repository for the disposal of SNF. The NWPA established the Nuclear Waste Fund to be used only for funding SNF disposal and is financed by a fee of $1 per megawatt hour of nuclear power generated. The U.S. Department of Energy (DOE) entered into Standard Contracts with the commercial nuclear power plants in which the DOE would begin to take title to, transport, and dispose of the SNF by January 31, 1998.

The 1987 amendment stipulated that only the Yucca Mountain site was to be characterized for the geologic repository. Opposition by the State of Nevada and other groups delayed the characterization and licensing of the Yucca Mountain site and to this date the license review has not been completed. Consequently, the DOE failed in taking title to and disposing of the SNF in 1998. Therefore, the nuclear utilities sued for breach of contract damages and the federal government was ordered to compensate the utilities by paying for onsite storage of SNF.

The NWPA also granted the DOE authority to build a Monitored Retrievable Storage

(MRS) facility, which would be a centralized interim storage facility for SNF in which the stored SNF would be owned by the DOE. Local and state opposition killed any attempts to site a SNF storage facility. However, under the NWPA, an interim storage site cannot be built and the MRS facility can only be constructed after construction begins for the Yucca Mountain geologic repository.

A private consortium of eight nuclear utilities called Private Fuel Storage, LLC (PFS) submitted a license application to the NRC in 1997 to build and operate a private interim storage facility for the nation's SNF on the Goshute Indian Tribe's reservation in Utah. However, intense opposition by the State of Utah delayed the licensing and construction of this facility until PFS cancelled this project in December, 2012 15 years after it submitted the license application to the Nuclear Regulatory Commission. Since this facility was privately owned, the DOE would not have taken title to any SNF that might have been stored there.

President Obama established the Blue Ribbon Commission on America's Nuclear Future to explore other SNF management options besides the Yucca Mountain repository. On January, 2012, the Blue Ribbon Committee released its report which recommended "prompt" efforts to develop concurrently one or more consolidated storage facilities, one or more geological disposal facilities (concurrent so that interim storage does not become or is perceived by the public to become the de facto permanent solution) , and the transportation infrastructure . These recommendations would require Congress to change the Nuclear Waste Policy Act (1).

With no reprocessing, disposal, or off-site storage option available, the nuclear power plants' only option is to store their SNF onsite. Initially, the SNF was stored in pools filled with water (wet storage) to cool the used fuel until it could be shipped for reprocessing. The utilities then repacked the SNF in the storage pools into a denser configuration, increasing storage capacity five-fold. By 1986, the more-densely packed storage pools approached their storage capacity limit; therefore, the utilities had to build dry storage cask systems and moved the older SNF from the storage pools to dry storage casks (dry storage). The Nuclear Regulatory Commission (NRC) performed risk calculations on both wet and dry storage and found both had acceptable risks but dry storage is considered safer than wet storage (2) (3).

Texas has two nuclear power plant sites: Comanche Peak (two units) in Glen Rose and the South Texas Project (two units) in Bay City. These nuclear power plants are relatively young compared to others in the United States and are not expected to begin decommissioning for over three decades (projected decommissioning dates from 2047 to 2053). If the DOE is not able to take title of the SNF within the next four decades, then the SNF will remain onsite in dry storage even though the nuclear facilities will be decommissioned.

Currently the only option for SNF management is onsite storage, which was not envisioned in the initial plans of nuclear power. Even though it is considered safe, it is not an adequate solution. When a nuclear power plant is decommissioned (which can be after up to 60 years of operating life), the SNF remains onsite with nowhere to go, incurring an annual cost of $4.5 to $8 million (4) maintaining and guarding this waste (paid for by U.S. tax payers) and preventing the full site to be returned to unlimited use. The annual cost would decrease if the SNF were to be stored in one or two centralized locations instead of at each individual nuclear facility.

A solution for onsite indefinite storage of SNF is clearly needed and should not be further delayed. Since the federal government assumed responsibility for regulating SNF and for its final disposal, it should be the primary party seeking a permanent solution to managing SNF. Congress needs to either fund the license review of the Yucca Mountain geologic repository so that it could be constructed or amend the NWPA to allow for a new site selection process for one or two geologic repositories. Further, even if the Yucca Mountain facility is built, the volume of SNF has grown larger than the planned disposal volume of this repository. Therefore, either a second repository would be needed or the disposal capacity of Yucca Mountain would need to be enlarged, both actions require Congressional action to change the NWPA.

It is important to note that storage of SNF would still be required for decades even if definite plans to construct a geologic repository were implemented. If the Yucca Mountain repository is completed in 2020, the DOE estimated that interim storage would still be needed until 2056 (5). Moving the SNF from storage to disposal is calculated to require 24 years (6). If the Yucca Mountain repository is cancelled and a new site selection process begins, the earliest date for a geologic repository would be 2048 (1).

To assist with the continued need for storage options, one or more centralized storage facilities in which the DOE takes title to the SNF should be constructed so that SNF can be moved off of the nuclear power plant sites. The Blue Ribbon Committee recommended "prompt" efforts to develop one or more consolidated storage facilities concurrently with one or more geological disposal facilities. Public perception and concern about interim storage becoming the de facto permanent solution will be significantly reduced if the interim storage facility is built concurrent to efforts to site and build a geologic repository. Both DOE and the Electric Power Research Institute (EPRI) estimate that a centralized interim storage facility could be constructed within six years but may take longer if outside interferences during the NRC hearing process delay the licensing process (1) (7).

Any attempt by a private corporation to site a centralized interim storage facility would probably face the same opposition that stopped the effort by PFS. Finding a site that has local and state support would greatly enhance the chance of a private centralized interim storage site being successfully sited and constructed. The successful implementation of siting and constructing a geologic repository by the federal government would also alleviate opposition.

However, one main issue with a private centralized interim storage site is that the nuclear power plants would still have title to the SNF and would have to take back the waste if the storage facility closes without a repository available. The failure of the DOE to take title to the SNF in 1998 and the high probability that the DOE will not be able to take title to SNF in the next ten to twenty years makes the successful siting and construction of a private centralized interim storage facility highly uncertain and may be too uncertain for a private company to attempt. However, an interim storage facility owned by the federal government would allow the DOE to take title to the SNF stored in it. DOE often uses private entities to operate its national laboratories and other facilities so a DOE owned interim storage facility could conceivable be operated by the private sector.

Any federal or private program to manage SNF (disposal, storage, or reprocessing) needs to be established in a manner that reduces the uncertainty due to changing prevailing political opinions and minimizes local and state opposition through stakeholder meetings, finding volunteer communities, financial incentives, and a process that is considered fair and technically rigorous. Otherwise, the effort to license and build these facilities may result in nothing but wasted time and wasted money like the Yucca Mountain repository, the PFS storage facility, or the MRS facility. In looking at how to successfully site a facility, one should take into account current successfully sited and built radioactive waste disposal facilities such as the Waste Isolation Project Plant in New Mexico for transuranic waste and the Low Level Radioactive Waste Disposal Facility in Texas. If the methodology used for siting these two sites is built upon, the siting and construction of a SNF storage or disposal facility is not only feasible but could be highly successful.

Introduction

The first commercial nuclear power plant, the Shippingport Atomic Power Station in Pennsylvania, began producing electricity on December 18, 1957 (8). As of January 2013, 104 commercial nuclear power plants are in operation in the United States in 31 states and at 65 sites (some sites have more than one nuclear reactor). Currently, nuclear power generates about 20% of the electricity in the United States per year (9).

When electricity is produced by nuclear fission using uranium, high level waste (HLW) is also generated. High level waste is defined in Title 10 of the Code of Federal Regulations (10 CFR) §60.4 as "(1) Irradiated reactor fuel, (2) liquid wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel, and (3) solids into which such liquid wastes have been converted."

Irradiated reactor fuel is commonly known as spent nuclear fuel (SNF) and sometimes as used nuclear fuel to emphasize that about 99% of the fissionable content is still available in the fuel when removed from the nuclear reactor (10). This remaining 99% of the fissionable content can be retrieved and made into new fuel in a process called reprocessing, which produces HLW as defined in items (2) and (3) of 10 CFR §60.4. The DOE owns the HLW produced from reprocessing and is currently storing it at several federal sites; none of them are in Texas (11). Therefore, this report will concern itself only with the storage, reprocessing, and disposal of SNF from commercial nuclear power plants.

The assumption in the early days of nuclear power was that the SNF would be reprocessed so that long-term storage onsite would not be necessary. The federal government took responsibility for developing a site for disposal of the HLW. However, decades later, no disposal or reprocessing option is available and all of the SNF is stored at various nuclear reactor sites.

SNF is currently stored at 77 different sites:

- 63 sites have one or more operating commercial nuclear power reactors (two of which are in Texas),
- 4 sites are operated by the DOE (The DOE owns about 4% of the nation's SNF),
- 9 sites formerly had one or more operating nuclear reactors which have since been decommissioned, and
- One site in Morris, Illinois which was a failed reprocessing plant that never began operation.

The SNF at the sites without an operating commercial nuclear power reactor are referred to as stranded SNF (5).

Technical Descriptions

Nuclear Fuel and How Nuclear Energy is Generated

Fission occurs when a neutron hits the nucleus of an atom and splits the nucleus into two nuclei, releasing energy and one or more neutrons. The two nuclei form two new atoms called fission fragments or fission products, which are usually radioactive. A nuclear reactor is designed so that the neutrons released in the initial fissions produce more fissions and more neutrons which produce even more fissions so that a chain reaction forms in which fissions are continually occurring in a controlled manner (criticality). The energy released in the fissions is used to heat water which produces electricity in a turbine.

The fuel used in a nuclear reactor is uranium oxide. The two main naturally occurring isotopes (atoms which are the same element because they have the same number of protons but with different number of neutrons) of uranium are uranium-238 (99.2745% abundant) and uranium-235 (0.7200% abundant). Uranium-235 is fissionable and is the main source of fissions in a nuclear reactor. The uranium used in nuclear fuel in the United States is processed to have a higher concentration of uranium-235 than found naturally in the earth. Uranium-235 concentration for the light water reactors in the United States ranges from 3% to 5% (12).

The typical fuel rod for a nuclear reactor is a hollow cylindrical tube of a zirconium alloy (called the cladding) that is about half an inch wide and 12 to 15 feet long. Ceramic pellets of uranium dioxide, each pellet about the size of a thumbnail, are placed inside the hollow rod. A fuel assembly contains dozens to hundreds of fuel rods which are bound together and typically have a width of 5 to 9 inches. During operations a reactor core contains from 200 to 800 fuel assemblies, the total of which weighs about 100 metric tons.

Some of the fission products formed are strong neutron absorbers and are called poisons because they hinder criticality by absorbing neutrons which would have otherwise caused a new fission. Eventually the fission poisons build up to a level that it is no longer economical to use that fuel rod to produce electricity even though, for light water reactors, only 1% of the available fuel in that rod had been used. Subsequently, a fuel rod's useful life is typically 4 to 6 years. Usually a third of the fuel assemblies are removed from the core every 18 to 24 months (5) (13).

Neutrons may also be absorbed by the uranium nuclei and instead of causing fission will transform the uranium atom into an atom with a higher atomic number, such as neptunium, plutonium, americium, and curium. These atoms are called transuranic elements (TRU). Absorption of neutrons results in the production of fissile plutonium-239 and plutonium-241 in the SNF, which are used in most nuclear weapons.

What is Spent Nuclear Fuel

This removed nuclear fuel is SNF and contains radioactive fission products of various half-life values. A half-life is the amount of time in which half of the radioactive isotopes will decay. Many of the radioactive fission products have short half-life values and will decay completely away within five years. The radioactive decay releases energy which heats up the SNF. The SNF loses 80% of its heat in 5 years and 95% in 100 years (13). This heat emission of SNF is the main factor in determining how many fuel assemblies can be placed in a cask for storage, transport, or disposal.

Shielding is required to protect humans near SNF from a potential lethal radioactive dose. Even 10 years after being removed from the reactor core, the radiation field at one meter away from SNF would be over 20,000 rem per hour. A rem is a unit of radiation dose and a dose of 5,000 rem would incapacitate a person immediately and cause the person's death within one week (14). SNF is not hazardous to the environment if it remains intact but it would damage the environment if the spent fuel pellets are aerosolized and dispersed.

Reprocessing of SNF

Reprocessing the SNF chemically separates the uranium and plutonium from the other material in the used fuel rod. Reprocessing also produces liquid HLW, which, after solidification, weighs approximately 20% of the initial weight of the SNF (15). The HLW contains the fission products. The uranium and plutonium are returned to the reactor in the form of a new mixed oxide fuel rod.

The presence of fissile plutonium in SNF has raised proliferation concerns over reprocessing SNF. When contained within the nuclear fuel rod, plutonium is considered safe from being used in building a nuclear bomb (especially considering the high radiation field) but once separated from the other material it can more easily be used for building a nuclear bomb.

Reprocessing of SNF is technologically feasible. Russia, France, United Kingdom, India, and Japan reprocess SNF from nuclear power plants (16). France and the United Kingdom also reprocess fuel from other nations and the HLW produced is returned to the other nation. Reprocessing is done in the United States only by the federal government for military applications.

Proliferation of nuclear weapon grade material has not increased due to reprocessing of nuclear fuel for commercial energy production by these nations. Proliferation concerns should not prevent commercial reprocessing in the United States if proper security and policies are put in place to prevent unauthorized access.

The DOE possesses HLW from its programs and also the HLW generated by the commercial reprocessing operations at West Valley, New York. These wastes are managed by the DOE and are not regulated by the NRC. Any SNF disposal plans must include the disposal of the DOE HLW as well as commercial SNF (11).

Reprocessing does not eliminate waste but simplifies HLW management since the HLW generated contains less radioactivity and lower volume than the untreated SNF. The fission products have shorter half-life values than the TRU elements. After a hundred years, the activity from fission products would be mostly from strontium-90, yttrium-90, and cesium-137, which have half-life values of 29 years, 3 days (yttrium-90 is produced by decay of strontium-90), and 30 years respectively. Plutonium-239 has a half-life value of 24,000 years. However, if reprocessed, the plutonium-239 would be reintroduced into the reactor to undergo fission and split into two shorter-lived fission products. After 700 years, the activity of the TRU waste in an unreprocessed SNF rod will exceed the activity of the fission products. Additionally, the TRU radionuclides typically emit alpha radiation whereas fission products typically emit beta radiation. Alpha radiation inflicts more damage to a person (by at least one order of magnitude) than beta radiation if the radionuclide is inside the body by either ingestion or inhalation. Thus, it can be seen how reprocessing may simplify HLW management. (17)

The United States uses the once-through cycle in which the SNF rods leaving the reactor are disposed or stored as waste. The once-through cycle is also known as the "throw-away" cycle due to the fissile content contained in the SNF rods that is not being utilized to produce energy. The nuclear reactors used in the U.S. are light water reactors (either a boiling water reactor or a pressurized water reactor) in which 0.6 of a fissile atom is produced for every fissile atom consumed. For a 1,000 MW electric pressurized water reactor, the used fuel removed from the reactor and treated as waste in a typical refueling operation contains 400 pounds of fissile plutonium and 480 pounds of uranium-235, which is equivalent to one million tons of coal in energy content. Reprocessing of SNF for a light water reactor over 30 years would reduce the need for uranium ore by 40% (17).

Due to the buildup of non-fissile TRU waste in the used fuel, the SNF from a light water reactor can only be reprocessed a limited number of times (typically once). The construction of fast reactors would increase the efficiency of reprocessing even further. When neutrons are released in a fission event, they contain a portion of the kinetic energy released from the fission event and are called "fast". A light water reactor is designed to slow down the neutrons until they are "thermal neutrons" which are then used to cause fissions. In a fast reactor, fast neutrons are used for fissions and even the non-fissile TRU can be caused to undergo fission by a fast neutron. SNF from a fast reactor could feasibly be reprocessed an indefinite number of times, thus significantly increasing the efficiency of energy production (18). Research and development of commercial fast reactors has been started by the DOE but changes in the presidential administration have resulted in these projects being cancelled.

History of Spent Nuclear Fuel Management

The federal government has played a major role in the history of SNF management and therefore a review of the history of federal policy towards SNF storage, disposal, and reprocessing would help in understanding the current situation and analyzing the options for a path forward.

The assumption in the decades following the first commercial nuclear power plant in 1957 was that the nuclear power utilities would ship their SNF to be reprocessed and that a disposal site would be available for the HLW produced at the reprocessing facility. Therefore nuclear power plants were not designed and built for indefinite onsite storage of the SNF.

Because nuclear power plants were not built for indefinite storage, the federal government agreed to take on the responsibility of developing a HLW disposal facility.

Reprocessing

Political History

In 1956, the Chairman of the Atomic Energy Commission (AEC), a federal agency authorized to regulate and promote nuclear power which has since been replaced by the NRC and the DOE, announced a program to encourage the development of commercial reprocessing of spent nuclear fuel. By 1963, SNF was reprocessed in a project sponsored by the AEC at Idaho Falls on federal land (19).

President Ford issued a presidential directive in 1976 that discouraged commercial reprocessing and recycling of plutonium in the U.S. due to concerns over nuclear weapons proliferation. In 1977, President Carter issued a similar directive that deferred indefinitely all commercial reprocessing of plutonium, which ended commercial reprocessing of SNF since SNF contains plutonium. In 1981, President Reagan reversed this decision but commercial reprocessing did not resume since it is cheaper to use newly-mined uranium in a one-time use fuel cycle than to reprocess and reuse the uranium (19) (4).

Further, in 1993, President Bill Clinton discouraged commercial reprocessing in a policy statement and stopped the funding for specific DOE projects that were designed to develop new reprocessing technology. However, in 2001, President George W. Bush encouraged the development of commercial reprocessing in his national energy policy (19).

The DOE announced in February 2006 the creation of the Global Nuclear Energy Partnership (GNEP), a program in which the U.S. would "work with other nations possessing advanced nuclear technologies to develop new proliferation-resistant recycling technologies in order to produce more energy, reduce waste and minimize proliferation concerns (20)." One of GNEP goals is the development of new reprocessing technologies and advanced nuclear reactors which are designed to optimize reprocessing (21). However, on June 29, 2009, President Obama canceled the GNEP Programmatic Environmental Impact Statement for the Technology Demonstration Program (first step in starting this program) because the DOE "is no longer pursuing domestic commercial reprocessing, which was the primary focus of the prior Administration's domestic GNEP program (22)."

History of Commercial Reprocessing Plants

In 1964, a permit was issued to a commercial reprocessing facility in West Valley, New York by the AEC. This facility reprocessed fuel generated both by commercial nuclear power plants and by the defense program for the federal government. Stricter regulations were issued which forced this facility to shut down in 1972 for upgrades but the operator decided to close the facility permanently because the upgrades were not considered economically feasible (19).

In 1967, General Electric Company was issued a license for a reprocessing facility at Morris, Illinois. The process worked well at the pilot scale but failed during pre-operational trials of the production plant. General Electric closed the facility without processing any SNF in 1972. Currently, SNF shipped to this facility is still being stored in a fuel storage pool (19) (16).

Beginning in 1970, Allied-General Nuclear Services Company started construction of a reprocessing plant at Barnwell, South Carolina but stopped in 1977 due to President Carter's presidential order (19) (16).

In 1992, with no domestic reprocessing facility, Long Island Power Authority sought to have its SNF processed in France by the firm Cogema, but President George H.W. Bush prohibited this shipment (19).

Currently, no economic driver exists for commercial reprocessing in the U.S. since the one-time use fuel cycle is cheaper than the projected costs of reprocessing. Studies by the National Academy of Sciences in 1996 and the National Research Council in 2007 stated that reprocessing SNF was not cost effective. The National Research Council report also concluded that development of a commercial program would not be possible without significant funding by the DOE (19). However, federal government funding for commercial reprocessing projects has been plagued by political uncertainty. Presidential orders have alternated between encouraging commercial reprocessing and prohibiting commercial reprocessing. If the federal government were to change course and allow commercial reprocessing again, it is estimated that the first commercial reprocessing facility would not be built and available until at least 2030 and maybe as late as 2040.

Further, the option of having another country reprocess SNF generated in the U.S. was effectively closed by Presidents Bush's decision to stop Long Island Power Authority from reprocessing its SNF in France in 1992. Even if Long Island Power Authority did reprocess its SNF in France, it would still need to take back the HLW generated from the reprocessing activity and store it onsite until a HLW repository opened.

Even though the reprocessing option is not available in the U.S. due to higher costs and the uncertainty of federal government funding, the reprocessing option should still be considered as a possible future choice. Advances in reprocessing technology or other changes, such as policy or economic, may make reprocessing more advantageous than the once-through or the "throw away" cycle. The unused fissile material in the SNF represents a considerable amount of energy that could change the view of SNF from a waste to an energy resource. Additionally, specific isotopes that are useful in research, industrial processes, and medicine are contained in the SNF and could be isolated from the other fission products in a reprocessing facility. Disposing of SNF in a non-retrievable manner may be viewed as a mistake by future generations. Storing or disposing of the SNF in an easily retrievable but safe and environmental sound manner should be considered as one option in managing this waste.

Nuclear Waste Policy Act of 1982 and its amendment in 1987

After President Carter banned commercial reprocessing for plutonium in 1977, he convened an "Interagency Review Group on Nuclear Waste Management" to develop a national policy for nuclear waste management. The recommendations in the report issued two years later by this group resulted in the National Waste Policy Act (NWPA) of 1982 (23). The NWPA and its amendment in 1987 is the legal framework in which the federal government is able and authorized to manage SNF and HLW in the United States to the current day.

Under NWPA the federal government has the sole regulatory authority over SNF. Any repository developed is to be characterized by the DOE and the repository licensed by the Nuclear Regulatory Commission (NRC). Specifically, the NRC is responsible for codifying the requirements and criteria for approving construction, operation, and closure of the repository including safeguards, security, and protection of workers from radiological exposures. The Environmental Protection Agency (EPA) determined the standards used by the NRC for protecting the general environment from offsite releases during the operational and post-closure periods. Worker protection, except for radiological exposure, was the responsibility of the Occupational Safety and Health Administration and the Department of Transportation (DOT) and NRC regulate different aspects of HLW transportation (4).

Act of 1982

Congress wrote the NWPA knowing that a Congressional mandate would be necessary to overcome opposition to the site selected for the geologic repository (the disposal method chosen in the NWPA) for HLW. The state chosen as the repository site could veto the decision but this veto could be overridden by a Congressional vote in both houses. Additionally, the Act stipulated that two repositories were to be built to alleviate the feeling by the chosen state that it was being unfairly assigned the task of taking all of the country's waste. The assumption, which was not stated in the NWPA, was that one repository would be in the West and the other in the East (4).

The NWPA established the Nuclear Waste Fund (NWF) to fund SNF disposal and was to be funded by a fee of $1 per megawatt hour of nuclear power generated. In exchange for funding the NWF, the DOE is to take title to, transport, and dispose of the SNF and HLW by January 31, 1998. The NWPA authorized the DOE to enter into Standard Contracts (see 10 CFR Part 961) with any person who has generated or holds title to SNF or HLW (mostly commercial nuclear power plants) which stipulated the requirements for funding the NWF and the DOE's taking of the SNF (24).

The NWPA provided two options for DOE to store SNF. The first option was for temporary storage, called federal interim storage, for a specific volume of SNF under specific conditions. The authority to provide federal interim storage expired in 1990 and was never used. The second option was to operate a Monitored Retrievable Storage (MRS) facility (24).

Amendment of 1987

Congress amended the NWPA in 1987 due to

- The intense opposition to the DOE site selection process for both the MRS facility and the geologic repository and
- The lengthy and expensive (about a billion dollars per site) characterizing process (23).

The amendment selected the Yucca Mountain site in Nevada as the only site to be characterized for the geologic repository and offered a financial incentive of $20 million per year to Nevada. The disposal capacity of the repository was limited to 70,000 MTHM (metric ton of heavy metal) (23).

Congress constricted the construction and operation of the MRS facility to alleviate concern from the host state that the MRS facility would become a de facto permanent solution. The NRC could only issue a construction license for the MRS facility after the NRC has issued a license for the construction of the geological repository at Yucca Mountain. The amendment also limited the size of the MRS to 10,000 MTHM of SNF before the geologic repository accepted its initial shipment of HLW and 15,000 MTHW afterwards. Consequently, the MRS facility could not accept waste for storage until, at the earliest, three years before the repository opens. (24) (23).

Further, the amendment offered a financial incentive of $10 million per year to the state chosen to host the MRS site. The DOE had chosen Oak Ridge, Tennessee before the amendment for the site of the MRS facility but due to political opposition the amended NWPA prohibited Oak Ridge to be the site. Additionally, the DOE was not allowed to site the MRS facility in Nevada since it was the host state to the geologic repository. The Office of the United States Nuclear Waste Negotiator was established and authorized to find sites for and to negotiate agreements with states or Native American tribes to host the MRS facility. The position was to be appointed by the President. Any agreement would need to be approved by Congress before going into effect (4) (23).

Efforts to Site and Build a Geologic Repository

In 1983, the DOE chose several locations for further consideration as sites for a geologic repository:

- Hanford in Washington State,
- Yucca Mountain in Nevada,
- Davis Canyon in Utah,
- Lavender Canyon in Utah,
- Deaf Smith County in Texas,
- Swisher in Texas,
- Vacherie dome in Louisiana,
- Richton Dome in Mississippi, and
- Cypress Creek Dome in Mississippi.

The sites were reduced to Hanford, Yucca Mountain, Davis Canyon, Deaf Smith County, and Richton Dome in 1986 and to Yucca Mountain (geologic formation of tuff), Deaf Smith County (salt deposit), and Hanford (basalt) in 1987 (15) (25).

Due to opposition from elected officials at each site under consideration, rising costs, and a decrease in the projected waste volumes, the DOE announced in May 1986 that only one site would be picked for a geologic repository and stopped all efforts at siting the second site (23).

In 2002, the DOE issued a formal finding that the Yucca Mountain site was suitable for a geological repository and President Bush recommended this site to Congress. The State of Nevada filed an official "Notice of Disapproval" which both houses of Congress voted to override (13). The NWPA stipulated that the DOE then had 90 days to apply to the NRC for a construction license but the application was not submitted until June 2008 due to litigation and insufficient funding. According to the NWPA, the NRC had up to four years to complete the license review.

In 2009, President Obama said that the Yucca Mountain site was "no longer considered a workable option" and in 2010, the DOE requested to withdraw the application. The NRC stopped reviewing the application in 2011 since no funds were allocated by Congress for this review and no additional funds have been allocated to the present day (11) (4). A total of $11 million for reviewing the application that was allocated before fiscal year 2011 was not spent (26).

Several parties petitioned the federal court to force the NRC to resume reviewing the Yucca Mountain repository license application. The United States Court of Appeals for the District of Columbia Circuit ordered the NRC on August 13, 2013 to use the unused $11 million dollars to work on the Yucca Mountain application. Judge Brett M. Kavanaugh wrote that "the president may not decline to follow a statutory mandate or prohibition simply because of policy objections (26)." The NRC decided in November 18, 2013 that the $11 million would be used to complete the Safety Evaluation Report, which is the first step in the license application review, and requested the DOE to prepare a supplemental environmental impact statement needed to complete the environmental review (27). Additional work cannot be completed after the $11 million is spent unless Congress allocates additional funding for reviewing the license application.

The DOE had spent almost $15 billion on characterizing the Yucca Mountain site and completing the construction license application, of which about $9.5 billion was paid by the Nuclear Waste Fund (1) (28).

Impacts of the Failure to Open a Repository

Due to the failure to construct a disposal repository, the DOE was unable to take title and dispose of the SNF from the commercial nuclear power plants and thus breached the Standard Contract. The majority (74 out of 76 standard contracts) of the persons with SNF have filed lawsuits to recover damages from this breach of contract (5). The federal courts have found the DOE in these cases to be in partial breach and the federal government is required to compensate the utilities for damages (24) by paying for the onsite storage until the DOE is able to remove the SNF from the reactor sites according to the "waste acceptance" schedule in the contract (23). Damages include the capital costs for additional wet storage racks, construction of the dry storage facilities, purchasing and loading the dry storage casks and canisters, and the personnel cost to design, license, and maintain these storage facilities (5).

The federal government may not use the Nuclear Waste Fund to pay the utility since the NWPA restricts this fund to only pay for disposal. Therefore, the damages are to be paid from the U.S. Treasury Judgment Fund, which is managed by the U.S. Department of Justice and is a permanent, indefinite appropriation used by the federal government to pay damages in cases against the United States. The first payments were made in 2000. As of November 2012, a total of $2.6 billion has been paid. The total payments by 2020 are expected to range from $11 billion to $21 billion and to cost $500 million per year after 2020 (1) (5) (23).

The U.S. Court of Appeals for the District of Columbia Circuit ruled on November 19, 2013 that the nuclear power plant operators do not have to pay into the Nuclear Waste Fund anymore. Annually about $750 million in fees was collected for the fund which was expected to be at $28 billion at the end of 2012, earning $1.3 billion in interest each year (29).

In addition to suits against the federal government several states (California, Connecticut, Illinois, Kentucky Maine, Oregon, West Virginia, and Wisconsin) have passed laws that prevent or hinder the construction of a new nuclear power plant in their state unless a disposal or reprocessing option is available for the SNF (30).

Efforts by Federal Government to site a storage site

In 1987, the DOE proposed to build the MRS facility on federal land near Oak Ridge, Tennessee because the DOE already operated nuclear energy research facilities in that town. Therefore, the technical infrastructure and skilled personnel needed for the MRS facility was already locally available. However, opposition from state and federal officials resulted in the prohibition of Oak Ridge being the site of the MRS facility in the 1987 amendment of the NWPA (23).

The Office of the Nuclear Waste Negotiator sent out formal invitations to states, local governments, and Indian tribes in June 1991. In 1992, seven communities (including 5 Indian tribes) expressed interest in hosting the MRS facility and each received $100,000 in DOE grants. The communities selected for a second phase of study would have be eligible for several million dollars in grants but no second phase grants were awarded. The host states for all of the seven communities opposed the siting of the MRS facility in their state (4). In 1993, Congress blocked funding for future grants due to the opposition which effectively stopped any further progress on siting the MRS facility. In January 1995, the authority of the waste negotiator expired and was not extended by Congress (23).

Private Efforts to construct an interim storage site

After the federal government failed in selecting a site for the MRS, eight nuclear utilities (Xcel Energy, Genoa Fuel Tech, Florida Power and Light Company, Southern Nuclear Operating Company, Entergy, Indiana-Michigan Power Company {American Electric Power}, GPU Nuclear Corporation, and Southern California Edison Company) formed a private consortium called Private Fuel Storage, L.L.C. (PFS) (31).

In 1996, PFS signed an agreement with the leadership of the Skull Valley Band of the Goshute Indian Tribe, who had also volunteered for the MRS facility, to construct and operate a dry cask storage site on their reservation in Utah. A lease for 25 years with a renewal option for 25 more years was signed between PFS and the Goshute Indian Tribe but required approval by the Bureau of Indian Affairs (31).

The majority of the residents of Utah and Utah's congressional delegation opposed the PFS interim storage facility. However, the State of Utah had limited power to interfere due to the sovereign rights of Indian tribes which prevents the jurisdiction of state and local governments from entering American Indian reservations (4).

PFS submitted a license application to the NRC to build an Independent Spent Fuel Storage Installation (ISFSI) for 40,000 MTHM in 1997. The SNF would be stored vertically in steel and concrete storage cask on a concrete pad. The volume of 40,000 MTHM is sufficient to store the SNF from the eight utilities that formed PFS and also SNF from other nuclear power plants. The goal of the facility was for a "safe, efficient, and economical alternative to continued SNF storage at reactor sites (31 p. xxxii)." The application also included a proposal to construct and operate a 32 mile long rail line on public land administered by the Bureau of Land Management of the U.S. Department of Interior, who had to approve the rail construction (31).

NRC's review of the application was delayed by legal battles and the license was issued on February 21, 2006. The license authorized the facility to store SNF for 20 years with a renewal option for another 20 years (4). After 40 years of storage, it was expected that a repository would be available for the stored SNF to be disposed. If a repository was not available at the end of 40 years, then the waste generators would still be responsible for their SNF and would be required to transfer the SNF from the storage facility back to the site of the nuclear power plant (31).

PFS never initiated construction of the ISFSI due to two actions of the Department of the Interior:

- The Bureau of Indian Affairs disapproved the lease of the tribe's land due to "uncertainty concerning when the SNF might leave trust land, combined with the Secretary's practical inability to remove or compel its removal once deposited on the reservation" (32) and
- The Bureau of Land Management denied the right of way over federal land for the railway. Without the use of the railway, SNF would have to be transported by truck, increasing the difficulty, risk, cost, and time for transportation (4).

The Goshute tribe and PFS filed a federal lawsuit in July 2007 to overturn these decisions claiming that the State of Utah applied political pressure to the U.S. Department of the Interior (DOI) (23). The federal court found the DOI's decisions to be arbitrary and capricious and remanded it for reconsideration (4) (33). However, the DOI did not change its decisions and in a December 20, 2012 letter to the NRC, PFS requested that its license be terminated (34)]. The planned interim storage facility was canceled after 15 years of planning and over $70 million of legal and licensing fees (23).

Blue Ribbon Commission and its Recommendations

In 2010, the Obama administration directed the DOE to establish the Blue Ribbon Commission (BRC) on America's Nuclear Future. The BRC is an advisory body of experts to the DOE who were to review the nuclear waste management alternatives to disposal at the Yucca Mountain site. The BRC issued a report on their findings in January 2012 (11) (13).

The BRC recommended "prompt" efforts to develop concurrently one or more consolidated storage facilities, one or more geological disposal facilities, and the transportation infrastructure required to transport SNF from the reactor sites to the storage and disposal sites. The BRC recommended that the storage and disposal facilities be developed concurrently so that interim storage does not become or is not perceived to potentially become the permanent solution by the public (4). Any of these recommendations would require legislative changes to the Nuclear Waste Policy Act (1).

A DOE report in January 2013 listed the following proposed earliest dates of when the facilities could be operational: a pilot interim storage facility by 2021, a larger interim storage facility by 2025, and a geologic repository by 2048 (1). The proposed dates include time for site selection, licensing, and construction. The DOE stated that legislative changes to the NWPA and funding reform, such as allowing the Nuclear Waste Fund to pay for interim storage, would be needed (24). DOE estimated that if the Yucca Mountain geologic repository was completed in 2020, interim storage would still be needed until 2056 because of the large amount of SNF (5).

Further, according to the Government Accountability Office, several decades will be needed to transport all of the SNF to a geologic repository. By 2040, most of the reactors currently in operations will be closed (13).

Waste Confidence Rule

The Waste Confidence rule is a generic action in which the NRC found reasonable assurance that SNF could be stored safely and with a minimal impact on the environment until a disposal option becomes available. The rule arose from an NRC statement that it "would not continue to license reactors if it did not have reasonable confidence that the wastes can and will in due course be disposed of safely." The Waste Confidence rule is used for the review of new reactor licenses, license renewals, and Independent Spent Fuel Storage Installation (ISFSI) licenses to prevent the need for litigation over waste management and disposal issues for each license application (35) (36).

In 1984 the Waste Confidence rule found "reasonable assurance that one or more mined geologic repositories for commercial HLW and SNF will be available by the years 2007-2009" and stated that SNF storage is acceptable for at least 30 years beyond the expiration of the reactor's operation license. The complete duration of SNF storage includes the operational period (40 years of the original license and an additional 20 years renewal) of the nuclear reactor and includes both wet and dry storage, which results in a total of 90 years of storage for the oldest fuel. The NRC also found "reasonable assurance that safe independent onsite or offsite spent fuel storage will be made available if such storage capacity is needed." The rule was revised in 1990 to change the date for the repository to the "first quarter of the twenty-first century" (35).

The most recent Waste Confidence rulemaking in 2010 modified the prior rule by changing the date that disposal capacity will be available from the "first quarter of the twenty-first century" to "when necessary" and lengthening the time that SNF can be stored safely to 60 years beyond the expiration of the reactor's operation license (a total of 120 years for the oldest fuel). The NRC analyzed degradation mechanisms and used the fact that the temperature of the spent fuel decreases over time which decreased degradation to determine these safe storage time periods (35) (37).

New York, Vermont, Connecticut, New Jersey, the Prairie Island Indian Community in Minnesota, and several environmental groups petitioned for review of the 2010 update to the NRC's waste confidence rule. On June 8, 2012, the U.S. Court of Appeals for the District of Columbia Circuit ruled that the Waste Confidence rule is a major federal action, and therefore requires an environmental impact statement or a finding of no significant environmental impact. Additionally, the court found that the NRC was deficient in concluding that disposal will be available "when necessary" which prevented the NRC from determining the effect if disposal does not become available.

In response to the Court's decision, the NRC decided to stop all licensing activities (mostly reactor license renewals) that rely on the Waste Confidence rule until they complete the Waste Confidence Generic Environmental Impact Statement (GEIS) and revise 10 CFR Part 51 accordingly which will be no later than September 2014. The NRC released the draft GEIS and the proposed rule change in September, 2013 (retains the determination that SNF can be stored safely 60 years after reactor shutdown).

The draft GEIS includes both low and high burnup fuel and analyzed three timeframes: short-term (60 years storage after reactor shutdown), long-term (160 years storage after reactor shutdown), and indefinite in which a repository never becomes available. The long-term and indefinite timeframe analysis assumed that the SNF storage canister and cask would be replaced, requiring the construction of a dry transfer system facility, every 100 years (38).

Additionally, NRC is currently conducting an extended storage effort (expected to be completed by 2020) for storage over 120 years which includes:

- Developing technical information concerning safety issues and environmental impact,
- Developing an environmental impact statement for a waste confidence decision for storage up to 300 years after reactor shutdown, and
- Revising the Waste Confidence rule appropriately.

The NRC states that any revisions to the waste confidence rulemaking does not indicate approval for waste storage for this time period and that any authorization for waste storage time is given through the licensing of the ISFSI and certification of the storage cask (38) (39).

Recent Developments in Response to the BRC's Recommendations

The Nuclear Waste Administration Act of 2013 (senate bill 1240) was introduced by Senator Ron Wyden (democrat from Oregon) based on the recommendations in the report released by the BRC. The bill, if made into law, would establish a new independent agency in the executive branch to manage HLW and would authorize the siting, construction, and operation of repositories and storage facilities, including a pilot program for the storage of priority waste. The bill would require the federal government to enter into a consent agreement with the host state and each affected unit of general local government or Indian tribe. The bill was referred to the Senate Energy and Natural Resources committee on June 27, 2013 and had a public hearing on July 30, 2013 (40). Disagreement between the House of Representatives and the Senate over the fate of the Yucca Mountain Disposal Facility has stalled further progress on this bill.

Representatives of state governments are communicating with the federal government their concerns about the potential future siting process and operation of any HLW disposal or storage facility. The Environmental Council of the States issued recommendations that the "states be considered partners with all appropriate federal agencies and should have a clear decision-making voice on activities proposed within their borders" (41). Past experience has shown that siting a radioactive waste facility often fails when the state strongly opposes it even though in nearly every case the affected local governments strongly supported the facility because of the jobs created and as a means of economic growth for the local area (42). Both local and state support will be needed to successfully site a HLW disposal or storage facility.

Some support for hosting a nuclear facility have been expressed by local communities or Indian tribes, such as those volunteers for a GNEP project in 2006. It is not possible to gauge the number of communities or the level of support for hosting a HLW repository or storage facility since new legislation for the siting process has not yet been passed and no call for volunteers has been issued. A search of news stories or Internet sites indicated interest from the state of Arizona to store SNF and one community actively promoting itself to be a site of an interim SNF storage facility: the Eddy Lee Energy Alliance (ELEA).

The ELEA is a limited liability corporation consisting of Eddy and Lea County in New Mexico and the cities of Carlsbad and Hobbs, which are located in a region called the New Mexico's Nuclear Corridor. The ELEA was formed in 2007 to obtain a grant under the GNEP as a possible site for a reprocessing plant and was one of eleven sites chosen as a potential candidate. Strong public support for the project was shown in three public meetings which were attended by several hundred local residents (43) (44). ELEA sent a notice of intent, dated February 26, 2013, to the NRC to submit a site-specific license application in 2015 for a consolidated SNF storage facility in response to the DOE's January 2013 Strategy Document for implementing the BRC's recommendations (45). ELEA has chosen the French firm AREVA to build the above-ground interim storage facility on 1,000 acres between Carlsbad and Hobbs which is estimated to create 150 jobs (armed guards, nuclear scientists, engineers, managerial and administrative staff) (46). No further developments have been made public since this report was written.

The Arizona Legislature passed a non-binding resolution on April 24, 2012 that requested the federal government to consider Arizona as the site of a SNF storage facility (47). The Arizona Energy-Education Fund Coalition is an assembly of stakeholders from the private sector, government, education and energy industries that has formed to support the siting of an interim or permanent storage facility for HLW in Arizona (48) (49).

Current Practices for storing SNF

Wet Storage

When nuclear fuel is removed from the reactor, it is placed inside a pool of water (called wet storage). The water provides both cooling for the hot SNF and shielding from the radiation for the workers at the reactor. The water in the pool is circulated to maintain the temperature at 120 °F; otherwise the water would boil. Without cooling, the SNF temperature can increase by hundreds or thousands of degrees Fahrenheit (13).

A storage pool has a stainless steel liner and reinforced concrete walls that are several feet thick. The fuel rods are stored vertically in the pool that is typically 40 feet deep so that over 20 feet of water is over the fuel rods. The water is filtered and the chemistry is carefully controlled to minimize corrosion. Consequently, a storage pool needs continual maintenance and a constant supply of electricity (5) (13).

The pool for a pressurized water reactor is at or below ground level, but for a boiling water reactor, the pool is about three stories above ground level, near the reactor vessel (13).

Utilities only allow SNF to occupy up to approximately three-fourths of the storage capacity in order to reserve space for at least one full reactor core load of fuel. The storage capacity of the pools range from 2,000 to 5,000 fuel assemblies (average of about 3,000) throughout the U.S. (5). The number of fuel assemblies that can be placed in a storage pool is limited by the decay heat emitted by the SNF and criticality concerns.

The storage pool and all pool activities are licensed by the NRC under the reactor's 10 CFR Part 50 operational license.

Denser Arrangement

Fuel storage pools were initially designed to store the SNF for a limited time until they cooled to a sufficiently low temperature at which time they could be shipped for reprocessing. Consequently, the pools were designed to only hold about one and one-third of a core's full loading of fuel rods. However, when no reprocessing or disposal option became available, utilities built new fuel storage racks to pack the fuel rods in a more dense formation, increasing the storage capacity five-times (13) (23) (50).

The NRC conducted safety studies and approved the more densely packed configuration provided that cooling is adequate, structure integrity is maintained, and steps are taken to prevent criticality (13). Neutron absorbers were added to the pool to negate any criticality concerns. The isotope Boron-10 is a strong neutron absorber and placed in the pool in the form of boron carbide in an aluminum metal matrix (51).

Even with this denser configuration by 1986, fuel storage pools were nearing their storage capacity limit (13) (23). When the pool approached its storage capacity, utilities began to move the older SNF into "dry cask" storage (28).

Risks of Accidents

The highest risk of wet storage is a loss of coolant (water) resulting in a self-sustaining fire. Risk is defined as the probability of an accident occurring multiplied by the consequences of the accident. A self-sustaining fire is a low probability, high consequence event (13).

A self-sustaining fire can only occur if enough water is lost so that the top half of the fuel rods are uncovered and the fuel reaches a temperature of 1,830 °F. The initiating event for the loss of water would need to be an earthquake over the design limit, terrorist attack, or other similar event that also disables the means to add more water to the pool. At 1,830 °F, the zirconium alloy can react with oxygen and release energy, burning like a welding torch. This fire can spread to other spent fuel rods if they are densely packed.

The SNF storage pool is designed and constructed to prevent and mitigate a self-sustaining fire (13).

An additional concern is that if the water heats up and produces steam, the steam can react with the hot zirconium cladding and produce hydrogen gas that can cause an explosion if it is mixed with oxygen (13).

The NRC calculated the risk of an individual early fatality (death within months verses a cancer death decades later) within one mile from a self-sustaining fire to be 1×10^{-7} per year (one death per ten million years) one month after the reactor has been shut down and it decreases to 2×10^{-8} per year (one death per fifty million years) five years after reactor shutdown. The risk of an individual latent cancer fatality within ten miles from a self-sustaining fire is 7×10^{-9} per year (one death per 143 million years) for both one month and five years after reactor shutdown. These risks were the maximum calculated risk assuming the highest possible radioactive content of the SNF and the highest seismic risk. The maximum calculated risks are an order of magnitude lower than the NRC safety goal and is thus regulatory acceptable (2).

On March 11, 2011, an earthquake and a tsunami hit the Fukushima Prefecture of Japan, causing a loss-of-coolant accident in Units 1 to 4 of the Fukushima Dai-ichi reactors. The reactors lost all power: power generated by the reactors, offsite power supplied by other power generators, and emergency onsite diesel generators. Therefore, they were unablc to continue to pump water. As a result of the loss of coolant and of hydrogen gas explosions, some of the nuclear fuel rods in the reactor melted and released radioactive material (52).

The dry storage cask onsite and storage pools outside of the reactor buildings were not damaged during this incident. The spent fuel storage pool inside the reactor containment structure was damaged due to rubble falling onto the pool when hydrogen explosions damaged the building. Additional damage may have occurred due to the loss of electricity which resulted in no ability to monitor the pool or add additional water. The SNF stored inside the damaged pool appears to be undamaged and efforts to remove them from the damaged pool began in November, 2013 and are expected to be completed at the end of 2014. Coolant water is currently being added to the storage pools as needed (5) (53).

Additionally, the NRC has determined that some storage pools have contributed to tritium and other radionuclide contamination of groundwater (along with other parts of the nuclear reactor). These leaks were determined to be within regulatory limits and therefore no significant public exposure or health impact resulted from these leaks (5) (54).

Dry Cask Storage of SNF

Dry cask storage is synonymous with Independent Spent Fuel Storage Installation (ISFSI) because all but one ISFSI site (the failed reprocessing plant at Morris, Illinois) uses dry casks (5). The first commercial onsite dry storage facility was built at the Surry Nuclear Power Plant in Virginia in 1986 (55). By 2020, it is expected that all reactors will be using dry storage casks onsite (23).

Dry cask storage is only feasible after the heat emitted by the spent fuel rod has decreased to a level sufficient for natural convection of ambient air to maintain the fuel temperature below 752 °F. The Zircaloy cladding may be damaged at temperatures above 752 °F.

Typically, five years of cooling after the fuel rod has been removed from the reactor core is considered necessary before it can be transferred to dry storage (13) (23). However, the NRC has authorized transfers into dry cask storage for SNF removed as early as 3 years from the core (28) and states that fuel may be moved to dry storage after only one year (55). The actual time for moving SNF into dry cask storage is on average ten years (28).

Description of Dry Storage Cask System

The SNF is placed inside a thin-walled steel canister which is filled with the inert gas helium to prevent oxidation from damaging the structural integrity of the canister. The lid is either welded or bolted shut. The canister is then placed inside a larger stainless steel or thick-walled concrete dry storage cask (which has an inner steel liner). The casks are cylindrical and the concrete thickness provides shielding from the radiation. Vents are placed on the top and bottom of the dry storage cask for convective heat transfer.

The casks are stored either vertical on a concrete pad or horizontal in a concrete vault in which the thick concrete wall of the vault provides radiation shielding. Some more recent systems have the dry storage cask placed in a hole which increases the security from attack or weather and reduces the radiation exposure. The dry storage cask containing hotter SNF may protrude from the hole by two feet to increase the cooling from air flow. The pad or vault is secured with safety systems and a security infrastructure, including radiation detection devices and intrusion detection systems (1) (5) (13) (23) (55).

The NRC has licensed over 50 different dry storage casks manufactured by about a dozen companies. The NUHOMS 61BT storage canister weighs 22 tons empty and 44 tons when loaded with SNF. A dry storage cask, fully loaded, can weigh from 100 to 180 tons (5) (13) (23) (55).

The number of SNF assemblies that can be stored in a dry storage cask is limited by the decay heat emitted by the used fuel. The longer the SNF is stored in the cooling pool, the lower the decay heat, and the more fuel assemblies that can be placed in the dry storage cask. If the cooling time in the pool is from 5 to 15 years, a less expensive storage cask can be used that does not need to be built to withstand a higher heat load (23).

By the end of 2012, about 200 dry storage casks out of 1700 in the United States (U.S.) contained high burnup fuel and nearly all of the SNF being loaded into dry storage casks is high burnup (56) (57).

Transfer from wet storage to dry storage

The first step to transferring a fuel assembly from wet storage to dry storage is to place the dry storage steel canister inside a transfer cask (usually has a four inch wall thickness of steel and lead) and then lower both into the storage pool. The water in the pool offers excellent radiation shielding for the transfer. A crane is used to place the spent fuel assembly into the dry storage steel canister. Afterwards, the transfer cask and its contents are lifted up from the pool and any water remaining inside it is removed using either vacuum drying or a force helium system. After drying, the lid is welded or bolted onto the canister. The spent fuel in the transfer cask is moved to the dry storage facility and the dry storage canister is transferred from the transport cask to the dry storage cask. Typically, before the transfer, the transfer cask is placed on top of the dry storage cask and the two casks are coupled together with a mating device (7) (13).

Transferring a cask from wet to dry storage requires several weeks. Some of the more time consuming steps in this process include:

- Mobilizing equipment requires two weeks and demobilization requires an additional two weeks,
- Training personnel, which includes practicing the procedure, and
- Actual transfer (typically a week), which includes drying and sealing the canister, transportation to the storage pad, and placement into the dry storage system.

In addition, constraints that limit the number of canisters that can be loaded concurrently are heavy lifting capacity, available space in the SNF storage pool, and available space to dry and seal the transportation canister (13).

Licensing and Certification

The NRC issues a certificate of compliance for a dry storage cask (which includes the canister to be placed inside) only if the manufacturer can demonstrate that the cask will protect the SNF in case of extreme events such as flood, earthquakes, tornado missiles, temperature extremes, and terrorist attack. Computer analyses, comparisons with other designs, component testing, and scale-model testing are all utilized in testing the cask and reviewing its design. Physical tests performed on the cask include being dropped from the maximum height possible during transfer operations, being tipped over, fires, and floods. The manufacturer must also commit to follow an approved quality control program that ensures the containers continuously meet design specifications. The certificate of compliance is issued for storage not to exceed 20 years, which may be renewed for up to an additional 40 years (13) (55) (58). Different criteria and tests are required for transportation certification.

The dry storage facility is licensed independently from the nuclear reactor as an ISFSI and is considered to be independent from the reactor even though they are located at the same site. The ISFSI license is either a site-specific license or a general license. Of the ISFSIs licensed by March, 2013, 48 are operating under a general license and 15 under specific licenses (23) (58).

If the planned ISFSI is to be constructed on the site of a facility already licensed to store SNF (such as a nuclear reactor) and a NRC certified cask is to be used, then the ISFSI can be authorized by a general license. A general license saves time and money by avoiding duplicating effort already performed during the license application process for the nuclear reactor, such as the environmental impact statement and seismic reviews. The Licensee must review and modify their existing procedures — such as safety, emergency preparedness and response, and security — to accommodate the ISFSI. Three and a half years is the typical time from designing the ISFSI to the first loading of SNF, assuming a NRC certified cask is used otherwise an additional two to three years will be needed (7).

If a person is not authorized to apply for a general license, he must then apply for a site specific license. Six years is the typical time from designing the ISFSI to the first loading of SNF, assuming a NRC certified cask is used (7).

An ISFSI may be licensed for 40 years with the option for a renewal of another 40 years (10 CFR §72.42). The GEIS from the waste confidence rule will also apply towards renewing the ISFSI license (38).

Some utilities have had public opposition to plans to store SNF onsite in a dry cask storage system but no dry cask storage has been prevented (59). However, some limitations have been placed on some utilities by the host state (60). For example, Minnesota law (M.S.A. §216B.243) requires the facility to "address the impacts of continued operations over the period for which approval is sought" before the state will issue a certificate of need for additional storage of SNF (30).

Stranded SNF at decommissioned reactors

When a reactor is decommissioned, all of the SNF in wet storage is transferred to dry cask storage and the storage pool is decommissioned. However, the entire nuclear power plant site cannot be decommissioned and returned to other use because the SNF is in dry storage. A common term used for the SNF in this situation is stranded SNF. In the U.S., nine former operating nuclear reactor sites have been decommissioned with SNF remaining onsite: seven have the SNF in dry storage and the other two are in the process of transferring the SNF from wet storage to dry storage (5) (13). The number of sites with stranded SNF will increase as reactors close without an off-site storage or disposal option available.

If any of the stranded SNF at these sites requires repackaging, there is no SNF storage pool to use to perform the transfer, which would increase cost, risk, and exposure to workers for any transfer. Either the SNF would need to be transported to a storage pool at another reactor site or a new transfer facility must be constructed.

One option that has been considered is to move the SNF from the decommissioned nuclear reactor site to another nuclear reactor that is still operating. However, the nuclear reactor operation license issued by the NRC authorizes the nuclear power plant to only possess the amount of SNF necessary to operate that reactor. Therefore, a license modification would be necessary to store additional SNF which would require public hearings at which local opposition would be expected (24). Transferring SNF from a decommissioned reactor to another operating reactor has only been done when both reactors are located at the same site and are owned by the same utility (5).

Risk of Accident

Dry cask storage is considered safer than wet storage because the dry cask storage system is not affected by loss of electricity, coolant, or significant active monitoring. Additionally, SNF in wet storage may be subject to a hydrogen explosion if a loss-of-coolant accident occurs in the reactor. Each dry storage cask holds less SNF and therefore less radioactivity (32 to 68 fuel assemblies per cask) than a storage pool (thousands of fuel assemblies), thereby lessening the consequences of any accident.

A radiological release off-site from a dry storage cask would require that the fuel be aerosolized and that a hole be formed in both the inner and outer shielding that is sufficiently large to allow the aerosolized fuel to escape. Aerosolization of the fuel, which is a ceramic, would require a source of energy, such as a fire.

The NRC estimated that a dry storage cask has a risk of causing a cancer fatality within 10 miles due to a containment failure of 1.8×10^{-12} per year in the first year of operation and 3.2×10^{-14} per year (one fatality ever 31.25 trillion years) for subsequent years. The NRC did not find any risk of a prompt fatality within 1 mile of the dry storage cask (3).

Accelerated Transfer

Since dry cask storage is considered safer than wet pool storage, over 150 community action and environmental groups have advocated for an accelerated transfer from wet storage to dry storage. Accelerating the transfer would decrease the SNF density in the storage pool which would in turn decrease the consequences for any accident in which the pool loses water (13).

Utilities typically wait until the storage pool approaches its capacity before moving the older SNF into dry cask storage because the NRC has determined that pool storage is adequately safe, the license and the regulations allow it, and to avoid what is viewed as an unnecessary cost of moving the fuel to dry storage (5). Reactor operators have stated that the increased risk and expense (billions of dollars) of accelerating the transfer of SNF out of pool storage is not worth the benefits, especially since there is no appreciable increase in safety (13).

The NRC position is that the risk for failure in both wet and dry storage is an acceptable risk and that both types of storage adequately protect the public health and safety, the environment, and security (13). Subsequently there is no urgent safety or security reason for accelerated transfer (28) (61).

Conversely, transferring SNF into the dry storage canister in the storage pool has a risk and accelerating this transfer may increase this risk (13). For example, the risk of an early fatality for a cask drop is 4×10^{-5} for 1 month after reactor shutdown and 7×10^{-8} for 5 years after reactor shutdown for the highest possible radioactivity scenario (2).

Costs

Estimates for the cost of licensing and construction of an onsite dry cask storage facility range from $19 million to $50 million. In addition to licensing and construction costs, costs of containments for storage are also significant. For instant, a storage cask that can store 20 to 30 SNF assemblies from a pressurized water reactor or 60 assemblies from a boiling water reactor costs from $750,000 to $1 million. Further, operating cost for an onsite storage facility is $1 million per year when the reactor is operating and increases to a range of $4.5 million to $8 million when the reactor is decommissioned and the SNF is stranded. And once the site is no longer operational, the cost of transferring SNF from pool storage to a dry storage cask ranges from $1 million to $1.8 million per dry storage canister (13) (4) (23) (62).

Higher Burnup Fuel

Within the last 15 years, utilities have been increasing the burnup rate of nuclear fuel by operating the reactor at a higher power level and extending the time the fuel is in the reactor. Until 2001, the burnup rates typically did not exceed 35,000 megawatt days per metric ton uranium (MWd/MTU). In 2013, the average burnup rate for Pressurized Water Reactors is 51,000 megawatt per metric ton heavy metal (MW/MTHM) and expected to increase up to 55,000 MW/MTHM by 2021; for Boiling Water Reactors the average is 45,000 MW/MTHM in 2013 and not expected to increase to more than 46,000 MW/MTHM in the future. The storage systems for SNF have been developed for the lower burnup rate and thus the increased burnup rate presents additional challenges for long-term storage of SNF. For example, higher burnup fuel emits more heat when removed from the reactor and is expected to require seven years of wet storage before it can be transferred to dry storage (1) (63) (56) (23).

Storage Lifetime Research

Determining the lifetime for the various components of the storage system (spent fuel, cladding, canisters, casks, and concrete shielding) is important since the SNF is expected to be stored indefinitely. Damage to the SNF and its containers may need to be rectified before it can be transported for interim storage or disposal.

Research has been conducted to determine the lifetime of SNF and other components of the dry storage system, mostly for fuel with a burnup below 45,000 MWd/MTU. In 1999 EPRI conducted an inspection, with the assistance by the NRC and DOE, of a SNF assembly (The fuel had a burnup of 35,000 MWd/MTU and was in dry storage for 14 years). The main objective was to inspect for any signs of degradation in the cask and in the spent fuel assembly, especially the Zircaloy cladding. Additional tasks were a visual examination of the cask and of the outer surface of the fuel assembly, check of the concrete pad, radiation survey to test the shielding for degradation, and an analysis of the gas inside the cask for any evidence of outside air having entered the cask or of gaseous fission products. Destructive analysis was also performed on the spent fuel rods.

No evidence of significant degradation was found:

- The gas analysis found no outside air or gaseous fission products inside the cask.
- The O-rings for the cask lid were in good shape.
- No major crud spallation was seen from the surface of the fuel rod.
- All parts of the fuel and dry cask storage system appeared the same in 1999 as

they did in 1984.

The destructive testing showed that the fuel and cladding properties were acceptable for safe storage. In addition, creep was not expected to increase significantly over time since the temperature decreases over time, which reduces stress and pressure (64) (65).

Building upon this inspection, EPRI is the lead contractor in a DOE-sponsored study (Extended Storage Collaboration Program) to research aging effects and mitigation options for long-term storage and subsequent transportation of HLW and SNF. The DOE, the NRC, and the U.S. Nuclear Waste Technical Review Board have completed a technical gap analysis to set the research priorities of this program. The three gaps that have the highest priority are

- Cladding degradation of high burnup fuel (over 50,000 MWd/MTU) due to creep and hydride reorientation,
- Corrosion on the outside surface of the stainless steel welded canister (containing SNF and helium inside), and
- Concrete, used for shielding and structure, degradation.

To address the first priority of high burnup fuel, EPRI plans to use a dry storage cask which is equipped with sensors to monitor the SNF for a period of up to 10 years at the ISFSI at Dominion Virginia Power's North Anna nuclear energy facility (66) (57).

Current Situation in Texas

Texas has four commercial nuclear power plants located at two sites and two universities with research nuclear reactors. The DOE Pantex site is located near Amarillo and it may contain HLW. The DOE dismantles nuclear weapons at this site and is outside the scope of this report.

The two nuclear power plants are relatively young (first one began operation in 1988) and, assuming they both renew their licenses for an additional 20 years, have at least 35 years before initiating decommissioning. One site has a dry cask storage system in use and the other site is expected to use dry storage by 2016. The dry storage systems will be paid for by the federal government. After the reactors are decommissioned, if an interim storage or disposal option is not yet available, the SNF will be stranded and will remain on the site in the dry storage system.

The DOE takes responsibility for the SNF produced in the university research reactors, as it does for all research reactors. Therefore, the universities do not face the same issues of SNF storage and disposal.

Comanche Peak

Comanche Peak Nuclear Power Plant is located at Glen Rose, about 40 miles southwest of Fort Worth. It is operated by Luminant Generation Co., LLC. The plant currently contains two units. Units 1 and 2 are both pressurized water reactors and both are licensed for 3,612 Megawatts thermal. The license for Unit 1 was issued on April 17, 1990 and will expire February 8, 2030 and the license for Unit 2 was issued on April 6, 1993 and will expire February 2, 2033. Both licenses can be renewed for another 20 years.

A license application for two new units (advanced pressurized water reactor) had been submitted to the NRC in September 19, 2008. The projected date for the NRC Commission to make a decision on granting the license is November 2015 (67). However, in November 2013, Luminant Generation Co. suspended its plans to build these new reactors but did not withdraw its application to the NRC (68).

A dry storage cask system of concrete casks stored vertical on a concrete pad was constructed in 2011 and the first SNF was loaded into these casks in 2012 (62).

South Texas Project

The South Texas Project (STP) Nuclear Power Plants are located at Bay City, about 90 miles southwest of Houston and are operated by STP Nuclear Operating Co. STP currently has two licensed units. Units 1 and 2 are both pressurized water reactors and both are licensed for 3,853 megawatts thermal. The license for Unit 1 was issued on March 22, 1988 and will expire August 20, 2027 and for Unit 2 was issued on March 28, 1989 and will expire December 15, 2028. Both licenses can be renewed for another 20 years. On September 20, 2007, STP submitted a license application for two new units (advanced boiling water reactor) (67). The NRC determined that the applicant did not meet foreign ownership requirements and the application review has been indefinitely delayed (69).

In June, 2013, Holtec International announced that it received the contract to build a dry storage system of concrete casks placed vertically for STP with initial loading of SNF in 2016 (70).

Research Reactor at Texas Universities

Texas A&M University at College Station has two reactors: an AGN-201M and a TRIGA Mark I. The AGN-201M has a thermal power rating of 5 W and was purchased by the university in 1957. The TRIGA Mark I has a thermal power rating of 1 MW (71). The University of Texas at Austin has a TRIGA Mark II which can achieve power levels up to 1 MW at steady-state operation or up to 1500 MW for up to 10 milliseconds in pulsing mode operation (72).

Research reactors differ from electricity producing commercial reactors in that the reactor is not operated continuously but only when needed for training or research. Consequently, a nuclear fuel rod could be in the reactor for up to twenty years. Research reactors also have a smaller core size. The volume of spent nuclear fuel stored onsite is considerably lower than the volume stored at commercial nuclear power plants.

The DOE owns the fuel in research reactors and picks up any SNF once contacted by the university. The time that SNF is stored onsite is dependent on the waste collection schedule of when the DOE can have the personnel and equipment ready for pick up.

Safe and secure storage of the SNF is available onsite. Since the DOE takes title of and picks up the SNF, the problem of SNF storage and disposal does not apply to these two universities.

Transportation issues

There are several methods used to transport SNF such as railways, barge, and public roads. In the U.S., over 3,000 shipments of SNF have been transported over a total of 1.7 million miles between 1970 and 2010 (2010 chosen since it is the time of the report referenced). In the course of those 3,000 shipments there were only a total of nine accidents. Further, of the nine accidents, only five involved radioactive material and in none of those accidents was any radioactive material released.

Generally, rail transport is considered to be less expensive than truck transport, but actual cost is difficult to calculate (23). Accident calculations also show that rail transport is safer and is expected to result in fewer accidents (6).

The transportation of the large number of SNF casks being stored at 77 different sites throughout the country will be a complex logistical project that will require time and money. Transporting all of the SNF to a single site (assuming 2,000 metric tons per year) is expected to take over twenty years (13) (23). The DOE estimated that SNF would be accepted over 24 years for the Yucca Mountain repository with up to 10,700 rail shipments (mostly rail scenario) or 53,000 truck (mostly truck scenario) shipments in highway transport (6). PFS expected that one to two trains would arrive each week, with each train carrying two to four shipping casks and each cask containing about 10 MTHM (31).

Requirements for Transportation Casks

The transportation casks must

- Have a strong structural integrity to withstand accidents without releasing radioactive material,
- Provide shielding from radiation, and
- Dissipate the heat emitted by the fuel.

In addition to the requirements listed above a cask must be certified by the NRC for transportation. The certification review and testing of the cask must demonstrate that in an accident the cask will not release any radioactive material, limit radiation doses to acceptable levels, and prevent criticality from occurring. Further, the cask must pass four tests which simulate severe accident scenarios:

- Impact: 30 foot drop onto an unyielding flat surface,
- Puncture: 40 inch drop onto a vertical steel bar,
- Fire: exposure of the entire cask to a fire for 30 minutes, and
- Submersion: immersed under three feet of water and also pressure is applied which is equivalent to 50 feet and 650 feet (only for casks designed to hold over a million Curies of radioactivity) of water (6).

Transportation casks are built to comply with all these requirements by having walls of steel and shielding materials (typically concrete) and a massive lid. To further ensure safety during transport, impact limiters are placed on both ends of the container during transport which absorb impacting forces during an accident. A truck typically carries one to two tons of SNF in a shipment that weighs, when including the weight of the transportation cask, about 25 tons. A rail transportation cask can carry up to 20 tons of SNF and weighs up to 150 tons (28).

To date, NRC has not issued a certificate for a cask to transport the high burnup SNF (13) (4). High burnup SNF may require additional time for cooling or to have fewer SNF assemblies loaded into a cask. Modifications for certified casks to transport high burnup fuel may include a redesign of the heat removal system, the radiation shielding, and the structural support for the SNF assemblies (56).

Dual-Purpose Casks: Storage and Transport

Casks certified for storage are tested and designed for different criteria than casks certified for transport. The NRC regulates the design and construction of the transportation casks under 10 CFR Part 71 and for storage under 10 CFR Part 72.

The development of dual-purpose (both storage and transport) casks began in the late eighties and now only dual-purpose casks can be procured (7). In the U.S. in 2010, about 238 of the 1,242 dry storage casks storing SNF are not dual-purpose casks (23). If transportation standards change, degradation has occurred, or if the fuel has changed from what was certified (such as higher burnup of fuel), then the dual-purpose cask may no longer be certified for transport.

As part of the Yucca Mountain project, the DOE designed a canister that can be used for storage, transport, and disposal to minimize any transferring of SNF from cask to cask. This canister is called the transportation, aging, and disposal (TAD) canister. However, no TAD canisters have been produced commercially (13) (23).

Standardization

The NRC has licensed over 50 different models of dry storage casks manufactured by about a dozen companies. The use of different storage casks and facilities throughout the country has the consequence of increasing transportation cost due to the inability to use standardized equipment such as the grappling hook or other equipment that needs to be modified to fit the various sizes of the transport casks. The DOE estimated that to move the stranded SNF at the seven sites in four years would require 20 NRC-certified transportation casks since the SNF is stored in six different types of casks and each cask type requires a specific transportation cask system (24).

Planning and Infrastructure

Transportation planning may take up to 10 years to determine agreed-upon transportation routes and to establish safety and security procedures (1). Required tasks include coordinating federal, state, and local emergency response plans along the expected transport routes, training first responders, designing and building infrastructure and equipment, and developing inspection protocols. The DOE has considerable experience in transportation planning and implementation with one example being the shipments of transuranic waste to the Waste Isolation Pilot Plant in New Mexico.

Infrastructure and equipment required for large scale shipments of the SNF in this country are not available and will need to be designed, fabricated, tested and licensed. The Association of American Railroads requires the rail cars to have a special safety feature to transport SNF and it is expected to take 5 to 7 years to design and develop rail cars with these features (4). The locomotives used to pull these rail cars also need special features, which had been designed and tested by PFS (23). The number of certified casks available for SNF transport is few and are mainly for use with trucks (4).

Another transportation challenge is to build rail spurs to the 72 commercial nuclear power plant sites and obtain permission to ship the SNF on the rail network. The DOE, in their investigation of developing a rail shipment scheme for the Yucca Mountain repository, determined that 25 of the commercial nuclear power plant sites had no direct rail access (12 had rail access within 10 road miles, 9 within 50 miles, and 4 within 200 miles) but a majority of them could use barge transport to access a port-rail facility (23).

Additionally, the reactor operators will need to modify the infrastructure at the storage site and procure dedicated equipment for moving the casks off the reactor sites (4).

Safety and Security

SNF is more vulnerable to sabotage or accidents during transportation compared to storage since fewer security personnel and fewer engineered barriers are available. Consequences due to sabotage or accidents are also higher during transport since the waste may be near population centers (60).

According to DOE calculations, the accident probability for a SNF shipment by rail is 1 in 10,000 and by truck is 1 in 1,000. Over the 24 years of shipping SNF to the repository, the number of expected accidents is one if shipments are mostly by rail (10,700 rail shipments) or 53 if shipments are predominately by truck (53,000 truck shipments). Further, the probability that an accident would result in even a small release of radioactive material or that the radiation shielding is damaged resulting in a low radiation exposure to the public in the nearby vicinity is 0.0001 (0.01%, 1 in 10,000). Therefore, the probability of the public being exposed to radiation in an accident over 24 years is 0.01% for the mostly rail shipment scenario and 0.53% for the mostly truck shipment scenario (6).

The "maximum reasonably foreseeable accident scenario" for truck transport in which radioactive material is released in a urbanized area results in a 0.15% increase in the probability of getting cancer for the maximum exposed individual and has a probability of occurring of 0.000023% (occurs once every 4.3 million years). For transport by rail, the "maximum reasonably foreseeable accident scenario" results in an increase cancer risk of 1.5% to the maximum exposed individual and has a probability of 0.000028%

(occurs once every 3.6 million years). For the 24 years of normal transportation (no accidents), the increase in cancer risk for the maximum exposed individual for the mostly truck scenario, which would be a truck stop worker, is 0.1% and in the mostly rail scenario, someone who lives next to a rail stop, is 0.01%. These increases in cancer risk are insignificant when compared to the national average probability of cancer of about 25% (6).

The NRC is currently modifying the security rules for transporting SNF and other high activity radioactive materials. Proposed changes include advance planning and coordination with states, increased notifications and communications, continuous and active shipment monitoring, armed escorts during the entire transport (currently it is required only in highly populated areas), and background investigations of personnel who have access to information about security and safeguards of the shipment (4).

Analysis of the Available Options

The federal government assumed responsibility for the disposal of HLW to promote nuclear energy while protecting the public and the environment. The NRC regulates nuclear power plants and the management of HLW. Under the NWPA, the DOE was to take title to and dispose of the SNF stored at the commercial nuclear power plants in 1998 but was unable to fulfill this requirement due to the lack of a repository successfully being built at Yucca Mountain. Attempts for centralized interim storage of the SNF, both by the federal government and by private companies, have also failed. Reprocessing of the SNF, though done in several other nations, is not a viable option in the United States. The current situation is that SNF is stored onsite at the nuclear power plant sites and will continue to be stored onsite indefinitely.

Reprocessing

Reprocessing of SNF is technologically feasible and would extend the energy potential in nuclear fuel and decrease the volume and radioactivity of HLW. The question on whether commercial reprocessing should be developed in the United States is a part of the much larger question on the future of nuclear power in this country, which is outside the scope of this report.

Reprocessing is currently not economical compared to the one-time use of nuclear fuel and thus there is no cost driver to build commercial reprocessing capability. Commercial reprocessing will need significant funding by the DOE to be viable. However, the current administration does not support reprocessing. The long time required to develop commercial reprocessing capability is longer than the average time in which political support for reprocessing changes which has effectively stalled any attempt to build a commercial reprocessing facility.

Even if a commercial reprocessing facility was to be built, it would not be available until 2030 to 2040 (5) (23). Therefore, near-term HLW management policies should not include the possibility of reprocessing. However, reprocessing technology can change the view of SNF as waste to that of a valuable energy resource. Advances in technology or changes in policy or economics could feasibly favor the development of commercial reprocessing in the future and should not be ruled out. Consequently, SNF storage and disposal facilities should be designed so that SNF can be easily retrieved in case reprocessing becomes available in the U.S.

Onsite Storage

NRC has determined that the current system of storing SNF in a dense configuration in the storage pool inside the reactor building and in a dry storage cask system on the site of the nuclear power plant is within acceptable safety limits. Studies have indicated that SNF can be safely stored in this manner for 120 years; however, these studies have some uncertainty concerning the higher burnup fuel that recently has been discharged from the reactors.

