RAI 2-6 Provide information and design characteristics of each pipeline near the proposed facility site, including the new proposed pipeline, as described in SAR Section 2.2.2 “Pipelines.” Information is also necessary for the temporary flexible pipeline currently at the site if the pipeline would be simply moved to an offsite location near the proposed facility during construction and operational phases of the proposed facility and would continue to operate in the new locations. In additions, information is needed for other temporary flexible pipelines close to the proposed site.

Although some information has been provided in SAR Section 2.2.2, “Pipelines,” additional information about the characteristics of every pipeline near the proposed site is necessary. Additionally, SAR Section 6.5.2 (d), “Potential Fire Hazards,” states that the temporary flexible pipeline at the proposed site would be moved prior to, or during, the early construction phases of the proposed facility. However, it is not clear to where this pipeline would be moved during construction and facility operation. If the new location is just outside the boundary of the proposed site, this pipeline can still pose a credible hazard to the proposed facility depending on its distance to important to safety structures and systems. Similarly, other temporary flexible pipelines near the proposed site may also pose a credible hazard to the proposed facility.

The information of the characteristics of the pipelines should include, at a minimum, the following:

a) Size, rated and operating pressure, flow rate, depth of burial, and other characteristics of each pipeline;
b) Location of each pipeline with respect to the important to safety structures and systems at the proposed CISF, including the route taken by the loaded cask transporter enroute to the storage pads;
c) Location(s) of the nearest shut-off valves and the pipeline control room for leak or break detection and taking necessary action(s) for each pipeline, and;
d) Expected time delay between leak detection and necessary actions taken to prevent further gas leakage.

This information is necessary to determine compliance with 10 CFR 72.24(a), 72.90(a) through (d), 72.94, and 72.122.

Holtec Response

The requested information for each permanent pipeline is provided below and has been added to SAR Section 2.2.2. This information has been collected by contacting the owners/operators of each of the pipelines [1].

1. Transwestern 20-inch gas pipeline:
    a. 20-inch diameter gas pipeline rated at 1,008 pounds per square inch (psi). Normally operates at 680 psi with a flow rate of 630,000 Mcf per day. The minimum depth of the pipeline is 36-inches from the top of the pipe to the ground surface, equating to a minimum of 36-inches of overburden.
    b. Located 0.8 miles west of the Site boundary and will not intersect the new extension of the railroad to the Site.
    c. Nearest shut-off valve is located 5.2 miles to the southwest at the Transwestern Compressor Station. Mainline pipe has remotely operated mainline valves and compressor stations have Emergency Shut Down (ESD) systems. ESD’s close

valves to reduce the amount of gas released in the event of a leak or rupture of the line. Valves, pressures, flows, and stations are monitored by Gas Control 24x7.

    d. Expected time delay between leak detection and necessary actions to prevent further loss is within 24-hours of Transwestern detecting a leak.

2. DCP Midstream (DCP) 20-inch gas pipeline:
    a. 20-inch diameter gas pipeline rated at 1,180 pounds per square inch (psi). Normally operates at 680 psi with a flow rate of 180,000 Mcf a day. The minimum depth of the pipeline is 36-inches from the top of the pipe to the ground surface, equating to a minimum of 36-inches of overburden.
    b. Located 0.16 miles east of the Site boundary. The railroad spur will traverse this pipeline at two locations.
    c. Nearest shut-off valve is located 6.2 miles to the northwest at the DCP Lusk Gas Plant. In the event of a leak, DCP will inspect the leak to determine the severity and take the proper steps to correct the leak.
    d. Expected time delay between leak detection and necessary actions to prevent further loss is within 24-hours of DCP detecting a leak.
3. DCP 10.75-inch gas pipeline:
    a. 10.75-inch diameter gas pipeline rated at 650 pounds per square inch (psi). Normally operates at 60 psi with a flow rate of 190 MCF a day. The minimum depth of the pipeline is 36-inches from the top of the pipe to the ground surface, equating to a minimum of 36-inches of overburden.
    b. Located 0.16 miles east of the Site boundary and 0.12 miles from the road entering the Site.
    c. Nearest shut-off valve is located 6.2 miles to the northwest at the DCP Lusk Gas Plant.
    d. Expected time delay between leak detection and necessary actions to prevent further loss is within 24-hours of DCP detecting a leak.
4. Lucid Energy 10-inch gas pipeline:
    a. 10-inch diameter gas pipeline rated at 650 pounds per square inch (psi). Normally operates at 60 psi with a flow rate of 270 MCF a day. The minimum depth of the pipeline is 36-inches from the top of the pipe to the ground surface, equating to a minimum of 36-inches of overburden.
    b. Located 0.16 miles east of the Site boundary and 0.12 miles from the road entering the Site.
    c. Nearest shut-off valve is located 6.2 miles to the northwest at the DCP Lusk Gas Plant.
    d. Expected time delay between leak detection and necessary actions to prevent further loss is within 24-hours of Lucid detecting a leak.

In regard to temporary pipelines, no temporary pipelines will be allowed to travel across Holtec owned land in any phase of facility operation after construction has started, unless they can be shown to not present any hazards to safety-related structures. This has been clarified in SAR Section 2.1.2. As these pipelines are temporary in nature and will not pose a threat to any safety-related structures, the specific details for existing temporary pipelines have not been compiled. Additionally, as shown in the response to RAI 2-7, the risks from pipelines that could have an effect on safety-related structures at the Facility are considered negligible. Therefore, any temporary pipelines that are established off-site would similarly not present any credible risk to safety-related structures at the Facility.

References for RAI 2-6:

1. CEHMM. "RAI 2-6." E-mail from Matt Mathis, Project Manager / Wildlife Biologist CEHMM, to Holtec on March 16, 2020.

2-7 Provide an assessment that evaluates the explosion hazards and consequences to important to safety structures or systems at the proposed CISF from a rupture of any pipeline resulting in release and subsequent ignition of the natural gas. (SAR Section 2.2.2, "Pipelines"). The assessment should specifically consider the released natural gas forming a vapor cloud, which can float away from the pipeline under the prevailing atmospheric conditions and subsequently ignite close to an important to safety structure or system.

The assessment should consider, at a minimum, the following:

a) Worst type of breakage of the pipeline, for example, a guillotine break of a pipeline;
b) Release of natural gas through the pipe break for the longest time possible, given the time to detect at the control room and rectify the situation by closing the flow at both ends of the break;
c) Worst-case meteorological conditions at the site that would carry the resulting vapor cloud the maximum distance with minimum turbulence or mixing and the justification for the selection;
d) Surrounding ground characteristics along with justification;
e) Methodology(ies) selected and the rationale for the selection; and
f) Assumptions made in the assessment along with the appropriate rationale for each assumption

The assessment should estimate the expected air overpressure from a potential vapor cloud explosion due to a pipeline breakage at the important to safety structures and systems including the loaded cask transporter enroute to the cask storage pad area at the proposed CISF and associated damage potential. The applicant may select to demonstrate the safety of the proposed facility from breakage of any natural gas pipelines using an alternative approach with appropriate justifications.

This information is necessary to determine compliance with 10 CFR 7224(a), 72.90(a) through (d), 72.94, and 72.122.

Holtec Response

U.S. Natural Gas Pipeline Industry - Background

Based on data from 2019, in the U.S., there are approximately 300,000 miles of onshore natural gas transmission pipelines, with approximately 6,500 miles in New Mexico (PHMSA Stats). These pipelines are designed to operate at high pressures that generally range from 500 to 1,000 pounds per square inch. If a relatively small quantity of natural gas leaks from a crack, flaw, or damaged section of the pipeline, a serious incident may result if repairs are not made in a timely manner. However, if a natural gas transmission line fails catastrophically, there is usually an initial explosion that can injure or kill people in the vicinity and cause extensive property damage. The escaping product continues to burn until the supply is shut off. Because the product is lighter than air, it rises and tends to dissipate quickly, usually posing few environmental risks.

Existing regulations consider surrounding land uses and population densities for pipeline operations. For example, 49 CFR 192, which applies to natural gas pipelines, defines area classifications on the basis of population density in the vicinity of a natural gas pipeline and specifies more rigorous requirements as human population density increases as discussed below. A class location unit is defined as an area that extends 220 yards, or 1⁄8 mile, on either side of the centerline of any continuous 1-mile length of natural gas pipeline (49 CFR 192.5). Class locations are categorized by the extent and type of development within those boundaries— the more dense the development, the more stringent the requirements. There are four area classifications:

Class 1. Offshore location or onshore locations with 10 or fewer buildings intended for human occupancy;

Class 2. Locations with more than 10 but fewer than 46 buildings intended for human occupancy;

Class 3. Locations with 46 or more buildings intended for human occupancy or where the pipeline lies within 100 yards of any building or small, well-defined outside area occupied by 20 or more persons on at least 5 days a week for 10 weeks in any 12-month period; and

Class 4. Locations where buildings with four or more stories aboveground are prevalent.

Natural gas pipelines constructed on land in Class 1 locations must be installed with a minimum depth of cover of 30 inches in normal soil or 18 inches in consolidated rock; pipelines installed in navigable rivers, streams, and harbors must have a minimum cover of 48 inches in soil or 24 inches in consolidated rock (49 CFR 192.327).

Pipelines in Class 2, 3, and 4 locations must be installed with a minimum depth of cover of 36 inches in normal soil or 24 inches in consolidated rock. In addition, pipe wall thickness, pipeline design pressures, hydrostatic test pressures, maximum allowable operating pressure, valve spacing, frequency of inspection and testing of welds, and frequency of pipeline patrols and leak surveys must conform to higher standards in more populated areas (49 CFR 192.327).

Natural Gas Pipelines Near the CIS Facility

There are approximately 27,500 miles of gas pipelines in New Mexico that are regulated by the U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA), of which approximately 6,500 miles are natural gas transmission lines (PHMSA Stats). Three pipelines are currently near the CIS Facility Site: (1) a Transwestern (TW) 20-inch diameter natural gas pipeline located approximately 0.8 miles from the western boundary of the Site, (2) a DCP Midstream (DCP) 20-inch diameter natural gas pipeline located approximately 0.16 miles east of the eastern boundary of the Site; and (3) a DCP 10-inch diameter natural gas pipeline located approximately 0.17 miles east of the eastern boundary of the Site. The two 20-inch pipelines are classified as high-pressure pipelines rated for a pressure of 1,180 pounds per square inch (psi). They are normally operated at a pressure of approximately 680 psi. A fourth pipeline is proposed to be constructed near the two DCP pipelines east of the CIS Facility Site. That pipeline would be a 10.75-inch diameter low-pressure natural gas pipeline and would run south-to-north between the two existing pipelines which are east of the CIS Facility (DOE WIPP).

Risk Review

The presence of the natural gas transmission lines is a potential risk to the operation or storage at the CIS facility. In order to evaluate this potential risk, the nature and frequency of the hazard and the potential consequences of the hazard must be determined. To identify the nature, frequency and consequences of the hazards associated with natural gas pipelines near the CIS facility, a review of the PHMSA database of incident reports for New Mexico was performed (PHMSA Safety Incidents).

PHMSA has collected pipeline incident reports since 1970. Although the reporting regulations and incident report formats have changed several times over the years, the PHMSA databases all include an incident report number, the date of the incidents, the incident type, the State the incident occurred in, the size of the natural gas pipeline involved in the incident, and the date the pipeline was either manufactured or installed, and a discussion of the incident. A review of the three databases for natural gas transmission line incidents in New Mexico over a 20-year time period was performed. The results of this review are summarized in Table 1 (GGTG-NM).

Table 1 – Summary of Natural Gas Transmission Line Incidents in New Mexico between 2000 and 2020

Report ID	Incident Date	Incident Type	Pipe Diameter	Year Built or installed	Description of Event
20000160	8/19/2000	Rupture	30 in	1950	Gas control noticed a pressure drop and determined that a failure had occurred. El Pasos 30-inch line 1103 ruptured. The cause of the failure was determined to be severe internal corrosion of that pipeline.
20030025	2/20/2003	Leak due to Connection Failure	30 in	1986	A non-hazardous leak on line 2000 was found in Luna County, New Mexico, during a scheduled leak survey. After further investigation, lack of fusion in the girth weld was identified.
20030026	2/20/2003	Pinhole Leak	30 in	1950	A non-hazardous leak on line 1103 was found in Luna County, New Mexico during a scheduled leak survey. Following a metallurgical investigation, a cluster of porosity was found in the long seam. The leak resulted from the intersection of a worm-hole pore with the finish pass crack.
20030073	7/24/2003	Lightning Strike	8 in		An apparent lightning strike hit the ground in the immediate area of an 8 inch above ground valve set causing gas to escape and catch fire.
20040030	2/26/2004		16 in	1976	Employee attempted to open a 12-inch pig launcher at the Thompson compressor station without first relieving the pressure.
20050073	6/24/2005	Pinhole Leak	26 in	1947	El Paso Natural Gas (EPNG) personnel were in the process of running the instrumented pig on line 1100, in New Mexico when several anomalies in the pipe were identified. After excavation and further examination, a small leak was discovered. External corrosion is the suspected cause.
20060108	7/29/2006	Puncture Leak	16 in		Pipeline was damaged by the unauthorized use of heavy equipment (bulldozer), that was driven into the pipeline by an intoxicated person or persons.
20070012	1/8/2007	Puncture Leak	16 in	2005	Contractor hit 16" main line while performing road work at the intersection of Unser and Idalia in Rio Rancho, NM.
20070087	7/18/2006	Compressor Failure	N/A	1985	Compressor failed. No in-patient hospitalization was required for the injury.

Report ID	Incident Date	Incident Type	Pipe Diameter	Year Built or installed	Description of Event
20110301	8/16/2011	Mechanical Puncture	4.5 in	1952	EPNG Company was notified of a natural gas release at McKinley County Road 57. EPNG gas control confirmed a rapid pressure drop in the EPNG 4" 2207 line and dispatched field personnel to the scene. A McKinley county road grader had punctured the pipeline but there was no fire or explosion and no injuries nor fatalities.
20120042	3/29/2012	Leak			EPNG employees were performing integrity management remediation work on line 1204. They noticed a small leak from a 30-inch valve in crossover piping which was used to isolate the pipeline segment. The leak was due to stem failure in the above ground stem riser of the 30-inch valve.
20130062	6/15/2013	Compressor Station Emergency Shut Down		1953	Ambitrol coolant leaking from engine component on to turbo charger insulation resulted in flash fire (burning coolant, not natural gas); unit was running at the time; fire eye saw flash fire; full station emergency shutdown occurred; 30-inch discharge valve did not close therefore allowing natural gas release through vent system. Investigation found closed power gas isolation valve rendering 30-inch discharge valve inoperable; not an equipment failure.
20130091	9/16/2013	Regulator failed causing relief valve to open.		1969	A Mooney Flowgrid regulator failed because of a diaphragm that ruptured due to loss of flexibility. The regulator failure triggered the relief valve to open. The relief valve functioned properly. The Mooney Flowgrid regulator is size 2 inch with a capacity of 535.956 mcf per hour. The Agco relief valve has an inlet size 3 inches and outlet size 4 inches with a capacity of 611.206 mcf per hour.
20150036 (TW)	2/22/2015	6" Ball Valve Opening Unintentional		2007	The TW Corona compressor station 8 - six inch discharge blowdown valve opened unintentionally and blew gas to the atmosphere. The blow down valve, Shafer operator pilot gas line froze off, due to sub zero temperatures causing a loss of pilot pressure, which holds the valve in the closed position.
20150108	8/8/2015	Release of Gas Due to Relief Valve Activation.		1953	An investigation into this incident determined that the relief valve actuated at a pressure below the maximum allowable operating pressure (MAOP) of the facility and vented gas to atmosphere for several hours. The gas loss originally reported to the National Response Center was revised to 5521mcf based on engineering calculations (originally calculated as a 4" orifice but the relief valve is a 1.28" orifice). The relief valve was inspected, and the cause of the equipment failure could not be determined.
20160030	3/10/2016	Mechanical Puncture	8 in	1976	A road grader scraped the pipeline with the blade and gouged a hole approximately 6" x 9". Grader operator did not call the NM one-call notification center for a locate request.
20170033	4/7/2017	The Flange on The Packing Case of Compressor Number 203 Failed.		2006	The Operator on call at the Enstor Grama Ridge gas storage facility received an alarm indicating that compressor unit C203 had shut down. Shortly thereafter, multiple other alarms were received. The operator arrived at the facility and observed a small fire inside the compressor building that extinguished itself shortly thereafter. The operator noted that the facility had activated the emergency shut-down system properly and as designed. The flange on the packing case of compressor number 203 failed. This failure caused the release of natural gas from the packing case and into the atmosphere. The gas encountered an ignition source and ignited resulting in an explosion and fire.

Report ID	Incident Date	Incident Type	Pipe Diameter	Year Built or installed	Description of Event
20170042	5/6/2017	Valve Stuck in Open Position During ESD, Releasing Natural Gas Through Vent Stack System		2007	A lightning strike at TransColorado Gas Transmission company's Blanco compressor station in Bloomfield, NM, caused a loss of electrical power that initiated a station emergency shutdown (ESD). Personnel discovered that a valve, intended to close during an ESD, failed to do so resulting in a loss of natural gas to the atmosphere through the blowdown vent system in excess of 3,000 mcf.
20170066	7/9/2017	Leaking Components on The Hydraulically Controlled Nozzle Actuator System		1971	This fire was associated to a couple of leaking components on the hydraulically controlled nozzle actuator system. Control oil continued to drip down onto the hot discharge air piping blankets until they were saturated, causing the lube oil to exceed the 200 degree auto-ignition flash point, and becoming the origin of this fire.
20170072	7/28/2017	Gas Release Through Vent Valve		2007	Based on station pressure and flow trends it has been determined the 2" station discharge vent valve most likely opened during a power outage.
20180033 (TW)	2/16/2018	Leak	36 in	2005	Gas control received notification from a landowner of a possible leak. The affected line segment was isolated and blown down between valve sections. Excavation operations confirmed leak source; crack in girth weld. The results of the metallurgical analysis indicated that the leak initiated at a bottom side crack in a girth weld.
20180055 (TW)	4/24/2018	Mechanical Puncture	30 in	1969	A third-party contractor struck and damaged the Transwestern 30" West Texas lateral loop pipeline. The line segment was isolated and blown down
20190104	8/3/2019	Equipment Malfunction: Suction Valve's Actuator Pilot Malfunctioned.		1956	Belen compressor station, Valencia County, New Mexico experienced a fire eye detection event which resulted in an ESD. The mainline 1300 west flow suction valve's actuator pilot malfunctioned resulting in the suction valve not closing upon initiation of the ESD. This malfunction kept the station piping from being isolated which resulted in a continuous release of gas through 6" ESD vent valve. An employee manually closed the suction valve. The natural gas loss was estimated to be 9,268 mcf. The original fire detection event was determined to have been a false event initiated by lighting in close proximity to the station as there were lighting storms in the area and there was no evidence of fire at the station.
20190106	8/21/2019	Rupture	20 in	1965	The Natural Gas Pipeline Company of America, LLC (NGPL) 20-inch Indian Basin pipeline experienced an in-service failure resulting in a pipeline rupture and liquid spray (a mixture of condensate and used oil), but no fire. Pipeline valves closed to isolate the section of pipe. The results of the metallurgical analysis indicate that the failure occurred at an area of wall thinning in the longitudinal seam weld due to external corrosion. The wall thinning led to a brittle fracture induced by the operating pressure. The brittle rupture behavior of the longitudinal seam was due in part to the low toughness and also the strain rate of the rupture event. Multiple corrosion mechanisms were observed at the rupture initiation site, including localized corrosion in the form of selective seam weld corrosion (sswc), pitting corrosion and general corrosion
20200039	4/1/2020	Mechanical Puncture	8 in	UNKNOWN	Zach Barlett Ranch hand was operating a dozer when he hit the transmission gas line at mile marker 371 north of Watrous, NM, operator did not call 811 for locates.

Report ID	Incident Date	Incident Type	Pipe Diameter	Year Built or installed	Description of Event
20200045 (TW)	4/7/2020	Relief Valve Opened at a Lower Pressure Than Desired and Failed to Reset.		UNKNOWN	Notified by Durango plant employee that the relief valve was venting at the Maljamar CS. Operations personnel verified that the relief valve was venting and blocked it in. The relief valve was repaired and tested by company employees prior to being put back in service.

A review of these incidents identified the following types of hazards associated with natural gas transmission lines:

- pipeline ruptures
- leaks
- punctures
- equipment failures
- lightning strikes

The estimated frequency and potential consequences of each of these hazards is evaluated below to determine the risk the natural gas pipelines pose to the CIS facility.

Of the 26 natural gas transmission line related incidents reported in NM between 2000 and 2020, only three of them were associated with pipelines operated and controlled by the companies that operate and control the pipelines near the CIS facility; TW and DCP. One of the incidents was a leak due to corrosion, one was an equipment failure, and one was a rupture due to a 3rd party excavating near the line. The rupture was the only incident in Lea County, NM. None of the incidents resulted in a fire or explosion.

Note that incident 20040030 is an operator error event associated with improper operation of equipment at a compressor station. Since the closest compressor station is over 5 miles from the CIS facility, and there are no operator actions associated with the normal operations of the buried natural gas transmission lines near the CIS facility, operator errors such as this were excluded from consideration.

Properties of Natural Gas (Nat Gas Prop)

Natural gas distributed by utilities varies in composition. The heat-producing hydrocarbons are composed of the elements Carbon and Hydrogen. Methane (CH4) is always the largest component. Ethane, propane (C3H8) and butane are heavier, "hotter" hydrocarbons produced from natural gas wells, and are present in low concentration. Nitrogen, Oxygen, and Carbon Dioxide are the major components (99.9%) of air but are considered contaminants of natural gas.

Natural gas will not burn unless the mixture is within a flammable range of roughly 4 to 15% gas per volume of air. Above and below these amounts it will not burn. The most efficient or ideal mixture is about 10% gas.

A combustible mixture of natural gas with air also has a very high ignition temperature of about 1150°F, which is almost twice the ignition temperature for gasoline. Here are possible sources of ignition:

- Any open flame such as a pilot light, match, or lighted candle.
- Static electricity spark.

- Heating element or motor in an electric appliance.
- Internal combustion engine, while running or starting.
- Overhead electrical transformer.

Natural gas is lighter than air, so it can dissipate into the air rapidly, making accidental combustion difficult. It is also colorless, non-toxic, and had no taste in its natural state. When taken from the ground, natural gas is odorless. Natural gas distribution companies add a non-toxic chemical odorant called mercaptan to make leaks easy to smell. However, there may be times when the smell of the odorant is weak or not present, even though there is a leak.

Altogether, these factors add up to making accidental ignition or combustion of natural gas an unlikely event.

Pipeline Ruptures

Pipeline rupture events were reviewed to determine the underlying cause of the ruptures and the consequences associated with them. The two rupture incidents (20000160, 20190106) both indicated corrosion associated with older piping as the mechanism that resulted in the failure of the pipeline and the resulting rupture. The first pipeline was installed in 1950 and the second was installed in 1965.

The consequences of the rupture events were then examined. In the first rupture event, there was an explosion that resulted in the death of 12 people. In the second, although there was no explosion or fire, and the only significant consequence was financial, the potential for an explosion existed.

To evaluate the potential risk to the CIS facility from rupture events, a review of the natural gas pipelines in the vicinity of the CIS facility was performed. This review indicated that the pipelines in the vicinity of the site are newer pipelines that were built in accordance with current regulations and should not be susceptible to the same age-related corrosion failures as the pipelines that ruptured. However, since other potential causes of ruptures could exist, a review of the potential risk associated with the worst-case consequences of a rupture event was performed. To evaluate the potential impact of a rupture of the pipelines near the CIS facility, a calculation developed by PHMSA that accounts for the size of the pipeline and the maximum allowable operating pressure was used. The term "PIR" means the radius of a circle within which the potential failure of a pipeline could have significant impact on people or property. The PIR is determined by the following formula (49 CFR 192.903):

$$r = 0.69 * (\text{square root of } (p * d^2)$$

where:

r = the radius of a circular area in feet surrounding the point of failure,
p = the maximum allowable operating pressure (MAOP) in the pipeline segment in pounds per square inch (psi), and
d = the nominal pipeline diameter in inches
0.69 = the factor for natural gas (this factor will vary for other gases depending upon their heat of combustion)

As discussed earlier, near the CIS facility there are two 20-inch pipelines, one 10-inch pipeline, and a proposed 10.75-inch pipeline. As the formulae above indicates, the larger the diameter pipe and the higher the pressure, the larger the hazard area. Based on this, the two 20-inch high pressure pipelines represent the greatest potential risk to the site from an explosion hazard. The two 20-inch pipelines are classified as high-pressure pipelines rated for a pressure of 1,180 pounds per square inch (psi) abut are normally operated at a pressure of approximately 680 psi (DOE WIPP). The hazard area radius for a 20-inch high pressure pipeline, operating at its maximum allowable operating pressure, is

calculated as shown below:

r = 0.69 * (square root of (1180 * $(20)^2$)
r = 0.69 * (square root of (1180 * 400)
r = 0.69 * (square root of (472,000)
r = 0.69 * 687.0226
r = 474.05 feet

Given that all pipelines near the CIS Facility are located more than 0.16 miles (844.8 feet) from the Site boundary, and even further from the ISFSI, it would be extremely unlikely for a pipeline rupture to impact operations at the facility.

With only 2 natural gas transmission pipeline ruptures having occurred in NM in the last 20 years and over 6500 miles of natural gas pipelines in the state, the potential for a pipeline rupture is estimated to be 1.54E-05/yr per pipeline mile (2 ruptures/20 years/6500 miles). Regardless of the quantify of the pipeline near the CIS facility, the fact that an explosion associated with the size and MAOP of the pipelines near the CIS Facility does not have the potential to impact the CIS facility due to the physical distance between the pipelines and the CIS facility, rupture hazards resulting in explosions can be screened from consideration as a threat to the CIS Facility.

Pipeline Leaks

A review of Table 1 indicates that many leaks were discovered during leak tests, and that most of them were due to corrosion, welding issues, or valve stem failures. The worst-case consequences of these incidents were losses of natural gas to the environment. None of these incidents resulted in death or significant property damage. Although these incidents resulted only in a loss of natural gas to the environment with no fire or other property damage, there is a potential for a fire to have occurred if the specific conditions were met. To evaluate the potential risk to the CIS facility from leaks, the potential for a leak to result in a fire that has the potential to directly and significantly impact the CIS Facility was evaluated.

For a fire/explosion associated with a natural gas leak to develop and have the potential to impact the CIS facility, the following conditions must exist:

- A leak must exist.
- Sufficient gas must escape from the leak to create a flammable or explosive mixture.
- The flammable/explosive mixture must propagate to the CIS facility.
- An ignition source cannot ignite the flammable/explosive mixture prior to the mixture propagating to the CIS facility.
- An ignition source must be present at the CIS facility to ignite the flammable/explosive mixture.

- The resulting fire/explosion must be of sufficient magnitude to cause damage to the CIS facility or the containers stored there.

As mentioned earlier, there are currently three pipelines near the CIS Facility: (1) a 20-inch diameter natural gas pipeline located approximately 0.8 miles from the western boundary of the Site, (2) a 20-inch diameter natural gas pipeline located approximately 0.16 miles east of the eastern boundary of the Site; and (3) a 10-inch diameter natural gas pipeline located approximately 0.17 miles east of the eastern boundary of the Site. In addition, a fourth pipeline that would be a 10.75-inches in diameter low-pressure natural gas pipeline has been proposed to be constructed running south-to-north between the two existing pipelines east of the CIS facility.

For a leak associated with the 20-inch pipeline located 0.8 miles from the western boundary of the site, the flammable/explosive gas cloud would need to travel in the Eastern direction. For a leak associated with either the 20-inch, the 10-inch, or the proposed 10.75 inch pipelines located approximately 0.16 miles east of the eastern edge of the CIS facility, the flammable/explosive gas cloud would need to travel in the Western direction. Based on the properties of natural gas and its ability to dissipate into the air rapidly (Nat Gas Prop), it is assumed that very low wind speeds (between 1.4 and 4 mph) would be required to enable the gas cloud to travel towards the CIS facility without dissipation occurring.

With the ISFSI pad being on the Western side of the CIS facility property, the flammable/explosive gas clouds from either location must travel over 1 mile prior to reaching a vulnerable location at the CIS Facility. In order for the flammable/explosive cloud to travel to the CIS facility and retain its flammable/explosive mixture, it is assumed that winds must be present to cause the cloud to move, the winds must be slight to prevent dispersion of the cloud, and the winds must be blowing in the direction of the CIS Facility.

To evaluate the potential for the conditions (wind direction and speed) to exist to allow a flammable/explosive cloud to propagate over 1 mile from the pipeline release location to the CIS facility without dispersing, the wind rose information shown in Figure 2 from the Lea County Regional Airport Station was used (Wind Data).

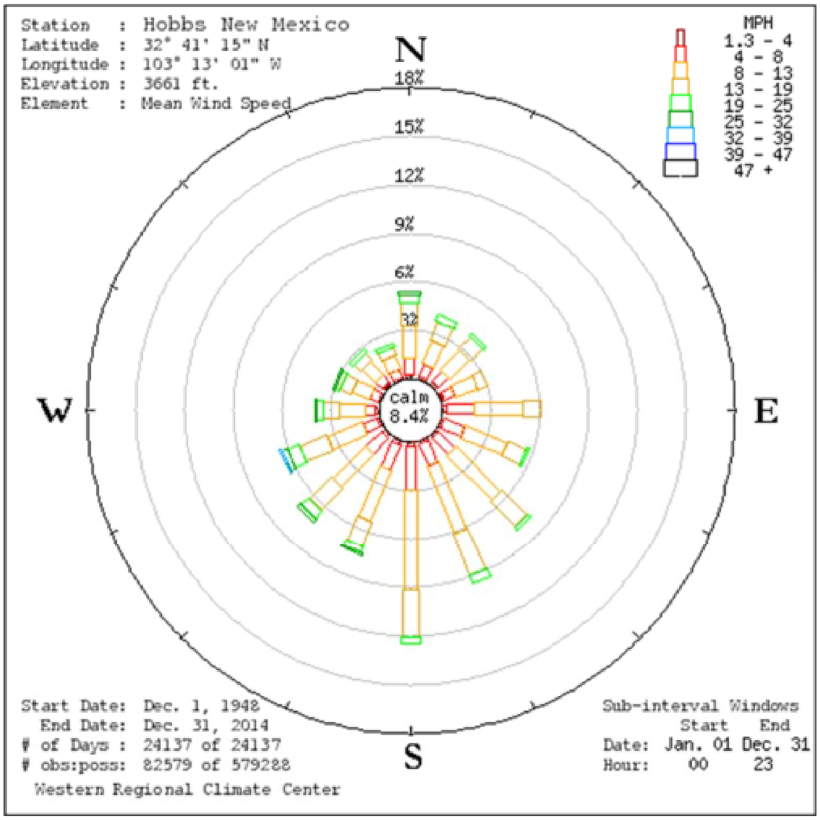

Figure 2: Lea County Regional Airport Station All Wind Rose (replicated from SAR Figure 2.3.2)

As shown in this wind rose:

- winds are calm (less than 1.3 mph) approximately 8.4% of the time
- blows from the west to the east ~6 percent of the time
    - speeds between 1.3 and 4 mph ~0.2% of the time
    - speeds greater than 4 mph ~6% of the time
- blows from the east to the west ~4% of the time
    - speeds between 1.3 and 4 mph ~0.1% of the time
    - speeds greater than 4 mph ~3.9% of the time

With only 5 leaks (20030025, 20030026, 20050073, 20120042, 20180033) occurring over the 20-year time period, the potential for a leak or puncture event to occur on a natural gas pipeline in the State of New Mexico was calculated to be 0.25 per year (5 incidents / 20 years). With less than 3 miles of pipelines currently running near the CIS facility, and over 6,500 miles of natural gas transmission pipelines in New Mexico, the potential for the leak to be associated with the portion of the pipeline near the CIS facility was calculated to be less than 5E-4 (3 miles/6500 miles).

This results in a frequency of 1.25E-4/yr (0.25 * 5E-4/yr) that a gas release due to leaks would occur near the CIS facility. To determine the potential risk of a gas leak to the CIS Facility, the following factors were considered:

1) The need for sufficient gas to be released to cause a flammable gas cloud
    - Based on the incidents, most of the leaks were pinhole sized and were found during normal leak inspections – these would not result in sufficient gas to be released to form a flammable cloud.
    - The leak would occur on a buried portion of natural gas pipeline since there are no above ground portions within the vicinity of the CIS Facility.
    - The natural gas pipelines are buried at least 18-inches underground in rocky areas, and 30-inches underground in normal soil.
    - The rock or soil cover will cause natural dispersion of the gas as it is being released.
    - Even if a leak were of sufficient size to result in a large enough quantity of natural gas to be released to potential create a flammable/explosive mixture, the natural dispersion qualities of the soil covering the pipeline would result in a dispersion of the gas prior to it reaching the surface.
    - As a gas cloud disperses two events occur; the concentration of the gas cloud decreases and with this change the gas cloud density will approach that of air. Therefore, as a gas cloud disperses its behavior changes and finally becomes neutral with air. A diluted gas will never separate again from air to produce higher concentrations.
    - Therefore, the probability of sufficient gas being released to form a flammable cloud was conservatively estimated to be 0.005.
2) The need for the flammable cloud to travel a minimum of 1 mile without dispersing
    - this requires winds to be blowing in the direction required to move the flammable cloud from the pipeline leak location to the CIS facility.
    - Based on wind data, the wind blows in the required direction at speeds between 1.3 and 4 mph approximately 0.3 percent of the time.
    - This equates to a probability of 0.003 that the winds will be blowing in the proper direction at the proper speed.
3) The need for the flammable cloud to not ignite prior to reaching the CIS facility
    - With the presence of high energy lines, roads, a railroad spur, and facilities between the pipeline locations and the location of the ISFSI, the probability that a flammable cloud could travel over 1 mile without igniting is very small.
    - The probability that the flammable cloud does not encounter an ignition source as it travels to the CIS Facility was conservatively estimated to be 0.01.
4) The need for the flammable cloud to ignite once it reaches the CIS Facility ISFSI pad was conservatively assumed to be 1.
5) The need for a sufficient fire/explosion to occur once the flammable cloud reaches the CIS facility
    - Due to the design of the casks used at the CIS Facility, a normal fire would not cause damage to the cask, an explosion would be required.
    - The quantify of natural gas that would be required to cause an explosion is significant, while the quantity of natural gas required to cause a fire is much smaller.
    - The probability that the flammable cloud is of sufficient size and concentration to cause an explosion was conservatively assumed to be 0.01.

The frequency of a leak resulting in a significant fire/explosion at the CIS facility is less than 2E-13/yr (1.25E-4/yr * 0.005 * 0.003 * 0.01 * 1 * 0.01). Even assuming higher probabilities associated with the wind direction and the potential explosion (assume an order of magnitude higher for each), the frequency of this event is still below 2E-11/yr. Therefore, this potential for this event is to occur is considered negligible and can be screened from further consideration.

Pipeline Punctures

Based on a review of Table 1, punctures were caused by people and the use of heavy equipment in the vicinity of the pipeline. In these instances, the people were either unaware of the presence of the pipeline, were intoxicated, or were not careful in their use of the heavy equipment. The worst-case consequences of these incidents were losses of natural gas to the environment and the damage to the pipeline itself from the heavy equipment. None of these incidents resulted in death or significant property damage. Although these incidents resulted only in a loss of natural gas to the environment with no fire or other property damage, there is a potential for a fire to have occurred if the specific conditions were met. To evaluate the potential risk to the CIS facility from punctures, the potential for a puncture to result in a fire that has the potential to directly and significantly impact the CIS Facility was evaluated.

For a fire/explosion associated with a natural gas line puncture to develop and have the potential to impact the CIS facility, the following conditions must exist:

- A puncture must exist.
- Sufficient gas must escape from the puncture to create a flammable or explosive mixture.
- The flammable/explosive mixture must propagate to the CIS facility.
- An ignition source cannot ignite the flammable/explosive mixture prior to the mixture propagating to the CIS facility.
- An ignition source must be present at the CIS facility to ignite the flammable/explosive mixture.
- The resulting fire/explosion must be of sufficient magnitude to cause damage to the CIS facility or the containers stored there.

As mentioned earlier, there are currently three pipelines near the CIS Facility: (1) a 20-inch diameter natural gas pipeline located approximately 0.8 miles from the western boundary of the Site, (2) a 20-inch diameter natural gas pipeline located approximately 0.16 miles east of the eastern boundary of the Site; and (3) a 10-inch diameter natural gas pipeline located approximately 0.17 miles east of the eastern boundary of the Site. In addition, a fourth pipeline that would be a 10.75-inches in diameter low-pressure natural gas pipeline has been proposed to be constructed running south-to-north between the two existing pipelines east of the CIS facility.

For a puncture associated with the 20-inch pipeline located 0.8 miles from the western boundary of the site, the flammable/explosive gas cloud would need to travel in the Eastern direction. For a puncture associated with either the 20-inch, the 10-inch, or the proposed 10.75 inch pipelines located approximately 0.16 miles east of the eastern edge of the CIS facility, the flammable/explosive gas cloud would need to travel in the Western direction. Based on the properties of natural gas and its ability to dissipate into the air rapidly (Nat Gas Prop), it is assumed that very low wind speeds (between 1.4 and 4 mph) would be required to enable the gas cloud to travel towards the CIS facility without dissipation occurring.

With the ISFSI pad being on the Western side of the CIS facility property, the flammable/explosive gas clouds from either location must travel over 1 mile prior to reaching a vulnerable location at the CIS Facility. In order for the flammable/explosive cloud to travel to the CIS facility and retain its flammable/explosive mixture, it is assumed that winds must be present to cause the cloud to move, the winds must be slight to prevent dispersion of the cloud, and the winds must be blowing in the direction of the CIS Facility.

Similar to the evaluation performed for the pipeline leak evaluation, wind data from the Lea County Regional Airport Station as shown on Figure 2 was used. Again, as shown by the wind rose:

- winds are calm (less than 1.3 mph) approximately 8.4% of the time
- blows from the west to the east ~6 percent of the time
    - o speeds between 1.3 and 4 mph ~0.2% of the time
    - o speeds greater than 4 mph ~6% of the time
- blows from the east to the west ~4% of the time
    - o speeds between 1.3 and 4 mph ~0.1% of the time
    - o speeds greater than 4 mph ~3.9% of the time

To evaluate the risk potentially associated with a puncture event, the probability that all the attributes required for a fire associated with a natural gas puncture to develop and have the potential to impact the CIS facility, was estimated.

With only 6 pipeline puncture incidents (20060108, 20070012, 20110301, 20160030, 20180055, 20200039) occurring over the 20-year time period, the potential for a puncture event to occur on a natural gas pipeline in the State of New Mexico was calculated to be 0.30 per year (6 incidents / 20 years). With less than 3 miles of pipelines currently running near the CIS facility, and over 6,500 miles of natural gas transmission pipelines in New Mexico, the potential for the leak to be associated with the portion of the pipeline near the CIS facility was calculated to be less than 5E-4 (3 miles/6500 miles).

This results in a frequency of 1.5E-4/yr (0.30 * 5E-4/yr) that a gas release due to leaks would occur near the CIS facility. To determine the potential risk of a gas leak to the CIS Facility, the following factors were considered:

1) The need for sufficient gas to be released to cause a flammable gas cloud
    - Based on the incidents, none of the punctures were of sufficient size to result in a fire or explosion.
    - Because a puncture is caused by heavy equipment impacting the pipeline, there is the potential for a significant puncture to result that would release sufficient natural gas to form a flammable/explosive mixture.
    - Therefore, the probability of sufficient gas being released to form a flammable/explosive cloud was conservatively estimated to be 0.5.
2) The need for the flammable/explosive cloud to travel a minimum of 1 mile without dispersing
    - this requires winds to be blowing in the direction required to move the flammable cloud from the pipeline leak location to the CIS facility.

- Based on wind data, the wind blows in the required direction at speeds between 1.3 and 4 mph approximately 0.3 percent of the time.
- This equates to a probability of 0.003 that the winds will be blowing in the proper direction at the proper speed.

6) The need for the flammable/explosive cloud to not ignite prior to reaching the CIS facility
    - All puncture events were cause by heavy equipment interacting with the buried natural gas pipeline.
    - The presence of the heavy equipment impacting the pipeline provides an ignition source at the location of the break.
    - Based on the multitude of ignition sources present at the break location (heat of the motor, sparks from the impact, sparks from the heavy equipment, etc.) in addition to the ignition sources present between the break location and the CIS facility, this probability of the flammable cloud traveling for over 1 mile without igniting was conservatively estimated to be 0.001.
7) The need for the flammable cloud to ignite once it reaches the CIS Facility ISFSI pad was conservatively assumed to be 1.
8) The need for a sufficient fire/explosion to occur once the flammable cloud reaches the CIS facility
    - Due to the design of the casks used at the CIS Facility, a normal fire would not cause damage to the cask, an explosion would be required.
    - The quantify of natural gas that would be required to cause an explosion is significant, while the quantity of natural gas required to cause a fire is much smaller.
    - The probability that the flammable cloud is of sufficient size and concentration to cause an explosion was conservatively assumed to be 0.01.

The frequency of a leak or puncture resulting in a significant fire/explosion at the CIS facility is less than 3E-12/yr (1.5E-4/yr * 0.5 * 0.003 * 0.001 * 1 * 0.01). Even assuming higher probabilities associated with the wind direction and the potential explosion (assume an order of magnitude higher for each), the frequency of this event is still below 3E-10/yr. Therefore, this potential for this event is to occur is considered negligible and can be screened from further consideration.

Equipment Failures

A review of Table 1 indicates that equipment failures such as failed relief valves and compressors contribute to larger gas releases, and therefore have a greater potential to result in a flammable gas cloud. A review of the natural gas pipelines in the vicinity of the CIS Facility shows that the pipelines are underground, and do not have any relief valves or other equipment in the vicinity of the CIS facility. The closest above ground gas pipeline compressor station is located approximately 5.2 miles southwest of the CIS Facility.

Therefore, although an equipment failure has a higher potential to form a flammable cloud, the lack of equipment in the area of the CIS facility that would be subject to failure would require the flammable cloud to travel much further prior to reaching the CIS Facility. The same logic applied during the evaluation of leaks and punctures was applied to the evaluation of equipment failures.

With 11 equipment failure incidents (20070087, 20130062, 20130091, 20150036, 20150108, 20170033, 20170042, 20170066, 20170072, 20190104, 20200045) occurring over the 20-year time period, the potential for an equipment failure event to occur on a natural gas pipeline in the State of New Mexico was calculated to be 0.55 per year (11 incidents / 20 years). With the closest gas compressor station over 5 miles from the CIS Facility, there is no potential for the equipment failure to be associated with the portion of the pipeline near the CIS facility. With less than 3 miles of pipelines currently running near the CIS facility, and over 6,500 miles of natural gas transmission pipelines in New Mexico, the potential for the leak to be associated with the portion of the pipeline near the CIS facility was calculated to be less than 5E-4 (3 miles/6500 miles).

Even though there are no facilities within 5 miles of the CIS facility that have above ground equipment associated with the natural gas transmission lines, it was conservatively assumed that that a valve was somewhere on the 3 miles of buried pipeline near the CIS Facility resulting in a probability of 5E-4 that an equipment failure could impact the pipelines near the CIS Facility.

Based on this, a frequency of 2.75E-4/yr (0.55 * 5E-4/yr) that a gas release due to equipment failure would occur near the CIS facility. To determine the potential risk of a gas release due to equipment failure to the CIS Facility, the following factors were considered:

1) The need for sufficient gas to be released to cause a flammable gas cloud
    - Based on the incidents, one of the equipment failures resulted in a natural gas fire/explosion.
    - Two of the incidents resulted in a fire associated with the equipment but did not catch the natural gas on fire.
    - Although only one of the 11 events resulted in a natural gas fire, the quantity of gas released from many of them exceeded the amount required for a flammable/explosive mixture to develop. Therefore, the probability of sufficient gas being released to form a flammable/explosive cloud was conservatively estimated to be 1.
2) The need for the flammable/explosive cloud to travel a minimum of 5 miles without dispersing
    - This requires winds to be blowing in the direction required to move the flammable cloud from the pipeline leak location to the CIS facility.
    - Based on wind data, the wind blows in the required direction at speeds between 1.3 and 4 mph approximately 0.3 percent of the time.
    - This equates to a probability of 0.003 that the winds will be blowing in the proper direction at the proper speed.
9) The need for the flammable/explosive cloud to not ignite prior to reaching the CIS facility
    - With the presence of high energy lines, roads, a railroad spur, and facilities between the pipeline locations and the location of the ISFSI, the probability that a flammable cloud could travel over 5 miles without igniting is extremely small.
    - The compressor stations have multiple electrical lines, rotating equipment, vehicles, etc. at them, all of which are ignition sources.
    - Based on the multitude of ignition sources present at a compressor station (heat of the compressor, sparks from the rotating equipment, sparks from electrical lines, etc.) in addition to the ignition sources present between the break location

and the CIS facility, this probability of the flammable cloud traveling for over 5 miles without igniting was conservatively estimated to be 0.001.

10) The need for the flammable cloud to ignite once it reaches the CIS Facility ISFSI pad was conservatively assumed to be 1.
11) The need for a sufficient fire/explosion to occur once the flammable cloud reaches the CIS facility
    - Due to the design of the casks used at the CIS Facility, a normal fire would not cause damage to the cask, an explosion would be required.
    - The quantify of natural gas that would be required to cause an explosion is significant, while the quantity of natural gas required to cause a fire is much smaller.
    - The probability that the flammable cloud is of sufficient size and concentration to cause an explosion was conservatively assumed to be 0.01.

The frequency of a leak or puncture resulting in a significant fire/explosion at the CIS facility is less than 1E-11/yr (2.75E-4/yr * 1 * 0.003 * 0.001 * 1 * 0.01). Even assuming higher probabilities associated with the wind direction and the potential explosion (assume an order of magnitude higher for each), the frequency of this event is still below 1E-9/yr. Therefore, this potential for this event is to occur is considered negligible and can be screened from further consideration.

Lightning Strikes

A review of Table 1 identified one incident directly associated with a lightning strike (20030073) and one indirectly associated with a lightning strike (20170042) Lightning strikes have the potential to cause fires in the vicinity of natural gas pipelines under two different conditions. The first condition is the lightning striking above ground piping or equipment causing gas to escape and catch fire. The second condition is lightning striking in the vicinity of an existing pipeline leak causing the escaping gas to catch fire. Since the natural gas pipelines near the CIS are all underground, a lightning strike hitting the pipeline or associated equipment is not a potential hazard for the site. The evaluation of natural gas pipeline leaks due to pipe or equipment failures discussed above includes the need for an ignition source in the vicinity of the leaking gas in order for a fire to occur. Lightning is just one of the many potential ignition sources that could cause the leaking gas to catch fire, and the probability of a lightning strike is much lower than the probability of other potential ignition sources being present. Therefore, lightning in the vicinity of the CIS facility resulting in a natural gas fire can be screened from consideration.

References for RAI 2-7

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2-8 Justify why having oil and gas exploration and production activities near the proposed facility would not pose a hazard in SAR Section 2.1.4, “Land and Water Use.”

As discussed in RAI 2-3, SAR Section 2.2.2, “Pipelines,” states that one oil/gas well is currently producing in the southwest portion of the property. Additional wells may also be drilled in nearby oil/gas leases in the future which could possibly travel below the proposed site. In addition, activities associated with well completion and production may pose hazard to the proposed facility for example, leakage of gas from the wellhead or gas flaring operation. Additionally, SAR Section 2.1.4, “Land and Water Use,” states that multiple horizontal holes will be drilled to the Bone Spring formation from the Belco Shallow and Belco Deep drill islands. These drill islands are very close to the proposed site, approximately 400 m [1,320 ft] and 800 m [2,640 ft], respectively. Similarly, holes were drilled from the Green Frog Café drill island just east of the proposed site. The potential for subsidence due to corrosion of the casings of the abandoned drill holes is illustrated by the formation of the Wink and Jal sinkholes described in SAR Section 2.1.4. The hazards from potential land subsidence induced by casing failure, any future horizontal drilling beneath the site, or from oil/gas production from nearby wells should be evaluated and assessed to demonstrate that important to safety structures at the proposed facility and facility operations are not affected.

This information is necessary to determine compliance with 10 CFR 72.24, 72.90(a) through (d), 72.94, and 72.98.

Holtec Response

This response addresses three hazards to the proposed CISF: sinkholes and subsidence from well casing failures, hazards from nearby active oil and gas wells, and hazards from horizontal drilling.

<u>Sinkholes and Subsidence from Well Casing Failures</u>

> Land subsidence is the phenomenon or response that occurs when an underground opening is created. The major hazard associated with land subsidence from drilling operations is the formation of sinkholes at or near the wellhead. As described in SAR Section 2.1.4, the Jal and Wink (Wink I and Wink II) sinkholes are examples of land subsidence associated with drilling operations. As described further below, the major causes of these sinkholes were inappropriate borehole management practices and excessive water control activities. Poor borehole management practices led to an increase in casing damage that resulted in casing failures that exposed large sections of

the salt layers to the borehole. Then, excessive water control activities increased the rates of salt dissolution in the underlying soils which created large underground cavities that eventually collapsed and resulted in sinkholes.

<u>Wink Sink I</u>

Wink Sink I formed approximately 2 miles north of Wink, TX on June 3, 1980 at the abandoned No. 10-A Hendrick oil well. The No. 10-A well is one of 1400 wells that have been drilled in the Hendrick oil field since its discovery in 1926. One of the major problems in the Hendrick field since its beginnings has been the disposal of great volumes of oil-field brine produced along with the oil. Water production in the field ranged from 600,000 to 875,000 barrels per day in the 1930s. Nearly 50 evaporative pits ranging in sizes from 1 to 30 acres were used at one time or another as disposal pits in the 4 square miles surrounding the Wink collapse and subsidence features. The sinkhole at Wink Sink I is approximately 400 ft in diameter with additional fissures (tension fractures) adjacent to the sinkhole. Salt dissolution and collapse associated with Wink Sink I resulted from, or at least was accelerated by, recharging shallow aquifers from leakage of unsaturated wastewater from the disposal pits along with oil-field activity in the immediate vicinity of the sink.