The nuclear power plants in Texas are relatively young compared to other reactors in the United States and are not expected to shut down for over 3 decades. If the DOE is not able to take title to the SNF in three to four decades, then the SNF will remain onsite in dry storage even though the reactor facility will be decommissioned.

Onsite storage for decades is currently the only available option for SNF management, which was not envisioned in the initial plans of nuclear power. Although considered safe, it should not be considered an adequate solution. A nuclear power plant has an operating life of up to 60 years and then is decommissioned. When a nuclear power plant is decommissioned, the SNF remains onsite with nowhere to go, increasing the cost of maintaining and guarding this waste (paid for by U.S. tax payers) and preventing the full site to be returned to unlimited use.

The lack of an alternative to onsite indefinite storage is hindering nuclear energy from being fairly considered as an energy option and is an embarrassment to this country's reputation for its capability to handle its waste. Every decade that SNF remains in storage increases the uncertainty that the fuel can be safely transported and potentially increases the risk and cost of transportation and disposal.

A solution for onsite indefinite storage of SNF is clearly needed and should not be delayed any further. Since the federal government has assumed responsibility for regulating SNF and for its final disposal, it will need to be the primary mover to achieve a permanent solution to managing SNF.

Geologic Repository

The federal government needs to either continue with the license application for the Yucca Mountain repository or immediately enact new legislation to authorize the site selection process for one or more new repositories.

The main benefit of continuing with the Yucca Mountain repository is that the site has already been characterized and the license application submitted to the NRC. However, attempting to rely solely on the Yucca Mountain repository makes the future of SNF management highly uncertain since the license review and repository construction could be continually delayed with the end result being more wasted time and money. To illustrate, political and legal battles have already delayed the planned opening of the repository from 1998 to the current day.

Even if the Yucca Mountain facility is built, the volume of SNF has increased beyond the planned disposal volume of this repository. The NWPA mandates that the Yucca Mountain repository is to have a disposal capacity of 70,000 MTHM, of which 63,000 MTHM will be from commercial reactors. An additional 40,000 MTHM of disposal capacity is projected to be needed if the current trend of renewing reactor licenses from 40 to 60 years continues (23).

Either a second repository is needed or the disposal capacity of Yucca Mountain needs to be enlarged. Either of these options requires Congressional action.

Further, the site selection and the design of the geologic repository needs to be undertaken in a manner that is free from political and legal interference and the suggestions in the Blue Ribbon Committee's report is a good starting point for Congress to begin the debate on the necessary revision to the NWPA.

Centralized Interim Storage

Storage of SNF would still be required for decades even if definite plans to construct a geologic repository were implemented. DOE estimates that:

- A geologic repository would not open until 2048 if the licensing and construction efforts began immediately (1),
- Interim storage would still be needed for 36 years after a geologic repository was completed (5), and
- Twenty-four years would be needed to transport all of the SNF to disposal (6).

The SNF will still require decades of storage before disposal can become available but this storage should not be at the nuclear power plant sites. One or more centralized storage facilities should be constructed so that SNF can be moved off of the nuclear power plant sites. The Blue Ribbon Committee recommended "prompt" efforts to develop one or more consolidated storage facilities concurrently with one or more geological disposal facilities.

Constructing only a disposal facility without one or more centralized interim storage sites should not be considered since a centralized interim storage facility would

- Reduce the cost (storage in one site verses storage at 77 sites),
- Increase safety and security,
- Allow the DOE to take title to the SNF sooner (by two to three decades), and
- Help the DOE to optimize the thermal loading of the HLW into the repository.

The annual operation costs of dry storage for SNF at the 72 commercial nuclear power plant sites will be greater than the annual costs of storing this SNF at a centralized interim storage site (assuming that reactors operate for 60 years) by 2030 (23).

On the other side, arguments against centralized interim storage are that the risk of transporting the SNF is greater than the benefits of centralized interim storage, the SNF would be transported twice — from the reactor to the storage site and from the storage site to the disposal site — which would result in greater cost and worker exposures, and the interim storage may become a permanent solution since pressure for a geological repository would diminished if the DOE takes title to all of the SNF while in storage.

Risk calculations for SNF transport show that the risk is not significant and that over 3,000 shipments of SNF have already been transported over a total of 1.7 million miles with no accidents involving release of radioactive material (23).

According to the BRC recommendations, public perception and concern about interim storage becoming the de facto permanent solution will be significantly reduced if the interim storage facility is built concurrent to efforts to site and build a geologic repository.

The DOE estimated that if the licensing and construction efforts began immediately, a pilot interim storage facility could be operational by 2021, a larger interim storage facility by 2025, and a geologic repository by 2048 (1). EPRI estimates that six years would be needed to develop an away-from-reactor ISFSI including designing the facility, the license application process, and construction, assuming the dry storage system is one that the NRC has already certified, no outside interferences during the NRC hearing process delay the licensing process, and the application is of good quality (7).

A centralized interim storage (or away-from-reactor) facility would require a site specific license under 10 CFR §72 for 40 years initially and an option to renew for another 40 years. The license application would not be able to use the generic environmental impact statement from the NRC waste confidence rule, the waste confidence rule, or the general license found in 10 CFR part 72 subpart K (38).

Private or Government Ownership or Operation of Interim Storage Site

Private off-site storage of the SNF from multiple reactors was attempted in Utah by PFS but local and state opposition delayed the start of construction for 15 years until PFS cancelled the project. Arguments against the PFS facility included:

- Transportation of the waste was seen as an unnecessary risk,
- That long-term storage may become de facto permanent,
- A private storage facility would derail the national HLW policy (concern that private industry may direct national waste policy),
- Safety of long-term storage,
- The operator of the facility would have minimal liability, and
- A feeling that it was unfair to Utah to have to store most of the nation's SNF (73).

Any attempt by a private corporation to site an interim centralized facility would probably face the same opposition. Therefore, finding a site that has local and state support would greatly enhance the chance of a private centralized interim storage site being successfully sited and constructed. The successful implementation of siting and constructing a geologic repository by the federal government would also enhance the probability of an interim storage facility being constructed. The NRC has already determined that the transportation and long-term safety risks are not significant.

It is important to note, however, that one problem with a private centralized interim storage site is that the nuclear power plants would still have title to the SNF and would have to take back the waste if the storage facility closes without a repository available. If the nuclear power plant has been decommissioned by this time, the waste generator would not be able to take back the waste. Stranded SNF at a closed centralized storage facility is one of the worries of those who oppose the building of a private centralized storage facility and was the reason given by the Bureau of Indian Affairs for rejecting the Goshute's lease with PFS (32).

The failure of the DOE to take title to the SNF in 1998 and the high probability that the DOE will not be able to take title to SNF in the next ten to twenty years makes the successful siting and construction of a private centralized interim storage facility highly uncertain and may be too uncertain for a private company to attempt. However, an interim storage facility owned by the federal government would allow the DOE to take title to the SNF stored in it, which would increase the probability that such a facility could be constructed. DOE often uses private entities to operate its national laboratories and other facilities so a DOE owned interim storage facility could conceivable be operated by the private sector.

Siting a Disposal or Storage Facility

Building the centralized storage site on federal land has been suggested, especially at or near one of the national laboratories that perform nuclear energy research so that the nuclear infrastructure (such as skilled and experienced personnel, rail transportation, and security services) would already be present. However, political opposition at the local and state level stopped the plan to build the MRS facility at Oak Ridge National Laboratory, so such a plan would not be a short cut through the siting process.

Another option to take advantage of available infrastructure and experience would be to build the storage site at one or more operating commercial nuclear power reactors. The facility would need to be part of a competitive selection process or local and state opposition and the subsequent political pressure would be expected to be strong.

Expanding the Waste Isolation Project Plant (WIPP) from disposing of only transuranic waste to high level waste has also been suggested. The geology of the WIPP plant has been demonstrated to be suitable for very long-term waste disposal. However, during the siting process of WIPP, the DOE agreed to not expand the mission of the WIPP to include other types of waste. Any attempt to dispose of HLW at WIPP will need to be part of a competitive and fair siting process.

Another option is to reconsider the seven communities who volunteered for the MRS or the eleven communities who volunteered to host the Global Nuclear Energy Partnership facilities. State opposition prevented any of the MRS sites from being characterized, so state as well as local support is necessary. Additionally, the DOE states that "that local willingness and support for a site initially does not ensure continued support for the facility during the long timeframe needed to license and build such a facility" (24).

Any federal program to manage HLW (disposal, storage, or reprocessing) needs to be established in a manner that reduces the uncertainty due to changing prevailing political opinions and minimizes local and state opposition through stakeholder meetings, financial incentives, and a process that is considered fair and technically rigorous. Otherwise, the effort to license and build these facilities may result in nothing but wasted time and wasted money like the Yucca Mountain repository, the PFS storage facility, or the MRS facility. However, successfully sited and built radioactive waste disposal facilities also exist such as WIPP in New Mexico for transuranic waste and the Low Level Radioactive Waste Disposal Facility in Texas. The siting and construction of a HLW storage or disposal facility is therefore feasible if the proper siting methodology is used.

An important recommendation of the Blue Ribbon Committee is that Congress should "authorize a new consent-based process to be used for selecting and evaluating sites and licensing consolidated storage and disposal facilities in the future, similar to the process established in the expired Nuclear Waste Negotiator provisions of the Act" (4). The siting options discussed above, though opposed and ultimately rejected in the past, may be considered favorably in the future if such a consent-based siting process is employed.

State governments are communicating with the federal government that they want to be considered partners with the federal government and have a clear decision-making voice on the siting, building, and operation of any HLW storage or disposal facility within their borders. Past experience has shown that both local and state support is necessary to successfully site a HLW disposal or storage facility. The WIPP facility is an example of how public support for the project was generated by the DOE working together with the state government, such as obtaining permits from the EPA and the state of New Mexico instead of self-regulating the facility. Past experience has shown that siting a radioactive waste facility often fails when the state strongly opposes it even though in nearly every case the affected local governments strongly supported the facility because of the jobs created and as a means of economic growth for the local area (42).

Conclusion

Onsite storage of SNF for decades is currently the only available option for commercial nuclear power plants, which was not envisioned in the initial plans of nuclear power. Although considered safe, it is not an adequate solution. A nuclear power plant typically operates for 60 years and then is closed and decommissioned. The SNF stored onsite remains at the site and the full site cannot be released for unrestricted use. A solution for onsite indefinite storage of SNF is clearly needed and should not be further delayed.

Since the federal government assumed responsibility for regulating and disposal of SNF, it will need to be the primary driver in finding a permanent solution for managing SNF. Congress needs to either fund the license review of the Yucca Mountain geologic repository so that it could be constructed or change the NWPA so that a new site selection process for one or two geologic repositories can begin. Additionally, Congress needs to amend the NWPA to authorize the construction of centralized interim storage facilities in which the DOE takes title to the stored SNF even if DOE does not actually operate the facility. DOE often uses private entities to operate its national laboratories and other facilities so a DOE owned interim storage facility could conceivable be operated by the private sector. In fact the consent-based siting recommended by the BRC make a public-private partnership approach even more attractive. It has already been done with great success where other approaches have repeatedly failed.

Because many earlier attempts to select a site for a repository or storage facility for SNF have failed due to local and state opposition. Selecting a site for and constructing an interim storage facility would have a greater chance for success if the site has local and state support and the federal program to site and build a geologic repository is also successful. Any federal and/or private program to store or dispose of SNF needs to be established in a manner that reduces the uncertainty due to changing prevailing political opinions and minimizes local and state opposition through stakeholder meetings, finding volunteer communities, financial incentives, giving the state a clear decision-making voice on the siting, building, and operation of the facility within their borders, and a process that is considered fair and technically rigorous.

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ATTACHMENT 2-1
LETTERS

State of New Mexico

Susana Martinez
Governor

April 10, 2015

Dr. Ernest Moniz, Secretary
U.S. Department of Energy
1000 Independence Ave., SW
Washington, DC 20585

Dear Secretary Moniz,

This letter is to inform you of my support of the community leaders who continue to spearhead the effort to bring a consolidated interim storage facility for spent fuel to southeastern New Mexico.

The recent decision by your administration to adopt a consent-based approach for waste management should highlight areas such as southeastern New Mexico where there is broad support in the region for such an endeavor. The Eddy-Lea Energy Alliance (ELEA) is an organization with regional participation by the City of Carlsbad, City of Hobbs, Eddy County and Lea County. As you are aware, the residents of this area have a high level of understanding of the nuclear industry and its importance to our national security. There is a strong pre-existing scientific and nuclear operations workforce in the area, and the dry, remote region is well-suited for an interim storage site. ELEA has already selected a location that has been vetted extensively.

There is a significant and growing national need for such an interim storage facility. Millions of taxpayer dollars are currently being spent on monitoring and oversight of spent fuel each year, and millions more are being spent on settlement payments related to waste disposition. In many instances, these actions are taking place where such activity and the presence of such waste is disagreeable to local communities.

These communities in New Mexico support safely moving spent fuel to a consolidated interim storage site using proven technology which is the most sensible approach to this problem until a permanent and long-term solution is available. Dry cask storage is a proven, passive, and safe system that has been used since 1984 with no adverse incidents.

Dr. Ernest Moniz
ELEA Interim Storage

Time and time again, the citizens of southeastern New Mexico have impressed me with their hard work ethic and willingness to tackle national problems that many others consider to be unsolvable. In one of the most remote areas of state, they have had the ingenuity and fortitude to carve out a niche in the nuclear industry to broaden their economic base. They understand the benefits not only to their local economy, but also to our country.

Therefore, I support the ELEA and its member cities and counties in their effort to establish a consolidated interim storage facility in southeastern New Mexico that will be regulated by the high safety and technical standards of the Nuclear Regulatory Commission.

Sincerely,

Susana Martinez
Governor

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5430 LBJ Freeway, Ste. 1700
Dallas, Texas 75240

Dr. CEO Lindquist and President Baltzer,

On behalf of the Skull Valley Band of Goshute Indians (SVBG) Executive Committee, I respectfully request a meeting with your company to discuss your February 6, 2015 notice to the Nuclear Regulatory Commission (NRC), regarding your intent to apply for a license for the interim storage of used nuclear fuel. The reason for this request is that SVBG has an NRC authorized private fuel facility to store spent nuclear fuel and high-level radioactive waste on its Indian reservation. The licensee is Private Fuel Storage LLC (PFS) and the license expires on February 21, 2026.

During the past few months, PFS has been in the process of dissolving its relationship with SVBG, which leaves the question about what to do with the license. SVBG Executive Committee desires to speak with your top leadership to discuss the possibility of transferring the license to your company.

SVBG completely understands that your application and implementation of your license for storage of used nuclear fuel may have many challenges and could take years, if not decades to complete. It is the hope of SVBG that your company would be interested in exploring any opportunities that there may be to overcome any of the challenges or lessen the time frames that you may face.

The SVBG Executive Committee will be in Albuquerque, New Mexico, the week of May 11, 2015, for the National Transportation Stakeholder Forum Annual Meeting. I cordially invite you, or some of your staff, to discuss any possibilities then.

Sincerely,

Lori Bear, Chairwoman
Skull Valley Band of Goshute Indians
Executive Committee

ATTACHMENT 2-2

SITE SCORING ANALYSIS

OPERATIONAL SELECTION SCORING SUMMARY								
Weight	Criteria		Weight %	Sub-criteria	Andrews County	Lea County	Eddy County	Loving County
80	Operational Considerations	Criterion 6 - Utilities	100	Electric Power Availability	10	7	7	3
			80	Cellular and Data Towers	10	8	8	3
			100	Water Supply	10	8	10	5
		Criterion 7 - Construction Labor Force	100	Sufficient Labor force	10	10	10	10
			50	Competing projects/sites	10	10	10	10
			90	Large Project Experience	10	10	10	10
		Criterion 8 - Operational Labor Force	100	Sufficient Labor Force	8	7	7	5
			80	Multi-Task Employees	8	7	7	5
			80	Technical School/training	9	9	9	3
			100	Mature Nuclear Safety Culture	10	8	8	1
			100	Radiation Worker Staff	10	8	8	1
			100	Health Physicist and Radiation Protection Organization	10	8	8	1
		Criterion 9 - Transport Routes	100	Site Railhead	9	6	8	0
			90	Access to Highways	10	10	10	3
			90	Traffic Capacity	10	10	10	3
			90	Efficient Access	8	8	8	3
		Criterion 10 - Amenities for Workforce	100	Housing	9	10	9	3
			100	Schools	10	10	10	10
			100	Health Services	10	10	10	5
			80	Parks/Recreation	9	9	10	5
				Score	**174.0**	**157.6**	**161.4**	**78.9**

Operational Considerations: Scoring weight and Attribute summary:

80% - Operational Considerations				The Criteria operational Considerations is weighed at 80%. WCS valued 100% as critical and it cannot be changed. Operational considerations can be changed if a fault is found.				
Criterion	Weight	Sub-criteria	Description	Weight summary	Andrews Country, TX	Loving County, TX	Lea County, NM	Eddy County, NM
Criterion 6 - Utilities	100	Electric Power Availability	This rating is based on the apparent relative availability and level of effort needed to construct electric power infrastructure needed by the CISF at the proposed site.	It is critical to have electrical power available for operations.	Electric power is readily available at the Andrews County Site.	No lines are available currently; this would have to be built from the ground up.	Have electrical power available, but needs more lines.	Needs a substation, but the distance is not as far as Lea county.
	80	Cellular and Data Towers	(cell phone, internet) - It is desirable that existing service is available for dependable cell phone and internet services.	The cellular and data towers are still important, but not as critical as electric and water. Scoring is based on what is already available.	The WCS Communications tower allows site wide cell phone service, high speed internet and landline communications.	This area has very spotty service, not reliable.	A communications tower that could possibly be used to provide cell phone and data service is located in the southwest corner of the Site.	A communications tower exists a few hundred yards to the northeast of the WIPP. This tower could potentially be used for cellular and data transmission to support construction and operations at the proposed CISF Site.
	100	Water Supply	It is desirable that groundwater or water from another source is readily available to provide ample water supply to the facility for both potable and process uses.	It is critical to have water supply available for operations.	A six-inch water line currently providing the WCS facilities with abundant water from the City of Eunice will provide sufficient water for construction and operations although water from WCS wells or other sources may be used for construction water as needed.	Groundwater is available.	The 3 mile long pipeline extension, requiring a federal right-of-way, would be needed to convey the water to the site.	Since the Eddy County Site is adjacent to the WIPP, it should be able to make use of the Carlsbad City Water System providing water to the WIPP Site through a water main. Possible extension is needed.

80% - Operational Considerations				The Criteria operational Considerations is weighed at 80%. WCS valued 100% as critical and it cannot be changed. Operational considerations can be changed if a fault is found.				
Criterion	Weight	Sub-criteria	Description	Weight summary	Andrews Country, TX	Loving County, TX	Lea County, NM	Eddy County, NM
Criterion 7 - Construction Labor Force	100	Sufficient Labor force	Local area has sufficient skilled construction labor pool to construct the facility on desired schedule. Craft requirements include all major construction crafts (e.g., steelworkers, electricians, pipe fitters, operators, finishers, etc.).	Skilled and reliable workers are needed to build this unique facility.	The contracting of construction companies from outside of the region, such as from Albuquerque, NM, Lubbock, TX and EI Paso, TX, is common practice in West Texas and Southeastern New Mexico, so the prospective CISF licensee should be able to find and contract an adequately skilled construction labor pool to construct the facility on the desired schedule even if another construction project were to interfere with local contracting.			
	50	Competing projects/sites	No major construction projects of same scope in the area competing for the same labor pool resources that would significantly limit resource availability.	Found this as not being a risk or a large impact for constructing this facility.	WCS did not consider this as a negative impact for any of the counties.			
	90	Large Project Experience	To support project cost, schedule and conformance to design basis, the CISF site applicant should possess the experience and technical qualifications needed to provide oversight of the planning and execution of a large nuclear facility construction project in accordance with ASME NQA-1, Quality Assurance Requirements for Nuclear Facility Applications.	Having experience in large project construction is important for constructing this facility, however WCS determined that no matter which county this facility was built in the same project management can be done anywhere.	WCS scored this the same for all counties, because no matter which county the project is in, it will still be managed (with the same expertise) from any location.			

80% - Operational Considerations				The Criteria operational Considerations is weighed at 80%. WCS valued 100% as critical and it cannot be changed. Operational considerations can be changed if a fault is found.				
Criterion	Weight	Sub-criteria	Description	Weight summary	Andrews Country, TX	Loving County, TX	Lea County, NM	Eddy County, NM
Criterion 8 - Operational Labor Force	100	Sufficient Labor Force	Sufficient supply of qualified labor that can readily be trained for plant operations, maintenance, technical support, and waste management.	For operation of the facility there is a need for the workers to be skilled and trained. This was scored based on the area(s) population and readily available trained workers.	WCS currently has employees at the current facilities that meet the expectations, what people they do not have can be hired.	This area is most rural, workers would need to travel a distance to get to work or relocate.	The population in Hobbs is enough to support hiring skilled workers.	WIPP is close by; trained/skilled employees have worked there.
	80	Multi-Task Employees	Local labor rules do not prohibit or discourage multi- tasking of employees.	This was scored based on each counties labor laws and union association. WCS found this to be important, but not critical.	Given that the Andrews County site is in West Texas, where workers have not joined unions, the labor environment is favorable to multi-tasking of employees.	Given the proximity of the site location many workers have joined unions and labor rules may be established at this site that prohibit or discourage multi-tasking employees.	Given the proximity of the Lea County site to the WIPP, where many workers have joined the United Steelworkers Union (USW) and the Oil, Chemical and Atomic Workers International Union (OCAW), labor rules may be established at this site that prohibit or discourage multi-tasking of these employees.	Given the proximity of Eddy County to the WIPP, where many workers have joined the United Steelworkers Union (USW) and the Oil, Chemical and Atomic Worker International Union (OCAW), labor rules may be established at this site that prohibit or discourage multitasking of these employees.

80% - Operational Considerations				The Criteria operational Considerations is weighed at 80%. WCS valued 100% as critical and it cannot be changed. Operational considerations can be changed if a fault is found.				
Criterion	Weight	Sub-criteria	Description	Weight summary	Andrews Country, TX	Loving County, TX	Lea County, NM	Eddy County, NM
Criterion 8 - Operational Labor Force Cont'd	80	Technical School/training	Community has technical school, technical/community college, or local nuclear facility that is willing to provide candidates and training classes for the plant operations.	This was scored based on the proximities of schools and the level of education that can be achieved. WCS found this to be important, but not critical.	Major universities and other post-secondary schools are located in Midland-Odessa and Lubbock, while a local junior college in Hobbs is available to assist with training and qualification of workers. Andrews county has better schools, but those are located outside the county and are further in driving distance.	There are no schools in the county, but there are a few within driving distance.	Major universities and other post-secondary schools are located in Midland-Odessa and Lubbock, while a local junior college in Hobbs is available to assist with training and qualification of workers. The community college is located in Lea County, but is only a 2-year degree school.	For four year and post-graduate degrees not available locally, major universities and other post-secondary schools are located in Midland-Odessa and Lubbock. There is an additional local junior college in Hobbs available to assist with training and qualification of workers.
	100	Mature Nuclear Safety Culture	It is advantageous to safety if CISF operations, maintenance, technical support, and waste management personnel available in area will be members of a pre-existing Mature Nuclear Safety Culture before, during and at the start of CISF operations.	This is scored based on employees available that understand the safety culture of the nuclear industry. WCS found this to be critically important to have proper operations of this facility.	The county supports this already, with the current facilities at WCS.	There is nothing there; workers with a mature safety culture would be hard to come by.	Lea county is close to the currently WCS facility and the WIPP facility, therefore the workers to hire for an established nuclear safety culture are achievable, but would need to relocate.	WIPP is close by; therefore workers with this safety mind set are readily available.

80% - Operational Considerations				The Criteria operational Considerations is weighed at 80%. WCS valued 100% as critical and it cannot be changed. Operational considerations can be changed if a fault is found.				
Criterion	Weight	Sub-criteria	Description	Weight summary	Andrews Country, TX	Loving County, TX	Lea County, NM	Eddy County, NM
Criterion 8 - Operational Labor Force Cont'd	100	Radiation Worker Staff	CISF site applicant pre-staffed with highly trained and experienced radiation workers (e.g., operations, maintenance, technical support, and waste management) who are permanent local residents.	This is scored based on employees available that are experienced in radiation safety. WCS found this to be critically important to have proper operations of this facility.	The county supports this already, with the current facilities at WCS. There are people with this experience that are permanent residents.	There is nothing there, workers that are trained and experience in radiation safety would be hard to come by.	Lea county is close to the currently WCS facility and the WIPP facility, therefore the workers to hire that are highly trained and experienced are achievable, but would need to relocate.	WIPP is close by, therefore workers to hire that are highly trained and experienced in radiation safety are achievable.
	100	Health Physicist and Radiation Protection Organization	It is highly desirable and significantly beneficial to ALARA planning and execution if the site chosen has a CISF applicant that has assembled and employed a functioning and proven team of experienced Health Physicists and Radiation Protection Technicians that are established in the area as permanent local residents as CISF start-up. This need is profound due to both the importance of immediately achieving and maintaining dose as-low-as-is-reasonably-achievable (ALARA) and the difficulties of hiring and retaining high demand, talented employees in remote locations such as those under consideration for the CISF.	This is scored based on employees available that experienced in health physicist. WCS found this to be critically important to have proper operations of this facility.	The county supports this already, with the current facilities at WCS. There are people with this experience that are permanent residents.	There is nothing there, workers that are health physicists would be hard to come by.	Lea county is close to the currently WCS facility and the WIPP facility, therefore the workers to hire that are health physicists are achievable, but would need to relocate.	WIPP is close by, therefore workers to hire that are health physicist are achievable.

80% - Operational Considerations				The Criteria operational Considerations is weighed at 80%. WCS valued 100% as critical and it cannot be changed. Operational considerations can be changed if a fault is found.				
Criterion	Weight	Sub-criteria	Description	Weight summary	Andrews Country, TX	Loving County, TX	Lea County, NM	Eddy County, NM
Criterion 9 - Transport Routes	100	Site Railhead	It is desirable to have a railhead located at the site.	Since the shipments will be brought in by rail, WCS considered this to be a highly critical criterion.	The site location in Andrews county currently has a rail that runs on the property, a railhead will need to be added where the CISF facility will be located.	There is currently no rail that runs in the county.	There is a 4 mile extension is needed for proper access. Construction of the new rail spur would be across public lands and would be along ROW to be obtained from the state and federal agencies also likely requiring additional NEPA analysis for ROW on Federal lands.	A 1/2 mile extension is needed.
	90	Access to Highways	Close proximity to controlled-access highways and/or interstate highways is desirable.	It is important that there is adequate access to the site for construction and operations of the facility. This was scored based on what highways gave access to the site and the distance to the site from these highways.	Highway 176, approximately 1.25 miles south of the Andrews County Site, provides for efficient operations and construction traffic. Several other highways from NM provide adequate access.	Currently many dirt roads, most access roads would need to be updated.	Highway 62/180 that serves the site.	4-lane, controlled-access highway (US 62/180) approximately 21 km (13 mi) north of the site. The US 285/Pecos Highway can be accessed by traveling approximately 26.7 miles southeast along New Mexico (NM) 128/31.

80% - Operational Considerations				The Criteria operational Considerations is weighed at 80%. WCS valued 100% as critical and it cannot be changed. Operational considerations can be changed if a fault is found.				
Criterion	Weight	Sub-criteria	Description	Weight summary	Andrews Country, TX	Loving County, TX	Lea County, NM	Eddy County, NM
Criterion 9 - Transport Routes Cont'd	90	Traffic Capacity	There should be traffic capacity for construction and operation activities, with minimal improvements required.	It is important to have adequate roads for the appropriate traffic capacity during construction and operations of the facility. This was scored based on what highways gave access to the site, the condition of the roads and the current traffic volume.	Existing routes and roads to the site should provide adequate traffic capacity for additional CISF construction and operations traffic/load, with minimal improvements required.	Currently many dirt roads, most access roads would need to be updated.	Existing routes and roads to the site should provide adequate traffic capacity for additional CISF construction and operations traffic/load, with minimal improvements required.	Existing routes and roads to the site should provide adequate traffic capacity for additional CISF construction and operations traffic/load, with minimal improvements required.
	90	Efficient Access	There should be optimal and efficient highway and rail access to support safe and reliable storage cask material, component, and other deliveries.	It is important to have adequate roads for efficient transporting of materials during construction and operations of the facility. This was scored based on what roads gave access to the site and the condition of these roads.	Highway 176 is currently a 2 lane road, with updates to be complete by the time facility construction will start, making parts of the road 3 lanes.	Currently many dirt roads, most access roads would need to be updated.	Currently there are 2 lane roads and 4 lanes roads that will be used for access to the site.	Currently there are 2 lane roads and 4 lanes roads that will be used for access to the site.

80% - Operational Considerations				The Criteria operational Considerations is weighed at 80%. WCS valued 100% as critical and it cannot be changed. Operational considerations can be changed if a fault is found.				
Criterion	Weight	Sub-criteria	Description	Weight summary	Andrews Country, TX	Loving County, TX	Lea County, NM	Eddy County, NM
Criterion 10 - Amenities for Workforce	100	Housing	It is desirable that housing, hotels, and lodging be available for the work force, as well as recreational facilities.	It is critical that employees have proper housing and lodging for out of towners. This was scored based on the number of rental property and the housing market. Also the population size per county.	Andrews has adequate housing, with rental property including houses and apartments. There are several hotel options.	The population is small, therefore it is believed the rental and housing market would be small. There are no known hotels in this area.	The population is highest in this county. There are many choices for rental property and lots of choices for housing. There are many hotels located in Hobbs.	There are many housing and hotel available in the Carlsbad area, but this is further in distance from the site, than the Lea county and Andrews county site locations.
	100	Schools	It is desirable for recruitment and retention of high quality scientific and technical CISF employees that the site selected allow for these workers to commute to residential areas in public school districts meeting state and federal accountability standards.	It is critical that the county have a school system. This was scored based on the fact that there is a school located in the county.	All counties have proper school systems			
	100	Health Services	WCS will assess whether emergency room & routine medical care is reasonably available to CISF personnel, contractors and visitors.	It is critical there is proper health care in the county. This was scored based on hospitals, doctor offices and/ or walk in clinics located in the county.	There is a hospital, doctor offices, dentist, walk in clinics, etc.	The county may have some health care options, but no hospital.	There is a hospital, doctor offices, dentist, walk in clinics, etc.	There is a hospital, doctor offices, dentist, walk in clinics, etc.
	80	Parks/Recreation	It is desirable that parks and recreational facilities be available in the CISF area for use by the workforce. It is also desirable that there be cultural activities at or near the area.	This criterion is important but not critical. The scoring was based on location and size of parks and/or recreational facilities.	The county has many parks and a community pool, with other community activities.	May have a park.	The county has community parks and larger parks close by.	The county has larger parks, rivers and lakes.

ENVIRONMENTAL SELECTION SCORING SUMMARY								
Weight	Criteria		Weight %	Sub-criteria	Andrews County	Lea County	Eddy County	Loving County
100	Environmental Considerations	Criterion 11 - Environmental Protection	100	Existing Site Characterization Data	10	6	6	1
			100	Documentation	10	9	5	3
			100	Neighboring Plume	10	8	10	10
			100	Future Migration	10	8	10	10
			100	No RAD Contamination	10	10	10	10
			100	Not CERCLA or RCRA	10	10	10	10
			100	No Remediation needed	10	10	10	10
			100	Flood Plain	10	10	10	10
			50	Ponding	10	10	10	10
			100	Protected Species	10	8	10	10
			100	Archeological and Cultural Resources	10	5	5	5
			80	Environmental Permits	10	10	10	10
			100	Environmental Justice	10	7	7	7
		Criterion 12 - Discharge Routes	50	Facility Discharge	10	10	10	10
			50	Differentiation	9	10	10	10
		Criterion 13 - Proximity of Hazardous Operations/High-Risk Facilities	90	Hazardous Chemical Sites	8	10	10	10
			80	Gas Pipelines	10	8	8	10
			70	Airports	10	10	10	10
			70	Emergency Area	8	10	10	10
			80	Air Quality	10	10	10	10
		Criterion 14 - Ease of Decommissioning	50	Ease of Decommissioning	10	10	10	10
			25	Adjacent Site's Medium/Long-Term Plans	8	10	10	10
		Criterion 15 - Disposal of Low-Level Waste	100	Availability to disposal options	10	8	8	8
				Score	**185.3**	**166.9**	**168.9**	**163.5**

Environmental Considerations: Scoring weight and Attribute summary:

100% - Environmental Considerations				The Criteria environmental considerations are weighed at 100%. WCS valued 100% as critical and it cannot be changed. Environmental issues/concerns are there and cannot be adjusted.				
Criterion	Weight	Sub-criteria	Description	Weight summary	Andrews County, TX	Loving County, TX	Lea County, NM	Eddy County, NM
Criterion 11 - Environmental Protection	100	Existing Site Characterization Data	It is highly preferable that site characterization surveys are available for: Hydrology, Meteorology (rain, wind, tornadoes, temperatures, etc.), Topography, Archeology and Protected species.	Having established characterization surveys is critical in determining an appropriate CISF site location. This scored based on how much characterization surveys are available and how close they are to the site locations.	AT the WCS current site there are site specific characterization surveys being preformed and analyzed. WCS site does have a current (2015) Archeology survey.	There is nothing in this county to support site characterization. Currently no surveys are being managed.	Currently there is a small amount of information. However, there is nothing site specific there is also no onsite tower for collecting data.	Currently there is a small amount of information. However, there is nothing site specific there is also no onsite tower for collecting data.
	100	Documentation	Well documented site surveys and monitoring for radiological, chemical, and hazardous material contamination.	It is critical to have a site or area that is well documented. This was scored based on how much documentation is available and how extensive the documentation is.	The WCS site has been under a monitoring plan to detect the release of trace amounts of radiological and hazardous chemical constituents since it was permitted and licensed in 1997. At the WCS current site every survey and monitoring characterization is well documented and saved on a secure site.	There is a document from a survey of land management.	There is some documentation.	There were no surveys or documentation before Cox McLain did their archeology report for WCS.

100% - Environmental Considerations				The Criteria environmental considerations are weighed at 100%. WCS valued 100% as critical and it cannot be changed. Environmental issues/concerns are there and cannot be adjusted.				
Criterion	Weight	Sub-criteria	Description	Weight summary	Andrews County, TX	Loving County, TX	Lea County, NM	Eddy County, NM
Criterion 11 - Environmental Protection Cont'd	100	Neighboring Plume	No facility in the area with existing release plume (air or water) of hazardous material or radiation release that includes site.	This is critical in knowing if there is a neighboring plum, before deciding to construct the CISF in a specific location. This was scored based on the information available for any local radiological release or hazard material.	There is no contamination.	There is no contamination.	This is inconclusive, there is some oil field waste.	There is no contamination.
	100	Future Migration	Future migration of contamination from adjoining or nearby sites negligible.	This is critical in knowing if there is any future migration, before deciding to construct the CISF in a specific location. This was scored based on the information available for any local radiological release or hazard material.	There is no contamination.	There is no contamination.	This is inconclusive, there is some oil field waste.	There is no contamination.

100% - Environmental Considerations				The Criteria environmental considerations are weighed at 100%. WCS valued 100% as critical and it cannot be changed. Environmental issues/concerns are there and cannot be adjusted.				
Criterion	Weight	Sub-criteria	Description	Weight summary	Andrews County, TX	Loving County, TX	Lea County, NM	Eddy County, NM
Criterion 11 - Environmental Protection Cont'd	100	No RAD Contamination	Site is not contaminated with radiological material in soil or groundwater to a level that would inhibit licensing or transfer of property with clear identification of liabilities.	This is critical in knowing if there is any Radiation contamination on the site, before deciding to construct the CISF in a specific location. This was scored based on the information available for any local radiological contamination.	There is no radiological contamination.			
	100	Not CERCLA or RCRA	Site is not identified as a CERCLA or RCRA site contaminated with hazardous wastes or materials.	This is critical in knowing if the site is CERLCA and/or RCRA contaminated with hazardous waste, before deciding to construct the CISF in a specific location. This was scored based on the information available.	Site not contaminated with CERCLA and/or RCRA hazardous waste or material.	Site not contaminated with CERCLA and/or RCRA hazardous waste or material.	Site not contaminated with CERCLA and/or RCRA hazardous waste or material.	Site not contaminated with CERCLA and/or RCRA hazardous waste or material.
	100	No Remediation needed	Site does not have contamination that would require remediation prior to construction.	This is critical in knowing if the site needs a remediation prior to construction. This was scored based on the information available.	Site does not have contamination that would require remediation prior to construction.	Site does not have contamination that would require remediation prior to construction.	Site does not have contamination that would require remediation prior to construction.	Site does not have contamination that would require remediation prior to construction.

100% - Environmental Considerations				The Criteria environmental considerations are weighed at 100%. WCS valued 100% as critical and it cannot be changed. Environmental issues/concerns are there and cannot be adjusted.				
Criterion	Weight	Sub-criteria	Description	Weight summary	Andrews County, TX	Loving County, TX	Lea County, NM	Eddy County, NM
Criterion 11 - Environmental Protection Cont'd	100	Flood Plain	The site is not within the 500-year flood plain.	It is critical in knowing if the site was in a flood plain. This was scored based on the information available for documenting the potential flood plain.	All of the counties are not at risk for a 500-year flood plain.			
	50	Ponding	It is desirable that the natural site contours minimize the potential for localized flooding or ponding. Factors to consider include stream beds, natural and potential runoffs, runoff from adjacent areas, storm drainage systems in place, and requirements for retention ponds.	It is good to know prior to constructing the facility if there is a potential for local flooding or ponding.	No potential flooding or ponding was found in any of the counties.			

100% - Environmental Considerations				The Criteria environmental considerations are weighed at 100%. WCS valued 100% as critical and it cannot be changed. Environmental issues/concerns are there and cannot be adjusted.				
Criterion	Weight	Sub-criteria	Description	Weight summary	Andrews County, TX	Loving County, TX	Lea County, NM	Eddy County, NM
Criterion 11 - Environmental Protection Cont'd	100	Protected Species	The site should not be a habitat for Protected Species (federal listed threatened or endangered species). Also, adjacent properties should have no areas designated as protected for wildlife or vegetation that would be adversely affected by the facility.	It is critical in knowing if there are any protected species in the area of where the facility construction will take place.	The WCS application for a license to authorize near-surface land disposal of low-level radioactive waste (LLRW), Appendix 11.9.2: Ecological Baseline Assessment, was used to describe site potential to adversely affect rare, threatened or endangered species and habitats. The assessment was performed during 2006. The dominant plant species on the site are native.	No protected or endanger species are in the site location.	There is potential bird migration.	There are no existing protected species surveys for the Eddy County Site. Existing information from the WIPP (WEST, 2002; DOE, 1996) indicate that no protected species occur on the WIPP Site. Given the homogeneity of the landscape between the proposed site and the WIPP Site and the narrow habitat requirements for the protected species known to occur in Eddy County, it is unlikely that protected species occur on this site.

100% - Environmental Considerations				The Criteria environmental considerations are weighed at 100%. WCS valued 100% as critical and it cannot be changed. Environmental issues/concerns are there and cannot be adjusted.				
Criterion	Weight	Sub-criteria	Description	Weight summary	Andrews County, TX	Loving County, TX	Lea County, NM	Eddy County, NM
Criterion 11 - Environmental Protection Cont'd	100	Archeological and Cultural Resources	The site should have a low probability of containing archeological/cultural resources.	This is critical to have the information before constructing the site. The scoring was based on the information available.	An intensive pedestrian archeological field survey carried out in 2015 observed no archeological materials of any kind.	No information was found and believes there is a high probability there has not been a survey conducted.	An archeological and cultural resources field survey has not been performed at the Lea County Site. A literature and archival search to establish baseline data for cultural resources that were already identified for the 1,040 acre Site and within a 6-mile zone around the Site was performed by Quivira Research Associates (QRA).	No information was found and it is believed there is a low probability there has not been a survey conducted.
	80	Environmental Permits	Any new facility construction or operations should not be hindered by any existing environmental or other permits in the area and any required new CISF environmental permits, such as for wastewater management, should be readily available.	It is important to know if there is any issue restricting a county from getting environmental permits.	There are no known concerns that would prevent the federal, state, and local regulatory and permitting requirements from being fulfilled for the construction of a CISF at the Site, for any of the counties.			

100% - Environmental Considerations				The Criteria environmental considerations are weighed at 100%. WCS valued 100% as critical and it cannot be changed. Environmental issues/concerns are there and cannot be adjusted.				
Criterion	Weight	Sub-criteria	Description	Weight summary	Andrews County, TX	Loving County, TX	Lea County, NM	Eddy County, NM
Criterion 11 - Environmental Protection Cont'd	100	Environmental Justice	The site should have a low probability of environmental justice issues.	This is critical in knowing if there is any concern for environmental justice. This was scored based on the information available to determine the low probability.	Socioeconomic information is in Section 5.1.5, Environmental Justice, of the Environmental Assessment Report, Appendix 13.A of this License Application.	There is no concern for environmental justices, but no documentation supporting.	Demographic information for the Lea County Site area indicates that there is little likelihood of disparate (Environmental Justice) impacts due to the CISF facilities.	There is no concern for environmental justices, but no documentation supporting.

100% - Environmental Considerations				The Criteria environmental considerations are weighed at 100%. WCS valued 100% as critical and it cannot be changed. Environmental issues/concerns are there and cannot be adjusted.				
Criterion	Weight	Sub-criteria	Description	Weight summary	Andrews County, TX	Loving County, TX	Lea County, NM	Eddy County, NM
Criterion 12 - Discharge Routes	50	Facility Discharge	Plant discharge and runoff controls are economically implemented for minimal effect to the existing environment.	This weighed at 50%; the risk is very low for this to happen. The canisters will be welded shut.	There is minimal chance of future contamination from adjacent facilities due to inherent facility design, safe conduct of operations and early detection from environmental monitoring programs.	There is minimal chance of future contamination from discharge routes. The only discharge would be stormwater runoff, but could be directed to natural drainage There is no anticipated radiological effluent.	Reference 4-28-07 ELEA Letter to DOE states that “A permit is required for facilities that discharge an aggregate waste water of more than 2,000 gallons per day to septic systems.	There is minimal chance of future contamination, from discharge routes. The only discharge from the adjunct WIPP site is to lined, evaporative lagoons.
	50	Differentiation	For sites with extant nuclear facilities, facility discharges are readily identifiable from extant facility discharges.	The risk is low that there would be a release.	Compared to the other counties, if there were a release at the Andrews county facility, it would take more investigation to determine where the release came from.	No risk in other facilities near the CISF causing a release.		

100% - Environmental Considerations				The Criteria environmental considerations are weighed at 100%. WCS valued 100% as critical and it cannot be changed. Environmental issues/concerns are there and cannot be adjusted.				
Criterion	Weight	Sub-criteria	Description	Weight summary	Andrews County, TX	Loving County, TX	Lea County, NM	Eddy County, NM
Criterion 13 - Proximity of Hazardous Operations/High-Risk Facilities	90	Hazardous Chemical Sites	WCS will consider the distance of the site from any facility storing, handling or processing large quantities of hazardous chemicals.	This is an important attribute to consider before constructing the CISF. This was scored based on the amounts of hazardous waste in each county's site location.	There are no facilities handling large quantities of hazardous materials chemicals or other material in proximity to the Site. NEF possesses Uranium Hexafluoride but manages it in a manner that minimizes risk to a CISF at the Site. However, there is a Low Level facility on the property.	There are no facilities in the county.	There are 12 industrial facilities ("potentially hazardous facilities") located within five miles of the Site boundary.	The Site is adjacent to an existing radiological hazard but that facility (the WIPP) does not handle spent nuclear fuel. The adjacent WIPP Site handles large quantities of transuranic wastes.
	80	Gas Pipelines	WCS will consider the distance of the site from one or more large propane or natural gas pipelines.	This is an important criterion to know before constructing the site. This was scored based on any pipelines on or around the site locations.	There are no major propane pipelines that pose a danger to the proposed CISF.	There are no gas lines running through or near the property.	Major natural gas transmission pipeline within 5 miles of the property.	High-pressure gas line runs through the WIPP Site, approximately 0.5 mile south of the site.

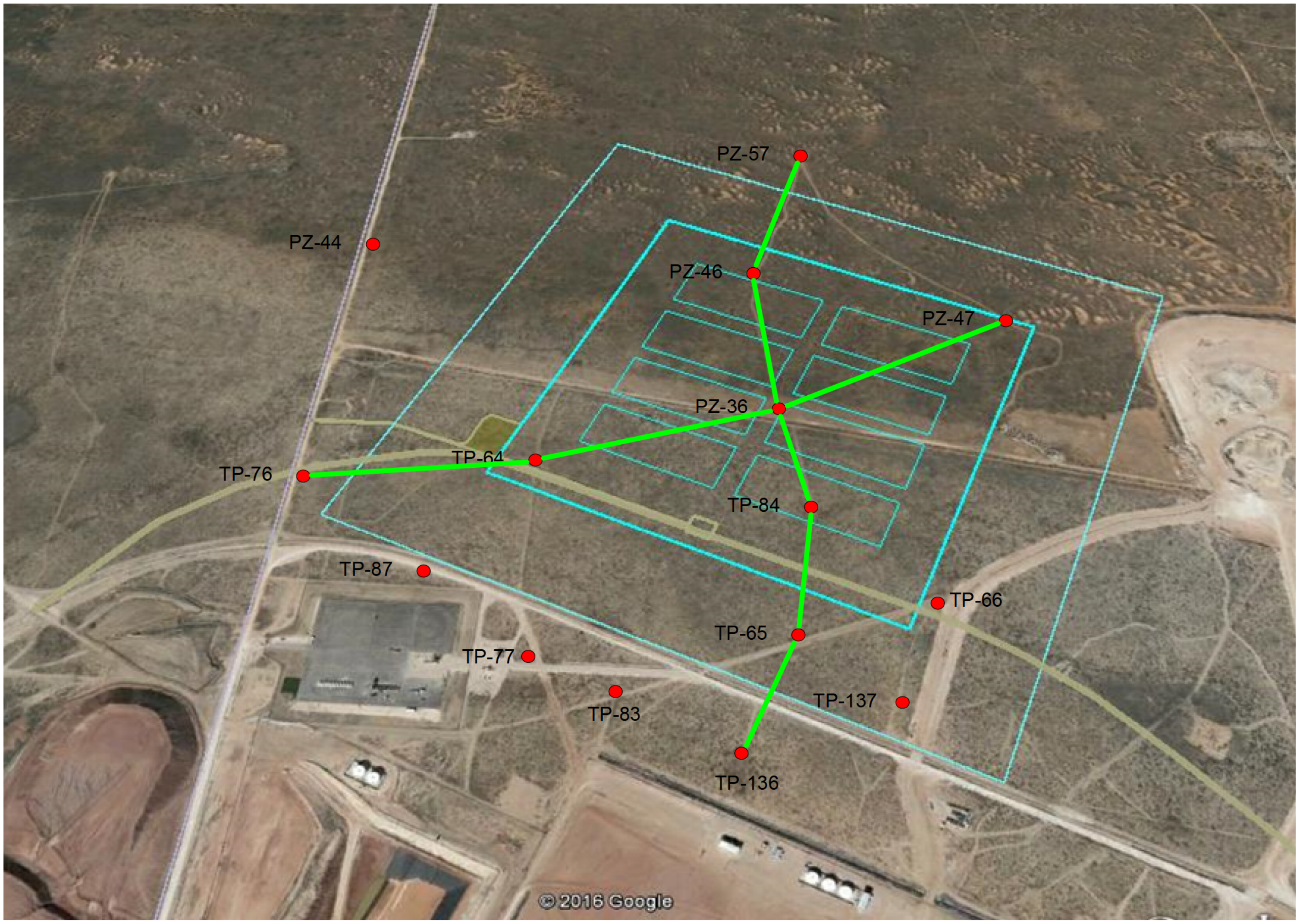
100% - Environmental Considerations				The Criteria environmental considerations are weighed at 100%. WCS valued 100% as critical and it cannot be changed. Environmental issues/concerns are there and cannot be adjusted.				
Criterion	Weight	Sub-criteria	Description	Weight summary	Andrews County, TX	Loving County, TX	Lea County, NM	Eddy County, NM
Criterion 13 - Proximity of Hazardous Operations/High-Risk Facilities Cont'd	70	Airports	The site should not be located within 16 km (10 mi) of a commercial airport.	This criterion is a good to know information before deciding where to construct the CISF.	The distance to the nearest commercial airport, Lea County Regional Airport, is approximately 25 miles.	There are no commercial airports within 16 km (10 mi).	There are no major airports within 10 miles of the Site. However, an abandoned landing strip (1,000 feet long) is located five miles west of the Site.	There are no commercial airports within 16 km (10 mi).
	70	Emergency Area	The site should be outside the general emergency area for any nearby hazardous operations facility (other than an extant nuclear-related facility).	This criterion is a good to know information before deciding where to construct the CISF.	Pre-existing to the site.	The site is not located in a general emergency area for any of these counties.		
	80	Air Quality	The site should not be located within 8 km (5 mi) of an operating/manufacturing facility that inhibits site air quality. In addition, the site should have high air quality. The site terrain should not limit air dispersal. Finally, the surrounding community's air quality should be within regulatory requirements.	This is an important criterion to know before constructing the site. This was scored based on any air quality concerns for the area where the site would be built.	There are no air quality concerns in any of the counties.			

100% - Environmental Considerations				The Criteria environmental considerations are weighed at 100%. WCS valued 100% as critical and it cannot be changed. Environmental issues/concerns are there and cannot be adjusted.				
Criterion	Weight	Sub-criteria	Description	Weight summary	Andrews County, TX	Loving County, TX	Lea County, NM	Eddy County, NM
Criterion 14 - Ease of Decommissioning	50	Ease of Decommissioning	Site characteristics (e.g., hydrology) do not negatively affect D&D activities.	This criterion is not a big risk in determination of the site location. The scoring was based on site characteristics information that was available.	The natural Site characteristics (Climate, hydrology, etc.) in all counties can be expected to support efficient D&D activities during decommissioning.			
	25	Adjacent Site's Medium/Long-Term Plans	It is desirable that planned major construction and heavy industrial activities in adjacent sites within 1.6 km (1 mi) of the site boundary are minimal over the reasonably anticipated period of CISF decommissioning.	This criterion is not a big risk in determination of the site location. The scoring was based on the probability of future construction of the sites.	Andrews county was rated lower because there are other activities going on within the property boundaries, but should not affect the decommissioning of the CISF.	There are no known future projects for the site vicinity that could add additional impacts to decommissioning the proposed facilities.		

100% - Environmental Considerations				The Criteria environmental considerations are weighed at 100%. WCS valued 100% as critical and it cannot be changed. Environmental issues/concerns are there and cannot be adjusted.				
Criterion	Weight	Sub-criteria	Description	Weight summary	Andrews County, TX	Loving County, TX	Lea County, NM	Eddy County, NM
Criterion 15 - Disposal of Low-Level Waste	100	Availability to disposal options	Site-specific issues (e.g., availability/access to nearby facilities for disposal of low-level waste, transportation modes, etc.) do not impede disposal of low-level waste.	It is critical to have access to dispose of waste. The scoring was based on the availability to receive license and the location of shipment of waste.	The adjacent LLRW Disposal Facility virtually eliminates high transportation costs for CISF generated LLRW and the CISF operator already possesses the necessary permits and licensed to dispose of CISF LLRW, mixed waste and hazardous waste.	To store and ship these wastes, Lea, Loving and Eddy county Sites would have to hire and build a waste management staff capable of demonstrating the technical qualifications required to obtain the appropriate LLRW licenses and authorizations for generating, storing and transporting CISF-generated wastes.		

ATTACHMENT 3-1

HIGH LEVEL – BORINGS AND LOCATIONS SECTION



Monitoring Well/ Piezometer Name	Date Drilled/ Completed	Total Depth Well (ft btoc)	Bottom of Well Elevation (ft msl)	Ground Elevation (ft msl)	Top of Casing Elevation (ft msl)	Depth to Top of Red Beds (ft bgs)	Top of Red Bed Elevation (ft msl)
PZ-36	7/20/05	78.98	3419.51	3494.79	3498.49	75.0	3419.79
PZ-44	1/22/08	82.98	3416.90	3496.59	3499.88	77.1	3419.49
PZ-46	1/23/08	93.83	3412.04	3502.38	3505.87	87.4	3414.98
PZ-47	1/24/08	92.22	3411.56	3500.60	3503.78	87.0	3413.60
PZ-57	1/23/08	99.56	3415.44	3511.79	3515.00	93.5	3418.29
TP-64	1/11/08	70.81	3433.99	3502.08	3504.80	65.3	3436.78
TP-65	1/11/08	57.68	3436.07	3490.40	3493.75	52.5	3437.90
TP-66	1/10/08	57.78	3430.88	3485.45	3488.66	51.0	3434.45
TP-76	2/7/08	53.42	3436.78	3487.06	3490.20	47.1	3439.96
TP-77	2/7/08	51.30	3436.09	3484.19	3487.39	45.4	3438.79
TP-83	2/11/08	55.55	3435.60	3487.77	3491.15	49.8	3437.97
TP-84	2/12/08	65.24	3429.59	3491.56	3494.83	58.7	3432.86
TP-87	3/15/08	49.02	3438.47	3484.17	3487.49	43.3	3440.87
TP-136	3/20/09	55.21	3438.01	3490.17	3493.22	50.5	3439.67
TP-137	3/20/09	56.46	3434.68	3488.00	3491.14	51.5	3436.50

WCS
AMERICA'S NUCLEAR SOLUTION

Figure 3.3-1
Location of Cross-Sections

ATTACHMENT 3-2
SOIL SURVEY

SOIL SURVEY OF

Andrews County, Texas

ELECTRONIC VERSION

This soil survey is an electronic version of the original printed copy dated August 1974. It has been formatted for electronic delivery. Additional and updated information may be available from the Web Soil Survey. In Web Soil Survey, identify an Area of Interest (AOI) and navigate through the AOI Properties panel to learn what soil data is available.

United States Department of Agriculture
Soil Conservation Service
In cooperation with
Texas Agricultural Experiment Station

Issued August 1974

Major fieldwork for this soil survey was done in the period 1966-70. Soil names and descriptions were approved in 1970. Unless otherwise indicated, statements in this publication refer to conditions in the county in 1970. This survey was made cooperatively by the Soil Conservation Service and the Texas Agricultural Experiment Station. It is part of the technical assistance furnished to the Gaines-Andrews Soil and Water Conservation District.

Either enlarged or reduced copies of the soil map in this publication can be made by commercial photographers, or they can be purchased on individual order from the Cartographic Division, Soil Conservation Service, United States Department of Agriculture, Washington, D.C., 20250.

HOW TO USE THIS SOIL SURVEY

This soil survey contains information that can be applied in managing farms and ranches; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of Andrews County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by series and gives the capability classification of each. It also shows the page where each soil is described and the page for the range site in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the range sites and capability units.

Game managers, sportsmen, and others can find information about soils and wildlife in the section "Use of the Soils for Wildlife."

Ranchers and others can find, under "Range Management," groupings of the soils according to their suitability for range, and the names of many of the plants that grow on each range site.

Engineers and builders can find, under "Engineering Uses of the Soils," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and Classification of the Soils."

Newcomers in Andrews County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given in the section "General Nature of the County."

Cover picture: Typical landscape view of range in Andrews County. Soils are Blakeney and Conger soils, gently undulating.

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SOIL SURVEY OF ANDREWS COUNTY, TEXAS

BY NATHANIEL R. CONNER, HAROLD W. HYDE, AND HERBERT R. STONER,
SOIL CONSERVATION SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE,
IN COOPERATION WITH THE TEXAS AGRICULTURAL EXPERIMENT STATION

Andrews County is in the extreme southern part of the High Plains area in Texas (fig. 1). Andrews County has a total area of 962,560 acres. Elevation ranges from 3,000 to 3,400 feet. The county consists of nearly level to undulating plains. The most common soils in the county are sandy, but the soils are loamy and clayey in some areas. Andrews County has a cool-temperate, dry steppe climate and mild winters. Average yearly rainfall is 13.89 inches.

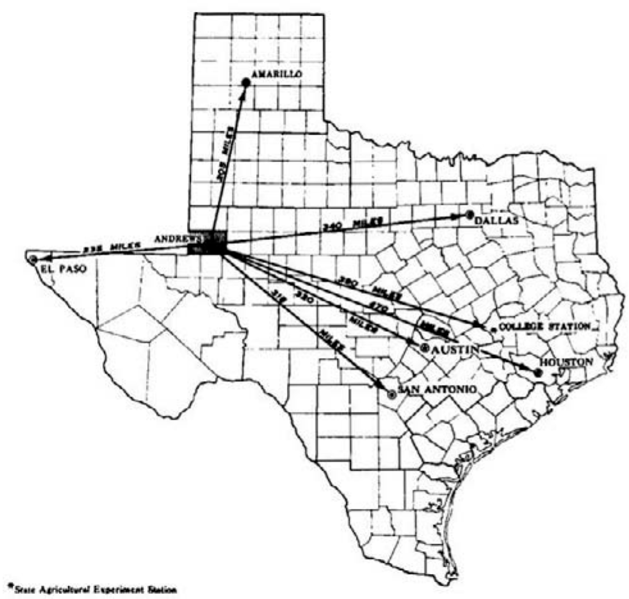

Figure 1.—Location of Andrews County in Texas.

In 1970, the county was dominantly range, and about 5 percent was used for crops such as cotton and grain sorghum. Cattle is the main type of livestock.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Andrews County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Faskin and Ratliff, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Triomas loamy fine sand, 0 to 3 percent slopes, is a phase within the Triomas series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map in the back of this publication was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful. in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Three such kinds of mapping units are shown on the soil. map of Andrews County: soil complexes, soil associations, and undifferentiated groups.

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Kimbrough-Slaughter complex, 0 to 3 percent slopes, is an example.

A soil association is made up of adjacent soils that occur as areas large enough to be shown individually on the soil map but are shown as one mapping unit because the time and effort of delineating them separately cannot be justified. There is a considerable degree of uniformity in pattern and relative extent of the dominant soils, but the soils may differ greatly one from another. The name of an association consists of the names of the dominant soils, joined by a hyphen. Jalmar-Penwell association, undulating, is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be, made up of only one of the dominant soils, or of two or more. The name of an undifferentiated group consists of the names of the dominant soils, joined by "and." Blakeney and Conger soils, gently undulating, is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely eroded that it cannot he classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Dune land is a land type in Andrews County.

While a soil survey is in progress, samples of soils are taken as needed for laboratory measurements and engineering tests. Laboratory data from the same kinds of soil in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

Only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, range managers, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others, then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Andrews County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large areas that are suitable for a certain kind of farming or other land use. Such a map is not suitable for planning the management of a farm or field, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect management.

The seven soil associations in Andrews County are each described in the following pages. The terms for texture used in the title for several of the associations apply to the surface layer. For example, in the title for association 1, the words "fine sands" refer to texture of the surface layer.

Soil associations and delineations on the general soil map in this survey do not fully agree with those of the general soil maps in adjacent counties published at a different date. Differences in the maps are the result of improvements in the classification of soils, particularly in the modifications or refinements in soil series concepts.

1. Jalmar-Penwell association

Deep, moderately permeable to rapidly permeable fine sands

This association consists of nearly level to undulating soils on uplands. It occupies broad areas throughout the county.

This association makes up about 36 percent of the county (fig. 2). Jalmar soils make up about 56 percent of the association and Penwell soils about 41 percent. The remaining 3 percent consists mainly of Triomas and Wickett soils and Dune land.

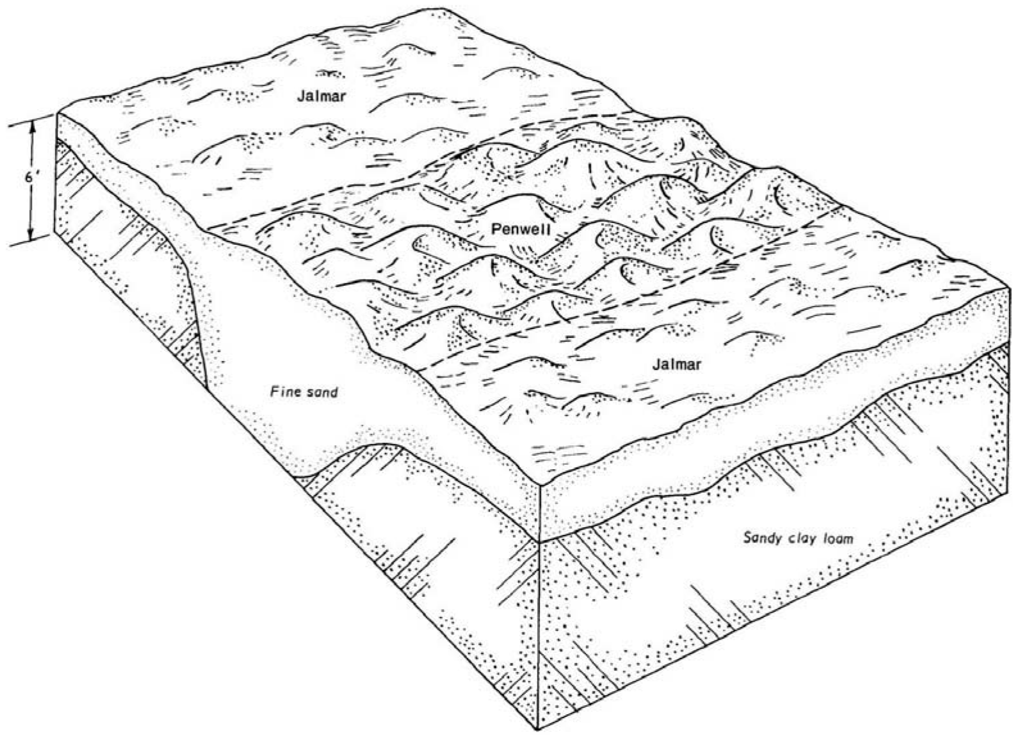

***Figure 2.*—Relationship of soils and underlying materials in the Jalmar-Penwell association.**

Jalmar soils are nearly level to gently undulating and occupy uplands. The surface layer is fine sand about 26 inches thick. It is brown in the upper part and reddish brown in the lower part. The next layer is red sandy clay loam in the upper 38 inches. Below this, to a depth of 80 inches, it is reddish-yellow sandy clay loam.

Penwell soils generally are undulating. The surface layer is pale-brown fine sand about 13 inches thick. The underlying material is fine sand that is very pale brown in the upper part and reddish yellow in the lower part. It extends to a depth of about 85 inches.

Most of this association is used for range. There is a severe hazard of soil blowing.

2. Triomas-Wickett association

Deep and moderately deep, moderately permeable to moderately rapidly permeable fine sands and loamy fine sands

This association consists of nearly level to gently undulating soils on uplands. It is in broad areas throughout the county.

This association occupies about 29 percent of the county. Triomas soils make up about 80 percent of the association and Wickett soils about 18 percent. The remaining 2 percent consists mainly of Douro, Faskin, Ima, and Jalmar soils (fig. 3).

Triomas soils have a surface layer of fine sand, about 16 inches thick, that is brown in the upper part and reddish brown in the lower part. The next layer is sandy clay loam to a depth of 80 inches. It is red in the upper part, light red in the middle part, and reddish yellow in the lower part.

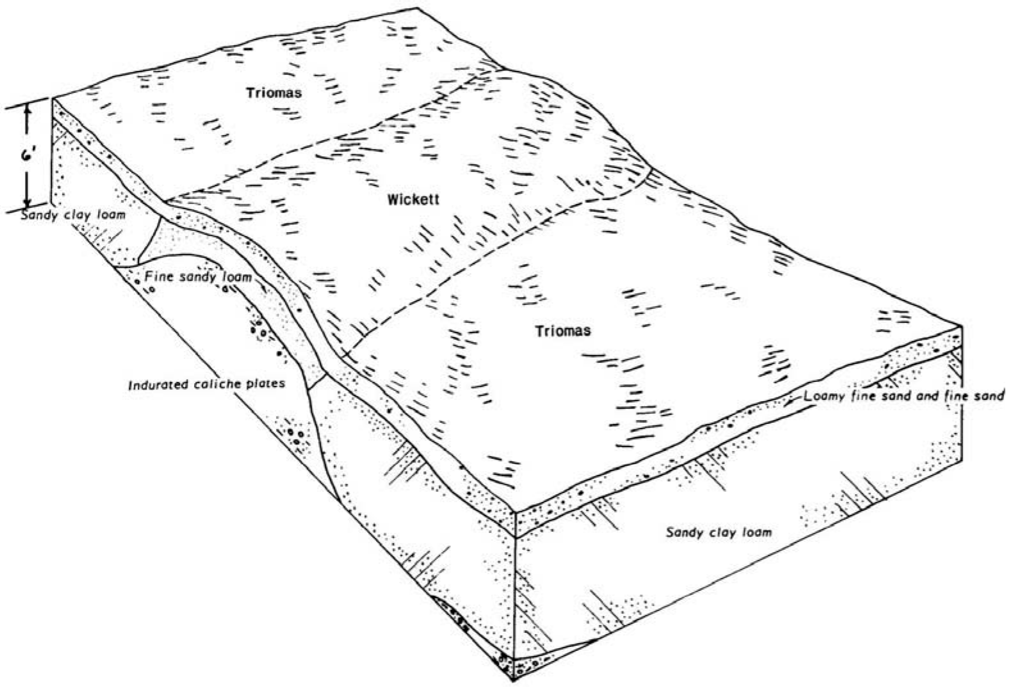

Figure 3.—Relationship of soils and underlying materials in the Triomas-Wickett association.

Wickett soils generally occupy the top part of upper slopes. The surface layer is a reddish-brown loamy fine sand about 16 inches thick. The next layer is yellowish-red fine sandy loam, about 17 inches thick, that is underlain by a layer of indurated platy caliche.

Most of this association is used for range, but some areas are farmed. There is a severe hazard of soil blowing.

3. Faskin-Douro association

Deep and moderately deep, moderately permeable fine sandy loams

This association consists of nearly level to gently undulating soils on uplands. It occupies broad areas throughout the county.

This association occupies about 16 percent of the county. Faskin soils make up about 70 percent of the association and Douro soils about 25 percent. The remaining 5 percent consists mainly of Blakeney, Conger, Lipan, Ratliff, Slaughter, Stegall, and Wickett soils.

Faskin soils have a surface layer of brown fine sandy loam about 8 inches thick. The next layer is sandy clay loam to a depth of 80 inches. It is reddish brown in the upper part, yellowish red and red in the middle part, and reddish yellow in the lower part.

Douro soils have a surface layer of reddish-brown fine sandy loam about 9 inches thick. The next layer is about 21 inches of sandy clay loam that is reddish brown in the upper part and red in the lower part. It is underlain by a layer of indurated caliche.

Most of this association is used for range. A few areas are cultivated to cotton and grain sorghum. The hazard of soil blowing is moderate.

4. Kimbrough-Slaughter-Stegall association

Very shallow to moderately deep, moderately permeable to moderately slowly permeable loams and clay loams

This association consists of nearly level to gently undulating soils on uplands. It is on mounds and ridges and in weakly concave areas.

This association occupies about 8 percent of the comity. Kimbrough soils make up about 80 percent of the association, Slaughter soils about 10 percent, and Stegall soils about 4 percent. The remaining 6 percent consists mainly of Blakeney, Conger, Douro, and Lipan soils.

Kimbrough soils are gently undulating and occupy mounds and ridges. The surface layer is dark-brown loam about 8 inches thick. It rests abruptly on a layer of indurated to strongly cemented caliche that extends to a depth of about 54 inches.

Slaughter soils are in nearly level, weakly concave areas. The surface layer is dark reddish-gray clay loam about 5 inches thick. The next layer is reddish-brown clay loam about 11 inches thick. It is underlain by indurated caliche plates.

Stegall soils also are in nearly level, weakly concave areas. The surface layer is grayish-brown clay loam about 5 inches thick. The next layer, about 24 inches thick, is clay loam that is dark grayish brown in the upper part and brown in the lower part. It is underlain by indurated caliche.

Most of this association is used for range. The hazard of soil blowing is slight to moderate.

5. Ratliff association

Deep, moderately permeable loams

This association consists of nearly level to gently undulating soils that are mostly on uplands. Some areas of the gently undulating soils are around the bottoms of enclosed depressions or intermittent lakes (playas), and some are around salt lakes.

This association occupies about 6 percent of the county. Ratliff soils make up about 85 percent of the association. The remaining 15 percent consists mainly of Blakeney, Conger, Faskin, Krade, Lipan, and Portales soils. Most of the areas occupied by salt lakes are also included in this association.

Ratliff soils are on uplands. They have a grayish-brown loam surface layer about 10 inches thick. The next layer is about 15 inches of light-brown clay loam, 42 inches of clay loam that is pink in the upper part and reddish yellow in the lower part, and 13 inches of pinkish-gray clay loam.

Most of this association is used for range; a few areas are cultivated. The hazard of soil blowing is moderate.

6. Blakeney-Conger association

Shallow, moderately rapidly permeable to moderately permeable fine sandy loams and loams

This association consists of nearly level to gently undulating soils that are on plains dissected by drainageways and on ridges around playas.

This association makes up about 3 percent of the county. Blakeney soils make up about 45 percent of the association and Conger soils about 40 percent. The remaining 15 percent consists mainly of Kimbrough, Lipan, and Potter soils.

Blakeney soils are gently undulating and generally occupy the slightly higher, more convex parts of the association. The surface, layer is brown fine sandy loam about 7 inches thick. The next layer is about 11 inches of brown fine sandy loam and is underlain by a layer of white, strongly cemented caliche.

Conger soils are less sloping and are in areas slightly below Blakeney soils. The surface layer is grayish-brown loam about 6 inches thick. The next layer is pale-brown clay loam about 11 inches thick. It is underlain by a layer of white caliche plates that are strongly to weakly cemented.

This association is used primarily for range. The hazard of soil blowing is moderate.

7. Ima-Potter-Portales association

Deep to very shallow, moderately rapidly permeable to moderately permeable loamy fine sands, loams, and clay loams

This association consists of nearly level to sloping soils that occupy the sides and bottoms of draws.

This association occupies about 2 percent of the county. Ima soils make up about 50 percent of the association, Potter soils, about 6 percent, and Portales soils, about 4 percent. The remaining 40 percent consists mainly of Blakeney, Jalmar, Kimbrough, Ratliff, and Triomas soils.

Ima soils are on the sides of draws. The surface layer is light yellowish-brown loamy fine sand about 14 inches thick. The next layer is yellowish-brown fine sandy loam to a depth of 36 inches. Below this, very pale brown fine sandy loam to sandy clay loam extends to a depth of 84 inches.

Potter soils generally are in the higher areas above the Ima soils. The surface layer is brown loam about 5 inches thick. This layer rests abruptly on a layer of platy caliche.

Portales soils occupy the bottoms of draws. The surface layer is grayish-brown clay loam about 15 inches thick. The next layer, clay loam about 32 inches thick, is brown in the upper part and pale brown in the lower part. The underlying material, to a depth of about 88 inches, is white clay loam.

Most of this association is used for range. A few areas are cultivated. The hazard of soil blowing is slight to severe.

Descriptions of the Soils

This section describes each of the soil series and the mapping units in Andrews County. The procedure is first to describe a soil series and then the mapping units in that series. Thus, to get full information on any given mapping unit, it is necessary to read the description of that unit and also the description of the soil series to which it belongs. The approximate acreage and proportionate extent of each mapping unit are given in table 1.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second, detailed and in technical terms, is for scientists, engineers, and others who need to make thorough and precise studies of soils.

One mapping unit, Dune land, is a land type and does not belong to a soil series. Nevertheless, it is listed in alphabetic order with the soil series.

In describing the representative profile, the color of each horizon is given by name and by the Munsell color notation, which measures hue, value, and chroma. For the profile described, the names of the colors and the color symbols are for dry soils, unless otherwise stated.

Following the name of each mapping unit is the symbol, in parentheses, that identifies the soil or land type on the detailed map at the back of the survey. Shown at the end of each mapping unit description are the capability classification and the range site in which the mapping unit has been placed. The page on which each mapping unit and range site is described is listed in the "Guide to Mapping Units."

Many of the terms used in describing soils can be found in the Glossary at the end of this survey, and more detailed information about the, terminology and methods of soil mapping can be obtained from the Soil Survey Manual *(5)*.

Blakeney Series

The Blakeney series consists of nearly level to gently undulating soils that are shallow over caliche. These soils formed in friable, calcareous, loamy sediments on uplands.

In a representative profile, the upper 18 inches is brown fine sandy loam that rests abruptly on a layer of strongly cemented caliche about 14 inches thick. Below this, to a depth of about 68 inches, is weakly cemented caliche.

These soils are well drained. Internal drainage is medium; permeability is moderately rapid. The hazards of soil blowing and water erosion are moderate.

In Andrews County, Blakeney soils are mapped only in an undifferentiated unit with the Conger soils.

Representative profile of a Blakeney fine sandy loam in an area of Blakeney and Conger soils, gently undulating (50 feet north of a point on Texas Highway 176 that is 15 miles northwest of Andrews County courthouse):

A1—0 to 7 inches, brown (10YR 5/3) fine sandy loam, brown (10YR 4/3) when moist; weak, medium, subangular blocky structure; slightly hard, friable; common very fine and fine roots and pores; common caliche fragments 5 to 10 millimeters in diameter; calcareous; moderately alkaline; gradual, smooth boundary.

B—7 to 18 inches, brown (10YR 5/3) fine sandy loam, brown (10YR 4/3) when moist; weak, coarse, prismatic structure parting to weak subangular blocky; slightly hard, friable; common very fine roots; common medium caliche fragments; calcareous; moderately alkaline; abrupt, wavy boundary.

C1cam—18 to 32 inches, white (10YR 8/2), strongly cemented, rounded caliche plates that are 2 to 4 inches in diameter; abrupt, wavy boundary.

C2ca—32 to 68 inches, pinkish-white (7.5YR 8/2) weakly cemented caliche that is about 25 percent, by volume, powdery masses of calcium carbonate; massive.

The A horizon ranges from 5 to 10 inches in thickness and is brown or light brown. The B horizon is 7 to 14 inches thick and is brown or pale brown. The C1cam horizon begins at a depth or 12 to 20 inches. The caliche plates range from 2 to 8 inches in diameter and from 1 to 3 inches in thickness.

Blakeney and Conger soils, gently undulating

(BCB).—These soils are along drainageways and around playas. Slopes range from 0 to 3 percent. Areas are irregular and range from 30 to several hundred acres in size. These soils have a profile described as representative for the Blakeney and Conger series.

Blakeney soils make up about 49 percent of the total acreage, and Conger soils, 47 percent. The remaining 4 percent is mainly Kimbrough and Potter soils. Some of the areas consist of either Blakeney or Conger soils. These soils do not occur in regular patterns, but it is not feasible to map them separately because their use and management are similar.

The hazard of soil blowing is moderate. Good management of these soils requires the return of large amounts of crop residue. Most of the acreage is used for range. These soils are better suited to irrigated farming than to dryland farming. A few areas are used for cotton and grain sorghum. Capability units VIe-2, dryland, and IIIe-6, irrigated; Mixed Plains range site.

Conger Series

The Conger series consists of nearly level to gently undulating soils that are shallow over caliche. These soils formed in friable, calcareous, loamy sediments on uplands.

In a representative profile, the surface layer is grayish-brown loam about 6 inches thick. The next layer is friable, pale-brown clay loam about 11 inches thick. It rests abruptly on a layer of white caliche plates about 22 inches thick. Below this, to a depth of about 75 inches, is weakly cemented caliche.

These soils are well drained. Internal drainage is medium; permeability is moderate. The hazards of soil blowing and water erosion are moderate.

In Andrews County, Conger soils are mapped only in an undifferentiated unit with the Blakeney soils.

Representative profile of a Conger loam in an area of Blakeney and Conger soils, gently undulating (200 feet north of a point on Texas Highway 176 that is 29 miles northwest of Andrews County courthouse):

A1—0 to 6 inches, grayish-brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) when moist; moderate, medium, subangular blocky structure; slightly hard, friable, sticky; common very fine and fine roots and pores; light brownish-gray (10YR 6/2), thin, platy surface crust about 1/4 inch thick; about 2 percent, by volume, is weakly to strongly cemented caliche fragments less than 10 millimeters in diameter; calcareous; moderately alkaline; clear, smooth boundary.

B—6 to 17 inches, pale-brown (10YR 6/3) clay loam, brown (10YR 5/3) when moist; moderate, coarse, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, friable, sticky; common very fine roots and pores; 5 to 10 percent, by volume, is medium caliche fragments less than 10 millimeters in diameter; calcareous; moderately alkaline; abrupt, wavy boundary.

C1cam—17 to 39 inches, white (10YR 8/2) caliche plates that are laminar and strongly cemented in the uppermost 1/2 inch; abrupt, wavy boundary.

C2ca—39 to 75 inches, white (10YR 8/2), weakly cemented caliche material that is about 50 percent, by volume, of visible calcium carbonate; massive.

The A horizon ranges from 4 to 6 inches in thickness and is grayish brown or brown. The B horizon ranges in thickness from 8 to 15 inches, and it is light brownish gray or pale brown. The C1cam horizon begins at a depth of 12 to 20 inches. The caliche plates range from 4 to 8 inches in diameter and from 1 to 3 inches in thickness. The laminar upper layer of the plates ranges from 1/2 inch to 2 inches in thickness.

Douro Series

The Douro series consists of nearly level to gently undulating soils that are moderately deep over caliche. These soils formed in friable, loamy sediments over indurated caliche on uplands.

In a representative profile (fig. 4), the surface layer is reddish-brown fine sandy loam about 9 inches thick. The next layer is friable sandy clay loam about 21 inches thick. This layer is reddish brown in the upper part and red in the lower part. It rests abruptly on a layer of indurated caliche.

These soils are well drained. Internal drainage is medium; permeability is moderate. The hazard of soil blowing is moderate and the hazard of water erosion is slight.

***Figure* 4.—Profile of Douro fine sandy loam.**

In Andrews County, Douro soils are only mapped in an undifferentiated unit with Faskin soils.

Representative profile of a Douro fine sandy loam in an area of Faskin and Douro soils, gently undulating (9 miles east of Andrews County courthouse, then 11.8 miles south of the intersection of State Highway 176 and Farm Road 1788, then 2.9 miles west on paved county road, then 0.2 mile north and 0.15 mile west, then 100 feet north of oilfield road):

A1—0 to 9 inches, reddish-brown (5YR 4/4) fine sandy loam, dark reddish brown (5YR 3/4) when moist; weak, fine, granular and weak, fine and medium, subangular blocky structure; slightly hard, friable, nonsticky; common very fine roots and pores; neutral; gradual, smooth boundary.

B21t—9 to 21 inches, reddish-brown (2.5YR 4/4) sandy clay loam, dark reddish brown (2.5YR 3/4) when moist; crushed color, dark red (2.5YR 3/6) when moist; moderate, coarse, prismatic structure parting to moderate, medium, subangular blocky; hard, firm, slightly sticky; common roots, few fine pores; few thin clay films on faces of prisms; neutral; gradual, smooth boundary.

B22t—21 to 30 inches, red (2.5YR 4/6) sandy clay loam, dark red (2.5YR 3/6) when moist; moderate, coarse, prismatic structure parting to moderate, medium, subangular blocky; hard, firm, slightly sticky; few very fine pores; few thin clay films; mildly alkaline; abrupt, wavy boundary.

C1cam—30 to 51 inches, platy indurated caliche; laminar in the upper 1/2 inch, strongly cemented in lower part; clear, wavy boundary.

C2ca—51 to 75 inches, weakly cemented caliche; more than 50 percent, by volume, of visible calcium carbonate; massive.

The A horizon ranges from 7 to 12 inches in thickness and is reddish brown or brown. Reaction is neutral or mildly alkaline. The B2t horizon ranges from 13 to 28 inches in thickness and is reddish brown to yellowish red or red. Reaction is neutral or mildly alkaline. The C1cam horizon begins at a depth of 20 to 40 inches below the surface. The caliche plates range from 2 to 8 inches in diameter and from 1/2 inch to 8 inches in thickness. The laminar upper part of the caliche ranges from 1/2 inch to 3 inches in thickness.

Dune Land

Dune land (DU) is a miscellaneous land type consisting of barren active sand dunes (fig. 5). These dunes range from 25 to 200 feet in height and from 50 to 300 acres in size, and they have slopes of 3 to 20 percent. They consist of eolian sand and have no horizon development. Dunes occur in association with Jalmar and Penwell soils.

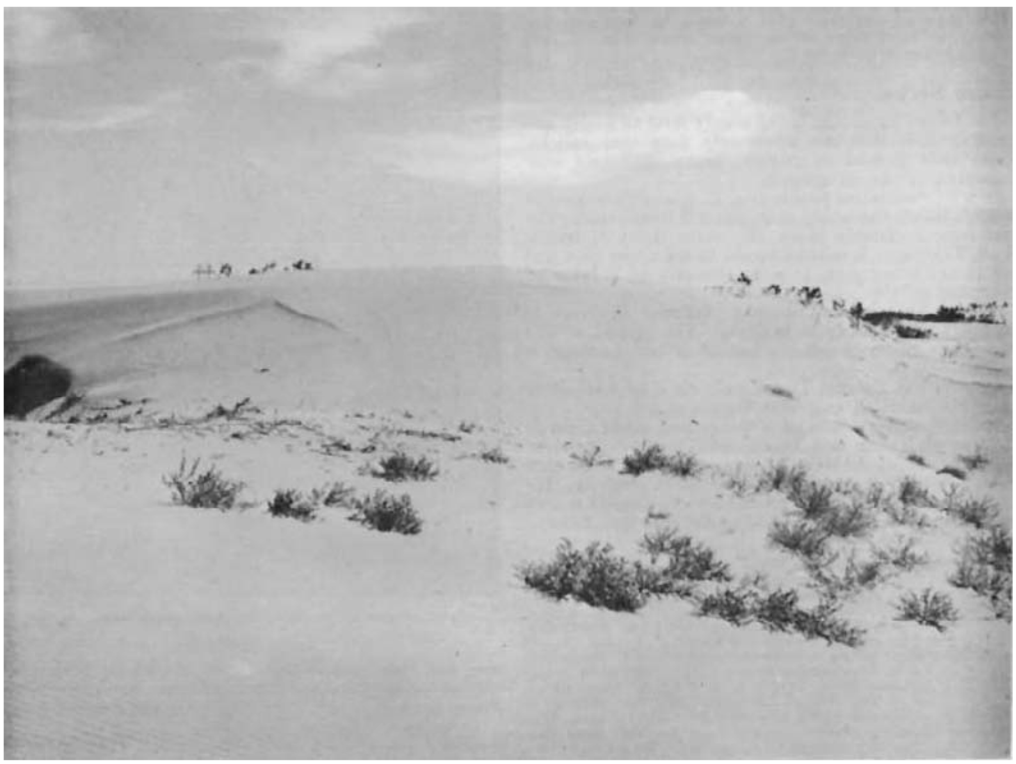

***Figure* 5.—Dune land showing severe effects of soil blowing.**

Dunes have a low available water capacity and are excessively drained and rapidly permeable. They are constantly shifted by wind and are more unstable on the east and north sides. They have no vegetation except on the outer edges, where shinnery and giant dropseed grow.

These areas have little value except for wildlife and should be protected from grazing by livestock. Capability unit VIIIe, dryland; not placed in a range site.

Faskin Series

The Faskin series consists of deep, nearly level to gently undulating soils. These soils formed in friable, loamy sediments of outwash and eolian material on uplands.

In a representative profile, the surface layer is brown fine sandy loam about 8 inches thick. The next layer is friable sandy clay loam to a depth of 80 inches. It is reddish brown in the upper part, yellowish red to red in the middle part, and reddish yellow in the lower part.

These soils are well drained. Internal drainage is medium; permeability is moderate. The hazard of soil blowing is moderate, and the hazard of water erosion is slight.

In Andrews County, the Faskin soils are mapped only in an undifferentiated unit with the Douro soils.

Representative profile of a Faskin fine sandy loam in an area of Faskin and Douro soils, gently undulating (9 miles east of the Andrews County courthouse, then 13.1 miles south of the intersection of State Highway 176 and Farm Road 1788, then 0.6 mile west of Farm Road 1788):

A1—0 to 8 inches, brown (7.5YR 4/4) fine sandy loam, dark brown (7.5YR 3/4) when moist; weak, fine, granular and subangular blocky structure; hard, friable, nonsticky; common very fine roots and pores and few fine roots; neutral; clear, smooth boundary.

B21t—8 to 20 inches, reddish-brown (5YR 4/4) sandy clay loam, dark reddish brown (5YR 3/4) when moist; moderate, coarse, prismatic structure parting to weak, medium, subangular blocky; very hard, friable, slightly sticky; common very line roots; few thin clay films on faces of pods and prisms; sand grains coated and bridged with clay; neutral; clear, smooth boundary.

B22t—20 to 34 inches, yellowish-red (5YR 5/6) sandy clay loam, yellowish red (5YR 4/6) when moist; moderate, coarse, prismatic structure parting to weak, medium, subangular blocky; very hard, friable, slightly sticky; few very fine to fine roots; nearly continuous clay films on faces of prisms and few thin clay films on faces of peds; mildly alkaline; clear, smooth boundary.

B23t—34 to 42 inches, red (2.5YR 4/6) sandy clay loam, dark red (2.5YR 3/6) when moist; moderate, coarse, prismatic structure parting to weak, medium, subangular blocky; hard, friable, slightly sticky; common very fine pores; nearly continuous clay films on faces of prisms and few thin clay films on faces of peds; noncalcareous; moderately alkaline; gradual, wavy boundary.

B24tca—42 to 66 inches, red (2.5YR 5/6) sandy clay loam, red (2.5YR 4/6) when moist; weak, coarse, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, slightly sticky; common thin clay films on pods; 10 percent, by volume, is soft masses of calcium carbonate, mainly coating on faces of peds; calcareous; moderately alkaline; gradual, wavy boundary.

B25t—66 to 80 inches, reddish-yellow (5YR 6/6) sandy clay loam, yellowish red (5YR 5/6) when moist; weak, coarse, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, slightly sticky; few discontinuous clay films on faces of peds; many films and threads of calcium carbonate; calcareous; moderately alkaline.

The A horizon ranges from 7 to 12 inches in thickness and is brown or reddish brown. The Bt horizon above the Btca horizon ranges from 29 to 50 inches in thickness. It is reddish brown, yellowish red, or red. Films and threads of secondary carbonates are within 32 to 50 inches of the surface. Reaction is neutral to moderately alkaline.

The Btca horizon begins at a depth of 36 to 53 inches and is red or reddish yellow. Soft masses of calcium carbonate comprise 10 to 50 percent, by volume, of this horizon. The Bt horizon below the Btca horizon is light reddish brown or reddish yellow. Films and threads of calcium carbonate comprise 5 to 15 percent, by volume, of this horizon.

Faskin and Douro soils, gently undulating (FDB).—These soils occupy the broad uplands. They are in irregular and oval-shaped areas that range from 30 to several hundred acres in size. Slopes are convex and range from 0.5 to 3 percent. These soils have the profiles described as representative for the Faskin and Douro series.

Faskin soils make up about 63 percent of the total acreage, and Douro soils, about 21 percent. The remaining 16 percent is mainly Blakeney, Lipan, Slaughter, and Stegall soils and other soils that are similar to Douro soils but are less than 20 inches thick over indurated caliche. All of these soils occur in irregular patterns, and it is not feasible to map them separately because their use and management are similar.

The hazard of soil blowing is moderate. Large amounts of fertilized crop residue need to be kept on the surface to maintain soil tilth and control soil blowing and water erosion. Most of the acreage is used for range, but a few areas are used for cotton and grain sorghum. Capability units IVe-1, dryland, and IIIe-3, irrigated; Sandy Loam range site.

Ima Series

The Ima series consists of deep, nearly level to gently sloping soils. These soils formed in friable, sandy, calcareous sediments on uplands.

In a representative profile, the surface layer is light yellowish-brown loamy fine sand about 14 inches thick. The next layer is yellowish-brown, friable fine sandy loam in the upper 22 inches and very pale brown fine sandy loam to sandy clay loam in the lower 19 inches. The underlying material, to a depth of 84 inches, is very pale brown sandy clay loam.

These soils are well drained. Internal drainage is rapid; permeability is moderately rapid in the upper 44 inches and moderate below. The hazard of soil blowing is severe, and the hazard of water erosion is slight.

Representative profile of Ima loamy fine sand, 0 to 3 percent slopes (9.7 miles north of Andrews County courthouse on U.S. Highway 385, then 2 miles east on Florey Road, then 0.2 mile south and 528 feet east):

A1—0 to 14 inches, light yellowish-brown (10YR 6/4) loamy fine sand, dark yellowish brown (10YR 4/4) when moist; weak, fine, granular and subangular blocky structure; soft, very friable, nonsticky; common very fine roots; mildly alkaline; clear, smooth boundary.

B21—14 to 36 inches, yellowish-brown (10YR 5/4) fine sandy loam, dark yellowish brown (10YR 4/4) when moist; weak, coarse, prismatic structure parting to weak, subangular blocky; slightly hard, friable, slightly sticky; few films, threads, and fragments of calcium carbonate; calcareous; moderately alkaline; clear, wavy boundary.

B22ca—36 to 44 inches, very pale brown (10YR 8/4) fine sandy loam, very pale brown (10YR 7/4) when moist; weak, fine, subangular blocky structure; slightly hard, friable, slightly sticky; 10 percent, by volume, is visible soft masses of calcium carbonate; calcareous; moderately alkaline; gradual, smooth boundary.

B3ca—44 to 55 inches, very pale brown (10YR 7/4) sandy clay loam, light yellowish brown (10YR 6/4) when moist; weak, medium, subangular blocky structure; slightly hard, friable, slightly sticky; 5 percent, by volume, is visible calcium carbonate; calcareous; moderately alkaline; clear, smooth boundary.

C—55 to 84 inches, very pale brown (10YR 7/3) sandy clay loam, pale brown (10YR 6/3) when moist; massive; soft, friable, slightly sticky; 5 percent, by volume, is visible calcium carbonate; calcareous; moderately alkaline.

The A horizon ranges from 10 inches to 14 inches in thickness and is brown, light yellowish brown, or light brown. The B2 horizon above the Bca horizon ranges from 15 to 36 inches in thickness and is pale brown, yellowish brown, or light brown. The Bca horizon begins at a depth of 29 to 48 inches and is reddish yellow or very pale brown.

Ima loamy fine sand, 0 to 3 percent slopes (ImB).—This nearly level to gently sloping soil occurs on uplands. Its areas are irregular and range from 30 to 100 acres in size. Included in mapping are small areas of Blakeney, Jalmar, and Triomas soils.

The hazard of soil blowing is severe. Large amounts of crop residue need to be kept on the surface to help control soil blowing and water erosion and to help maintain soil tilth. Most of the acreage is used for range. This soil is not suited to dryland farming, but it is suited to irrigated farming. A few areas are used for cotton and grain sorghum. Capability units VIe-5, dryland, and IIIe-5, irrigated; Sandyland range site.

Jalmar Series

The Jalmar series consists of deep, nearly level to undulating soils. These soils formed in friable, eolian, sandy material on uplands.

In a representative profile, the surface layer is fine sand about 26 inches thick. It is brown in the upper part and reddish brown in the lower part. The next layer is sandy clay loam to a depth of 80 inches. This layer is red in the upper 38 inches and reddish yellow below.

These soils are well drained. Internal drainage is medium; permeability is moderate. The hazard of soil blowing is severe, and the hazard of water erosion is slight.

In Andrews County, Jalmar soils are mapped only in an association with Penwell soils.

Representative profile of a Jalmar fine sand in an area of Jalmar-Penwell association, undulating (9.7 miles north of the Andrews County courthouse on U.S. Highway 385, then 1.8 miles east on Florey Road, then 0.8 mile north on oilfield road and 75 feet east):

A11—0 to 14 inches, brown (7.5YR 5/4) fine sand, dark brown (7.5YR 4/4) when moist; single grain; loose, nonsticky; common fine roots; neutral; gradual, smooth boundary.

A12—14 to 26 inches, reddish-brown (5YR 5/4) fine sand, reddish brown (5YR 4/4) when moist; single grain; loose, nonsticky; common fine roots; neutral; clear, smooth boundary.

B21t—26 to 52 inches, red (2.5YR 4/6) sandy clay loam, dark red (2.5YR 3/6) when moist; moderate, coarse, prismatic structure parting to moderate, medium, subangular blocky; very hard, firm, slightly sticky; few fine roots and pores; few thin clay films on ped faces; neutral; gradual, wavy boundary.

B22t—52 to 64 inches, red (2.5YR 5/6) sandy clay loam, red (2.5YR 4/6) when moist; moderate, coarse, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, friable, slightly sticky; common distinct clay films on prism faces; neutral; gradual, wavy boundary.

B23tca—64 to 80 inches, reddish-yellow (5YR 6/6) sandy clay loam, yellowish red (5YR 5/6) when moist; moderate, coarse, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, friable, slightly sticky; few thin clay films on ped faces; about 25 percent, by volume, is visible calcium carbonate in soft masses and coatings on peds; calcareous; moderately alkaline.

The A horizon ranges from 22 to 39 inches in thickness and is reddish brown or brown. The Bt horizon above the Btca horizon ranges from 28 to 48 inches in thickness. It is light red, red, or yellowish red. Reaction is neutral or mildly alkaline. A Btca horizon occurs between 50 and 70 inches below the surface.

Jalmar-Penwell association, undulating (JPC).—Areas of these soils range from 600 to 3,000 acres in size. Slopes are convex and range from 0.5 to 8 percent. These soils have the profiles described as representative for the Jalmar and Penwell series.

Jalmar soils make up about 56 percent of the total acreage, and Penwell soils, about 40 percent. The remaining 4 percent is mainly Triomas soils, unstabilized Dune land, and a soil that is similar to Jalmar soils but has a fine sand surface layer more than 40 inches thick. Soils in this association occur together in regular patterns, but they are not mapped separately because their use and management are similar.

The hazard of soil blowing is severe. Large amounts of crop residue need to be kept on the surface to help control soil blowing. Most of the acreage is used for range, but a few areas are used for cotton and grain sorghum. These soils are not suited to dryland farming. Capability units VIe-3, dryland, and IVe-2, irrigated, for Jalmar soils; and VIIe-1, dryland, for Penwell soils; Deep Sand range site.

Kimbrough Series

The Kimbrough series consists of gently undulating soils that are very shallow to shallow over caliche. These soils formed in friable, loamy sediments over indurated caliche on uplands.

In a representative profile, the surface layer is dark-brown loam about 8 inches thick. It rests abruptly on a layer of indurated plates of caliche about 23 inches thick. Below this, to a depth of about 54 inches, are strongly cemented caliche plates (fig. 6).

Kimbrough soils are well drained. Internal drainage is medium; permeability is moderate. The hazards of soil blowing and water erosion are slight.

Representative profile of a Kimbrough loam in an area of Kimbrough soils, gently undulating (9 miles east of the Andrews County courthouse, then 11.8 miles south of the intersection of State Highway 176 and Farm Road 1788, then 1.4 miles west on county road, 0.2 mile north):

A1—0 to 8 inches, dark-brown (7.5YR 4/2) loam, dark brown (7.5YR 3/2) when moist; weak, medium, subangular blocky structure; slightly hard, friable, slightly sticky; common very fine to fine roots and pores; 2 percent medium to coarse fragments of calcium carbonate in lower part; mildly alkaline; abrupt, wavy boundary.

C1cam—8 to 31 inches, indurated plates of caliche that are laminar in the upper 1/2 inch; few plates are fractured; abrupt, wavy boundary.

C2ca—31 to 54 inches, strongly cemented plates of caliche coated with calcium carbonate; plates range from 7 to 15 inches along the long axis.

The A horizon ranges from 4 to 10 inches in thickness and is brown or dark brown. Coarse fragments cover 2 to 15 percent of the surface area. Reaction is neutral or moderately alkaline. Texture is mainly loam but may be clay loam. The C1cam horizon begins at a depth of 4 to 10 inches and ranges from 20 to 26 or more inches in thickness. The caliche plates range from 6 to 12 inches in diameter and are laminar in the upper 1/2 inch to 2 inches. The plates in this horizon range from strongly cemented to indurated.

Figure 6.—**Profile of a Kimbrough soil.**

Kimbrough soils, gently undulating (KMB).—Areas of these soils are irregular and range from 40 to 400 acres in size. Slopes are weakly convex to slightly concave and range from 0 to 3 percent. One of these soils has the profile described as representative for the Kimbrough series, but in places the surface layer is clay loam rather than loam.

Included in mapping are small areas of Conger, Lipan, and Slaughter soils.

Most of the acreage is used for range, recreational areas, and wildlife habitat. Capability unit VIIs-1, dry-land; Very Shallow range site.

Kimbrough-Slaughter complex, 0 to 3 percent slopes (KsB).—These nearly level to gently sloping soils occur in such intricate patterns that it is not practical to map them separately. Kimbrough soils are gently sloping and are on mounds and ridges. Slaughter soils are nearly level to weakly concave and are in circular areas a few inches below the Kimbrough soils. Areas of the complex range from 110 acres to 3,500 acres in size.

Kimbrough soils have a brown loam surface layer that is about 5 inches thick over indurated caliche. Slaughter soils have a reddish-brown clay loam surface layer that is about 16 inches thick over indurated caliche.

Kimbrough soils make up about 48 percent of the total acreage, and Slaughter soils, about 32 percent. The remaining 20 percent is mainly Conger, Blakeney, Lipan, and Stegall soils.

This complex is not suited to crops because of the shallow depth of the Kimbrough soils. It is best suited to range, recreational areas, or wildlife habitat. Capability unit VIIs-1; dryland; Very Shallow range site.

Krade Series

The Krade series consists of deep, undulating soils on uplands. They formed in friable, loamy sediments high in content of lime.

In a representative profile, the surface layer is brown fine sandy loam about 7 inches thick. The next layer is fine sandy loam to a depth of about 80 inches. The upper 22 inches of this layer is brown, and the lower part is pink and contains a few films and threads of calcium carbonate.

These soils are well drained. Internal drainage is medium; permeability is moderately rapid. The hazards of soil blowing and water erosion are severe (fig. 7).

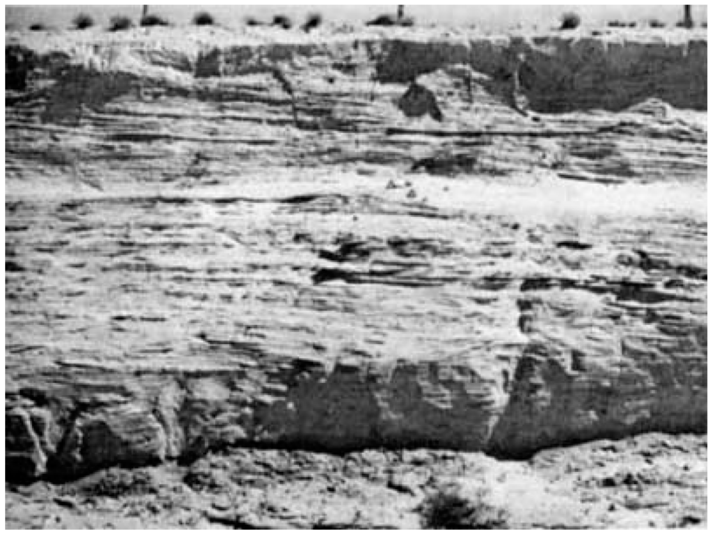

Figure 7.—**An area of Krade soils. This roadside cut shows a layer of wind-deposited material.**

Representative profile of a Krade fine sandy loam in an area of Krade soils, undulating (8 miles north of Andrews County courthouse, then 3.9 miles west, of intersection of U.S. Highway 385 and Farm Road 1967, then 0.7 mile south on oilfield road and 100 feet west):

A1—0 to *7* inches, brown (10YR 5/3*)* fine sandy loam, brown (10YR 4/3) when moist; weak, line, subangular blocky structure; soft, very friable; common very fine roots and pores; calcareous; moderately alkaline; clear, smooth boundary.

C1—7 to 29 inches, light-brown (7.5YR 6/4) fine sandy loam, brown (7.5YR 5/4) when moist; massive; soft, friable; few roots; common very fine pores; calcareous; moderately alkaline; gradual, smooth boundary.

C2—29 to 80 inches, pink (7.5YR 7/4) fine sandy loam, light brown (7.5YR 6/4) when moist; slightly hard, friable; few films and threads of calcium carbonate; calcareous; moderately alkaline.

The A horizon ranges from 5 to 10 inches in thickness and is brown, grayish brown, or dark grayish brown. Its texture is mainly fine sandy loam but ranges to loam or loamy sand. The C1 horizon ranges from 11 to 23 inches in thickness and is light brown, light gray, or very pale brown.

Krade soils, undulating (KRC).—These soils occupy upland areas around salt lakes and playas. Areas are irregular in shape and range from 100 to 300 acres in size but generally are about 200 acres. Slopes range from 1 to 5 percent. Texture of the surface layer is mainly fine sandy loam but ranges to loam and loamy sand.

Included in mapping are small areas of Ratliff soils. Also included is a soil that is underlain by gypsum within 10 to 20 inches of the surface. This included soil makes up about 10 percent of the total area. In the vicinity of some salt lakes, small areas of underlying red beds are exposed.

Most of the acreage is used for range, recreational areas, and wildlife habitat. Capability unit VIe-4, dry-land; High Lime range site.

Lipan Series

The Lipan series consists of deep, nearly level soils that occupy the bottoms of enclosed depressions of intermittent lakes (playas). These soils formed in clayey, calcareous sediments.

In a representative profile, the surface layer is very firm gray clay about 16 inches thick. The next layer is firm, light brownish-gray clay about 34 inches thick. This layer is underlain by a firm layer of light-gray clay to a depth of about 60 inches (fig. 8).

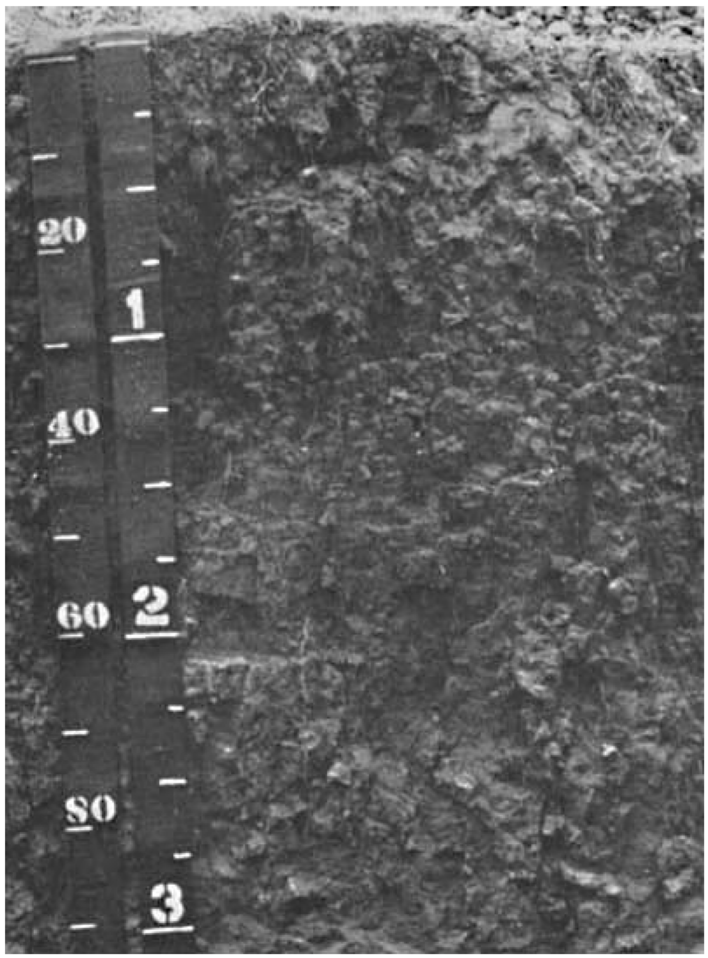

Figure 8.—Profile of Lipan clay.

These soils are moderately well drained. Internal drainage and permeability are very slow. The hazards of soil blowing and water erosion are slight.

Representative profile of Lipan clay (30 feet west of a point on Farm Road 1788 that is 15.4 miles south of intersection of Farm Road 1788 and Texas Highway 176, 9 miles east of Andrews County courthouse):

A11—0 to 4 inches, gray (10YR 5/1) clay, dark gray (10YR 4/1) when moist; moderate, medium and fine, blocky structure; very hard, very firm, sticky;

many fine roots; few very fine concretions of calcium carbonate; calcareous; moderately alkaline; clear, smooth boundary.

A12—4 to 16 inches, gray (10YR 5/1) clay, dark gray (10YR 4/1) when moist; moderate, medium and coarse, blocky structure; extremely hard, very firm, sticky; few fine roots; few very fine concretions of calcium carbonate; calcareous; moderately alkaline; gradual, wavy boundary.

AC—16 to 50 inches, light brownish-gray (10YR 6/2) clay, grayish brown (10YR 5/2) when moist; few intersecting slickensides and parallelepipeds; medium and coarse blocky structure; extremely hard, firm, sticky; few very fine roots; few very fine concretions of calcium carbonate; calcareous; moderately alkaline; gradual, wavy boundary.

Cca—50 to 60 inches, light-gray (10YR 7/2) clay, light brownish gray (10YR 6/2) when moist; massive; hard, firm, sticky; 12 percent, by volume, is very fine masses and threads of calcium carbonate; calcareous; moderately alkaline.

The A horizon ranges from 13 to 20 inches in thickness. This horizon is noncalcareous to calcareous and is mildly alkaline or moderately alkaline. The AC horizon ranges from 30 to 40 inches in thickness and is light brownish gray or dark grayish brown. The Cca horizon begins at a depth of 43 to 60 inches. This horizon is 5 to 15 percent calcium carbonate, by volume.

Lipan clay (Lc).—This soil occupies weakly concave playas. These depressions are rounded or oval shaped and range from 10 to 50 acres or more in size. Slopes are 0 to 1 percent.

Included in mapping are small areas of Ratliff and Portales soils on the outer edge of the depressions.

This soil is periodically inundated by excess water from adjacent soils. It swells when wet and cracks when dry and is not suited to cultivation unless drained. It is better suited to range and wildlife habitat. Capability unit VIw–1; included in surrounding range, site.

Penwell Series

The Penwell series consists of deep, undulating soils on uplands. These soils formed in loose, neutral, sandy eolian sediments. Slopes range from 1 to 8 percent.

In a representative profile, the surface layer is pale-brown fine sand about 13 inches thick. The next layer is loose fine sand to a depth of about 85 inches. It is very pale brown in the upper part; and reddish yellow in the lower part.

These soils are well drained. Internal drainage and permeability are rapid. The hazard of soil blowing is severe, and the hazard of water erosion is slight.

In Andrews County, Penwell soils are mapped only in an association with Jalmar soils.

Representative profile of a Penwell fine sand in an area of Jalmar-Penwell association, undulating (15 miles southwest of the Andrews County courthouse, then 3.7 miles south of the intersection of Farm Road 181 and State Highway 115, then 0.2 mile west):

A1—0 to 13 inches, pale-brown (10YR 6/3) line sand, brown (10YR 5/3) when moist; single grain; loose; few roots; neutral; gradual, smooth boundary.

C1—13 to 60 inches, very pale brown (10YR 7/4) fine sand, light yellowish brown (10YR 6/4) when moist; single grain; loose; few roots; neutral; gradual, smooth boundary.

C2—60 to 85 inches, reddish-yellow (7.5YR 7/6) fine sand, reddish yellow (7.5YR 6/6) when moist; single grain; loose; neutral.

The A horizon ranges from 8 to 15 inches in thickness and is pale brown or yellowish brown. The C horizon is 50 inches or more thick; it is very pale brown or reddish yellow.

Portales Series

The Portales series consists of deep, nearly level soils. These soils formed in friable, loamy, calcareous sediments.

In a representative profile, the surface layer is grayish-brown clay loam about 15 inches thick. The next layer is friable clay loam, about 32 inches thick, that is brown in the upper part and pale brown in the lower part. The underlying material, to a depth of about 88 inches, is white clay loam.

These soils are well drained. Internal drainage is medium; permeability is moderate. The hazards of soil blowing and water erosion are slight.

Representative profile of Portales clay loam (9 miles east of Andrews County courthouse, then 11.8 miles south of the intersection of. Farm Road 1788 and State Highway 176, then 2.9 miles east on county road, then 1.9 miles north on oilfield road and 0.2 mile west):

A1—0 to 15 inches, grayish-brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) when moist; weak, fine and medium, granular and weak, fine, subangular blocky structure; hard, friable, slightly sticky; common fine and few medium roots and pores; calcareous; moderately alkaline; gradual, smooth boundary.

B2—15 to 36 inches, brown (10YR 5/3) clay loam, dark brown (10YR 4/3) when moist; weak, fine, subangular blocky structure; slightly hard, friable, slightly sticky; few fine roots; calcareous; moderately alkaline; gradual, smooth boundary.

B3ca—36 to 47 inches, pale-brown (10YR 6/3) clay loam, brown (10YR 5/3) when moist; weak, fine, subangular blocky structure; slightly hard, friable, slightly sticky; estimated 10 percent, by volume, is fine concretions and soft masses of calcium carbonate; calcareous; moderately alkaline; clear, wavy boundary.

Cca—47 to 88 inches, white (10YR 8/2) clay loam, light gray (10YR 7/2) when moist; massive; about 40 percent, by volume, calcium carbonate concretions; few fine gypsum crystals, snail shells, and brownish-yellow mottles in lower part.

The A horizon ranges from 10 to 17 inches in thickness and is grayish brown or dark grayish brown. The B2 horizon ranges from 10 to 25 inches in thickness and is brown or pale brown. The B3ca horizon ranges from 5 to 20 inches in thickness and is light brown or pale brown. Five to 10 percent, by volume, of this horizon is calcium carbonate. The Cca horizon begins at a depth of 40 to 47 inches. It is white or very pale brown. This horizon is 30 to 50 percent, by volume, calcium carbonate.

Portales clay loam (Po).—This soil occupies flood plains of intermittent streams and draws. Its areas are narrow and several miles long. Slopes are 0 to 1 percent.

Included in mapping are areas of Ratliff soils. Also included are areas of a soil that is similar to this Portales soil except that the grayish-brown surface layer ranges up to 30 inches in thickness.

This Portales soil receives excess runoff water from surrounding areas and is occasionally subject to flooding. The hazard of soil blowing is slight. Most of the acreage is used for range, although the soil is suitable for cultivation if protected from flooding. Large amounts of fertilized crop residue need to be kept on the surface to maintain soil tilth and control soil blowing and water erosion. Capability units IVe-2, dryland, and IIe-2, irrigated; Valley range site.

Potter Series

The Potter series consists of sloping soils that are very shallow over caliche. These soils formed in loamy, calcareous sediments over caliche on uplands.

In a representative profile, the surface layer is brown loam about 5 inches thick. It rests abruptly on a layer of white platy caliche about 5 inches thick. Below this, to a depth of about 36 inches, is a mixture of white, slightly platy caliche and pinkish earth.

Potter soils are well drained. Internal drainage is slow to medium; permeability is moderate. The hazard of soil blowing is slight, and the hazard of water erosion is moderate (fig. 9).

***Figure* 9.—An area of Potter soils, sloping, and Portales clay loam in the bottom.**

Representative profile of a Potter loam in an area of Potter soils, sloping (14.6 miles northeast of the Andrews County courthouse, then 0.6 mile northwest of State Highway 115 and 175 feet northeast):

A1—0 to 5 inches, brown (10YR 5/3) loam, dark brown (10YR 4/3) when moist; weak, tine, subangular blocky structure; soft, friable, slightly sticky; common very fine roots and pores; many fragments of calcium carbonate 5 to 20 millimeters in diameter; calcareous; moderately alkaline; abrupt, wavy boundary.

Cca—5 to 10 inches, white (10YR 8/2) platy caliche; plates are 1 to 2 inches thick and have a hardness of less than 3 on Mohs' scale; plates are fractured in places, allowing some roots to penetrate; roots adhere to surface and bottom of plates; plates are 3 to 7 inches in diameter.

C2ca—10 to 36 inches, white (10YR 8/2) slightly platy caliche; plates are 1 to 2 inches in length; pinkish earth is between layers of caliche; estimated 30 to 40 percent, by volume, is weakly cemented caliche; more nearly massive than C1ca horizon.

The A horizon ranges from 4 to 10 inches in thickness and is light brown, brown, or pale brown. Texture is mainly loam but some areas are gravelly loam. Coarse fragments are on 10 to 15 percent of the surface. The Cca horizon begins at a depth of 4 to 10 inches. This horizon is weakly to strongly cemented.

Potter soils, sloping (PTC).—These soils are on the sides of Mustang and Seminole Draws. They occupy irregular, long areas that range from 15 to 100 acres in size. Slopes are convex and range from 5 to 8 percent. The surface layer is mainly loam but, in some areas, is gravelly loam.

Included in mapping are small areas of Blakeney and Ima soils. Also included are some areas of Potter soils that; have slopes of 3 to 5 percent and 8 to 12 percent.

The hazard of soil blowing is slight, and the hazard of water erosion is moderate. Most of the acreage is used for range. Erosion can be controlled by maintaining a good cover of grasses. Capability unit VIIs-1, dryland; Very Shallow range site.

Ratliff Series

The Ratliff series consists of deep, nearly level to gently undulating soils. These soils formed in friable, calcareous, loamy sediments on uplands.

In a representative profile, the surface layer is grayish-brown loam about 10 inches thick. The next layer is friable clay loam to a depth of 80 inches. The upper 15 inches of this layer is light brown, the next 20 inches is pink, the next 22 inches is reddish yellow, and the lower part is pinkish gray.

These soils are well drained. Internal drainage is medium; permeability is moderate. The hazard of soil blowing is moderate, and the hazard of water erosion is slight.

Representative profile of a Ratliff loam in an area of Ratliff soils, gently undulating (9 miles east of the Andrews County courthouse, then 12.1 miles south of the intersection of Farm Road 1788 and State Highway 176 then 0.15 mile west of Farm Road 1788):

A1—0 to 10 inches, grayish-brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) when moist; moderate, medium, subangular blocky structure; slightly hard, friable, slightly sticky; light brownish-gray platy surface crust 1/8-inch thick; common fine roots and pores; calcareous; moderately alkaline; clear, smooth boundary.

B21—10 to 25 inches, light-brown (7.5YR 6/4) clay loam, brown (7.5YR 4/4) when moist; moderate, coarse, prismatic structure parting to fine and medium subangular blocky; slightly hard, friable, slightly sticky; common very fine roots and pores; few films and threads of calcium carbonate; calcareous; moderately alkaline; clear, wavy boundary.

B22ca—25 to 45 inches, pink (7.5Y11 8/4) clay loam, light brown (7.5Y11 6/4) when moist; weak, fine, subangular blocky structure; slightly hard, friable, sticky; estimated 30 percent, by volume, is concretions and soft masses of calcium carbonate; calcareous; moderately alkaline; gradual, wavy boundary.

B23ca—45 to 67 inches, reddish-yellow (7.5YR 6/6) clay loam, strong brown (7.5YR 5/6) when moist; weak, medium, subangular blocky structure; slightly hard, friable, sticky; estimated 10 percent, by volume, is soft masses of calcium carbonate; calcareous; moderately alkaline; gradual, wavy boundary.

B24ca—67 to 80 Inches, pinkish-gray (7.5YR 7/2) clay loam, pinkish gray (7.5Y11 6/2) when moist; weak, medium, subangular blocky structure; slightly hard, friable, slightly sticky; estimated 30 percent, by volume, is calcium carbonate; common black coatings on peds; calcareous; moderately alkaline.

The A horizon ranges from 8 to 10 inches in thickness and is brown or grayish brown. Texture is mainly loam but ranges to fine sandy loam. The B2 horizon above the B22ca horizon ranges from 15 to 28 inches in thickness and is light brown or pale brown. The Bca horizon begins at a depth of 23 to 38 inches. It is reddish yellow, pink, pinkish gray, or pinkish white. This horizon is an estimated 30 to 50 percent, by volume, soft masses and fragments of calcium carbonate.

Ratliff soils, gently undulating (RAB).—These soils are on uplands in irregular to oval-shaped areas ranging from 20 to 300 acres in size. Slopes are convex and range from 0.5 to 3 percent. Texture of the surface layer is mainly loam but ranges to fine sandy loam.

Included in mapping are small areas of Blakeney and Conger soils. Also included are areas of a soil that is similar to Ratliff soils, except that it has an accumulation of calcium carbonate within 20 inches of the surface.

The hazard of soil blowing is moderate on these soils. Large amounts of crop residue need to be kept on the surface to help control soil blowing and maintain soil tilth. Most of the acreage is used for range. These soils are not suited to dryland farming, but they are suited to irrigated farming. A. few areas are used for cotton and gram sorghum. Capability units VIe-7, dryland, and IIIe-2, irrigated; Mixed Plains range site.

Slaughter Series

The Slaughter series consists of nearly level soils that are shallow over caliche. These soils formed in loamy sediments on uplands.

In a representative profile, the surface layer is dark reddish-gray clay loam about 5 inches thick. The next layer is reddish-brown clay loam about 11 inches thick. It rests abruptly on a layer of indurated caliche that extends to a depth of about 30 inches.

These soils are well drained. Internal drainage is medium; permeability is moderately slow. The hazard of soil blowing is moderate, and the hazard of water erosion is slight.

In this county, the Slaughter soils are mapped in an undifferentiated unit with Stegall soils and in a complex with the Kimbrough soils.

Representative profile of a Slaughter clay loam in an area of Stegall and Slaughter soils (9 miles east of the Andrews County courthouse, then 11.8 miles south of the intersection of Farm Road 1788 and State Highway 176, then 0.9 mile west on county road and 0.1 mile north):

A1—0 to 5 inches, dark reddish-gray (5YR 4/2) clay loam, dark reddish brown (5YR 3/2) when moist; moderate, medium, subangular blocky structure; hard, firm, sticky; many very fine and common fine roots and pores; neutral; abrupt, smooth boundary.

B21t—5 to 8 inches, reddish-brown (YR 4/3) clay loam, dark reddish brown (5YR 3/3) when moist; moderate, medium, blocky structure; extremely hard, firm, sticky; common very fine roots and pores; common thin clay films; neutral; clear, smooth boundary.

B22t—8 to 16 inches, reddish-brown (5YR 4/4) clay loam, dark reddish brown (5YR 3/4) when moist; moderate, medium, blocky structure; extremely hard, firm, sticky; common very fine roots and pores; common thin clay films; neutral; abrupt, wavy boundary.

Ccam—16 to 30 inches, indurated plates of caliche that are laminar in the upper 1/2 inch.

The A horizon ranges from 4 to 8 inches in thickness and is dark reddish gray, brown, or reddish brown. Reaction is neutral or mildly alkaline. The B2t horizon ranges from 6 to 12 inches in thickness and is reddish brown or brown. Reaction is neutral or mildly alkaline. The Ccam horizon begins at a depth of 10 to 20 inches.

Stegall Series

The Stegall series consists of nearly level soils that are moderately deep over caliche. The soils developed in moderately fine textured sediments on uplands.

In a representative profile, the surface layer is grayish-brown clay loam about 5 inches thick. The next layer is firm clay loam about 24 inches thick. It is dark grayish brown in the upper part and brown in the lower part. A few films and threads of calcium carbonate are in the lower part, which rests abruptly on a layer of indurated caliche that extends to a depth of 40 inches.

These soils are naturally well drained. Internal drainage is medium; permeability is moderately slow. The hazards of soil blowing and water erosion are slight.

In Andrews County, Stegall soils are mapped only in an undifferentiated unit with Slaughter soils.

Representative profile of a Stegall clay loam in an area of Stegall and Slaughter soils (9 miles east of the Andrews County courthouse, then 11.8 miles south of the intersection of Farm Road 1788 and State Highway 176, then 2.9 miles east of Farm Road 1788 on an oilfield road, 0.3 mile north and 25 feet west):

A1—0 to 5 inches, grayish-brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, subangular blocky structure; hard, firm, sticky; common fine and few medium roots and pores; neutral; clear, smooth boundary.

B21t—5 to 15 inches, dark grayish-brown (10YR 4/2) clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, angular blocky structure; extremely hard, firm, sticky, plastic; few fine and medium roots and pores; common clay films; neutral; clear, smooth boundary.

B22t—15 to 24 inches, brown (7.5YR 5/2) clay loam, brown (7.5Y11 4/2) when moist; moderate, medium, angular blocky structure; extremely hard, firm, sticky, plastic; few fine roots; common thin clay films; neutral; clear, smooth boundary.

B23t—24 to 29 inches, brown (7.5YR 5/4) clay loam, brown (7.5YR 4/4) when moist; moderate, medium, angular blocky structure; extremely hard, firm, sticky, slightly plastic; common thin clay films; few films and threads of calcium carbonate; calcareous; moderately alkaline; abrupt, wavy boundary.

Ccam—29 to 40 inches, indurated plates of caliche that are laminar in the upper 1/2 inch.

The A horizon ranges from 4 to 8 inches in thickness and is brown, grayish brown, or yellowish brown. The B2t horizon ranges from 18 to 29 inches in thickness and is reddish brown, dark grayish brown, or brown. The lower part of this horizon is calcareous in some locations. Reaction is neutral or moderately alkaline. The Ccam horizon begins at a depth of 24 to 36 inches. This horizon consists of indurated plates of caliche that are laminar in the upper 1/2 inch to 2 inches. These plates range from 3 to 10 inches in diameter from 2 to 6 inches in thickness.

Stegall and Slaughter soils (SsA).—These nearly level soils are on smooth plains. They occupy rounded to irregularly shaped areas that range from 30 to several hundred acres in size. Slopes are 0 to 1 percent. These soils have the profiles described as representative for the Stegall and Slaughter series.

Stegall soils make up about 52 percent of the total acreage, and Slaughter soils, 40 percent. Some areas, however, consist of either Stegall or Slaughter soils. Soils of this undifferentiated unit do not occur in a regular pattern, and it is not feasible to map them separately because their use and management are similar.

The hazard of soil blowing is slight for the Stegall soils and moderate for the Slaughter soils. Most of the acreage is used for range. A few areas are used for cotton and grain sorghum and are suited to irrigated farming. Large amounts of fertilized crop residue need to be kept on the surface to maintain soil tilth and control soil blowing and water erosion. Capability units IVe-3, dryland, and IIe-1, irrigated, for Stegall soils, and capability units VIe-6, dryland, and IIIe-6, irrigated, for Slaughter soils; Deep Hardland range site.

Triomas Series

The Triomas series consists of deep, nearly level to gently undulating soils. These soils formed in eolian, loamy sediments on uplands.

In a representative profile, the surface layer is fine sand, about 16 inches thick, that is brown in the upper 6 inches and reddish brown in the lower 10 inches. The next layer is friable sandy clay loam to a depth of 80 inches. This layer is red in the upper 36 inches, light red in the next 16 inches, and reddish yellow in the lower part (fig. 10).

***Figure 10.*—Profile of Triomas fine sand showing thickness of the A horizon. Here, the A horizon is 16 inches thick.**

These soils are well drained. Internal drainage is medium; permeability is moderate. The hazard of soil blowing is severe, and the hazard of water erosion is slight.

Representative profile of Triomas fine sand in an area of Triomas and Wickett soils, gently undulating (11 miles north of Andrews County courthouse on U.S. Highway 385, then 2 miles west on county road, then 1.1 miles north):

A11—0 to 6 inches, brown (7.5YR 5/4) fine sand, dark brown (7.5YR 4/4) when moist; single grain; loose, nonsticky; common very fine and fine roots; neutral; gradual, smooth boundary.

A12—6 to 16 inches, reddish-brown (5YR 5/4) fine sand, reddish brown (5YR 4/4) when moist; single grain; loose, nonsticky; common very fine roots; neutral; clear, smooth boundary.

B21t—16 to 36 inches, red (2.5YR 4/6) sandy clay loam, dark red (2.5YR 3/6) when moist; moderate, coarse, prismatic structure parting to moderate, medium, subangular blocky; hard, friable, sticky; common very fine roots and pores; few thin clay films; neutral; gradual, smooth boundary.

B22t—36 to 52 inches, red (2.5YR 5/6) sandy clay loam, red (2.5YR 4/6) when moist; moderate, coarse, prismatic structure parting to moderate, medium, subangular blocky; hard, friable, sticky; few fine pores; few thin clay films; neutral; gradual, smooth boundary.

B23t—52 to 68 inches, light-red (2.5YR 6/5) sandy clay loam, red (2.5YR 5/8) when moist; moderate, coarse, prismatic structure parting to weak, medium, subangular blocky; slightly hard, friable, sticky; fine and very fine pores; few thin clay films on faces of peds; few very small pockets of clean sand grains; mildly alkaline; clear, wavy boundary.

B24tca—68 to 80 incites, reddish-yellow (5YR 7/6) sandy clay loam, reddish yellow (5YR 6/6) when moist; moderate, coarse, prismatic structure parting to moderate, medium, subangular blocky; slightly hard, friable, slightly sticky; few thin clay films; about 25 percent visible calcium carbonate in soft masses; calcareous; moderately alkaline.

The A horizon ranges from 10 to 20 inches in thickness and is reddish brown or brown. Texture is dominantly fine sand but ranges to loamy flue sand. The Bt horizon above the Btca horizon ranges from 46 to 56 inches in thickness and is red, light red, reddish brown, or yellowish red. The Btca horizon is at depths of more than 60 inches and does not. occur in all places.

Triomas loamy fine sand, 0 to 3 percent slopes (TrB).—These nearly level to gently sloping soil is on uplands. It occupies irregularly shaped areas that range from 100 to 300 acres in size but are generally about 200 acres. The surface layer is reddish-brown loamy fine sand about 15 inches thick. The next layer is red sandy clay loam about 45 inches thick. The next lower layer, to a depth of 75 inches, is reddish-yellow sandy clay loam. Included in mapping are small areas of Wickett and Faskin soils.

The hazard of soil blowing is severe on this soil. Most of the acreage is used for range. This soil is not suite to dryland farming, but it is suited to irrigated farming. A few areas are used for cotton and grain sorghum. Large amounts of crop residue need to be kept on the surface to help control soil blowing and to help maintain soil tilth. Capability units VIe-1, dryland, and IIIe-5, irrigated; Sandyland range site.

Triomas and Wickett soils, gently undulating (TWB).—These soils are on uplands. They occupy irregular to oblong-shaped areas ranging from 100 to several thousand acres in size. Slopes range from 0 to 5 percent. These soils have the profiles described as representative for the Triomas and Wickett series.

Triomas soils make up about 78 percent of the total acreage, and Wickett soils, about 16 percent. Some of the smaller areas consist of either Triomas or Wickett soils. 'The remaining 6 percent is mainly Douro, Ima, and Jalmar soils and a soil that is similar to Wickett soils, except that it is less than 20 inches deep over indurated caliche. Soils of this undifferentiated unit do not occur together in regular patterns, but it is not feasible to separate them in mapping because their use and management are similar.

The hazard of soil blowing is severe on these soils. Most of the acreage is used for range. These soils are not suited to dryland farming but are suited to irrigated farming. A. few areas are used for cotton and grain sorghum. Large amounts of crop residue need to be kept on the soil surface to help control soil blowing and maintain soil tilth. Capability units VIe-1, dryland, and IIIe-5, irrigated; Sandyland range site.

Wickett Series

The Wickett series consists of nearly level to gently undulating soils that are moderately deep over caliche. These soils formed in loamy sediments over indurated caliche on uplands.

In a representative profile, the surface layer is reddish-brown loamy fine sand about 16 inches thick. The next layer is a yellowish-red fine sandy loam about; 17 inches thick. It rests abruptly on a layer of indurated platy caliche.

These soils are well drained. Internal drainage is medium; permeability is moderately rapid. The hazard of soil blowing is severe, and the hazard of water erosion is slight.

In this county, the Wickett soils are mapped only in an undifferentiated unit with Triomas soils.

Representative profile of Wickett loamy fine sand in an area of Triomas and Wickett soils, gently undulating (13.6 miles south of Andrews County courthouse on U.S. Highway 385, then 2 miles east on county road, then 5 miles north and 0.25 mile west):

A1—0 to 16 inches, reddish-brown (5Y11 5/4) loamy fine sand, reddish brown (5YR 4/4) when moist; single grain; loose, nonsticky; common very fine and fine roots; mildly alkaline; clear, smooth boundary.

B2t—16 to 33 inches, yellowish-red (5YR 5/6) fine sandy loam, yellowish red (5YR 4/6) when moist; moderate, coarse, prismatic structure parting to weak subangular blocky; slightly hard, friable, slightly sticky; few thin clay films and grains coated and bridged with clay; mildly alkaline; abrupt, wavy boundary.

C1cam—33 to 53 inches, indurated platy caliche; laminar in the upper 1 inch, strongly cemented in lower part; clear, wavy boundary.

C2ca—53 to 67 inches, weakly cemented caliche; estimated visible calcium carbonate about 50 percent.

The A horizon ranges from 8 to 20 inches in thickness and is reddish brown or brown. Reaction is neutral or mildly alkaline. The B2t horizon ranges from 12 to 20 inches in thickness and is reddish brown or yellowish red. The C1cam horizon begins at a depth of 20 to 40 inches. The caliche plates range from 2 to 8 inches in diameter and from 1/2 to 8 inches in thickness. They are laminar in the upper 1/2 inch to 3 inches.

Use and Management of the Soils

This section discusses the use and management of the soils for crops. It gives a brief description of irrigation in the county and predicts estimated crop yield on different soils. It also discusses range management, engineering uses of soils, and use of the soils for wildlife.

Capability Grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations, the risk of damage when used for field crops, and the way they respond to treatment. The grouping does not take into account major and generally expensive Landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to horticultural crops or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range or for engineering.

In the capability system, kinds of soil are grouped at three levels: capability class, subclass, and unit. These are discussed in the following paragraphs.

Capability classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants, require moderate conservation practices, or both.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife habitat.

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit; their use largely to pasture, range, woodland, or wildlife habitat.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife habitat.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife habitat, or water supply, or to esthetic purposes.

Capability subclasses are soil groups within one class; they are designated by adding a small letter *e*, *w*, *s*, or *c*, to the class numeral; for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife habitat, or recreation.

Capability units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example IVe-3 or VIe-2. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the preceding paragraph; and the Arabic numeral specifically identities the capability unit within each subclass.

The capability units in Andrews County are described as follows:

IIe-1, irrigated.—Moderately deep, moderately slowly permeable clay loams.
IIe-2, irrigated.—Deep, moderately permeable clay loams.
IIIe-2, irrigated.—Deep, moderately permeable loams.
IIIe-3, irrigated.—Deep to moderately deep, moderately permeable fine sandy loams.
IIIe-5, irrigated.—Deep to moderately deep, moderately permeable and moderately rapidly permeable fine sands and loamy fine sands.
IIIe-6 irrigated.—Shallow, moderately slowly to moderately rapidly permeable fine sandy loams, loams, and clay loams.
IVe-2, irrigated.—Deep, moderately permeable fine sands.
IVe-1, dryland.—Deep to moderately deep, moderately permeable fine sandy loams.
IVe-2, dryland.—Deep, moderately permeable clay loams.
IVe-3, dryland.—Moderately deep, moderately slowly permeable clay loams.
VIe-1, dryland.—deep to moderately deep, moderately permeable and moderately rapidly permeable fine sands and loamy fine sands.
VIe-2, dryland.—Shallow, moderately permeable to moderately rapidly permeable fine sandy loams and loams.
VIe-3, dryland.—Deep, moderately permeable fine sands.
Vle-4, dryland.—Deep, moderately rapidly permeable fine sandy loams.
Vle-5, dryland.—Deep, moderately rapidly permeable, calcareous loamy fine sands.
Vle-6, dryland.—Shallow, moderately slowly permeable clay loams.
Vle-7, dryland.—Deep, moderately permeable loams.
VIw-1, dryland.—Deep, very slowly permeable clays.
VIIe-1 dryland.—Deep, rapidly permeable fine sands.
VIIs-1, dryland.—Very shallow to shallow, moderately permeable and moderately slowly permeable clay loams and loams.
VIIIe, dryland.—Deep, rapidly permeable sands.

Predicted Yields

Crop yields in Andrews County depend on the kind of management the soils receive. Consistently high yields can be obtained if the soils are used within their capabilities and are managed according to their needs.

Table 2 lists all the mapping units in the county and gives, for each soil that is cultivated, predicted average yields per acre under a high level of management. These predictions are for cotton and grain sorghum grown on dryland and irrigated soils. The predictions are based on information obtained from farmers and others familiar with the soils.

Under a high level of management, the following practices are used for dryland farming:

1. Moisture is conserved.
2. Crop residue is used to help control soil blowing and water erosion.
3. Soil tillage and insect and weed control are timely.

4. Improved varieties of crops and improved methods of farming are employed.

Under a high level of management, the following practices are used for irrigation farming:

1. A properly designed irrigation system is used.
2. Rainfall is conserved.
3. Fertilizers are used according to the needs of the crop.
4. Crop residue is used for maximum soil cover.
5. Improved varieties of crops and improved methods of farming are employed.
6. Soil tillage and insect and weed control are timely.

Irrigation

Andrews County has 8,000 acres of irrigated cropland. Of this, approximately 5,000 acres are in cotton, and the remaining acres are used for grain sorghum. Wells are 125 to 150 feet deep, and water is pumped from the Ogallala Formation.

Most of the irrigated soils are fine sandy barns, loams, or line sands of the Faskin, Douro, Ratliff, and Triomas series. Water is pumped from the irrigation wells into a sprinkler irrigation system. Some of the systems are moved over the field by hand, and others are the self-propelled type.

Soils in Andrews County are best suited to a sprinkler irrigation system. Irrigation systems need to be designed to prevent soil and water losses. Cropping systems on irrigated soils should include crops in the rotation that produce large amounts of crop residue. Crop residue kept on the surface helps to maintain favorable soil conditions and control soil blowing and water erosion.

Most irrigated farmland responds to commercial fertilizers. A soil test should be used to determine the amount of fertilizer needed.

Range Management

By Joe B. Norris, range conservationist, Soil Conservation Service, Abilene, Texas.

Ranching is the most important farm enterprise in Andrews County. Native grasses cover about 94 percent of the total acreage. The 40 ranches in the county range from 2,000 to 110,000 acres in size, but the average is 22,000 acres. Since average annual rainfall is 13.9 inches, grass production is normally sparse.

Most of the grassland in the county is on coarse, sandy soils that favor growth of many kinds of grasses and forbs. The sands and deep sands produce mid and tall grasses; the sandy loams produce primarily mid grasses and lesser amounts of tall grasses where moisture supply is more favorable; and the small areas of clay loams, short grasses. Soils that have a high content of lime produce salt-tolerant short or mid grasses and are confined to areas surrounding salt lakes. Shallow soils occur throughout the county.

The native grassland has been heavily grazed for several generations. As a result, a high percentage of the more desirable grasses and forbs have been grazed out. This has permitted less desirable grasses, weeds, and brush to invade. The sandy soils commonly produce an over abundance of shin oak and low-order dropseeds instead of the taller, more robust grasses. The more clayey soils have been invaded by mesquite. The shallow sites now produce an over abundance of noxious weeds.

A close look at all of these sites, however, reveals remnants of the original adapted species. Generally, these species increase if the grassland is given proper care and treatment.

Range sites and condition classes

Range sites are distinctive kinds of rangeland that have a different potential for producing forage plants. Range sites differ from each other in their ability to produce significantly different kinds or proportions of plant species or total annual yield. Significant differences are those great enough to require some variation in management, such as a different rate of socking.

Differences in kinds, proportion, and production of plants that different sites are capable of supporting are due in large measure to variations in environmental factors such as soil, topography, and climate. Therefore, range sites can be identified by the kinds of soil known to be capable of producing the distinctive potential plant community characteristic of a specific site.

Most of the native grassland in Andrews County has been heavily grazed for several generations, and the original plant cover has been altered. *Range condition* is the present state of the vegetation of a range site in relation to the potential plant cover (climax) for that site. *Range condition classes* measure the degree to which the present plant composition, expressed in percent, resembles that of the climax plant community of a range site.

A range is in *excellent* condition if 76 to 100 percent of the vegetation is of the same kind as that in the original stand; in *good* condition if 51 to 75 percent of the vegetation is of the same kind as that in the original stand; in *fair* condition if 26 to 50 percent of the vegetation is of the same kind as that in the original stand; and in *poor* condition if 0 to 25 percent of the vegetation is of the same kind as that in the original stand.

In determining present range condition class, plants are grouped in accordance with their response to the degree of grazing they receive on specific range sites. These groups of plants are *decreasers, increasers,* and *invaders.*

Decreaser plants are members of the potential plant community or climax plant cover that decrease in relative abundance if they are subject to continued heavy grazing use. Most of these plants have a high grazing preference and decrease from excessive use. The total of all such species is counted in determining range condition class.

Increaser plants are species in the climax community that normally increase in relative abundance when the community is subjected to continued heavy grazing use. Some increasers with moderately high grazing preference may initially increase and then decrease as grazing pressure continues. Others of low grazing preference may continue to increase either in actual plant numbers or in relative proportions. Only the percentages of increaser plants normally expected to occur in the climax community are counted in determining range condition.

Invader plants are not members of the climax plant community for the site. They invade the community as a result of various kinds of disturbance. They may be annuals or perennials and may be grasses, weeds, or woody plants. Some have, relatively high grazing value, but many are worthless. Invader plants are not counted in determining range condition class.

For most range sites and most range livestock operations, the higher the range condition class, the greater the quality and amount of available forage.

Descriptions of range sites

Eight range sites are described in the following pages, and the climax plants and, in some cases, the principal invaders are named. Also given is the estimated annual yield of air-dry herbage for each site when it is in excellent condition. The soils in each site can be determined by referring to the "Guide to Mapping Units." Dune land and Lipan clay have not been placed in a range site.

Deep Hardland range site

This site consists of nearly level to gently undulating, moderately fine textured soils on mostly smooth upland plains. It is accessible to livestock and is a favorite for grazing (fig. 11). The soils in this site are moderately slowly permeable and have a low to high available water capacity. In many places the intake of moisture is reduced by surface crusting and by the compacted layer, or hoof pan, caused by trampling.

***Figure* 11.—Tobosagrass, buffalograss, and blue grama on an area of Stegall and Slaughter soils that have a clay loam surface layer. These soils are in the Deep Hardland range site.**

The climax plant cover on this site is about 40 percent blue grama, 25 percent buffalograss, 15 percent tobosagrass, and smaller amounts of western wheatgrass, vine-mesquite, feathery bluestem, sand dropseed, and perennial three-awn. Continuous overgrazing results in an immediate loss of blue grama. Further deterioration of the range results in invasion by perennial three-awn, hairy tridens, broom snakeweed, and mesquite.

If the range condition is deteriorating and during years in which there is a wet spring, annuals invade the bare spots. The most common invaders are Texas filaree, evax, various plantains, bladderpod, plains greenthread, bitterweed actinea, common broomweed, and little barley. The common perennial forbs that invade this site are western ragweed, silverleaf night shade, and Dakota verbena.

This site is capable of only limited production. Vegetative cover is necessary to reduce surface crusting and to prevent erosion. Once the range is in poor condition, recovery is very slow because of the lack of desirable seed plants, crusted soils, and heavy infestation of mesquite.

If the site is in excellent condition, the total annual yield of air-dry herbage ranges from 1,200 to 2,500 pounds per acre, depending on rainfall. About 55 percent of this yield is forage for livestock and wildlife.

Deep Sand range site

This site consists of nearly level to gently undulating and hummocky soils. Commonly, the soils give the appearance of stabilized dunes (fig. 12).

The soils are deep, moderately to rapidly permeable fine sands. Available water capacity is low to moderate. The site deteriorates rapidly under continued heavy grazing but responds favorably to good management.

***Figure 12.*—Deep Sand range site on which the major grasses are giant dropseed and bluestem. This site is normally invaded by shinnery (Havard oak). The soils are Jalmar and Penwell fine sands in the Jalmar-Penwell association, undulating.**

The climax plant cover on this site is about 20 percent sand bluegrass, 20 percent little bluestem, 20 percent giant dropseed, and smaller amounts of spike dropseed, Havard panicgrass, sand dropseed, perennial three-awn, Havard oak, and hairy grama.

If the site is in excellent condition, the total annual yield of air-dry herbage ranges from 1,000 to 2,500 pounds per acre, depending on rainfall. About two-thirds of this yield is suitable forage for livestock and wildlife.

High Lime range site

This site consists of undulating soils on the east and northeast sides of large lakes. It is generally 30 to 50 feet higher than surrounding sites. These soils are moderately rapidly permeable, high in content of lime, and moderately coarse textured (fig. 13). The available water capacity is moderate.

It is difficult to determine the exact composition of the climax vegetation because these areas commonly are high in salt content. The percentage of salt generally is highest adjacent to the lakes, where vegetation is limited to salt-tolerant species such as alkali sacaton. This vegetation normally grades into less salt-tolerant vegetation as the distance from the lakes increases.

The climax plant cover on this site is about 25 percent alkali sacaton, 20 percent side-oats grama, 15 percent blue grama, and smaller amounts of vine-mesquite, plains bristlegrass, black grama, slim tridens, sand dropseed, hooded windmillgrass, and fall witchgrass.

If the site is in excellent condition, the total annual yield of air-dry herbage ranges from 800 to 1,500 pounds per acre, depending on rainfall. About 80 percent of this yield is suitable forage for livestock and wildlife.

Figure 13.—**An area of the High Lime range site where the major grasses are alkali sacaton and black grama. The soil is Krade fine sandy loam in the mapping unit Krade soils, undulating.**

Mixed Plains range site

This site consists of nearly level to gently undulating soils on broad plains. These, soils are medium textured to moderately coarse textured. Permeability is moderately to moderately rapid, and available water capacity is low to moderate.

The climax plant, cover on this site is about 20 percent side-oats grama, 15 percent blue grama, and smaller amounts of silver bluestem, vine-mesquite, black grama, alkali sacaton, fall witchgrass, hairy grama, perennial three-awn, sand dropseed, buffalograss, and four-winged saltbush (fig. 14).

The kind of vegetation on this site varies widely, depending on the amount of salt in the soil. In some places where the salt content is high, alkali sacaton makes up a high percentage of the total composition.

If the site is in excellent condition, the total annual yield of air-dry herbage ranges from 900 to 2,100 pounds per acre, depending on rainfall. About 75 to 80 percent of this yield is suitable forage for livestock and wildlife.

***Figure 14.*—An area of the Mixed Plains range site where the major grasses are black grama, blue grama, and silver bluestem.**

Sandyland range site

This site consists of smooth and nearly level to gently sloping and gently undulating soils. These soils are coarse textured are moderately permeable to moderately rapidly permeable, and have a low to moderate available water capacity. If properly managed, they produce a good stand of mid and tall grasses (fig. 15).

The climax plant cover on this site is about 25 percent little bluestem, 20 percent side-oats grama, 15 percent giant dropseed, and smaller amounts of spike dropseed, mesa, dropseed, fall witchgrass, sand dropseed, perennial three-awn, sand bluestem, hairy grama, and Havard oak.

Any deterioration of this site results in a rapid increase of small soapweed (yucca), shin oak, and annuals. Invading grasses include annual three-awn, fringed signal-grass, tumble windmillgrass, gummy lovegrass, red love-grass, and tumble lovegrass. The chief invading weeds are tumble ringwing, annual wildbuckwheat, prairie sunflower, woolywhite, beebalm, pricklypoppy, Riddel grounsel, and stillingia.

Shin oak readily invades the site. On many ranches it must be controlled before grasses can make satisfactory recovery. Mechanical methods of control are not feasible, because soil blowing is a severe hazard. The site responds favorably to chemical control of shin oak.

If the site is in excellent condition, the total annual yield of air-dry herbage ranges from 800 to 2,000 pounds per acre, depending on rainfall. About two-thirds of this yield is suitable forage for livestock and wildlife.

***Figure 15.*—An area of the Sandyland range site where the major grasses are sand dropseed and black grama. The soil is Triomas fine sand in the mapping unit Triomas and Wickett soils, gently undulating.**

Sandy Loam range site

This site consists of nearly level to gently undulating, moderately coarse textured soils on upland plains (fig. 16). Permeability is moderate to rapid, and available water capacity is low to moderate. Hoof pans and surface crusts form readily if the site is unprotected by plant cover.