The No. 10-A Hendrick well was drilled at the site of the sinkhole. It is believed that the well was drilled with freshwater drilling fluid that enlarged or washed out the borehole within the salt layer. Ineffective cement jobs, and possible fractures in the cement, may have opened pathways for water movement up or down the borehole outside of the casing. Because of probable salt dissolution and borehole enlargement during drilling through the Salado salts, the small amount of cement reportedly used (800 sacks) to set the casing in the hole was probably only enough to cement the lower part of the hole, thus leaving most of the salt section exposed behind the casing. The casing in the well is also suspected to be further damaged by corrosion from production of great quantities of oilfield brine as well as from the use of explosives to realign the well. It is possible that the explosives not only fractured the Tansill formation and increased its permeability locally but also may have fractured the cement farther up the borehole. Additionally, final removal of the casing from the well in 1964 left an uncemented borehole in the interval from the base of the Santa Rosa aquifer to the top of the Rustler Formation.

All of the above-mentioned activities aided in conducting fresh water from the swollen shallow aquifers down the borehole to the salt beds thus dissolving the salt and forming a void which eventually caused the sink hole [1]. Salt dissolving waters may also have ascended from below the salt layer with similar results. The hydraulic head of the Capitan Reef is above the elevation of the Salado at the No. 10-A Hendrick well. Fresh water could rise under artesian pressure and denser brine could move down the borehole under gravity exacerbating the cavity formation.

<u>Wink Sink II</u>

On May 21, 2002, Wink Sink II developed 1 mile south of Wink Sink I and is centered on the site of a former water-supply well, the Gulf Oil Corporation No. WS-8 Grisham-Hunter Surface Fee. The sinkhole at Wink Sink II is approximately 950 ft in diameter. The Gulf WS-8 well was completed September 18, 1960, and was drilled into the Capitan Reef to a total depth of 3,583 ft. At this well location the top and base of the

Salado Formation are at depths of 1,353 ft and 2,252 ft, respectively. The Gulf WS-8 was plugged prior to formation of Wink Sink II, but during its productive life it yielded about 800 million bbl of water for waterflood operations. It is suspected that Wink Sink II formed mainly because of the water production at the Gulf WS-8 well [1]. Specifically, produced water from the Capitan Reef leaked through the well tubing and casing into the salt formation. It is also possible that unsaturated water from shallow aquifers may have flowed down through the borehole against the salt or water from the Capitan Reef ascended under artesian pressure after the well was abandoned creating a brine density flow similar to Wink I.

<u>Jal Sink</u>

The Jal Sink formed about 8 miles north-northwest of Jal, NM sometime between August 31 and September 5, 1998. The sinkhole is roughly 75 ft east of the Skelly No. 2 Jal Water System (Jal WS-2) water-supply well and is approximately 170 ft in diameter. The stratigraphy in the vicinity of the Jal Sinkhole is similar to that at the Wink Sinkholes. In the Jal WS-2 well, the depth to the top of salt in the Rustler Formation is 1,530 ft, and the depth range of the salt-bearing Salado Formation is 1,944 ft to 3,310 ft. The Jal WS-2 produced relatively low salinity water for waterflood operations from the Capitan Reef at depths from 3,890 ft to a total depth of 4,500 ft. In 1979, a workover of the Jal WS-2 well revealed collapsed casing in the Rustler interval at 1,642 ft. The well was plugged and abandoned, with cement plugs set in the casing at depths of 1,418-1,550 ft, 72-414 ft, and 0-10 ft. The casing was then perforated, and cement was emplaced at three levels: behind the casing at 1,250 ft, below a packer at 1,140 ft, and behind the casing at 400 ft. It is suspected that salt dissolution might have occurred after plugging of the well, because approximately 300 ft of the salt section was exposed behind the casing. However, the 1979 workover report indicates that the casing in the salt-bearing Rustler interval had collapsed prior to plugging. Salt also may have been dissolved during operation of the well, possibly as a result of a lack of integrity of the casing. Ultimately, it is believed that the sinkhole resulted from dissolution of salts from well leakage during well operations and the circulation of fresh water and uncontrolled dissolution of evaporites after the well was plugged and abandoned [2].

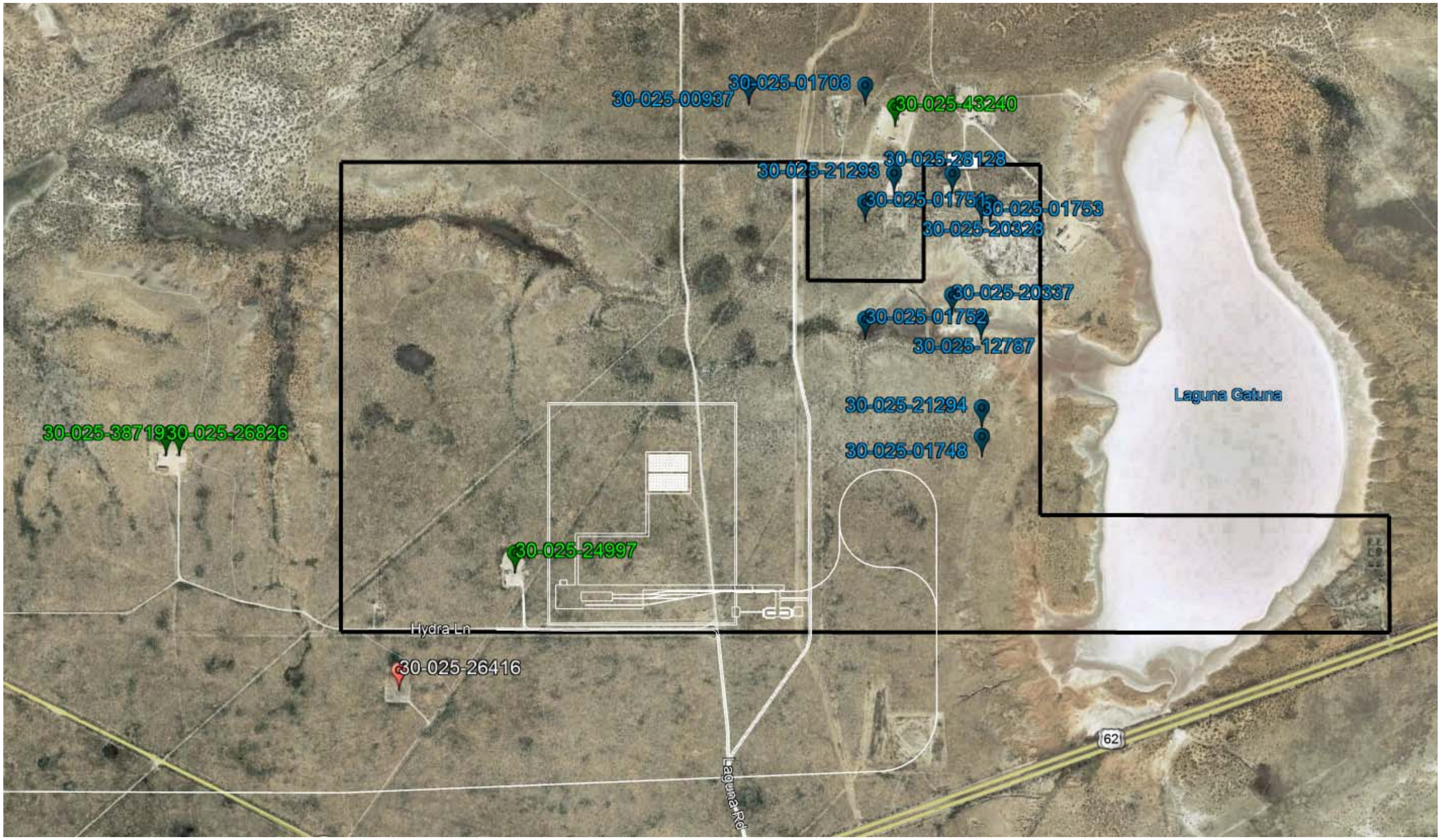
<u>Relevant Information for Existing Wells Near the CISF</u>

Table 1 below shows the relevant information for all oil and gas wells within 1 mile of the facility including their approximate distance to the ISFSI [3]. Figure 1 shows their relative location to the proposed HI-STORE Facility. As noted, there is 1 active gas well, 3 active oil wells, 12 plugged oil wells, and 1 cancelled oil well (never drilled). Note, information on the regional stratigraphy can be found in SAR Section 2.6 and Section 3.3 of the HI-STORE Environmental Report.

Table 1: Oil and Gas Wells within 1 mile of HI-STORE Facility

API	Well Name	Well Type	Well Status	Vertical Depth (ft)	Original Drilling Completion Date	Plug Date	Appr. Dist. to ISFSI (ft)
30-025-00937	Monroe #1 (PRE-ONGARD WELL #001)	Oil	Plugged (site released)	3,126	Jul-1943	Jul-1943	4,000
30-025-01708	Brooks-7 Well # 1 (PRE-ONGARD WELL #001)	Oil	Plugged (site released)	3,123	Oct-1941	Nov-1948	4,350
30-025-01748	Welch State #1 (PRE-ONGARD WELL #001)	Oil	Plugged (site released)	3,117	Sep-1945	May-1947	3,250
30-025-01751	Leonard-Welch State #1 (PRE-ONGARD WELL #001)	Oil	Plugged (site released)	3,102	Jun-1941	Mar-1947	3,250
30-025-01752	Welch State #2 (PRE-ONGARD WELL #002)	Oil	Plugged (site released)	3,104	Sep-1941	Mar-1947	2,350
30-025-01753	Welch State #3 (PRE-ONGARD WELL #003)	Oil	Plugged (site released)	3,099	Oct-1941	Feb-1948	4,200
30-025-12787	Welch State #4 (PRE-ONGARD WELL #004)	Oil	Plugged (site released)	3,087	Nov-1941	Mar-1947	3,500
30-025-20328	Bass State #1	Oil	Plugged (site released)	3,100	Sep-1963	Jun-1982	4,250
30-025-20337	Bass State #2	Oil	Plugged (site released)	3,100	Jan-1964	Jun-1982	3,350
30-025-21293	Bass State #3	Oil	Plugged (site released)	3,120	Apr-1965	Jun-1982	3,700
30-025-21294	Bass State #4 (PRE-ONGARD WELL #004)	Oil	Plugged (site released)	3,144	Aug-1965	Dec-1982	3,300
30-025-24997	Hanson State #1	Gas	Active	13,363	Aug-1975	N/A	1,750
30-025-26416	Boyd A #1 (PRE-ONGARD WELL #001)	Oil	Cancelled	N/A	N/A	N/A	3,600
30-025-26826	Belco AIA Federal #1	Oil	Active	13,250	Feb-1992	N/A	5,450
30-025-28128	Bass State #6	Oil	Plugged (site released)	3,079	Jan-1983	Aug-1998	4,200
30-025-38719	Belco AIA Federal #3H	Oil	Active	7,772	Feb-2008	N/A	5,300
30-025-43240	Rusty Anchor 7 Federal Corn #1H	Oil	Active	9,902	Dec-2016	N/A	4,400

Figure 1: Oil and Gas Wells within 1 mile of HI-STORE Facility



Assessment of Risks for Existing Wells near the CISF

As described above, the Jal and Wink sinkholes resulted from subsurface dissolution of salt caused by freshwater leakage in improperly cased abandoned oil and water wells. The key factor at the Wink II and Jal sinkholes was that their source wells during their operating years were used for oilfield brine extraction or freshwater extraction for waterflood operations. These operations likely corroded the well casings. Leakage from Wink I, Wink II, and Jal were further exacerbated by poor borehole management activities (the use of explosives for well realignment, ineffective cement jobs, and removal of the casings prior to plugging). The development of underground cavities which eventually became sinkholes was likely initiated and then accelerated by the activities during the productive years of each well continuing when they were plugged and abandoned.

As none of the wells in the vicinity of the proposed Facility has been used for these types of water extraction activities, Holtec believes that there is little risk of these wells experiencing land subsidence or becoming sinkholes during the life of the Facility. Additionally, as it relates to evaluating the risk to safety-related structures, all of the wells and drill islands are greater than 1,000 ft away from the storage area. As stated above the Jal, Wink I, and Wink II sinkholes are approximately 170, 400, and 950 ft in diameter, respectively. Therefore, even if any one of the wells near the proposed Facility were to become a sinkhole similar to what happened at the Jal and Wink sinkholes, they would not pose any risk to safety-related structures at the Facility.

Risks of New Wells near the CISF

According to Order 3324, all future wells near the site would be on drill islands. All drill islands are outside the site boundary. Current state regulations set much stricter requirements for drilling and completion of wells when compared to the processes that have been used historically in the area. All new wells near the Facility will follow the latest regulations for drilling, operations, and eventual plugging or abandonment of wells [4]. The current regulations are designed to ensure the integrity of the borehole and to prevent the mechanisms that lead to salt dissolution. Specifically, current drilling regulations are designed to prevent communication between underground sources of oil, gas, and water strata. During the drilling of an oil well, operators are required to seal and separate the different strata above the producing or injection horizon to prevent their contents from passing into other strata. Drilling fluid must be of sufficient salinity as to match the salt content of the zone being drilled [5]. This requirement is specifically intended to prevent enlarged drill holes. Casing levels (surface, intermediate, and production) and cement plugs are designed and placed to ensure that all formations bearing usable-quality ground water, oil, gas, and geothermal resources, are protected through isolation. The current regulations and drilling practices described above make the risk of casing corrosion (which can cause casing failure) and transmission between strata minimal.

Hazards from Nearby Active Oil and Gas Wells

No new oil and gas wells will be constructed within the Facility boundaries because new drill islands will not be permitted on the privately owned land and, as described further below, any new drilling outside of Facility boundaries would not pose any risk to the safety-related structures. The hazardous effects associated with gas leakage at the well head and gas flaring operations can be characterized as heat dissipation and overpressure resulting from an ignition of the combustible oil or gas.

When considering the distance between the safety-related structures at the Facility and a prospective new oil and gas well, the only heat transfer from a fire would be through radiative effects and the heat exchange factor (view factor) would be so small that any effects from the fire would be negligible. Therefore, the hazardous effect of most concern for the safety-related structures at the Facility is the possible overpressure that would result from an explosion event. As shown in the response to RAI 2-7, the probability for a pipeline leakage to be large enough, in the right location, and to lead to an explosion large enough to have any effect on safety-related structures at the Facility are so small that they can be considered negligible and screened from further consideration. Holtec's position is that the risks associated with gas leakage at wellheads would be similar to those for pipeline leakage.

Gas flaring is an activity where a combustion device is used to burn unwanted or excess gases and liquids released during normal or unplanned oil and gas extraction operations. The flaring of associated gas may occur at the top of a vertical flare stack or it may occur in a ground-level flare in an earthen pit. Gas flaring is usually a controlled burn with hazardous effects characterized as heat dissipation and noise generation from the active flame and possible overpressure from initial gas ignition. These effects can be considered localized to the immediate area surrounding the wellhead. Therefore, when considering the minimum distance to a prospective new or active wells, gas flaring operations do not have any impact on safety-related structures at the Facility.

Therefore, there would be no risks to safety-related structures at the Facility due to leakage of gas from the wellhead or gas flaring operations.

<u>Hazards from Horizontal Drilling</u>

Currently, there are no horizontal wells that travel beneath the Site. Any new wells with horizontal legs that travel beneath the site would first be drilled offsite vertically to a depth greater than 3,050 ft, as this is the shallowest oil or gas formation in the vicinity of the site. Once a wellbore starts travelling horizontally, it stays within its own strata (within the production zone). Because of this, horizontal drilling does not create any additional risk of fluid transfer across multiple strata which is the greatest concern for dissolution of salts and land subsidence. If a horizontal well were to collapse at a depth greater than 3,050 ft, there would be no noticeable effect at the ground surface. Therefore, as long as the vertical portion of the wellbore is maintained properly and in accordance with the current regulations (described above), a well with horizontal legs does not create any additional hazards to the Facility when compared with vertical wells.

<u>Conclusions</u>

Based on the above information, there is little to no potential for hazards to important-to-safety structures at the proposed facility from oil and gas well activity including existing plugged wells, currently active producing wells, and any future well exploration and production activities. The above information in Table 1 and Figure 1 has been added into SAR Section 2.1.

References:

1. Johnson, Kenneth & Collins, Edward & Seni, Steven. (2003). Sinkholes and land subsidence owing to salt dissolution near Wink, Texas, and other sites in western Texas and New Mexico. Evaporite Karst and Engineering/environmental Problems in the United States. 109. 183-195.
2. Powers, Dennis. (2003). Jal Sinkhole in Southeastern New Mexico: Evaporite dissolution, drillholes, and the potential for sinkhole development.
3. New Mexico Oil Conservation Division, NM OCD Oil and Gas Map - ArcGIS Web Application, <nm-emnrd.maps.arcgis.com/apps/webappviewer/index.html>.
4. New Mexico Administrative Code Title 19, "Natural Resources and Wildlife".
5. State of New Mexico Energy, Minerals and Natural Resources Department – Oil Conservation Commission, Case No. 9316, Order No. R-111-P.

2-10: Provide the status of activities associated with extraction of potash ore from the remnant pillars using the solution mining technique, as described in SAR Section 2.1.4, "Land and Water Use." Describe the mining process and the extraction ration achieved, including the date of completion of the solution mining operations in nearby mines, and any additional surface subsidence resulting from solution mining activities.

Section 2.1.4 of the SAR, states that Intrepid Potash LLC was recently approved to extract a portion of the remaining potash ore from the suspended mines using solution mining technology. However, this information dates from 2012, and information on the current status of potash extraction using solution mining technology is not given. Any additional subsidence at the surface due to potash extraction from remnant pillars using solution mining technology is needed to assess the potential effects on the proposed storage facility.

This information is necessary to determine compliance with 10 CFR 72.24(a), 72.90(a) through (d), 72.94, and 72.98.

Holtec Response

The closest current potash mine workings are approximately 2.1 miles away from the ISFSI, FSAR Figure 2.1.23. The Intrepid North mine, at which underground operations have been closed since 1982, can be seen approaching the western side of Laguna Plata in this figure. The Intrepid East Mine, which still has active underground workings, is located further to the south of the site.

As described in section 2.1.4, areas vulnerable to subsidence from potash mine collapse can be determined using an angle of influence of 45° from vertical from the mine workings to the surface. Considering an approximate maximum depth for a potash mine of 3,000 feet, the resulting zone of disturbance would extend 3,000 feet surrounding the mine workings. With this area of disturbance, there is no risk of mine related subsidence to operations at the Site. Potash reserves in area 13 and the proposed CISF site are at a depth of approximately 2,000 feet [1]. The 3,000 foot depth discussed above is a conservative assumption to expand the affected area.

The Intrepid-operated HB Solution Mine, which received final approval to operate in 2012, is over 15 miles west of the site. No solution mine workings are located near the site. The solution mining process, including the extraction ratio achieved, is described in section 2.1.4. Additional information regarding solution mining is provided in response to RAI 2-11. Considering the locations of potash mine workings as described in chapter 2 and the zone of subsidence described above, there is no additional risk of subsidence at the site from potash mining.

Section 2.1.4 language has been clarified to show that Intrepid only uses solution mining at the HB Solution Mine.

References for 2-10:

Salaz, R., “Letter to CEHMM for Potash Resource Evaluation.” United Stated Department of Interior, Bureau of Land Management, April 2019

2-11: Describe the operations to extract potash ore and the resulting subsidence based on observations at mines near the proposed site.

Section 2.1.4 of the SAR, “Land and Water Use,” does not mention the specific mining method(s) used in the nearby mines to extract potash ore. Although several potential methods are mentioned (e.g., room and pillar, longwall, cut and fill, and open stopping), the SAR does not specify which is used. Additionally, the height of the mine openings in the nearby mines is not specified in the SAR to estimate the maximum subsidence that may be realized at the surface. In addition, SAR Section 2.1.4 mentions use of mine roof control practices, such as backfilling, to limit the surface subsidence.

In addition, SAR Section 2.1.4, states that the maximum surface subsidence observed in the southeaster New Mexico potash mines is nominally 4 ft for an average mining height of 6 ft using the room and pillar mining method. Use of the solution mining technique to extract the remnant pillars from the existing room and pillar mines would induce additional subsidence, as the support provided by these remnant pillars would be removed. As stated in SAR Section 2.1.4, Intrepid Potash LLC has been authorized to use the solution mining technique to extract additional potash ore from the remnant pillars, including mines where potash mining was suspended in the past. It is not clear from the SAR whether any of the nearby mines has used this technique to extract potash and the resulting additional surface subsidence.

The description of operations to extract potash ore and the resulting subsidence based on observations at mines near the proposed site should include, at a minimum, the following information:

1. Thickness and depth of the potash bearing strata near the site;
2. Mining method(s) used to extract potash in the vicinity of the site;
3. Dimensions of mine workings (height, width, and length), especially in the vicinity of the proposed site;
4. Roof control practice(s) used;
5. Extraction ratio(s) of the potash mining. If room and pillar method is/was used to extract potash, provide the extraction ratio in the first mining pass and the second mining pass along with the overall extraction ratio;
6. Whether any of the nearby surface mines has used or is using the solution mining technique to extract potash from the remnant pillars, and;
7. Observed surface subsidence from original mining and additional subsidence if solution mining technique was used or will be used to extract potash from the remnant pillars.

This information is necessary to determine compliance with 10 CFR 72.24(a), 72.90(a) – (d), 72.94, and 72.98.

Holtec Response

Per Section 2.1.4 of the SAR Chapter 2, the closest potash mine workings are located 2.1 miles from the Site. This mine utilized the room and pillar method during its mining processes. It is no longer active. Dimensions of this and other mine workings surrounding the site vary in size. The potash reserves in the area are located at approximately 2000 feet in depth [1]. The typical height of mine workings ranges between six and ten feet, while widths vary from 25 to 30 feet. The length of mine rooms can span between 20 and 30 feet. Roof bolts five to six feet in length are utilized for support.

As discussed in response to RAI 2-10 no mine workings are located close enough to the site for subsidence to affect the storage operations, as such, any subsidence related to these mine workings is not discussed. Mining areas utilized an overall extraction ratio ranging from 70% to 80%, with a first stage potash mining extraction rate of 60% to 70%.

Solution mining is being utilized at the HB Solution mine located at T20S R29E and T20S R30E (over 15 miles from the site) to flood the existing mine workings and pillars that have been left in the floor. Other Intrepid mining operations closer to the site have not been approved for solution mining.

Discussion in SAR section 2.1.4 provides description of methods used in regional mines. The Intrepid East and North mines, the closest mine working to the site, both use/used room and pillar methods. An additional statement has been added to describe the roof bolts typically used.

<u>References for 2-11:</u>

1. Salaz, R., “Letter to CEHMM for Potash Resource Evaluation.” United Stated Department of Interior, Bureau of Land Management, April 2019.

2-12: Provide a rationale for why mining operations at nearby underground potash mines or extraction of oil and gas from underneath the CISF would not pose any hazard to the proposed facility from surface subsidence. Also, justify why mining of potash would not be feasible beneath or around the proposed CISF site for the proposed duration of the license.

Section 2.1.4 of the SAR, “Land and Water Us,” states that for potash mining at a depth of 900 m [3,000 ft], the horizontal extent of the surface subsidence would be another 900 m [3,000 ft] extended outward from the farthest mine workings undergoing collapse of the overlying strata, assuming an angle of influence of 40^{o}. Consequently, the applicant states that any subsidence from the nearby mines would not pose any hazard to the proposed facility. However, current locations of the mine workings nearest to the proposed facility site are not provided in the SAR. Section 2.1.4 of the SAR states that the mine workings of the Intrepid East Mine are nearly 9.6 km [6 mi] southwest of the proposed site, citing the proposed GNEP Siting Study (Reference 2.1.3 of SAR). Additionally, SAR Figure 2.1.17, citing a figure from the 2007 GNEP Siting Study (Reference 2.1.3 of the HI-STORE SAR), states that the nearest underground potash mine working is 3.2 km [2 mi] from the proposed site. Information on the distance of the nearest mine working from the proposed site dates from 2007. Therefore, information on any progress of the mine workings in the ensuing years should be described and the current location(s) as well as any projected future mine workings should be used and provided in assessing the potential subsidence hazards to the proposed site.

Sections 2.1.4 and 2.6.4 of the SAR, "Stability of Subsurface Materials," state that Intrepid will not conduct any potash mining on the site and cites an agreement between the applicant and Intrepid Potash LLC. The application should discuss the rationales for the conclusion that potash would not be extracted under and around the site during the licensed life of the project. Similarly, SAR Section 2.6.4 states that there would be no subsidence concerns from any future oil and gas extraction beneath the site. The application should also discuss the rationale for why future oil and gas extraction beneath the site would not present a subsidence concern.

This information is necessary to determine compliance with 10 CFR 72.24(a), 72.90(a) through (d), 72.94, and 72.98.

Holtec Response

The proposed CISF resides in the Secretary of the Interior's Designated Potash Area as defined under the authority of the Mineral Leasing Act of 1939. Oil, gas, and potash leasing and development are closely controlled by Order 3324 [1]. This order ensures coordinated development between oil and gas and potash to ensure mine safety. Additional discussion of the local mines is provided in response to RAI 2-10. To ensure safety in potash mines, the Order requires a ½ mile buffer around gas vertical wells and a ¼ mile buffer around oil vertical wells, Figure 1. Also, it should be noted that Order 3324 restricts new wells to drill islands to limit interference between oil, gas, and potash operations. This buffer provides a horizontal standoff between vertical drilling and mining operations. Applying the buffer system to the drill islands and active wells around the proposed CISF shows that potash mining is not probable in the vicinity of the proposed CISF, Figure 1 (added to FSAR Chapter 2). Subsidence effects from potash mining will not likely be seen over the life of the facility based on the following:

1. Location of potash mines (SAR Figure 2.1.23).
2. Current inactive status of the closest mine workings. The closest mine workings approaching the mining accessible side (west) of the site are part of the Intrepid North facility and are not actively mined. The facility is used for surface operations only.
3. Distance mines would have to be extended to affect the facility;
4. Location of the vertical well buffers, Figure 1 (new SAR Figure 2.1.24).

As stated previously, all future oil and gas vertical wells must be installed on drill islands designated by the BLM [1,3]. It should also be noted that the shallowest oil and gas formation, the Yates formation, is greater than 3050ft below the surface at the CISF site and located below the Salado Formation (salt layer). Because of this fact, any horizontal drilling under the site would occur at greater than 3050ft. Subsidence from horizontal drilling is shown not to be a concern, as described in RAI 2-8. The combination of the depth of horizontal drilling, the thick Salado Formation, and the limited subsidence potential of a horizontal borehole (small diameter casing to collapse, no dissolution risk in oil formation) makes any surface effects non-existent.

Discussion of Order 3324 added to SAR section 2.1.4. Figure 2.1.24 added to show drill island buffer zones.

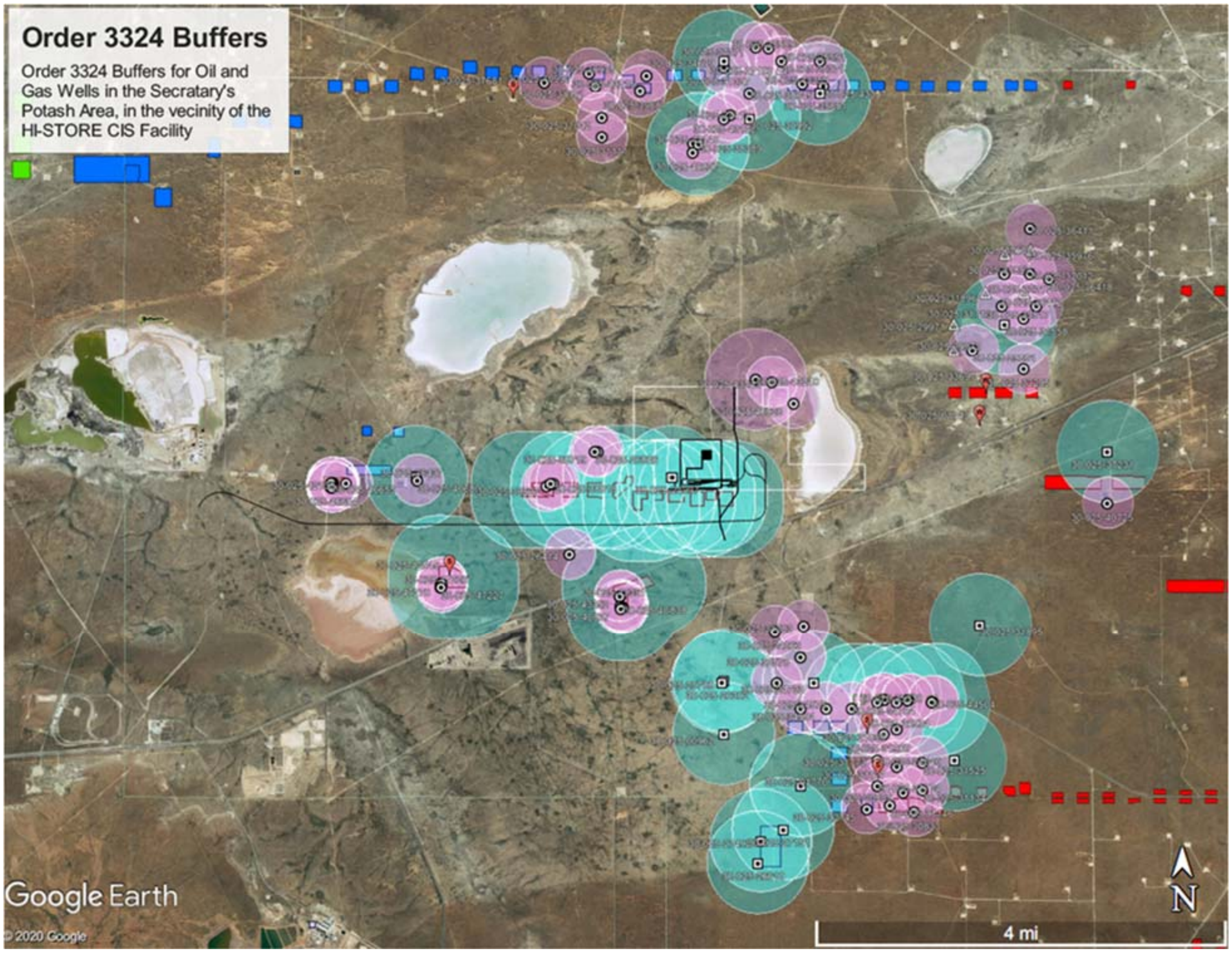


Figure 1 –Order 3324 Buffers for Oil and Gas Wells in the Secretary's Potash Area in the vicinity of the HI-STORE CIS Facility [1][2]

<u>References for 2-12:</u>

1. Secretary of the Interior, "Order No. 3324 – Oil, Gas, And Potash Leasing and Development within the Designated Potash Area of Eddy and Lea Counties, New Mexico." 2012.
2. New Mexico Oil Conservation Division, NM OCD Oil and Gas Map - ArcGIS Web Application, <nm-emnrd.maps.arcgis.com/apps/webappviewer/index.html>.
3. Bureau of Land Management, "Carlsbad Field Office Drill Islands Map." Carlsbad, New Mexico, 8/25/2019.

2-13: Clarify in SAR Section 2.1.4, "Land and Water Use," whether there are any brine wells used for mining salt near the proposed site. If there are brine wells near the site, provide an assessment of the hazards these could pose to the proposed CISF.

Section 2.1.4 of the SAR discusses extraction of salt using brine wells; however, it is not clear from the discussion whether any past, present, or future salt extraction using brine wells has occurred or will occur near the site. Additionally, no assessment is provided regarding potential hazards to the proposed CISF from brine wells near the site.

This information is necessary to determine compliance with 10 CFR 72.24(a), 72.90(a)-(d), 72.94, and 72.98.

Holtec Response

There are no brine wells near the site therefore there is no hazard from brine wells. The closest active brine well (API 30-025-03154) to the proposed CISF is 22.2 miles away [1]. This well will have no effect on the proposed CISF.

RAI 2-8 Figure 1 and Table 1 show all existing well locations within one mile of the Site. None utilized brine welling for mining salt at any time in the past. No future brine wells will be permitted on the proposed site and future wells off the proposed site will be strictly enforced by the New Mexico Oil Conservation Division. Brine wells are regulated as Class III injection wells per NMAC Section 20.6.2 [2]. The NMAC requirements include a requirement for evaluation of all aquifers and surface facilities within the review boundary or that may be affected by the well. The inclusion of the HI-STORE site into a review for a future proposed brine well would be reason for denial of the application for permit if the facility could be shown to be negatively affected.

Section 2.1.4 has been updated to discuss the location of the closest active brine well. Figure 2.1.25 and Table 2.1.5 from RAI 2-8 have been added and referenced as well. These figures show that there are no brine wells local to the CISF site.

<u>References for 2-13</u>:

1. New Mexico Oil Conservation Division, NM OCD Oil and Gas Map - ArcGIS Web Application, <nm-emnrd.maps.arcgis.com/apps/webappviewer/index.html>.
2. New Mexico Administrative Code Title 20, “Environmental Protection.”

2-14: Justify in SAR Section 2.2.4, “Ground Transportation,” that hazardous cargo transported through U.S. Highway 62/180 would not pose any credible hazard to the proposed CISF.

Section 2.2.4 of the SAR states that hazardous cargo that may be transported through U.S. Highway 62/180 includes: gasoline, diesel fuel, acids, carbon dioxide, nitrogen, chlorine gas, refrigerants, fuel gases, oxygen, explosives, and low-level radioactive waste for disposal at the Waste Isolation Pilot Plant facility. The applicant states that the State of New Mexico does not keep records of the specific types and quantities of hazardous materials on this highway. However, an assessment is necessary to demonstrate that all safety-related structures and systems would continue to operate in a safe manner even in a worst-case accident involving hazardous materials on transport via the U.S. Highway 62/180.

The applicant may assess the potential hazards posed by each hazardous material considering the maximum amount that may be legally transported on U.S. highways. The assessment should consider the effects on important to safety structures and systems at the proposed facility, in addition to the loaded cask transporter enroute to the cask storage pad area. Alternatively, the applicant may select a bounding scenario(s), with appropriate assumptions for the types and quantities of hazardous materials, to assess the potential for fire, explosion, or release of noxious gases while being transported though the U.S. Highway 62/180.

This information is necessary to determine compliance with 10 CFR 72.24(a), 72.90(a) through (d), 72.94, and 72.122.

Holtec Response

As described in SAR Section 2.2.4, Highway 62/180 is approximately 1 mile (greater than 2,500 feet) south of the proposed Facility. Per US NRC Regulatory Guide 1.91 [1], the maximum probable solid cargo for a single highway truck is 50,000 pounds. Considering this cargo size and the distance between the highway and the Facility, the only credible effect to the Facility that could result from an accident involving hazardous materials on transport via Highway 62/180 would be the overpressure effects from an explosion event. At this distance, the only heat transfer from a postulated fire to the casks would be from radiative effects. The heat exchange factor (view factor) at this distance would be so small that any effects from the fire would be completely negligible. Additionally, due to the passive nature of the cask system, a release of noxious gases would not have any effect on the safety-related structures at the Facility.

An analysis of bounding hazardous cargo transporters from ground transportation (highway and railroad) is performed in Holtec Report HI-2200797 [2]. The analysis in this report determines a conservatively low minimum pressure threshold that could affect safety-related structures at the HI-STORE Facility and then compares this with maximum overpressure values that could result from explosion of the hazardous cargo transporters. The minimum pressure threshold is determined by calculating the minimum steady-state pressure wave that could cause the VCT carrying the HI-TRAC CS to begin to slide or tip which bounds the design basis overpressure for storage conditions in the UMAX ISFSI. This pressure threshold was determined with a steady state (continuous) pressure wave and bounding input parameters (component weights, component dimensions, coefficient of friction, etc.). Additionally, the hazardous cargo transporters are conservatively assumed to be completely made of TNT to determine bounding explosive overpressure values. As shown in HI-2200797 and described above, the hazardous cargo from ground transportation routes near the proposed Facility will not pose any danger to safety-related structures and systems at the Facility.

References for 2-14:

1. USNRC Regulatory Guide 1.91, “Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants,” Revision 2.
2. Holtec International Report HI-2200797, “Hazards Assessment of Ground Transportation Routes near HI-STORE”, Revision 1.

2-15 Justify in SAR Section 2.2.4, Ground Transportation, that hazardous cargos while being transported by rail cars near the proposed site would not pose any credible hazard to the proposed CISF.

Section 2.2.4 of the SAR states that the nearest operating railroad transports potash ore from the mines to the refiner; however, shipments by rail could also include gasoline, diesel fuel, acids, carbon dioxide, nitrogen, chlorine gas, refrigerants, fuel gases, oxygen, and explosives. The applicant states that the State of New Mexico does not keep records of the specific types and quantities of hazardous materials on this railroad. However, an assessment is necessary to demonstrate that all safety-related structures and systems at the proposed CISF would continue to operate in a safe manner even in a worst-case accident scenario involving hazardous materials transported via the nearby railroad.

The applicant may assess the potential hazards from each type of hazardous material by considering the maximum amount that may be legally transported on U.S. highways. Alternatively, the applicant may select a bounding scenario(s), with appropriate assumptions for the types of quantities of hazardous materials, to assess the potential for fire, explosion, or release of noxious gases during transport via the nearby railroad. The assessment should consider the effects on important to safety structures and systems at the proposed facility in addition to the loaded cask transporter enroute to the cask storage pad area.

This information is necessary to determine compliance with 10 CFR 72.24(a), 72.90(a) through (d), 72.94, and 72.122.

Holtec Response

As described in SAR Section 2.2.4, the nearest operating railroad is an industrial railroad approximately 3.8 miles west of the Facility. Per US NRC Regulatory Guide 1.91 [1], the maximum probable cargo in a single railroad boxcar is approximately 132,000 pounds. Additionally, RG 1.91 states that when shipments are made in connected vehicles, such as railroad cars or barge trains, investigating the possibility that the contents of more than one vehicle may explode is necessary.

Considering the distance between the railroad and the Facility, the only credible effect to the Facility that could result from an accident involving hazardous materials on transport via the railroad would be the overpressure effects from an explosion event. At this distance, the only heat transfer from a postulated fire to the casks would be from radiative effects. The heat exchange factor (view factor) at this distance would be so small that any effects from the fire would be completely negligible. Additionally, due to the passive nature of the cask system, a release of noxious gases would not have any effect on the safety-related structures at the Facility.

An analysis of bounding hazardous cargo transporters from ground transportation (highway and railroad) is performed in Holtec Report HI-2200797 [2]. A bounding case for multiple railroad boxcars is also included to address the possibility of more than one connected vehicle. As described in the response to RAI 2-14 and shown in HI-2200797, the hazardous cargo from ground transportation routes near the proposed Facility will not pose any danger to safety-related structures and systems at the Facility.

References for 2-15:

1. USNRC Regulatory Guide 1.91, “Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants,” Revision 2.
2. Holtec International Report HI-2200797, “Hazards Assessment of Ground Transportation Routes near HI-STORE”, Revision 1.

2-16 Provide additional information to justify the use of a 24-hour, 7.5-inch rain storm to reach the ‘flood dry’ conclusion on the basis of the water mass-balance analysis, as outlined in SAR Section 2.4.2, “Floods.”

Section 2.4.2 of the SAR states that the storm water mass-balance analysis summarized therein is to determine the amount of flooding that would occur at the proposed CISF site with a 7.5-inch, 24-hour rain storm. The applicant also states that this rain storm is the maximum precipitation at the site. In SAR Table 2.4.1, the applicant reports that the estimated 24-hour, 100-year rain storm at Hobbs, New Mexico varies from less than 6.4 inches to more than 7.0 inches, based on Atlas 14 Point Precipitation Frequency Estimates of New Mexico by the National Oceanic and Atmospheric Administration (NOAA). A point precipitation estimate generally differs from areal precipitation estimates (see discussion in HMR 52, NOAA, 1982). For example, the National Weather Service Hydrometeorological Report No. 51 suggests that, in the New Mexico High Plain area, the all season 24-hour and 72-hour probable maximum precipitation (PMP) events could be as high as 34 inches and 40 inches for a watershed of 10 $mile^2$ (NOAA, 1978, Figures 20 and 22), respectively. Figure 2.4.11 of the SAR indicates that the areas of the two sub-watersheds associated with Laguna Plata and Laguna Gatuna are in the order of 50 square miles.

In the GNEP siting report (Eddy-Lea Energy Alliance, 2007), the 7.5-inch rain storm is identified as the largest rainfall event ever recorded, by citing an unidentified report (WUSRCC, 2000.) No record length was cited from the data source to explain why the 24-hour, 7.5-inch rain storm was selected as design-basis precipitation for water mass-balance analysis. The application should provide additional information supporting the identification of the storm as the basis for flood water level analyses. It should also identify or determine the return period of the 7.5-inch, 24-hour rain storm and clarify the rationale for how this may relate to the design basis, the term of the license for the proposed CISF, and the suggestion that the storm is the maximum precipitation under all probable hydrological conditions.

In SAR Section 2.4.3, the applicant states that the proposed CISF site can be considered "flood-dry." The American National Standards Institute/American Nuclear Society (ANSI/ANS) 2.8-1981 (ANSI/ANS, 1981) defines a flood-dry site as a site where safety-related structures are so high above potential sources of flooding that safety is obvious or can be documented with minimum analysis. However, the application does not discuss how the site can be considered "flood-dry" under all circumstance and combinations of hydrological conditions, including PMP events of the watershed areas under consideration. The application should provide a justification that an extreme event, such as PMP's of various durations (e.g., 6 hours, 24 hours, and 72 hours) would not result in flood water levels that are higher than those presented in SAR Section 2.4.2.

This information is necessary to demonstrate compliance with 10 CFR 72.90(b) through (c), 10 CFR 72.92(a) through (b), 72.98(a), and 72.122(b)(2)(A) through (B).

Reference

1. Eddy-Lea Energy Alliance, 2007. Final Detailed Siting Report, Eddy-Lea Siting Study.
2. National Oceanic and Atmospheric Administration (NOAA), 1978. Probable Maximum Precipitation Estimates, United States East of the 105th Meridian, National Weather Service Hydrometeorological Report No. 51.
3. National Oceanic and Atmospheric Administration (NOAA), 1978. Application of Probable Maximum Precipitation Estimates - United States East of the 105th Meridian, National Weather Service Hydrometeorological Report No. 52.
4. American National Standards Institute/American Nuclear Society (ANSI/ANS), 1981. Standards for Determining Design Basis Flooding at Power Reactor Sites, ANSI/ANS2.8-1981.

Holtec Response:

An updated study has been developed for the Probable Maximum Precipitation (PMP) and Probable Maximum Flood (PMF) based on a conservative approach with simplified assumptions in general accordance with the hierarchical hazard assessment (HHA) presented by the U.S.

Nuclear Regulatory Commission (NRC) NUREG/CR-7046 titled “Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America” (NRC, 2011).

The updated analyses include PMP calculations based on the Colorado – New Mexico (CO-NM) Extreme Precipitation Study developed in 2018 (CO-NM, 2018). The 2018 CO-NM study is based on a storm-based approach to derive deterministic precipitation values and analyses of PMP-type storm events that occurred over the geographic region. The 2018 CO-NM methods for computing extreme precipitation are up to date, reflect the current standard of practice, and were developed to replace previous Hydrometeorological Reports (HMRs) 51/52 (NOAA, 1982) for PMP work in Colorado and New Mexico.

The analyses indicated that the 6- and 24-hr PMP rainfall values for the local storm are the governing storm types for the HI-STORE CISF project. The CO-NM approach was used to derive the precipitation values, in inches, for the project basins (Gatuna, Tonto, and HI-STORE CISF site, see GEI report Figure 2 (GEI, 2020)). The governing PMP values from the CO-NM method are provided in Table 2-16-1.

Table 2-16-1. CO-NM Governing PMP Values (GEI, 2020)

	6-hr PMP			24-hr PMP		
	Gatuna	**Tonto**	**HI-STORE CISF Site**	**Gatuna**	**Tonto**	**HI-STORE CISF Site**
PMP Values (inches)	18.1	20.4	21.3	18.8	20.4	21.3

The updated analysis also includes a refined delineation of watershed areas upstream of and including the proposed Phase I HI-STORE CISF. The methods and findings of the updated hydrologic and hydraulic analyses are summarized in the GEI report “Probable Maximum Flood Analysis, HI-STORE CISF, Lea County, New Mexico”, dated September 2020.

SAR section 2.4.2 was revised to clarify that the previous flood evaluation was performed for an estimated 100-yr storm. SAR section 2.4.3 was revised to include discussion of the updated PMP/PMF analyses. Statements regarding “flood dry” conditions have been revised to accurately reflect the results of the updated PMP/PMF analysis. The table above has been included in SAR Chapter 2 as Table 2.4.2, and Figure 2 from the GEI report (GEI, 2020) was included in the SAR as Figure 2.4.12

<u>References for 2-16:</u>

NRC, 2011 - U.S. Nuclear Regulatory Commission, NUREG/CR 7046 “Design Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America”, November 2011

CO-NM, 2018 - Colorado Division of Water Resources, Department of Natural Resources “Colorado – New Mexico Regional Extreme Precipitation Study, Summary Report, Volume II. Deterministic Regional Probable Maximum Precipitation Estimation.”, November 2018.

NOAA, 1982 - National Oceanic and Atmospheric Administration, “Application of Probable Maximum Precipitation Estimates – United States East of the 105th Meridian, Hydrometeorological Report Number 52 (HMR-52)”, August 1982

GEI, 2020 - GEI Consultants, Inc. Report CIS-RP 003-00 “Probable Maximum Flood Analysis, HI-STORE CISF, Lea County, New Mexico”, September 2020

2-17 reduction of infiltration depth to the restrictive soil layer is acceptable and conservative. Specifically, justify the rationale for selecting the storm water mass-balance approach versus other industry used methods, and the basis for selecting the 50% capacity/depth reduction as conservative. The justification should take into consideration all phases of the site development.

In SAR Section 2.4.2, the applicant provided a storm water mass-balance approach to determine flood water levels in Laguna Gatuna and Laguna Plata. Two HUC-12 watersheds, associated with the two lagunas, and an infiltration capacity of 50% of the soil water capacity above the restrictive soil layer were used to determine the balance of storm water in each watershed that can be stored in the two lagunas. The applicant states that a 50% reduction in the soil saturation capacity/depth to restriction was added into the mass-balance model as a conservative measure.

This information is necessary to demonstrate compliance with 10 CFR 72.90(a), 72.90(b), and 72.92(c).

Reference

1. Natural Resources Conservation Service, United States Department of Agriculture,1986. Urban Hydrology for Small Watersheds, TR-55.
2. United States Army Corps of Engineers, Hydrologic Engineering Center, 2015. Hydrologic Modeling System, HEC-HMS, User’s Manual, 600pp.
3. Beven, J. K., 2001. Rainfall – Runoff Modeling. England: Wiley, p. 360.
4. Liu, Q. Q., Chen, L., Li, J. C., and Singh, V. P., 2004. Two-dimensional kinematic wavemodel of overland-flow. Journal of Hydrology, 291, 28–41.

Holtec Response:

Updated hydrologic analyses have been performed using a deterministic analytical approach for the estimation of design-basis floods consistent with NUREG/CR-7046. The analysis was performed for both existing conditions and the post construction Phase I CISF condition.

The Probable Maximum Flood (PMF) was evaluated by applying the PMP to the drainage basins upstream of and including the project site. The runoff resulting from the PMP was estimated by transforming rainfall to runoff based on inputs such as land use, soil type, and the Digital Elevation Model (DEM) to compute time of concentration and loss rates consistent with NUREG/CR-7046. This work was performed using Microsoft Excel spreadsheets and the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) Version 4.4 (2020) software.

Initial loss rate and constant infiltration rates were derived based on the Soil Conservation Service (SCS) Runoff Curve Number (CN), an empirical parameter used in hydrology for predicting direct runoff or infiltration from rainfall excess. The CN was developed based on SCS guidelines (USDA, 1986), hydrologic soil groups downloaded from the Web Soil Survey (USDA, 2020), and data downloaded from the National Land Cover Database (NLCD) (MRLC, 2019).

The percent impervious area was derived from the NLCD Percent Developed Imperviousness Dataset CONUS (MRLC, 2020) and using the Geographic Information System (GIS) software Esri ArcGIS™.

The constant infiltration rate is based on hydrologic soil groups and infiltration rates as described in the “Hydrologic Analysis for Dams” (NMSOE,2008). For the Proposed Condition of the HI-STORE CISF, new construction (i.e. buildings, roads, railways, etc.) was considered impervious with a conservative CN of 98 and impervious percent of 100. A summary of the methods and findings for the weighted curve number, Initial Loss, Constant Infiltration Rate, and Percent Impervious are included in the report titled: Probable Maximum Flood Analysis, HI-STORE CISF, Lea County, New Mexico, dated September 2020 and summarized in Table 2-17-1 below.

Table 2-17-1. Initial and Constant HEC-HMS Parameters

Sub Basin	Model Scenario	Curve Number (CN)	Initial Loss (in)	Constant Infiltration Rate (in/hr)	Impervious Area (%)
Laguna Gatuna	Existing	45	2.48	0.27	0.28
Laguna Gatuna	Proposed	45	2.48	0.27	0.29
Laguna Tonto	Existing/Proposed	37	3.43	0.34	0.28
HI-STORE Site	Existing	67	0.97	0.08	0.23
HI-STORE Site	Proposed	68	0.95	0.08	1.89

SAR section 2.4.2 was revised to clarify that the previous flood evaluation was performed for an estimated 100-yr storm. SAR section 2.4.3 was revised to include discussion of the updated PMP/PMF analyses.

References for 2-17:

USACE, 2020 - US Army Corps of Engineers, HEC-HMS, “Hydrologic Engineering Center – Hydrologic Modeling System”, Version 4.4, April 2020.

USDA, 1986 - United States Department of Agriculture, Natural Resources Conservation Service, TR-55 “Urban Hydrology for Small Watersheds”, June 1986

USDA, 2020 - United States Department of Agriculture, Natural Resources Conservation Service, Web Soil Survey. Accessed July 9, 2020 from: https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm.