The climax plant cover on this site is about 20 percent blue grama, 15 percent side-oats grama, 15 percent Arizona cottontop, 15 percent plains bristlegrass, and smaller amounts of buffalograss, black grama, sand dropseed, perennial three-awn, hooded windmillgrass, feathery bluestem, little bluestem, and fall witchgrass.

If the site is in excellent condition, the total annual yield of air-dry herbage ranges from 1,200 to 2,000 pounds per acre, depending on rainfall. About two-thirds of this yield is suitable forage for livestock and wildlife.

***Figure 16.*—An area of the Sandy Loam range site where the major grasses are black grama, sand dropseed, and plains bristlegrass. The soils are Faskin and Douro fine sandy loams in the mapping unit Faskin and Douro soils, gently undulating.**

Valley range site

This site consists of nearly level, moderately fine textured soils in the major draws. These soils are moderately permeable, and the available water capacity is high. Extra water is received as runoff from adjacent soils. Although flooded from time to time, the site is under water for only a short period. Thus, any damage to vegetation is ordinarily from sedimentation rather than from wetness. The composition of climax vegetation depends on the depth of the soil and the frequency that extra water is received.

The climax plant cover on this site is about 25 percent side-oats grama, 20 percent cane bluestem, 20 percent blue grama, 15 percent vine-mesquite, and smaller amounts of white tridens, buffalograss, and tobosagrass.

This site responds favorably to rest, particularly if management is applied before, all the more desirable grasses are grazed out.

If the site is in excellent condition, the total annual yield of air-dry herbage ranges from 1,500 to 2,000 pounds per acre, depending on rainfall. About 90 percent of this yield is suitable forage for cattle.

Very Shallow range site

This site consists of nearly level to gently undulating and sloping soils on uplands. The soils are medium textured, calcareous, and moderately permeable. They are underlain by caliche. The available water capacity is low.

The stand of grass is sparse, but the site generally is in better condition than adjacent sites (fig. 17). Generally enough of the better grasses remain to allow management that improves the vegetation.

***Figure* 17.—An area of the Very Shallow range site where the plants are black grama and plains bristlegrass. The soils are Kimbrough soils, gently undulating.**

The climax plant cover on this site is about 25 percent side oats grama, 15 percent blue grama, 15 percent black grama,15 percent feathery bluestem, and smaller amounts of little bluestem, sand bluestem, indiangrass, plains bristlegrass, New Mexico feathergrass, and fall witchgrass.

If the site is in excellent condition, the total annual yield of air-dry herbage ranges from 400 to 850 pounds per acre, depending on rainfall. Sixty percent of this yield is considered suitable livestock forage.

Engineering Uses of the Soils

By Beade O. Northcut, civil engineer, Soil Conservation Service, Big Spring, Texas.

This section provides information of special interest to engineers, contractors, farmers, and others who use soil as structural or foundation material. Properties of the soils that affect construction and maintenance of roads and airports, pipelines, building foundations, water storage facilities, erosion control structures, and sewage disposal systems are in this section. Among the soil properties most important in engineering arc permeability, compressibility, compaction characteristics, shear strength, density, shrink-swell potential, available water capacity, grain-size distribution, plasticity, and reaction.

Information concerning these and related soil properties are furnished in tables 3, 4, and 5. The estimates and interpretations of soil properties in these tables can be used in:

1. Planning of agricultural drainage systems, farm ponds, irrigation systems, diversion terraces, and other structures for controlling water and conserving soil.
2. Selecting potential locations for highways, airports, pipelines, and underground cables.

3. Selecting potential industrial, commercial, residential, and recreational areas.

The engineering interpretations in this soil survey do not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads and where the excavations are deeper than the depths of layers here reported. The estimated values for traffic-supporting capacity expressed in words should not be assigned specific values. There are small areas of other soils and contrasting situations included in the mapping units that may have different engineering properties than those listed. Even in these situations, however, the soil map is useful in planning more detailed field investigations and for indicating the kinds of problems to be expected.

Engineering classifications

The two systems most commonly used in classifying samples of soil horizons for engineering are the AASHO system adopted by the American Association of State Highway Officials (1), and the Unified Soil Classification system (7) used by the Soil Conservation Service engineers, Department of Defense, and others.

The AASHO system is used to classify soils according to those properties that affect use, in highway construction. In this system, a soil is placed in one of seven basic groups ranging from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index.

In group A-1 are gravelly soils of high hearing strength, or the best soils for subgrade (foundation) and, at the other extreme, clay soils that have low strength when wet. The best soils for subgrade are therefore classified as A-1, the next best A-2. and so to class A-7, the poorest soils for subgrade. If laboratory data are available to justify a breakdown, the A-1, A-2, and A-7 groups are divided as follows: A-1-a, A-1-b; A-2-4, A-2-5, A-2-6, A-2-7; and A-7-5 and A-7-6. If soil material is near a, classification boundary it is given a symbol showing both classes; for example, A-2 or A-4. Within each group, the relative engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The AASHO classification for tested soils, with index numbers in parentheses, is shown in table 5; the estimated classification, without group index numbers, is given in table 3 for all soils mapped in the county.

In the Unified system soils are classified according to particle-size distribution, plasticity index, liquid limit, and organic-matter content. Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as CW, GP, GM, CC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes; for example, CH or MH.

Soil properties significant in engineering

Table 3 provides estimates of soil properties important to engineering. The estimates are based on field classification and description, physical and chemical tests of selected representative samples, test data from comparable soils in adjacent areas, and detailed experience in working with the individual kind of soil in the survey area.

Hydrologic soil groups are used in watershed planning to estimate runoff from rainfall. Soil properties are considered that influence the minimum rate of infiltration obtained for a bare soil *after prolonged wetting.* These properties are: depth of seasonally high water table, intake rate and permeability after prolonged wetting, and depth to very slowly permeable layer. The influence of ground cover is treated independently—not in hydrologic soil groups.

The soils have been classified into four groups, A through D.

A. (Low runoff potential). Soils having a high infiltration rate, even when thoroughly wetted. They are chiefly deep, well-drained to excessively drained sands or gravels. These soils have a high rate of water transmission.

B. (Moderately low runoff potential). Soils having a moderate infiltration rate when thoroughly wetted. They are chiefly moderately deep to deep, moderately well drained to well drained soils that have a moderately fine to moderately coarse texture. These soils have a moderate rate of water transmission.

C. (Moderately high runoff potential). Soils having a slow infiltration rate when thoroughly wetted. They are chiefly soils that have a layer that impedes downward movement of water, soils that have a moderately fine to fine texture, or soils that have a moderately deep water table. These soils may be somewhat poorly drained.

D. (High runoff potential). Soils having a very slow infiltration rate when thoroughly wetted. They are chiefly clay soils that have a high swelling potential, a permanent high water table, or a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

Depth to bedrock is the distance from the surface of the soil to the upper surface of the rock layer.

USDA texture is determined by the relative proportions of sand, silt, and clay in soil material that is less than 2.0 millimeters in diameter. "Sand," "silt," "clay," and some of the other terms used in the USDA textural classification are defined in the Glossary.

Permeability, as used table 3, relates only to movement of water downward through undisturbed and uncompacted soil. It does not include lateral seepage. The estimates are based on structure and porosity of the soil. Plowpans, surface crusts, and other properties resulting from use of the soils are not considered. The values used in the table should not be confused with the coefficient of permeability of "K" used by engineers.

Available water capacity is the capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is expressed as inches of water per inch of soil.

Reaction is the degree of acidity or alkalinity of a soil, expressed as a pH value. The pH value and relative terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential is an indication of the volume change to be expected of the soil material with changes in moisture content. Shrinking and swelling of soils cause much damage to building foundations, roads, and other structures. A high shrink-swell potential indicates hazards to the maintenance of structures constructed in, on, or with such materials.

Engineering interpretations

Table 4 contains selected information useful to engineers and others who plan to use material in the construction of highways, farm facilities, buildings, sewage disposal systems, and recreational facilities. Detrimental or undesirable features are emphasized, but very important desirable features also may be listed. The ratings and other interpretations in this table are based on estimated engineering properties of the soils in table 3; on available test data, including those in table 5; and on field experience. Strictly, the information applies only to soil depths indicated in table 3, but it is reasonably reliable to depths of about 6 feet for most soils and several more feet for some soils.

Topsoil is a term used to designate a fertile soil or soil material, ordinarily rich in organic matter, used as a top dressing for lawns, gardens, roadbanks, and the like. The ratings indicate suitability for such use.

Road subgrade is material used to build embankments. The ratings indicate suitability of soil material moved from borrow areas for these purposes.

Highway location is influenced by features of the undisturbed soil that affect construction and maintenance of highways. The soil features listed, favorable as well as unfavorable, are the principal ones that affect geographic locations of highways.

Foundations for low buildings are affected chiefly by features of the undisturbed soil that influence its capability to support low buildings that have normal foundation loads.

Septic tank filter fields are affected mainly by permeability, location of water table, and susceptibility to flooding. The degree of limitation and principal reasons for assigning moderate or severe limitations are given.

Sewage lagoons are influenced chiefly by soil features such as permeability, location of water table, and slope. The degree of limitation and principal reasons for assigning moderate or severe limitations are given.

Camp areas are areas used intensively for tents and small camp trailers and the accompanying activities of outdoor living. It is assumed that little site preparation will be done other than shaping and leveling for tent and parking areas. The soils should be suitable for heavy foot; traffic and for limited vehicular traffic. Soil suitability for growing and maintaining vegetation is not a part of this evaluation but is an item to consider in the final evaluation of a site.

Picnic areas are areas used intensively as park-type picnic areas. It is assumed that most vehicular traffic will be confined to access roads. Soil suitability for growing vegetation is not a part of this evaluation but is an item to consider in the final evaluation of a site.

Playgrounds are areas used for baseball, football, badminton, and other similar organized games. These areas are subject to intensive foot traffic. A nearly level surface, good drainage, and a soil texture and consistence that gives a firm surface are generally required. The most desirable soils are free of rock outcrops and coarse fragments. Soil suitability for growing vegetation is not a part of this evaluation but is an important item to consider in the final evaluation of a site.

Paths and trails applies to soils to be used for local and cross-country footpaths and trails and for bridle paths. It is assumed that, these areas will be used as they occur in nature and that little or no soil will be moved (excavated or filled). Soil features that affect trafficability, dust, design, and maintenance of trafficways are given special emphasis in this evaluation.

Irrigation is affected by such factors as soil texture, water-intake rate, erodibility, and available water capacity.

Corrosivity as used here, indicates the potential danger to buried, uncoated steel structures through chemical action of the soil that dissolves or weakens the structural material. Corrosivity of concrete structures is not a problem in Andrews County. Structural materials may corrode when buried in soil, and a given material corrodes in some kinds of soil more rapidly than in others. Extensive installations that intersect soil boundaries or soil horizons are more likely to be damaged by corrosion than are installations entirely in one kind of soil or soil horizon. Ratings for corrosivity are based on soil conditions at a depth of 5 feet.

Interpretations for several engineering uses of soils are not given in table 4. None of the soils in Andrews County is a good source of sand and gravel, but the Penwell, Triomas, and Wickett soils are a fair source of sand in some places. Most soils in the county have severe limitations for the reservoir areas and embankments of farm ponds, though the limitation for this use is only slight on Lipan soils and is moderate on Faskin soils. Use of terraces, diversions, and waterways is not advisable in Andrews County. Soil blowing fills terrace channels and grassed waterways too quickly for installation to be feasible. Water erosion is not a severe hazard on soils of the county. Drainage and salinity are not limitations.

Engineering test data

Table 5 contains the results of engineering tests per-formed by the Texas Highway Department on three important soils in Andrews County, Texas. The table shows the specific locations where samples were taken, the depth to which sampling was done, and the results of tests to determine particle-size distribution and other properties significant in soil engineering.

Following are definitions of some of the properties included in table 5. The columns not discussed are self-explanatory or are defined elsewhere in this survey.

Shrinkage limit.—As moisture leaves a soil, the soil shrinks and decreases in volume in direct proportion to the loss in moisture until a condition of equilibrium is reached. Shrinkage limit is reached when further reduction of moisture does not result in shrinkage of the soil. It is reported as a percentage of the oven-dry weight of soil.

Linear shrinkage.—Linear shrinkage is the decrease in one dimension, expressed as a percentage of the original dimension, of the soil mass when the moisture content is reduced from the stipulated percentage to the shrinkage limit.

Shrinkage ratio.—The shrinkage ratio is the volume change (expressed as a percentage of the volume of the dry soil pat) divided by the moisture loss above the shrinkage limit (expressed as a percentage of the weight of the dry soil pat).

Liquid limit.—The liquid limit is the percentage of moisture at which a soil passes from a plastic to a liquid state.

Plasticity index.—The plasticity index is defined as the numerical difference between the liquid limit and the plastic limit (the percentage of moisture at which a soil changes from a semisolid to a plastic state).

Use of the Soils for Wildlife

By James Henson, biologist, Soil Conservation Service, San Angelo, Texas.

In Andrews County the principal kinds of wildlife are antelope, jackrabbit, cottontail rabbit, bobwhite quail, and scaled (blue) quail. Also present are raccoon, skunk, and other furbearers. Many species of nongame birds, reptiles, and small mammals are in the county. The common predators are bobcat and coyote.

Small game hunting centers around quail and dove. Because of the migratory habit of doves, the supply is erratic. The quail population is more dependable; however, it varies with rainfall and range conditions. Big game hunting in Andrews County is limited to antelope.

Successful management of wildlife on any tract of land requires that food, cover, and water be available in a suitable combination. Lack of any one of these necessities, an unfavorable balance between them, or inadequate distribution of them may severely limit or account for the absence of desired wildlife species. Soil information provides a valuable tool in creating, improving, or maintaining a suitable habitat for wildlife.

Most wildlife habitats are managed by planting suitable vegetation, by manipulating existing vegetation to bring about natural establishment or improvement of desired plants, or by combinations of such measures. The possible influence of a soil on the growth of plants is known for many species and can be inferred for others from a knowledge of the characteristics and behavior of the soil. In addition, water areas can be created or natural ones improved as wildlife habitats.

Soil interpretations are an aid in selecting the more suitable sites for various kinds of wildlife management. They serve as indicators of the level of management intensity needed to achieve satisfactory results. They also show why it may not be generally feasible to manage a particular area for a given kind of wildlife. These interpretations are also useful in broad-scale planning of wildlife management areas, parks, and nature areas or for acquiring wildlife areas.

Soil properties that affect the growth of wildlife habitat are: (1) thickness of soil useful for crops; (2) texture of the surface layer; (3) available water capacity to a 40-inch depth; (4) degree of wetness; (5) surface stoniness or rockiness; (6) flood hazard; and (7) slope.

The areas shown on the map are rated without regard to positional relationships with adjoining areas. The size, shape, or location of the outlined area does not affect the rating. Certain influences on habitats, such as elevation and aspect, must be appraised onsite.

Table 6 lists the soils of the county and rates their suitability for the creation, improvement, or maintenance of six elements of wildlife habitat. These ratings are based on limitations imposed by characteristics of the soils. The ratings are *well suited, suited, poorly suited,* and *unsuited.* They are defined in the following paragraphs.

Well suited indicates that habitats generally are easily created, improved, or maintained; that the soil has few or no limitations that affect management; and that satisfactory results can be expected.

Suited indicates that habitats can be created, improved, or maintained in most places; that the soil has moderate limitations that affect management; and that moderate intensity of management and fairly frequent attention may be required for satisfactory results.

Poorly suited indicates that habitats can be created, improved, or maintained in most places; that the soil has rather severe limitations; that habitat management is difficult and expensive and requires intensive effort; and that results are not always satisfactory.

Unsuited indicates that the soil limitation is so extreme that it is impractical, if not impossible, to manage the designated habitat element. Unsatisfactory results are probable. (For short-term use, soils rated as poorly suited may provide easy establishment and temporary values.)

The six habitat elements rated in table 6 are discussed in the following paragraphs.

Grain and seed crops consist of agricultural grains or seed-producing annuals planted to produce food for wildlife. Examples are corn, sorghum, millet, soybeans, wheat, oats, and sunflowers.

Grasses and legumes consist of domestic perennial grasses and legumes that are established by planting and that furnish food and cover for wildlife. Examples are plains bristlegrass, switchgrass, weeping lovegrass, vine-mesquite, and panicgrass. Legumes includes clover, annual lespedeza, bush lespedeza, and cowpeas.

Wild herbaceous upland plants are perennial grasses, forbs, and weeds that provide food and cover for wildlife. Examples are beggarweed, perennial lespedeza, wild bean, indiangrass, wild ryegrass, plains bristlegrass, wild buckwheat, Havard panicum, croton, and bluestem.

Hardwood trees and shrubs are nonconiferous trees, shrubs, and woody vines that produce fruits, nuts, buds, catkins, or foliage (browse) used extensively as food by wildlife. These plants commonly become established through natural processes, but they may be planted. Examples are shin oak, mesquite, whitebrush, catclaw, wild plum, Russian-olive, desert-willow, Arizona cypress, redcedar, and Osage-orange.

Wetland food and cover plants consist of annual and perennial wild herbaceous plants in moist to wet sites, exclusive of submerged or floating aquatic plants, that produce food or cover that is extensively and dominantly used by wetland forms of wildlife. Examples are smartweed, wild millet, bulrush, spike-sedge, rushes, sedges, burreed, wildrice, cutgrass, sourdock, and cattails.

Shallow water developments are low dikes and water control structures established to create habitats, principally for waterfowl. They may be designed so that they can be drained, planted, and flooded or they may be used as permanent impoundments to grow submerged aquatics. Both freshwater and brackish water developments are included.

The three general kinds of wildlife rated in table 6 are defined as follows:

Openland wildlife refers to birds and mammals that normally frequent farmed areas, pastures, and areas overgrown with grasses, herbs, and shrubs. Examples of openland wildlife are antelope, cottontail rabbit, jack-rabbit, quail, and the many species of nongame birds.

Brushland wildlife refers to birds and mammals that normally frequent areas of hardwood trees and shrubs. Examples of brushland wildlife are deer, turkey, squirrel, raccoon, and the various species of nongame birds that are associated with these areas.

Wetland wildlife refers to birds and mammals that normally frequent ponds, streams, ditches, marshes, and swamps. Examples of wetland wildlife are ducks, geese, rails, shorebirds, and snipe.

Formation and Classification of the Soils

This section discusses the five factors that affect soil formation in Andrews County. Also, the current system of soil classification is explained and the soils in the county are placed in some categories of the system.

Factors of Soil Formation

Soil is produced by the action of soil-forming processes on materials deposited or accumulated by geologic agents. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated; (3) the plant and animal life on and in the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of soil development have acted on the soil material.

Climate and vegetation are active factors of soil genesis. They act on the parent material that has accumulated through the weathering of rocks and slowly change it into a natural body with genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of profile that can be formed and, in extreme cases, determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil profile. It may be much or little, but some time is always required for horizon differentiation. Usually a long time is required for the development of distinct horizons.

The factors of soil genesis are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one unless conditions are specified for the other four.

Parent material

Parent material refers to the unconsolidated mass in which the soil develops. The soils in Andrews County developed in eolian and alluvial deposits of the Quaternary and late Tertiary periods that have been reworked by soil-building forces. These deposits are mostly sandy and silty sediments that are unconsolidated, calcareous, and alkaline. The Faskin soils developed in these sediments.

Some soils developed over a geological stratum called the Ogallala Formation. The parent material was deposited over the mantle of indurated caliche and was subjected to soil-forming processes. Examples of this are the Stegall and Slaughter soils.

Potter soils, located on the sides of Monument and Seminole Draws, developed in parent material derived from the weathering of exposed caliche.

Portales soils, located in the bottom of Monument and Seminole Draws, developed in material transported by water and subjected to soil-blowing forces.

The removal of the silt and clay particles from the parent material by wind led to the development of the Ima soils.

Climate

Andrews County has a cool-temperate, dry steppe climate characterized by low rainfall and rapid evaporation. Soils such as those of the Ima, Ratliff, and Portales series have a horizon in which calcium carbonate has accumulated because of water leaching the soluble material to certain depths. At the same time, these soils have free lime throughout the profile because not enough water passes through them to leach out all of the free lime. Andrews County has mild winters and hot summers, and these contribute to the continuous decomposition of residue from plants and animals by micro-organisms, which results in a high organic-matter content in some soils. Examples are the Kimbrough and Stegall soils. High winds contributed to the development of soils in Andrews County by depositing parent materials that were subject to soil-building forces. An example is the Jalmar soils.

Plants and animals

Plants, animals, insects, bacteria, and fungi are important in the formation of soils. They affect gains or losses in organic matter and plant nutrients. Structure and porosity are also affected by living organisms.

Plants have an important effect on soil formation in Andrews County. Most of the soils are low in organic-matter content because of the limited amount of vegetation. Organic matter is formed from decaying leaves and stems; hence, with the amount of vegetation limited, soils such as those of the Faskin and Douro series are low in organic matter. Earthworms and insects such as termites increase soil porosity by burrowing channels throughout the soil profile. Insects and plant roots increase water and air movement in the soil.

Relief

Relief, or slope, affects soil formation through its influence on runoff and drainage. Drainage in Andrews County is confined to areas surrounding the three mineralized salt lakes and along Monument and Seminole Draws. The county ranges from nearly level in the southeastern part to sloping and undulating in the western and northwestern parts.

Soils such as those of the Jalmar and Penwell series have little or no runoff because of their high rate of water intake. Potter and Blakeney soils, located along Monument and Seminole Draws, have relief that is sloping and nearly level to gently undulating. These soils are shallow over caliche, and soil material is removed from them by water erosion, retarding soil-forming processes.

Time

Time is an important phase of soil formation. The length of time that parent material has been in place is reflected in the degree of development of the soil profile.

Soils such as the Penwell show little development in the profile and are young soils. Soils such as the Douro and Faskin have well-defined horizons and are older soils.

Classification of the Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us to understand their behavior and their responses to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge to specific fields and other tracts of land.

Thus, in classification, soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and applied in managing farms, fields, and range; in developing rural areas; in engineering work; and in many other ways. They are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 *(2)* and revised later *(4)*. The system currently used by the National Cooperative Soil Survey was developed in the early sixties and was adopted in 1965 *(6, 3).* It is under continual study.

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. The criteria for classification are soil properties that are observable or measurable, but the properties are selected so that soils of similar genesis are grouped together. The placement of some soil series in the current system of classification, particularly with respect to families, may change as more precise information becomes available.

Table 7 shows the classification of the soil series of Andrews County by family, subgroup, and order, according to the current system.

ORDER: Ten soil orders are recognized. They are Entisols, Alfisols, Inceptisols, Aridisols, Mollisols, Spodosols, Vertisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate these orders are those that tend to produce broad climatic groupings of soils. Two exceptions, the Entisols and Histosols, occur in many different kinds of climate. The four soil orders in Andrews County are Entisols, Aridisols, Vertisols, and Mollisols.

Entisols are recent soils that do not have genetic horizons or that have only the beginning of such horizons.

Aridisols are primarily soils of dry places. They do not have a sufficient accumulation of organic matter to be dark colored in the uppermost part.

Vertisols are soils in which natural churning or inversion of soil material takes place, primarily through the shrinking and swelling of clays.

Mollisols are soils that have a high base supply, a dark A horizon that is friable or soft, and a high organic-matter content.

SUBORDER: Each order is divided into suborders, primarily on the basis of those soil characteristics that seem to have the greatest similarity in genesis. Suborders narrow the broad climatic ranges of soils in the orders. Soil properties used to separate suborders primarily reflect either the presence or lack of waterlogging or soil differences produced through the effects of climate or vegetation.

GREAT GROUP: Suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and other features. The horizons used as a basis for distinguishing between great groups are those in which (1) clay, iron, or humus has accumulated; (2) a pan has formed that interferes with growth of roots, movement of water, or both; or (3) a thick, dark-colored surface layer has formed. The other features commonly used are the self-mulching properties of clay, temperature of the soil, major differences in chemical composition (mainly the bases calcium, magnesium, sodium, and potassium), or the dark-red or dark-brown colors associated with soils formed in material weathered from basic rocks.

SUBGROUP: Great groups are divided into subgroups, one of which represents the central, or typic, segment of the group. Other subgroups have properties of the group but have also one or more properties of another great group, subgroup, or order. These are called intergrades. Subgroups may also be made for soils that have properties that intergrade outside the range of any other great group, suborder, or order.

FAMILY: Families are separated within a subgroup primarily on the basis of properties important to the growth of plants or to the behavior of soils used for engineering. Among the properties considered are texture, minerology, reaction, soil temperature, permeability, thickness of horizons, and consistence.

SERIES: The series is a group of soils that have major horizons that, except for texture of the surface layer, are similar in important characteristics and in arrangement in the profile.

General Nature of the County

This section was prepared for those who desire general information about Andrews County. It briefly discusses the history and development, farming, geology, and climate.

History and Development

The Comanche Indians ruled this area of West Texas for more than 400 years. In 1865, Colonel Rufus Shafter led an exploration to the West Texas area. This marked the end of the Andrews County area as an Indian stronghold.

Andrews County was formed from Bexar County in August 1876 and was organized in 1910. It was named for Richard Andrews, a Texas revolutionary soldier and the first Texan killed in the war for independence from Mexico.

In 1890 the county had a population of 24, and by 1960 the number was 13,450. Andrews is the county seat.

The most important natural resources in the county are its soil, water, and oil. On the soils of the county, grasses are grown for grazing livestock, and cotton and grain sorghum are planted.

From the Ogallala Formation comes most of the ground water. Enough water is supplied for the city of Andrews by 19 wells north and northeast of the city. These wells have a daily capacity of 8,000,000 gallons, although the maximum daily demand has been only half that amount.

Oil was first discovered in the county in 1929. In May 1965, Andrews County produced its billionth barrel of crude oil. There are 196 oil and gas fields that produce some 60 million barrels of crude oil annually, along with 65 million cubic feet of natural gas.

Farming

Cattle ranching and dryland and irrigation farming are the chief farming enterprises in the county.

Cattle ranching is extensive and is the main type of farming. Livestock operations are primarily of the cow-calf type. Supplemental feeding is generally heavy, especially from December through March. Calves are often sold on a contract basis with delivery dates late in spring and early in summer. Most ranching operations are centered around the native grasses and forbs on range.

Cotton and grain sorghum are grown on medium-sized to large, fully mechanized farms. On these farms, raising livestock is a minor enterprise.

Geology

Andrews County is in one of the principal geological areas of Texas. Early in geological history, perhaps 250 million years ago, a mountain range extended from southwest to northwest across central Texas. In the northwest a shallow sea covered much of the State. This western area now is known as the Permian Basin.

This area covers middle western, north-central, western, and northwestern Texas, as well as parts of eastern New Mexico. The basin of this former sea dips downward to the west from the north-central part of Texas, with its low point in the vicinity of

Midland County, located southeast of Andrews County; then rises in elevation towards the northwest across Andrews County.

The material deposited during the Permian period is too deep to influence the soils of the county, but vast petroleum reservoirs are located in these ancient red-bed formations.

The uppermost geologic formation beneath the soils of Andrews County is the Ogallala Formation. The soils formed in eolian and water-laid parent material deposited on the surface of this formation. The parent material was deposited during the Pliocene epoch, was derived from older sedimentary rocks, and has passed through more than one cycle of weathering, erosion, and deposition. The material, commonly called Rocky Mountain outwash, consists of alkaline to calcareous, unconsolidated, sandy, clayey, and silty sediments, and the soils that formed in these sediments naturally have similar characteristics.

Climate

By Robert B. Orton, climatologist for Texas, National Weather Service, U.S. Department of Commerce.

Andrews County has a cool-temperate, dry steppe climate characterized by mild winters. Table 8 gives temperature and precipitation data compiled from records kept at Andrews, Texas.

The average annual precipitation in the county is 13.89 inches. Approximately 84 percent of this amount falls during the warm season, April through October. Rains occur most frequently as the result of thunderstorms, and monthly and annual amounts are extremely variable. Periods when rainfall is scant for several months are not uncommon. Table 9 lists percentages of probability that specified amounts of precipitation will fall in 1-month periods at Andrews, Texas.

The prevailing winds in this area are southwesterly from November through March and southeasterly to south-southeasterly from May through September. Winds in October are southerly most of the time. The average annual wind speed is about 10.4 miles per hour. In this dry climate, the mean relative humidity at noon is estimated at 45 percent in January, 35 percent in April, 40 percent in July, and 40 percent in October. Andrews County receives approximately 70 percent of the total possible sunshine in winter, 73 percent in spring, 78 percent in summer, and 73 percent in the fall. In an average year, annual free-water (lake) evaporation exceeds precipitation by about 58 inches.

The winter season is marked by frequent surges of cold polar air accompanied by strong northerly winds and sharp drops in temperature. However, cold spells rarely last longer than 48 hours before sunshine and southwesterly winds bring rapid warming. Freezes occur on about three out of every four nights in winter. Precipitation is light and most often falls as snow. Moisture received from snow is rarely distributed uniformly because the snow usually piles up in drifts.

Spring weather is characterized by frequent and rather abrupt changes. Through March and April, warm and cold spells follow each other in rapid succession. These are the windiest months of the year. Infrequently, persistently strong southwesterly to northwesterly winds produce duststorms in the area. Thunderstorms, which rarely occur in winter, increase in number through spring and occur on about 6 days in May.

Thunderstorm activity reaches its peak in summer, when storms occur on about 6 or 7 days of each month. Daily high temperature usually exceeds 90° during the summer months, and the daily low is most often in the upper sixties.

Fall weather, like that of summer, is very pleasant, but fall has greater variety because polar air masses return and bring changes. Rainfall decreases progressively from September through November. Mild sunny days and clear cool nights characterize the fall season.

The warm season (freeze-free period) in Andrews County averages 213 days. The average dates of the last occurrence of a temperature of 32° F. or below in spring and the first occurrence in fall are April 6 and November 5, respectively.

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Glossary

Alkali soil. Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is low from this cause.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Association, soil. A group of soils geographically associated in a characteristic repeating pattern.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Blowout. An excavation produced by wind action in loose soil, usually sand.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Caliche. A more or less cemented deposit of calcium carbonate in many soils of warm-temperate areas, as in the Southwestern States. The material may consist of soft, thin layers in the soil or of hard, thick beds just beneath the solum, or it may be exposed at the surface by erosion.

Channery soil. A soil that contains thin, flat fragments of sandstone, limestone, or schist, as much as 6 inches in length along the longer axis. A single piece is called a fragment.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeters in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Climax vegetation. The stabilized plant community on a particular site; it reproduces itself and does not change so long as the environment does not change.

Coarse fragments. Mineral or rock particles more than 2 millimeters in diameter.

Coarse-textured soils. Sand and loamy sand.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Fine-textured soils. Sandy clay, silty clay, and clay. Roughly, soil that contains 35 percent or more of clay.

Fertility, soil. The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors such as light, moisture, temperature, and the physical condition of the soil are favorable.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the oven-dry weight, after the gravitational, or free, water has been allowed to drain away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity, or capillary capacity.*

Gypsum. Calcium sulphate.

Hardpan. A hardened or cemented soil horizon, or layer. The soil material may be sandy or clayey, and it may be cemented by iron oxide, silica, calcium carbonate, or other substance.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A *horizon.*—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active, and therefore it is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

Internal soil drainage. The downward movement of water through the soil profile. The rate of movement is determined by the texture, structure, and other characteristics of the soil profile and underlying layers, and by the height of the water table, either permanent or perched. Relative terms for expressing internal drainage are *none, very slow, medium, rapid,* and *very rapid.*

Medium-textured soil. Very fine sandy loam, loam, silt loam, or silt.

Mineral soil. Soil composed mainly of inorganic (mineral) material and low in content of organic material. Its bulk density is greater than that of organic soil.

Moderately fine textured soil. Clay loam, sandy clay loam, and silty clay loam.

Munsell notation. A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4.

Parent material. Disintegrated and partly weathered rock from which soil has formed.

Permeability. The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Range site. An area of range where climate, soil, and relief are sufficiently uniform to produce a distinct kind of climax vegetation.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH
Extremely acid	Below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure *are—platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular. Structureless* soils are either *single grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically, the part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Upland (geology). Land consisting of material unworked by water in recent geologic time and lying, in general, at a higher elevation than the alluvial plain or stream terrace. Land above the lowlands along rivers.

Tables

The tables in this soil survey contain information that affects land use planning in this survey area. More current data tables may be available from the Web Soil Survey at the Tabular Data tab.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soils	Acres	Percent	Soils	Acres	Percent
Blakeney and Conger soils, gently undulating	27, 111	2. 8	Portales clay loam	1, 152	0. 1
Dune land	3, 313	. 3	Potter soils, sloping	1, 386	. 1
Faskin and Douro soils, gently undulating	154, 603	16. 0	Ratliff soils, gently undulating	52, 746	5. 5
Ima loamy fine sand, 0 to 3 percent slopes	9, 951	1. 0	Stegall and Slaughter soils	6, 332	. 7
Jalmar-Penwell association, undulating	342, 769	35. 7	Triomas loamy fine sand, 0 to 3 percent slopes	4, 589	. 5
Kimbrough soils, gently undulating	59, 182	6. 2	Triomas and Wickett soils, gently undulating	227, 248	28. 9
Kimbrough-Slaughter complex, 0 to 3 percent slopes	12, 510	1. 2	Salt lakes	2, 247	. 2
Krade soils, undulating	5, 541	. 6			
Lipan clay	1, 880	. 2	Total	962, 560	100. 0

TABLE 2.—*Predicted average acre yields of principal crops*

[Dashes indicate that crop is not grown on this soil or is not suited to it]

Soi	Cotton (lint)		Grain sorghum	
	Dryland	Irrigated	Dryland	Irrigated
	Lb.	*Lb.*	*Lb.*	*Lb.*
Blakeney and Conger soils, gently undulating	----------	385	----------	2, 700
Dune land	----------	----------	----------	----------
Faskin and Douro soils, gently undulating	150	585	1, 125	3, 800
Ima loamy fine sand, 0 to 3 percent slopes	----------	425	----------	2, 600
Jalmar-Penwell association, undulating (Jalmar part)	----------	250	----------	2, 000
Kimbrough soils, gently undulating	----------	----------	----------	----------
Kimbrough-Slaughter complex, 0 to 3 percent slopes	----------	----------	----------	----------
Krade soils, undulating	----------	----------	----------	----------
Lipan clay	----------	----------	----------	----------
Portales clay loam	150	550	1, 200	3, 800
Potter soils, sloping	----------	----------	----------	----------
Ratliff soils, gently undulating	----------	500	----------	2, 700
Stegall and Slaughter soils	125	400	875	3, 000
Triomas loamy fine sand, 0 to 3 percent slopes	----------	450	----------	3, 000
Triomas and Wickett soils, gently undulating	----------	450	----------	3, 000

TABLE 3.—*Estimates of soil properties significant in engineering*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. These soils may have different properties and limitations, therefore it is necessary to follow carefully the instructions for referring to other series that appear in the first column. The symbol > means greater than. The symbol < means less than]

Soil series and map symbols	Hydrologic group	Depth to bedrock	Depth from surface	Classification: USDA texture	Classification: Unified	Classification: AASHO	Percentage passing sieve—No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	Permeability	Available water capacity	Reaction	Shrink-swell potential
		Inches	*Inches*								*Inches per hour*	*Inches per inch of soil*	*pH*	
*Blakeney: BCB. For the Conger part of unit BCB, see the Conger series.	B	12-20	0-18	Fine sandy loam	SM, ML	A-4	-----	100	70-85	40-55	2.0-6.3	0.08-0.12	7.9-8.4	Low.
			18-32	Strongly cemented rounded caliche.										
			32-68	Weakly cemented caliche.										
Conger. Mapped only in an undifferentiated unit with Blakeney soils.	B	12-20	0-6	Loam	ML-CL	A-4, A-6	-----	100	85-95	60-75	0.63-2.0	0.10-0.15	7.9-8.4	Low.
			6-17	Clay loam	CL	A-6	-----	100	85-95	60-75	0.63-2.0	0.14-0.18	7.9-8.4	Low.
			17-39	Caliche plates, strongly cemented.										
			39-75	Weakly cemented caliche.										
Douro. Mapped only in an undifferentiated unit with Faskin soils.	B	20-40	0-9	Fine sandy loam	SM, ML	A-4	-----	100	70-85	40-55	2.0-6.3	0.08-0.12	6.6-7.8	Low.
			9-30	Sandy clay loam	SC, CL	A-6	-----	100	80-90	35-55	0.63-2.0	0.12-0.16	6.6-7.8	Low.
			30-51	Platy caliche, indurated.										
			51-75	Weakly cemented caliche.										
Dune land: DU: Materials are too variable to be rated.														
*Faskin: FDB. For the Douro part of unit FDB, see the Douro series.	B	>60	0-8	Fine sandy loam	SM, ML	A-4	-----	100	70-95	40-60	2.0-6.3	0.05-0.10	6.6-7.3	Low.
			8-42	Sandy clay loam	SC, CL, ML-CL	A-6	-----	100	80-90	40-70	0.63-2.0	0.10-0.15	6.6-8.4	Low.
			42-80	Sandy clay loam	SC, CL, ML-CL	A-6	-----	100	80-90	40-70	0.63-2.0	0.10-0.15	6.6-8.4	Low.
Ima: ImB	B	>60	0-14	Loamy fine sand	SM	A-2	-----	100	75-90	25-35	2.0-6.3	0.05-0.10	7.4-7.8	Low.
			14-44	Fine sandy loam	SM	A-4 or A-2	-----	100	75-90	30-50	2.0-6.3	0.05-0.10	7.9-8.4	Low.
			44-84	Sandy clay loam	SC, CL	A-6	-----	100	80-90	35-55	0.63-2.0	0.10-0.15	7.9-8.4	Low.
*Jalmar: JPC. For the Penwell part of unit JPC, see the Penwell series.	A	>60	0-26	Fine sand	SP-SM, SM	A-2-4	-----	100	65-99	10-20	6.3-20.0	0.03-0.07	6.6-7.3	Low.
			26-64	Sandy clay loam	SC, SM-SC	A-2-6, A-2-4	-----	100	80-98	26-35	0.63-2.0	0.13-0.16	6.6-7.8	Low.
			64-80	Sandy clay loam	SC, SM-SC	A-2-6, A-2-4	-----	100	80-98	25-35	0.63-2.0	0.13-0.16	7.9-8.4	Low.
*Kimbrough: KsB, KMB. For the Slaughter part of unit KsB, see Slaughter series.	C	4-10	0-8	Loam	CL	A-4	90-100	90-100	80-95	60-70	0.63-2.0	0.13-0.15	6.6-8.4	Low.
			8-31	Indurated caliche plates.										
			31-54	Strongly cemented caliche plates.										
Krade: KRC	B	>60	0-80	Fine sandy loam	SM, ML, ML-CL	A-4	-----	100	70-90	40-70	2.0-6.3	0.08-0.12	7.9-8.4	Low.
Lipan: Lc	D	>60	0-60	Clay	CH	A-7	-----	100	95-100	85-95	<0.06	0.15-0.20	7.4-8.4	High.
Penwell. Mapped only in an association with Jalmar soils.	A	>60	0-85	Fine sand	SM, SP-SM, SP	A-2-4	-----	100	70-100	2-15	6.3-20.0	0.03-0.07	6.6-7.3	Low.
Portales: Po	B	>60	0-88	Clay loam	CL	A-6 or A-7	-----	100	90-100	60-75	0.63-2.0	0.13-0.15	7.9-8.4	Low.
Potter: PTC	C	4-10	0-5	Loam	ML, CL	A-6, A-4	80-95	70-90	60-85	51-70	0.63-2.0	0.12-0.16	7.9-8.4	Low.
			5-36	Platy and slightly platy caliche	GM, GC, SM, SC	A-2, A-4, A-6	30-80	25-75	20-60	12-50	0.63-2.0	<0.02	7.9-8.4	Low.
Ratliff: RAB	B	>60	0-10	Loam	ML-CL, CL, SC	A-4, A-6	-----	100	85-95	40-60	0.63-2.0	0.10-0.15	7.9-8.4	Low.
			10-80	Clay loam	CL, ML-CL	A-6	100	95-100	90-95	50-70	0.63-2.0	0.12-0.15	7.9-8.4	Low.
Slaughter. Mapped only in a complex with Kimbrough soils and an undifferentiated unit with Stegall soils.	C	10-20	0-16	Clay loam	CL, ML-CL	A-6, A-7-6	-----	100	90-95	70-80	0.20-0.63	0.15-0.19	6.6-7.3	Moderate.
			16-30	Indurated caliche plates.										

TABLE 3.—*Estimates of soil properties significant in engineering*—Continued

Soil series and map symbols	Hydrologic group	Depth to bedrock	Depth from surface	Classification: USDA texture	Classification: Unified	Classification: AASHO	Percentage passing sieve—No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.	Permeability	Available water capacity	Reaction	Shrink-swell potential
		Inches	*Inches*								*Inches per hour*	*Inches per inch of soil*	*pH*	
*Stegall: SsA. For the Slaughter part of unit SsA, see the Slaughter series.	C	24-36	0-24	Clay loam	CL, ML-CL	A-6, A-7-6	-----	100	90-100	70-80	0.20-0.63	0.16-0.20	6.6-8.4	Low.
			24-29	Clay loam	CL, ML-CL	A-6, A-7-6	-----	100	90-100	70-90	0.20-0.63	0.16-0.20	6.6-8.4	Moderate.
			29-40	Indurated caliche plates.										
*Triomas: TWB, TrB. For the Wickett part of unit TWB, see the Wickett series.	B	>60	0-16	Fine sand	SP-SM, SM	A-2-4	-----	100	65-98	10-20	6.30-20.0	0.03-0.07	6.6-7.3	Low.
			16-68	Sandy clay loam	SC, SM-SC	A-2-6, A-2-4	-----	100	80-99	26-35	0.63-2.0	0.12-0.16	6.6-7.8	Low.
			68-80	Sandy clay loam	SC, SM-SC	A-2-6, A-2-4	-----	100	80-95	26-35	0.63-2.0	0.12-0.16	7.9-8.4	Low.
Wickett. Mapped only in an undifferentiated unit with Triomas soils.	C	20-40	0-16	Loamy fine sand	SM	A-2-4	100	98-100	90-95	20-25	2.0-6.3	0.08-0.10	6.6-7.8	Low.
			16-33	Fine sandy loam	SM, SM-SC	A-4, A-2-4	100	98-100	90-98	25-40	2.0-6.3	0.11-0.14	7.4-7.8	Low.
			33-53	Indurated platy caliche.										
			53-67	Weakly cemented caliche.										

TABLE 4.—*Engineering interpretations of the soils*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. These soils may have different properties and limitations, therefore it is necessary to follow carefully the instructions for referring to other series that appear in the first column]

Soil series and map symbols	Suitability as source of—		Degree of limitations and soil features affecting—			Degree of limitations and soil features affecting—Continued					Soil features affecting irrigation	Corrosivity rating of soil for uncoated steel
							Recreation areas					
	Topsoil	Road subgrade	Highway location	Foundations for low buildings	Septic tank filter fields	Sewage lagoons	Camp areas	Picnic areas	Playgrounds	Paths and trails		
*Blakeney: BCB. For the Conger part of unit BCB, see the Conger series.	Fair: 12 to 20 inches of fine sandy loam.	Poor: 12 to 20 inches of material.	Severe: strongly cemented caliche at a depth of 12 to 20 inches.	Severe: strongly cemented caliche at a depth of 12 to 20 inches.	Severe: strongly cemented caliche at a depth of 12 to 20 inches.	Severe: strongly cemented caliche at a depth of 12 to 20 inches.	Moderate: dust hazard.	Moderate: dust hazard.	Severe: strongly cemented caliche at a depth of 12 to 20 inches.	Moderate: dust hazard.	Strongly cemented caliche at a depth of 12 to 20 inches.	Low.
Conger. Mapped only in an undifferentiated unit with Blakeney soils.	Poor: 4 to 6 inches of loam.	Poor: 12 to 20 inches of material.	Severe: strongly cemented caliche at a depth of 12 to 20 inches.	Severe: strongly cemented caliche at a depth of 12 to 20 inches.	Severe: strongly cemented caliche at a depth of 12 to 20 inches.	Severe: strongly cemented caliche at a depth of 12 to 20 inches.	Moderate: dust hazard.	Moderate: dust hazard.	Severe: strongly cemented caliche at a depth of 12 to 20 inches.	Moderate: dust hazard.	Strongly cemented caliche at a depth of 12 to 20 inches.	Moderate: clay loam texture.
Douro. Mapped only in an undifferentiated unit with Faskin soils.	Fair: 7 to 12 inches of fine sandy loam.	Fair: fair traffic-supporting capacity.	Moderate: fair traffic-supporting capacity.	Slight.	Severe: platy caliche, indurated at a depth of 20 to 40 inches.	Severe: platy caliche, indurated at a depth of 20 to 40 inches.	Slight.	Slight.	Moderate: platy caliche, indurated at a depth of 20 to 40 inches.	Slight.	Platy caliche, indurated at a depth of 20 to 40 inches.	Moderate: sandy clay loam texture.
Dune land: DU. Soil properties are too variable to be rated.												
*Faskin: FDB. For the Douro part of unit FDB, see the Douro series.	Fair: fine sandy loam at a depth of 7 to 12 inches.	Fair: fair traffic-supporting capacity.	Moderate: fair traffic-supporting capacity.	Slight.	Slight.	Moderate: moderate permeability.	Slight.	Slight.	Slight.	Slight.	All features favorable.	Moderate: sandy clay loam texture.
Ima: ImB.	Poor: loamy fine sand texture.	Fair: fair traffic-supporting capacity.	Moderate: fair traffic-supporting capacity.	Slight.	Slight.	Severe: moderately rapid permeability, calcareous.	Severe: loamy fine sand texture.	Severe: loamy fine sand texture.	Severe: loamy fine sand texture.	Severe: loamy fine sand texture.	Loamy fine sand texture; moderately rapid permeability.	Moderate: sandy clay loam texture; conductivity.

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TABLE 4.—*Engineering interpretations of the soils*—Continued

Soil series and map symbols	Suitability as source of—		Degree of limitations and soil features affecting—			Degree of limitations and soil features affecting—Continued					Soil features affecting irrigation	Corrosivity rating of soil for uncoated steel
							Recreation areas					
	Topsoil	Road subgrade	Highway location	Foundations for low buildings	Septic tank filter fields	Sewage lagoons	Camp areas	Picnic areas	Playgrounds	Paths and trails		
*Jalmar: JPC. For the Penwell part of unit JPC, see the Penwell series.	Poor: fine sand texture.	Good.	Slight.	Slight.	Slight.	Moderate: moderate permeability.	Severe: fine sand texture.	Severe: fine sand texture.	Severe: fine sand texture.	Severe: fine sand texture.	Rapid intake rate; erodible.	Moderate: sandy clay loam texture.
*Kimbrough: KaB, KMB. For the Slaughter part of unit KaB, see the Slaughter series.	Poor where 4 to 6 inches of loam, 10 to 12 percent fragments. Fair where 6 to 10 inches of loam, 3 to 10 percent fragments.	Poor: 4 to 10 inches of suitable material.	Severe: indurated caliche plates at a depth of 4 to 10 inches.	Severe: indurated caliche plates at a depth of 4 to 10 inches.	Severe: indurated caliche plates at a depth of 4 to 10 inches.	Severe: indurated caliche plates at a depth of 4 to 10 inches.	Slight.	Slight.	Severe: indurated caliche plates at a depth of 4 to 10 inches.	Slight.	Indurated caliche plates at a depth of 4 to 10 inches.	High: conductivity.
Krade: KRC.	Good.	Fair: fair traffic-supporting capacity.	Moderate: fair traffic-supporting capacity.	Slight.	Slight.	Severe: moderately rapid permeability.	Moderate: dust hazard.	Moderate: dust hazard.	Moderate where slopes are 0 to 2 percent: dust hazard. Severe where slopes are 2 to 5 percent: dust hazard.	Moderate: dust hazard.	Slopes; calcareous soils.	Low.
Lipan: Lc.	Poor: clay texture.	Poor: high shrink-swell potential; poor traffic-supporting capacity.	Severe: high shrink-swell potential; poor traffic-supporting capacity.	Severe: high shrink-swell potential.	Severe: very slow permeability.	Slight.	Severe: very slow permeability; clay texture.	Severe: clay texture.	Severe: very slow permeability; clay texture.	Severe: clay texture.	Slow intake rate; flooding.	High: clay texture.
Penwell. Mapped only in an association with Jalmar soils.	Poor: fine sand texture.	Good.	Slight where slopes are 0 to 6 percent; moderate where slopes are 6 to 8 percent.	Slight where slopes are 0 to 6 percent; moderate where slopes are 6 to 8 percent.	Severe: inadequate filtration.	Severe: rapid permeability.	Severe: fine sand texture.	Severe: fine sand texture.	Severe: fine sand texture.	Severe: fine sand texture.	High intake rate; low available water capacity; dune topography; erodible.	Low.
Portales: Po.	Fair: clay loam texture.	Fair: fair traffic-supporting capacity.	Moderate: fair traffic-supporting capacity.	Slight.	Slight.	Moderate: moderate permeability.	Moderate: clay loam texture.	Moderate: clay loam texture.	Moderate: clay loam texture.	Moderate: clay loam texture.	All features favorable.	Moderate: conductivity; clay loam texture.
Potter: PTC.	Poor: 10 to 15 percent coarse fragments.	Poor: 4 to 10 inches of suitable material.	Severe: platy caliche at a depth of 4 to 10 inches.	Severe: platy caliche at a depth of 4 to 10 inches.	Severe: platy caliche at a depth of 4 to 10 inches.	Severe: permeable, calcareous substratum; platy caliche at a depth of 4 to 10 inches.	Slight.	Slight.	Severe: platy caliche at a depth of 4 to 10 inches.	Slight.	Platy caliche at a depth of 4 to 10 inches.	Moderate: conductivity.
Ratliff: RAB.	Fair: 8 to 10 inches of loam.	Fair: fair traffic-supporting capacity.	Moderate: fair traffic-supporting capacity.	Slight.	Slight.	Moderate: moderate permeability.	Moderate: dust hazard.	Moderate: dust hazard.	Moderate: dust hazard.	Moderate: dust hazard.	All features favorable.	Moderate: clay loam texture.
Slaughter. Mapped in an undifferentiated unit with Stegall soils and in a complex with Kimbrough soils.	Fair: clay loam texture.	Poor: 10 to 20 inches of suitable material.	Severe: indurated platy caliche at a depth of 10 to 20 inches.	Severe: indurated platy caliche at a depth of 10 to 20 inches.	Severe: indurated platy caliche at a depth of 10 to 20 inches.	Severe: indurated platy caliche at a depth of 10 to 20 inches.	Moderate: moderately slow permeability; clay loam texture.	Moderate: clay loam texture.	Severe: indurated platy caliche at a depth of 10 to 20 inches.	Moderate: clay loam texture.	Indurated platy caliche at a depth of 10 to 20 inches.	Moderate: clay loam texture.

TABLE 4.—*Engineering interpretations of the soils*—Continued

Soil series and map symbols	Suitability as source of—		Degree of limitations and soil features affecting—			Degree of limitations and soil features affecting—Continued					Soil features affecting irrigation	Corrosivity rating of soil for uncoated steel
							Recreation areas					
	Topsoil	Road subgrade	Highway location	Foundations for low buildings	Septic tank filter fields	Sewage lagoons	Camp areas	Picnic areas	Playgrounds	Paths and trails		
*Stegall: SsA. For Slaughter part of unit SsA, see the Slaughter series.	Fair: clay loam texture.	Fair: 24 to 36 inches of suitable material.	Severe: indurated caliche plates at a depth of 24 to 36 inches.	Moderate: moderate shrink-swell potential.	Moderate: indurated caliche plates at a depth of 24 to 36 inches.	Severe: indurated caliche plates at a depth of 24 to 36 inches.	Moderate: moderately slow permeability; clay loam texture.	Moderate: clay loam texture.	Moderate: moderately slow permeability; indurated caliche plates at a depth of 24 to 36 inches.	Moderate: clay loam texture.	Indurated caliche plates at a depth of 24 to 38 inches.	Moderate: clay loam texture.
*Triomas: TWB, TrB. For the Wickett part of unit TWB, see the Wickett series.	Poor: fine sand texture.	Good.	Slight.	Slight.	Moderate: moderate permeability.	Moderate: moderate permeability.	Severe: fine sand texture.	Severe: fine sand texture.	Severe: fine sand texture.	Severe: fine sand texture.	Rapid intake rate; erodible.	Moderate: sandy clay loam texture.
Wickett. Mapped only in an undifferentiated unit with Triomas soils.	Poor: loamy fine sand texture.	Fair where 24 to 40 inches of suitable material; poor where 20 to 24 inches of suitable material.	Severe where indurated caliche is at a depth of 20 to 36 inches; moderate where indurated platy caliche is at a depth of 36 to 40 inches.	Slight.	Severe: indurated platy caliche at a depth of 20 to 40 inches.	Severe: indurated platy caliche at a depth of 20 to 40 inches; moderately rapid permeability.	Moderate: loamy fine sand texture.	Moderate: loamy fine sand texture.	Moderate: indurated platy caliche at a depth of 20 to 40 inches; loamy fine sand texture.	Moderate: loamy fine sand texture.	Rapid intake rate; erodible.	Low.

TABLE 5.—*Engineering test data*

[Tests performed by Texas Highway Department]

Soil name and location	Parent material	Report No.	Depth from surface	Shrinkage limit	Linear shrinkage	Shrinkage ratio	Percentage passing sieve—[1]			Liquid limit	Plasticity index	Classification	
							No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)			AASHO	Unified
			Inches	*Percent*	*Percent*								
Jalmar fine sand in an area of Jalmar-Penwell association, undulating: 800 feet west, then 10 feet north of the northeast corner of sec. 3, block A 50, public school land. In range on north side of oil field road. (modal).	Eolian sandy sediments.	68-332-R	0-10	18	0	1.76	100	97	13	21	3	A-2-4(0)	SM
		68-333-R	10-24	18	1.1	1.71	100	99	13	19	2	A-2-4(0)	SM
		68-334-R	24-56	17	4.7	1.80	100	98	31	26	13	A-2-6(0)	SC
		68-335-R	56-78	18	2.9	1.76	100	98	27	23	7	A-2-4(0)	SM-SC
Penwell fine sand in an area of Jalmar-Penwell association, undulating: 4,800 feet west and 300 feet south of northeast corner sec. 25, block 11, university land. On west side of Farm Road 181 in range. (modal).	Noncalcareous eolian sands.	68-342-R	0-12	18	.3	1.71	------------	100	6	20	3	A-2-4(0)	SP-SM
		68-343-R	12-64	19	0	1.70	------------	100	2	22	3	A-2-4(0)	SP
Triomas fine sand in an area of Triomas and Wickett soils, gently undulating: 800 feet west of the northeast corner of sec. 2, block A 49, public school land. In range east of ranch road. (modal).	Eolian sandy sediments.	68-328-R	0-17	18	.8	1.75	100	98	12	21	3	A-2-4(0)	SP-SM
		68-329-R	17-34	18	3.7	1.77	100	99	29	24	9	A-2-4(0)	SC
		68-330-R	34-54	17	4.5	1.77	100	97	29	26	12	A-2-4(0)	SC
		68-331-R	54-68	18	4.4	1.77	100	96	27	26	11	A-2-6(0)	SC

[1] Mechanical analyses according to the AASHO Designation T88-57 (*1*). Results by this procedure differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, fine material is analyzed by the hydrometer method, and the various grain-size fractions are calculated on the basis of all material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method, and material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analysis data used in this table are not suitable for naming textural classes for soils.

TABLE 6.—*Suitability of soils for wildlife habitat elements and for kinds of wildlife*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. These soils may have different properties and limitations, therefore it is necessary to follow carefully the instructions for referring to other series that appear in the first column]

Soil series and map symbols	Wildlife habitat elements			Wildlife habitat elements—Continued			Kinds of wildlife		
	Grain and seed crops	Grass and legumes	Wild herbaceous upland plants	Hardwood trees and shrubs	Wetland food and cover plants	Shallow water developments	Openland	Brushland	Wetland
*Blakeney: BCB For the Conger part of unit BCB, see the Conger series.	Poorly suited	Poorly suited	Suited	Unsuited	Unsuited	Unsuited	Poorly suited	Poorly suited	Unsuited.
Conger Mapped only in an undifferentiated unit with Blakeney soils.	Poorly suited	Poorly suited	Suited	Unsuited	Unsuited	Unsuited	Poorly suited	Poorly suited	Unsuited.
Douro Mapped only in an undifferentiated unit with Faskin soils.	Suited	Well suited	Well suited	Unsuited	Unsuited	Unsuited	Well suited	Poorly suited	Unsuited.
Dune land: DU	Unsuited	Unsuited	Unsuited	Unsuited	Unsuited	Unsuited	Poorly suited	Unsuited	Unsuited.
*Faskin: FDB For the Douro part of unit FDB, see the Douro series.	Well suited	Well suited	Well suited	Unsuited	Unsuited	Unsuited	Well suited	Poorly suited	Unsuited.
Ima: ImB	Poorly suited	Well suited	Well suited	Unsuited	Unsuited	Unsuited	Suited	Poorly suited	Unsuited.
*Jalmar: JPC For the Penwell part of unit JPC, see the Penwell series.	Poorly suited	Suited	Poorly suited	Unsuited	Unsuited	Unsuited	Suited	Poorly suited	Unsuited.
*Kimbrough: KaB, KMB For the Slaughter part of unit KaB, see the Slaughter series.	Unsuited	Unsuited	Poorly suited	Unsuited	Unsuited	Unsuited	Poorly suited	Poorly suited	Unsuited.
Krade: KRC	Poorly suited	Well suited	Well suited	Unsuited	Unsuited	Unsuited	Suited	Poorly suited	Unsuited.
Lipan: Lc	Poorly suited	Poorly suited	Suited	Unsuited	Poorly suited	Poorly suited	Poorly suited	Poorly suited	Suited.
Penwell Mapped only in an association with Jalmar soils.	Poorly suited	Suited	Poorly suited	Unsuited	Unsuited	Unsuited	Poorly suited	Poorly suited	Unsuited.
Portales: Ps	Well suited	Well suited	Well suited	Unsuited	Unsuited	Unsuited	Well suited	Poorly suited	Unsuited.
Potter: PTC	Unsuited	Unsuited	Poorly suited	Unsuited	Unsuited	Unsuited	Poorly suited	Poorly suited	Unsuited.
Ratliff: RAB	Poorly suited	Well suited	Well suited	Unsuited	Unsuited	Unsuited	Well suited	Poorly suited	Unsuited.
Slaughter Mapped in an undifferentiated unit with Stegall soils and in a complex with Kimbrough soils.	Poorly suited	Poorly suited	Suited	Unsuited	Unsuited	Unsuited	Poorly suited	Poorly suited	Unsuited.
*Stegall: SsA For the Slaughter part of unit SsA, see the Slaughter series.	Well suited	Well suited	Well suited	Unsuited	Unsuited	Unsuited	Well suited	Poorly suited	Unsuited.
*Triomas: TrB, TWB For the Wickett part of unit TWB, see the Wickett series.	Poorly suited	Well suited	Well suited	Unsuited	Unsuited	Unsuited	Suited	Poorly suited	Unsuited.
Wickett Mapped only in an undifferentiated unit with Triomas soils.	Poorly suited	Well suited	Well suited	Unsuited	Unsuited	Unsuited	Well suited	Poorly suited	Unsuited.

TABLE 7.—*Classification of soil series*

Soil series	Family	Subgroup	Order
Blakeney	Loamy, mixed, thermic, shallow	Ustochreptic Paleorthids	Aridisols.
Conger	Loamy, mixed, thermic, shallow	Ustollic Paleorthids	Aridisols.
Douro	Fine-loamy, mixed, thermic	Petrocalcic Ustalfic Paleargids	Aridisols.
Faskin	Fine-loamy, mixed, thermic	Ustalfic Haplargids	Aridisols.
Ima	Coarse-loamy, mixed, thermic	Ustochreptic Camborthids	Aridisols.
Jalmar	Loamy, mixed, thermic	Arenic Ustalfic Haplargids	Aridisols.
Kimbrough	Loamy, mixed, thermic, shallow	Petrocalcic Calciustolls	Mollisols.
Krade	Coarse-loamy, mixed (calcareous), thermic	Ustic Torriorthents	Entisols.
Lipan	Fine, montmorillonitic, thermic	Entic Pellusterts	Vertisols.
Penwell	Mixed, thermic	Ustic Torripsamments	Entisols.
Portales	Fine-loamy, mixed, thermic	Aridic Calciustolls	Mollisols.
Potter	Loamy, carbonatic, thermic, shallow	Ustollic Calciorthids	Aridisols.
Ratliff	Fine-loamy, mixed, thermic	Ustollic Calciorthids	Aridisols.
Slaughter	Clayey, mixed, thermic, shallow	Petrocalcic Paleustolls	Mollisols.
Stegall	Fine, mixed, thermic	Petrocalcic Paleustolls	Mollisols.
Triomas	Fine-loamy, mixed, thermic	Ustalfic Haplargids	Aridisols.
Wickett	Coarse-loamy, mixed, thermic	Petrocalcic Ustalfic Paleargids	Aridisols.

TABLE 8.—*Temperature and precipitation data*

[Data compiled from records at Andrews, Tex., elevation 3,172 feet. Temperature data for period 1962–69, precipitation for 1949–69]

Month	Temperature				Precipitation					
	Average daily maximum	Average monthly maximum	Average daily minimum	Average monthly minimum	Average monthly total	Average number of days with— 0.1 inch or more	Average number of days with— 0.5 inch or more	Average number of days with— 1 inch or more	Snow, sleet: Average monthly total	Snow, sleet: Maximum monthly
	°F.	°F.	°F.	°F.	Inches				Inches	Inches
January	59.3	75.6	29.5	10.4	0.61	1	(1)	0	1.0	4.0
February	60.0	74.9	30.6	15.7	.43	1	(1)	0	.6	2.8
March	69.1	85.3	38.6	20.0	.48	1	(1)	(1)	(2)	(2)
April	80.1	90.9	50.6	38.6	.74	2	1	(1)	0	0
May	87.1	99.9	58.1	45.4	1.78	3	1	(1)	0	0
June	93.2	100.9	65.8	55.4	1.36	3	1	(1)	0	0
July	95.5	102.0	68.6	61.4	2.37	4	2	1	0	0
August	93.3	102.1	67.1	59.1	1.62	4	1	1	0	0
September	85.8	96.0	60.9	47.6	2.19	3	2	1	0	0
October	78.9	92.4	50.1	37.5	1.60	2	1	(1)	0	0
November	67.8	81.3	40.9	25.0	.41	1	(1)	0	(2)	(2)
December	58.6	75.0	31.4	17.1	.30	1	(1)	0	.5	4.0
Year	77.4	89.7	49.4	36.1	13.89	26	9	3	2.1	4.0

(1) Less than one-half day.
(2) Trace, an amount too small to measure.

TABLE 9.—*Probabilities of receiving selected amounts of precipitation*

[Data recorded at Andrews, Tex., for period 1949–69. The symbol < means less than]

Month	Probability of receiving during month—							
	Trace or less	0.5 inch or more	1 inch or more	2 inches or more	3 inches or more	4 inches or more	5 inches or more	6 inches or more
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
January	6	45	23	10	2	1	<1	<1
February	15	40	18	4	1	<1	<1	<1
March	17	30	10	4	1	<1	<1	<1
April	5	50	30	10	3	2	<1	<1
May	<1	80	60	40	20	12	8	5
June	<1	80	58	30	19	8	5	3
July	5	85	70	40	21	11	6	3
August	1	80	60	32	12	7	3	2
September	1	72	54	33	20	12	7	3
October	4	80	80	32	15	8	4	2
November	23	35	15	3	1	<1	<1	<1
December	11	46	24	5	1	<1	<1	<1

NRCS Accessibility Statement

The Natural Resources Conservation Service (NRCS) is committed to making its information accessible to all of its customers and employees. If you are experiencing accessibility issues and need assistance, please contact our Helpdesk by phone at 1-800-457-3642 or by e-mail at helpdesk@helpdesk.itc.nrcs.usda.gov. For assistance with publications that include maps, graphs, or similar forms of information, you may also wish to contact our State or local office. You can locate the correct office and phone number at http://offices.sc.egov.usda.gov/locator/app.

ATTACHMENT 3-3
AGENCY CONSULTATION

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, FORT WORTH DISTRICT
P. O. BOX 17300
FORT WORTH, TEXAS 76102-0300

June 24, 2019

Regulatory Division

SUBJECT: Project Number SWF-2019-00145, Consolidated Interim Storage Facility

Mr. Jay Britten
Interim Storage Partners
Waste Control Specialists LLC
9998 W. Highway 176
Andrews, Texas 79714

Dear Mr. Britten:

This letter is in regard to the information received April 15, 2019, and subsequent submittal dated May 16, 2019, concerning the proposed by Interim Storage Partners to construct an interim storage facility adjacent to Waste Control Specialists, LLC facilities located in Andrews County, Texas. This project has been assigned Project Number SWF-2019-00145. Please include this number in all future correspondence concerning this project.

We have reviewed the site in question in accordance with Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899. Under Section 404, the USACE regulates the discharge of dredged and fill material into waters of the United States, including wetlands. Our responsibility under Section 10 is to regulate any work in, or affecting, navigable waters of the United States.

Based on the report that you submitted, and other information available to us, waters of the United States under Section 404 do not exist on the site. We concur with the delineation of waters that is made in the above referenced report. This approved jurisdictional determination (JD) is valid for a period of no more than five years from the date of this letter unless new information warrants revision of the delineation before the expiration date.

This determination does not convey any property rights, either in real estate or material or any exclusive privileges, nor does it authorize any injury to property or invasion of rights or any infringement of Federal, State, or local laws or regulations. This determination does not eliminate the requirements to obtain State or local permits or approvals as needed.

Department of the Army authorization would be required for the discharge of dredged or fill material into any areas identified as waters of the United States. If you anticipate a discharge, please provide us with a detailed description of the proposed project, a suitable map of the proposed project area showing the location of proposed discharges, the type and amount of material (temporary or permanent), if any, to be discharged, and plan and cross-section views of the proposed project. Please note that it is unlawful to start work without a Department of the Army permit if one is required.

The Applicant may accept or appeal this approved JD or provide new information in accordance with the enclosed Notification of Administration Appeal Options and Process and Request for Appeal (NAAOP-RFA). If the Applicant elects to appeal this approved JD, the Applicant must complete Section II (Request for Appeal or Objections to an Initial Proffered Permit) of the enclosure and return it to the Division Engineer, ATTN: CESWD-PD-O Appeals Review Officer, U.S. Army Corps of Engineers, 1100 Commerce Street, Dallas, Suite 831, Texas 75242-0216 within 60 days of the date of this notice. Failure to notify the USACE within 60 days of the date of this notice means you accept the approved JD in its entirety and waive all rights to appeal the approved JD.

Thank you for your interest in our nation's water resources. If you have any questions concerning our regulatory program please refer to our website at http://www.swf.usace.army.mil/Missions/Regulatory or contact Ms. Katie Roeder at telephone (817) 886-1740 and refer to your assigned project number.

Please help the regulatory program improve its service by completing the survey on the following website: http://corpsmapu.usace.army.mil/cm_apex/f?p=regulatory_survey

Sincerely,

Stephen L Brooks
Chief, Regulatory Division

Enclosures

Copies furnished (without enclosures):

Mr. Ryan Blankenship
Cox McLain Environmental Consulting, Inc.
600 E. John Carpenter Freeway Suite 186
Irving, Texas 75062

NOTIFICATION OF ADMINISTRATIVE APPEAL OPTIONS AND PROCESS AND REQUEST FOR APPEAL

Applicant: Jay Britten		File Number: SWF-2019-00145	Date: 06-24-2019
Attached is:			See Section below
	INITIAL PROFFERED PERMIT (Standard Permit or Letter of permission)		A
	PROFFERED PERMIT (Standard Permit or Letter of permission)		B
	PERMIT DENIAL		C
x	APPROVED JURISDICTIONAL DETERMINATION		D
	PRELIMINARY JURISDICTIONAL DETERMINATION		E

SECTION I - The following identifies your rights and options regarding an administrative appeal of the above decision. Additional information may be found at http://www.usace.army.mil/Missions/CivilWorks/RegulatoryProgramandPermits/appeals.aspx or Corps regulations at 33 CFR Part 331.

A: INITIAL PROFFERED PERMIT: You may accept or object to the permit.

- ACCEPT: If you received a Standard Permit, you may sign the permit document and return it to the district engineer for final authorization. If you received a Letter of Permission (LOP), you may accept the LOP and your work is authorized. Your signature on the Standard Permit or acceptance of the LOP means that you accept the permit in its entirety, and waive all rights to appeal the permit, including its terms and conditions, and approved jurisdictional determinations associated with the permit.
- OBJECT: If you object to the permit (Standard or LOP) because of certain terms and conditions therein, you may request that the permit be modified accordingly. You must complete Section II of this form and return the form to the district engineer. Your objections must be received by the district engineer within 60 days of the date of this notice, or you will forfeit your right to appeal the permit in the future. Upon receipt of your letter, the district engineer will evaluate your objections and may: (a) modify the permit to address all of your concerns, (b) modify the permit to address some of your objections, or (c) not modify the permit having determined that the permit should be issued as previously written. After evaluating your objections, the district engineer will send you a proffered permit for your reconsideration, as indicated in Section B below.

B: PROFFERED PERMIT: You may accept or appeal the permit

- ACCEPT: If you received a Standard Permit, you may sign the permit document and return it to the district engineer for final authorization. If you received a Letter of Permission (LOP), you may accept the LOP and your work is authorized. Your signature on the Standard Permit or acceptance of the LOP means that you accept the permit in its entirety, and waive all rights to appeal the permit, including its terms and conditions, and approved jurisdictional determinations associated with the permit.
- APPEAL: If you choose to decline the proffered permit (Standard or LOP) because of certain terms and conditions therein, you may appeal the declined permit under the Corps of Engineers Administrative Appeal Process by completing Section II of this form and sending the form to the division engineer. This form must be received by the division engineer within 60 days of the date of this notice.

C: PERMIT DENIAL: You may appeal the denial of a permit under the Corps of Engineers Administrative Appeal Process by completing Section II of this form and sending the form to the division engineer. This form must be received by the division engineer within 60 days of the date of this notice.

D: APPROVED JURISDICTIONAL DETERMINATION: You may accept or appeal the approved JD or provide new information.

- ACCEPT: You do not need to notify the Corps to accept an approved JD. Failure to notify the Corps within 60 days of the date of this notice, means that you accept the approved JD in its entirety, and waive all rights to appeal the approved JD.
- APPEAL: If you disagree with the approved JD, you may appeal the approved JD under the Corps of Engineers Administrative Appeal Process by completing Section II of this form and sending the form to the division engineer. This form must be received by the division engineer within 60 days of the date of this notice.

E: PRELIMINARY JURISDICTIONAL DETERMINATION: You do not need to respond to the Corps regarding the preliminary JD. The Preliminary JD is not appealable. If you wish, you may request an approved JD (which may be appealed), by contacting the Corps district for further instruction. Also you may provide new information for further consideration by the Corps to reevaluate the JD.

SECTION II - REQUEST FOR APPEAL or OBJECTIONS TO AN INITIAL PROFFERED PERMIT

REASONS FOR APPEAL OR OBJECTIONS: (Describe your reasons for appealing the decision or your objections to an initial proffered permit in clear concise statements. You may attach additional information to this form to clarify where your reasons or objections are addressed in the administrative record.)

ADDITIONAL INFORMATION: The appeal is limited to a review of the administrative record, the Corps memorandum for the record of the appeal conference or meeting, and any supplemental information that the review officer has determined is needed to clarify the administrative record. Neither the appellant nor the Corps may add new information or analyses to the record. However, you may provide additional information to clarify the location of information that is already in the administrative record.