MRLC, 2019 - Multi-Resolution Land Characteristics Consortium, “NLCD 2016 Land Cover Conterminous United States.” January 2019. Downloaded on April 25, 2019 from https://www.mrlc.gov/.

MRLC, 2020 - Multi-Resolution Land Characteristics Consortium, "NLCD Land Cover (CONUS) All Years.", Downloaded on July 30, 2020 from: https://www.mrlc.gov/data/nlcd-land-cover-conus-all-years.

NMSOE, 2008 - New Mexico Office of the State Engineer Dam Safety Bureau, "Hydrologic Analysis for Dams", August 15, 2008

GEI, 2020 - GEI Consultants, Inc. Report CIS-RP 003-00 "Probable Maximum Flood Analysis, HI-STORE CISF, Lea County, New Mexico", September 2020

NRC, 2011 - U.S. Nuclear Regulatory Commission, NUREG/CR 7046 "Design Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America", November 2011

2-18 Provide additional information describing the topographic, hydraulic, and hydrologic characteristics of the two HUC-12 watersheds associated with Laguna Plata and Laguna Gatuna.

In SAR Section 2.4.2, the applicant described a storm water mass-balance analysis to determine flood water levels in Laguna Plata and Laguna Gatuna. Two HUC-12 watersheds associated with the lagunas were identified, and two digital elevation maps were created for the watersheds at one-foot contour interval. Soil attributes, such as depth to restriction and saturated hydraulic conductivity, were obtained from the NRCS. Infiltration to soil layers down to 50% of restriction was subtracted from the 24-hour, 7.5-inch rain storm. Excess rainfall depth from the infiltration was accumulated spatially and applied to the capacity of the two lagunas, from which flood water levels on the west and east sides of the CISF were calculated. The applicant assumed that the playas were dry prior to the 24-hour/7.5-inch rain event. The two sub-watersheds, Laguna Plata and Laguna Gatuna, were identified in SAR Figure 2.4.11. Soil types near the CISF were shown in SAR Figure 2.1.7, with hydrologic and hydraulic characteristics of these soils provided in Appendix D of the Environmental Report and summarized in SAR Section 2.1.2.

In order to evaluate the safety of the proposed CISF against probable flooding events, the staff needs additional information regarding the sensitivity of the calculated flood water levels to individual soil attributes when generic NRCS soil hydrologic and hydraulic characteristics are used in place of data obtained specifically for the proposed CISF site. The application should provide additional information on the areas of the watersheds and the areal coverage of individual soil groups inside and outside the CISF. Outside the immediate proximity of the proposed CISF, additional information is also needed on the soil groups and their spatial coverage, their depths to restriction, and their soil hydrologic and hydraulic characteristics. The application should also (1) clarify the assumption applied to the infiltration capacity or hydraulic conductivity of the lake bed sediment of the two lagunas, (2) provide additional information on the storage-elevation curves of the two lagunas, and (3) justify the assumption that the playa lakes were dry before the rain event. The application should provide digital information or figures regarding the one-foot contour maps created for the two watersheds.

This information is necessary to demonstrate compliance with 10 CFR 72.90(a), 72.92(b), and 72.92(c).

Holtec Response:

Updated hydrologic and hydraulic analyses have been performed using methods consistent with NUREG/CR-7046. The methods and findings of the updated hydrologic and hydraulic analyses are summarized in the GEI report titled: Probable Maximum Flood Analysis, HI-STORE CISF, Lea County, New Mexico, dated September 2020 (GEI, 2020). A brief summary of the study methods is included below.

Watershed delineation was re-developed based initially on boundaries downloaded from the United States Geological Survey (USGS) National Hydrography Dataset (USGS, 2020a) and refined based on the most detailed, readily available terrain data downloaded from USGS (2020b). See GEI report Figure 2 (GEI, 2020)

An updated hydrologic model was developed to transform the PMP to runoff. Results indicated that of the three transform methods evaluated, the Clark Unit Hydrograph method was most conservative, producing greater runoff volume and higher flow than the other two methods and was therefore selected as the unit hydrograph method for the project.

The Soil Conservation Service (SCS) Runoff Curve Number (CN), an empirical parameter, was used to compute direct runoff from rainfall excess. CNs for the HI-STORE project and upstream watersheds relied on SCS guidelines (USDA, 1986), hydrologic soil groups from the Web Soil Survey (USDA, 2020) and data from the National Land Cover Database (NLCD) (MRLC, 2019). The curve numbers, which account for land use, soil type, and antecedent soil moisture condition were used to calculate the initial loss rate and constant infiltration rate. See GEI Report Table 3 for loss and infiltration rate and Figures 3 and 4 for land cover and soil type respectively (GEI, 2020). Conservatively, new construction associated with the HI-STORE project (i.e. buildings, roads, railways, etc.) was considered impervious with a CN of 98 and an impervious percent of 100. Hydrologic modeling involved the Initial and Constant Loss Method in the HEC-HMS software. Project specific work included the development of input parameters for Initial Loss Rate, Constant Infiltration Rate, and Percent Impervious. The percent impervious area was calculated using the NLCD Percent Developed Imperviousness Dataset CONUS (MRLC, 2020).

The hydraulic model, which uses the results of the hydrologic model as input, simulates flow over an area of approximately 14.3 square miles. The two-dimensional (2D) flow area was developed to include the Proposed HI-STORE Site and Laguna Plata. The model grid size was set 50 ft by 50 ft to optimize model accuracy, stability, and run time. The underlying terrain in the model consists of a DEM developed from the 1/3 arc-second (about 10 meters) National Elevation Dataset (NED) DEM produced and distributed by USGS (2020b). At the time of the study, this was the most detailed and readily available terrain data. The DEM elevations are referenced to North American Vertical Datum of 1988 (NAVD 88). Breaklines were input to enforce mesh generation to align the cell faces at linear features such as the Vehicle Barrier System (VBS), buildings, roads, and railroads and other features likely to control flow.

The 2D flow area includes spatially varied Manning's n-values based on the 2016 National Land Cover Database (NLCD) for the Conterminous United States (MRLC, 2019). The proposed HI-STORE CISF conditions scenario accounts for all components of the Phase I facility, including buildings, railroads, and concrete/asphalt structures (i.e. access roads, parking lots, VBS, etc.) (see SAR Figure 2.4.14). Manning's n-values for the proposed structures were updated in the model with buildings assigned a Manning's n-value of 100 to represent very low to no-flow, and concrete/asphalt assigned a Manning's n-value of 0.017 consistent with Chow (1959).

In accordance with NUREG/CR-7046 methods, the analyses conservatively assumed that the storage areas, Laguna Gatuna, Laguna Tonto, and Laguna Plata were in an "extreme full" condition prior to commencement of the PMP, and that culverts are blocked and incapable of passing flow. It should be noted that the lagunas typically have very little water and are frequently dry. The conservative "extreme full" condition assumes a water elevation high enough to create outflow, which is at least 20 ft higher than the average water elevation in each of the lagunas. See GEI report Figure 10, which illustrates the difference between "normal full" conditions and the "extreme full" initial conditions for the PMP/PMF analysis.

SAR section 2.4.2 was revised to clarify that the previous flood evaluation was performed for an estimated 100-yr storm. SAR section 2.4.3 was revised to include discussion of the updated PMP/PMF analyses. In order to illustrate the updated watersheds used in the PMP/PMF analysis, GEI report Figure 2 was added to the SAR as Figures 2.4.12. Additionally, GEI report Figure 10 was added to the SAR as Figure 2.4.13.

<u>References for 2-18</u>:

USGS, 2020a - U.S. Geological Survey, National Hydrography Dataset (NHD), accessed on June 15, 2020 from: https://catalog.data.gov/dataset/usgs national hydrography dataset nhd best resolution 20171223 for new mexico state or territor14296.

USGS, 2020b - U.S. Geological Survey, National Elevation Dataset (NED), Raster Digital Data. Accessed June 11, 2020 from: https://viewer.nationalmap.gov/advanced-viewer.

USDA, 1986 - United States Department of Agriculture, Natural Resources Conservation Service, TR-55 "Urban Hydrology for Small Watersheds", June 1986

USDA, 2020 - United States Department of Agriculture, Natural Resources Conservation Service, Web Soil Survey. Accessed July 9, 2020 from: https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm.

MRLC, 2019 - Multi-Resolution Land Characteristics Consortium, "NLCD 2016 Land Cover Conterminous United States." January 2019. Downloaded on April 25, 2019 from https://www.mrlc.gov/.

MRLC, 2020 - Multi-Resolution Land Characteristics Consortium, "NLCD Land Cover (CONUS) All Years.", Downloaded on July 30, 2020 from: https://www.mrlc.gov/data/nlcd-land-cover-conus-all-years.

GEI, 2020 - GEI Consultants Inc. Report CIS-RP 003-00 "Probable Maximum Flood Analysis, HI-STORE CISF, Lea County, New Mexico", September 2020

Chow, 1959 - Chow, V. T, "Open Channel Hydraulics", McGraw-Hill Book Company, Inc., New York

NRC, 2011 - U.S. Nuclear Regulatory Commission, NUREG/CR 7046 "Design Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America", November 2011

2-19 Provide additional information on storage and movement of surface water by the ephemeral washes described in SAR Figure 2.1.9, specifically describing (1) the hydrologic and hydraulic characteristics of the two ephemeral washes, (2) the effect of extreme weather events on water flow in the ephemeral washes and water level within and around the proposed CISF, and (3) soil erodibility along the ephemeral washes and other exposed soil surface on the CISF during extreme weather events.

Two ephemeral washes drain from the west and north of the proposed CISF (SAR Figure 2.1.9). SAR Section 2.4.1 states that "a topographic high is present within the central portion of the property with ephemeral washes draining from this point; one to the west into Laguna Plata and another to the east into Laguna Gatuna." The application should provide additional information to evaluate (1) the likelihood that water may flow in the washes, and (2) back-water effects may occur in the washes, affecting surface water levels within and around the proposed CISF during extreme weather events. It should also evaluate the effects of soil erosion along and around the ephemeral washes on the stability of the proposed CISF during extreme weather events, given the proximity of the ephemeral washes to the proposed facility (SAR Figures 2.1.9).

This information is necessary to demonstrate compliance with 10 CFR 72.90(a), 72.92(b), and 72.92(c).

Holtec Response:
Hydrologic and hydraulic models were developed for the HI-STORE CISF site for existing and proposed conditions to compute the peak water surface elevations, depths, and velocities during the Probable Maximum Precipitation (PMP) and Probable Maximum Flood (PMF) events. The work was performed using a conservative approach with simplified assumptions in general accordance with the hierarchical hazard assessment (HHA) presented by the U.S. Nuclear Regulatory Commission (NRC) NUREG/CR-7046 titled "Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America" (NRC, 2011).

The movement of surface water at the proposed CISF site, and along the two ephemeral washes located north and west of the site, was modeled using the USACE Hydrologic Engineering Center River Analysis System (HEC-RAS) software version 5.0.7 (USACE, 2019). The HEC-RAS model simulated the PMP flood wave routing using 2-dimensional (2D) unsteady analysis, the full momentum equation set (for greater accuracy over the diffusion wave equations), and a 5-second computation interval adjusted for the Courant condition.

The HEC-RAS 2D hydraulic model routed the hydrographs computed by the hydrologic model for the PMP rainfall. The results of the 2D hydraulic model provide information on the peak water surface elevations, depths, and velocities across the 2D flow area for the PMF event. The peak flows and water surface elevations in Laguna Plata would not be expected to create backwater conditions at the proposed HI-STORE CISF site. All water during the PMF would flow into Laguna Plata. This analysis was performed to quantify conditions at Phase I of the HI-STORE Consolidated Interim Storage Facility (CISF) and to demonstrate adequacy of the proposed project during a PMP rainfall event. A summary of the methods and findings are included in the GEI report titled: Probable Maximum Flood Analysis, HI-STORE CISF, Lea County, New Mexico, dated September 2020 (GEI, 2020).

The hydraulic analysis was also performed to evaluate the sediment erodibility potential at the two ephemeral washes and other exposed soil surfaces at the CISF. The erodibility potential was evaluated by comparing peak velocities computed by the hydraulic model for the PMP event with published allowable velocity thresholds to indicate the potential for sediment mobilization from peak flows during the PMF event. Sediment mobilization is assumed to occur when the velocity acting on the sediment exceeds the resistance of that particle to movement based on threshold values in published references by the Natural Resources Conservation Service (NRCS, 2007).

Velocity thresholds are typically used to determine the highest permissible velocity that can pass through a design channel or canal without causing erosion. When used for design purposes, a factor of safety is included so the results are considered conservative estimates with higher velocities most likely needed to cause sediment mobilization (NRCS, 2007).

Tables 8-4 and Figure 8-3 in NRCS Chapter 8, Threshold Channel Design of the National Engineering Handbook (2007) were used to evaluate critical velocities for sediments at locations along the ephemeral washes, the non-concrete ISFSI area, and the North East Corner of the VBS (see Table 2-19_2).

The erosion potential analysis compares the soil grain size analysis developed for the GEI Geotechnical Data Report dated February 2018 (GEI, 2018) and uses GEI's hydrologic and hydraulic model results to evaluate the potential for sediment at the site to become mobilized resulting in erosion. Table 2-19-1 below presents the sediment sample locations, soil classifications, and D_{50} information from the 2018 GEI Geotechnical Data Report. Table 2-19-2 compares the D_{50} with permissible velocity thresholds, above which sediment would be expected to become mobilized. As these results indicate, the peak velocities in the washes exceed allowable values and therefore sediment in these washes would be expected to be mobilized during the PMP and PMF events. Given their geologic nature, the slow erosion in the washes would not have any effect on the facility. Both the existing conditions and proposed HI-STORE CISF conditions provide the same erosion potential results in the washes.

Table 2-19-1. Sediment Information

Boring/Test Pit No.	Sample No.	Depth of Sample (ft)	USCS	Description	D_{50} (mm)
B106	S5	10 to 12	GW-GM	Widely-graded GRAVEL with silt and sand	4.5
B106	S7	15 to 17	SC	Clayey SAND	0.2
B107	S7	15 to 17	SC	Clayey SAND	0.1

Notes:

1) Boring, soil classification and D_{50} information from (GEI 2018).
2) Boring locations and depths were selected for this analysis to represent the most shallow samples collected at the HI-STORE site.

Table 2-19-2. Allowable Velocity

HEC-RAS Data Point	Peak Velocity (ft/s)	Depth of Flow at Peak Velocity (ft)	D_{50} (mm)	Allowable Velocity (ft/s)
Wash to West	8.0	4.3	0.15	1.9
			4.5	3.3
Wash to North	13.2	13.9	0.15	3.0
			4.5	4.8
ISFSI Area (non-concrete)	2.8	0.3	0.15	1.9
			4.5	3.3
NE corner VBS	3.4	6.7	0.15	2.4
			4.5	4.1

Notes:

1) The best available samples collected and analyzed under the 2018 Geotechnical Data Report were collected below ground surface at specific boring locations.
2) The D_{50} for samples B106 (S7) and B107 (S7) were averaged to 0.15 mm.
3) Allowable velocity information is based on thresholds published by the NRCS (2007).

Peak velocities in the ISFSI area and North-East corner of the VBS also exceed the allowable velocity for sediment erosion. Engineered backfill materials in both areas would likely have improved erosion resistance. Given the improved backfill material and depth to the base of the ISFSI any potential erosion would not undermine or affect the safety of the ISFSI. After storm waters recede, eroded materials in the CISF would be replaced and appropriately regraded.

SAR section 2.4.2 was revised to clarify that the previous flood evaluation was performed for an estimated 100-yr storm. SAR section 2.4.3 was revised to include discussion of the updated PMP/PMF analyses as well as discussion of potential erosion as a result of the PMF. Figures 2.4.14, and 2.4.15 have been added to the SAR illustrating maximum water depth and peak velocities during the PMF.

<u>References for 2-19</u>:

NRC, 2011 - U.S. Nuclear Regulatory Commission, NUREG/CR 7046 “Design Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America”, November 2011

USACE, 2019 - US Army Corps of Engineers, HEC-RAS, “Hydrologic Engineering Center – River Analysis System”, Version 5.0.7, March 2019.

NRCS, 2007 - Natural Resources Conservation Service, National Engineering Handbook Hydrology Chapters. Accessed multiple dates from: https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/manage/hydrology/?cid=STELPRDB1043063

GEI, 2020 - GEI Consultants Inc. Report CIS-RP 003-00 "Probable Maximum Flood Analysis, HI-STORE CISF, Lea County, New Mexico", September 2020

GEI, 2018 – GEI Consultants Inc. Report CIS-RP 001-01, "Geotechnical Data Report HI-STORE CISF Phase 1 Site Characterization, Lea County, New Mexico" February 2018

2-20 Provide additional information regarding existing hydraulic structures between the proposed CISF and Laguna Gatuna, including their status and functions.

Section 2.4.3 of the SAR states that two ephemeral washes drain from the local topographic high near the proposed CISF; one to the west into Laguna Plata and another to the east into Laguna Gatuna. On SAR Figures 2.1.2 and 2.1.7, existing hydraulic structures between Laguna Gatuna along the ephemeral wash east of the proposed CISF are clearly visible in the satellite pictures of the site.

The application should provide additional information on the status and functions of the hydraulic structures, the effect of the hydraulic structures on probable maximum flood in the ephemeral wash flowing east into Laguna Gatuna, particularly during PMP events.

This information is necessary to demonstrate compliance with10 CFR 72.90(a), and 72.122(b)(2)(A) and (B).

Holtec Response:
In the updated hydrologic analysis, the HI-STORE CISF project was modeled in HEC-HMS as three primary sub-watersheds with two reservoirs and one output junction. Use of this software is consistent with methods outlined in NUREG/CR-7046. Also in accordance with NUREG/CR-7046 method, the reservoirs at Laguna Tonto and Laguna Gatuna were conservatively assumed to be "full" at the start of the storm, a condition created by raising the elevation of zero storage in the stage-storage relationship in Laguna Tonto to elevation 3,558 ft North American vertical Datum of 1988 (NAVD88) and Laguna Gatuna to elevation 3,520 ft NAVD88. The stage-storage relationships for Laguna Tonto and Laguna Gatuna were input as HEC-HMS "paired data curves." It should be noted that the lagunas typically have very little water and are frequently dry; the modeled elevations are at least 20 ft higher than the average water elevation (see SAR Figure 2.4.13).

The outflow structure of each laguna (reservoir) was represented by a broad-crested spillway input to replicate the natural channel downstream of the reservoirs with channel geometry estimated based on USGS topographic maps, the digital elevation model downloaded from USGS, and Google Earth Imagery.

The updated hydraulic analysis simulates flow over an area of approximately 14.3 square miles. This area includes the Proposed HI-STORE Site and encompasses Laguna Plata to the west. The purpose of using the 2D hydraulic model was to capture flow conditions including shallow and split flows across the HI-STORE site and to capture detailed flow conditions in the washes from runoff entering from Laguna Gatuna and Laguna Tonto watersheds, and runoff from the HI-STORE watershed. GEI hydraulically modeled Laguna Plata as "full" by setting the initial water surface elevation to 3,490 ft, the elevation of the outlet of the laguna. Again, Laguna Plata typically has very little water and is frequently dry; the modeled elevation is well over 20 ft higher than the average water elevation (see SAR Figure 2.4.13). The geometry of these hydraulic structures is summarized in the GEI report titled: Probable Maximum Flood Analysis, HI-STORE CISF, Lea County, New Mexico, dated September 2020.

As can be seen in SAR Figures 2.1.2, 2.1.5, 2.1.10, 2.1.11, and 2.4.7 an ephemeral wash north of the site, which drains towards Laguna Plata ends at the existing CR-55 roadway. East of that high point on the roadway, an ephemeral wash which drains towards Laguna Gatuna can be seen. During a storm event occurring with typical Laguna water elevations, runoff from portions of the CISF property would drain through the wash leading to Laguna Gatuna. During the PMP/PMF all water flows into Laguna Plata because Laguna Gatuna is initially assumed to be in the extreme full condition, which includes the "east wash". The discharge point for Laguna Gatuna, modeled in the updated PMP/PMF analyses, is approximately the point where the "east ephemeral wash" meets the ephemeral wash north of the site (at the existing roadway).

SAR section 2.4.2 was revised to clarify that the previous flood evaluation was performed for an estimated 100-yr storm. SAR section 2.4.3 was revised to include discussion of the updated PMP/PMF analyses.

<u>References for 2-20</u>:

NRC, 2011 - U.S. Nuclear Regulatory Commission, NUREG/CR 7046 "Design Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America", November 2011

GEI, 2020 - GEI Consultants Inc. Report CIS-RP 003-00 "Probable Maximum Flood Analysis, HI-STORE CISF, Lea County, New Mexico", September 2020

2-21: Provide additional information describing modifications to site topography, and the elevations of on-site structures, including the UMAX systems, the security building, and the cask transfer facility. Provide additional information that determines their effects on flood water levels in Laguna Gatuna and Laguna Plata before and after site modification. This should include all phases of the proposed CISF with all UMAX systems installed and in place.

Section 2.1.2 of the SAR states that "plot views of the HI-STORE CIS Facility with all phases complete are shown in Figures 2.1.6(a), (b), and (c)." Figure 21.6(a) indicates the proximity of the proposed CISF to Laguna Gatuna. Figure 2.1.6(b) of the SAR shows four above-ground buildings to the south and southeast of the facility. Figure 2.1.6(c) of the SAR identifies the buildings as administrative, security, cask transfer, and storage buildings. However, no topographical information, such as elevation or surface contours, were provided in the figures. The application should provide additional information about the elevations of on-site structures and any modifications to the site topography to assess the flooding hazards of important to safety structures at the site. The application should include assessment with all planned on-site structures for all phases in place to evaluate the bounding flood hazards as a result of site modification, whereby the footprint of the entire UMAX systems will be backfilled with low permeability materials.

This information is necessary to demonstrate compliance with 10 CFR 72.122(b)(2).

Holtec Response

Figures 2.1.10, 2.1.11, 2.4.7, and 2.6.15 have been revised to illustrate the HI-STORE Facility in relation to current site topography [1] (consistent with the rest of Chapter 2, the figure represents Phase 1 only).

- The facility will be graded such that the existing surface drainage, generally to the north and west, will be maintained. The foundations for each of the buildings will be slabs on grade with top of concrete approximately at or slightly above grade.
- The Haul Path and other paved areas will either be concrete or asphalt, approximately at existing grade, and sloped to allow adequate drainage.
- The ISFSI Top mat is also a concrete slab at grade, slope to allow adequate drainage in a northerly direction

Approximate nominal elevation of each structure at the site is provided in the table below.

Building	**Approximate Nominal Elevation**
Admin Building Foundation	3545’
Security Building Foundation	3545’
Cask Transfer Building Foundation	3540’
Warehouse Foundation	3540’
ISFSI	3535’

Section 2.4.1 has been revised to include this additional discussion of the grading of the facility.

Effects of the site modifications on the probable maximum flood are being assessed and will be provided in response to RAIs 2-16 to 2-20.

It should be noted that in response to other chapter 2 RAIs, the quoted passage above no longer states, “with all phases complete” and the related figures reflect only the phase 1 design. These changes were made in a previous revision to SAR Chapter 2.

References for RAI 2-21:

[1] U.S. Geological Survey, Laguna Gatuna Quadrangle, New Mexico, 7.5-Minute Series, 1:24,000

2-22: Provide additional information describing the proposed rail track and embankment that will connect the proposed CISF with the existing railway spur (SAR Figure 2.1.5). The information should include elevations of railroad embankment, any hydraulic structures incorporated into the embankment, and design parameters of the hydraulic structures if applicable. Also provide information on the likelihood of failure for the rail track and embankment during extreme weather events, e.g., a PMP, and the effect of such failure to the flooding of proposed CISF on-site structures, systems, and components.

Given the proximity of the rail track to the southern high point of the site, storm water during extreme weather events may result in storm water build-up behind the embankment, impacting the surface water level within and around the proposed CISF. The application should provide additional information about the proposed rail line and embankment and any embedded hydraulic structures. The application should further evaluate the likelihood of failure for the rail track and embankment during extreme weather events, e.g., a PMP, and the effect of such failure to the flooding of proposed CISF on-site structures, systems, and components.

Section 2.1.3 of the SAR states that “topography of the site shows a high point located on the southern border of the site and gentle slopes leading to the two drainages (Laguna Plata and Laguna Gatuna).” Section 2.4.1 of the SAR states that “site topography is irregular, with a slight slope toward the north.” The topography of the site suggests that surface storm water may flow north and northwest from the topographic high points on the southern border of the site across the boundary of the proposed CISF and towards the two playa lakes.

Section 2.1.2 of the SAR state that “aerial view of the site is shown in Figure 2.1.5 and several plot views of the HI-STORE CIS Facility with all phases complete are shown in Figures 2.1.6(a), (b), and (c).” Figure 2.1.5 of the SAR indicates that a rail track is proposed to connect the proposed CISF to an existing rail spur to the west of the site. Figure 2.1.6(a) of the SAR indicates that the proposed rail track will run between the proposed CISF and Laguna Gatuna but does not provide the elevation of the rail track and any potential hydraulic structure incorporated into the railroad embankment.

This information is necessary to demonstrate compliance with 10 CFR 72.122(b)(2).

Holtec Response

The rail track that will be constructed for the HI-STORE Facility will tie into the existing track approximately 5 miles west of the site. The existing track services the Intrepid Potash North Facility and is operated by BNSP Railways. HI-STORE Rail track shall be designed for the applicable loads in accordance with BNSF guidelines and specifications [1]. The rail will generally follow the natural terrain with the embankment kept to a minimum and graded to maintain the requirements of the BNSF Standards. A figure illustrating the standard embankment design for the industry track, is shown below [1]. Drainage features, including culverts where necessary, shall be installed beneath the embankment in order to maintain current drainage. The drainage features shall be sized in accordance with BNSF specifications. For culverts specifically, the specifications state:

> “The minimum diameter for all culverts installed under main tracks or tracks maintained by BNSF is 36 inches. This is to accommodate regular inspection and cleaning. Culverts maintained by the Customber should be 24 inches or larger.” [1]

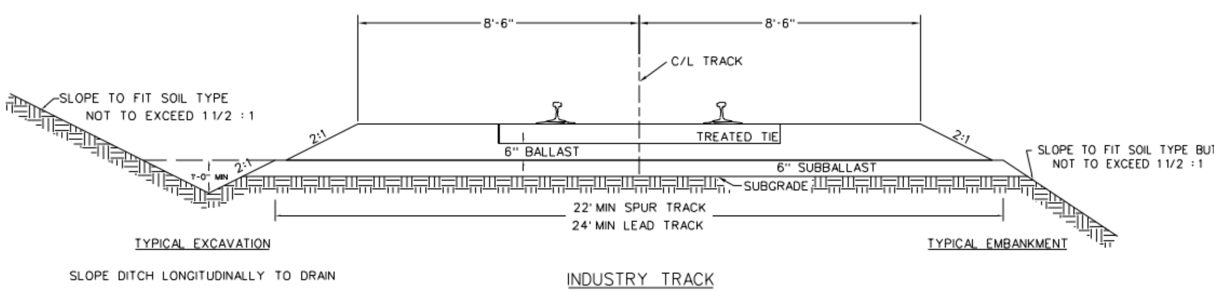


Figure 2.1.10 has been revised to illustrate the HI-STORE Facility, including the portion of the rail line between the facility and Laguna Gatuna, in relation to current site topography.

Effects of the rail on the probable maximum flood are being assessed and will be provided in response to RAIs 2-16 to 2-20.

References for RAI 2-22:

[1] BNSF Railway, Engineering Services, System Design & Construction, "Guidelines for Industry Trach Projects," August 2018

2-24: Provide additional information to demonstrate that spatially and temporally variable hydrologic conditions in the sub-grade soils would not affect the structural performance of the UMAX pad system, such as differential settling or the consequences of earthquakes. Provide a description of possible hydrologic effects on the site-specific geotechnical properties that influence the stability of the under-grade (residual soil), support pad foundation, and subgrade components.

In SAR Section 2.6, the geotechnical properties related to the stability of the under-grade and subgrade materials are described in terms of processes related to differential settlement and to earthquakes. Some of the geomechanical conditions and properties (see RAIs for SAR Section 2.6.4) depend on hydrological conditions, particularly the water content of the material. Varying groundwater conditions that change in both time and space may lead to heterogeneous saturation conditions below the under-grade and lateral to both the under-grade and subgrade. Potential interaction of the hydrologic conditions in the natural sediments with the support foundation pad and subgrade are not described in the SAR.

Sections 2.5 and 2.6 of the SAR state that site specific saturated groundwater levels are in the Chinle and Santa Rosa units of the bedrock below the facilities. The groundwater system in the shallow, quaternary sediments is said to generally be unsaturated, but may locally be perched (i.e., saturated). However, information about water wells near the site of the facility provided in SAR Figure 2.5.2 suggests that the hydrological conditions may vary in the subsurface environment in and around the under-grade, support foundation pad, and subgrade in response to precipitation events, and seasonal and annual climatic variations. Temporal patterns may vary due to recharge in the highly permeable shallow alluvial sediments, and spatial patterns may exist due to the influence of the caliche horizons. In addition, groundwater brine levels adjacent to the playas are expected to vary during and after precipitation events due to infiltration adjacent to the playas and runoff submerging the playas. Perched water and transient lateral drainage towards the playas in the subsurface, possibly channelized, may interact with or be impeded by the under-grade, support foundation, and subgrade. The residual sediments of the under-grade in the design are projected to be at 3500 ft elevation and above. The brines supported by the playa is stated to be at the same elevation. The present dayground surface at the site is at 3520 to 3540 ft elevation above sea level.

This information is necessary to demonstrate compliance with 10 CFR 72.90(a), 72.92(a), and 72.122(b).

Holtec Response:

Sections 2.4 and 2.5 of the SAR have been revised to provide a more extensive description of the surface and sub-surface hydrologic effects on the site-specific geotechnical properties. In short, the possible hydrologic effects at the HI-STORE CISF Site do not have a destabilizing influence on under-grade (residual soil), support foundation pad, or subgrade components because of the following:

a) The primary groundwater table depth is approximately 253 to 263 feet below the ground surface at the ISFSI site, which places it within the bedrock layer known as the Santa Rosa Formation.

b) Even the shallowest water-bearing zone measured to the east of the ISFSI site (in 2007) is 34 feet below the ground surface, which is below the residual soil layer and the support foundation pad.
c) The natural drainage (topography) of the area directs water away from the proposed CIS Facility Site and provides a natural area for impoundment of excess runoff during severe storms.

2-25: Provide additional information on the potential for surface deformation due to past, present or future human activities at the proposed site. Specifically, clarify whether there are any oil and gas extraction activities, including casing corrosion or failure leading to dissolution of carbonate or evaporite deposits in the subsurface, that could result in surface deformation. Justify the basis for the 5,000 ft minimum depth of oil drilling or fracking activities; clarify the depth to the shallowest oil or gas field in the site subsurface; and characterize the potential for surface deformation at the site due to drilling or fracking at the depth of the shallowest oil or gas resource mining exploration or extraction activities in the subsurface for the licensed life of the proposed facility.

Section 2.6.4 of the SAR, "Stability of Subsurface Materials," states that "[t]here are no surface, drillhole, or mining indications that subsidence and collapse chimneys occur at the Site or surrounding area." However, SAR Section 2.1.4, "Land and Water Use," states that "because of the extent of the evaporites (salt and anhydride), drilling and completion operations have to be conducted in a manner that prevents the dissolution of the salt and protects the well during drilling and through the productive lives of the wells, often 20 to 30 years or more." SAR Section 2.1.4 also states that "[t]here are several examples in the Permian Basin of catastrophic subsidence as a result of suspected oil field casing corrosion and dissolution of salt," including the Wink Sinks and al Sink, both of which have similar subsurface stratigraphy to the HI-STORE CISF site. Despite the occurrence of past catastrophic subsidence at these locations, and potential for future oil and gas extraction activities at the site, the application does not address the potential for catastrophic subsidence at the CISF site due to current and future oil and gas extraction activities or describe actions to prevent future catastrophic subsidence. Section 2.6.4 of the SAR further states that "any future oil drilling or fracking beneath the Site would occur at greater than 5,000 feet depth, which ensures there would be no subsidence concerns." However, public information from the State of New Mexico's Energy, Minerals and Natural Resources Department shows the presence of nearby active oil and gas wells within a three-mile radius of the site that are less than 5,000 ft depth. In addition, the application does not consider surface deformation from the exploration or extraction of minerals or other resources other than potash, oil, or gas.

This information is necessary to determine compliance with 10 CFR 72.98(c)(2) and 72.103(f)(2)(ii).

Holtec Response

Note that the minimum horizontal drilling depth has been revised throughout the SAR to reflect the shallowest oil and gas deposit in the area being 3050' below the surface.

See the response to RAI 2-8 for location and status of oil and gas wells within a 1-mile radius of the site. Horizontal drilling activities, including hydraulic fracturing (fracking) , beneath the site will be a minimum of 3050' deep as the shallowest oil and gas deposits in the area are in the Yates/Seven Rivers [1] formation, which resides below the salt layer, the Salado Formation.

Fracking poses negligible potential for surface subsidence as the materials being extracted are generally being removed by replacement. The extracted materials are forced out by a sand/water mixture, with the sand remaining in the fractures. Fracking occurs in generally non-compressible rock formations and does not leave large void spaces that would be available to collapse. The potential for subsidence at the surface due to horizontal drilling activities is negligible and is also discussed in the response to RAI 2-8 and 2-12.

The statement referenced in the RAI above regarding site specific surface indications, discussed in FSAR section 2.6.4, references surveys performed of the site to determine if any current or past drilling operations would affect the CISF. These surveys show that there are no signs of these issues at the surface. The statement referenced in the RAI above regarding current drilling regulations, discussed in FSAR section 2.1.4, describes the overall protection required of drilling operations by current regulations to prevent the dissolution and subsidence effects experienced in early less regulated drilling activities in the state. Detailed description of the current active and inactive

drilling operations adjacent to the site can be reviewed in response to RAI 2-8.

As discussed in the Response to RAI 2-8, the existing oil and gas wells near the CISF facility are at a great enough distance from the ISFSI to be considered not a hazard, including any potential for surface deformation. Future vertical drilling near the site in the secretary's potash area can only occur within permitted drill islands per Order 3324. Drill islands will not be allowed on the HI-STORE Property. Therefore, any future vertical drilling will also be sufficiently distant from the ISFSI to not pose a hazard. Additionally, all new oil and gas drilling in New Mexico is regulated by NMAC Title 19 Chapter 15 requirements, which ensure the wells are safe during operation and abandonment.

The potential for surface deformation due to mining activities near the site is discussed in the Response to RAI's 2-10, 2-11, and 2-12. FSAR chapter revisions for these RAIs are described in each response.

<u>References for 2-25:</u>

1. New Mexico Oil Conservation Division, NM OCD Oil and Gas Map - ArcGIS Web Application, <nm-emnrd.maps.arcgis.com/apps/webappviewer/index.html>.

2-26: Related to origin of potential dissolution features at the site

Explain the origin of the features circled in red in Figures 2.1.2 and 2.1.5, particularly with respect to dissolution of the Capitan Reef of other subsurface carbonate and evaporite deposits either through natural process or human activities. Also, assess the future potential for similar surface deformation as a result of natural processes or human activities in the site area.

Figure 2.6.2 of the SAR shows the site is underlain by over 1,000 feet of the Capitan Reef, a carbonate formation in the site region that is well-known for the large-scale karst features that have developed at the surface and at depth. Most notable of these features is the Carlsbad Caverns, approximately 65 miles southwest of the site. The staff also notes the presence of additional carbonate and evaporite rocks both above and below the Capitan Reef and the association of subsurface halite dissolution above the Capitan Reef with several sinkhole features in southeastern New Mexico. Additionally, SAR Figures 2.1.2 and 2.1.5 show numerous circular features throughout the site and surrounding areas but the application does not discuss the origin of these features. On Figures 2.1.2 and 2.1.5, these features are indicated by red circles. The green box on Figure 2.1.5 is the general outline of the area covered by Figure 2.1.2.

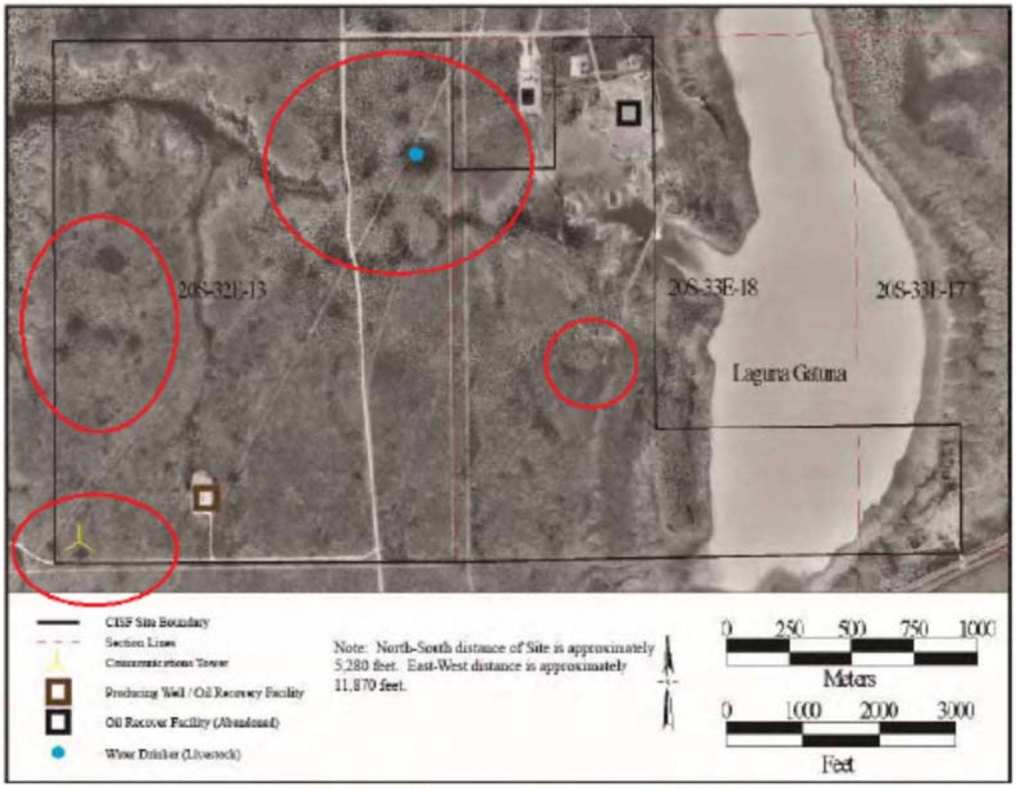


Figure 2.1.2: HI-STORE CIS Facility Site Boundaries [2.1.3]

Figure 2.1.5: Aerial View of the Site (Full Build-Out) [2.1.8]

This information is necessary to determine compliance with 10 CFR 72.103(f)(2)(ii).

Holtec Response

The features identified by the NRC in RAI 2-26 are localized surface depressions generally without surficial drainage outlet and are typically about 2-foot deep or less, and less than 100-feet across in plan dimension. Ground surface elevation changes are often subtle at the edges of these depressions. In the vicinity of the Site these depressions can generally be identified based on vegetation changes when compared to the surrounding area, which is likely attributable to these depressions intermittently holding water, as indicated by the USGS topographic maps and aerial photography. The locations of these depressions relative to the Site are shown in Figure 2.6.17.

According to the Soil Survey of Lea County, New Mexico (United States Department of Agriculture, 1974), such undrained depressions are common features in Southeastern New Mexico. These depressions, locally referred to as buffalo wallows, are believed to have been formed by leaching of the caliche cap and subsequent removal of the loosened material by winds (United States Department of Agriculture, 1974). As discussed below, the available evidence indicates that the features circled in red by the NRC in SAR Figures 2.1.2 and 2.1.5 were formed by this leaching and wind removal process, and not by the dissolution of the Capitan Reef or other deep, subsurface carbonate and evaporite deposits.

Shallow processes, including leaching of the caliche cap and windblown erosion, are localized and will not impact the constructed features at the Site. The ground surface will be regraded and protected, concrete structures will be built, and stormwater controls and drainage system features will be implemented as part of construction and operations. Also, the caliche cap will be excavated beneath and immediately adjacent to the cask storage pads where excavation to a depth of 25 feet below grade is expected.

Clarifications have been made to section 2.6.4 to highlight this discussion. Figure 2.6.17 has been added to show depression features.

References for RAI 2-26:

1. Turner, Millard T. et al. (1974). Soil Survey of Lea County New Mexico, United States Department of Agriculture, Soil Conservation Service

2-27: Related to Mescalero caliche

Justify the conclusion that “dissolution of this unit [Mescalero caliche] may have resulted in the development of a number of small shallow depressions in the area; however, this is not regarded as an active or significant karst process at the Site.” Specifically, provide a figure showing the location of these small shallow depressions relative to the site. Also, explain how it was determined that dissolution of the caliche layer and not dissolution of deeper layers resulted in the observed “small shallow depressions.”

Section 2.6.4 of the SAR states that the “[…] Mescalero caliche is soluble and situated at or near land surface […]” and goes on to state that “[…] dissolution of this unit may have resulted in the development of a number of small shallow depressions in the area; however this is not regarded as an active or significant karst process at the Site.” The staff reviewed the reference cited for this conclusion (SAR Reference 2.1.3) and a reference cited therein (Bachman, 1976). Bachman (1976) noted that although dissolution of soluble rocks has caused subsidence and surface collapse in southeastern New Mexico, these processes have been active in this area for long intervals in geologic time. Bachman (1976) further concludes that the Mescalero caliche is a "widespread datum for determining the relative time of solution and collapse of many modern karst features." Although deformation of the Mescalero caliche records three episodes of solution and collapse, Bachman (1976) does not attribute the deformation of the Mescalero caliche to dissolution of the Mescalero caliche.

This information is necessary to determine compliance with 10 CFR 72.103(f)(2)(ii).

Holtec Response

There is no evidence from the borings drilled at the CISF Site that the Mescalero caliche or other surficial deposits at the Site have been deformed due to underlying dissolution and development of karst features. The contact between the caliche and the Dockum Group was observed at a uniform elevation across the Site.

The Site is underlain by the Dockum Group and the Dewey Lake Red Beds, both of which are composed of insoluble, clastic rocks (Ref. [1]). These insoluble rocks are estimated to extend to a depth of about 1,000 feet below the Site. The elevation of the bottom of Dewey Lake Red Beds (top of Rustler Formation) is at approximately El. 2,500 ft in the vicinity of the Site and the Site ground surface is at approximately El. 3,500 to 3,550 ft. Karst features do not develop in or above these insoluble units unless significant dissolution of underlying formations has occurred.

Potentially soluble materials exist beneath the Dewey Lake Red Beds which include the Rustler, Castile, and Salado Formations. According to the National Geologic Map Database of the United States Geological Survey, the Rustler Formation is composed of a limestone and siltstone-mudstone and the Castile and Salado Formations are composed of an anhydrite. According to Powers, there is no evidence from regional drillhole data that dissolution in these underlying rocks has occurred (Ref. [2]). Drillhole data and downhole geophysics suggest the top of the Rustler Formation slopes down gradually from west to east in the vicinity of the Site. Regional contours of the Rustler and Salado Formations indicate generally uniform slopes across the top of these formations with no evidence of major karst features in the area (Ref. [2]).

Deep-seated dissolution within the Delaware Basin in the vicinity of the Site is also less probable because of physical limitations on the circulation of fresh water at depth (Bachman, 1985). As previously discussed, the Dockum Group and Dewey Lake Red Beds overlie the Rustler Formation and other soluble rocks at the Site. Since the Dockum Group and Dewey Lake Red Beds are not soluble, and water does not move through them freely, there is no indication that conditions exist that would cause dissolution resulting in subsidence or collapse over the next few thousands of years (Powers, 2007).

Clarifications have been made to section 2.6.4 to highlight this discussion.

References for RAI 2-217

1. Bachman, George O. (1985). Assessment of Near-Surface Dissolution at and Near the Waste Isolation Pilot Plant (WIPP), Southeastern New Mexico.
2. Powers, Dennis W. (2007). Report on Evaporite Stability in the Vicinity of the Proposed GNEP Site, Lea County, New Mexico.

2-28: Related to subsurface stratigraphy

Section 2.6.1 of the SAR describes the geology of the HI-STORE CISF site, including the underlying stratigraphic units. Clarify the stratigraphic units present in the subsurface of the site, including their correlative units at a regional scale, as discussed below:

a) Describe subsurface layer at the site, including the formation name, composition or lithology, US Geological Survey (USGS) designation, if appropriate, and age; and provide an updated stratigraphic column based on this information. Include whether each unit is indurated or unconsolidated, and if so, whether the unit is saturated or unsaturated.
b) Clarify which subsurface units correlate to the Upper and Lower Gatuna Formation and the Ogallala Formation, as these units are included in the stratigraphic column in SAR Figure 2.6.5 but are not identified in the text of SAR Section 2.6.1 nor in the boring subsurface profiles (SAR Figures 2.6.6 through 2.6.8 and in the Geotechnical Data Report).
c) Identify and describe the geologic units of the Dockum Group in the subsurface and clarify the correlation of those geologic units to other recognized layers within the Dockum Group (such as the Redonda, Cooper Canyon, Trujilo and Tecovas Formations).

The staff uses the stratigraphic information in SAR Section 2.6.1 as input to its confirmatory calculations as part of the review of SAR Sections 2.6.2 and 2.6.4. Section 2.6.1 of the SAR states that most boreholes penetrate a top soil layer. caliche layer, residual layer, Chinle layer and Santa Rosa layer. The application also states that the near-surface layers consisted of Surface soil, Mescalero caliche, Quaternary sands, and Dockum Group in the upmost 25 feet at the site. Figure 2.6.5 of the SAR shows the uppermost layers at the site as Quaternary Pediments, Valley Fills, Upper Gatuna Formation, Tertiary Lower Gatuna Formation, and Ogallala, all of which overlie the Triassic Dockum Group. Although SAR Figures 2.6.2 and 2.6.5 list formation names, the application does not describe the composition of the individual units.

The applicant divides the Dockum Group into the Chinle Formation and Santa Rosa Sandstone, however, the USFS geologic map of the Tucumcari Sheet further subdivides the Dockum Group into the Chinle, Tujillo, and Tecovas Formations overlying the Santa Rosa Sandstone, each with a distinct composition. Additionally, a 2004 geology report for a nearby site (ML041910489) states that some strata that were previously identified as Chinle Formation have been more recently identified as Cooper Canyon Formation, and divides the Chinle Formation into the Cooper Canyon, Trujillo and Tecovas Formations.

This information is necessary to determine compliance with 10 CFR 72.103(f)(1)-(3).

Holtec Response

History of Stratigraphic Nomenclature

As observed during the 2017 field explorations, the subsurface at the Site consists of the following stratigraphic units as defined by the National Geologic Map Database of the United States Geological Survey (USGS):

- Eolian sand deposits
- Mescalero Caliche

- Gatuna Formation
- Dockum Group Members

The stratigraphy of the Site as previously documented in the Safety Analysis Report (SAR) Section 2.6.1 was classified in accordance with historic nomenclature of the Dockum Group. A history of the stratigraphic nomenclature for the Dockum Group in New Mexico is shown in Figure 2.6.16. Early classifications of the Dockum Group did not include subdivision because intricate facies changes and varying lithologies within the Dockum Group of eastern New Mexico led to problems of correlation (Ref. [2]). The term ‘Chinle Formation’ was used to formerly classify the upper rocks of the Dockum Group and this terminology was also used during the 2017 exploration.

Revised Site Stratigraphic Nomenclature

The stratigraphy of the Site has been updated in accordance with the Geologic Map Database of the USGS. An updated stratigraphic column for the Delaware Basin and observed lithology at the Site is shown in Figure 2.6.5.

Based on the updated USGS regional nomenclature the material previously referred to as residual soil in the 2017 explorations is the Gatuna Formation. Regionally, the Gatuna Formation is not further divided as shown in Figure 2.6.5.

The upper formation of Dockum Group, previously referred to as Chinle in the 2017 explorations, is the Tecovas Formation.

Based on the observed lithology at the Site, the contact between the Tecovas (noted as Chinle on GEI 2017 boring logs) and Santa Rosa Formations was at approximately El. 3321 and the contact between the Gatuna (formerly classified as residual soil) and the Tecovas Formation was at approximately El. 3500. The stratigraphic column for B101 as shown in Figure 2.6.5 is described in detail below.

In order to correlate the observed lithology during the 2017 field explorations to the USGS nomenclature of the Dockum Group, the observed lithology was compared to explorations in the region. During subsurface explorations to evaluate potential water resources in the Dockum Group and Dewey Lake Formation for the Bureau of Land Management, Powers (2014) classified drillhole NP-1, approximately 8.5 miles north of the Site. According to Powers, the Tecovas Formation was approximately 187 feet below ground surface (El. 3508) and the contact between the Tecovas and the Santa Rosa Formations was approximately 705 feet below ground surface (El. 2989). Powers (2010) similarly classified drillhole SNL-6, approximately 6 miles south-southeast of the Site, in order to provide geological data and hydrological testing of the Culebra Dolomite Member of the Permian Rustler Formation to the northeast of the Waste Isolation Pilot Plant (WIPP) site. Powers classified the Dockum Group at SNL-6 as undivided; However, the boring log indicates the base of the Tecovas Formation (and top of the Santa Rosa Formation) may be approximately 296 feet below ground surface (El. 3347).

Description of Stratigraphic Units Observed in 2017 Explorations

<u>Units not Encountered:</u>

Rocks of the earlier Mesozoic (Jurassic and Cretaceous), as well as the Cenozoic (Tertiary) are absent in southeastern New Mexico. It is assumed all of southeastern New Mexico has been above sea level and subjected to erosion since the Cretaceous (Ref. [2]). Upper Tertiary and Quaternary formations are the only Cenozoic rocks preserved in southeastern New Mexico.

The Ogallala Formation was not encountered during the 2017 subsurface explorations. The Ogallala Formation also was not encountered in drillholes NP-1 or SNL-6 in the vicinity of the Site (Ref. [3] and [4]). Geologic literature indicates the Mescalero Ridge delineates the western edge of the Ogallala Formation (Ref. [1]), approximately 12 miles east of the Site.