POINT OF CONTACT FOR QUESTIONS OR INFORMATION:

If you have questions regarding this decision and/or the appeal process you may contact:	If you only have questions regarding the appeal process you may also contact:
Katie Roeder Regulatory Specialist, Evaluation Branch Regulatory Division U.S. Army Corps of Engineers Ft. Worth District 819 Taylor Street Fort Worth, Texas 76102-00300 Phone: 817-886-1740	Mr. Elliott Carman Administrative Appeals Review Officer (CESWD-PD-O) U.S. Army Corps of Engineers 1100 Commerce Street, Suite 831 Dallas , Texas 75242-1317 469-487-7061

RIGHT OF ENTRY: Your signature below grants the right of entry to Corps of Engineers personnel, and any government consultants, to conduct investigations of the project site during the course of the appeal process. You will be provided a 15 day notice of any site investigation, and will have the opportunity to participate in all site investigations.

______________________ Signature of appellant or agent.	Date:	Telephone number:

APPROVED JURISDICTIONAL DETERMINATION FORM
U.S. Army Corps of Engineers

This form should be completed by following the instructions provided in Section IV of the JD Form Instructional Guidebook.

SECTION I: BACKGROUND INFORMATION

A. REPORT COMPLETION DATE FOR APPROVED JURISDICTIONAL DETERMINATION (JD): April 11, 2019

B. DISTRICT OFFICE, FILE NAME, AND NUMBER: SWF-2019-00145

C. PROJECT LOCATION AND BACKGROUND INFORMATION:

State: Texas County/parish/borough: Andrews City: N/A
Center coordinates of site (lat/long in degree decimal format): Lat. 32.44558° N, Long. -103.04298° W.
Universal Transverse Mercator:
Name of nearest waterbody: Monument Draw
Name of nearest Traditional Navigable Water (TNW) into which the aquatic resource flows: None
Name of watershed or Hydrologic Unit Code (HUC): HUC 13070007
☒ Check if map/diagram of review area and/or potential jurisdictional areas is/are available upon request.
☐ Check if other sites (e.g., offsite mitigation sites, disposal sites, etc...) are associated with this action and are recorded on a different JD form.

D. REVIEW PERFORMED FOR SITE EVALUATION (CHECK ALL THAT APPLY):

☒ Office (Desk) Determination. Date: May 8, 2018
☐ Field Determination. Date(s):

SECTION II: SUMMARY OF FINDINGS

A. RHA SECTION 10 DETERMINATION OF JURISDICTION.

There **Are no** "*navigable waters of the U.S.*" within Rivers and Harbors Act (RHA) jurisdiction (as defined by 33 CFR part 329) in the review area. [*Required*]
☐ Waters subject to the ebb and flow of the tide.
☐ Waters are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce. Explain: .

B. CWA SECTION 404 DETERMINATION OF JURISDICTION.

There **Are no** "*waters of the U.S.*" within Clean Water Act (CWA) jurisdiction (as defined by 33 CFR part 328) in the review area. [*Required*]

1. **Waters of the U.S.**
   a. **Indicate presence of waters of U.S. in review area (check all that apply):** [1]
      ☐ TNWs, including territorial seas
      ☐ Wetlands adjacent to TNWs
      ☐ Relatively permanent waters[2] (RPWs) that flow directly or indirectly into TNWs
      ☐ Non-RPWs that flow directly or indirectly into TNWs
      ☐ Wetlands directly abutting RPWs that flow directly or indirectly into TNWs
      ☐ Wetlands adjacent to but not directly abutting RPWs that flow directly or indirectly into TNWs
      ☐ Wetlands adjacent to non-RPWs that flow directly or indirectly into TNWs
      ☐ Impoundments of jurisdictional waters
      ☐ Isolated (interstate or intrastate) waters, including isolated wetlands

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By____________

   b. **Identify (estimate) size of waters of the U.S. in the review area:**
      Non-wetland waters: 0 linear feet: 0 width (ft) and/or 0.00 acres.
      Wetlands: 0.00 acres.

   c. **Limits (boundaries) of jurisdiction** based on: **Not A licable.**
      Elevation of established OHWM (if known): .

2. **Non-regulated waters/wetlands (check if applicable):**[3]
   ☒ Potentially jurisdictional waters and/or wetlands were assessed within the review area and determined to be not jurisdictional. Explain: **A delineation of waters of the U.S., including wetlands, was conducted for the approximately 1,534-acre project area in February 2019. The proposed project area includes three classifications of aquatic features. A series of upland man-made drainage ditches, a series of non-wetland vegetated swales, and three playa lakes are located within the project area. None of the aquatic features within the project area are considered waters of the U.S. since all**

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[1] Boxes checked below shall be supported by completing the appropriate sections in Section III below.
[2] For purposes of this form, an RPW is defined as a tributary that is not a TNW and that typically flows year-round or has continuous flow at least "seasonally" (e.g., typically 3 months).
[3] Supporting documentation is presented in Section III.F.

features are isolated and do not have a direct hydrologic connection to any other identified downstream water. The results of the wetland delineation indicate that no waters of the U.S., including wetlands, are located within the project area.

The upland man-made drainage ditches located within the project area would not be considered waters of the U.S. since they are located entirely within uplands and drain only uplands. These features are a result of excavation by WCS to facilitate operation of their facility.

The non-wetland vegetated swales observed within the project area would not be considered waters of the U.S. since they lacked an observable OHWM, clearly defined bed and banks, and wetland indictors, and do not appear to convey sufficient surface flows to create a hydrologic connection to other downstream aquatic features.

The three playas located within the project area (northern playa, eastern playa, and southern playa) are naturally occurring topographic features that collect local rainfall. They are closed depressions and do not have a clear surface hydrologic connection to any other identified aquatic feature.

SECTION III: CWA ANALYSIS

A. TNWs AND WETLANDS ADJACENT TO TNWs

The agencies will assert jurisdiction over TNWs and wetlands adjacent to TNWs. If the aquatic resource is a TNW, complete Section III.A.1 and Section III.D.1. only; if the aquatic resource is a wetland adjacent to a TNW, complete Sections III.A.1 and 2 and Section III.D.1.; otherwise, see Section III.B below.

1. **TNW**
   Identify TNW: N/A.

   Summarize rationale supporting determination: N/A.

2. **Wetland adjacent to TNW**
   Summarize rationale supporting conclusion that wetland is "adjacent": N/A.

B. CHARACTERISTICS OF TRIBUTARY (THAT IS NOT A TNW) AND ITS ADJACENT WETLANDS (IF ANY):

This section summarizes information regarding characteristics of the tributary and its adjacent wetlands, if any, and it helps determine whether or not the standards for jurisdiction established under *Rapanos* have been met.

The agencies will assert jurisdiction over non-navigable tributaries of TNWs where the tributaries are "relatively permanent waters" (RPWs), i.e. tributaries that typically flow year-round or have continuous flow at least seasonally (e.g., typically 3 months). A wetland that directly abuts an RPW is also jurisdictional. If the aquatic resource is not a TNW, but has year-round (perennial) flow, skip to Section III.D.2. If the aquatic resource is a wetland directly abutting a tributary with perennial flow, skip to Section III.D.4.

A wetland that is adjacent to but that does not directly abut an RPW requires a significant nexus evaluation. Corps districts and EPA regions will include in the record any available information that documents the existence of a significant nexus between a relatively permanent tributary that is not perennial (and its adjacent wetlands if any) and a traditional navigable water, even though a significant nexus finding is not required as a matter of law.

If the waterbody[4] is not an RPW, or a wetland directly abutting an RPW, a JD will require additional data to determine if the waterbody has a significant nexus with a TNW. If the tributary has adjacent wetlands, the significant nexus evaluation must consider the tributary in combination with all of its adjacent wetlands. This significant nexus evaluation that combines, for analytical purposes, the tributary and all of its adjacent wetlands is used whether the review area identified in the JD request is the tributary, or its adjacent wetlands, or both. If the JD covers a tributary with adjacent wetlands, complete Section III.B.1 for the tributary, Section III.B.2 for any onsite wetlands, and Section III.B.3 for all wetlands adjacent to that tributary, both onsite and offsite. The determination whether a significant nexus exists is determined in Section III.C below.

1. **Characteristics of non-TNWs that flow directly or indirectly into TNW**

   (i) **General Area Conditions:**
   Watershed size: **Pick List**
   Drainage area: **Pick List**
   Average annual rainfall: inches
   Average annual snowfall: inches

   (ii) **Physical Characteristics:**
   (a) Relationship with TNW:
   ☐ Tributary flows directly into TNW.
   ☐ Tributary flows through **Pick List** tributaries before entering TNW.

   Project waters are **Pick List** river miles from TNW.
   Project waters are **Pick List** river miles from RPW.
   Project waters are **Pick List** aerial (straight) miles from TNW.
   Project waters are **Pick List** aerial (straight) miles from RPW.
   Project waters cross or serve as state boundaries. Explain: .

   Identify flow route to TNW[5]: .
   Tributary stream order, if known: .

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[4] Note that the Instructional Guidebook contains additional information regarding swales, ditches, washes, and erosional features generally and in the arid West.
[5] Flow route can be described by identifying, e.g., tributary a, which flows through the review area, to flow into tributary b, which then flows into TNW.

(b) General Tributary Characteristics (check all that apply):

Tributary is: ☐ Natural
☐ Artificial (man-made). Explain: .
☐ Manipulated (man-altered). Explain: .

Tributary properties with respect to top of bank (estimate):
Average width: feet
Average depth: feet
Average side slopes: **Pick List.**

Primary tributary substrate composition (check all that apply):
☐ Silts ☐ Sands ☐ Concrete
☐ Cobbles ☐ Gravel ☐ Muck
☐ Bedrock ☐ Vegetation. Type/% cover:
☐ Other. Explain: .

Tributary condition/stability [e.g., highly eroding, sloughing banks]. Explain: .
Presence of run/riffle/pool complexes. Explain: .
Tributary geometry: **Pick List**
Tributary gradient (approximate average slope): %

(c) Flow:
Tributary provides for: **Pick List**
Estimate average number of flow events in review area/year: **Pick List**
Describe flow regime: .
Other information on duration and volume: .

Surface flow is: **Pick List.** Characteristics: .

Subsurface flow: **Pick List**. Explain findings: .
☐ Dye (or other) test performed: .

Tributary has (check all that apply):
☐ Bed and banks
☐ OHWM[6] (check all indicators that apply):
☐ clear, natural line impressed on the bank ☐ the presence of litter and debris
☐ changes in the character of soil ☐ destruction of terrestrial vegetation
☐ shelving ☐ the presence of wrack line
☐ vegetation matted down, bent, or absent ☐ sediment sorting
☐ leaf litter disturbed or washed away ☐ scour
☐ sediment deposition ☐ multiple observed or predicted flow events
☐ water staining ☐ abrupt change in plant community
☐ other (list):
☐ Discontinuous OHWM.[7] Explain: .

If factors other than the OHWM were used to determine lateral extent of CWA jurisdiction (check all that apply):
☐ High Tide Line indicated by: ☐ Mean High Water Mark indicated by:
☐ oil or scum line along shore objects ☐ survey to available datum;
☐ fine shell or debris deposits (foreshore) ☐ physical markings;
☐ physical markings/characteristics ☐ vegetation lines/changes in vegetation types.
☐ tidal gauges
☐ other (list):

(iii) Chemical Characteristics:
Characterize tributary (e.g., water color is clear, discolored, oily film; water quality; general watershed characteristics, etc.).
Explain: .
Identify specific pollutants, if known: .

[6]A natural or man-made discontinuity in the OHWM does not necessarily sever jurisdiction (e.g., where the stream temporarily flows underground, or where the OHWM has been removed by development or agricultural practices). Where there is a break in the OHWM that is unrelated to the waterbody's flow regime (e.g., flow over a rock outcrop or through a culvert), the agencies will look for indicators of flow above and below the break.
[7]Ibid.

(iv) Biological Characteristics. Channel supports (check all that apply):

- ☐ Riparian corridor. Characteristics (type, average width): .
- ☐ Wetland fringe. Characteristics: .
- ☐ Habitat for:
  - ☐ Federally Listed species. Explain findings: .
  - ☐ Fish/spawn areas. Explain findings: .
  - ☐ Other environmentally-sensitive species. Explain findings: .
  - ☐ Aquatic/wildlife diversity. Explain findings: .

2. **Characteristics of wetlands adjacent to non-TNW that flow directly or indirectly into TNW**

(i) Physical Characteristics:

(a) General Wetland Characteristics:

Properties:

Wetland size: acres

Wetland type. Explain: .

Wetland quality. Explain: .

Project wetlands cross or serve as state boundaries. Explain: .

(b) General Flow Relationship with Non-TNW:

Flow is: **Pick List**. Explain: .

Surface flow is: **Pick List**

Characteristics: .

Subsurface flow: **Pick List**. Explain findings: .

☐ Dye (or other) test performed: .

(c) Wetland Adjacency Determination with Non-TNW:

- ☐ Directly abutting
- ☐ Not directly abutting
  - ☐ Discrete wetland hydrologic connection. Explain: .
  - ☐ Ecological connection. Explain: .
  - ☐ Separated by berm/barrier. Explain: .

(d) Proximity (Relationship) to TNW

Project wetlands are **Pick List** river miles from TNW.

Project waters are **Pick List** aerial (straight) miles from TNW.

Flow is from: **Pick List.**

Estimate approximate location of wetland as within the **Pick List** floodplain.

(ii) Chemical Characteristics:

Characterize wetland system (e.g., water color is clear, brown, oil film on surface; water quality; general watershed characteristics; etc.). Explain: .

Identify specific pollutants, if known: .

(iii) Biological Characteristics. Wetland supports (check all that apply):

- ☐ Riparian buffer. Characteristics (type, average width): .
- ☐ Vegetation type/percent cover. Explain: .
- ☐ Habitat for:
  - ☐ Federally Listed species. Explain findings: .
  - ☐ Fish/spawn areas. Explain findings: .
  - ☐ Other environmentally-sensitive species. Explain findings: .
  - ☐ Aquatic/wildlife diversity. Explain findings: .

3. **Characteristics of all wetlands adjacent to the tributary (if any)**

All wetland(s) being considered in the cumulative analysis: **Pick List**

Approximately ( ) acres in total are being considered in the cumulative analysis.

For each wetland, specify the following:

Directly abuts? (Y/N)	Size (in acres)	Directly abuts? (Y/N)	Size (in acres)

Summarize overall biological, chemical and physical functions being performed: .

C. SIGNIFICANT NEXUS DETERMINATION

A significant nexus analysis will assess the flow characteristics and functions of the tributary itself and the functions performed by any wetlands adjacent to the tributary to determine if they significantly affect the chemical, physical, and biological integrity of a TNW. For each of the following situations, a significant nexus exists if the tributary, in combination with all of its adjacent wetlands, has more than a speculative or insubstantial effect on the chemical, physical and/or biological integrity of a TNW. Considerations when evaluating significant nexus include, but are not limited to the volume, duration, and frequency of the flow of water in the tributary and its proximity to a TNW, and the functions performed by the tributary and all its adjacent wetlands. It is not appropriate to determine significant nexus based solely on any specific threshold of distance (e.g. between a tributary and its adjacent wetland or between a tributary and the TNW). Similarly, the fact an adjacent wetland lies within or outside of a floodplain is not solely determinative of significant nexus.

Draw connections between the features documented and the effects on the TNW, as identified in the *Rapanos* Guidance and discussed in the Instructional Guidebook. Factors to consider include, for example:

- Does the tributary, in combination with its adjacent wetlands (if any), have the capacity to carry pollutants or flood waters to TNWs, or to reduce the amount of pollutants or flood waters reaching a TNW?
- Does the tributary, in combination with its adjacent wetlands (if any), provide habitat and lifecycle support functions for fish and other species, such as feeding, nesting, spawning, or rearing young for species that are present in the TNW?
- Does the tributary, in combination with its adjacent wetlands (if any), have the capacity to transfer nutrients and organic carbon that support downstream foodwebs?
- Does the tributary, in combination with its adjacent wetlands (if any), have other relationships to the physical, chemical, or biological integrity of the TNW?

Note: the above list of considerations is not inclusive and other functions observed or known to occur should be documented below:

1. **Significant nexus findings for non-RPW that has no adjacent wetlands and flows directly or indirectly into TNWs.** Explain findings of presence or absence of significant nexus below, based on the tributary itself, then go to Section III.D: .

2. **Significant nexus findings for non-RPW and its adjacent wetlands, where the non-RPW flows directly or indirectly into TNWs.** Explain findings of presence or absence of significant nexus below, based on the tributary in combination with all of its adjacent wetlands, then go to Section III.D: .

3. **Significant nexus findings for wetlands adjacent to an RPW but that do not directly abut the RPW.** Explain findings of presence or absence of significant nexus below, based on the tributary in combination with all of its adjacent wetlands, then go to Section III.D: .

D. DETERMINATIONS OF JURISDICTIONAL FINDINGS. THE SUBJECT WATERS/WETLANDS ARE (CHECK ALL THAT APPLY):

1. **TNWs and Adjacent Wetlands.** Check all that apply and provide size estimates in review area:
   ☐ TNWs: linear feet width (ft), Or, acres.
   ☐ Wetlands adjacent to TNWs: acres.

2. **RPWs that flow directly or indirectly into TNWs.**
   ☐ Tributaries of TNWs where tributaries typically flow year-round are jurisdictional. Provide data and rationale indicating that tributary is perennial: .
   ☐ Tributaries of TNW where tributaries have continuous flow "seasonally" (e.g., typically three months each year) are jurisdictional. Data supporting this conclusion is provided at Section III.B. Provide rationale indicating that tributary flows seasonally: .

Provide estimates for jurisdictional waters in the review area (check all that apply):
☐ Tributary waters: linear feet width (ft).
☐ Other non-wetland waters: acres.
Identify type(s) of waters: .

3. **Non-RPWs[8] that flow directly or indirectly into TNWs.**
☐ Waterbody that is not a TNW or an RPW, but flows directly or indirectly into a TNW, and it has a significant nexus with a TNW is jurisdictional. Data supporting this conclusion is provided at Section III.C.

Provide estimates for jurisdictional waters within the review area (check all that apply):
☐ Tributary waters: linear feet width (ft).
☐ Other non-wetland waters: acres.
Identify type(s) of waters: .

4. **Wetlands directly abutting an RPW that flow directly or indirectly into TNWs.**
☐ Wetlands directly abut RPW and thus are jurisdictional as adjacent wetlands.
☐ Wetlands directly abutting an RPW where tributaries typically flow year-round. Provide data and rationale indicating that tributary is perennial in Section III.D.2, above. Provide rationale indicating that wetland is directly abutting an RPW: .

☐ Wetlands directly abutting an RPW where tributaries typically flow "seasonally." Provide data indicating that tributary is seasonal in Section III.B and rationale in Section III.D.2, above. Provide rationale indicating that wetland is directly abutting an RPW: .

Provide acreage estimates for jurisdictional wetlands in the review area: acres.

5. **Wetlands adjacent to but not directly abutting an RPW that flow directly or indirectly into TNWs.**
☐ Wetlands that do not directly abut an RPW, but when considered in combination with the tributary to which they are adjacent and with similarly situated adjacent wetlands, have a significant nexus with a TNW are jurisidictional. Data supporting this conclusion is provided at Section III.C.

Provide acreage estimates for jurisdictional wetlands in the review area: acres.

6. **Wetlands adjacent to non-RPWs that flow directly or indirectly into TNWs.**
☐ Wetlands adjacent to such waters, and have when considered in combination with the tributary to which they are adjacent and with similarly situated adjacent wetlands, have a significant nexus with a TNW are jurisdictional. Data supporting this conclusion is provided at Section III.C.

Provide estimates for jurisdictional wetlands in the review area: acres.

7. **Impoundments of jurisdictional waters.[9]**
As a general rule, the impoundment of a jurisdictional tributary remains jurisdictional.
☐ Demonstrate that impoundment was created from "waters of the U.S.," or
☐ Demonstrate that water meets the criteria for one of the categories presented above (1-6), or
☐ Demonstrate that water is isolated with a nexus to commerce (see E below).

E. ISOLATED [INTERSTATE OR INTRA-STATE] WATERS, INCLUDING ISOLATED WETLANDS, THE USE, DEGRADATION OR DESTRUCTION OF WHICH COULD AFFECT INTERSTATE COMMERCE, INCLUDING ANY SUCH WATERS (CHECK ALL THAT APPLY):[10]
☐ which are or could be used by interstate or foreign travelers for recreational or other purposes.
☐ from which fish or shellfish are or could be taken and sold in interstate or foreign commerce.
☐ which are or could be used for industrial purposes by industries in interstate commerce.
☐ Interstate isolated waters. Explain: .
☐ Other factors. Explain: .

Identify water body and summarize rationale supporting determination: .

---

[8] See Footnote # 3.
[9] To complete the analysis refer to the key in Section III.D.6 of the Instructional Guidebook.
[10] **Prior to asserting or declining CWA jurisdiction based solely on this category, Corps Districts will elevate the action to Corps and EPA HQ for review consistent with the process described in the Corps/EPA *Memorandum Regarding CWA Act Jurisdiction Following Rapanos.***

Provide estimates for jurisdictional waters in the review area (check all that apply):

☐ Tributary waters: linear feet width (ft).

☐ Other non-wetland waters: acres.

Identify type(s) of waters: .

☐ Wetlands: acres.

F. NON-JURISDICTIONAL WATERS, INCLUDING WETLANDS (CHECK ALL THAT APPLY):

☒ If potential wetlands were assessed within the review area, these areas did not meet the criteria in the 1987 Corps of Engineers Wetland Delineation Manual and/or appropriate Regional Supplements.

☒ Review area included isolated waters with no substantial nexus to interstate (or foreign) commerce.

☐ Prior to the Jan 2001 Supreme Court decision in "*SWANCC*," the review area would have been regulated based solely on the "Migratory Bird Rule" (MBR).

☐ Waters do not meet the "Significant Nexus" standard, where such a finding is required for jurisdiction. Explain: .

☐ Other: (explain, if not covered above): .

Provide acreage estimates for non-jurisdictional waters in the review area, where the sole potential basis of jurisdiction is the MBR factors (i.e., presence of migratory birds, presence of endangered species, use of water for irrigated agriculture), using best professional judgment (check all that apply):

☒ Non-wetland waters (i.e., rivers, streams): **16,718** linear feet **N/A** width (ft).

☐ Lakes/ponds: acres.

☒ Other non-wetland waters: 7.7 acres. List type of aquatic resource: Playa.

☐ Wetlands: acres.

Provide acreage estimates for non-jurisdictional waters in the review area that do not meet the "Significant Nexus" standard, where such a finding is required for jurisdiction (check all that apply):

☐ Non-wetland waters (i.e., rivers, streams): linear feet, width (ft).

☐ Lakes/ponds: acres.

☐ Other non-wetland waters: acres. List type of aquatic resource: .

☐ Wetlands: acres.

SECTION IV: DATA SOURCES.

A. SUPPORTING DATA. Data reviewed for JD (check all that apply - checked items shall be included in case file and, where checked and requested, appropriately reference sources below):

☒ Maps, plans, plots or plat submitted by or on behalf of the applicant/consultant:Aerial (NAIP, 2016).

☒ Data sheets prepared/submitted by or on behalf of the applicant/consultant.

☐ Office concurs with data sheets/delineation report.

☐ Office does not concur with data sheets/delineation report.

☐ Data sheets prepared by the Corps: .

☐ Corps navigable waters' study: .

☐ U.S. Geological Survey Hydrologic Atlas: .

☐ USGS NHD data.

☐ USGS 8 and 12 digit HUC maps.

☒ U.S. Geological Survey map(s). Cite scale & quad name:1:2,000 Eunice NE (1983).

☒ USDA Natural Resources Conservation Service Soil Survey. Citation:NRCS (2018).

☒ National wetlands inventory map(s). Cite name:NWI (2018).

☐ State/Local wetland inventory map(s): .

☐ FEMA/FIRM maps: .

☐ 100-year Floodplain Elevation is: (National Geodectic Vertical Datum of 1929)

☒ Photographs: ☒ Aerial (Name & Date):NAIP (2016).

or ☒ Other (Name & Date):Site Visit, February 5, 2019.

☒ Previous determination(s). File no. and date of response letter:SWF-2007-173. August 29, 2007.

☐ Applicable/supporting case law: .

☐ Applicable/supporting scientific literature: .

☐ Other information (please specify): .

B. ADDITIONAL COMMENTS TO SUPPORT JD: The proposed project area includes three classifications of aquatic features. A series of upland man-made drainage ditches, a series of non-wetland vegetated swales, and three playa lakes are located within the project area. None of the aquatic features within the project area are considered waters of the U.S. since all features are isolated and do not have a direct hydrologic connection to any other identified downstream water.

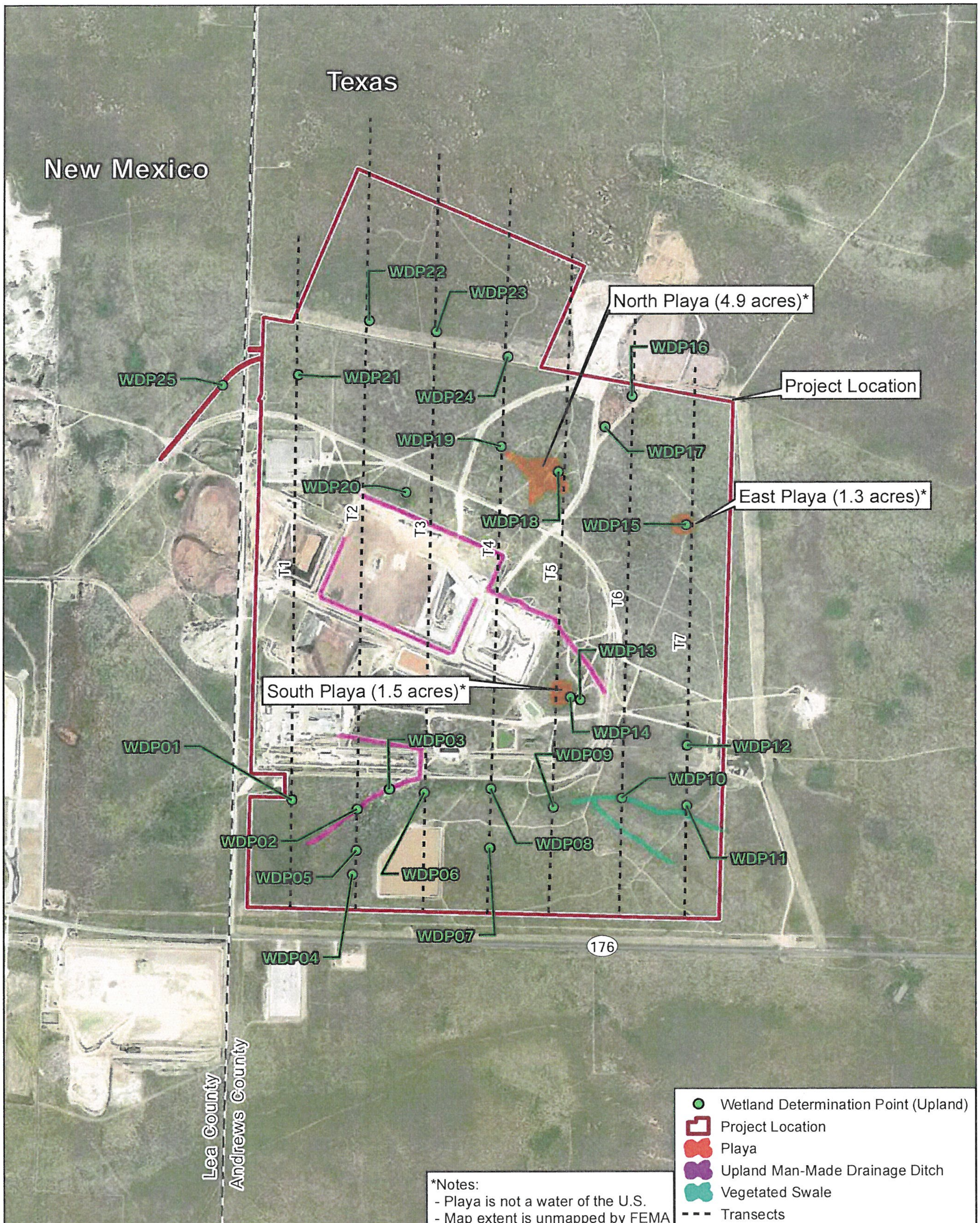

Figure 7

Potential Waters of the U.S.

Interim Storage Partners, Consolidated Interim Storage Facility, SWF-2007-173

Data Sources: CMEC (2019)
Aerial Source: ESRI (2017)

COX | McLAIN Environmental Consulting

0 2,000 Feet
0 600 Meters

1 in = 2,000 feet
Scale: 1:24,000
Date: 3/5/2019

G:\Projects\WCS\InterimStoragePartners\Figure 7_Potential_Waters_Of_US_20190214.mxd

Table 1: Summary of Aquatic Features within the Project Area

Feature Number	Name of Water	Resource Type	Ordinary High Water Mark Width	Amount of Aquatic Resource (linear feet/acres)	Water of the U.S.? (Yes/No)
1	Upland Man-made Drainage Ditches	Upland Man-made Drainage Ditch	n/a	12,841 linear feet	No
2	Non-wetland Vegetated Swales	None-wetland Vegetated Swale	n/a	3,877 linear feet	No
3	Southern Playa	Playa	n/a	1.5 acres	No
4	Eastern Playa	Playa	n/a	1.3 acres	No
5	Northern Playa	Playa	n/a	4.9 acres	No
Total				16,718 linear feet/ 7.7 acres	

ATTACHMENT 3-4

INTENSIVE ARCHEOLOGICAL SURVEY OF THE PROPOSED WASTE CONTROL SPECIALISTS SPENT NUCLEAR FUEL CONSOLIDATED INTERIM STORAGE FACILITY, ANDREWS COUNTY, TEXAS

Proprietary Information in Attachment 3-4 (22 pages)
Withheld Pursuant to 10 CFR 2.390.

ATTACHMENT 3-5

CULTURAL RESOURCE SURVEY OF A PROPOSED WASTE FACILITY, ANDREWS COUNTY, TX (1994) AND TEXAS HISTORIC COMMISSION "NO EFFECT" CONFIRMATION LETTERS (1994 AND 2004)

ATTACHMENT 2: JUNE 2004 TEXAS HISTORIC PRESERVATION "NO EFFECT" CONFIRMATION LETTER

URS

RECEIVED
JUN 21 2004
TEXAS HISTORICAL COMMISSION

June 15, 2004

Mr. Mark Denton
Texas Historical Commission
P.O. Box 12276
Austin, TX 78711

Re: Waste Control Specialists- No Effect Confirmation

Dear Mr. Denton:

As a follow up to our recent telephone conversation on June 10, 2004, this letter is being submitted to receive an updated stamp of the "No Effect" determination for the Waste Control Specialists (WCS) site located in Andrews County. Enclosed is a copy of the cover letter stamped by Dr. James Bruseth in 1994 for the WCS site. WCS is planning to expand operations located within the same area (approximately 1300 acres) included in the original evaluation of the site and is not proposing any activities that would be located outside the area previously considered.

If you have any questions or require any additional information, please contact me at 801-904-4019. Thank you for your assistance.

Sincerely,

Jeff Linn
URS Corporation

NO HISTORIC PROPERTIES AFFECTED
PROJECT MAY PROCEED
[signature]
for F. Lawrence Oaks
State Historic Preservation Officer
6-25-04

URS Corporation
756 East Winchester Street, Suite 400
Salt Lake City, Utah 84107
Tel: 801.904.4000
Fax: 801.904.4100
www.urscorp.com

ATTACHMENT 3: AUGUST 1994 TEXAS HISTORIC PRESERVATION "NO EFFECT" CONFIRMATION LETTER

ENVIRONMENTAL

RECEIVED
AUG 1 4 1994
TEXAS HISTORICAL COMMISSION

August 12, 1994 Hand Delivered

Mr. James E. Bruseth, Ph.D.
Deputy State Historic Preservation Officer
TEXAS HISTORICAL COMMISSION
P.O. Box 12276
Austin, Texas 78711

Attn.: Timothy K. Perttula, Ph.D.

Re: Waste Control Specialists
TNRCC Permit No. 50358

Dear Mr. Bruseth:

Enclosed is one copy of the report prepared by Galván Eling Associates, Inc. entitled "Cultural Resource Survey of A Proposed Waste Facility Andrews County, Texas". This report provides the results of the cultural resource survey as requested by your letter of 18 July 1994 and as agreed during our meeting of 26 July 1994. The report concludes that the study area offered few enticements to prehistoric people or early settlers and that no evidence of their use of this tract was found and no cultural resources stand as an impediment to construction of this waste facility.

We look forward to your timely approval of the report. If you have any questions or need additional information in the intervening time, please call me at (512) 327-5775.

Sincerely,

Allen Messenger, P.E.

enclosure

NO EFFECT
On National Register-eligible or listed properties or State Archeological Landmarks
PROJECT MAY PROCEED
BY
James E. Bruseth, Ph.D., DSHPO
Date 8/12/94

cc: K. N. Bigham, WCS, Pasadena
Mike Woodward, Woodward & Stewart, Austin

1016 Mopac Circle, # 101 Austin, Texas 78746 (512) 327-5775 Fax 327-4570

ATTACHMENT 4: CULTURAL RESOURCE SURVEY OF A PROPOSED WASTE FACILITY, ANDREWS COUNTY, TX

Cultural Resource Survey of A Proposed Waste Facility
Andrews County, Texas

Submitted to:
AM Environmental, Inc.
Austin, Texas

Galván Eling Associates, Inc.
3200 Breeze Terrace
Austin, Texas 78722

August, 1994

Abstract

On August 4, 1994, Galván Eling Associates, Inc. assessed the cultural resource potential of a 150-acre tract in Andrews County, Texas for AM Environmental, Inc. of Austin. The absence of prehistoric or significant historic occupation or exploitation of this tract can be attributed to the lack of essential resources. Cultural resources do not stand as an impediment to construction of a waste facility on this property.

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2. Environmental setting 4

Introduction

At the request of AM Environmental Inc., Galván Eling Associates, Inc. conducted a cultural resources assessment of a 150-acre waste control facility site in Andrews County, Texas (Figure 1). The survey area is on the Flying W Diamond Ranch, 30 miles northwest of Andrews, immediately east of the New Mexico-Texas state line and north of Texas Hwy 176. The field work was accomplished by Carole Medlar, Frank Garcia, and Kelly Scott on August 4, 1994.

Methods

The survey tract was inspected by pedestrian transects walked at intervals ranging from 10 to 30 meters, depending upon the local topography. Close interval transects paralleled the only ephemeral drainage on the survey tract and encircled as well as crosscut the five depressions, or buffalo wallows, that were considered to hold some, albeit minor, potential for prehistoric or early historic exploitation. Photographs were taken to document the general topography and vegetation.

Natural Environment

Application for a hazardous waste permit requires exhaustive and complete environmental analysis. The environmental information pertinent to the potential for archeological resources on the tract is detailed in volume 4 of AM Environmental, Inc.'s (1993) permit application and is only summarized here.

The survey area is in the southern portion of the North American Great Plains physiocgraphic zone on the southwestern edge of the Southern High Plains or Llano Estacado. The region is bounded by the Pecos River plain to the south and west, Mescalero Ridge to the northwest, Monument Draw (New Mexico) and Rattlesnake Ridge to the west, and the Llano Estacado to the north and east. The waste facility will be built in an area where the caliche sediments of the Tertiary Ogallala Formation lay unconformably on Triassic red bed clay of the Dockham Group (Bureau of

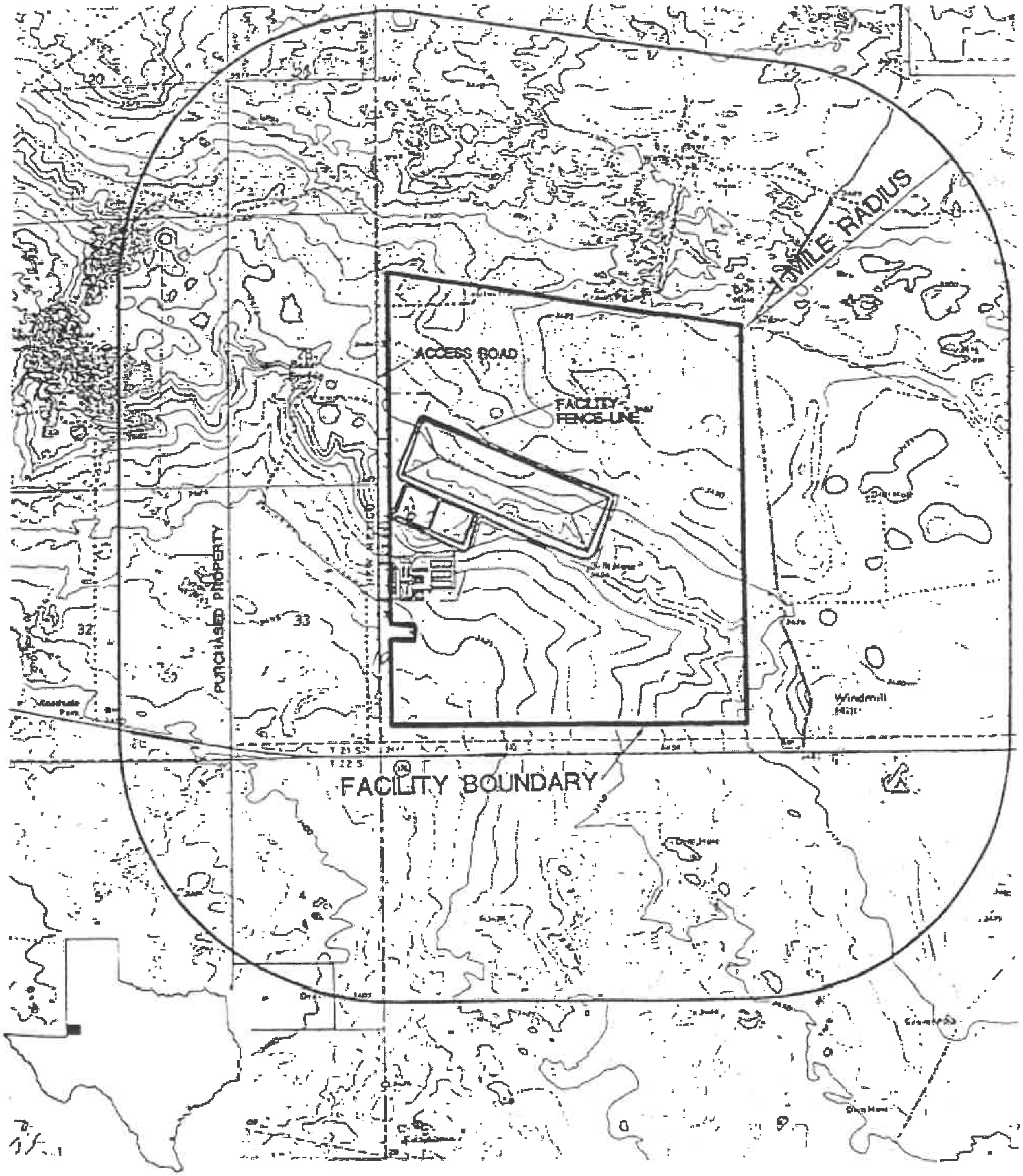

FIGURE 1. Map of study area.

2

Economic Geology 1976). In the survey tract, the windblown sands that caused Ferguson (1986) to call this area the "Seminole Sand Sheet" are a thin veneer overlying shallow brown silty sandy sediments broken by outcrops of the underlying caliche. Sand, gravel, and highly cemented caliche are quarried less than a mile west of the state line and the western boundary of the waste facility tract.

The nearest major drainage is Monument Draw, southwest of the study area in New Mexico (not to be confused with Texas' Monument Draw that flows east through northern Andrews County). Baker Spring, 650 meters west of the facility, was a seasonal seep emanating from an outcrop of the Ogallala Formation but flow ceased some 7 years ago. Water is sometimes found at the base of the Ogallala Formation in isolated gravel beds under slight depressions, locally called buffalo wallows. Thus, these topographic features influence human and animal exploitation of the arid plains.

The climate is temperate and arid, averaging 14.5 inches of annual precipitation . About 70% of the rain falls between May and October and the annual evaporation rate exceeds precipitation by 58 inches. The mean annual high temperature is 77.4 degrees F; the minimum is 49.4 degrees F. (Bomar 1983).

The plains were described as a sea of grass that supported huge herds of grazing animals, the mainstay of the native economies (Hughes 1989). Modern land use has been solely cattle pasture and the resident fauna are now coyotes, jack rabbits, field rodents, snakes and other reptiles, and a varied bird population. The vegetation of the study area is low grasses broken by scrub mesquite that grows more thickly in the five slight depressions that pock the generally level terrain (Figure 2a). Elevation ranges from 3,487 to 3,422 feet AMSL and the relief does not vary by more than 3 or 4 feet at maximum. Two "ridges" rise about 1 or 2 feet above the plain; the deepest of the depressions does not exceed 4 feet in depth (AM Environmental, Inc. 1993).

Prehistoric environmental changes in the region generally correlate with the Antevs (1955) model, and consist of a post-Pleistocene, cool and moist Anathermal (10,000-7500 B.P.), a warm and dry Altithermal (7500-4000 B.P.) and a moderate Medithermal (4000 B.P. to present). These periods correlate to documented heavy occupation of the Llano Estacado in the Paleoindian period, from 14,000 to 7000 B.P., a dearth of occupation between 7000-4000 B.P., the Early and Middle Archaic periods, and the resumption of aboriginal occupation around 4000 B.P., a presence which was sustained until Historic times (Hughes 1989).

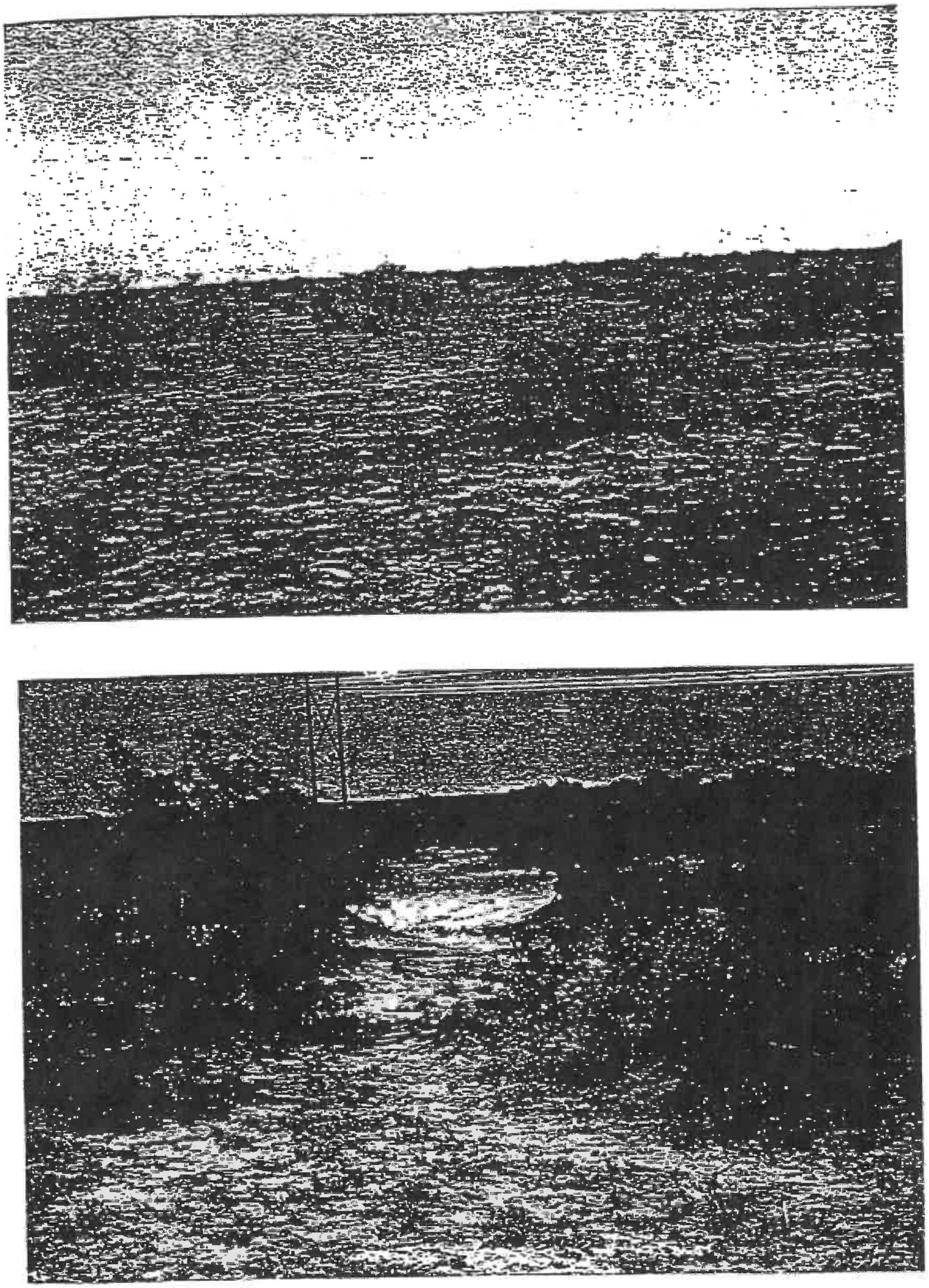

FIGURE 2. Environmental setting. a) topography and vegetation in the study area; b) slight depression in ephemeral drainway, trampled by cattle.

Cultural Background

Hughes (1989) summarized prehistoric cultural developments on the High Plains, including the South Plains or Llano Estacado. Ignoring variability introduced by ethnic diversity and the influences radiating from more complex nieghboring societies, the long span of prehistory was divided into Paleoindian, Archaic, and Neoindian stages, with the latter two further subdivided into Early and Late substages. The Historic period begins with Coronado's expedition in 1540 but the area remained largely under the control of Plains Indians until the mid-1870s. Andrews County, named for a Texas revolutionary, was formed from Bexar County in 1876 and organized in 1910 (Conner, et al. 1974). In 1890, only 24 people lived in the county. Oil was struck in 1929. The modern economy is dominated by cattle ranching and energy production, both evidenced on the Flying W Diamond Ranch.

The majority of the 52 recorded sites in Andrews County were recorded as part of the permitting process for oil and gas pipelines. Most are burned rock or burned caliche features or scatters with few other artifacts found in dune blowouts with no apparent nearby water source; a lesser number were on dunes or eroded uplands next to playas (see Kibler 1991 for a discussion of site distributions in this region). The dominant period of occupation, when determinable, was during the Late Archaic and Late Prehistoric periods. One site recorded by a local amateur archeologist, 41AD42, contained three Paleoindian points (Scottsbluff, Milnesand and Eden).

The only systematic archeological study in the county that exceeded the survey level of investigation was accomplished by Collins (1968) who documented the Andrews Lake site complex. Eight sites, ranging in age from Paleoindian to Historic, and featuring masonry foundations of several dwellings, clay and stone-lined hearths, burned rock hearths, numerous burials, caches and stone walls, were apparently supported by semi-permanent water in Andrews Lake, east of the current survey area.

Results of the Survey

Despite the special attention paid to the one subtle drainage feature and the slight depressions that had some limited potential for prehistoric exploitation, no cultural remains worthy of site designation were found by this survey. Six pieces of burned caliche, averaging less than 3.5 cm in maximum dimension, were noted on the northeast side of the drainway, next to a slight depression that had been heavily trampled by cattle (Figure 2b). Two clusters of three pieces, linearly distributed over an area about 1 meter long, were found 20 meters apart, separated by a barren stretch of hard packed shallow sediments littered with unburned lumps of caliche. The area was subjected to intensive scrutiny, including cutting a profile into one of the nearby remnant hummocks of soil, but no evidence bearing upon the age or origin of the burned caliche was produced. This drainway lacks both gathering and retentive capability and probably holds water for less than a day after a heavy rain.

Two of the five slight depressions in the study area are shown as playas on the USGS Eunice NE 7.5' quadrangle map but none of these "buffalo wallows" have much water retention capacity. According to the geologic reports, they lack the impermeable clay linings that inhibit rainfall absorption in true playas. No evidence of historic or prehistoric use of this features was found beyond the intensified grazing of cattle drawn to the grasses that grow in the bottoms of these depressions.

Comparative data were obtained by a visit to Baker Spring, shown on the USGS maps less than 400 meters west of the state line that is the western boundary of the study area. According to local informants, spring flow ceased about 7 years ago, a fact they attribute to blasting at the adjacent quarry. Historic debris, reportedly the remains of early ranch buildings, was abundant but prehistoric material consisted solely of less than 10 chert flakes and one thin end scraper. This site is in New Mexico and was not recorded but it serves as a standard for judging the low intensity of prehistoric use of the immediate area.

The study area offered few enticements to prehistoric people or early settlers. It is not surprising that no evidence of their use of this tract was found and no cultural resources stand as an impediment to construction of this waste facility.

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ATTACHMENT 3-6

INTERIM STORAGE PARTNERS (ISP), WASTE CONTROL SPECIALISTS (WCS): ECOLOGICAL RESOURCES REPORT

INTERIM STORAGE PARTNERS (ISP), WASTE CONTROL SPECIALISTS (WCS): ECOLOGICAL RESOURCES REPORT

July 2019

Prepared for Interim Storage Partners, LLC

COX | McLAIN
Environmental Consulting

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Figure 8: Lesser Prairie-Chicken Critical Habitat and Listening Stations

1.0 INTRODUCTION AND PROJECT DESCRIPTION

Interim Storage Partners, LLC (ISP) is requesting authorization to construct and operate a Consolidated Interim Storage Facility (CISF) in Andrews County, Texas (**Figure 1** and **Figure 2**). ISP has submitted a license application for a CISF for approval by the U.S. Nuclear Regulatory Commission (NRC) pursuant to the requirements specified in Title 10 of the Code of Federal Regulations (CFR), Part 72, Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste. The CISF would be constructed and operated on an approximately 100-acre initial footprint within approximately 320 acres, where security would be maintained. The CISF would be located north of and adjacent to the existing Waste Control Specialists (WCS) Low-Level Radioactive Waste Disposal Facilities licensed by the TCEQ in accordance with Texas Radioactive Material License No. R04100. This property will be referred to as the “survey area” henceforth. The Low-Level Radioactive Waste Disposal Facility is located on 1,338 acres in Andrews County, Texas.

CMEC understands that Ecological Resources Reports have been conducted for the survey area in 1997, 2004, and 2007 (Ecology Group 1997, Doug Regan & Associates 2004, and URS Corporation 2007). The purpose of this report is to document any site-specific changes from previously documented conditions and address specific issues of concern regarding ecological resources within the survey area. This Ecological Resources Report includes:

- A description of the principal ecological features of the survey area and immediate vicinity, transportation corridors, and region, with an emphasis on the plant and animal communities that may be affected by the proposed action;
- A description of ecological resources and habitat needs of species in the survey area;
- A complete species list of state and federally listed threatened and endangered species; and
- A summary of the consultations with appropriate agencies.

Survey area figures are included in **Attachment A**. **Figure 1** depicts an aerial image of the survey area, **Figure 2** depicts a topographic map of the survey area, **Figure 3** depicts the survey area geology, **Figure 4** depicts the survey area soils, **Figure 5** depicts the Vegetation Types of Texas (TPWD) within the survey area, **Figure 6** depicts the observed vegetation within the survey area, and **Figure 7** depicts the Texas Natural Diversity Database (TXNDD) Element Occurrence records within the survey area. **Figure 8** depicts Lesser Prairie-Chicken Critical Habitat and Listening Stations. Photographs of the survey area are included in **Attachment B.** Data forms from the Lesser Prairie-Chicken (LPC) Presence/Absence Survey are included in **Attachment C**. **Attachment D** includes the Andrews County Rare, Threatened, and Endangered Species of Texas List. **Attachment E** includes the USFWS Information for Planning and Consultation Report.

2.0 PROTECTED SPECIES REGULATIONS

Rare species are protected under the federal Endangered Species Act, the federal Bald and Golden Eagle Protection Act, and state regulations, as discussed below.

2.1 FEDERAL ENDANGERED SPECIES ACT

Federally listed threatened or endangered species and their habitats are protected under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1544, 87 Stat. 884). Specifically, the Act authorizes the determination and listing of species as endangered or threatened; prohibits unauthorized taking, possession, sale, and transport of endangered species; provides authority for land acquisition for conservation of listed species using land and water conservation funds; authorizes the establishment of cooperative agreements and grants-in-aid to states that establish and maintain threatened and endangered species programs; authorizes assessment of civil and criminal penalties for violating the Act; and authorizes payment of rewards for information leading to arrest and conviction of violations of the Act. There have been various amendments to the Act, including provisions for designation of critical habitat, recovery plans, and monitoring for candidate and recovered species.

2.2 BALD AND GOLDEN EAGLE PROTECTION ACT

Bald Eagles (*Haliaeetus leucocephalus*) and Golden Eagles (*Aquila chrysaetos*) are afforded protection under the Bald and Golden Eagle Protection Act of 1940, as amended (16 U.S.C. 668-668d, 54 Stat. 250). The law generally prohibits the taking, possession, and commerce of the two species. Amendments in 1972 and 1978 increased penalties for violation of the Act, provided rewards for information leading to arrest and conviction for violation of the Act, and authorized the Secretary of the Interior to permit taking of Golden Eagle nests that interfere with resource development or recovery. A 1994 Executive Memorandum set policy concerning collection and distribution of eagle feathers for Native American religious purposes.

2.3 STATE OF TEXAS ENDANGERED SPECIES REGULATIONS

The Texas Parks and Wildlife Department (TPWD) regulations prohibit the taking, possession, transport, or sale of individuals of any state-designated endangered or threatened animal species without issuance of a permit (Texas Parks and Wildlife [TPW] Code Chapters 67–68 and Texas Administrative Code [TAC] Title 31, Sections 65.171–65.176). Commerce of state-designated endangered or threatened plant species is also prohibited, as is collection of listed plant species from public land without a permit (TPW Code Chapter 88 and TAC Title 31, Sections 69.01–69.9).

2.4 MIGRATORY BIRD TREATY ACT OF 1918

The Migratory Bird Treaty Act of 1918 makes it unlawful to "pursue, hunt, take, capture, kill, attempt to take, capture, or kill, possess, offer for sale, sell, offer to purchase, purchase, deliver for shipment, ship, cause to be shipped, deliver for transportation, transport, cause to be transported, carry, or cause to be carried by any means whatever, receive for shipment, transportation or carriage, or export, at any time, or in any manner, any migratory bird… or any part, nest, or egg of any such bird" (16 U.S.C. 703).

3.0 METHODS OF HABITAT ASSESSMENT

3.1 LITERATURE REVIEW

Lists of threatened and endangered species maintained by the United States Fish and Wildlife Service (USFWS) and TPWD were consulted for Andrews County in order to determine which species could potentially occur in the survey area and whether critical habitat has been designated for those species (USFWS 2019; TPWD 2019b). Habitat requirements for each species were determined based on a number of sources, including USFWS, TPWD, and species-specific literature reviews.

TPWD's live version of the Texas Natural Diversity Database (TXNDD) was consulted on April 30, 2019, for information regarding recorded occurrences of listed and rare species (TPWD 2019a). TXNDD provides known historical records for rare, threatened, and endangered species. Occurrence data are generally presented by TPWD as large polygons rather than point location data (for protection of the species). Information files were reviewed for the known locations of species in the *Hobbs SE, Brinson Ranch, Eunice NE, Jumbo Hill, Eunice SE, and Frankel City SW, Texas* U.S. Geological Survey (USGS) *7.5-minute* topographical quadrangle maps (which include the survey area and surrounding vicinity) (**Figure 3**).

3.2 FIELD HABITAT ASSESSMENT

Qualified biologists from Cox|McLain Environmental Consulting, Inc. (CMEC) conducted site visits in October 2018 and April 2019 in order to evaluate ecological conditions within the survey area. CMEC holds a USFWS-issued native endangered and threatened species recovery permit (#TE168185-5) and a TPWD scientific research permit (#SPR-0691-409).

During the field visits, CMEC biologists performed a native wildlife species survey and characterized observed vegetation types. Vegetation types were identified based on species composition, canopy cover, and morphology. The specific habitat requirements for each threatened or endangered species were then compared to the vegetation present to determine whether appropriate habitat for the species occurs within the survey area. Additionally, all audible calls where identified to species and visually observed wildlife were recorded for each site visit (October 2018 and April 2019). A full list of observed species identified is included in **Table 5**.

3.3 LESSER PRAIRIE-CHICKEN PRESENCE/ABSENCE SURVEY

The Western Association of Fish and Wildlife Agencies (WAFWA) Crucial Habitat Assessment Tool (CHAT) indicates that the survey area is located within modeled habitat for the LPC (**Figure 8**). Field investigations conducted in October 2018 by CMEC confirmed the potentially suitable habitat for LPC within the survey area.

The LPC was previously federally listed threatened by the USFWS. As of July 19, 2016, due to a court order, the LPC was removed from the List of Endangered and Threatened Wildlife. Currently, the LPC is under review by the USFWS and has been designated as a Species of Greatest Conservation Need in Texas. While this species is not afforded any regulatory protection at this time, it is of federal and state importance.

A LPC survey was conducted in Andrews County in 2004 that yielded negative results (Lyons 2004). Despite the negative results of the survey in 2004, a presence/absence survey for the LPC was conducted by CMEC within the survey area during the April 2019 field investigations after observing potentially suitable habitat in October 2018 in the Havard Oak Dunes vegetation type (approximately 76 acres) within the northern extent of the survey area (**Figure 6**). The survey was conducted by Ryan Blankenship (who has completed WAFWA' technical service provider (TSP) training in 2016) in accordance with the *Western Association of Fish and Wildlife Agencies' LPC Survey Protocol for Project Clearance (Updated February 2016)*.

The survey was conducted over three days during the April 2019 site visit to verify the presence/absence of this species. Surveys were conducted in the morning hours, lasted approximately 1.5 hours, and consisted of utilizing seven fixed-point listening stations which were placed within the survey area and within a one-mile vicinity of the survey area (**Figure 8**). This diurnal survey time is optimal for observing LPC that may occur within or adjacent to the survey area. The survey was conducted during the LPC survey timeframe outlined in the *Western Association of Fish and Wildlife Agencies' LPC Survey Protocol for Project Clearance (Updated February 2016)* survey protocol. Observers listened for audible calls and visually surveyed suitable habitat within a 5-minute time period at each fixed-point listening station each day. **Attachment C** includes the dates and times for each survey event and atmospheric conditions (temperature, wind speed, and cloud cover).

4.0 DESCRIPTION OF THE SURVEY AREA AND SURROUNDING AREA

4.1 LAND USES

The survey area is located within the High Plains Level III Ecoregion (EPA 2013). The survey area primarily consists of vacant, undeveloped land. Surrounding land use is also primarily undeveloped land with heavy industrial sites in the vicinity of the survey area.

Bisecting the central extent of the survey area is a haul road. Additionally, there are several arterial two-track 4x4 roads within the survey area that provide increased access. East of the survey area, there are material stockpile areas. A portion of the westernmost stockpile partially enters the northeastern extent of the survey area.

Immediately south of the survey area is a 1,338-acre property currently owned by WCS. The facilities within this property comprise a commercial waste management facility. To facilitate operations within the commercial waste management facility, there is a maintained dirt road network that connects the various structures and features within the facility.

4.2 TOPOGRAPHY

Topography of the survey area is slightly sloping throughout. Elevations are highest in the northern extent and sloping down toward the southern extent. Elevations range approximately 3,485 feet in the southwestern extent to 3,521 feet above mean sea level in the northern extent.

The USGS topographic map (**Figure 3**) depicts a single drill hole in the central extent of the survey area. A two-track 4x4 road runs west to east in the western extent of the survey area. No water features are mapped within the extent of the survey area. A single open water feature is depicted adjacent to the eastern survey area boundary and existing rail line. The topographic features within the *Eunice NE* USGS 7.5-minute topographical quadrangle map were generally confirmed within the survey area during the October 2018 and April 2019 field investigations.

4.3 GEOLOGY AND SOILS

The survey area is located on four geologic substrates: Windblown Sand (dunes, dune ridges, and sheets undivided), Windblown Cover Sand, Ogallala Formation, and Playa Deposits (**Figure 3**) (Texas Natural Resource Information System 2018).

Information regarding soils within the survey area was obtained from the United States Department of Agriculture NRCS Soil Survey for Andrews County, Texas (NRCS 2019). Four soil map units are found within the survey area. Information regarding these soil map units are provided in **Table 1**, and the mapped soils are depicted on **Figure 4**.

Table 1: Survey Area Soils

Map Unit Symbol	Map Unit Name	Hydric?
BcB	Blakeney and Conger soils, gently undulating	No
JPC	Jalmar-Penwell association, undulating	No
RaB	Ratliff soils, gently undulating	No
TwB	Triomas and Wickett soils, gently undulating	No

Sources: USDA NRCS 2019.

5.0 VEGETATION

The survey area is located within the *Havard Shin-Oak-Mesquite Brush* Vegetation Type of Texas (TPWD 2003) (**Figure 5**). During field investigations, three distinct vegetation types were observed within the survey area. Identification of the vegetation types was based on species composition, canopy cover, and morphology. The observed vegetation types located within the survey area are summarized in **Table 2** and depicted on **Figure 6**.

Table 2: Observed Vegetation Types within the Survey Area

Observed Vegetation Type	Acreage within the Survey Area
Mesquite Thorn-Scrub	230.5
Havard Oak Dunes	76.0
Maintained Grassland	17.8

5.1 MESQUITE THORN-SCRUB

The Mesquite Thorn-Scrub observed vegetation type is mostly located within the central and southern extents of the survey area. The woody vegetation in this area is dominated by honey mesquite (*Prosopis glandulosa*) trees and saplings. Other woody vegetation includes Havard oak (*Quercus havardii*), fourwing saltbush (*Atriplex canescens*), Peruvian peppertree (*Schinus molle*), and Siberian elm (*Ulmus pumila*). The herbaceous community consisted of pricklypear (*Opuntia* sp.), silverleaf nightshade (*Solanum elaeagnifolium*), Lehmann lovegrass (*Eragrostis lehmanniana*), hooded windmill grass (*Chloris cucullata*), broom snakeweed (*Gutierrezia sarothrae*), blue grama (*Bouteloua gracilis*), soft goldenaster (*Chrysopsis pilosa*), prairie tea (*Croton monanthogynus*), scarlet globemallow (*Sphaeralcea coccinea*), red lovegrass (*Eragrostis secundiflora*), horse crippler (*Echinocactus texensis*), plains bristlegrass (*Setaria vulpiseta*), smut grass (*Sporobolus indicus*), purple threeawn (*Aristida purpurea*), annual ragweed (*Ambrosia artemisiifolia*), sand sagebrush (*Artemisia filifolia*), yucca (*Yucca* sp.), plains blackfoot (Melampodium leucanthum), coastal sandbur (Cenchrus spinifex), camphorweed (*Heterotheca subaxillaris*), longleaf jointfir (*Ephedra trifurca*), and twinleaf senna (*Senna bauhinioides*). Approximately 230.5 acres of this vegetation type would be impacted by the proposed project.

This vegetation type provides potentially suitable habitat for an array of migratory bird species as well as the state-listed Texas horned lizard. Animal species observed within this vegetation type during the October 2018 and/or April 2019 site visits included, but are not limited to: black-tailed jackrabbit, eastern cottontail, mule deer, javelina, robber fly, red harvester ant (and mounds), six-lined racerunner, and various bird species and inactive nests.

5.2 HAVARD OAK DUNES

The Havard Oak Dunes observed vegetation type is mostly located within the northern extent of the survey area. The woody vegetation in these areas is dominated by Havard oak. The herbaceous vegetation in this area consisted of Indiangrass (*Sorghastrum nutans*), camphorweed, coastal sandbur, field ragweed, woolly groundsel (*Packera cana*), touristplant (*Dimorphocarpa wislizeni*), narrowleaf four o'clock (*Mirabilis linearis*), yucca, Texas wintergrass (*Nassella leucotricha*), dallisgrass (*Paspalum dilatatum*), little bluestem (*Schizachyrium scoparium*), queen's-delight (*Stillingia sylvatica*), Lehmann lovegrass, flaxflowered ipomopsis (*Ipomopsis longiflora*), and false boneset (*Brickellia eupatorioides*). Approximately 76.0 acre of this vegetation type would be impacted by the proposed project.

This vegetation type provides potentially suitable habitat for an array of migratory bird species, dunes sagebrush lizard (Species of Greatest Conservation Need (SGCN)), and Lesser Prairie-Chicken (SGCN). Animal species observed within this vegetation type during the October 2018 and/or April 2019 site visits included, but are not limited to western box turtle, queen butterfly, and various bird species and inactive bird nests.

5.3 MAINTAINED GRASSLAND

The Maintained Grassland observed vegetation type is mostly located within the central extent of the survey area along the maintained roadway and graded area. This area is maintained and largely devoid of woody vegetation. Sparse honey mesquite saplings are present. The herbaceous community consisted of threadleaf ragwort (*Senecio flaccidus*), soft goldenaster, lovegrass (*Eragrostis* sp.), silverleaf nightshade, hooded windmill grass, sandmat (*Chamaesyce* sp.), western tansymustard (*Descurainia pinnata*), coastal sandbur, annual ragweed, pigweed (*Amaranthus* sp.), hairy grama (*Bouteloua hirsuta*), scarlet globemallow, and prairie tea. Approximately 17.8 acres of this vegetation type would be impacted by the proposed project.

This vegetation type provides potentially suitable habitat for an array of migratory bird species as well as the state-listed Texas horned lizard. Animal species observed within this vegetation type during the October 2018 and/or April 2019 site visits included, but are not limited to eastern cottontail, various bird species, and inactive bird nests.

6.0 THREATENED AND ENDANGERED SPECIES HABITAT ASSESSMENT

6.1 LISTED SPECIES OF ANDREWS COUNTY

Lists of threatened and endangered species maintained by the USFWS and TPWD were consulted to determine species of potential occurrence in the vicinity of the survey area. In all, 41 federally listed endangered, threatened, candidate species or state-listed endangered, threatened species, or SGCNs were identified as having the potential to occur in Andrews County, TX (TPWD 2019b; USFWS 2019). **Table 2** contains a list of these species, their regulatory listing status, habitat description, and a determination of whether appropriate habitat for the species occurs in the survey area. Two insect species are listed on the Andrews County Rare, Threatened, and Endangered Species of Texas list provided by TPWD with no available habitat description (TPWD 2019b). Because no habitat information is available for these species, they are excluded from **Table 2**. The complete county list is available in **Attachment D**.

6.2 WILDLIFE

The survey area includes a mixture of native and invasive vegetative species. Habitat types contained within the survey area provide potentially suitable habitat for a variety of terrestrial and avian species. Numerous species of migratory and resident wildlife, including songbirds (*Passeriformes*) and game species, may utilize the survey area for breeding and foraging.

Wildlife species identified through sightings, tracks, or scat during spring October 2018 and April 2019 field investigations included plant, reptile, avian, and mammal species. A complete list of observations can be found in **Table 3**.

Table 3: Rare, Threatened, and Endangered Species of Potential Occurrence in Andrews County, Texas

Species	Federal Status	State Status	Habitat Description	Potential Habitat Present?	Effect/Impact on the Species	Justification
PLANTS						
Cory's ephedra *Ephedra coryi*	NL	SGCN	Dune areas and dry grasslands in the southern Plains Country; Perennial; Flowering April-Sept; Fruiting May-Sept	Yes	May impact	Both dune areas and dry grasslands occur in the survey area. This species was observed within the survey area during the April 2019 site visit (**Attachment B**).
Dune umbrella-sedge *Cyperus onerosus*	NL	SGCN	Moist to wet sand in swales and other depressions among active or partially stabilized sand dunes; flowering/fruiting late summer-fall	Yes	No impact	Although swales and other depressions among active or partially stabilized sand dunes are present, no individuals of this species were observed during the April 2019 site visit.
Dune unicorn-plant *Proboscidea sabulosa*	NL	SGCN	Deep, dry to seasonally moist loose sands on sparsely vegetated, unstabilized dunes and in openings in shinneries; in New Mexico, one location found as a secondary successional species in fallow fields; does not germinate in years with inadequate summer rainfall, but may be locally abundant during unusually wet summers; flowering July-August, with fruits maturing in fall	Yes	No impact	Deep, dry to seasonally moist loose sands on sparsely vegetated, unstabilized dunes are present within the survey area. However, no individuals of this species were observed during the April 2019 site visit.
Hinckley's spreadwing *Eurytaenia hinckleyi*	NL	SGCN	Loose sandy soils of the Monahans/Kermit Sandhills; Annual; Flowering/Fruiting May-July	No	No impact	While loose sandy soils are present within the survey area, the survey area is outside of the Monahans/Kermit Sandhills.
FISHES						
Blue Sucker *Cycleptus elongatus*	NL	T	Usually inhabits channels and flowing pools with a moderate current, with bottoms of exposed bedrock sometimes in combination with hard clay, sand, and gravel; generally intolerant of highly turbid conditions. Larger portions of major rivers in Texas; adults winter in deep pools and move upstream in spring to spawn on riffles	No	No impact	The survey area occurs within the Rio Grande basin. No water features occur within the survey area.

Species	Federal Status	State Status	Habitat Description	Potential Habitat Present?	Effect/Impact on the Species	Justification
Headwater Catfish *Ictalurus lupus*	NL	SGCN	Originally throughout streams of the Edwards Plateau and the Rio Grande basin, currently limited to Rio Grande drainage, including Pecos River basin; springs, and sandy and rocky riffles, runs, and pools of clear creeks and small rivers	No	No impact	The survey area does occur within the Rio Grande basin. However, no water features occur with the survey area.
Smalleye Shiner *Notropis buccula*	LE	T	Endemic to upper Brazos River system and its tributaries (Clear Fork and Bosque); apparently introduced into adjacent Colorado River drainage; medium to large prairie streams with sandy substrate and turbid to clear warm water; presumably eats small aquatic invertebrates	No	No effect	The survey area occurs within the Rio Grande basin. This species is endemic to the Upper Brazos River. In addition, no water features occur within the survey area.
AMPHIBIANS						
Woodhouse's toad *Anaxyrus woodhousii*	NL	SGCN	Extremely catholic up to 5000 feet, does very well (except for traffic) in association with man.	Yes	May impact	Survey area is vast and devoid of structures. Habitat is present within the survey area. No individuals of this species were observed during the October 2018 or April 2019 site visits.
REPTILES						
Dunes sagebrush lizard *Sceloporus arenicolus*	NL	SGCN	Confined to active sand dunes near Monahans; dwarf shin-oak sandhills with sagebrush and yucca; opportunistic insectivore; sit and wait predator; burrows in sand or plant litter to escape enemies	Yes	May impact	Sand dunes and dwarf shin-oak sandhills occur in the northern section of the survey area within the observed Havard Oak Dunes vegetation type. No individuals of this species were observed during the October 2018 or April 2019 site visits. A single individual was observed during a survey conducted in 2004 by others (Lyons 2004).
Massasauga *Sistrurus tergeminu**	NL	SGCN	Quite common in gently rolling prairie occasionally broken by creek valley or rocky hillside.	Yes	May impact	The survey area is characterized by a gently rolling landscape. This species has the potential to occur within the survey area. No individuals of this species were observed during the October 2018 or April 2019 site visits.

Species	Federal Status	State Status	Habitat Description	Potential Habitat Present?	Effect/Impact on the Species	Justification
Texas Horned Lizard *Phrynosoma cornutum*	NL	T	Occurs to 6000 feet, but largely limited below the pinyon-juniper zone on mountains in the Big Bend area. Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive; breeds March-September.	Yes	May impact	Open, arid, and semi-arid areas with sparse vegetation occur in the survey area. Harvester ant mounds (the primary prey item for this species) were identified within the survey area during field visits. No individuals of this species were observed during either the spring or fall field visits.
Western box turtle *Terrapene ornata*	NL	SGCN	Ornate or western box trutles inhabit prairie grassland, pasture, fields, sandhills, and open woodland. They are essentially terrestrial but sometimes enter slow, shallow streams and creek pools. For shelter, they burrow into soil (e.g., under plants such as yucca) (Converse et al. 2002) or enter burrows made by other species; winter burrow depth was 0.5-1.8 meters in Wisconsin (Doroff and Keith 1990), 7-120 cm (average depth 54 cm) in Nebraska (Converse et al. 2002). Eggs are laid in nests dug in soft well-drained soil in open area (Legler 1960, Converse et al. 2002). Very partial to sandy soil.	Yes	May impact	Sandhills/dunes occur in the survey area. Multiple individuals of this species were observed during both the October 2018 and April 2019 field investigations (**Table 3**).
Western hognose snake *Heterodon nasicus*	NL	SGCN	Habitat consists of areas with sandy or gravelly soils, including prairies, sandhills, wide valleys, river floodplains, bajadas, semiagricultural areas (but not intensively cultivated land), and margins of irrigation ditches (Degenhardt et al. 1996, Hammerson 1999, Werler and Dixon 2000, Stebbins 2003). Also thornscrub woodlands and chaparral thickets. Seems to prefer sandy and loamy soils, not necessarily flat. Periods of inactivity are spent burrowed in the soil or in existing burrows. Eggs are laid in nests a few inches below the ground surface (Platt 1969).	Yes	May impact	Sandy and gravelly soils were observed within the survey area. The observed Mesquite Thorn-Scrub vegetation type was present within the central and southern extents of the survey area. The survey area is characterized by a gently sloping landscape. This species has the potential to occur within the survey area, however, none were observed during the October 2018 or April 2019 site visits.

Species	Federal Status	State Status	Habitat Description	Potential Habitat Present?	Effect/Impact on the Species	Justification
Western rattlesnake *Crotalus viridis*	NL	SGCN	Grassland, both desert and prairie; shrub desert rocky hillsides; edges of arid and semi-arid river breaks.	Yes	May impact	Observed vegetation types included Maintained Grassland and Mesquite Thorn-Scrub. This species has the potential to occur within the survey area, however, none were observed during the October 2018 or April 2019 site visits.
BIRDS						
American Peregrine Falcon *Falco peregrinus anatum**	DL	T	Year-round resident and local breeder in west Texas, nests in tall cliff eyries; also, migrant across state from more northern breeding areas in US and Canada, winters along coast and farther south; occupies wide range of habitats during migration, including urban, concentrations along coast and barrier islands; low-altitude migrant, stopovers at leading landscape edges such as lake shores, coastlines, and barrier islands.	No	No impact	No breeding or wintering habitat is present within the proposed project area. The species is a potential migrant; any use of the survey area would be incidental.
Bald Eagle *Haliaeetus leucocephalus*	DL	T	Found primarily near rivers and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds	No	No impact	No breeding or wintering habitat is present within the proposed project area. The species is a potential migrant; any use of the survey area would be incidental.
Franklin's Gull *Leucophaeus pipixcan*	NL	SGCN	Nests in marshes and along inland lakes. Winters along the coast in bays, estuaries, and along sandy beaches (Burger and Gochfeld 2009).	No	No impact	No breeding or wintering habitat is present within the proposed project area. The species is a potential migrant; any use of the survey area would be incidental.
Interior Least Tern *Sterna antillarum**	LE	E	Sand beaches, flats, bays, inlets, lagoons, islands. Subspecies is listed only when inland (more than 50 miles from a coastline); nests along sand and gravel bars within braided streams, rivers; also know to nest on man-made structures (inland beaches, wastewater treatment plants, gravel mines, etc); eats small fish and crustaceans, when breeding forages within a few hundred feet of colony	No	No effect	No sand or gravel bars within braided streams occur within the survey area. Additionally, the USFWS only considers impacts to this species for Wind Energy Projects. No breeding or wintering habitat is present within the proposed project area. The species is a potential migrant; any use of the survey area would be incidental.

Species	Federal Status	State Status	Habitat Description	Potential Habitat Present?	Effect/Impact on the Species	Justification
Lesser Prairie-Chicken *Tympanuchus pallidicinctus*	NL	SGCN	Arid grasslands, generally interspersed with shrubs such as sand sagebrush, sand plum, skunkbush sumac, and shinnery oak shrubs, but dominated by sand dropseed, sideoats grama, sand bluestem, and little bluestem grasses; nests in a scrape lined with grasses	Yes	No impact	Priority Level 3 and 4 ("crucial") habitat modeled by the Western Association of Fish and Wildlife Agencies Crucial Habitat Assessment Tool is present throughout survey area. Havard Oak Dunes and Maintained Grassland vegetation types were observed throughout the survey area. This species has the potential to occur within the survey area, however, no individual were heard or seen during field site visits at listening locations during the April 2019 site visit.
Mountain Plover *Charadrius montanus**	NL	SGCN	Breeding: nests on high plains or shortgrass prairie, on ground in shallow depression; nonbreeding: shortgrass plains and bare, dirt (plowed) fields; primarily insectivorous	No	No impact	No breeding is present within the survey area. The species is a potential migrant; any use of the survey area would be incidental.
Northern Aplomado Falcon *Falco femoralis septentrionalis**	LE	E	Open country, especially savanna and open woodland, and sometimes in very barren areas; grassy plains and valleys with scattered mesquite, yucca, and cactus; nests in old stick nests of other bird species	Yes	No effect	Inactive stick nests were observed throughout the survey area. Other raptor species (*Accipiter* sp. and *Buteo* sp.) were observed. The survey area is characterized by an open, gently sloping landscape and the Mesquite Thorn-Scrub vegetation type within the central and southern extents of the survey area. No individuals of the species were observed, and no active nesting was observed. The site visits conducted in October 2018 and April 2019 were both conducted during the breeding season, and no individuals were observed (Baicich and Harrison 2005). The species is a potential migrant; any use of the survey area would be incidental.

Species	Federal Status	State Status	Habitat Description	Potential Habitat Present?	Effect/Impact on the Species	Justification
Piping Plover *Charadrius melodus**	LT	T	Beaches, sandflats, and dunes along Gulf Coast beaches and adjacent offshore islands. Also spoil islands in the Intracoastal Waterway. Based on the November 30, 1992 Section 6 Job No. 9.1, Piping Plover and Snowy Plover Winter Habitat Status Survey, algal flats appear to be the highest quality habitat. Some of the most important aspects of algal flats are their relative inaccessibility and their continuous availability throughout all tidal conditions. Sand flats often appear to be preferred over algal flats when both are available, but large portions of sand flats along the Texas coast are available only during low-very low tides and are often completely unavailable during extreme high tides or strong north winds. Beaches appear to serve as a secondary habitat to the flats associated with the primary bays, lagoons, and inter-island passes. Beaches are rarely used on the southern Texas coast, where bayside habitat is always available, and are abandoned as bayside habitats become available on the central and northern coast. However, beaches are probably a vital habitat along the central and northern coast (i.e. north of Padre Island) during periods of extreme high tides that cover the flats. Optimal site characteristics appear to be large in area, sparsely vegetated, continuously available or in close proximity to secondary habitat, and with limited human disturbance.	No	No effect	No beaches, sandflats, or dunes are located within the survey area. Additionally, the USFWS only considers impacts to this species for Wind Energy Projects. No breeding or wintering habitat is present within the proposed project area. The species is a potential migrant; any use of the survey area would be incidental.

Species	Federal Status	State Status	Habitat Description	Potential Habitat Present?	Effect/Impact on the Species	Justification
Red Knot *Calidris canutus rufa**	LT	NL	Red knots migrate long distances in flocks northward through the contiguous United States mainly April-June, southward July-October. The Red Knot prefers the shoreline of coast and bays and also uses mudflats during rare inland encounters. Primary prey items include coquina clam (*Donax* spp.) on beaches and dwarf surf clam (*Mulinia* lateralis) in bays, at least in the Laguna Madre. Wintering Range includes- Aransas, Brazoria, Calhoun, Cameron, Chambers, Galveston, Jefferson, Kennedy, Kleberg, Matagorda, Nueces, San Patricio, and Willacy. Habitat: Primarily seacoasts on tidal flats and beaches, herbaceous wetland, and Tidal flat/shore.	No	No effect	No coastal shoreline with mudflats exists within the survey area. Additionally, the USFWS only considers impacts to this species for Wind Energy Projects. No breeding or wintering habitat is present within the proposed project area. The species is a potential migrant; any use of the survey area would be incidental.
Western Burrowing Owl *Athene cunicularia hypugaea*	NL	SGCN	Open grasslands, especially prairie, plains, and savanna, sometimes in open areas such as vacant lots near human habitation or airports; nests and roosts in abandoned burrows	Yes	May impact	Maintained Grassland was observed within the central extent of the survey area. Mammal burrows were observed throughout the survey area, but no individuals of this species were observed during the October 2018 or April 2019 site visits.
White-faced Ibis *Plegadis chihi*	NL	T	Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; currently confined to near-coastal rookeries in so-called hog-wallow prairies. Nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats.	No	No impact	No breeding or wintering habitat is present within the proposed project area. The species is a potential migrant; any use of the survey area would be incidental.
MAMMALS						
American badger *Taxidea taxus*	NL	SGCN	This species occurs west of the Great Lakes region throughout the Great Plains and Rocky Mountains. Locally, they are most common in portions of West and South Texas although they occasionally are sighted in the eastern part of the state.	Yes	May impact	This species has been documented within Andrews County (Schmidly and Bradley 2016). The survey area is relatively open with the potential for small mammals (prey) to occur. This species has the potential to occur within the survey area, however, no individuals were observed during the October 2018 or April 2019 site visit.

Species	Federal Status	State Status	Habitat Description	Potential Habitat Present?	Effect/Impact on the Species	Justification
Big free-tailed bat *Nyctinomops macrotis*	NL	SGCN	Habitat data sparse but records indicate that species prefers to roost in crevices and cracks in high canyon walls, but will use buildings, as well; reproduction data sparse, gives birth to single offspring late June-early July; females gather in nursery colonies; winter habits undetermined, but may hibernate in the Trans-Pecos; opportunistic insectivore	No	No impact	No roosting habitat (canyons or buildings) is located within the survey area. This species might use the air space within the vicinity of the survey area to forage.
Black-tailed prairie dog *Cynomys ludovicianus*	NL	SGCN	Dry, flat, short grasslands with low, relatively sparse vegetation, including areas overgrazed by cattle; live in large family groups	Yes	No impact	Sparsely vegetated areas occur with the survey area. No prairie dog town were observed during the Fall 2018 or Spring 2019 site visits. This species is not expected to occur within the survey area.
Eastern red bat *Lasiurus borealis*	NL	SGCN	Found in a variety of habitats in Texas. Usually associated with wooded areas. Found in towns especially during migration.	No	No impact	The survey area contains Havard Oak Dunes and Mesquite Thorn-Scrub vegetation types. These areas are not densely wooded enough to provide suitable roosting habitat. This species might use the air space within the vicinity of the survey area to forage.
Hoary bat *Lasiurus cinereus*	NL	SGCN	Known from montane and riparian woodland in Trans-Pecos, forests and woods in east and central Texas.	No	No impact	Montane and riparian woodlands to not occur within the survey area. This species might use the air space within the vicinity of the survey area to forage.
Kit fox *Vulpes macrotis*	NL	SGCN	Open desert grassland; avoids rugged, rocky terrain and wooded areas.	Yes	May impact	The survey area contains Maintained Grassland and Mesquite Thorn-Scrub vegetation types. Mammal burrows were observed throughout the survey area, however no individuals of this species were observed.
Long-tailed weasel *Mustela frenata*	NL	SGCN	Includes brushlands, fence rows, upland woods and bottomland hardwoods, forest edges & rocky desert scrub. Usually live close to water.	Yes	May impact	The survey area included brushlands, fence rows, and upland woods. Mammal burrows were observed throughout the survey area, however no individuals of this species were observed.
Mexican free-tailed bat *Tadarida brasiliensis*	NL	SGCN	Roosts in buildings in east Texas. Largest maternity roosts are in limestone caves on the Edwards Plateau. Found in all habitats, forest to desert.	Yes	No impact	The survey area is located in west Texas. This species might use the air space within the vicinity of the survey area to forage. No buildings or other structures that could be for roosting are present within the survey area.

Species	Federal Status	State Status	Habitat Description	Potential Habitat Present?	Effect/Impact on the Species	Justification
Mountain lion *Puma concolor*	NL	SGCN	Rugged mountains & riparian zones.	No	No impact	No rugged mountains or riparian zones occur within the survey area.
Pronghorn *Antilocapra americana*	NL	SGCN	Prefers hilly & plateau areas of open grassland, desert-grassland, & desert-scrub, where it frequents south-facing slopes & other sheltered areas.	Yes	No impact	The survey area does contain observed Maintained Grassland and Mesquite Thorn-Scrub vegetation types. However, the entire survey area is surrounded by fences, which this species is not expected to cross. This species was not observed during the October 2018 or April 2019 site visits and is not expected to occur within the survey area.
Thirteen-lined ground squirrel *Ictidomys tridecemlineatus*	NL	SGCN	Typical habitat is short-grass prairie, but they have invaded tall-grass areas where they live principally in pastures and along fencerows (Schmidly and Bradley 2016).	Yes	No Impact	The survey area is surrounded by fences, however, it does not contain prairie habitats. This species has not been observed within Andrews County and is not expected to occur within the survey area (Schmidly and Bradley 2016).
Western hog-nosed skunk *Conepatus leuconotus*	NL	SGCN	Habitats include woodlands, grasslands & deserts, to 7200 feet, most common in rugged, rocky canyon country; little is known about the habitat of the ssp. *telmalestes*	Yes	No impact	Maintained Grassland was observed in the central extent of the survey area. This species has not been observed within Andrews county and is not expected to occur within the survey area (Schmidly and Bradley 2016).
Western spotted skunk *Spilogale gracilis*	NL	SGCN	This species has been recorded from the southwestern part of Texas, as north as Garza and Howard counties, and as east as Bexar and Duval counties (Schmidly and Bradley 2004).	Yes	No impact	The survey area occurs within Andrews County. The species has not been observed within this county and is not expected to occur within the survey area (Schmidly and Bradley 2016).

Status Codes:
E = State-listed Endangered
T = State-listed Threatened
LT= Federally Listed Threatened
SGCN = Species of Greatest Conservation Need
LE = Federally Listed Endangered
NL = Not Listed
DL = Delisted

* = Species not recognized by the TPWD as occurring within the county but designated by USFWS as potentially occurring within the survey area

Sources: TPWD 2019b; USFWS 2019.

Table 4: Species Observed within the Survey Area

Common Name	Scientific Name	October 23, 2018	October 24, 2018	October 25, 2018	April 23, 2019	April 24, 2019	April 25, 2019
INSECTS							
Robber fly	*Asilidae*	X					
Queen butterfly	*Danaus gilippus*		X				
Dung beetle	*Phanaeus vindex*	X					
Red harvester ant	*Pogonomyrmex barbatus*	X		X		X	
Darkling beetle	*Tenebrionidae*	X					
REPTILES							
Six-lined racerunner	*Cnemidophorus sexlineatus*						X
Western Box turtle	*Terrapene ornata*	X			X		
BIRDS							
Grasshopper Sparrow	*Ammodramus savannarum*					X	
Red-tailed Hawk	*Buteo jamaicensis*	X					
Swainson's Hawk	*Buteo swainsoni*				X	X	X
Lark Bunting	*Calamospiza melanocorys*				X		X
Scaled Quail	*Callipepla squamata*	X	X	X	X	X	X
Cactus Wren	*Campylorhynchus brunneicapillus*	X				X	
Northern Cardinal	*Cardinalis cardinalis*				X		
Pyrrhuloxia	*Cardinalis sinuatus*	X		X			
Hermit Thrush	*Catharus guttatus*			X	X		
Lark Sparrow	*Chondestes grammacus*					X	
Northern Harrier	*Circus hudsonius*	X	X	X	X		X
Northern Bobwhite	*Colinus virginianus*				X	X	X
American Crow	*Corvus corax*				X	X	
Chihuahuan Raven	*Corvus cryptoleucus*			X			
Ladder-backed Woodpecker	*Dryobates scalaris*	X			X		
American Kestrel	*Falco sparverius*	X		X	X	X	
Dark-eyed Junco	*Junco hyemalis*			X			
Loggerhead Shrike	*Lanius ludovicianus*	X	X	X	X	X	
Lincoln's Sparrow	*Melospiza lincolnii*				X		
Song Sparrow	*Melospiza melodia*					X	
Northern Mockingbird	*Mimus polyglottos*				X	X	X
Brown-headed Cowbird	*Molothrus ater*	X					
Ash-throated Flycatcher	*Myiarchus cinerascens*					X	X
Savannah Sparrow	*Passerculus sandwichensis*	X	X	X			
Vesper Sparrow	*Pooecetes gramineus*	X		X			

Common Name	Scientific Name	October 23, 2018	October 24, 2018	October 25, 2018	April 23, 2019	April 24, 2019	April 25, 2019
Great-tailed Grackle	*Quiscalus mexicanus*					X	
Ruby-crowned Kinglet	*Regulus calendula*			X			
Yellow-rumped Warbler	*Setophaga coronata*			X	X	X	
Dickcissel	*Spiza americana*			X			
Chipping Sparrow	*Spizella passerina*	X	X	X		X	
Field Sparrow	*Spizella pusilla*	X	X	X		X	X
Western Meadowlark	*Sturnella neglecta*	X	X	X	X	X	X
Curve-billed Thrasher	*Toxostoma curvirostre*			X			
Scissor-tailed Flycatcher	*Tyrannus forficatus*				X		X
Western Kingbird	*Tyrannus verticalis*					X	X
Cassin's Kingbird	*Tyrannus vociferans*				X		
Barn Owl	*Tyto alba*	X		X			
Mourning Dove	*Zenaida macroura*	X			X	X	X
White-crowned Sparrow	*Zonotrichia leucophrys*	X	X	X	X		
MAMMALS							
Mule deer	*Odocoileus virginianus*				X		
Black-tailed jackrabbit	*Lepus californicus*	X		X		X	X

6.3 DESCRIPTION OF STATE-LISTED SPECIES POTENTIALLY IMPACTED BY THE PROJECT

Texas Horned Lizard (*Phrynosoma cornutum*) – State-Listed Threatened (TX)

The Texas horned lizard is a flat-bodied lizard with horns on its head. It is found primarily in arid and semiarid habitats in open areas with sparse plant cover. Horned lizards dig for hibernation, nesting, and insulation purposes, and are commonly found in loose sand or loamy soils (TPWD 2010). The range of the Texas horned lizard stretches from the south-central U.S. (throughout much of Texas, Oklahoma, Kansas, and New Mexico) to northern Mexico. Once found throughout the state of Texas, populations have become increasingly rare in Central and North Texas and have nearly completely disappeared from East Texas. Now, they are mainly found throughout West Texas and the Panhandle (TPWD 2010). Horned lizards feed primarily on harvester ants (*Pogonomyrmex* sp.) and are typically found in areas with numerous harvester ant nests. The primary causes of the decline in Texas horned lizard populations is reduction in harvester ant populations (because of competition from imported fire ants [*Solenopsis invicta*]), as well as collection for the pet trade (TPWD 2009).

No recorded occurrences of the species have been noted within 1.5 miles of the survey area. It is likely that individuals utilize the survey area as potentially suitable habitat as ample harvester ant mounds are present. The proposed project may impact individual Texas horned lizards (should they occur within the survey area). If any individuals of this state-listed species are observed within the project area during construction, care should be taken to avoid harming them, and the contractor should be educated about the potential presence of this species.

Species of Greatest Conservation Need

Although of importance to TPWD, they currently are not afforded regulatory protection. Twenty-eight SGCNs that have no additional federal conservation status have the potential to occur within Andrews County. Two of these species, dunes sagebrush lizard and Lesser Prairie-Chicken, while not listed, are of federal importance. The dunes sagebrush lizard is the subject of the Texas Conservation Plan for the Dunes Sagebrush Lizard (USFWS 2012). The Lesser Prairie-Chicken is currently under review by the U.S. Fish and Wildlife Service. Because of their special status, these two species are discussed in further detail below.

Dunes sagebrush lizard

The dunes sagebrush lizard is a small, light brown lizard with an average total body length of from 2.6 inches (males) and 2.8 inches (females) (Degenhardt et al. 1996). This species is diurnal, active during the morning and late afternoon. The dunes sagebrush lizard is most active March through October, with activity peaking mid-April through July during the breeding season (Fitzgerald and Painter 2009). This species diet consists primarily of small insects and other invertebrates (Degenhardt and Jones 1972, Fitzgerald and Painter 2009). Primary predators include predatory birds and snakes associated with their habitat (Hughes 1996, Yosef 1996, Smallwood and Bird 2002). The dunes sagebrush lizard is a habitat specialist associated with Havard oak dunes found in southeastern New Mexico and west Texas (Axtell 1988, Painter et al. 1999, Laurencio et al. 2007, Fitzgerald and Painter 2009, Laurencio and Fitzgerald 2010). This habitat provides necessary shelter for the dunes sagebrush lizard while also providing the necessary prey (Sena 1985, Fitzgerald et al. 1997, Peterson and Boyd 1998). The dunes sagebrush lizard was listed as a candidate species by the USFWS in 1982 but was never formally listed.

There are no recorded TXNDD Elements of Occurrence within 1.5 miles of the study area (**Figure 7**). In 2004, an individual was observed within the survey area during a survey conducted by Reagan and Associates, LLC (2004). During the April 2019 survey, no dunes sagebrush lizards were observed; however, a formal presence absence survey was not conducted. The study area does include the Havard Oak Dunes vegetation type. The study area is located within an area with a high and very high likelihood of occurrence for the species (Texas Comptroller of Public Accounts 2019).

Lesser Prairie-Chicken

The Lesser Prairie-Chicken is a medium-sized, grayish brown bird with a total body length of approximately 38-41 centimeters (Johnsgard 1983). The historical range of this species included Colorado, Kansas, New Mexico, Oklahoma, and Texas (USFWS 2019). Male displays typically take place at dusk and dawn from late February to early May with females arriving in mid-April. Vocalizations made during this time can be used to identify Lesser Prairie-Chicken leks (Copelin 1963, Haukos 1988). Lesser Prairie-Chickens prefer native short- and mixed-grass prairies with a shrub component dominated by sand sagebrush or shinnery oak (Taylor and Guthery 1980b, Giesen 1998). This species requires a relatively large, unfragmented, diverse nativescape that does not overlap with another lek. It was estimated by Taylor and Guthery (1980b) that a minimum contiguous area of at least 7,9000 acres and with at least 63 percent of preferred habitat would meet the minimum requirements for a single lek.

Although potentially suitable habitat for the LPC is located within the survey area, the April 2019 presence/absence survey did not locate any individuals of these species within the survey area. There are no recorded TXNDD Elements of Occurrence within 1.5 miles of the study area (**Figure 7**). It is believed that the habitat located within the survey area is not occupied by these species at this time. A summary of the Lesser Prairie-Chicken survey effort is included in **Table 5** and **Attachment C**. The results of this survey effort are consistent with a statewide survey conducted in 2000 and a survey conducted within and adjacent to the survey area in 2004 (NMDGF 2000, Lyons 2004).

6.4 ELEMENTS OF OCCURRENCE RECORDS

According to TPWD's TXNDD data for the *Hobbs SE, Brinson Ranch, Eunice NE, Jumbo Hill, Eunice SE, and Frankel City SW, Texas* quadrangles (received on April 30, 2019), no elements of occurrence (EO) are mapped within the survey area (**Figure 7**and **Table 4**) (TPWD 2019a).

6.5 SUMMARY OF THREATENED AND ENDANGERED SPECIES PRESENCE/ABSENCE SURVEYS

The survey area includes potentially suitable habitat for the Lesser Prairie-Chicken. This species is not federally listed but is a Species of Greatest Conservation Need in Texas. A presence/absence survey was conducted within the survey area during the April 2019 site visit in accordance with the *Western Association of Fish and Wildlife Agencies' LPC Survey Protocol for Project Clearance (Updated February 2016)*. The weather conditions, survey period times, and observations made during each survey were recorded and are provided in **Appendix C**. A complete summary of the survey dates and species observations is provided in **Table 5.**

Table 5: Presence/Absence Survey Results

Date of Survey	Number of Lesser Prairie-Chicken	Notes
April 23, 2019	0	No Lesser Prairie-Chickens observed or heard.
April 24, 2019	0	No Lesser Prairie-Chickens observed or heard.
April 25, 2019	0	No Lesser Prairie-Chickens observed or heard.

7.0 AGENCY COORDINATION

7.1 USFWS COORDINATION

Prior to the October 2018 and April 2019 field investigations, the USFWS Official Species lists were generated using IPaC to identify any potential federal resources within the survey area. Four species were identified by the Austin Ecological Services Field Office Official Species List: Least Tern (*Sterna antillarum*, Endangerd), Northern Aplomado Falcon (*Falco femoralis septentrionalis*, Endangerd), Piping Plover (*Charadrius melodus*, Threatened), and Red Knot (*Calidris canutus rufa*, Threatened). No Critical Habitats under the jurisdiction of the Austin Ecological Services Field Office were identified.

Based on the opinions of qualified biologists, none of the federal resources identified by the USFWS IPaC query are likely to be affected by the proposed project. Because a "no effect" determination was made for the identified federal resources, there is no need to seek concurrence with USFWS. Should the proposed project plans be altered in the future, the information and opinions contained in this report should be reevaluated.

7.2 TPWD COORDINATION

The TPWD Annotated County List of Rare Species for Andrews County was consulted prior to the October 2018 and April 2019 field investigations. Nine state-listed threatened or endangered species were identified as having the potential to occur with Andrews County. Twenty-nine species designated by TPWD as SGCNs have the potential to occur within Andrews County. Although of importance to TPWD, these species currently are afforded no regulatory protection.

According to TPWD's TXNDD data for the *Hobbs SE*, *Brinson Ranch*, *Eunice NE*, *Jumbo Hill*, *Eunice SE*, and *Frankel City SW*, Texas quadrangles (received on April 30, 2019), no elements of occurrence are mapped as occurring within the survey area or within 1.5 miles of the survey area (**Figure 7**) (TPWD 2019).

Potentially suitable habitat for one state-listed threatened species, the Texas horned lizard, is present within the Mesquite Thorn-Scrub observed vegetation type within the survey area. There is no regulatory requirement to conduct pre-construction presence/absence surveys for this species. However, state law prohibits direct harm to state-listed species. If any individuals of these state-listed species are observed within the survey area during construction, care should be taken to avoid harming them, and the contractor should be educated about the potential presence of these species

8.0 SUMMARY AND RECOMMENDATIONS

8.1 LAND USES

The proposed project is anticipated to change the currently vacant, undeveloped land to facilitate the construction of a consolidated interim storage facility.

8.2 VEGETATION

Impacts to vegetation would be limited to the construction phase of the proposed project. Select site clearing and thinning of vegetation is proposed within footprint of the consolidated interim storage facility and associated facilities within the survey area. No impacts to vegetation would occur outside of these facilities. Approximately 230.5 acres of Mesquite Thorn-Scrub, 76.0 acres of Havard Oak Dunes, and 17.8 acres of Maintained Grassland could be impacted by the proposed project.

8.3 WILDLIFE

Construction-related activities may directly and/or indirectly affect animals that reside on or adjacent to the survey area. Heavy machinery could kill small, low-mobility animals or could cause soil compaction, impacting animals that live underground. Larger, more mobile species will typically avoid construction activities and move into adjacent areas. Fragmentation of wildlife habitats that may affect migratory birds and resident wildlife species is dependent on the final design of the proposed project. However, efforts should be made to maintain wildlife travel corridors and reduce the footprint of the project, where practicable.

The Migratory Bird Treaty Act of 1916 states that it is unlawful to kill, capture, collect, possess, buy, sell, trade, or transport any migratory bird, nest, young, feather, or egg in part or in whole, without a federal permit issued in accordance with the Act's policies and regulations. Site clearing should occur outside the migratory bird nesting season (which is approximately March through September) to reduce the risk to nesting migratory birds. If site clearing must occur during the nesting season, a pre-construction site visit by a qualified biologist should be conducted to document the occurrence and status of any nesting migratory birds.

Bald Eagles and Golden Eagles are afforded protection under the Bald and Golden Eagle Protection Act of 1940, as amended (16 U.S.C. 668–668d, 54 Stat. 250). The law generally prohibits the taking, possession, and commerce of the two species. The survey area does not contain potentially suitable habitat for Bald or Golden Eagles. Additionally, no Bald or Golden Eagle nests were observed, and no Bald or Golden Eagles were observed or heard within the survey area during the October 2018 or April 2019 field investigations.

8.4 FEDERALLY LISTED AND STATE-LISTED THREATENED AND ENDANGERED SPECIES

The survey area does not contain potentially suitable habitat for any federally listed species. Additionally, no federally listed species were observed within the survey area during the October 2018 or April 2019 field investigations. The project has the potential to impact one state-listed endangered species for which potentially suitable habitat is located within the survey area: the Texas horned lizard. No state-listed threatened or endangered individuals were observed during the October 2018 or April 2019 field investigations. State law prohibits direct harm to state-listed species. If any individuals of these state-listed species are observed within the survey area during construction, care should be taken to avoid harming them, and the contractor should be educated about the potential presence of these species. No further coordination is required with the USFWS or TPWD at this time.

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Attachment A - Figures

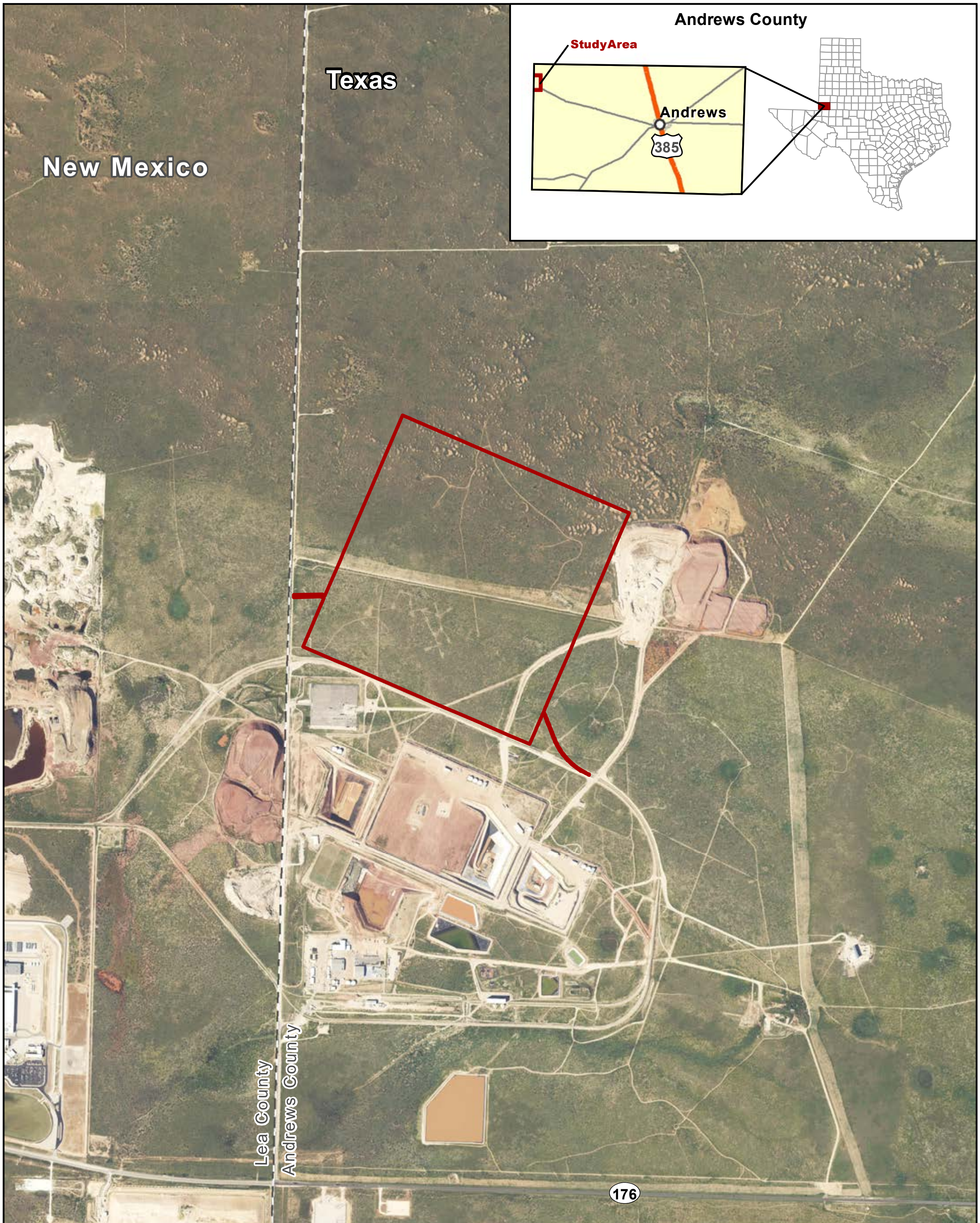


Figure 1

Project Location (Aerial Base)

Interim Storage Partners (ISP) Spent Fuel Storage Facility

Aerial Source: NAIP (2016)

G:\Projects\WCS\InterimStoragePartners\Figure 1_Project Location_Aerial_20190514.mxd

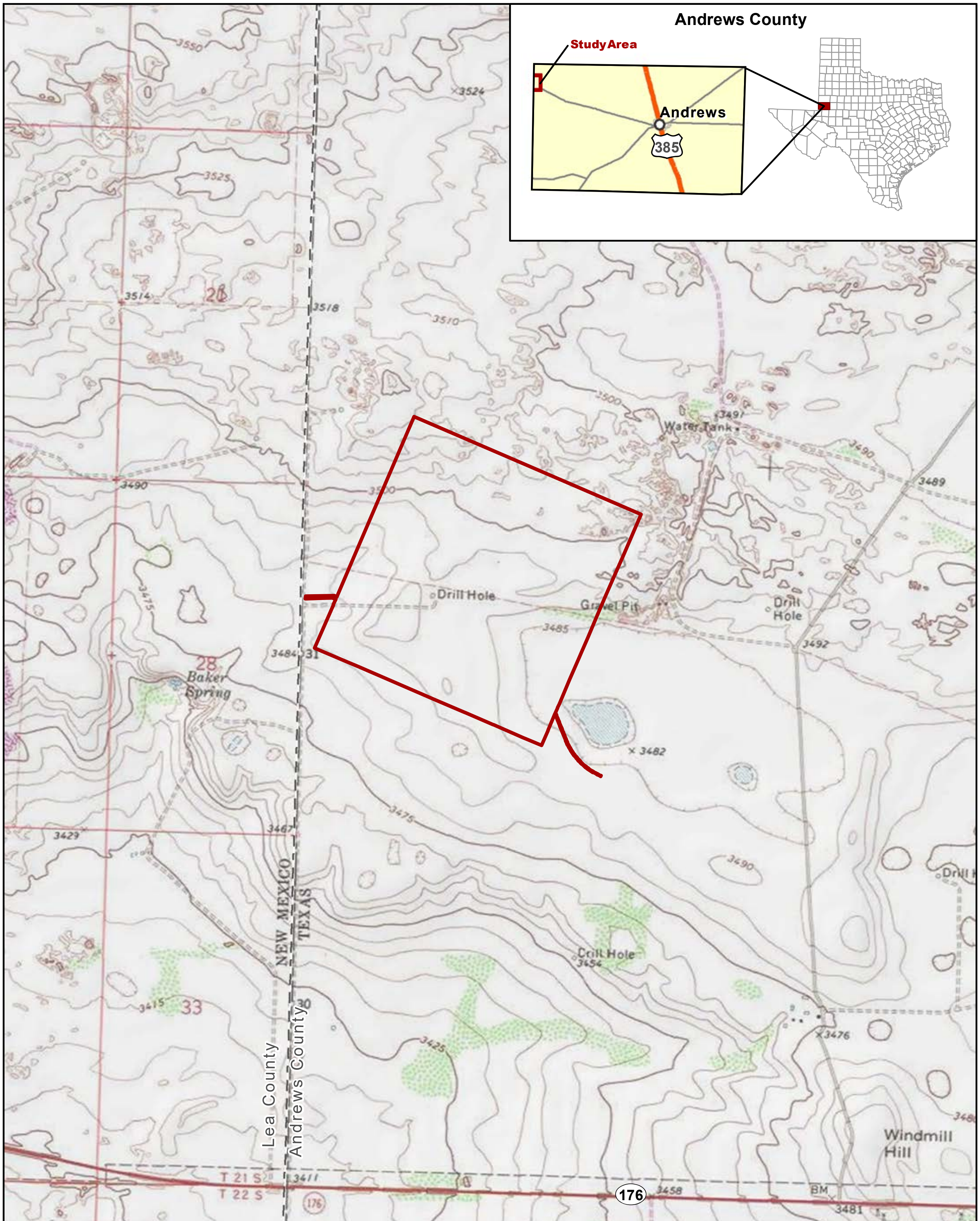


Figure 2

Project Location (Topographicl Base)

Interim Storage Partners (ISP) Spent Fuel Storage Facility

Study Area

Basemap Source: USGS Eunice NE 7.5' Quadrangle (1983)

COX | McLAIN Environmental Consulting

0 — 2,000 Feet
0 — 600 Meters

1 in = 2,000 feet
Scale: 1:24,000
Date: 6/18/2019

G:\Projects\WCS\InterimStoragePartners\Figure 2_Project Location_Topo_20190514.mxd

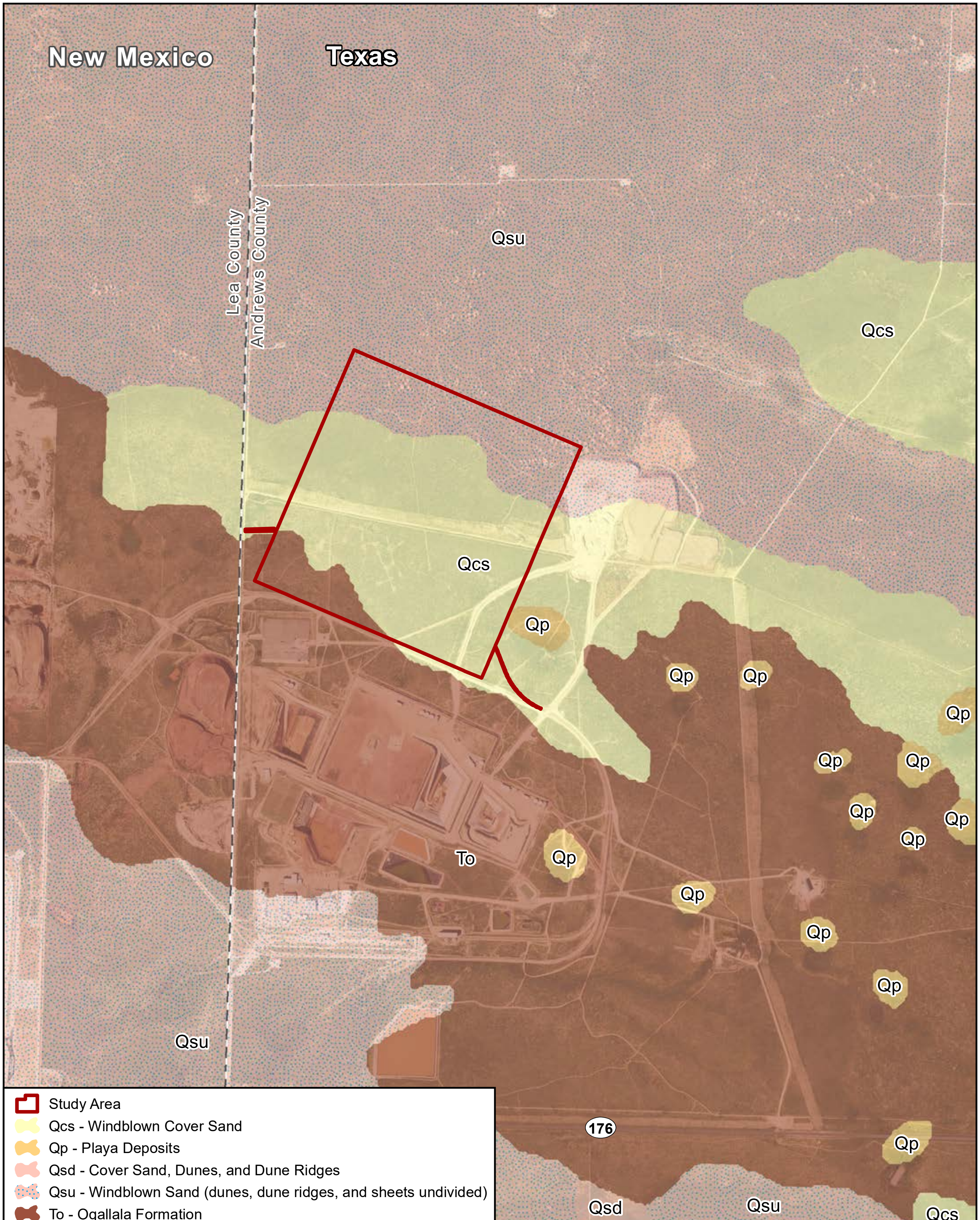


Figure 3

Project Area Geology

Interim Storage Partners (ISP) Spent Fuel Storage Facility

Data Source: Geologic Database of Texas (2007)/
Geologic Atlas of Texas Hobbs Sheet (1976)
Aerial Source: NAIP (2016)

COX | McLAIN
Environmental Consulting

0 2,000 Feet
0 600 Meters

1 in = 2,000 feet
Scale: 1:24,000
Date: 6/18/2019

G:\Projects\WCS\InterimStoragePartners\Figure 3_Geology_20190215.mxd

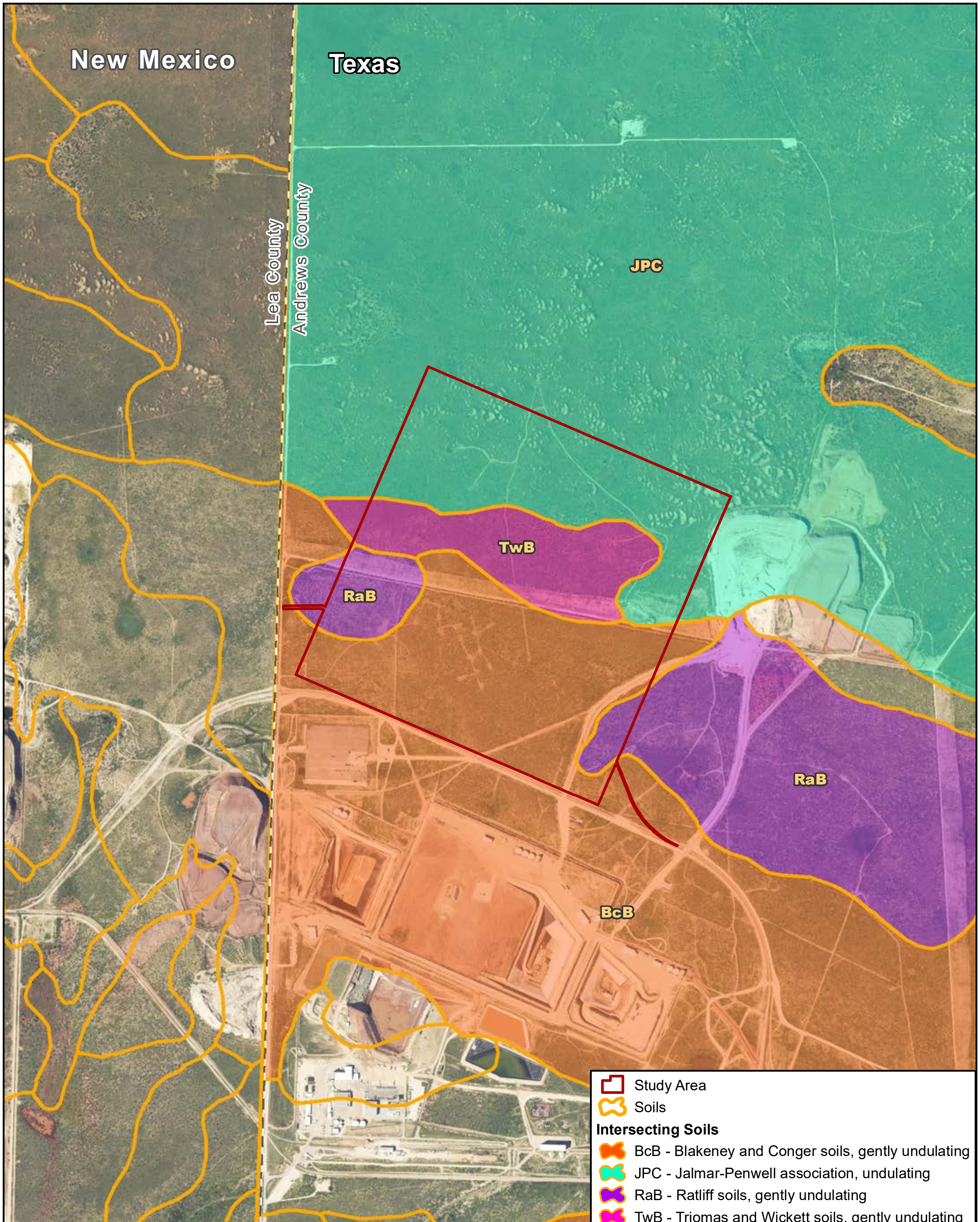


Figure 4

Project Area Soils

Interim Storage Partners (ISP) Spent Fuel Storage Facility

Data Source: NRCS (2018)
Aerial Source: NAIP (2016)

COX | McLAIN Environmental Consulting

0 1,500 Feet
0 400 Meters

1 in = 1,500 feet
Scale: 1:18,000
Date: 7/8/2019

G:\Projects\WCS\InterimStoragePartners\Figure 4_Soils_20190514.mxd

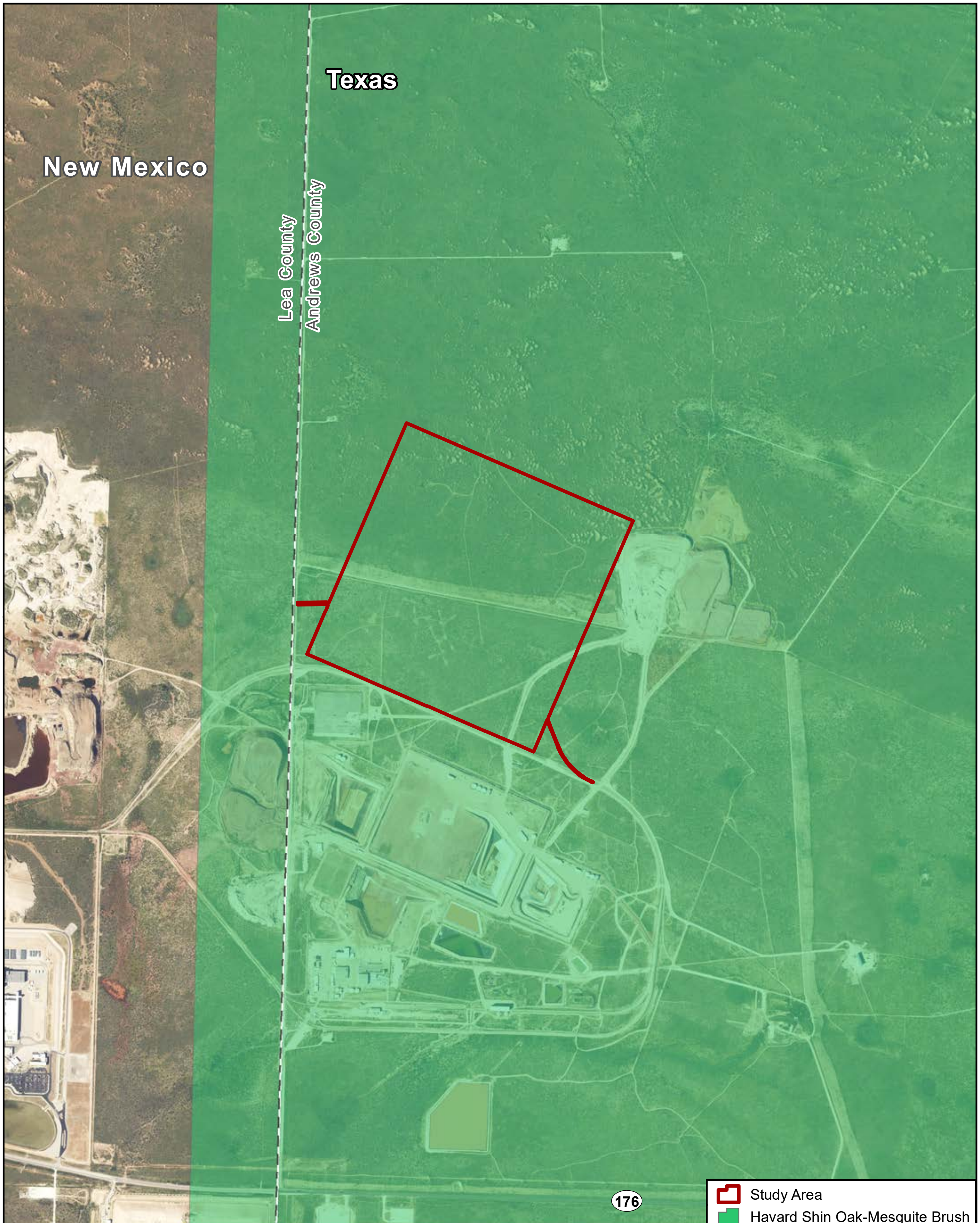


Figure 5

Vegetation Types of Texas

Interim Storage Partners (ISP) Spent Fuel Storage Facility

Data Source: TPWD (2003)/McMahan, et. al (1984)
Aerial Source: NAIP (2016)

G:\Projects\WCS\InterimStoragePartners\Figure 5_Vegetation Types of TX_20190509.mxd

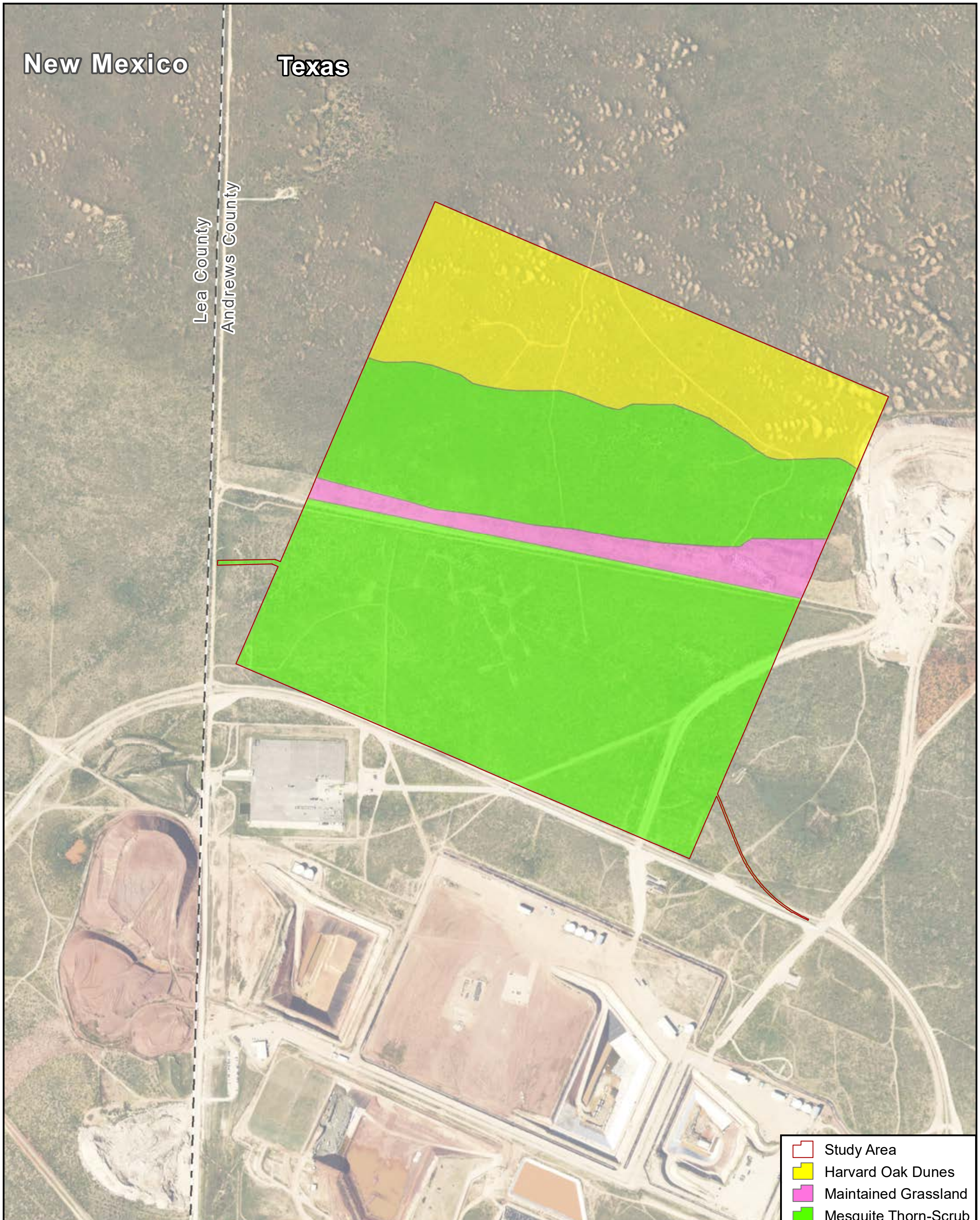


Figure 6

Observed Vegetation Types

Interim Storage Partners (ISP) Spent Fuel Storage Facility

Data Source: CMEC (2019)
Aerial Source: NAIP (2016)

COX | McLAIN Environmental Consulting

0 — 1,000 Feet
0 — 300 Meters

1 in = 1,000 feet
Scale: 1:12,000
Date: 6/18/2019

G:\Projects\WCS\InterimStoragePartners\Figure 6_Observed_Vegetation_20190513.mxd

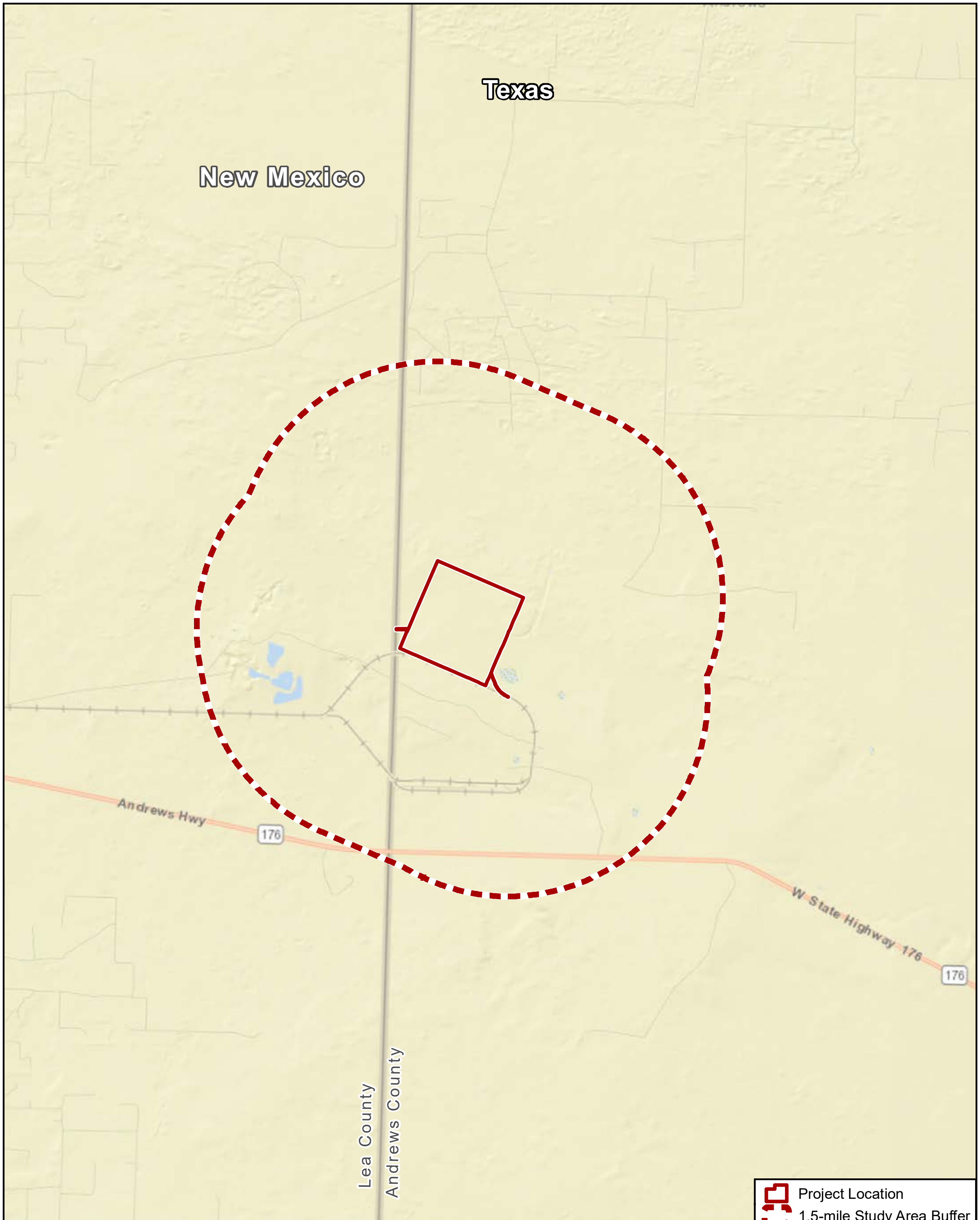


Figure 7

Note: no elements of occurrence within the map extent

TXNDD Elements of Occurrence

Interim Storage Partners (ISP) Spent Fuel Storage Facility

Data Source:
TPWD (04/22/2019)
Basemap Source:
ESRI (2019)

COX | McLAIN Environmental Consulting

0 — 1 Mile
0 — 1 Kilometer

1 in = 1 mile
Scale: 1:63,360
Date: 6/18/2019

G:\Projects\WCS\InterimStoragePartners\Figure 7_TXNDD_20190509.mxd

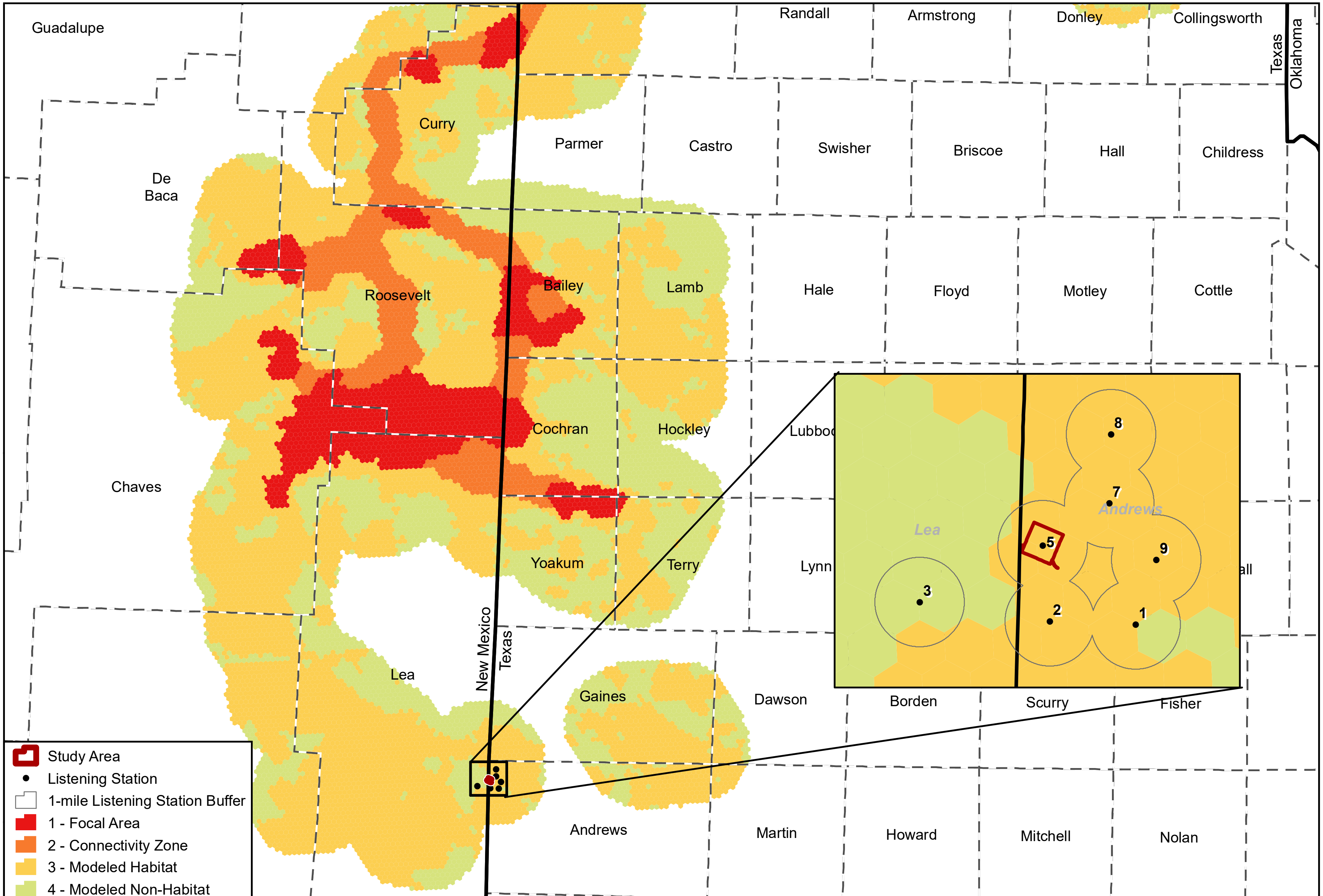


Figure 8

Lesser Prairie-Chicken Critical Habitat and Listenting Stations

Interim Storage Partners (ISP) Spent Fuel Storage Facility

Data Source: WAFWA CHAT (2019)

COX | McLAIN Environmental Consulting

0 30 Miles
0 40 Kilometers

1 in = 30 miles
Scale: 1:1,900,800
Date: 6/18/2019

G:\Projects\WCS\InterimStoragePartners\Figure 8_Prairie_Chicken_Habitat_20190513.mxd

Attachment B – Survey Area Photographs

Photos taken in Fall 2018

Photo 1: The Mesquite Thorn-scrub vegetation type observed in the southern extent of the project area during the Fall 2018 site visit.

Photo 2: The Mesquite Thorn-scrub vegetation type observed in the southern extent of the project area during the Fall 2018 site visit.

Photo 3: The Mesquite Thorn-scrub vegetation type observed in the southern extent of the project area during the Fall 2018 site visit.

Photo 4: The Mesquite Thorn-scrub vegetation type observed along the western rail spur of the project area during the Fall 2018 site visit.

Photo 5: The Mesquite Thorn-scrub vegetation type observed along the eastern rail spur of the project area during the Fall 2018 site visit.

Photo 6: The Havard Oak Dunes vegetation type observed in the northern extent of the project area during the Fall 2018 site visit.

Photo 7: The Havard Oak Dunes vegetation type observed in the northern extent of the project area during the Fall 2018 site visit.

Photo 8: The Havard Oak Dunes vegetation type observed in the northern extent of the project area during the Fall 2018 site visit.

Photo 9: The Maintained Grassland vegetation type observed in the central extent of the project area during the Fall 2018 site visit.

Photo 10: White tridens (*Tridens albescens)* observed within the project area on October 23, 2018.

Photo 11: Broom snakeweed (*Gutierrezia sarothrae*) observed within the project area on October 23, 2018.

Photo 12: Red lovegrass (*Eragrostis secundiflora*) observed within the project area on October 23, 2018.

Photo 13: Camphorweed (*Heterotheca subaxillaris*) observed within the project area on October 23, 2018.

Photo 14: Riddell's ragwort (*Senecio riddellii*) observed within the project area on October 23, 2018.

Photo 15: Palmer's spectaclepod (*Dimorphocarpa candicans*) observed within the project area on October 23, 2018.

Photo 16: Four o'clock (*Nyctaginaceae* sp.) observed within the project area on October 23, 2018.

Photo 17: Flaxflowered ipomopsis (*Ipomopsis longiflora*) observed in the project area on October 23, 2018.

Photo 18: Cory's jointfir (*Ephedra coryi)* observed in the project area on October 23, 2018.

Photo 19: Scarlet globe mallow (*Sphaeralcea coccinea)* observed in the project area on October 23, 2018.

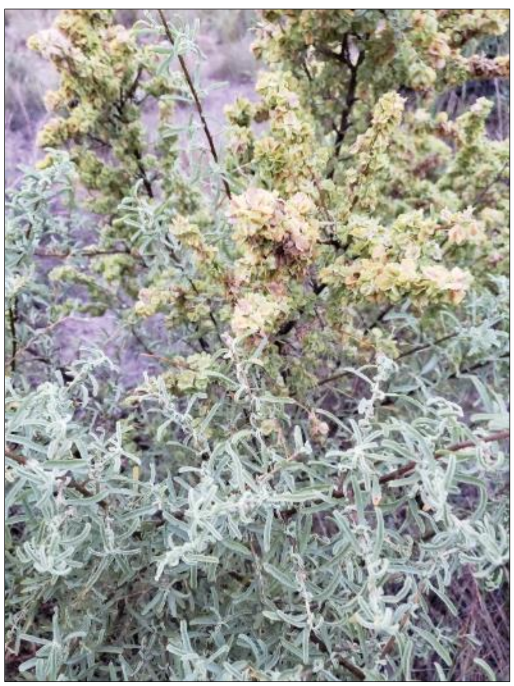


Photo 20: Fourwing saltbush (*Atriplex canescens*) observed within the project area on October 24, 2018.

Photo 21: Purple threeawn (*Aristida purpurea*) observed within the project area on October 24, 2018.

Photo 22: Prairie flameleaf sumac (*Rhus lanceolata*) observed within the project area on October 24, 2018.

Photo 23: Siberian elm (*Ulmus pumila*) observed within the project area on October 24, 2018.

Photo 20: A robber fly (*Asilidae*) observed in the project area on October 23, 2018.

Photo 25: A western box turtle (*Terrepene ornata*) observed in the project area on October 23, 2018.

Photo 26: A darkling beetle (*Tenebrionidae* sp.) observed in the project area on October 23, 2018.

Photo 27: A queen butterfly (*Danaus gilippus)* observed in the project area on October 24, 2018.

Photo 28: A short-horned grasshopper (*Acrididae* sp.) observed in the project area on October 25, 2018.

Photo 29: An inactive bird nest observed in the project area during Fall 2018.

Photo 30: An inactive bird nest observed in the project area during Fall 2018.

Photo 31: An inactive bird nest observed in the project area during Fall 2018.

Photos taken in Spring 2019

Photo 32: The Mesquite Thorn-scrub vegetation type observed in the southern extent of the project area during the Spring 2019 site visit.

Photo 33: The Mesquite Thorn-scrub vegetation type observed in the southern extent of the project area during the Spring 2019 site visit.

Photo 34: The Havard Oak Dunes vegetation type observed in the northern extent of the project area during the Spring 2019 site visit.

Photo 35: The Havard Oak Dunes vegetation type observed in the northern extent of the project area during the Spring 2019 site visit.

Photo 36: The Havard Oak Dunes vegetation type observed in the northern extent of the project area during the Spring 2019 site visit.

Photo 37: The Havard Oak Dunes vegetation type observed in the northern extent of the project area. Visible sand dune blow-out habitat observed during the Spring 2019 site visit.

Photo 38: The Maintained Grassland vegetation type observed in the central extent of the project area during the Spring 2019 site visit.

Photo 39: Lazy daisy (*Aphanostephus ramosissimus*) observed in the project area on April 23, 2019.

Photo 40: Indian blanket (*Gaillardia pulchella*) observed in the project area on April 23, 2019.

Photo 41: Matted bluet (*Houstonia humifusa*) observed in the project area on April 23, 2019.

Photo 42: Plains yucca (*Yucca campestris*) observed in the project area on April 23, 2019.

Photo 43: James' holdback (*Pomaria jamesii*) observed in the project area on April 23, 2019.

Photo 44: Woolly locoweed (*Astragalus mollissimus*) observed within the project area on April 23, 2019.

Photo 45: White-stem evening-primrose (*Oenothers albicaulis*) observed within the project area on April 23, 2019.

Photo 46: Texas winter grass (*Nassella leucotricha*) observed within the project area on April 23, 2019.

Photo 47: Scarlet beeblossum (*Oenothera suffrutescens*) observed within the project area on April 23, 2019.

Photo 48: Thicksepal cryptantha (*Cryptantha crassisepala*) observed within the project area on April 23, 2019.

Photo 49: Fendler's penstemon (*Penstemon fendleri*) observed in the project area on April 23, 2019.

Photo 50: Firewheel (*Gaillardia pulchella)* observed in the project area on April 23, 2019.

Photo 51: A western box turtle *(Terrapene ornata)* observed in the project area on April 23, 2019.

Photo 52: Horse crippler *(Echinocactus texensis*) observed in the project area on April 24, 2019.

Photo 53: Tree cholla (*Cylindropuntia imbricate*) observed in the project area on April 24, 2019.

Photo 54: Prairie spiderwort (*Tradescantia occidentalis)* observed in the project area on April 24, 2019.

Photo 55: Havard Oak (*Quercus havardii)* observed in the project area on April 24, 2019.

Photo 56: Palmer's spectaclepod *(Dimorphocarpa candicans)* observed in the project area on April 24, 2019.

Photo 57: Pygmy bluet *(Houstonia wrightii)* observed in the project area on April 24, 2019.

Photo 58: Purple mat *(Nama demissum)* observed in the project area on April 24, 2019.

Photo 59: Snowball sand verbena *(Abronia fragans)* observed in the project area on April 24, 2019.

Photo 60: Viviparous foxtail cactus (*Escobaria vivipara)* observed in the project area on April 24, 2019.

Photo 61: Hartweg's sundrops *(Oenothera hartwegii)* observed in the project area on April 25, 2019.

Photo 62: Notch-leaf scorpion-weed (*Phacelia crenulate*) observed in the project area on April 25, 2019.

Photo 63: Silverleaf nightshade (*Solanum elaeagnigolium)* observed in the project area on April 25, 2019.

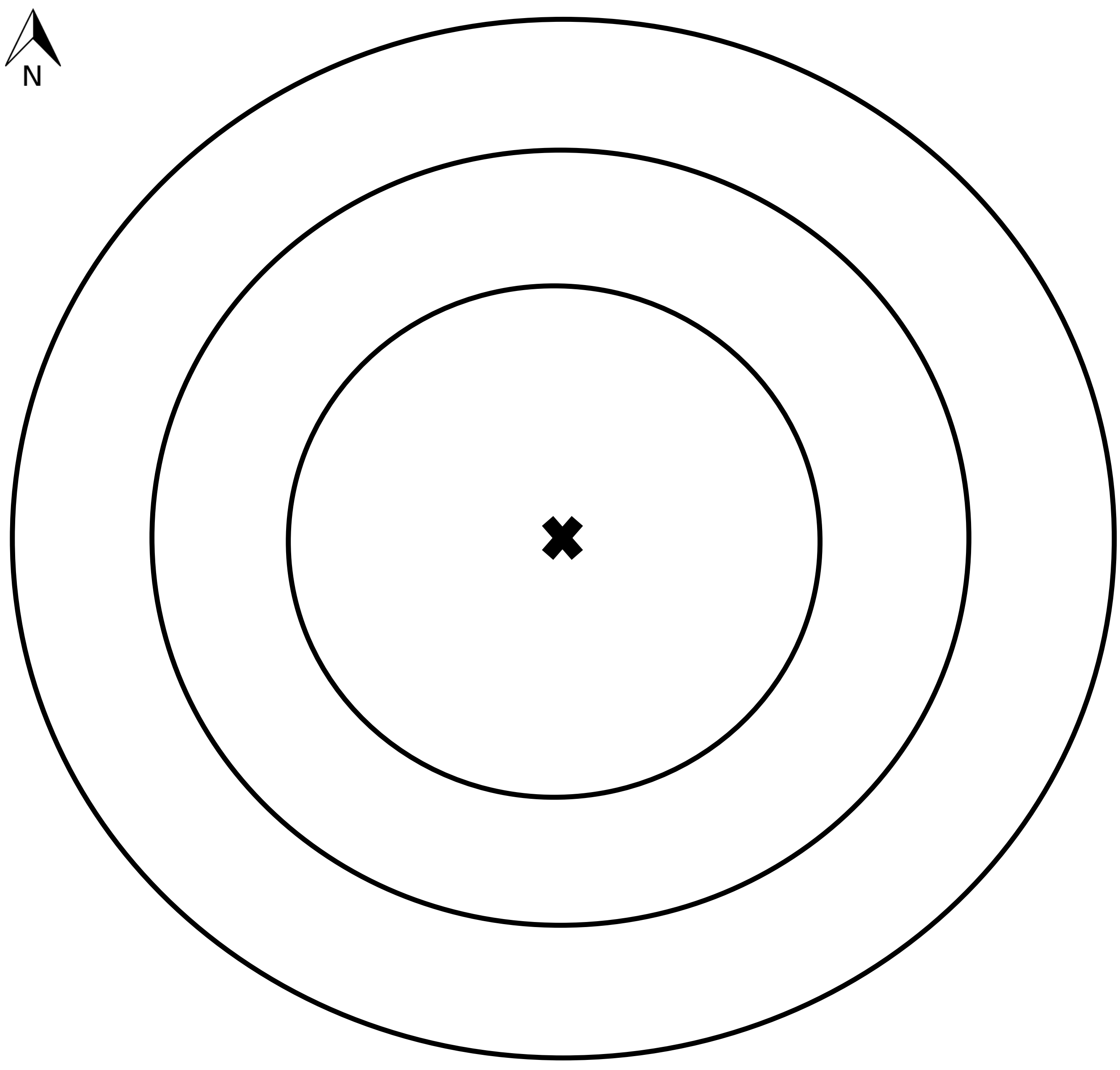
Photo 64: An inactive bird nest observed in the project area during Spring 2019.