The Dockum Group consists of claystone, sandstone, and siltstone which compose the following units from youngest to oldest: the Redonda, Cooper Canyon, Trujillo, Tecovas, and the Santa Rosa (Lehman 1994). The Redonda, Cooper Canyon, or Trujillo Formations were not identified during the 2017 subsurface explorations.

<u>Eolian Sand Deposits (Surface Soil):</u>

Eolian sand deposits were encountered at the surface at the Site. Eolian sand deposits consist of varying amounts of sand and clay. Berino soil is reportedly found in the vicinity of the Site, which is red, sandy, and has little carbonate (Chugg et al., 1971, as cited in Ref. [3]). These surficial deposits are unconsolidated and unsaturated.

<u>Mescalero Caliche:</u>

The Mescalero caliche is an informal soil stratigraphic unit defined by Bachman (Ref. [2]). The Mescalero caliche is a pale brown to very pale brown, very calcareous sandstone to sandy limestone (Ref. [4]). The Mescalero caliche is poorly indurated and unsaturated. The caliche, as observed during the 2017 subsurface explorations, was generally about 4.4 to 13.5 feet thick.

<u>Gatuna Formation (Residual Soil):</u>

The Gatuna Formation ranges from a coarse-grained sand with gravelly zones to siltstone and claystone (Ref. [7]). The Gatuna Formation is light red to red or light reddish-brown, in contrast to the underlying Dockum Group which appears deeper reddish-brown with a purplish cast (Ref. [7]). The Gatuna Formation encountered in the 2017 explorations at the site was weathered and was classified in the field as residual soil. The Gatuna Formation underlies the Mescalero caliche and eolian sand deposits of the Holocene. The Gatuna Formation ranged in thickness from 17 – 28 feet and was encountered from El. 3518 to 3528. The contact between the Gatuna Formation and underlying Dockum Group was identified by visual and gradational changes in the stratigraphy. The Gatuna Formation is generally poorly indurated and unsaturated.

<u>Tecovas Formation:</u>

The Tecovas Formation consists of unsaturated mudstone, claystone, and siltstone which is sandy in places, micaceous, calcareous locally, poorly to moderately indurated, and reddishbrown (Bureau of Economic Geology, 1983). The Tecovas Formation was described as mainly an argillaceous siltstone that is calcareous and reddish-brown to dark reddish-brown at NP-1 (Ref. [3]). The contact between the Tecovas and Santa Rosa Formations was observed approximately between El. 3322 – 3321 during the 2017 field explorations.

<u>Santa Rosa Formation:</u>

The Santa Rosa Formation is a fine- to coarse grained sandstone which unconformably overlies the Dewey Lake Formation (Ref. [9]). The Santa Rosa Formation is well indurated and is the principal aquifer in the region in the western third of Southern Lea County (Ref. [9]). Groundwater measurements taken during the 2017 field explorations indicated groundwater at a depth of approximately 50 feet below the top of the Santa Rosa Formation.

Additional clarifying information to correlate between the USGS regional nomenclature and the 2017 site investigation, added figure 2.6.16 for the history of USGS nomencalture, direct statements about the level of induration and saturation of each layer encountered in the 2017 site investigations, description of the regional formations that were not encountered, and description of the noted fractures in the investigations, and description of the pedogenic slickensides were added to section 2.6.1. Figure 2.6.5 has been updated.

References for RAI 2-28

1. Lehman, T.M. (1994). The Saga of the Dockum Group and the Case of the Texas/New Mexico Boundary Fault: Bulletin 150, New Mexico Bureau of Mines and Mineral Resources, p. 37 - 51.
2. Bachman, G. R. (1971). Regional Geology and Cenozoic History of Pecos Region, Southeastern New Mexico. United States Department of the Interior Geological Survey.
3. Powers, Dennis W. (2014). Basic Data Report for Drillhole NP-1 (CP-1163). Section 1, T19S, R32E, Lea County, New Mexico.
4. Powers, Dennis W. (2010). Basic Data Report for Drillhole SNL-6 & -6A (CP-3151) (Waste Isolation Pilot Plant).
5. Lowry, T. S., Schuhen, M. D., Roberts, B. L., Arnold, B. W., McKenna, S. A., & Kirby, C. L. “BLM Lea County Water Study for the Dewey Lake and Santa Rosa Formations: Final Report.” Sandia National Laboratories, 2015.
6. Bachman, George O. (1973). Surficial Features and Late Cenozoic History in Southeastern New Mexico. United States Department of the Interior Geological Survey.
7. Powers, Dennis W. and Holt, Robert M. (1993). The Upper Cenozoic Gatuna Formation of Southeastern New Mexico. New Mexico Geological Society. 44(1), 271– 82.
8. Barnes, V.E., et al. (1983). Geologic Atlas of Texas, Tucumcari Sheet (1983). University at Texas at Austin, Bureau of Economic Geology.
9. Nicholson, A., Jr., & Clebsch, A., Jr. (1961). Groundwater Report No. 6, Geology and Groundwater Conditions in Southern Lea County, New Mexico. State Bureau of Mines and Mineral Resources, New Mexico Institute of Mining & Technology, Campus Station, Socorro, New Mexico.

2-29: Related to information in the Geotechnical Data Report

Supplement the Geotechnical Data Report and/or SAR Section 2.6 to provide the following additional information:

a) Provide high-quality photos of all recovered core for the borings completed at the site.
b) Describe the portions of B101 that do not include photos in the Geotechnical Data Report (depths of 104.5-106 ft, 110-111 ft, 209-210 ft, 259-260 ft, 2130-310.5 ft, and 324-325.5 ft).
c) Describe the fractures encountered in the rock in the context of the subsurface stratigraphy described in SAR Section 2.6.1 and presented in SAR Figures 2.6.2 and 2.6.5 through 2.6.8.

d) Discuss the origin of the fractures in the context of the geologic history described in SAR Section 2.6.1 including any associated geologic or tectonic events which may have influenced the formation of these fractures.
e) Discuss any anticipated effects of the fractured rock in the subsurface particularly the potential for surface deformation due to the same mechanism that caused the fractures in the rock.
f) Discuss the slickensides encountered at similar elevations in boreholes B102, B105 and B106, including their origin and any associated geological structures and the current or future potential for surface deformation.

The boring logs provided in the Geotechnical Data Report describe the presence of numerous areas of fractured rock and several occurrences of slickensides. Section 2.6.1 of the SAR describes the subsurface materials but does not mention fractures or slickensides observed in the rock units at the site. The Geotechnical Data Report also does not include the observed fractures or slickensides in the description of the materials encountered in the borings. The SAR and Geotechnical Data Report to not describe the origin of these fractures and slickensides and do not assess the potential for surface deformation at the site or settlement of the storage pads and the Canister Transfer Facility associated with the mechanism(s) that formed the fractures and slickensides.

This information is necessary to determine compliance with 10 CFR 72.103(f)(2)(ii).

Holtec Response

Core Photos

Photos of all recovered core for the borings completed during the 2017 field explorations are provided in an attachment to this letter.

Descriptions of Core Excluded from Photos

Rock core recoveries from B101 C1 (101 – 106 feet), C2 (106 – 111 feet), and C23 (205.6 – 210.6 feet) were 70%, 82%, and 66% respectively. Rock core photos of the recovered material are shown in an attachment to this letter

Rock core descriptions for core runs C1, C2, and C23 were provided in the boring logs. The rock was generally poorly indurated and moderately to severely weathered. Rock core descriptions from C1 and C2 indicate a mudstone with laminar bedding, brownish-red to gray, and soft. Rock core descriptions for C23 indicate a mudstone with highly fractured zones and a moderately weathered sandstone with calcite veins.

In the compiled photo log for boring B101 in the 2017 Geotechnical Data Report the unrecovered portion of the core is shown as a gap in the photo log at the bottom of each run.

A photo of B101 C34 (259 – 260’) from the 2017 field explorations is provided in an attachment to this letter. As described in the boring log, C34 was a reddish-brown with gray clasts, medium grained, well sorted, sandstone with cross-stratification. The core was medium hard and slightly weathered with near-horizontal, planar fractures.

The core sections identified by the NRC from C45 and C48 were removed from the core box for laboratory testing prior to photographing the core box. Photos of C45 (310 – 310.5’) and C48 (324 – 325.5’) from laboratory testing are also provided in the attachment to this letter. As described in the boring logs, C45 was red and gray, fine grained, well sorted, sandstone with cross-stratification. The core was medium hard and slightly weathered with near-horizontal, planar fractures. C48 was a reddish brown and gray, fine grained, mudstone with laminar bedding. The rock was soft and slightly weathered with near-horizontal, planar fractures.

Fractures Observed

Fractures were encountered in the rock in the Tecovas (formerly identified as the Chinle) and the Santa Rosa Formations during the 2017 field explorations. Fractures were typically planar, between 0 to 30° from horizontal, with most between 0 and 10°, and generally formed along bedding planes.

Fracture Origin

As discussed in SAR Section 2.6.1, uplift following the Triassic Period resulted in erosion and/or nondeposition until the middle to late Cenozoic. The fractures observed during the 2017 field explorations likely formed as material above eroded, relieving pressures and stress following the Triassic Period. It is believed all of southeastern New Mexico has been above sea level and subjected to erosion since the Cretaceous (Ref. [1]).

Potential for Deformation By Same Mechanism that Caused Fractures

We did not observe evidence of deformation or offsets in the subsurface profiles, as shown in Figures 2.5.3 – 2.5.5, that would suggest deformations due to other geologic processes. The erosion that caused the observed fracturing is a long-term, regional geologic process that is not expected to cause localized deformations during the operation of the CISF.

Sickensides

Slickensides were observed in B102, B105, and B106 between El. 3338 – 3445. Powers (Ref. [2]) has made similar observations of slickensides in the area and refers to them as pedogenic slickensides (i.e., slickensides that form during soil deposition and induration) as opposed to slickensides formed during tectonic processes. Pedogenic slickensides form during expansion and contraction in clay soils (Ref. [3]). These features appear in undeformed rocks (Ref. [3]). We did not observe evidence of deformation or offsets in the subsurface profiles as shown in Figures 2.5.3 – 2.5.5, . The processes that formed these pedogenic slickensides are not active and do not pose a concern for future deformation at the Site.

Additional clarifying information to correlate between the USGS regional nomenclature and the 2017 site investigation, added figure 2.6.16 for the history of USGS nomencalture, direct statements about the level of induration and saturation of each layer encountered in the 2017 site investigations, description of the regional formations that were not encountered, and description of the noted fractures in the investigations, and description of the pedogenic slickensides were added to section 2.6.1. Figure 2.6.5 has been updated.

References for RAI 2-29:

1. Bachman, G. R. (1971). Regional Geology and Cenozoic History of Pecos Region, Southeastern New Mexico. United States Department of the Interior Geological Survey.
2. Powers, Dennis W. (2014). Basic Data Report for Drillhole NP-1 (CP-1163). Section 1, T19S, R32E, Lea County, New Mexico.

3. Gray, Mary Beth and Nickelsen, Richard P. (1989). Pedogenic Slickensides, Indicators of Strain and Deformation Processes in Redbed Sequences of the Appalachian Foreland. Geology; 17 (1): 72–75.

RAI 2-30: Provide details about how the potential for induced seismicity was considered when developing the site design basis earthquake.

Section 2.6.2 of the SAR, "Vibratory Ground Motion," discusses the approach taken to develop the site seismic design ground motion. The seismic design ground motion was developed by taking the USGS National Seismic Hazard Mapping Project (NSHMP) results for the site location and using a Regulatory Guide 1.60 spectrum anchored at 0.15g as the design basis earthquake (DBE), as defined in Table 2.7.1 and Table 4.3.3 of the SAR. However, this approach to developing the DBE does not account for the potential for induced seismicity in the site region, because the NSHMP approach removes induced and potentially induced seismicity from its earthquake catalog prior to performing the hazard analysis. Because the site is located within a region of both induced seismicity and extensive oil and gas production (along with any associated wastewater disposal), the potential for induced seismicity should be included in the development of the DBE.

This information is necessary to determine compliance with 10 CFR 72.103.

Holtec Response

The potential for induced seismicity at the site and the uncertainties of site-specific subsurface geologic and geophysical properties are accounted for by using a bounding earthquake as input to the design basis seismic analysis of the HI-STORM UMAX system at the HI-STORE site. This bounding earthquake is referred to as the Design Extended Condition Earthquake (DECE), which is defined in Subsection 4.3.6 of the SAR and has a peak ground acceleration that is two-thirds greater than the DBE (0.25g vs. 0.15g). The motivation for using the DECE, as stated in Subsection 4.3.6 of the SAR, is for "additional conservatism and to overcome any potential uncertainty or future adjustments to the site seismological data", including the potential for induced seismicity and the effects of site-specific subsurface geologic and geophysical properties. In Chapter 5 of the SAR, the DECE is conservatively used to inform the structural evaluation of the HI-STORM UMAX system at the HI-STORE site.

RAI 2-31: Justify not incorporating site-specific subsurface geologic and geophysical properties through a site response analysis for the development of the site-specific design basis earthquake (DBE).

Section 2.6.2 of the SAR describes the applicant's approach used to develop the site's DBE. However, the applicant relies on results of the USGS NSHMP, which is performed on a grid across the United States for a subset of pre-defined subsurface conditions that may not adequately capture the subsurface properties of the Holtec site. A site-specific probabilistic seismic hazard assessment (PSHA) performed by the NRC staff, which incorporates at-site and regional velocity and stratigraphic information, indicates an exceedance of the DBE at frequencies greater than 15 Hz. Given the lack of site-specific hazard development, this exceedance should be justified.

This information is necessary to determine compliance with 10 CFR 72.103.

Holtec Response

See response to RAI 2-30.

RAI 2-32: Provide the corrected blow count N-values from the Standard Penetration Test (SPT) for each borehole drilled at the site, as described in the Geotechnical Data Report: HI-STORE CISF Phase 1 Site Characterization, Lea County, New Mexico (GEI, 2017), as a function of depth and justify the conclusion in SAR Section 2.6.4, "Stability of Subsurface Materials," that the strata beneath the storage pads and the Cask Transfer Facility (CTF) are not liquefiable.

Section 2.6.4 of the SAR states that corrected SPT blow count N-values have been used to assess the potential for liquefaction of the strata beneath the storage pads and the CTF. However, Attachment F of the Geotechnical Data Report: HI-STORE CISF Phase 1 Site Characterization, Lea County, New Mexico (GEI, 2017), shows only correction for the hammer energy (C_E), as per equation (8) of Youd et al. (2001) (Reference 2.6.12 of SAR), that has been done for the field-measured N-values from the SPT test. It is not clear whether other corrections to the measured N-values, as shown in equation (8) of Youd et al. (2001) (Reference 2.6.12 of SAR), have been conducted to estimate the $(N_1)_{60\ \mathrm{Clean\ Sand}}$ values for assessing the geotechnical properties of the subsurface and the liquefaction potential. The methodology of Youd et al. (2001) (Reference 2.6.12 of SAR) requires all the necessary corrections be made to the field-measured N-values to determine the $(N_1)_{60\ \mathrm{Clean\ Sand}}$ values for assessing the liquefaction potential. Therefore, corrected SPT blow count N-values are needed to assess whether the strata beneath the storage pads and the CTF could liquefy.

This information is necessary to determine compliance with 10 CFR 72.24, 72.103, and 72.122.

Holtec Response

The field-measured N-values have been corrected to determine the $(N_1)_{60\ \mathrm{Clean\ Sand}}$ values, and a re-assessment of the liquefaction potential of the strata beneath the storage pads and the CTF has been performed. The results are presented in Reference 13, which concludes that the site is not susceptible to liquefaction, and also summarized in Appendix C of Report No. HI-2188143, Revision 1.

RAI 2-33: Justify why the material properties, as given in Table 5.3 of the report HI-STORE Bearing Capacity and Settlement Calculations (Report No. HI-2188143), are appropriate to represent the materials at the proposed site.

First, Table 5.3 of Report No. HI-2188143 states that only a few properties were directly measured on samples obtained from the proposed site and most of the remaining properties were estimated using the Standard Penetration Test (SPT) blow count N-values and empirical relationships available in Bowles (1997) (Reference [8] of HI-2188143). For example, friction angle) for the Residual Soil and Chinle Formation was estimated using the SPT blow count N values and an empirical equation (Equation 3-5) given in Bowles (1997) (Reference [8] of HI-2188143). However, Bowles (1997) gives three empirical equations (3-5) to estimate) from the selected N-value. Report No. HI-2188143 did not identify which equation was used to estimate the friction angle) for the Residual Soil and Chinle Formation. It is also not clear whether all the necessary corrections were carried out to adjust the field-measured SPT N-values prior to using the empirical equation. Additionally, the Report No. HI-2188143 does not provide the specific N-values that were used to estimate the friction angles) of the Residual Soil and Chinle

Formation. Moreover, discuss why the selected N-values would represent the characteristics of the entire Residual Soil and Chinle Formation (mudstone) of the proposed site when the borehole logs, given in the Geotechnical Data Report (GEI, 2017), show considerable variation with depth and spatially from one borehole to another.

Moreover, these empirical equations given in Bowles (1997) (Reference [8] of HI-2188143) use the SPT blow count of N_{70} values, indicating an energy ratio of 70. Attachment F to the Geotechnical Data Report (GEI, 2017) shows that the field-measured SPT blow counts were normalized to 60% of the hammer energy (N_{60}). It is not clear whether appropriate conversions were carried out before using the empirical equation from Bowles (1997) to estimate the friction angle ⎞ of the Residual Soil and Chinle Formation. Therefore, a justification is needed to demonstrate that the estimated friction angles of the Residual Soil and the Chinle Formation have been appropriately estimated and represent the strata behavior appropriately.
Similarly, elastic modulus E of the Residual Soil is estimated using an empirical relationship given by Bowles (1997) (Reference [8] of HI-2188143), correlating with the Plasticity Index and SPT blow count at 55% energy ratio, or N_{55}. Values of Plasticity Index and N_{55} used are not given. It is also unclear why the elastic modulus of the Residual Soil changed from 27.81 ksf, as given in Table 5.3, to 39.68 ksf in page A.2 of Report No. HI-2188143, and in subsequent uses. Therefore, a justification is needed to demonstrate that the elastic modulus of the Residual Soil has been estimated appropriately considering the characteristics of the stratum at the proposed site.

Next, the elastic modulus E of the Chinle Formation in Table 5.3 of Report No. HI-2188143 appears to be measured on Sample C6 from Boring B107, as shown in Table 4 of the Geotechnical Data Report (GEI, 2017). However, another test using a sample from the same depth interval shows significantly lower elastic modulus (2,727 ksf vs. 900 ksf). It is not clear why one value was preferred over another. Additionally, the strength test, by its very nature, was conducted on relatively intact rock samples. The Chinle Formation, especially the upper portion, is highly fractured with fracture spacing as low as 1 inch (GEI, 2017). Most of these fractures are horizontal or sub-horizontal (less than 30° from the horizontal), as given in the boring logs in GEI (2017). These fractures are expected to make the rock mass (Chinle Formation) more deformable, especially in the vertical direction. Therefore, to estimate the settlement beneath the storage pads, the rock mass modulus instead of the intact rock modulus, may be more appropriate to capture the deformation characteristics from the vertical load imposed by the pad structures and the multipurpose canisters. Accordingly, a justification is necessary to demonstrate that the elastic modulus of the Chinle Formation has been estimated appropriately, taking into consideration the characteristic of the stratum at the proposed site.

Additionally, Poisson's ratio μ for the Residual Soil and Chinle Formation were adopted from literature (e.g., Bowles, 1997, Table 2-7) (Reference [8] of HI-2188143). Unfortunately, Bowles (1997) (Reference [8] of HI-2188143) provided values of Poisson's ratio in terms of broad material types (e.g. clay, rock). It is not clear what would be the appropriate values of Poisson's ratio for the Residual Soil (mostly CL or sandy clay) and mudstone from the possible ranges given in Bowles (1997) (Reference [8] of HI-2188143). Additionally, property values listed in Table 5.3 of the Report No. HI-2188143 indicate the Residual Soil to be an extremely soft clay material compared to mudstone (Chinle Formation) in the axial direction only (almost 70 to 100 times softer); however, it is stiffer than mudstone in the lateral direction (Poisson's ratio of the Residual Soil is 0.2 versus 0.3 for mudstone in Table 5.3 of HI-2188143). The report does not discuss why these Poisson's ratio values would be appropriate for the materials available at the proposed site. Therefore, a justification is needed to demonstrate that the estimated values of Poisson's ratio of the Residual Soil and the Chinle Formation appropriately represent the strata at the proposed site.

Lastly, it is not clear how the cohesion C of Residual Soil and Chinle Formation were determined, as given in Table 5.3 of Report No. HI-2188143. Report No. HI-2188143, where it states that Equation (2.93) of Das (2016) (Reference [4] of HI-2188143), was used to estimate the cohesion values. However, Equation (2.93) of Das (2016) (Reference [4] of HI-2188143) is for unconsolidated-undrained tests when friction angle $\phi = 0$ for saturated clays. Table 5.3 of HI-288143 shows the friction values ϕ for both the Residual Soil and Chinle formation, estimated from the SPT N-values. No explanation is provided for the selected approach to estimate cohesion of the Residual Soil and Chinle Formation assuming zero friction. Additionally, both the Residual Soil and Chinle Formation are assumed cohesionless in Report No. HI-2188143 when estimating the elastic or immediate settlement after construction of the storage pads and the CTF without any explanation. Therefore, a justification is needed to demonstrate that the methodology used to estimate the cohesion of the Residual Soil and the Chinle Formation is appropriate and the estimated values appropriately represent the characteristics of the strata at the proposed site. Additionally, assumptions used about the strata behavior should be consistent throughout the analysis and appropriately justified.

This information is necessary to determine compliance with 10 CFR 72.24(a), 72.103, and 72.122.

Holtec Response

Report No. HI-2188143 has been revised significantly, including the geotechnical properties in Table 5.3, to address the issues identified in the above RAI, as well as the other RAIs on SAR Section 2.6.

RAI 2-34: Justify why Equation 10.6.2.4.2-1, given in the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications (Reference [1] in Report No. HI-2188143, “HI-STORE Bearing Capacity and Settlement Calculations”), is appropriate to estimate the elastic or immediate settlement of the storage pads and the CTF at the proposed facility.

AASHTO LRFD Bridge Design Specifications (Reference [1] in Report No. HI-2188143) provides the equation 10.6.2.4.2-1 to estimate the elastic settlement in cohesionless soils in Section 10.6.2.4.2, “Settlement of Footings on Cohesionless Soils.” However, Table 5.3 of Report No. HI-2188143, which lists the values of different geotechnical parameters used in estimating the settlement of the storage pads and the CTF, shows both the Residual Soil and Chinle Formation have cohesion (4,000 and 8,060 psf, respectively). Therefore, a justification is needed why it is appropriate to use the methodology given in AASHTO LRFD Bridge Design Specifications (Reference [1] in Report No. HI-2188143) for cohesionless soils to estimate the elastic or immediate settlement of cohesive soils.

This information is necessary to determine compliance with 10 CFR 72.24(a), 72.103, and 72.122.

Holtec Response

Per the soil index properties in Table 2.6.2 of the SAR, the average composition of the Residual Soil material is 58.7% sand and 41.3% fines (based on 4 samples). This indicates that the

Residual Soil material behaves more like a granular (cohesionless) soil, which supports the use of Equation 10.6.2.4.2-1. Also, the commentary to Section 10.6.2.4.3 of AASHTO LRFD Bridge Design Specifications (Reference [1] in Report No. HI-2188143) states:

"In practice, footings on cohesive soils are most likely founded on overconsolidated clays, and settlements can be estimated using elastic theory"

This statement applies to the upper layer of the Chinle Formation, which is in fact an overconsolidated clay layer based on the data provided in the Geotechnical Data Report (Reference [2] of HI-2188143). The GNEP siting study (Reference [2.1.3] in the SAR) also indicates favorable conditions for foundations at the Site. This collective information provides the justification for using elastic theory to estimate the elastic or immediate settlement of the storage pads and the CTF at the proposed facility.

Finally, in the latest revision to Report No. HI-2188143 the elastic/immediate settlement is calculated using the elastic methodology presented in Section 5-6 of Bowles (1997) (Reference [8] of HI-2188143) instead of equation 10.6.2.4.2-1 of AASHTO LRFD Bridge Design Specifications.

RAI 2-35: Justify the weighting scheme adopted in Report No. HI-2188143, "HI-STORE Bearing Capacity and Settlement Calculations," to estimate the weighted average of the elastic modulus and Poisson's ratio for calculating the elastic or immediate settlement of the storage pads and the CTF.