Photo 65: An inactive bird nest observed in the project area during Spring 2019.

Attachment C – Lesser Prairie-Chicken Presence/Absence Survey Data Forms

FIXED POINT CALL COUNTS DATA SHEET

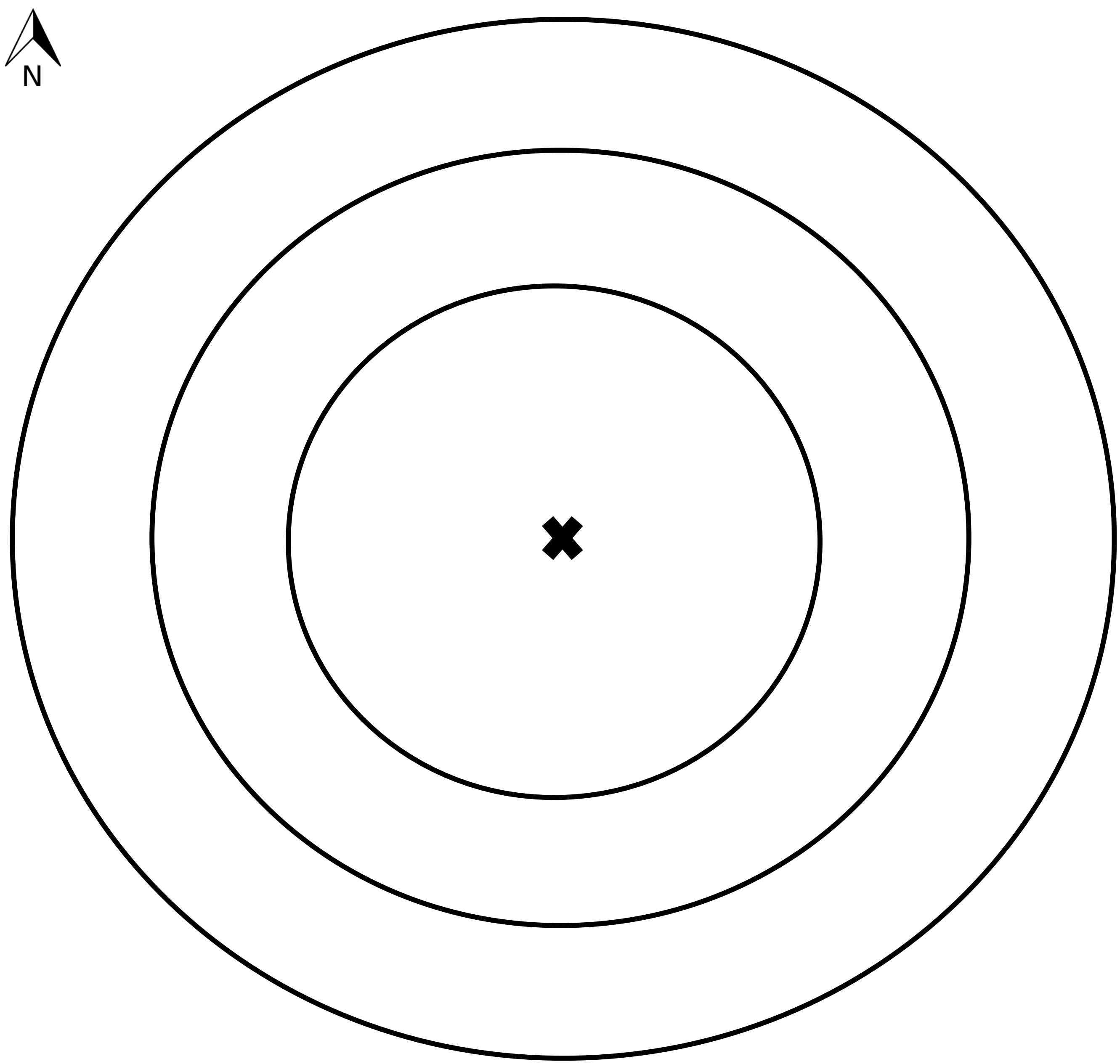
PROPERTY NAME/ID: WCS	DATE:4-23-2019
START TIME: 0656	END TIME: 0701
GPS LOCATION:32.43322585, -103.1024278	Listening Station: 3
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 54.8° F, Wind Speed Max: 7.2mph, Average: 4.5mph	
HABITAT DESCRIPTION: Grassland, Traffic Noise High	



NUMBER OF ROOSTERS/COVEYS: N/A	
CALL TALLY: N/A	

FIXED POINT CALL COUNTS DATA SHEET

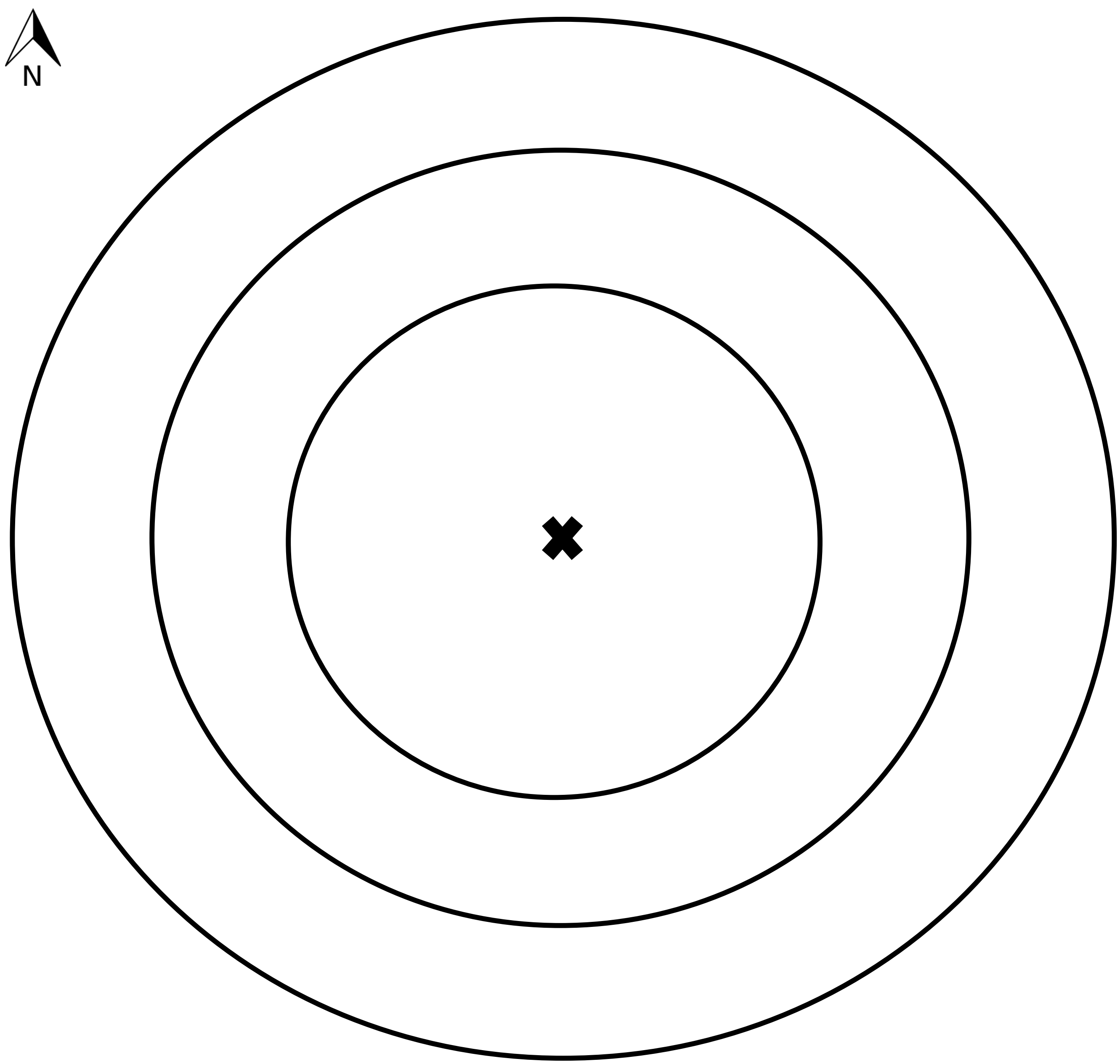
PROPERTY NAME/ID: WCS	DATE:4-23-2019
START TIME: 0706	END TIME: 0711
GPS LOCATION:32.42819737, -103.0525019	Listening Station: 2
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 54.7° F, Wind Speed Max: 10.4mph, Average: 6.2mph	
HABITAT DESCRIPTION: Grassland, Traffic Noise High	



NUMBER OF ROOSTERS/COVEYS: N/A
CALL TALLY: N/A

FIXED POINT CALL COUNTS DATA SHEET

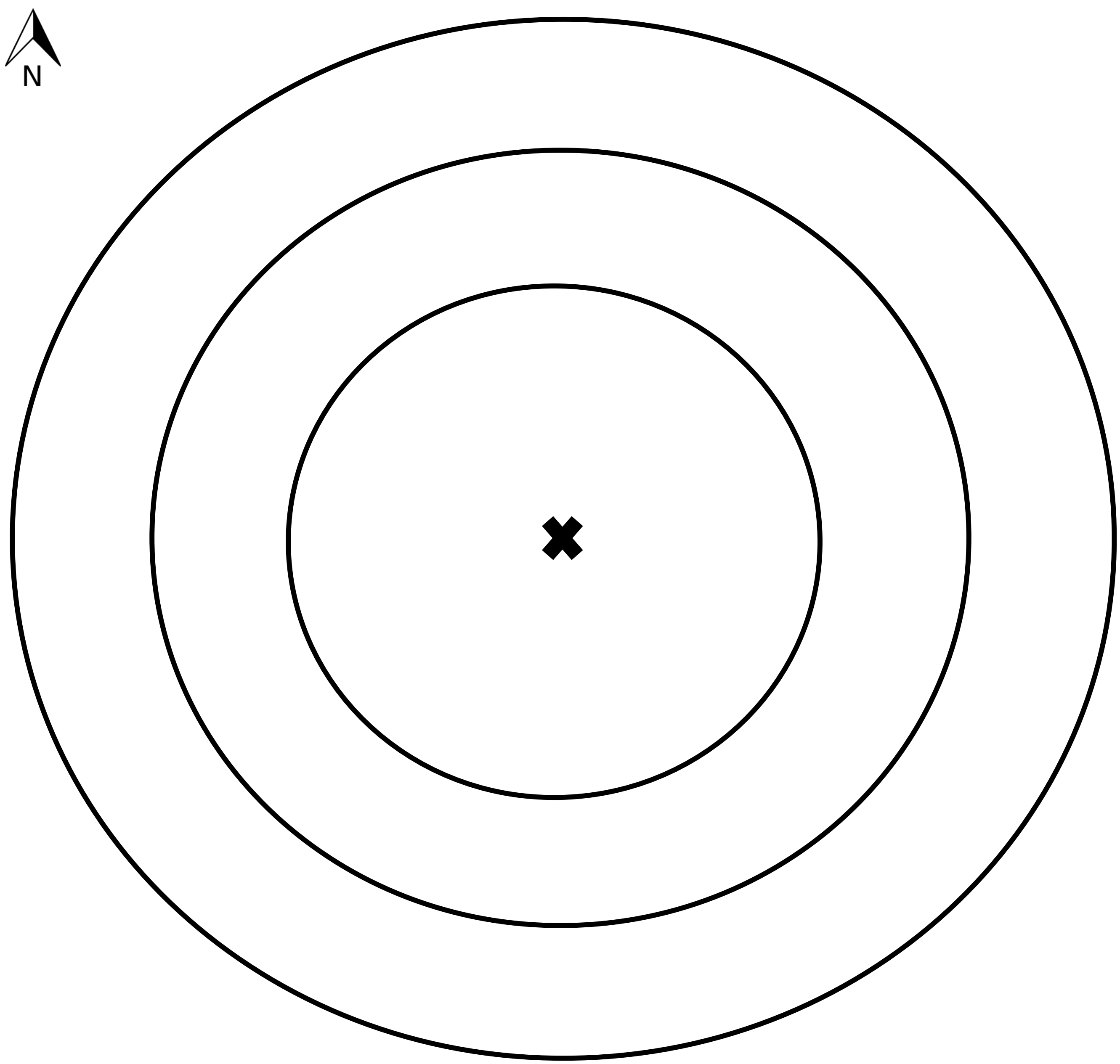
PROPERTY NAME/ID: WCS	DATE:4-23-2019
START TIME: 0713	END TIME: 0718
GPS LOCATION: 32.42790229, -103.0196225	Listening Station: 1
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 55.8° F, Wind Speed Max: 10.3mph, Average: 5.2mph	
HABITAT DESCRIPTION: Grassland, Traffic Noise High	



NUMBER OF ROOSTERS/COVEYS: N/A	
CALL TALLY: N/A	

FIXED POINT CALL COUNTS DATA SHEET

PROPERTY NAME/ID: WCS	DATE:4-23-2019
START TIME: 0738	END TIME: 0742
GPS LOCATION: 32.44915362, -103.0123435	Listening Station: 9
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 56.4° F, Wind Speed Max: 6.3mph, Average: 3.2mph	
HABITAT DESCRIPTION: Grassland, Traffic Noise Low	

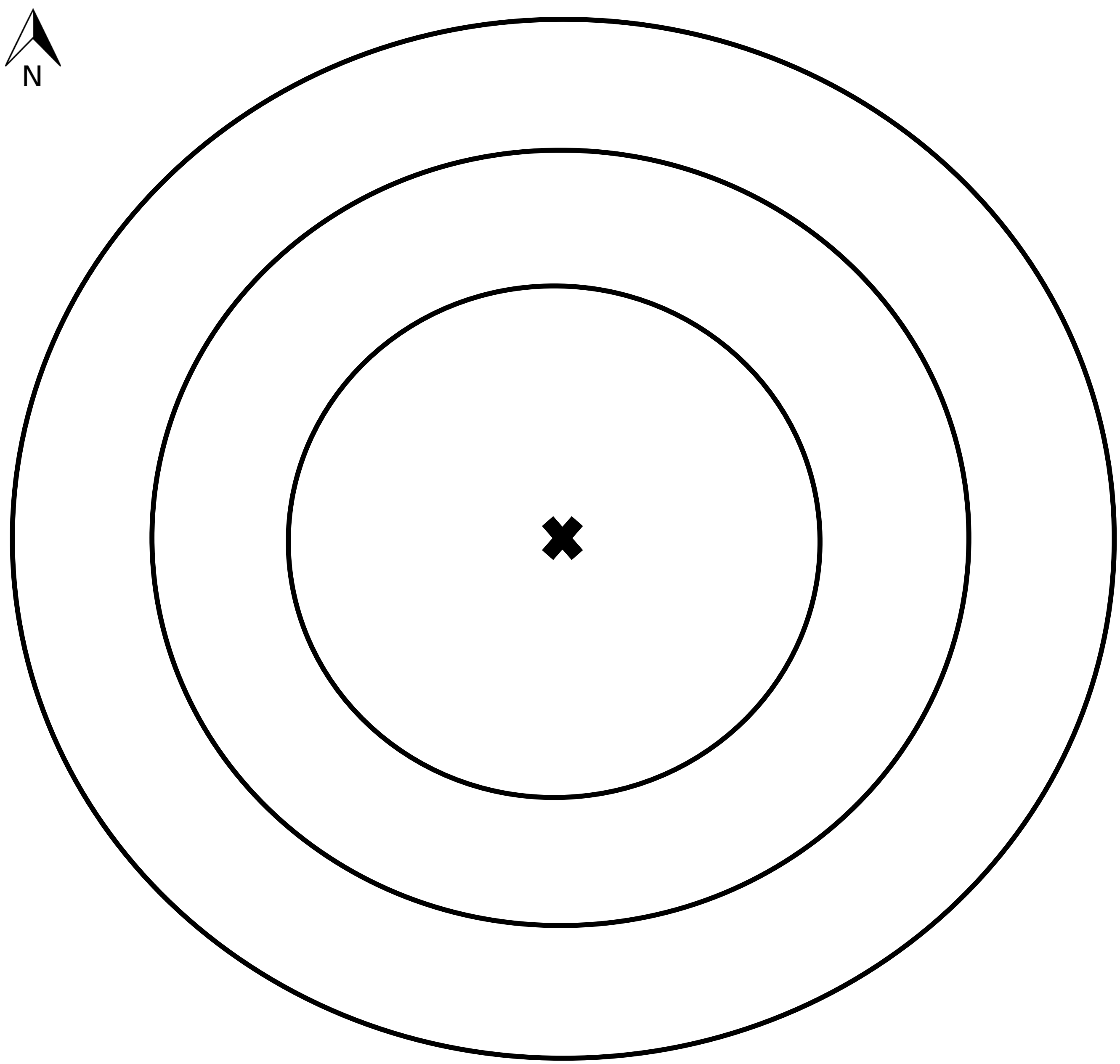


NUMBER OF ROOSTERS/COVEYS: N/A

CALL TALLY: N/A

FIXED POINT CALL COUNTS DATA SHEET

PROPERTY NAME/ID: WCS	DATE:4-23-2019
START TIME: 0756	END TIME: 0801
GPS LOCATION: 32.45281831, -103.0560104	Listening Station: 5
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 54.5° F, Wind Speed Max: 10.3mph, Average: 6.7mph	
HABITAT DESCRIPTION: Grassland, Noise- none	

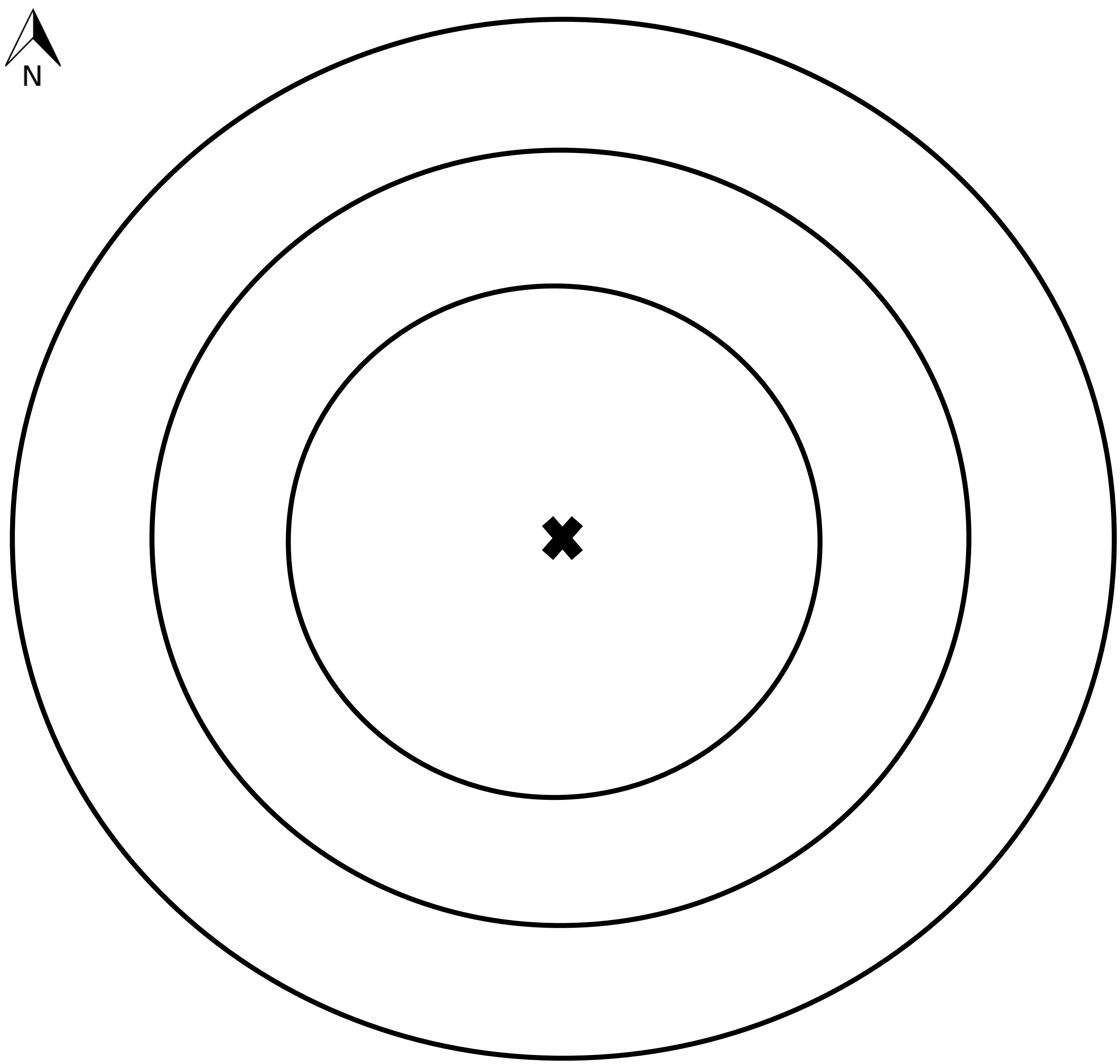


NUMBER OF ROOSTERS/COVEYS: N/A

CALL TALLY: N/A

FIXED POINT CALL COUNTS DATA SHEET

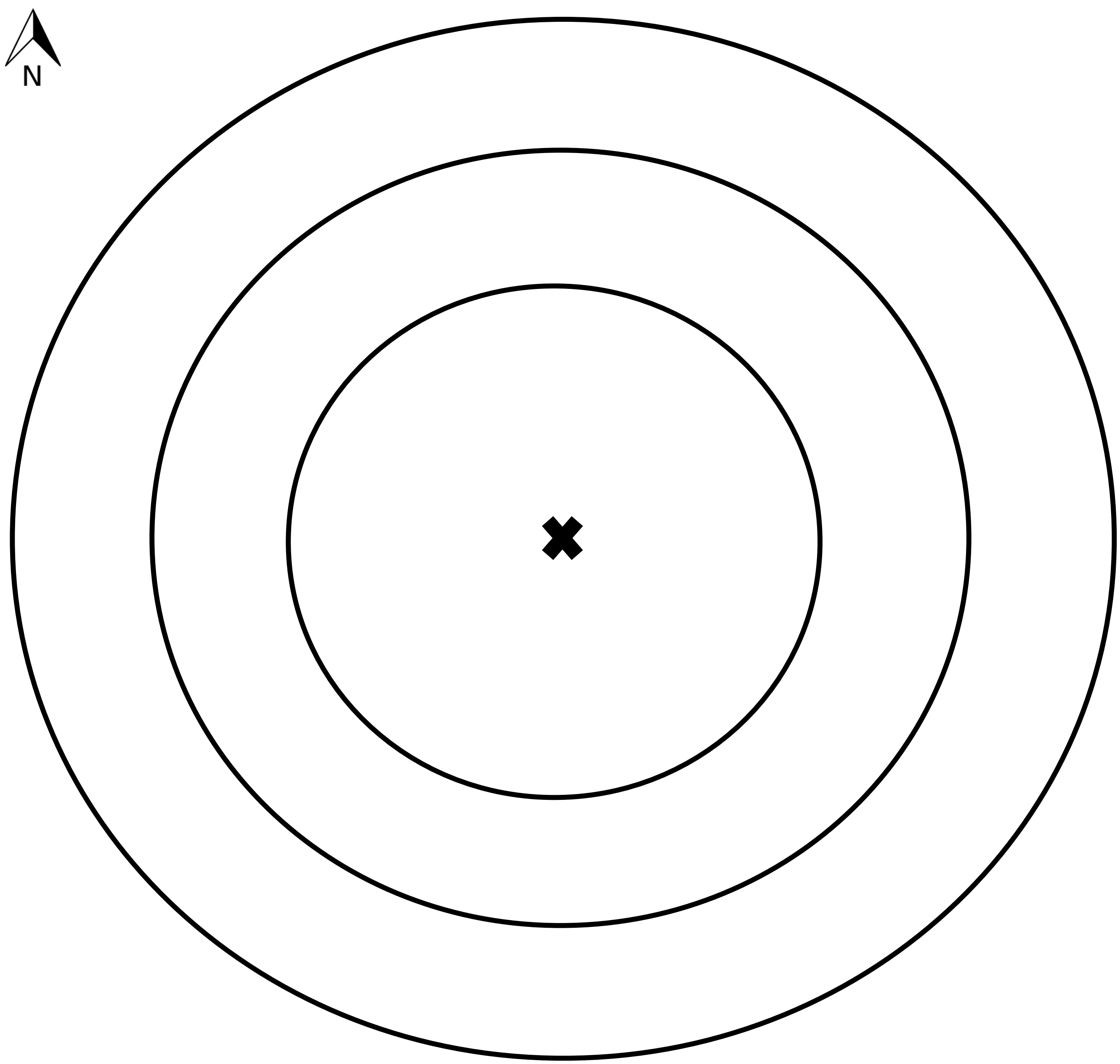
PROPERTY NAME/ID: WCS	DATE:4-23-2019
START TIME: 0808	END TIME: 0813
GPS LOCATION: 32.46703654, -103.0309761	Listening Station: 7
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 54.6° F, Wind Speed Max: 12.4mph, Average: 7.9mph	
HABITAT DESCRIPTION: Grassland, Noise- none	



NUMBER OF ROOSTERS/COVEYS: N/A	
CALL TALLY: N/A	

FIXED POINT CALL COUNTS DATA SHEET

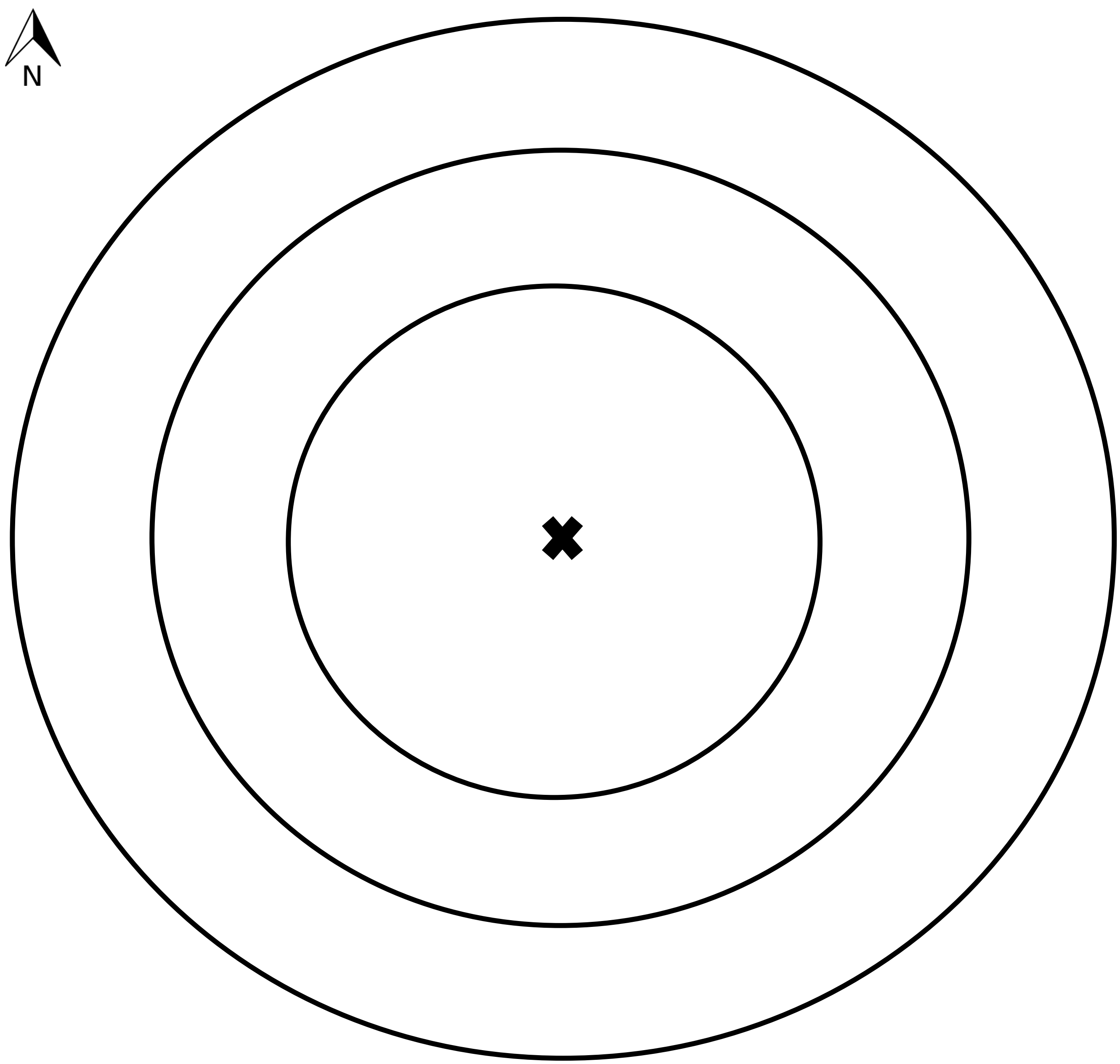
PROPERTY NAME/ID: WCS	DATE:4-23-2019
START TIME: 0825	END TIME: 0830
GPS LOCATION: 32.47649487, -103.031017	Listening Station: 8
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 54° F, Wind Speed Max: 11mph, Average: 6.7mph	
HABITAT DESCRIPTION: Grassland, Noise- low, pumpjacks	



NUMBER OF ROOSTERS/COVEYS: N/A	
CALL TALLY: N/A	

FIXED POINT CALL COUNTS DATA SHEET

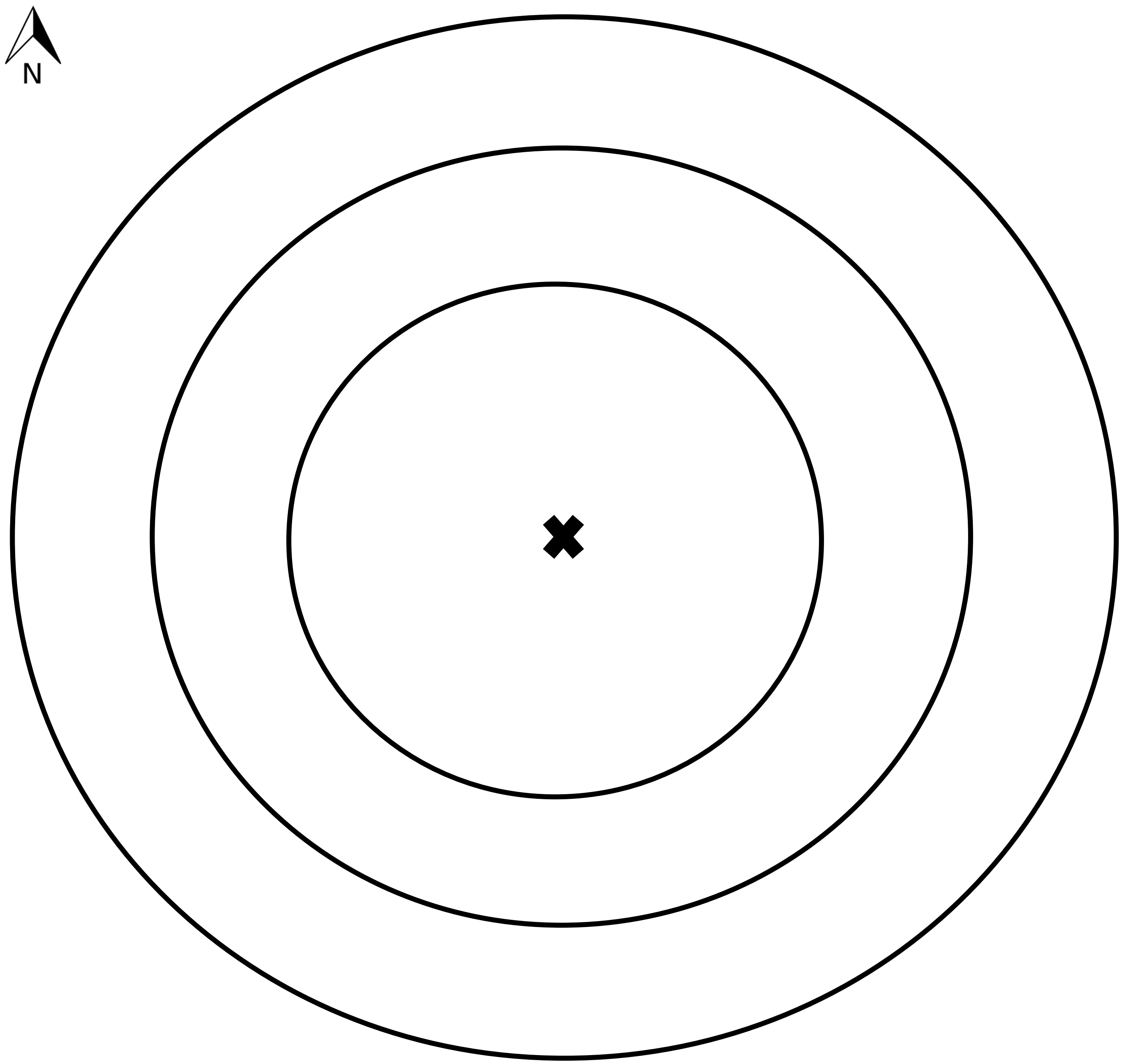
PROPERTY NAME/ID: WCS	DATE:4-24-2019
START TIME: 0658	END TIME: 0703
GPS LOCATION: 32.43322585, -103.1024278	Listening Station: 3
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 50.2° F, Wind Speed Max: 3.3mph, Average: 1.4mph	
HABITAT DESCRIPTION: Grassland, Traffic Noise High	



NUMBER OF ROOSTERS/COVEYS: N/A
CALL TALLY: N/A

FIXED POINT CALL COUNTS DATA SHEET

PROPERTY NAME/ID: WCS	DATE:4-24-2019
START TIME: 0707	END TIME: 0712
GPS LOCATION: 32.42819737, -103.0525019	Listening Station: 2
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 51.8° F, Wind Speed Max: 5.2mph, Average: 3mph	
HABITAT DESCRIPTION: Grassland, Traffic Noise High	

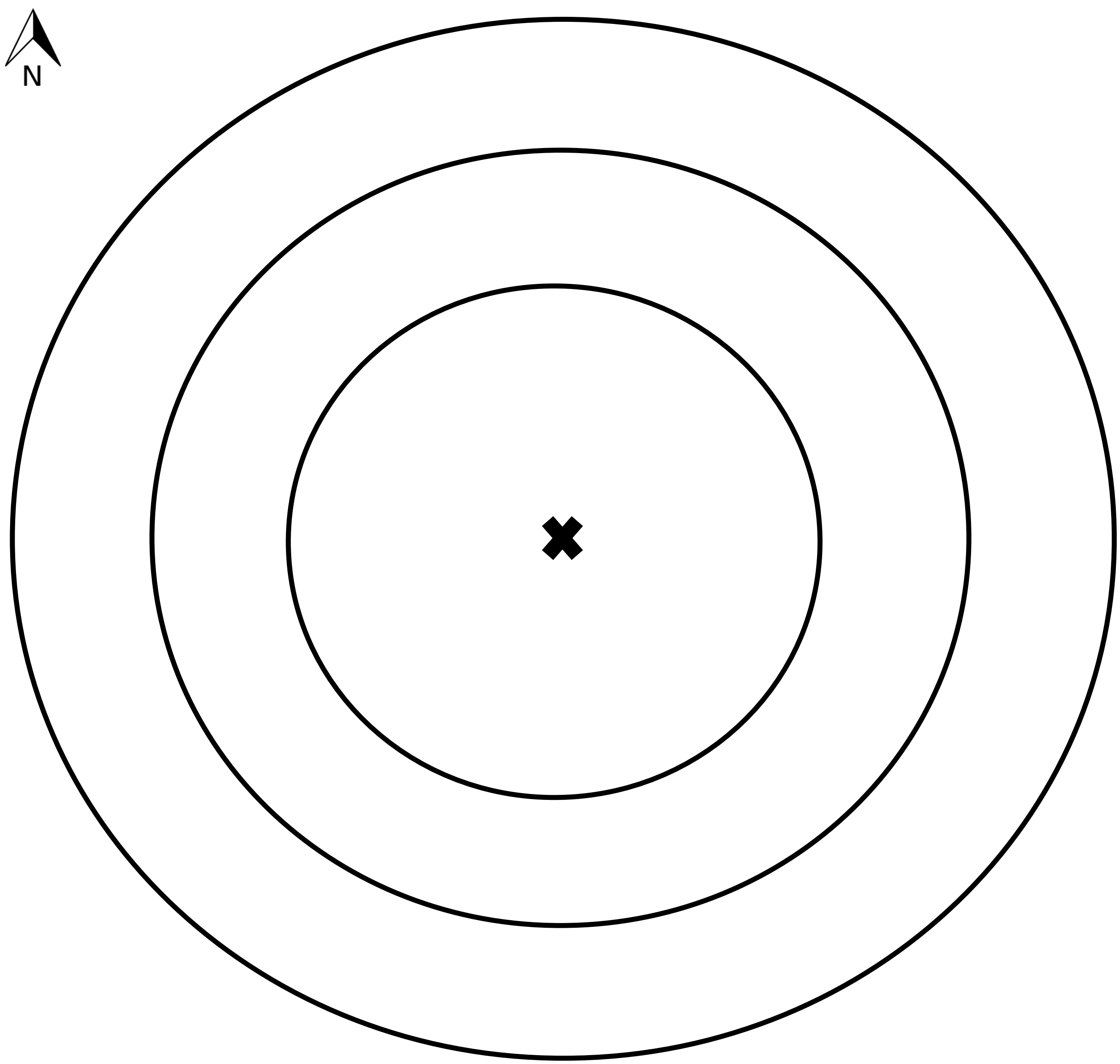


NUMBER OF ROOSTERS/COVEYS: N/A

CALL TALLY: N/A

FIXED POINT CALL COUNTS DATA SHEET

PROPERTY NAME/ID: WCS	DATE:4-24-2019
START TIME: 0714	END TIME: 0719
GPS LOCATION: 32.42790229, -103.0196225	Listening Station: 1
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 49.2° F, Wind Speed Max: 4.9mph, Average: 3.1mph	
HABITAT DESCRIPTION: Grassland, Traffic Noise High	

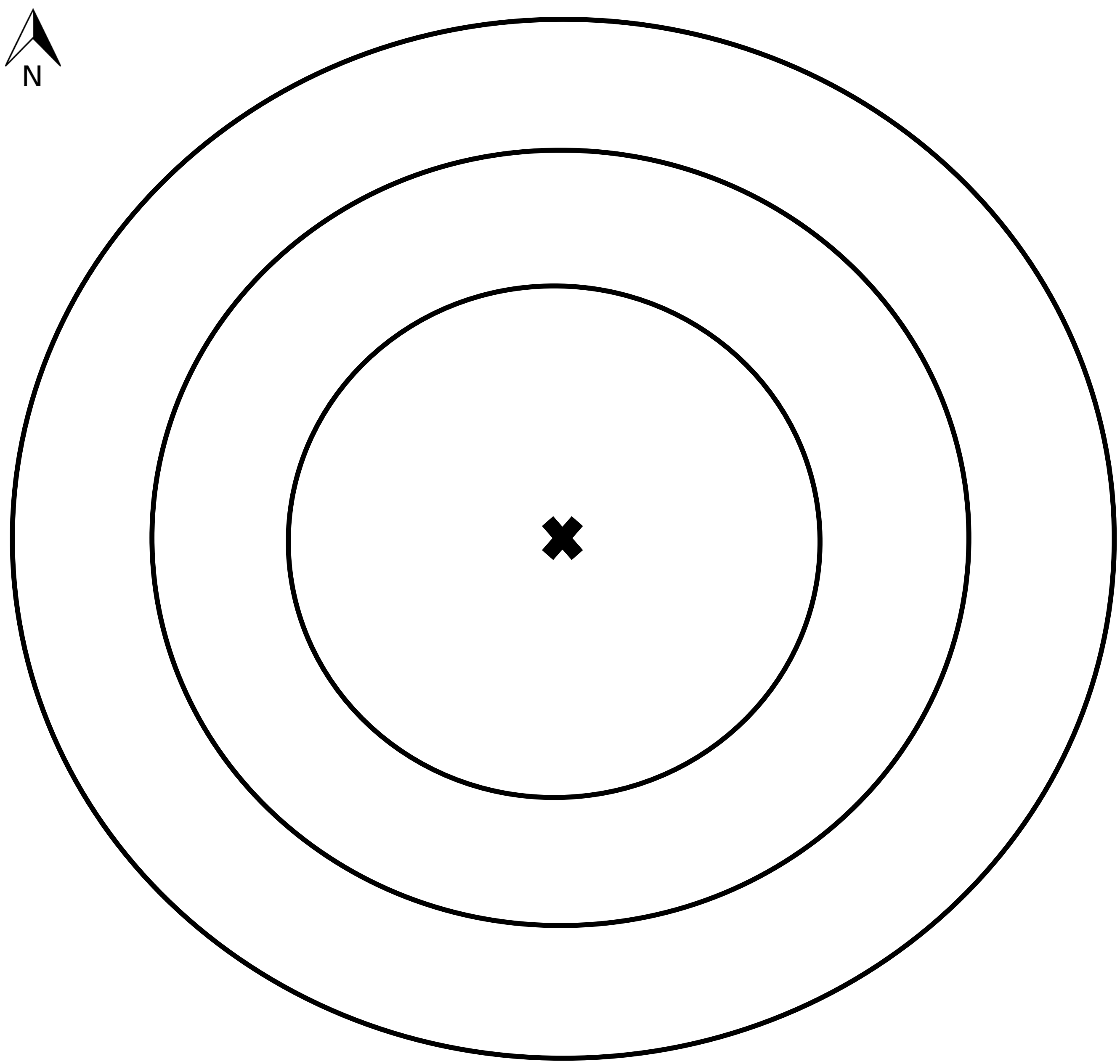


NUMBER OF ROOSTERS/COVEYS: N/A

CALL TALLY: N/A

FIXED POINT CALL COUNTS DATA SHEET

PROPERTY NAME/ID: WCS	DATE:4-24-2019
START TIME: 0738	END TIME: 0742
GPS LOCATION: 32.44915362, -103.0123435	Listening Station: 9
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 50.4° F, Wind Speed Max: 5.4mph, Average: 3.2mph	
HABITAT DESCRIPTION: Grassland, Traffic Noise Low	

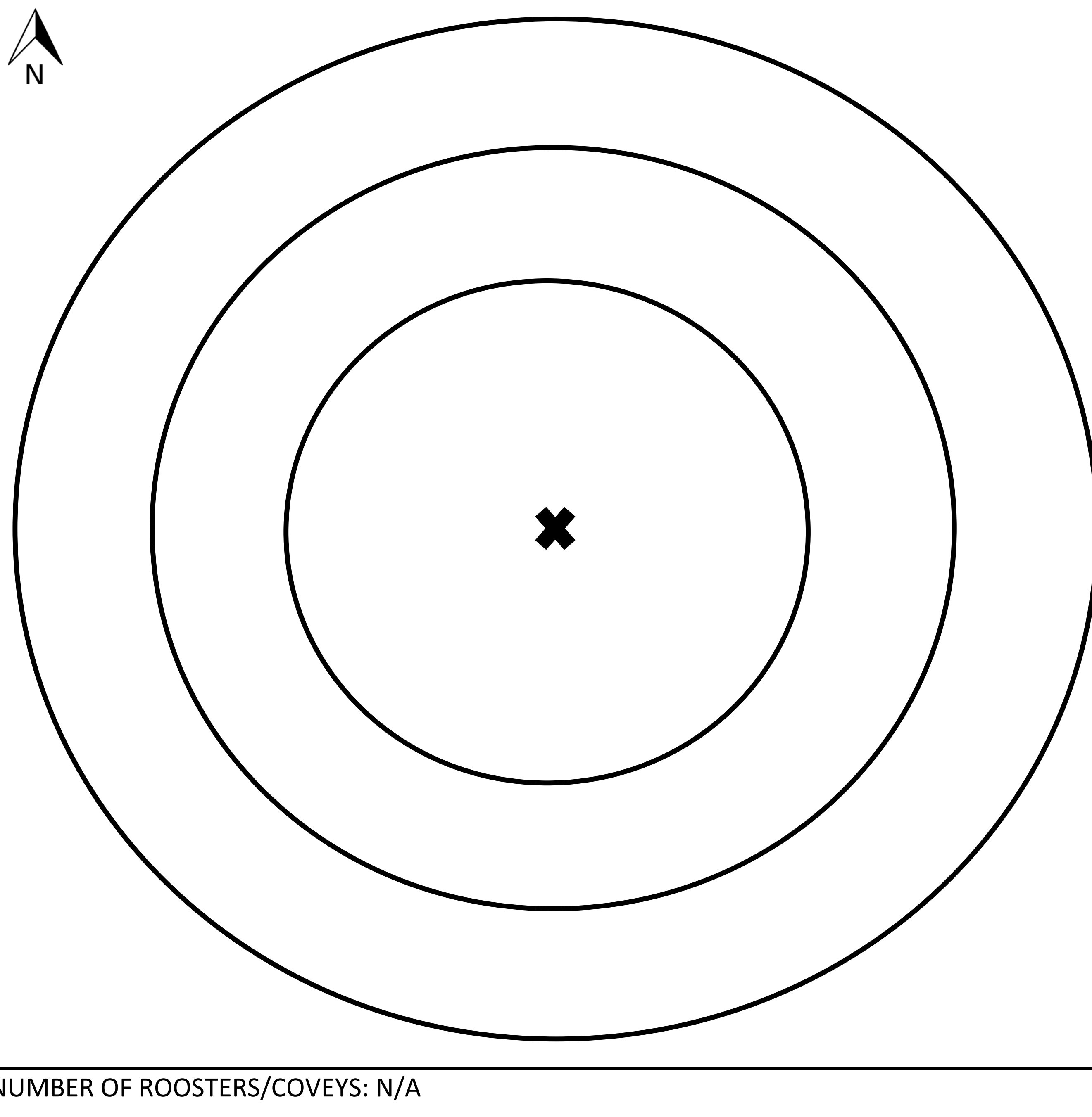


NUMBER OF ROOSTERS/COVEYS: N/A

CALL TALLY: N/A

FIXED POINT CALL COUNTS DATA SHEET

PROPERTY NAME/ID: WCS	DATE:4-24-2019
START TIME: 0756	END TIME: 0802
GPS LOCATION: 32.45281831, -103.0560104	Listening Station: 5
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 52.3° F, Wind Speed Max: 3.9mph, Average: 2.2mph	
HABITAT DESCRIPTION: Grassland, Noise Traffic low	

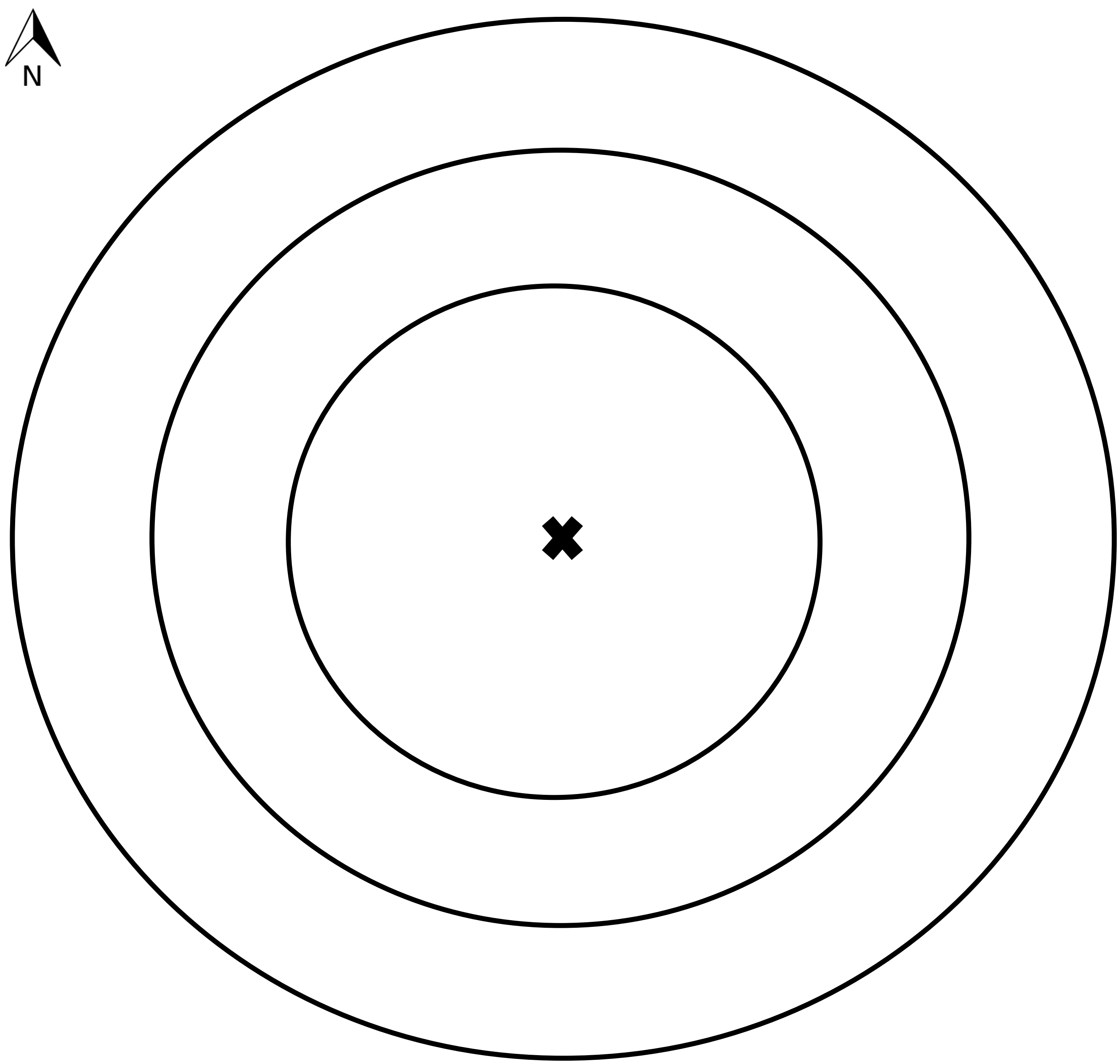


NUMBER OF ROOSTERS/COVEYS: N/A

CALL TALLY: N/A

FIXED POINT CALL COUNTS DATA SHEET

PROPERTY NAME/ID: WCS	DATE:4-24-2019
START TIME: 0807	END TIME: 0812
GPS LOCATION: 32.45281831, -103.0560104	Listening Station: 5
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 50.0° F, Wind Speed Max: 4mph, Average: 2.4mph	
HABITAT DESCRIPTION: Grassland, Noise Traffic low	

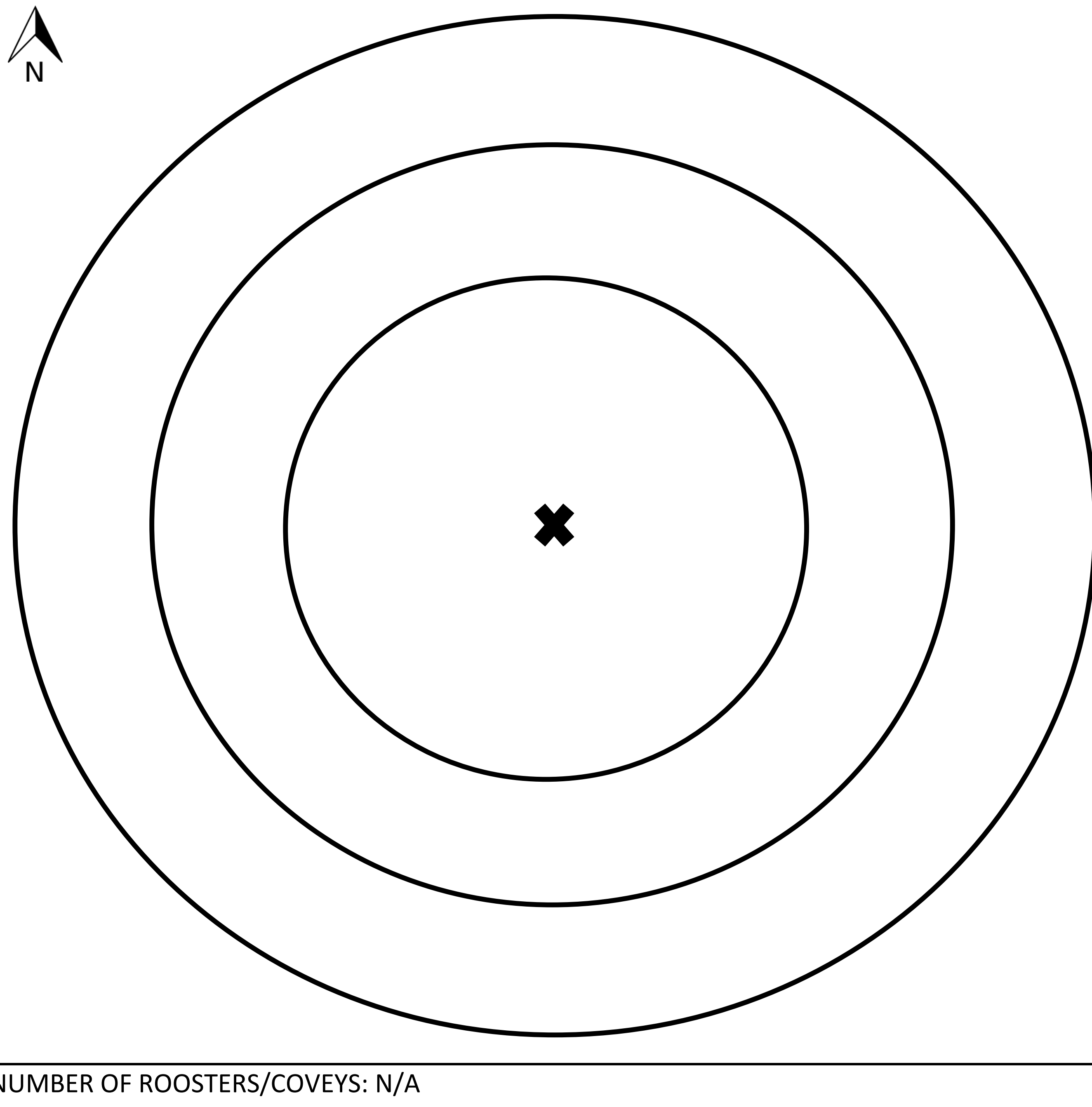


NUMBER OF ROOSTERS/COVEYS: N/A

CALL TALLY: N/A

FIXED POINT CALL COUNTS DATA SHEET

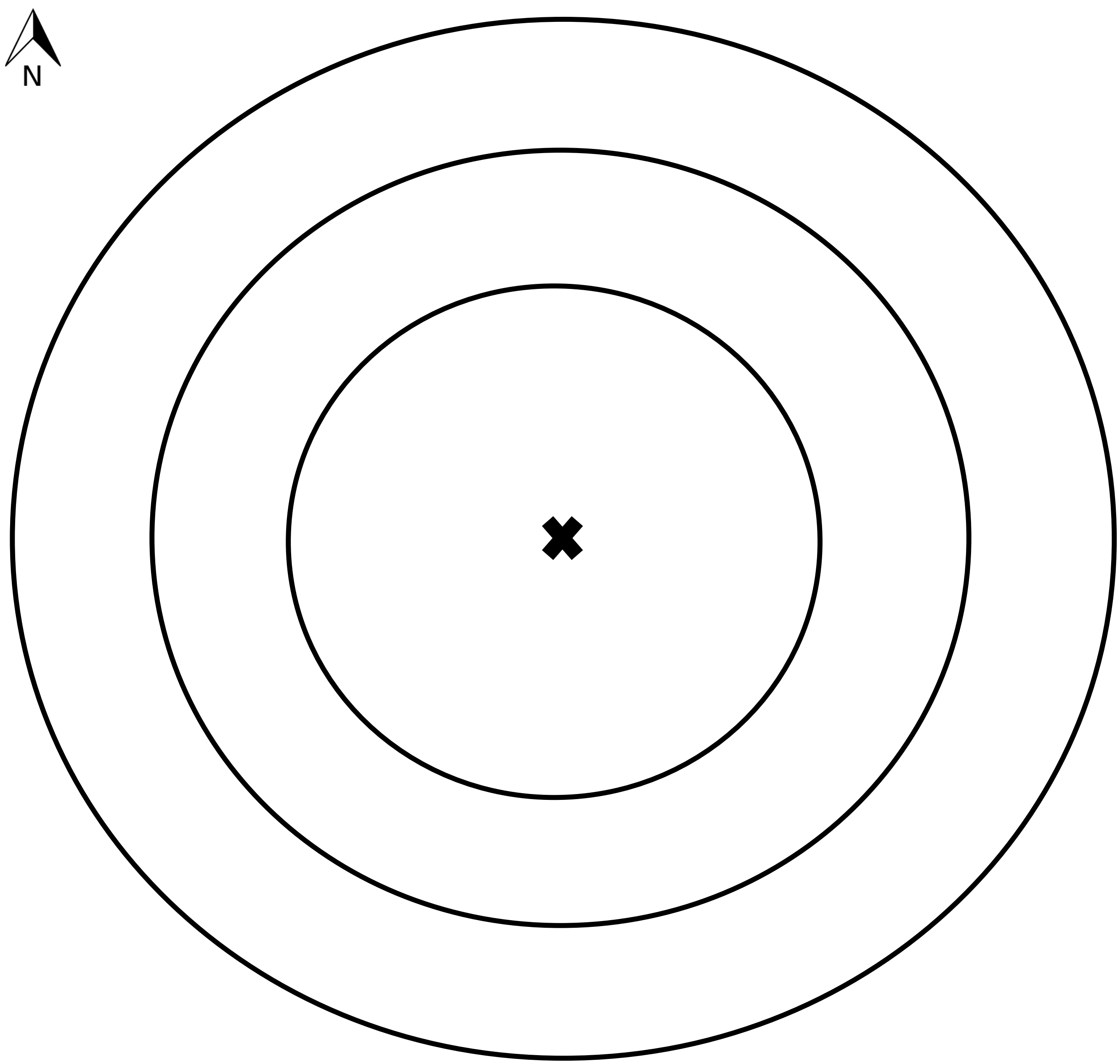
PROPERTY NAME/ID: WCS	DATE:4-24-2019
START TIME: 0818	END TIME: 0822
GPS LOCATION: 32.47649487, -103.031017	Listening Station: 8
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 51.4° F, Wind Speed Max: 3.8mph, Average: 1.9mph	
HABITAT DESCRIPTION: Grassland, Traffic Noise, construction, pumpjack -moderate	



NUMBER OF ROOSTERS/COVEYS: N/A	
CALL TALLY: N/A	

FIXED POINT CALL COUNTS DATA SHEET

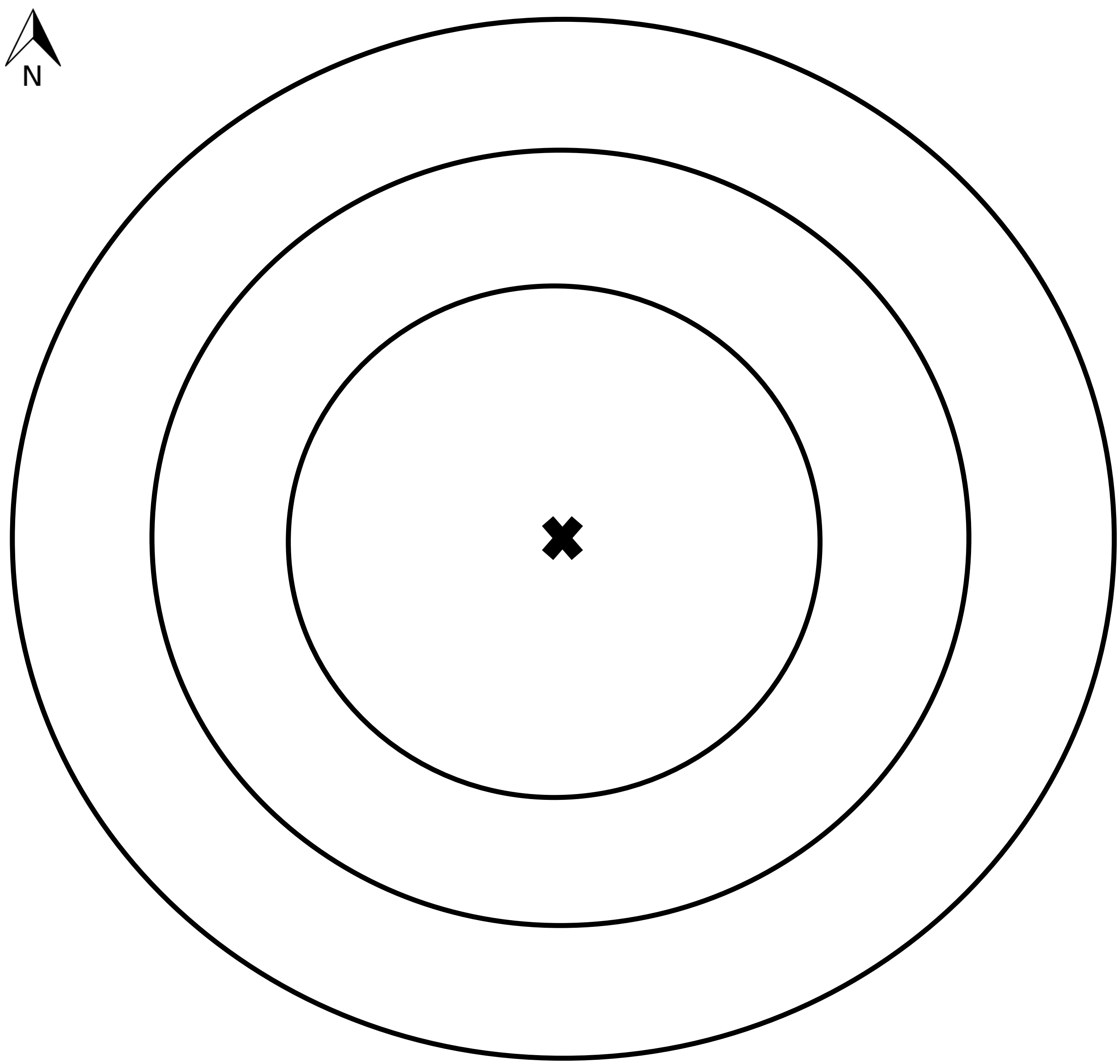
PROPERTY NAME/ID: WCS	DATE:4-25-2019
START TIME: 0641	END TIME: 0646
GPS LOCATION: 32.43322585, -103.1024278	Listening Station: 3
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 46.8° F, Wind Speed Max: 1.9mph, Average: 1.1mph	
HABITAT DESCRIPTION: Grassland, Traffic Noise High	



NUMBER OF ROOSTERS/COVEYS: N/A	
CALL TALLY: N/A	

FIXED POINT CALL COUNTS DATA SHEET

PROPERTY NAME/ID: WCS	DATE:4-25-2019
START TIME: 0650	END TIME: 0655
GPS LOCATION: 32.42819737, -103.0525019	Listening Station: 2
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 51.6° F, Wind Speed Max: 1.5mph, Average: 0.7mph	
HABITAT DESCRIPTION: Grassland, Traffic Noise High	

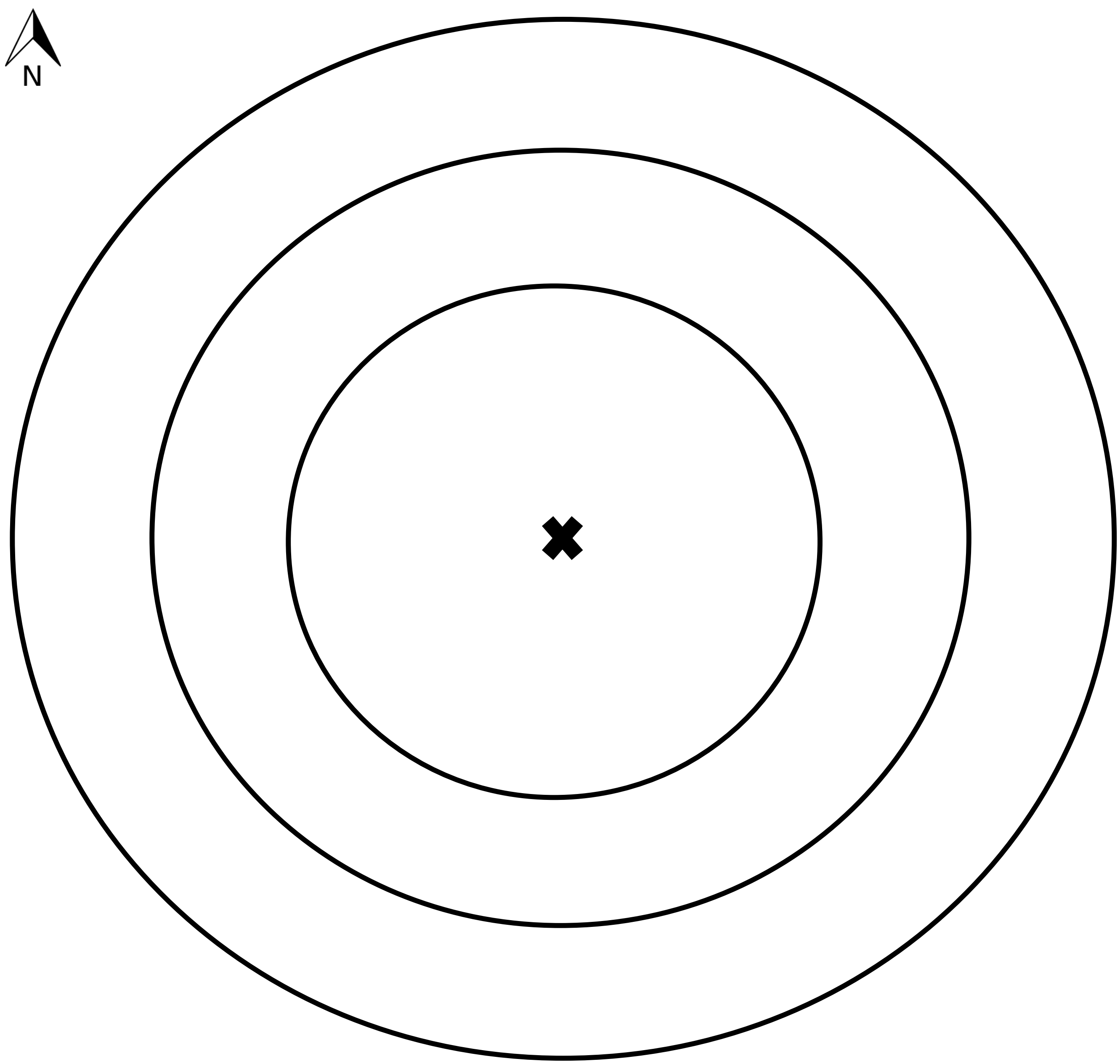


NUMBER OF ROOSTERS/COVEYS: N/A

CALL TALLY: N/A

FIXED POINT CALL COUNTS DATA SHEET

PROPERTY NAME/ID: WCS	DATE:4-25-2019
START TIME: 0657	END TIME: 0702
GPS LOCATION: 32.42790229, -103.0196225	Listening Station: 1
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 50.8° F, Wind Speed Max: 3.6mph, Average: 2.1mph	
HABITAT DESCRIPTION: Grassland, Traffic Noise High	

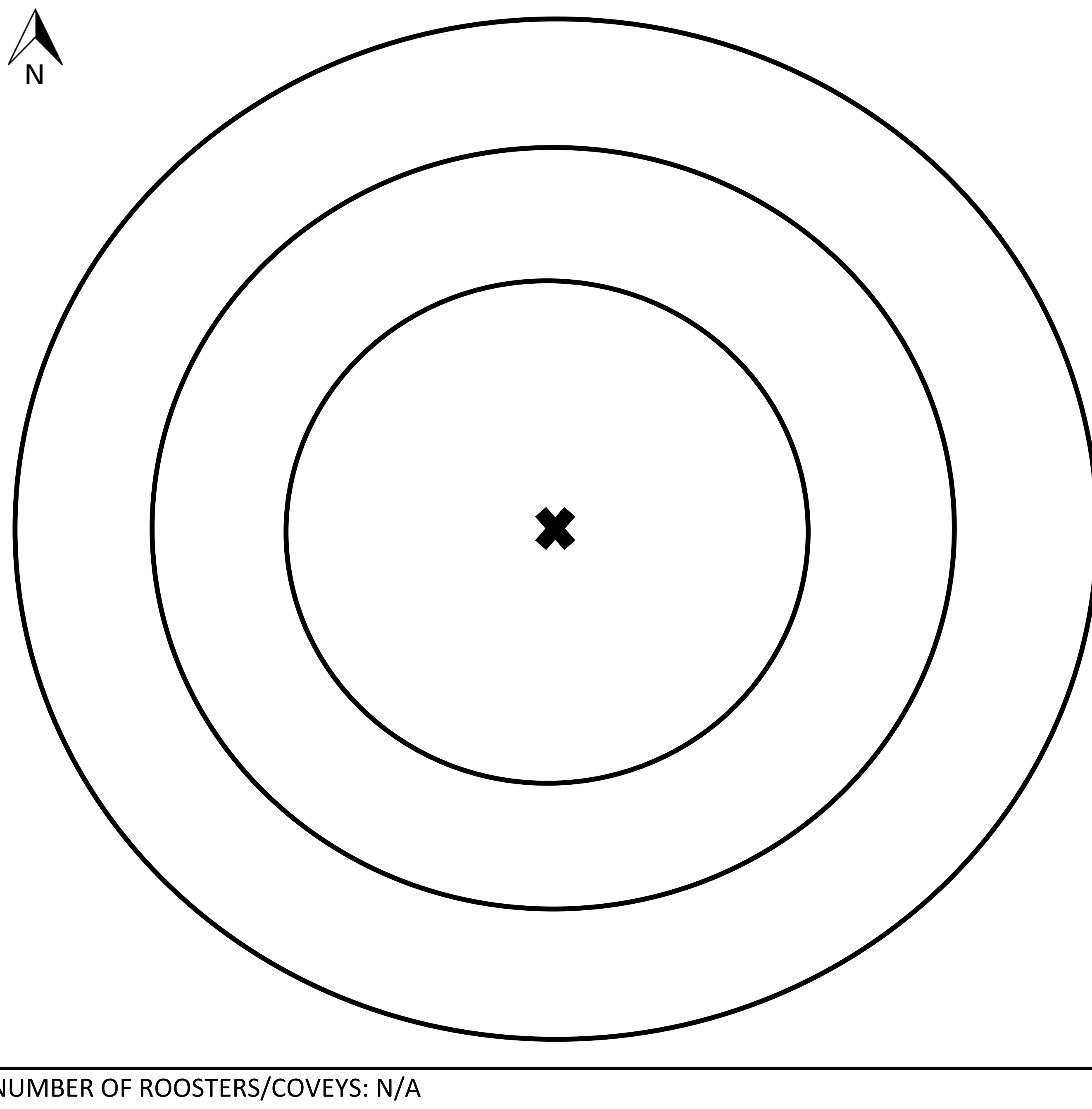


NUMBER OF ROOSTERS/COVEYS: N/A

CALL TALLY: N/A

FIXED POINT CALL COUNTS DATA SHEET

PROPERTY NAME/ID: WCS	DATE:4-25-2019
START TIME: 0720	END TIME: 0725
GPS LOCATION: 32.44915362, -103.0123435	Listening Station: 9
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 51° F, Wind Speed Max: 3.1mph, Average: 1.8mph	
HABITAT DESCRIPTION: Grassland, Traffic Noise Low	