Report No. HI-2188143 uses a weighting scheme, as given in Bowles (1997) (Reference [8] of HI-2188143), for estimating the weighted average of the elastic modulus E and Poisson's ratio μ for multi-layered strata. The methodology described in page 308 of Bowles (1997) indicates that the weighting scheme at the proposed site should follow the alternative approach because the Chinle Formation is almost 70 to 100 times stiffer than the Residual Soil (Table 5.3 of HI-2188143). Therefore, the Chinle Formation should be considered as the hard stratum for estimating the immediate or elastic settlement by the applicant, based on Bowles (1997). The immediate settlement would be controlled by the Residual Soil layer only with a thickness of 12 ft, measured from the bottom of the storage pads to where the hard stratum (Chinle Formation) is encountered, not up to 5 times the pad width, as used in Report No. HI-2188143. Therefore, a justification is needed why it would be appropriate to use the adopted weighting scheme for estimating the immediate or elastic settlement of the storage pads and the CTF.

This information is necessary to determine compliance with 10 CFR 72.24(a), 72.103, and 72.122.

Holtec Response

The elastic modulus of the Residual Soil was significantly underestimated in Revision 0 of Report No. HI-2188143. In the latest revision, the elastic modulus of the Residual Soil is estimated based on the empirical formula in Table 5-6 of Bowles (1997) (Reference [8] of HI-2188143) and the average N_{55} value from Appendix C of HI-2188143. The resulting modulus value is 1,424 ksf, which is roughly one-half of the stiffness of the Chinle Formation. Since the elastic modulus values of the Residual Soil and the Chinle Formation are of similar magnitude, the use of the weighting scheme from Bowles (1997) to determine the effective soil properties is justified.

RAI 2-36: Justify why the consolidation settlement estimated at the upper 6 ft of the Residual Soil layer (measured from the bottom of the storage pad) would be the total consolidation settlement of the entire Residual Soil layer (total thickness of 12 ft) below the storage pads.

Report No. HI-2188143, "HI-STORE Bearing Capacity and Settlement Calculations," states that the thickness of the Residual Soil layer is 12 ft; however, it has estimated the increase of vertical stress due to construction of a storage pad only at a depth of 6 ft from the bottom of the storage pads (Page A.8 of HI-2188143) and associated consolidation settlement. The report does not provide an explanation why the lower 6 ft of Residual Soil would behave as a rigid body and would not undergo any consolidation settlement when it can sustain elastic or immediate settlement (Page A.6 of HI-2188143). Therefore, a justification is needed to explain why the consolidation settlement of the top 6 ft of the Residual Soil would be the total consolidation settlement of the entire 12 ft thick Residual Soil.

This information is necessary to determine compliance with 10 CFR 72.24(a), 72.103, and 72.122.

Holtec Response

The staff's observation is correct and Holtec regrets that there is an error in the formula on page A.8 of Report No. HI-2188143.

Specifically, the formula for the increase of vertical stress at the bottom of the Residual Soil layer ($\Delta\sigma_b$) is incorrect. Consistent with Equation 6.18 from Das (2016) (Reference [4] of HI-2188143), the foundation load spreads at a 2:1 ratio (vertical to horizontal) and therefore the horizontal spread on all perimeter sides should be equal to 6 feet at the bottom on the 12-foot deep Residual Soil layer. Accordingly, the formula for the increase of vertical stress at the bottom of the Residual Soil layer has been revised as follows:

$$\Delta\sigma_b = \frac{\Delta Q}{(B_{pad} + H_{res})(L_{pad} + H_{res})}$$

Likewise, the formula for the increase of vertical stress at mid-depth has been revised to replace "$H_{res}/4$" with "$H_{res}/2$" in the denominator. The net effect of these changes is a reduction in the total average stress increase since the load is spread over a wider area than before.

RAI 2-37: Justify why the consolidation-related properties measured in mudrock (Chinle Formation) are appropriate for estimating the consolidation settlement of the Residual Soil layer below the storage pads and the CTF.

The consolidation-related properties include the Preconsolidation Stress or the maximum past vertical stress σ_c, Compression Ratio, and the Recompression or Swelling Ratio. Report No. HI-2188143, "HI-STORE Bearing Capacity and Settlement Calculations" has taken the consolidation-related properties of the Residual Soil that are measured on two samples from the Chinle Formation obtained from two different depths. For estimating the consolidation settlement, the Residual Soil layer beneath the storage pads has been replaced by a layer of Chinle Formation with a thickness of 6 ft. This is followed by a 6 ft thick rigid layer of Residual soil over the original Chinle Formation. The report does not provide an explanation for why a layer of the Chine Formation placed just beneath the storage pads would represent the consolidation processes in the Residual Soil in reality. As such, Page A.9 of HI-2188143 states that the Chinle Formation is considered bedrock. It would undergo consolidation settlement, although significantly lower than the Residual Soil. Therefore, a justification is needed to explain why it would be appropriate to use the consolidation-related properties of the Chinle Formation to estimate the consolidated settlement of the Residual Soil.

This information is necessary to determine compliance with 10 CFR 72.24(a), 72.103, and 72.122.

Holtec Response

Holtec Report HI-2188143 has been revised to update the consolidation settlement calculation for the under-grade beneath UMAX support foundation pad. In doing so, the focus is placed on the Chinle Formation, and the Residual Soil layer is neglected since it is less susceptible to consolidation settlement. The reasons that the consolidation settlement in the Residual Soil layer is negligible are (a) its soil composition is more than 50% sand, and (b) it is situated above the water table and has very low moisture content (10-15%). In the revised report, the 1-D consolidation test results for the Chinle samples, from the Geotechnical Data Report: HI-STORE CISF Phase 1 Site Characterization, Lea County, New Mexico (GEI, 2017) (Reference [2] in HI-2188143), are now used appropriately to estimate the consolidation settlement of the HI-STORM UMAX system.

RAI 2-38: Justify the methodology used to estimate the consolidation-related settlement underneath the storage pads and the CTF.

Report No. HI-2188143, “HI-STORE Bearing Capacity and Settlement Calculations,” uses Equation 2.67 of Das (2016) (Reference [4] in HI-2188143) to estimate the long-term consolidation settlement under the storage pads and the CTF. According to Das (2016) (Reference [4] in HI-2188143), the value of Preconsolidation Stress or the maximum past vertical stress σ_c determines whether the soil is normally consolidated or overconsolidated. Additionally, the preconsolidation stress with respect to the initial effective vertical stress before construction and the additional effective vertical stress imposed by the storage pads with the storage modules or the CTF would determine which equation should be used if the soil is normally consolidated or overconsolidated (Das, 2016, Reference [4] of HI-2188143). In Report No. HI-2188143, the preconsolidation stress σ_c of the Residual Soil is taken as the value estimated in sample SW1 obtained at depth 73.9 to 74.6 ft of the Chinle Formation, and Equation 2.67 of Das (2016) (Reference [4] in HI-2188143) has been used. However, it is not clear whether any standard practice (e.g., ASTM International) has been followed to determine the preconsolidation stress from the laboratory-measured test results. Additionally, other consolidation-related parameters, Compression Ratio and Recompression or Swelling Ratio, are measured in Sample SW2 obtained at a depth of 100.5 to 101.1 ft of the Chinle Formation. It is not clear how parameter values measured on two different samples from two different depths in mudrock (Chinle Formation) are appropriate to represent the consolidation characteristics of the Residual Soil. Therefore, a justification is necessary for the appropriateness of the estimated Preconsolidation Stress value and for why the approach adopted would provide acceptable estimates of the consolidation settlement under the storage pads and the CTF.

This information is necessary to determine compliance with 10 CFR 72.24(a), 72.103, and 72.122.

Holtec Response

See response to RAI-37. The preconsolidation stress for the Chinle Formation is determined from the vertical strain vs. vertical stress plot that resulted from the 1-D consolidation test for Sample SW2, which was conducted in accordance with ASTM D 2435. Based on consideration of the preconsolidation stress, the effective pressure on the soil, and the added pressure due to the HI-STORM UMAX system, the Chinle Formation is determined to be overconsolidated, which justifies the use of Equation 2.67 of Das (2016) (Reference [4] in HI-2188143).

RAI 2-39: Justify why the secondary settlement of the storage pads and the CTF would be negligible at the proposed site.

AASHTO LRFD Bridge Design Specifications (2012) (Reference [1] in HI-2188143) specifies total settlement would be the summation of three components: (1) elastic settlement, (2) primary consolidation settlement, and (3) secondary settlement (Equation 10.6.2.4.1-1 of Reference [1] in HI-2188143). However, the secondary settlement under the storage pads and the CTF has not been estimated in Report No. HI-2188143 and no explanation has been provided. A justification is necessary to explain why the secondary settlement at the proposed site would be negligible.

This information is necessary to determine compliance with 10 CFR 72.24(a), 72.103, and 72.122.

Holtec Response

The secondary settlement of the storage pads and the CTF is negligible for the HI-STORE site because the vast majority of the soils within the site (about 90% per Section 2.1.2 of the SAR) are classified as fine sandy loam, which is made of approximately 65% sand, 25% silt, and 10% clay material (see Figure 2-39-1). Secondary settlement, or creep settlement, is negligible for sand material, which has an index of secondary compression in the range of 0.00003-0.0006 versus 0.01 for clay material. Report No. HI-2188143 has been revised to include this explanation why secondary settlement at the proposed site is negligible.

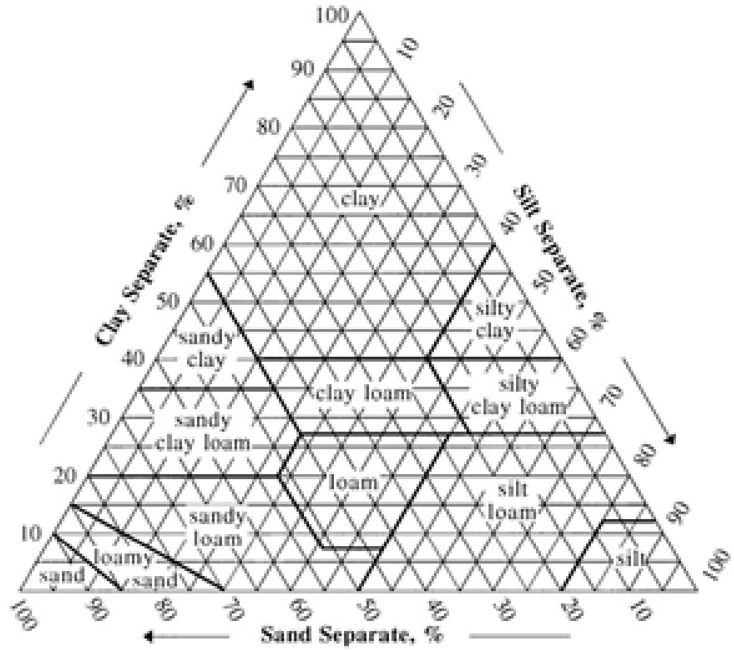


Figure 2-39-1: Soil Composition Chart

RAI 2-40: Demonstrate that the Residual Soil beneath a spent fuel storage pad would not undergo settlement more than the maximum allowable of 0.2 inch, as per the HI-STORM UMAX Canister Storage System FSAR, considering the construction sequence and operational timeframes.

The construction sequence of a storage pad starts with the placement of the Support Foundation Pad (SFP) over the prepared surface. This is followed by placing the Cavity Enclosure Container (CEC) shells on the SFP. Then, Controlled Low Strength Material (CLSM) is placed. After the CLSM pour is complete, concrete for the ISFSI pad is poured. Later, one loaded multi-purpose canister (MPC) is placed in each of the 250 cavities with other components of the Vertical Ventilated Module (VVM).

Report No. HI-2188143, "HI-STORE Bearing Capacity and Settlement Calculations" estimates the total settlement of the SFP in terms of two components: (1) immediate or elastic settlement and (2) consolidation settlement. By estimating the immediate or elastic settlement of the SPF from the total load of the storage pad (SFP + CLSM + Top ISFSI Pad + 250 VVMs), the report inherently assumes that the construction of the storage pad structure and placement of 250 VVMs would be complete in a very short time before appreciable consolidation settlement from any of the load components begins. As per Bowles (1997) (Reference [8] of HI-2188143), the construction and placement of 250 VVMs need to be over within approximately 7 days from placement of the SFP before the consolidation settlement of the Residual Soil beneath the SFP starts, first from the load imposed by the SFP and later by the other components in the order they were placed. Neither Report No. HI-2188143 nor the SAR provide the time taken by the construction process of the pad structure, in addition to placement of all 250 VVMs. It is, therefore, not clear whether the consolidation settlement from loads already placed would start before the next load component is placed over the SFP causing immediate or elastic settlement of the Residual Soil underneath.

It is also not clear whether the long-term settlement of the SFP can be the only consolidation settlement component, as assumed in Report No. HI-2188143, as some components of the total load may be placed after significant time has elapsed since the SFP has been constructed. The soil below the SFP may undergo consolidation settlement from the load(s) already placed when a new load is placed on the SFP. Therefore, an assessment is necessary to determine whether the long-term settlement of the SFP would be comprised only of the consolidation settlement from the individual load components, or if it may include some of the immediate or elastic settlement from loads placed later in time. If that is not the case, an assessment is necessary to determine whether the SFP would be able to sustain the immediate or elastic settlement imposed by the subsequent load components, in addition to the consolidation settlement as the long-term settlement (less than 0.2 in as per HI-STORM UMAX FSAR).

This information is necessary to determine compliance with 10 CFR 72.24(a), 72.103, and 72.122.

Holtec Response

The determination of the maximum long-term settlement at the proposed CIS Facility Site is consistent with the methodology established in the HI-STORM UMAX FSAR. Specifically, per subparagraph 3.4.4.1.2 (item C) of the HI-STORM UMAX FSAR, the maximum long-term settlement is calculated "assuming that the total load "P" (modeled as a uniform pressure at the top of the subgrade) is equivalent to that produced by the SFP fully populated with loaded VVMs for the entire life".

The limiting long-term settlement of 0.2 inches is used in the HI-STORM UMAX FSAR to compute an effective elastic modulus for the soil column under the support foundation pad (SFP), which is then used as input to the finite element model of the SFP to evaluate the pad flexure under the factored dead load. The methodology summarized in subparagraph 3.4.4.1.2 of the HI-STORM UMAX FSAR is further described in Holtec Position Paper DS-338, "A Methodology to Compute the Equivalent Elastic Properties of the Subgrade Continuum to Incorporate the Effect of Long-Term Settlement" (Reference [3.4.7] in FSAR).

In order to satisfy the conditions of the HI-STORM UMAX generic license, the calculated long-term settlement for a candidate site shall not exceed the permissible value of 0.2 inches per Table 2.3.2 of the HI-STORM UMAX FSAR, using the same methodology described in paragraph 3.4.4.1 of the FSAR. This demonstration is made in Holtec Report No. HI-2188143 for the proposed HI-STORE CIS Facility.

RAI 2-41: Provide an assessment(s), using site-measured geotechnical properties, to demonstrate that the strata at the subgrade and under-grade of the storage pads and the CTF would have sufficient bearing capacity and would not undergo excessive differential settlement, both immediately and in the long-term, due to spatial and vertical variation of the subsurface geotechnical properties.

In response to RAI 2-2, dated March 28, 2018, the applicant submitted Report No. HI-2188143, "HI-STORE Bearing Capacity and Settlement Calculations." However, the analysis in this report did not address the potential effects of spatial variation of the subsurface geotechnical properties on the bearing capacity and estimated settlement. The proposed storage pads to be constructed at the HI-STORE CISF are large and spatial variations of the geotechnical properties may significantly affect the settlement of the Support Foundation Pads. Similarly, the borehole logs in GEI (2017) show significant variations with depth. However, Report No. HI-2188143 assumed the materials underneath the storage pads to be vertically uniform. Therefore, a justification is necessary to demonstrate that the spatial and vertical variation of the geotechnical properties are small enough to affect the immediate or elastic as well as the consolidation settlement substantially.

This information is necessary to determine compliance with 10 CFR 72.24(a), 72.103, and 72.122.

Holtec Response

The detailed subsurface profiles in the Geotechnical Data Report: HI-STORE CISF Phase 1 Site Characterization, Lea County, New Mexico (GEI, 2018) show that the boundary between the Residual Soil layer and the Chinle Formation at the proposed ISFSI site is encountered at elevation 3500 ft with minimal spatial variation. This is evident from detailed subsurface profiles shown in Figures 6 through 8 of Geotechnical Data Report, as well as the text in Subsection 5.2.2 which confirms that the top of the Chinle Formation is located between El. 3499 and El. 3502. Moreover, the Geotechnical Data Report describes the Chinle Formation as the upper bedrock region and generally characterizes the material as “very hard soil to soft rock”. This means that when the storage pads and CTF are constructed at the proposed site they will be supported by a relatively uniform, 12-foot thick layer of Residual Soil, which lies atop the Chinle bedrock. As such, the bearing capacity and the immediate or elastic settlement are controlled by the weaker Residual Soil layer, and the consolidation settlement of the hard clay and mudstone found in the Chinle Formation is quite small. This discussion has been incorporated in Report No. HI-2188143.

RAI 2-42: Justify why a two-layer system, as used in the Report No. HI–2188143, “HI-STORE Bearing Capacity and Settlement Calculations,” would be appropriate for estimating the bearing capacity and settlement of the storage pads.

Geotechnical Data Report: HI-STORE CISF Phase 1 Site Characterization, Lea County, New Mexico (GEI, 2017) (Section 5.2.1.3, Residual Soil) states that the difference between the Residual Soil and underlying Chinle Formation was made “based upon hammer refusal in the Standard Penetration Test, difficulty in advancing augers, and visual and gradational changes in the stratigraphy.” Boring logs given in Attachment C of this report show that the material in each borehole immediately below the Residual Soil–Chinle Formation is classified as Lean or Sandy Lean Clay CL, following the Unified Soil Classification System. The depth at which this CL soil changes to mudstone of the Chinle Formation varies from boring to boring with a range of 2 (B106) to 66 ft (B101). Below this boundary between the CL Soil–Mudstone, the mudstone is moderately weathered and severely to moderately fractured. Section 2.4.6.4, “Stability of Subsurface Materials,” of NUREG–1567 defines rock as having shear wave velocity at least 1,166 m/s [3,500 ft/s]. However, the measured shear wave velocity at the proposed site does not reach 1,166 m/s [3,500 ft/s] even at a depth of 31.5 m [105 ft] from the surface (Table 2.6.4 and Figure 2.6.10 of SAR). Consequently, a two-layer system may not be representative of the subsurface strata below the pad; instead, the Chinle Formation overlain by the Residual Soil divided into three sub-layers with a CL soil layer on top, followed by a moderately fractured layer, and a less fractured layer, with material properties for each sub-layer, may be more appropriate. Therefore, a justification is necessary why a two-layer system of Residual Soil–Chinle Formation with one set of material properties would be appropriate for assessing the bearing capacity and expected settlement at the proposed site.

This information is necessary to determine compliance with 10 CFR 72.24, 72.103, and 72.122

Holtec Response

In the latest revision of Report No. HI-2188143, the top CL soil layer is conservatively assumed throughout the entire 175 ft depth of the Chinle Formation. This is conservative because the top CL soil layer is the weakest among the three sublayers that comprise the Chinle Formation. Thus, the bearing capacity is conservatively underestimated, while the expected settlement is overestimated.

ER-GEN-2: Clarify whether Holtec qualifies for National Pollutant Discharge Elimination System (NPDES) General Permits for construction and industrial stormwater. If Holtec qualifies for both General Permits, confirm that no additional State water quality authorization is required. If Holtec does not qualify for both General Permits, describe Holtec's plans and schedule for applying for individual NPDES stormwater permits, a water quality certification under Section 401 of the Clean Water Act (CWA), or for requesting a waiver from the State for the Section 401 water quality certification.

Section 1.4.2.1 of the HI-STORE CISF Environmental Report identifies the need for a National NPDES Construction Stormwater Permit during construction to prevent impacts to jurisdictional waters, and a NPDES General Permit for Industrial Stormwater or an individual NPDES permit during operations for stormwater runoff to waters of the State.

A NPDES permit pursuant to Section 402 of the CWA is subject to a CWA Section 401 water quality certification. Under Section 401 of the CWA, a federal agency may not issue a permit or license to conduct activity that may result in discharge into waters of the U.S. unless a Section 401 certification is issued verifying compliance with existing water quality requirements, or a waiver is issued from the State.

This information is necessary to determine compliance with 10 CFR 51.45(b), (c), and (d).

Holtec Response

Per discussions with USACE Albuquerque District's Regulatory Office on 6/15/2020, the USACE does not consider the areas surrounding the Site, Waters of the United States (WOTUS). Therefore, the areas are under the jurisdiction of the New Mexico Environmental Department, Ground Water Quality Bureau and Surface Water Qualities Bureau.

Holtec is currently working with the program manager of the NMED Surface Water Quality Bureau and is in the process of submitting a Notice of Intent (NOI) with these agencies. Upon review of the NOI, the agencies will determine the applicable permits. Upon acceptance of the HI-STORE license, Holtec will file for the identified permits with the intention that the permits will be acquired prior to construction or operation as applicable. Holtec will continue to work with the NMED program manager or their designee throughout the process.

ER-WR-8: Clarify the status of the determination of jurisdictional wetlands by the U.S. Army Corps of Engineers within the proposed CISF project boundary.

Section 3.5.1 of the Environmental Report states that there are no sensitive riparian habitats or jurisdictional wetlands at the site. Provide information regarding any wetland surveys performed at the site or why none were needed. Provide the basis for the statement that there are no jurisdictional wetlands at the site or clarify the current status of any pending jurisdictional determination. Also clarify whether, based on the National Wetland Inventory, any riverine habitat, freshwater pond habitat, and/or lake habitat is present within the proposed project area.

This information is necessary to determine compliance with 10 CFR 51.45(b), (c), and (d).

Holtec Response

Per the USACE Albuquerque District's Regulatory Office on 6/15/2020 there areas are not considered Jurisdictional wetlands of the USACE. Thus, confirming the statements made in the Environmental Report.

The National Wetlands Inventory Mapper indicates several Freshwater Emergent Wetlands and two Riverine Habitats on the northern half of the property in addition to considering Laguna Gatuna a Lake Habitat Surrounded by Freshwater Emergent Wetlands. The Freshwater Emergent Wetlands and Riverine Habitats are disconnected and are classified as seasonally or intermittently flooded.

The three Freshwater Emergent Wetlands closest to the site are classified PEM1C [1]:

> System Palustrine (P) : The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 ppt. It also includes wetlands lacking such vegetation, but with all of the following four characteristics: (1) area less than 8 ha (20 acres); (2) active wave-formed or bedrock shoreline features lacking; (3) water depth in the deepest part of basin less than 2.5 m (8.2 ft) at low water; and (4) salinity due to ocean-derived salts less than 0.5 ppt.
>
> Class Emergent (EM) : Characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants.
>
> Subclass Persistent (1) : Dominated by species that normally remain standing at least until the beginning of the next growing season. This subclass is found only in the Estuarine and Palustrine systems.
>
> Water Regime Seasonally Flooded (C) : <u>Surface water is present for extended periods especially early in the growing season, but is absent by the end of the growing season in most years. The water table after flooding ceases is variable, extending from saturated to the surface to a water table well below the ground surface.</u>

The three additional disconnected Freshwater Emergent Wetlands are classified PEM1J [1]:

> Water Regime Intermittently Flooded (J) : <u>The substrate is usually exposed, but surface water is present for variable periods without detectable seasonal periodicity. Weeks, months, or even years may intervene between periods of inundation. The dominant plant communities under this Water Regime may change as soil moisture conditions change. Some areas exhibiting this Water Regime do not fall within our definition of wetland because they do not have hydric soils or support hydrophytes. This Water Regime is generally limited to the arid West.</u>

One Riverine Habitat is classified R4SBA while the other is R4SBJ [1]:

> System Riverine (R) : The Riverine System includes all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts of 0.5 ppt or greater. A channel is an open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water.
>
> Subsystem Intermitten (4) : This Subsystem includes channels that contain flowing water only part of the year. When the water is not flowing, it may remain in isolated pools or surface water may be absent.
>
> Class Streambed (SB) : Includes all wetlands contained within the Intermittent Subsystem of the Riverine System and all channels of the Estuarine System or of the Tidal Subsystem of the Riverine System that are completely dewatered at low tide.
>
> Water Regime Temporary Flooded (A) : <u>Surface water is present for brief periods (from a few days to a few weeks) during the growing season, but the water table usually lies well below the ground surface for the most of the season.</u>
>
> Water Regime Intermittently Flooded (J) : <u>The substrate is usually exposed, but surface water is present for variable periods without detectable seasonal periodicity. Weeks, months, or even years may intervene between periods of inundation. The dominant plant communities under this Water Regime may change as soil moisture conditions change. Some areas exhibiting this Water Regime do not fall within our definition of wetland because they do not have hydric soils or support hydrophytes. This Water Regime is generally limited to the arid West.</u>

It should be noted that these NWI determinations are strictly based on satellite imagery/aerial photography with limited physical site verifications [1]. Additionally, several of the Freshwater Emergent wetlands align with the small depressions described in the responses to RAI 2-26 and 2-27.

Phase one of the HI-STORE Facility will not impact any of these features while the full build out will impact all but one of the Freshwater Emergent Wetlands. Neither will impact Laguna Gatuna. As detailed above, USACE has confirmed that none of these features are jurisdictional wetlands.

<u>References for ER-WR-8:</u>

[1] National Wetlands Inventory (NWI) Surface Waters and Wetlands Mapper, BLM Wetland and Riparian Mapping Assessment -New Mexico, Project ID, R02Y19P01