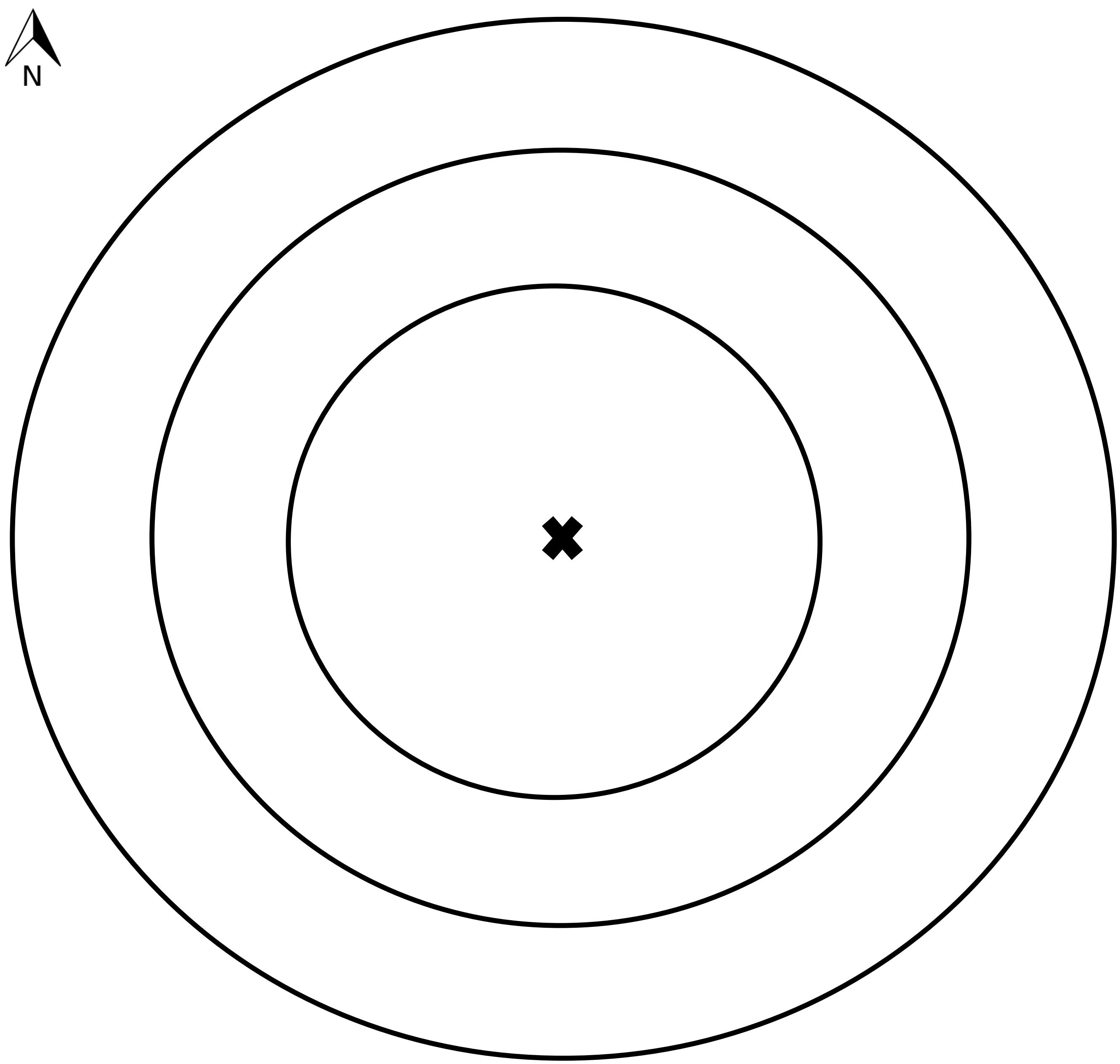


NUMBER OF ROOSTERS/COVEYS: N/A

CALL TALLY: N/A

FIXED POINT CALL COUNTS DATA SHEET

PROPERTY NAME/ID: WCS	DATE:4-25-2019
START TIME: 0743	END TIME: 0748
GPS LOCATION: 32.45281831, -103.0560104	Listening Station: 5
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 53.6° F, Wind Speed Max: 2.1mph, Average: 1.2mph	
HABITAT DESCRIPTION: Grassland, Noise, construction and traffic- low	

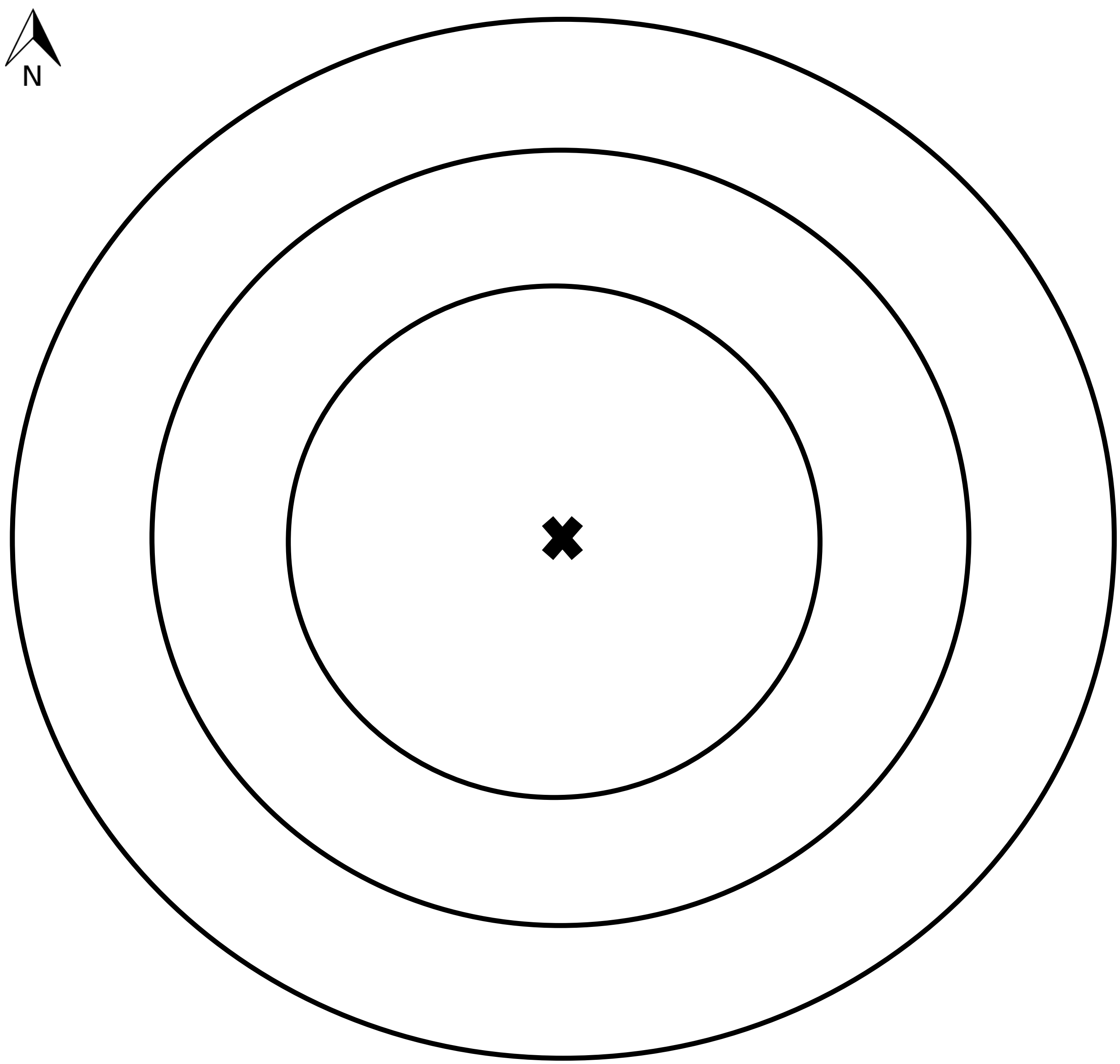


NUMBER OF ROOSTERS/COVEYS: N/A

CALL TALLY: N/A

FIXED POINT CALL COUNTS DATA SHEET

PROPERTY NAME/ID: WCS	DATE:4-25-2019
START TIME: 0800	END TIME: 0805
GPS LOCATION: 32.46703654, -103.0309761	Listening Station: 7
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 56° F, Wind Speed Max: 3.6mph, Average: 2.2mph	
HABITAT DESCRIPTION: Grassland, Noise- moderate: construction/traffic	

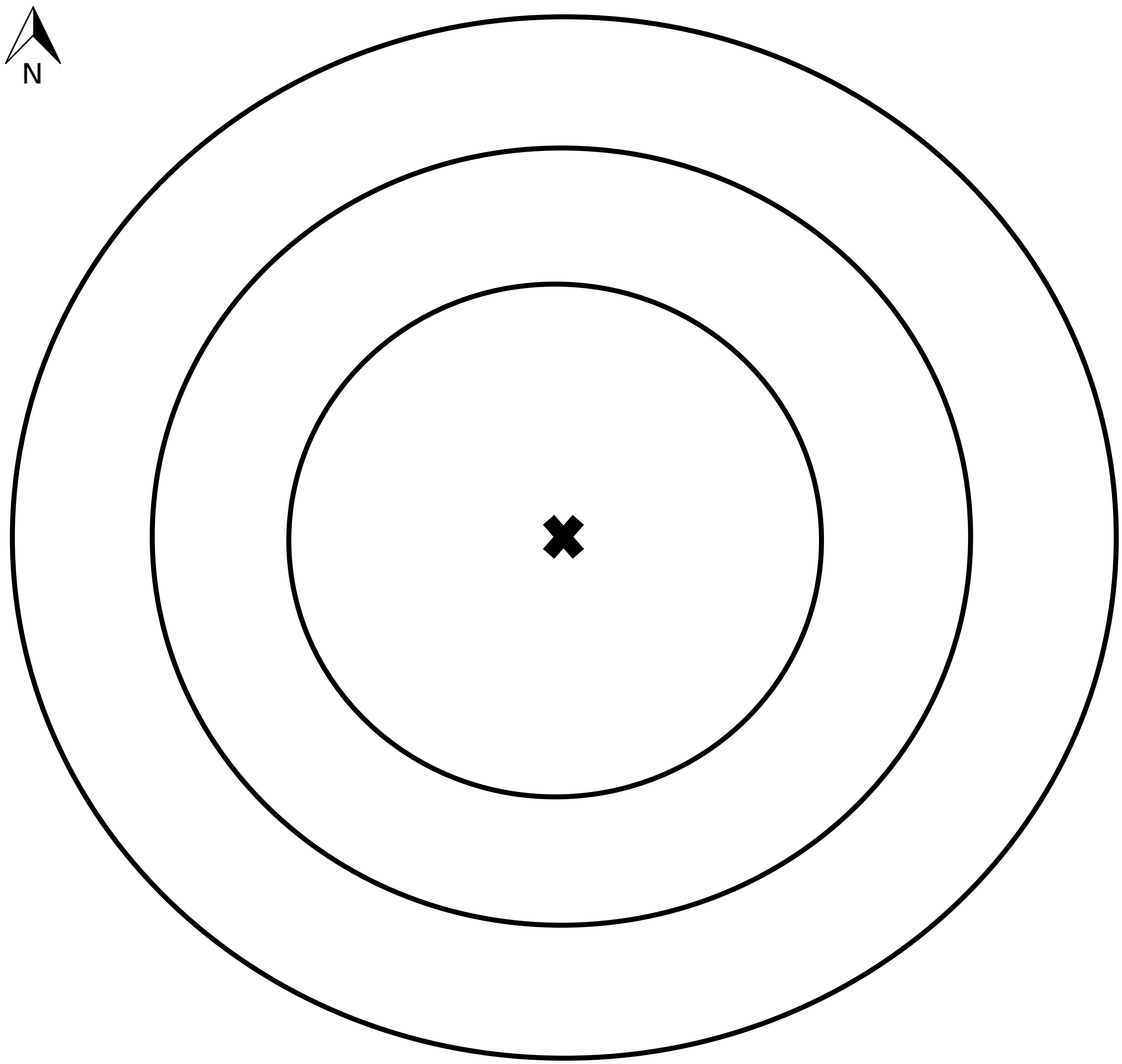


NUMBER OF ROOSTERS/COVEYS: N/A

CALL TALLY: N/A

FIXED POINT CALL COUNTS DATA SHEET

PROPERTY NAME/ID: WCS	DATE:4-25-2019
START TIME: 0811	END TIME: 0816
GPS LOCATION: 32.489425, -103.0647047	Listening Station: 8
OBSERVATION PERIOD: Spring 2019	
WEATHER CONDITIONS: 54.6° F, Wind Speed Max: 3.2mph, Average: 1.9mph	
HABITAT DESCRIPTION: Grassland, Noise moderate- traffic/pumpjack	



NUMBER OF ROOSTERS/COVEYS: N/A
CALL TALLY: N/A

Attachment D - Andrews County Rare, Threatened, and Endangered Species of Texas list

Last Update: 4/15/2019

ANDREWS COUNTY

AMPHIBIANS

Woodhouse's toad *Anaxyrus woodhousii*

Extremely catholic up to 5000 feet, does very well (except for traffic) in association with man.

Federal Status:	State Status:	SGCN: Yes
Endemic: N	Global Rank: G5	State Rank: SU

BIRDS

American peregrine falcon *Falco peregrinus anatum*

Year-round resident and local breeder in west Texas, nests in tall cliff eyries; also, migrant across state from more northern breeding areas in US and Canada, winters along coast and farther south; occupies wide range of habitats during migration, including urban, concentrations along coast and barrier islands; low-altitude migrant, stopovers at leading landscape edges such as lake shores, coastlines, and barrier islands.

Federal Status:	State Status: T	SGCN: Yes
Endemic: N	Global Rank: G4T4	State Rank: S2B

bald eagle *Haliaeetus leucocephalus*

Found primarily near rivers and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds

Federal Status:	State Status: T	SGCN: Yes
Endemic: N	Global Rank: G5	State Rank: S3B,S3N

Franklin's gull *Leucophaeus pipixcan*

Habitat description is not available at this time.

Federal Status:	State Status:	SGCN: Yes
Endemic: N	Global Rank: G4G5	State Rank: S2N

lesser prairie-chicken *Tympanuchus pallidicinctus*

Arid grasslands, generally interspersed with shrubs such as sand sagebrush, sand plum, skunkbush sumac, and shinnery oak shrubs, but dominated by sand dropseed, sideoats grama, sand bluestem, and little bluestem grasses; nests in a scrape lined with grasses

Federal Status:	State Status:	SGCN: Yes
Endemic: N	Global Rank: G3	State Rank: S2

mountain plover *Charadrius montanus*

Breeding: nests on high plains or shortgrass prairie, on ground in shallow depression; nonbreeding: shortgrass plains and bare, dirt (plowed) fields; primarily insectivorous

Federal Status:	State Status:	SGCN: Yes
Endemic: N	Global Rank: G3	State Rank: S2

ANDREWS COUNTY

BIRDS

western burrowing owl *Athene cunicularia hypugaea*

Open grasslands, especially prairie, plains, and savanna, sometimes in open areas such as vacant lots near human habitation or airports; nests and roosts in abandoned burrows

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G4T4 State Rank: S2

white-faced ibis *Plegadis chihi*

Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; currently confined to near-coastal rookeries in so-called hog-wallow prairies. Nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats.

Federal Status: State Status: T SGCN: Yes

Endemic: N Global Rank: G5 State Rank: S4B

FISH

blue sucker *Cycleptus elongatus*

Usually inhabits channels and flowing pools with a moderate current, with bottoms of exposed bedrock sometimes in combination with hard clay, sand, and gravel; generally intolerant of highly turbid conditions.Larger portions of major rivers in Texas; adults winter in deep pools and move upstream in spring to spawn on riffles

Federal Status: State Status: T SGCN: Yes

Endemic: N Global Rank: G3G4 State Rank: S3

headwater catfish *Ictalurus lupus*

Originally throughout streams of the Edwards Plateau and the Rio Grande basin, currently limited to Rio Grande drainage, including Pecos River basin; springs, and sandy and rocky riffles, runs, and pools of clear creeks and small rivers

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G3 State Rank: S2

smalleye shiner *Notropis buccula*

Endemic to upper Brazos River system and its tributaries (Clear Fork and Bosque); apparently introduced into adjacent Colorado River drainage; medium to large prairie streams with sandy substrate and turbid to clear warm water; presumably eats small aquatic invertebrates

Federal Status: LE State Status: SGCN: Yes

Endemic: Y Global Rank: G2 State Rank: S2

INSECTS

No accepted common name *Polyphylla monahansensis*

Habitat description is not available at this time.

Federal Status: State Status: SGCN: Yes

Endemic: Global Rank: GNR State Rank: SNR

ANDREWS COUNTY

INSECTS

No accepted common name *Polyphylla pottsorum*

Habitat description is not available at this time.

Federal Status: State Status: SGCN: Yes

Endemic: Global Rank: GNR State Rank: SNR

MAMMALS

American badger *Taxidea taxus*

Habitat description is not available at this time.

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G5 State Rank: S5

Big Free-tailed Bat *Nyctinomops macrotis*

Habitat data sparse but records indicate that species prefers to roost in crevices and cracks in high canyon walls, but will use buildings, as well; reproduction data sparse, gives birth to single offspring late June-early July; females gather in nursery colonies; winter habits undetermined, but may hibernate in the Trans-Pecos; opportunistic insectivore

Federal Status: State Status: SGCN: Yes

Endemic: Global Rank: G5 State Rank: S3

black-tailed prairie dog *Cynomys ludovicianus*

Dry, flat, short grasslands with low, relatively sparse vegetation, including areas overgrazed by cattle; live in large family groups

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G4 State Rank: S3

eastern red bat *Lasiurus borealis*

Found in a variety of habitats in Texas. Usually associated with wooded areas. Found in towns especially during migration.

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G3G4 State Rank: S4

hoary bat *Lasiurus cinereus*

Known from montane and riparian woodland in Trans-Pecos, forests and woods in east and central Texas.

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G3G4 State Rank: S4

kit fox *Vulpes macrotis*

Open desert grassland; avoids rugged, rocky terrain and wooded areas.

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G4 State Rank: S1S2

ANDREWS COUNTY

MAMMALS

long-tailed weasel *Mustela frenata*

Includes brushlands, fence rows, upland woods and bottomland hardwoods, forest edges & rocky desert scrub. Usually live close to water.

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G5 State Rank: S5

Mexican free-tailed bat *Tadarida brasiliensis*

Roosts in buildings in east Texas. Largest maternity roosts are in limestone caves on the Edwards Plateau. Found in all habitats, forest to desert.

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G5 State Rank: S5

mountain lion *Puma concolor*

Rugged mountains & riparian zones.

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G5 State Rank: S2S3

pronghorn *Antilocapra americana*

Prefers hilly & plateau areas of open grassland, desert-grassland, & desert-scrub, where it frequents south-facing slopes & other sheltered areas.

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G5 State Rank: S5

thirteen-lined ground squirrel *Ictidomys tridecemlineatus*

Habitat description is not available at this time.

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G5 State Rank: S5

western hog-nosed skunk *Conepatus leuconotus*

Habitats include woodlands, grasslands & deserts, to 7200 feet, most common in rugged, rocky canyon country; little is known about the habitat of the ssp. telmalestes

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G4 State Rank: S4

western spotted skunk *Spilogale gracilis*

Habitat description is not available at this time.

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G5 State Rank: S5

ANDREWS COUNTY

REPTILES

dunes sagebrush lizard *Sceloporus arenicolus*

Confined to active sand dunes near Monahans; dwarf shin-oak sandhills with sagebrush and yucca; opportunistic insectivore; sit and wait predator; burrows in sand or plant litter to escape enemies

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G2G3 State Rank: S1

massasauga *Sistrurus tergeminus*

Quite common in gently rolling prairie occasionally broken by creek valley or rocky hillside.

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G3G4 State Rank: S3S4

Texas horned lizard *Phrynosoma cornutum*

Occurs to 6000 feet, but largely limited below the pinyon-juniper zone on mountains in the Big Bend area. Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive; breeds March-September.

Federal Status: State Status: T SGCN: Yes

Endemic: N Global Rank: G4G5 State Rank: S3

western box turtle *Terrapene ornata*

Ornate or western box trutles inhabit prairie grassland, pasture, fields, sandhills, and open woodland. They are essentially terrestrial but sometimes enter slow, shallow streams and creek pools. For shelter, they burrow into soil (e.g., under plants such as yucca) (Converse et al. 2002) or enter burrows made by other species; winter burrow depth was 0.5-1.8 meters in Wisconsin (Doroff and Keith 1990), 7-120 cm (average depth 54 cm) in Nebraska (Converse et al. 2002). Eggs are laid in nests dug in soft well-drained soil in open area (Legler 1960, Converse et al. 2002). Very partial to sandy soil.

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G5 State Rank: S3

western hognose snake *Heterodon nasicus*

Habitat consists of areas with sandy or gravelly soils, including prairies, sandhills, wide valleys, river floodplains, bajadas, semiagricultural areas (but not intensively cultivated land), and margins of irrigation ditches (Degenhardt et al. 1996, Hammerson 1999, Werler and Dixon 2000, Stebbins 2003). Also thornscrub woodlands and chaparral thickets. Seems to prefer sandy and loamy soils, not necessarily flat. Periods of inactivity are spent burrowed in the soil or in existing burrows. Eggs are laid in nests a few inches below the ground surface (Platt 1969).

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G5 State Rank: S4

western rattlesnake *Crotalus viridis*

Grassland, both desert and prairie; shrub desert rocky hillsides; edges of arid and semi-arid river breaks.

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G5 State Rank: S5

ANDREWS COUNTY

PLANTS

Cory's ephedra *Ephedra coryi*

Dune areas and dry grasslands in the southern Plains Country; Perennial; Flowering April-Sept; Fruiting May-Sept

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G3 State Rank: S3

dune umbrella-sedge *Cyperus onerosus*

Moist to wet sand in swales and other depressions among active or partially stabilized sand dunes; flowering/fruiting late summer-fall

Federal Status: State Status: SGCN: Yes

Endemic: Y Global Rank: G2 State Rank: S2

dune unicorn-plant *Proboscidea sabulosa*

Deep, dry to seasonally moist loose sands on sparsely vegetated, unstabilized dunes and in openings in shinneries; in New Mexico, one location found as a secondary successional species in fallow fields; does not germinate in years with inadequate summer rainfall, but may be locally abundant during unusually wet summers; flowering July-August, with fruits maturing in fall

Federal Status: State Status: SGCN: Yes

Endemic: N Global Rank: G3 State Rank: S2

Hinckley's spreadwing *Eurytaenia hinckleyi*

Loose sandy soils of the Monahans/Kermit Sandhills; Annual; Flowering/Fruiting May-July

Federal Status: State Status: SGCN: Yes

Endemic: Y Global Rank: G3 State Rank: S3

Attachment E – USFWS IPaC Report

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Austin Ecological Services Field Office
10711 Burnet Road, Suite 200
Austin, TX 78758-4460
Phone: (512) 490-0057 Fax: (512) 490-0974
http://www.fws.gov/southwest/es/AustinTexas/
http://www.fws.gov/southwest/es/EndangeredSpecies/lists/

In Reply Refer To: June 19, 2019
Consultation Code: 02ETAU00-2019-SLI-1044
Event Code: 02ETAU00-2019-E-02619
Project Name: WCS

Subject: Updated list of threatened and endangered species that may occur in your proposed project location, and/or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, that *may* occur within the county of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.).

Please note that new information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Also note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the ECOS-IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 *et seq.*), Federal agencies are required to utilize their authorities to carry out programs for the conservation of federally listed as threatened or endangered species and to determine whether projects may affect these species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

While a Federal agency may designate a non-Federal representative to conduct informal consultation or prepare a biological assessment, the Federal Agency must notify the Service in writing of any such designation. The Federal agency shall also independently review and evaluate the scope and content of a biological assessment prepared by their designated non-Federal representative before that document is submitted to the Service.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by a federally funded, permitted or authorized activity, the agency is required to consult with the Service pursuant to 50 CFR 402. The following definitions are provided to assist you in reaching a determination:

- *No effect* - the proposed action will not affect federally listed species or critical habitat. A “no effect” determination does not require section 7 consultation and no coordination or contact with the Service is necessary. However, if the project changes or additional information on the distribution of listed or proposed species becomes available, the project should be reanalyzed for effects not previously considered.
- *May affect, but is not likely to adversely affect* - the project may affect listed species and/or critical habitat; however, the effects are expected to be discountable, insignificant, or completely beneficial. Certain avoidance and minimization measures may need to be implemented in order to reach this level of effect. The Federal agency or the designated non-Federal representative should consult with the Service to seek written concurrence that adverse effects are not likely. Be sure to include all of the information and documentation used to reach your decision with your request for concurrence. The Service must have this documentation before issuing a concurrence.
- *Is likely to adversely affect* - adverse effects to listed species may occur as a direct or indirect result of the proposed action. For this determination, the effect of the action is neither discountable nor insignificant. If the overall effect of the proposed action is beneficial to the listed species but the action is also likely to cause some adverse effects to individuals of that species, then the proposed action “is likely to adversely affect” the listed species. The analysis should consider all interrelated and interdependent actions. An “is likely to adversely affect” determination requires the Federal action agency to initiate formal section 7 consultation with our office.

Regardless of the determination, the Service recommends that the Federal agency maintain a complete record of the evaluation, including steps leading to the determination of effect, the qualified personnel conducting the evaluation, habitat conditions, site photographs, and any other related information. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at: http://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF.

Migratory Birds

For projects that may affect migratory birds, the Migratory Bird Treaty Act (MBTA) implements various treaties and conventions for the protection of these species. Under the MBTA, taking, killing, or possessing migratory birds is unlawful. Migratory birds may nest in trees, brushy areas, or other areas of suitable habitat. The Service recommends activities requiring vegetation removal or disturbance avoid the peak nesting period of March through August to avoid destruction of individuals, nests, or eggs. If project activities must be conducted during this time, we recommend surveying for nests prior to conducting work. If a nest is found, and if possible, the Service recommends a buffer of vegetation remain around the nest until the young have fledged or the nest is abandoned.

For additional information concerning the MBTA and recommendations to reduce impacts to migratory birds please contact the U.S. Fish and Wildlife Service Migratory Birds Office, 500 Gold Ave. SW, Albuquerque, NM 87102. A list of migratory birds may be viewed at https://www.fws.gov/birds/management/managed-species/migratory-bird-treaty-act-protected-species.php. Guidance for minimizing impacts to migratory birds for projects including communications towers can be found at: https://www.fws.gov/birds/management/project-assessment-tools-and-guidance/guidance-documents/communication-towers.php. Additionally, wind energy projects should follow the wind energy guidelines

https://www.fws.gov/birds/management/project-assessment-tools-and-guidance/guidance-documents/wind-energy.php) for minimizing impacts to migratory birds and bats.

Finally, please be aware that bald and golden eagles are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668 et seq.), and projects affecting these species may require development of an eagle conservation plan https://www.fws.gov/birds/management/project-assessment-tools-and-guidance/guidance-documents/eagles.php.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Tracking Number in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment(s):

- Official Species List

Official Species List

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

Austin Ecological Services Field Office
10711 Burnet Road, Suite 200
Austin, TX 78758-4460
(512) 490-0057

Project Summary

Consultation Code: 02ETAU00-2019-SLI-1044

Event Code: 02ETAU00-2019-E-02619

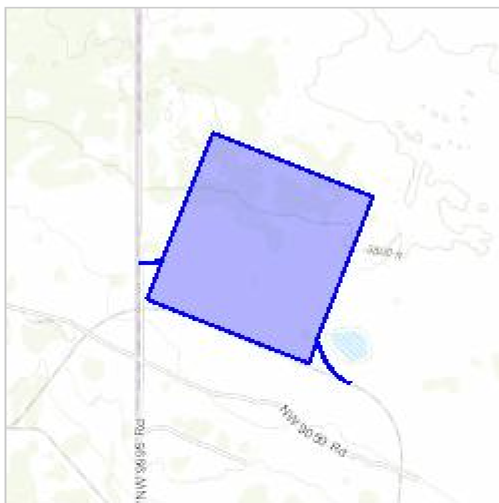
Project Name: WCS

Project Type: Landfill

Project Description: Potential disposal site

Project Location:

Approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/place/32.45280859712197N103.0564301707575W



Counties: Andrews, TX

Endangered Species Act Species

There is a total of 4 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species. Note that 3 of these species should be considered only under certain conditions.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

Birds

NAME	STATUS
Least Tern *Sterna antillarum* Population: interior pop. No critical habitat has been designated for this species. This species only needs to be considered under the following conditions: ▪ Wind Energy Projects Species profile: https://ecos.fws.gov/ecp/species/8505	Endangered
Northern Aplomado Falcon *Falco femoralis septentrionalis* Population: Wherever found, except where listed as an experimental population No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/1923	Endangered
Piping Plover *Charadrius melodus* Population: [Atlantic Coast and Northern Great Plains populations] - Wherever found, except those areas where listed as endangered. There is **final** critical habitat for this species. Your location is outside the critical habitat. This species only needs to be considered under the following conditions: ▪ Wind Energy Projects Species profile: https://ecos.fws.gov/ecp/species/6039	Threatened
Red Knot *Calidris canutus rufa* No critical habitat has been designated for this species. This species only needs to be considered under the following conditions: ▪ Wind Energy Projects Species profile: https://ecos.fws.gov/ecp/species/1864	Threatened

Critical habitats

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

ATTACHMENT 4-1

EXPLANATION OF TRANSPORTATION ANALYSIS

Explanation of Transportation Analysis

Collective and occupational doses were calculated for incident-free shipments between twelve shutdown reactor sites and the WCS Consolidated Interim Storage Facility (CISF) in Andrews County, Texas, and between the CISF and Yucca Mountain using risk factor output from RADTRAN 6 together with routing and population density output from WebTRAGIS. Doses were also calculated for shipments where an accident occurs.

RADTRAN is a computer code that allows the calculation of unit risk factors (URF) for the shipment of one SNF transport cask over one kilometer through a population density of one person per square kilometer. User input parameters are used to define the characteristics of the cask, route and source terms for a shipment. The URF differs for rural, suburban and urban route segments due to differences in environmental shielding. The URF values are output in RADTRAN 6 as values for rural, suburban or urban route segments and have the units of person-rem per kilometer per person-per-square-kilometer.

WebTRAGIS is a computer code that allows determination of route length and state-level population density for rural, suburban, and urban route segments. ISP used the RADTRAN 1 mile (1.6 kilometers) transport corridor width (0.5 miles on each side of the vehicle). To calculate collective dose, the URF calculated by RADTRAN was multiplied by the length of the transport route and the population density from WebTRAGIS for rural, suburban, and urban route segments in an Excel spreadsheet. Collective doses calculated for routes between the twelve sites and the CISF and between Yucca Mountain and the CSIF were all of the same order of magnitude. The bounding collective dose was for the longest transport route, Maine Yankee Nuclear Power Plant to the WCS CISF, at approximately 4.36E-02 person-rem per shipment (8.73 person-rem for an annual shipment of 200 casks).

RADTRAN was also used to calculate occupational dose. Doses to inspectors, rail yard workers, and first responders were determined by inputting appropriate values into transport “stops” in the RADTRAN code. The main inputs for stops are distance from the source, exposure time, and number of persons exposed. Occupational dose to transport crews and escorts are determined by multiplying the URF for the crews by the route distance and number of persons. Escorts are assumed to have a 25% higher dose than crew because they have to be in line of sight to the SNF and have less shielding. Occupational doses calculated during incident-free shipment for the twelve sites to Yucca Mountain are small and remain bounded by the collective dose for the longest transport route, Maine Yankee Nuclear Power Plant to the WCS CISF.

Accidents with no release resulted in doses that are small, with first responders being the maximally-exposed individual (MEI) receiving an occupational dose of 1.60E-01 rem after 10 hours at 3 meters (see Table 4.2-10 of Section 4.2.7.2). Accidents with loss of shielding (LOS) resulted in a dose to the MEI of 8.1E-3 Sv (0.81 rem) per hour at 5 meters (LOS due to fire), or 7.1E-3 Sv (0.71 rem) per hour at 5 meters (LOS due to impact). Accidents with release result in an occupational dose to the MEI of 7.71 rem after 1 day within 33 meters. LOS Accident doses are included in Table 4.2-16 of Section 4.2.8.3.

For accidents with release, collective doses were also calculated. The internal collective dose was calculated by multiplying the transport accident rate, cask damage conditional probability, route length, population density, plume area of release and the sum of the internal doses (inhalation and re-suspension). The external collective dose was calculated by multiplying the transport accident rate, cask damage conditional probability, route length, population density, plume area of release and the sum of the external doses (cloud-shine and ground-shine). Release parameters were taken for casks sealed with elastomeric or metal O-rings with uncanisterized SNF, which is a very conservative approach for shipments of canisterized SNF since NUREG-2125 concluded that there would be no release from such casks.

The RADTRAN input parameters used in calculating the URF are shown in Table 4.1-1 with the exception of the radionuclide inventory values used in transportation accident release calculations which are included in Table 4.1-2. As described in Section 4.2.8.2 the radionuclides and values are based on a NUHOMS® 61BT canister containing sixty-one 7x7 BWR assemblies in the NUHOMS® MP197 shipping cask. The SNF has a burnup of 40,000 MWd/MTU, an initial average bundle enrichment of 3.3 weight percent and is 10 year cooled.

The pertinent portions of the spreadsheets for calculating collective doses for a single shipment are included in Table 4.1-3. The spreadsheets, and results in Table 4.1-3 include the following representative routes and modes of transport:

1. Maine Yankee
    a. Maine Yankee to Portland ME (Barge)
    b. Portland ME to Monahans TX (Rail)
    c. Maine Yankee to Monahan's TX (Rail)
2. Yankee Rowe
    a. Yankee Rowe to Albany NY (Heavy Haul Truck)
    b. Albany NY to Monahans TX (Rail)
    c. Yankee Rowe to Monahans TX (Rail)
3. Connecticut Yankee
    a. Haddam Neck to Middletown Junction (Heavy Haul Truck)
    b. Middletown Junction to Monahans TX (Rail)
    c. Haddam Neck to New Haven CT (Barge)
    d. New Haven CT to Monahans TX (Rail)
4. Humboldt Bay
    a. Humboldt Bay to San Francisco, CA (Barge)
    b. San Francisco, CA to Monahans TX (Rail)
5. Big Rock Point
    a. Big Rock Point to Cadillac MI (Heavy Haul Truck)
    b. Cadillac MI to Monahans TX (Rail)
6. Rancho Seco
    a. Rancho Seco to Monahans TX (Rail)
7. Trojan
    a. Trojan to Monahans TX (Rail)

   b. Trojan to Willamette River, Portland OR (Barge)
   c. Willamette River, Portland OR to Monahans TX (Rail)

8. LaCrosse
   a. LaCrosse to Monahans TX (Rail)
   b. LaCrosse to Genoa WI (Barge)
   c. Genoa WI to Monahans TX (Rail)
9. Zion
   a. Zion to Monahans TX (Rail)
   b. Zion to Rock Island-Davenport (Barge)
   c. Rock Island-Davenport to Monahans TX (Rail)
10. Crystal River
    a. Crystal River to Monahans TX (Rail)
11. Kewaunee
    a. Kewaunee to Green Bay, WI (Heavy Haul Truck)
    b. Green Bay, WI to Monahans TX (Rail)
12. San Onofre
    a. San Onofre to Monahans TX (Rail)
13. WCS to Yucca Mountain

Occupational dose for accidents during SNF transport for the twelve shutdown reactor sites plus Yucca Mountain were also calculated using RADTRAN and WebTRAGIS, with the MEI being the bounding individual for occupational dose. Accidents with no releases, accidents with loss of shielding (LOS, resulting from impact or fire), and accidents with releases were considered. Table 4.1-4 is a copy of the pertinent portion of the spreadsheet used to assess occupational doses from routine, incident-free transportation of SNF on a per shipment basis.

Table 4.1-1
Input Parameters for RADTRAN 6
(2 pages)

Package-Specific Parameters		
PARAMETER	VALUE	SOURCE
Dose Rate at 1 meter (mrem/hr.)	14.00	Estimate based on dose limit of two meters from package surface of 10 mrem/hr.
Gamma fraction	0.41	Table A.5-1, MP197 Transportation Safety Analysis Report, Rev.14.
Neutron Fraction	0.59	MP197 Transportation Safety Analysis Report, Rev.14.
Length (Longest Dimension in meters)	5.28	NRC Certificate of Compliance No. 9302; Cask Length

Vehicle-Specific Parameters		
PARAMETER	VALUE	SOURCE
Exclusive Use	Yes	NRC Certificate of Compliance No. 9302
Transportation Mode	Rail	NRC Certificate of Compliance No. 9302
Dose Rate at 1 meter (mrem/hr.)	14.00	Estimate based on dose limit of two meters from vehicle (package) surface of 10 mrem/hr.
Gamma fraction	0.41	See above
Neutron Fraction	0.59	See above
Length	5.28	NRC Certificate of Compliance No. 9302; Same as Cask Length
Number of shipments	1	Unit Risk Factor (one shipment travelling one kilometer past a population density of one person per square kilometer)
Number of crew	3	NUREG-2125, Page B-38
Distance of crew to cask (m)	150	Data Entry for RADTRAN in NUREG-2125, Figure B-6
Crew Shielding Factor	1	Data Entry for RADTRAN in NUREG-2125, Figure B-6; accounts for shielding in rail cars.
Crew View Dimension (m)	2.30	NRC Certificate of Compliance No. 9302; Cask Diameter
Number of casks per railcar	1	Unit Risk Factor (one shipment travelling one kilometer past a population density of one person per square kilometer)

Table 4.1-1
Input Parameters for RADTRAN 6
(Continued)

Route Parameters for Unit Risk Calculations		
PARAMETER	VALUE	SOURCE
Rural vehicle speed (km/hr.)	40.4	Maximum speed limit is 80 km/hr. per Association of American Railroads Circular OT-55-P
Suburban vehicle speed (km/hr.)	40.4	Assumed Lower Speed for Suburban Areas
Urban vehicle speed (km/hr.)	24.0	Assumed Lower Speed for Urban Areas
Barge Speed (km/hr.)	12.8	Used in NUREG-2125
Heavy Haul speed (km/hr.)	32.2	Used in FEIS for Yucca Mountain
Rural vehicle density (railcars/hr.)	17	NUREG-2125, Table B-2
Suburban vehicle density (railcars/hr.)	17	NUREG-2125, Table B-2
Urban vehicle density (railcars/hr.)	17	NUREG-2125, Table B-2
Persons (Crew) per vehicle	3	NUREG-2125, Page B-38
Farm Fraction (rural)	0.5	NUREG-2125, Table B-2
Farm Fraction (suburban)	0.0	Data Entry for RADTRAN in NUREG-2125, Figure B-6
Farm Fraction (urban)	0.0	Data Entry for RADTRAN in NUREG-2125, Figure B-6
Minimum distance of stop from nearby residents (m)	200	NUREG-2125, Table 2-10
Maximum distance of stop from nearby residents (m)	800	NUREG-2125, Table 2-10
Stop time for classification (hours)	27	NUREG-2125, Table 2-10
Stop time in transit for railroad change (hours)	4	NUREG-2125, Table 2-10
Escort Distance from Cask (m)	16	NUREG-2125, Table B-2

Accident Parameters used in RADTRAN		
Train Accident Rate (accidents/km)	1.1E-07	NUREG-2125, Section 5.2
Accident Severities (Conditional Probabilities) and Release Fractions	Various	NUREG-2125, Table E-16 Note: Release fractions equal rod to cask release fraction times cask to environment release fraction.
Loss of Shielding Parameters	Various	NUREG-2125, Table E-2

Table 4.1-2
Radionuclide Inventory used in Transportation Accident release Calculations

Radionuclide	Curies	TBq	Physical Group
H-3	3.90E+03	1.44E+02	GAS
KR-85	1.03E+03	3.81E+01	GAS
I-129	7.62E-03	2.82E-04	GAS
CO-60	1.22E-02	4.51E-04	CRUD
SR-90	8.30E+05	3.07E+04	PARTICULATE
CS-134	7.93E+04	2.93E+03	VOLATILE
CS-137	1.23E+06	4.56E+04	VOLATILE
PU-241	1.10E+06	4.09E+04	VOLATILE
Y-90	8.30E+05	3.07E+04	PARTICULATE
RU-106	7.02E+03	2.60E+02	PARTICULATE
SB-125	8.05E+03	2.98E+02	PARTICULATE
PM-147	1.28E+05	4.74E+03	PARTICULATE
SM-151	4.62E+03	1.71E+02	PARTICULATE
EU-154	8.05E+04	2.98E+03	PARTICULATE
EU-155	2.81E+04	1.04E+03	PARTICULATE
PU-238	5.00E+04	1.85E+03	PARTICULATE
PU-239	3.86E+03	1.43E+02	PARTICULATE
PU-240	6.65E+03	2.46E+02	PARTICULATE
AM-241	2.48E+04	9.16E+02	PARTICULATE

Table 4.1-3
Pertinent Portions Of The Spreadsheets For Calculating Collective Doses For A Single Shipment
(15 pages)

Maine Yankee

Maine Yankee to the WCS CISF by Rail									
	Rural Pop	Rural	Rural	Suburban	Suburban	Suburban	Urban	Urban	Urban
	Density	Distance	Population	Density	Distance	Population	Density	Distance	Population
State	per/sq mi	mile		per/sq mi	mile		per/sq mi	mile	
CT	95.90	10.2	978	1447.70	104.35	151067	8130.70	36.41	296039
IL	21.10	181.18	3823	1235.00	54.28	67036	4687.80	10.38	48659
IN	43.90	88.83	3900	1075.80	80.8	86925	4598.40	9.66	44421
KS	20.40	74	1510	1028.00	16.93	17404	0.00	0.00	0
MA	73.50	10.33	759	1215.40	57.07	69363	7653.00	19.52	149387
ME	79.30	28.54	2263	1049.30	54.45	57134	5644.70	7.40	41771
MO	30.50	258.84	7895	1164.20	116.9	136095	3785.10	8.22	31114
NH	91.40	5.9	539	873.10	25.62	22369	5916.10	3.27	19346
NJ	66.90	18.13	1213	1268.10	50.1	63532	7756.20	28.96	224620
NY	47.50	109.67	5209	1236.10	61.63	76181	16710.70	40.71	680293
OH	40.10	206.65	8287	734.80	59.03	43375	4486.10	5.01	22475
OK	35.40	220.1	7792	1130.60	107.56	121607	6666.10	5.90	39330
PA	54.30	249.26	13535	1030.00	167.84	172875	5758.30	23.71	136529
TX	28.10	389.22	10937	868.90	105.97	92077	5205.70	16.18	84228
WV	63.50	3.43	218	785.00	1.37	1075	0.00	0.00	0
total dist		1854.28			1063.9			215.33	
km		2984.18			1712.18			346.54	
population			68857			1178116			1818210
PD (per/sq km	14.42			430.05			3279.21		
person-rem			2.63E-03			3.92E-02			2.10E-03

Table 4.1-3
Pertinent Portions Of The Spreadsheets For Calculating Collective Doses For A Single Shipment
(Continued)

Maine Yankee

Maine Yankeee to Portland by Barge									
	Rural Pop	Rural	Rural	Suburban	Suburban	Suburban	Urban	Urban	Urban
	Density	Distance	Population	Density	Distance	Population	Density	Distance	Population
State	per/sq mi	mile		per/sq mi	mile		per/sq mi	mile	
ME	13	26.64	346	414.1	1.73	716	3912.1	0.38	1487
total dist		26.64			1.73			0.38	
km		42.87			2.78			0.61	
population			346			716			1487
PD (per/sq km)	5.05			160.83			1519.29		
person-rem			8.27E-05			1.49E-04			1.07E-05

Portland to the WCS CISF by Rail									
	Rural Pop	Rural	Rural	Suburban	Suburban	Suburban	Urban	Urban	Urban
	Density	Distance	Population	Density	Distance	Population	Density	Distance	Population
State	per/sq mi	mile		per/sq mi	mile		per/sq mi	mile	
CT	95.9	10.2	978	1447.7	104.35	151067	8130.7	36.41	296039
IL	21.1	181.18	3823	1235	54.28	67036	4687.8	10.38	48659
IN	43.9	88.83	3900	1075.8	80.8	86925	4598.4	9.66	44421
KS	20.4	74	1510	1028	16.93	17404	0	0	0
MA	73.5	10.33	759	1215.4	57.07	69363	7653	19.52	149387
ME	79.3	12.89	1022	1049.3	28.06	29443	5644.7	2.15	12136
MO	30.5	258.84	7895	1164.2	116.9	136095	3785.1	8.22	31114
NH	91.4	5.9	539	873.1	25.62	22369	5916.1	3.27	19346
NJ	66.9	18.13	1213	1268.1	50.1	63532	7756.2	28.96	224620
NY	47.5	109.67	5209	1236.1	61.63	76181	16710.7	40.71	680293
OH	40.1	206.65	8287	734.8	59.03	43375	4486.1	5.01	22475
OK	35.4	220.1	7792	1130.6	107.56	121607	6666.1	5.9	39330
PA	54.3	249.26	13535	1030	167.84	172875	5758.3	23.71	136529
TX	28.1	389.22	10937	868.9	105.97	92077	5205.7	16.18	84228
WV	63.5	3.43	218	785	1.37	1075	0	0	0
total dist		1838.63			1037.51			210.08	
km		2958.99			1669.71			338.09	
population			67616			1150425			1788576
PD (per/sq km	14.28			430.62			3306.38		
person-rem			2.58E-03			3.83E-02			2.07E-03

Table 4.1-3
Pertinent Portions Of The Spreadsheets For Calculating Collective Doses For A Single Shipment
(Continued)

Yankee Rowe

Yankee Rowe to Albany by Heavy Haul

State	Rural Pop Density per/sq mi	Rural Distance mile	Rural Population	Suburban Density per/sq mi	Suburban Distance mile	Suburban Population	Urban Density per/sq mi	Urban Distance mile	Urban Population
MA	3.5	1.55	5	0	0	0	0	0	0
NY	55.1	16.02	883	1814.7	11.23	20379	6491.2	7.24	46996
VT	14	18.13	254	645.7	2.17	1401	5161.4	0.83	4284
total dist		35.7			13.4			8.07	
km		57.45			21.57			12.99	
population			1142			21780			51280
PD (per/sq km	12.42			631.23			2467.78		
person-rem			1.09E-04			1.81E-03			1.48E-04

Albany to the WCS CISF by Rail

State	Rural Pop Density per/sq mi	Rural Distance mile	Rural Population	Suburban Density per/sq mi	Suburban Distance mile	Suburban Population	Urban Density per/sq mi	Urban Distance mile	Urban Population
IA	57.3	14.28	818	478.6	5.51	2637	0	0	0
IL	21.5	162.85	3501	1398.4	62.55	87470	4854.4	14.51	70437
IN	41.9	90.88	3808	985.4	50.42	49684	4686.5	2.84	13310
KS	28.5	124.58	3551	1194.3	30.92	36928	3876.6	5.26	20391
MO	28.1	176.88	4970	1133.3	20.39	23108	9425.9	5.7	53728
NY	62.5	174.07	10879	1152	160.33	184700	5571.8	25.88	144198
OH	50.4	128.34	6468	1348.7	99.12	133683	4332.3	19.54	84653
OK	29.6	187.56	5552	1107.5	54.46	60314	3532.1	1.87	6605
PA	61.2	18.89	1156	1760	19.45	34232	5934.1	5.51	32697
TX	31.5	314.73	9914	1033.2	131.95	136331	5142.5	17.2	88451
total dist		1393.06			635.1			98.31	
km		2241.92			1022.10			158.21	
population			50618			749087			514470
PD (per/sq km)	14.11			458.06			2032.32		
person-rem			1.93E-03			2.49E-02			5.95E-04

Table 4.1-3
Pertinent Portions Of The Spreadsheets For Calculating Collective Doses For A Single Shipment
(Continued)

Connecticut Yankee

Haddam Neck to New Haven by Barge

	Rural Pop	Rural	Rural	Suburban	Suburban	Suburban	Urban	Urban	Urban
	Density	Distance	Population	Density	Distance	Population	Density	Distance	Population
State	per/sq mi	mile		per/sq mi	mile		per/sq mi	mile	
CT	20.6	56.53	1165	1665.6	7.17	11942.352	6749.1	0.82	5534.262
total dist		56.53			7.17			0.82	
km		90.98			11.54			1.32	
population			1165			11942			5534
PD (per/sq km)	8.00			646.85			2621.06		
person-rem			2.78E-04			2.48E-03			4.00E-05

New Haven to the WCS CISF by Rail

	Rural Pop	Rural	Rural	Suburban	Suburban	Suburban	Urban	Urban	Urban
	Density	Distance	Population	Density	Distance	Population	Density	Distance	Population
State	per/sq mi	mile		per/sq mi	mile		per/sq mi	mile	
AR	37.5	204.70	7676	953.3	96.22	91727	5509.4	4.02	22148
CT	99.8	1.00	100	1182.7	48.83	57751	5494.3	7.74	42526
IL	28.2	183.15	5165	721.8	44.9	32409	3785.7	0.69	2612
IN	46.3	64.76	2998	1361.1	87.14	118606	10054.7	10.6	106580
MA	34.6	35.67	1234	1116.1	26.77	29878	6586	6.68	43994
MO	28.2	76.03	2144	774.2	17.92	13874	0	0	0
NY	61.9	210.68	13041	1056.2	166.21	175551	5671.9	22.95	130170
OH	46.4	139.61	6478	1400.2	109.2	152902	4135.9	20.48	84703
PA	61.2	18.89	1156	1760	19.45	34232	5934.1	5.51	32697
TX	34.3	401.83	13783	1192.8	185.53	221300	6694.6	25.77	172520
total dist		1336.32			802.17			1336.32	
km		2150.60			1290.97			2150.60	
population			13783			928230			637950
PD (per/sq km)	4.01			449.39			185.40		
person-rem			5.26E-04			3.09E-02			7.38E-04

Table 4.1-3
Pertinent Portions Of The Spreadsheets For Calculating Collective Doses For A Single Shipment
(Continued)

Connecticut Yankee

Haddam Neck to Middletown Junction by Heavy Haul									
	Rural Pop	Rural	Rural	Suburban	Suburban	Suburban	Urban	Urban	Urban
	Density	Distance	Population	Density	Distance	Population	Density	Distance	Population
State	per/sq mi	mile		per/sq mi	mile		per/sq mi	mile	
CT	72.1	8.03	579	584.7	5.14	3005	4028	0.12	483
total dist		8.03			5.14			0.12	
km		12.92			8.27			0.19	
population			579			3005			483
PD (per/sq km)	28.00			227.07			1564.30		
person-rem			5.53E-05			2.50E-04			1.40E-06

Middletown Junction to the WCS CISF by Rail									
	Rural Pop	Rural	Rural	Suburban	Suburban	Suburban	Urban	Urban	Urban
	Density	Distance	Population	Density	Distance	Population	Density	Distance	Population
State	per/sq mi	mile		per/sq mi	mile		per/sq mi	mile	
AR	37.5	204.7	7676	953.3	96.22	91727	5509.4	4.02	22148
CT	134	0.19	25	1469.2	48.83	71741	5494.3	7.74	42526
IL	28.2	183.15	5165	721.8	44.9	32409	3785.7	0.69	2612
IN	46.3	64.76	2998	1361.1	87.14	118606	10054.7	10.6	106580
MA	34.6	35.67	1234	1116.1	26.77	29878	6586	6.68	43994
MO	28.2	76.03	2144	774.2	17.92	13874	0	0	0
NY	61.9	210.68	13041	1056.2	166.21	175551	5671.9	22.95	130170
OH	46.4	139.61	6478	1400.2	109.2	152902	4135.9	20.48	84703
PA	61.2	18.89	1156	1760	19.45	34232	5934.1	5.51	32697
TX	34.3	401.83	13783	1192.8	185.53	221300	6694.6	25.77	172520
total dist		1335.51			802.17			104.44	
km		2149.30			1290.97			168.08	
population			53701			942219			637950
PD (per/sq km)	15.62			456.16			2372.19		
person-rem			2.05E-03			3.13E-02			7.38E-04

Table 4.1-3
Pertinent Portions Of The Spreadsheets For Calculating Collective Doses For A Single Shipment
(Continued)

Humboldt Bay

Humboldt Bay To San Franisco by Barge

State	Rural Pop Density per/sq mi	Rural Distance mile	Rural Population	Suburban Density per/sq mi	Suburban Distance mile	Suburban Population	Urban Density per/sq mi	Urban Distance mile	Urban Population
CA	1.4	10.1	14	8552	0.17	1454			
Ocean	0	324.92	0	0	0	0			
total dist		335.02			0.17			0	
km		539.16			0.27			0.00	
population			14			1454			0
PD (per/sq km)	0.02			3321.22					
person-rem			3.37E-06			3.02E-04			0

San Francisco to the WSC CISF by Rail

to wcs rail State	Rural Pop Density per/sq mi	Rural Distance mile	Rural Population	Suburban Density per/sq mi	Suburban Distance mile	Suburban Population	Urban Density per/sq mi	Urban Distance mile	Urban Population
AZ	18.6	314.42	5848	1046.6	70.53	73817	4273.7	5.19	22181
CA	35.4	422.09	14942	1318.9	201.64	265943	6675.9	119.68	798972
NM	7.1	156.66	1112	917.5	10.86	9964	0	0	0
TX	9	207.14	1864	1058	28.63	30291	6508.8	14.08	91644
total dist		1100.31			311.66			138.95	
km		1770.78			501.57			223.62	
population			23767			380014			912796
PD (per/sq km)	8.39			473.53			2551.21		
person-rem			9.08E-04			1.26E-02			1.06E-03

Table 4.1-3
Pertinent Portions Of The Spreadsheets For Calculating Collective Doses For A Single Shipment
(Continued)

Big Rock Point

Big Rock Point to Cadillac by Heavy Haul									
	Rural Pop	Rural	Rural	Suburban	Suburban	Suburban	Urban	Urban	Urban
	Density	Distance	Population	Density	Distance	Population	Density	Distance	Population
State	per/sq mi	mile		per/sq mi	mile		per/sq mi	mile	
MI	21.8	358.37	7812.466	774.8	33.22	25739	0	0	0
total dist		358.37			33.22			0	
km		576.74			53.46			0.00	
population			7812.466			25739			0
PD (per/sq km)	8.47			300.90					
person-rem			7.46E-04			2.14E-03			0.00E+00

Cadillac to the WCS CISF by Rail									
	Rural Pop	Rural	Rural	Suburban	Suburban	Suburban	Urban	Urban	Urban
	Density	Distance	Population	Density	Distance	Population	Density	Distance	Population
State	per/sq mi	mile		per/sq mi	mile		per/sq mi	mile	
IL	26.2	205.63	5388	1094	64.97	71103	4030.1	7.08	28533
IN	57.7	41.27	2381	1283	31.35	40225	4022.5	7.97	32059
KS	28.5	124.58	3551	1194	30.92	36928	3876.6	5.26	20391
MI	45.7	174.43	7971	1155	89.09	102890	5064.2	10.69	54136
MO	32.4	212.71	6892	1314	61.8	81193	7196.5	15.62	112409
OK	29.6	187.56	5552	1108	54.46	60314	3532.1	1.87	6605
TX	31.5	314.73	9914	1033	131.95	136331	5142.5	17.2	88451
total dist		1260.91			464.54			65.69	
km		2029.24			747.61			105.72	
population			41648			528984			342585
PD (per/sq km	12.83			442.23			2025.35		
person-rem			1.59E-03			1.76E-02			3.96E-04

Table 4.1-3
Pertinent Portions Of The Spreadsheets For Calculating Collective Doses For A Single Shipment
(Continued)

Rancho Seco

Ranch Seco to the WCS CISF by Rail									
	Rural Pop	Rural	Rural	Suburban	Suburban	Suburban	Urban	Urban	Urban
	Density	Distance	Population	Density	Distance	Population	Density	Distance	Population
State	per/sq mi	mile		per/sq mi	mile		per/sq mi	mile	
AZ	18.6	314.42	5848	1046.6	70.53	73817	4273.7	5.19	22181
CA	36	407.21	14660	1300.5	189.83	246874	5223.9	73.43	383591
NM	7.1	156.66	1112	917.5	10.86	9964	0	0	0
TX	9	207.14	1864	1058	28.63	30291	6508.8	14.08	91644
total dist		1085.43			299.85			92.7	
km		1746.83			482.56			149.19	
population			23484			360945			497415
PD (per/sq	8.40			467.48			2083.87		
person-rem			8.97E-04			1.20E-02			5.75E-04

Trojan

Trojan to the WCS CISF by Rail									
	Rural Pop	Rural	Rural	Suburban	Suburban	Suburban	Urban	Urban	Urban
	Density	Distance	Population	Density	Distance	Population	Density	Distance	Population
State	per/sq mi	mile		per/sq mi	mile		per/sq mi	mile	
AZ	18.6	314.42	5848	1046.6	70.53	73817	4273.7	5.19	22181
CA	35.6	612.1	21791	1245.4	278.52	346869	5102.3	94.7	483188
NM	7.1	156.66	1112	917.5	10.86	9964	0	0	0
OR	29.9	254.54	7611	1044.9	91.89	96016	6650.1	31.22	207616
TX	9	207.14	1864	1058	28.63	30291	6508.8	14.08	91644
total dist		1544.86			480.43			145.19	
km		2486.22			773.18			233.66	
population			38226			556956			804628
PD (per/sq km	9.61			450.22			2152.23		
person-rem			1.46E-03			1.85E-02			9.30E-04

Table 4.1-3
Pertinent Portions Of The Spreadsheets For Calculating Collective Doses For A Single Shipment
(Continued)

Trojan

Trojan to Portland By Barge

State	Rural Pop Density per/sq mi	Rural Distance mile	Rural Population	Suburban Density per/sq mi	Suburban Distance mile	Suburban Population	Urban Density per/sq mi	Urban Distance mile	Urban Population
OR	11	27.98	308	282.7	3.3	933	0	0	
total dist		27.98			3.3			0	
km		45.03			5.31				
population			308			933			
PD (per/sq km	4			110					
person-rem			7.35E-05			1.94E-04			

Portland to the WCS CISF by Rail

State	Rural Pop Density per/sq mi	Rural Distance mile	Rural Population	Suburban Density per/sq mi	Suburban Distance mile	Suburban Population	Urban Density per/sq mi	Urban Distance mile	Urban Populatior
AZ	18.6	314.42	5848	1046.6	70.53	73817	4273.7	5.19	22,181
CA	35.6	612.1	21791	1245.4	278.52	346869	5102.3	94.7	483,188
NM	7.1	156.66	1112	917.5	10.86	9964	0	0	0
OR	28.1	234.88	6600	1110.3	79.88	88691	6629.5	30.97	205,316
TX	9	207.14	1864	1058	28.63	30291	6508.8	14.08	91,644
total dist		1525.2			468.42			144.94	
km		2454.58			753.85			233.26	
population			37216			549631			802,328
PD (per/sq km	9.48			455.69			2149.78		
person-rem			1.42E-03			1.83E-02			9.28E-04

Table 4.1-3
Pertinent Portions Of The Spreadsheets For Calculating Collective Doses For A Single Shipment
(Continued)

LaCrosse

LaCrosse to the WCS CISF by Rail

State	Rural Pop Density per/sq mi	Rural Distance mile	Rural Population	Suburban Density per/sq mi	Suburban Distance mile	Suburban Population	Urban Density per/sq mi	Urban Distance mile	Urban Population
IA	57.3	14.28	818	478.6	5.51	2637	0	0	0
IL	24	165.61	3975	675.9	27.81	18797	4469.4	1.46	6525
KS	23.8	169.24	4028	1209.1	52.29	63224	4157.9	6.81	28315
MO	28.1	176.88	4970	783.3	18.12	14193	8523.2	3.96	33752
OK	38.8	168.52	6539	1240.4	62.87	77984	4791	16.2	77614
TX	32.2	305.57	9839	1034.1	119.34	123409	6083.7	12.96	78845
WI	27.9	95.43	2662	1057.2	16.14	17063	3621.9	2.14	7751
total dist		1095.53			302.08			43.53	
km		1763.09			486.15			70.05	
population			32832			317308			232802
PD (per/sq km)	11.64			407.93			2076.96		
person-rem			1.25E-03			1.06E-02			2.69E-04

La Crosse to Genoa by Barge

State	Rural Pop Density per/sq mi	Rural Distance mile	Rural Population	Suburban Density per/sq mi	Suburban Distance mile	Suburban Population	Urban Density per/sq mi	Urban Distance mile	Urban Population
IL	0	27.2	0	0	0	0	0		
IN	64	0.91	58	0	0	0			
MI	627.18	3.2	2007	3869.3	19.2	74291			
total dist		31.31			19.2			0	
km		50.39			30.90			0.00	
population			2065			74291			0
PD (per/sq km	25.62			1502.67					
person-rem			4.93E-04			1.54E-02			0

Table 4.1-3
Pertinent Portions Of The Spreadsheets For Calculating Collective Doses For A Single Shipment
(Continued)

LaCrosse

Genoa to the WCS CISF by Rail									
	Rural Pop	Rural	Rural	Suburban	Suburban	Suburban	Urban	Urban	Urban
	Density	Distance	Population	Density	Distance	Population	Density	Distance	Population
State	per/sq mi	mile		per/sq mi	mile		per/sq mi	mile	
IA	57.3	14.28	818	478.6	5.51	2637	0	0	0
IL	24	165.61	3975	675.9	27.81	18797	4469.4	3.12	13945
KS	23.8	169.24	4028	1209.1	52.29	63224	4157.9	6.81	28315
MO	28.1	176.88	4970	783.3	18.12	14193	8523.2	3.96	33752
OK	38.8	168.52	6539	1240.4	62.87	77984	4791	16.2	77614
TX	32.2	305.57	9839	1034.1	119.34	123409	6083.7	12.96	78845
WI	19.2	84.85	1629	691.2	8.22	5682	0	0	0
total dist		1084.95			294.16			43.05	
km		1746.06			473.41			69.28	
population			31798			305926			232471
PD (per/sq km)	11.38			403.89			2097.13		
person-rem			1.21E-03			1.02E-02			2.69E-04

Zion

Zion to the WCS CISF by Rail									
	Rural Pop	Rural	Rural	Suburban	Suburban	Suburban	Urban	Urban	Urban
	Density	Distance	Population	Density	Distance	Population	Density	Distance	Population
State	per/sq mi	mile		per/sq mi	mile		per/sq mi	mile	
IA	45.2	204.71	9253	863.8	90.19	77906	3794.6	3.33	12636
IL	42.4	65.96	2797	1498.1	71.02	106395	4892.8	28.62	140032
KS	28.5	124.58	3551	1194.3	30.92	36928	3876.6	5.26	20391
MO	28.9	108.12	3125	1447	20.75	30025	8156.5	2.38	19412
OK	29.6	187.56	5552	1107.5	54.46	60314	3532.1	1.87	6605
TX	31.5	314.73	9914	1033.2	131.95	136331	5142.5	17.2	88451
total dist		1005.66			399.29			58.66	
km		1618.46			642.60			94.40	
population			34191			447899			287527
PD (per/sq km)	13.20			435.63			1903.56		
person-rem			1.31E-03			1.49E-02			3.32E-04

Table 4.1-3
Pertinent Portions Of The Spreadsheets For Calculating Collective Doses For A Single Shipment
(Continued)

Zion

Zion to Rock Island (Davenport) by Barge

State	Rural Pop Density per/sq mi	Rural Distance mile	Rural Population	Suburban Density per/sq mi	Suburban Distance mile	Suburban Population	Urban Density per/sq mi	Urban Distance mile	Urban Population
IL	0	27.2	0	0	0	0	0	0	0
IN	64	0.91	58	0	0	0	0	0	0
MI	3.2	627.18	2007	19.82	3869.3	76690	0	0	0
total dist		655.29			3869.3			0	
km		1054.59			6227.05			0	
population			2065			76690			0
PD (per/sq km)	1.22			7.70					
person-rem			4.93E-04			1.59E-02			0.00E+00

Rock Island (Davenport) to the WCS CISF by Rail

State	Rural Pop Density per/sq mi	Rural Distance mile	Rural Population	Suburban Density per/sq mi	Suburban Distance mile	Suburban Population	Urban Density per/sq mi	Urban Distance mile	Urban Population
IA	57.3	14.28	818	478.6	5.51	2637	0	0	0
IL	23	81.87	1883	1164.8	24.07	28037	3979.7	3.12	12417
KS	23.8	169.24	4028	1209.1	52.29	63224	4157.9	6.81	28315
MO	28.1	176.88	4970	783.3	18.12	14193	8523.2	3.96	33752
OK	38.8	168.52	6539	1240.4	62.87	77984	4791	16.2	77614
TX	32.2	305.57	9839	1034.1	119.34	123409	6083.7	12.96	78845
total dist		916.36			282.2			43.05	
km		1474.74			454.16			69.28	
population			28077			309484			230943
PD (per/sq km)	11.90			425.90			2083.35		
person-rem			1.07E-03			1.03E-02			2.67E-04

Table 4.1-3
Pertinent Portions Of The Spreadsheets For Calculating Collective Doses For A Single Shipment
(Continued)

Crystal River

Crystal River to the WCS CISF by Rail									
	Rural Pop	Rural	Rural	Suburban	Suburban	Suburban	Urban	Urban	Urban
	Density	Distance	Population	Density	Distance	Population	Density	Distance	Population
State	per/sq mi	mile		per/sq mi	mile		per/sq mi	mile	
AL	48.9	191.5	9364	1088.1	104.49	113696	6476.7	7.32	47409
AR	32.9	191.23	6291	970.8	95.38	92595	5509.4	4.02	22148
FL	42.8	127.9	5474	717.6	39.82	28575	0	0	0
GA	30.7	219.06	6725	842.8	62.1	52338	3442.6	0.3	1033
MS	45	22.65	1019	989.2	11.42	11297	3403.9	0.02	68
TN	38.2	56.03	2140	1674.3	20.92	35026	5018.5	10.92	54802
TX	34.3	401.83	13783	1192.8	185.53	221300	6694.6	25.77	172520
total dist		1210.2			519.66			48.35	
km		1947.63			836.31			77.81	
population			44797			554826			297980
PD (per/sq km)	14.38			414.64			2393.43		
person-rem			1.71E-03			1.84E-02			3.45E-04

Kewaunee

Kewaunee to Green Bay by Heavy Haul									
	Rural Pop	Rural	Rural	Suburban	Suburban	Suburban	Urban	Urban	Urban
	Density	Distance	Population	Density	Distance	Population	Density	Distance	Population
State	per/sq mi	mile		per/sq mi	mile		per/sq mi	mile	
WI	34.7	21.17	735	1258.6	11.94	15028	3634.4	1.48	5379
total dist		21.17			11.94			1.48	
km		34.07			19.22			2.38	
population			735			15028			5379
PD (per/sq k	13.48			488.79			1411.44		
person-rem			7.01E-05			1.25E-03			1.55E-05

Table 4.1-3
Pertinent Portions Of The Spreadsheets For Calculating Collective Doses For A Single Shipment
(Continued)

Kewaunee

Green Bay to the WCS CISF by Rail

State	Rural Pop Density per/sq mi	Rural Distance mile	Rural Population	Suburban Density per/sq mi	Suburban Distance mile	Suburban Population	Urban Density per/sq mi	Urban Distance mile	Urban Population
AR	37.5	204.7	7676	953.3	96.22	91727	5509.4	4.02	22148
IL	36.1	233.58	8432	1328.4	130.28	173064	4962.6	50.68	251505
MO	28.2	76.03	2144	774.2	17.92	13874	0	0	0
TX	34.3	401.83	13783	1192.8	185.53	221300	6694.6	25.77	172520
WI	60.8	70.34	4277	1506.3	82.39	124104	4820.2	13.94	67194
total dist		986.48			512.34			94.41	
km		1587.59			824.53			151.94	
population			36312			624068			513366
PD (per/sq k	14.30			473.05			2111.73		
person-rem			1.39E-03			2.08E-02			5.94E-04

San Onofre

San Onofre to the WCS CISF by Rail

State	Rural Pop Density per/sq mi	Rural Distance mile	Rural Population	Suburban Density per/sq mi	Suburban Distance mile	Suburban Population	Urban Density per/sq mi	Urban Distance mile	Urban Population
AZ	18.6	314.42	5848	1046.6	70.53	73817	4273.7	5.19	22181
CA	23.3	139.13	3242	1723.7	76.58	132001	6396.8	65.64	419886
NM	7.1	156.66	1112	917.5	10.86	9964	0	0	0
TX	9	207.14	1864	1058	28.63	30291	6508.8	14.08	91644
total dist		817.35			186.6			84.91	
km		1315.40			300.30			136.65	
population			12066			246072			533710
PD (per/sq km	5.73			512.13			2441.05		
person-rem			4.61E-04			8.18E-03			6.17E-04

Table 4.1-3
Pertinent Portions Of The Spreadsheets For Calculating Collective Doses For A Single Shipment
(Concluded)

WCS CISF to Yucca Mountain

WCS CISF to Yucca Mountain by Rail									
	Rural Pop	Rural	Rural	Suburban	Suburban	Suburban	Urban	Urban	Urban
	Density	Distance	Population	Density	Distance	Population	Density	Distance	Population
State	per/sq mi	mile		per/sq mi	mile		per/sq mi	mile	
AZ	21.9	299.28	6554	1338.1	87.95	117686	7165.7	37.01	265203
CA	3.1	296.94	921	266.4	2.36	629	0	0	0
NM	13.7	161.02	2206	1030.7	29.01	29901	4004.3	2.76	11052
NV	3.2	12.65	40	178	0.63	112	0	0	0
TX	11.7	207.95	2433	1349.7	46.37	62586	5180	18.64	96555
total dist		977.84			166.32			58.41	
km		1573.68			267.67			94.00	
population			12154			210913			372810
PD (per/sq km)	4.83			492.48			2478.74		
person-rem			4.64E-04			7.01E-03			4.31E-04

Table 4.1-4
Calculation Spreadsheet Used to Assess Occupational Doses per Shipment from Routine, Incident-Free Transportation of SNF

			OCCUPATIONAL DOSES PER SHIPMENT FROM ROUTINE, INCIDENT-FREE TRANSPORTARTIONSHIPMENT					
			Maine Yankee to WCS					
						TRAIN CREW IN TRANSIT	DISTANCE	TRIP DOSE
						3 PEOPLE		
	RADTRAN OUTPUT					person-rem/km	km	person-rem
	Link	CREW			Rural	7.78E-07	2984.18	2.32E-03
	GENR	7.78E-07			Suburan	7.78E-07	1712.18	1.33E-03
	GENS	7.78E-07			Urban	1.31E-06	346.54	4.54E-04
	GENU	1.31E-06						
							TOTAL	4.11E-03
	CLASSIFICATION-NONLINK					**RAIL YARD WORKERS**	Hours	Dose
		1.65E-02				person-rem		
						Classification Stop	27	1.65E-02
						Railorad Tranfer	4	2.44E-03
	HANDLING					**HANDLERS**		
	LINE-SOURCE					5 PEOPLE		
						person-rem	5	4.01E-01
						ESCORTS		
						2 PEOPLE		
						Escorts assumed to have		
						25% greater dose than crew		3.42E-03
						NUREG 2125 (page B-52)		
	STOP	DISTANCE	DOSE					
		m	person-rem					
	INSPECTOR	2	9.55E-02			**INSPECTORS**		DOSE
						rem/inspection		person-rem
						2 meters for 4 hours		9.55E-02
	STOP	DISTANCE	DOSE			**FIRST RESPONDERS**		DOSE
		m	person-rem			PERSON-REM/RESPONDER		person-rem
	RESPONDER	3	1.60E-01			3 meters for 10 hours		1.60E-01